

2011 ENGINE

Engine Mechanical - 2.4L - Repair Instructions - On Vehicle - Regal

INTAKE MANIFOLD COVER REPLACEMENT

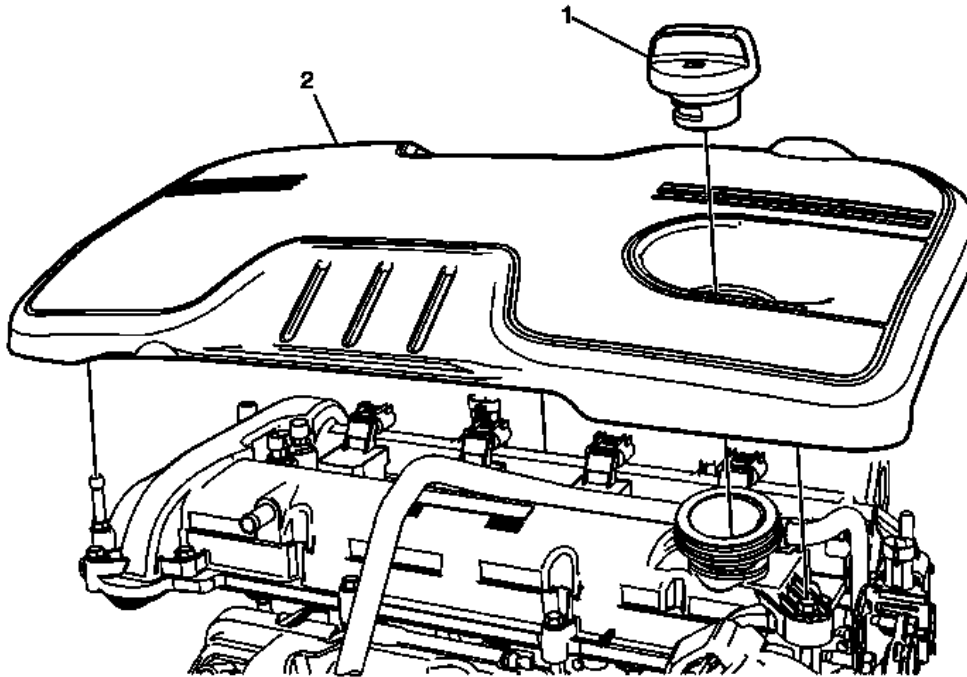
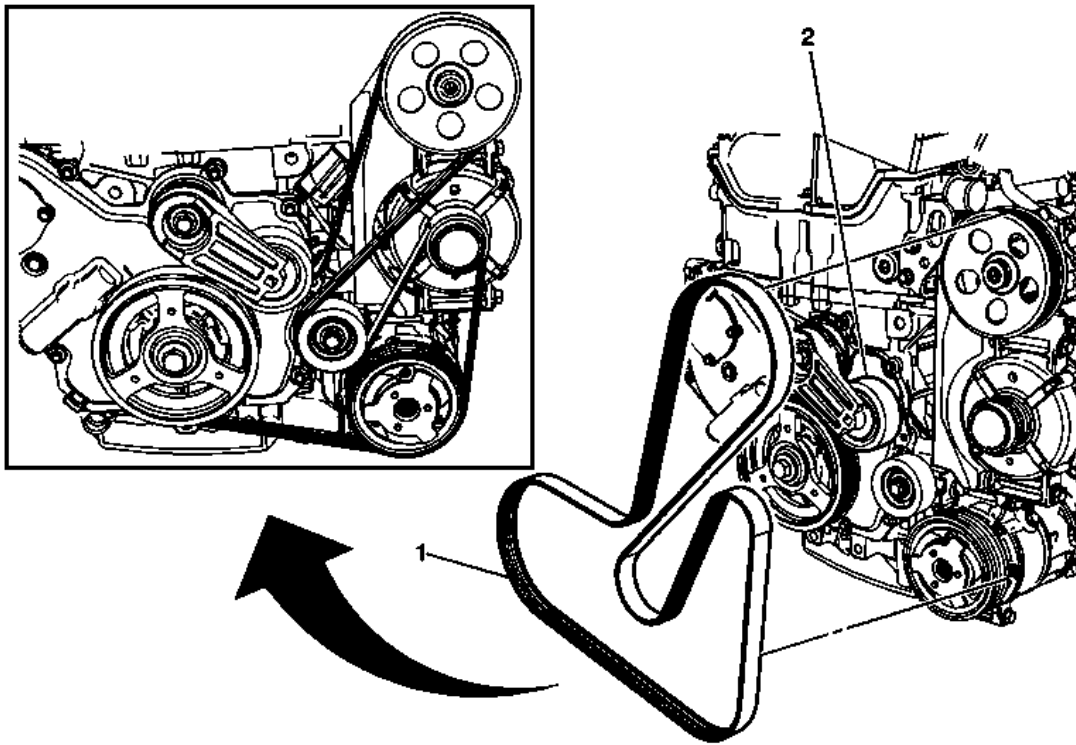


Fig. 1: Intake Manifold Cover
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Oil Cap Procedure: Remove oil cap to remove intake manifold cover.
2	Intake Manifold Cover Procedure: Transfer components as necessary.

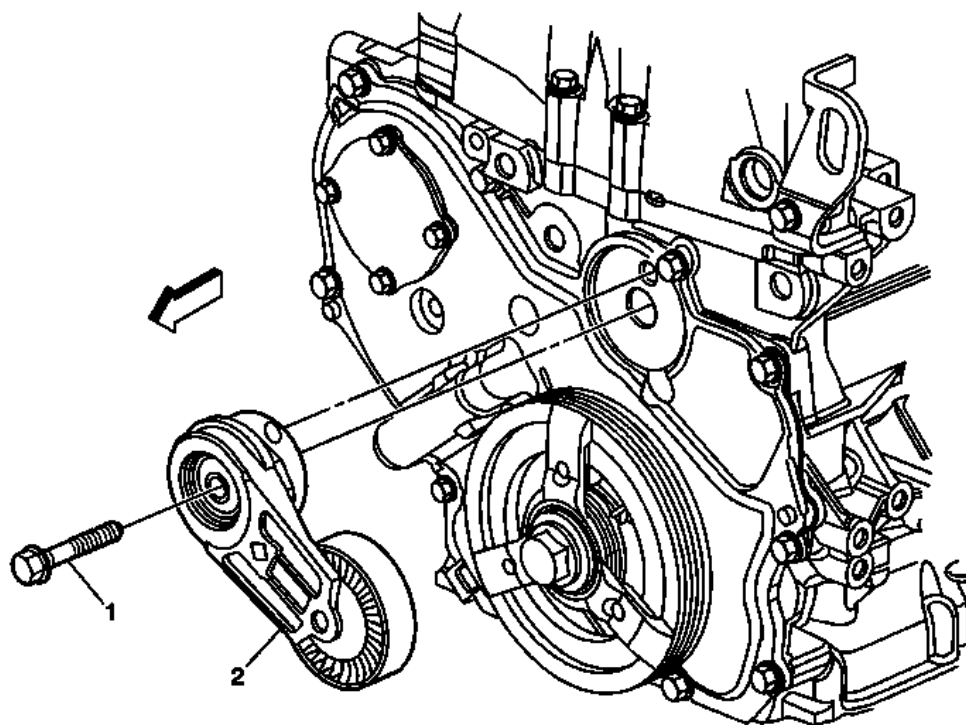
DRIVE BELT REPLACEMENT

**Fig. 2: Drive Belt Routing**

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove the Engine Mount. Refer to <u>Engine Mount Replacement</u>	
1	Drive Belt Procedure 1. Use the proper tool to rotate the drive belt tensioner. 2. Remove the drive belt from the pulleys and tensioner.
2	Drive Belt Tensioner Procedure 1. Clean and inspect the drive belt surfaces of all the pulleys. 2. Inspect the drive belt for correct alignment.

DRIVE BELT TENSIONER REPLACEMENT

**Fig. 3: Drive Belt Tensioner**

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedures 1. Remove the engine mount bracket. Refer to <u>Engine Mount Bracket Replacement</u>. 2. Remove the drive belt. Refer to <u>Drive Belt Replacement</u>.	
1	Drive Belt Tensioner Fastener CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 45 N.m (33 lb ft)
2	Drive Belt Tensioner Procedure: Transfer components as necessary.

ENGINE OIL PRESSURE SWITCH REPLACEMENT

REMOVAL PROCEDURE

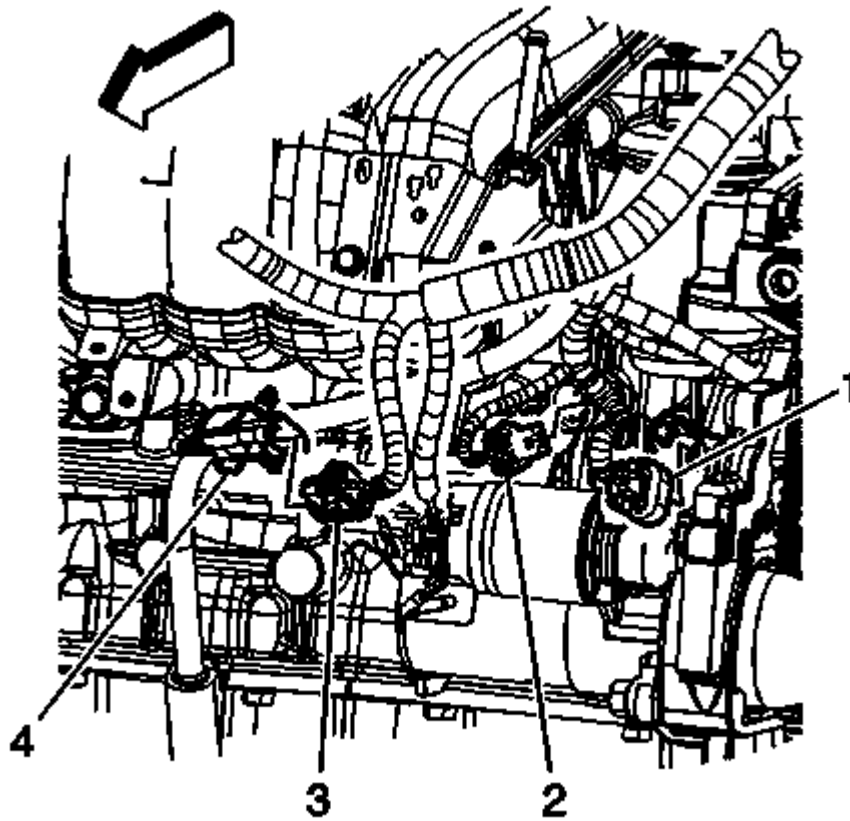


Fig. 4: Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the starter. Refer to **Starter Replacement (L4)** .
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch.

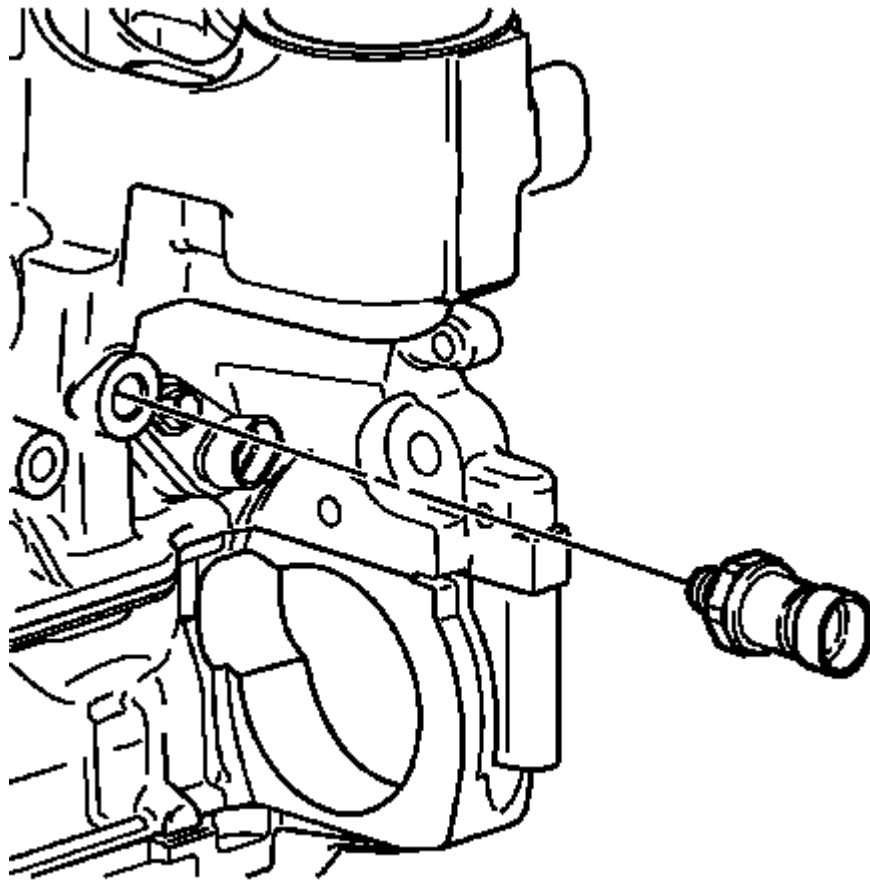


Fig. 5: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch.

