

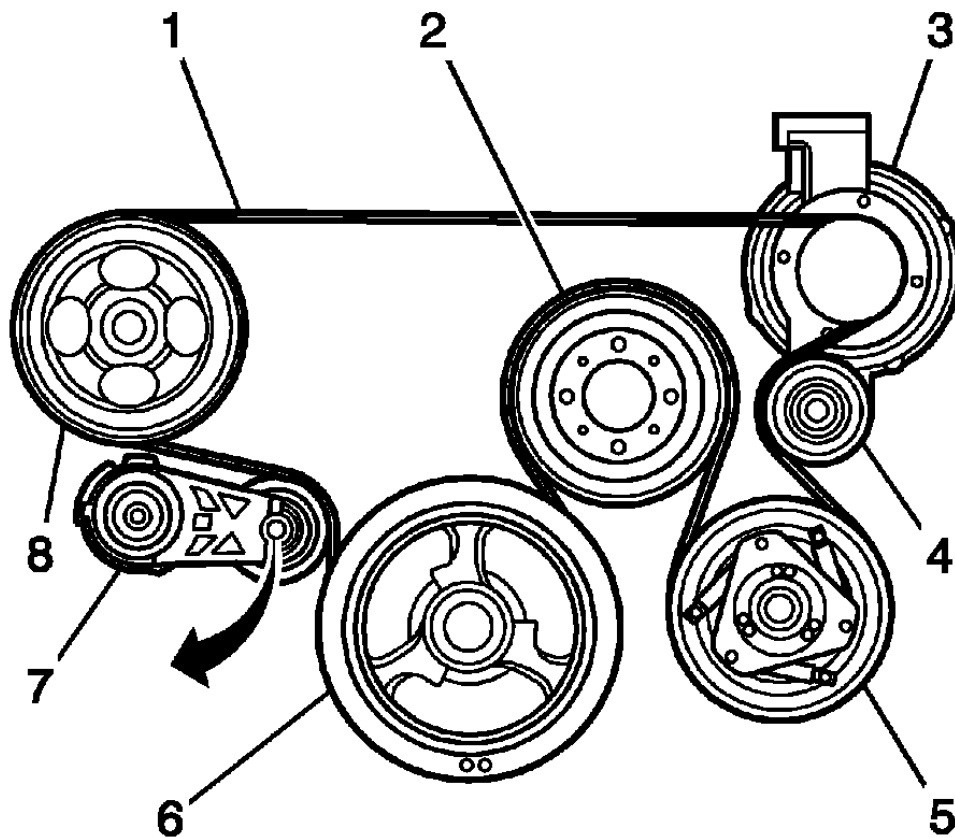
2012 Engine**Engine Mechanical - 2.9L - Repair Instructions - On Vehicle - Canyon, Colorado****REPAIR INSTRUCTIONS - ON VEHICLE****DRIVE BELT REPLACEMENT****Removal Procedure**

Fig. 1: View Of Drive Belt Routing & Pulleys (With A/C)
Courtesy of GENERAL MOTORS COMPANY

1. Install a 3/8 inch breaker bar into the drive belt tensioner (7) and rotate the tensioner (7) clockwise, enough to relieve the tension on the drive belt (1).
2. Slide the drive belt (1) from the water pump pulley (2).
3. Allow the drive belt tensioner (7) to return to the relaxed position.
4. Remove the drive belt (1) from the remaining pulleys.

Installation Procedure

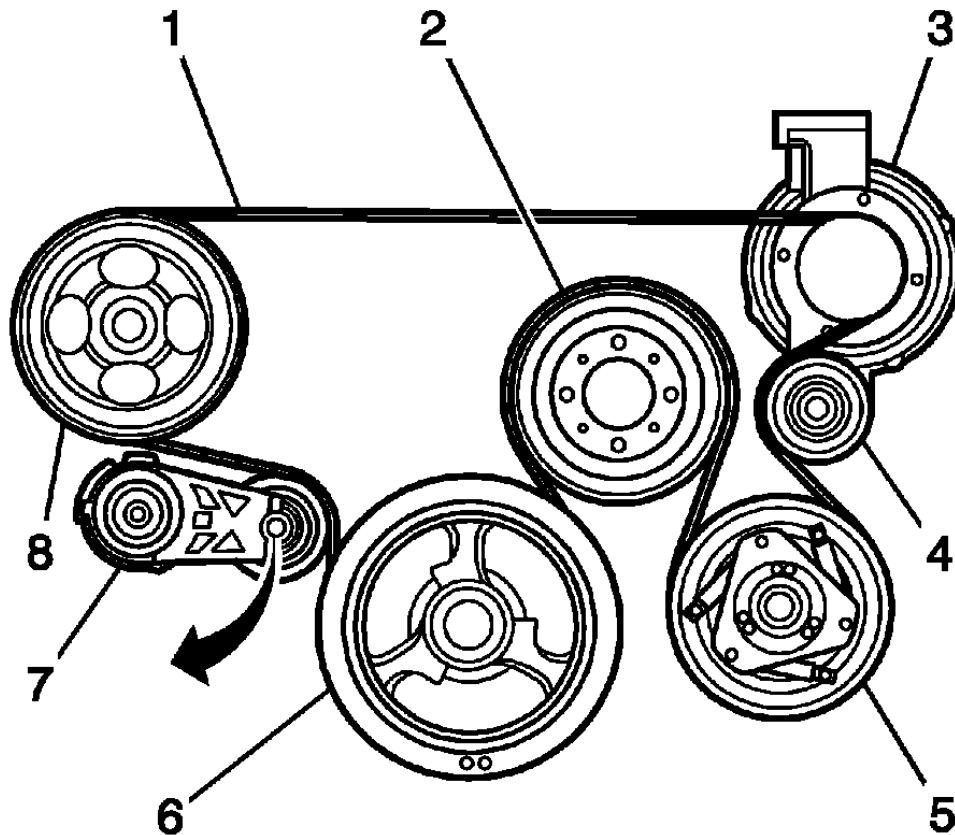


Fig. 2: View Of Drive Belt Routing & Pulleys (With A/C)
 Courtesy of GENERAL MOTORS COMPANY

1. Route the drive belt (1) over all the pulleys, excluding the water pump pulley (2).
2. Install the 3/8 inch breaker bar on the drive belt tensioner (7) and rotate the tensioner (7) clockwise.
3. Route the drive belt (1) over the top of the water pump pulley (2).
4. Slowly release the tension to the drive belt tensioner (7).

IMPORTANT: Ensure the drive belt is properly aligned and seated into the grooves of the drive pulleys.

5. Inspect for proper installation of the drive belt (1) on the pulleys.

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

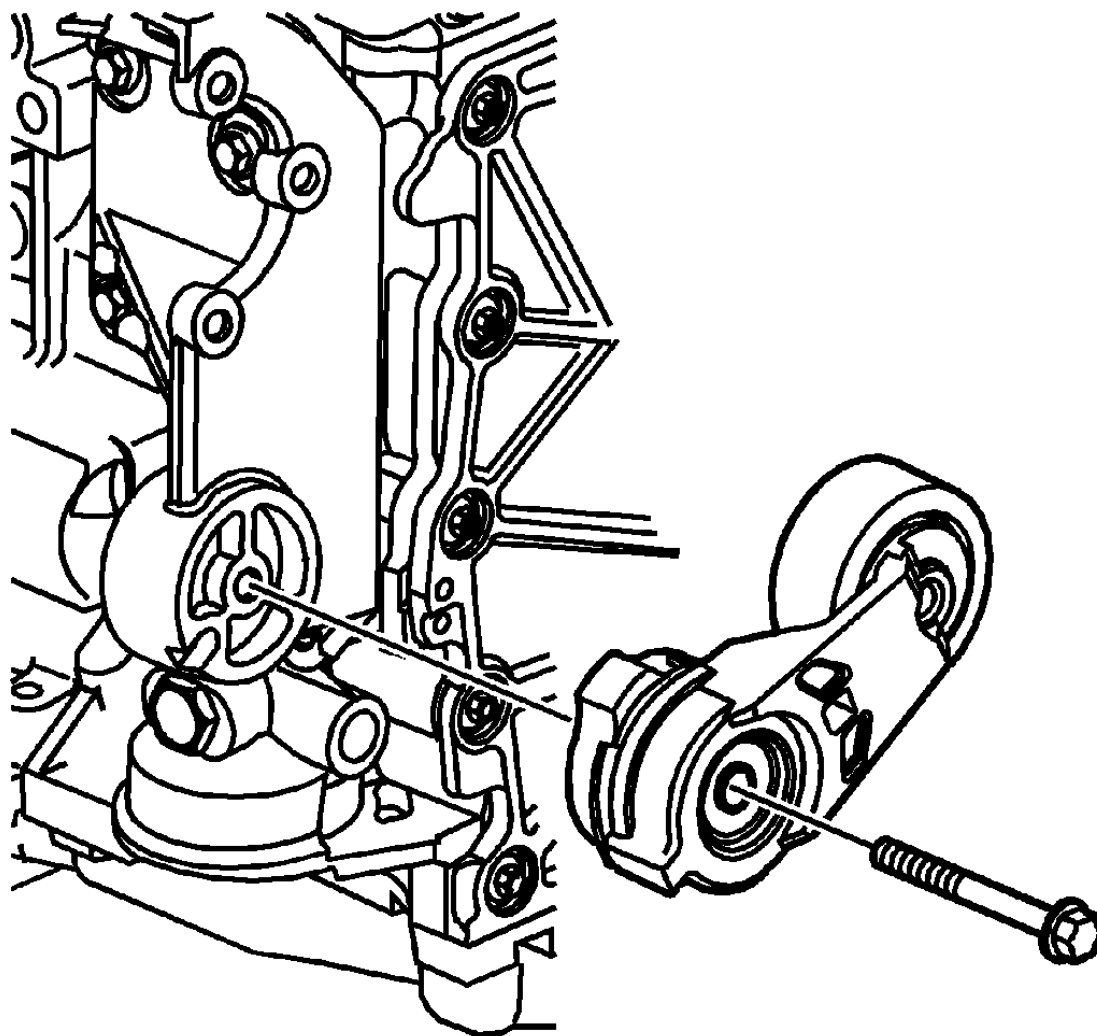


Fig. 3: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS COMPANY

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Inspect the drive belt. Change the drive belt as necessary.
3. Using a wrench loosen and remove the drive belt tensioner bolt.
4. Remove the drive belt tensioner.

Installation Procedure

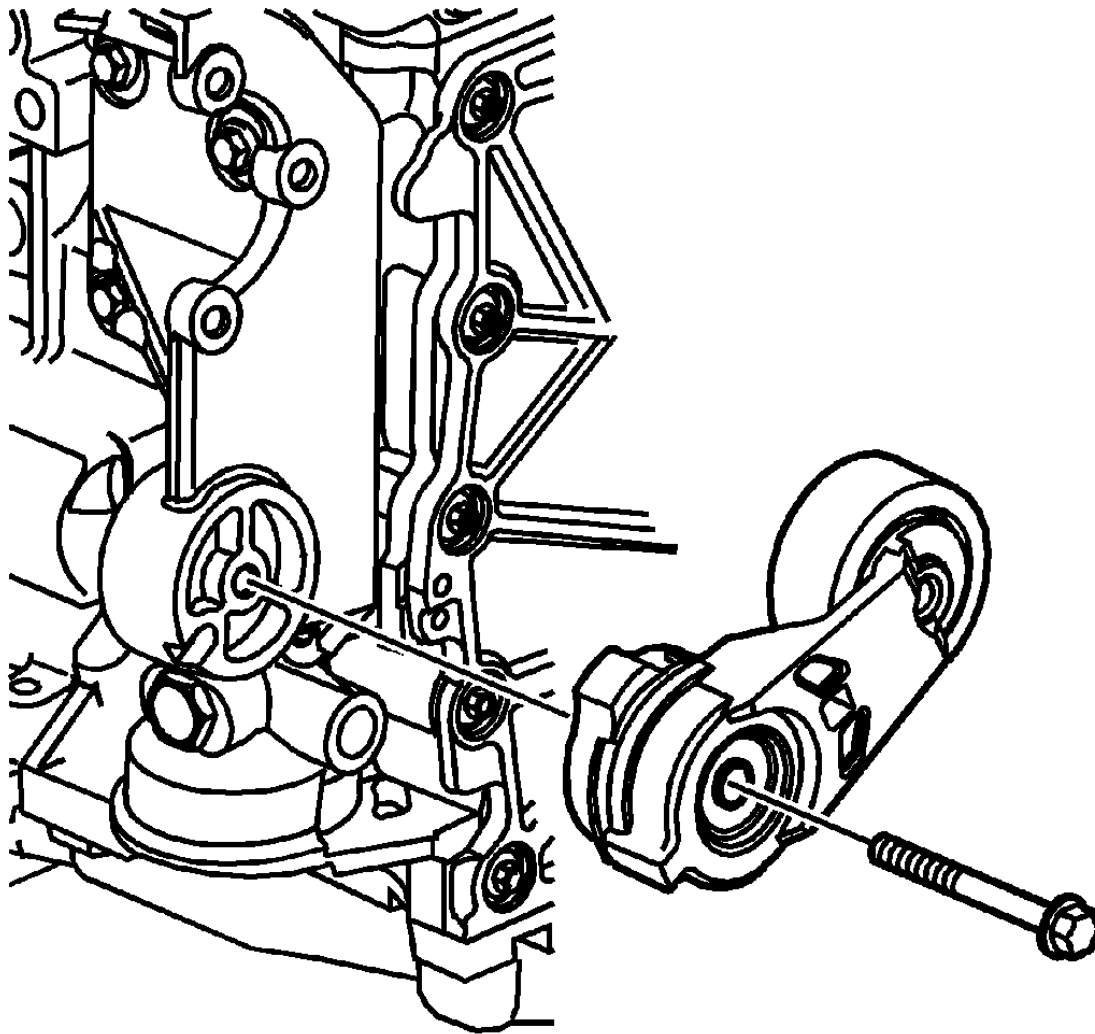


Fig. 4: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS COMPANY

1. Install the drive belt tensioner.

CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt and tighten to 50 N.m (37 lb ft).
3. Install the drive belt Drive Belt Replacement.

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

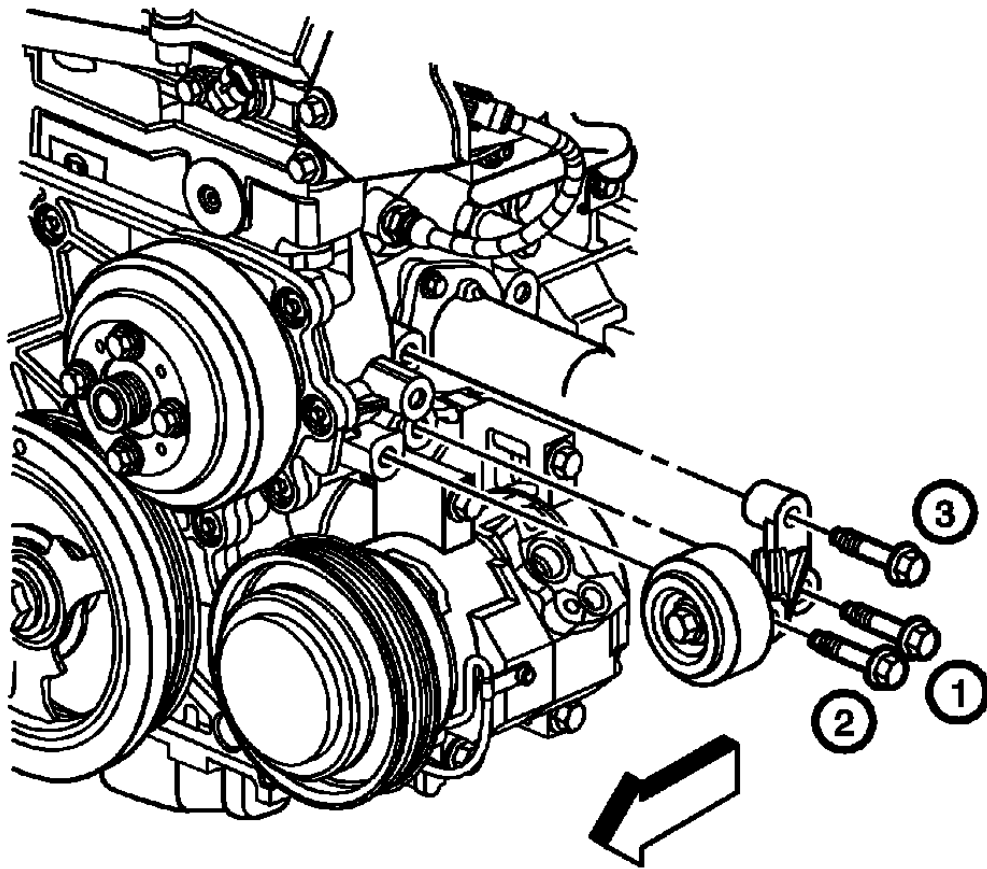


Fig. 5: View Of Drive Belt Idler Pulley & Bolts
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the left wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement**.
3. Remove the air conditioning (A/C) suction hose from the compressor. Refer to **Suction Hose Replacement (LLV, LLR)**.
4. Remove the A/C discharge hose from the compressor. Refer to **Discharge Hose Replacement (LLV, LLR)**.
5. Remove the bolts securing the drive belt idler pulley to the engine.
6. Remove drive belt idler pulley from the engine.

Installation Procedure

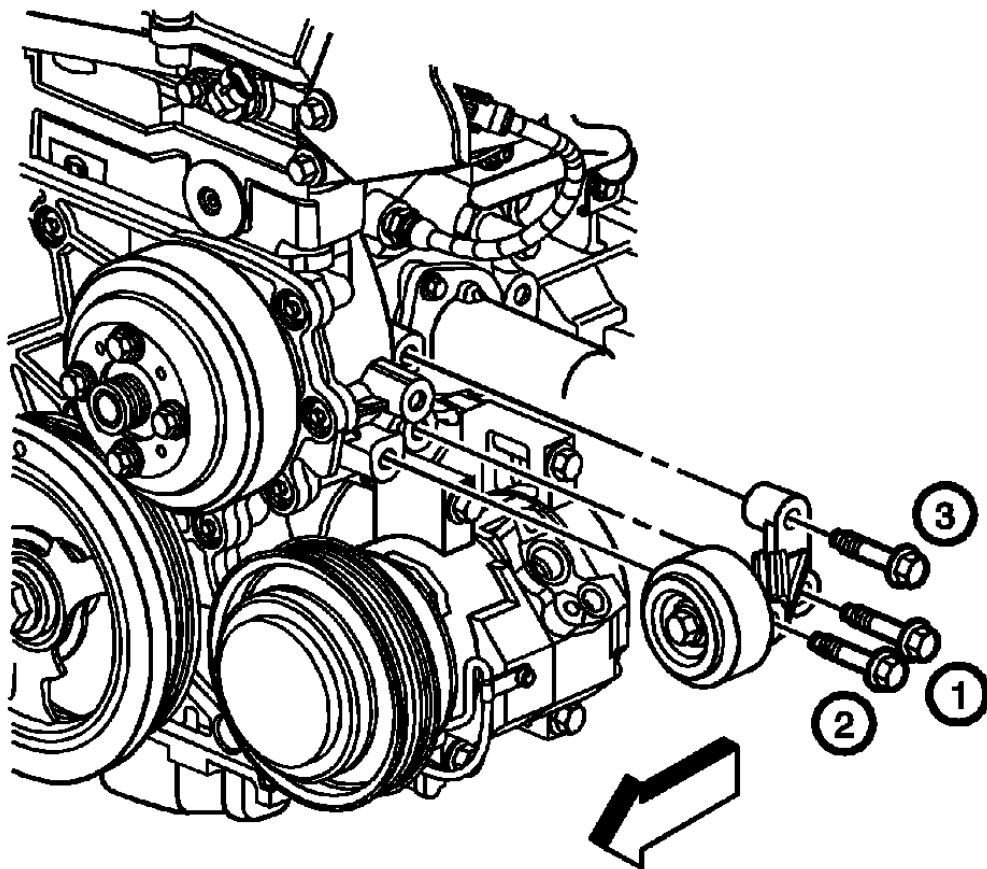


Fig. 6: View Of Drive Belt Idler Pulley & Bolts
 Courtesy of GENERAL MOTORS COMPANY

1. Position drive belt idler pulley to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the bolts securing the drive belt idler pulley to the engine.

Tighten the bolts in sequence to 50 N.m (37 lb ft).

3. Install the A/C suction hose to the compressor. Refer to Suction Hose Replacement (LLV, LLR) .
4. Install the A/C discharge hose to the compressor. Refer to Discharge Hose Replacement (LLV, LLR) .
5. Install the left wheelhouse liner. Refer to Front Wheelhouse Liner Replacement .
6. Install the drive belt. Refer to Drive Belt Replacement.

ENGINE MOUNT INSPECTION

CAUTION: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

CAUTION: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Measure the engine movement at the engine mount in order to inspect for damage to the rubber portions of the mount.
 1. Apply the park brake.
 2. Start the engine.
 3. Firmly apply and hold the primary brakes.
 4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
 5. Slightly load the engine shifting from drive to reverse a few times.
 6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, inspect for loose engine mount bolts.
2. If the engine mount bolt torque is within specifications, inspect the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:
 - Heat check cracks cover the rubber cushion surface.
 - The rubber cushion is separated from the metal plate of the mount.
 - There is a split through the rubber cushion.

ENGINE MOUNT REPLACEMENT - LEFT SIDE**Removal Procedure**

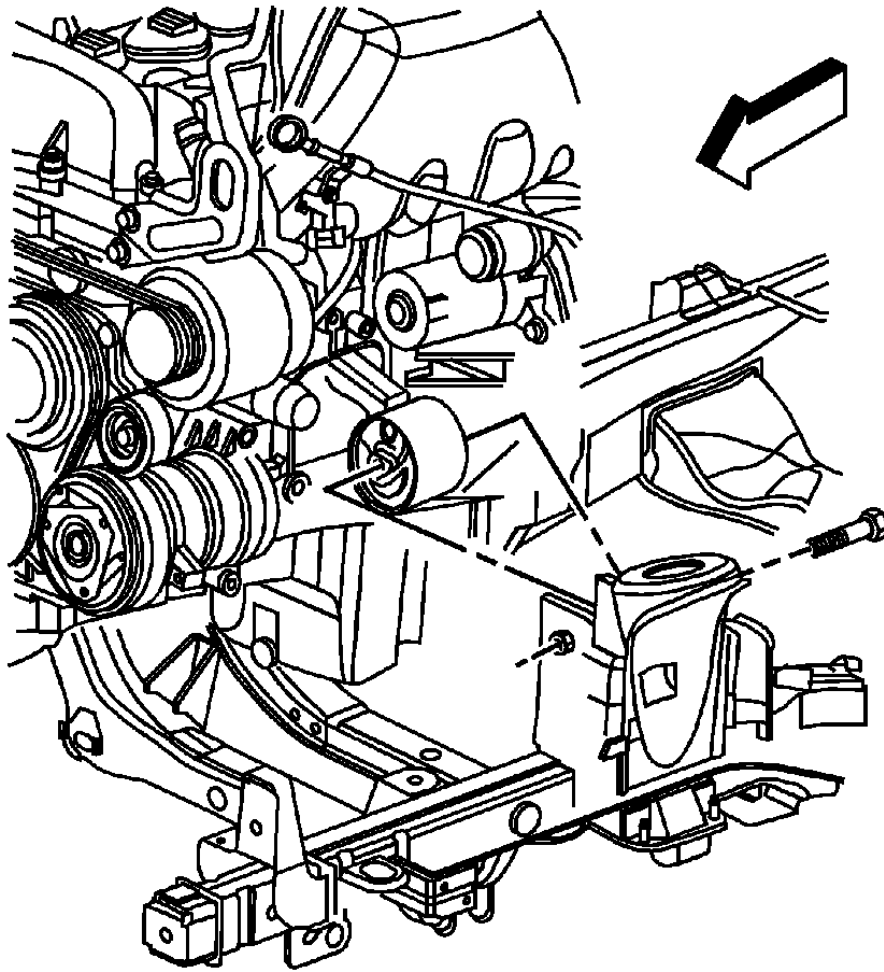


Fig. 7: View Of Engine Mount - Left
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the wheel and tire assembly. Refer to **Tire and Wheel Removal and Installation** .
2. Remove the engine shield, if equipped. Refer to **Engine Protection Shield Replacement** .
3. Remove the lower intermediate steering shaft. Refer to **Lower Intermediate Steering Shaft Replacement** .
4. Support the engine using a jack stand and a block of wood.
5. Remove the engine mount-to-frame bracket through bolt for the mount being replaced.
6. Loosen the right side through bolt.
7. Remove the heater pipe bracket bolt from the engine mount. Refer to **Heater Outlet Hose Replacement** .
8. Raise the engine using the jack stand; the engine will tilt to one side.

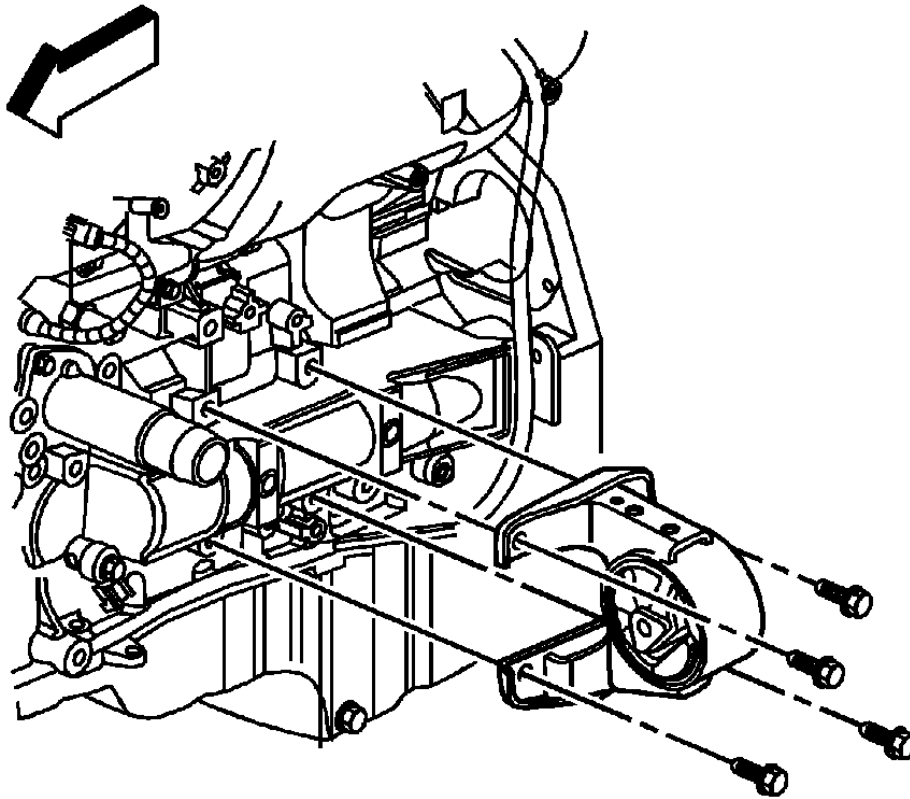


Fig. 8: View Of Engine Mount - Left
Courtesy of GENERAL MOTORS COMPANY

9. Remove the engine mount bolts.
10. Remove the engine mount. You will need to articulate the mount in order to remove the mount.

Installation Procedure

NOTE: You will need to articulate the mount in order to install the mount.

1. Install the engine mount.

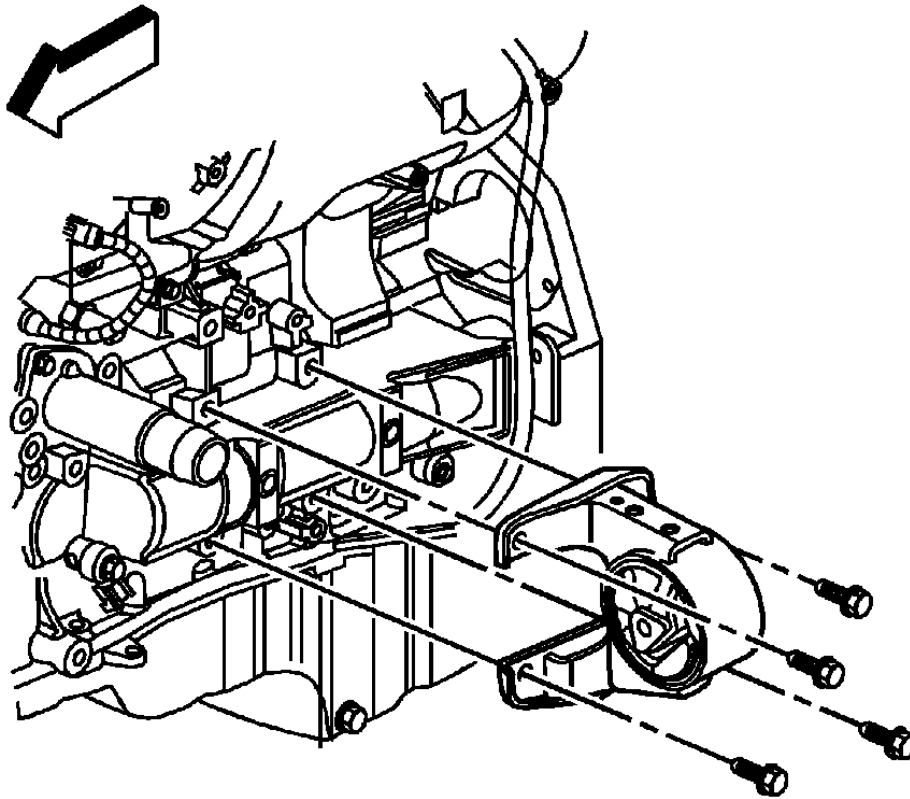


Fig. 9: View Of Engine Mount - Left
Courtesy of GENERAL MOTORS COMPANY

2. Install the engine mount bolts.

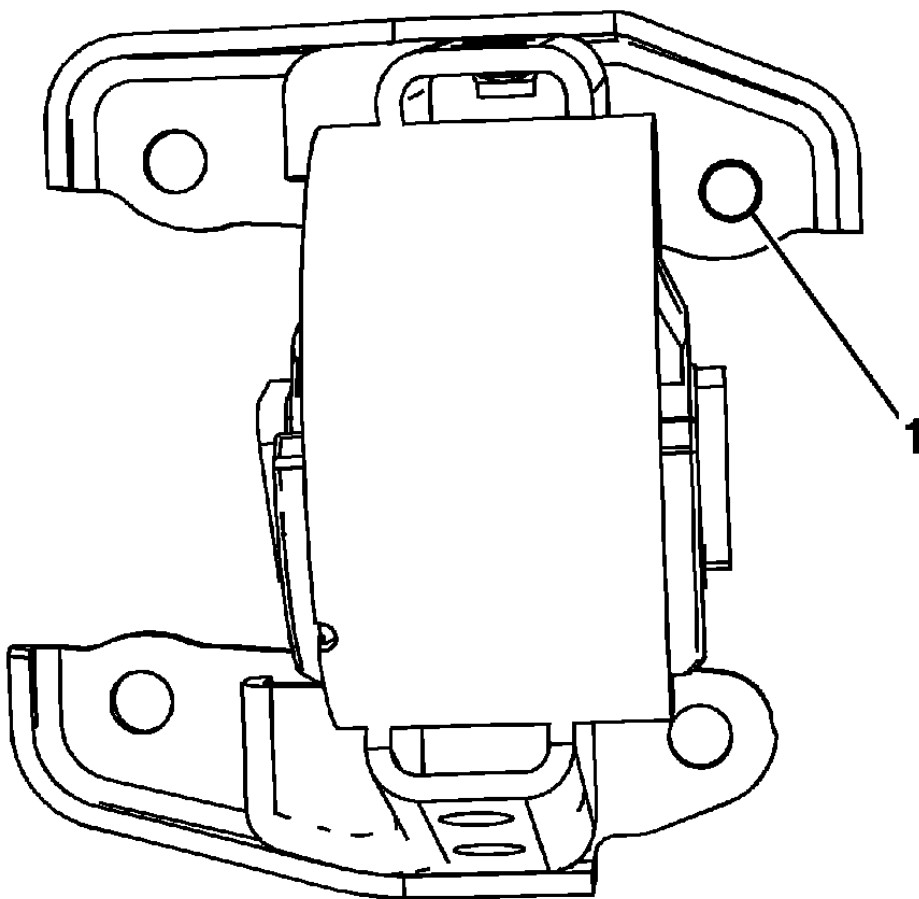


Fig. 10: Locating Installation Start Bolt - Left
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. To aid in the installation of the bolts, start a bolt in position (1) first. Tighten the bolts to 50 N.m (37 lb ft).
4. Lower the engine.

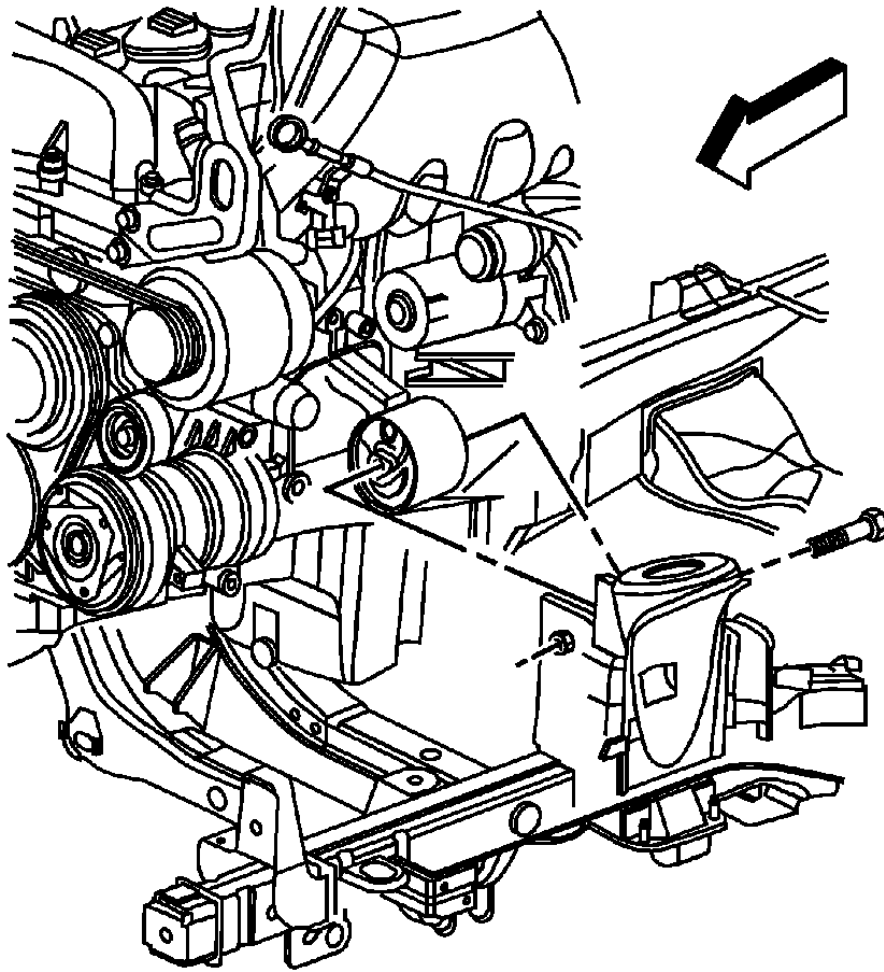


Fig. 11: View Of Engine Mount - Left
 Courtesy of GENERAL MOTORS COMPANY

5. Install the engine mount-to-frame bracket through bolt and tighten to 85 N.m (63 lb ft).
6. Install the engine coolant pipe bracket bolt from the engine mount. Refer to **Heater Outlet Hose Replacement** .
7. Remove the jack stand.
8. Install the lower intermediate steering shaft. Refer to **Lower Intermediate Steering Shaft Replacement** .
9. Install the engine shield, if equipped. Refer to **Engine Protection Shield Replacement** .
10. Install the wheel and tire assembly. Refer to **Tire and Wheel Removal and Installation** .

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

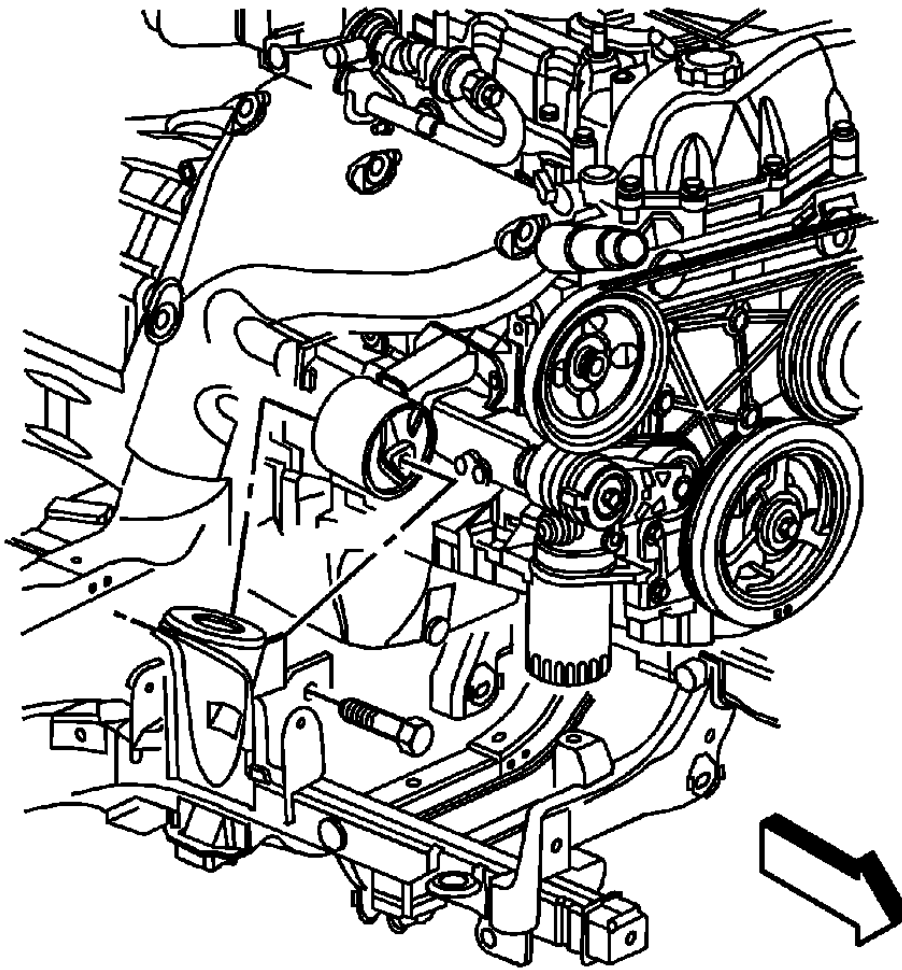


Fig. 12: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

1. Remove the wheel and tire assembly. Refer to **Tire and Wheel Removal and Installation** .
2. Remove the engine shield if equipped. Refer to **Engine Protection Shield Replacement** .
3. Support the engine using a jack stand and a block of wood.
4. Remove the engine mount-to-frame bracket through bolt for the mount being replaced.
5. Loosen the left side through bolt.
6. Raise the engine using the jack stand. The engine will tilt to one side.

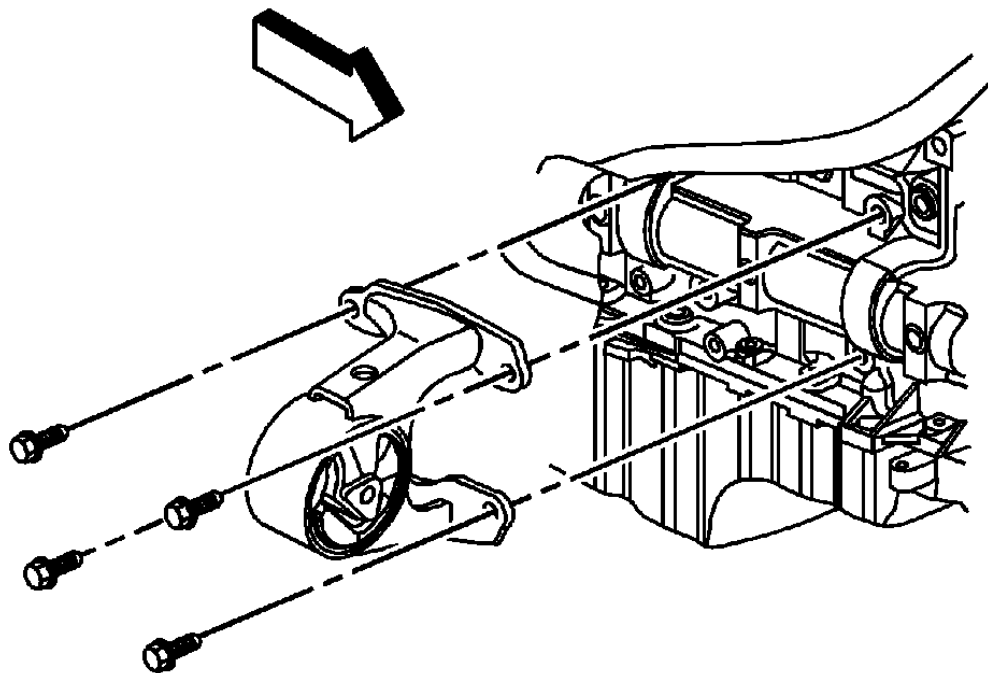


Fig. 13: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine mount bolts.
8. Remove the engine mount. You will need to articulate the mount in order to remove the mount.

Installation Procedure

NOTE: **You will need to articulate the mount in order to install the mount.**

1. Install the engine mount.

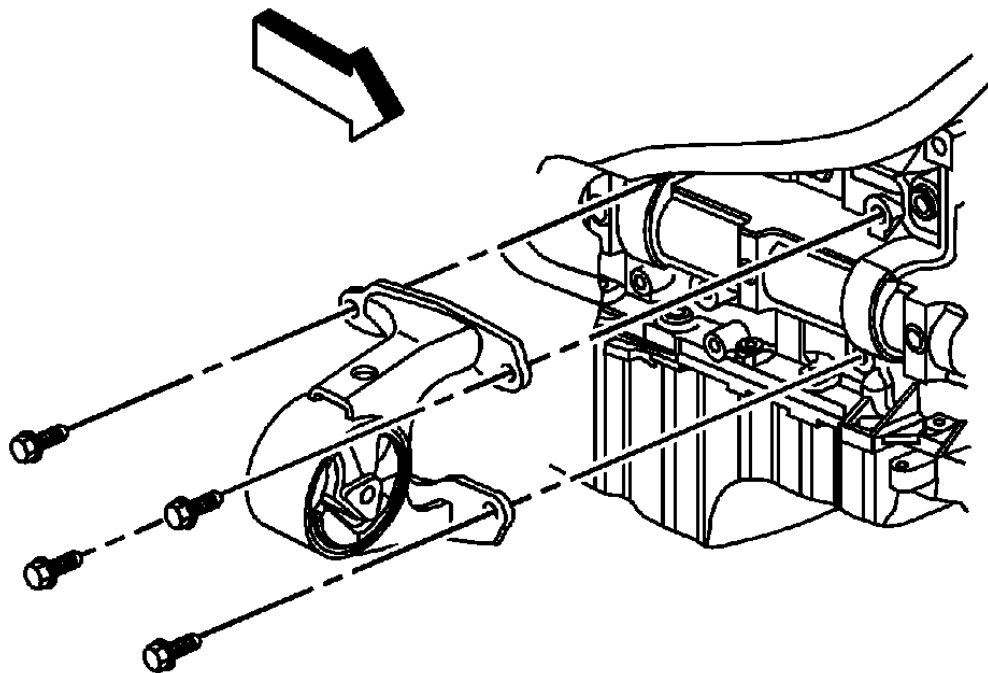


Fig. 14: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

2. Install the engine mount bolts.

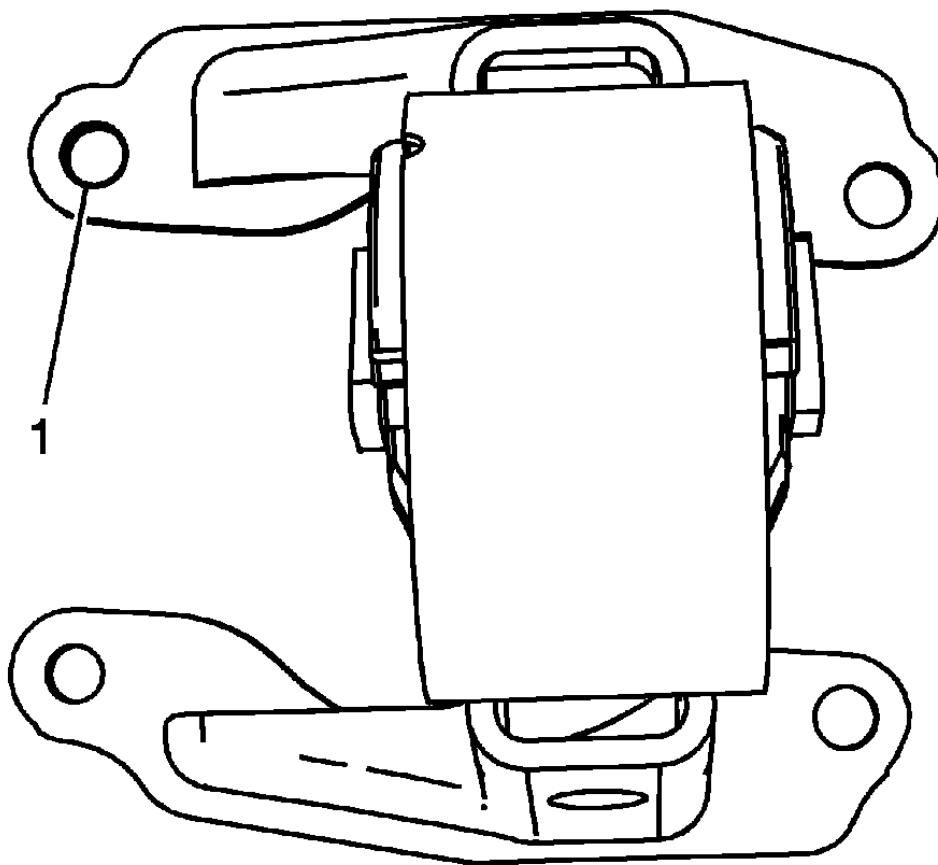


Fig. 15: Locating Installation Start Bolt - Right
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. To aid in the installation of the bolts, start a bolt in position (1) first. Tighten the bolts to 50 N.m (37 lb ft).
4. Lower the engine.

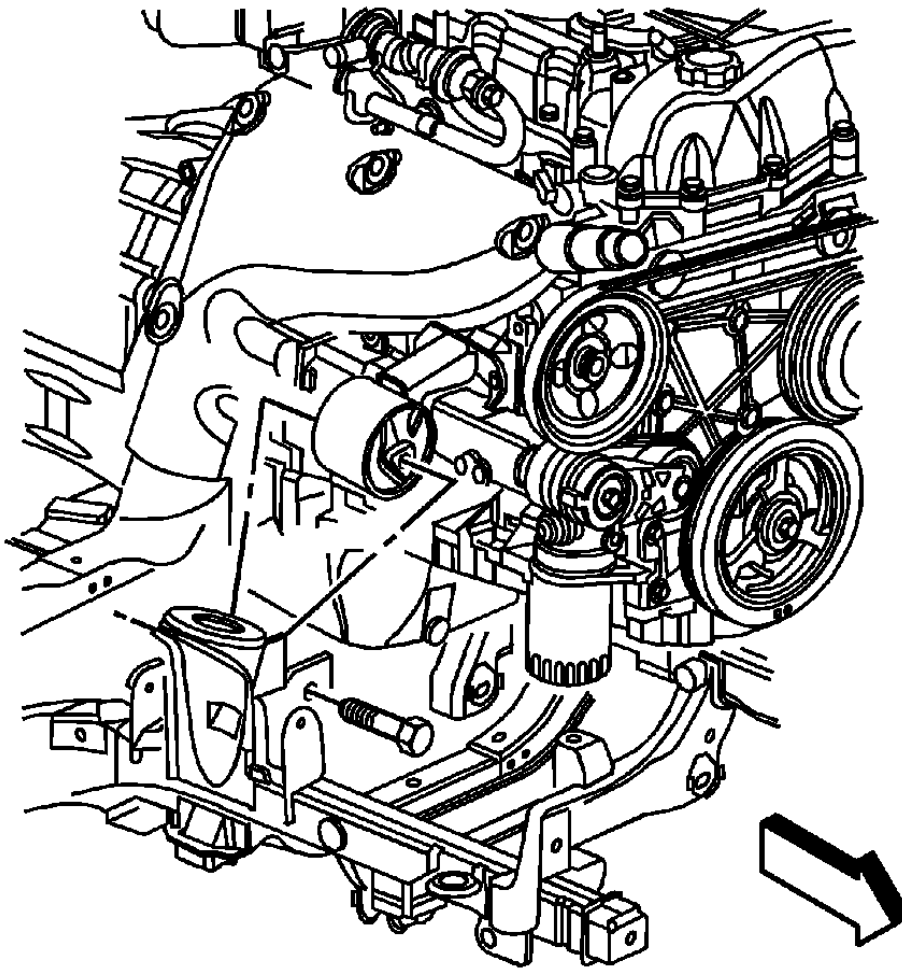


Fig. 16: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

5. Install the engine mount-to-frame bracket through bolt and tighten to 85 N.m (63 lb ft).
6. Remove the jack stand.
7. Install the engine shield if equipped. Refer to **Engine Protection Shield Replacement** .
8. Install the wheel and tire assembly. Refer to **Tire and Wheel Removal and Installation** .

ENGINE LIFT BRACKET REPLACEMENT

Removal Procedure

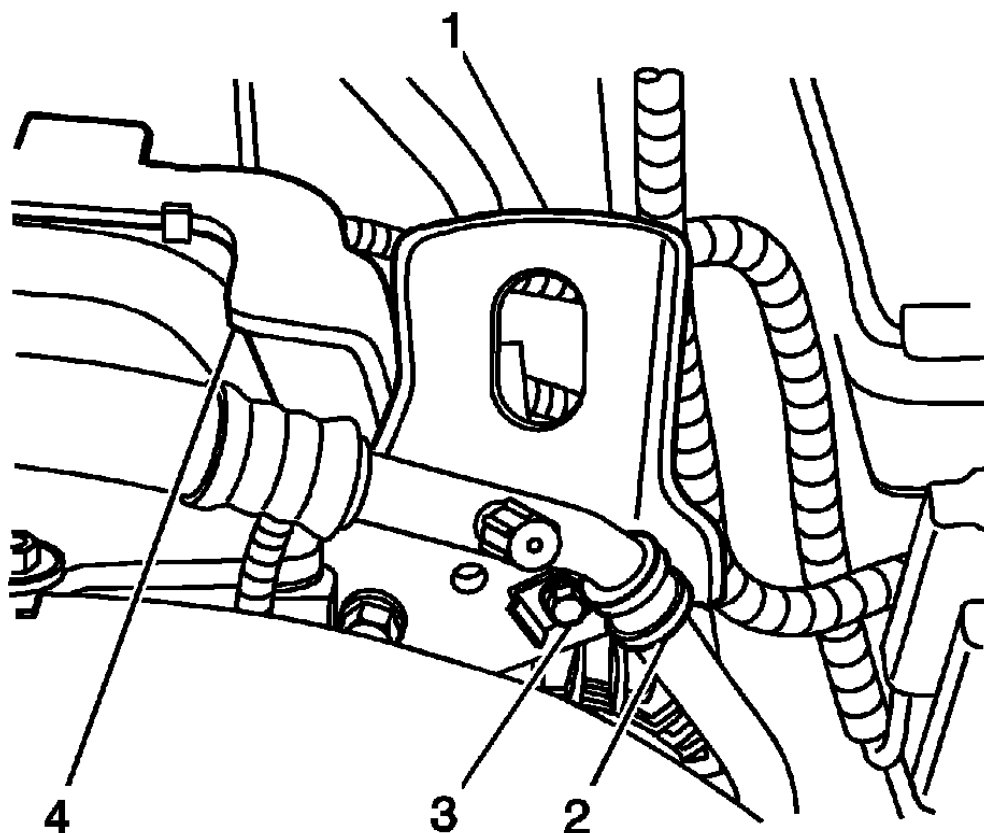


Fig. 17: View Of Engine Lift Bracket & Attachments
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the bolt (3) securing the A/C compressor hose/pipe bracket (2) to the engine lift bracket (1).
3. Carefully disengage the engine wiring harness conduit (4) from the engine lift bracket (1).

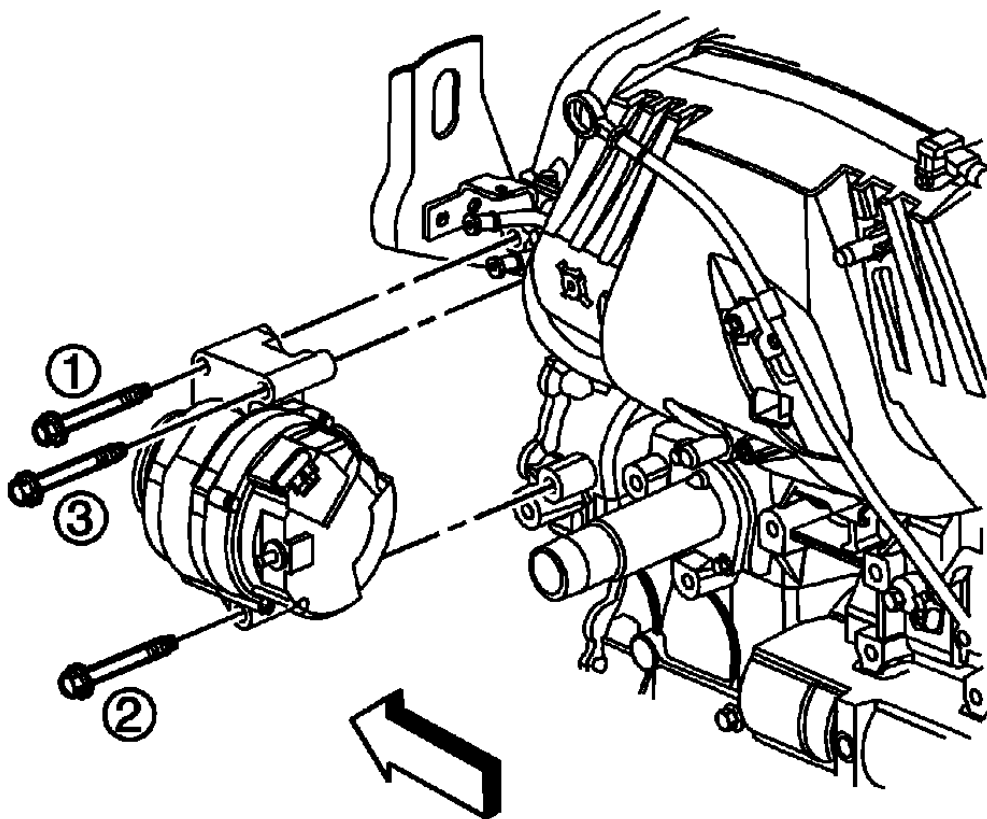


Fig. 18: Generator Mounting Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Remove the 3 generator bolts.

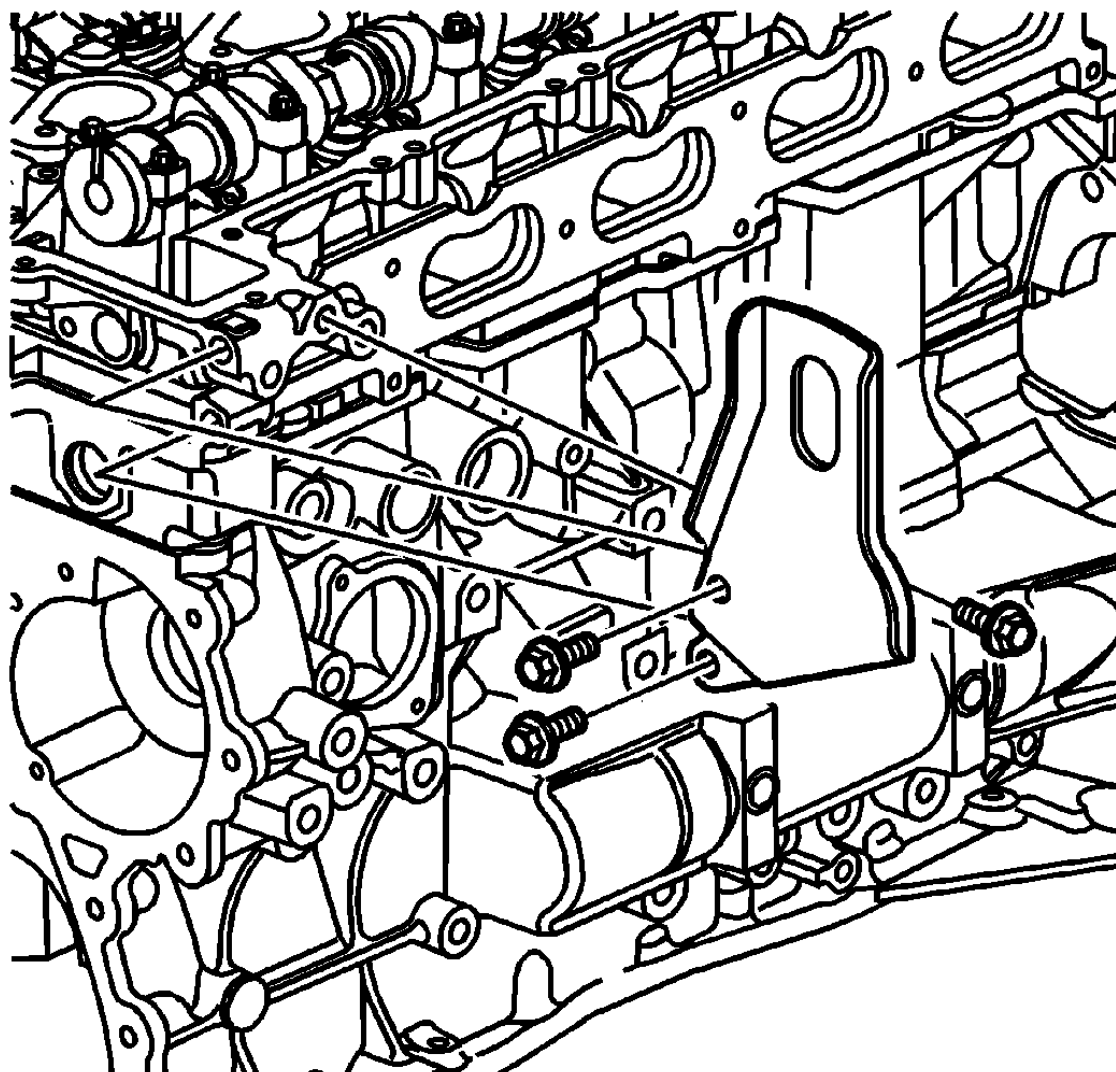


Fig. 19: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

5. Remove the bolts securing engine lift bracket to the engine.
6. Remove the engine lift bracket from the engine.

Installation Procedure

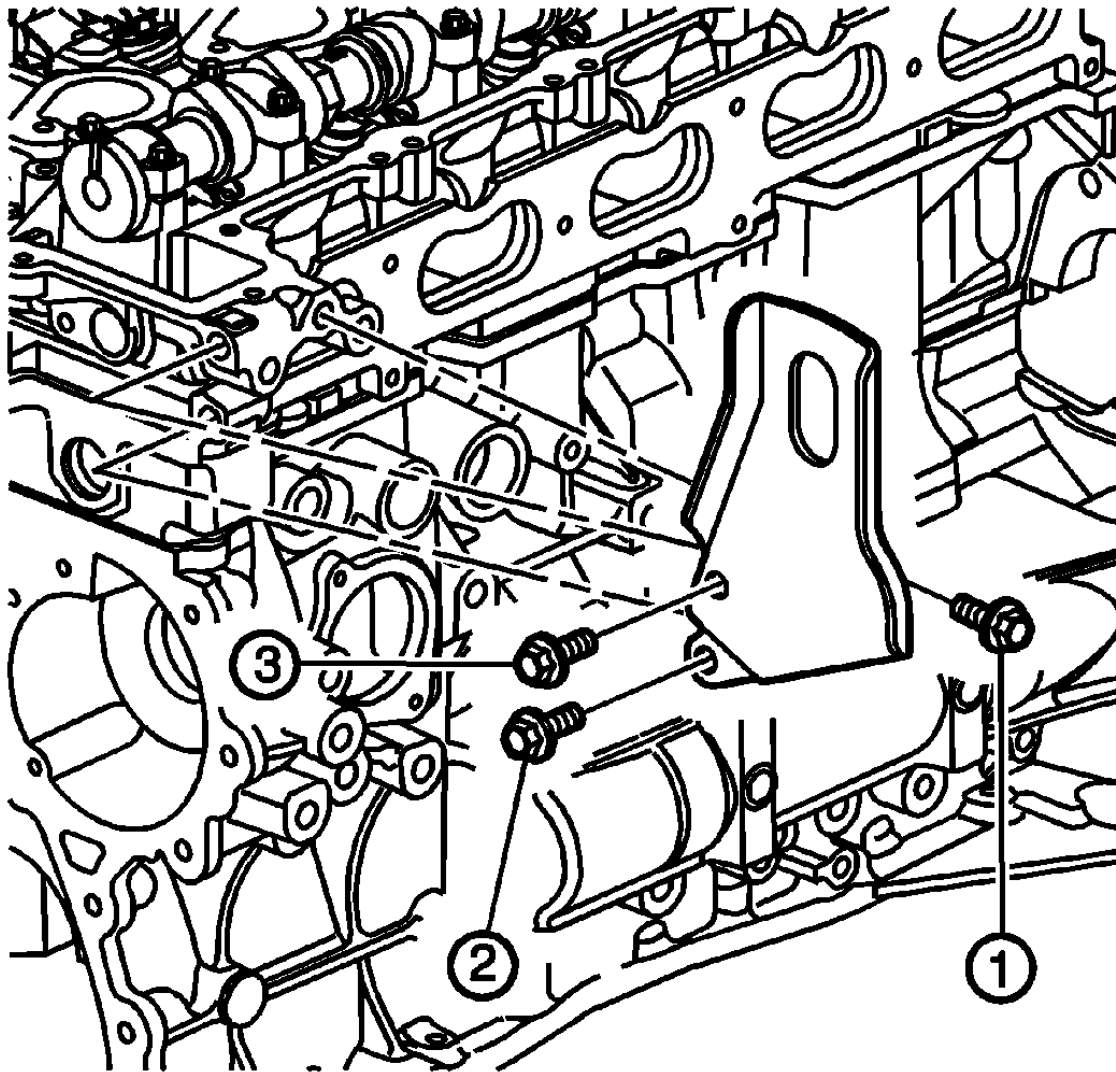


Fig. 20: Engine Lift Bracket & Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

1. Position the engine lift bracket to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the bolts securing engine lift bracket to the engine.
 - Tighten the bolts in sequence to 5 N.m (44 lb in).
 - Tighten the bolts in sequence to 50 N.m (37 lb ft).
3. Position the generator to the engine.

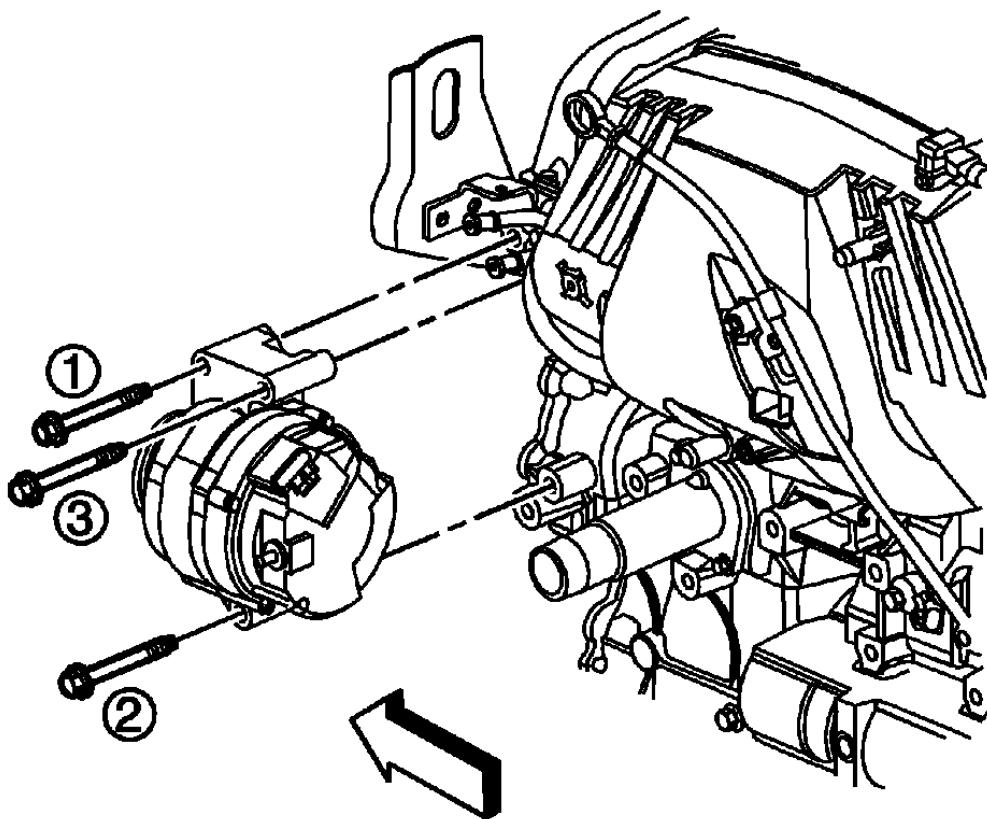


Fig. 21: Generator Mounting Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Install the generator bolts and tighten in sequence to 50 N.m (37 lb ft).

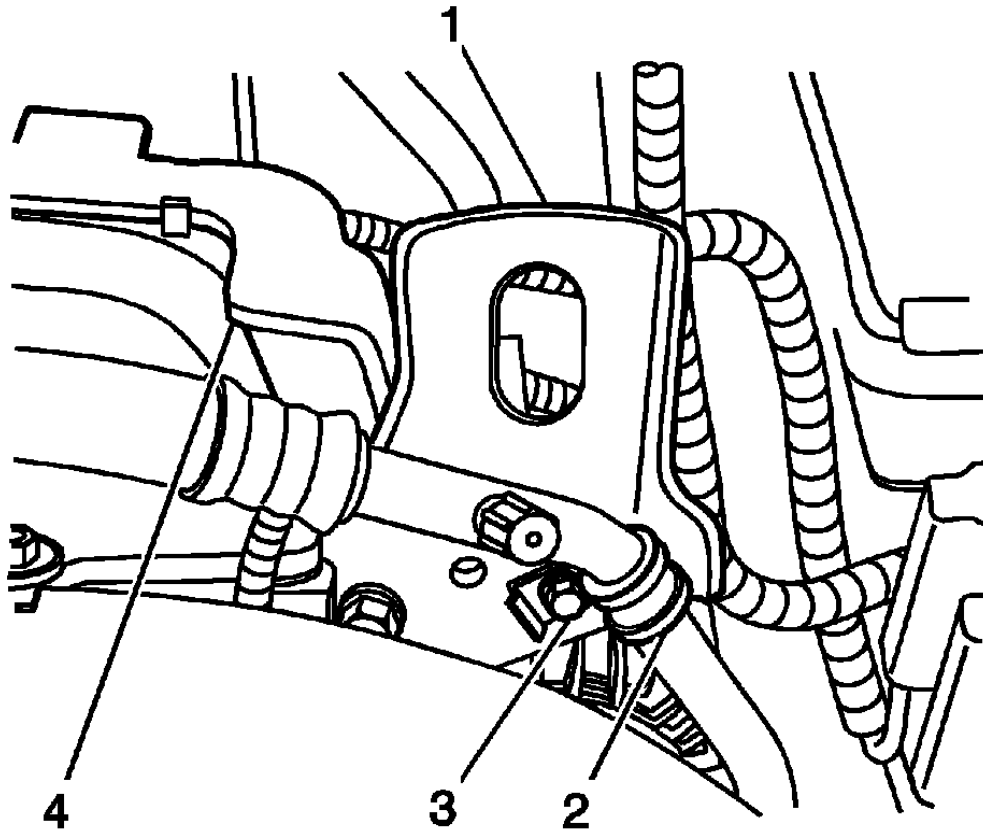


Fig. 22: View Of Engine Lift Bracket & Attachments
Courtesy of GENERAL MOTORS COMPANY

5. Engage the engine wiring harness conduit (4) to the engine lift bracket (1).
6. Install the bolt (3) securing the A/C compressor hose/pipe bracket (2) to the engine lift bracket (1).

Tighten the bolt to 9 N.m (80 lb in).

7. Install the drive belt. Refer to **Drive Belt Replacement**.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

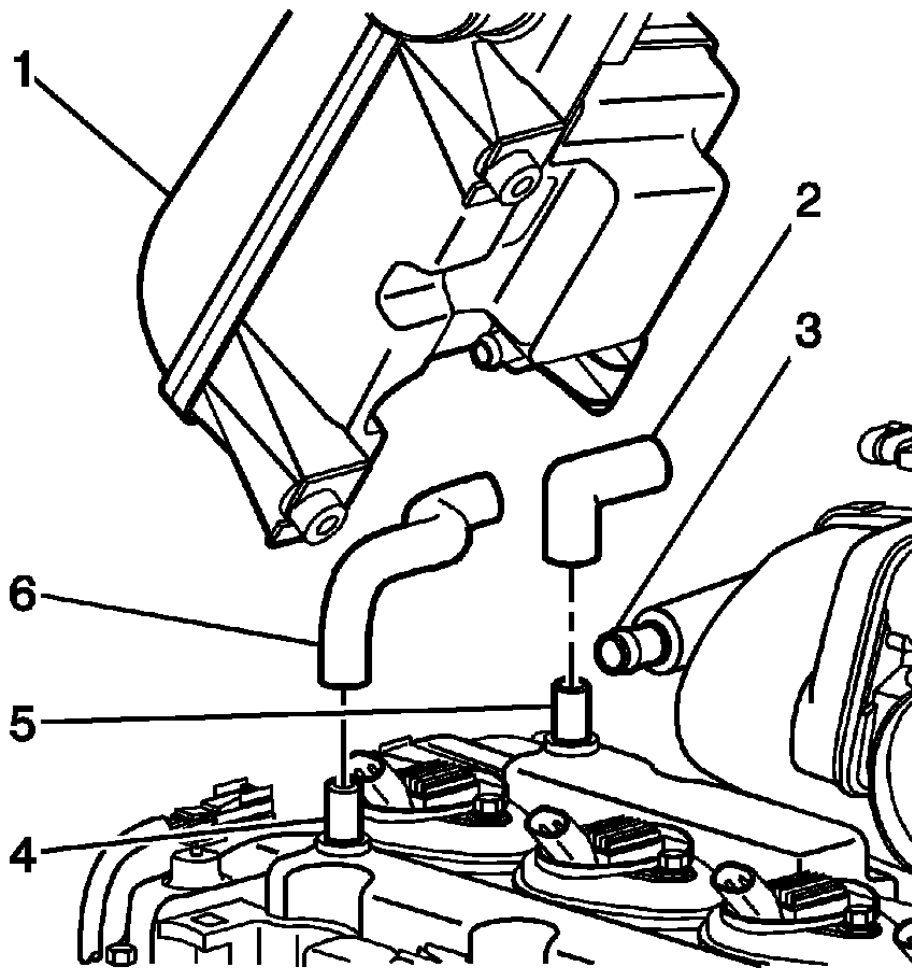


Fig. 23: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS COMPANY

1. Remove the air cleaner resonator and outlet duct. Refer to [Air Cleaner Resonator and Outlet Duct Replacement](#) .
2. Disconnect the positive crankcase ventilation (PCV) fresh air tube (6) from the air cleaner resonator (1).
3. Disconnect the PCV dirty air tube (2) from the following:
 - The camshaft cover (5)
 - The intake manifold (3)

Installation Procedure

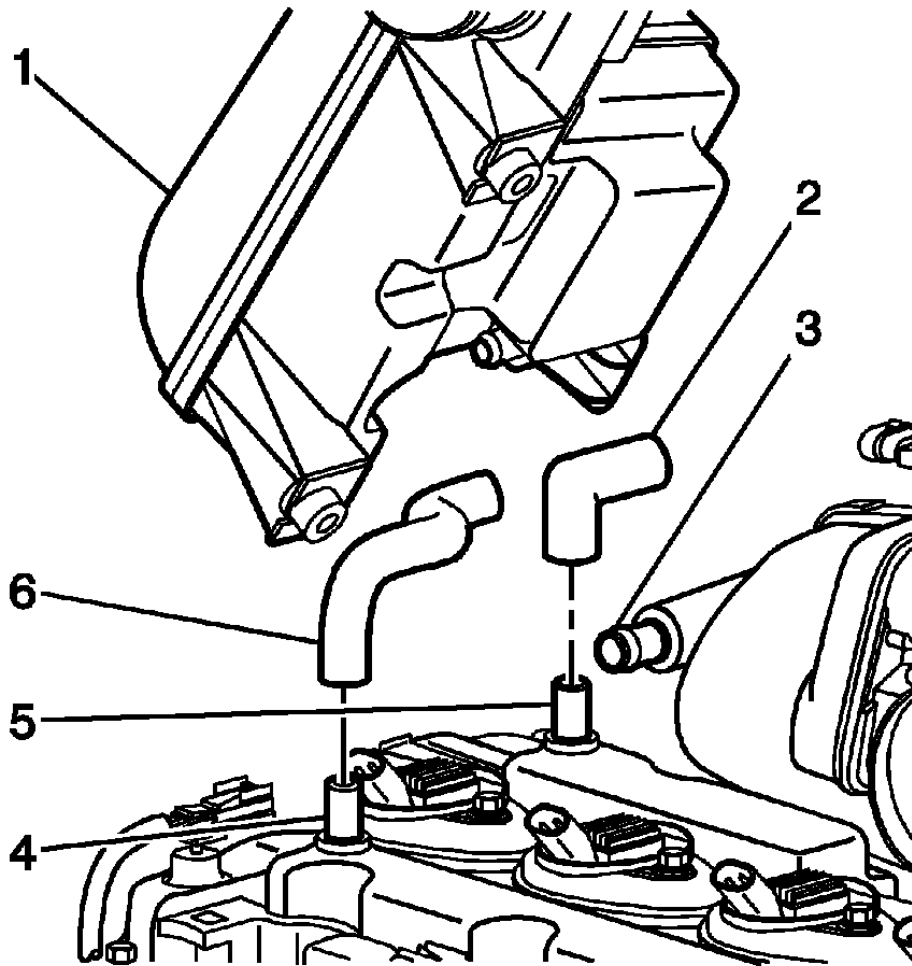


Fig. 24: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS COMPANY

1. Connect the PCV fresh air tube (6) to the air cleaner resonator (1).
2. Connect the PCV dirty air tube (2) to the following:
 - The camshaft cover (5)
 - The intake manifold (3)
3. Install the air cleaner resonator and outlet duct. Refer to **Air Cleaner Resonator and Outlet Duct Replacement** .

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

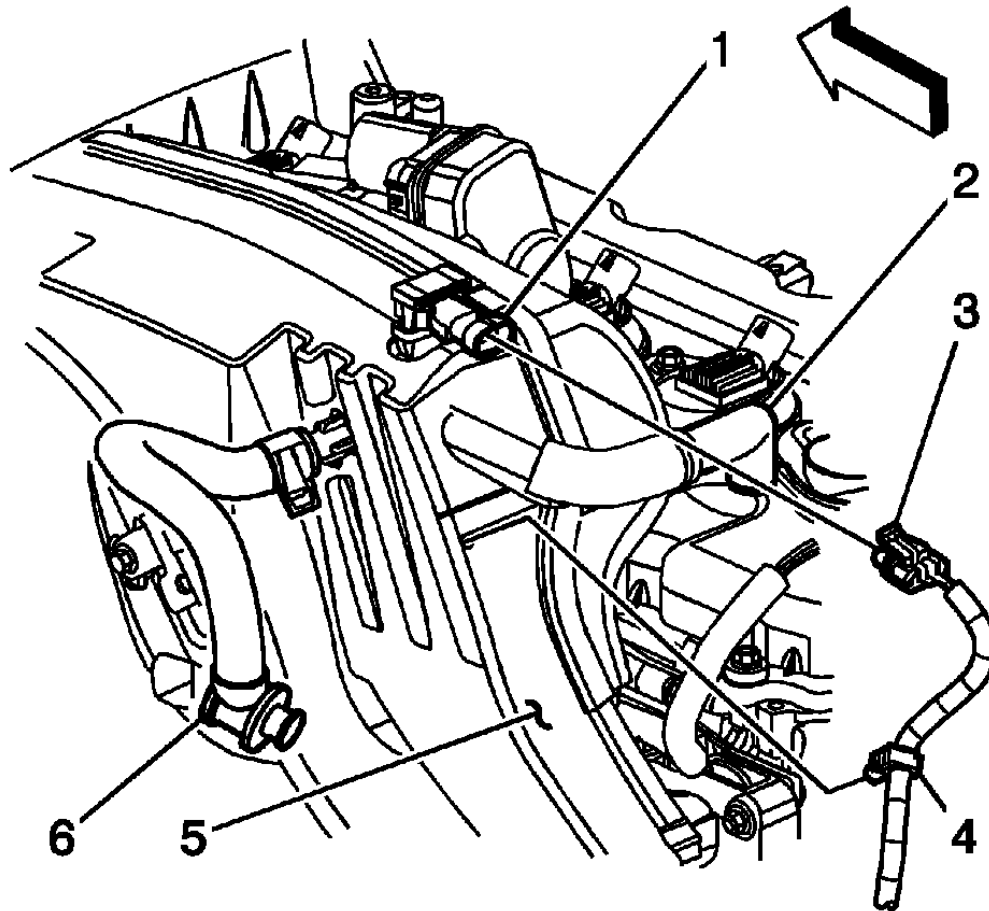


Fig. 25: Identifying Intake Manifold External Components
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
2. Remove the battery box. Refer to **Battery Box Replacement** .
3. Remove the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.
4. Disconnect the brake booster hose (6) from the brake booster.
5. Disconnect the engine wiring harness electrical connector (3) from the manifold absolute pressure (MAP) sensor.
6. Disconnect the engine wiring harness retainer (4) from the intake manifold (5).
7. Disconnect the positive crankcase ventilation (PCV) dirty air tube (2) from the camshaft cover.
8. Remove the generator. Refer to **Generator Replacement (LLV/LLR)** .

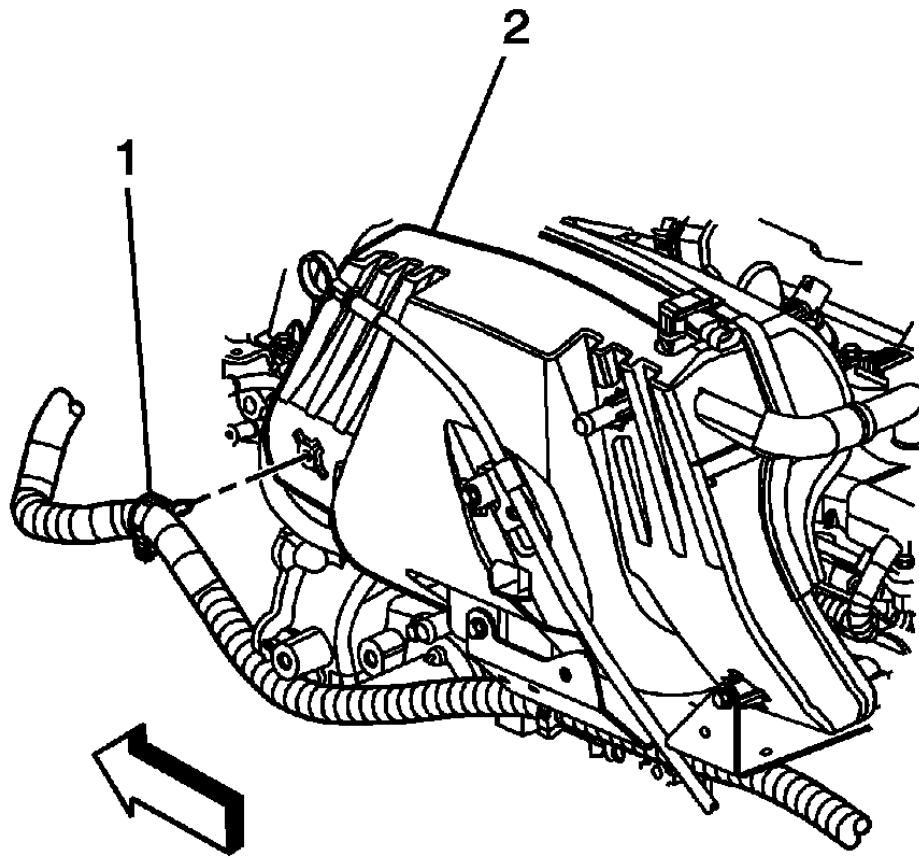


Fig. 26: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

9. Disconnect the engine wiring harness retainer (1) from the intake manifold (2).

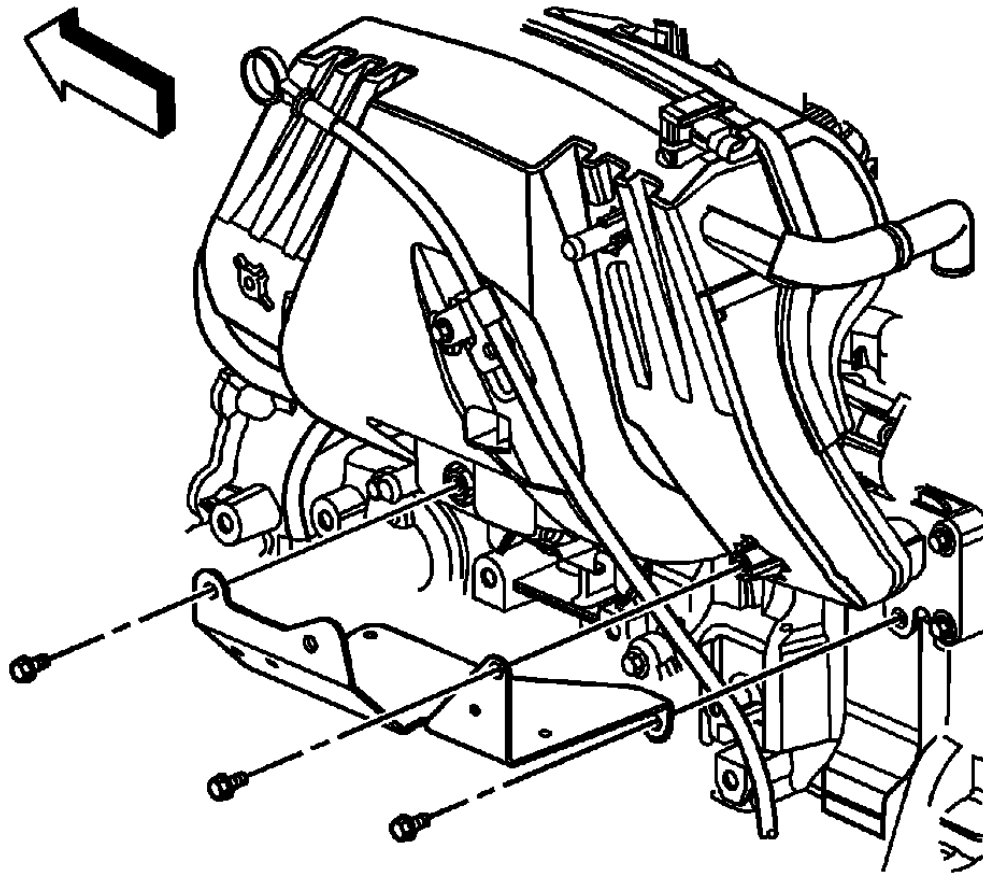


Fig. 27: View Of Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS COMPANY

10. Remove the upper 2 bolts securing the engine wiring harness bracket to the intake manifold.
11. Raise and support the vehicle only high enough to access the remaining components through the wheelhouse. Refer to **Lifting and Jacking the Vehicle** .
12. Remove the left front wheel. Refer to **Tire and Wheel Removal and Installation** .
13. Remove the left front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .

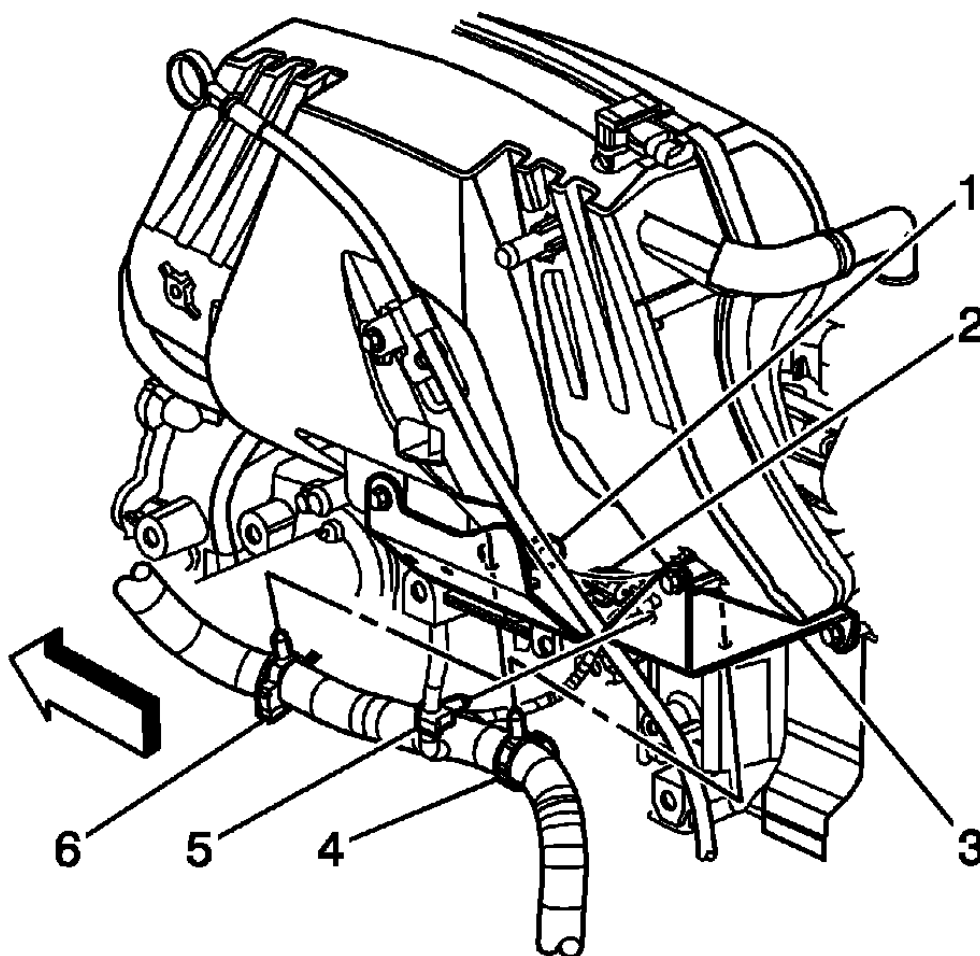


Fig. 28: View Of Wiring Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

14. Disconnect the following wiring harness retainers from the engine wiring harness bracket:
- The battery cable
 - The engine (4, 6)
 - The MAP sensor (5)

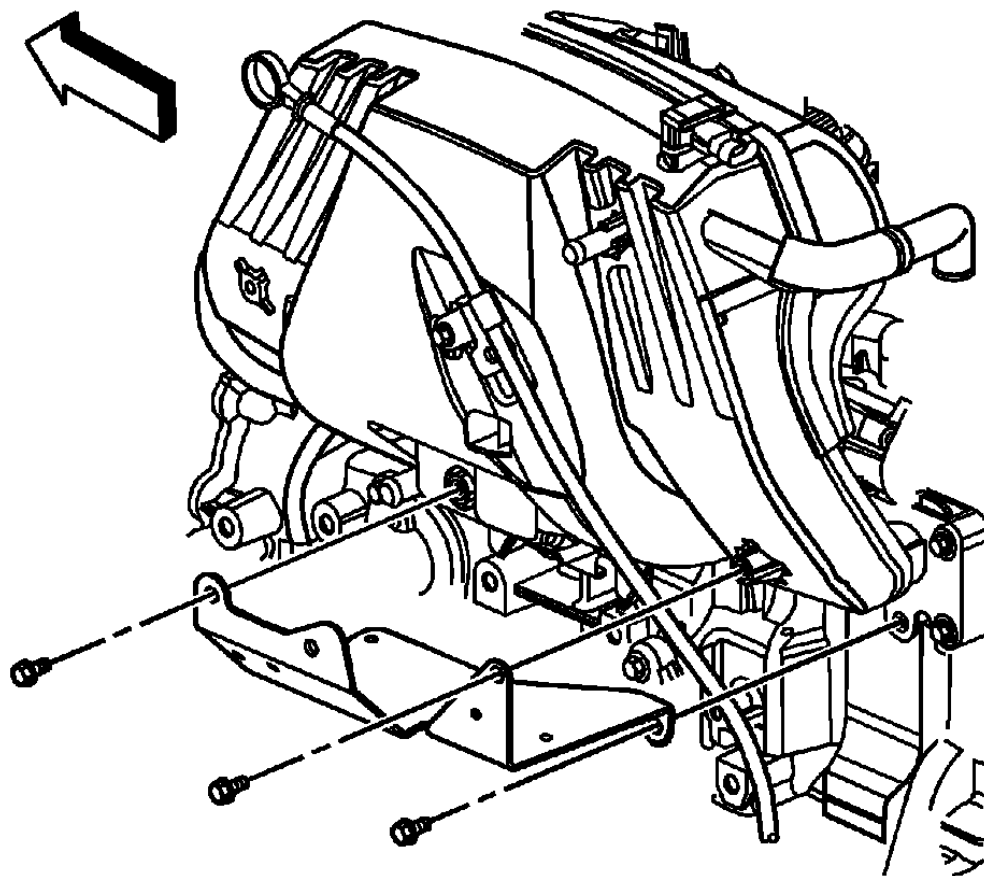


Fig. 29: View Of Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS COMPANY

15. Remove the remaining engine wiring harness bracket lower bolt.

Remove the bracket from the engine compartment through the wheelhouse opening.

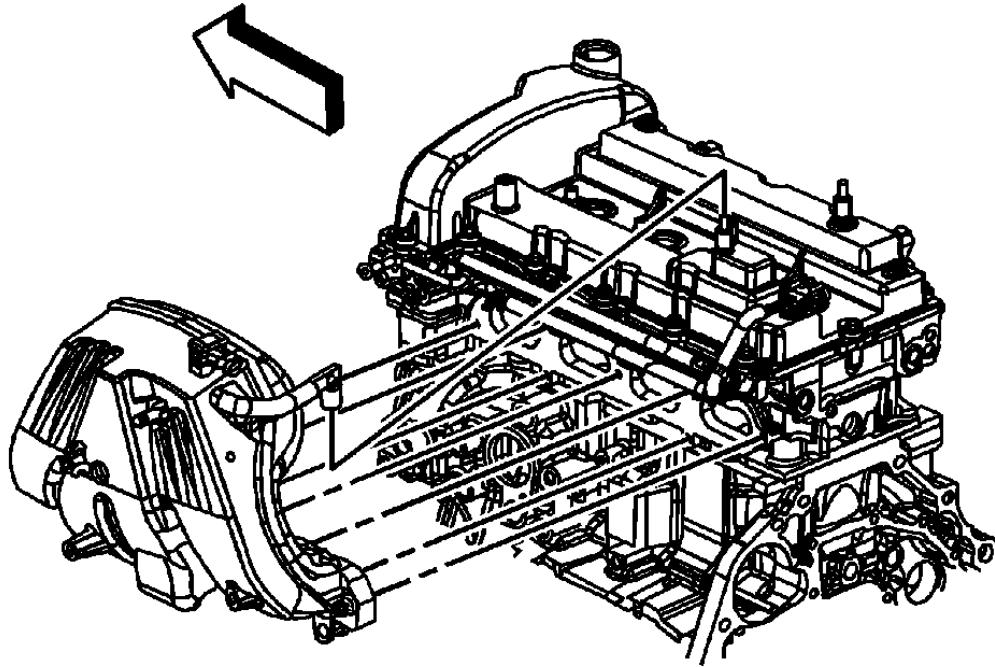


Fig. 30: View Of Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

16. Remove the intake manifold bolts.
17. Lower the vehicle.
18. Remove the intake manifold from the cylinder head.
19. Remove the seal from the intake manifold. Discard the seal.
20. Mask off the open ports to the cylinder head, in order to prevent foreign objects from entering the engine.

Installation Procedure

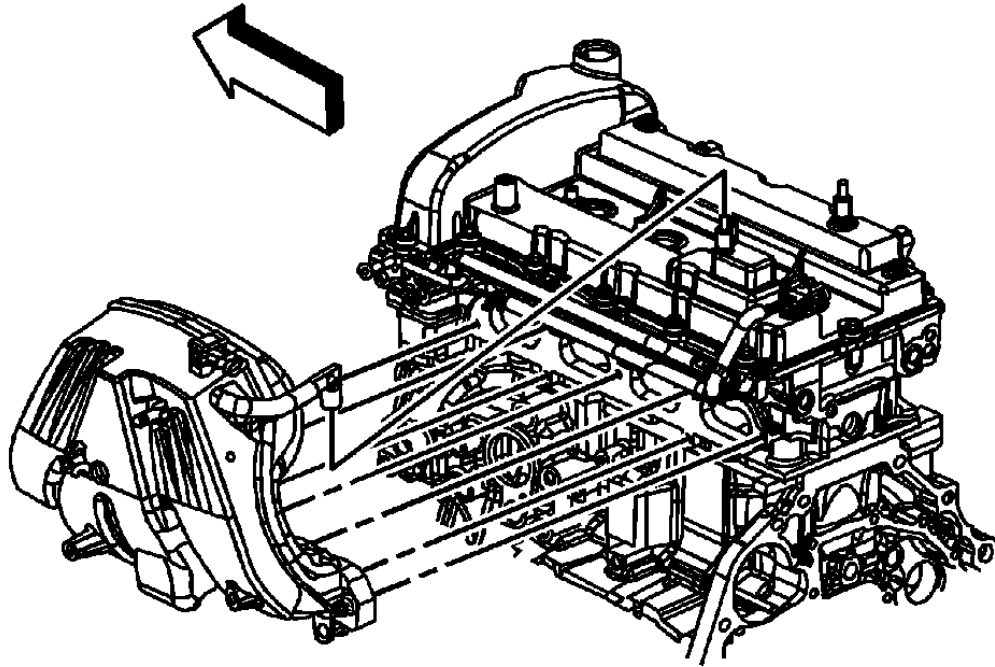


Fig. 31: View Of Intake Manifold
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the masking from the cylinder head and ensure the sealing surface is clean and dry.
2. Install a NEW seal into the intake manifold groove.
3. Position the intake manifold to the cylinder head.
4. Raise and support the vehicle only high enough to access the following components through the wheelhouse. Refer to **Lifting and Jacking the Vehicle** .
 - The intake manifold bolts
 - The engine wiring harness bracket bolts
 - The wiring harnesses

CAUTION: Refer to **Fastener Caution** .

5. Install the intake manifold bolts and tighten from the inside working outward to 10 N.m (89 lb in).

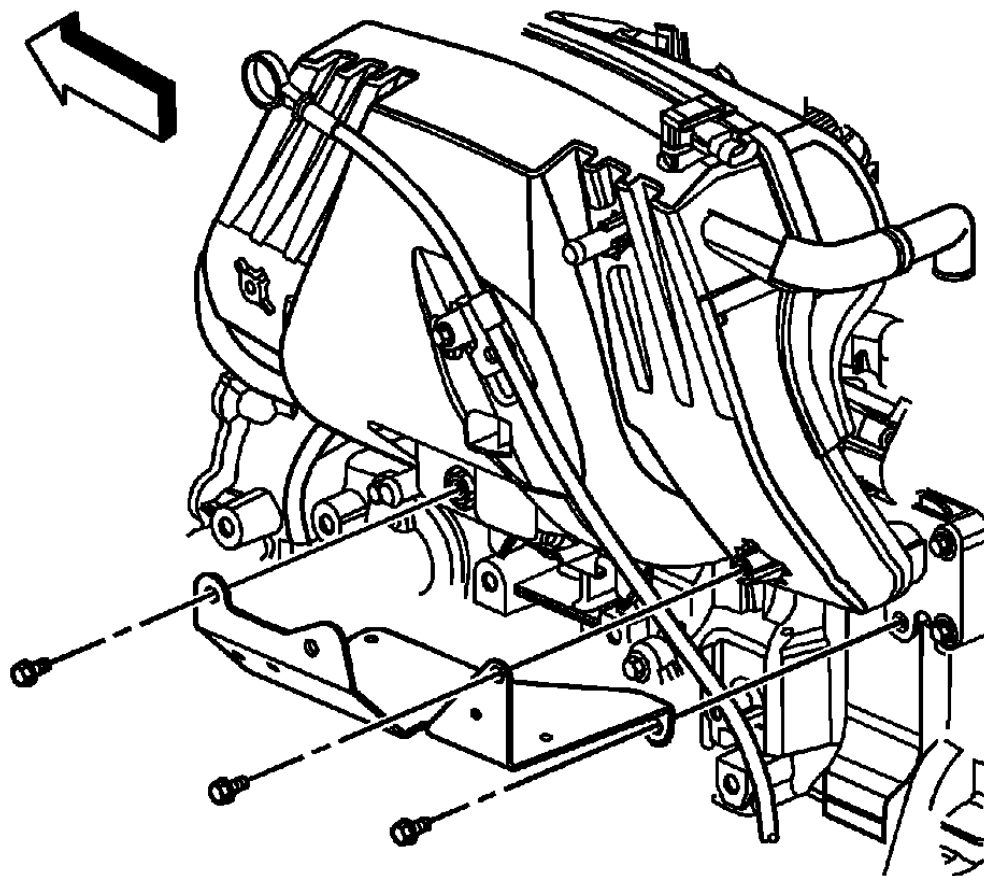


Fig. 32: View Of Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS COMPANY

6. Position the engine wiring harness bracket to the engine.
7. Install the engine wiring harness bracket bolts and tighten to 10 N.m (89 lb in).

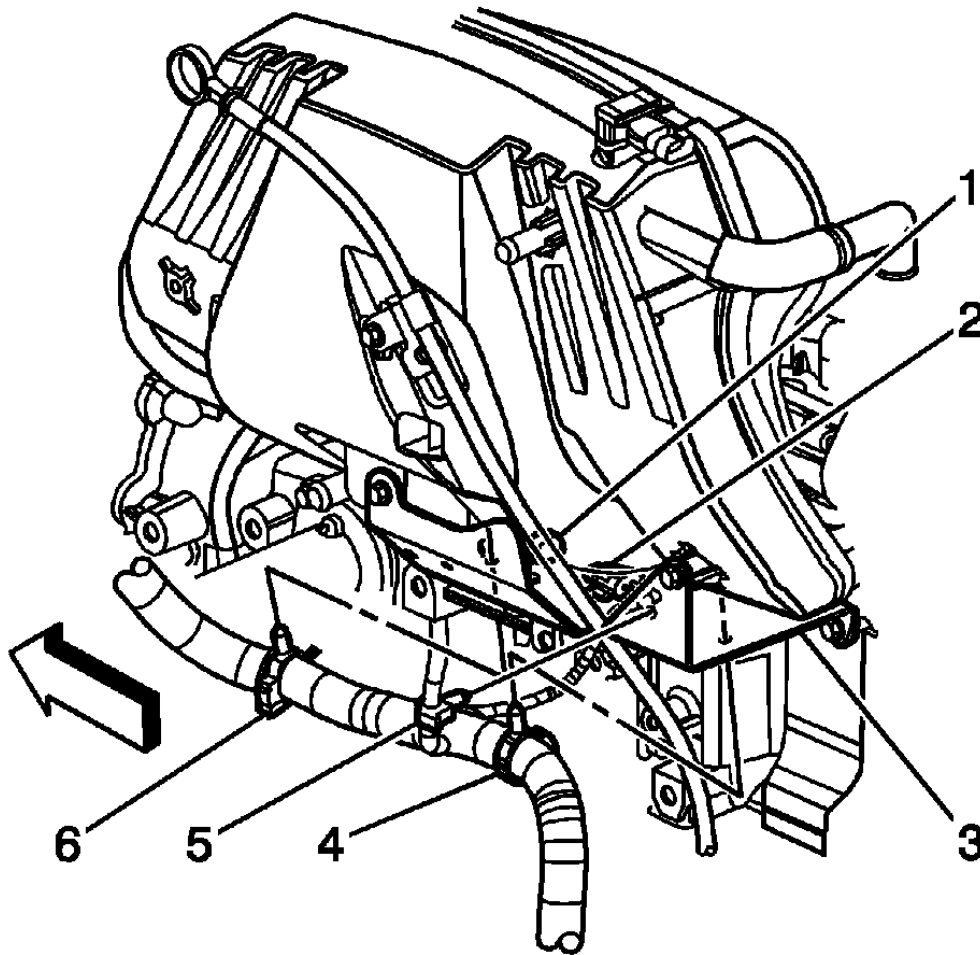


Fig. 33: View Of Wiring Harness Retainers
 Courtesy of GENERAL MOTORS COMPANY

8. Secure the following engine wiring harness retainers to the bracket:
 - The battery cable
 - The engine (4, 6)
 - The MAP sensor (5)
9. Install the left front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
10. Install the left front wheel. Refer to **Tire and Wheel Removal and Installation** .
11. Lower the vehicle.

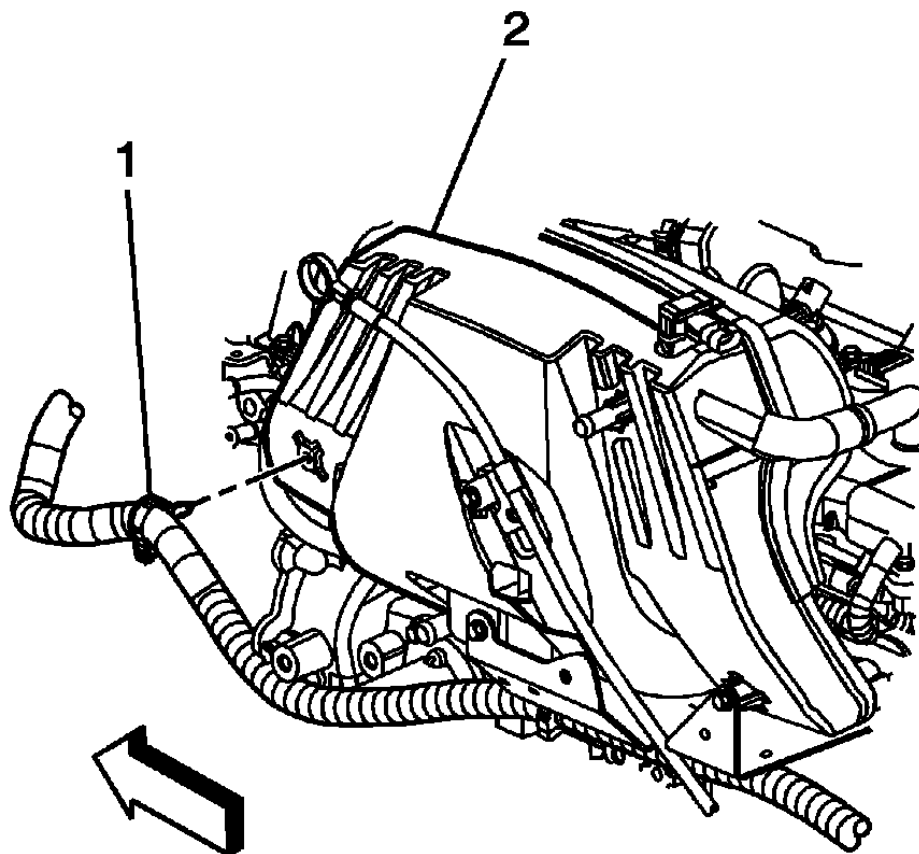


Fig. 34: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

12. Connect the engine wiring harness retainer (1) to the intake manifold (2).
13. Install the generator. Refer to **Generator Replacement (LLV/LLR)** .

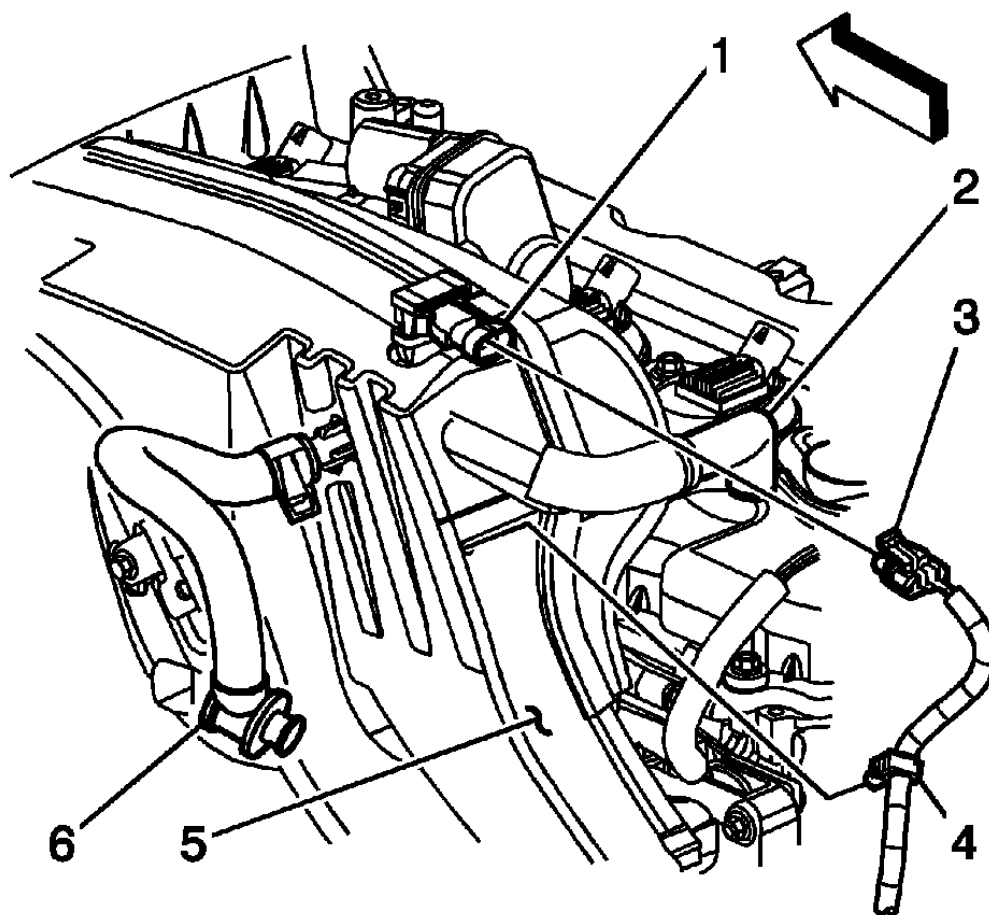


Fig. 35: Identifying Intake Manifold External Components
 Courtesy of GENERAL MOTORS COMPANY

14. Connect the PCV dirty air tube (2) to the camshaft cover.
15. Connect the engine wiring harness retainer (4) to the intake manifold (5).
16. Connect the engine wiring harness electrical connector (3) to the MAP sensor.
17. Connect the brake booster hose (6) to the brake booster.
18. Install the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.
19. Install the battery box. Refer to **Battery Box Replacement**.
20. Install the throttle body. Refer to **Throttle Body Assembly Replacement**.

