

## 2012 Engine

### Engine Mechanical - 2.4L - Repair Instructions - Off Vehicle (Overhaul) - Captiva Sport

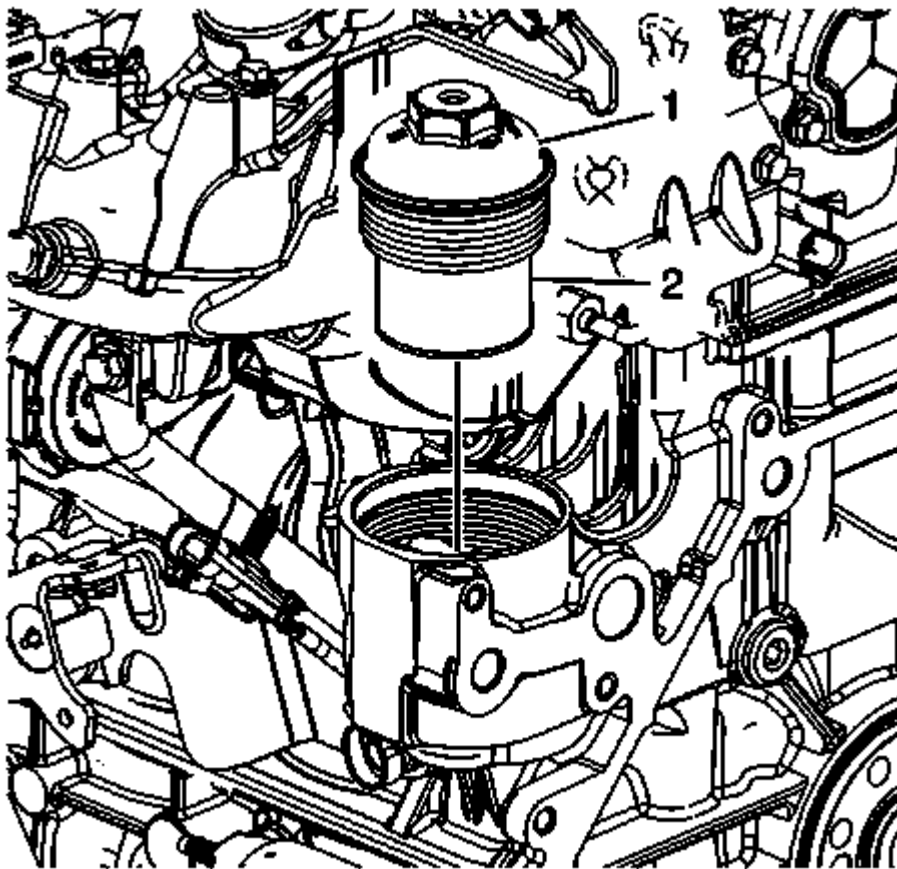
## REPAIR INSTRUCTIONS - OFF VEHICLE

### DRAINING FLUIDS AND OIL FILTER REMOVAL

#### Special Tools

EN-44887 Oil Filter Wrench

For equivalent regional tools, refer to Special Tools .



**Fig. 1: View of Draining Fluids and Oil Filter**  
Courtesy of GENERAL MOTORS COMPANY

1. Use EN-44887 wrench to remove the oil filter cap (1). Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter (2) from the cap and discard.
3. Clean the oil filter housing in the engine block.

**CAUTION:** Refer to Fastener Caution .

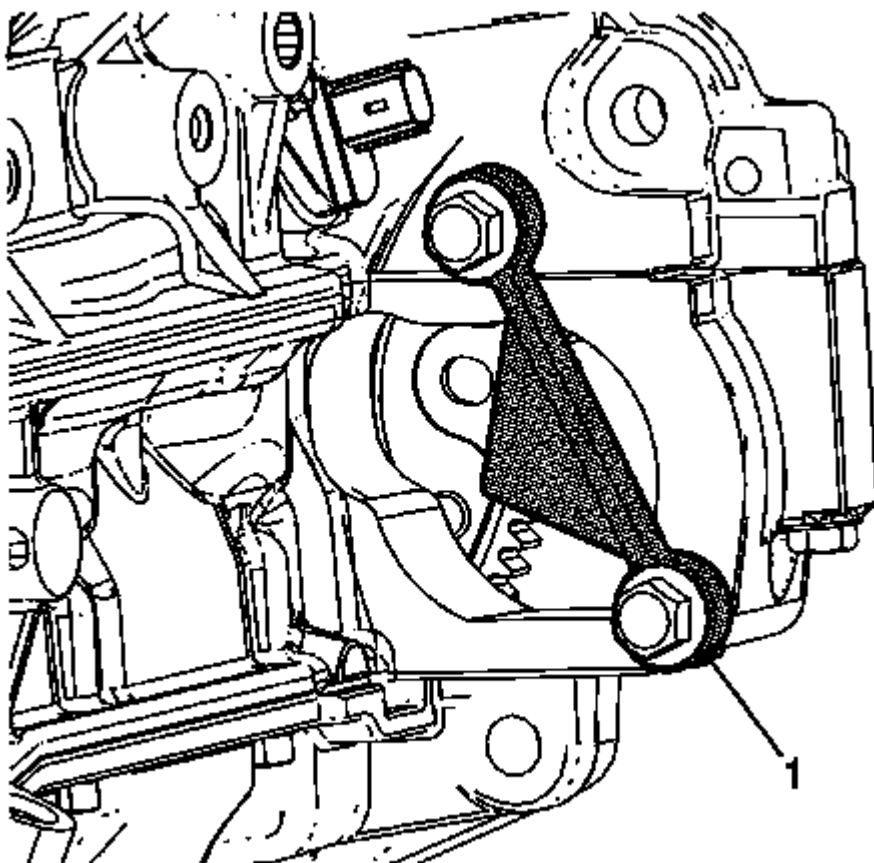
4. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
5. Remove the water pump drain plug from the water pump and allow the coolant to drain from the water jacket.
6. Apply sealant to the water pump drain plug. Refer to Adhesives, Fluids, Lubricants, and Sealers .
7. Install the water pump drain plug and tighten to 20 N.m (15 lb ft).
8. If cleaning or repairing the engine block, it is not necessary to reinstall the plugs.

## CRANKSHAFT BALANCER REMOVAL

### Special Tools

**EN 43653** Flywheel Holding Tool

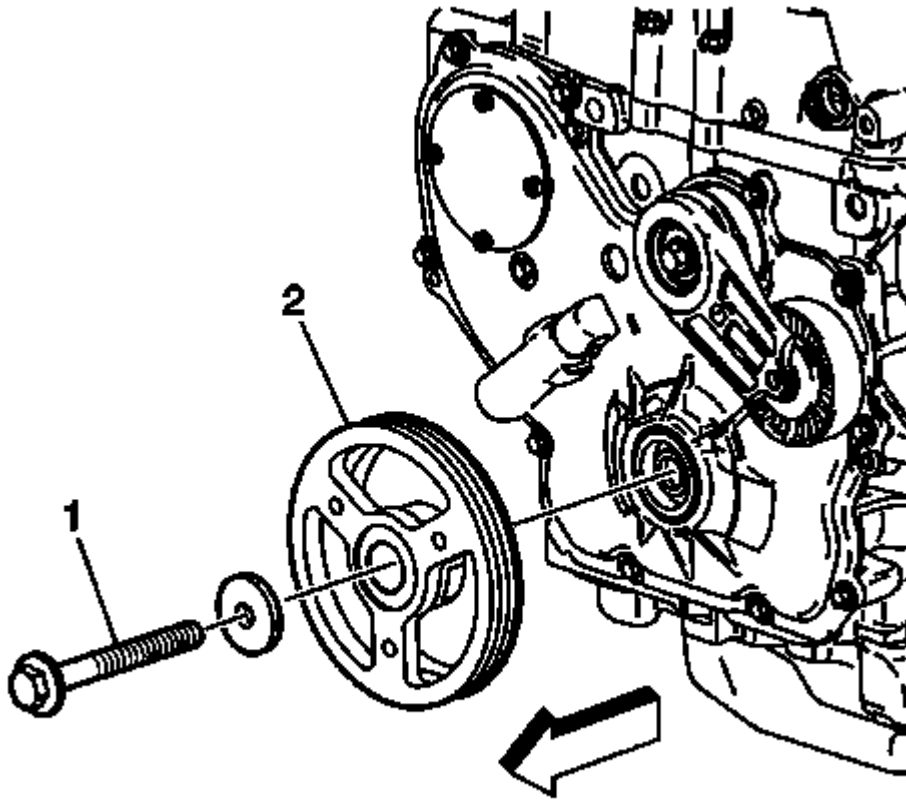
For equivalent regional tools, refer to Special Tools



**Fig. 2: View of Engine Flywheel**

Courtesy of GENERAL MOTORS COMPANY

1. Install **EN 43653** holding tool (1) in the starter assembly location, engaging the flywheel, in order to prevent crankshaft rotation.



**Fig. 3: Balancer & Retaining Bolt**  
Courtesy of GENERAL MOTORS COMPANY

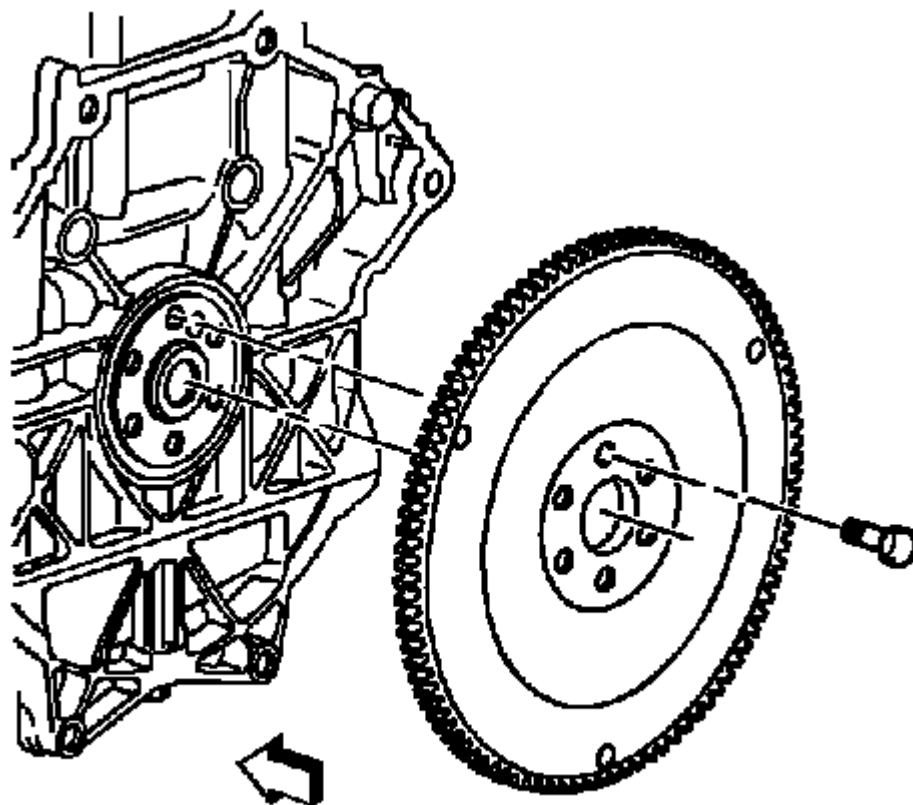
2. Remove the balancer retaining bolt (1) and washer. Discard the bolt.
3. Remove the balancer (2) using a universal removal tool.

## **ENGINE FLYWHEEL REMOVAL**

### **Special Tools**

#### **EN 43653** Flywheel Holding Tool

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

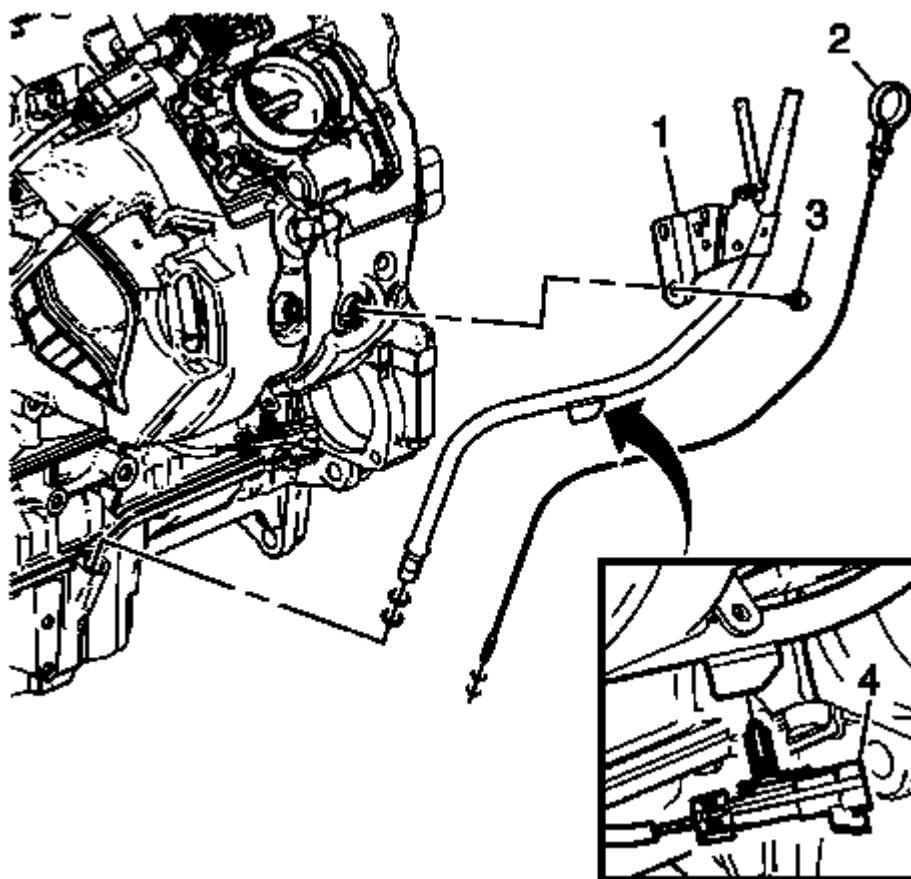


**Fig. 4: View Of Flywheel**

**Courtesy of GENERAL MOTORS COMPANY**

1. Ensure that **EN 43653** tool is installed and engaging the flywheel to prevent crankshaft rotation.
2. Remove the flywheel attaching bolts.
3. Remove the flywheel.
4. Remove **EN 43653** tool.

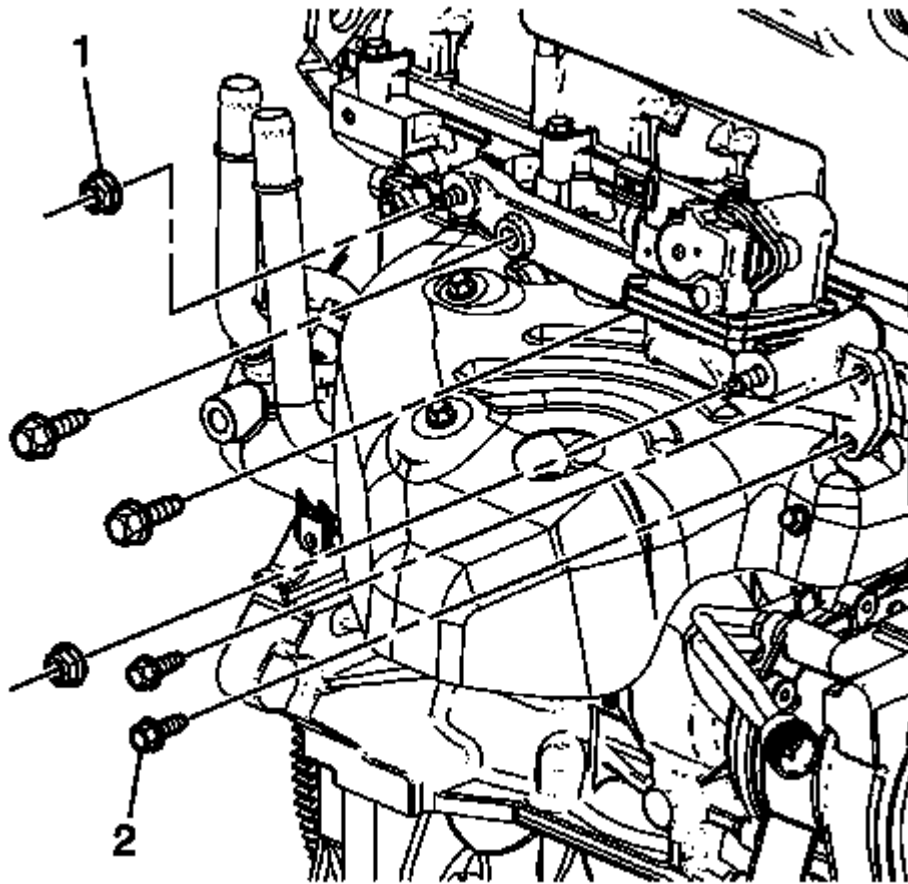
#### **OIL LEVEL INDICATOR AND TUBE REMOVAL (2.4L LEA)**



**Fig. 5: Oil Level Indicator Tube Components**  
 Courtesy of GENERAL MOTORS COMPANY

1. Remove knock sensor connector (4) from the oil level indicator tube.
2. Remove the electrical wiring harness from the oil level indicator tube.
3. Remove the oil level indicator tube bracket bolt (3).
4. Remove the oil level indicator (2) and the oil level indicator tube (1) from the oil pan.
5. Inspect the O-ring and replace if necessary.

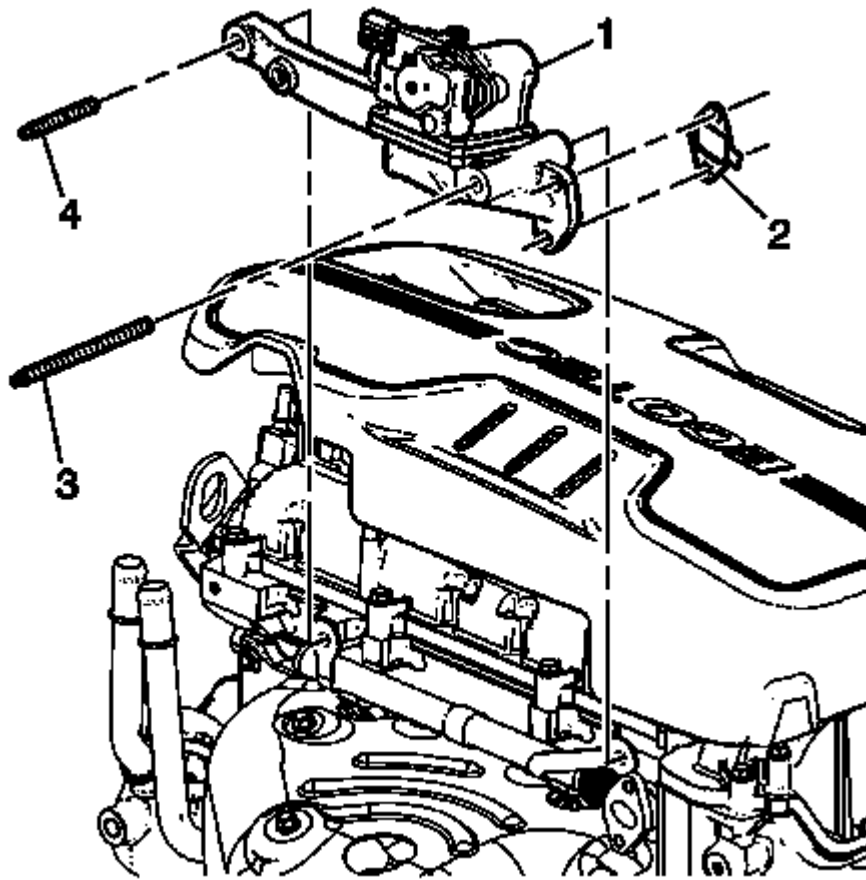
## EXHAUST MANIFOLD REMOVAL



**Fig. 6: Secondary Air Injection Bolts And Nuts**

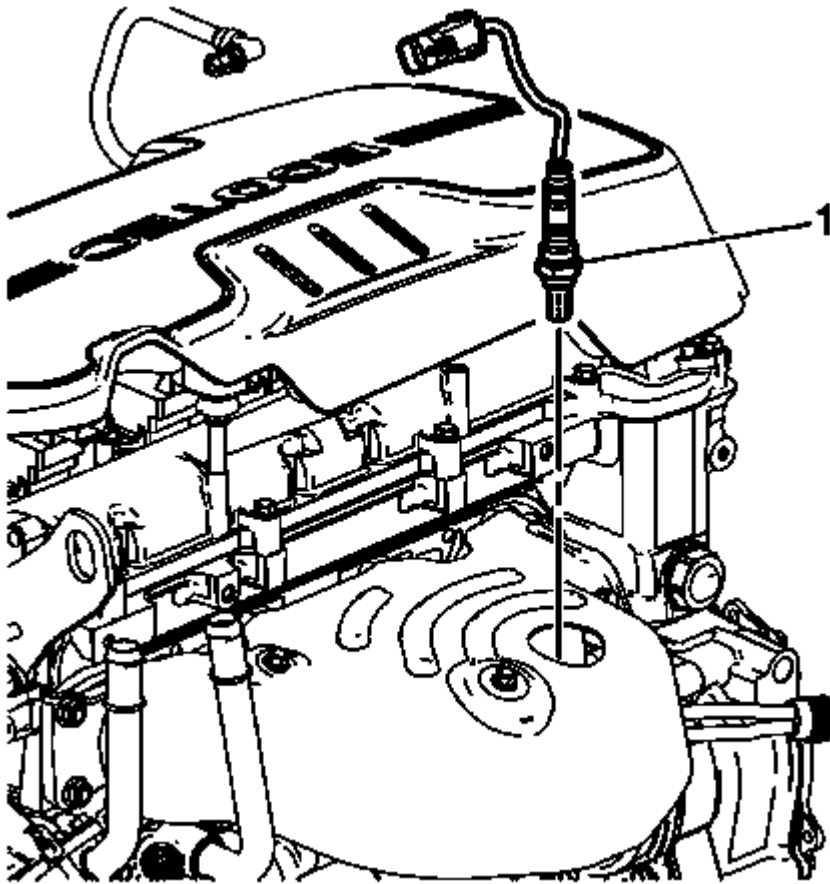
Courtesy of GENERAL MOTORS COMPANY

1. Remove the secondary air injection bolts (2) and nuts (1).



**Fig. 7: Secondary Air Injection Valve Assembly, Studs And Gasket**  
**Courtesy of GENERAL MOTORS COMPANY**

2. Remove the secondary air injection studs (3 and 4).
3. Remove the secondary air injection valve assembly (1).
4. Remove the secondary air injection gasket (2) and discard.

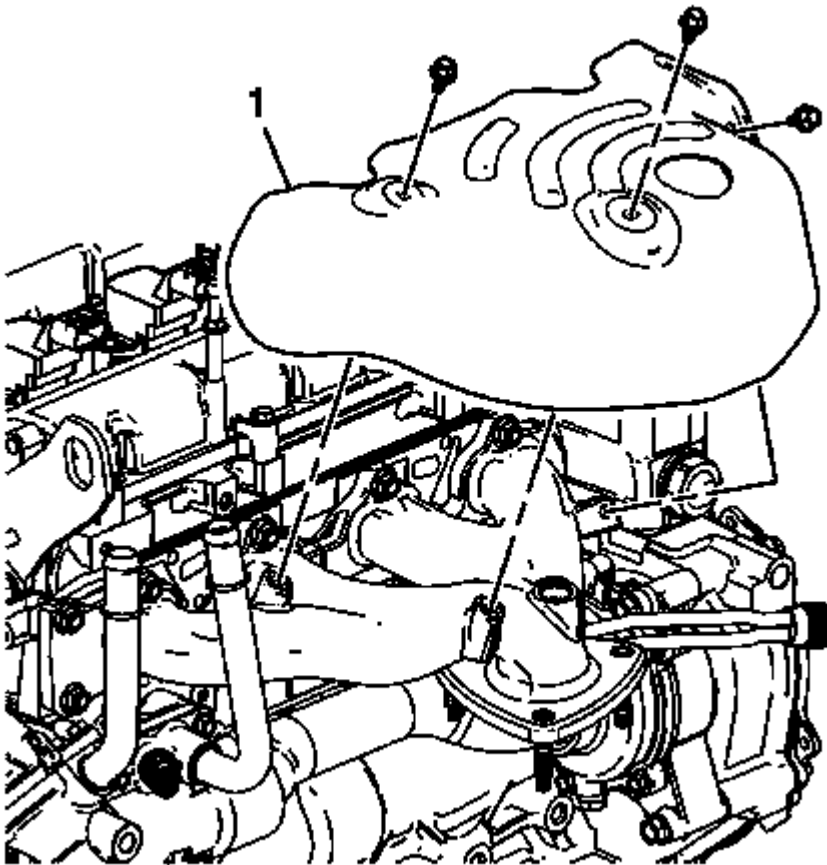


**Fig. 8: Oxygen Sensor**

Courtesy of GENERAL MOTORS COMPANY

5. Remove the oxygen sensor (1).

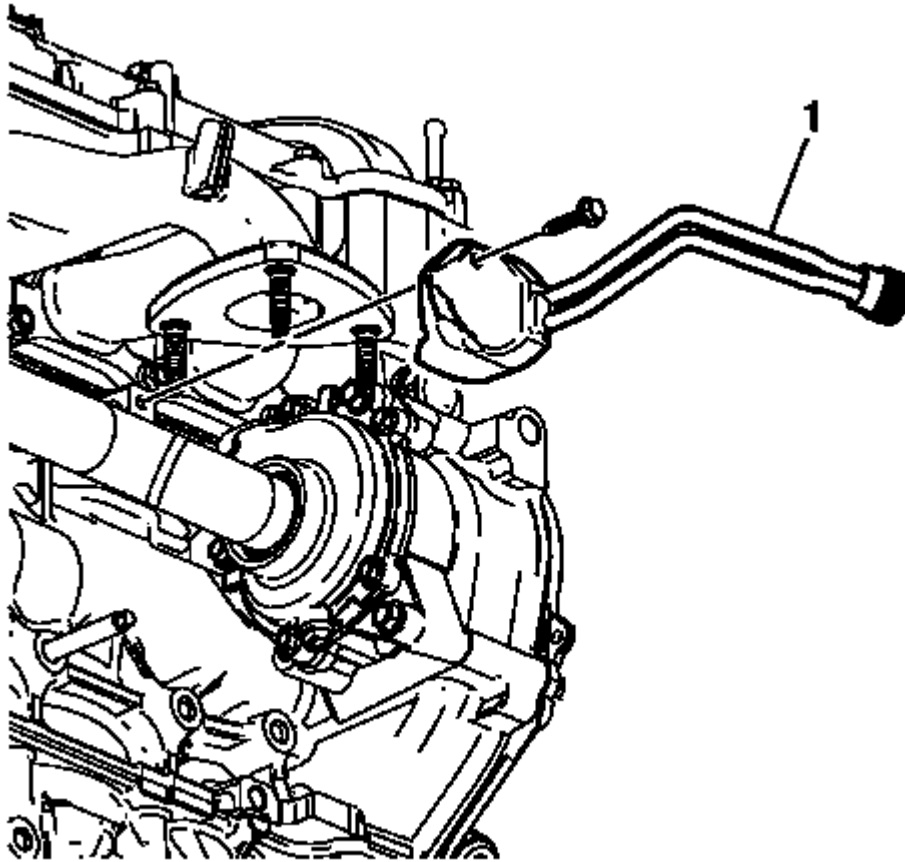




**Fig. 9: Exhaust Manifold Heat Shield**

**Courtesy of GENERAL MOTORS COMPANY**

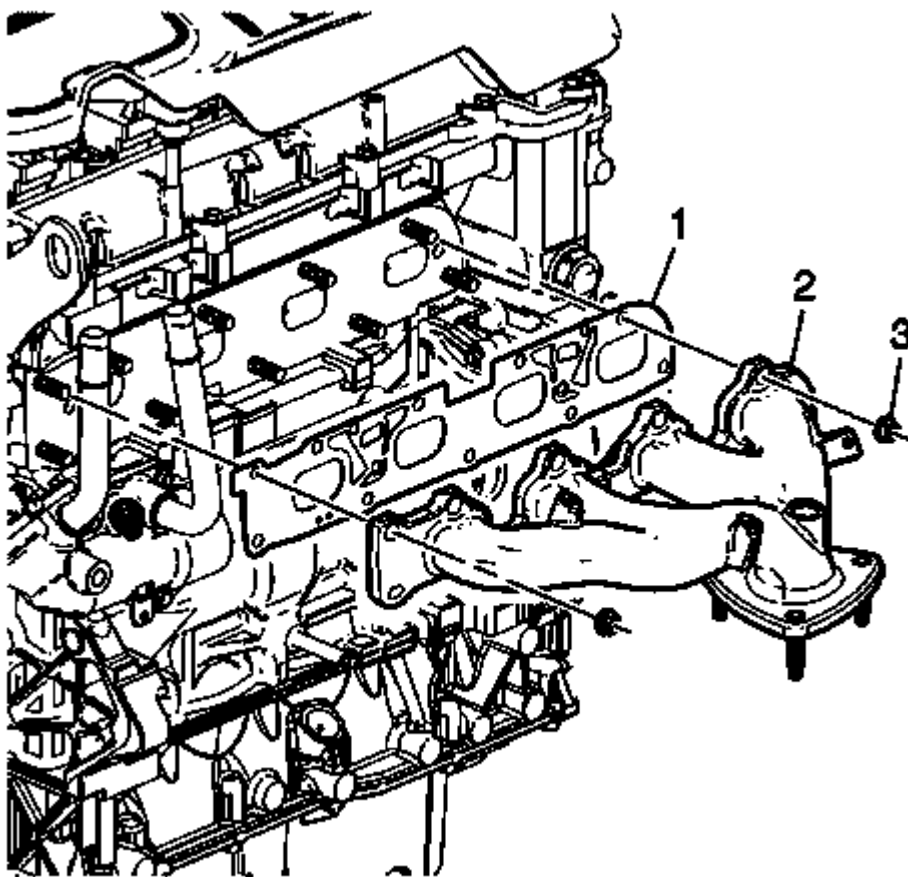
6. Remove the exhaust manifold heat shield bolts.
7. Remove the exhaust manifold heat shield (1).



**Fig. 10: Block Heater**

Courtesy of GENERAL MOTORS COMPANY

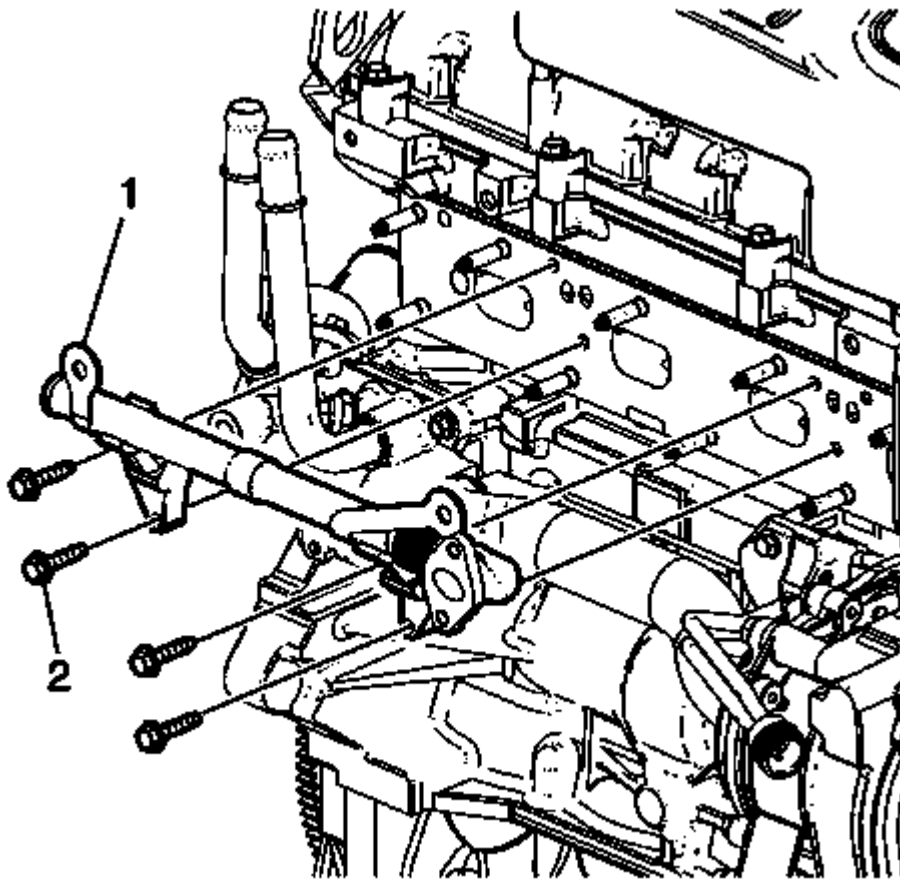
8. Remove the block heater (1), if equipped.



**Fig. 11: Exhaust Manifold Components**

Courtesy of GENERAL MOTORS COMPANY

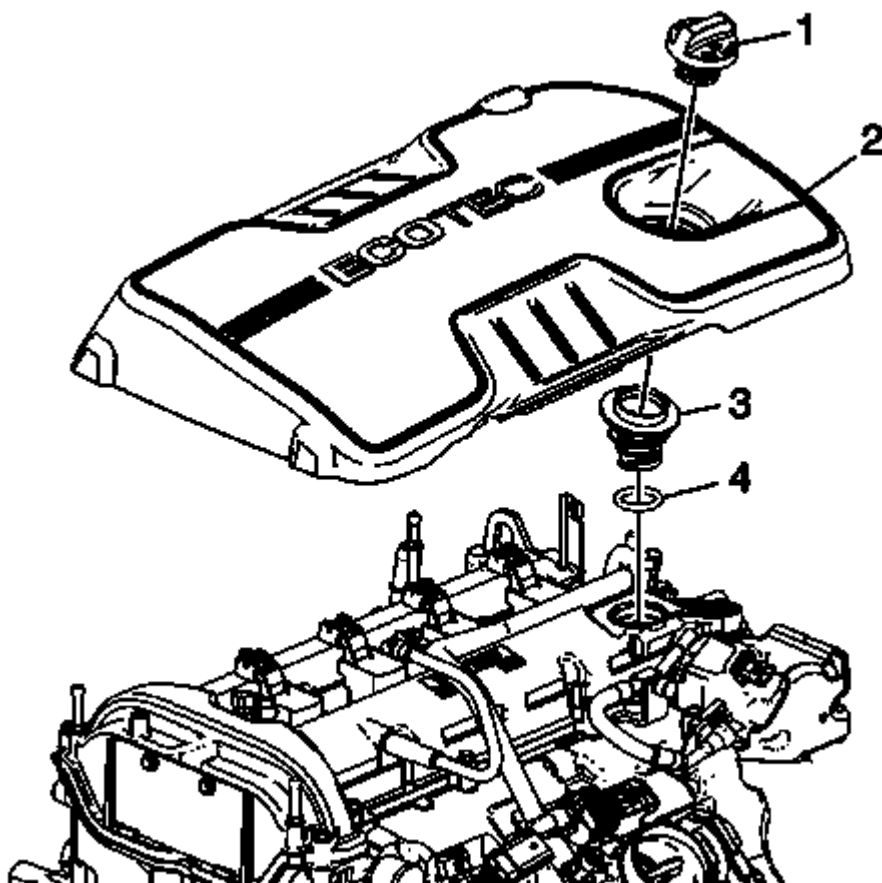
9. Remove and discard the exhaust manifold to cylinder head retaining nuts (1).
10. Remove the exhaust manifold (2).
11. Remove the exhaust manifold gasket (3).
12. Clean all of the sealing surfaces.
13. If the exhaust manifold is being replaced, transfer the following parts:
  - The exhaust manifold heat shield
  - The oxygen sensor



**Fig. 12: Secondary Air Injection Pipe Assembly**  
**Courtesy of GENERAL MOTORS COMPANY**

14. Remove the secondary air injection pipe assembly bolts (2).
15. Remove the secondary air injection pipe assembly (1).

## **INTAKE MANIFOLD REMOVAL**

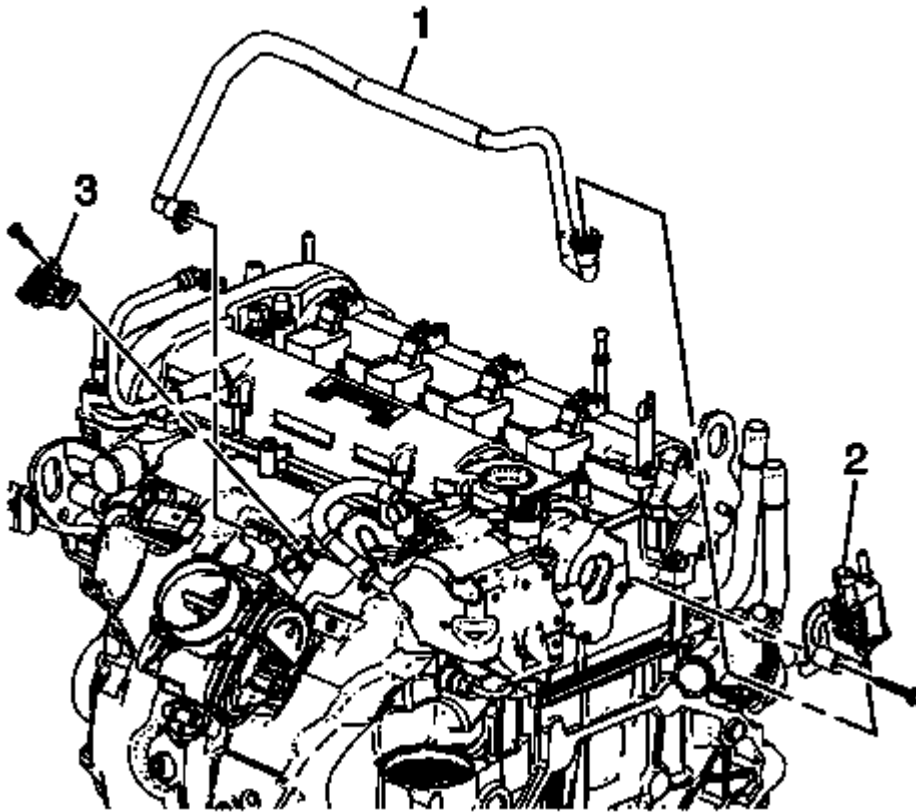


**Fig. 13: Oil Fill Cap Components**

Courtesy of GENERAL MOTORS COMPANY

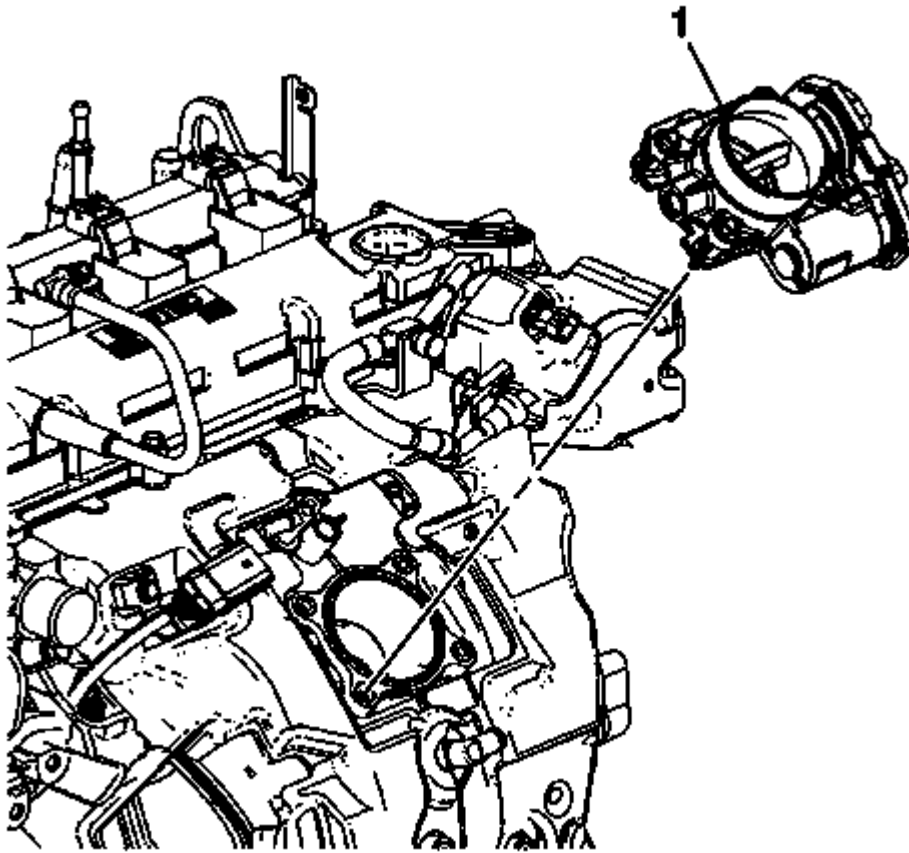
**CAUTION:** Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold can be damaged if it is removed when the engine is hot.

1. Remove the oil fill cap (1).
2. Remove the intake manifold cover (2).
3. Remove the oil fill tube assembly (3) and O-ring (4).



**Fig. 14: EVAP Canister Valve, Tube & MAP Sensor**  
**Courtesy of GENERAL MOTORS COMPANY**

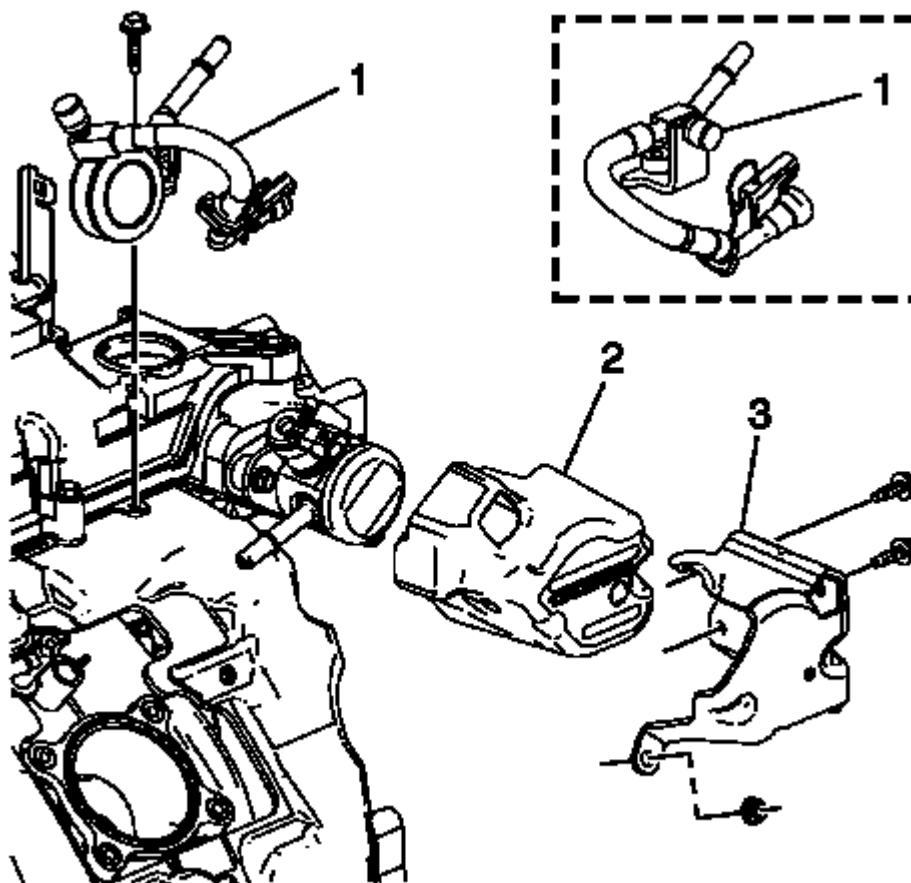
4. Remove the evaporative (EVAP) emission canister valve tube (1).
5. Remove the EVAP canister valve (2).
6. Remove the MAP sensor (3).



**Fig. 15: Throttle Body**

**Courtesy of GENERAL MOTORS COMPANY**

7. Remove the throttle body (1).



**Fig. 16: Fuel Pump Components**

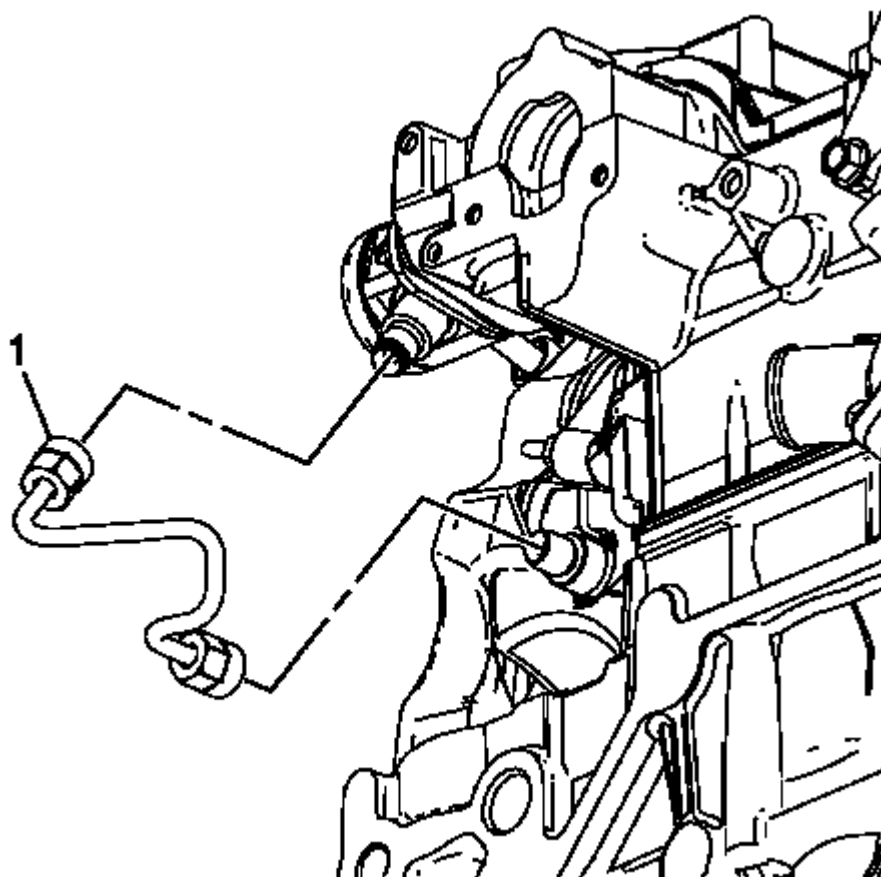
Courtesy of GENERAL MOTORS COMPANY

8. Remove the fuel pump cover nut, bolts, and cover (3).

**NOTE:** The low pressure fuel pipe used is model dependent.

9. Remove the bracket bolt and low pressure fuel pipe assembly (1).
10. Remove the fuel pump insulator (2).



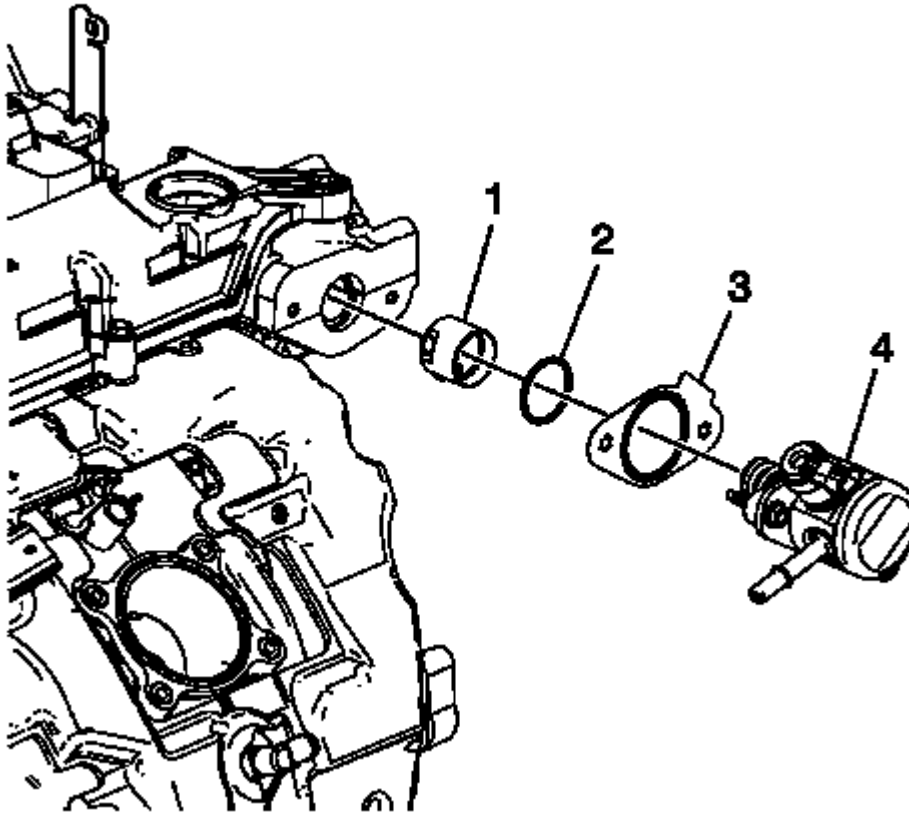


**Fig. 17: High Pressure Fuel Line**

Courtesy of GENERAL MOTORS COMPANY

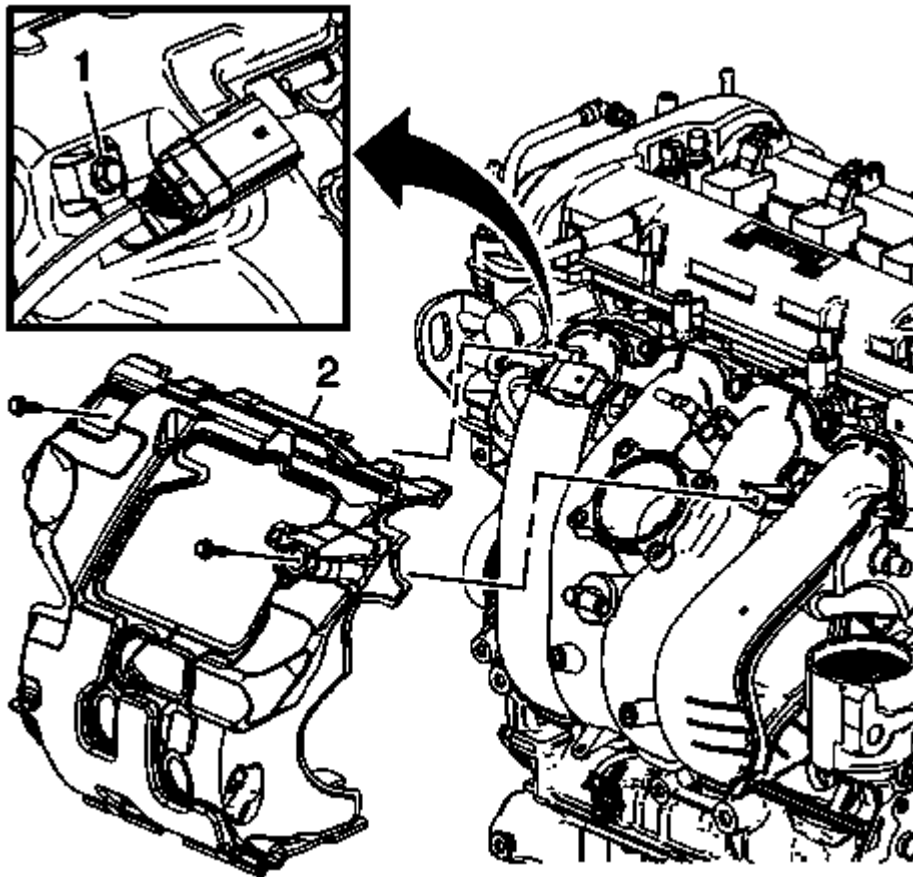
**WARNING:** Fuel that flows out at high pressure can cause serious injury to the skin and eyes. **ALWAYS** depressurize the fuel system before removing components that are under high fuel pressure.

11. Remove and discard the fuel feed intermediate pipe (1).



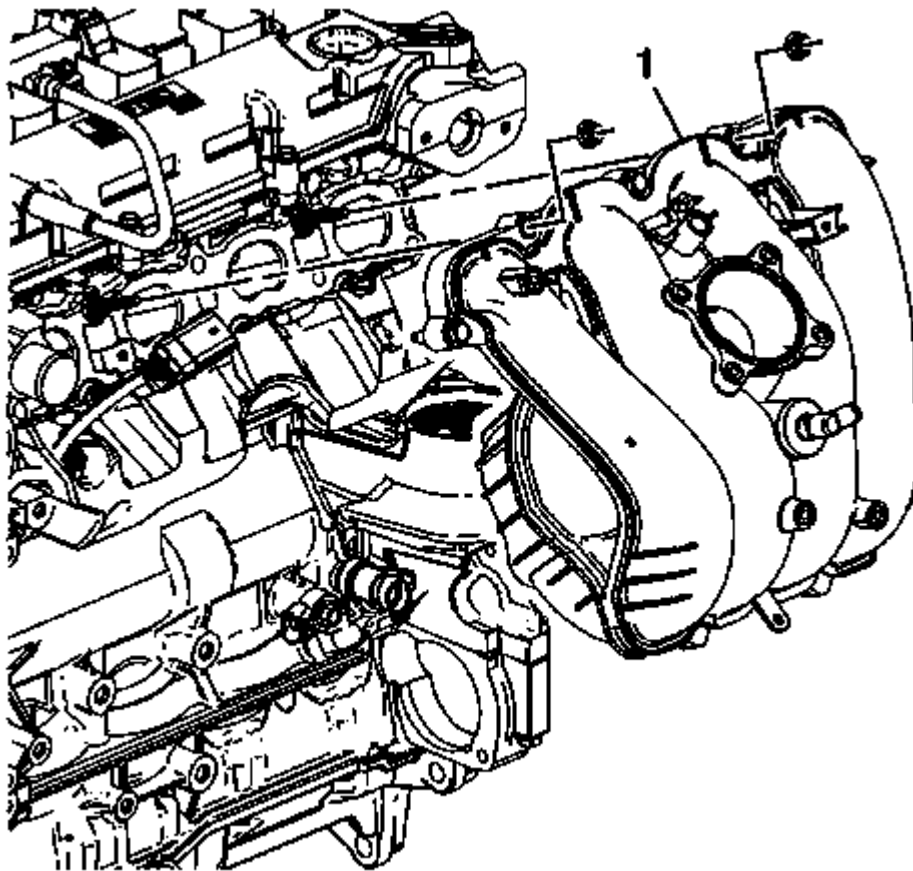
**Fig. 18: Fuel Pump Assembly Components**  
Courtesy of GENERAL MOTORS COMPANY

12. Remove the fuel pump assembly (4).
13. Remove and discard the fuel pump housing O-ring (2) and gasket (3).
14. Remove the fuel pump roller lifter (1).



**Fig. 19: Fuel Rail Harness Connector Bracket And Intake Manifold Insulator**  
Courtesy of GENERAL MOTORS COMPANY

15. Remove the fuel rail harness connector bracket bolt (1) and intake manifold insulator bolt.
16. Remove the intake manifold insulator (2).



**Fig. 20: Intake Manifold Retaining Nuts And Bolts**  
Courtesy of GENERAL MOTORS COMPANY

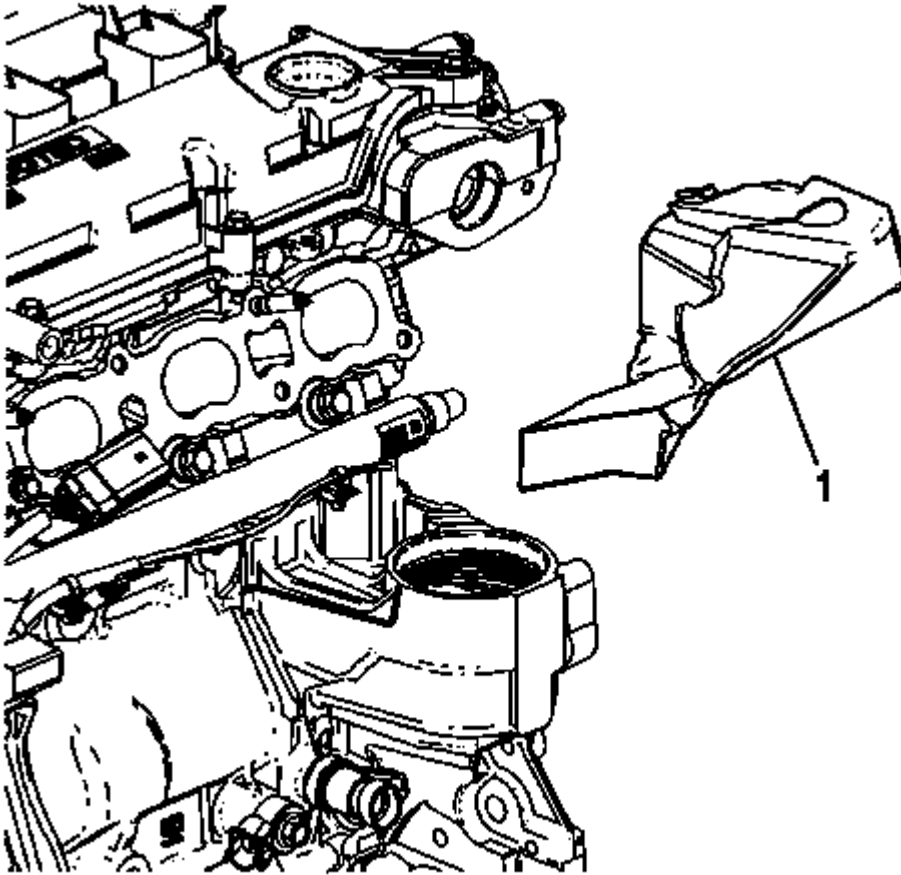
17. Remove the intake manifold retaining nuts and bolts.
18. Remove the intake manifold (1).
19. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

## **FUEL RAIL AND INJECTORS REMOVAL**

### **Special Tools**

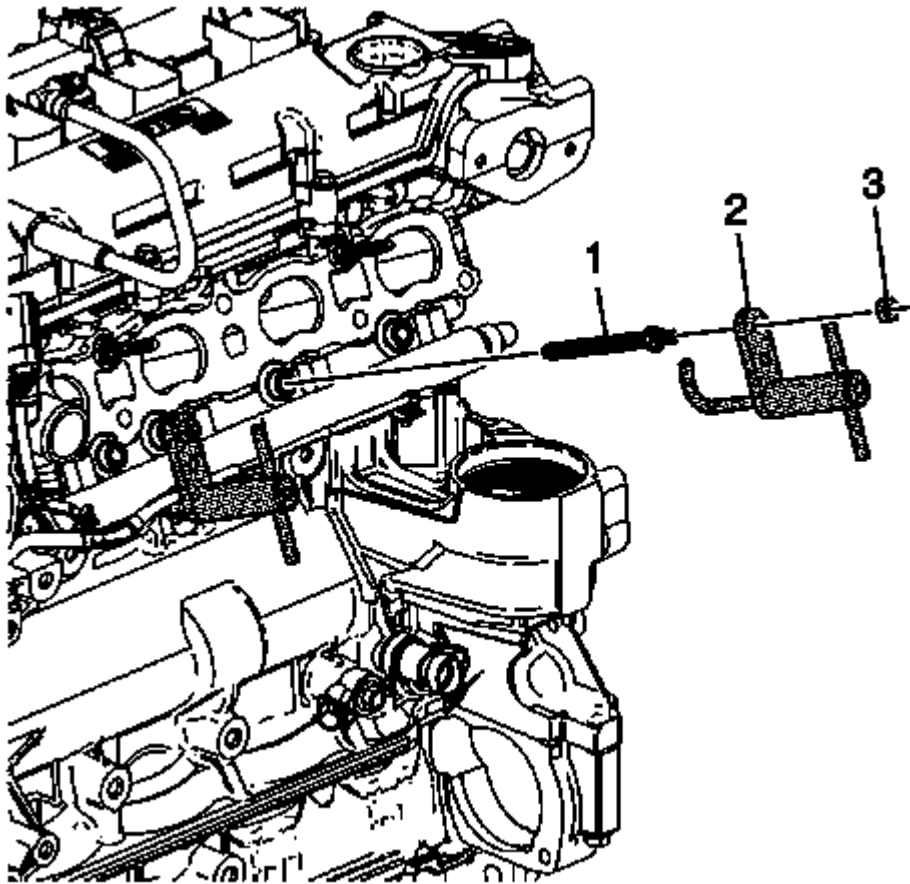
**EN-49248** Fuel Rail Assembly Remover

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



**Fig. 21: Fuel Injection Fuel Rail Noise Shield**  
Courtesy of GENERAL MOTORS COMPANY

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

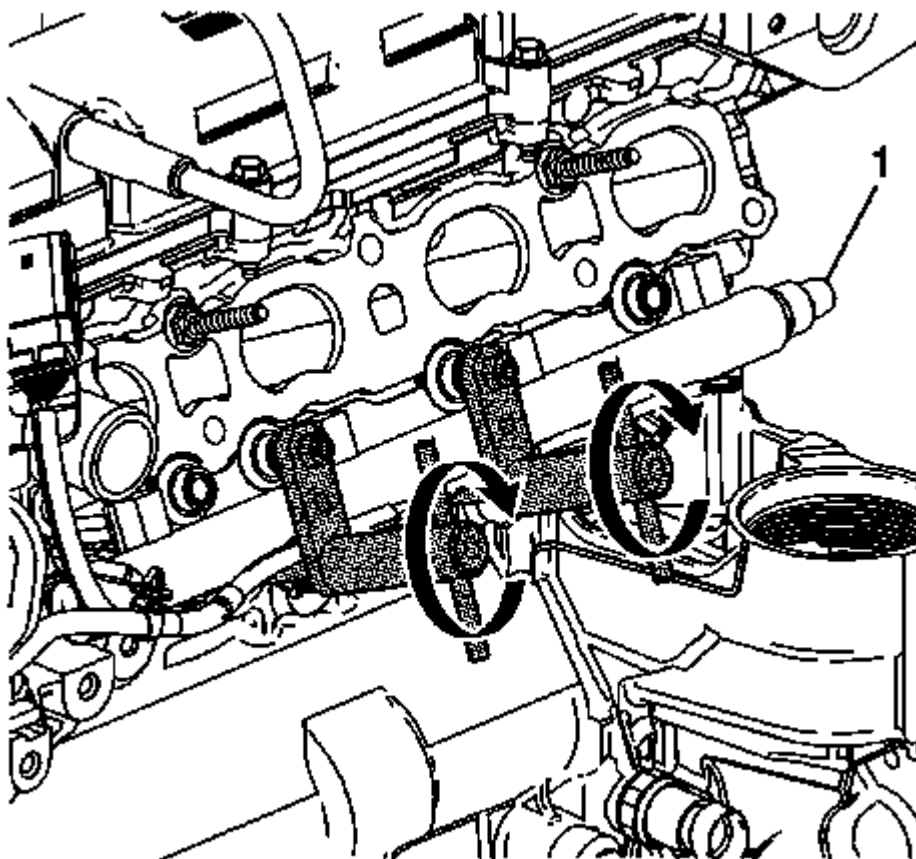


**Fig. 22: Electrical Harness And Fuel Rail Harness**  
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical harness from the fuel rail harness connection.
3. Disconnect all 4 fuel injector electrical connections.
4. Remove the fuel rail assembly retaining bolts.

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

5. Install **EN-49248** studs (1) into the 2 center fuel rail assembly retaining bolt locations. Tighten the studs to 22 N.m (16 lb ft).
6. 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. 23: Removing Fuel Rail Assembly**

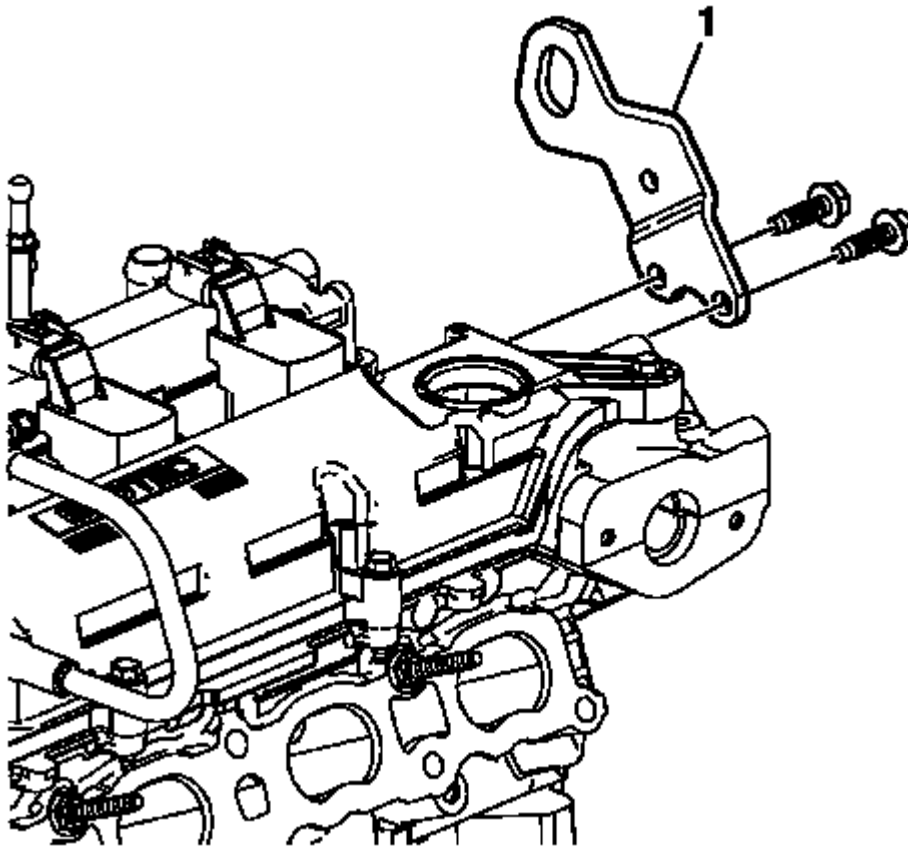
Courtesy of GENERAL MOTORS COMPANY

**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.

7. Using EN-49248 remover remove the fuel rail assembly (1).

#### **CAMSHAFT COVER REMOVAL (2.4L LEA)**

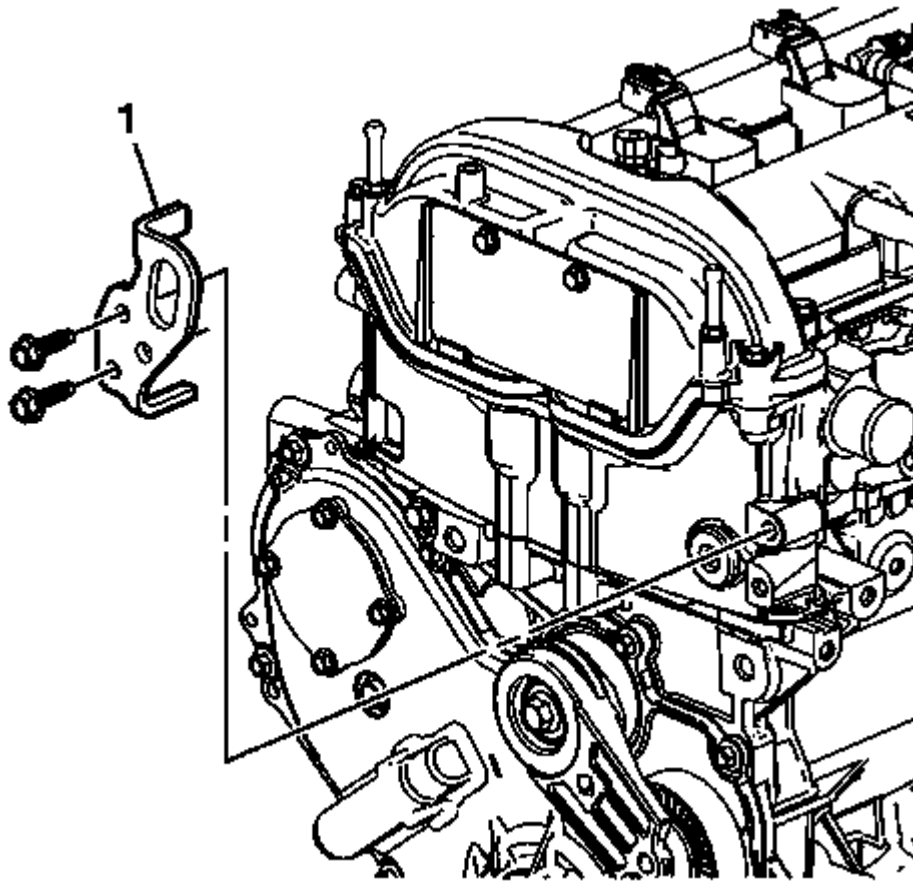


**Fig. 24: Rear Lift Bracket**

Courtesy of GENERAL MOTORS COMPANY

1. Remove the rear lift bracket (1).

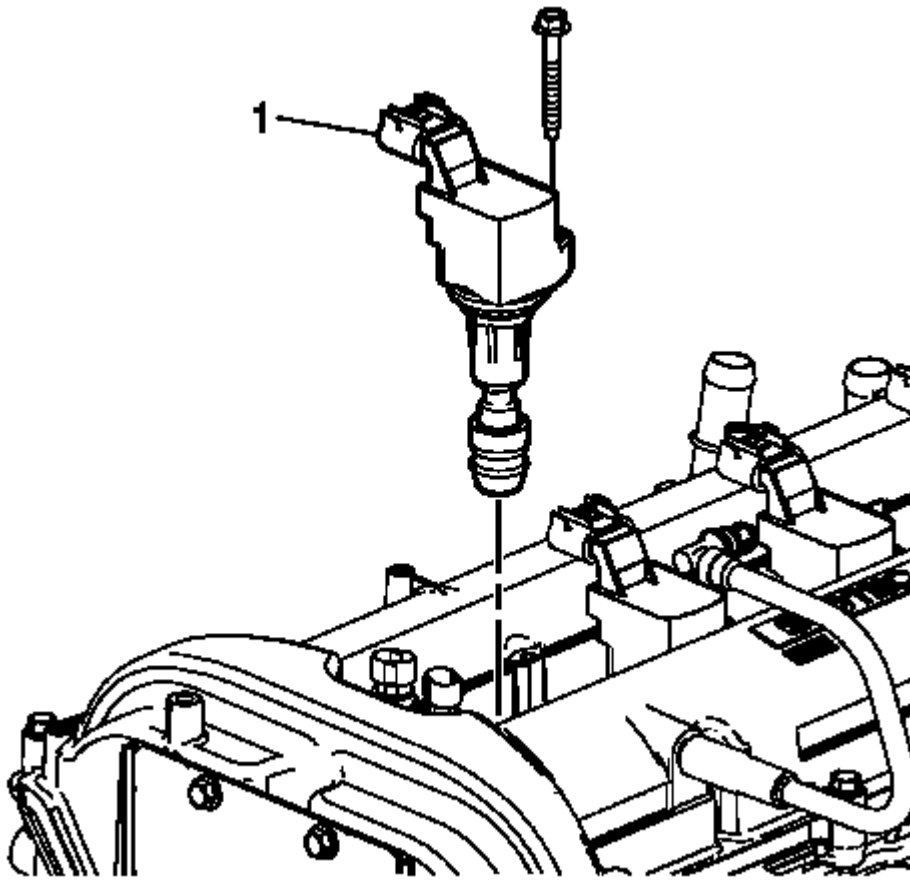




**Fig. 25: Front Lift Bracket**

**Courtesy of GENERAL MOTORS COMPANY**

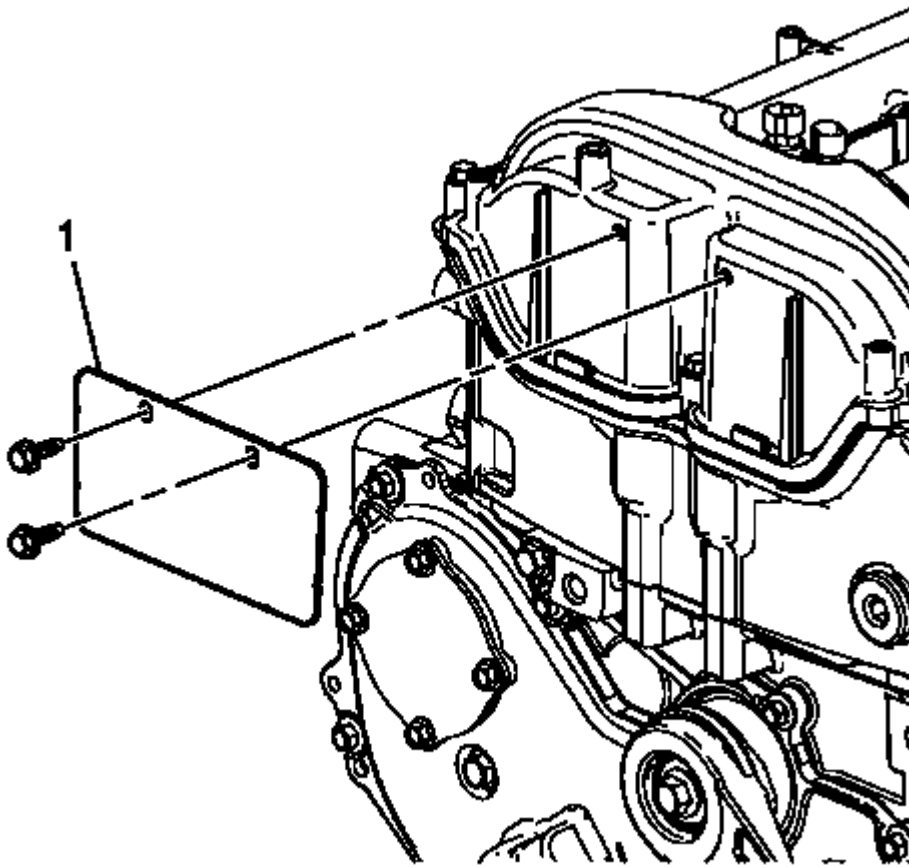
2. Remove the front lift bracket (1).



**Fig. 26: Ignition Coil**

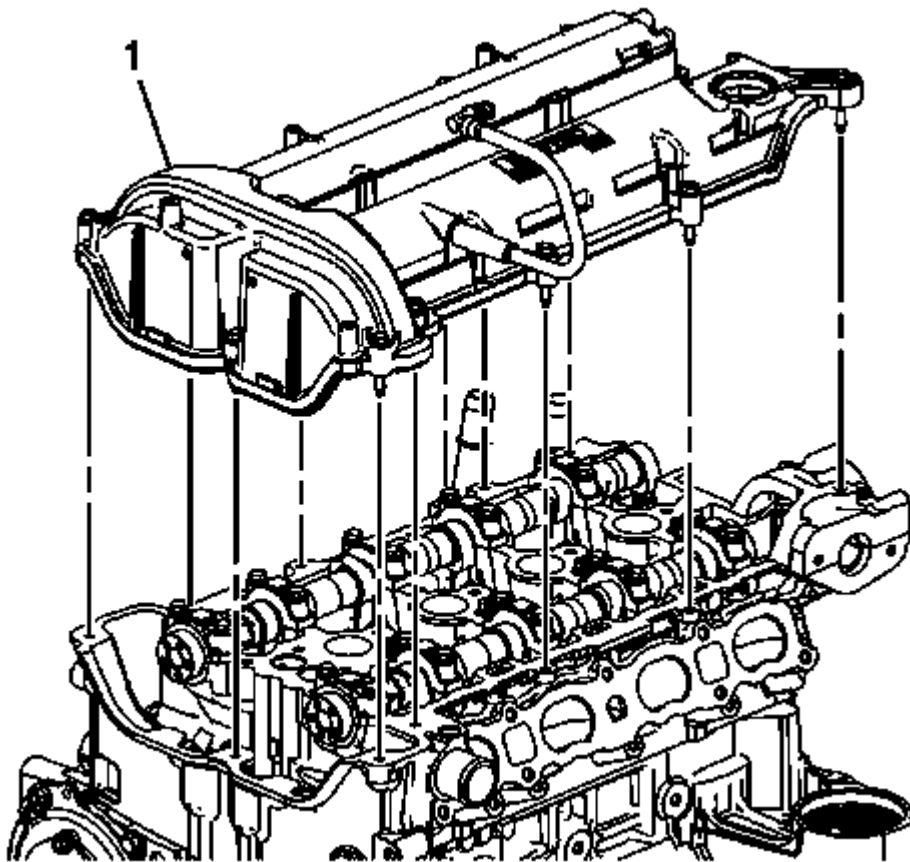
Courtesy of GENERAL MOTORS COMPANY

3. Remove the ignition coil (1).



**Fig. 27: Camshaft Housing Cover Insulator**  
Courtesy of GENERAL MOTORS COMPANY

4. Remove the camshaft housing cover insulator (1).



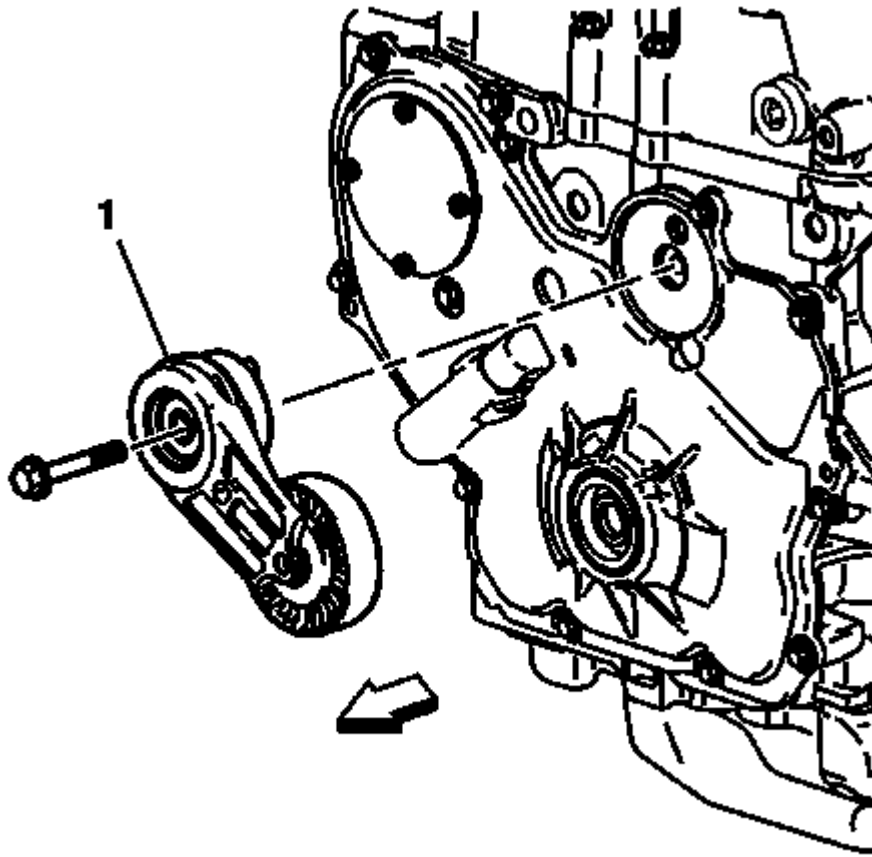
**Fig. 28: Camshaft Cover Assembly**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:**        **DO NOT** remove the PCV hose from the camshaft cover. If damage to the hose or connectors is present, the cover must be replaced.

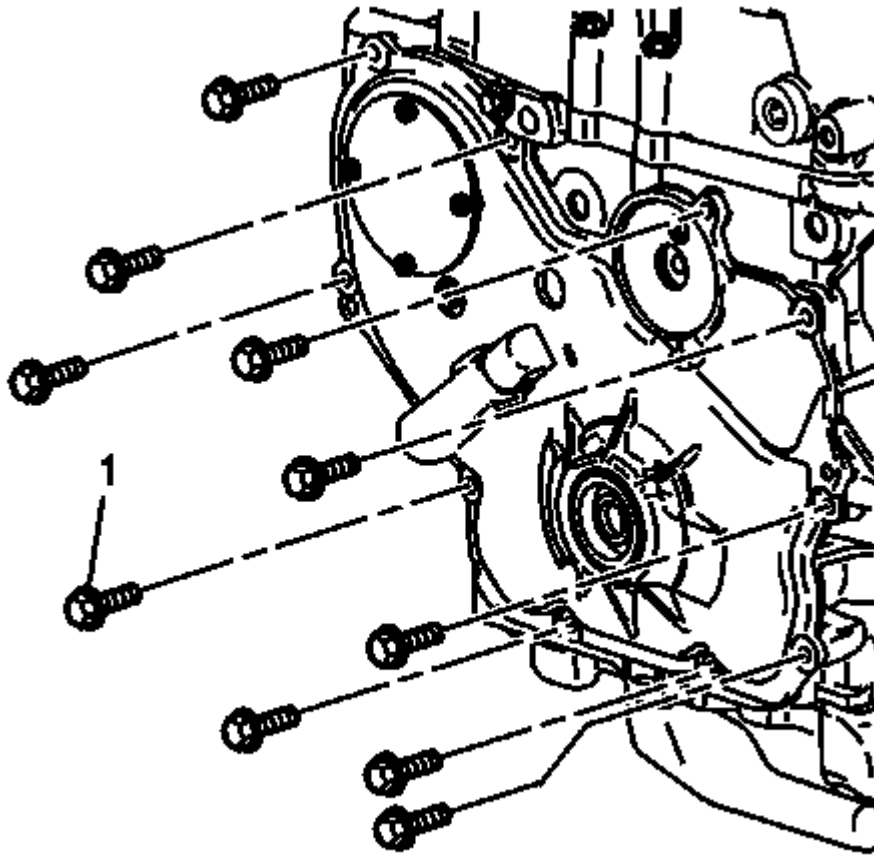
5. Remove the camshaft cover assembly (1).
6. Remove and discard the camshaft cover gasket, camshaft cover grommets, and camshaft cover bolts if they are serviced with the grommet.

## **ENGINE FRONT COVER AND OIL PUMP REMOVAL**



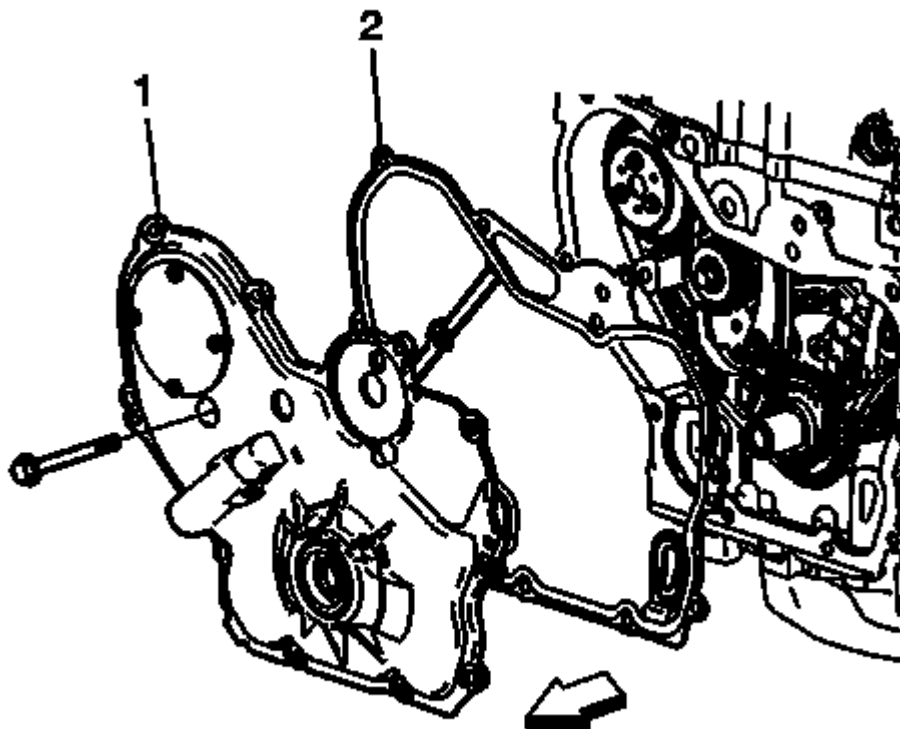
**Fig. 29: Accessory Drive Belt Tensioner And Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 30: Engine Front Cover Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 31: Long Water Pump Bolt And Engine Front Cover**  
Courtesy of GENERAL MOTORS COMPANY

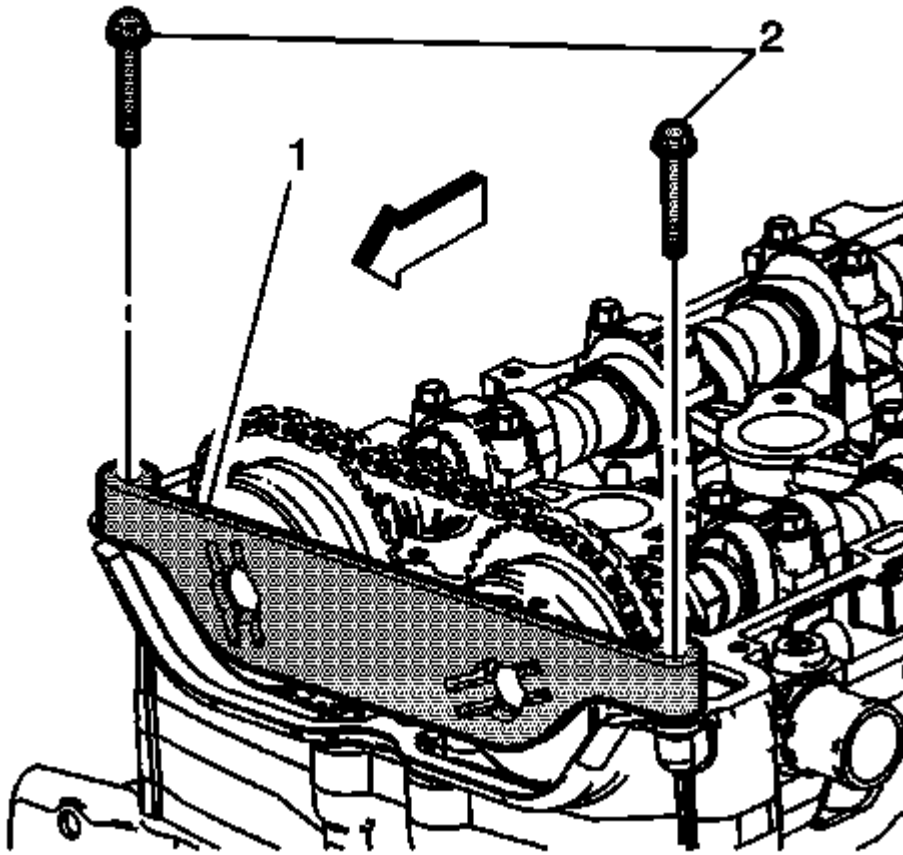
4. Remove the long water pump bolt.
5. Remove the engine front cover (1) and gaskets (2).
6. Remove the crankshaft front cover oil seal with an appropriate tool.

## **CAMSHAFT TIMING CHAIN AND TENSIONER REMOVAL (2.4L LEA)**

### **Special Tools**

**EN-48953** Camshaft Actuator Locking Tool

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



**Fig. 32: View Locking Tool**

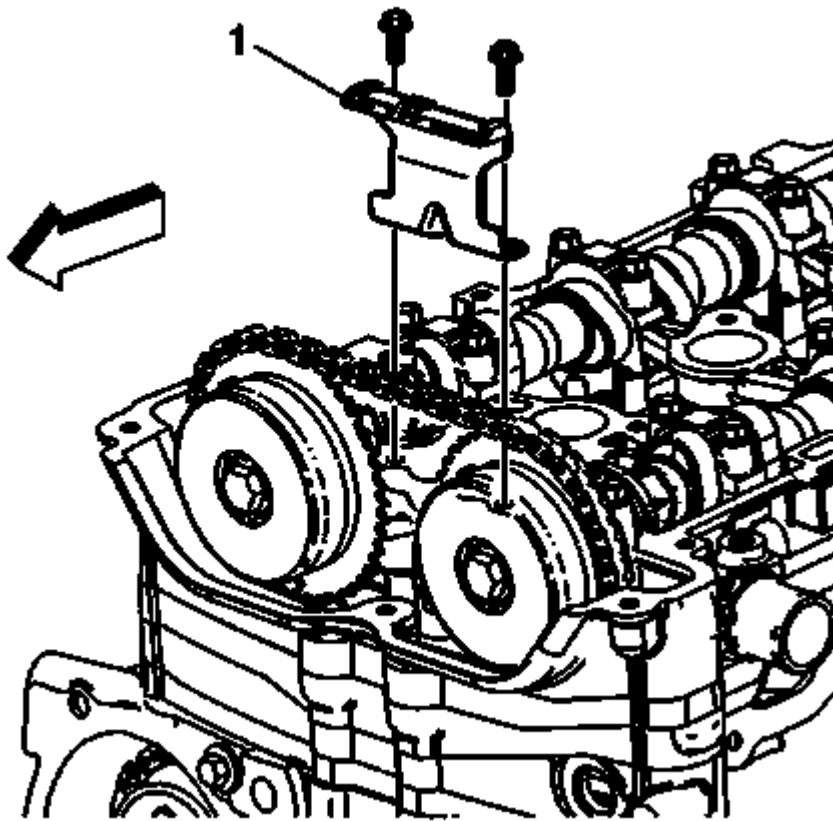
Courtesy of GENERAL MOTORS COMPANY

1. Rotate the crankshaft to install EN-48953 locking tool (1).

**NOTE:** Marking the chain and actuators is crucial to procedures operation. The camshaft actuator and timing chain must have oil removed from the surface prior to marking both actuators and chain.

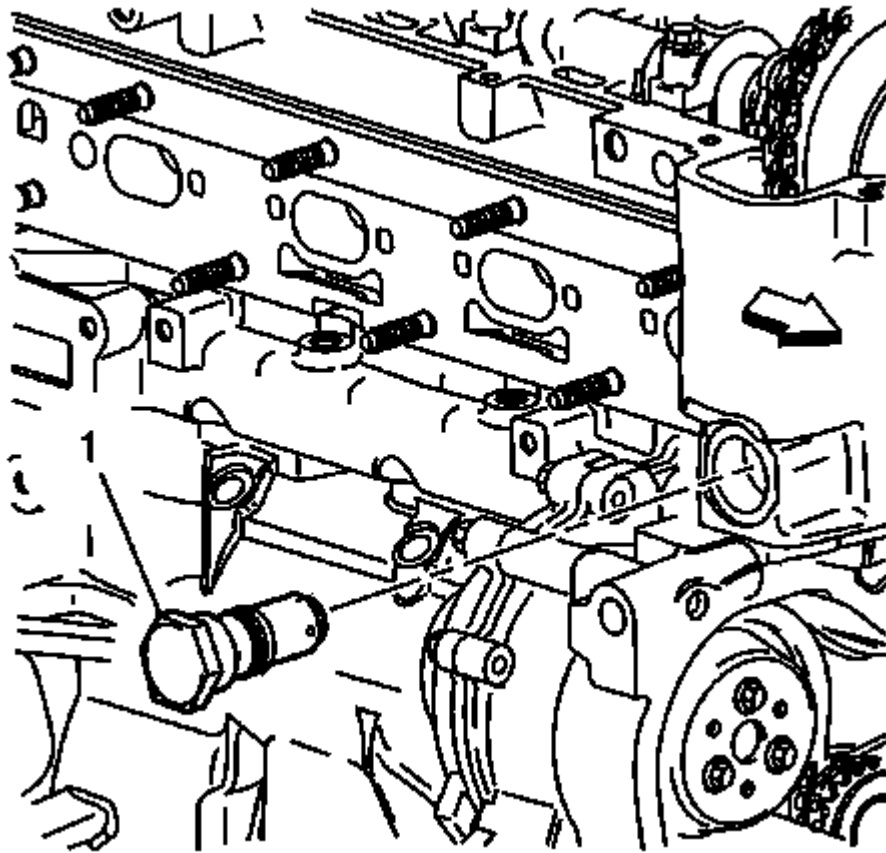
2. Install EN-48953 locking tool onto the cylinder head and tighten to 10 N.m (89 lb in). If the intake camshaft actuator is moving independent of cam and is not locked, rotate the intake camshaft counterclockwise and the tool will hold the actuator, locking the actuator to the cam.
3. Loosen the intake camshaft actuator bolt.
4. Loosen the exhaust camshaft actuator bolt.
5. Remove EN-48953 locking tool.





**Fig. 33: View of Timing Chain and Tensioner**  
**Courtesy of GENERAL MOTORS COMPANY**

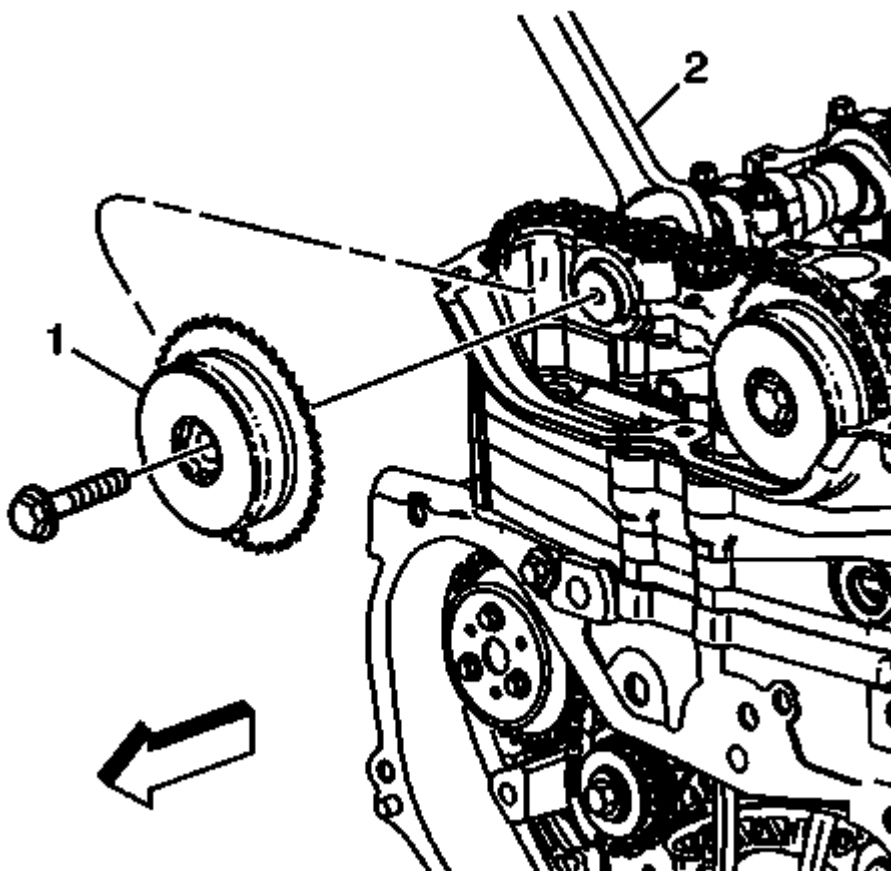
6. Remove the upper timing chain guide bolts.
7. Remove the upper timing chain guide (1).



**Fig. 34: Identifying Timing Chain Tensioner Plunger**  
Courtesy of GENERAL MOTORS COMPANY

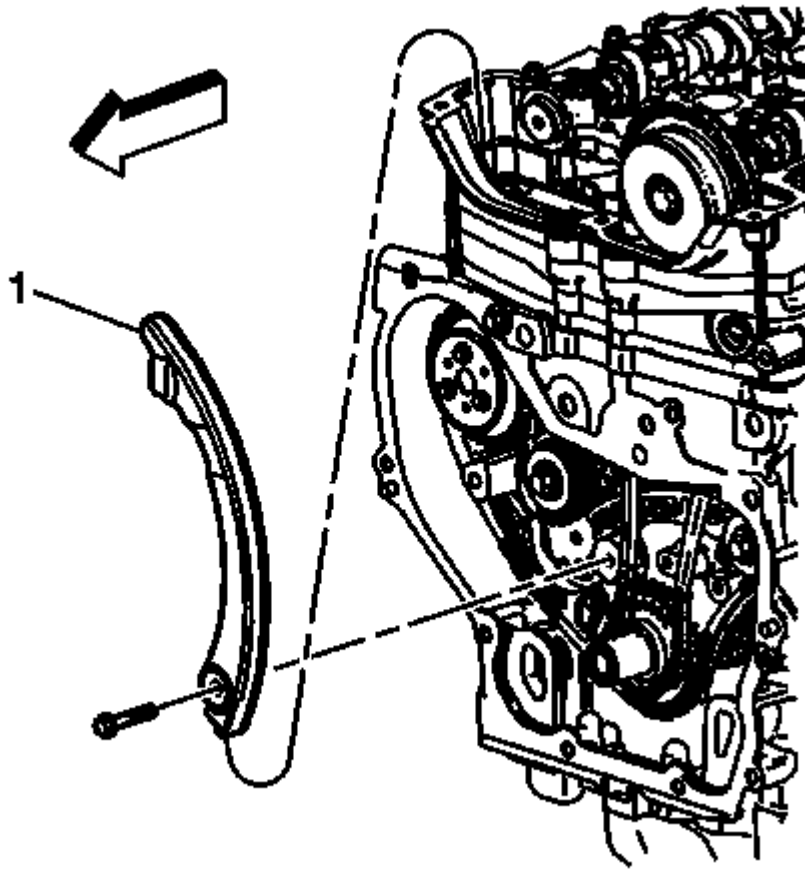
**NOTE:** The timing chain tensioner must be removed to unload chain tension before the timing chain is removed.