INSTALLATION PROCEDURE

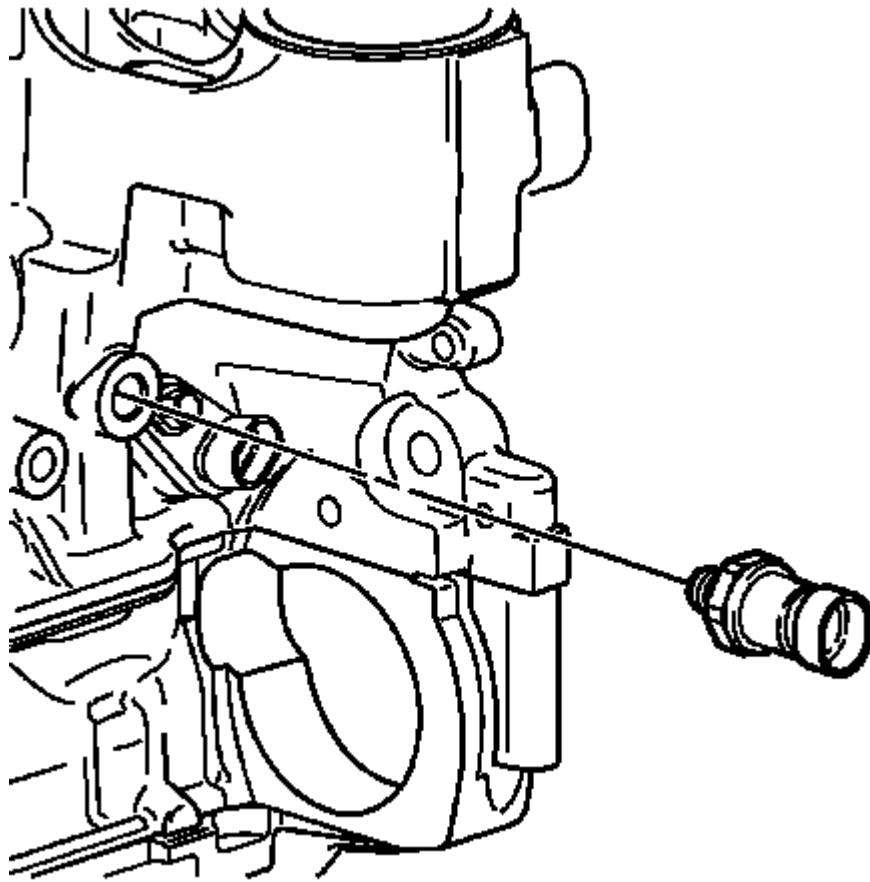


Fig. 6: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil pressure switch. Tighten the switch to 22 N.m (16 lb ft).

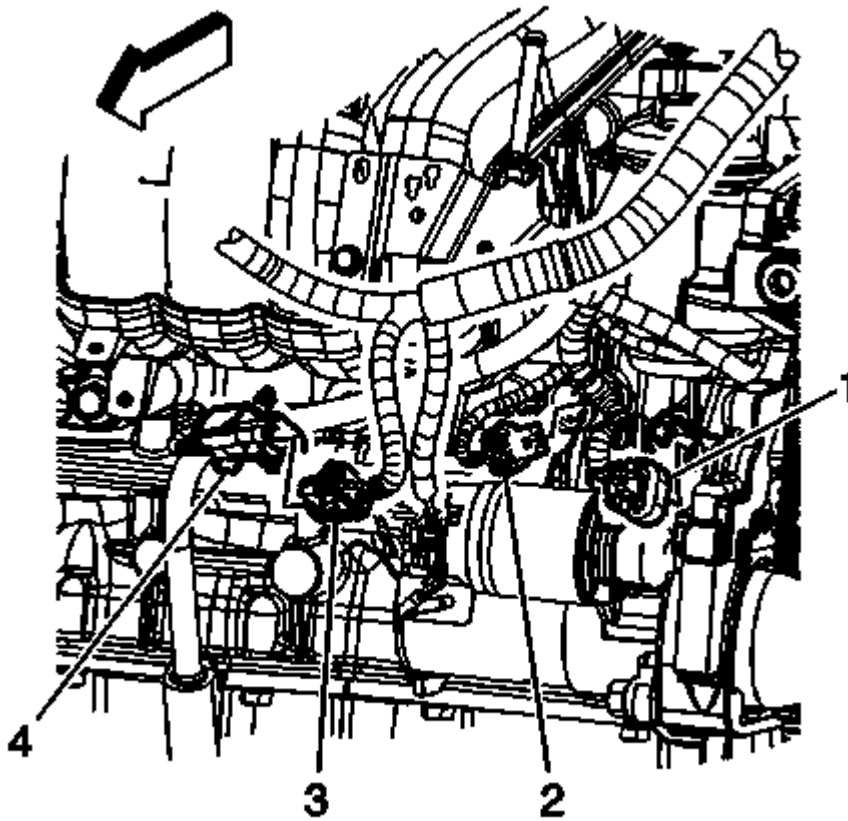


Fig. 7: Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness electrical connector (2) to the oil pressure switch.
3. Install the starter. Refer to **Starter Replacement (L4)** .

ENGINE MOUNT INSPECTION

NOTE: Before replacing any engine mount due to suspected fluid loss, verify that the source of the fluid is the engine mount, not the engine or accessories.

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Raise the engine slightly and observe the engine mount. Raising the engine removes the weight from the engine mount and creates a slight tension on the rubber portion.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber is covered with heat check cracks.
 - The rubber is separated from the metal plate of the engine mount.
 - The rubber is split through the center of the engine mount.
 - The engine mount itself is leaking fluid.

4. For engine mount replacement. Refer to Engine Mount Replacement.

ENGINE MOUNT BRACKET REPLACEMENT

REMOVAL PROCEDURE

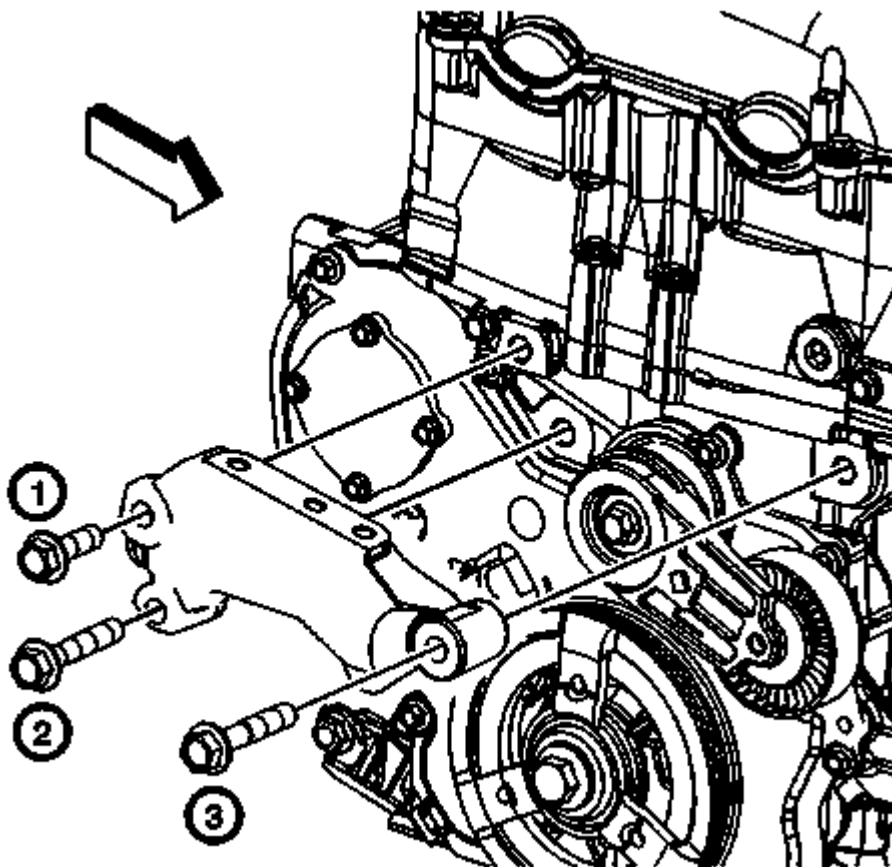


Fig. 8: Engine Mount Bracket To Engine & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to Engine Mount Replacement.
2. Remove the engine mount bracket to engine bolts.
3. Remove the engine mount bracket.

INSTALLATION PROCEDURE

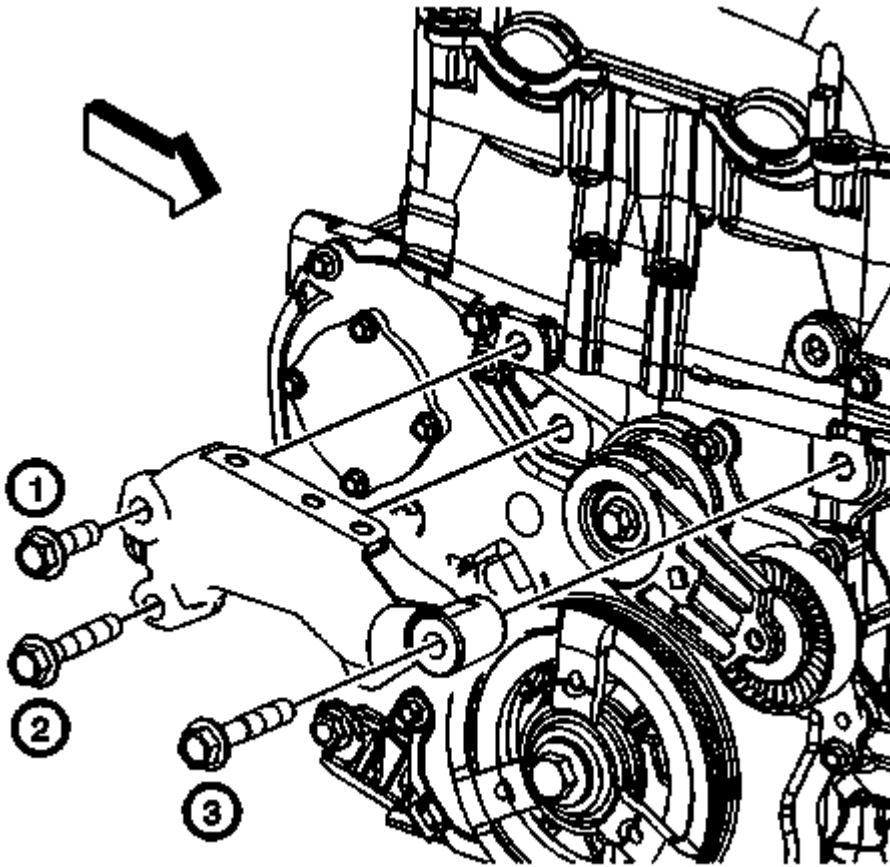


Fig. 9: Engine Mount Bracket To Engine & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket to the engine.
2. Install the engine mount bracket bolts in the following locations:
 - The long bolts in the forward and lower Rear holes
 - The short bolt in the upper rear hole

CAUTION: Refer to Fastener Caution .