CAMSHAFT COVER REPLACEMENT

Removal Procedure

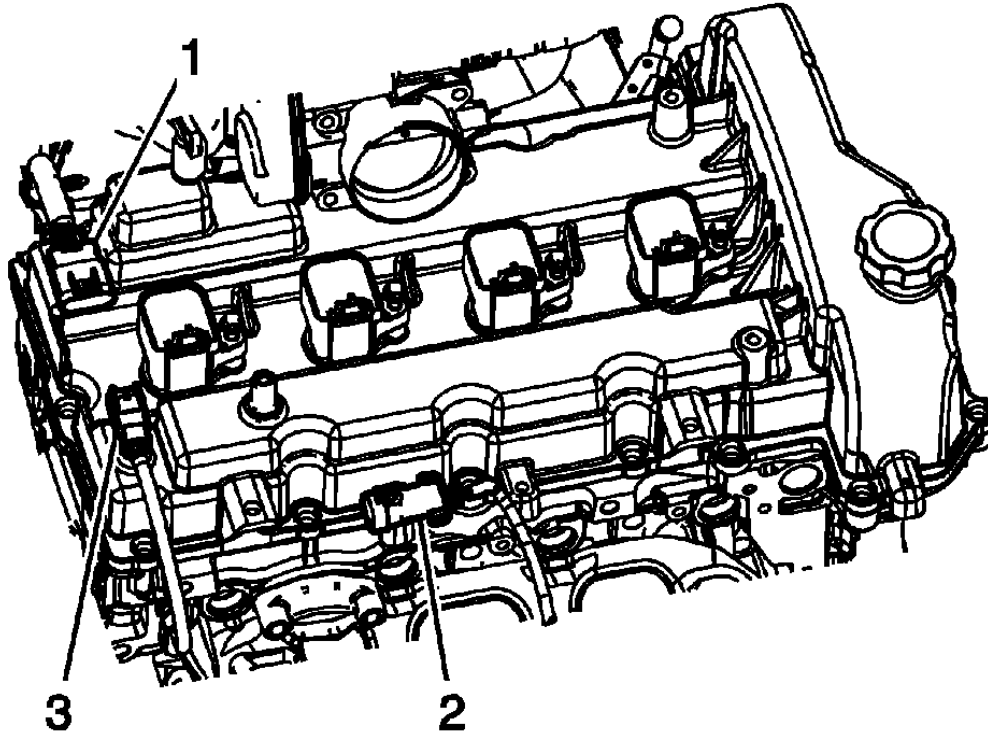


Fig. 36: View Of Engine Fuel Injector, Oxygen Sensor And ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the ignition coils. Refer to **Ignition Coil Replacement**.
3. Remove the following electrical connectors from the camshaft cover.
 - The fuel injector (1)
 - The heated oxygen sensor (HO2S) (2)
 - The engine coolant temperature (ECT) sensor (3)

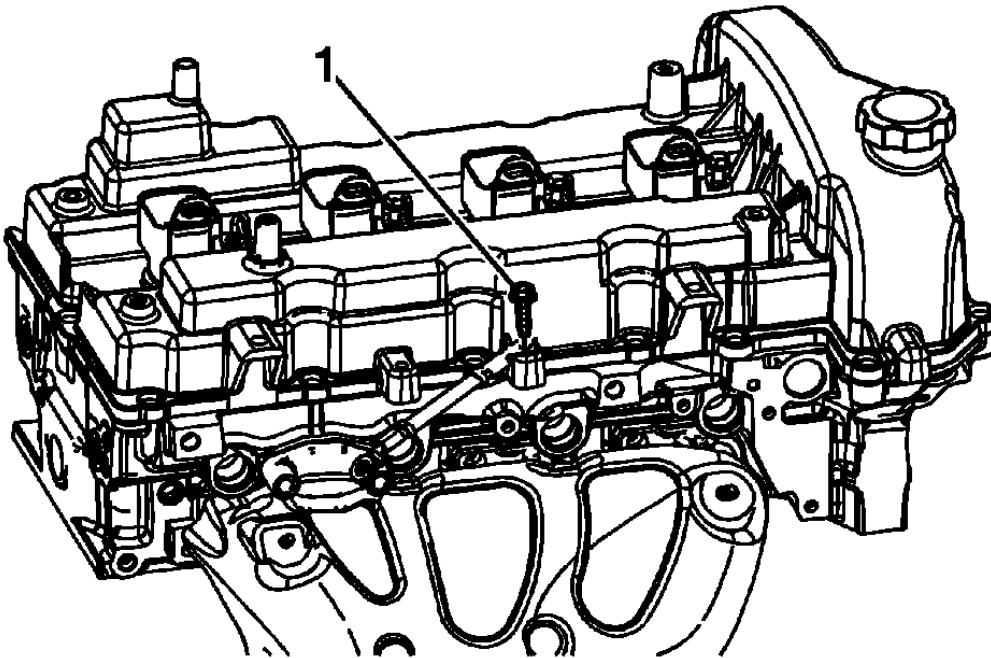


Fig. 37: Locating Ground Wire At Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

4. Remove the camshaft cover ground wire bolt (1) from the cover.
5. Remove the ground wire from cover.

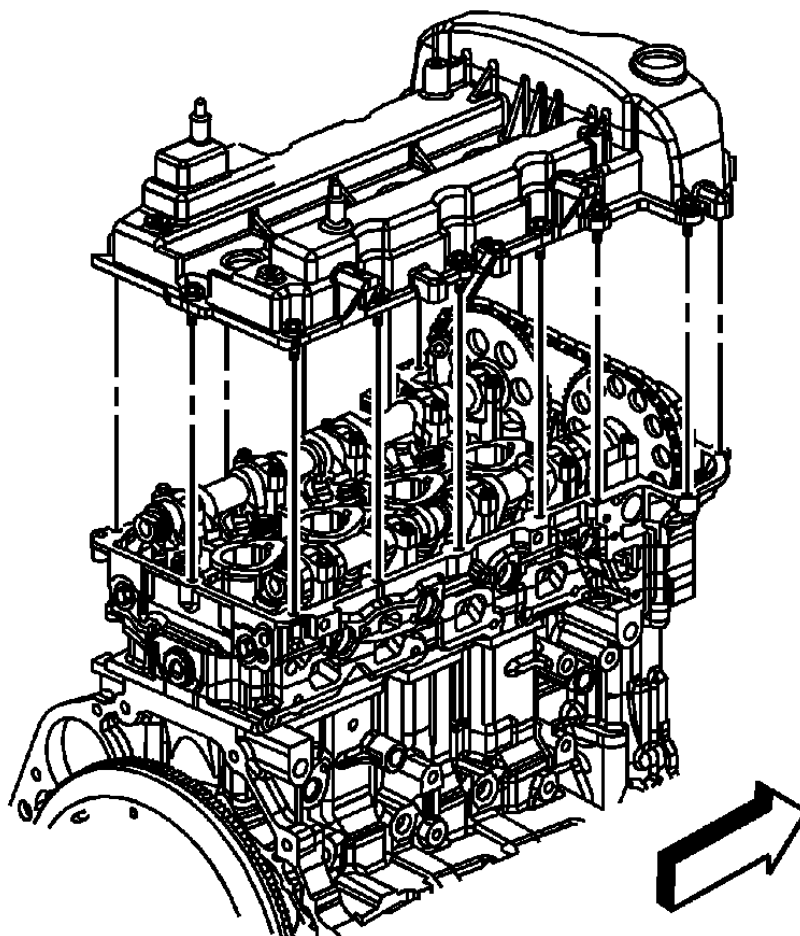


Fig. 38: View Of Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

6. Remove the camshaft cover bolts.
7. Remove the camshaft cover from the cylinder head.
8. Remove the seals from the camshaft cover.

Do not reuse the seals.

9. Clean and inspect the cylinder head sealing surface.

Installation Procedure

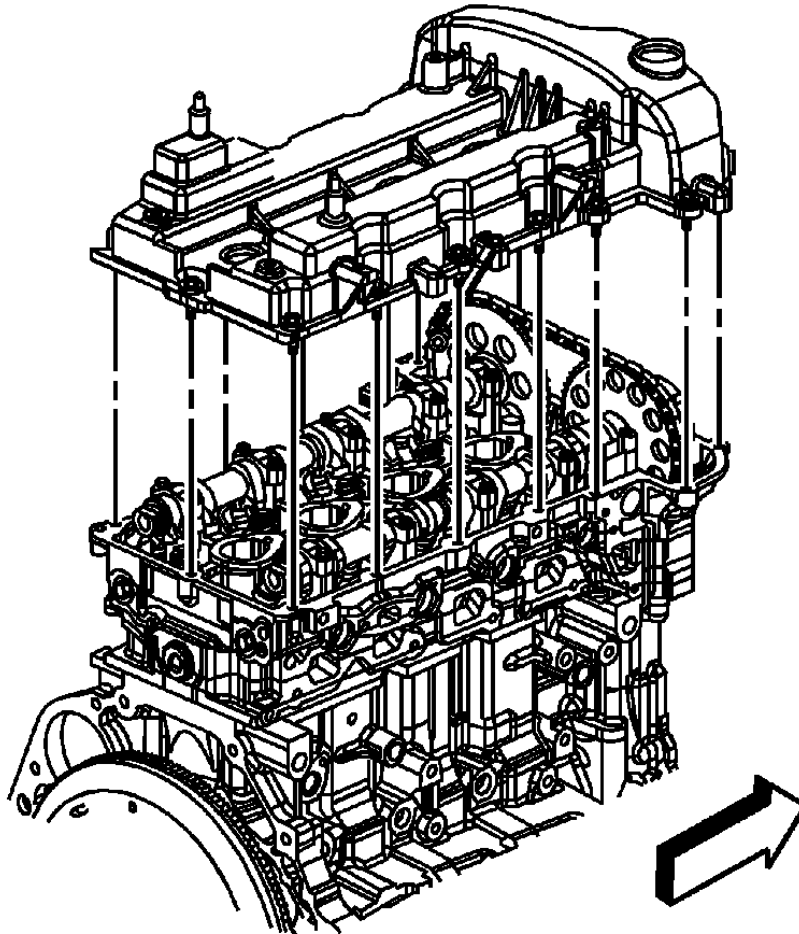


Fig. 39: View Of Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW camshaft cover seal into the camshaft cover groove.
2. Install NEW ignition coil seals into the camshaft cover grooves.
3. Place the camshaft cover onto the cylinder head.

CAUTION: Refer to Fastener Caution .

4. Install the camshaft cover bolts and tighten to 10 N.m (89 lb in).

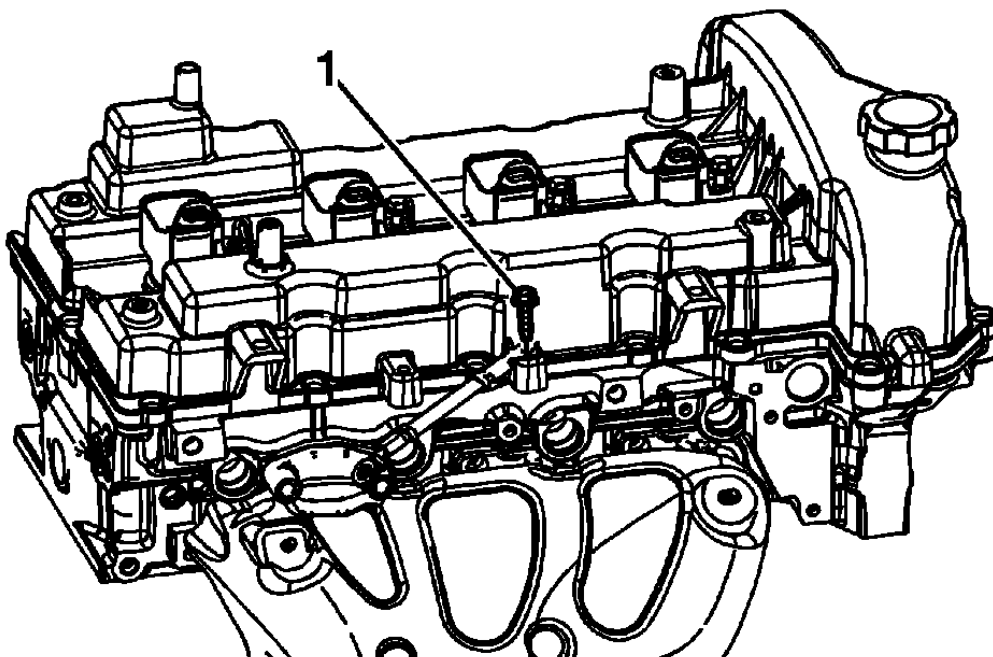


Fig. 40: Locating Ground Wire At Camshaft Cover
Courtesy of GENERAL MOTORS COMPANY

5. Position the ground wire to the camshaft cover. Ensure that the anti rotation tab is seated against the cover.
6. Install the camshaft cover ground wire bolt (1) to the cover and tighten to 10 N.m (89 lb in).

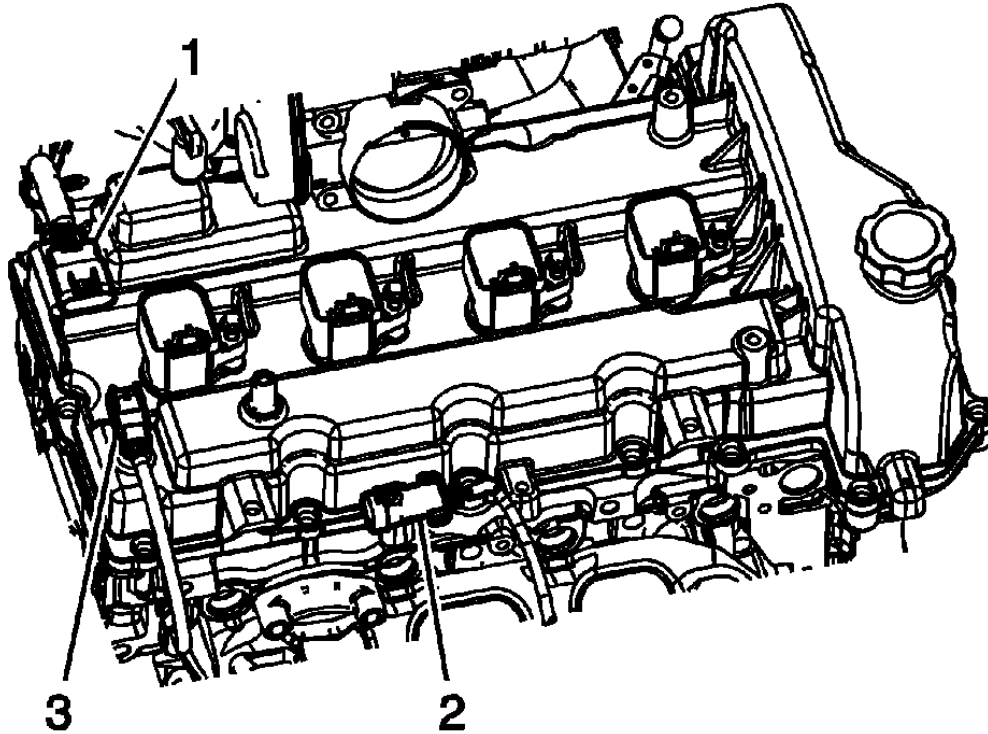


Fig. 41: View Of Engine Fuel Injector, Oxygen Sensor And ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

7. Install the following electrical connectors to the camshaft cover.
 - The fuel injector (1)
 - The HO2S (2)
 - The ECT sensor (3)
8. Install the ignition coils. Refer to **Ignition Coil Replacement** .
9. Install the intake manifold. Refer to **Intake Manifold Replacement**.

VALVE ROCKER ARM AND HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT

Tools Required

EN-47945 Valve Spring Compressor

Removal Procedure

1. Remove the camshaft cover . Refer to **Camshaft Cover Replacement**.
2. Rotate the crankshaft until the affected cylinder valve is fully open (cam lobe fully depressing the spring).

IMPORTANT: Engine design and packaging does not allow all cylinder locations to use both fasteners for holding the tool to the cylinder head. One fastener is sufficient in these locations.

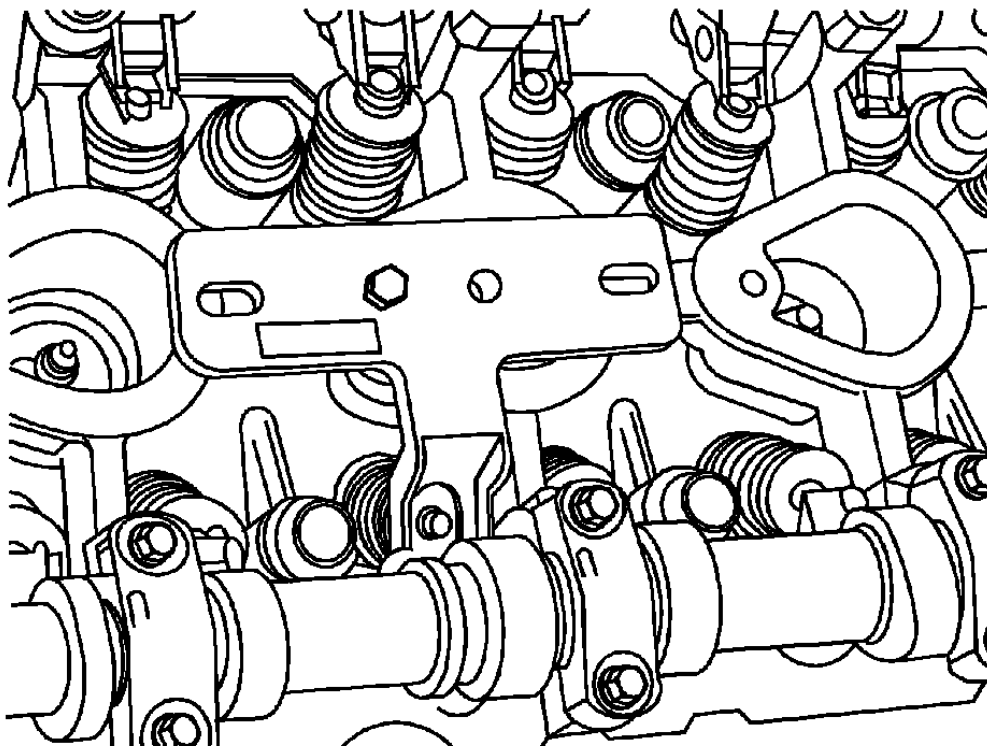


Fig. 42: Compressing Valve Spring

Courtesy of GENERAL MOTORS COMPANY

3. Install the **EN-47945** valve spring compressor on the engine cylinder head using either one or two of the supplied fasteners installed in the coil fastener hole.

IMPORTANT: **DO NOT** rotate the engine with the tool installed. It is possible to damage the valves if they contact the piston. Rotate the engine enough to come back to the base circle of the cam.

4. Rotate the engine clockwise enough to ensure the cam is on the base circle (spring will stay compressed

by the tool).

This will allow the lash adjuster and rocker to be removed.

5. Remove the valve rocker arm and valve lash adjuster.
6. Clean and inspect the valve rocker arm and valve lash adjuster. Refer to **Valve Rocker Arm and Hydraulic Valve Lash Adjuster Cleaning and Inspection** .

Installation Procedure

1. Lubricate the valve rocker arm and fill the valve lash adjuster with oil.
2. Install the valve rocker arm and valve lash adjuster.
3. When the valve rocker arm and valve lash adjuster are in place, slowly rotate the engine counterclockwise enough that the cam lobe fully depresses the spring again.

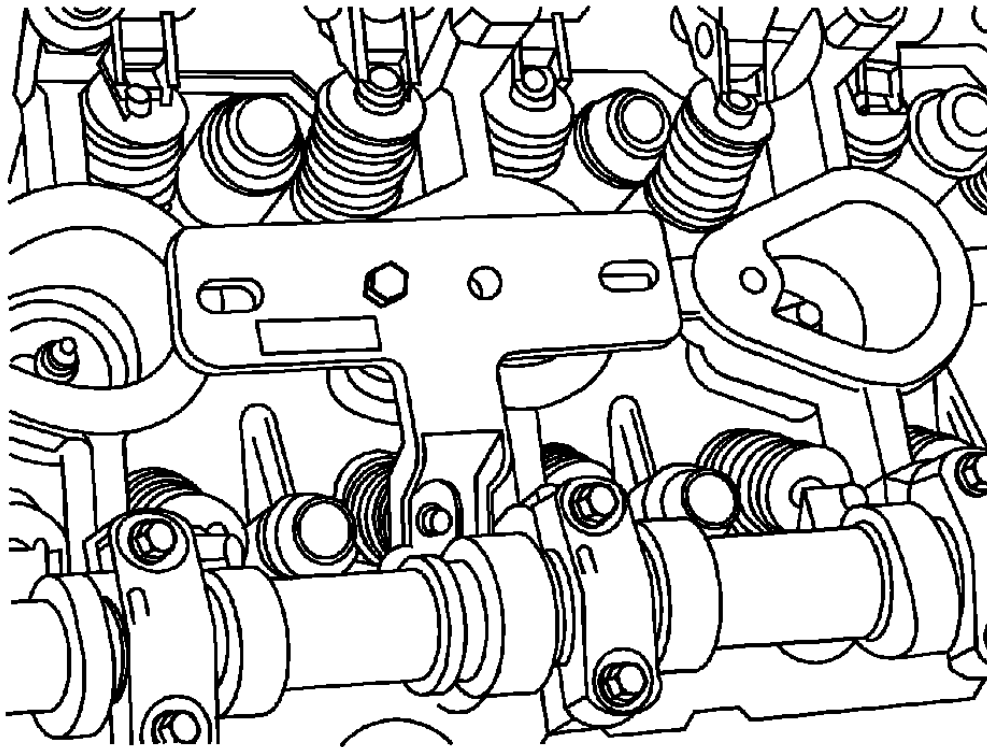


Fig. 43: Compressing Valve Spring
Courtesy of GENERAL MOTORS COMPANY

4. Remove the **EN-47945** valve spring compressor from the cylinder head and repeat as required.
5. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- **EN 46547** Flywheel Holding Tool
- **J 38820** Valve Stem Seal Installer
- **J 39313** Spark Plug Port Adapter
- **J 43059** Valve Retainer Remover/Installer
- **J-44228-A** Valve Spring Compressor

Removal Procedure

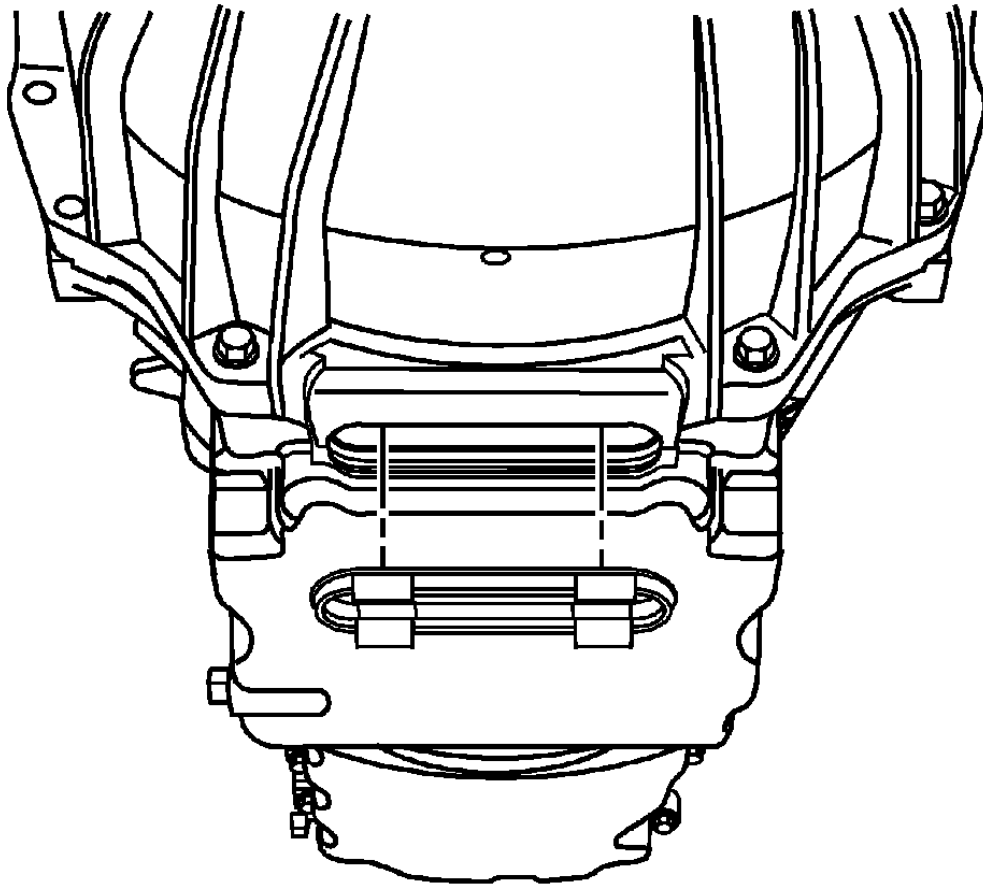


Fig. 44: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the service slot plug.

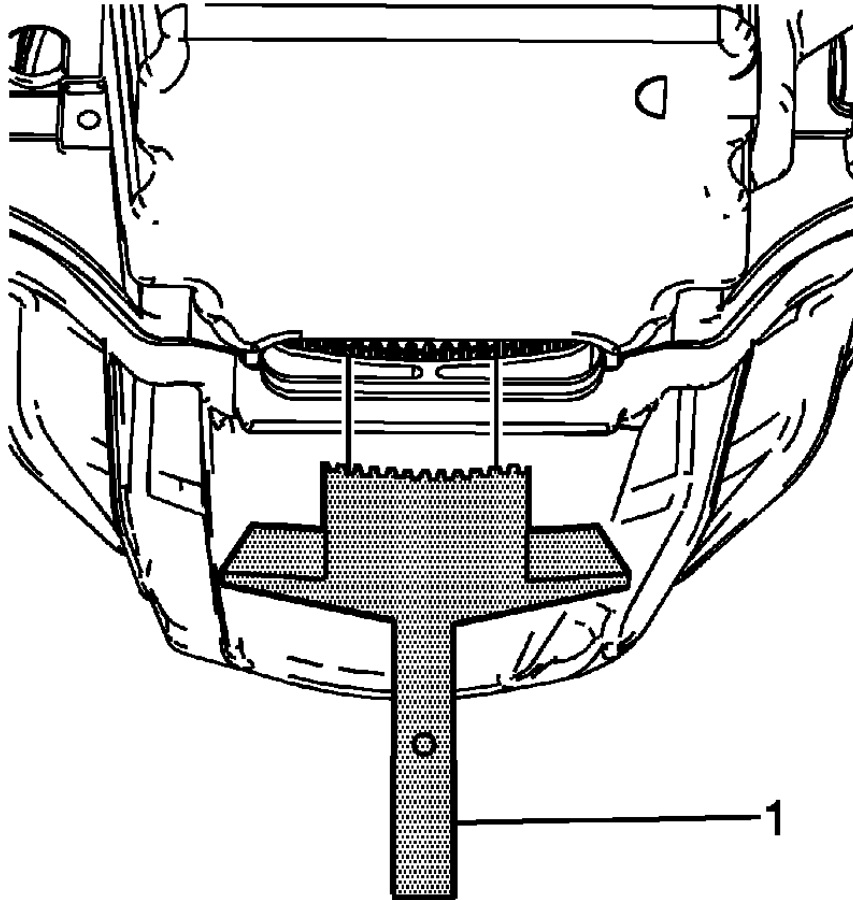


Fig. 45: Flywheel Holding Tool

Courtesy of GENERAL MOTORS COMPANY

3. Install the **EN 46547** flywheel holding tool (1) into the flywheel teeth.
4. Lower the vehicle.
5. Remove the camshafts. Refer to **Camshaft Replacement**.
6. Remove the spark plugs. Refer to **Spark Plug Replacement** .

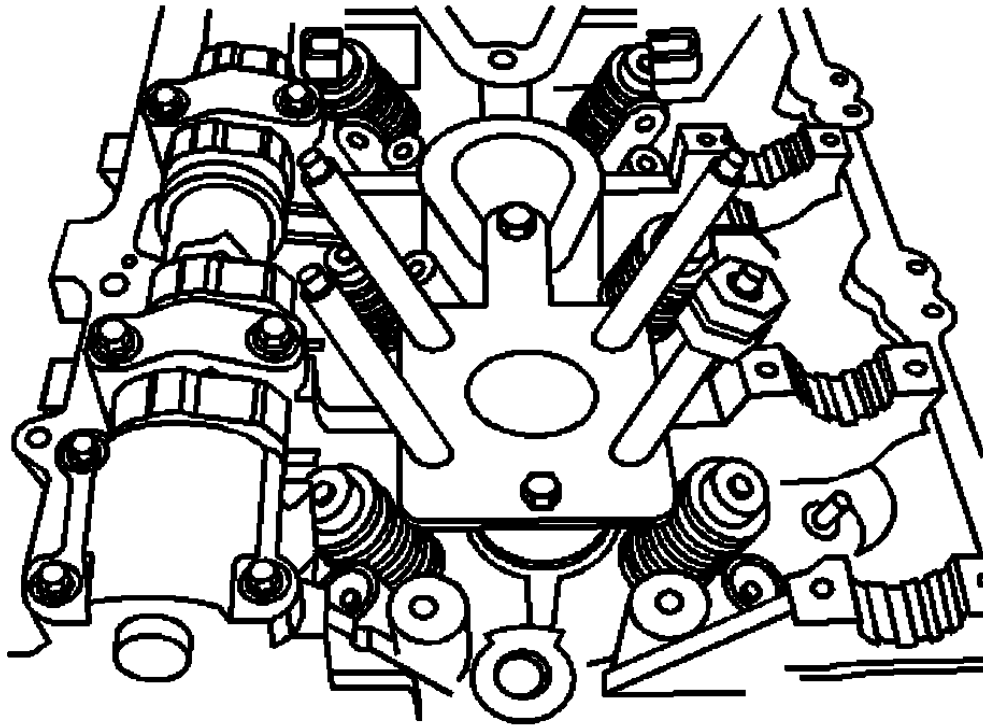


Fig. 46: Valve Spring Compressor Base Plate
Courtesy of GENERAL MOTORS COMPANY

7. Install the base plate of the **J-44228-A** valve spring compressor over the spark plug hole of the cylinder to be serviced.
8. Install the **J 39313** spark plug port adapter in the spark plug hole.
9. Apply constant air pressure to the **J 39313** spark plug port adapter in order to keep the valve closed.
10. Install the arm and swivel nut of the **J-44228-A** valve spring compressor over the stud corresponding to the valve to be serviced.

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.

11. Tighten the swivel nut of the **J-44228-A** valve spring compressor down only enough to allow access for removal of the valve locks.

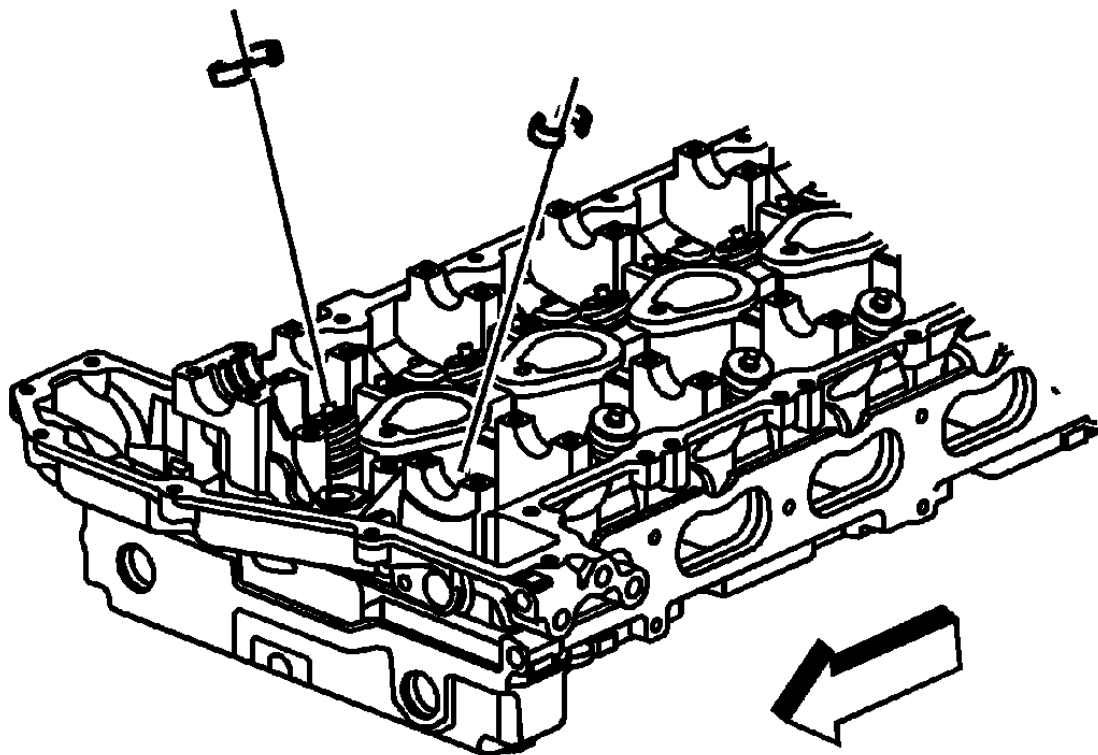


Fig. 47: View Of Valve Keys

Courtesy of GENERAL MOTORS COMPANY

12. Remove the valve locks. A magnet is the most suitable tool for this activity.
13. Loosen the swivel nut of the **J-44228-A** valve spring compressor and swing the arm away from the valve spring retainer.

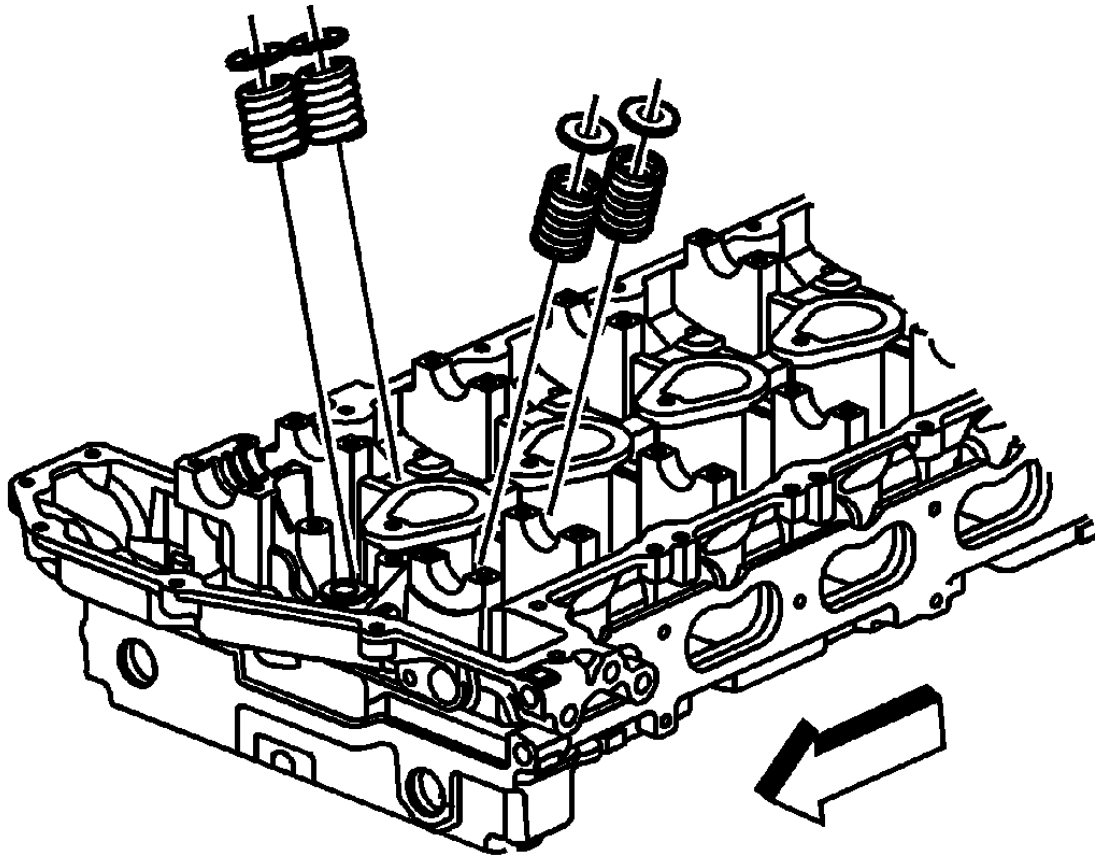


Fig. 48: View Of Valve Springs & Retainers
Courtesy of GENERAL MOTORS COMPANY

14. Remove the valve spring retainer and valve spring.

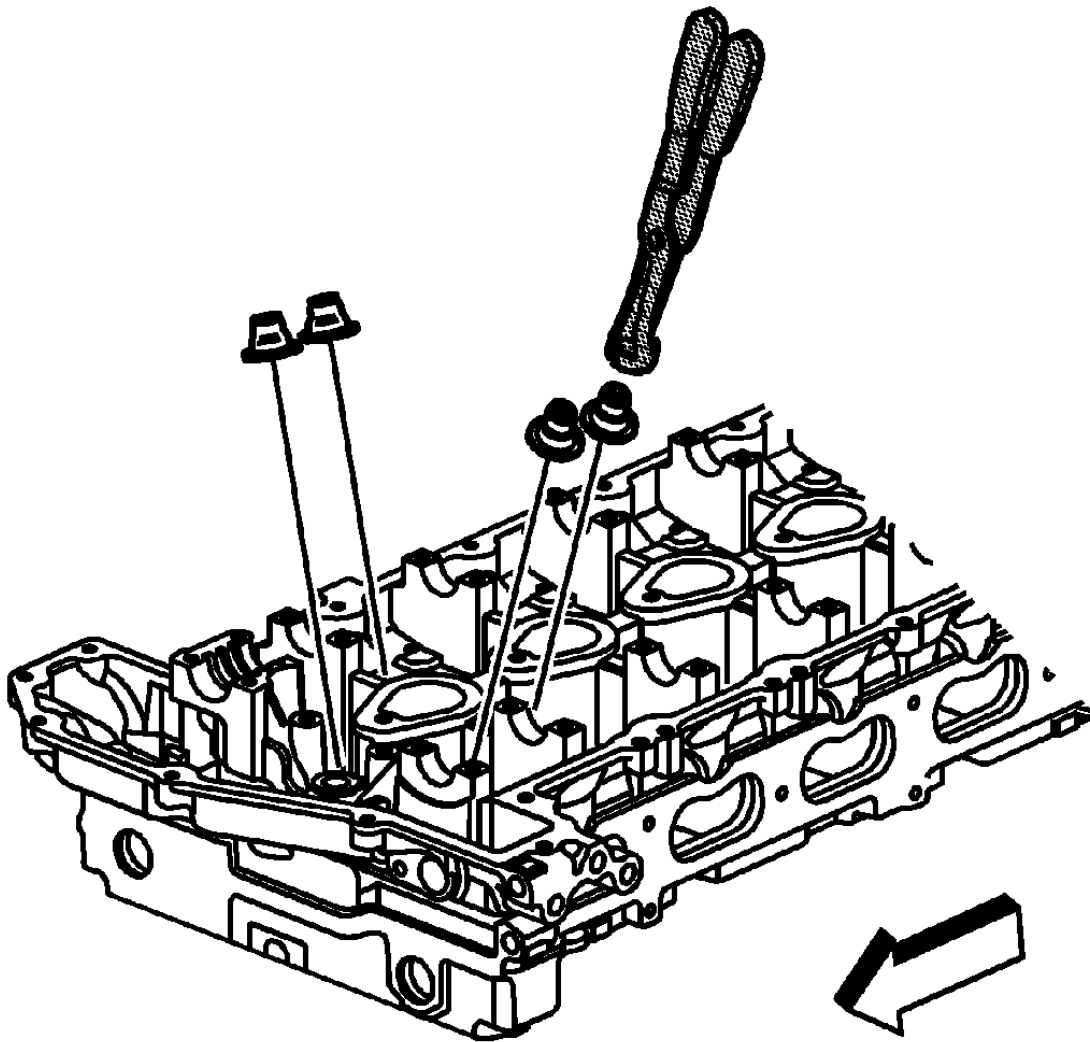


Fig. 49: View Of Valve Stem Seals And Seal Tool
Courtesy of GENERAL MOTORS COMPANY

15. Use the **J 38820** valve stem seal installer in order to grip the seal. Remove the seal by exerting a twisting, pulling motion.

Discard the old valve stem seal.

Installation Procedure

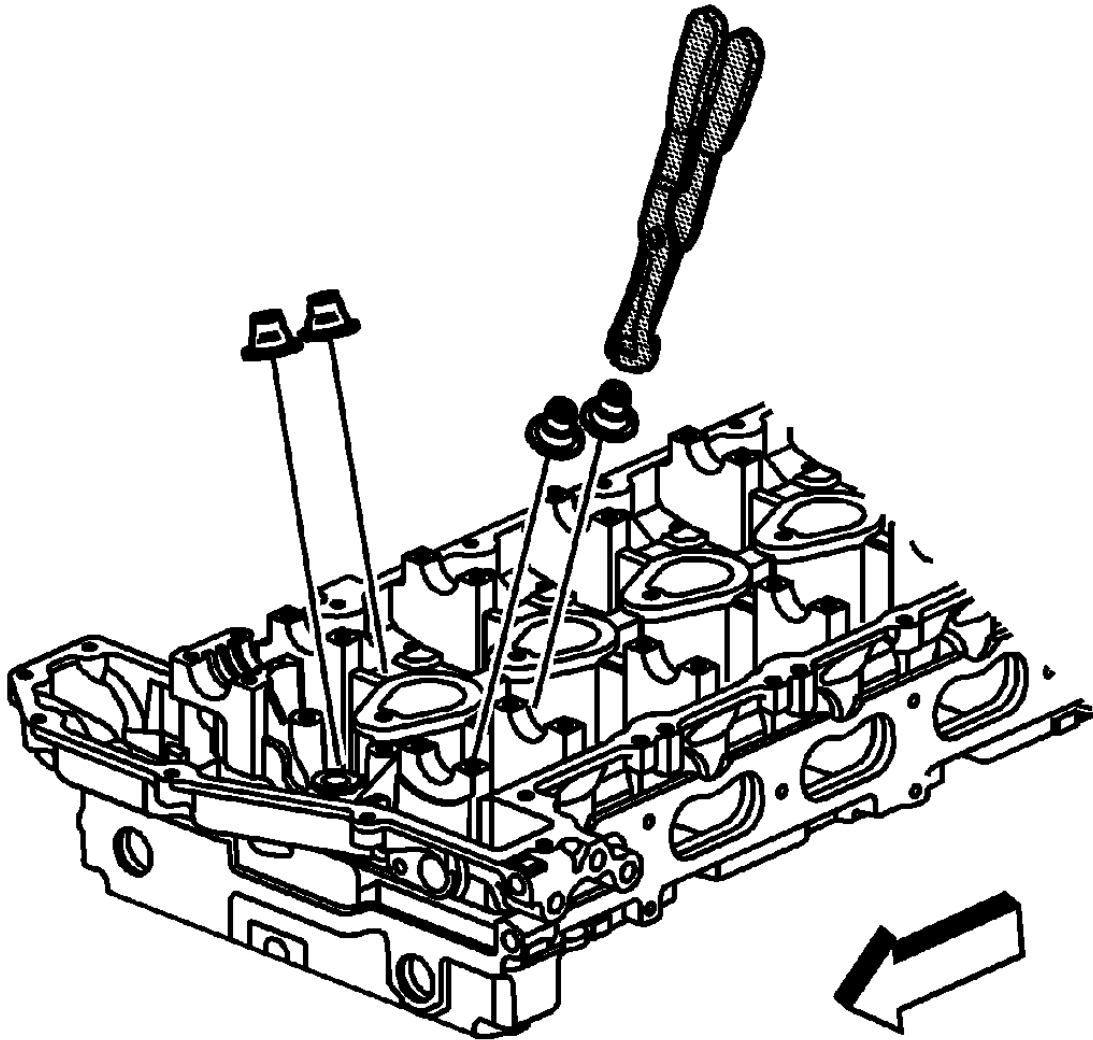


Fig. 50: View Of Valve Stem Seals And Seal Tool
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the valve stem and inner diameter of the new seal with clean engine oil.

NOTE: **Install a seal protector over the valve stem prior to installing the valve stem seal.**

2. Using a twisting, pushing motion install the NEW valve stem seal using the **J 38820** valve stem seal installer.

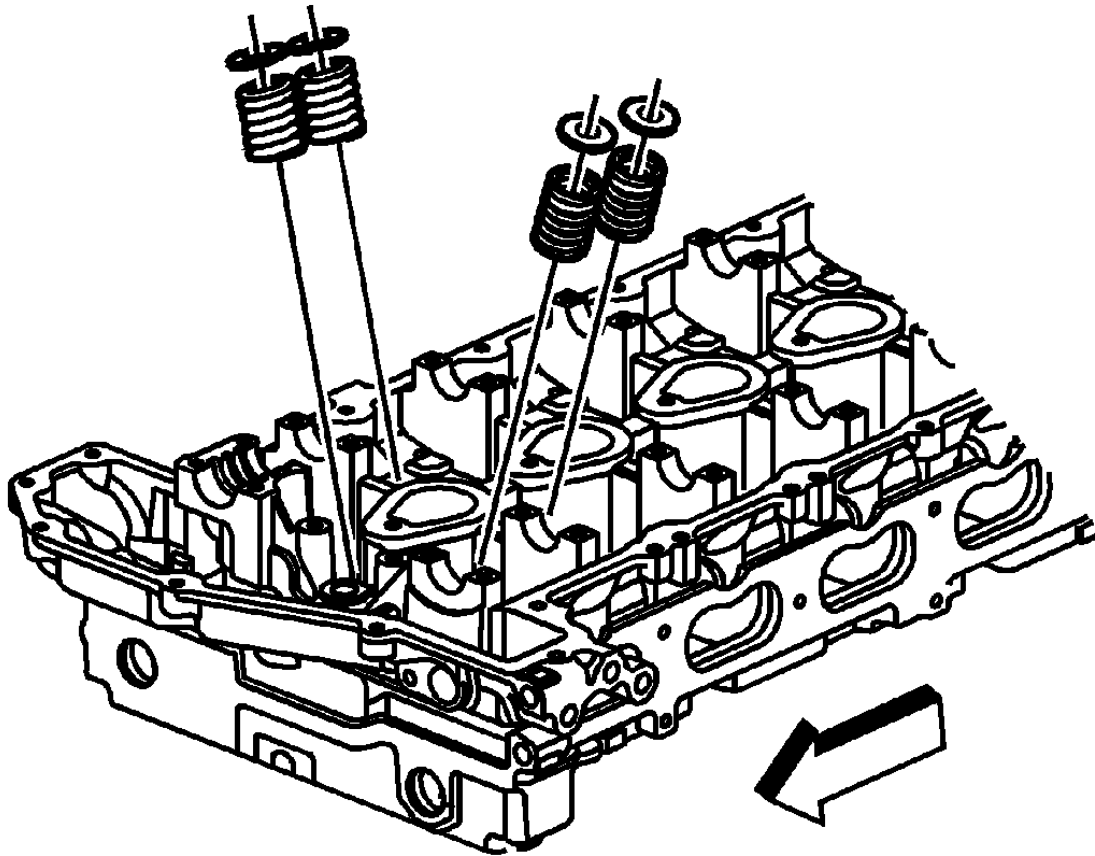


Fig. 51: View Of Valve Springs & Retainers
Courtesy of GENERAL MOTORS COMPANY

3. Install the valve spring and valve spring retainer.

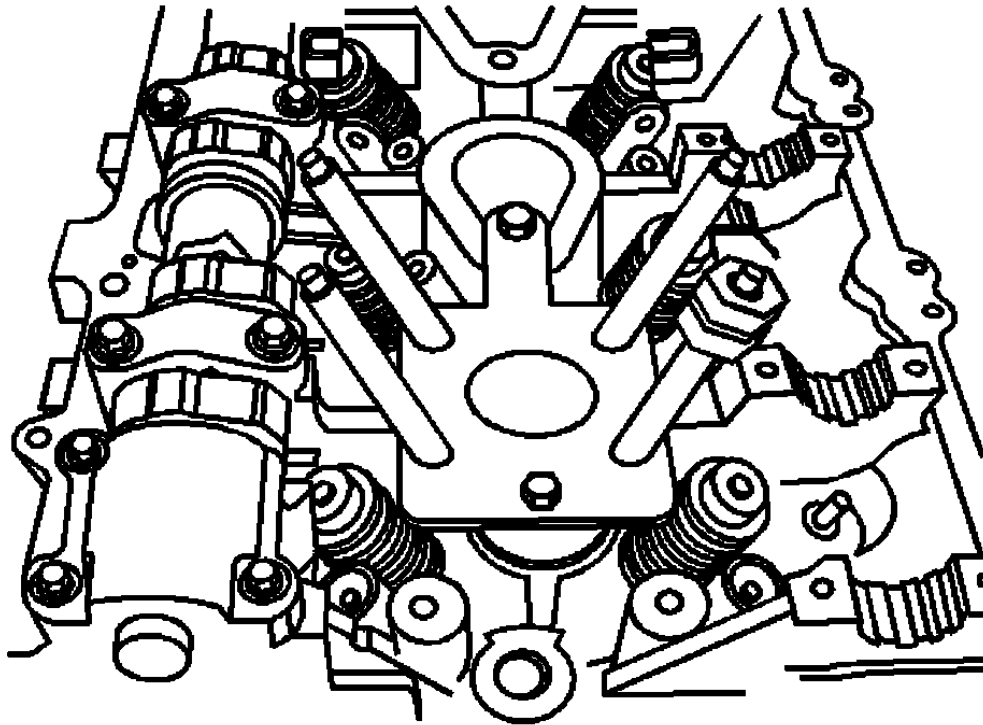


Fig. 52: Valve Spring Compressor Base Plate
Courtesy of GENERAL MOTORS COMPANY

4. Swing the arm over the valve spring retainer and tighten the swivel nut of the **J-44228-A** valve spring compressor down only enough to allow access for installation of the valve locks.
5. Position the valve locks to the valve stem retainer groove using the **J 43059** valve retainer remover/installer.
6. Remove the swivel nut and arm of the **J-44228-A** valve spring compressor
7. Install the arm and swivel nut of the **J-44228-A** valve spring compressor over the stud of any other valves being serviced for this cylinder and repeat removal steps 11 through 16 and installation steps 1 through 7.
8. Relieve the air pressure to the cylinder being serviced.
9. Remove the **J 39313** spark plug port adapter from the spark plug hole.
10. Remove the base plate of the **J-44228-A** valve spring compressor.
11. Repeat removal steps 7 through 16 and installation steps 1 through 10 on any other cylinders being serviced.
12. Install the spark plugs. Refer to **Spark Plug Replacement**.
13. Install the camshafts. Refer to **Camshaft Replacement**.

14. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

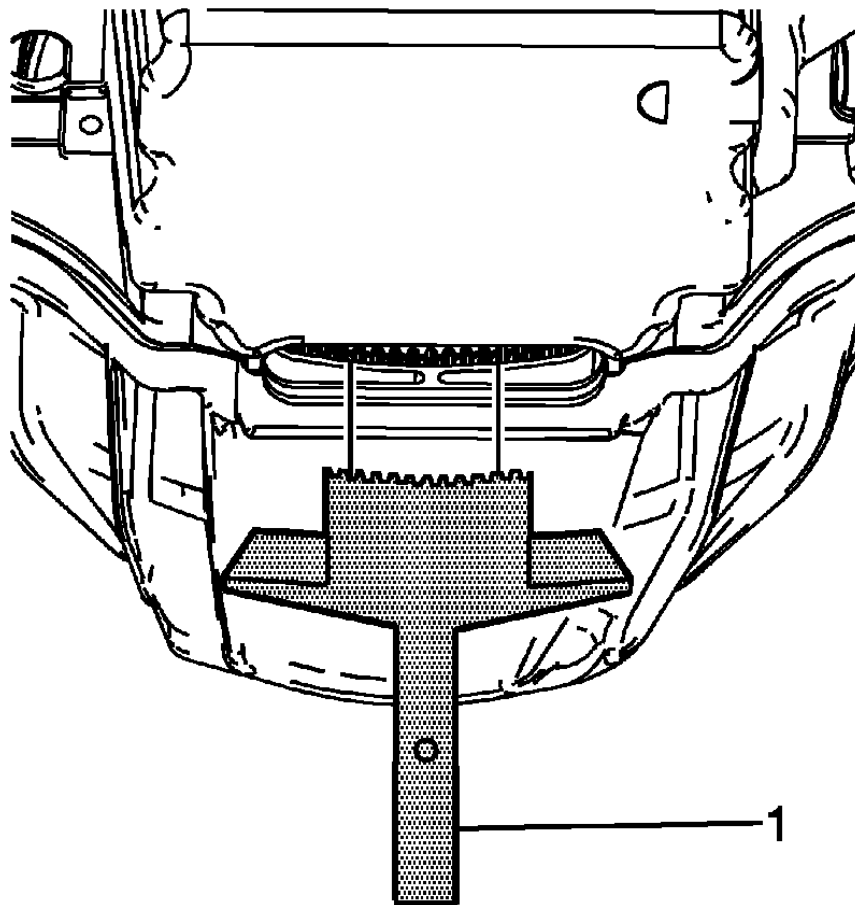


Fig. 53: Flywheel Holding Tool

Courtesy of GENERAL MOTORS COMPANY

15. Remove the **EN 46547** flywheel holding tool (1) from the flywheel teeth.

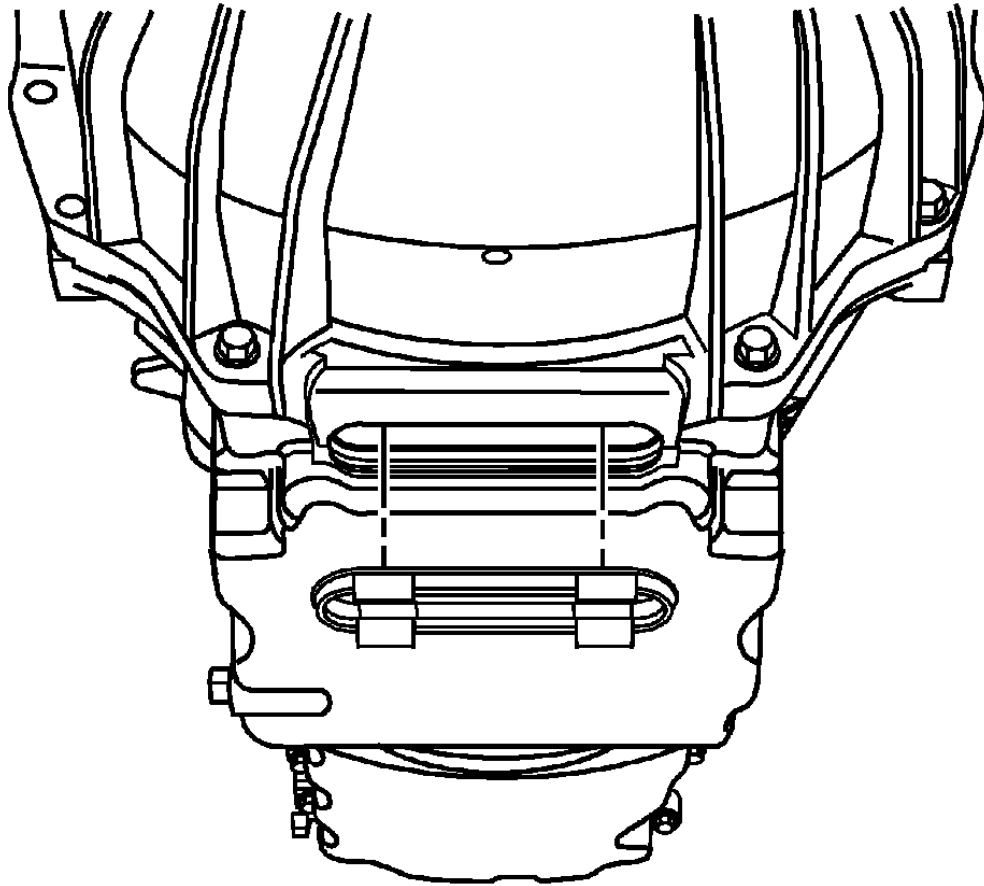


Fig. 54: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

16. Install the service slot plug.
17. Lower the vehicle.

OIL LEVEL INDICATOR TUBE REPLACEMENT

Removal Procedure

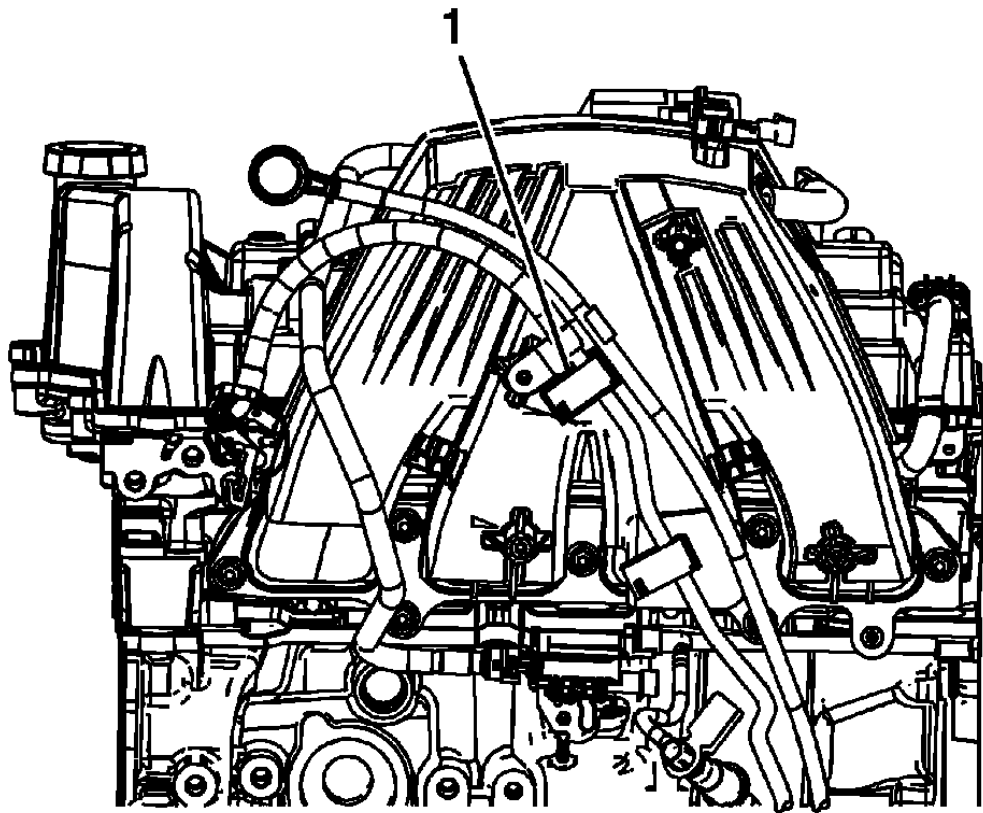


Fig. 55: View Of Fuel Line Clip

Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel line clip (1) from the oil level indicator bracket.

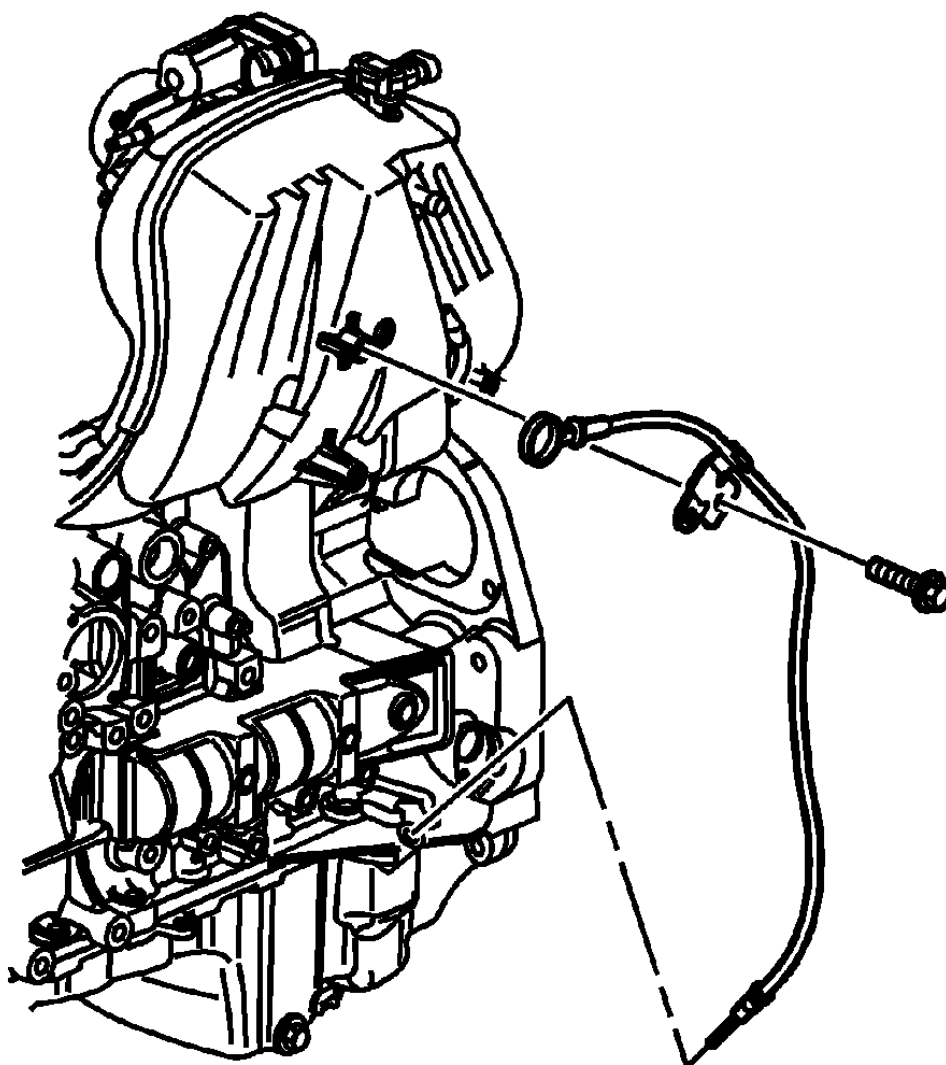


Fig. 56: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

2. Pull the oil level indicator from the tube.
3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube from the engine oil pan.

Installation Procedure

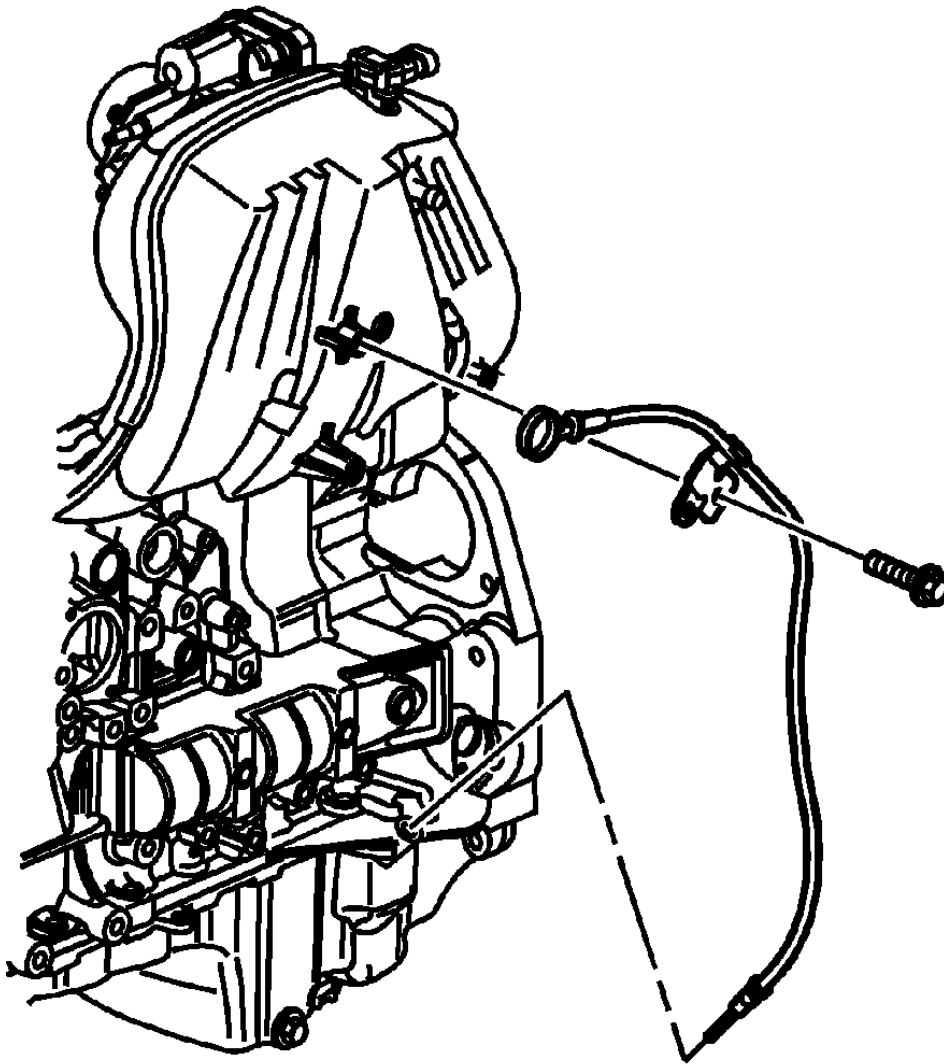


Fig. 57: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

1. Lightly lubricate the O-ring seal with clean engine oil.
2. Install the oil level indicator tube into the engine oil pan.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bolt and tighten to 10 N.m (89 lb in).
4. Install the oil level indicator into the tube.

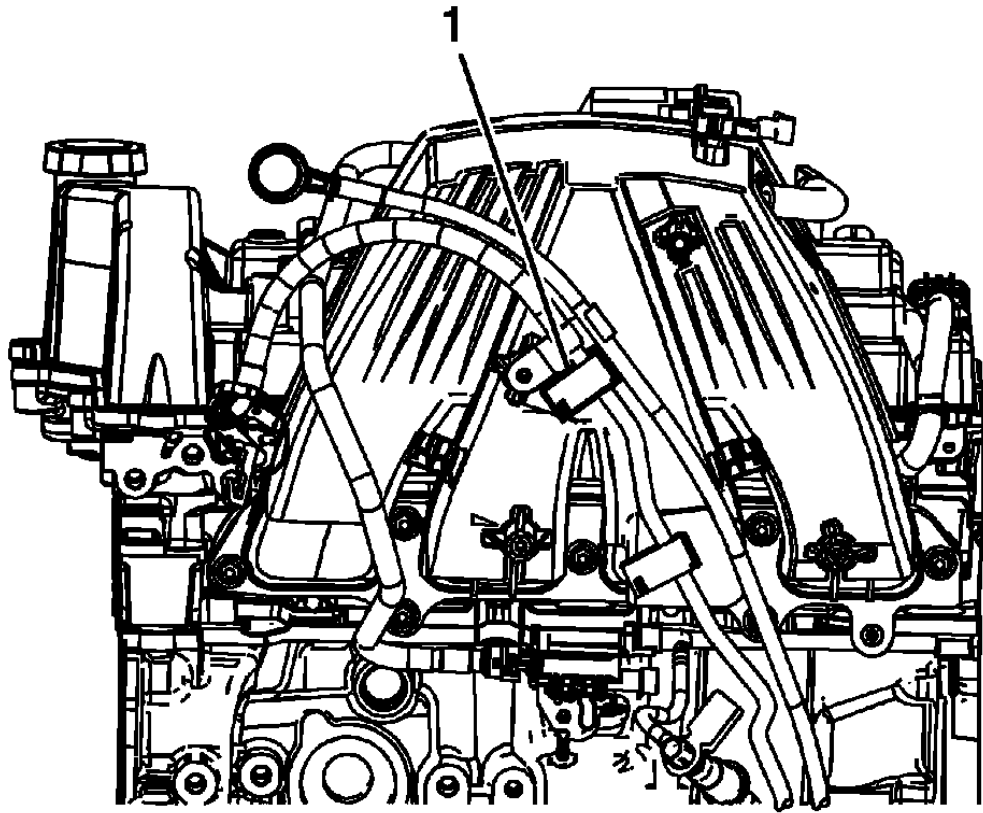


Fig. 58: View Of Fuel Line Clip

Courtesy of GENERAL MOTORS COMPANY

5. Install the fuel line clip (1) to the oil level indicator bracket.

CYLINDER HEAD REPLACEMENT

Special Tools

- **EN 46547** Flywheel Holding Tool
- **EN-47702** Bolt Extractor Kit
- **EN-48464** Lower Timing Gear Tensioner Holding Tool
- **J 44221** Camshaft Holding Tool
- **J 45059** Angle Meter

Removal Procedure

1. Bleed the fuel pressure. Refer to **Fuel Pressure Relief (Without CH-48027)** , **Fuel Pressure Relief (CH**

48027) .

2. Remove the air induction assembly from the vehicle. Refer to **Air Cleaner Resonator and Outlet Duct Replacement** , and **Air Cleaner Assembly Replacement** .
3. Remove the battery from the vehicle. Refer to **Battery Replacement (LLV/LLR)** .
4. Disconnect the fuel/EVAP lines from the intake manifold and move aside. Includes fuel line removal from fuel rail. Refer to **Evaporative Emission Line Replacement - Engine** .
5. Remove the bolt holding the oil indicator tube to the intake manifold and move the oil indicator tube aside. Do not remove.
6. Lift the vehicle. Refer to **Lifting and Jacking the Vehicle** .
7. Remove the engine shield from the vehicle.
8. Remove the oil pan skid plate from the vehicle.
9. Remove the drive belt. Refer to **Drive Belt Replacement**.
10. Drain the engine coolant. Refer to **Cooling System Draining and Filling (Static Fill)** , **Cooling System Draining and Filling (Vac N Fill)** .
11. Remove the left front wheelhouse panel. Refer to **Front Wheelhouse Liner Replacement** .
12. Remove the fir tree wiring harness connectors from the engine wring harness bracket from the left front wheelhouse opening.
13. From the left front wheelhouse, remove the engine wiring harness bracket from the engine and set aside.

NOTE: **On two-wheel drive vehicles, the intake manifold bolts are removed from the top of the engine, not through the left front wheelhouse panel. Refer to Intake Manifold Replacement.**

14. Remove the intake manifold bolts from the wheelhouse access. The bolts stay with intake manifold.
15. Lower the vehicle.

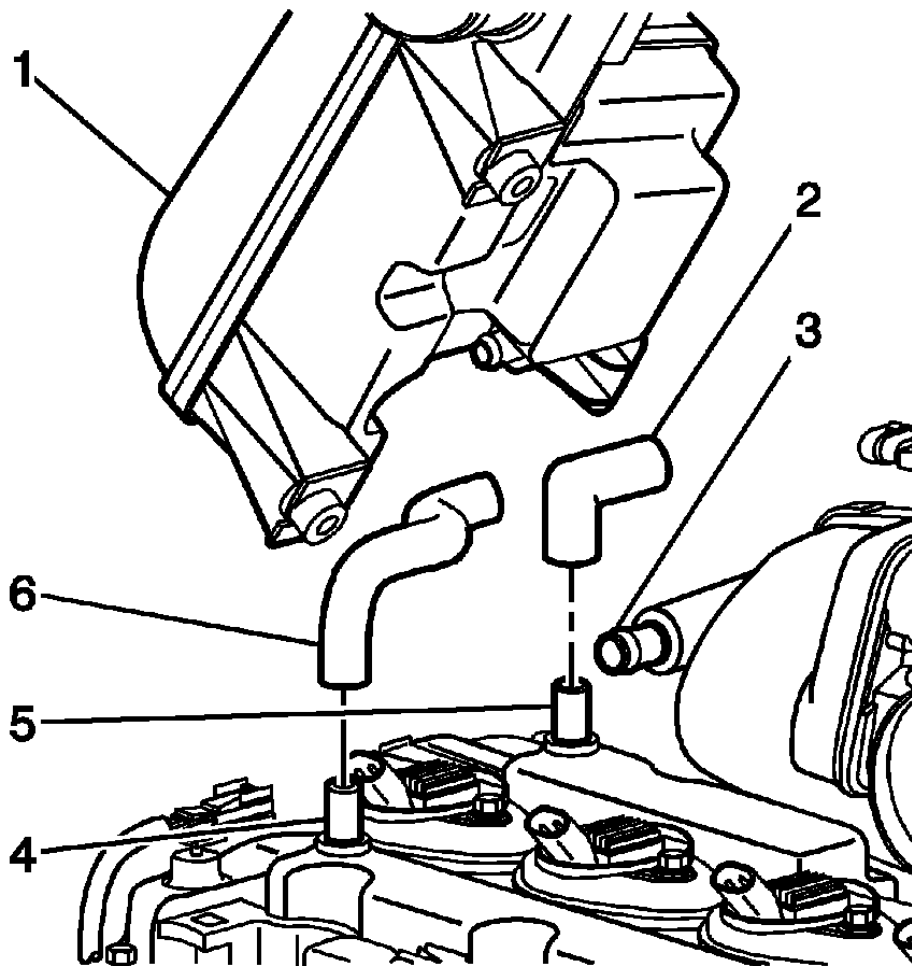


Fig. 59: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS COMPANY

16. Remove the positive crankcase ventilation (PCV) pipes (2, 6) from the cam cover and remove the intake manifold from the vehicle.
17. Remove the generator output BAT terminal nut.
18. Remove the generator lead from the generator.
19. Disconnect the generator electrical connector.

NOTE: The generator does not have to be removed from the vehicle. On a two-wheel drive vehicle, the generator must be removed from the vehicle.

20. Remove the generator bolts and set the generator aside. Refer to Generator Replacement (LLV/LLR).
21. Disconnect the A/C pipe clamp from the engine lift hook bracket.
22. Remove the engine lift hook bracket bolts and bracket from the vehicle.
23. Remove the bolts holding the windshield washer solvent container and coolant recovery reservoir to the right inner fender. Move aside to gain access to the engine wiring harness to the powertrain control

module (PCM). Refer to **Windshield Washer Solvent Container Replacement** .

24. Disconnect the following cross-vehicle engine wiring harness connectors:

- PCM
- Engine coolant temperature sensor
- Manifold absolute pressure (MAP) sensor
- Ignition coils
- Harness clamps at power steering pump
- Wiring harness fastener at right front inner fender
- Throttle body
- Camshaft sensors
- Exhaust camshaft actuator
- Fuel injectors
- HO2S 1

Set aside the cross-vehicle engine wiring harness on the left side of the vehicle.

25. If equipped, remove the secondary air injection (AIR) injection pipe block-off plate bolts from the cylinder head.
26. If equipped, remove the AIR injection pipe block-off plate.

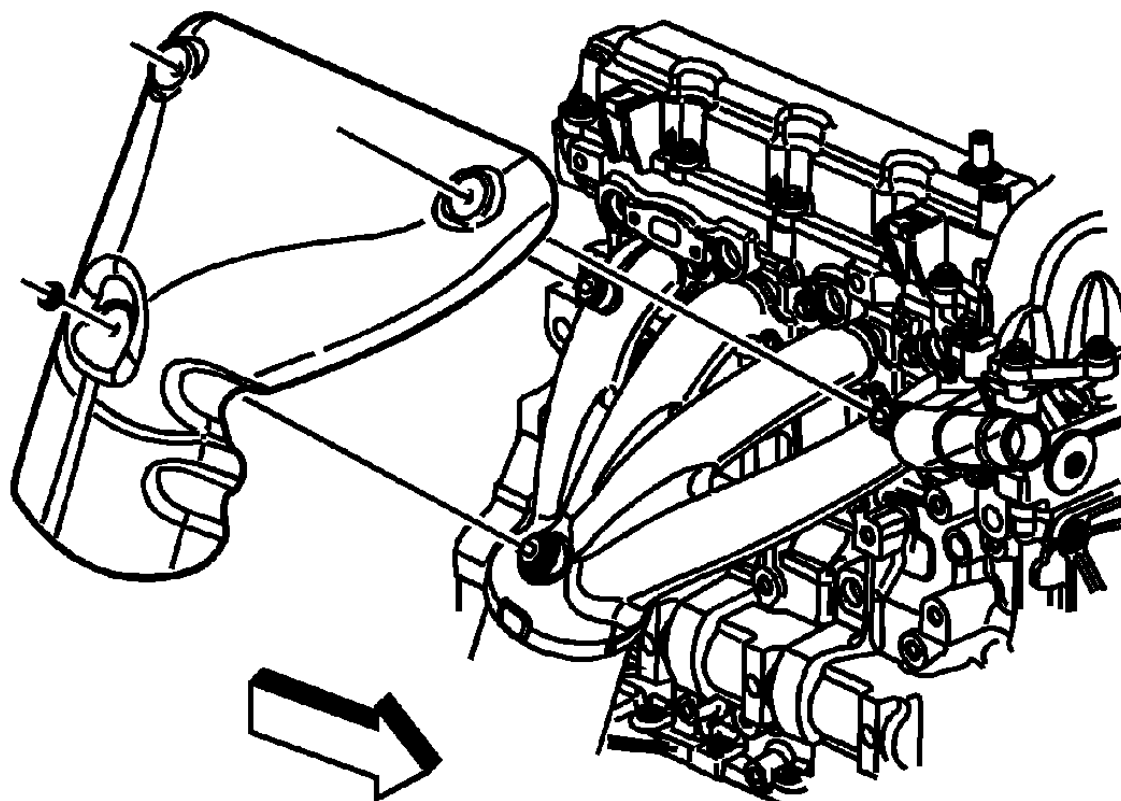


Fig. 60: View Of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS COMPANY

27. Remove the bolts from the exhaust manifold heat shield.
28. Remove the exhaust manifold heat shield.

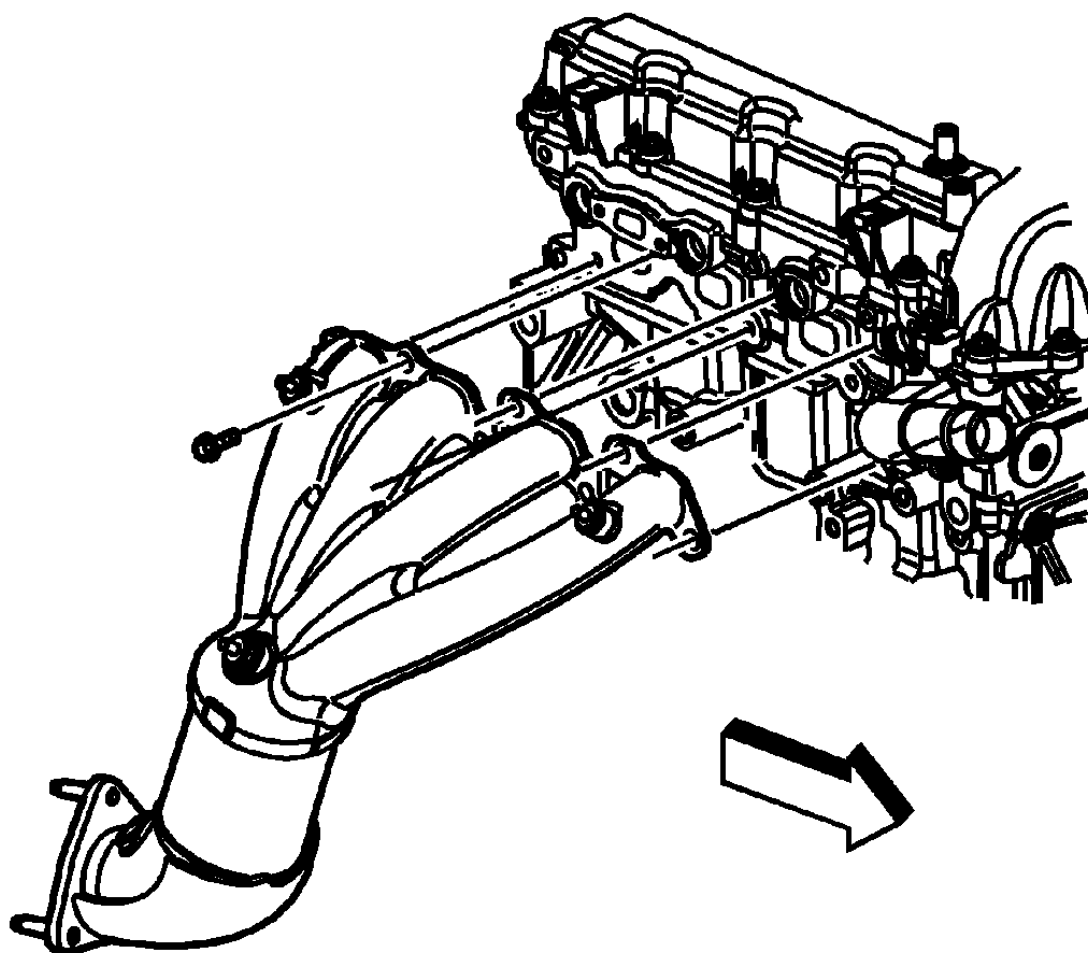


Fig. 61: View Of Exhaust Manifold

Courtesy of GENERAL MOTORS COMPANY

29. Remove the exhaust manifold bolts.
30. Move the exhaust manifold back and away from the cylinder head.

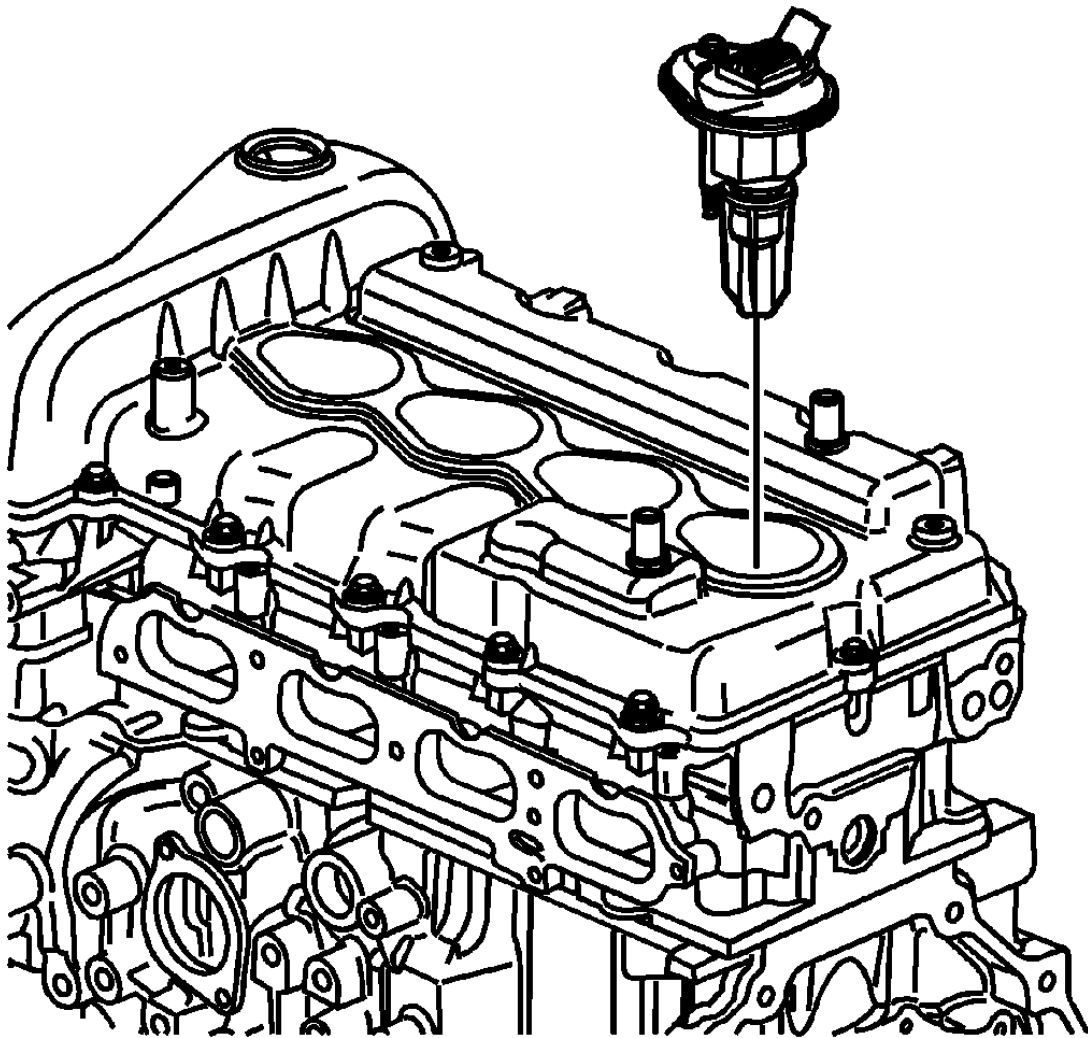


Fig. 62: View Of Ignition Control Module
Courtesy of GENERAL MOTORS COMPANY

31. Remove the bolts to all ignition coil assemblies and remove all ignition coil assemblies from the cam cover.
32. Remove all the spark plugs from the cylinder head.
33. Remove the cam cover from the cylinder head. Refer to **Camshaft Cover Replacement**.
34. Remove the inlet radiator hose and clamp from the cylinder head. Refer to **Radiator Inlet Hose Replacement (LLV, LLR)**.

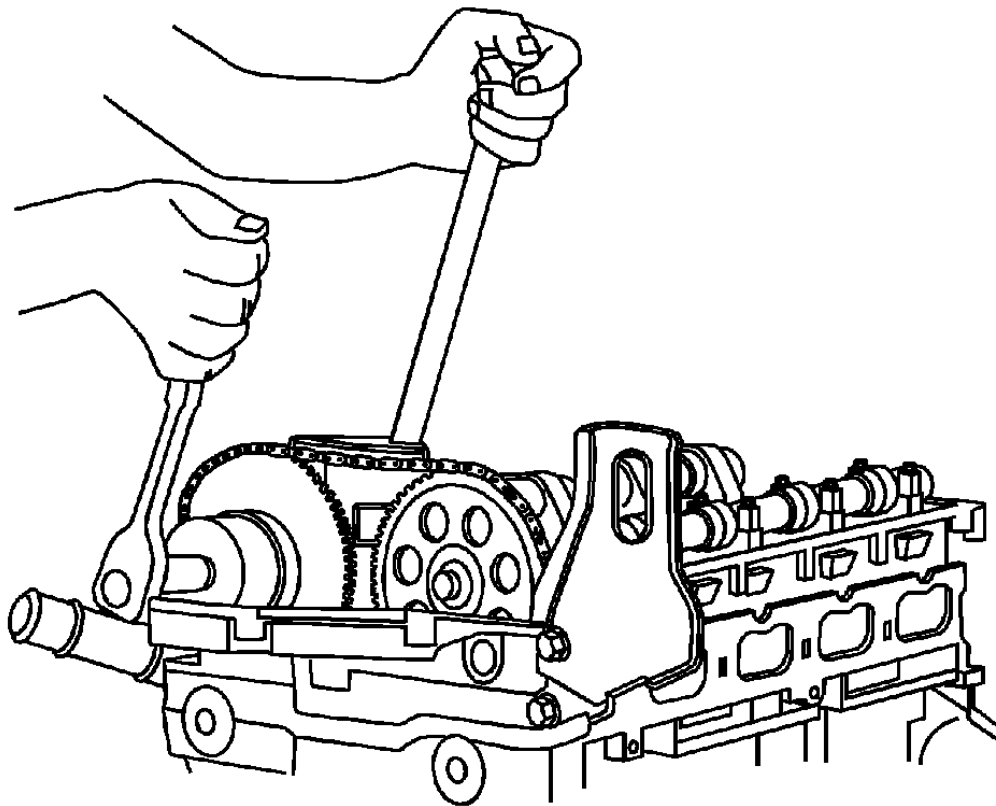


Fig. 63: Loosening Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

35. Before performing one of the top dead center (TDC) procedures, break loose both the exhaust and intake camshaft sprocket bolts. Use a 25 mm (1 in) open end wrench on the camshaft hexes to hold the camshaft from turning. DO NOT remove the bolts.
36. Perform one of the following methods for the service timing procedure.

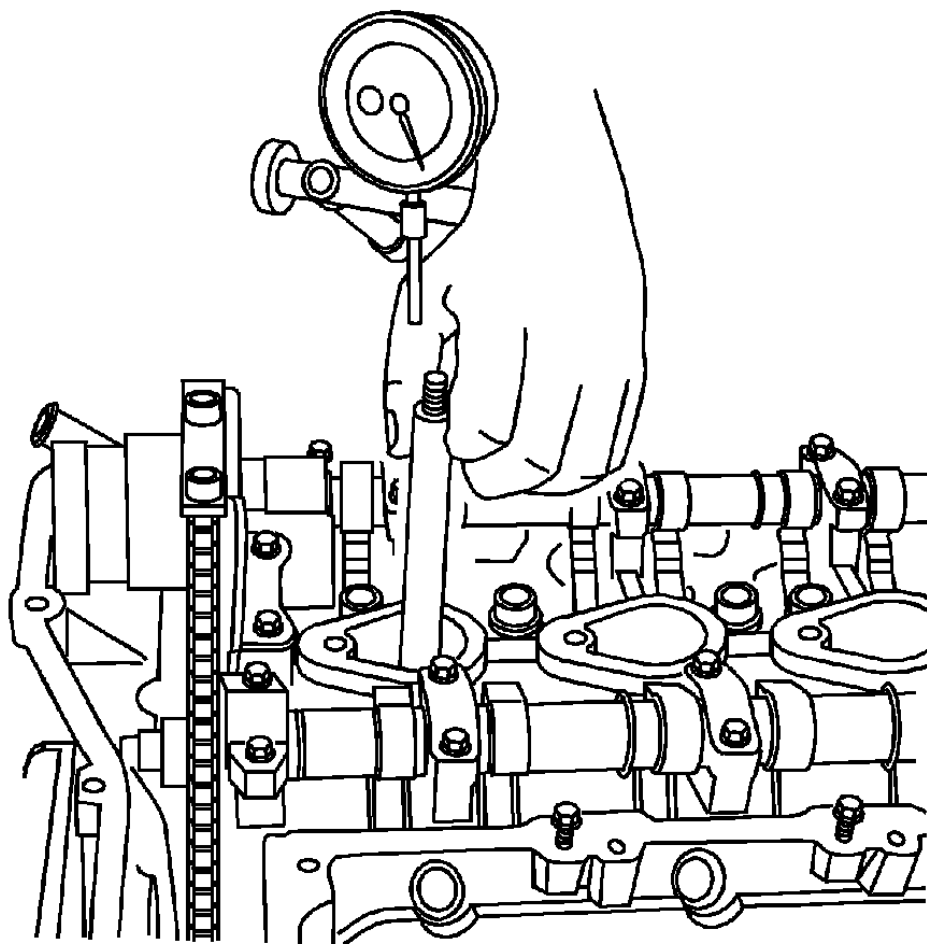


Fig. 64: Rotating Engine To TDC

Courtesy of GENERAL MOTORS COMPANY

37. First Method-Rotate the engine clockwise by hand to TDC on the compression stroke by using a piston TDC indicator tool and/or dial indicator in the number 1 cylinder.

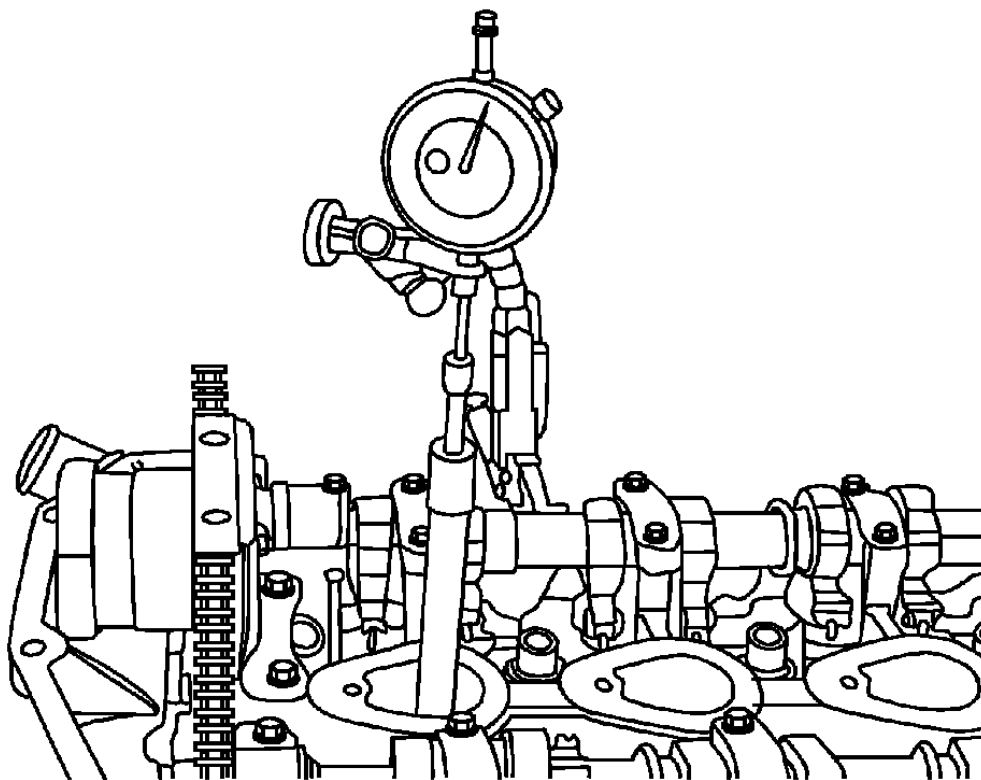


Fig. 65: View Of TDC Indicator Tool
Courtesy of GENERAL MOTORS COMPANY

38. First Method (continued) - The TDC indicator tool graduation marks on the shaft should note top of the piston stroke.

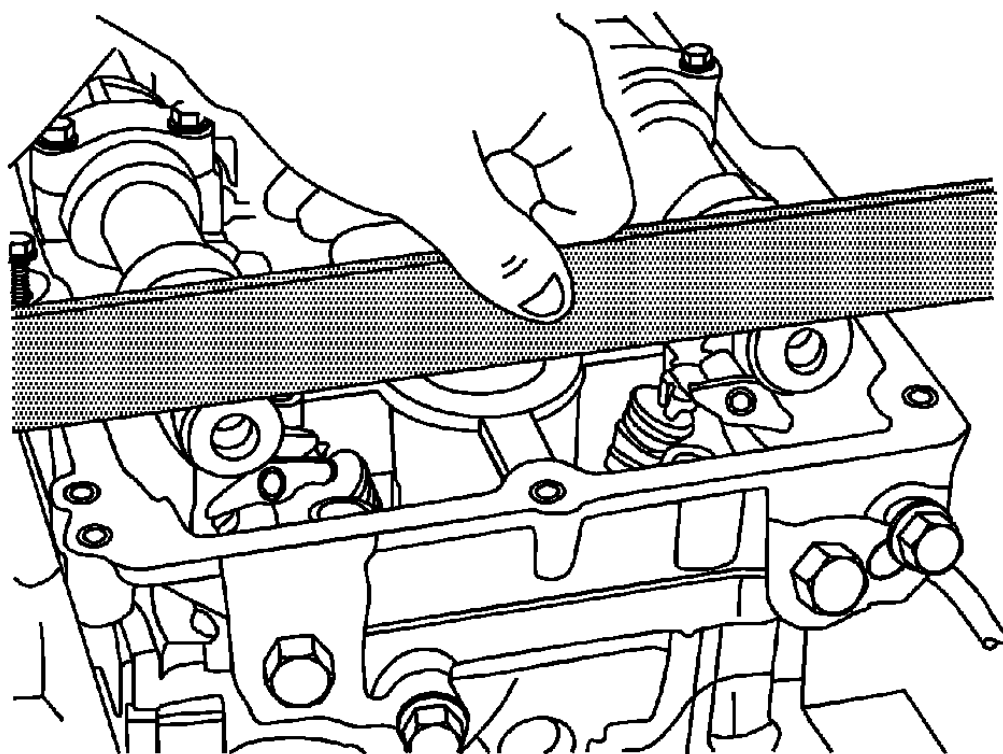


Fig. 66: Checking For TDC Position
Courtesy of GENERAL MOTORS COMPANY

39. First Method (continued) - When the piston is at TDC, the flats at the rear of the camshafts will be facing up and level when using a straight edge across the camshaft flats.

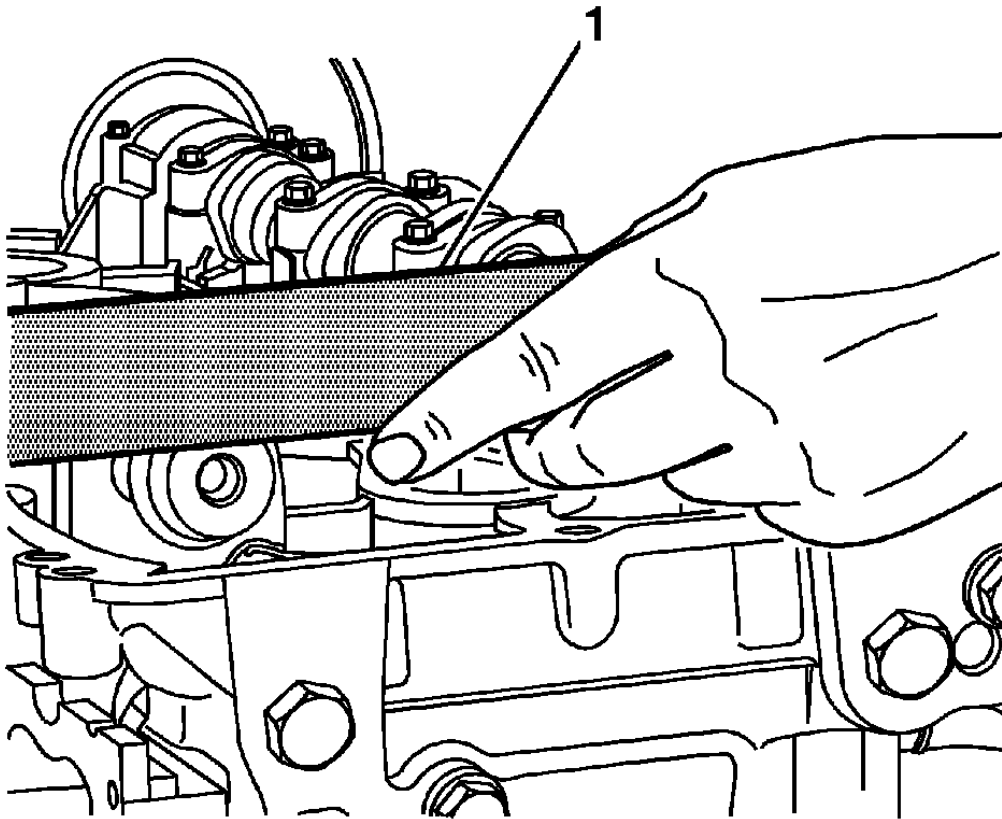


Fig. 67: Checking For TDC Position (Method 2)
Courtesy of GENERAL MOTORS COMPANY

40. Second Method-Rotate the crankshaft in the engine rotational direction clockwise until the number 1 piston is at TDC on the compression stroke. The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface. When the piston is at TDC, the flats at the rear of the camshafts will be facing up and level when using a straight edge across the camshaft flats. A 0.005 inch feeler gauge should not slide under the straight edge (1).

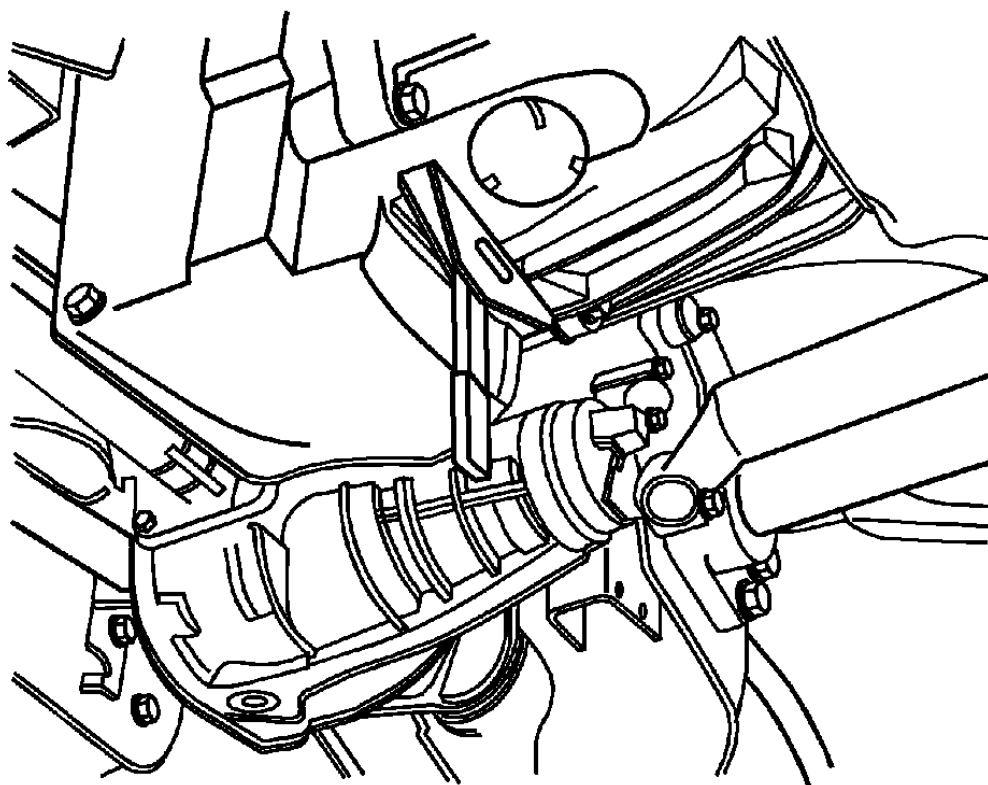


Fig. 68: Locking Flywheel With Special Tools
Courtesy of GENERAL MOTORS COMPANY

41. Once TDC is located for the number 1 cylinder using above methods, raise the vehicle and lock the flywheel with the **EN 46547** flywheel holding tool.

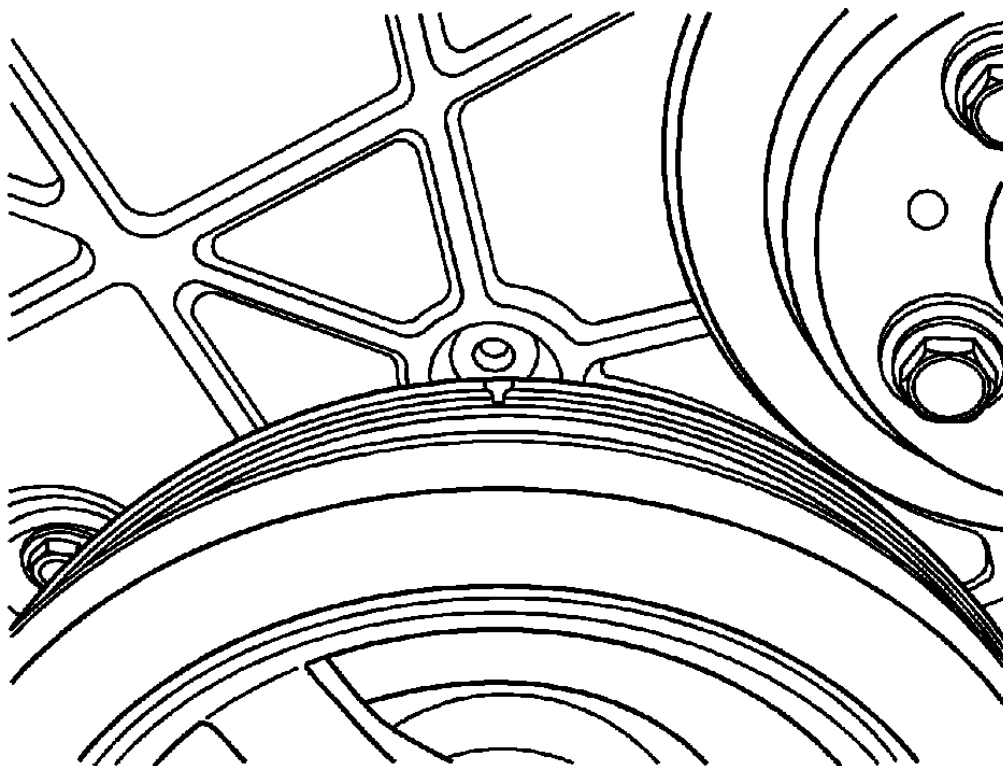


Fig. 69: View Of Reference Mark On Harmonic Balancer
Courtesy of GENERAL MOTORS COMPANY

42. Use a white paint pen or equivalent to place a reference mark on the harmonic balancer to the front cover for alignment purposes.
43. Lower the vehicle.

