

Engine

Engine Mechanical - 2.0L (LTG) - Repair Instructions - Off Vehicle - CTS Sedan

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

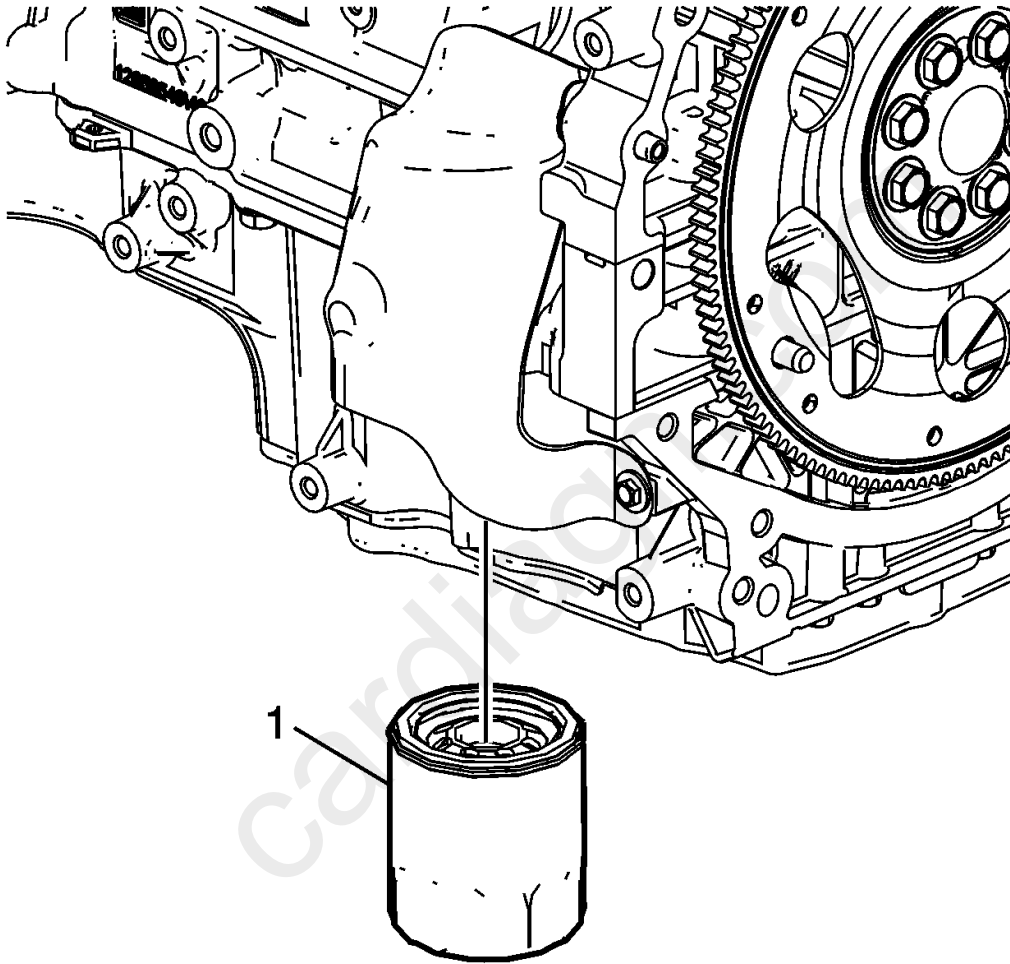


Fig. 1: Engine Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter (1). Remove the oil pan drain plug and allow the oil to drain out.
2. Clean the oil filter housing in the engine block.

CAUTION: Refer to Fastener Caution .

3. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).

4. If cleaning or repairing the engine block, it is not necessary to reinstall the plug.

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **EN-41816** Crankshaft Balancer Remover
- **EN-41816-A** Crankshaft End Protector
- **EN 50792** Flywheel Holding Tool

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

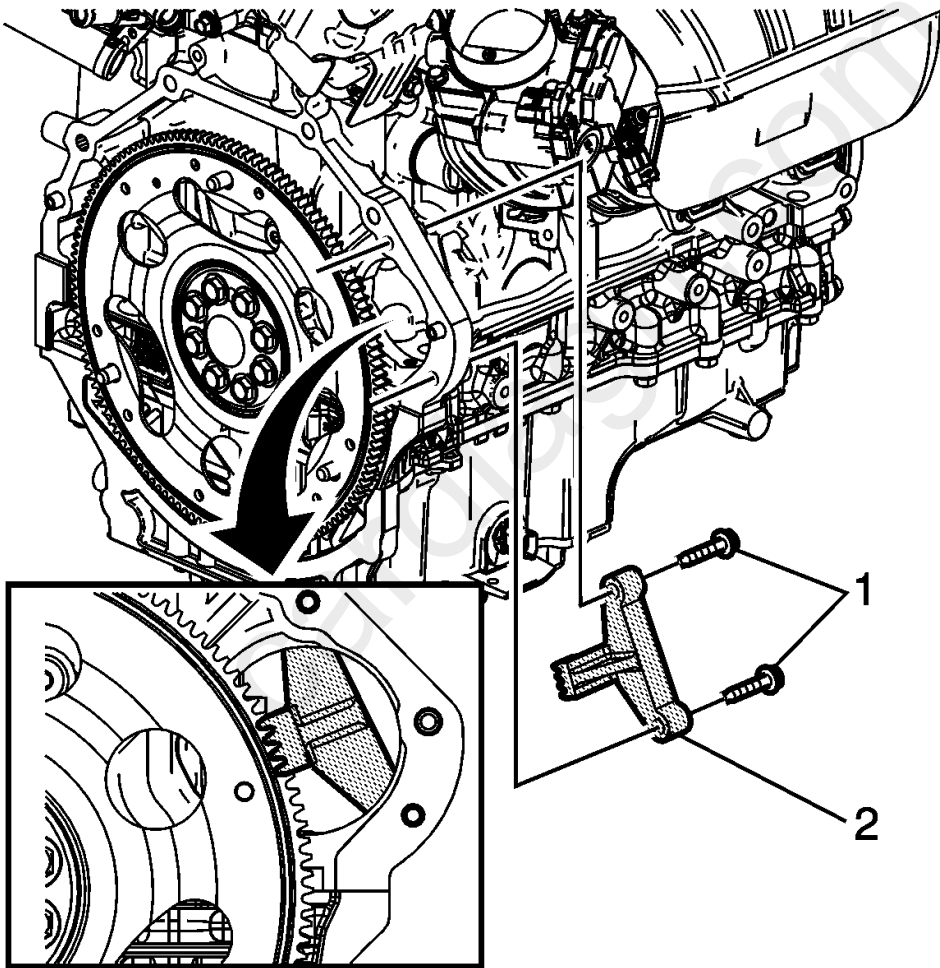


Fig. 2: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install **EN 50792** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

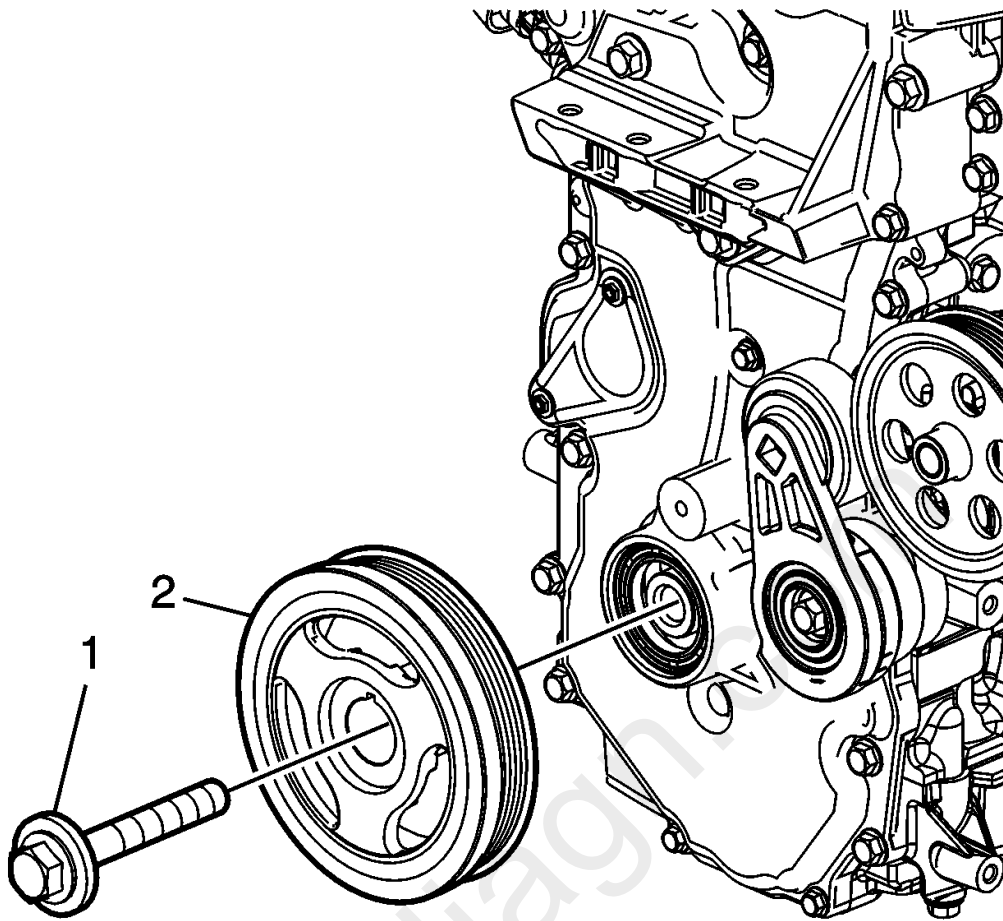


Fig. 3: Crankshaft Balancer

Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the crankshaft balancer bolt (1) and washer.
3. Install **EN-41816-A** protector to protect the crankshaft end during balancer removal.
4. Using **EN-41816** remover , remove the balancer (2).
5. Remove the special tools.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

EN 50792 Flywheel Holding Tool

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

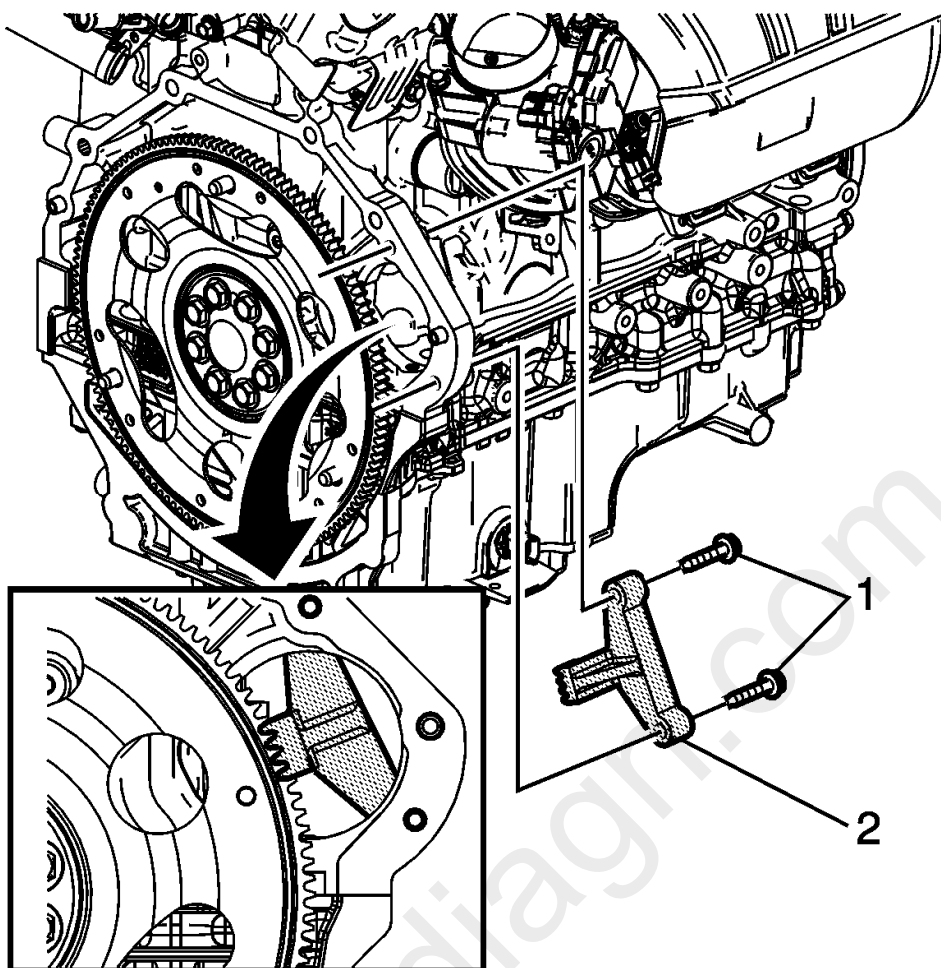


Fig. 4: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install EN 50792 holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

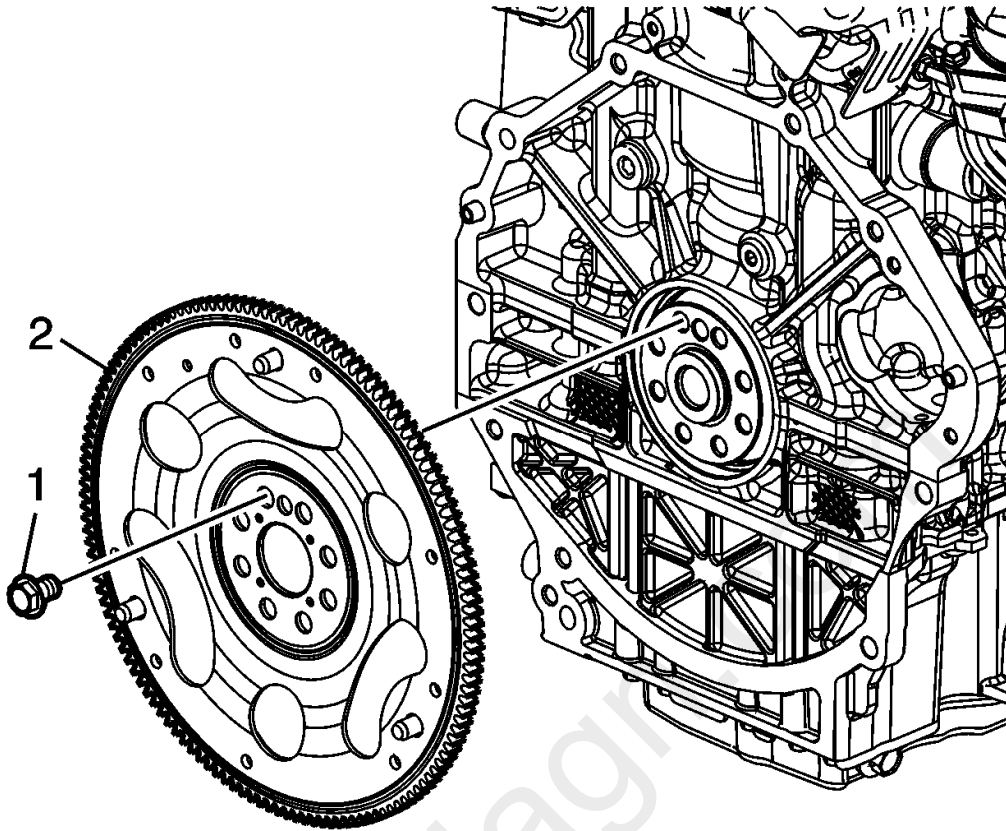


Fig. 5: Flywheel Attaching Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the flywheel attaching bolts (1).
3. Remove the flywheel (2).
4. Remove **EN 50792** holding tool.

INTAKE MANIFOLD REMOVAL

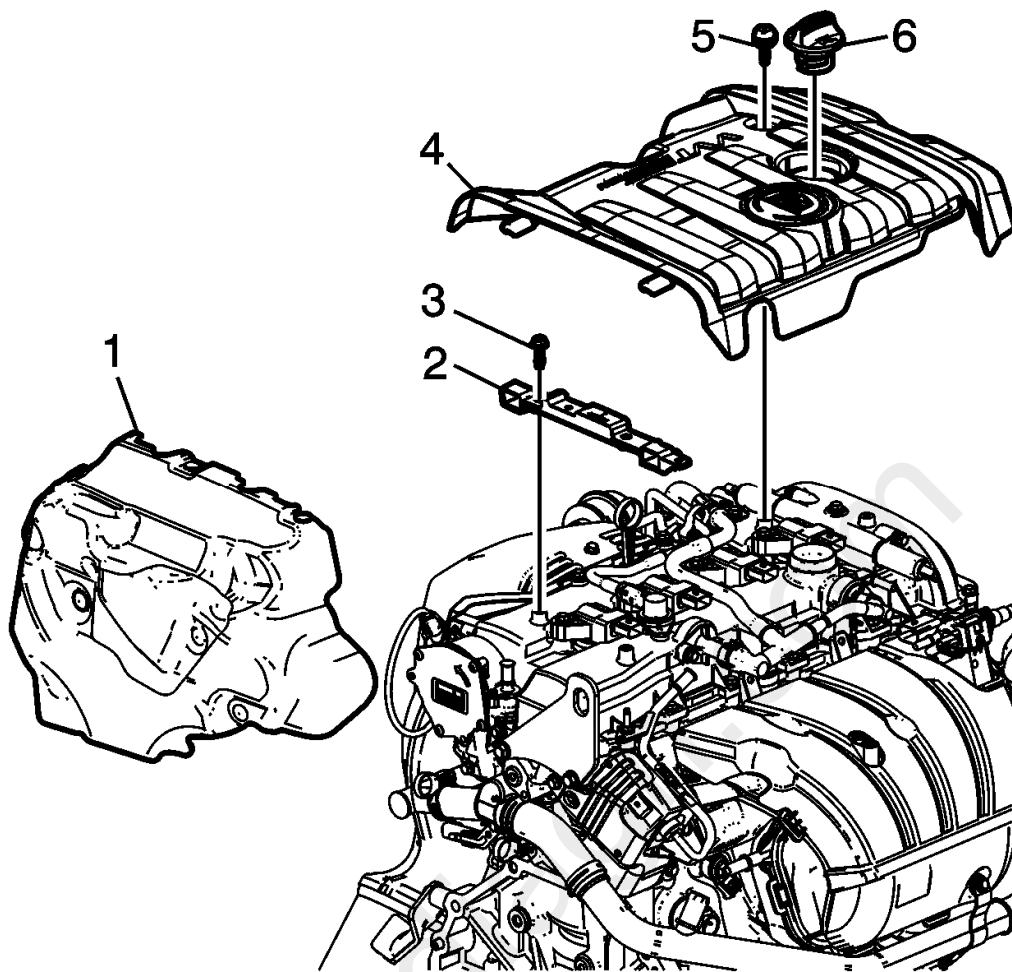


Fig. 6: Intake Manifold And Components
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold can be damaged if it is removed when the engine is hot.

1. Remove the oil fill cap (6).
2. Remove the fuel pump insulator (1).
3. Remove the intake manifold cover bolt (5).
4. Remove the intake manifold cover (4).
5. Remove the upper intake manifold bracket bolt (3).
6. Remove the upper intake manifold bracket (3).

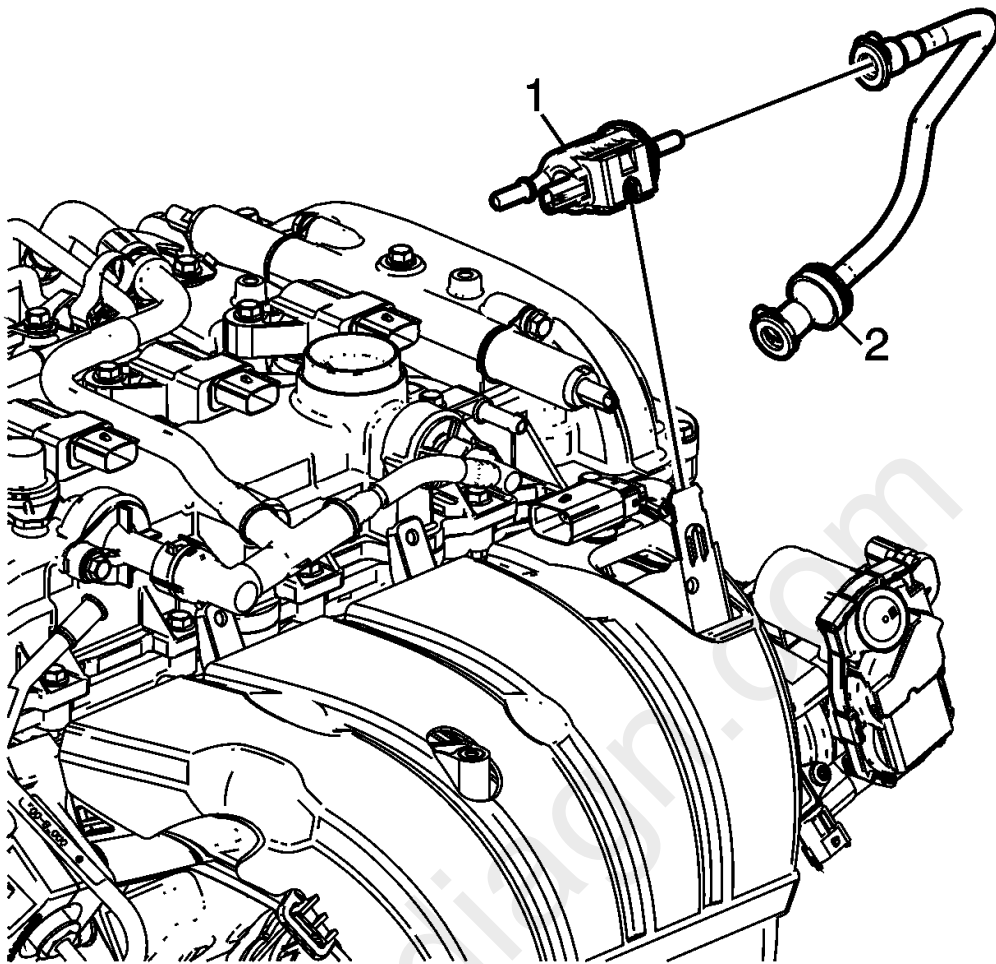


Fig. 7: Evap Canister Valve And Valve Pipe Assembly
Courtesy of GENERAL MOTORS COMPANY

7. Remove the EVAP canister valve (1).
8. Remove the EVAP canister valve pipe assembly (2).

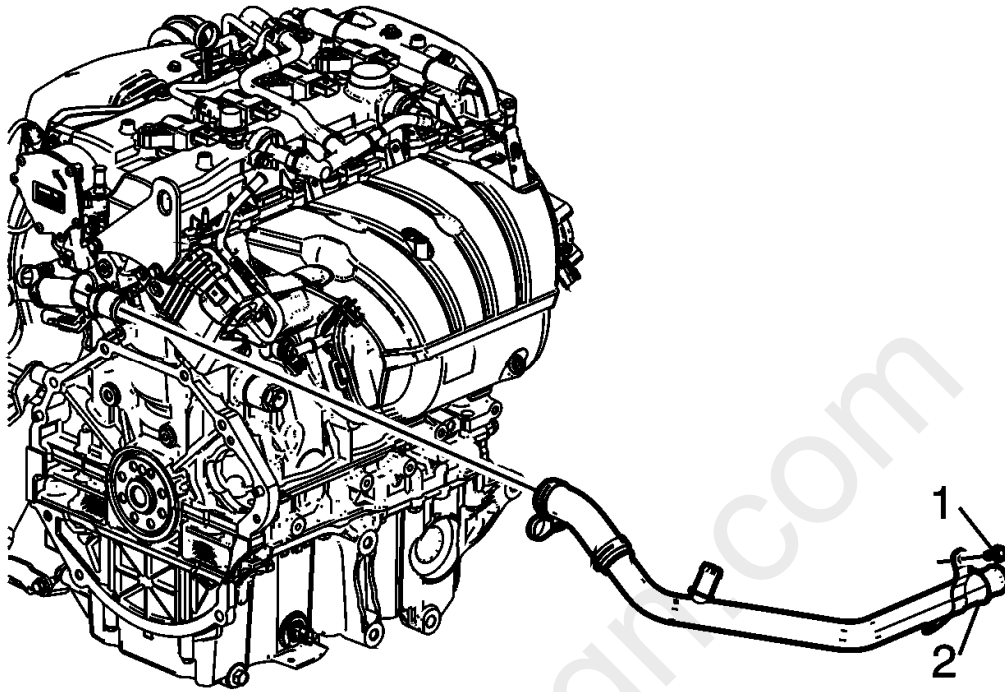


Fig. 8: Radiator Inlet Pipe And Hose
Courtesy of GENERAL MOTORS COMPANY

9. Remove the radiator inlet pipe bolt (1).
10. Disconnect the radiator inlet hose from the water outlet assembly, and remove the radiator inlet pipe and hose assembly (2).

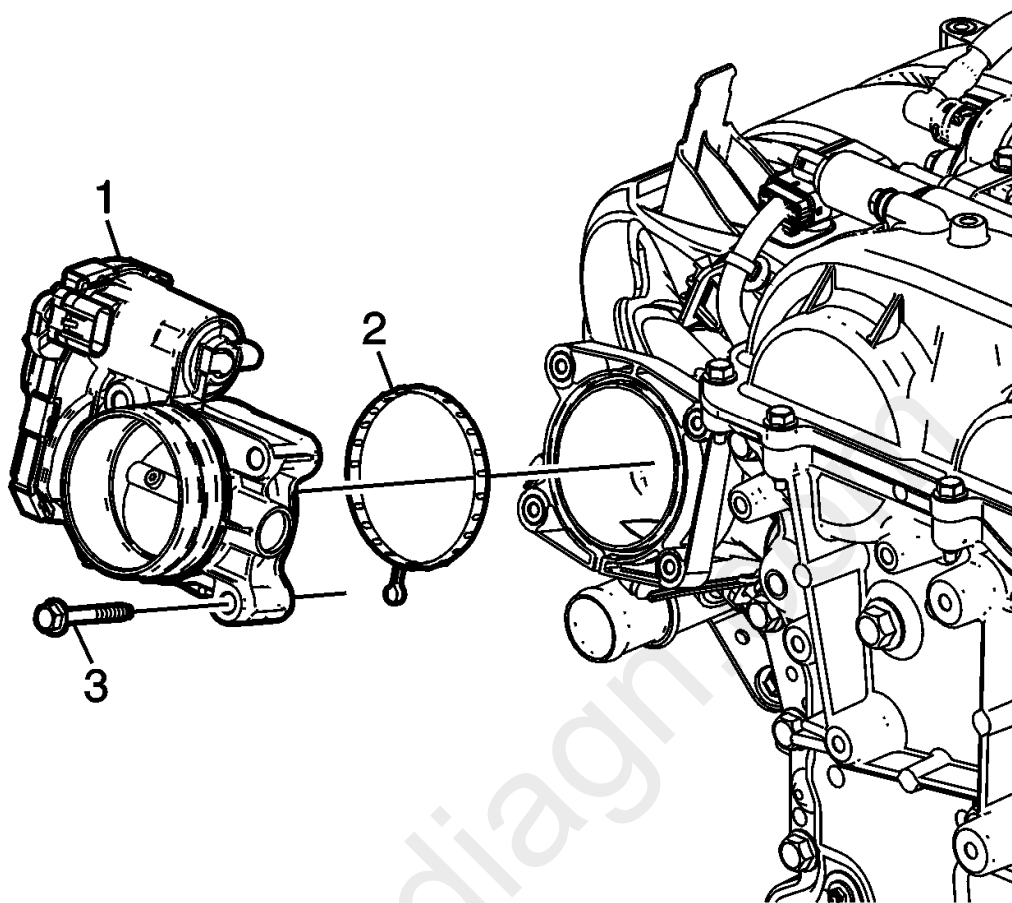


Fig. 9: Throttle Body
Courtesy of GENERAL MOTORS COMPANY

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

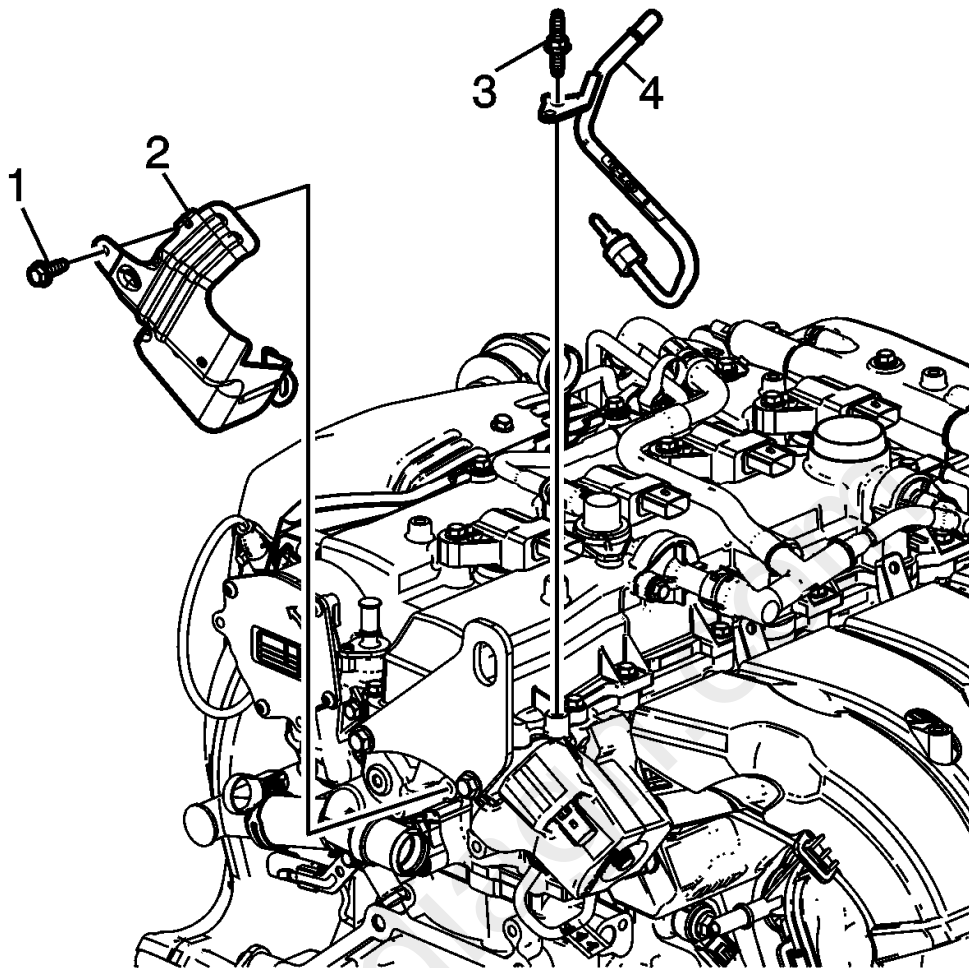


Fig. 10: Fuel Pump Cover And Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

13. Remove the fuel pump cover bolts (1) and fuel pump cover (2).

WARNING: Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure.

14. Remove the fuel feed pipe stud (3) and the fuel feed pipe (4).

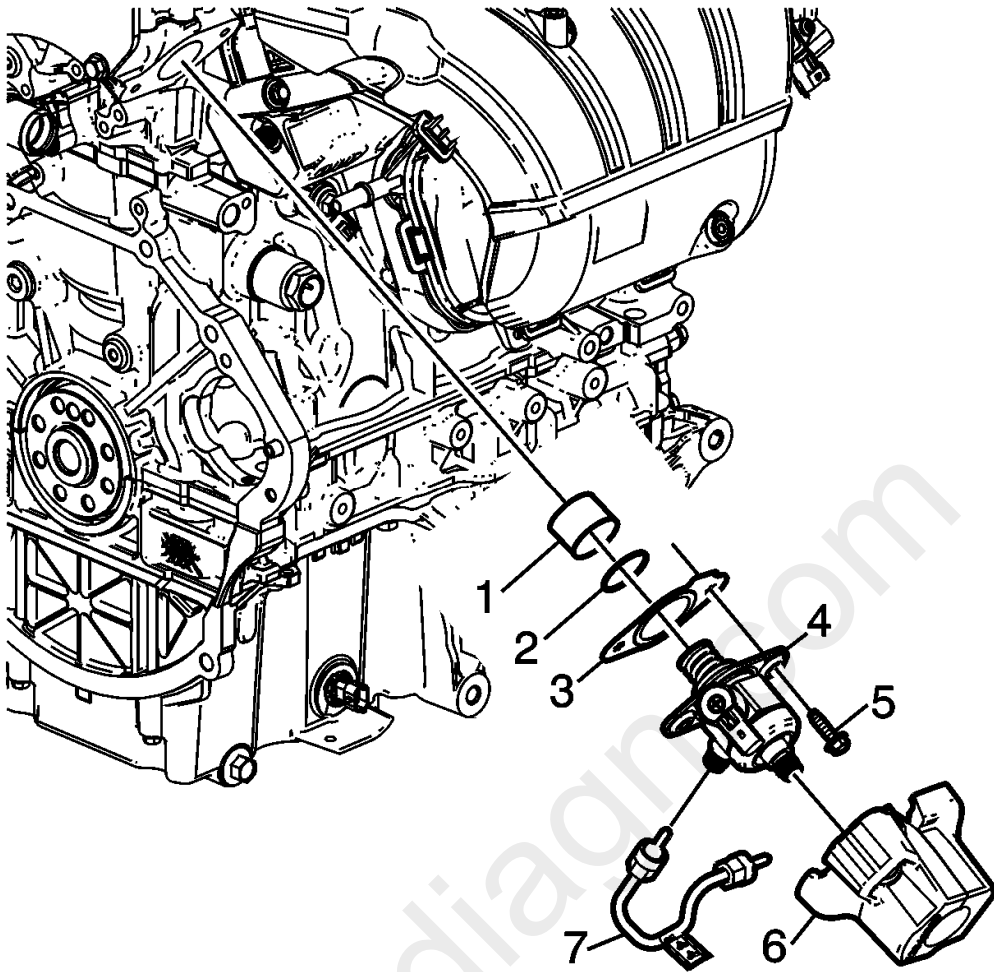


Fig. 11: Exploded View Of Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

15. Remove the fuel pump insulator (6).
16. Remove and discard the fuel feed intermediate pipe (7).
17. Remove the fuel pump bolts (5).
18. Remove the fuel pump (4), O-ring (2), and gasket (3).
19. Remove the valve lifter follower (1).

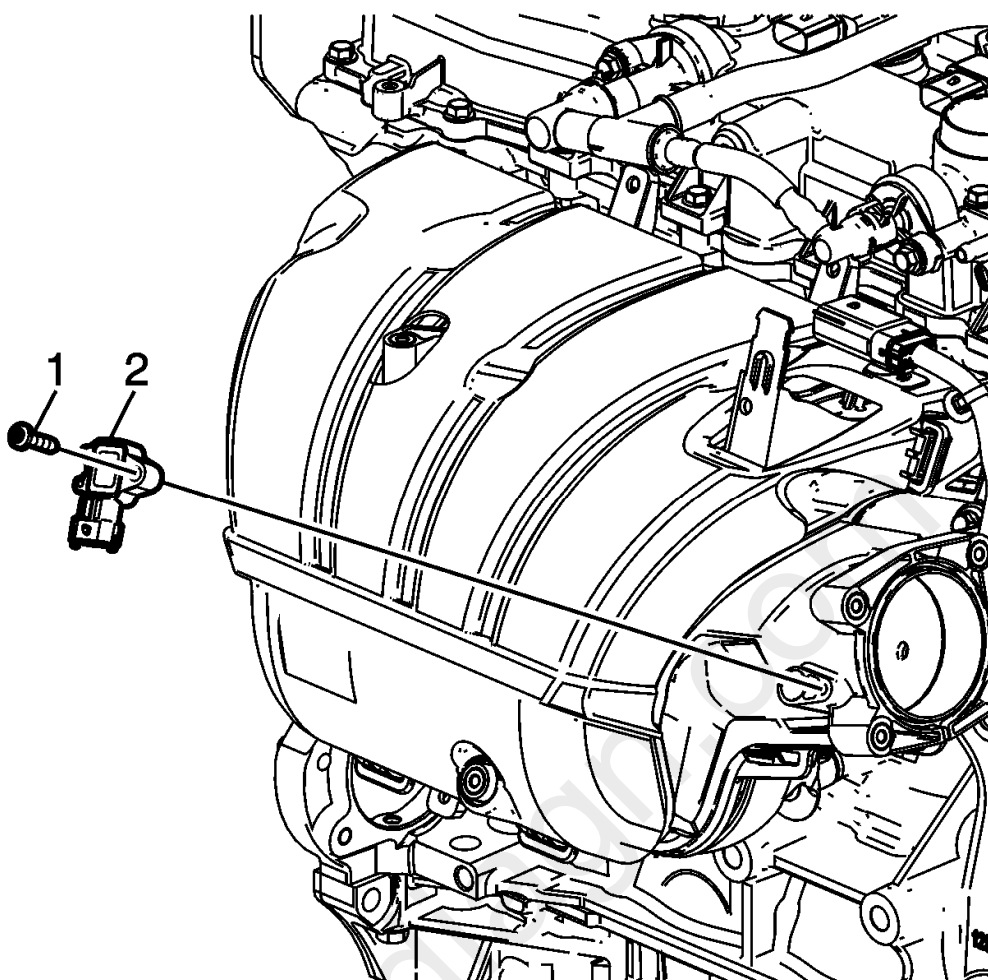


Fig. 12: MAP Sensor
Courtesy of GENERAL MOTORS COMPANY

20. Remove the MAP sensor (2) and bolt (1).

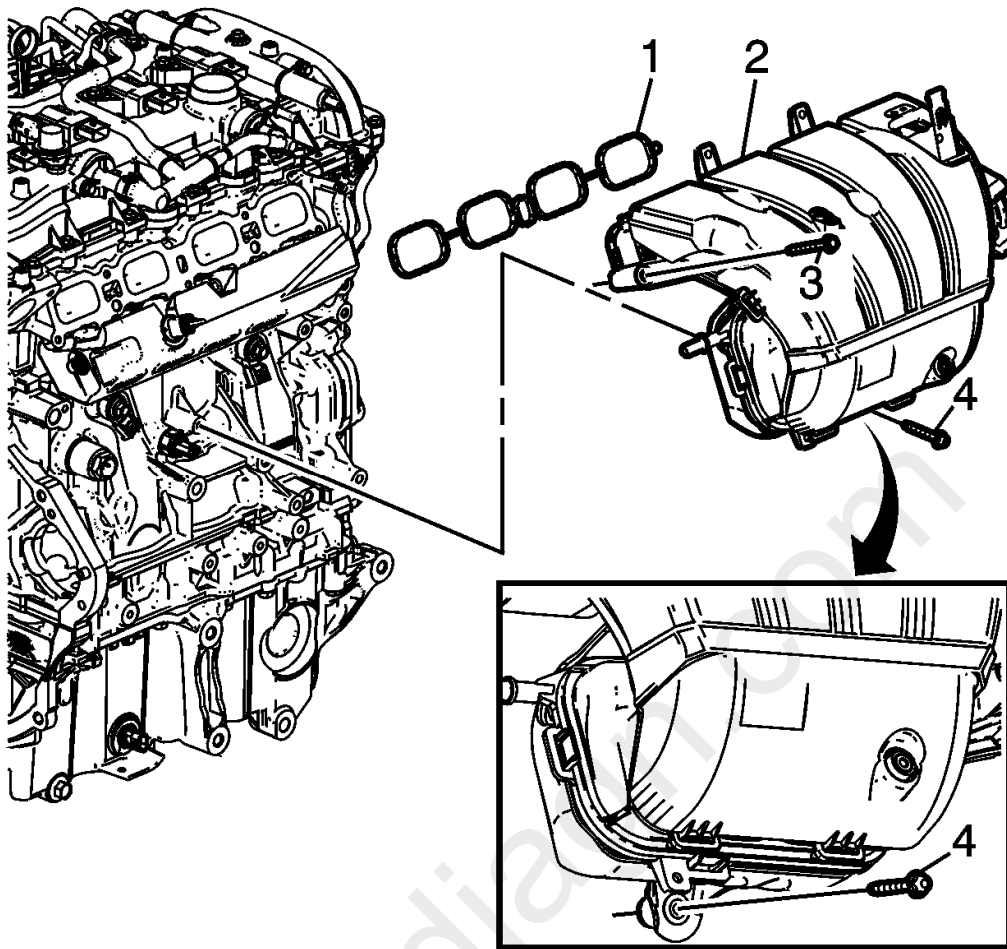


Fig. 13: Engine Intake Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

21. Remove the intake manifold retaining bolts (3, 4).
22. Remove the intake manifold (2) and gasket (1).
23. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

TURBOCHARGER REMOVAL

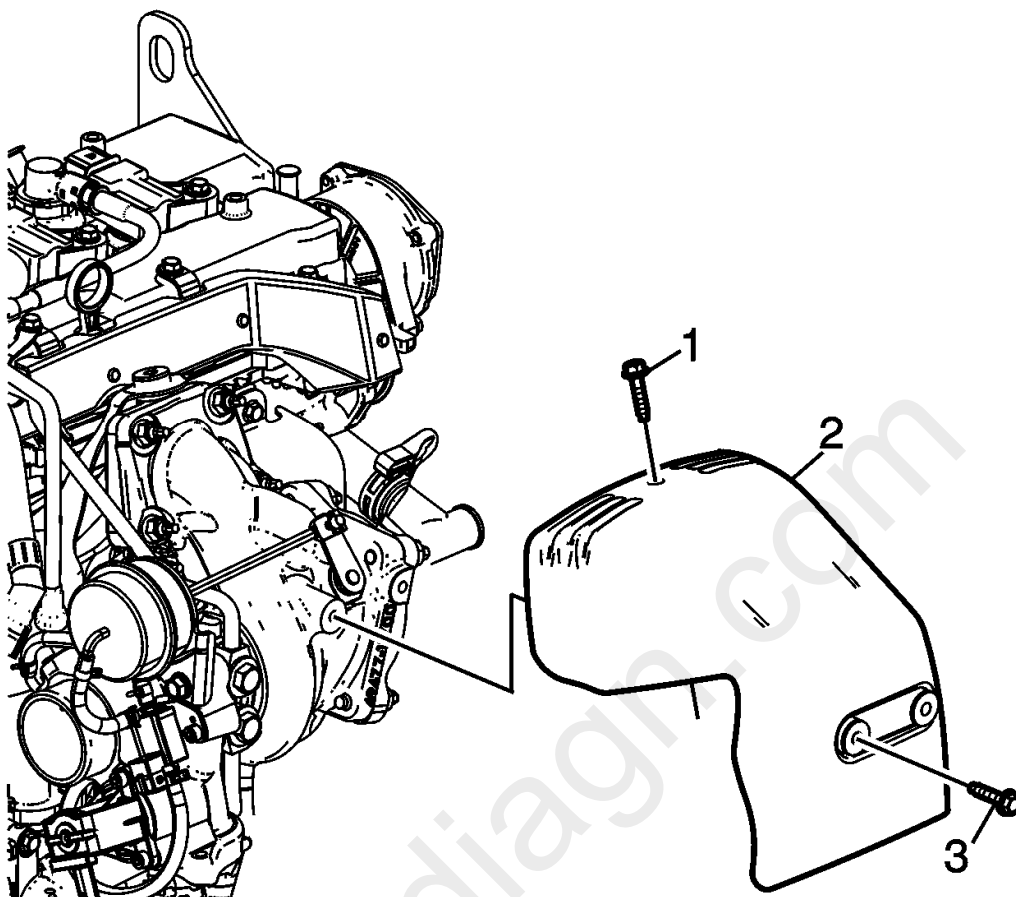


Fig. 14: Turbocharger Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt.

1. Remove the turbocharger heat shield bolts (1, 3).
2. Remove the turbocharger heat shield (2).

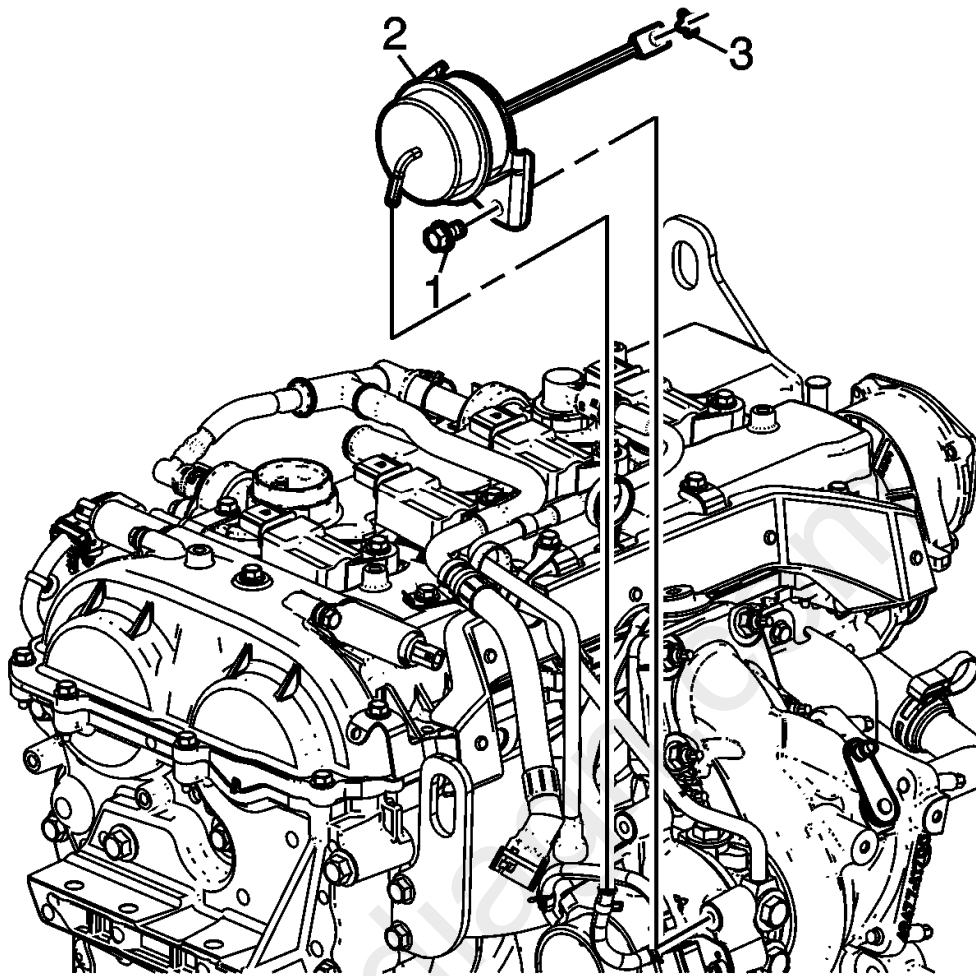


Fig. 15: Turbocharger Wastegate Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Remove the turbocharger wastegate actuator arm retainer (3).
4. Remove the turbocharger wastegate actuator bolts (1) and actuator (2).

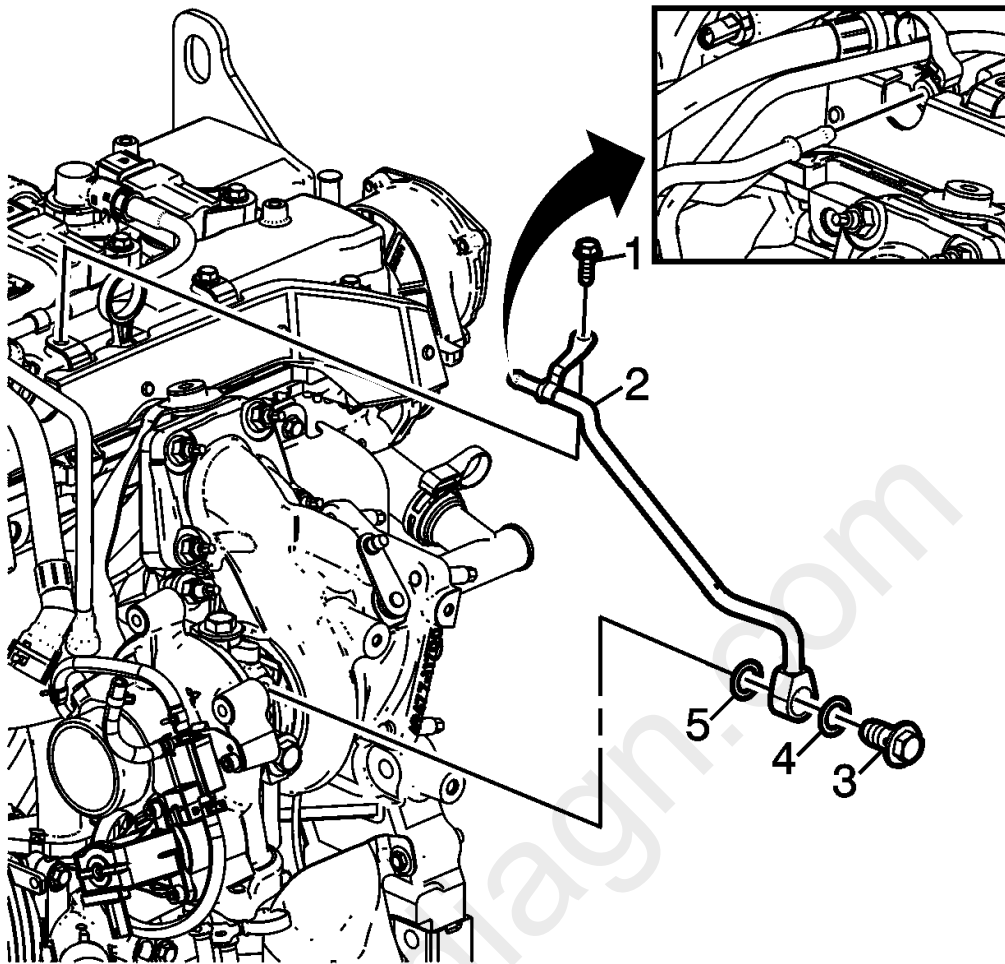


Fig. 16: Camshaft Cover Heat Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Remove the camshaft cover heat shield bolt (1) that retains the turbocharger coolant return pipe (2) at the camshaft cover.
6. Disconnect the turbocharger coolant return pipe from the air bleed hose.
7. Remove the turbocharger coolant return pipe bolt (3).
8. Remove the turbocharger coolant return pipe (2) and washers (4, 5). Discard the washers.

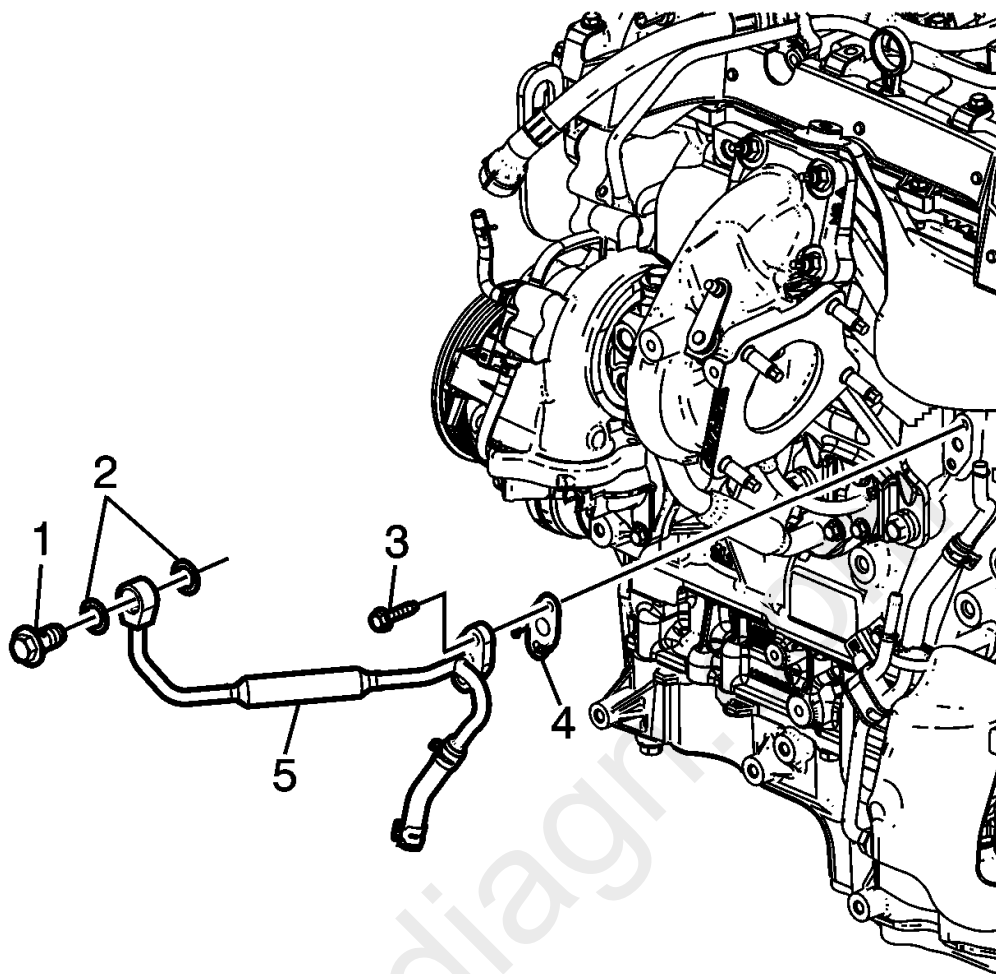


Fig. 17: Turbocharger Coolant Feed Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the turbocharger coolant feed pipe bolts (1, 3).
10. Disconnect the turbocharger coolant feed pipe hose from the engine oil cooler.
11. Remove the turbocharger coolant feed pipe gasket (4) and discard.
12. Remove the turbocharger coolant feed pipe (5) and washers (2). Discard the washers.

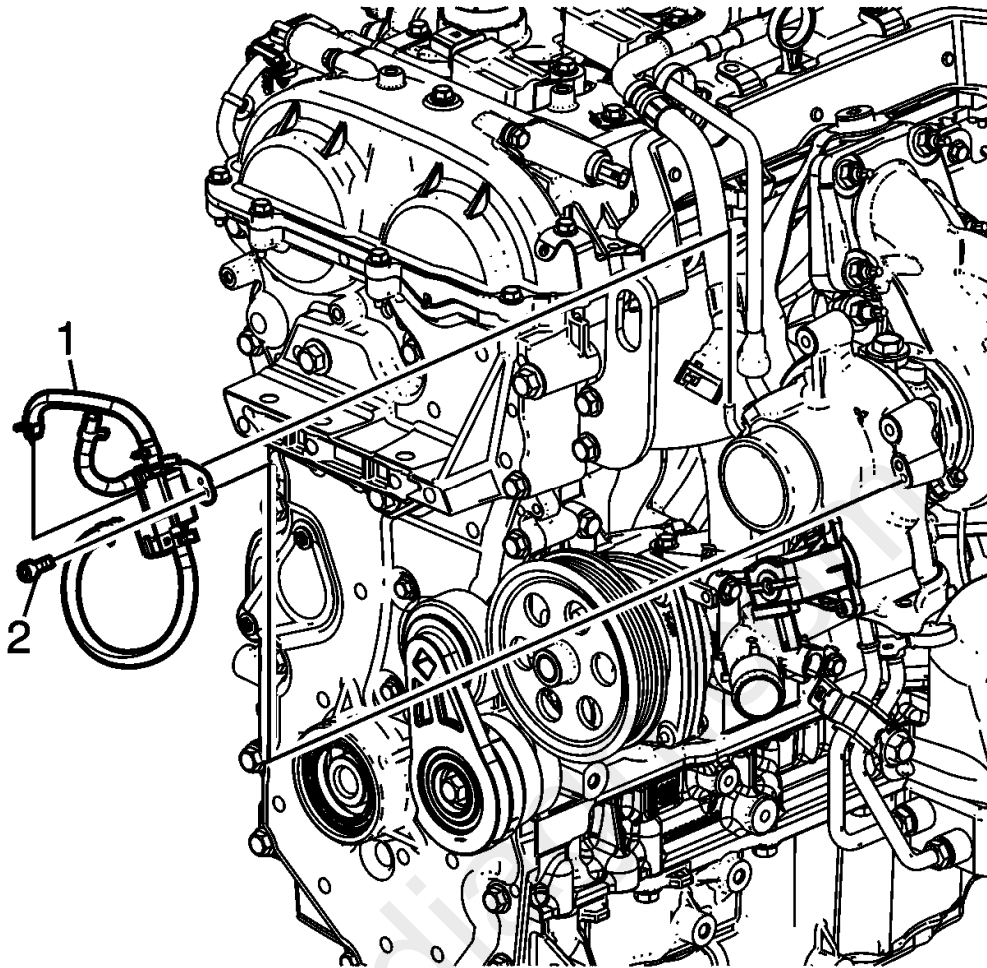


Fig. 18: Turbocharger Wastegate Regulator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the turbocharger wastegate regulator solenoid valve hoses from the turbocharger.
14. Remove the turbocharger wastegate regulator solenoid valve bracket bolt (2).
15. Remove the turbocharger wastegate regulator solenoid valve (1).

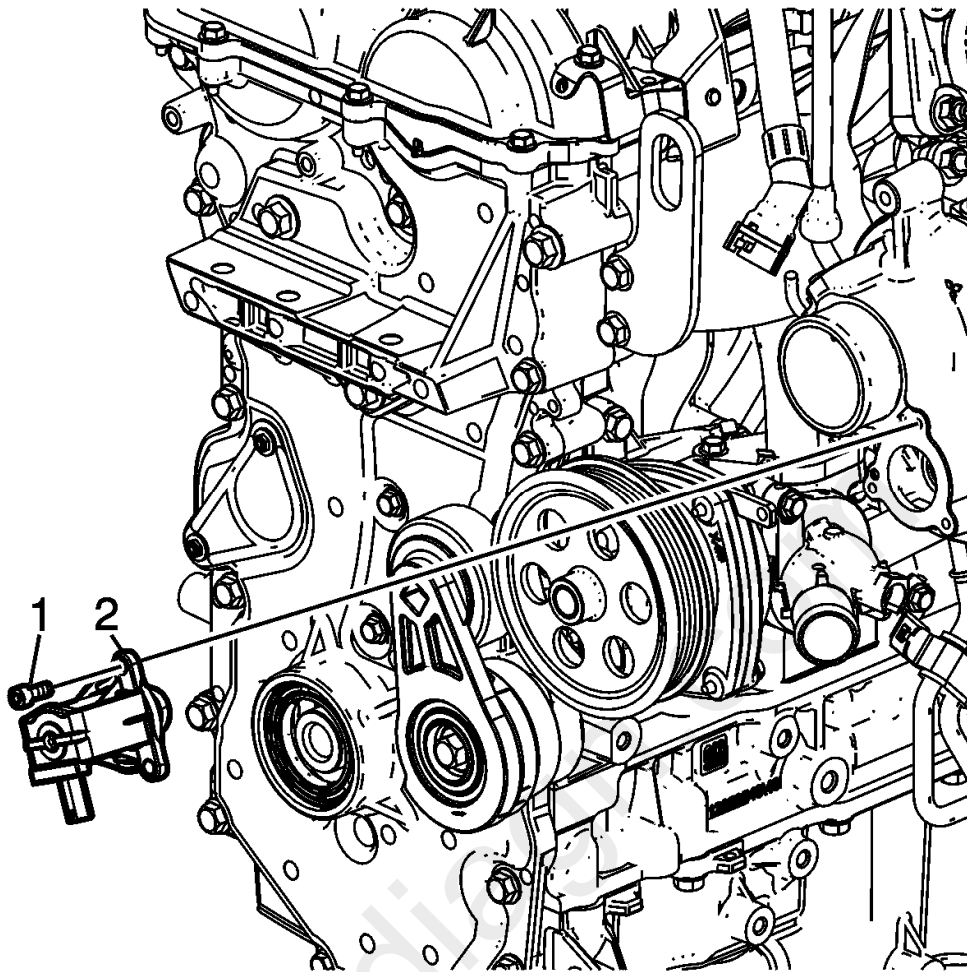


Fig. 19: Turbocharger Bypass Valve Solenoid Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the turbocharger bypass valve solenoid bolts (1).
17. Remove the turbocharger bypass valve solenoid (2).

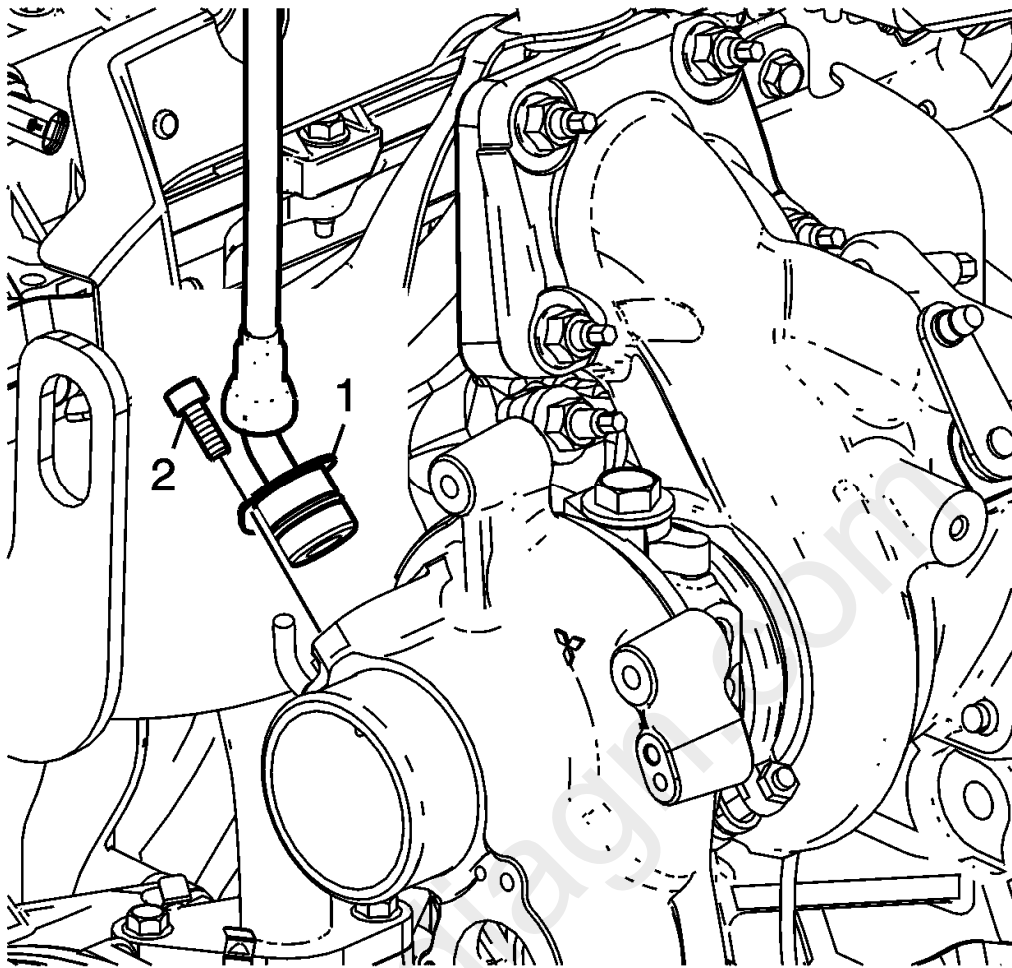


Fig. 20: PCV Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not disturb the joint between the PCV hose and PCV hose fitting at the turbocharger. This is a permanent connection.

18. Remove the PCV hose fitting bolt (2). Disconnect the PCV hose fitting (1) with the PCV hose attached from the turbocharger.

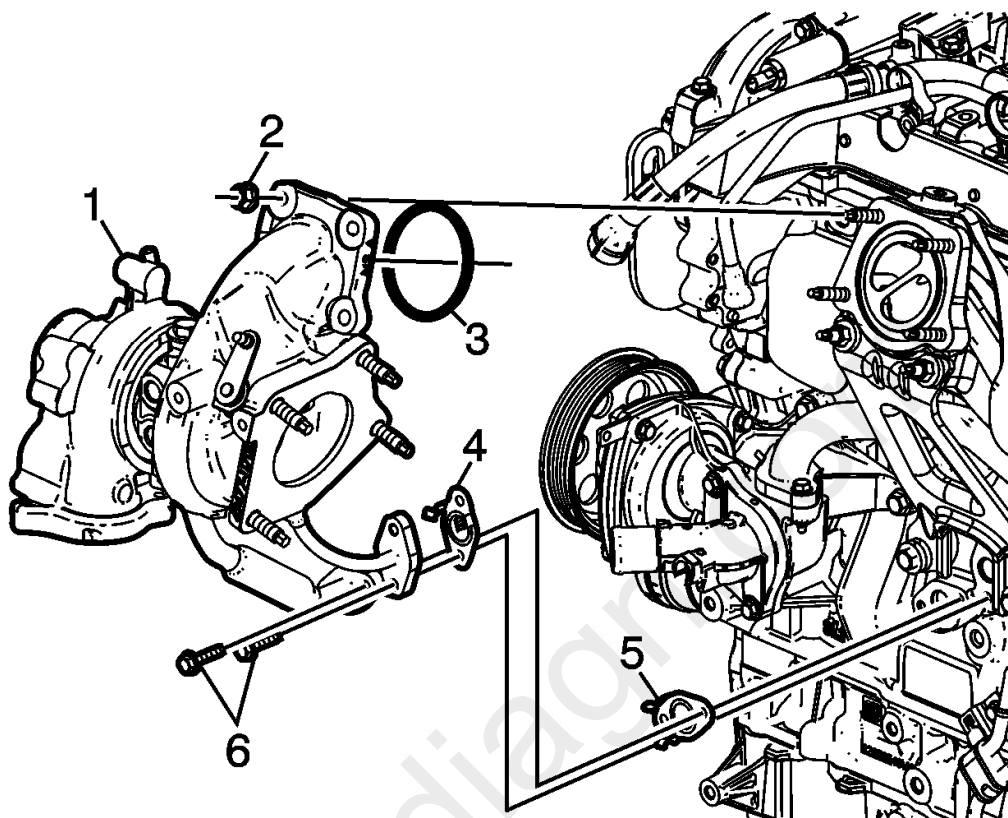


Fig. 21: Turbocharger Nuts

Courtesy of GENERAL MOTORS COMPANY

19. Remove the turbocharger nuts (2) and discard.
20. Remove the turbocharger oil feed and return pipe bolts (6) at the engine block.
21. Remove the turbocharger (1) with the oil return pipe and oil feed pipe attached.
22. Remove the turbocharger oil feed and oil return pipe gaskets (4, 5) and discard.
23. Remove the turbocharger gasket (3) and discard.

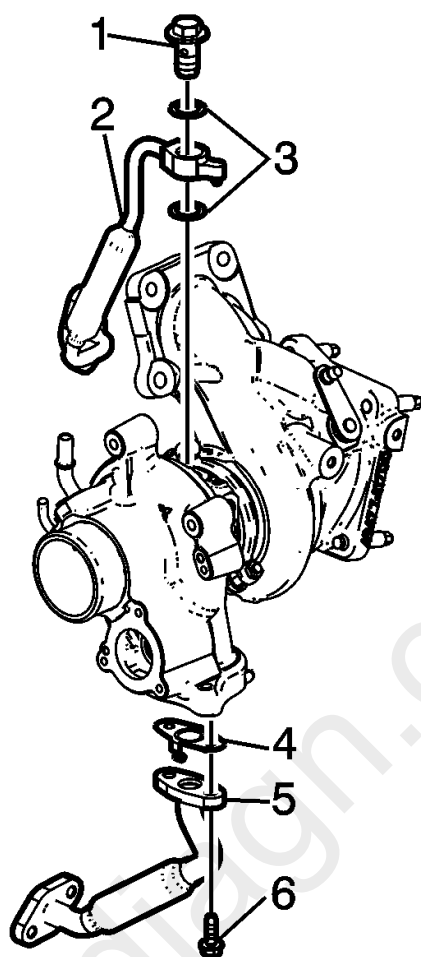


Fig. 22: Turbocharger Oil Feed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

24. Remove the turbocharger oil feed pipe bolt (1) from the turbocharger.
25. Remove the turbocharger oil feed pipe (2) and washers (3). Discard the washers.
26. Remove the turbocharger oil return pipe bolts (6).
27. Remove the turbocharger oil return pipe (5).
28. Remove and discard the turbocharger oil return pipe gasket (4).
29. Clean and inspect the turbocharger and components. Refer to **Turbocharger Cleaning and Inspection.**

EXHAUST MANIFOLD REMOVAL

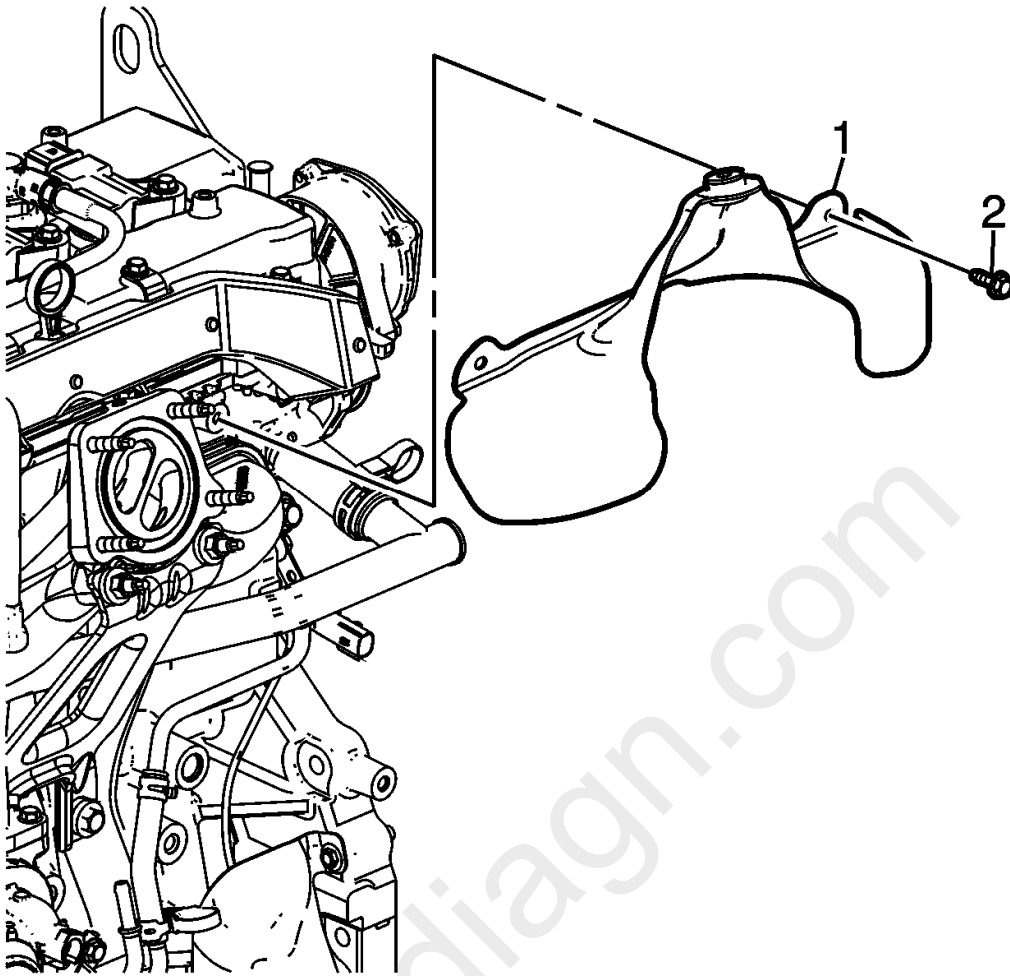


Fig. 23: Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt.

1. Remove the exhaust manifold heat shield bolts (2).
2. Remove the exhaust manifold heat shield (1).

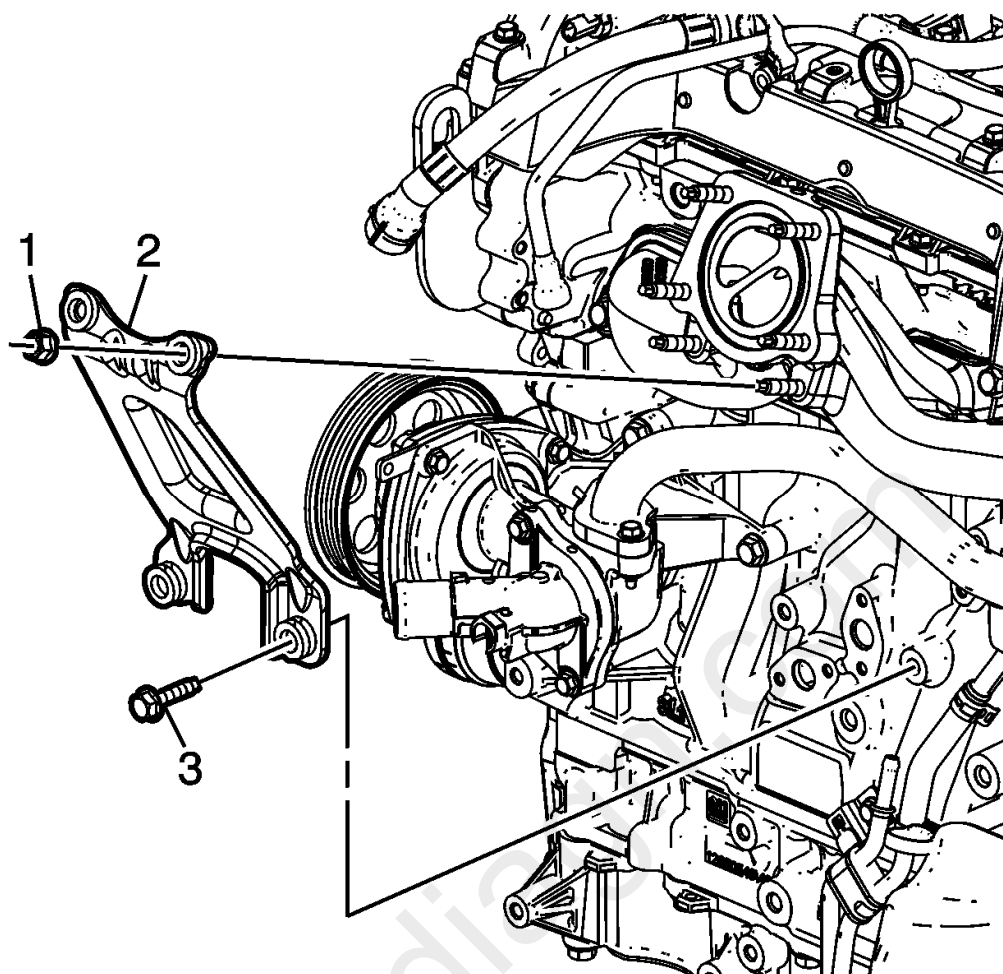


Fig. 24: Exhaust Manifold Brace Nuts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the exhaust manifold brace nuts (1) and discard.
4. Remove the exhaust manifold brace bolts (3).
5. Remove the exhaust manifold brace (2).

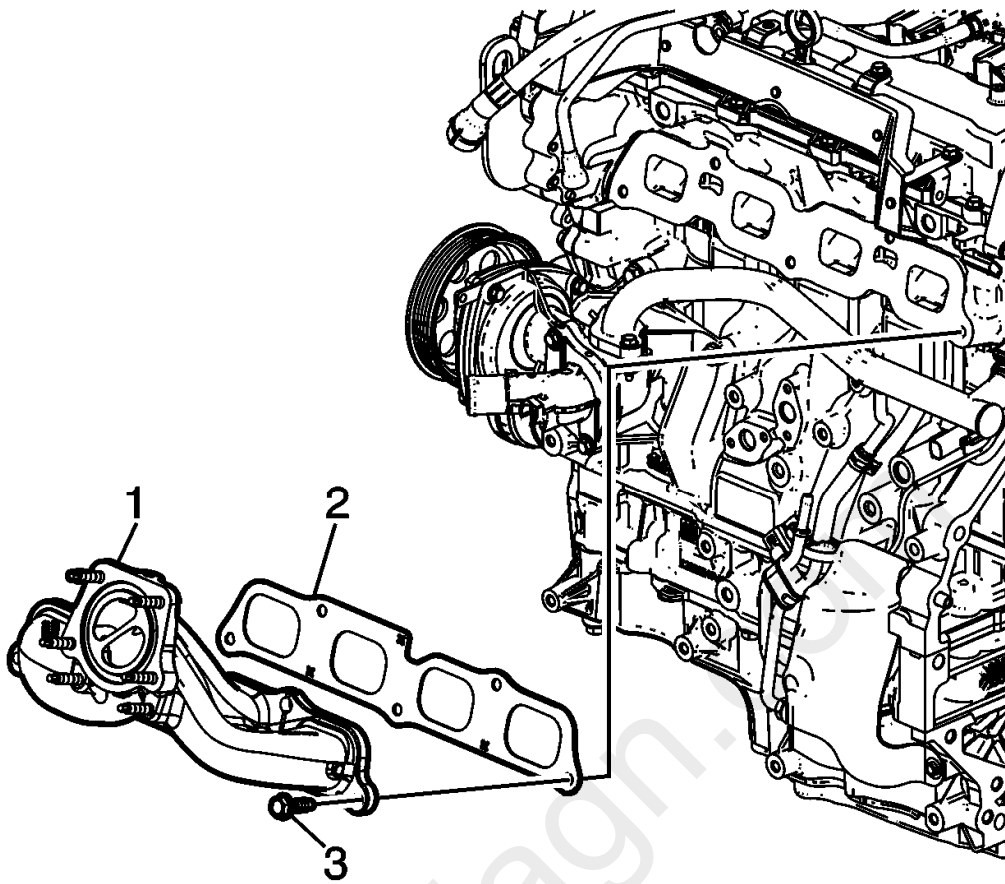


Fig. 25: Exhaust Manifold And Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the exhaust manifold to cylinder head bolts (3).
7. Remove the exhaust manifold (1).
8. Remove and discard the exhaust manifold gasket (2).
9. Clean all of the sealing surfaces.

SECONDARY AIR INJECTION CHECK VALVE REMOVAL

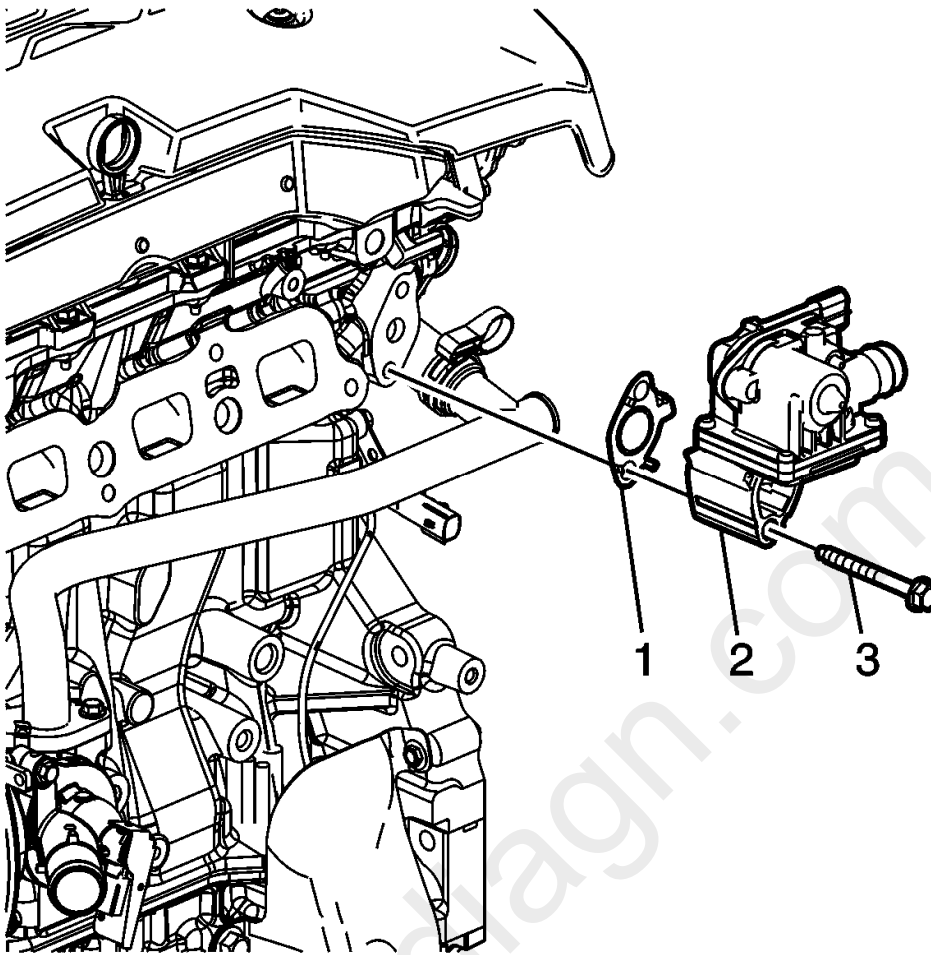


Fig. 26: Secondary Air Injection Check Valve Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the secondary air injection check valve bolts (3).
2. Remove the secondary air injection check valve assembly (2).
3. Remove and discard the check valve gasket (1).

FUEL RAIL AND INJECTORS REMOVAL

Special Tools

EN-49248 Fuel Rail Assembly Remover

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

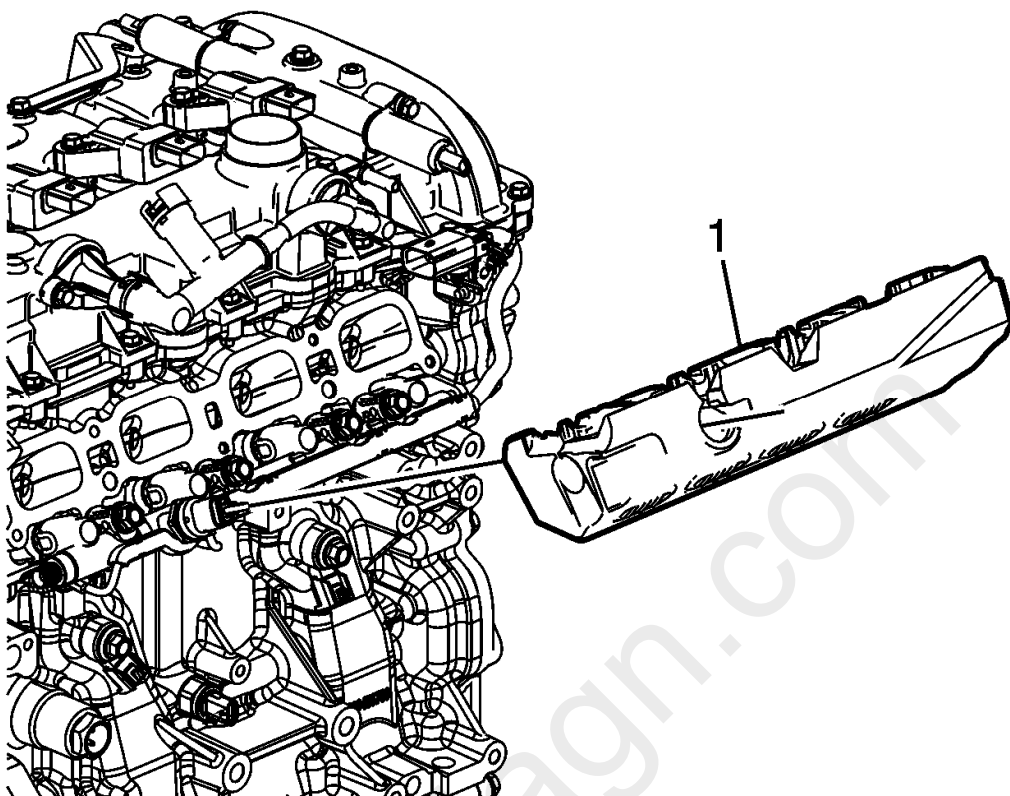


Fig. 27: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

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

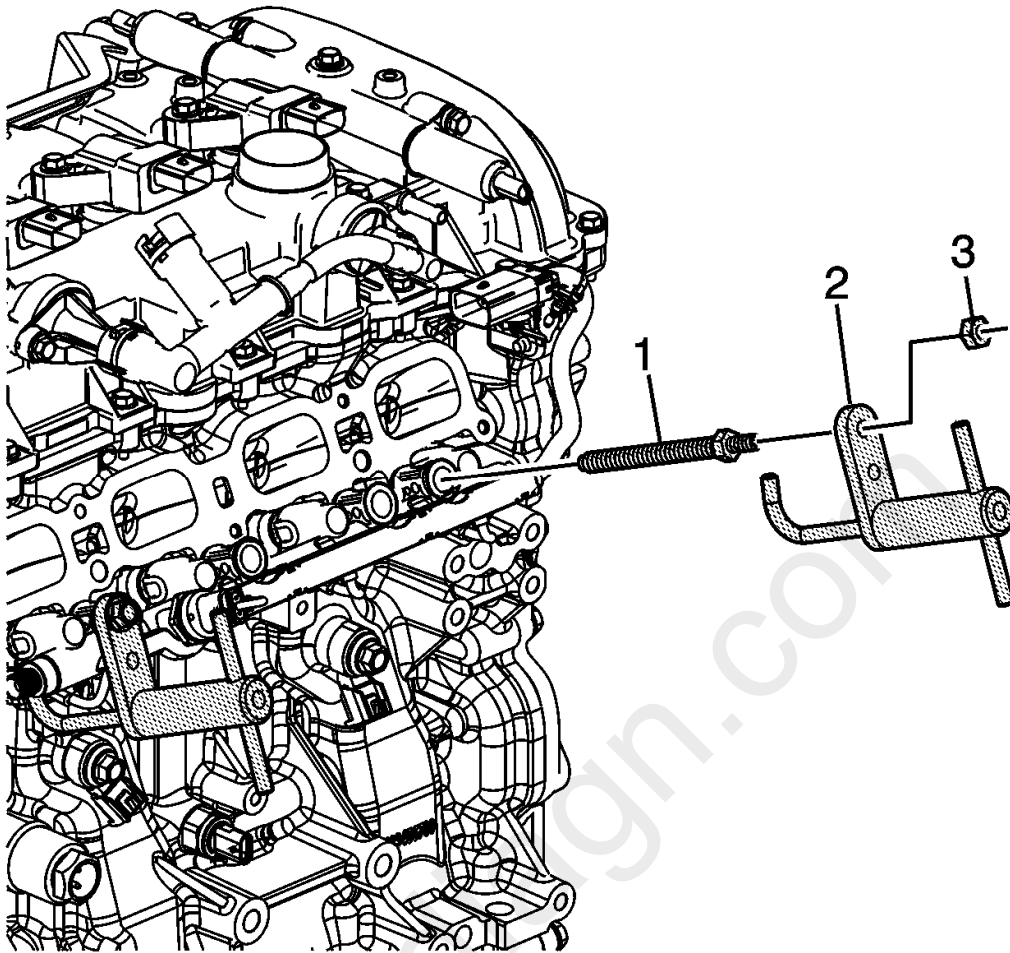


Fig. 28: Identifying Fuel Rail Assembly Remover Studs
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical harness from the fuel rail harness connection.
3. Remove the fuel rail assembly retaining bolts and upper rubber grommet, if necessary.

NOTE: Use care to avoid contact with the fuel rail harness during special tool installation and fuel rail removal.

4. Install **EN-49248** studs (1) into the 2 outermost fuel rail assembly retaining bolt locations. Tighten the studs to 22 N.m (16 lb ft).
5. Install **EN-49248** remover (2) onto each stud, and engage the hooks to the fuel rail. Install the nuts (3) retaining the remover onto the studs and tighten until snug.

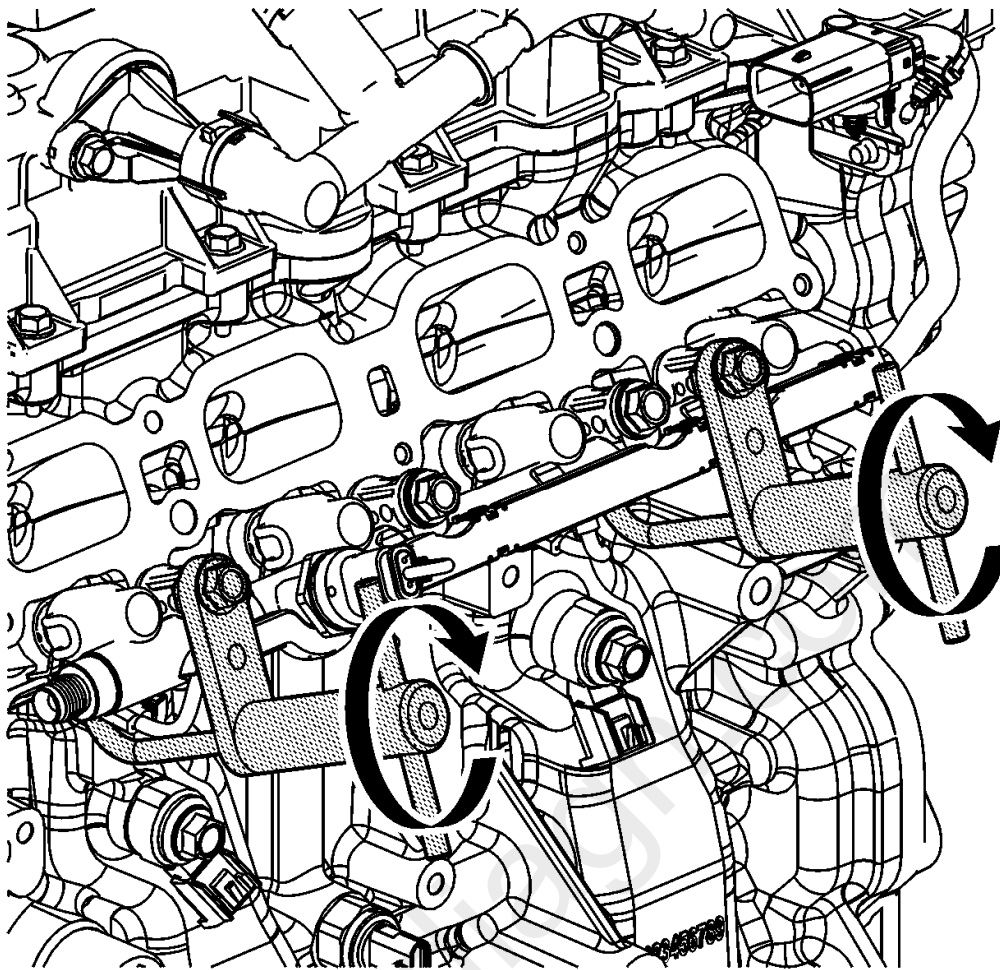


Fig. 29: Removing Fuel Rail Assembly Using Fuel Rail Assembly Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE: EN-49248 will assist in the proper removal of the fuel rail assembly. Ensure that the following conditions are met:

- Turn the handles simultaneously in order to pull the fuel rail straight out along the fuel injector axis.
- DO NOT twist when pulling out on the fuel rail and injector assembly.

6. Using **EN-49248** remover , remove the fuel rail assembly.

CAMSHAFT COVER REMOVAL

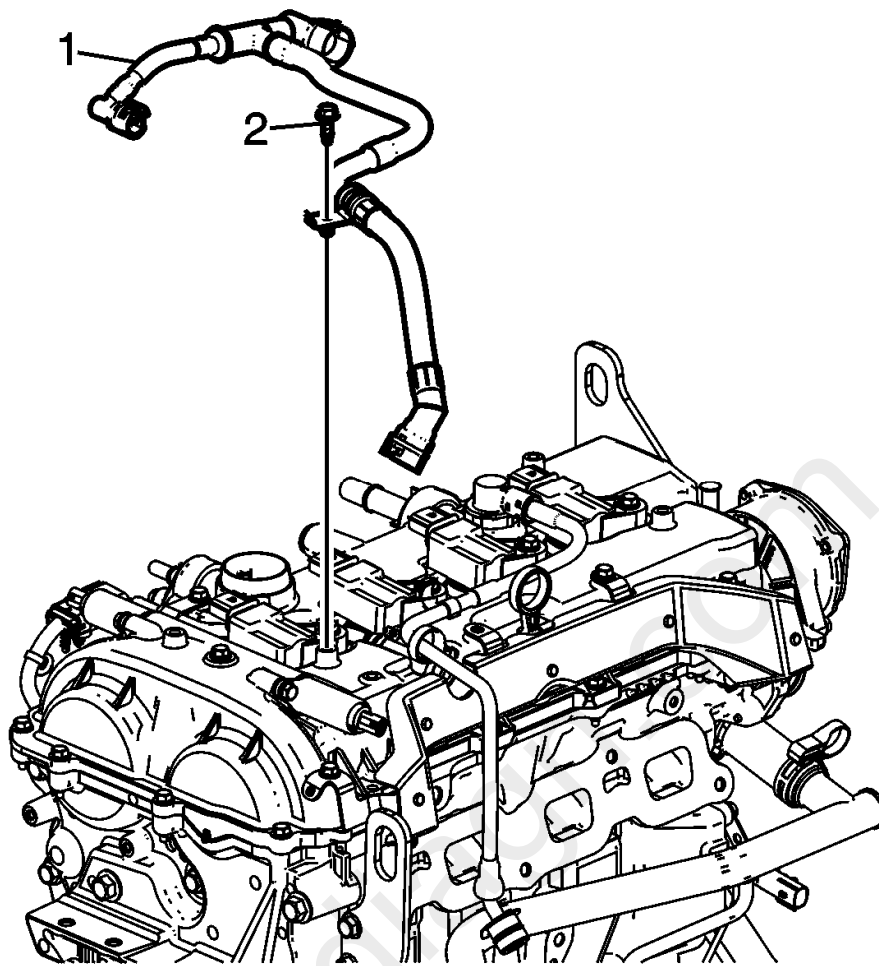


Fig. 30: PCV Hose Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the PCV hose bolt (2) from the camshaft cover.
2. Disconnect the PCV tube assembly (1) at the quick-connect fittings.

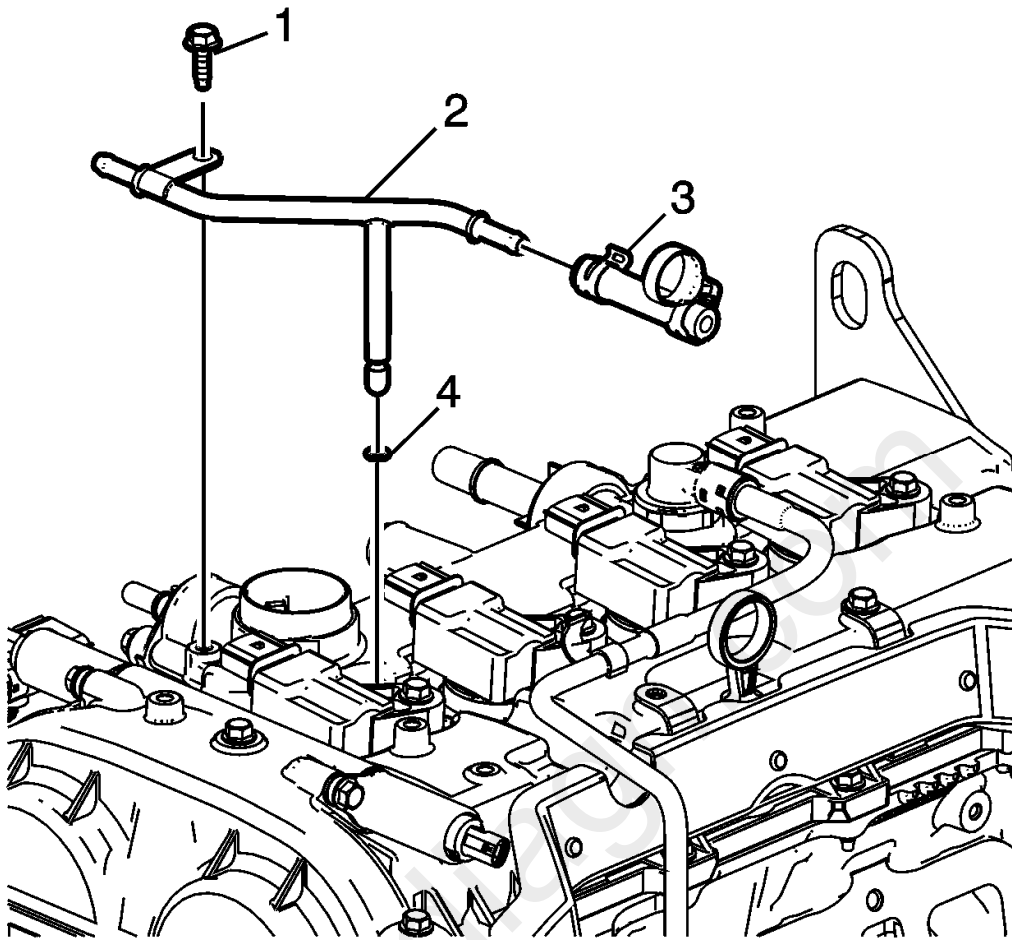


Fig. 31: Engine Coolant Air Bleed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the engine coolant air bleed pipe bolt (1).
4. Remove the engine coolant air bleed pipe (2), hose (3), and O-ring (4). Inspect O-ring and discard if necessary.

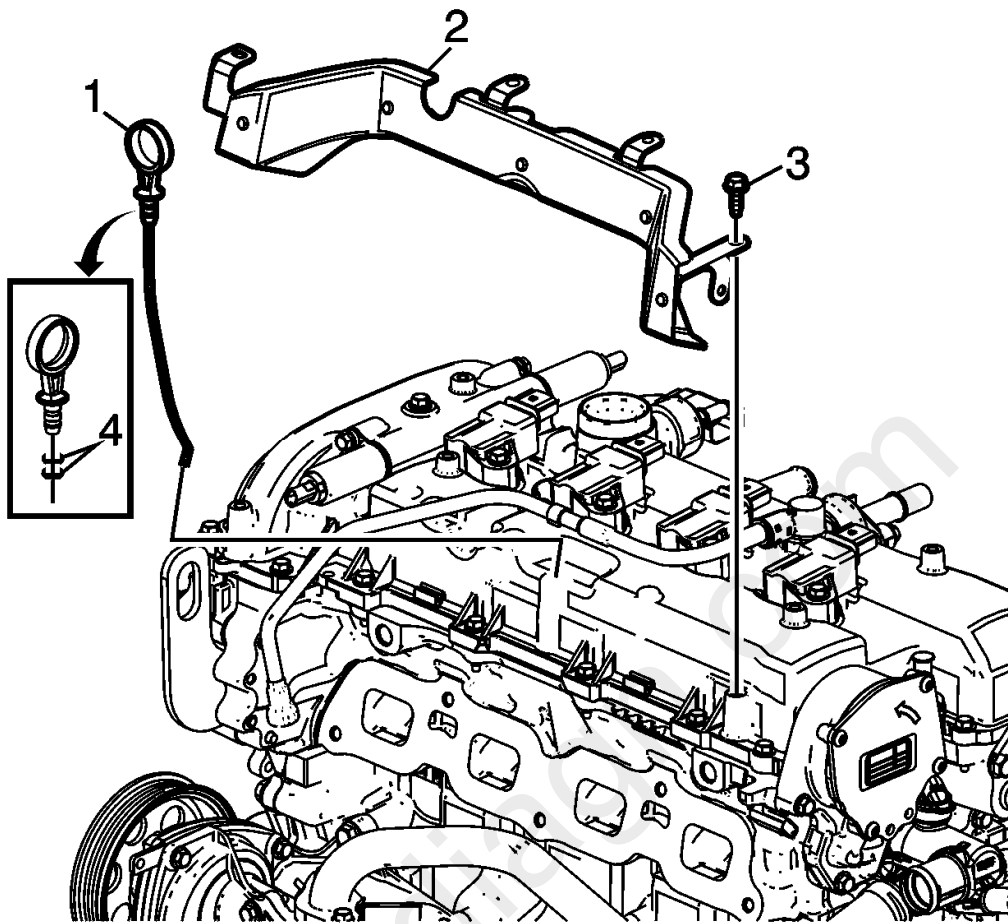


Fig. 32: Camshaft Cover Heat Shield
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil level indicator (1). Inspect and replace the oil indicator O-ring seals (4), if necessary.
6. Remove the camshaft cover heat shield (2) and bolts (3).

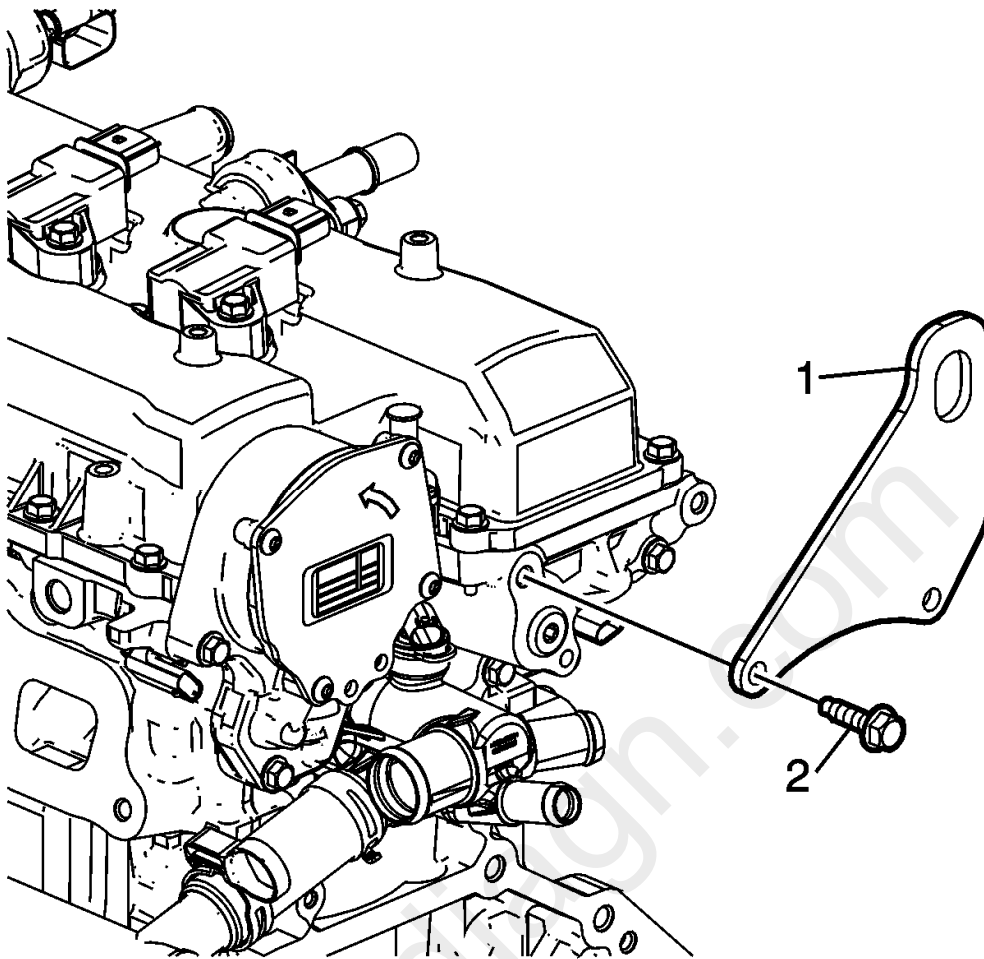


Fig. 33: Rear Lift Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the rear lift bracket (1) and bolts (2).

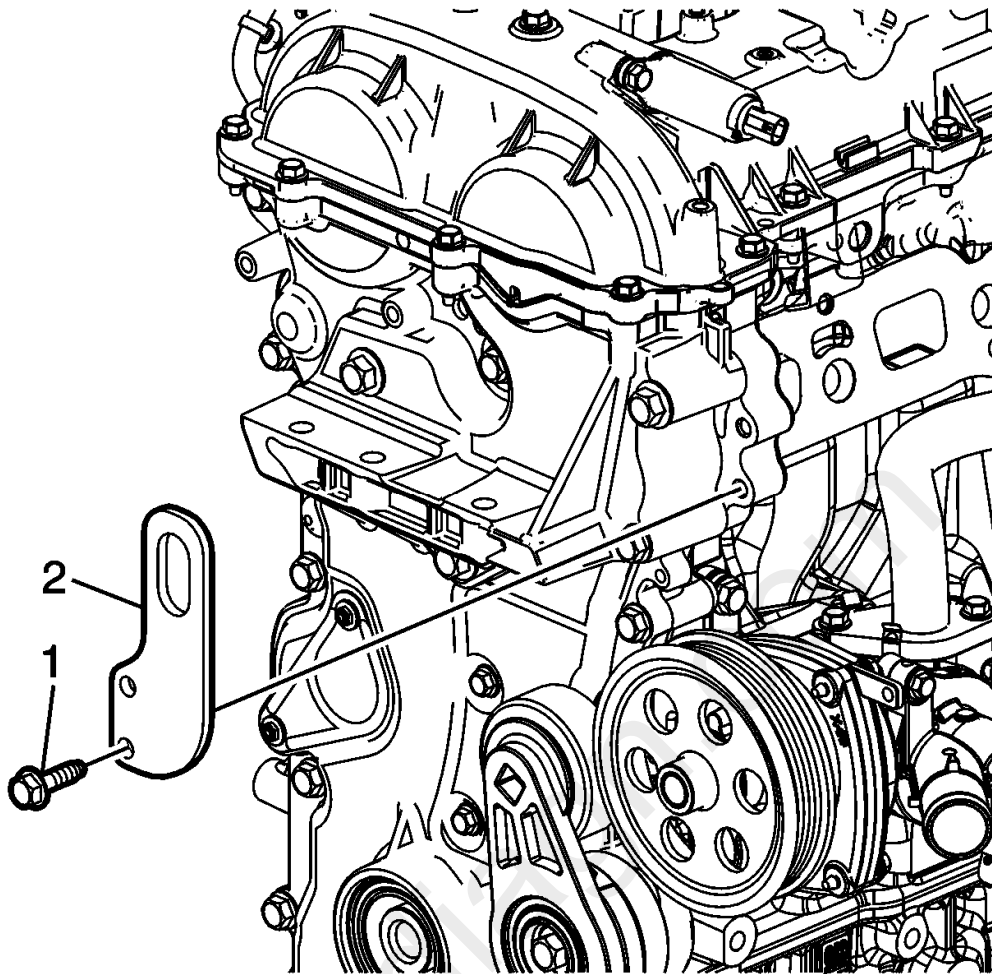


Fig. 34: Front Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

8. Remove the front lift bracket (2) and bolts (1).

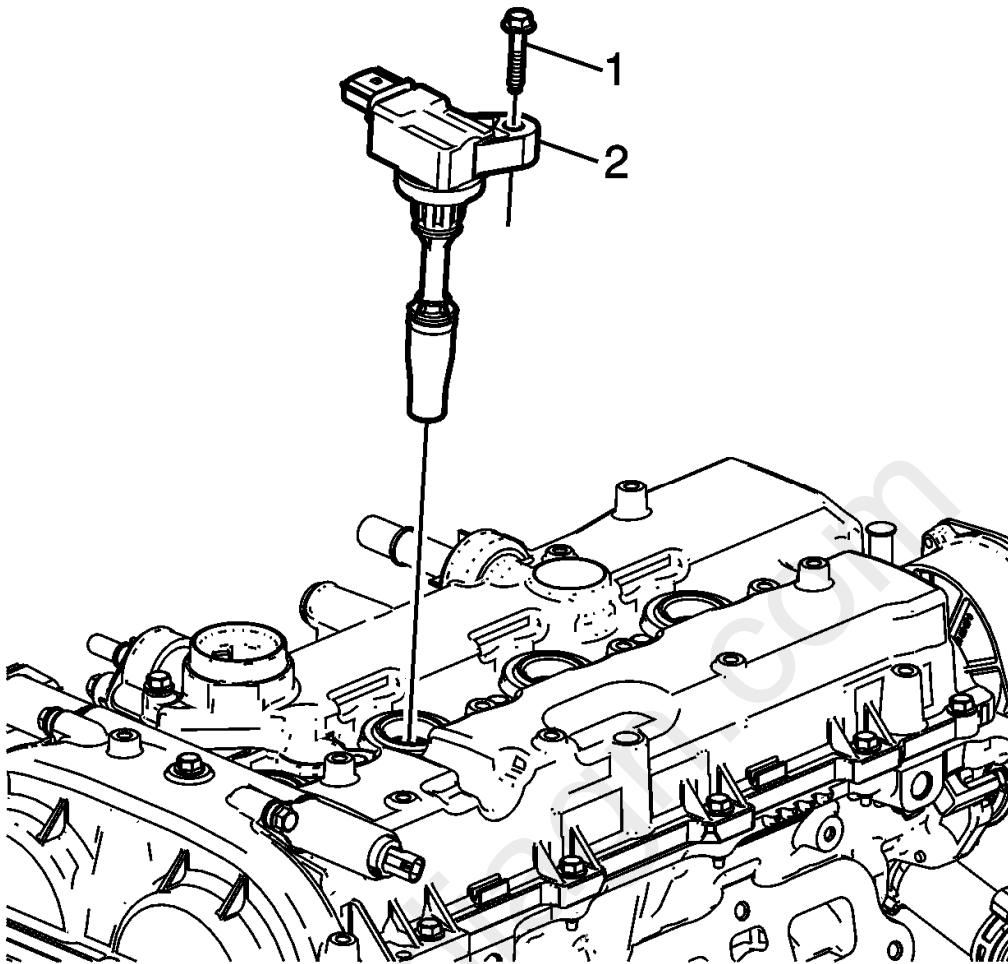


Fig. 35: Ignition Coils And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the ignition coils (2) and bolts (1).

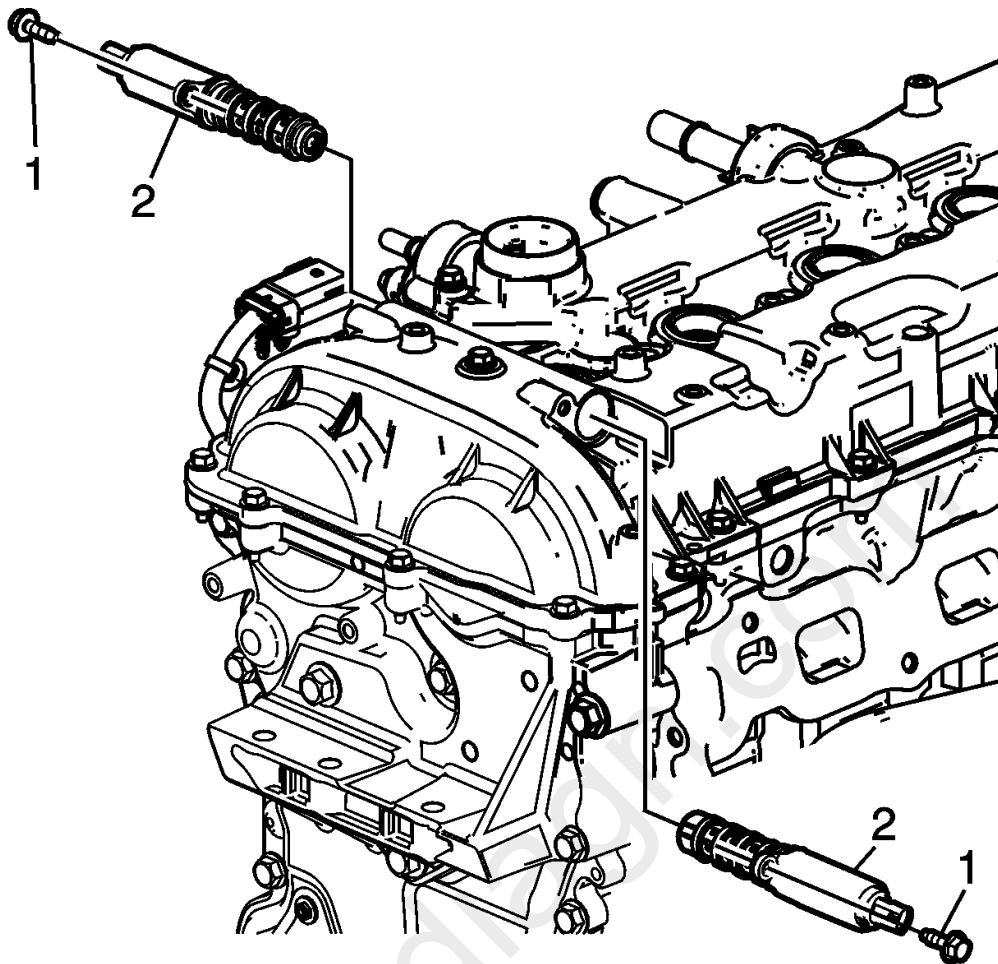


Fig. 36: Camshaft Position Actuator Control Solenoid Valves
Courtesy of GENERAL MOTORS COMPANY

10. Remove the camshaft position actuator control solenoid valves (2) and bolts (1).

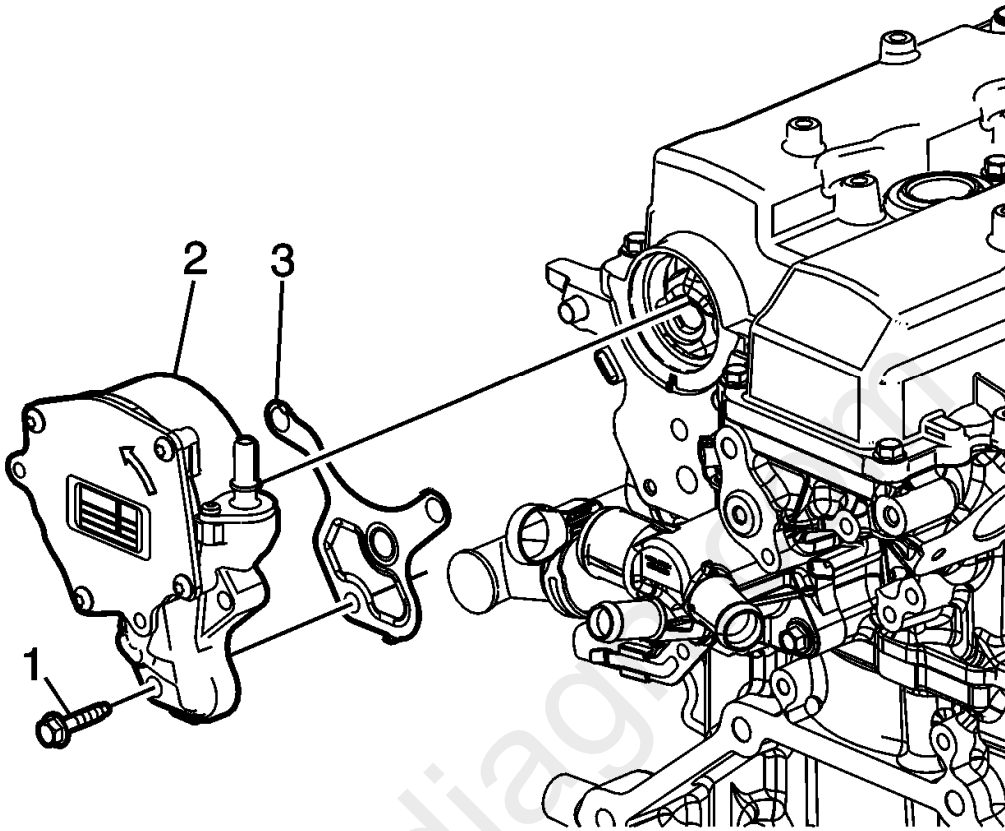


Fig. 37: Vacuum Assembly And Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Remove the vacuum assembly (2) and bolts (1).
12. Remove the vacuum assembly gasket (3) and discard.