3. Tighten the engine mount bracket bolts in the sequence shown to 100 N.m (74 lb ft)
4. Install the engine mount. Refer to Engine Mount Replacement.

POWERTRAIN MOUNT BALANCING

NOTE: Follow the balance procedure steps listed below when no starting point has been established such as in a collision repair.

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

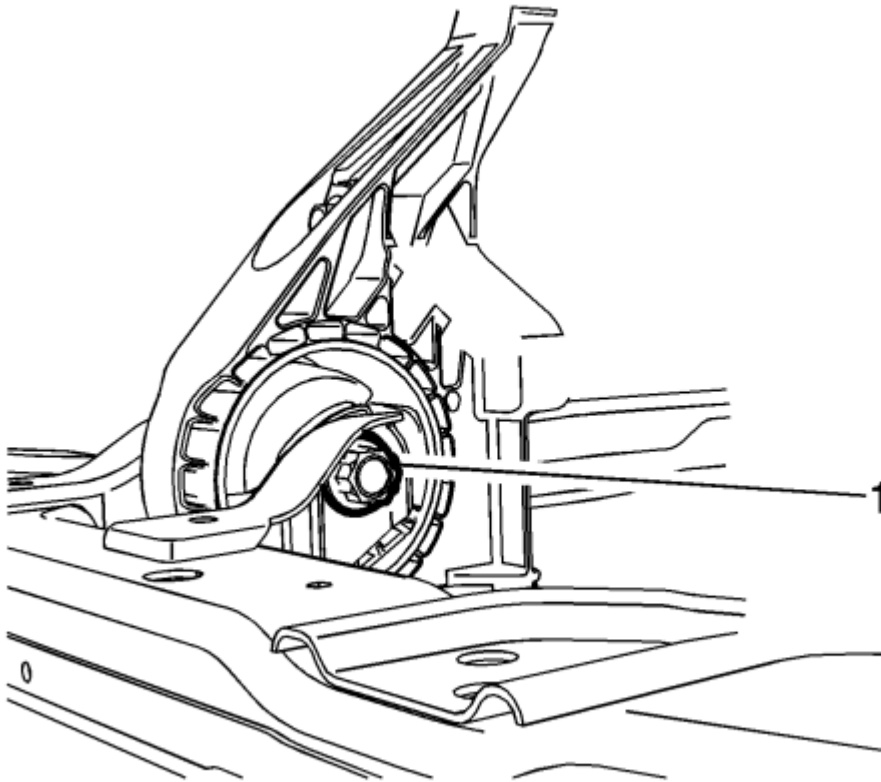


Fig. 10: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the front transaxle mount through bolt (1) until it is finger tight.

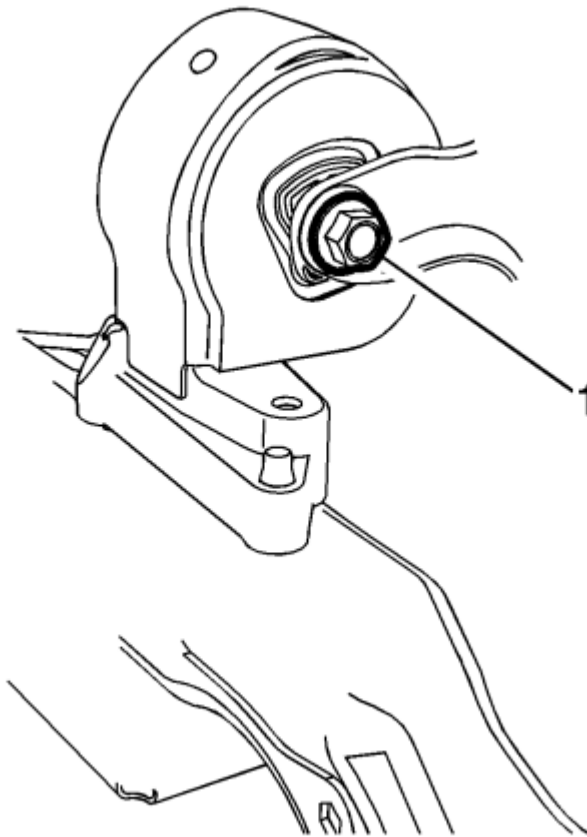


Fig. 11: Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear transaxle mount (1) through bolt until it is finger tight.
4. Lower the vehicle.

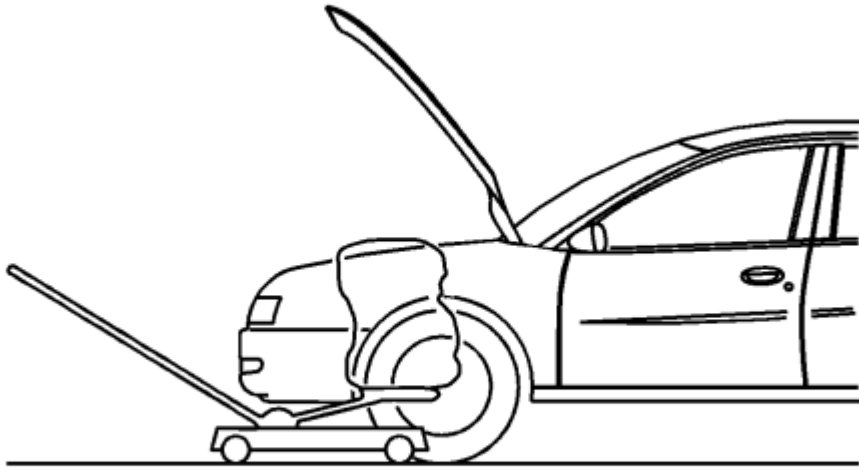


Fig. 12: Supporting Engine/Transmission With Hydraulic Floor Jack
Courtesy of GENERAL MOTORS CORP.

5. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.

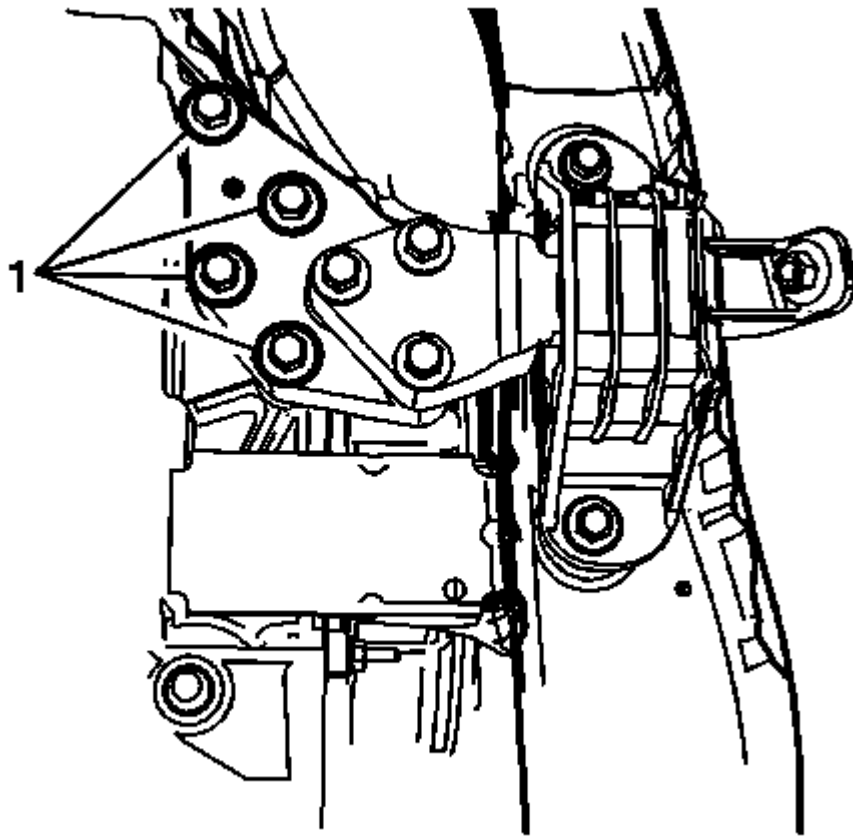


Fig. 13: Transaxle Bolts

Courtesy of GENERAL MOTORS CORP.

6. Loosen the transaxle adapter to transaxle bolts (1).

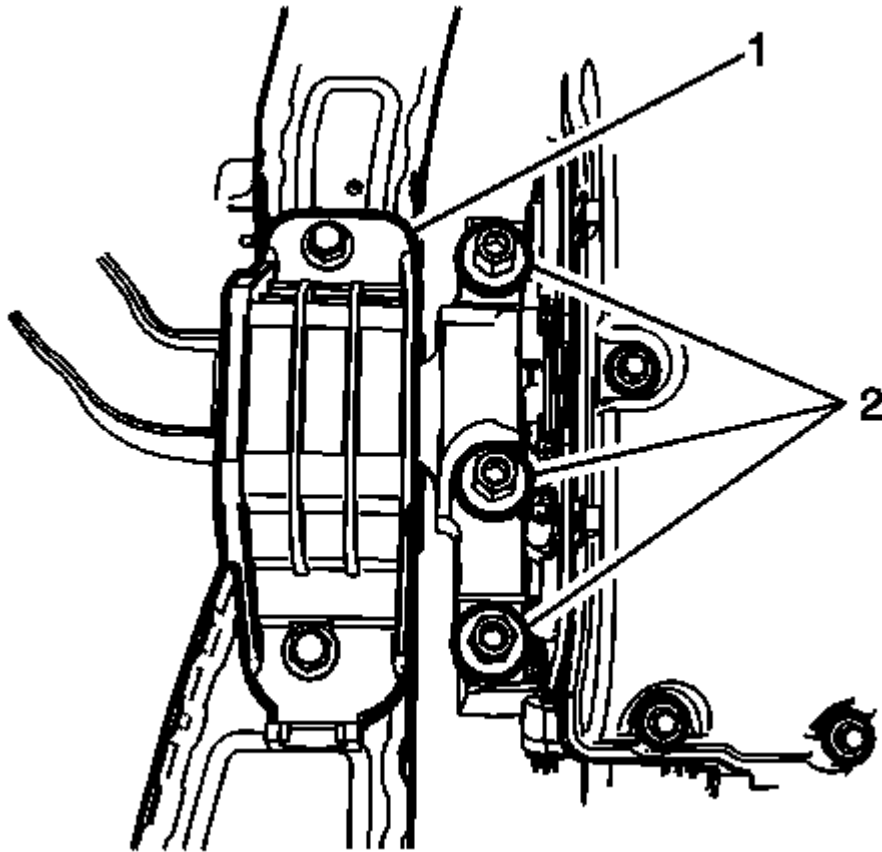


Fig. 14: Engine Mount And Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the engine mount (1) to bracket bolts (2).
8. Lower the floor jacks in order to allow a 1/4 inch (6 mm) gap between the upper engine mount and engine mount bracket, and also between the transmission and left transmission mount.

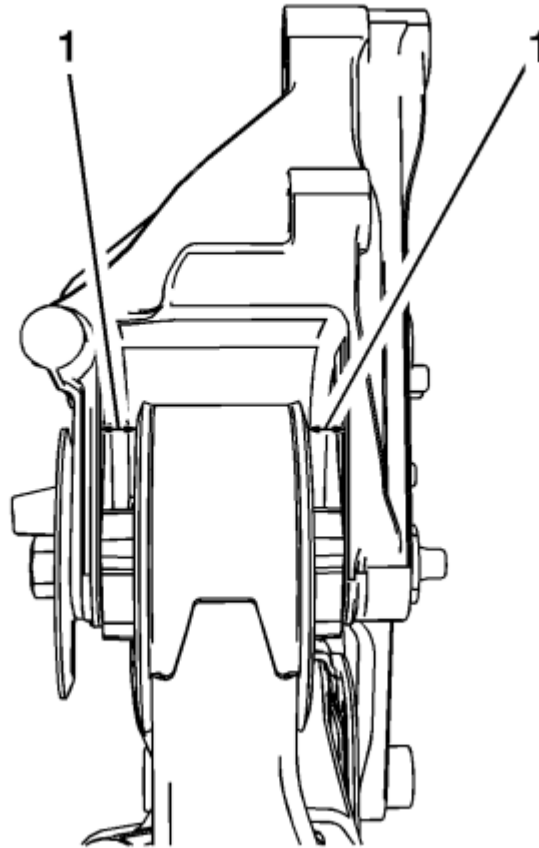


Fig. 15: Front And Rear Mounts

Courtesy of GENERAL MOTORS CORP.