8. Remove the timing chain tensioner plunger (1).



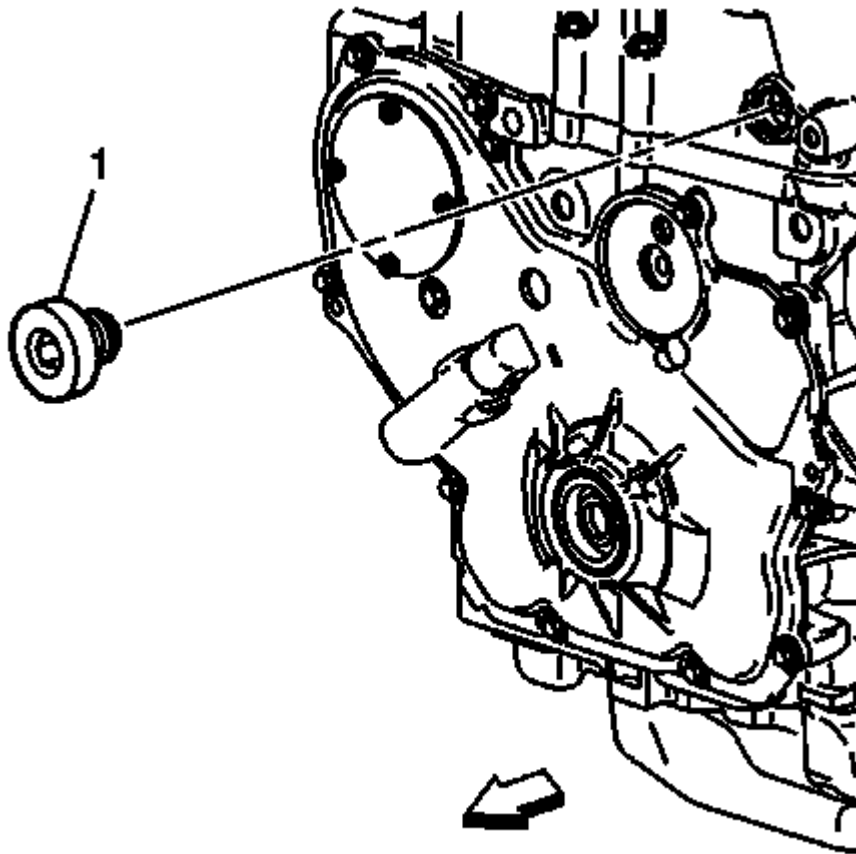
**Fig. 35: Identifying Exhaust Camshaft Actuator**  
Courtesy of GENERAL MOTORS COMPANY

9. Locate hex on the exhaust camshaft and hold with a wrench (2).
10. Remove the exhaust camshaft bolt and the exhaust camshaft actuator (1). Discard the bolt.



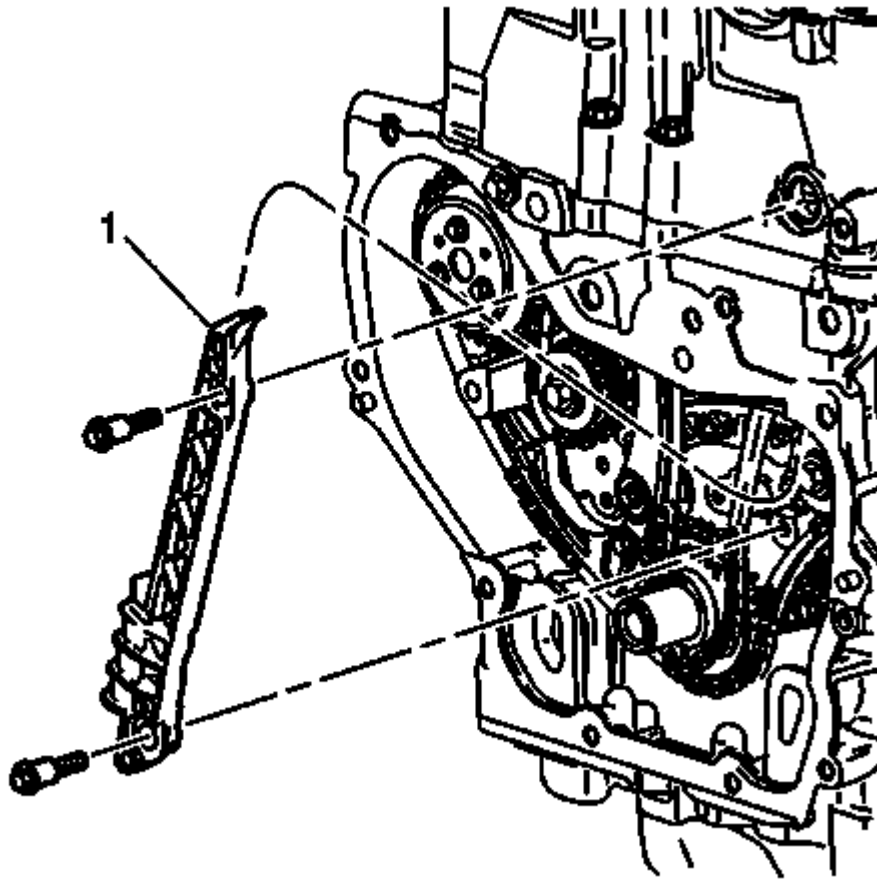
**Fig. 36: View of Adjustable Timing Chain Guide Bolt.**  
Courtesy of GENERAL MOTORS COMPANY

11. Remove the adjustable timing chain guide bolt.
12. Remove the adjustable timing chain guide (1).



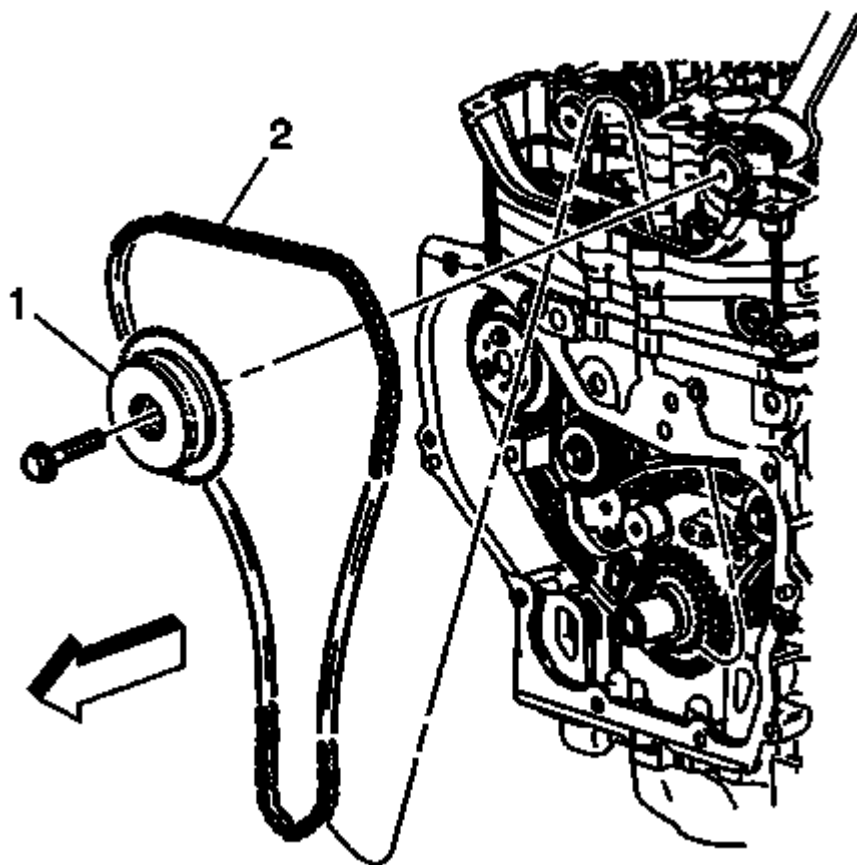
**Fig. 37: Identifying Fixed Timing Chain Guide Bolt Plug**  
Courtesy of GENERAL MOTORS COMPANY

13. Remove the plug (1) to gain access to the fixed timing chain guide bolt.



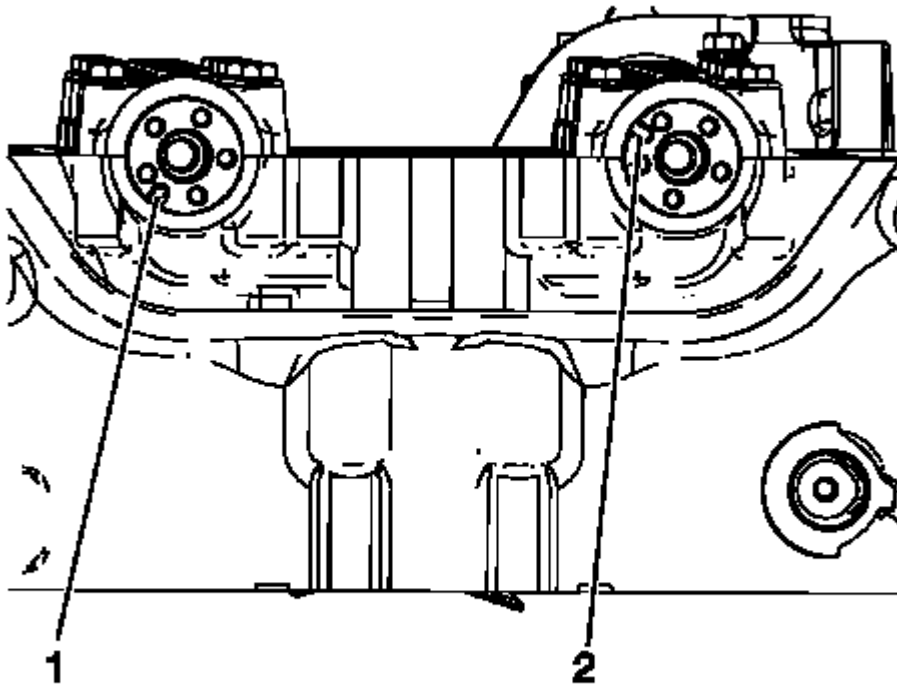
**Fig. 38: View of Fixed Timing Chain Guide**  
**Courtesy of GENERAL MOTORS COMPANY**

14. Remove the fixed timing chain guide bolts.
15. Remove the fixed timing chain guide (1).



**Fig. 39: Identifying Intake Camshaft Actuator & Timing Chain**  
Courtesy of GENERAL MOTORS COMPANY

16. Locate hex on the intake camshaft and hold with a wrench.
17. Remove the intake camshaft actuator bolt, the intake camshaft actuator (1) and the timing chain (2) through the top of the cylinder head. Discard the bolt.

**Fig. 40: Camshaft Notches**

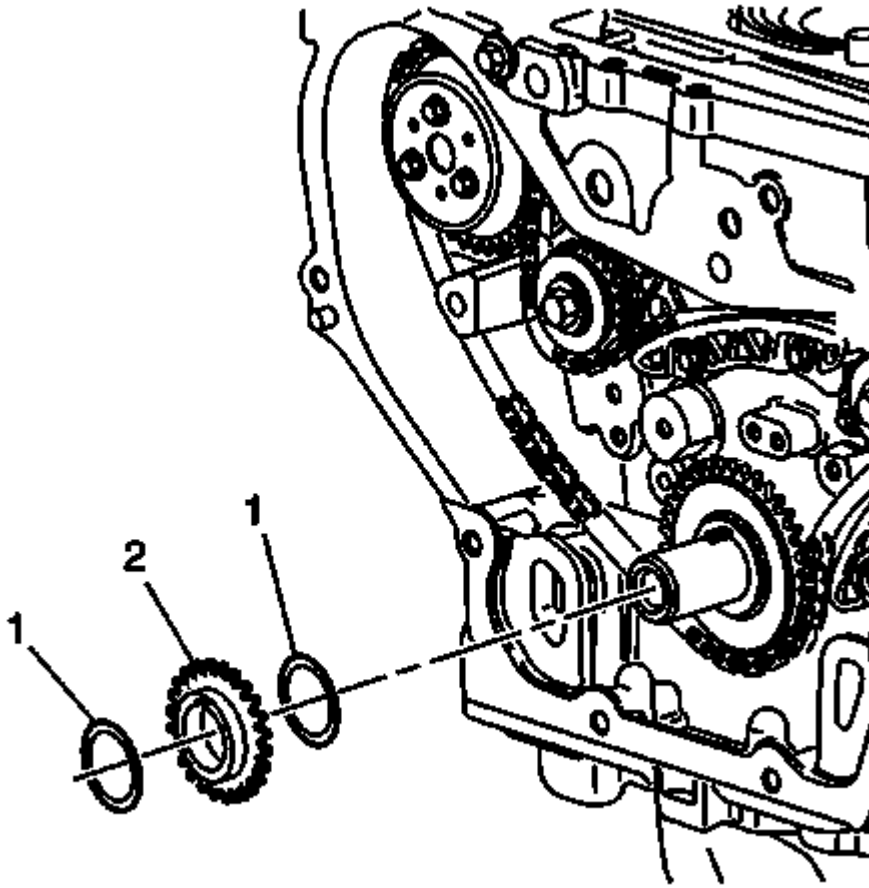
Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

- The number 3 exhaust valves are open.
- Note the position and direction of the camshafts before removal. Mark the cylinder head in relation to the locking notches before component removal.

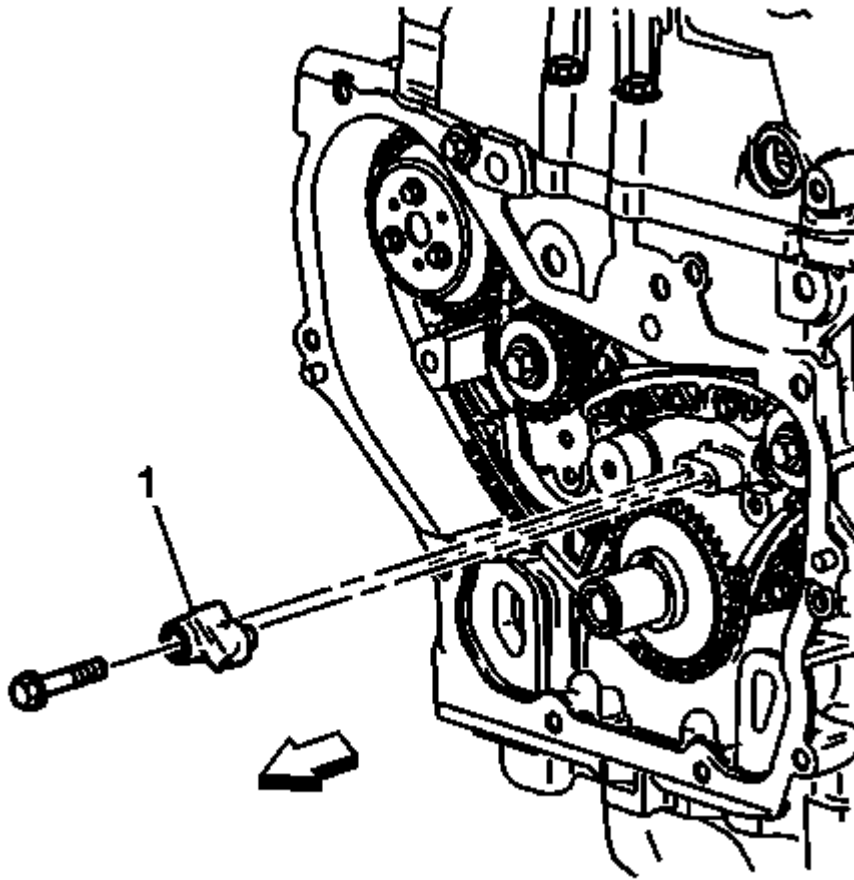
18. Mark the cylinder head where the exhaust camshaft actuator locking notch (1) and intake camshaft locking notch (2) are lined up with the cylinder head.





**Fig. 41: View Of Crankshaft Sprocket**  
**Courtesy of GENERAL MOTORS COMPANY**

19. Remove the crankshaft sprocket (2) and friction washers (1), if equipped.

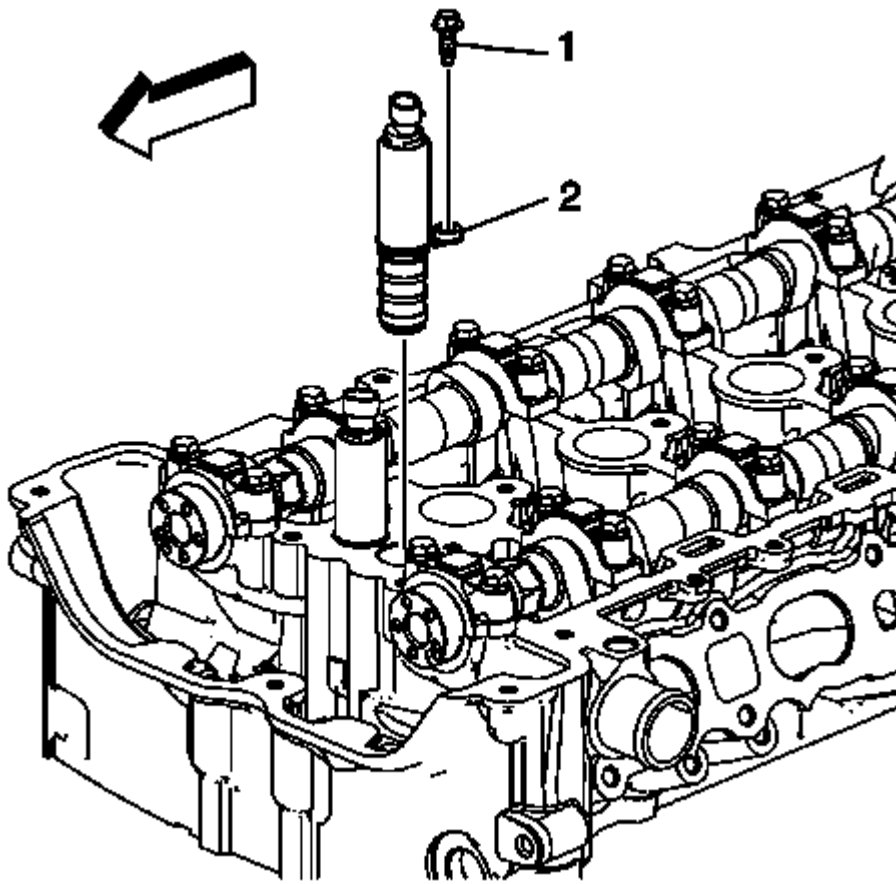


**Fig. 42: View of Timing Chain Oil Nozzle**  
Courtesy of GENERAL MOTORS COMPANY

20. Remove the timing chain oil nozzle bolt.
21. Remove the timing chain oil nozzle (1).

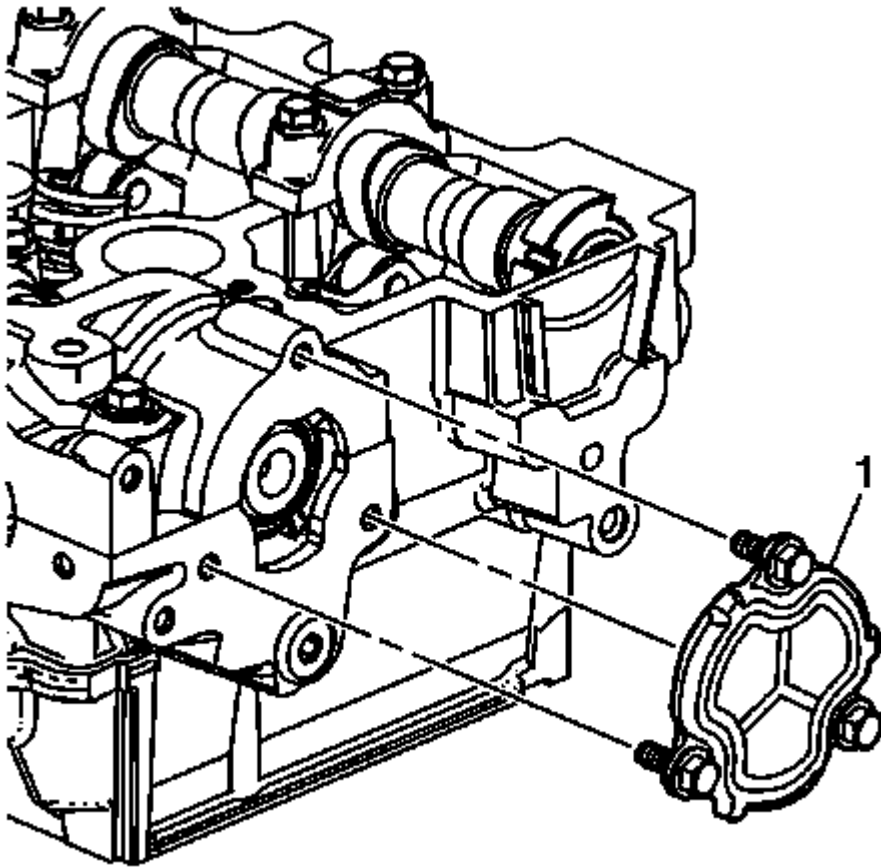
## **INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL (2.4L LEA)**

### **Intake Camshaft and Components Removal**



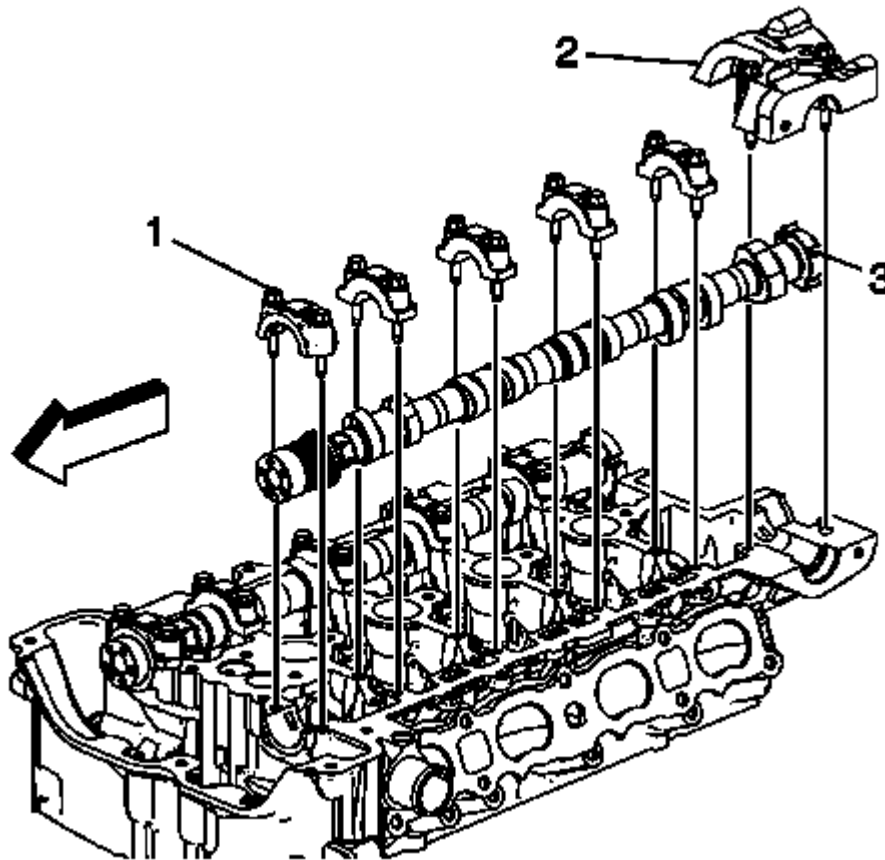
**Fig. 43: Intake Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the intake camshaft position actuator solenoid valve bolt (1) and valve (2).



**Fig. 44: Rear Cylinder Head Cover Plate**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the rear cylinder head cover plate (1).

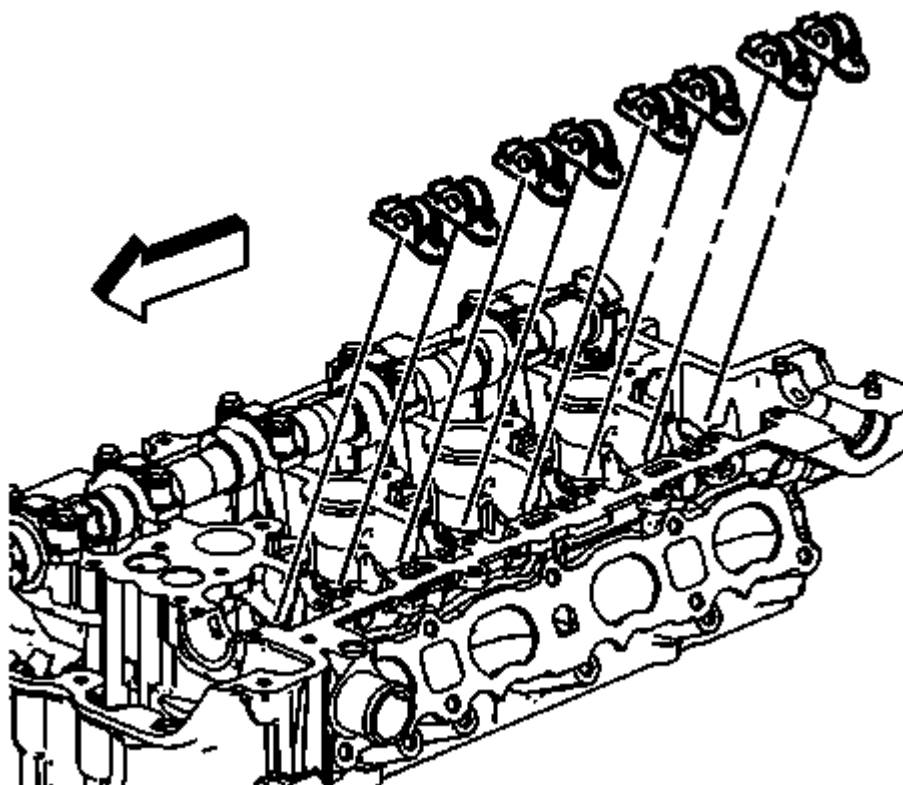


**Fig. 45: Intake Camshaft Bearing Rear Cap Bolts And Cap**  
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the intake camshaft bearing rear cap bolts and cap (2).

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

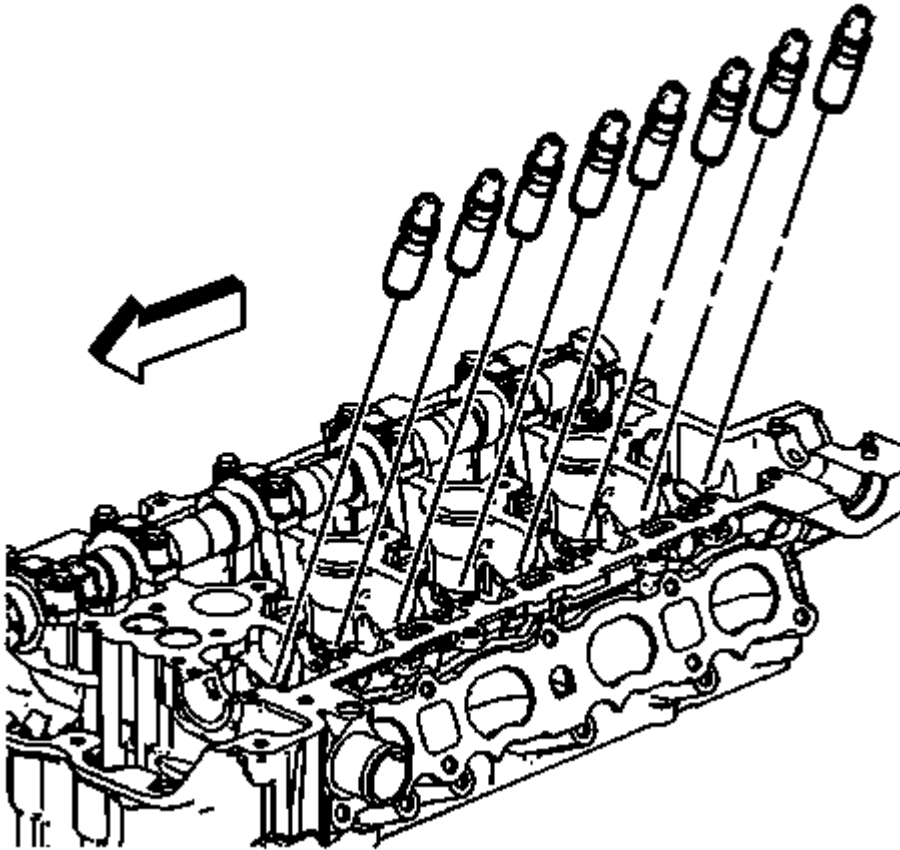
4. Mark camshaft caps to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts.
6. Remove the camshaft caps (1).
7. Remove the intake camshaft (3).



**Fig. 46: 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.

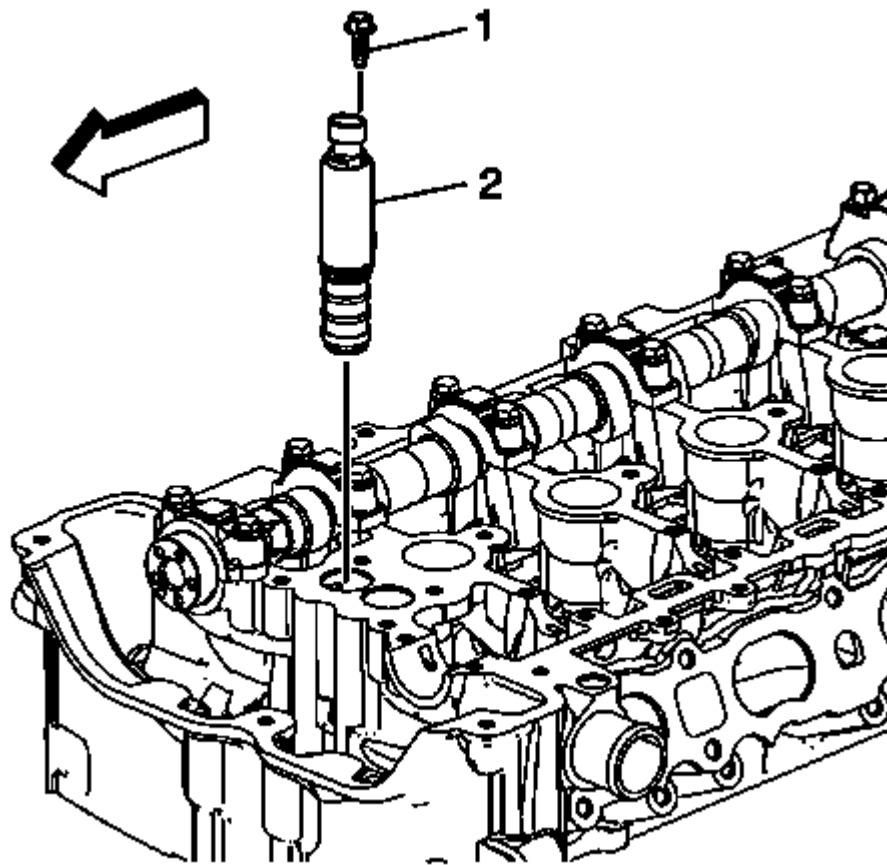
8. Remove the intake camshaft roller finger followers.



**Fig. 47: Hydraulic Lash Adjusters**  
Courtesy of GENERAL MOTORS COMPANY

9. Remove the hydraulic lash adjusters.

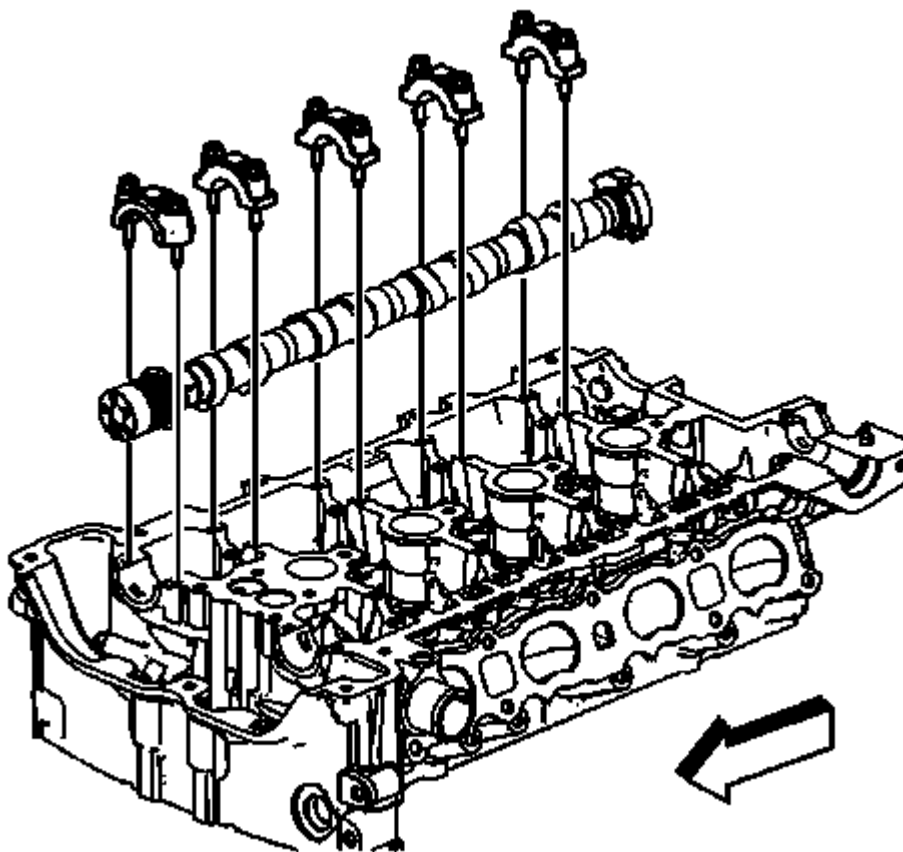
#### **Exhaust Camshaft and Components Removal**



**Fig. 48: Exhaust Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the exhaust camshaft position actuator solenoid valve bolt (1) and valve (2).

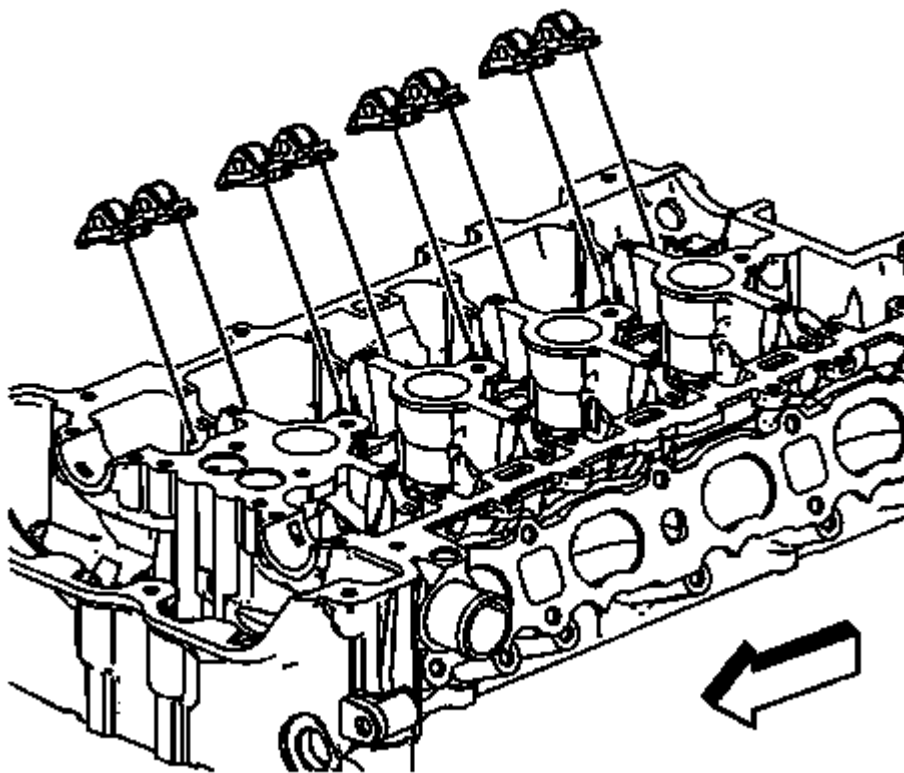




**Fig. 49: Exhaust Camshaft & Caps**  
Courtesy of GENERAL MOTORS COMPANY

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

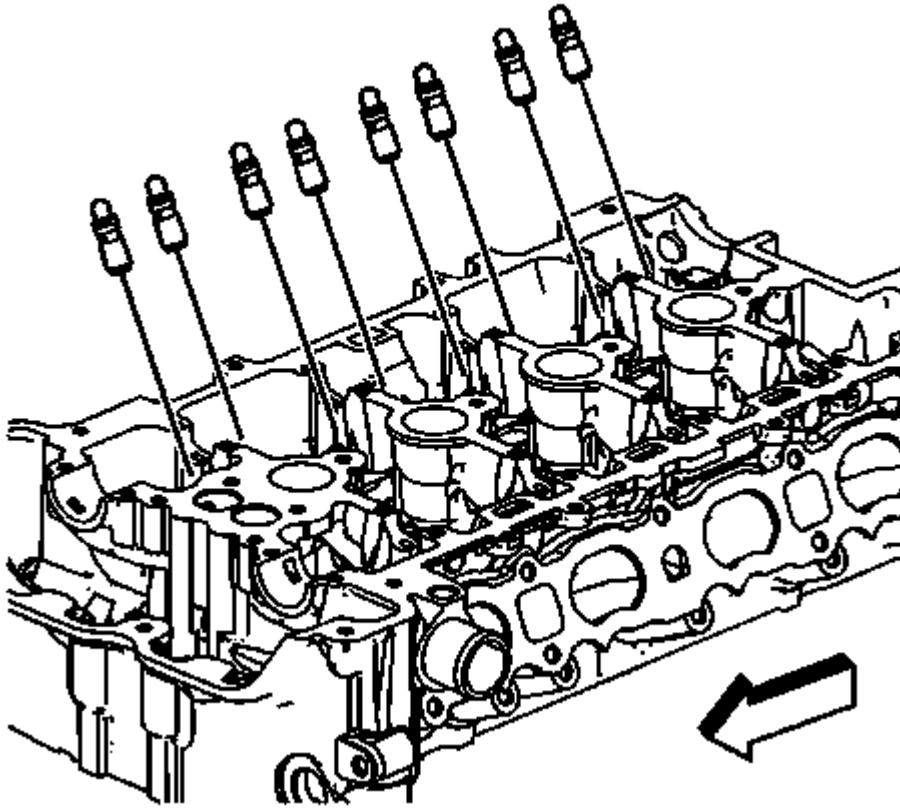
2. Mark camshaft caps to ensure they are installed in the same position.
3. Remove the exhaust camshaft cap bolts.
4. Remove the camshaft caps ensuring they are marked and refitted in same position on assembly.
5. Remove the exhaust camshaft.



**Fig. 50: 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.

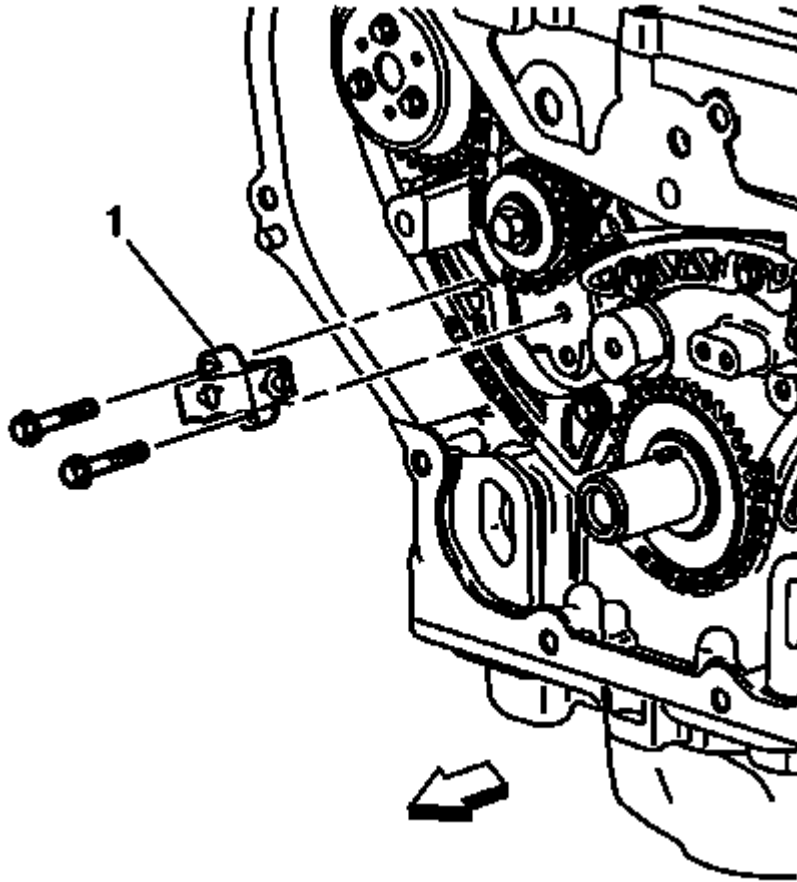
6. Remove the exhaust camshaft roller finger followers.



**Fig. 51: Hydraulic Lash Adjusters**  
Courtesy of GENERAL MOTORS COMPANY

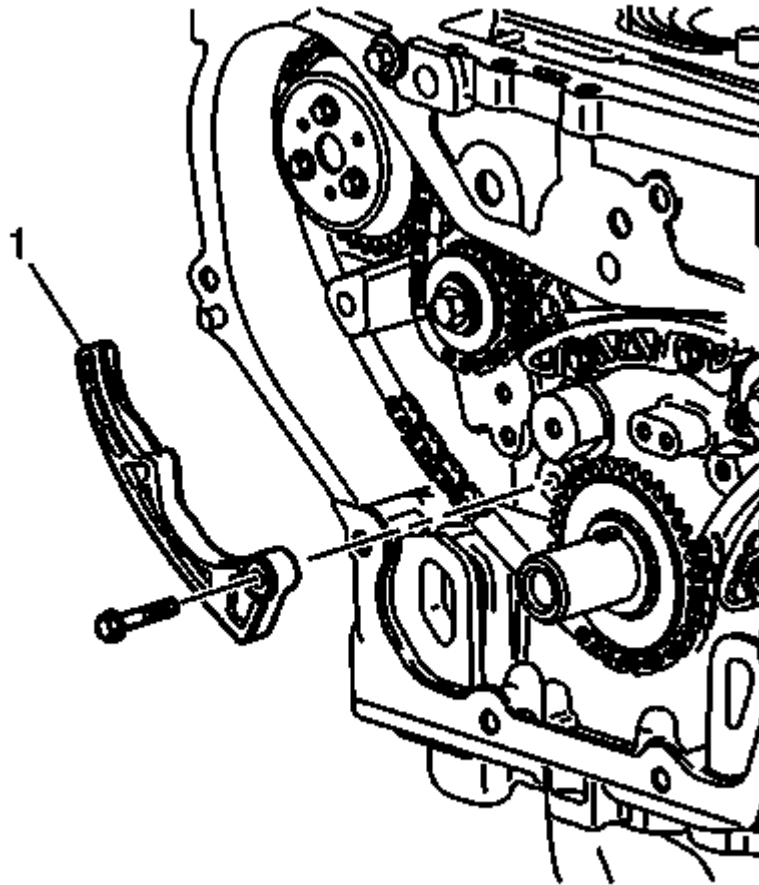
7. Remove the hydraulic lash adjusters.

## **WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER REMOVAL**



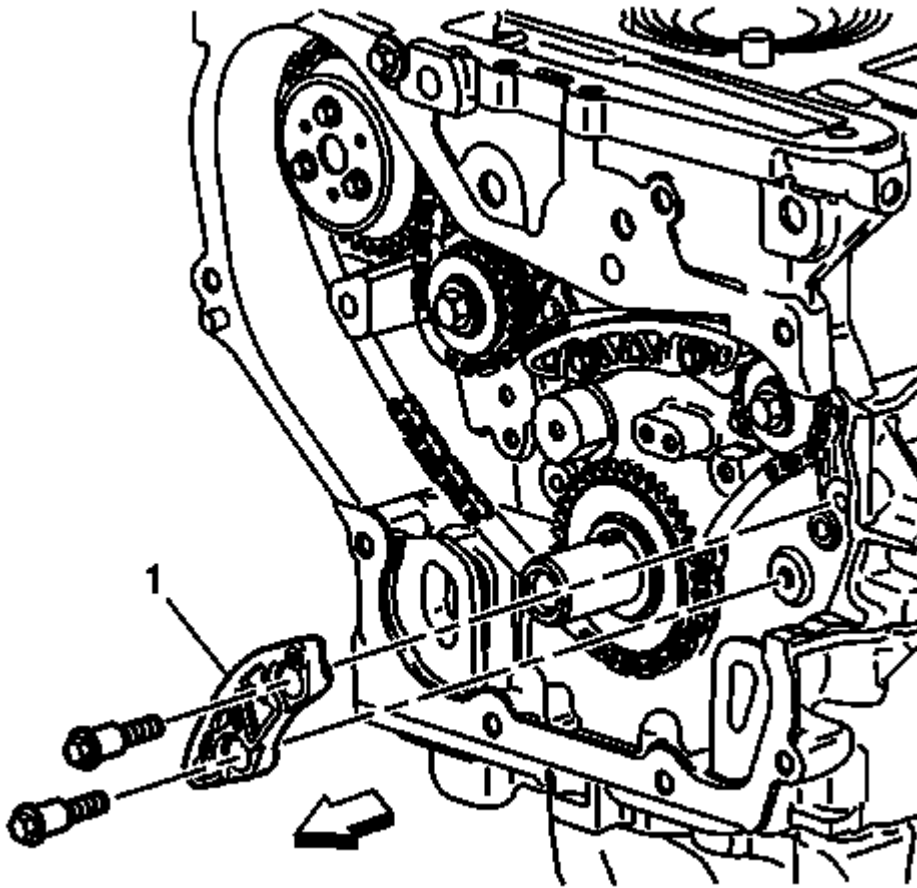
**Fig. 52: Balance Shaft Drive Chain Tensioner And Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balance shaft drive chain tensioner bolts.
2. Remove the balance shaft drive chain tensioner (1).



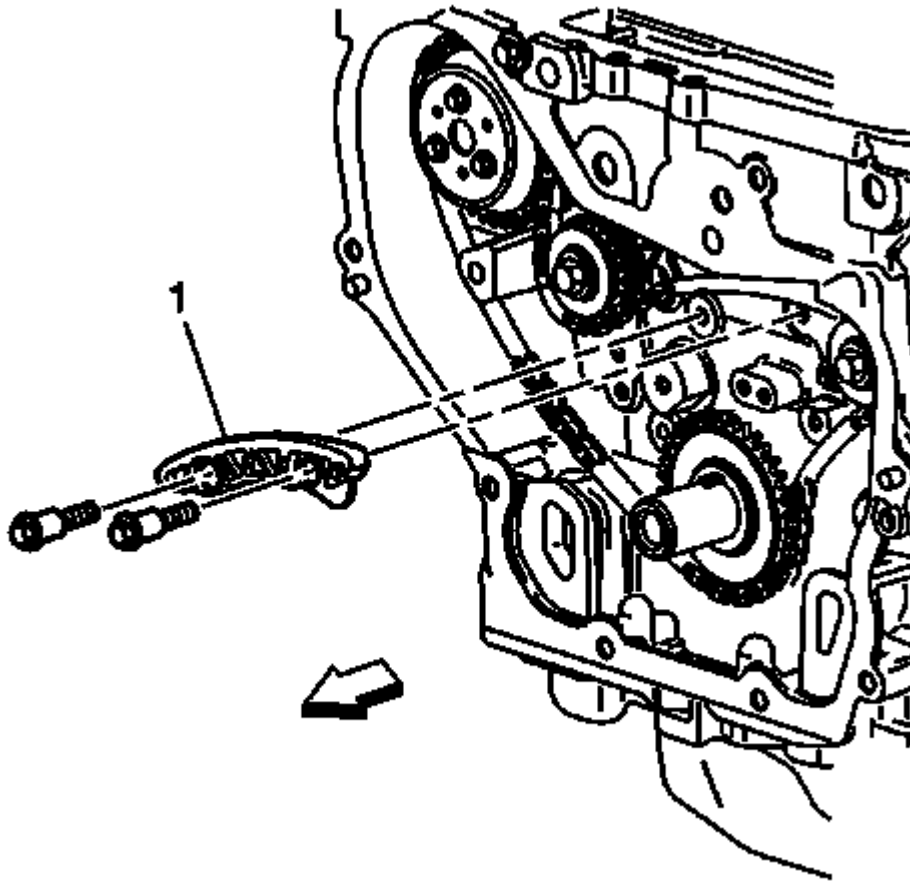
**Fig. 53: Adjustable Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide (1).



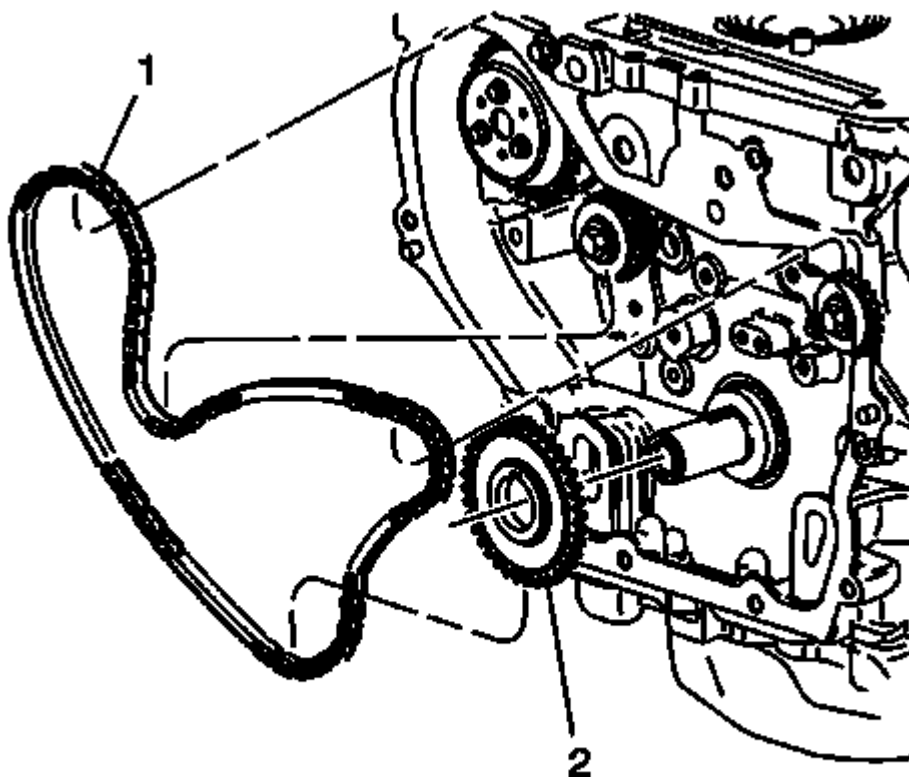
**Fig. 54: Small Balance Shaft Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide (1).



**Fig. 55: Upper Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide (1).



**Fig. 56: Balance Shaft Drive Chain And Sprocket**  
 Courtesy of GENERAL MOTORS COMPANY

**NOTE:** It may ease removal of the balance shaft drive chain to get all of the slack in the chain between the crankshaft and water pump sprockets.

9. Remove the balance shaft drive chain (1).
10. Remove the balance shaft drive sprocket (2).

## BALANCE SHAFT REMOVAL

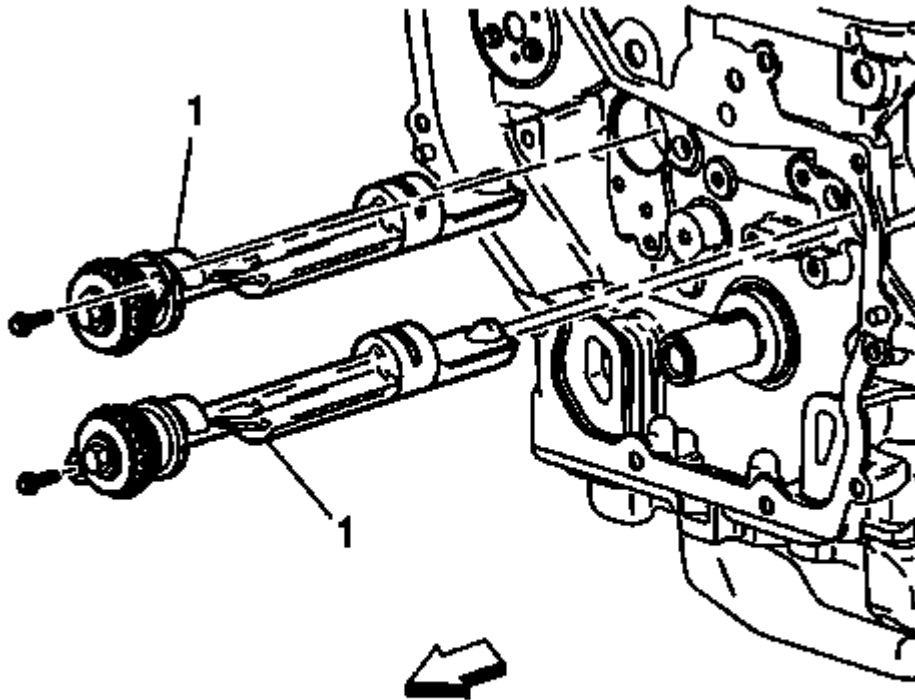
**NOTE:** This procedure is not used in Europe.

### Special Tools

EN-43650 Balancer Shaft Bearing Remover and Installer

For equivalent regional tools, refer to Special Tools .





**Fig. 57: View of Balance Shaft Bolts**

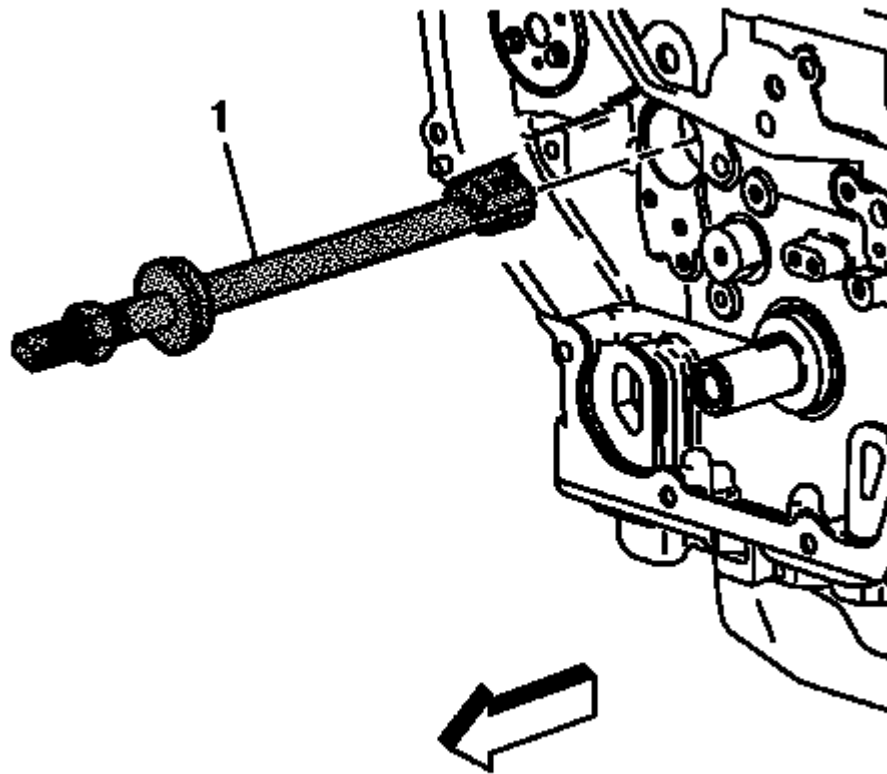
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balance shaft bearing carrier bolts.

**NOTE:**

- It is possible to install the intake side balance shaft into the exhaust side and vice versa. Please use care not to install the balance shafts into the wrong bores. Engine vibration will result.
- Do not remove the bolt holding the sprocket.

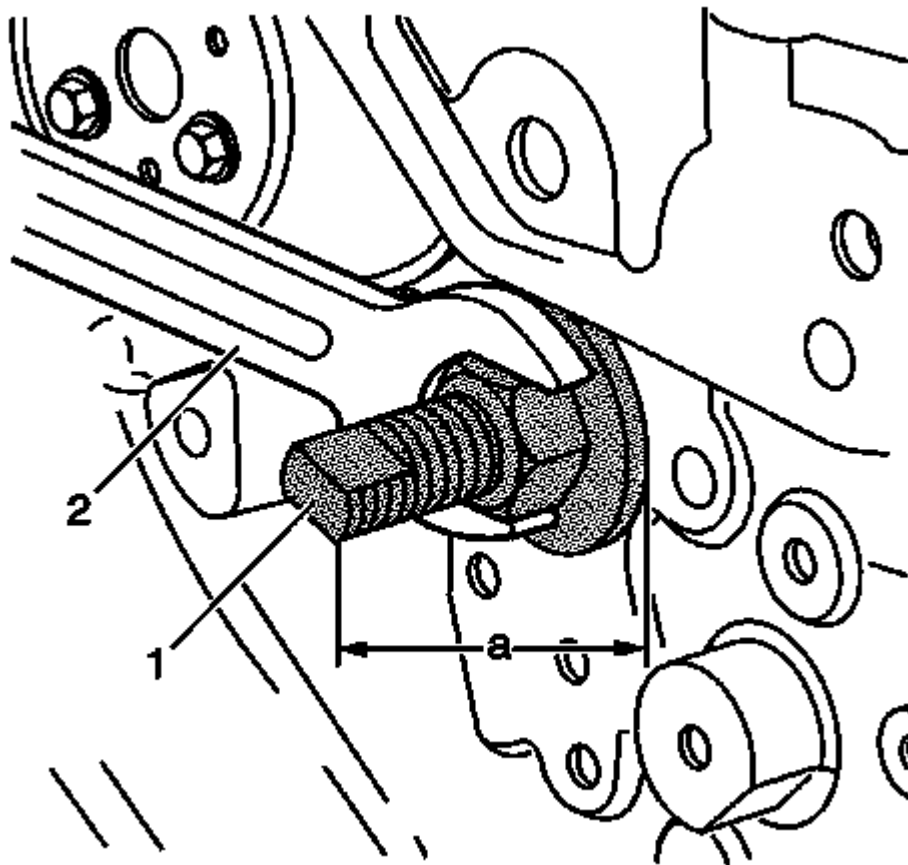
2. Remove the balance shaft assemblies (1).



**Fig. 58: Balance Shaft Bushing Remover**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Proper centering of the tool is required on the balance shaft bushing. If the tool is not properly centered then damage to the bearing bore and block will occur.

3. Install the **EN-43650** remover (1) into the balance shaft hole. Insert the tool with the foot parallel to the shaft.

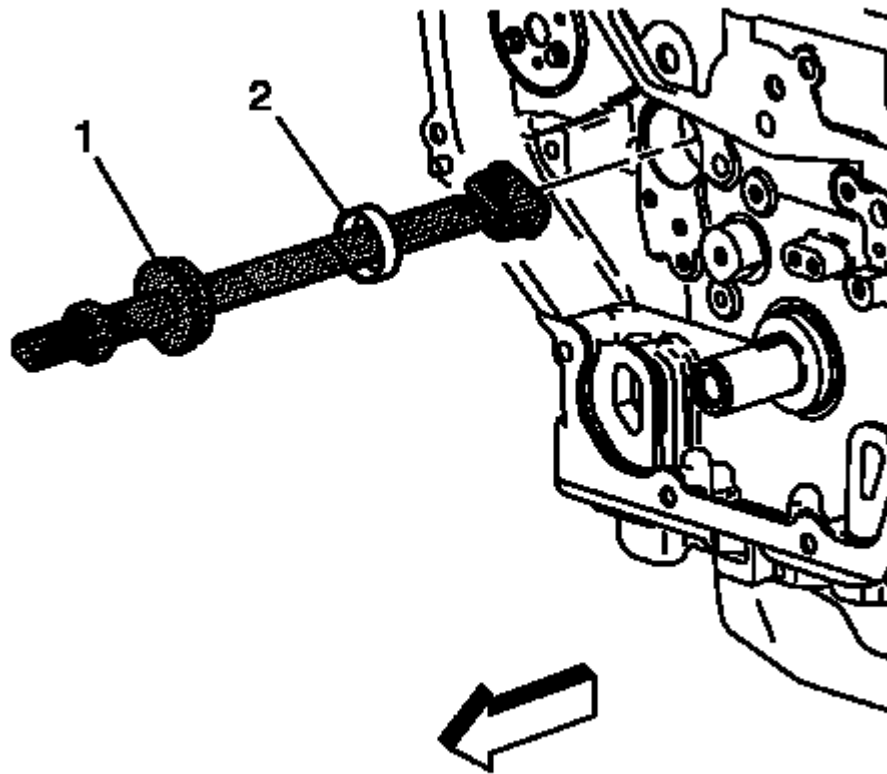


**Fig. 59: Identifying Properly Installed Remover**  
Courtesy of GENERAL MOTORS COMPANY

4. When the **EN-43650** remover (1) is inserted in the block turn the **EN-43650** remover so that the foot becomes perpendicular to the shaft.
5. Center the foot of the **EN-43650** remover on the balance shaft bushing.
6. Once the **EN-43650** remover is centered on the balance shaft bushing, then insert the centering guide into the front balance shaft bore and tighten the nut with an appropriate wrench (2).

When the **EN-43650** remover is properly installed, before removing the bushing, the end of the tool should be 116 mm (4.6 in) (a) from the block face.

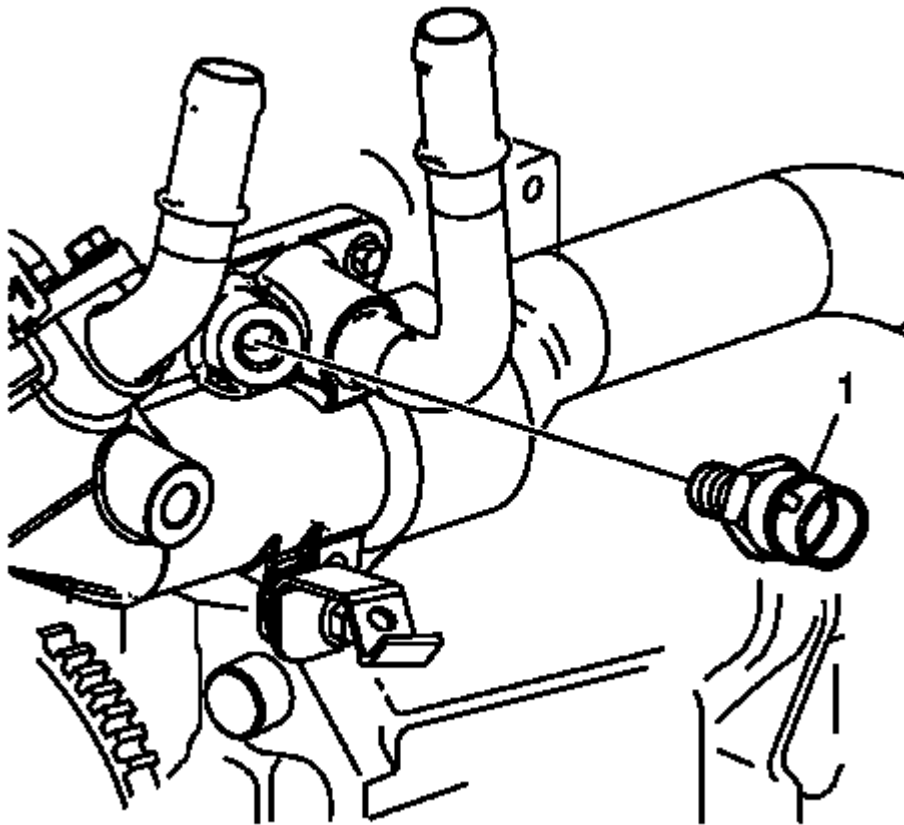
If the **EN-43650** remover is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.



**Fig. 60: Remover & Balance Shaft Bushing**  
 Courtesy of GENERAL MOTORS COMPANY

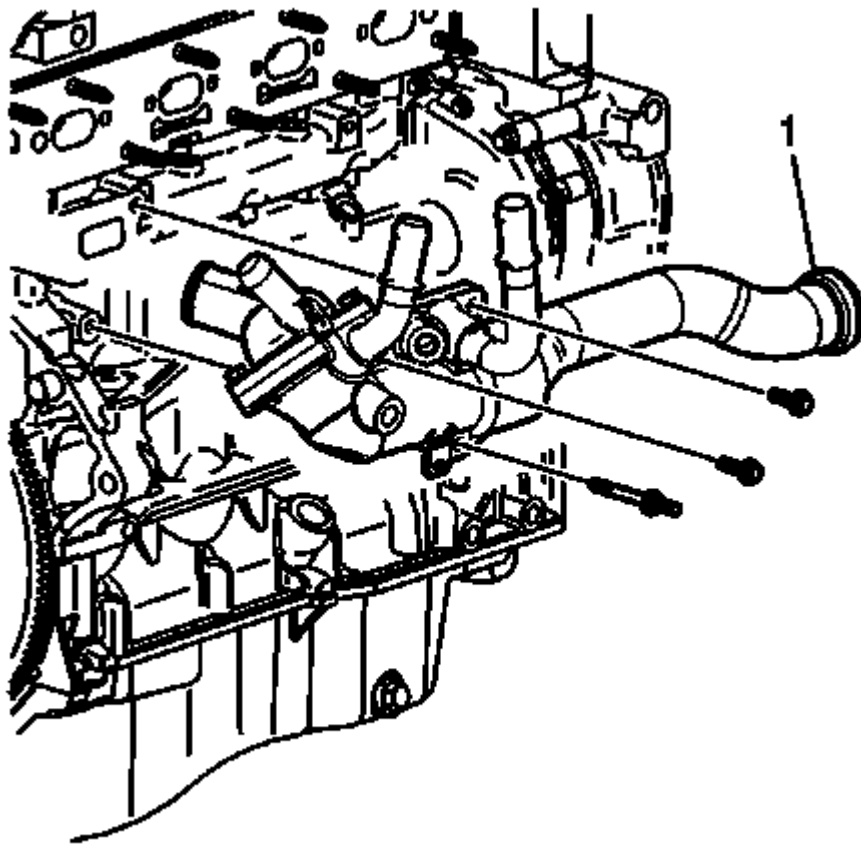
7. Tighten the nut on the **EN-43650** remover (1) until the tension releases. When the tension releases, remove the **EN-43650** remover and the balance shaft bushing (2).

## WATER PUMP REMOVAL



**Fig. 61: Engine Coolant Temperature Sensor**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine coolant temperature sensor (1).

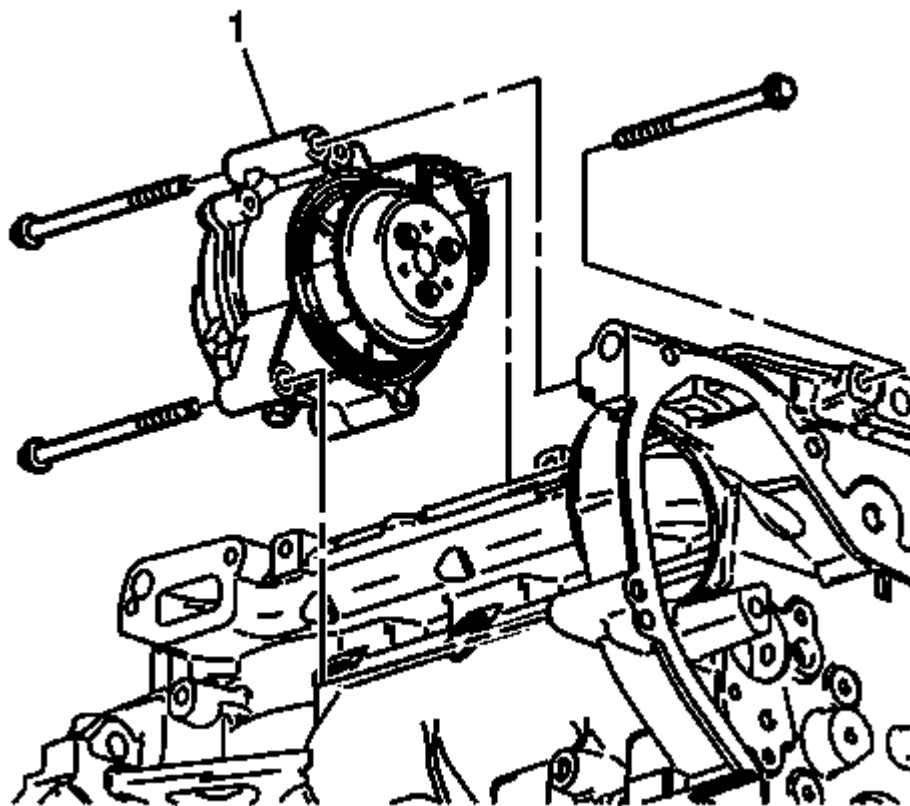


**Fig. 62: Thermostat Housing And Water Feed Pipe & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the thermostat and water feed pipe retaining bolts.

**NOTE:** Twist the water feed pipe while pulling to remove it from the water pump cover.

3. Remove the thermostat housing and water feed pipe (1) from the water pump cover.



**Fig. 63: Water Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

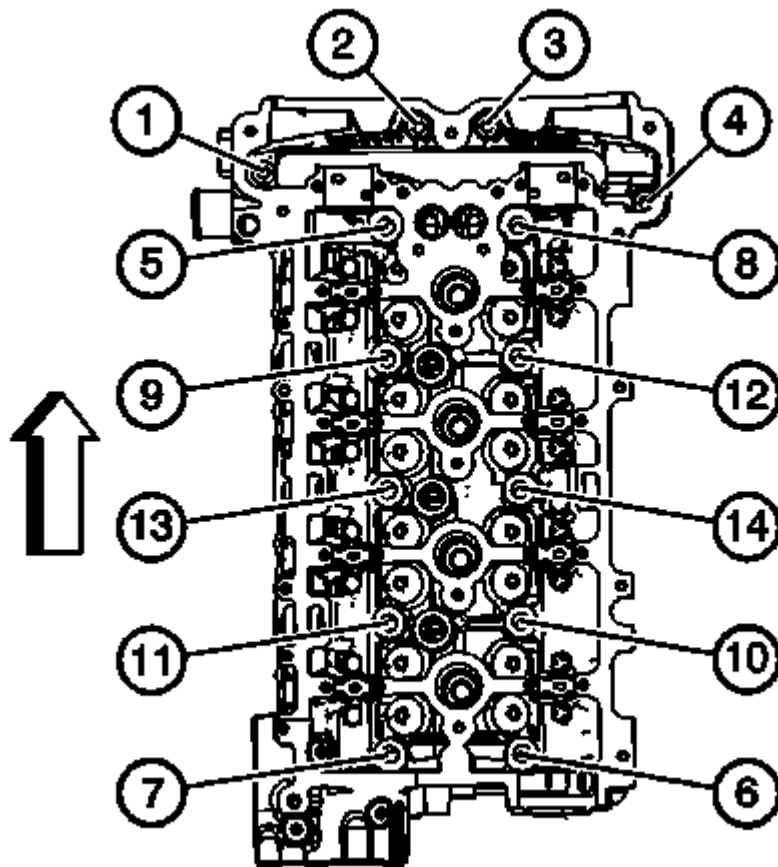
4. Remove the water pump retaining bolts. Be sure to remove the bolt that goes through the front of the engine block.
5. Remove the water pump assembly (1).

## **CYLINDER HEAD REMOVAL (2.4L LEA)**

### **Special Tools**

**EN 38188** Cylinder Head Broken Bolt Extractor Kit

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

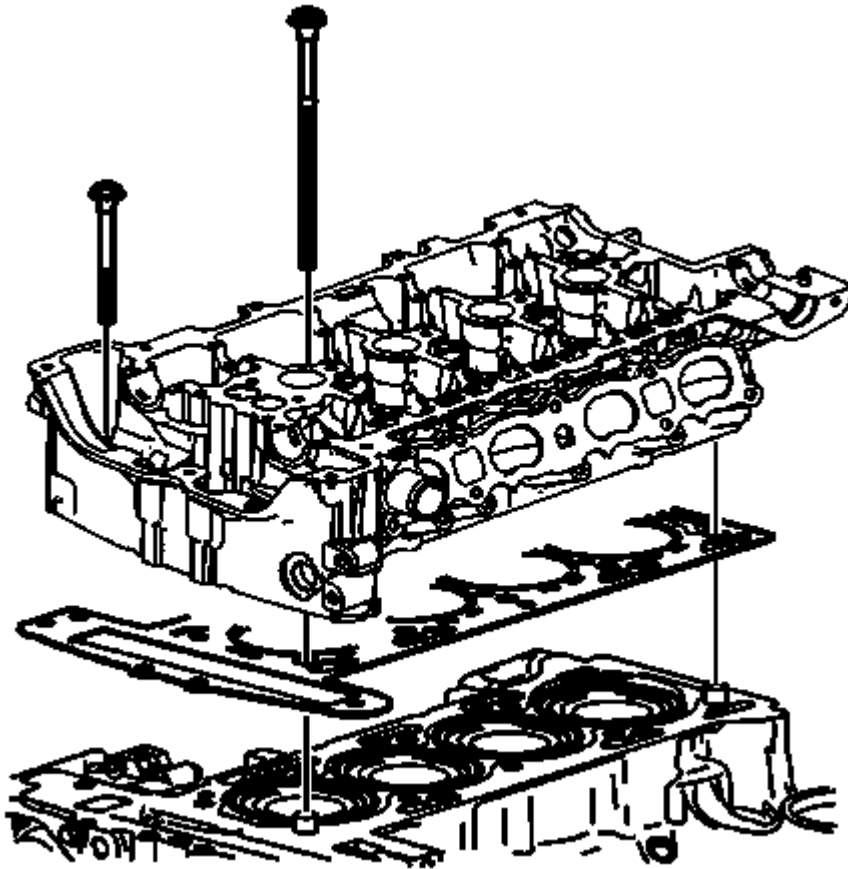


**Fig. 64: Cylinder Head-To-Block Bolt Removal Sequence**  
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the cylinder head to the block bolts in sequence.

Discard the bolts.





**Fig. 65: Cylinder Head**

Courtesy of GENERAL MOTORS COMPANY

**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.
3. Remove the cylinder head gasket.
4. Clean all of the gasket surfaces.
5. 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.

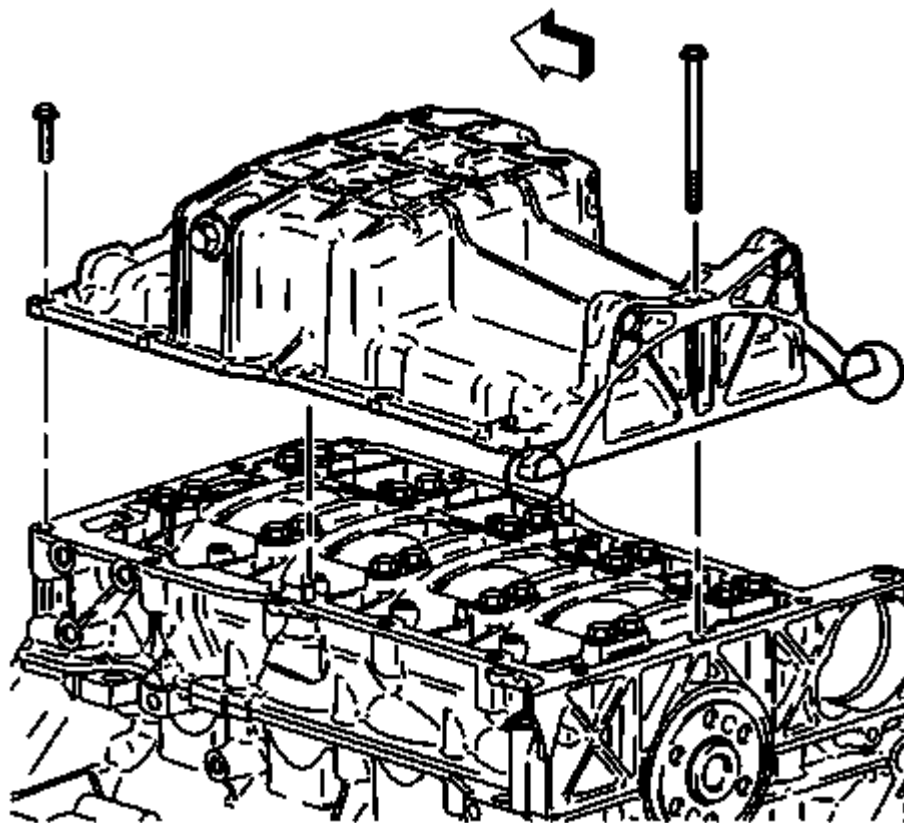
**NOTE:** Do not use a tap to clean the cylinder head bolt holes.

6. Clean the old sealer/lube and dirt from the bolt holes.
7. 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.

8. 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.
9. Remove any broken long cylinder head bolts using the **EN 38188** kit.

## **OIL PAN REMOVAL**



**Fig. 66: View Of Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

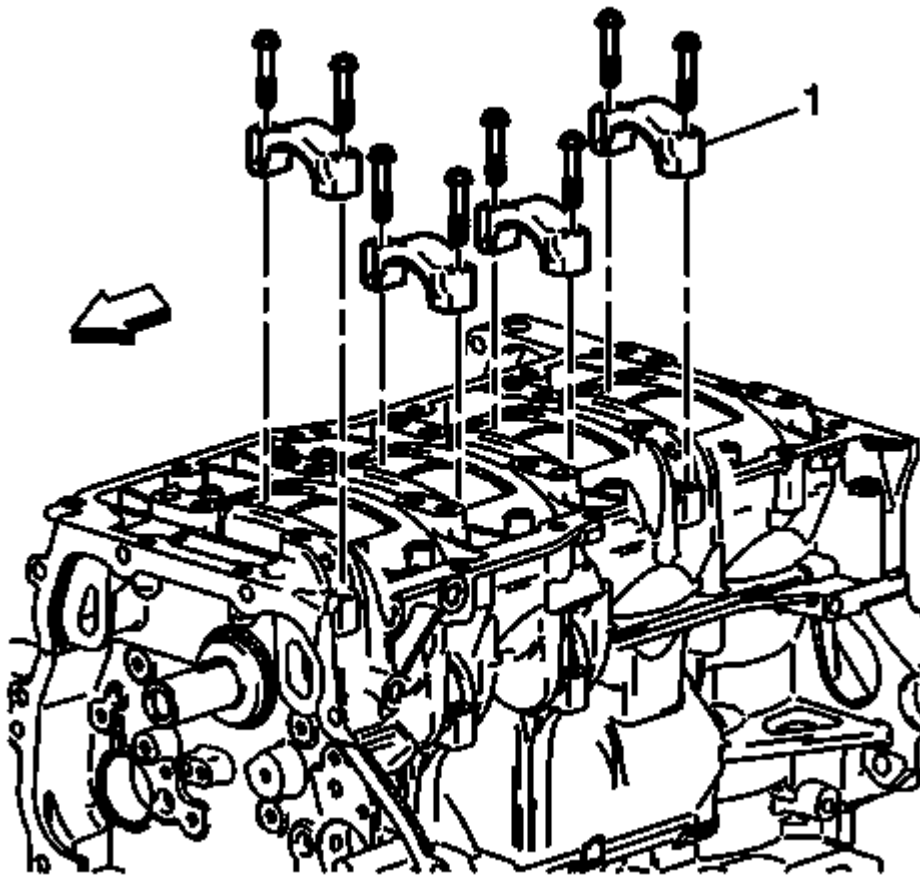
1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

## **PISTON, CONNECTING ROD, AND BEARING REMOVAL**

### **Special Tools**

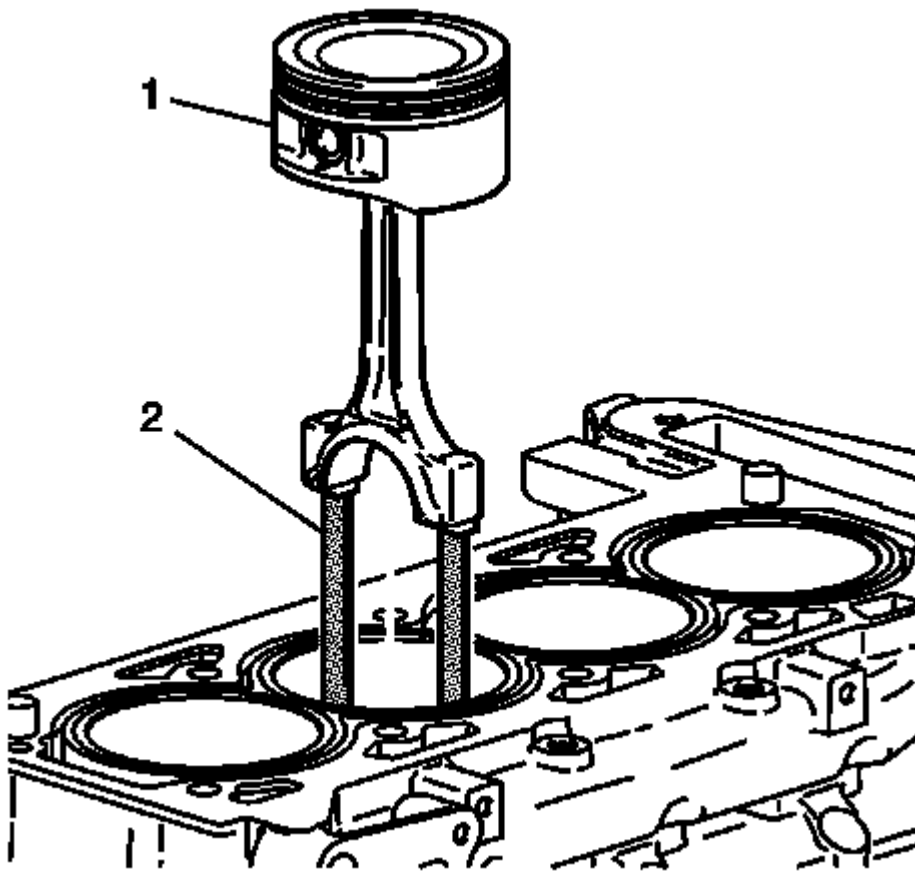
**EN-43966-1** Connecting Rod Guides

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



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

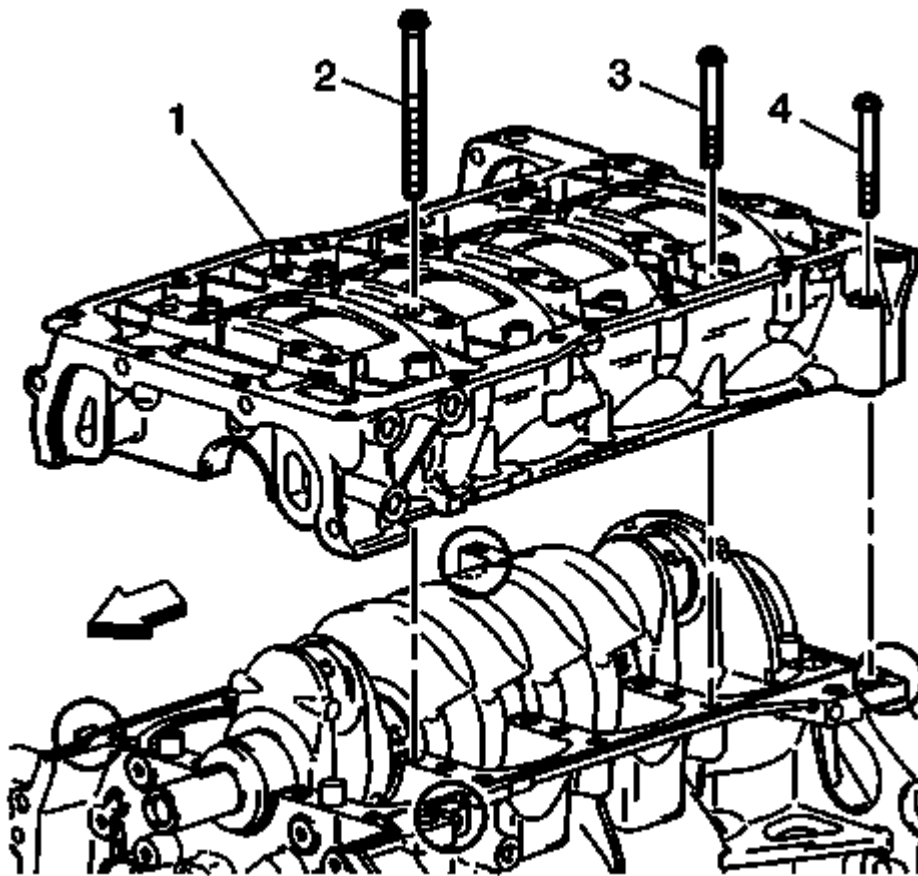
1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder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



**Fig. 68: View Of Connecting Rod Guides**  
Courtesy of GENERAL MOTORS COMPANY

6. Install **EN-43966-1** guides (2) on the connecting rod bolts before removing the piston and connecting rod assembly.
7. Remove the piston and connecting rod assembly (1).

## **LOWER CRANKCASE REMOVAL**



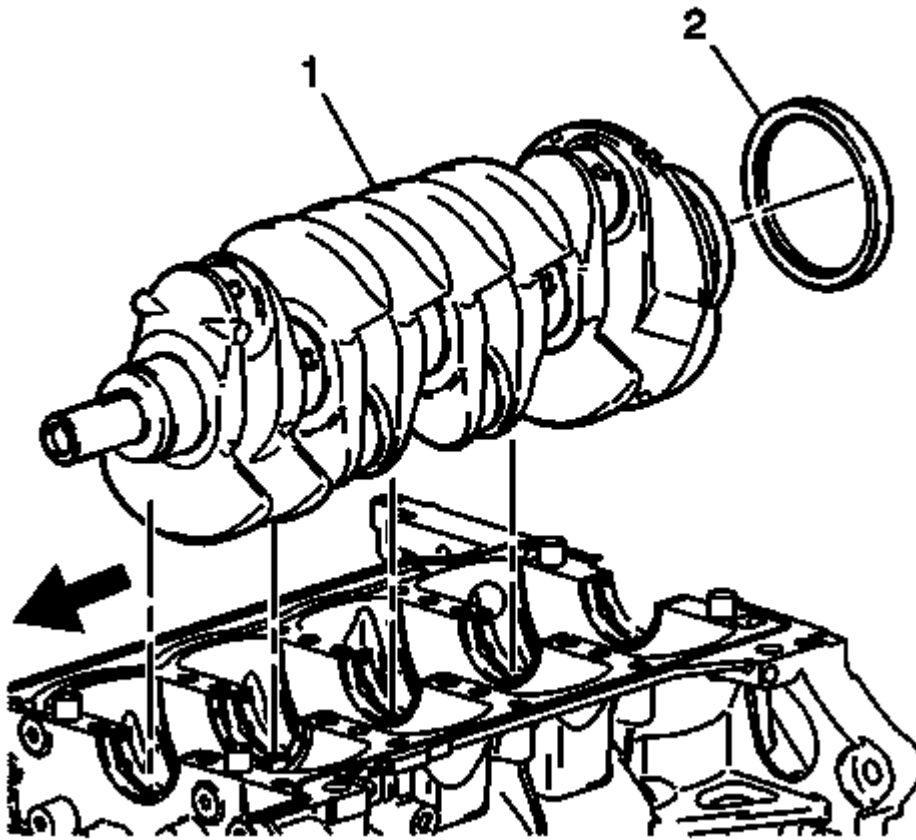
**Fig. 69: Upper And Lower Crankcase With Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the bedplate perimeter bolts (3).

**NOTE:** Do not forget the 2 outside rear bolts (4).

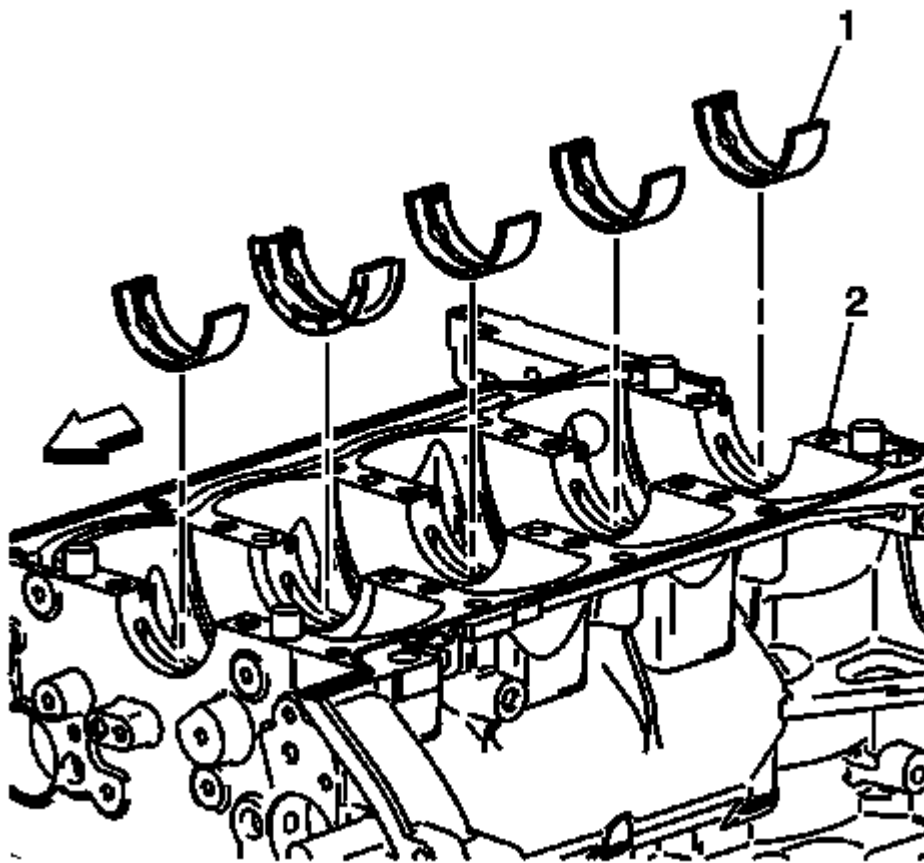
2. Remove and discard the crankshaft bearing bolts (2).
3. Using the pry-points and an appropriate prying tool, gently separate the upper and lower crankcase (1).

## CRANKSHAFT AND BEARING REMOVAL



**Fig. 70: Crankshaft And Rear Oil Seal**  
Courtesy of GENERAL MOTORS COMPANY

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

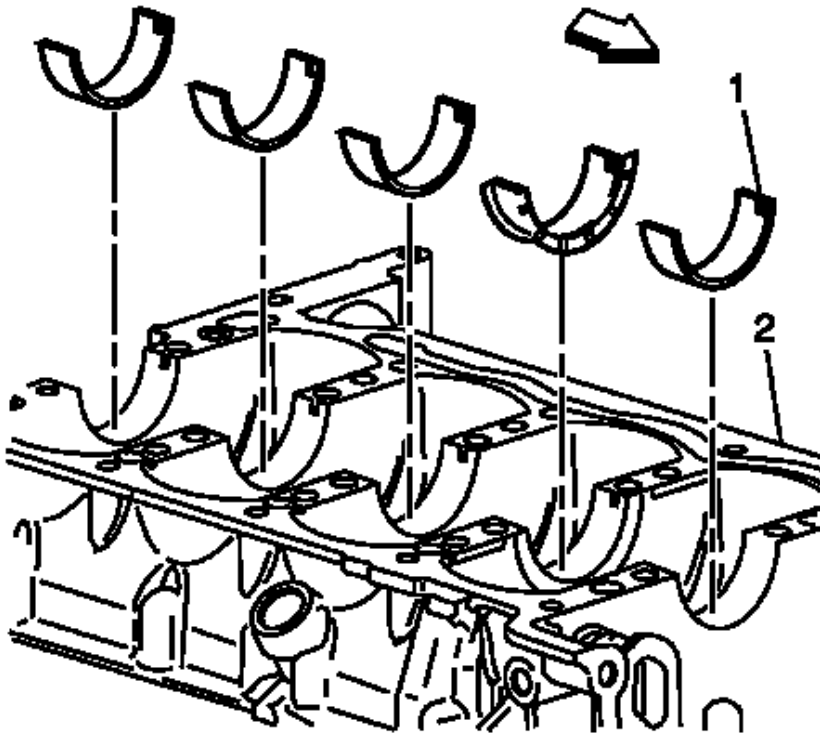


**Fig. 71: View of Upper Crankshaft Bearings**  
Courtesy of GENERAL MOTORS COMPANY

**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 bearing inserts (1) from the block (2).





**Fig. 72: View of Lower Bearing Halves**  
Courtesy of GENERAL MOTORS COMPANY

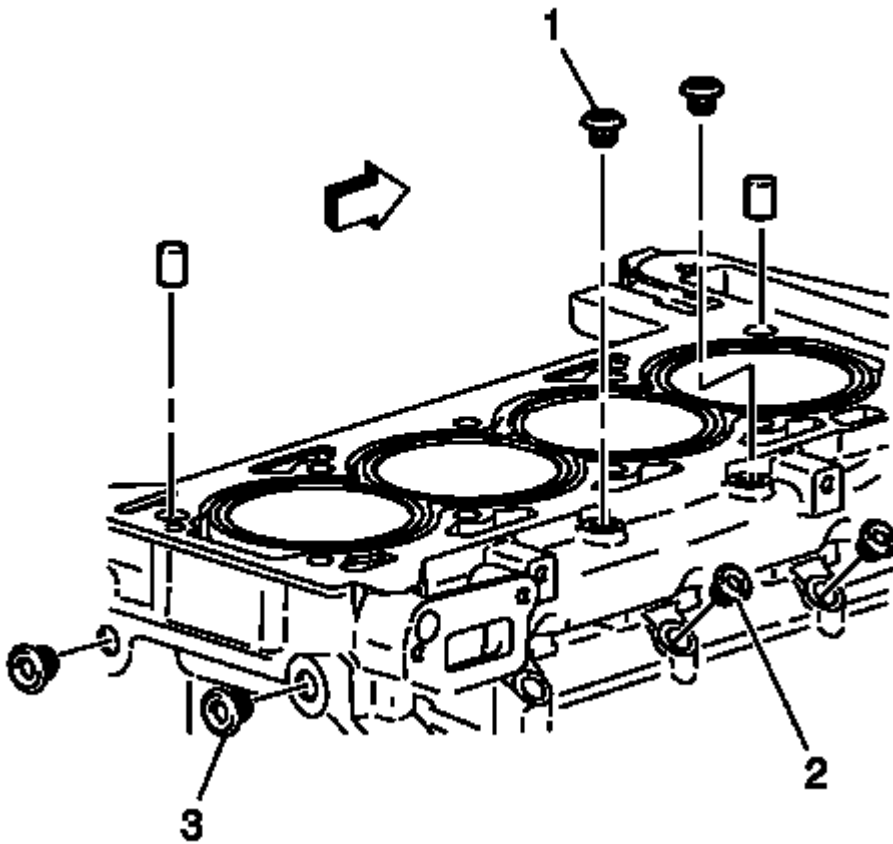
4. Remove the bearing inserts (1) from the bed plate (2).
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
  - Cracks
  - Chips
  - Gouges
  - Roughness
  - 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.

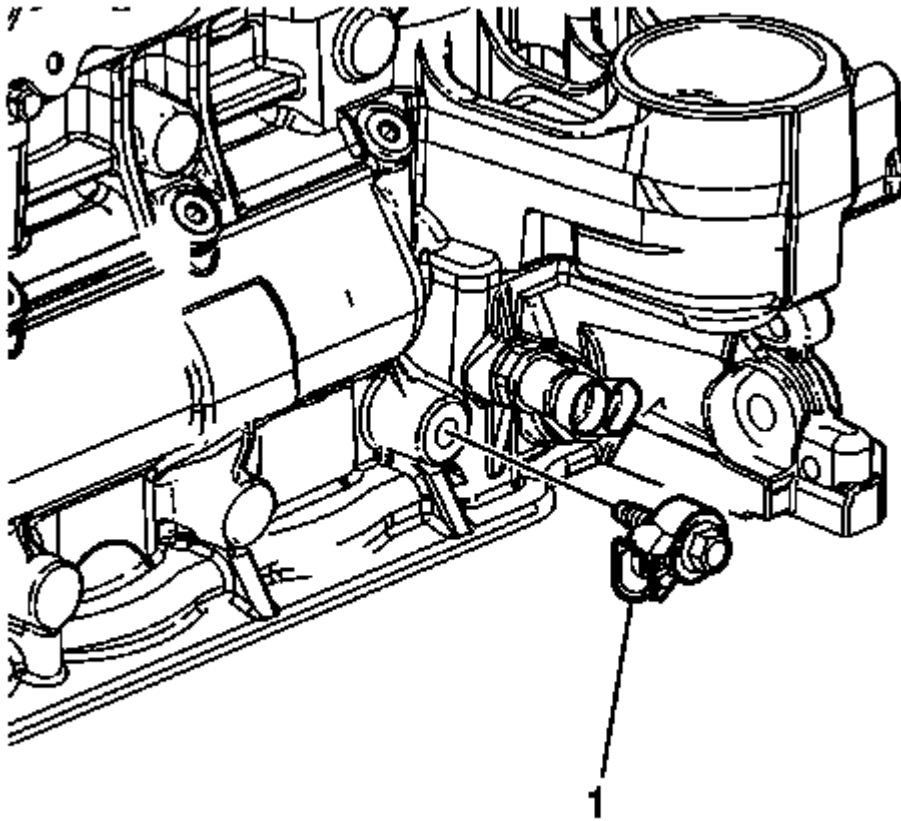
## ENGINE BLOCK DISASSEMBLE



**Fig. 73: Locating Block Plugs**

Courtesy of GENERAL MOTORS COMPANY

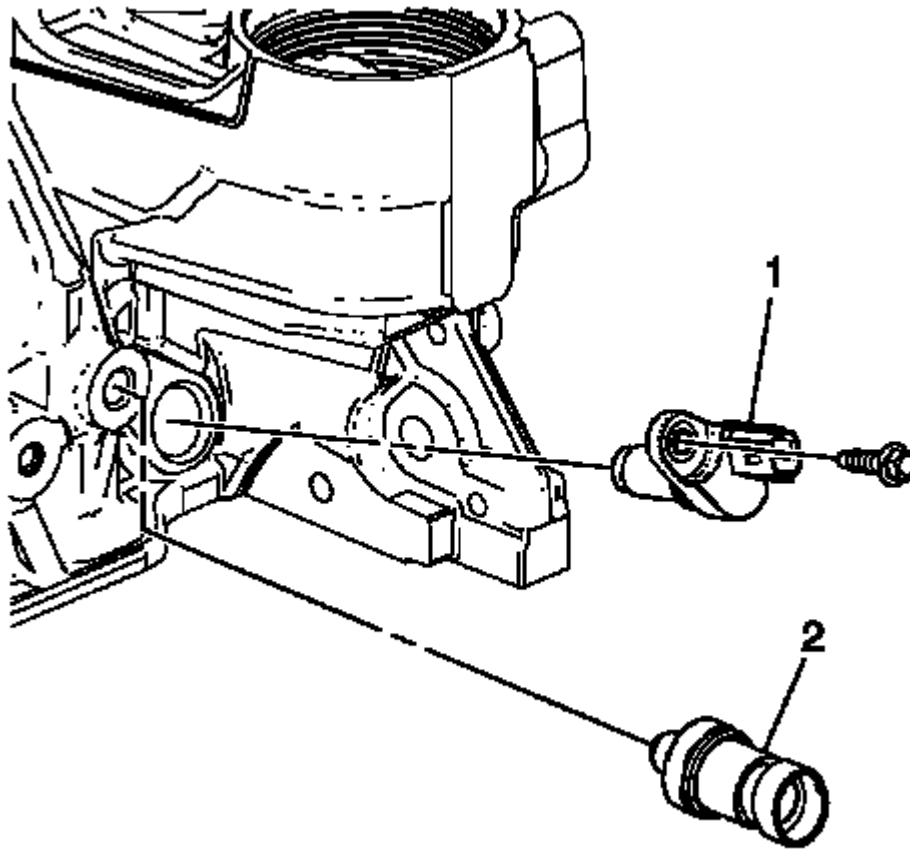
1. Remove the engine block coolant drain plug.
2. Remove the oil flow check valve.
3. Remove the rear oil passage plugs (3).
4. Remove the 3 oil passage plugs on each side of the block (2).
5. Remove the 2 water passage plugs on the top of the block (1).
6. Remove the 2 front oil passage plugs.