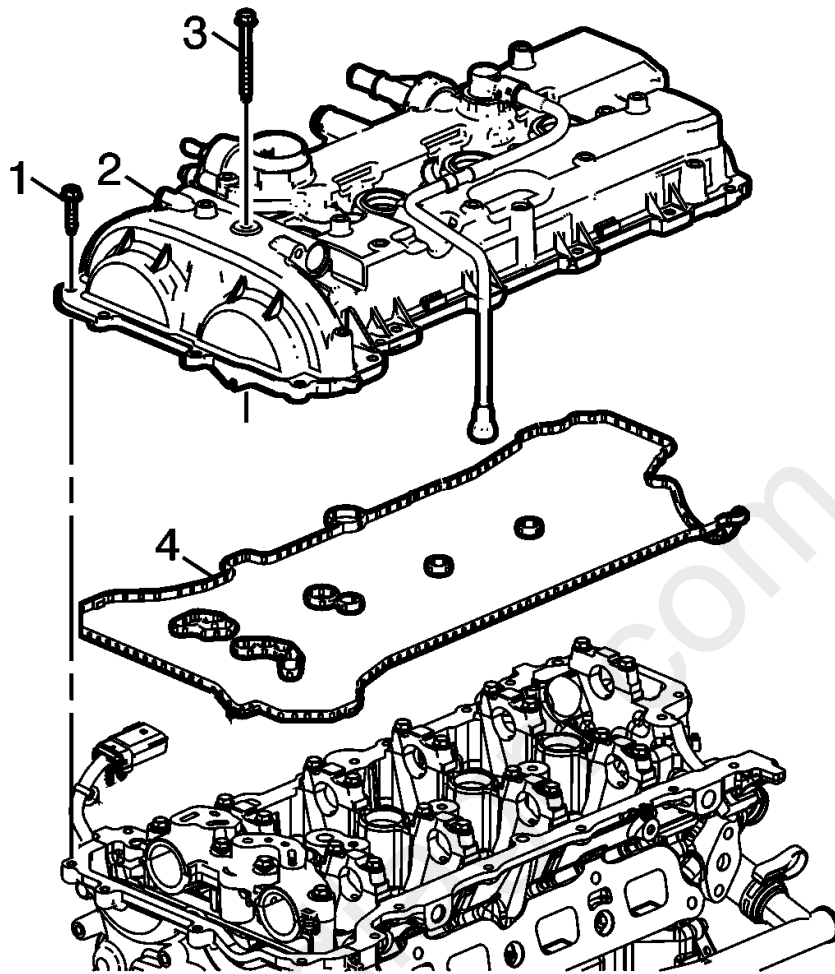


Fig. 38: Camshaft Cover Assembly
Courtesy of GENERAL MOTORS COMPANY

13. Remove the camshaft cover assembly (2).
14. Remove and discard the camshaft cover gasket (4).

ENGINE FRONT COVER REMOVAL

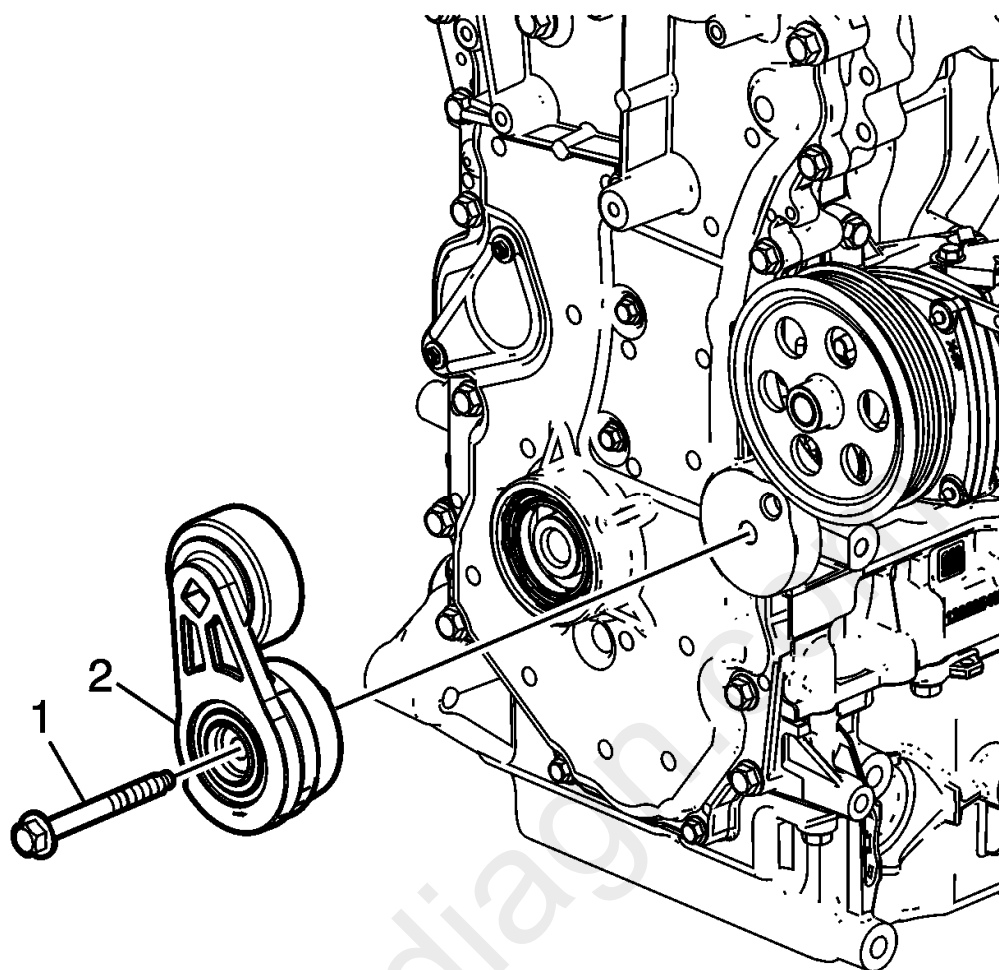


Fig. 39: Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS COMPANY

1. Remove the accessory drive belt tensioner bolt (1).
2. Remove the accessory drive belt tensioner (2).

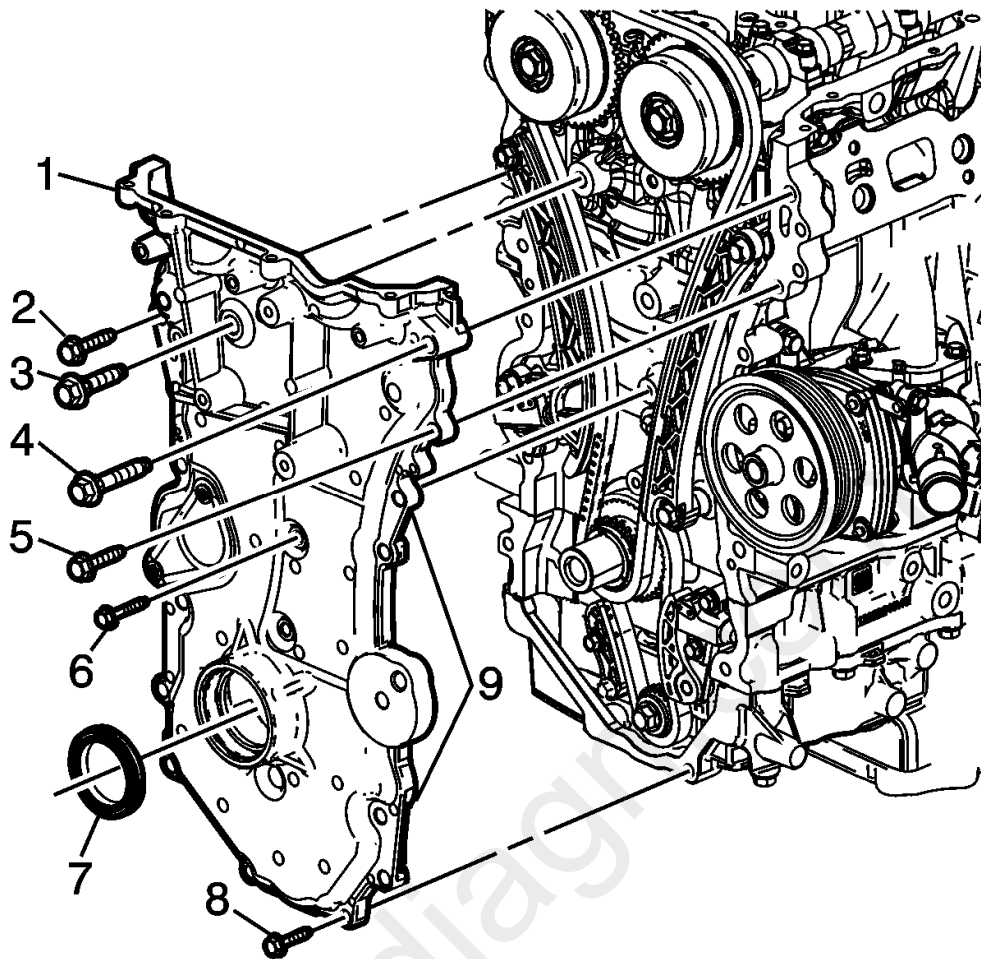


Fig. 40: Exploded View Of Engine Front Cover And Components
Courtesy of GENERAL MOTORS COMPANY

3. Remove the engine front cover bolts (2-6, 8).
4. Remove the engine front cover (1).
5. Remove the front oil seal (7) with an appropriate tool.

CAMSHAFT TIMING CHAIN AND TENSIONER REMOVAL

Special Tools

EN 50837 Timing Chain Tensioner Retraction Tool

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

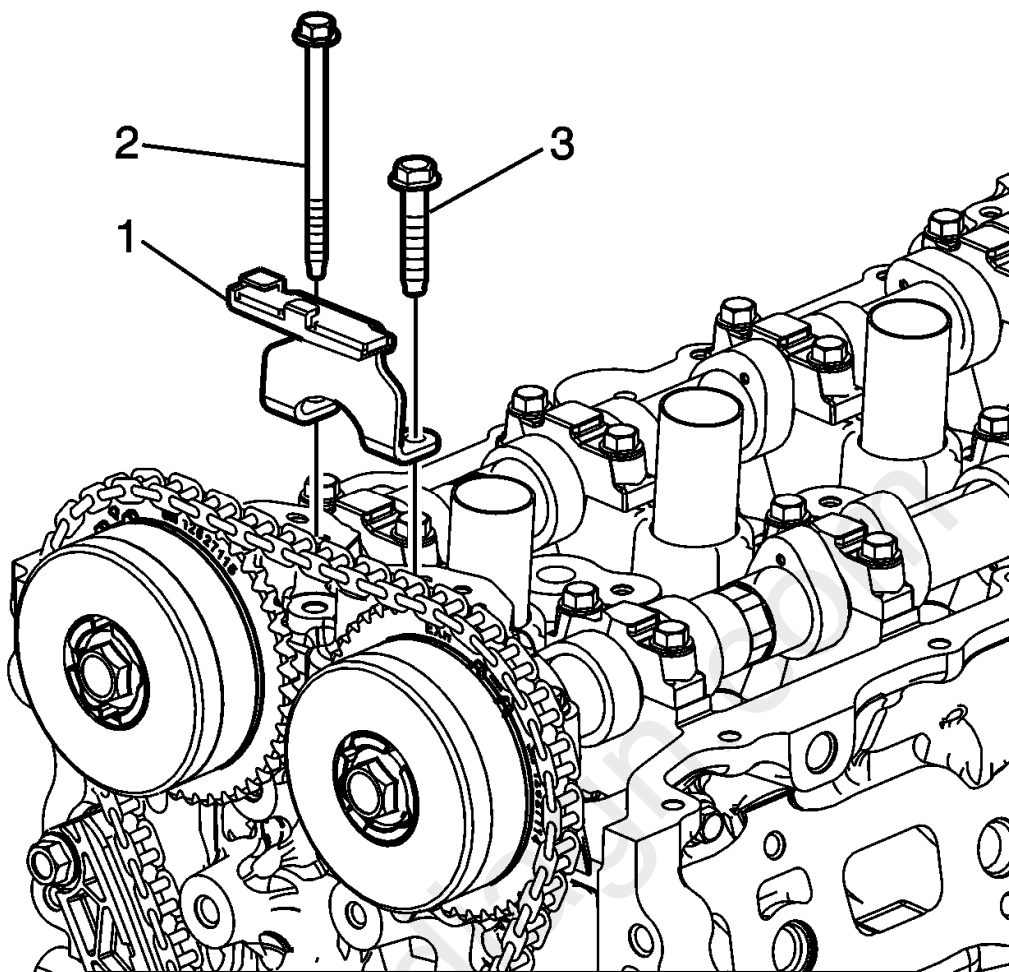


Fig. 41: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the upper timing chain guide bolts (2, 3).
2. Remove the upper timing chain guide (1).

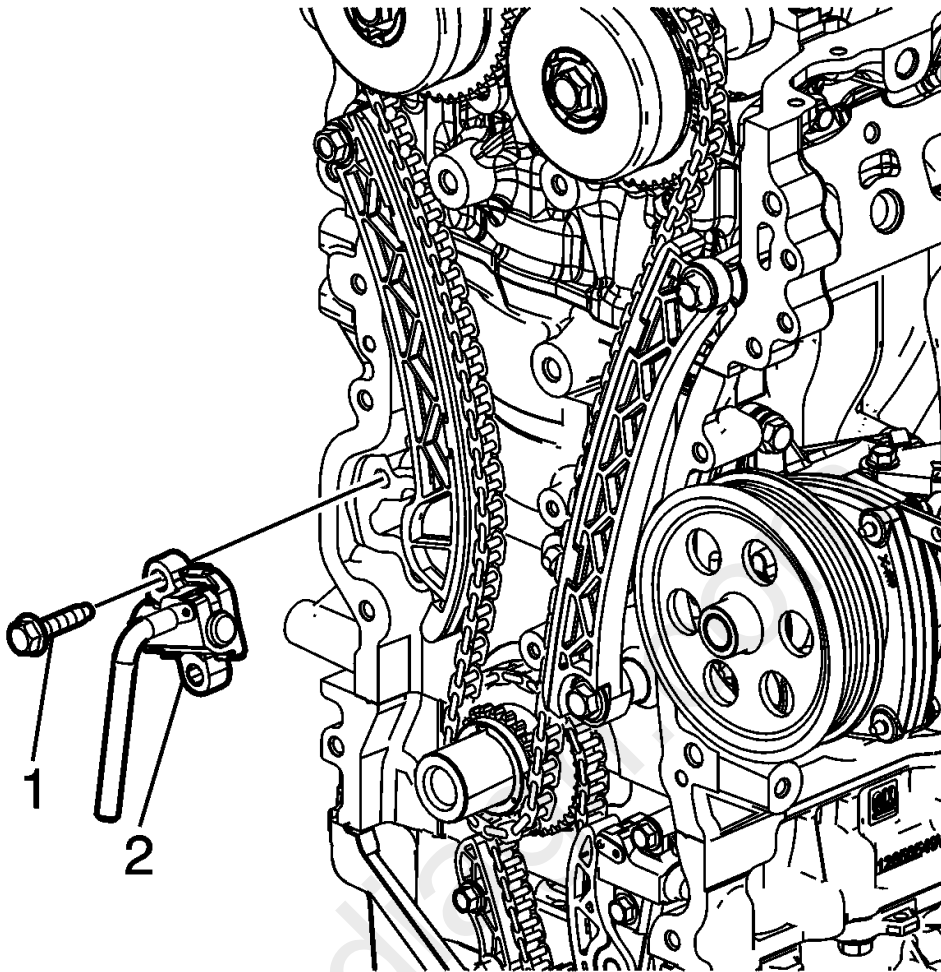


Fig. 42: Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the timing chain tensioner bolts (1) and timing chain tensioner (2).
4. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.

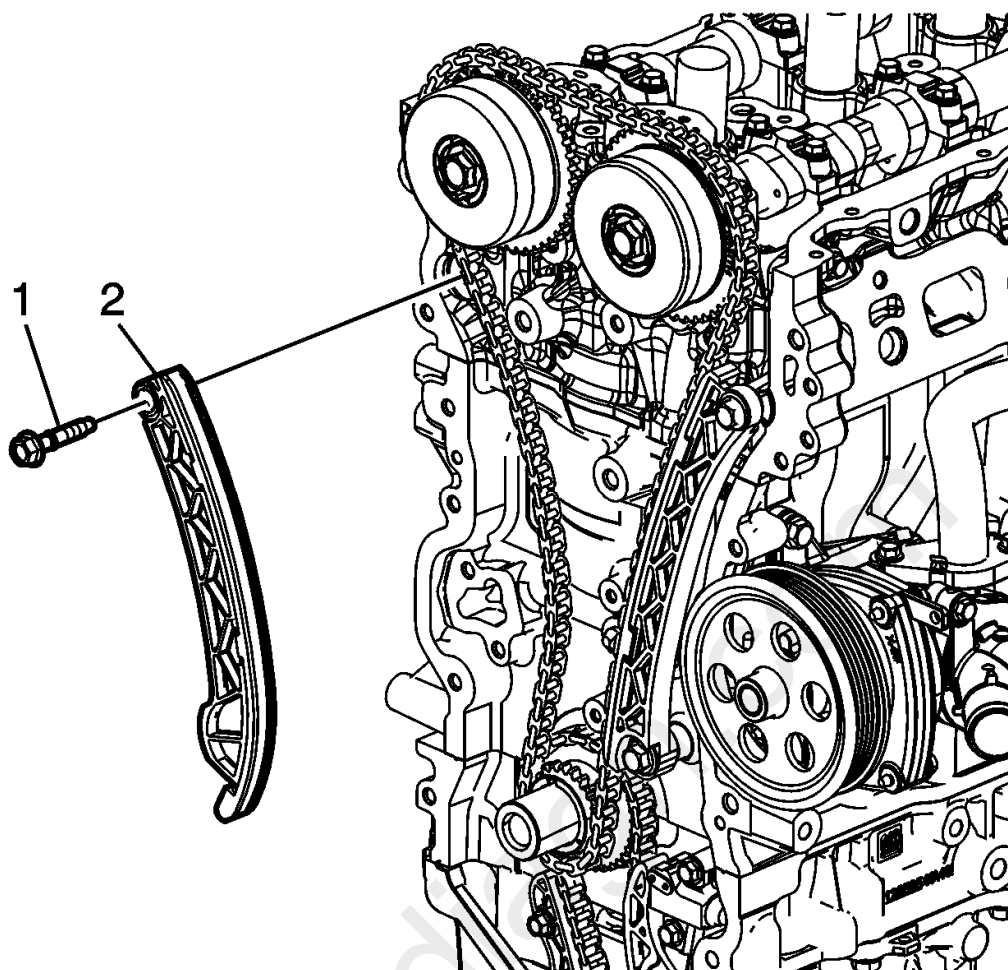


Fig. 43: Timing Chain Tensioner Pivot Arm Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Remove the timing chain tensioner pivot arm bolt (1).
6. Remove the timing chain tensioner pivot arm (2).

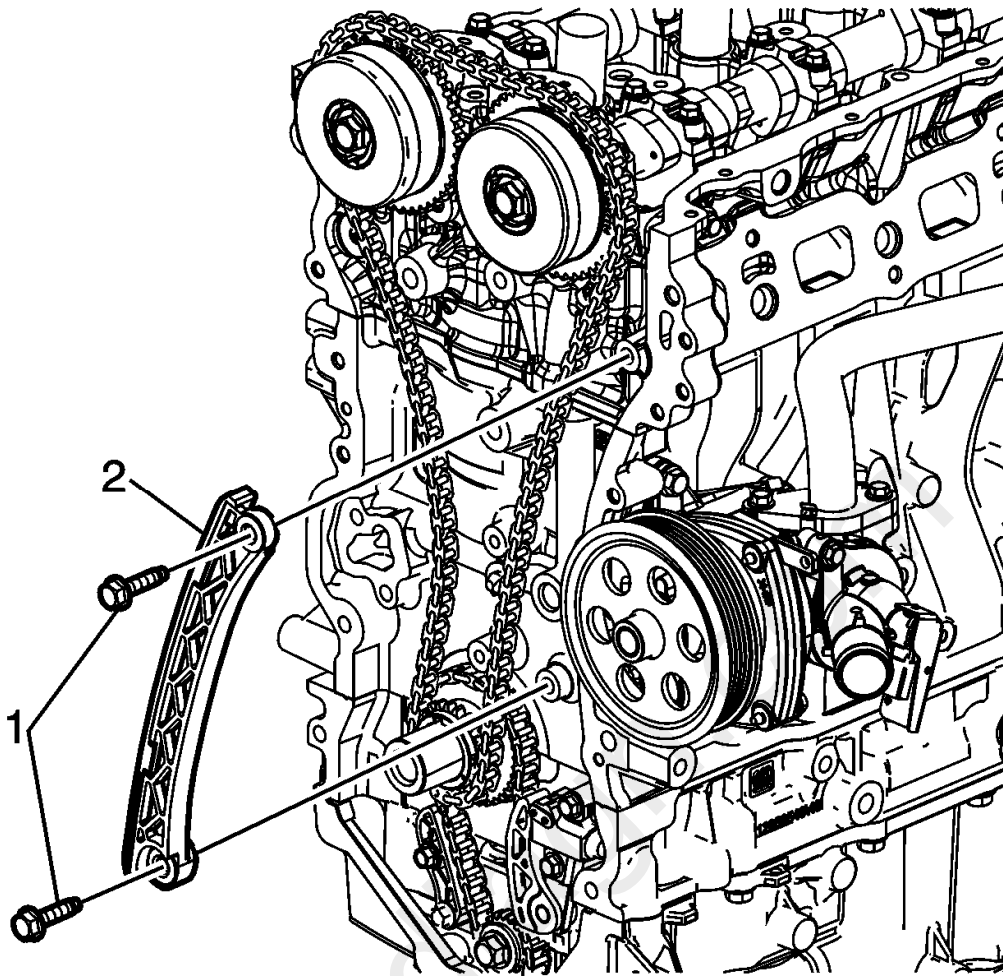


Fig. 44: Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the timing chain guide bolts (1).
8. Remove the timing chain guide (2).

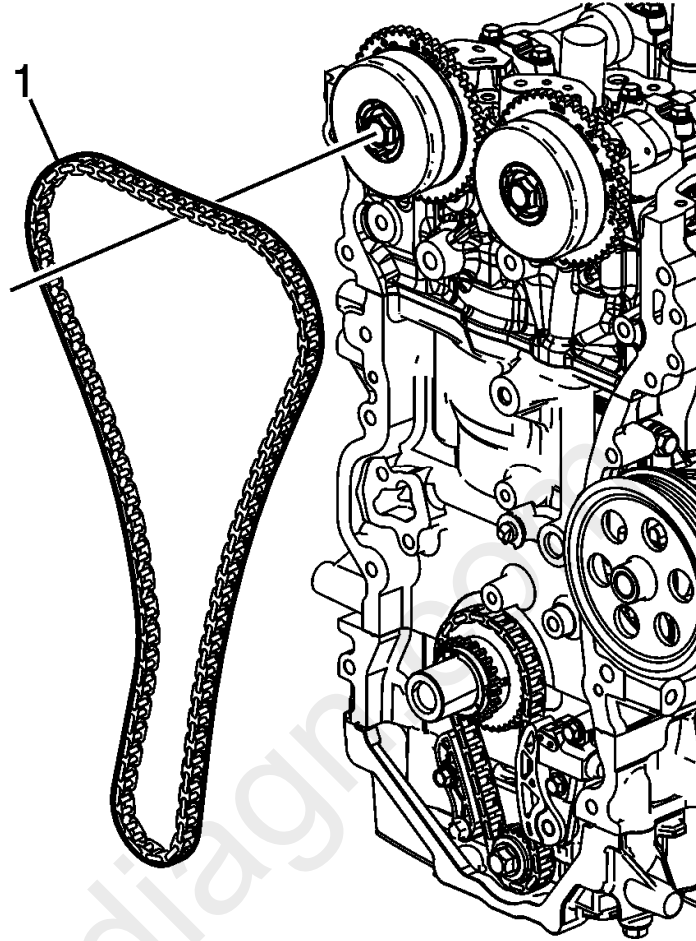


Fig. 45: Timing Chain
Courtesy of GENERAL MOTORS COMPANY

9. Remove the timing chain (1).

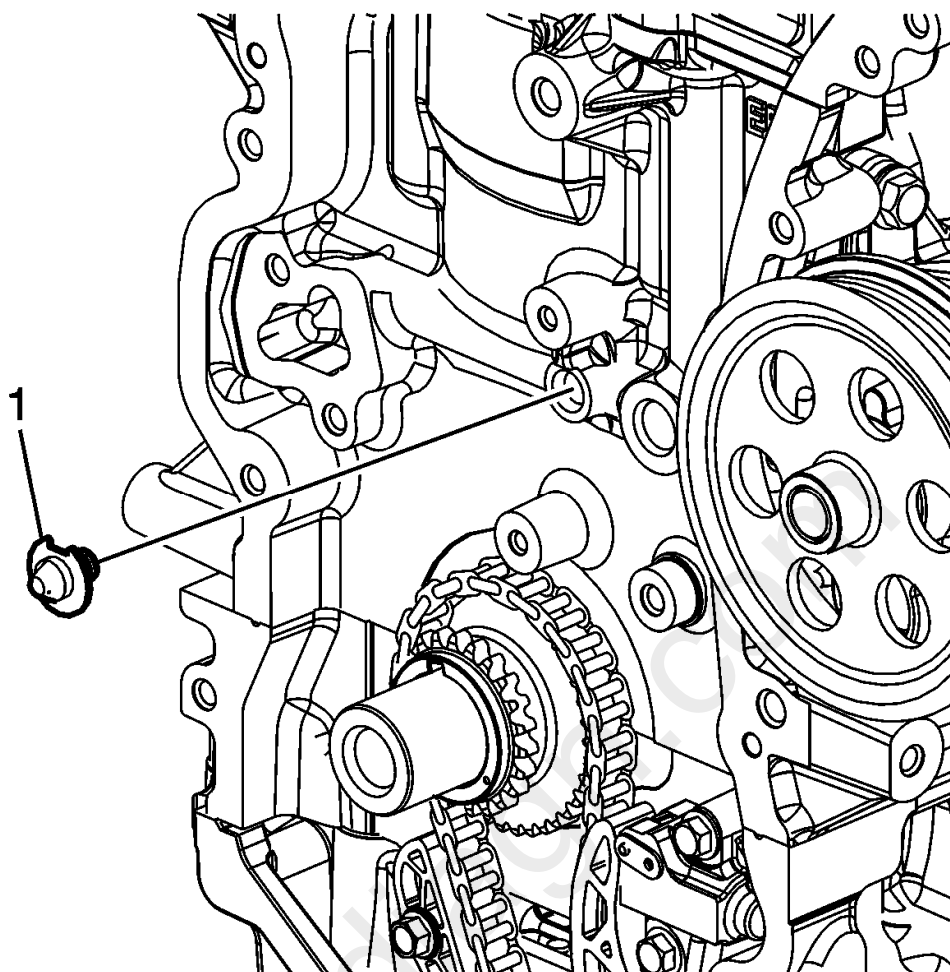


Fig. 46: Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS COMPANY

10. Remove the timing chain oil nozzle (1).

OIL PAN REMOVAL

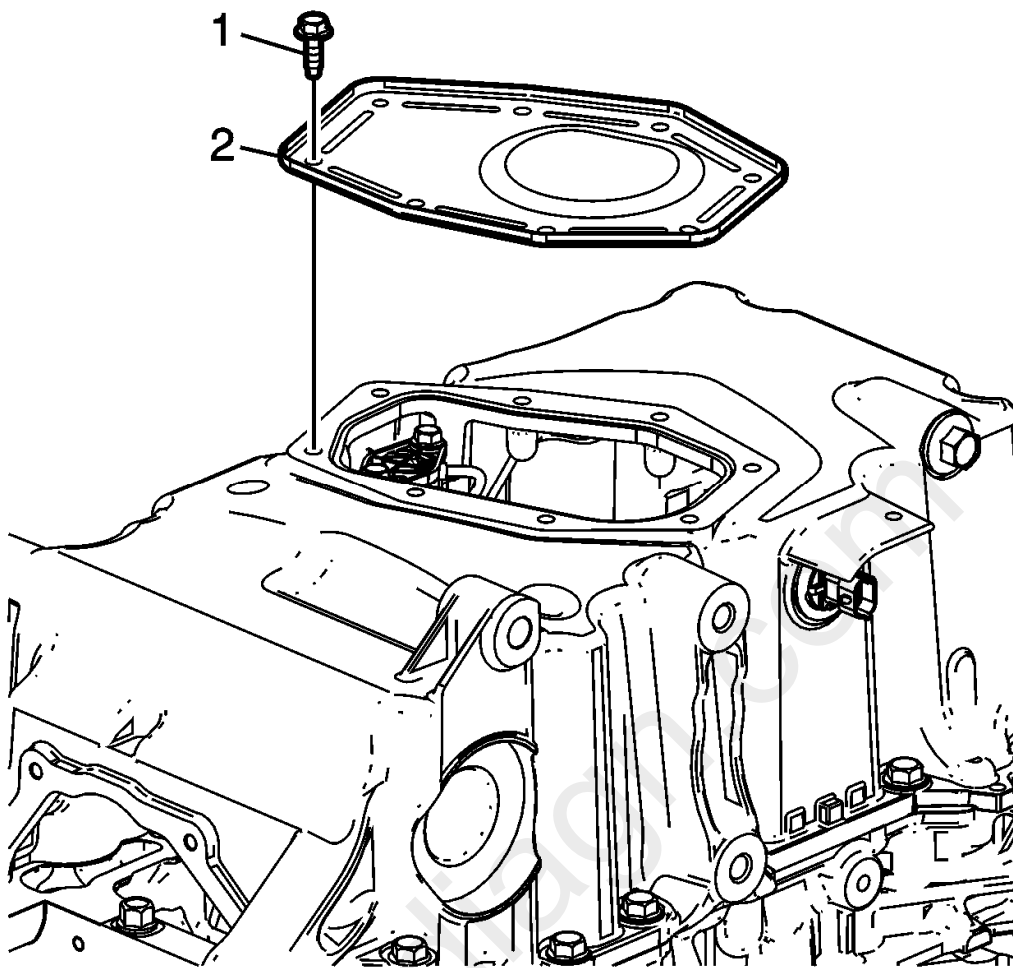


Fig. 47: Engine Oil Pan Lower Cover
Courtesy of GENERAL MOTORS COMPANY

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

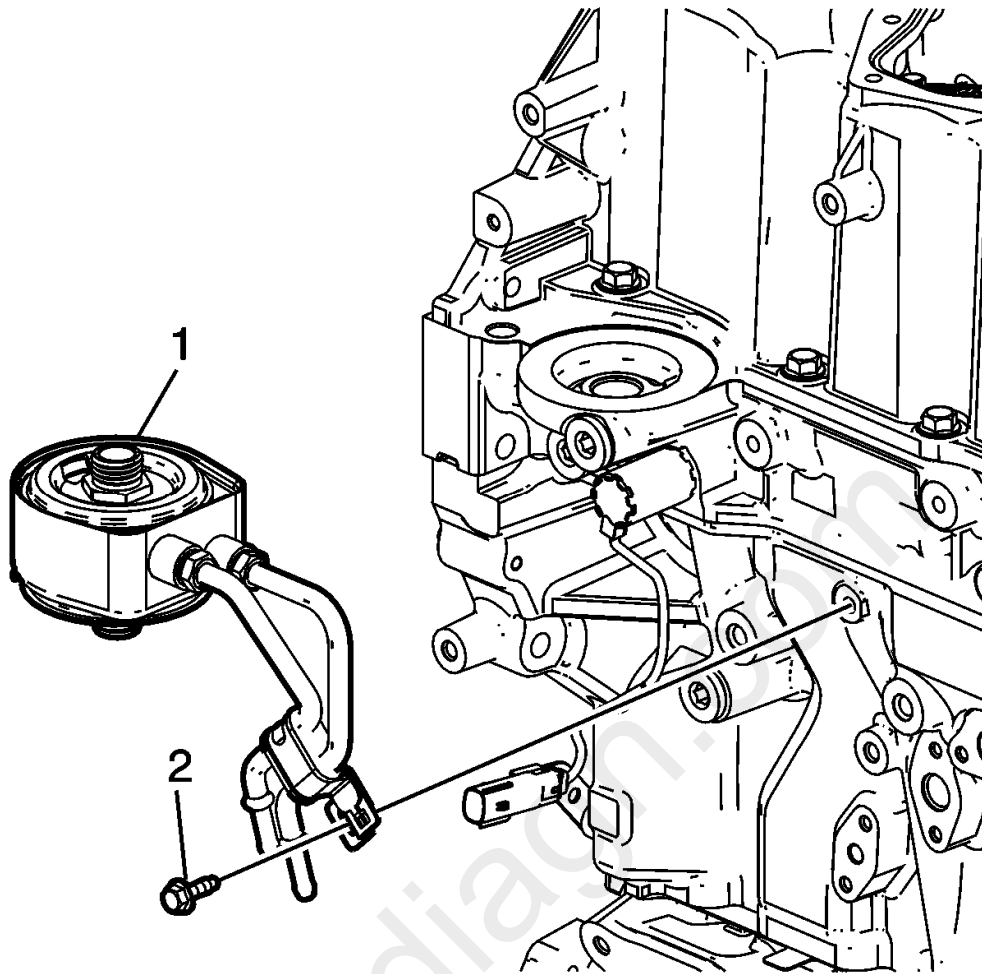


Fig. 48: Engine Oil Cooler

Courtesy of GENERAL MOTORS COMPANY

3. Remove the engine oil cooler (1) and bolts (2).

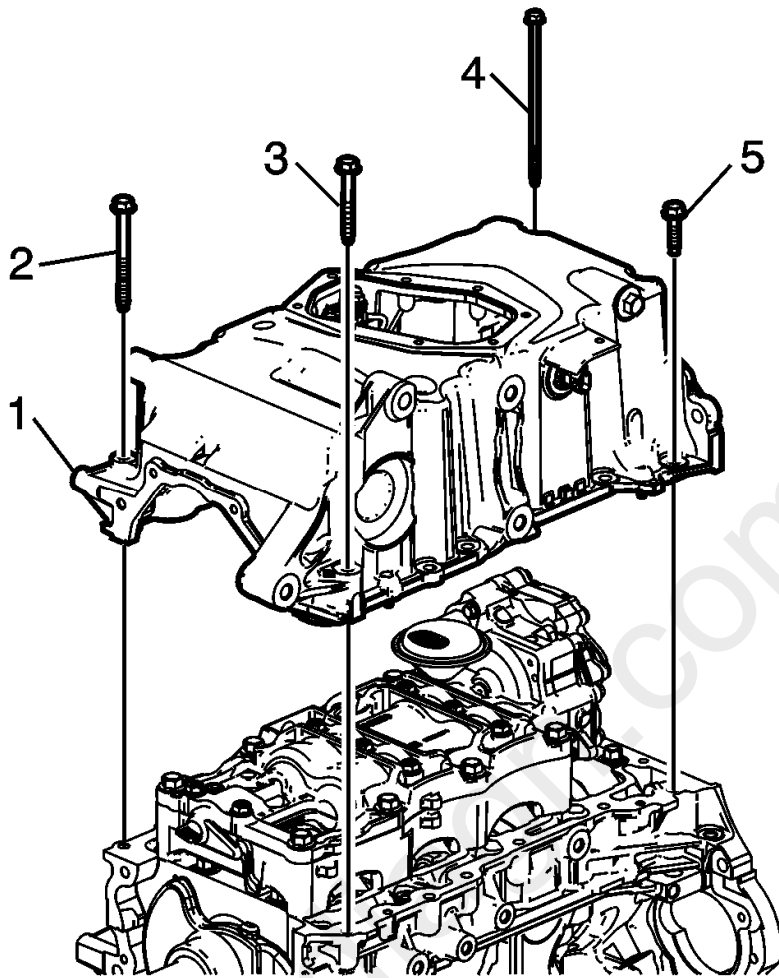


Fig. 49: Upper Engine aOil Pan
Courtesy of GENERAL MOTORS COMPANY

4. Remove the upper oil pan bolts (2-5).
5. Remove the upper oil pan (1).

BALANCER CHAIN, SPROCKET, AND TENSIONER REMOVAL

Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

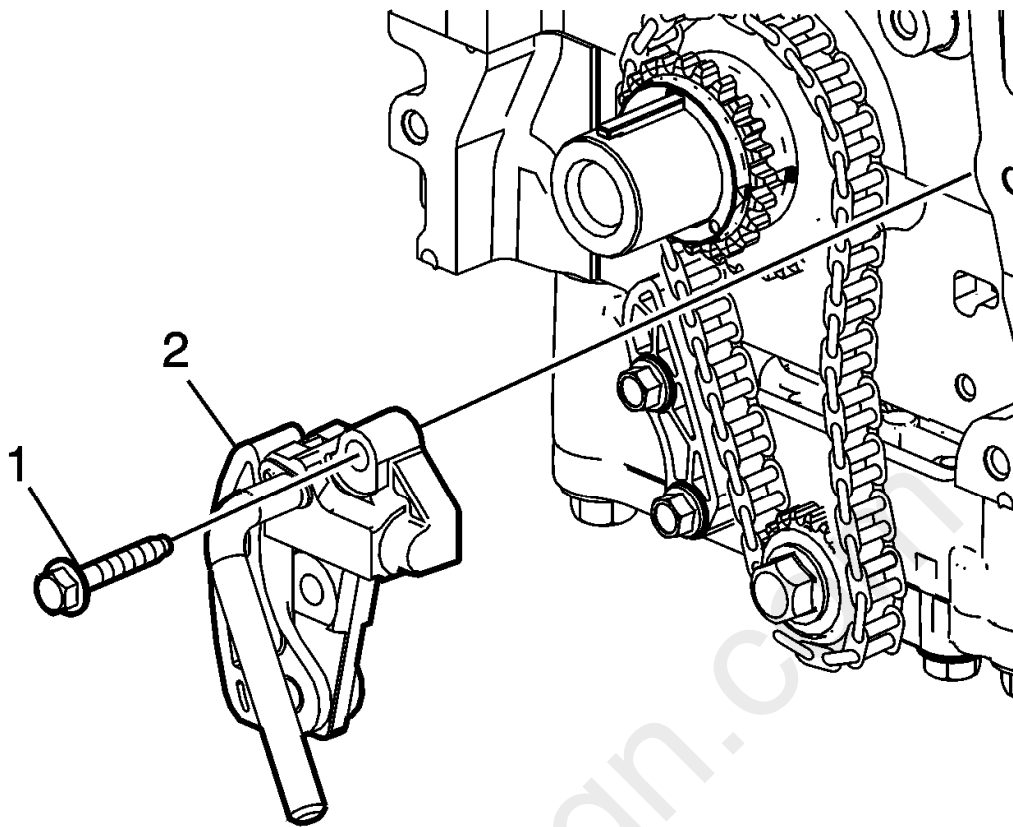


Fig. 50: Balancer Chain Tensioner Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balancer chain tensioner bolt (1).
2. Remove the balancer chain tensioner (2).
3. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.

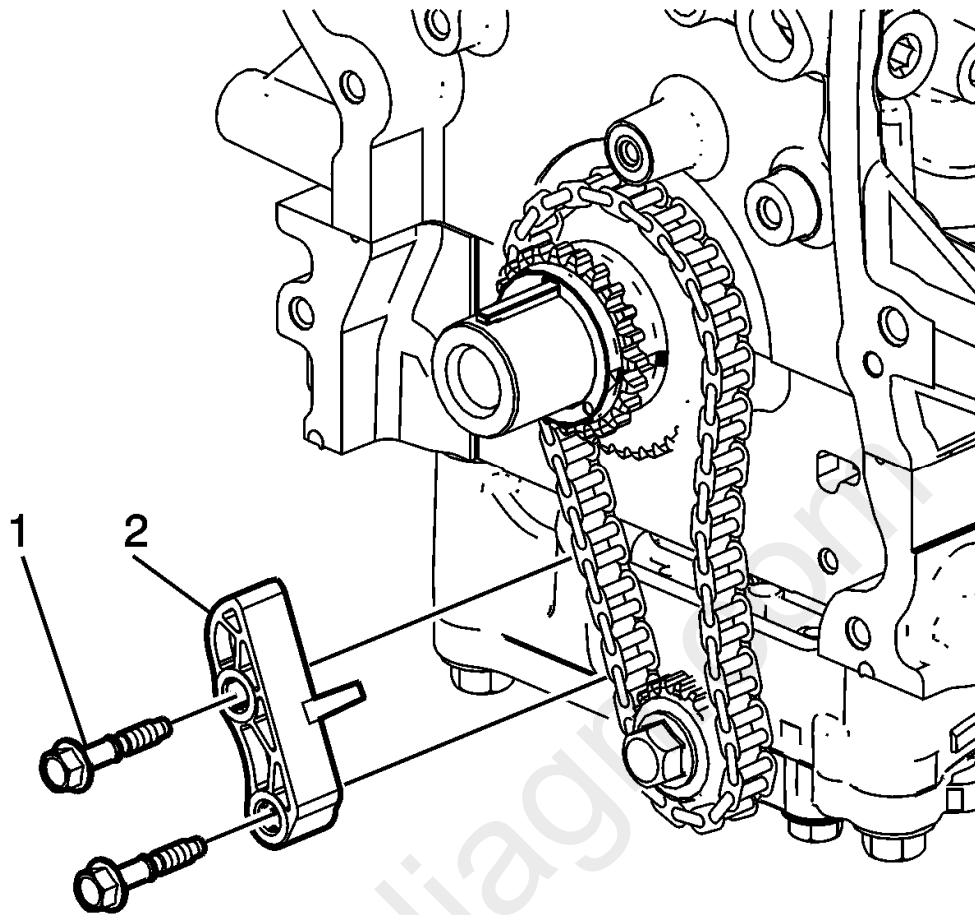


Fig. 51: Balancer Chain Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the balancer chain guide bolt (1).
5. Remove the balancer chain guide (2).

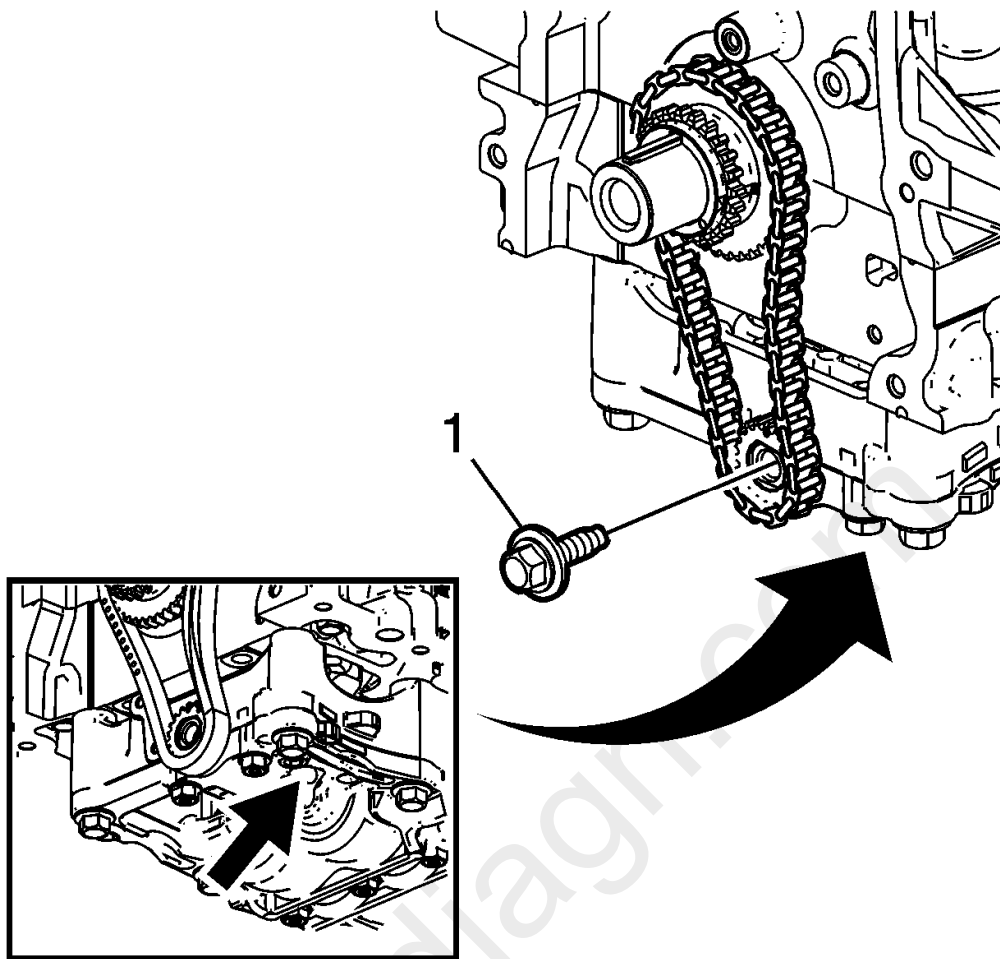


Fig. 52: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Use an 18 mm open end wrench over flat on balance shaft while loosening balancer shaft sprocket bolt. Remove and discard the balancer shaft driven sprocket bolt (1).

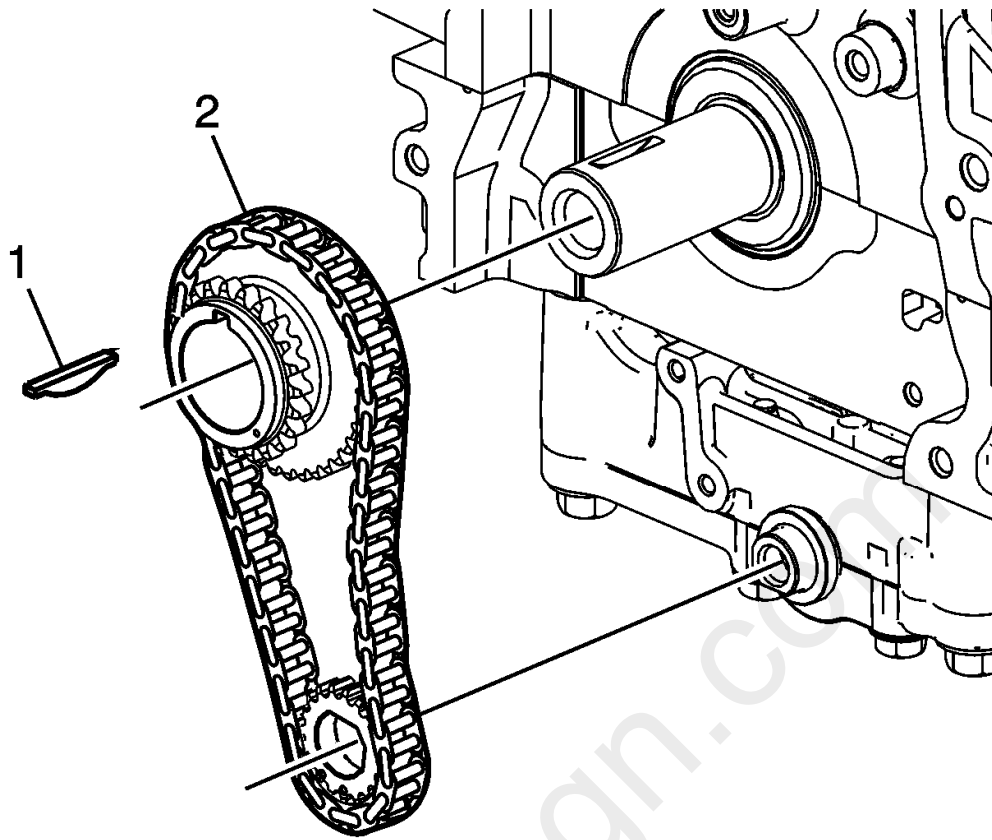


Fig. 53: Balancer Shaft Driven Sprocket And Balancer Chain
Courtesy of GENERAL MOTORS COMPANY

7. Remove the crankshaft key (1).
8. Remove the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain (2) simultaneously.

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

Intake Camshaft and Components Removal

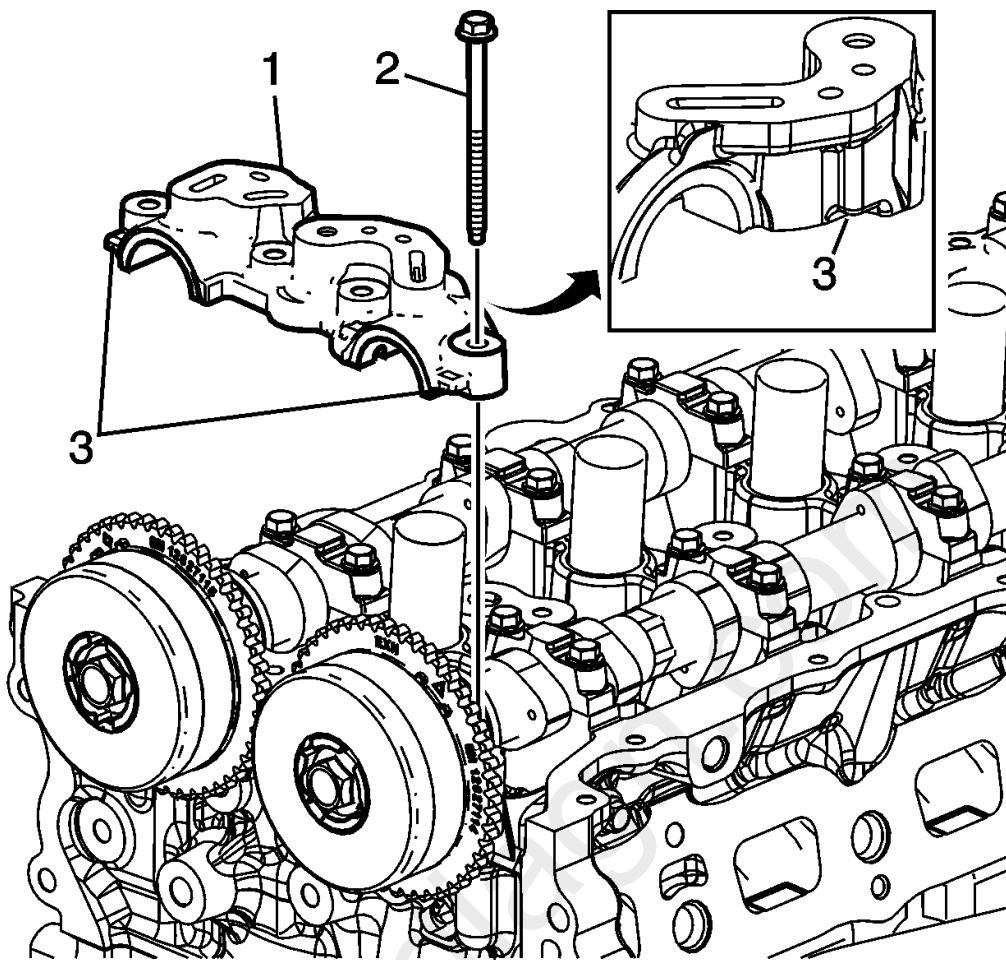


Fig. 54: Camshaft Front Bearing Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft front bearing cap bolts (2).

NOTE:

- Locate the pry points (3) on the camshaft front bearing cap.
- When using the pry points to remove the front bearing cap, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.
- Use 2 pry tools simultaneously to pry the upper front bearing cap away from the lower bearing cap evenly.

2. Using suitable pry tools, remove the camshaft front bearing cap (1)

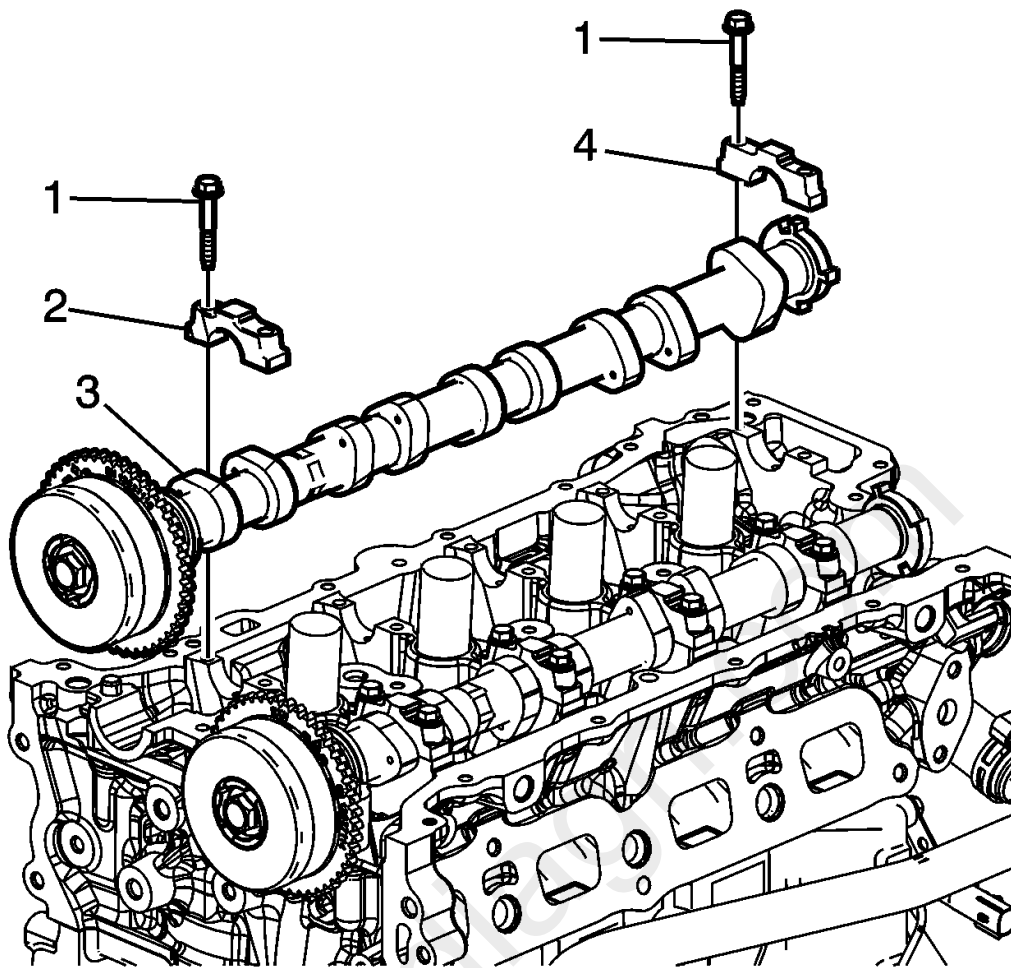


Fig. 55: Intake Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

3. Mark the intake camshaft rear cap to ensure it is installed in the same position. Remove the intake camshaft bearing rear cap bolts (1) and cap (4).

NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

4. Mark the camshaft caps (2) to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts (1).
6. Remove the camshaft caps (2).
7. Remove the intake camshaft (3).

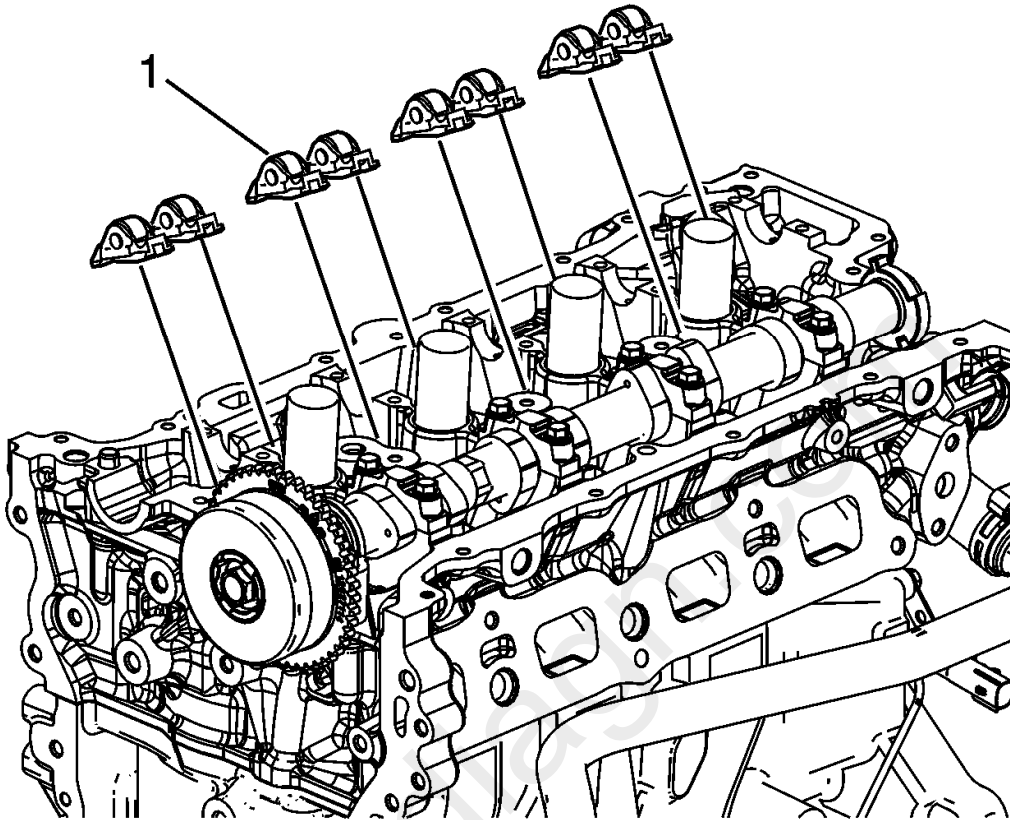


Fig. 56: Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS COMPANY

NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

8. Remove the intake camshaft roller finger followers (1).

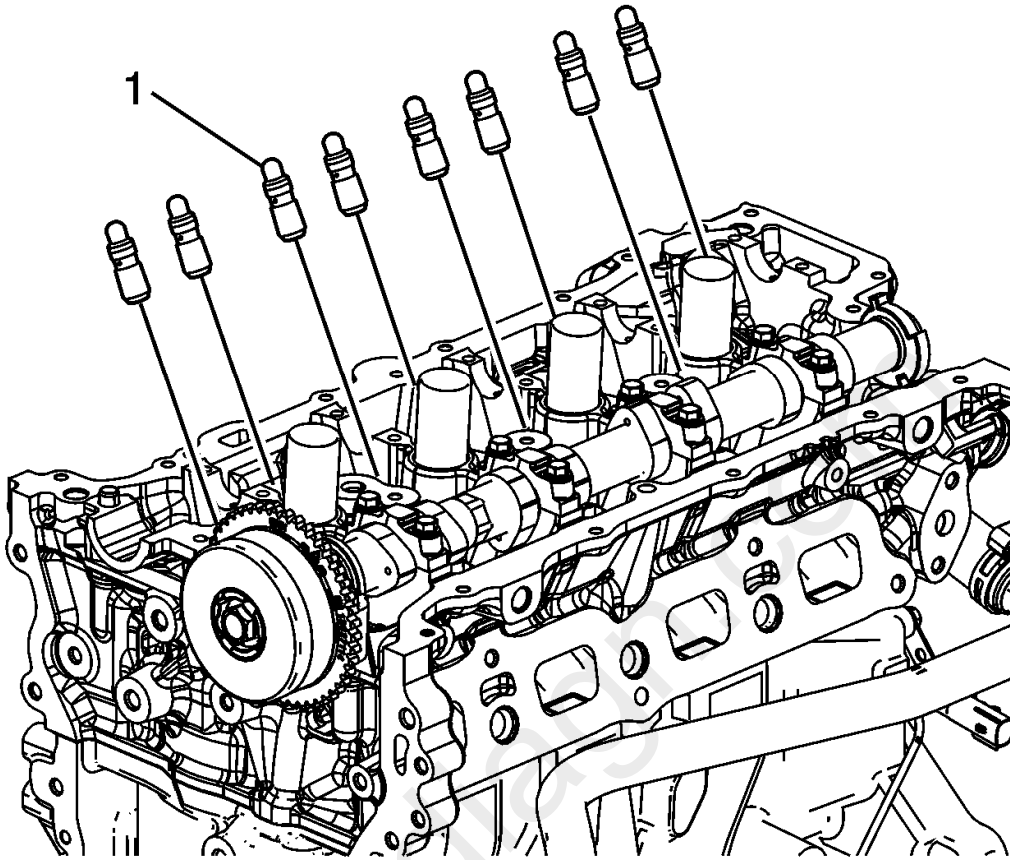


Fig. 57: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS COMPANY

9. Remove the hydraulic lash adjusters (1).

Exhaust Camshaft and Components Removal

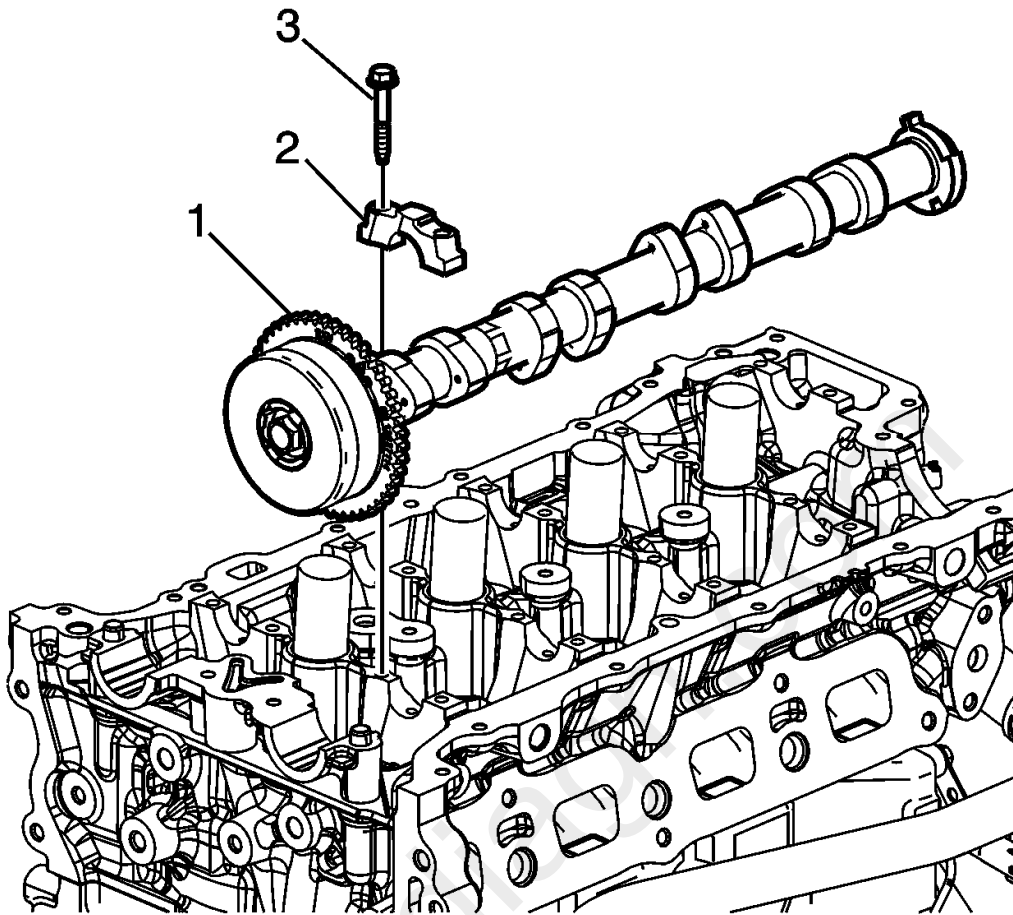


Fig. 58: Mark Camshaft Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: Loosen each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

1. Mark camshaft caps (2) to ensure they are installed in the same position.
2. Remove the exhaust camshaft cap bolts (3).
3. Remove the camshaft caps (2) ensuring they are marked and refitted in same position on assembly.
4. Remove the exhaust camshaft (1).

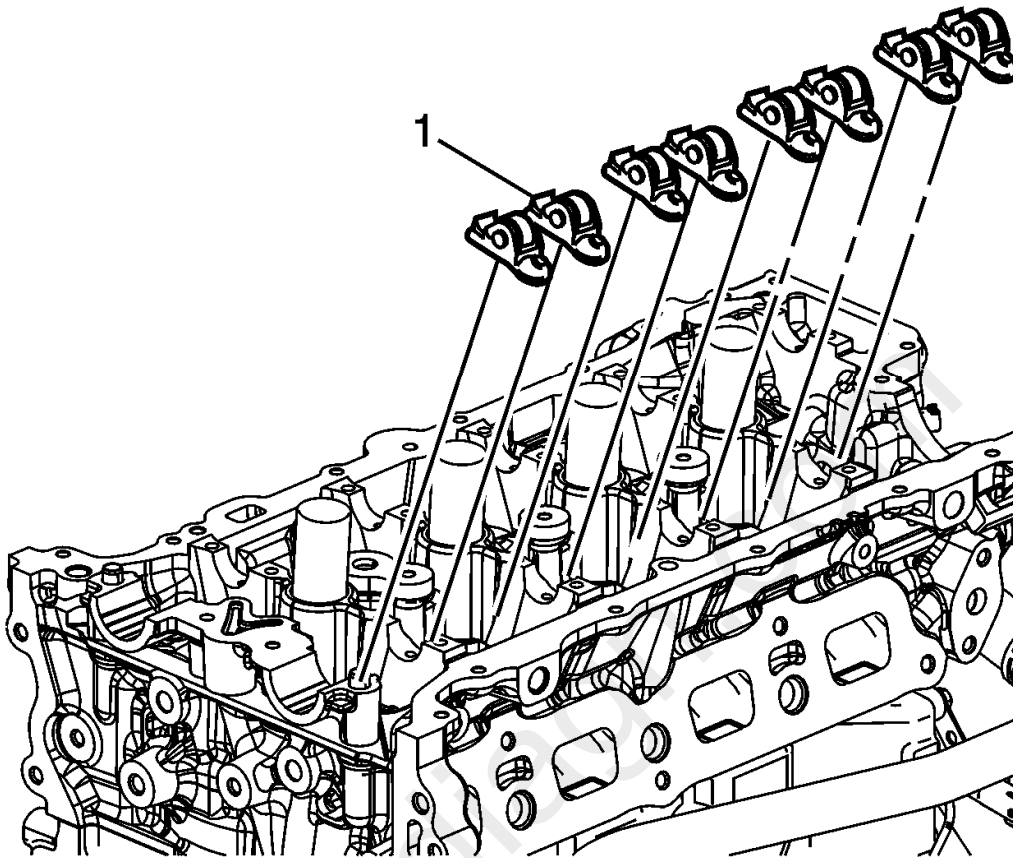


Fig. 59: Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS COMPANY

NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

5. Remove the exhaust camshaft roller finger followers (1).

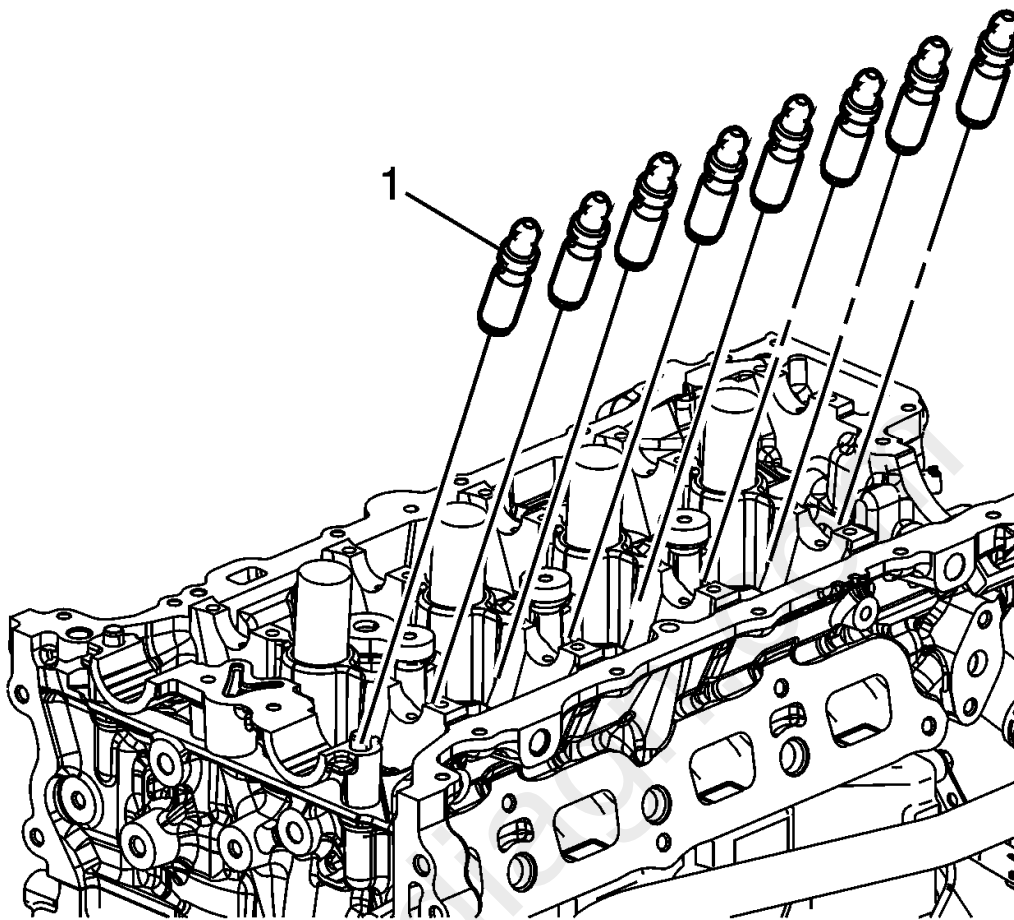


Fig. 60: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS COMPANY

6. Remove the hydraulic lash adjusters (1).

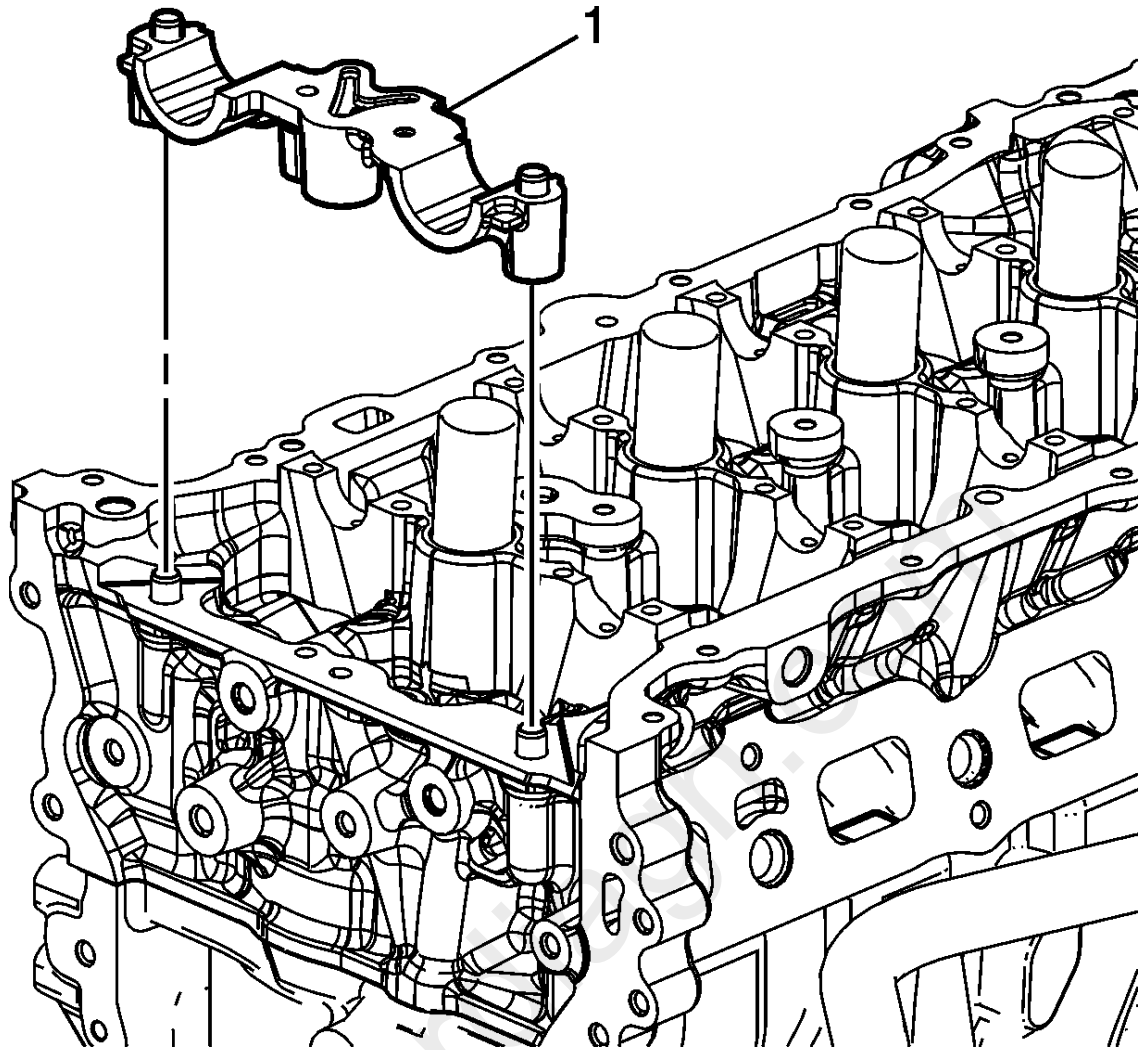


Fig. 61: Camshaft Bearing Lower Front Cap
Courtesy of GENERAL MOTORS COMPANY

7. Remove the camshaft bearing lower front cap (1).

WATER PUMP REMOVAL

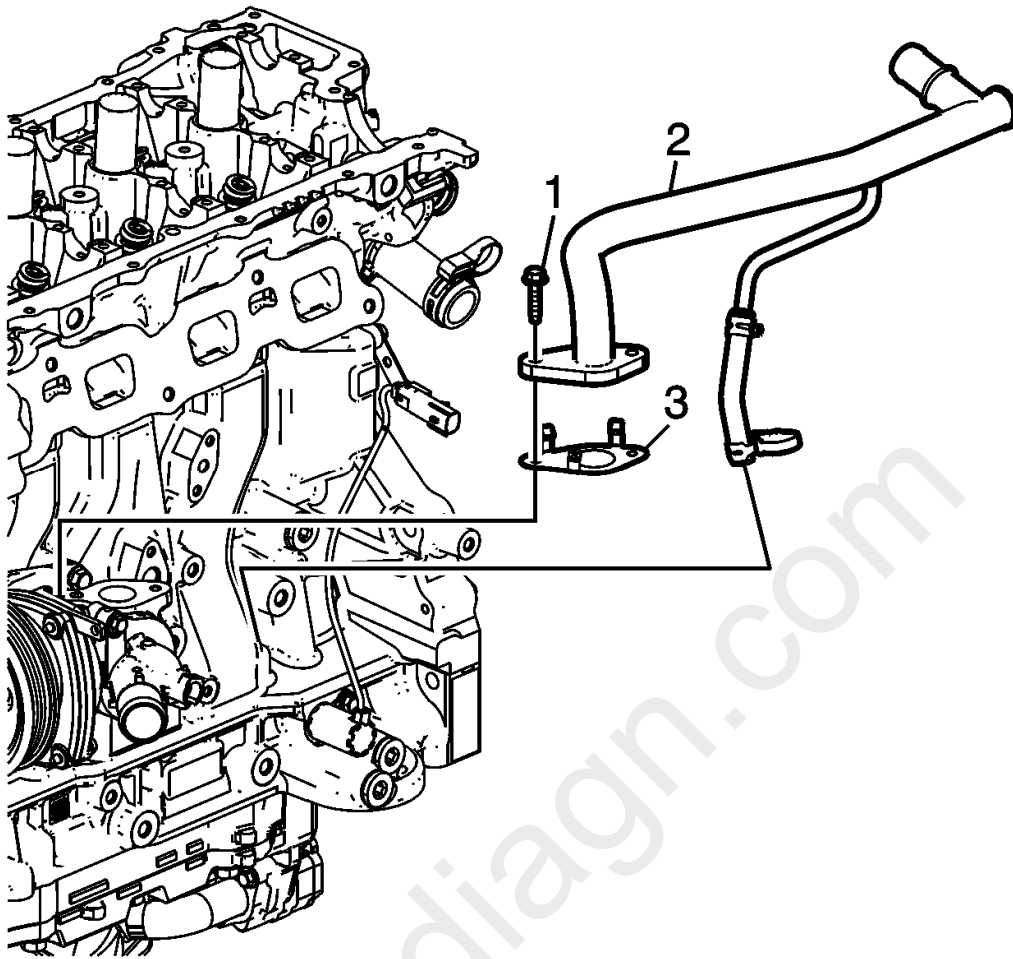


Fig. 62: Thermal Bypass Pipe Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect the thermal bypass hose at the engine oil cooler.
2. Remove the thermal bypass pipe bolts (1) at the water pump assembly.
3. Disconnect the pipe from the water outlet assembly.
4. Remove the thermal bypass pipe (2) and gasket (3) from the water pump assembly. Discard the gasket.

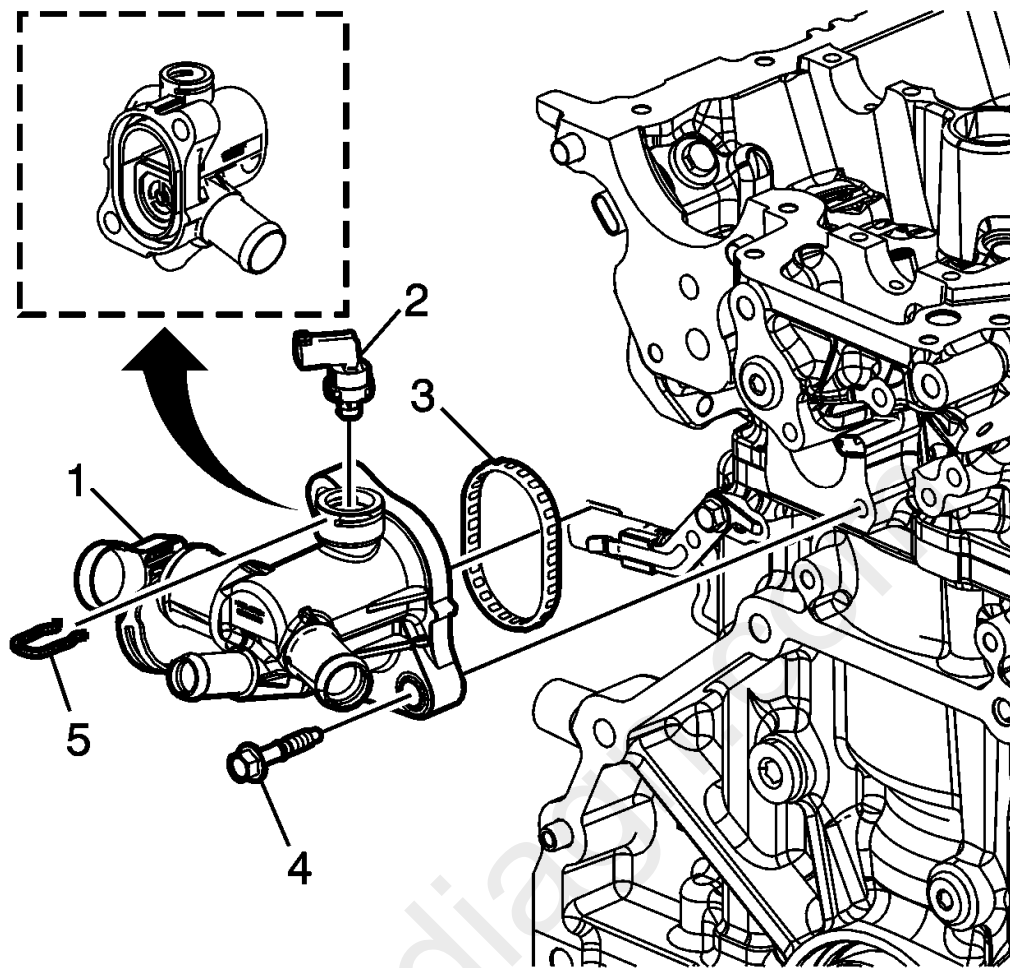


Fig. 63: Retaining Clip And Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

5. Remove the retaining clip (5) and engine coolant temperature sensor (2).
6. Remove the water outlet assembly (1), bolts (4), and gasket seal (3). Discard the gasket.

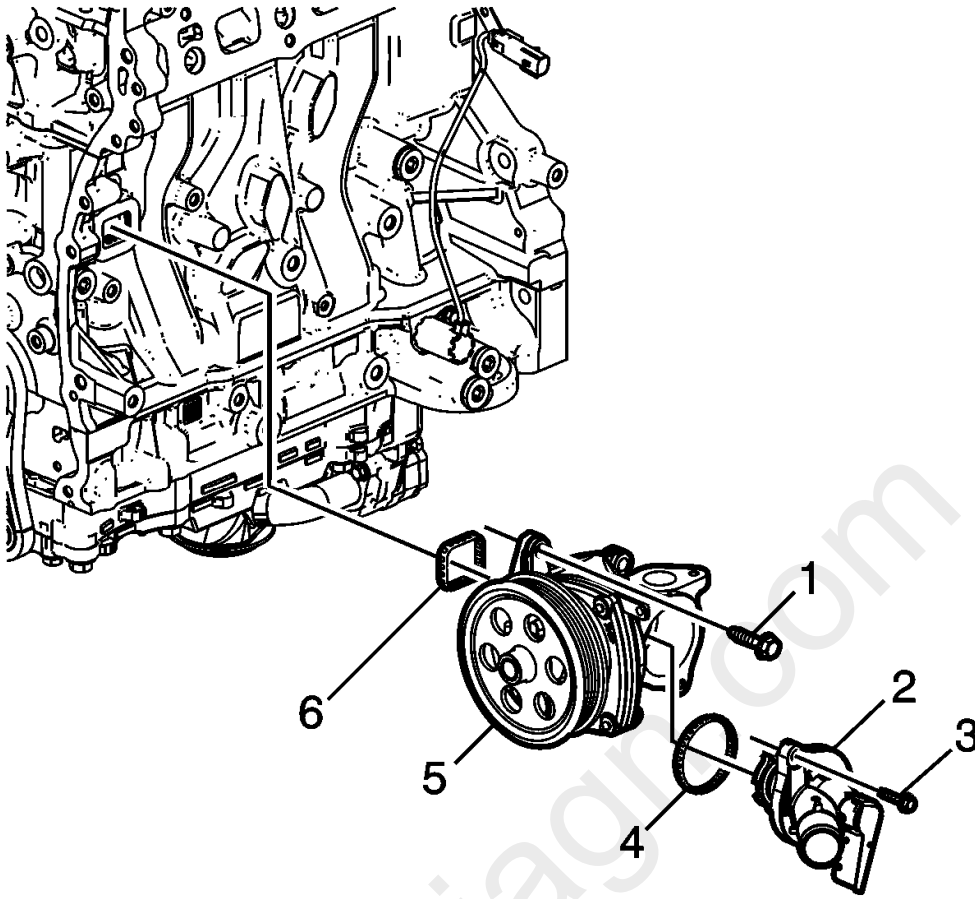


Fig. 64: Thermostat Assembly And Gasket Seal
Courtesy of GENERAL MOTORS COMPANY

7. Remove the thermostat assembly (2), bolts (3), and gasket seal (4). Discard the gasket.
8. Remove the water pump assembly (5), bolts (1), and seal (6). Discard the seal.

CYLINDER HEAD REMOVAL

Special Tools

EN 38188 Cylinder Head Broken Bolt Extractor Kit

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

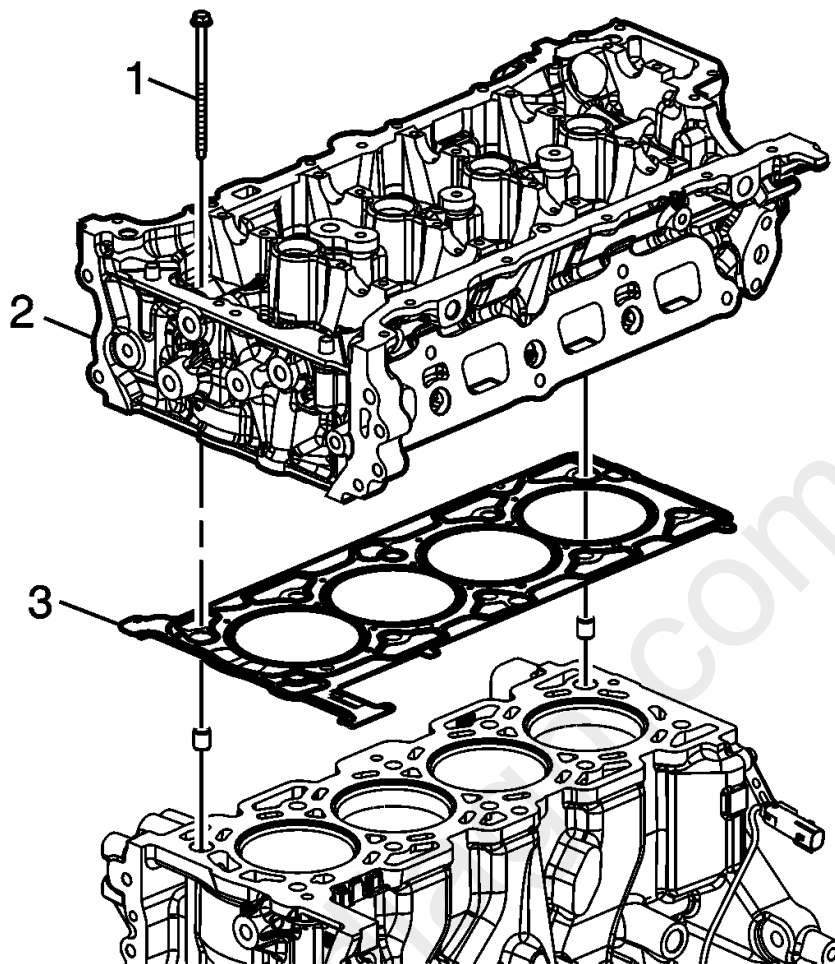


Fig. 65: Cylinder Head Gasket
Courtesy of GENERAL MOTORS COMPANY

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

CAUTION: In order to prevent damage to the valves and injectors during cylinder head removal, set the cylinder head on blocks.

2. Remove the cylinder head (2).
3. Remove the cylinder head gasket (3).
4. Inspect the cylinder head locating pins. Remove the locating pins and discard, if necessary.
5. Clean all of the gasket surfaces.
6. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:
 - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

NOTE: Do not use any other method or technique to clean these gasket

surfaces.

- Use a new razor blade for each cylinder head and cylinder block.

NOTE: Be careful not to gouge or scratch the gasket surfaces. Do not gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the new gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

NOTE: Do not use a tap to clean the cylinder head bolt holes.

7. Clean the old sealer/lube and dirt from the bolt holes.
8. Clean the bolt holes with a nylon bristle brush.

WARNING: Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.

9. When cleaning the cylinder head bolt holes use a suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun to reach the bottom of the holes.
10. Remove any broken long cylinder head bolts using the **EN 38188** kit.

BALANCER SHAFT WITH OIL PUMP REMOVAL

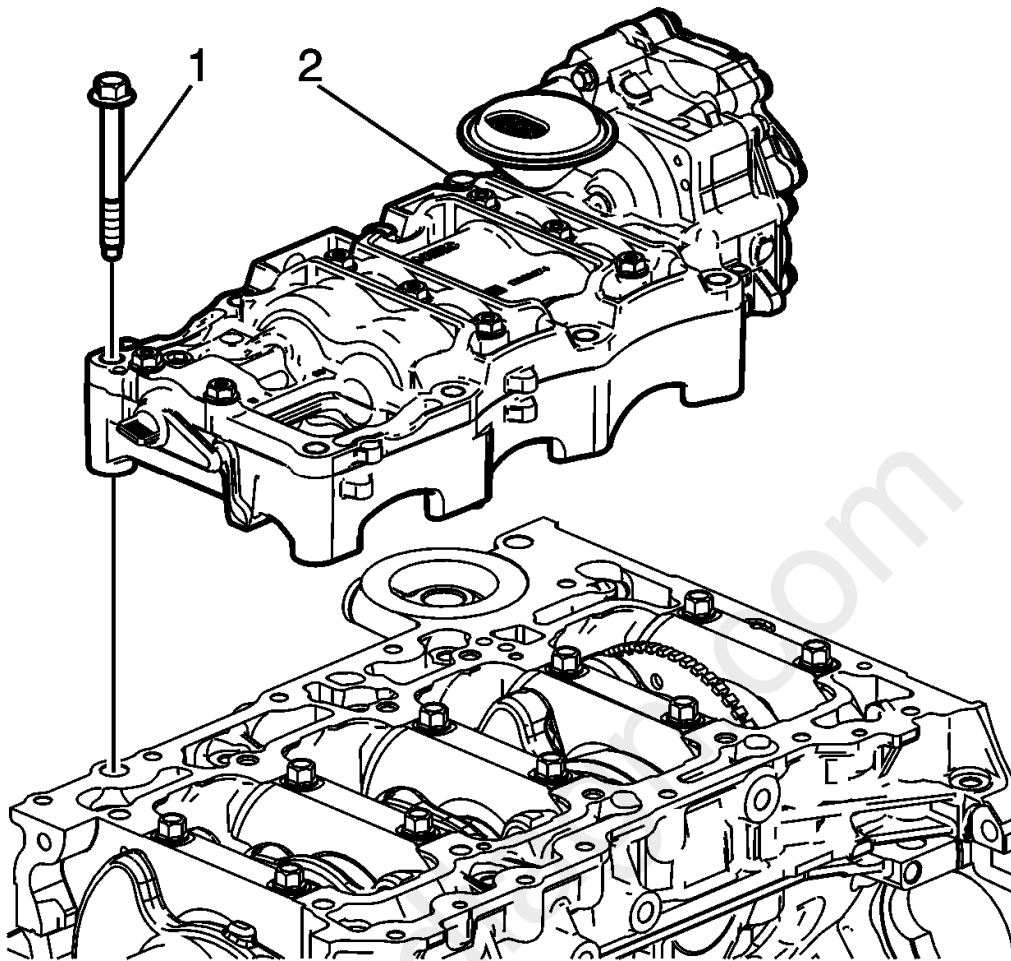


Fig. 66: Balancer And Oil Pump Shaft Assembly Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balancer and oil pump shaft assembly bolts (1).
2. Remove the balancer and oil pump shaft assembly (2).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

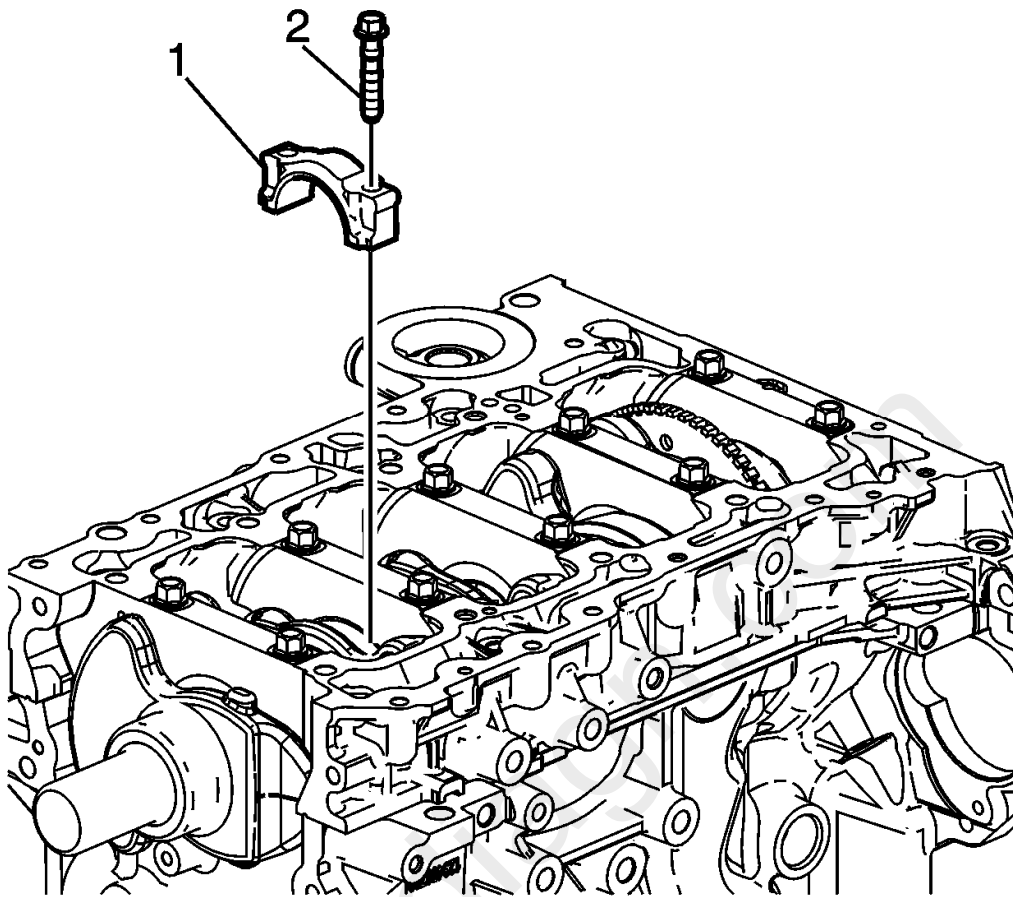


Fig. 67: Connecting Rod Cap
Courtesy of GENERAL MOTORS COMPANY

1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove and discard the connecting rod bolts (2).
5. Remove the connecting rod cap (1).

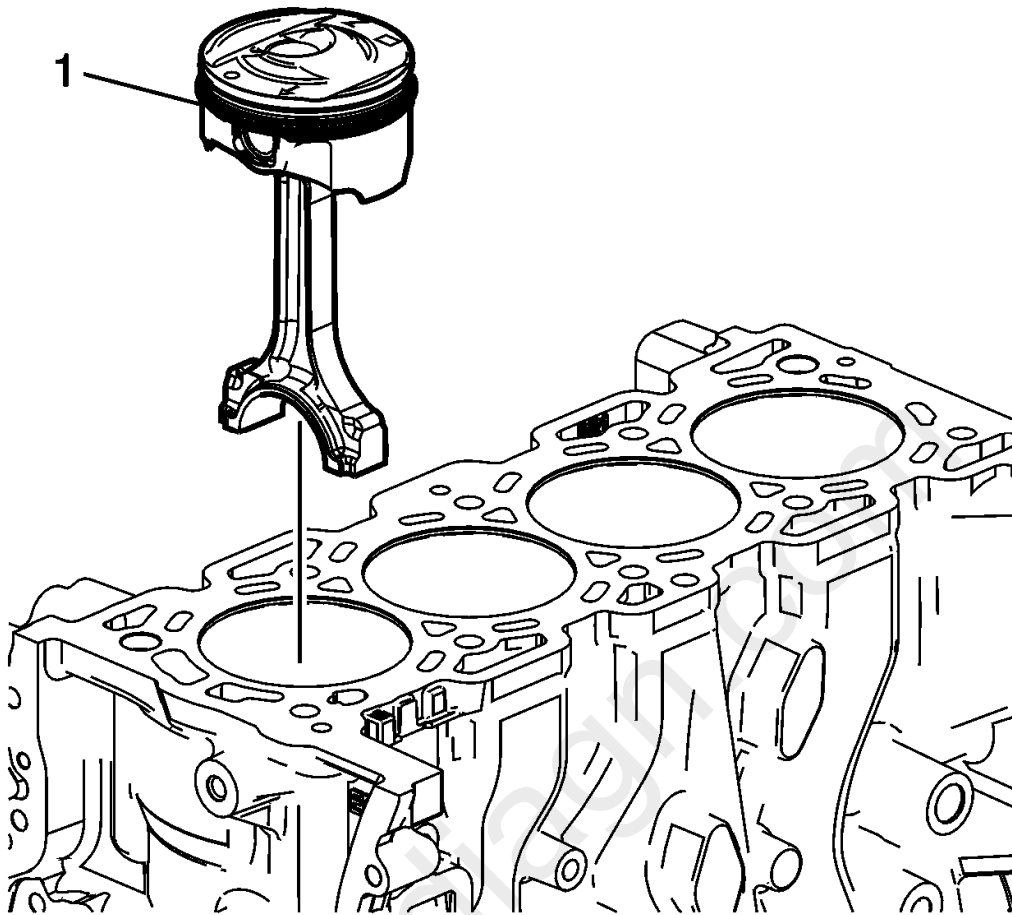


Fig. 68: Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

6. Remove the piston and connecting rod assembly (1).

LOWER CRANKCASE REMOVAL

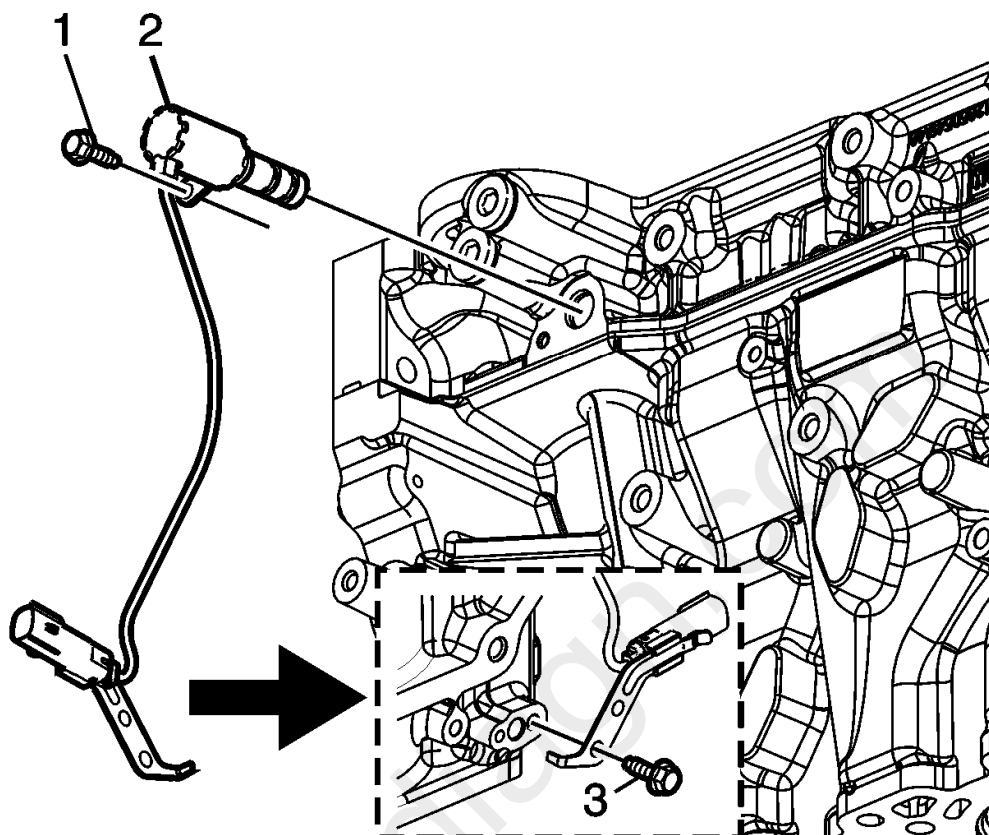


Fig. 69: Oil Pump Flow Control Valve And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pump flow control valve (2) and bolts (1, 3).

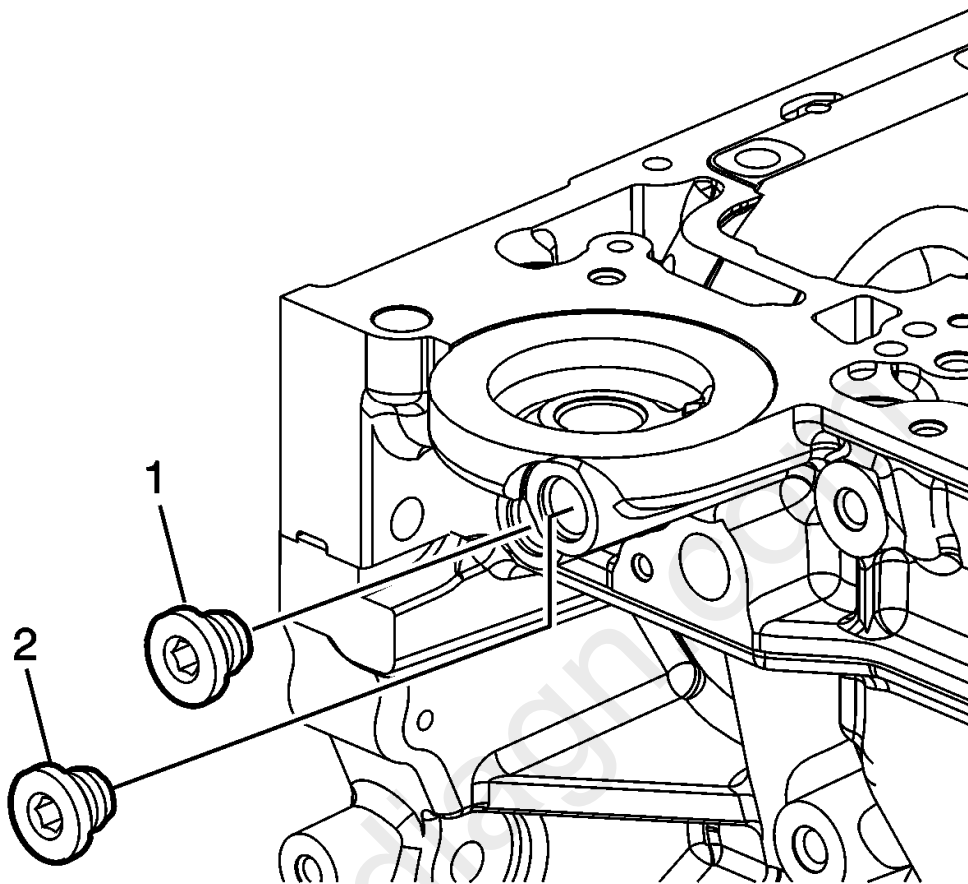


Fig. 70: Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil gallery plugs (1, 2).

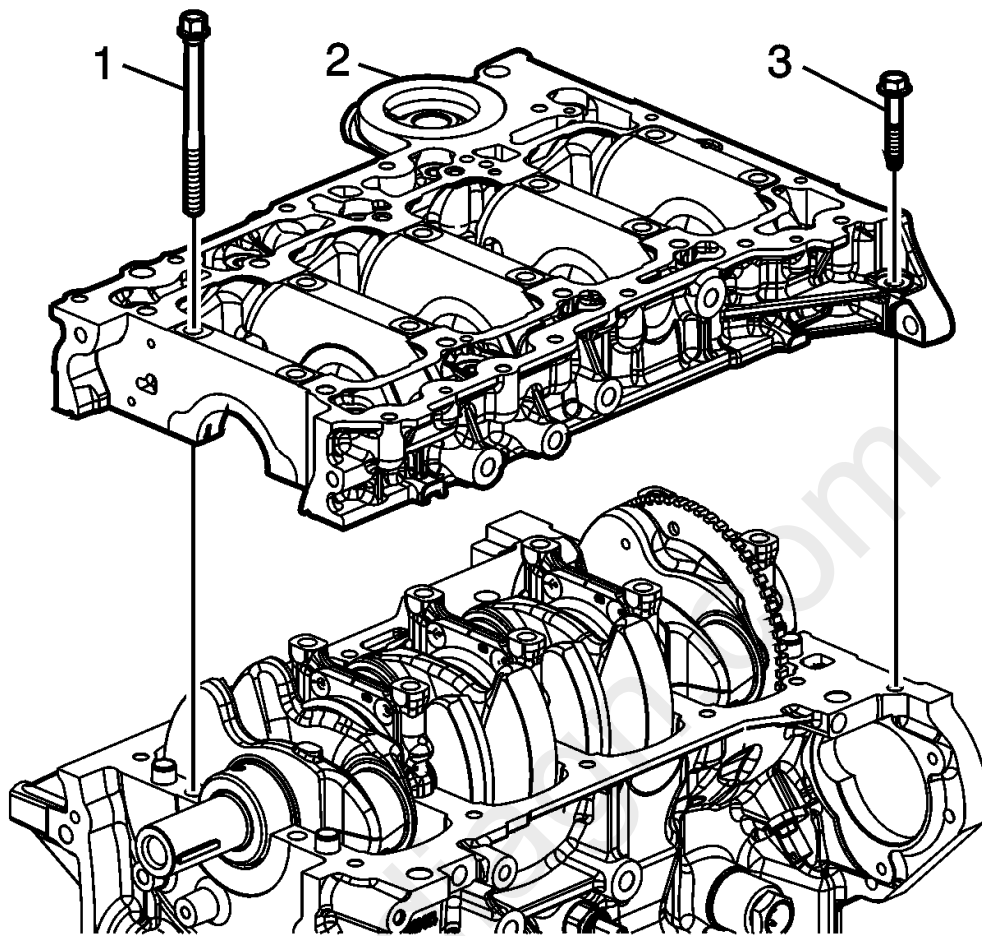


Fig. 71: Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the lower crankcase perimeter bolts (3).
4. Remove and discard the crankshaft bearing bolts (1).
5. Gently separate the lower crankcase (2) from the block.

CRANKSHAFT AND BEARING REMOVAL

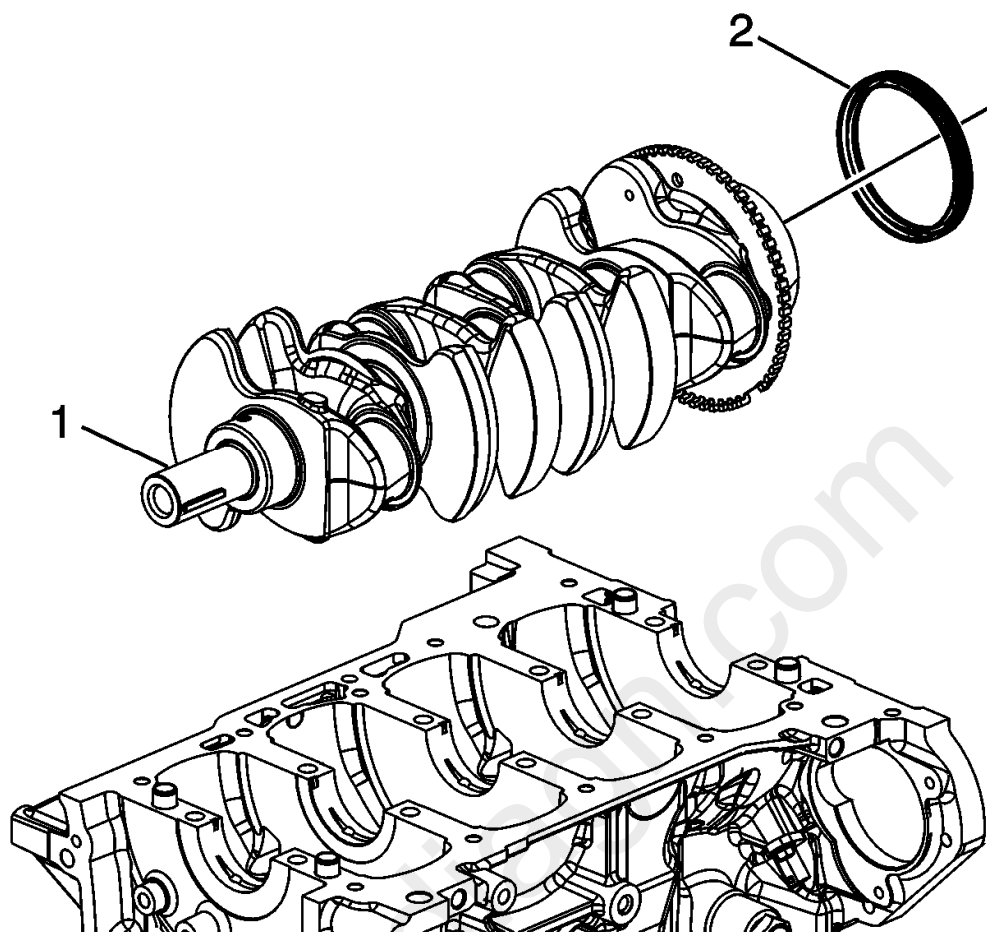


Fig. 72: Crankshaft

Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft (1) from the block.
2. Remove the crankshaft rear oil seal (2) from the block and discard.

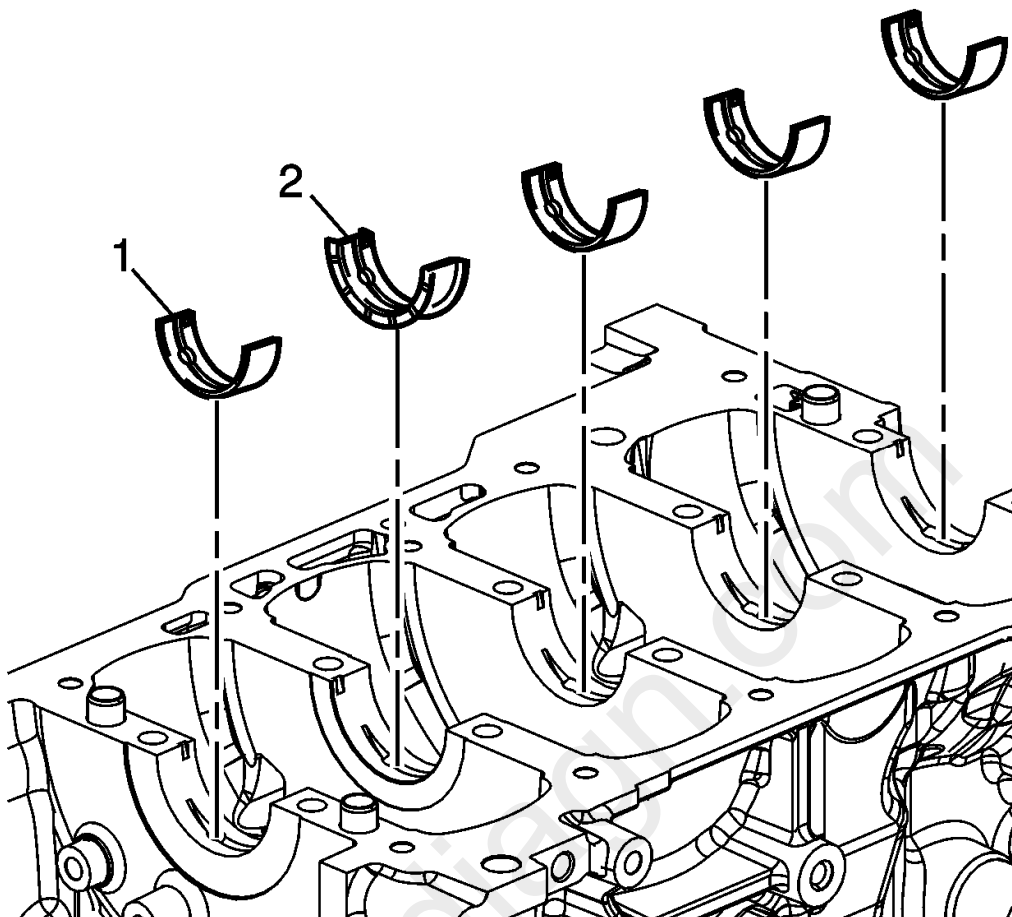


Fig. 73: Crankshaft Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

3. Remove the crankshaft upper bearings (1) and the crankshaft upper thrust bearing (2) from the block.

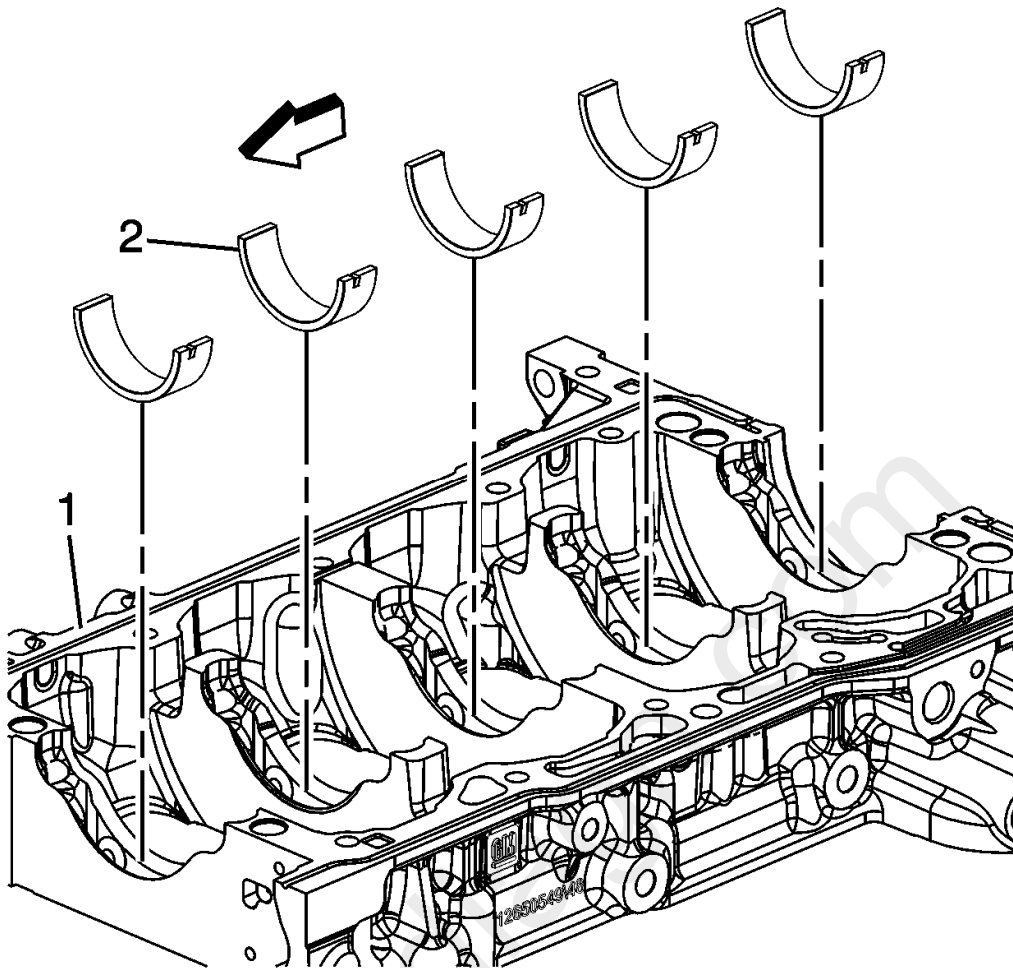


Fig. 74: Crankshaft Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft lower bearings (2) from the lower crankcase (1).
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves
 - Overheating (discoloration)
9. Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

NOTE: Replace the crankshaft if cracks, severe gouges or burned spots are found. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

10. Measure the crankshaft journals. Use a micrometer or dial indicator to measure the taper and runout. Note the result for the later selection of bearing inserts. If not within limits the crankshaft must be replaced.