9. Check that the front and rear mounts are centered (1) in the mount brackets, adjust if necessary.
10. Tighten the left hand (transaxle side) mount bolts, starting with the bolt nearest to the center of the mount. See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

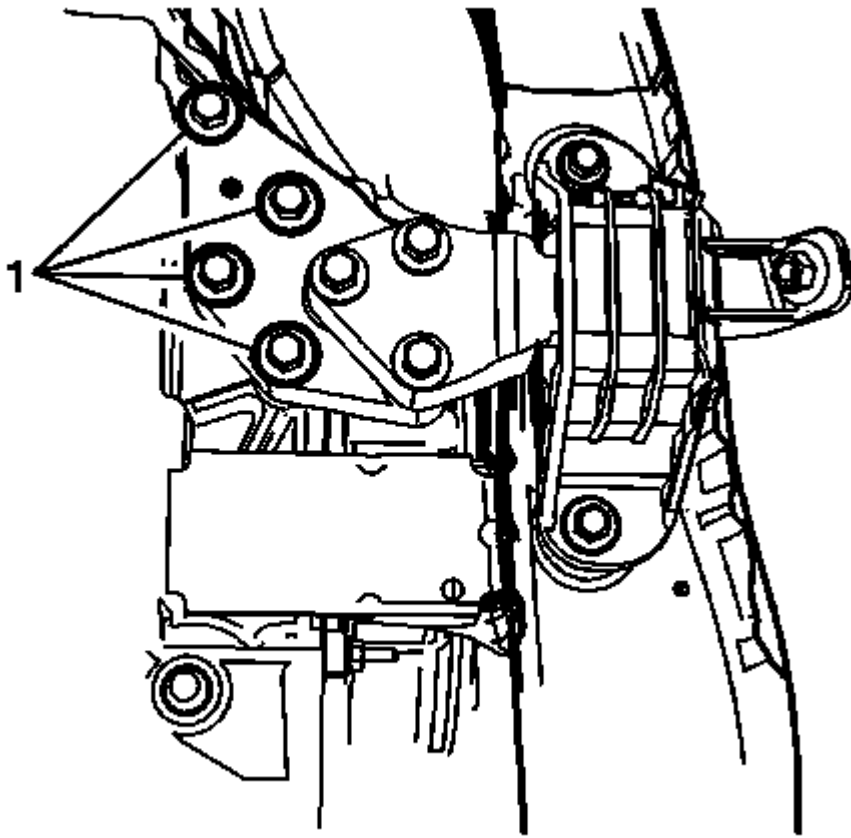


Fig. 16: Transaxle Bolts

Courtesy of GENERAL MOTORS CORP.

11. Tighten the right hand (engine side) mount bolts (1), starting with the bolt nearest to the center of the mount. See the appropriate engine mount replacement procedure for the fastener tightening specifications.
12. Remove the floor jacks from under the oil pan and transmission.
13. Raise the vehicle.
14. Shake the powertrain from front to rear and allow the powertrain to settle.

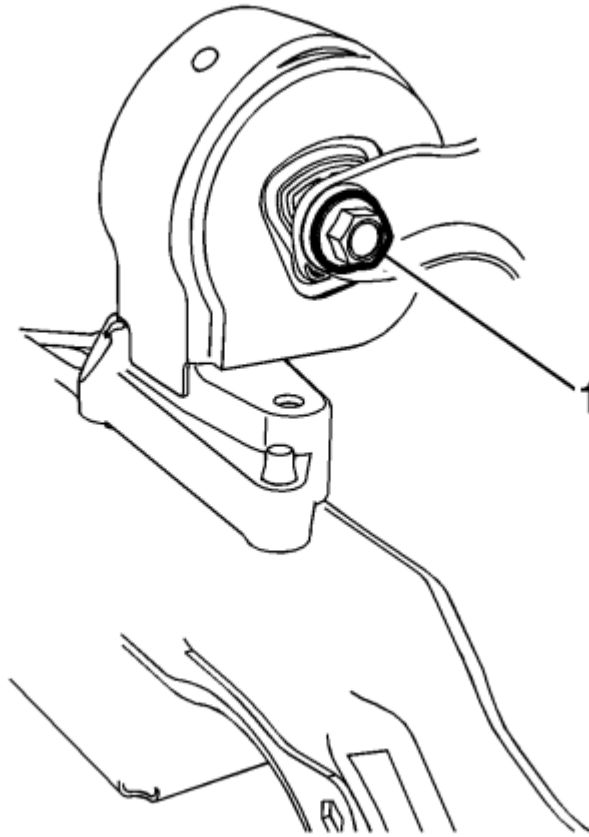


Fig. 17: Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: It is essential that the lower mount through bolts should be as close to centered as possible in the oversized mount insert holes before tightening to specification.

15. Tighten the rear transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

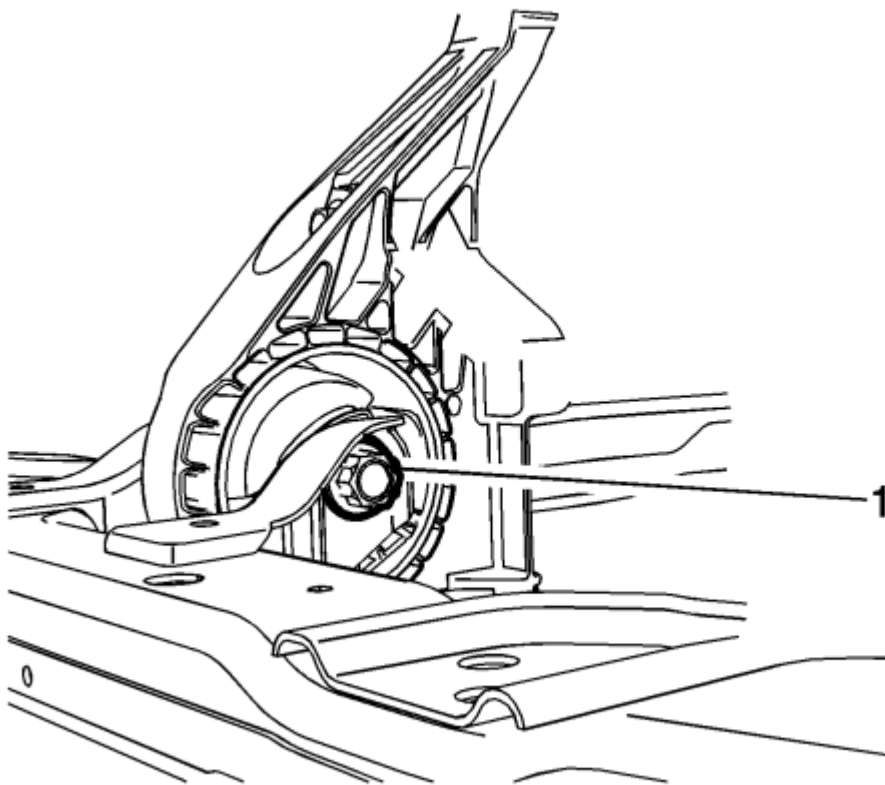


Fig. 18: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

16. Tighten the front transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.
17. Lower the vehicle.

POWERTRAIN MOUNT BALANCING - LOWER

NOTE: Follow the balance procedure steps listed below when front or rear mounts through bolts are loosened or removed during a repair procedure.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .

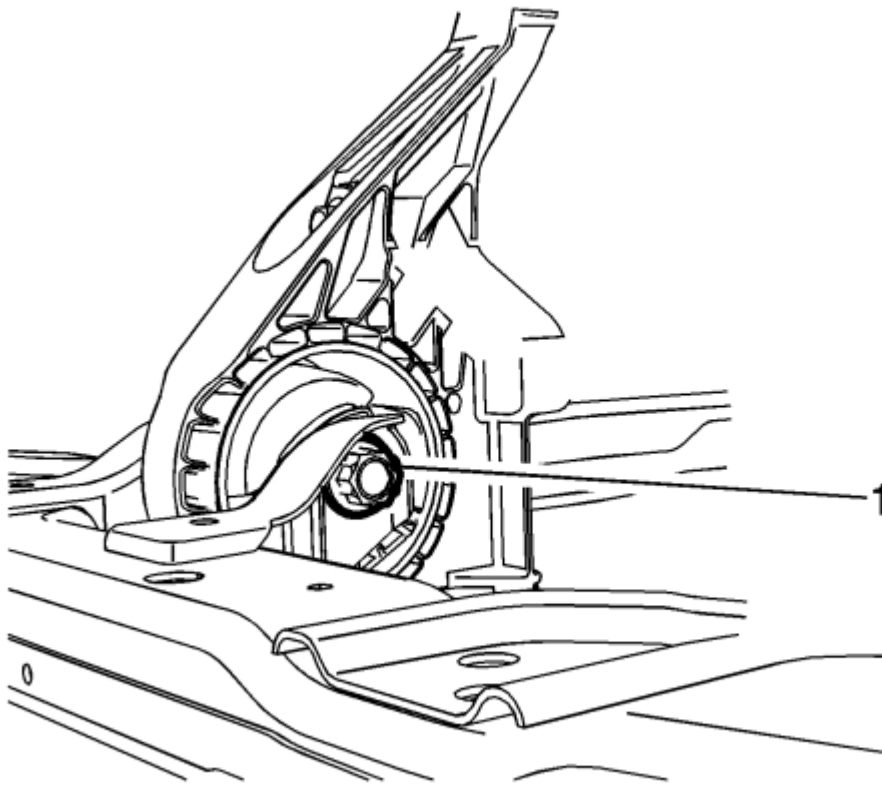


Fig. 19: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the front transaxle mount through bolt (1).

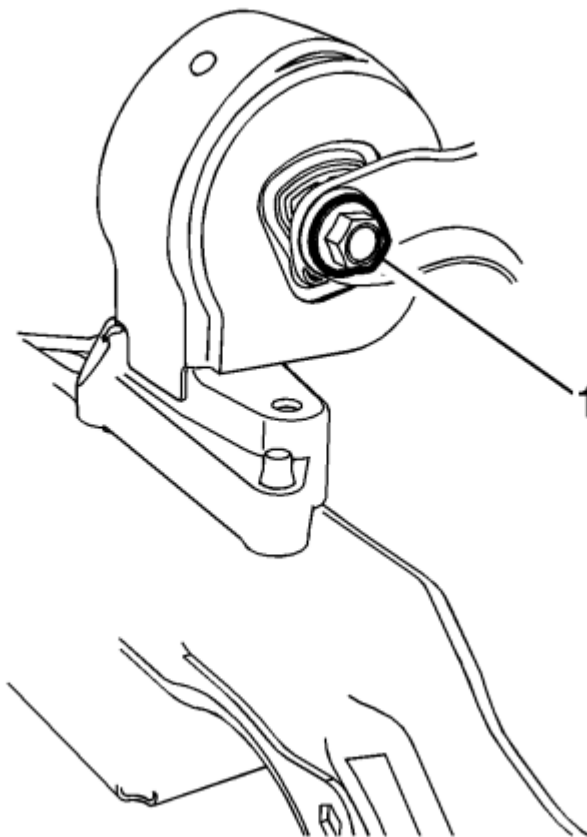


Fig. 20: Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear transaxle mount through bolt (1).
4. Shake the powertrain from front to rear and allow the powertrain to settle.