**Fig. 74: Knock Sensor**

**Courtesy of GENERAL MOTORS COMPANY**

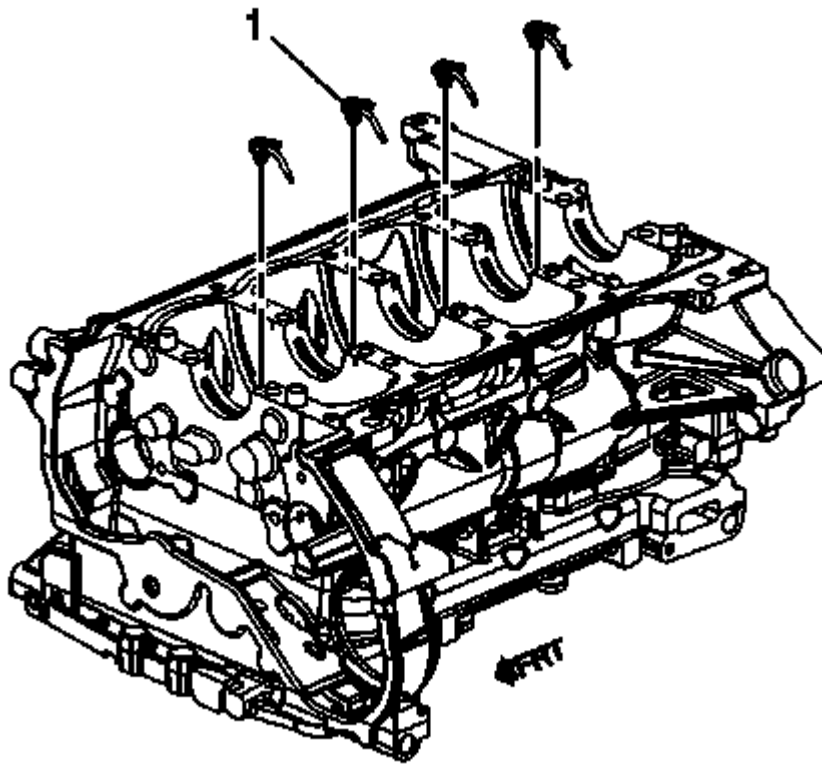
7. Remove the knock sensor (1) and bolt.



**Fig. 75: Oil Pressure Switch**

**Courtesy of GENERAL MOTORS COMPANY**

8. Remove the oil pressure switch (2).
9. Remove the crankshaft position (CKP) sensor (1) and bolt.



**Fig. 76: Piston Oil Nozzle Assembly**

Courtesy of GENERAL MOTORS COMPANY

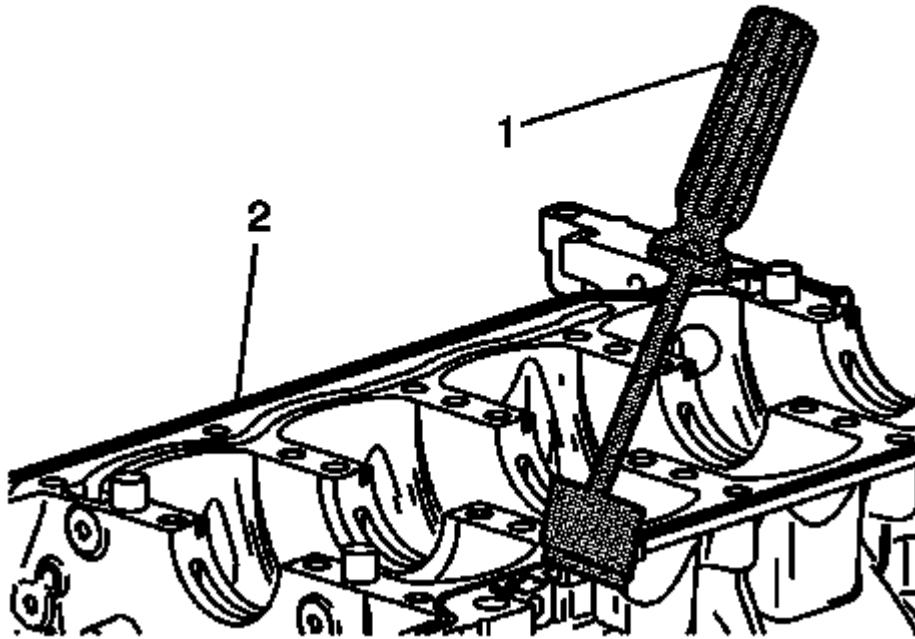
10. If equipped, loosen the piston oil nozzle assembly (1) bolt and remove the piston oil nozzle assembly.

## **ENGINE BLOCK CLEANING AND INSPECTION**

### **Special Tools**

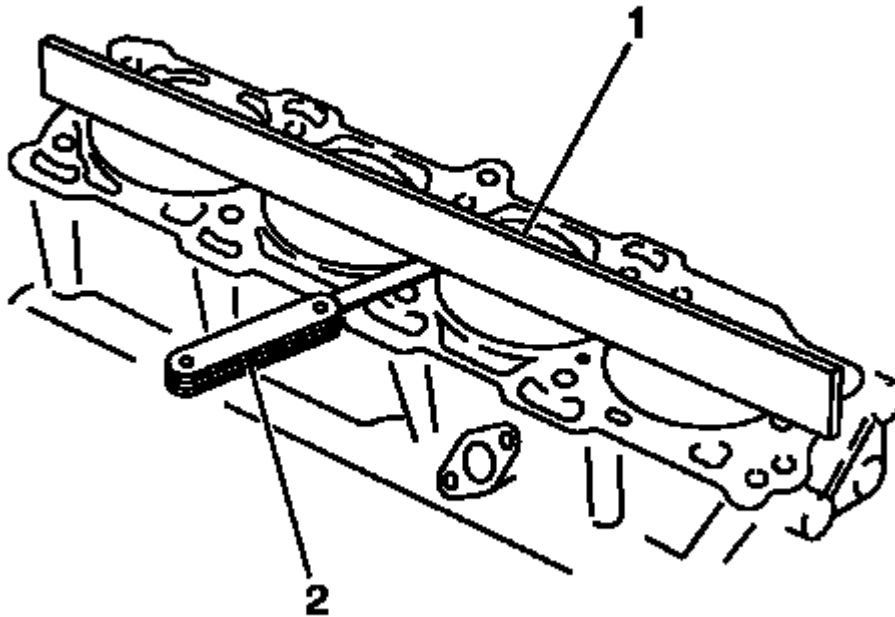
- **EN-8087** Cylinder Bore Gauge
- **GE-7872** Magnetic Base Dial Indicator

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



**Fig. 77: Clean Sealing Material From Gasket Mating Surfaces With A Suitable Tool**  
Courtesy of GENERAL MOTORS COMPANY

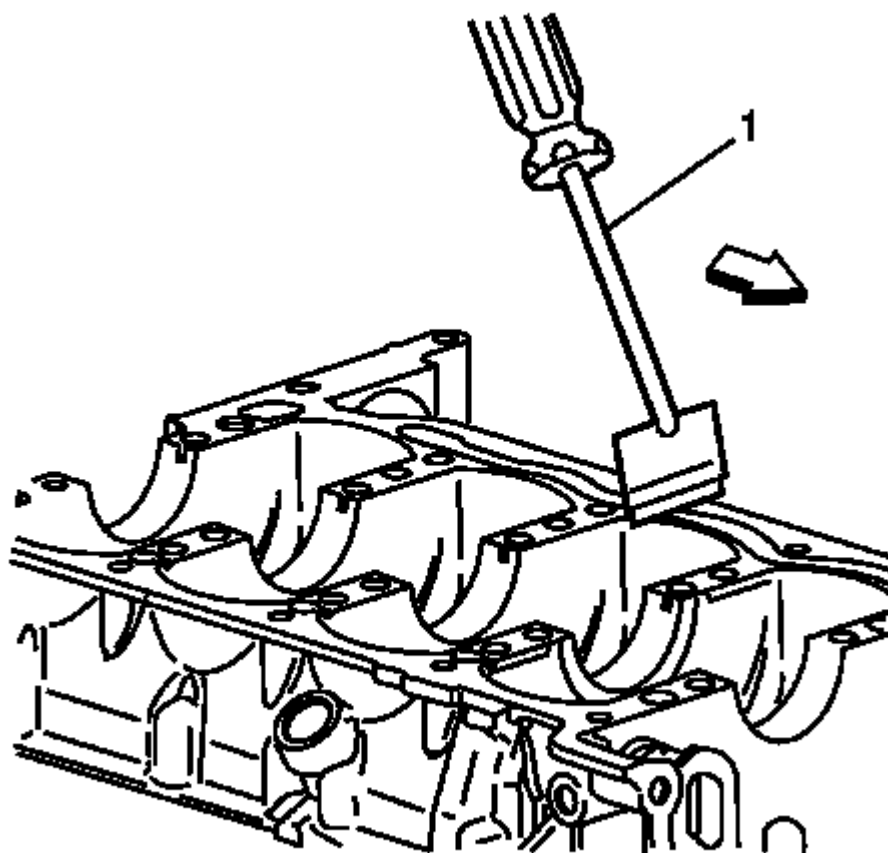
1. Clean the sealing material from the gasket mating surfaces (2) with a suitable tool (1).
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Inspect the cylinder bores for glazing. If the bore is glazed but otherwise serviceable, refer to Deglazing Procedure in **Cylinder Boring and Honing (2.4L LEA)**.
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. 78: Use A Straight Edge And Feeler Gage To Check Deck Surface For Flatness**  
 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.

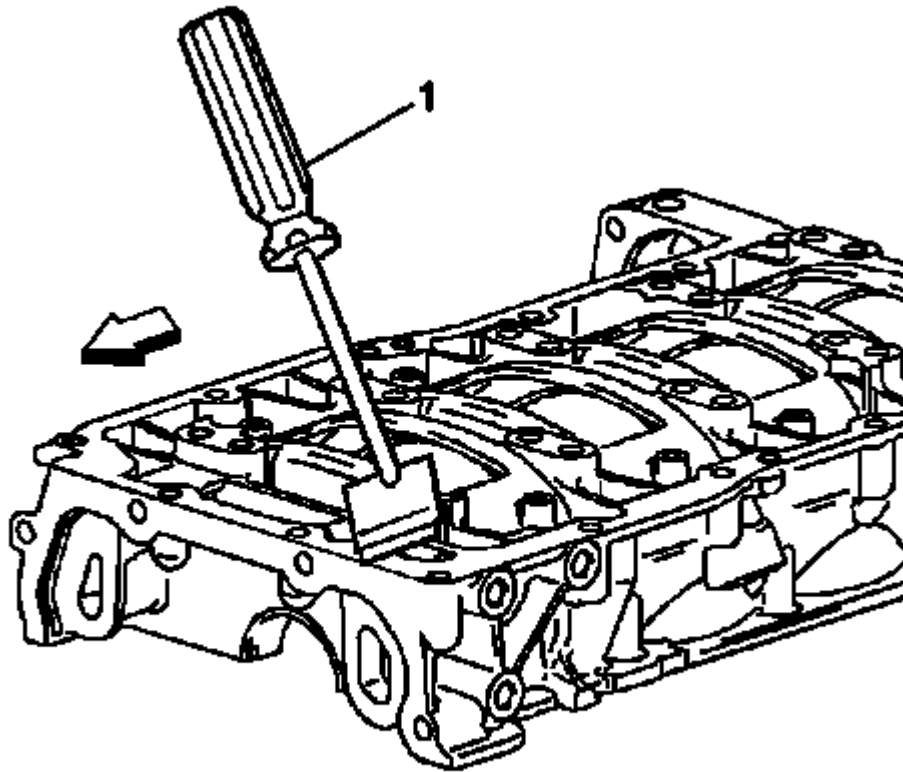


**Fig. 79: Clean Sealing Material From Gasket Mating Surfaces On Lower Crankcase Engine Block Side With Suitable Tool**

Courtesy of GENERAL MOTORS COMPANY

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side with a suitable tool (1).

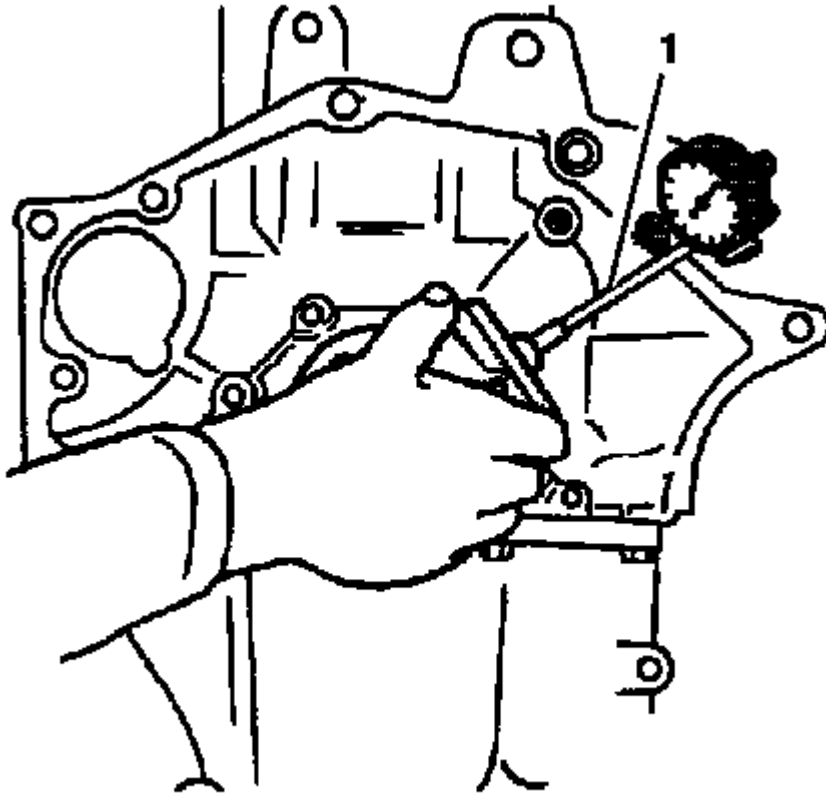




**Fig. 80: Clean Sealing Material From Gasket Mating Surfaces On Lower Crankcase Oil Pan Side With Suitable Tool**

**Courtesy of GENERAL MOTORS COMPANY**

12. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side with a suitable tool (1).



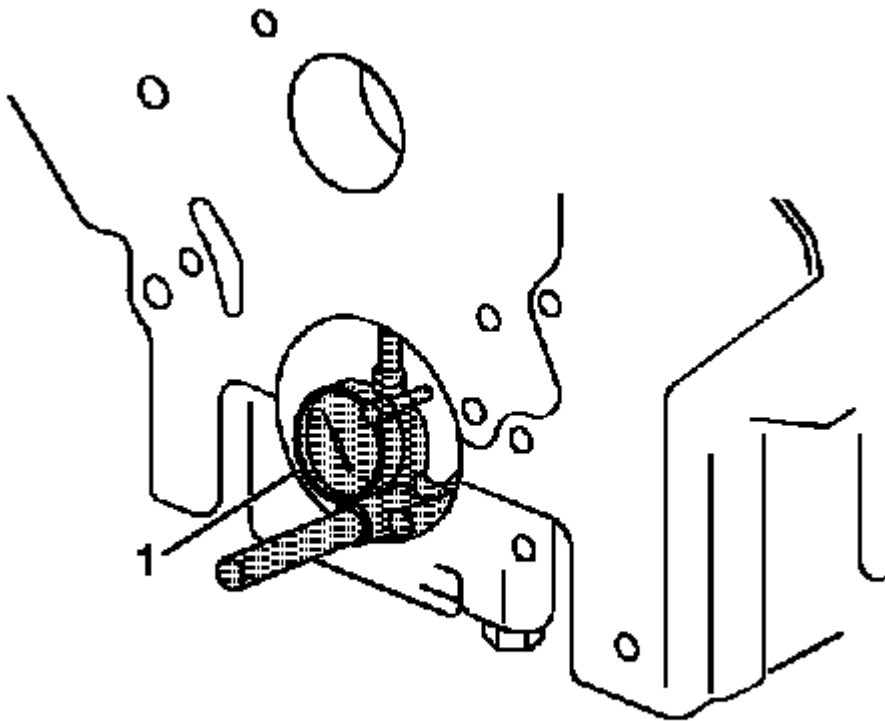
**Fig. 81: Inspect The Mating Surfaces Of The Transmission Face**

Courtesy of GENERAL MOTORS COMPANY

13. Inspect the mating surfaces of the transmission face.

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

14. 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.

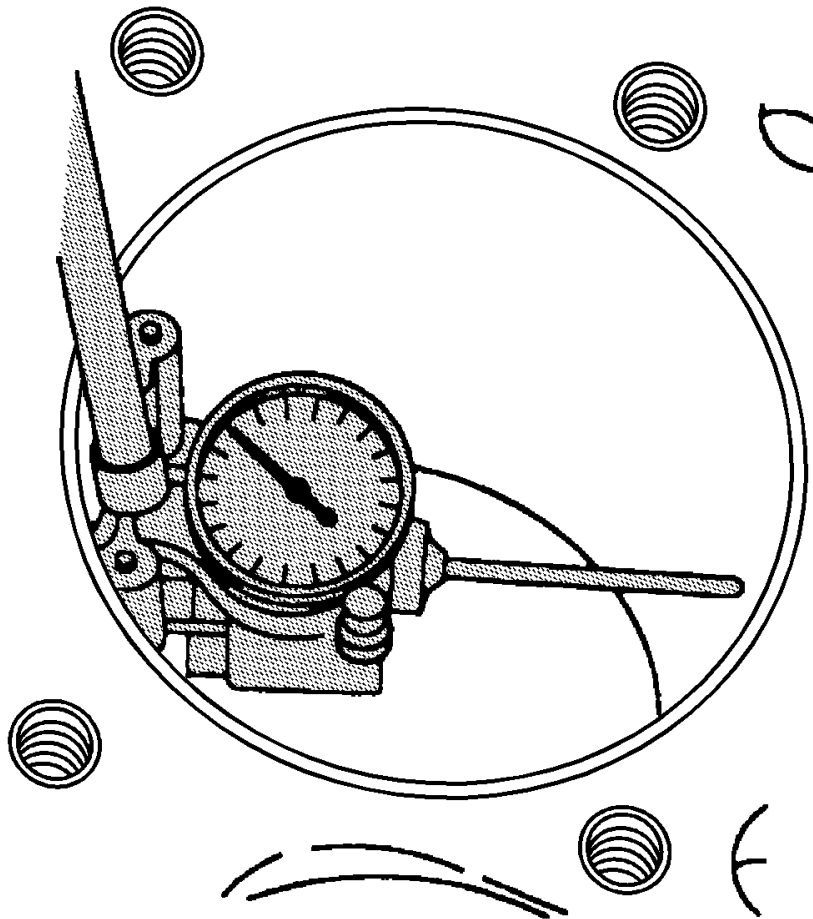


**Fig. 82: Measuring Bearing Bore**

Courtesy of GENERAL MOTORS COMPANY

15. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
16. 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 (2.4L LEA)** .
17. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
18. Remove the bed plate.

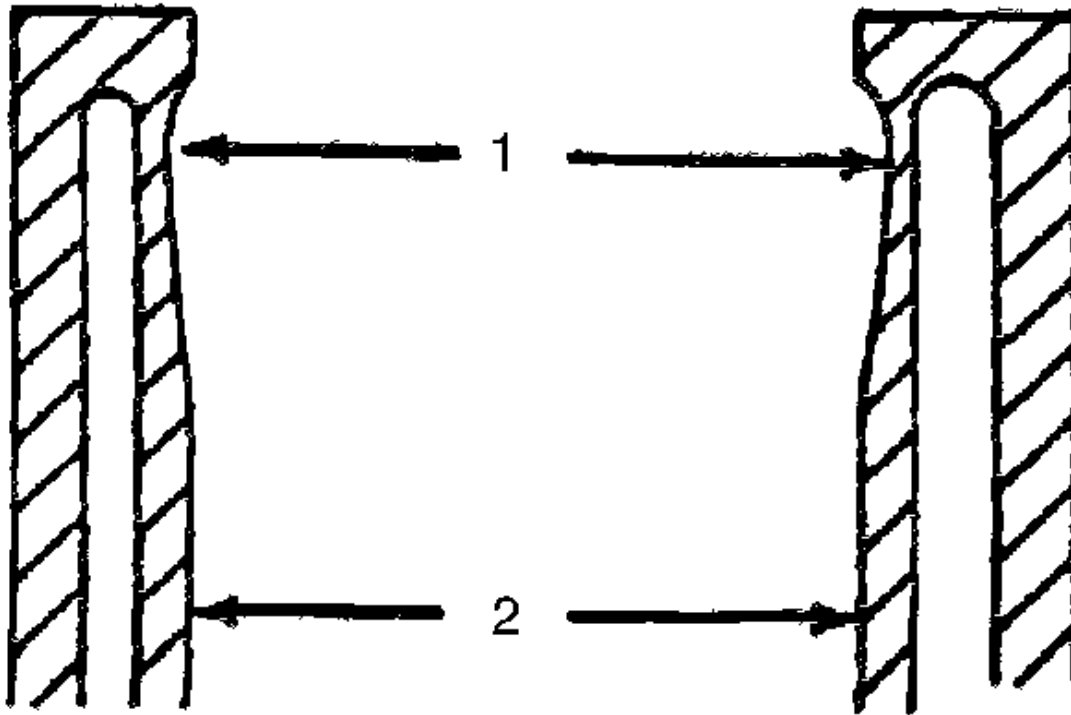
#### Measuring Cylinder Bore Diameter



**Fig. 83: Measuring Cylinder Bore**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN-8087** gauge.
2. Compare your results with the **Engine Mechanical Specifications (2.4L LEA)** , . 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 (2.4L LEA)**.

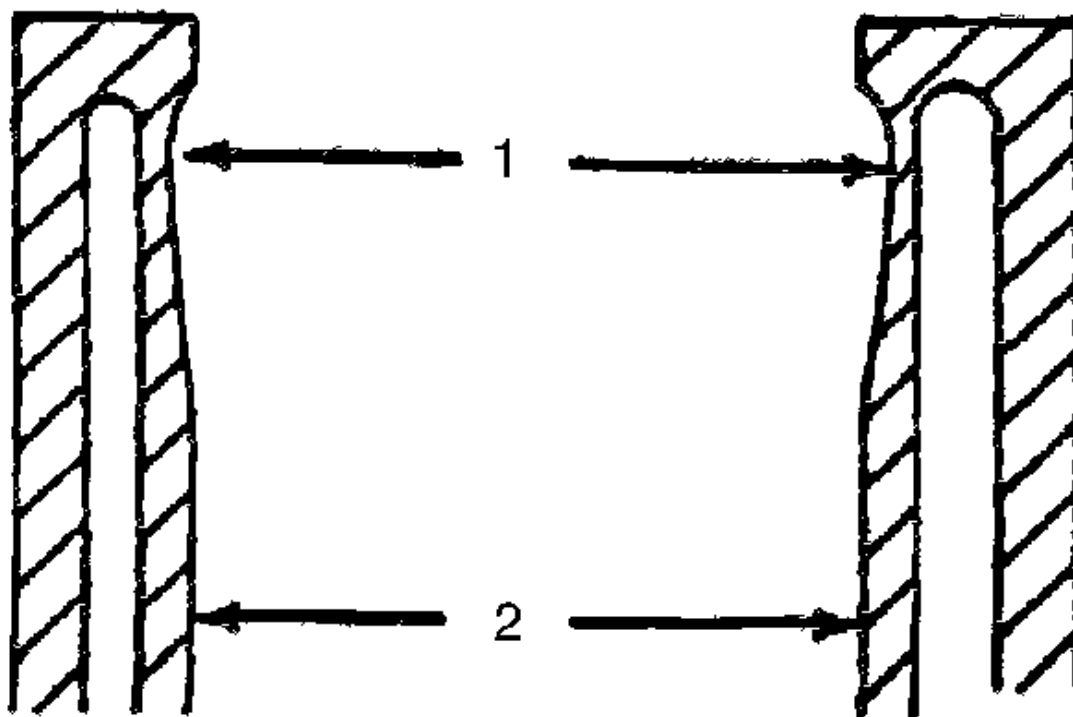
#### Measuring Cylinder Bore Taper



**Fig. 84: Measuring Head Gasket Dimensions**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 13 mm (0.510 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 100 mm (3.938 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 (2.4L LEA)** , . 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 (2.4L LEA)**.

#### Measuring Cylinder Bore Out-of-Round



**Fig. 85: Measuring Head Gasket Dimensions**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure both the thrust and non-thrust cylinder diameter at 13 mm (0.510 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 100 mm (3.938 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 (2.4L LEA)** , . 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 (2.4L LEA)**.

**CYLINDER BORING AND HONING (2.4L LEA)****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 0.03 mm (0.001 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**

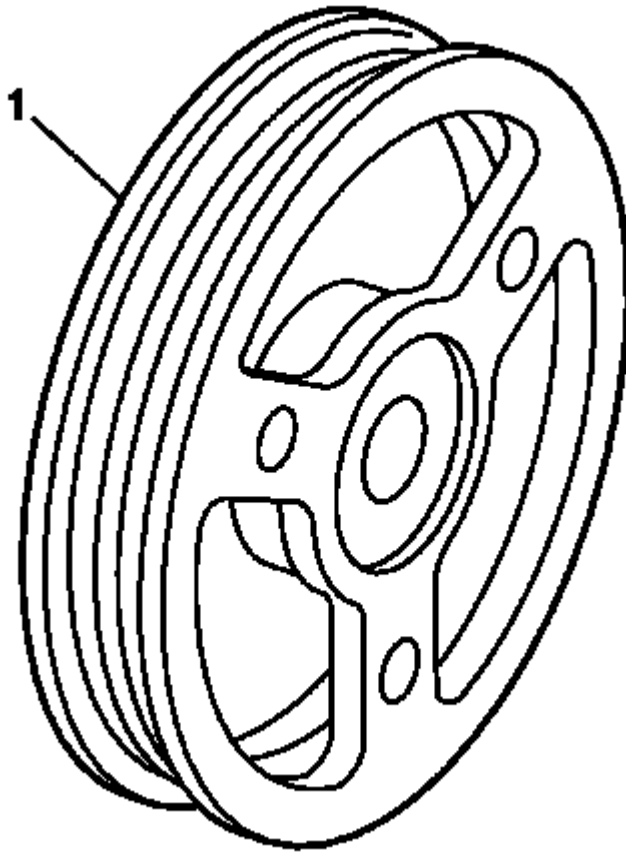
1. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. Refer to **Piston, Connecting Rod, and Bearing Installation (LAF, LAT, LE5, LE9, LEA, or LUK)**.

**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. 86: Crankshaft Balancer**

Courtesy of GENERAL MOTORS COMPANY

1. Clean the crankshaft balancer (1).
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.

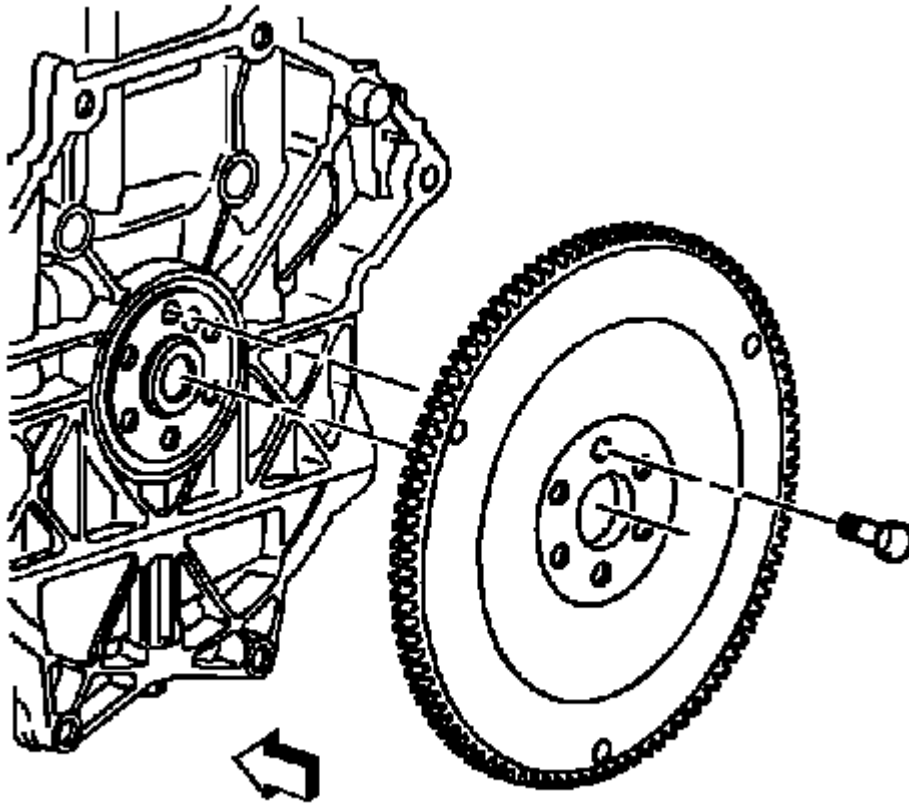
**NOTE:** In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- 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

## ENGINE FLYWHEEL CLEANING AND INSPECTION



**Fig. 87: View Of Flywheel**

Courtesy of GENERAL MOTORS COMPANY

1. Clean the flywheel in solvent.

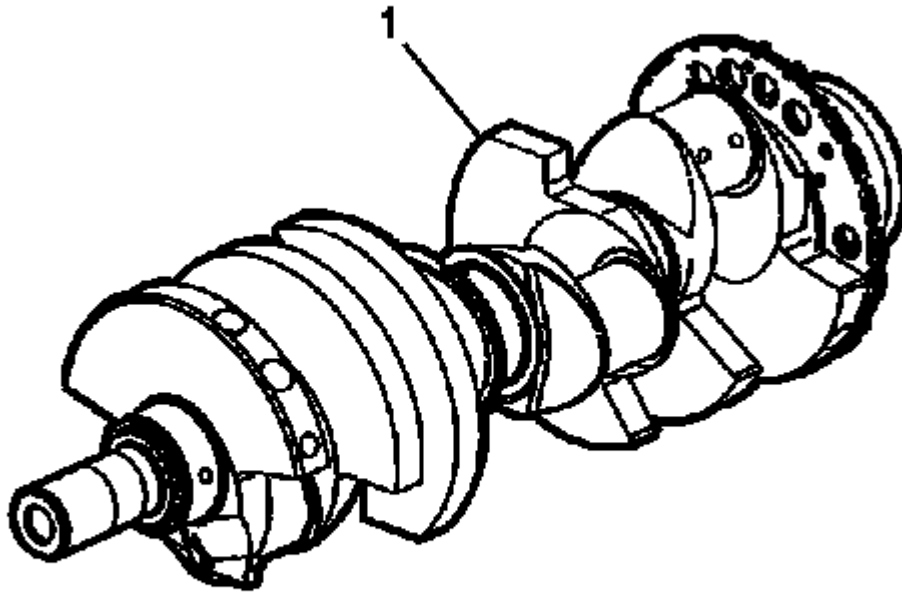
**WARNING:** Refer to Safety Glasses Warning .

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. 88: Clean Crankshaft With Solvent**  
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.

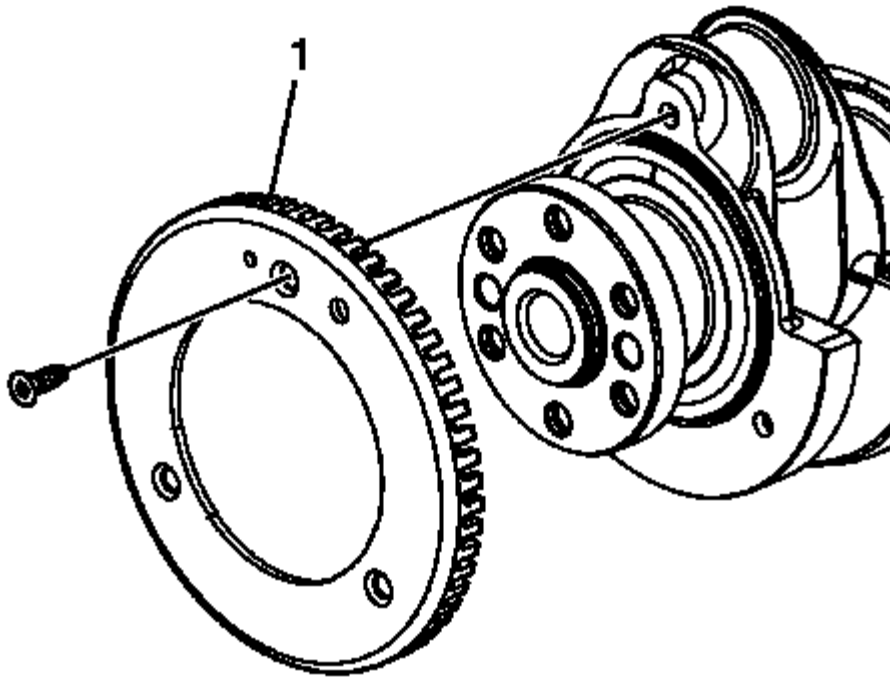
**WARNING:** Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

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

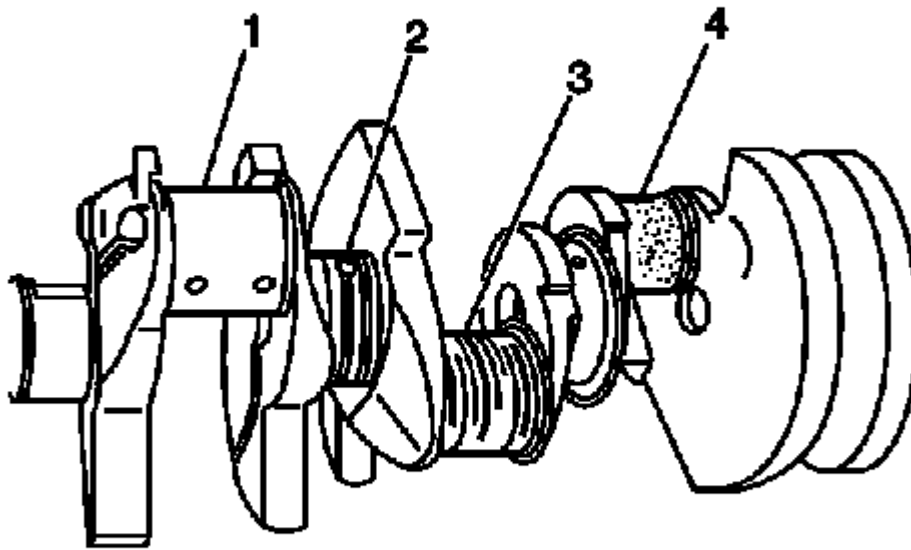
Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.



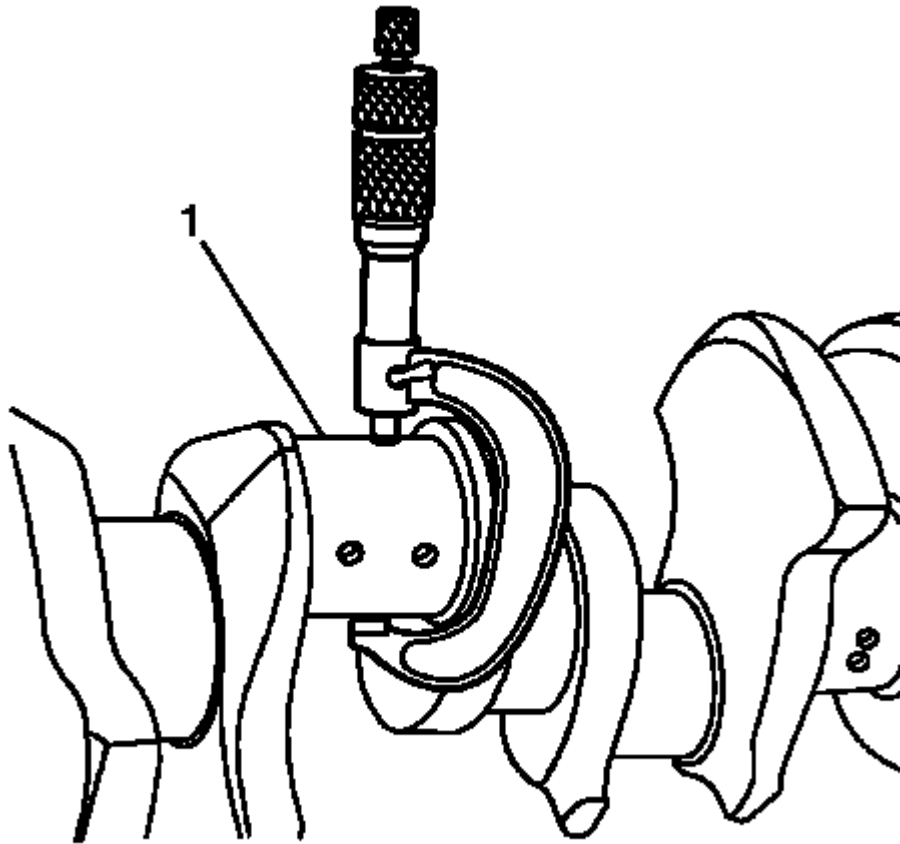
**Fig. 89: View of Crankshaft Position Reluctor Ring**  
Courtesy of GENERAL MOTORS COMPANY

5. The crankshaft position reluctor ring (1) may be replaced if damaged. Tighten the crankshaft position reluctor ring bolts to 15 N.m (11 lb ft).



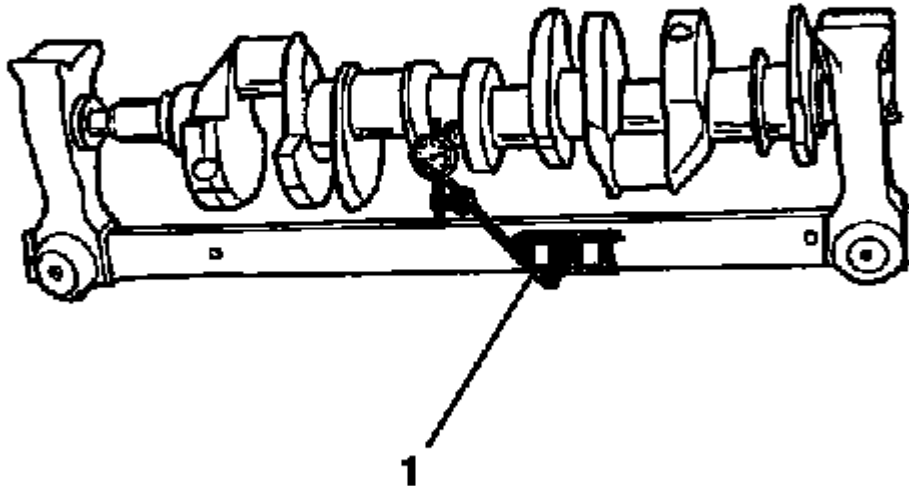
**Fig. 90: Identifying Different Crankshaft Journal Wear Patterns**  
Courtesy of GENERAL MOTORS COMPANY

6. Inspect the crankshaft journals for wear (1). The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring (2).
8. Inspect the crankshaft journals for scratches or wear (3).
9. Inspect the crankshaft journals for pitting or imbedded bearing material (4).



**Fig. 91: Measure Crankshaft Journals For Out-Of-Round**  
Courtesy of GENERAL MOTORS COMPANY

10. Measure the crankshaft journals (1) for out-of-round.
11. Measure the crankshaft journals for taper.

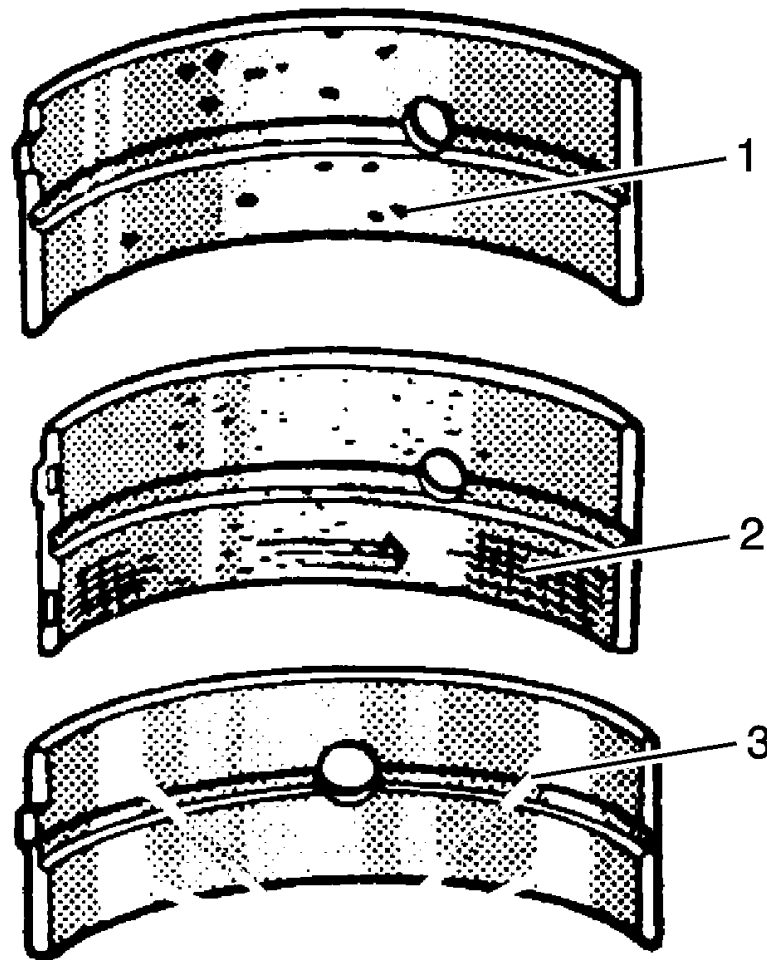


**Fig. 92: Measuring Crankshaft Runout**  
**Courtesy of GENERAL MOTORS COMPANY**

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.

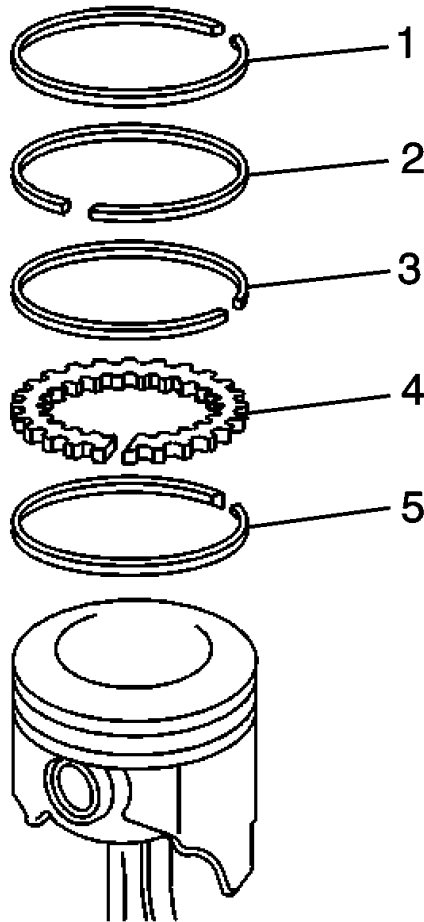


## PISTON AND CONNECTING ROD DISASSEMBLE

### Special Tools

**EN-46745** Piston Pin Retainer Remover and Installer

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

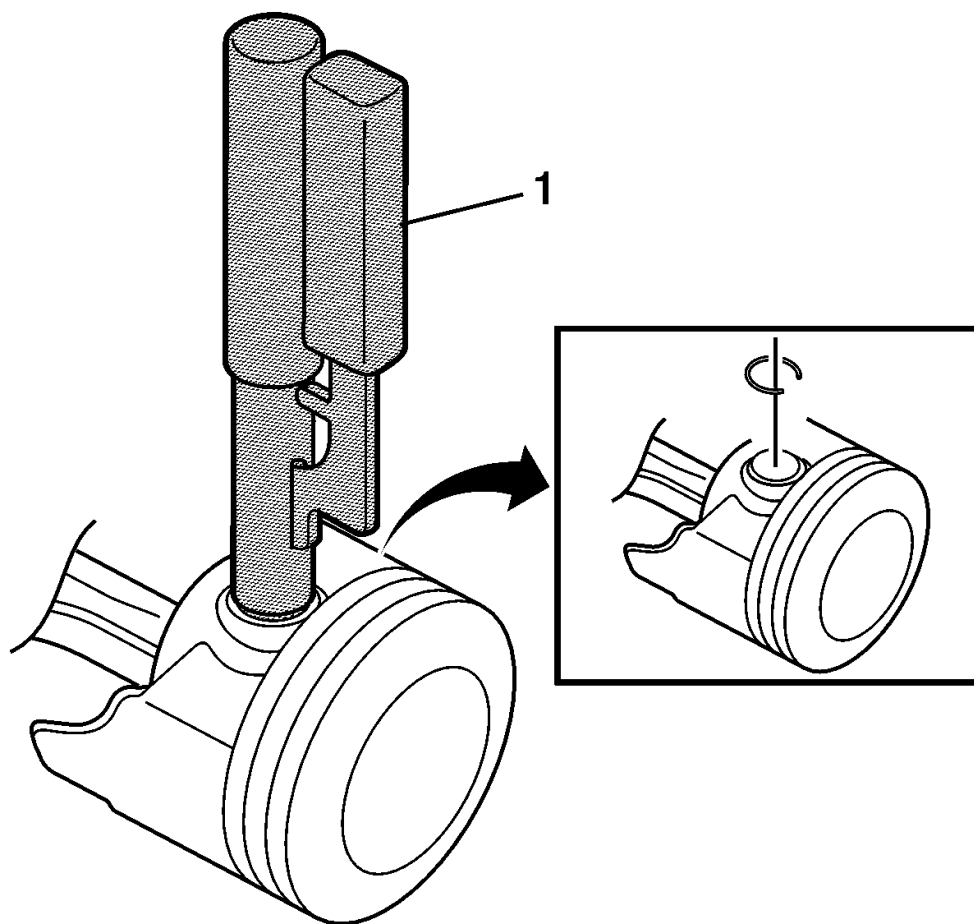


**Fig. 94: Identifying Piston Rings**

Courtesy of GENERAL MOTORS COMPANY

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

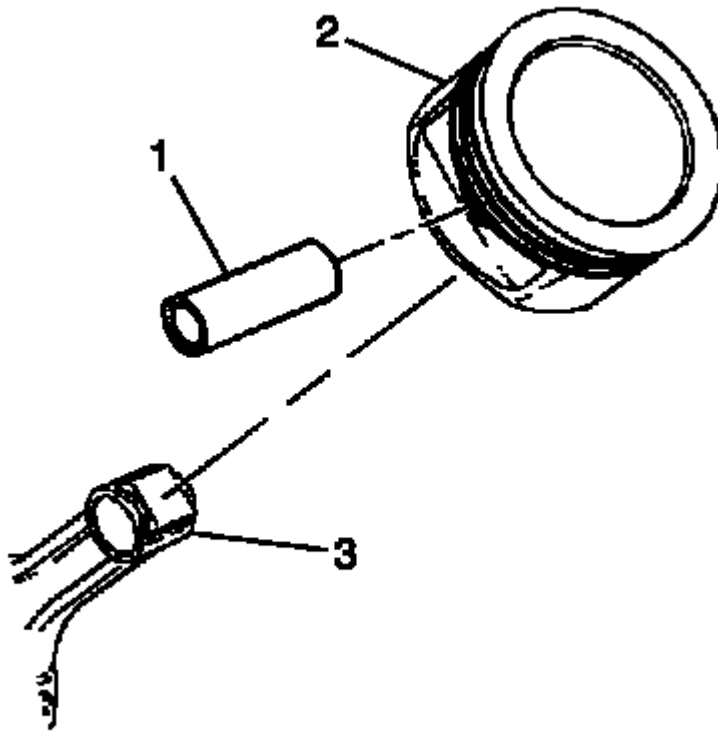
1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.



**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).

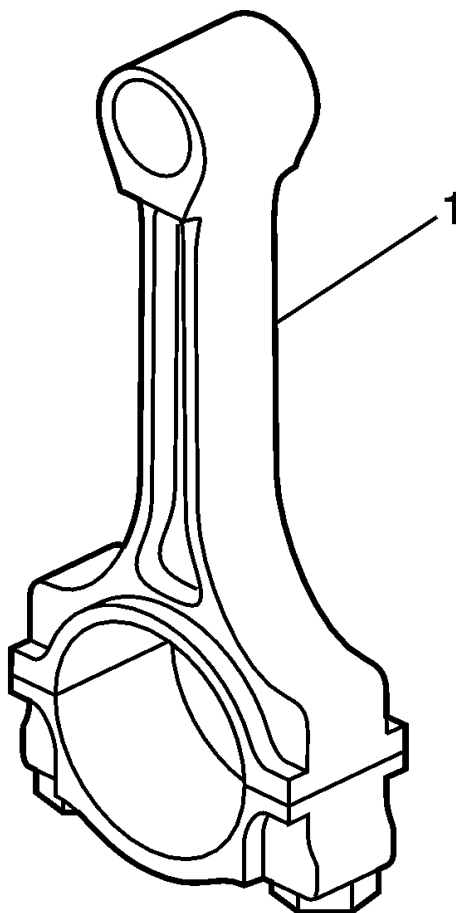


**Fig. 96: Identifying Piston Pin And Connecting Rod**  
Courtesy of GENERAL MOTORS COMPANY

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

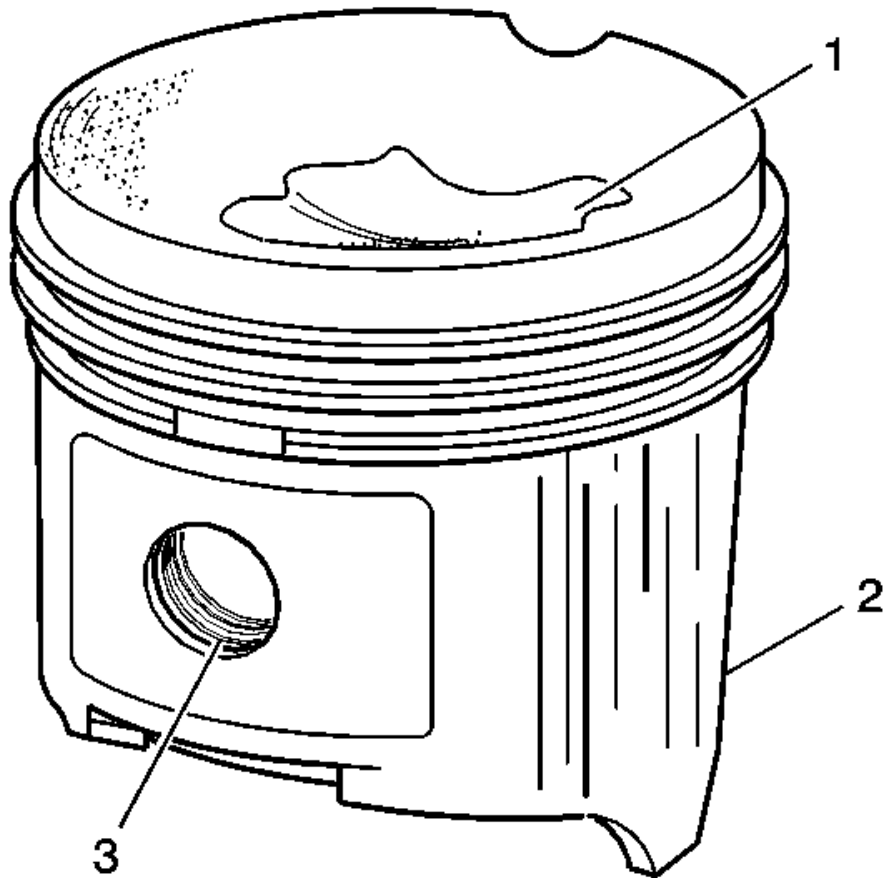
## **PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION**

### **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).

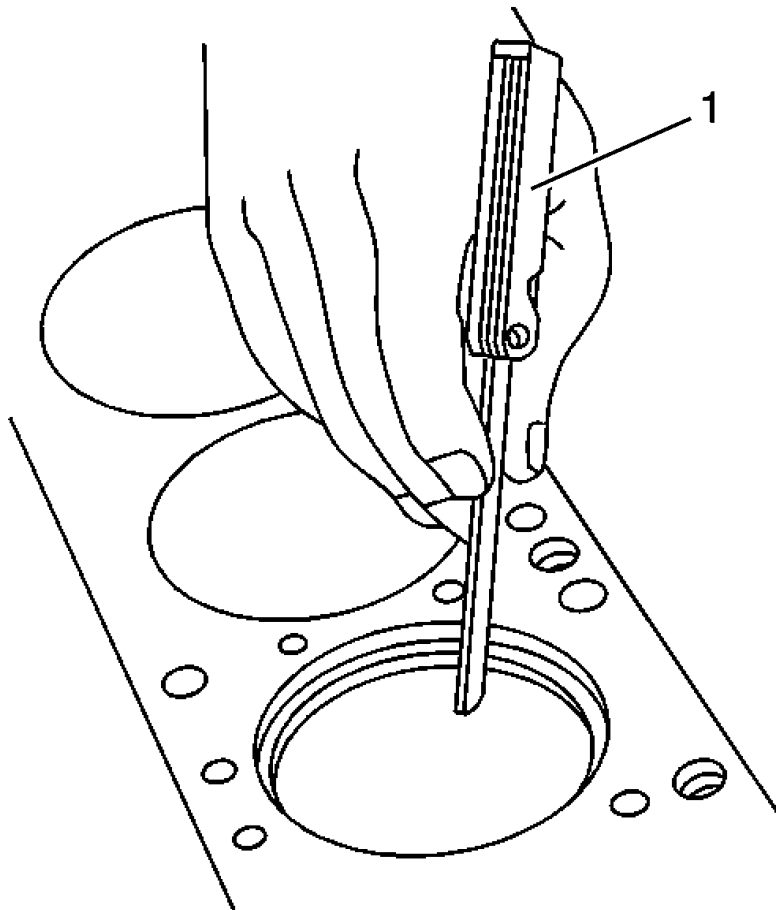
6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

**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.

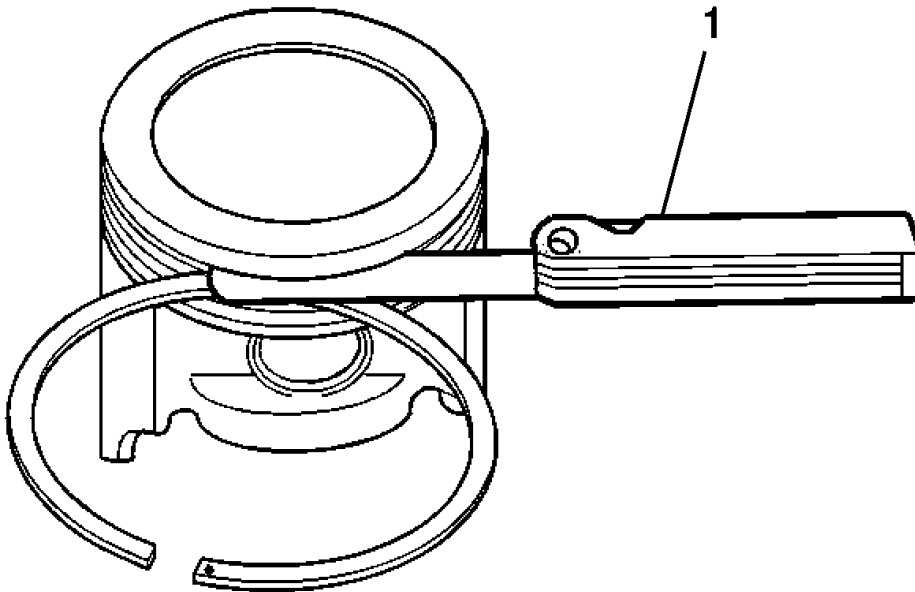


**Fig. 99: Measuring Piston Ring End Gap**  
 Courtesy of GENERAL MOTORS COMPANY

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.

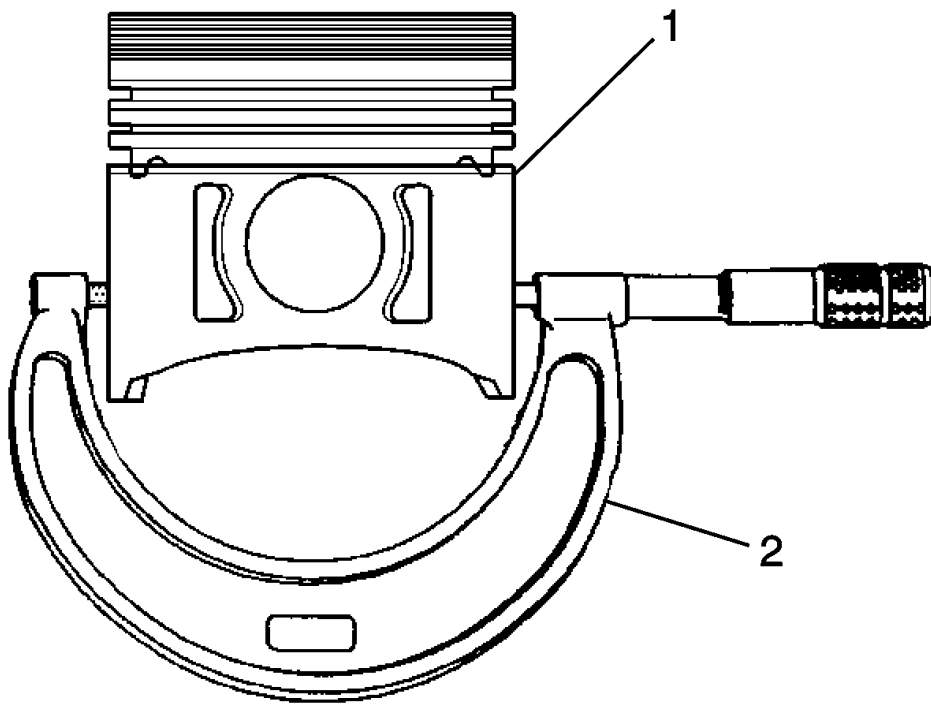
2. Measure the end gap of the piston ring with feeler gauges (1). Compare the measurements with those provided below:
  - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
  - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
  - The oil ring end 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**

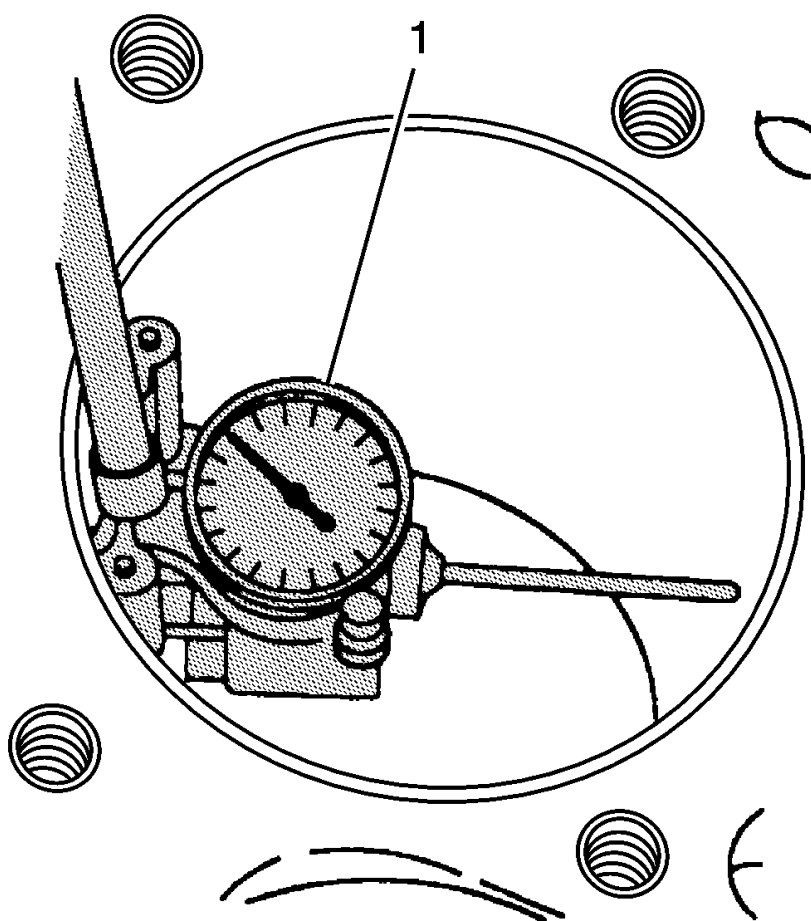
Courtesy of GENERAL MOTORS COMPANY

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 (0.0006-0.0016 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



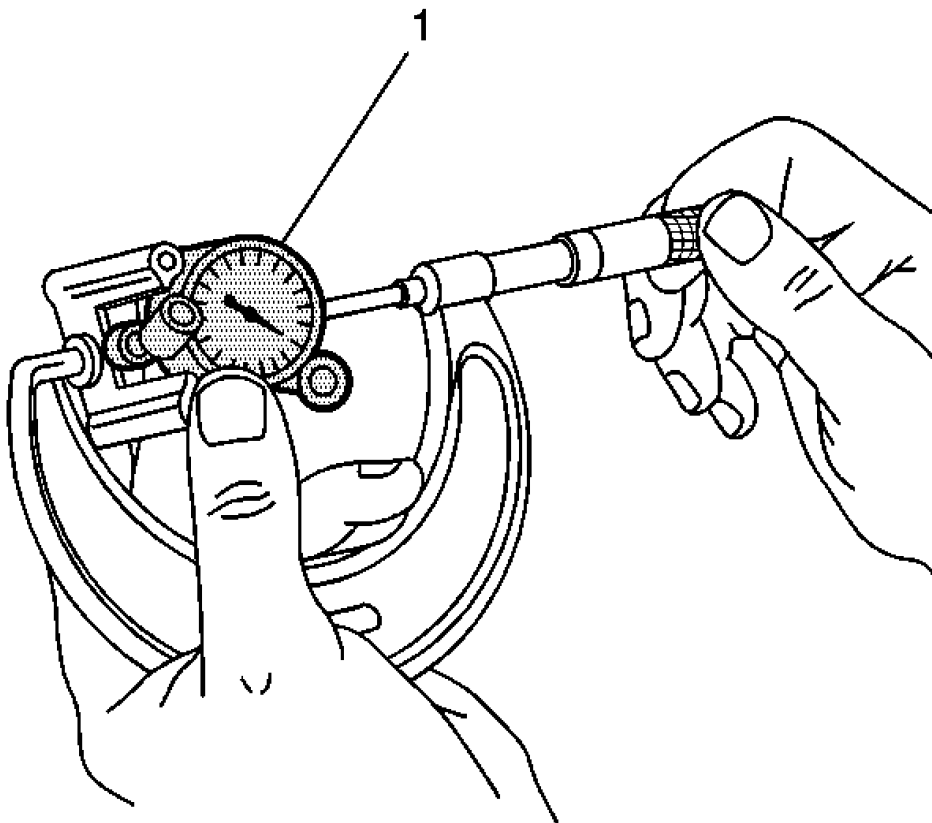
**Fig. 102: Measuring Cylinder Bore**  
Courtesy of GENERAL MOTORS COMPANY

**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.**

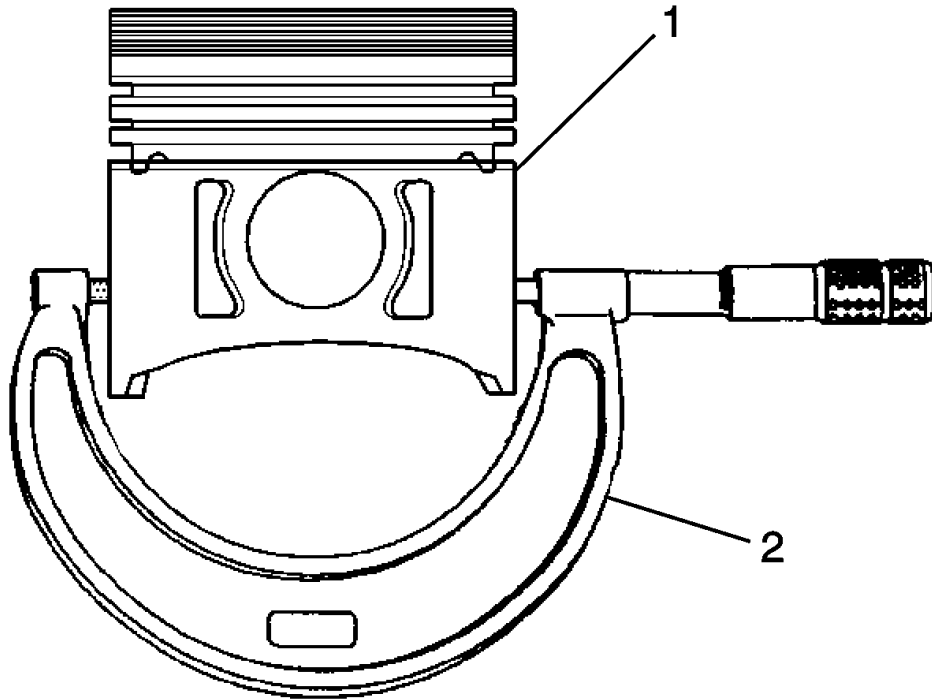
**A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.**

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

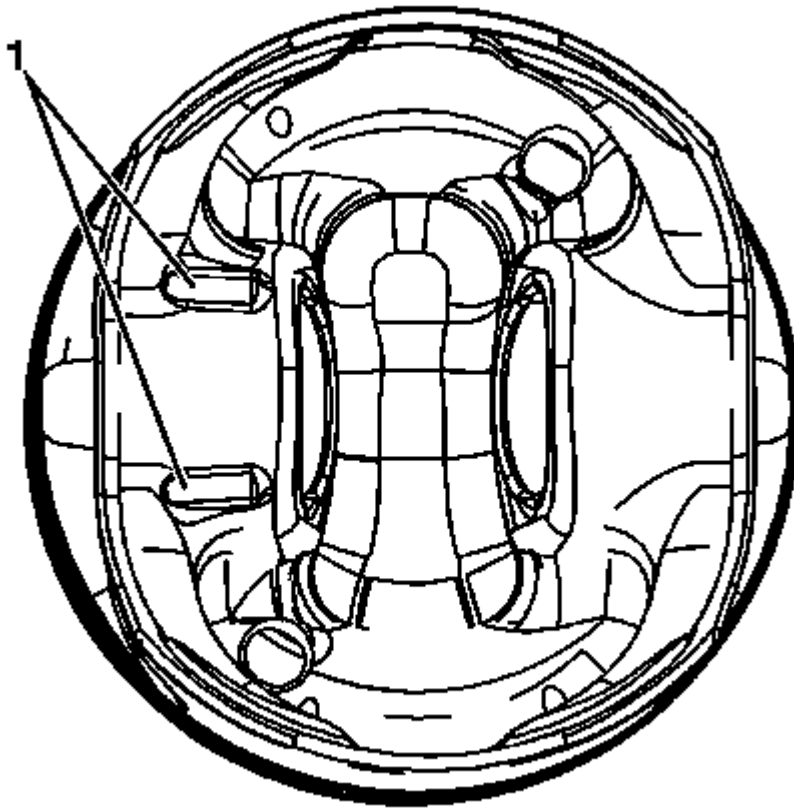
5. With a micrometer (2) or caliper at a right angle to the piston (1), measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine Mechanical Specifications (2.4L LEA)** .
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 Retainer Remover and Installer

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

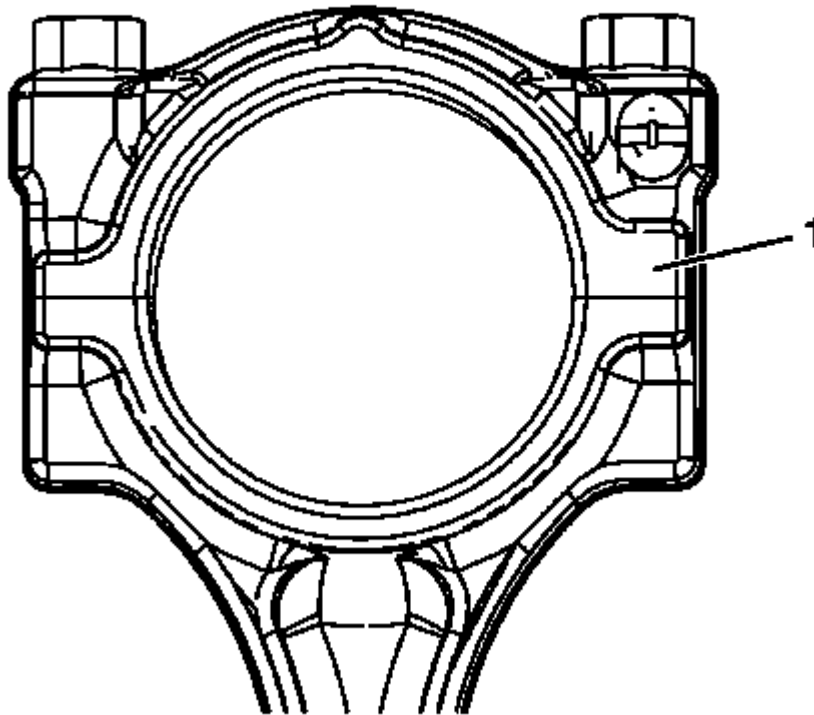


**Fig. 105: Locating "Cast Boss" On Underside of Piston**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Install the piston onto the connecting rod with the arrow on top of the piston toward the front oriented toward the front of the engine.

**NOTE:** The cast boss (1) can be in either or both locations depending on displacement.

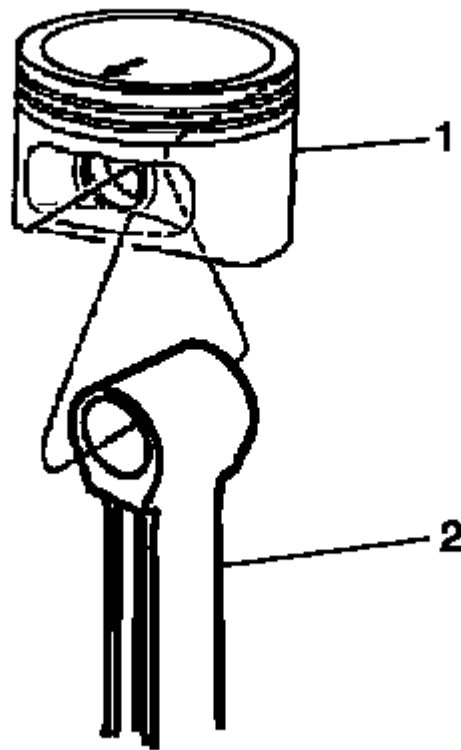
1. The cast boss (1), on the underside of the piston, must go to the rear of the block.



**Fig. 106: Identifying Cast Mark**

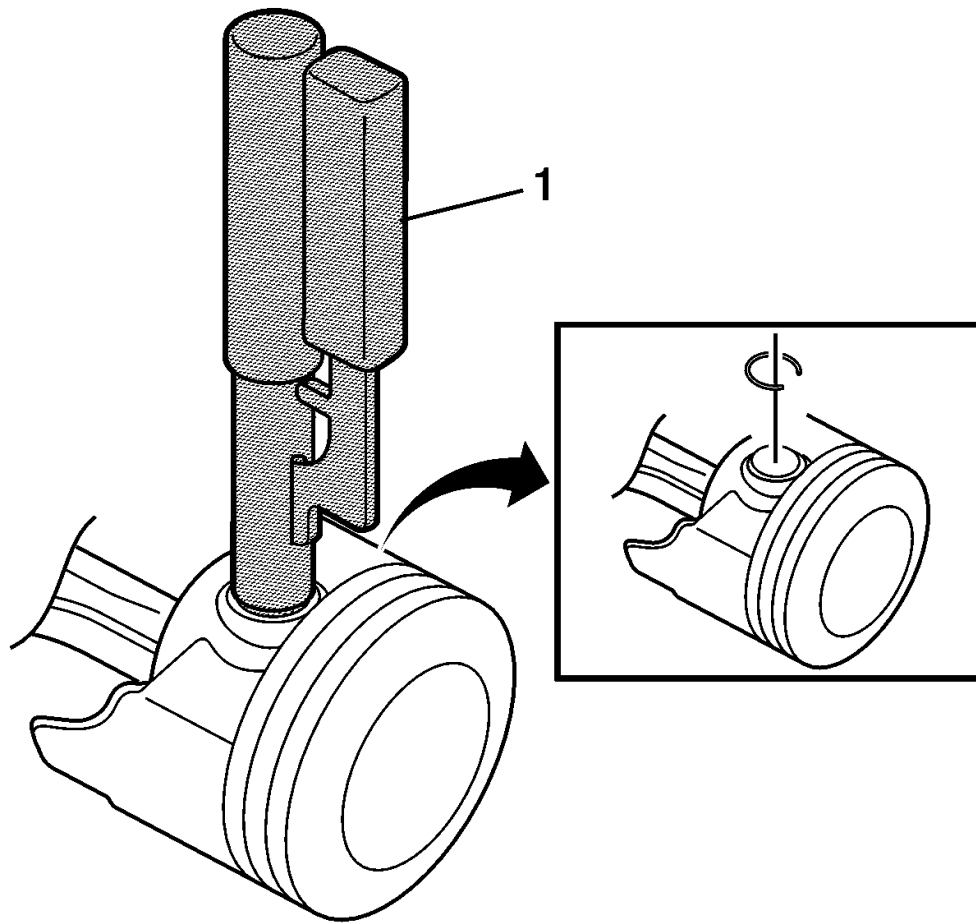
**Courtesy of GENERAL MOTORS COMPANY**

2. The larger feature (1), at the split line located on one side of the connecting rod, must go to the front of the block.



**Fig. 107: View of Connecting Rod and Piston**  
**Courtesy of GENERAL MOTORS COMPANY**

3. Assemble the connecting rod (2) and the piston (1).



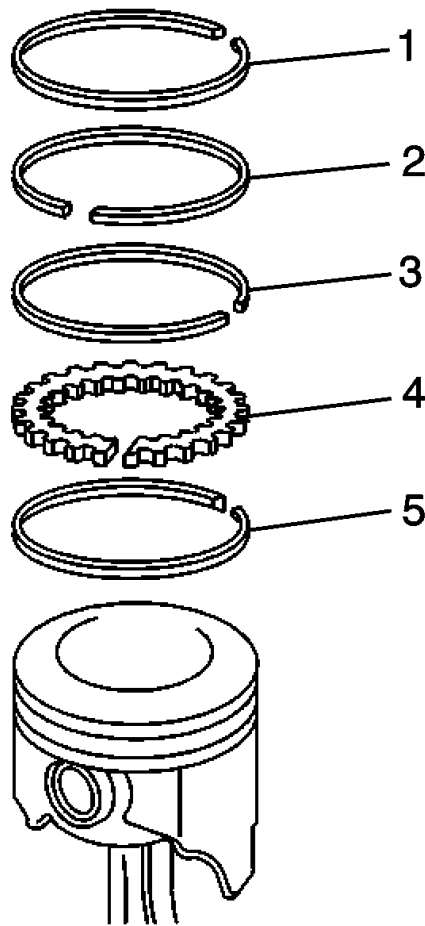
**Fig. 108: View of Piston Pin Retainers**  
Courtesy of GENERAL MOTORS COMPANY

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

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 piston pin retainer into the retaining groove using **EN-46745** installer. 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 piston pin retainer, using **EN-46745** installer (1) .
5. Ensure that the piston moves freely.



**Fig. 109: Identifying Piston Rings**

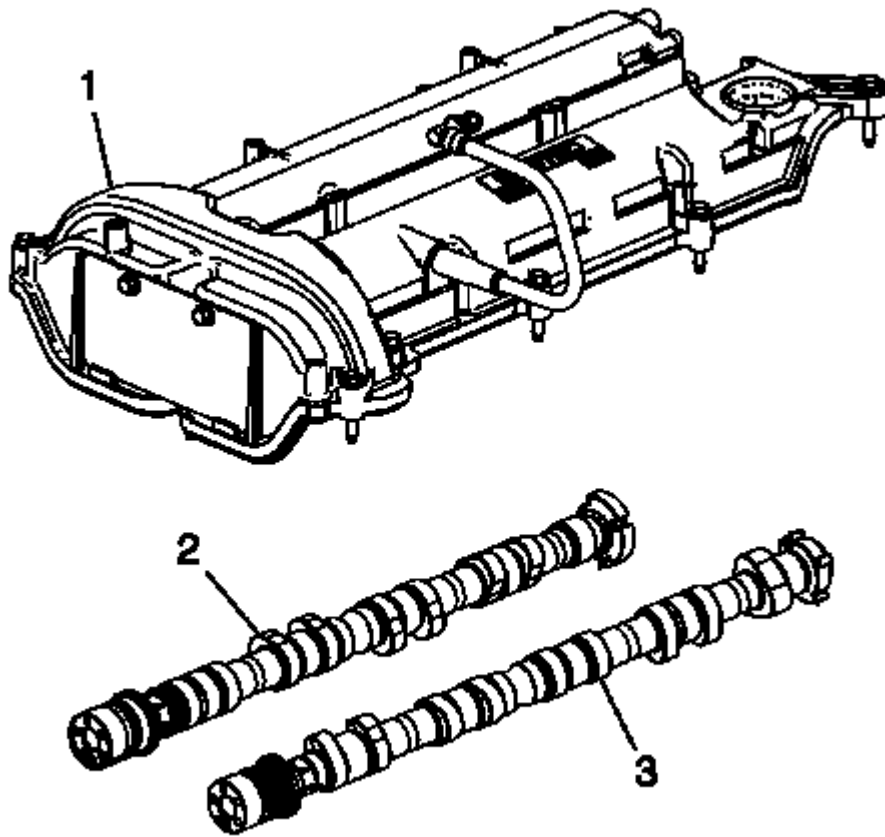
Courtesy of GENERAL MOTORS COMPANY

**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 (bottom ring):
  1. The expander (5)
  2. The lower oil control ring (4)
  3. The upper control ring (3)
6. Install the lower compression ring (2). Place the manufacturer's mark facing up.
7. Install the upper compression ring (1).

## CAMSHAFT CLEANING AND INSPECTION (2.4L LEA)



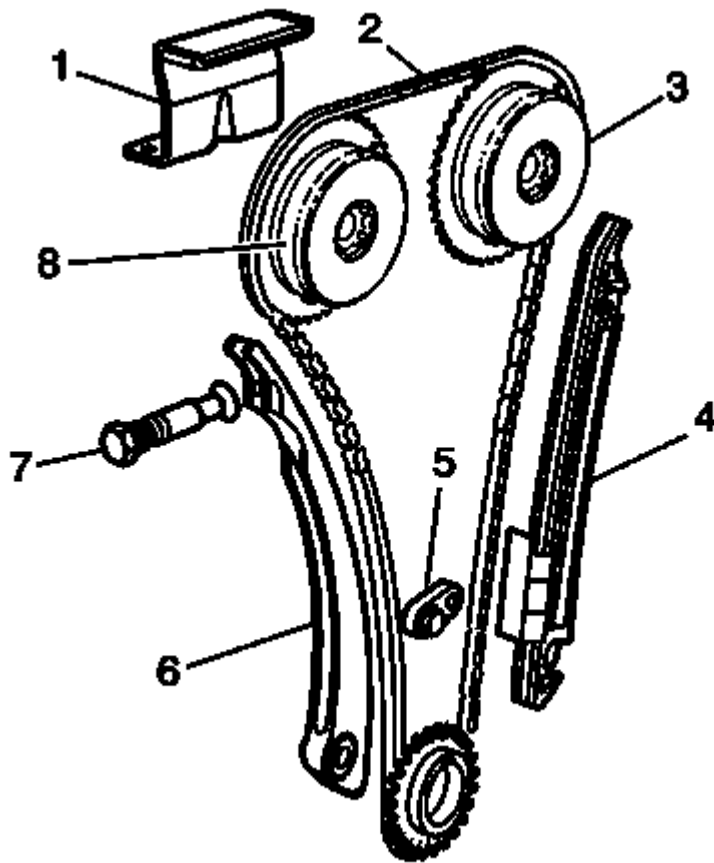


**Fig. 110: Camshaft Cover And Camshafts**

**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. Inspect the camshaft cover (1) for damage or loose oil control baffles.
4. Clean the camshaft cover.
5. Wash the camshafts (2, 3) in solvent.
6. Oil the camshafts.
7. Inspect the camshaft cover for cracks or other signs of damage.

## **CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION**

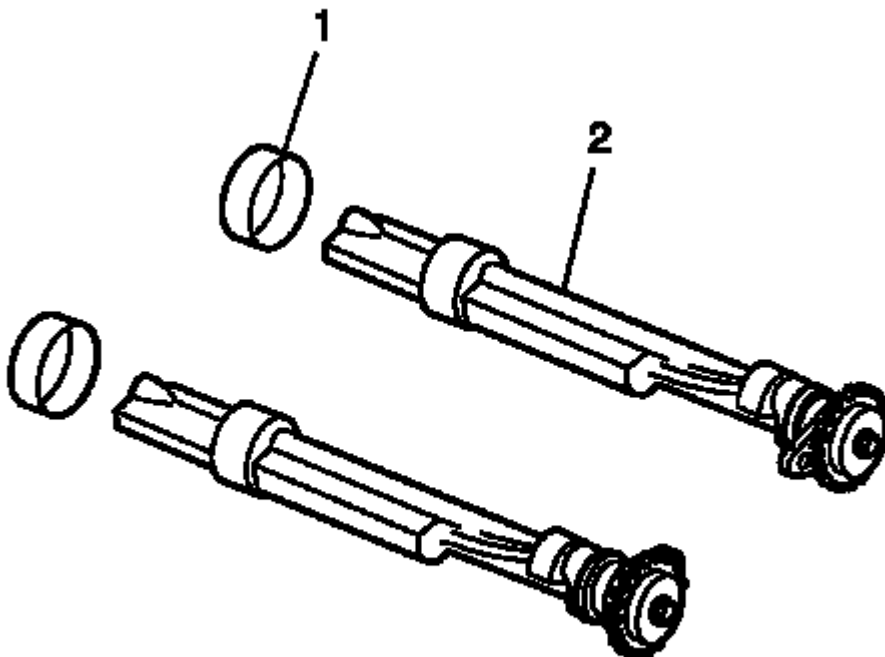


**Fig. 111: Locating Timing Chain Guides**

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the timing chain guides (1, 4, 6) 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 shoe for wear.
4. Replace the timing chain tensioner shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain (2) and actuators (3, 8) 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 oil nozzle body (5) 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 (7) for the scoring or free movement.
11. Inspect the timing chain tensioner washer and O-ring for damage. If damaged, replace the timing chain tensioner.

## BALANCE SHAFT CLEANING AND INSPECTION



**Fig. 112: Balance Shafts**

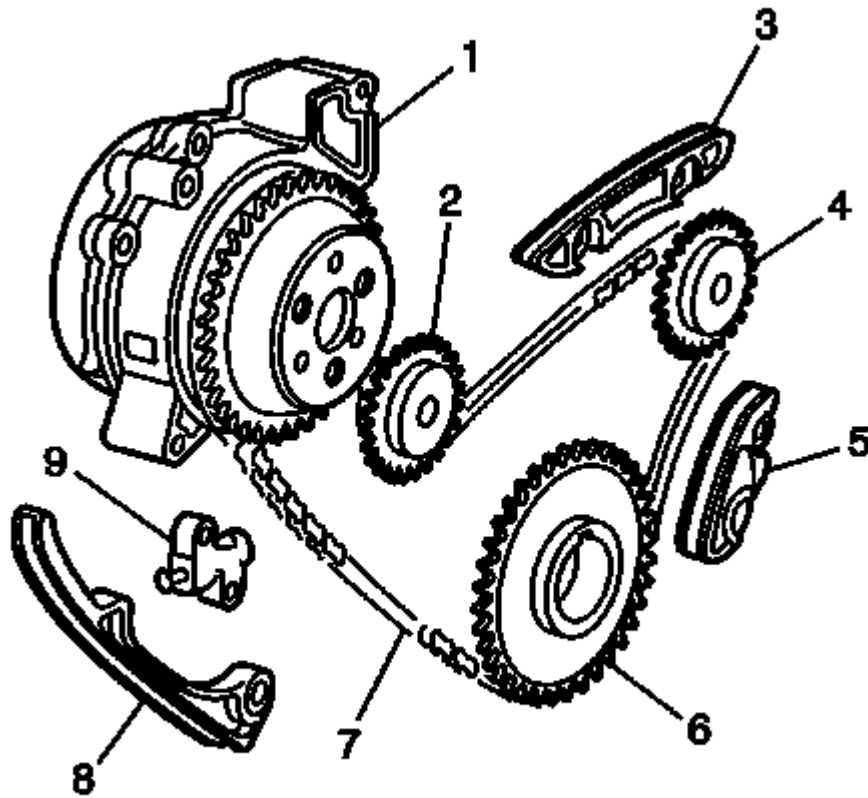
Courtesy of GENERAL MOTORS COMPANY

1. Clean the balance shafts (1) in solvent.
2. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.

**NOTE:** Do not remove the balance shaft drive sprockets.

3. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth.
4. Measure the rear bearing journals on the balance shafts, the journals should be 36.723-36.743 mm (1.4458-1.4466 in) in diameter.
5. Measure the front bearing journals on the balance shafts, the front bearing journals should be 20.020-20.000 mm (0.7881-0.7874 in) in diameter.
6. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

## WATER PUMP AND BALANCE SHAFT CHAIN AND SPROCKET CLEANING AND INSPECTION



**Fig. 113: Water Pump, Balance Shaft Chain And Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the balance shaft drive chain guides (3, 5, 8) for cracking or wear.
2. Replace the balance shaft drive chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the balance shaft drive chain tensioner guide shoe for wear.

Replace the balance shaft drive chain tensioner guide shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.

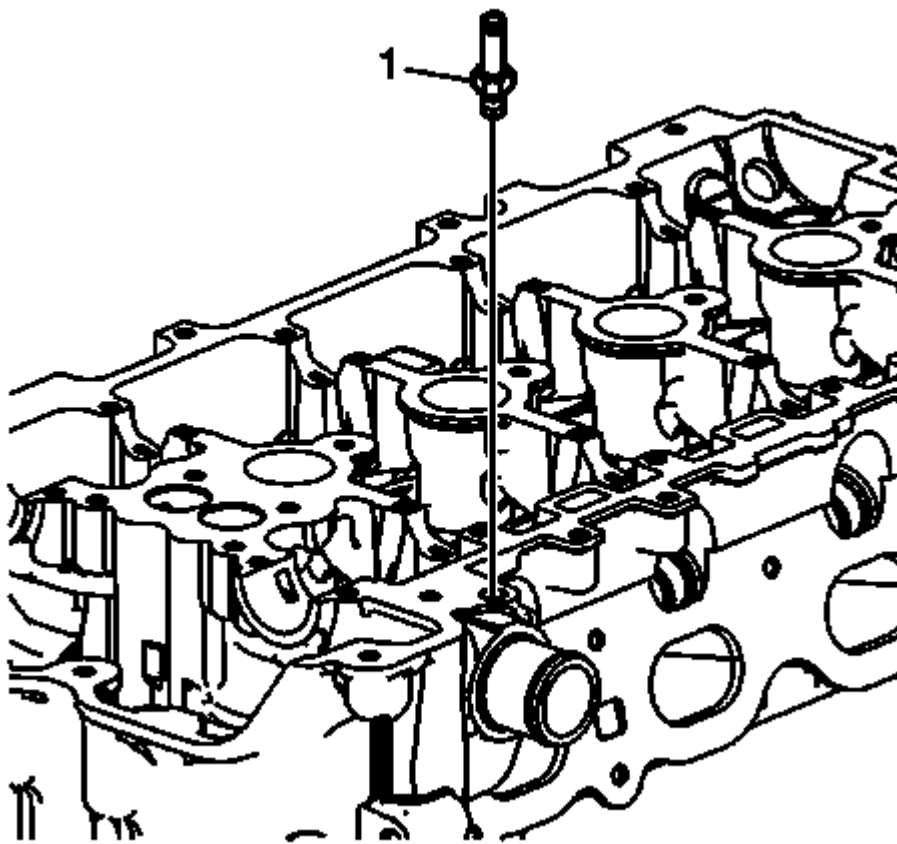
4. Inspect the balance shaft drive chain (7) and sprockets (2, 4) for wear.
5. Inspect the crankshaft sprocket (6) faces for signs of movement.
6. Inspect the alignment notch in the balance shaft for cracking or damage.
7. Inspect the water pump (1), crankshaft, and balance shaft sprocket teeth and chain for signs of excessive wear, chipping, or seizure of the balance shaft drive chain links.
8. Inspect the timing chain tensioner (9) for damage or wear.

## CYLINDER HEAD DISASSEMBLE (2.4L LEA)

**Special Tools**

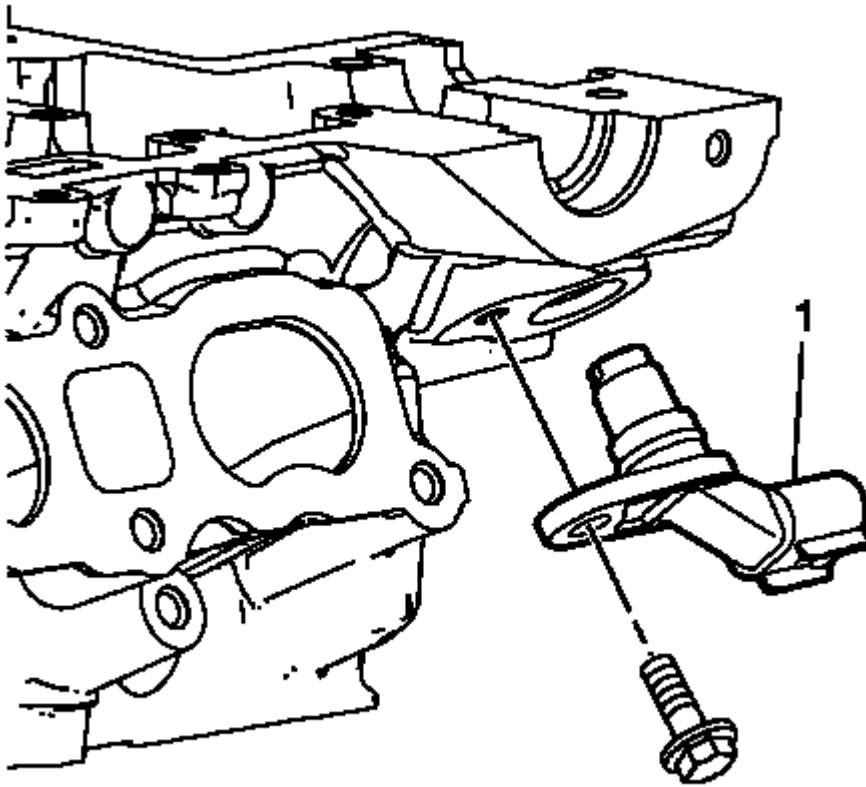
- **EN-8062** Valve Spring Compressor
- **EN-36017** Valve Seal Remover
- **EN-43963** Valve Spring Compressor (off car)

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



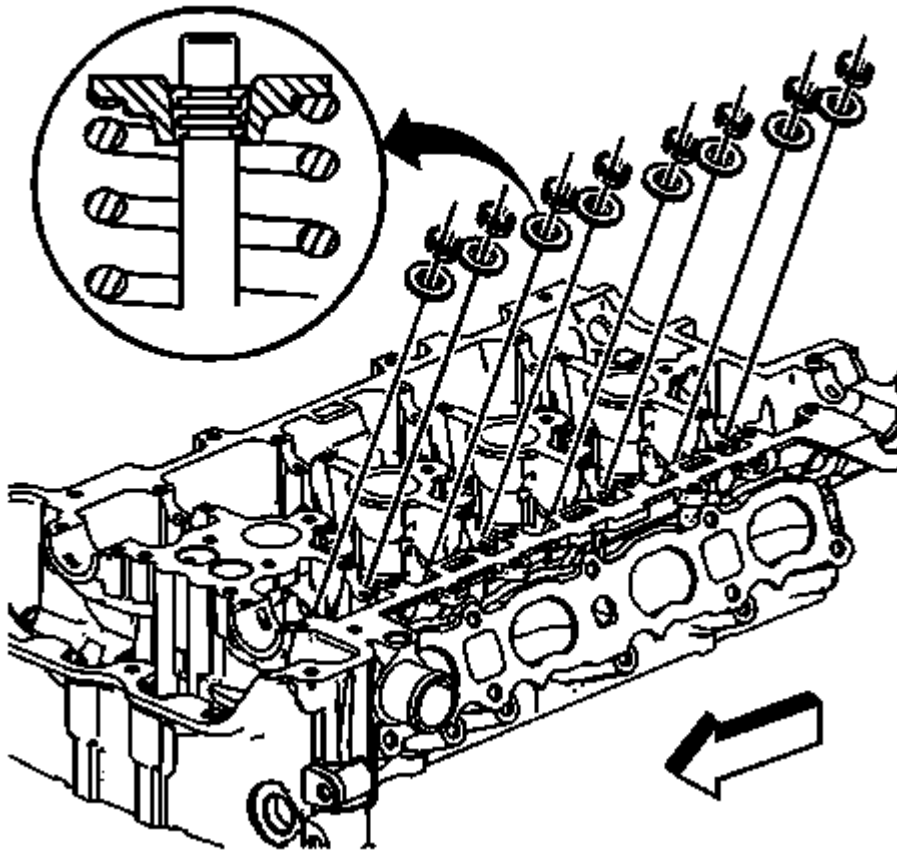
**Fig. 114: Identifying the Coolant Air Bleed Hose Fitting**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the coolant air bleed hose fitting (1).



**Fig. 115: Intake Camshaft Position Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 116: Valve Train Components**  
Courtesy of GENERAL MOTORS COMPANY

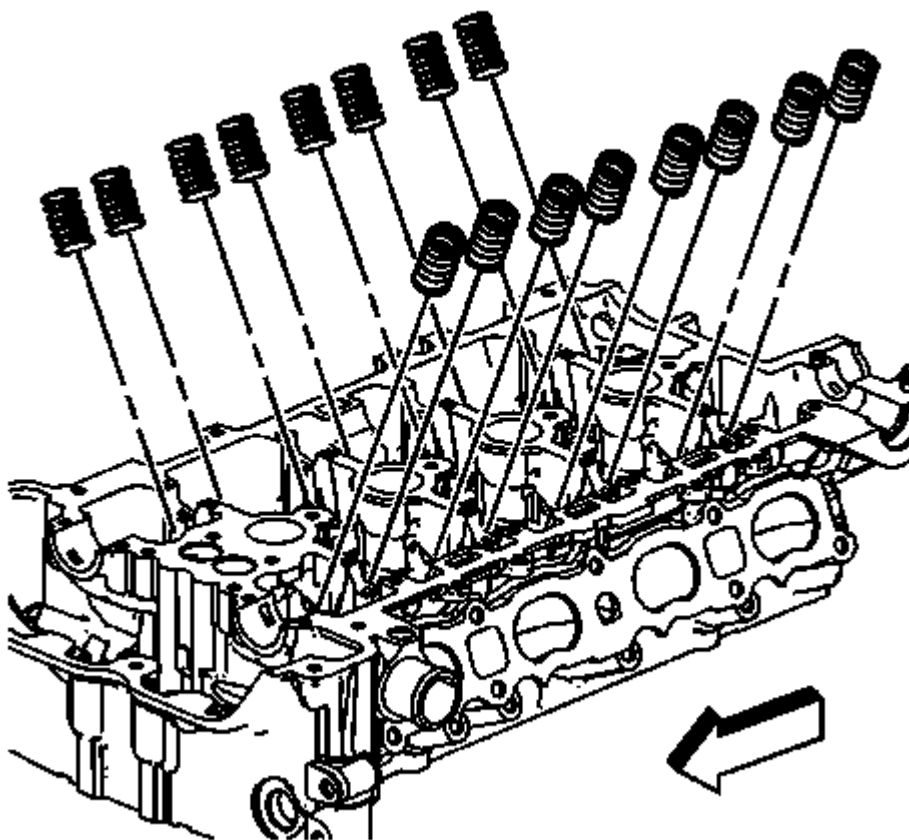
**WARNING:** Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve 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-8062** compressor and the **EN-43963** compressor compress the valve spring.

2. Remove the valve keys.
3. Slowly release the **EN-8062** compressor and the **EN-43963** compressor from the valve spring assembly.
4. Remove the retainer.