Note the location of the main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

ENGINE BLOCK DISASSEMBLE

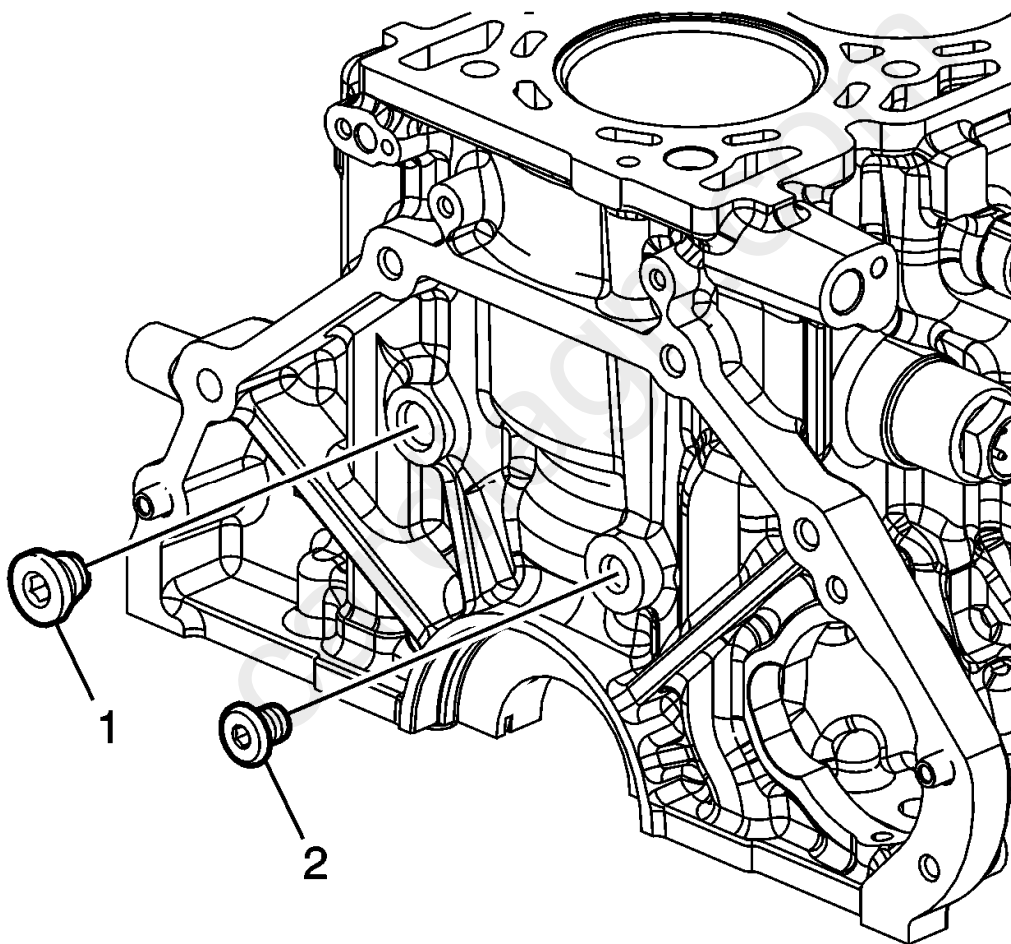


Fig. 75: Engine Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine oil gallery plugs (1, 2) from the rear of the block.

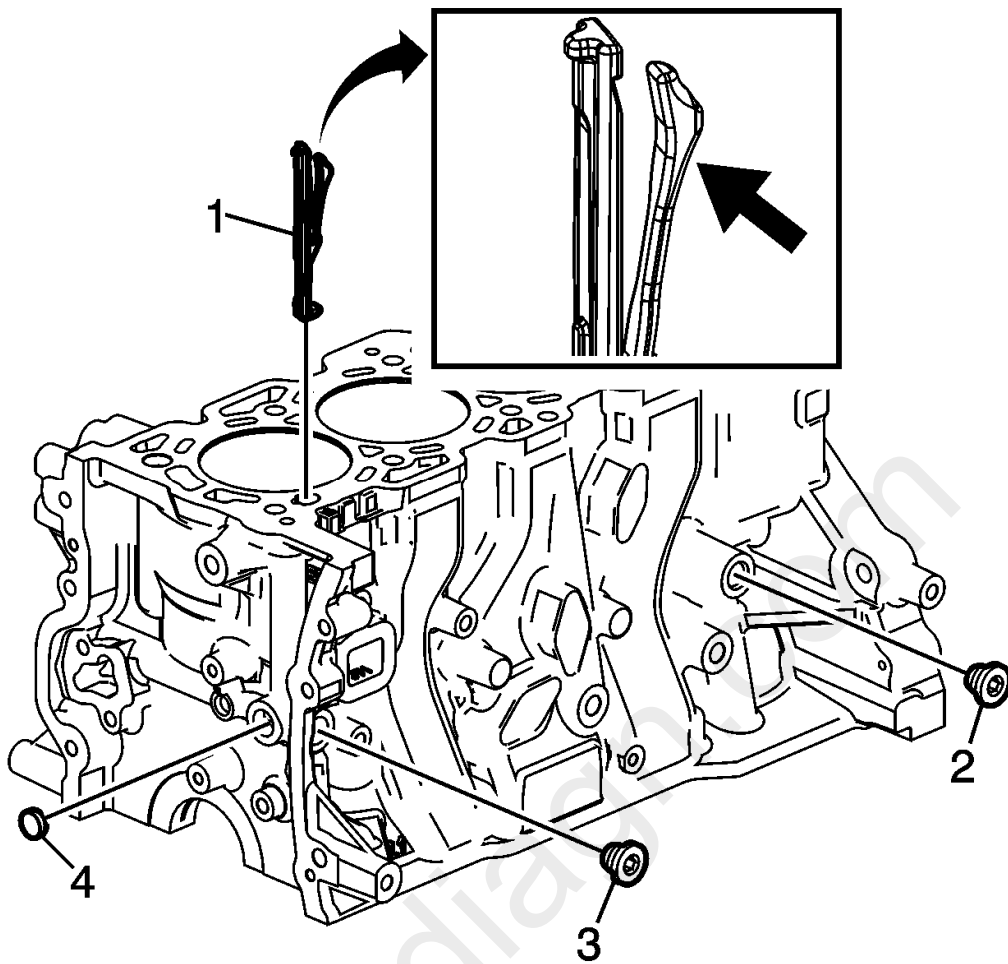


Fig. 76: Engine Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil gallery plugs (2, 3, 4) from the left side and front of the block.
3. Use a suitable hook tool to catch the clip feature and gently remove the engine block coolant baffle (1).

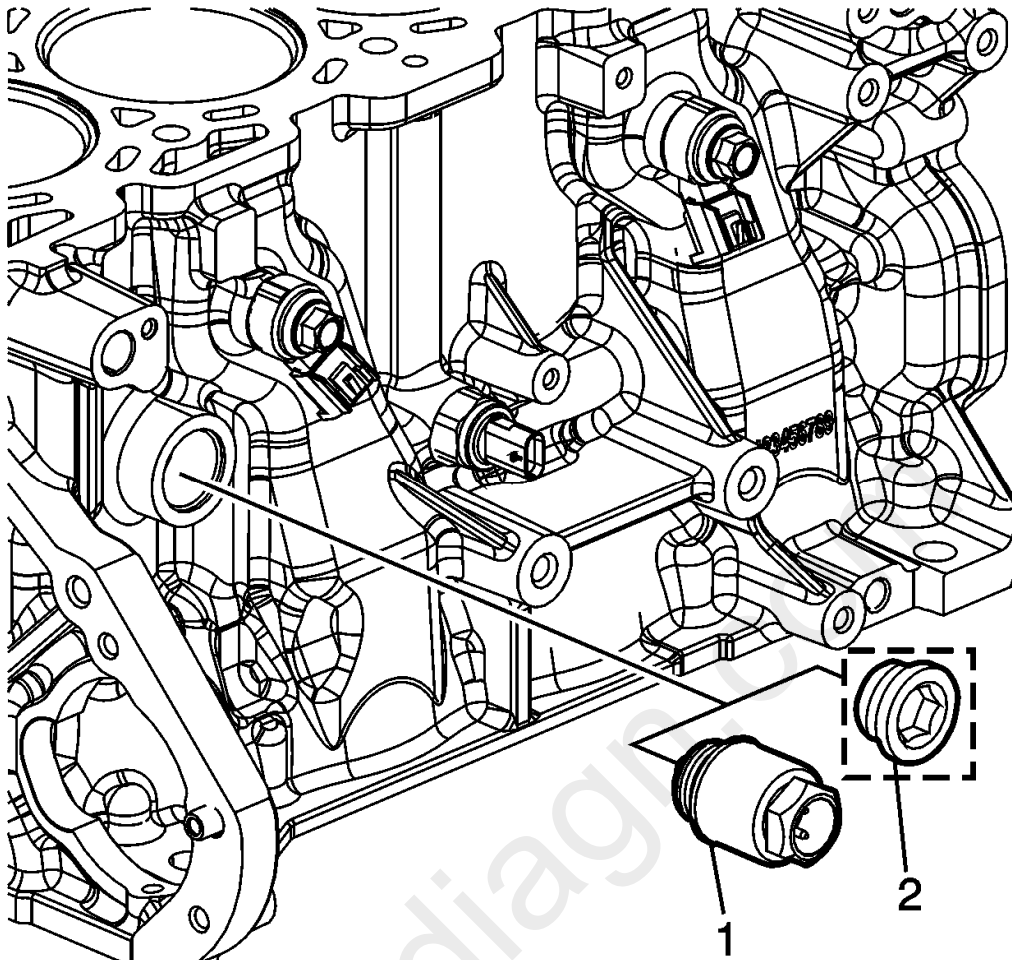


Fig. 77: Engine Coolant Heater
Courtesy of GENERAL MOTORS COMPANY

4. Remove the engine coolant heater (1), if equipped. Remove the engine coolant heater hole plug (2) if the heater is not present.

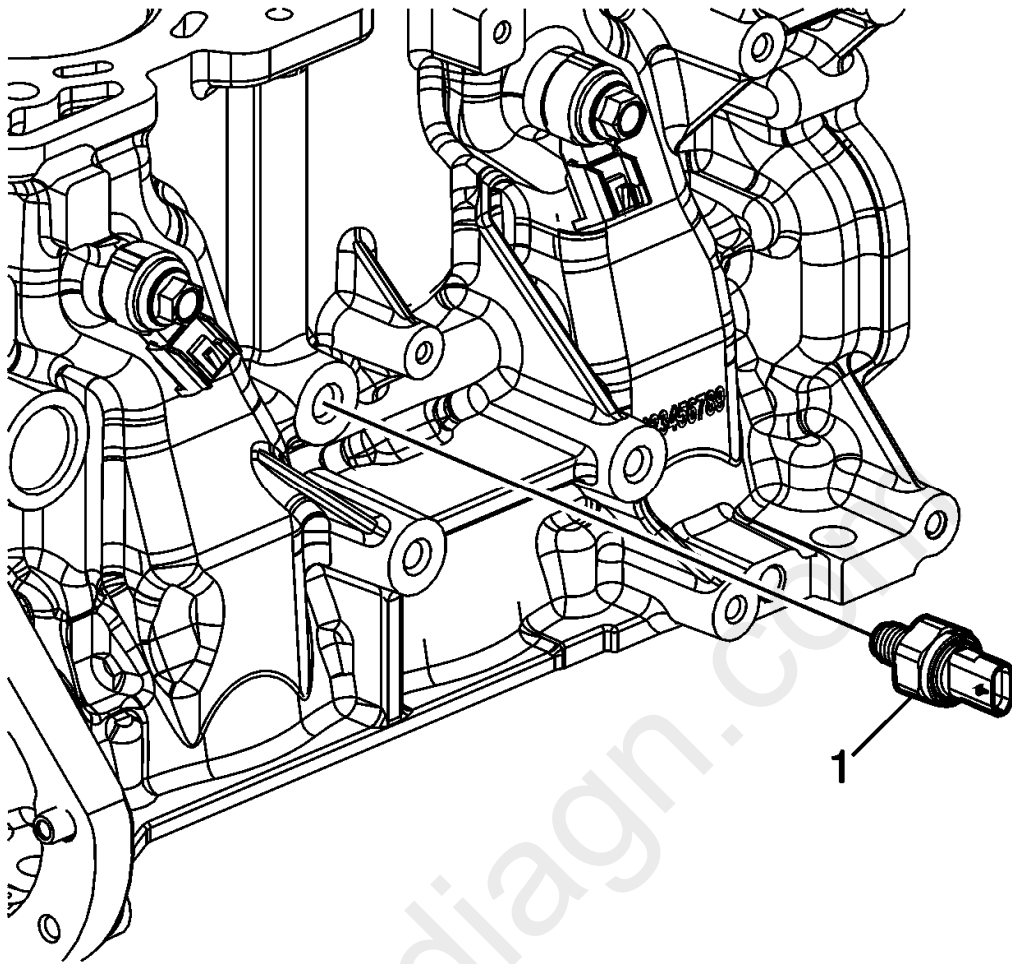


Fig. 78: Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

5. Remove the engine oil pressure sensor (1).

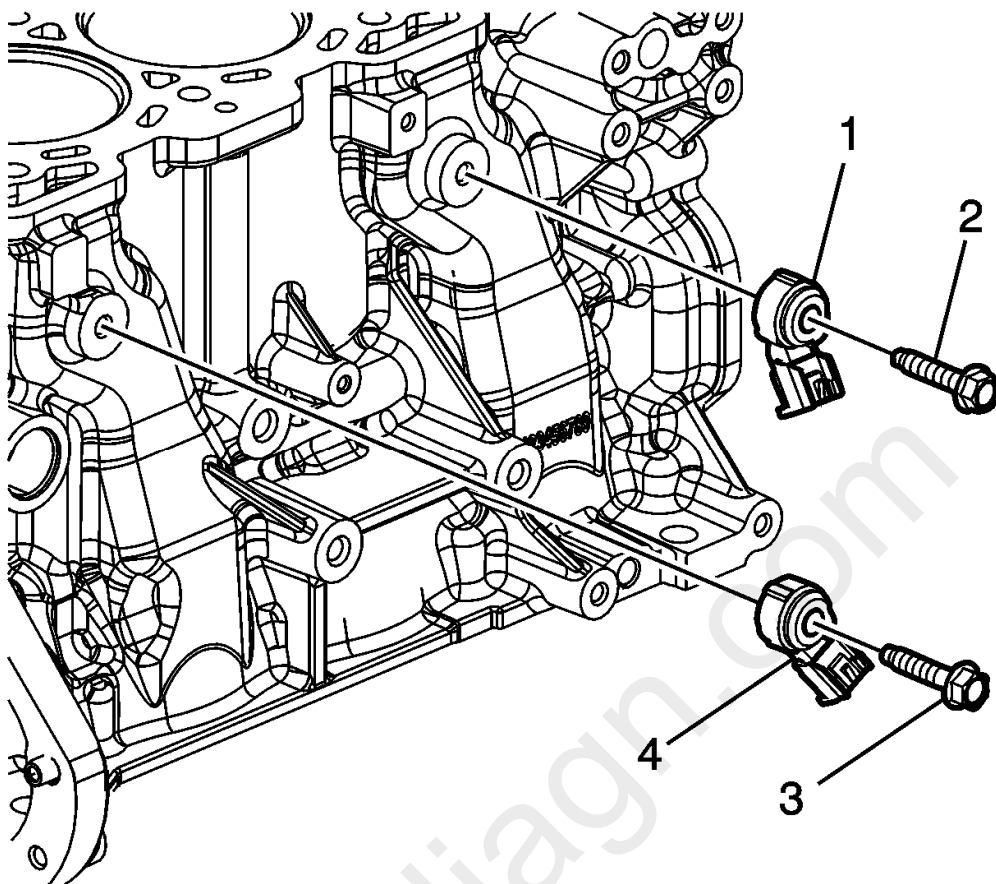


Fig. 79: Knock Sensors And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the knock sensors (1, 4) and bolts (2, 3).

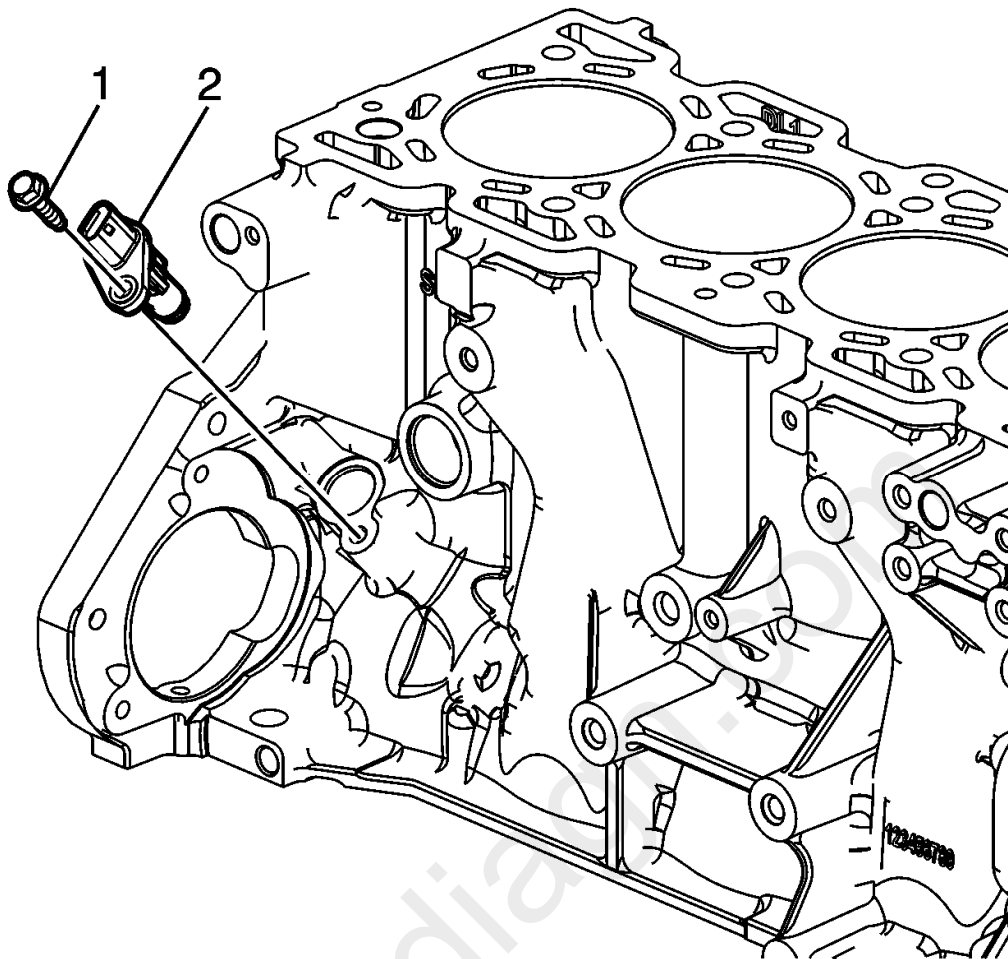


Fig. 80: Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS COMPANY

7. Remove the crankshaft position (CKP) sensor (2) and bolt (1).

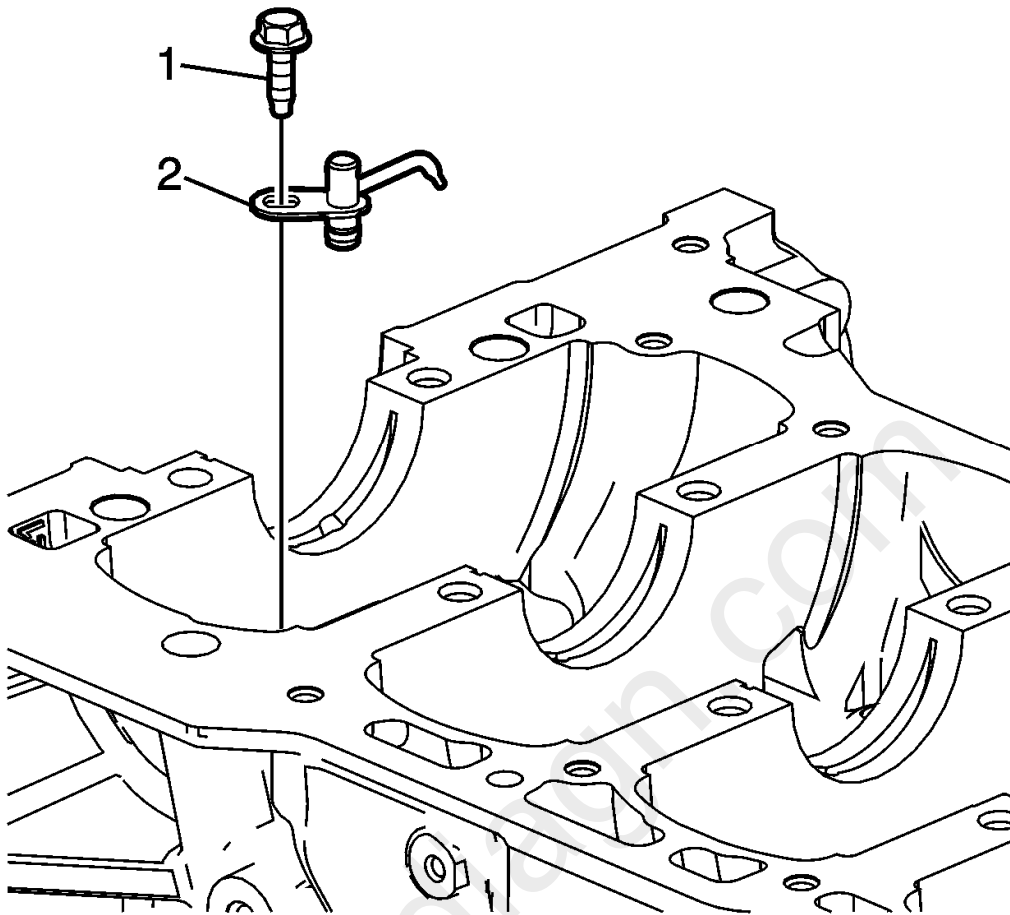


Fig. 81: Piston Oil Nozzle Assembly Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Loosen the piston oil nozzle assembly bolt (1) and remove the piston oil nozzle assembly (2).

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- EN-8087 Cylinder Bore Gauge
- GE-7872 Magnetic Base Dial Indicator

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

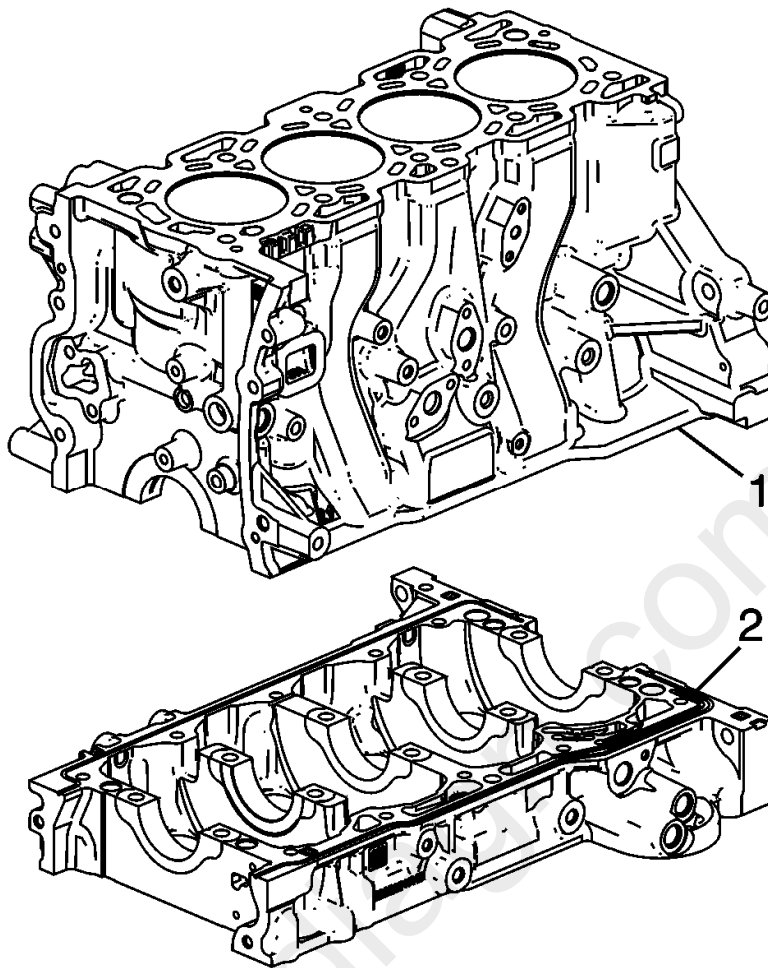


Fig. 82: Sealing Material And Engine Block
Courtesy of GENERAL MOTORS COMPANY

1. Clean the sealing material from the engine block (1) and lower crankcase (2) gasket mating surfaces with a suitable tool.
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Inspect the cylinder bores for glazing. If the bore is glazed but otherwise serviceable, refer to Deglazing Procedure in Cylinder Boring and Honing.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to Thread Repair.

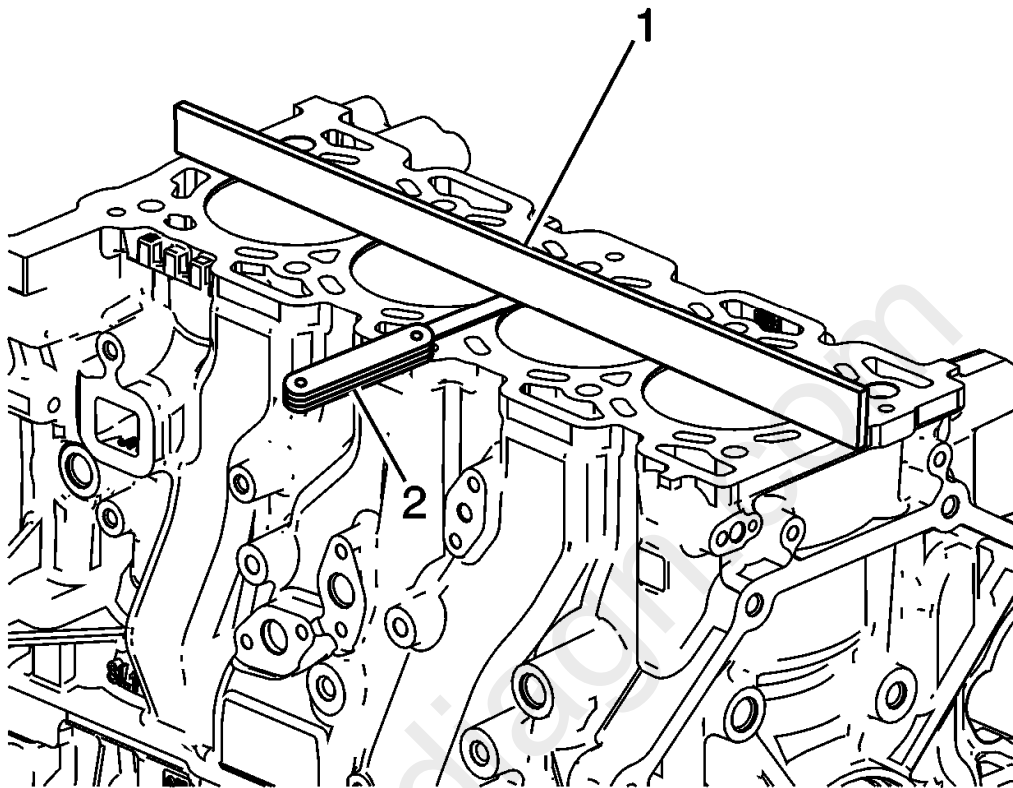


Fig. 83: Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

9. Use a straight edge (1) and a feeler gauge (2) to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

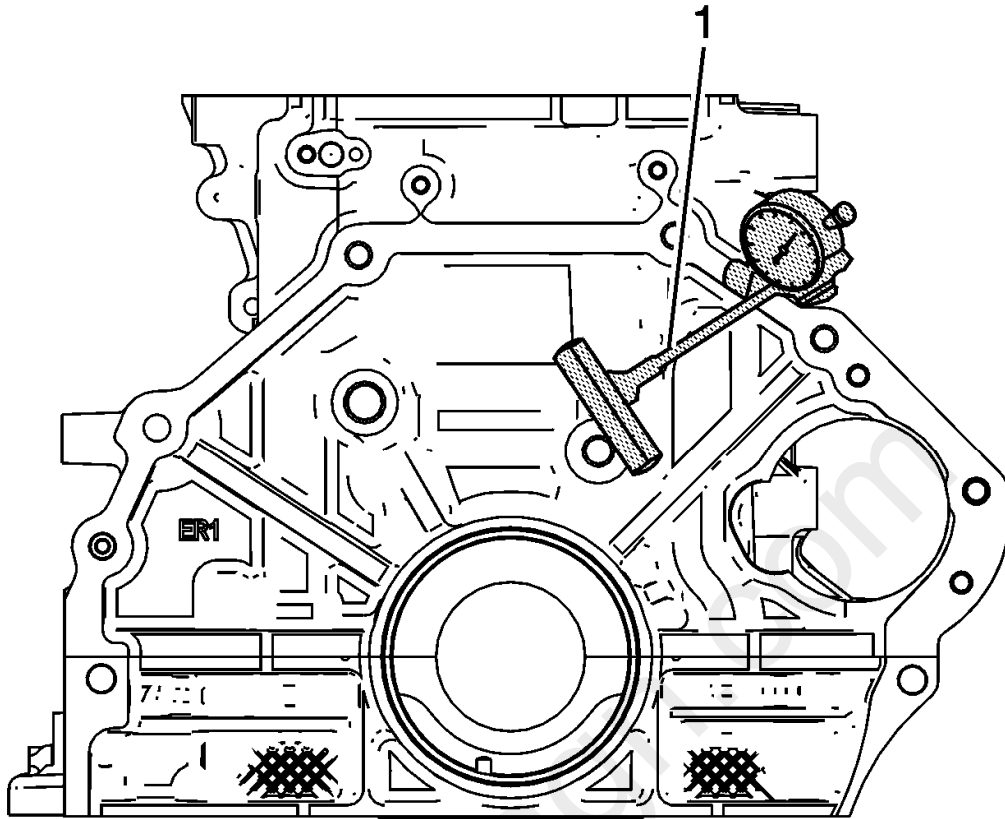


Fig. 84: Crankshaft Flange Runout Using Magnetic Base Dial Indicator
Courtesy of GENERAL MOTORS COMPANY

11. Inspect the mating surfaces of the transmission face.

CAUTION: A broken flywheel may result if the transmission case mating surface is not flat.

12. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
 1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **GE-7872** dial indicator (1)
 2. Hold the gauge plate flat against the crankshaft flange.
 3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
 4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.203 mm (0.008 in).
 5. Recheck the crankshaft flange runout if the readings vary more than 0.203 mm (0.008 in).

6. Remove the crankshaft and bearings.

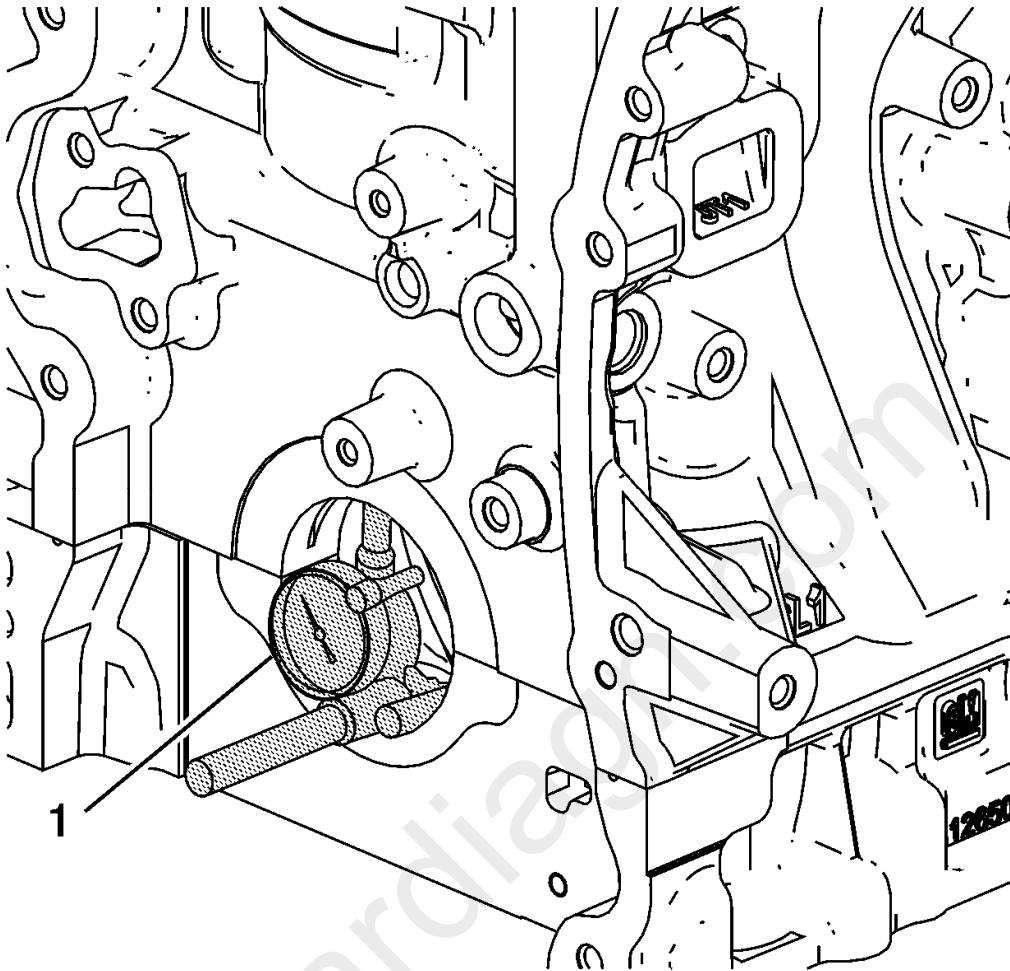


Fig. 85: View Of Cylinder Bore Gauge
Courtesy of GENERAL MOTORS COMPANY

13. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
14. Inspect the crankshaft main bearing bores. Use the **EN-8087** gauge (1) to measure the bearing bore concentricity and alignment. Refer to **Engine Mechanical Specifications** .
15. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
16. Remove the bed plate.

Measuring Cylinder Bore Diameter

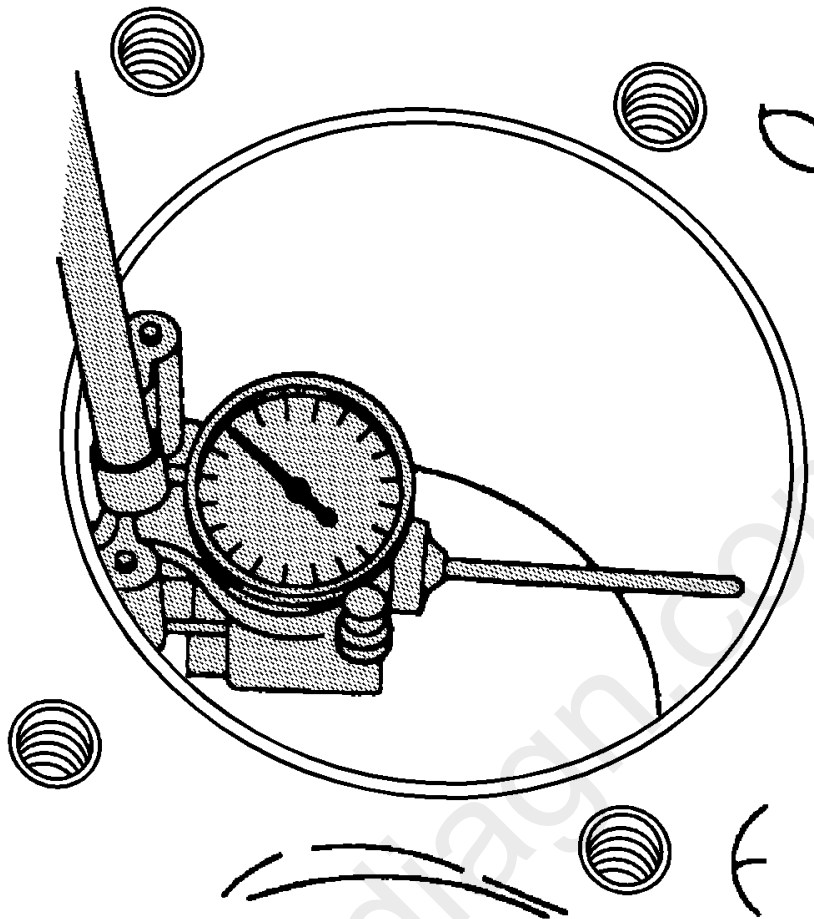


Fig. 86: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore diameter 35 mm (1.378 in) from the deck face using the **EN-8087** gauge.
2. Compare your results with the **Engine Mechanical Specifications** , . 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. Refer to **Cylinder Boring and Honing**.

Measuring Cylinder Bore Taper

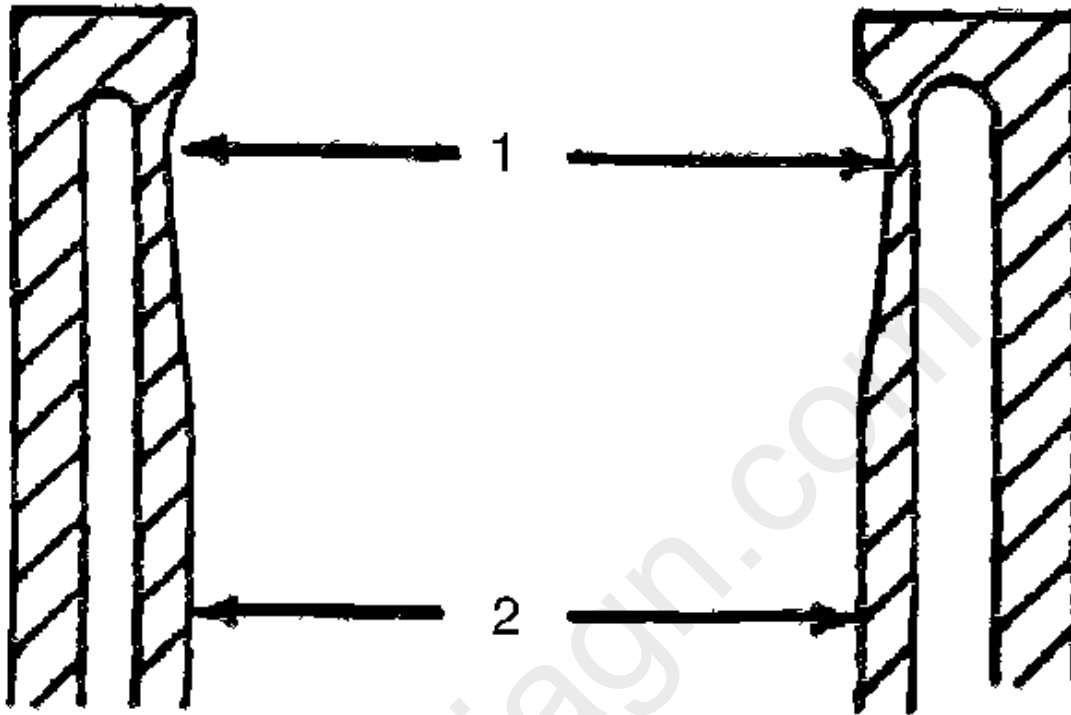


Fig. 87: Measuring Head Gasket Dimensions
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.394 in) below the deck surface (1) and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 125 mm (4.921 in) below the deck surface (2) and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications** , . If the cylinders exceed the specifications, the 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. Refer to **Cylinder Boring and Honing**.

Measuring Cylinder Bore Out-of-Round

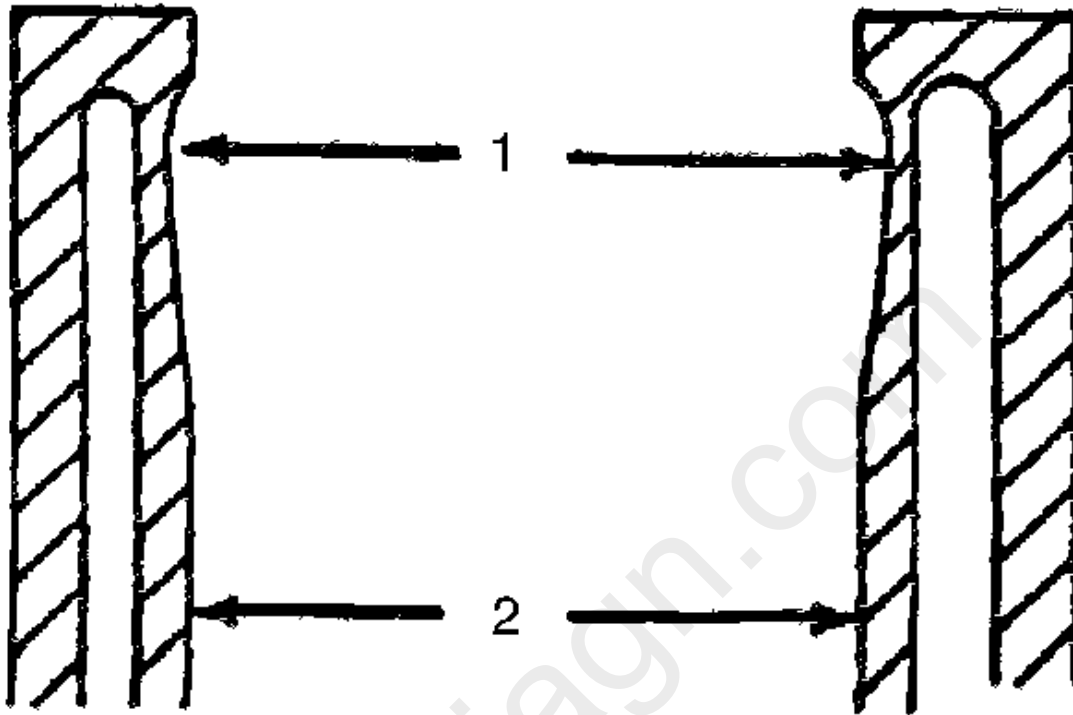


Fig. 88: Measuring Head Gasket Dimensions
Courtesy of GENERAL MOTORS COMPANY

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.394 in) below the deck surface (1). 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 125 mm (4.921 in) below the deck surface (2). Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications** , . If the cylinders exceed these specifications, the 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. Refer to **Cylinder Boring and Honing**.

CYLINDER BORING AND HONING

Boring Procedure

1. Measure all pistons with a micrometer to determine the cylinder bore diameter. Refer to **Engine Block Cleaning and Inspection**.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block, removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.075 mm (0.003 in) on the cylinder bore diameter for the finish honing and fit of the piston.

Honing Procedure

NOTE: Fine vertical scratches made by the ring ends do not, by themselves, cause excessive oil consumption. Do not hone the cylinder in order to remove these scratches.

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.

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

2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly check the cylinder bore for fit with the selected piston.
3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100-grit stone.

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

4. Perform final cylinder honing with a 240-grit stone and obtain a 45 degree cross hatch pattern.
5. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
6. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
7. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not

allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.

8. Perform final measurements of the piston and the cylinder bore.
9. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure

1. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. Refer to **Piston, Connecting Rod, and Bearing Installation**.

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

2. Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240-grit stone of silicone carbide, or equivalent, material when performing the deglazing procedure.
 1. The honing stones must be clean, sharp, and straight.
 2. Move the hone slowly up and down to produce a 45 degree cross-hatch pattern.
 3. Clean the bore thoroughly with soap and water.
 4. Dry the bore.
 5. Rub clean engine oil in the bore.
 6. Re-measure the bore.
3. If the cylinder bore is out of specification, the cylinder bore may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.
4. If honing is not required, clean the cylinder bores with hot water and detergent. Apply clean engine oil to the bore after washing and drying the bore.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

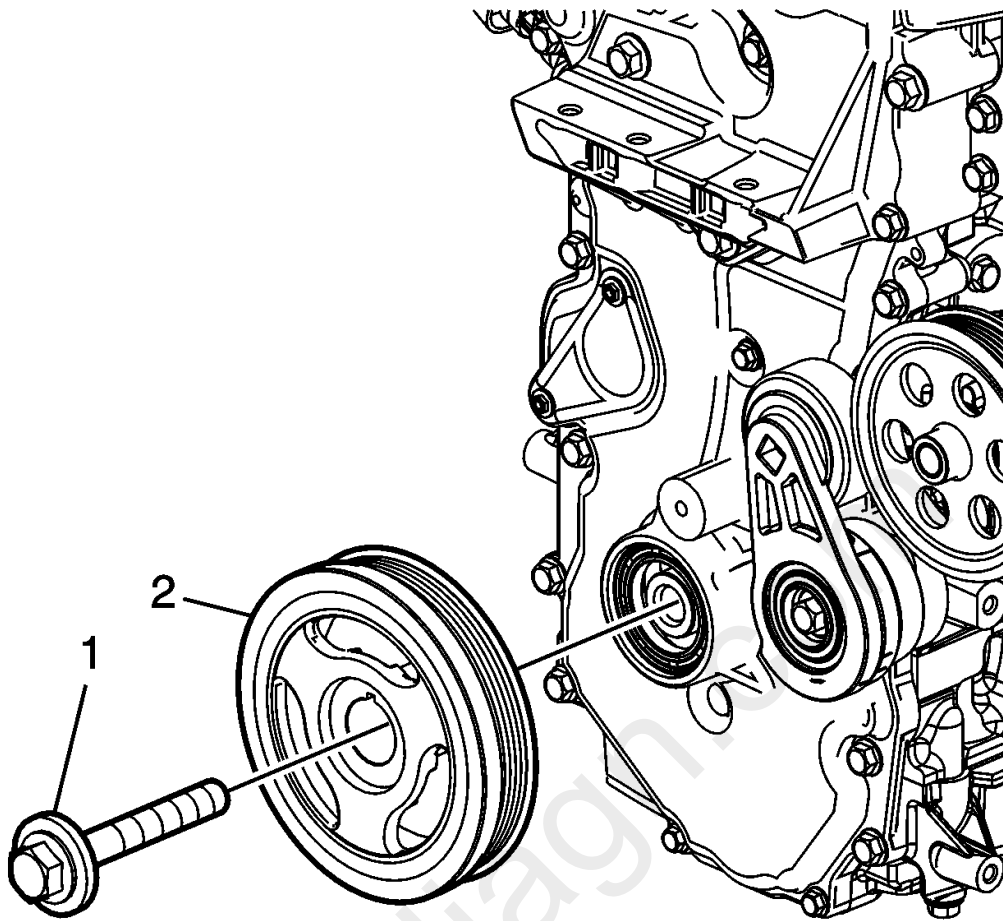


Fig. 89: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

1. Clean the crankshaft balancer (2).
2. Clean the belt grooves of all dirt or debris with a wire brush.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:
 - Worn, grooved, or damaged hub seal surface.
 - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

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

- Dirty or damaged belt grooves

The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

- Minor imperfections may be removed with a fine file.
- Worn, chunking or deteriorated rubber between the hub and pulley.

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

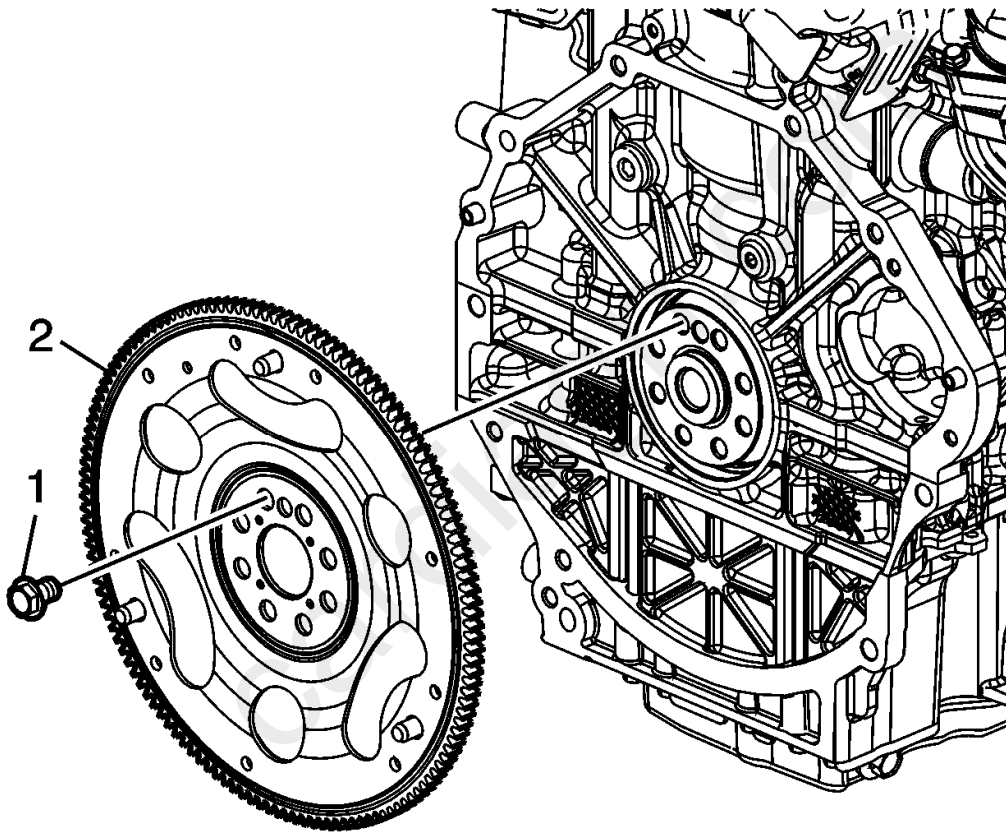


Fig. 90: Flywheel Attaching Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Clean the flywheel (2) in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following:
 - Damaged ring gear teeth.
 - Stress cracks around the flywheel-to-crankshaft bolt hole locations.
 - Weight saving holes.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator Set

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

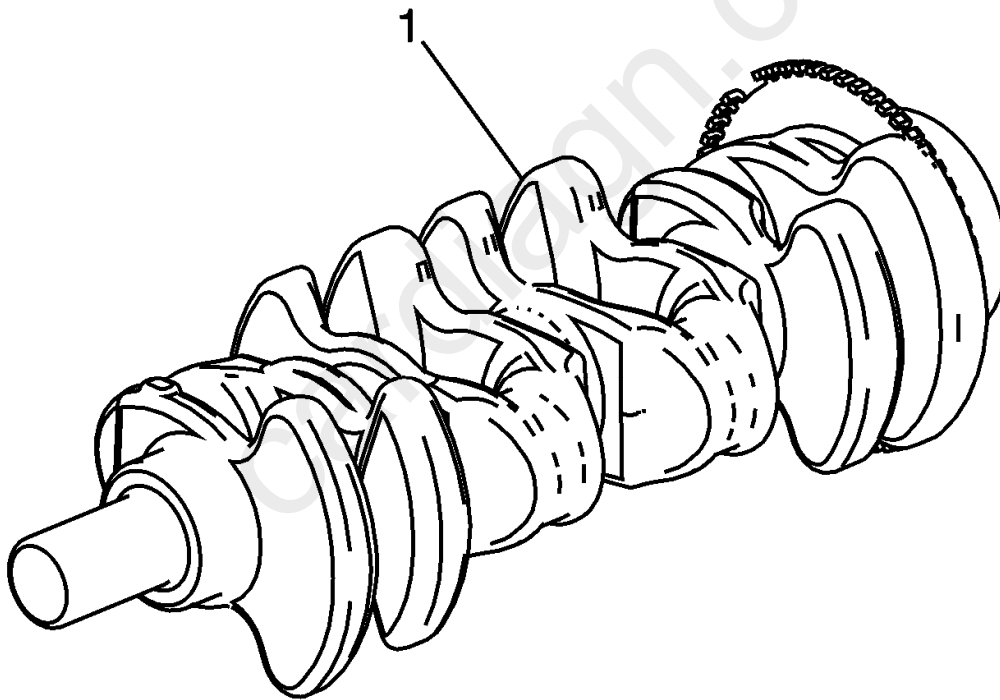


Fig. 91: Measuring Bearing Clearance Using Method A
Courtesy of GENERAL MOTORS COMPANY

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

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

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

NOTE: Reluctor ring teeth should not have imperfections on the rising or falling edges.

Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.
5. Inspect the crankshaft reluctor ring. Replace the crankshaft assembly if damage to the reluctor ring is present.
6. Inspect the crankshaft journals for wear. The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring.
8. Inspect the crankshaft journals for scratches or wear.
9. Inspect the crankshaft journals for pitting or imbedded bearing material.
10. Measure the crankshaft journals for out-of-round.
11. Measure the crankshaft journals for taper.

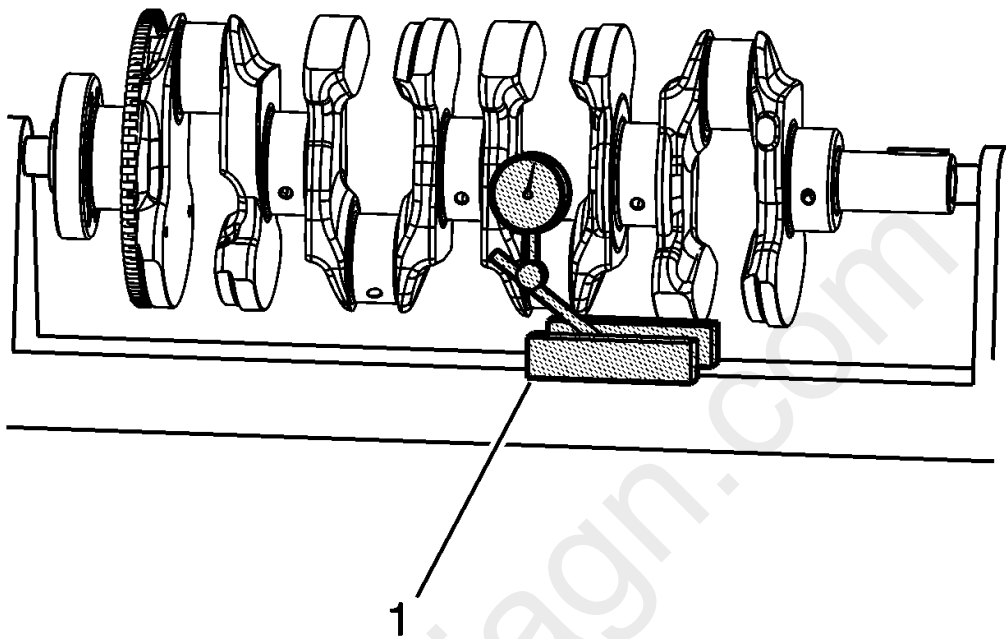


Fig. 92: View Of Magnetic Base Dial Indicator
Courtesy of GENERAL MOTORS COMPANY

12. Measure the crankshaft runout.

Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **GE-7872** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **GE-7872** indicator in order to measure the runout of the crankshaft rear flange.
15. Replace the crankshaft if the measurements are not within specifications.

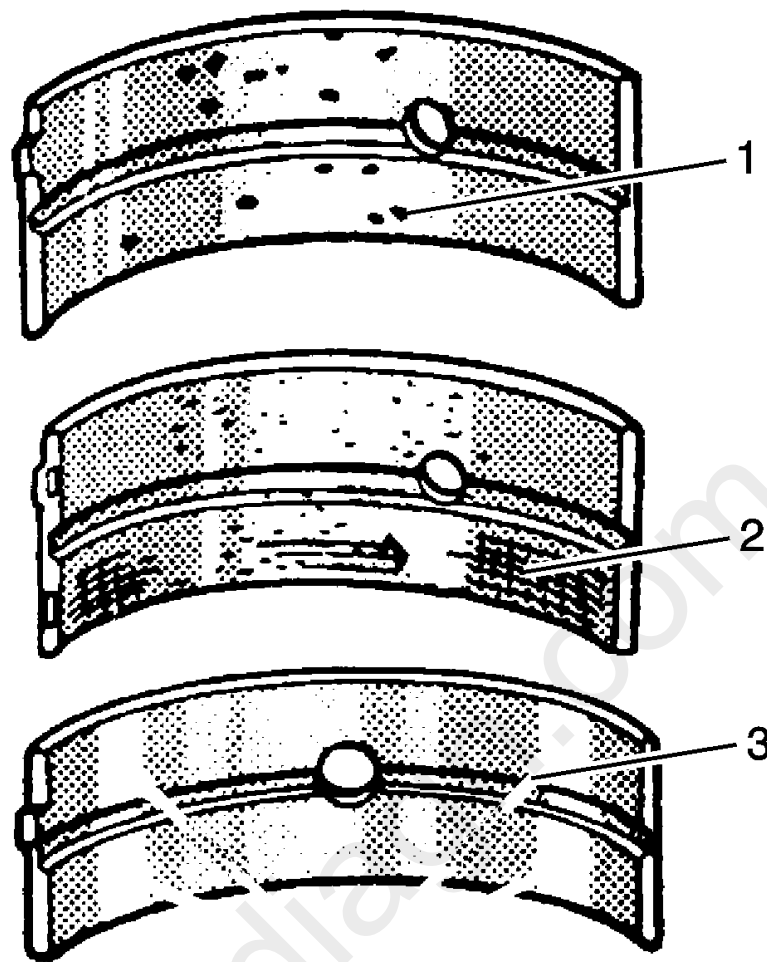


Fig. 93: Identifying Crankshaft Bearings For Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

16. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.
17. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

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

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

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

- EN-46745 Piston Pin Clip Remover/Installer
- EN-46745-4 Piston Pin Clip Remover/Installer Adapter

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

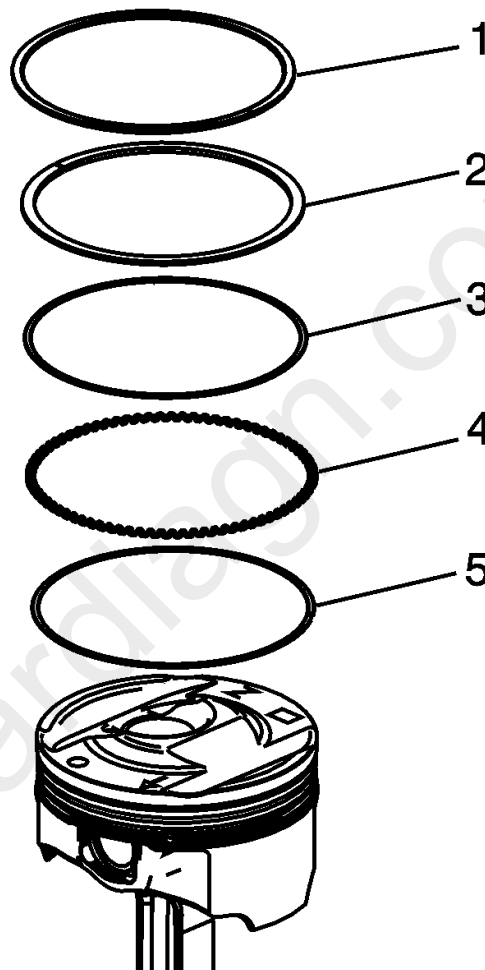


Fig. 94: Piston Rings

Courtesy of GENERAL MOTORS COMPANY

WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.

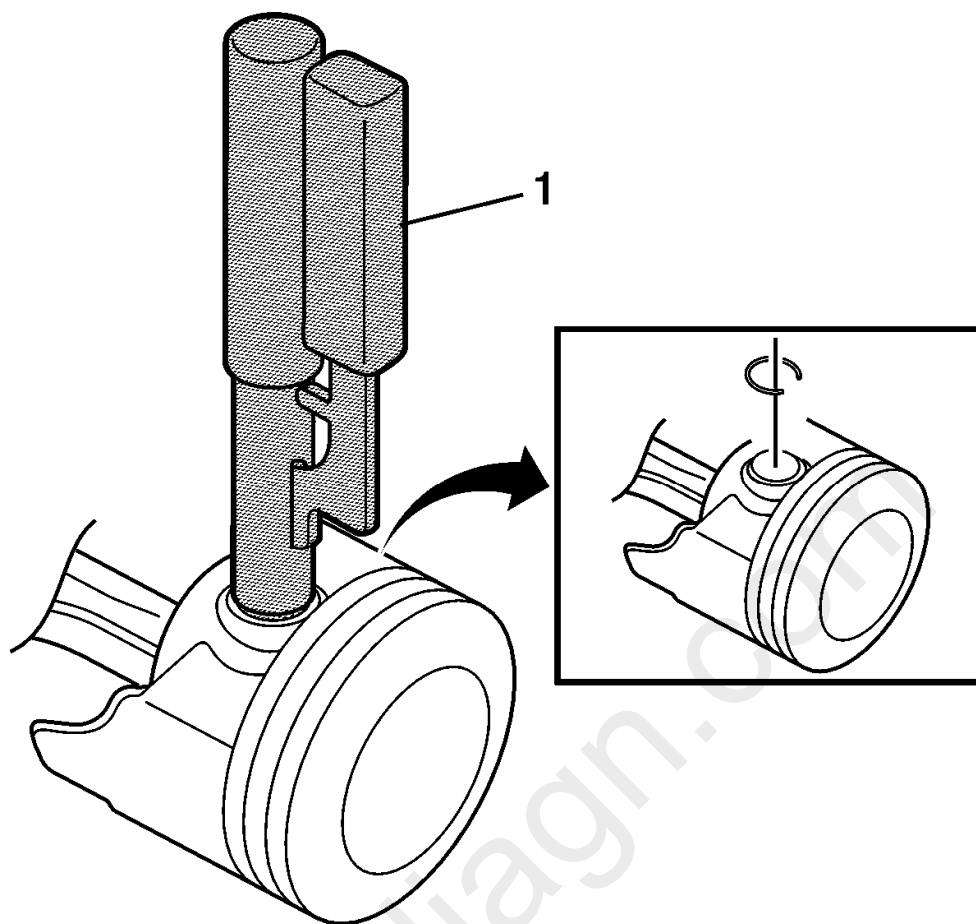


Fig. 95: View of Piston Pin Retainers
Courtesy of GENERAL MOTORS COMPANY

NOTE: Two retainers hold the piston pins in place. No special tools are required to remove the piston pins. Ensure that the piston pin is not damaged. Do not reuse the retainers.

2. Remove the piston pin retainers using the **EN-46745** remover (1) and **EN-46745-4** adapter.

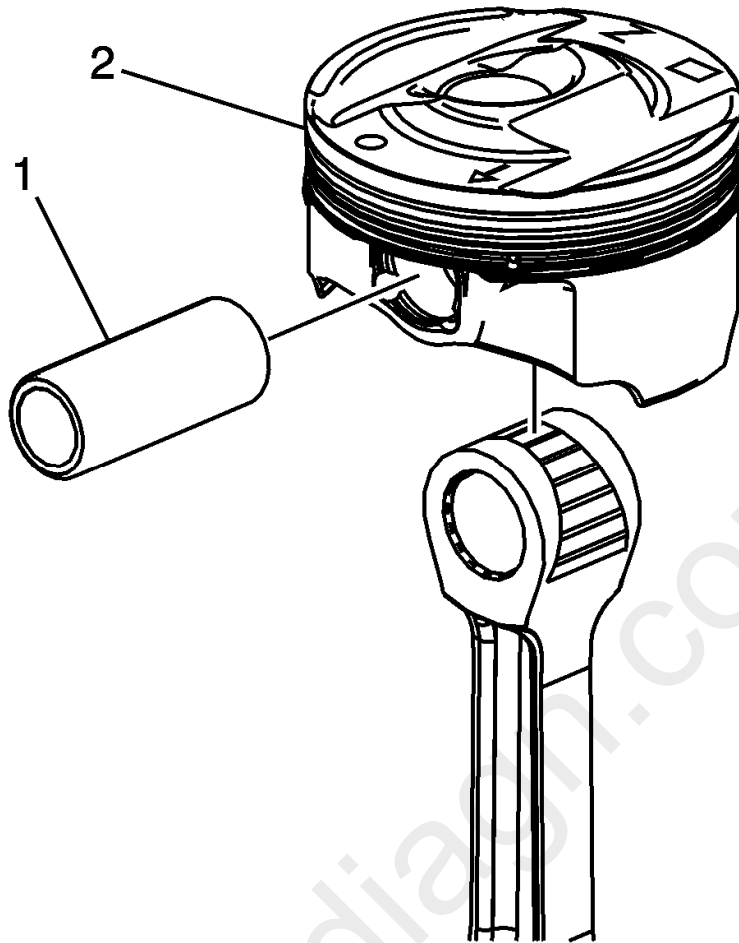


Fig. 96: Piston Pin And Connecting Rod
Courtesy of GENERAL MOTORS COMPANY

3. Remove the piston pin (1) and the connecting rod (3) from the piston (2).

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

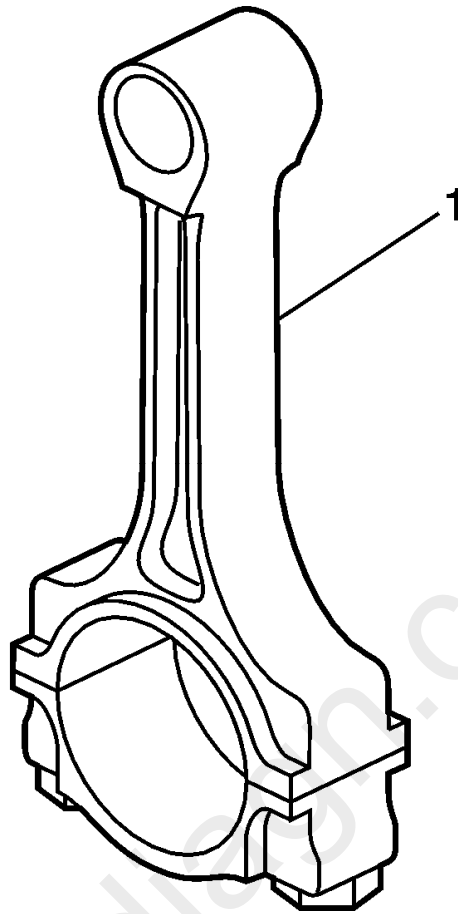


Fig. 97: Connecting Rod
Courtesy of GENERAL MOTORS COMPANY

1. Clean the connecting rods (1) in solvent and dry with compressed air.
2. Inspect the connecting rods for the following:
 - Signs of being twisted, bent, nicked, or cracked
 - Scratches or abrasion on the rod bearing seating surface
3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT scrape the rod or rod cap.
4. If the beam of the rod is scratched or has other damage replace the connecting rod.
5. Measure the piston pin to connecting rod bore using the following procedure:
 1. Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
 2. Using an inside micrometer, measure the connecting rod piston pin bore.
 3. Subtract the piston pin diameter from the piston pin bore diameter.
 4. The clearance should not be more than 0.021 mm (0.0008 in).

6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

Piston Measurement

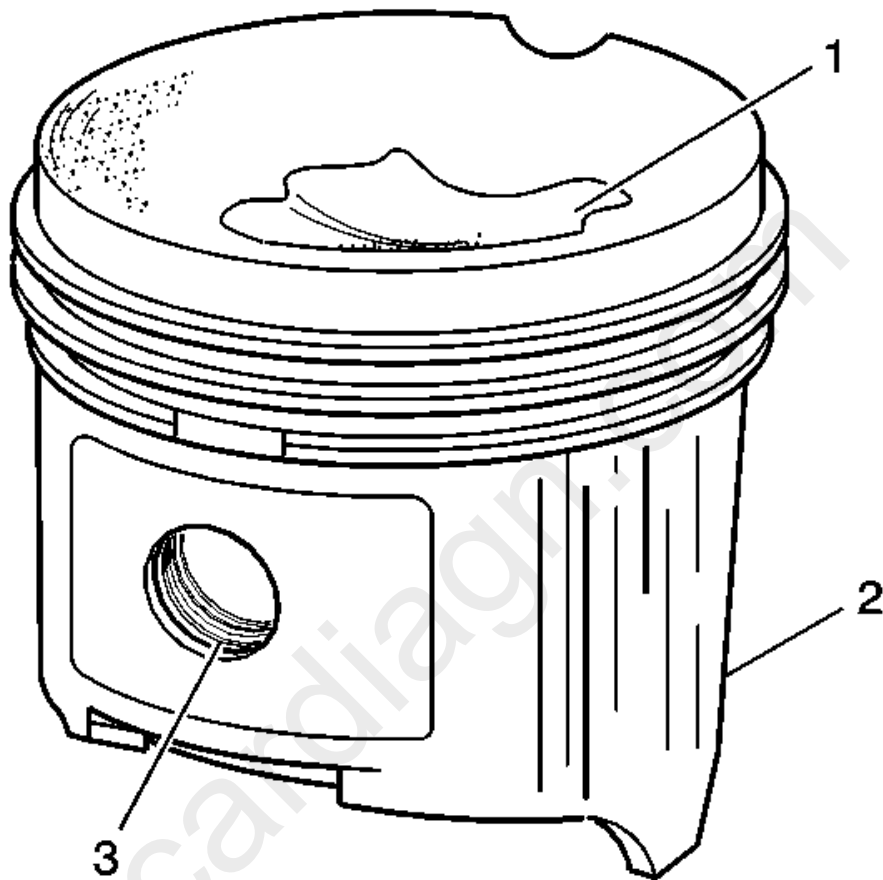


Fig. 98: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts, or pin bosses
 - Ring grooves for nicks, burrs that may cause binding
 - Warped or worn ring lands
 - Eroded areas at the top of the piston (1)
 - Scuffed or damaged skirts (2)

- Worn piston pin bores (3)
4. Replace pistons that show any signs or damage or excessive wear.
 5. 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.
 3. Using an inside micrometer, measure the piston pin bore.
 4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002-0.012 mm (0.00007-0.00047 in).
 5. If the clearance is excessive, determine which component is out of specification.

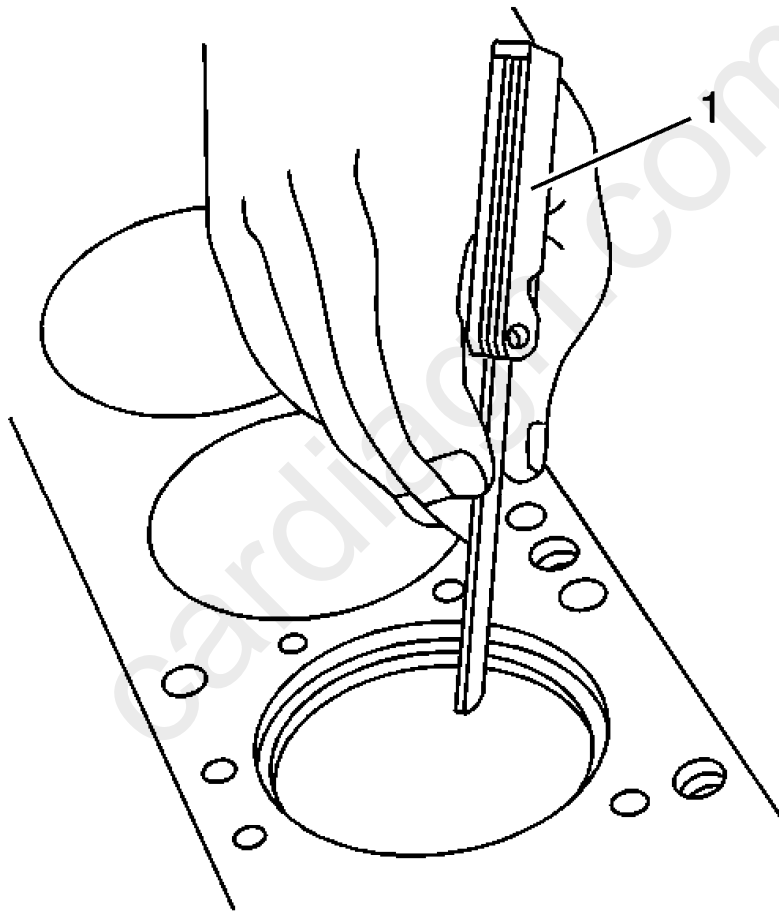


Fig. 99: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS COMPANY

6. 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 or 1 inch down from the deck surface). Be sure 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 (1). Compare the measurements with those provided below:
 - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
 - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
 - The oil ring end gap should be 0.25-0.76 mm (0.0098-0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

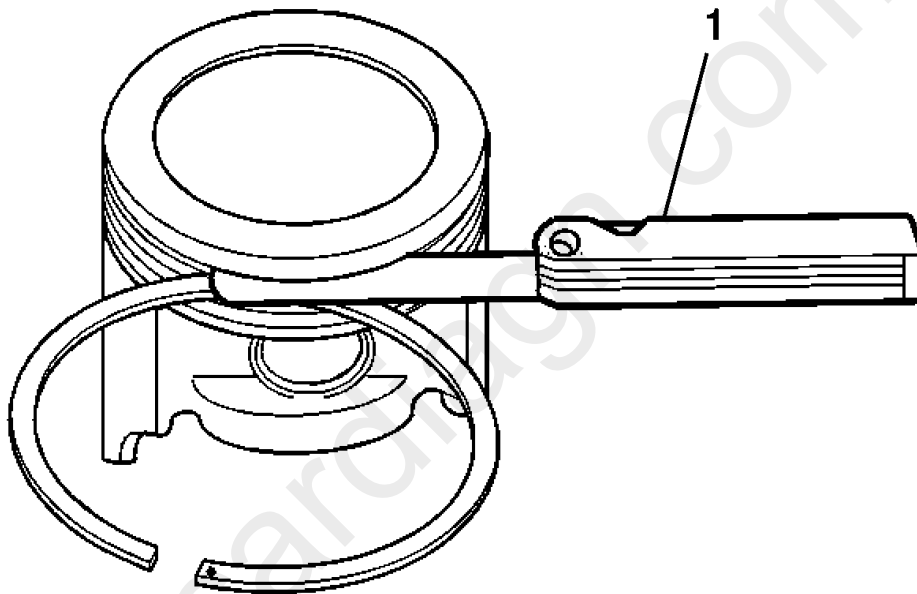


Fig. 100: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

7. 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 a distorted piston ring, replace the ring.
 2. With the piston ring on the piston, use feeler gauges (1) to check clearance at multiple locations.

3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
4. If the clearance is greater than specifications, replace the piston ring.
5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.
8. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.
9. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
10. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.

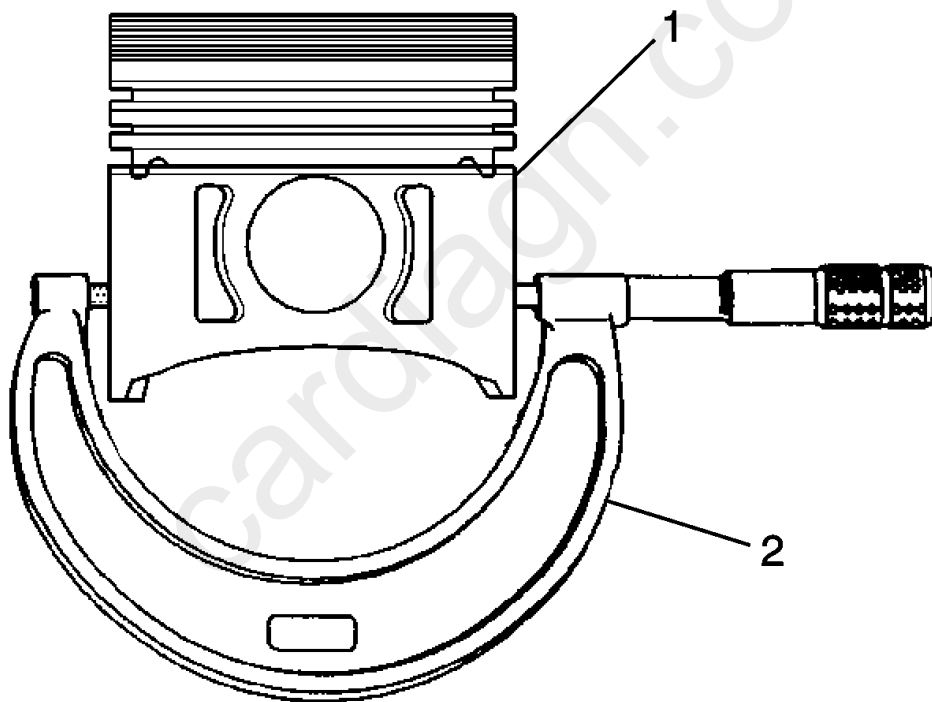


Fig. 101: Measuring Piston Width
Courtesy of GENERAL MOTORS COMPANY

11. Measure piston width using the following procedure:

1. Using an outside micrometer (2), measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
 2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
 3. The proper clearance specification for the piston is 0.010-0.041 mm (0.0004-0.0016 in).
12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston (1).

Piston Selection

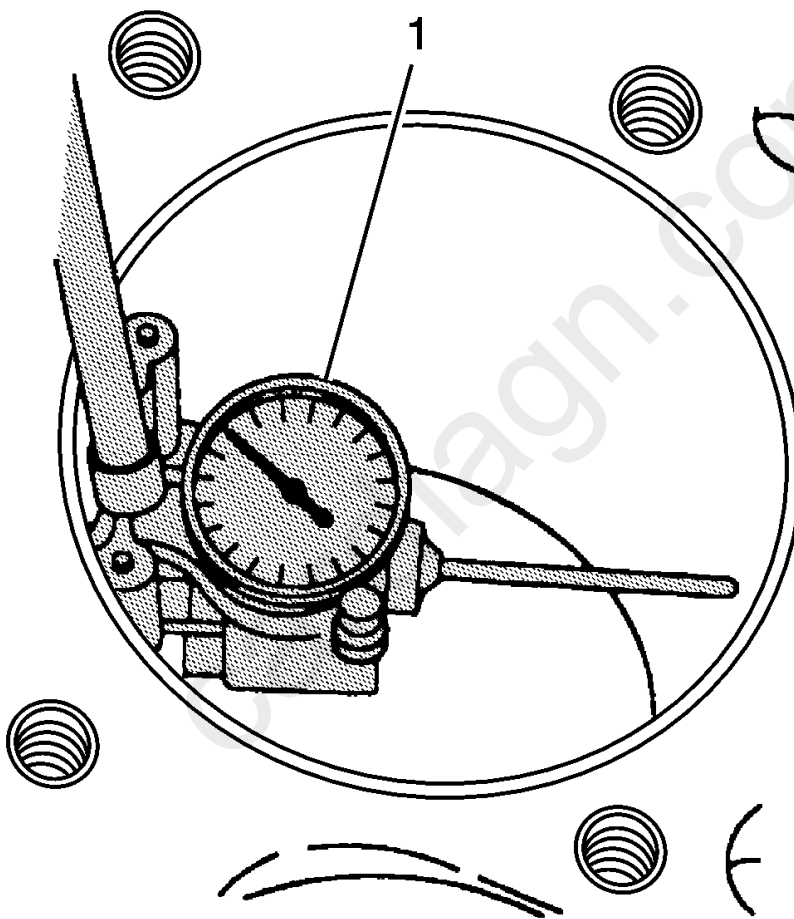


Fig. 102: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

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

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

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

1. Inspect the engine block cylinder bore. Refer to Engine Block Cleaning and Inspection.
2. Inspect the piston and the piston pin.
3. Use a bore gauge (1) and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

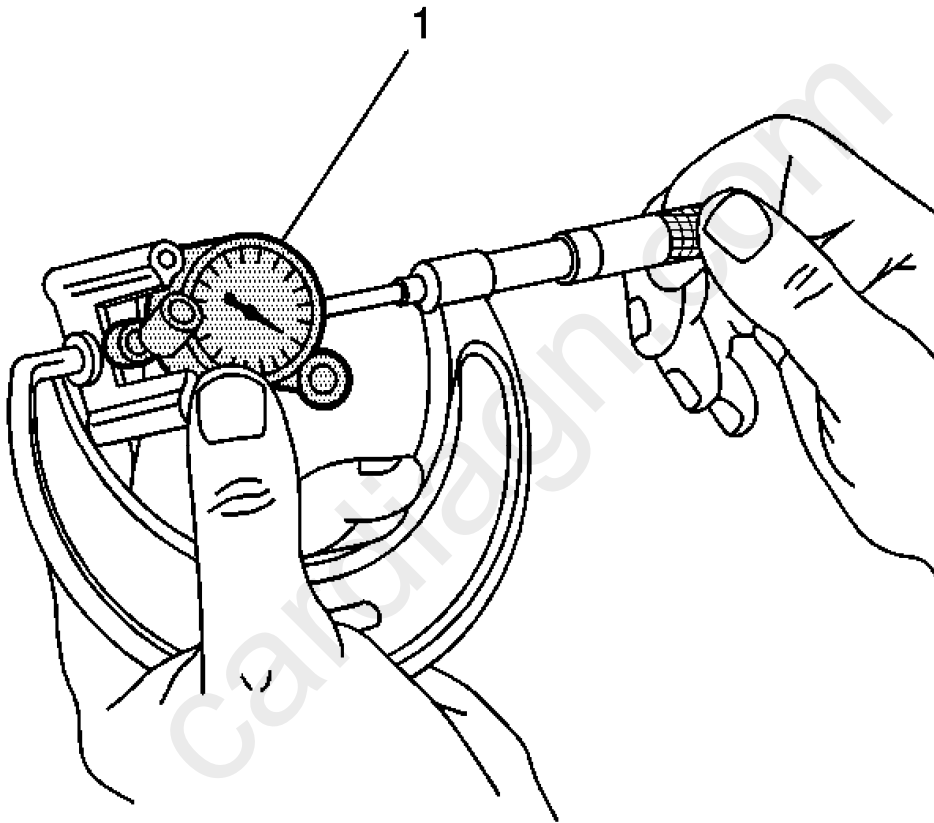


Fig. 103: Measuring Bore Gauge
Courtesy of GENERAL MOTORS COMPANY

4. Measure the bore gauge with a micrometer (1) and record the reading.

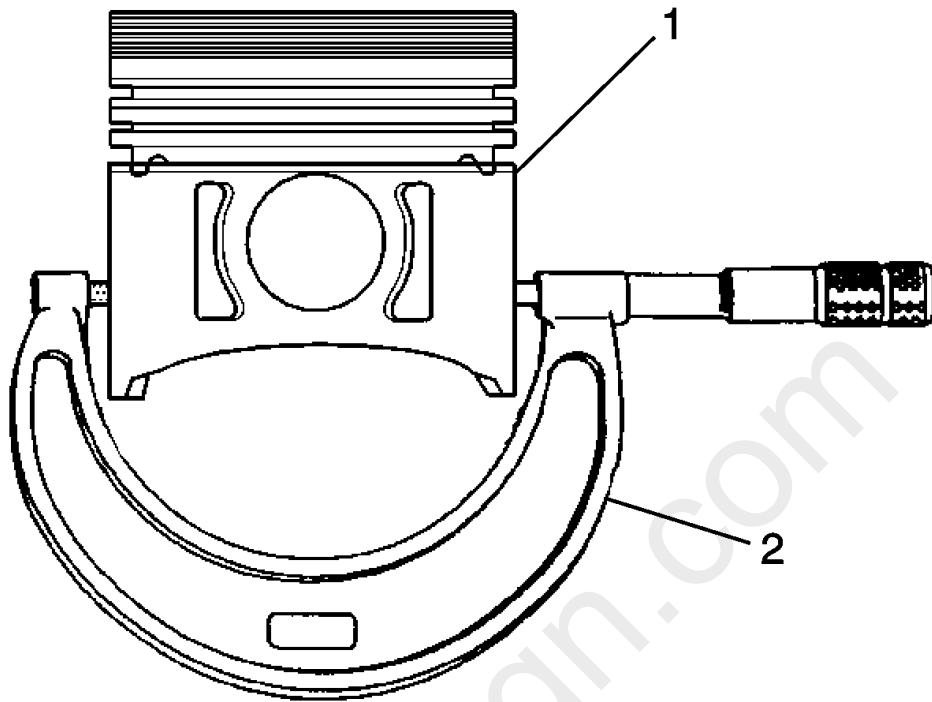


Fig. 104: Measuring Piston Width
Courtesy of GENERAL MOTORS COMPANY

5. With a micrometer (2) or caliper at a right angle to the piston (1), measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine Mechanical Specifications** .
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to **Separating Parts** .

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

- EN-46745 Piston Pin Clip Remover/Installer
- EN-46745-4 Piston Pin Clip Remover/Installer Adapter

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

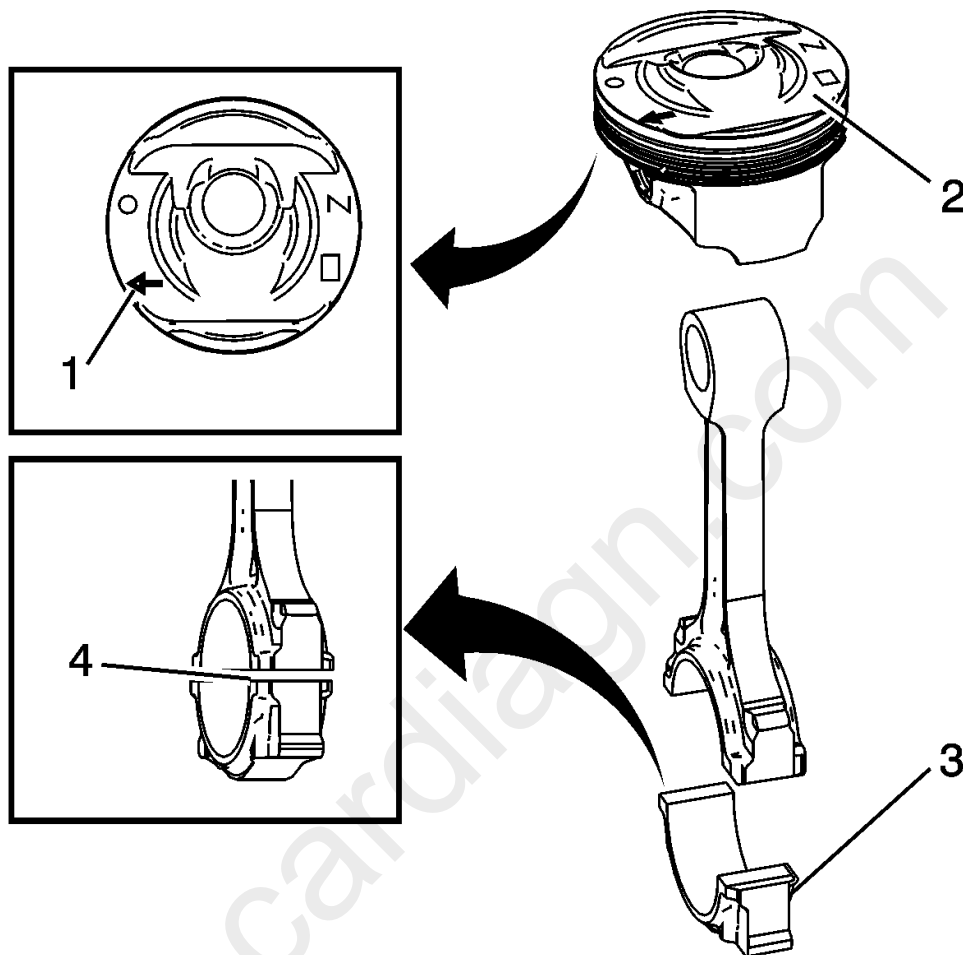


Fig. 105: Connecting Rod And Piston
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the piston onto the connecting rod with the arrow on top of the piston oriented to the same side as the cast feature at the split line of the connecting rod.

1. The arrow (1), on the top of the piston, must go to the front of the block.
2. The feature at the split line (4), located on one side of the connecting rod, must go to the front of the block.
3. Assemble the connecting rod (3) and the piston (2).

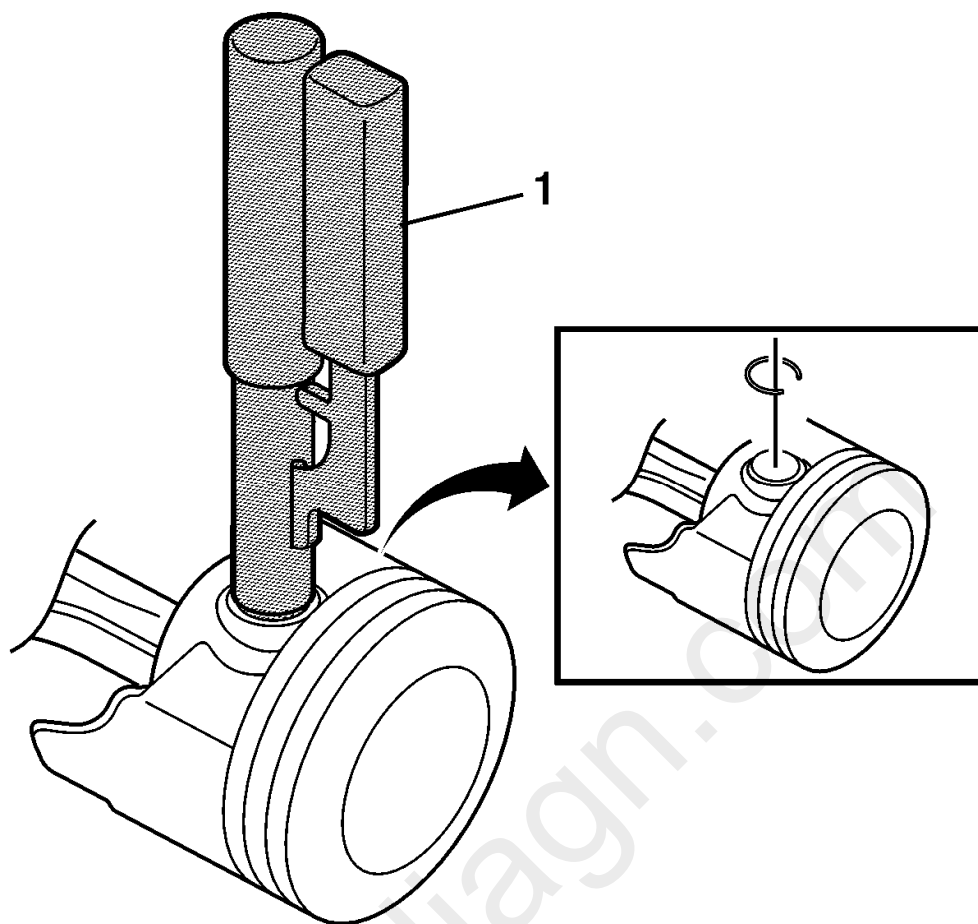


Fig. 106: View of Piston Pin Retainers
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

NOTE: Use NEW retainers.

4. Use the following procedure to assemble the piston pin and the retainer:
 1. Coat the piston pin with oil.
 2. Install one side of one NEW piston pin retainer into the retaining groove using **EN-46745** installer and **EN-46745-4** adapter. Rotate the retainer until it is fully seated in the groove.
 3. Install the connecting rod and the piston pin.

Push the piston pin until it bottoms in the previously installed retainer.

4. Install the second NEW piston pin retainer, using **EN-46745** installer (1) and **EN-46745-4** adapter.

5. Ensure that the piston moves freely.

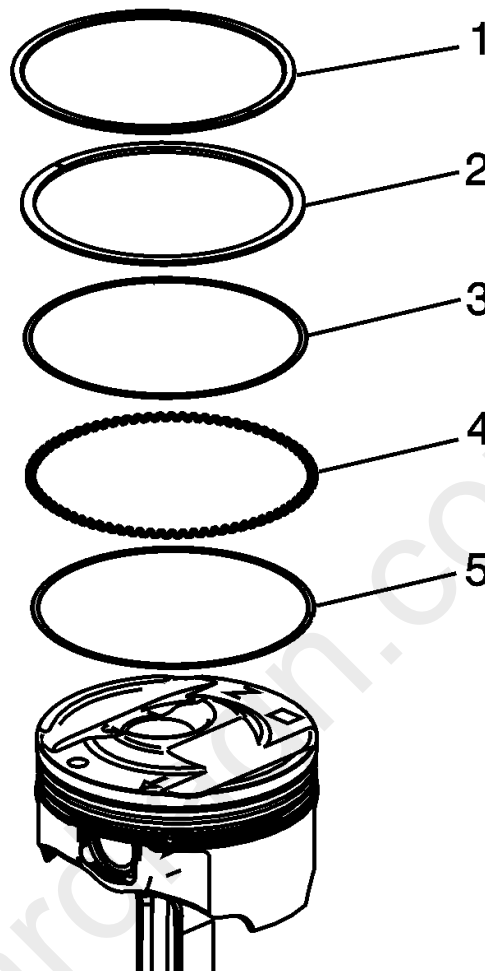


Fig. 107: Piston Rings
Courtesy of GENERAL MOTORS COMPANY

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

5. Install the following components of the oil control ring assembly:
 1. The piston oil ring rail (5)
 2. The piston oil ring rail spacer (4)
 3. The second piston oil ring rail (3)
6. Install the piston lower compression ring (2). Place the manufacturer's mark facing up.
7. Install the piston upper compression ring (1).

CAMSHAFT ASSEMBLY DISASSEMBLE

Fig. 108: Camshaft Assembly
Courtesy of GENERAL MOTORS COMPANY

Camshaft Assembly Disassemble

Callout	Component Name
Preliminary Procedures	
1. Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device. 2. Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position. 3. Install one of the camshafts in the exhaust camshaft position on the cylinder head. 4. Install the camshaft bearing front upper cap and bolts. 5. Install the camshaft bearing caps and bolts. 6. Install EN-50793 locking tool onto the camshaft actuator and engine front cover. 7. The camshaft actuator bolt can now be loosened and the actuator removed from the camshaft. Repeat preliminary procedure for the remaining camshaft assembly.	

1	Camshaft, Intake and Exhaust
2	Camshaft Position Actuator Bolt NOTE: Discard the bolt. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to <u>Special Tools</u> .
3	Camshaft Position Actuator, Intake and Exhaust

CAMSHAFT CLEANING AND INSPECTION

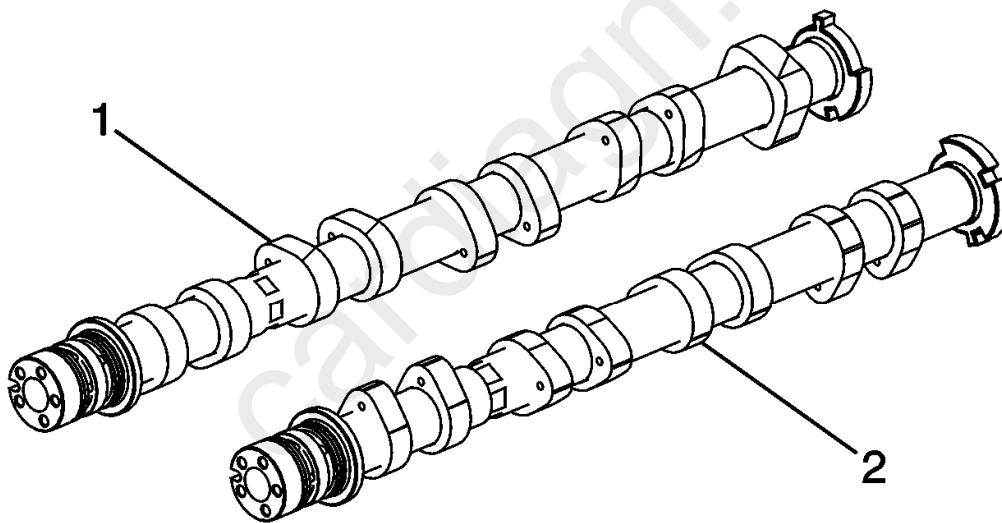


Fig. 109: Camshaft Journals And Lobes
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft journals and lobes for wear or scoring.

2. Inspect the camshaft sprocket alignment notch for damage.
3. Wash the camshafts (1, 2) in solvent.
4. Oil the camshafts.

CAMSHAFT ASSEMBLY ASSEMBLE



Fig. 110: Camshaft Assembly
Courtesy of GENERAL MOTORS COMPANY

Camshaft Assembly Assemble

Callout	Component Name
Preliminary Procedures	
1. Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device. 2. Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position. 3. Install one of the camshafts in the exhaust camshaft position on the cylinder head.	

4. Install the camshaft bearing front upper cap and bolts.
5. Install the camshaft bearing caps and bolts.
6. Install the appropriate actuator for the camshaft currently installed on the cylinder head.
7. Install **EN-50793** locking tool onto the camshaft actuator and engine front cover.
8. The camshaft actuator bolt can now be installed and tightened to final specification. Repeat preliminary procedure for the remaining camshaft assembly.

1	Camshaft, Intake and Exhaust NOTE: Ensure that the oil seal near the front of the camshaft is rotated so that the split line on the oil seal is aligned with the notch, and both the notch and split line are at 12 O'clock when installed on the cylinder head.
2	Camshaft Position Actuator, Intake and Exhaust NOTE: Upon camshaft assembly, ensure the camshaft actuator pin aligns with the camshaft notch. The actuator, camshaft, and bolt can be assembled by hand and then placed on the cylinder head for final torque.
3	Camshaft Position Actuator Bolt CAUTION: Refer to <u>Fastener Caution</u> . CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. Tighten 30 (22 lb ft) plus 100 Degrees. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to <u>Special Tools</u> .

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER CLEANING AND INSPECTION

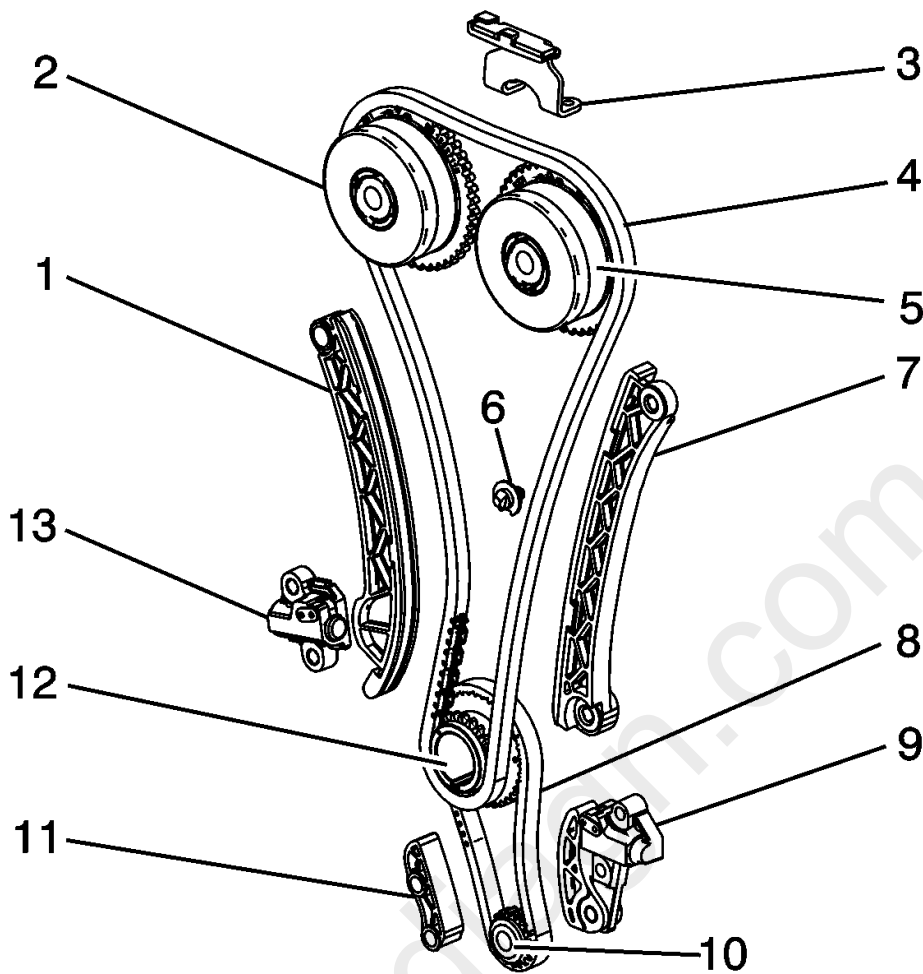


Fig. 111: Camshaft Timing Chain, Sprocket, And Tensioner
 Courtesy of GENERAL MOTORS COMPANY

1. Inspect the timing chain guides (3, 7) and timing chain tensioner pivot arm (1) for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner (13) shoe for wear.
4. Replace the timing chain tensioner if shoe wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain (4) and actuators (2, 5) for wear.
6. Inspect the camshaft actuator faces for signs of movement.
7. Inspect the camshaft actuator teeth and chain for signs of excessive wear, chipping, or seizure of the timing chain links.
8. Inspect the timing chain oil nozzle (6) for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged.
9. Verify oil nozzle oil flow with compressed air.
10. Inspect the timing chain tensioner (13) for scoring or free movement.

11. Inspect the timing chain tensioner washer. If damaged, replace the timing chain tensioner.
12. Inspect the crankshaft sprocket (12) for excessive wear or chipping.
13. Inspect the balancer chain (8) for wear.
14. Inspect the balancer chain guide (11) for wear.
15. Inspect the balancer chain tensioner (9) for wear.
16. Inspect the balancer shaft driven sprocket (10) for wear or chipping.

CYLINDER HEAD DISASSEMBLE

Special Tools

- EN-50717 Valve Spring Compressor
- EN-36017 Valve Seal Remover
- EN-43963 Valve Spring Compressor (off car)

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

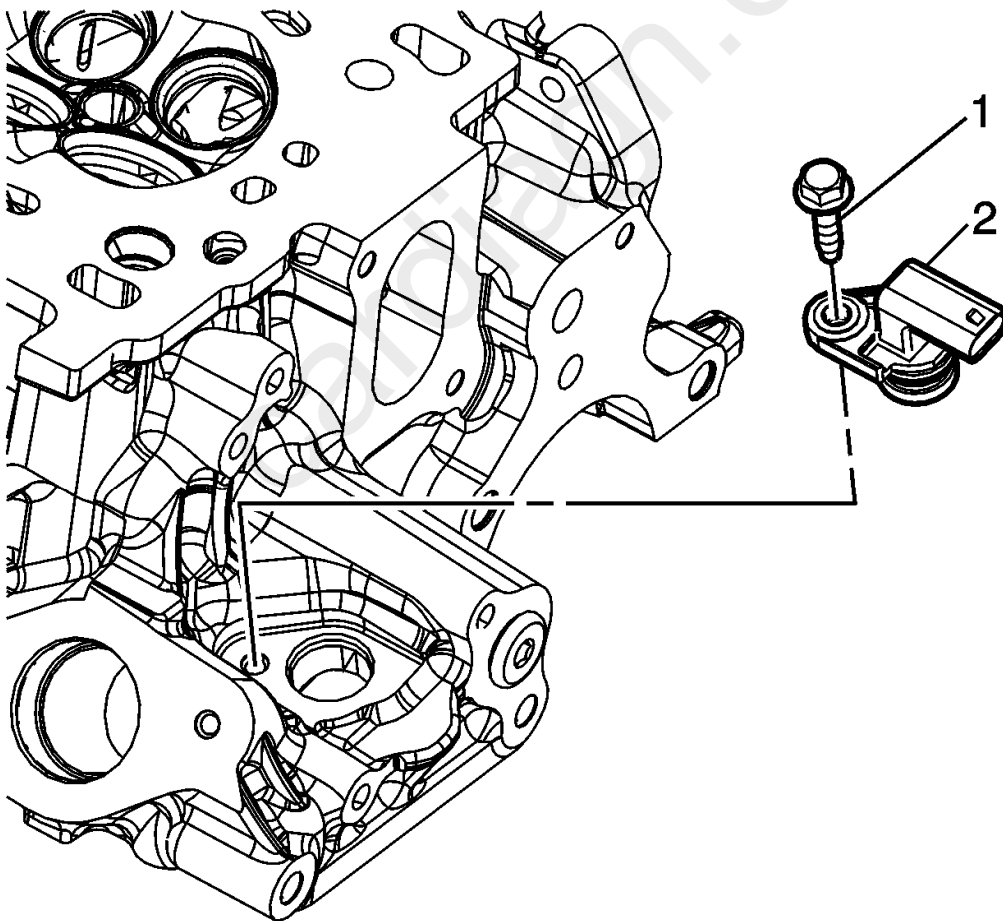


Fig. 112: Intake Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the intake camshaft position sensor (2) and bolt (1).

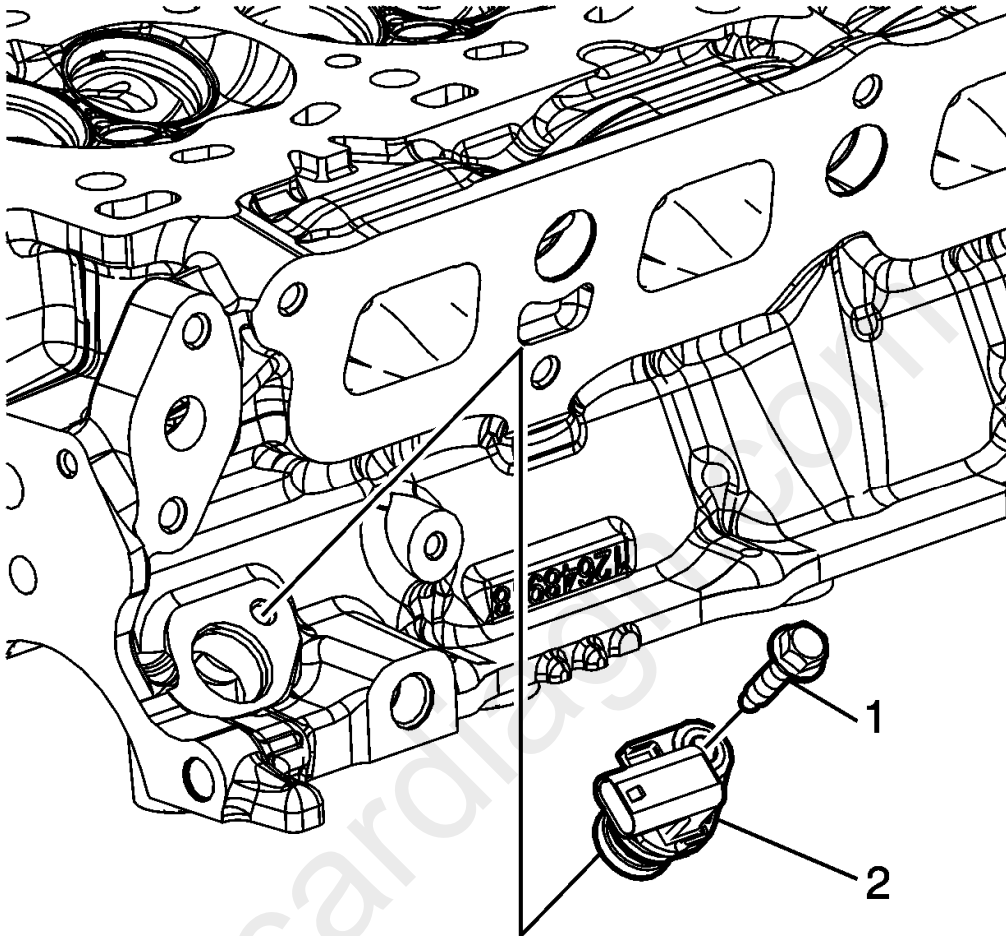


Fig. 113: Exhaust Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the exhaust camshaft position sensor (2) and bolt (1).

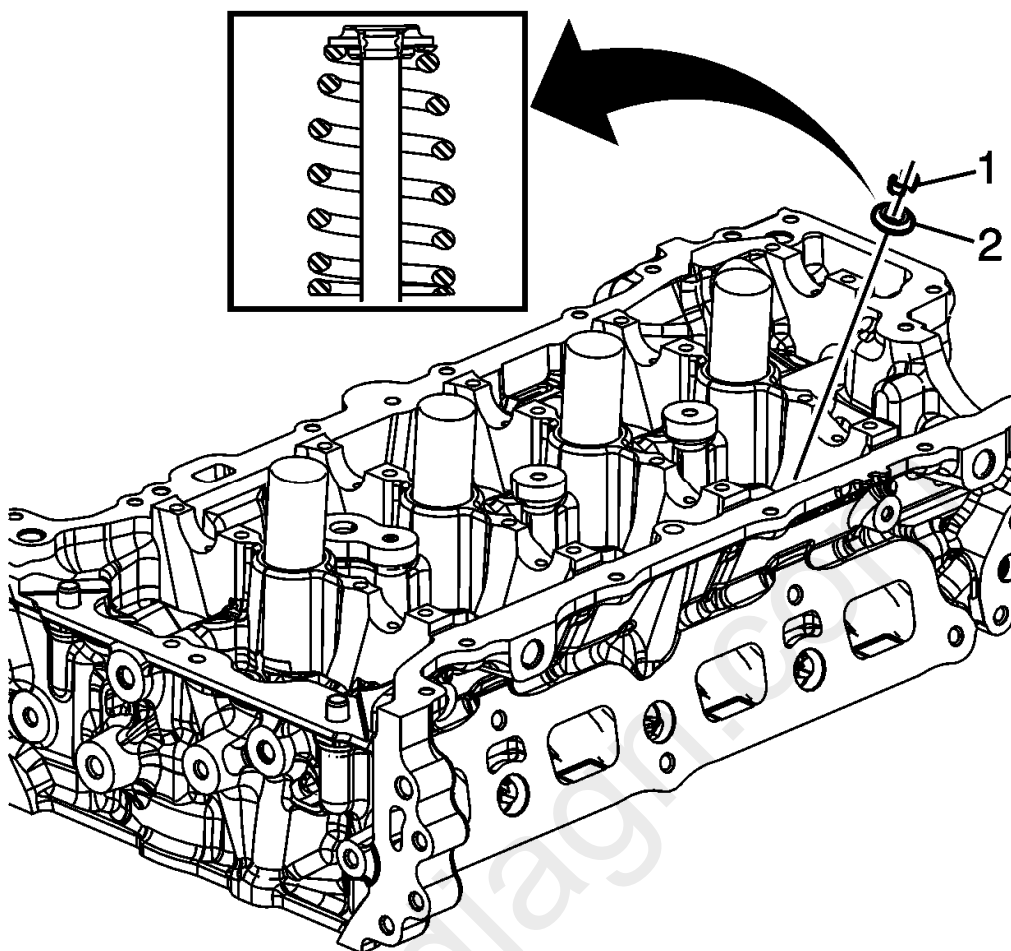


Fig. 114: Valve Keys, Springs, And Retainers
Courtesy of GENERAL MOTORS COMPANY

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.

NOTE: Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

3. Perform the following procedure to remove the valve keys, springs, and retainers:
 1. Using the **EN-50717** fixture and the **EN-43963** compressor adapter , compress the valve spring.
 2. Remove the valve keys (1).
 3. Slowly release the compression from the valve spring assembly.
 4. Remove the retainer (2).