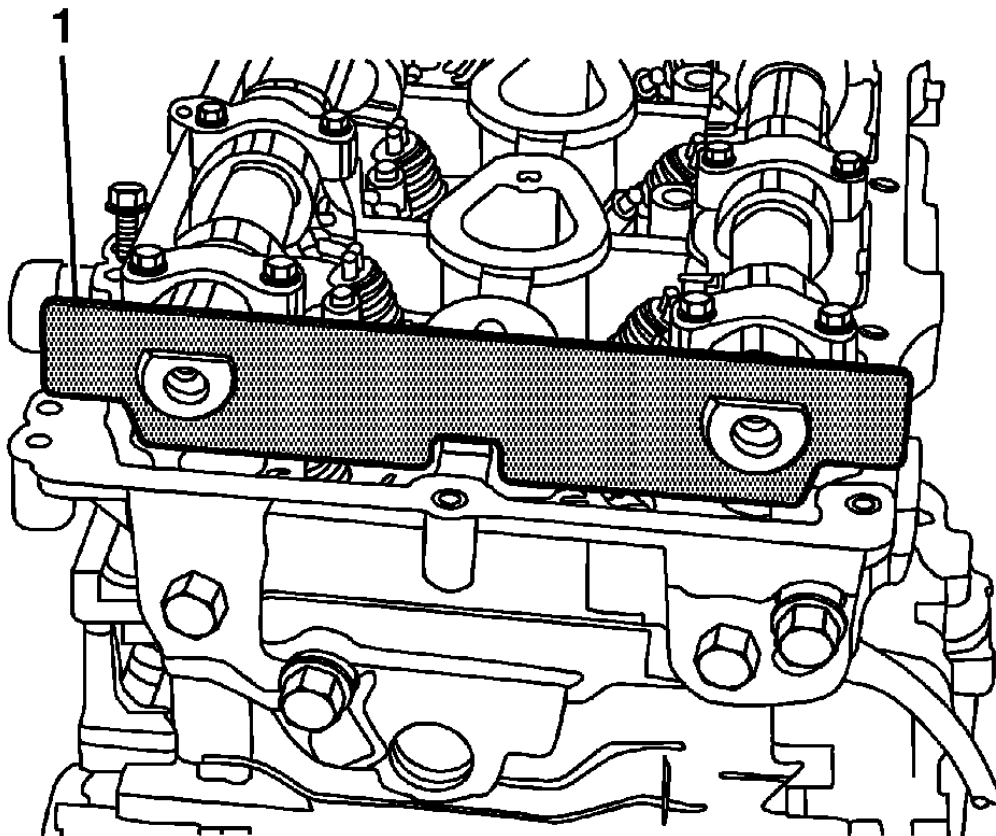


Fig. 70: Securing Camshafts

Courtesy of GENERAL MOTORS COMPANY

WARNING: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

NOTE: If the timing is correct, TDC compression stroke number 1 cylinder, the camshaft flats will be in the up position.

44. Install **J 44221** camshaft holding tool (1) to the back of the camshafts.
45. Remove the upper timing chain guide to the cylinder head.

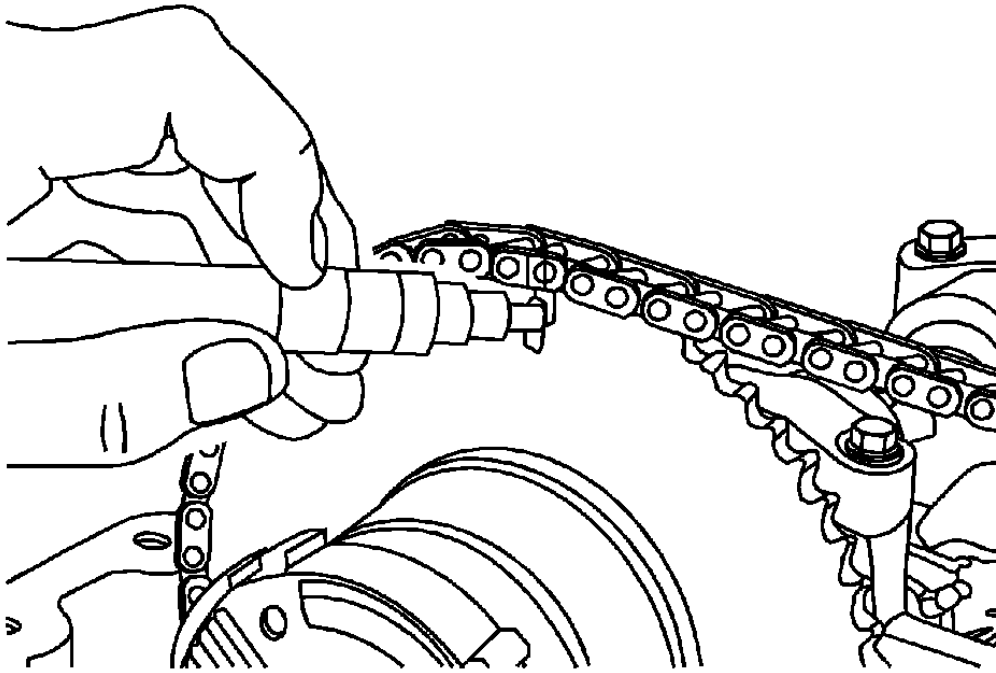


Fig. 71: Cleaning Timing Chain

Courtesy of GENERAL MOTORS COMPANY

46. Clean the timing chain and gears with brake cleaner or suitable solvent. Use a white paint pen or equivalent to place a reference mark on both timing gear sprockets and the timing chain to mark location prior to disassembly. It is recommended that the paint marks be in the 12 o'clock position.

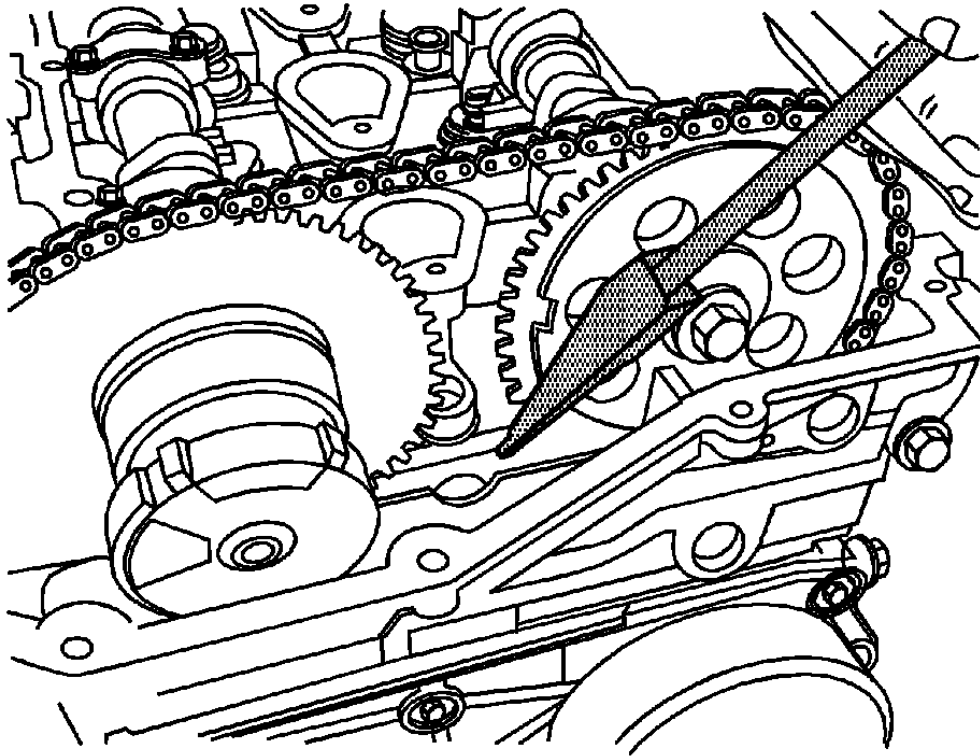


Fig. 72: Wedge Tool

Courtesy of GENERAL MOTORS COMPANY

CAUTION: DO NOT use excessive force to seat the wedge tool. If excessive force is used, you may damage the timing chain tensioner or break the front cover bolt requiring complete disassembly of the front engine.

47. Install **EN-48464** lower timing gear tensioner holding tool. It is important to install the tool with the proper orientation and to ensure that it is seated square against the timing chain and against the timing cover center bolt.

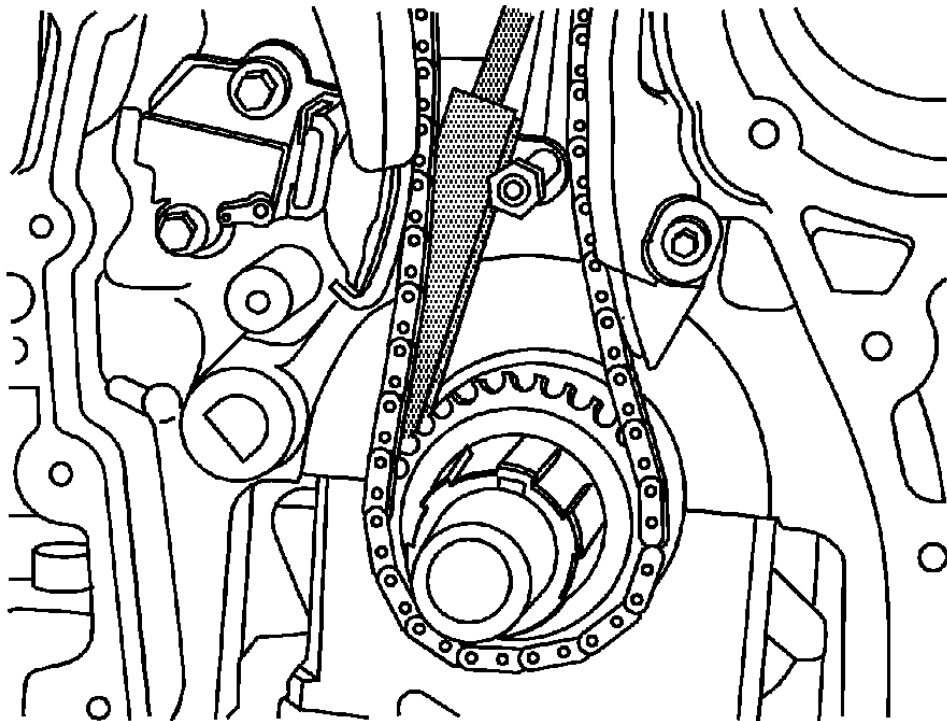


Fig. 73: Ensuring Proper Placement Of Wedge Tool
Courtesy of GENERAL MOTORS COMPANY

48. The narrow ramp of the wedge tool needs to be placed so that it faces the timing chain. Front cover removed for illustration purposes.

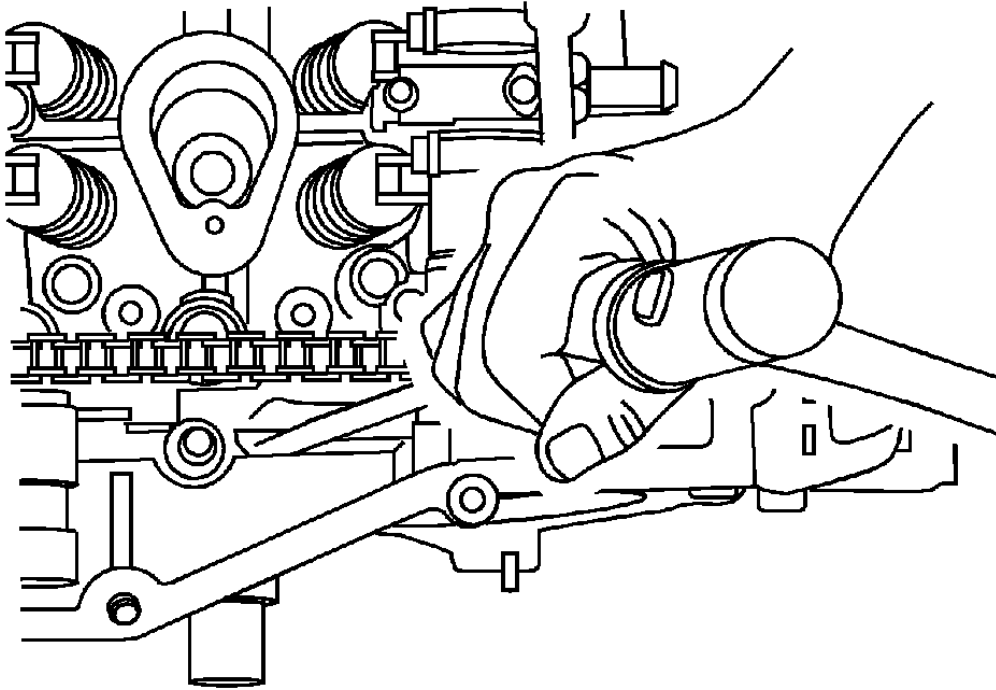


Fig. 74: Securing Wedge Tool

Courtesy of GENERAL MOTORS COMPANY

CAUTION: DO NOT continue to hammer on EN-48464 once it has stopped moving. Damage will occur to the engine or the tool, or the tool could become lodged in the engine making it very difficult to remove.

49. The wedge tool should be lightly seated using a couple of very light taps with a small plastic or brass hammer. The wedge tool will be fully seated against the tensioner after it moves about 25 mm (1 in).
50. Once the tool is correctly installed, unscrew the handle and remove the handle.

NOTE:

- Use a 25 mm (1 in) open end wrench on the camshaft hexes to hold the camshaft from turning. It is critical that the crankshaft does not move and is held at TDC when the intake and exhaust camshaft sprocket bolts are removed.
- If the crankshaft is not held in place, the wedge tool could be dislodged. If the crankshaft moves, or if the tool is not seated properly allowing the timing chain tensioner to extend, the repair will

have to be completed by removing the front cover to release the timing chain tensioner.

51. Remove both upper cylinder head access hole plugs from the front of the cylinder head.
52. Remove the 1 long and 2 short cylinder head bolts next to the exhaust and intake timing chain tensioner shoes and discard the bolts.
53. Remove upper timing chain tensioner shoe bolt.
54. Remove upper timing chain tensioner guide bolt.
55. Remove the exhaust and the intake camshaft sprocket bolts. Discard the bolts.

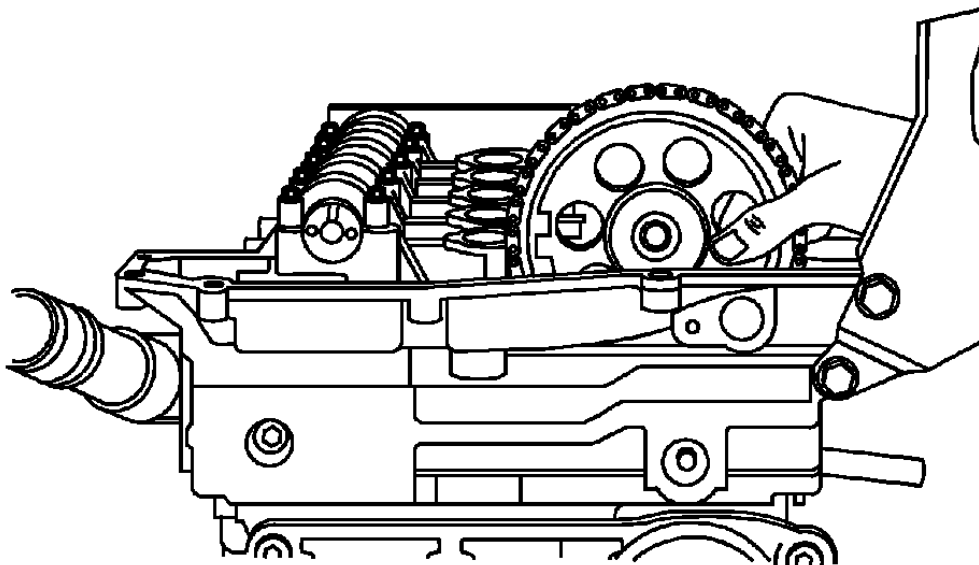


Fig. 75: View Of Camshaft Sprockets
Courtesy of GENERAL MOTORS COMPANY

56. Carefully remove the exhaust and intake camshaft sprockets with the timing chain from the exhaust and intake camshafts. The illustration shows the exhaust camshaft sprocket already removed.

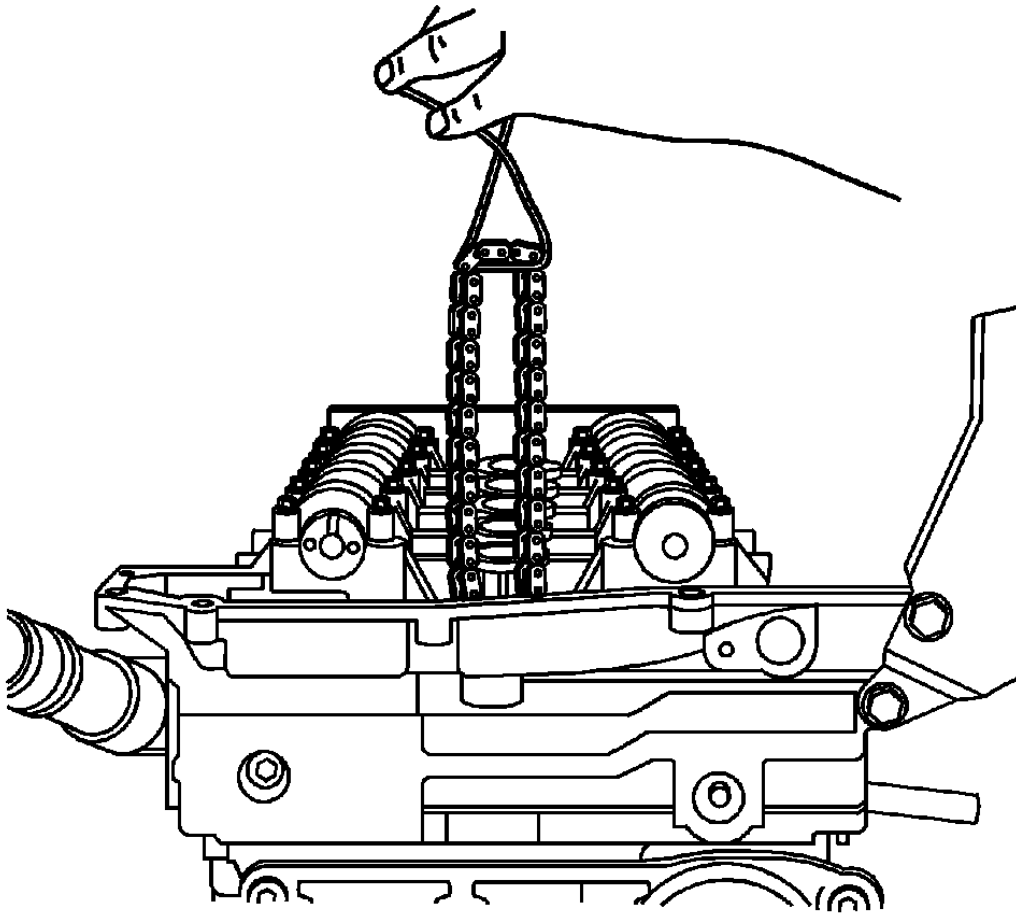


Fig. 76: Attaching Wire To Timing Chain
Courtesy of GENERAL MOTORS COMPANY

57. Remove the sprockets from the chain, tie a piece of mechanic's wire on the timing chain and let it drop.

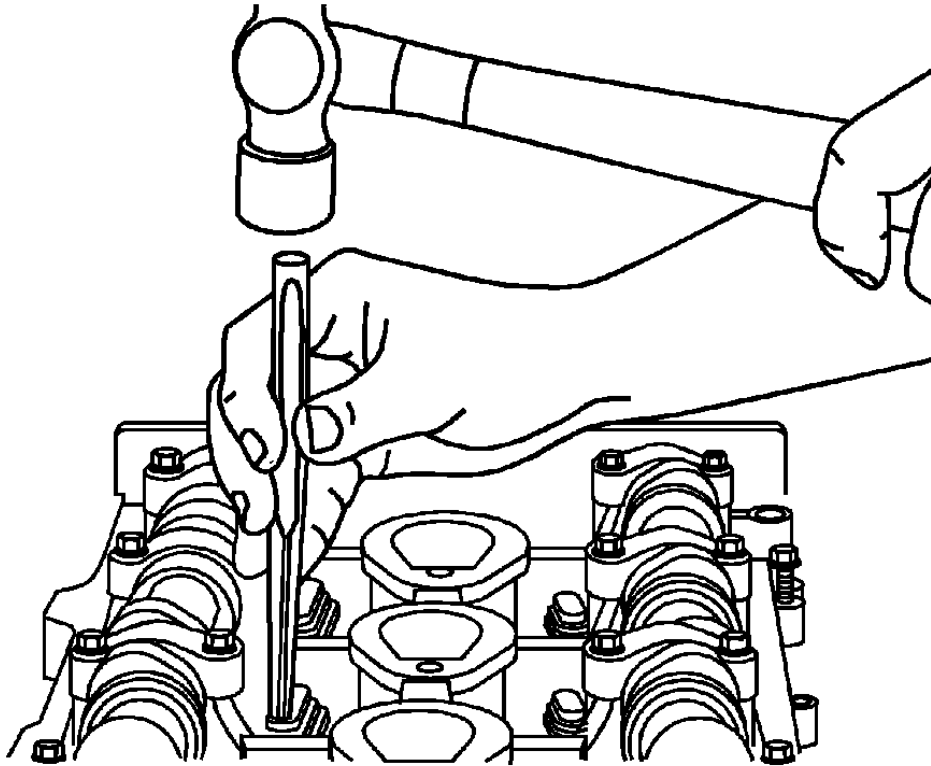


Fig. 77: Striking Head Bolts With Hammer Prior To Removal
Courtesy of GENERAL MOTORS COMPANY

58. Before removing the cylinder head bolts, use a drift punch and hammer to shock the bolts. This will ensure that the cylinder head bolts will not strip out the threads in the engine block or break. If a bolt breaks during engine disassembly, **EN-47702** bolt extractor kit is available to assist in the removal of the remaining bolt segment.

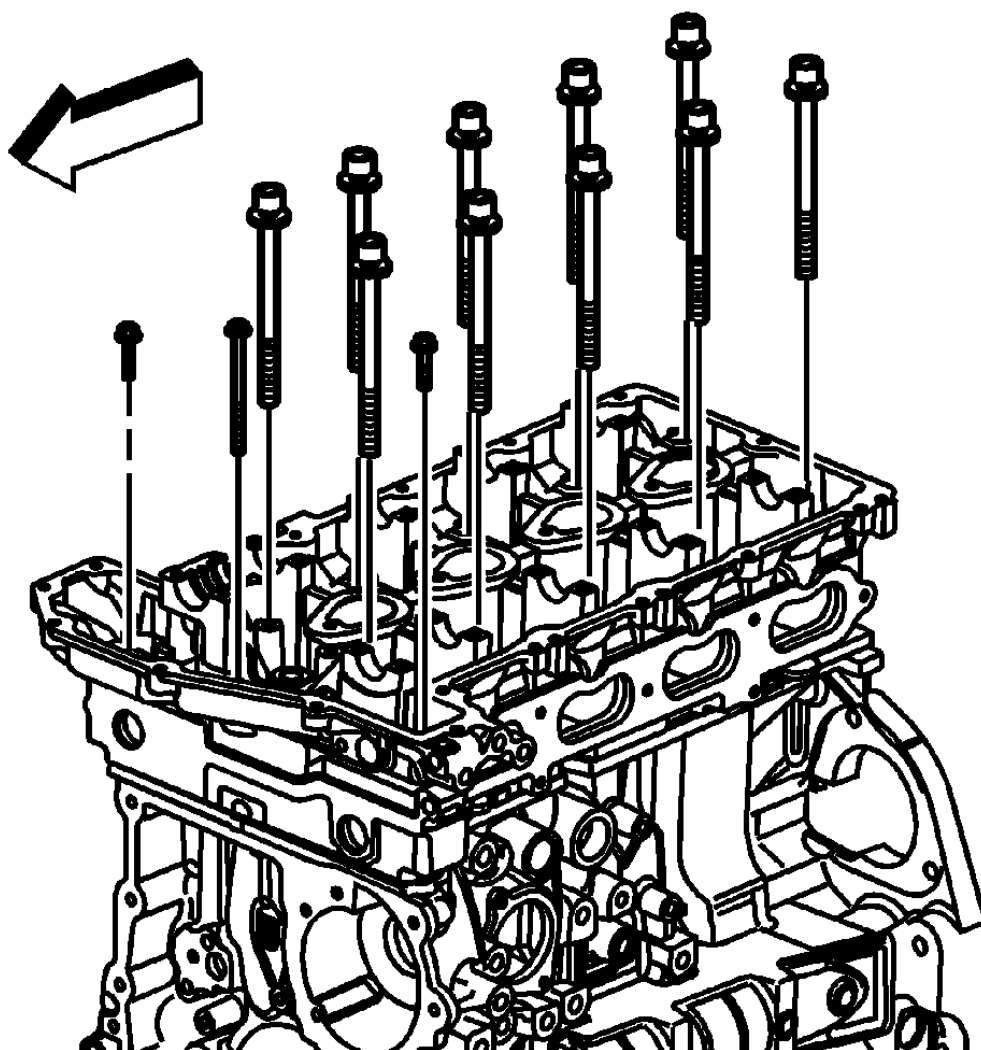


Fig. 78: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

59. Remove the cylinder head bolts. Discard the bolts.

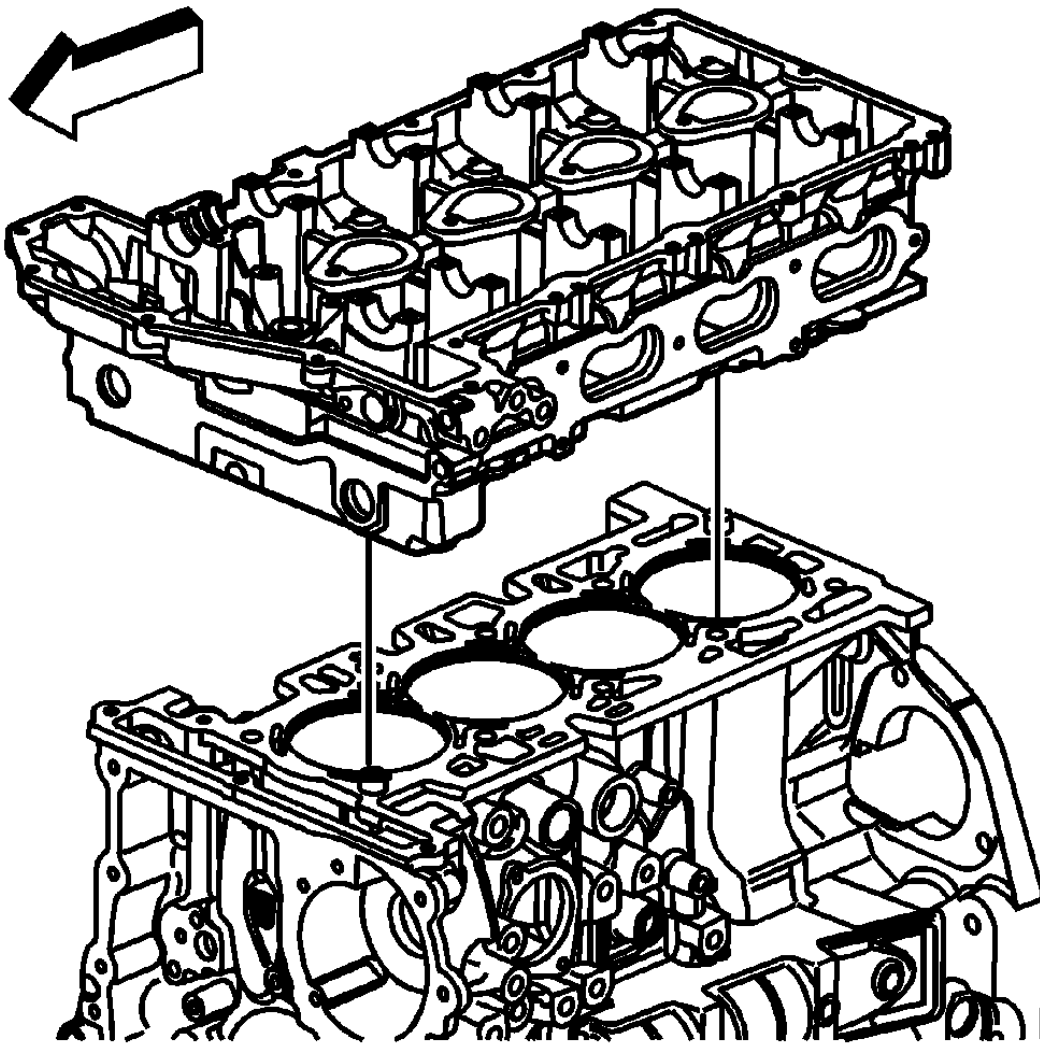


Fig. 79: View Of Cylinder Head

Courtesy of GENERAL MOTORS COMPANY

60. Remove the cylinder head.
61. Place the cylinder head on a flat, clean surface with the combustion chambers face up, in order to prevent damage to the deck face.

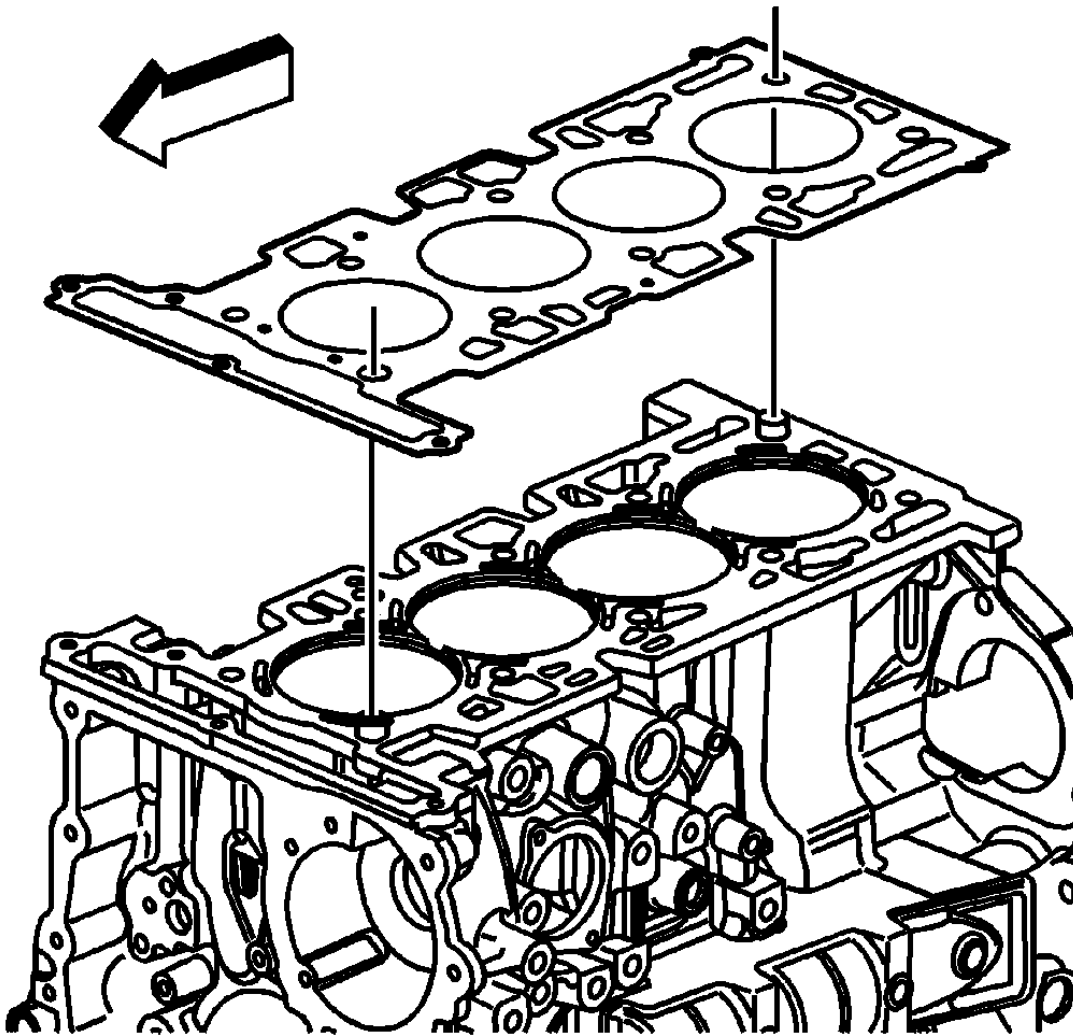


Fig. 80: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS COMPANY

62. Remove the cylinder head gasket.

Discard the gasket.

63. Remove all remaining gasket material from the engine block.
64. Inspect the cylinder head gasket mating surface on the engine block.
65. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .
66. Disassemble the cylinder head if necessary. Refer to **Cylinder Head Disassemble** .

Installation Procedure

1. Assemble the cylinder head if necessary. Refer to **Cylinder Head Assemble** .

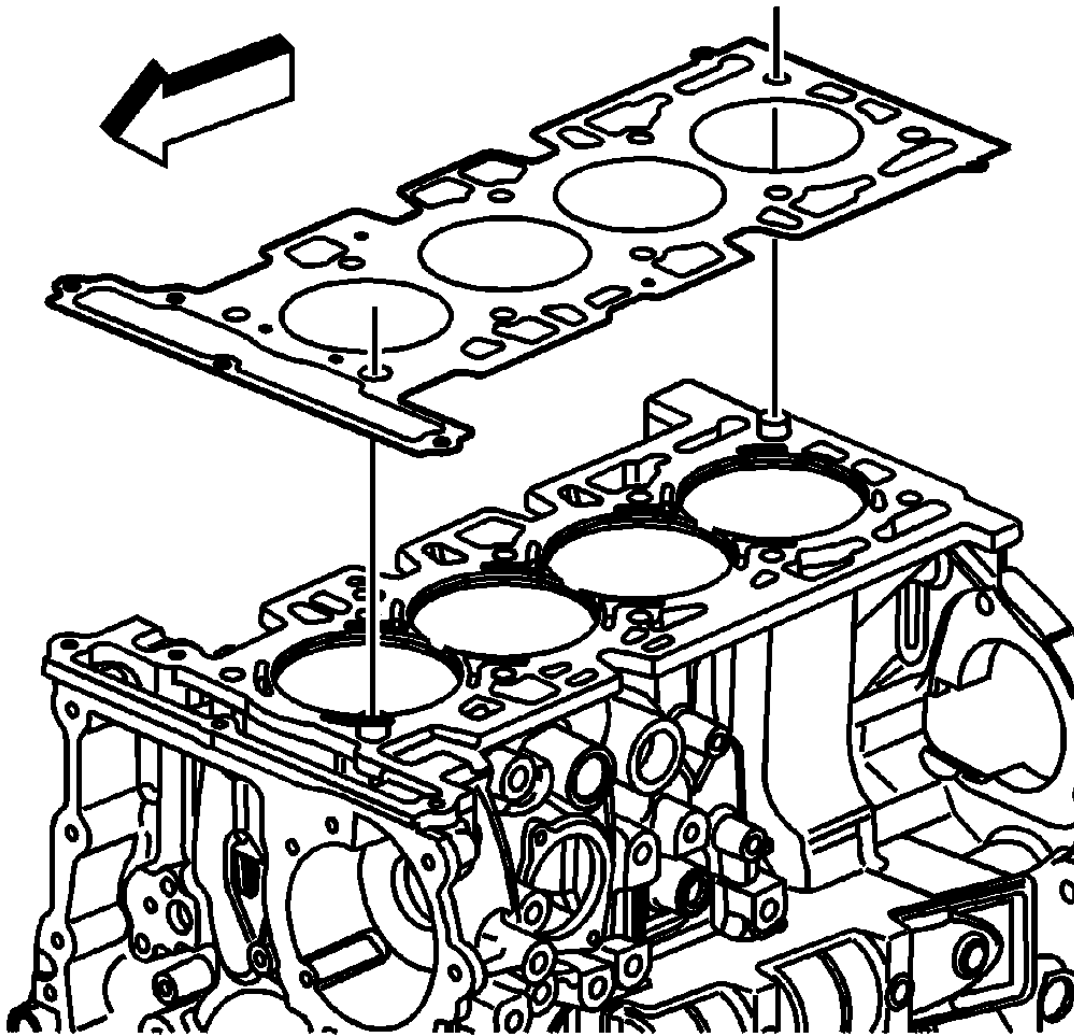


Fig. 81: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Install the dowel pins, cylinder head locator, if necessary.
3. Position a NEW cylinder head gasket to the engine block.

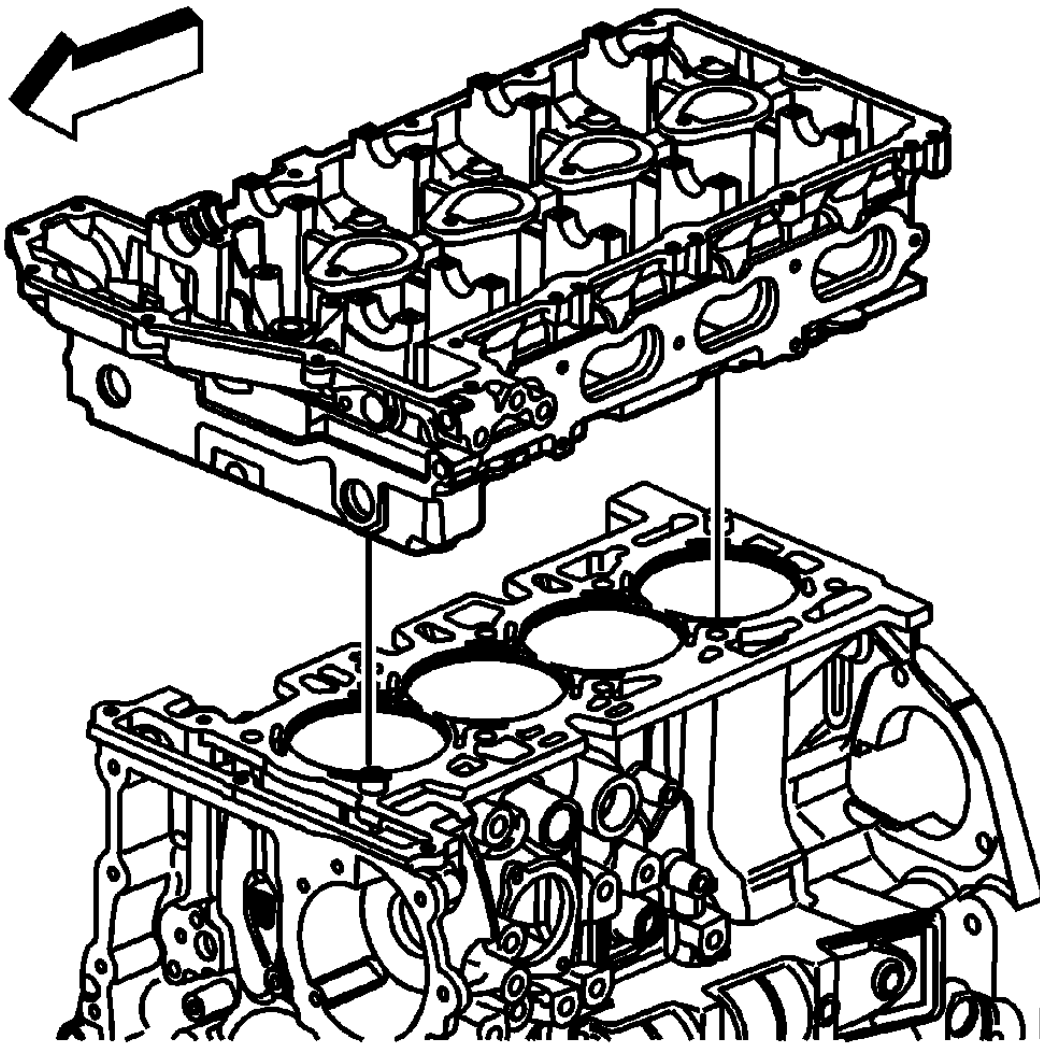


Fig. 82: View Of Cylinder Head

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure all wires, components, etc. are out of the way when installing the cylinder head.

4. Install the cylinder head.

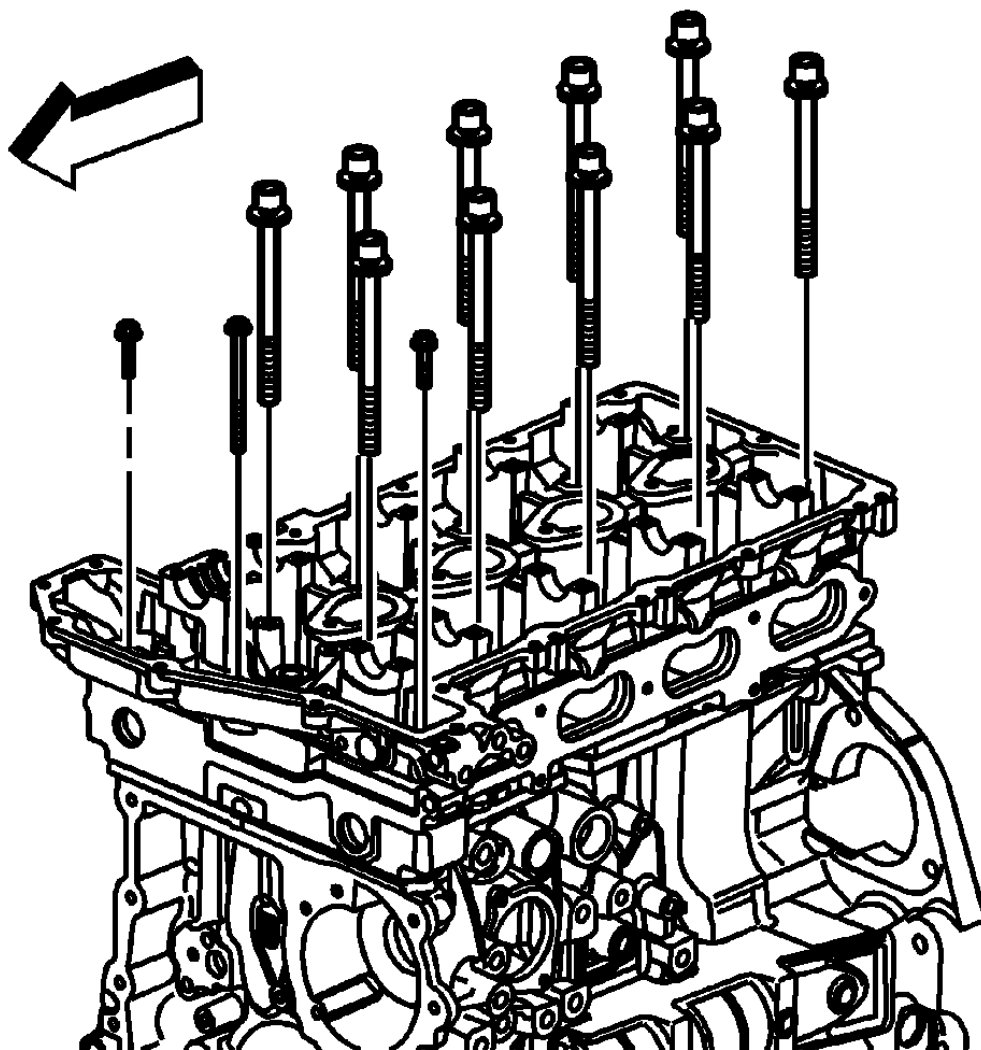


Fig. 83: View Of Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

5. Install NEW cylinder head bolts.

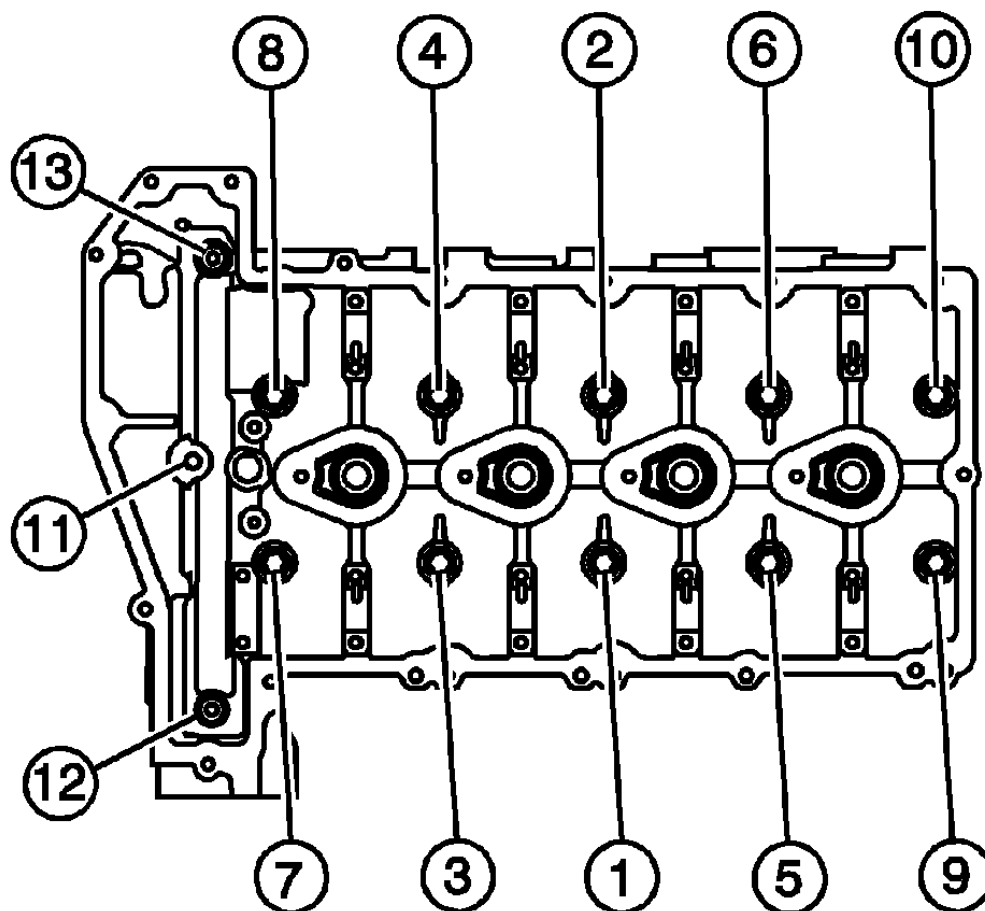


Fig. 84: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Tighten the NEW cylinder head bolts in the following sequence:
 1. Tighten the cylinder head bolts (1-10) in sequence to 30 N.m (22 lb ft). Use the **J 45059** angle meter to rotate the cylinder head bolts (1-10) in sequence an additional 155 degrees.
 2. Tighten the (2 short) end bolts (12-13) to 7 N.m (62 lb in). Use the **J 45059** angle meter to rotate the short cylinder head end bolts (12-13) an additional 60 degrees.
 3. Tighten the (1 long) end bolt (11) to 7 N.m (62 lb in). Use the **J 45059** angle meter to rotate the long cylinder head end bolt (11) an additional 120 degrees.

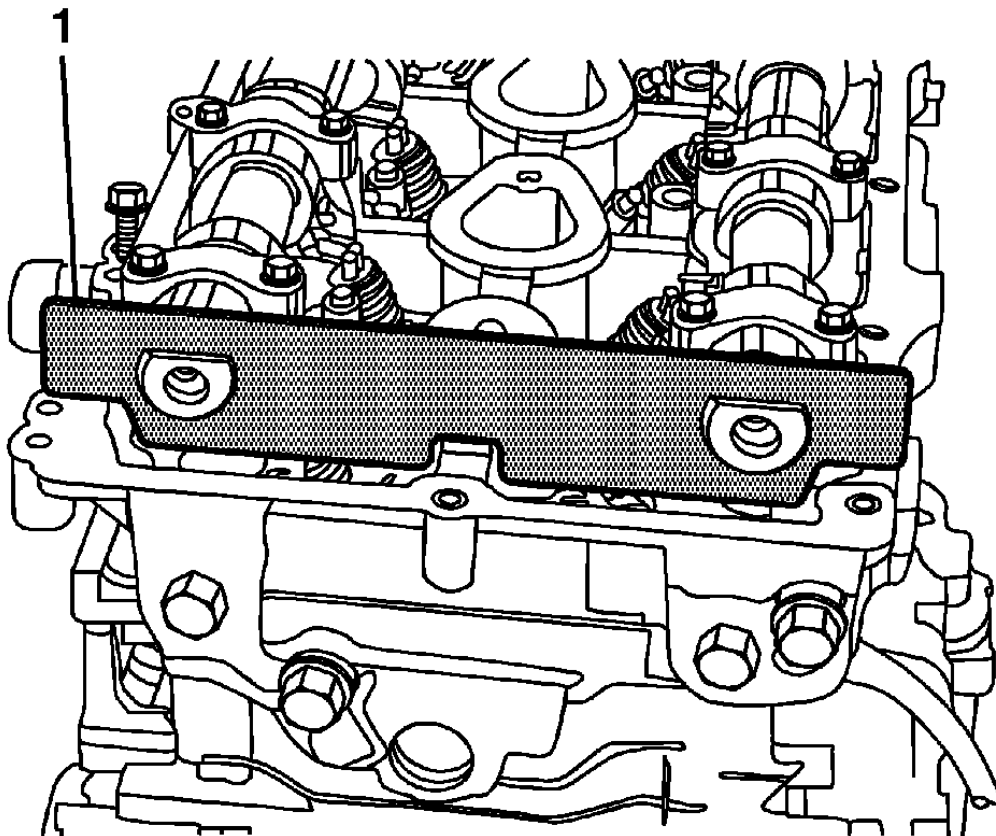


Fig. 85: Securing Camshafts

Courtesy of GENERAL MOTORS COMPANY

WARNING: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

NOTE: Before installing the camshafts, refer to Camshafts Cleaning and Inspection .

7. Install the camshafts with the flats up using J 44221 camshaft holding tool (1). Refer to Camshaft Installation .

CAUTION: Tension must be always kept on the intake side of the timing chain to properly keep the engine in time. If the chain is loose the timing will be off, which may cause internal engine damage or set DTC P0017.

CAUTION: The exhaust camshaft actuator must be fully advanced during installation. Engine damage may occur if the camshaft actuator is not fully advanced.

NOTE: To aid in aligning the actuator to the camshaft, use a 25 mm (1 in) open end wrench on the hex of the camshaft to rotate. This will ensure the alignment pin is properly engaged with the camshaft and hand tighten the new exhaust camshaft sprocket bolt.

8. Install the exhaust camshaft actuator/sprocket and chain onto the exhaust camshaft. Use the paint marks as an alignment guide.

NOTE: To aid in aligning the intake sprocket to the camshaft, use a 25 mm (1 in) open end wrench on the hex of the camshaft to rotate. This will ensure the alignment pin is properly engaged with the camshaft and hand tighten the new intake camshaft sprocket bolt.

9. Install the intake camshaft sprocket and chain onto the intake camshaft. Use paint marks as alignment guide.

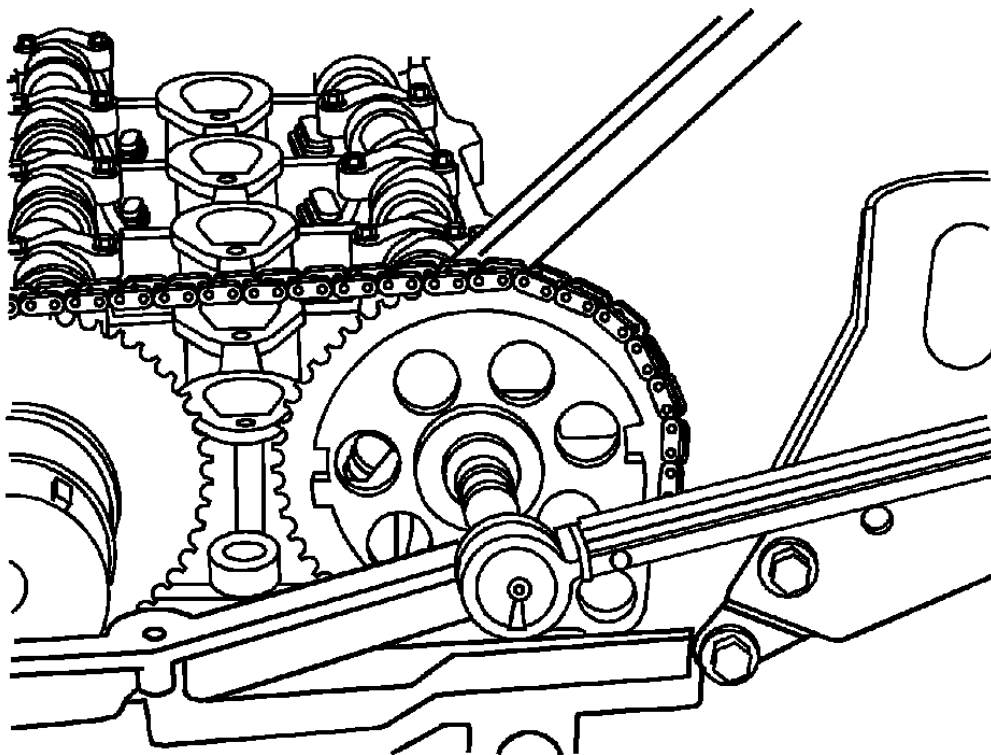


Fig. 86: Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Tighten the new intake camshaft sprocket bolt.

Using **J 45059** angle meter , tighten the intake camshaft sprocket bolt to 20 N.m (15 lb ft) plus 100 degrees.

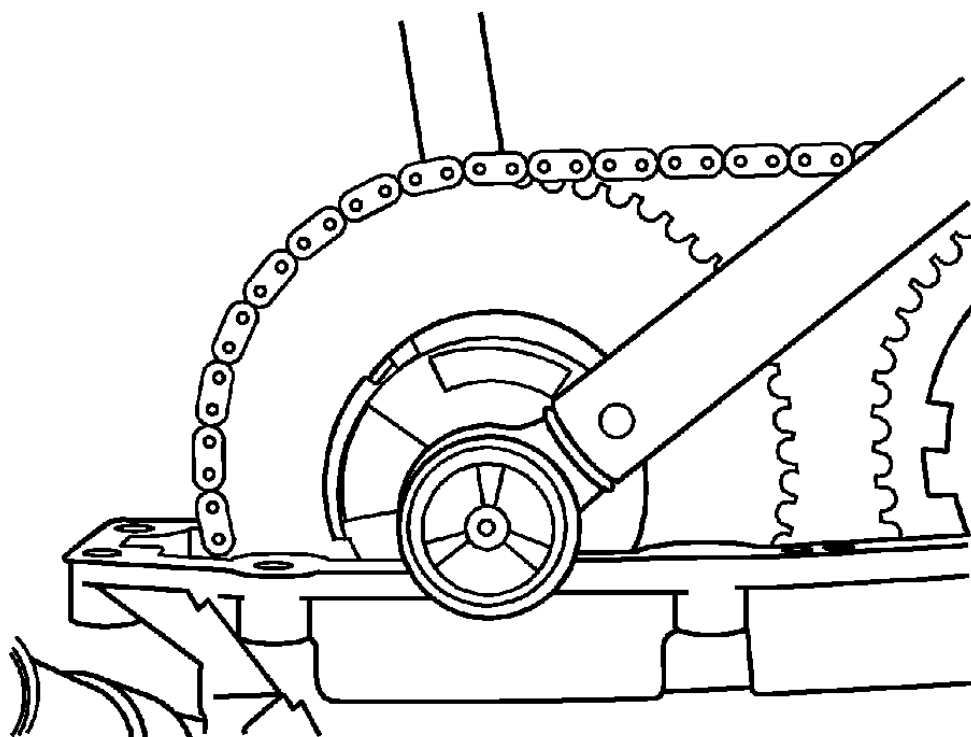


Fig. 87: Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Tighten the new exhaust camshaft actuator sprocket bolt.

Using **J 45059** angle meter , tighten the exhaust camshaft actuator sprocket bolt to 25 N.m (18 lb ft) plus 135 degrees.

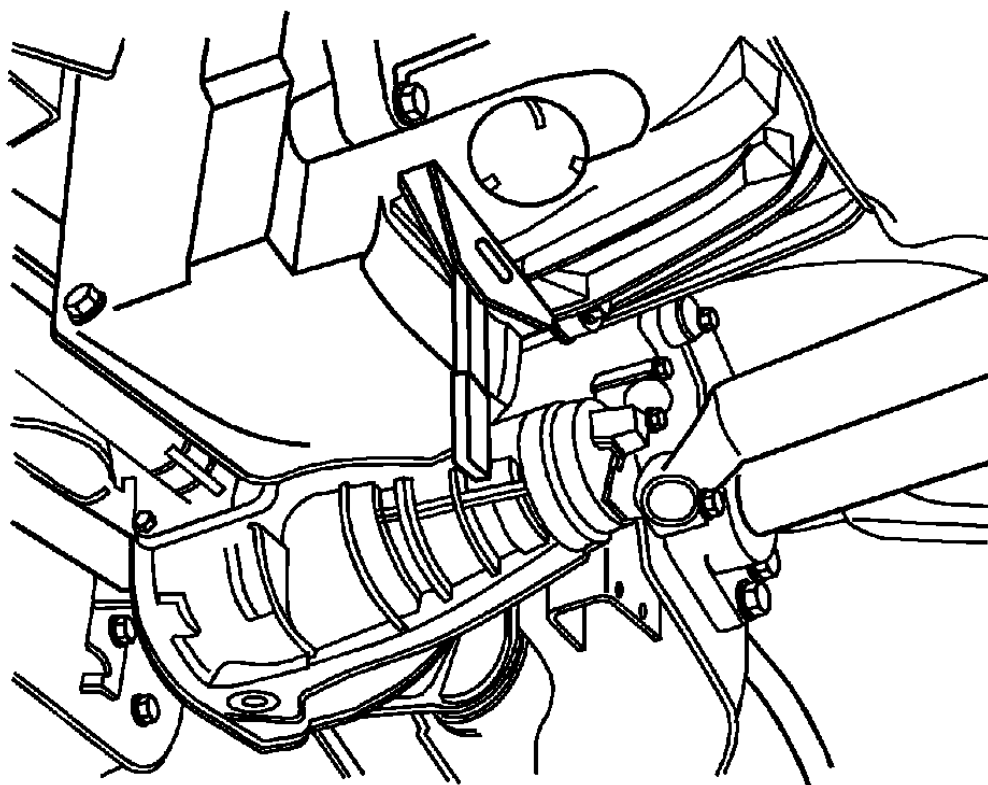


Fig. 88: Flywheel Holding Tool

Courtesy of GENERAL MOTORS COMPANY

12. Lift the vehicle and remove the **EN 46547** flywheel holding tool.
13. Lower the vehicle.
14. Remove the **J 44221** camshaft holding tool from the back of the camshafts.
15. Install the chain guide and tensioner shoe bolts prior to removing the wedge tool.

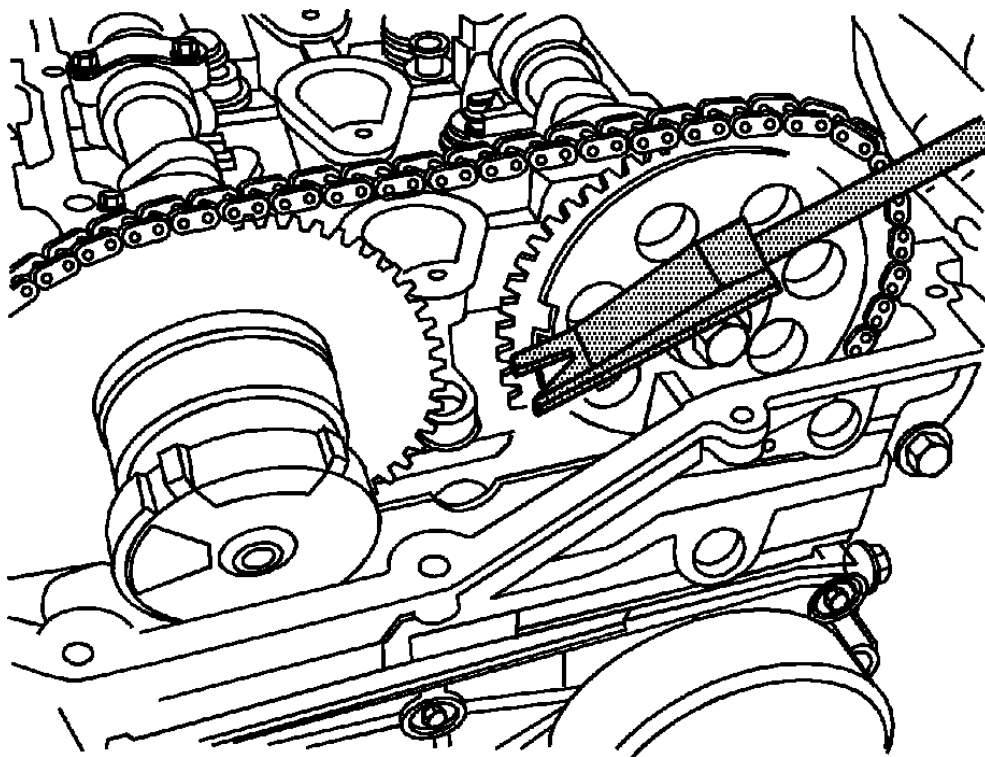


Fig. 89: View Of Wedge Tool

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Ensure that the wedge tool is removed from engine prior to rotation.
If the wedge tool is not removed, engine damage will result.

16. Install the handle of **EN-48464** lower timing gear tensioner holding tool and remove the wedge portion of the tool from the engine.

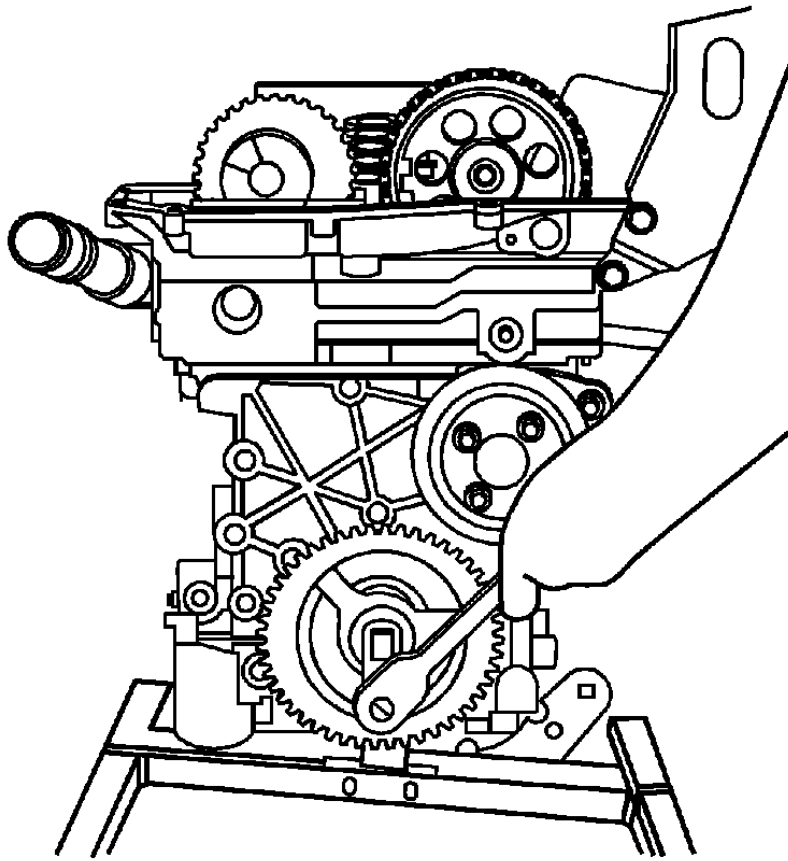


Fig. 90: Rotating Engine Clockwise
Courtesy of GENERAL MOTORS COMPANY

NOTE: It is critical that the engine is at TDC and not a couple of degrees off. If in doubt, repeat this step.

17. Rotate the engine clockwise by hand 2 complete revolutions to TDC number 1 on the compression stroke. Refer to First Method or Second Method for TDC. If you go past TDC, rotate the engine back approximately 45 degrees before TDC and then rotate clockwise up to TDC to ensure that the timing chain is tight (no slack) between the crank sprocket and the timing gears.

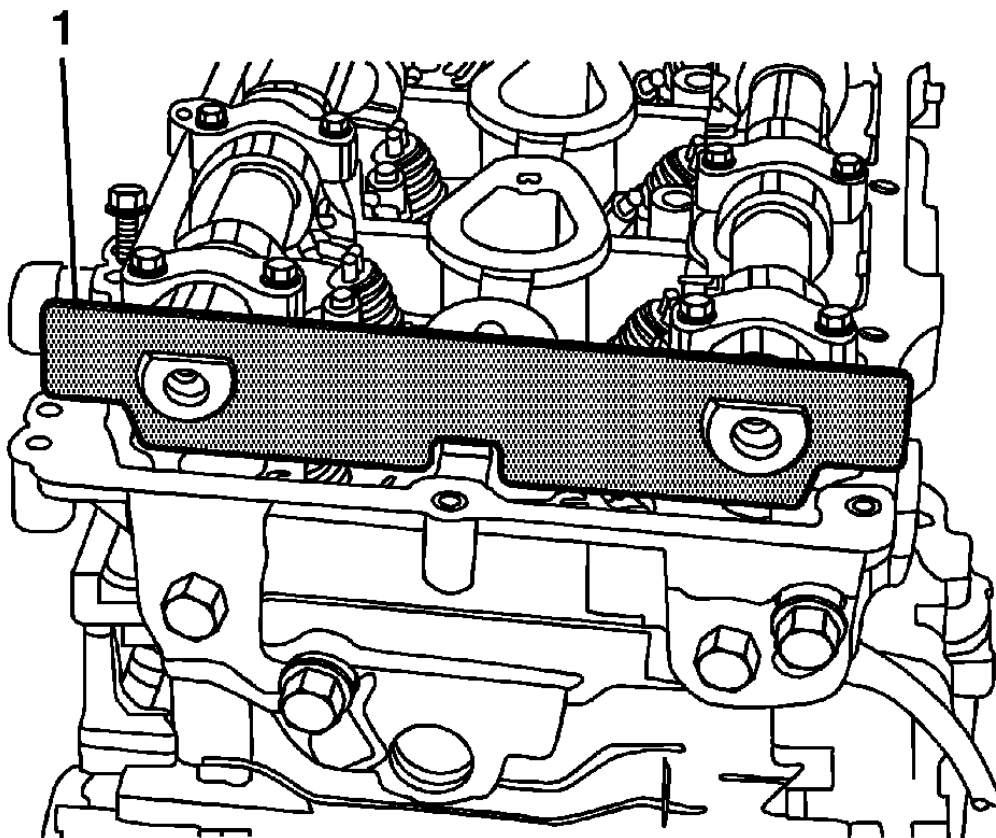


Fig. 91: Securing Camshafts

Courtesy of GENERAL MOTORS COMPANY

NOTE: DO NOT use the J 44221 camshaft holding tool , installed to the back of the camshafts, as a method to verify timing.

18. Both intake and exhaust camshaft flats should be facing up and flat and level with the cylinder head. If J 44221 camshaft holding tool (1) is used to verify cam timing, you could be off approximately one tooth and cause DTC P0017 to set. If a worn or new J 44221 camshaft holding tool is used to verify timing, the timing will be off.

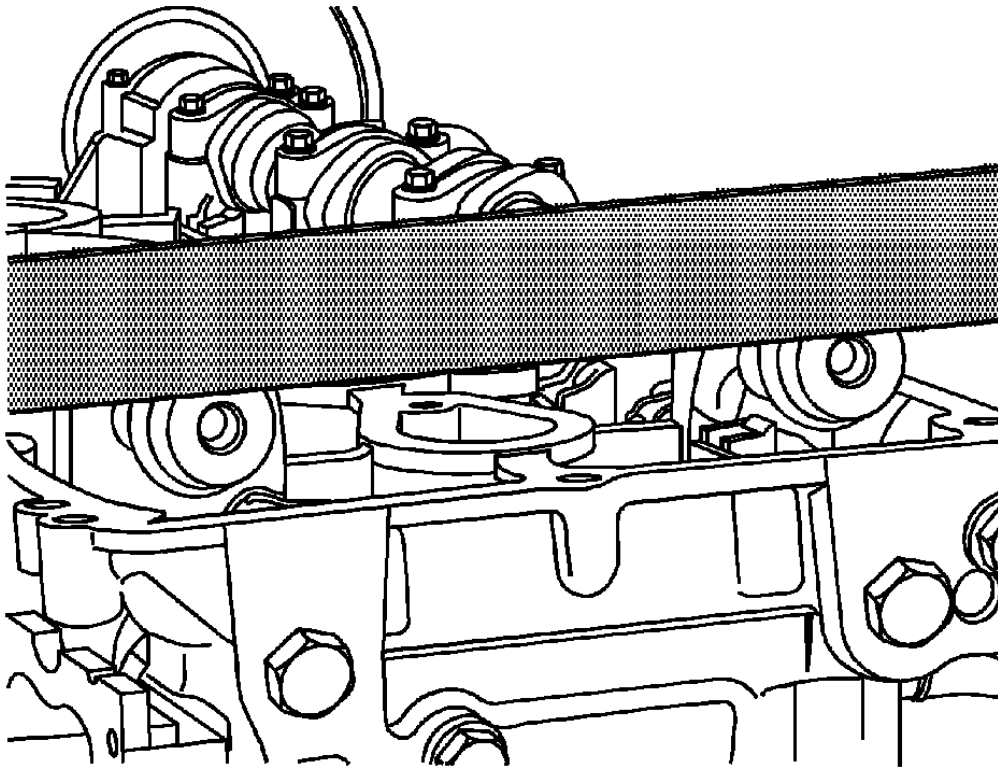


Fig. 92: Verifying Camshaft Placement With Straightedge
Courtesy of GENERAL MOTORS COMPANY

19. To verify timing, set a straight edge across the flats of the camshafts.

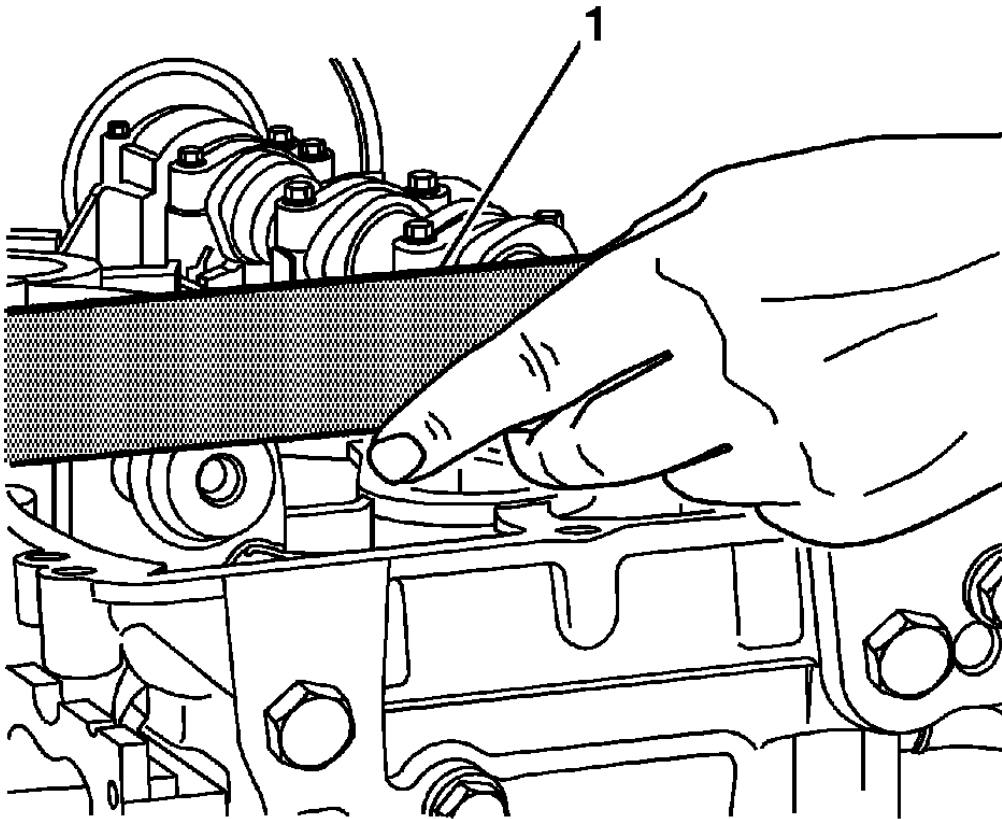


Fig. 93: Measuring Clearance Under Camshaft Flats
 Courtesy of GENERAL MOTORS COMPANY

20. A 0.005 inch feeler gauge should not be able to slip under the straight edge (1). If the feeler gauge slips under one or both camshaft flats, then the timing is off. Repeat step 20 and recheck. If the camshaft flats are still not flat, the camshaft timing will have to be reset. This may require removal and reinstallation of one or both camshaft sprockets.
21. Install the 1 long and 2 short cylinder head bolts next to the exhaust and intake timing chain tensioner shoes and tighten the bolts.
22. Position the upper timing chain guide to the cylinder head. Apply threadlocker GM P/N 89021297 (Canadian P/N 10953488) to the upper timing chain guide bolt threads.
23. Install the upper timing chain guide bolts and tighten to 10 N.m (89 lb in).
24. Install the radiator inlet hose and clamp to the cylinder head. Refer to **Radiator Inlet Hose Replacement (LLV, LLR)**.
25. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection**.

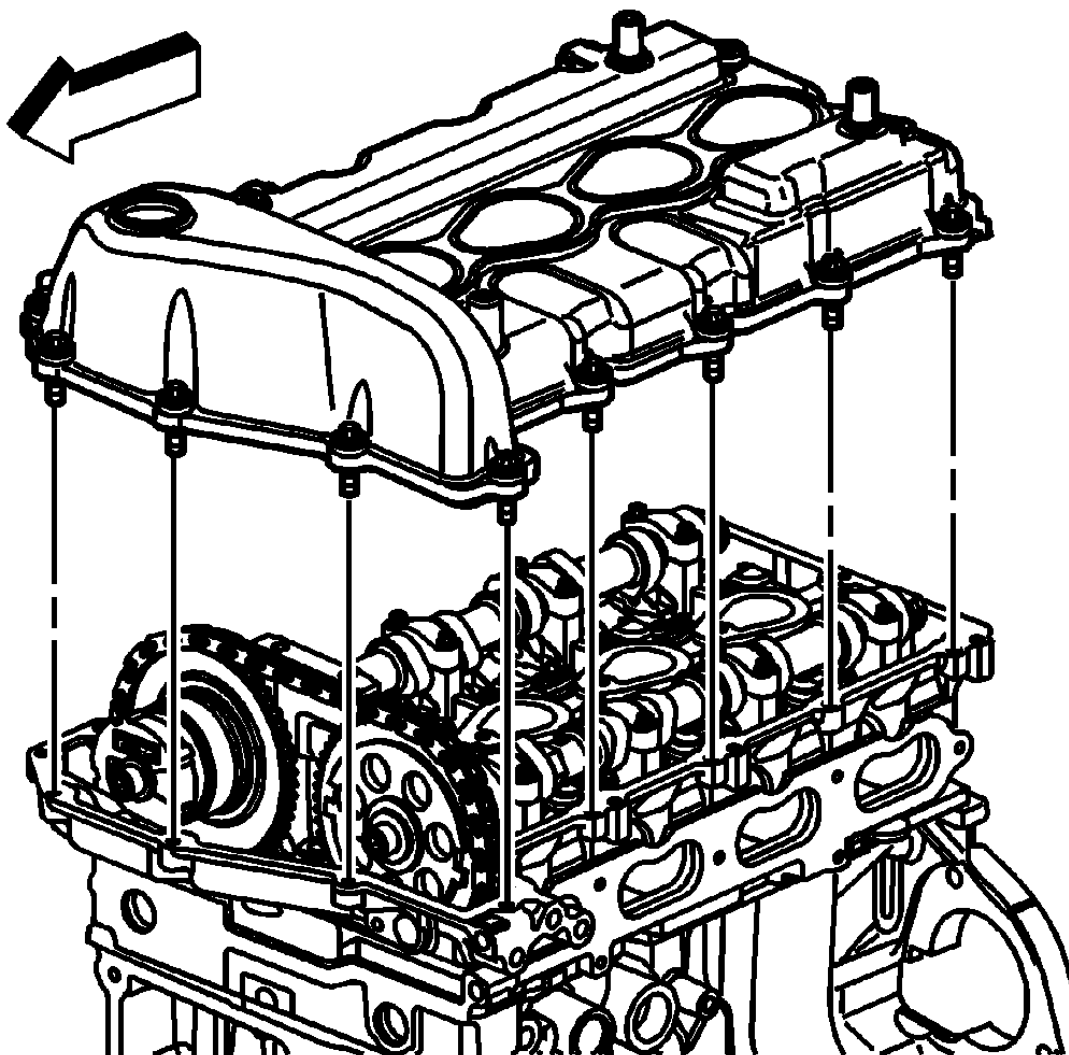


Fig. 94: View Of Camshaft Cover

Courtesy of GENERAL MOTORS COMPANY

26. Install a NEW camshaft cover seal and NEW ignition control module seals to the cam cover. Position the camshaft cover to the cylinder head.
27. Install the camshaft cover bolts and tighten to 10 N.m (89 lb in).
28. Check the gap on all of the spark plugs. The gap should be 1.08 mm (0.042 in). Tighten all of the spark plugs to 18 N.m (13 lb ft).
29. Install the ignition coils into the camshaft cover.

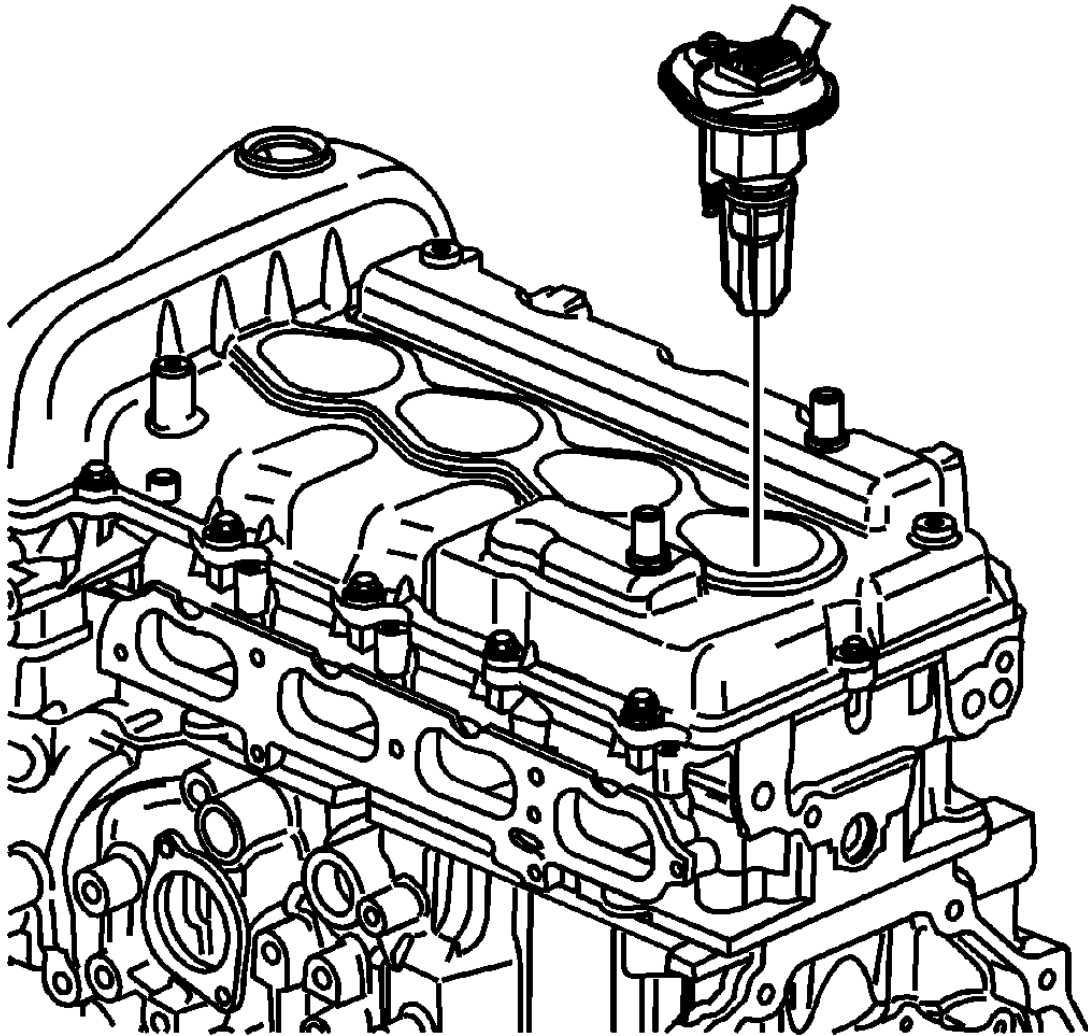


Fig. 95: View Of Ignition Control Module
Courtesy of GENERAL MOTORS COMPANY

30. Install the ignition coil bolts and tighten to 10 N.m (89 lb in).
31. Reposition the exhaust manifold to cylinder head and install the exhaust manifold bolts to the cylinder head. Refer to **Exhaust Manifold Replacement (LLV)** .
32. If equipped, install a NEW AIR injection gasket, then the cover and pipe studs to the cylinder head. Tighten the pipe studs to 25 N.m (18 lb ft).
33. Install the exhaust manifold heat shield to the exhaust manifold.
34. Apply anti-seize GM P/N 12371386 (Canadian P/N 89021945) to the exhaust manifold heat shield nuts.
35. Install the exhaust manifold heat shield nuts and tighten to 10 N.m (89 lb in).
36. Install the intake manifold to the cylinder head. Refer to **Intake Manifold Replacement**.

Four-wheel drive-Raise the vehicle and install the blind intake manifold bolts from the left front wheelhouse access.

Two-wheel drive-The bolts are accessible from the top of the engine.

37. Reposition the engine wiring harness bracket to the engine and harnesses. Install the engine wiring harness bracket bolts and tighten to 10 N.m (89 lb in).
38. Install the left front wheelhouse panel and the left wheel and tire. Refer to **Front Wheelhouse Liner Replacement**.
39. If removed, install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LLV, LLR)**.
40. Install the oil pan skid plate and the engine shield. Refer to **Engine Protection Shield Replacement**.
41. Install the engine shield.
42. Lower the vehicle.
43. Install the cross-vehicle wiring harness connectors to the following components:
 - PCM
 - Map sensor
 - Ignition coils
 - Harness clamps at power steering pump
 - Wiring harness fastener at right front inner fender
 - Throttle body
 - Camshaft sensors
 - Exhaust camshaft actuator
 - Fuel injectors
 - HO2S 1
44. Install the windshield washer solvent container and coolant recovery reservoir bolts to the right inner fender. Tighten the bolts to 10 N.m (89 lb in).
45. Install the PCV pipes to the intake manifold. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.
46. Reposition the oil indicator (dipstick) tube and tighten the bolt to the intake manifold. Refer to **Oil Level Indicator Tube Replacement**.
47. Reposition the fuel/EVAP lines to the intake manifold retainer. Refer to **Evaporative Emission Line Replacement - Engine**.
48. Install the following components:
 - Generator-Refer to **Generator Replacement (LLV/LLR)**.
 - A/C compressor hose/pipe bracket clamp for the engine lift bracket-Refer to **Engine Lift Bracket Replacement**.
 - Drive belt-Refer to **Drive Belt Replacement**.
49. Install the battery. Refer to **Battery Replacement (LLV/LLR)**.
50. Install the air induction assembly. Refer to **Air Cleaner Resonator and Outlet Duct Replacement**, and **Air Cleaner Assembly Replacement**.
51. Change the engine oil and filter. Refer to **Engine Oil and Oil Filter Replacement**.
52. Install NEW coolant. Refer to **Cooling System Draining and Filling (Static Fill)**, **Cooling System Draining and Filling (Vac N Fill)**.

53. Install a scan tool and start the engine.

1. Check for DTCs.
2. Check for fluid leaks.
3. Road test the vehicle. DTC P0017 is a Type B diagnostic code. Three consecutive ignition key cycles must be performed during the road test with a minimum of a one minute run time between key cycles to verify that a DTC P0017 did not set. For further information on DTC P0017, refer to **DTC P0017**.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **EN 46547** Flywheel Holding Tool
- **EN-48034** Harmonic Balancer Installer
- **J 41816-A** Crankshaft Balancer Remover
- **J 41816-2** Crankshaft End Protector
- **J 45059** Angle Meter

Removal Procedure

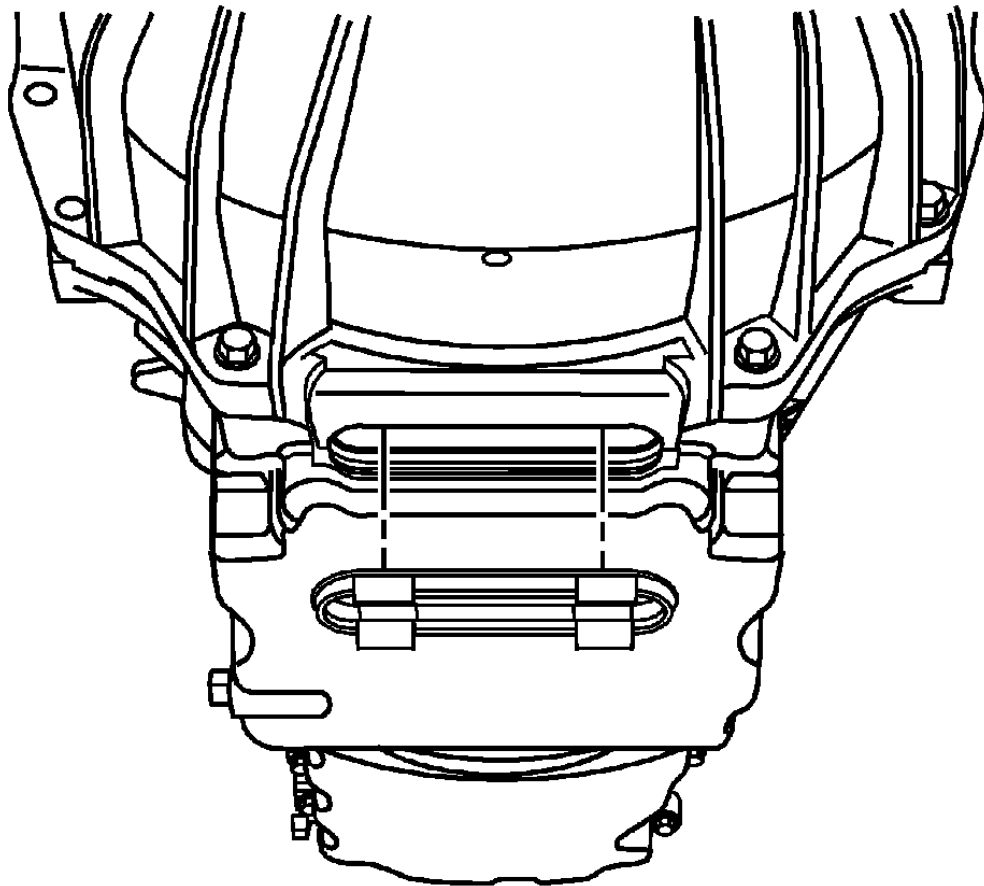


Fig. 96: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

1. Remove the radiator. Refer to **Radiator Replacement** .
2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the service slot plug.

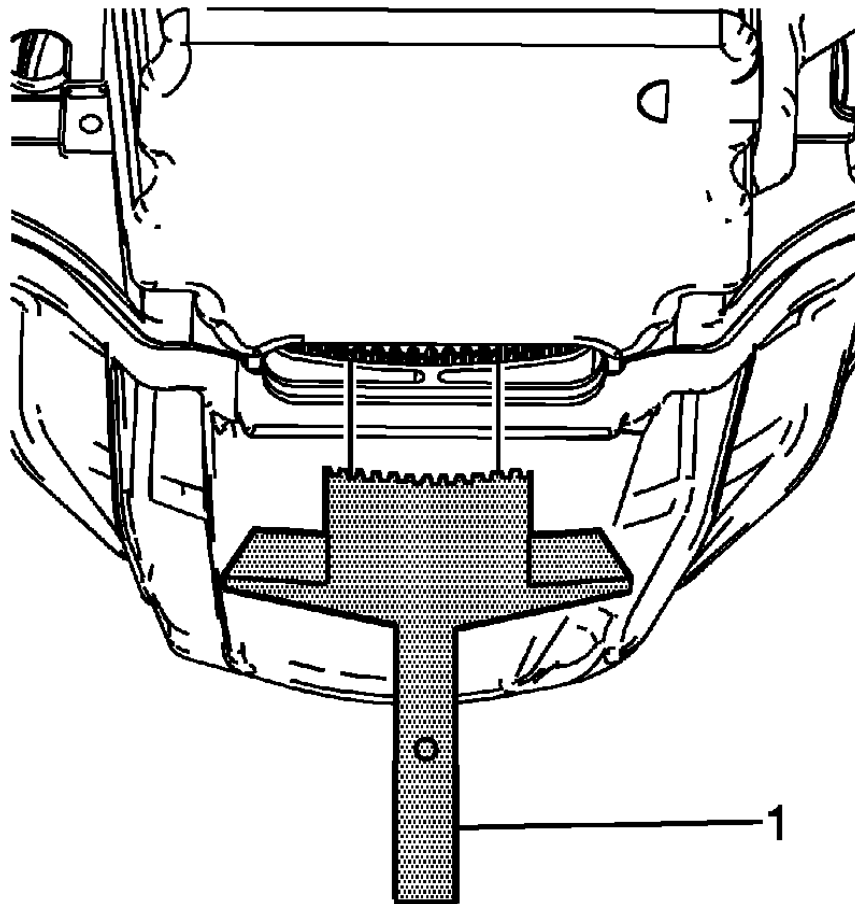


Fig. 97: Flywheel Holding Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft balancer does not have a key-way; so the crankshaft could turn when tightening, causing an improper torque.

5. Install the **EN 46547** flywheel holding tool (1) into the flywheel teeth.
6. Lower the vehicle.

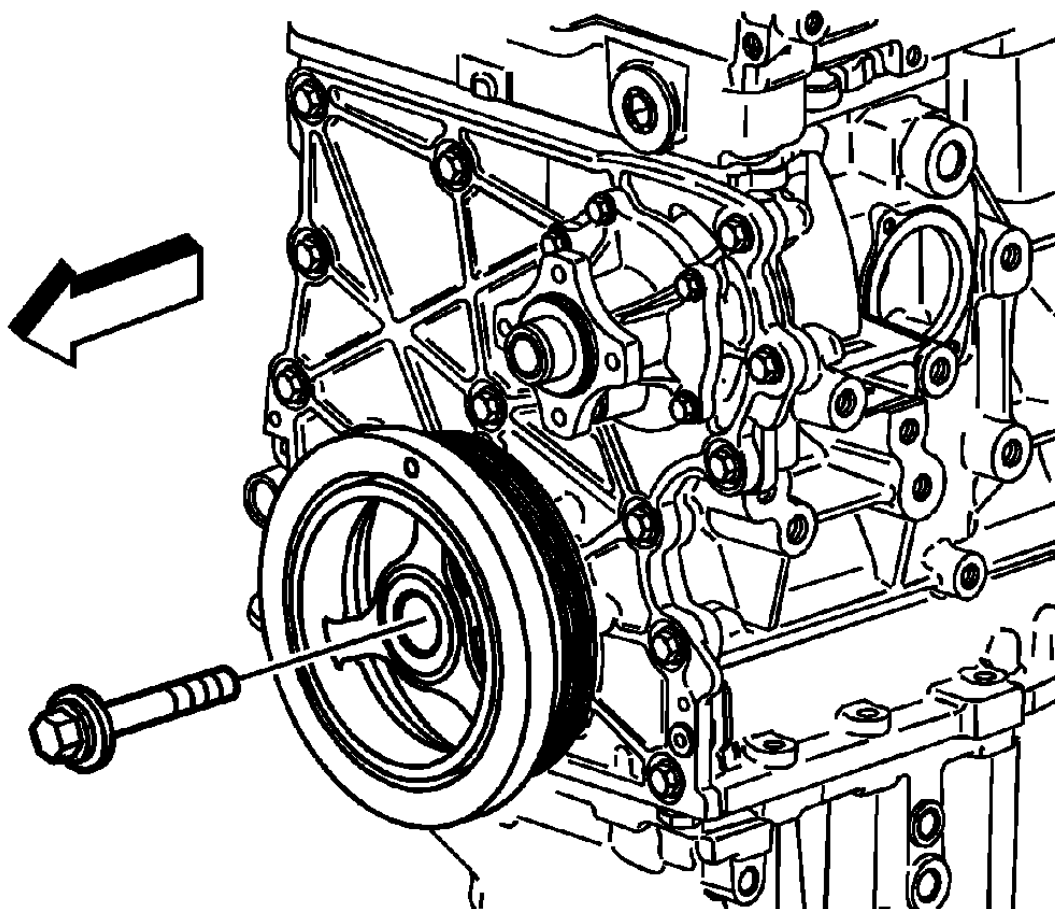


Fig. 98: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Remove and discard the crankshaft balancer bolt.

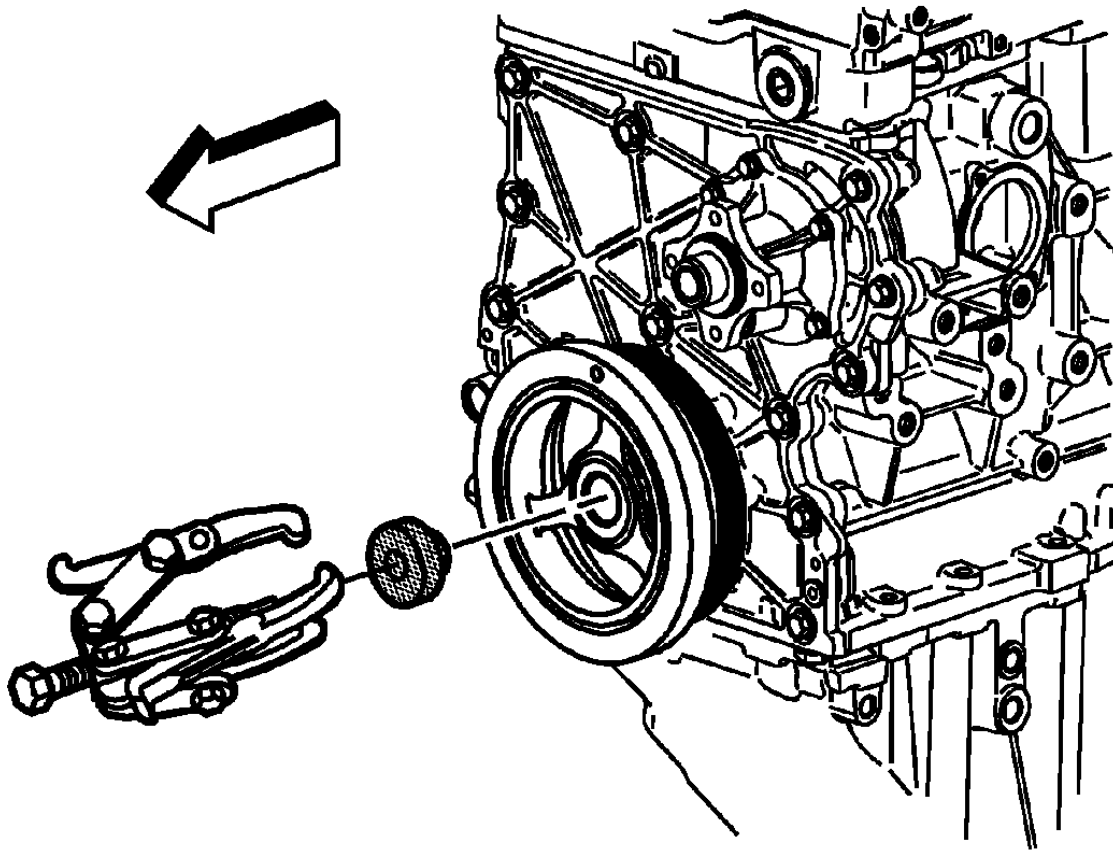


Fig. 99: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

8. Install the **J 41816-2** crankshaft end protector and **J 41816-A** crankshaft balancer remover to the crankshaft balancer.

NOTE: Do not pull on outer edge of the crankshaft balancer.

9. Remove the crankshaft balancer.
10. Remove the **J 41816-2** crankshaft end protector and **J 41816-A** crankshaft balancer remover.

Installation Procedure

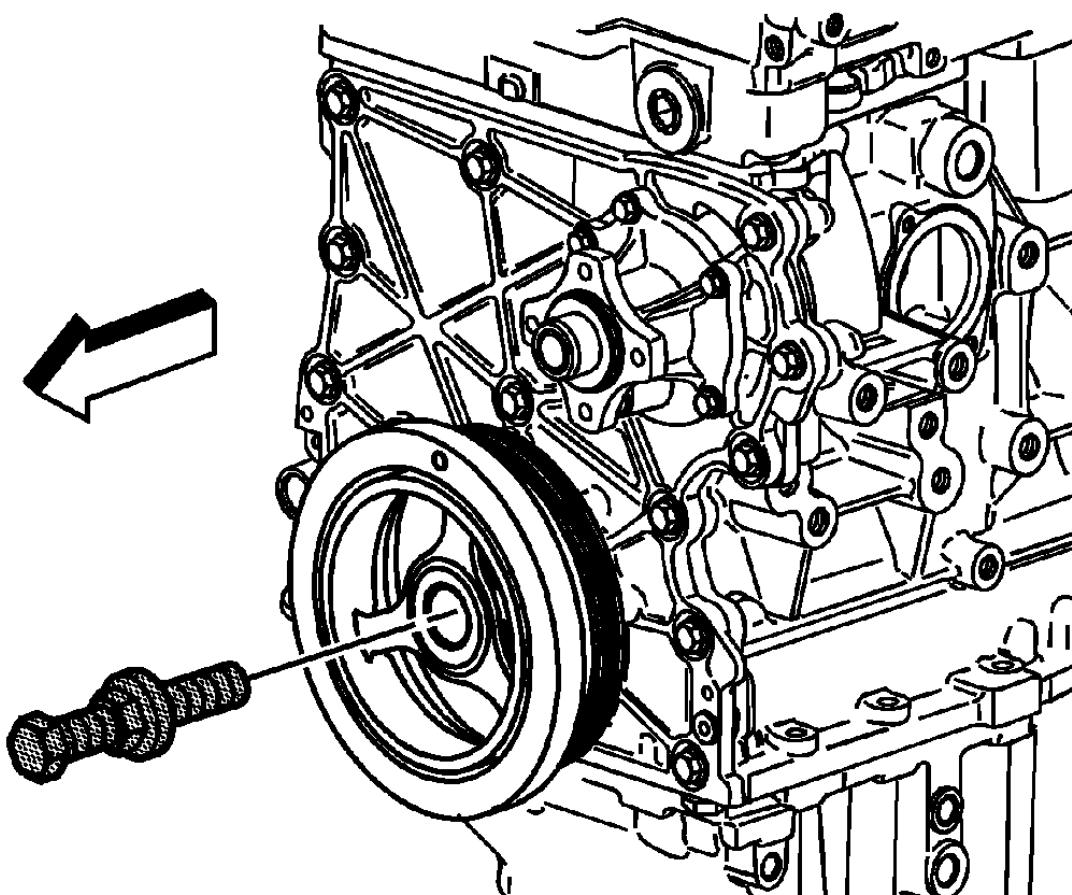


Fig. 100: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft balancer using the **EN-48034** harmonic balancer installer.
2. Remove the **EN-48034** harmonic balancer installer.

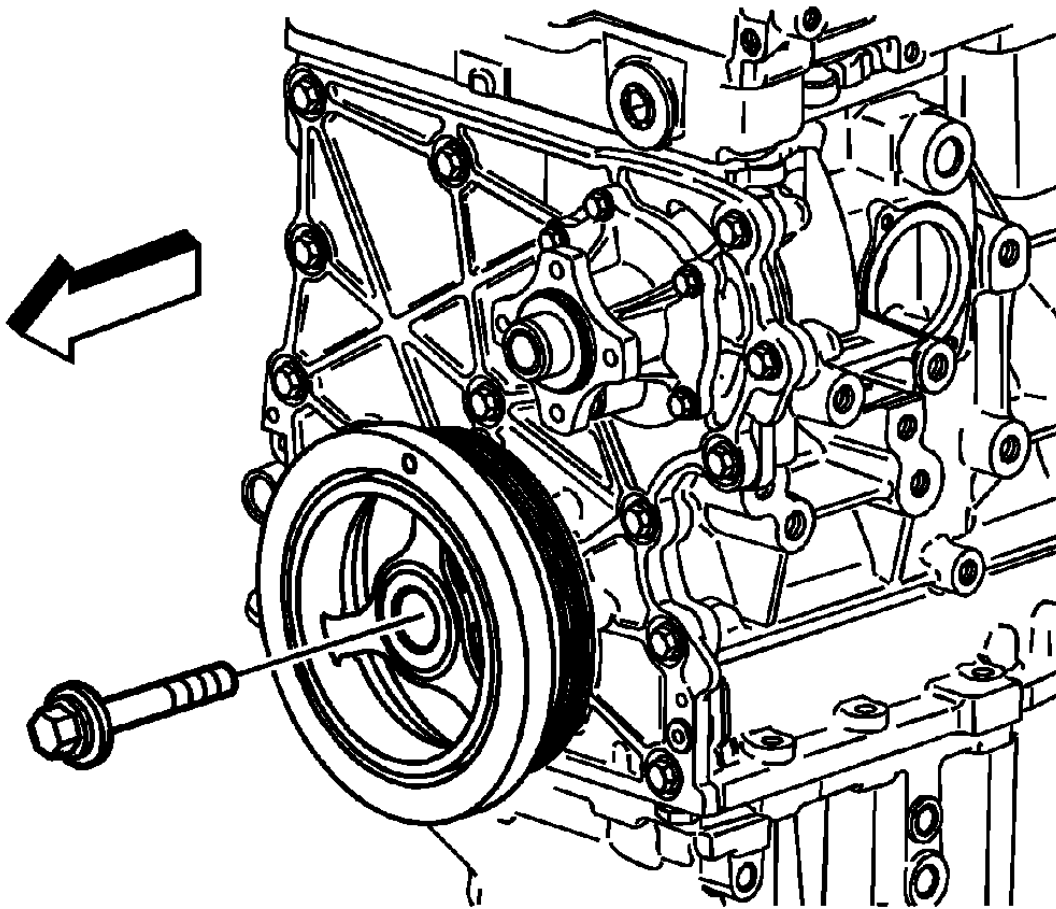


Fig. 101: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Install the crankshaft balancer washer and NEW bolt and tighten to 150 N.m (111 lb ft) plus an additional 180 degrees using the **J 45059** angle meter.
4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .

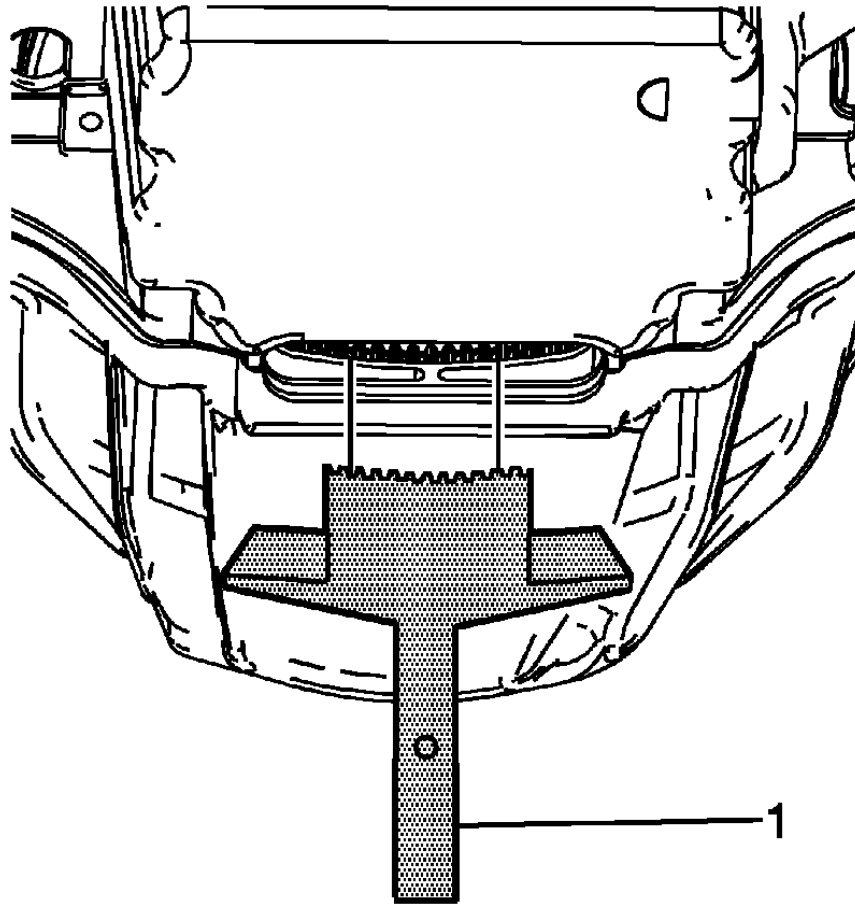


Fig. 102: Flywheel Holding Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN 46547** flywheel holding tool (1) from the flywheel teeth.