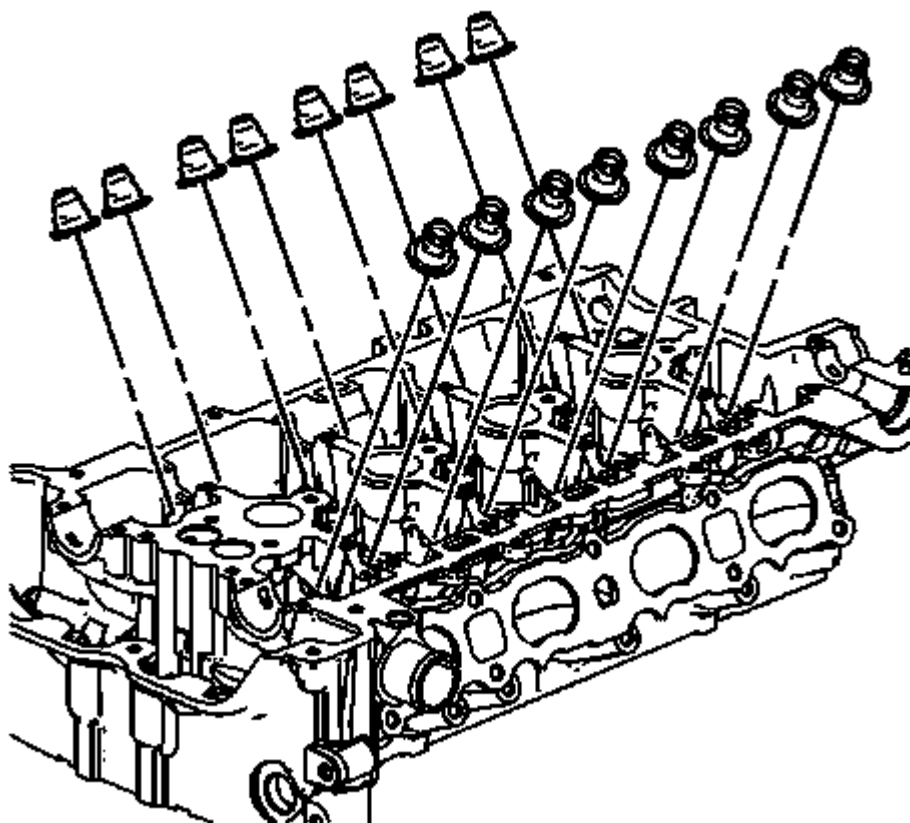


**Fig. 117: Valve Springs**

Courtesy of GENERAL MOTORS COMPANY

4. Remove the springs.



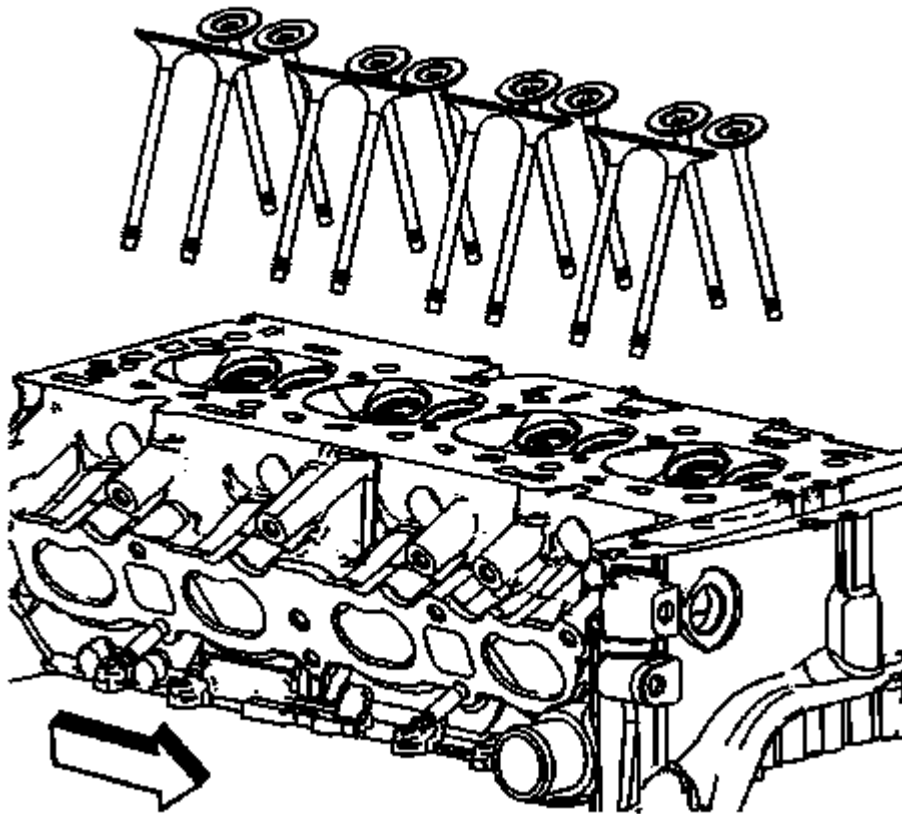


**Fig. 118: Valve Guides**

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.

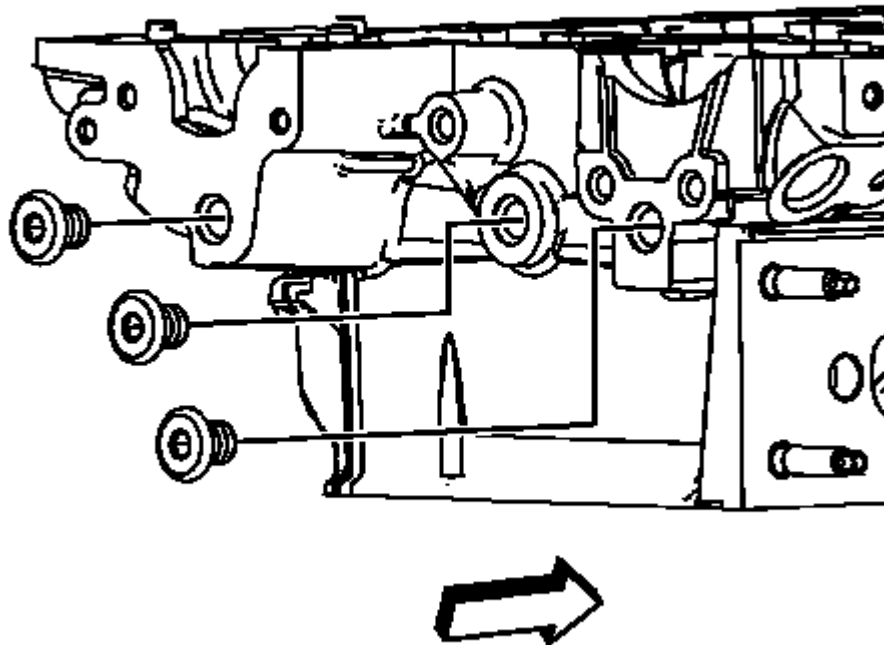
5. Using **EN-36017** remover remove the valve seals. Discard the seals, do not reuse.



**Fig. 119: Valves**

Courtesy of GENERAL MOTORS COMPANY

6. Remove the valves.



**Fig. 120: Cylinder Head Plugs**

Courtesy of GENERAL MOTORS COMPANY

7. Remove the cylinder head plugs.

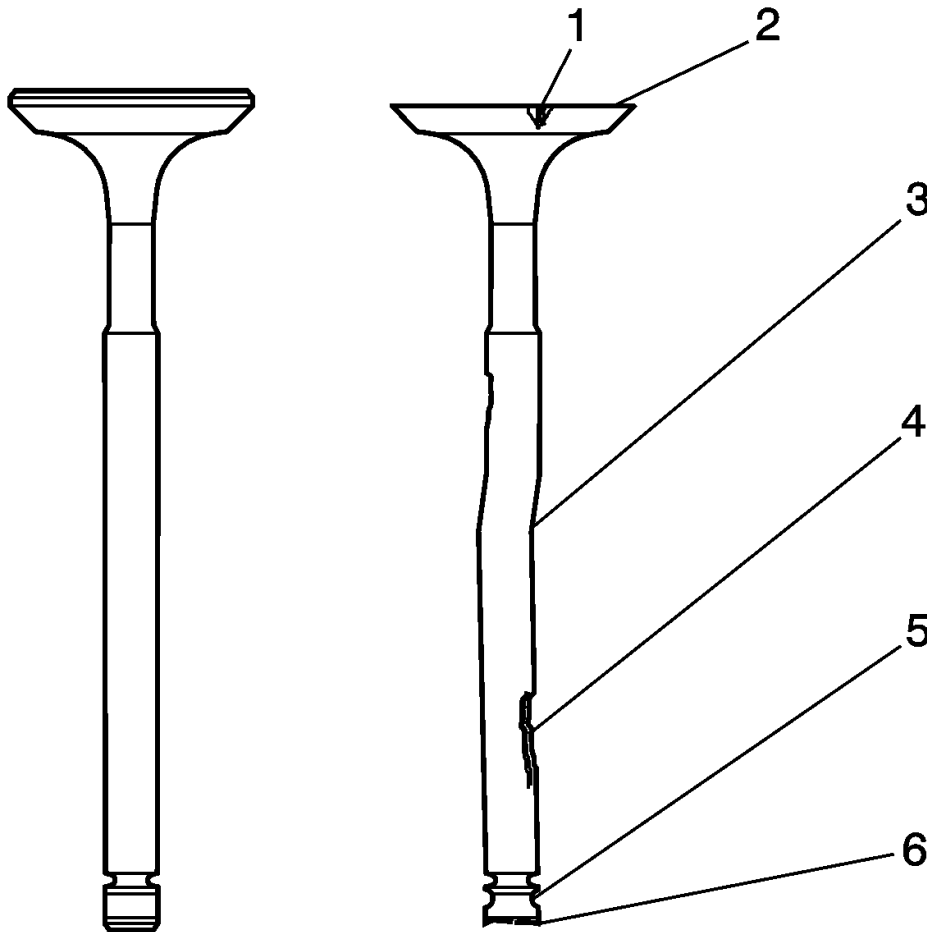
## **CYLINDER HEAD CLEANING AND INSPECTION (2.4L LEA)**

### **Special Tools**

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

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

### **Valve Cleaning and Inspection**



**Fig. 121: Valve Inspection Areas**

Courtesy of GENERAL MOTORS COMPANY

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

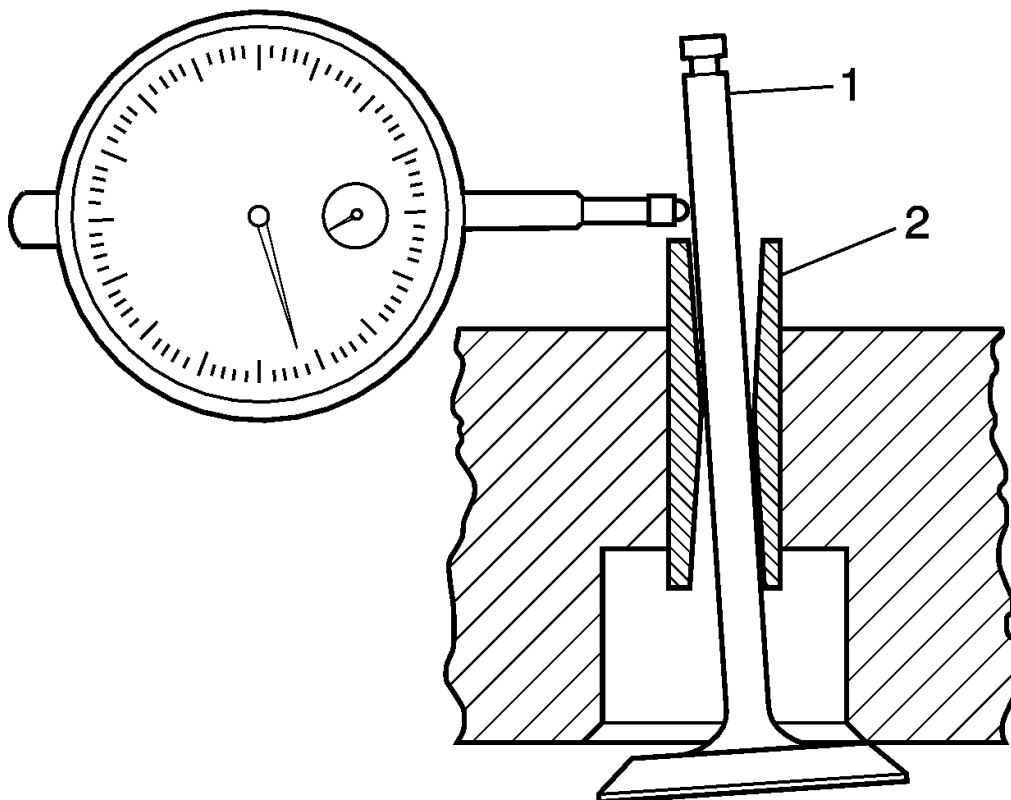
**NOTE:** Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

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. 122: 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 (2.4L LEA)** 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.**

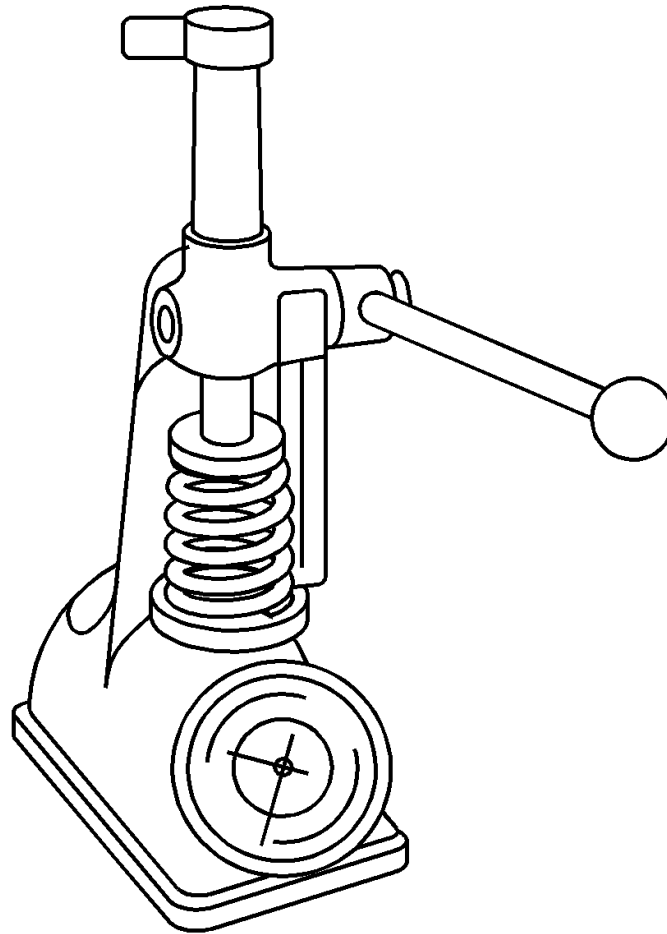
6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

#### **Valve Spring Cleaning and Inspection**

1. Clean the valve springs in solvent.

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

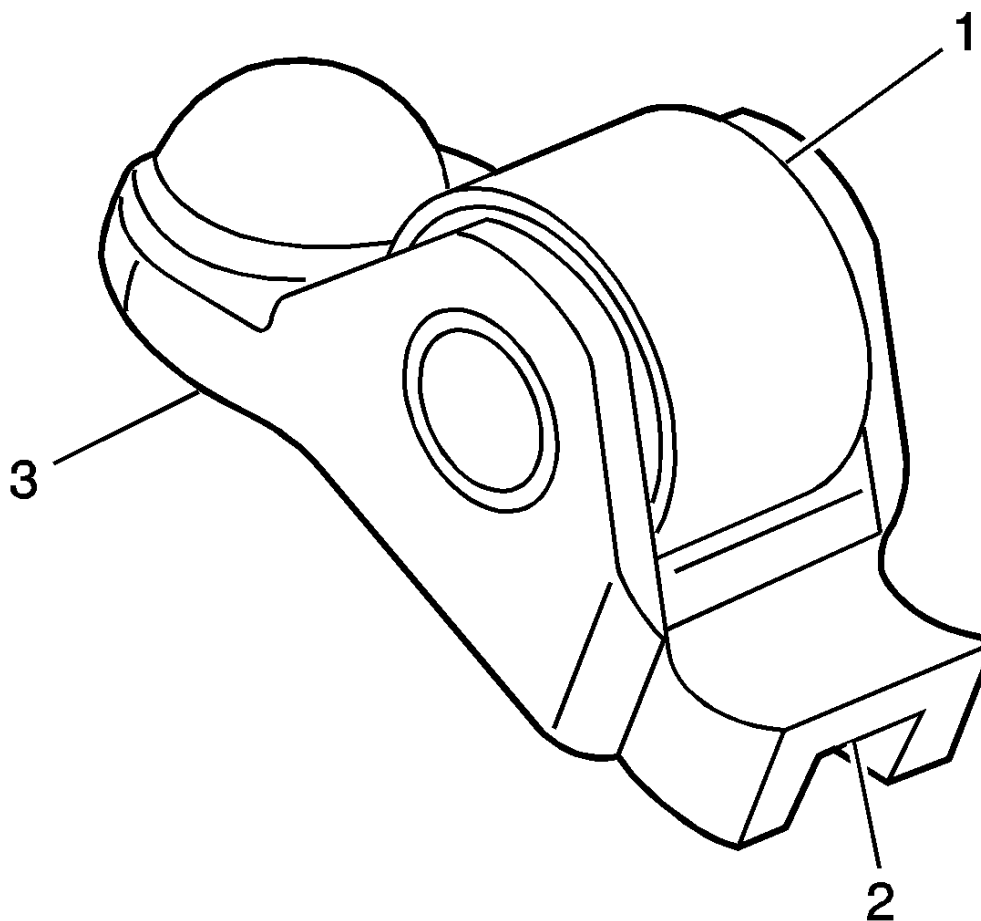
2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.



**Fig. 123: 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 (2.4L LEA)**
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**



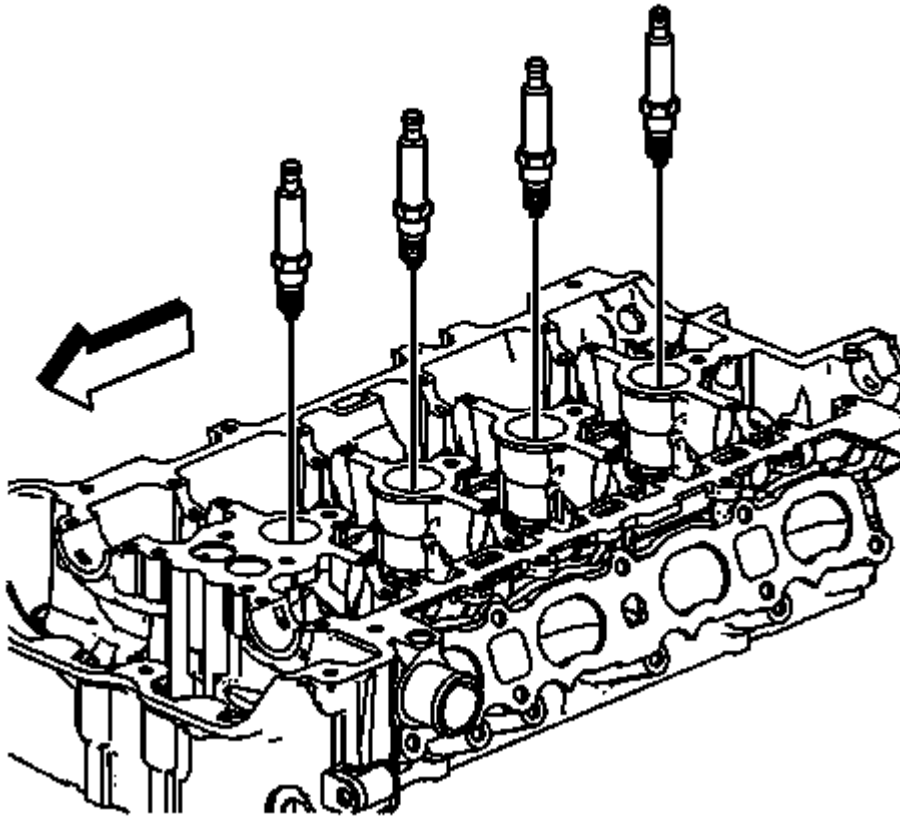
**Fig. 124: Inspecting Valve Rocker Arms**

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**

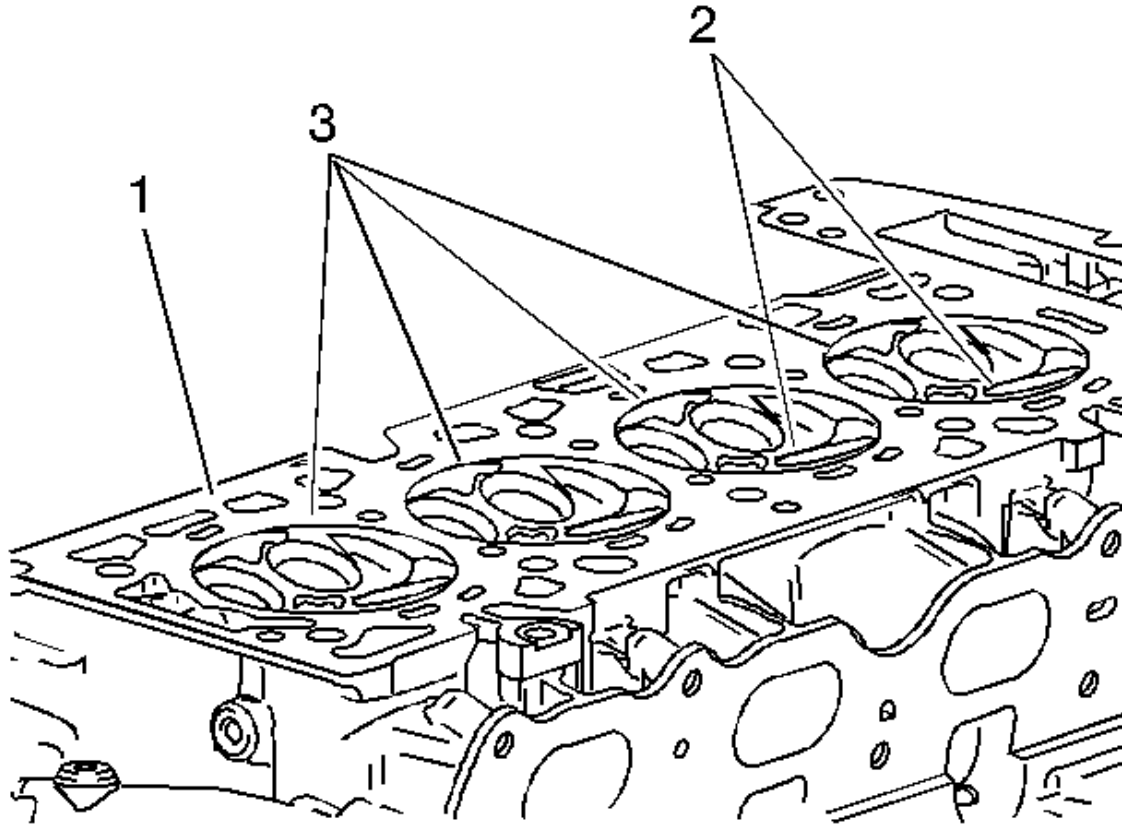




**Fig. 125: Spark Plugs**

Courtesy of GENERAL MOTORS COMPANY

1. Remove the spark plugs.
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. 126: Cylinder Head Inspection Areas**  
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).
4. Clean the cylinder head bolts.

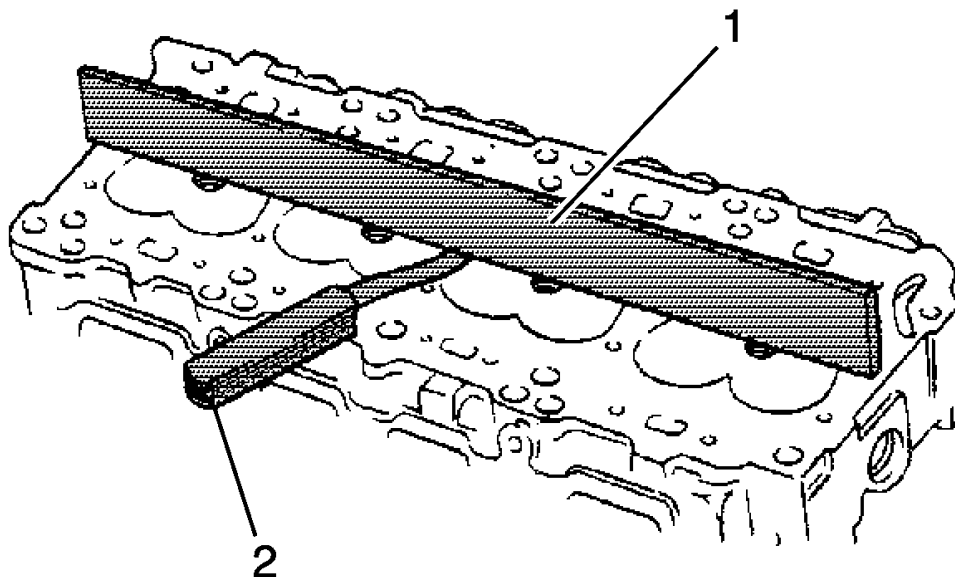
**NOTE:** Do not use a wire brush on any gasket sealing surface.

5. 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.

6. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
7. Clean the valve guides.
8. Clean the threaded holes. Use a nylon bristle brush.
9. Clean the remains of the sealer from the plug holes.
10. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
11. Replace all suspect bolts.
12. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

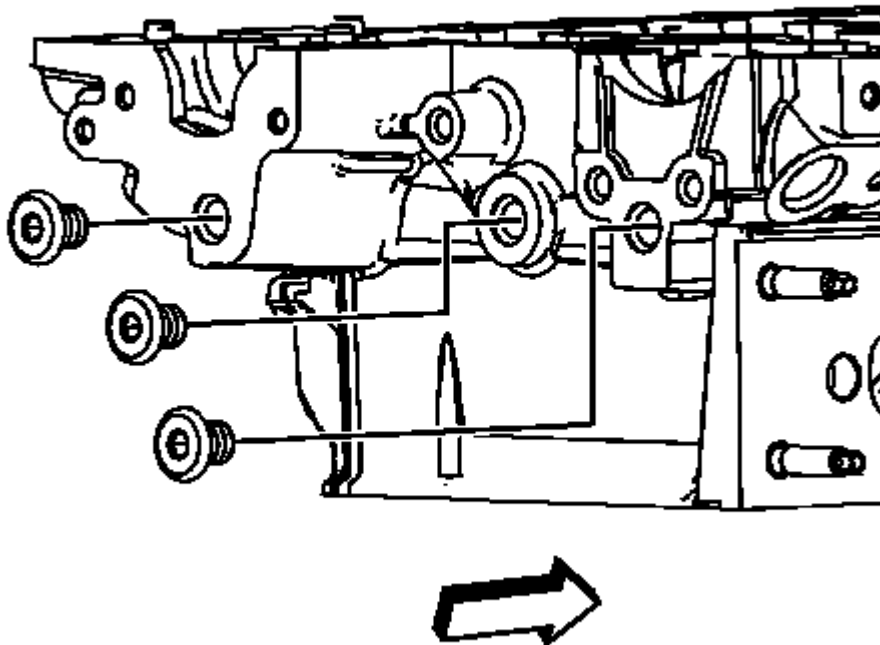
**NOTE:** Do not attempt to weld the cylinder head, replace it.

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



**Fig. 127: Checking Cylinder Head Deck Surface For Flatness**  
Courtesy of GENERAL MOTORS COMPANY

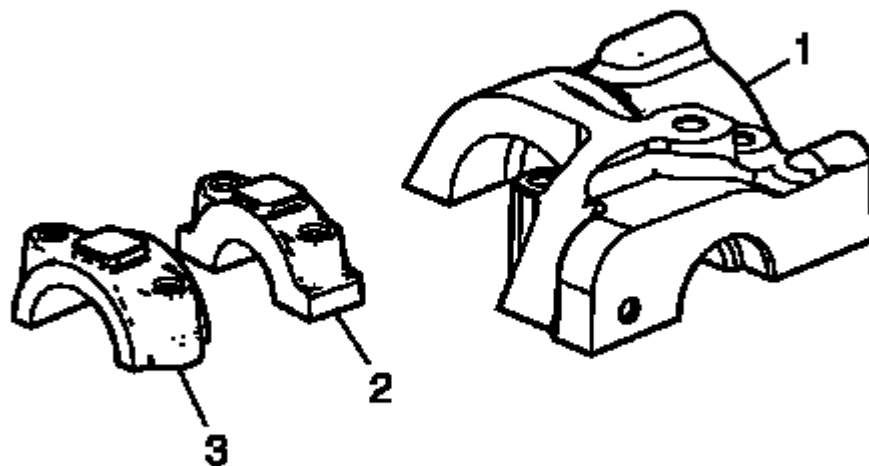
14. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications (2.4L LEA)** . If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
15. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
16. Inspect the sealing surfaces.



**Fig. 128: Cylinder Head Plugs**

Courtesy of GENERAL MOTORS COMPANY

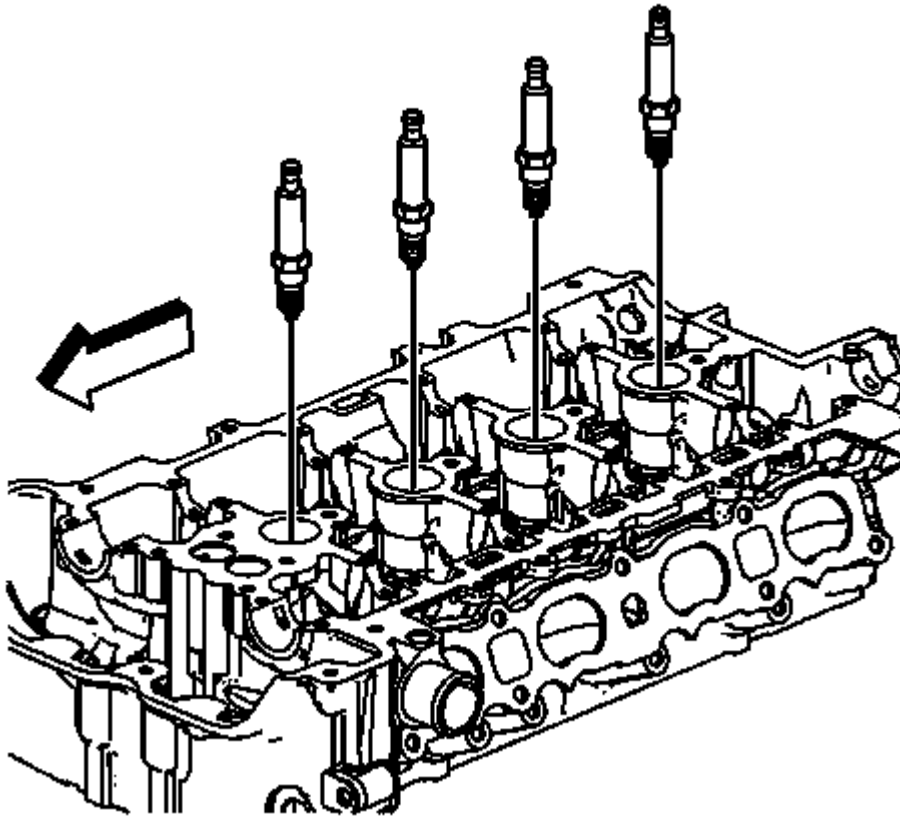
17. Inspect the cylinder head plugs and verify the oil orifice is clear and free of debris.



**Fig. 129: Bearing Caps**

Courtesy of GENERAL MOTORS COMPANY

18. Clean the sealant from the rear cap mating surface with **EN-28410** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
19. Inspect the intake camshaft bearing rear cap (1) for damage.
20. Inspect the rear bearing mating surfaces for damage.
21. Inspect the camshaft bearing caps (2) for damage.
22. Inspect the camshaft front bearing caps (3) for damage.



**Fig. 130: Spark Plugs**

Courtesy of GENERAL MOTORS COMPANY

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

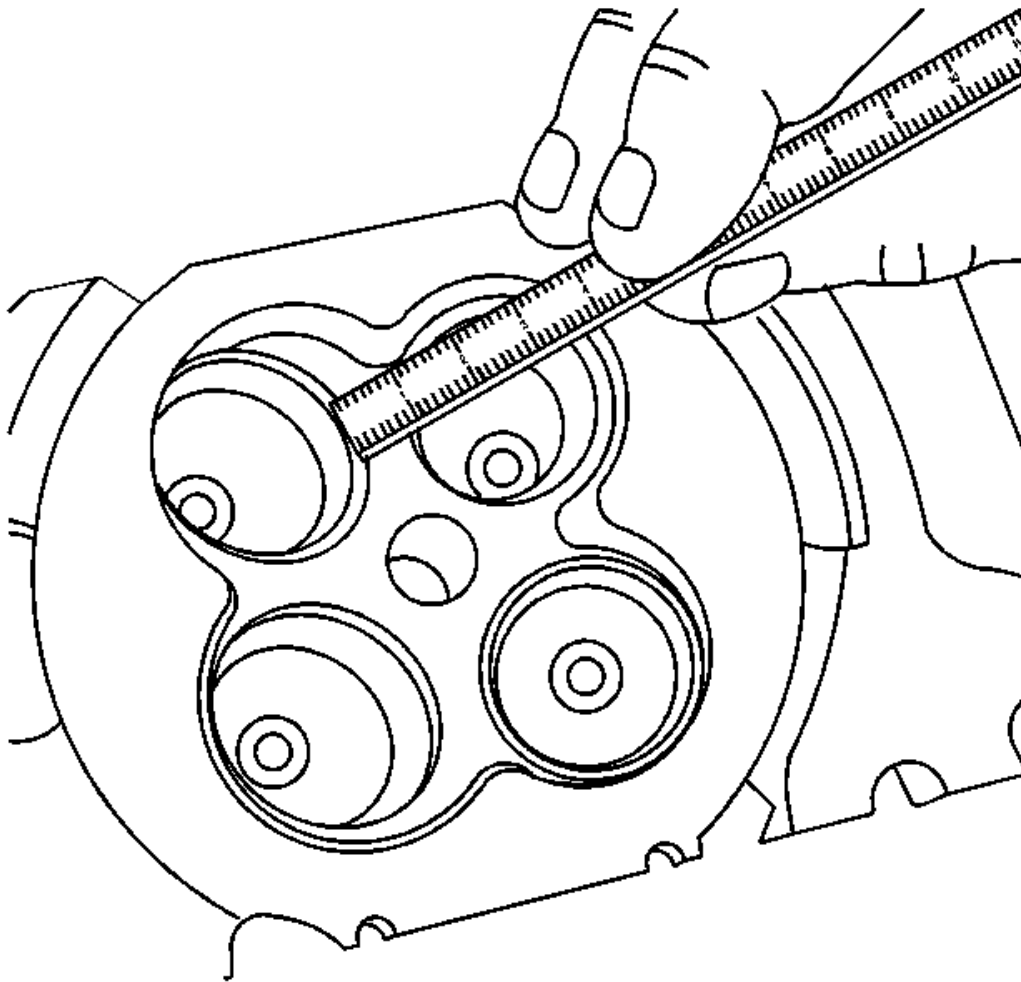
23. Install the spark plugs. Tighten the plugs to 20 N.m (15 lb ft).

## VALVE AND SEAT GRINDING

### Valve Measurement and Reconditioning Overview

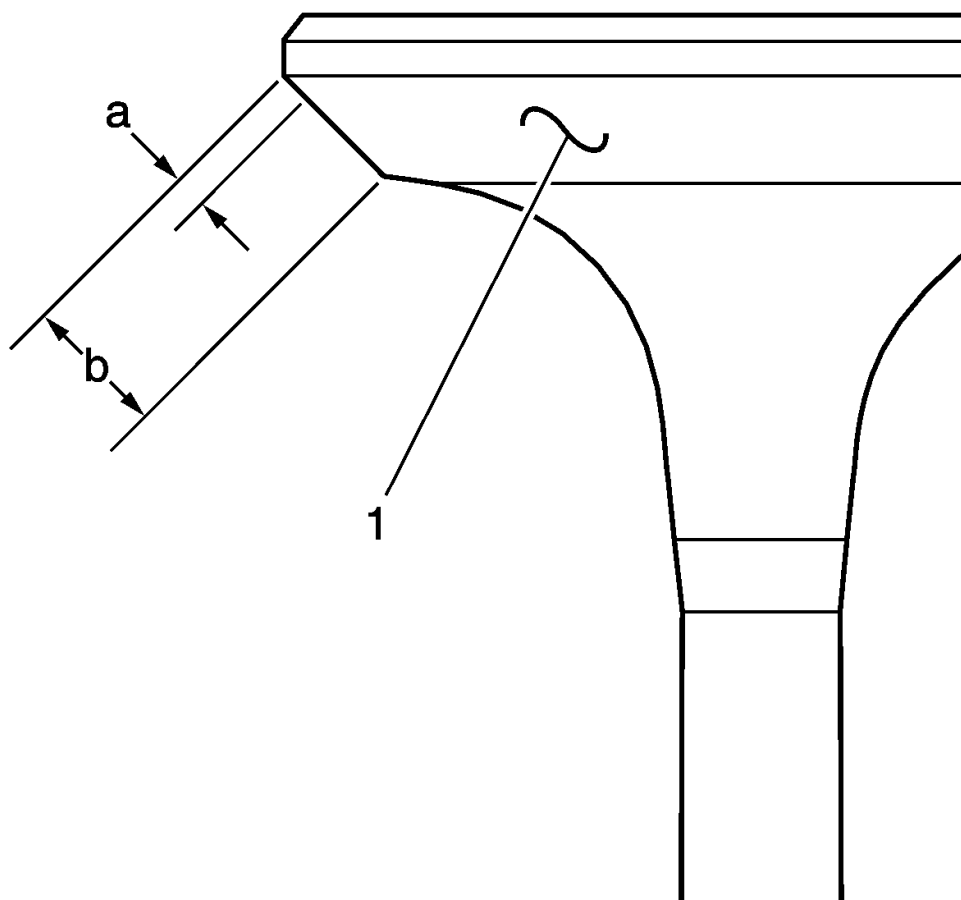
- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

### Valve Seat Width Measurement Procedure



**Fig. 131: Checking Valve Seat Width**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 132: 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 (2.4L LEA).
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.



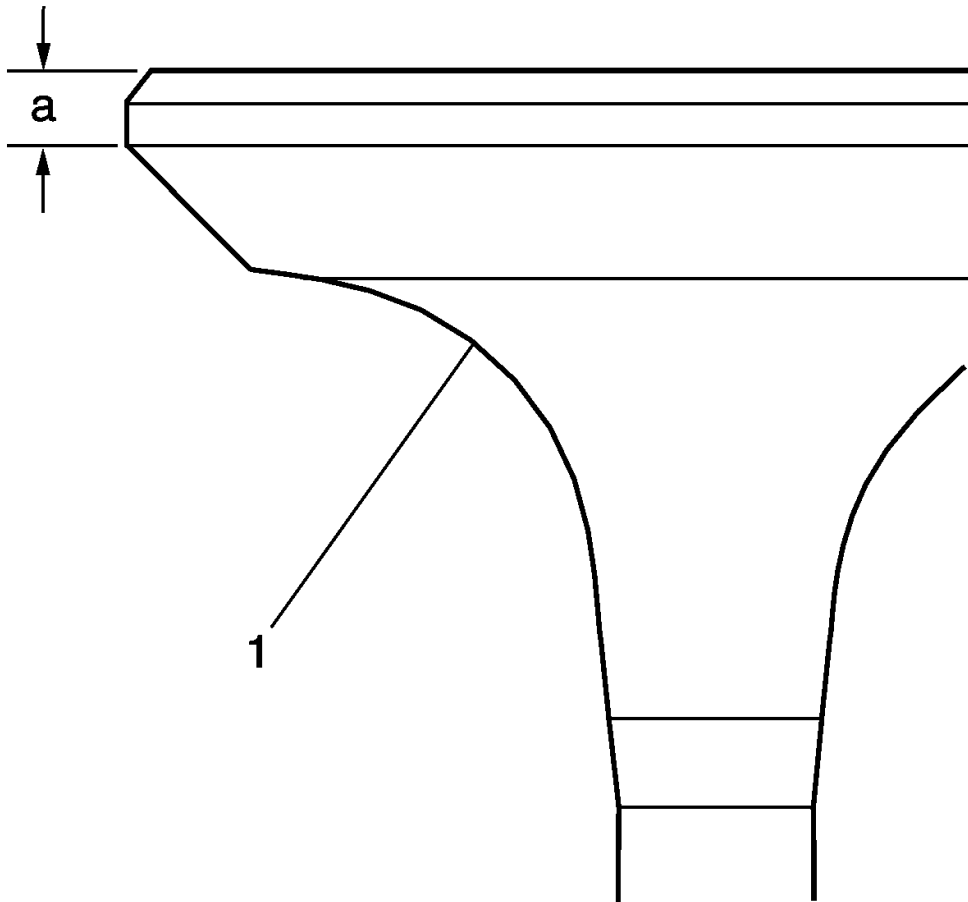
### Valve Seat Roundness Measurement Procedure

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 (2.4L LEA).
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



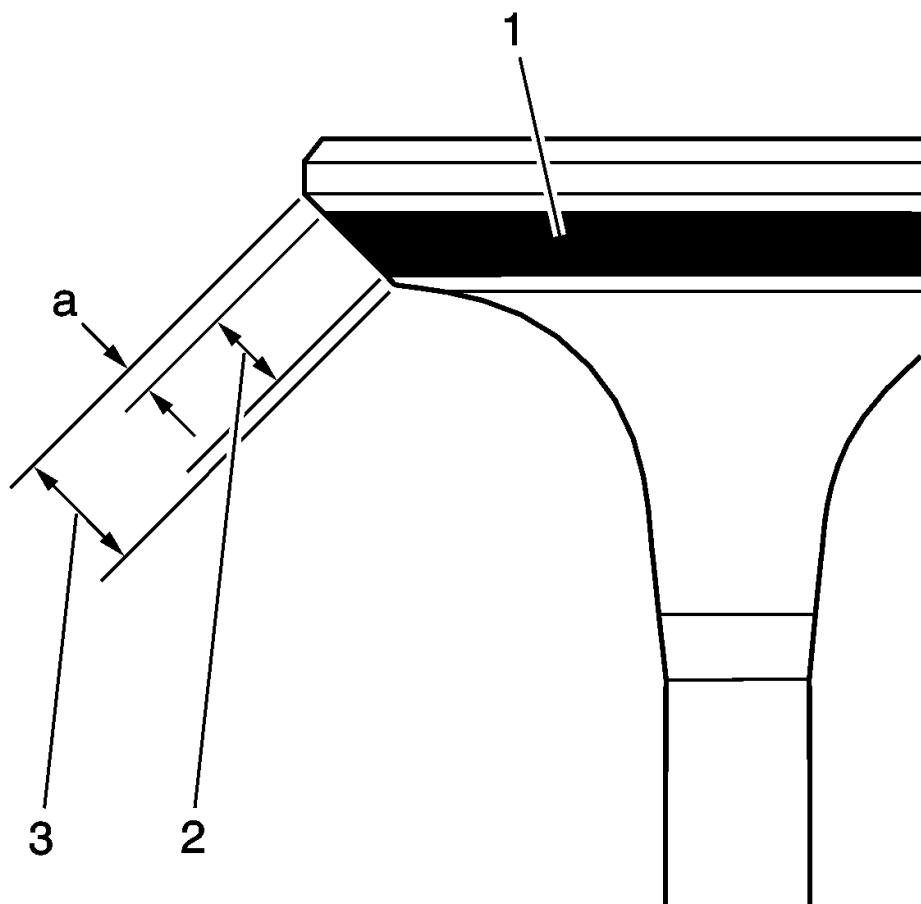
**Fig. 133: View Of Valve Head O.D. & Chamfer**  
 Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to **Engine Mechanical Specifications (2.4L LEA)**.
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. 134: 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.

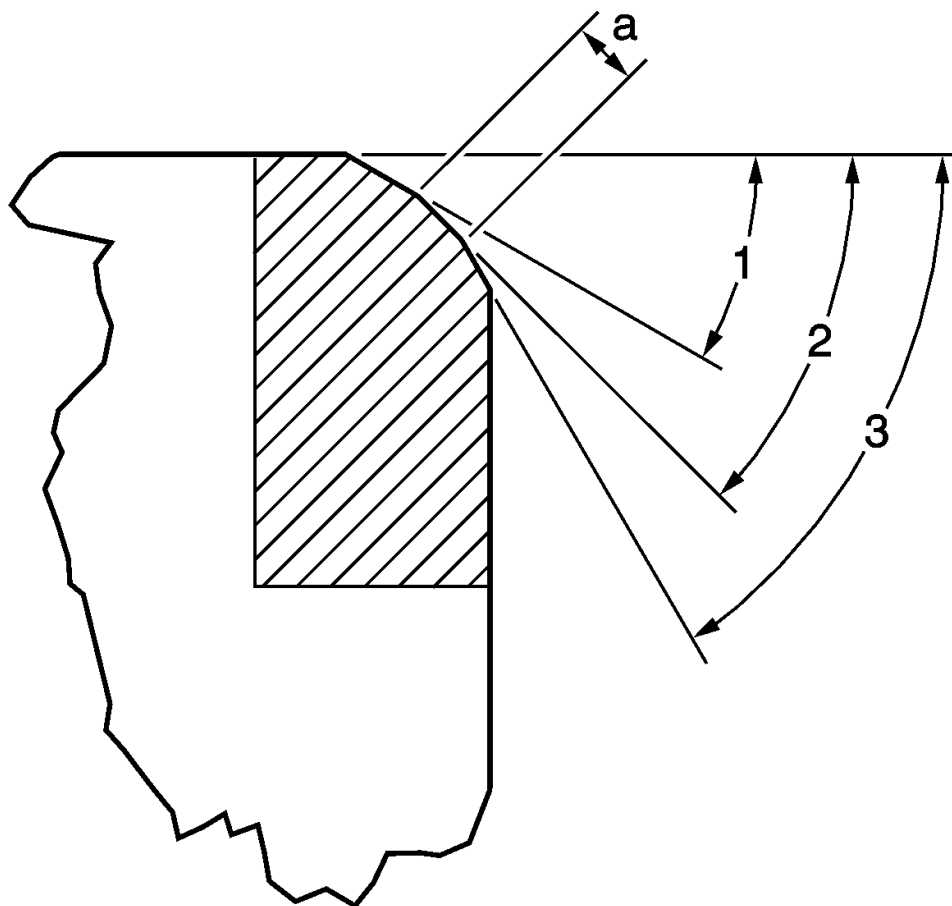
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
  - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

**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. 135: Valve Seating Surface Angle**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

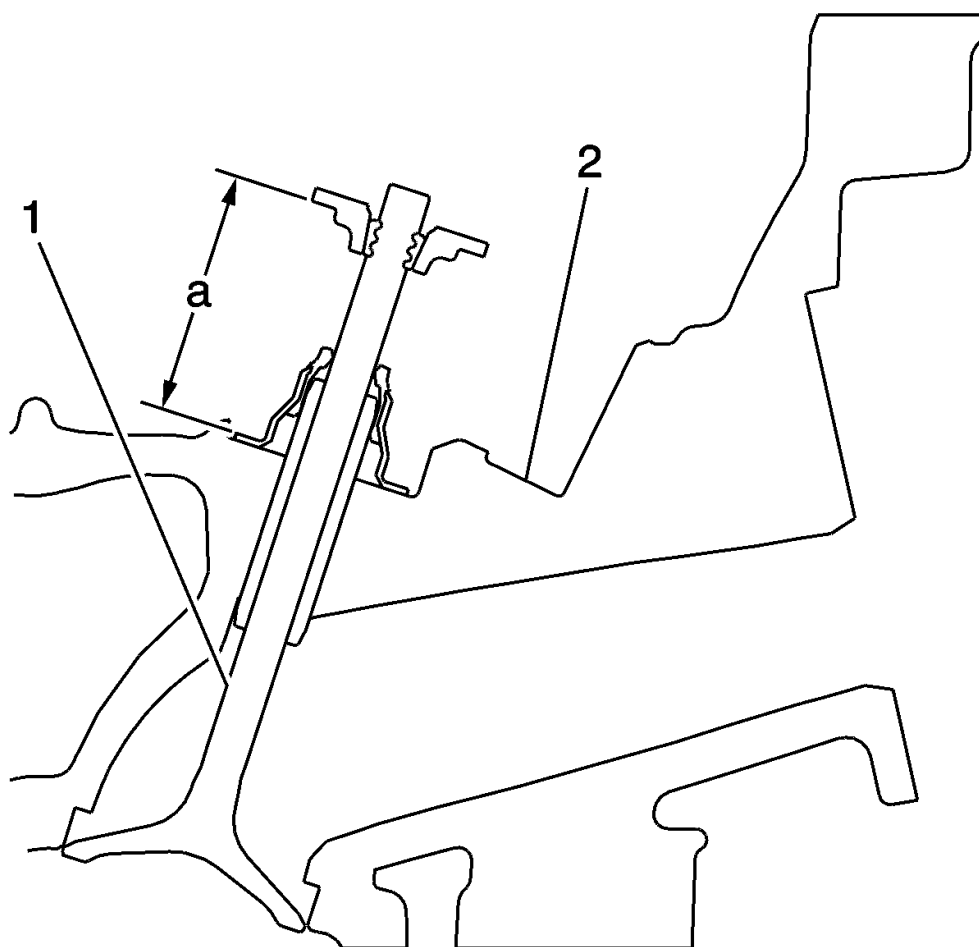
- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seating surface (a) to the proper angle specification (2) listed in **Engine Mechanical Specifications (2.4L LEA)** .
2. Grind the valve relief surface to the proper angle specification (1) listed in **Engine Mechanical Specifications (2.4L LEA)** 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 (2.4L LEA)** , to narrow the valve seating surface width (a) to the specifications listed in **Engine Mechanical Specifications (2.4L LEA)** .

**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 (2.4L LEA)**.
5. If the original exhaust valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications (2.4L LEA)**. 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. 136: 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 (2.4L LEA)**.
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.**

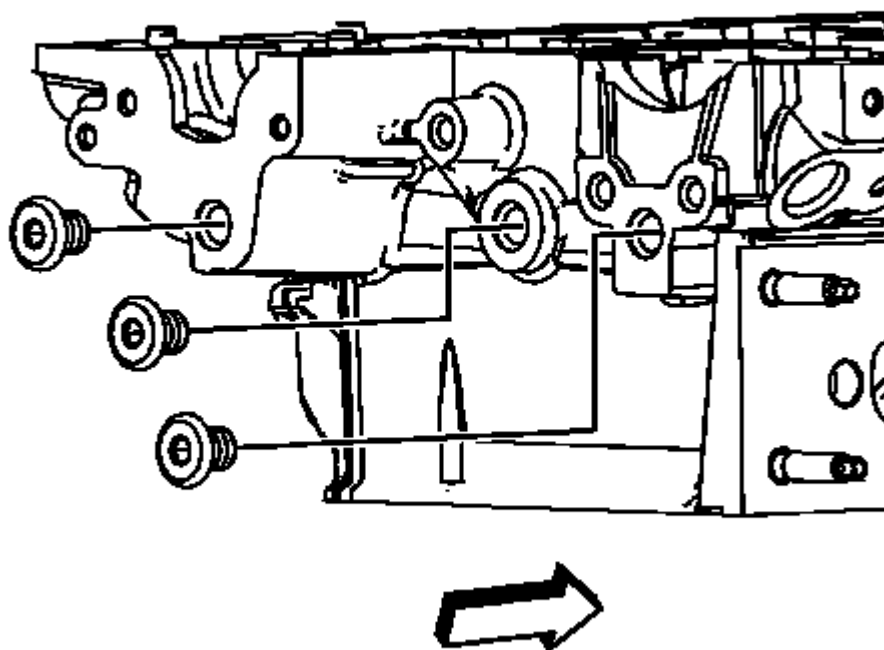
7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

### CYLINDER HEAD ASSEMBLE (2.4L LEA)

#### Special Tools

- **EN-8062** Valve Spring Compressor
- **EN-9666** Valve Spring Tester
- **EN-43963** Valve Spring Compressor (off car)

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



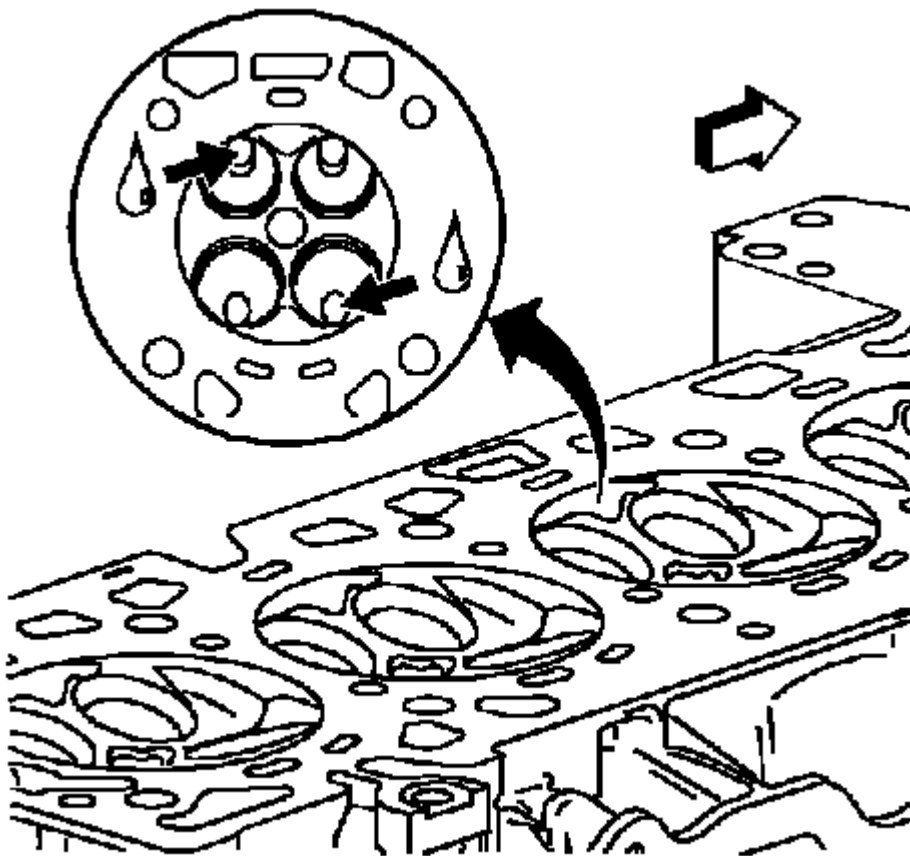
**Fig. 137: Cylinder Head Plugs**

Courtesy of GENERAL MOTORS COMPANY

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

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

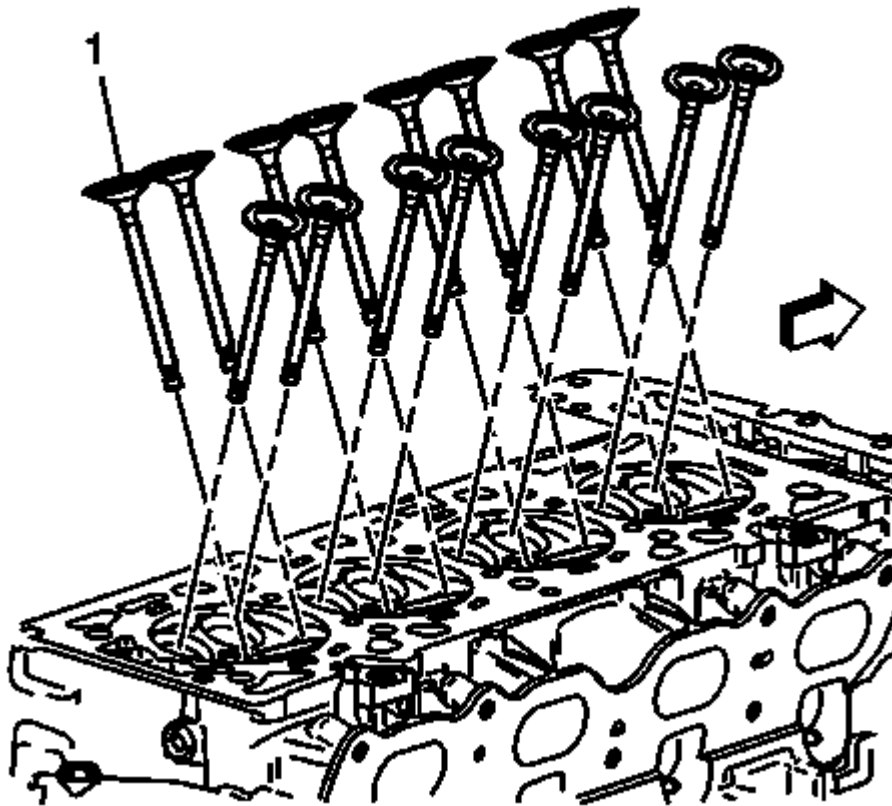
1. Install NEW cylinder head plugs. Coat the plugs with sealer. Refer to Adhesives, Fluids, Lubricants, and Sealers .
2. Inspect the valve springs for the following conditions:
  - Expanded height
  - Unparallel spring ends
  - Spring tension using **EN-9666** tester
  - Any distorted springs should be replaced



**Fig. 138: Applying Prussian Blue**  
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the valves and the valve seats. Refer to Valve and Seat Grinding.

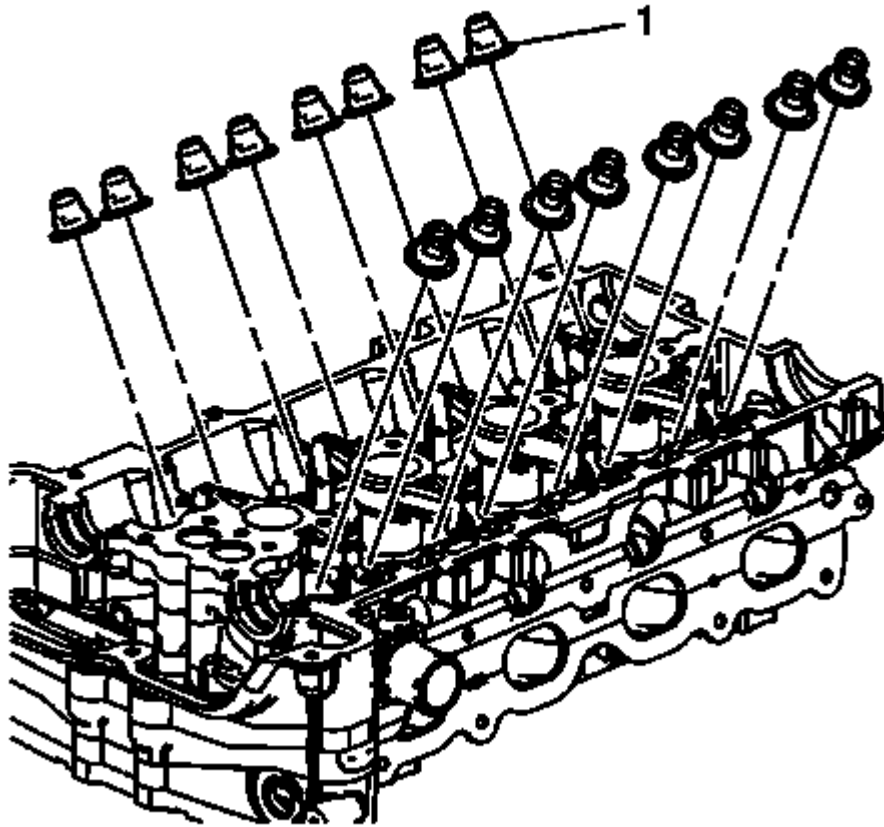




**Fig. 139: View of Valves**

Courtesy of GENERAL MOTORS COMPANY

4. Install the valves (1). Replace the valves, if required.

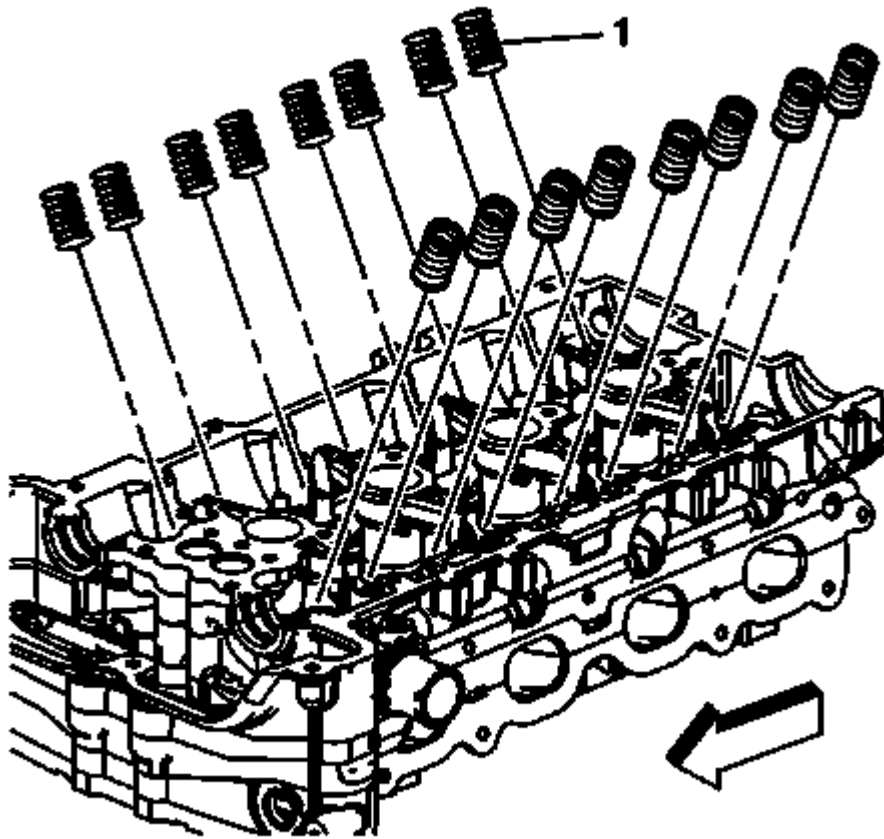


**Fig. 140: View of Valve Seals**

Courtesy of GENERAL MOTORS COMPANY

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

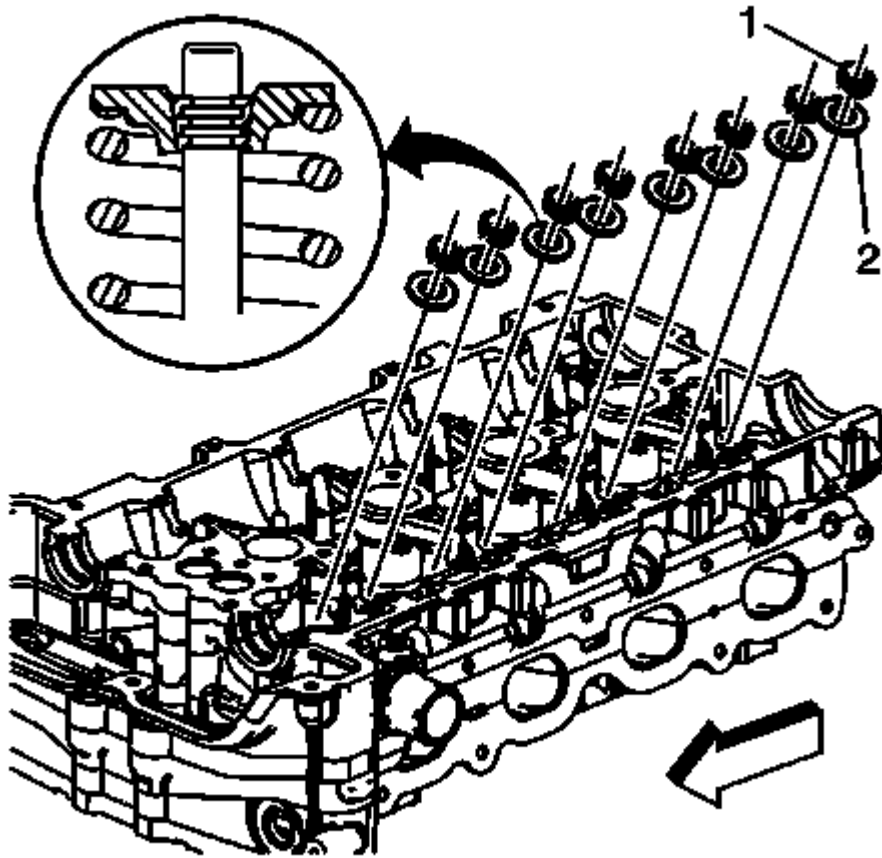
5. Install the NEW valve seals (1). Fully seat the seals on the valve guides.



**Fig. 141: View of Valve Springs**

Courtesy of GENERAL MOTORS COMPANY

6. Install the springs (1).



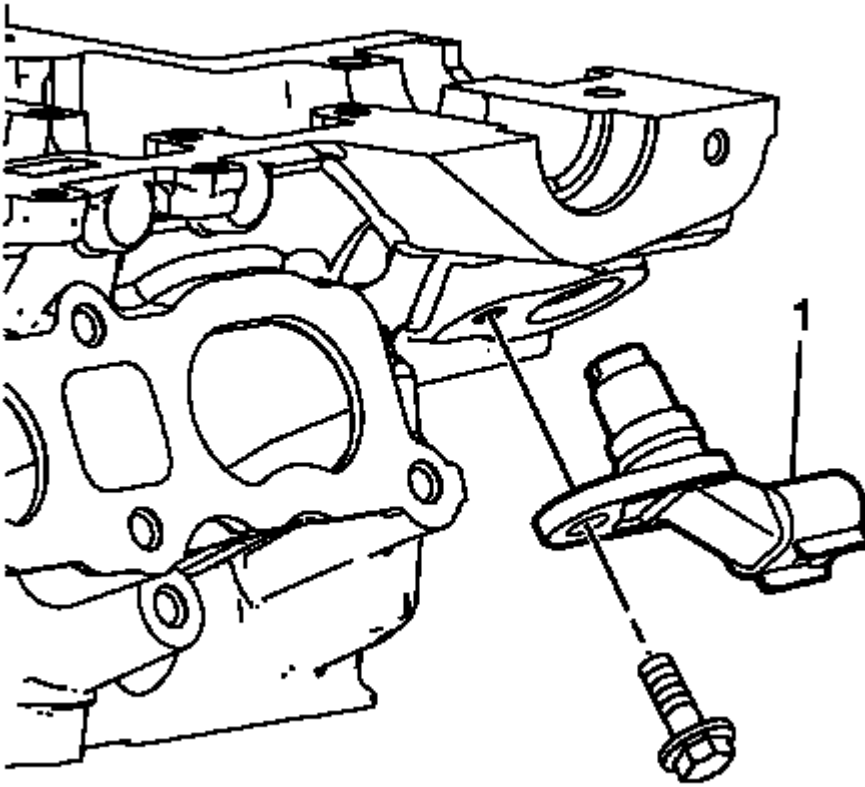
**Fig. 142: View of Valve Keys and Retainer**  
Courtesy of GENERAL MOTORS COMPANY

**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.

7. Install the retainers and keys using the following procedure:
  1. Install the retainer (2).
  2. Using the **EN-8062** compressor and the **EN-43963** compressor compress the valve spring.
  3. Install the valve keys (1).

4. Slowly release the **EN-8062** compressor and the **EN-43963** compressor (off car) from the valve/spring assembly.
5. Inspect for proper valve key seating.

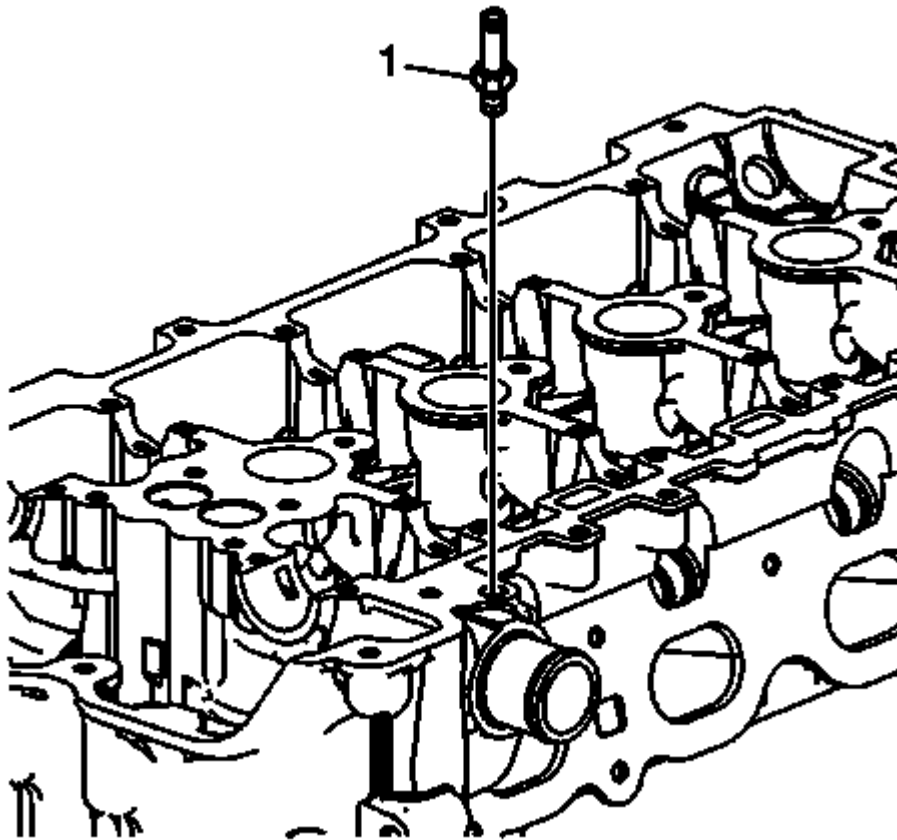


**Fig. 143: Intake Camshaft Position Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

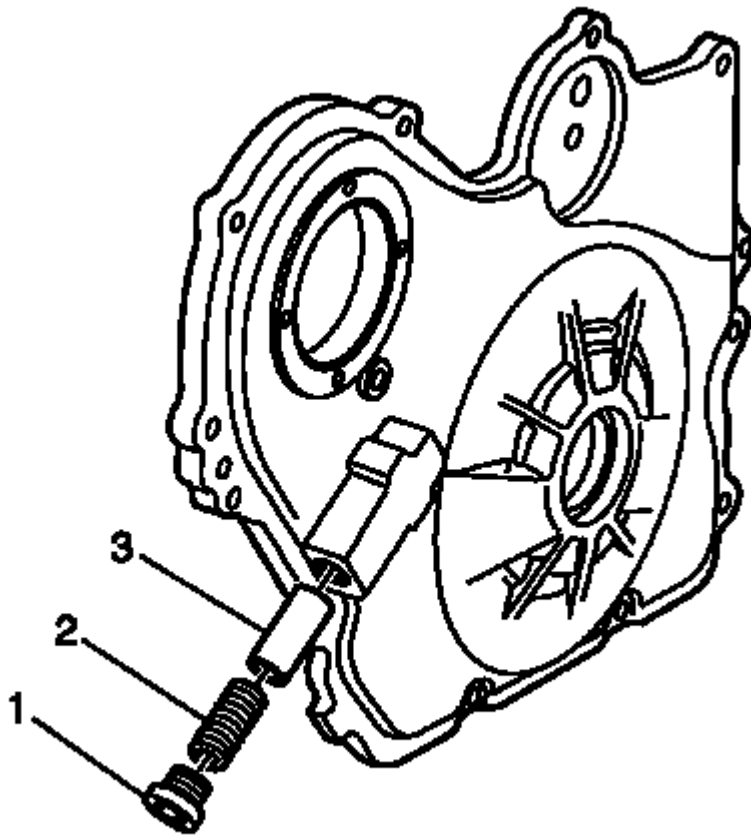
9. Install the intake camshaft position sensor (1) and bolt. Tighten the bolt to 10 N.m (89 lb in).



**Fig. 144: Identifying the Coolant Air Bleed Hose Fitting**  
Courtesy of GENERAL MOTORS COMPANY

10. Install the cylinder head air bleed tube (1) and tighten the tube to 15 N.m (11 lb ft).

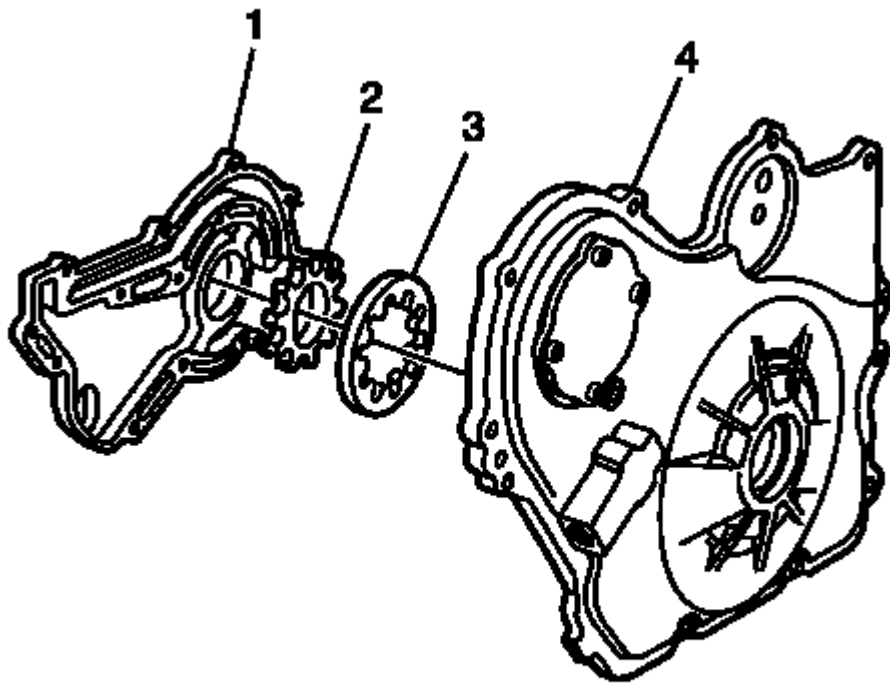
## OIL PUMP DISASSEMBLE



**Fig. 145: Pressure Relief Valve**

Courtesy of GENERAL MOTORS COMPANY

1. Remove the pressure relief plug (1), spring (2), and plunger (3).



**Fig. 146: Oil Pump Assembly**

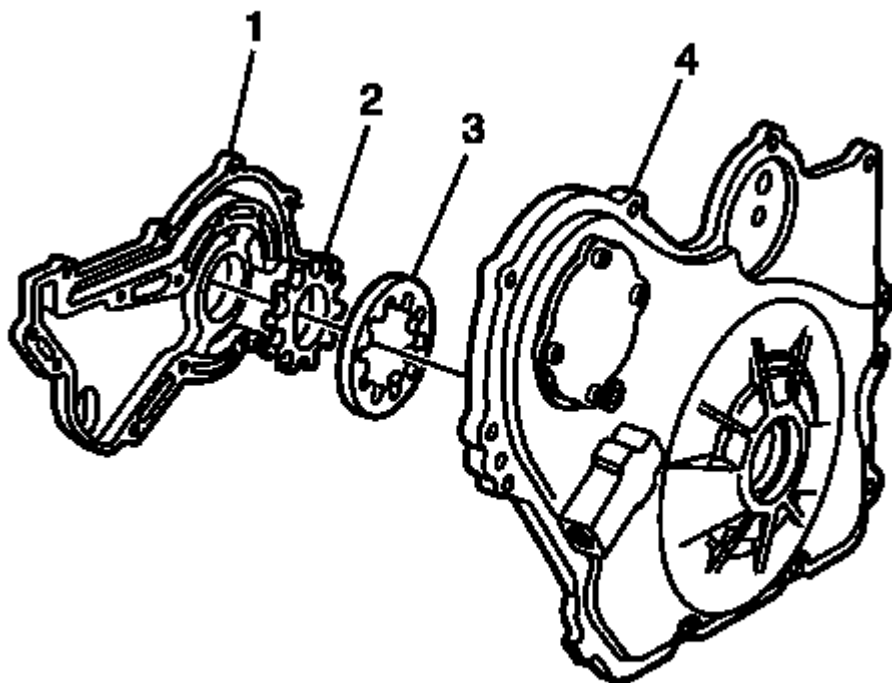
Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil pump gerotor cover (1) and bolts.
3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump (2, 3) for wear and scoring. Ensure that all components are within specifications. Refer to **Engine Mechanical Specifications (2.4L LEA)** .

Replace the front cover (4) and oil pump assembly if it is out of specification or damaged.

## OIL PUMP ASSEMBLE





**Fig. 147: Oil Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

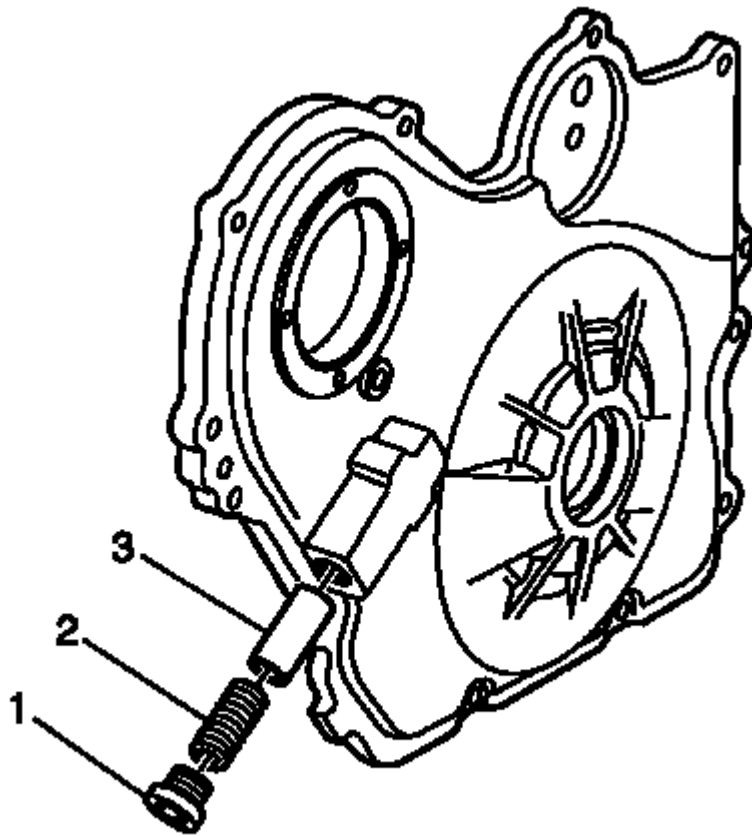
1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear (2) into the outer gear (3).

**NOTE:** If gears are improperly installed in the front cover, the gerotor cover will not bolt on.

3. Install the gears together into the front cover (4) with the hub of the center gear facing the front cover.

**CAUTION:** Refer to Fastener Caution .

4. Install the oil pump gerotor cover (1) and bolts and tighten to 6 N.m (53 lb in).



**Fig. 148: Pressure Relief Valve**

Courtesy of GENERAL MOTORS COMPANY

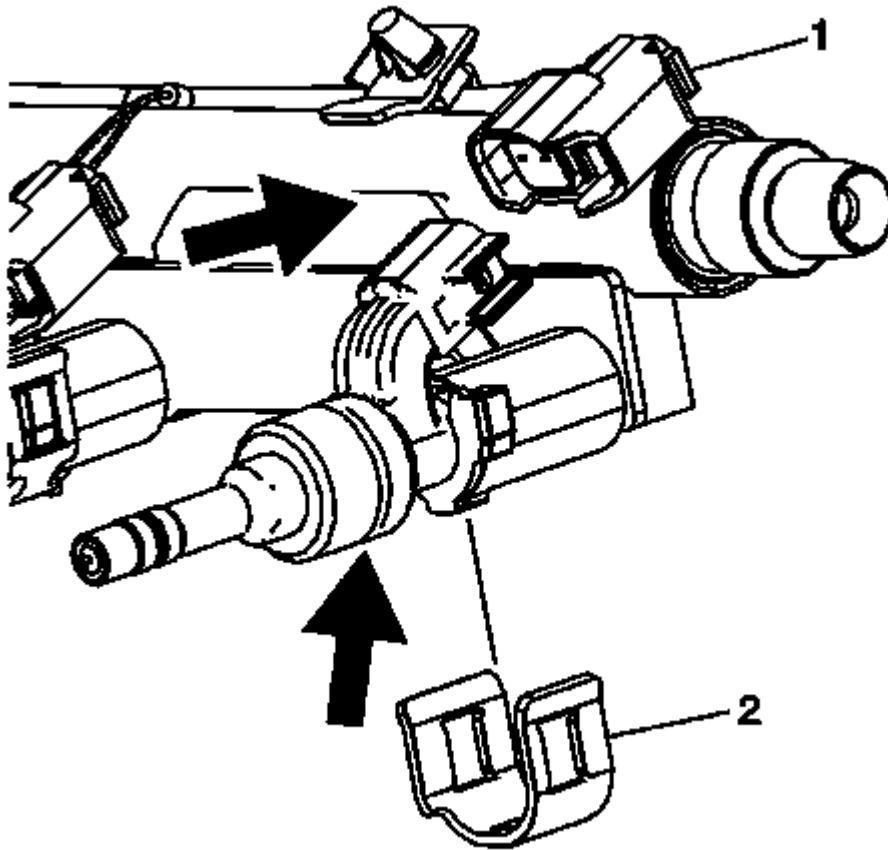
5. Install the pressure relief valve plunger (3).
6. Install the pressure relief valve spring (2).
7. Install and tighten the pressure relief valve plug (1) to 40 N.m (30 lb ft).

## FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

### Special Tools

- EN-48266 Fuel Injector Seal Installer and Sizer
- EN-49245-1 Fuel Injector Seal Installer and Sizer
- EN-49247 Injector Retaining Clip Installer

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



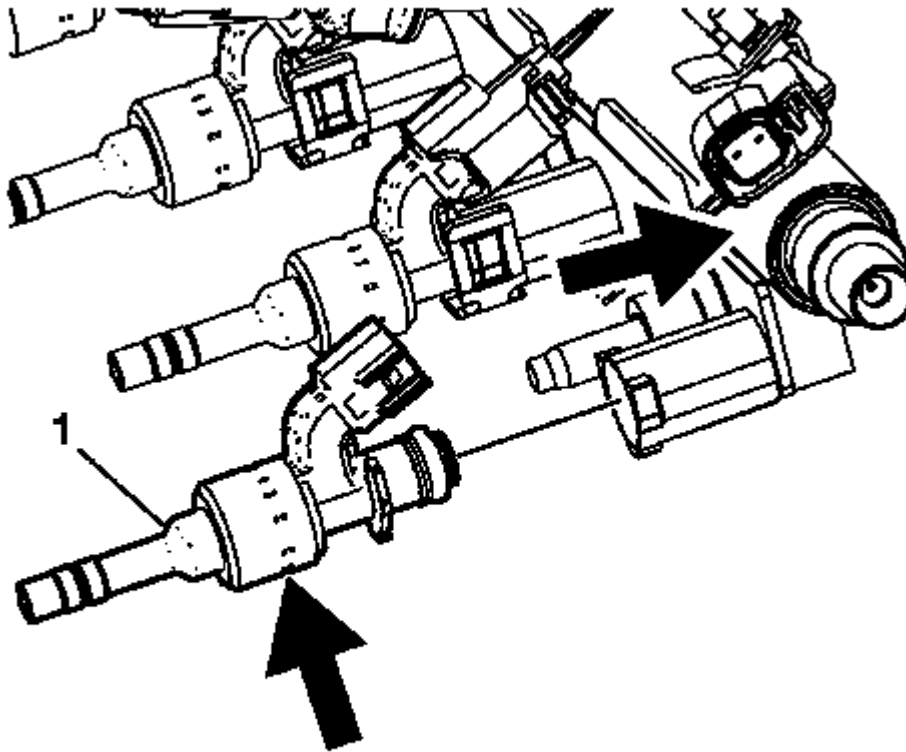
**Fig. 149: Fuel Injectors & Retainers**

Courtesy of GENERAL MOTORS COMPANY

1. Disconnect the electrical connections from the fuel injectors (1).

**NOTE:** Support the fuel rail along the bottom, indicated by the arrow. Support the fuel injector at the widest point, indicated by the arrow. DO NOT support or hold the fuel injector by the tip or connector when removing the fuel injector retainer.

2. Remove and discard the fuel injector retainer (2).



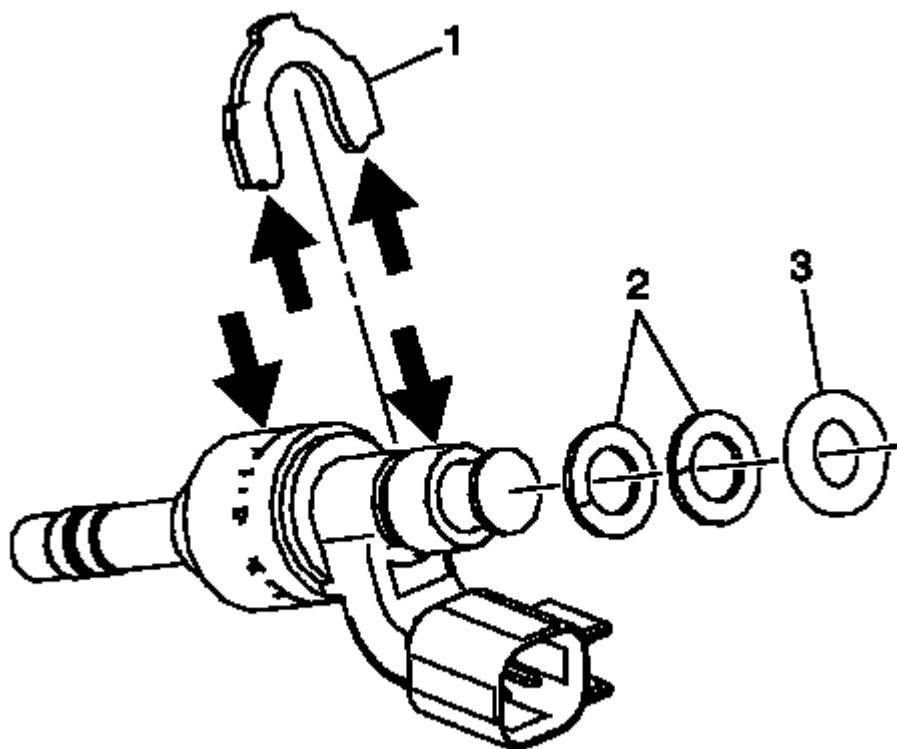
**Fig. 150: Supporting Fuel Injector**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Support the fuel injector at the widest point, indicated by the arrow. Support the fuel rail at the point indicated by the arrow.

- DO NOT support or hold the fuel injector by the tip or connector
- DO NOT tilt or excessively twist the injector during removal

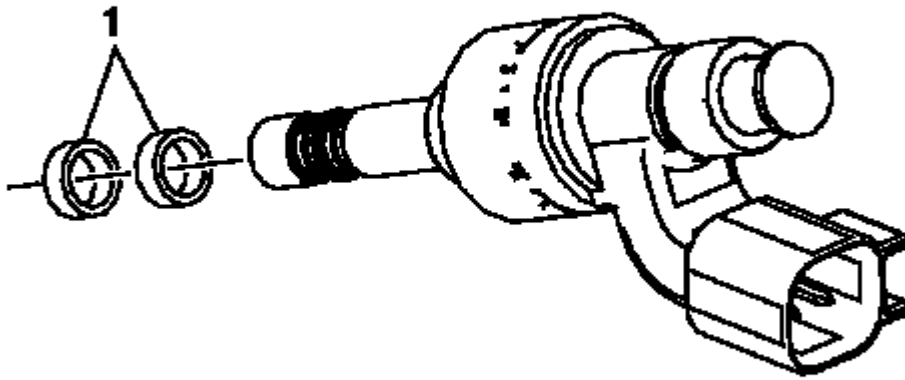
3. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable.



**Fig. 151: Fuel Injector Bushing, O-Ring And Spacers**  
 Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Support the fuel injector at the widest point, and directly behind the bushing location, indicated by the arrows. DO NOT support or hold the fuel injector by the tip or connector when removing the fuel injector bushing.

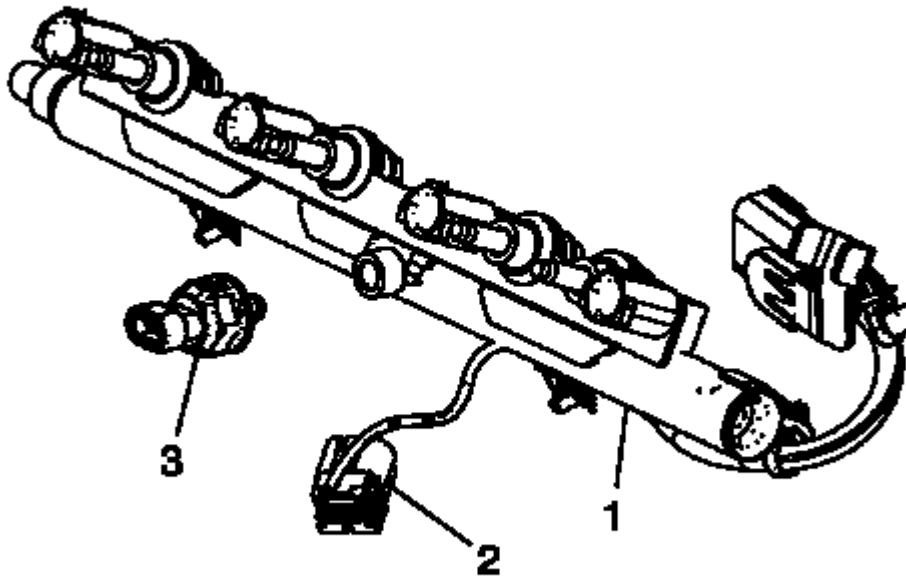
4. Using a suitable tool, remove the fuel injector bushing (1) by pushing straight off at the bushing tabs, indicated by the arrows. Discard the bushing.
5. Remove and discard the fuel injector O-ring (3) and plastic spacers (2).



**Fig. 152: Fuel Injector Seals**

Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the fuel injector seals (1).



**Fig. 153: Fuel Rail, Connector & Pressure Sensor**  
Courtesy of GENERAL MOTORS COMPANY

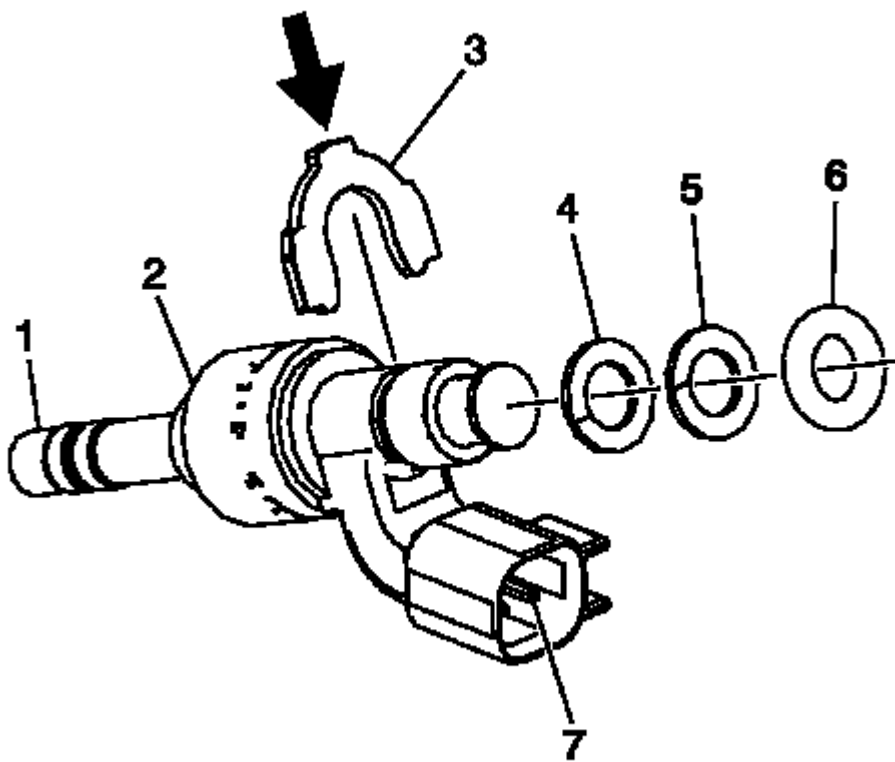
**NOTE:** Do not soak or submerge the fuel rail or injectors in solvent.

7. Clean the exterior of the fuel rail (1) and injectors in solvent.
8. 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
9. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

**CAUTION:** Refer to Fastener Caution .

10. 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. 154: Fuel Injector Components**

Courtesy of GENERAL MOTORS COMPANY

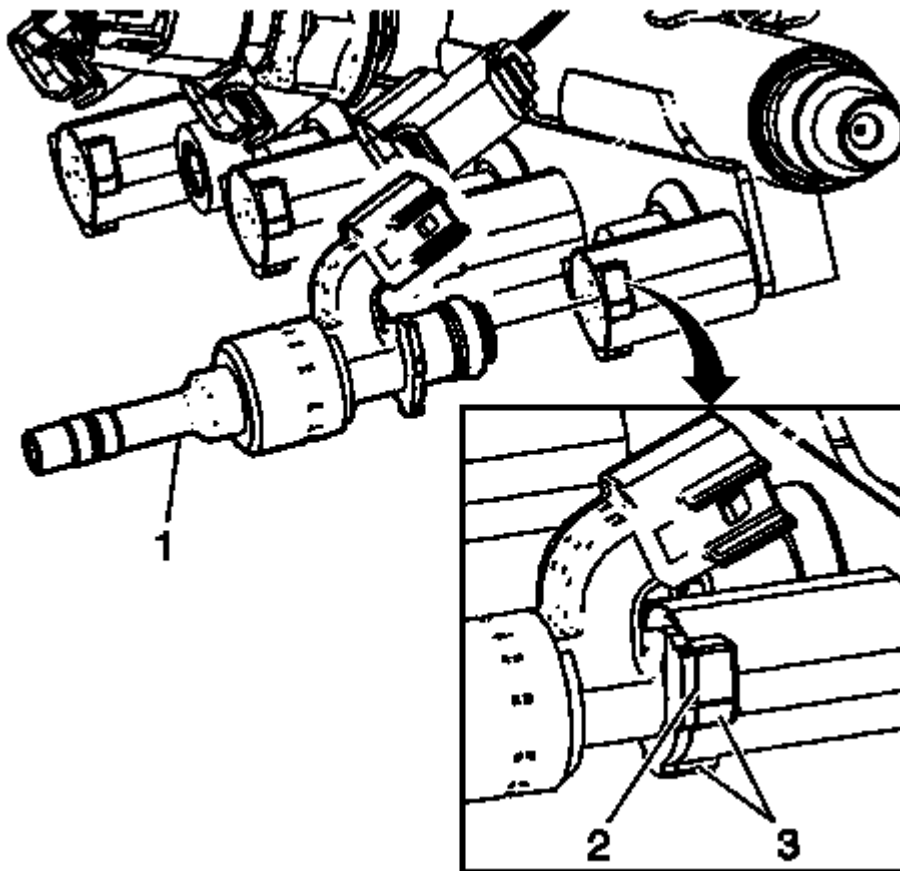
11. Inspect the fuel injectors for the following conditions:
  - Damage to the fuel injector connector (7)
  - Damage to the fuel injector harness connector
  - Damage to the fuel injector tip (1)
  - Damage to the tolerance ring (2)
12. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.



13. Install a new fuel injector bushing (3) onto the fuel injector. The bushing should seat with a distinct "snap" sound and feel.

**NOTE:**        **DO NOT** reverse the order of the plastic spacers. Identify the correct order in which the new plastic spacers are installed by the color of the spacer.

14. Install the new white plastic spacer (4) on the fuel injector first.
15. Install the new brown plastic spacer (5) second.
16. Lubricate the new O-ring (6) with 5W30 engine oil.
17. Install the O-ring on the injector.