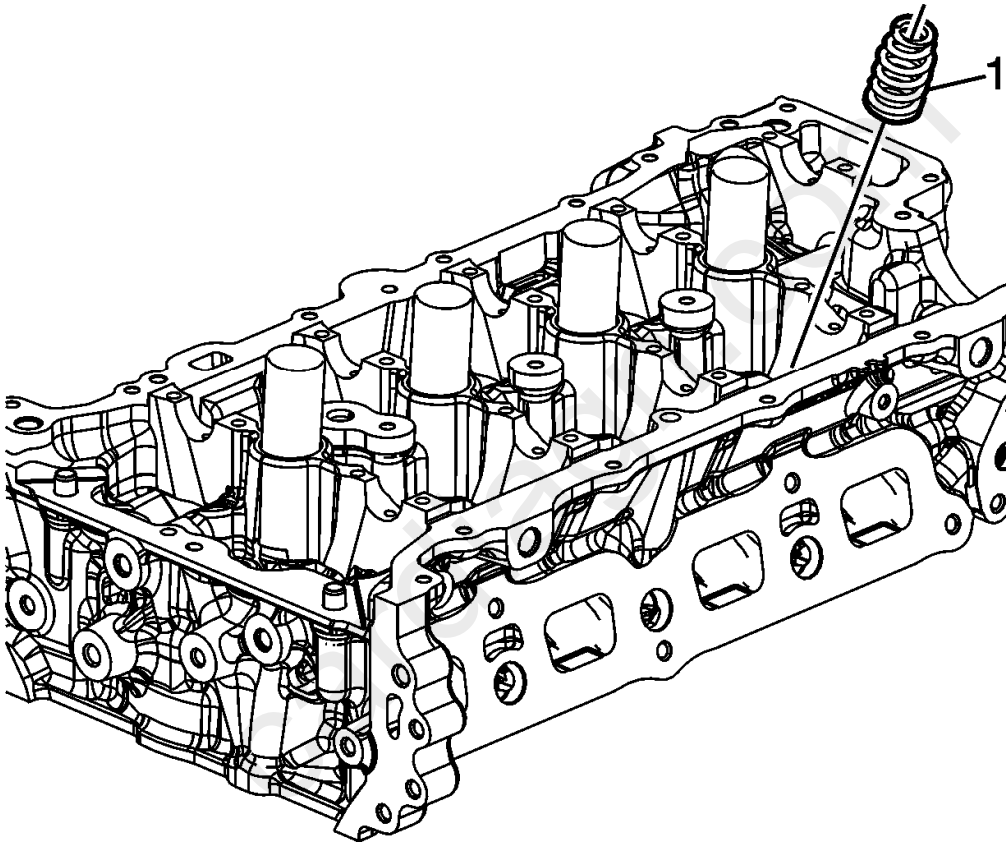


Fig. 115: Springs
Courtesy of GENERAL MOTORS COMPANY

4. Remove the springs (1).

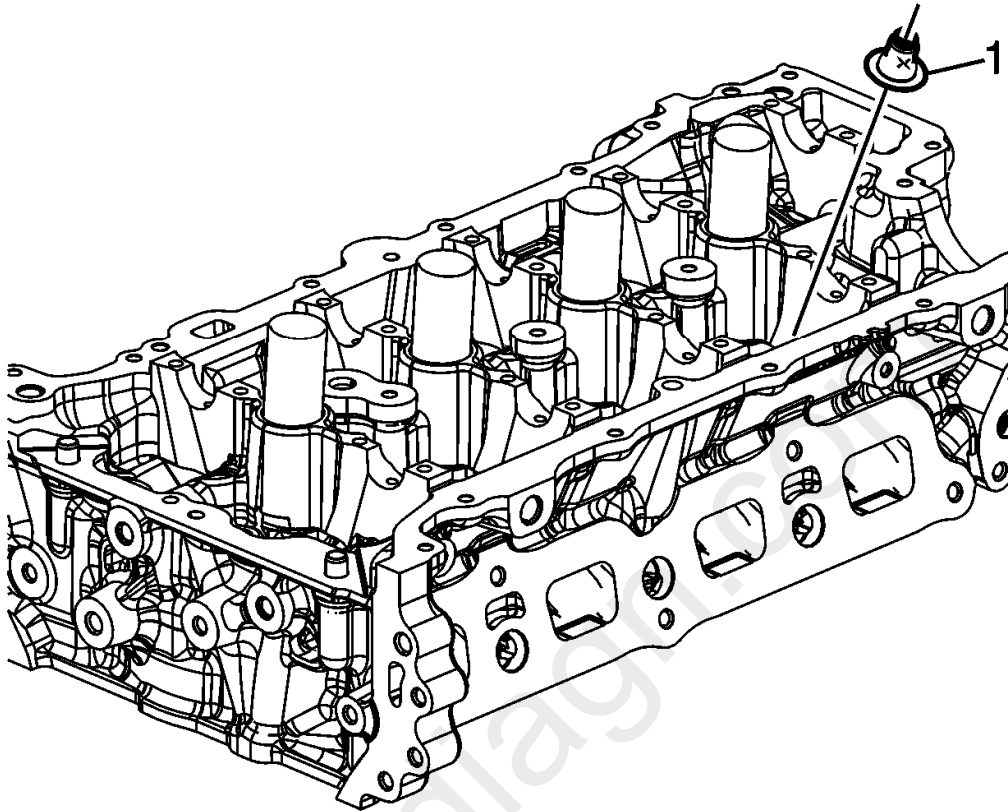


Fig. 116: Valve Seals
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

5. Using **EN-36017** remover , remove the valve seals (1). Discard the seals, do not reuse.

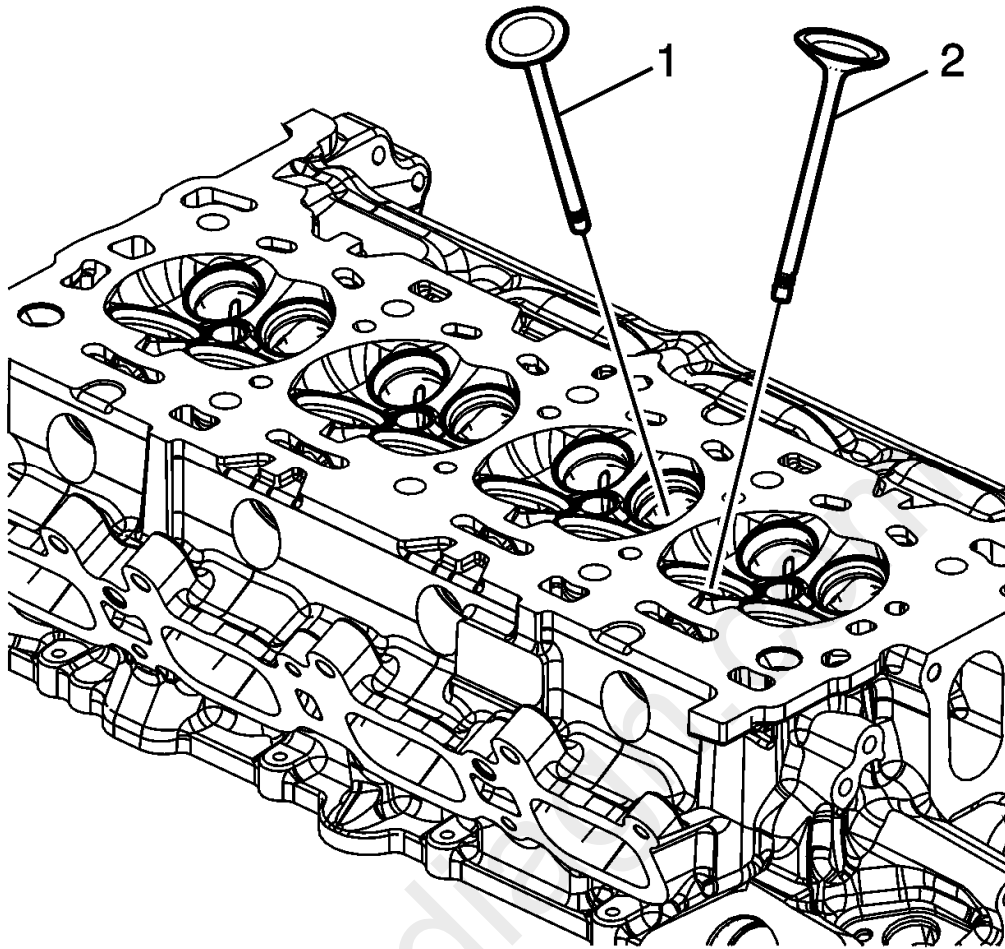


Fig. 117: Valves

Courtesy of GENERAL MOTORS COMPANY

6. Remove the valves (1, 2).

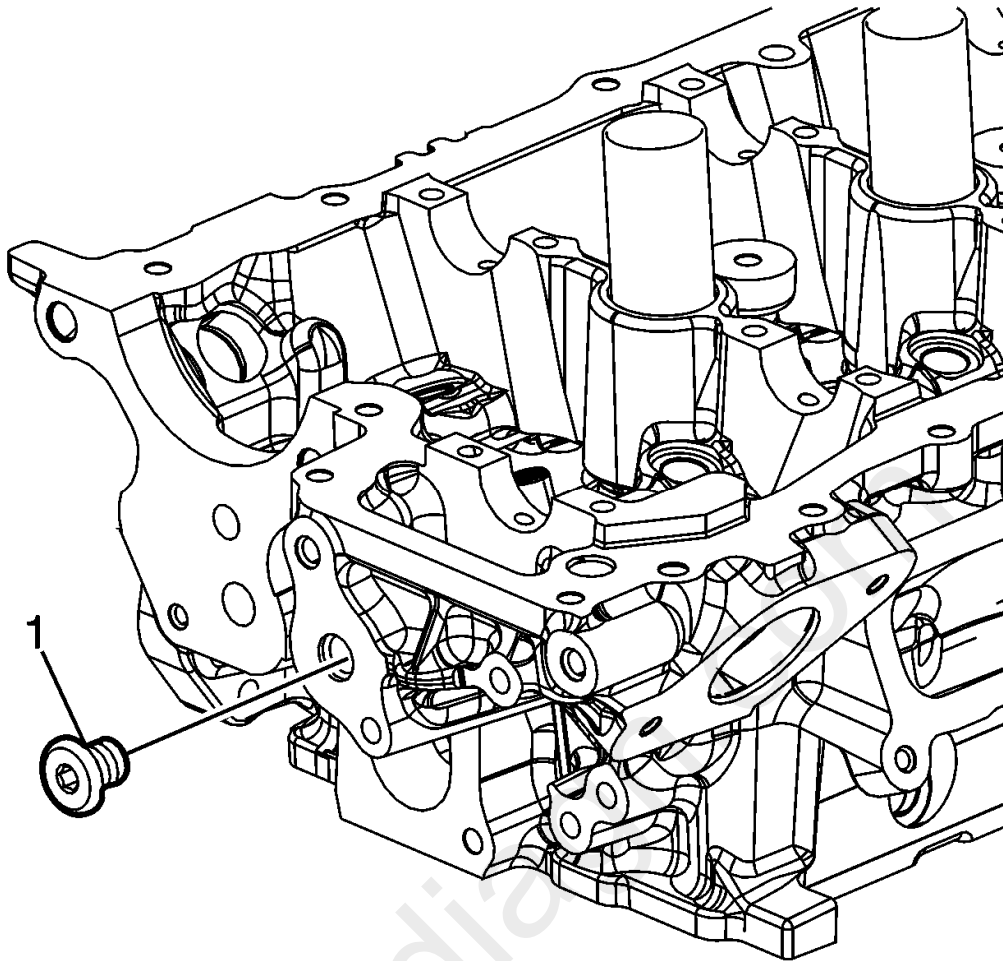


Fig. 118: Cylinder Head Plug
Courtesy of GENERAL MOTORS COMPANY

7. Remove the cylinder head plug (1).

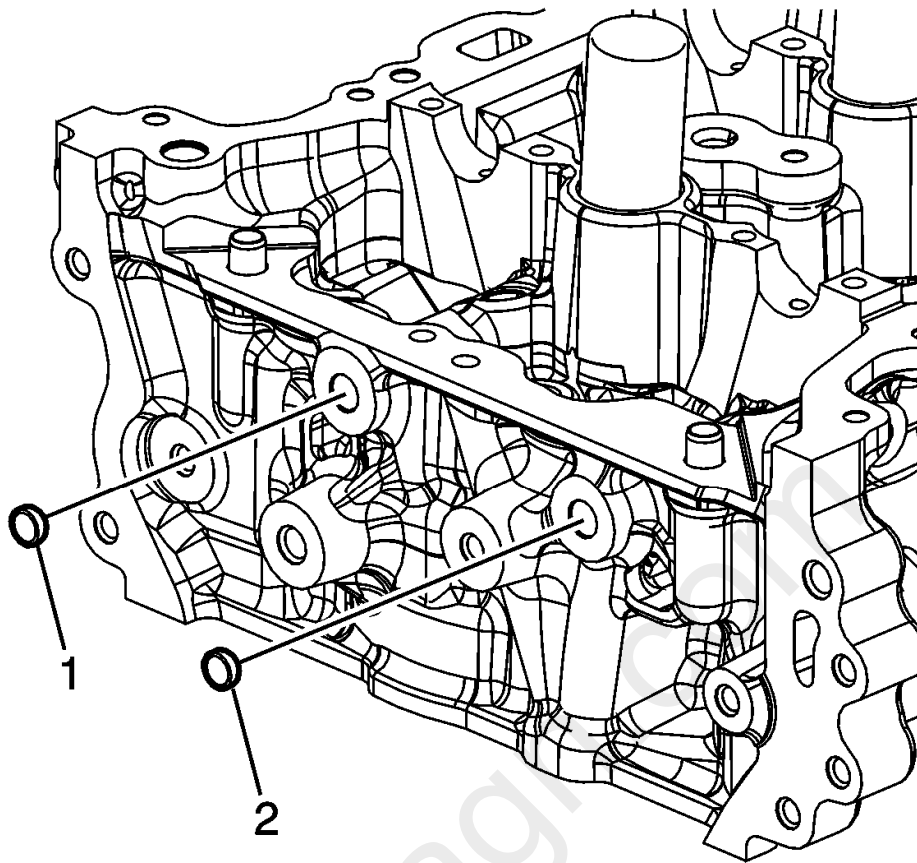


Fig. 119: Cylinder Head Plugs
Courtesy of GENERAL MOTORS COMPANY

8. Remove the cylinder head plugs (1, 2).

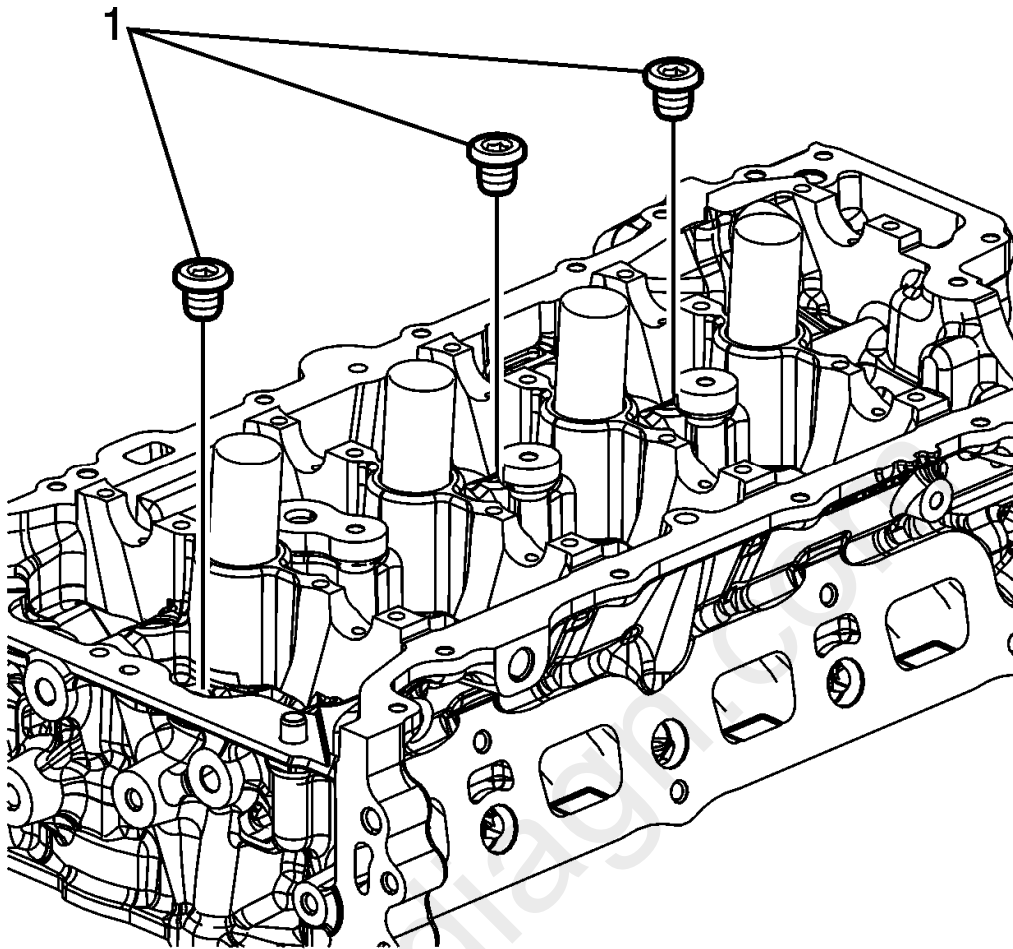


Fig. 120: Cylinder Head Plugs
Courtesy of GENERAL MOTORS COMPANY

9. Remove the cylinder head plugs (1).

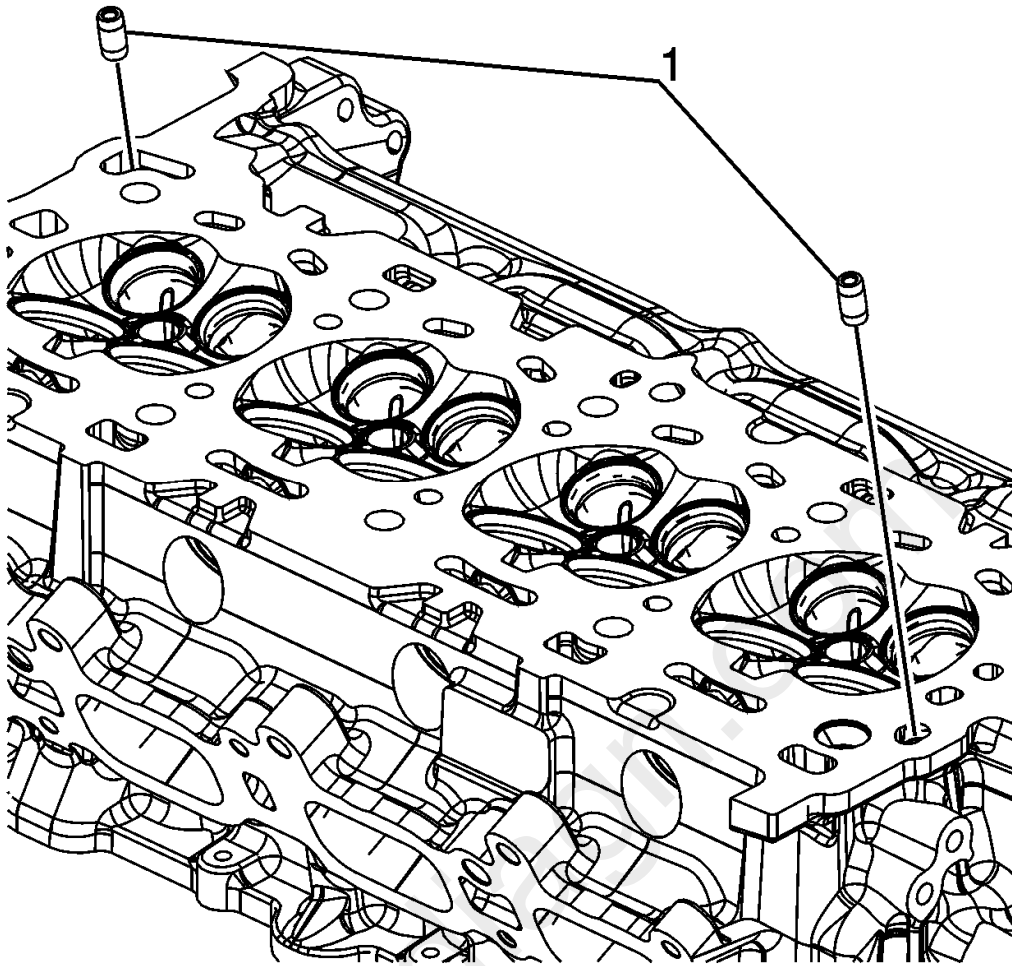


Fig. 121: Cylinder Head Oil Gallery Restrictors
Courtesy of GENERAL MOTORS COMPANY

10. Remove the cylinder head oil gallery restrictors (1).

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **EN 22738-B** Valve Spring Tester
- **EN-28410** Gasket Remover
- **EN-39358** Spark Plug Socket
- **GE 7872** Magnetic Base Dial Indicator

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

Valve Cleaning and Inspection

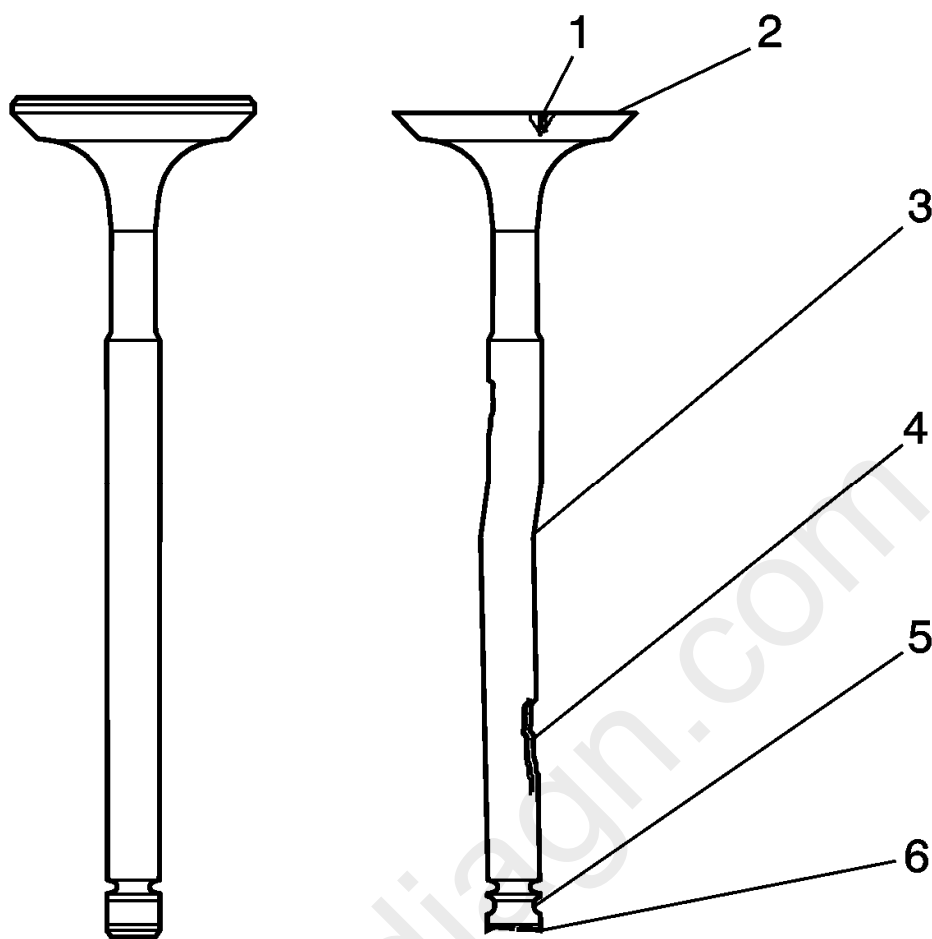


Fig. 122: Valve Inspection Areas

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not use a wire brush on any part of the valve stem.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

1. Clean the valves of carbon, oil and varnish. Use a soft bristle wire brush to clean any carbon build-up from the valve head. Varnish can be removed by soaking in Parts Immersion Solvent. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Clean the valve guides.
3. Inspect the valve stem for pitting or wear (4).
4. Inspect the valve key groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil

stone.

7. Inspect the valve stem for straightness (3) and the valve head for bending or distortion using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. Replace the valve if the valve head O.D. and chamfer (2) is worn or out of specification. Refer to **Valve and Seat Grinding**.
11. The valves may be lightly lapped to the valve seats.
12. Replace the valve if the valve tip (6) is worn.
13. If no apparent wear, pitting, grooving, or distortion is present, perform the valve measurement and reconditioning procedure to verify valve specification. Refer to **Valve and Seat Grinding**.

Valve Guide Measurement

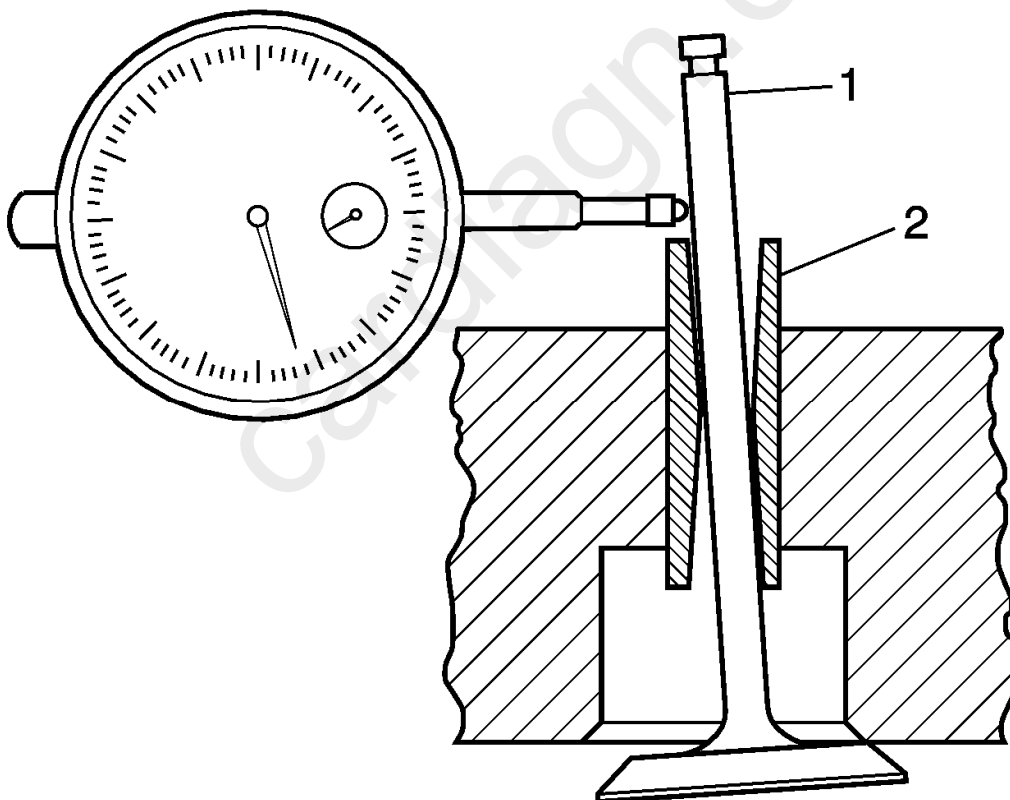


Fig. 123: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS COMPANY

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 7872** dial indicator 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** for proper clearance.

NOTE: **Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.**

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

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.

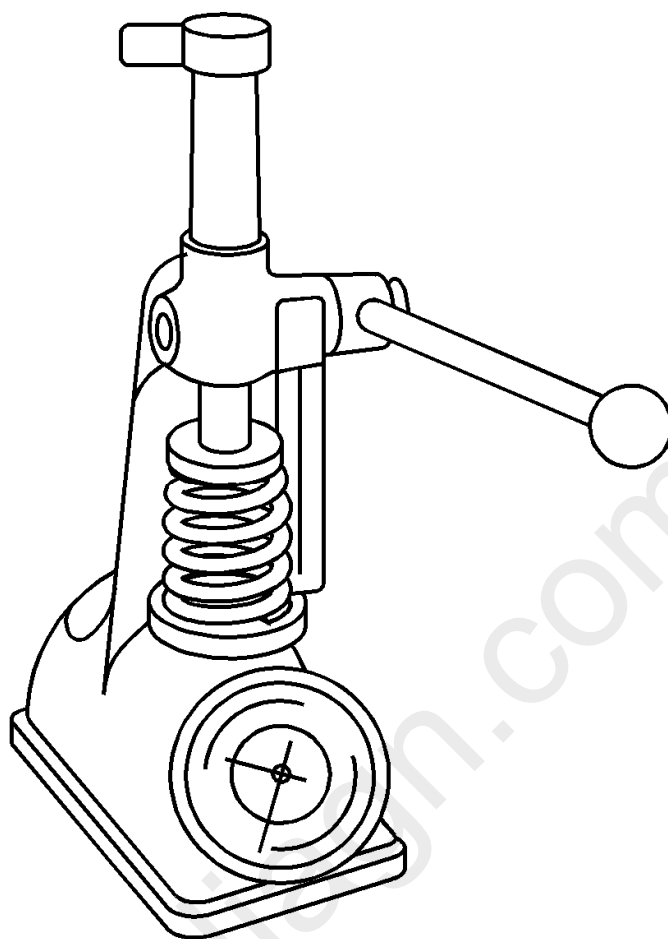


Fig. 124: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS COMPANY

4. Measure the valve spring tension using the EN 22738-B tester. Refer to **Engine Mechanical Specifications**
5. 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 Rocker Arm Cleaning and Inspection

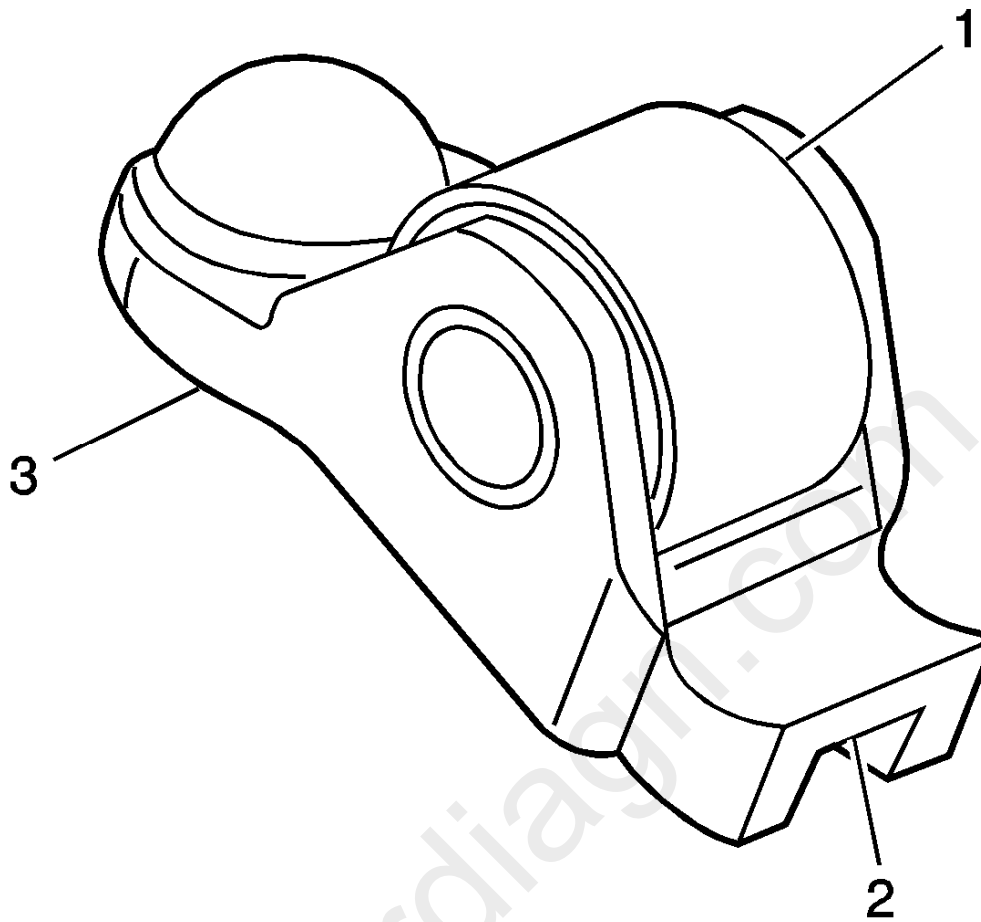


Fig. 125: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS COMPANY

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.

Cylinder Head and Gasket Surface Cleaning and Inspection

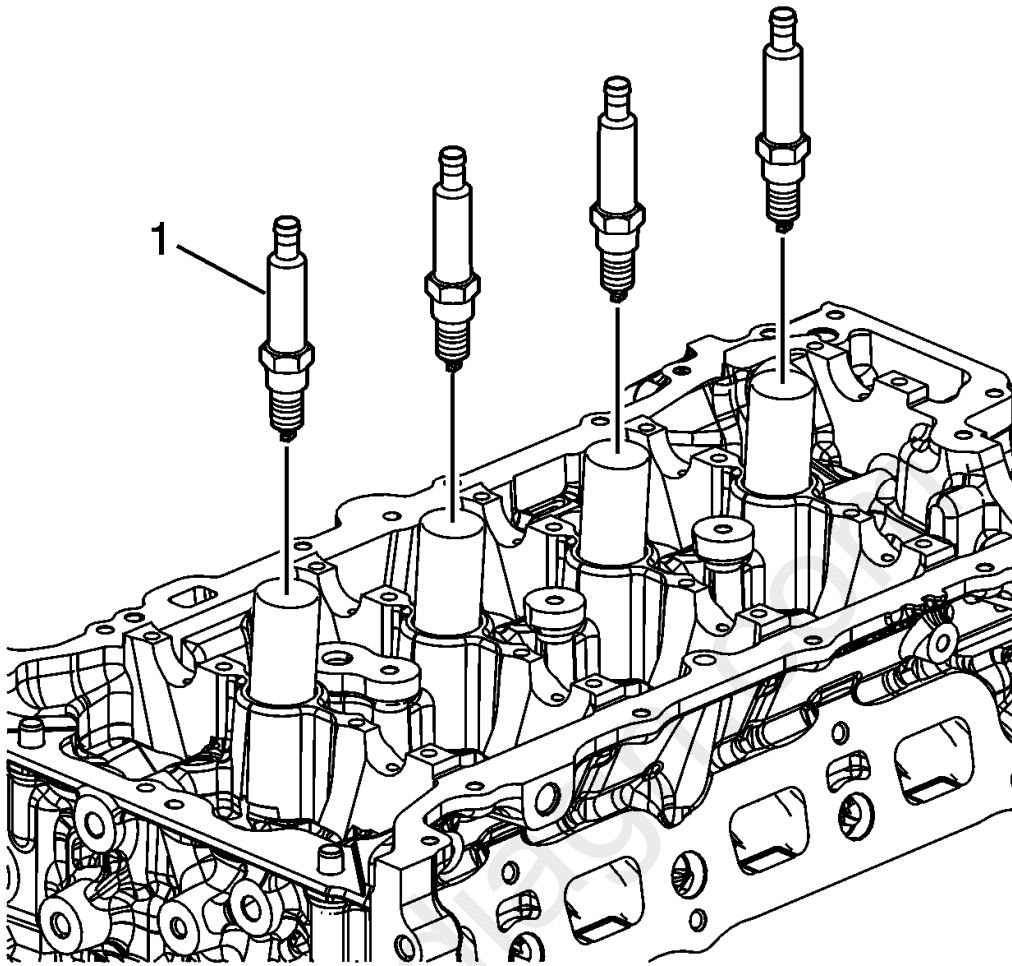


Fig. 126: Spark Plugs

Courtesy of GENERAL MOTORS COMPANY

1. Remove the spark plugs (1) using **EN-39358** socket.
2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:
 1. Improper installation
 2. Loose or warped cylinder head
 3. Missing, off location or not fully seated dowel pins
 4. Corrosion in the seal area around the coolant passages
 5. Chips or debris in the cylinder head bolt holes
 6. Bolt holes in the cylinder block not drilled or tapped deep enough

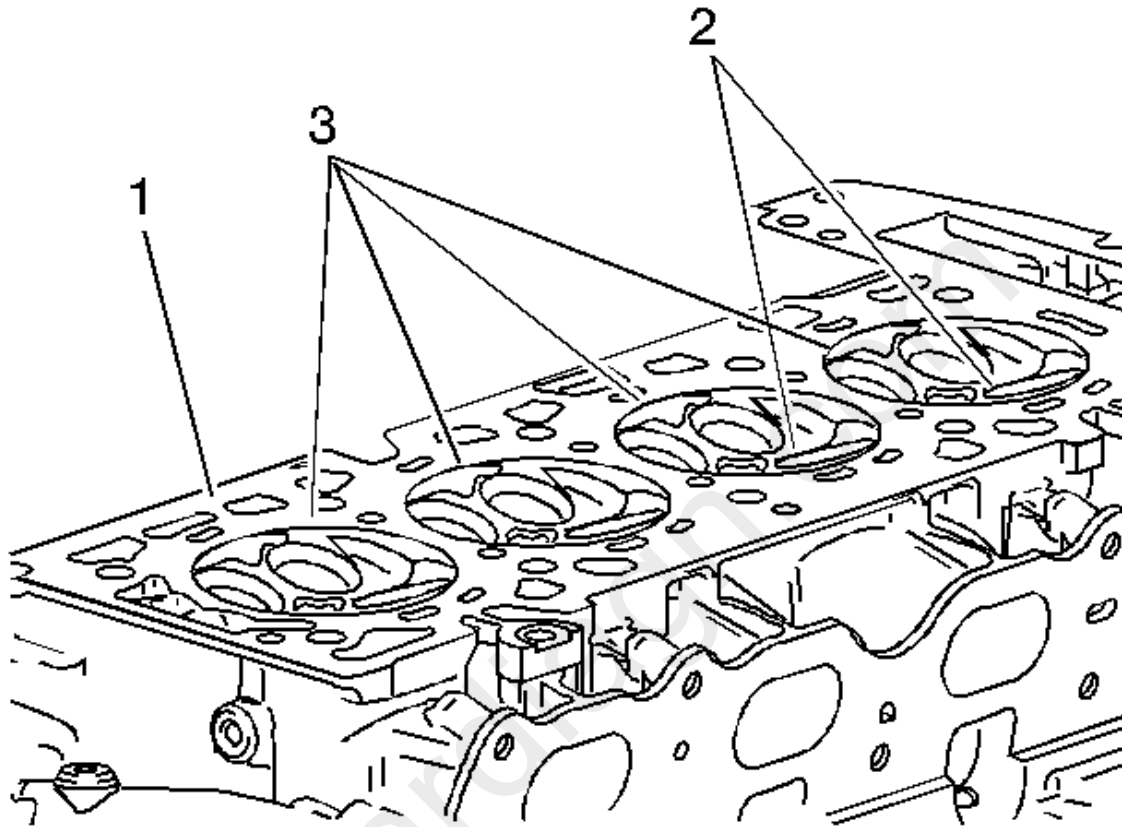


Fig. 127: Locating Combustion Chambers
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the cylinder head gasket surface.
 - Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
 - Replace the cylinder head if the area between the valve seats is cracked (2).
 - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).

NOTE: **Do not use a wire brush on any gasket sealing surface.**

4. Remove the sealant from the rear cap mating surface with **EN-28410** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
5. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.

6. Clean the valve guides.
7. Clean the threaded holes. Use a nylon bristle brush.
8. Clean the remains of the sealer from the plug holes.
9. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

NOTE: **Do not attempt to weld the cylinder head, replace it.**

10. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

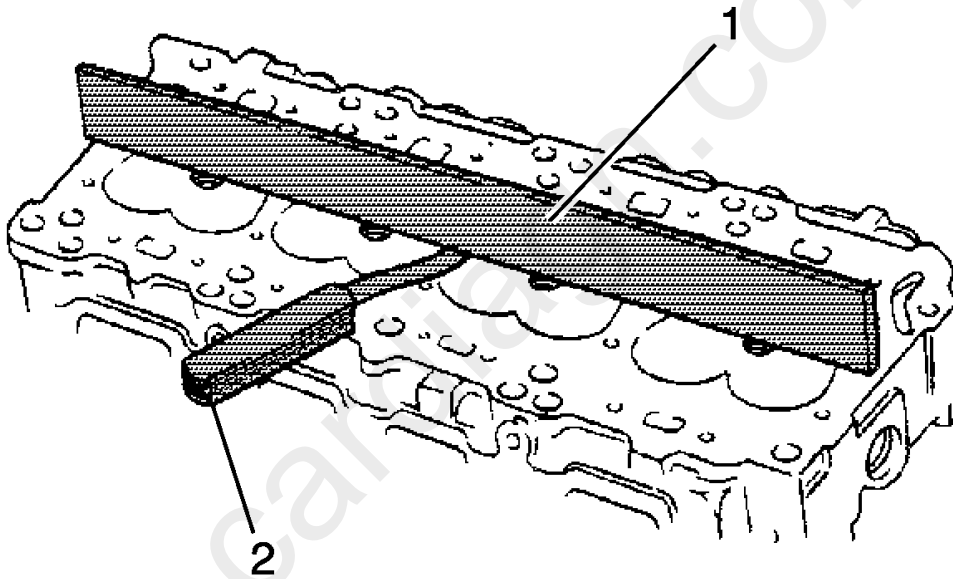


Fig. 128: Checking Cylinder Head Deck Surface For Flatness
Courtesy of GENERAL MOTORS COMPANY

11. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications** . If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
12. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
13. Inspect the sealing surfaces.

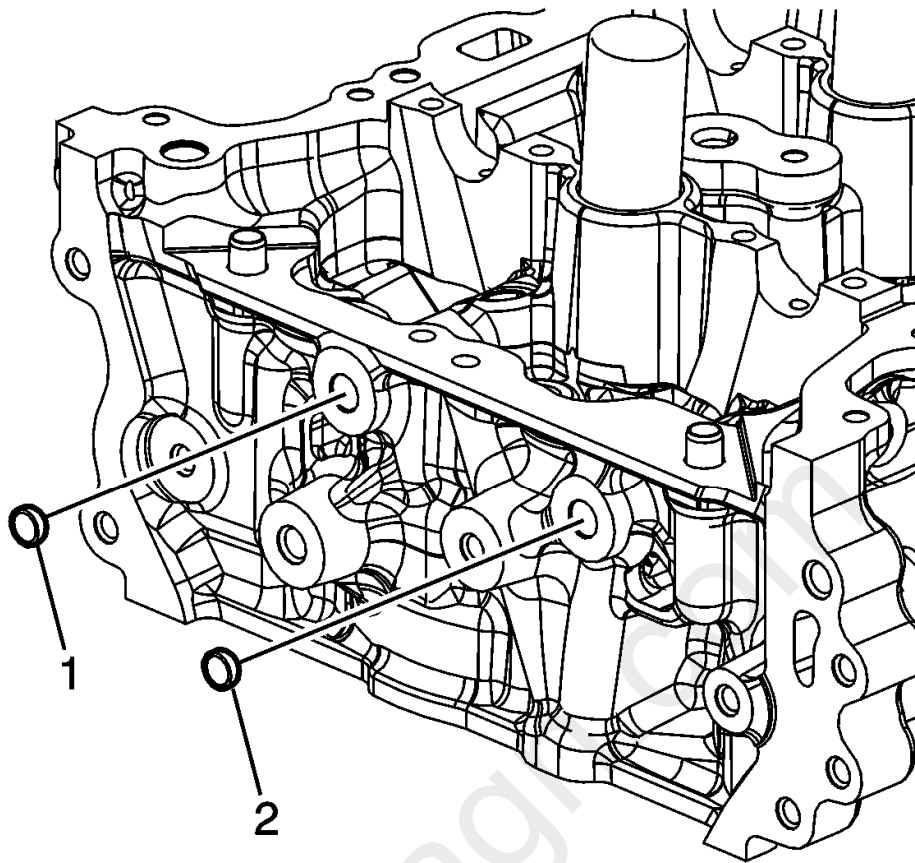


Fig. 129: Cylinder Head Plugs
Courtesy of GENERAL MOTORS COMPANY

14. Inspect the cylinder head plugs (1, 2) and verify the oil orifice is clear and free of debris.

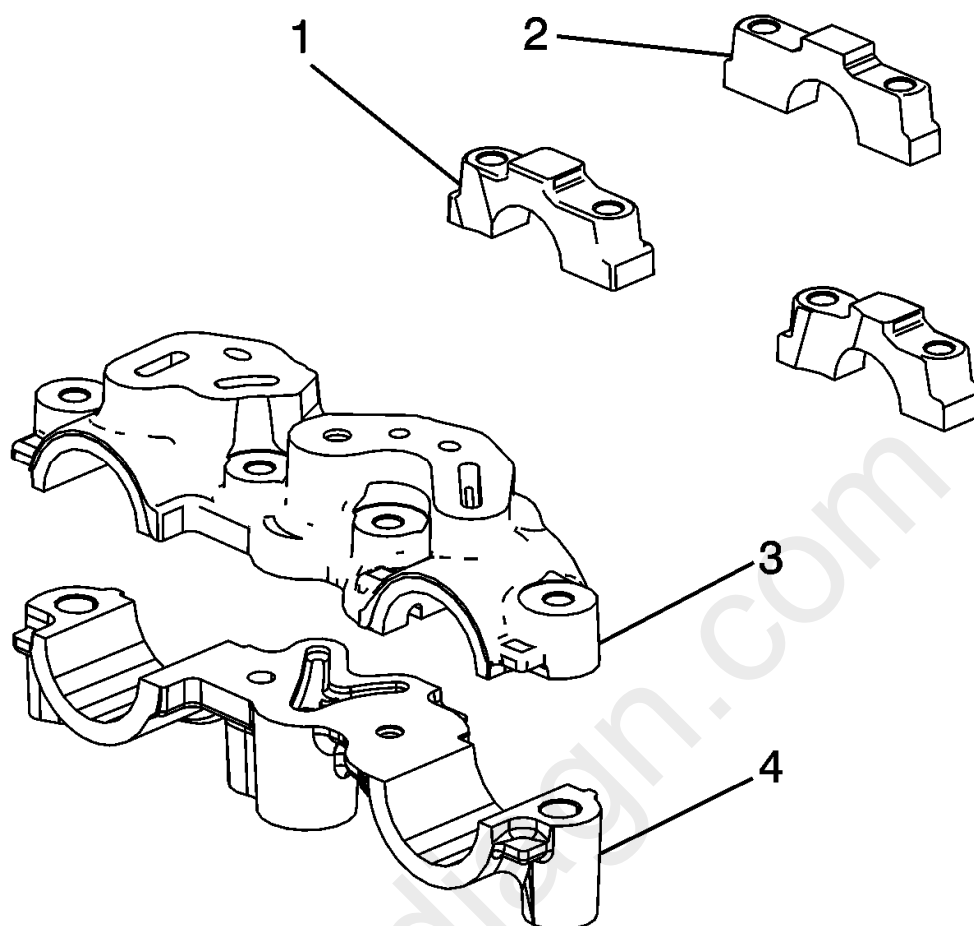


Fig. 130: Intake Camshaft Bearing Rear Cap
Courtesy of GENERAL MOTORS COMPANY

15. Inspect the intake camshaft bearing rear cap (2) for damage.
16. Inspect the camshaft bearing caps (1) for damage.
17. Inspect the camshaft front upper and lower bearing caps (3, 4) for damage.

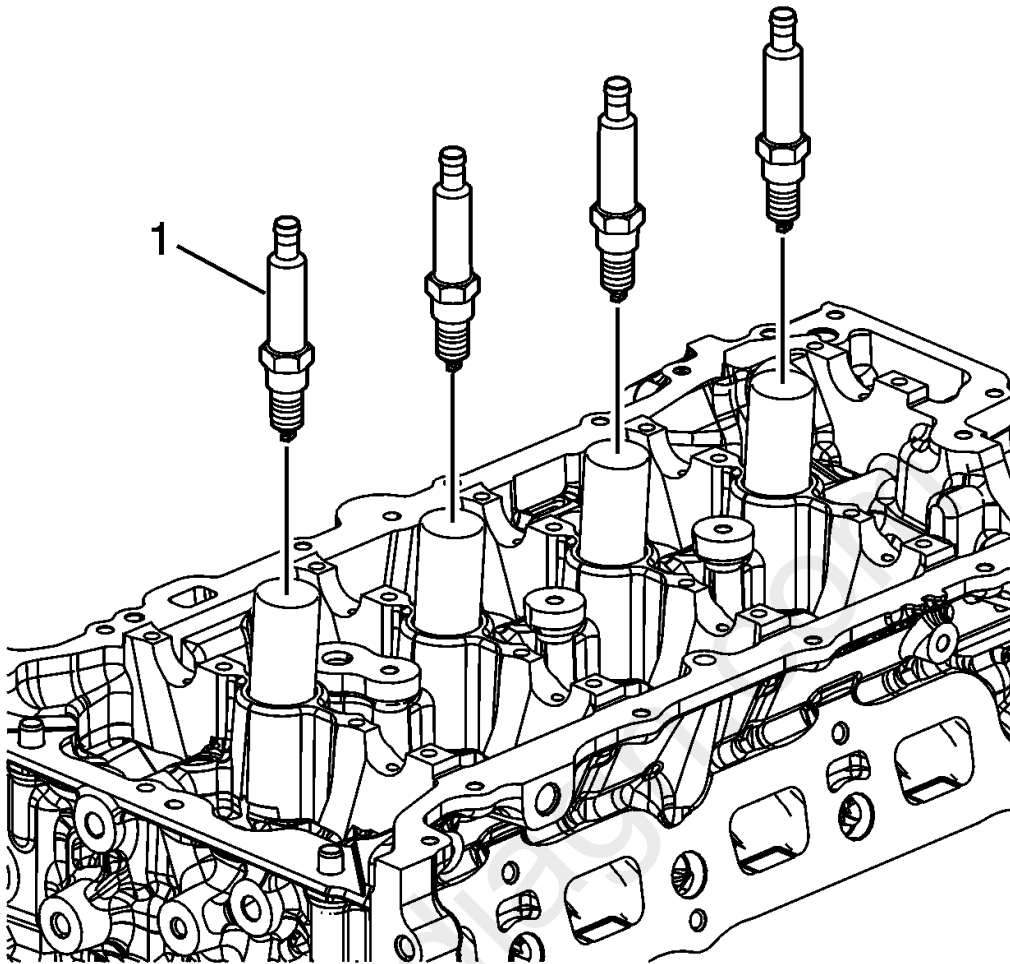


Fig. 131: Spark Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Component Fastener Tightening Caution .

18. Install the spark plugs (1) using **EN-39358** socket. Tighten the plugs to 20 N.m (15 lb ft).

VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- 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

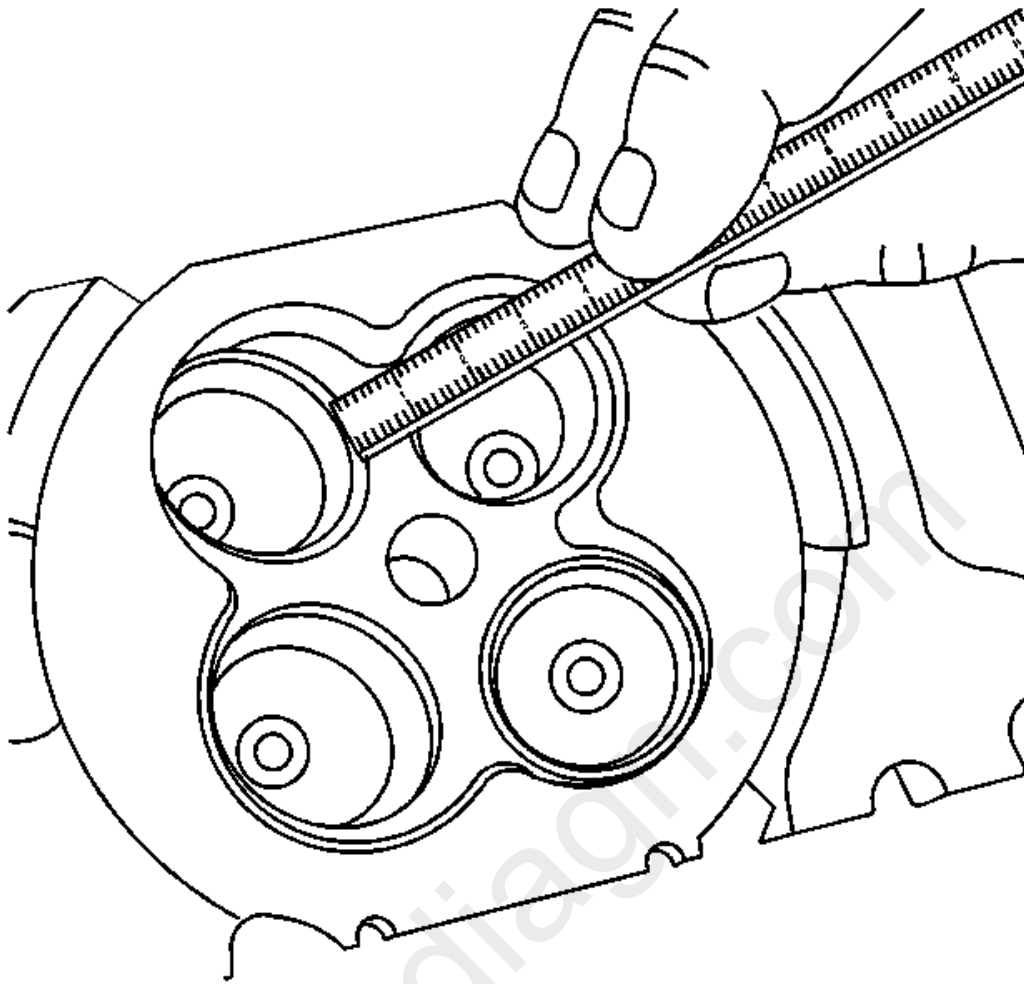


Fig. 132: Checking Valve Seat Width
Courtesy of GENERAL MOTORS COMPANY

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

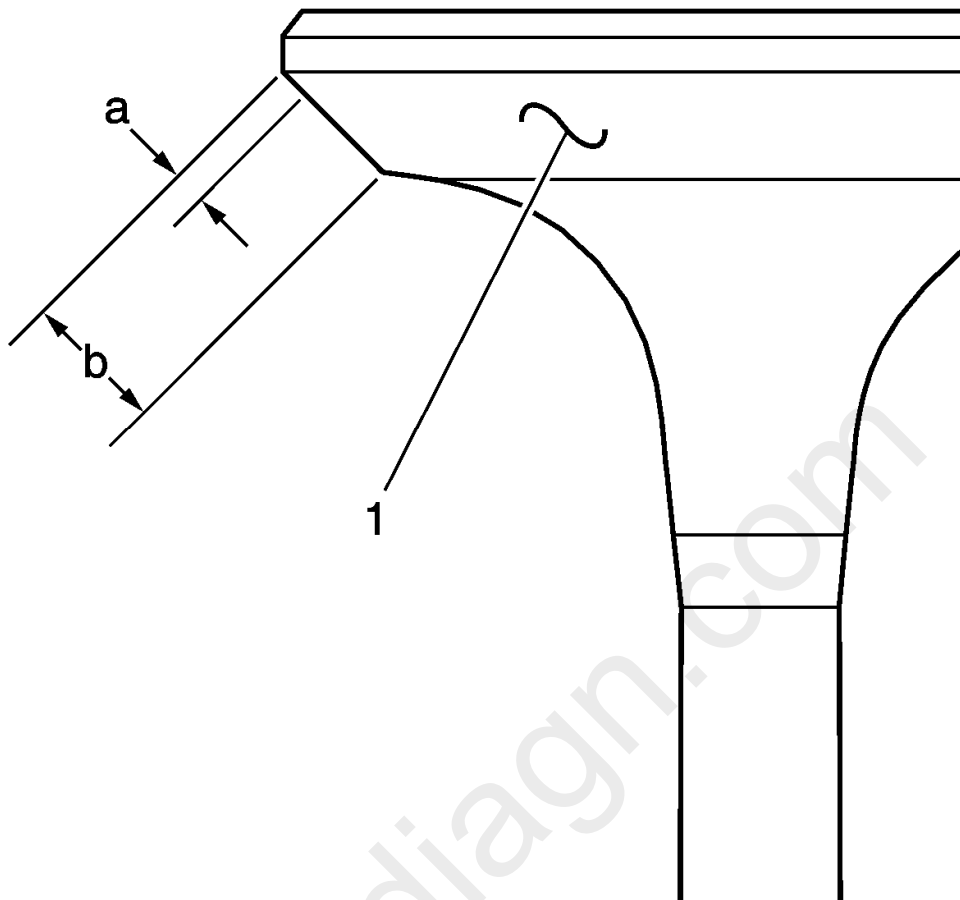


Fig. 133: Valve Face Seat width
Courtesy of GENERAL MOTORS COMPANY

2. Measure the seat width (b) 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 (a), 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 .
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 .
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 Head O.D. and Chamfer Measurement Procedure

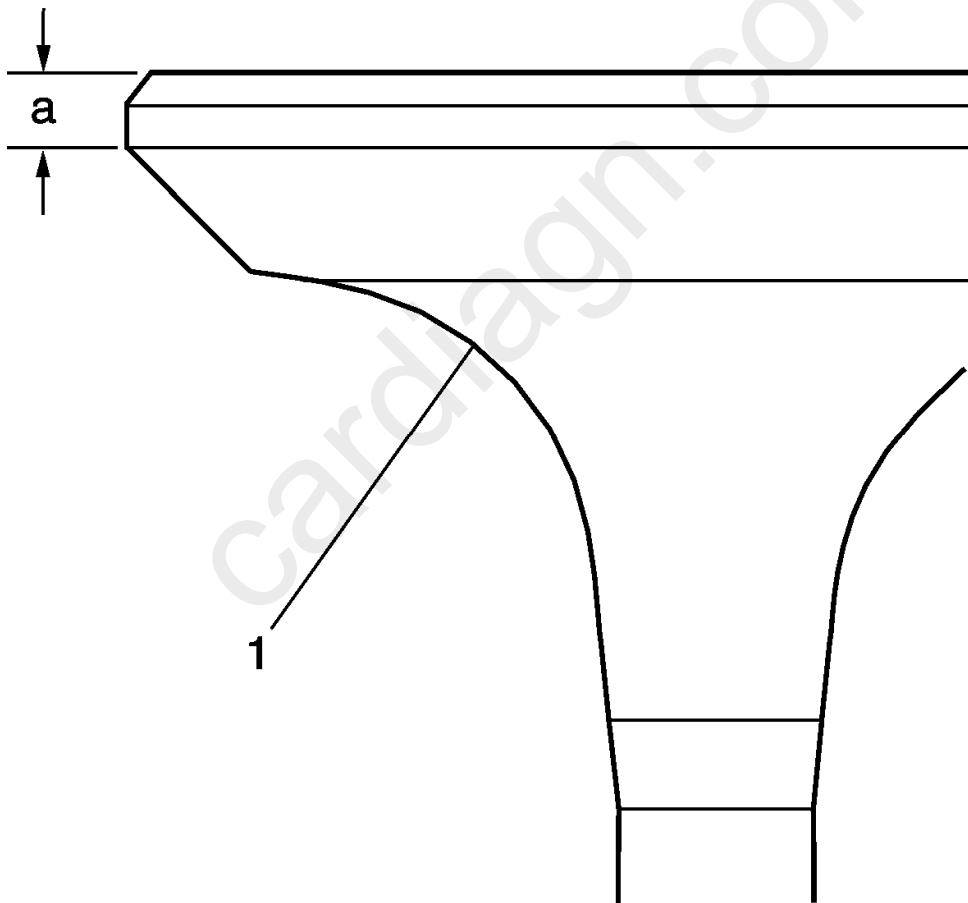


Fig. 134: View Of Valve Head O.D. & Chamfer
Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to Engine Mechanical Specifications .

2. If the valve head O.D. and chamfer is within specification, test the valve (1) for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure. Reinspect the valve head O.D. and chamfer after completing the concentricity measurement if valve seat reconditioning is performed.

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.

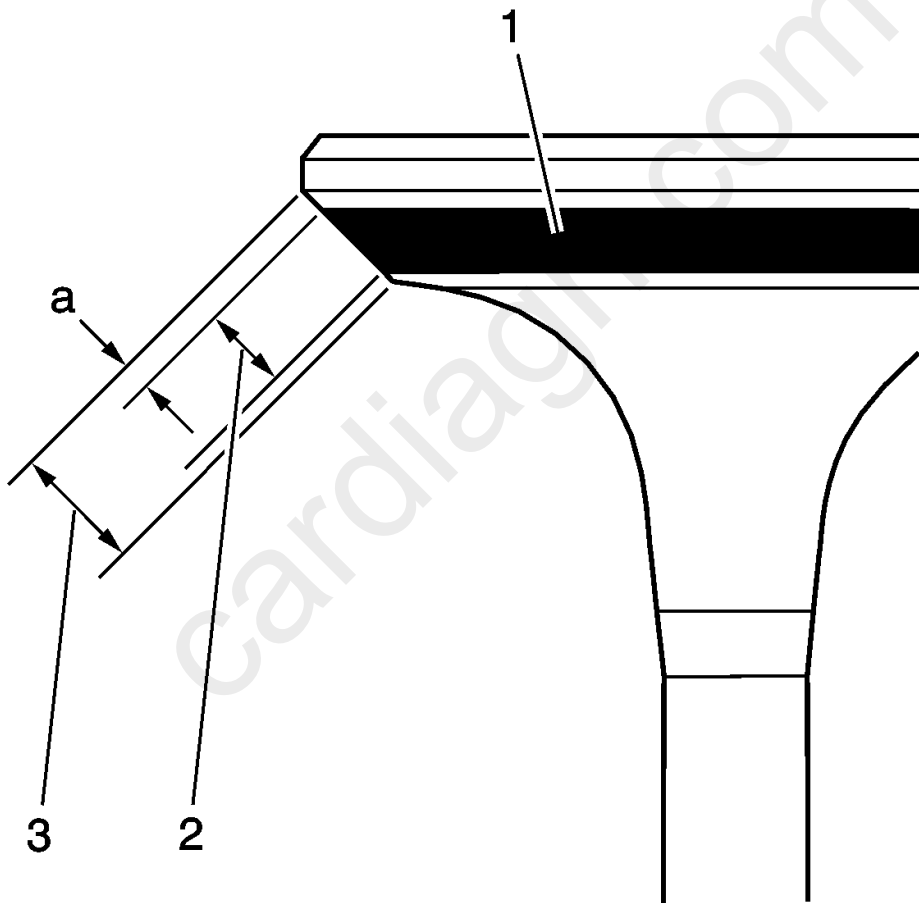


Fig. 135: Inspecting Valve Face
Courtesy of GENERAL MOTORS COMPANY

1. Coat the valve face (3) lightly with blue dye (1).
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 (2) will be made around the entire face.

NOTE: The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), 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.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

- 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

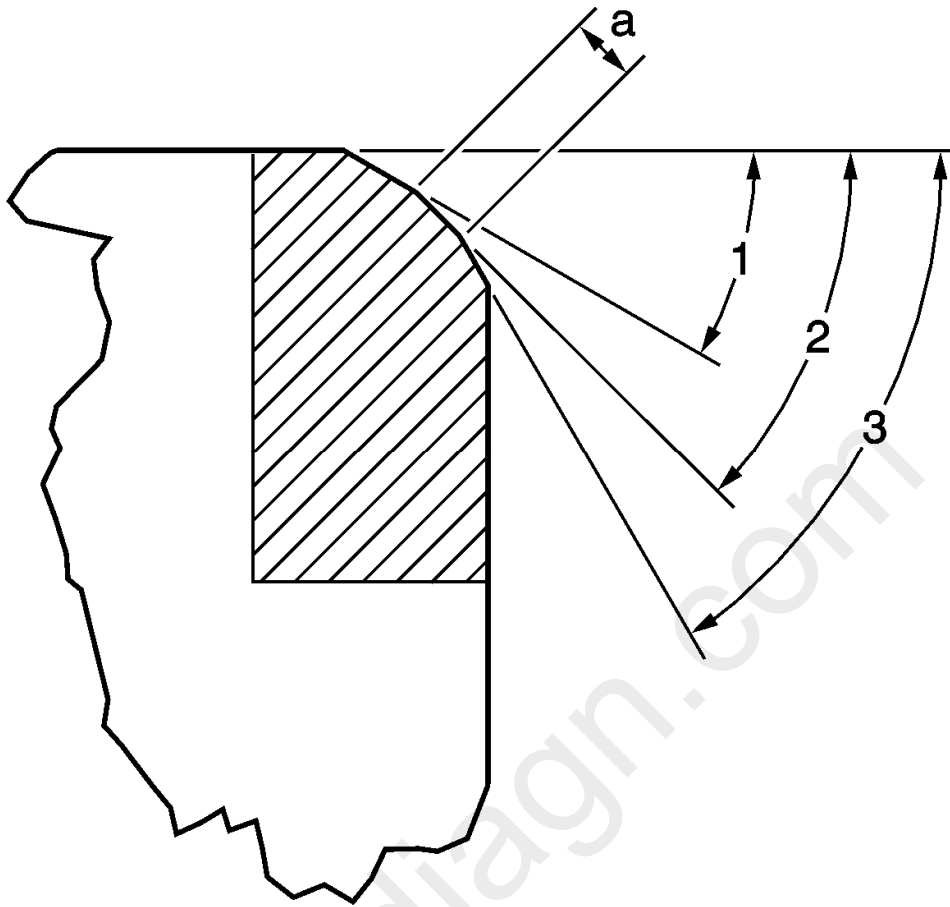


Fig. 136: Valve Seating Surface Angle
Courtesy of GENERAL MOTORS COMPANY

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 seating surface (a) to the proper angle specification (2) listed in **Engine Mechanical Specifications** .
2. Grind the valve relief surface to the proper angle specification (1) listed in **Engine Mechanical Specifications** , to correctly position the valve seating surface (a) to the valve.
3. Grind the valve undercut surface to the proper angle specification (3) listed in **Engine Mechanical Specifications** , to narrow the valve seating surface width (a) to the specifications listed in **Engine Mechanical Specifications** .

NOTE: **Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.**

4. Replace the intake valve if it is out of specification. Refer to **Engine Mechanical Specifications** .
5. If the original exhaust valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications** . Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
 - If you are using refaced exhaust 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.
 - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. 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.
9. 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

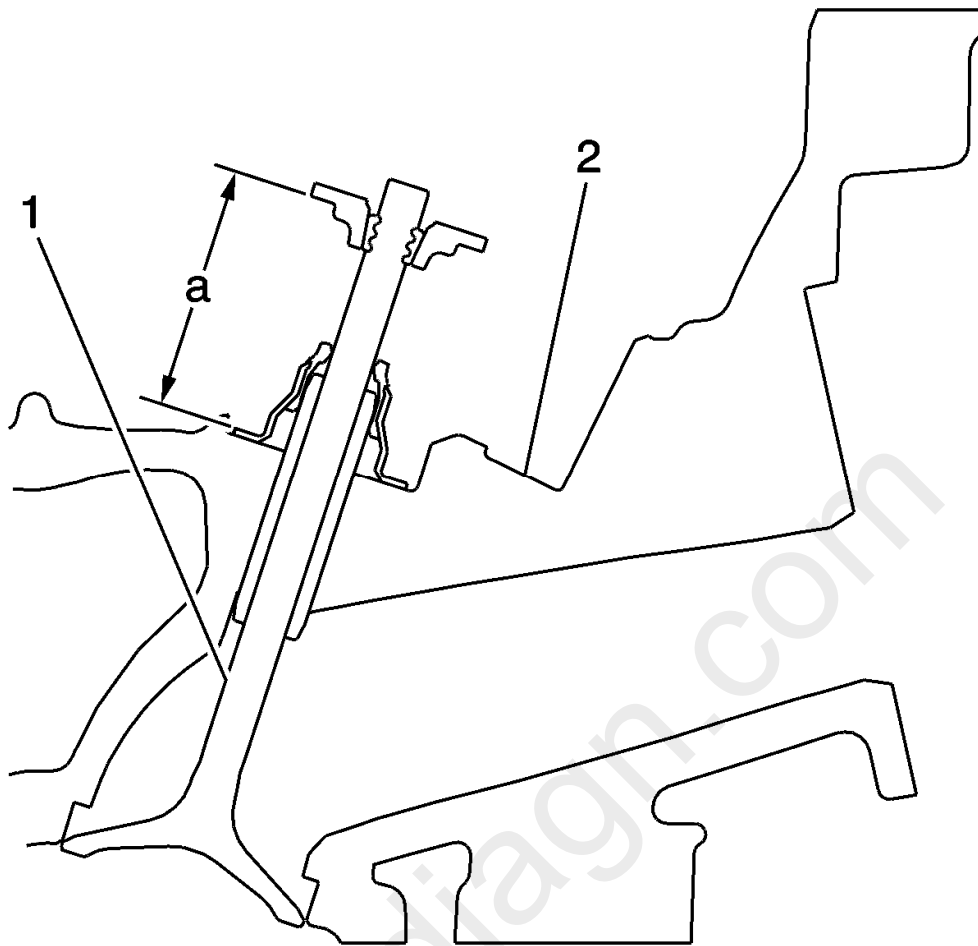


Fig. 137: Valve Stem Height Measurement
Courtesy of GENERAL MOTORS COMPANY

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

1. Install the valve (1) into the valve guide in the cylinder head (2).
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 (a) between the valve seal lip to the bottom of the valve spring retainer. Refer to **Engine Mechanical Specifications**.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

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

premature wear and possible engine damage.

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

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

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-50717** Valve Spring Compressor
- **EN-9666** Valve Spring Tester
- **EN-43963** Valve Spring Compressor (off car)

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

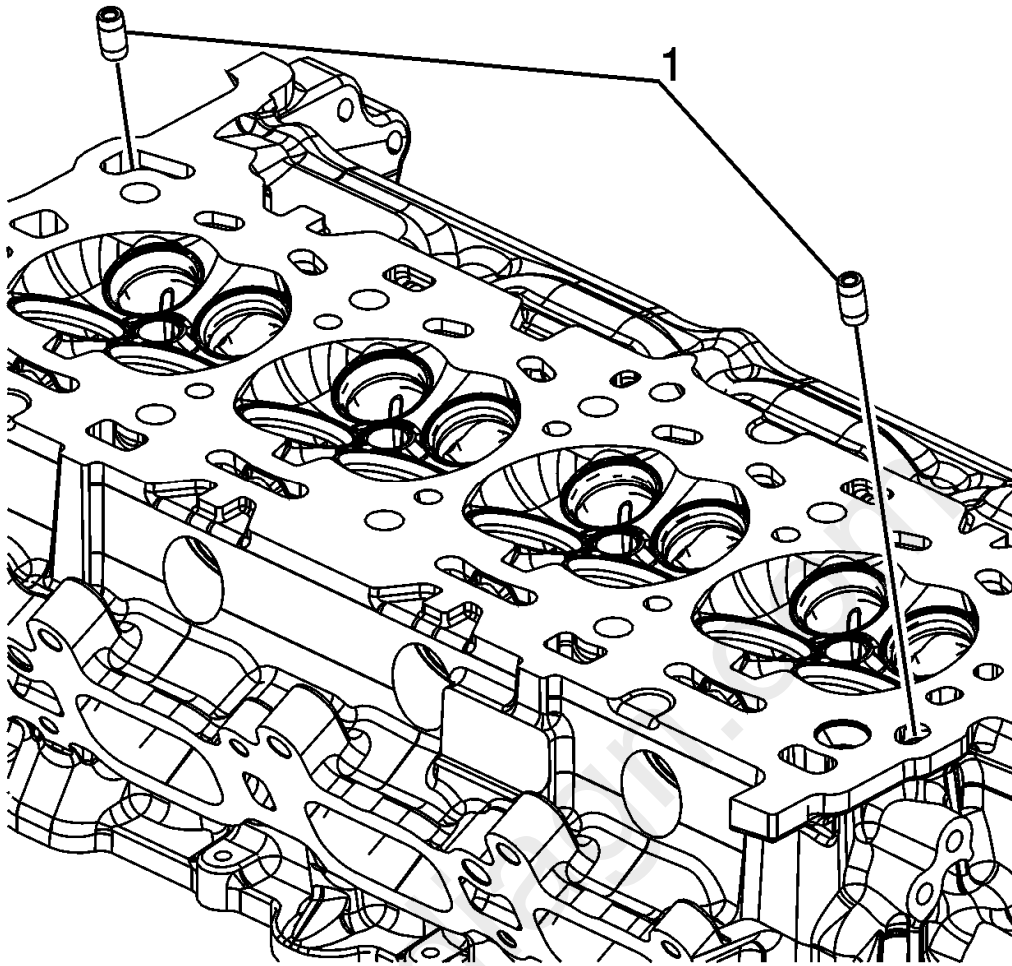


Fig. 138: Cylinder Head Oil Gallery Restrictors
Courtesy of GENERAL MOTORS COMPANY

1. Install the cylinder head oil gallery restrictors (1).

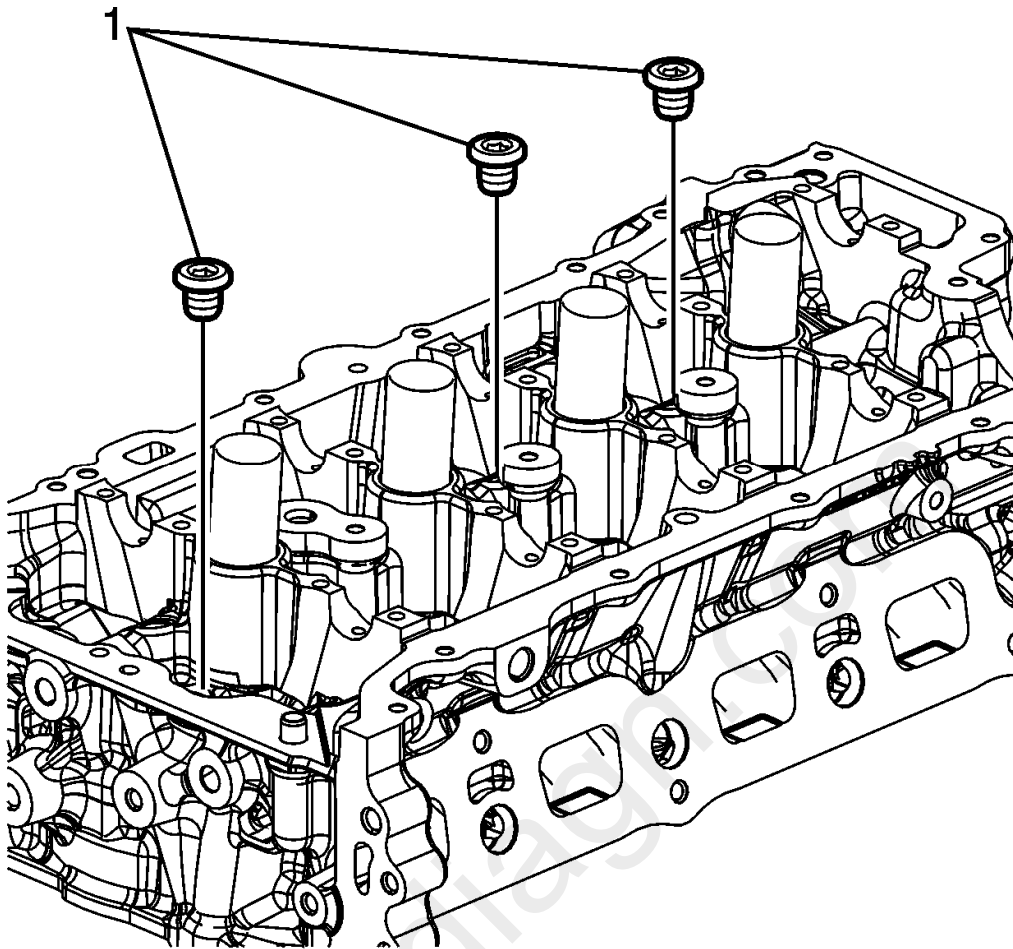


Fig. 139: Cylinder Head Plugs

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Component Fastener Tightening Caution .

CAUTION: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

2. Install NEW cylinder head plugs. Coat the plugs with sealer. Refer to Adhesives, Fluids, Lubricants, and Sealers .
3. Install the water jacket hole plugs (1) in the top of the cylinder head. Tighten the plugs to 50 N.m (37 lb ft).

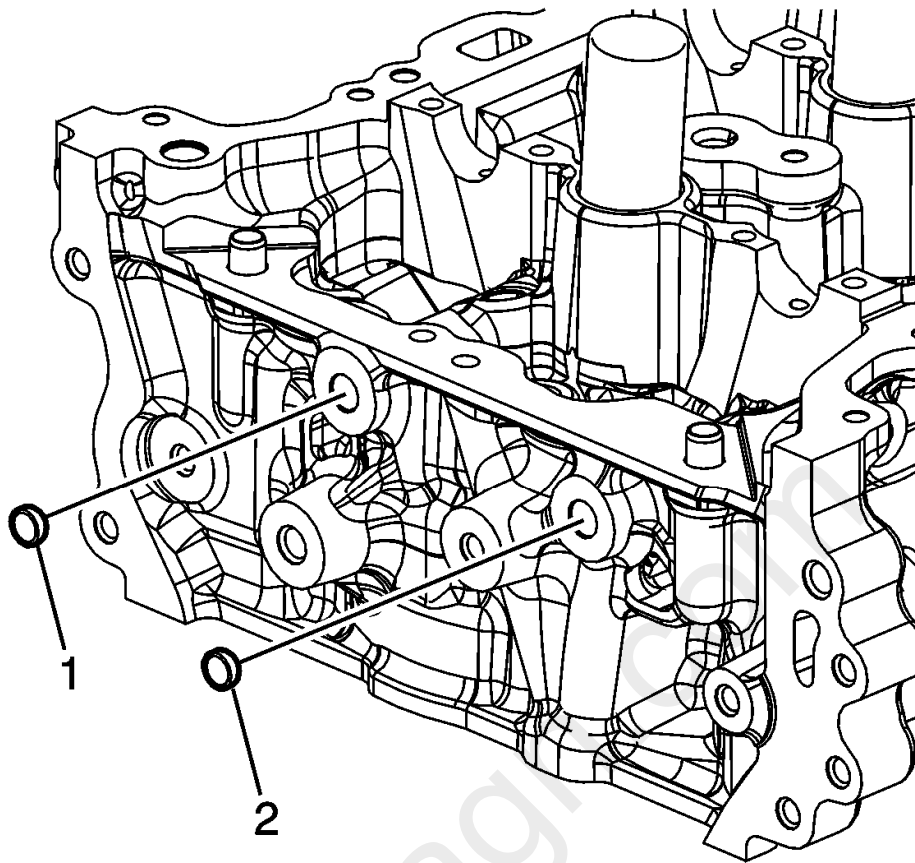


Fig. 140: Cylinder Head Plugs
Courtesy of GENERAL MOTORS COMPANY

4. Install the oil gallery plugs (1, 2) in the front of the cylinder head.

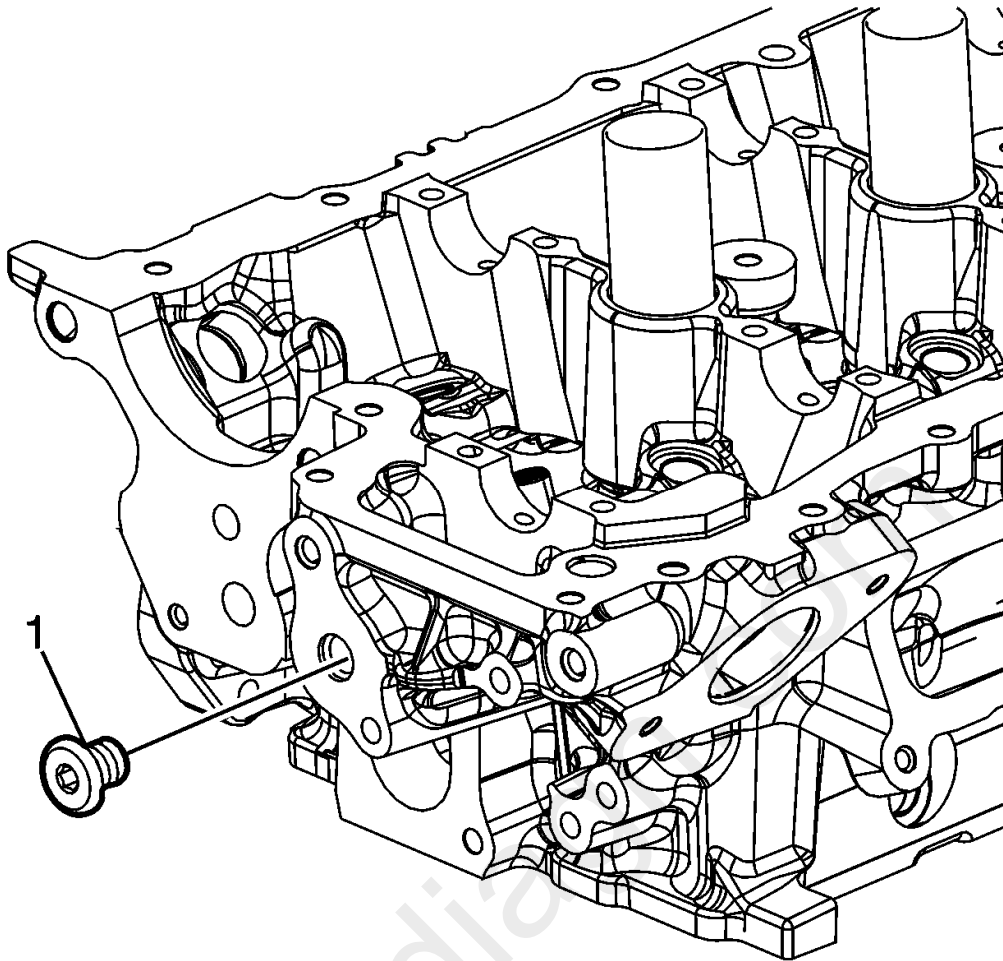


Fig. 141: Cylinder Head Plug
Courtesy of GENERAL MOTORS COMPANY

5. Install the oil gallery plug (1) in the rear of the cylinder head. Tighten the plug to 40 N.m (30 lb ft).
6. Inspect the valve springs for the following conditions:
 - Expanded height
 - Unparallel spring ends
 - Spring tension using **EN-9666** tester
 - Any distorted springs should be replaced

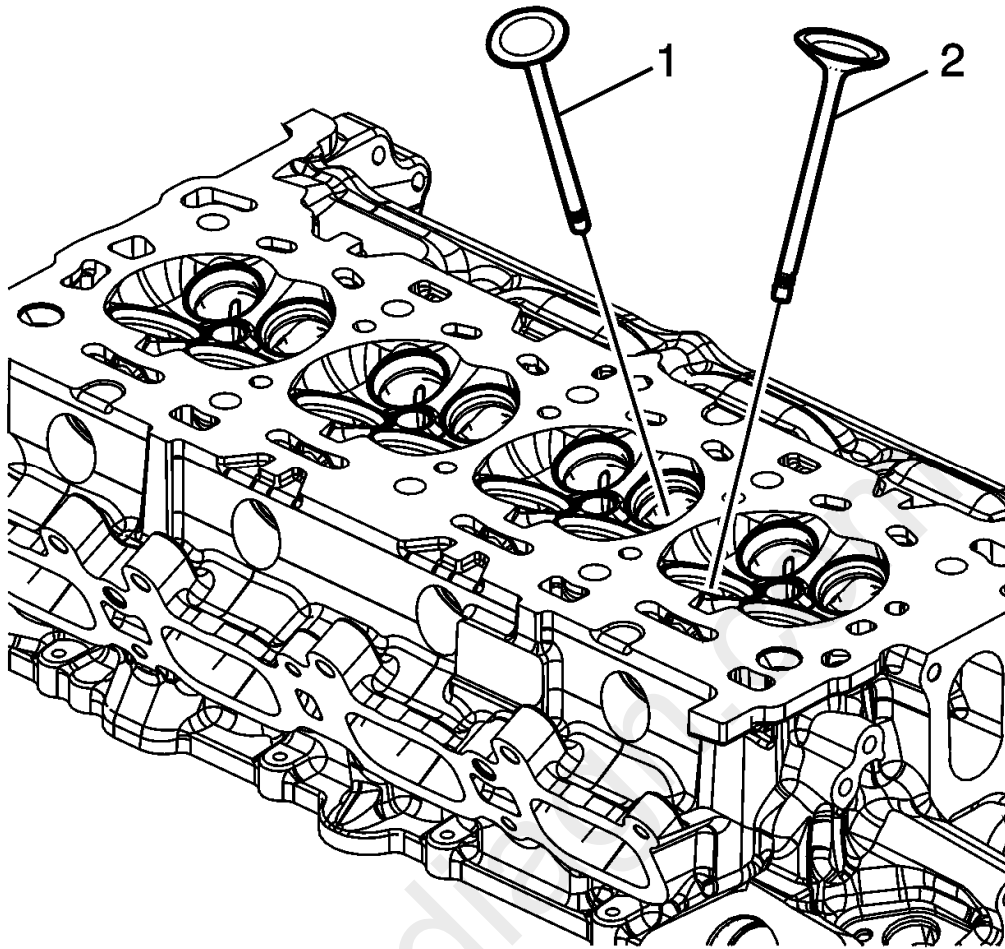


Fig. 142: Valves

Courtesy of GENERAL MOTORS COMPANY

7. Inspect the valves and the valve seats. Refer to **Valve and Seat Grinding**.
8. Install the valves (1, 2). Replace the valves, if required.

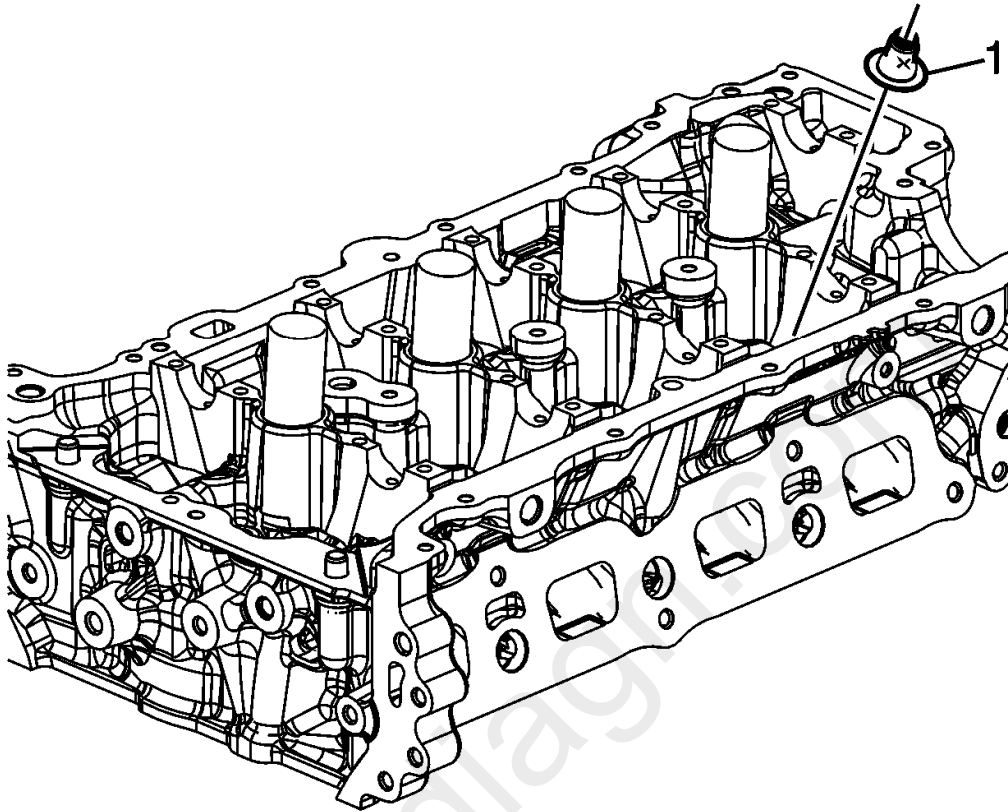


Fig. 143: Valve Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: Always use NEW valve stem oil seals when assembling the cylinder head.

9. Install the NEW valve seals (1). Fully seat the seals on the valve guides.

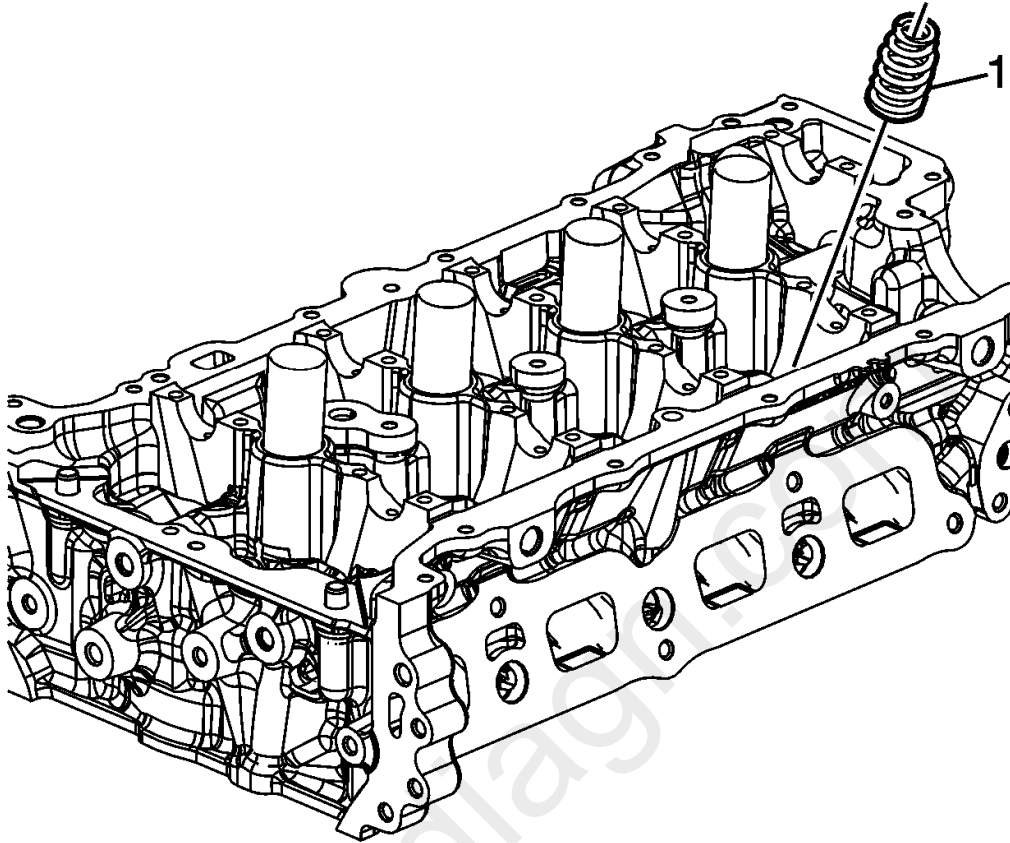


Fig. 144: Springs
Courtesy of GENERAL MOTORS COMPANY

10. Install the springs (1).

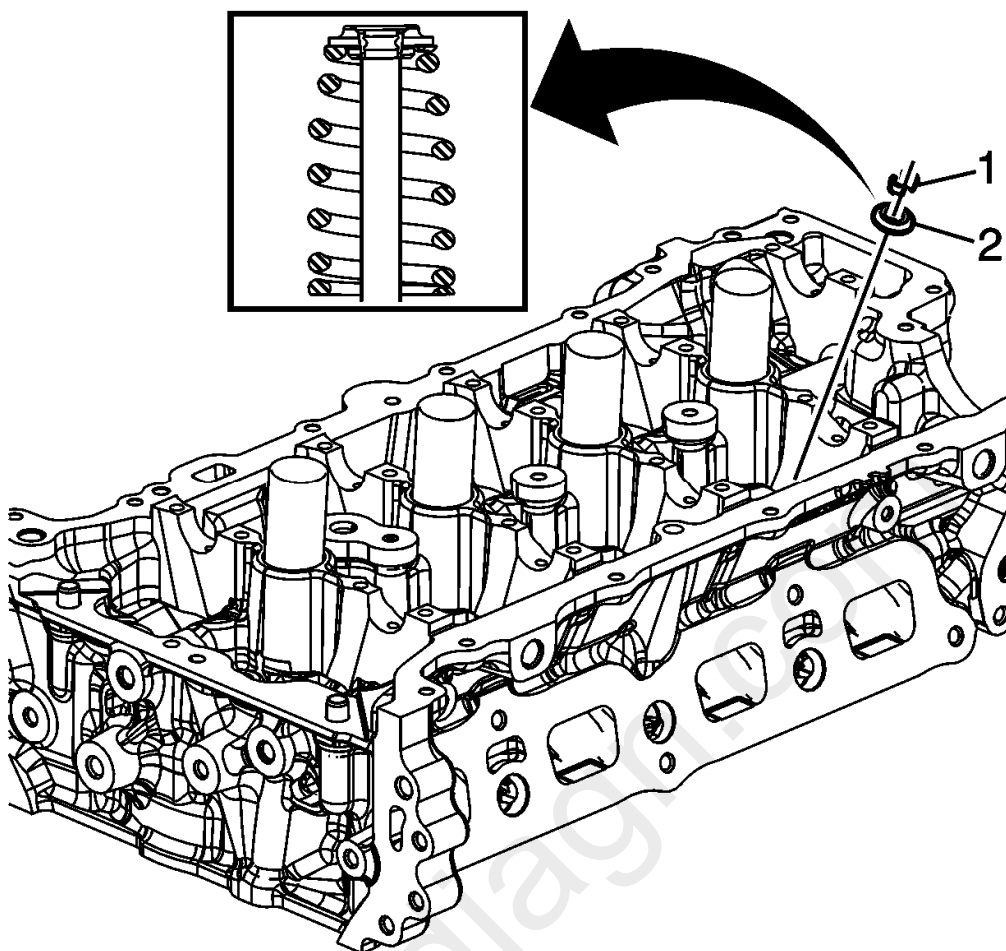


Fig. 145: Valve Keys, Springs, And Retainers
Courtesy of GENERAL MOTORS COMPANY

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.

11. Install the retainers and keys using the following procedure:
 1. Install the retainer (2).
 2. Using the **EN-50717** compressor and the **EN-43963** adapter , compress the valve spring.

3. Install the valve keys (1).
4. Slowly release the compression from the valve/spring assembly.
5. Inspect for proper valve key seating.

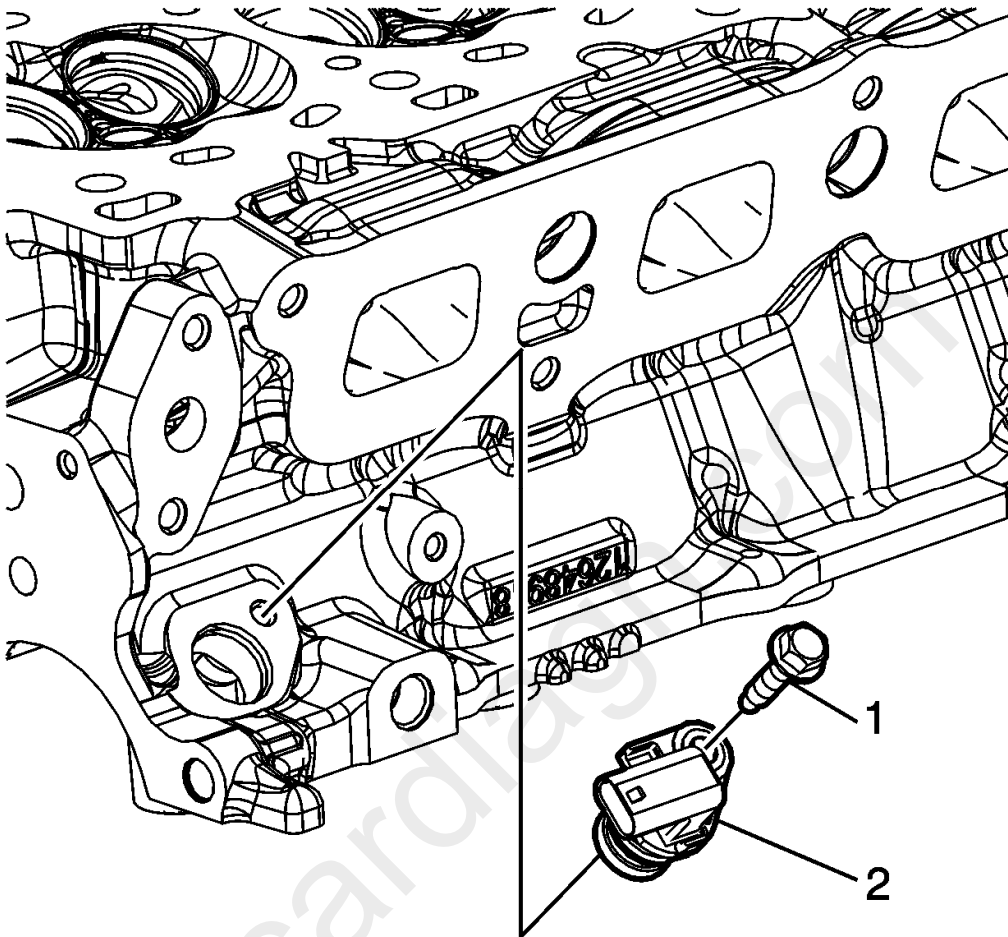


Fig. 146: Exhaust Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

12. Lubricate the camshaft position sensor O-ring with clean engine oil.

CAUTION: Refer to Fastener Caution .

13. Install the exhaust camshaft position sensor (2) and bolt (1). Tighten the bolt to 10 N.m (89 lb in).

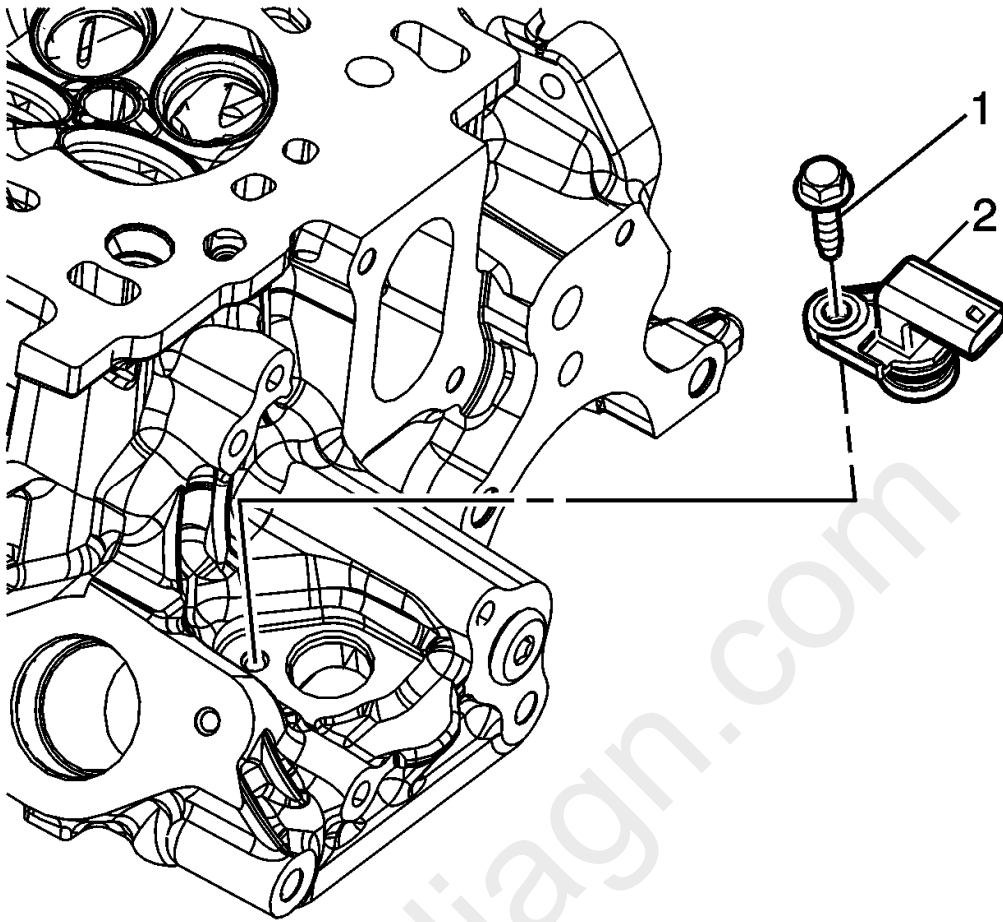


Fig. 147: Intake Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

14. Lubricate the camshaft position sensor O-ring with clean engine oil.
15. Install the intake camshaft position sensor (2) and bolt (1). Tighten the bolt to 10 N.m (89 lb in).

BALANCER SHAFT WITH OIL PUMP DISASSEMBLE

Fig. 148: Oil Pump Assembly
 Courtesy of GENERAL MOTORS COMPANY

Balancer Shaft with Oil Pump Disassemble

Callout	Component Name
1	Oil Pump Suction Pipe Bolt
2	Oil Pump Screen Assembly with Suction Pipe
3	Oil Pump Screen Gasket NOTE: Discard the gasket.
4	Oil Pump Assembly Bolt
5	Oil Pump Assembly
6	Oil Pump Cover
7	Oil Pump Locating Pin
8	Balancer Shaft Module

BALANCER SHAFT WITH OIL PUMP CLEANING AND INSPECTION

Fig. 149: Oil Pump Assembly
 Courtesy of GENERAL MOTORS COMPANY

Balancer Shaft with Oil Pump Cleaning and Inspection

Callout	Component Name
Preliminary Procedures 1. Completely inspect the balancer with oil pump shaft assembly and components. 2. Clean all mating surfaces. 3. Inspect all threaded holes for damage. 4. Inspect the oil pump screen assembly.	
1	Oil Pump Assembly
2	Oil Pump Cover
3	Balancer Shaft Module
4	Oil Pump Locating Pin
5	Oil Pump Screen Assembly with Suction Pipe

BALANCER SHAFT WITH OIL PUMP ASSEMBLE

Fig. 150: Balancer Shaft Module, Oil Pump Locating Pin And Oil Pump Assembly
 Courtesy of GENERAL MOTORS COMPANY

Balancer Shaft with Oil Pump Assemble

Callout	Component Name
1	Balancer Shaft Module
2	Oil Pump Locating Pin
3	Oil Pump Cover
4	Oil Pump Assembly
5	Oil Pump Assembly Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 10 (89 lb in)
6	Oil Pump Screen Gasket NOTE: Use NEW gasket.
7	Oil Pump Screen Assembly with Suction Pipe
8	Oil Pump Suction Pipe Bolt Tighten 10 (89 lb in)

CAMSHAFT COVER CLEANING AND INSPECTION

Camshaft Cover - Right Side

Fig. 151: Camshaft Cover -- Right Side
Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - Right Side

Callout	Component Name
Preliminary Procedure Thoroughly clean the camshaft cover and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Camshaft Cover
2	Camshaft Position Actuator Control Solenoid Valve - Intake
3	PCV Valve
4	PCV Valve Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 10 N.m (89 lb in)
5	PCV Valve
	PCV Valve Bolt

6	Tighten 10 N.m (89 lb in)
7	PCV Tube Assembly NOTE: Component may vary by model.
8	Camshaft Cover Plug Tighten 35 N.m (26 lb ft)

Camshaft Cover - Left Side

Fig. 152: Camshaft Cover -- Left Side
Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - Left Side

Callout	Component Name
Preliminary Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Engine Coolant Air Bleed Pipe O-Ring
2	Engine Coolant Air Bleed Pipe NOTE: Component may vary by model.

3	Ignition Coil
4	Vacuum Pump Seal Special Tools DT 45866 Input Shaft Seal Installer For equivalent regional tools, refer to Special Tools .
5	Camshaft Position Actuator Control Solenoid Valve

Camshaft Cover - PCV Valve Components for Turbocharger Models

Fig. 153: Camshaft Cover -- PCV Valve Components for Turbocharger Models
Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - PCV Valve Components for Turbocharger Models

Callout	Component Name
Preliminary Procedure Inspect each component while attached to the camshaft cover. Do not remove the PCV components unless inspection indicates a suspect component. Replace the PCV valve, PCV tube assembly, and PCV hose fitting as an assembly. The connections between these components are permanent.	
1	PCV Valve NOTE: When the PCV valve is removed, small particles of the valve will break and fall into the cover.

	Procedure Inspect the PCV valve. If the PCV valve is suspect, use a suitable tool to pry the valve off of the cover. Retrieve any particles that fall onto the baffle in the cover. Discard the valve and particles.
2	PCV Tube Assembly
3	PCV Hose Fitting

Camshaft Cover - Bottom

Fig. 154: Camshaft Cover Pins & Seal -- Bottom
Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - Bottom

Callout	Component Name
Preliminary Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Camshaft Cover Locating Pin
2	Spark Plug Shield Seal Special Tools EN 34115 Sprocket Bearing Installer For equivalent regional tools, refer to Special Tools .

TURBOCHARGER CLEANING AND INSPECTION

Turbocharger and Components

Fig. 155: Turbocharger and Components
 Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Components

Callout	Component Name
Preliminary Procedure 1. Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Refer to <u>Symptoms - Engine Mechanical</u> . 2. Clean all mating surfaces. 3. Inspect all threaded holes for damage. 4. Inspect the compressor and turbine blades for bent or broken conditions, and foreign material. PCV fluids and combustion product buildup are common and not a sign of failure. Replace the turbocharger if damage is found.	
1	Turbocharger
2	Turbocharger Bypass Valve Solenoid NOTE:

	Inspect the bypass valve solenoid for damage. Replace if necessary.
3	Turbocharger Bypass Valve Solenoid Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 8 N.m (71 lb in)
4	Turbocharger Wastegate Regulator Solenoid Valve NOTE: Inspect the solenoid valve and bracket for damage only. Do not disassemble solenoid valve from bracket. Replace if necessary.
5	Turbocharger Wastegate Regulator Solenoid Valve Bracket Bolt Tighten 8 N.m (71 lb in)
6	Turbocharger Wastegate Actuator NOTE: Inspect the wastegate actuator rod for damage or tampering. Replace the wastegate actuator if damage is found.
7	Turbocharger Wastegate Actuator Bolt Tighten 8 N.m (71 lb in)
8	Turbocharger Wastegate Actuator Arm Retainer

Turbocharger Inlet and Wastegate Regulator Solenoid Hoses

Fig. 156: Turbocharger Inlet and Wastegate Regulator Solenoid Hoses
 Courtesy of GENERAL MOTORS COMPANY

Turbocharger Inlet and Wastegate Regulator Solenoid Hoses

Callout	Component Name
Preliminary Procedure 1. Inspect the turbocharger compressor inlet, compressor outlet, turbine inlet, and turbine outlet surfaces for damage. Replace the turbocharger if damage is found. 2. Inspect the turbocharger wastegate regulator solenoid hoses for damage. Replace the hoses if necessary.	
1	Turbocharger Inlet Flange Partition Wall NOTE: Do not replace the turbocharger if cracks are found on the turbocharger inlet flange partition wall. Replacement should only be performed if external leaks are present or a section is loose or missing.
2	Turbocharger Wastegate Regulator Solenoid Hoses

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- **EN-47909** Injector Bore and Sleeve Cleaning Kit
- **EN-49245** Fuel Injector Seal Install/Sizer
- **EN-50791** Fuel Injector Nozzle Installer

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

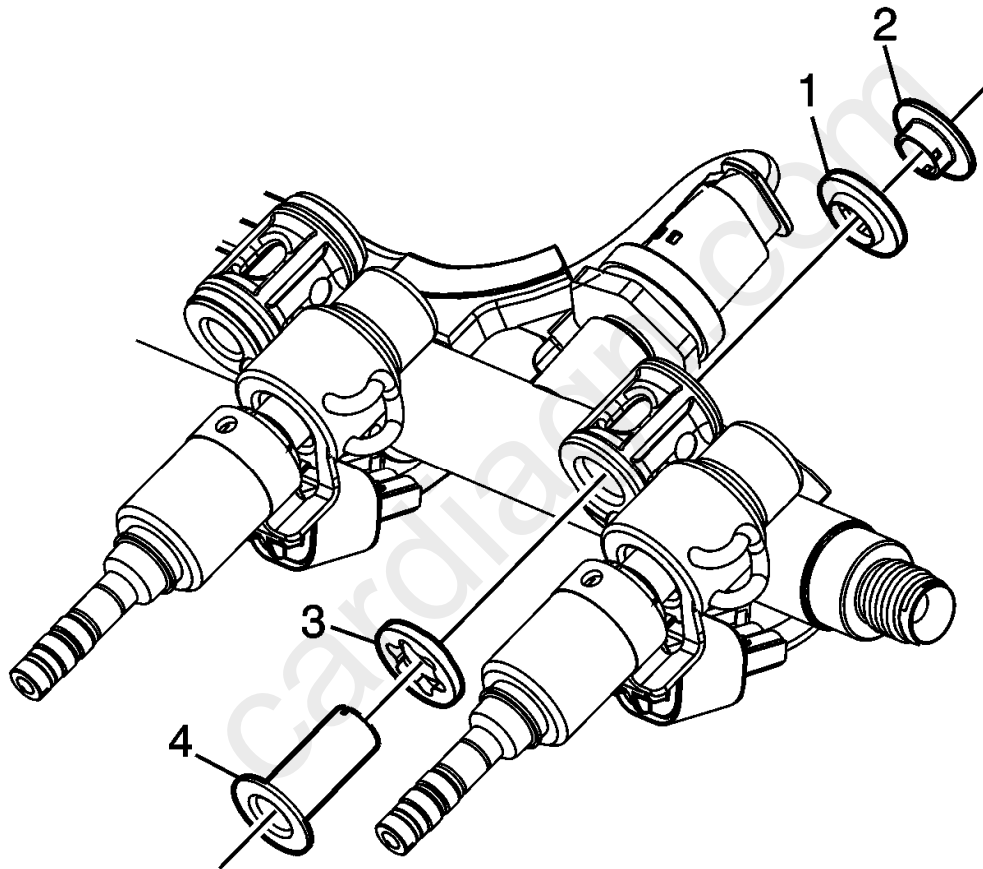


Fig. 157: Fuel Rail Insulator Assemblies
Courtesy of GENERAL MOTORS COMPANY

1. Remove and inspect the fuel rail insulator assemblies (1-4). Replace the entire assembly if any components show signs of wear or the insulators (4) show the following conditions:
 - Dry or cracked appearance
 - Flattened or misshapen appearance

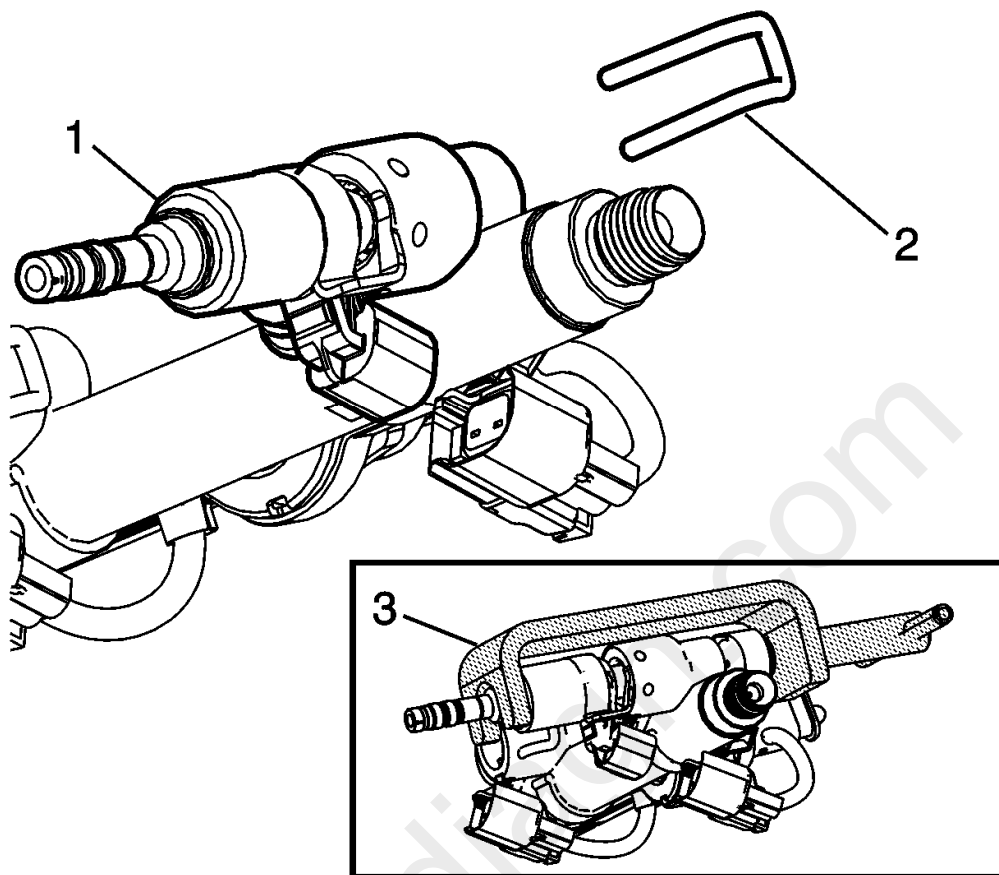


Fig. 158: Fuel Injector And Retaining Pin
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical connections from the fuel injectors.
3. Use **EN-50791** installer (3) to compress the fuel injector (1), and relieve pressure on the retaining pin (2). Remove the fuel injector retaining pin (2). Remove **EN-50791** installer once the retaining pin is removed.