NOTE: It is essential that the through bolts are as close to centered as possible in the oversized mount insert holes before tightening to specification.

5. Tighten the rear transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

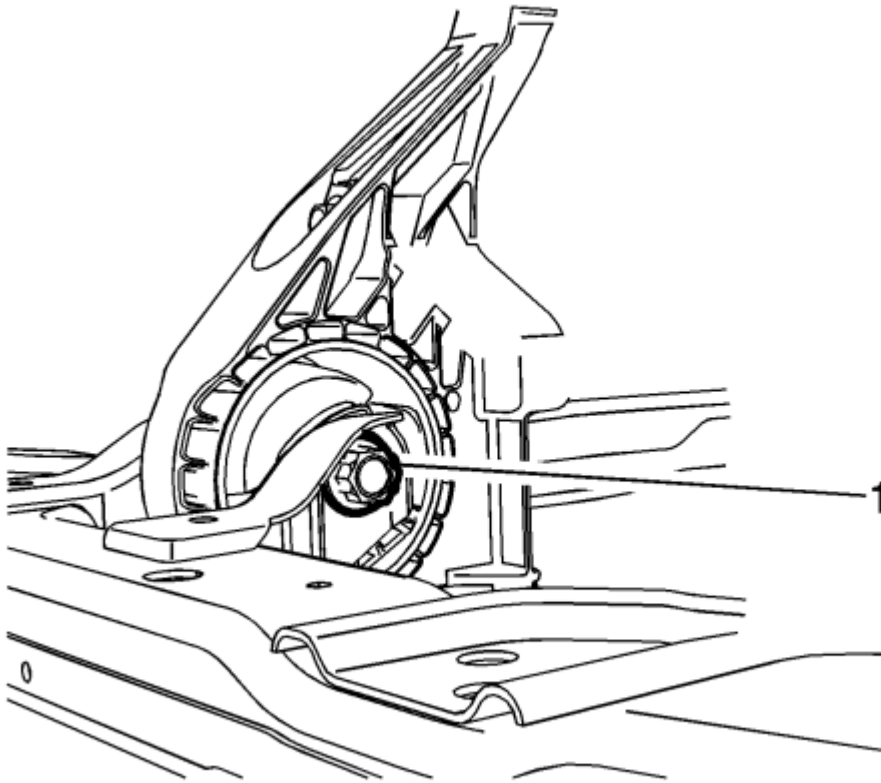


Fig. 21: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

6. Tighten the front transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.
7. Lower the vehicle.

ENGINE MOUNT REPLACEMENT

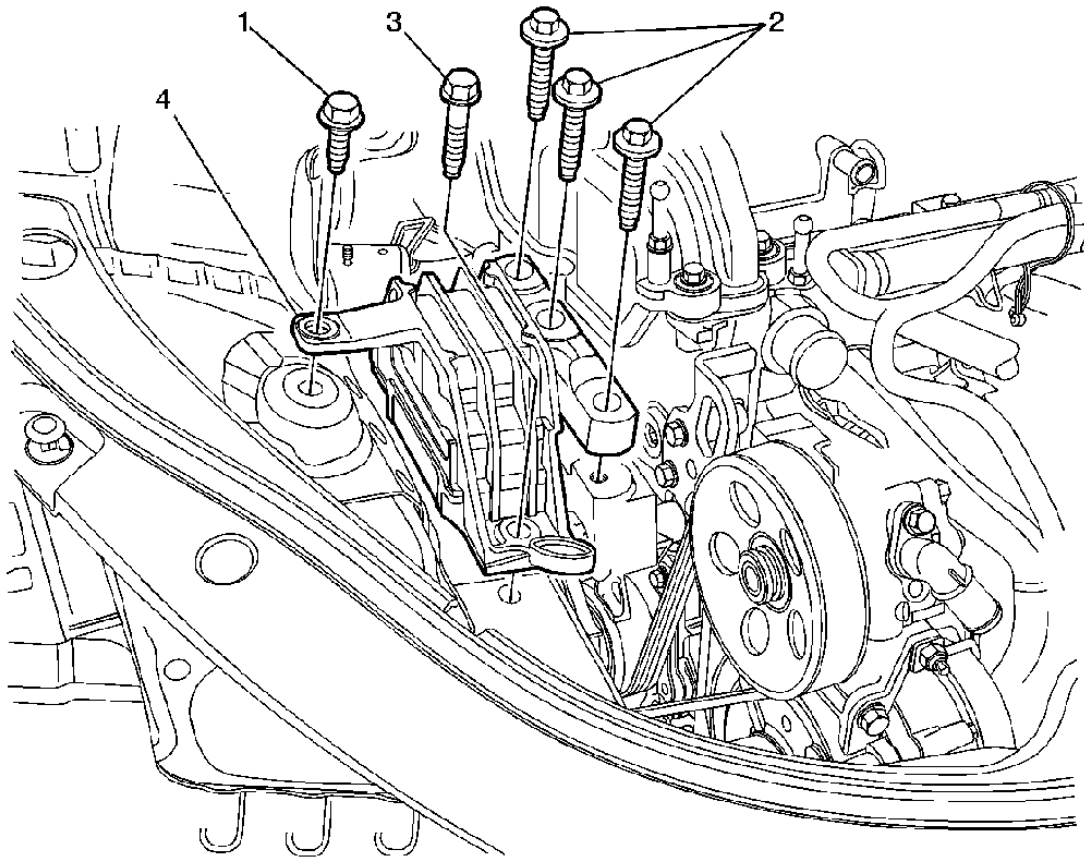


Fig. 22: Engine Mount

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedures	
1. Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u> . 2. Install engine support fixture. Refer to <u>Engine Support Fixture</u>. 3. Prior to removing the mount, mark mount to bracket, mount to body interfaces and fasteners to mount interfaces using spray paint or a marker for correct positioning during installation.	
1	Engine Mount Fastener CAUTION: Refer to <u>Fastener Caution</u> . Procedure: If the front and/or rear lower mount through bolts were loosened or removed, perform the <u>Powertrain Mount Balancing - Lower</u> . Refer to the appropriate engine information. If ALL powertrain mounts are replaced with new components,

	perform the <u>Powertrain Mount Balancing</u> . Refer to the appropriate engine information. Tighten: 62 N.m (46 lb ft)
2	Engine Mount Fastener (Qty: 3) Tighten: 62 N.m (46 lb ft)
3	Engine Mount Fastener (Qty: 2) Tighten: 62 N.m (46 lb ft)
4	Engine Mount Procedure: Transfer components as necessary.

ENGINE SUPPORT FIXTURE

SPECIAL TOOLS

- **EN-28467-B:** Universal Engine Support Fixture
- **EN-28467-500B:** Engine Support Fixture
- **EN-43405-10:** Engine Support Fixture Adaptor

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

PROCEDURE

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

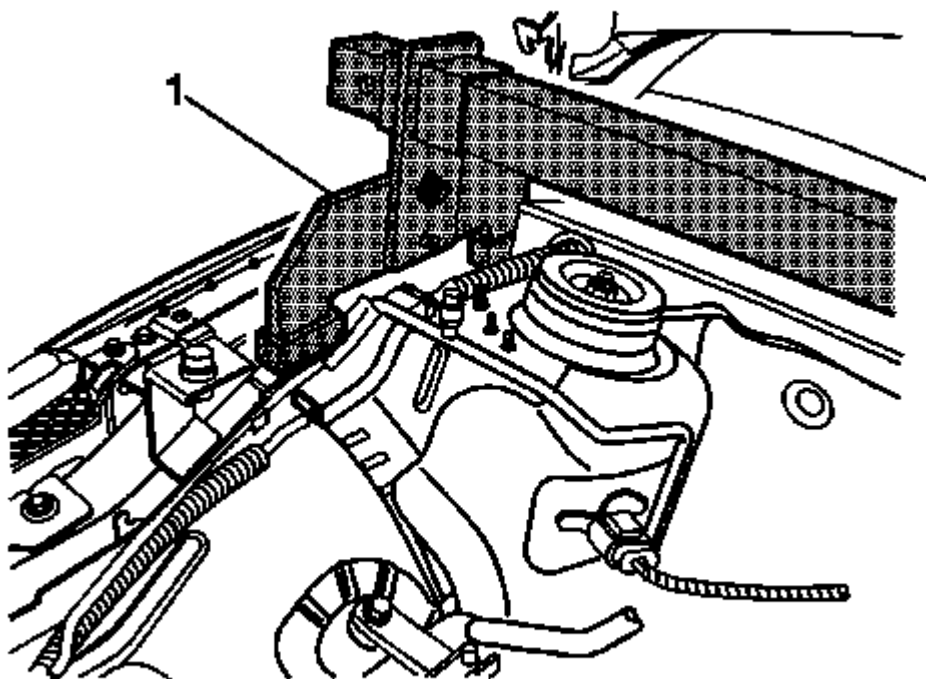


Fig. 23: Special Tool

Courtesy of GENERAL MOTORS CORP.

2. Assemble the **EN-28467-B: Universal Engine Support Fixture** to the **EN-43405-1: Engine Support Feet (Passenger Side)** and **EN-43405-2: Engine Support Feet (Drivers Side)** (1) and place across the engine compartment.

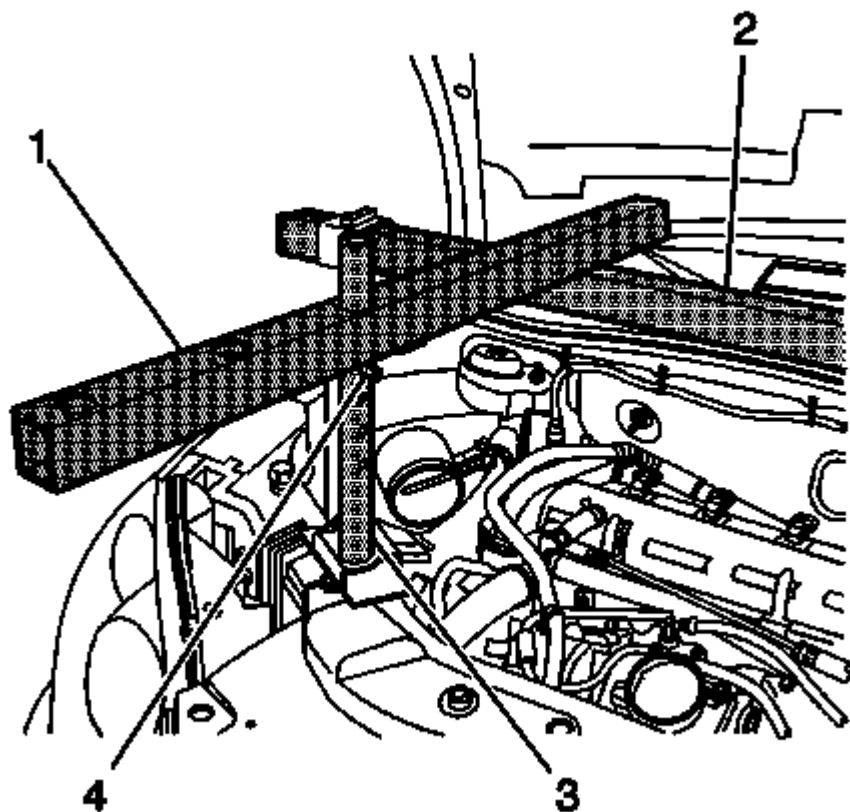


Fig. 24: Front Support Assembly

Courtesy of GENERAL MOTORS CORP.

3. From the **EN-28467-500B: Universal Engine Support Fixture**, install the radiator shelf tube J-28467-2A (1) on top of the strut tower tube J-28467-3 (2) above the engine front (right back) lift hook bracket.
4. Install the round tube of the front support assembly J-28467-4A (3) through the large hole in the radiator shelf tube J-28467-2A.
5. Locate the J-28467-4A front support assembly to the upper tie bar.
6. Install the J-28467-9 7/16 inch x 2.0 inch quick-release pin (4) through the top hole in the J-28467-4A front support assembly.