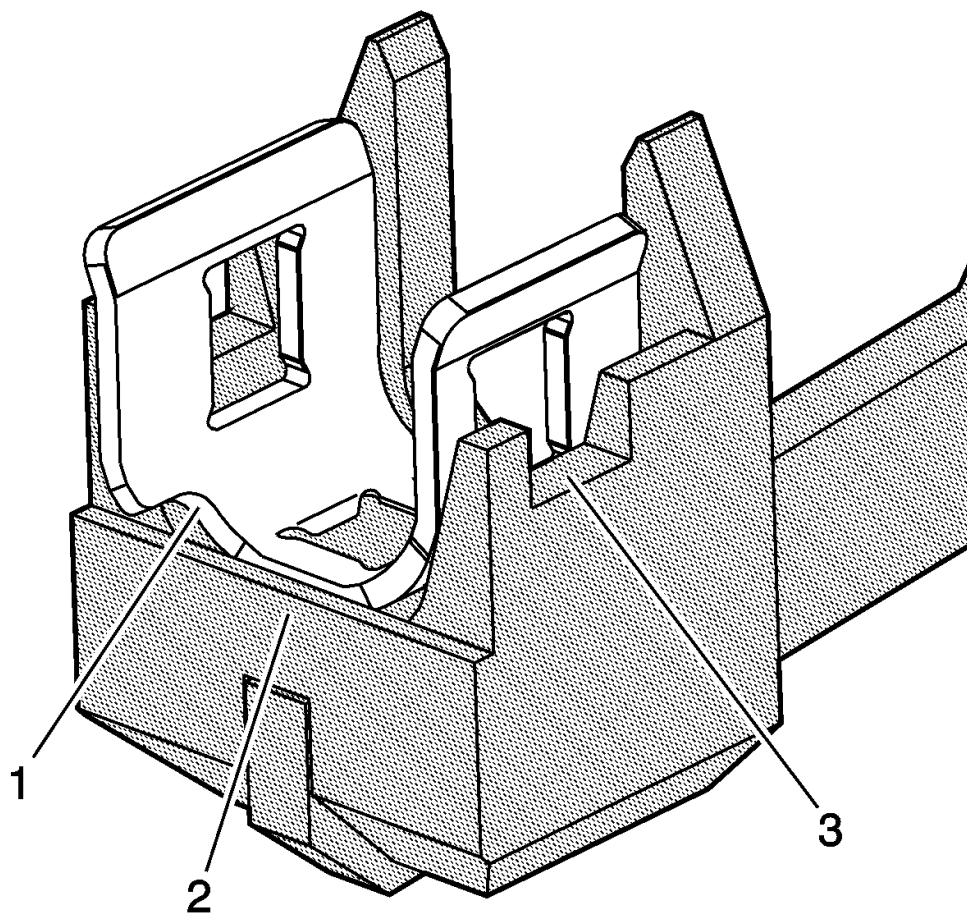


**Fig. 155: Fuel Injectors**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:**        **The injector must be fully installed and properly aligned with the fuel rail in order to install the retainer.**

18. Install the fuel injectors (1) into the fuel rail.
  - Ensure the fuel injector is fully seated in the fuel rail, and no gaps are present (2).
  - Ensure the injector and fuel rail flanges are aligned (3)



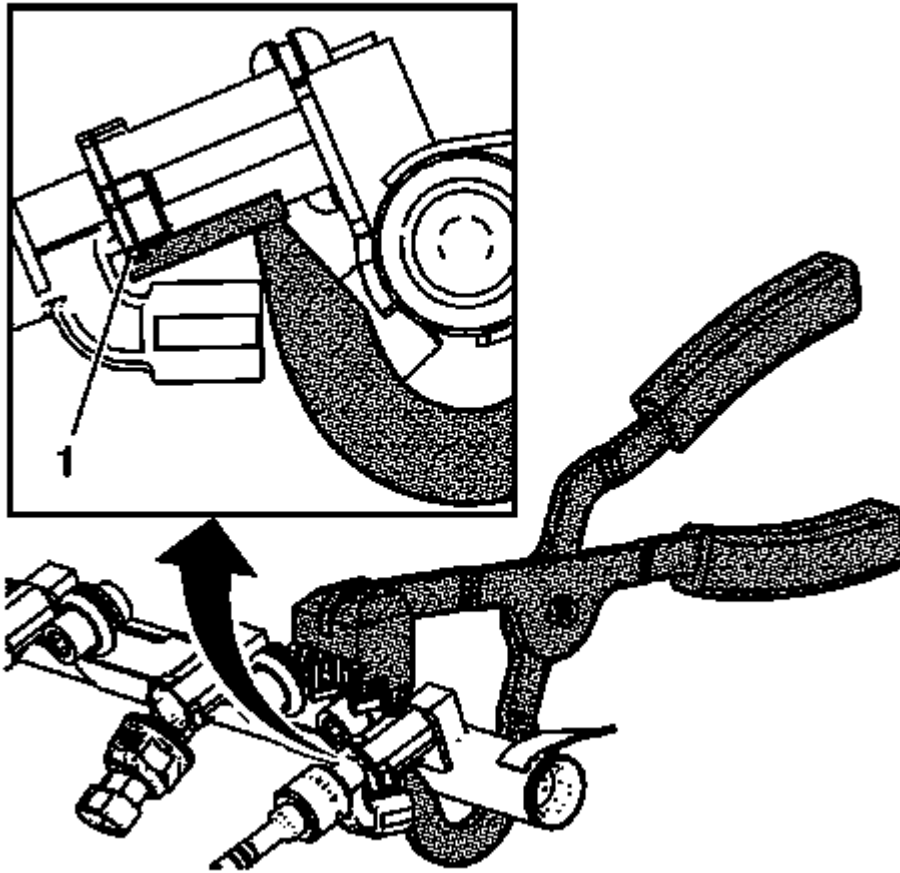
**Fig. 156: Retainer Installer**

Courtesy of GENERAL MOTORS COMPANY

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

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

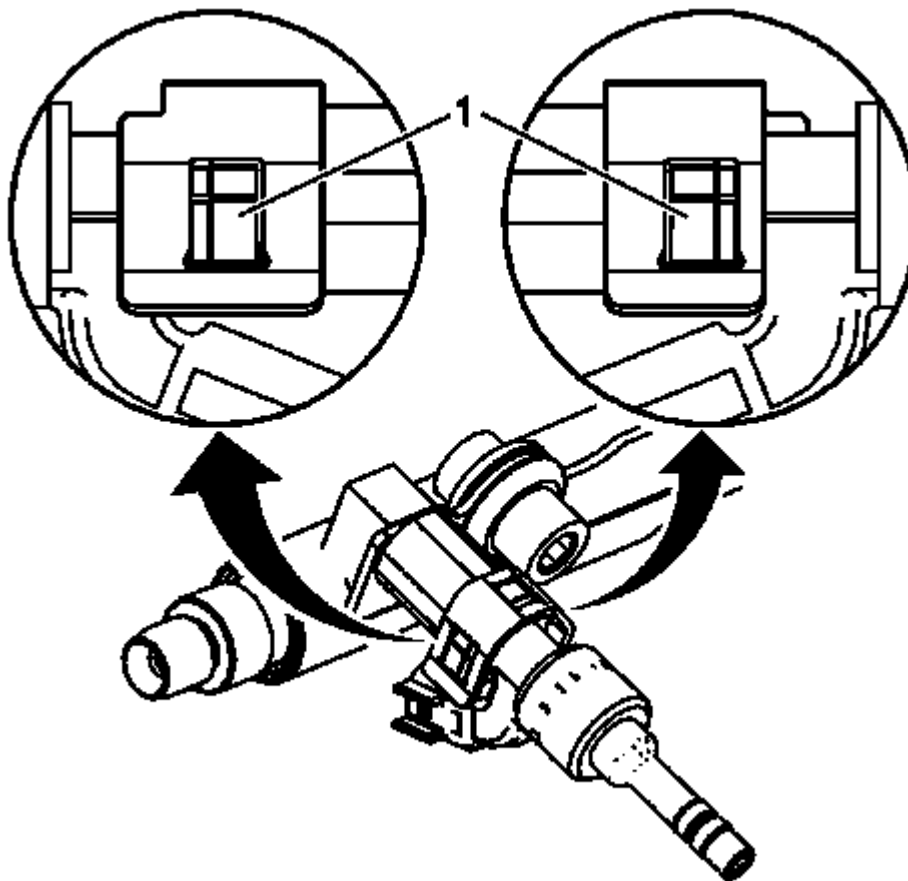
19. Install the fuel injector retainer onto the **EN-49247** installer.



**Fig. 157: Installing Fuel Injector Retainer**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ensure the tool is resting on the flange of the injector bushing (1).

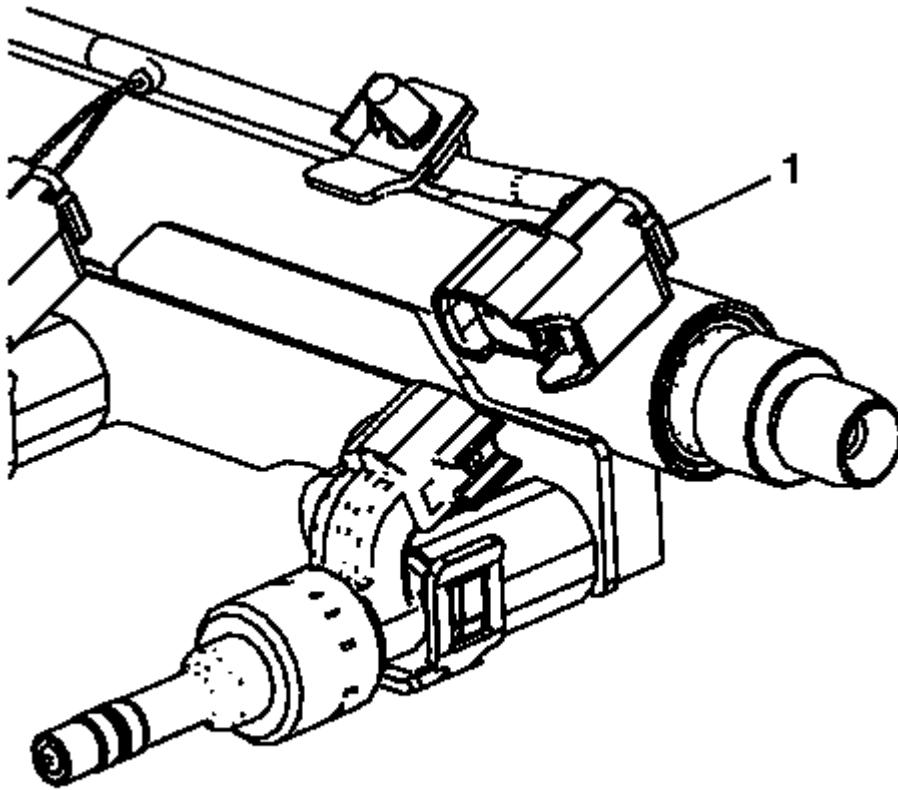
20. Using **EN-49247** installer install the fuel injector retainer.



**Fig. 158: Proper Injector Retainer Installation**  
 Courtesy of GENERAL MOTORS COMPANY

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

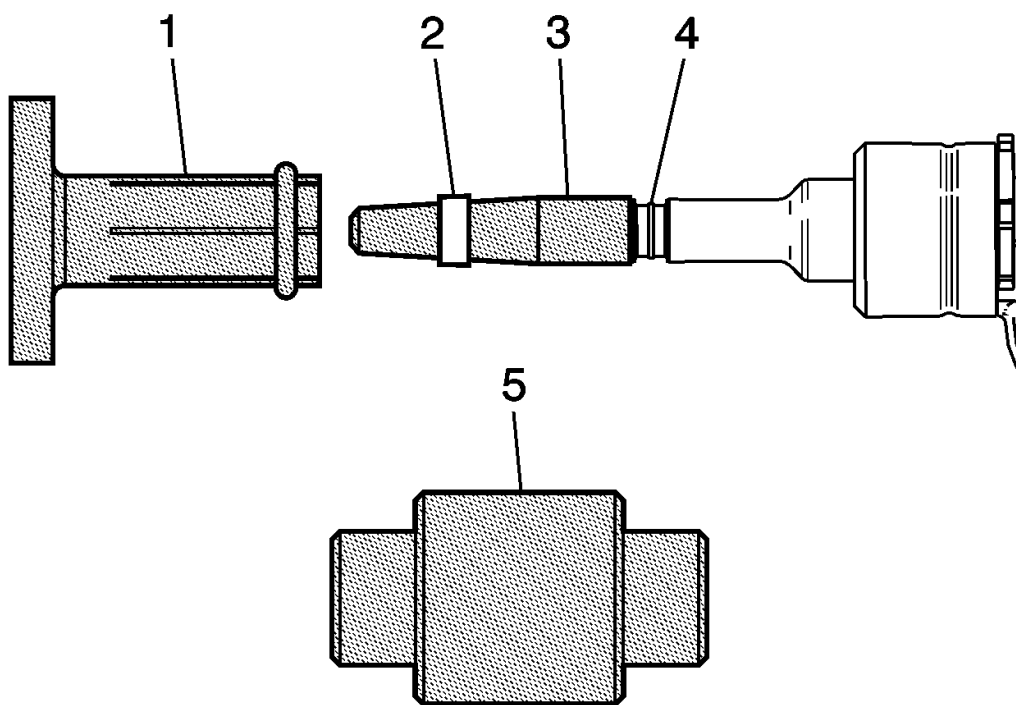
21. Inspect each installed fuel injector retainer, and ensure the retainer is fully seated on the fuel rail and fuel injector bushing flanges (1). The flanges on each side and at the top of the fuel injector should seat completely into the window on the retainer.



**Fig. 159: Fuel Rail Harness Connector**

Courtesy of GENERAL MOTORS COMPANY

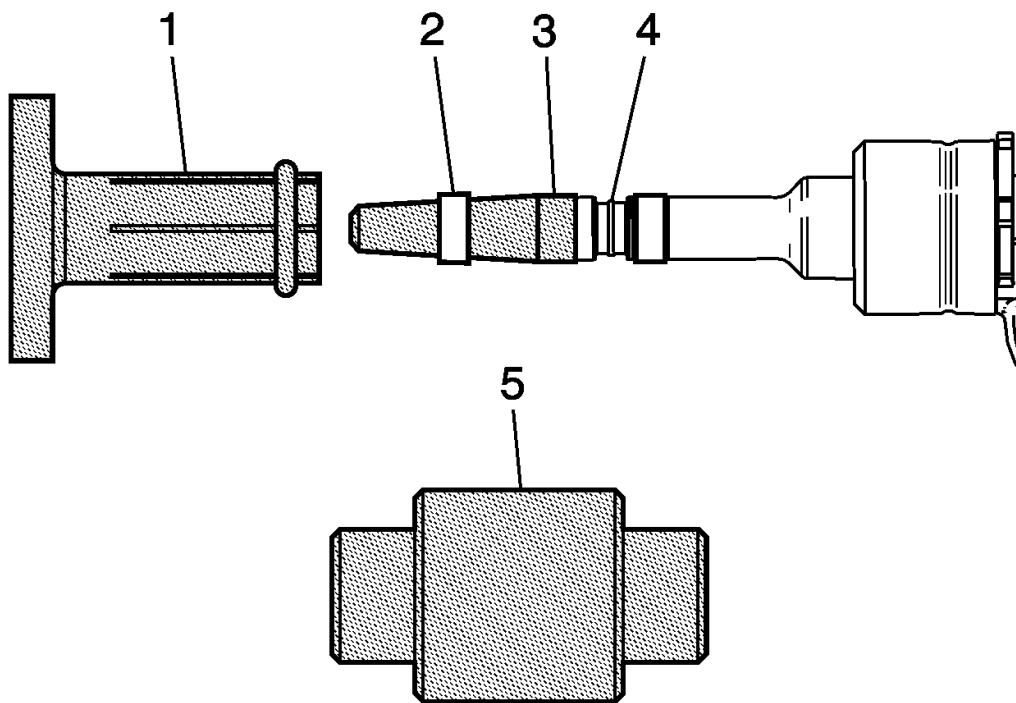
22. Connect the electrical connection to the fuel rail.
23. Connect the fuel rail harness connectors (1) to the fuel injectors.



**Fig. 160: Installing Seals With Long Protector**  
Courtesy of GENERAL MOTORS COMPANY

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

24. Install **EN-49245-1** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on **EN-49245-1** long protector.
25. Compress the seal with your fingers, then resize the seal using the **EN-48266** sizer (5).

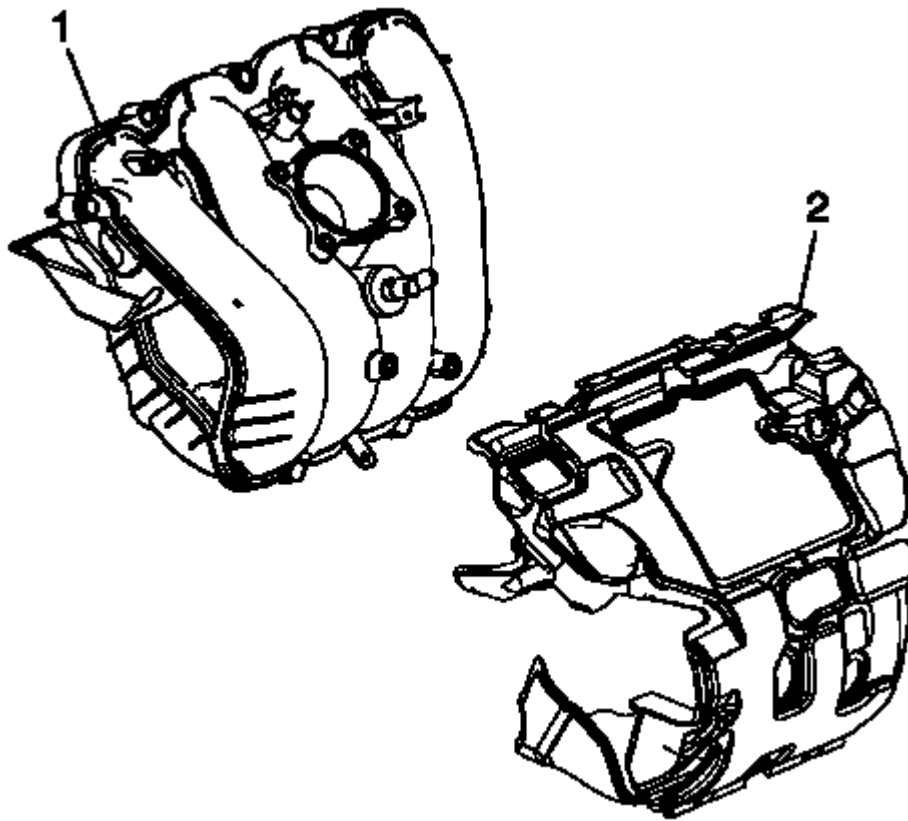


**Fig. 161: Installing Seals With Short Protector**  
Courtesy of GENERAL MOTORS COMPANY

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

26. Install **EN-48266** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-48266** short protector.
27. Install the seal into the first recessed area (4) of the fuel injector.
28. Compress the seal with your fingers, then resize the seal using the **EN-48266** sizer (5).

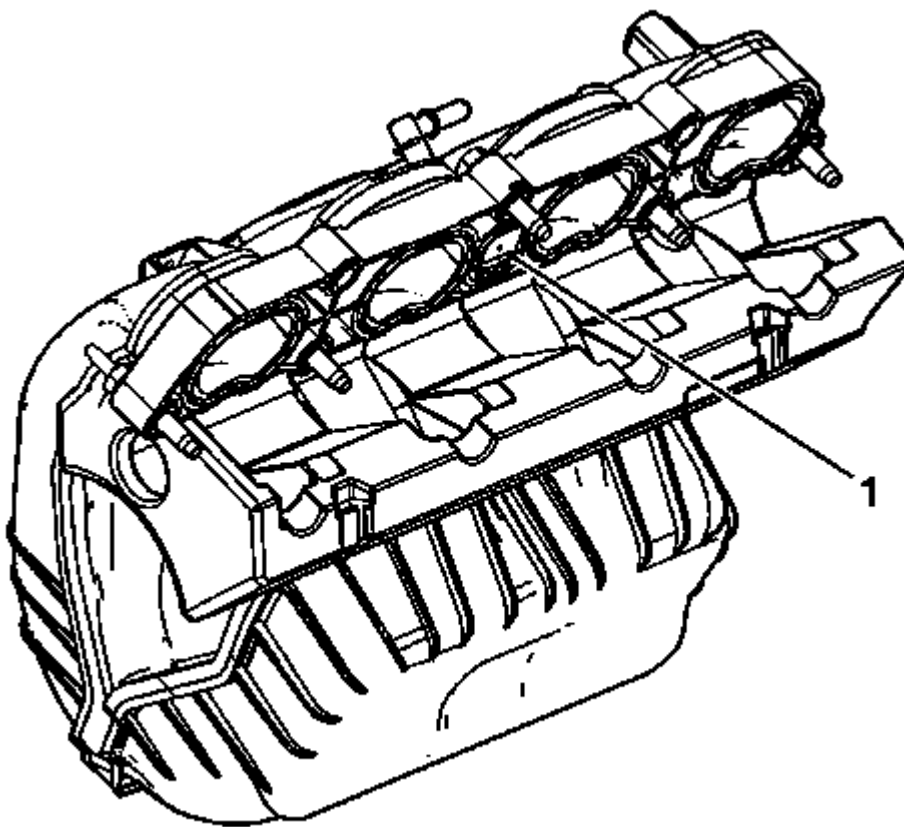
#### INTAKE MANIFOLD CLEANING AND INSPECTION (2.4L LEA)



**Fig. 162: Intake Manifold And Intake Manifold Insulator**  
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.
4. Clean and inspect the intake manifold insulator (2) for damage.





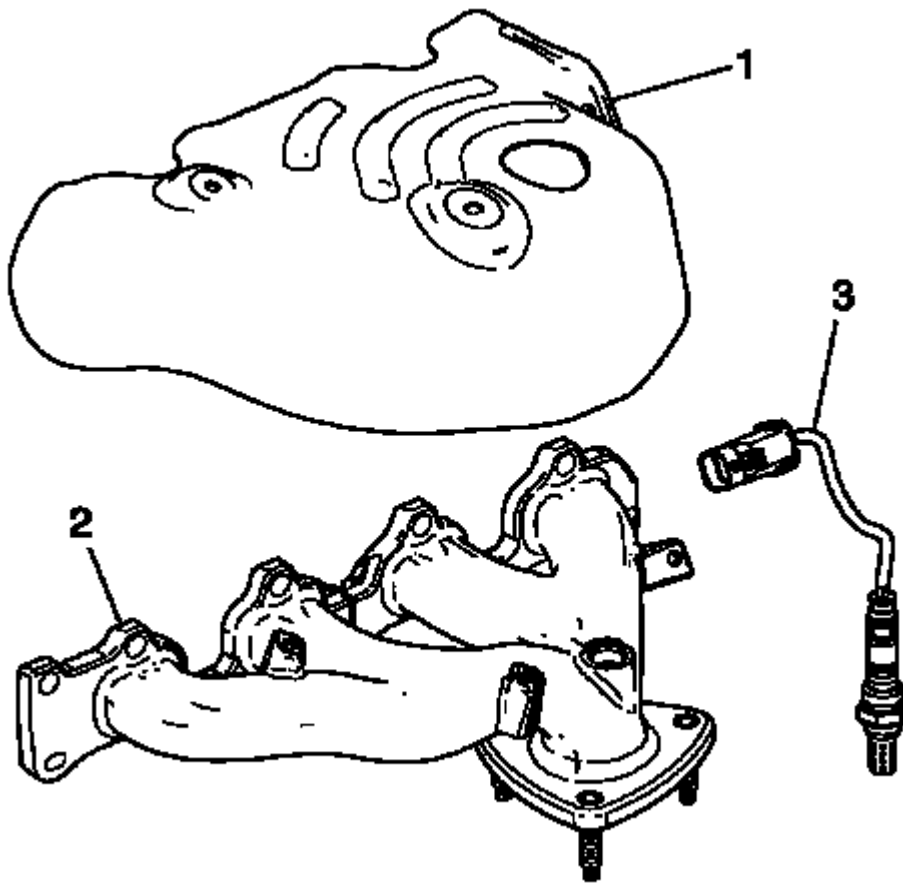
**Fig. 163: Crankcase Ventilation Passages**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

## **EXHAUST MANIFOLD CLEANING AND INSPECTION**



**Fig. 164: Exhaust Manifold & Oxygen Sensor**  
Courtesy of GENERAL MOTORS COMPANY

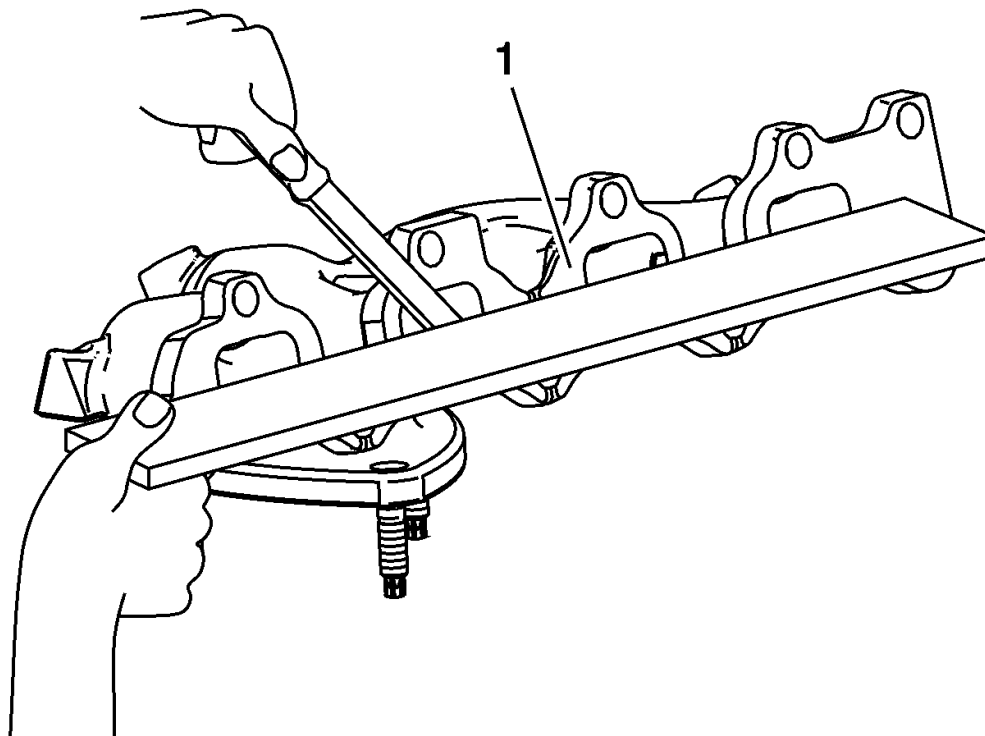
**NOTE:**

- 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 (3) from the manifold.
2. Clean the exhaust manifold (2) in solvent.

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

3. Dry the exhaust manifold with compressed air.
4. Inspect the heat shield (1) for damage.

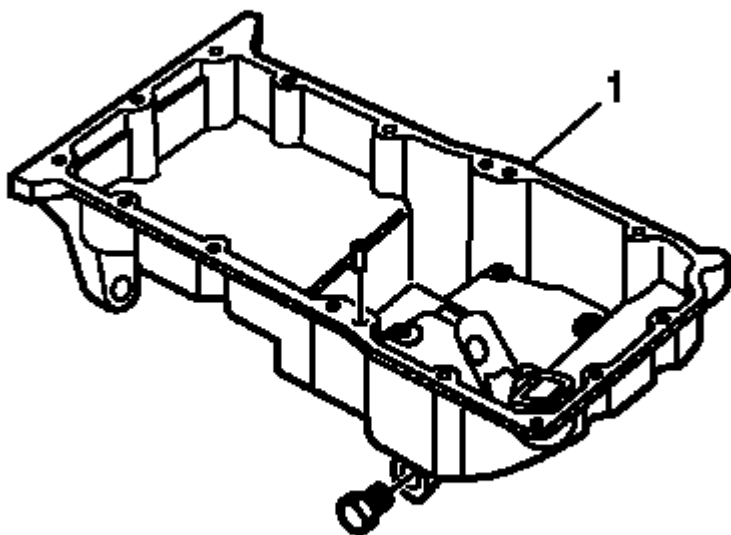


**Fig. 165: Measuring Exhaust Manifold Mounting Face**  
Courtesy of GENERAL MOTORS COMPANY

5. 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. 166: Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

1. Clean the oil pan mating surface.
2. Clean the oil pan (1). Remove all the sludge and the oil deposits.
3. Inspect the threads for the engine oil drain plug.
4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
5. Inspect the oil pan for cracking resulting from impact or flying road debris.

**NOTE:**        **The oil pan baffle and pickup screen are not removable from the oil pan.**

6. Inspect the oil pan baffle and pickup screen.
7. Repair or replace the oil pan as necessary.

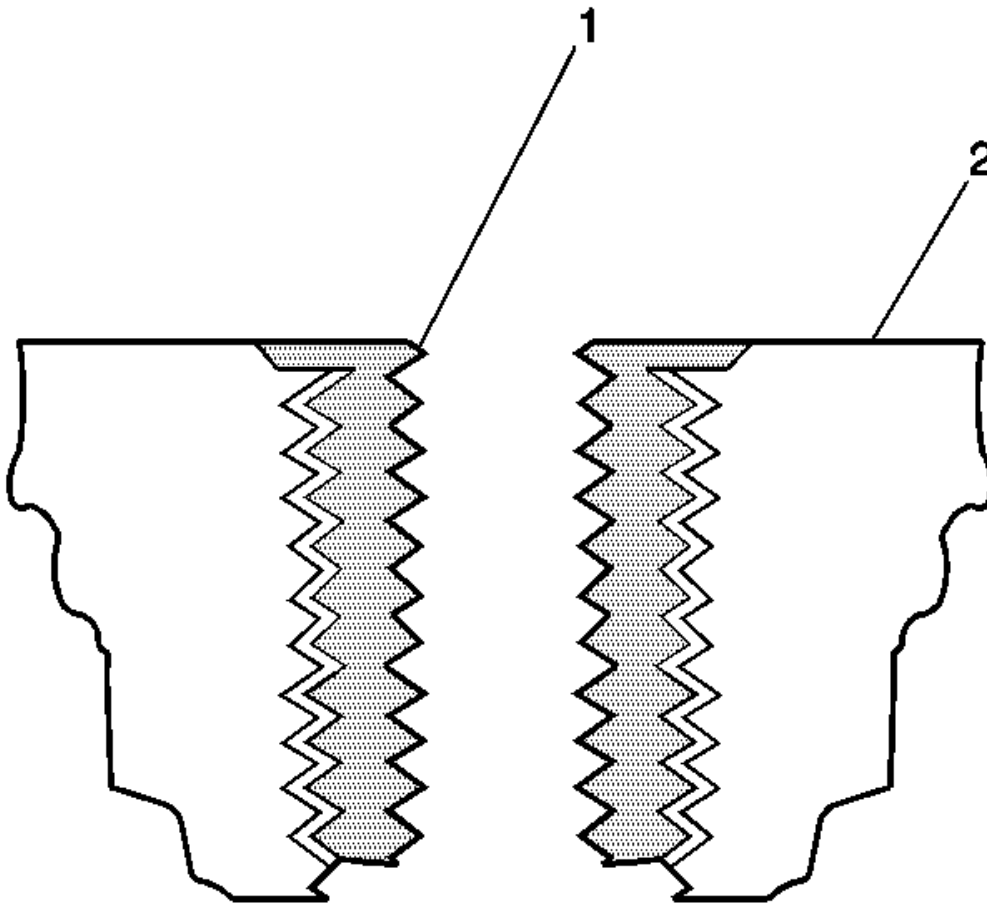
## **THREAD REPAIR**

### **Special Tools**

**EN 42385-850** Thread Repair Kit

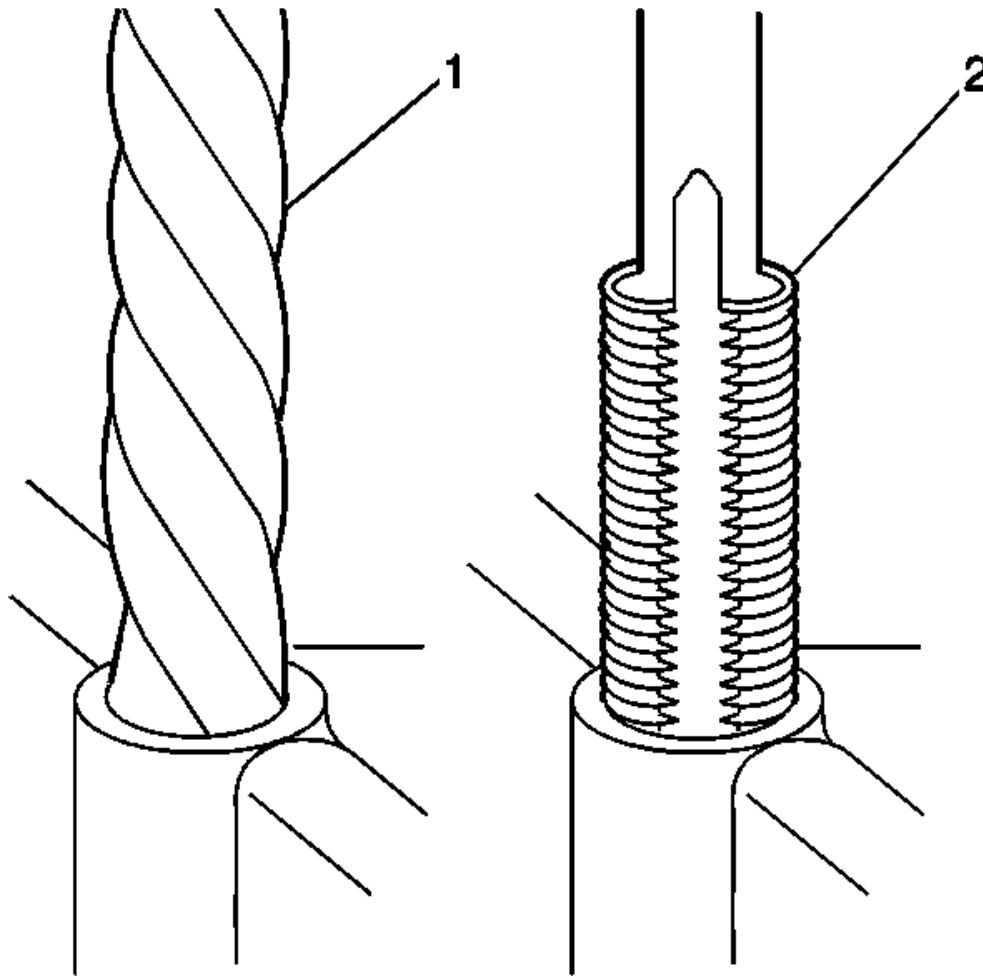
For equivalent regional tools, refer to **Special Tools** .

### General Thread Repair



**Fig. 167: 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. 168: 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 .

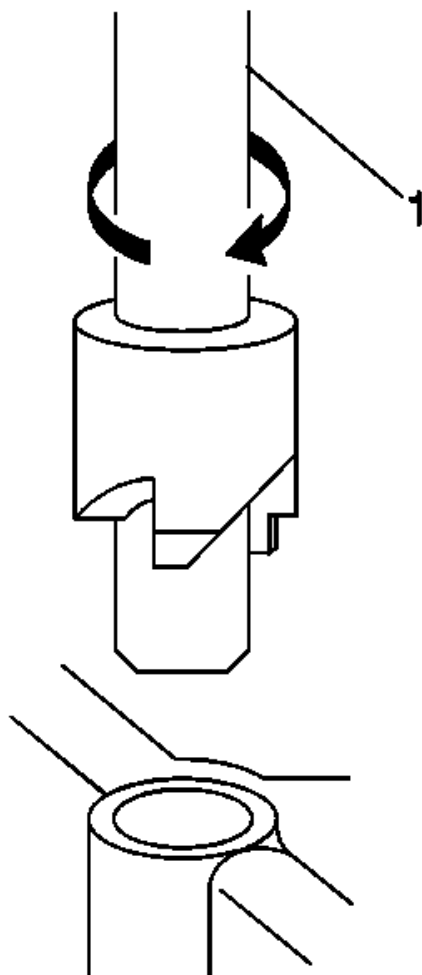
**Driver oil MUST be used on the installer driver tool.**

**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).

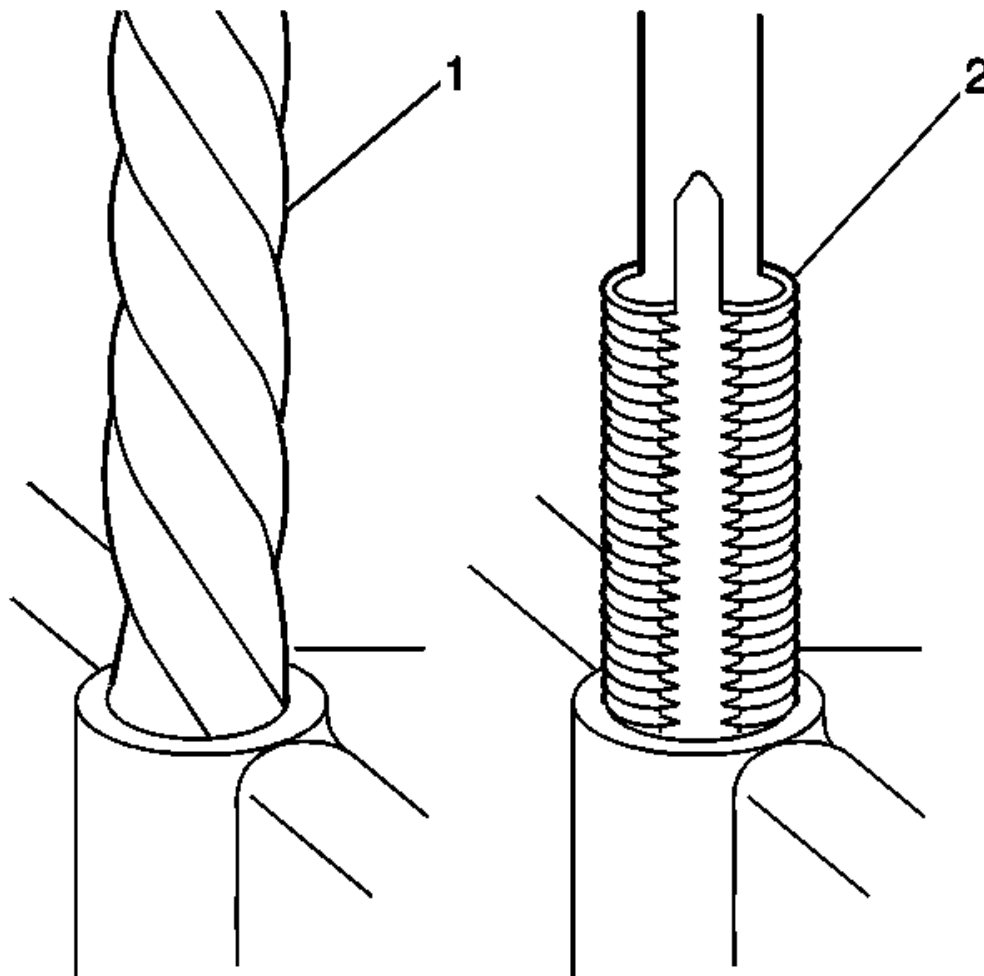
**WARNING:** Refer to Safety Glasses and Compressed Air Warning .

2. Using compressed air, clean out any chips.



**Fig. 169: 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. 170: 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).

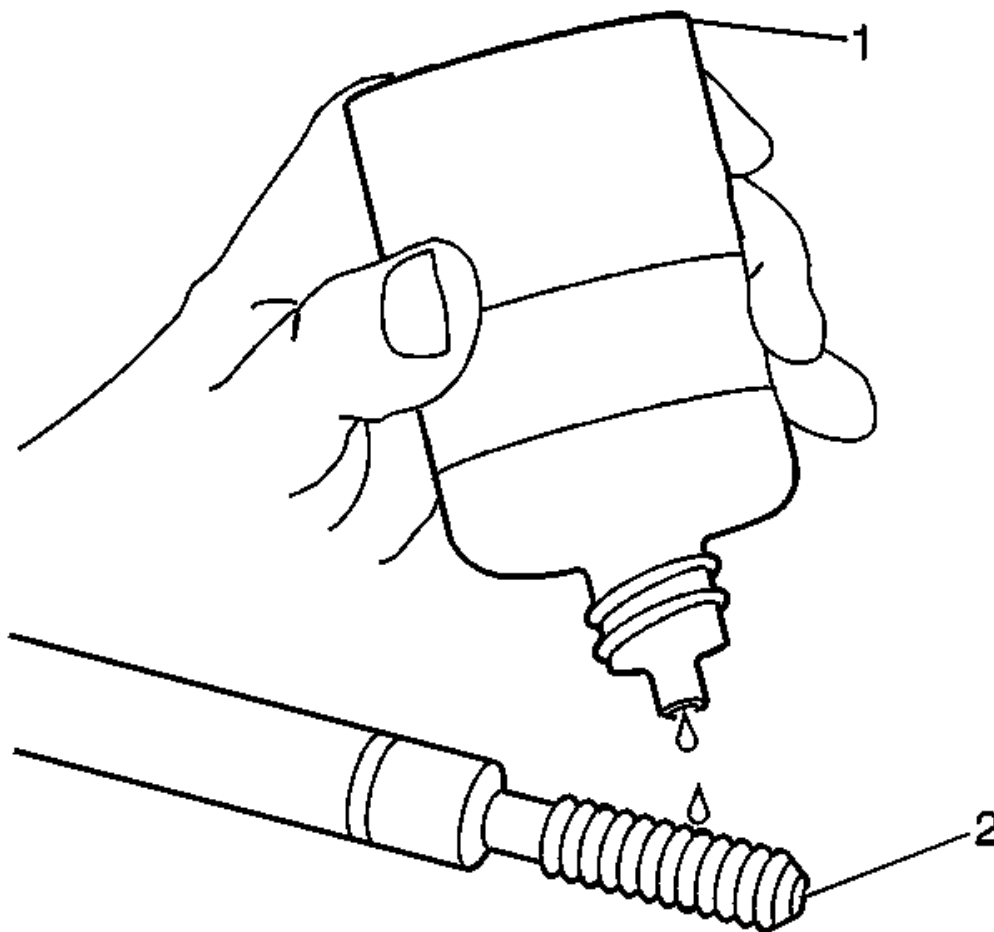
**WARNING:** Refer to Safety Glasses and Compressed Air Warning .

**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.

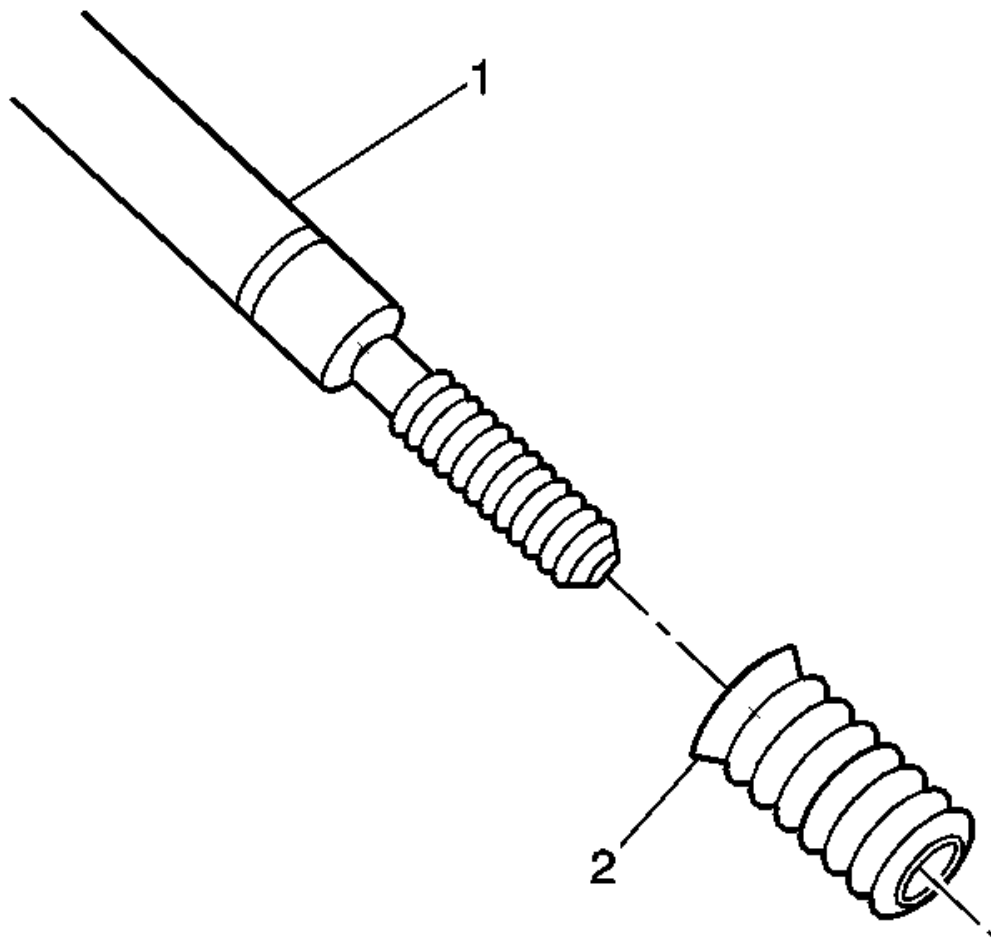


**Fig. 171: Lubricating Installer Tool Using Driver Oil**

Courtesy of GENERAL MOTORS COMPANY

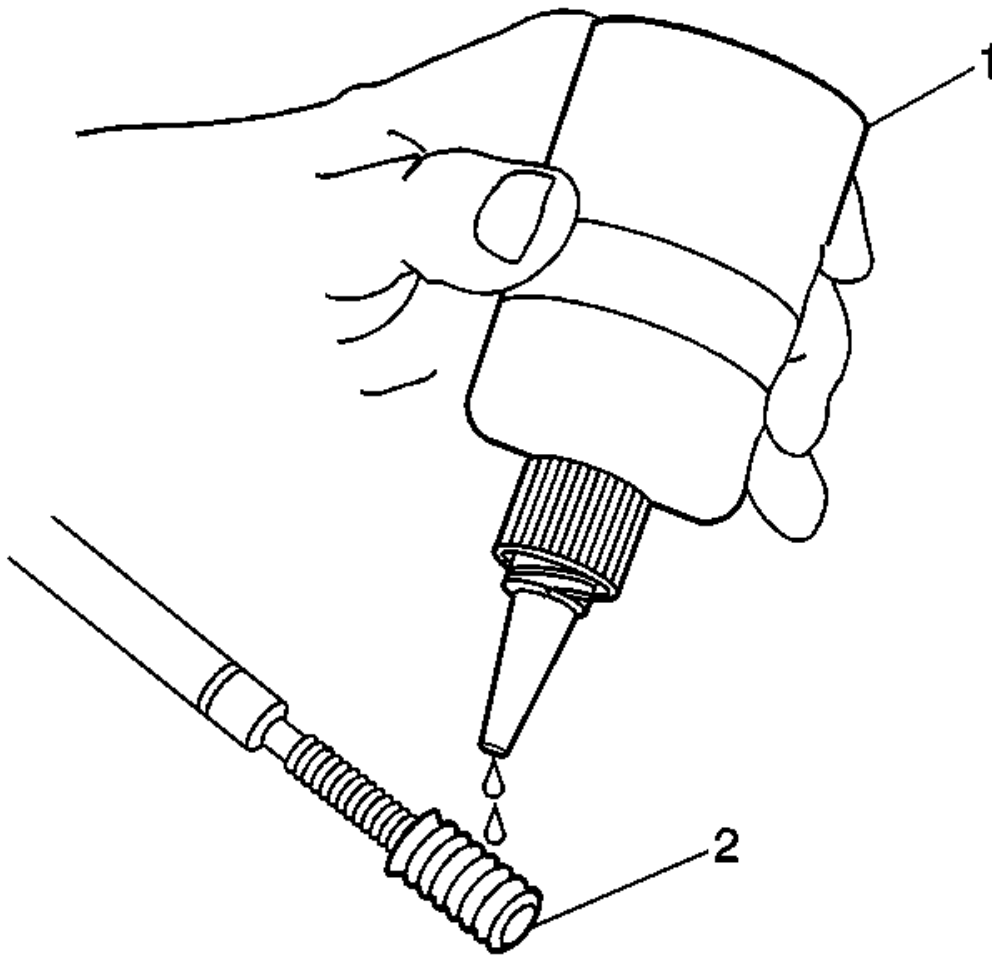
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



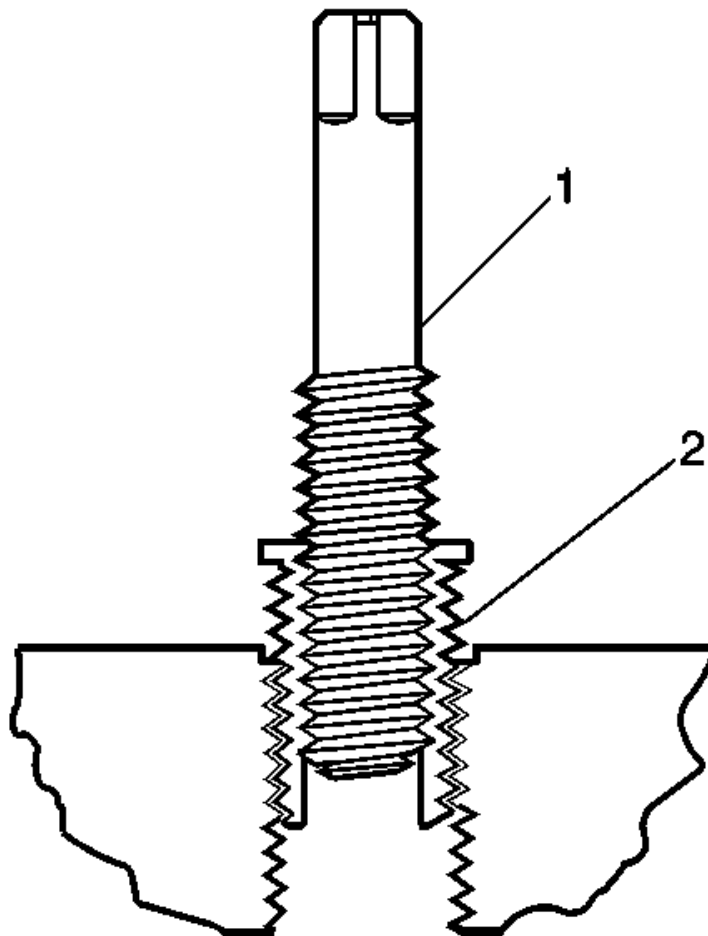
**Fig. 172: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 173: 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).

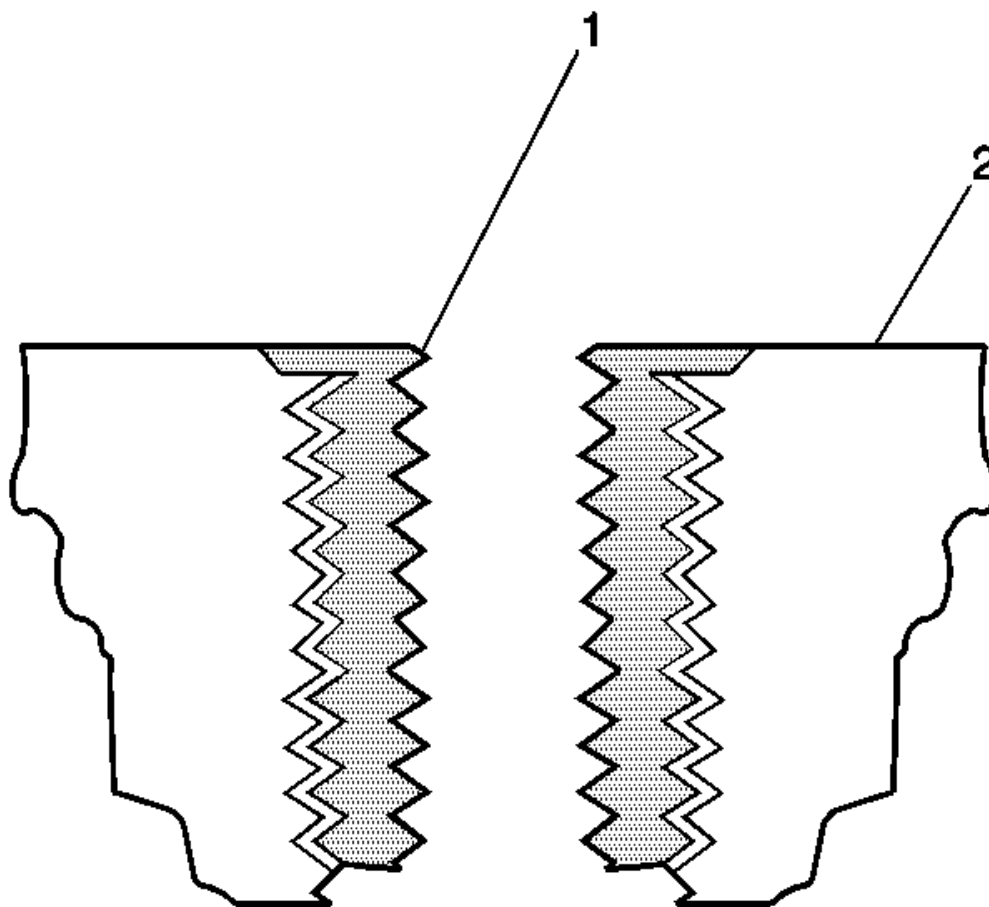


**Fig. 174: View Of Insert In Tapped Bolt Hole**  
Courtesy of GENERAL MOTORS COMPANY

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.

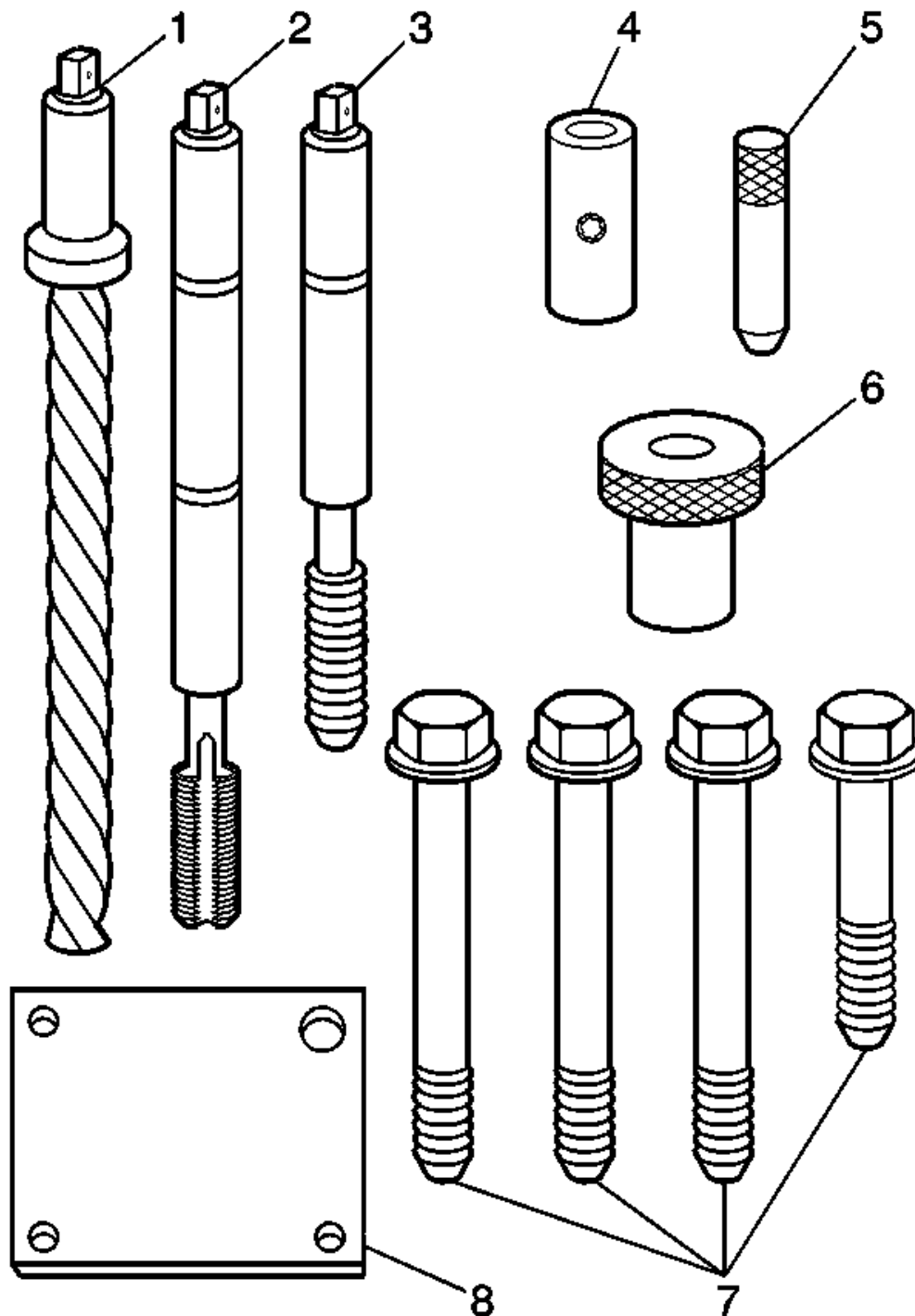


**Fig. 175: View Of Bushing Type Insert & Base Material**  
Courtesy of GENERAL MOTORS COMPANY

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).

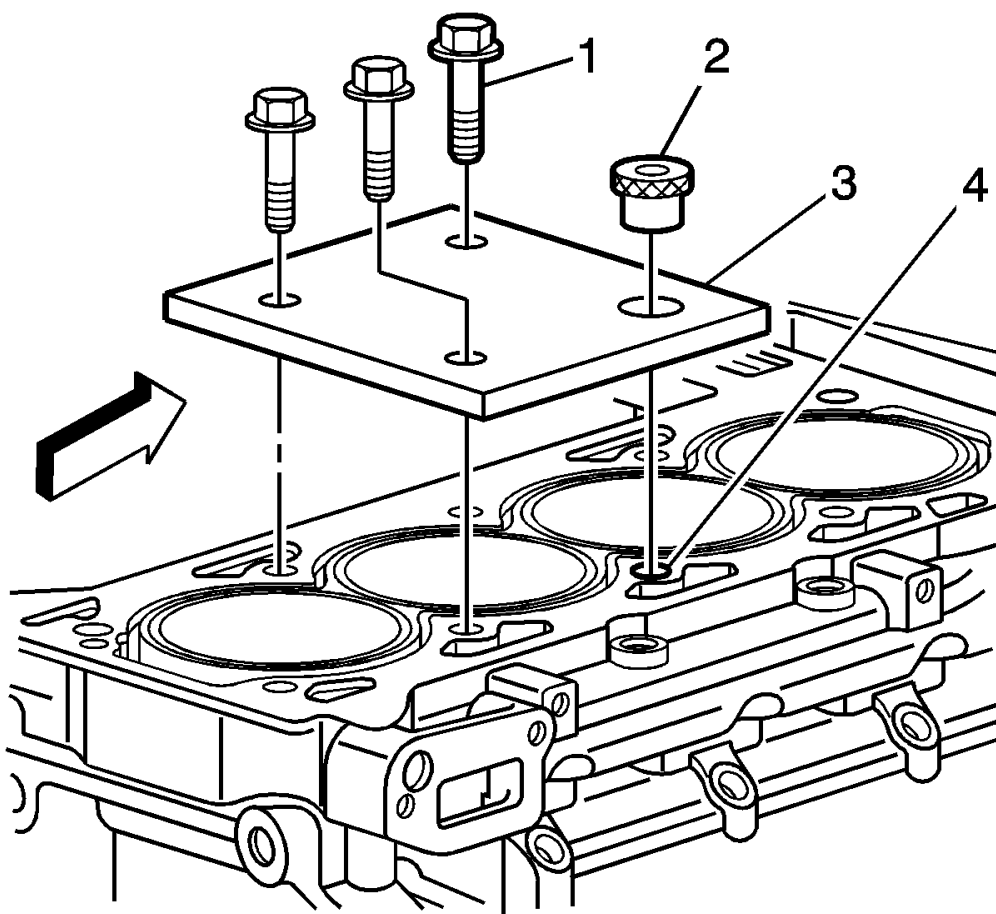
#### **Cylinder Head Bolt Hole Thread Repair**



**Fig. 176: Identifying Thread Repair Kit Components**  
 Courtesy of GENERAL MOTORS COMPANY

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. 177: Installing Fixture Plate, Bolts, & Bushing**  
Courtesy of GENERAL MOTORS COMPANY

**WARNING: Refer to Safety Glasses and Compressed Air Warning .**

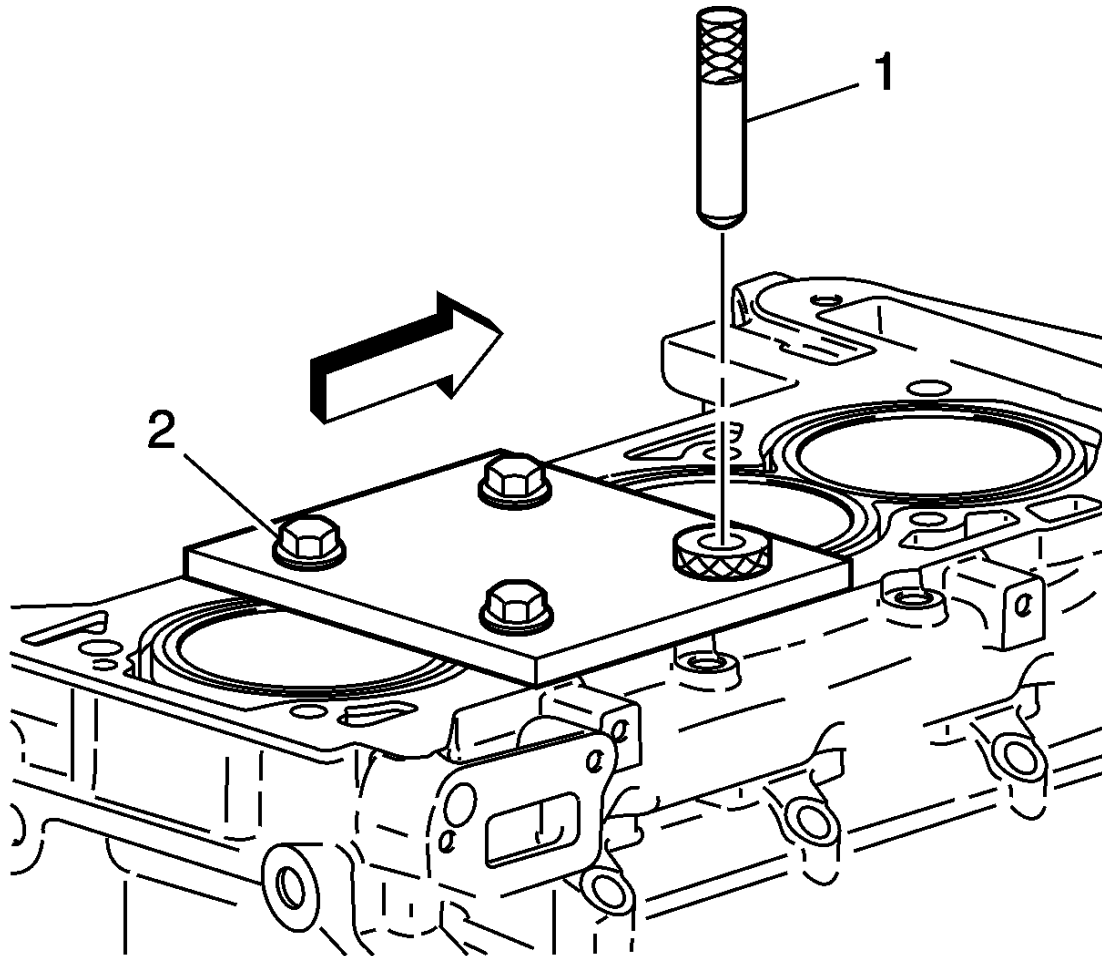
**NOTE:** The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers .

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).

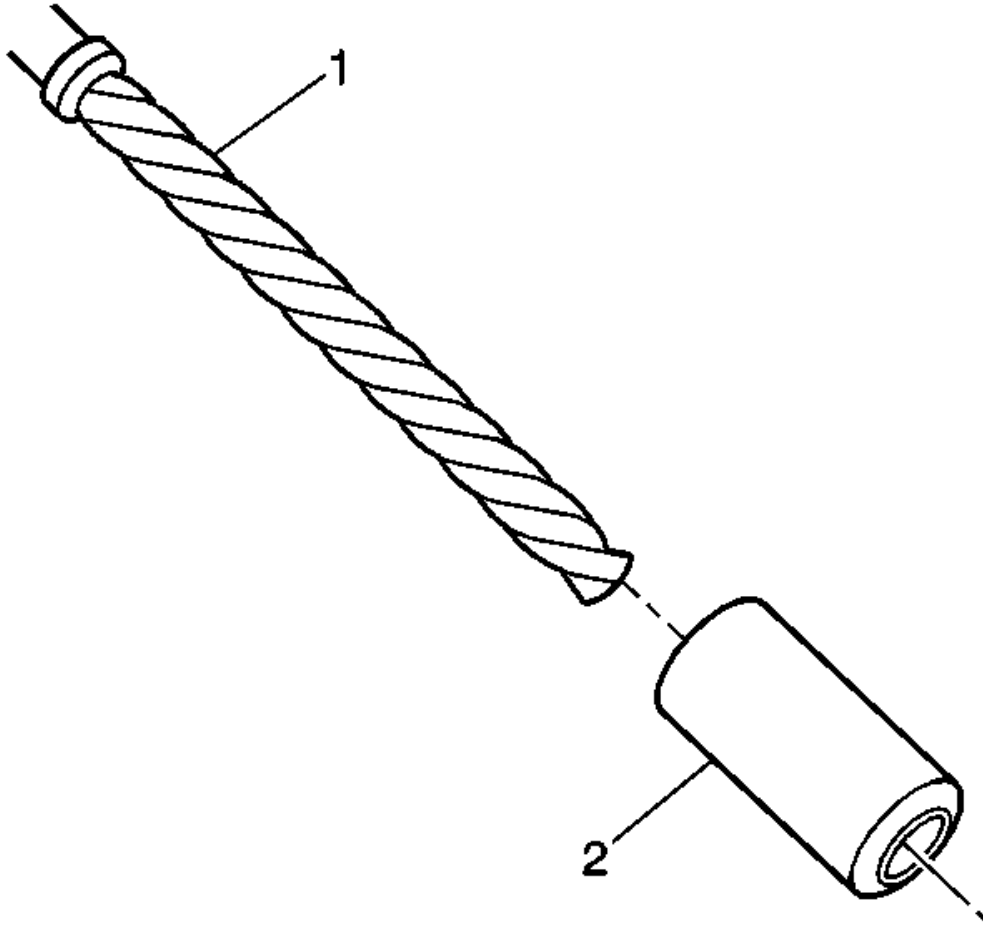


**Fig. 178: Identifying Alignment Pin**  
Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the hole.

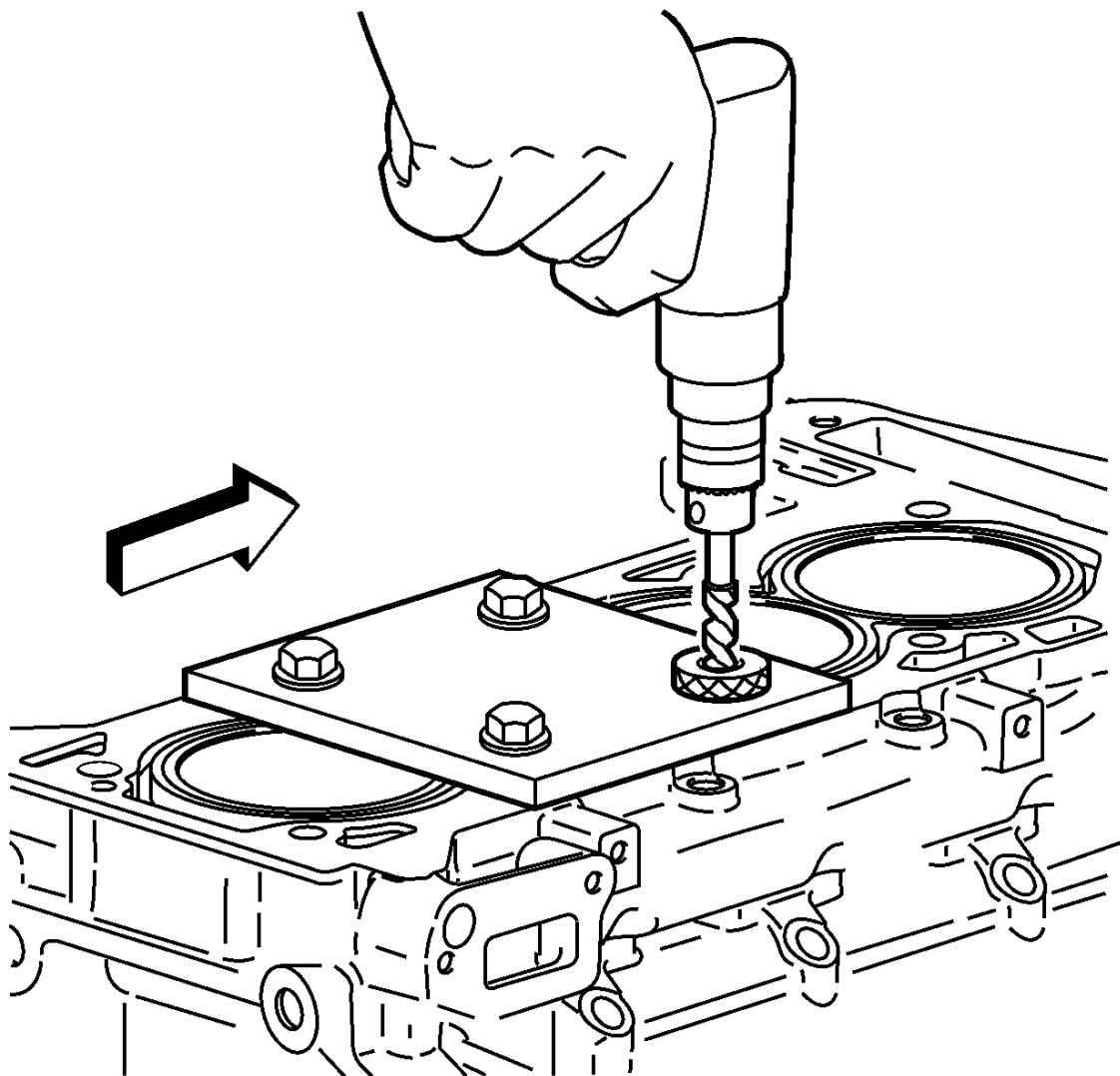


4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.



**Fig. 179: View Of Stop Collar & Counterbore Drill**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 180: Drilling Out Threads Of Damaged Hole**  
Courtesy of GENERAL MOTORS COMPANY

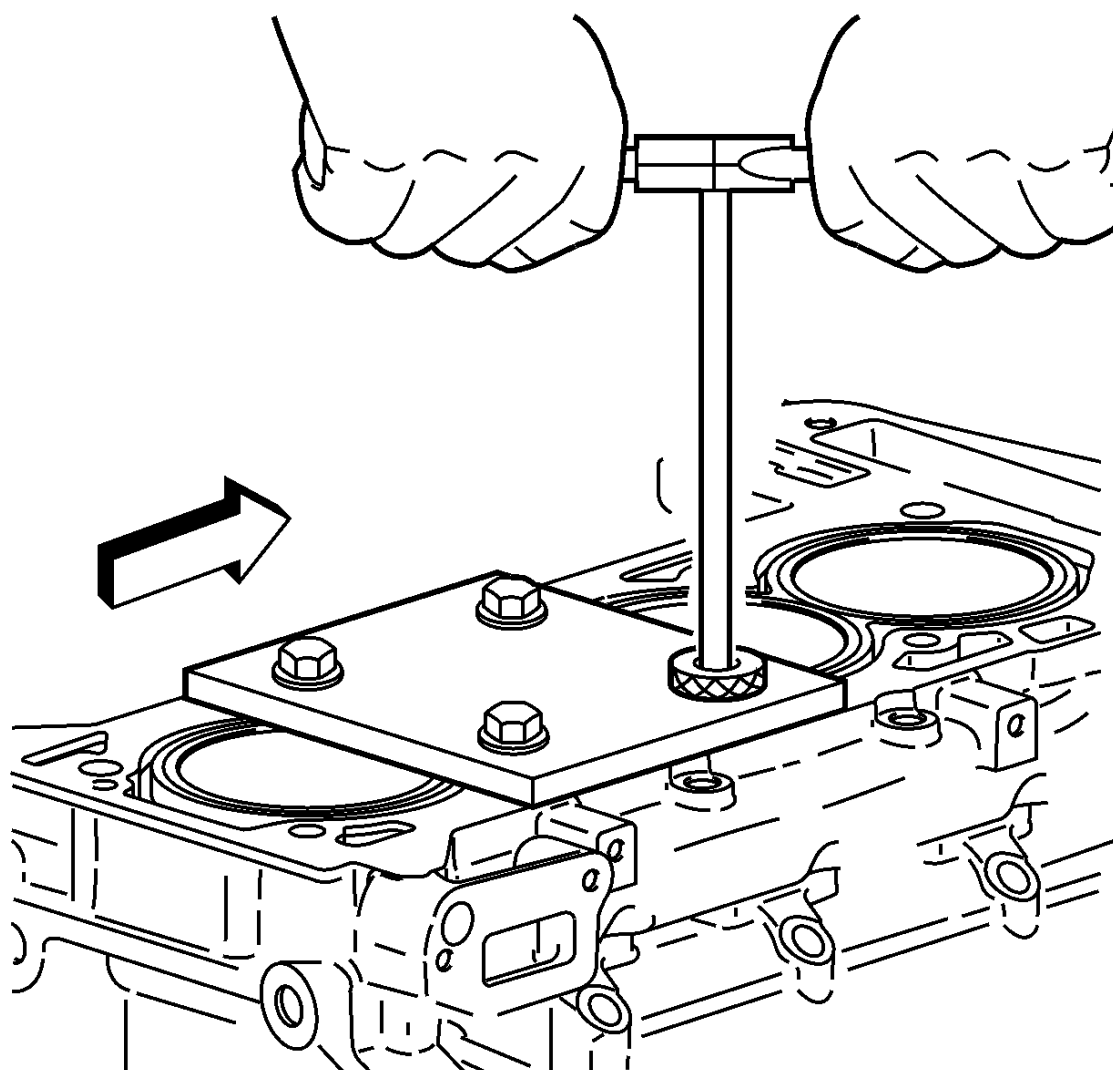
**NOTE:** During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

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.

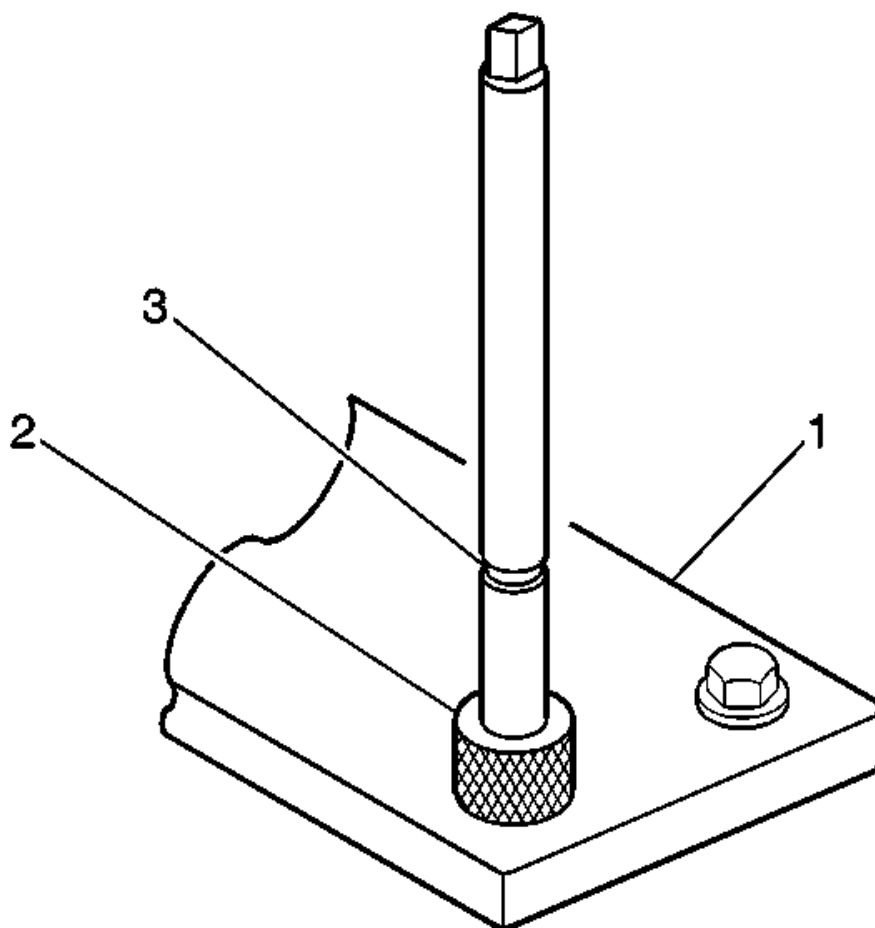
**WARNING: Refer to Safety Glasses and Compressed Air Warning .**

8. Using compressed air, clean out any chips.



**Fig. 181: 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. 182: 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.

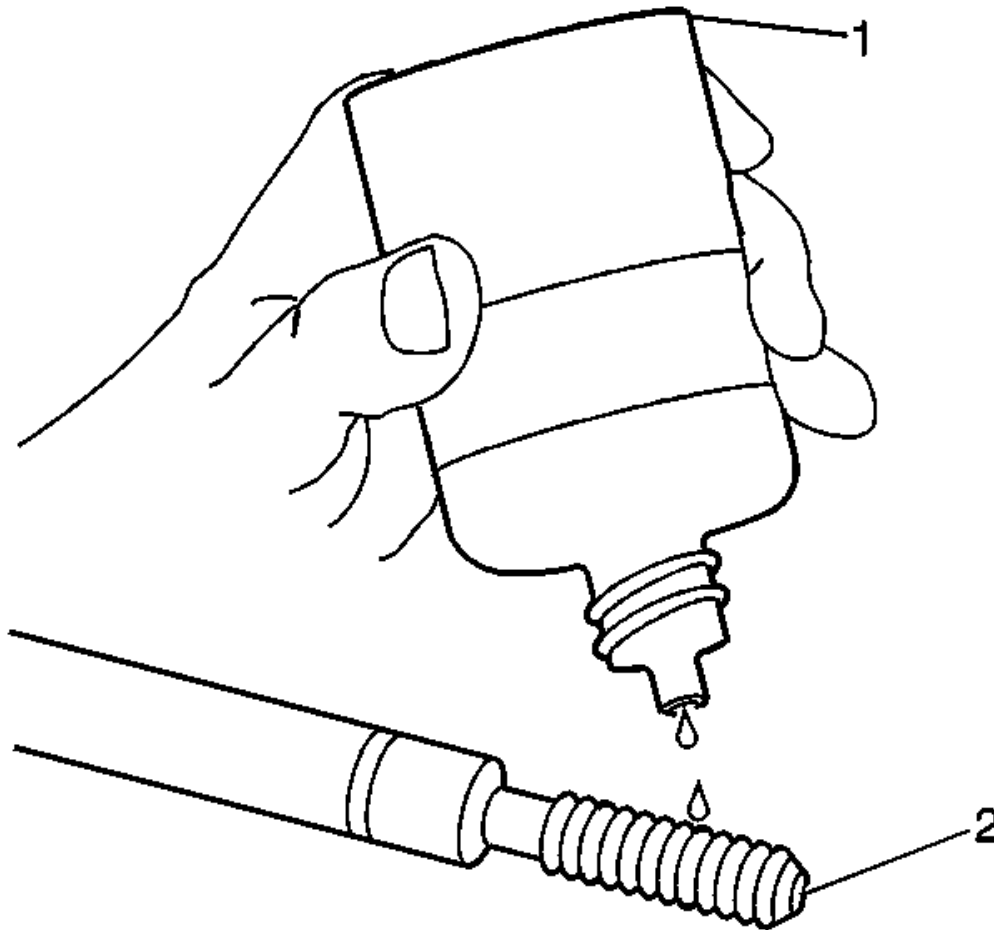
In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

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 .**

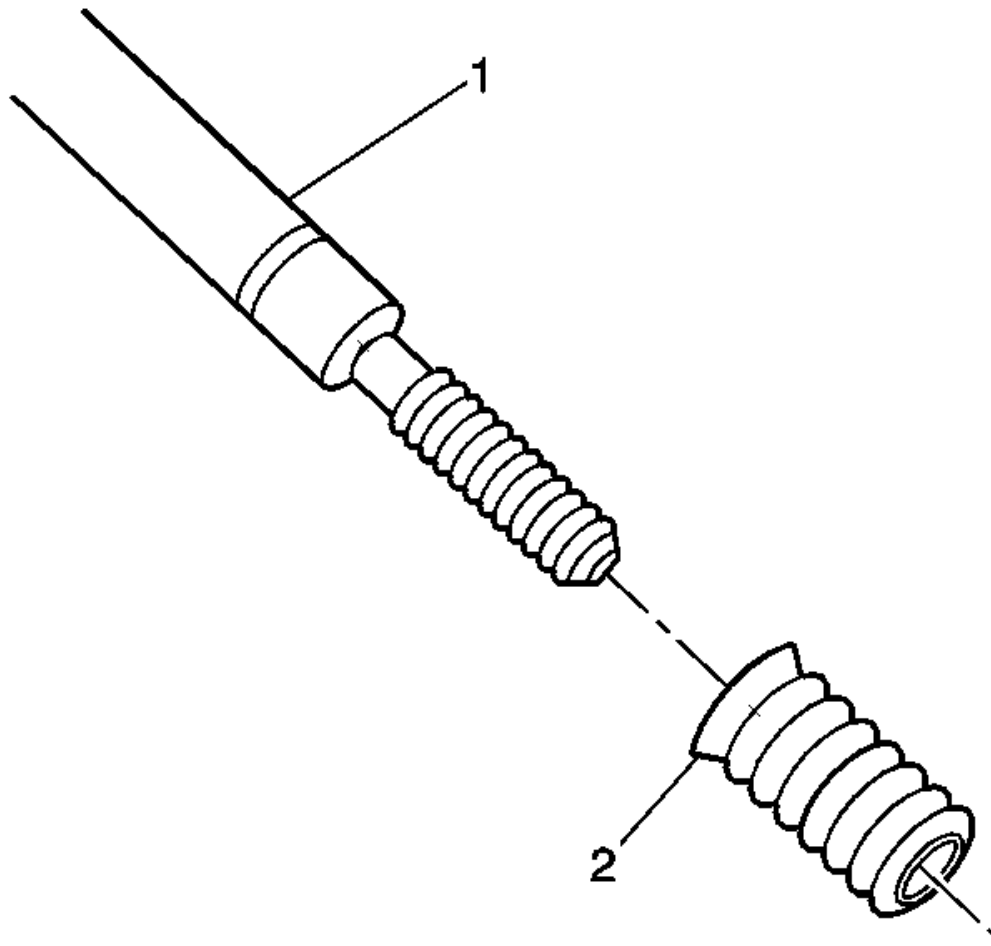
12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
14. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 183: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS COMPANY

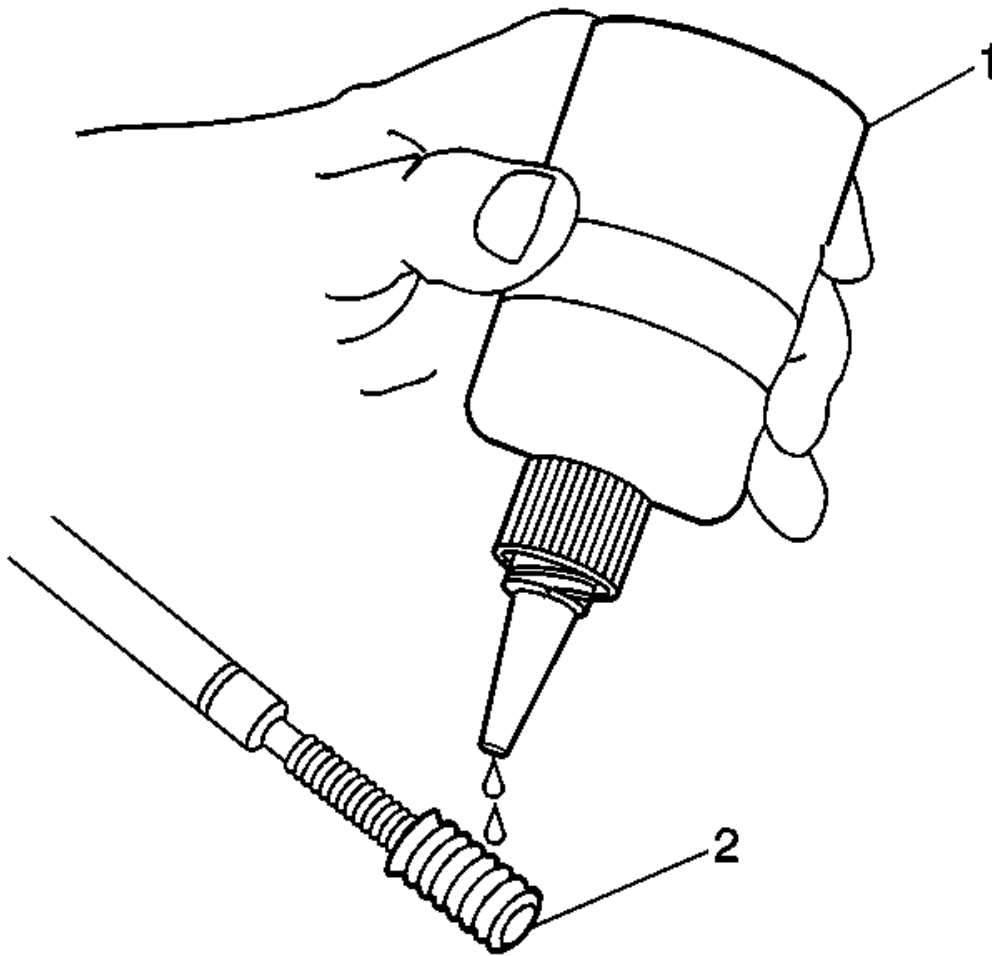
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



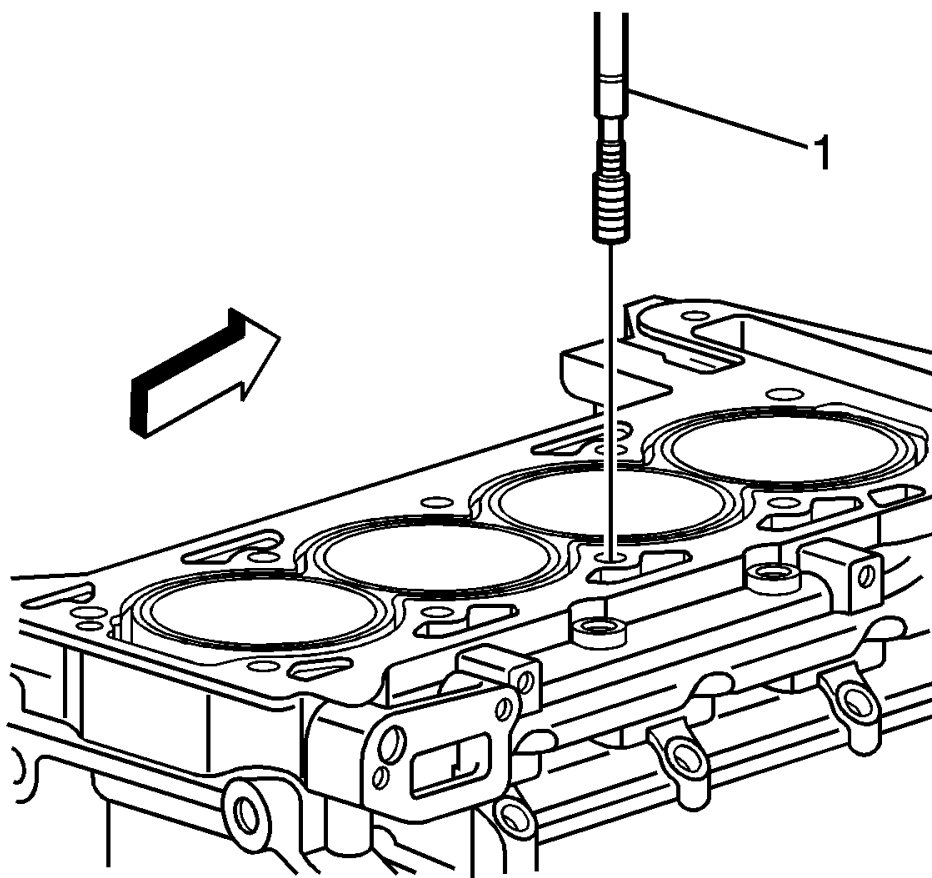
**Fig. 184: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 185: 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. 186: Installing & Inserting Driver Into Hole**  
Courtesy of GENERAL MOTORS COMPANY

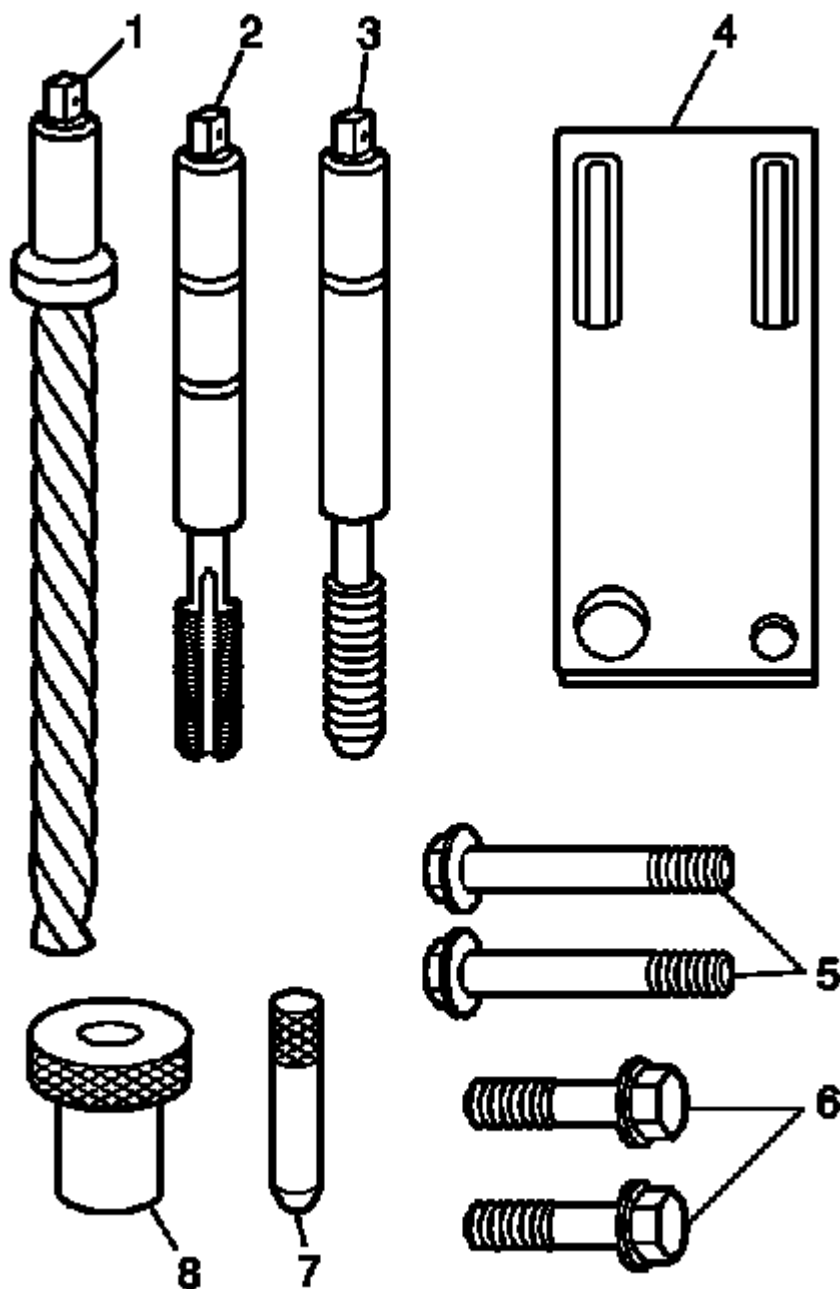
18. Install the insert and driver (1) into the hole.

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.

#### **Main Cap Bolt Hole Thread Repair**

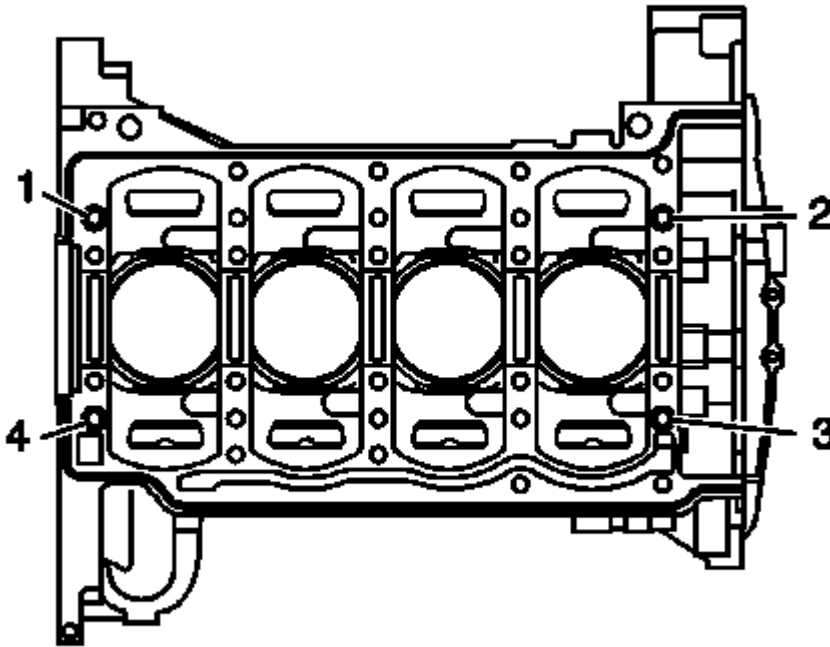




**Fig. 187: Identifying Thread Repair Kit Components**  
Courtesy of GENERAL MOTORS COMPANY

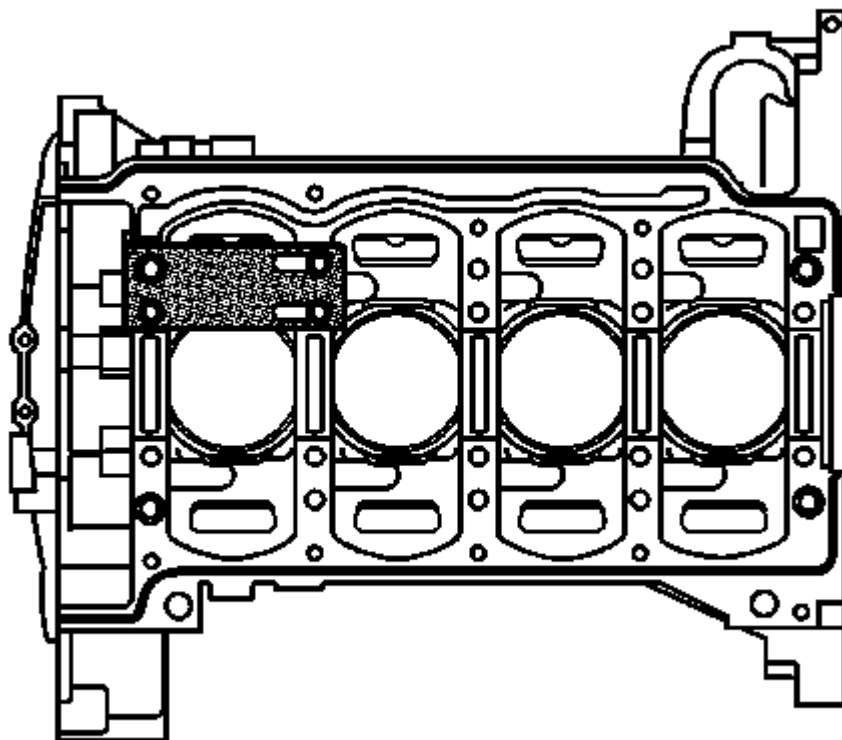
1. The main cap bolt hole thread repair kit consists of the following items:
  - Drill (1)
  - Tap (2)
  - Installer (3)

- Fixture Plate (4)
- Long Bolts (5)
- Short Bolts (6)
- Alignment Pin (7)
- Bushing (8)



**Fig. 188: Identifying Alignment Dowel Pins**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the alignment dowel pins from the holes (1-4), if necessary.



**Fig. 189: Installing Fixture Plate, Bolt, & Bushing Onto Engine Block**  
Courtesy of GENERAL MOTORS COMPANY

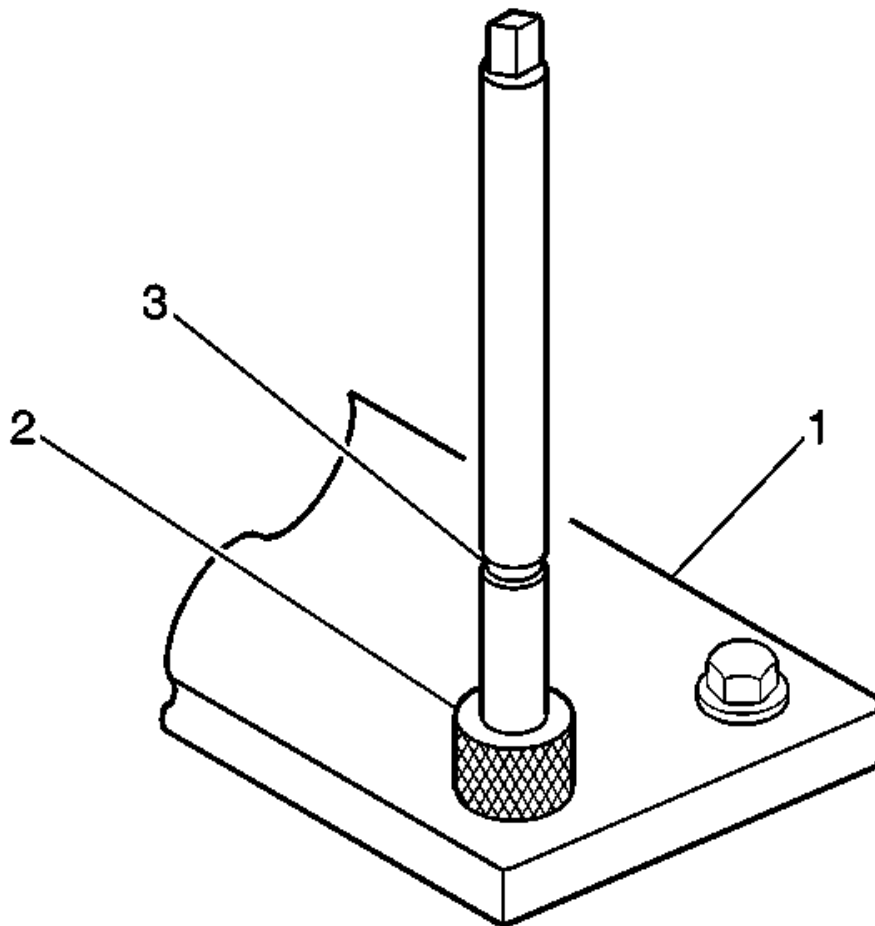
3. Install the fixture plate, bolt, and bushing, onto the engine block.

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

4. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.
5. Drill out the damaged hole.

**WARNING: Refer to Safety Glasses and Compressed Air Warning .**

6. Using compressed air, clean out any chips.



**Fig. 190: View Of Fixture Plate, Drill Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS COMPANY

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

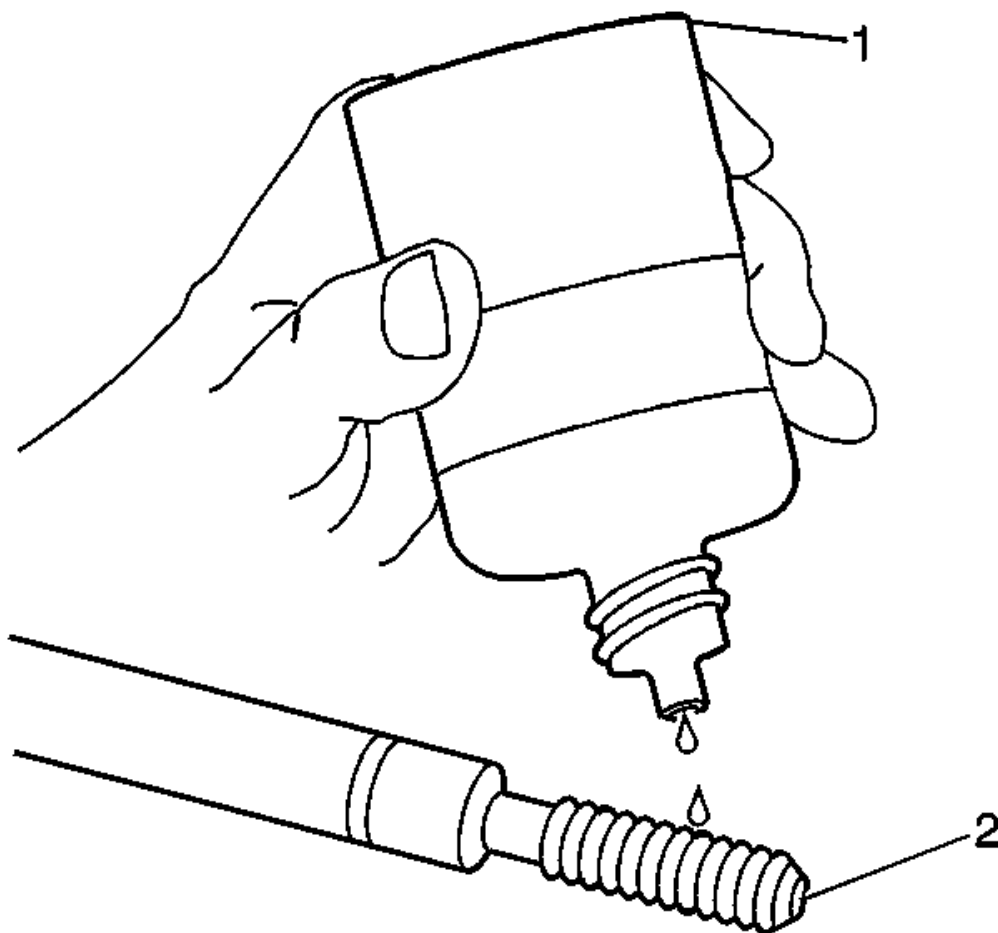
In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap aligns with the top of the bushing (2).