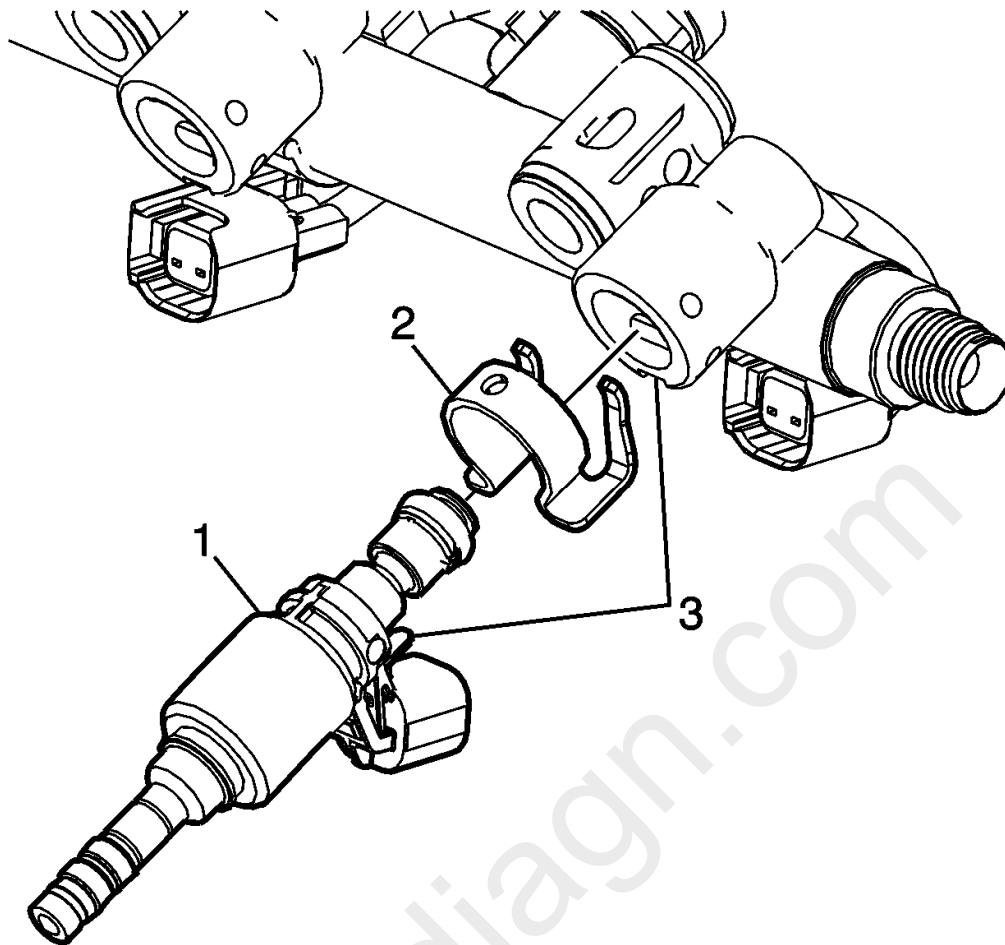


Fig. 159: Injectors And Fuel Rail Slot
Courtesy of GENERAL MOTORS COMPANY

NOTE: Support the fuel injector at the widest point. Support the fuel rail along the bottom.

- DO NOT support or hold the fuel injector by the tip or connector
 - DO NOT tilt or excessively twist the injector during removal
4. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable as long as excessive force is not applied to the fuel injector tab while engaged in the fuel rail slot (3).
 5. Remove the fuel injector holding clamp (2) from the rear of the fuel injector.

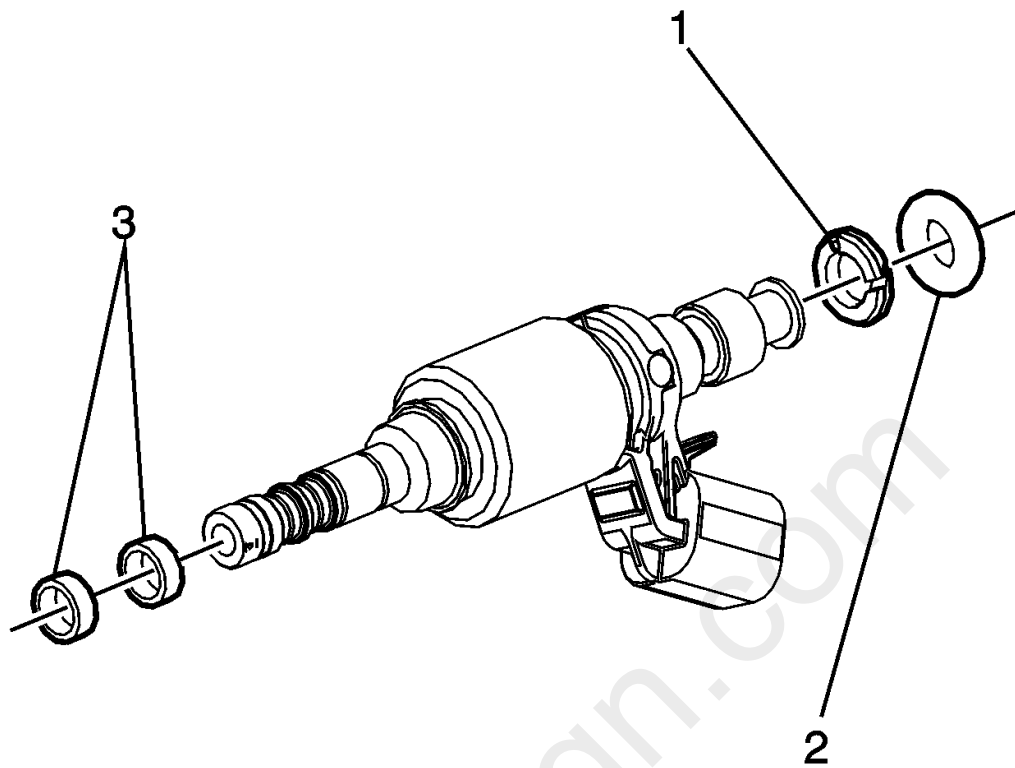


Fig. 160: Fuel Injector O-ring And Plastic Spacer
Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the fuel injector O-ring (2) and plastic spacer (1).
7. Remove and discard the fuel injector seals (3).

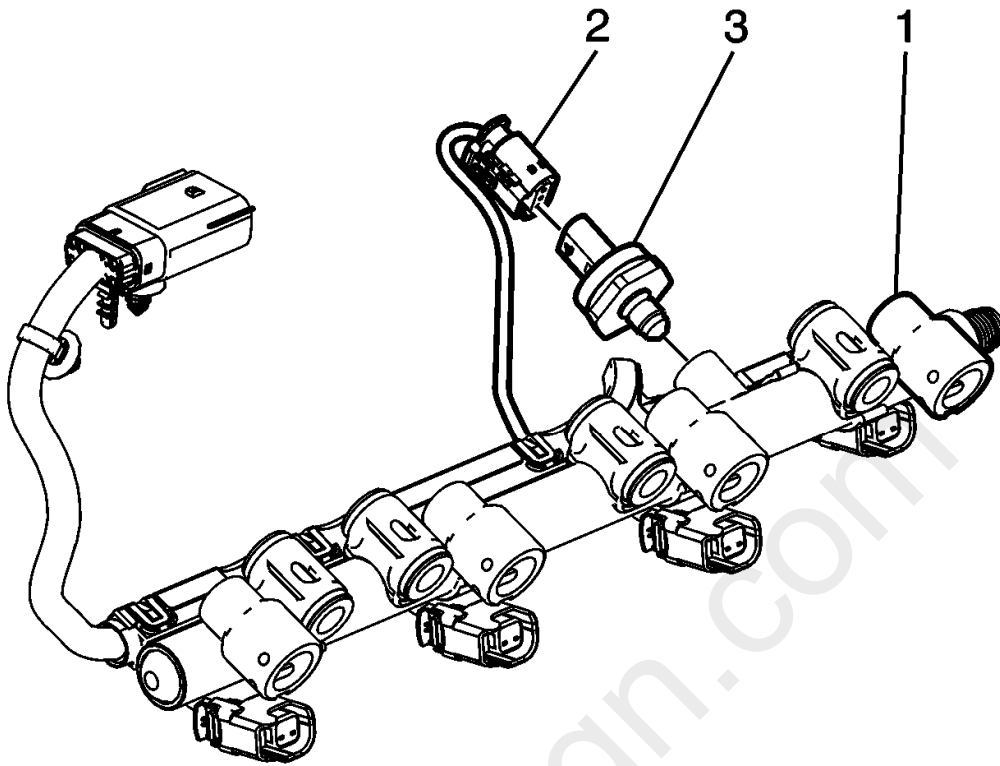


Fig. 161: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

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

8. Clean the exterior of the fuel rail (1) and injectors in solvent.
9. Using **EN-47909** cleaning kit , clean the fuel injector bores and sleeves.
10. Inspect the fuel rail 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
 - Damage to the threads on the fuel rail fuel feed fitting
11. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

CAUTION: Refer to Fastener Caution .

NOTE: Remove and inspect the fuel pressure sensor only if the sensor is suspect.

12. Inspect the fuel pressure sensor (3) for damage.
 1. Disconnect the harness connector (2) from the fuel pressure sensor.
 2. Remove the fuel pressure sensor. Dry the fuel pressure sensor bore in the fuel rail with a lint free cloth. The bore should be free of fuel, debris, and burrs.
 3. Lubricate the fuel rail fuel pressure sensor bore with clean engine oil.
 4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
 5. Install the fuel pressure sensor hand tight.
 6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
 7. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft).
 8. Connect the harness connector to the fuel pressure sensor.

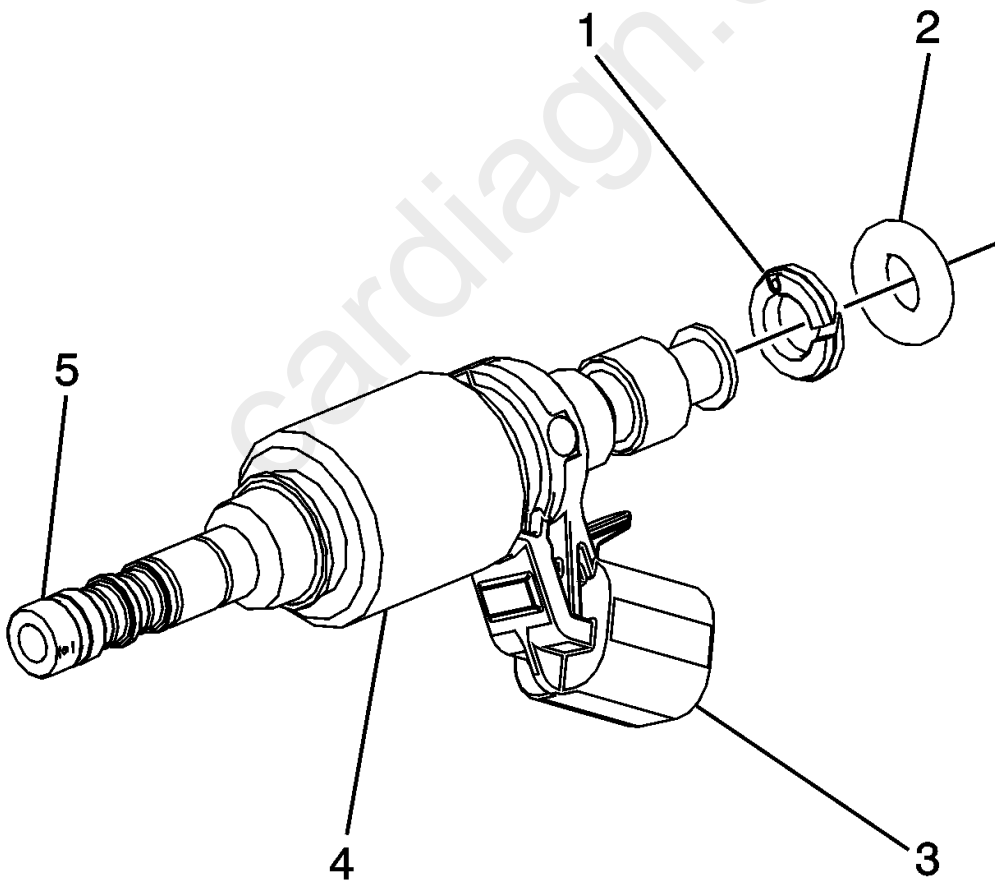


Fig. 162: Fuel Injector Connector

Courtesy of GENERAL MOTORS COMPANY

13. Inspect the fuel injectors for the following conditions:
 - Damage to the fuel injector connector (3)
 - Damage to the fuel injector harness connector
 - Damage to the fuel injector tip (5)
 - Damage to the fuel injector (4)
14. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.
15. Install the a new fuel injector spacer (1).
16. Lubricate the new O-ring (2) with clean, silicone-free 5W30 engine oil.
17. Install the O-ring on the injector.

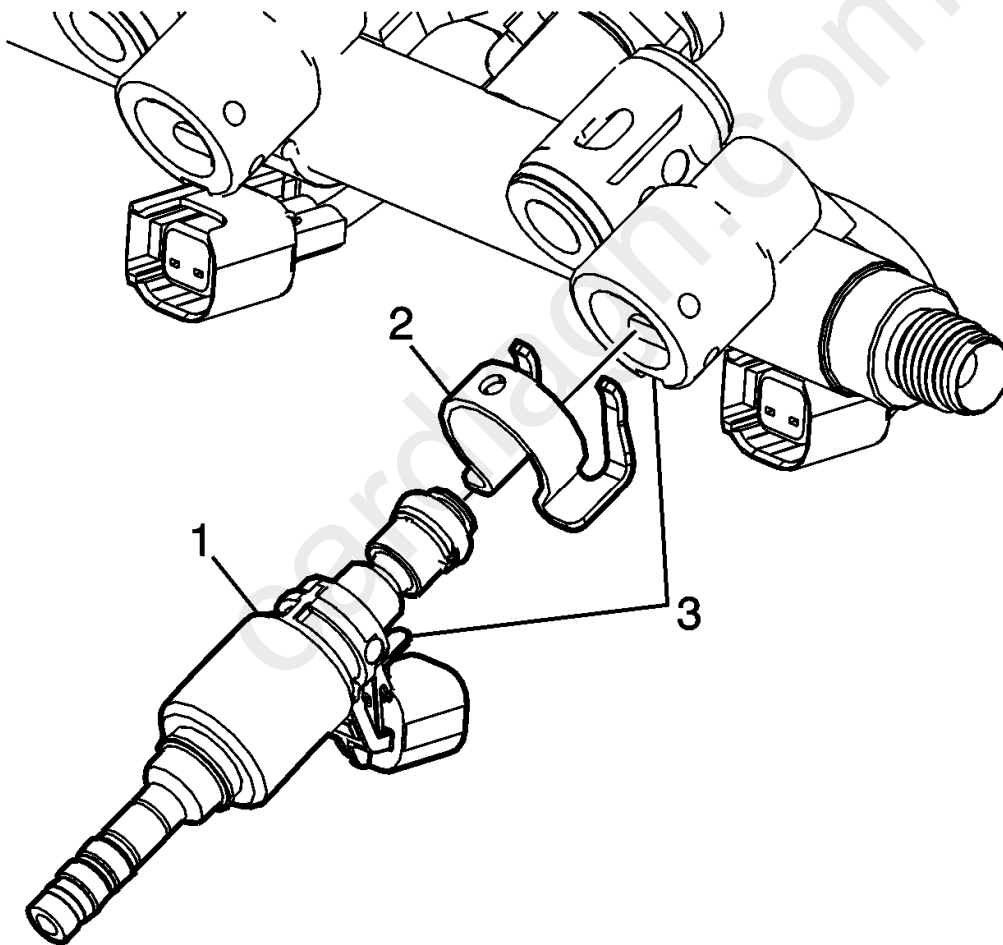


Fig. 163: Injectors And Fuel Rail Slot
Courtesy of GENERAL MOTORS COMPANY

18. Install the fuel injector holding clamp (2) onto the rear of the fuel injector.
19. Hand install fuel injectors (1) to the fuel rail, carefully aligning the fuel injector tab to the slot in the fuel

rail (3).

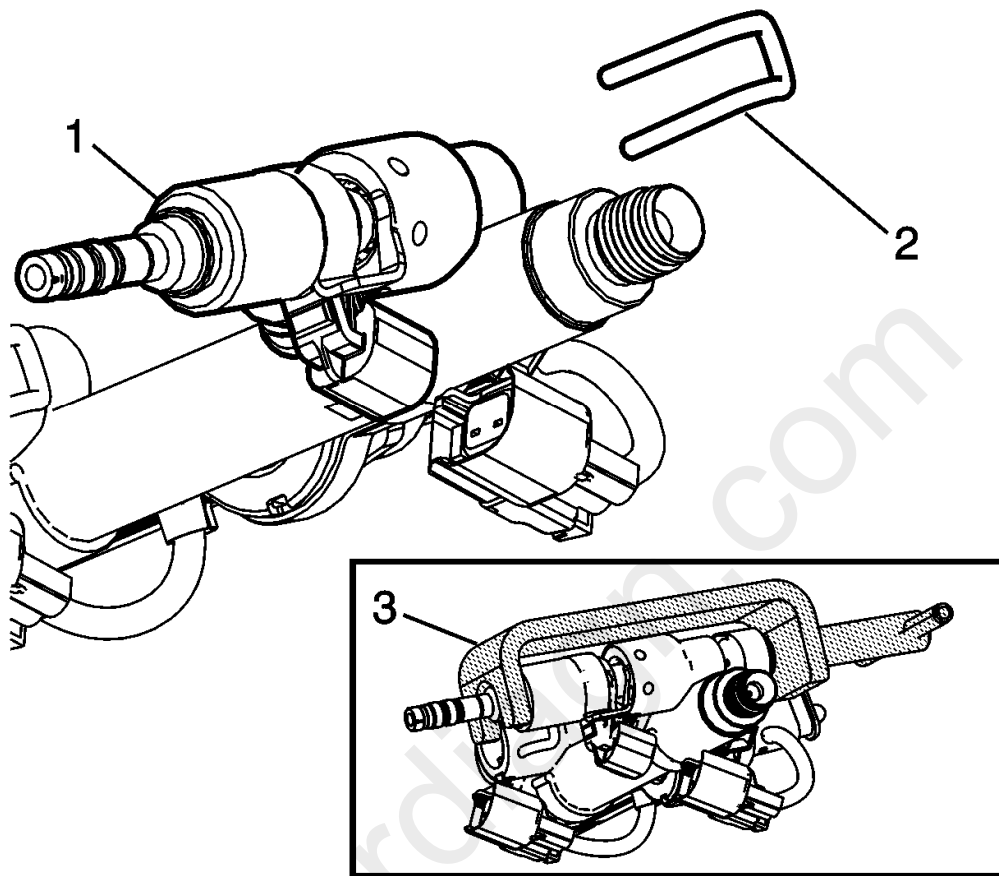


Fig. 164: Fuel Injector And Retaining Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE: The injector must be fully installed and properly aligned with the fuel rail before installing the retaining pin.

20. Using **EN-50791** installer (3), compress the fuel injector (1) into the fuel rail.
21. Ensure the fuel injector is fully seated in the fuel rail, and install the fuel injector retaining pin (4).
22. Ensure the fuel injector retaining pin is fully seated in the fuel rail. Remove **EN-50791** installer. Repeat process until all fuel injectors are properly installed to the fuel rail.

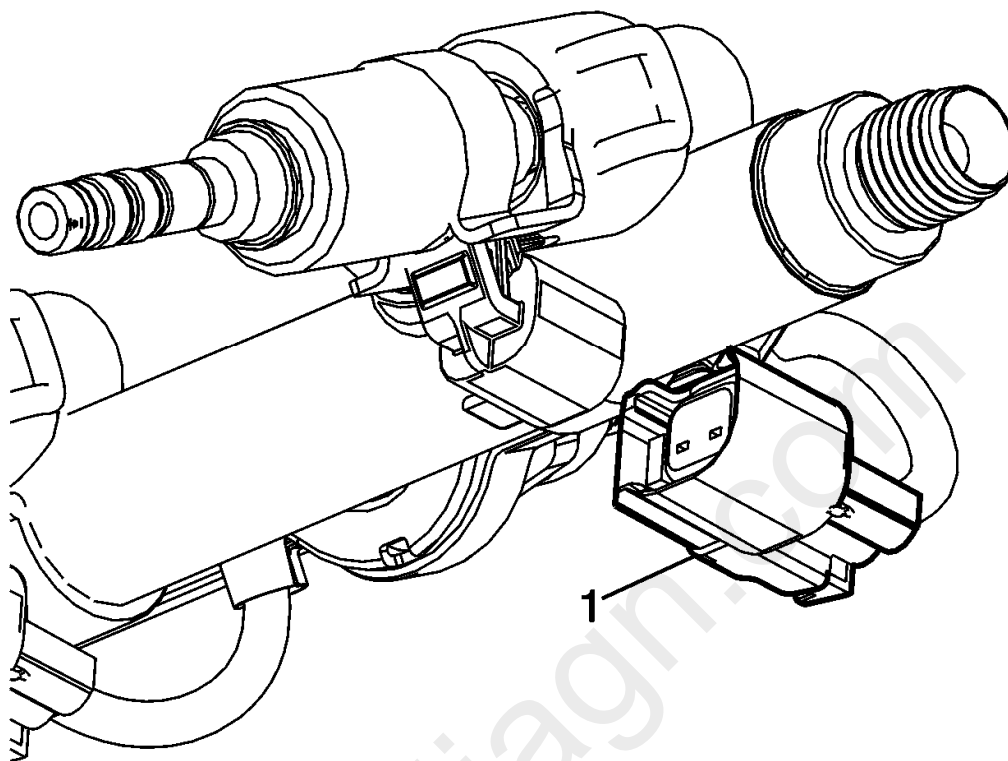


Fig. 165: Fuel Rail Harness Connectors
Courtesy of GENERAL MOTORS COMPANY

23. Connect the electrical connection to the fuel rail.
24. Connect the fuel rail harness connectors (1) to the fuel injectors.

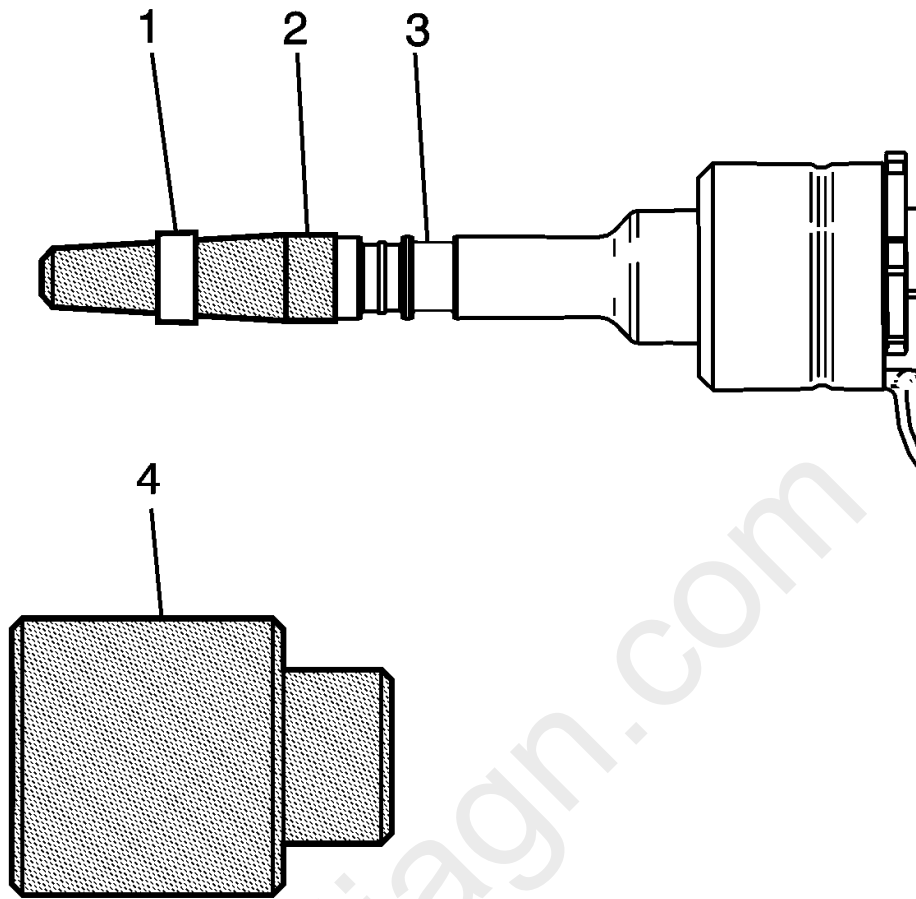


Fig. 166: Second Recessed Area And NEW Seal
Courtesy of GENERAL MOTORS COMPANY

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

25. Install **EN-49245** protector (2) onto the fuel injector tip. Place a NEW seal (1) on **EN-49245** protector.
26. Install a seal into the second recessed area (3) of the fuel injector.
27. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).
28. Place a second NEW seal (1) on **EN-49245** protector.
29. Install the seal into the first recessed area of the fuel injector.
30. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).

INTAKE MANIFOLD CLEANING AND INSPECTION

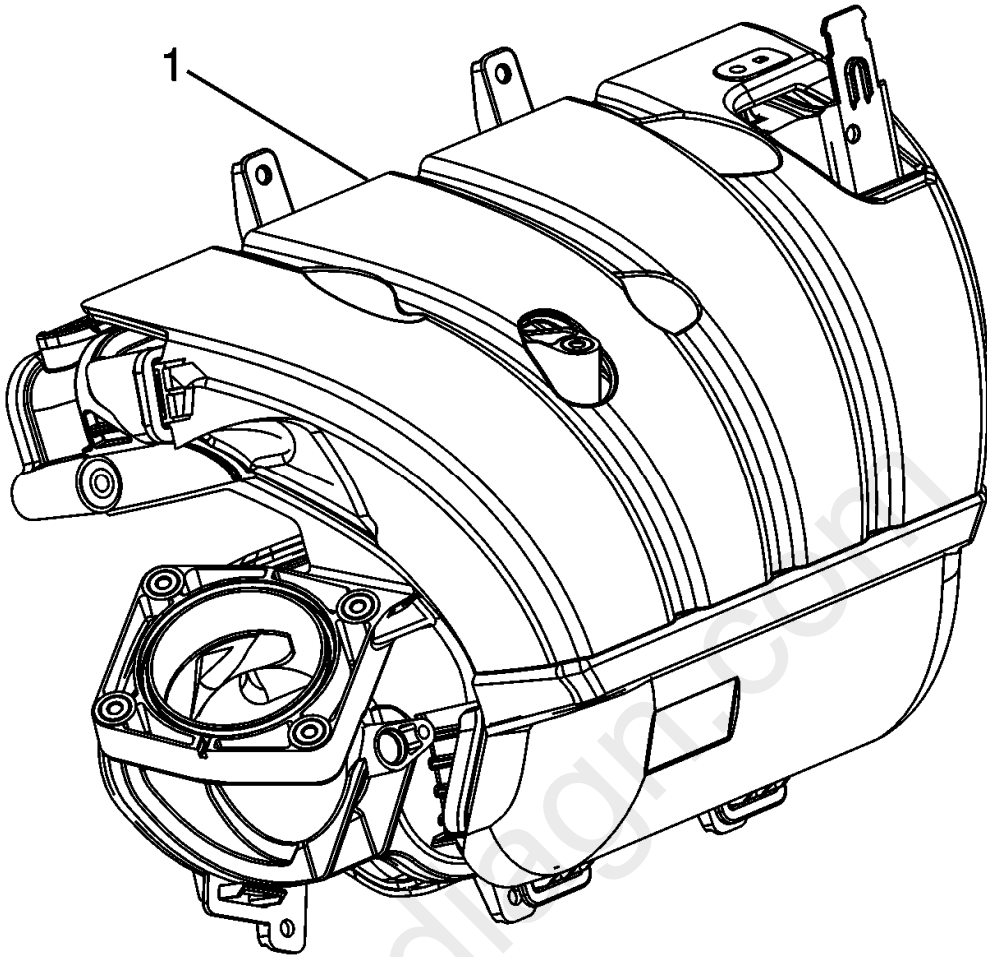


Fig. 167: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

1. Clean the intake manifold (1) mating surfaces.
2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.

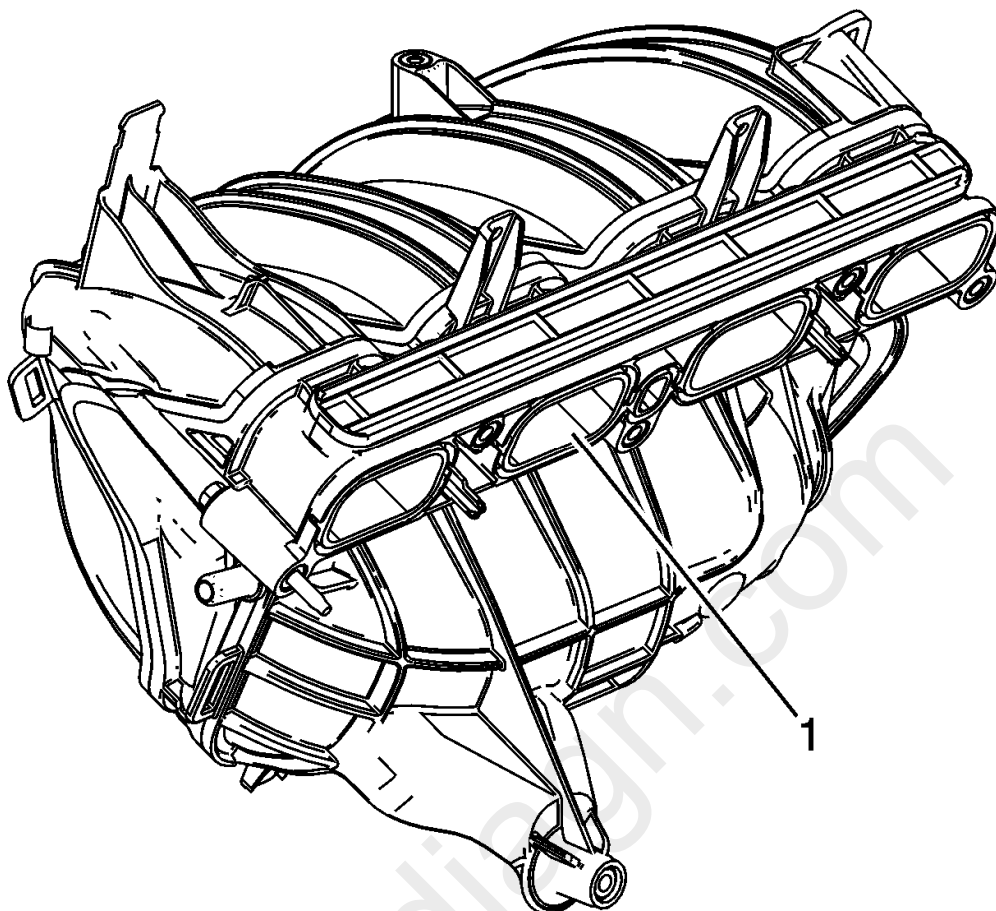


Fig. 168: Crankcase Ventilation Passages
Courtesy of GENERAL MOTORS COMPANY

4. Inspect the crankcase ventilation passages (1) in the intake manifold face for blockage.

WARNING: Refer to Safety Glasses Warning .

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

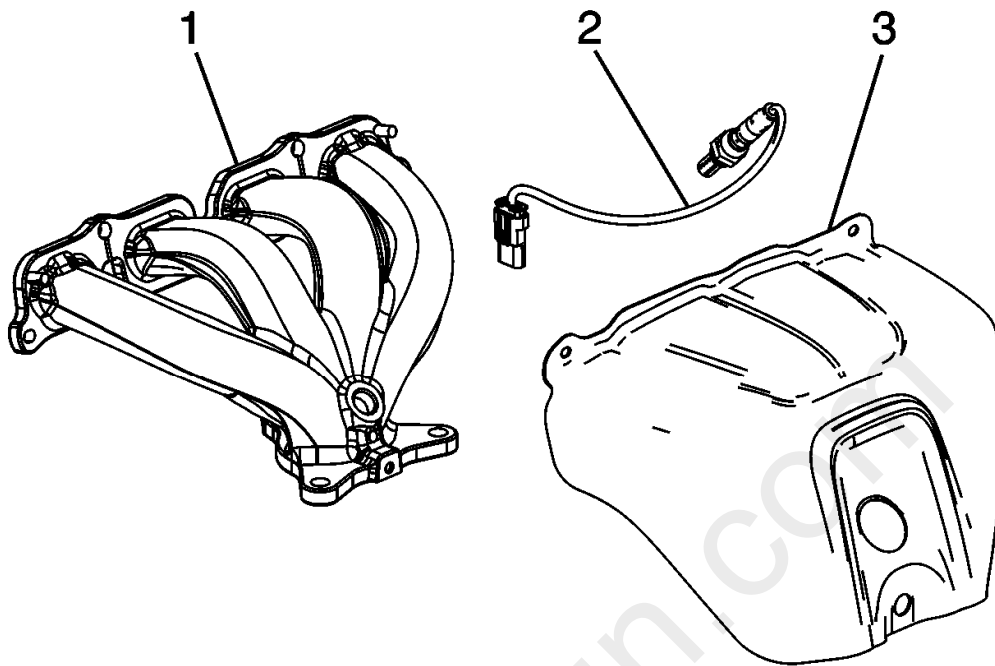


Fig. 169: Exhaust Manifold And Oxygen Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.
- Remove the oxygen sensor prior to cleaning the manifold. Do not submerge the oxygen sensor in cleaning solvent.

1. Remove the oxygen sensor (2) from the manifold.
2. Clean the exhaust manifold (1) in solvent.

WARNING: Refer to Safety Glasses Warning .

3. Dry the exhaust manifold with compressed air.

4. Inspect the exhaust manifold (1) for damage.
5. Inspect the heat shield (3) for damage.

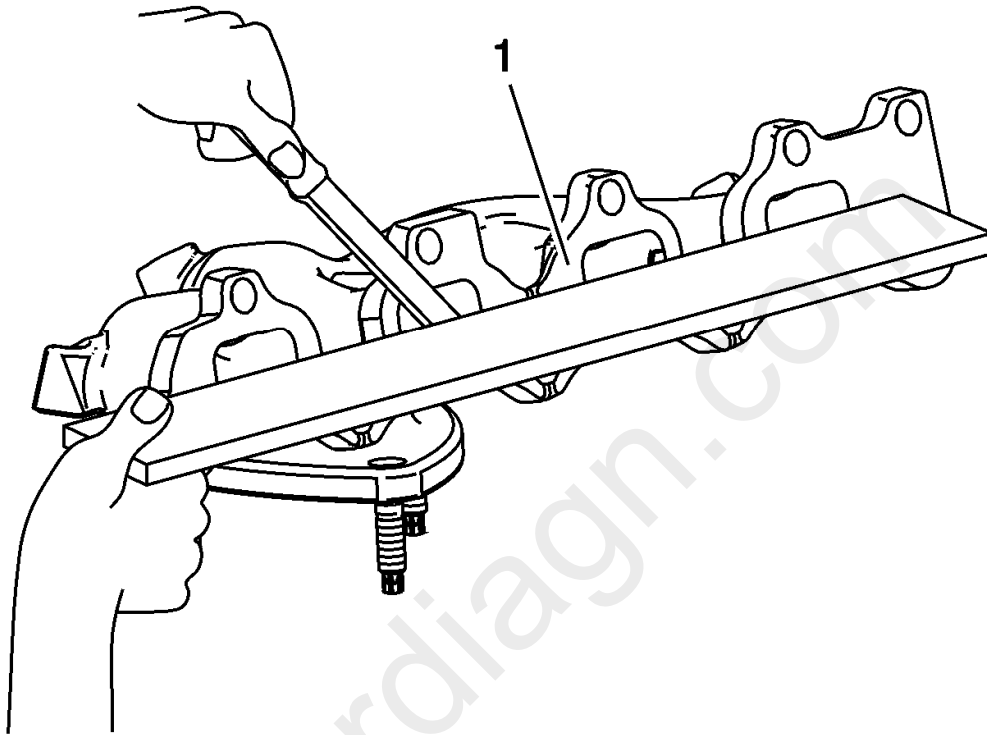


Fig. 170: Measuring Exhaust Manifold Mounting Face
Courtesy of GENERAL MOTORS COMPANY

6. Use a straight edge and a feeler gauge and measure the exhaust manifold mounting face (1) for warpage.

An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

OIL PAN CLEANING AND INSPECTION

Fig. 171: Oil Pan Cleaning And Inspection
Courtesy of GENERAL MOTORS COMPANY

Oil Pan Cleaning and Inspection

Callout	Component Name
Preliminary Procedure	
1. Thoroughly clean the oil pans and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 2. Remove all sludge and oil deposits. 3. Inspect the oil pan for cracking near the pan rail and the transmission mounting points. 4. Inspect the oil pan for cracking resulting from impact or flying road debris.	
1	Upper Oil Pan NOTE: Component may vary depending on model.
	Lower Oil Pan

2	NOTE: Component may vary depending on model.
3	Engine Oil Drain Plug
4	Engine Oil Drain Plug Washer NOTE: It is only necessary to replace the washer if inspection indicates damage is present.
5	Oil Pan Locating Pins NOTE: It is not necessary to remove the locating pins unless the inspection indicates replacement.
6	Engine Oil Level Indicator Switch O-ring Seal
7	Engine Oil Level Indicator Switch
8	Engine Oil Level Indicator Switch Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 10 N.m (89 lb in)
9	Engine Oil Level Indicator Switch Connector Retainer
10	Oil Pan Baffle
11	Oil Pan Baffle Bolt Tighten 10 N.m (89 lb in)

THREAD REPAIR

Special Tools

- **EN 42385-700** High Feature Thread Repair Kit
- **EN 42385-850** Thread Repair Kit
- **EN 42385-880** Head Bolt Thread Repair Adapter Kit

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

General Thread Repair

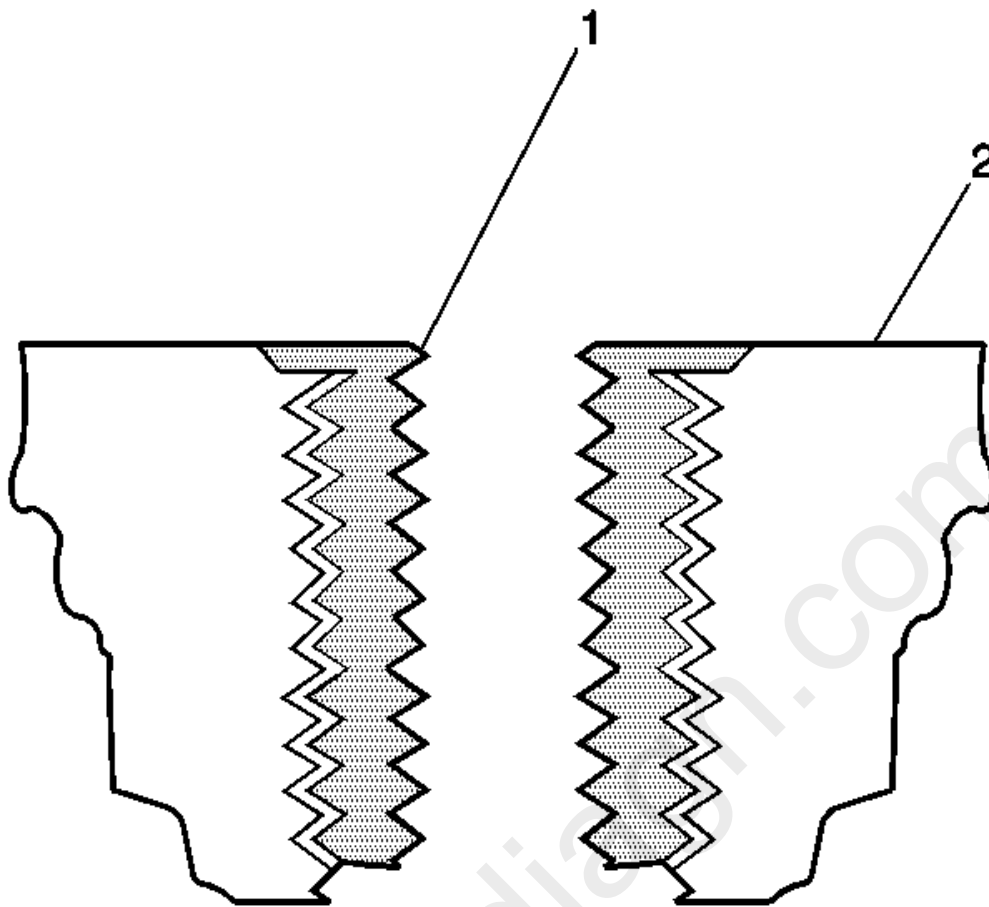


Fig. 172: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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

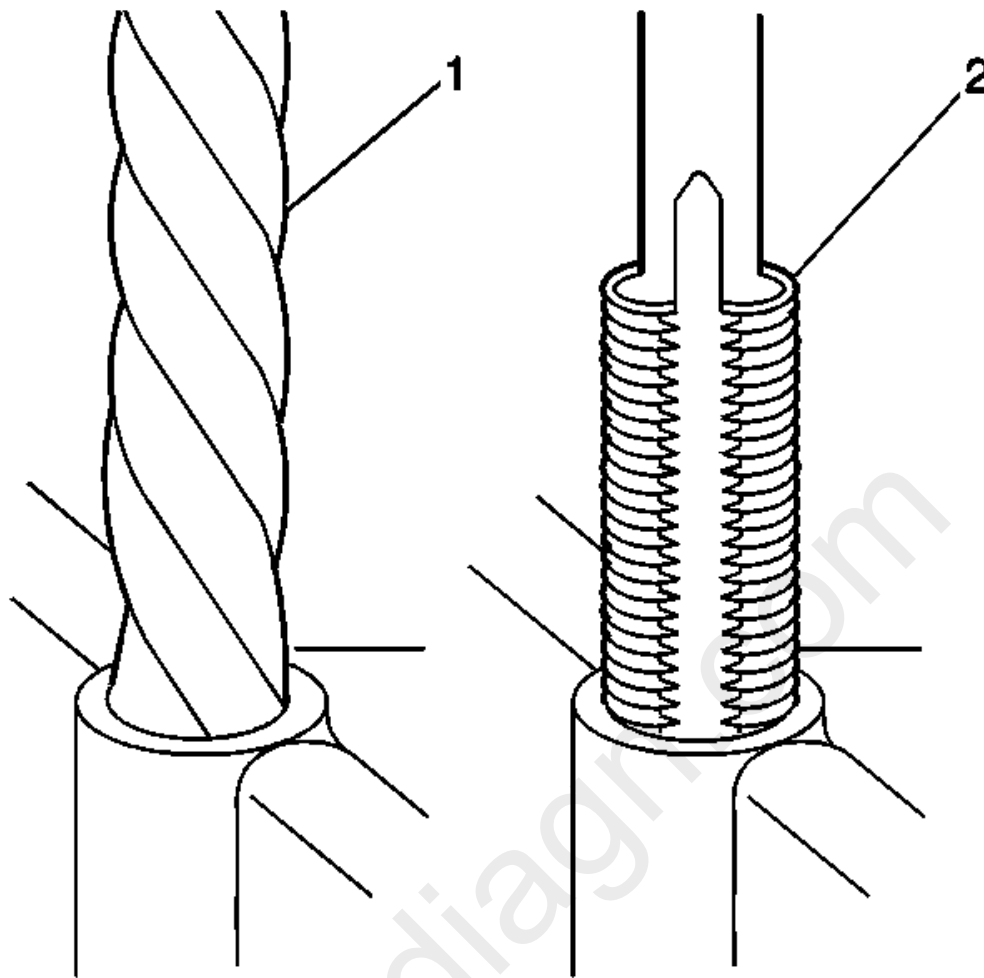


Fig. 173: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

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

Driver oil MUST be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

1. Drill out the threads of the damaged hole (1).
 - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
 - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
 - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Using compressed air, clean out any chips.

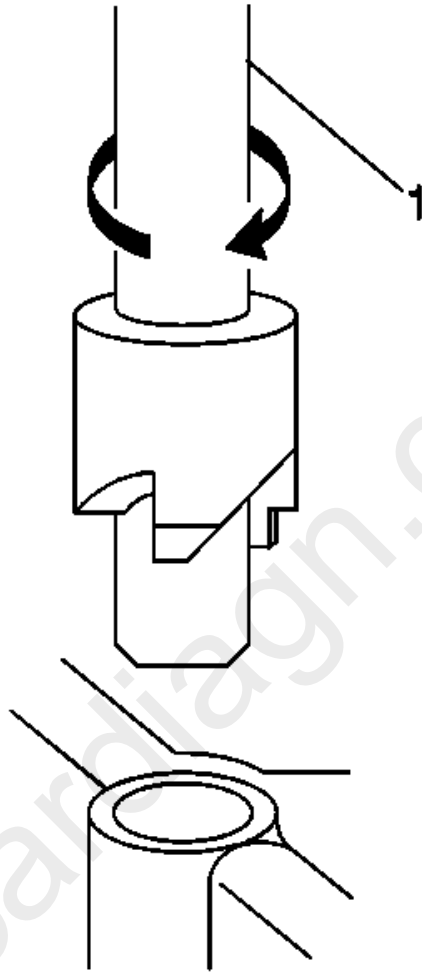


Fig. 174: Identifying Tool Used To Counterbore The Hole
Courtesy of GENERAL MOTORS COMPANY

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

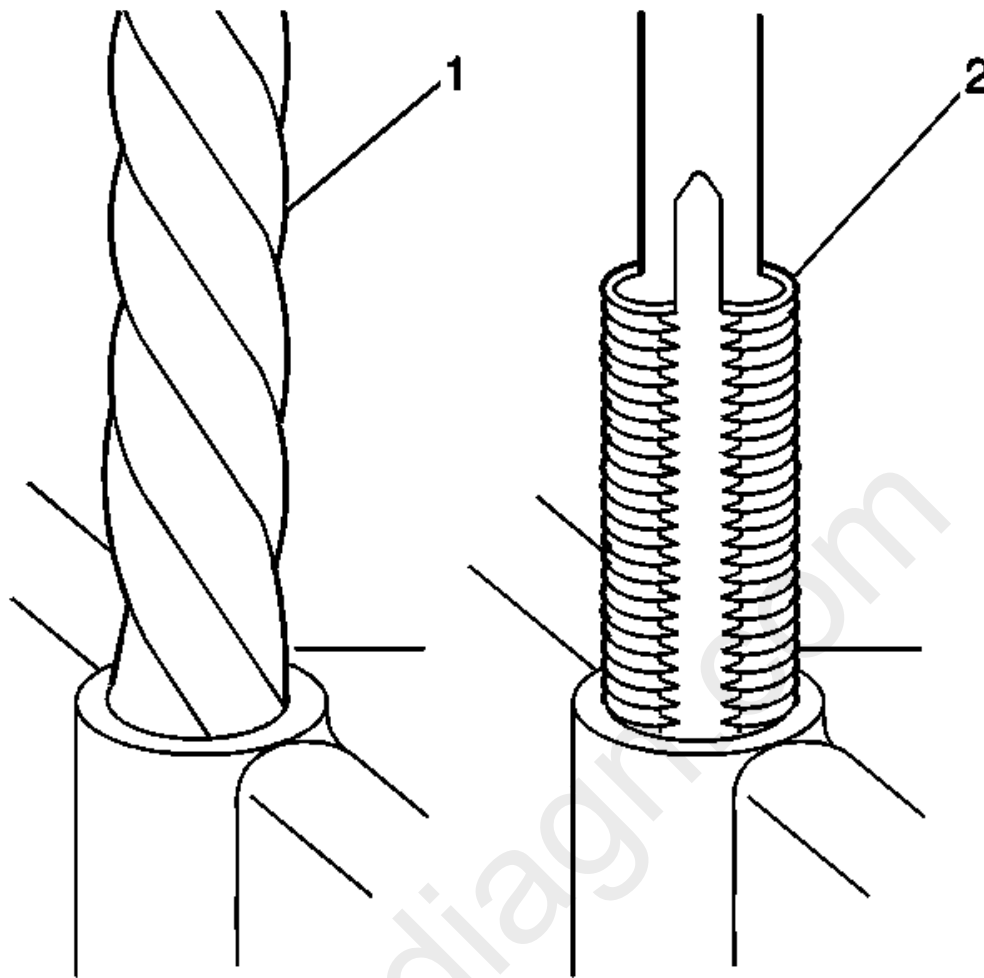


Fig. 175: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

6. Using compressed air, clean out any chips.

7. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
8. Using compressed air, clean any cutting oil and chips out of the hole.

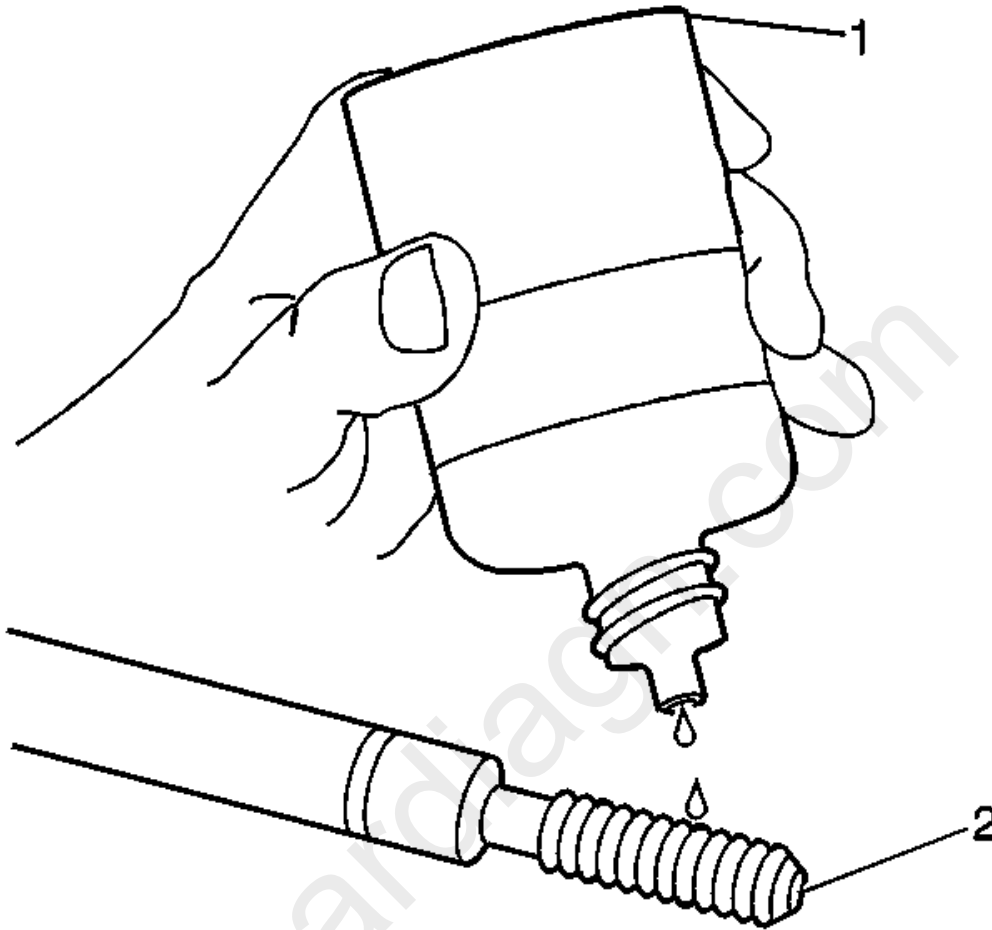


Fig. 176: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

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

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

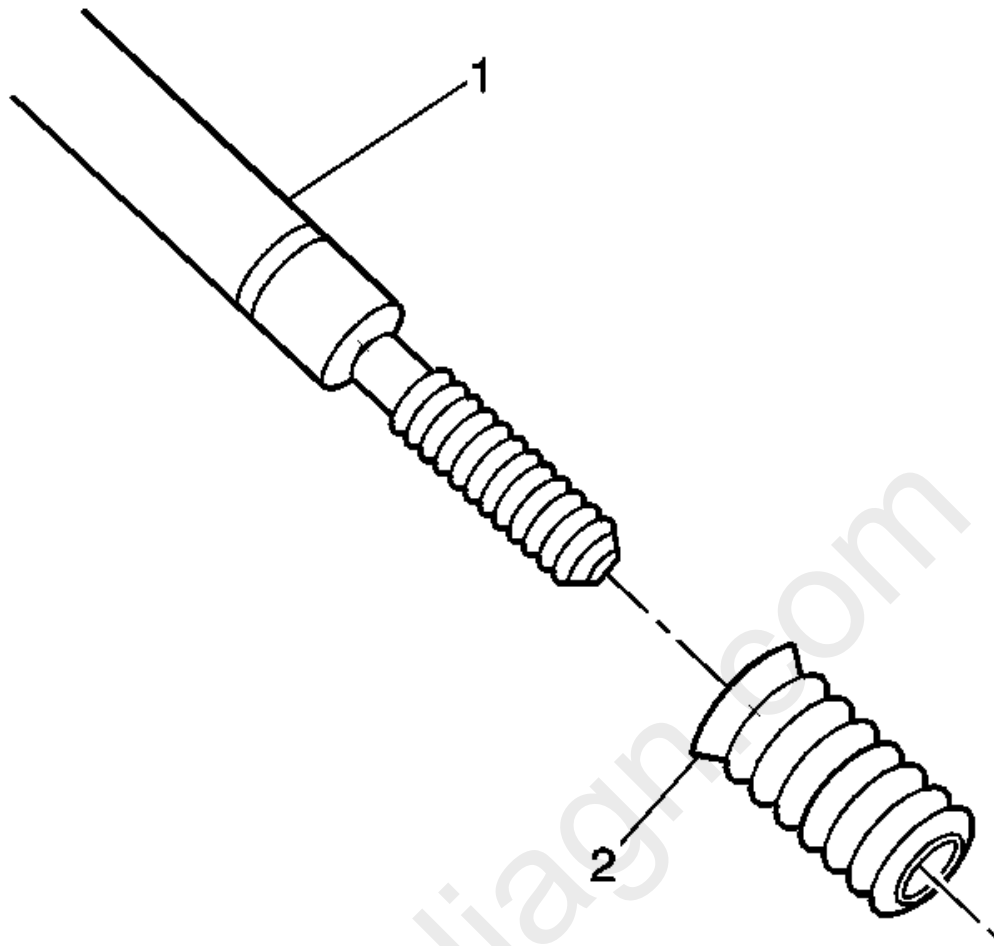


Fig. 177: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

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

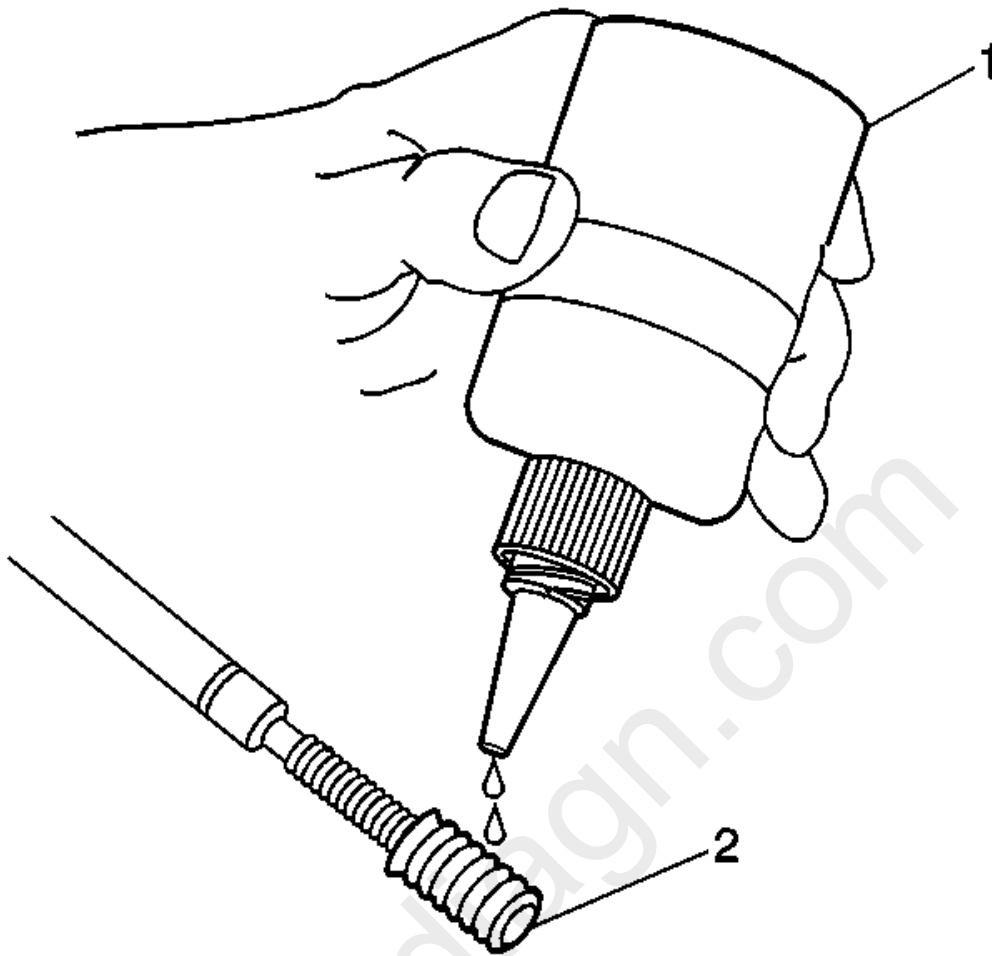


Fig. 178: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

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

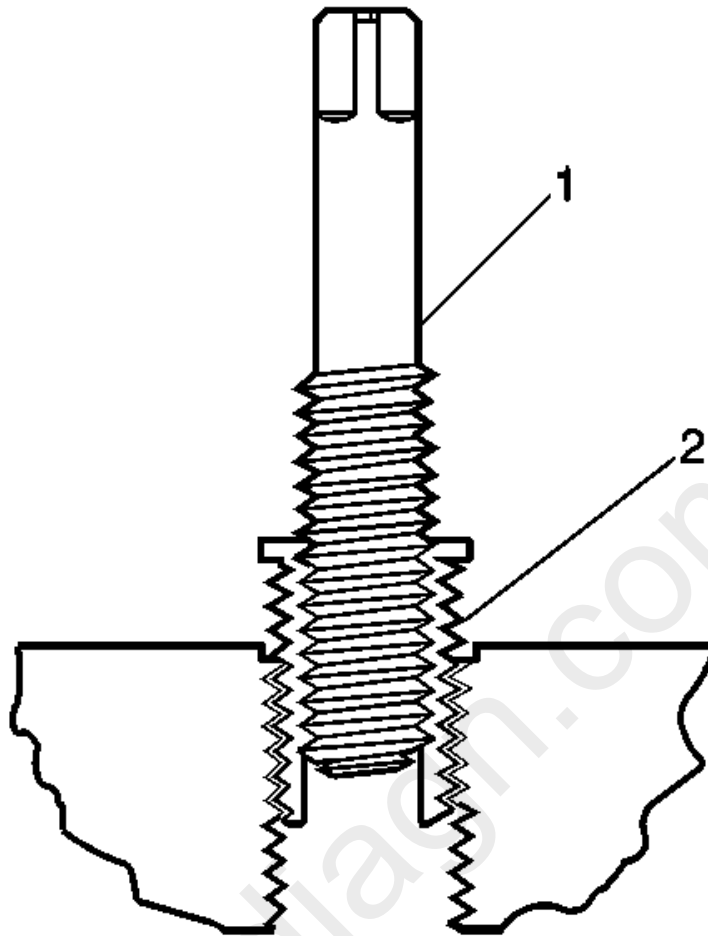


Fig. 179: View Of Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

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

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

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

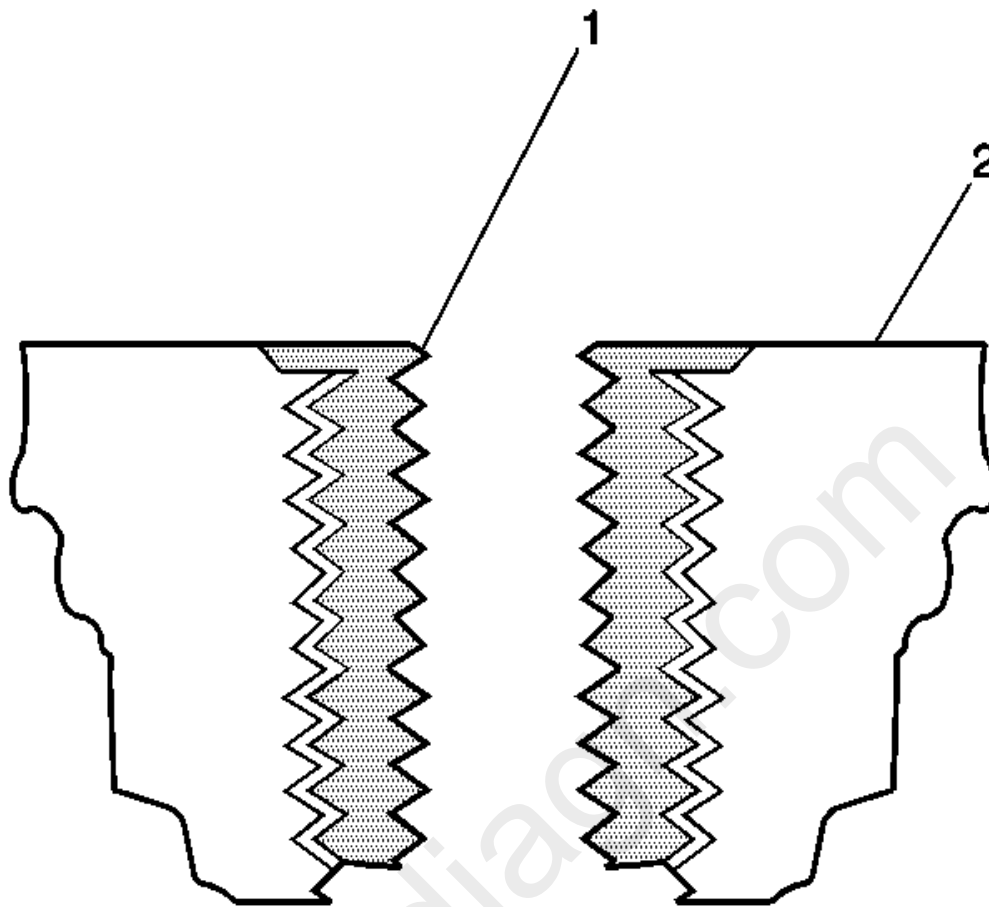


Fig. 180: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

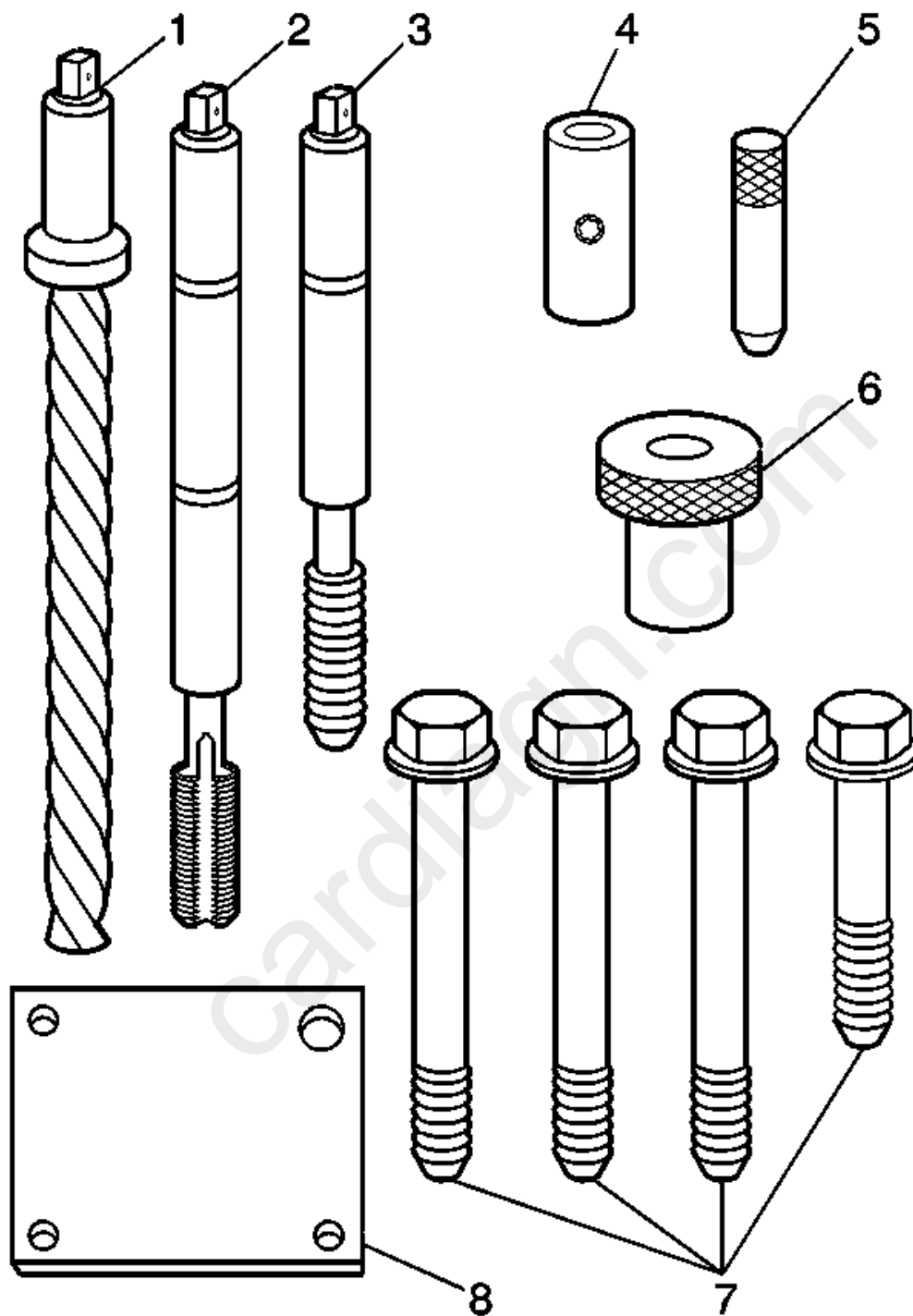


Fig. 181: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: The tools listed may not necessarily represent the exact tools used for the procedure.

1. The cylinder head bolt hole thread repair kit consists of the following items:

- Drill (1)
- Tap (2)
- Installer (3)
- Sleeve (4)
- Alignment Pin (5)
- Bushing (6)
- Bolts (7)
- Fixture Plate (8)

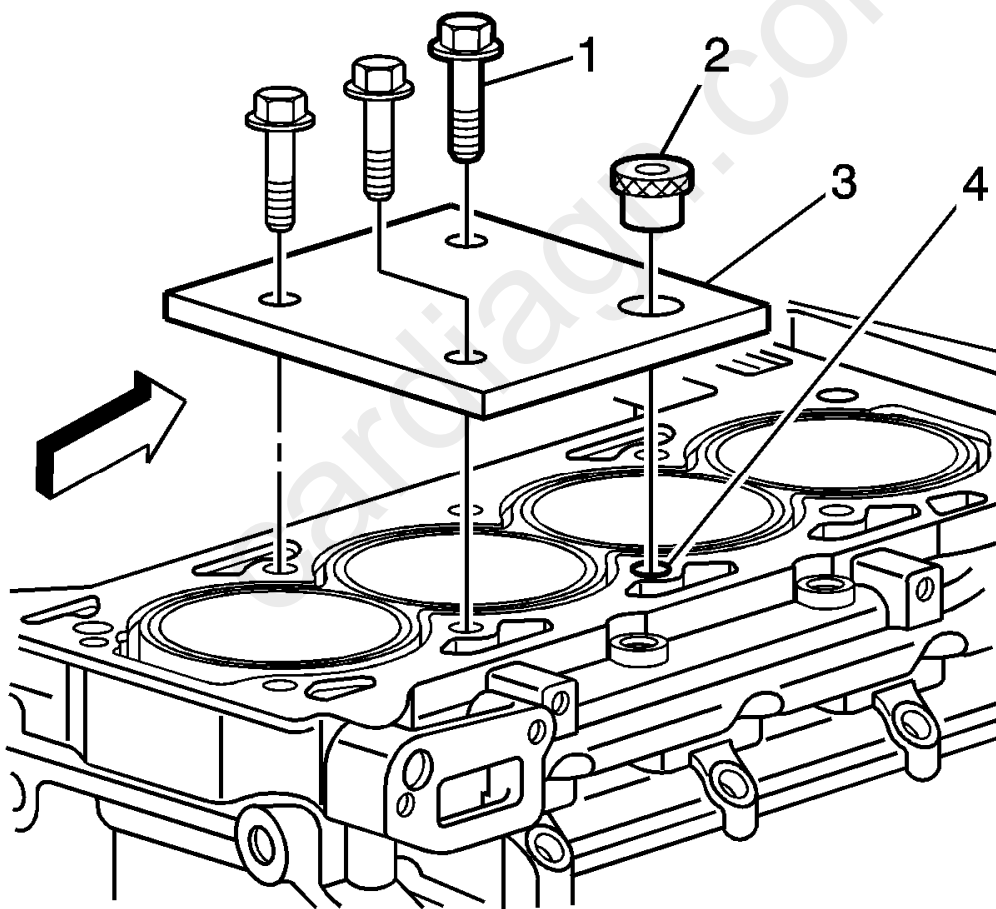


Fig. 182: Installing Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses and Compressed Air Warning .

NOTE: The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers .

Driver oil **MUST** be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

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

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

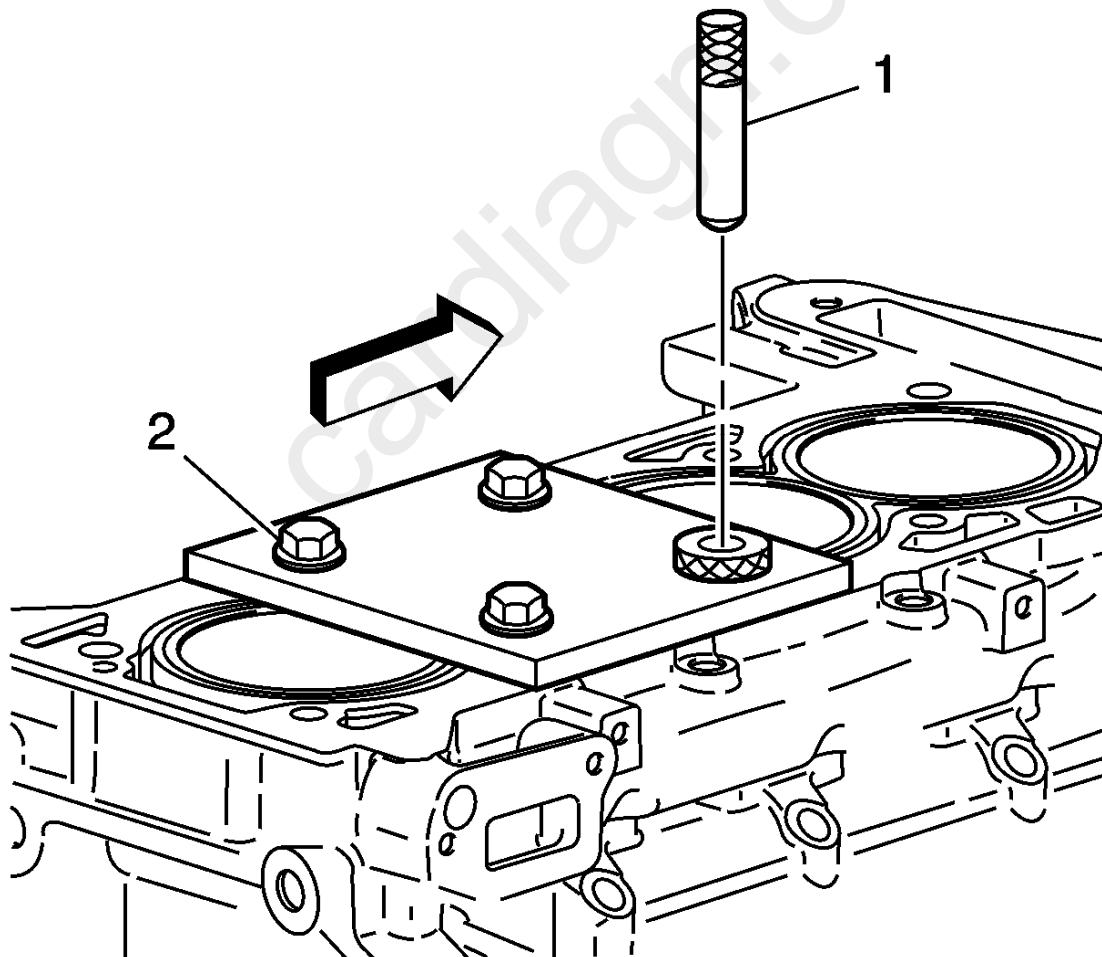


Fig. 183: Identifying Alignment Pin

Courtesy of GENERAL MOTORS COMPANY

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

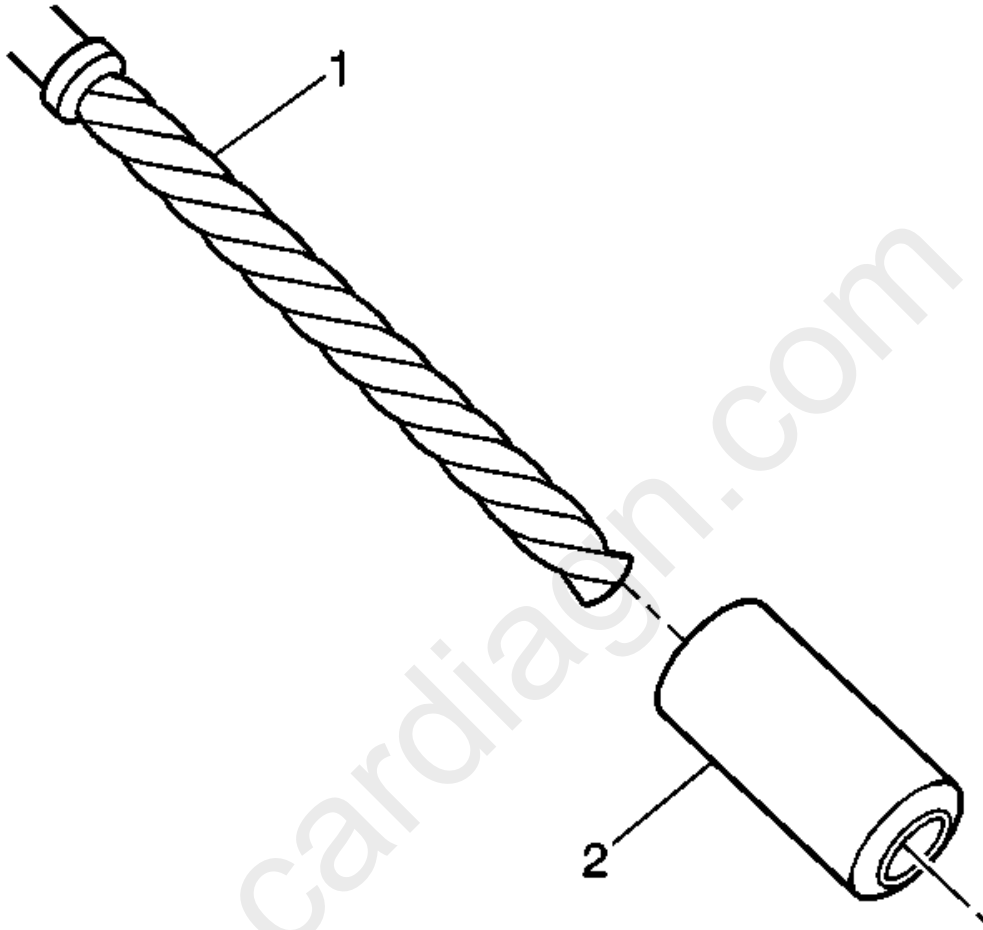


Fig. 184: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

6. Install the sleeve (2) onto the drill (1), if required.

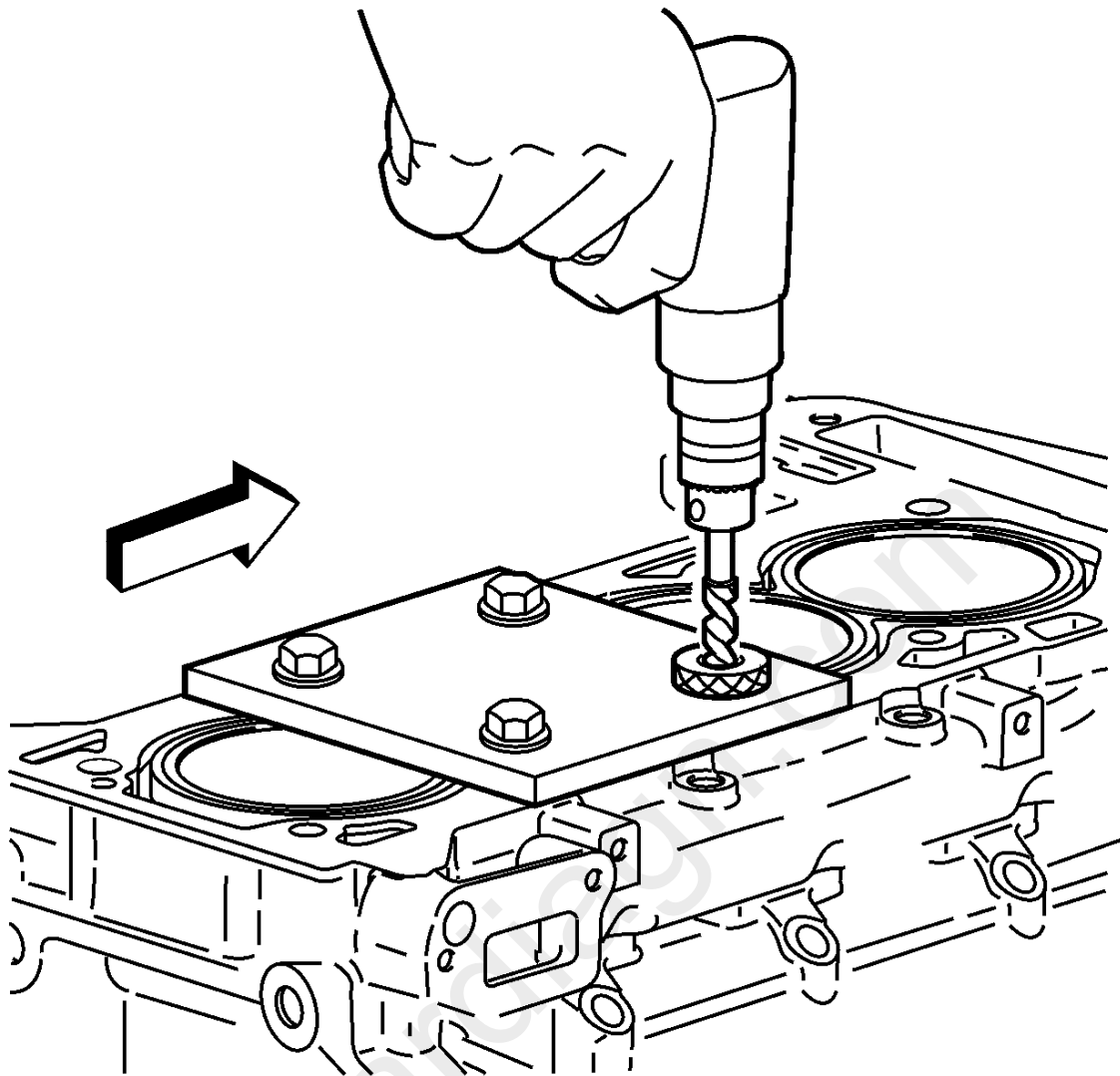


Fig. 185: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

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

7. Drill out the threads of the damaged hole.

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

WARNING: Refer to Safety Glasses and Compressed Air Warning .

8. Using compressed air, clean out any chips.

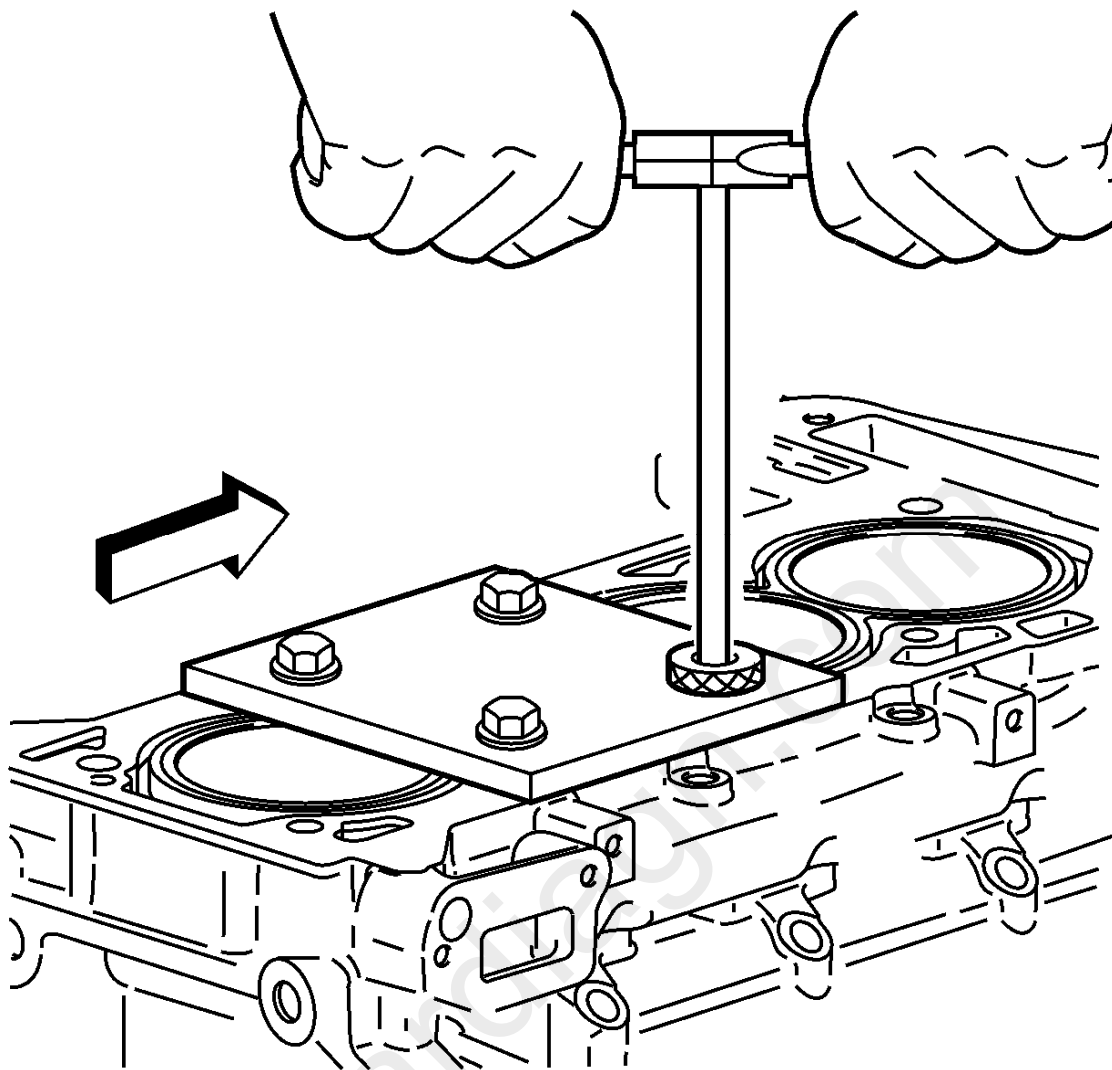


Fig. 186: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS COMPANY

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

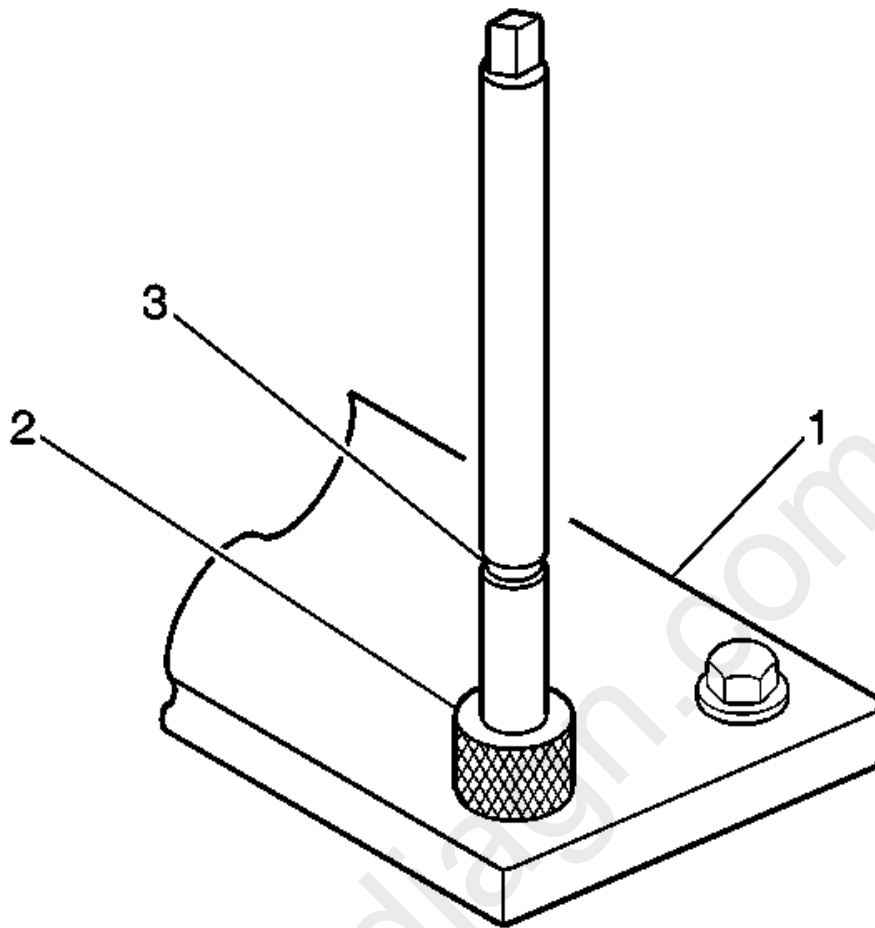


Fig. 187: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

10. Using a TAP wrench, tap the threads of the drilled hole.

In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

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

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
14. Using compressed air, clean any cutting oil and chips out of the hole.

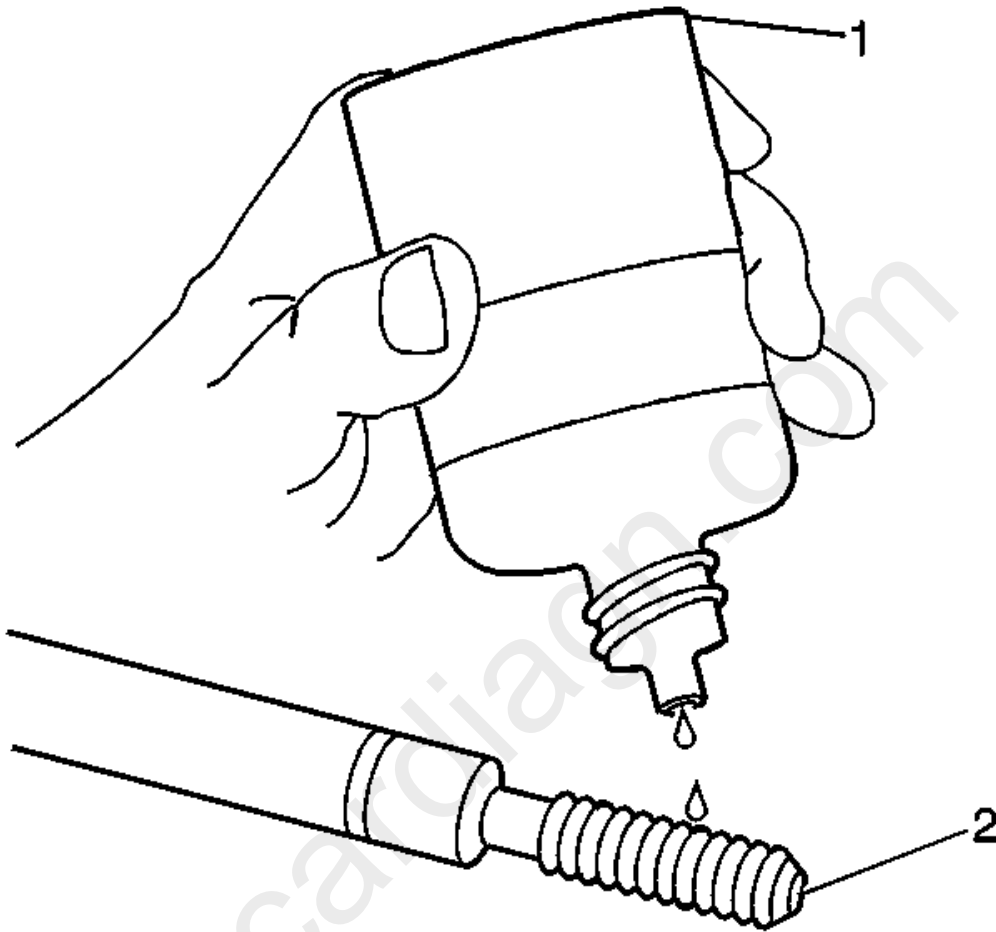


Fig. 188: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

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

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

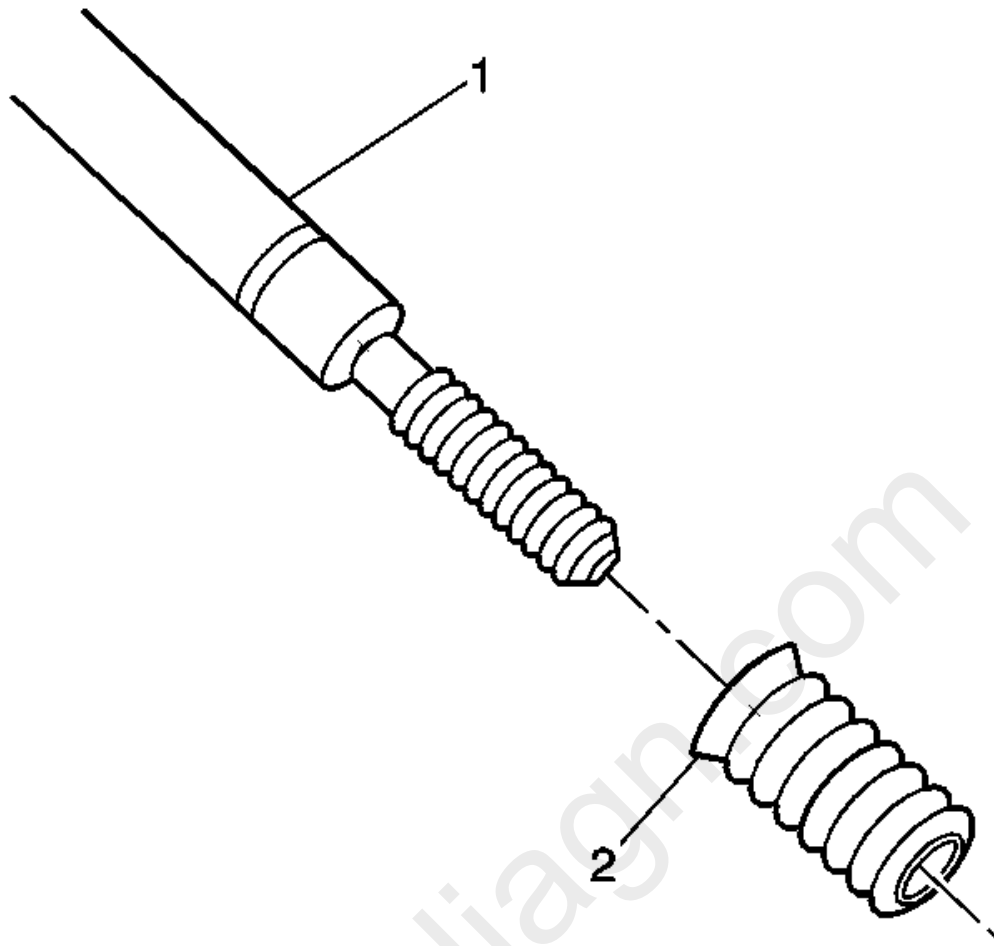


Fig. 189: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

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

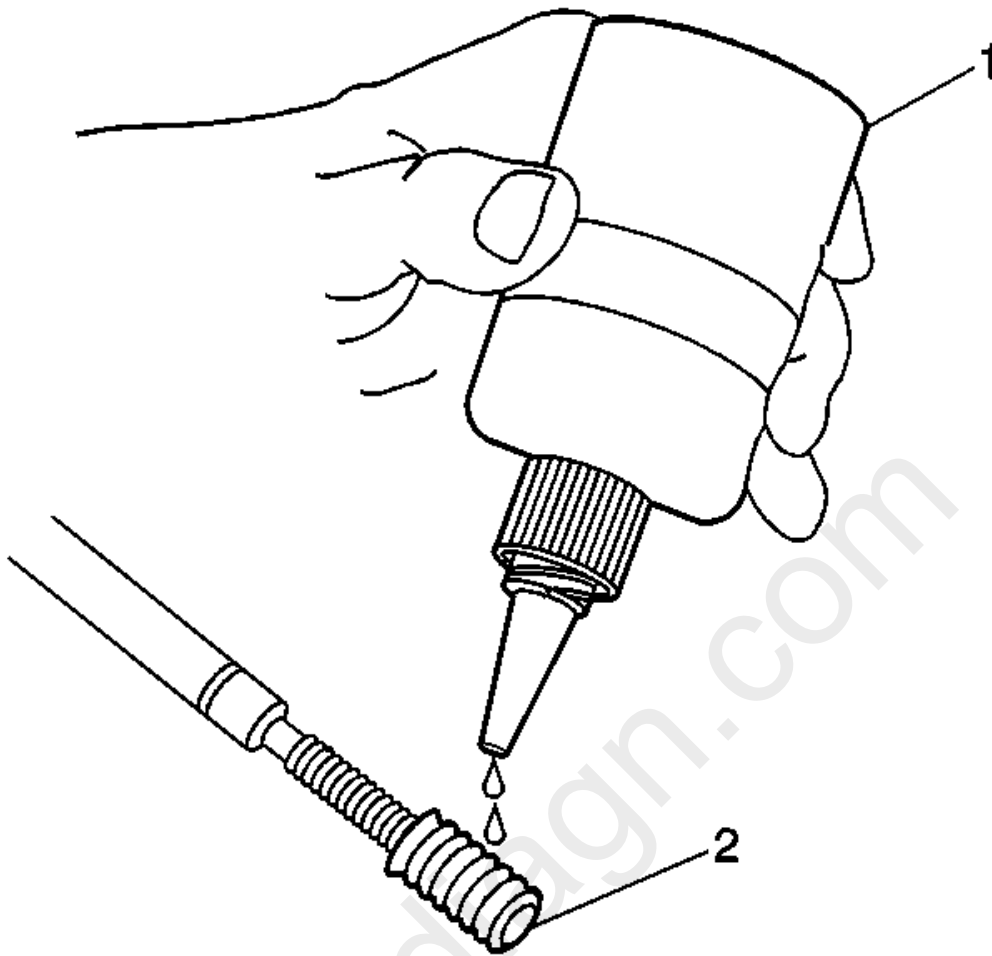


Fig. 190: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

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

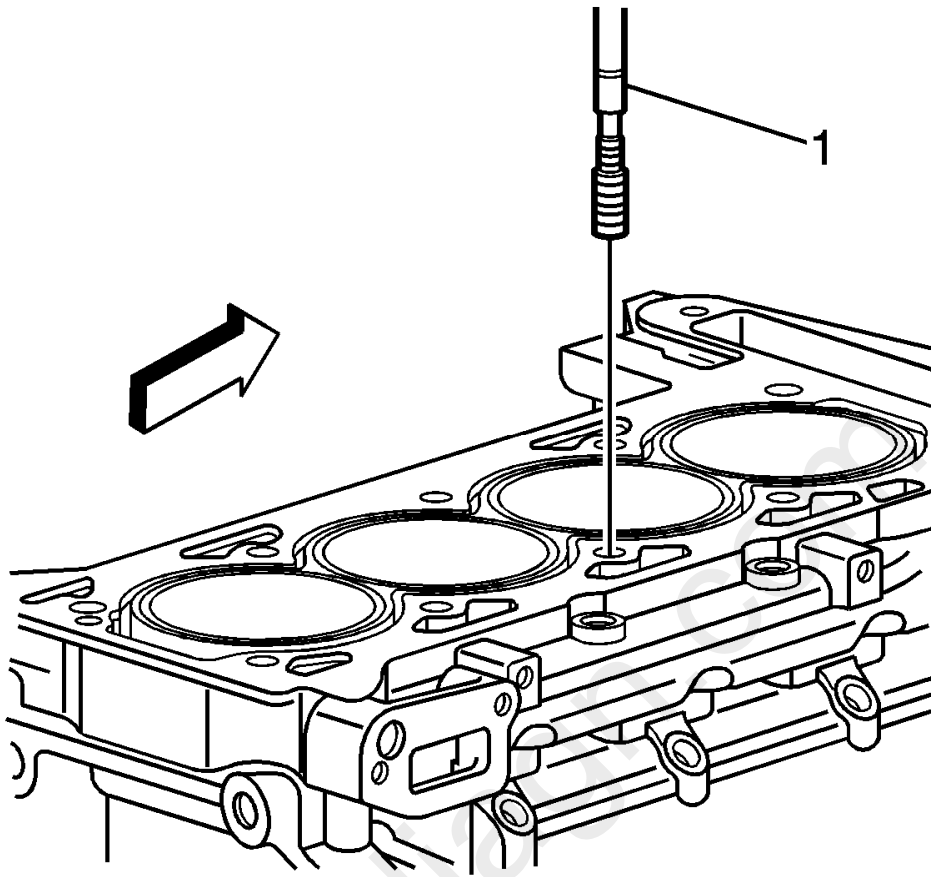


Fig. 191: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS COMPANY

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

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

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

SERVICE PRIOR TO ASSEMBLY

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This

is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

ENGINE BLOCK ASSEMBLE

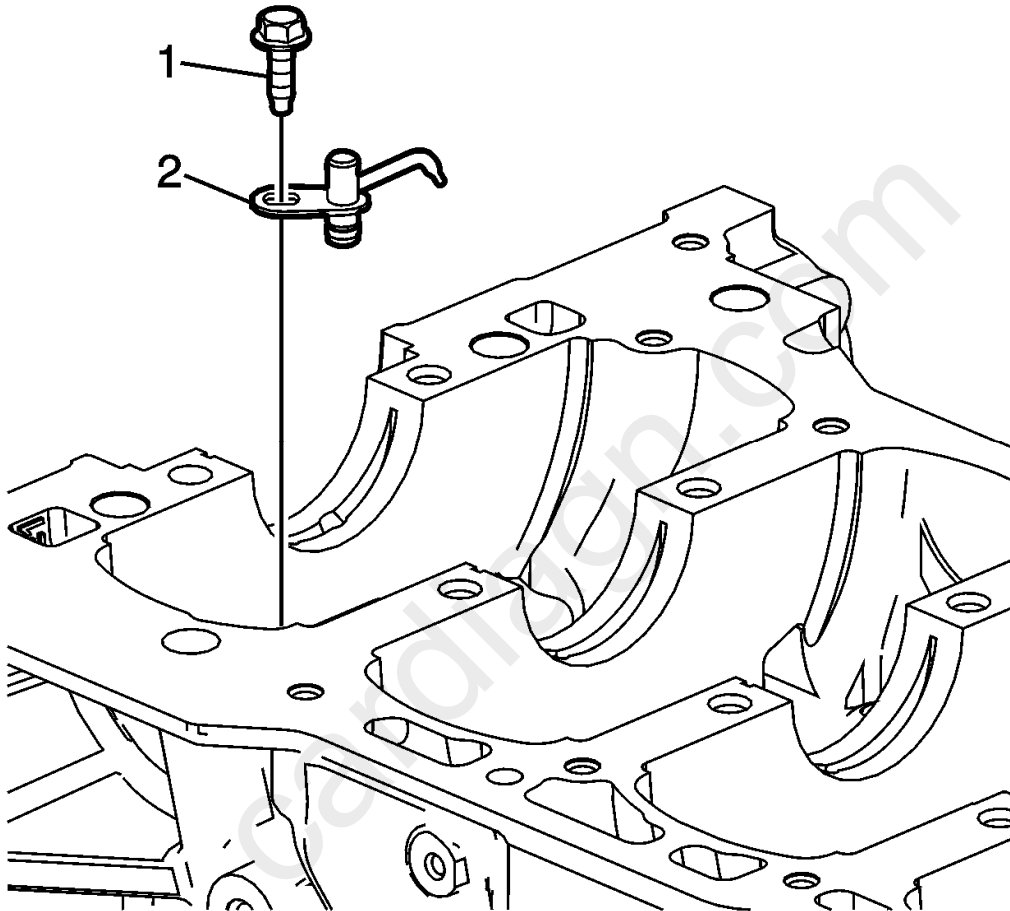


Fig. 192: Piston Oil Nozzle Assembly Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install the piston oil nozzle assemblies (2), if equipped.

CAUTION: Refer to Fastener Caution .

2. Install the piston oil nozzle bolts (1) and tighten to 10 N.m (89 lb in).

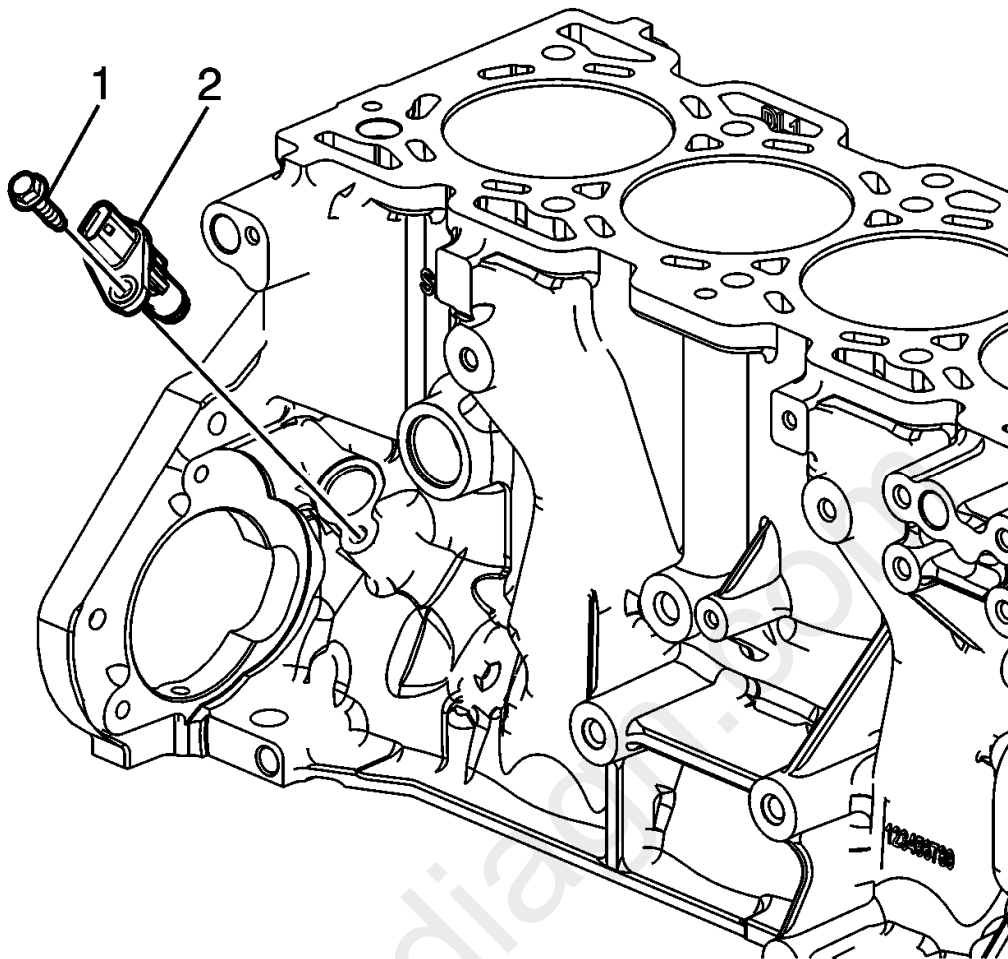


Fig. 193: Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS COMPANY

3. Lubricate the crankshaft position sensor O-ring with engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

CAUTION: Refer to **Component Fastener Tightening Caution** .

4. Install the crankshaft position sensor (2) and bolt (1) and tighten to 10 N.m (89 lb in).

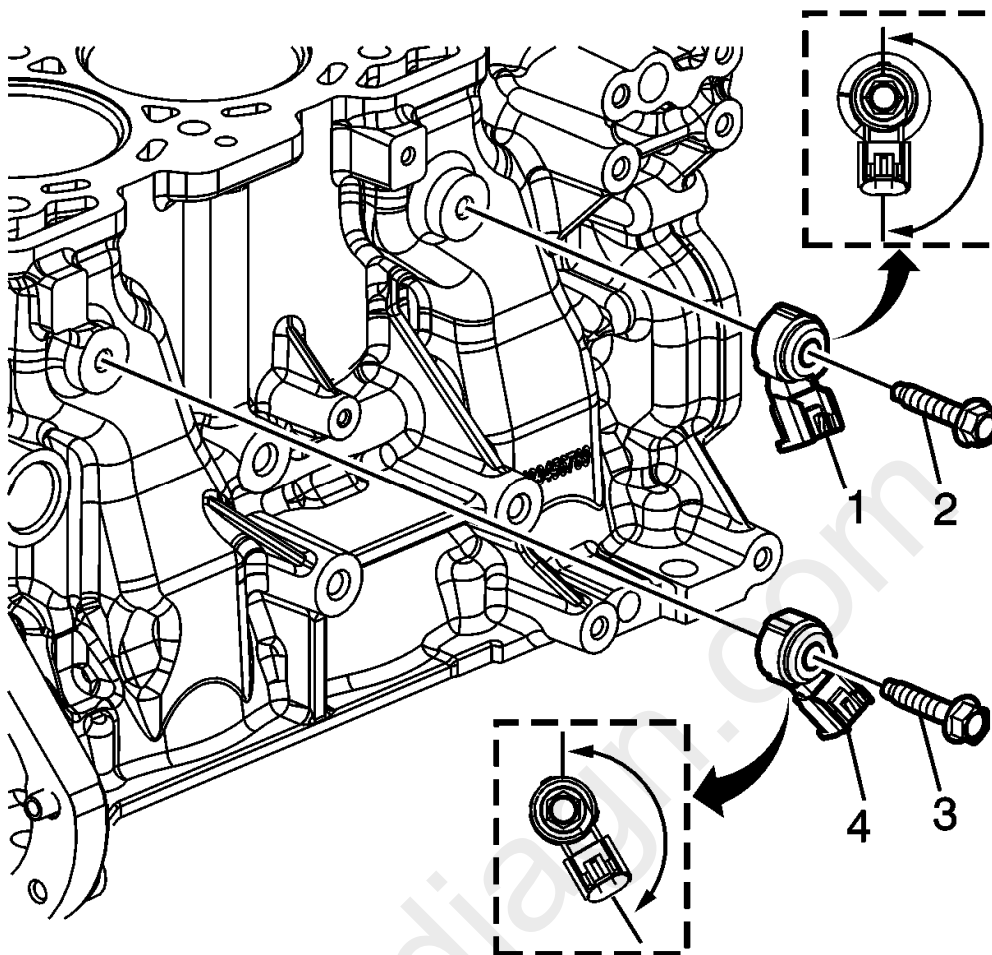


Fig. 194: Knock Sensor
Courtesy of GENERAL MOTORS COMPANY

5. Install the knock sensor (1) at 6 O' clock. Install the bolt (2) and tighten to 25 N.m (18 lb ft).
6. Install the knock sensor (4) at 5 O' clock. Install the bolt (3) and tighten to 25 N.m (18 lb ft).

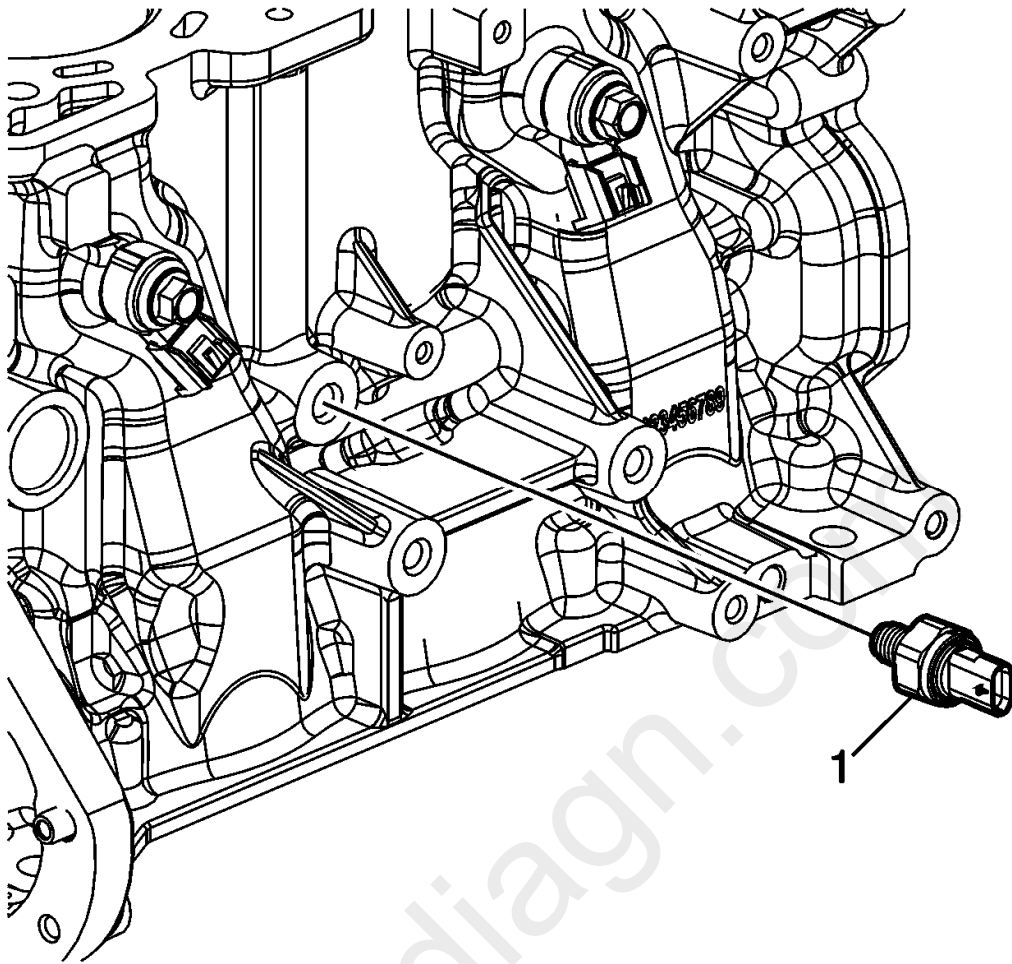


Fig. 195: Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

7. Install the engine oil pressure sensor (1) and tighten to 27 N.m (20 lb ft).

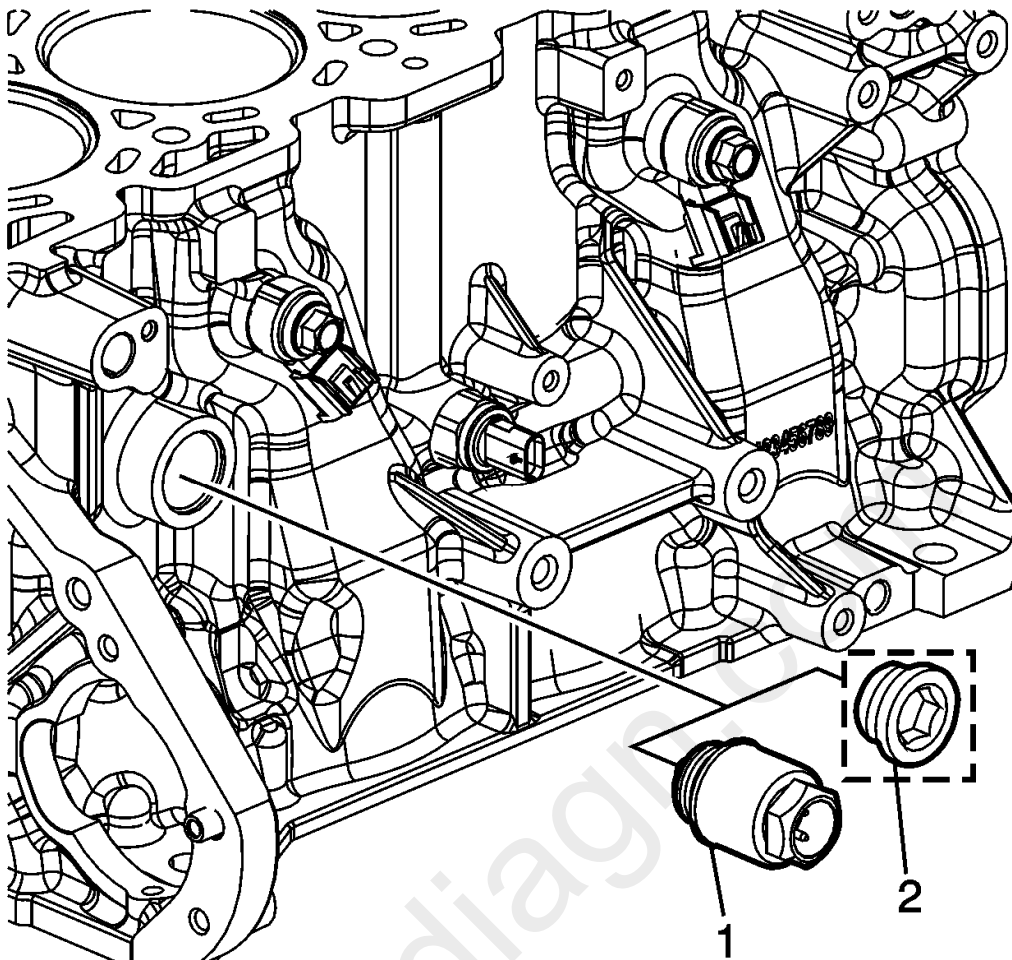


Fig. 196: Engine Coolant Heater
Courtesy of GENERAL MOTORS COMPANY

8. Install the engine coolant heater assembly (1), if equipped. Tighten the assembly to 50 N.m (37 lb ft).
9. If the engine coolant heater assembly is not equipped, install the engine coolant heater hole plug (2). Tighten the plug to 60 N.m (44 lb ft).