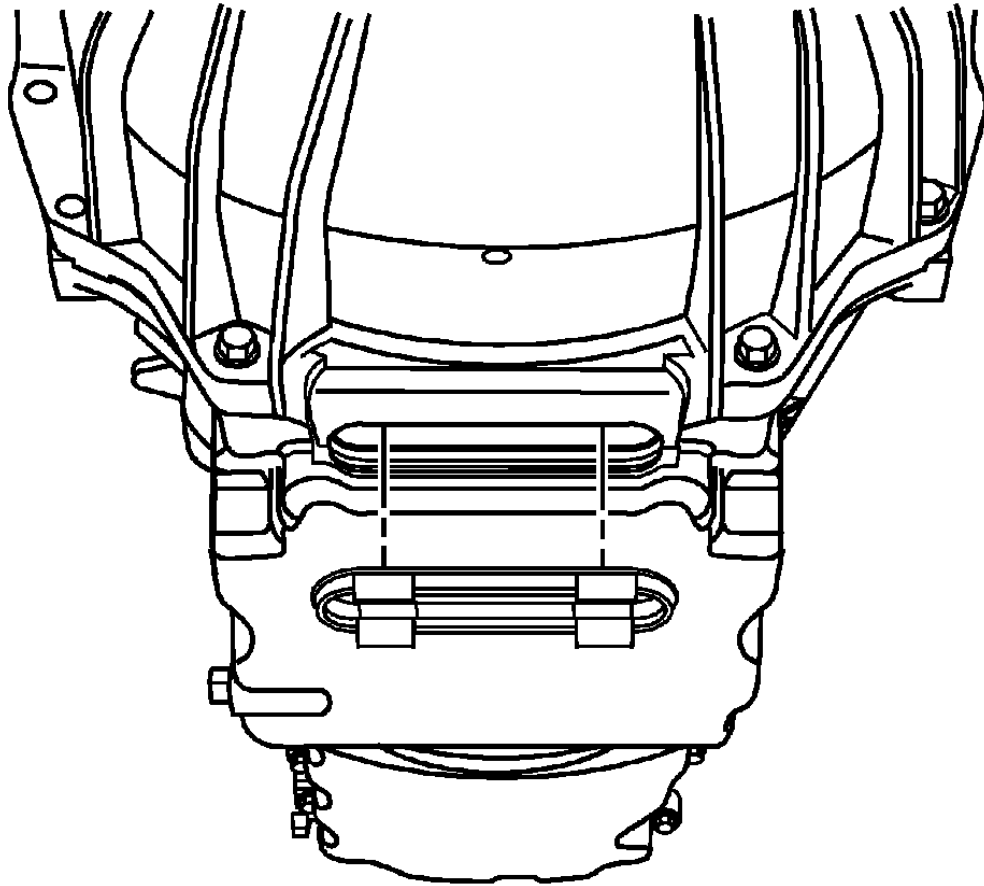


Fig. 103: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

6. Install the service slot plug.
7. Lower the vehicle.
8. Install the drive belt. Refer to **Drive Belt Replacement**.
9. Install the radiator. Refer to **Radiator Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

J 45951 Front Seal Installer

Removal Procedure

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

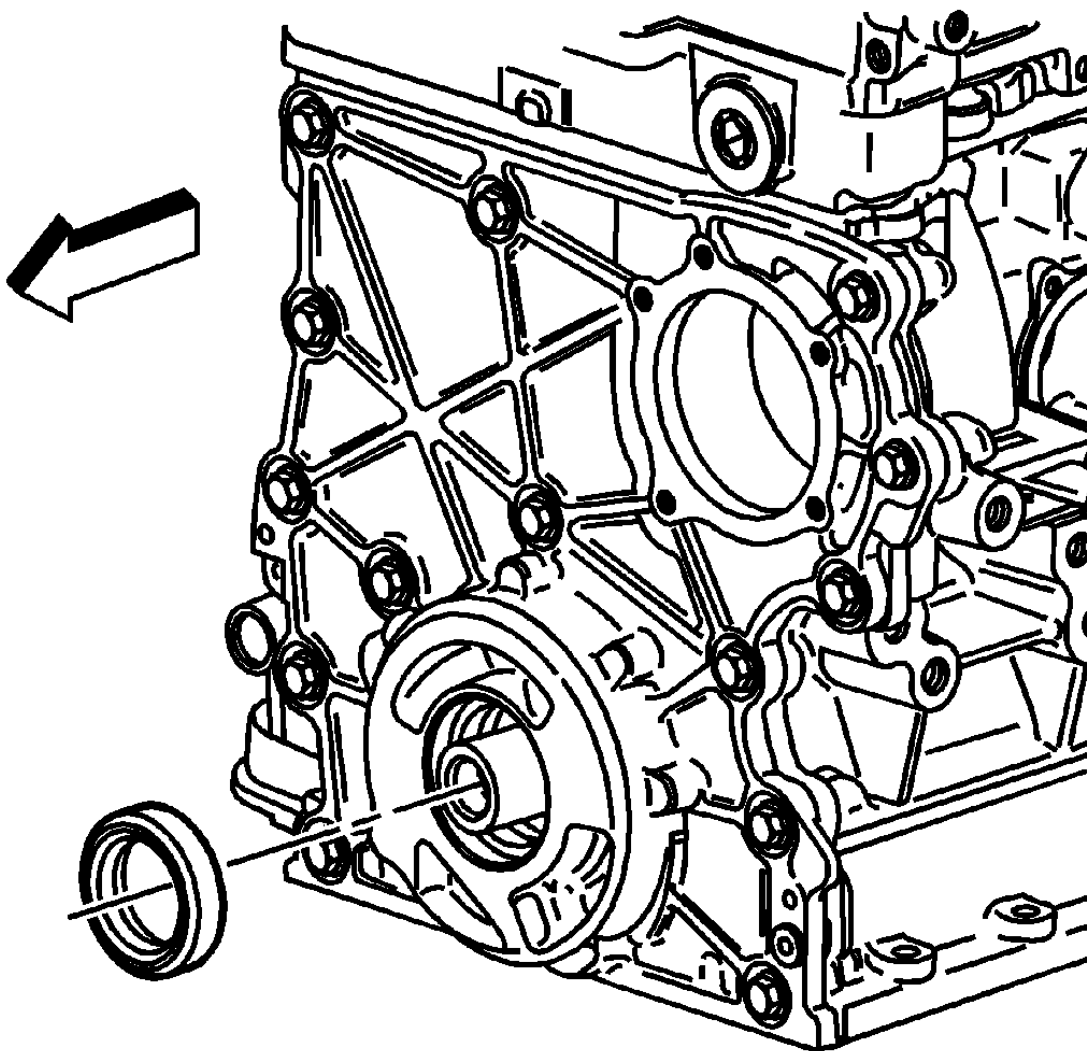


Fig. 104: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Do not damage the engine front cover or the crankshaft.

2. Pry out the crankshaft front oil seal using a suitable tool and discard the seal.

Installation Procedure

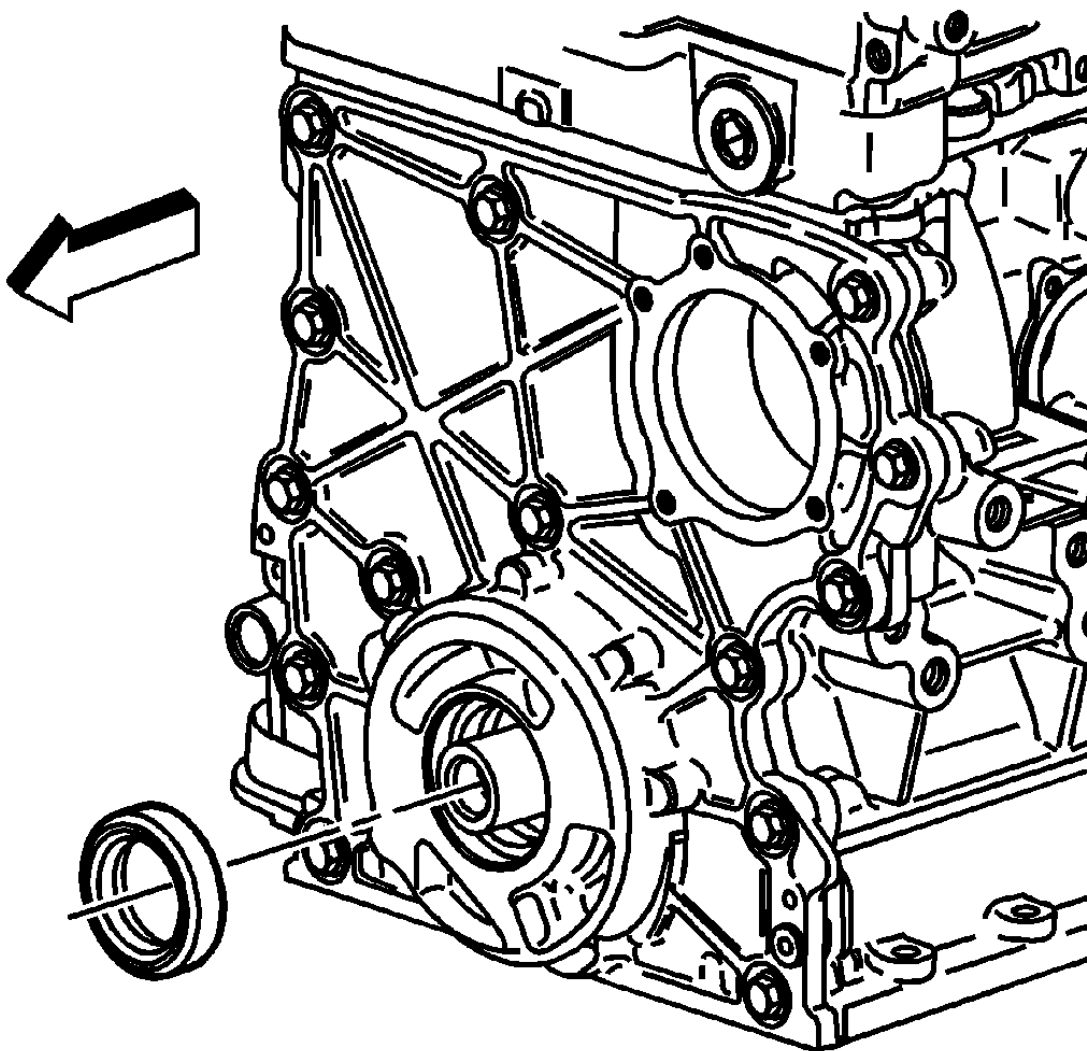


Fig. 105: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

1. Apply the engine oil to the outside diameter of the crankshaft front oil seal.

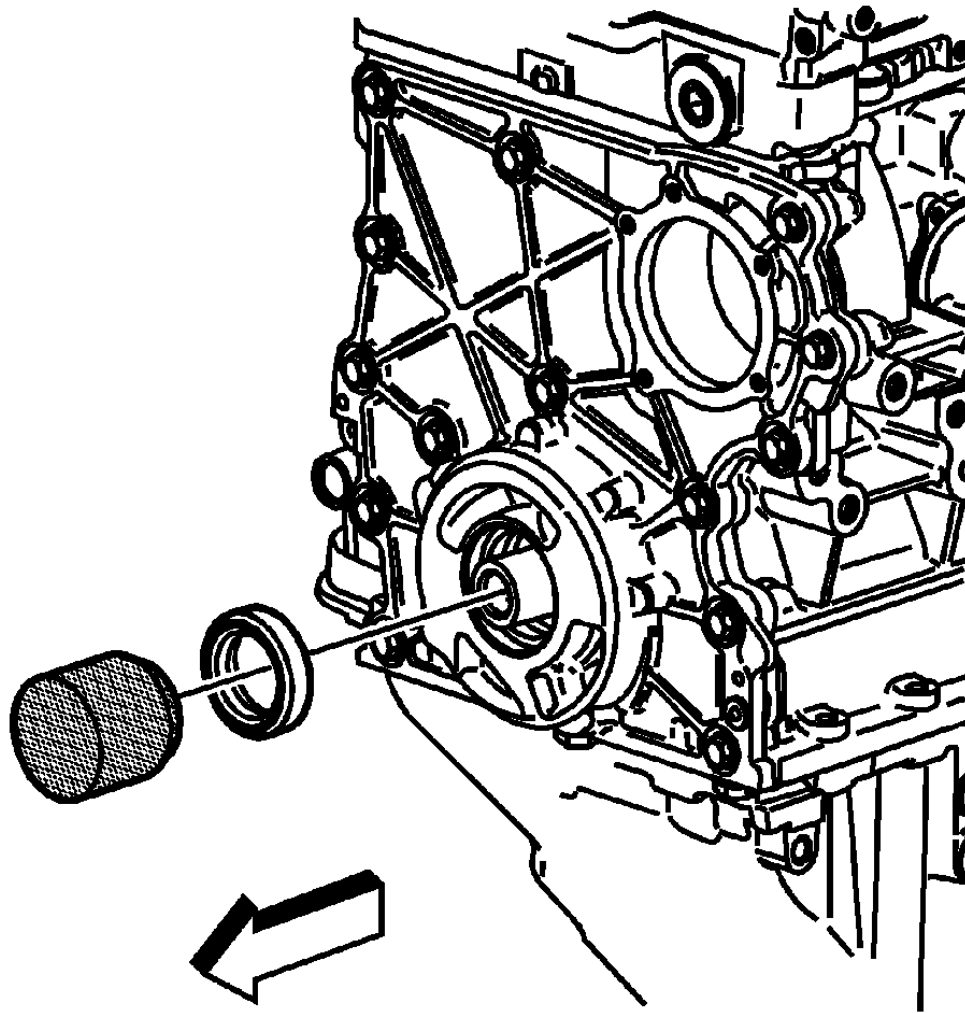


Fig. 106: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. Use the **J 45951** front seal installer to install the NEW crankshaft front oil seal.
3. Remove the **J 45951** front seal installer.
4. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Special Tools

J 44219 Cover Alignment Pins

Removal Procedure

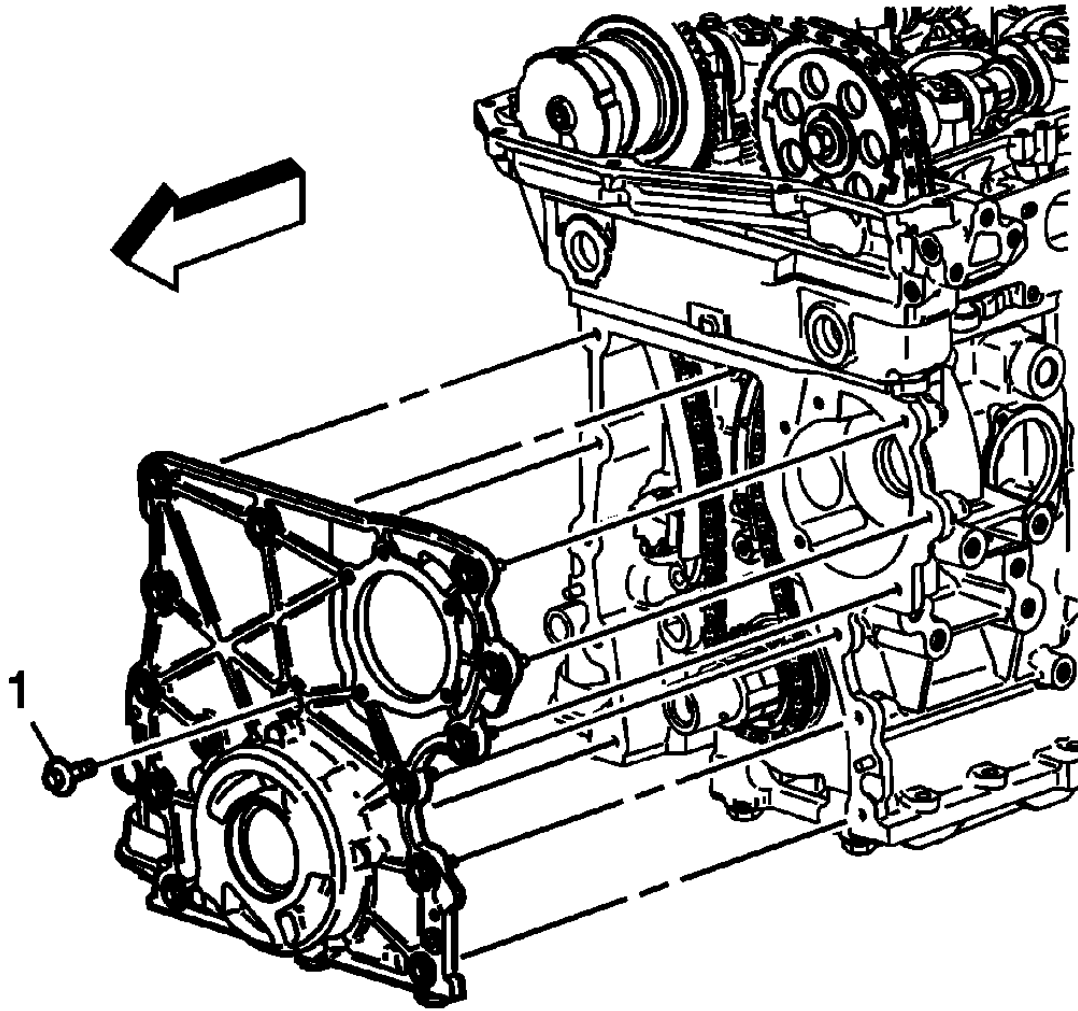


Fig. 107: View Of 7 mm Center Bolt
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the water pump. Refer to **Water Pump Replacement (LLV,LLR)** .
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
4. Remove the power steering pump. Refer to **Power Steering Pump Replacement (LLV, LLR)** .
5. Remove the oil pump pipe and screen assembly. Refer to **Oil Pump Suction Pipe and Screen Assembly Replacement**.
6. Lower the vehicle.
7. Remove the 7 mm center bolt (1).
8. Remove the remaining engine front cover bolts.
9. Install 2 bolts into the threaded holes to act as jack screws and tighten evenly to release the engine front cover from the engine block.
10. Remove the engine front cover.

11. Remove the 2 bolts from the jack screw holes.
12. Remove the oil pump, if necessary. Refer to **Oil Pump Replacement**.
13. Clean and inspect the engine block sealing surface.

Installation Procedure

1. Install the oil pump, if previously removed. Refer to **Oil Pump Replacement**.

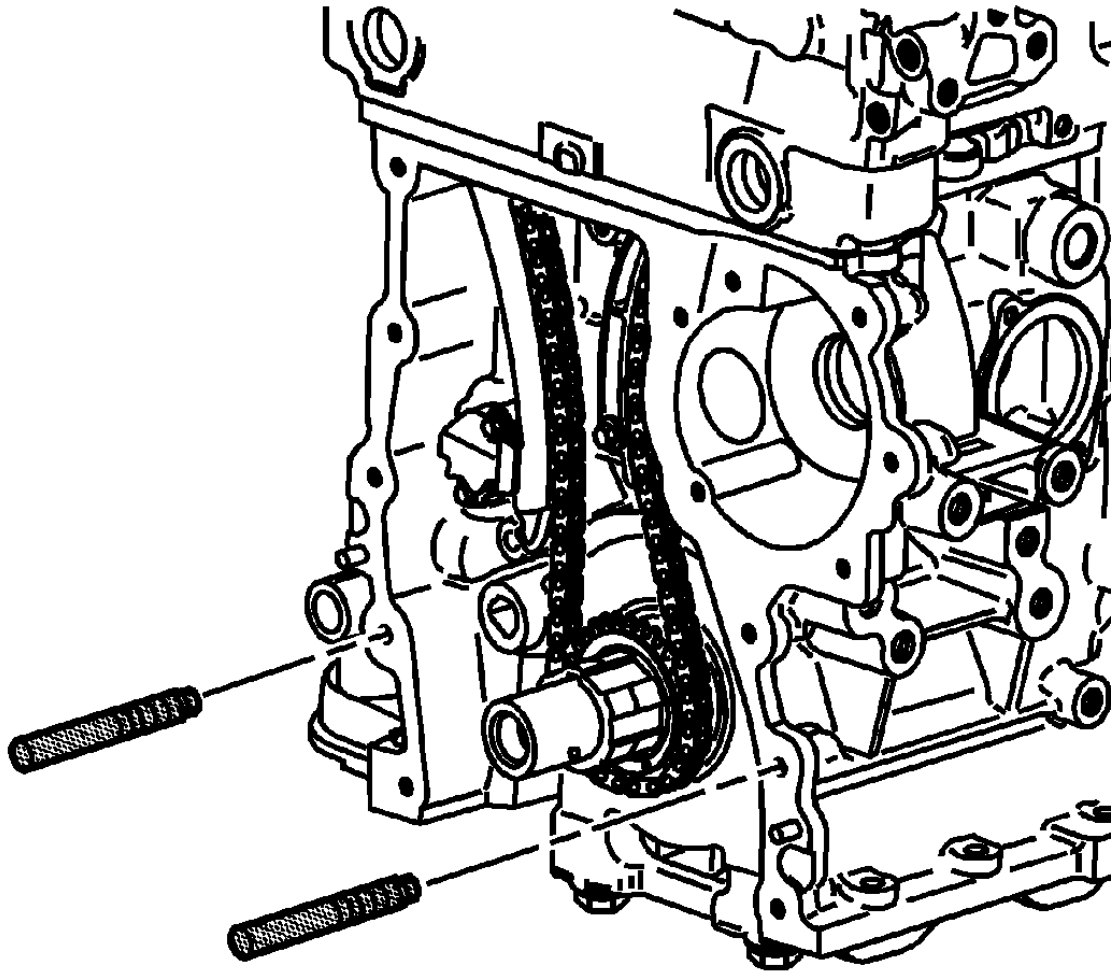


Fig. 108: Cover Alignment Pins

Courtesy of GENERAL MOTORS COMPANY

2. To aid in alignment of the cover, thread the **J 44219** cover alignment pins into the engine block.

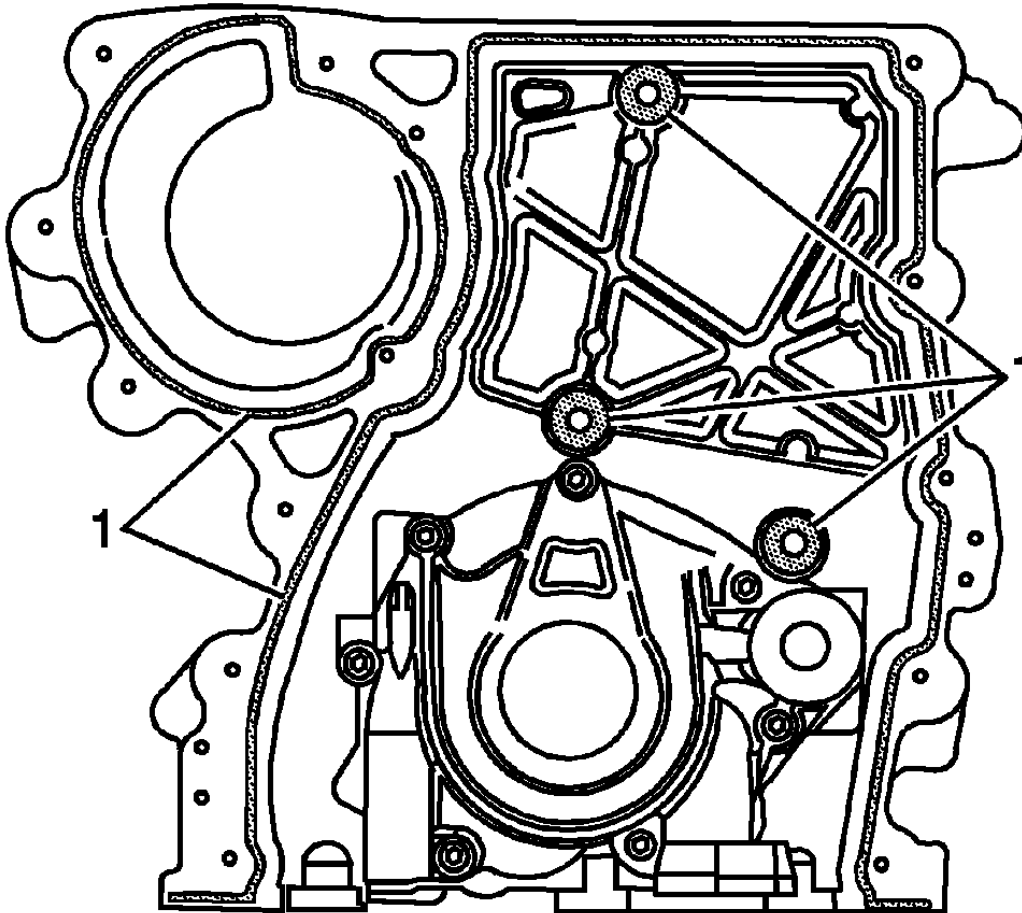


Fig. 109: Applying Sealant To Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine front cover must be installed within 10 minutes from when the sealer was applied.

3. Apply a 3 mm (0.12 in) bead of sealer to the engine front cover (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

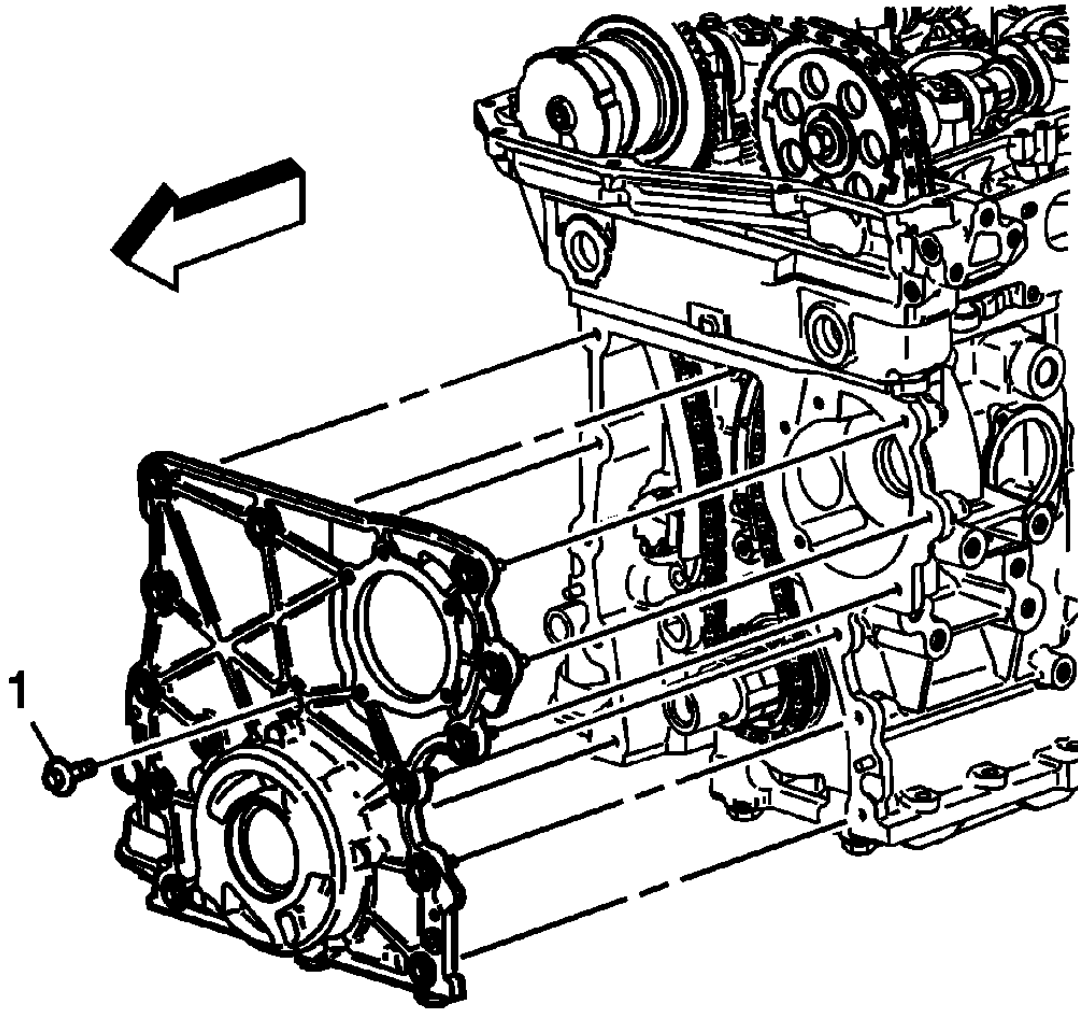


Fig. 110: View Of 7 mm Center Bolt
 Courtesy of GENERAL MOTORS COMPANY

4. Align the oil pump to the crankshaft sprocket splines.
5. Position the engine front cover over the **J 44219** cover alignment pins , and to the engine block.
6. Install the engine front cover bolts.
7. Remove the **J 44219** cover alignment pins from the engine block.

CAUTION: Refer to Fastener Caution .

8. Install the 2 remaining engine front cover bolts.
 - Tighten the bolts to 10 N.m (89 lb in).
 - Tighten the small center bolt (1) last to 8 N.m (71 lb in).
9. Install the oil pump pipe and screen assembly. Refer to **Oil Pump Suction Pipe and Screen Assembly**

Replacement.

10. Install the power steering pump. Refer to **Power Steering Pump Replacement (LLV, LLR)** .
11. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
12. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
13. Install the water pump. Refer to **Water Pump Replacement (LLV/LLR)** .

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT**Special Tools**

- **J-44217** Timing Chain Retention Tool
- **J-44217-45** Chain Holding Tool
- **J-44221** Camshaft Holding Tool
- **J-45059** Angle Meter

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

Removal Procedure

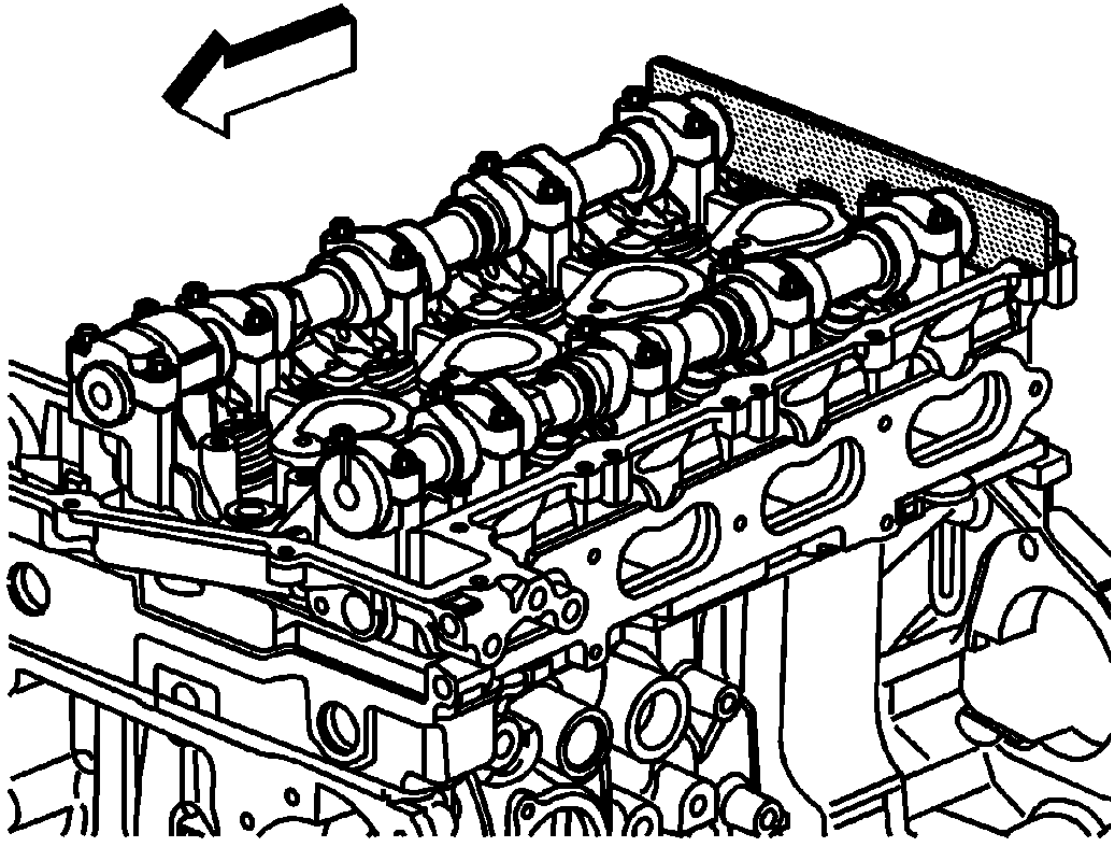


Fig. 111: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
2. Remove the CMP sensor. Refer to Camshaft Position Sensor Replacement.
3. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.
4. Using the timing mark on the exhaust camshaft position actuator sprocket as a reference, make a mark on the timing chain link adjacent to it.

WARNING: Refer to Camshaft Holding Tool Warning.

5. Install the **J-44221** holding tool to the rear of the camshafts.

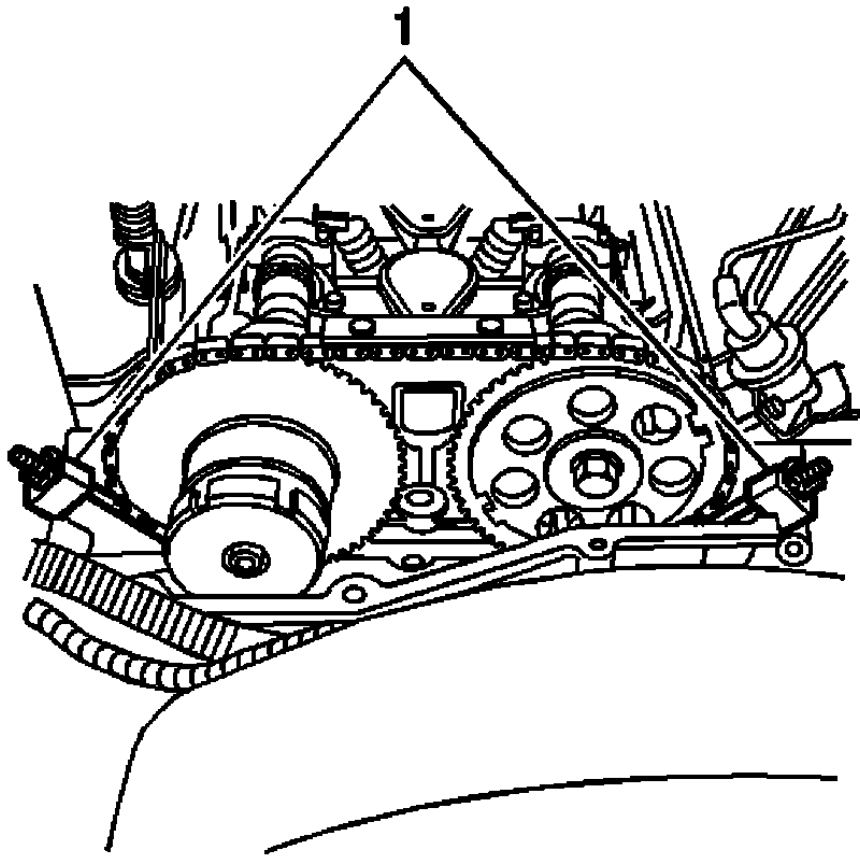


Fig. 112: Timing Chain Retention Tools
 Courtesy of GENERAL MOTORS COMPANY

6. Complete the following in order to install the **J-44217** retention tool (1) and **J-44217-45** holding tool (1).
 1. Install the hook portion of the timing chain retention tools into one of the timing chain links near the timing chain shoe on both sides of the engine.
 2. Tighten the wingnuts.
 3. Ensure the hooks are still in one of the links and the gauge blocks of the tool are firmly in place on the edge of the head.

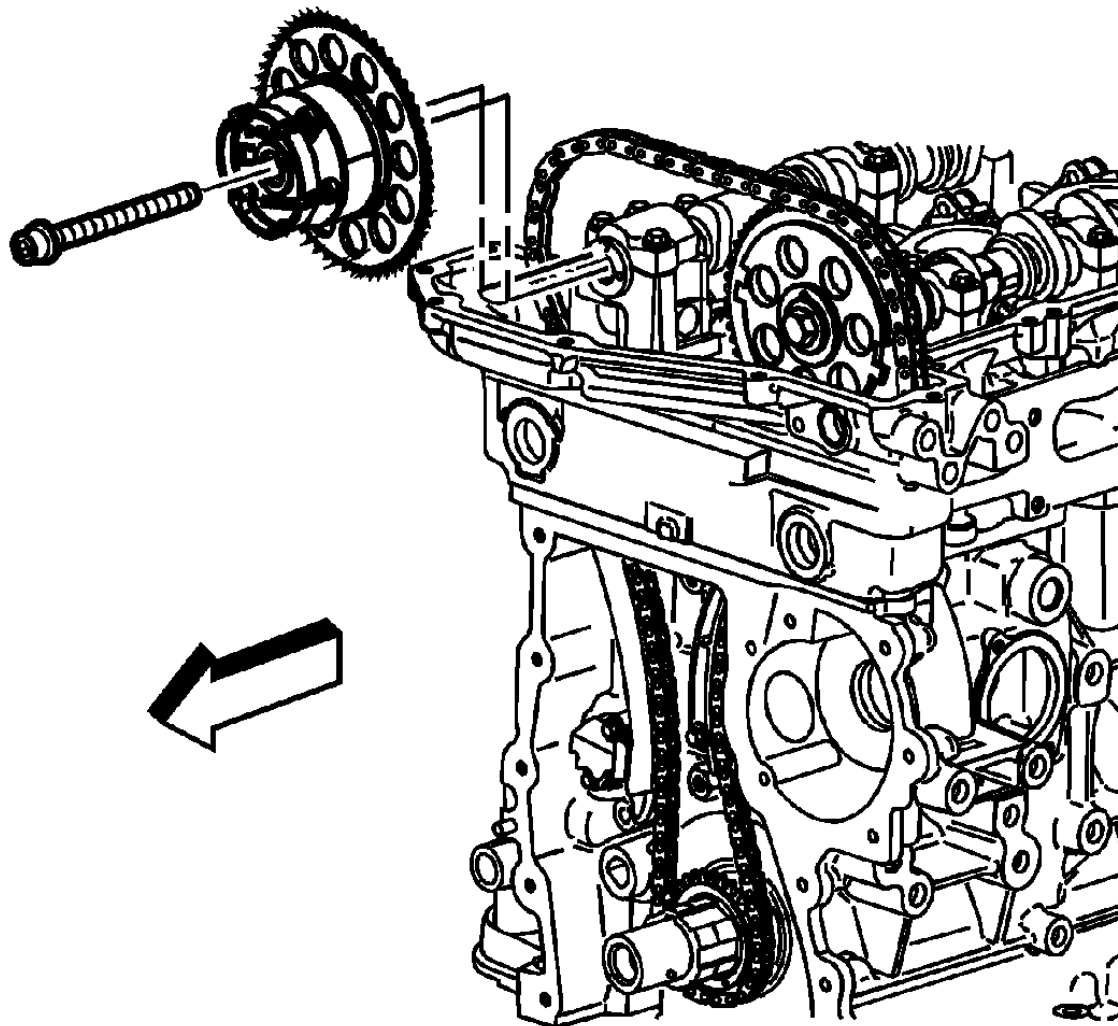


Fig. 113: Identifying Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Remove and discard the exhaust camshaft position actuator bolt.
8. Remove the exhaust camshaft position actuator.

Installation Procedure

1. Ensure the camshaft actuator is fully advanced prior to installation.

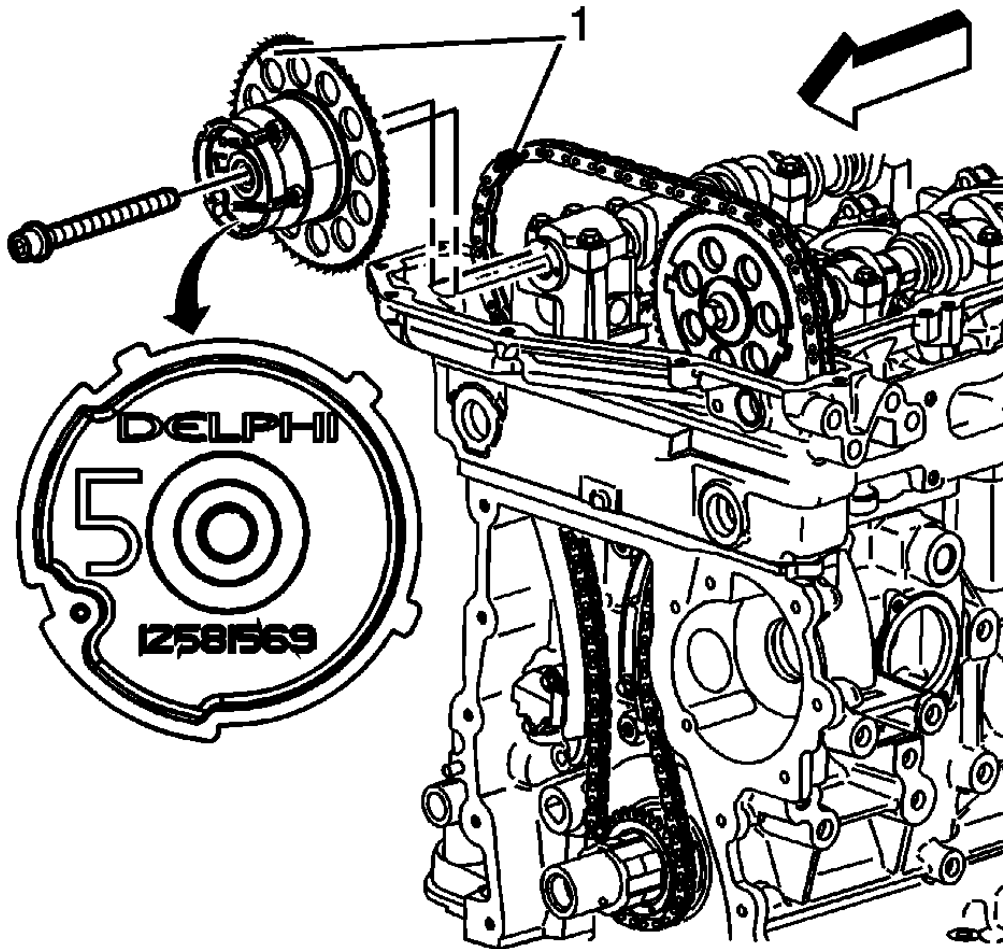


Fig. 114: View Of Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS COMPANY

2. Install the exhaust camshaft actuator into the timing chain.

Aligning the marked link (1) on the timing chain with the timing mark (1) on the exhaust camshaft position actuator sprocket.

NOTE:

- To aid in aligning the actuator to the camshaft , use a 25 mm (1 in) wrench on the hex of the camshaft to rotate.
- Ensure the alignment pin is properly engaged with the camshaft.

3. Install the exhaust camshaft actuator onto the exhaust camshaft.

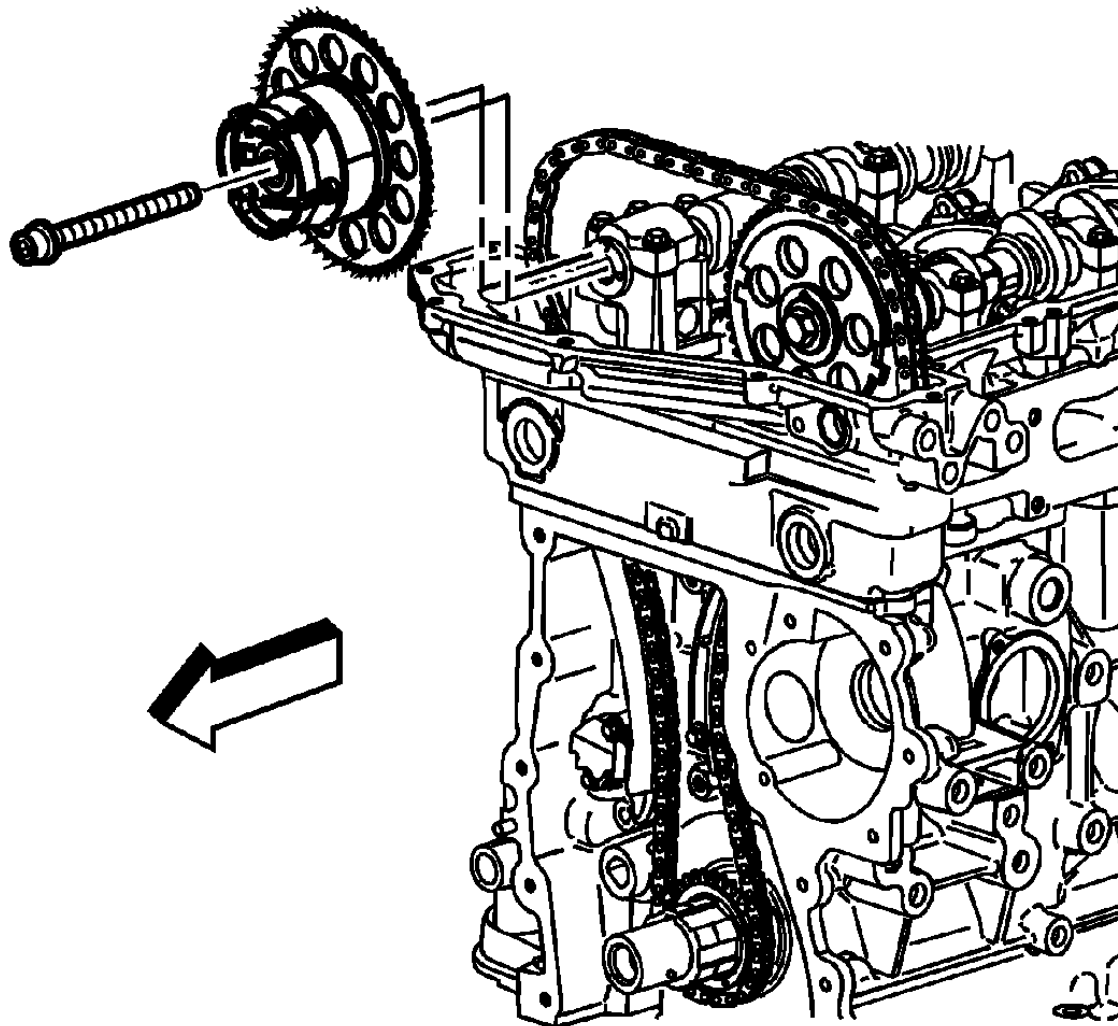


Fig. 115: Identifying Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the new exhaust camshaft actuator bolt. Tighten the bolt to 25 N.m (18 lb ft) plus an additional 135 degrees using the **J-45059** meter.

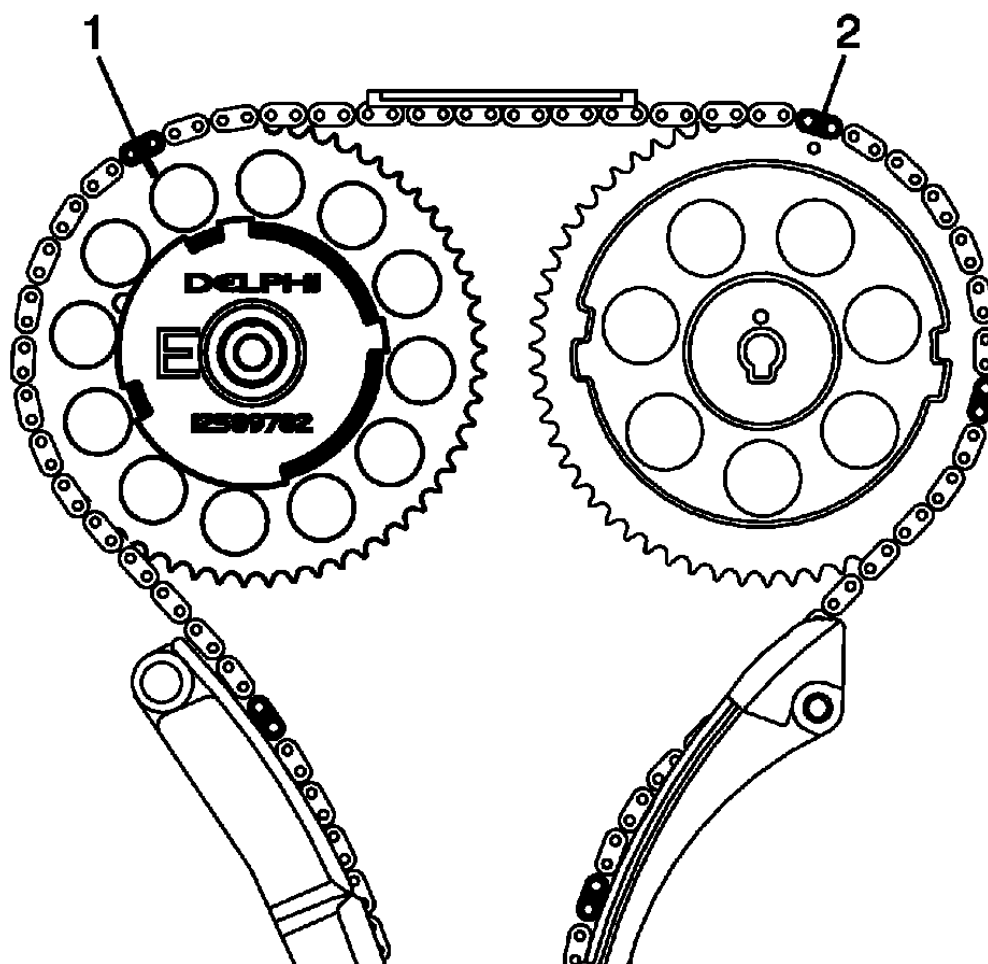


Fig. 116: Identifying Exhaust And Intake Timing Marks
Courtesy of GENERAL MOTORS COMPANY

5. Once the timing is set, ensure there are 15 links between the exhaust timing mark (1) and the intake timing mark (2).

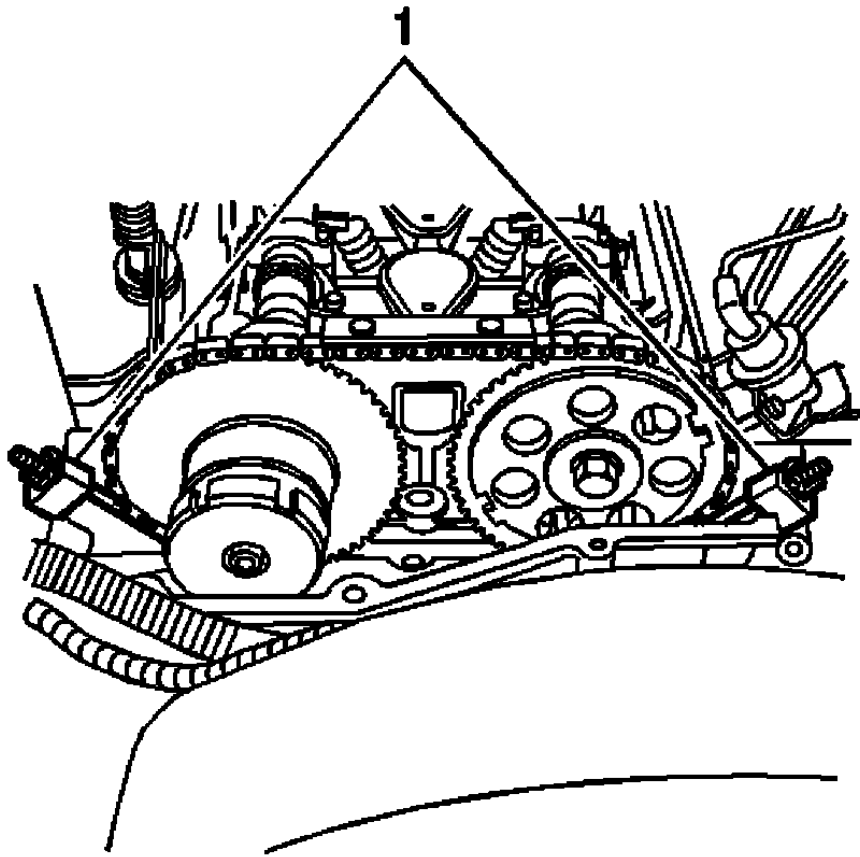


Fig. 117: Timing Chain Retention Tools
Courtesy of GENERAL MOTORS COMPANY

6. Remove the **J-44217** retention tool (1) and **J-44217-45** holding tool (1).

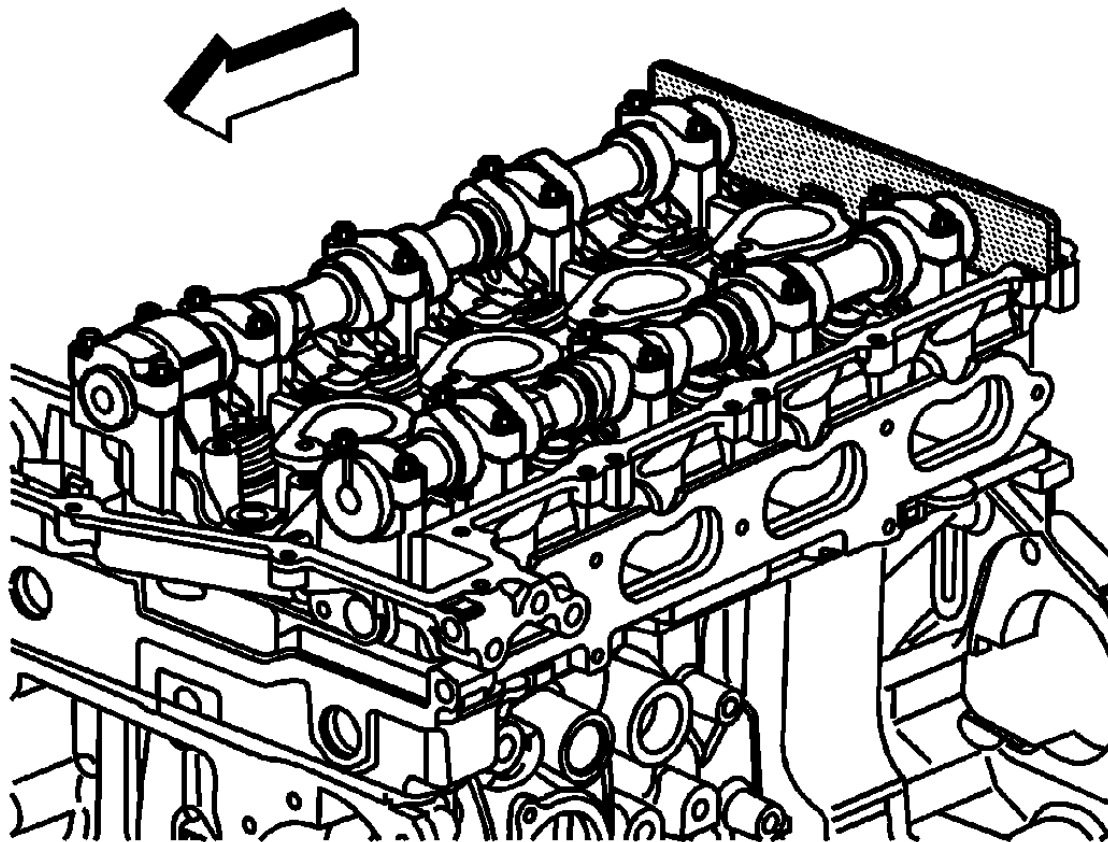


Fig. 118: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

7. Remove the **J-44221** holding tool from the camshafts.
8. Install the CMP sensor. Refer to **Camshaft Position Sensor Replacement** .
9. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT INTAKE SPROCKET REPLACEMENT

Special Tools

- **J 44217** Timing Chain Retention Tool
- **J-44217-45** Chain Holding Tool
- **J 44221** Camshaft Holding Tool
- **J 45059** Angle Meter

Removal Procedure

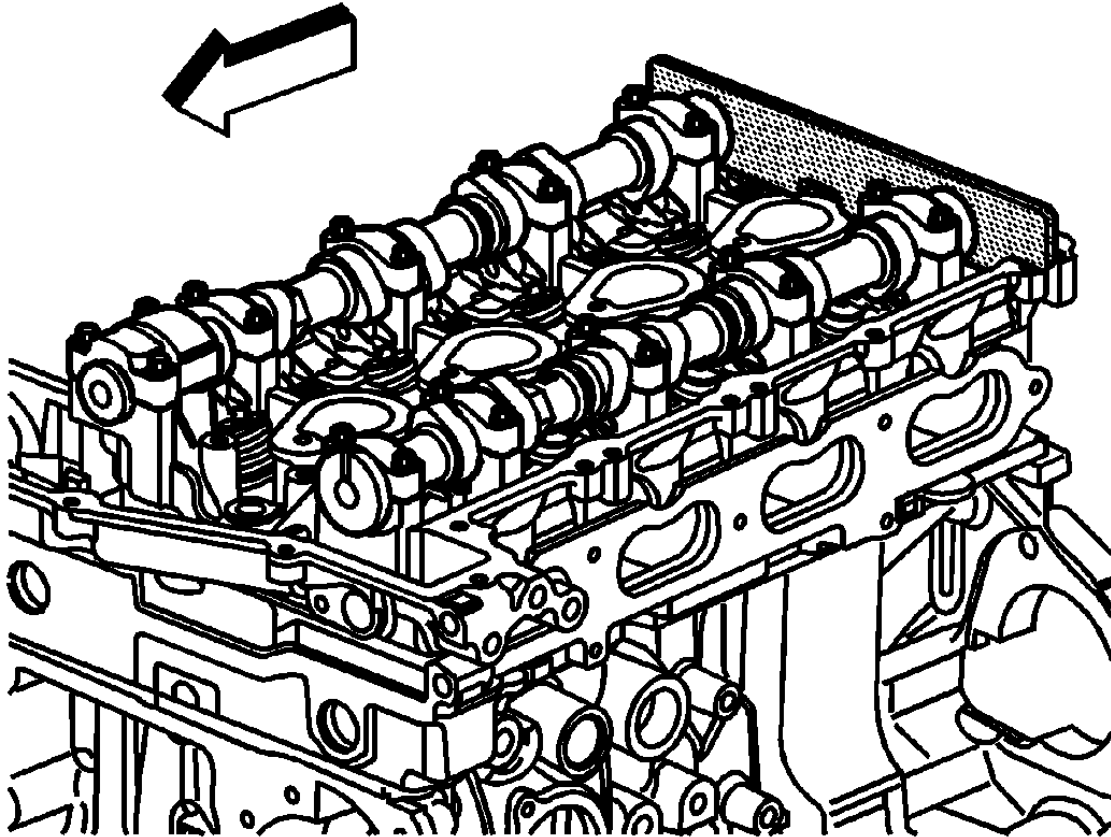


Fig. 119: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.
3. Using the timing mark on the intake camshaft sprocket as a reference, make a mark on the timing chain link adjacent to it.

WARNING: Refer to **Camshaft Holding Tool Warning** .

4. Install the **J 44221** camshaft holding tool to the rear of the camshafts.

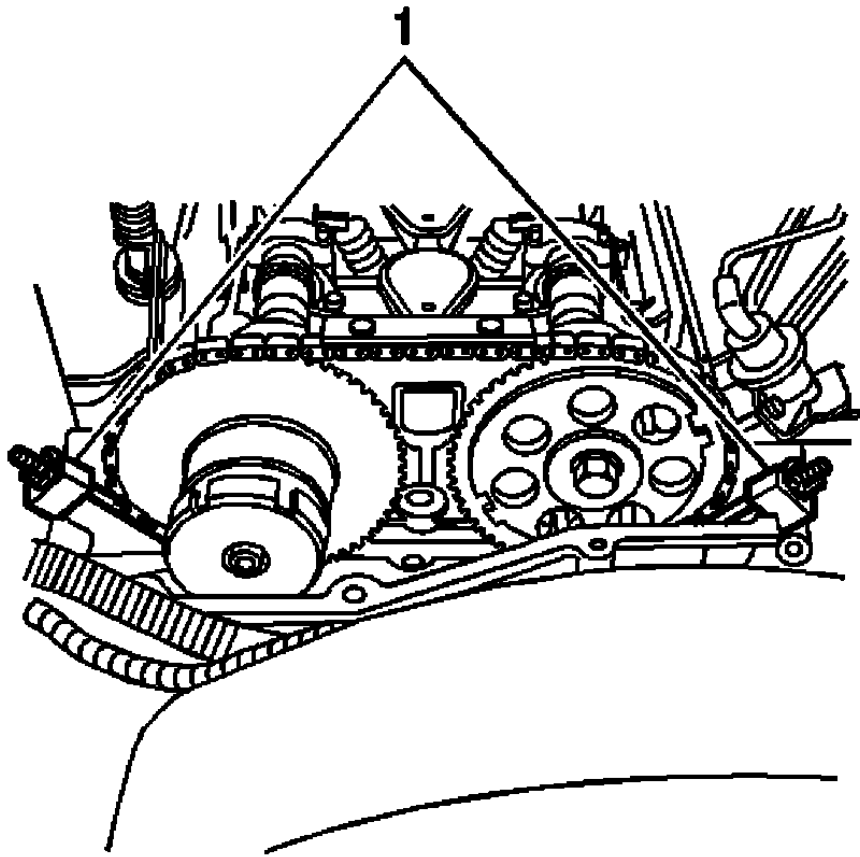


Fig. 120: Timing Chain Retention Tools
Courtesy of GENERAL MOTORS COMPANY

5. Complete the following in order to install the **J 44217** timing chain retention tool (1) and **J-44217-45** chain holding tool (1).
 1. Install the hook portion of the timing chain retention tools into one of the timing chain links near the timing chain shoe on both sides of the engine.
 2. Tighten the wingnuts.
 3. Ensure the hooks are still in one of the links and the gauge blocks of the tool are firmly in place on the edge of the head.

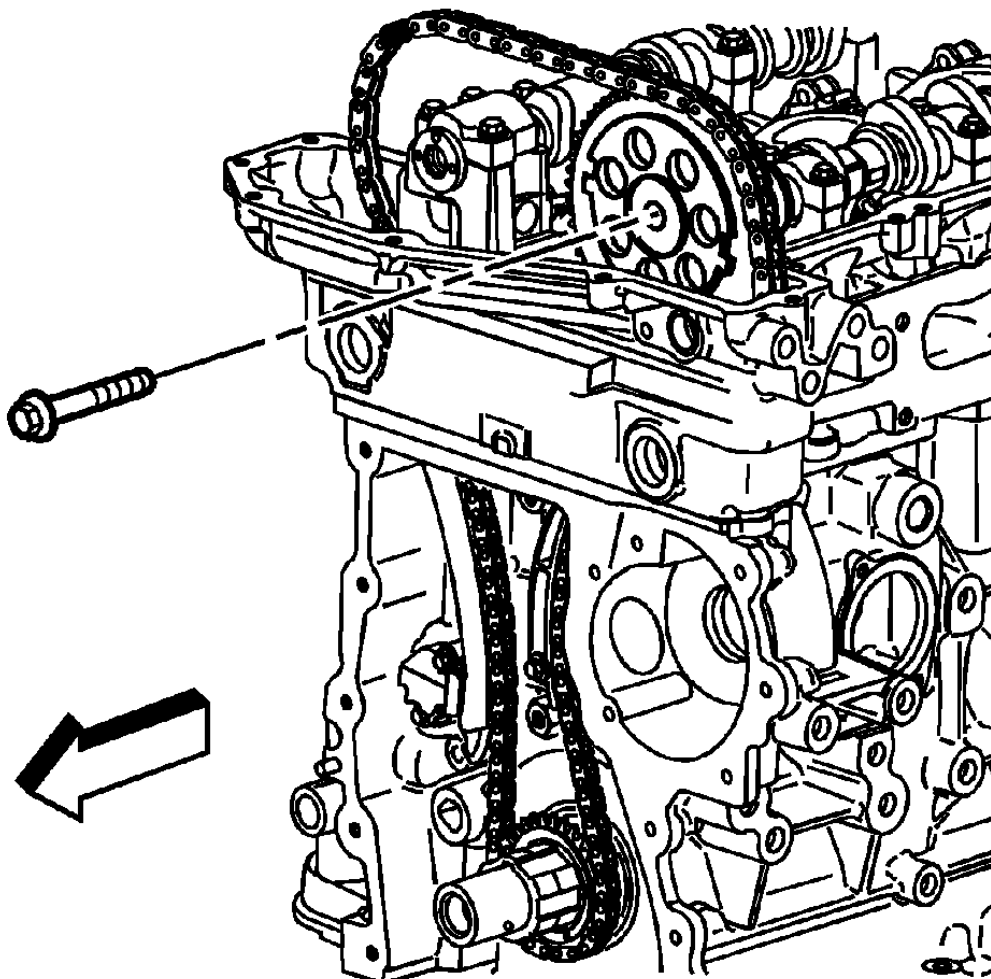


Fig. 121: View Of Intake Camshaft Sprocket Washer & Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the intake camshaft sprocket bolt.
7. Remove the intake camshaft sprocket.

Installation Procedure

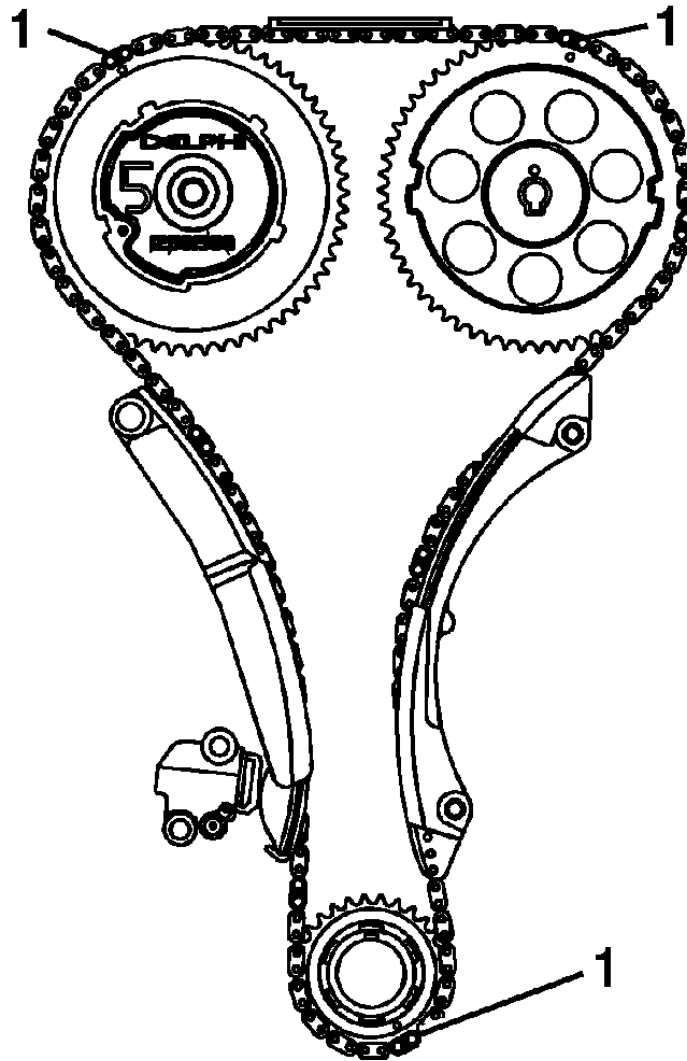


Fig. 122: Identifying Chain Alignment Links
Courtesy of GENERAL MOTORS COMPANY

1. Install the intake camshaft sprocket into the timing chain.

Aligning the marked link (1) on the timing chain with the timing mark on the intake camshaft sprocket.

NOTE:

- To aid in aligning the sprocket to the camshaft , use a 25 mm (1 in) wrench on the hex of the camshaft to rotate.
- Ensure the alignment pin is properly engaged with the camshaft.

2. Install the intake camshaft sprocket onto the intake camshaft.

CAUTION: Refer to Fastener Caution .

3. Install the new intake camshaft sprocket bolt and tighten to 20 N.m (15 lb ft) plus an additional 100 degrees using the **J 45059** angle meter.

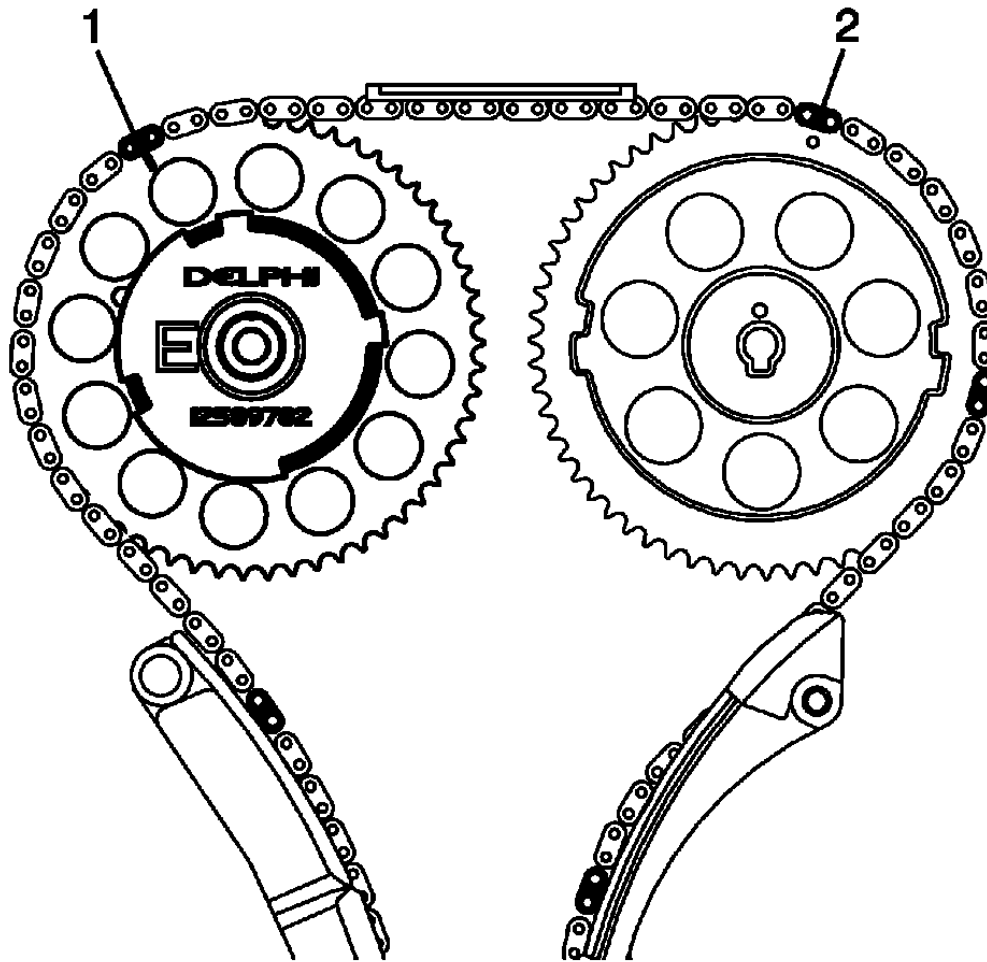


Fig. 123: Identifying Exhaust And Intake Timing Marks
Courtesy of GENERAL MOTORS COMPANY

4. Once the timing is set, ensure there are 15 links between the exhaust timing mark (1) and the intake timing mark (2).

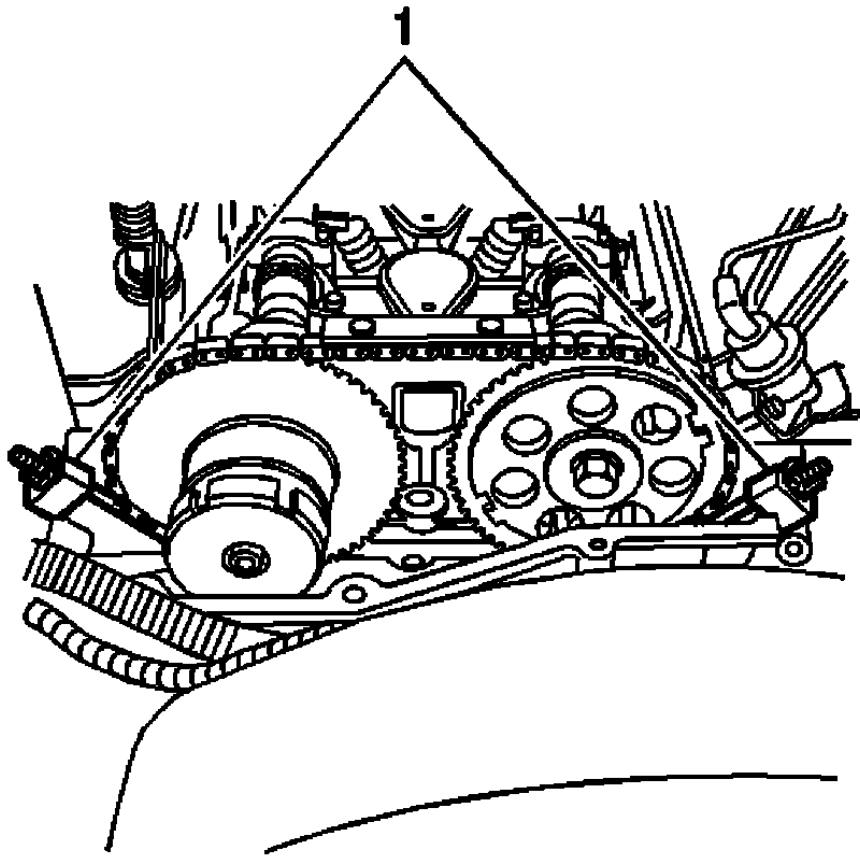


Fig. 124: Timing Chain Retention Tools
Courtesy of GENERAL MOTORS COMPANY

5. Remove the **J 44217** timing chain retention tool (1) and **J-44217-45** chain holding tool (1).

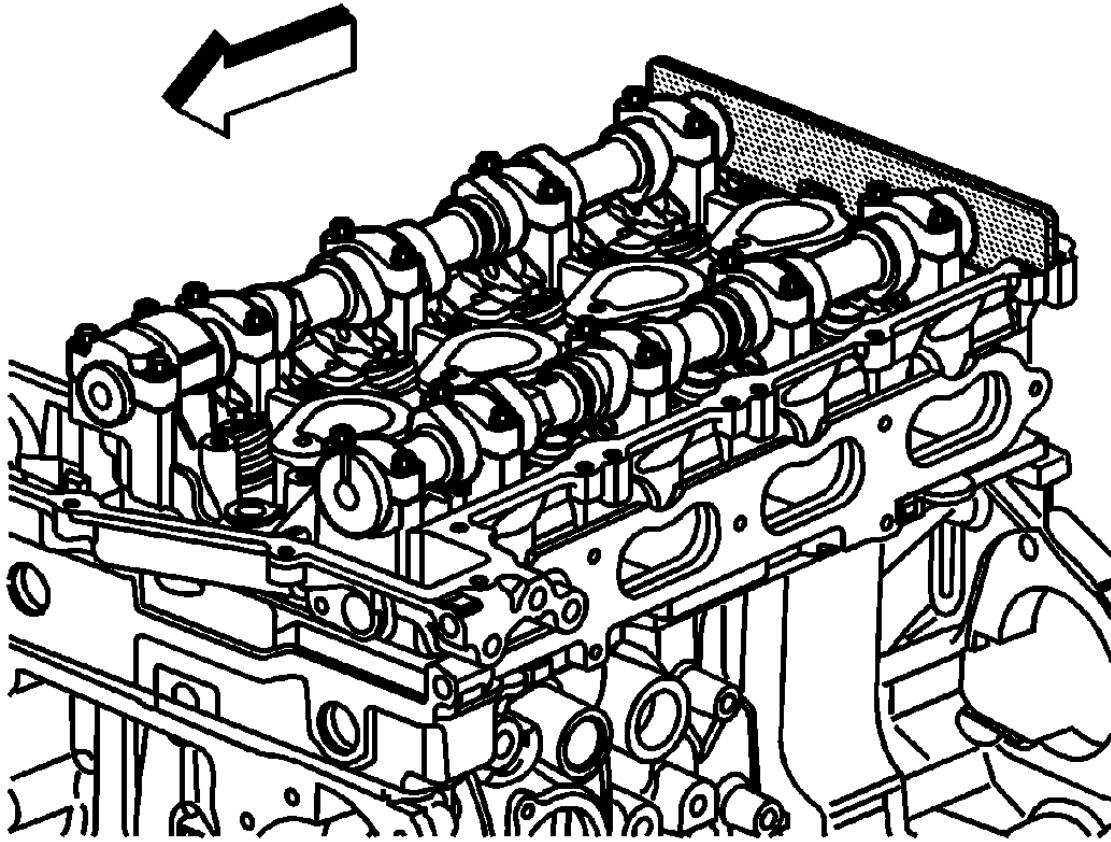


Fig. 125: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

6. Remove the **J 44221** camshaft holding tool from the camshafts.
7. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT TIMING CHAIN AND SPROCKET REPLACEMENT

Special Tools

- **J 44221** Camshaft Holding Tool
- **J 45059** Angle Meter

Removal Procedure

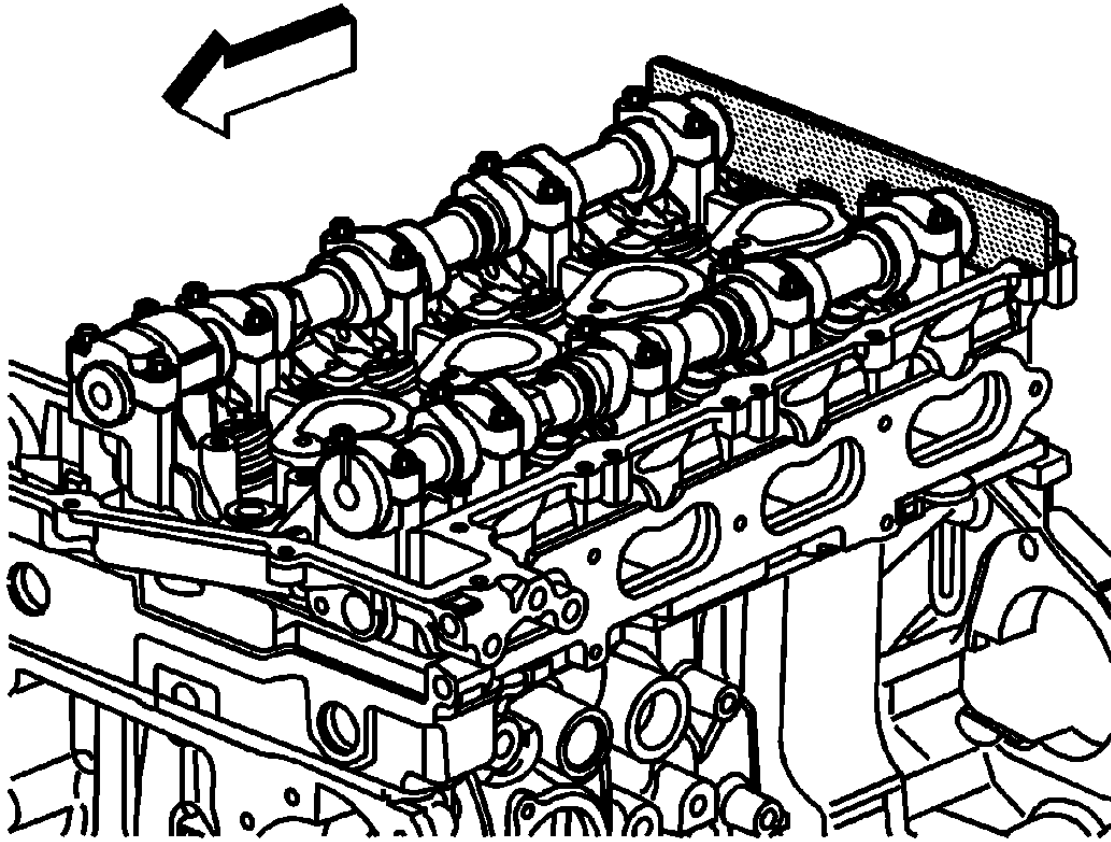


Fig. 126: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove #1 cylinder spark plug. Refer to [Spark Plug Replacement](#) .
2. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
3. Remove the camshaft position (CMP) sensor. Refer to [Camshaft Position Sensor Replacement](#) .
4. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
5. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

WARNING: Refer to [Camshaft Holding Tool Warning](#) .

6. Install the **J 44221** camshaft holding tool to the rear of the camshafts.

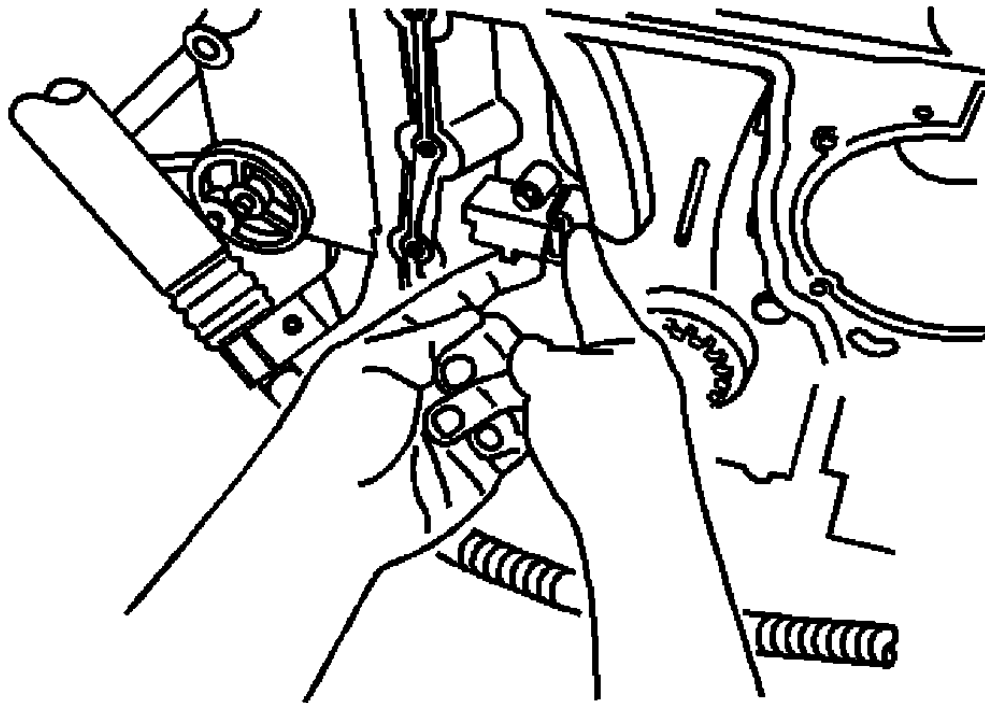


Fig. 127: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS COMPANY

7. Release the tension on the timing chain by moving the tensioner shoe in.

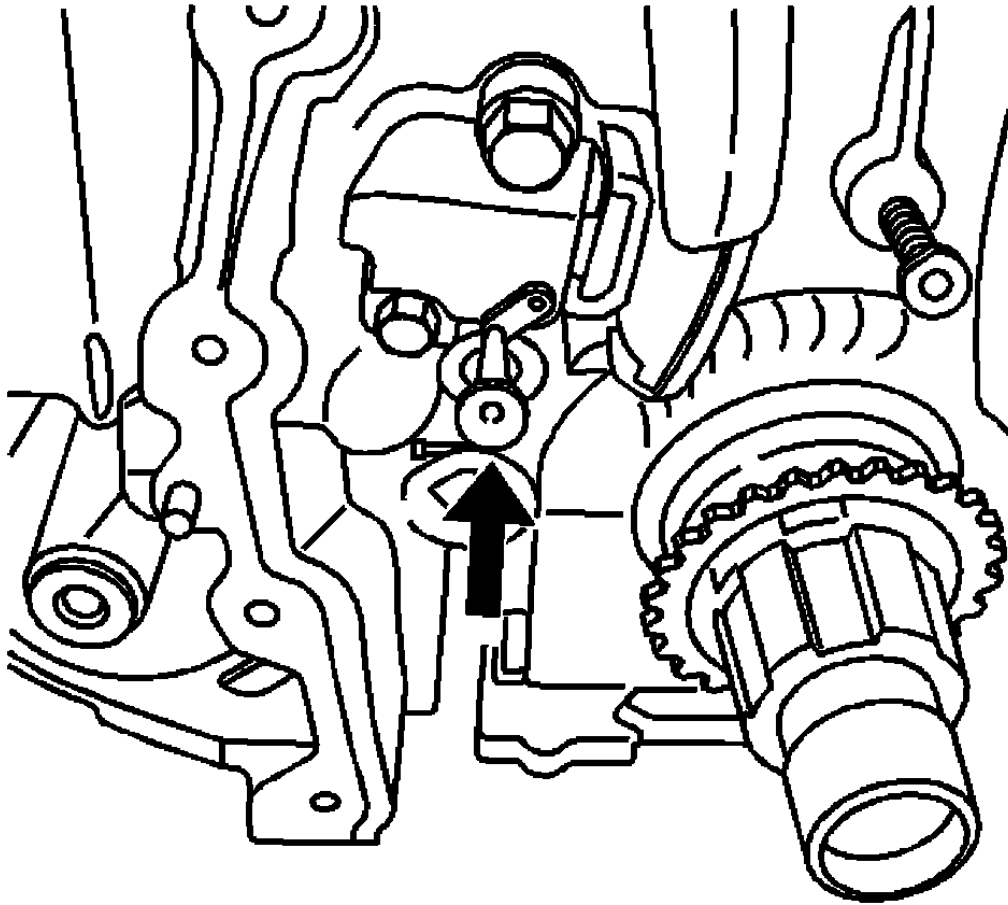


Fig. 128: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

8. Place the tee into the tensioner to hold the shoe in place.

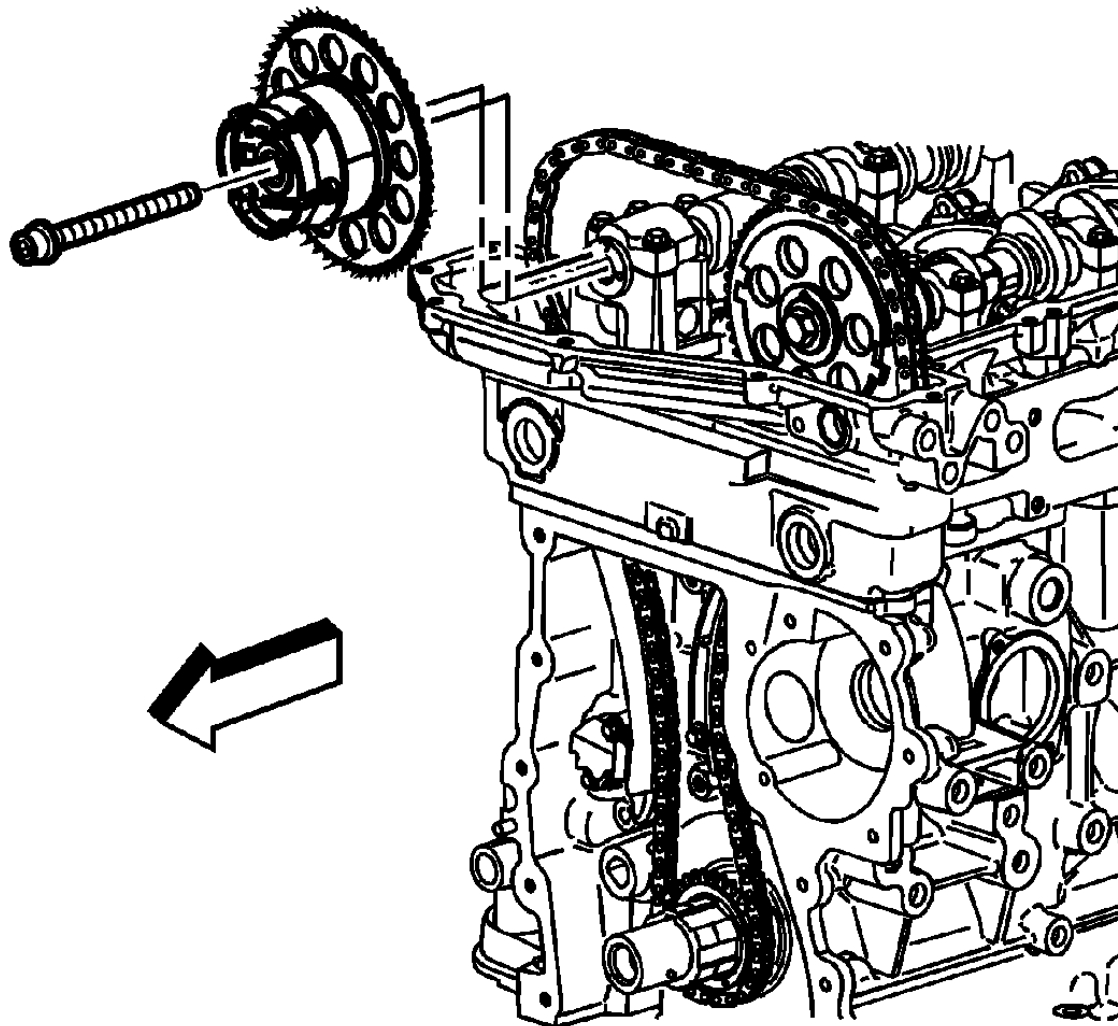


Fig. 129: Identifying Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Remove and discard the exhaust camshaft position actuator bolt.
10. Remove the exhaust camshaft position actuator.

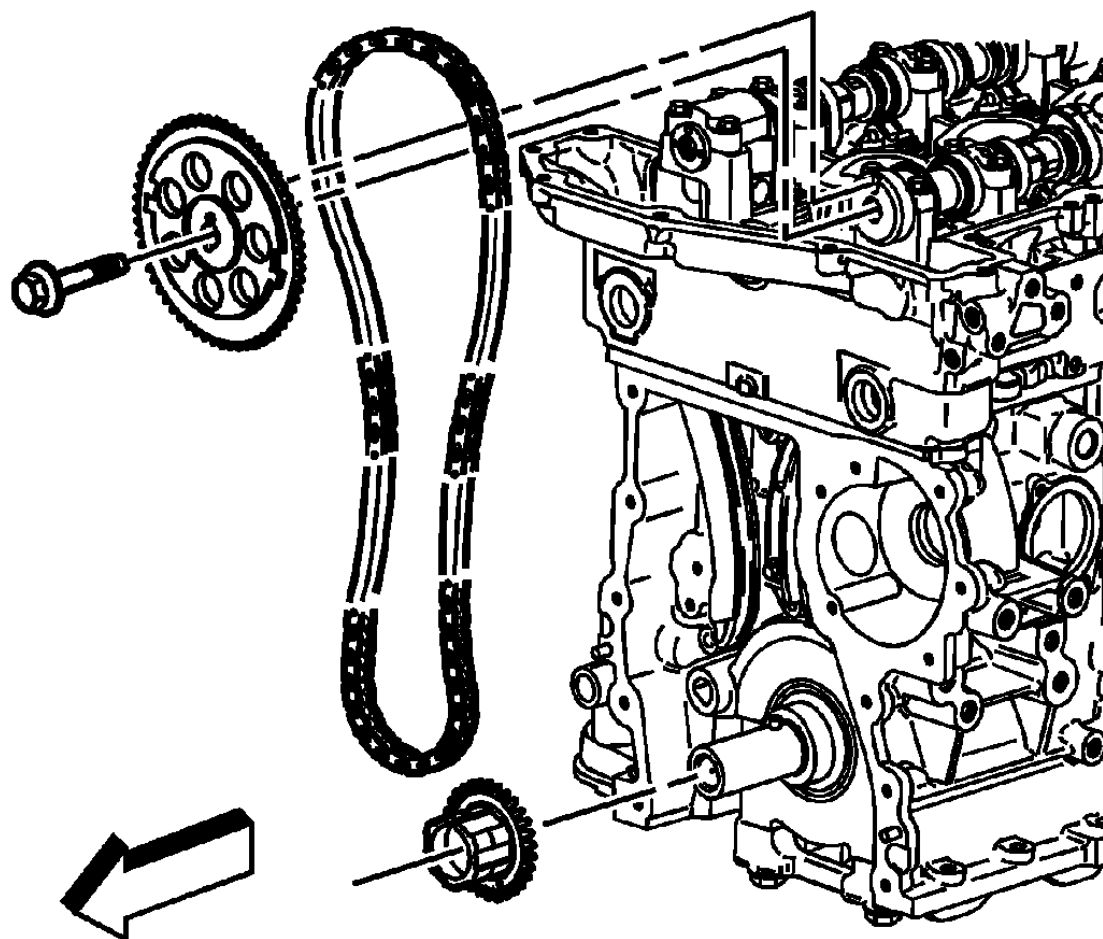


Fig. 130: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS COMPANY

11. Remove and discard the intake camshaft sprocket bolt.
12. Remove the intake camshaft sprocket.
13. Remove the timing chain.
14. Remove the crankshaft sprocket.

Installation Procedure

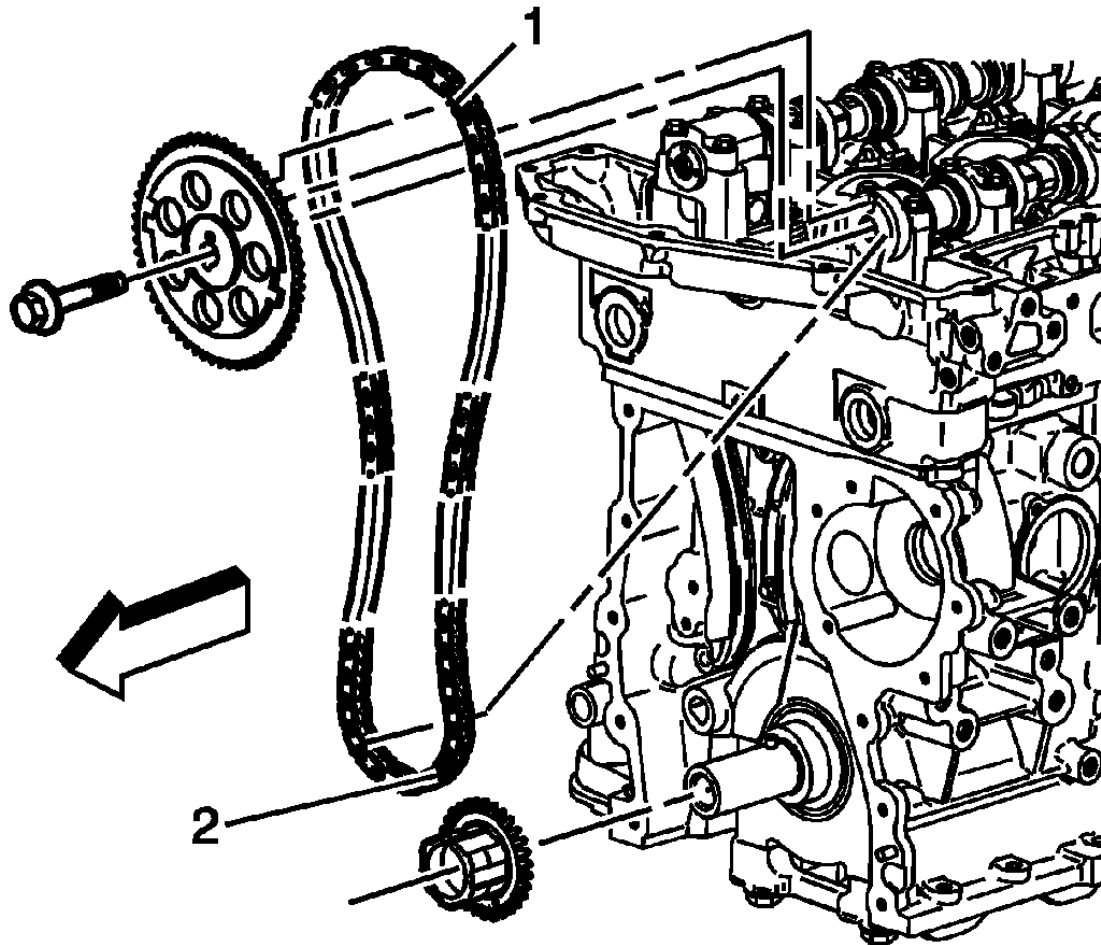


Fig. 131: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the #1 piston is at TDC. The pin on the crankshaft for the timing chain sprocket should be straight up.

1. Install the crankshaft sprocket to the crankshaft snout.

NOTE: Every 7th link of the timing chain is darkened to aid in aligning the timing marks.

2. Install the intake camshaft sprocket into the timing chain.

Aligning the dark link (1) of the timing chain with the timing mark on the intake camshaft sprocket.

3. Feed the timing chain down through the opening in the cylinder head.

4. Install the timing chain on the crankshaft sprocket.

Aligning the dark link (2) of the timing chain with the timing mark on to the crankshaft sprocket.

NOTE: Ensure the alignment pin is properly engaged with the camshaft

5. Install the intake camshaft sprocket onto the intake camshaft.

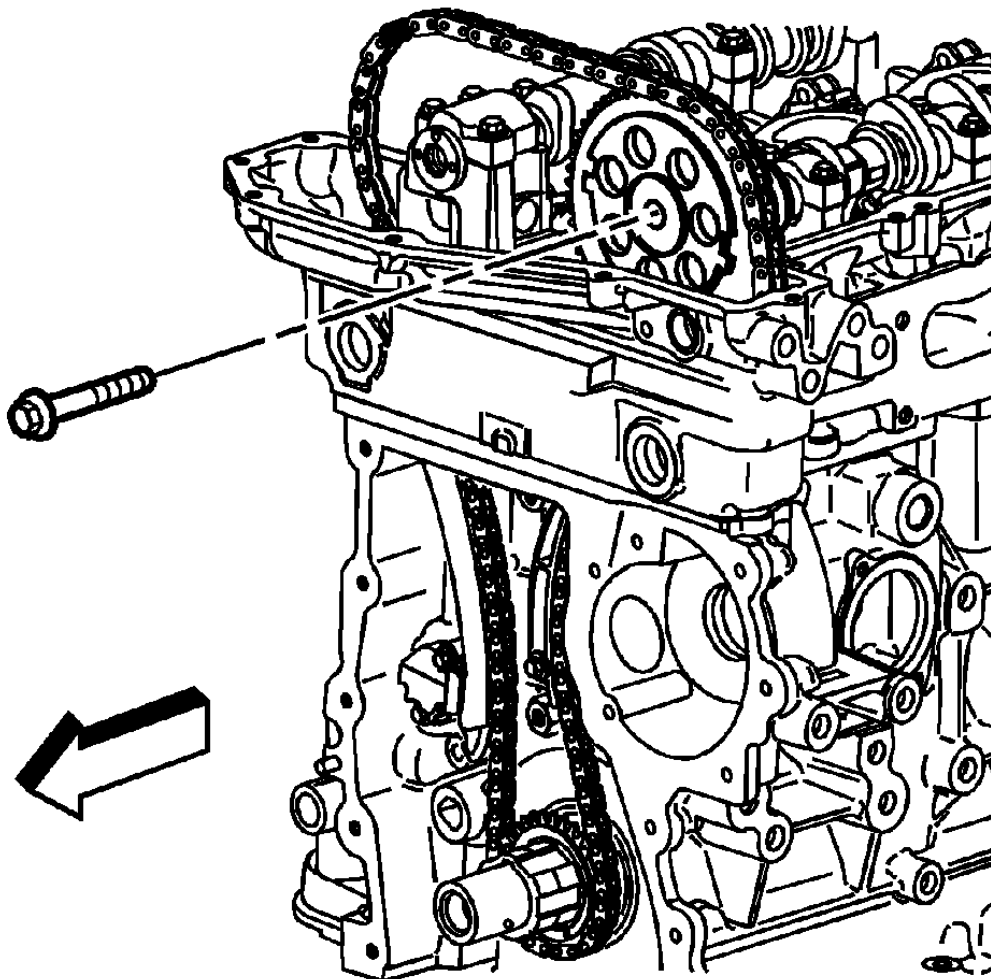


Fig. 132: View Of Intake Camshaft Sprocket Washer & Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Install the new intake camshaft sprocket bolt and tighten to 20 N.m (15 lb ft) plus an additional 100 degrees using the **J 45059** angle meter.

7. Ensure the camshaft actuator is fully advanced prior to installation.

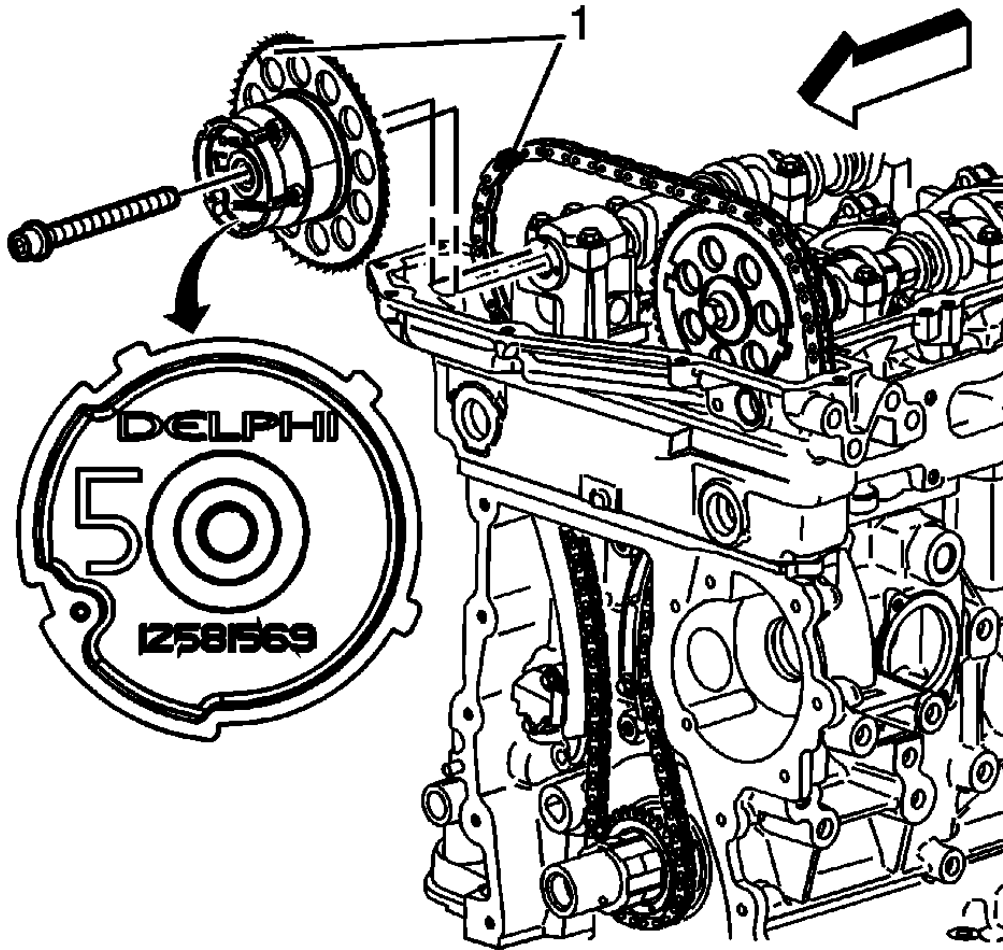


Fig. 133: View Of Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust camshaft actuator into the timing chain.

Aligning the dark link (1) of the timing chain with the timing mark (1) on the exhaust camshaft position actuator sprocket.

NOTE:

- To aid in aligning the actuator to the camshaft , use a 25 mm (1 in) wrench on the hex of the camshaft to rotate.
- Ensure the alignment pin is properly engaged with the camshaft.

9. Install the exhaust camshaft actuator onto the exhaust camshaft.

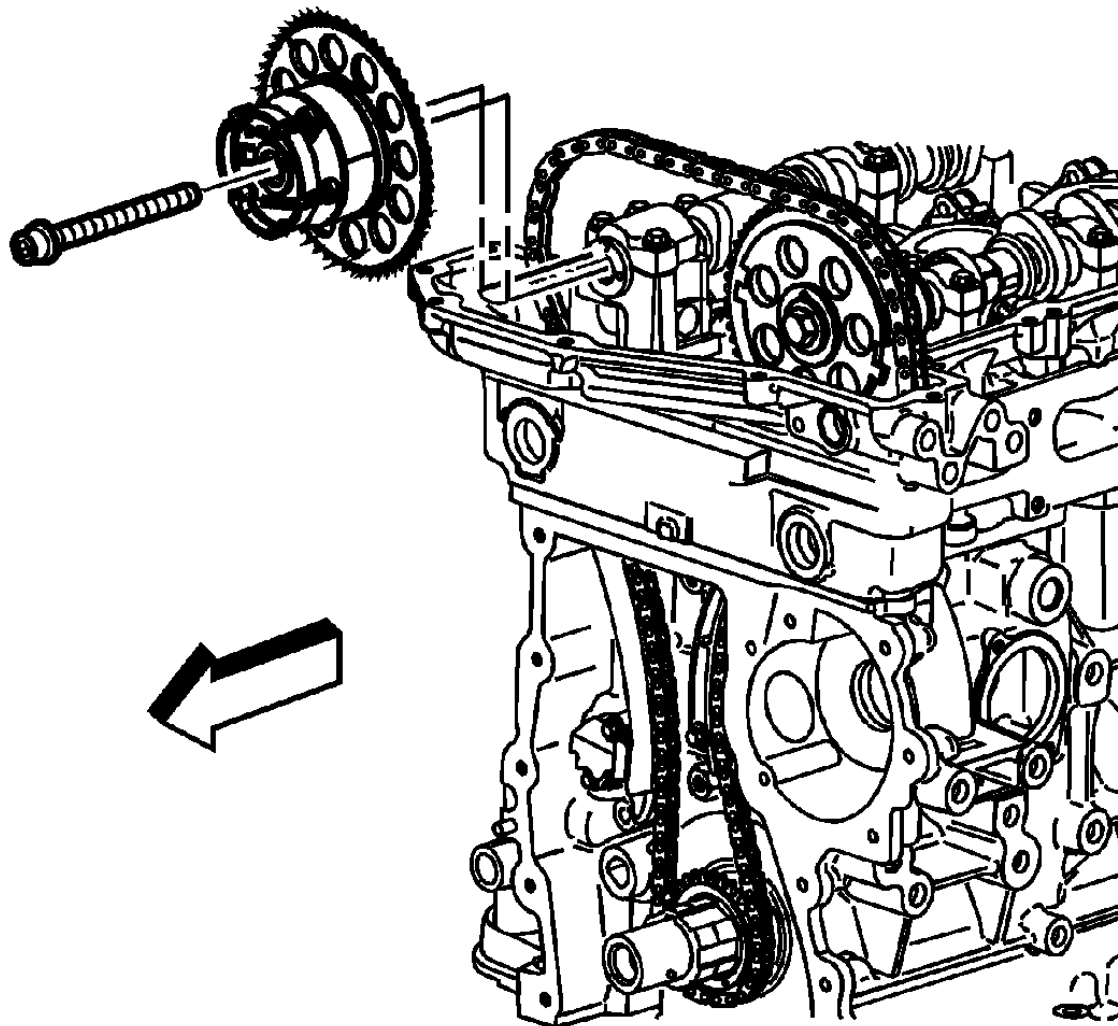


Fig. 134: Identifying Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Install the new exhaust camshaft actuator bolt and tighten to 25 N.m (18 lb ft) plus an additional 135 degrees using the **J 45059** angle meter.