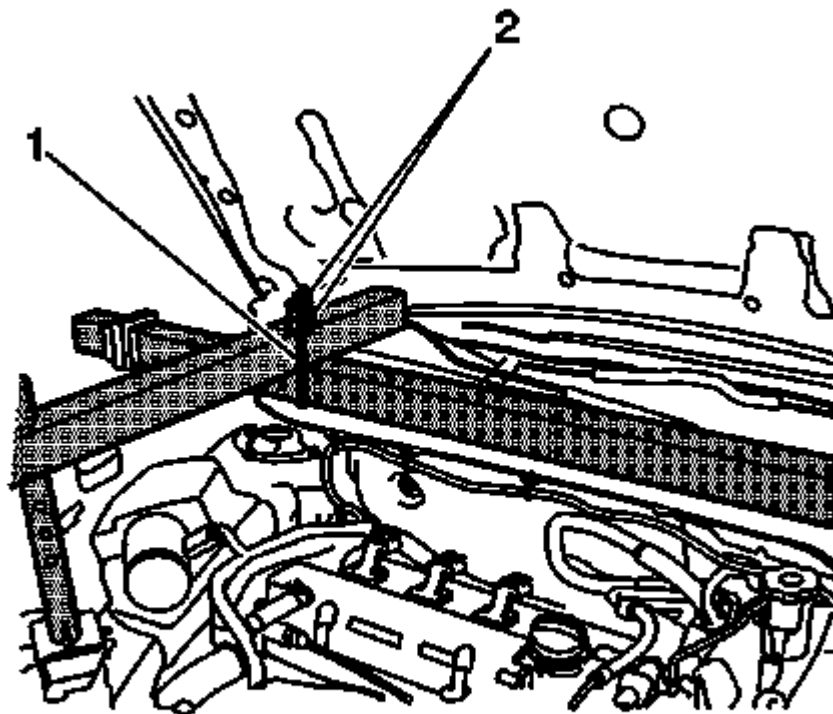


Fig. 25: Cross Bracket Assembly & Wing Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install the J-28467-1A cross bracket assembly (1).
8. Hand tighten the J-28467-1A cross bracket wing nuts (2).

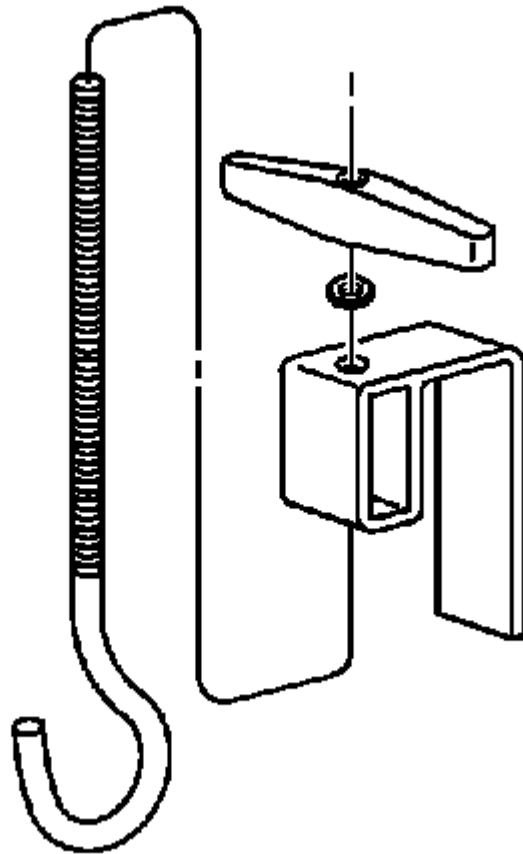


Fig. 26: Lift Hook Assembly

Courtesy of GENERAL MOTORS CORP.

9. Install the J-28467-7A bolt hook through the J-28467-6A bracket.
10. Install the J-28467-34 lift hook wing nut and washer to the J-28467-7A lift hook.
11. Repeat the previous 2 steps in order to assemble 2 lift hooks and brackets.

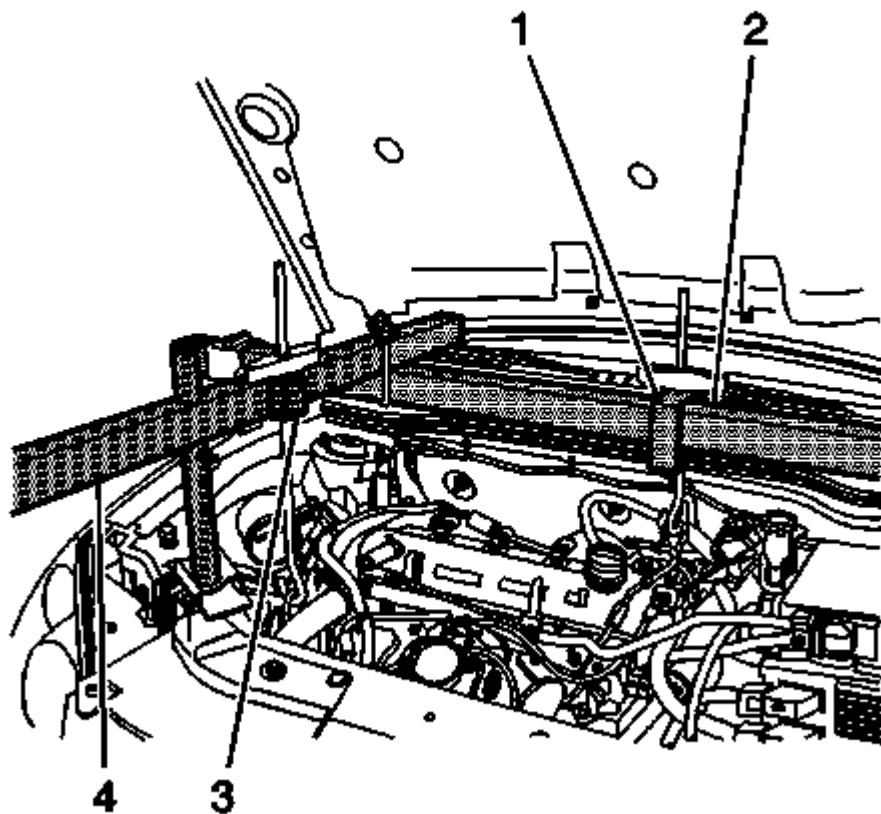


Fig. 27: Lift Hook & Bracket Assemblies
Courtesy of GENERAL MOTORS CORP.

12. Install one of the lift hook and bracket assemblies (1) to the engine support fixture long bar (2).
13. Install the other lift hook and bracket assembly (3) to the J-28467-2A radiator shelf tube (4) above the engine front lift bracket.

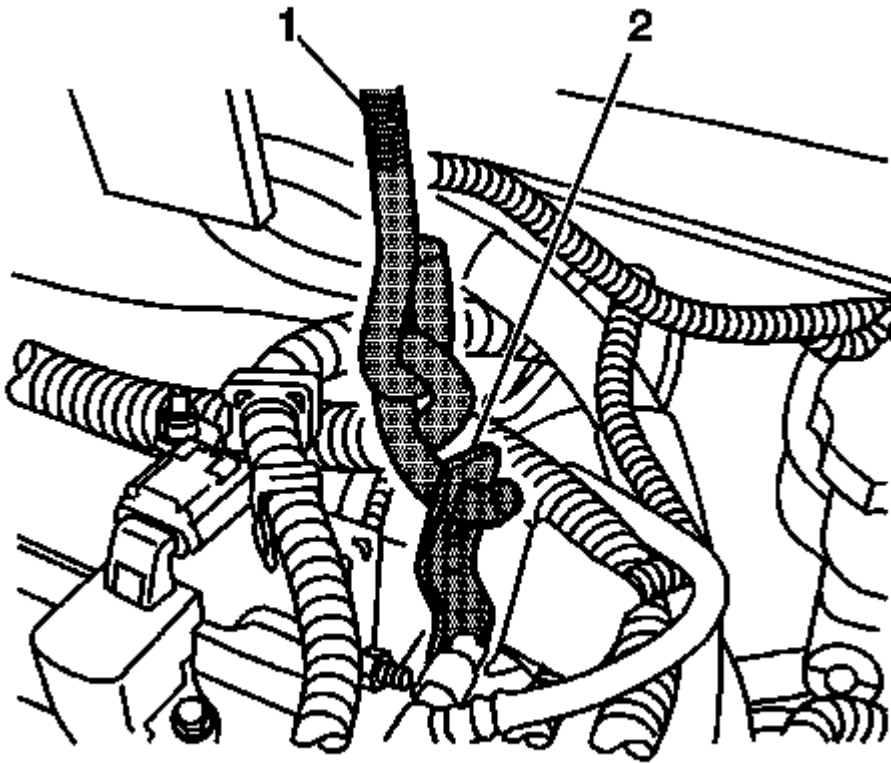


Fig. 28: Inserting Lift Hook Through Engine Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

14. Install the lift hook J-28467-7A through the engine rear lift bracket (2).

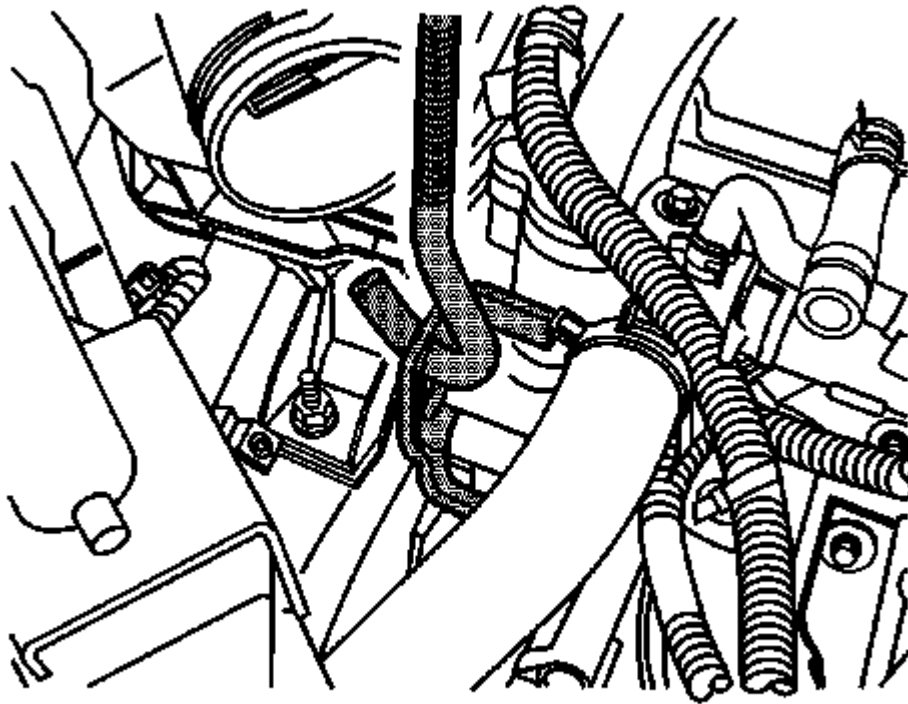


Fig. 29: Inserting Lift Hook Through Engine Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

15. Install the lift hook J-28467-7A (3) through the engine front lift bracket (4).
16. Hand tighten the lift hook wing nuts J-28467-34 (5) in order to remove all slack from the engine support fixture assembly.