**WARNING:** Refer to Safety Glasses and Compressed Air Warning .

**WARNING:** Refer to Cleaning Solvent Warning .

8. Using compressed air, clean out any chips.
9. Spray cleaner into the hole. Refer to Adhesives, Fluids, Lubricants, and Sealers .

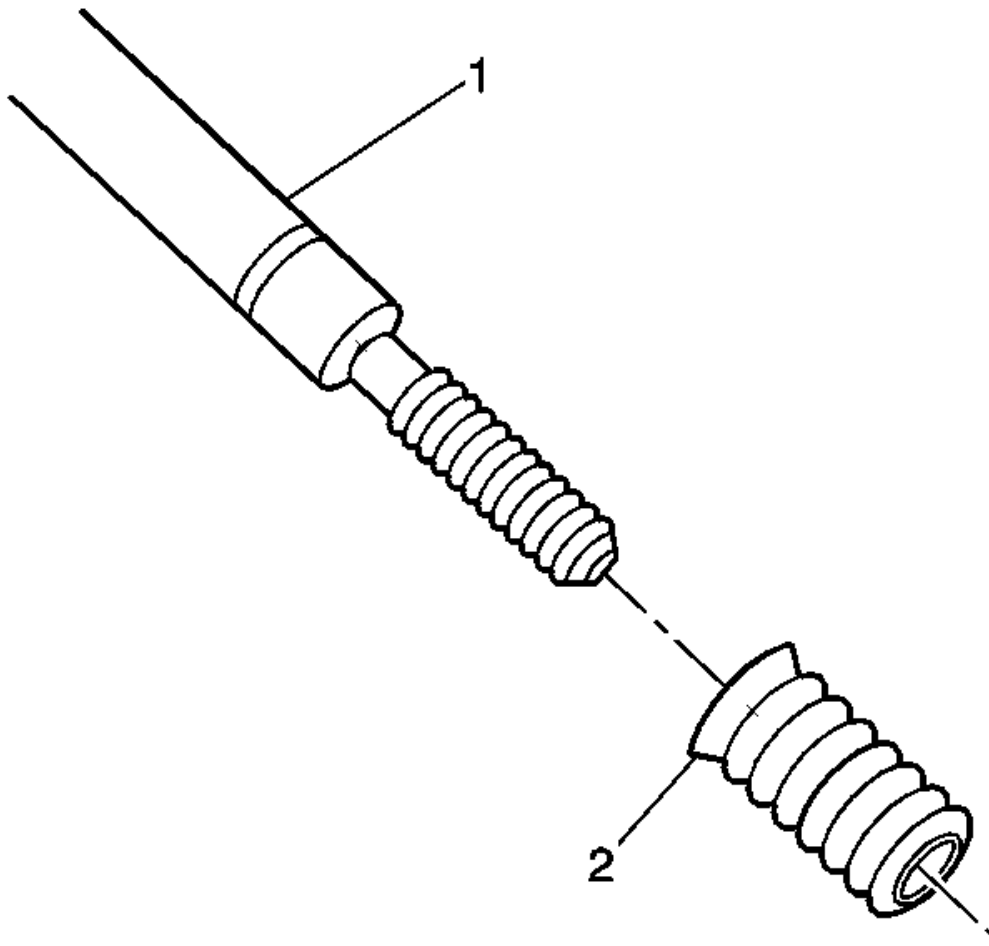
10. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 191: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS COMPANY

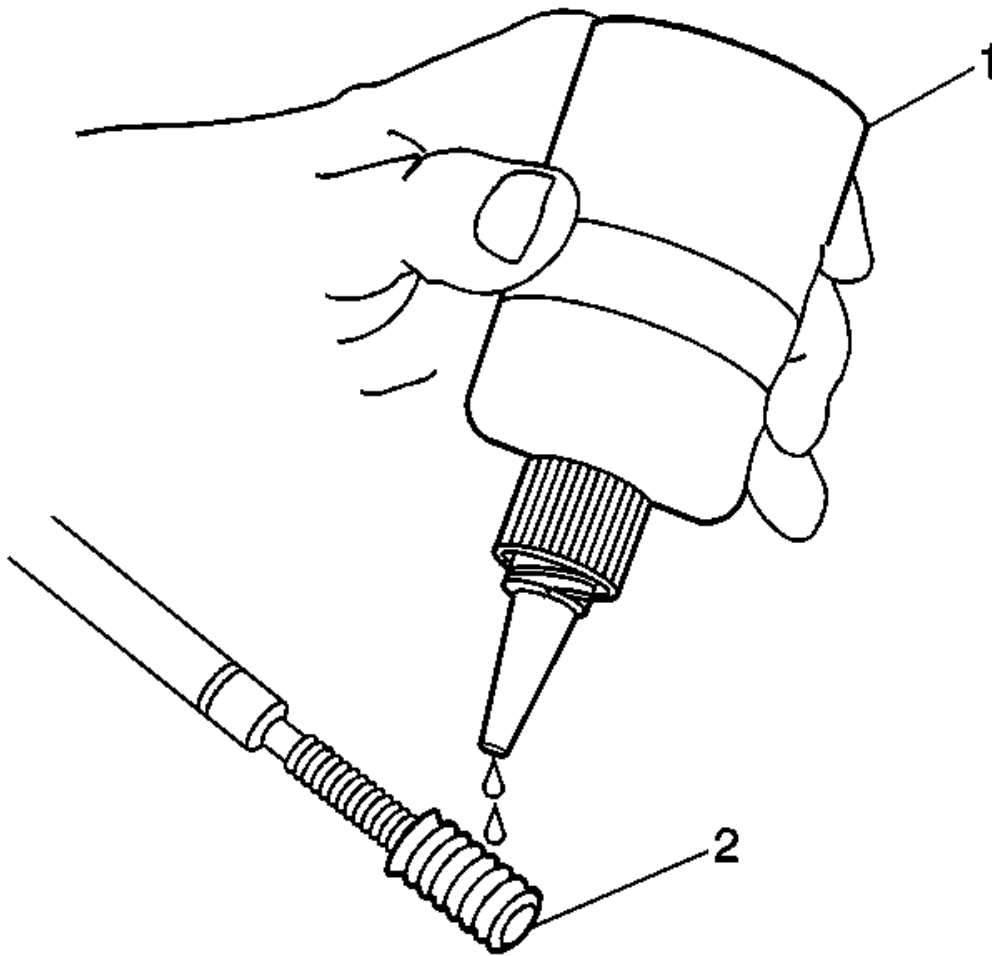
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



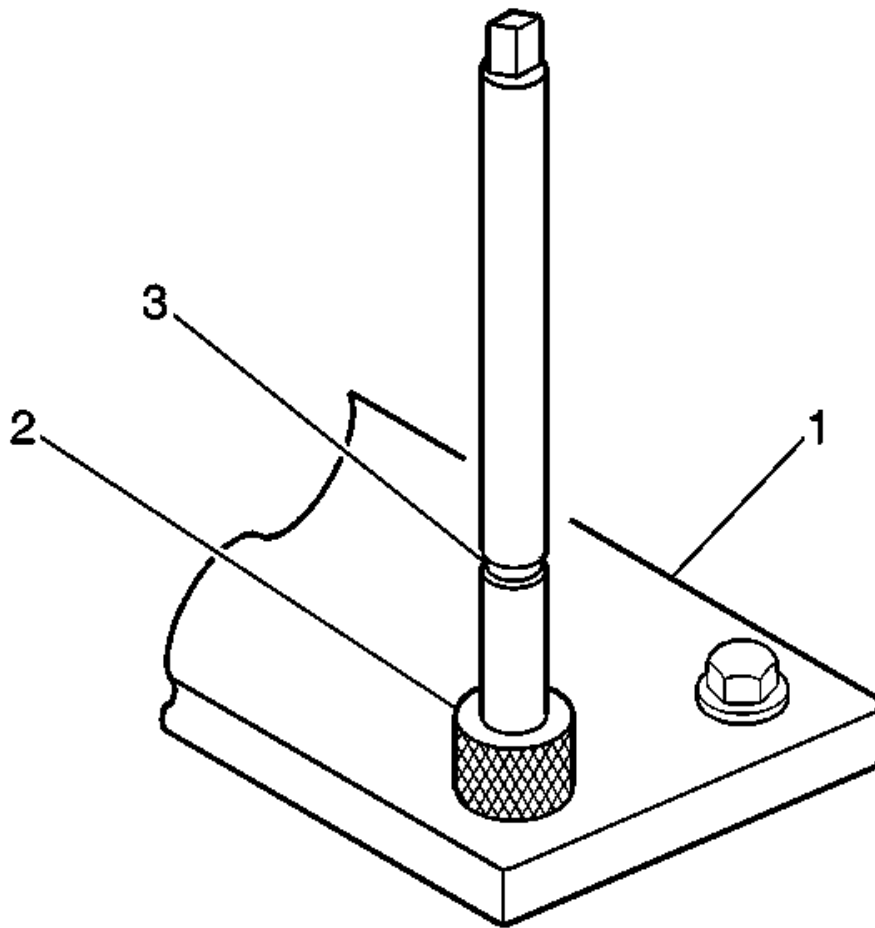
**Fig. 192: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 193: Applying Threadlock To Insert**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 194: View Of Fixture Plate, Drill Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS COMPANY

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

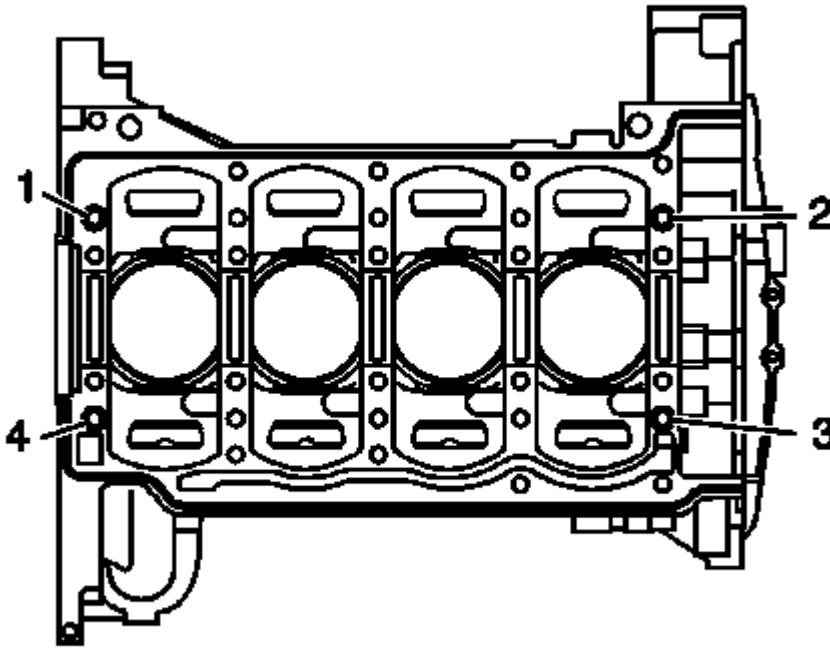
14. Install the insert and driver through the bushing (2), fixture plate (1) and into the hole.

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

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

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





**Fig. 195: Identifying Alignment Dowel Pins**  
Courtesy of GENERAL MOTORS COMPANY

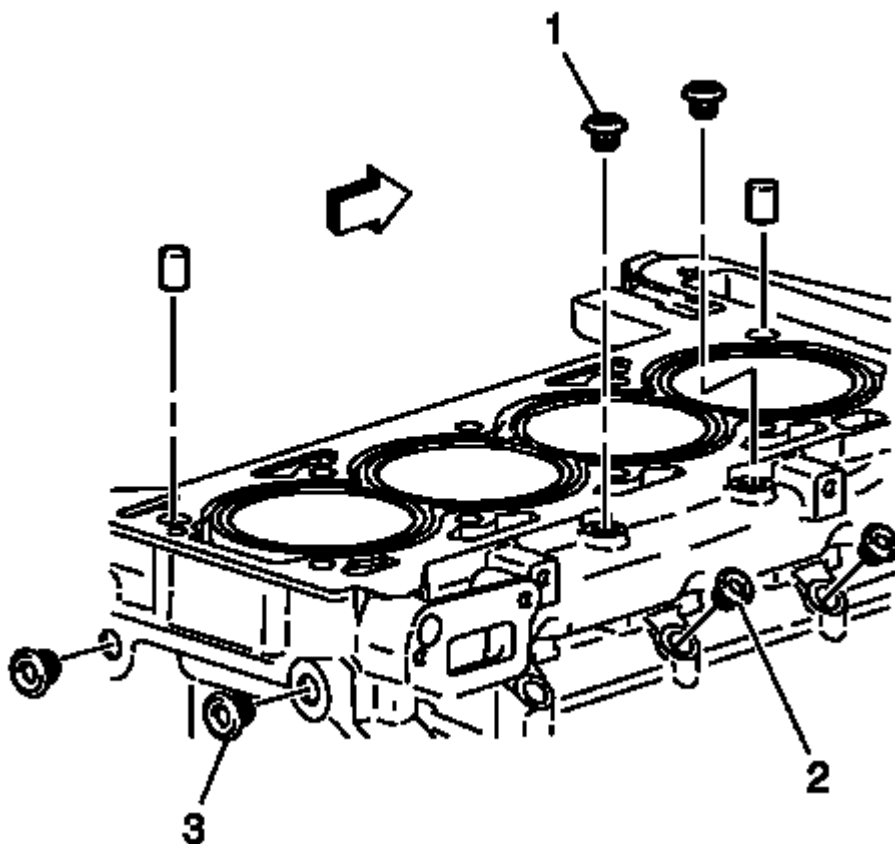
16. Install the alignment dowel pins in holes (1-4), if necessary.

### **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**



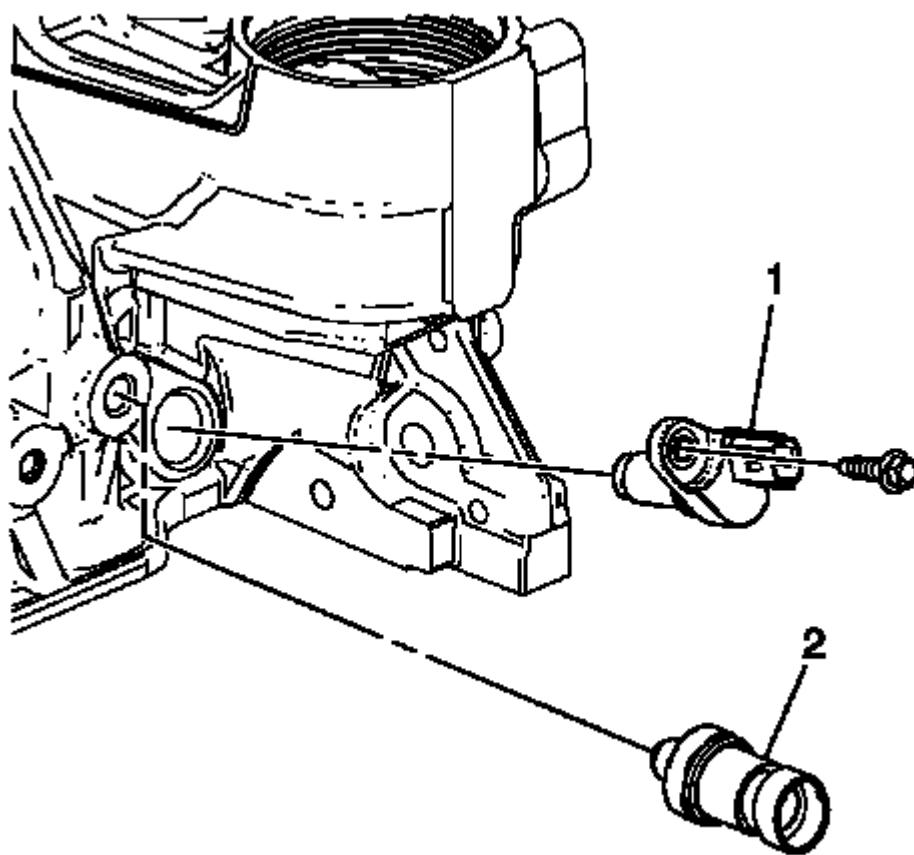
**Fig. 196: Locating Block Plugs**

Courtesy of GENERAL MOTORS COMPANY

1. Apply sealant to all plugs (1, 2, 3) prior to installation. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Install the drain plug, with sealant, in the water pump.

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

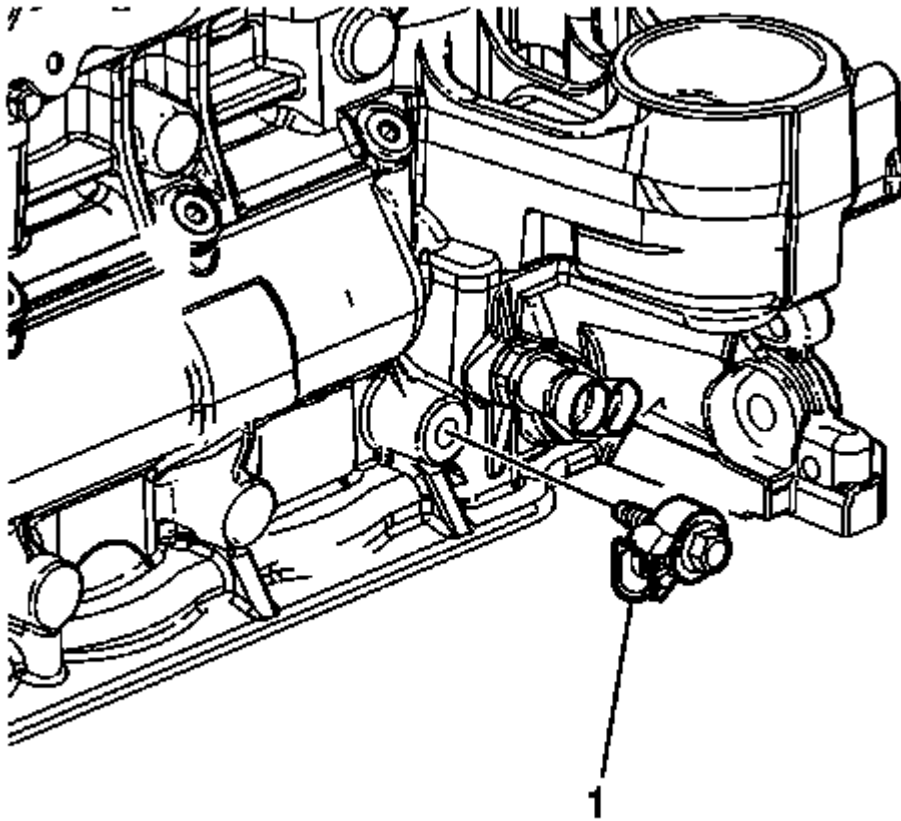
3. Install the coolant jacket plugs, with sealant, and tighten to 35 N.m (26 lb ft).
4. Install the rear oil passage plugs, with sealant, and tighten to 60 N.m (44 lb ft).
5. Install the other oil passage plugs, with sealant, and tighten to 35 N.m (26 lb ft).



**Fig. 197: Oil Pressure Switch**

Courtesy of GENERAL MOTORS COMPANY

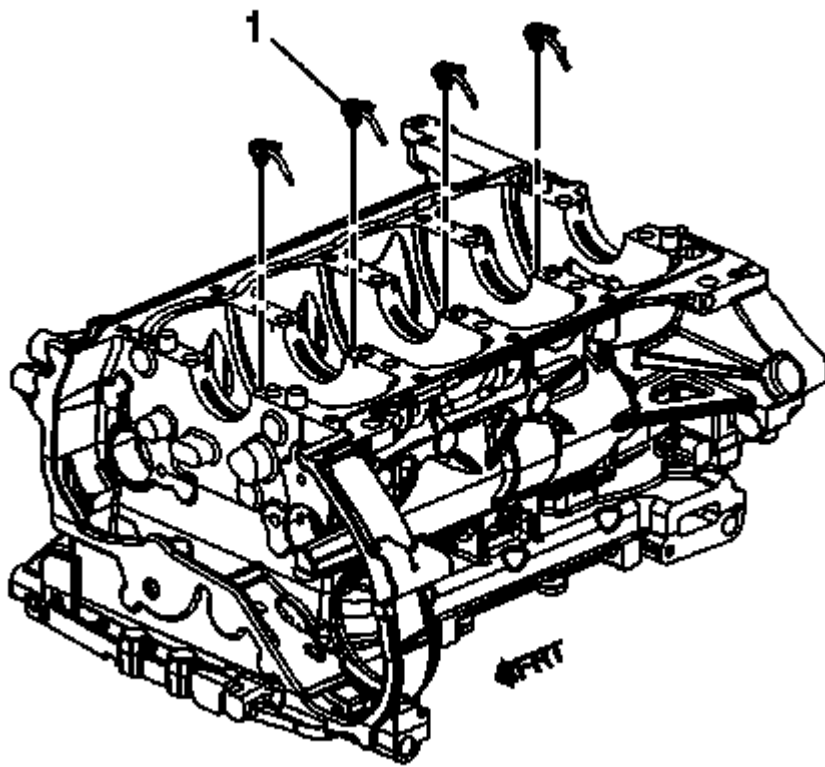
6. Lubricate the crankshaft position sensor O-ring with engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
7. Install the crankshaft position sensor (1) and bolt and tighten to 10 N.m (89 lb in).
8. Install the oil pressure switch (2) and tighten to 26 N.m (19 lb ft).



**Fig. 198: Knock Sensor**

**Courtesy of GENERAL MOTORS COMPANY**

9. Install the knock sensor (1) and bolt and tighten to 25 N.m (18 lb ft).



**Fig. 199: Piston Oil Nozzle Assembly**  
Courtesy of GENERAL MOTORS COMPANY

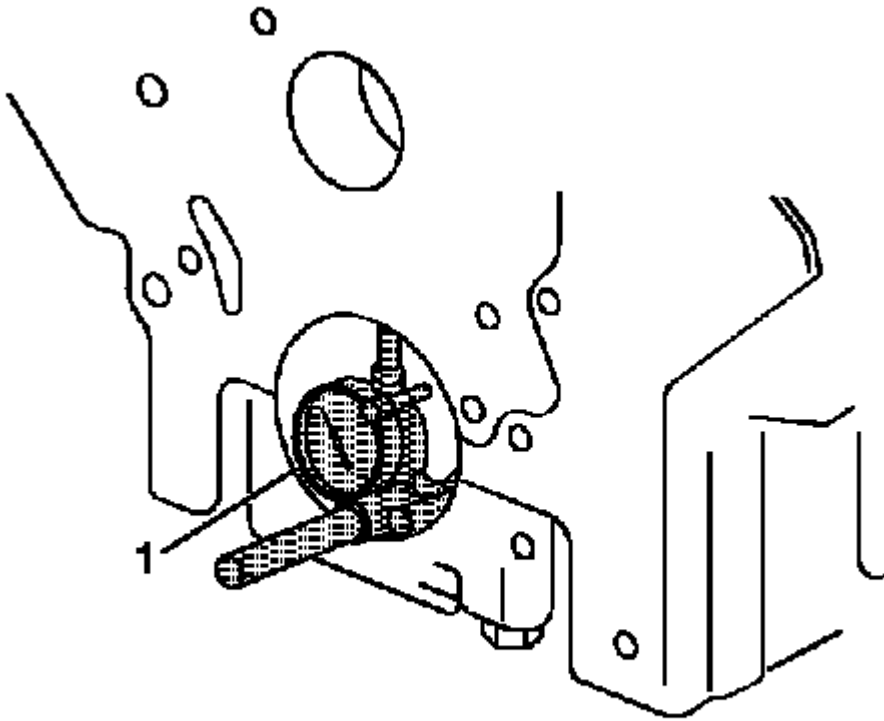
10. Install the piston oil nozzle assemblies (1), if equipped.
11. Install the piston oil nozzle assembly bolts and tighten to 15 N.m (11 lb ft).

## **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. 200: Measuring Bearing Bore**

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.

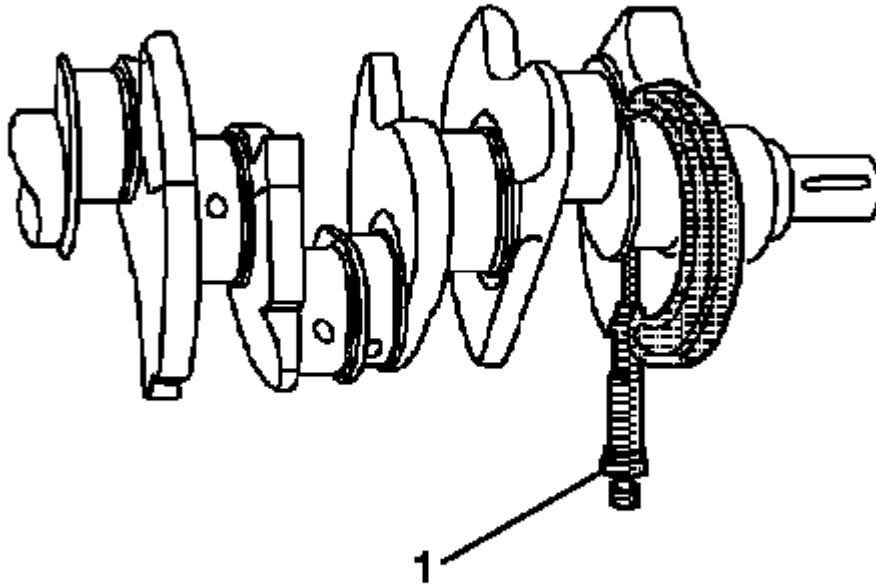
Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- 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 2 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.

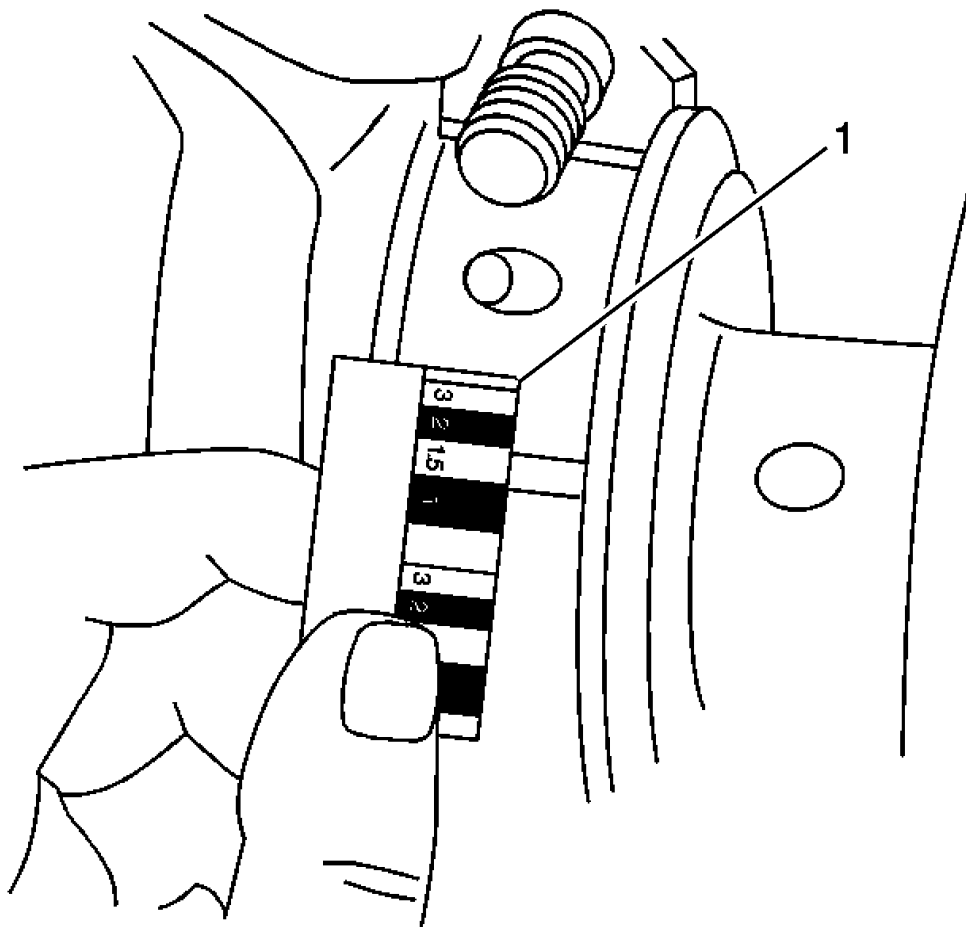


**Fig. 201: View of Measuring Crankshaft Bearing Journal Using Method A**  
 Courtesy of GENERAL MOTORS COMPANY

**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 (1) 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. 202: 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.
  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.**

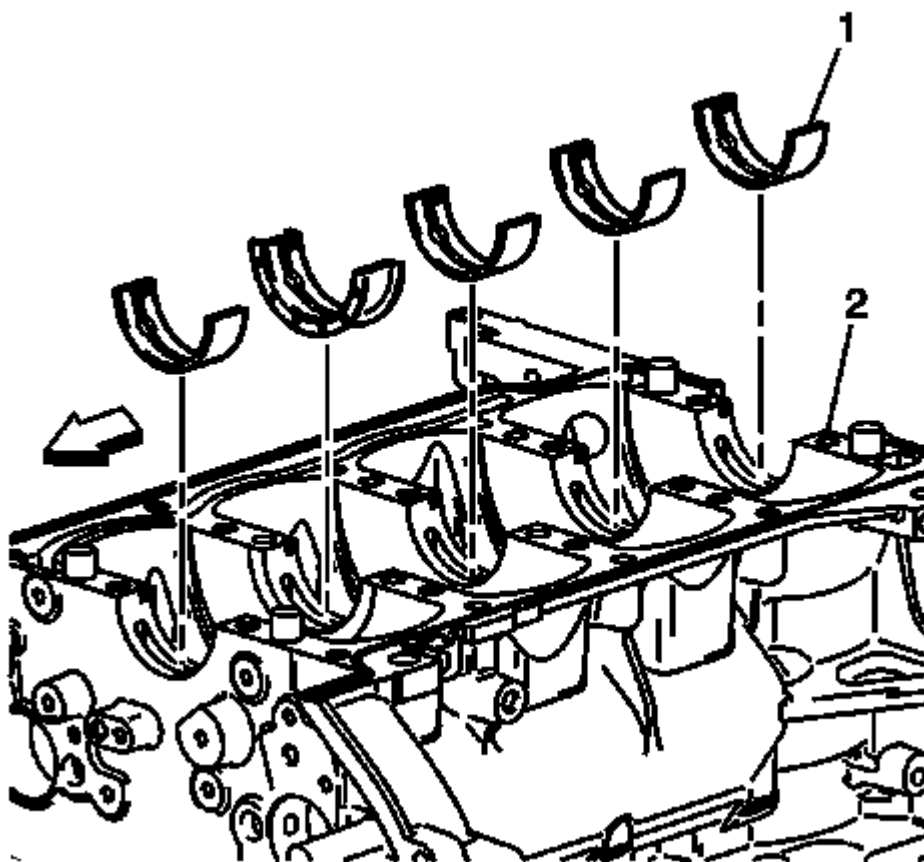
6. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or to the bearing cap.
7. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
8. Remove the gauging plastic.

## **LOWER CRANKCASE INSTALLATION**

### **Special Tools**

**EN 45059** Angle Meter

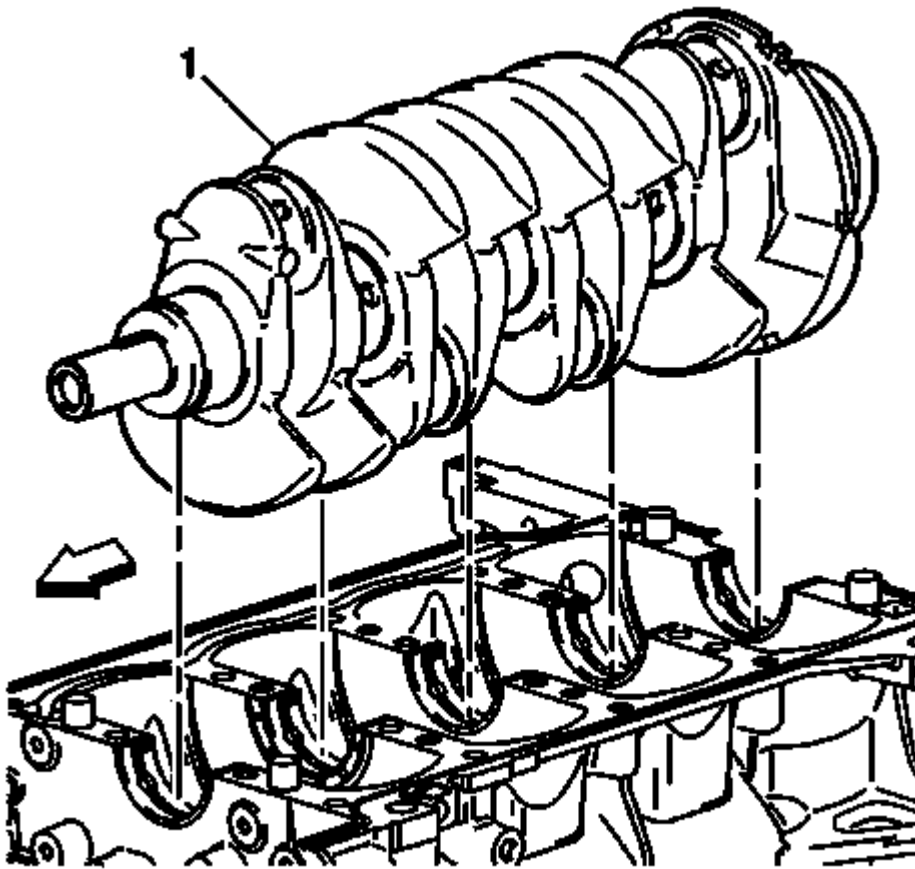
For equivalent regional tools, refer to **Special Tools** .



**Fig. 203: View of Upper Crankshaft Bearings**  
Courtesy of GENERAL MOTORS COMPANY

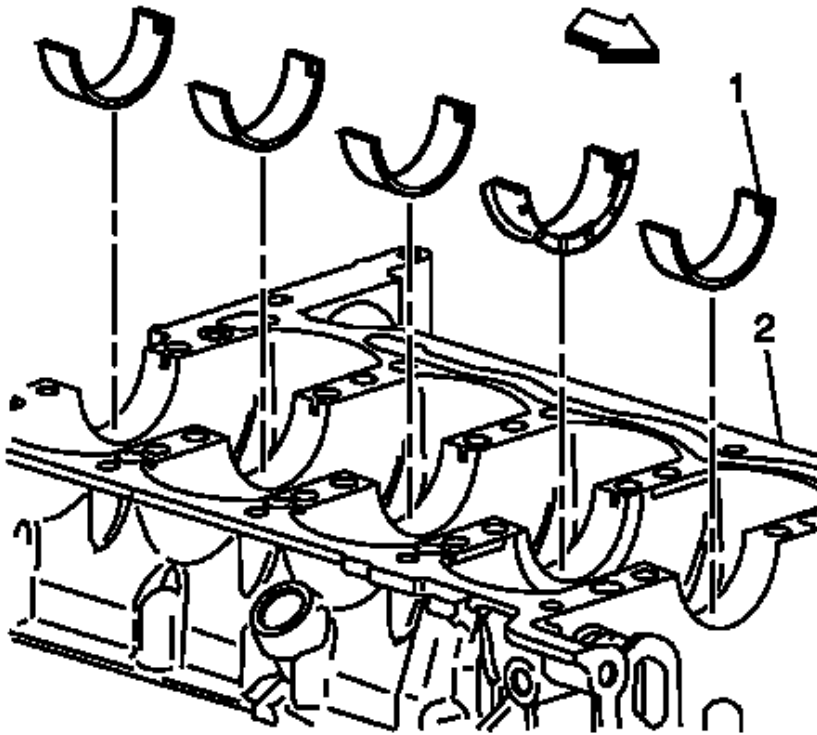
**NOTE:** Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.

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



**Fig. 204: View of Crankshaft**  
Courtesy of GENERAL MOTORS COMPANY

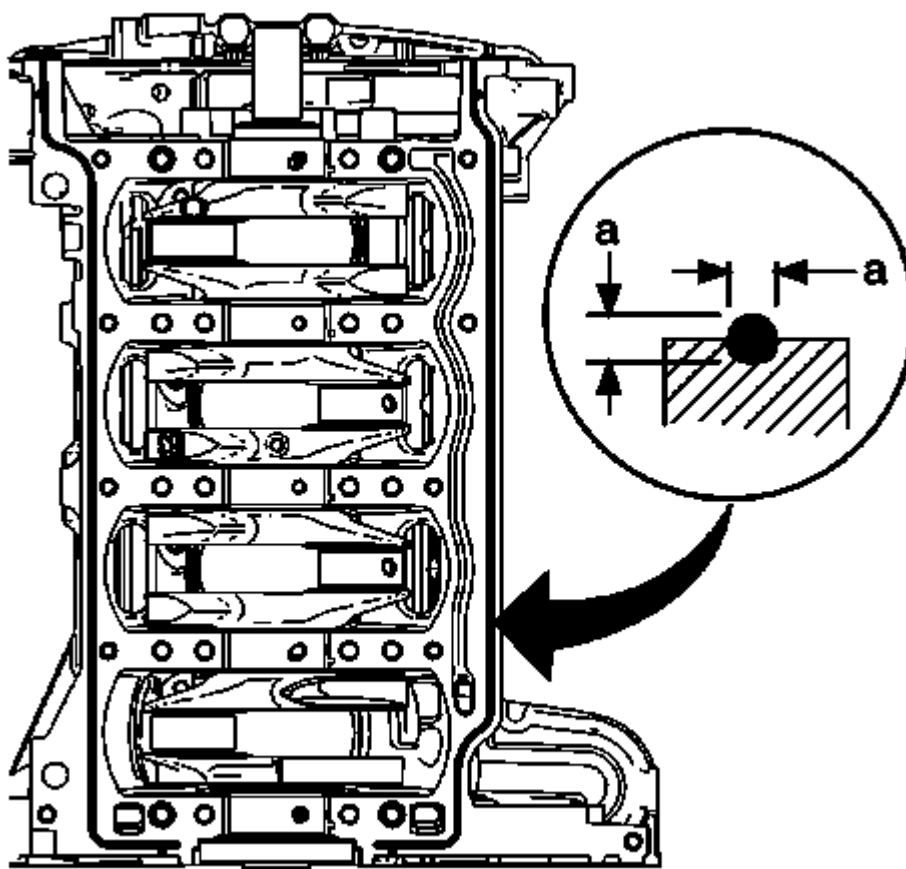
2. Install the crankshaft (1) on the journals.



**Fig. 205: View of Lower Bearing Halves**

Courtesy of GENERAL MOTORS COMPANY

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

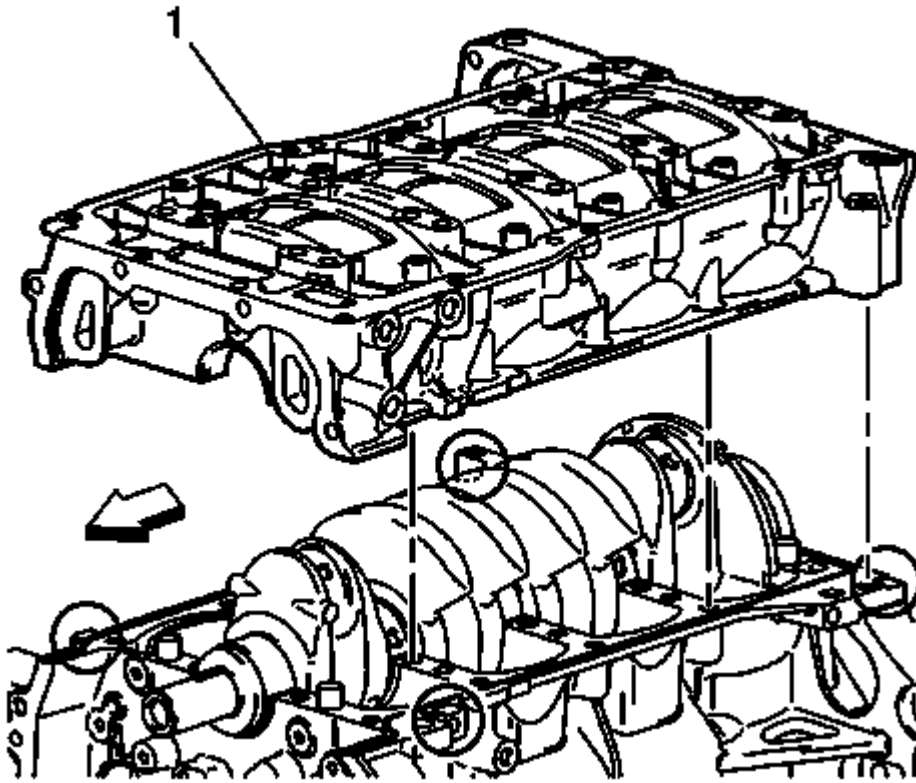


**Fig. 206: View of Bead of Sealer on Bedplate Mating Surface**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

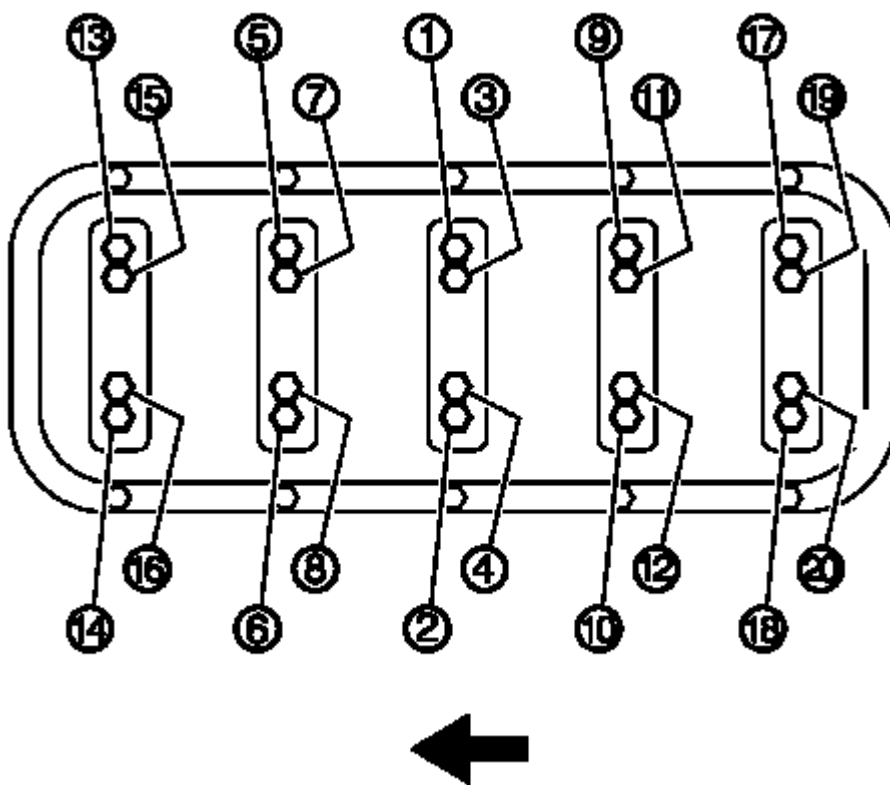
- The block assembly surface must be free of contamination prior to applying the sealer.
- Install and align the bedplate to block within 20 minutes of applying the sealer.
- The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.

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



**Fig. 207: View of Lower Crankcase**  
**Courtesy of GENERAL MOTORS COMPANY**

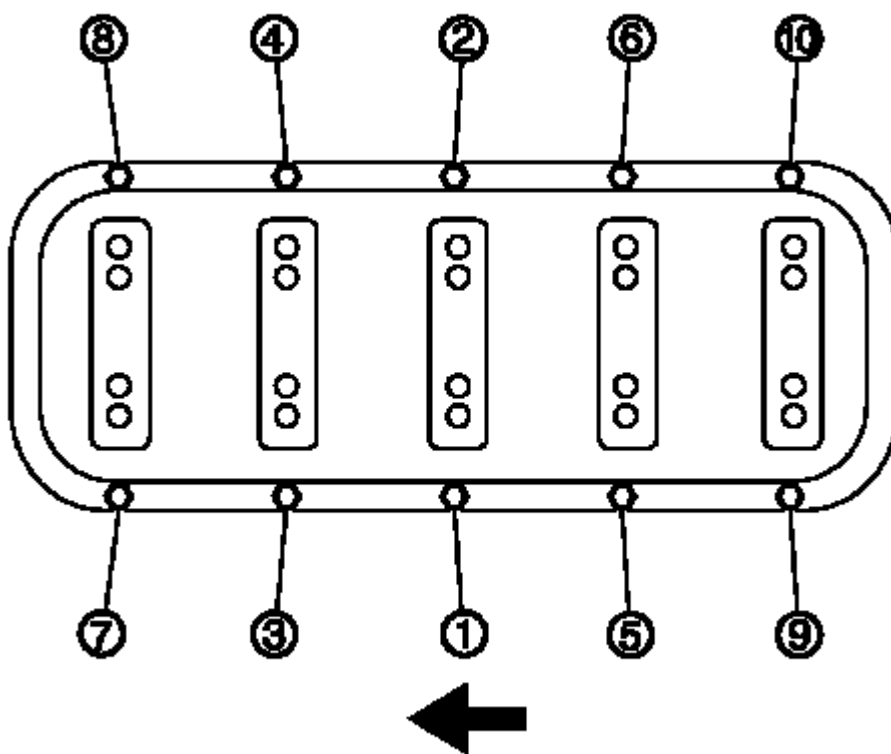
5. Install the lower crankcase (1). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.



**Fig. 208: Identifying Crankshaft Bearing Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

6. Install the NEW crankshaft bearing bolts in sequence finger tight.
  1. Tighten the crankshaft bearing bolts in sequence to 20 N.m (15 lb ft).
  2. Tighten the crankshaft bearing bolts in sequence using the **EN 45059** meter an additional 70 degrees.



**Fig. 209: Lower Crankcase Perimeter Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

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

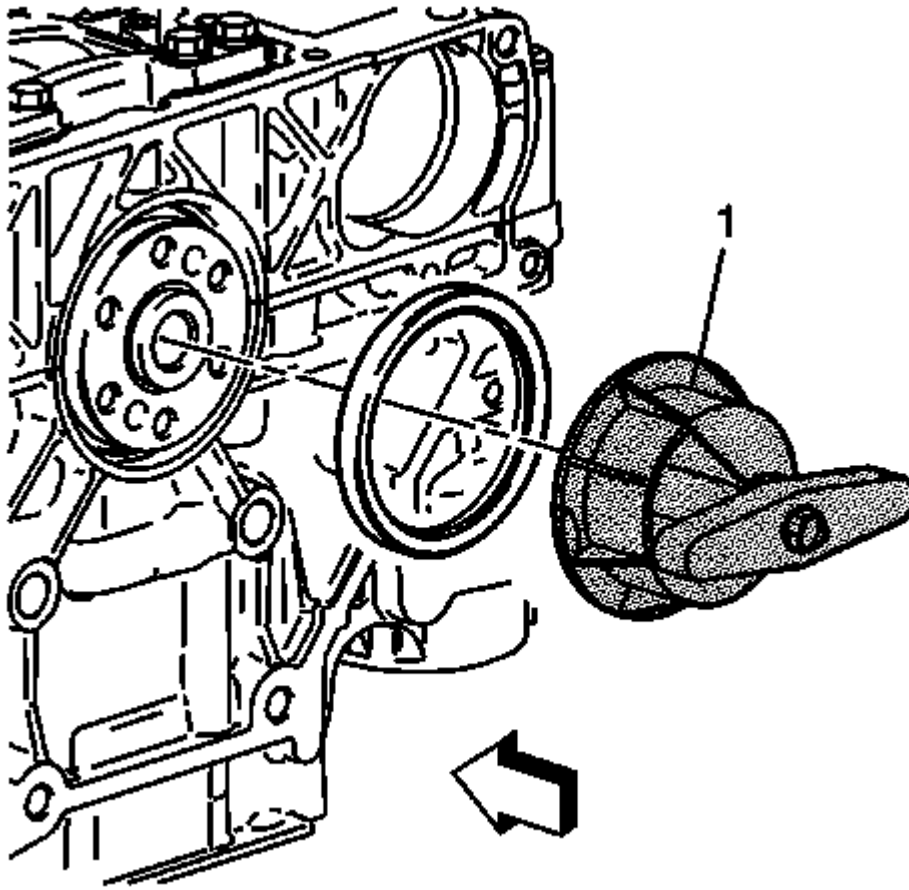
## CRANKSHAFT REAR OIL SEAL INSTALLATION

### Special Tools

EN-42067 Rear Main Seal Installer

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





**Fig. 210: Rear Crankshaft Seal & Installer**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove excess sealer from seal recess.
2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **EN-42067** installer (1), press the new crankshaft seal into the housing. The **EN-42067** installer also establishes the depth of the seal in the crankshaft seal bore.

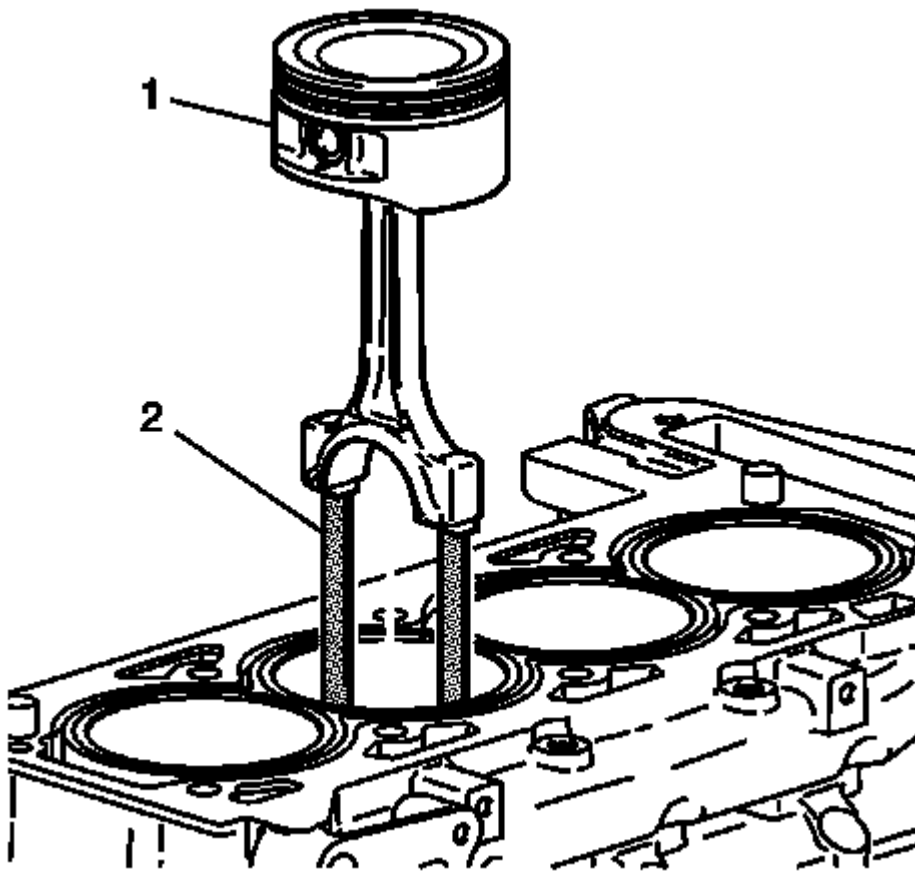
## PISTON, CONNECTING ROD, AND BEARING INSTALLATION (2.4L LEA)

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

### Special Tools

- **EN-43966** Connecting Rod Guides
- **EN 45059** Angle Meter
- **EN-47836** Piston Ring Compressor

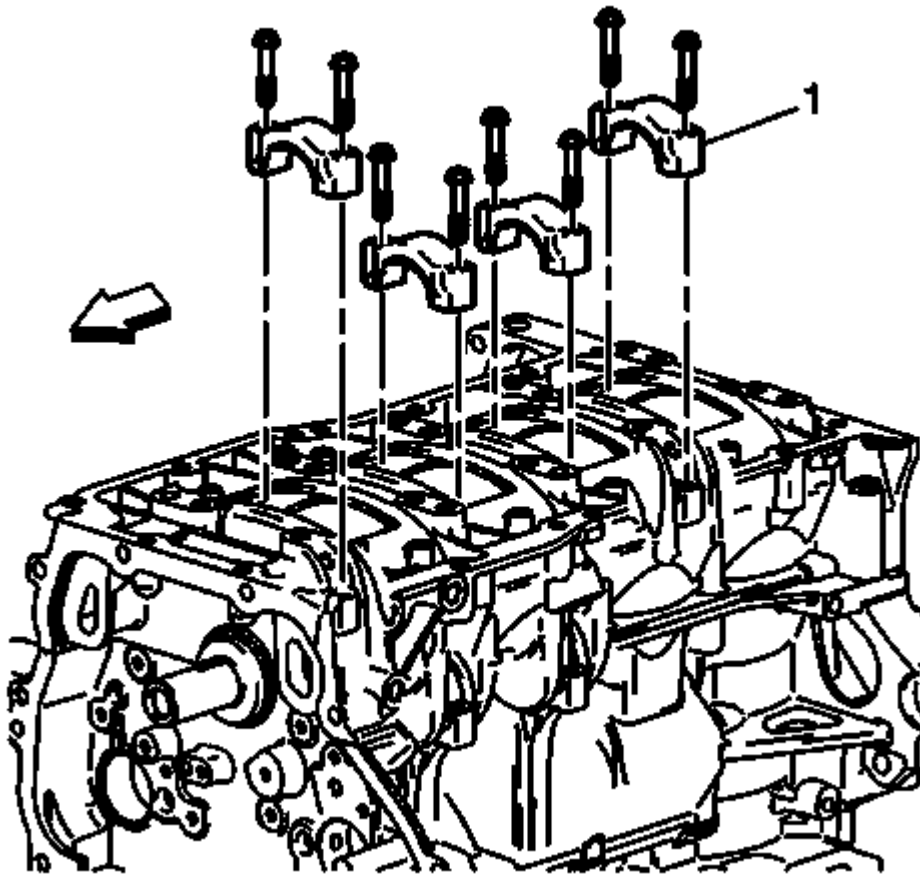
For equivalent regional tools, refer to **Special Tools** .



**Fig. 211: View Of Connecting Rod Guides**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the connecting rod bearings. Use NEW bearings.
  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 (1) into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.
3. Install **EN-47836** compressor piston, 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 mark on the top of the piston faces the front of the engine.
  5. 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-47836** 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.



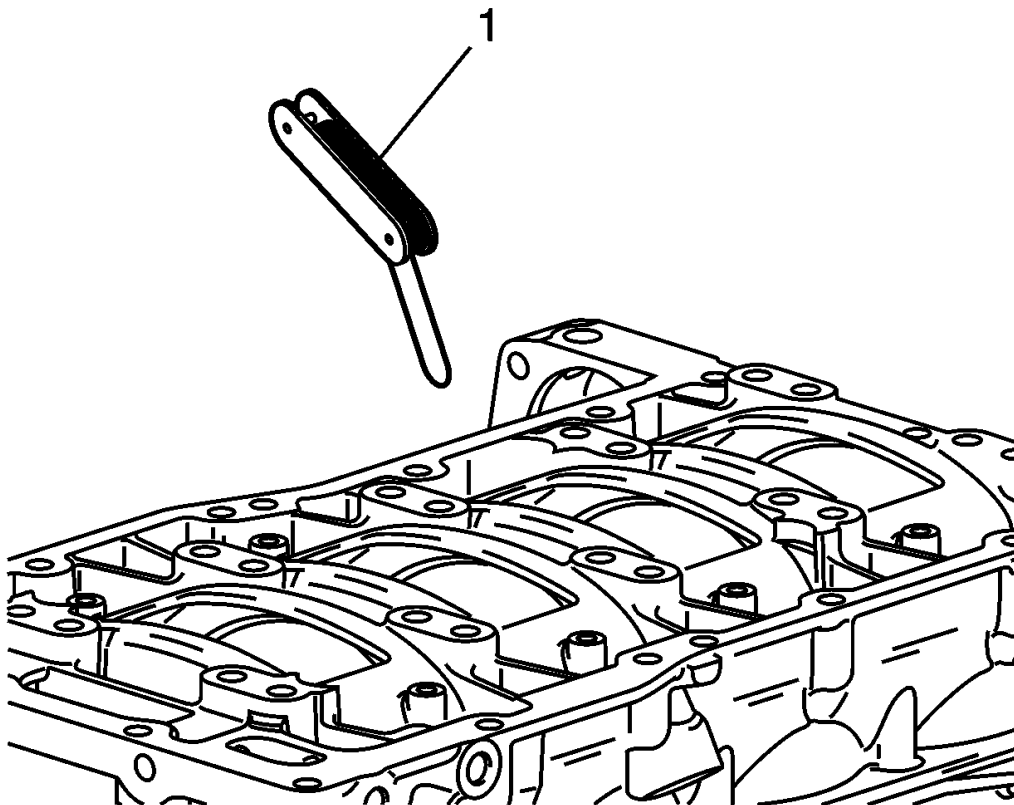
**Fig. 212: View of Connecting Rod Cap**  
Courtesy of GENERAL MOTORS COMPANY

**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 .

5. Install the connecting rod bolts. Always use new bolts. Tighten the connecting rod bolts to 25 N.m (18 lb ft), plus 100 degrees using the EN 45059 meter.
6. Install the remaining connecting rods and piston assemblies.



**Fig. 213: View of Checking Rod Side Clearance With Feeler Gage**  
Courtesy of GENERAL MOTORS COMPANY

7. Measure the connecting rod side clearance with a feeler gauge (1).

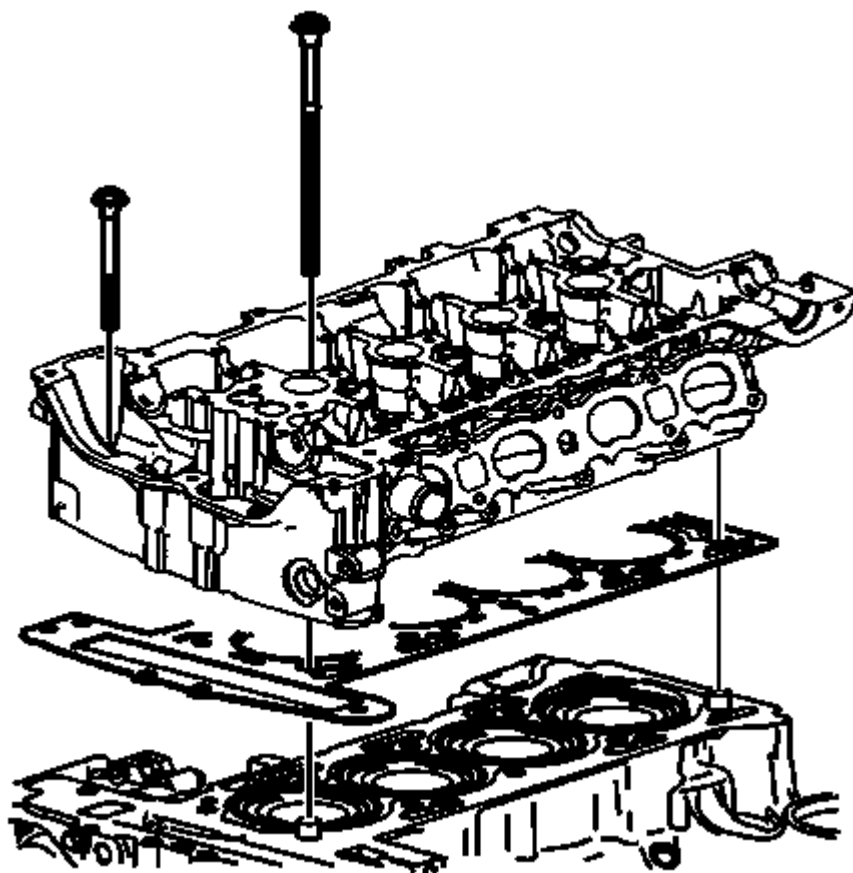
The correct clearance is 0.07-0.37 mm (0.0027-0.0145 in).

## **CYLINDER HEAD INSTALLATION (2.4L LEA)**

### **Special Tools**

**EN 45059** Angle Meter

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

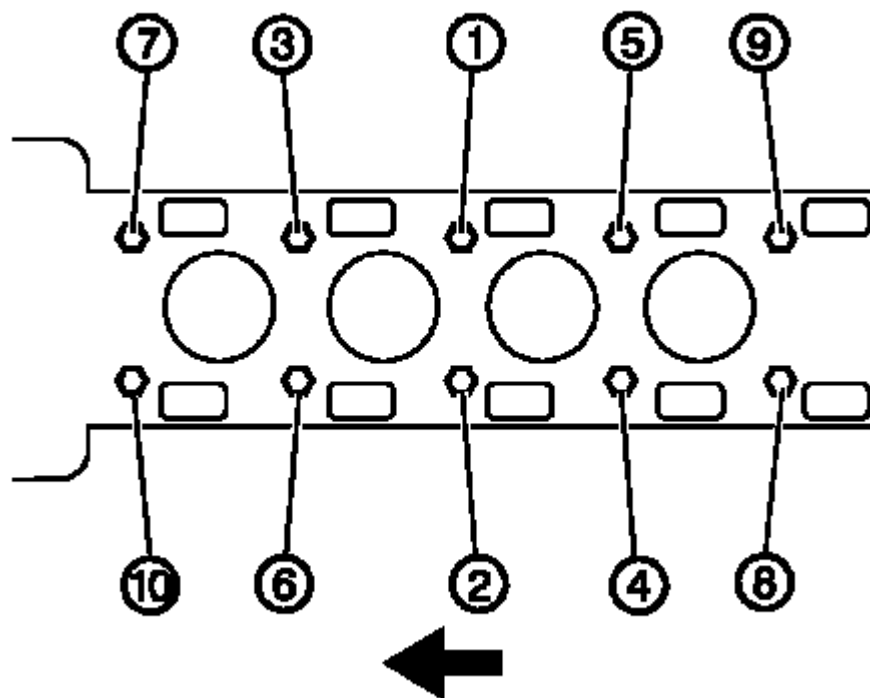


**Fig. 214: Cylinder Head**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Do not use any sealing material.

1. Install the cylinder head gasket to the block.
2. Install the cylinder head. 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.

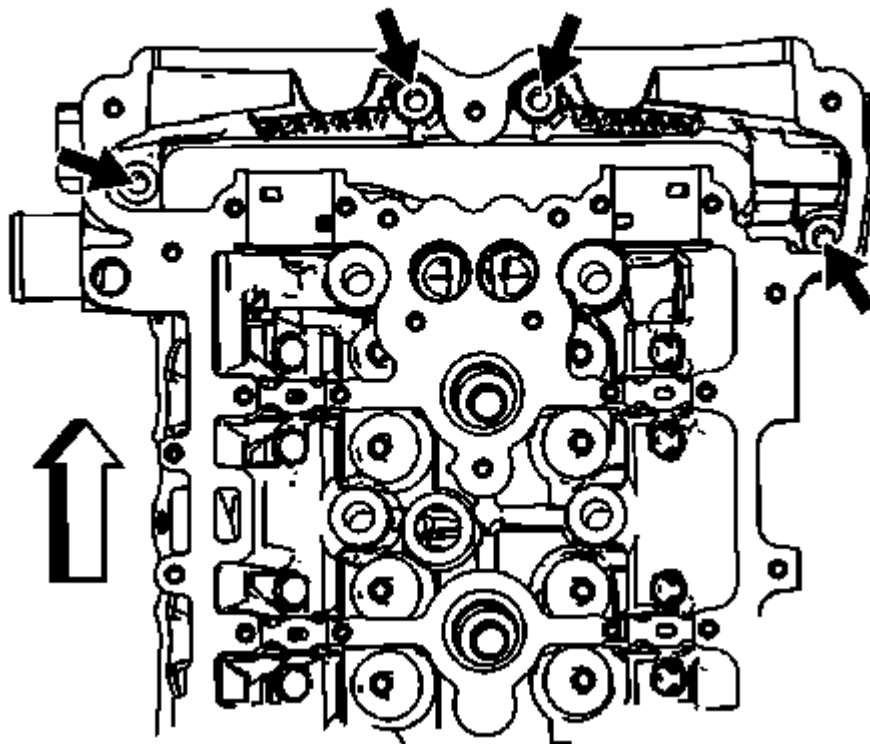


**Fig. 215: Identifying Cylinder Head Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Always use **NEW** cylinder head bolts.

3. Install the cylinder head bolts.
  1. Tighten the bolts in sequence to 30 N.m (22 lb ft).
  2. Tighten the bolts an additional 155 degrees in sequence using the **EN 45059** meter.

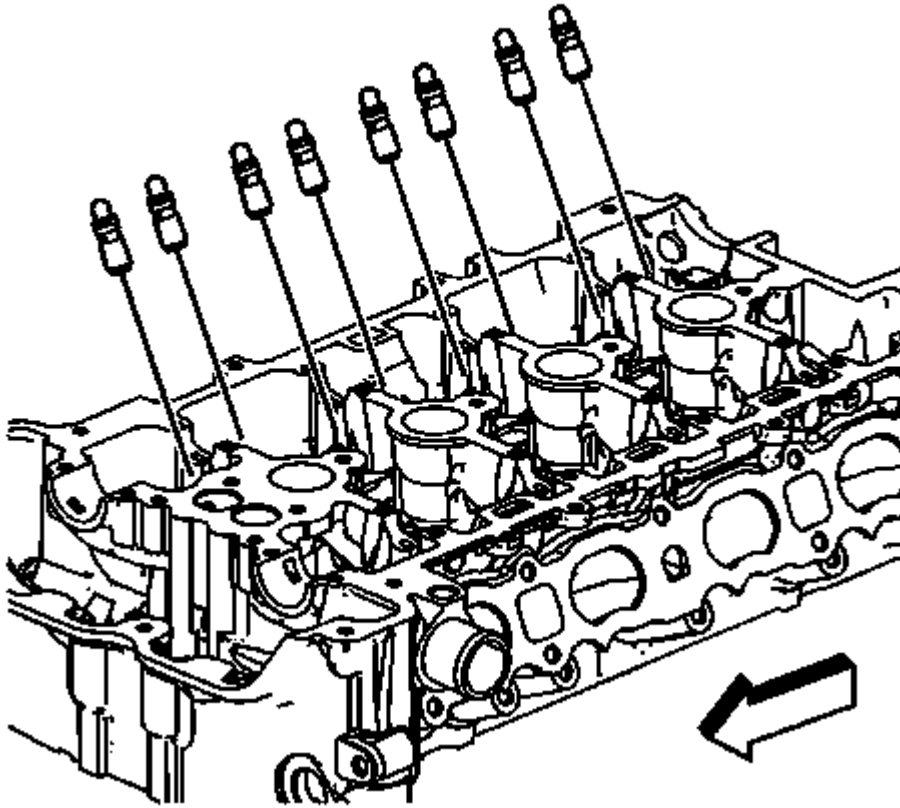


**Fig. 216: Locating Front Cylinder Head Bolts**  
Courtesy of GENERAL MOTORS COMPANY

4. Install the front cylinder head bolts and tighten to 30 N.m (22 lb ft).

#### **INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION (2.4L LEA)**

##### **Exhaust Camshaft Installation**

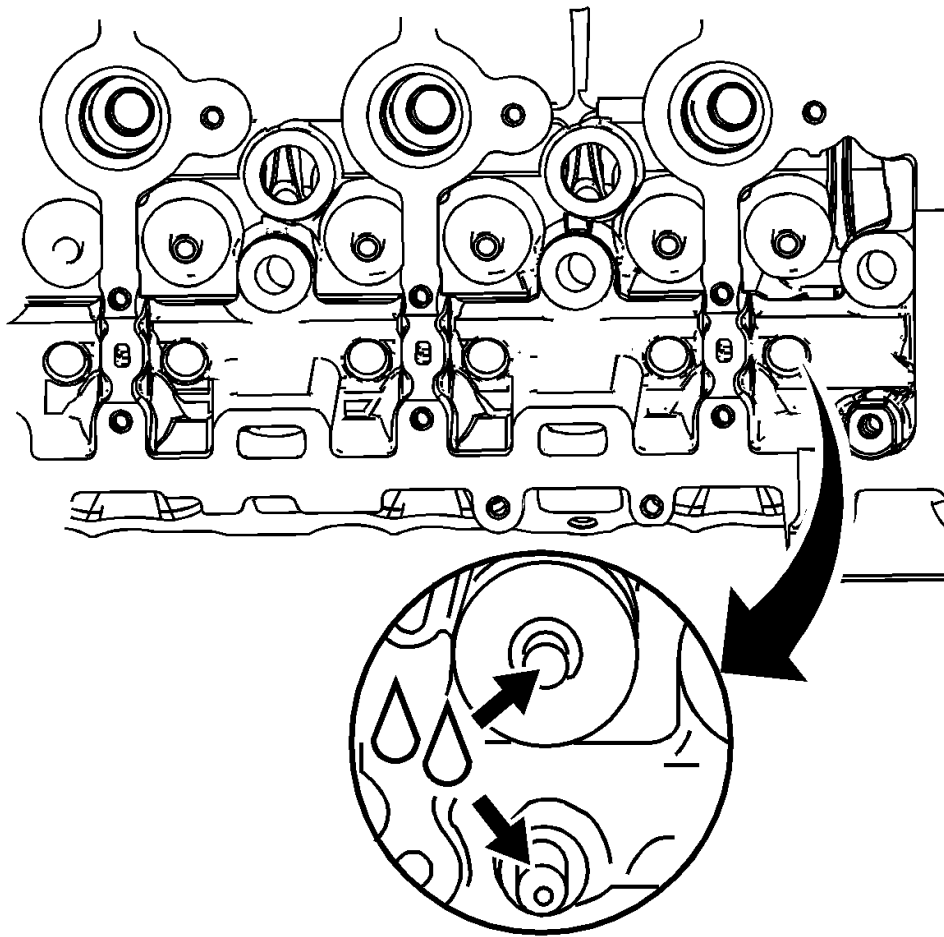


**Fig. 217: Hydraulic Lash Adjusters**

Courtesy of GENERAL MOTORS COMPANY

1. Install the hydraulic lash adjusters into their bores in the cylinder head and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

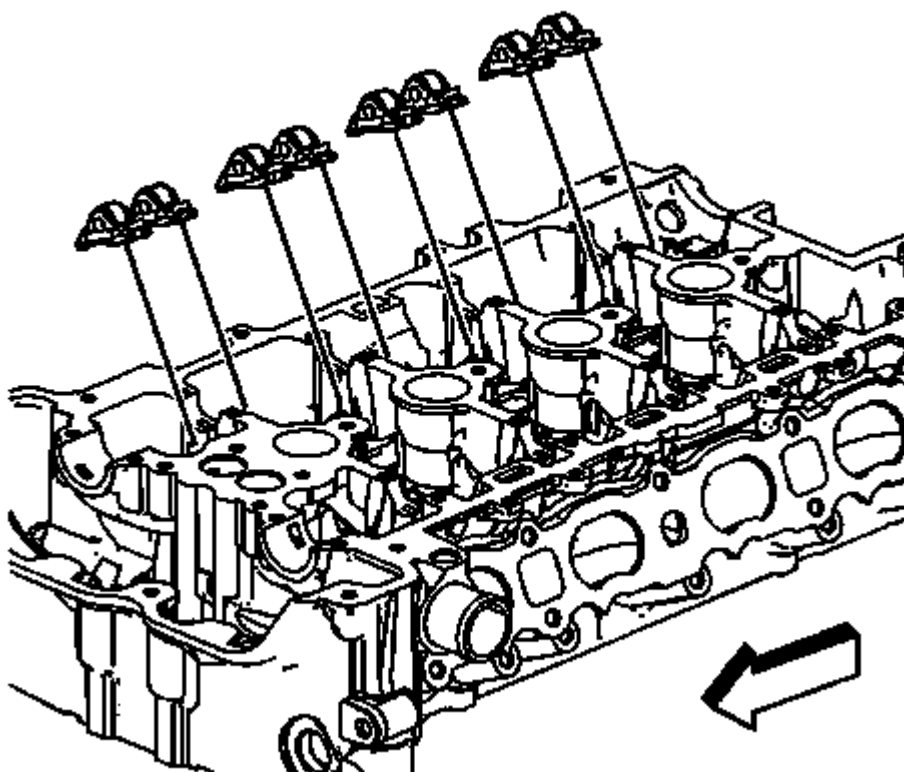




**Fig. 218: Valve Tips**

Courtesy of GENERAL MOTORS COMPANY

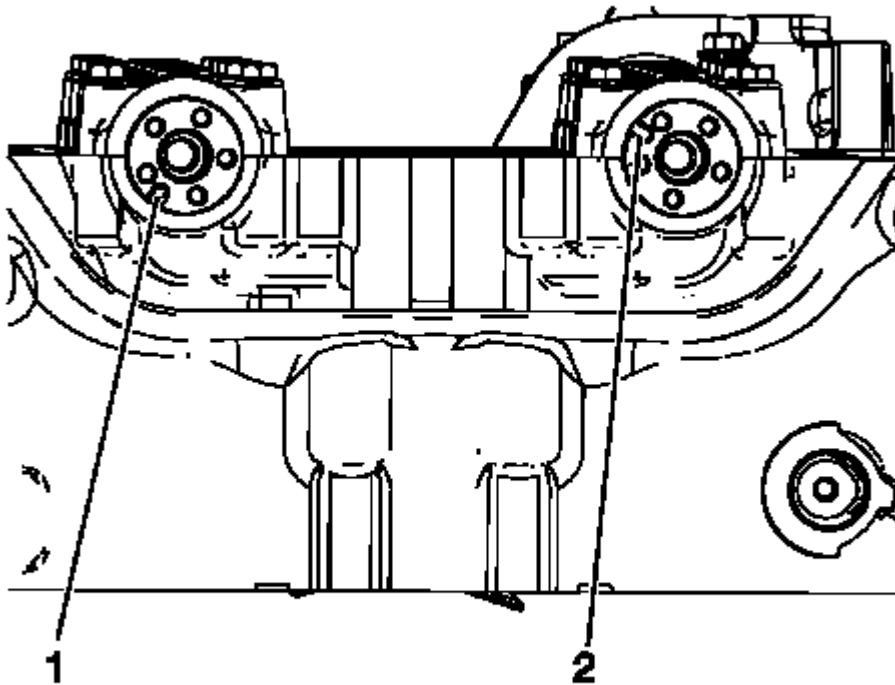
2. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers .



**Fig. 219: Exhaust Camshaft Roller Finger Followers**  
Courtesy of GENERAL MOTORS COMPANY

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

3. Position the roller followers on the tip of the valve stem and on the lash adjuster and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

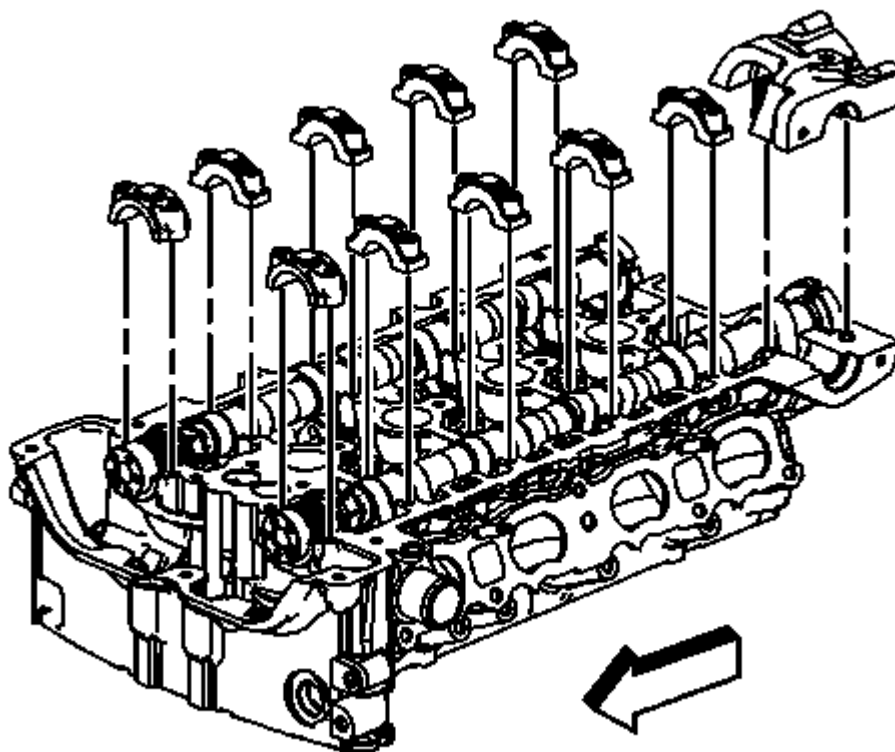


**Fig. 220: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

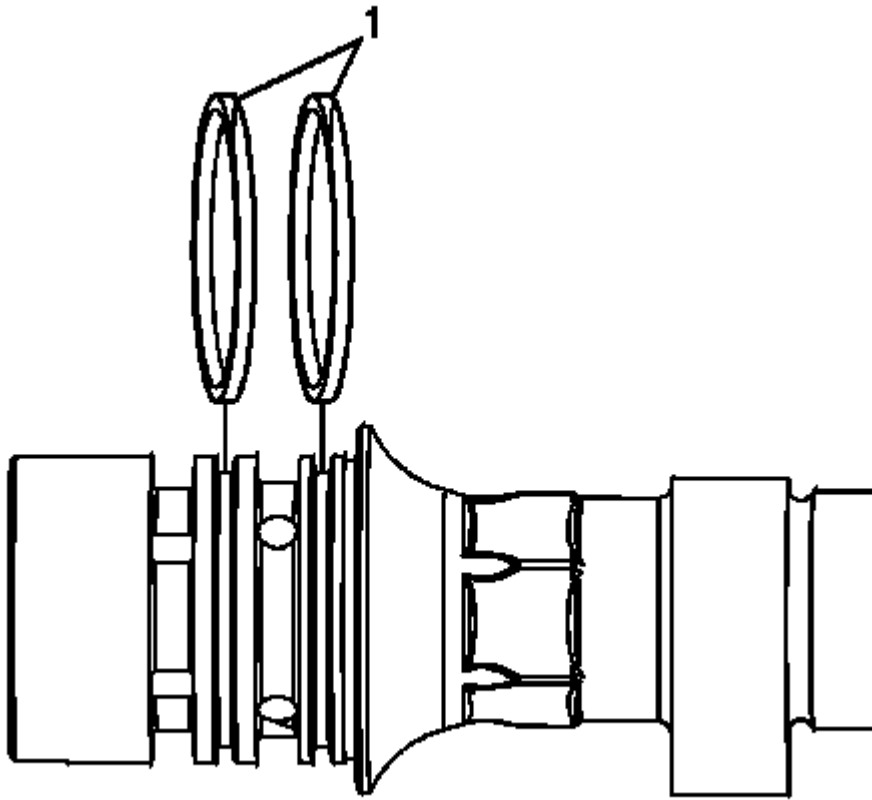
**NOTE:** The engine is timed top-dead center exhaust stroke.

4. When installing the camshafts, ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

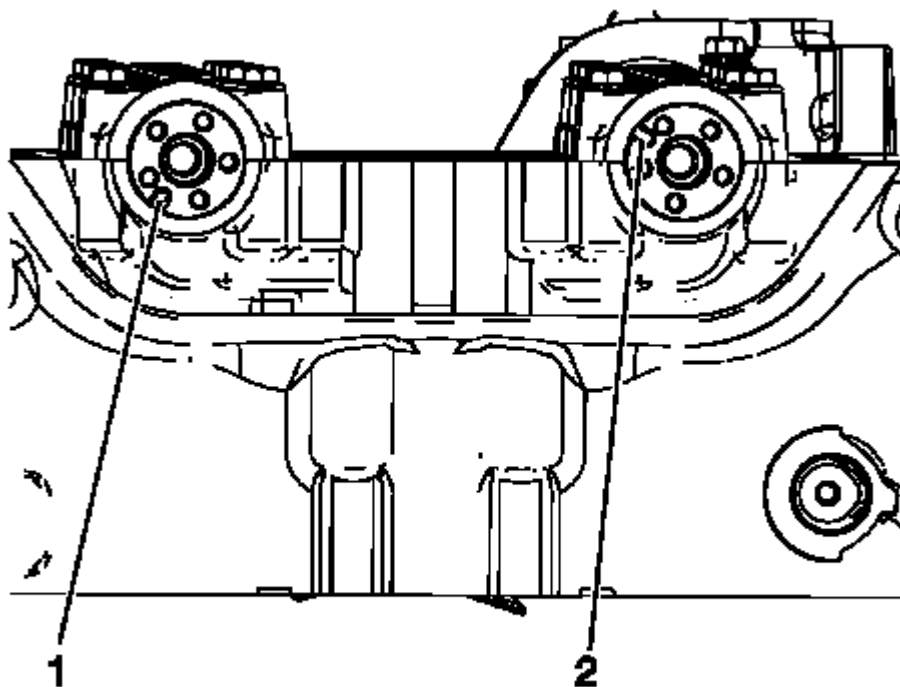


**Fig. 221: Intake Camshaft & Caps**  
Courtesy of GENERAL MOTORS COMPANY

5. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

**Fig. 222: Oil Seals****Courtesy of GENERAL MOTORS COMPANY**

6. Rotate the oil seal in the groove of the number one camshaft journal so the split line (1) is at approximately the 12:00 position before installing the camshaft caps.



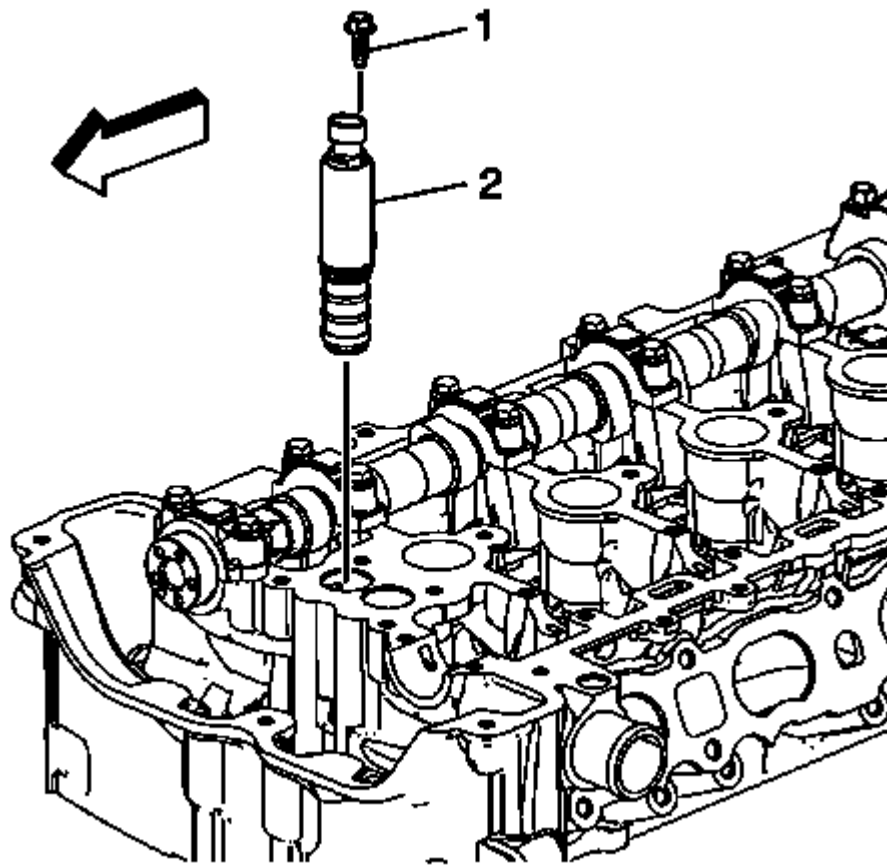
**Fig. 223: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

7. Install the exhaust camshaft with the notch on the front (1) at approximately the 7 o'clock position.
8. Install the camshaft caps and hand start the camshaft cap bolts.

**CAUTION: Refer to Fastener Caution .**

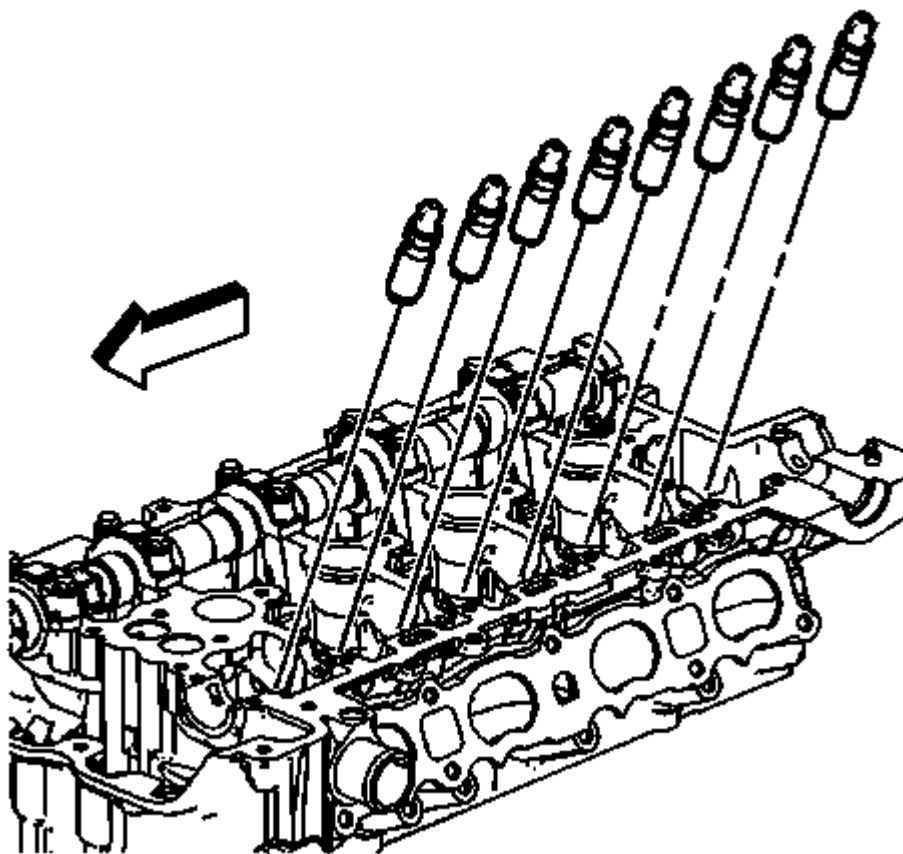
9. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).



**Fig. 224: Exhaust Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

10. Install the exhaust camshaft position actuator solenoid valve (2). Tighten the solenoid valve bolt (1) to 10 N.m (89 lb in).

#### **Intake Camshaft Installation**

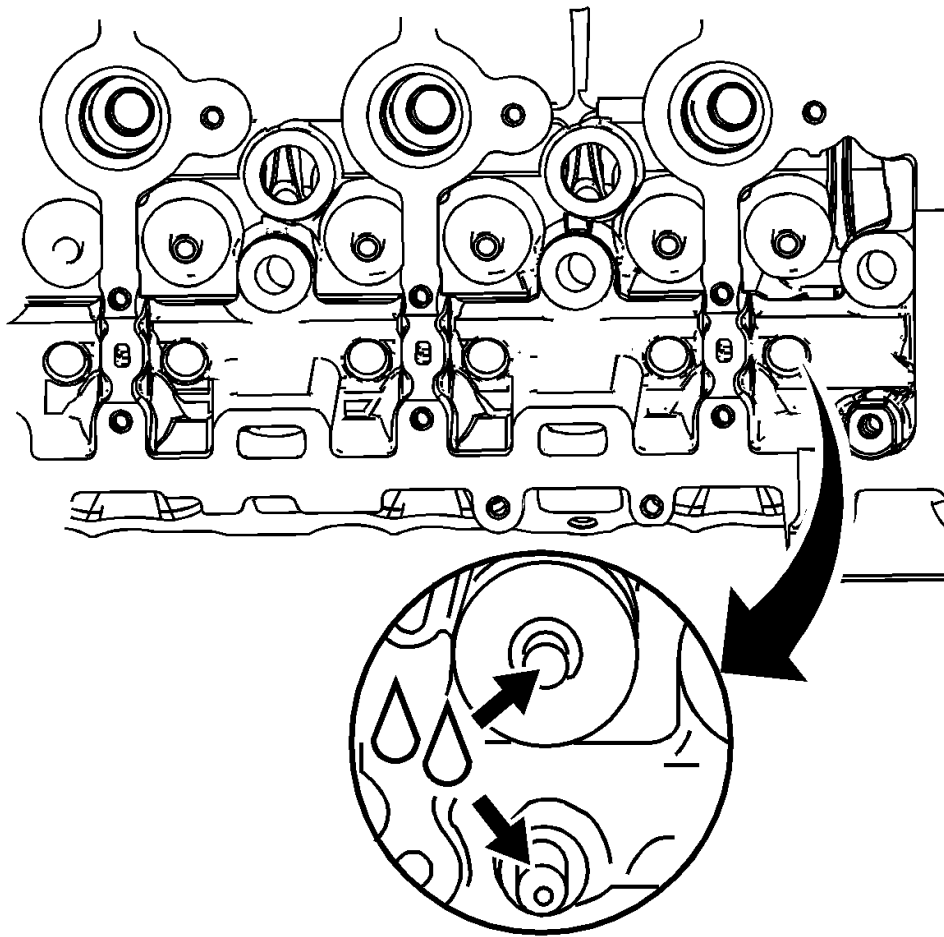


**Fig. 225: Hydraulic Lash Adjusters**

Courtesy of GENERAL MOTORS COMPANY

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

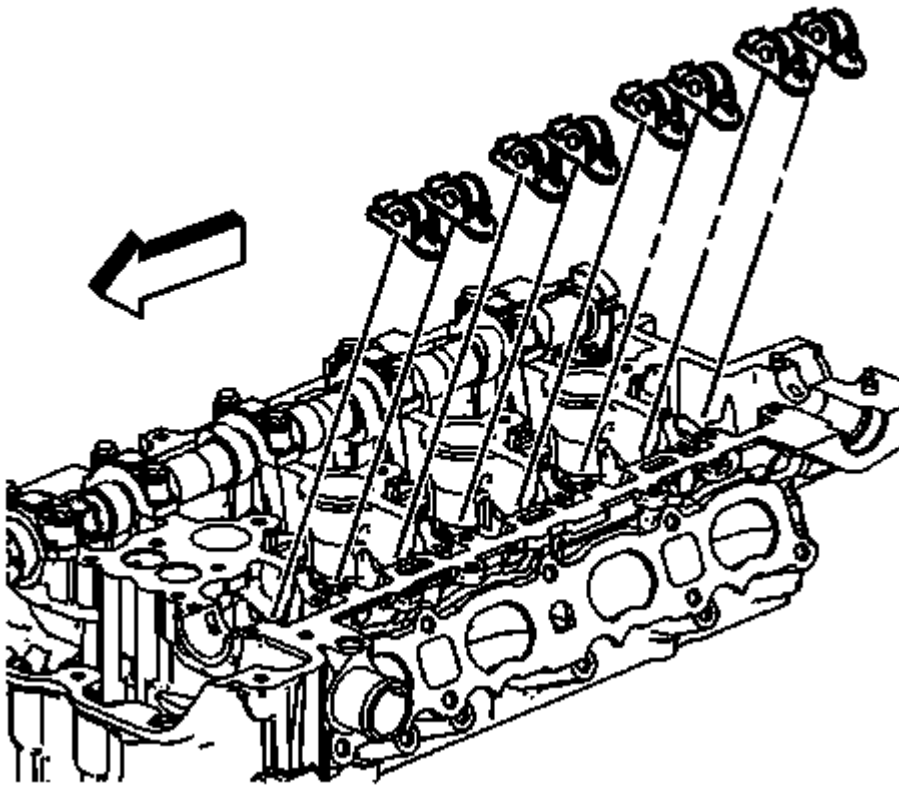




**Fig. 226: Valve Tips**

Courtesy of GENERAL MOTORS COMPANY

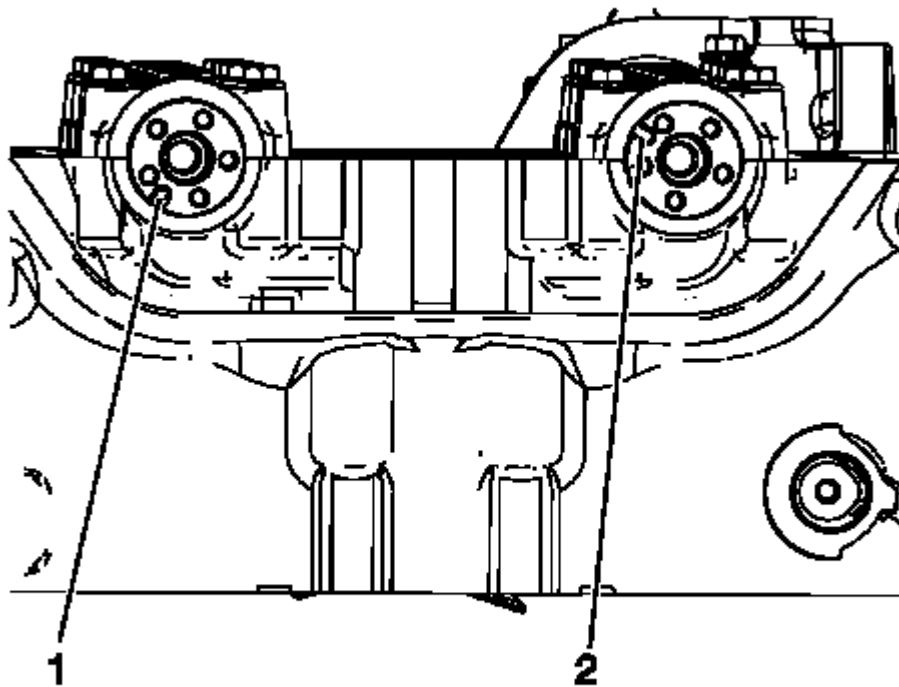
3. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers .



**Fig. 227: Intake Camshaft Roller Finger Followers**  
 Courtesy of GENERAL MOTORS COMPANY

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

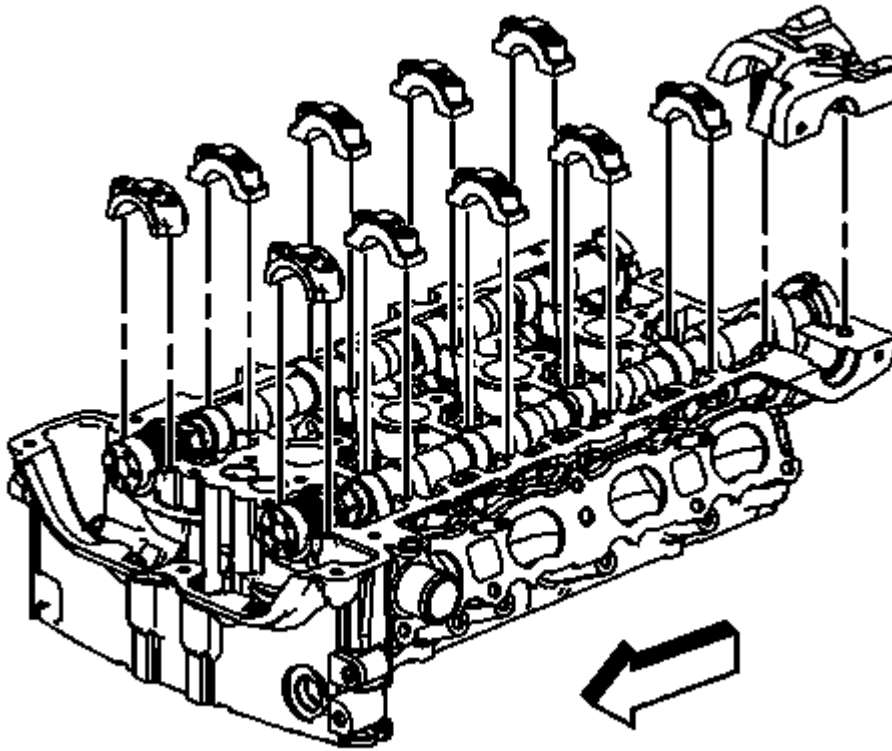
4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Lubricate roller followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

**Fig. 228: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

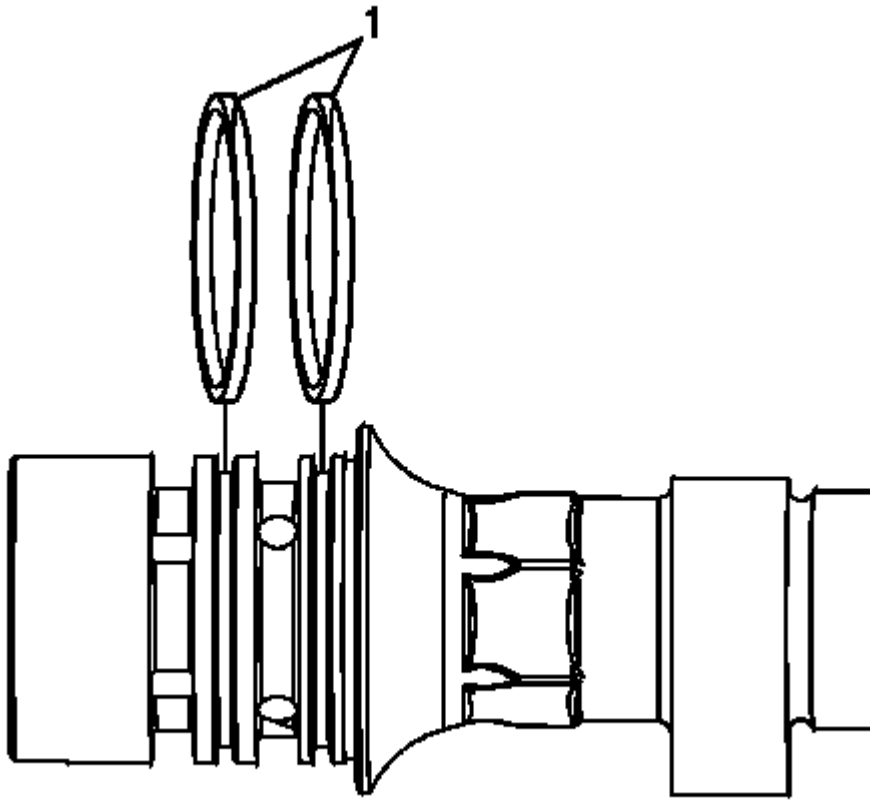
**NOTE:** The engine is timed top-dead center exhaust stroke.