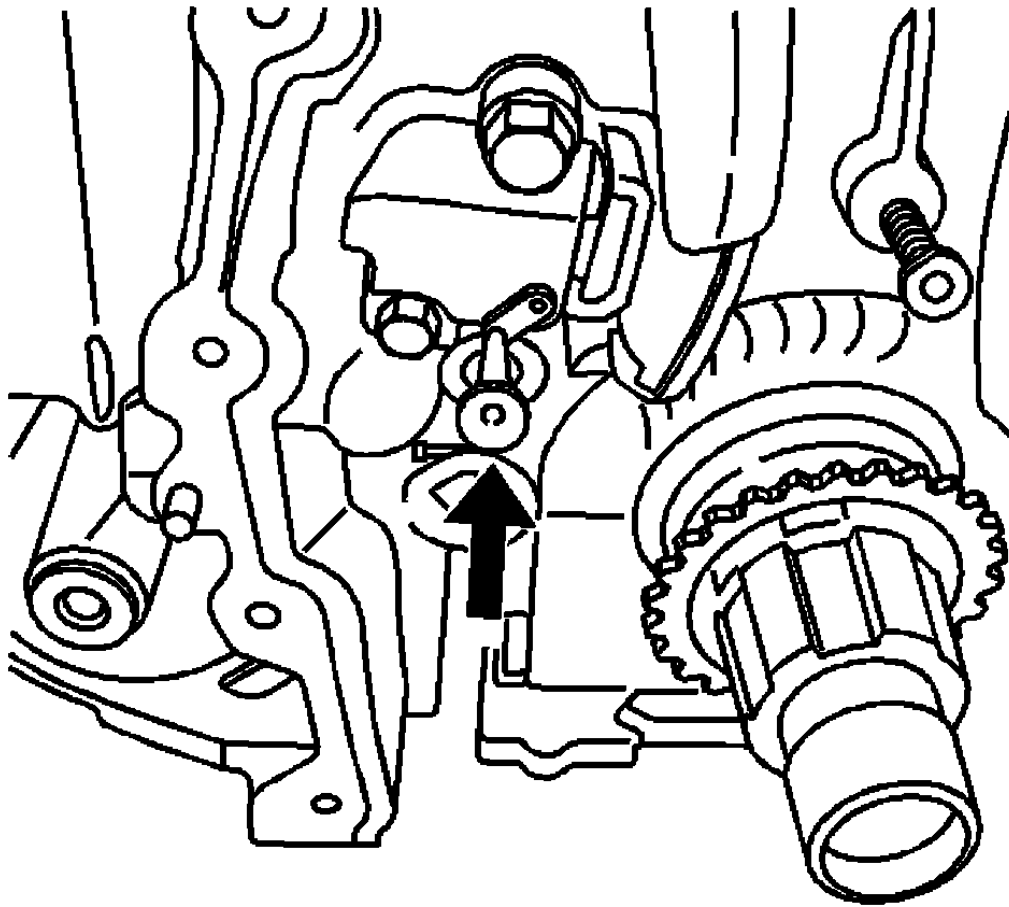


Fig. 135: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

11. Remove the tee in the timing chain tensioner to regain tension on the timing chain.

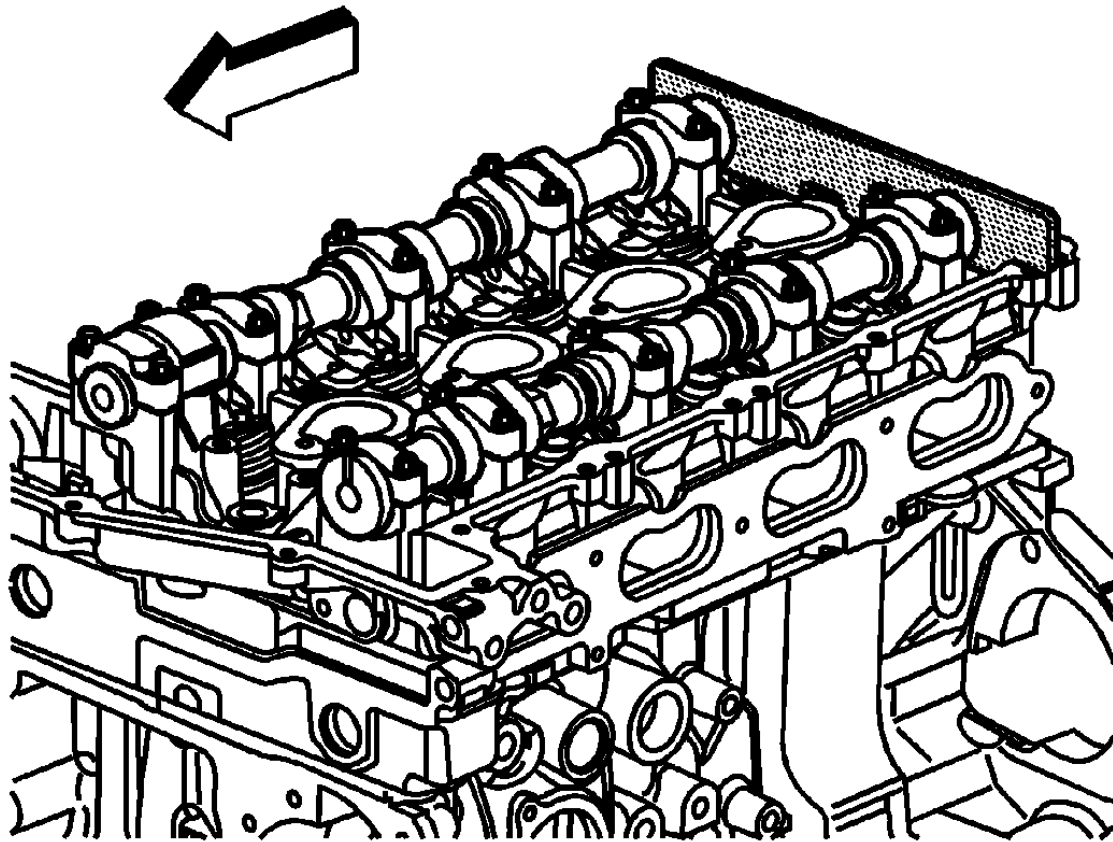


Fig. 136: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

12. Remove the **J 44221** camshaft holding tool from the camshafts.

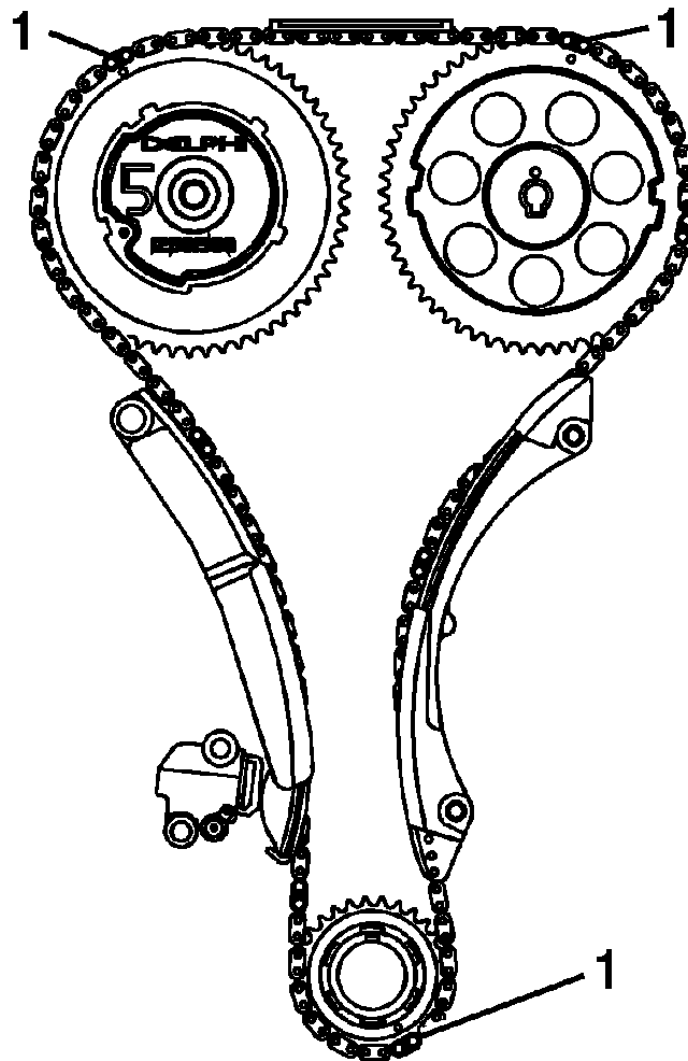


Fig. 137: Identifying Chain Alignment Links
 Courtesy of GENERAL MOTORS COMPANY

13. The dark links (1) on the timing chain should be aligned with the marks on the sprockets as shown.

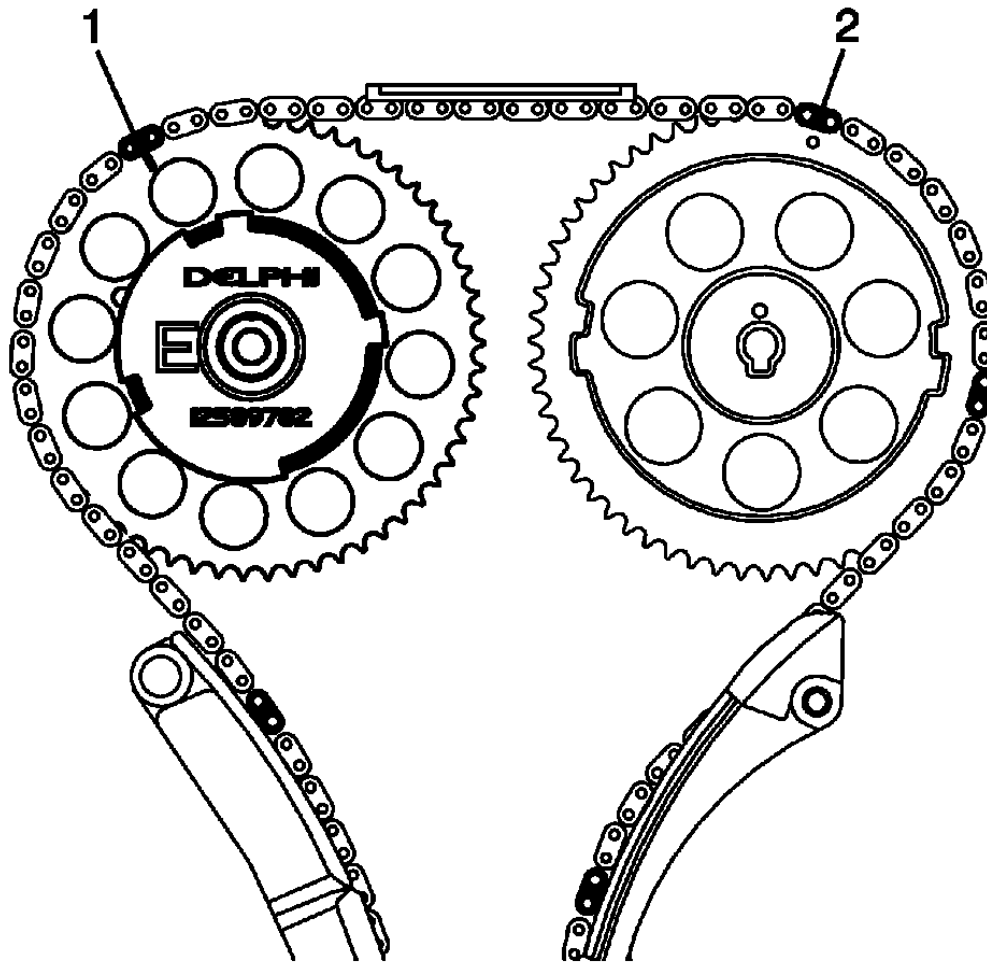


Fig. 138: Identifying Exhaust And Intake Timing Marks
Courtesy of GENERAL MOTORS COMPANY

14. Once the timing is set, ensure there are 15 links between the exhaust timing mark (1) and the intake timing mark (2).
15. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).
16. Install the camshaft position (CMP) sensor. Refer to [Camshaft Position Sensor Replacement](#).
17. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).
18. Install #1 cylinder spark plug. Refer to [Spark Plug Replacement](#).

TIMING CHAIN TENSIONER REPLACEMENT

Special Tools

J 44221 Camshaft Holding Tool

Removal Procedure

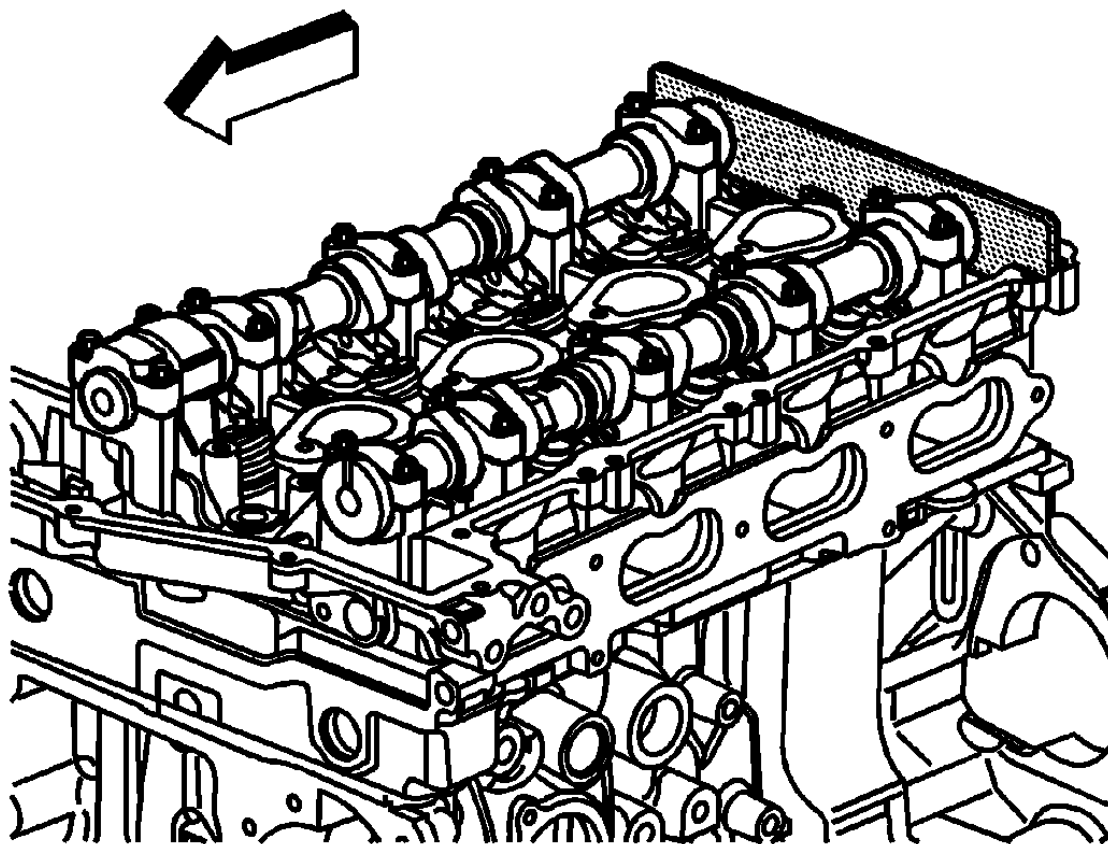


Fig. 139: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
2. Remove the engine front cover. Refer to Engine Front Cover Replacement.
3. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

WARNING: Refer to Camshaft Holding Tool Warning .

4. Install the **J 44221** camshaft holding tool to the rear of the camshafts.

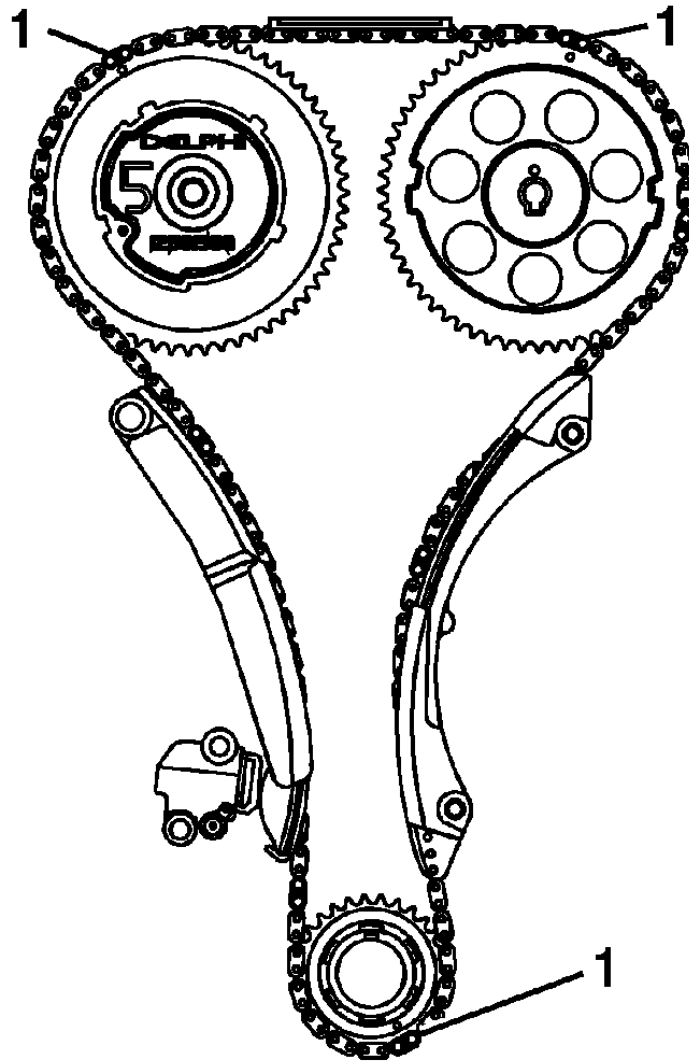


Fig. 140: Identifying Chain Alignment Links
 Courtesy of GENERAL MOTORS COMPANY

5. Using the timing marks on the following as a reference, make a mark on the timing chain links (1) adjacent to them:
 - The exhaust camshaft position actuator sprocket
 - The intake camshaft sprocket
 - The crankshaft sprocket

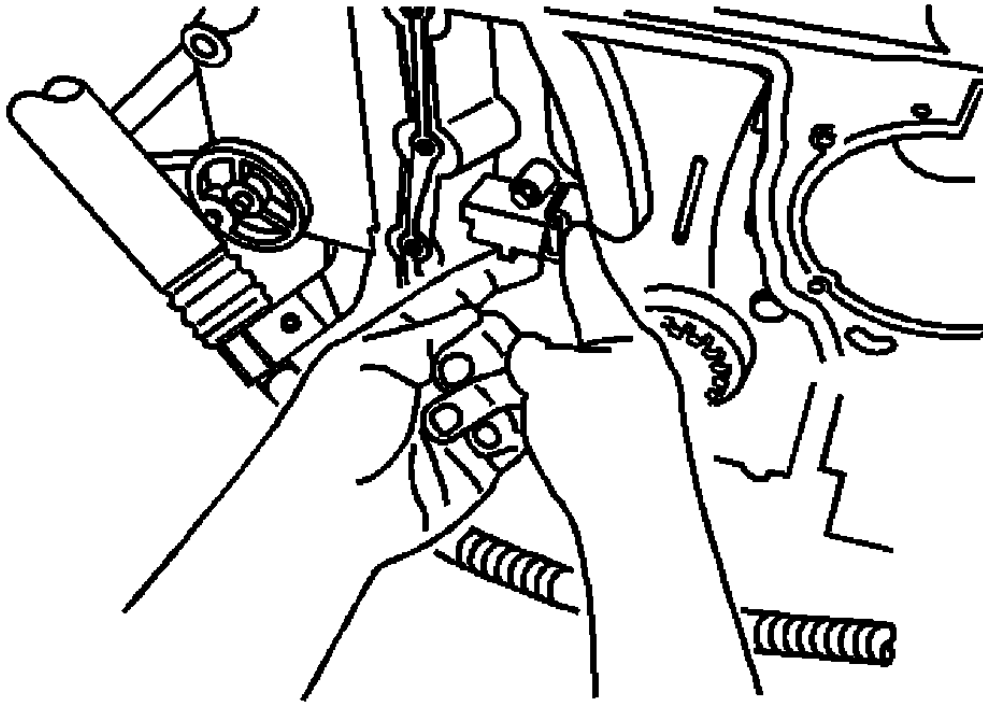


Fig. 141: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS COMPANY

6. Release the tension on the timing chain by moving the tensioner shoe in.

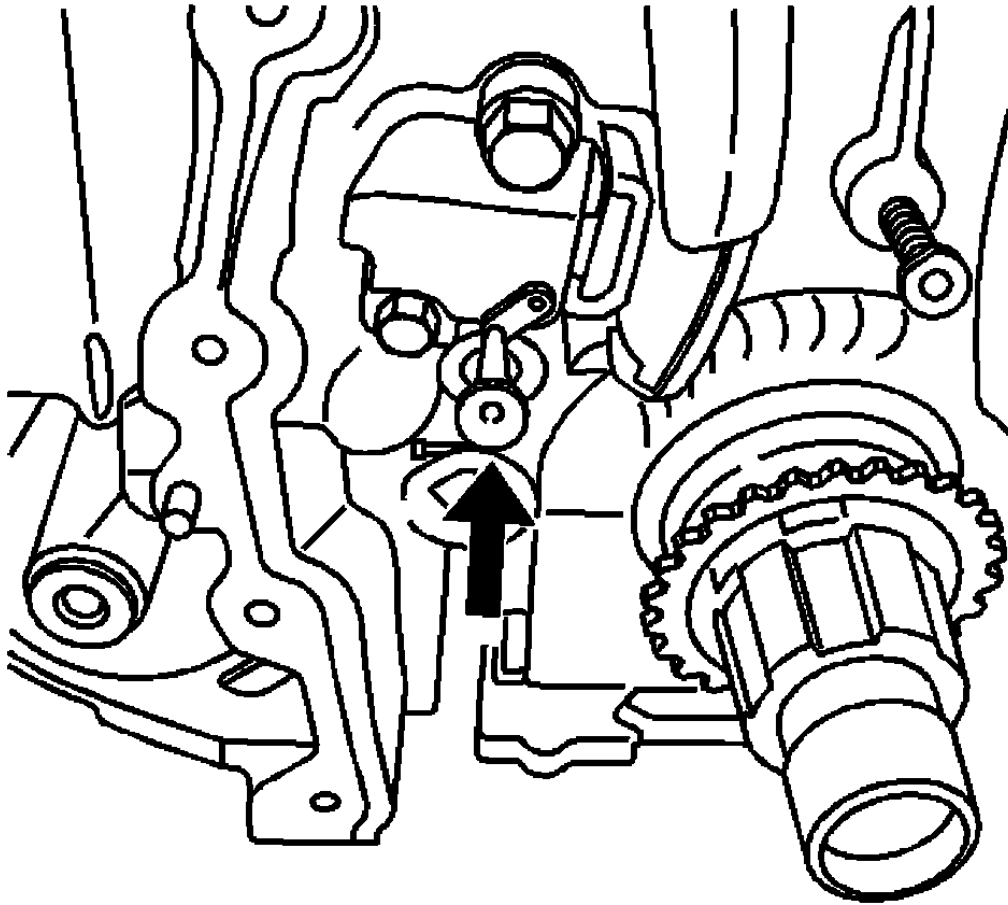


Fig. 142: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

7. Place the tee into the tensioner to hold the shoe in place.

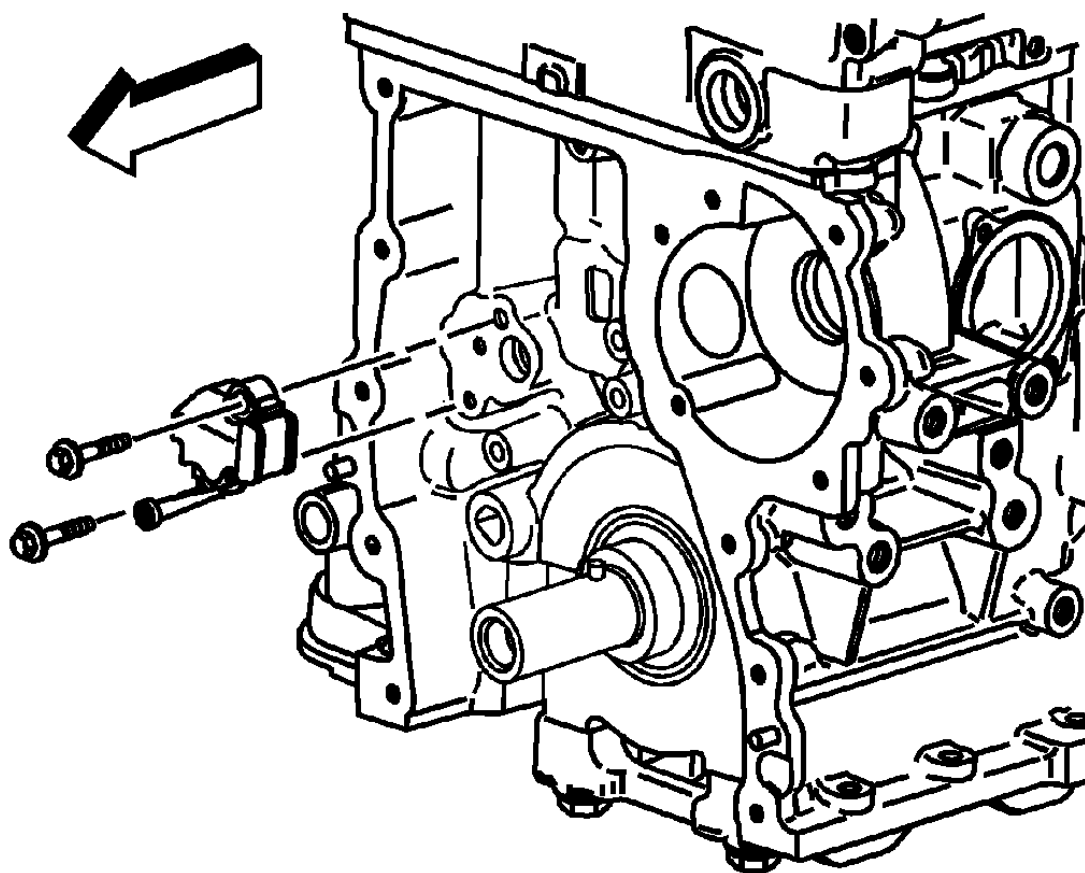


Fig. 143: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Remove the timing chain tensioner bolts.
9. Remove the timing chain tensioner from the engine.

Installation Procedure

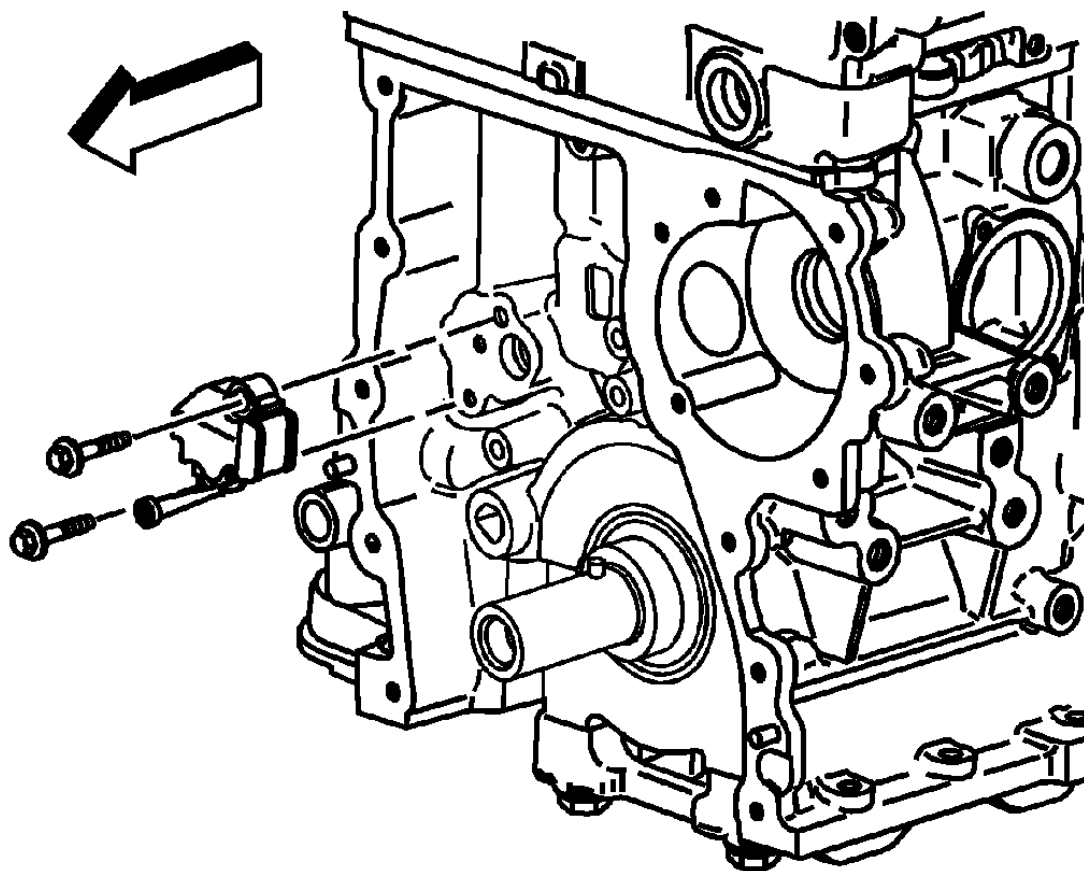


Fig. 144: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Position the timing chain tensioner to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the timing chain tensioner bolts and tighten to 25 N.m (18 lb ft).

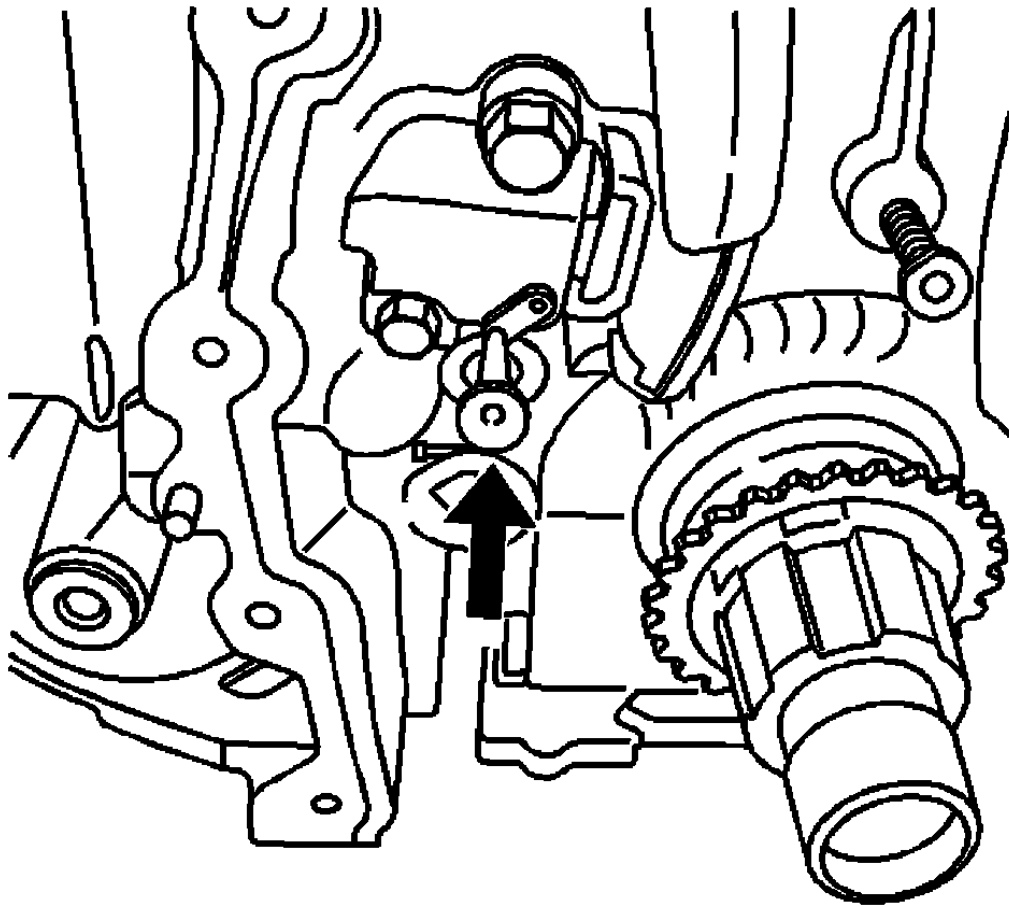


Fig. 145: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

3. Remove the tee in the timing chain tensioner to regain tension on the timing chain.

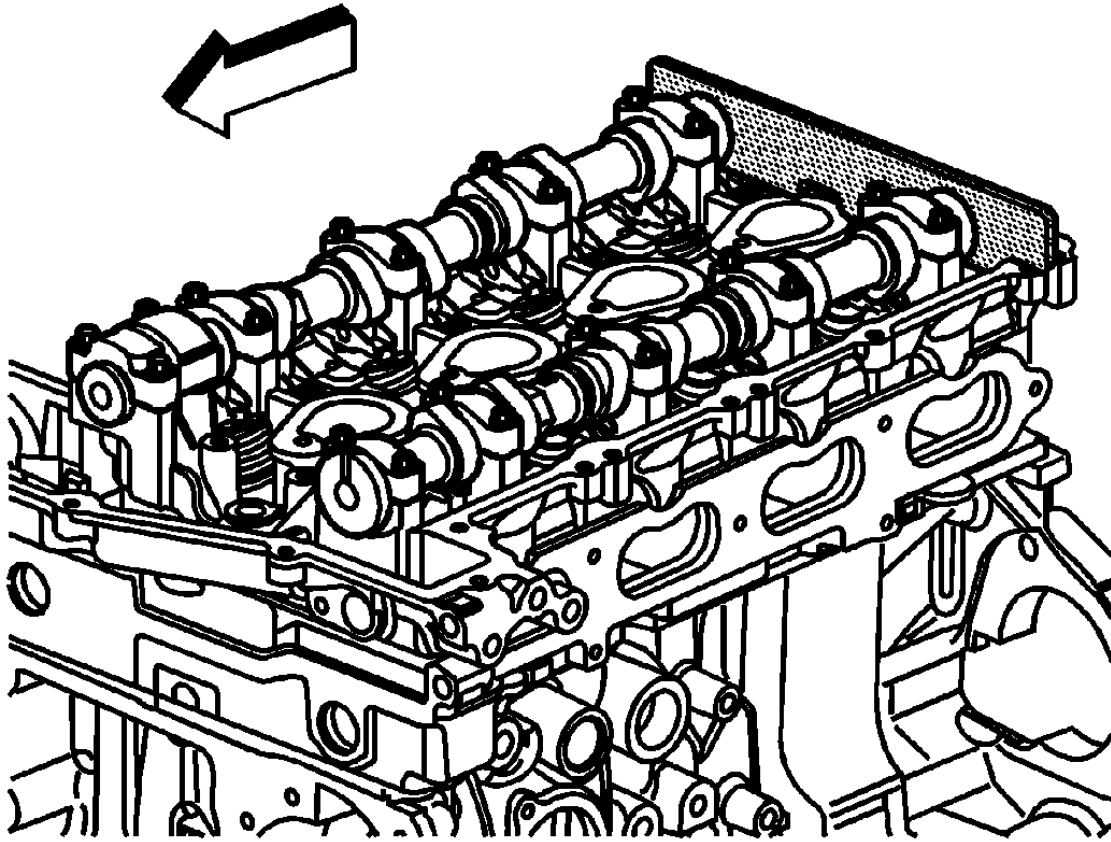


Fig. 146: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

4. Remove the **J 44221** camshaft holding tool from the camshafts.

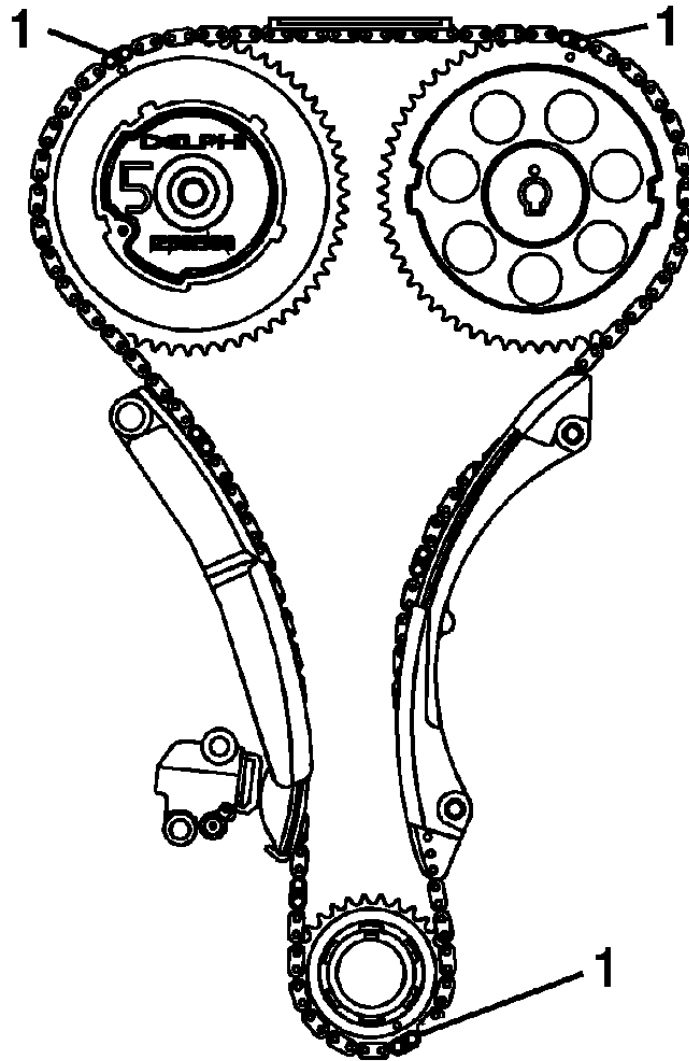


Fig. 147: Identifying Chain Alignment Links
Courtesy of GENERAL MOTORS COMPANY

NOTE: Every 7th link of the timing chain is darkened to aid in aligning the timing marks.

5. Align the marked links (1) on the timing chain with the timing marks on the following:
 - The exhaust camshaft position actuator sprocket
 - The intake camshaft sprocket
 - The crankshaft sprocket

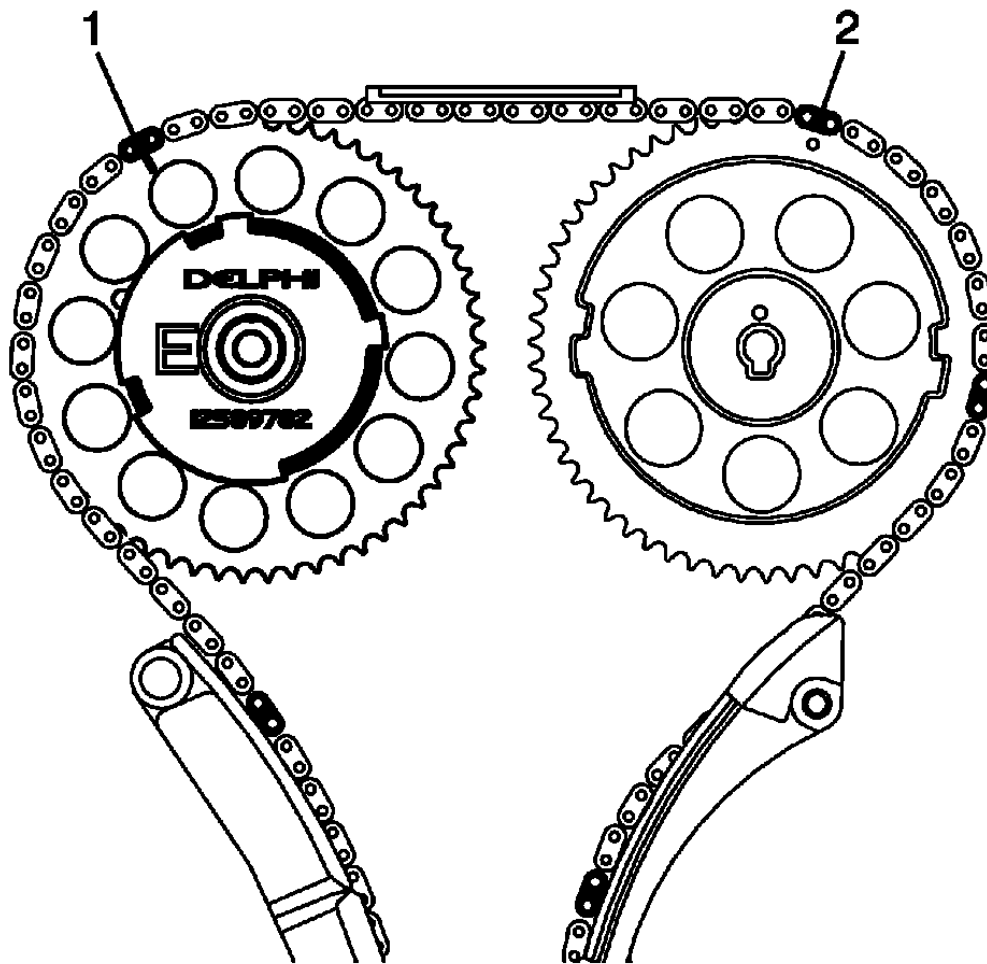


Fig. 148: Identifying Exhaust And Intake Timing Marks
 Courtesy of GENERAL MOTORS COMPANY

6. Once the timing is set, ensure there are 15 links between the exhaust timing mark (1) and the intake timing mark (2).
7. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).
8. Install the camshaft cover. Refer to [Camshaft Cover Replacement](#).

TIMING CHAIN TENSIONER SHOE REPLACEMENT

Special Tools

J 44221 Camshaft Holding Tool

Removal Procedure

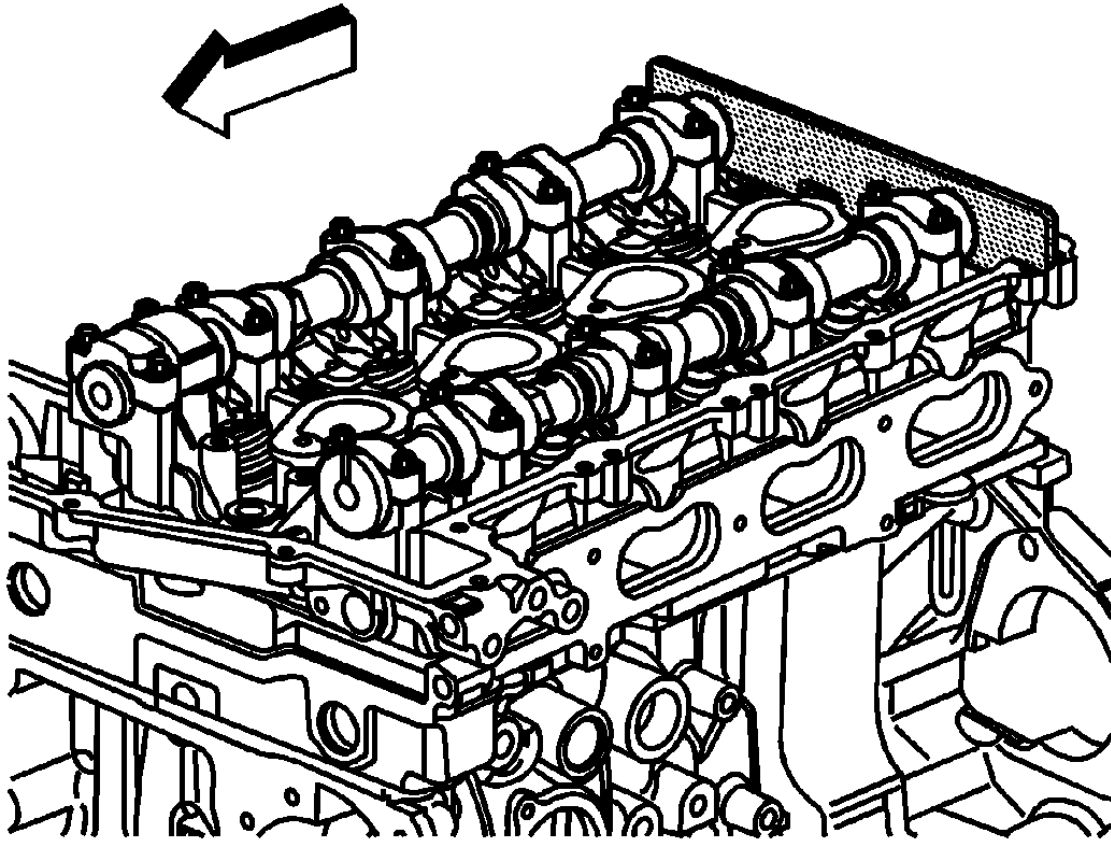


Fig. 149: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
2. Remove the engine front cover. Refer to Engine Front Cover Replacement.
3. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

WARNING: Refer to Camshaft Holding Tool Warning .

4. Install the **J 44221** camshaft holding tool to the rear of the camshafts.

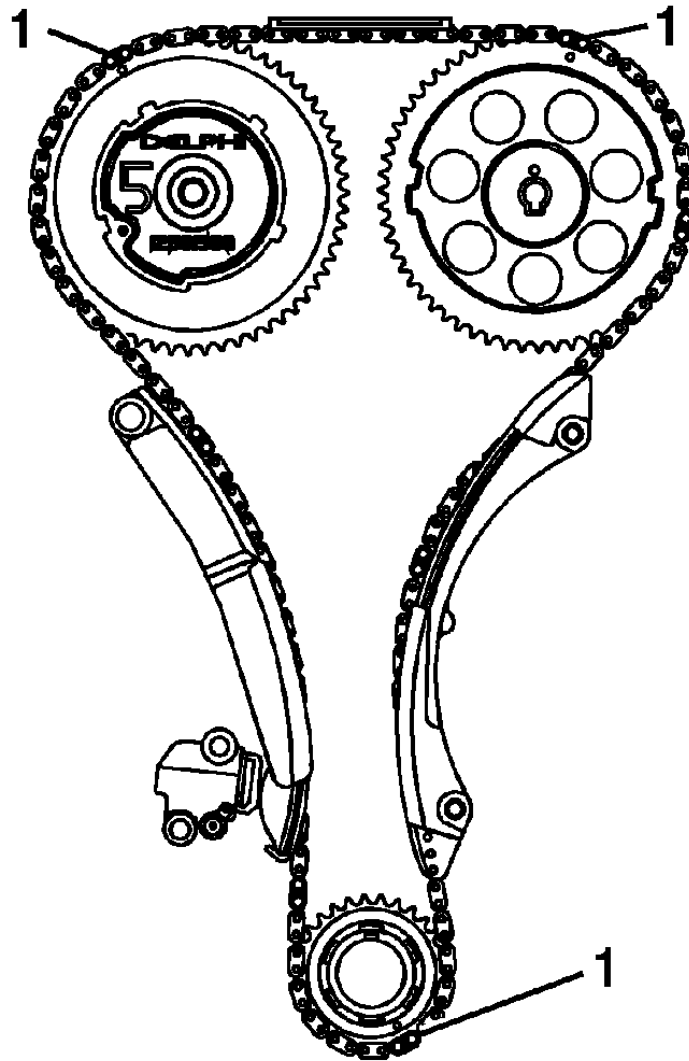


Fig. 150: Identifying Chain Alignment Links
 Courtesy of GENERAL MOTORS COMPANY

5. Using the timing marks on the following as a reference, make a mark on the timing chain links (1) adjacent to them:
 - The exhaust camshaft position actuator sprocket
 - The intake camshaft sprocket
 - The crankshaft sprocket

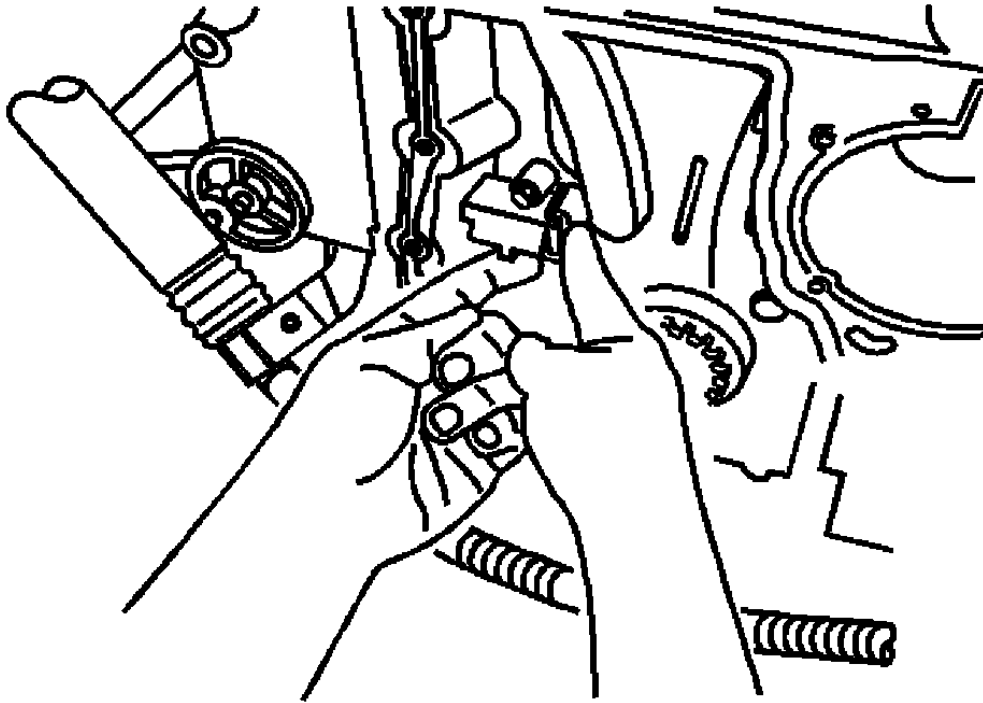


Fig. 151: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS COMPANY

6. Release the tension on the timing chain by moving the tensioner shoe in.

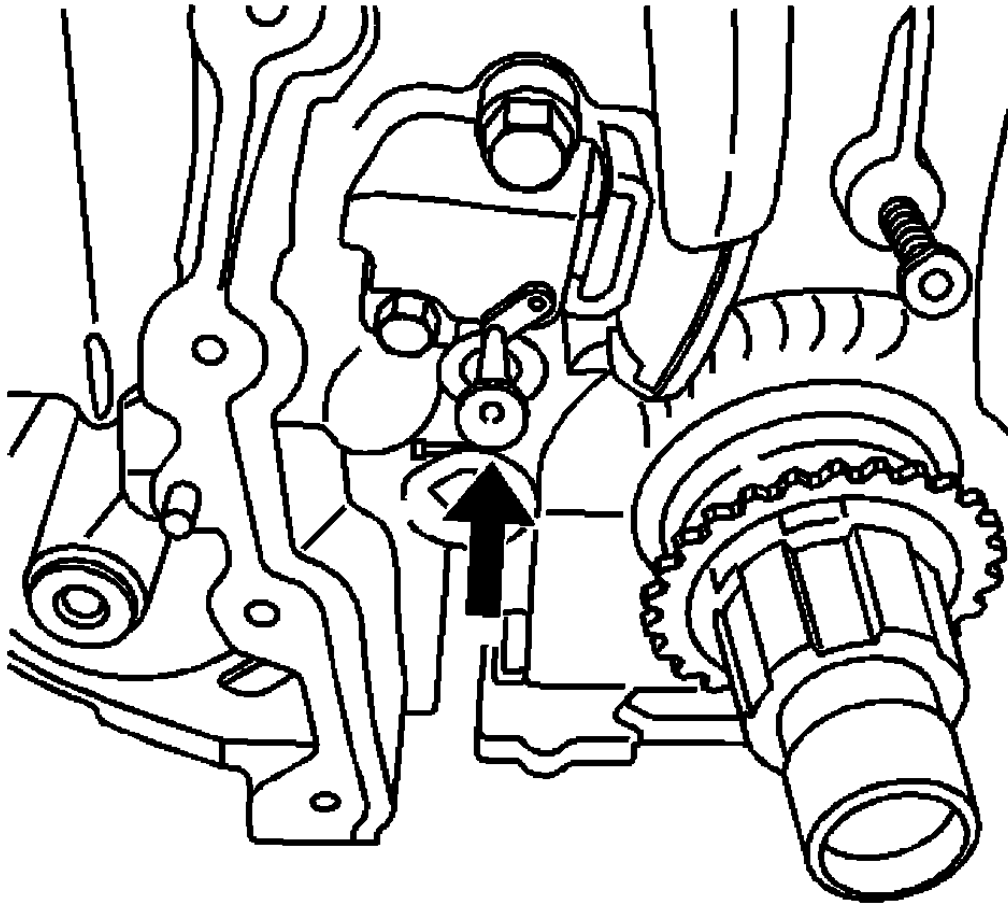


Fig. 152: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

7. Place the tee into the tensioner to hold the shoe in place.

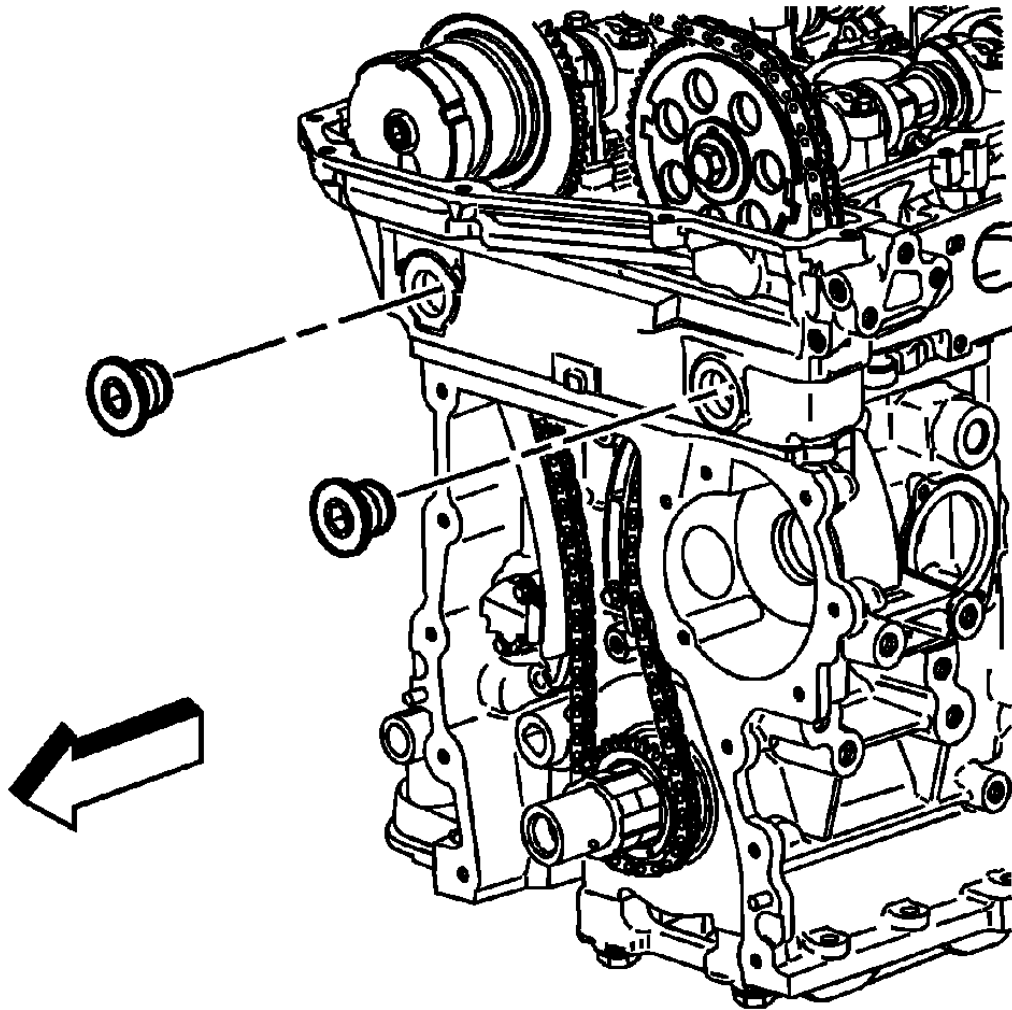


Fig. 153: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

8. Remove the cylinder head access hole plug.

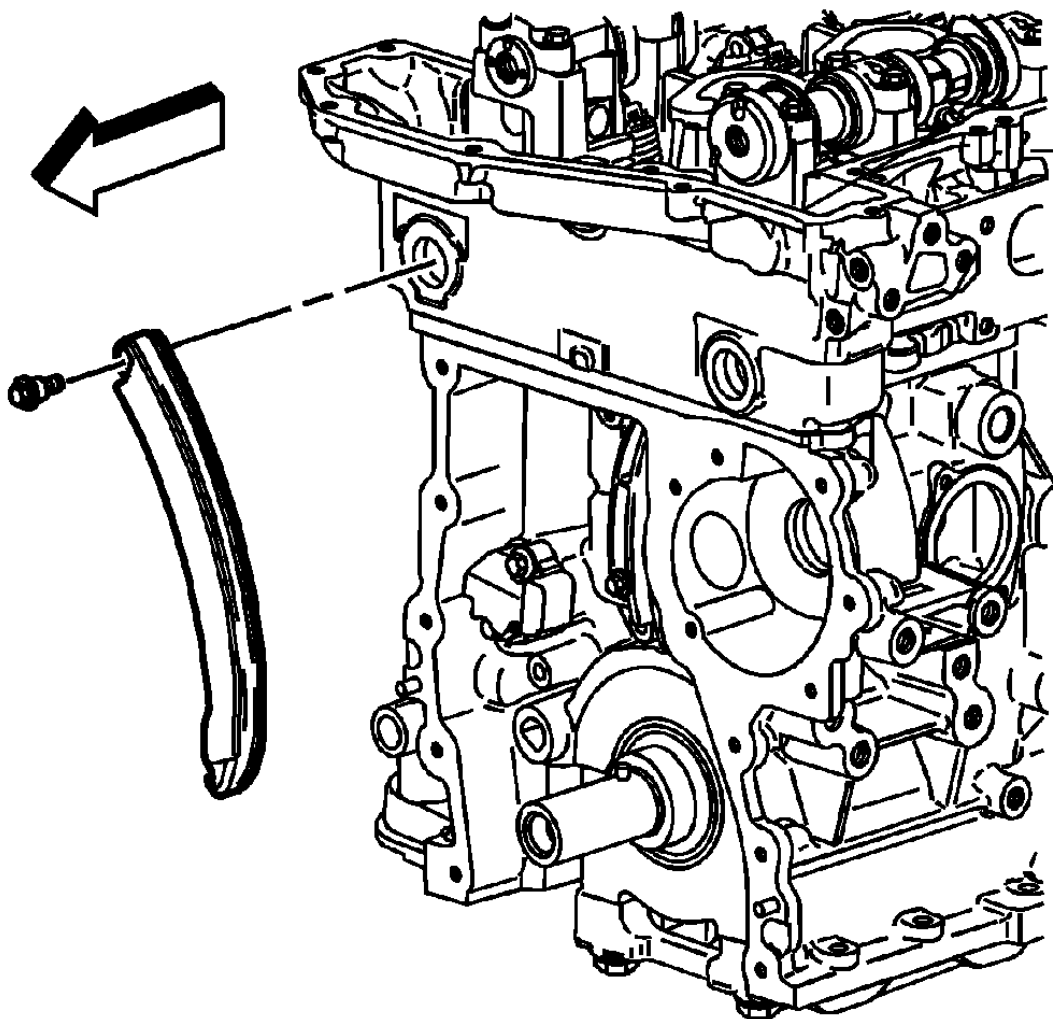


Fig. 154: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Remove the timing chain tensioner shoe bolt.
10. Remove the timing chain tensioner shoe from the engine.

Installation Procedure

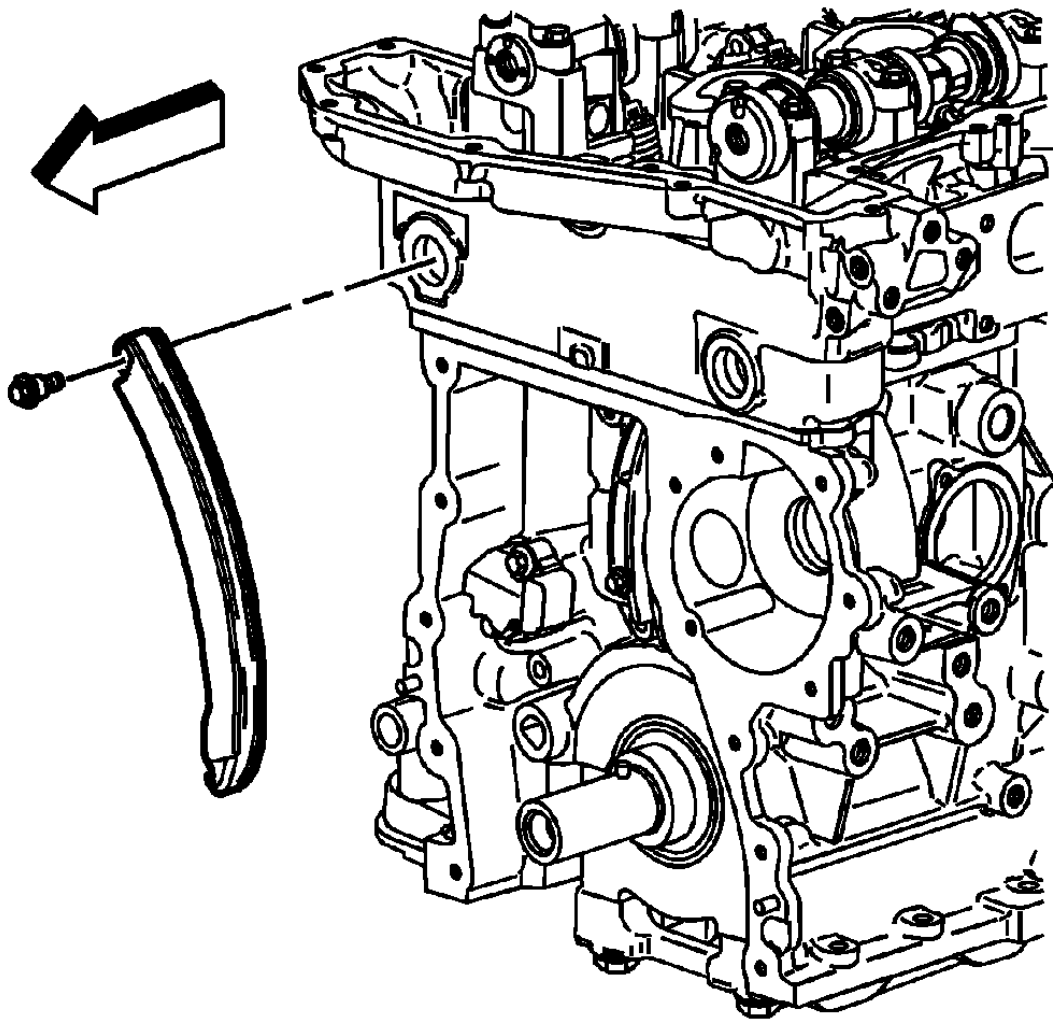


Fig. 155: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Position the timing chain tensioner shoe to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the timing chain tensioner shoe bolt and tighten to 25 N.m (18 lb ft).

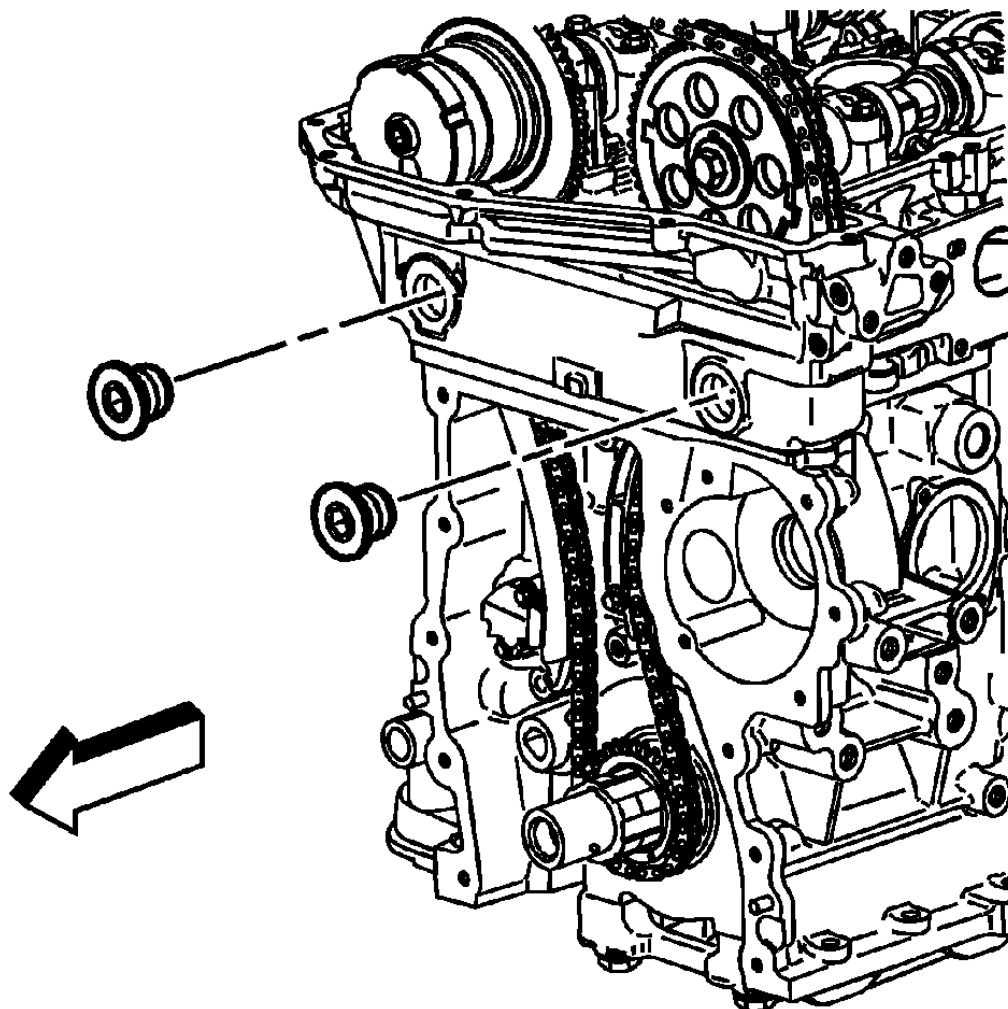


Fig. 156: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

3. Install the cylinder head access hole plug and tighten to 5 N.m (44 lb in).

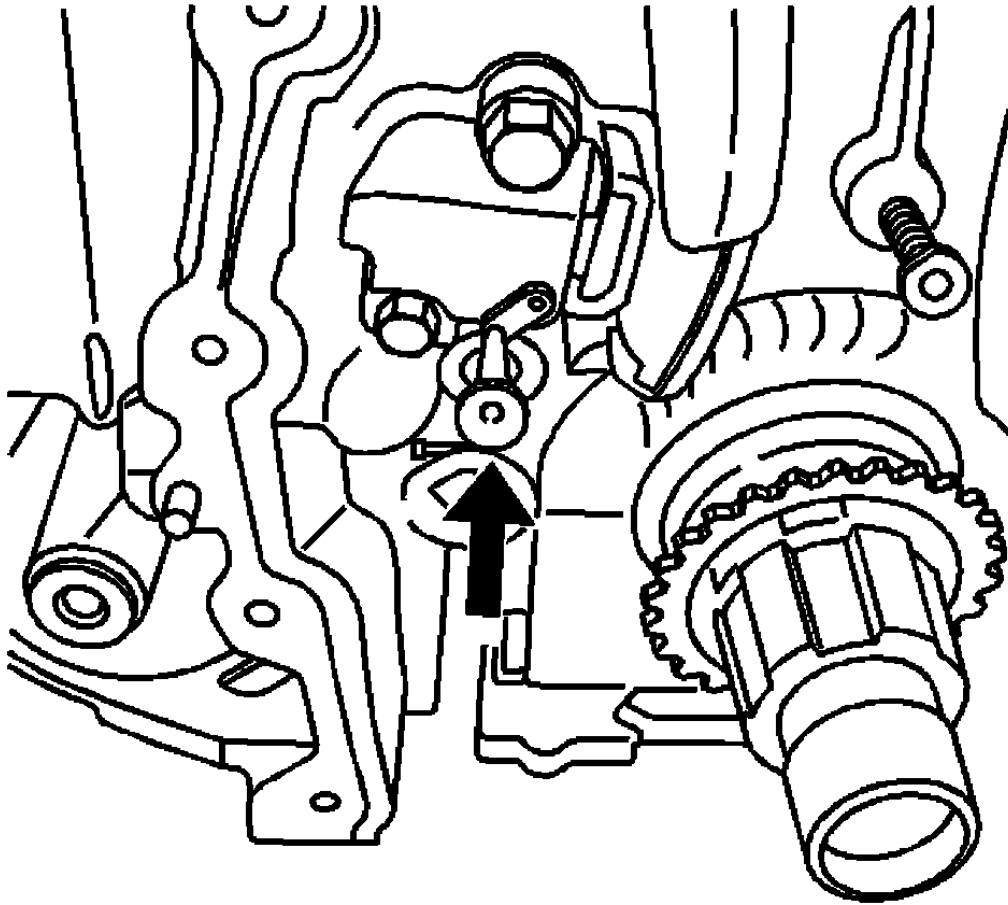


Fig. 157: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

4. Remove the tee in the timing chain tensioner to regain tension on the timing chain.

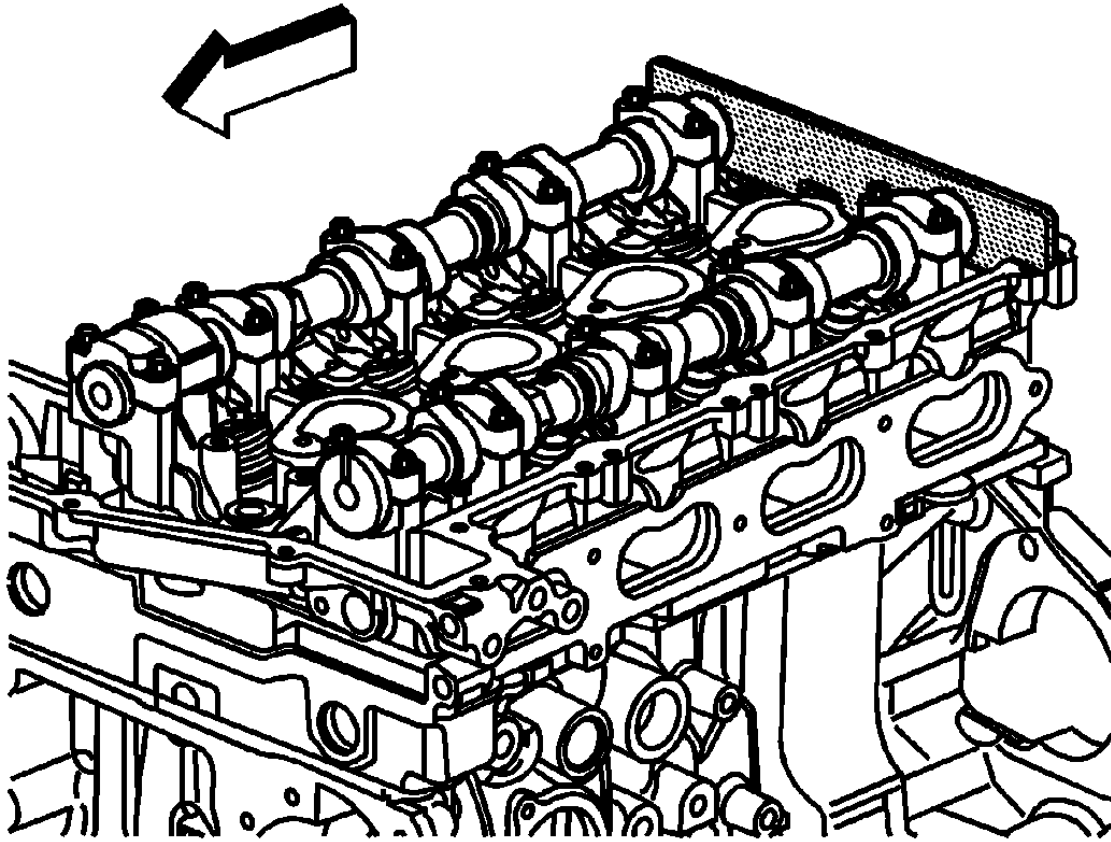


Fig. 158: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **J 44221** camshaft holding tool from the camshafts.

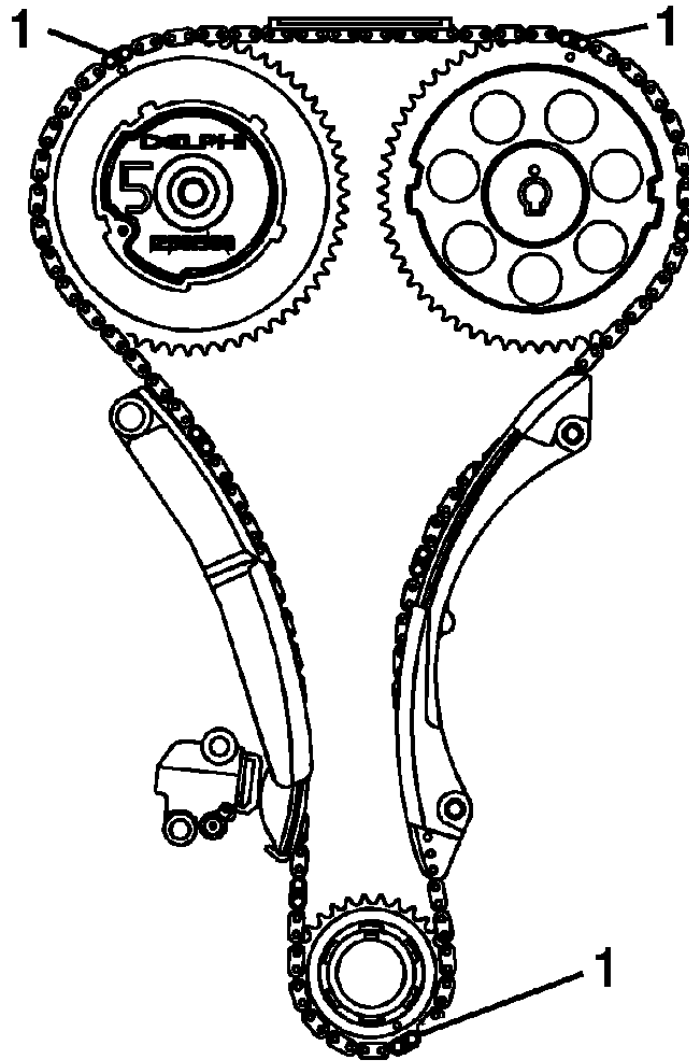


Fig. 159: Identifying Chain Alignment Links
Courtesy of GENERAL MOTORS COMPANY

NOTE: Every 7th link of the timing chain is darkened to aid in aligning the timing marks.

6. Align the marked links (1) of the timing chain with the timing marks on the following:
 - The exhaust camshaft position actuator sprocket
 - The intake camshaft sprocket
 - The crankshaft sprocket

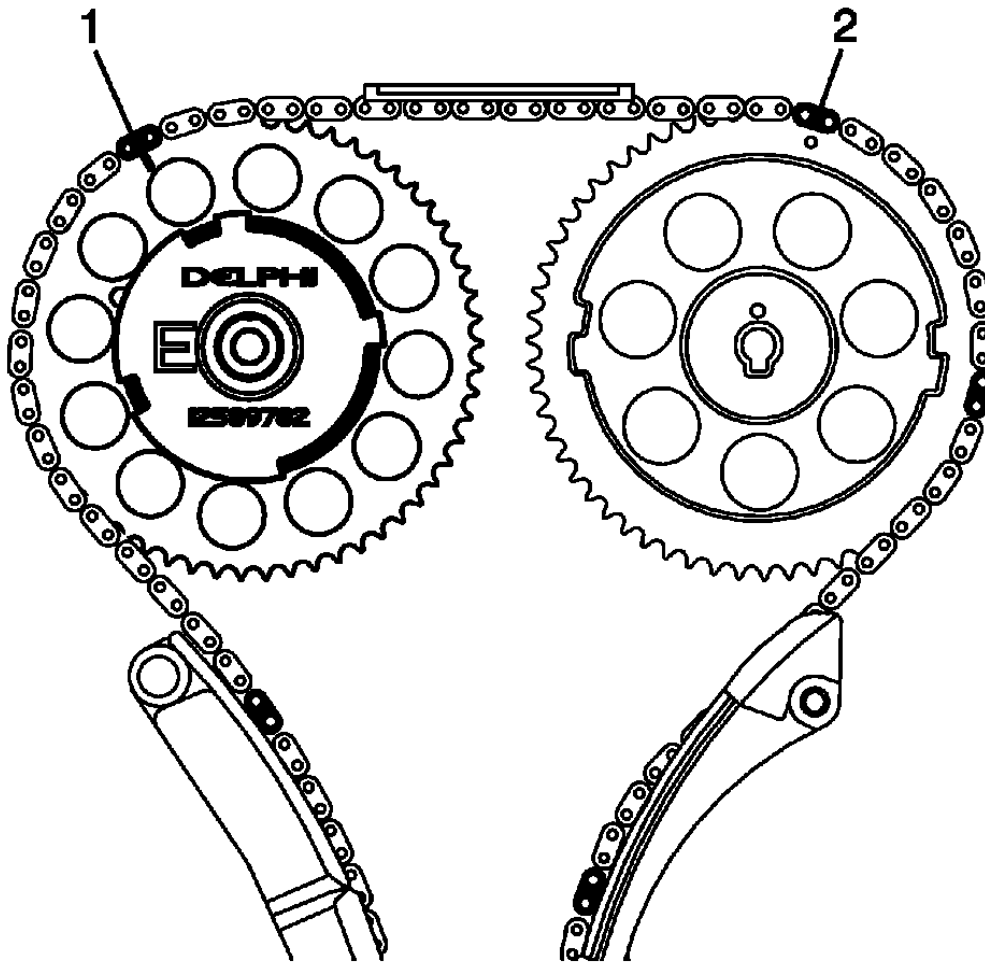


Fig. 160: Identifying Exhaust And Intake Timing Marks
 Courtesy of GENERAL MOTORS COMPANY

7. Once the timing is set, ensure there are 15 links between the exhaust timing mark (1) and the intake timing mark (2).
8. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
9. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

TIMING CHAIN UPPER GUIDE REPLACEMENT

Removal Procedure

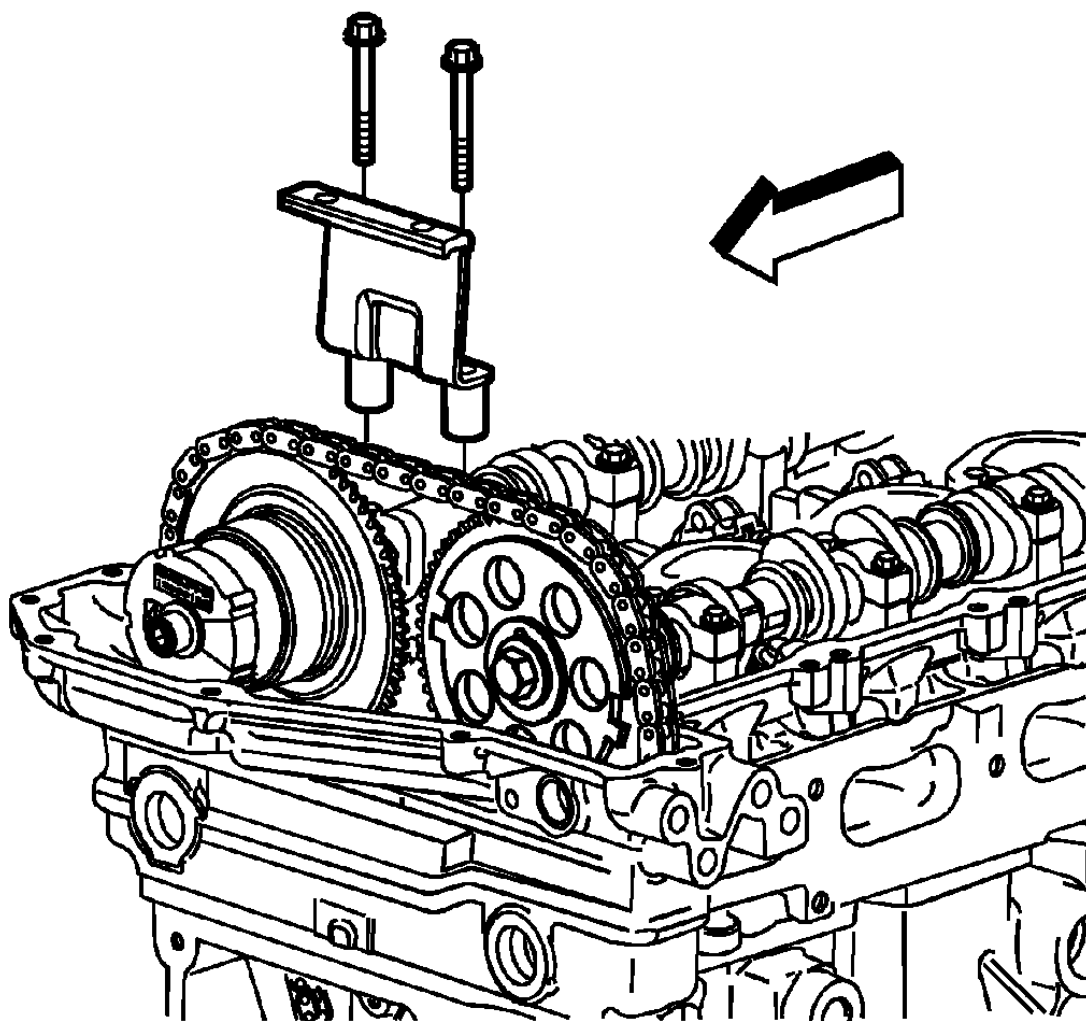


Fig. 161: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the upper timing chain guide bolts.
3. Remove the upper timing chain guide from the cylinder head.

Installation Procedure

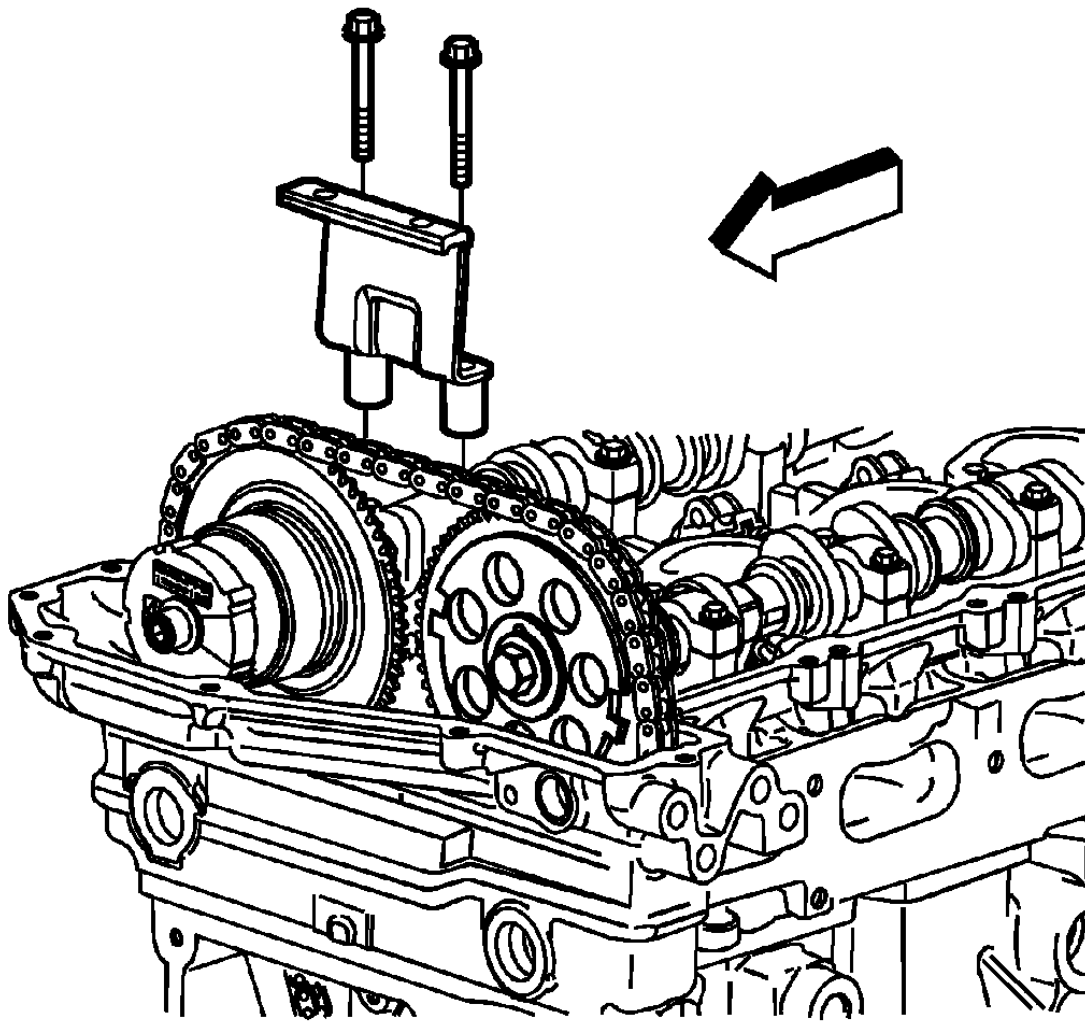


Fig. 162: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS COMPANY

1. Position the upper timing chain guide to the cylinder head.
2. Apply threadlock to the upper timing chain guide bolt threads. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

CAUTION: Refer to **Fastener Caution** .

3. Install the upper timing chain guide bolts and tighten to 10 N.m (89 lb in).
4. Install the camshaft cover. Refer to **Engine Front Cover Replacement**.

TIMING CHAIN LOWER GUIDE REPLACEMENT

Removal Procedure

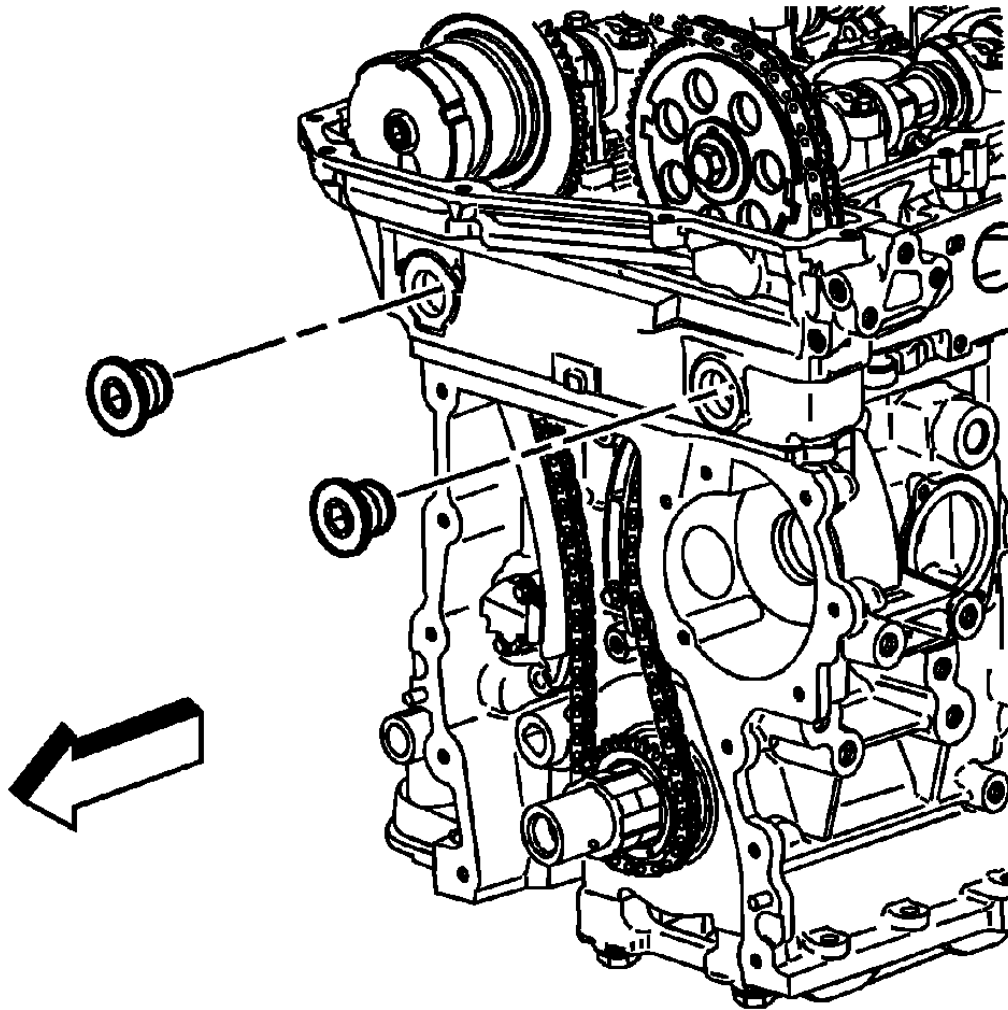


Fig. 163: View Of Cylinder Head Access Hole Plugs
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the timing chain tensioner shoe. Refer to **Timing Chain Tensioner Shoe Replacement**.
2. Slide the crankshaft sprocket from the crankshaft sprocket snout, in order to gain slack in the timing chain to remove the lower timing chain guide.
3. Remove the cylinder head access hole plug.

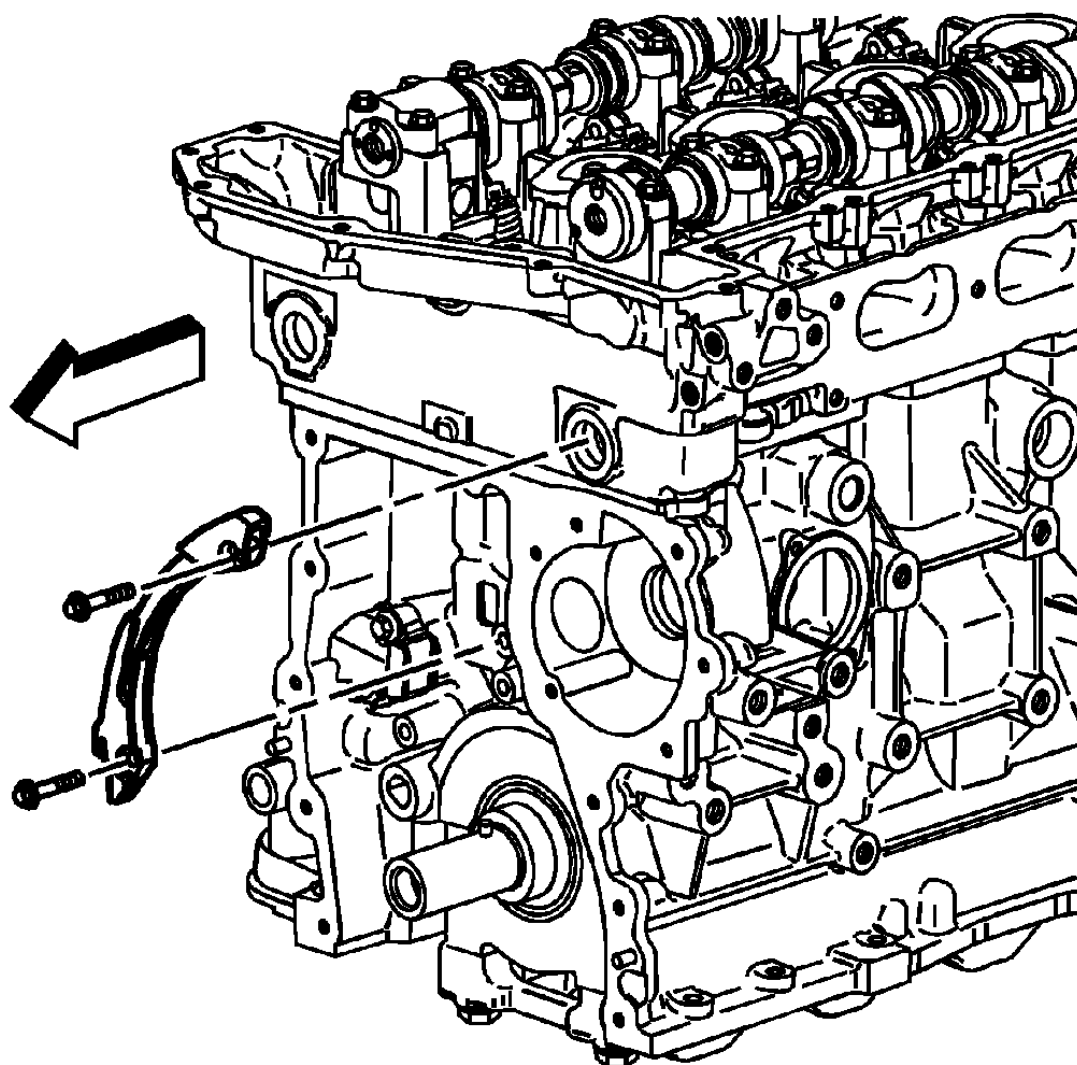


Fig. 164: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the lower timing chain guide bolts.
5. Remove the lower timing chain guide from the engine.

Installation Procedure

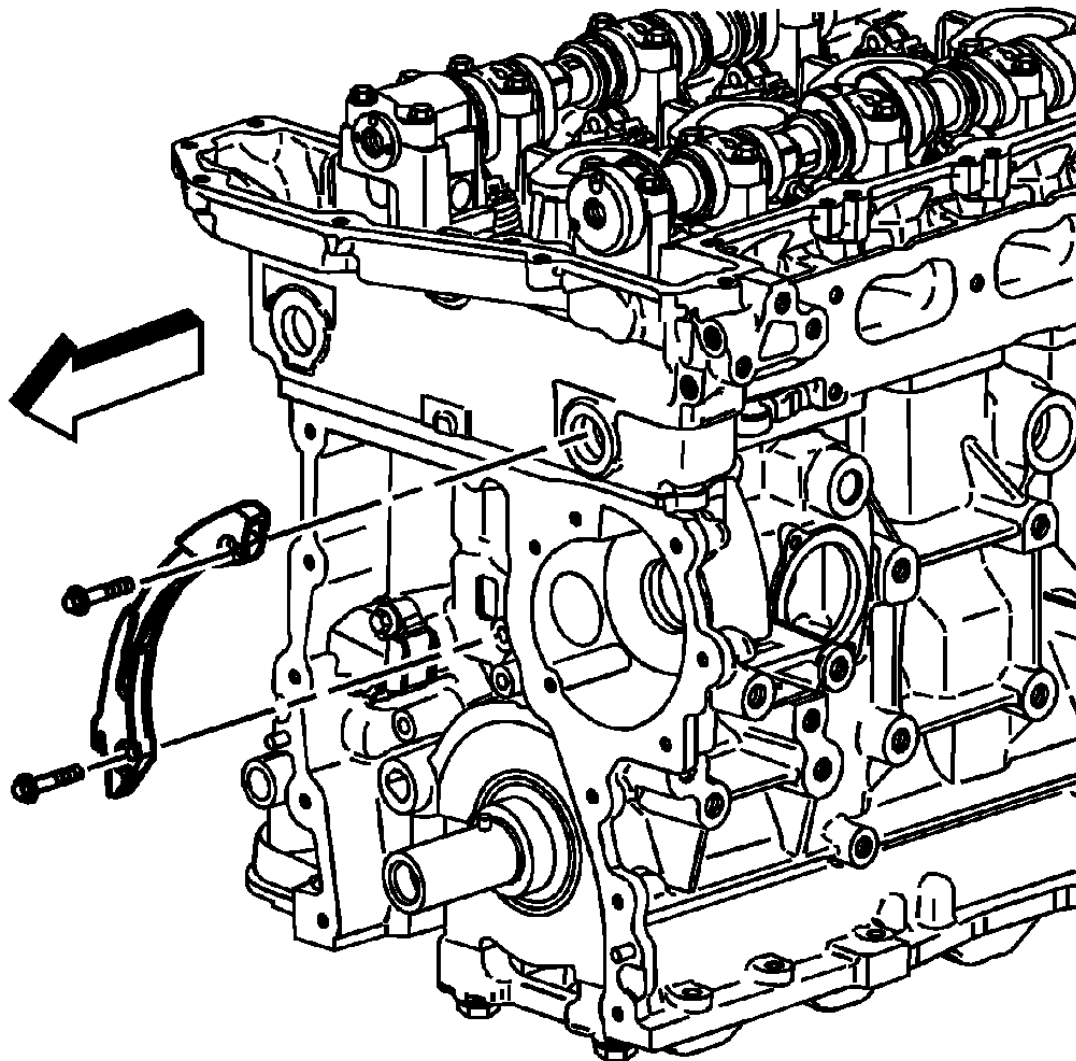


Fig. 165: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Position the lower timing chain guide to the engine.

CAUTION: Refer to Fastener Caution .

2. Install the lower timing chain guide bolts and tighten to 12 N.m (107 lb in).

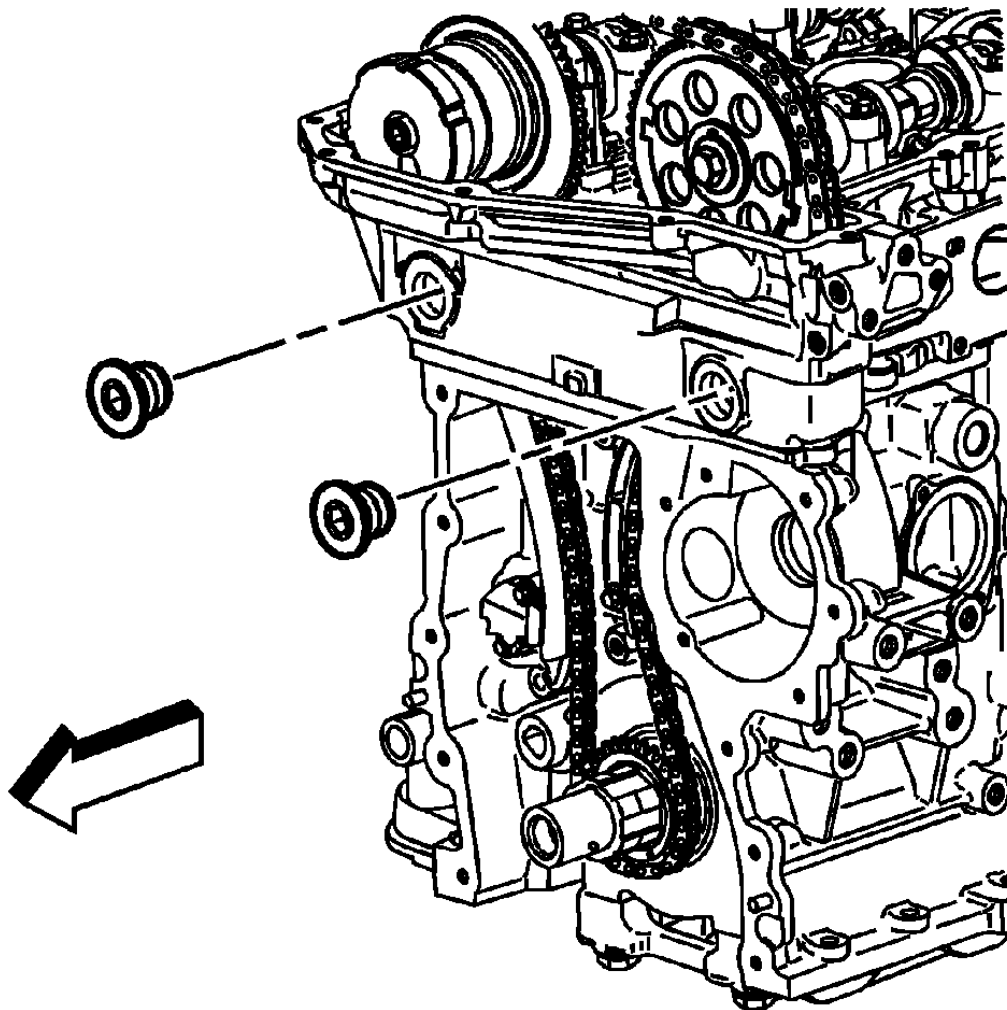


Fig. 166: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

3. Install the cylinder head access hole plug and tighten to 5 N.m (44 lb in).
4. Install the crankshaft sprocket to the crankshaft sprocket snout.

Align the marked link on the timing chain with the timing mark on the crankshaft sprocket.

5. Install the timing chain tensioner shoe. Refer to **Timing Chain Tensioner Shoe Replacement**.

CAMSHAFT REPLACEMENT

Special Tools

- J 44221 Camshaft Holding Tool
- J 44222 Camshaft Sprocket Holding Tool

- **J 45059** Angle Meter

Removal Procedure

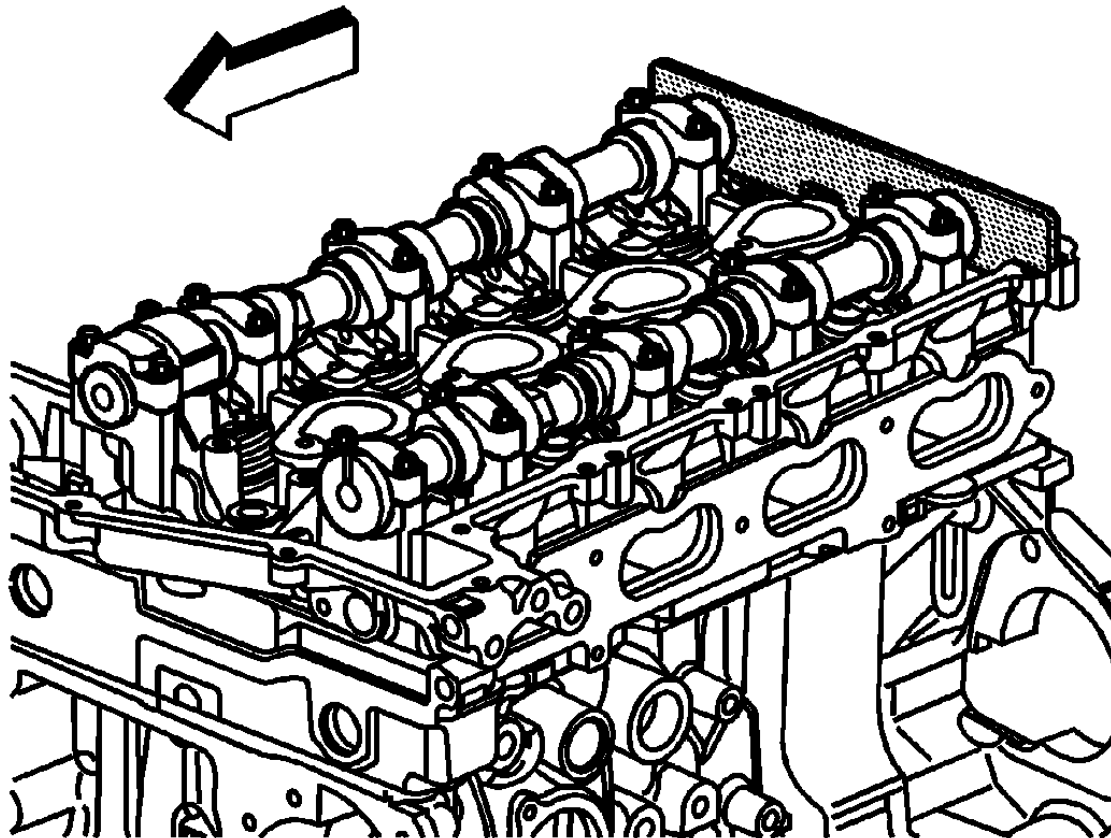


Fig. 167: Camshaft Holding Tool
Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the camshaft position (CMP) sensor. Refer to **Camshaft Position Sensor Replacement**.
3. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

WARNING: Refer to **Camshaft Holding Tool Warning**.