OIL LEVEL INDICATOR TUBE REPLACEMENT

REMOVAL PROCEDURE

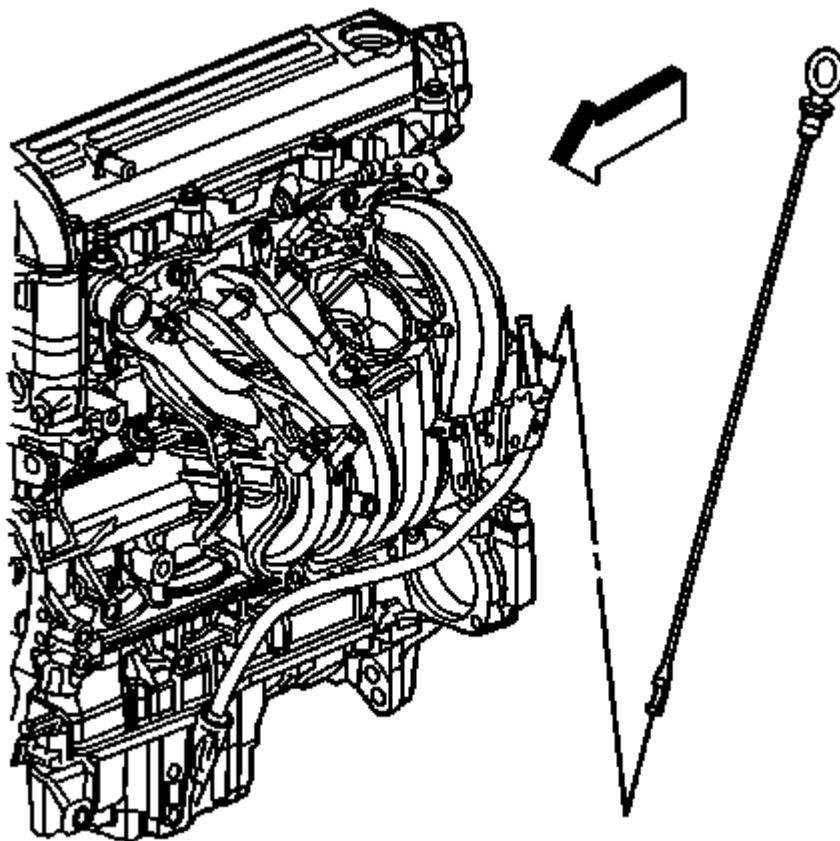


Fig. 30: Oil Level Indicator

Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#) .
2. Remove the oil level indicator.

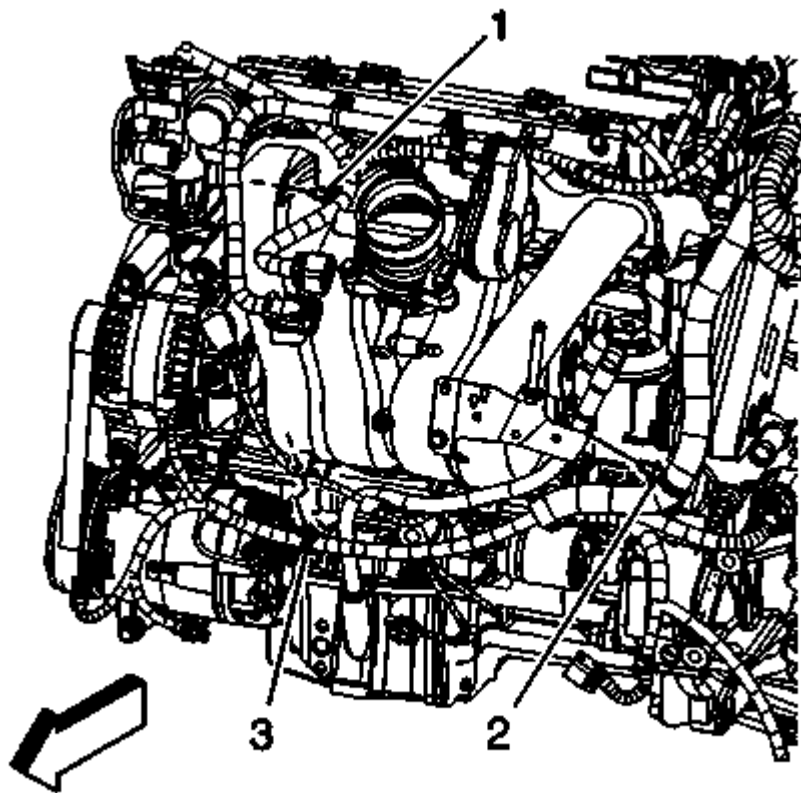


Fig. 31: Engine Harness Clip

Courtesy of GENERAL MOTORS CORP.

3. Remove the engine harness clip (2) from the oil level indicator tube bracket.

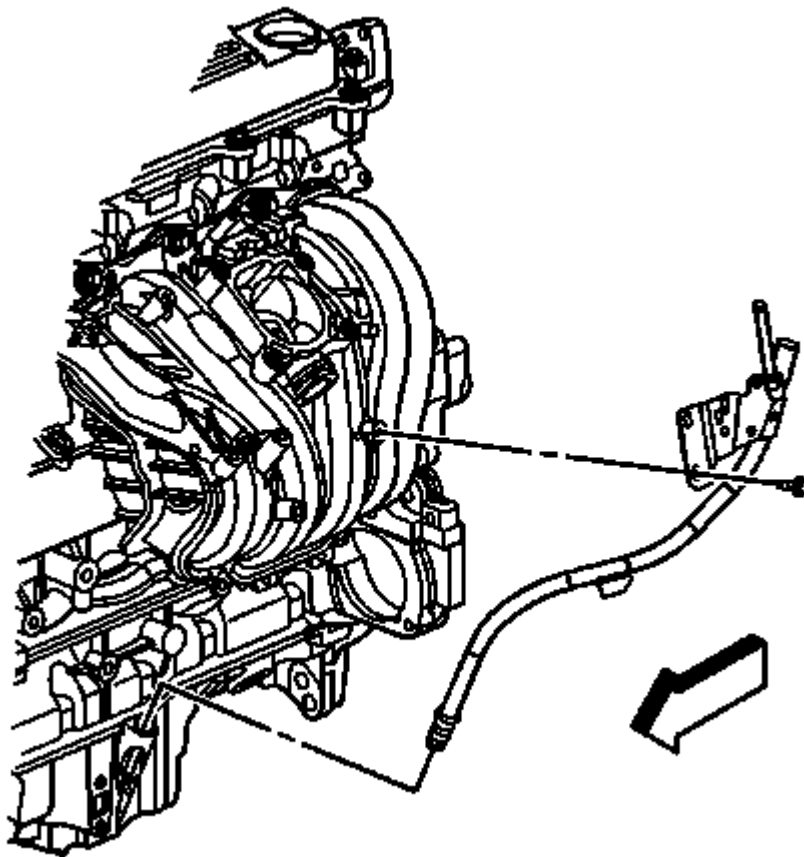


Fig. 32: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level indicator tube bolt.
5. Remove the oil level indicator tube.
6. Remove the oil level indicator tube O-ring seals, if necessary.
7. Disconnect electrical connector as needed.
8. Disconnect the brake vacuum pump connectors.

INSTALLATION PROCEDURE

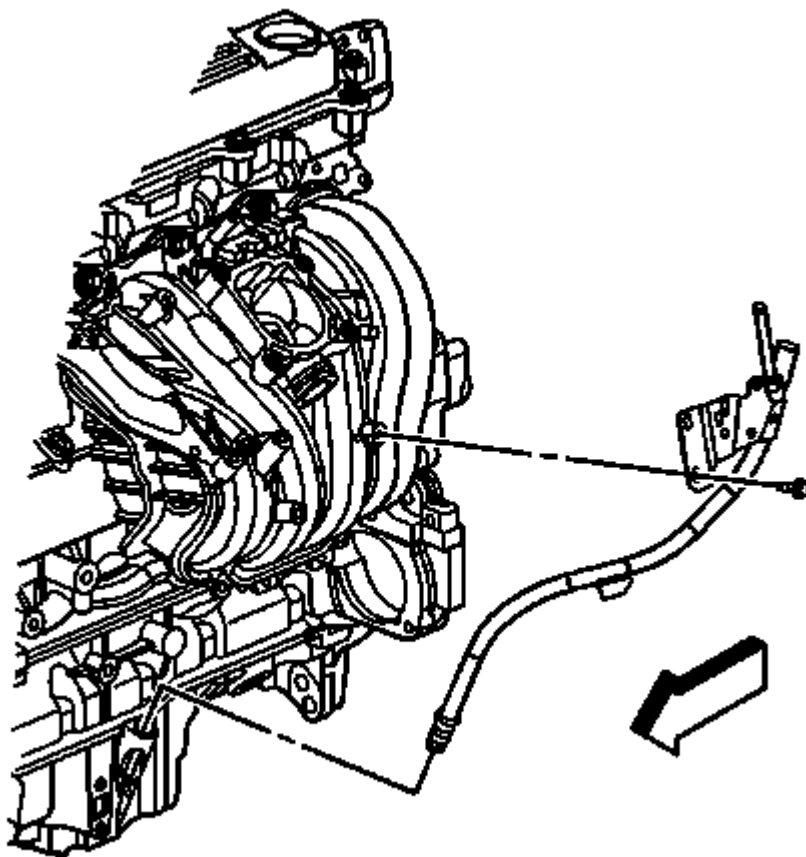


Fig. 33: Oil Level Indicator Tube
 Courtesy of GENERAL MOTORS CORP.

1. Install NEW oil level indicator tube O-ring seals, if necessary.
2. Install the oil level indicator tube.

CAUTION: Refer to Fastener Caution .

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

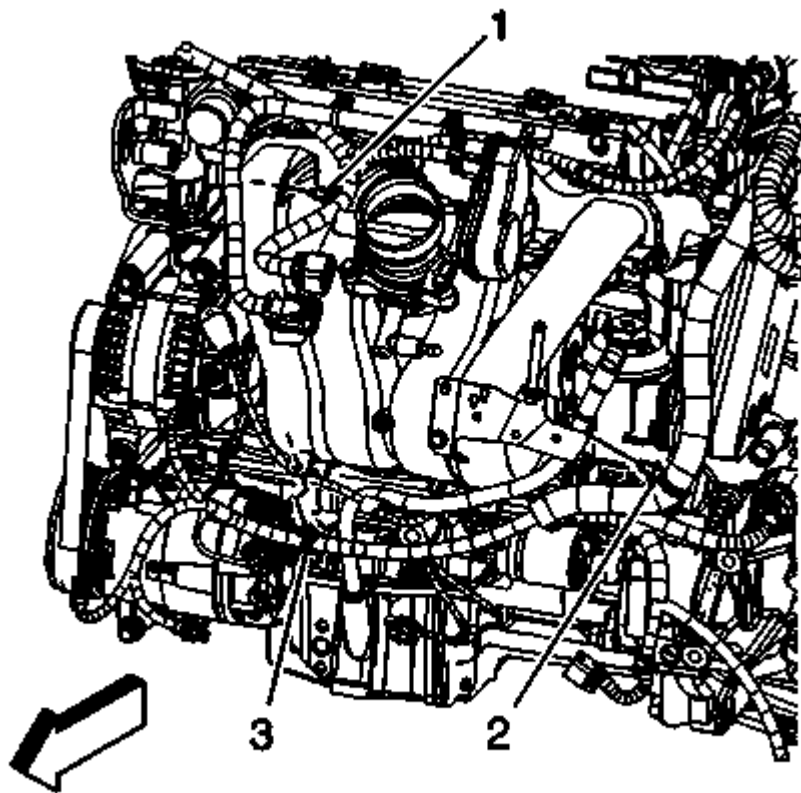


Fig. 34: Engine Harness Clip

Courtesy of GENERAL MOTORS CORP.