5. When installing the camshafts, ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.



**Fig. 229: Intake Camshaft & Caps**  
Courtesy of GENERAL MOTORS COMPANY

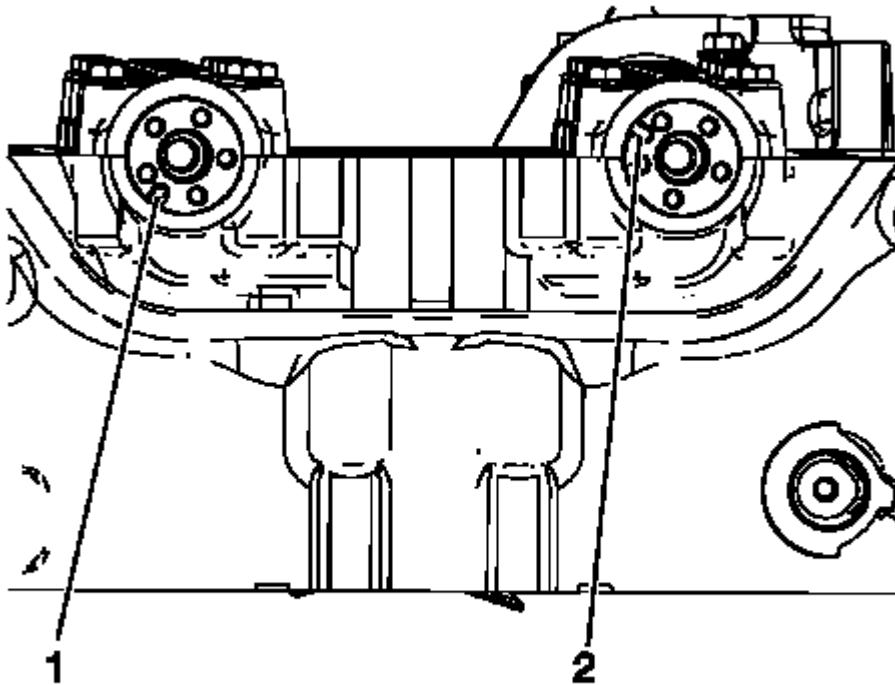
6. Set the intake camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .



**Fig. 230: Oil Seals**

**Courtesy of GENERAL MOTORS COMPANY**

7. Rotate the oil seal in the groove of the number one camshaft journal so the split line (1) is at approximately the 12:00 position before installing the camshaft caps.

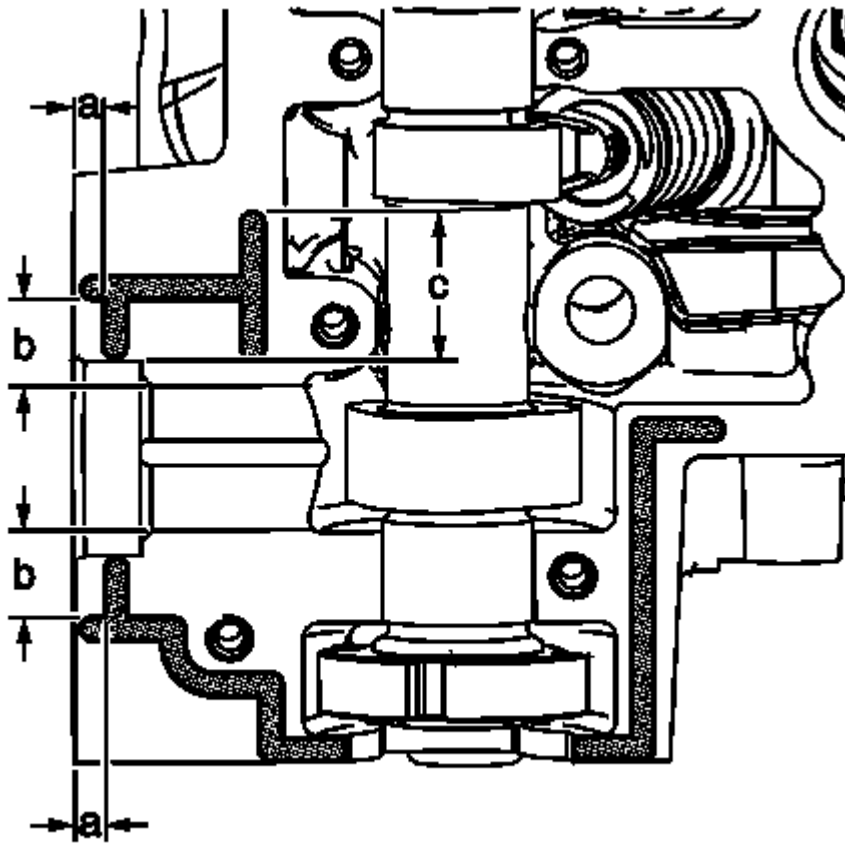


**Fig. 231: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** The number 1 cylinder must be at top dead center (TDC), crankshaft keyway at the 12 o'clock position.

8. Install the intake camshaft with the notch on the front at approximately the 10 o'clock position (2).
9. Install the camshaft caps and hand start the camshaft cap bolts.
10. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).



**Fig. 232: Sealer Application Areas**

Courtesy of GENERAL MOTORS COMPANY

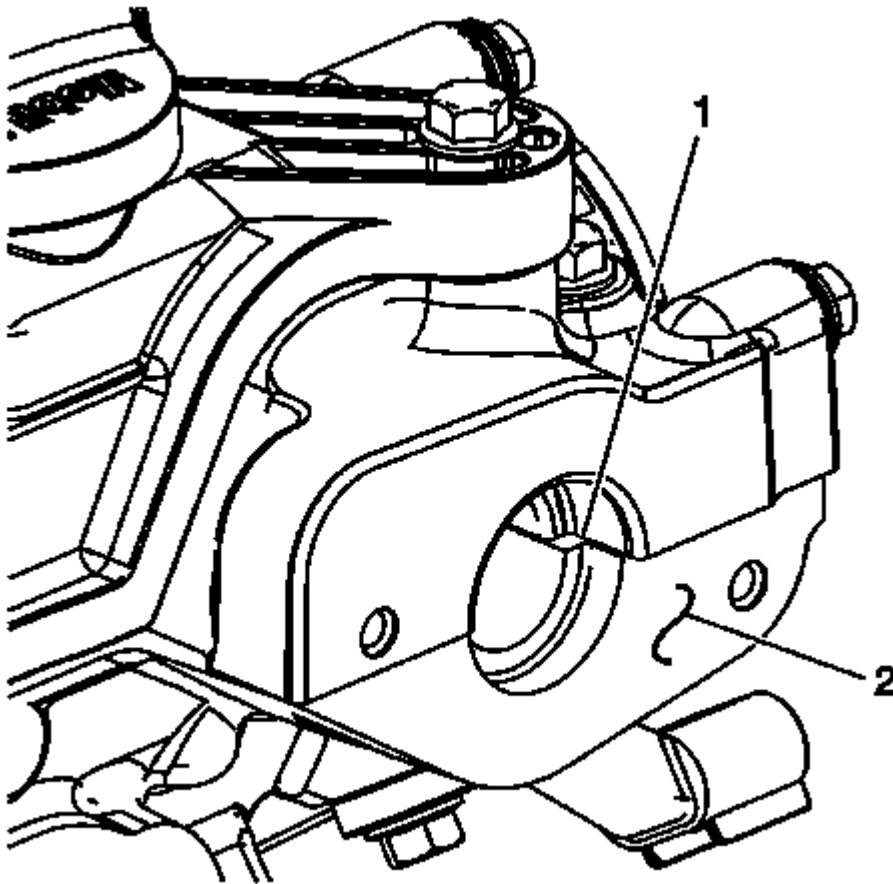
**NOTE:** It is critical during installation to ensure the bearing rear cap and cylinder head alignment is correct and the mating surfaces are flush.

- Ensure that all sealing material has been removed from the components, and the sealing surfaces are clean and free of contamination prior to applying the sealer.
- Install and align the rear cap within 20 minutes of applying the sealer.

**NOTE:** Apply the sealer to all locations centrally locating the bead on the rail.

- Run bead to 5.0 mm, dimension a, as shown.
- Where the cap ends on the perimeter rail, extend bead approximately 4.0 mm beyond edge of cap.
- Run bead, dimension c, 32 mm from the edge of the cylinder head as shown.
- Run beads, dimension b, 20 mm from edge of cylinder head as shown.

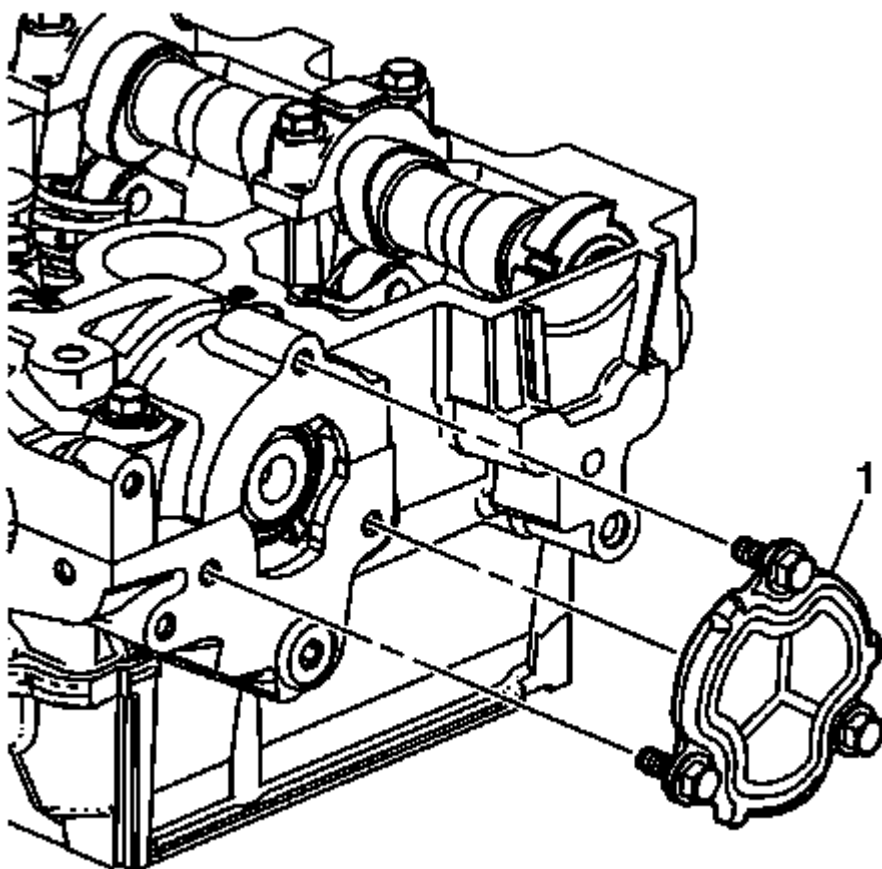
11. Apply a 2.5 mm bead of sealer to the cylinder head at the number 6 intake camshaft rear cap mating surface. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
12. Install the number 6 intake camshaft rear cap.
  1. Tighten the cap bolts evenly to 5 N.m (44 lb in).
  2. Tighten the cap bolts evenly to 10 N.m (89 lb in).
  3. Back the cap bolts out 120 degrees.
  4. Tighten the cap bolts evenly a final pass to 10 N.m (89 lb in).



**Fig. 233: Identifying Fuel Pump Roller Lifter Orifice**  
Courtesy of GENERAL MOTORS COMPANY

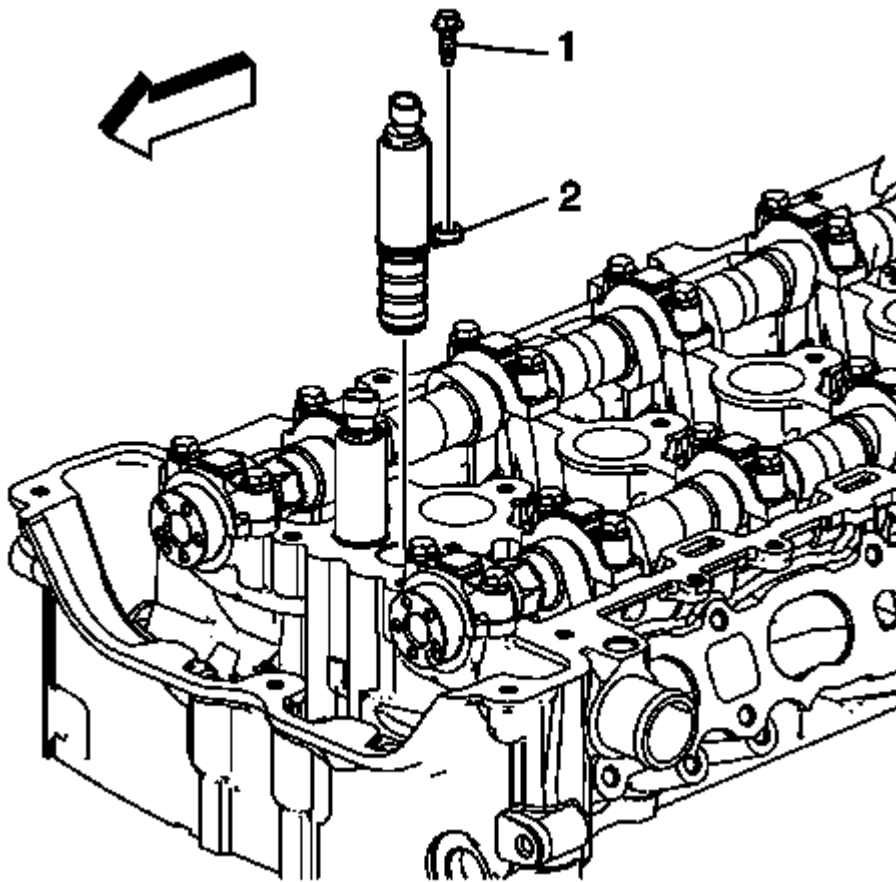
13. Remove all excess sealing material from the fuel pump roller lifter bore (1), and ensure the bore is free of debris. Do not allow any excess sealing material to remain within the cylinder head or on any sealing surface.
14. Remove all excess sealing material from the fuel pump assembly sealing surface (2).





**Fig. 234: Rear Cylinder Head Cover Plate**  
 Courtesy of GENERAL MOTORS COMPANY

15. Verify the seal on the cylinder head cover plate (1) is intact and in good condition.
16. Ensure that the opening plate sealing surface is clean and free of excess sealing material. Install the rear cylinder head opening plate (1) and tighten the bolts to 10 N.m (89 lb in).



**Fig. 235: Intake Camshaft Position Actuator Solenoid Valve & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

17. Install the intake camshaft position actuator solenoid valve (2). Tighten the solenoid valve bolt (1) to 10 N.m (89 lb in).

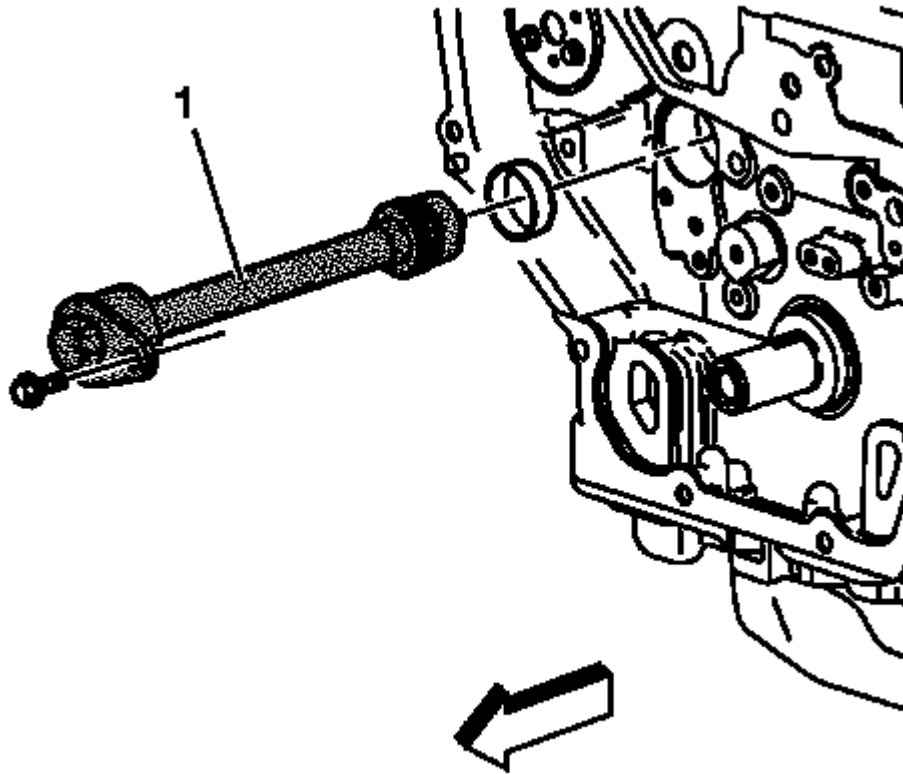
## BALANCE SHAFT INSTALLATION

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

### Special Tools

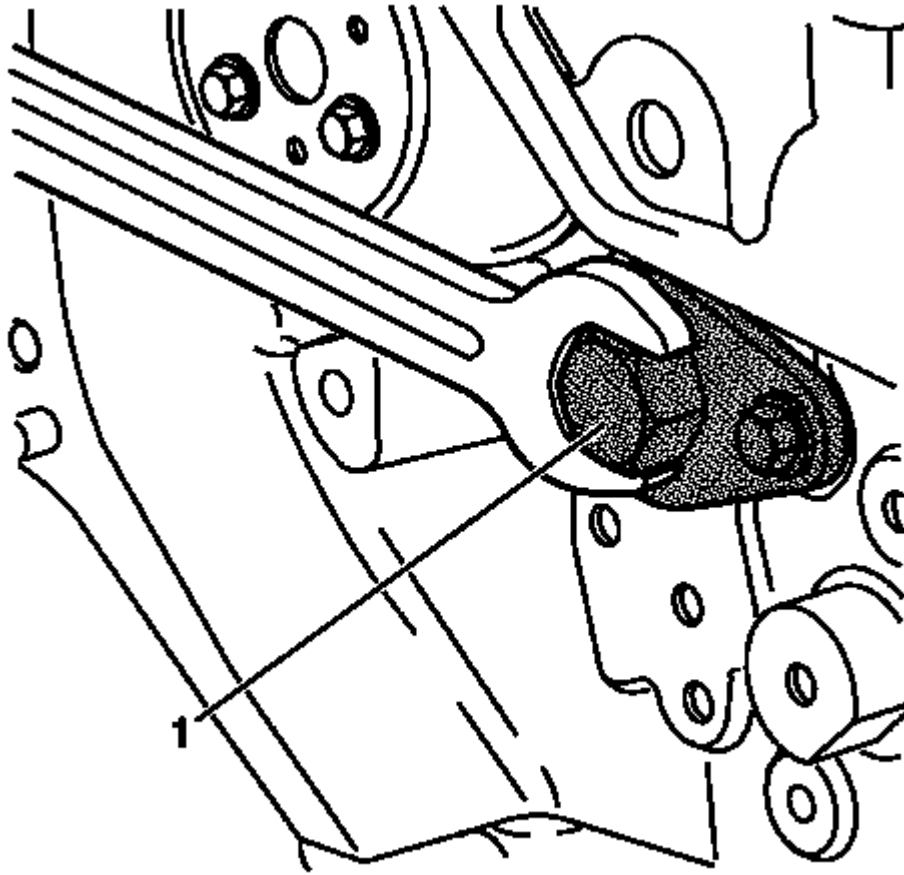
**EN-43650** Balance Shaft Bushing Remover/Installer

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



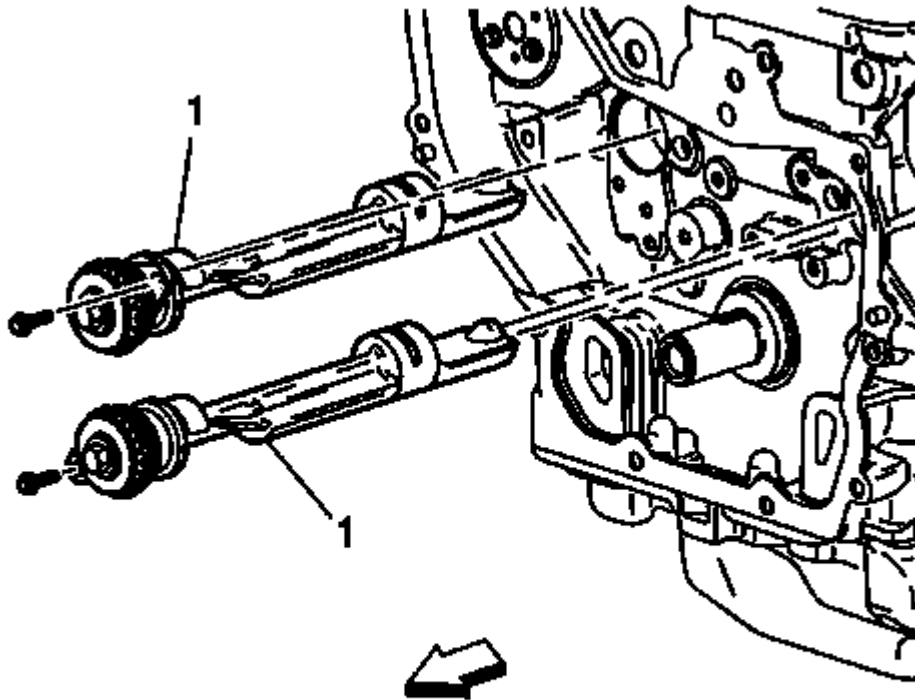
**Fig. 236: Installing Balance Shaft Bushing**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the balance shaft bushing using the **EN-43650** installer (1).



**Fig. 237: Seating Balance Shaft Bushing**  
Courtesy of GENERAL MOTORS COMPANY

2. Seat the balance shaft bushing into the bore using the **EN-43650** installer (1) and a wrench.
3. When the **EN-43650** installer is fully seated in the engine block, remove it with a wrench.



**Fig. 238: View of Balance Shaft Bolts**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

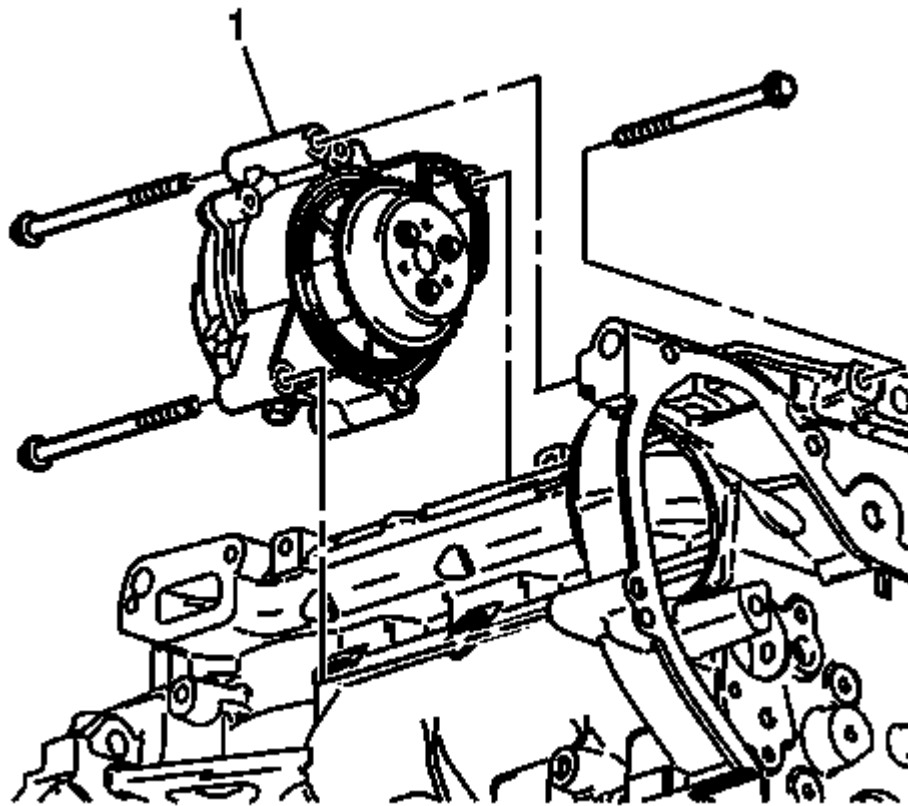
4. Place the number one piston at top dead center (TDC).
5. Lubricate the balance shaft lobes with engine oil.
6. Install the balance shafts (1) into their bores.

**CAUTION:** Refer to Fastener Caution .

7. Install the balance shaft retaining bolts and tighten to 10 N.m (89 lb in).

## 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.

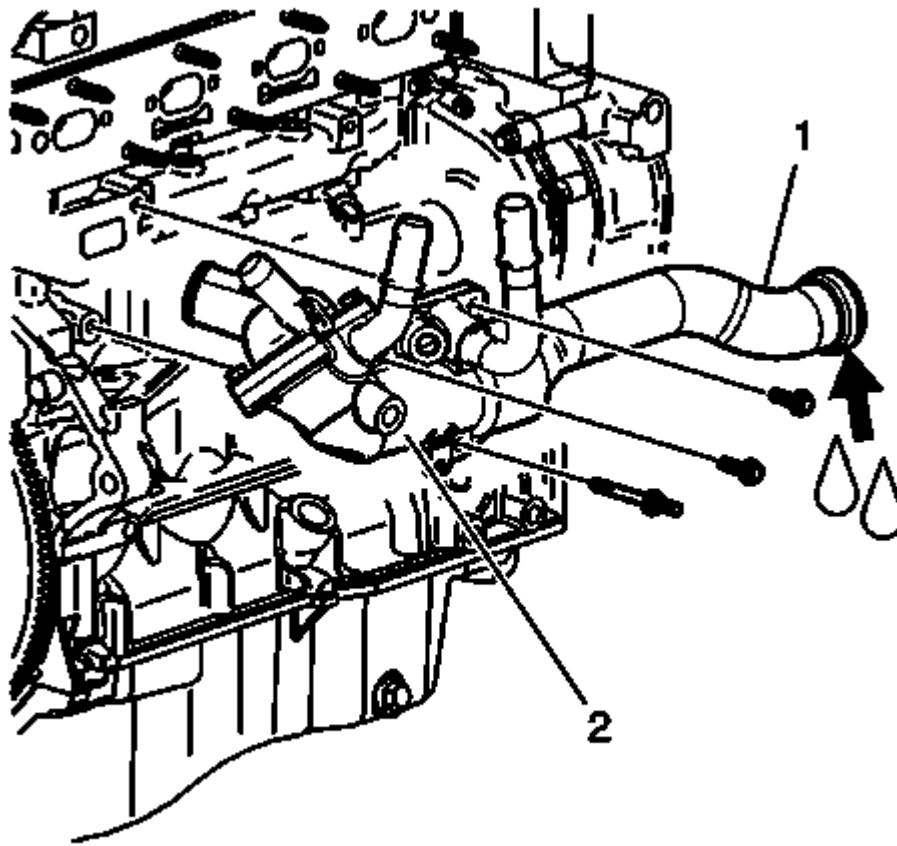


**Fig. 239: Water Pump Assembly**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the water pump assembly (1).
2. Install the water pump bolts. Finger tighten the bolts.

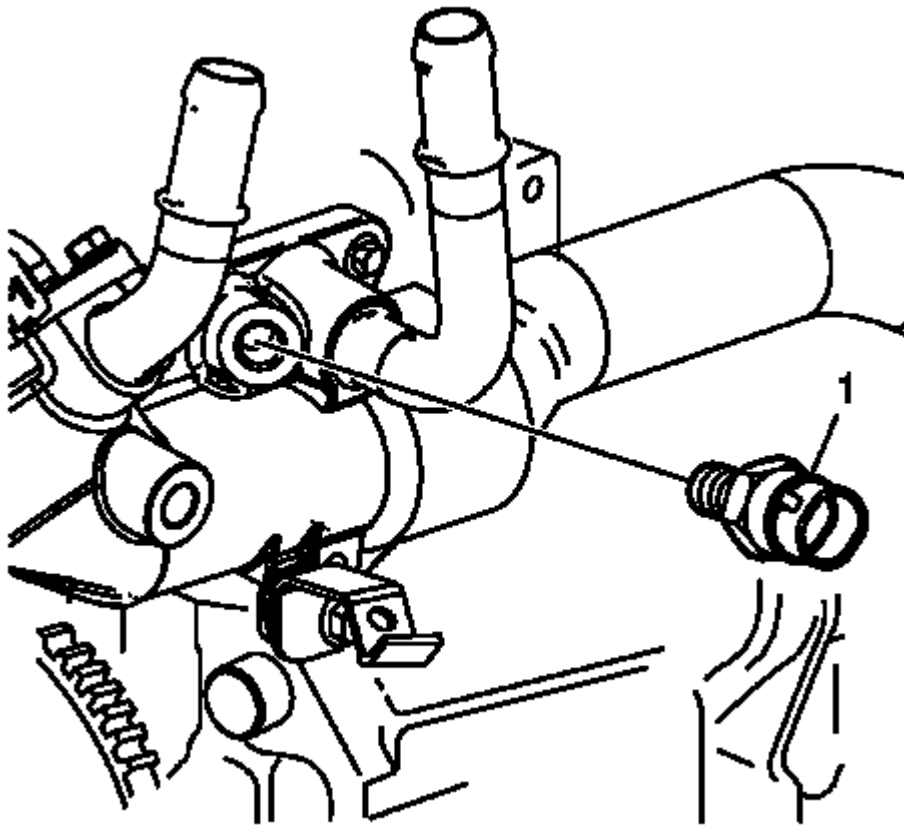
**CAUTION: Refer to Fastener Caution .**

3. Tighten the water pump bolts to 25 N.m (18 lb ft).
4. Apply sealant to the water pump drain plug. Refer to Adhesives, Fluids, Lubricants, and Sealers .
5. Install the water pump drain plug, if necessary. Tighten to 20 N.m (15 lb ft).



**Fig. 240: Water Feed Tube & Thermostat Housing**  
Courtesy of GENERAL MOTORS COMPANY

6. Install the water feed tube (1).
7. Lubricate the feed tube O-ring with antifreeze.
8. Install the water feed tube by twisting and pushing toward the water pump. Take care not to tear or damage the O-ring.
9. Install the thermostat housing (2) to block bolts and stud and tighten to 10 N.m (89 lb in).

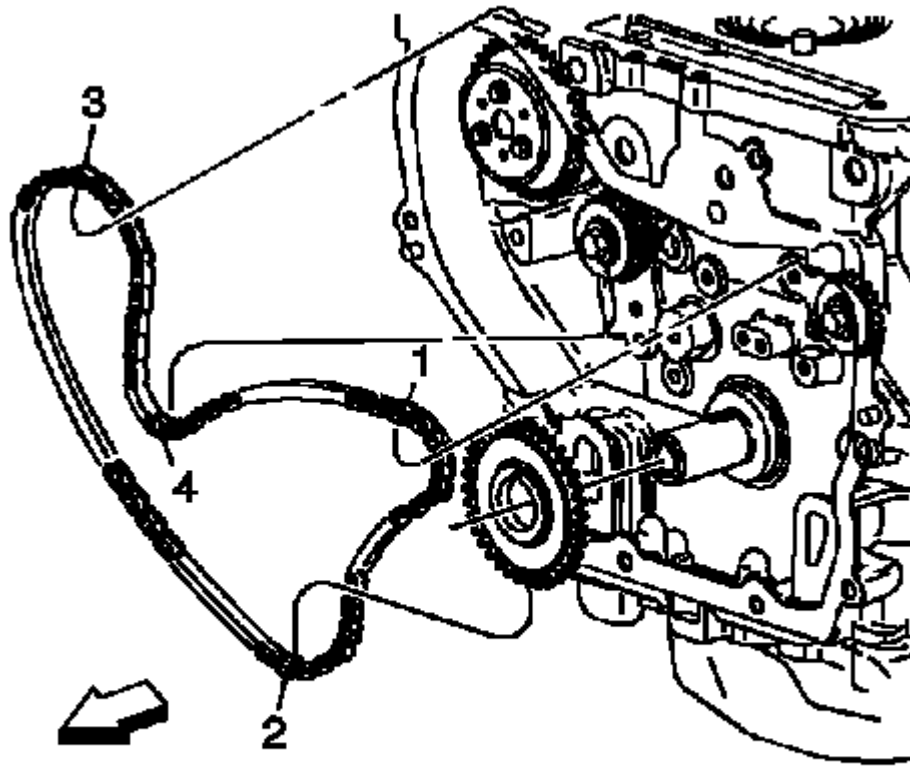


**Fig. 241: Engine Coolant Temperature Sensor**  
Courtesy of GENERAL MOTORS COMPANY

10. Install the engine coolant temperature sensor (1) by hand.
11. Tighten the engine coolant temperature sensor and tighten to 20 N.m (15 lb ft).

**BALANCE SHAFT TO ENGINE TIMING (2.4L LEA)**





**Fig. 242: Aligning Balance Shaft Drive Chain**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the balance shaft drive sprocket.

**NOTE:** If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

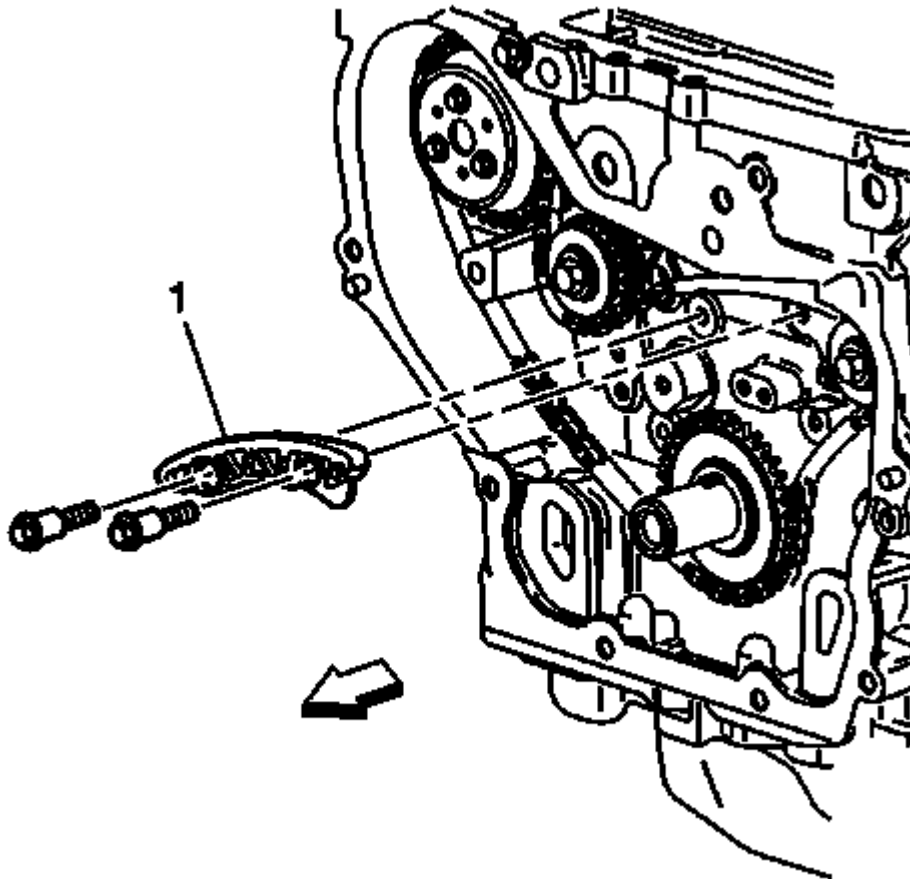
2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three colored links on the chain. Two links are of matching colors, and one link is of a unique color. Use the following procedure to line up the links with the sprockets:

Orient the chain so that the colored links are visible.

3. Place the uniquely colored link (1) so that it lines up with the timing mark on the intake side balance shaft sprocket.
4. Working clockwise around the chain, place the first matching colored link (2) in line with the timing mark on the crankshaft drive sprocket, approximately 6 o'clock position on the crank sprocket.
5. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
6. Align the last matching colored link (4) with the timing mark on the exhaust side balance shaft drive

sprocket.

## WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER INSTALLATION

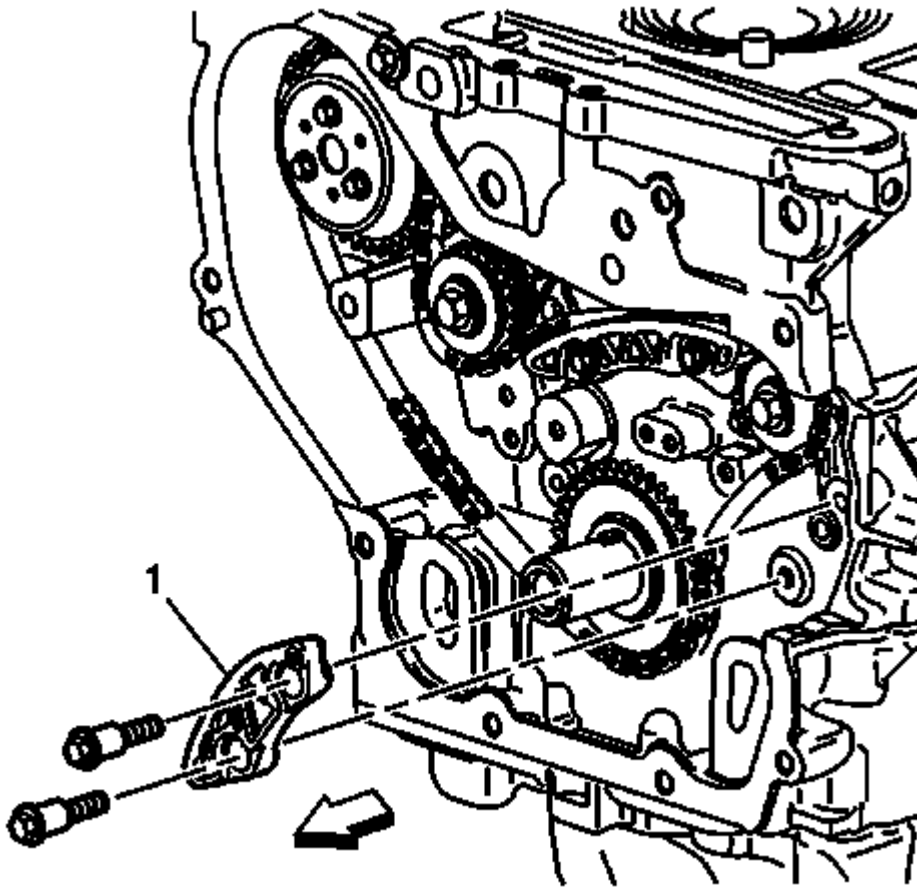


**Fig. 243: Upper Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

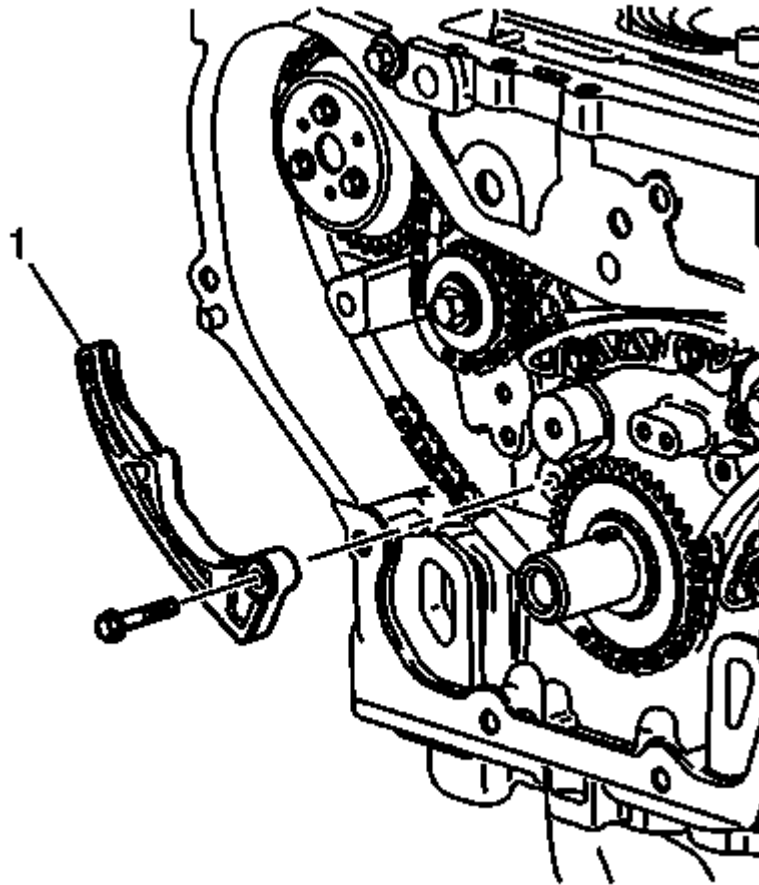
**NOTE:** If the balance shafts are not properly timed to the engine, the engine may vibrate and make noise.

1. Install the upper balance shaft chain guide (1) and bolts and tighten to 12 N.m (106 lb in).



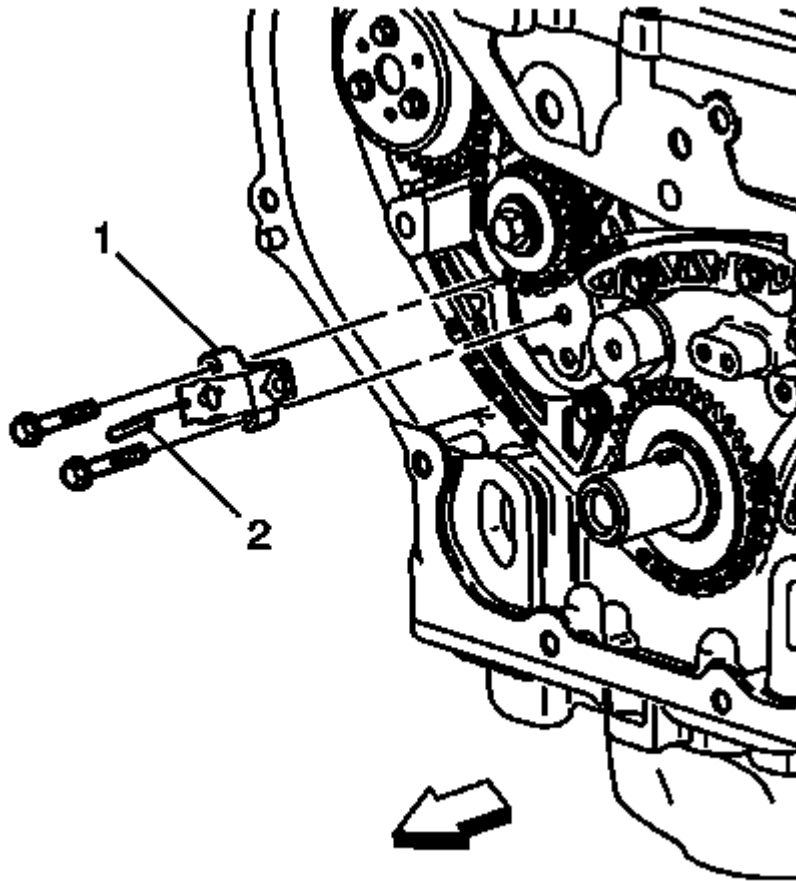
**Fig. 244: Small Balance Shaft Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

2. Install the small balance shaft chain guide (1).
3. Install the balance shaft chain guide bolts and tighten to 12 N.m (106 lb in).



**Fig. 245: Adjustable Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

4. Install the adjustable balance shaft drive chain guide (1).
5. Install the adjustable balance shaft drive chain guide bolts and tighten to 10 N.m (89 lb in).



**Fig. 246: Timing Chain Tensioner**

Courtesy of GENERAL MOTORS COMPANY

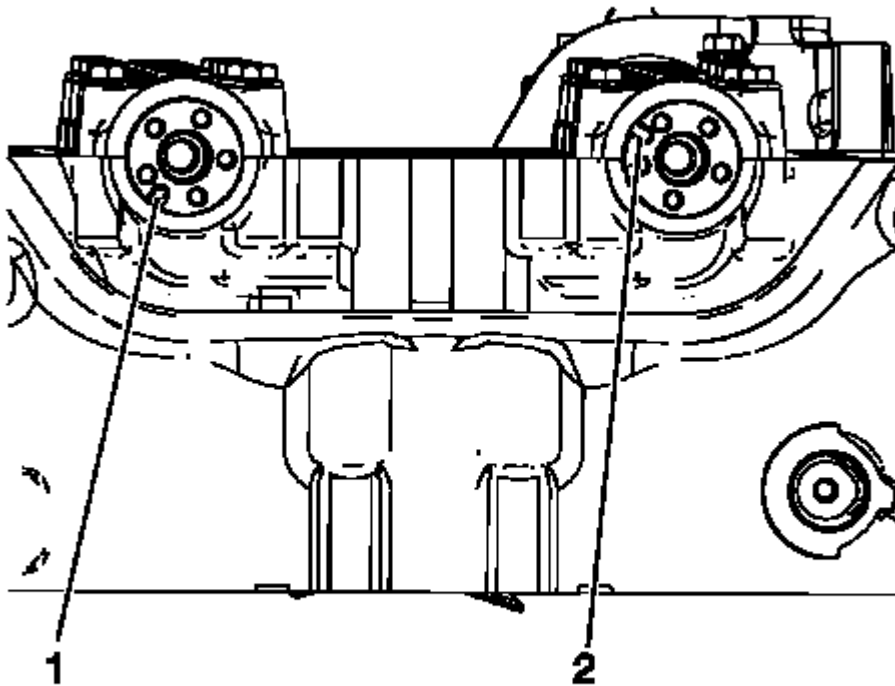
6. Reset the timing chain tensioner (1) by performing the following steps:
  1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.
  2. Turn the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hole in the tensioner plunger.
7. Install the timing chain tensioner.
8. Install the chain tensioner bolts and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

## CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER INSTALLATION (2.4L LEA)

### Special Tools

- EN-45027 Tensioner Tool
- EN 45059 Angle Meter
- EN-48953 Camshaft Actuator Locking Tool

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

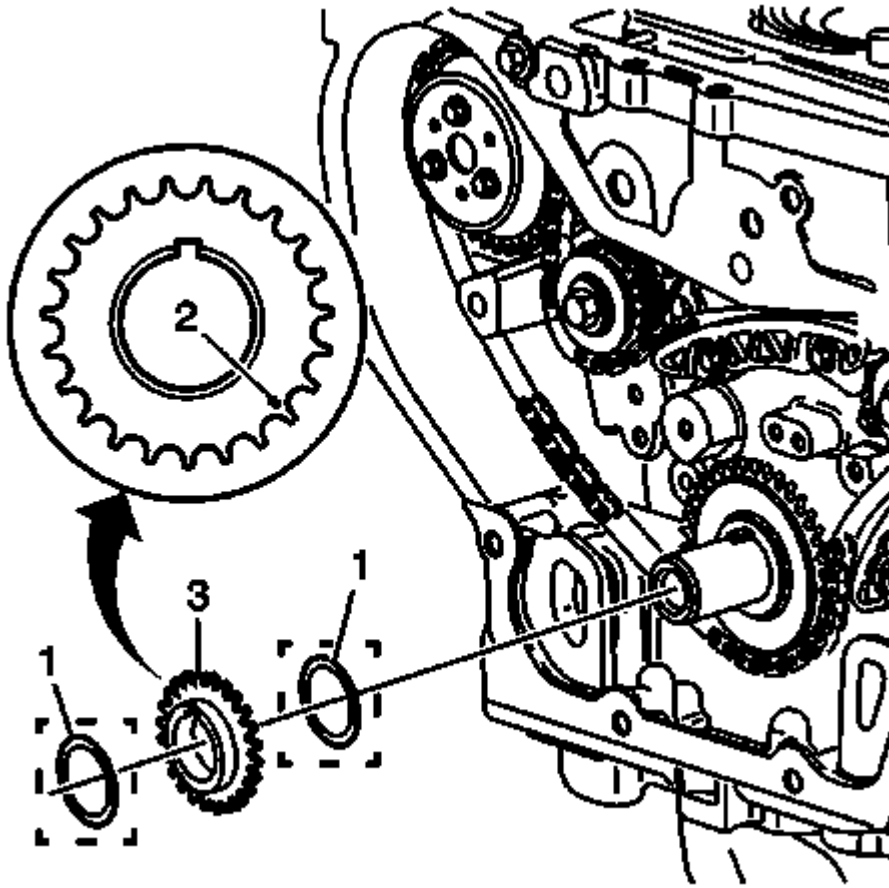


**Fig. 247: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** The engine is timed top-dead center exhaust stroke.

1. Ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

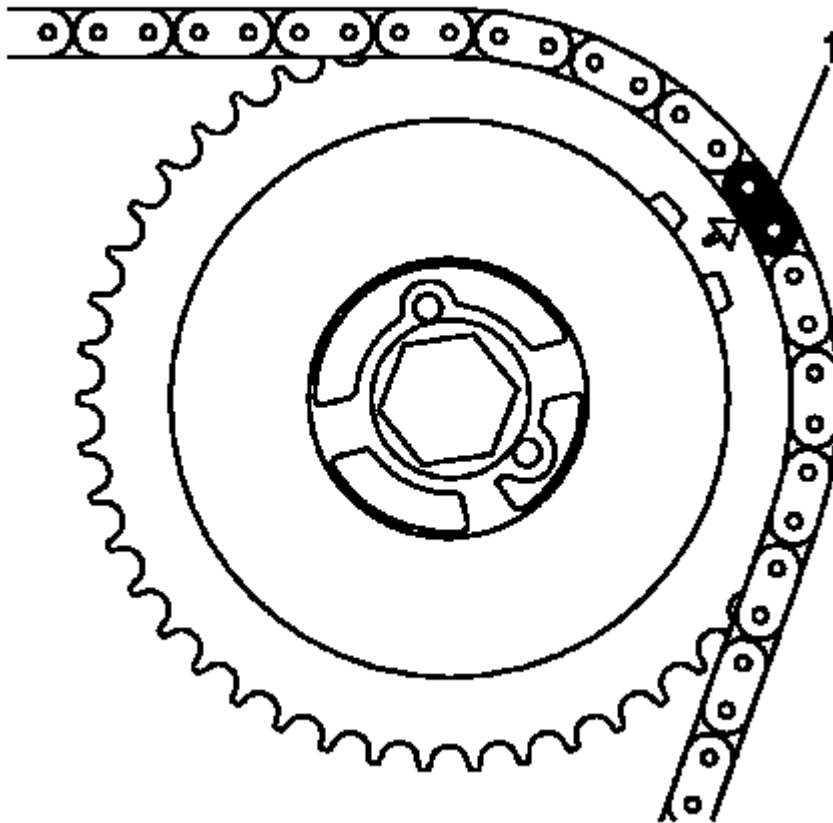


**Fig. 248: View of Friction Washer and Timing Chain Drive Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

2. Install a friction washer (1), if equipped.
3. Install the timing chain drive sprocket (3) to the crankshaft with the timing mark (2) in the 5 o'clock position and the front of the sprocket facing out.

**NOTE:** The outer spacer/washer (1) is in between the crank/balancer pulley and the lower timing gear and may remain in place when the pulley is removed. The spacer/washer (1) has a dot/mark on its surface that may be mistaken for the lower timing mark, and blocks the proper timing mark on the gear from view. The outer spacer/washer (1) must be removed when timing the engine in order to view the correct timing mark on the lower crank gear.

4. Install a second friction washer (1), if equipped.

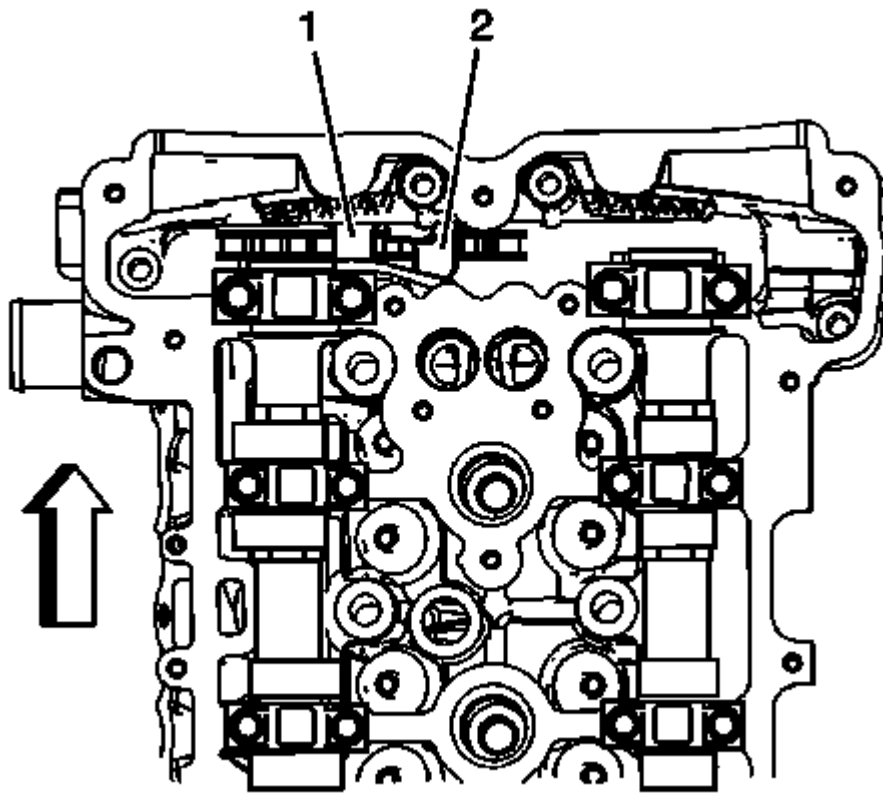


**Fig. 249: Identifying Colored Links On Timing Chain**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** There are three colored links on the timing chain. Two links are of matching color, and one link is of 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.

5. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).



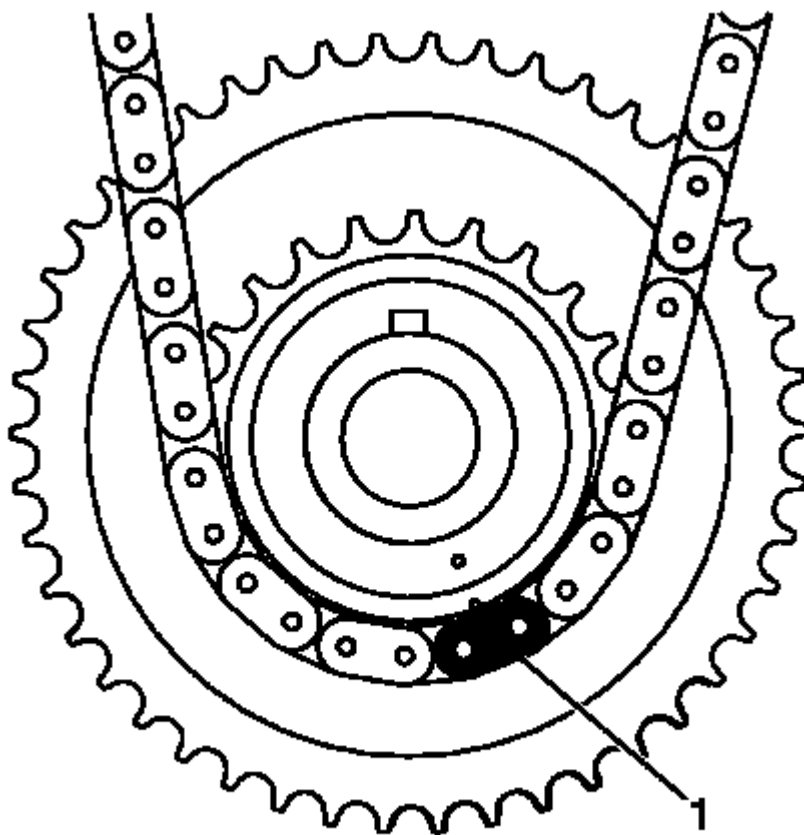


**Fig. 250: Identifying Cylinder Head Opening**  
Courtesy of GENERAL MOTORS COMPANY

6. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).
7. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.

**NOTE:** Always use NEW actuator bolts.

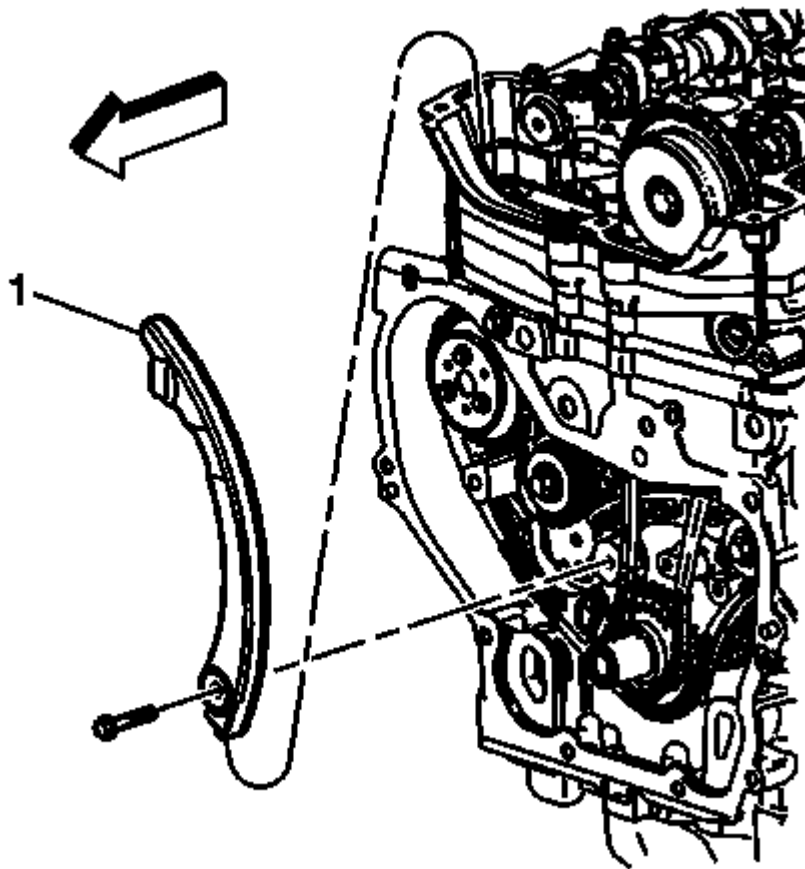
8. Hand tighten the new intake camshaft actuator bolt.



**Fig. 251: Identifying Timing Mark on Crankshaft Sprocket and Lining Up With First Matching Colored Link**

Courtesy of GENERAL MOTORS COMPANY

9. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (1) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

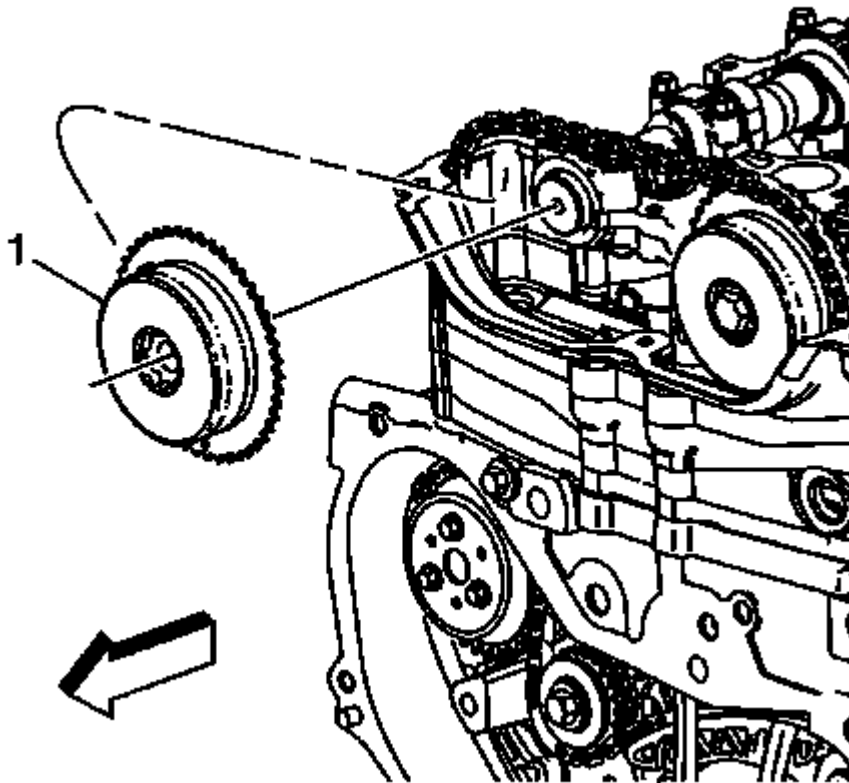


**Fig. 252: View of Adjustable Timing Chain Guide Bolt.**  
Courtesy of GENERAL MOTORS COMPANY

10. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.

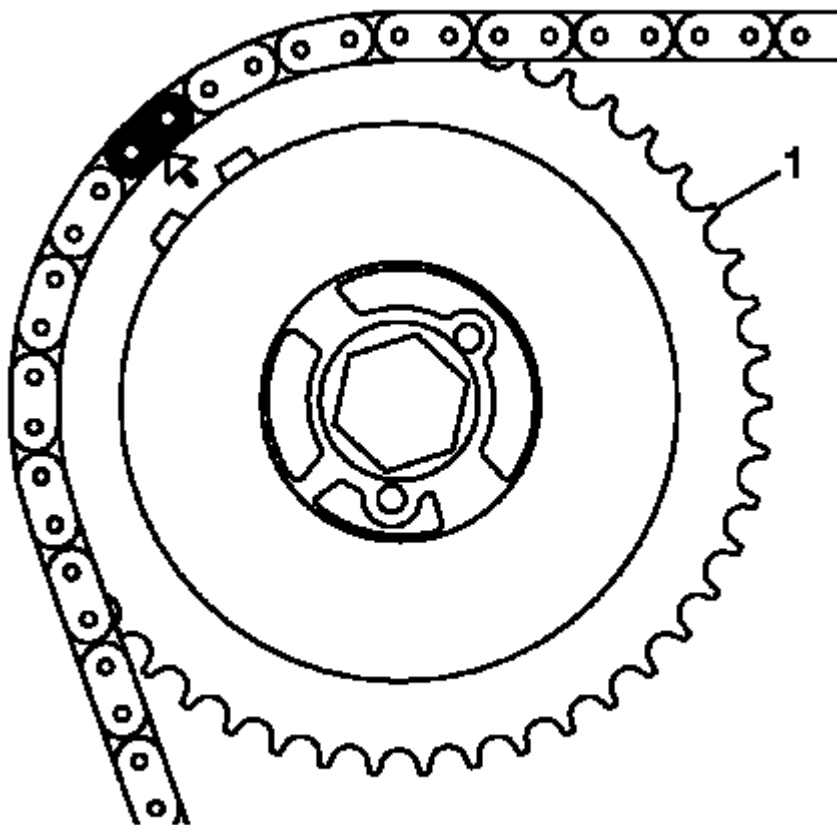
**CAUTION: Refer to Fastener Caution .**

11. Install the adjustable timing chain guide (1) down through the opening in the cylinder head and install the adjustable timing chain bolt and tighten to 10 N.m (89 lb in).



**Fig. 253: View of Exhaust Camshaft Actuator**  
**Courtesy of GENERAL MOTORS COMPANY**

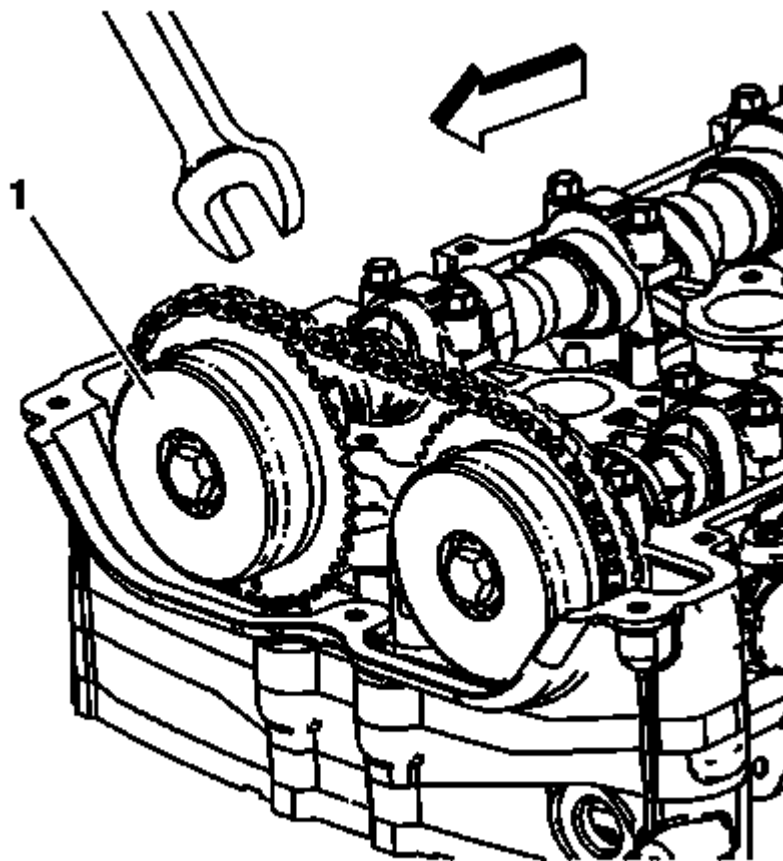
12. Install the exhaust camshaft actuator (1) into the timing chain with the timing mark lined up with the second matching colored link.



**Fig. 254: Exploded View of Exhaust Camshaft Actuator**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Always install NEW actuator bolts.

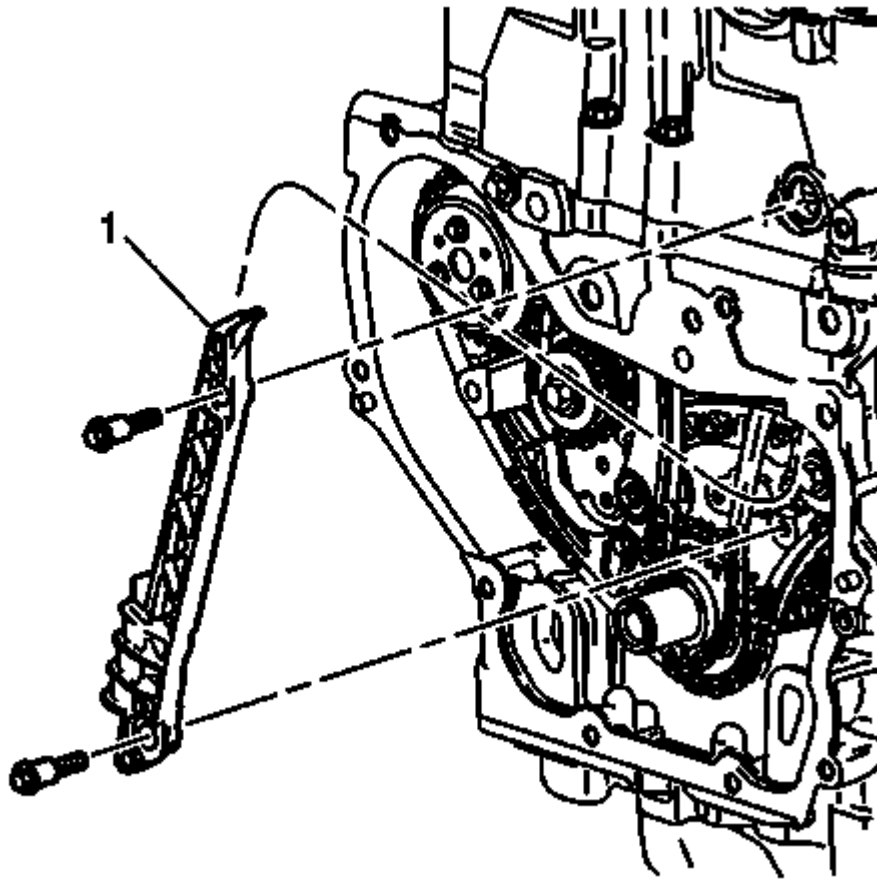
13. Install the exhaust camshaft actuator (1) onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
14. Using a 23-24 mm open end wrench, rotate the exhaust camshaft clockwise until the dowel pin in the camshaft actuator goes into the camshaft slot.



**Fig. 255: View of Actuator**

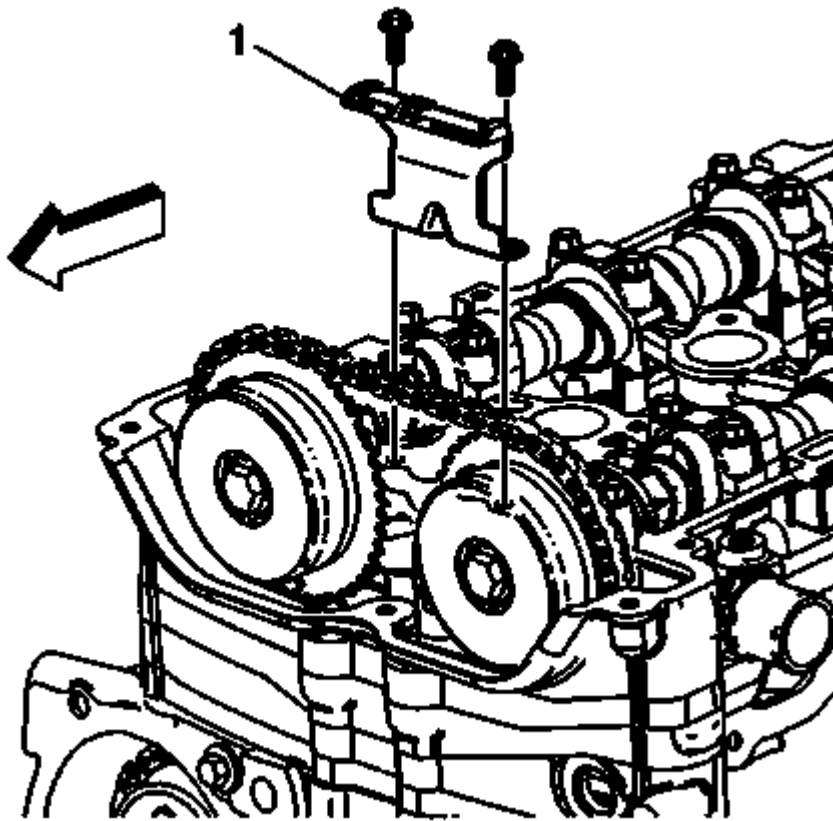
**Courtesy of GENERAL MOTORS COMPANY**

15. When the actuator (1) seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.
16. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not, repeat the portion of the procedure necessary to align the timing marks.



**Fig. 256: View of Fixed Timing Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

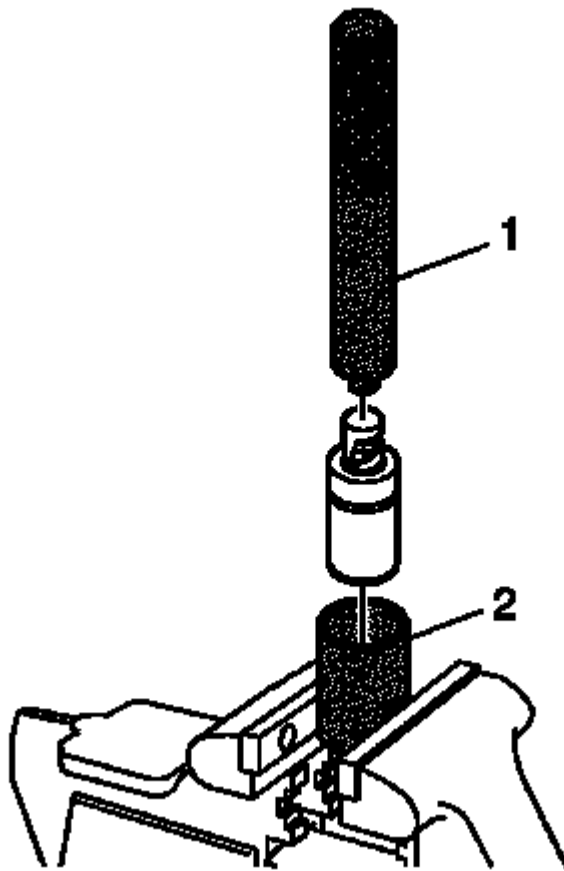
17. Install the fixed timing chain guide (1) and bolts and tighten to 12 N.m (106 lb in).



**Fig. 257: View of Timing Chain and Tensioner**  
Courtesy of GENERAL MOTORS COMPANY

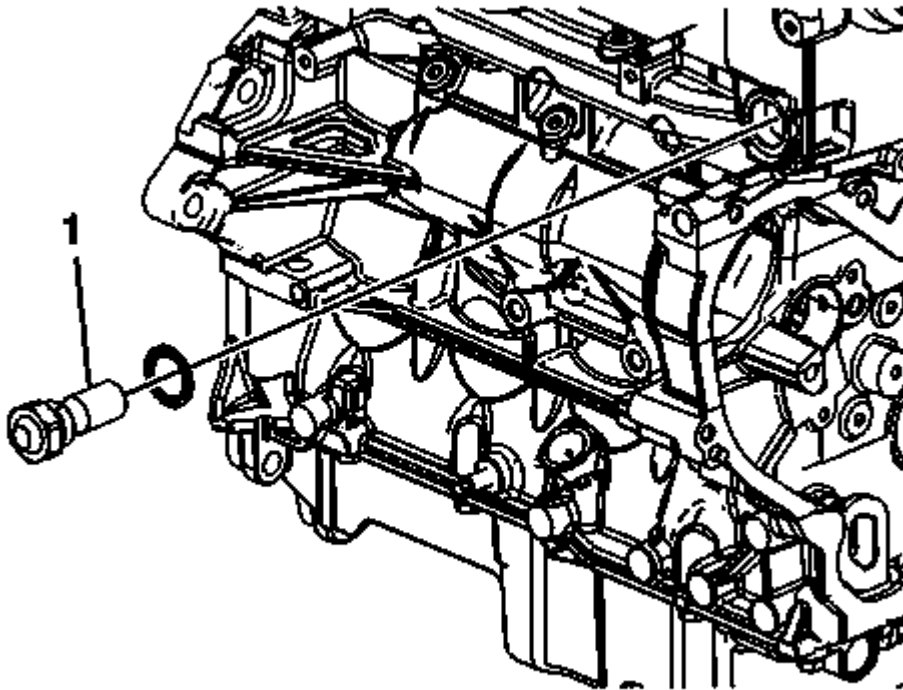
18. Install the upper timing chain guide (1) and bolts and tighten to 10 N.m (89 lb in).





**Fig. 258: Compressing Timing Chain Tensioner**  
 Courtesy of GENERAL MOTORS COMPANY

19. Reset the timing chain tensioner by performing the following steps:
  1. Remove the snap ring.
  2. Remove the piston assembly from the body of the timing chain tensioner.
  3. Install the **EN-45027-2 (2)** tensioner into a vise.
  4. Install the notch end of the piston assembly into the **EN-45027-2 (2)** tensioner.
  5. Using the **EN-45027-1 (1)** tensioner turn the ratchet cylinder into the piston.
  6. Reinstall the piston assembly into the body of the tensioner.
  7. Install the snap ring.



**Fig. 259: View of Timing Chain Tensioner Seal**  
 Courtesy of GENERAL MOTORS COMPANY

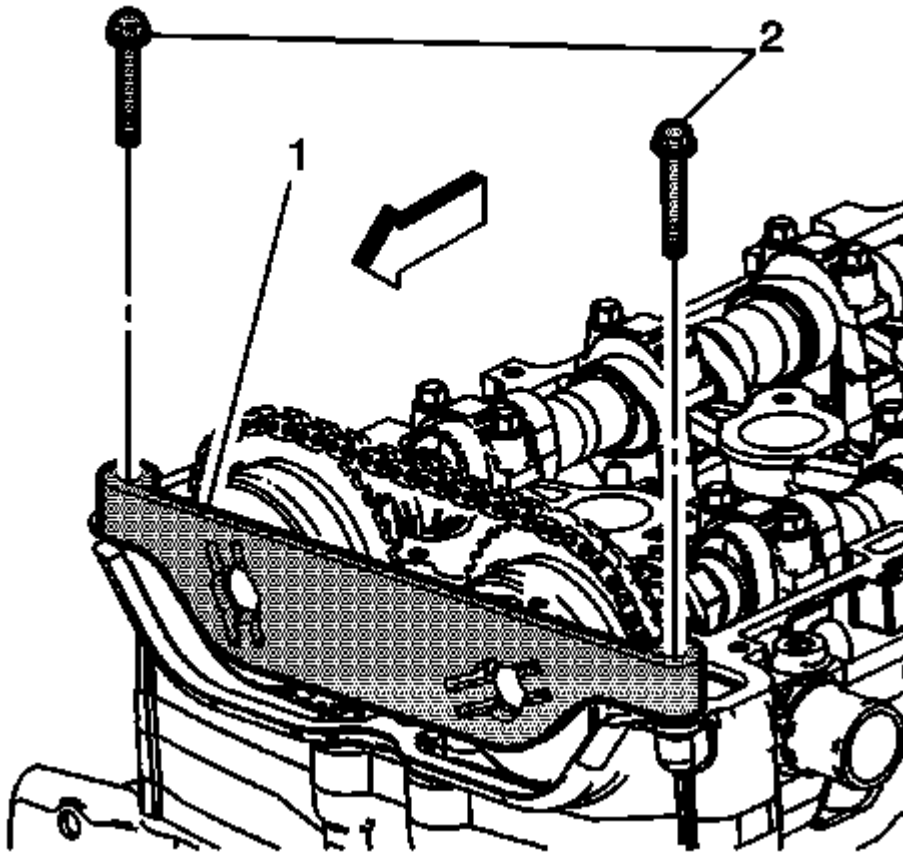
20. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
21. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

**NOTE:** Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.

22. Install the timing chain tensioner assembly (1) and tighten to 75 N.m (55 lb ft).

**NOTE:** The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet.

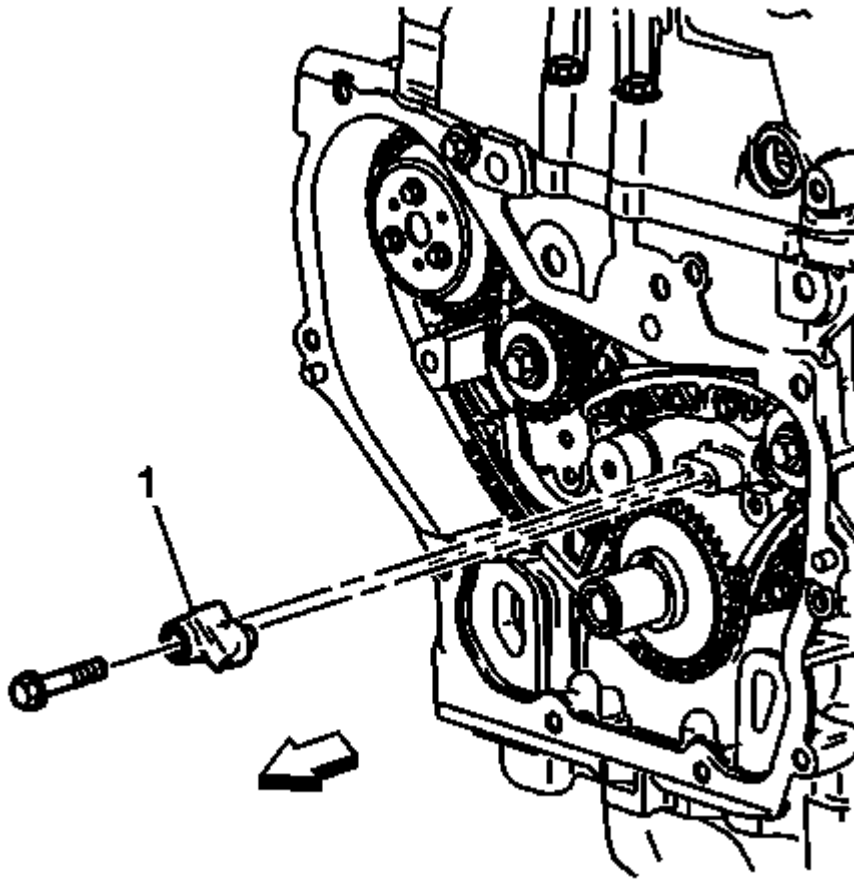
23. The crankshaft balancer must be installed in order to release the tensioner. Refer to **Crankshaft Balancer Installation**.



**Fig. 260: View Locking Tool**

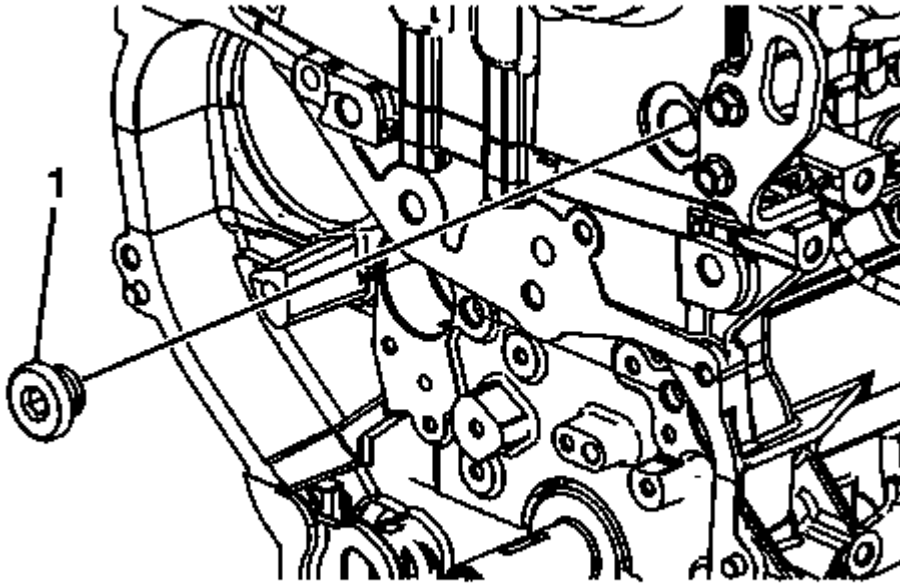
Courtesy of GENERAL MOTORS COMPANY

24. Install **EN-48953** locking tool (1) and tighten the bolts into the cylinder head to 10 N.m (89 lb in).
25. Using a torque wrench, tighten the intake camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **EN 45059** meter.
26. Using a torque wrench, tighten the exhaust camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **EN 45059** meter.
27. Remove **EN-48953** locking tool.



**Fig. 261: View of Timing Chain Oil Nozzle**  
Courtesy of GENERAL MOTORS COMPANY

28. Install the timing chain oiling nozzle (1) and tighten the bolt to 10 N.m (89 lb in).



**Fig. 262: View of timing Chain Guide Bolt Access Hole Plug**  
Courtesy of GENERAL MOTORS COMPANY

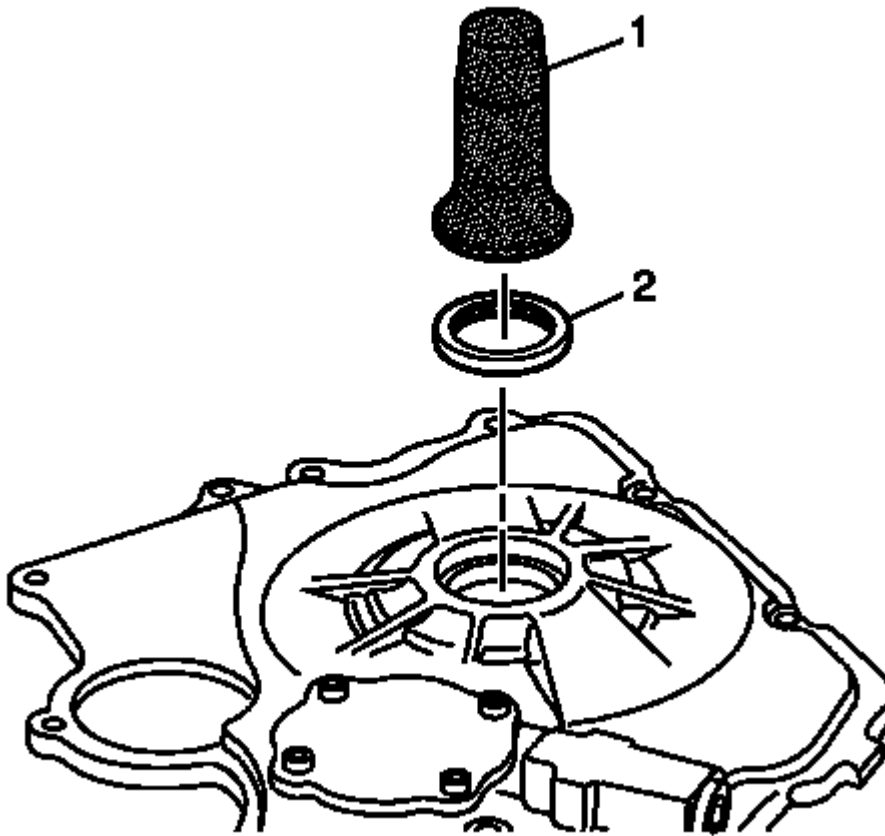
29. Apply sealant to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
30. Install the timing chain guide bolt access hole plug (1) and tighten to 75 N.m (55 lb ft).

## **CRANKSHAFT FRONT OIL SEAL INSTALLATION**

### **Special Tools**

**EN-35268-A** Camshaft/Front Main Seal Installer

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

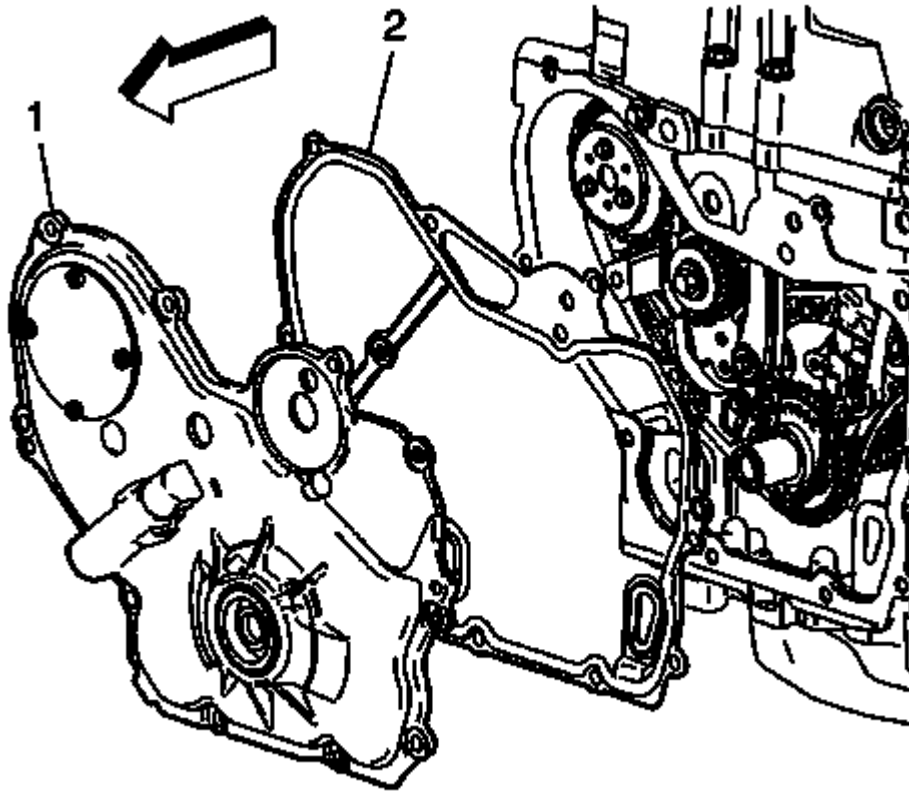


**Fig. 263: Crankshaft Front Oil Seal**

Courtesy of GENERAL MOTORS COMPANY

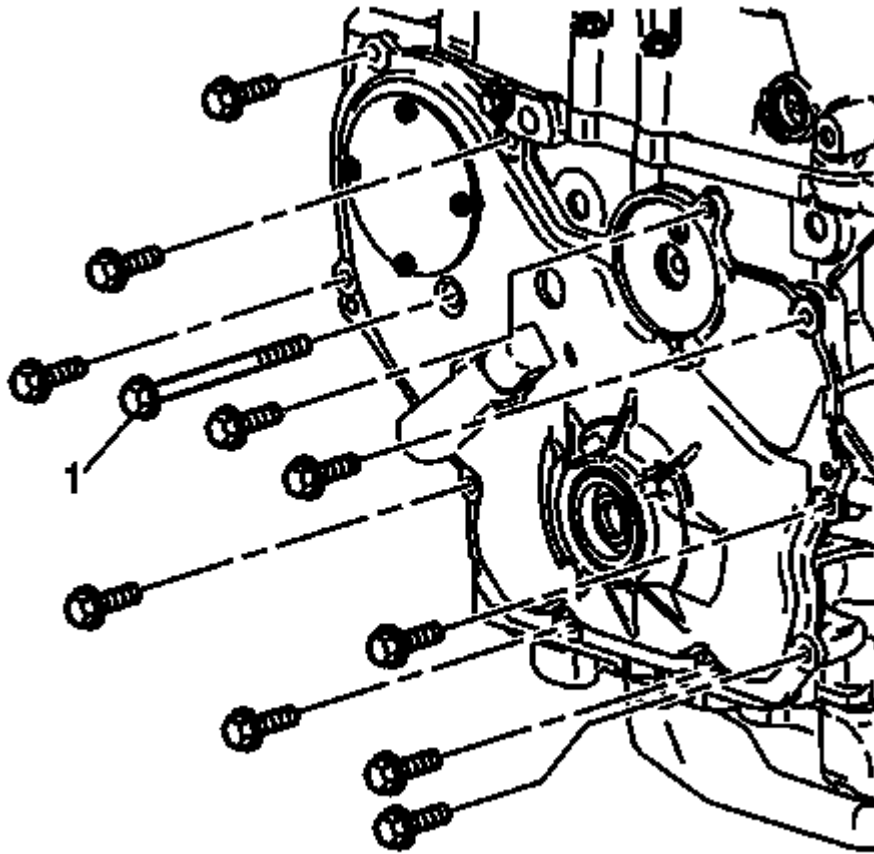
1. Install the seal (2) into the front cover using the EN-35268-A installer (1).
2. Ensure that the engine front cover is properly supported when installing the seal.

## **ENGINE FRONT COVER AND OIL PUMP INSTALLATION**



**Fig. 264: View Of Engine Front Cover & Gasket**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the engine front cover (1) with a new gasket (2).



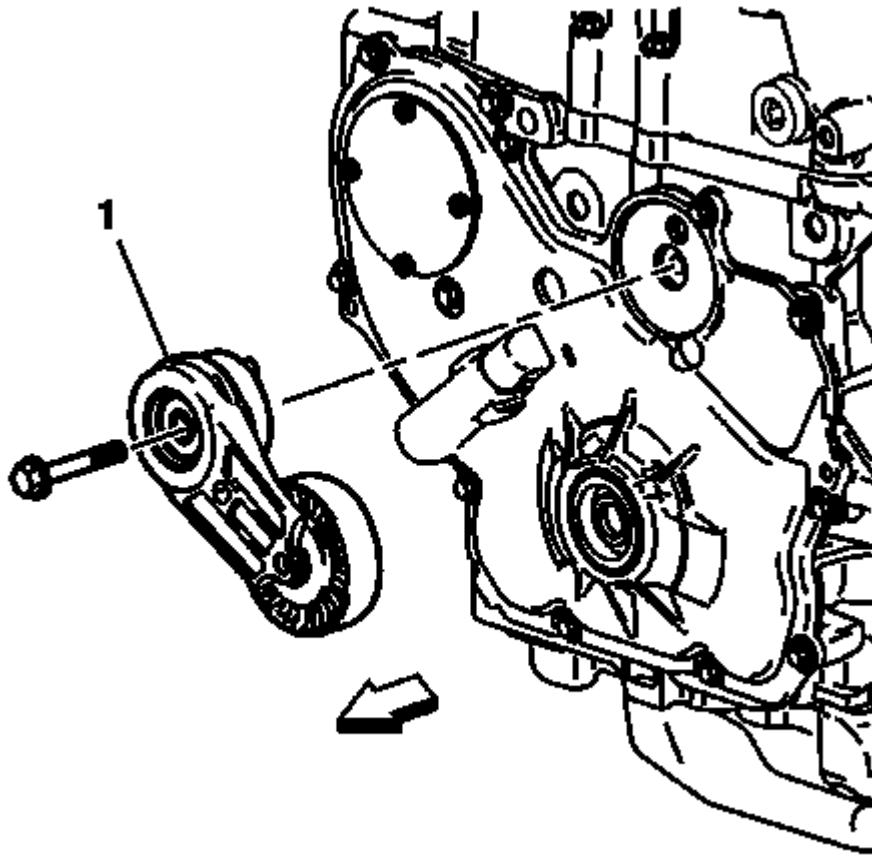
**Fig. 265: Engine Front Cover Bolts & Long Water Pump Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

**NOTE:** The center bolt (1) should be tightened last.

2. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
3. Install the long water pump bolt (1) and tighten to 25 N.m (18 lb ft).

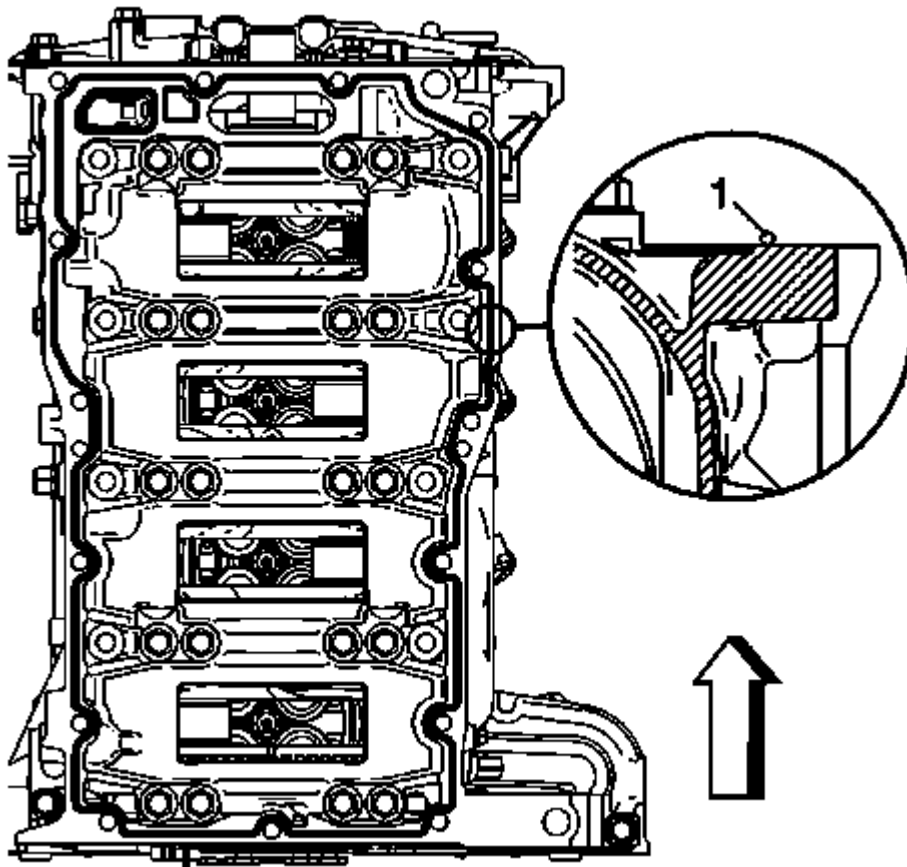




**Fig. 266: Accessory Drive Belt Tensioner And Bolt**  
Courtesy of GENERAL MOTORS COMPANY

4. Install the accessory drive belt tensioner (1).
5. Install the accessory drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).