4. Install the **J 44221** camshaft holding tool to the rear of the camshafts.

5. Remove and discard the intake and the exhaust camshaft sprocket bolts.

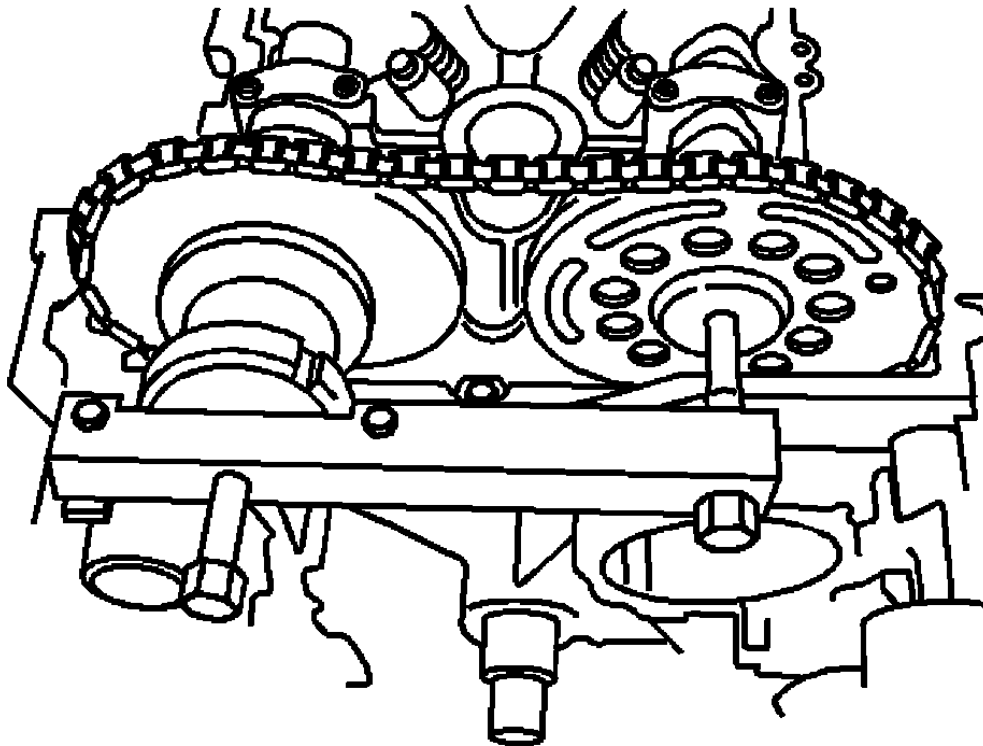


Fig. 168: Camshaft Sprocket Holding Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: In order to maintain timing chain tension, make sure the 2 bolts that hold J 44222 camshaft sprocket holding tool to the front of the cylinder head are completely tightened and the horizontal bolt into the exhaust camshaft phaser actuator sprocket is adjusted correctly before sliding the sprockets off the camshafts. Failure to do so may disturb the timing chain components.

6. Install the **J 44222** camshaft sprocket holding tool onto the cylinder head and adjust the horizontal bolts into the camshaft sprockets in order to maintain chain tension and keep from disturbing the timing chain components.
7. Carefully slide the sprockets with the timing chain from the camshafts to the **J 44222** camshaft sprocket holding tool.

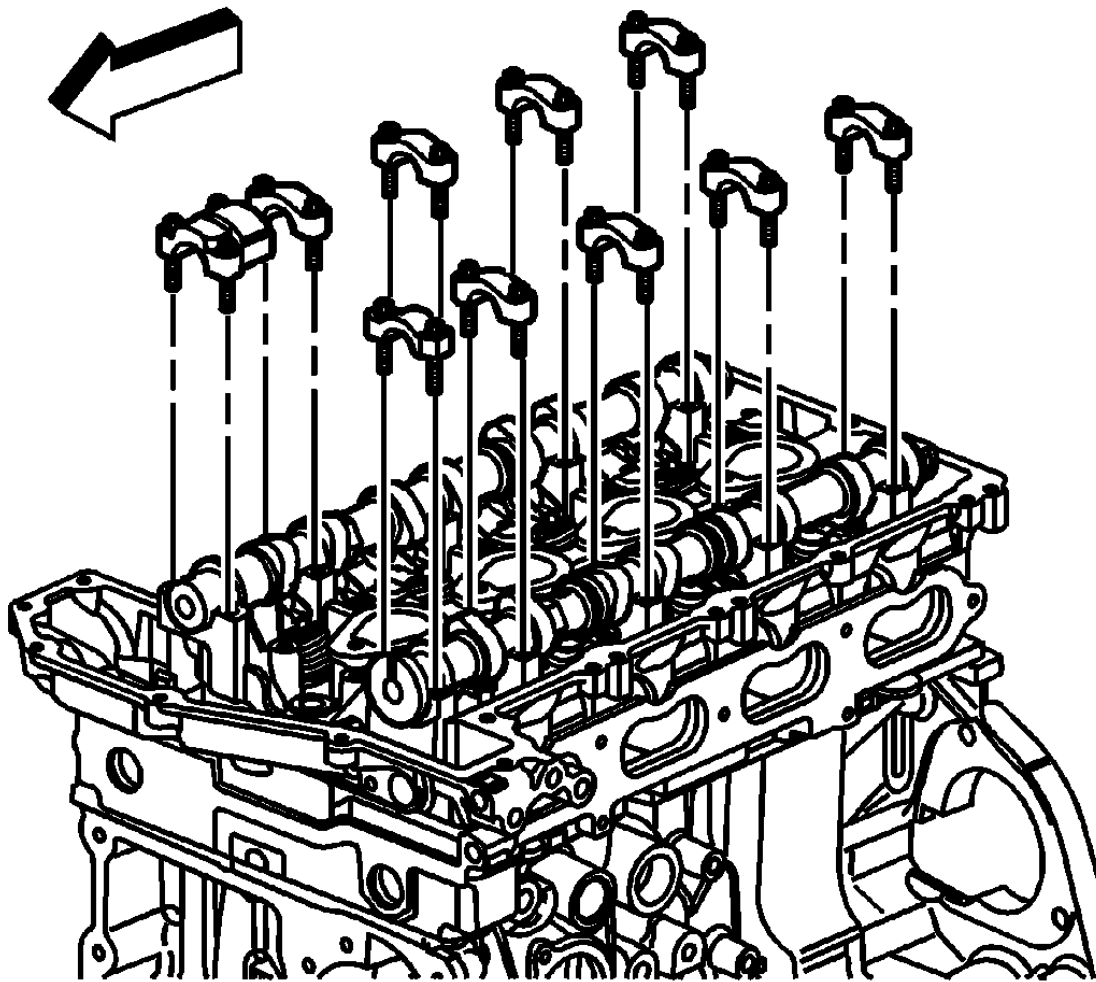


Fig. 169: View Of Camshaft Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Alternately loosen the camshaft cap bolts a few turns at a time until all valve spring pressure has been released.

NOTE: Place the camshaft caps in a rack to ensure the caps are installed in the same location from which they were removed.

9. Remove the camshaft caps.
10. Remove the **J 44221** camshaft holding tool from the camshafts.

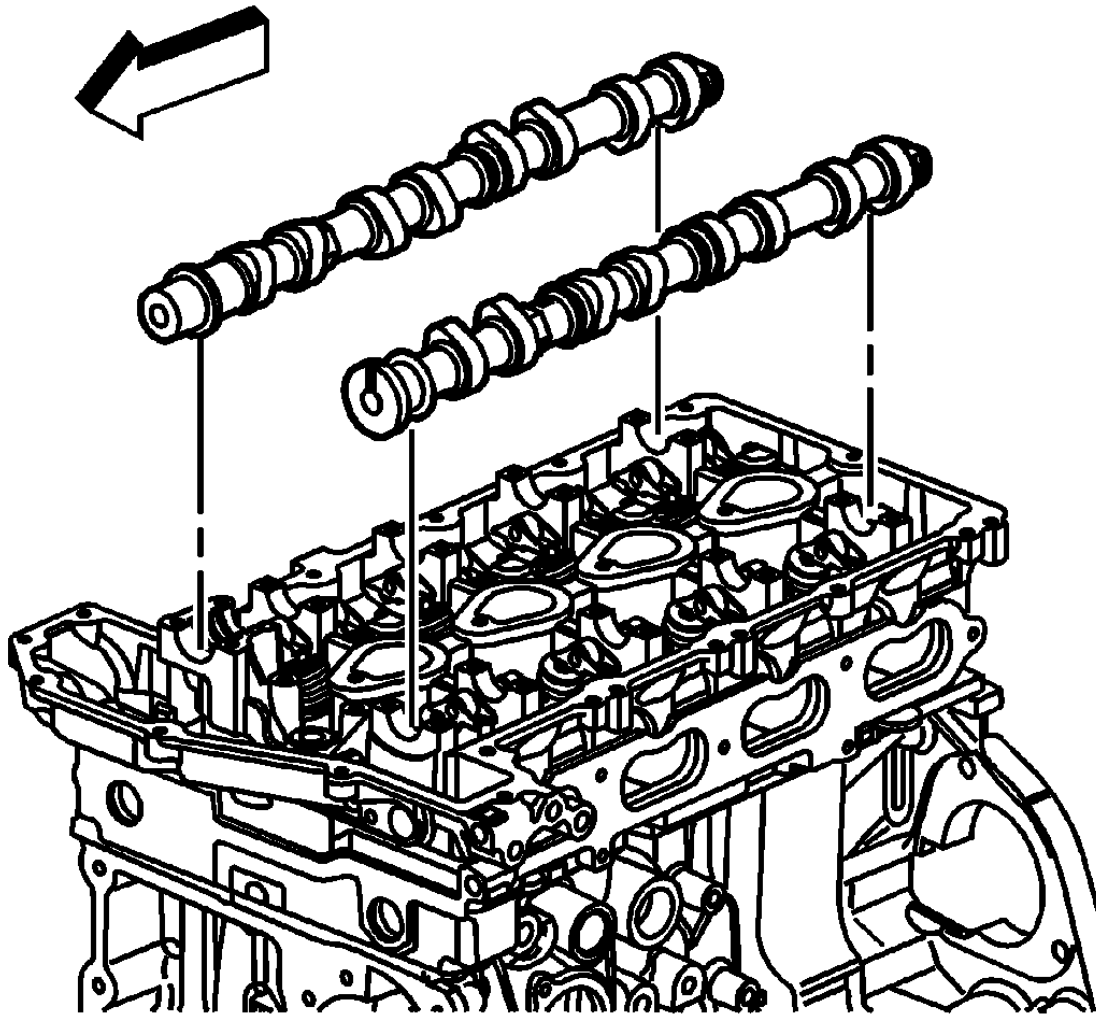


Fig. 170: View Of Camshafts

Courtesy of GENERAL MOTORS COMPANY

11. Remove the camshafts from the cylinder head.

Installation Procedure

1. Coat the camshaft journals, camshaft journal thrust face, and camshaft lobes with clean engine oil.

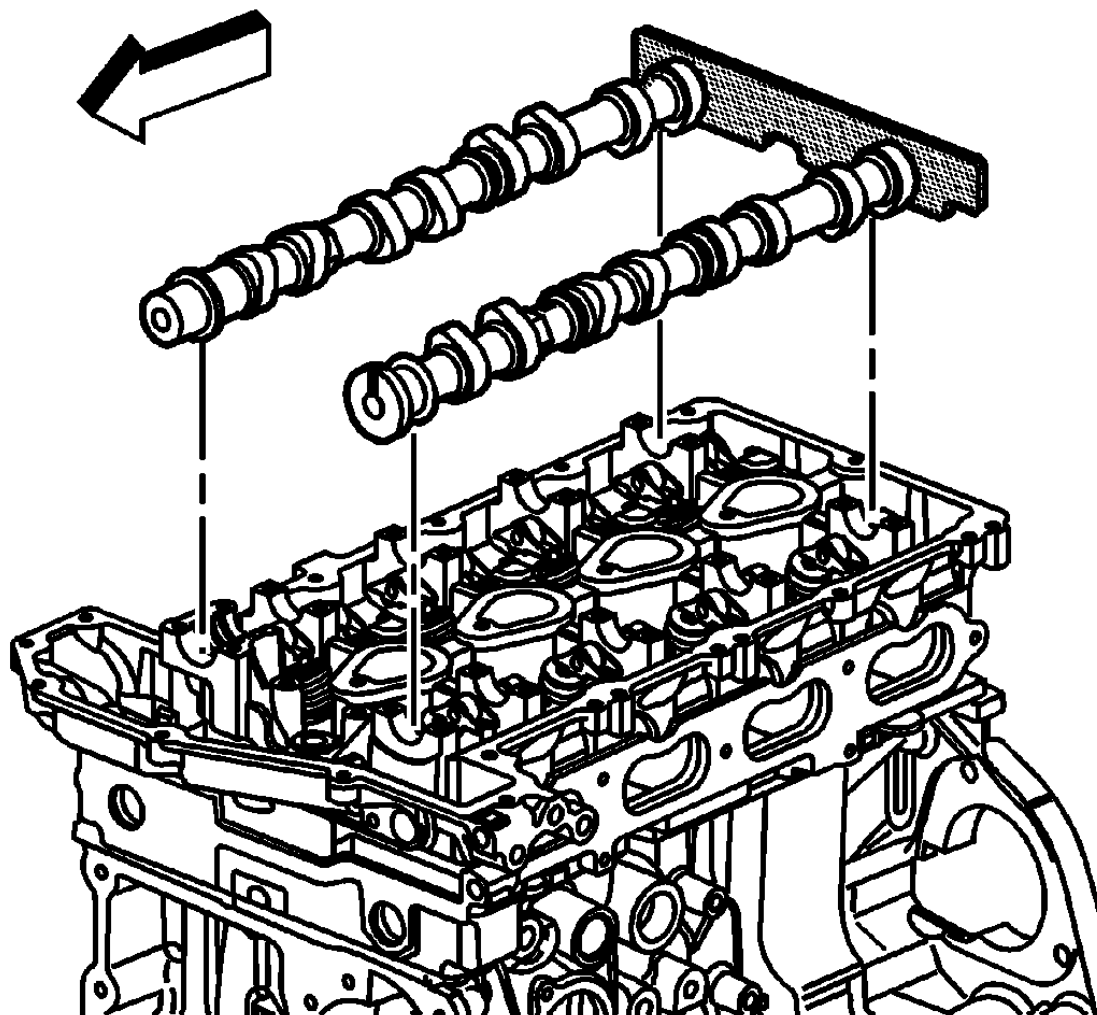


Fig. 171: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

2. Install the J 44221 camshaft holding tool with the camshaft flats up and the #1 piston at TDC.
3. Install the intake and exhaust camshafts to their original positions.

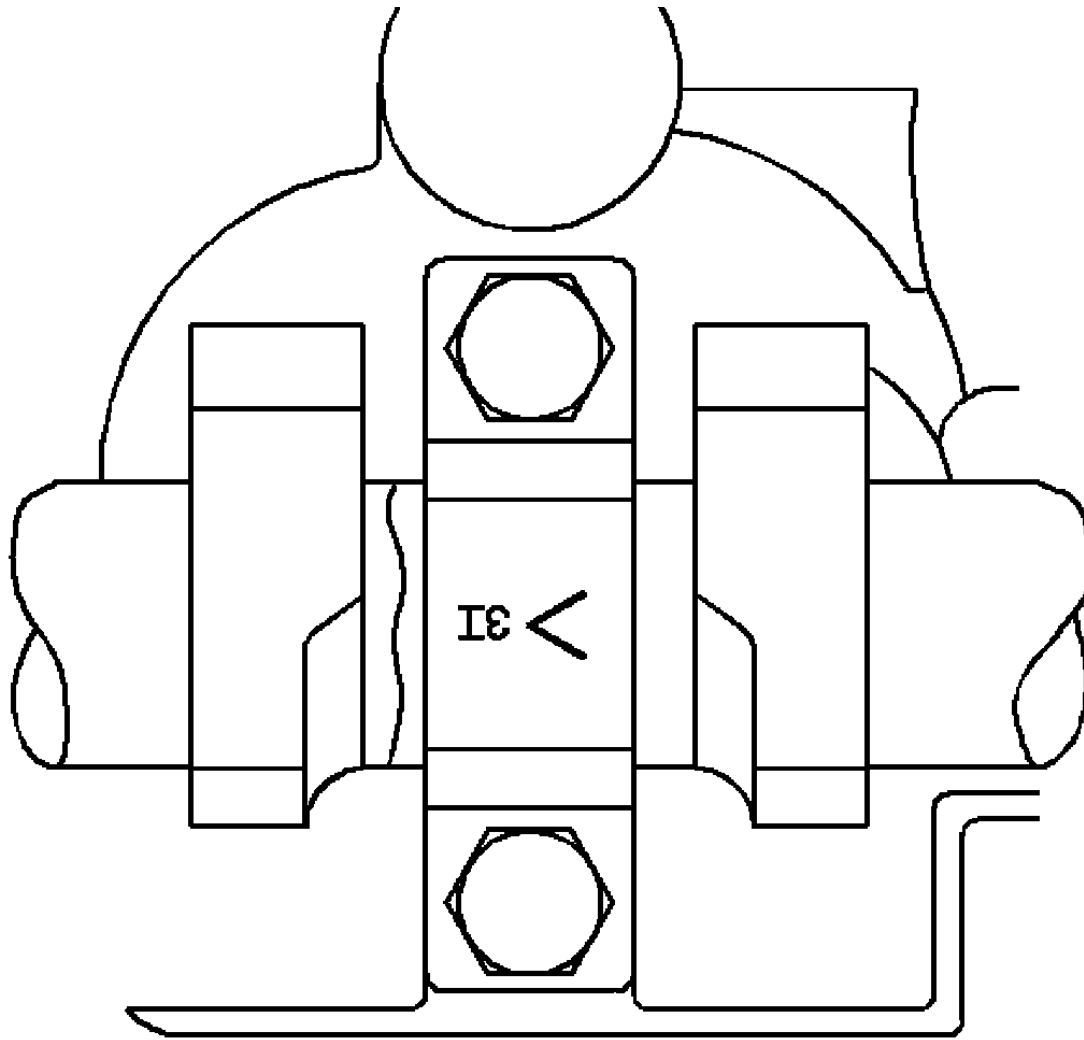


Fig. 172: Identifying Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS COMPANY

4. Observe the markings on the camshaft caps. Each camshaft cap is marked in order to identify its location. The markings have the following meanings:
 - The arrow should point to the front of the engine.
 - The number indicates the position from the front of the engine.
 - The "E" indicates the exhaust camshaft.
 - The "I" indicates the intake camshaft.

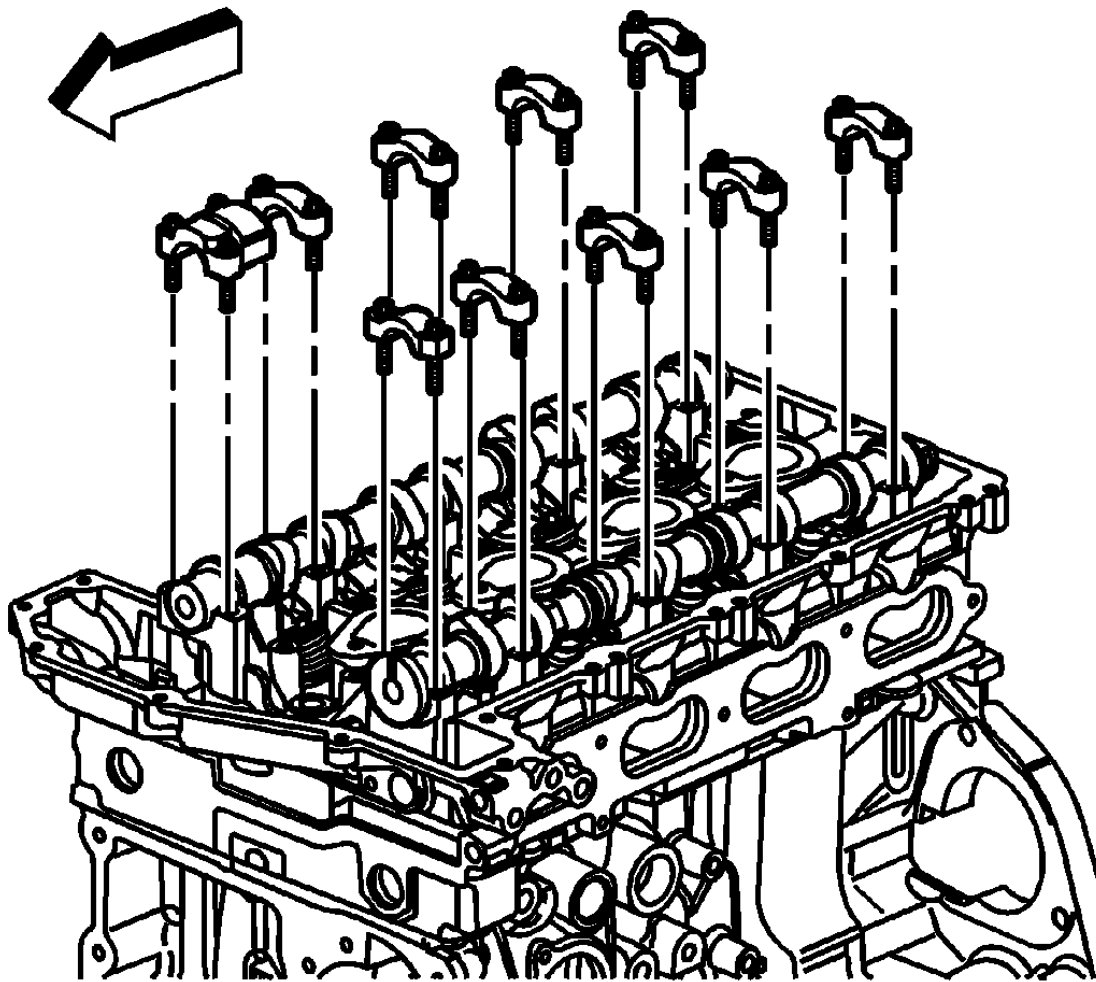


Fig. 173: View Of Camshaft Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Install the camshaft caps according to the identification marks.

CAUTION: Refer to Fastener Caution .

6. Install the camshaft cap bolts. Tighten the bolts evenly in order to compress the valve springs before final torque.

Tighten the bolts to 12 N.m (106 lb in).

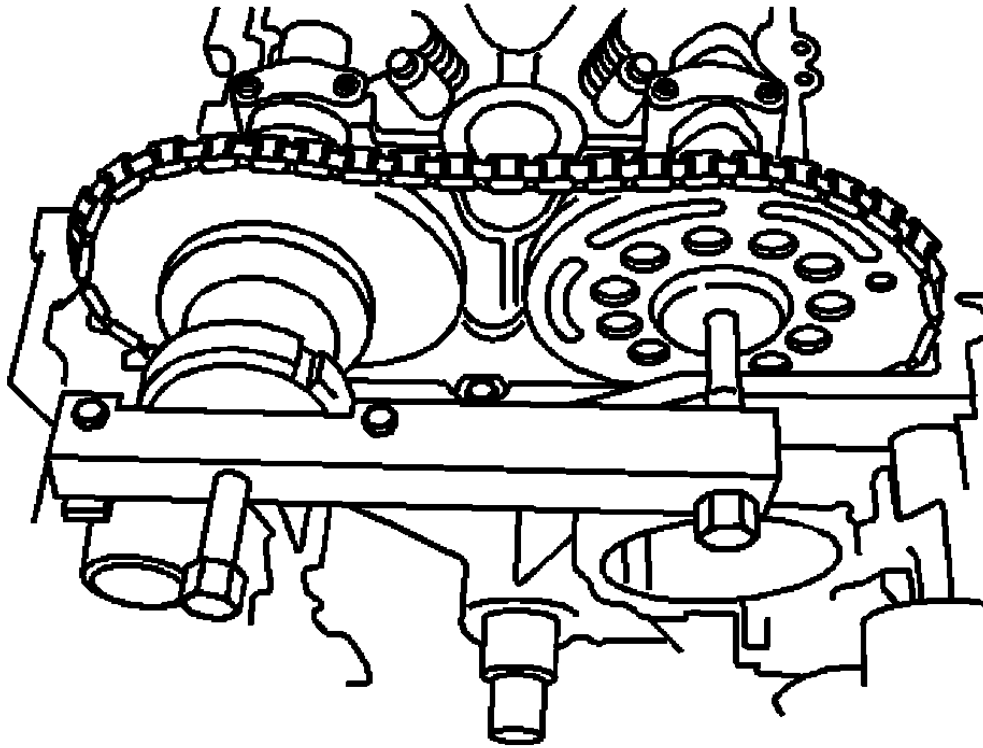


Fig. 174: Camshaft Sprocket Holding Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- To aid in aligning the sprockets to the camshafts, use a 25 mm (1 in) wrench on the hex of the camshafts to rotate.
- Ensure the alignment pins are properly engaged with the camshafts.

7. Carefully slide the sprockets with the timing chain from the **J 44222** camshaft sprocket holding tool to the camshafts.
8. Remove the **J 44222** camshaft sprocket holding tool from the cylinder head.
9. Install the new intake camshaft sprocket bolt.
10. Install the new exhaust camshaft actuator bolt.
 - Tighten the intake camshaft sprocket bolt to 20 N.m (15 lb ft) plus an additional 100 degrees using the **J 45059** angle meter.
 - Tighten the exhaust camshaft actuator bolt to 25 N.m (18 lb ft) plus an additional 135 degrees using the **J 45059** angle meter.

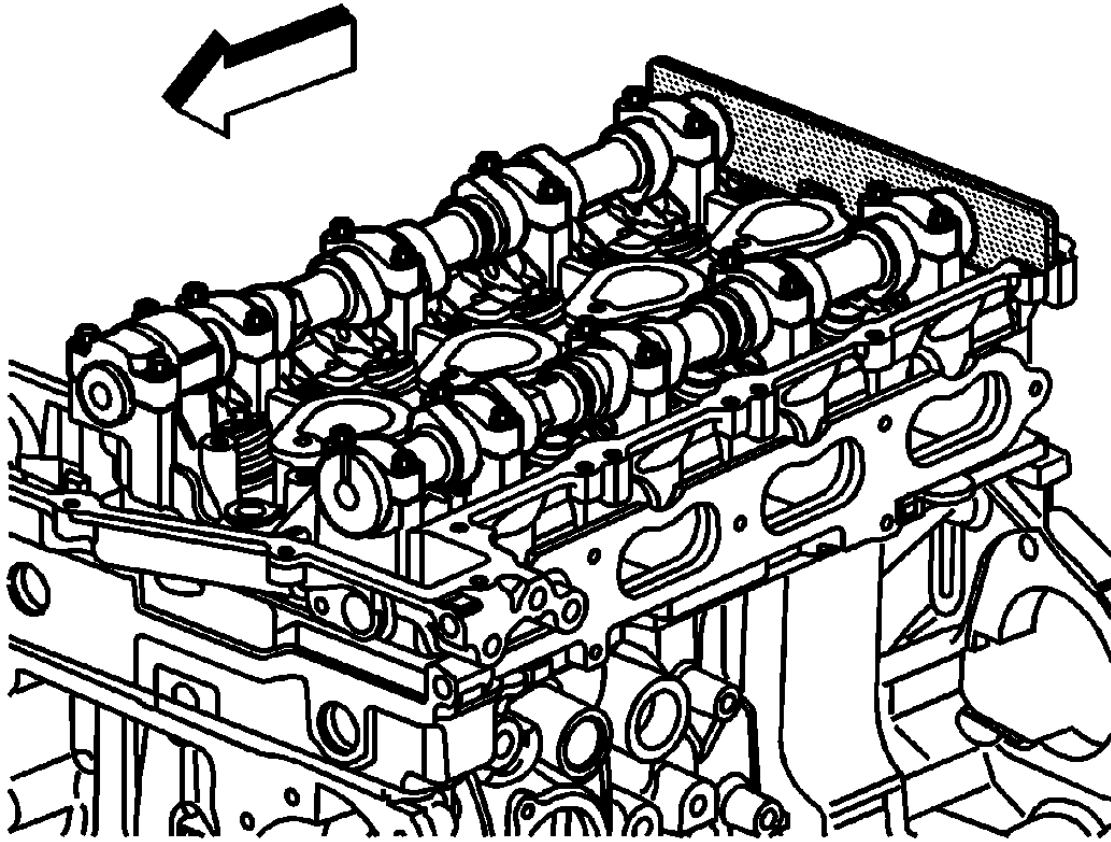


Fig. 175: Camshaft Holding Tool

Courtesy of GENERAL MOTORS COMPANY

11. Remove the **J 44221** camshaft holding tool from the camshafts.
12. Install the CMP sensor. Refer to **Camshaft Position Sensor Replacement** .
13. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

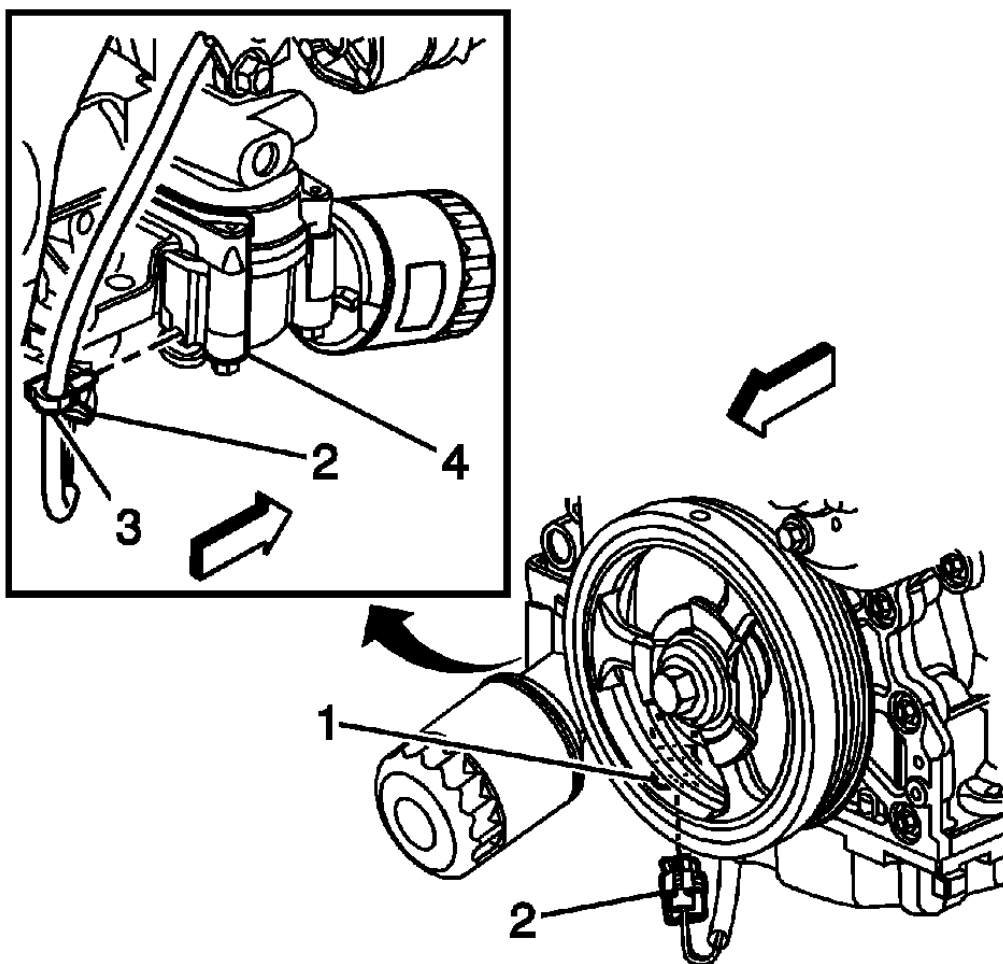


Fig. 176: View Of Oil Pressure Switch Electrical Connector & Oil Filter Adapter Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch (1).
3. Disconnect the engine wiring harness retainer (3) from the oil filter adapter (4).
4. Remove the engine oil pressure switch, if necessary. Refer to **Engine Oil Pressure Sensor and/or Switch Replacement**.

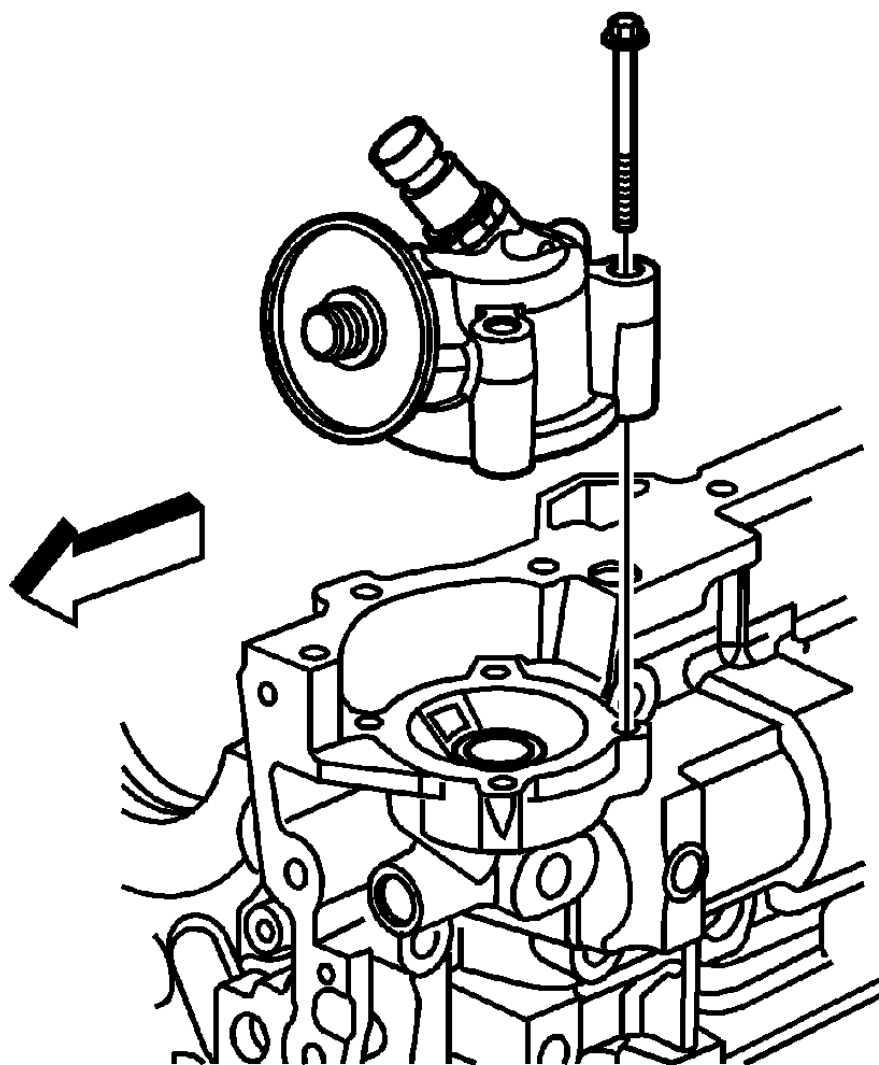


Fig. 177: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil filter adapter bolts.
6. Remove the oil filter adapter from the engine block.

Installation Procedure

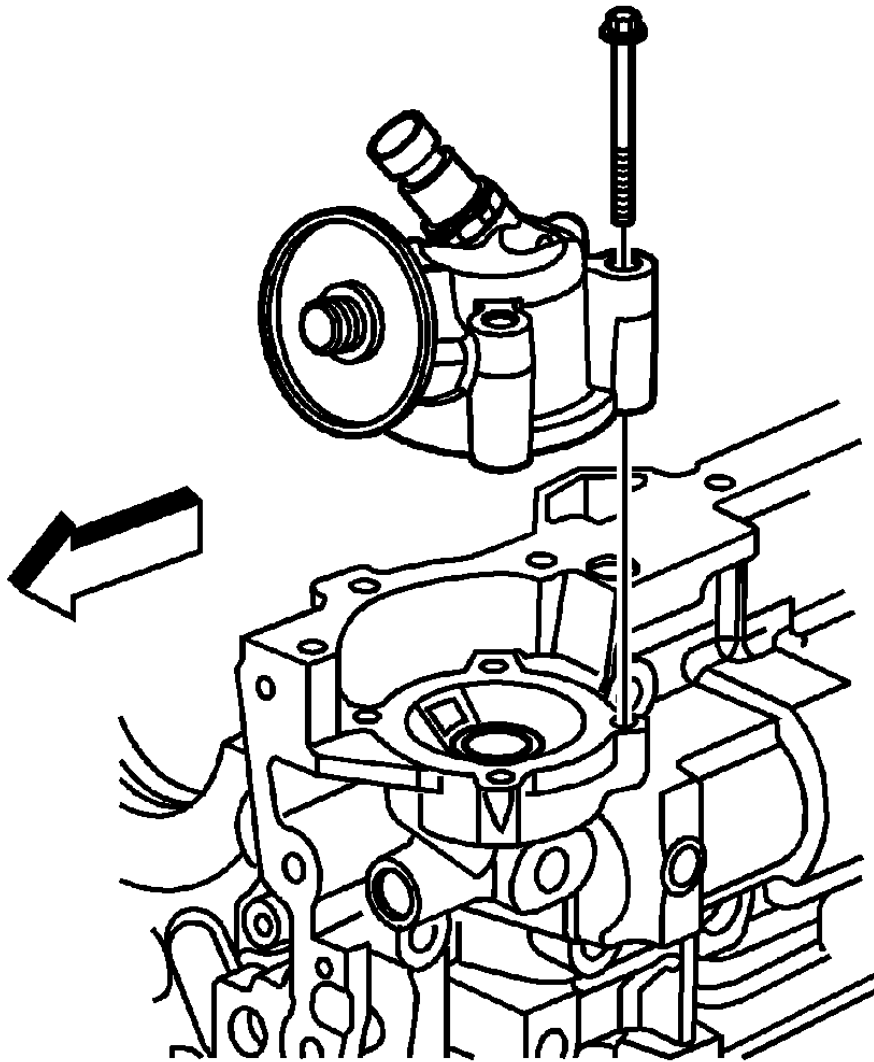


Fig. 178: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Position the oil filter adapter to the engine block and tighten the bolts to 10 N.m (89 lb in).
2. Install the engine oil pressure switch, if previously removed. Refer to Engine Oil Pressure Sensor and/or Switch Replacement.

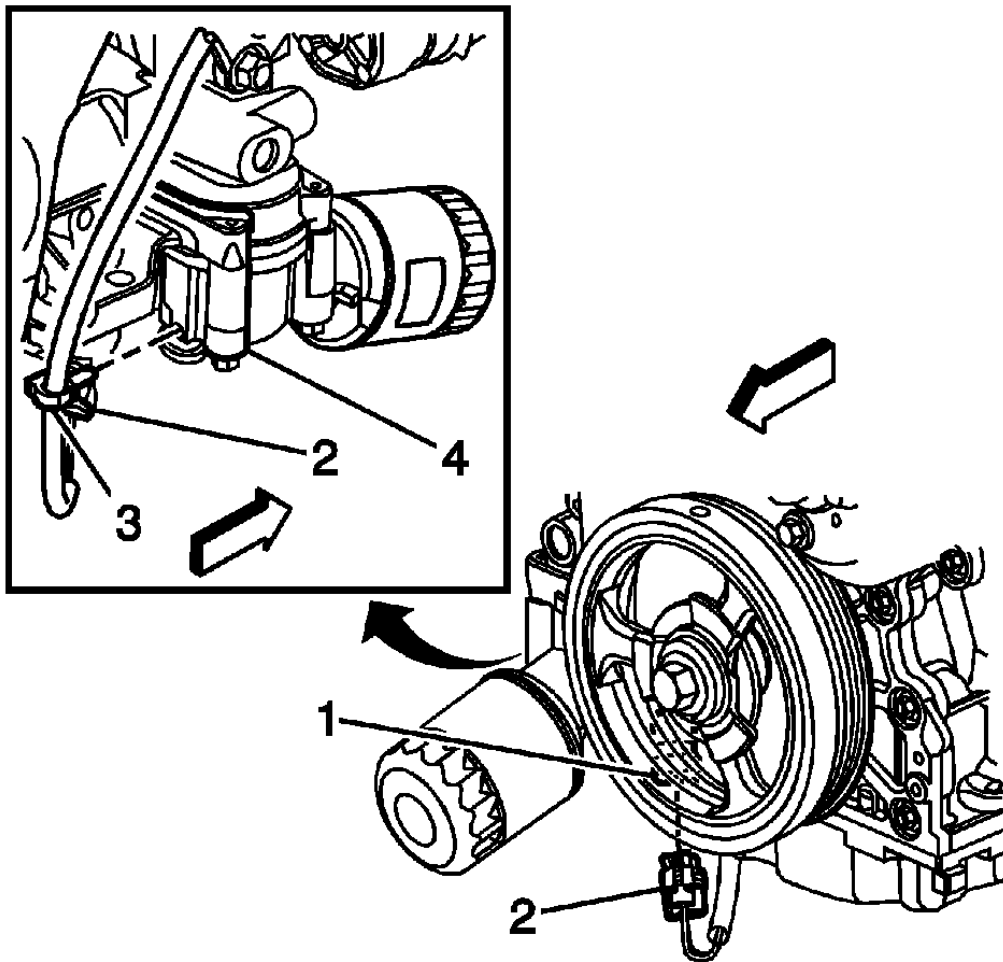


Fig. 179: View Of Oil Pressure Switch Electrical Connector & Oil Filter Adapter Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

3. Connect the engine wiring harness electrical connector (2) to the oil pressure switch (1).
4. Connect the engine wiring harness retainer (3) to the oil filter adapter (4).
5. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

OIL FILTER BYPASS VALVE REPLACEMENT

Removal Procedure

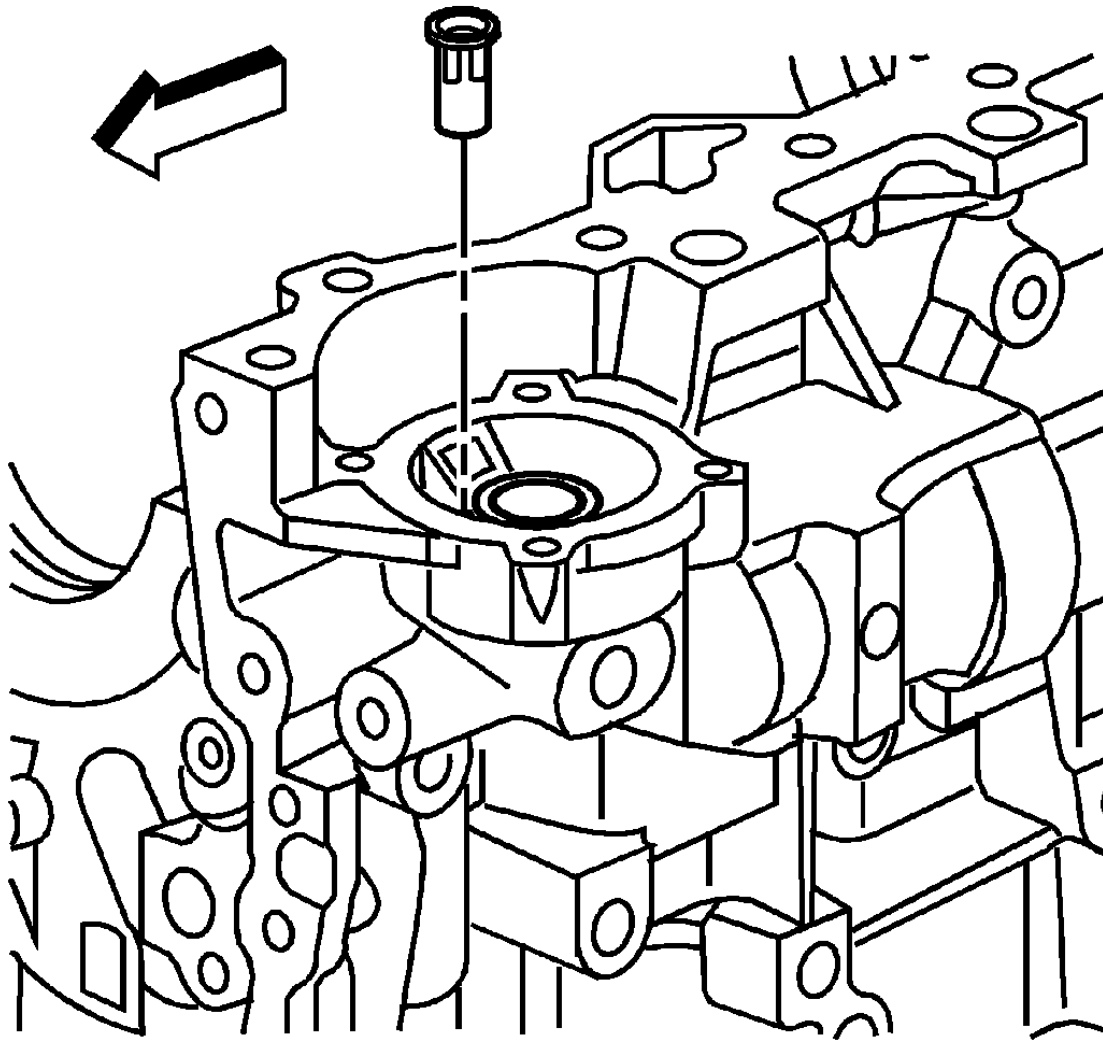


Fig. 180: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
2. Using a suitable tool, pry the oil filter bypass valve from the engine block.

Discard the oil filter bypass valve.

Installation Procedure

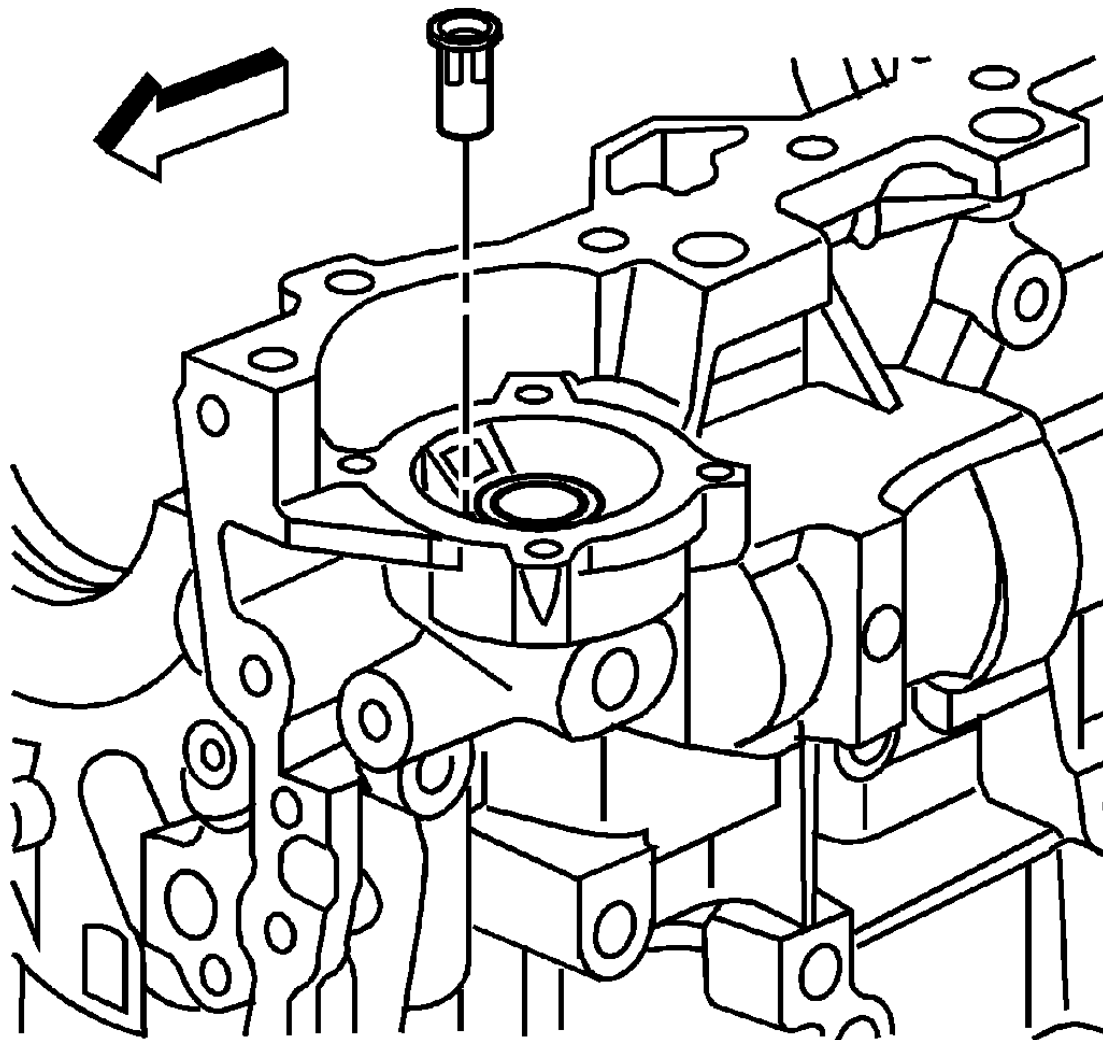


Fig. 181: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS COMPANY

1. Press the new oil filter bypass valve into the engine block.
2. Install the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.

OIL PAN REPLACEMENT

Removal Procedure

1. Remove the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.
2. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement**.
3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Remove the applicable components in order to gain clearance to remove the oil pan:
 - RWD

Remove the power steering gear. Refer to **Steering Gear Replacement** .

- 4WD

1. Remove the front propeller shaft. Refer to **Front Propeller Shaft Replacement** .

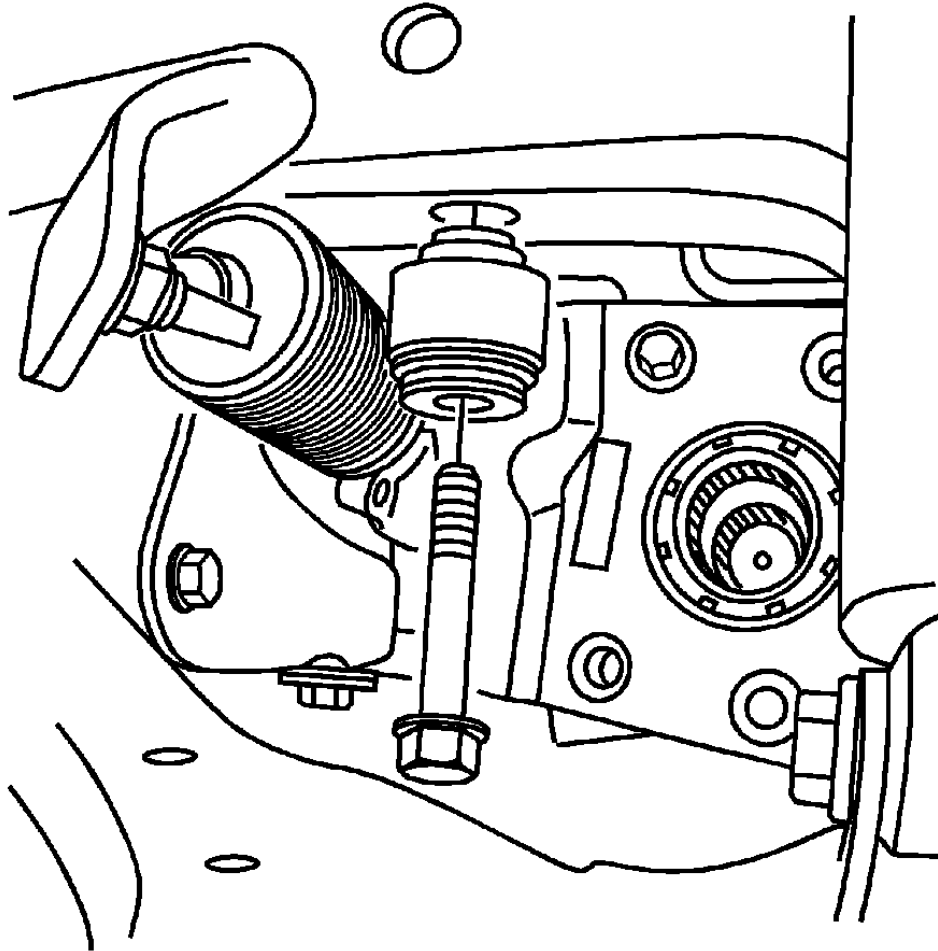


Fig. 182: View Of Mounting Bracket To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the differential carrier assembly bushing to frame bolts ONLY.
3. Pull the differential carrier assembly downward.
4. Secure the pinion yoke, in order to prevent the differential carrier from rotating.

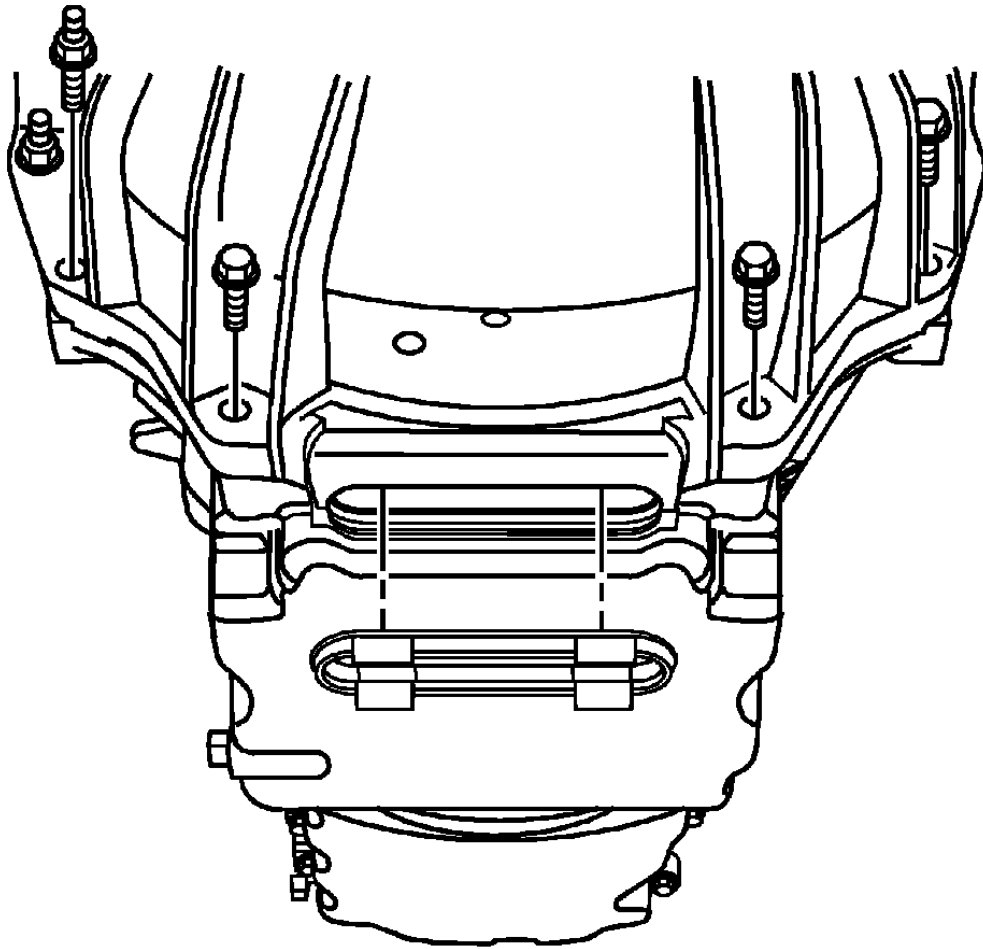


Fig. 183: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the service slot plug.
6. Remove the nuts securing the fuel hose/pipe bracket to the transmission, and position aside.
7. Remove 4 lower transmission mounting bolts that are attached to the oil pan.
8. For the 4WD only, remove the power steering gear mounting bolts ONLY. Refer to **Steering Gear Replacement** .
9. Pull the power steering gear downward in order to gain access to the oil pan.
10. Disconnect the engine wiring harness retainers from the oil pan.

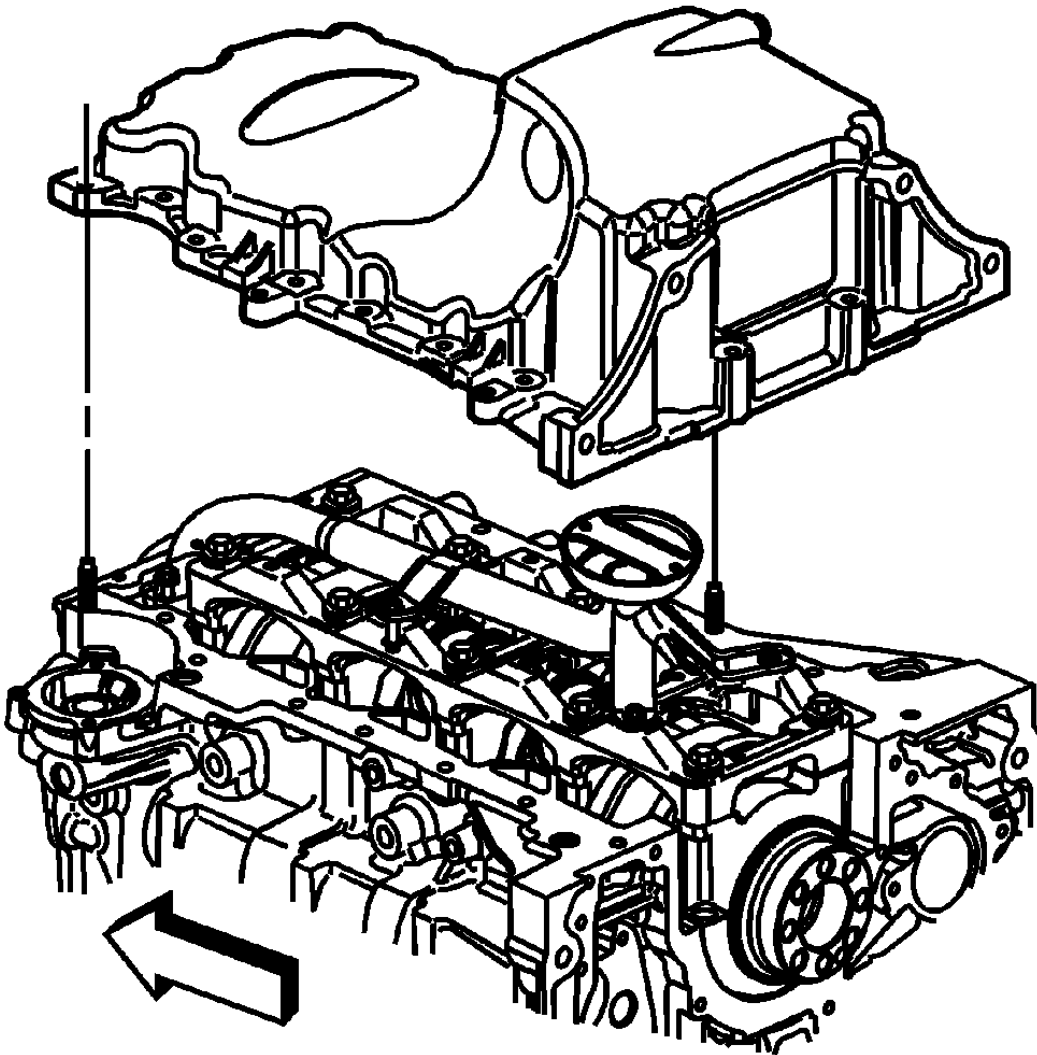


Fig. 184: View Of Oil Pan

Courtesy of GENERAL MOTORS COMPANY

11. Remove the oil pan bolts.
12. Install 2 bolts in the threaded holes at the rear of the oil pan to act as jack screws and tighten evenly to release the oil pan from the engine block.
13. Remove the oil pan.
14. Remove the 2 bolts from the jack screw holes.
15. Clean and inspect the engine block sealing surface.

Installation Procedure

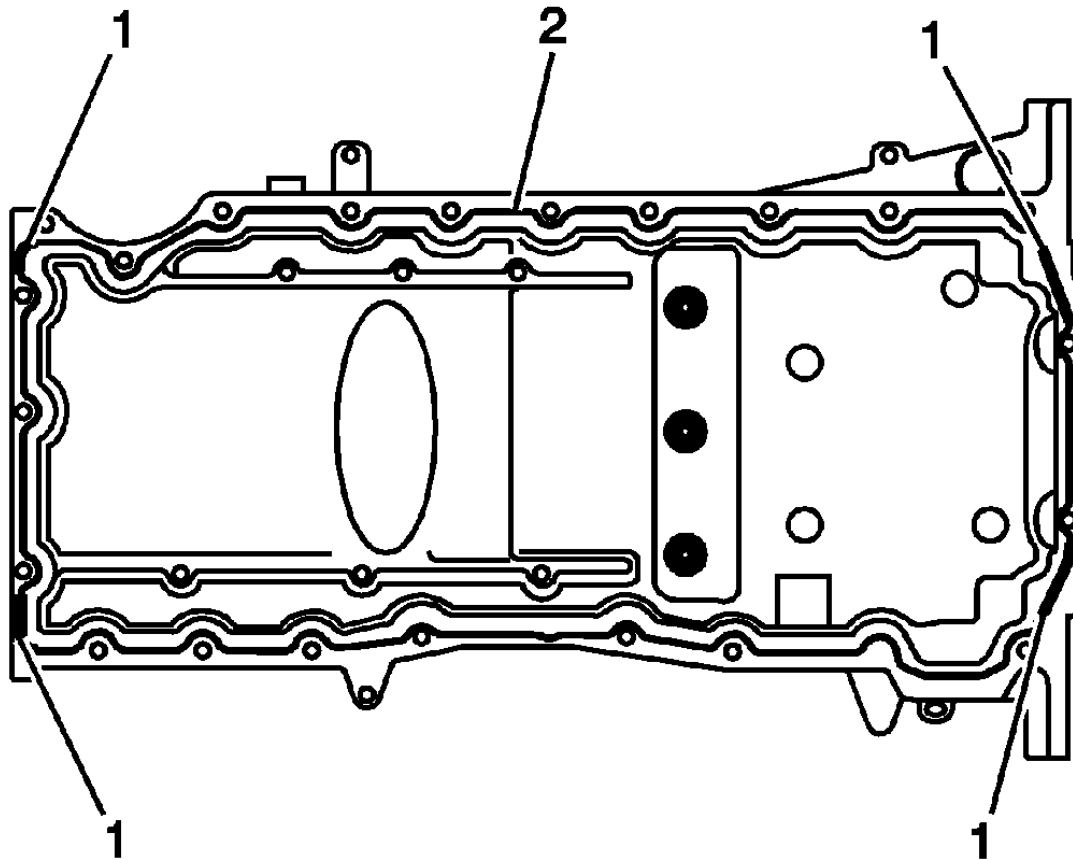


Fig. 185: View Of Oil Pan Sealant Application
Courtesy of GENERAL MOTORS COMPANY

NOTE: The oil pan must be installed within 10 minutes from when the sealer was applied.

1. Apply a 5.5 mm (0.22 in) bead of sealer to the oil pan in the areas marked (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Apply a 3 mm (0.12 in) bead of sealer to the oil pan in the area marked (2). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

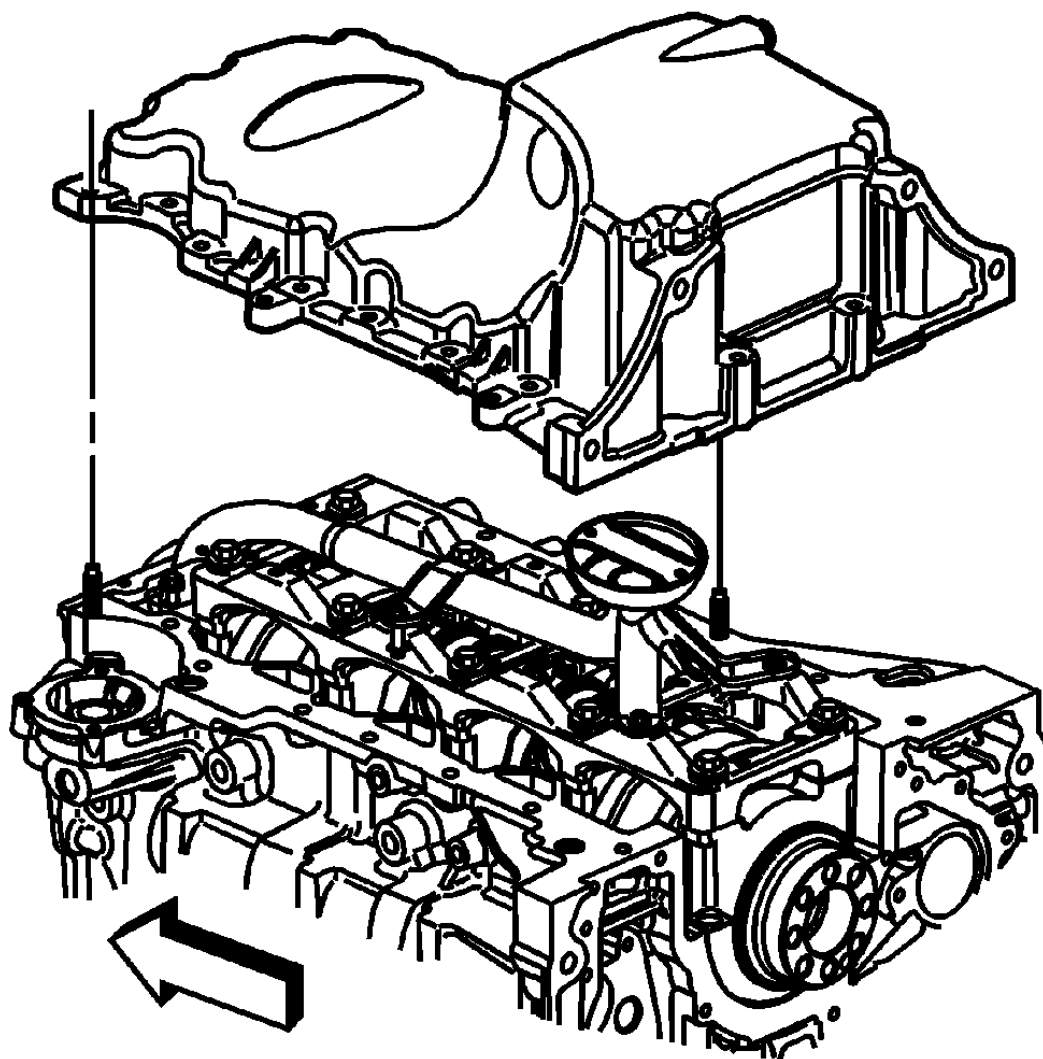


Fig. 186: View Of Oil Pan

Courtesy of GENERAL MOTORS COMPANY

NOTE: Use care not to allow the sealer to contact the oil pump pipe and screen assembly.

3. Position the oil pan to the engine block.

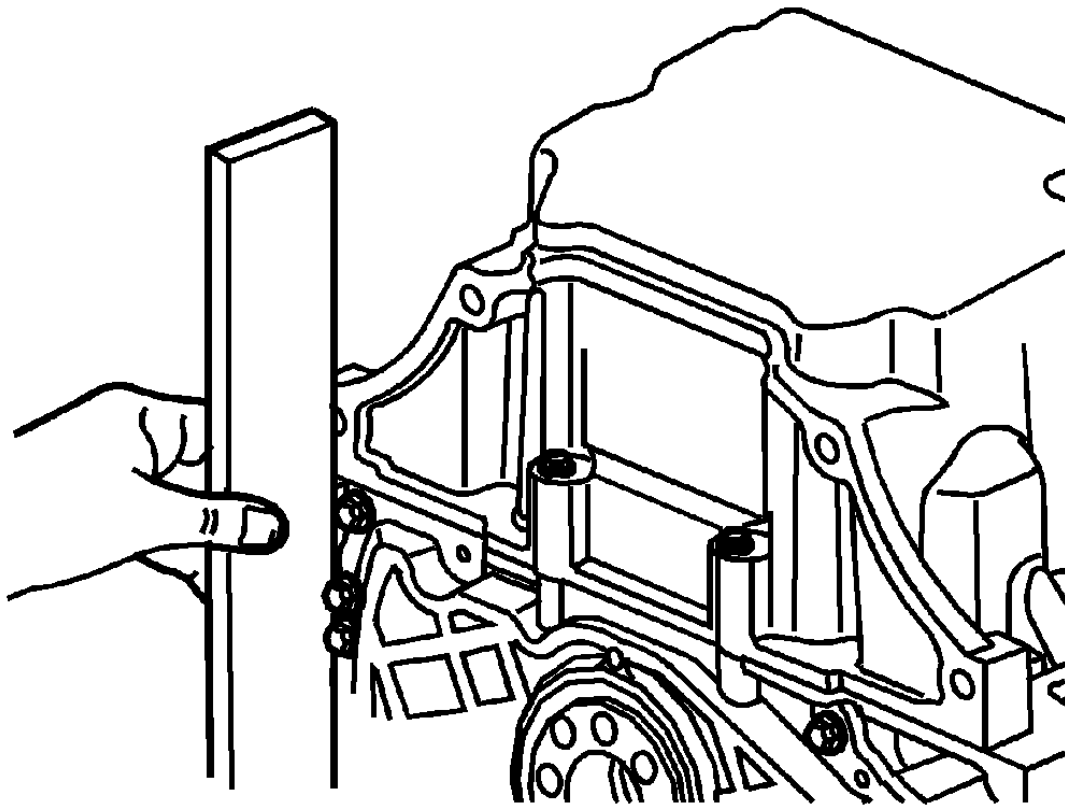


Fig. 187: Aligning Oil Pan

Courtesy of GENERAL MOTORS COMPANY

NOTE: The rear oil pan surface needs to be flush with the rear block surface.

4. Use the following applicable step to properly align the oil pan:

- Transmission Removed

Use a straight edge at the rear of the block and oil pan for proper alignment.

- Transmission Installed

Ensure the oil pan is positioned fully rearward against the transmission mounting surface.

5. Install the oil pan bolts.

CAUTION: Refer to Fastener Caution .

Tighten the oil pan bolts.

- Tighten the (side) oil pan bolts to 25 N.m (18 lb ft).
 - Tighten the (end) oil pan bolts to 10 N.m (89 lb in).
6. Connect the engine wiring harness retainers to the oil pan.
 7. For the 4WD only, position the power steering gear upward to the frame assembly.
 8. For the 4WD only, install the power steering gear mounting bolts. Refer to Steering Gear Replacement .

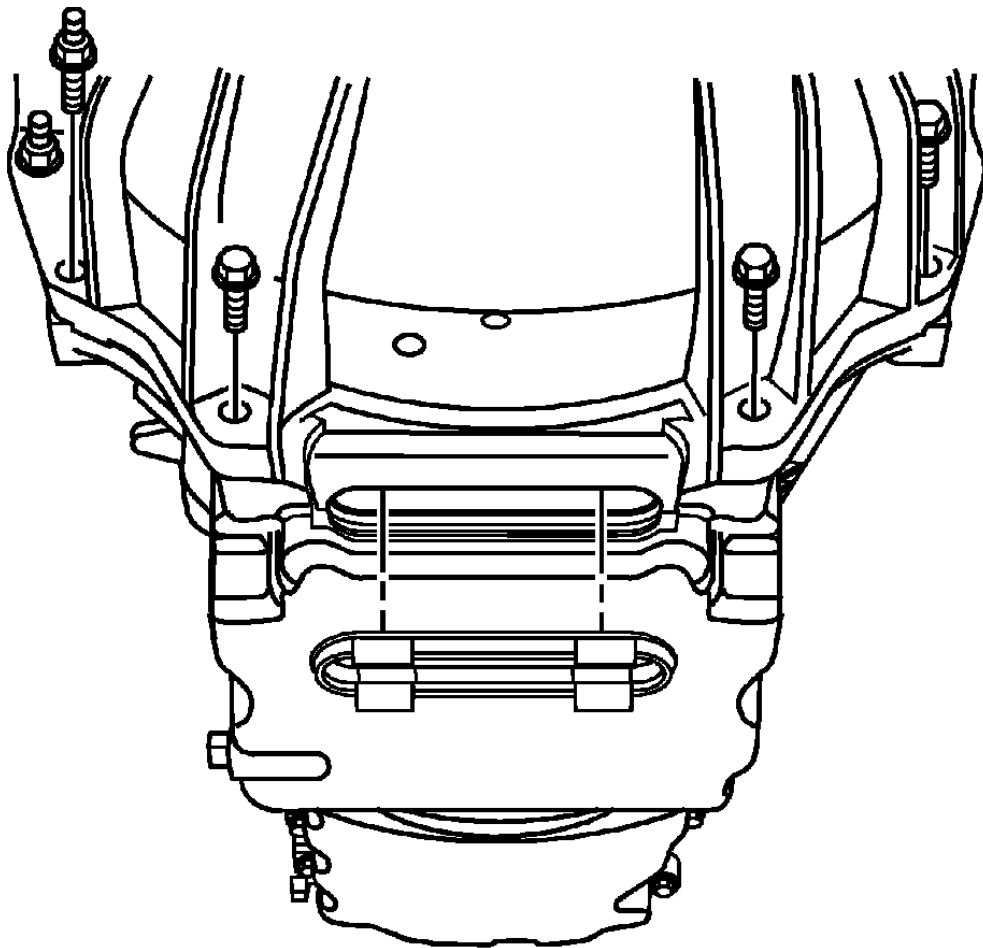


Fig. 188: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Install the 4 lower transmission mounting bolts and tighten to 50 N.m (37 lb ft).
10. Install the nuts securing the fuel hose/pipe bracket to the transmission. Tighten the nuts to 20 N.m (15 lb ft).
11. Install the service slot plug.

12. Install the applicable components:

- RWD

Install the power steering gear. Refer to **Steering Gear Replacement** .

- 4WD

1. Position the differential carrier assembly to the frame.

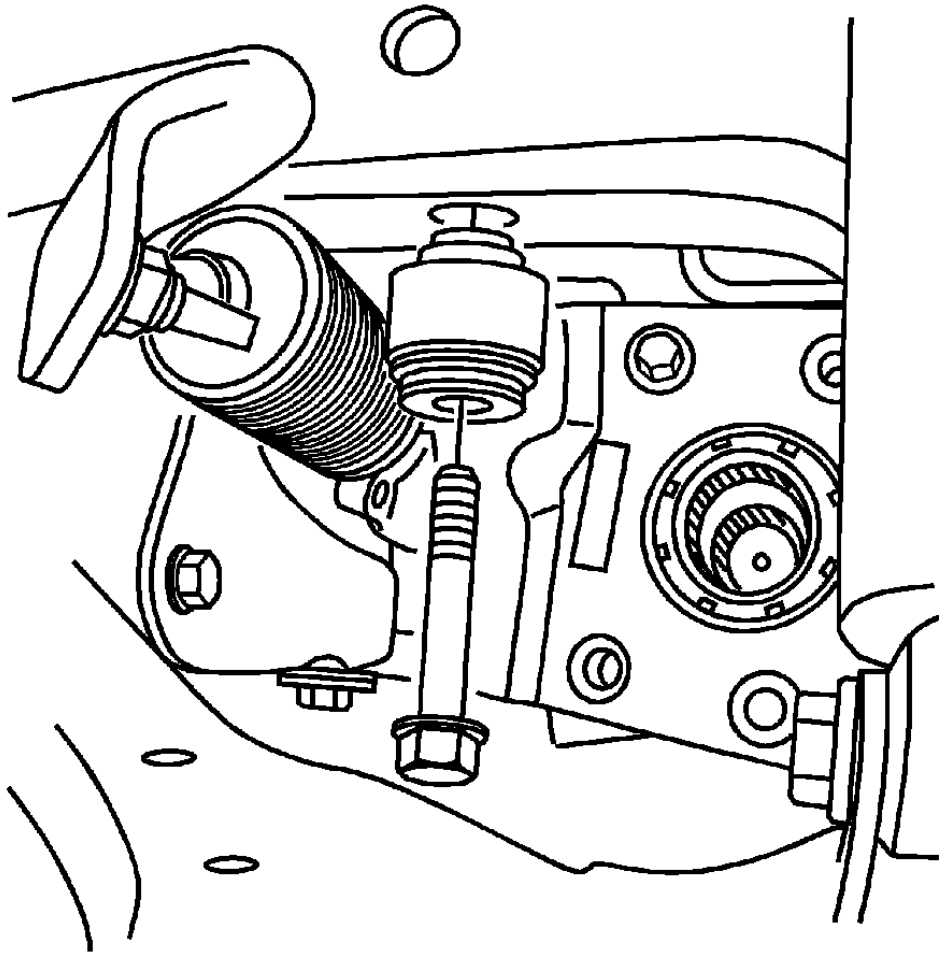


Fig. 189: View Of Mounting Bracket To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the differential carrier assembly bushing to frame bolts and tighten to 152 N.m (112 lb ft).
 3. Install the front propeller shaft. Refer to **Front Propeller Shaft Replacement** .
13. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** .
14. Install the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.
15. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

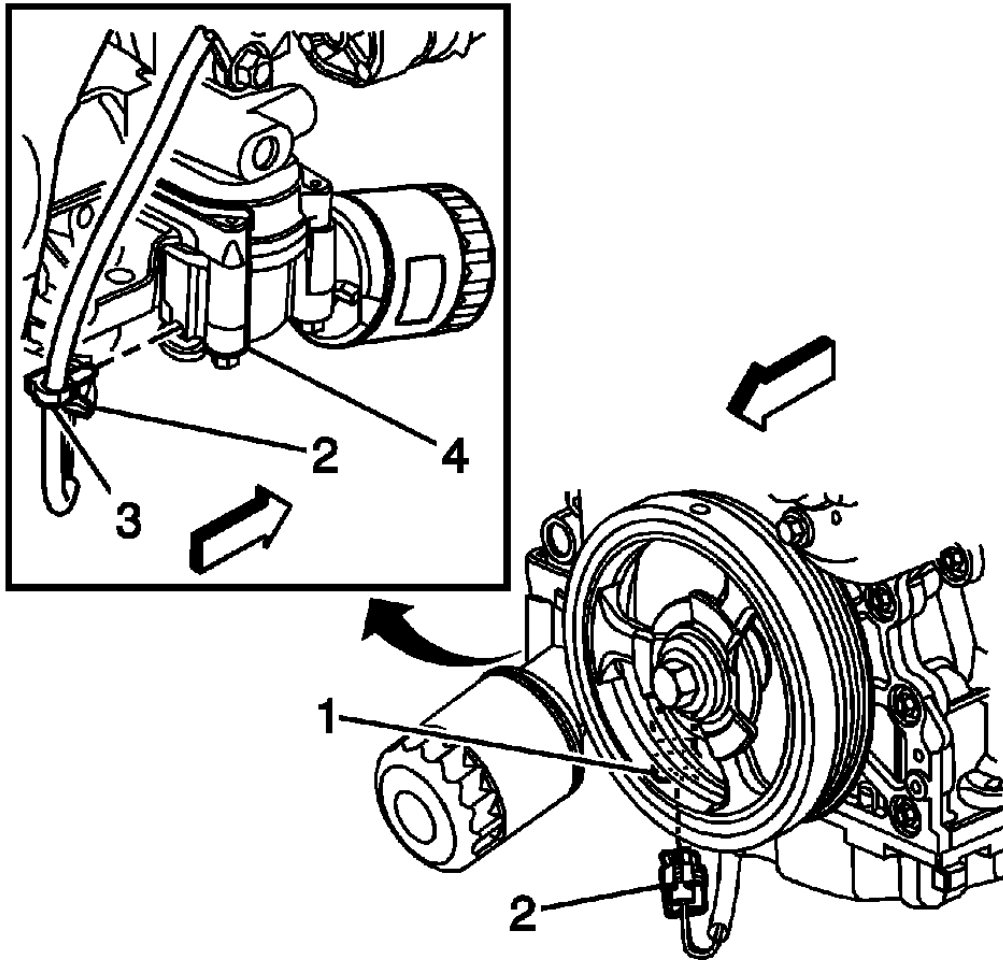


Fig. 190: View Of Oil Pressure Switch Electrical Connector & Oil Filter Adapter Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch (1).

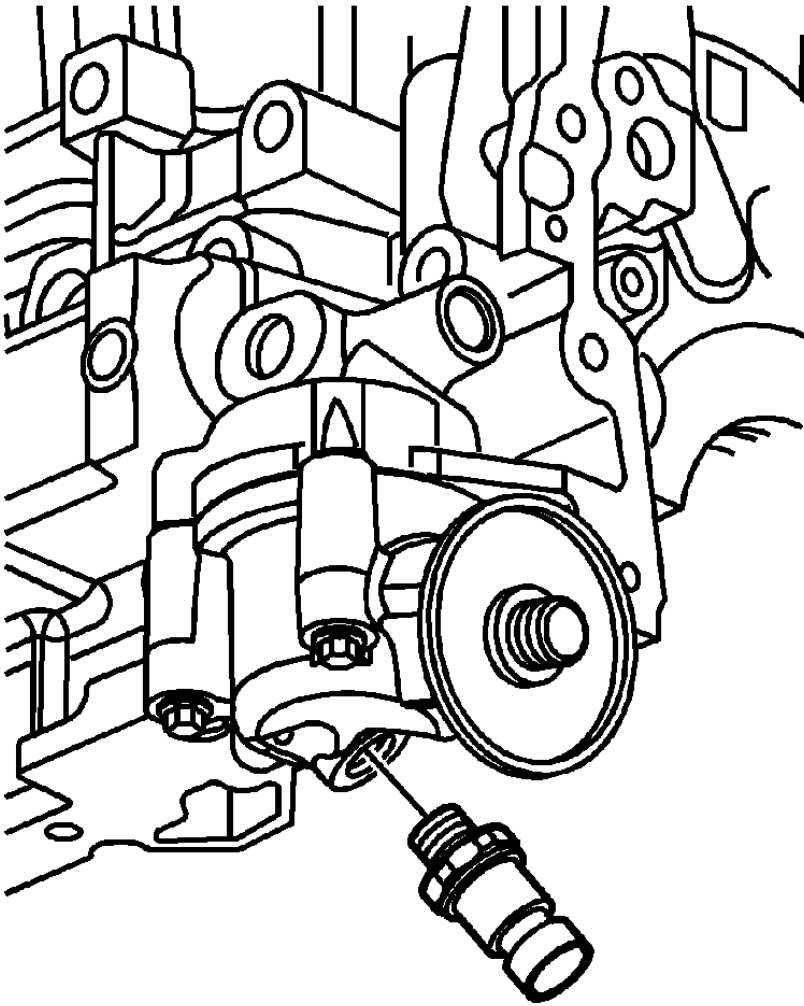


Fig. 191: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS COMPANY

3. Remove the engine oil pressure switch.

Installation Procedure

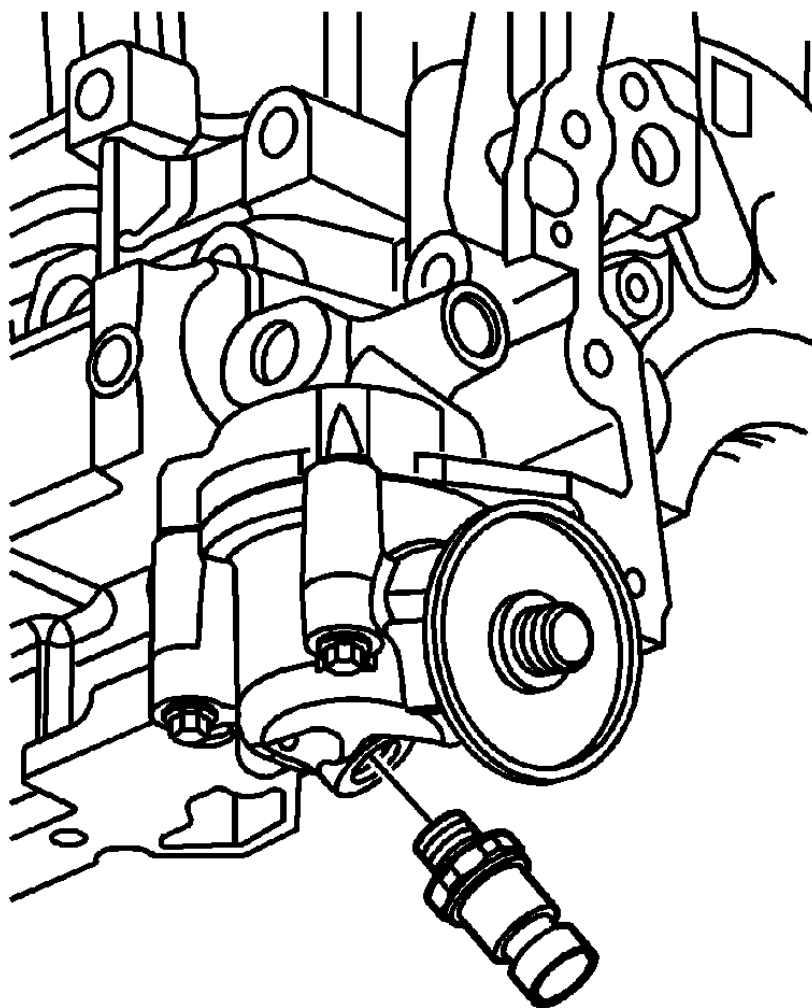


Fig. 192: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Component Fastener Tightening Caution .

1. Install the engine oil pressure switch and tighten to 20 N.m (15 lb ft).

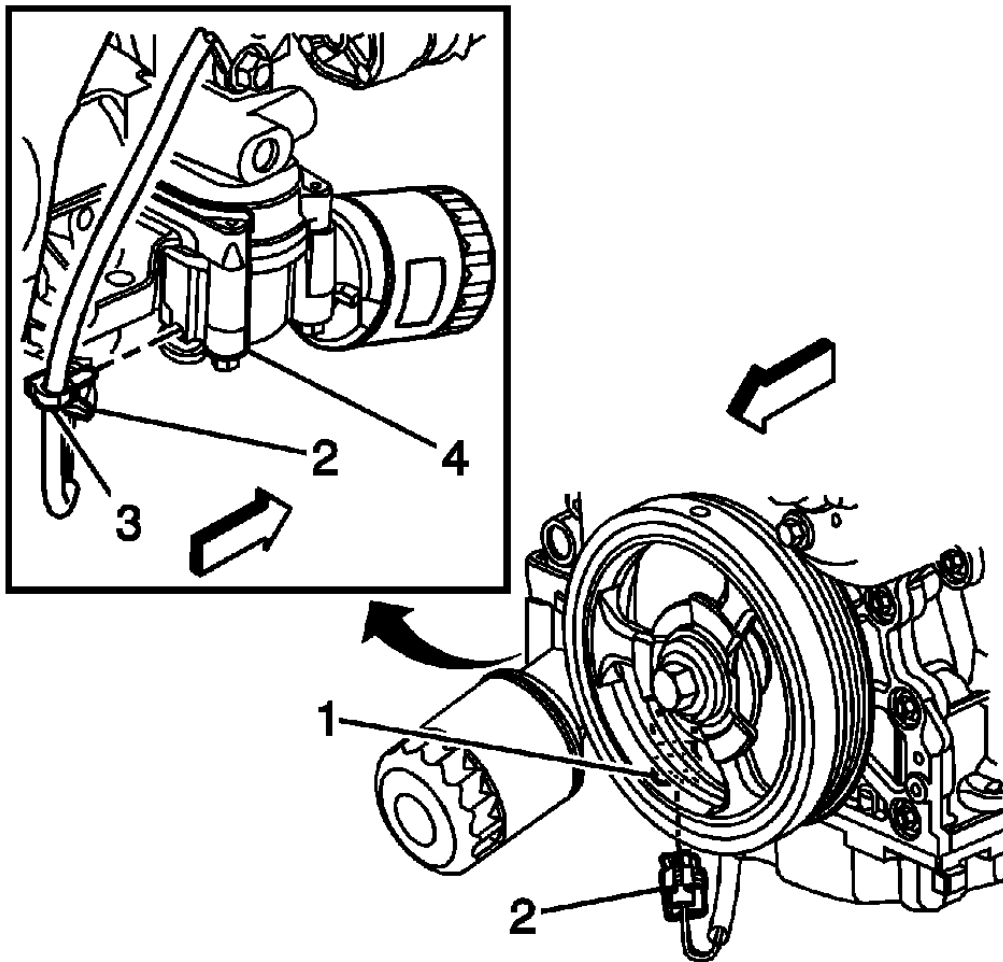


Fig. 193: View Of Oil Pressure Switch Electrical Connector & Oil Filter Adapter Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

2. Connect the engine wiring harness electrical connector (2) to the oil pressure switch (1).
3. Lower the vehicle.

OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY REPLACEMENT

Removal Procedure

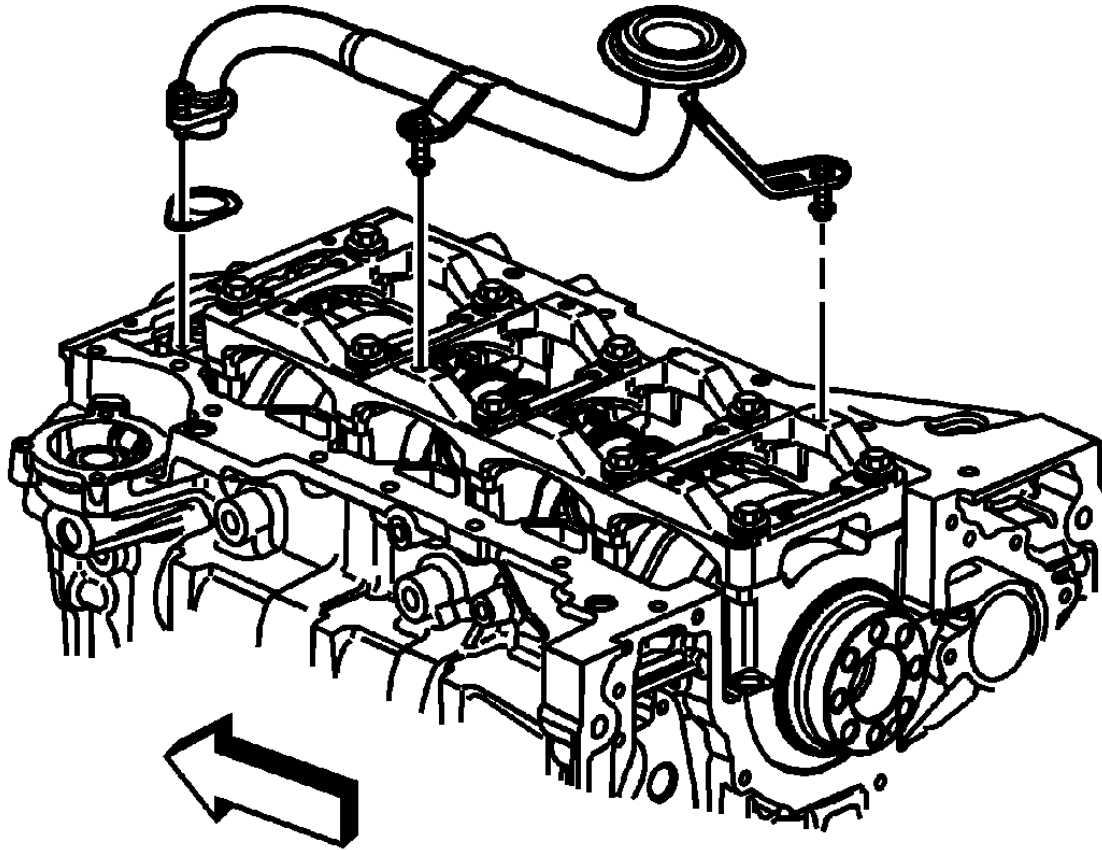


Fig. 194: View Of Oil Pump Pipe
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the oil pump pipe screen brace bolts.
3. Remove the oil pump pipe screen bolt.
4. Remove the oil pump pipe screen from the engine.
5. Remove and discard the oil pump pipe seal.
6. Clean and inspect the oil pump pipe screen.

Installation Procedure

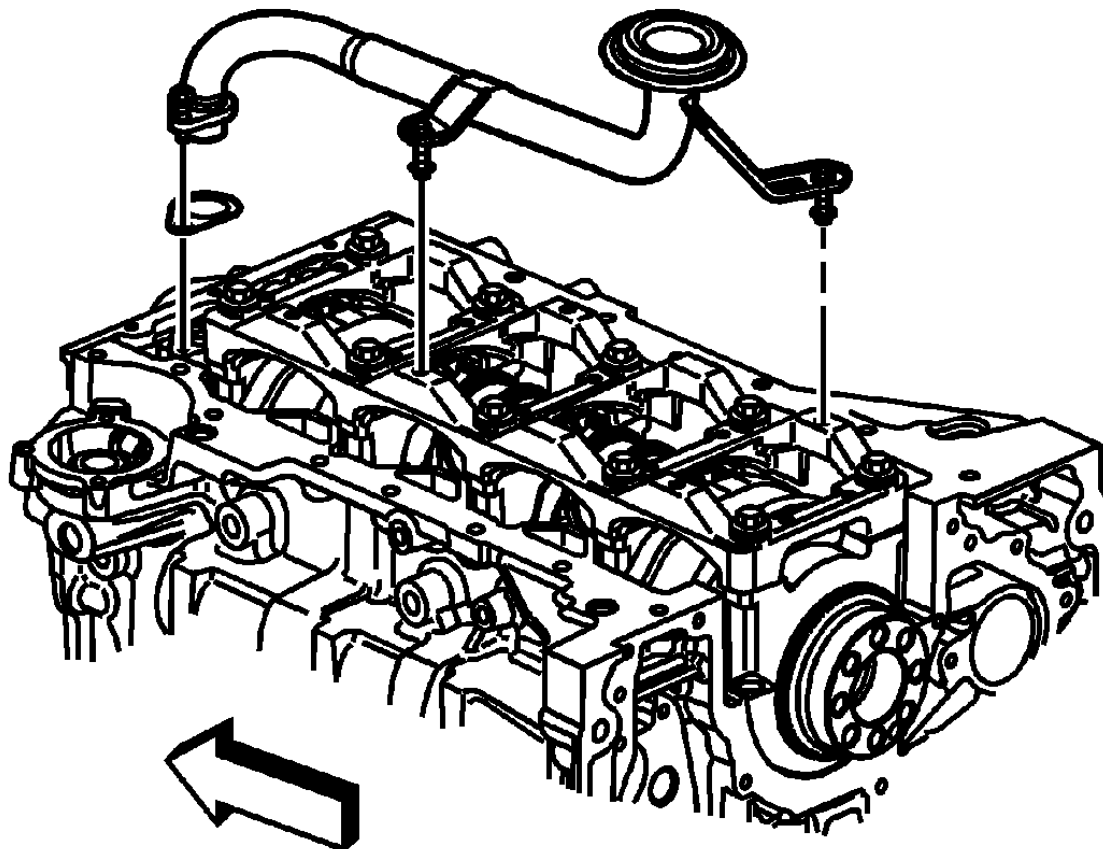


Fig. 195: View Of Oil Pump Pipe

Courtesy of GENERAL MOTORS COMPANY

1. Position a new oil pump pipe seal to the oil pump pipe screen assembly.
2. Position the oil pump pipe screen to the engine.
3. Apply sealant to the oil pump pipe bolt threads. Refer to Adhesives, Fluids, Lubricants, and Sealers .

CAUTION: Refer to Fastener Caution .

4. Install the oil pump pipe screen assembly bolts and tighten to 10 N.m (89 lb in).
5. Install the oil pan. Refer to Oil Pan Replacement.

OIL PUMP REPLACEMENT

Removal Procedure

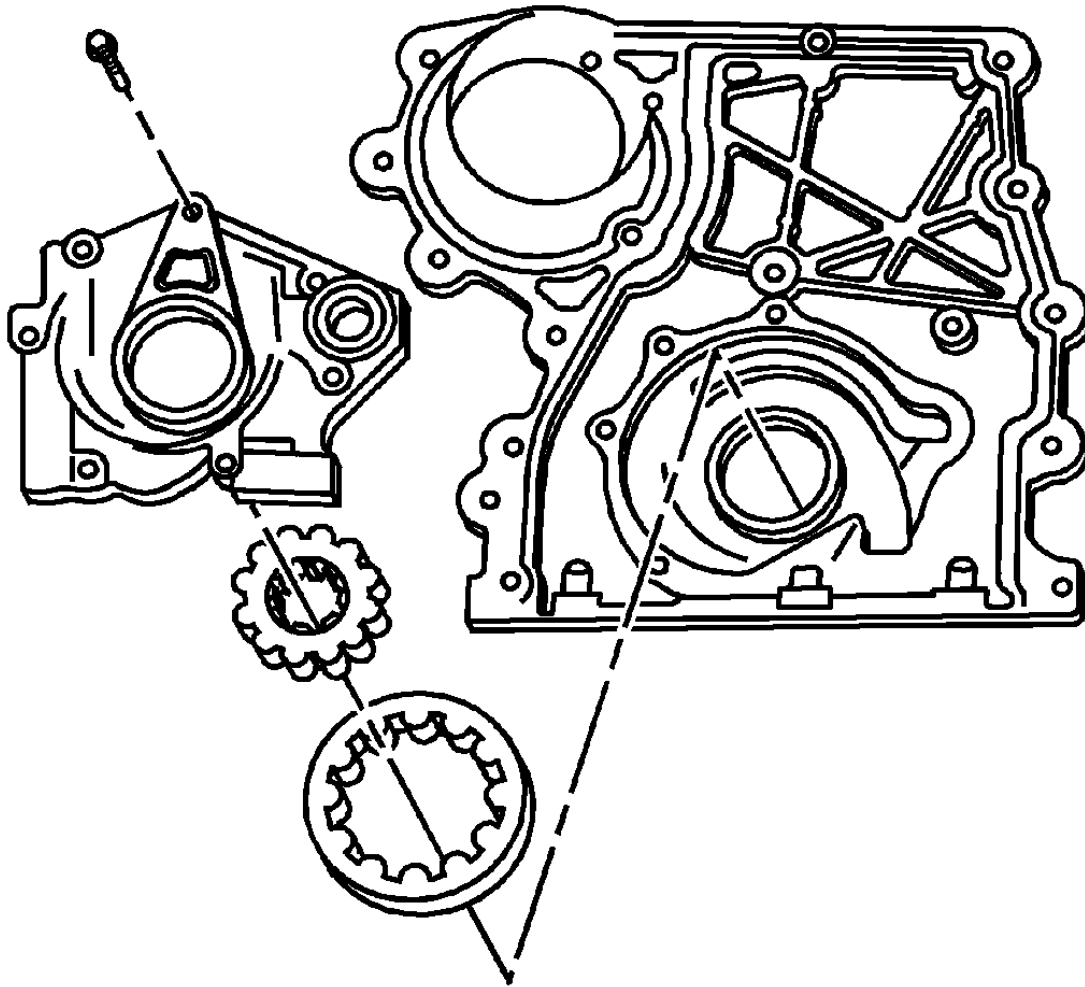


Fig. 196: Exploded View Of Oil Pump
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the oil pump cover bolts.
3. Remove the oil pump cover.
4. Mark the inner and the outer gears in relation to the oil pump housing.
5. Remove the inner and the outer oil pump gears.
6. Remove the oil pump pressure relief valve plug.
7. Remove the oil pump pressure relief valve and the spring.

Installation Procedure

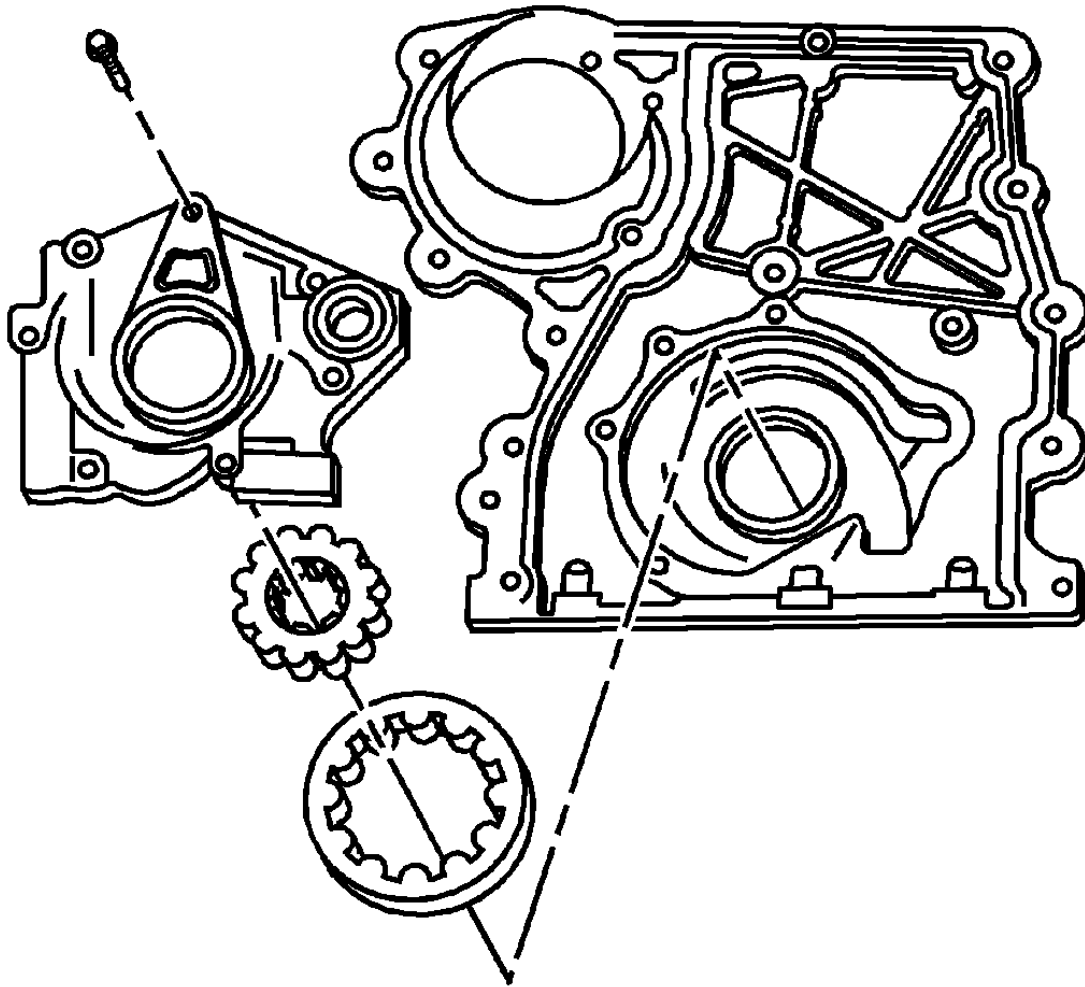


Fig. 197: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS COMPANY

1. Install the oil pump pressure relief valve and the spring.

CAUTION: Refer to Component Fastener Tightening Caution .

2. Install the oil pump pressure relief valve plug and tighten to 14 N.m (124 lb in).
3. Install the oil pump outer and inner gears as removed.
4. Install the oil pump cover.

CAUTION: Refer to Fastener Caution .

5. Install the oil pump cover bolts and tighten to 10 N.m (89 lb in).
6. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

CRANKSHAFT REAR OIL SEAL AND HOUSING REPLACEMENT

Special Tools

- GE-8092 Driver Handle
- J 44215 Rear Seal Installer

Removal Procedure

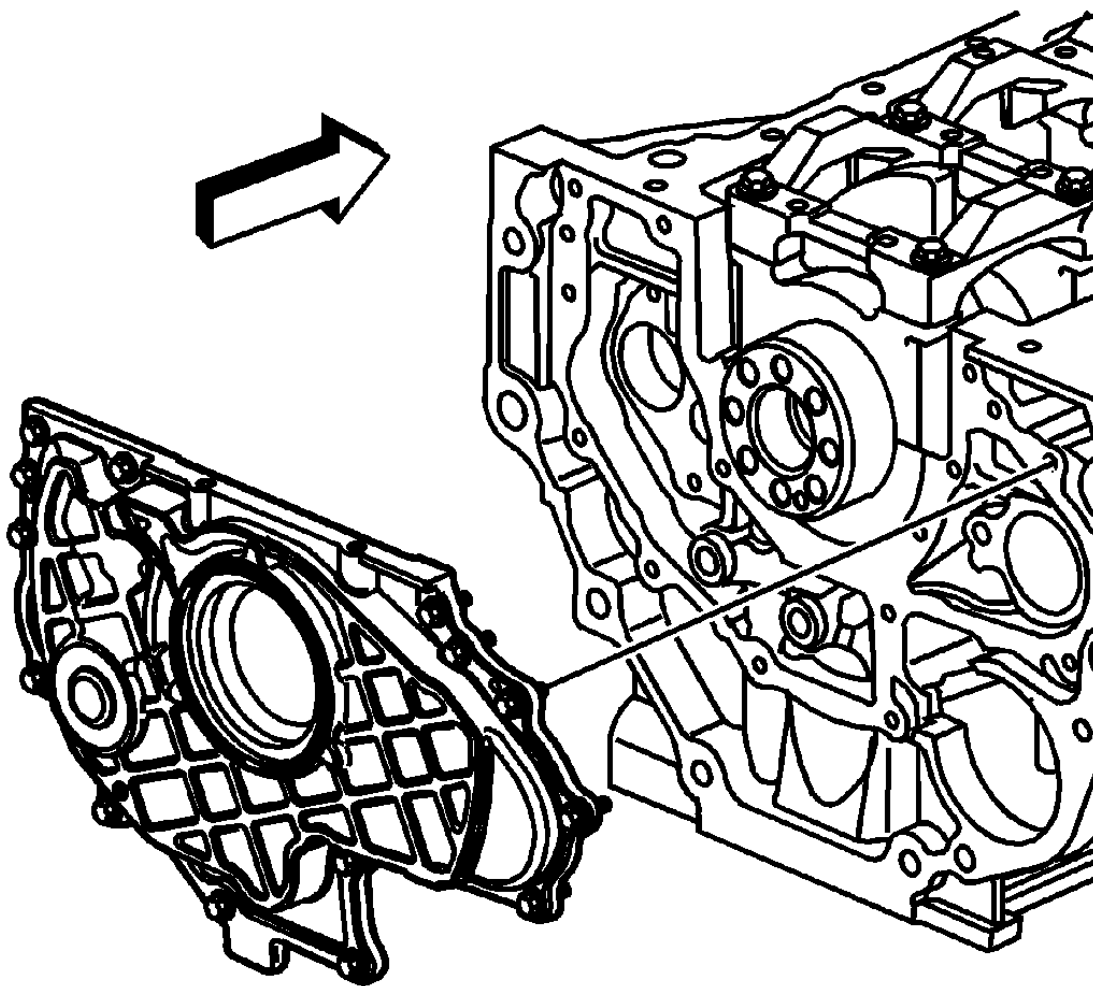


Fig. 198: View Of Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

1. Remove the flywheel. Refer to **Engine Flywheel Replacement (with Automatic Transmission)**.

2. Remove the 2 bolts securing the oil pan to the crankshaft rear oil seal housing.
3. Remove the crankshaft rear oil seal housing bolts.
4. Install 2 bolts into the threaded holes to act as jack screws and tighten evenly to release the crankshaft rear oil seal housing from the engine block and oil pan.
5. Remove the crankshaft rear oil seal housing.
6. Remove the 2 bolts from the jack screw holes.