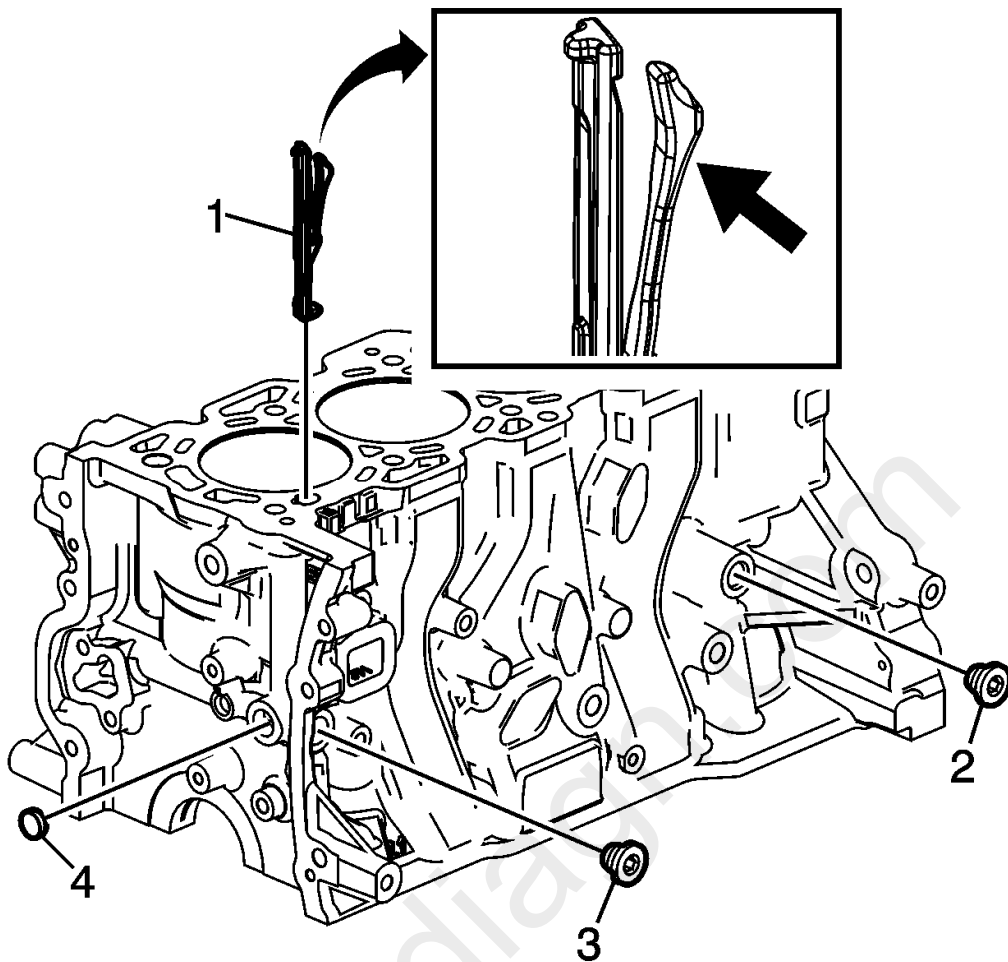


Fig. 197: Engine Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

10. Apply sealant to all plugs prior to installation. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
11. Install the engine oil gallery cup plug (4).
12. Install the engine oil gallery plugs (2, 3), with sealant, and tighten to 65 N.m (48 lb ft).

NOTE: Always install the baffle with the forked end pointed up. Do not force the baffle into place. Aligning the shape of the orifice and the baffle, and gently depressing the clip will allow the baffle to easily drop into place.

13. Carefully align and install the engine block coolant baffle (1).

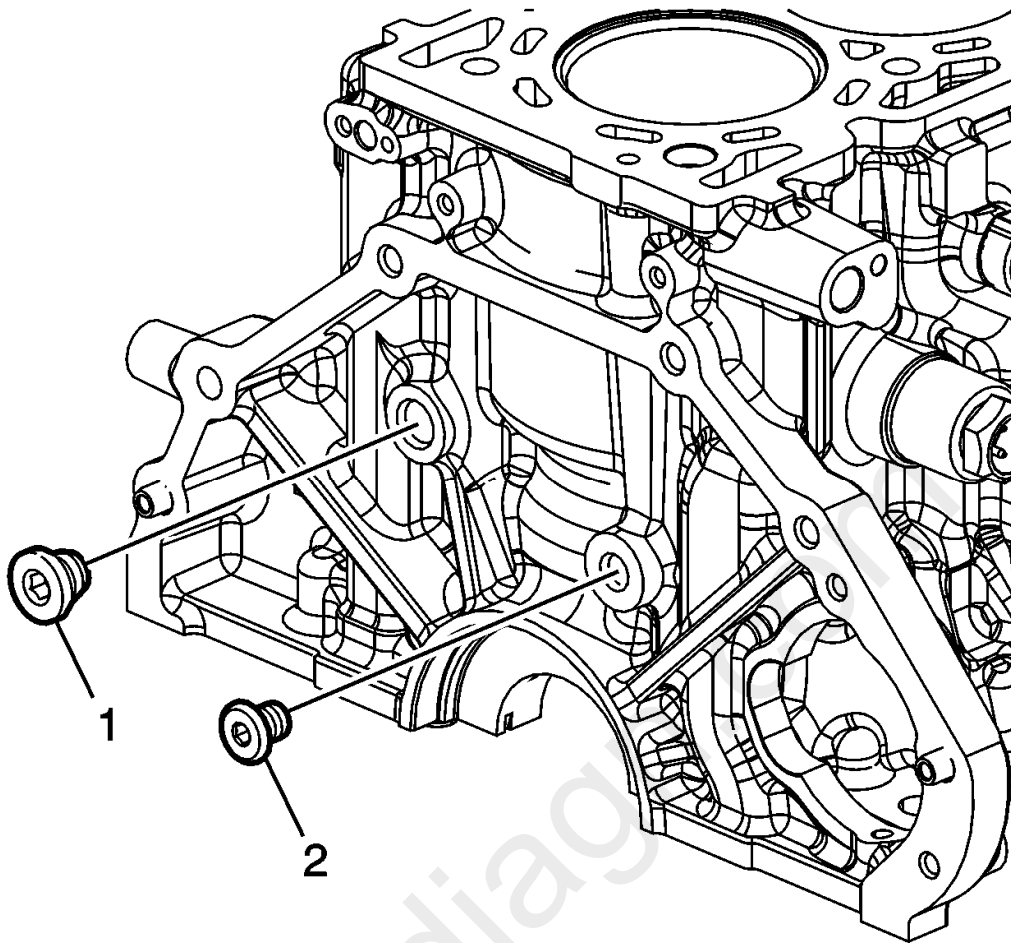


Fig. 198: Engine Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

14. Install the engine oil gallery plug (1), with sealant, and tighten to 65 N.m (48 lb ft).
15. Install the engine oil gallery plug (2), with sealant, and tighten to 40 N.m (30 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **EN-8087** Cylinder Bore Checking Gauge
- **EN 45059** Angle Meter

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

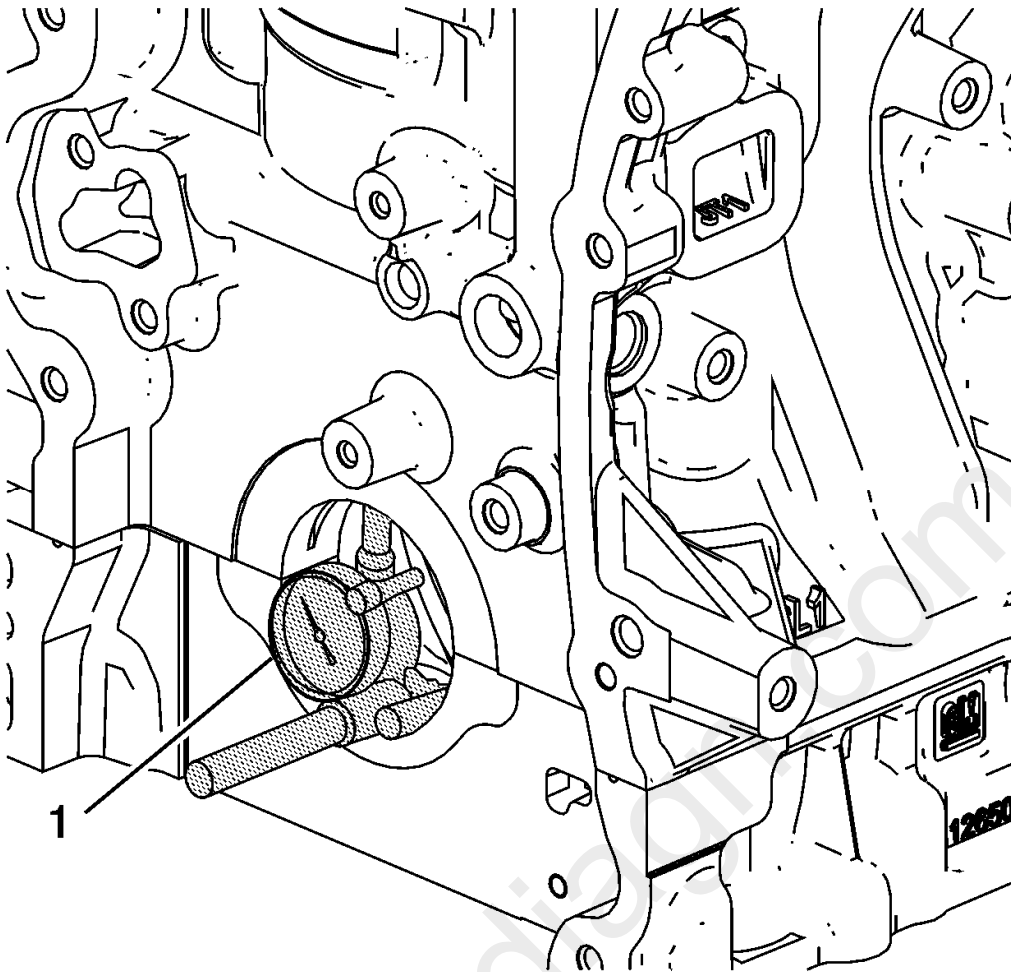


Fig. 199: View Of Cylinder Bore Gauge
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.
- If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **EN 45059** meter.
- Measure the bearing bore for taper and out-of-round using the **EN-8087** gauge (1).
- No taper or out-of-round should exist.

Bearing Selection

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are two

methods to measure bearing clearance. Method A gives more reliable results and is preferred.

- Method A yields measurement from which the bearing clearance can be computed.
- Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

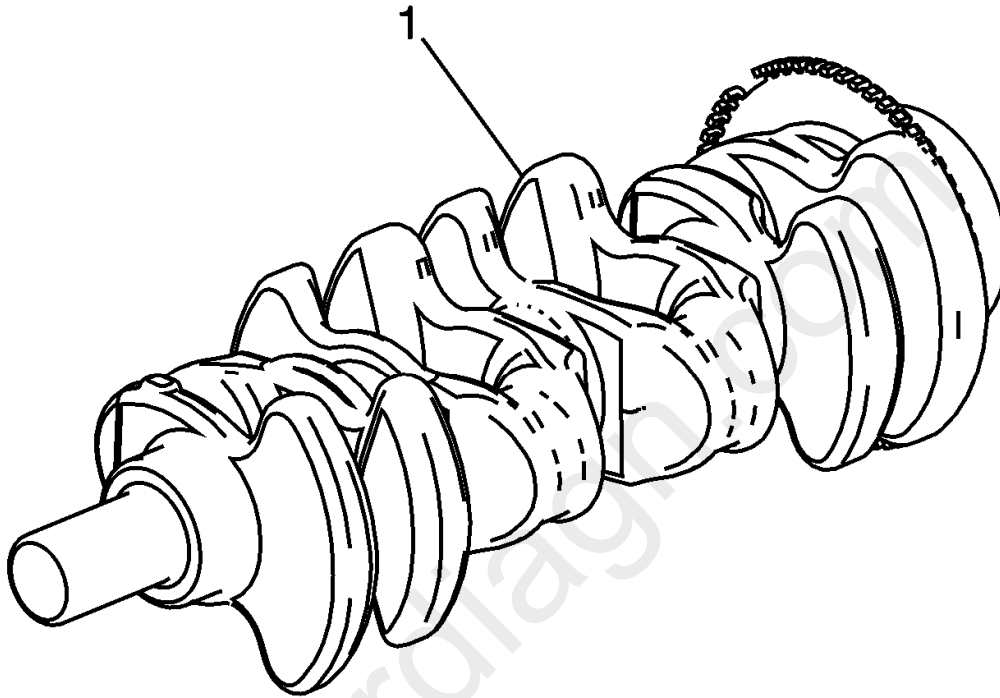


Fig. 200: Measuring Bearing Clearance Using Method A
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
 1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
 2. Measure the crankshaft bearing journal taper and runout.
 3. Install the lower crankcase and tighten the bearing cap bolts to specification.
 4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
 5. Subtract journal measurement from bearing ID measurement to determine clearance.

6. Determine whether clearance is within specification.
7. If out of specification, choose different inserts.
8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
9. Measure the crankshaft main bearing inside diameter with an inside micrometer.

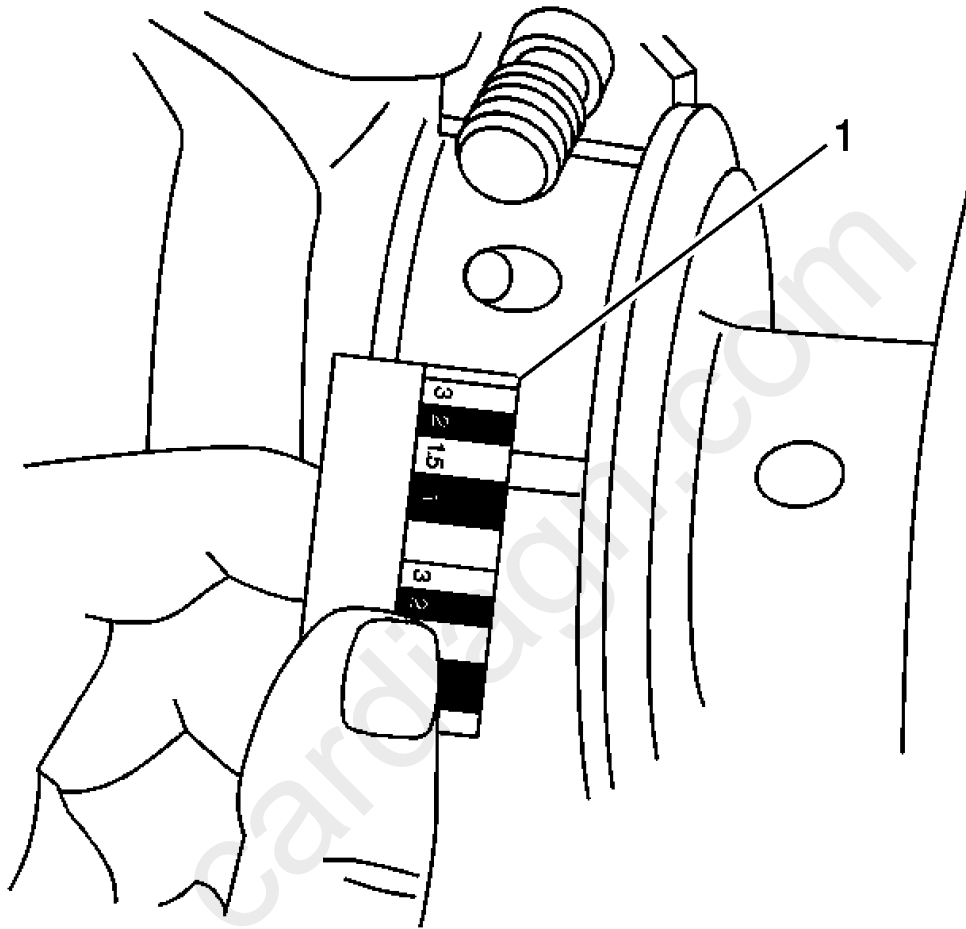


Fig. 201: Measuring Bearing Clearance Using Method B
Courtesy of GENERAL MOTORS COMPANY

3. To measure bearing clearance using Method B, use the following procedure:
 1. Clean the used bearing inserts.
 2. Install the used bearing inserts.
 3. Place a piece of gaging plastic across the entire bearing width at 90 degrees to block/lower crankcase split line.
 4. Install the bearing caps.

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

5. Install the bearing cap bolts to specification.

NOTE: **Do not rotate the crankshaft.**

6. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or to the bearing cap.
7. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
8. Remove the gauging plastic.

Crankshaft Installation

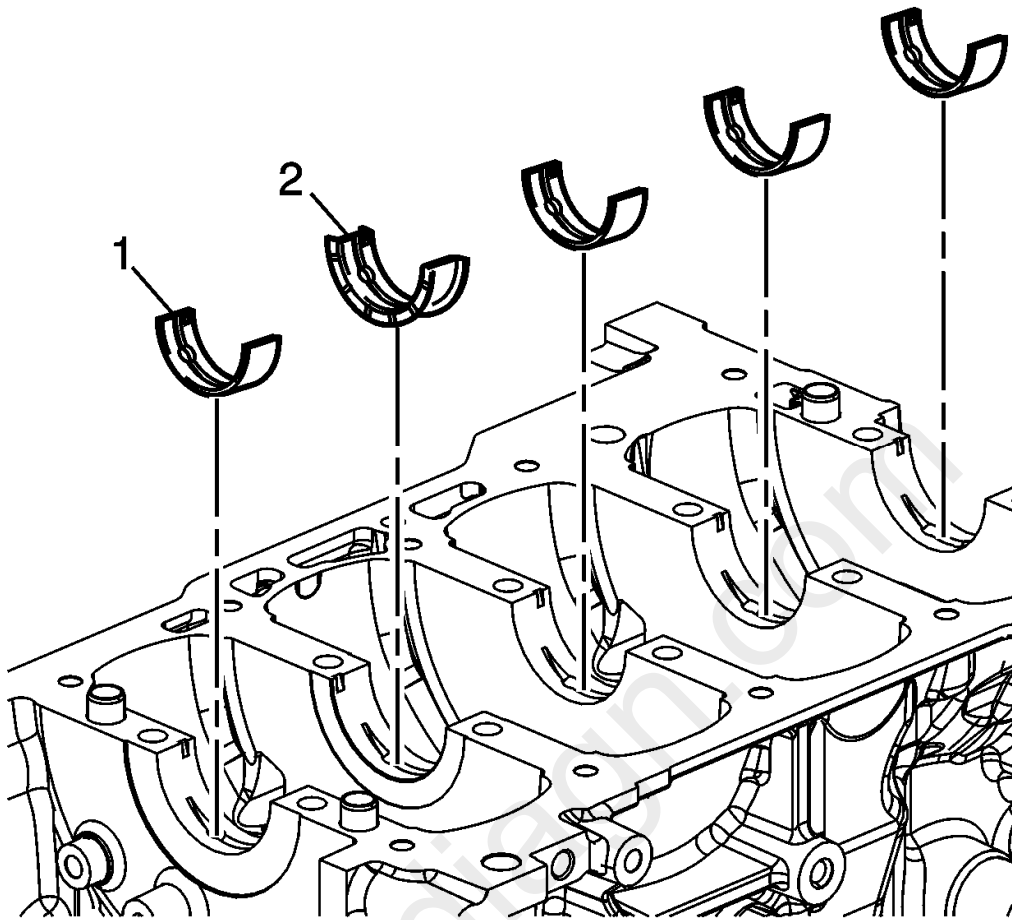


Fig. 202: Crankshaft Upper Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.
2. Install the crankshaft upper thrust bearing (3) and lubricate bearing surfaces with engine oil.

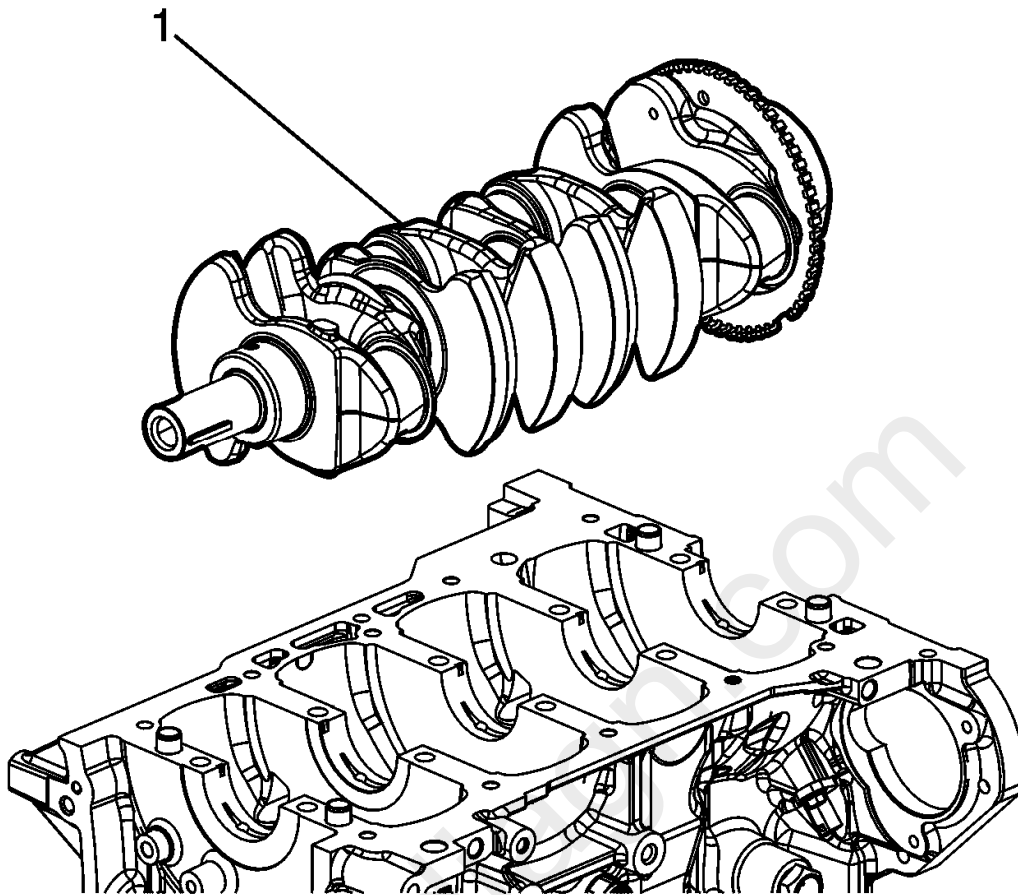


Fig. 203: Crankshaft
Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft (1) on the journals.

LOWER CRANKCASE INSTALLATION

Special Tools

- EN 45059 Angle Meter
- EN-51380 Seal Installer

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

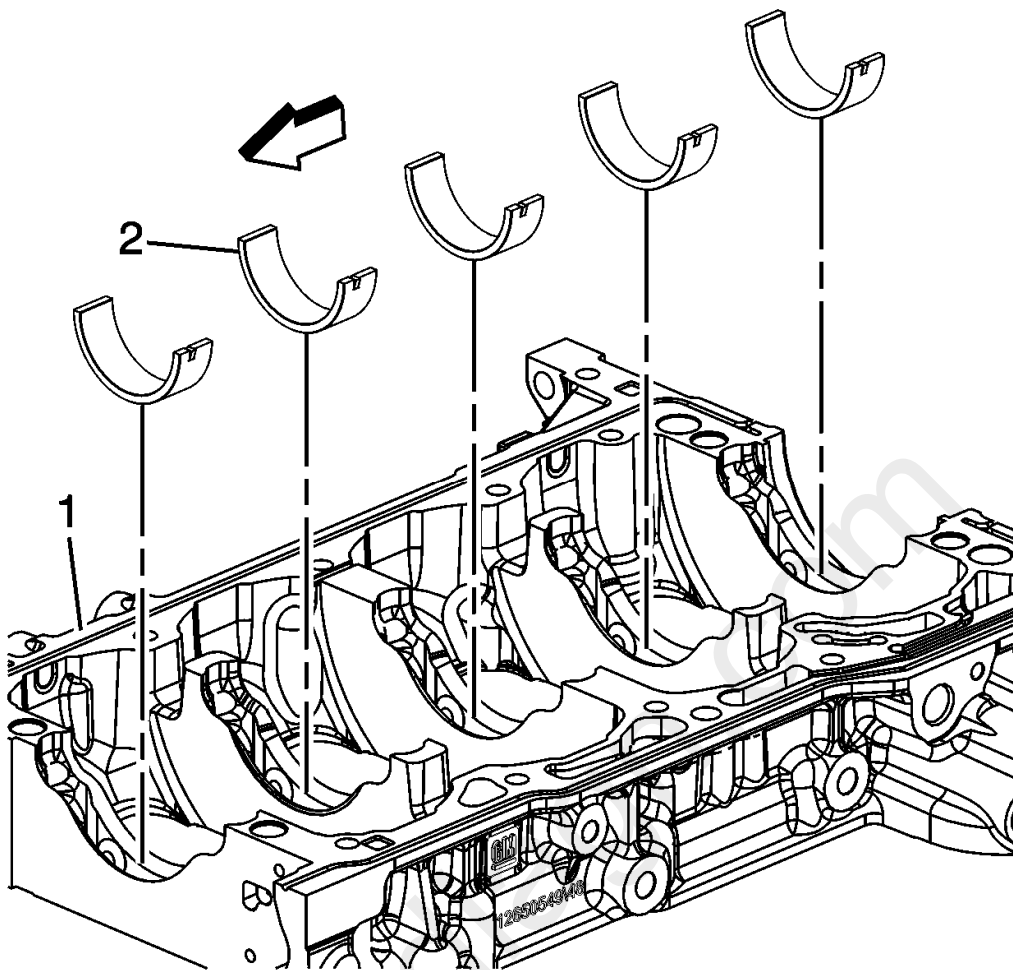


Fig. 204: Crankshaft Lower Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

1. Install the lower bearing halves (2), without grooves, into the lower crankcase (1). Apply oil to bearing surfaces.

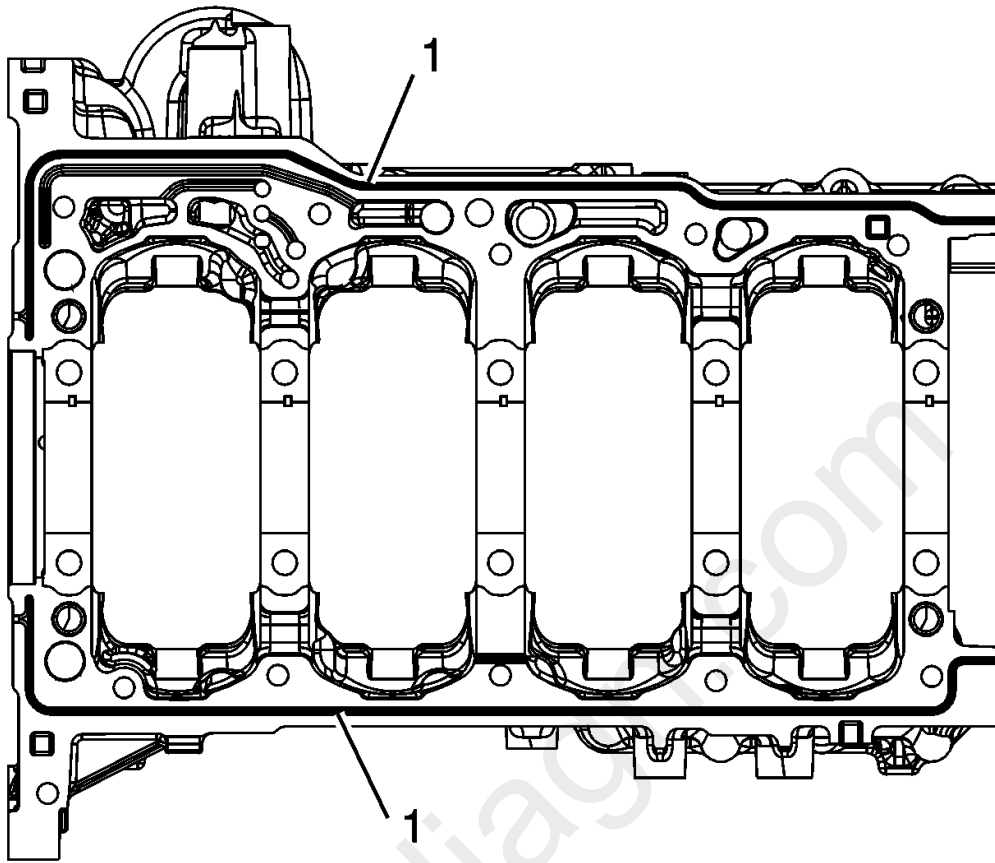


Fig. 205: Applying Bead Of Sealer Directly In Groove
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The block assembly surface must be free of contamination prior to applying the sealer.
- Install and align the bedplate to block within 20 minutes of applying the sealer.
- The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.

2. Apply a 4.25 mm bead of sealer directly in the groove (1) of the block to bedplate mating surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers .

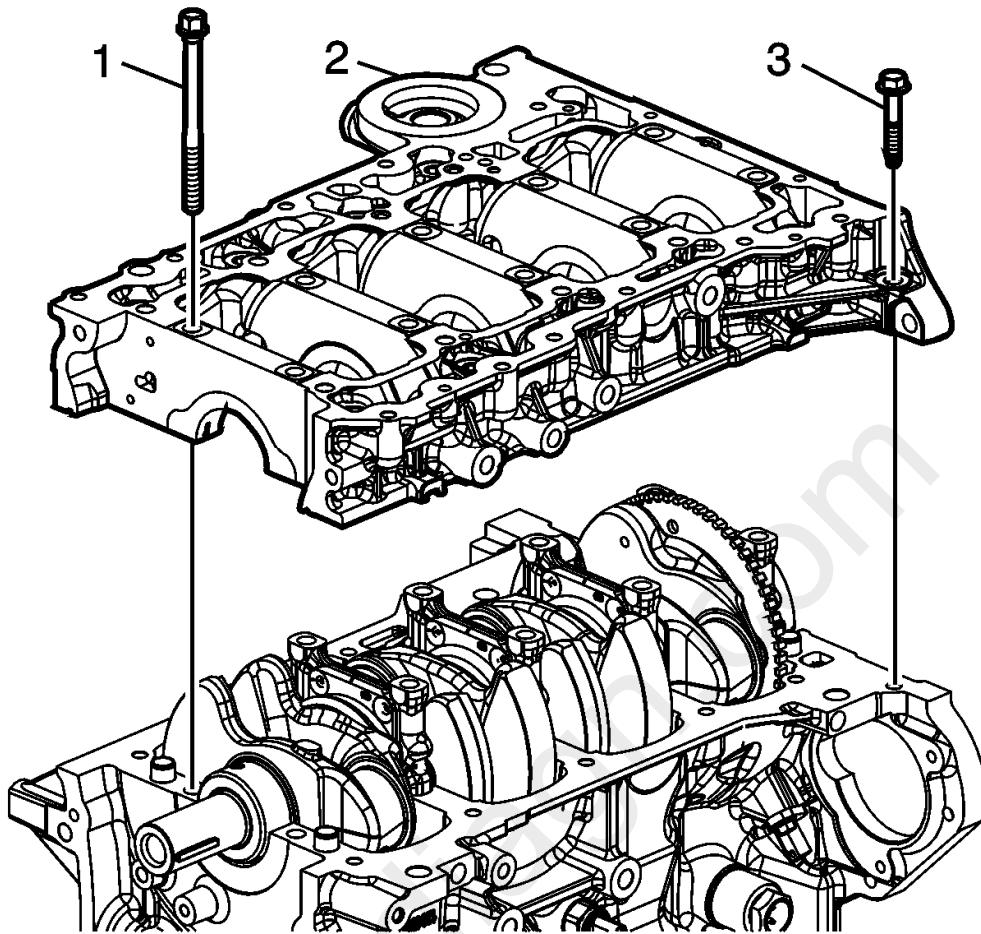


Fig. 206: Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the lower crankcase (2). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

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

4. Install the NEW crankshaft bearing bolts (1) finger tight.
5. Install NEW lower crankcase perimeter bolts (3) finger tight.

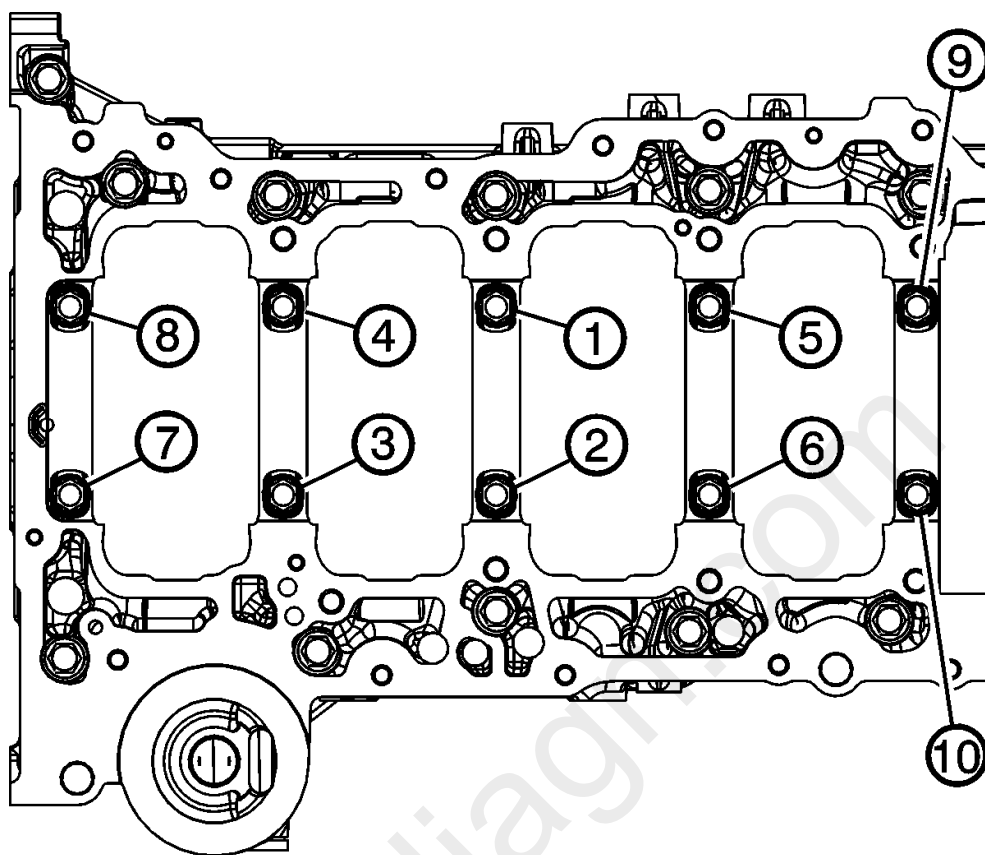


Fig. 207: Crankshaft Bearing Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Tighten the crankshaft bearing bolts in sequence using the following procedure:
 1. Tighten the crankshaft bearing bolts a first pass in sequence to 20 N.m (15 lb ft).
 2. Tighten the crankshaft bearing bolts a final pass in sequence using the **EN 45059** meter an additional 140 degrees.

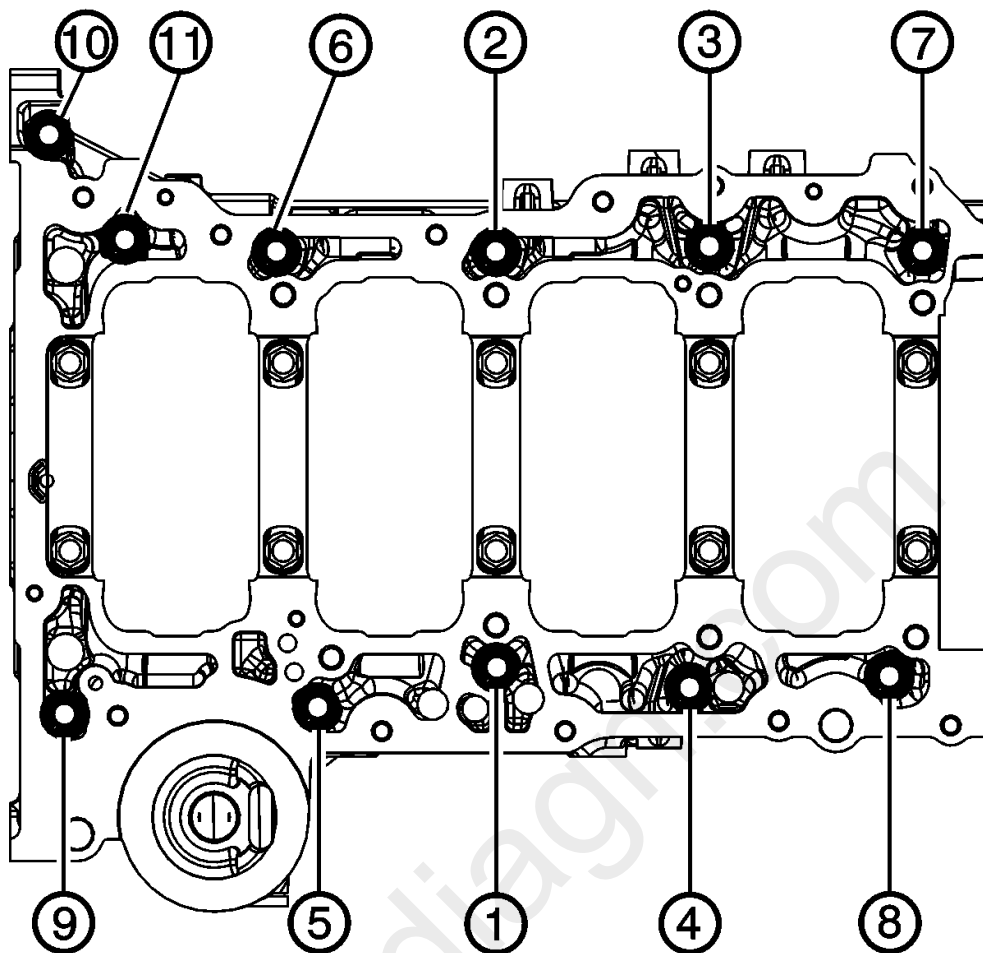


Fig. 208: Lower Crankcase Perimeter Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

7. Tighten the lower crankcase perimeter bolts in sequence to 25 N.m (18 lb ft).

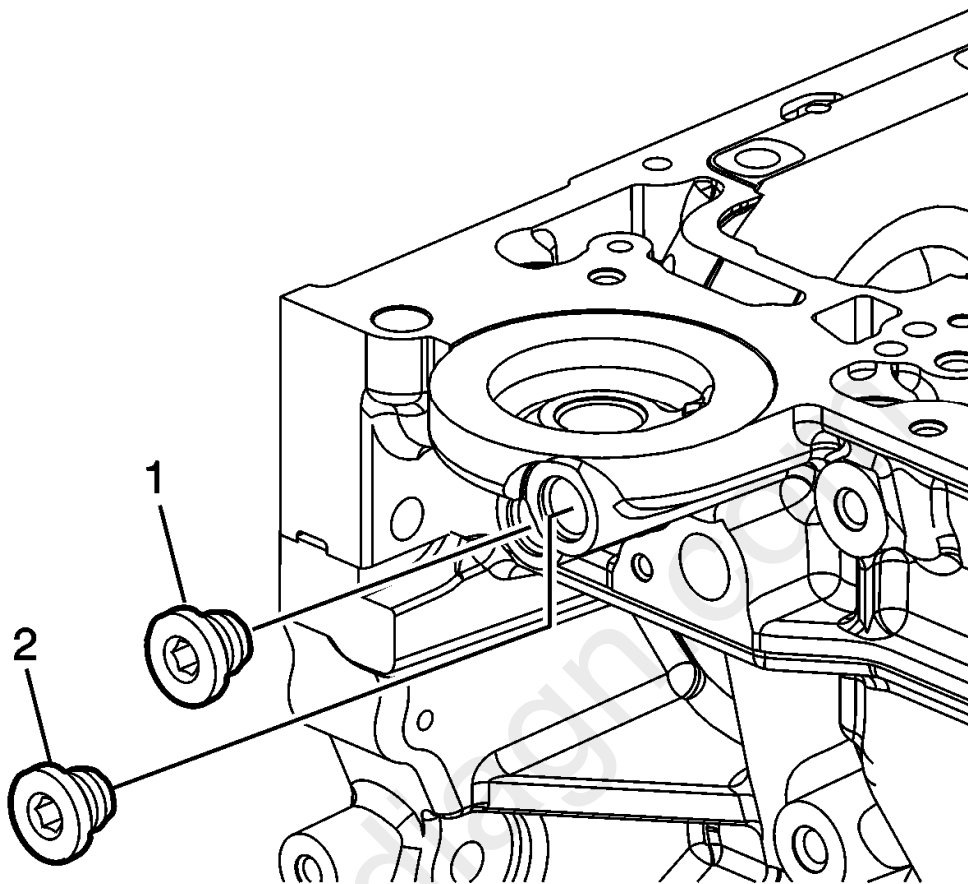


Fig. 209: Oil Gallery Plugs
Courtesy of GENERAL MOTORS COMPANY

8. Install the engine oil gallery plugs (1, 2). Tighten the plugs to 65 N.m (48 lb ft).

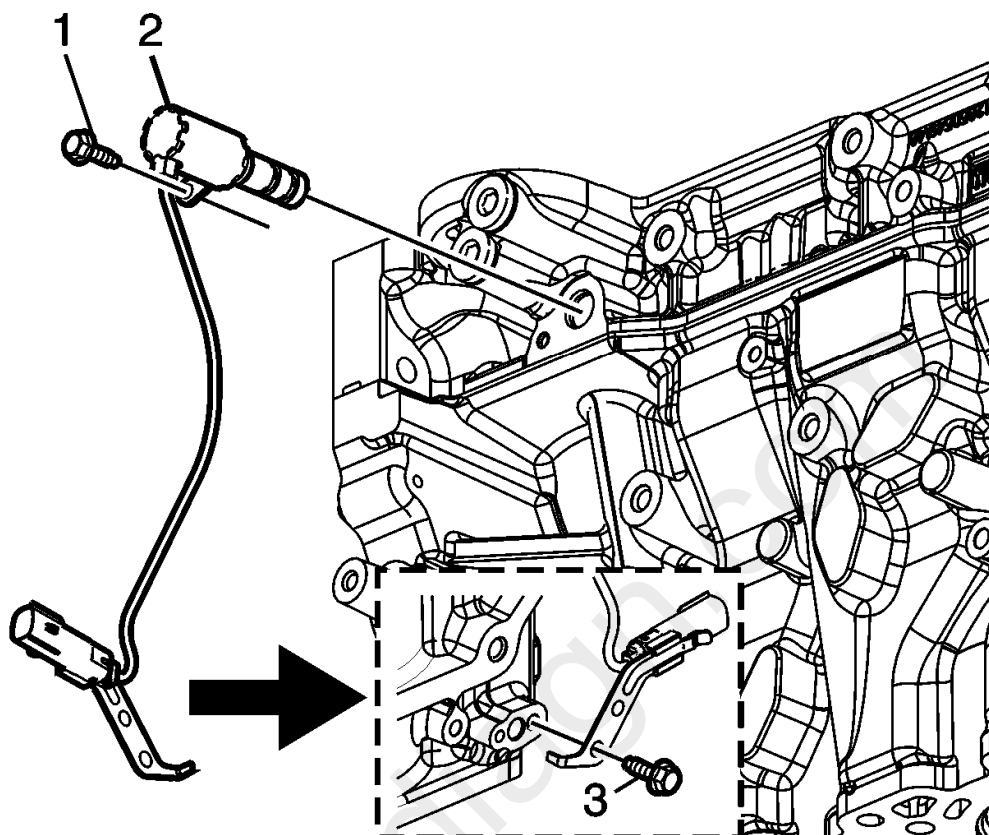


Fig. 210: Oil Pump Flow Control Valve And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Install the oil pump flow control valve (2) and bolts (1, 3). tighten the bolts to 10 N.m (89 lb in).

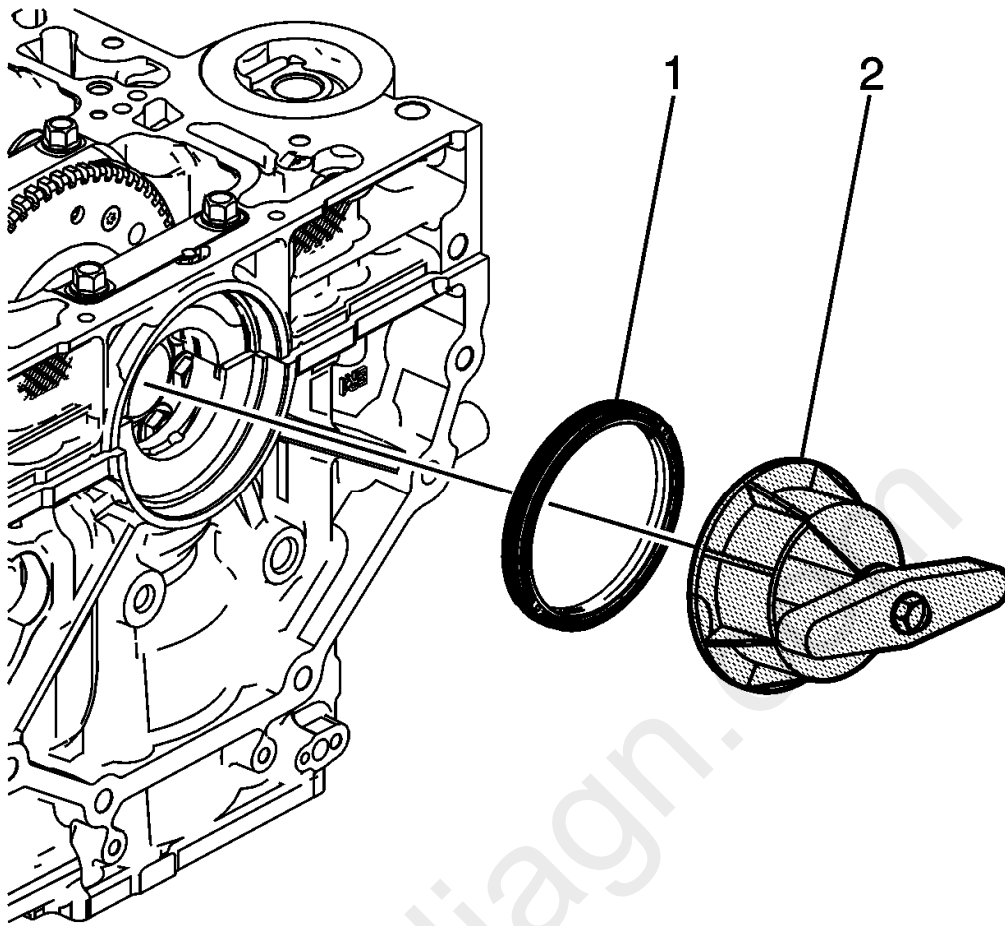


Fig. 211: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

10. Using **EN-51380** installer (2), install the crankshaft rear oil seal (1) flush or recessed up to 0.5 mm to block.
11. Rotate the crankshaft to ensure that it moves freely and does not bind.
12. Measure and record the crankshaft endplay. Refer to **Engine Mechanical Specifications** .

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

NOTE: **This procedure is not used in Europe.**

Special Tools

- **EN-8037** Ring Compressor
- **EN-43966** Connecting Rod Guides
- **EN 45059** Angle Meter

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

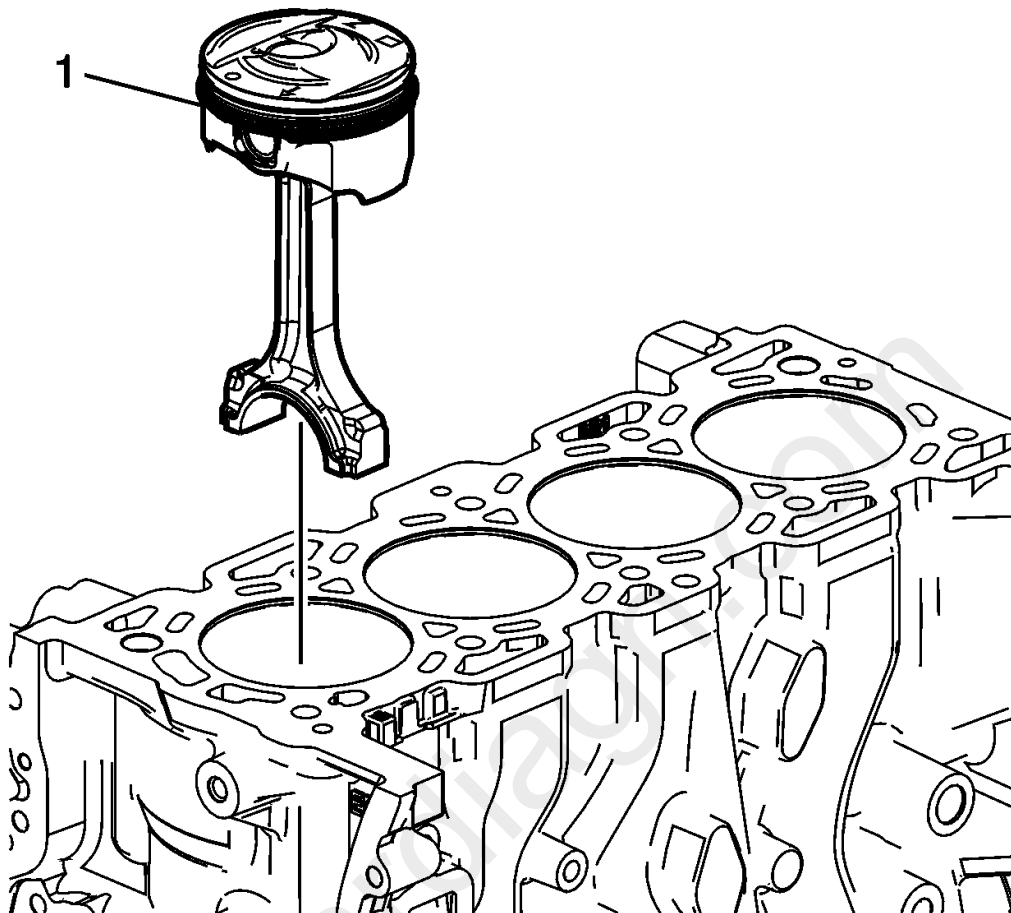


Fig. 212: Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: The connecting rods and caps must be installed in the same order and orientation in which they were removed. If new connecting rods are required, the connecting rod is provided as an assembly, and the upper rod will need to be disassembled from the lower cap.

1. Install the connecting rod bearings. Use NEW bearings.

NOTE: The connecting rod bearing anti-rotation tab grooves are to point toward the right-hand side of the engine.

1. Install the bearing inserts into the connecting rod and the connecting rod cap.
2. Lubricate the connecting rod bearings with engine oil.
2. Install the **EN-43966** guides (2) into the connecting rod bolt holes. This protects the crankshaft journal

during piston and connecting rod installation.

3. Install **EN-8037** compressor , piston (1), and the connecting rod to the correct bore.
 1. Stagger each piston ring end gap equally around the piston.
 2. Lubricate the piston and the piston rings with engine oil.
 3. Do not disturb the piston ring end gap location.
 4. The piston must be installed so that the arrow mark on the top of the piston points to the front of the engine.
 5. Lubricate the engine bore with engine oil, then place the piston in its matching bore.
 6. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
 7. Hold the **EN-8037** compressor against the engine block until all the rings have entered the cylinder bore.
 8. Remove the connecting rod guides from the connecting rod bolt holes.

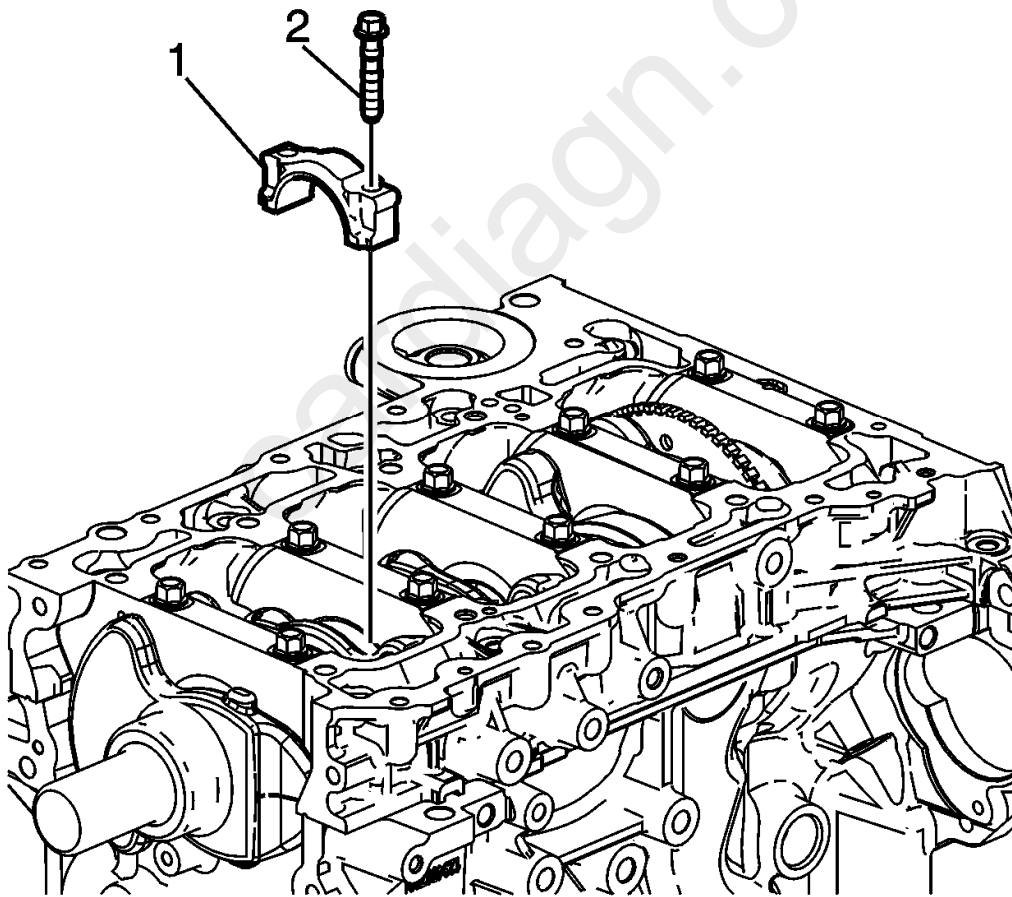


Fig. 213: Connecting Rod Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap (1).

CAUTION: Refer to Fastener Caution .

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

5. Install the NEW connecting rod bolts (2).
 1. Tighten all the connecting rod bolts a first pass to 25 N.m (18 lb ft).
 2. Tighten all the connecting rod bolts a final pass an additional 110 degrees using the **EN 45059** meter.
6. Install the remaining connecting rods and piston assemblies.

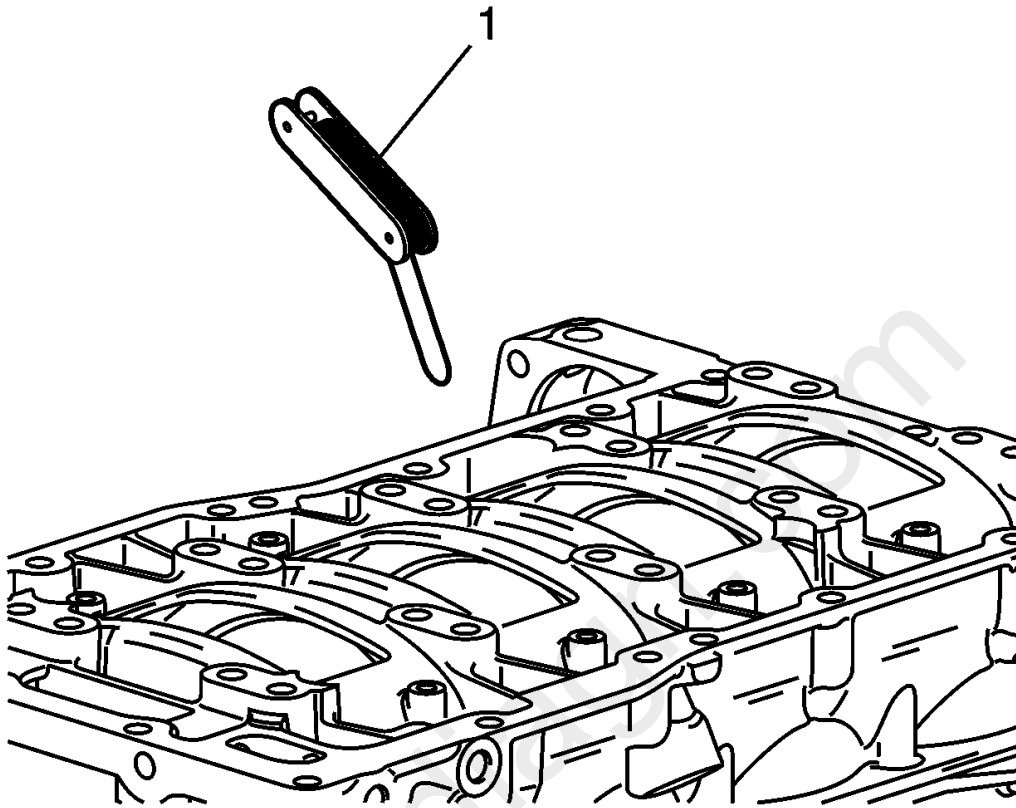


Fig. 214: View of Checking Rod Side Clearance With Feeler Gage
Courtesy of GENERAL MOTORS COMPANY

NOTE: Rotate the crankshaft to ensure that it moves freely and does not bind.

7. Measure the connecting rod side clearance with a feeler gauge (1). Refer to **Engine Mechanical Specifications** .
8. Measure the piston deck height. Refer to **Engine Mechanical Specifications** .

BALANCER SHAFT WITH OIL PUMP INSTALLATION

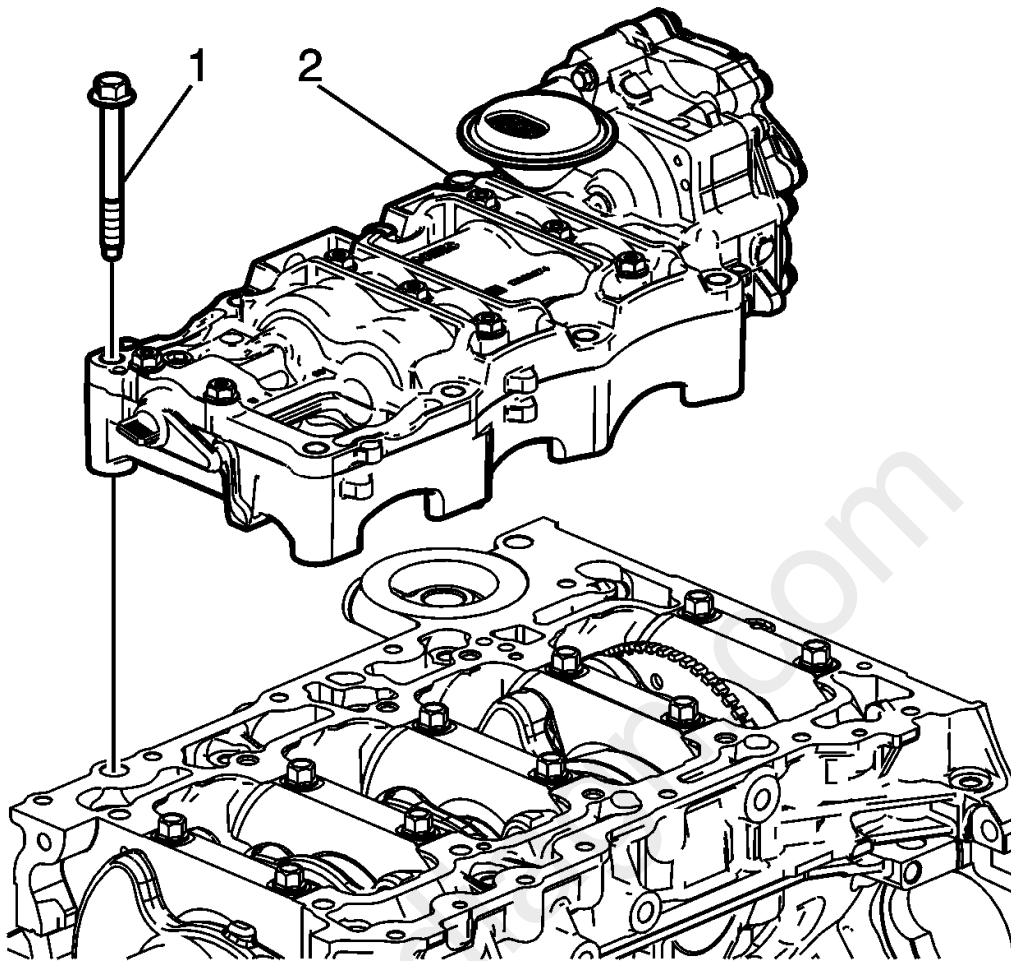


Fig. 215: Balancer And Oil Pump Shaft Assembly Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the balancer and oil pump shaft assembly (2).
2. Install the balancer and oil pump shaft assembly bolts (1) finger tight.

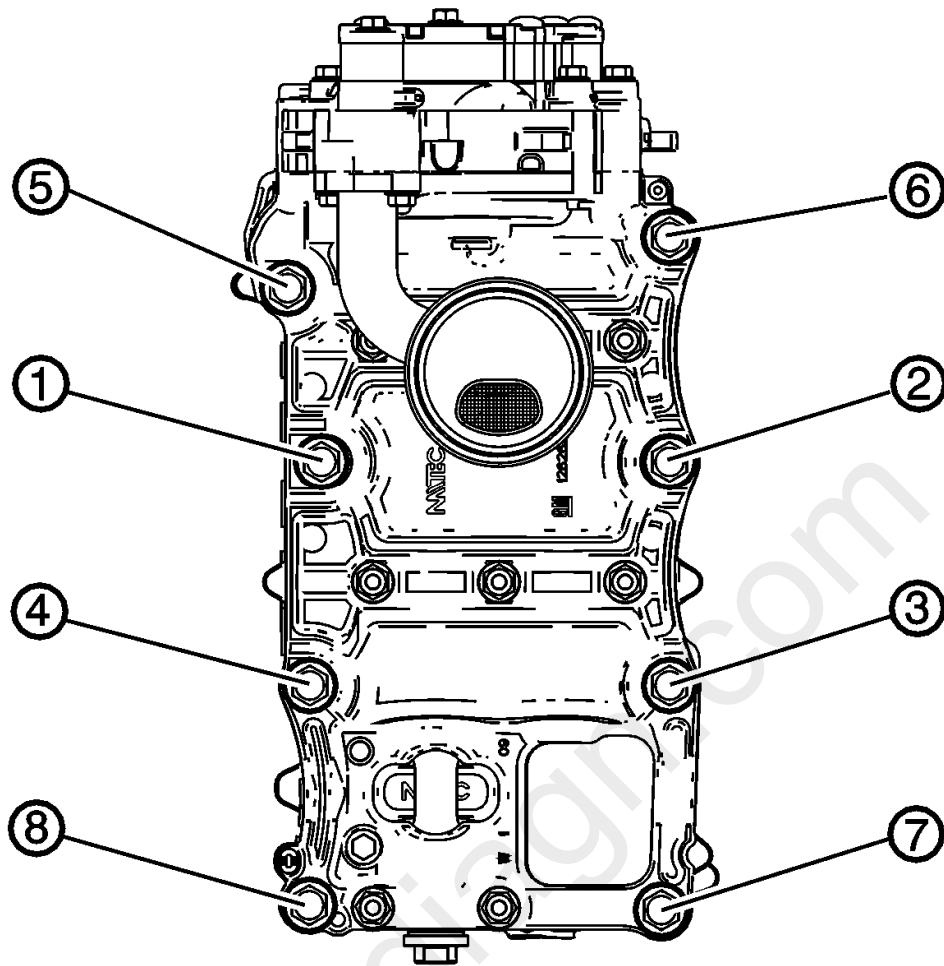


Fig. 216: Balancer And Oil Pump Shaft Assembly Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

3. Tighten the bolts twice in sequence to 58 N.m (43 lb ft).

CYLINDER HEAD INSTALLATION

Special Tools

EN 45059 Angle Meter

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

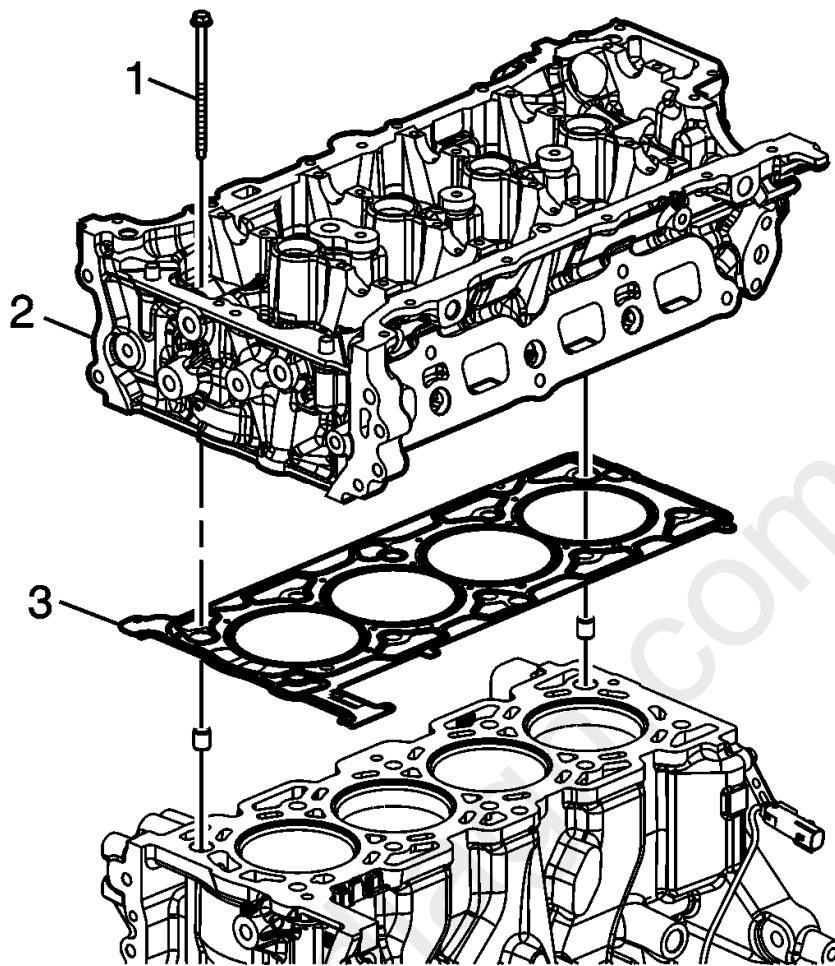


Fig. 217: Cylinder Head Gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not use any sealing material. Ensure that all mating surfaces are clean and free of debris.

1. If necessary, install NEW cylinder head locating pins.
2. Install the cylinder head gasket (3) to the block.
3. Install the cylinder head (2). Ensure the number 1 cylinder is at top dead center (TDC). The key on the crankshaft should be on top in the 12 o'clock position.

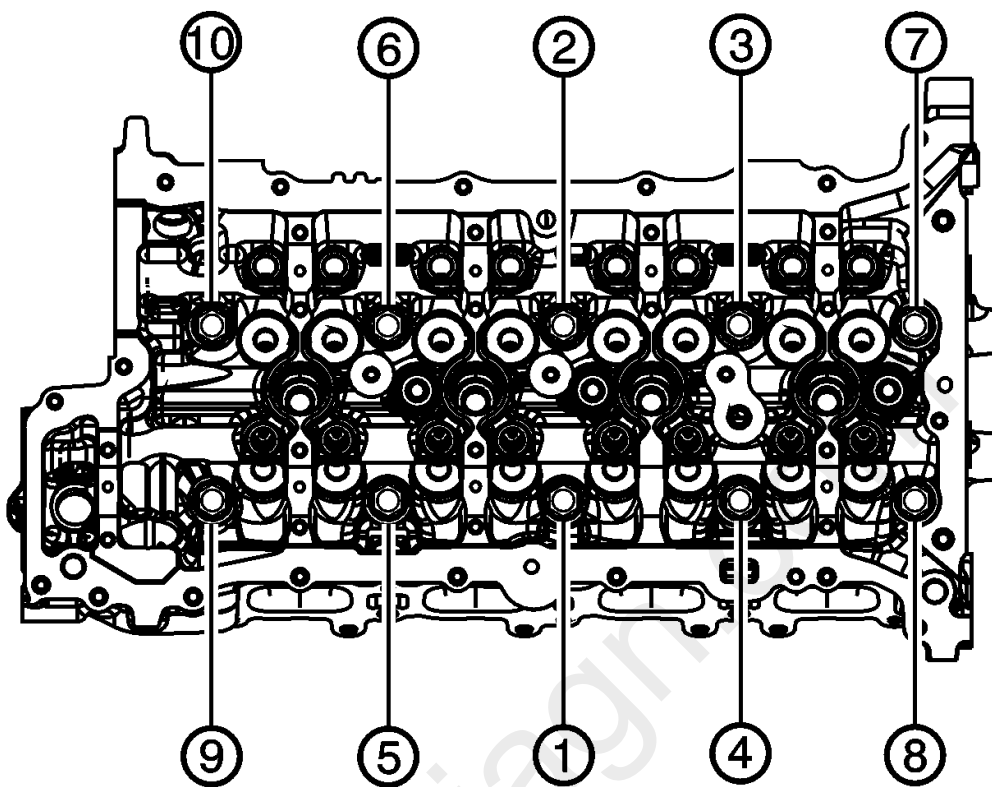


Fig. 218: Cylinder Head Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

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

4. Install the NEW cylinder head bolts.
 1. Tighten the bolts in sequence to 30 N.m (22 lb ft).
 2. Tighten the bolts an additional 190 degrees in sequence using the EN 45059 meter.

WATER PUMP INSTALLATION

Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to ensure proper sealing.

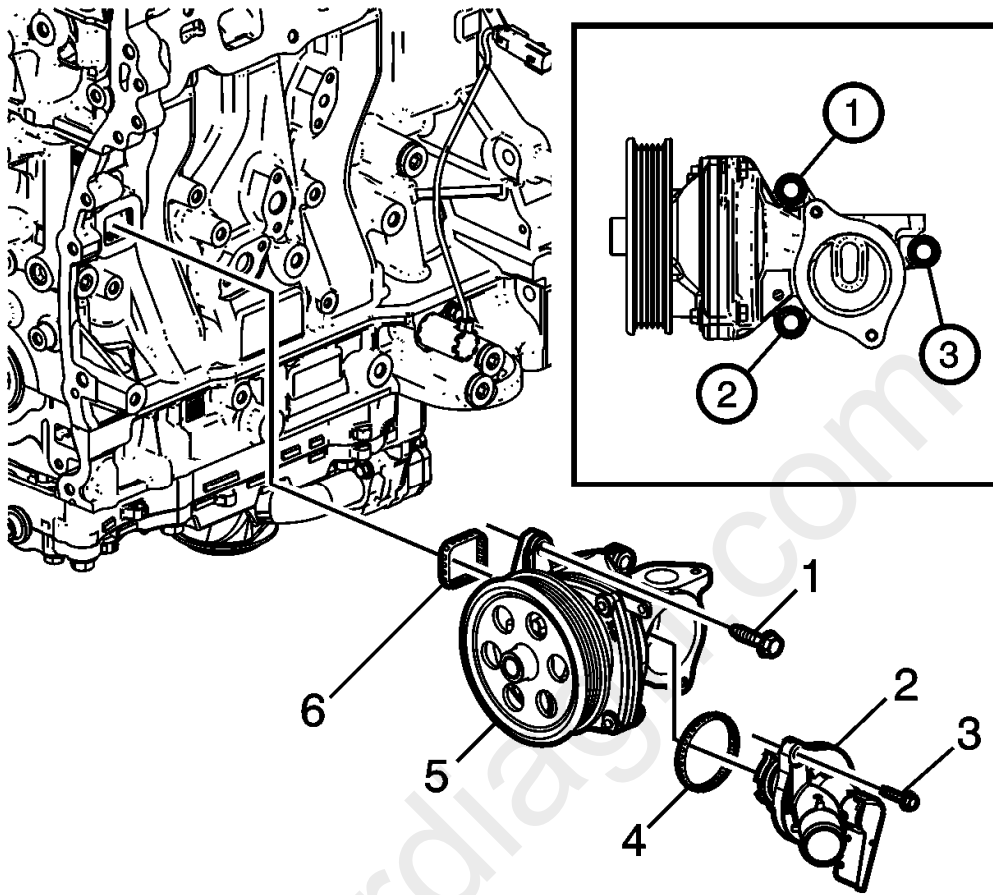


Fig. 219: Water Pump Gasket And Water Pump Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW water pump gasket (6) and the water pump assembly (5).
2. Install the water pump bolts (1). Finger tighten the bolts.

CAUTION: Refer to Fastener Caution .

NOTE: The sequence allows the fasteners closest to compress the seal.

3. Tighten the water pump bolts in sequence to 25 N.m (18 lb ft).
4. Install a NEW thermostat assembly gasket (4) and the thermostat assembly (2).
5. Install the thermostat assembly bolts (3) and tighten to 10 N.m (89 lb in).

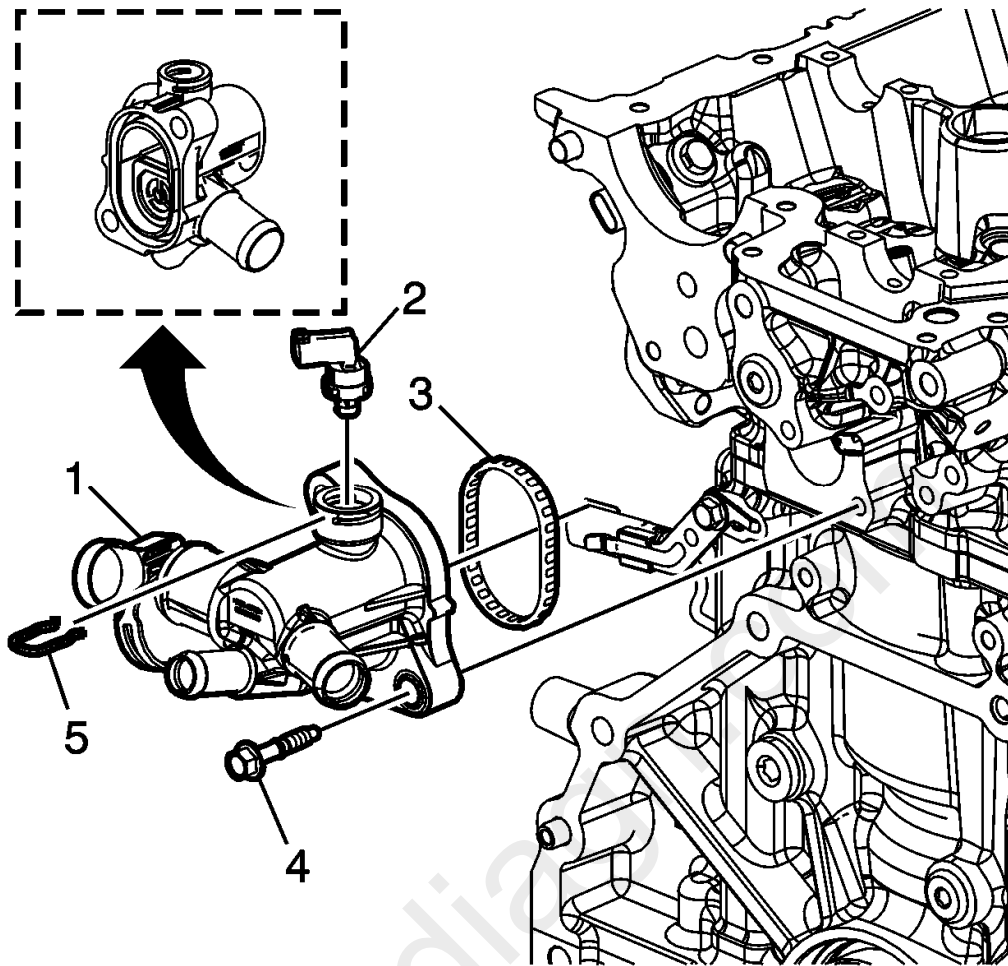


Fig. 220: Retaining Clip And Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

6. Install a NEW water outlet assembly gasket (3), and the water outlet assembly (1).
7. Install the water outlet assembly bolts (4) and tighten to 10 N.m (89 lb in).
8. Install the engine coolant temperature sensor (2).
9. Install the engine coolant temperature sensor retaining clip (5).

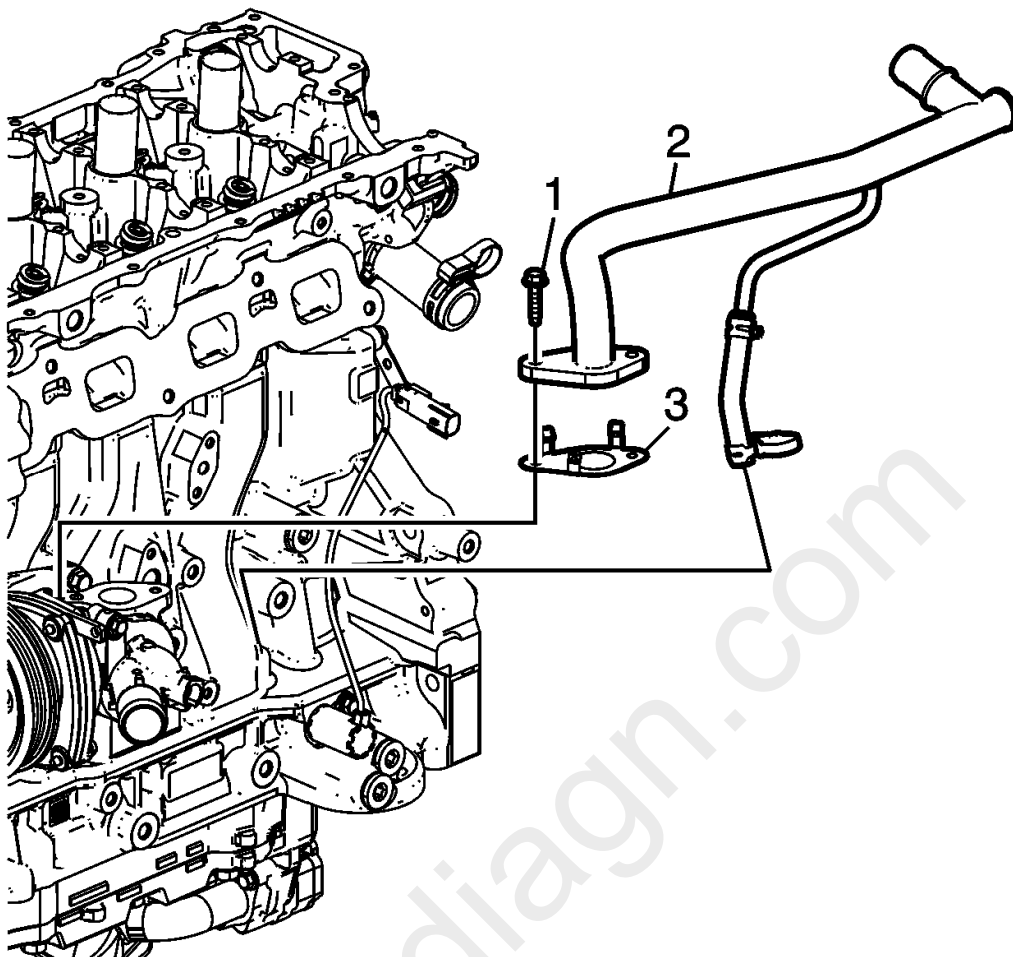


Fig. 221: Thermal Bypass Pipe Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

10. Connect the thermal bypass pipe (2) to the water outlet assembly.
11. Connect the thermal bypass hose to the engine oil cooler.
12. Install a NEW thermal bypass pipe gasket (3) on the thermal bypass pipe. Install the thermal bypass pipe to the water pump assembly. Install the bolts (1) and tighten to 10 N.m (89 lb in).

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

Exhaust Camshaft Installation

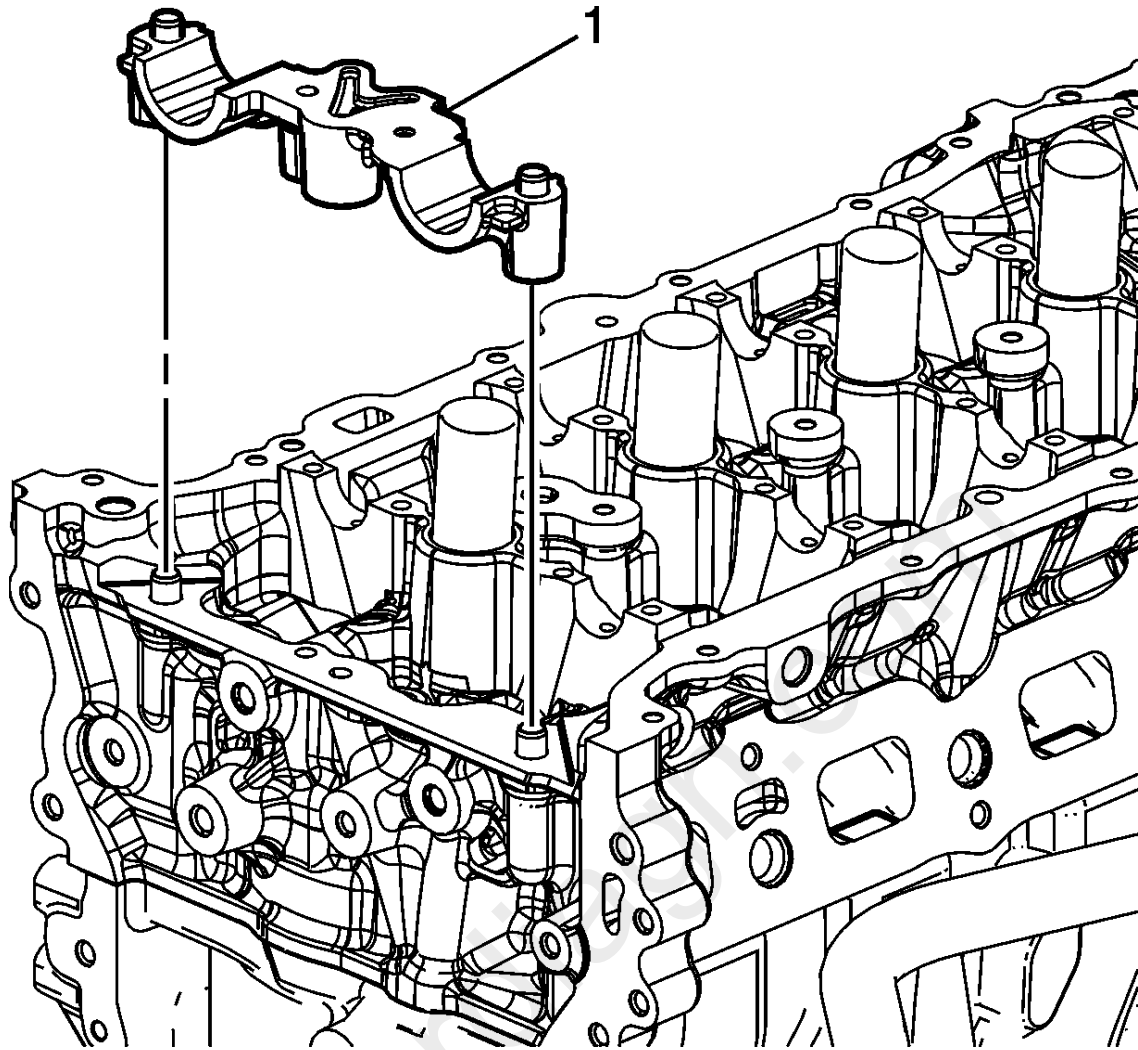


Fig. 222: Camshaft Bearing Lower Front Cap
Courtesy of GENERAL MOTORS COMPANY

1. Install the camshaft bearing lower front cap (1).

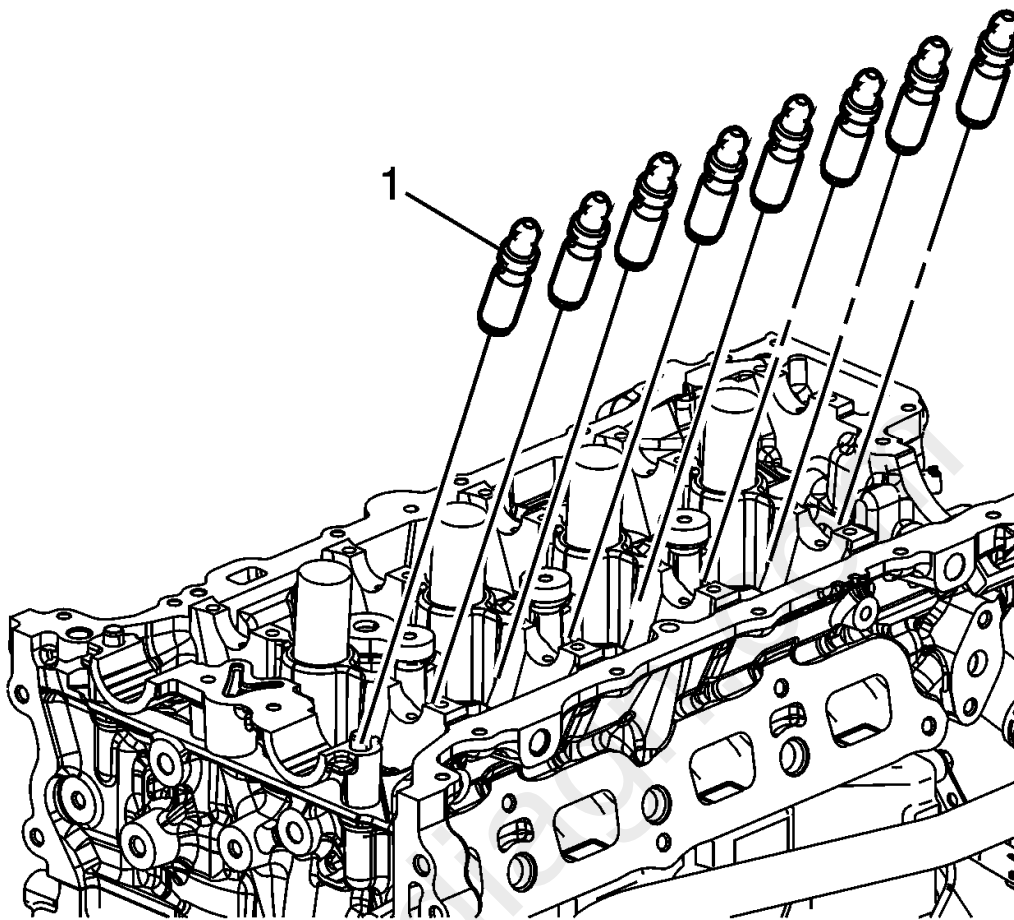


Fig. 223: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

2. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

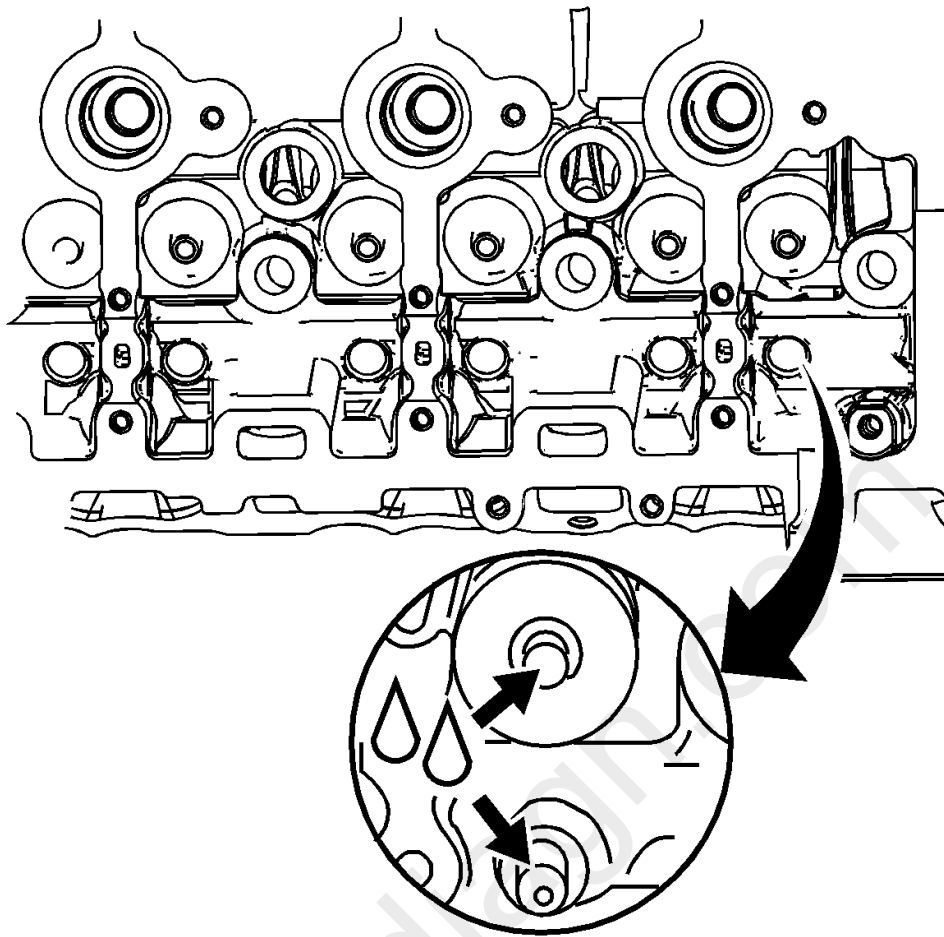


Fig. 224: Valve Tips
Courtesy of GENERAL MOTORS COMPANY

3. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers .

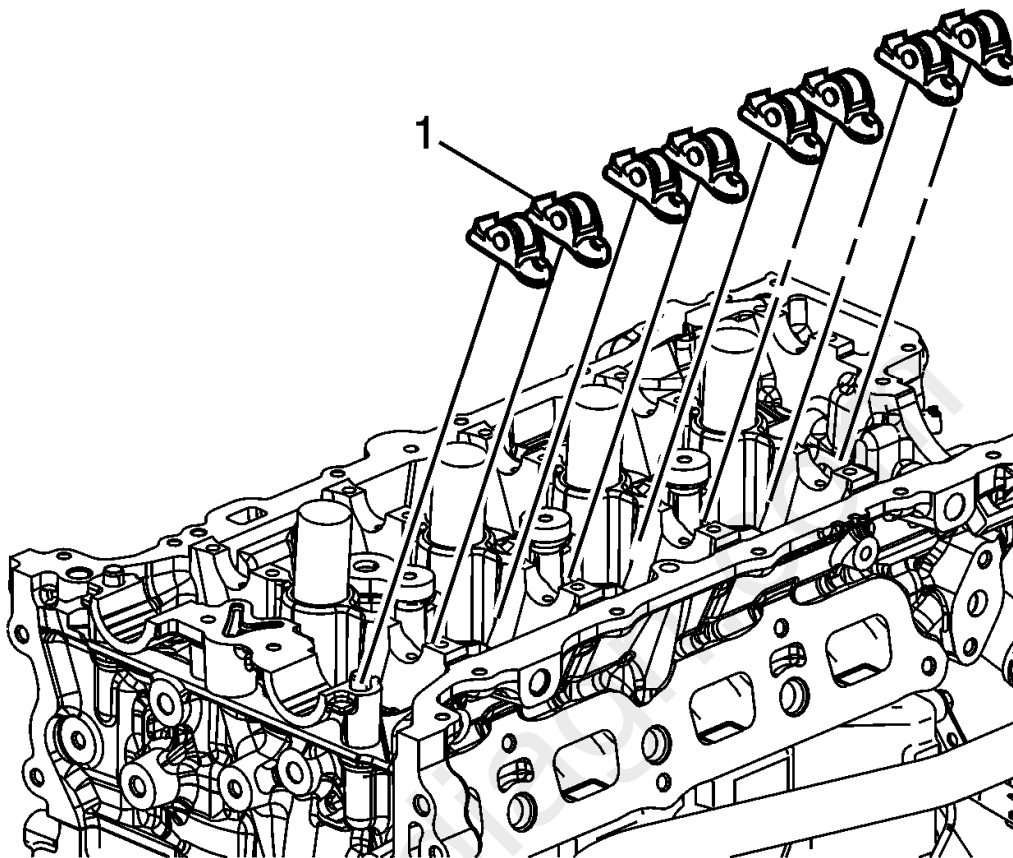


Fig. 225: Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS COMPANY

NOTE: Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.

NOTE: Pre-oil roller bearings before installation.

4. Lubricate the roller bearings with valve rocker arm lubricant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
5. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

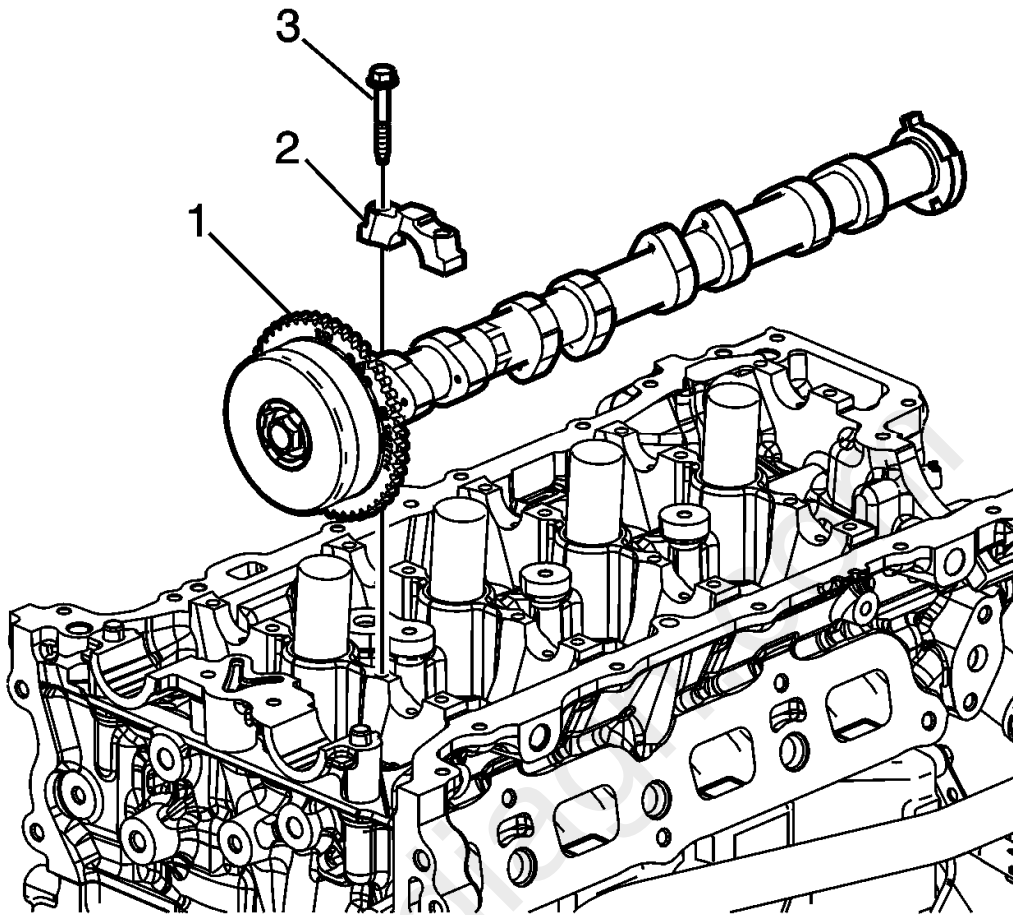


Fig. 226: Mark Camshaft Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

6. Lubricate the exhaust camshaft lobes and journals with camshaft lubricant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
7. Set the exhaust camshaft (1) on top of the rocker arms in the camshaft bearing journals with the actuator timing mark at approximately the 1 O'clock position.

NOTE:

- Do not apply final torque at this time. Camshaft cap final torque is applied in sequence when all caps are installed on both intake and exhaust camshafts.
- To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

8. Install the camshaft cap bolts (3) into the camshaft caps (2).

9. Install the camshaft caps (2) and hand start the camshaft cap bolts (3).

Intake Camshaft Installation

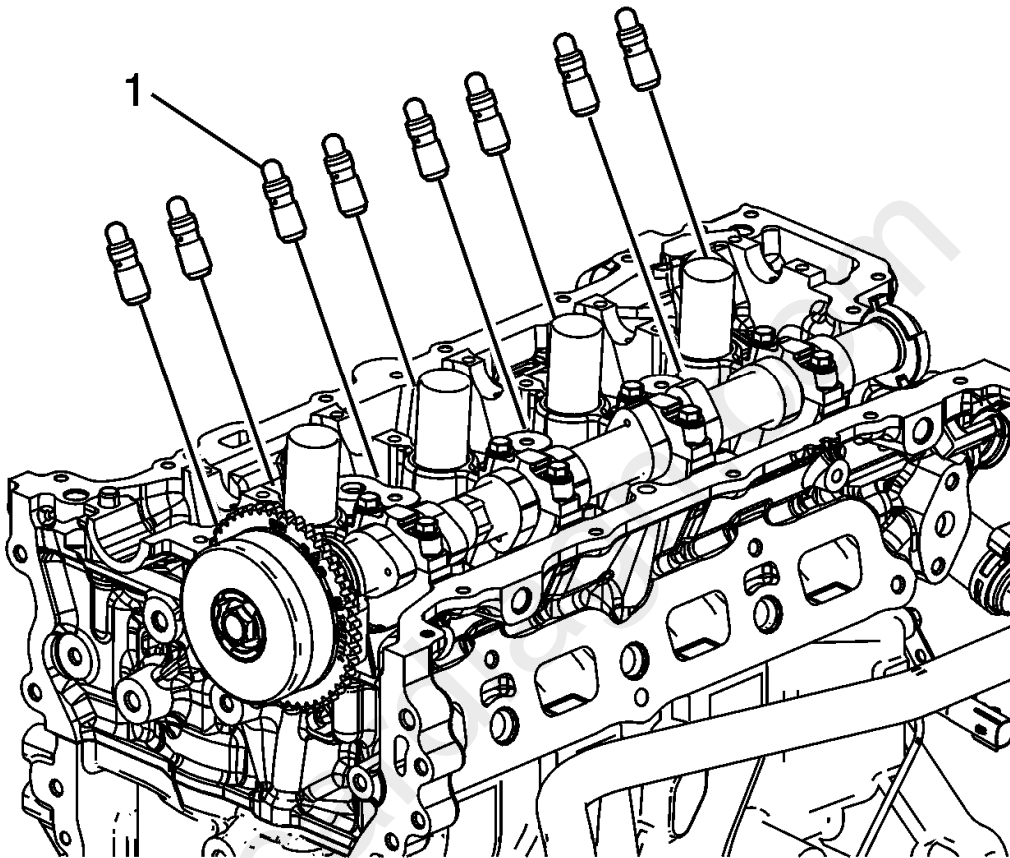


Fig. 227: Hydraulic Lash Adjusters

Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to Adhesives, Fluids, Lubricants, and Sealers .

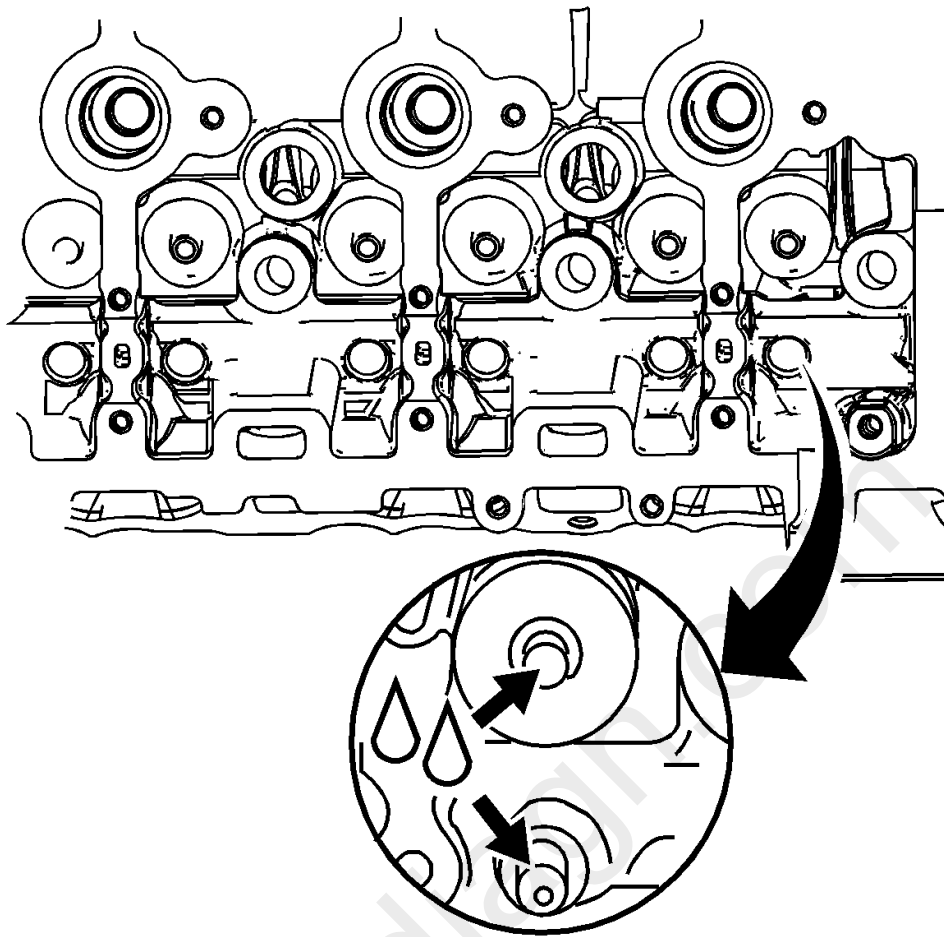


Fig. 228: Valve Tips
Courtesy of GENERAL MOTORS COMPANY

2. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

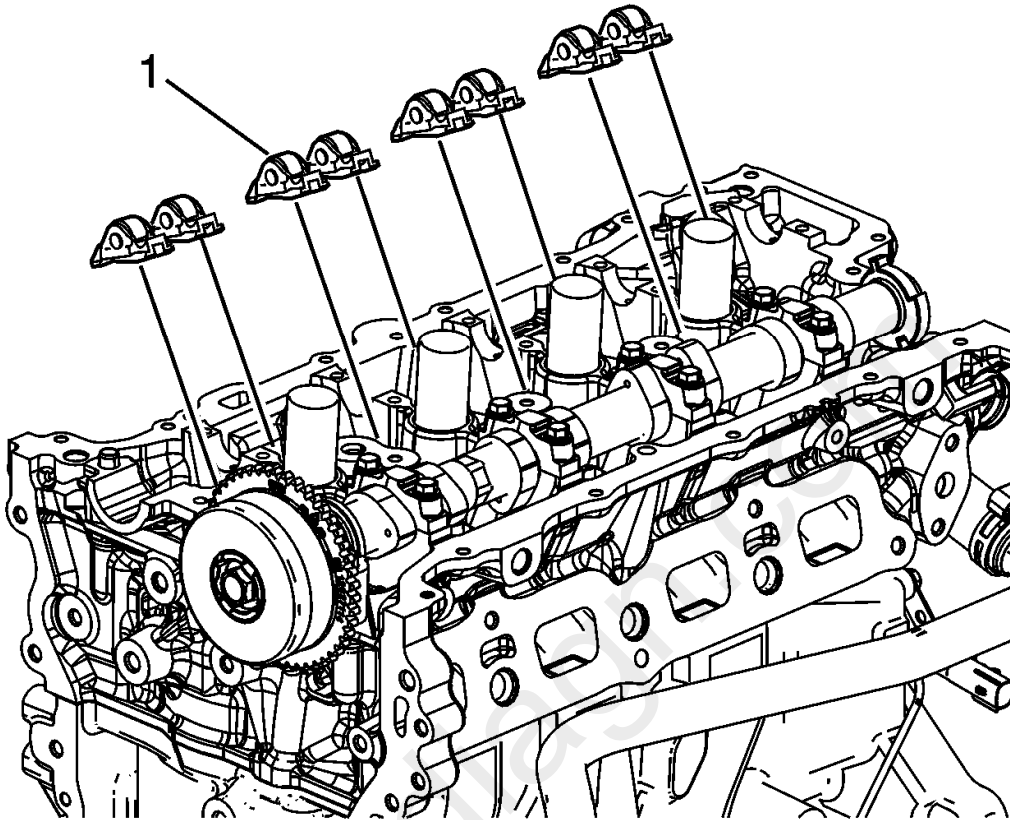


Fig. 229: Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS COMPANY

NOTE: Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.

NOTE: Pre-oil roller bearings before installation.

3. Lubricate the roller bearings with valve rocker arm lubricant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
4. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

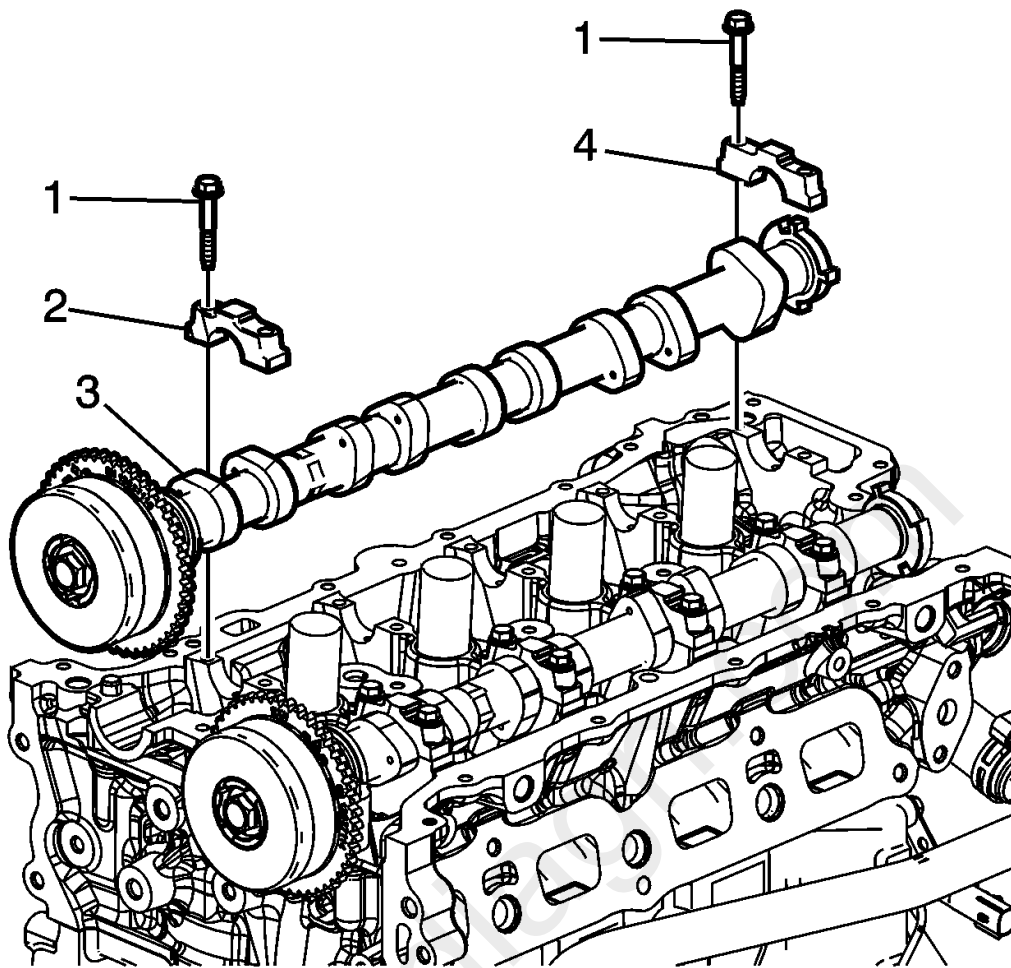


Fig. 230: Intake Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

5. Lubricate the intake camshaft lobes and journals with camshaft lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers .

Set the intake camshaft (3) on top of the roller followers in the camshaft bearing journals with the intake actuator timing mark at approximately the 11 O'clock position.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

6. Install the camshaft cap bolts (1) into the camshaft caps (2, 4).
7. Install the camshaft caps (2) and hand start the camshaft cap bolts (1).
8. Install the camshaft rear cap (4) and hand start the camshaft cap bolts (1).

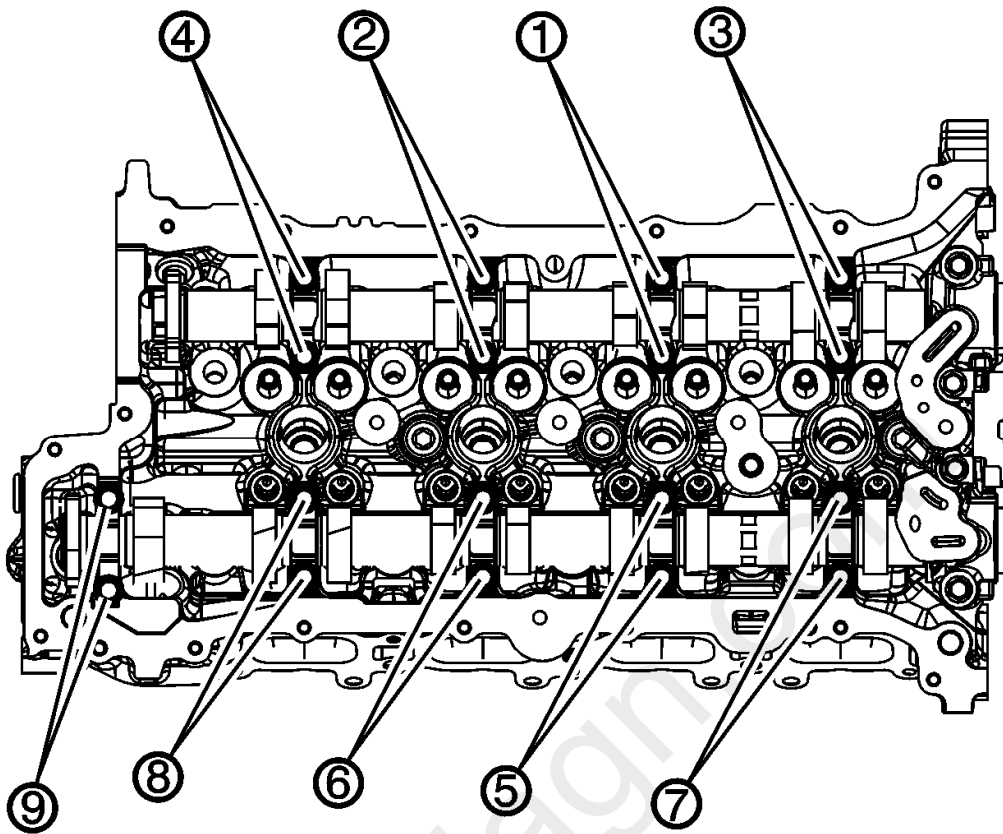


Fig. 231: Camshaft Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

9. Tighten the camshaft cap bolts in sequence using the following procedure:
 1. Tighten the camshaft cap bolts in sequence to 8 N.m (71 lb in).
 2. Loosen both bolts in each cap in sequence to 180 degrees.
 3. Tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

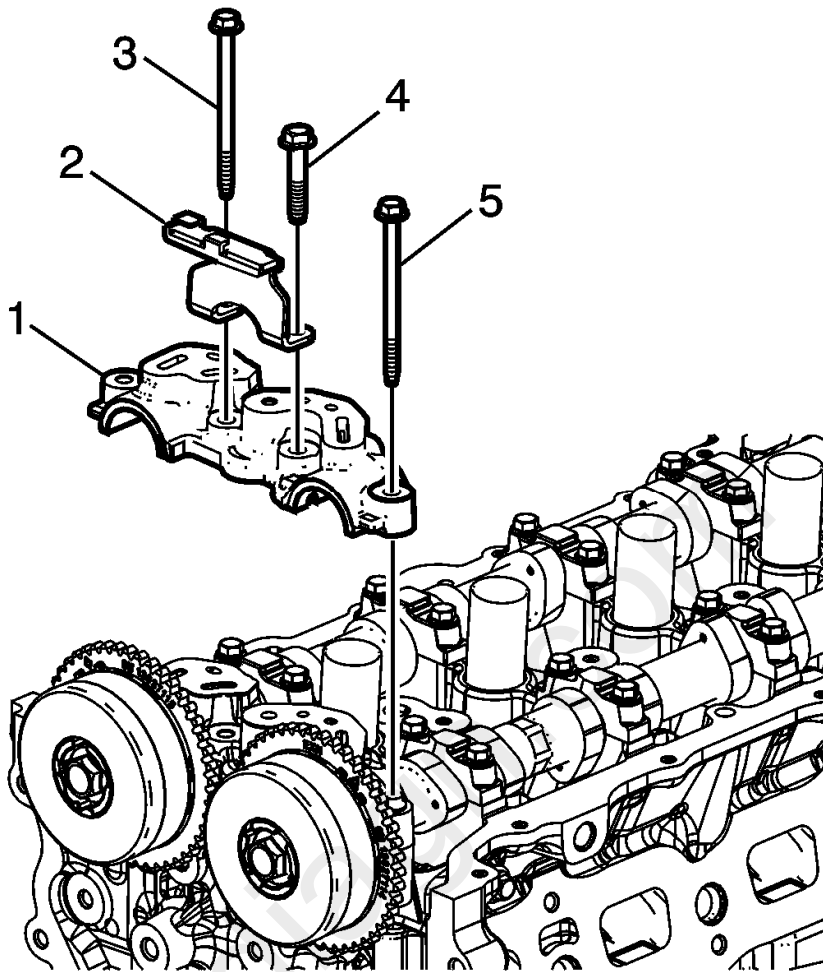


Fig. 232: Front Camshaft Bearing Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Installation of the timing chain guide (2) and bolts (3, 4), and final torque for the front bearing cap is performed after the timing chain is installed.