## **OIL PAN INSTALLATION**

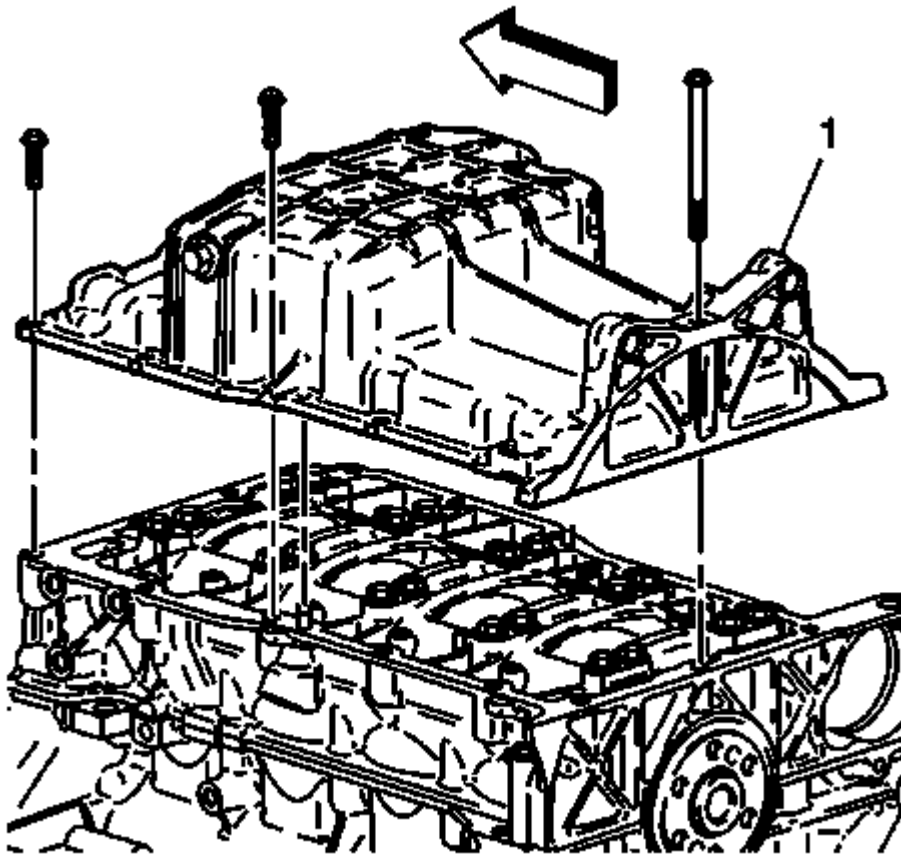


**Fig. 267: Identifying Bead of Sealer on Oil Pan**  
Courtesy of GENERAL MOTORS COMPANY

**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.

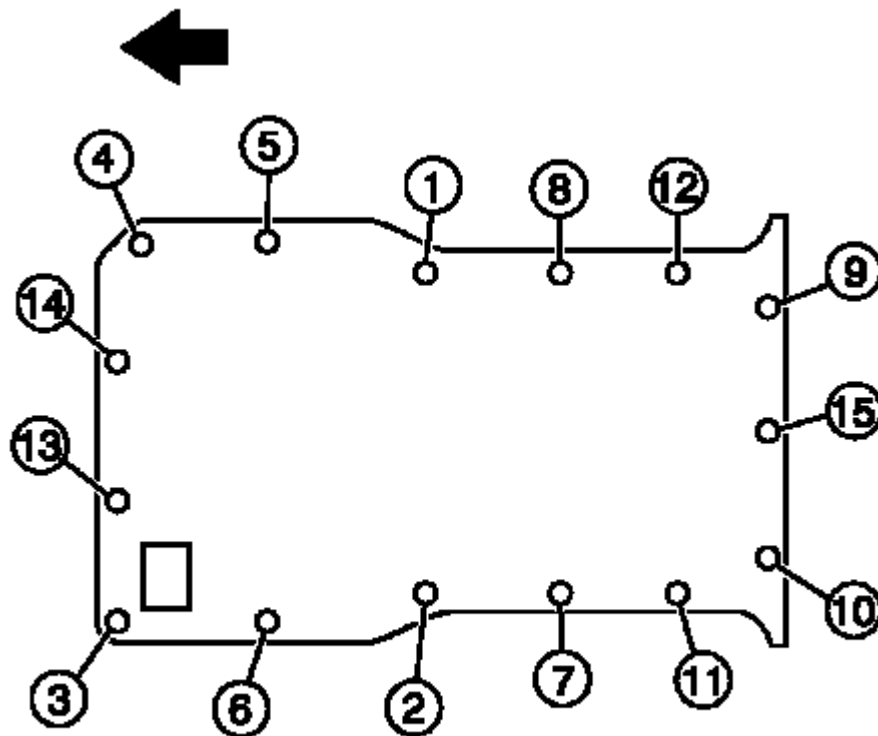
1. Apply a 2.25 mm bead of sealer (1) on the level part of the flange next to the chamfer around the perimeter of the oil pan and the oil suction port opening. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .



**Fig. 268: Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pan (1).



**Fig. 269: Identifying Oil Pan Bolts Removal & Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

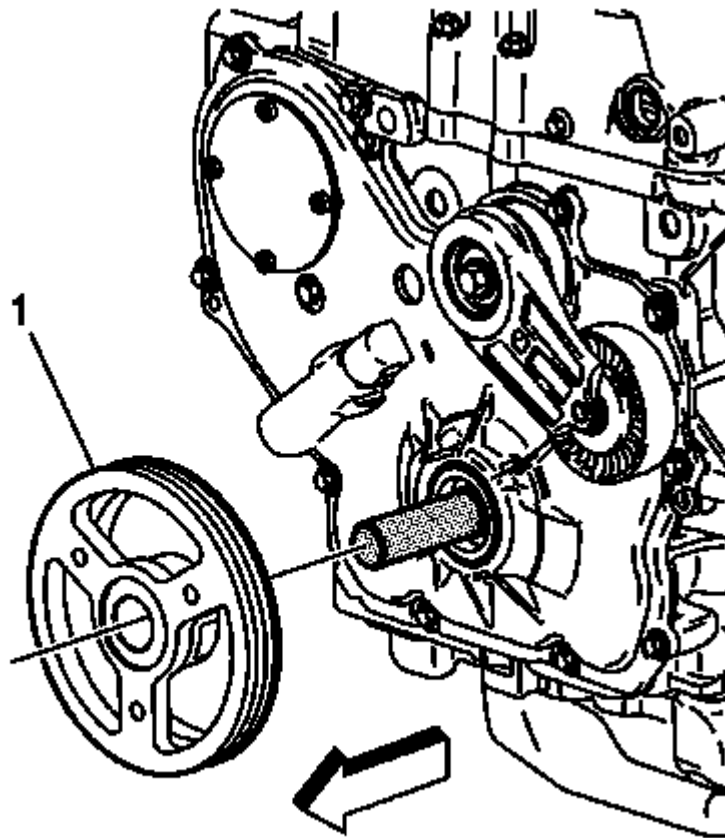
3. Install the oil pan bolts and tighten to 25 N.m (18 lb ft) in sequence.

## CRANKSHAFT BALANCER INSTALLATION

### Special Tools

- EN-48585 Crankshaft Balancer Guide
- EN-48953 Camshaft Actuator Locking Tool
- EN 38122-A Crankshaft Balancer Holder
- EN 43653 Flywheel Holding Tool
- EN 45059 Angle Meter

For equivalent regional tools, refer to Special Tools .

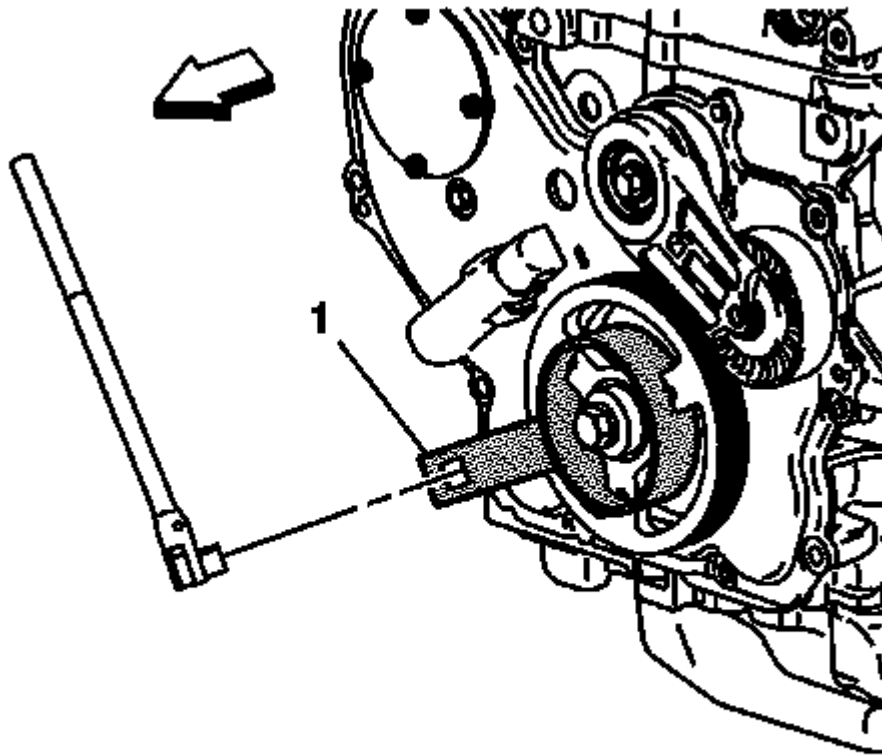


**Fig. 270: Identifying Balancer**

Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the **EN 38122-A** holder into the end of the crankshaft.
2. Install the balancer (1) onto the **EN-48585** guide. Use care to properly align the keyway and flats on the balancer with the oil pump drive.



**Fig. 271: Crankshaft Holder**

Courtesy of GENERAL MOTORS COMPANY

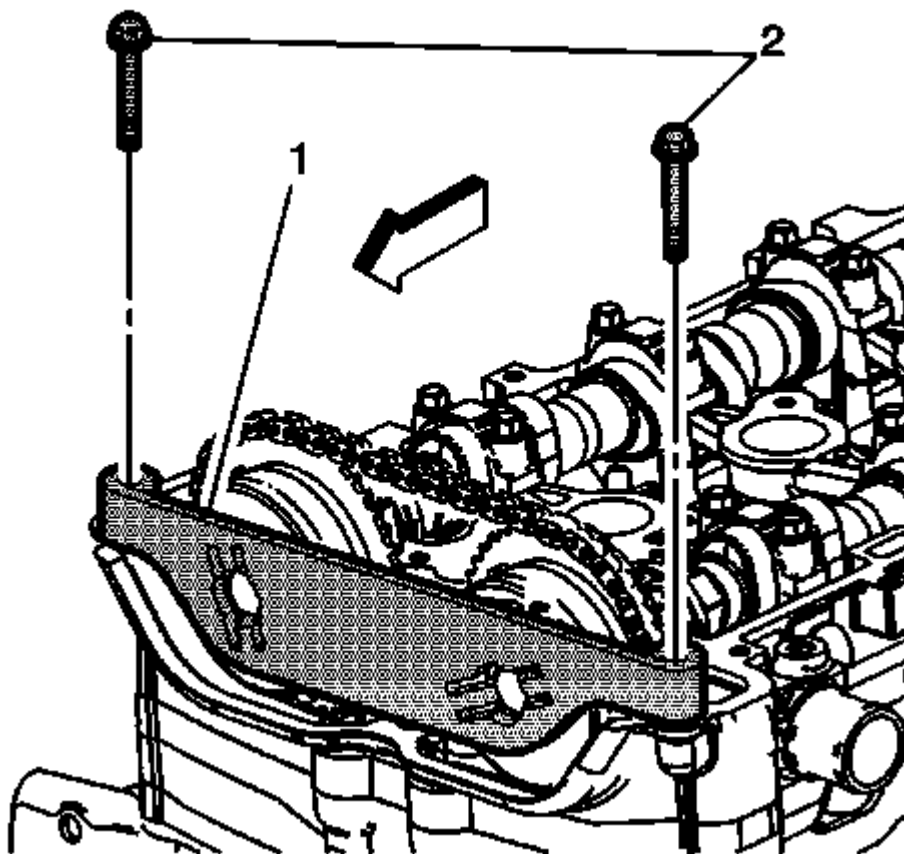
**NOTE:** EN 43653 locking tool may be used instead of EN 38122-A holder to prevent crankshaft rotation.

3. Install the EN 38122-A holder (1).

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Always install a new crankshaft balancer retaining bolt and washer.

4. Install a new retaining bolt and washer. Use the EN 38122-A holder and a breaker bar to prevent the crankshaft from rotating when tightening the bolt. Tighten the bolt to 150 N.m (111 lb ft) plus 100 degrees using the EN 45059 meter.

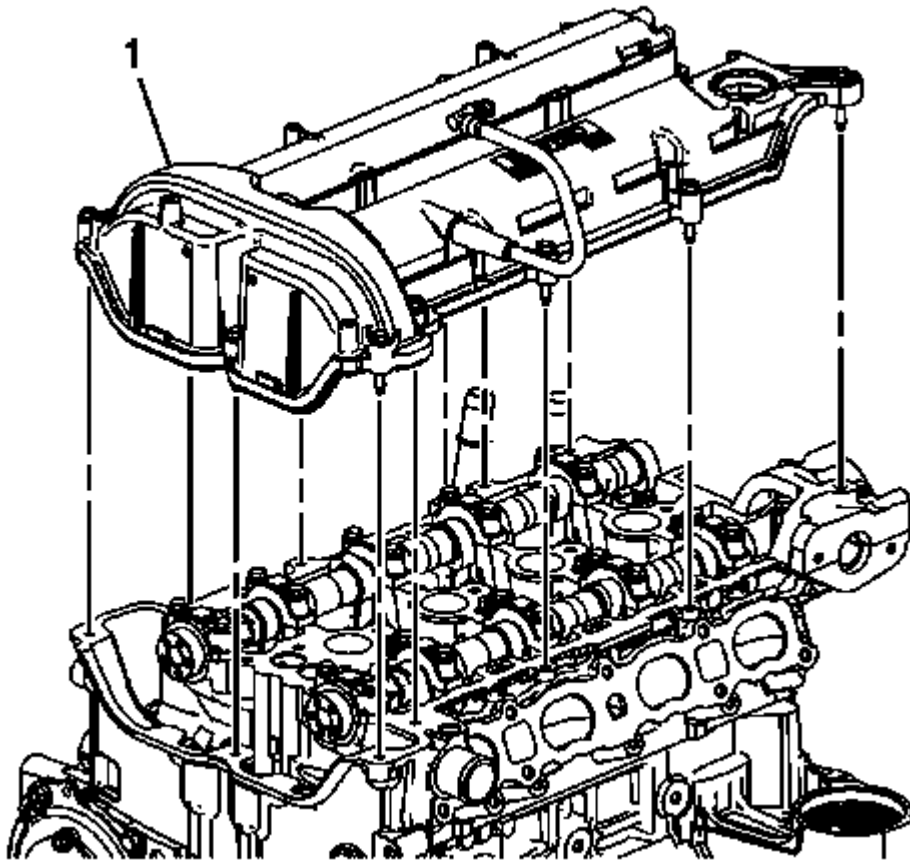


**Fig. 272: View Locking Tool**

Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-48953** locking tool (1) and tighten the bolts into the cylinder head. Tighten the **EN-48953** locking tool retaining bolts to 10 N.m (89 lb in).
6. Release the timing chain tensioner by applying 45 N.m (33 lb ft) counterclockwise torque to the crankshaft balancer bolt.
7. Remove the **EN-48953** locking tool.

### CAMSHAFT COVER INSTALLATION (2.4L LEA)



**Fig. 273: Camshaft Cover Assembly**

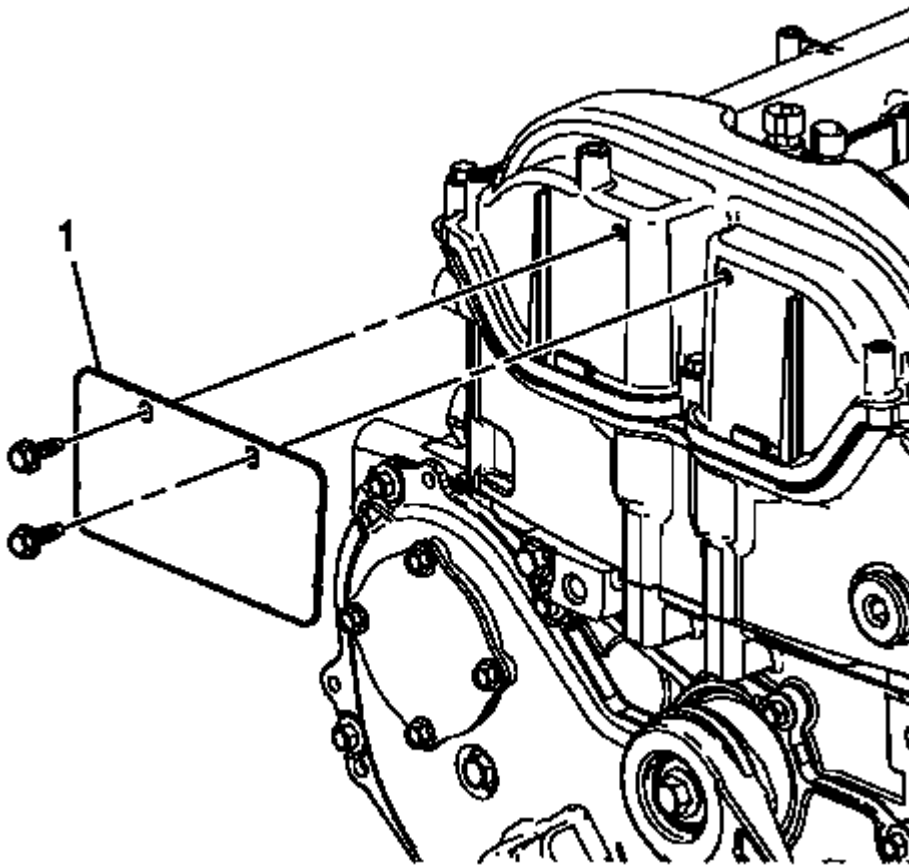
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.
2. Assemble the camshaft cover (1) and a NEW gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

**CAUTION: Refer to Fastener Caution .**

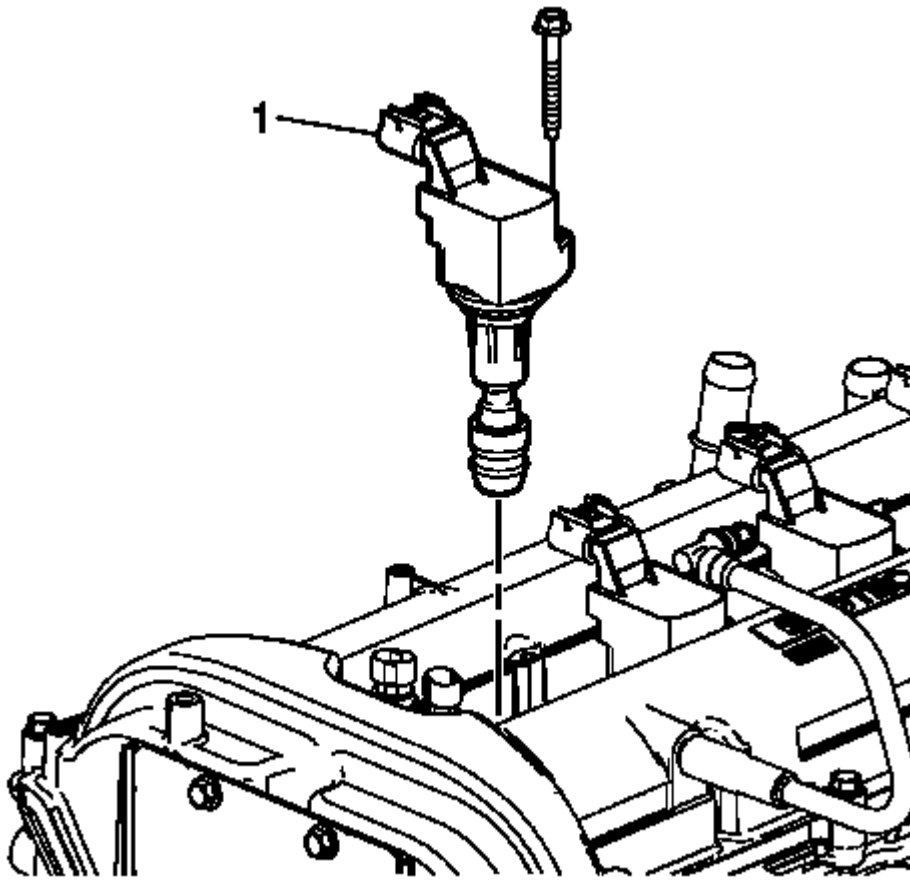
3. Install the cover on the cylinder head and hand start the bolts. Tighten the bolts to 10 N.m (89 lb in).





**Fig. 274: Camshaft Housing Cover Insulator**  
Courtesy of GENERAL MOTORS COMPANY

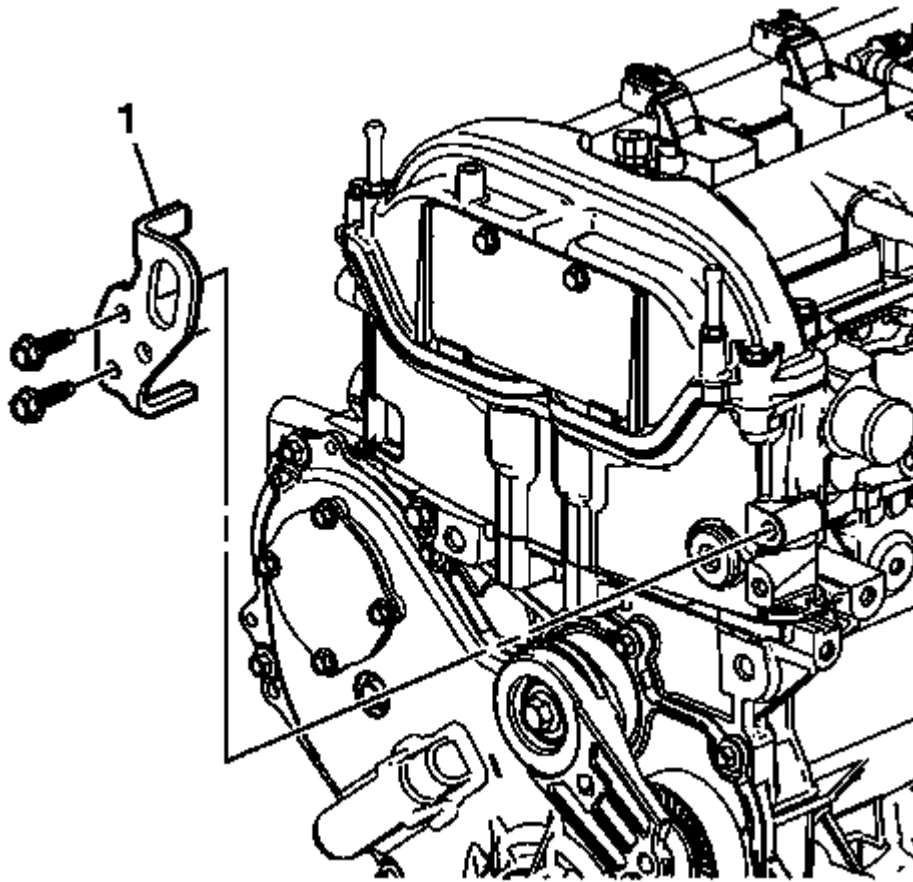
4. Install the camshaft housing cover insulator (1). Tighten the bolts to 10 N.m (89 lb in).



**Fig. 275: Ignition Coil**

Courtesy of GENERAL MOTORS COMPANY

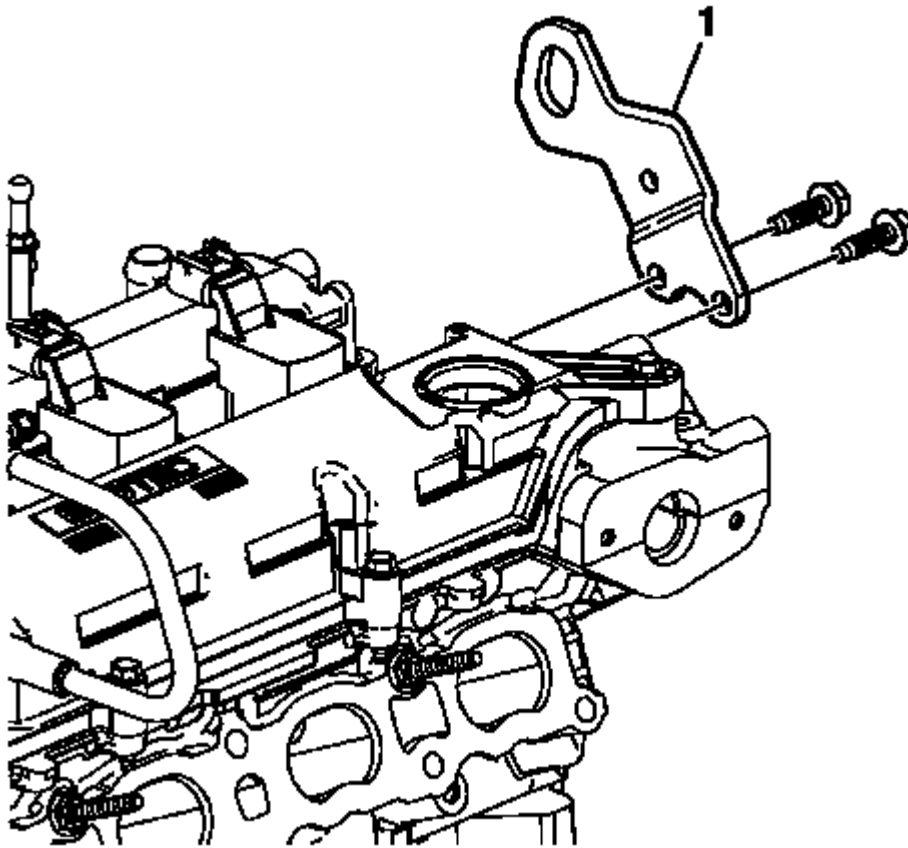
5. Install the ignition coil (1). Tighten the bolt to 10 N.m (89 lb in).



**Fig. 276: Front Lift Bracket**

**Courtesy of GENERAL MOTORS COMPANY**

6. Install the front lift bracket (1).
7. Install the front lift bracket bolts and tighten to 25 N.m (18 lb ft).



**Fig. 277: Rear Lift Bracket**

Courtesy of GENERAL MOTORS COMPANY

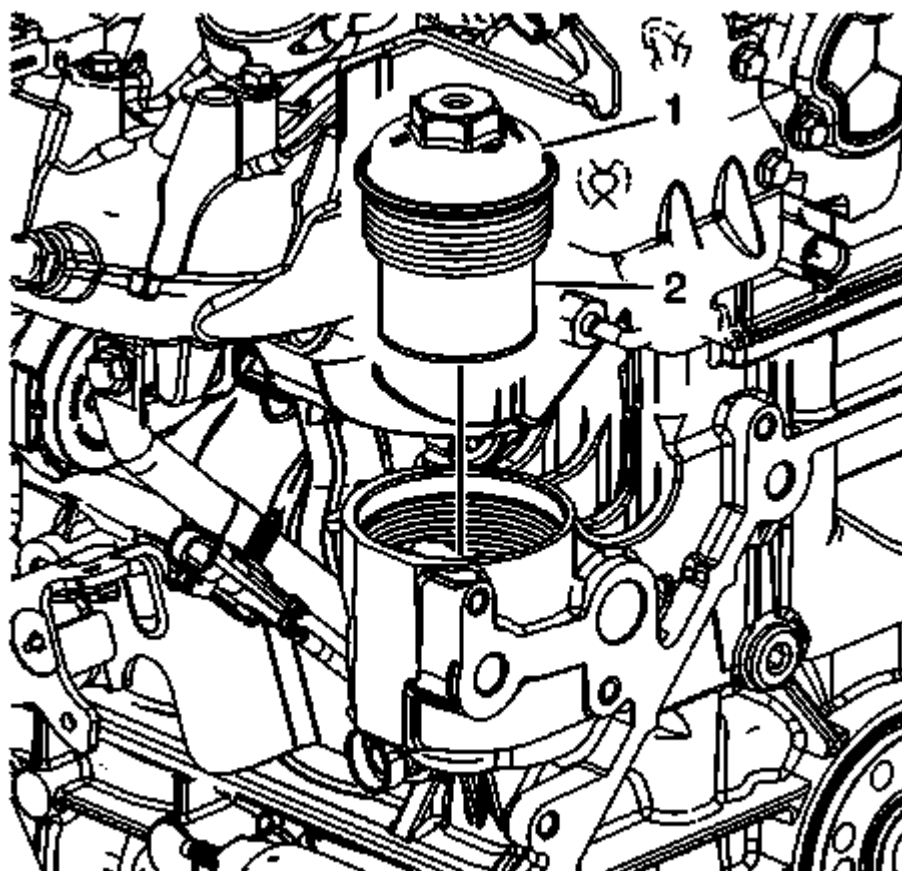
8. Install the rear lift bracket (1).
9. Install the rear lift bracket bolts and tighten to 25 N.m (18 lb ft).

## **OIL FILTER WITH CAP AND SEAL INSTALLATION**

### **Special Tools**

**EN-44887** Oil Filter Wrench

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



**Fig. 278: View of Draining Fluids and Oil Filter**  
 Courtesy of GENERAL MOTORS COMPANY

1. Install a new oil filter (2) on the oil filter cap (1).
2. Lubricate the O-ring on the oil filter cap with 5W30 engine oil.

**CAUTION: Refer to Fastener Caution .**

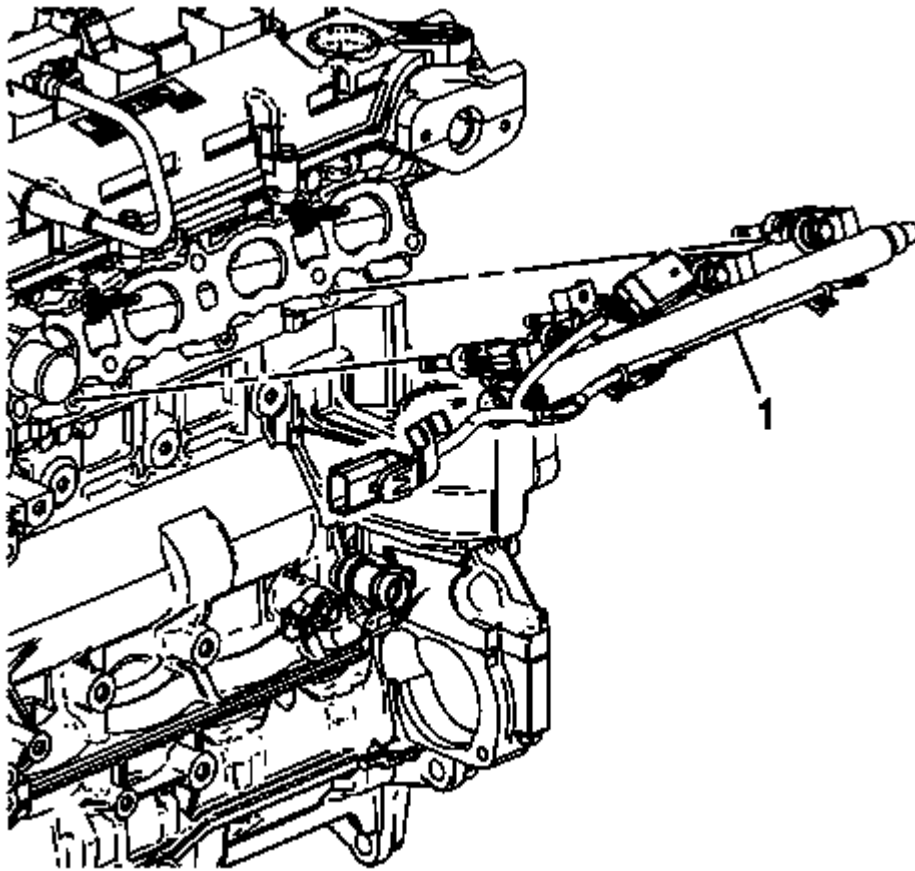
3. Use **EN-44887** wrench to install the oil filter cap. Tighten the oil filter cap to 25 N.m (18 lb ft).

## FUEL RAIL AND INJECTORS INSTALLATION

### Special Tools

**EN-47909** Injector Bore and Sleeve Cleaning Kit

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



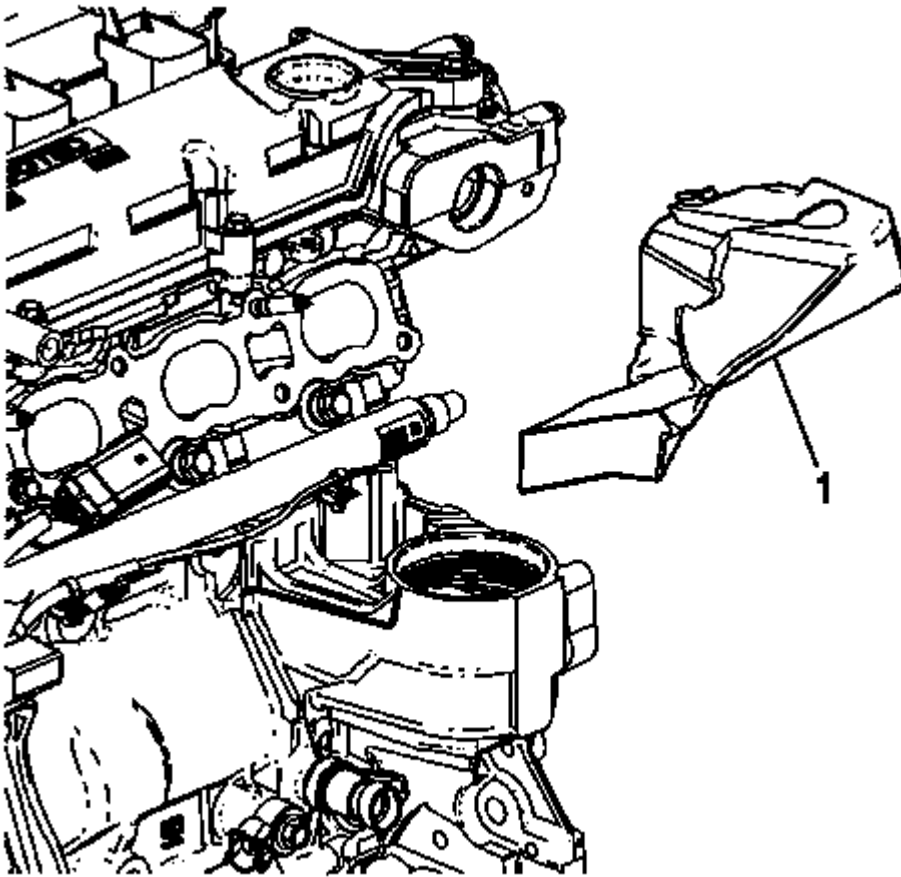
**Fig. 279: Fuel Rail**

Courtesy of GENERAL MOTORS COMPANY

1. Clean the fuel injector bore in the cylinder head using the **EN-47909** kit.
2. Install the fuel rail (1) with injectors into the cylinder head evenly.
3. Hand tighten the 2 outer fuel rail bolts to seat the injector into the injector bores.

**CAUTION: Refer to Fastener Caution .**

4. Start and hand tighten the remaining fuel rail bolts. Tighten the bolts in sequence to final torque using the following procedure:
  1. Tighten first pass in sequence to 25 N.m (18 lb ft).
  2. Tighten final pass in sequence to 25 N.m (18 lb ft).
5. Connect the electrical harness to the fuel rail harness connections.



**Fig. 280: Fuel Injection Fuel Rail Noise Shield**  
Courtesy of GENERAL MOTORS COMPANY

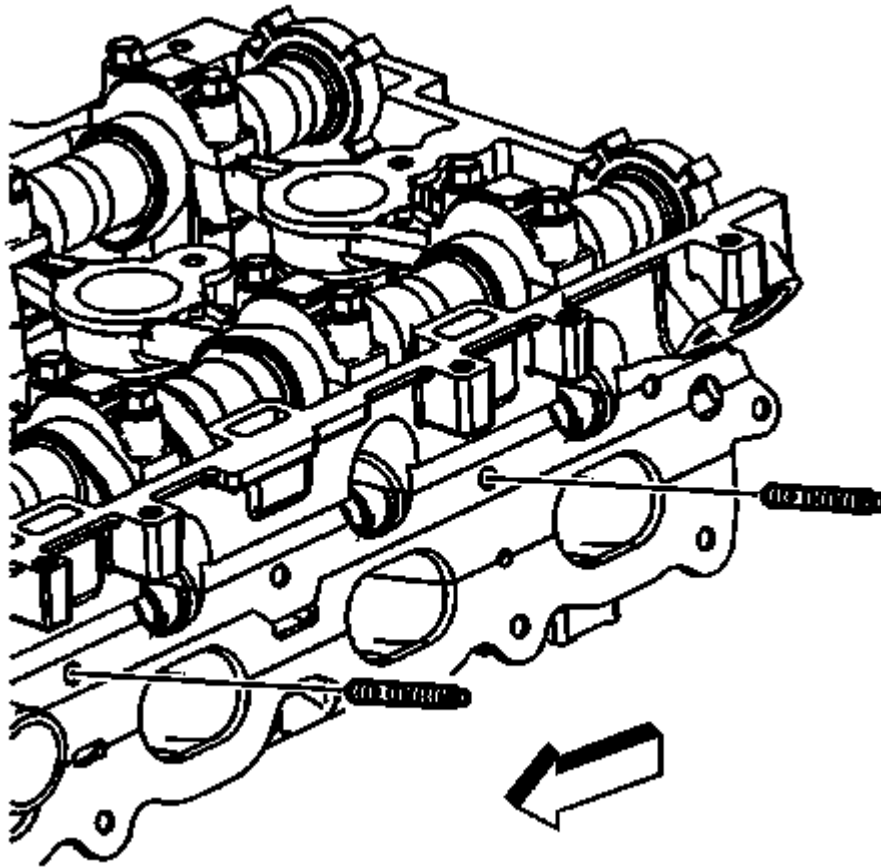
6. Install the fuel injection fuel rail noise shield (1).

## INTAKE MANIFOLD INSTALLATION

### Special Tools

**EN-48896** HP Fuel Pump Installation Alignment Gauge

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



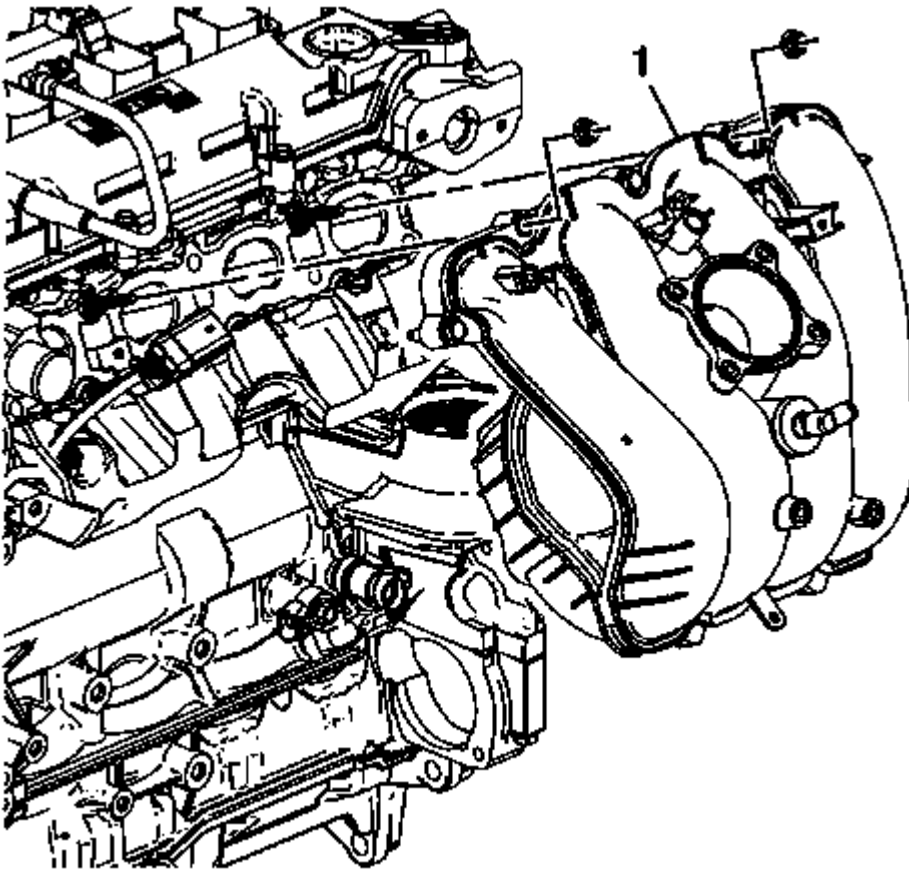
**Fig. 281: Intake Manifold Studs**

Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

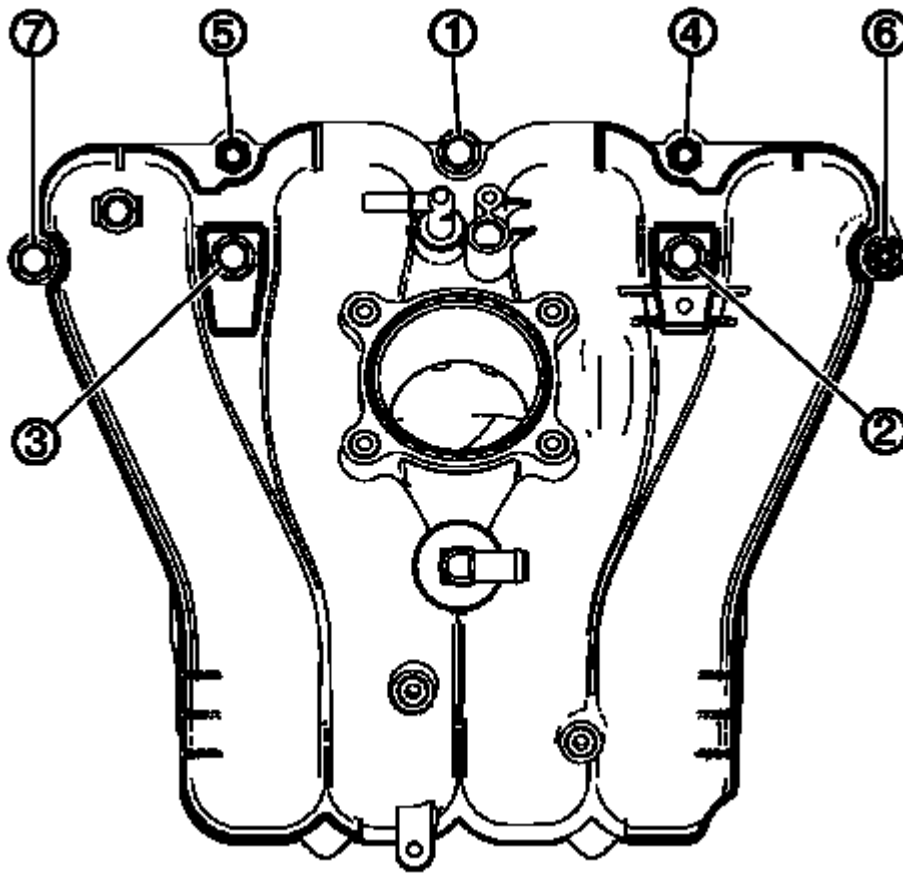
1. Install the intake manifold studs in the manifold face and tighten to 15 N.m (11 lb ft).





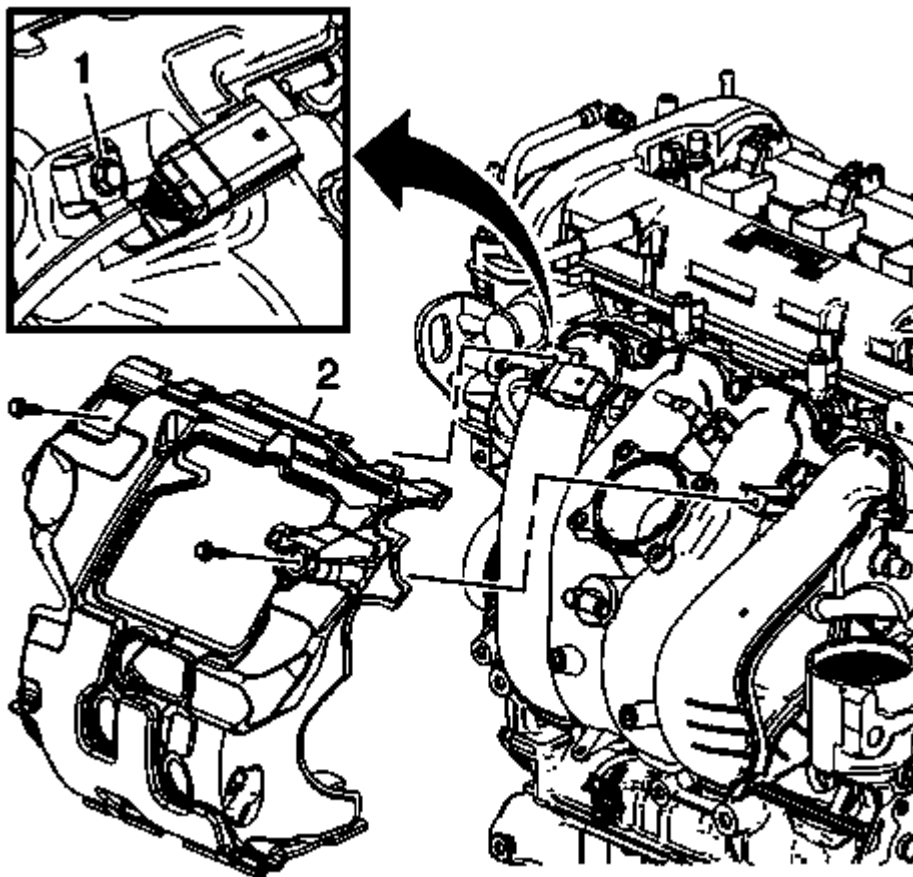
**Fig. 282: Intake Manifold Retaining Nuts And Bolts**  
Courtesy of GENERAL MOTORS COMPANY

2. Install the intake manifold (1). Start and hand tighten the intake manifold bolts and nuts.



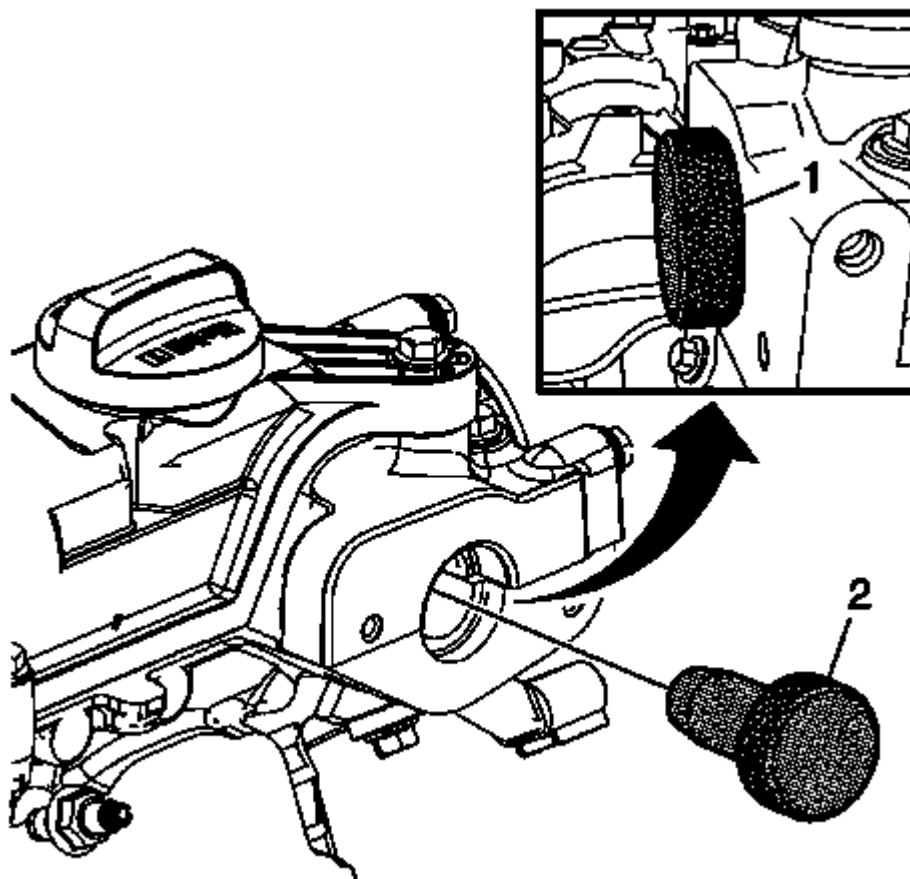
**Fig. 283: Identifying Intake Manifold Bolts And Nuts**  
Courtesy of GENERAL MOTORS COMPANY

3. Tighten the bolts and nuts in sequence to 25 N.m (18 lb ft).



**Fig. 284: Fuel Rail Harness Connector Bracket And Intake Manifold Insulator**  
Courtesy of GENERAL MOTORS COMPANY

4. Install the intake manifold insulator (2).
5. Install the insulator bolt and tighten to 10 N.m (89 lb in).
6. Install the fuel rail harness connector bracket (1) to the intake manifold. Tighten the bracket bolt to 10 N.m (89 lb in).

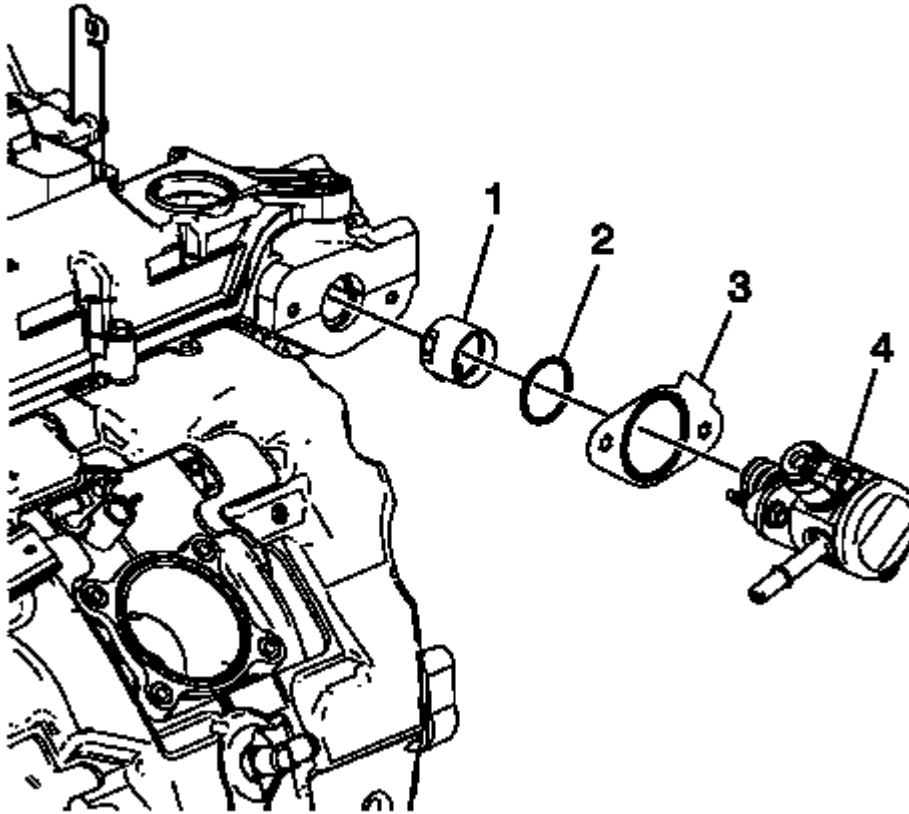


**Fig. 285: Using Alignment Gauge**

Courtesy of GENERAL MOTORS COMPANY

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

7. Use the EN-48896 alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head (1).



**Fig. 286: Fuel Pump Assembly Components**  
Courtesy of GENERAL MOTORS COMPANY

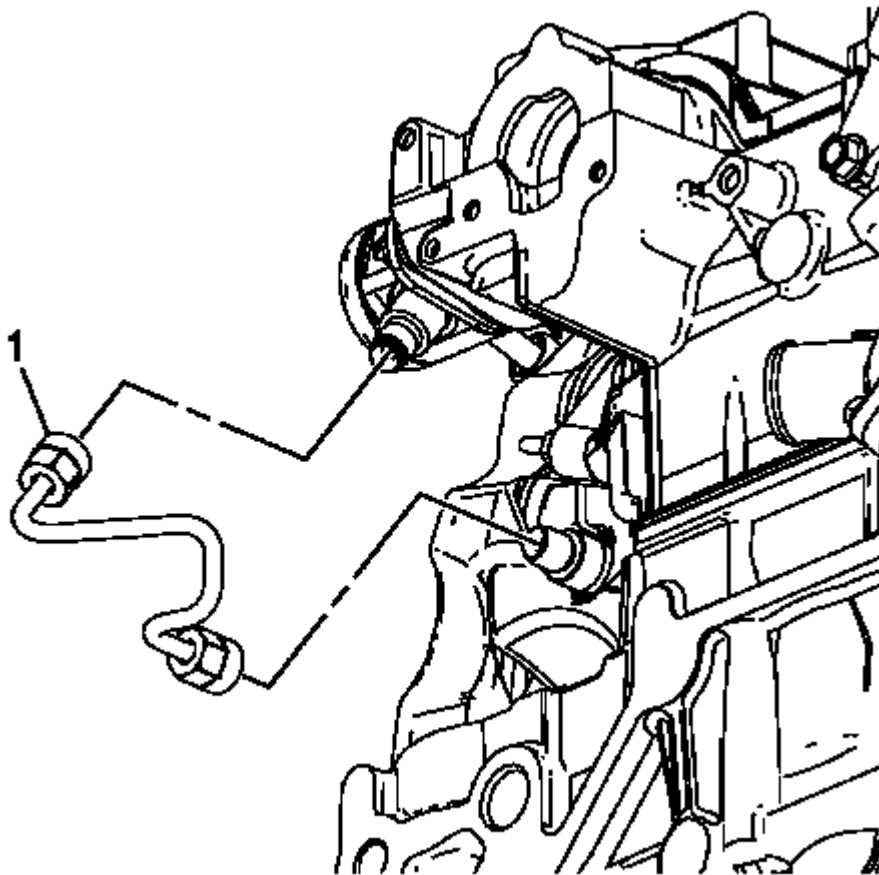
8. Lubricate the high pressure fuel pump cylinder head bore with 5W30 engine oil.

**NOTE:** Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle, and the number 1 piston is at top dead center (TDC) on the exhaust stroke. The distance from the mounting flange surface to the camshaft at base circle should be 52 mm (2.05 in).

9. Lubricate the high pressure fuel pump roller lifter (1) with 5W30 engine oil and install into the cylinder head bore.
10. Install a NEW fuel pump housing O-ring (2) and gasket (3).

**NOTE:** Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.

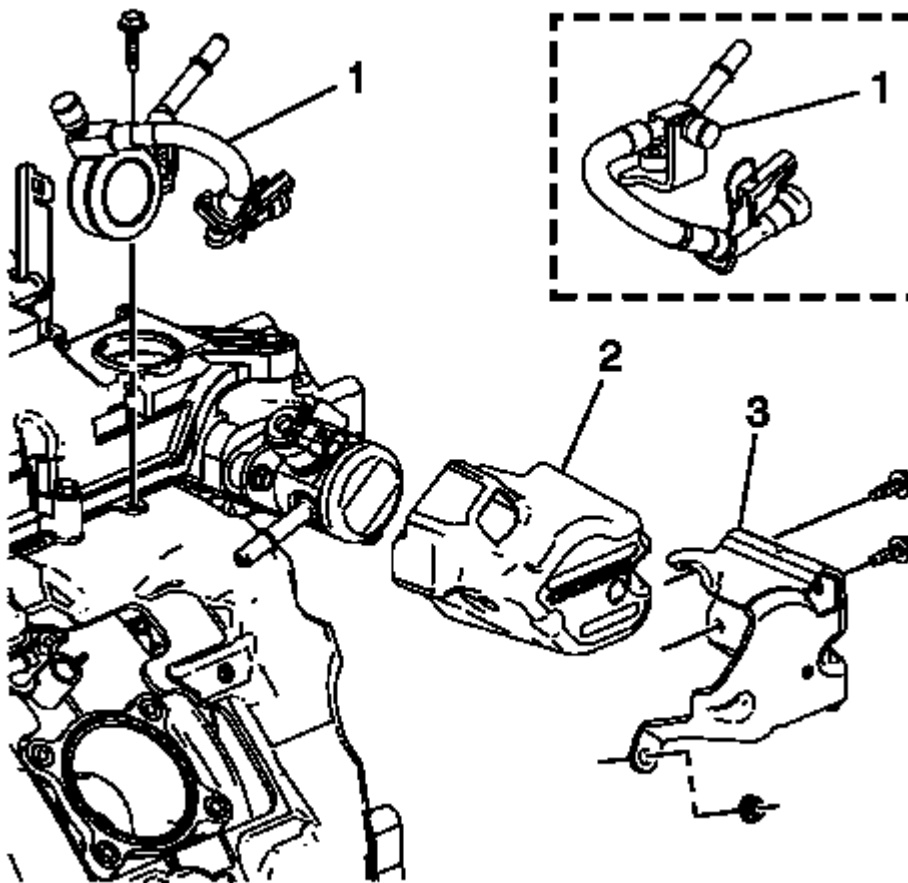
11. Install the fuel pump assembly (4).
12. Start and hand-tighten the fuel pump assembly bolts evenly. Tighten the fuel pump bolts evenly to 15 N.m (11 lb ft).



**Fig. 287: High Pressure Fuel Line**

Courtesy of GENERAL MOTORS COMPANY

13. Install and hand-tighten both ends of the NEW high pressure fuel line (1). Tighten the high pressure fuel line fitting nuts to 30 N.m (22 lb ft).



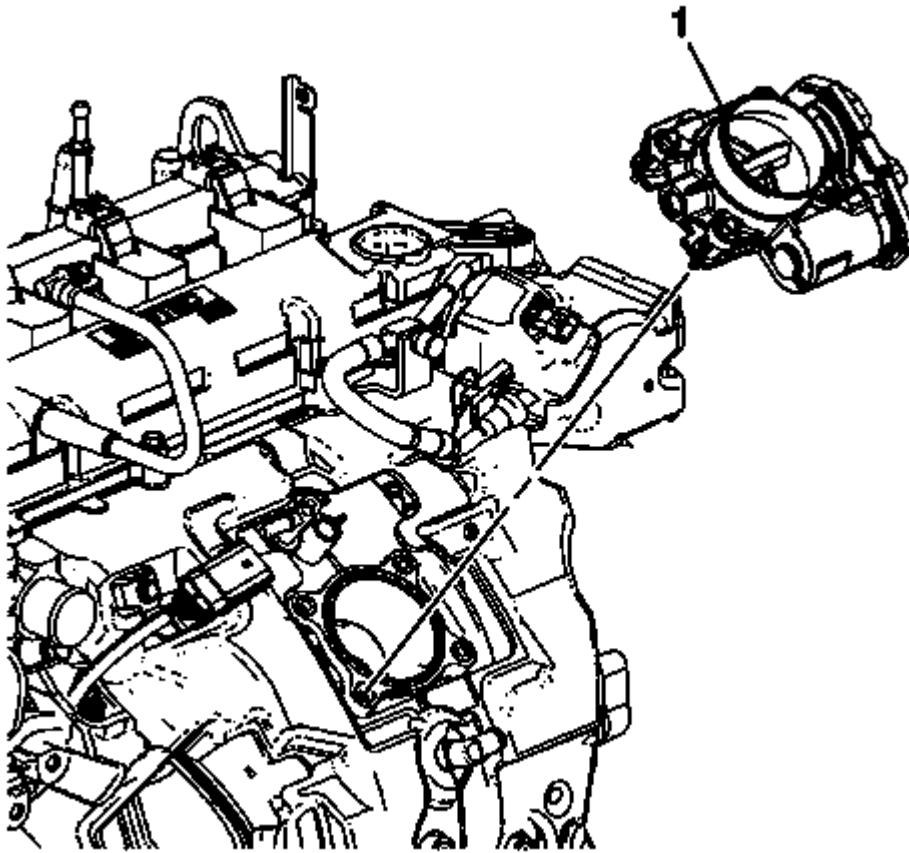
**Fig. 288: Fuel Pump Components**

Courtesy of GENERAL MOTORS COMPANY

14. Install the fuel pump insulator (2).

**NOTE:** The low pressure fuel pipe used is model dependent.

15. Install the low pressure fuel pipe assembly (1).
16. Install the fuel pump cover (3) and nut. Tighten the nut to 10 N.m (89 lb in).
17. Install the fuel pump cover bolts. Tighten the bolts to 10 N.m (89 lb in).

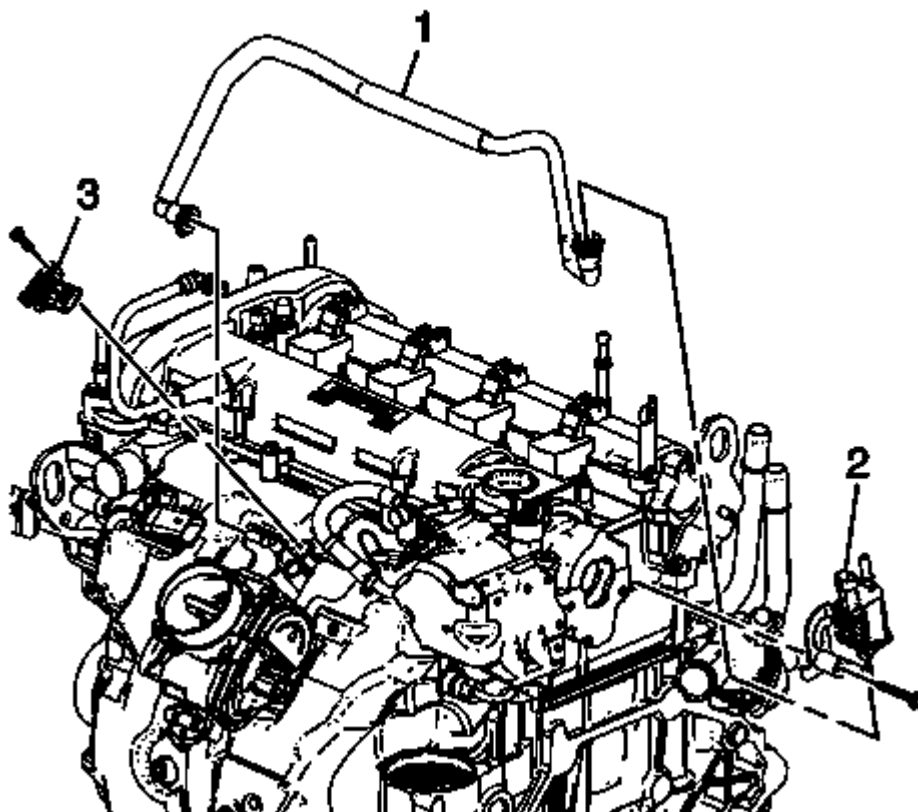


**Fig. 289: Throttle Body**

Courtesy of GENERAL MOTORS COMPANY

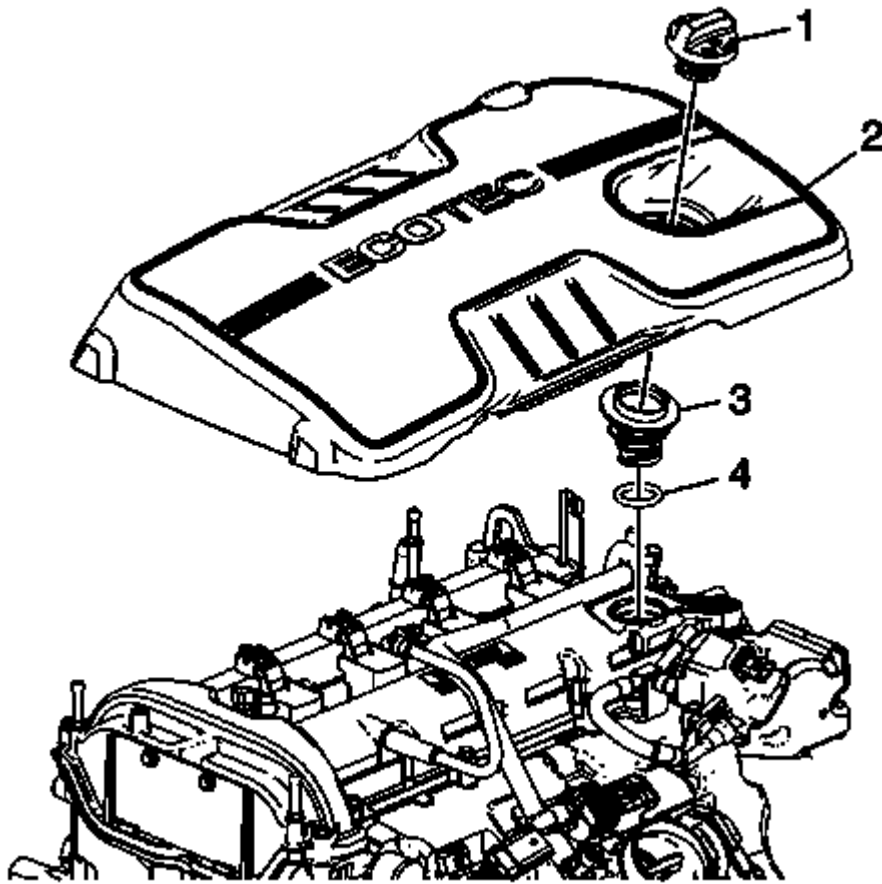
18. Install a new throttle body gasket.
19. Install the throttle body (1).
20. Install the throttle body bolts and tighten to 10 N.m (89 lb in).





**Fig. 290: EVAP Canister Valve, Tube & MAP Sensor**  
**Courtesy of GENERAL MOTORS COMPANY**

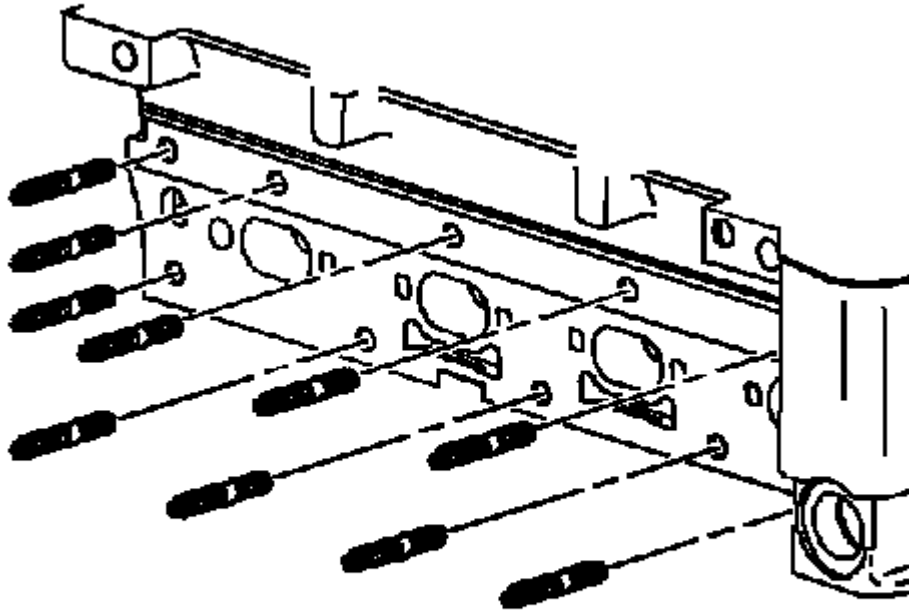
21. Install the MAP sensor (3). Tighten the sensor bolt to 4 N.m (35 lb in).
22. Install the EVAP canister valve (2) and tighten to 25 N.m (18 lb ft).
23. Install the EVAP canister valve tube (1).



**Fig. 291: Oil Fill Cap Components**  
Courtesy of GENERAL MOTORS COMPANY

24. Install the O-ring and oil fill tube assembly (3).
25. Install the intake manifold cover (2) onto the camshaft cover ball studs.
26. Install the oil fill cap (1).

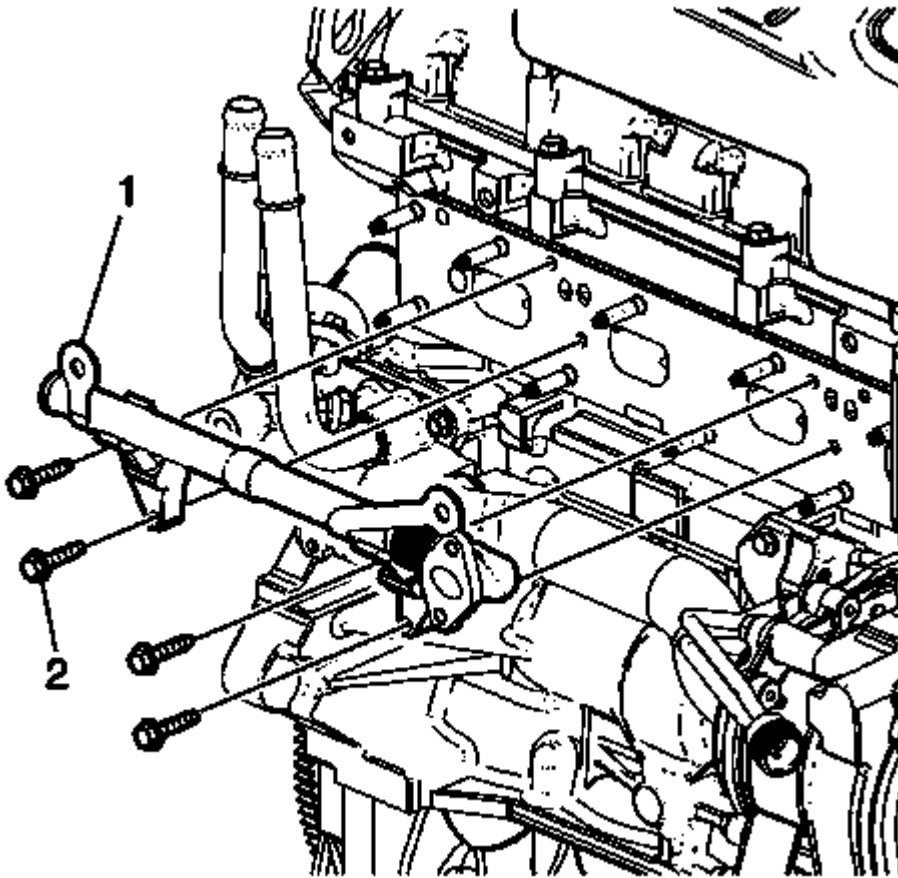
## EXHAUST MANIFOLD INSTALLATION



**Fig. 292: View Of Exhaust Manifold Studs**  
Courtesy of GENERAL MOTORS COMPANY

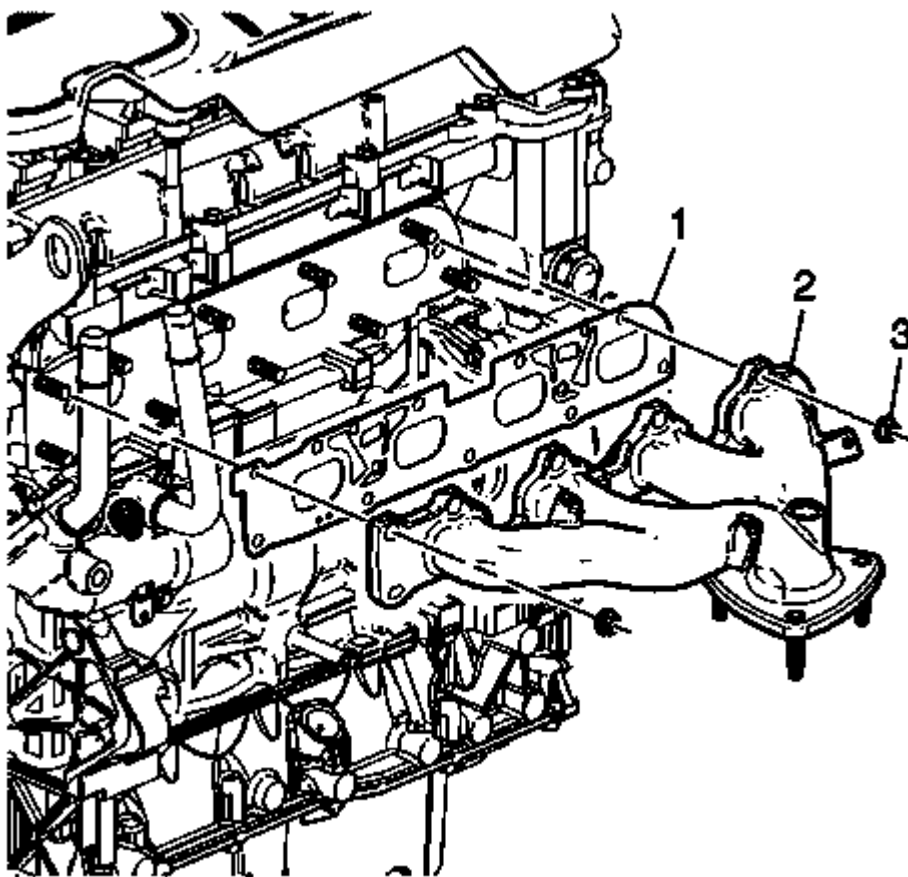
**CAUTION:** Refer to Fastener Caution .

1. Install new exhaust manifold studs and tighten to 10 N.m (89 lb in).



**Fig. 293: Secondary Air Injection Pipe Assembly**  
Courtesy of GENERAL MOTORS COMPANY

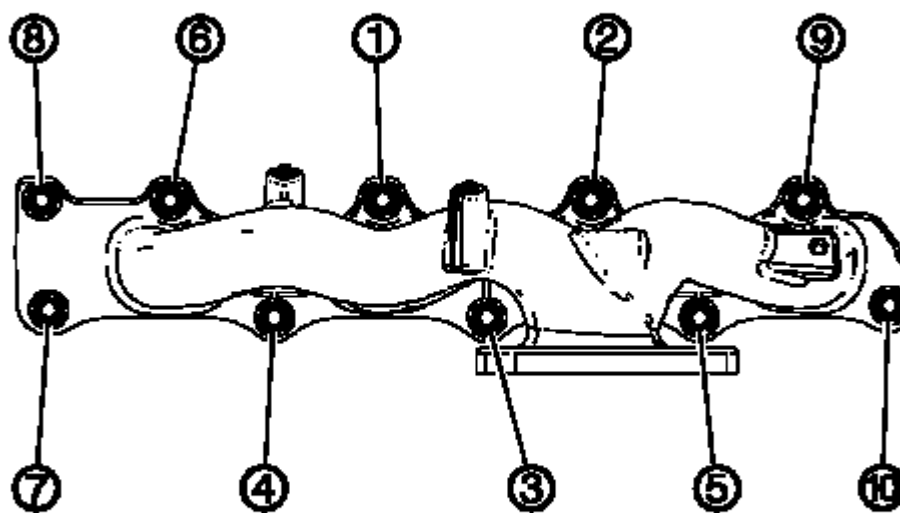
2. Install the secondary air injection pipe assembly (1).
3. Install the secondary air injection pipe assembly bolts (2) and tighten to 10 N.m(89 lb in).



**Fig. 294: Exhaust Manifold Components**

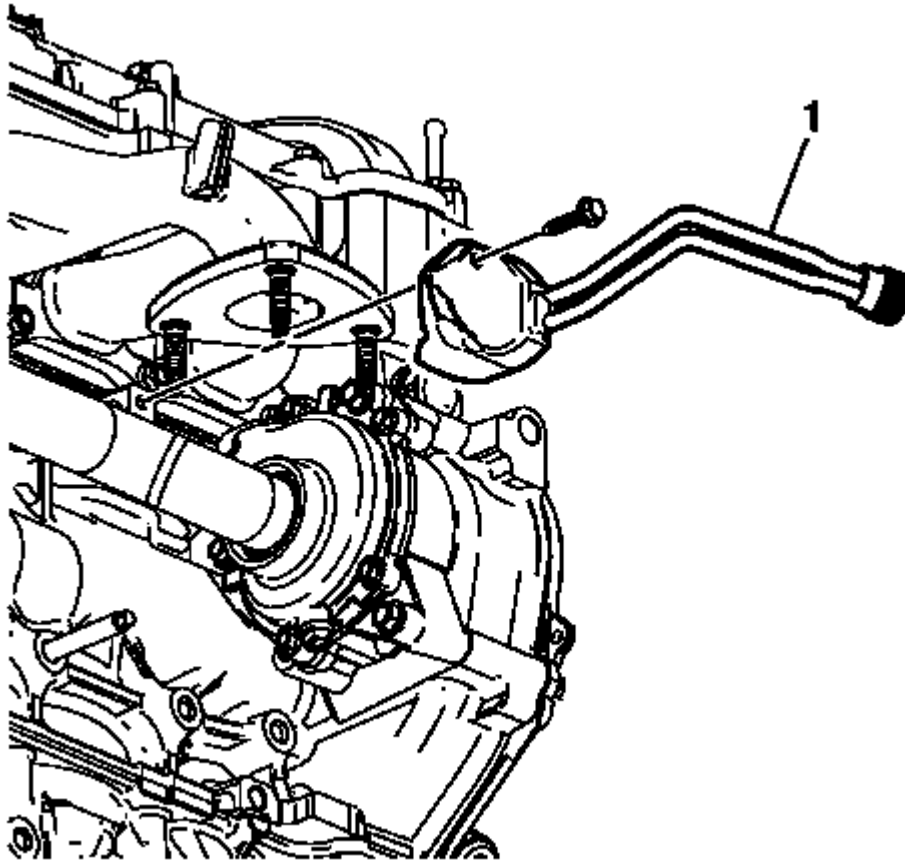
Courtesy of GENERAL MOTORS COMPANY

4. Install the exhaust manifold gasket (3).
5. Install the exhaust manifold (2) to the cylinder head.
6. Install NEW exhaust manifold to cylinder head retaining nuts (1) finger tight.



**Fig. 295: Identifying Exhaust Manifold To Cylinder Head Retaining Nut Tightening Sequence**  
 Courtesy of GENERAL MOTORS COMPANY

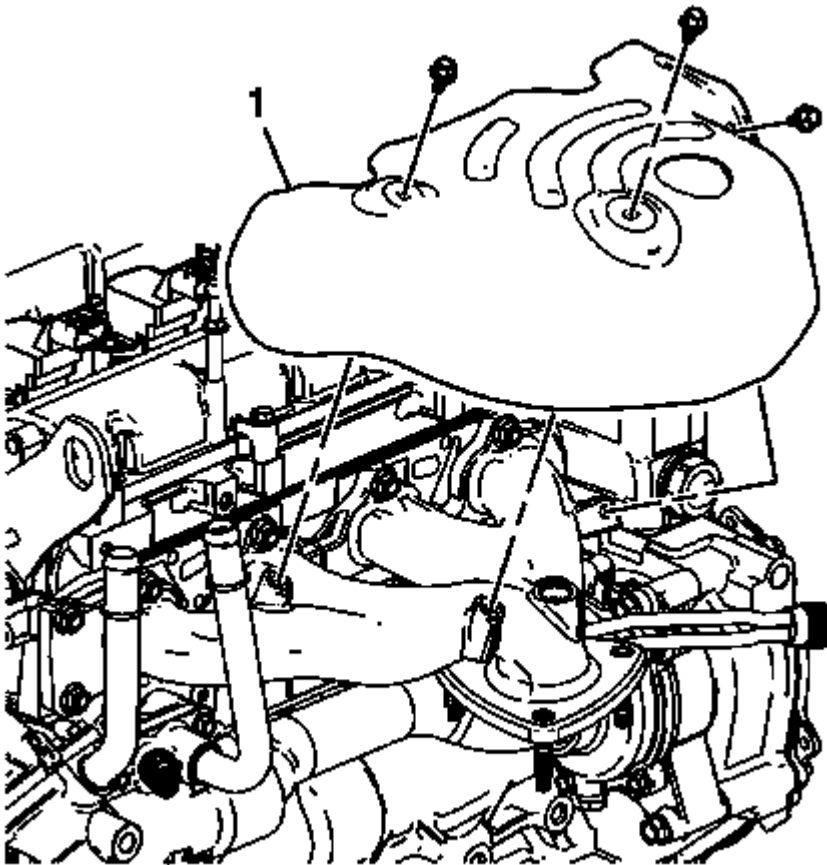
7. Tighten the NEW exhaust manifold to cylinder head retaining nuts two passes in sequence:
  1. Tighten first pass in sequence to 14 N.m (124 lb in).
  2. Tighten final pass in sequence to 14 N.m (124 lb in).



**Fig. 296: Block Heater**

Courtesy of GENERAL MOTORS COMPANY

8. Install the block heater (1). Tighten the bolt to 10 N.m (89 lb in).

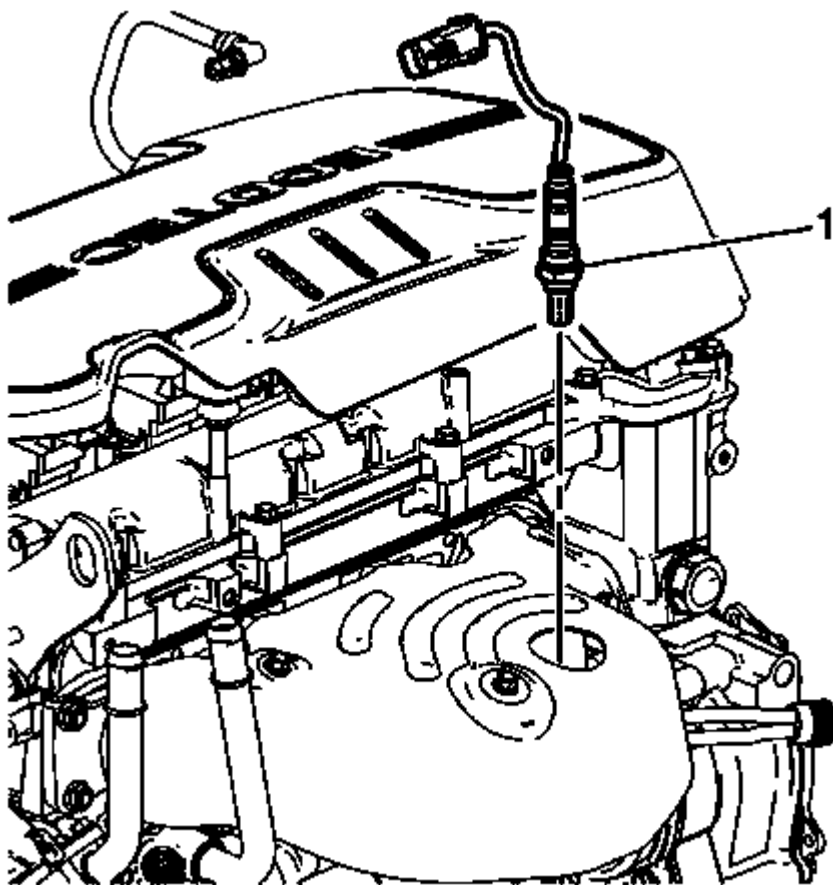


**Fig. 297: Exhaust Manifold Heat Shield**

Courtesy of GENERAL MOTORS COMPANY

9. Install the exhaust manifold heat shield (1).
10. Install the exhaust manifold heat shield bolts and tighten to 10 N.m (89 lb in).



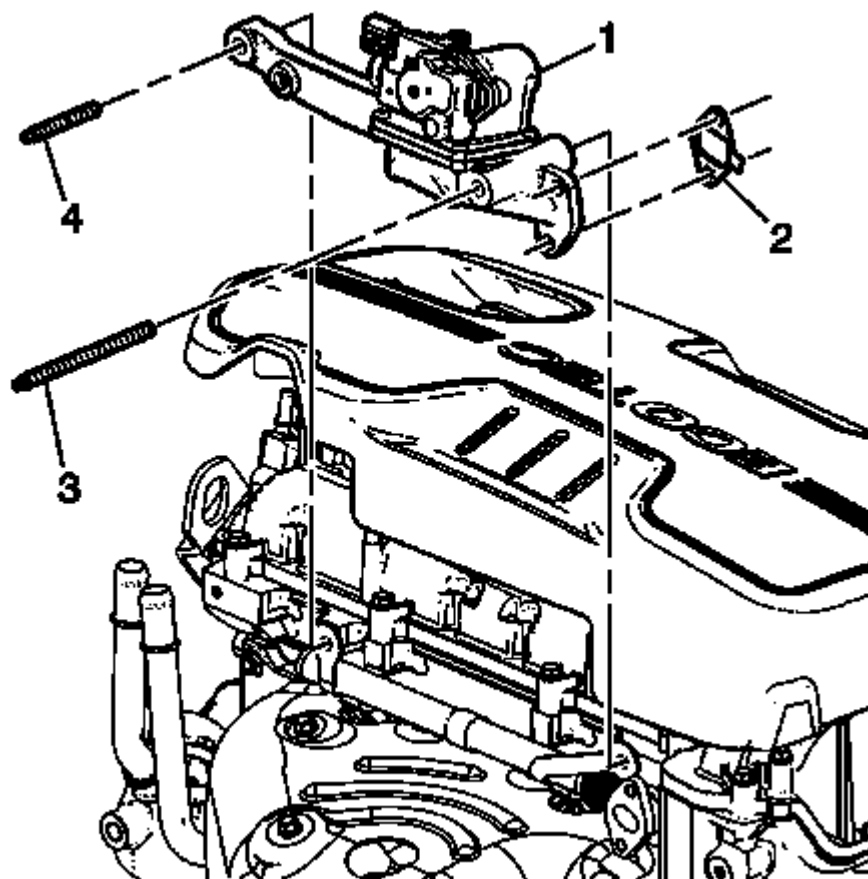


**Fig. 298: Oxygen Sensor**

Courtesy of GENERAL MOTORS COMPANY

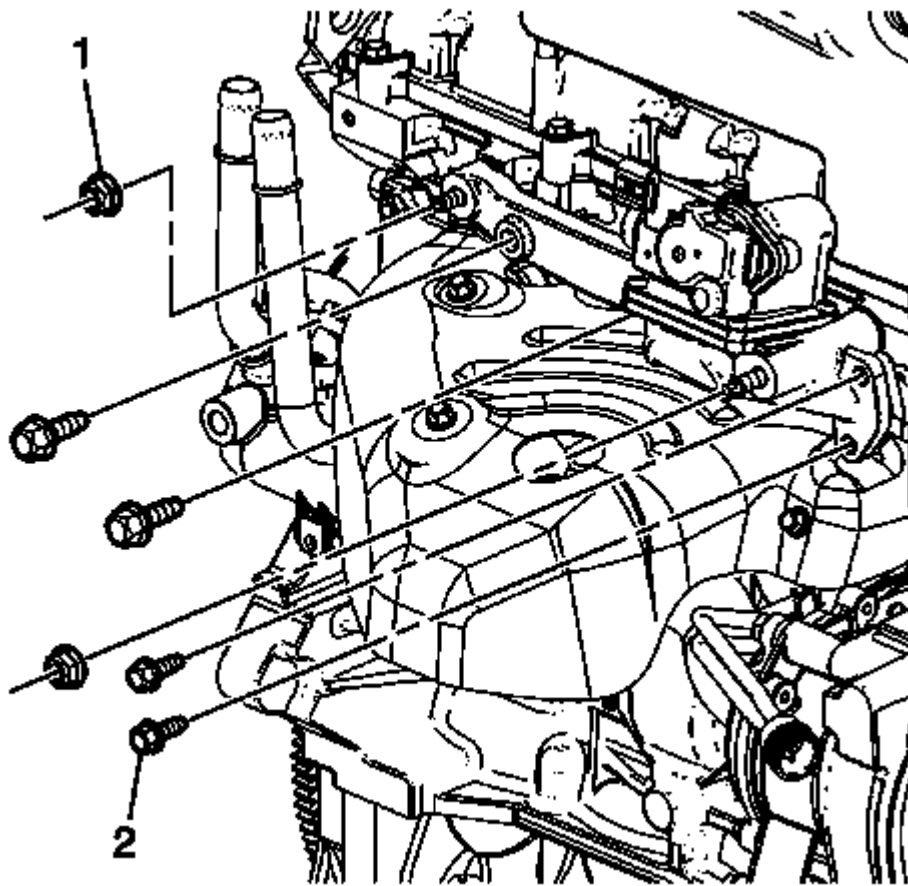
**NOTE:** An equivalent antiseize may be used.

11. Coat the threads of the oxygen sensor (1) with antiseize GM P/N 12397953. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
12. Install the oxygen sensor and tighten to 42 N.m (31 lb ft).



**Fig. 299: Secondary Air Injection Valve Assembly, Studs And Gasket**  
Courtesy of GENERAL MOTORS COMPANY

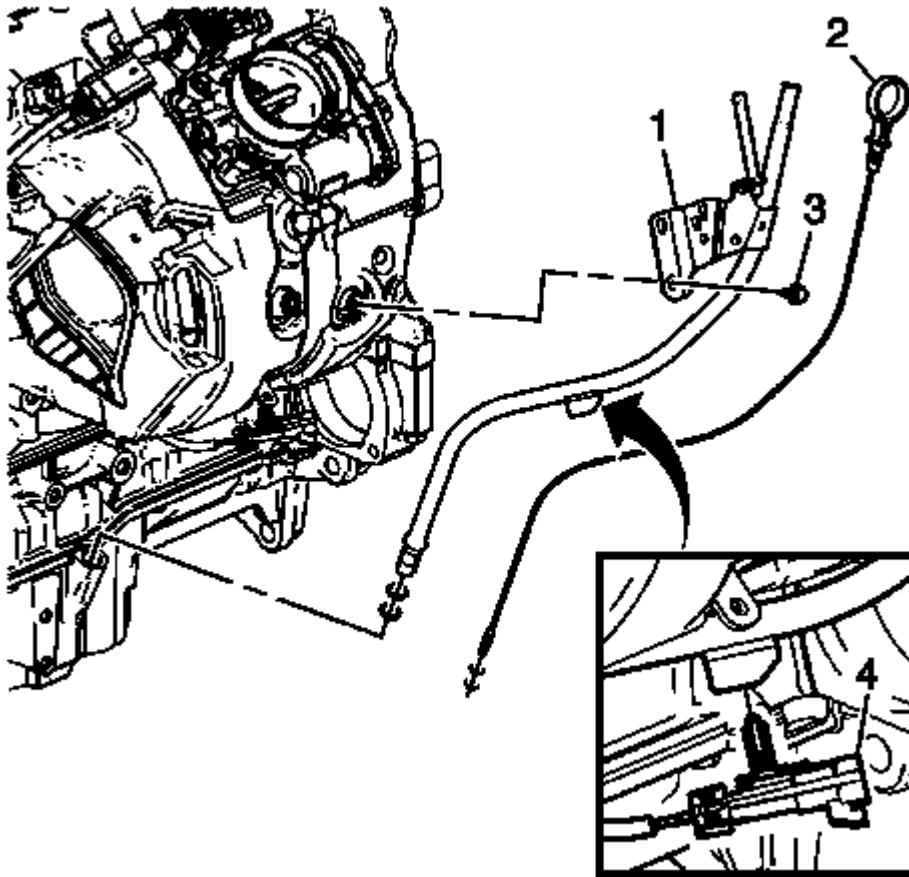
13. Install the secondary air injection studs (3 and 4) and tighten to 10 N.m(89 lb in).
14. Install the secondary air injection valve assembly (1) with a NEW gasket (2).



**Fig. 300: Secondary Air Injection Bolts And Nuts**  
Courtesy of GENERAL MOTORS COMPANY

15. Install the secondary air injection bolts (2, 3) and nuts (1).
  1. Tighten the secondary air injection assembly to cylinder head bolts (3) to 22 N.m(16 lb ft)
  2. Tighten the secondary air injection assembly to pipe assembly bolts (2) to 10 N.m(89 lb in)
  3. Tighten the secondary air injection assembly nuts (1) to 22 N.m(16 lb ft)

#### **OIL LEVEL INDICATOR AND TUBE INSTALLATION (2.4L LEA)**



**Fig. 301: Oil Level Indicator Tube Components**  
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the oil level indicator tube O-ring. Refer to Adhesives, Fluids, Lubricants, and Sealers .
2. Install the oil level indicator (2) and the oil level indicator tube (1) into the oil pan.

**CAUTION:** Refer to Fastener Caution .

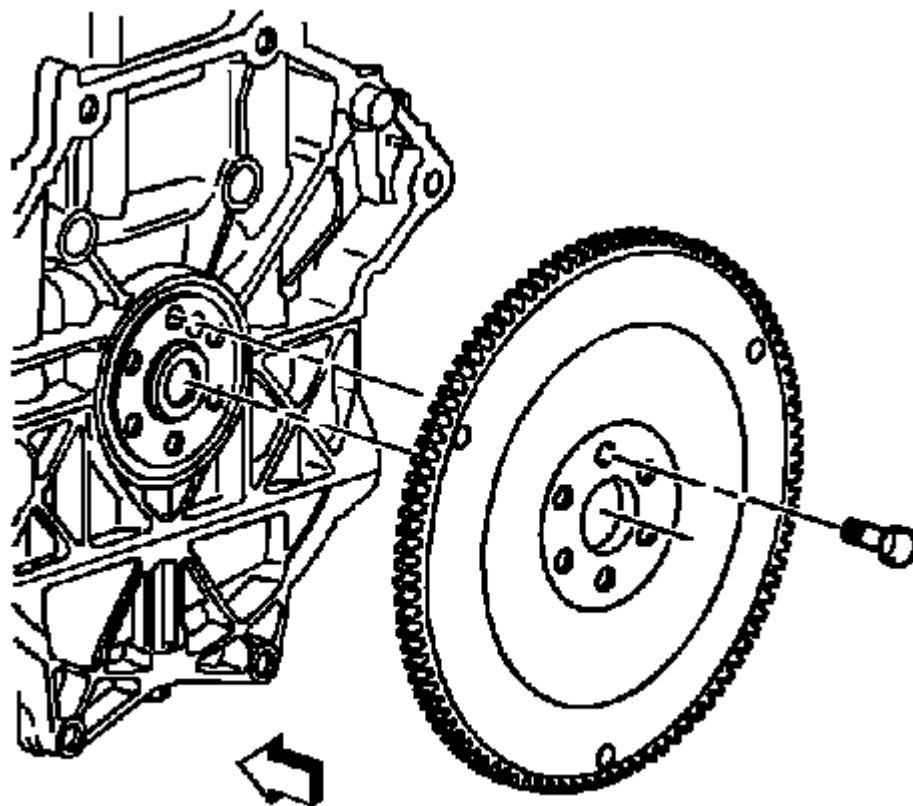
3. Install the oil level indicator tube bracket bolt (3) to the intake manifold and tighten to 10 N.m (89 lb in).
4. Install the electrical wiring harness to the oil level indicator tube.
5. Install the knock sensor wiring clip (4) into the oil level indicator tube.

## ENGINE FLYWHEEL INSTALLATION

### Special Tools

- EN-38122-A Crankshaft Balancer Holder
- EN-43653 Flywheel Holding Tool
- EN-45059 Angle Meter

For equivalent regional tools, refer to Special Tools .



**Fig. 302: View Of Flywheel**

Courtesy of GENERAL MOTORS COMPANY

1. Install the flywheel.
2. Install NEW bolts.

**CAUTION:** Refer to Fastener Caution .

**NOTE:** EN-43653 flywheel holding tool may be used instead of EN-38122-A holder in order to prevent crankshaft rotation.

3. Holding the crankshaft balancer with EN-38122-A holder tighten the bolts evenly. Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the EN-45059 meter

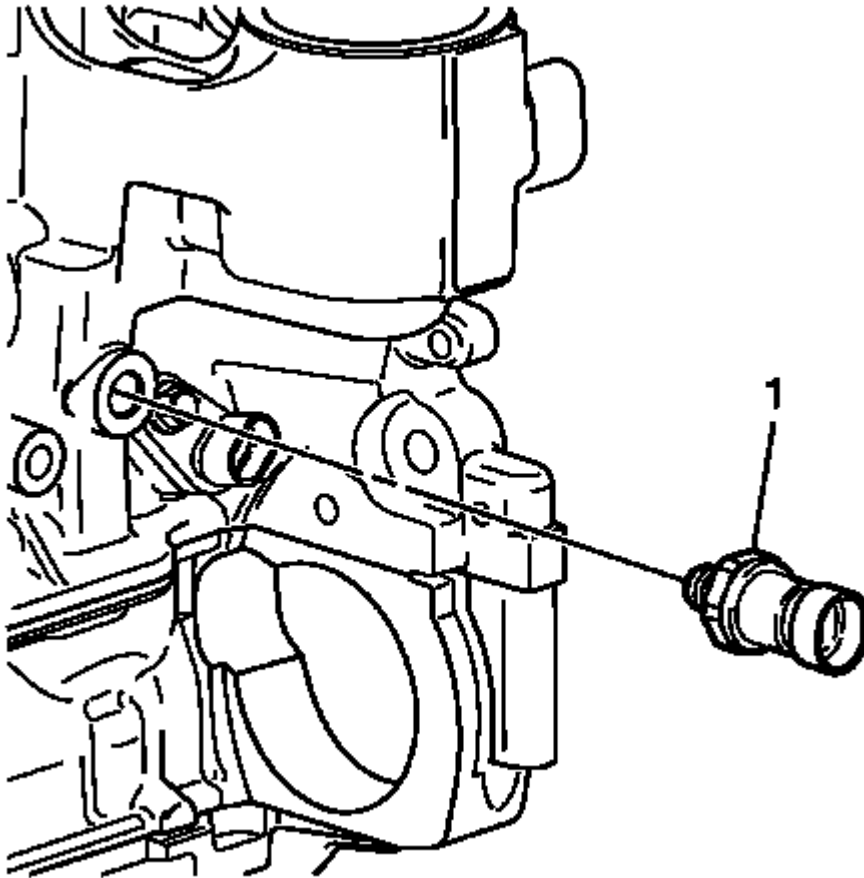
## ENGINE PRELUBING

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

## Special Tools

### EN-45299 Engine Preluber

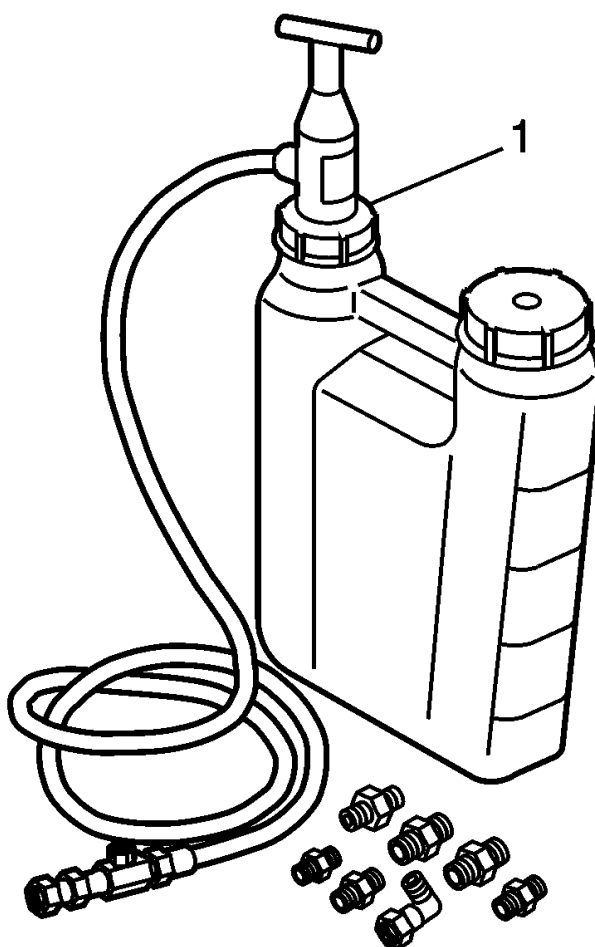
For equivalent regional tools, refer to Special Tools .



**Fig. 303: Identifying the M12 x 1.75 Adapter**  
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 oil pressure switch.
2. Install the M12 x 1.75 adapter (1) P/N 509376.



**Fig. 304: 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 oil pressure switch to the engine and tighten to 22 N.m (16 lb ft).
7. Top-off the engine oil to the proper level.