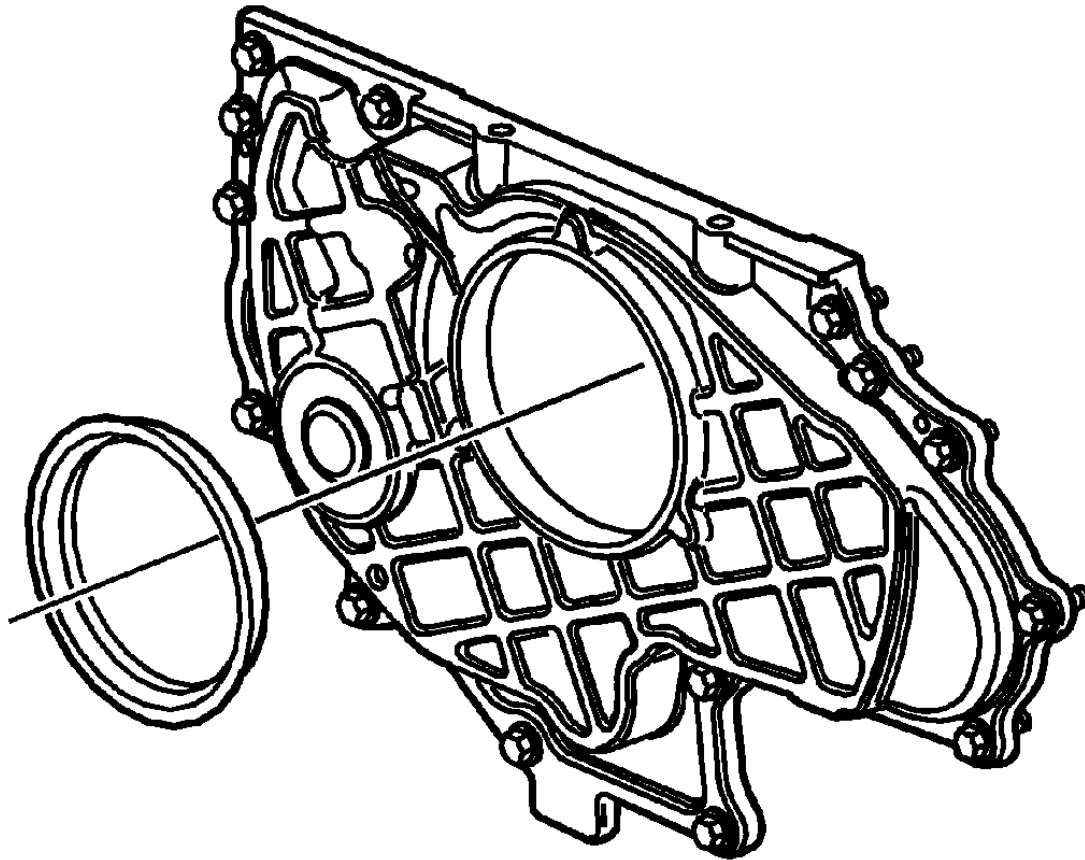


Fig. 199: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not damage the seal bore.

7. Using a hammer and a punch, remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Discard the seal.

8. Clean and inspect the crankshaft rear oil seal housing.
9. Clean and inspect the engine block and oil pan sealing surface.

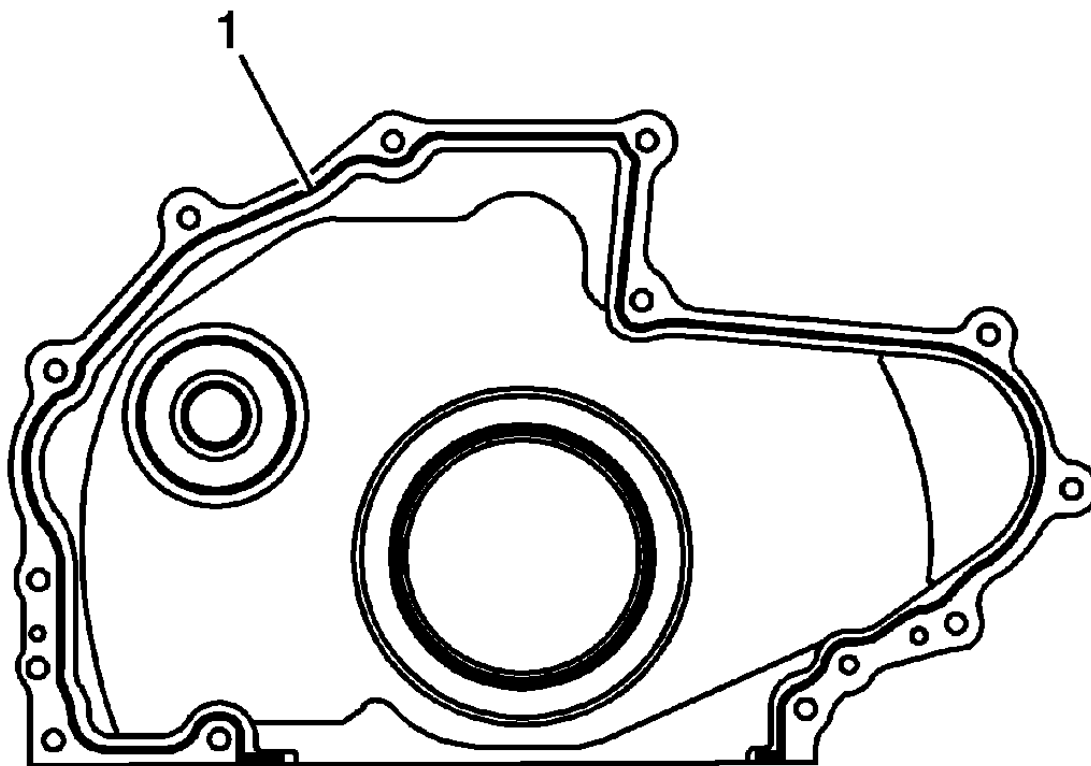
Installation Procedure

Fig. 200: View Of Crankshaft Rear Oil Seal Housing Sealant Application
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The crankshaft rear oil seal housing must be installed within 10 minutes from when the sealer was applied.**

1. Apply a 3 mm (0.12 in) bead of sealer (1) to the following:
 - The crankshaft rear oil seal housing, where the housing meets the engine block
 - The surface of the crankshaft rear oil seal housing, where the housing meets the oil pan
 - The surface of the oil pan, where the oil pan meets the housing

Refer to Adhesives, Fluids, Lubricants, and Sealers .

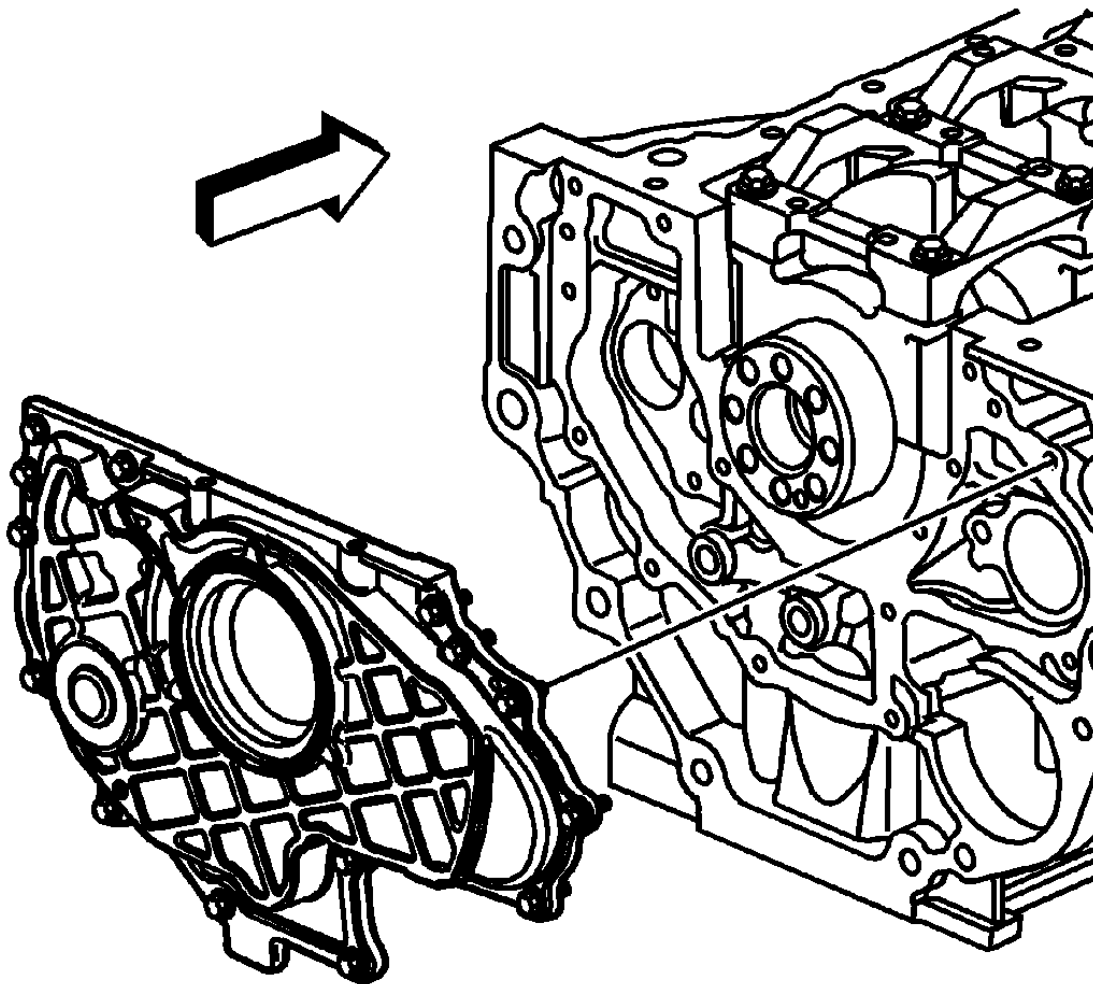


Fig. 201: View Of Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

NOTE: Tilting the crankshaft rear oil seal housing will allow sealer between the housing and the oil pan.

2. Complete the following to install the crankshaft rear oil seal housing:
 1. Align the housing with the right alignment dowel, tilting the left side up slightly.
 2. Align the housing with the left alignment dowel.
 3. Press the housing against the engine block into place.
3. Install the crankshaft rear oil seal housing bolts.

CAUTION: Refer to Fastener Caution .

4. Install the 2 oil pan bolts.
 - Tighten the crankshaft rear oil seal housing bolts to 10 N.m (89 lb in).
 - Tighten the oil pan bolts to 10 N.m (89 lb in).
5. Lightly lubricate the crankshaft rear oil seal lip with clean engine oil.
6. Position the plastic installation sleeve supplied with the new seal to the crankshaft.

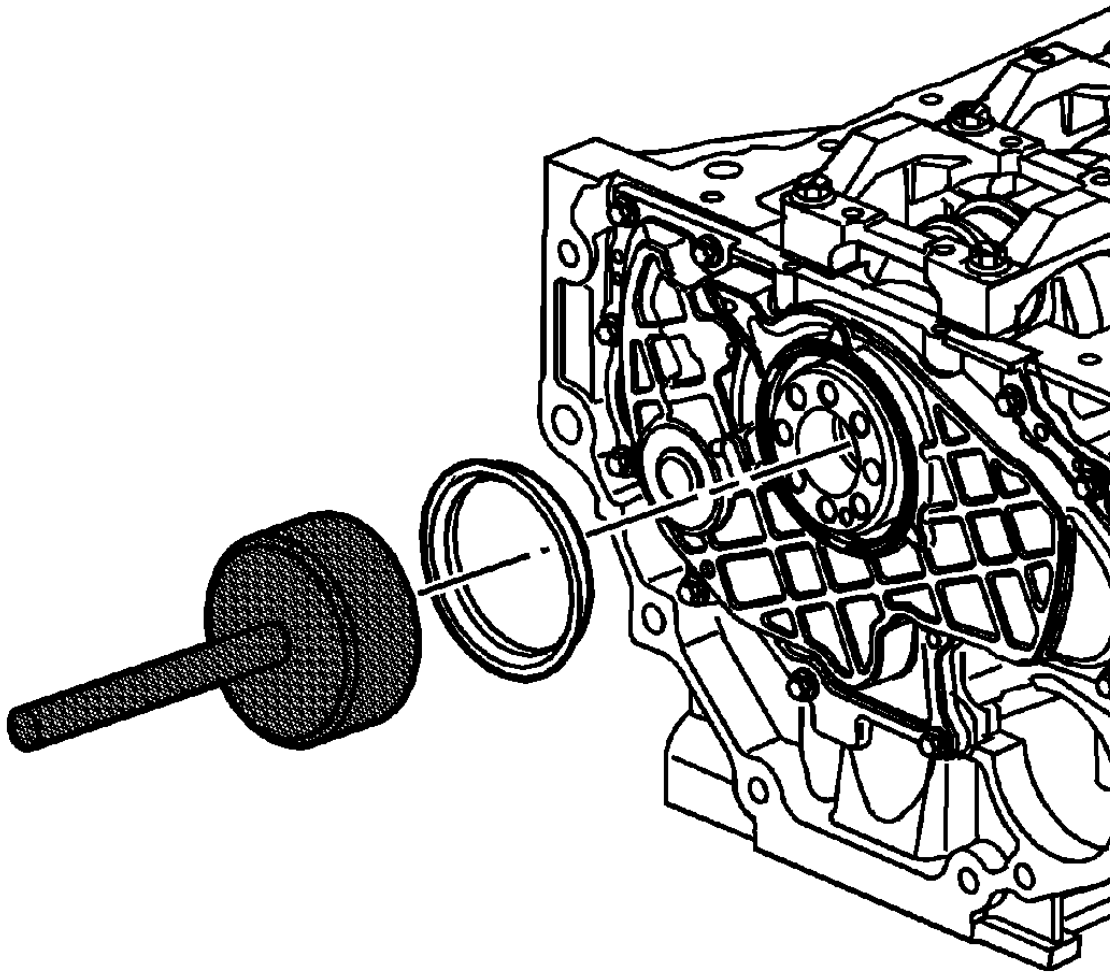


Fig. 202: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

7. Use the **J 44215** rear seal installer with the **GE-8092** driver handle and a hammer to install the crankshaft rear oil seal into the crankshaft rear oil seal housing.
 - Ensure the seal is installed squarely.
 - The seal will bottom out in the housing when fully installed.
8. Install the flywheel. Refer to **Engine Flywheel Replacement (with Automatic Transmission)**.

BALANCE CHAIN TENSIONER REPLACEMENT

Removal Procedure

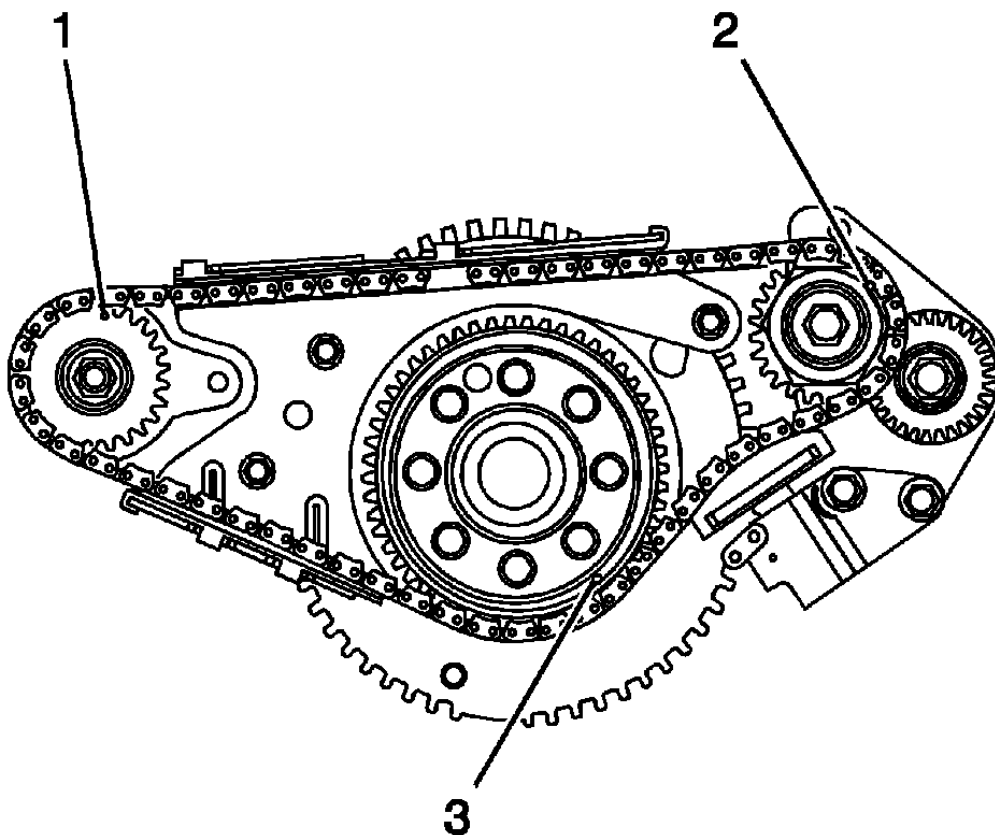


Fig. 203: View Of Sprocket Timing Marks

Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft rear oil seal housing. Refer to [Crankshaft Rear Oil Seal and Housing Replacement](#).

NOTE: Every 11-crankshaft rotations, 3 of the 5 dark links on the timing chain will line up with the timing marks.

2. Rotate the crankshaft until the correct timing chain and timing marks align:
 - The left-hand balance shaft sprocket timing mark (1) is at the 12:00 position.
 - The right-hand balance shaft sprocket timing mark (2) is at the 2:30 position.
 - The crankshaft sprocket timing mark (3) is at the 4:30 position.
 - The 3 timing marks (1-3) on the sprockets line up with a dark link on the chain.

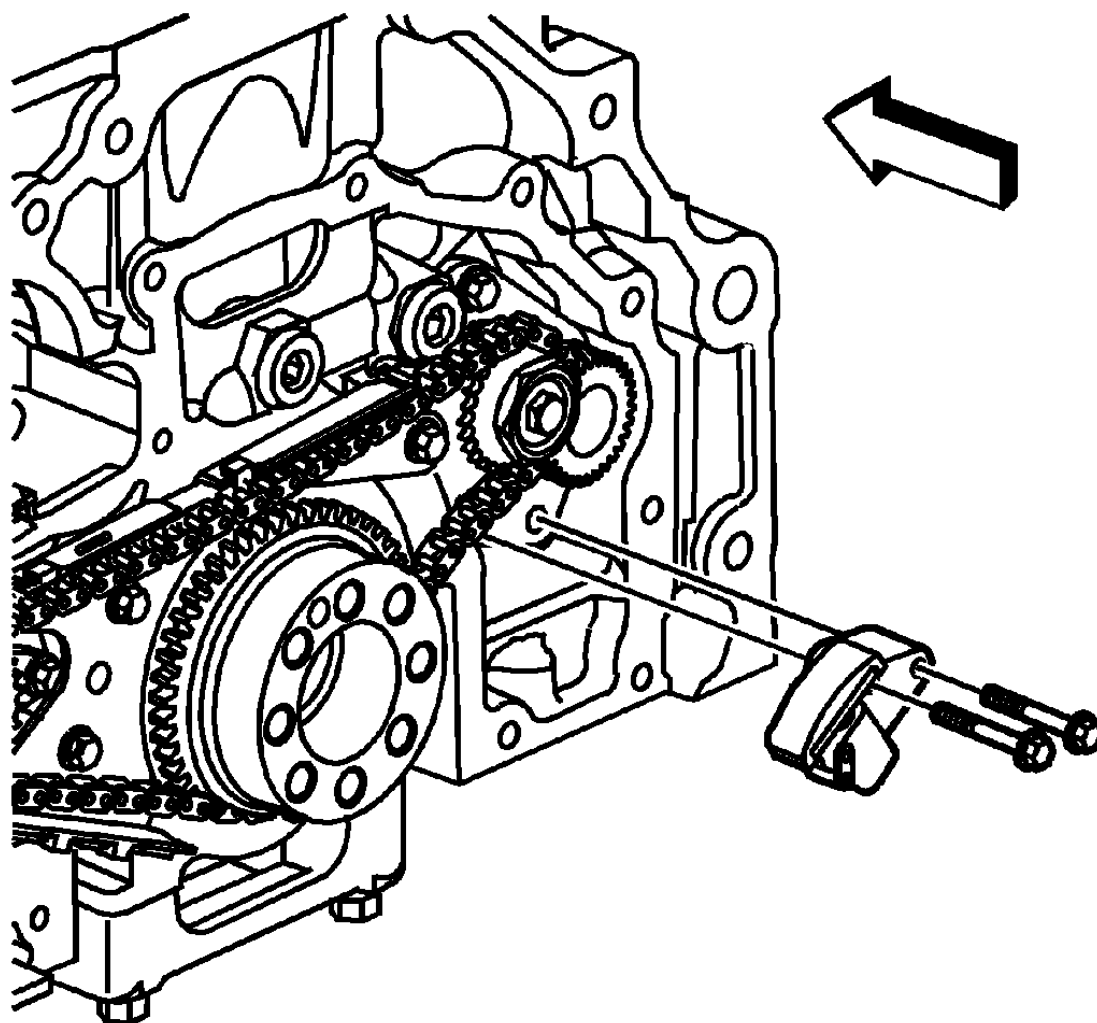


Fig. 204: View Of Balance Shaft Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

3. Remove the balance shaft chain tensioner bolts.
4. Remove the balance shaft chain tensioner.

Installation Procedure

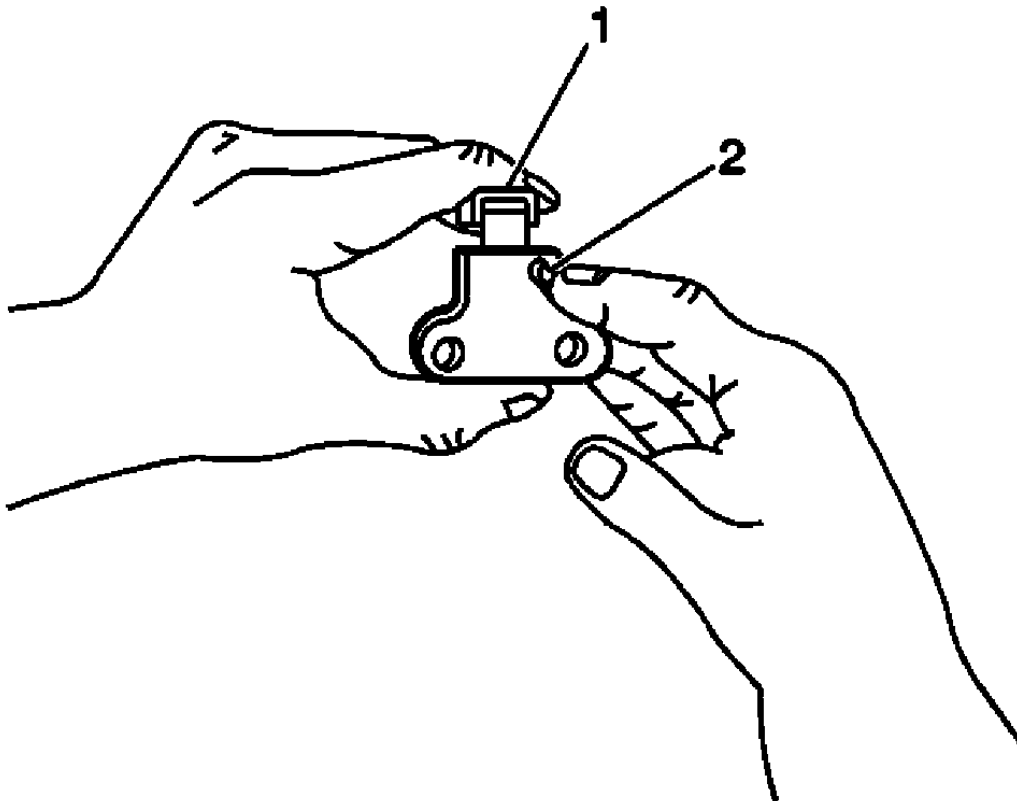


Fig. 205: View Of Primary Camshaft Drive Chain Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS COMPANY

1. Collapse the balance shaft chain tensioner using the following procedure:
 1. Rotate the ratchet release lever (2) clockwise and hold.
 2. Collapse the tensioner shoe (1) and hold.
 3. Release the ratchet lever.
2. Slowly release the pressure on the shoe, until the ratchet lever moves to the first detent and a "click" is heard and felt.

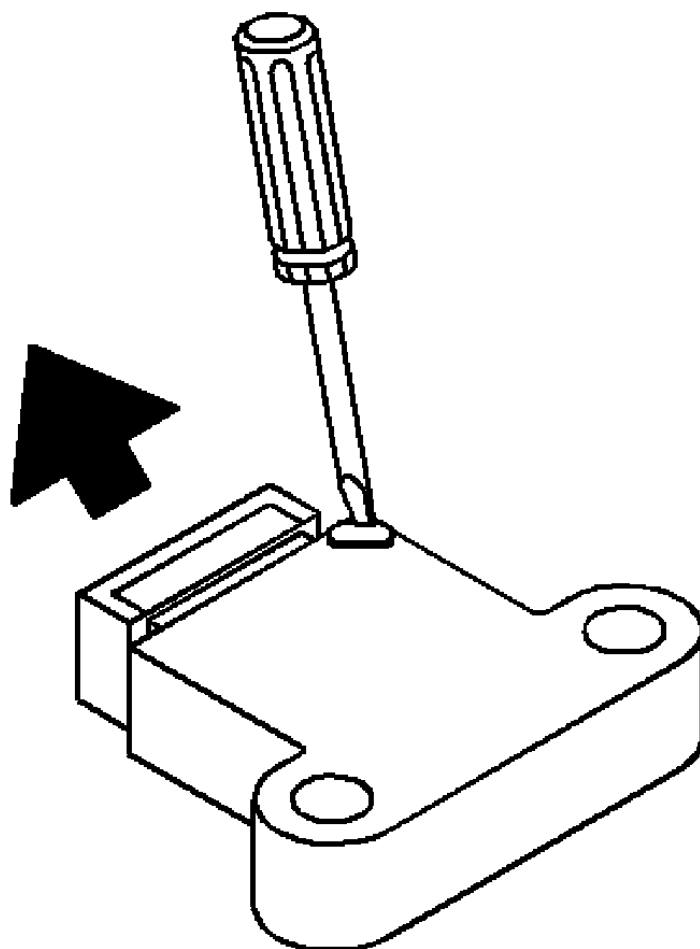


Fig. 206: Locking Primary Camshaft Drive Chain Tensioner Shoe Into Collapsed Position
Courtesy of GENERAL MOTORS COMPANY

3. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

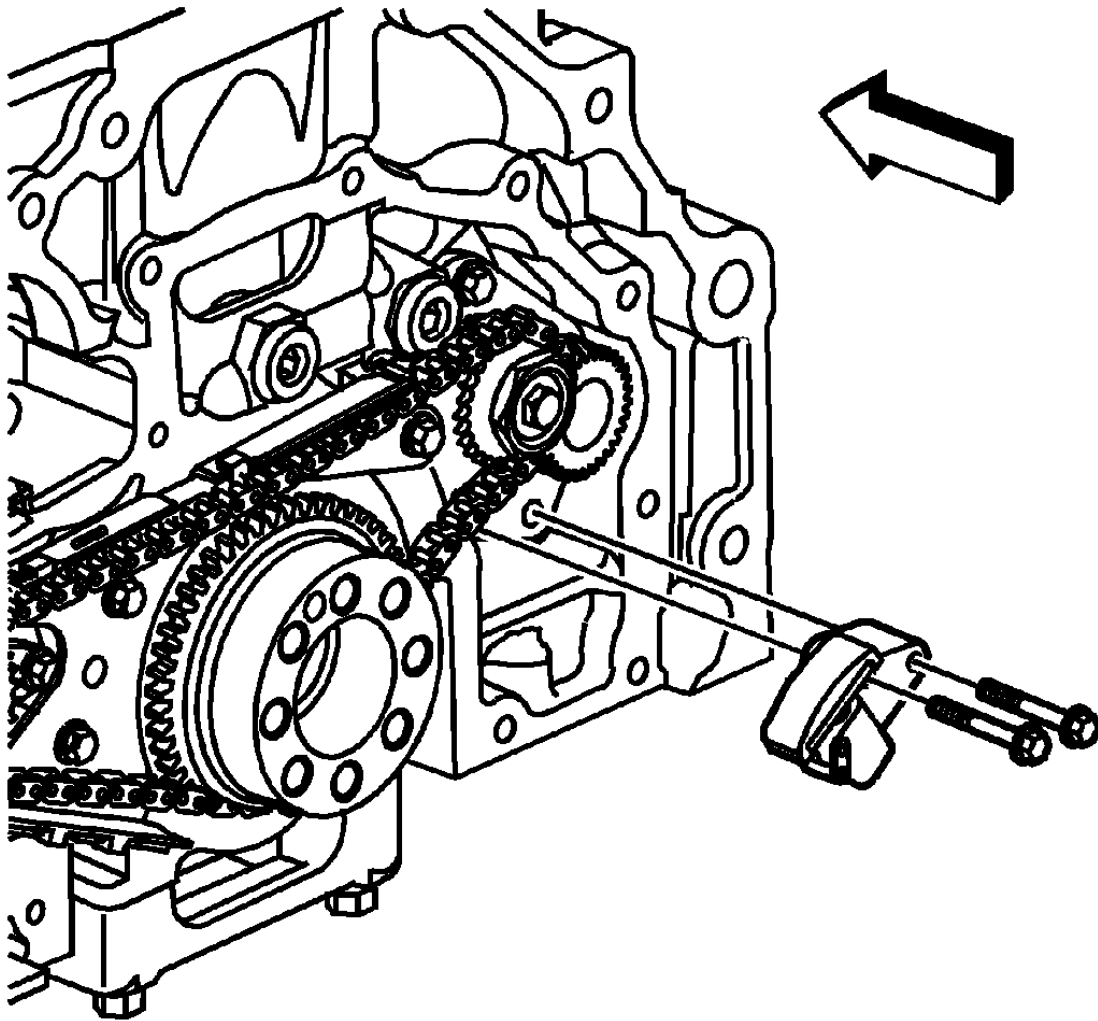


Fig. 207: View Of Balance Shaft Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE: Ensure the tensioner release lever is facing outward.

4. Install the balance shaft chain tensioner and bolts and tighten the bolts to 10 N.m (89 lb in).
5. Remove the pin holding the tensioner to tighten any slack in the balance shaft drive chain.

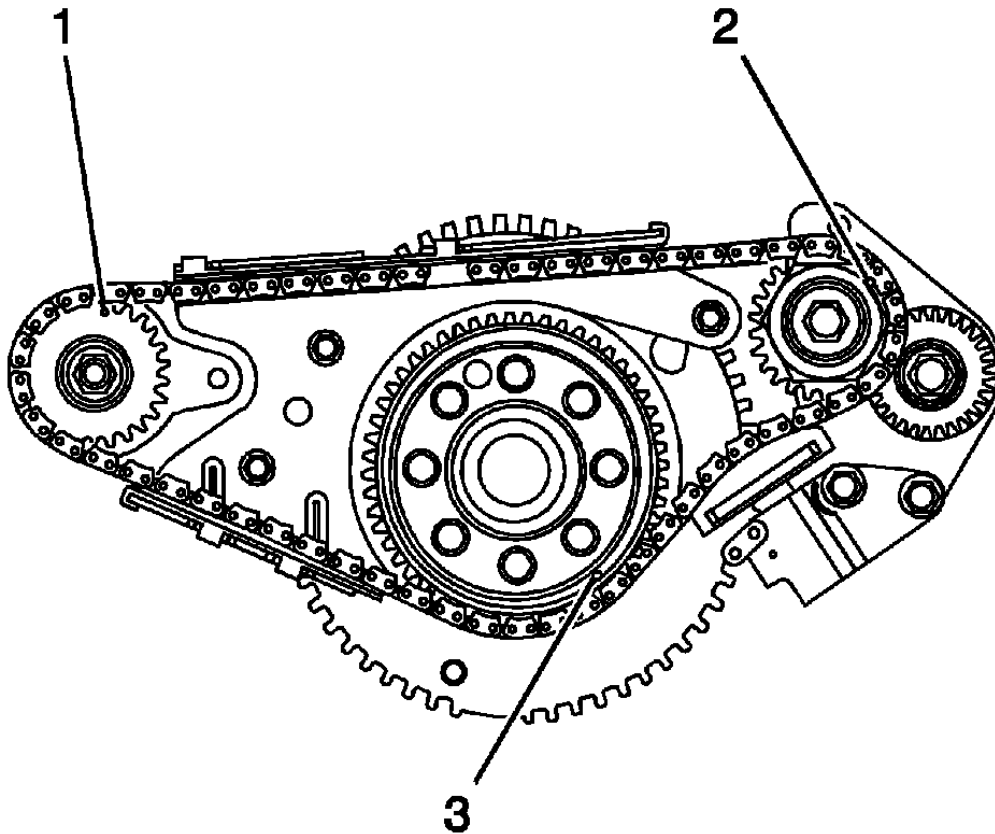


Fig. 208: View Of Sprocket Timing Marks
 Courtesy of GENERAL MOTORS COMPANY

6. Verify the correct timing chain and timing mark alignments:
 - The left-hand balance shaft sprocket timing mark (1) is at the 12:00 position.
 - The right-hand balance shaft sprocket timing mark (2) is at the 2:30 position.
 - The crankshaft sprocket timing mark (3) is at the 4:30 position.
 - The 3 timing marks (1-3) on the sprockets line up with a dark link on the chain.
7. Install the crankshaft rear oil seal housing. Refer to **Crankshaft Rear Oil Seal and Housing Replacement**.

BALANCE CHAIN REPLACEMENT

Removal Procedure

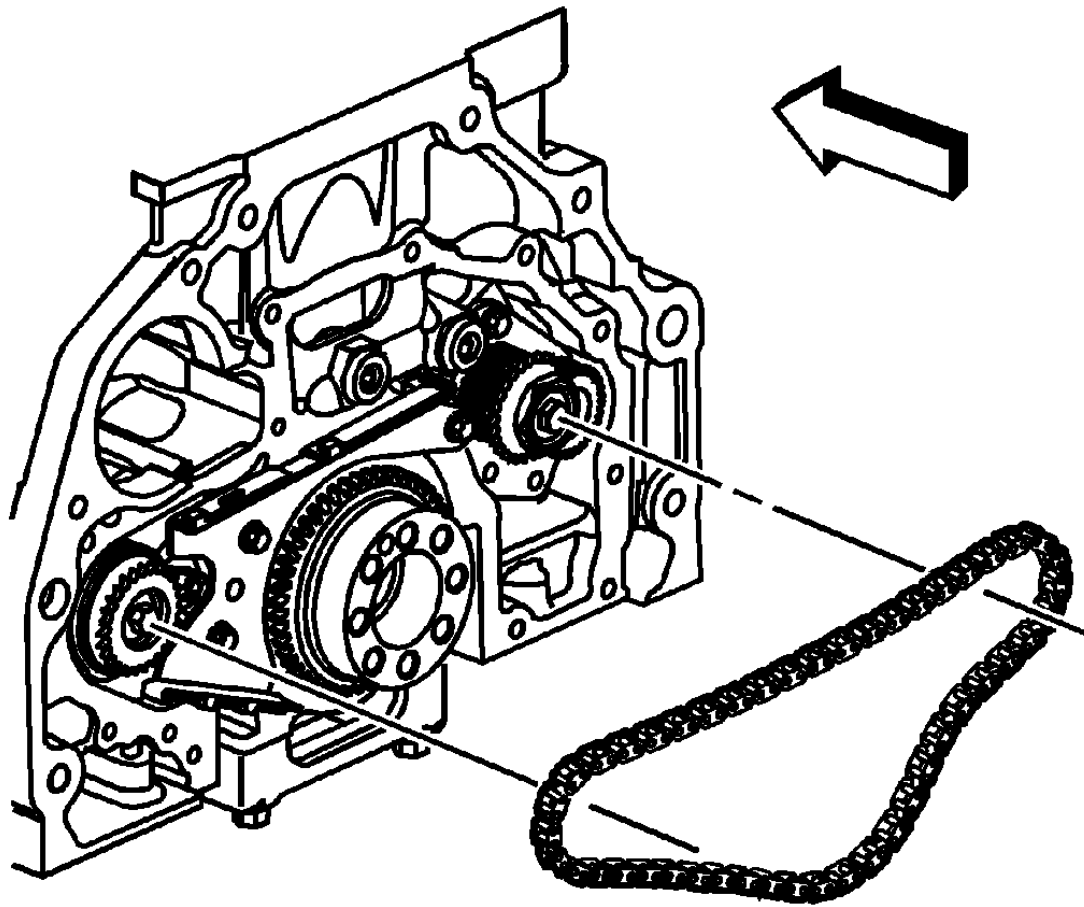


Fig. 209: View Of Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balance shaft chain tensioner. Refer to **Balance Chain Tensioner Replacement**.
2. Remove the balance shaft drive chain from the following:
 1. The crankshaft sprocket.
 2. The left balance sprocket.
 3. The right balance sprocket.

Installation Procedure

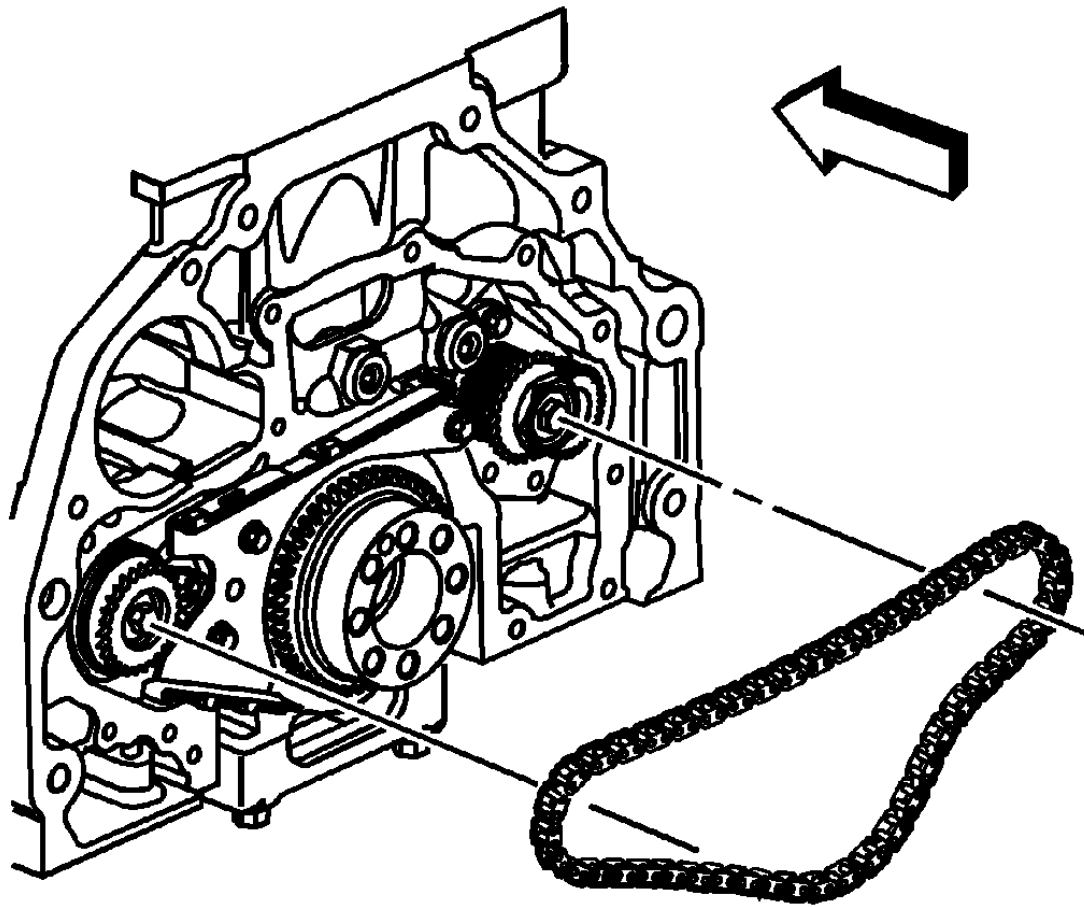


Fig. 210: View Of Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Ensure the darkened links are facing outward.

1. Install the balance shaft drive chain to the following:
 1. The left balance sprocket.
 2. The right balance sprocket.
 3. The crankshaft sprocket.

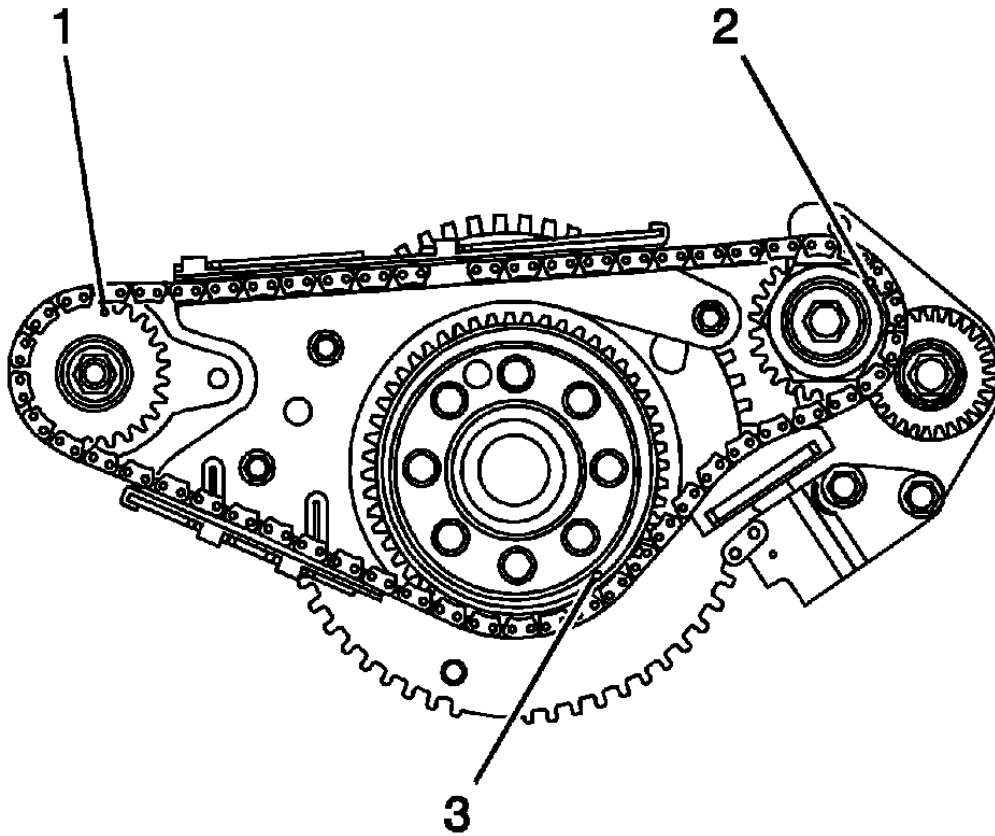


Fig. 211: View Of Sprocket Timing Marks
 Courtesy of GENERAL MOTORS COMPANY

2. Verify the correct timing chain and timing mark alignments:
 - The left hand balance shaft sprocket timing mark (1) is at the 12:00 position
 - The right hand balance shaft sprocket timing mark (2) is at the 2:30 position
 - The crankshaft sprocket timing mark (3) is at the 4:30 position
 - The 3 timing marks (1-3) on the sprockets line up with a dark link on the chain
3. Install the balance shaft chain tensioner. **Balance Chain Tensioner Replacement.**

BALANCE SHAFT REPLACEMENT - LEFT SIDE

Removal Procedure

1. Remove the balance shaft drive chain. Refer to **Balance Chain Replacement.**

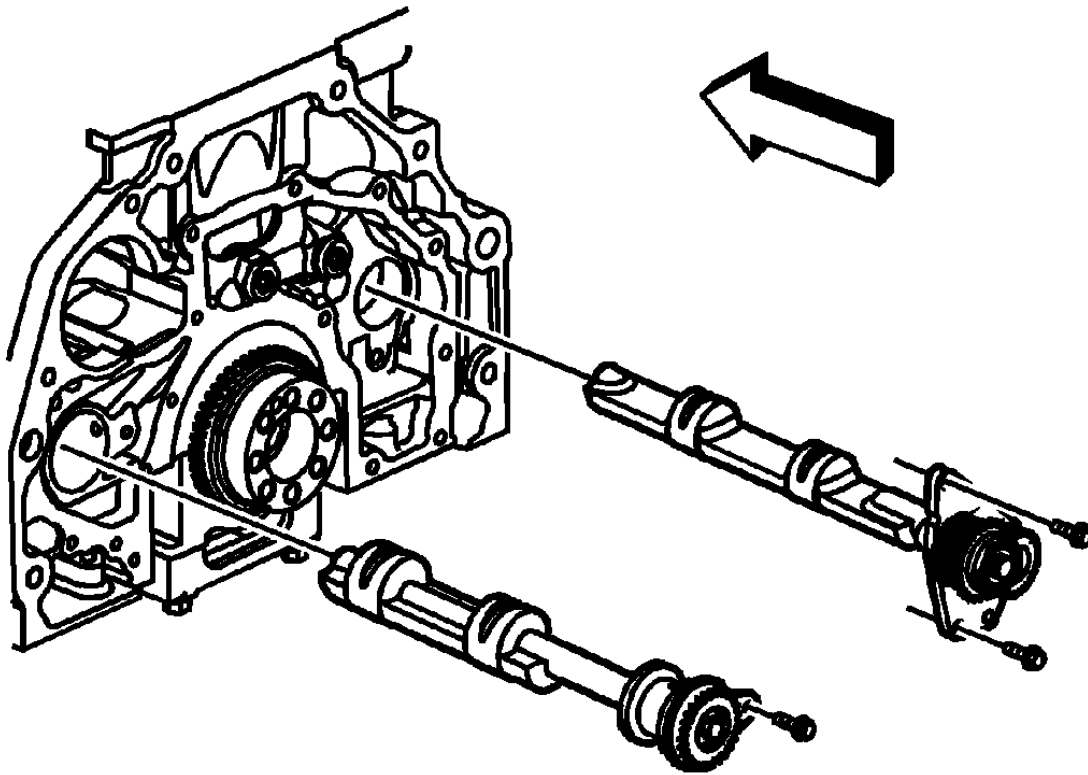


Fig. 212: View Of Balance Shaft Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Do not disassemble the balance shaft assembly. Remove and install the balance shaft as a complete assembly.
- Rotate the balance shaft to check for free rotation. If the balance shaft does not turn free, inspect the balance shaft bearings and bearing surface for damage.

2. Remove and discard the left balance shaft retaining bolt.
3. Remove the left balance shaft assembly.

Installation Procedure

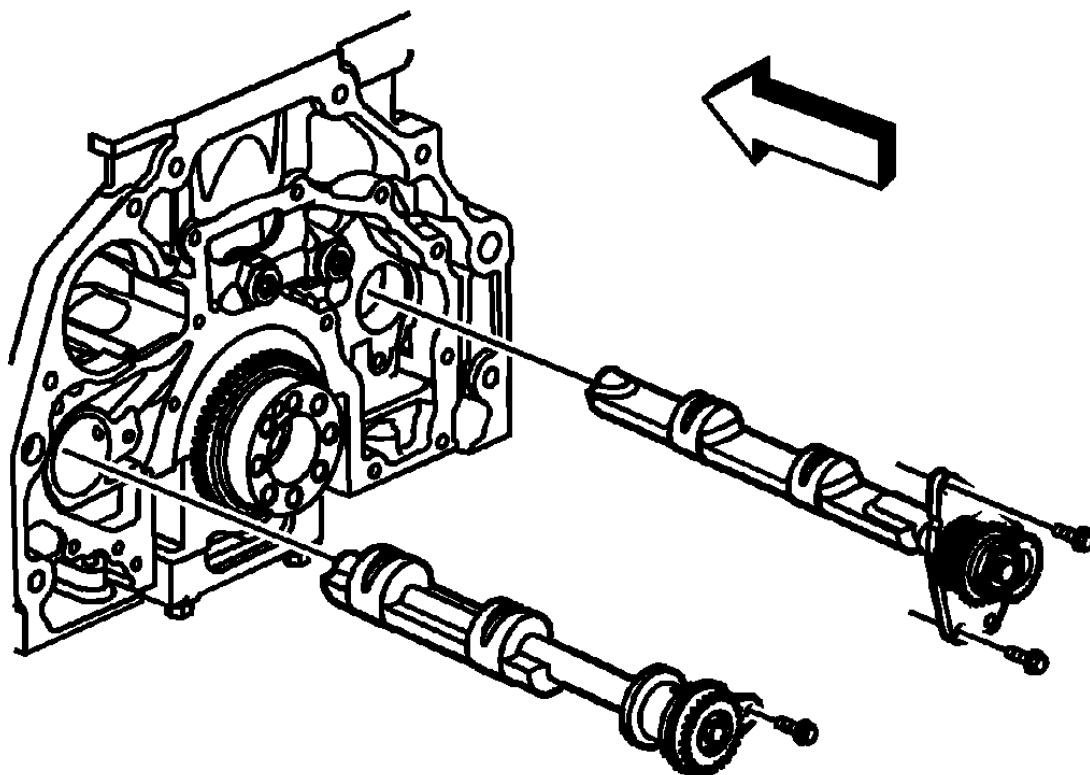


Fig. 213: View Of Balance Shaft Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the balance shaft bearing journals with clean engine oil.
2. Install the left balance shaft assembly with the counterweight down to prevent damage to the balance shaft bearings.

CAUTION: Refer to Fastener Caution .

3. Install a new balance shaft retaining bolt and tighten to 12 N.m (106 lb in).
4. Install the balance shaft drive chain. Refer to Balance Chain Replacement.

BALANCE SHAFT REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Remove the balance shaft drive chain. Refer to **Balance Chain Replacement**.

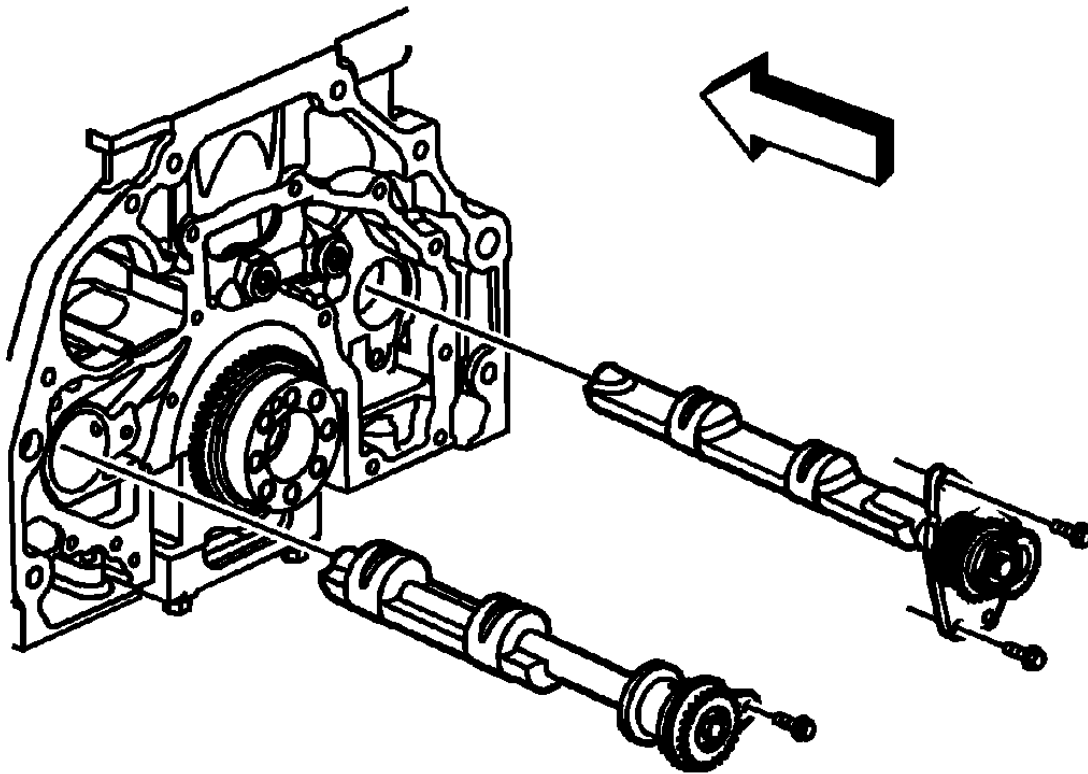


Fig. 214: View Of Balance Shaft Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Do not disassemble the balance shaft assembly. Remove and install the balance shaft as a complete assembly.
- Rotate the balance shaft to check for free rotation. If the balance shaft does not turn free, inspect the balance shaft bearings and bearing surface for damage.

2. Remove and discard the right balance shaft retaining bolts.
3. Remove the right balance shaft assembly.

Installation Procedure

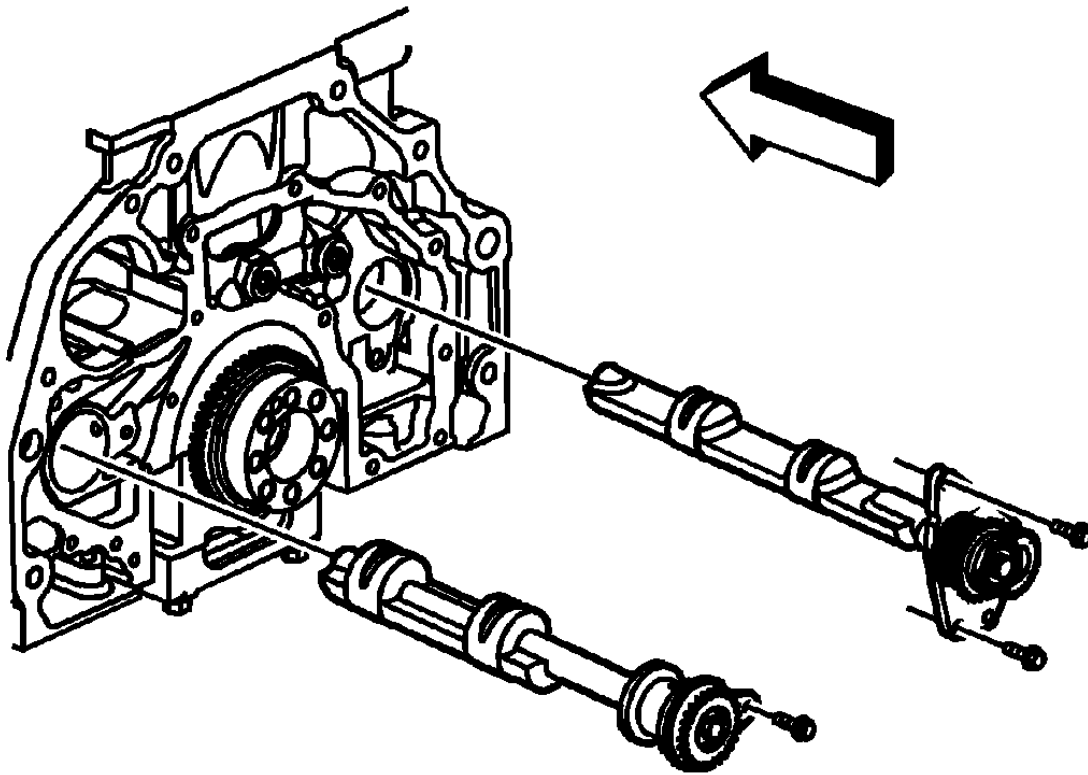


Fig. 215: View Of Balance Shaft Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the balance shaft bearing journals with clean engine oil.
2. Install the right balance shaft assembly with the counterweight down to prevent damage to the balance shaft bearings.

CAUTION: Refer to Fastener Caution .

3. Install the new balance shaft retaining bolts and tighten to 12 N.m (106 lb in).
4. Install the balance shaft drive chain. Refer to Balance Chain Replacement.

BALANCER CHAIN GUIDE REPLACEMENT

Removal Procedure

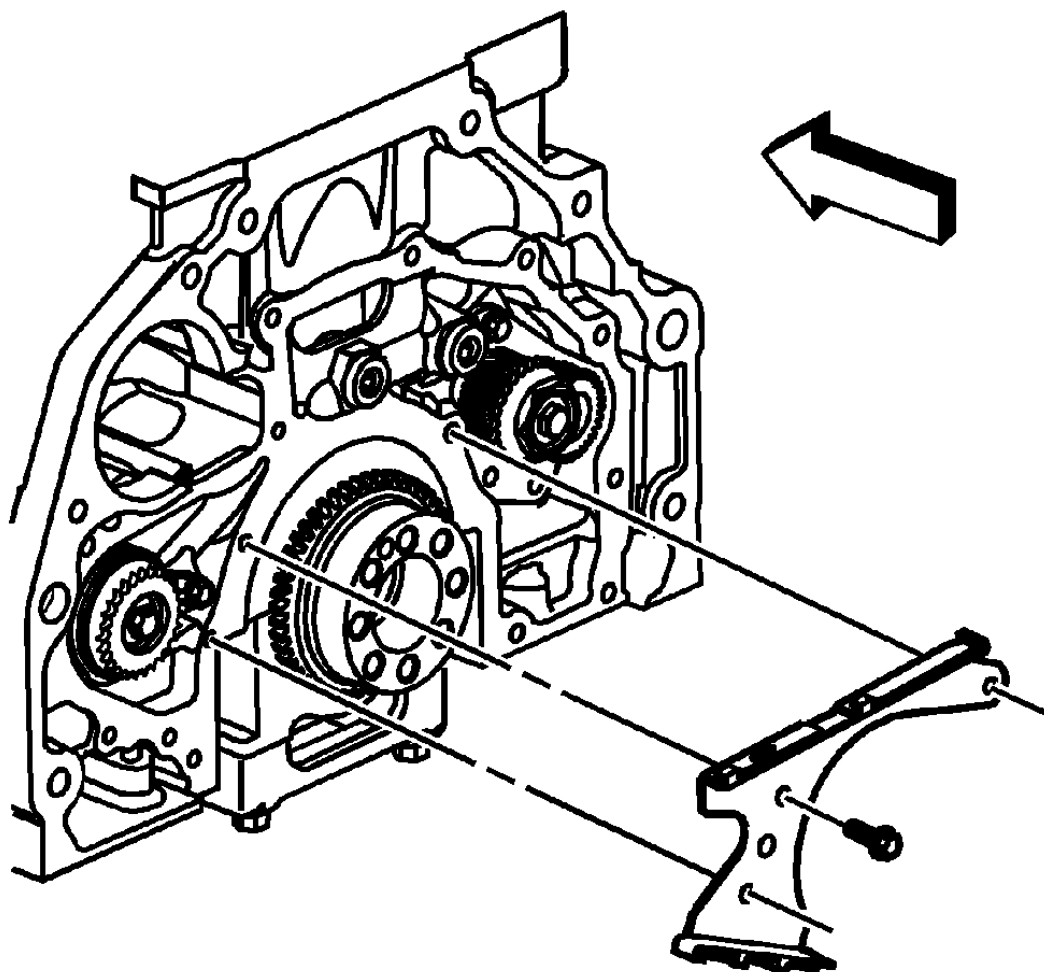


Fig. 216: View Of Balance Shaft Chain Guide
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the balance shaft drive chain. Refer to **Balance Chain Replacement**.
2. Remove the balance shaft chain guide bolts.
3. Remove the balance shaft chain guide.

Installation Procedure

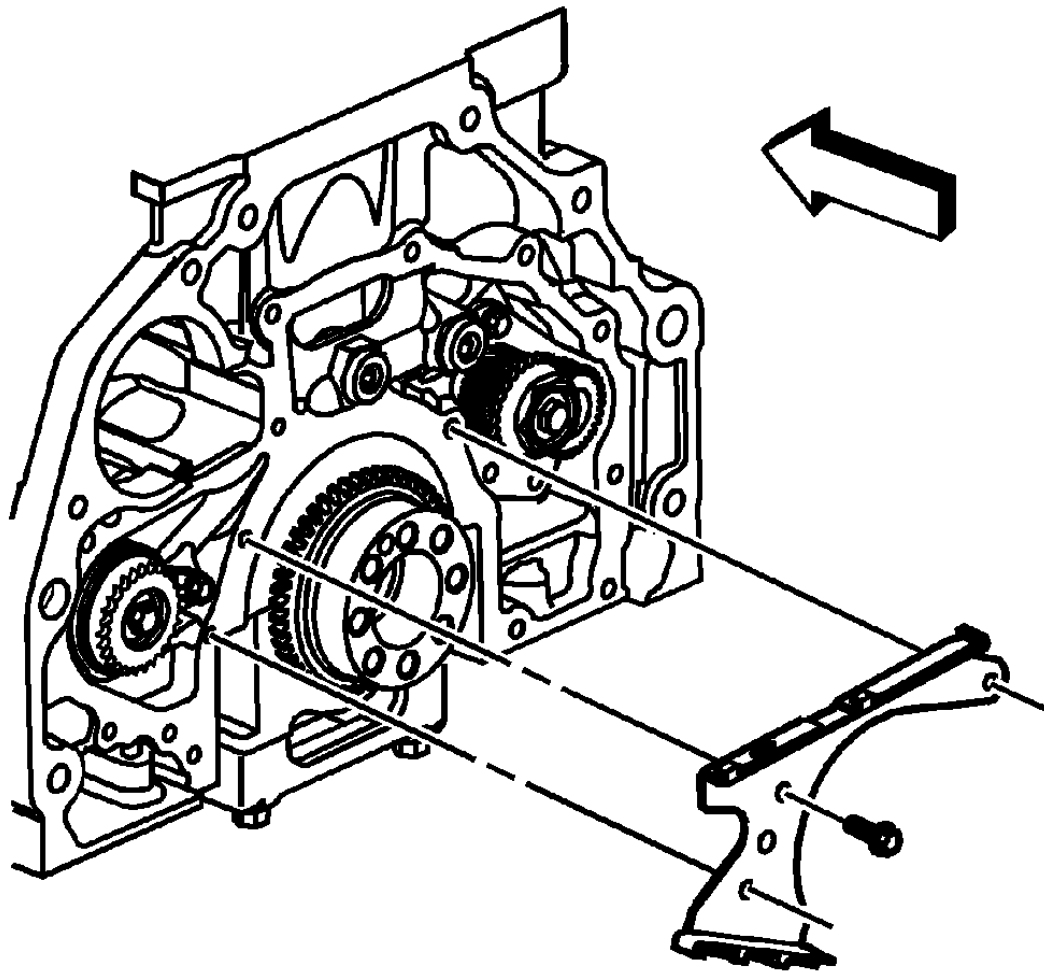


Fig. 217: View Of Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS COMPANY

1. Install the balance shaft chain guide.

CAUTION: Refer to Fastener Caution .

2. Install the balance shaft chain guide bolts and tighten to 10 N.m (89 lb in).
3. Install the balance shaft drive chain. Refer to Balance Chain Replacement.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

- GE-8092 Driver Handle

- **J 44215** Rear Seal Installer

Removal Procedure

1. Remove the flywheel. Refer to **Engine Flywheel Replacement (with Automatic Transmission)**.

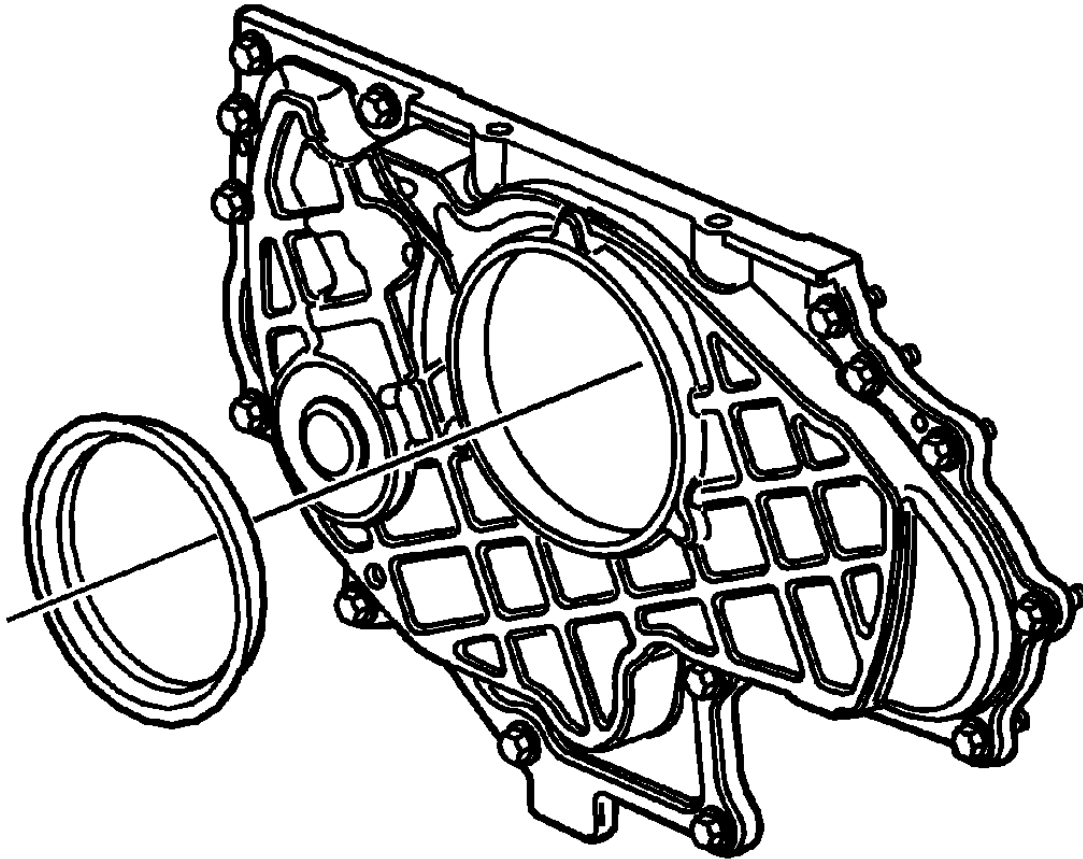


Fig. 218: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Do not damage the crankshaft or seal bore.

2. Using a suitable tool, pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Discard the seal.

Installation Procedure

1. Lightly lubricate the crankshaft rear oil seal lip with clean engine oil.
2. Position the plastic installation sleeve supplied with the new seal to the crankshaft.



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Fig. 219: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

3. Use the **J 44215** rear seal installer with the **GE-8092** driver handle and a hammer to install the crankshaft rear oil seal into the crankshaft rear oil seal housing.
 - Ensure the seal is installed square
 - The seal will bottom out in the housing when fully installed
4. Install the flywheel. Refer to **Engine Flywheel Replacement (with Automatic Transmission)**.

ENGINE FLYWHEEL REPLACEMENT (WITH AUTOMATIC TRANSMISSION)

Special Tools

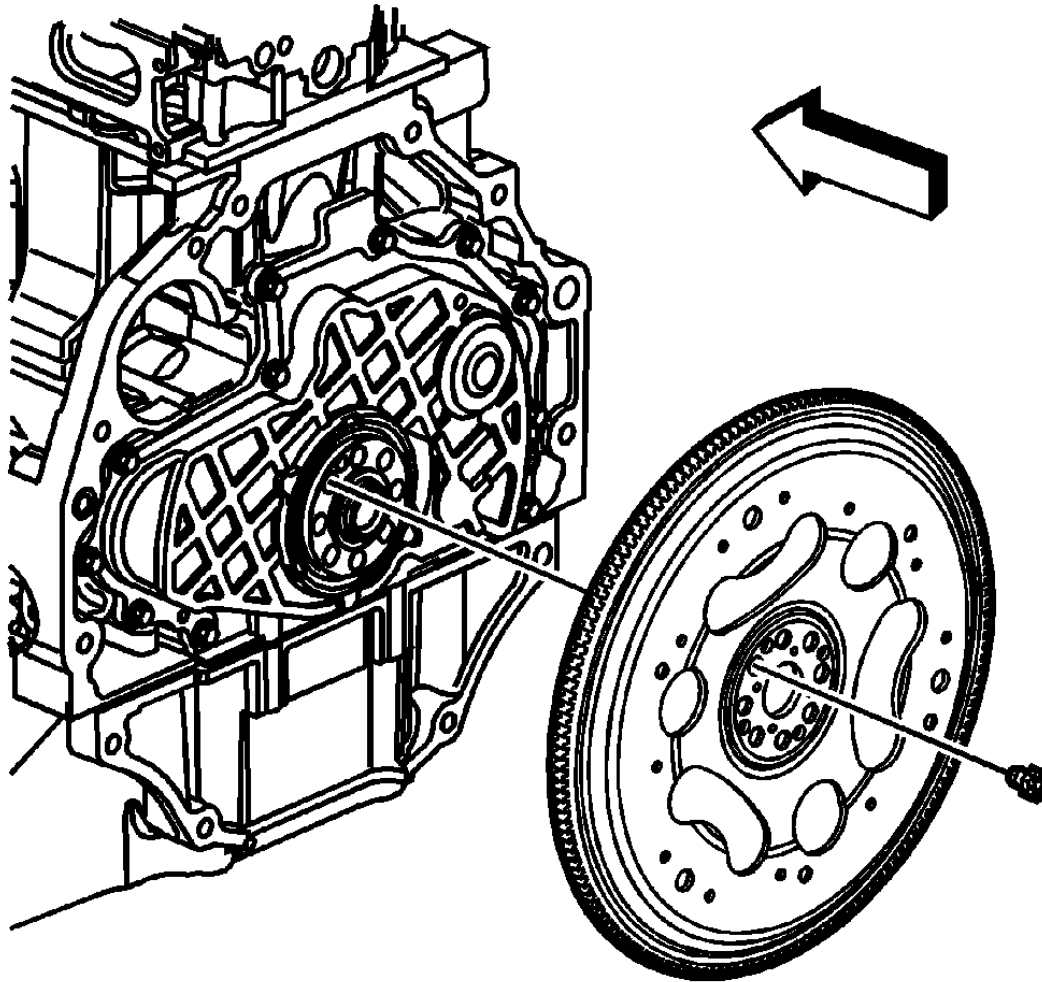
J 45059 Angle Meter**Removal Procedure**

Fig. 220: View Of Engine Flywheel
Courtesy of GENERAL MOTORS COMPANY

1. Remove the transmission. Refer to Transmission Replacement (4WD 2.9L and 3.7L) , Transmission Replacement (2WD 2.9L and 3.7L) .
2. Remove and discard the flywheel bolts.
3. Remove the flywheel.

Installation Procedure

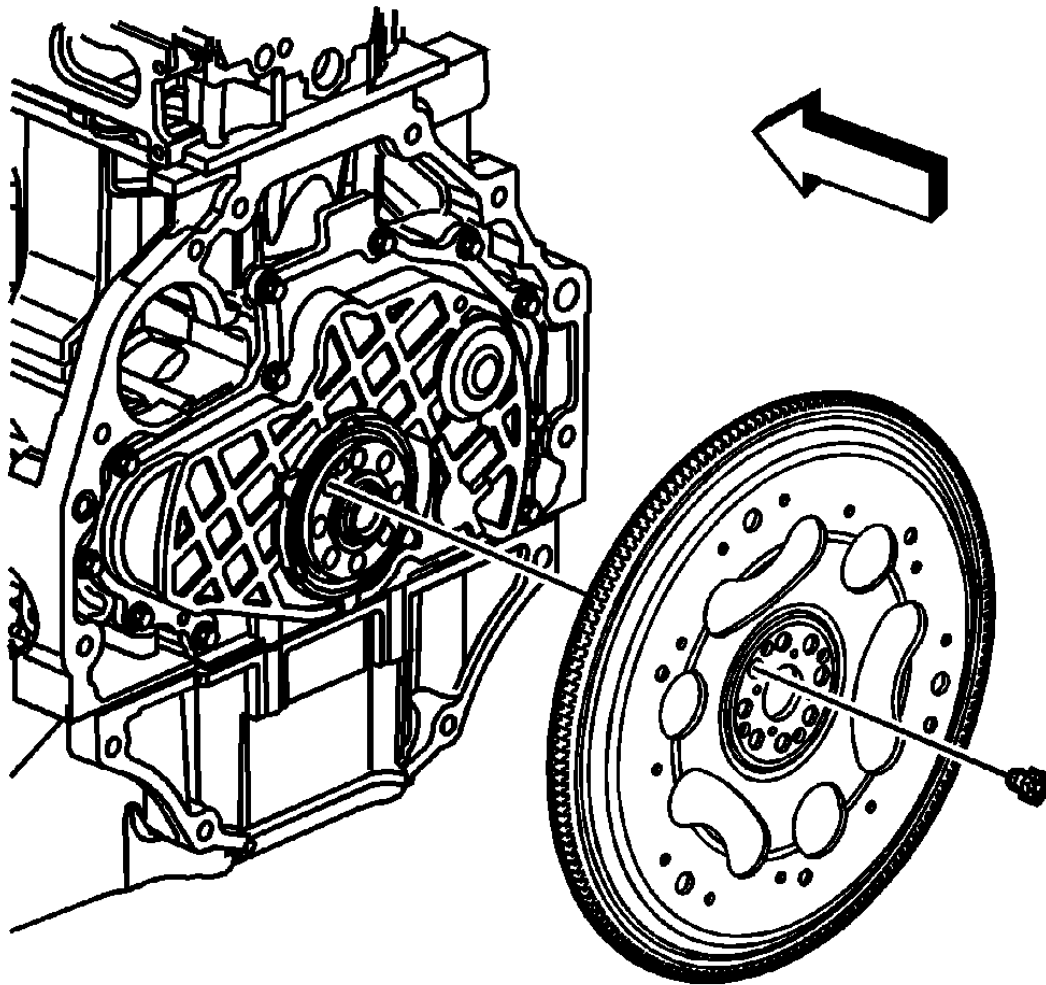


Fig. 221: View Of Engine Flywheel
Courtesy of GENERAL MOTORS COMPANY

1. Position the flywheel to the crankshaft

CAUTION: Refer to Fastener Caution .

2. Install the new flywheel bolts and tighten to 40 N.m (30 lb ft) plus an additional 45 degrees using the J 45059 angle meter.
3. Install the transmission. Refer to Transmission Replacement (4WD 2.9L and 3.7L) , Transmission Replacement (2WD 2.9L and 3.7L) .

ENGINE REPLACEMENT

Special Tools

- **J 38185** Hose Clamp Pliers
- **J 44220** Engine Lift Bracket

Removal Procedure

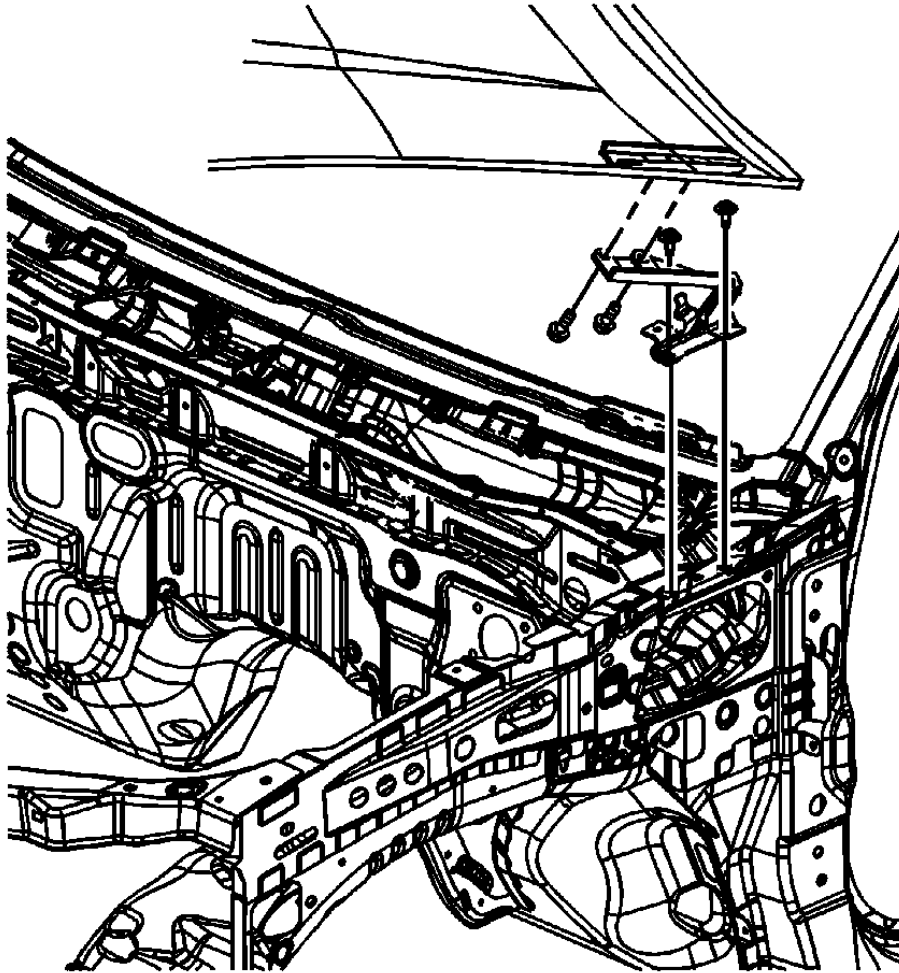


Fig. 222: View Of Hood Hinges
Courtesy of GENERAL MOTORS COMPANY

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the battery box. Refer to **Battery Box Replacement** .
3. Remove the left inner wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
4. Drain the engine coolant. Refer to **Cooling System Draining and Filling (Static Fill)** , **Cooling System Draining and Filling (Vac N Fill)** .
5. Remove the cooling fan. Refer to **Fan Replacement (LLV, LLR)** .
6. Remove the air cleaner resonator and outlet duct. Refer to **Air Cleaner Resonator and Outlet Duct Replacement** .
7. Remove the A/C compressor from the engine. Position the A/C compressor aside and support it to the

vehicle. It is not necessary to discharge the refrigerant..

8. Remove the generator. Refer to **Generator Replacement (LLV/LLR)**.
9. Reinstall the engine lift bracket. Refer to **Engine Lift Bracket Replacement**.

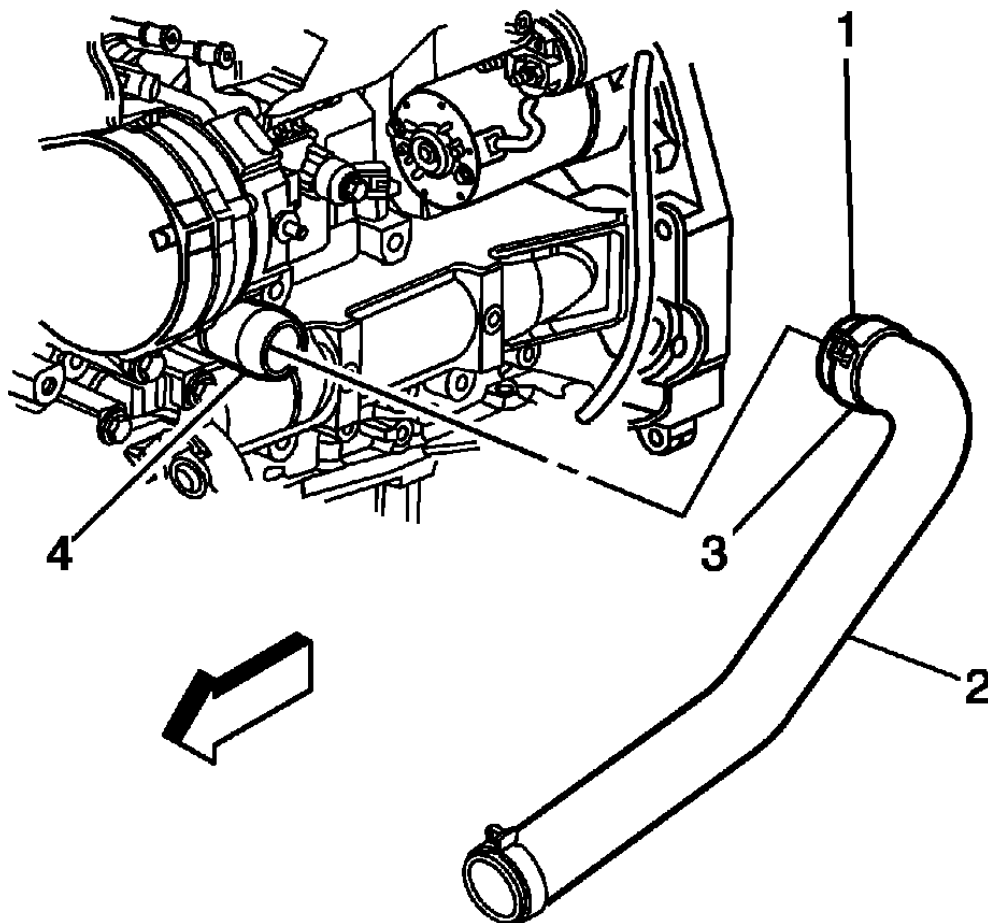


Fig. 223: View Of Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

10. Use the **J 38185** hose clamp pliers to remove the inlet radiator hose (2) from the thermostat housing (4).
11. Remove the washer solvent container/coolant recovery reservoir mounting bolts **ONLY**, in order to gain clearance to remove the engine wiring harness. Refer to **Windshield Washer Solvent Container Replacement**.

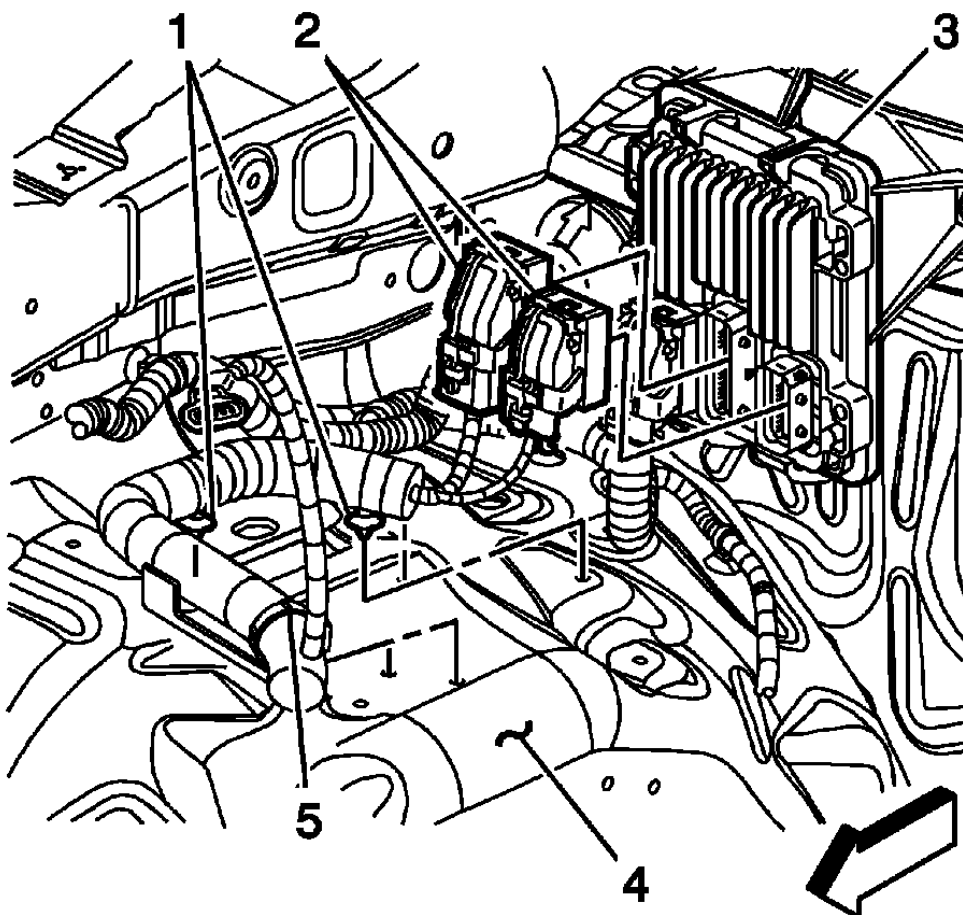


Fig. 224: View Of Engine Wiring Harness & Retainers
Courtesy of GENERAL MOTORS COMPANY

12. Disconnect the 2 engine wiring harness connectors (2) from the powertrain control module (PCM) (3).
13. Disconnect the engine wiring harness retainers (1) from the wheelhouse (4).
14. Open the engine wiring harness retainer (5).

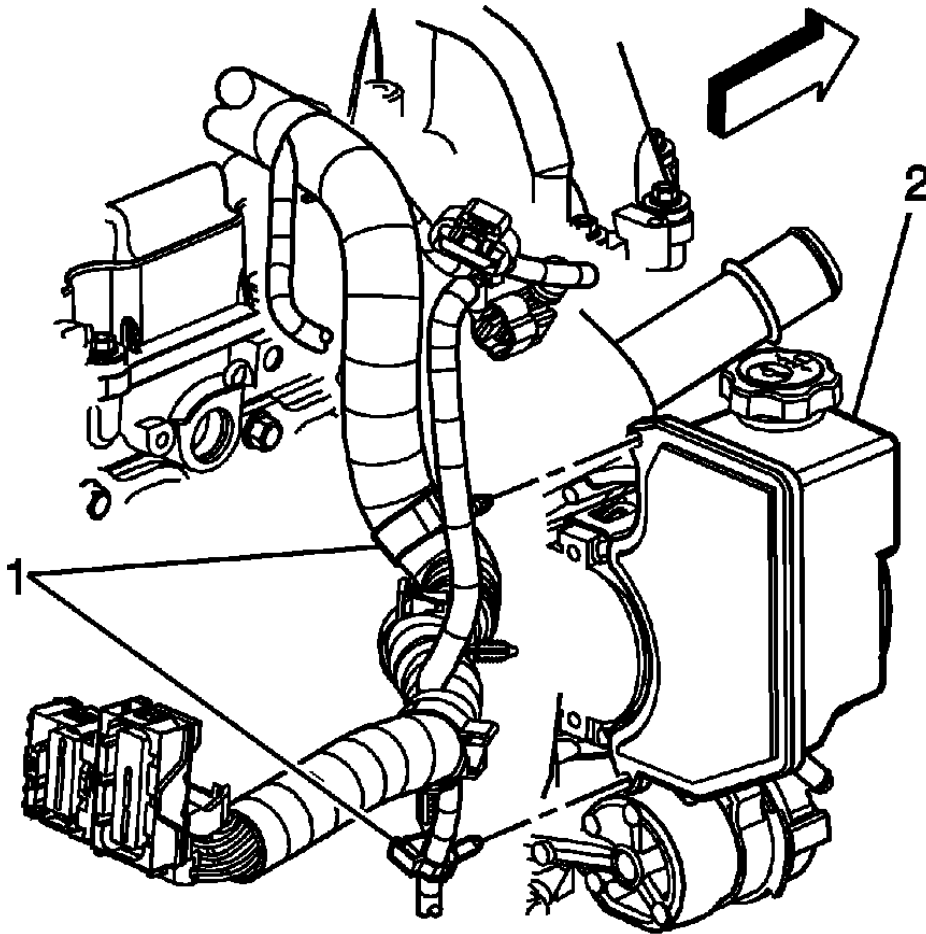


Fig. 225: View Of Power Steering Pump & Engine Wiring Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

15. Disconnect the engine wiring harness retainers (1) from the power steering pump (2).
16. Disconnect the engine wiring harness connectors from the following components:
 - The electric motor actuator connector (4WD only)
 - The oil pressure switch

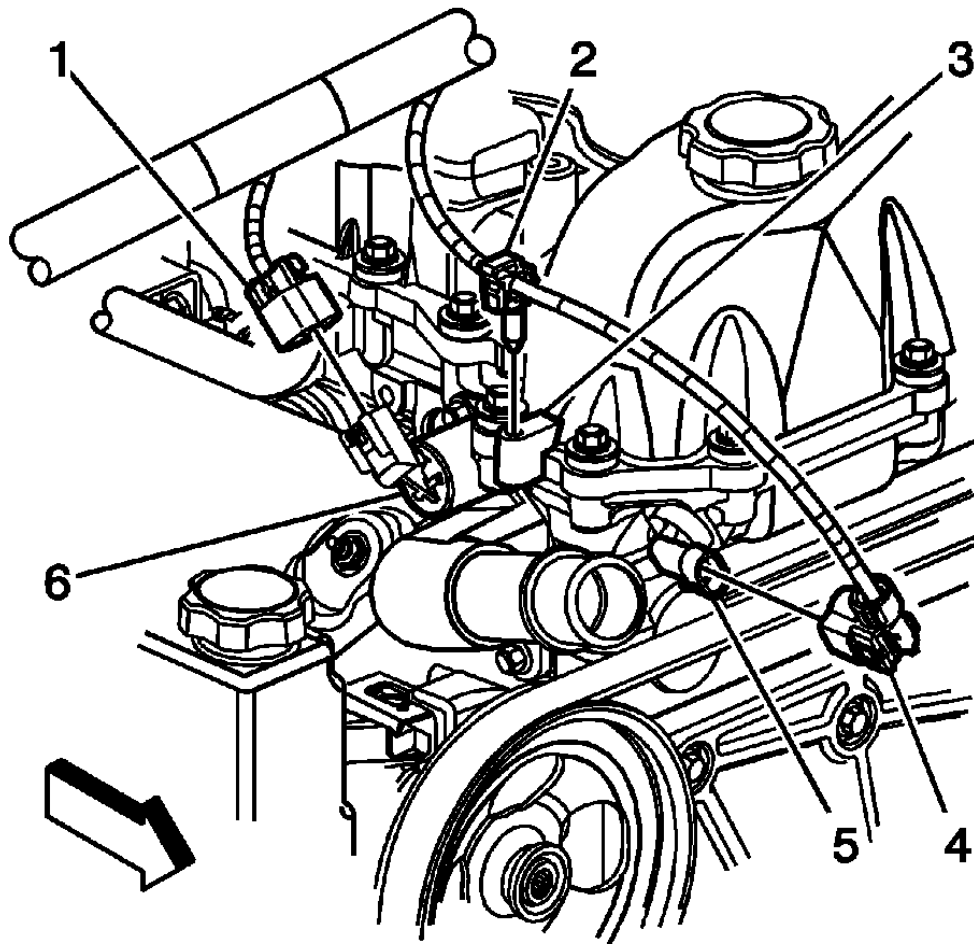


Fig. 226: View Of CMP Sensor Connector, Exhaust Camshaft Actuator Connector & Engine Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

17. Disconnect the engine wiring harness retainer (2) from the camshaft cover (3).
18. Disconnect the engine wiring harness connectors from the following components:
 - The exhaust camshaft position (CMP) sensor (5)
 - The exhaust camshaft actuator (6)

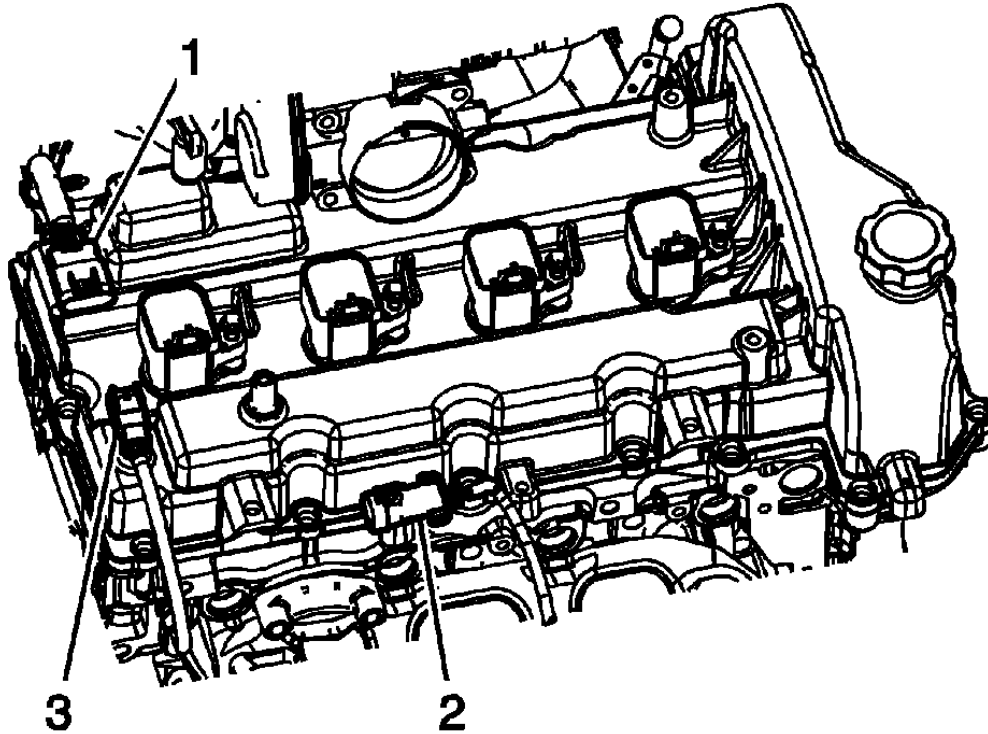


Fig. 227: View Of Engine Fuel Injector, Oxygen Sensor And ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

19. Disconnect the following electrical connectors from the camshaft cover:

- The fuel injector harness (1)
- The heated oxygen sensor (HO2S) (2)
- The engine coolant temperature (ECT) sensor (3)



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Fig. 228: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

20. Disconnect the engine wiring harness electrical connectors from the ignition coils.



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Fig. 229: View Of Throttle Body Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

21. Disconnect the engine wiring harness retainer (3) from the camshaft cover (4).
22. Disconnect the engine wiring harness connector (2) from the throttle body (1).

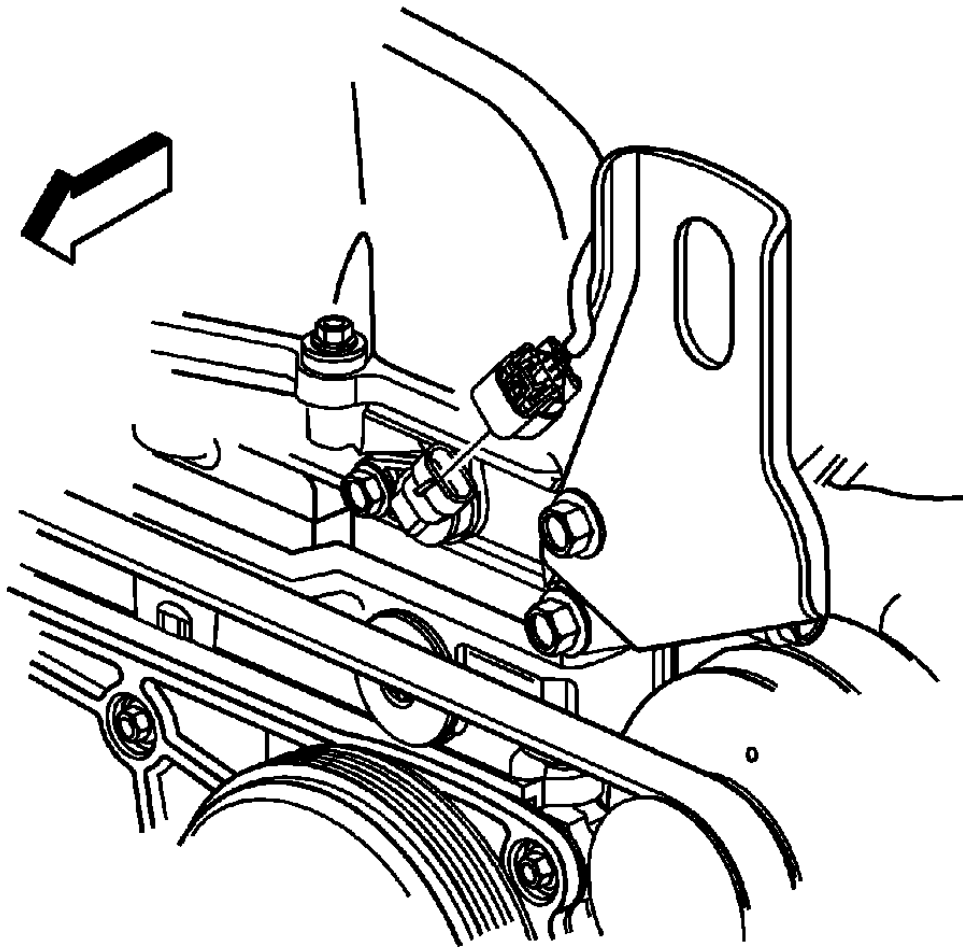


Fig. 230: View Of Intake CMP Sensor
Courtesy of GENERAL MOTORS COMPANY

23. Disconnect the engine wiring harness connector from the intake CMP sensor.



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Fig. 231: View Of Engine Wiring Harness Connections
Courtesy of GENERAL MOTORS COMPANY

24. Carefully disengage the engine wiring harness conduit from the camshaft cover.
25. Remove the transmission filler tube (M30 only). Refer to **Transmission Fluid Filler Tube and Seal Replacement (2.9L, 3.7L)**.
26. Drain the engine oil, if necessary. Refer to **Engine Oil and Oil Filter Replacement**.

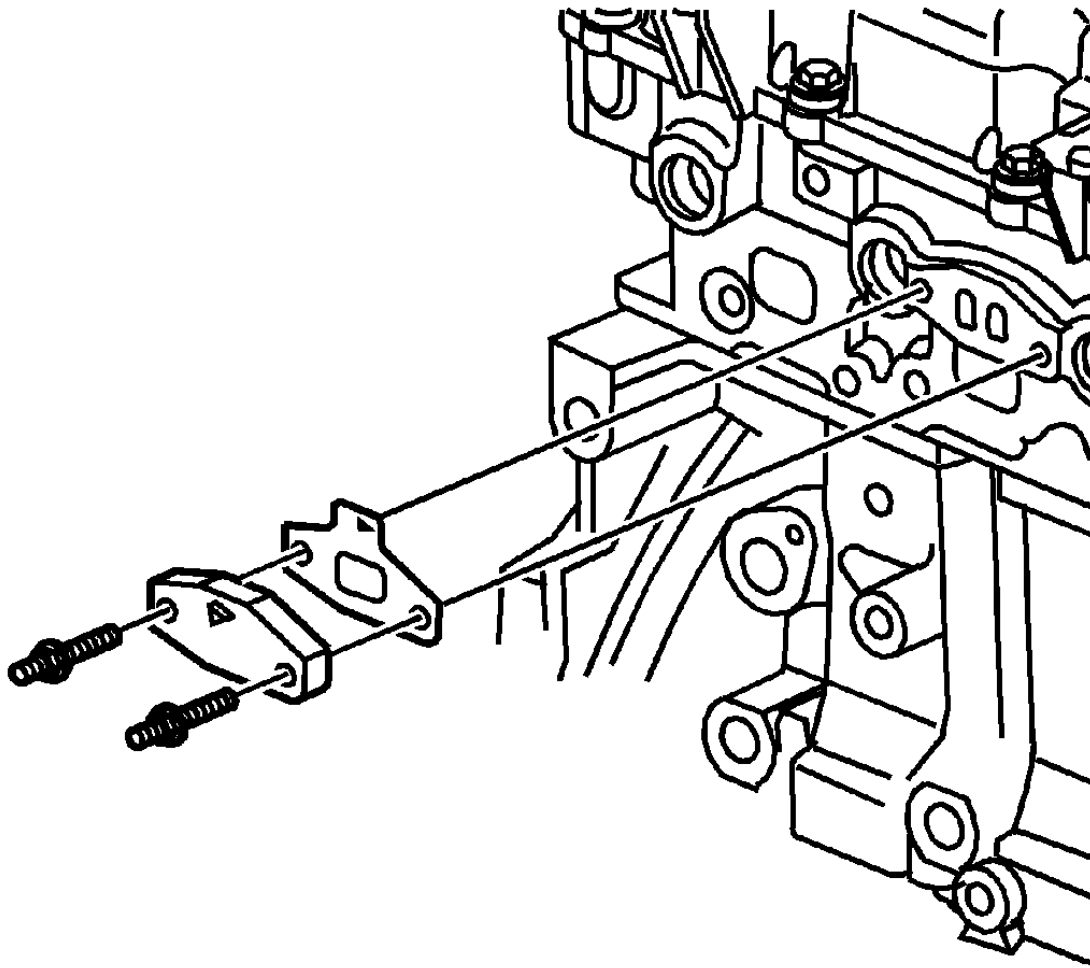


Fig. 232: View Of A.I.R. Injection Pipe Cover
Courtesy of GENERAL MOTORS COMPANY

27. Remove the studs securing the secondary air injection (AIR) pipe cover to the cylinder head.
 1. Remove the AIR injection pipe cover studs.
 2. Remove the AIR pipe cover and gasket.
 3. Discard the gasket.



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Fig. 233: Engine Lift Bracket

Courtesy of GENERAL MOTORS COMPANY

28. Install the **J 44220** engine lift bracket in place of the AIR adapter.



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Fig. 234: View Of Inlet Heater Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

29. Disconnect the inlet heater hose quick connect (1) from the heater core (2), and secure to the engine.



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Fig. 235: View Of Power Steering Pump & Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

30. Remove the power steering pump mounting bolts ONLY, and position aside.



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Fig. 236: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

31. Remove the right engine mount-to-frame bracket bolt.



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Fig. 237: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

32. Disconnect the engine wiring harness retainer (1) from the intake manifold (2).
33. Position the engine wiring harness aside.
34. Disconnect the fuel feed pipe from the fuel rail. Refer to **Plastic Collar Quick Connect Fitting Service** .
35. Disconnect the evaporative emission (EVAP) pipe at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .
36. Remove the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.

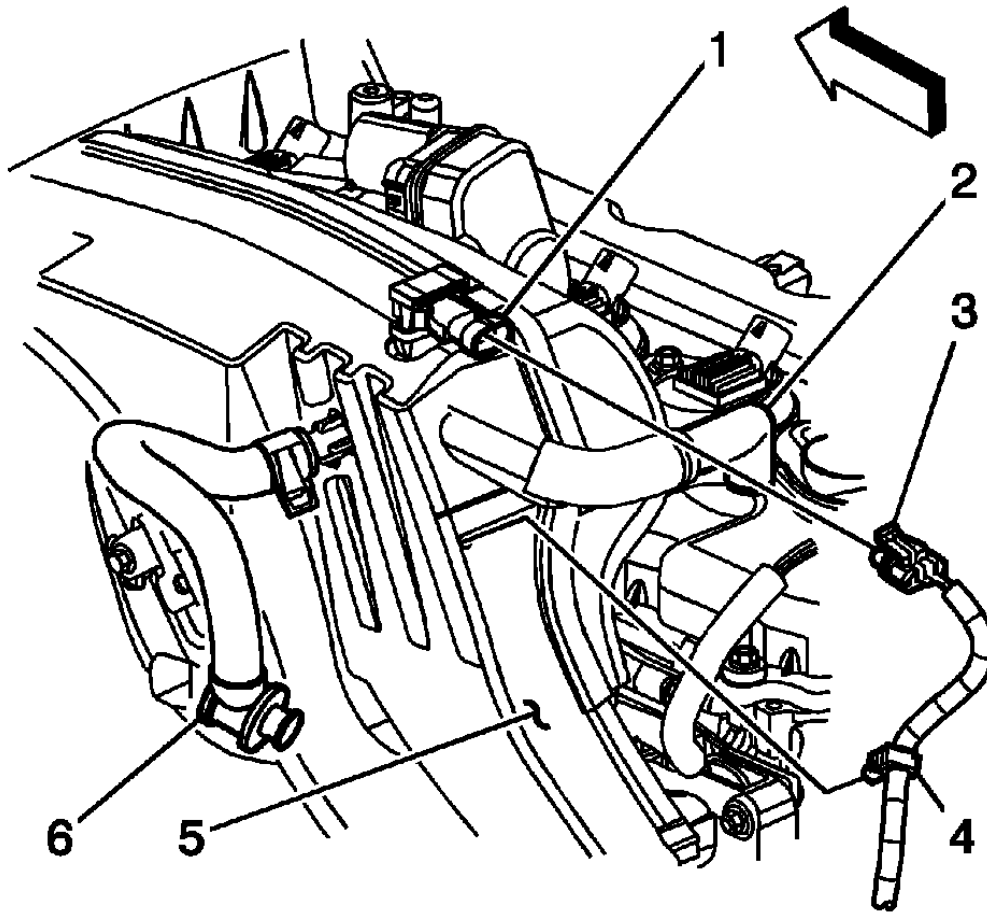


Fig. 238: Identifying Intake Manifold External Components
 Courtesy of GENERAL MOTORS COMPANY

37. Disconnect the brake booster hose (6) from the brake booster.
38. Disconnect the manifold absolute pressure (MAP) sensor wiring harness retainer (4) from the intake manifold (5).
39. Raise and support the vehicle only high enough to access the wiring harnesses through the wheelhouse. Refer to **Lifting and Jacking the Vehicle**.



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Fig. 239: View Of Wiring Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

40. Disconnect the following wiring harness retainers from the engine wiring harness bracket:
- The battery cable
 - The engine wire harness (4, 6)
 - The MAP sensor (5)

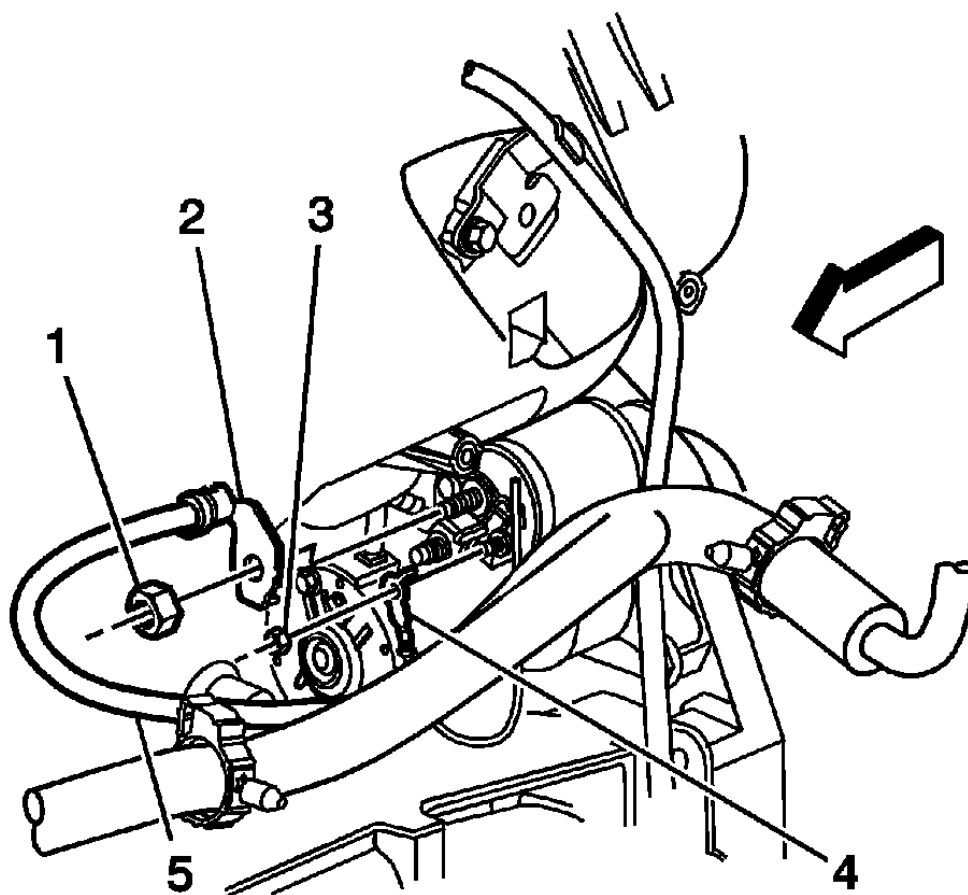


Fig. 240: Locating Positive Battery Cable
Courtesy of GENERAL MOTORS COMPANY

41. Remove the starter solenoid "S" terminal nut (3) and disconnect the lead (4) from the starter.
42. Remove the starter terminal nut (1) and disconnect the battery positive cable (2) from the starter.