10. Install the front camshaft bearing cap (1). Install the 2 outer bolts (5) for the front camshaft bearing cap finger tight.

BALANCER CHAIN, SPROCKET, AND TENSIONER INSTALLATION

Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

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

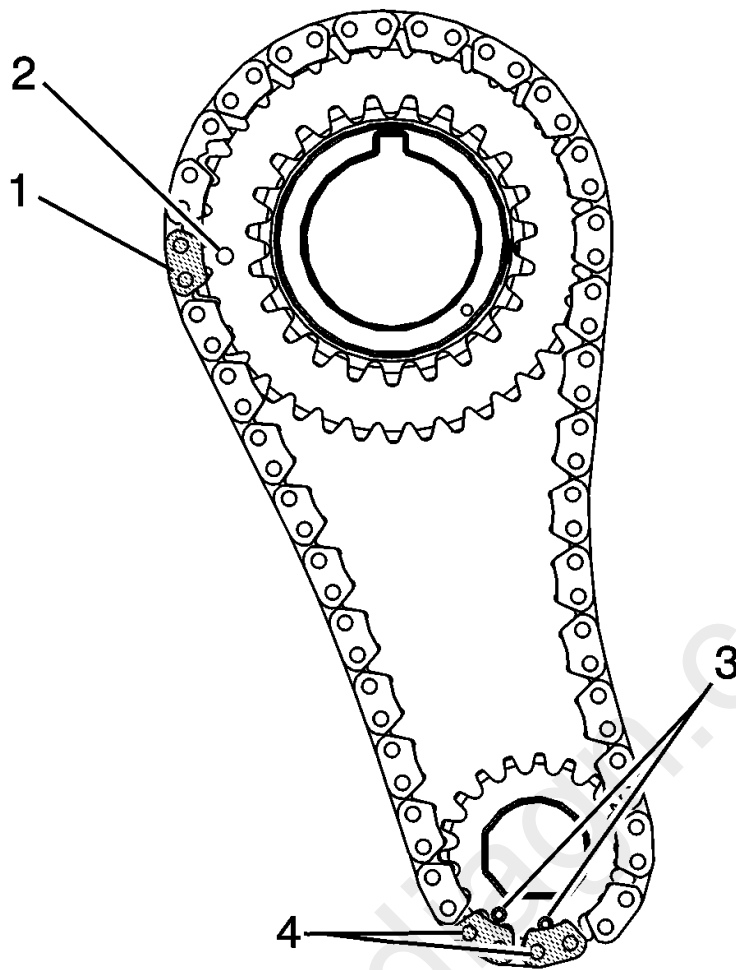


Fig. 233: Timing Link Lines Up And Timing Mark
Courtesy of GENERAL MOTORS COMPANY

NOTE: Proper setup is critical to ensure correct timing when installing the sprockets and chain simultaneously onto the shafts. The timing links are heat treated blued steel.

1. Assemble the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain. Ensure the timing link (1) lines up with the timing mark (2) on the crankshaft sprocket. Ensure that both timing teeth (3) on the balancer shaft driven sprocket line up with the timing links (4).

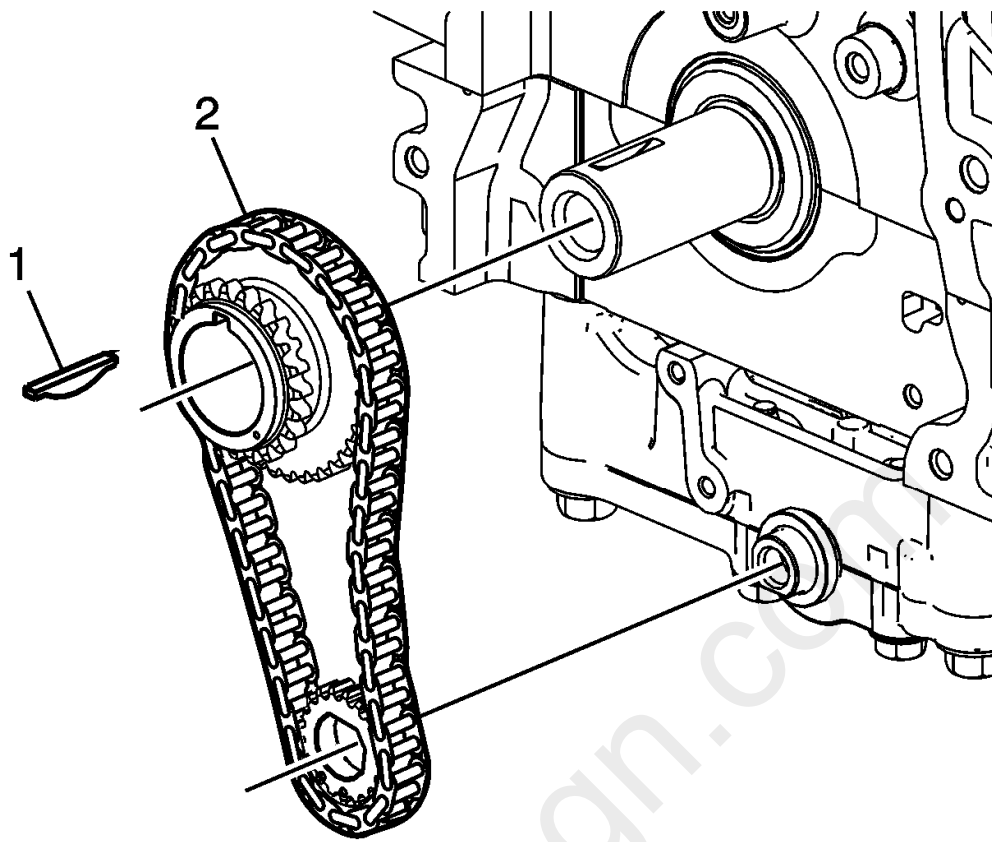


Fig. 234: Balancer Shaft Driven Sprocket And Balancer Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft keyway should be in the 12 O'clock position.

2. Install the sprockets and chain (2) as an assembly to the crankshaft and balancer shaft assembly.
3. Install the crankshaft key (1).

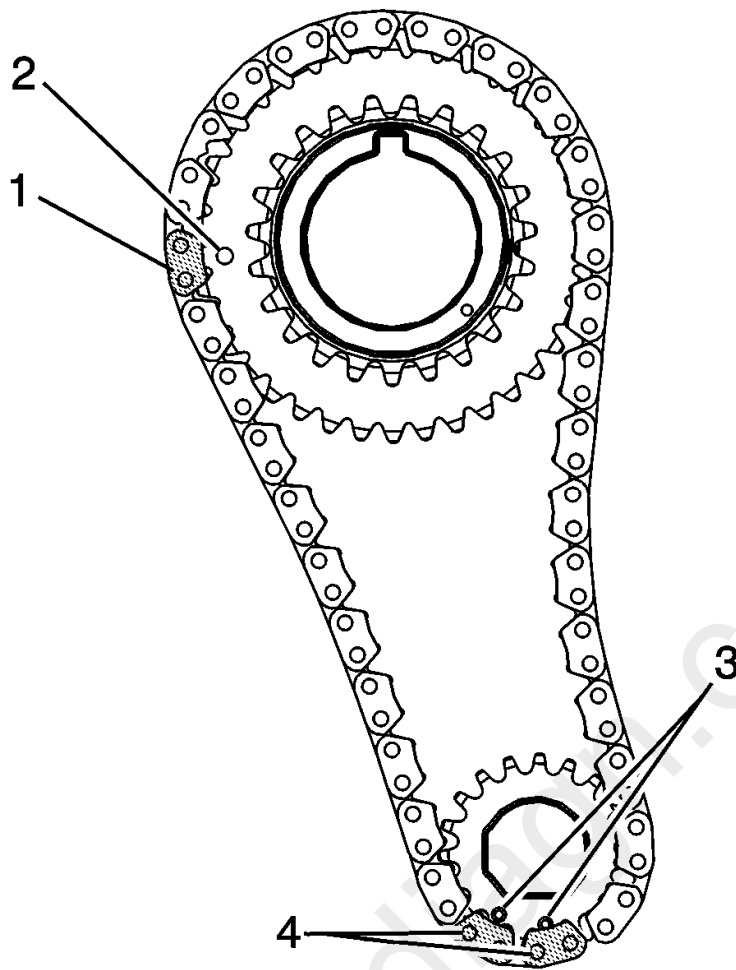


Fig. 235: Timing Link Lines Up And Timing Mark
Courtesy of GENERAL MOTORS COMPANY

4. Ensure the timing link (1) is aligned with the crankshaft sprocket timing mark (2).
5. Ensure the adjacent timing links (4) are aligned with both of the timing marks (3) on the balancer shaft driven sprocket.

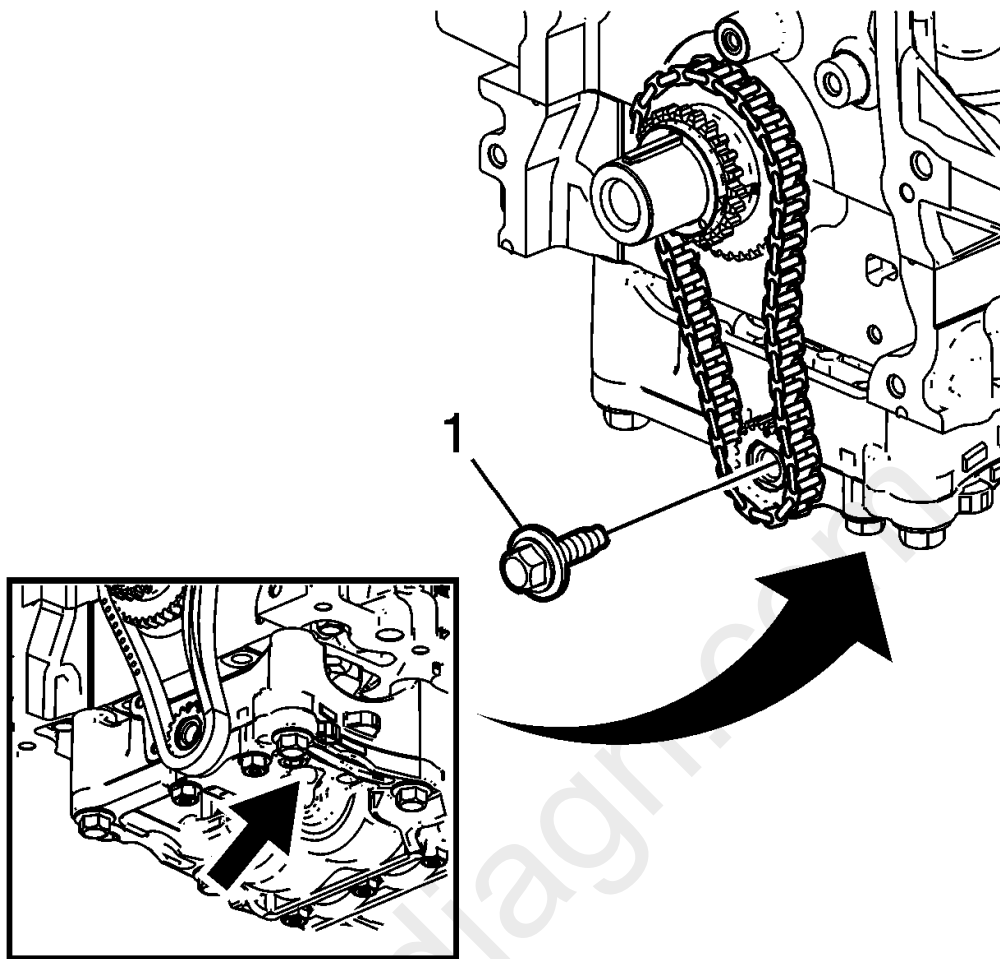


Fig. 236: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

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

6. Install the NEW balancer shaft driven sprocket bolt (1).

CAUTION: Refer to Fastener Caution .

7. Use an 18 mm open end wrench over flat on balance shaft while tightening the balancer shaft sprocket bolt to specification. Tighten the balancer shaft driven sprocket bolt to 40 N.m (30 lb ft) plus 50 degrees.

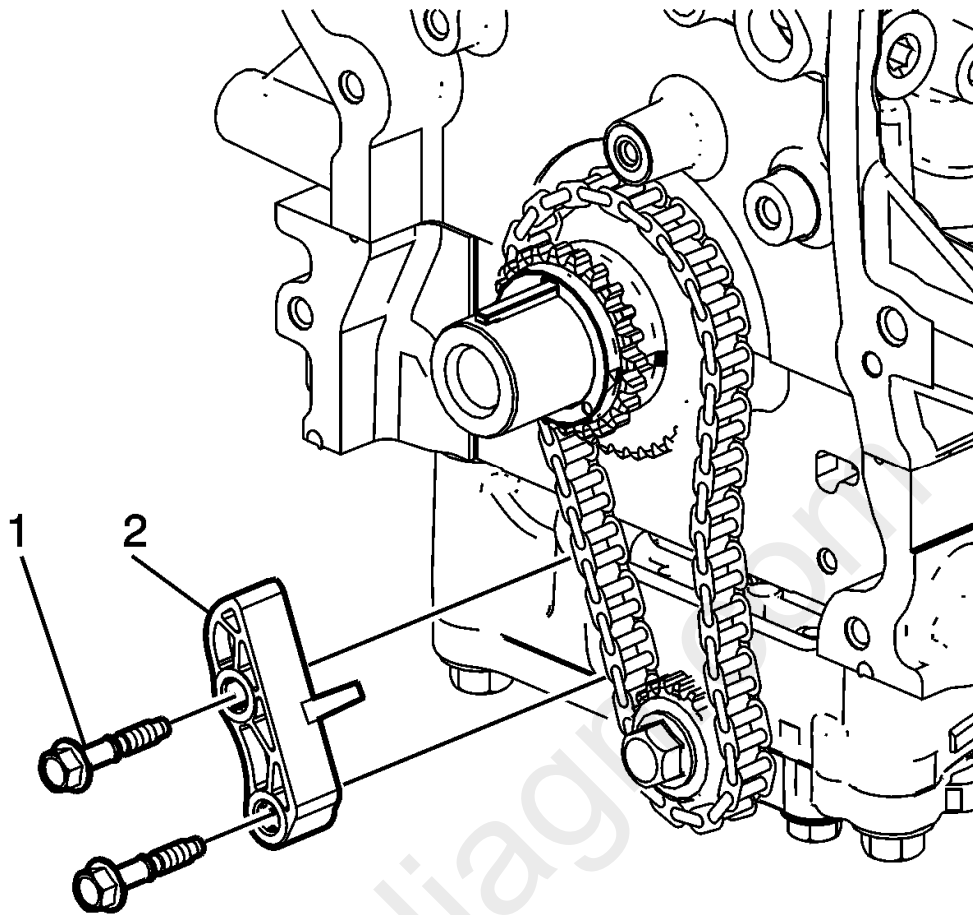


Fig. 237: Balancer Chain Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the guide is installed in the correct orientation. The long end must point toward the crankshaft and the flat edge must be adjacent to the balance chain.

8. Install the balancer chain guide (2).
9. Install the balancer chain guide bolts (1). Tighten the bolts to 10 N.m (89 lb in).

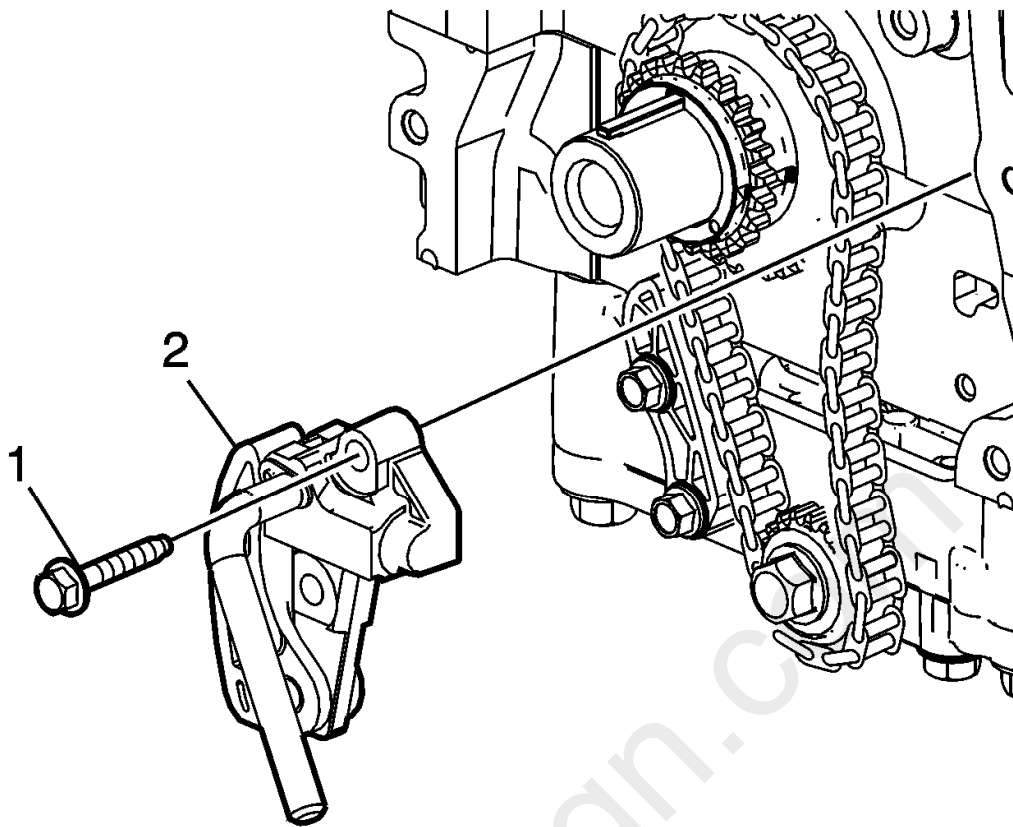


Fig. 238: Balancer Chain Tensioner Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Install the balancer chain tensioner (2).
11. Install the balancer chain tensioner bolts (1). Tighten the bolts to 10 N.m (89 lb in).
12. Remove **EN-50837** retention tool to restore the tension to the balancer chain.

OIL PAN INSTALLATION

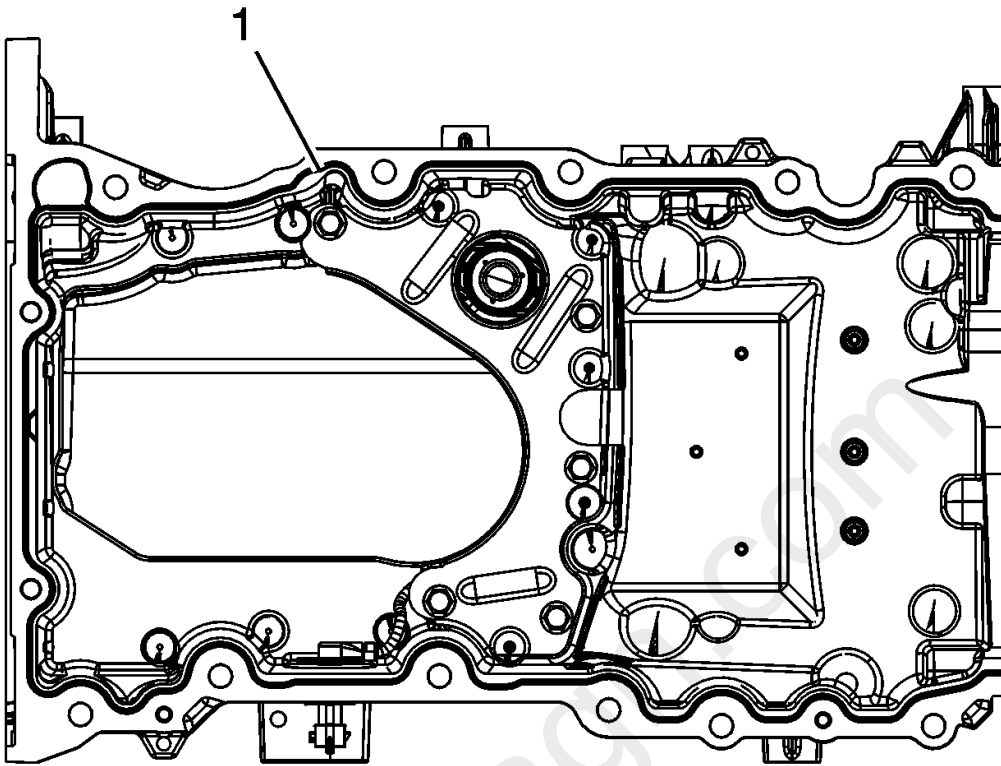


Fig. 239: Short Lower Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 20 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

1. Apply a 4.25 mm bead of sealer (1) on the level part of the flange around the perimeter of the oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers .

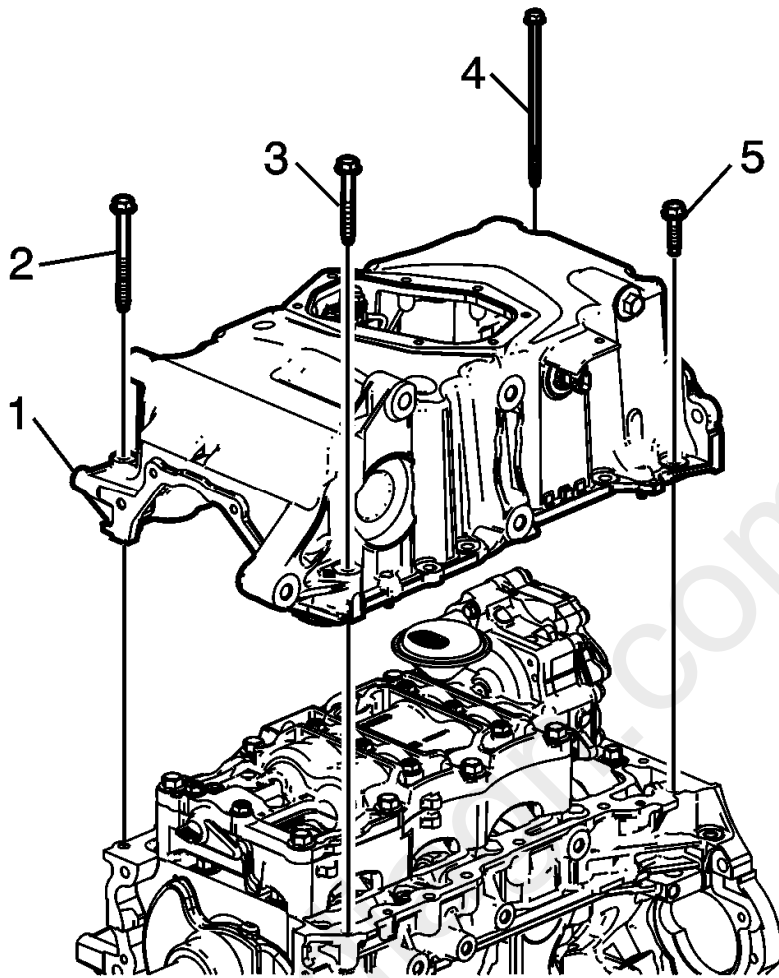


Fig. 240: Upper Engine aOil Pan
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pan (1).
3. Install the oil pan bolts (2-5) finger tight.

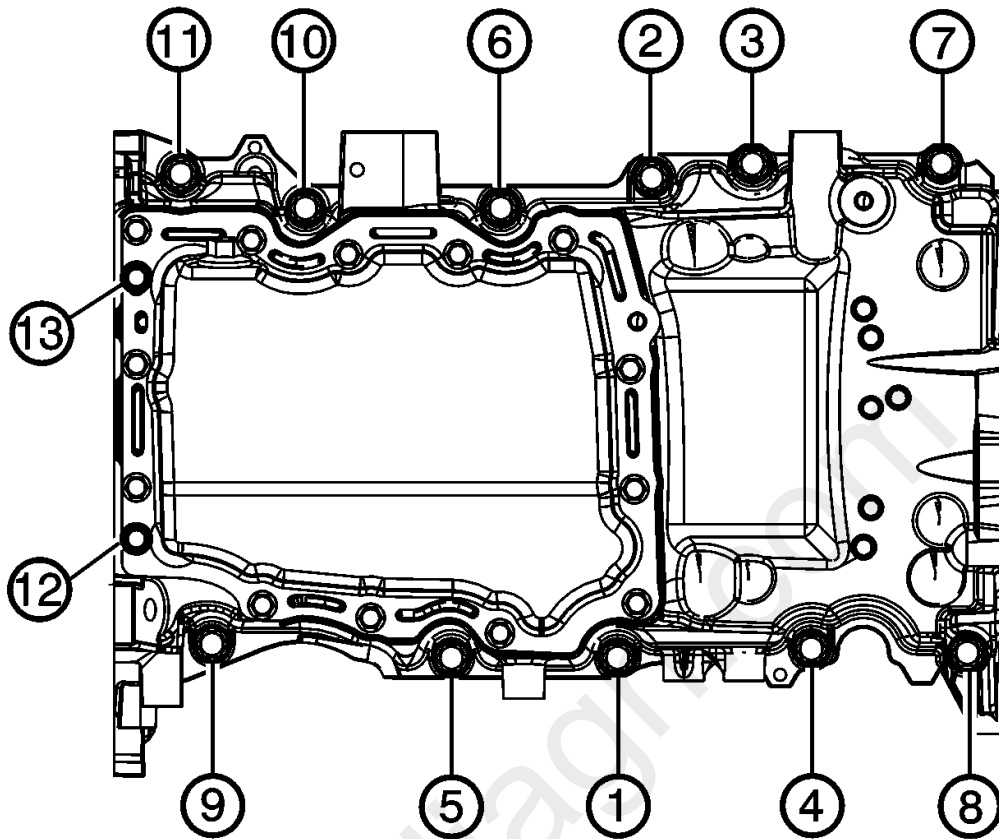


Fig. 241: Engine Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Tighten the oil pan bolts in sequence to final torque twice using the following procedure:
 1. Tighten bolts in sequence 1-11 to 25 N.m (18 lb ft).
 2. Tighten bolts in sequence 12-13 to 10 N.m (89 lb in).

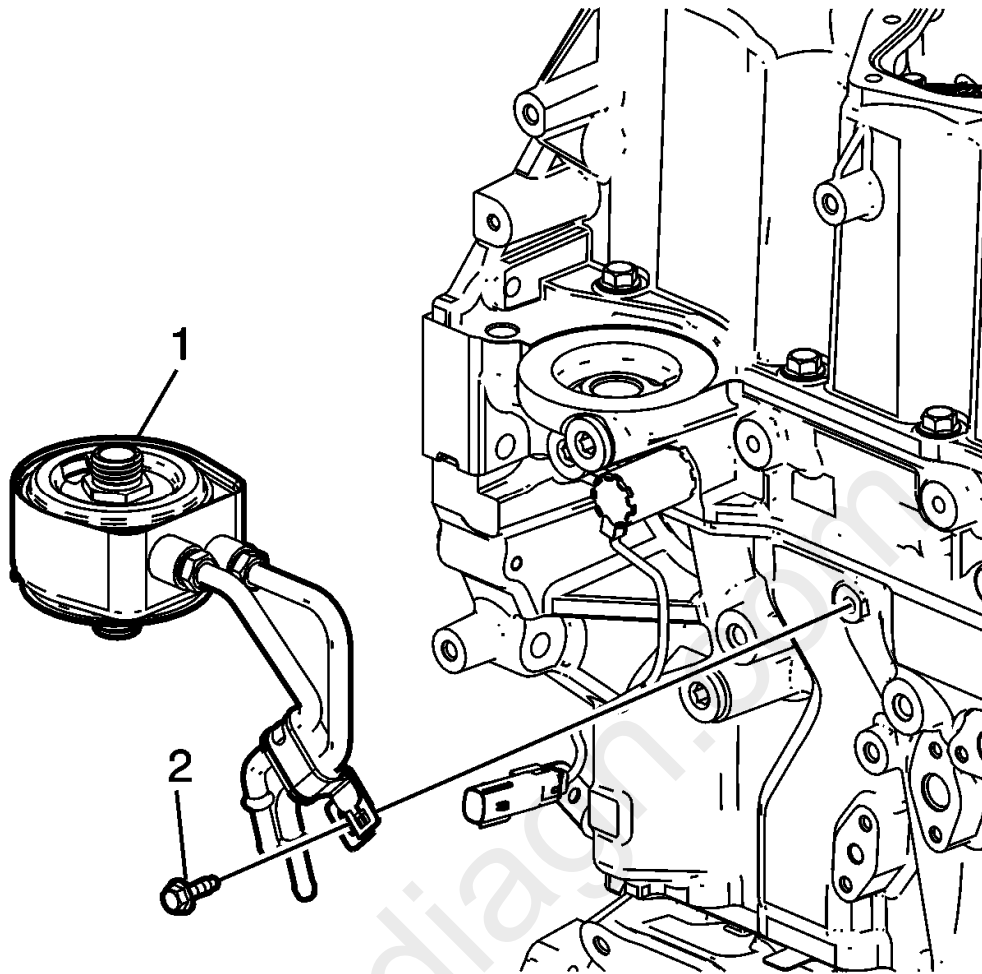


Fig. 242: Engine Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

5. Install the engine oil cooler (1).
6. Install the engine oil cooler bolt (2) and tighten to 10 N.m (89 lb in).

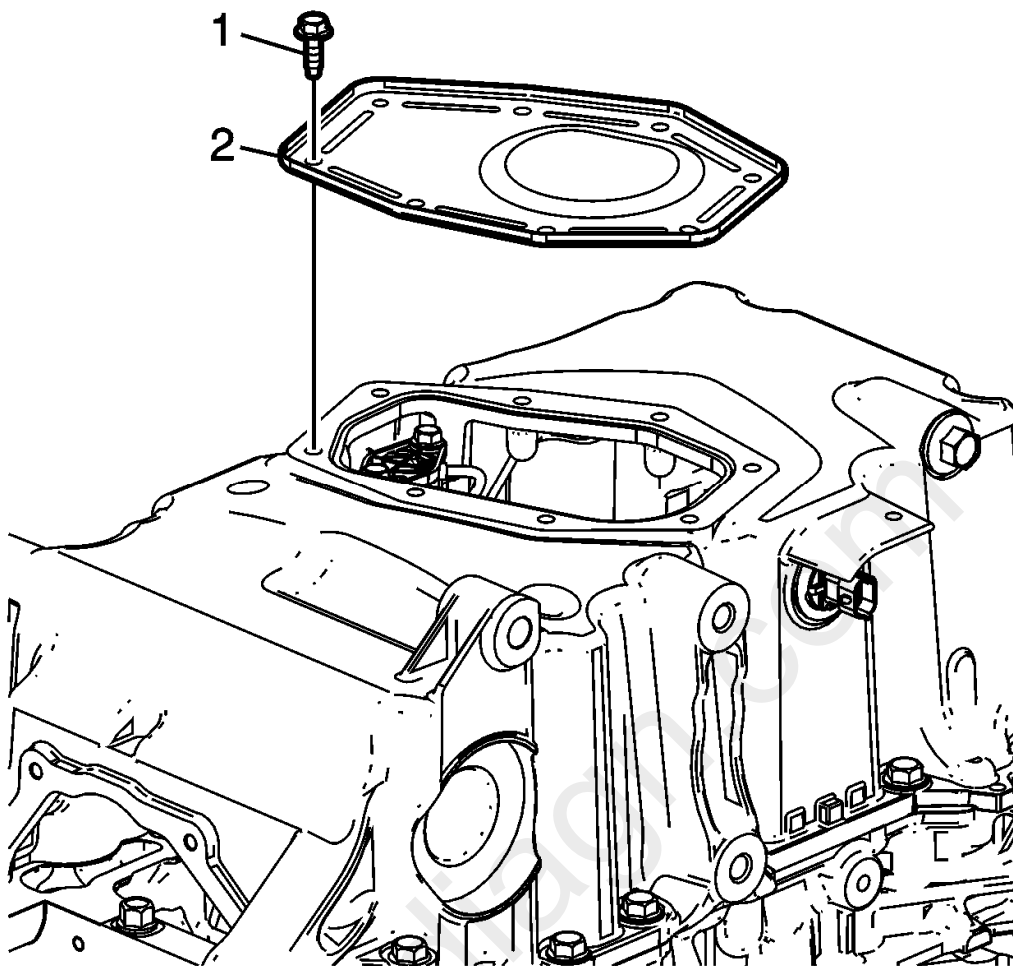


Fig. 243: Engine Oil Pan Lower Cover
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The oil pan sealing surfaces must be free of contamination prior to applying the sealer.
- Install and align the oil pans within 20 minutes of applying the sealer.
- The oil pans must be fastened to final torque specification within 60 minutes of applying the sealer.

7. Apply a bead of RTV sealant to the perimeter of the lower oil pan.
8. Install the lower oil pan (2).
9. Install the lower oil pan bolts (1) and tighten to 10 N.m (89 lb in).

CAMSHAFT TIMING CHAIN AND TENSIONER INSTALLATION

Special Tools

- **EN 45059** Angle Meter
- **EN 50837** Timing Chain Tensioner Retraction Tool

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

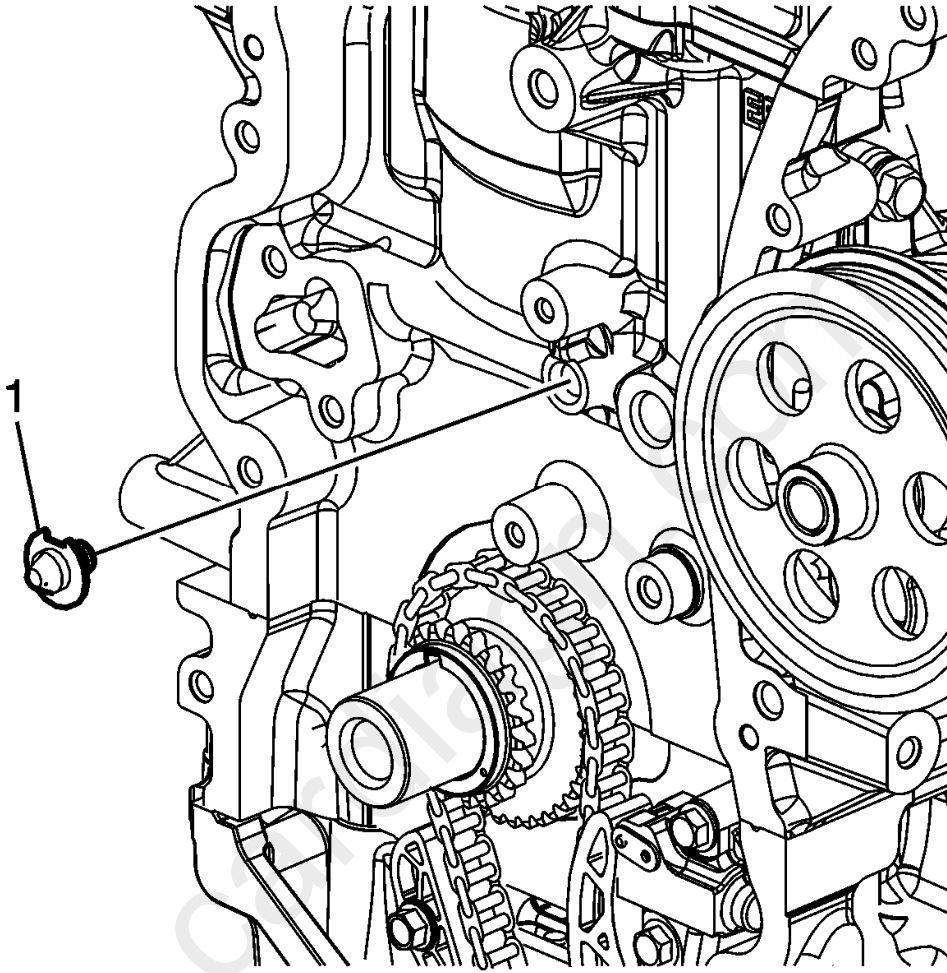


Fig. 244: Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the timing chain oil nozzle is rotated with the notch facing upward, and aligned with the tab on the engine block.

1. Install the timing chain oil nozzle (1).

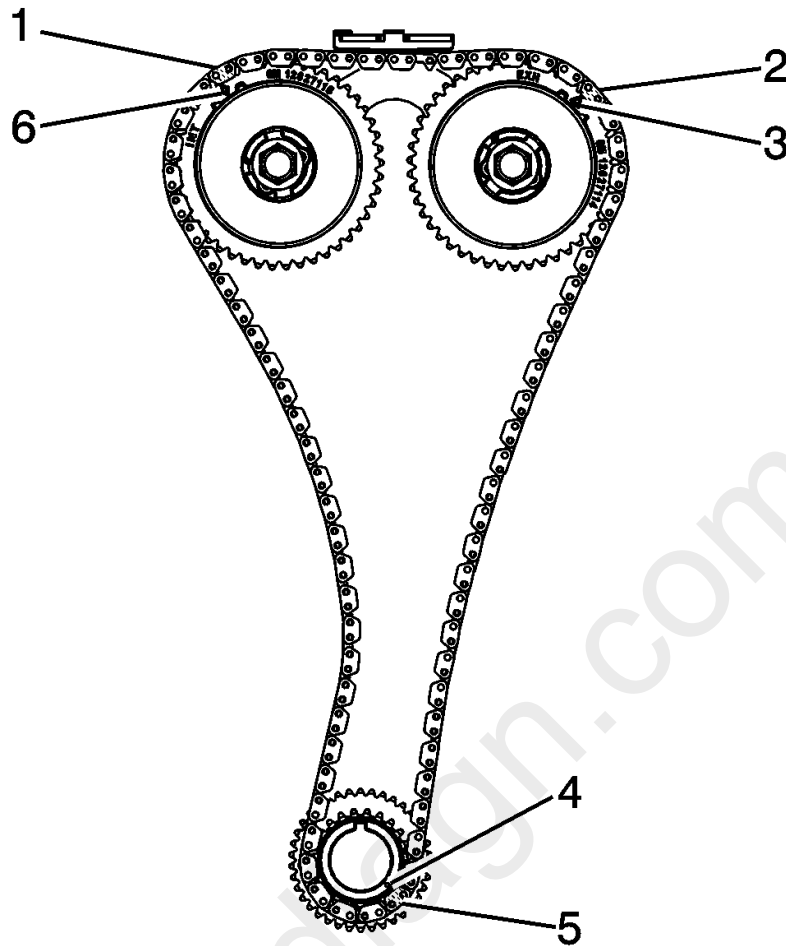


Fig. 245: Timing Chain Oil Nozzle
 Courtesy of GENERAL MOTORS COMPANY

NOTE: There are three colored links on the timing chain. The two links that align to the timing marks on the actuators are the same color. The timing link that aligns with the timing mark on the crankshaft sprocket is a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

2. Loop the timing chain over the intake and exhaust camshaft actuators, aligning one of the same colored links (2) with the timing mark on the exhaust camshaft actuator (3).

NOTE: The same colored link corresponding to the intake actuator will not initially align with the intake actuator timing mark, nor the unique colored timing chain link align with the crankshaft sprocket timing mark.

3. Ensure the crankshaft key in the 12 O'clock position. Loop the timing chain onto the crankshaft sprocket.

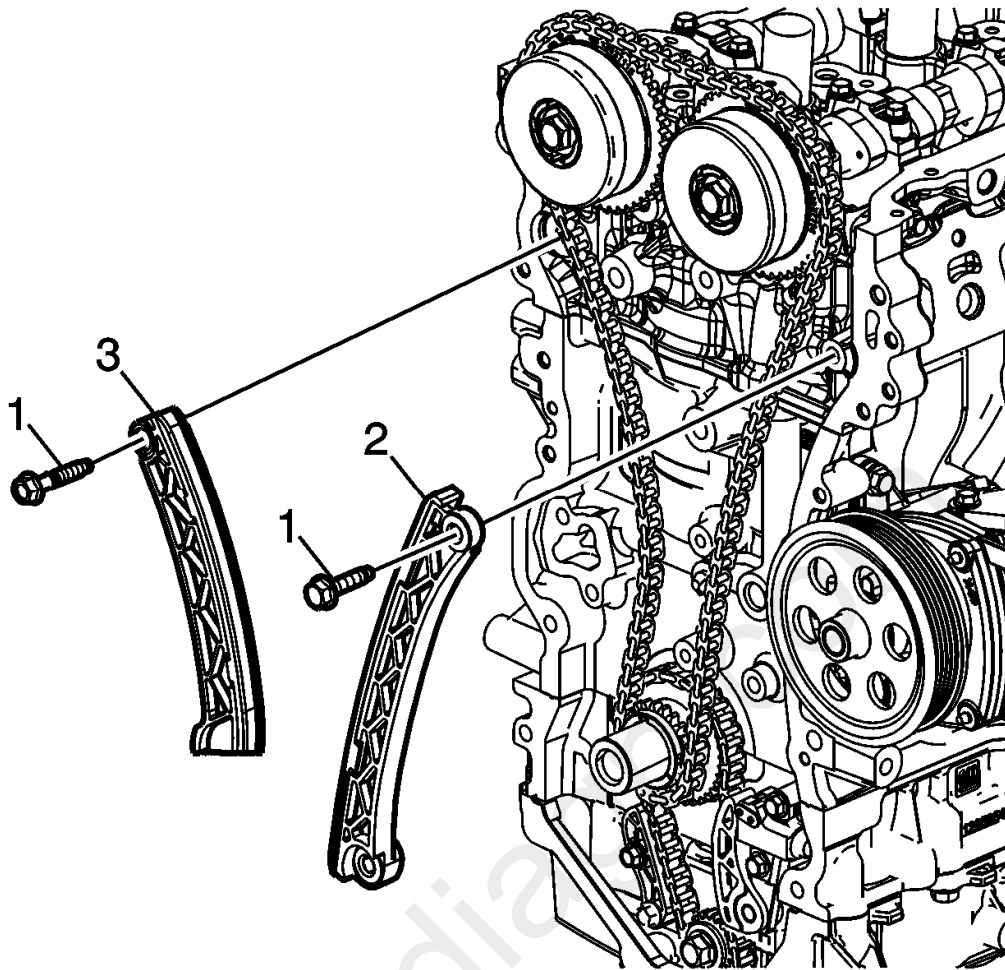


Fig. 246: Timing Chain Guide And Upper Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Timing will be established before the final install and torque of the guide bolts.

4. Install the timing chain guide (2) and upper bolt (1) only, finger tight.
5. Install the timing chain tensioner pivot arm (3).
6. Install the pivot arm bolt (1) finger tight.

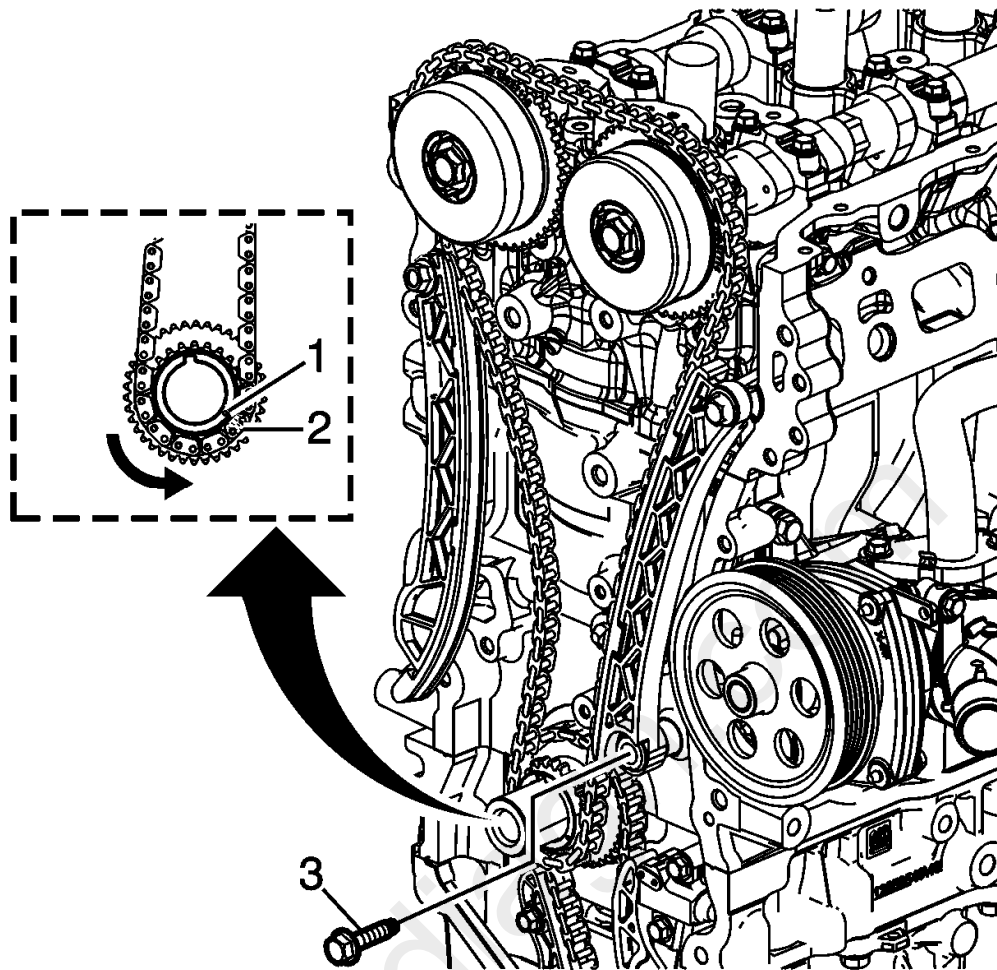


Fig. 247: Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

7. With a suitable tool, rotate the crankshaft counterclockwise to align the timing mark on the crankshaft sprocket (1) with the unique colored timing link (2).

NOTE:

- Continue to rotate the crankshaft counterclockwise as necessary to maintain timing alignment.
- Ensure that the alignment mark on the exhaust camshaft actuator remains aligned with the corresponding same colored timing link.

8. Rotate the lower end of the fixed timing chain guide into installation position and install the lower bolt (3).

CAUTION: Refer to Fastener Caution .

9. Tighten the timing chain guide upper and lower bolts to 25 N.m (18 lb ft).

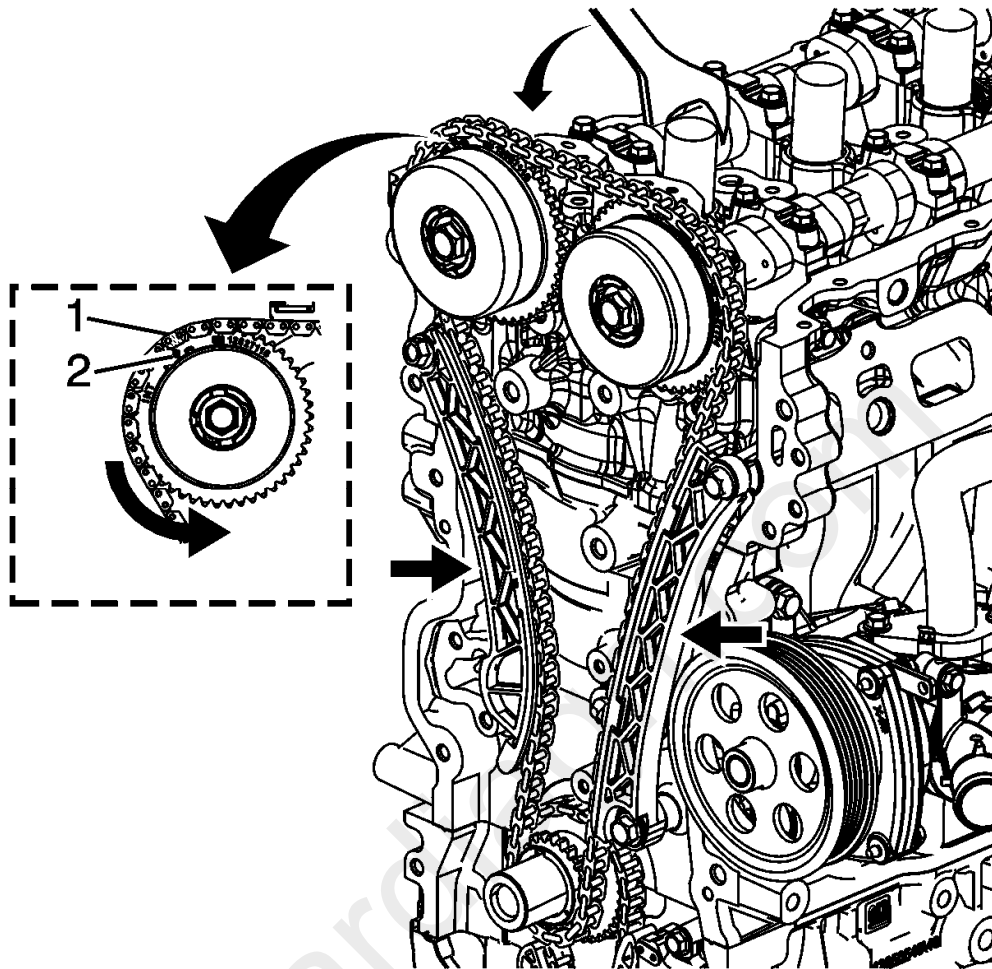


Fig. 248: Timing Mark On Intake Actuator
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The timing for the exhaust camshaft actuator and the crankshaft sprocket has been established.
 - Applying or loosening pressure by hand between the timing chain guides will allow the chain to slip or bind during counterclockwise rotation of the camshaft.
10. Using a suitable tool, rotate the intake camshaft counterclockwise until the timing mark on the intake actuator (2) is aligned with the corresponding same colored timing link (1). Maintain tension on intake camshaft until the timing chain tensioner can be installed and activated.

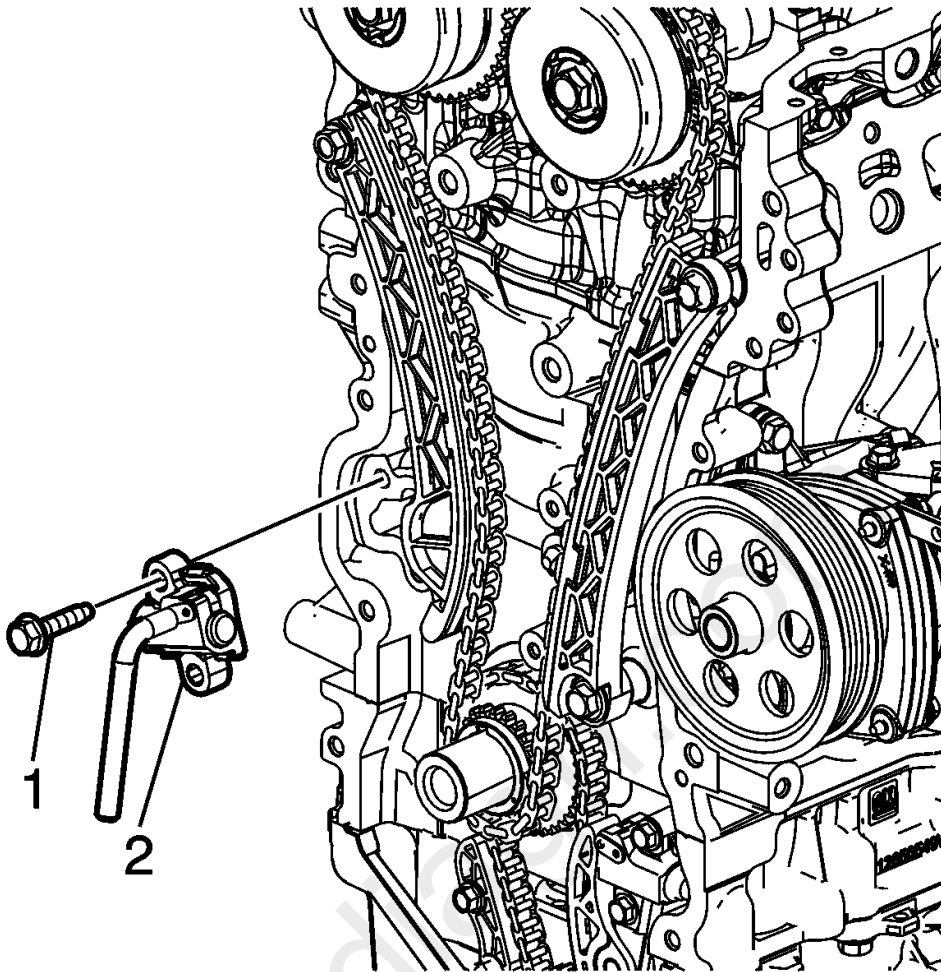


Fig. 249: Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure EN-50837 retraction tool is installed and the tensioner is locked in a compressed state before installing.

11. While maintaining the intake camshaft actuator timing alignment, install the timing chain tensioner (2) and bolts (1) and tighten to 25 N.m (18 lb ft).
12. Tighten the pivot arm bolt to 25 N.m (18 lb ft).
13. Remove **EN-50837** retraction tool.

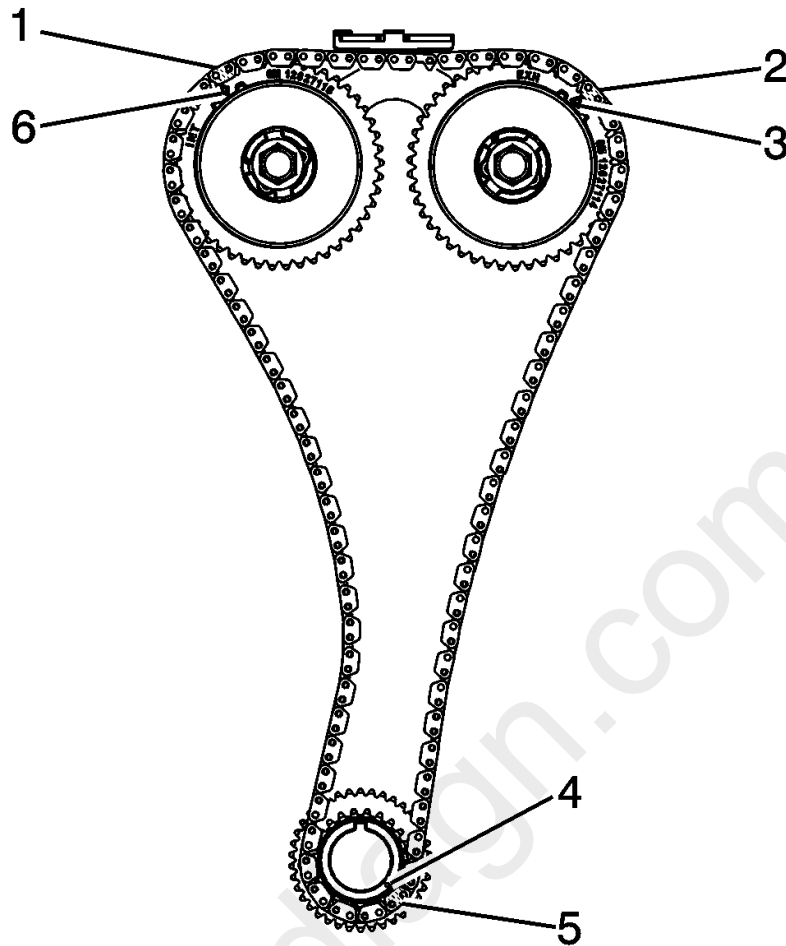


Fig. 250: Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS COMPANY

14. Verify the timing links on the timing chain are properly aligned to the timing marks:
 1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
 2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
15. If they are not, repeat the portion of the procedure necessary to align the timing marks.

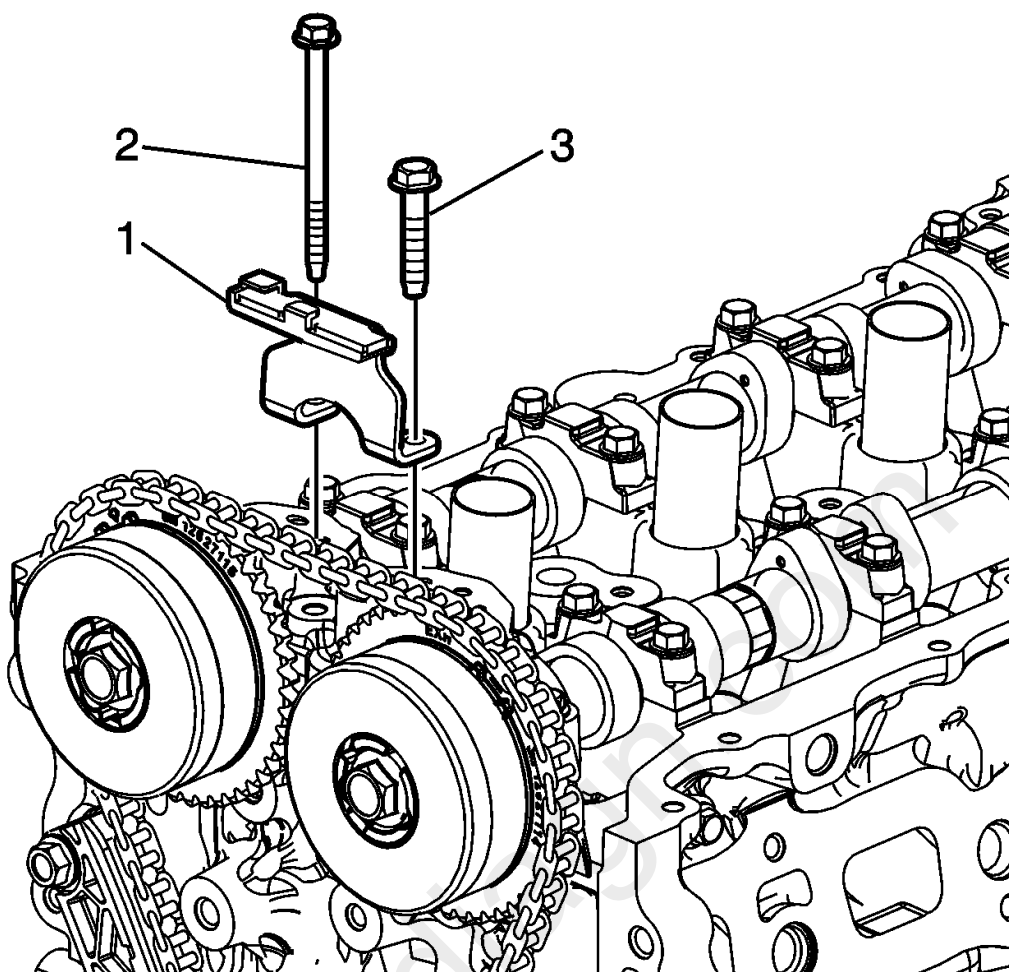


Fig. 251: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Install the timing chain guide (1) and bolts (2, 3) finger tight.

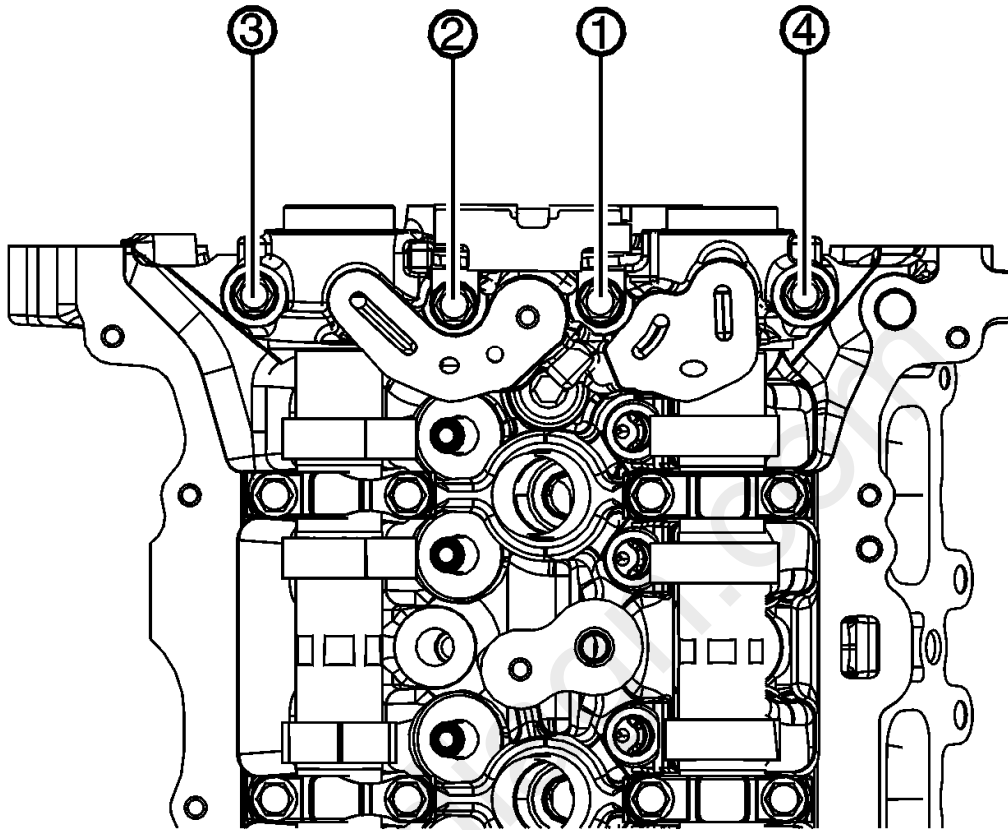


Fig. 252: Front Camshaft Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

17. Tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

NOTE: Rotating the crankshaft will engage the tensioner and remove slack from the timing chain.

18. Rotate the crankshaft slightly in a clockwise direction. If the timing chain jumps actuator teeth, repeat procedure to align the timing marks.

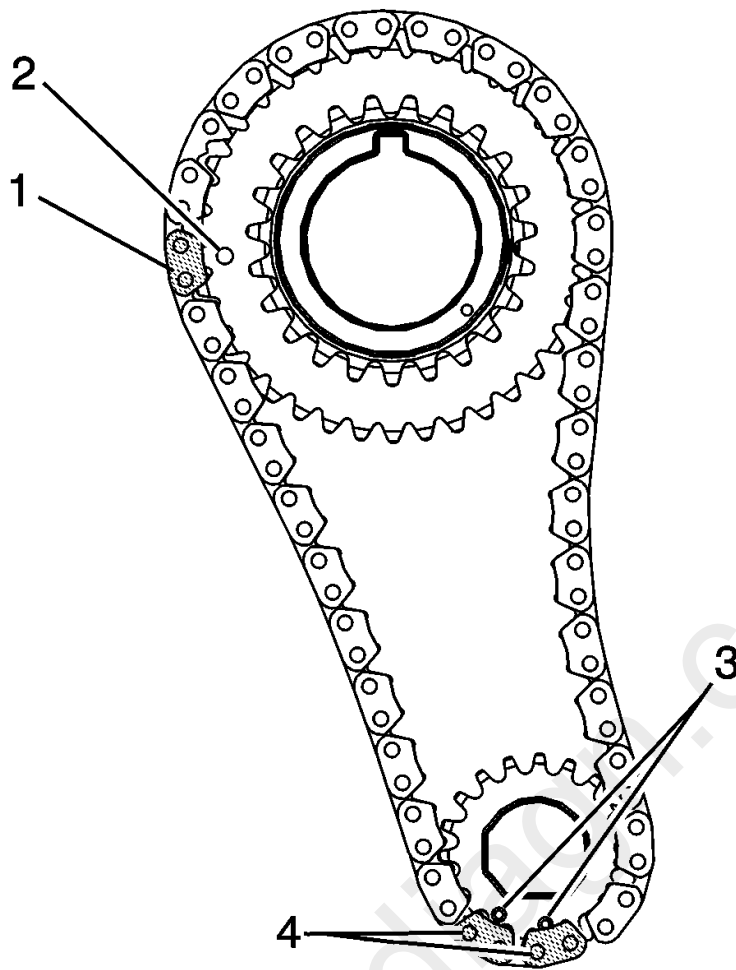


Fig. 253: Timing Link Lines Up And Timing Mark
Courtesy of GENERAL MOTORS COMPANY

NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

19. Verify the timing links on the balance chain are properly aligned to the timing marks:
 1. The timing link (1) is aligned to the timing mark on the crankshaft sprocket (2).
 2. The adjacent timing links (4) are aligned with both timing marks (3) on the balancer shaft driven sprocket.

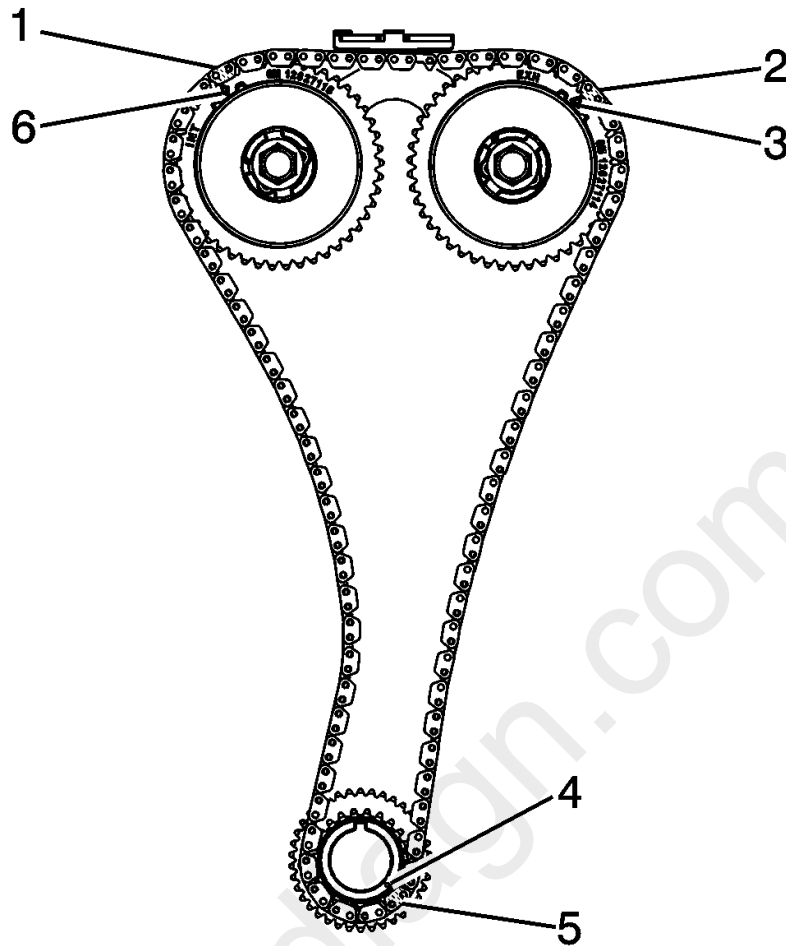


Fig. 254: Timing Chain Oil Nozzle
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

20. Verify the timing links on the timing chain are properly aligned to the timing marks:
 1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
 2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
21. If they are not, repeat the portion of the procedure necessary to align the timing marks.

ENGINE FRONT COVER INSTALLATION

Special Tools

EN-50820 Front Crankshaft Seal Installer

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

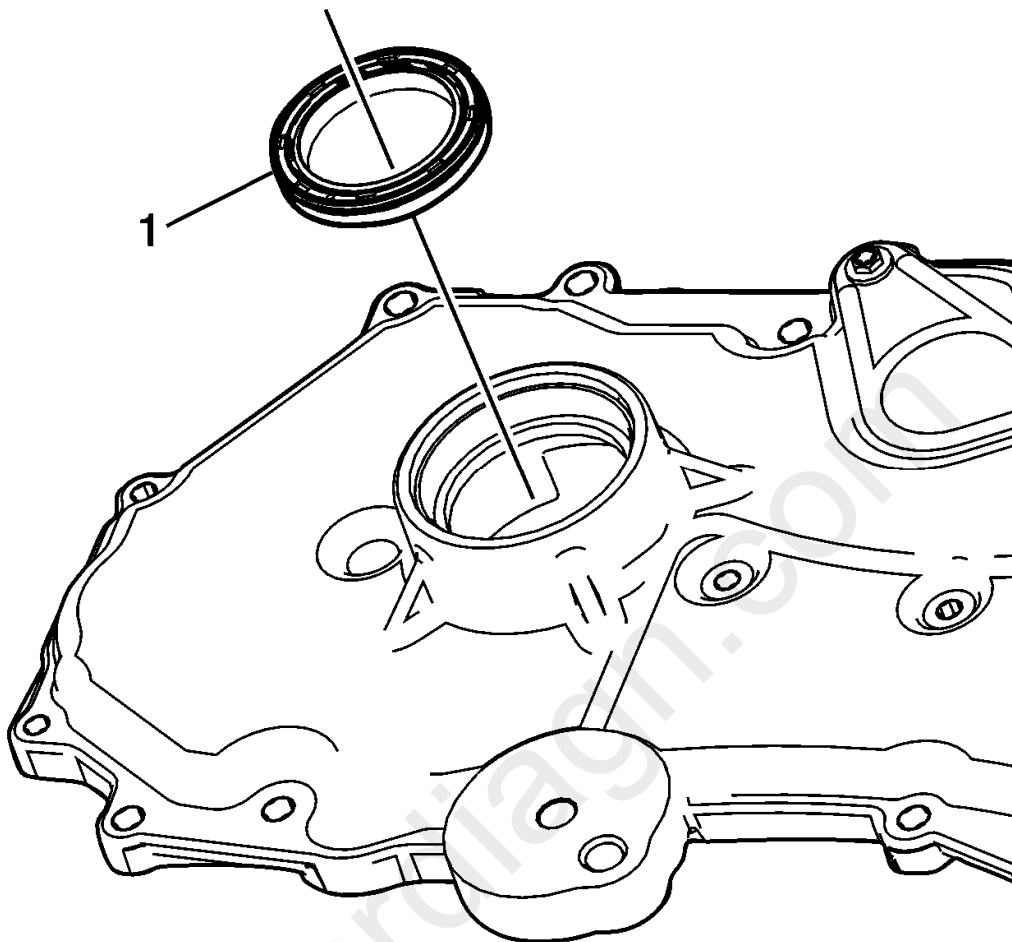


Fig. 255: Front Crankshaft Seal

Courtesy of GENERAL MOTORS COMPANY

1. Using **EN-50820** installer , install the front crankshaft seal (1) into the engine front cover.

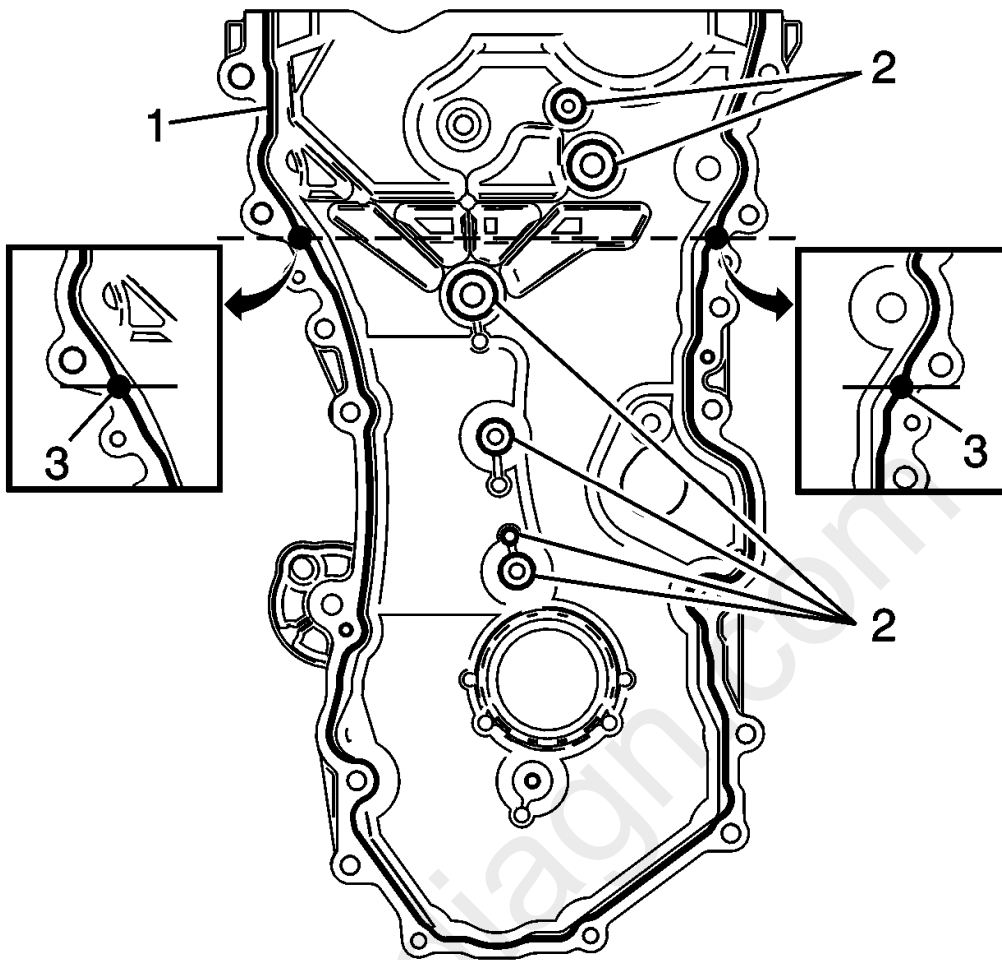


Fig. 256: Applying Bead Of Sealer Directly In Flange
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The engine front cover surface must be free of contamination prior to applying the sealer.
- Install and align the cover within 20 minutes of applying the sealer.
- The cover must be fastened to final torque specification within 60 minutes of applying the sealer.
- Additional sealant is necessary to reduce the possibility of leakage where the cylinder head to engine block interface along the bead path flange on the front cover.

2. Apply a 5 mm bead of sealer directly in the flange (1) of the engine front cover perimeter mating surface. Also apply a 5 mm bead of sealer directly to the locations indicated (2). Finally, apply a 14 mm dab of sealant at the locations indicated (3). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

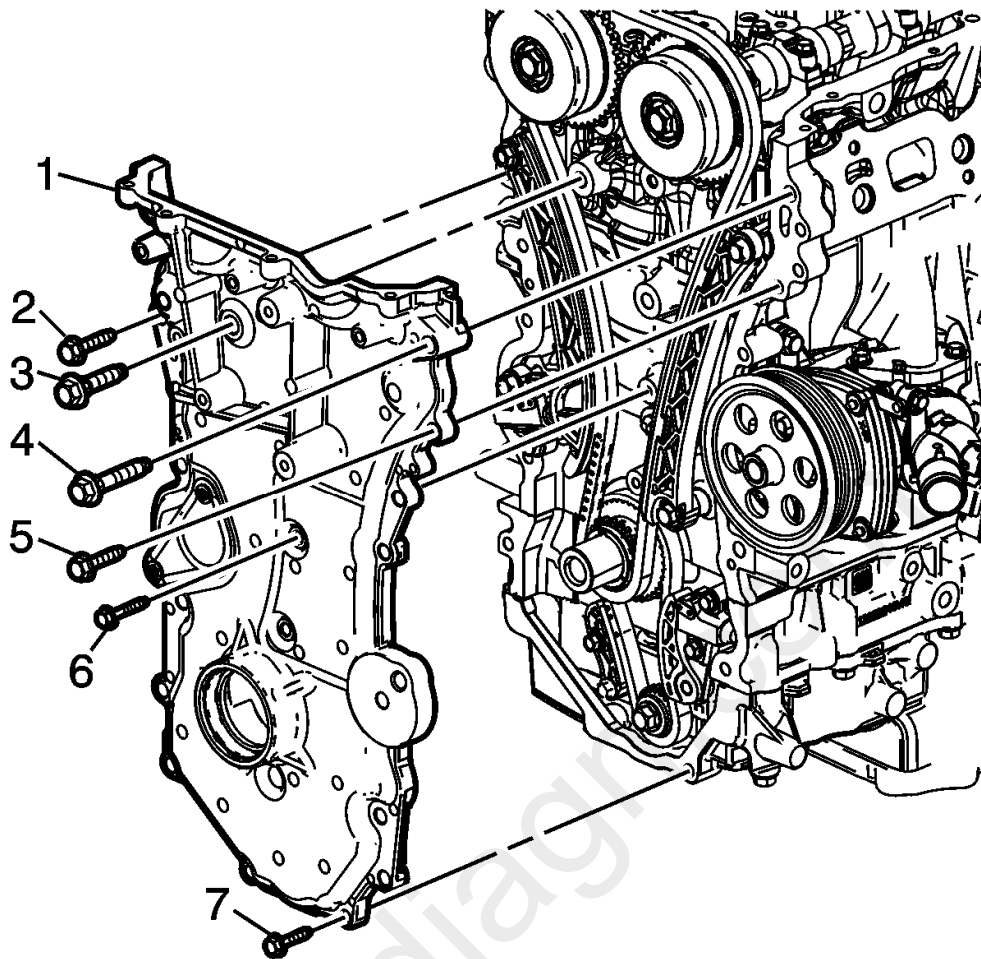


Fig. 257: Exploded View Of Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

3. Install the engine front cover (1).
4. Hand start the engine front cover bolts (2-6, 7).

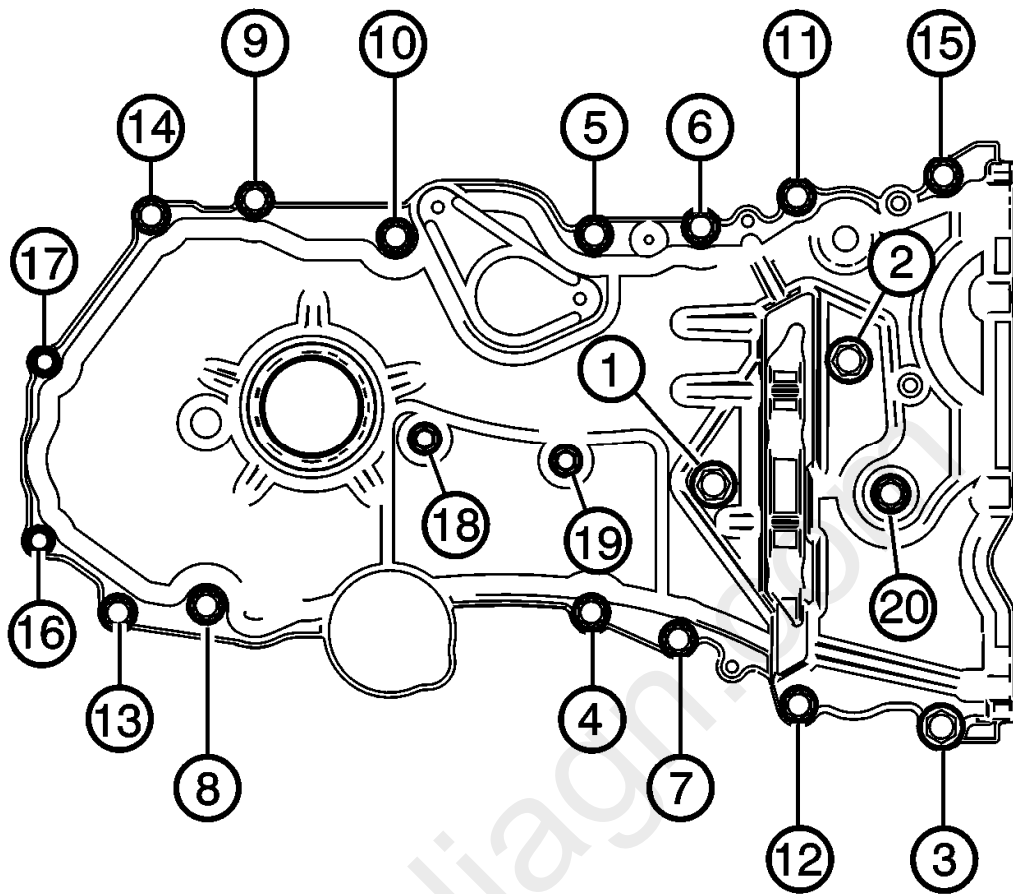


Fig. 258: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Tighten the engine front cover bolts in sequence to final torque twice:
 1. Tighten sequence 1-3 bolts to 58 N.m (43 lb ft).
 2. Tighten sequence 4-11 bolts to 25 N.m (18 lb ft).
 3. Tighten sequence 12 bolt to 25 N.m (18 lb ft).
 4. Tighten sequence 13-15 bolts to 25 N.m (18 lb ft).
 5. Tighten sequence 16-17 bolts to 10 N.m (89 lb in).
 6. Tighten sequence 18-19 bolts to 10 N.m (89 lb in).
 7. Tighten sequence 20 bolt to 25 N.m (18 lb ft).

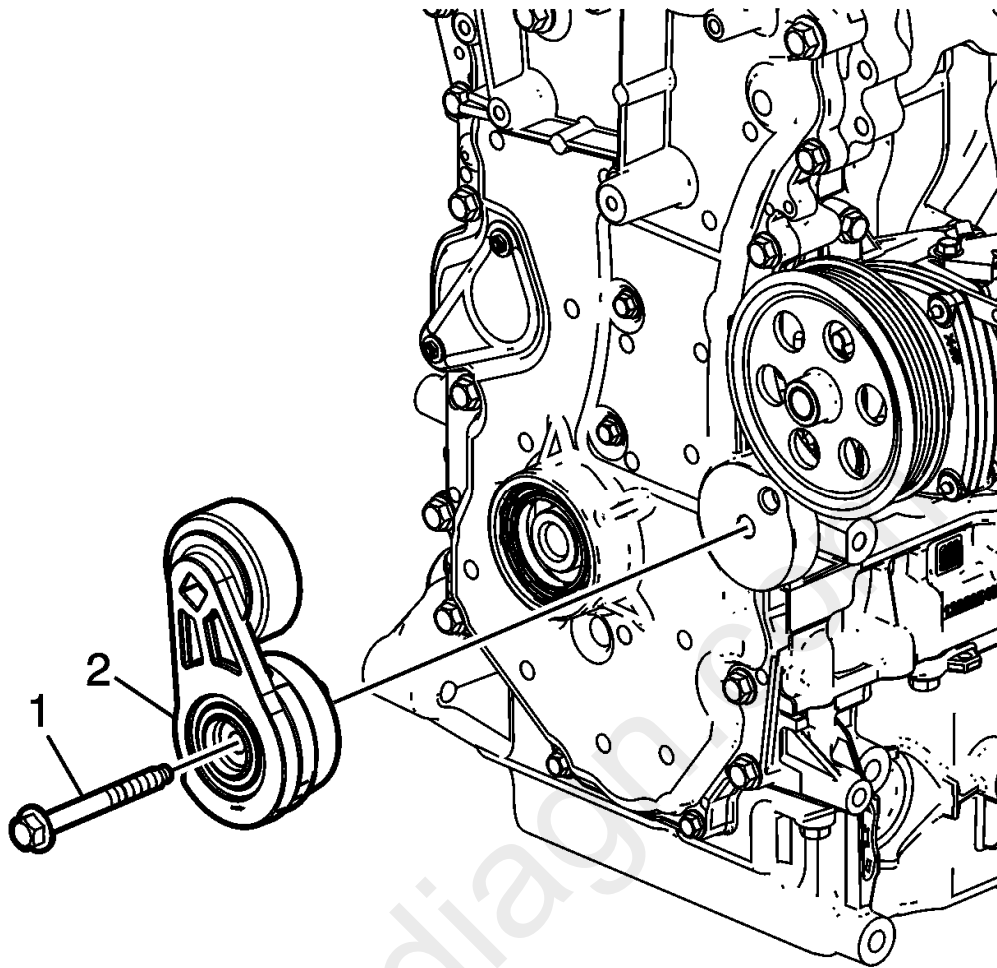


Fig. 259: Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS COMPANY

6. Install the accessory drive belt tensioner (2).
7. Install the accessory drive belt tensioner bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT COVER INSTALLATION

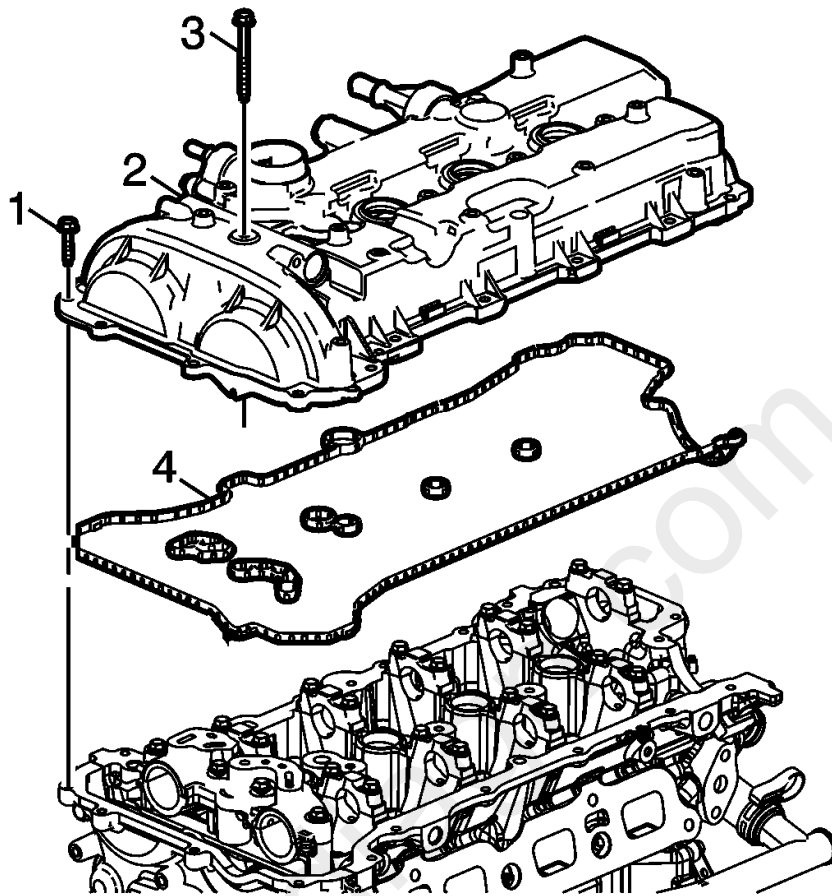


Fig. 260: Camshaft Cover Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Assemble the camshaft cover (2) and a NEW gasket (4). Ensure that the gasket is located in the retaining groove in the camshaft cover.
2. Install the cover on the cylinder head and hand start the bolts (1, 3).

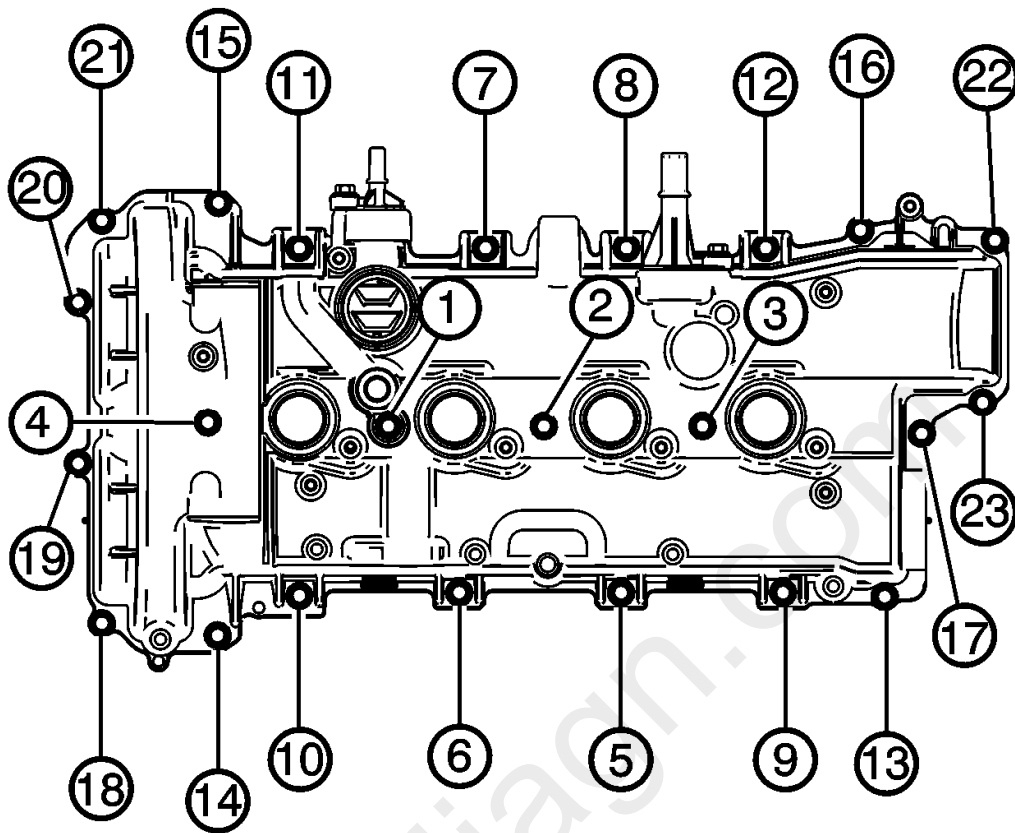


Fig. 261: Camshaft Cover Bolts In Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Tighten the camshaft cover bolts in sequence to 10 N.m (89 lb in).

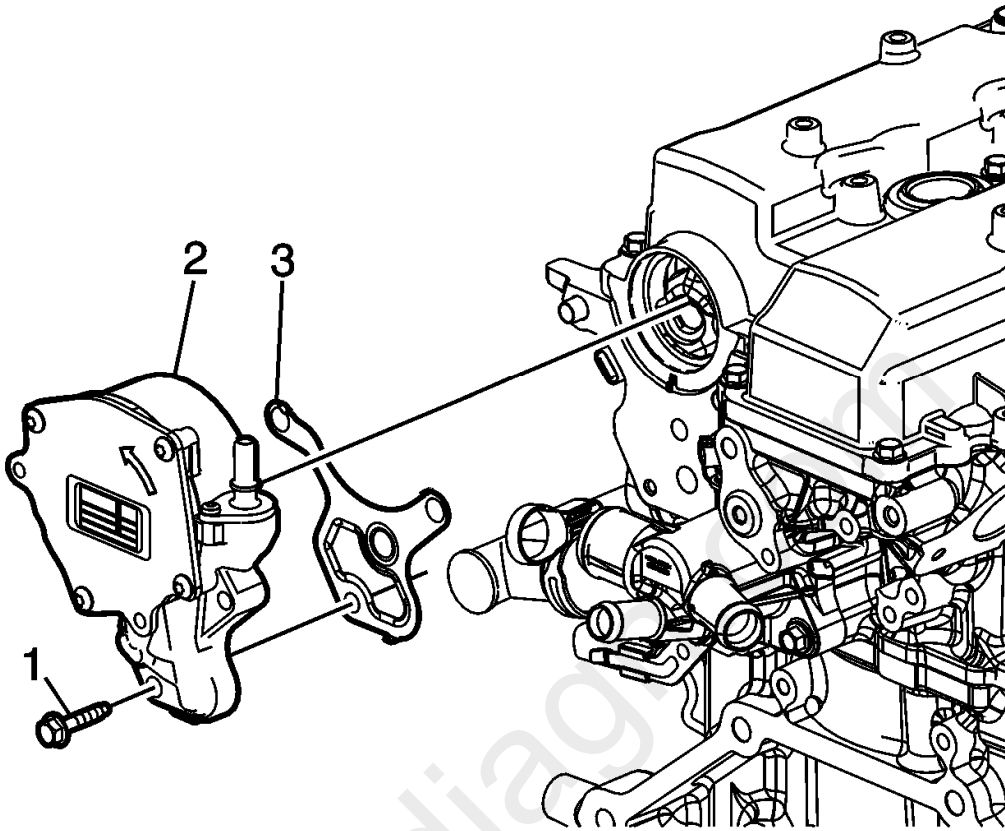


Fig. 262: Vacuum Assembly And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the vacuum pump seal does not need to be replaced, and the sealing surface is clean prior to installing the gasket and pump.

4. Inspect the vacuum pump seal. Refer to Camshaft Cover Cleaning and Inspection.
5. Install a NEW vacuum pump assembly gasket (3) on the vacuum pump assembly (2).
6. Install the vacuum pump assembly (2) and bolts (1). Tighten the bolts to 10 N.m (89 lb in).

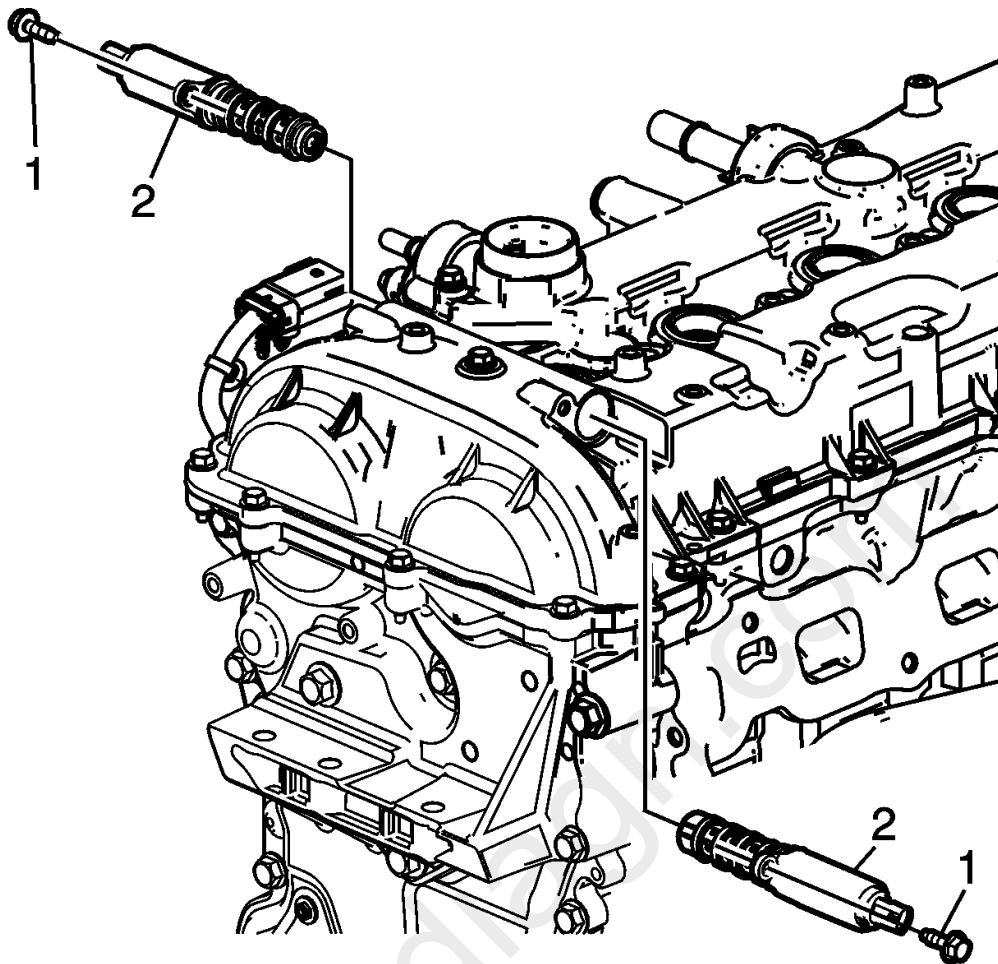


Fig. 263: Camshaft Position Actuator Control Solenoid Valves
Courtesy of GENERAL MOTORS COMPANY

7. Install the camshaft position actuator control solenoid valves (2) and bolts (1). Tighten the bolts to 10 N.m (89 lb in).

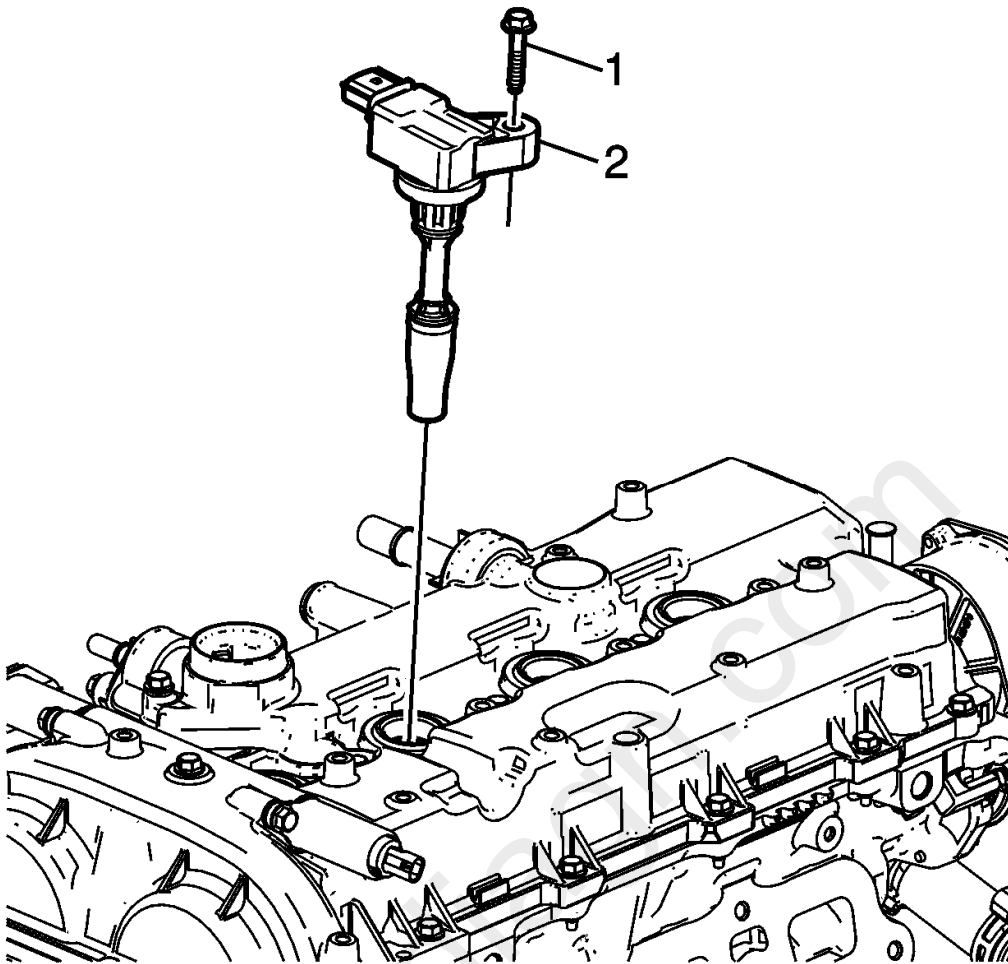


Fig. 264: Ignition Coils And Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:
 1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
9. Install the ignition coils (2) and bolts (1). Tighten the bolt to 10 N.m (89 lb in).

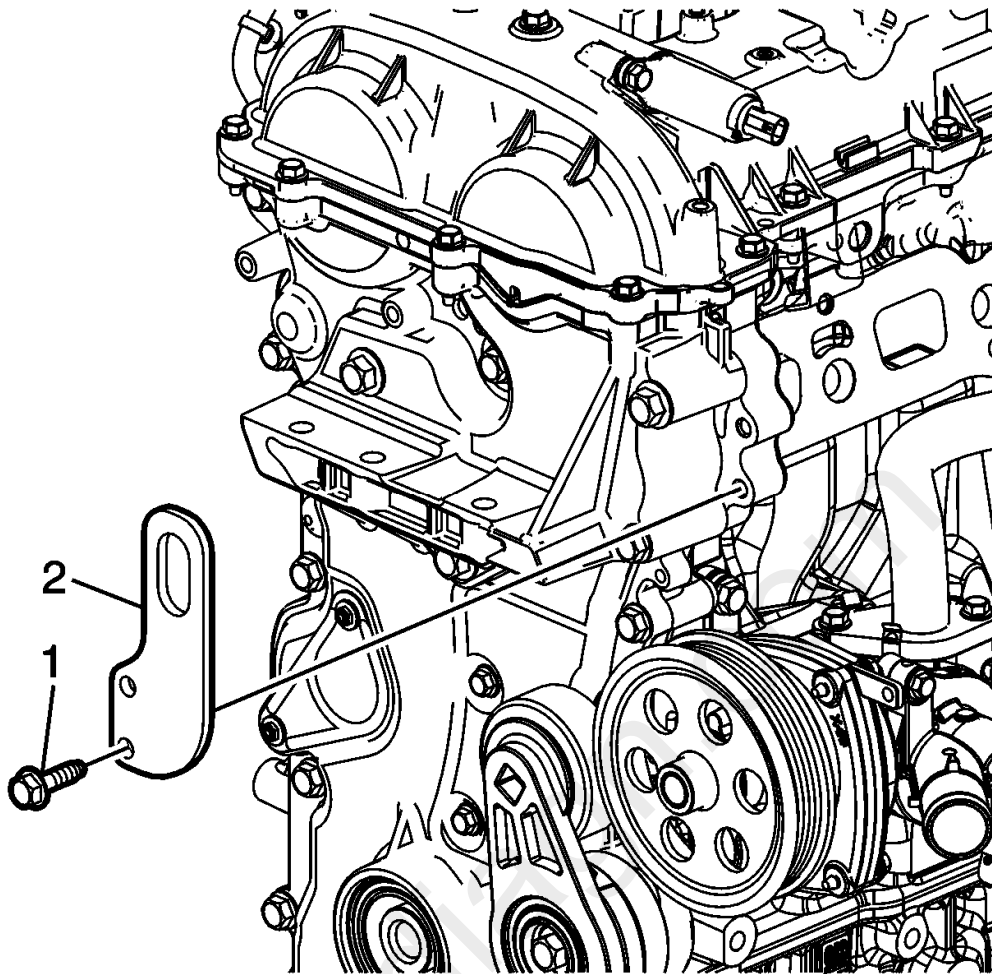


Fig. 265: Front Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

10. Install the front lift bracket (2).
11. Install the front lift bracket bolts (1) and tighten to 25 N.m (18 lb ft).

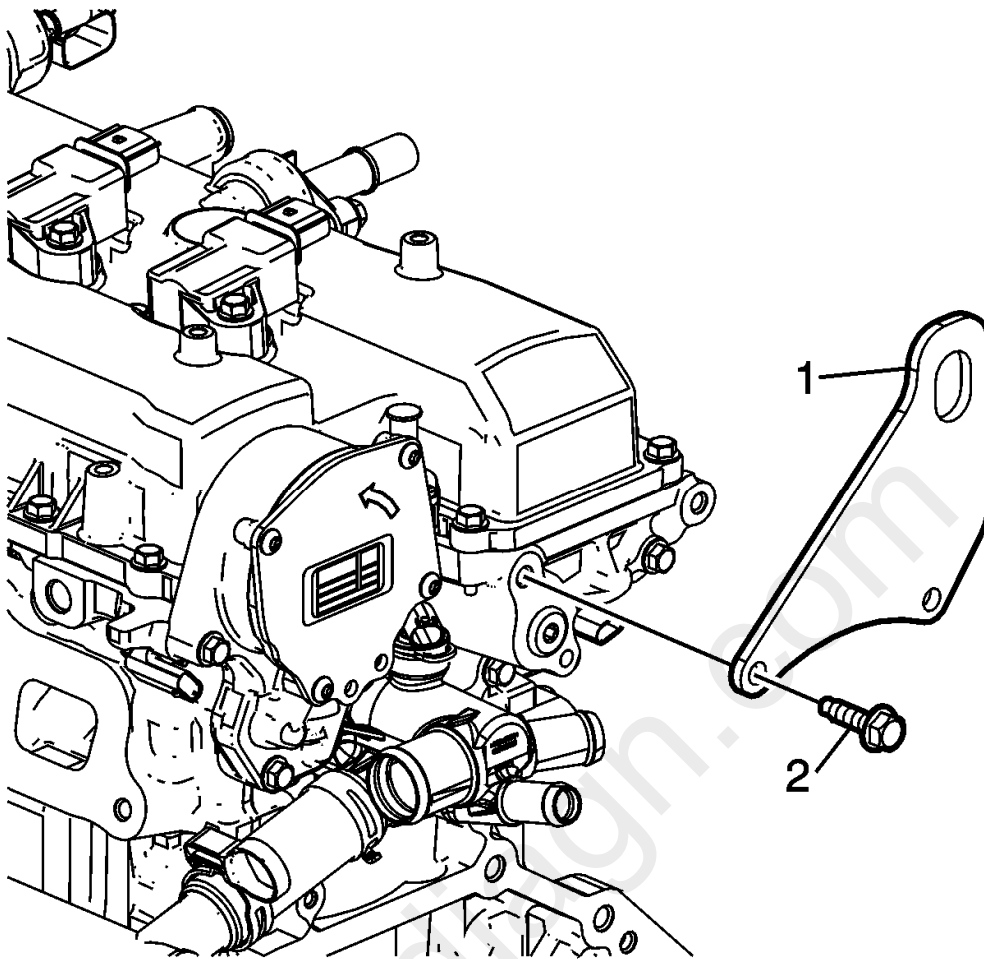


Fig. 266: Rear Lift Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

12. Install the rear lift bracket (1).
13. Install the rear lift bracket bolts (2) and tighten to 25 N.m (18 lb ft).

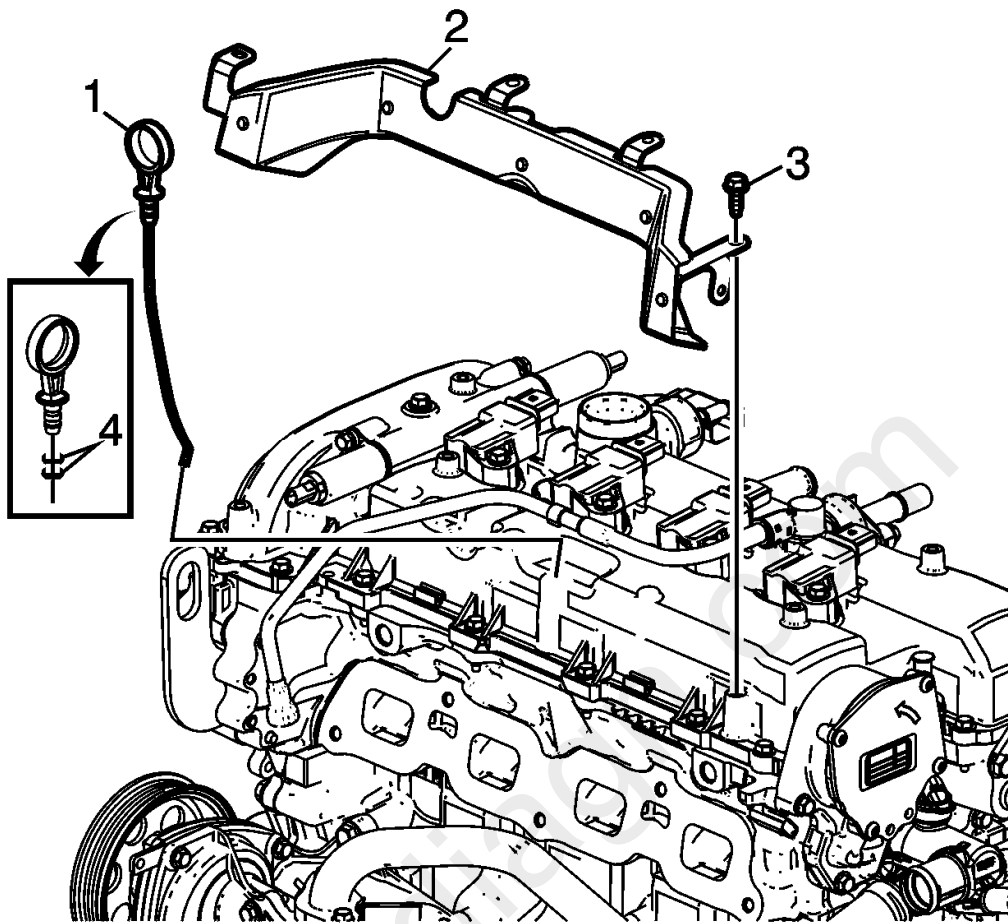


Fig. 267: Camshaft Cover Heat Shield
Courtesy of GENERAL MOTORS COMPANY

14. Install the camshaft cover heat shield (2) and bolts (3). Tighten the bolts to 10 N.m (89 lb in).
15. Inspect the oil level indicator O-ring seals (4) and replace if necessary. Install the oil level indicator (1).

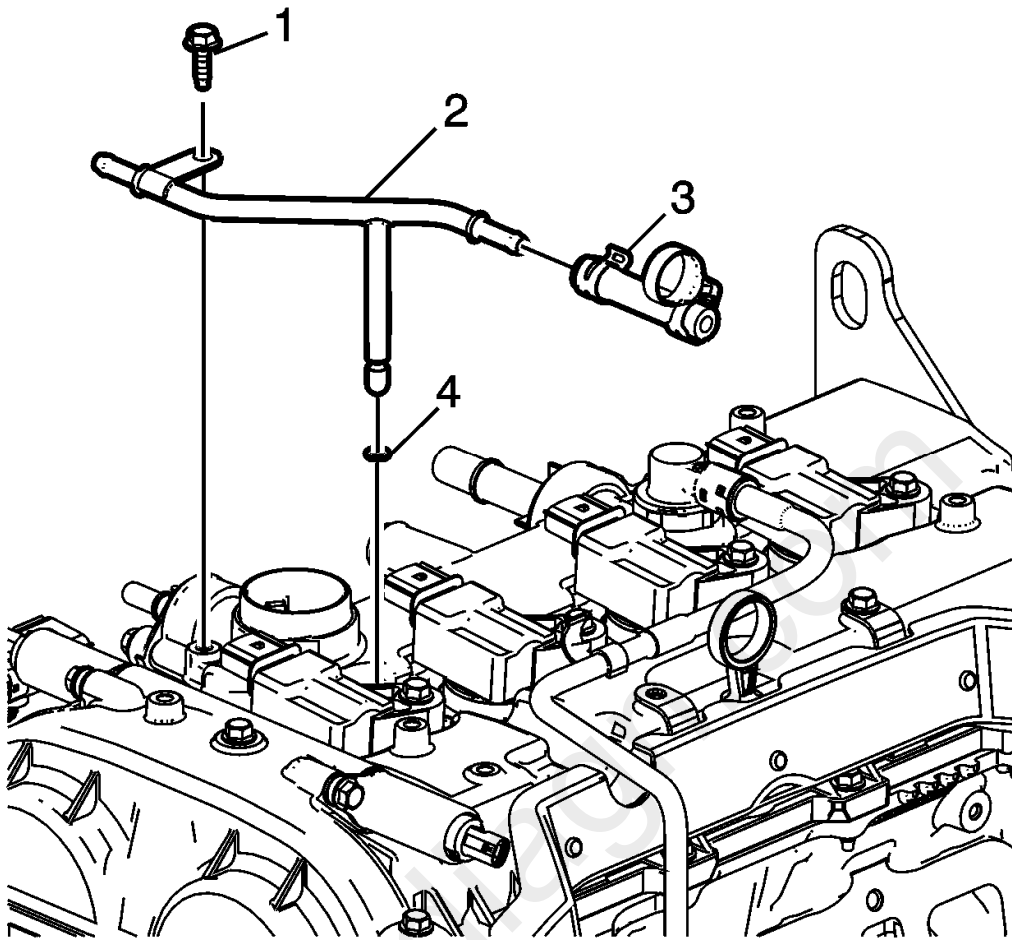


Fig. 268: Engine Coolant Air Bleed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

16. Inspect the O-ring (4) on the engine coolant air bleed pipe. Replace if necessary.
17. Install the engine coolant air bleed hose (3), if necessary.
18. Install the engine coolant air bleed pipe (2).
19. Install the pipe bolt (1) and tighten to 10 N.m (89 lb in).

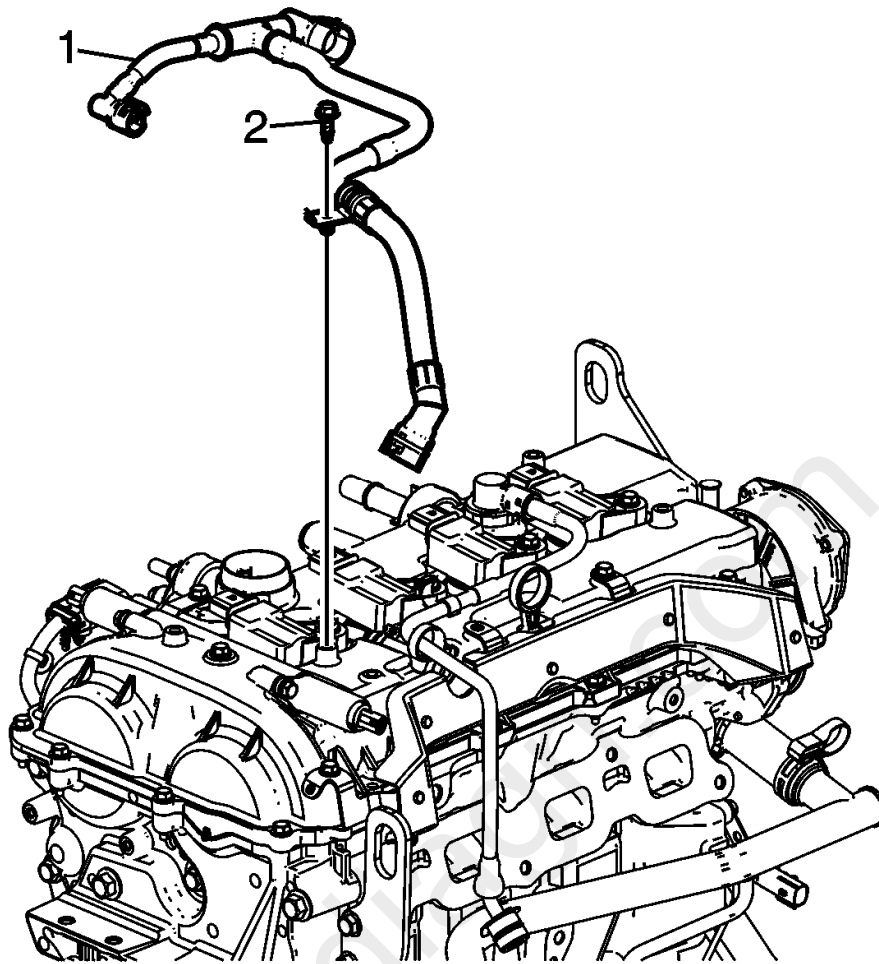


Fig. 269: PCV Hose Bolt
Courtesy of GENERAL MOTORS COMPANY

20. Install the PCV hose assembly (1) at the quick-connect fittings.
21. Install the PCV hose bolt (2) and tighten to 12 N.m (106 lb in).

FUEL RAIL AND INJECTORS INSTALLATION

Special Tools

EN-47909 Injector Bore and Sleeve Cleaning Kit

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

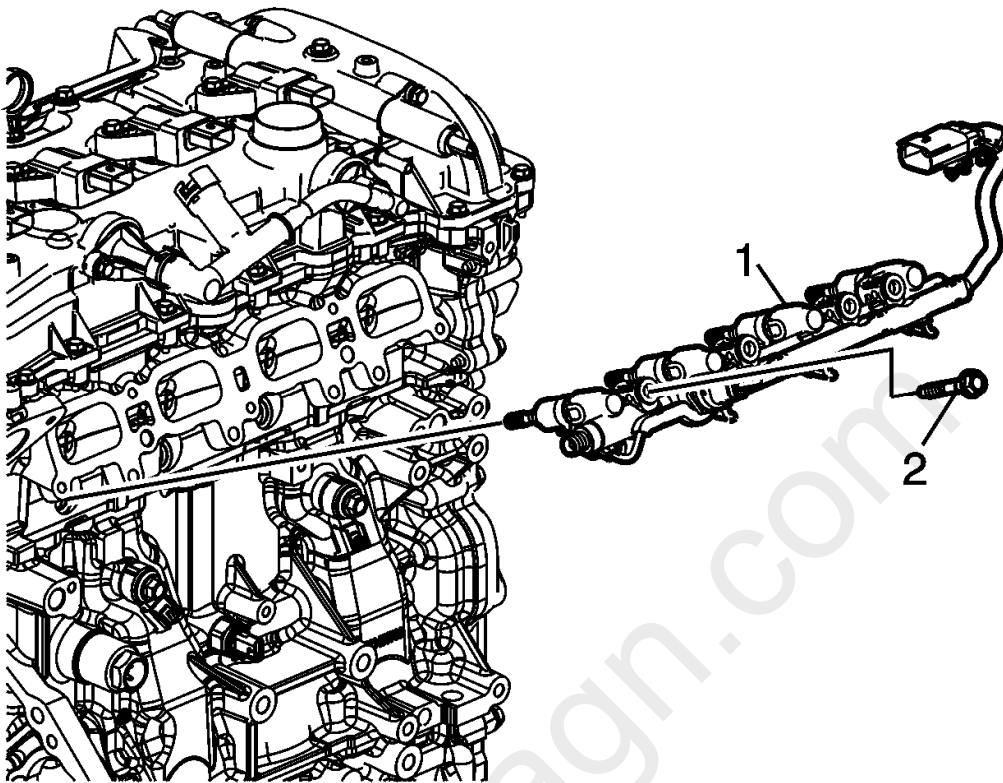


Fig. 270: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

1. Clean the fuel injector bore in the cylinder head using the **EN-47909** kit.
2. Replace the fuel rail insulators, if necessary. Refer to **Fuel Rail and Injectors Cleaning and Inspection**. Replace the fuel rail bolts, if necessary.
3. Install the fuel rail (1) with injectors into the cylinder head evenly.

NOTE: **Mount the bolts evenly to avoid cocking of the fuel injectors during installation.**

4. Hand start the 2 outer fuel rail bolts (2) to seat the injectors into the injector bores.
5. Hand start the remaining fuel rail bolts.

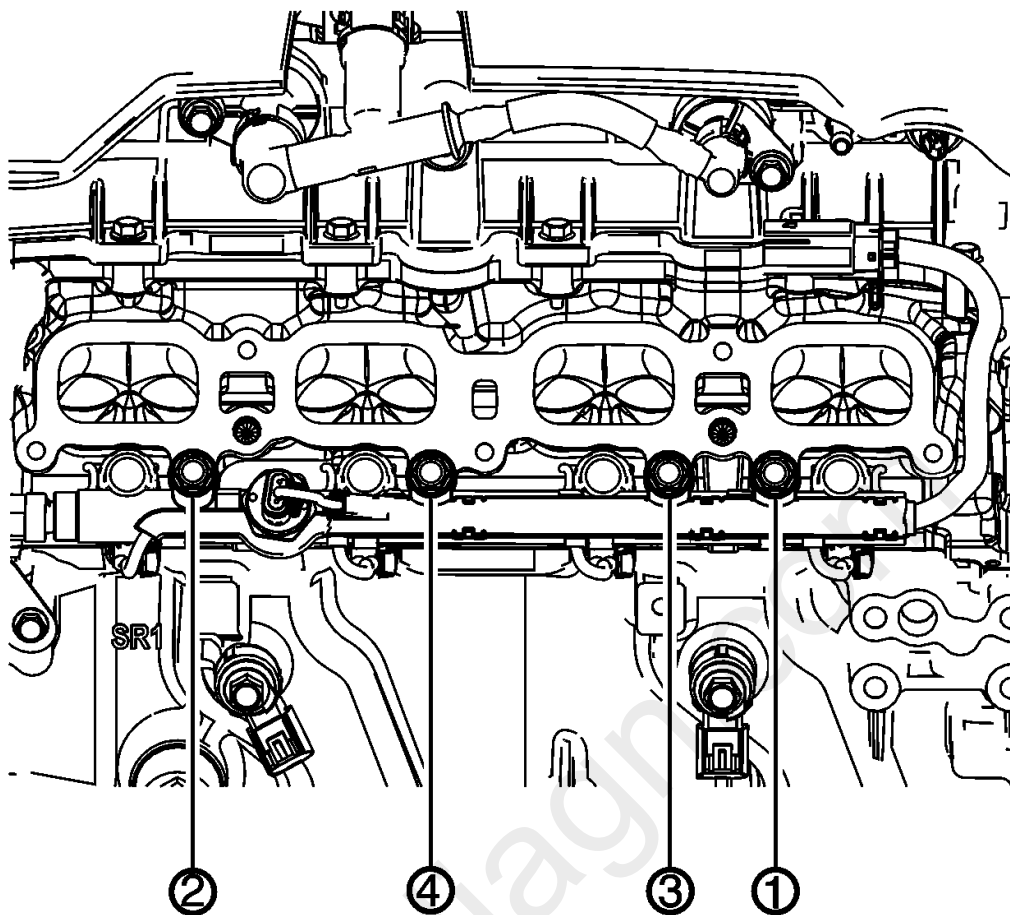


Fig. 271: Fuel Rail Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Tighten the fuel rail bolts in sequence to 25 N.m (18 lb ft).
7. Connect the electrical harness to the fuel rail harness connections.

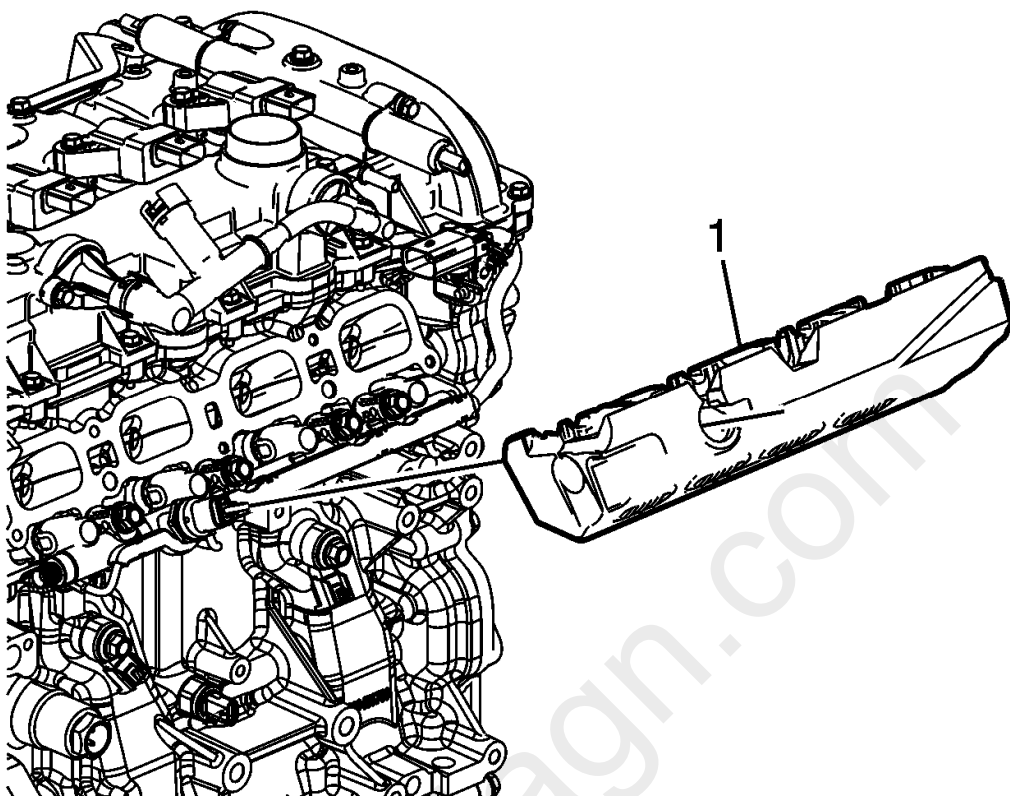


Fig. 272: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

8. Install the fuel injection fuel rail noise shield (1).

SECONDARY AIR INJECTION CHECK VALVE INSTALLATION

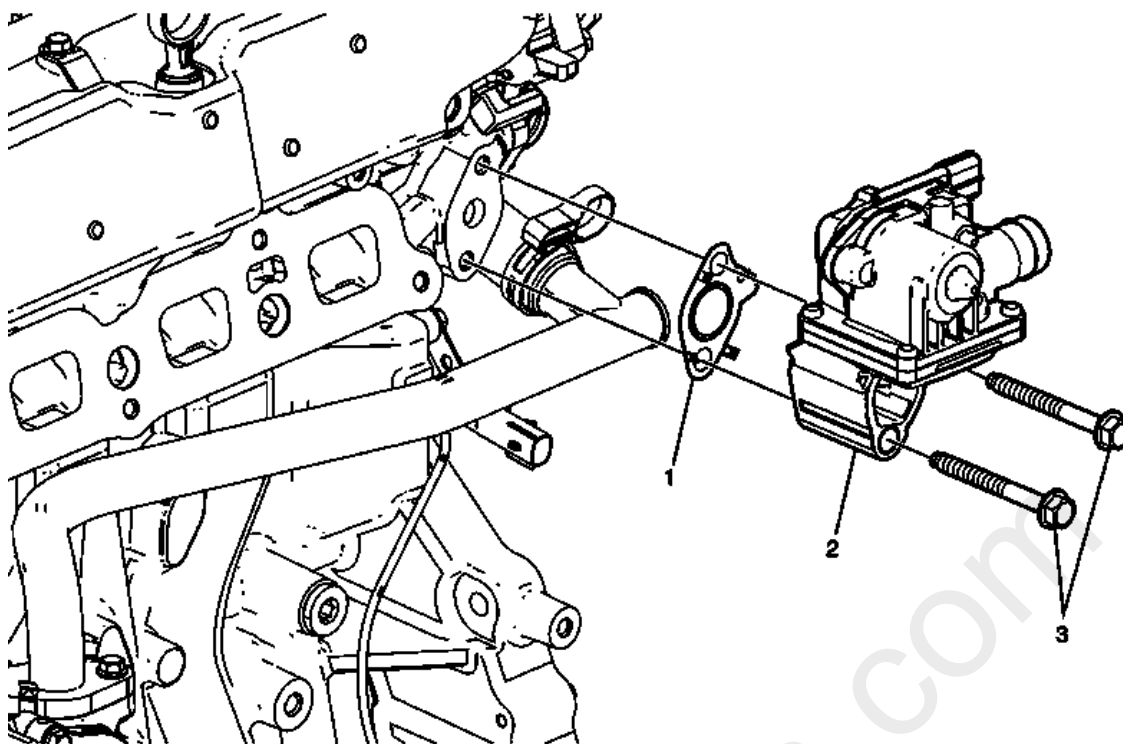


Fig. 273: Secondary Air Injection Check Valve
 Courtesy of GENERAL MOTORS COMPANY

Secondary Air Injection Check Valve Installation

Callout	Component Name
1	Secondary Air Injection Check Valve Gasket
2	Secondary Air Injection Check Valve
3	Secondary Air Injection Check Valve Bolt (Qty: 2) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 25 (18 lb ft)

EXHAUST MANIFOLD INSTALLATION

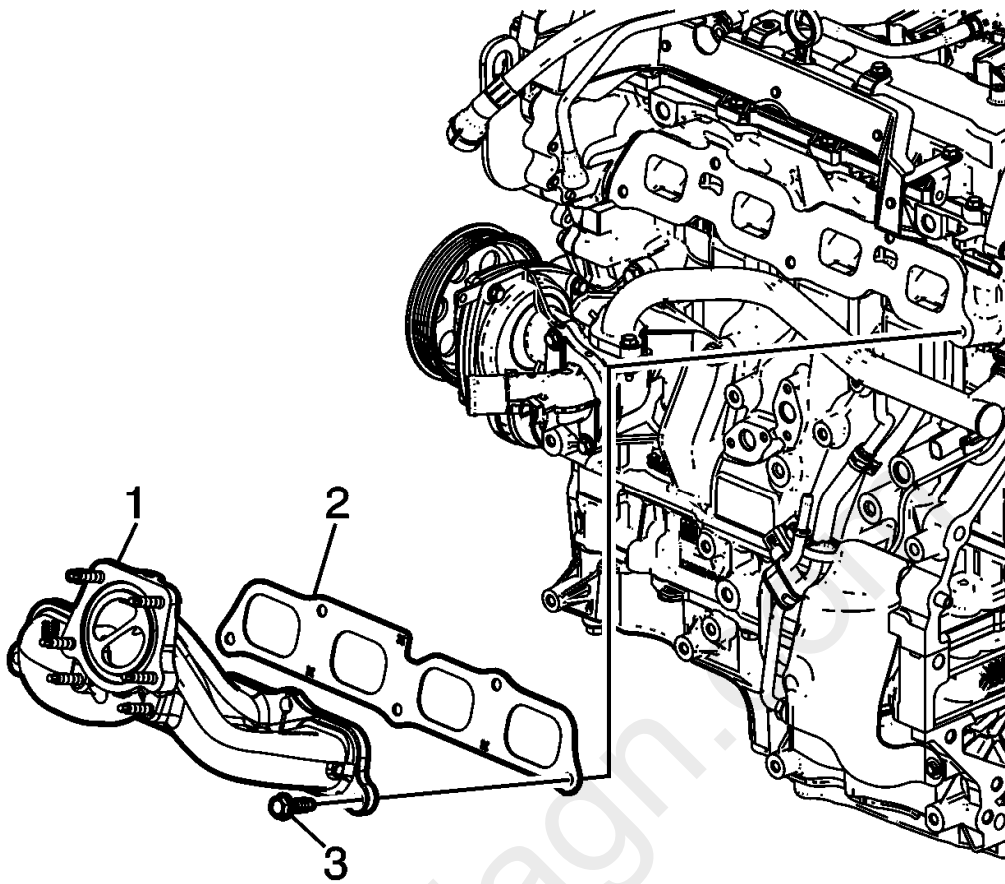


Fig. 274: Exhaust Manifold And Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW exhaust manifold gasket (2).
2. Install the exhaust manifold (1) to the cylinder head.
3. Hand start NEW exhaust manifold to cylinder head retaining bolts (3).

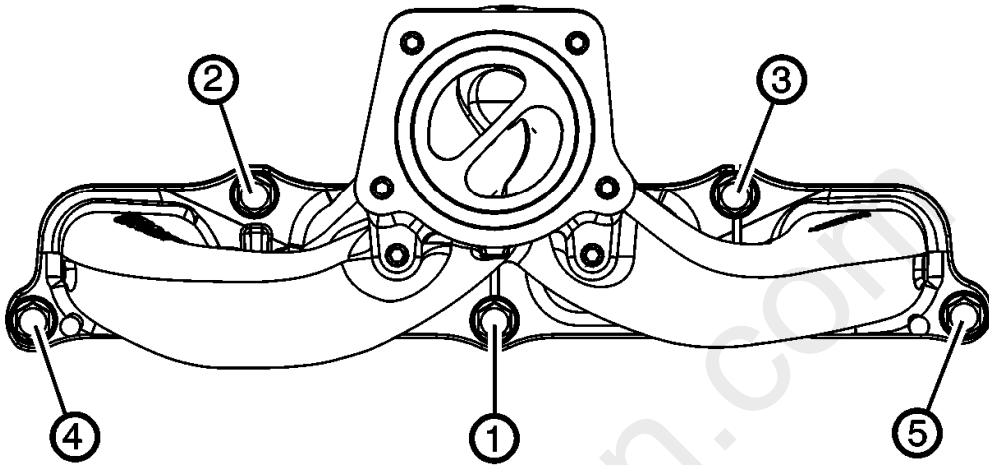


Fig. 275: Cylinder Head Retaining Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

4. Tighten the NEW exhaust manifold to cylinder head bolts three passes in sequence to 20 N.m (15 lb ft).

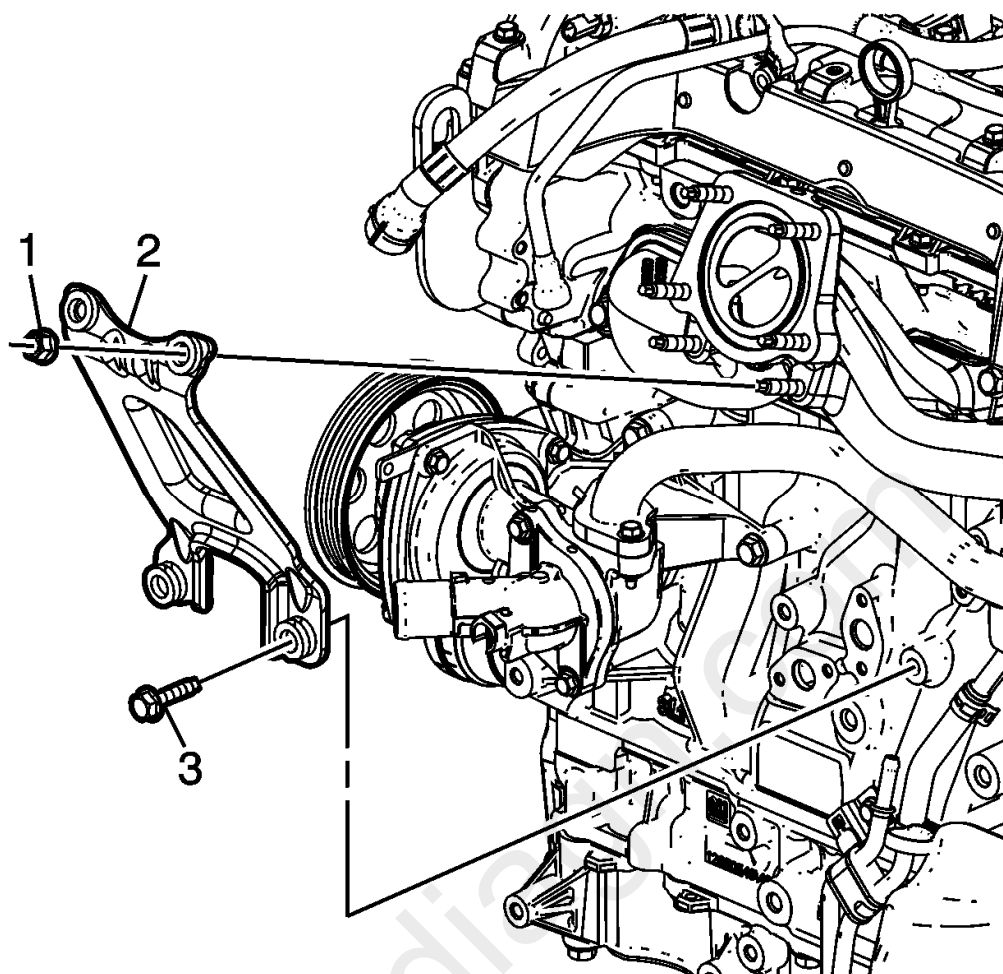


Fig. 276: Exhaust Manifold Brace Nuts
Courtesy of GENERAL MOTORS COMPANY

5. Install the exhaust manifold brace (2).
6. Install the exhaust manifold brace bolts (3) and tighten to 25 N.m (18 lb ft)
7. Install NEW exhaust manifold brace nuts (1) and tighten to 25 N.m (18 lb ft)

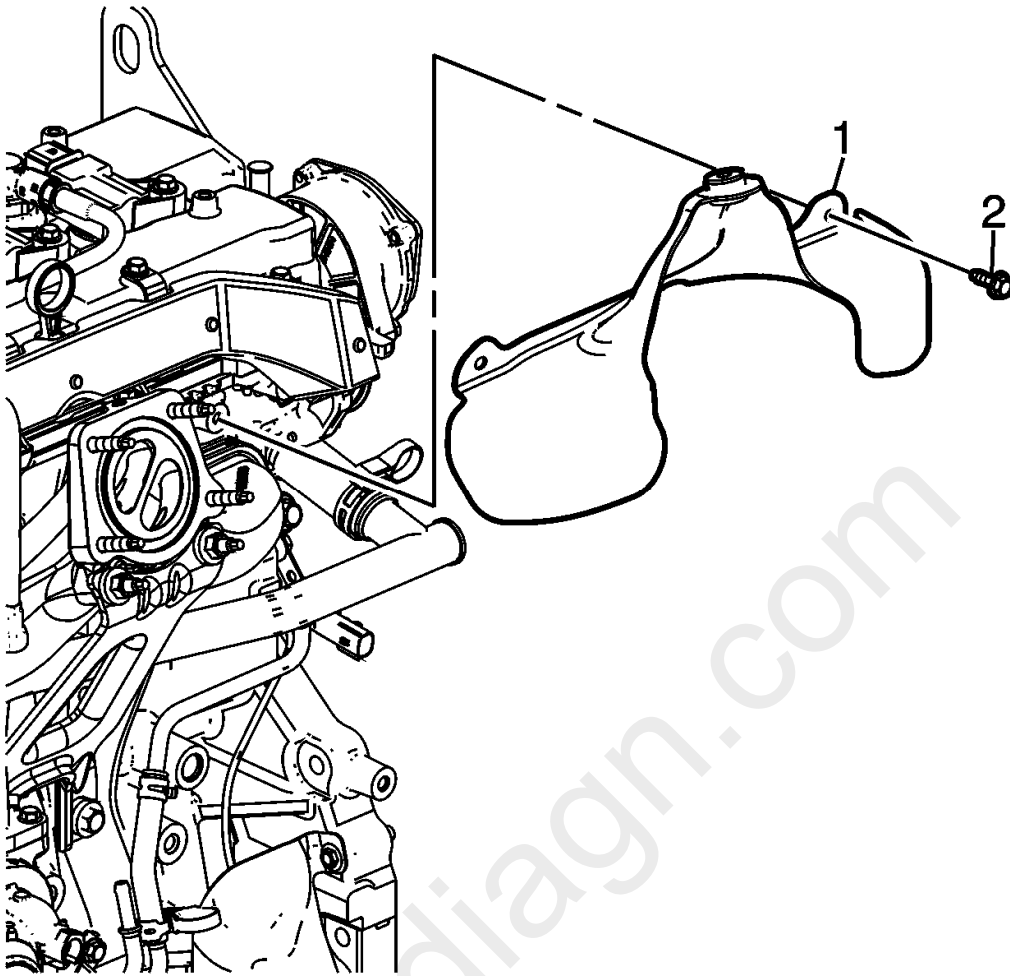


Fig. 277: Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust manifold heat shield (1).
9. Install the exhaust manifold heat shield bolts (2) and tighten to 14 N.m (124 lb in).

INTAKE MANIFOLD INSTALLATION

Special Tools

EN-50790 HP Fuel Pump Installation Alignment Gauge

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

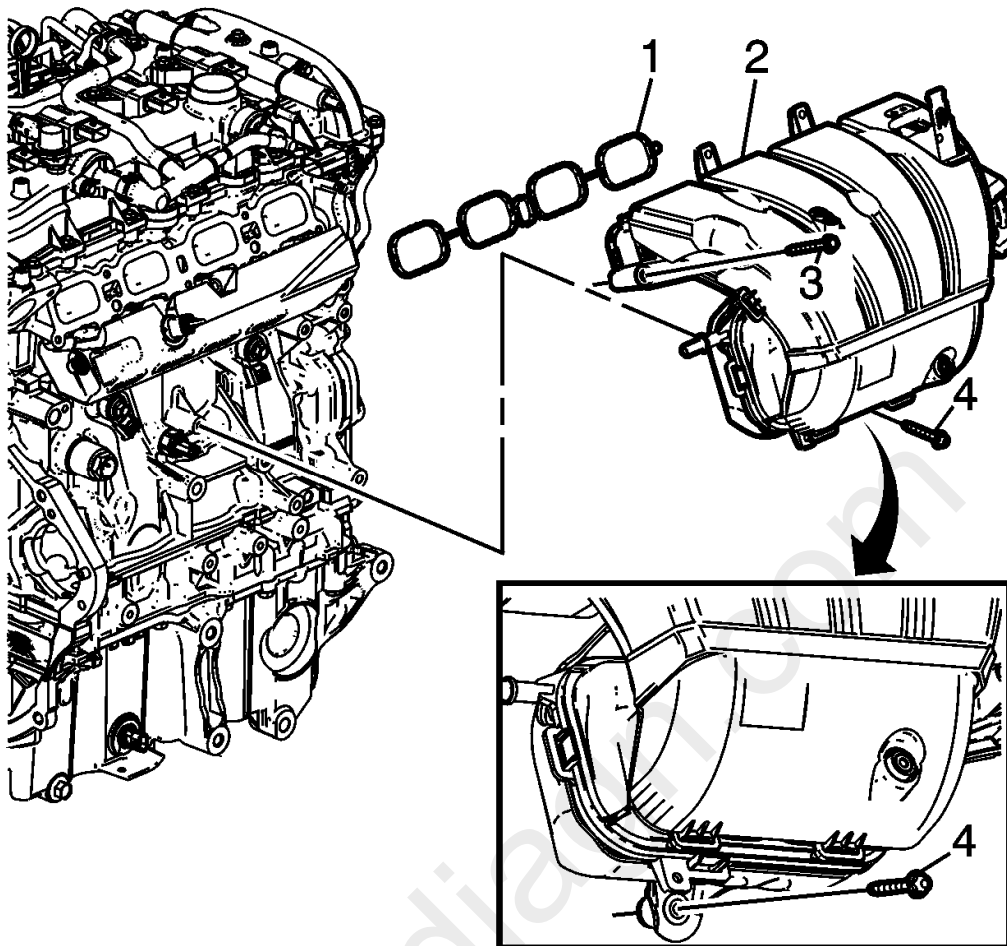


Fig. 278: Engine Intake Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW gasket (1) on the intake manifold (2). Install the intake manifold and hand start the intake manifold bolts (3, 4).

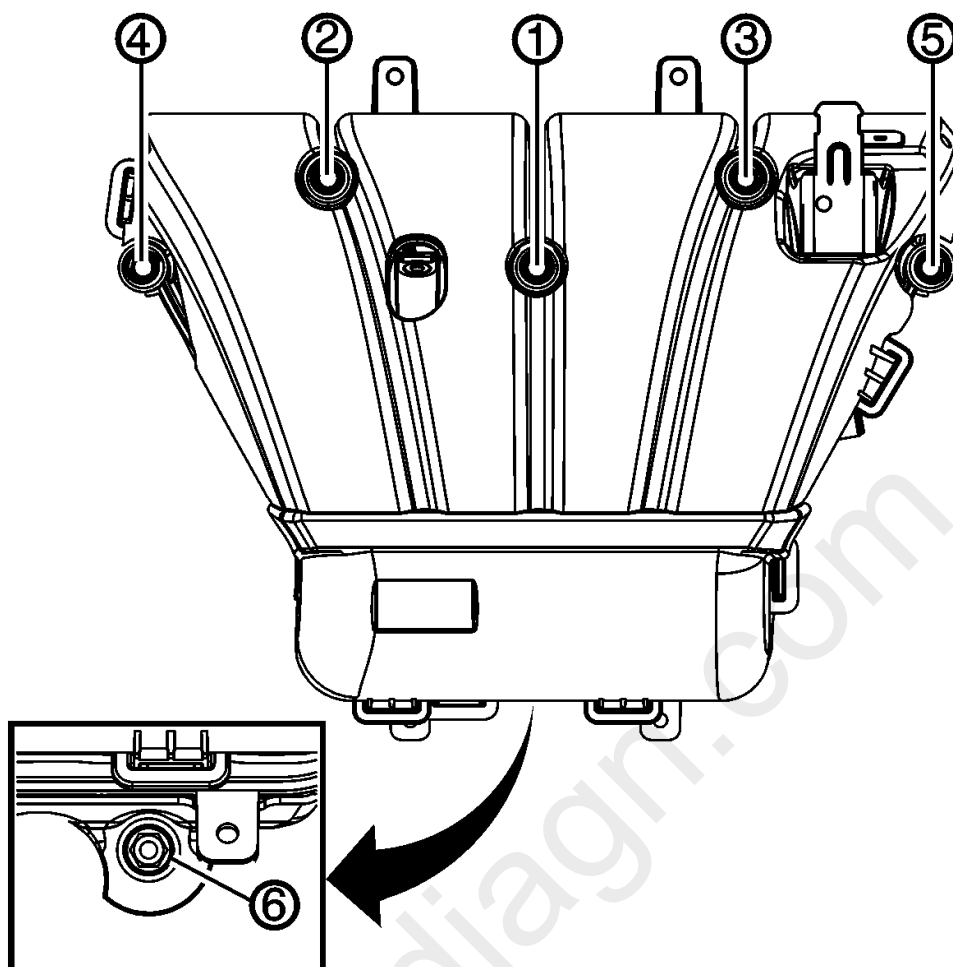


Fig. 279: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Tighten the bolts and nuts in sequence twice to 12 N.m (106 lb in).

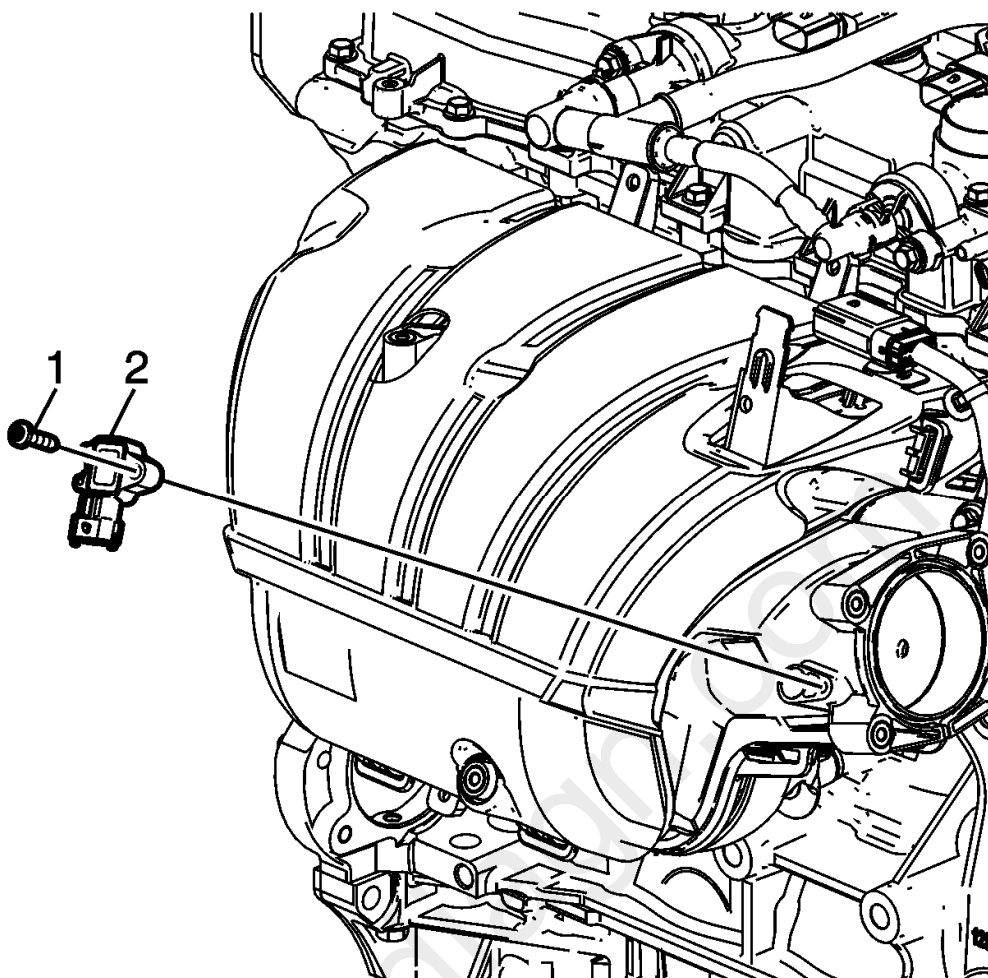


Fig. 280: MAP Sensor
Courtesy of GENERAL MOTORS COMPANY

3. Install the MAP sensor (2) and bolt (1). Tighten the bolt to 5 N.m (44 lb in).

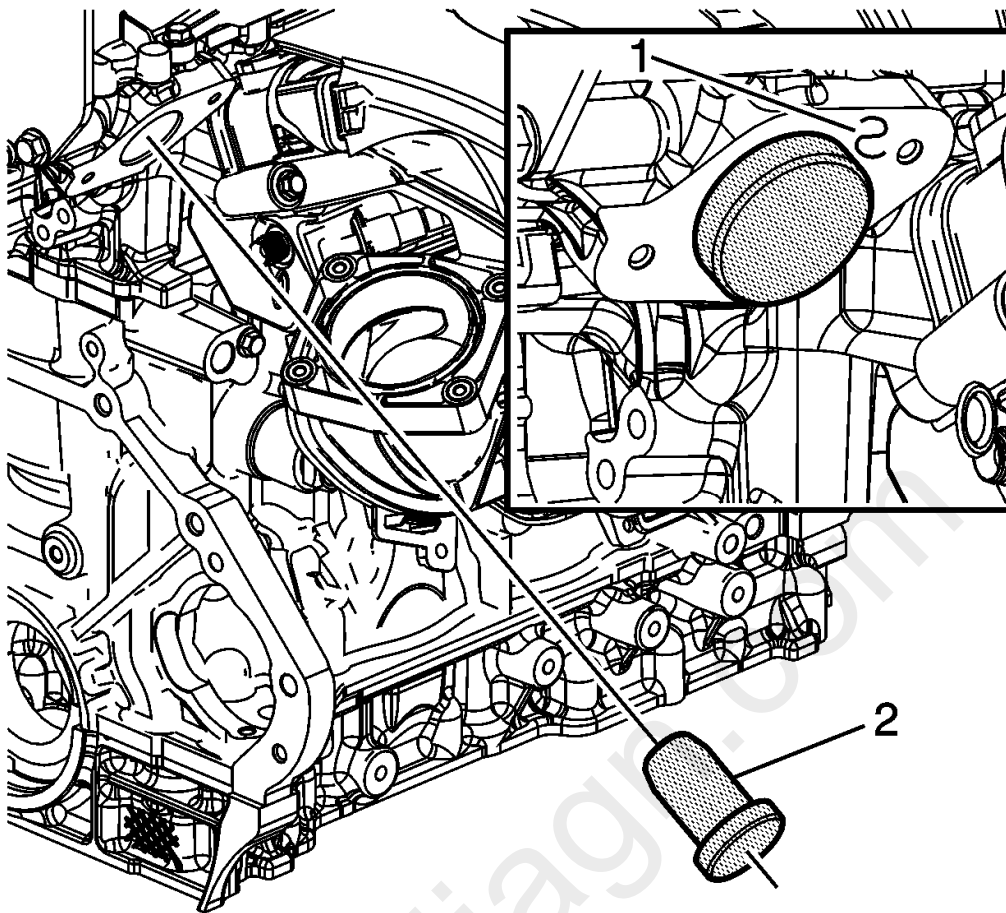


Fig. 281: View Of HP Fuel Pump Installation Alignment Gauge
Courtesy of GENERAL MOTORS COMPANY

NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed.

4. Use the **EN-50790** 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).

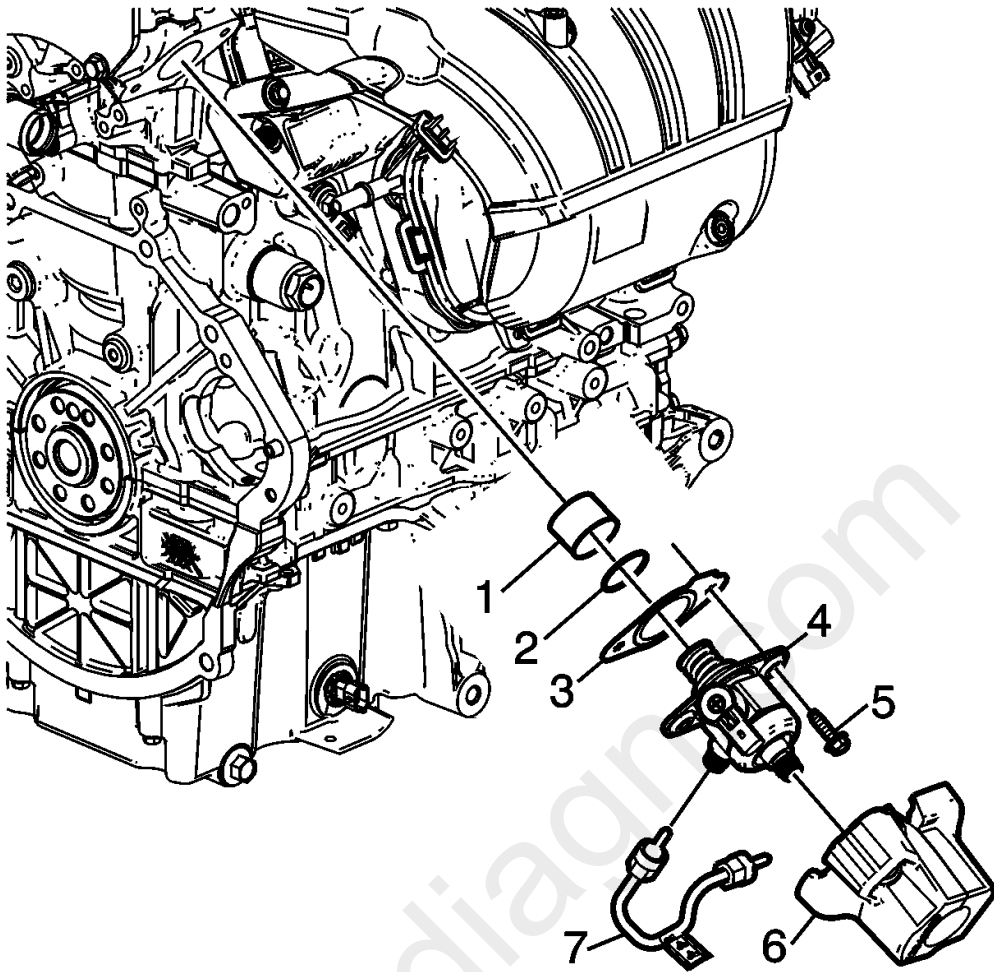


Fig. 282: Exploded View Of Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

5. 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, and the camshaft is at base circle.

6. Lubricate the high pressure fuel pump roller lifter (1) with 5W30 engine oil and install into the cylinder head bore.

NOTE: Ensure the fuel pump housing gasket (3) is properly aligned with the tab upward at the 2 O'clock position.

7. Install a NEW fuel pump housing O-ring (2) and gasket (3).
8. Install the fuel pump assembly (4).
9. Hand start the fuel pump assembly bolts (5) evenly. Tighten the fuel pump bolts evenly to 15 N.m (11 lb ft).

10. Hand start both ends of the NEW fuel feed intermediate pipe (7).
 1. Tighten the fitting nut to the fuel rail to 15 N.m (11 lb ft).
 2. Tighten the fitting nut to the fuel pump to 15 N.m (11 lb ft).
 3. Tighten the fitting nut to the fuel rail a final pass to 30 N.m (22 lb ft).
 4. Tighten the fitting nut to the fuel pump a final pass to 30 N.m (22 lb ft).
11. Install the fuel pump insulator (6).

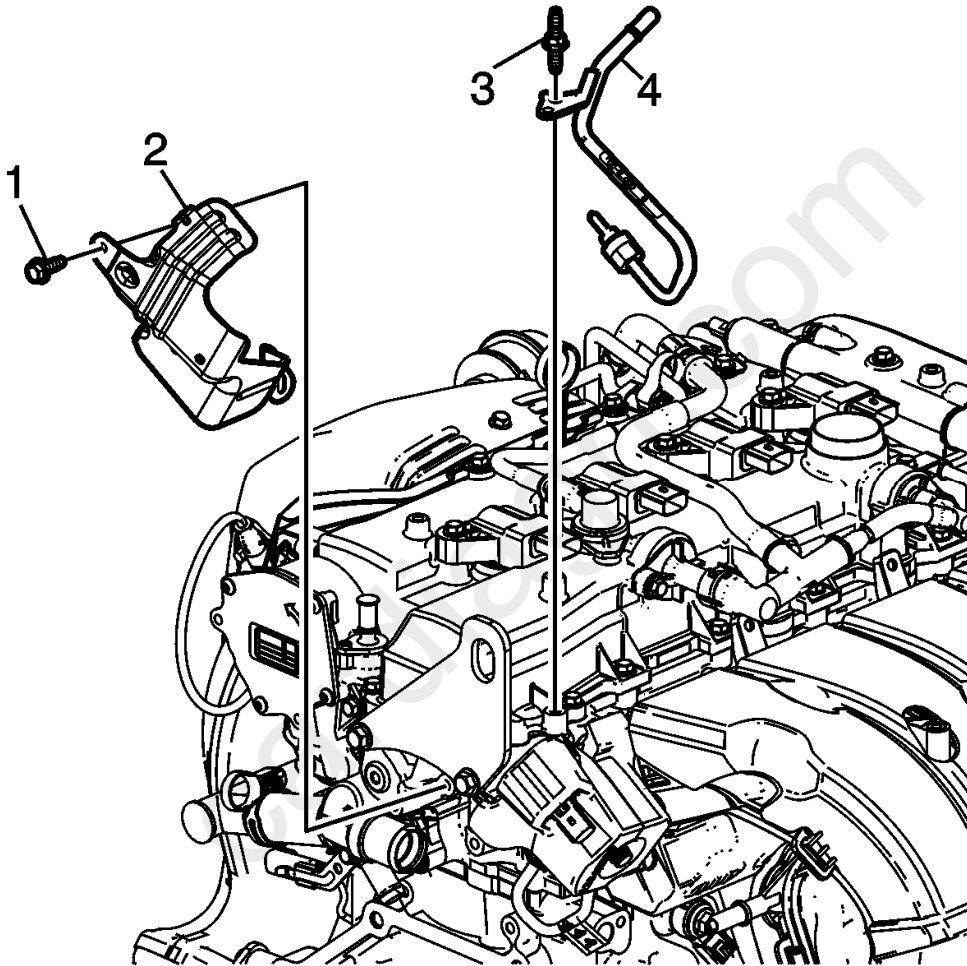


Fig. 283: Fuel Pump Cover And Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

12. Hand start the fitting nut on the fuel feed pipe (4). Tighten the fitting nut to 30 N.m (22 lb ft).
13. Install the fuel feed pipe stud (3).
14. Install the fuel pump cover (2) and bolts (1). Tighten the bolts to 10 N.m (89 lb in).

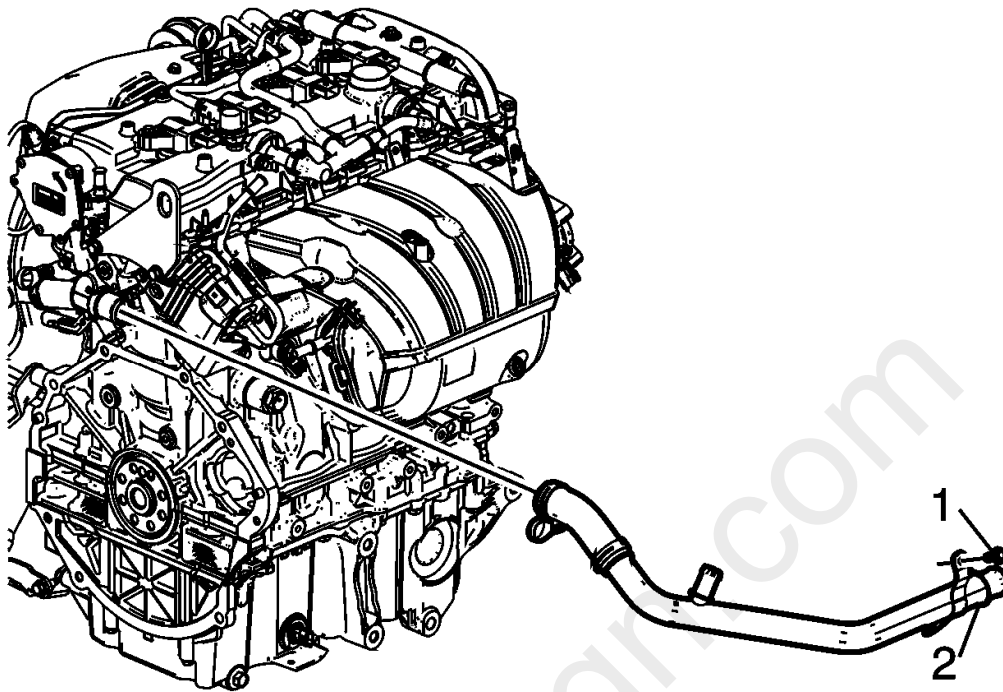


Fig. 284: Radiator Inlet Pipe And Hose
Courtesy of GENERAL MOTORS COMPANY

15. Connect the hose on the radiator inlet pipe assembly (2) to the water outlet assembly.
16. Install the radiator inlet pipe bolt (1).

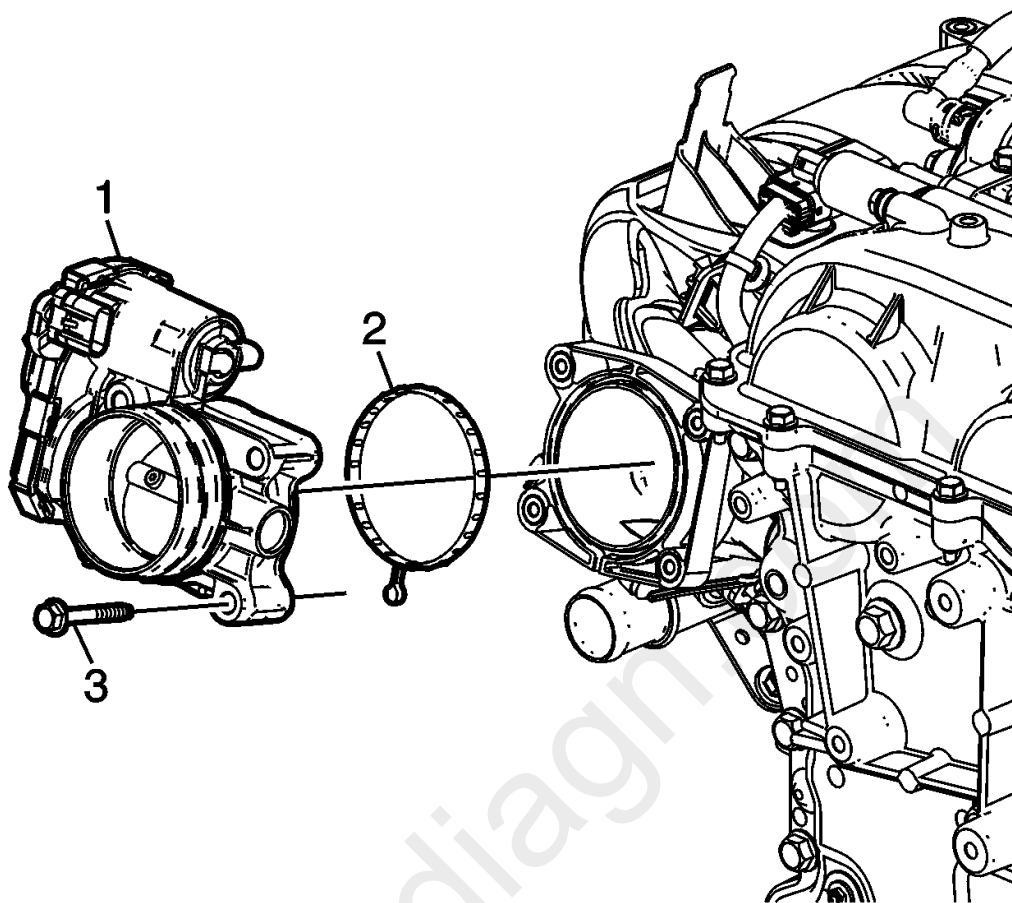


Fig. 285: Throttle Body
Courtesy of GENERAL MOTORS COMPANY

17. Install a new throttle body gasket (2).
18. Install the throttle body (1).
19. Install the throttle body bolts (3) and tighten to 10 N.m (89 lb in).

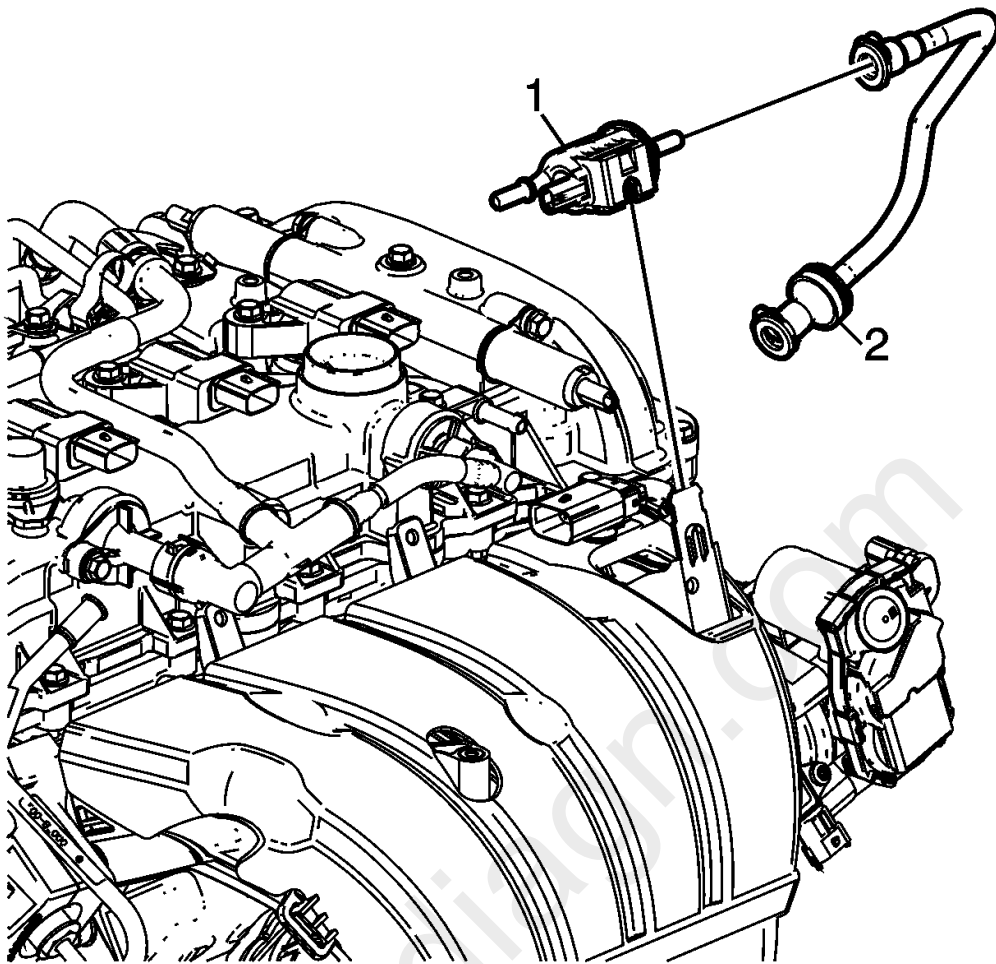


Fig. 286: Evap Canister Valve And Valve Pipe Assembly
Courtesy of GENERAL MOTORS COMPANY

20. Install the EVAP canister valve tube assembly (2).

NOTE: **Ensure the quick-connect is clean and free of debris. The latch should move freely prior to installation.**

21. Install the EVAP canister valve (1) and connect the EVAP canister valve tube.

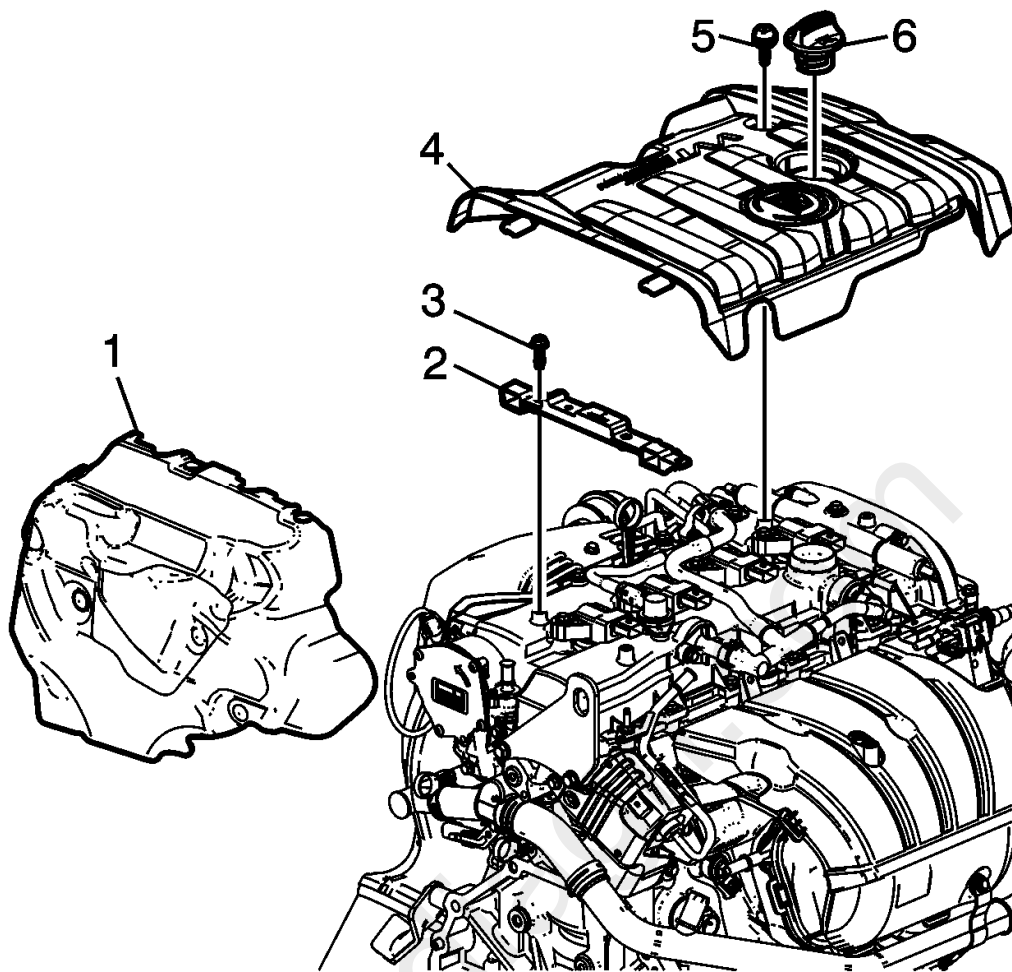


Fig. 287: Intake Manifold And Components
Courtesy of GENERAL MOTORS COMPANY

22. Install the upper intake manifold bracket (2) and bolts (3).
23. Install the intake manifold cover (4) onto the camshaft cover.
24. Install the intake manifold cover bolt (5) and tighten to 9 N.m (80 lb in).
25. Install the oil fill cap (6).
26. Install the fuel pump insulator (1).

TURBOCHARGER INSTALLATION

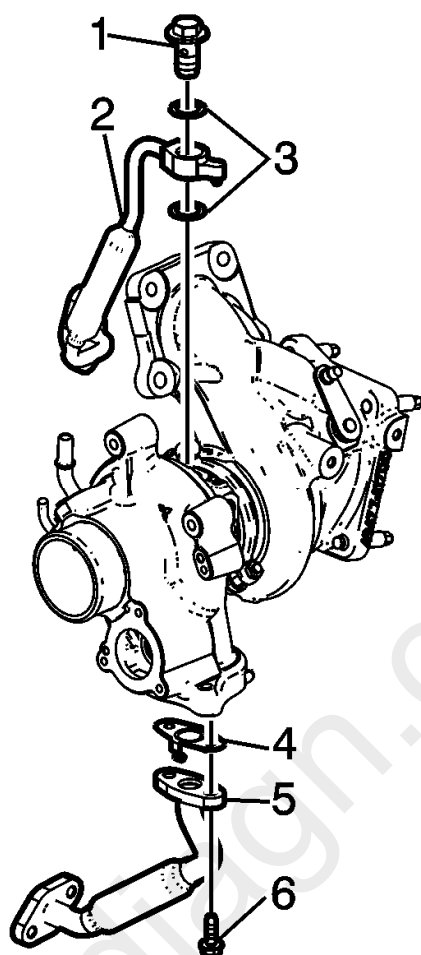


Fig. 288: Turbocharger Oil Feed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: The exhaust pipe studs do not come installed on new turbochargers. If the turbocharger is being replaced, new studs will need to be installed.

1. Install the turbocharger oil feed pipe (2) and NEW washers (3) onto the turbocharger.

CAUTION: Refer to Fastener Caution .

2. Install the turbocharger oil feed pipe bolt (1) and tighten to 35 N.m (26 lb ft).
3. Install a NEW turbocharger oil return pipe gasket (4).
4. Install the turbocharger oil return pipe (5) onto the turbocharger.
5. Install the turbocharger oil return pipe bolts (6) and tighten to 10 N.m (89 lb in).

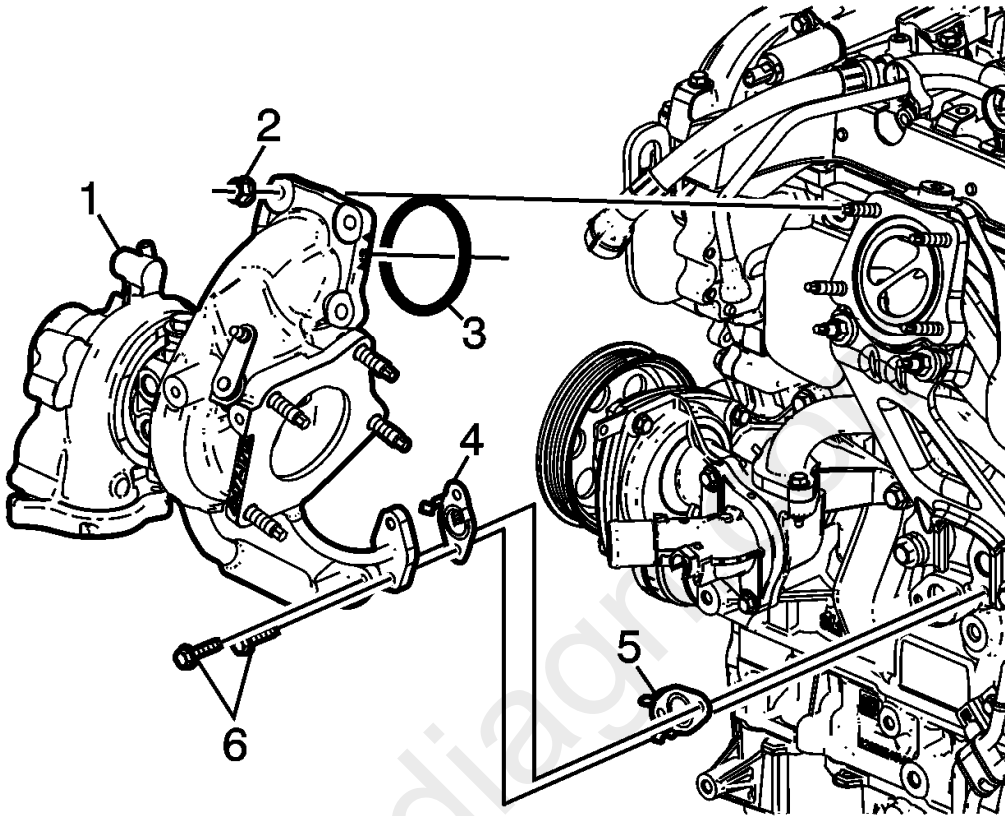


Fig. 289: Turbocharger Nuts
Courtesy of GENERAL MOTORS COMPANY

6. Install a NEW turbocharger gasket (3) on the turbocharger.
7. Install NEW turbocharger oil feed and oil return pipe gaskets (4, 5).
8. Install the turbocharger (1).

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

9. Install NEW turbocharger nuts (2) finger tight.
10. Install the turbocharger oil feed and return pipe bolts (6) at the engine block. tighten the bolts to 10 N.m (89 lb in).

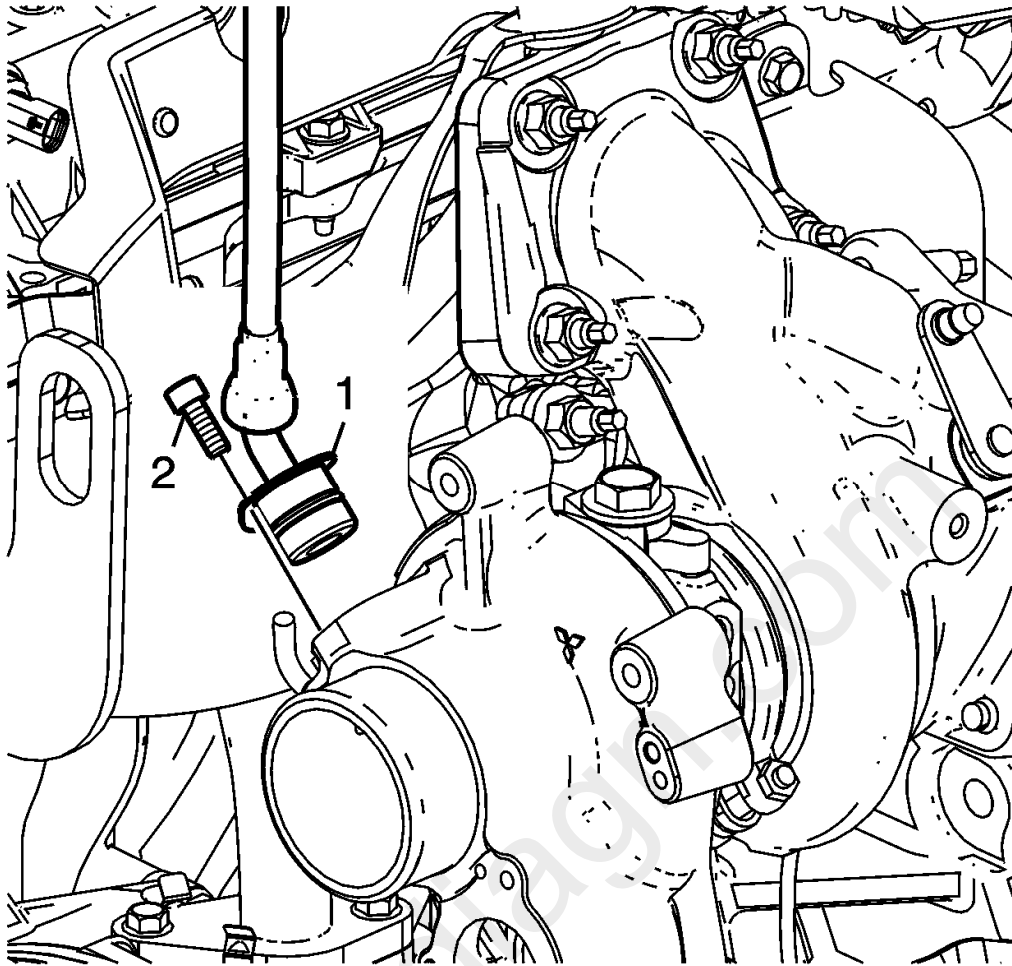


Fig. 290: PCV Hose Fitting Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: The PCV hose and fitting assembly connection is permanent. Reinstall these components as an assembly unless new components are being used.

11. Install the PCV hose and fitting assembly (1) to the turbocharger. Install the PCV hose fitting assembly bolt (2) and tighten to 8 N.m (71 lb in).

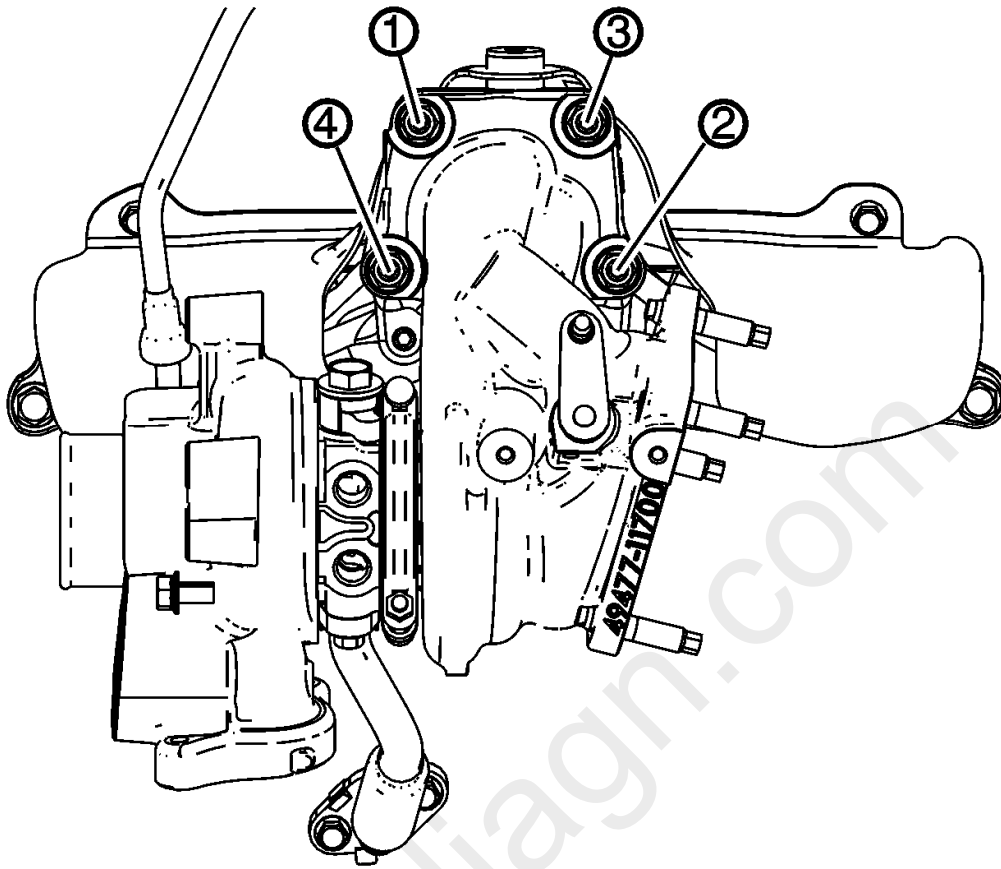


Fig. 291: Turbocharger Nut Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

12. Tighten the turbocharger nuts in sequence to 30 N.m (22 lb ft) plus 90 degrees.

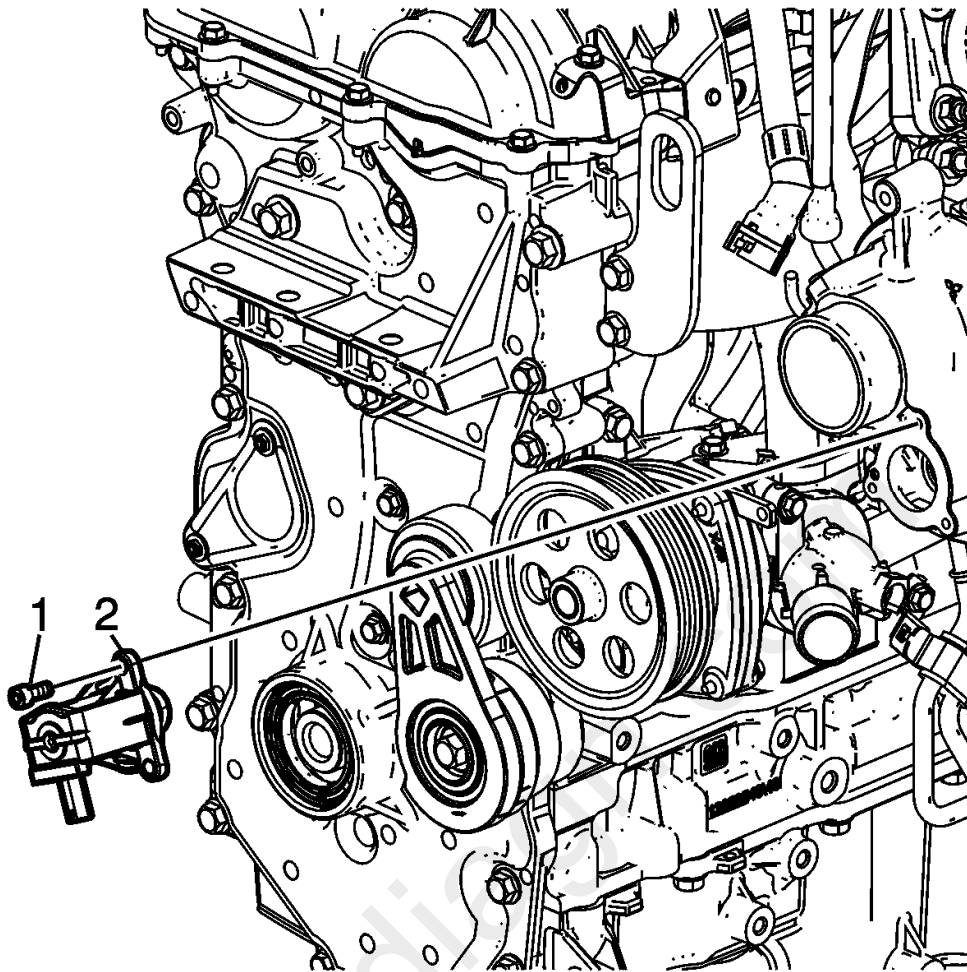


Fig. 292: Turbocharger Bypass Valve Solenoid Bolts
Courtesy of GENERAL MOTORS COMPANY

13. Install the turbocharger bypass valve solenoid (2).
14. Install the turbocharger bypass valve solenoid bolts (1) and tighten to 8 N.m (71 lb in).

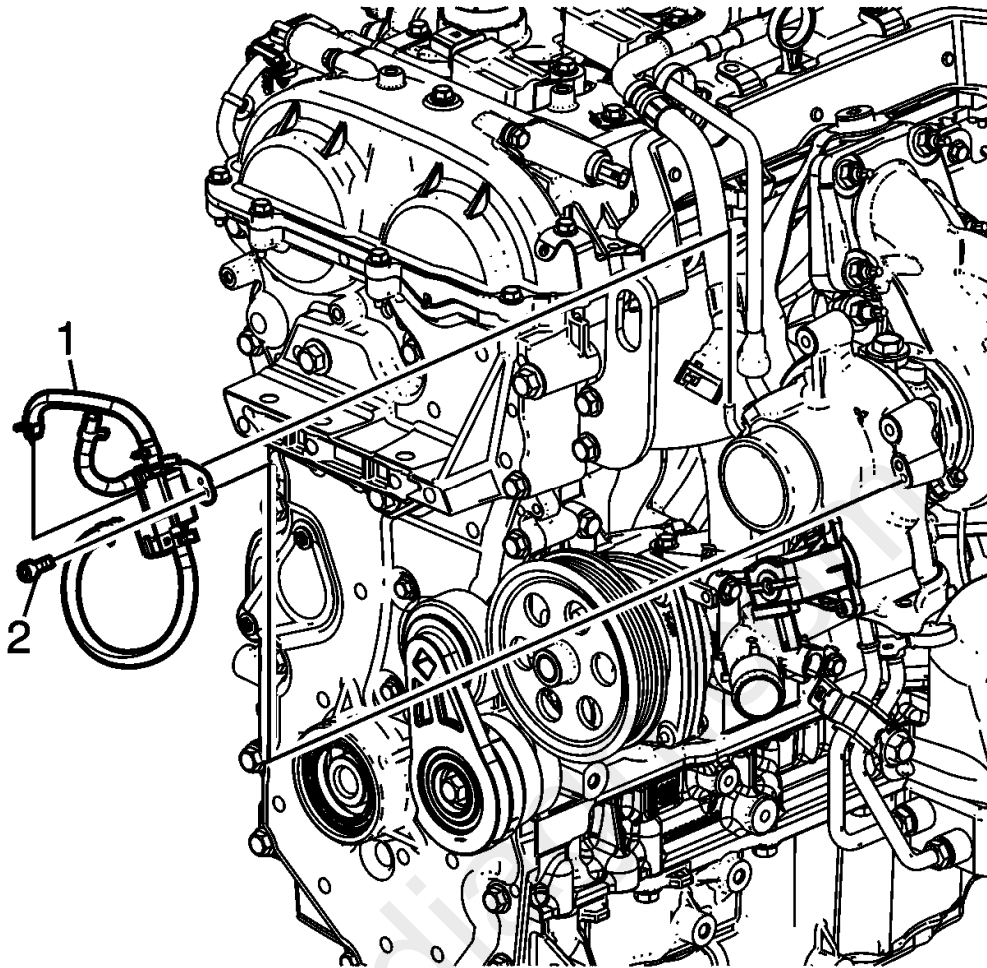


Fig. 293: Turbocharger Wastegate Regulator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

15. Install the turbocharger wastegate regulator solenoid valve (1).
16. Install the turbocharger wastegate regulator solenoid valve bracket bolt (2) and tighten to 8 N.m (71 lb in).
17. Connect the turbocharger wastegate regulator solenoid valve hoses to the turbocharger.

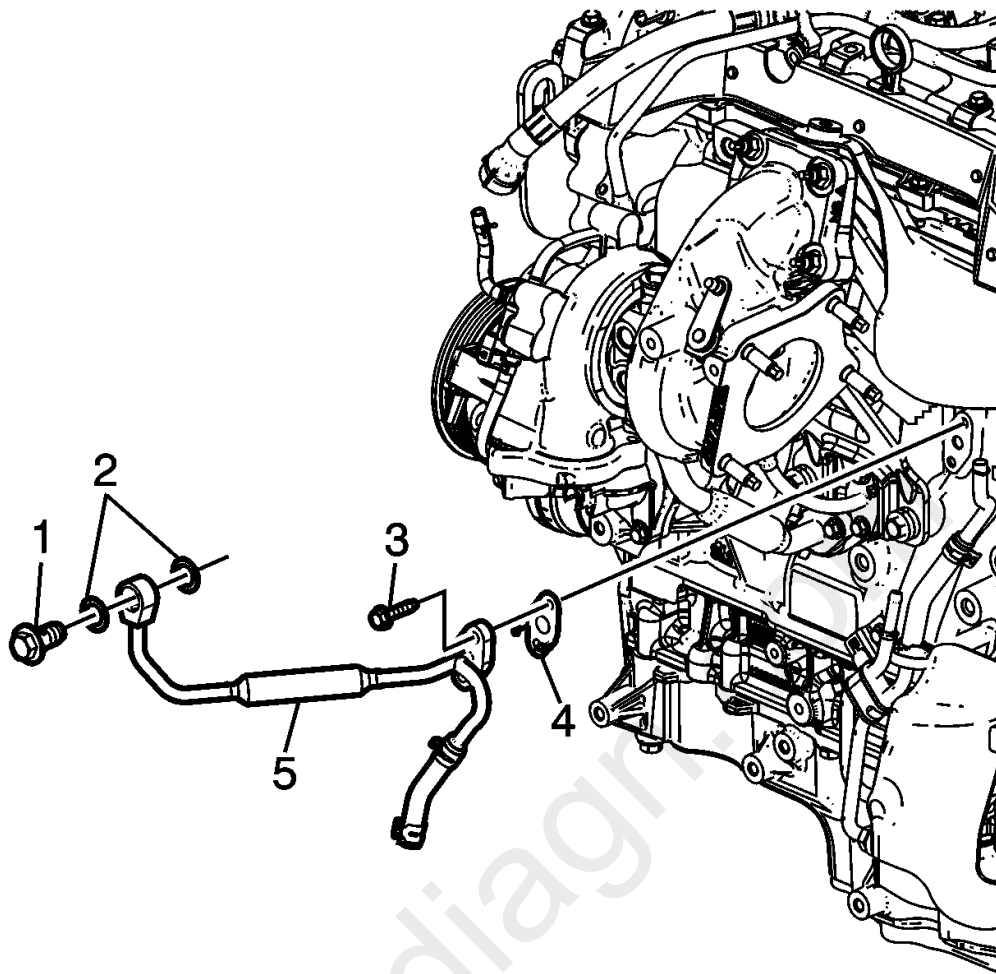


Fig. 294: Turbocharger Coolant Feed Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

18. Install the turbocharger coolant feed pipe (5) and NEW washers (2) on the turbocharger.
19. Install the turbocharger coolant feed pipe bolt (1) and tighten to 35 N.m (26 lb ft).
20. Install a NEW turbocharger coolant feed pipe gasket (4).
21. Install the turbocharger coolant feed pipe bolts (3) and tighten to 10 N.m (89 lb in).
22. Connect the turbocharger coolant feed pipe hose to the engine oil cooler.

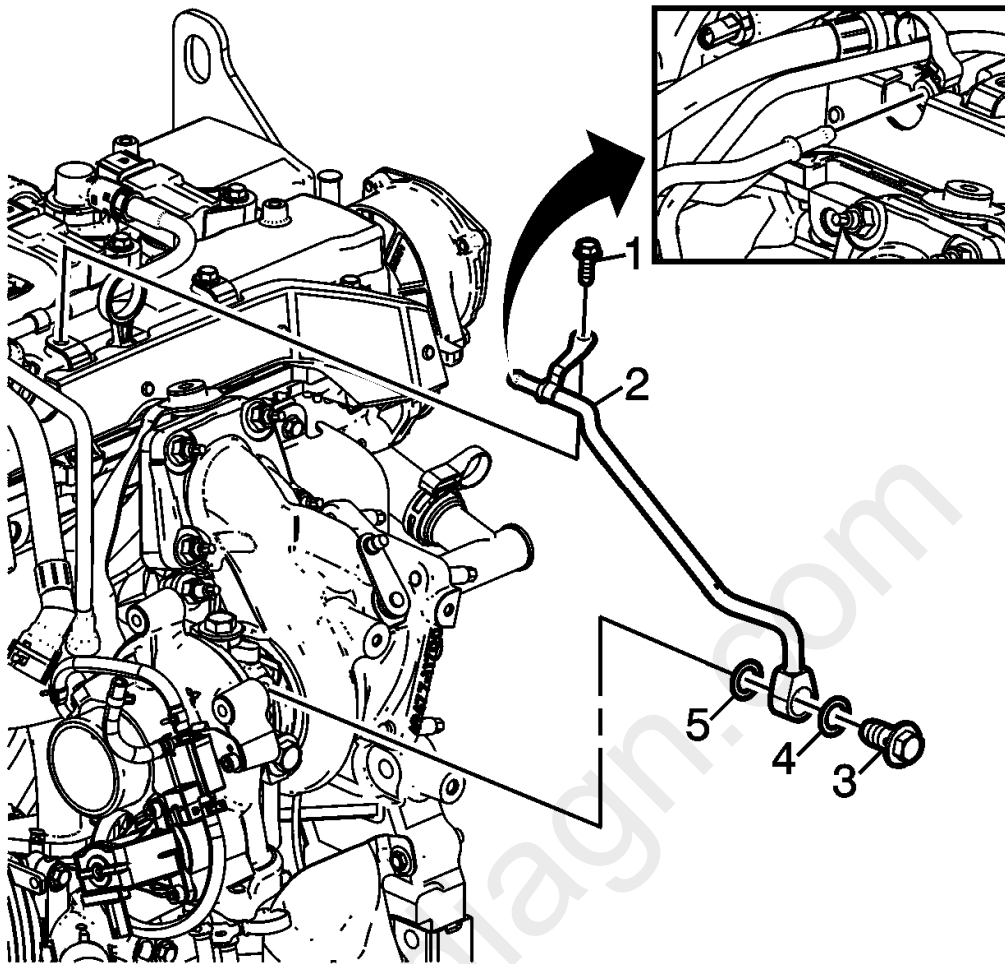


Fig. 295: Camshaft Cover Heat Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

23. Install the turbocharger coolant return pipe (2) and NEW washers (4, 5) on the turbocharger.
24. Install the turbocharger coolant return pipe bolt (3) and tighten to 35 N.m (26 lb ft).
25. Connect the turbocharger coolant return pipe to the air bleed hose.
26. Install the camshaft cover heat shield bolt (1) that retains the turbocharger coolant return pipe (2) at the camshaft cover. Tighten the bolt to 10 N.m (89 lb in).

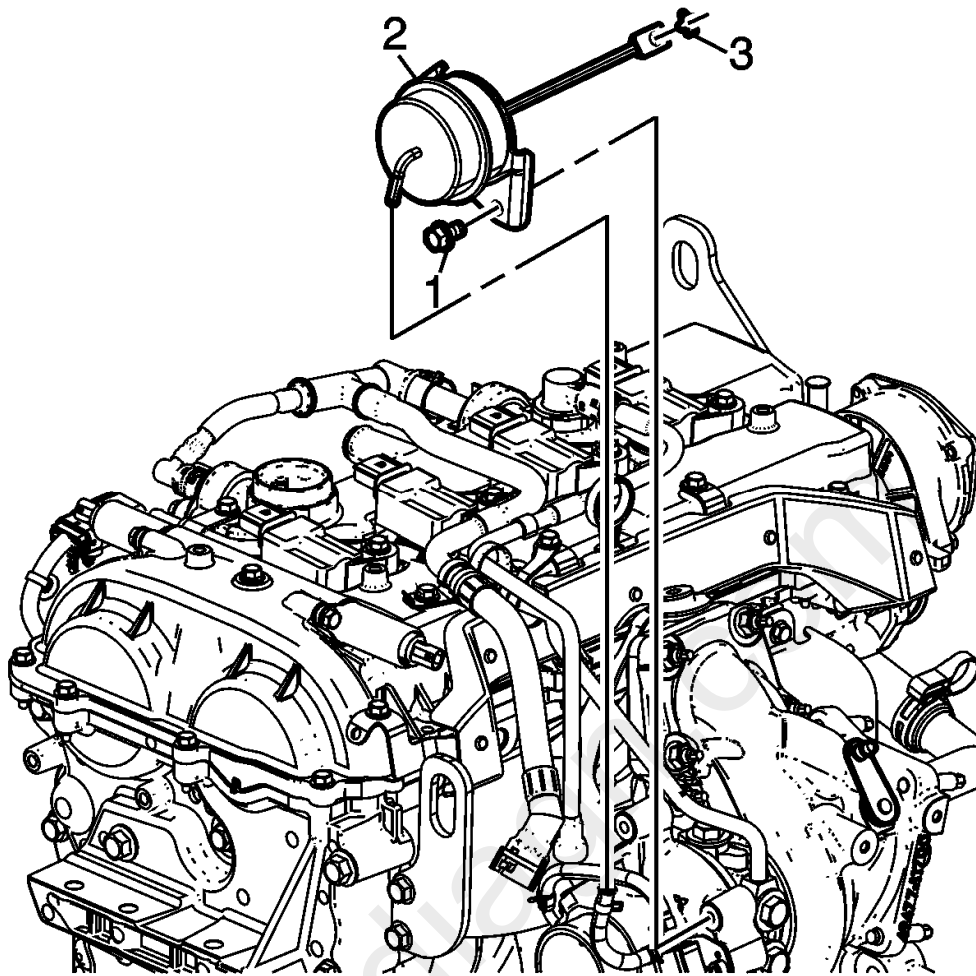


Fig. 296: Turbocharger Wastegate Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

27. Install the turbocharger wastegate actuator (2) and actuator bolts (1) and tighten to 8 N.m (71 lb in).
28. Install the turbocharger wastegate actuator arm retainer (3).

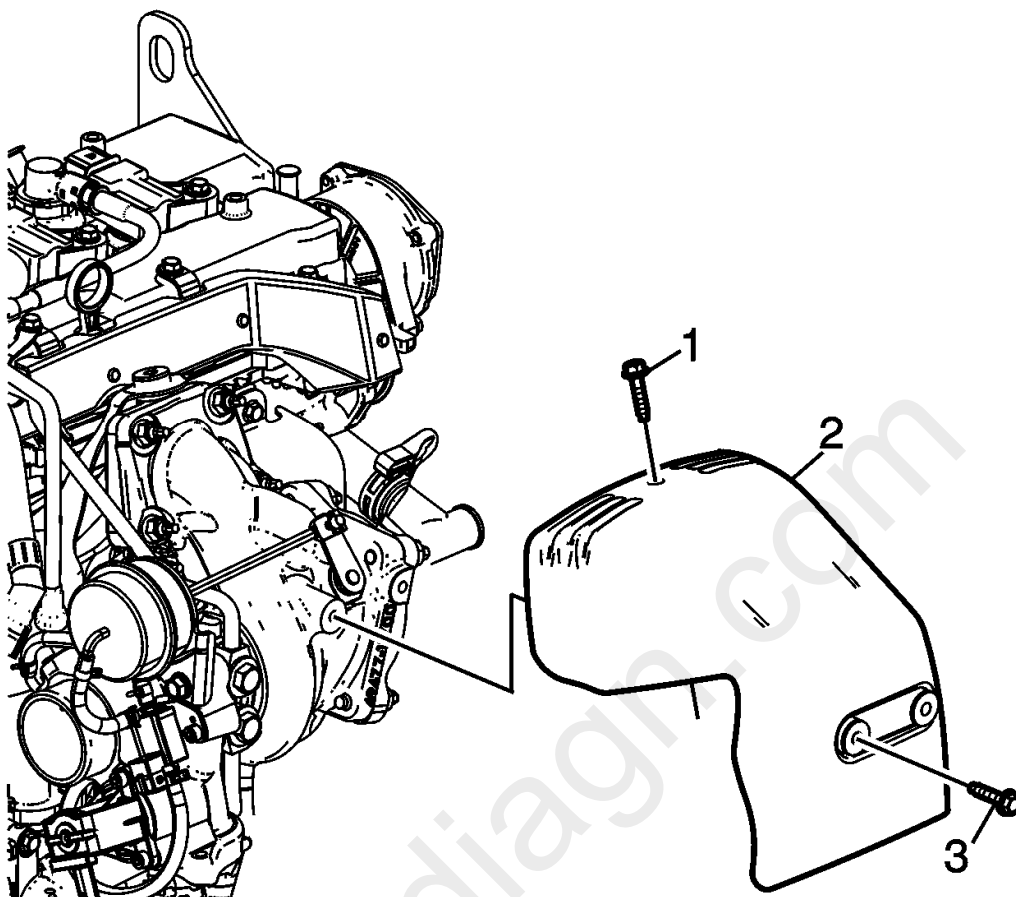


Fig. 297: Turbocharger Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

29. Install the turbocharger heat shield (2).
30. Install the turbocharger heat shield bolts (1, 3) and tighten to 14 N.m (124 lb in).

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

- **EN-50792** Flywheel Holding Tool
- **EN-45059** Angle Meter

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

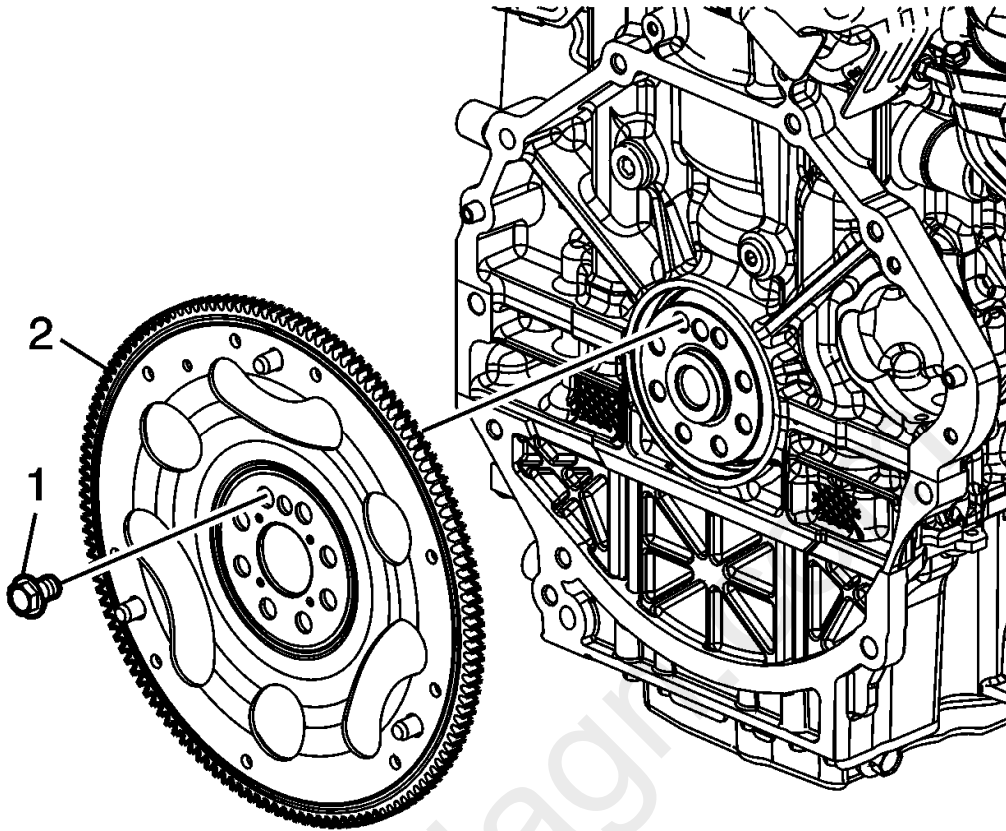


Fig. 298: Flywheel Attaching Bolts
Courtesy of GENERAL MOTORS COMPANY

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

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

1. Install the flywheel (2) and hand start NEW bolts (1).

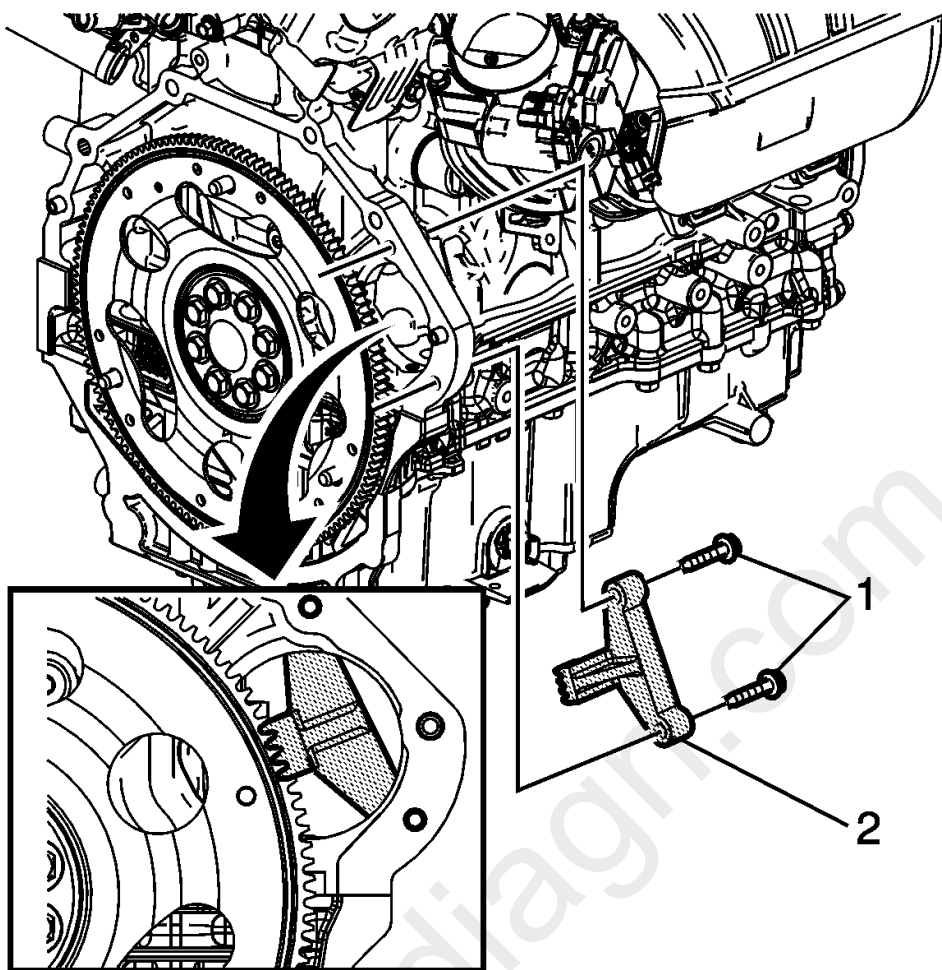


Fig. 299: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

2. To prevent crankshaft rotation, install **EN-50792** flywheel holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

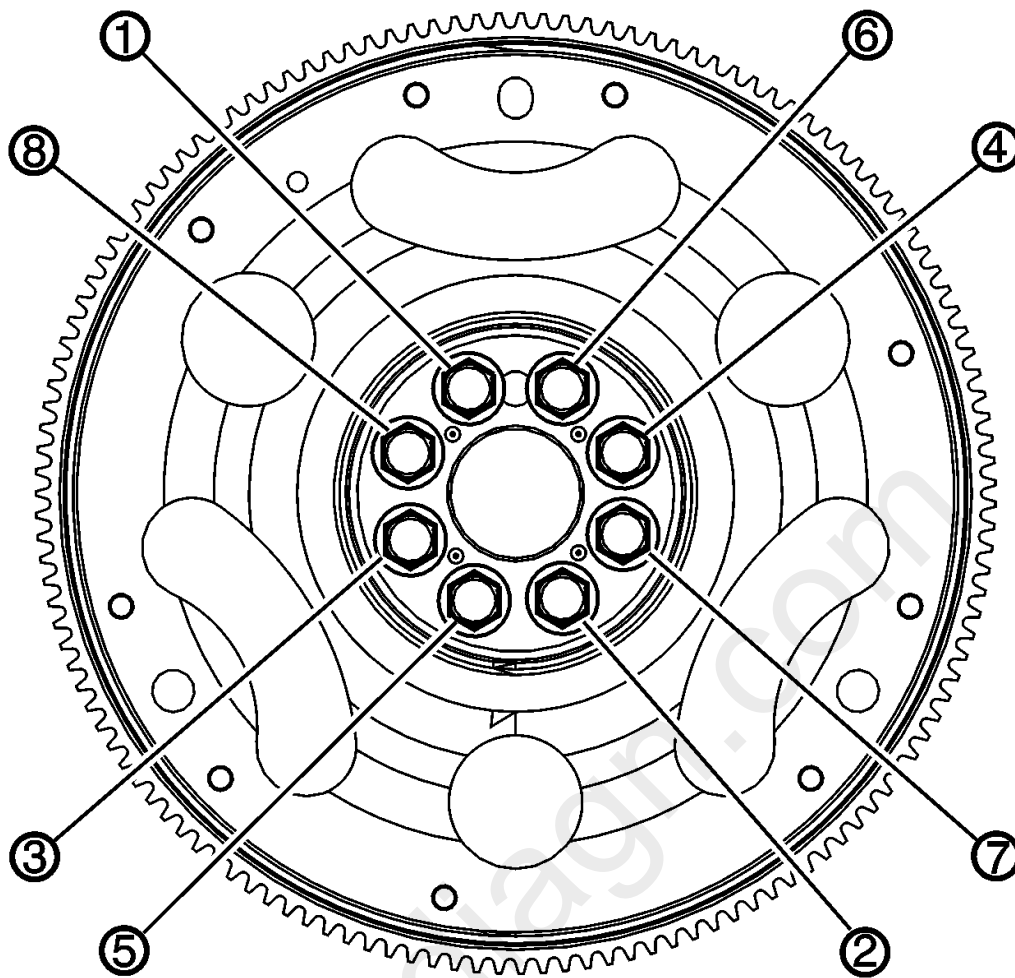


Fig. 300: Flywheel Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Tighten the bolts evenly using the following procedure:
 1. Tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
 2. Tighten the bolts a second pass in sequence to 30 N.m (22 lb ft).
 3. Tighten the bolts a final pass in sequence 40 degrees using the **EN-45059** meter.
4. Remove **EN-50792** flywheel holding tool.

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **EN 45059** Angle Meter

- **EN 48034** Crankshaft Balancer Installer
- **EN-50792** Flywheel Holding Tool

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

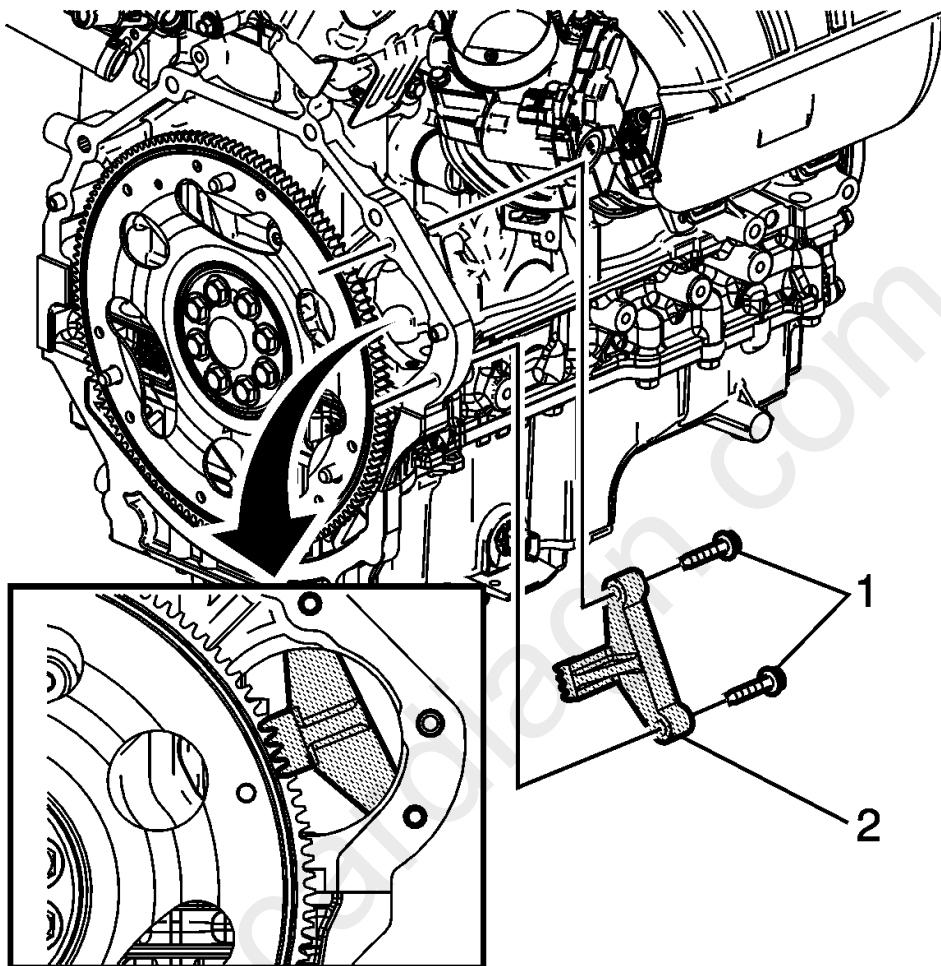


Fig. 301: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install **EN-50792** flywheel holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

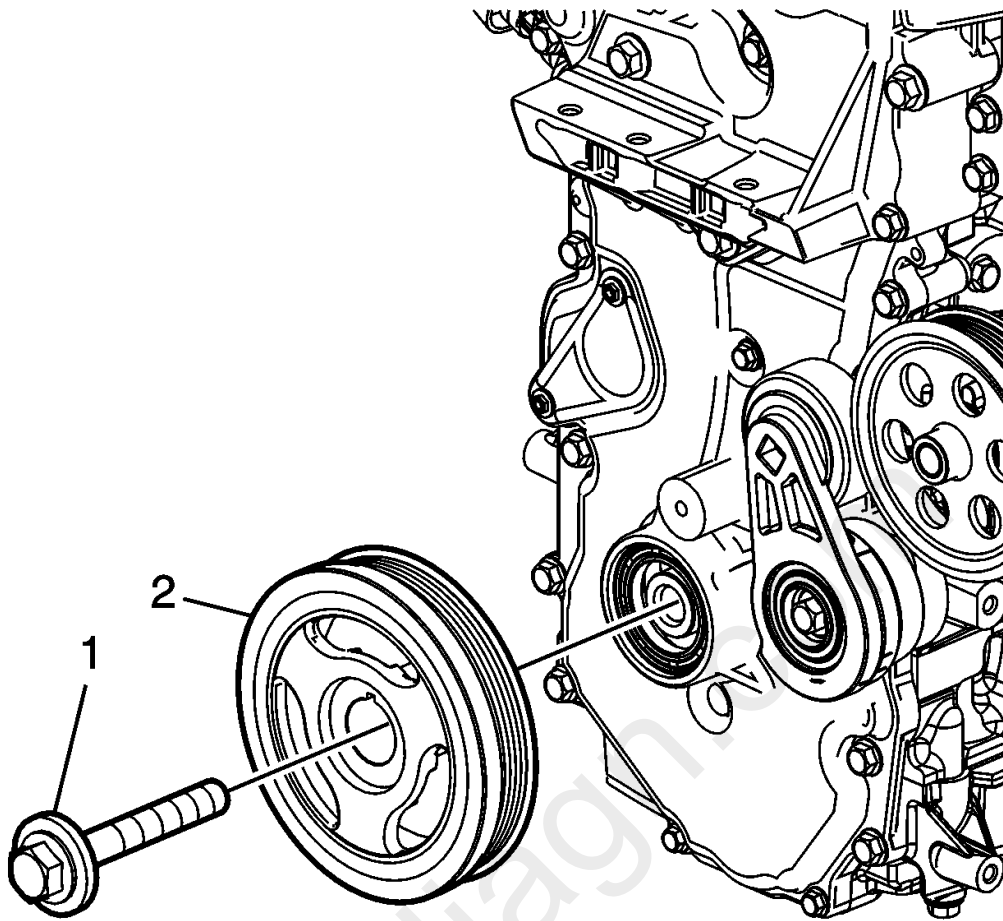


Fig. 302: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

2. Using **EN-48034** installer , install the crankshaft balancer (2).

CAUTION: Refer to Fastener Caution .

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

3. Install a NEW crankshaft balancer bolt and washer. Tighten the bolt to 150 N.m (111 lb ft) plus 180 degrees using the **EN 45059** meter.
4. Remove **EN-50792** flywheel holding tool.

OIL FILTER INSTALLATION

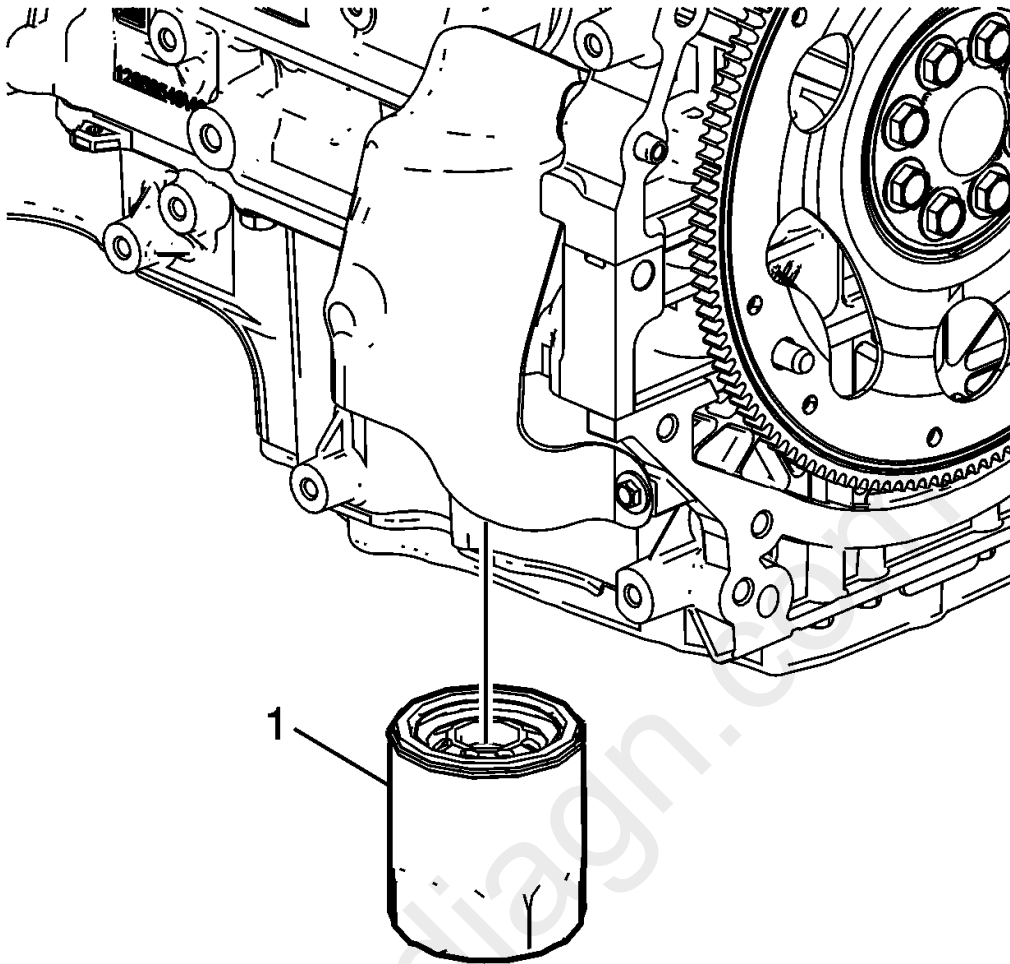


Fig. 303: Engine Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the O-ring on the oil filter with 5W30 engine oil.
2. Install a new oil filter (1).

CAUTION: Refer to Fastener Caution .

3. Tighten the oil filter to 30 N.m (22 lb ft).

ENGINE PRELUBING

NOTE: This procedure is not used in Europe.

Special Tools

EN-45299 Engine Preluber

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

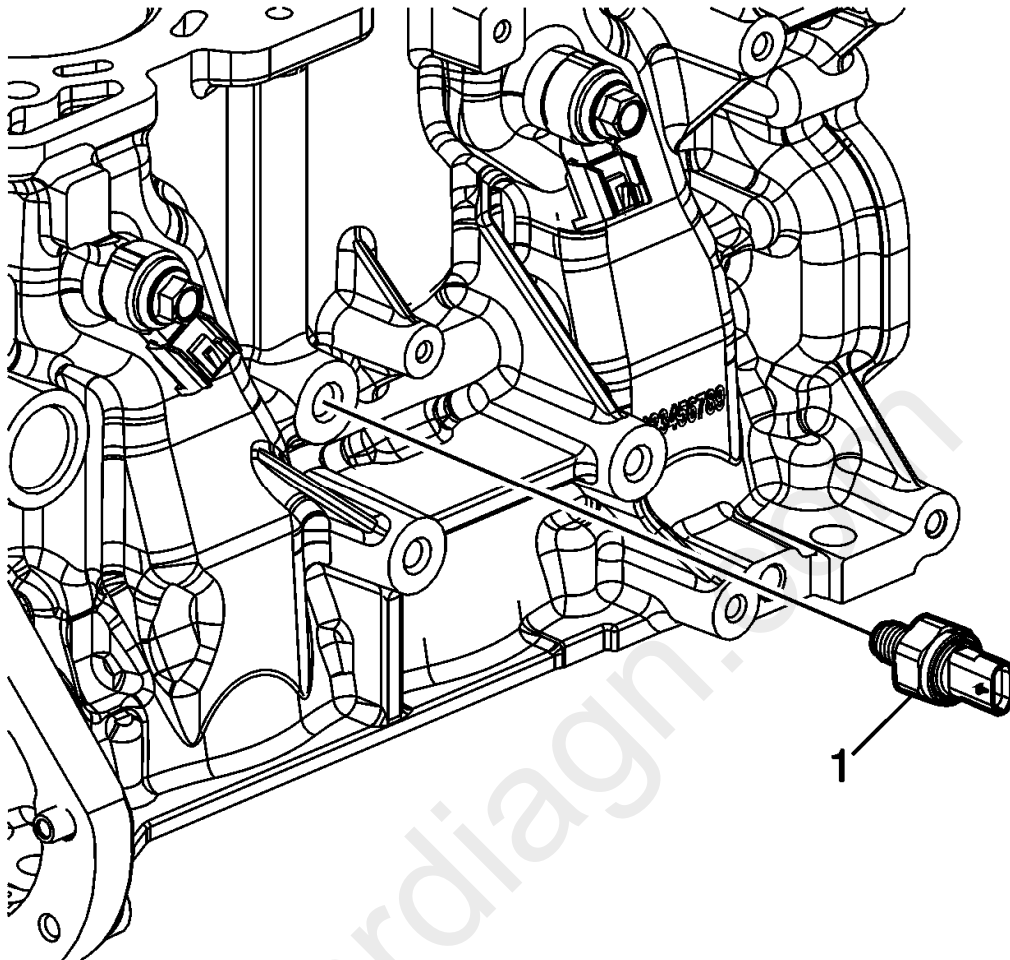


Fig. 304: Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

1. Remove the engine oil pressure sensor (1).
2. Install the M12 x 1.75 adapter P/N 509376.

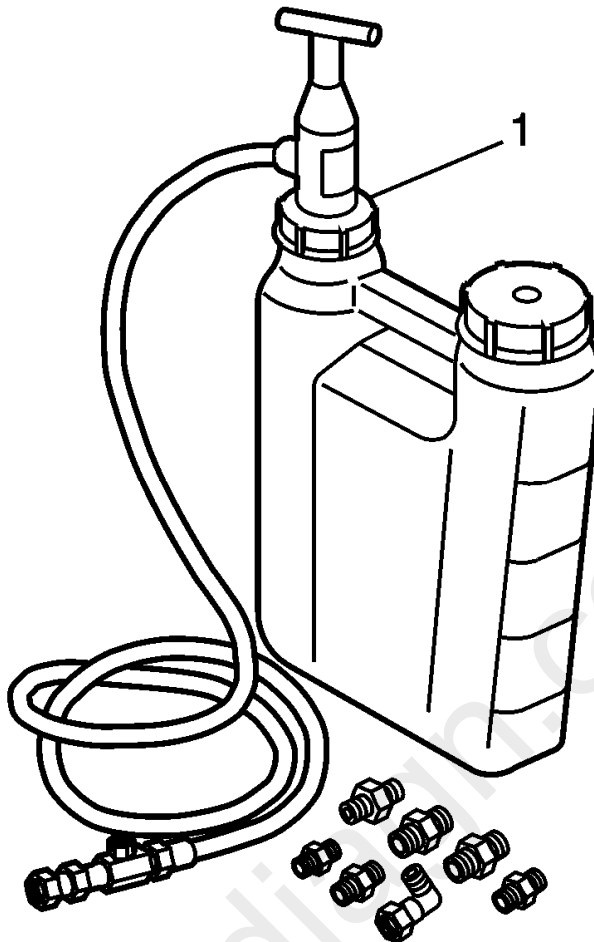


Fig. 305: View of Flexible Hose, Adapter and Preluber
Courtesy of GENERAL MOTORS COMPANY

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **EN-45299** preluber (1) 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.
5. Close the valve and remove the flexible hose and adapter from the engine.

CAUTION: Refer to Fastener Caution .

6. Install the engine oil pressure sensor and tighten to 27 N.m (20 lb ft).
7. Top-off the engine oil to the proper level.