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Fig. 241: Locating Negative Battery Cable
Courtesy of GENERAL MOTORS COMPANY

43. Remove the bolt (4) securing the battery negative cable (5) to the engine block (1).

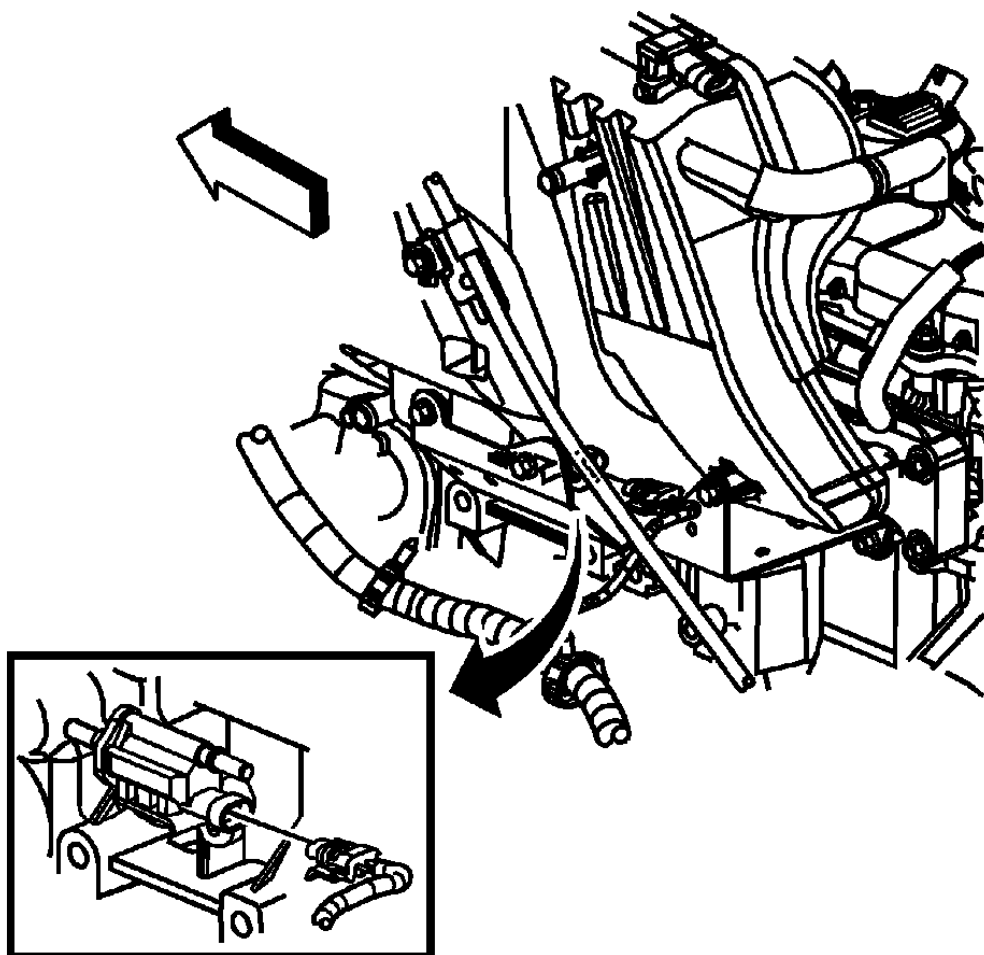


Fig. 242: View Of EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

44. Disconnect the engine wiring harness connector from the EVAP canister purge solenoid valve.



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Fig. 243: View Of KS Engine Wiring Harness Connector
Courtesy of GENERAL MOTORS COMPANY

45. Disconnect the engine wiring harness connector (3) from knock sensor 2 (1).
46. Disconnect the coolant heater cord from the coolant heater, if equipped.



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Fig. 244: View Of #1 Knock Sensor & Engine Oil Pan Rail Engine Wiring Harness Connectors
Courtesy of GENERAL MOTORS COMPANY

47. Disconnect the engine wiring harness connector from knock sensor 1 (2).
48. Disconnect the engine wiring harness retainer (4) from the engine oil pan rail.



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Fig. 245: View Of Heater Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

49. Remove the bolt (5) securing the heater outlet hose/pipe to the left engine mount (4).
50. Remove the heater outlet hose/pipe using **J 38185** hose clamp pliers.



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Fig. 246: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

51. Disconnect the engine wiring harness connector (3) from the crankshaft position (CKP) sensor (1).
52. Raise the vehicle completely. Refer to **Lifting and Jacking the Vehicle** .
53. Remove the 3 bolts securing the engine wiring ground leads (2) to the engine block.
54. Disconnect the engine wiring harness retainers (5) from the engine oil pan rail.
55. Position the engine wiring harness aside.

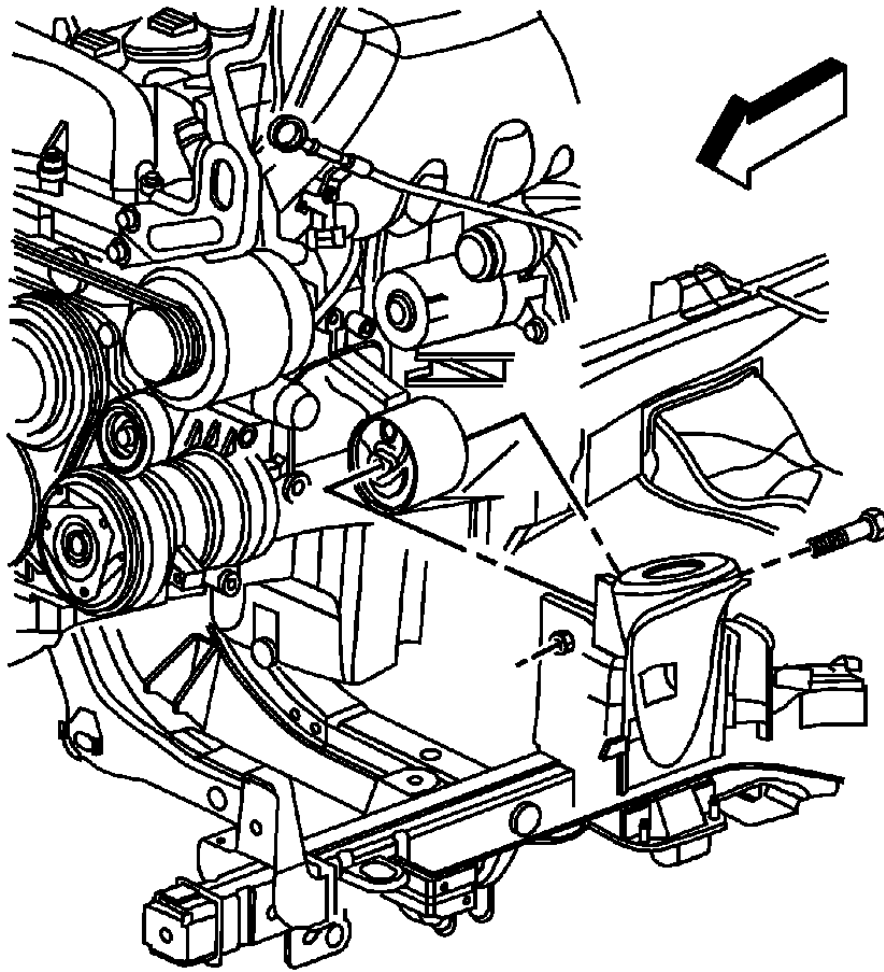


Fig. 247: View Of Engine Mount - Left
Courtesy of GENERAL MOTORS COMPANY

56. Remove the left engine mount-to-frame bracket bolt.



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Fig. 248: View Of Fuel Hose/Pipe Bracket & Nuts (MA5)
Courtesy of GENERAL MOTORS COMPANY

57. Remove the nuts securing the fuel hose/pipe brackets to the transmission (MA5 only).

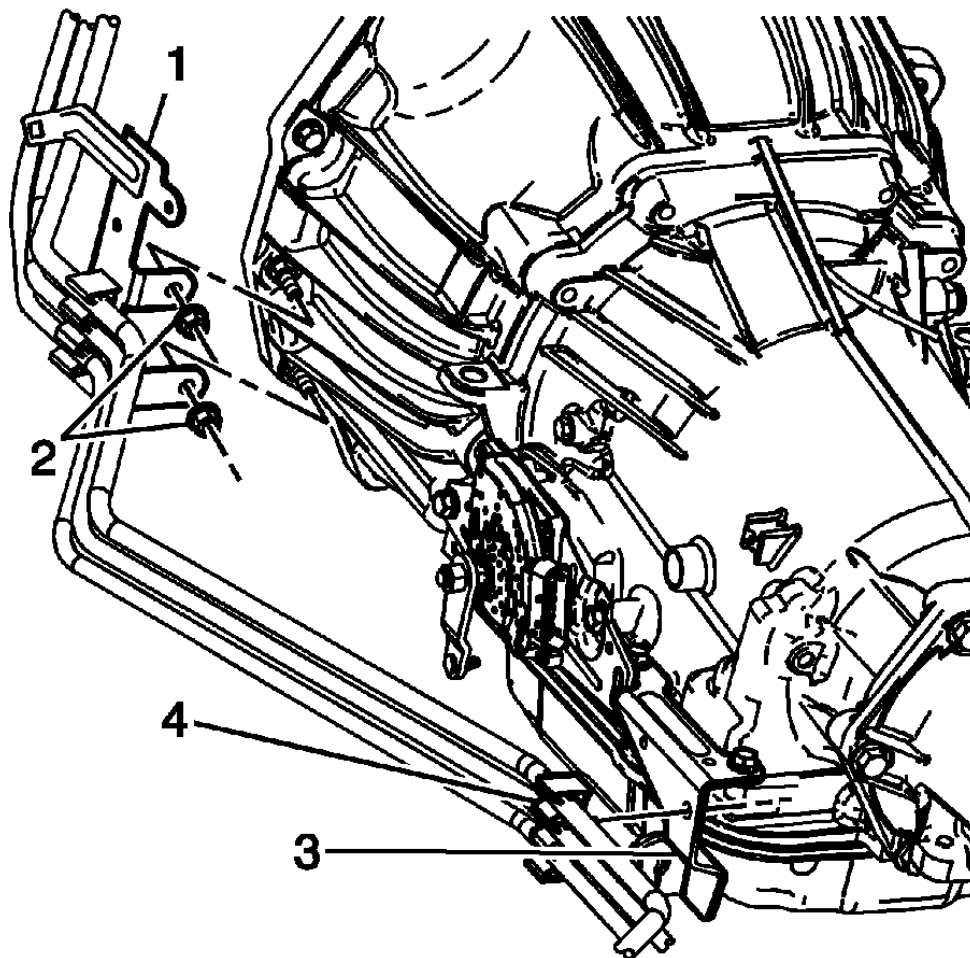


Fig. 249: View Of Fuel Hose/Pipe Bracket & Nuts (M30)

Courtesy of GENERAL MOTORS COMPANY

58. Remove the nuts (2) securing the fuel hose/pipe bracket (1) to the transmission (M30 only).
59. Disconnect the fuel hose/pipe retainer (4) from the range selector cable bracket (3), and position aside the fuel hose/pipe bundle (M30 only).
60. Remove the applicable components in order to gain clearance to remove the engine:
 - RWD

Remove the crossmember. Refer to **Transmission Support Crossmember Replacement (4WD)** , **Transmission Support Crossmember Replacement (2WD)** .

- 4WD

1. Remove the front propeller shaft. Refer to **Front Propeller Shaft Replacement** .



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Fig. 250: View Of Mounting Bracket To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the differential carrier assembly bushing to frame bolts ONLY.
 3. Position the differential carrier assembly forward.
 4. Secure the pinion yoke, in order to prevent the differential carrier from rotating.
61. Disconnect the exhaust and remove the exhaust seal. Refer to **Exhaust Seal Replacement (LLV/LLR)** .

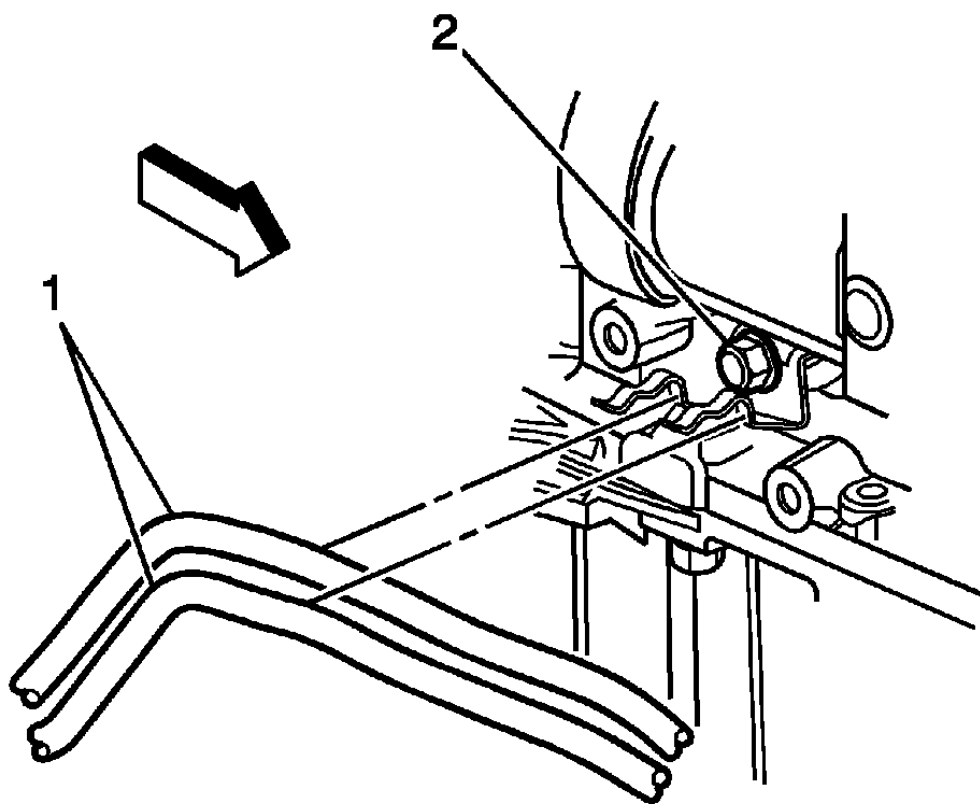


Fig. 251: View Of Transmission Oil Cooler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

62. Remove the bolt (2) securing the transmission oil cooler pipe bracket to the right side of the engine oil pan rail (M30 only).



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Fig. 252: View Of Inspection Plug
Courtesy of GENERAL MOTORS COMPANY

63. Remove the inspection plug (3) from the transmission (1) (M30 only).
64. Mark the torque converter to flexplate/flywheel orientation to ensure proper realignment (M30 only).

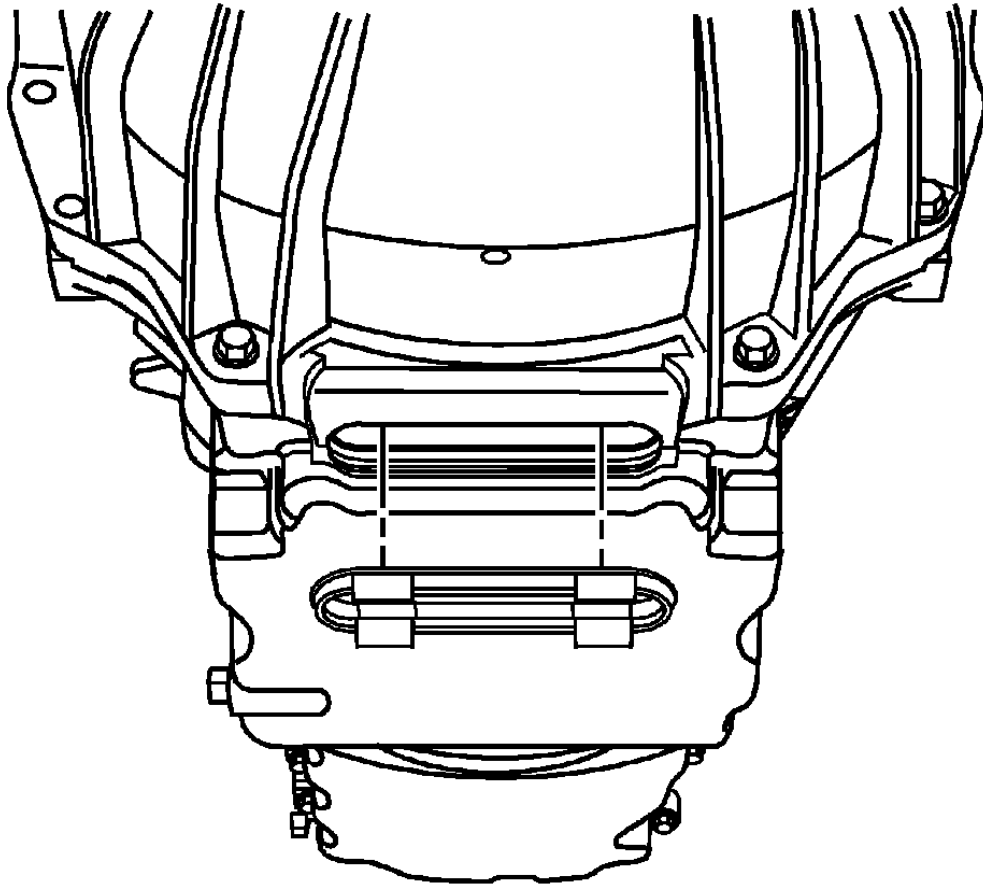


Fig. 253: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

65. Remove the service slot plug.
66. Repeat the following steps for all 3 torque converter bolts (M30 only):
 1. Rotate the harmonic balancer center bolt clockwise ONLY, in order to access the torque converter bolt through the service slot.
 2. Remove the torque converter bolt using one of the following:
 - 18 mm crowfoot wrench
 - Short T50 TORX bit

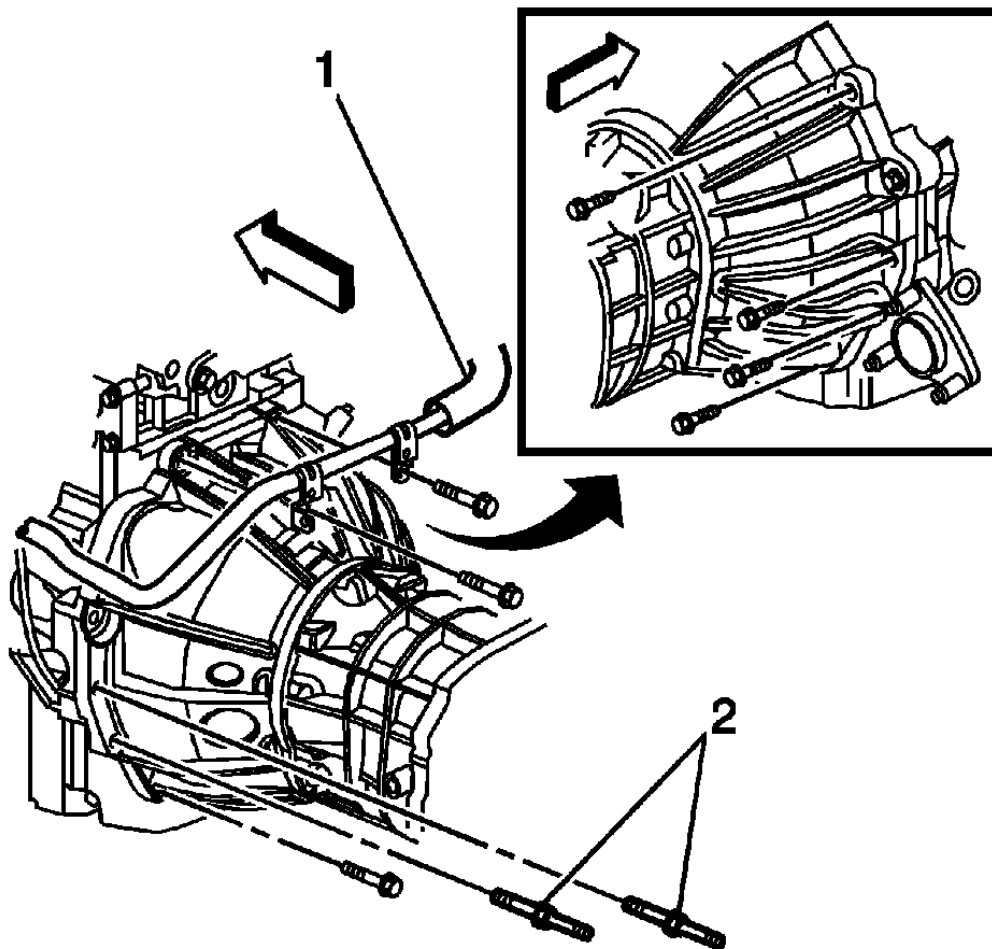


Fig. 254: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

67. Remove the 9 transmission mounting bolts (2).



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Fig. 255: View Of Transmission Mounting Bolts & Engine Dowels
Courtesy of GENERAL MOTORS COMPANY

68. Remove the remaining transmission mounting bolts (2).
69. Lower the vehicle.
70. Place a jack under the transmission for support.

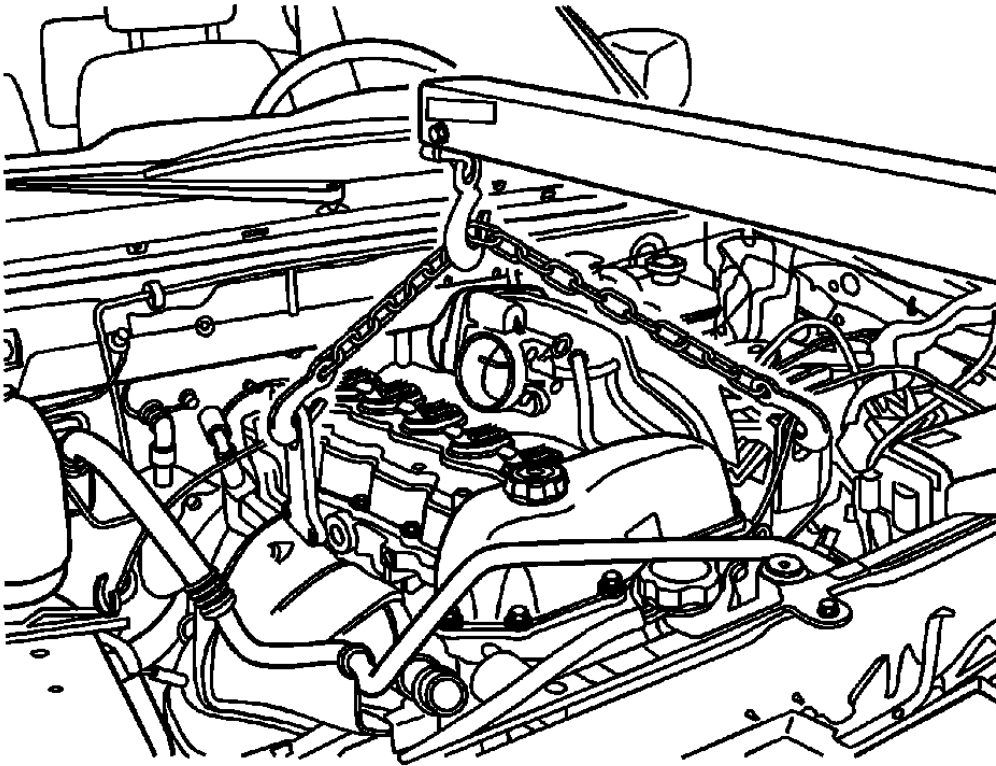


Fig. 256: View Of Engine Lift Chain
Courtesy of GENERAL MOTORS COMPANY

71. Install an engine lift chain to the engine lift brackets and attach to an engine lift devise.
72. Using the engine lift devise, raise the engine only enough to remove the engine mounts.
73. Remove the bolts securing the following to the engine block:
 - The left engine mount
 - The right engine mount
74. Position the engine mounts away from the engine.

NOTE: **Ensure clearance is maintained between the engine and the following:**

- The A/C compressor
- The A/C hoses
- The engine mounts
- The engine wiring harness

- **The fuel hose/pipes**
- **The heater outlet hose/pipe**
- **The power steering pump**
- **The radiator**
- **The transmission input shaft (MA5 only)**
- **The transmission oil cooler pipes (M30 only)**

75. Carefully raise the engine from the engine compartment, ensuring the transmission stays supported.
76. If equipped with an automatic transmission, remove the automatic transmission flywheel locator. Refer to **Flywheel Locator Removal** .
77. Install the engine to an engine stand.
78. Remove the engine lift chain from the engine lift brackets.

Installation Procedure

1. Install an engine lift chain to the engine lift brackets and attach to an engine lift devise.
2. Remove the engine from the engine stand.
3. If equipped with an automatic transmission, install the automatic transmission flywheel locator. Refer to **Flywheel Locator Installation** .
4. Ensure the torque converter is fully engaged with the transmission oil pump (M30 only).



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Fig. 257: View Of Engine Lift Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure clearance is maintained between the engine and the following:

- The A/C compressor
- The A/C hoses
- The engine mounts
- The engine wiring harness
- The fuel hose/pipes
- The heater outlet hose/pipe
- The power steering pump
- The radiator
- The transmission input shaft (MA5 only)
- The transmission oil cooler pipes (M30 only)

5. Carefully lower the engine into the engine compartment, aligning the engine dowels with the transmission.

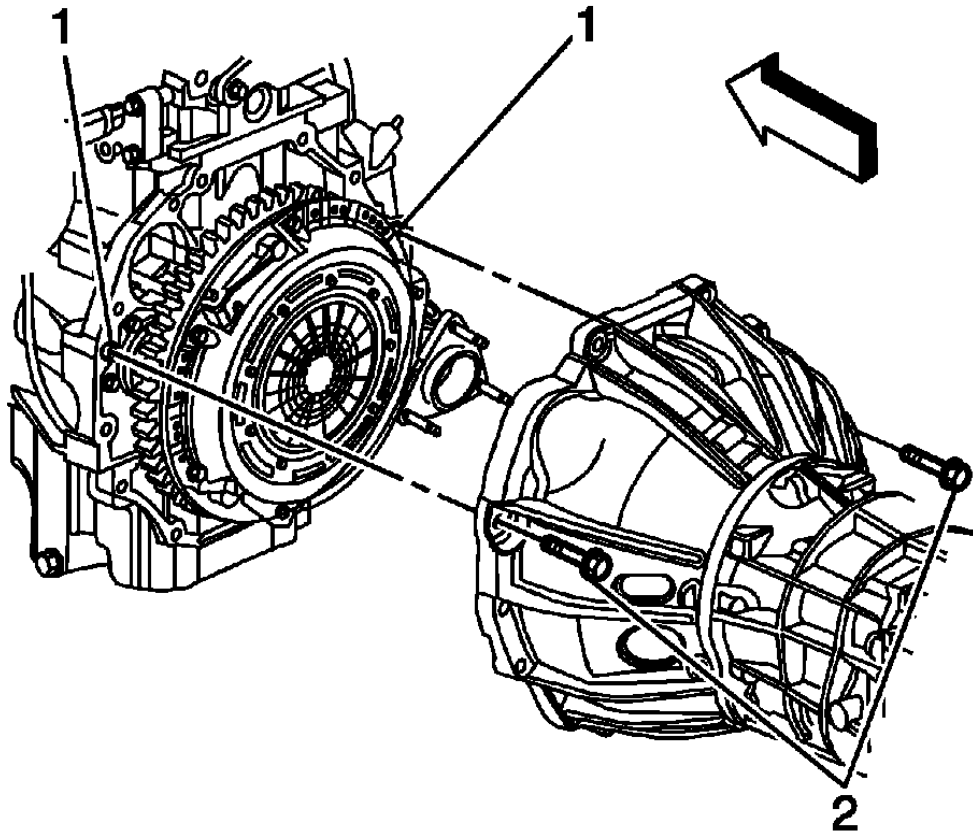


Fig. 258: View Of Transmission Mounting Bolts & Engine Dowels

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the torque converter turns freely while tightening the transmission mounting bolts (M30 only).

6. Align the engine dowels (1) with the transmission.
7. Loosely install the 2 transmission mounting bolts (2).

Ensure the dowels (1) are fully engaged into the transmission.

8. Remove the jack from under the vehicle.
9. Position the engine mounts to the engine.



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Fig. 259: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

10. Install the bolts securing the right engine mount to the engine block.

The engine lift devise may have to be raised or lowered slightly to install these bolts.

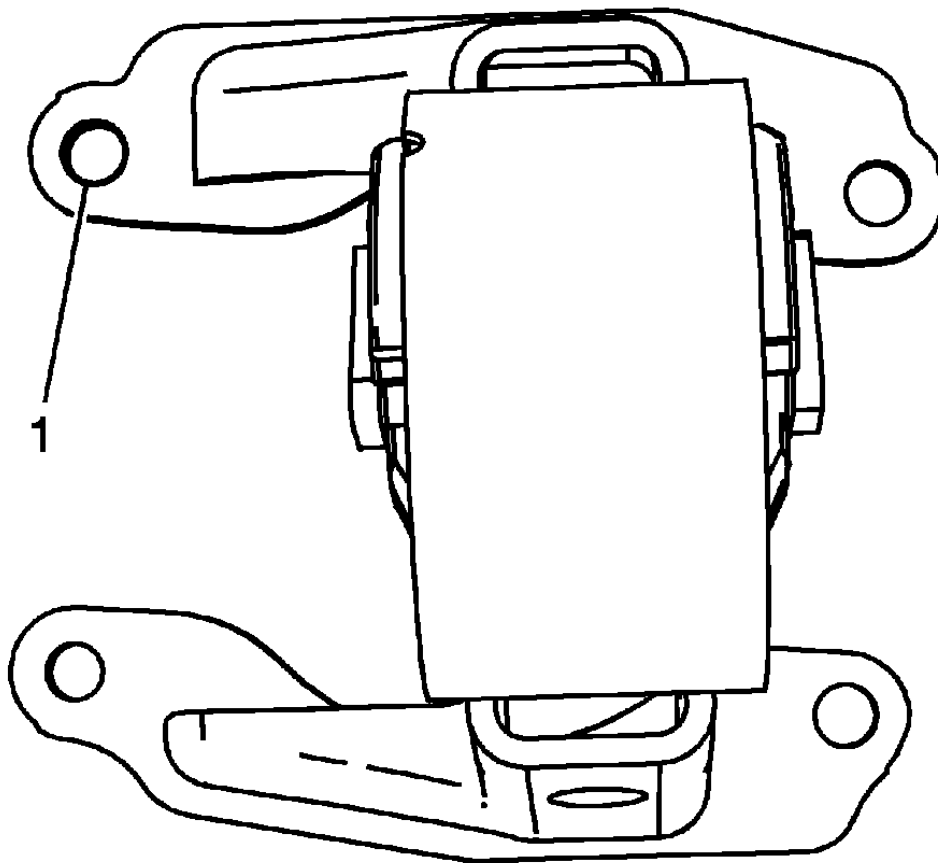


Fig. 260: Locating Installation Start Bolt - Right
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

11. To aid in the installation of the bolts, start bolt in this position (1) first. Tighten the bolts to 50 N.m (37 lb ft).



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Fig. 261: View Of Engine Mount - Left
Courtesy of GENERAL MOTORS COMPANY

12. Install the bolts securing the left engine mount to the engine block.

The engine lift devise may have to be raised or lowered slightly to install these bolts.

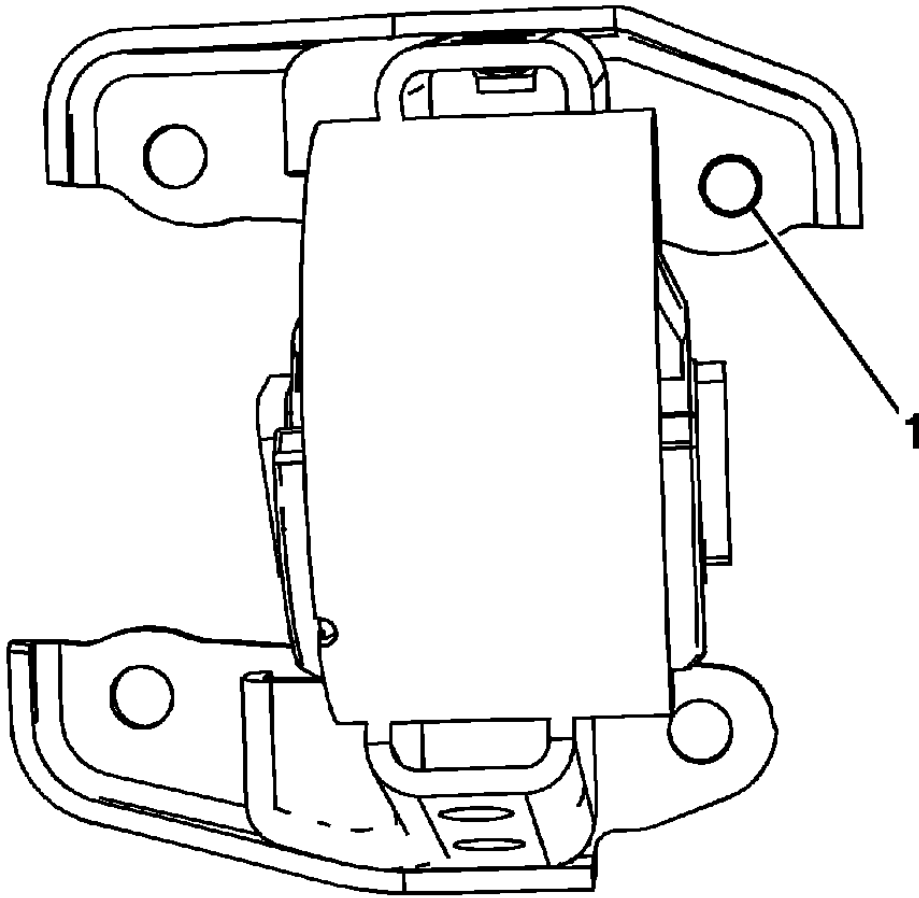


Fig. 262: Locating Installation Start Bolt - Left
Courtesy of GENERAL MOTORS COMPANY

13. To aid in the installation of the bolts, start bolt in this position (1) first. Tighten the bolts to 50 N.m (37 lb ft).
14. Lower the engine fully on to the engine mounts.
15. Remove the engine lift chain from the engine lift brackets.
16. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

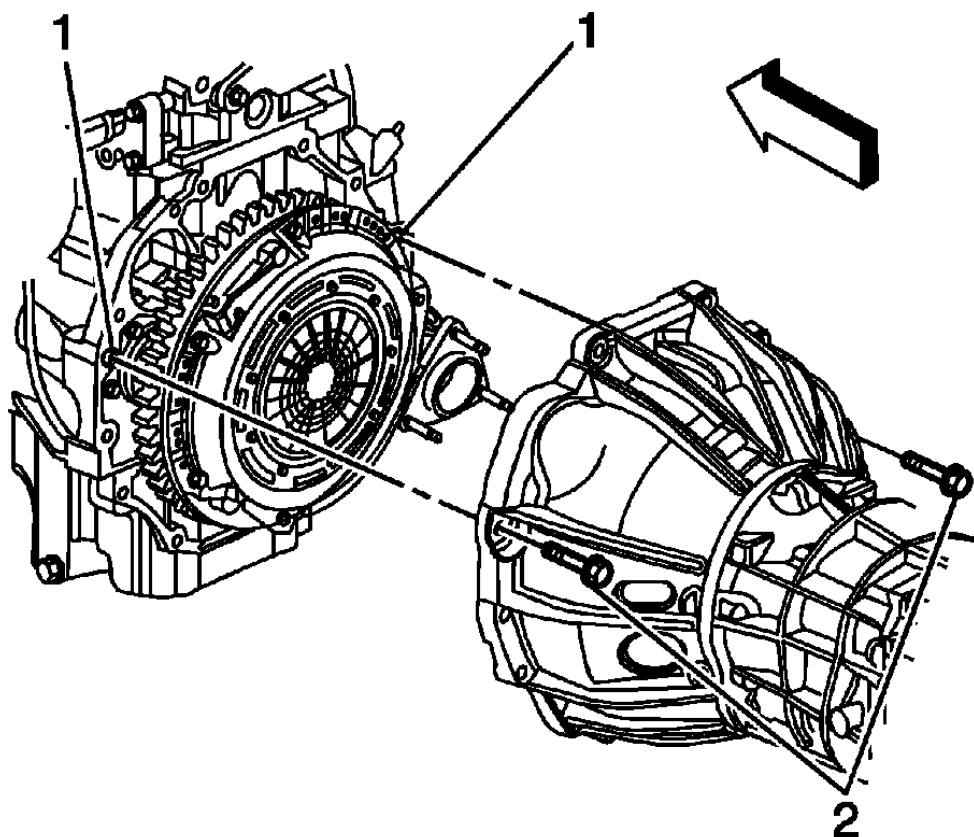


Fig. 263: View Of Transmission Mounting Bolts & Engine Dowels
Courtesy of GENERAL MOTORS COMPANY

17. Tighten the 2 transmission mounting bolts (2) previously installed. Tighten the bolts to 50 N.m (37 lb ft).

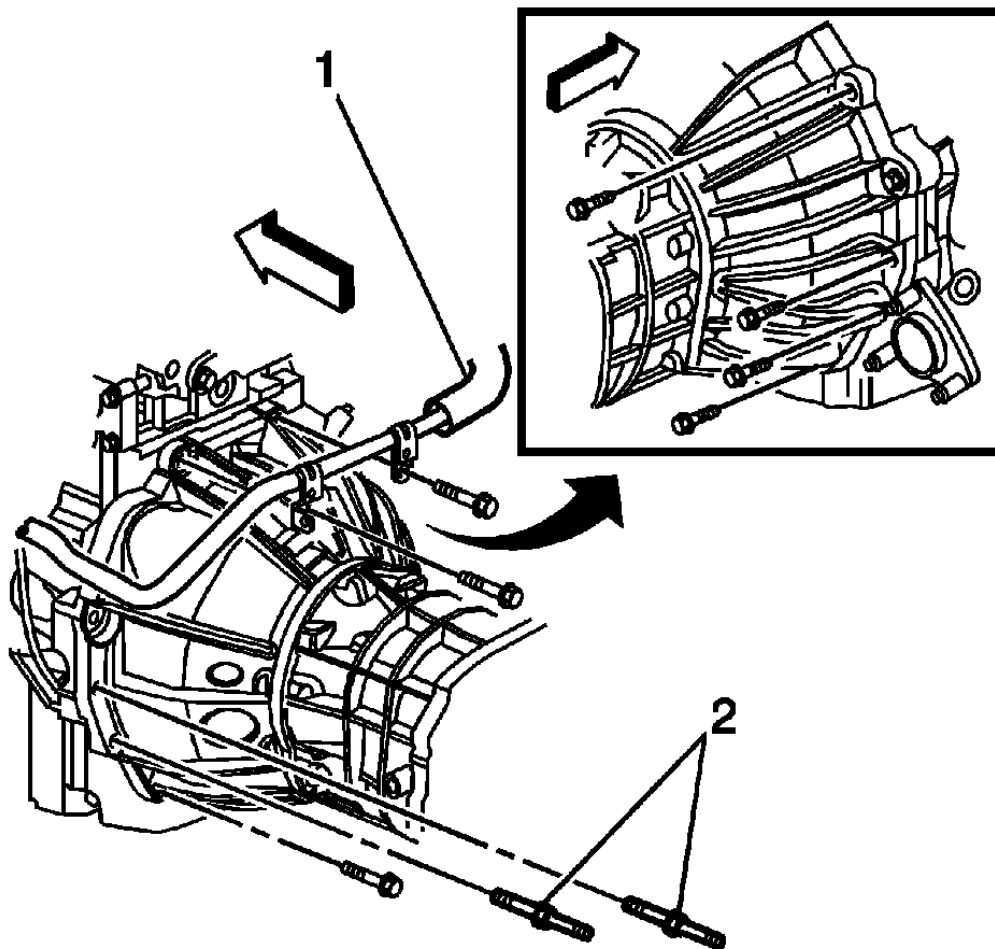


Fig. 264: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Ensure the studded mounting bolts (2) are located in the correct position.
- The heater pipe (1) must be secured with the 2 upper mounting bolts.

18. Install the remaining transmission mounting bolts and tighten to 50 N.m (37 lb ft).
19. Align the torque converter to flexplate/flywheel orientation marks made during the removal procedure (M30 only).
20. Repeat the following steps for all 3 torque converter bolts (M30 only):
 1. Rotate the harmonic balancer center bolt clockwise ONLY, in order to access the torque converter bolt holes in the flexplate/flywheel through the service slot.
 2. To aid in alignment of the torque converter to the flexplate/flywheel, install all 3 torque converter bolts before fully tightening using one of the following:
 - 18 mm crowfoot wrench
 - Short T50 TORX bit

Tighten the bolts to 60 N.m (44 lb ft).

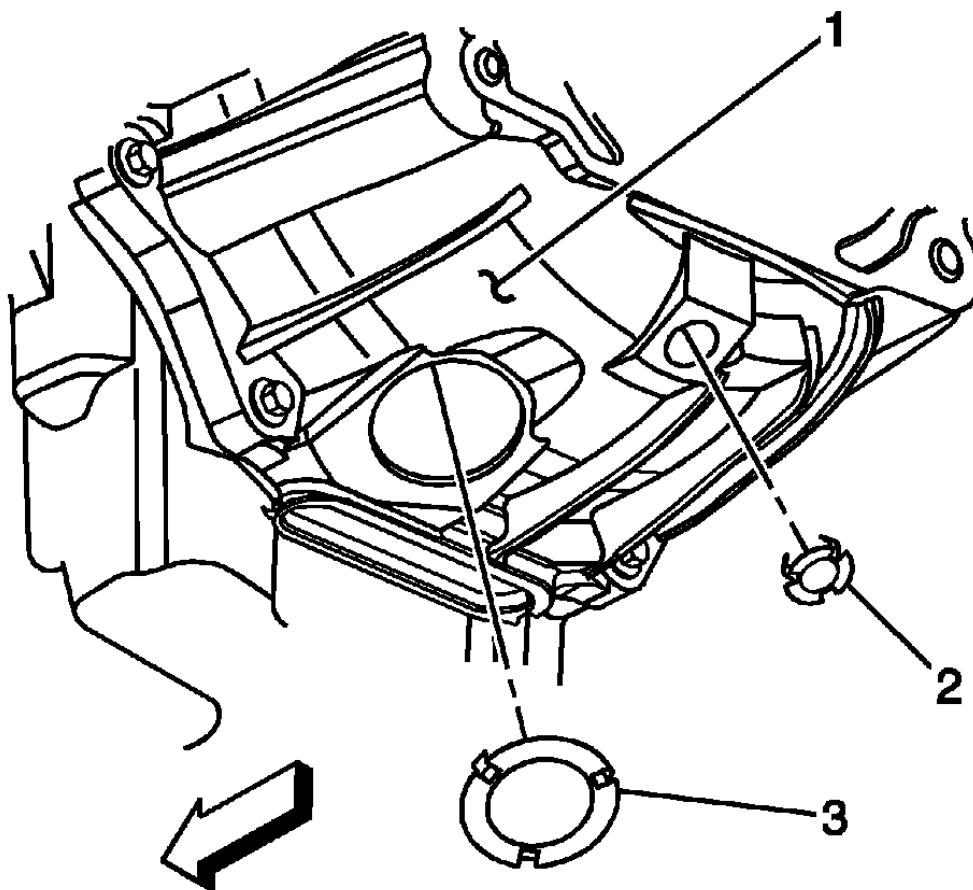


Fig. 265: View Of Inspection Plug
Courtesy of GENERAL MOTORS COMPANY

21. Install the inspection plug (3) to the transmission (1) (M30 only).



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Fig. 266: View Of Transmission Oil Cooler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

22. Install the bolt (2) securing the transmission oil cooler pipe bracket to the right side of the engine oil pan rail (M30 only).

Tighten the bolt to 20 N.m (15 lb ft).

23. Install the exhaust seal. Refer to **Exhaust Seal Replacement (LLV/LLR)** .

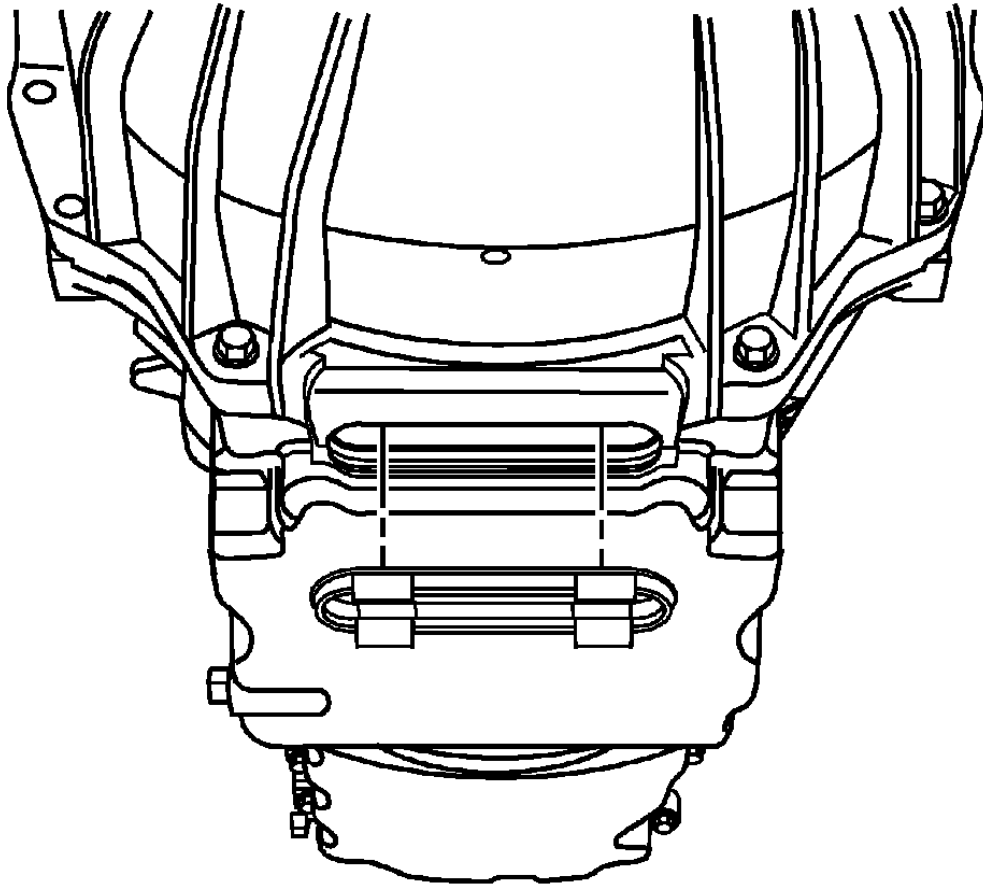


Fig. 267: View Of Service Slot Plug
Courtesy of GENERAL MOTORS COMPANY

24. Install the service slot plug.
25. Install the applicable components:
 - RWD

Install the crossmember. Refer to **Transmission Support Crossmember Replacement (4WD)** ,
Transmission Support Crossmember Replacement (2WD) .

- 4WD
 1. Position the differential carrier assembly to the frame.

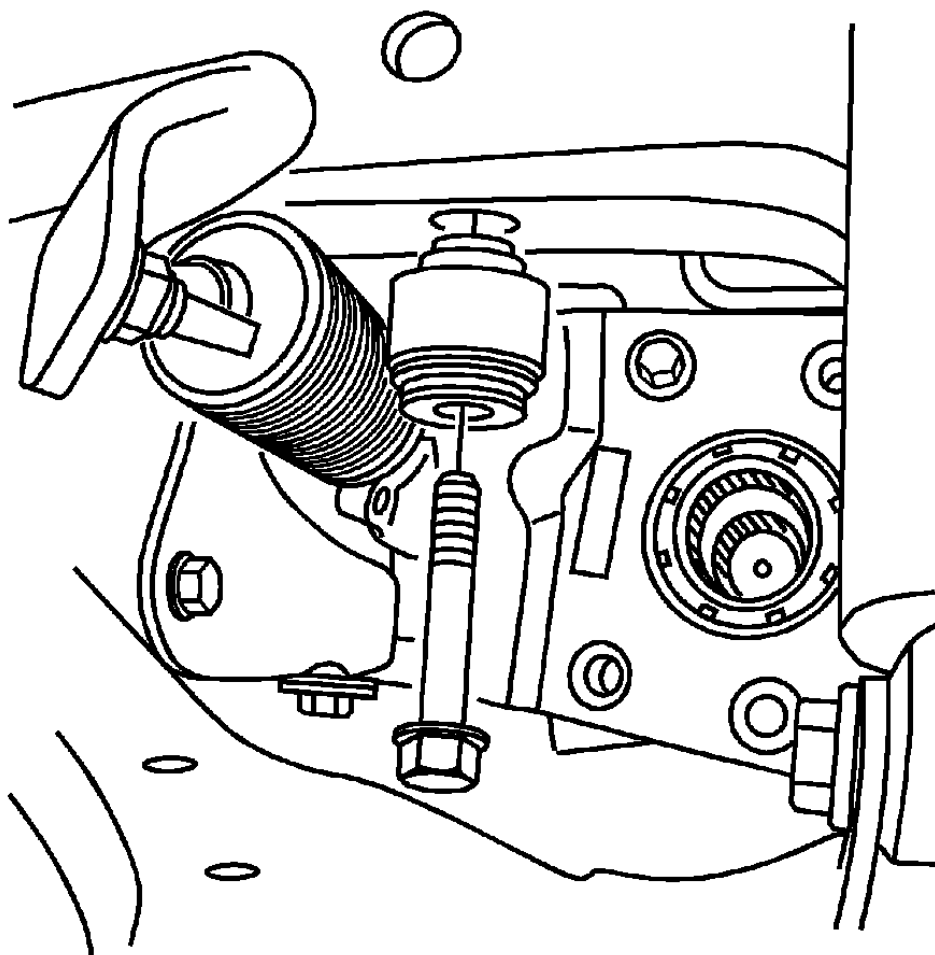


Fig. 268: View Of Mounting Bracket To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the differential carrier assembly bushing to frame bolts and tighten to 152 N.m (112 lb ft).
3. Install the front propeller shaft. Refer to **Front Propeller Shaft Replacement** .

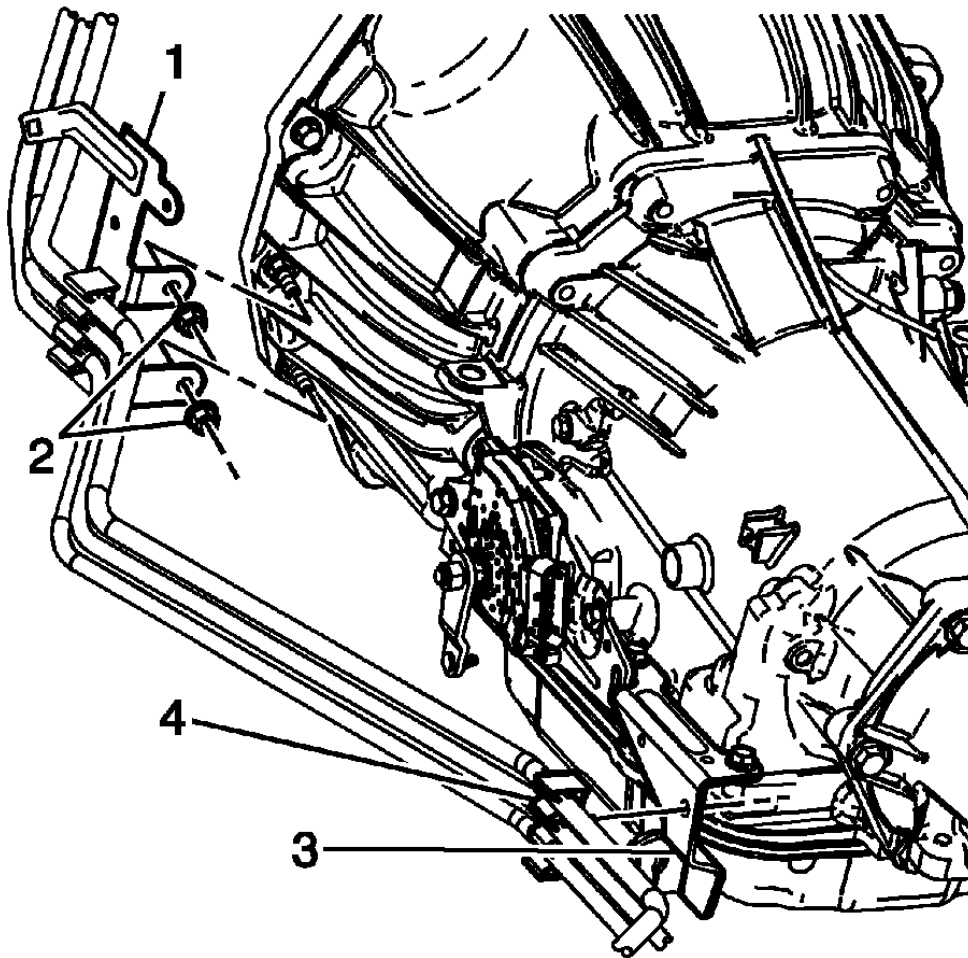


Fig. 269: View Of Fuel Hose/Pipe Bracket & Nuts (M30)

Courtesy of GENERAL MOTORS COMPANY

26. Install the nuts (2) securing the fuel hose/pipe bracket (1) to the transmission (M30 only). Tighten the nuts to 20 N.m (15 lb ft).
27. Connect the fuel hose/pipe retainer (4) to the range selector cable bracket (3) (M30 only).

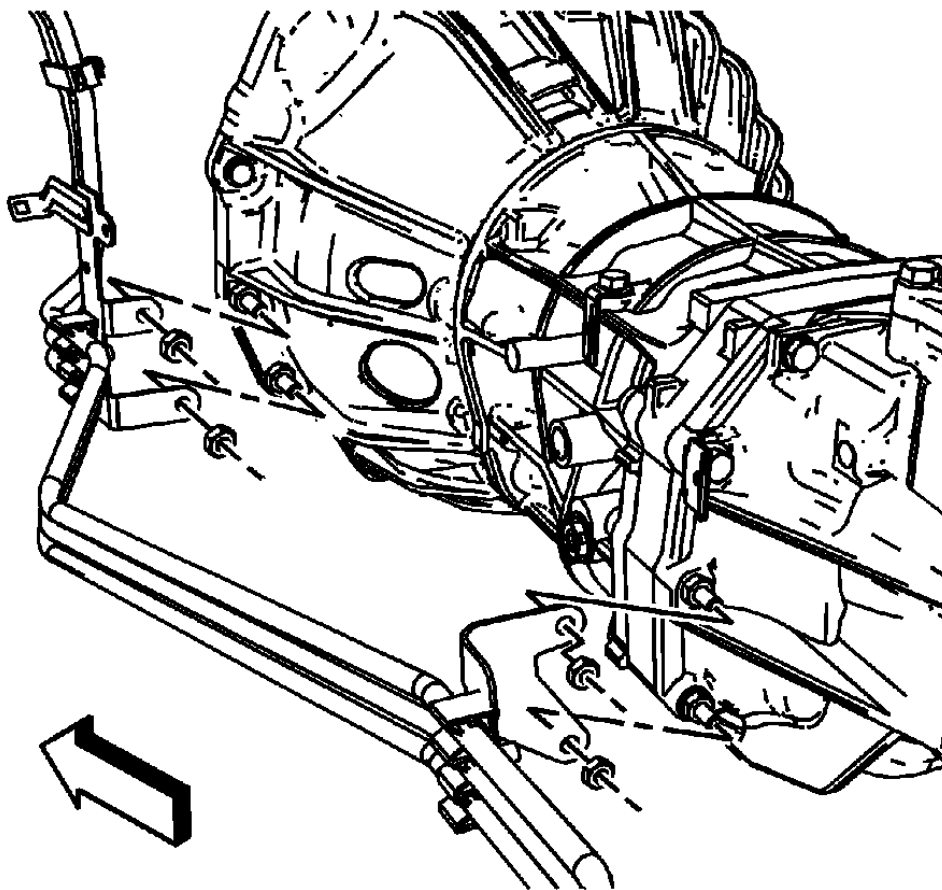


Fig. 270: View Of Fuel Hose/Pipe Bracket & Nuts (MA5)
Courtesy of GENERAL MOTORS COMPANY

28. Install the nuts securing the fuel hose/pipe brackets to the transmission (MA5 only). Tighten the nuts to 20 N.m (15 lb ft).



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Fig. 271: View Of Engine Mount - Left
Courtesy of GENERAL MOTORS COMPANY

29. Install the left engine mount-to-frame bracket bolt and tighten to 85 N.m (63 lb ft).



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Fig. 272: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

30. Connect the engine wiring harness retainers (5) to the engine oil pan rail.
31. Install the 3 bolts securing the engine wiring ground leads (2) to the engine block. Tighten the bolts to 20 N.m (15 lb ft).
32. Lower the vehicle to chest level in order to access the components through the wheelhouse.
33. Connect the engine wiring harness connector (3) to the CKP sensor (1).



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Fig. 273: View Of Heater Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

34. Install the heater outlet hose/pipe to the thermostat housing and install the retainer using **J 38185** hose clamp pliers.
35. Install the bolt (5) securing the heater outlet hose/pipe to the left engine mount (4) and tighten to 9 N.m (80 lb in).



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Fig. 274: View Of #1 Knock Sensor & Engine Oil Pan Rail Engine Wiring Harness Connectors
Courtesy of GENERAL MOTORS COMPANY

36. Connect the engine wiring harness retainer (4) to the engine oil pan rail.
37. Connect the engine wiring harness connector to the knock sensor 1 (2).



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Fig. 275: View Of KS Engine Wiring Harness Connector
Courtesy of GENERAL MOTORS COMPANY

38. Connect the engine wiring harness connector (3) to the knock sensor 2 (1).
39. Connect the coolant heater cord to the coolant heater, if equipped.

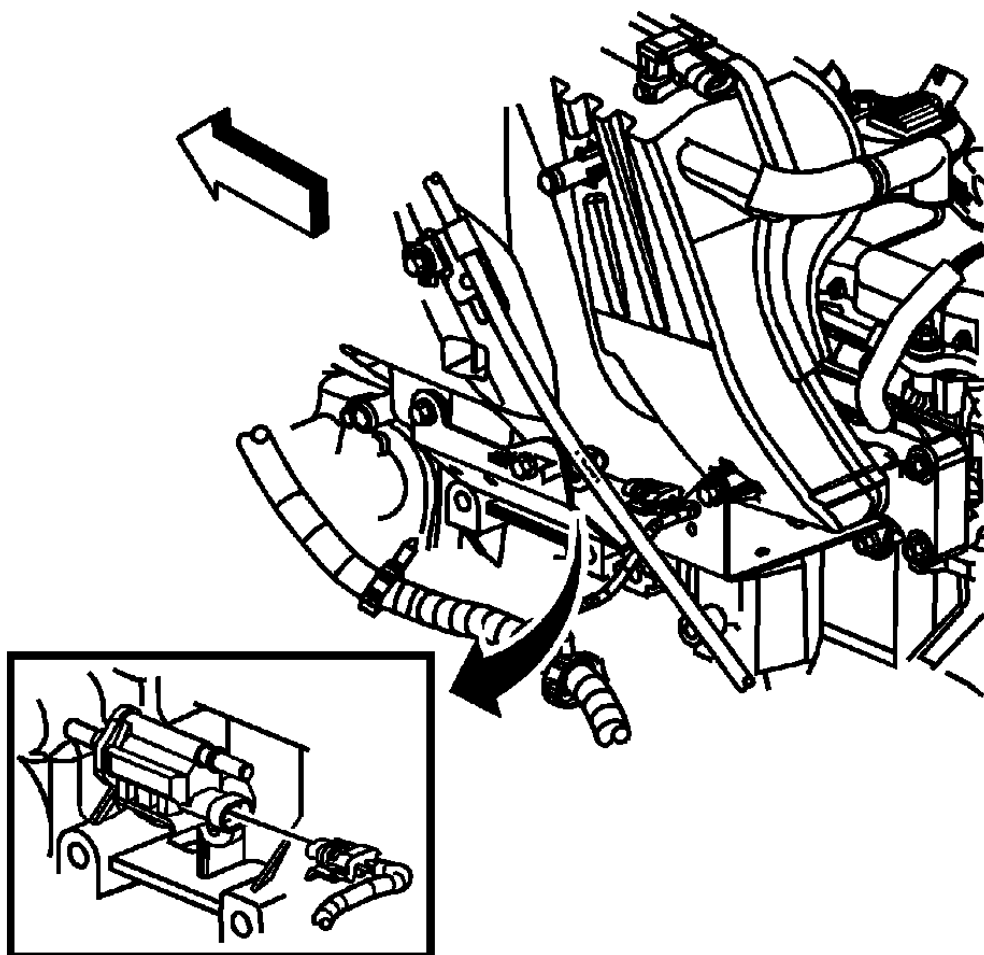


Fig. 276: View Of EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

40. Connect the engine wiring harness connector to the EVAP canister purge solenoid valve.



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Fig. 277: Locating Negative Battery Cable
Courtesy of GENERAL MOTORS COMPANY

41. Install the bolt (4) securing the battery negative cable (5) to the engine block (1). Tighten the bolt to 35 N.m (26 lb ft).

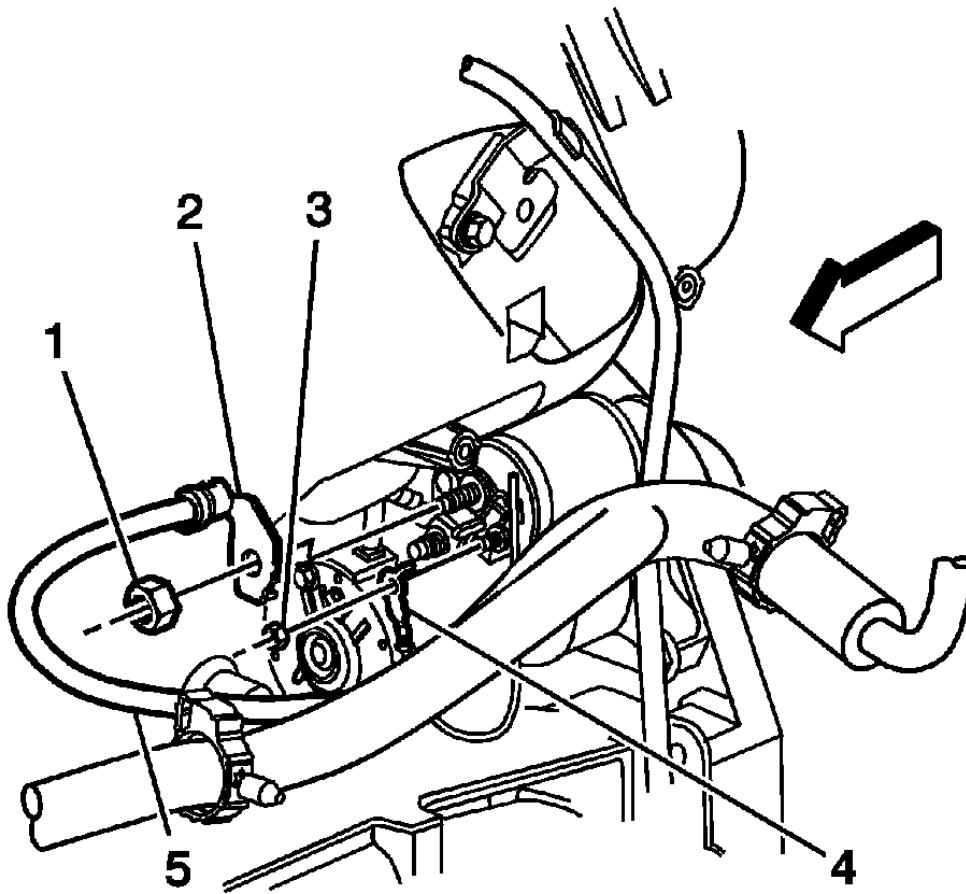


Fig. 278: Locating Positive Battery Cable
Courtesy of GENERAL MOTORS COMPANY

42. Connect the battery positive cable (2) to the starter and install the starter terminal nut (1) and tighten to 9 N.m (80 lb in).
43. Connect the lead (4) to the starter solenoid and install the starter solenoid "S" terminal nut (3) and tighten to 3.5 N.m (31 lb in).



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Fig. 279: View Of Wiring Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

44. Secure the following wiring harness retainers to the engine wiring harness bracket:
 - The battery cable
 - The engine wiring harness (4, 6)
 - The MAP sensor (5)
45. Lower the vehicle.

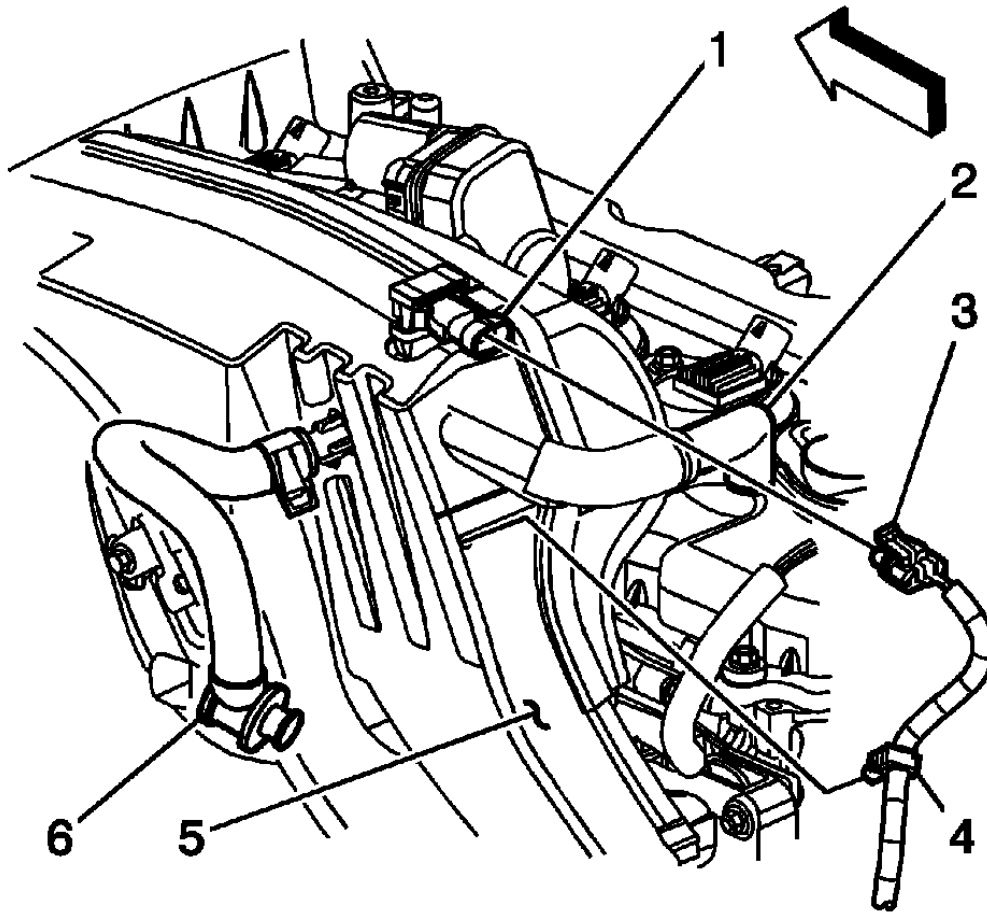


Fig. 280: Identifying Intake Manifold External Components
 Courtesy of GENERAL MOTORS COMPANY

46. Connect the MAP sensor wiring harness retainer (4) to the intake manifold (5).
47. Connect the brake booster hose (6) to the brake booster.
48. Install the oil level indicator and tube. Refer to **Oil Level Indicator Tube Replacement**.
49. Connect the EVAP pipe at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service**.
50. Connect the fuel feed pipe to the fuel rail. Refer to **Plastic Collar Quick Connect Fitting Service**.

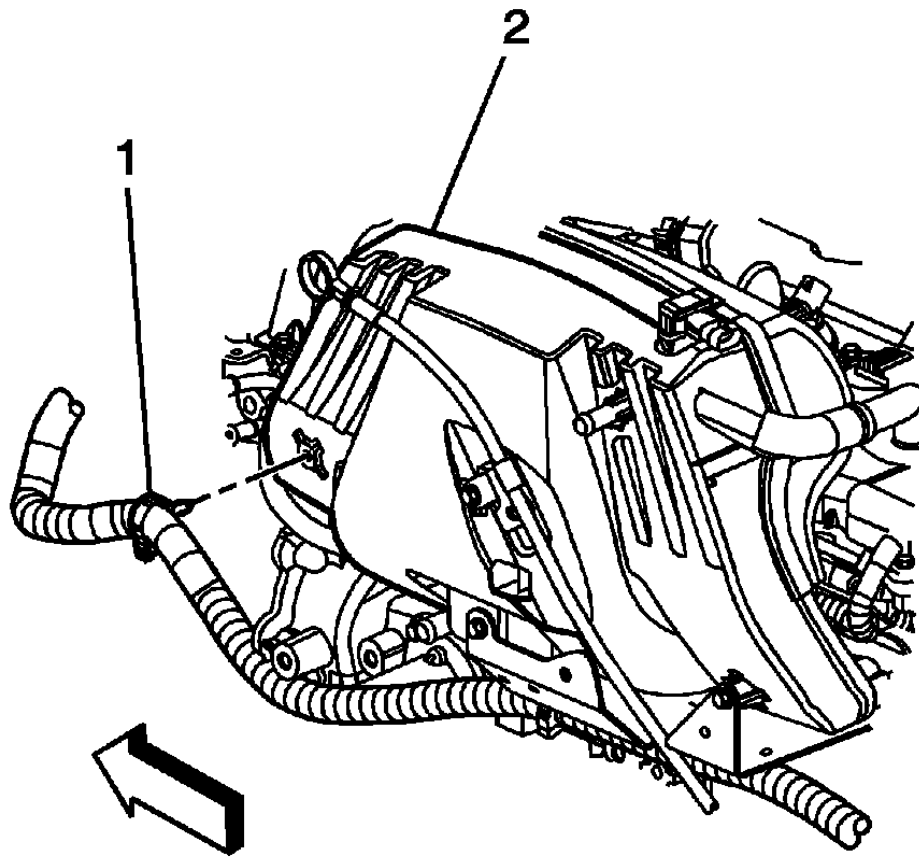


Fig. 281: View Of Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

51. Connect the engine wiring harness retainer (1) to the intake manifold (2).



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Fig. 282: View Of Engine Mount - Right
Courtesy of GENERAL MOTORS COMPANY

52. Install the right engine mount-to-frame bracket bolt and tighten to 85 N.m (63 lb ft).

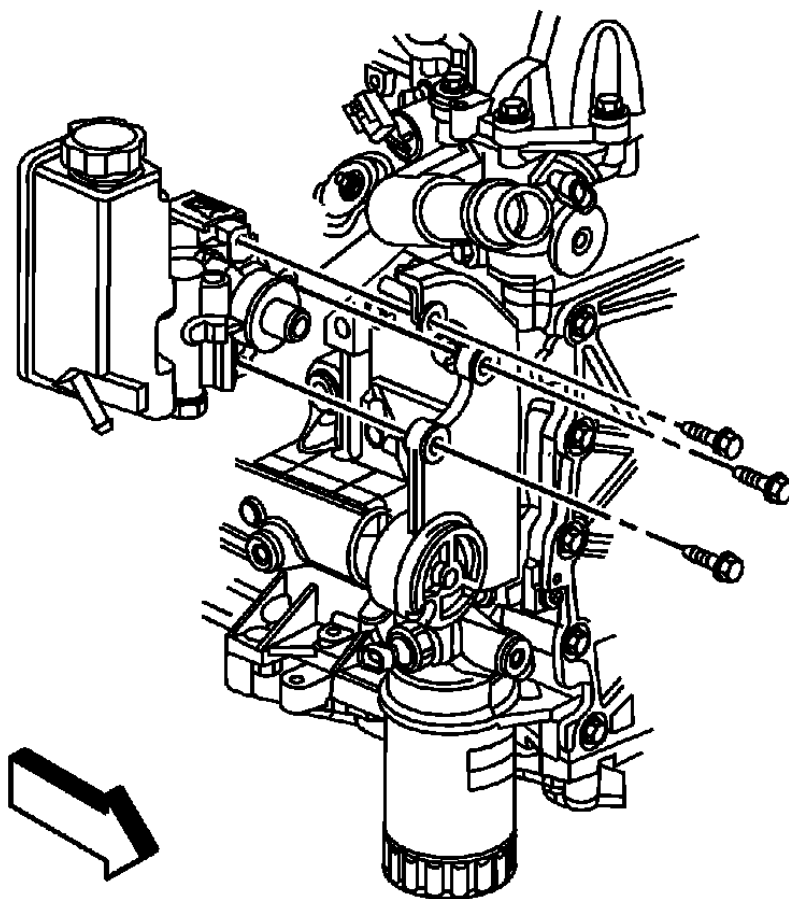


Fig. 283: View Of Power Steering Pump & Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

53. Position the power steering pump to the power steering pump bracket.
54. Install the power steering pump mounting bolts and tighten to 25 N.m (18 lb ft).



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Fig. 284: View Of Inlet Heater Hose Quick Connect
Courtesy of GENERAL MOTORS COMPANY

55. Connect the inlet heater hose quick connect (1) to the heater core (2).



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Fig. 285: Engine Lift Bracket

Courtesy of GENERAL MOTORS COMPANY

56. Remove the **J 44220** engine lift bracket from the cylinder head.



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Fig. 286: View Of A.I.R. Injection Pipe Cover
Courtesy of GENERAL MOTORS COMPANY

57. Position the AIR pipe cover and NEW gasket to the cylinder head.
58. Install the AIR pipe cover studs and tighten to 25 N.m (18 lb ft).
59. Install the transmission filler tube (M30 only). Refer to **Transmission Fluid Filler Tube and Seal Replacement (2.9L, 3.7L)** .

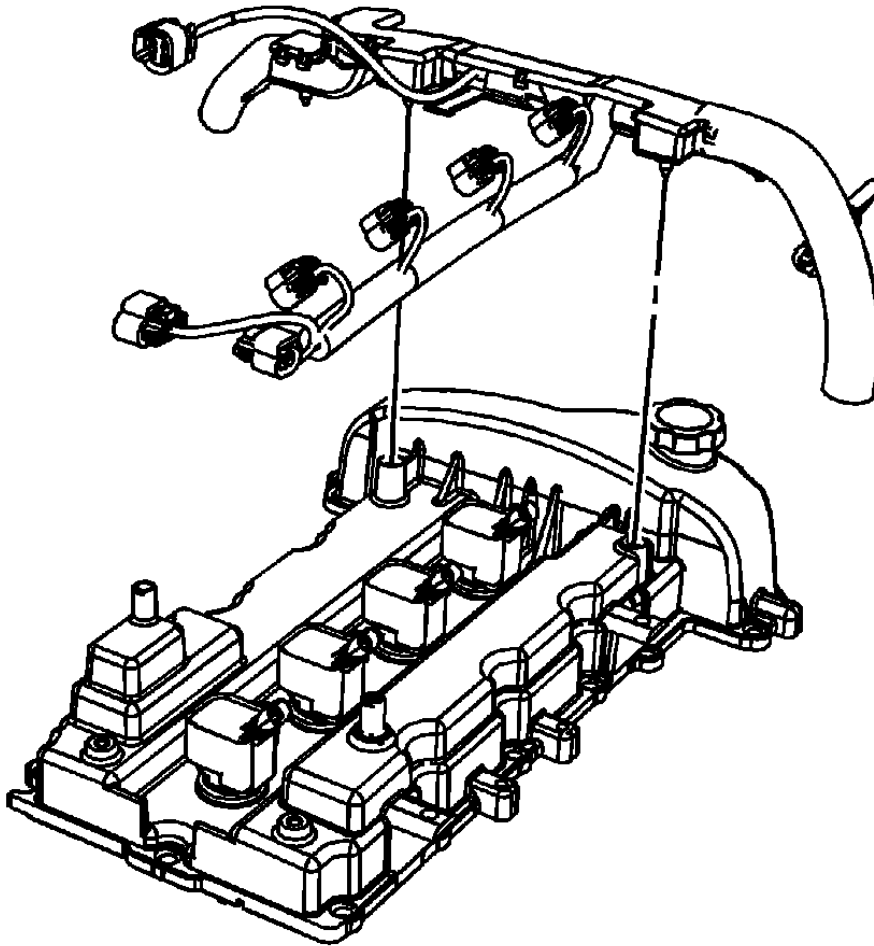


Fig. 287: View Of Engine Wiring Harness Connections
Courtesy of GENERAL MOTORS COMPANY

60. Engage the engine wiring harness conduit to the camshaft cover.



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Fig. 288: View Of Intake CMP Sensor
Courtesy of GENERAL MOTORS COMPANY

61. Connect the engine wiring harness connector to the intake CMP sensor.

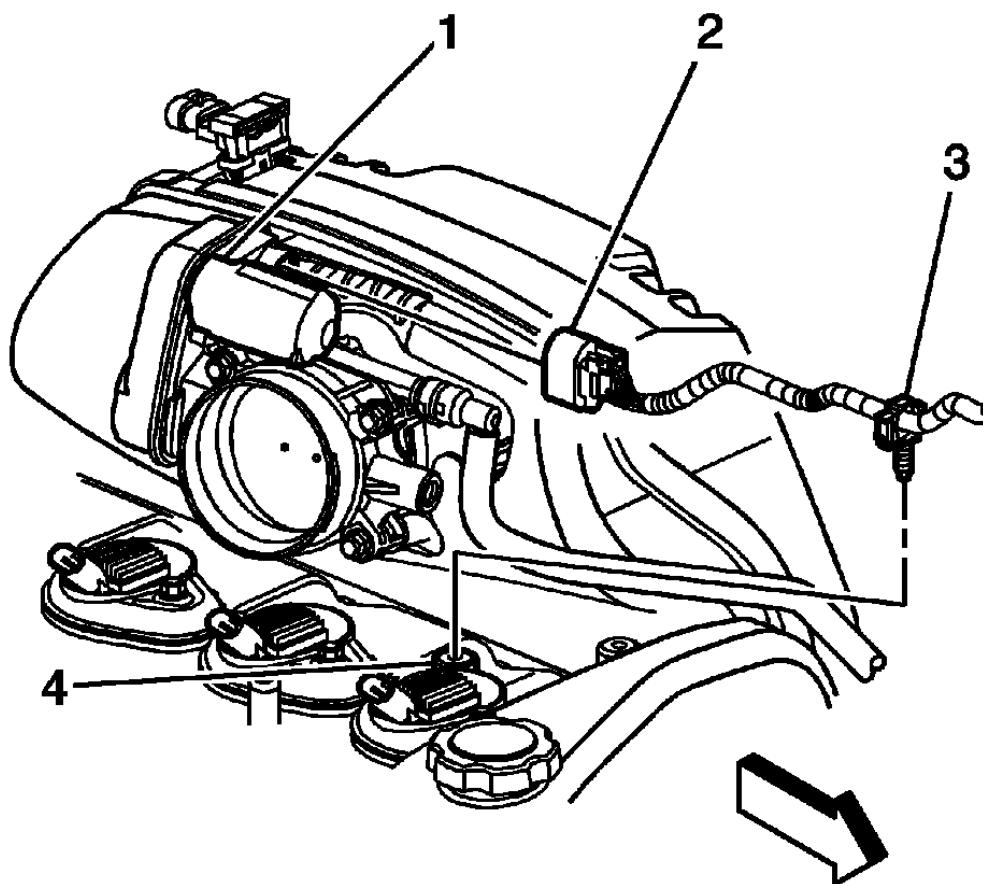


Fig. 289: View Of Throttle Body Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

- 62. Connect the engine wiring harness retainer (3) to the camshaft cover (4).
- 63. Connect the engine wiring harness connector (2) to the throttle body (1).

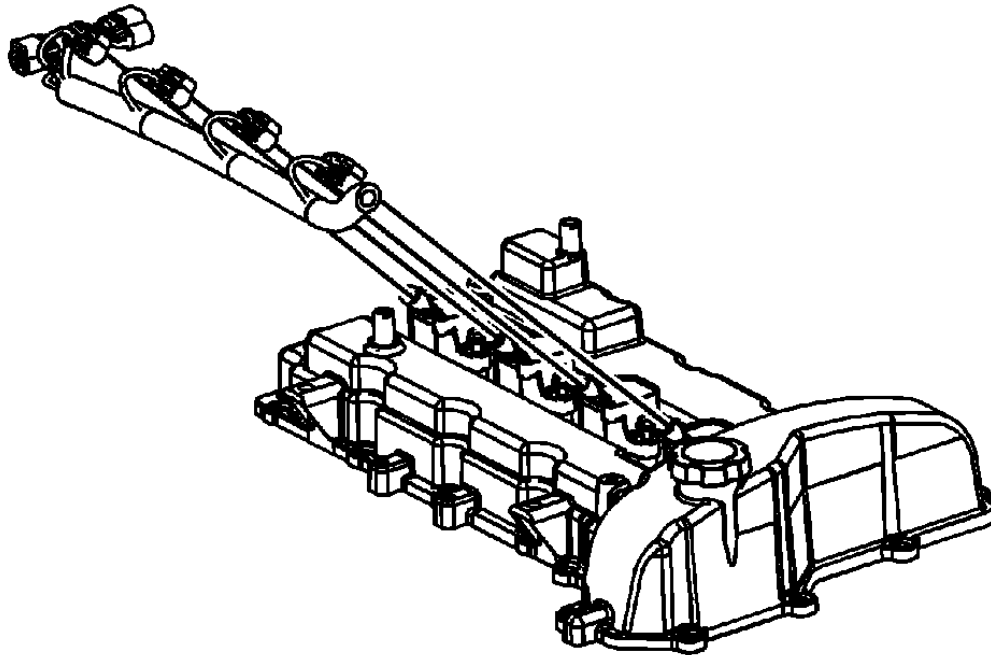


Fig. 290: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

64. Connect the engine wiring harness electrical connectors to the ignition coils.



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Fig. 291: View Of Engine Fuel Injector. Oxygen Sensor And ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

65. Connect the following electrical connectors to the camshaft cover:

- The fuel injector harness (1)
- The HO2S (2)
- The ECT sensor (3)



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Fig. 292: View Of CMP Sensor Connector, Exhaust Camshaft Actuator Connector & Engine Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

66. Connect the engine wiring harness retainer (2) to the camshaft cover (3).
67. Connect the engine wiring harness connectors to the following components:
 - The exhaust CMP sensor (5)
 - The exhaust camshaft actuator (6)

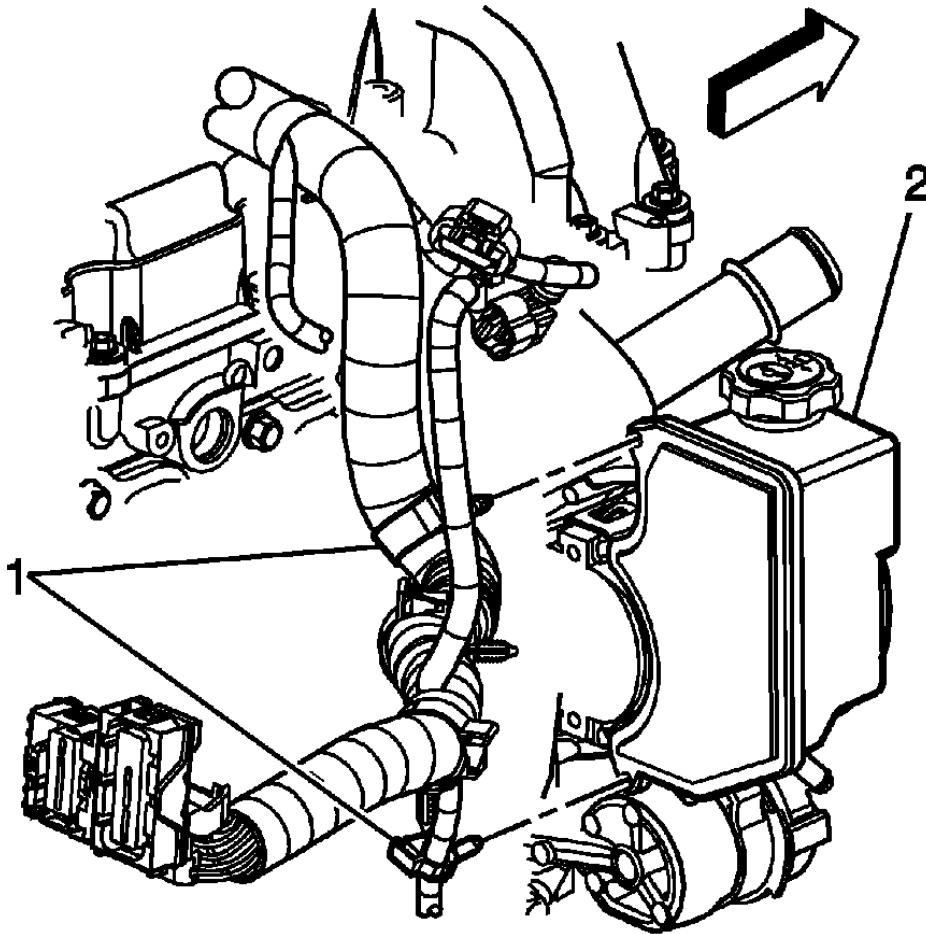


Fig. 293: View Of Power Steering Pump & Engine Wiring Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

68. Connect the engine wiring harness retainers (1) to the power steering pump (2).
69. Connect the engine wiring harness connectors to the following components:
 - The electric motor actuator connector (4WD only)
 - The oil pressure switch

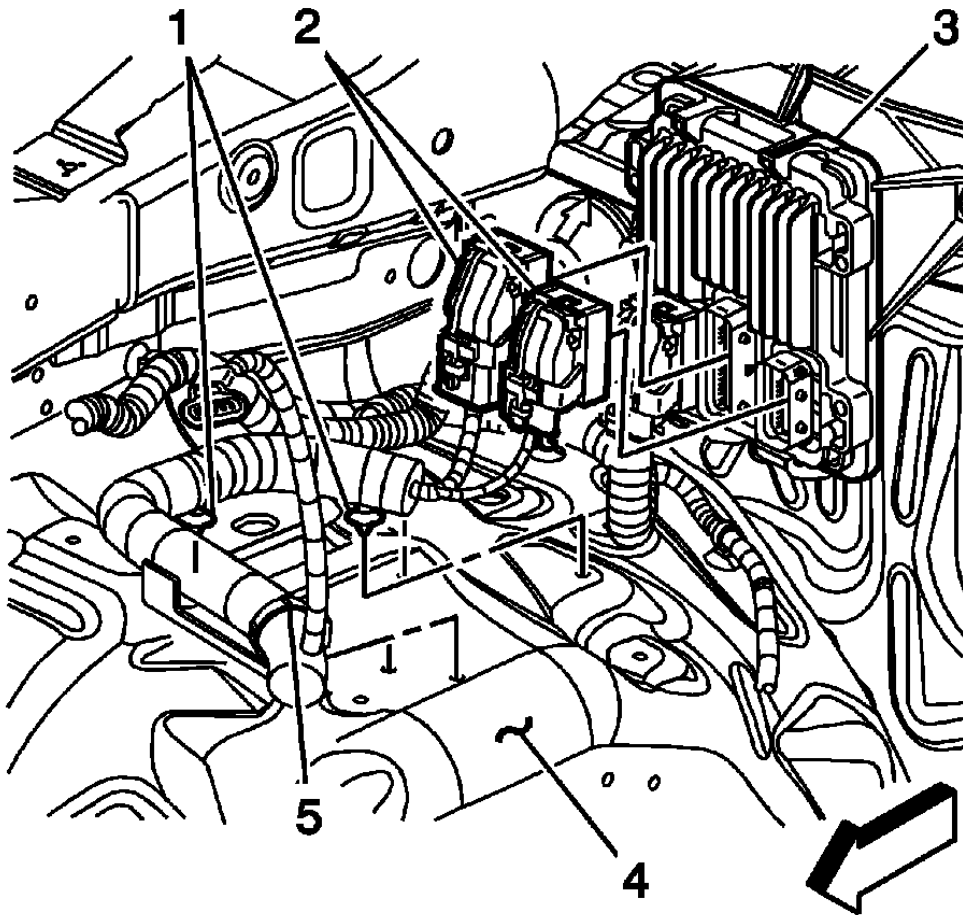


Fig. 294: View Of Engine Wiring Harness & Retainers
 Courtesy of GENERAL MOTORS COMPANY

70. Connect the engine wiring harness retainers (1) to the wheelhouse (4).
71. Close the engine wiring harness retainer (5).
72. Connect the 2 engine wiring harness connectors (2) to the PCM (3).
73. Install the washer solvent container/coolant recovery reservoir mounting bolts. Refer to **Windshield Washer Solvent Container Replacement**.



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Fig. 295: View Of Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

74. Install the inlet radiator hose (2) to the thermostat housing (4) using **J 38185** hose clamp pliers.
75. Remove the engine lift bracket. Refer to **Engine Lift Bracket Replacement**.
76. Install the generator. Refer to **Generator Replacement (LLV/LLR)** .
77. Install the A/C compressor.
78. Install the air cleaner resonator and outlet duct. Refer to **Air Cleaner Resonator and Outlet Duct Replacement** .
79. Install the cooling fan. Refer to **Fan Replacement (LLV, LLR)** .
80. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** , **Cooling System Draining and Filling (Vac N Fill)** .
81. Install the left inner wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
82. Install the battery box. Refer to **Battery Box Replacement** .

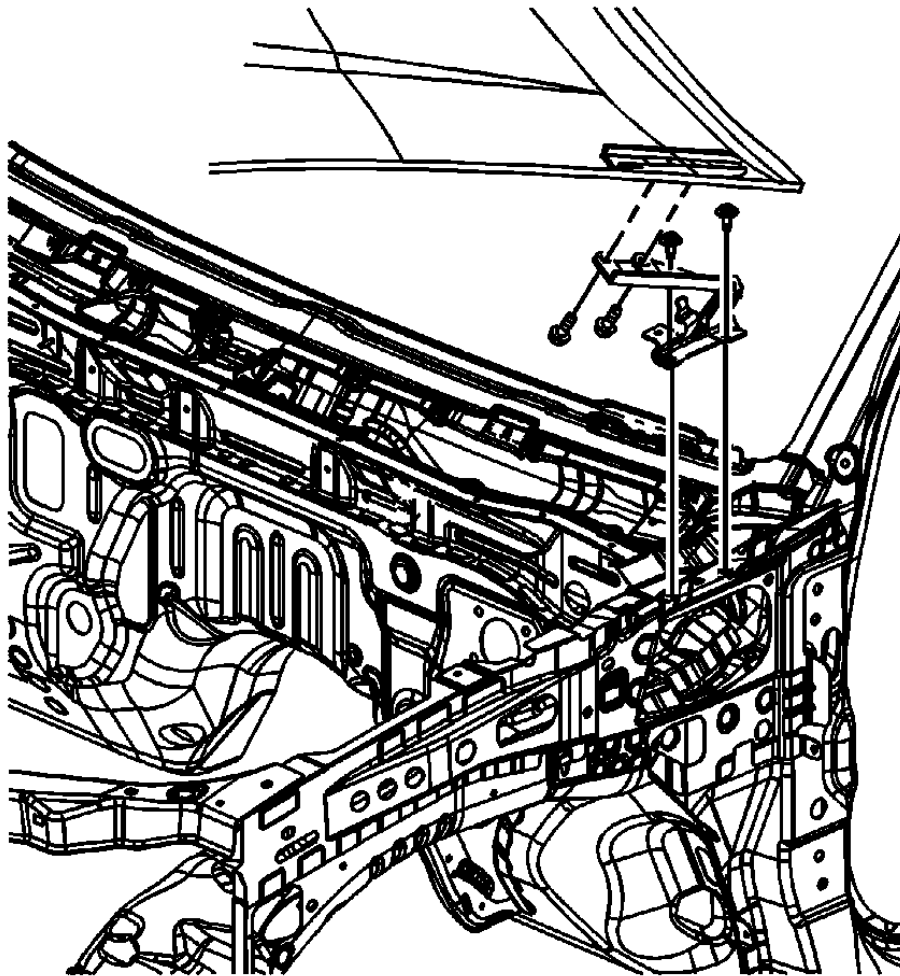


Fig. 296: View Of Hood Hinges

Courtesy of GENERAL MOTORS COMPANY

83. Install the hood. Refer to **Hood Replacement** .
84. Fill the engine oil, if previously drained. Refer to **Engine Oil and Oil Filter Replacement**.

Engine Final Test and Inspection

Complete the following procedure after the engine is installed in the vehicle:

1. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any parts are binding.
2. Start the engine and listen for abnormal conditions.
3. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
4. Run the engine at approximately 1000 RPM until the engine reaches normal operating temperature.
5. While the engine continues to idle raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
6. Inspect for oil, coolant, transmission fluid, and exhaust leaks while the engine is idling.

7. Lower the vehicle.
8. Perform the crankshaft (CKP) variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .
9. Perform a final inspection for the proper engine oil, transmission fluid and coolant levels.
10. Road test the vehicle.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

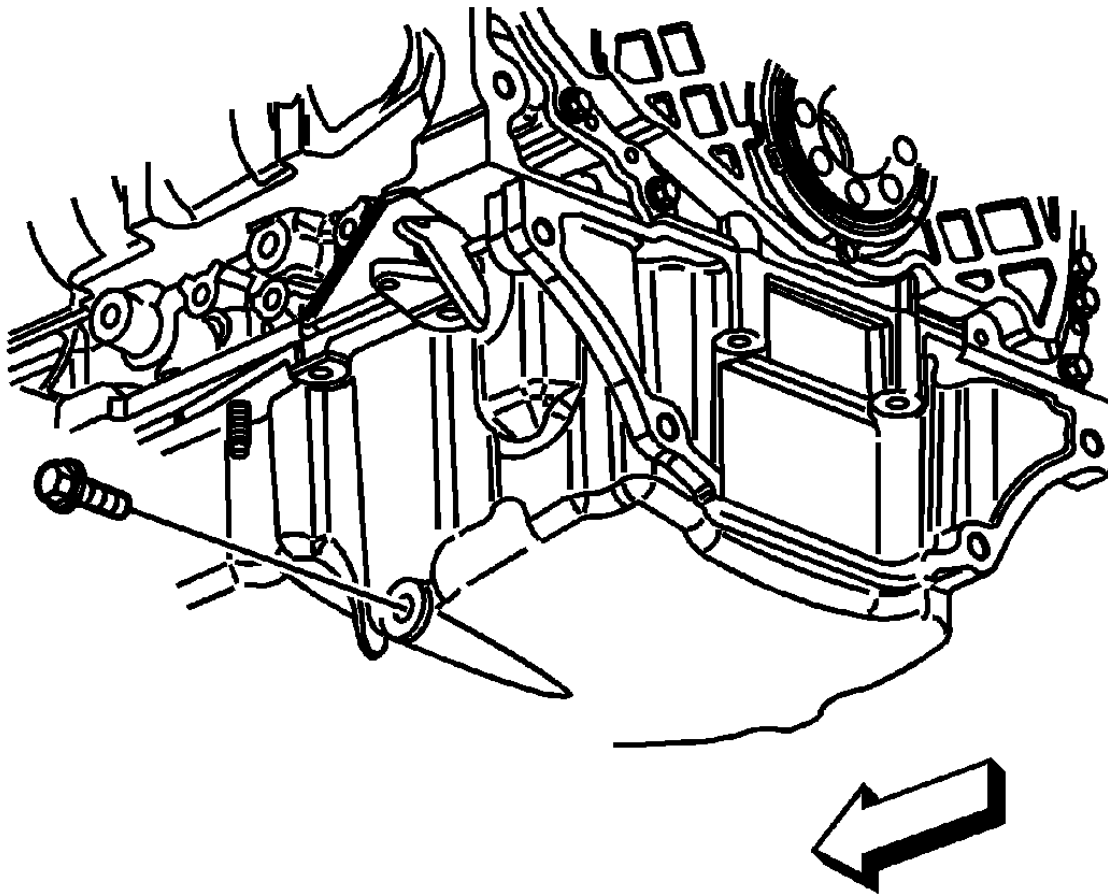


Fig. 297: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil fill cap.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Clean any dirt and/or debris away from the oil pan drain plug area.

4. Position a suitable drain pan under the oil pan drain plug.
5. Remove the oil pan drain plug.
6. Allow the oil to drain completely.
7. Clean and inspect the oil pan drain plug, replace if necessary.
8. Clean and inspect the oil pan drain plug sealing surface, replace the oil pan if necessary.
9. Wipe any remaining oil from the drain plug hole and reinstall the oil pan drain plug until snug.
10. Position the container under the engine oil filter drain deflector.

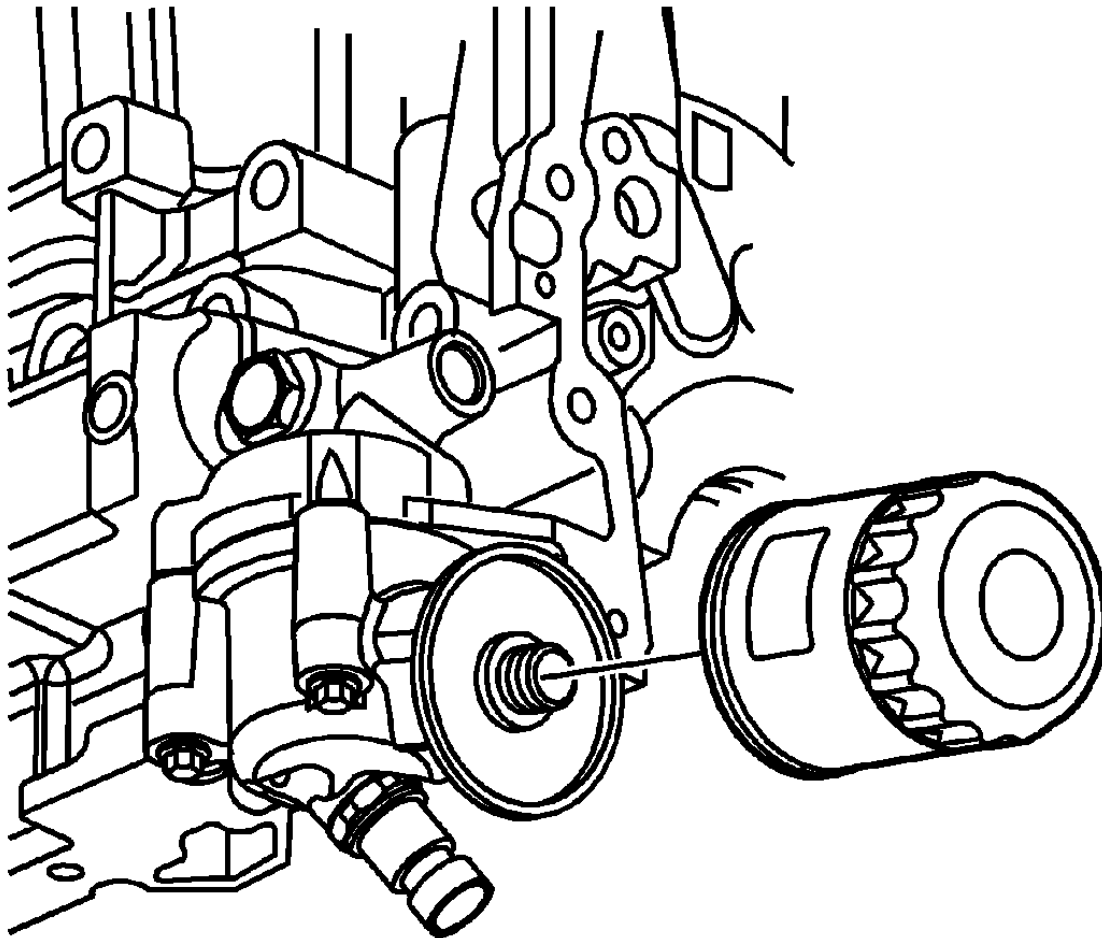
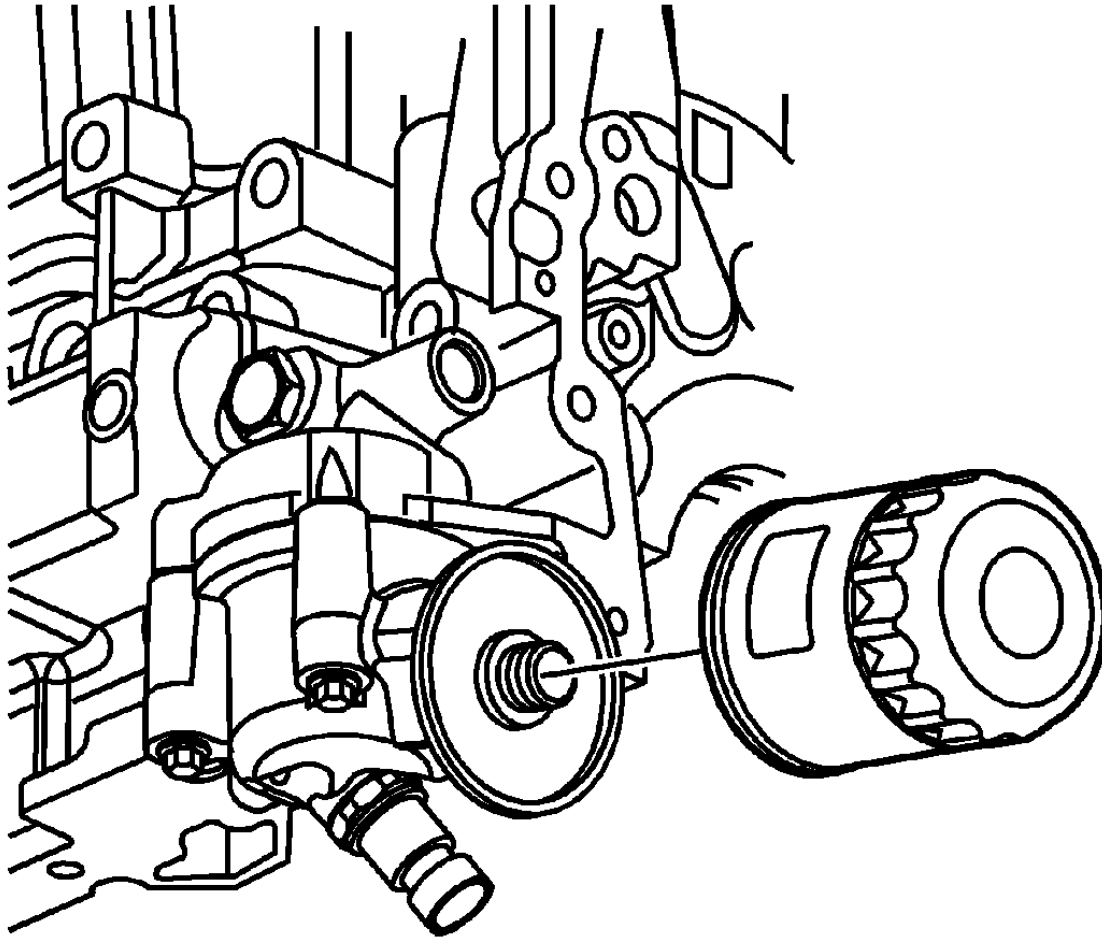


Fig. 298: View Of Oil Filter

Courtesy of GENERAL MOTORS COMPANY

11. Position a suitable drain pan under the oil filter.
12. Remove the oil filter.
13. Ensure that the oil filter gasket is still on the old oil filter, if not remove the oil filter gasket from the adapter.

Installation Procedure**Fig. 299: View Of Oil Filter****Courtesy of GENERAL MOTORS COMPANY**

1. Apply clean engine oil to the NEW oil filter gasket.

CAUTION: Refer to Component Fastener Tightening Caution .

2. Install the NEW oil filter and tighten to 10 N.m (89 lb in), plus an additional 150 degrees.
3. Wipe any excess oil from the oil filter drain deflector.



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Fig. 300: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS COMPANY

4. Tighten the oil pan drain plug and tighten to 26 N.m (19 lb ft).
5. Remove the oil drain pan from under the vehicle.
6. Lower the vehicle.
7. Fill the engine with new engine oil. Refer to **Fluid and Lubricant Recommendations** , and **Approximate Fluid Capacities** .
8. Start the engine.
9. Inspect for oil leaks after engine start up.
10. Turn off the engine and allow the oil a few minutes to drain back into the oil pan.
11. Remove the oil level indicator from the oil indicator tube.
12. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
13. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.

14. Again, remove the oil level indicator from the oil level indicator tube keeping the tip of the oil level indicator down.
15. Check the level of the engine oil on the oil level indicator.
16. If necessary, adjust the oil level by adding or draining oil.
17. Check for oil leaks.
18. Install the oil fill cap.