4. Install the engine harness clip (1) to the oil level indicator tube bracket.

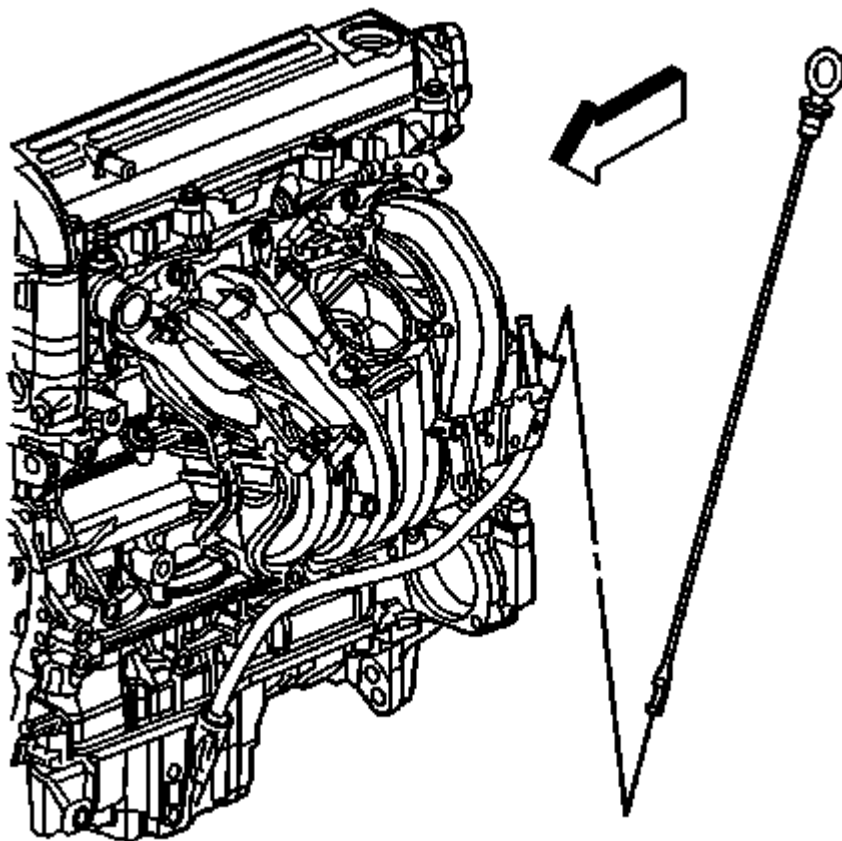


Fig. 35: Oil Level Indicator

Courtesy of GENERAL MOTORS CORP.

5. Install the oil level indicator.
6. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#) .
7. Connect electrical connector as needed.
8. Reconnect the brake vacuum pump connectors.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

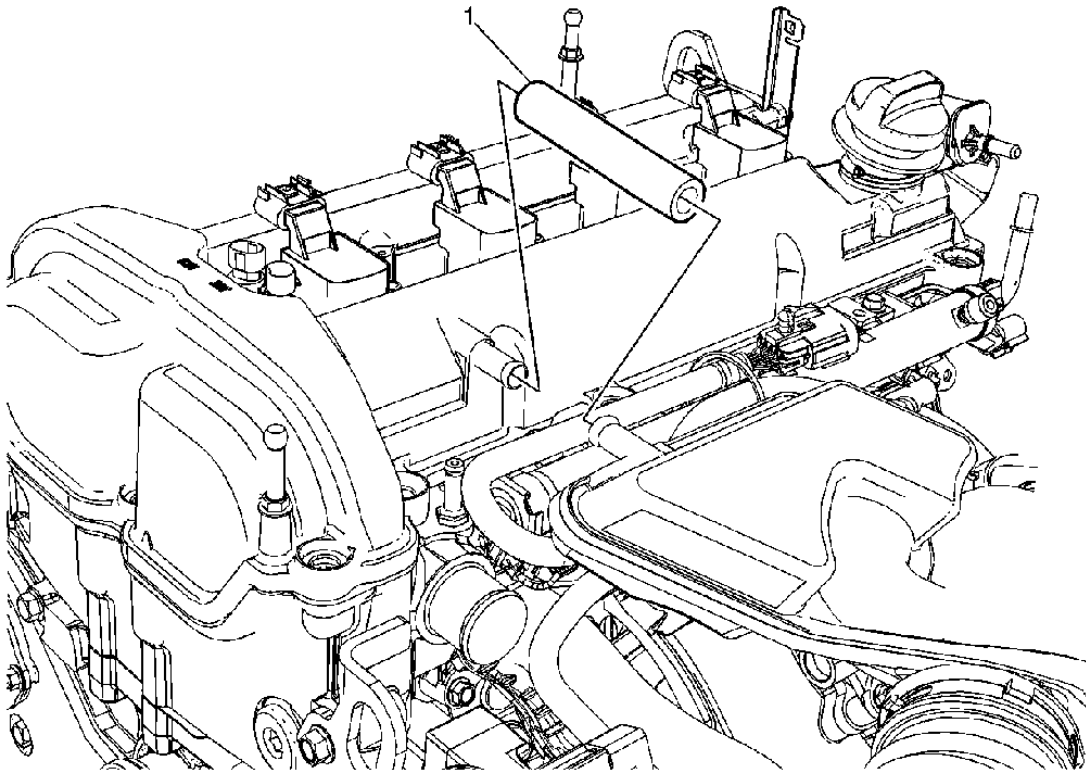


Fig. 36: Positive Crankcase Ventilation Hose/Pipe/Tube
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove intake manifold cover. Refer to <u>Intake Manifold Cover Replacement</u> .	
1	Positive Crankcase Ventilation Hose/Pipe/Tube Procedure 1. Disconnect the electrical connectors, as needed. 2. Transfer components as necessary.

INTAKE MANIFOLD REPLACEMENT

REMOVAL PROCEDURE

1. Remove the positive crankcase ventilation hose/pipe/tube. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.
2. Remove the throttle body. Refer to **Throttle Body Assembly Replacement**.
3. Remove the evaporative emission (EVAP) canister purge solenoid valve tube. Refer to **Plastic Collar Quick Connect Fitting Service**.

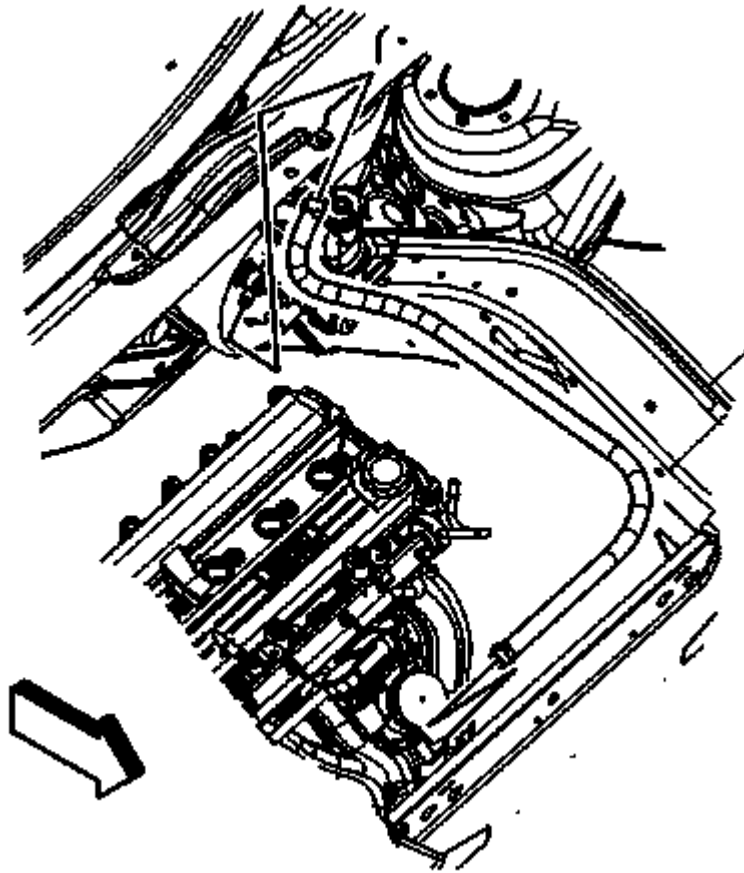
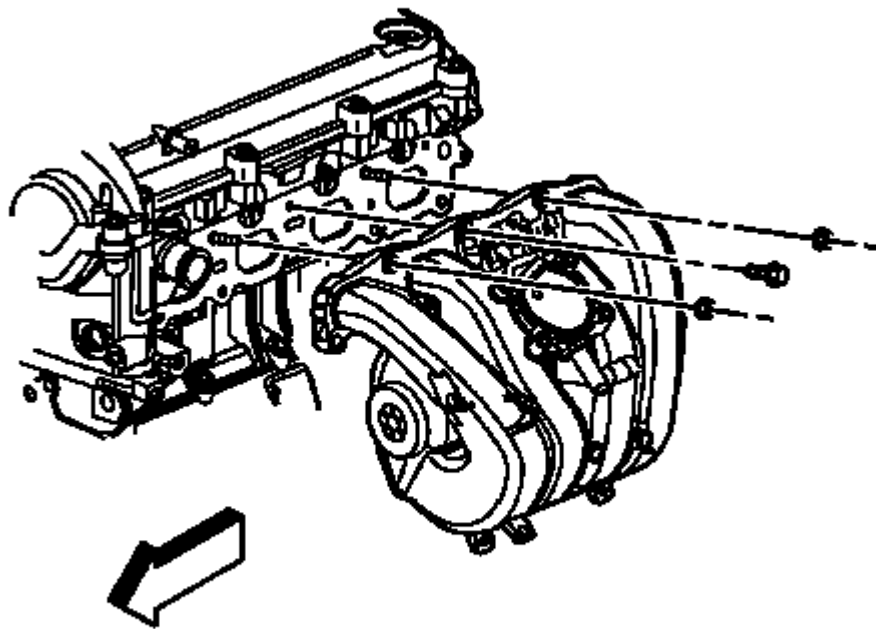


Fig. 37: Brake Booster Vacuum Hose & Clamps
 Courtesy of GENERAL MOTORS CORP.

4. Reposition the brake booster vacuum hose clamp at the intake manifold.
5. Remove the brake booster hose from the intake manifold.
6. Disconnect the engine harness electrical connector from the fuel injector inline electrical connector.
7. Remove the fuel injector inline connector clip from the intake manifold.
8. Disconnect the MAP sensor connector.
9. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
10. Remove the engine wire harness clip from the intake manifold.
11. Remove the intake manifold insulator.
12. Remove the fuel pump cover.
13. Disconnect the fuel feed hose from the chassis fuel line.

**Fig. 38: Intake Manifold****Courtesy of GENERAL MOTORS CORP.**

14. Remove the intake manifold bolts and nuts.
15. Remove the intake manifold.

NOTE: The intake manifold gasket is reusable. Only replace the gasket if damage has occurred.

16. Remove the intake manifold gasket, if necessary.

INSTALLATION PROCEDURE

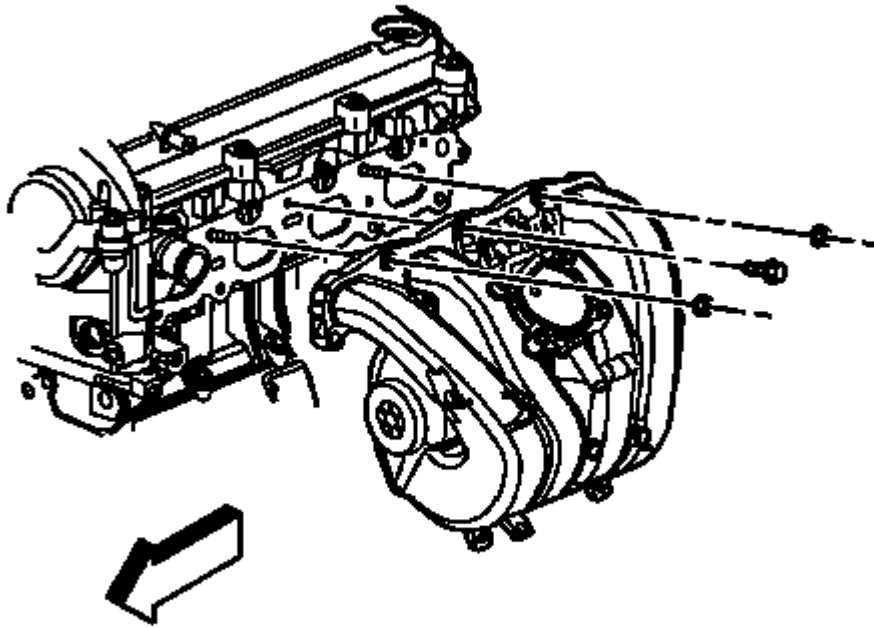


Fig. 39: Intake Manifold

Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold gasket, if necessary.
2. Install the intake manifold.

CAUTION: Refer to Fastener Caution .

3. Install the intake manifold bolts and nuts and tighten to 10 N.m (89 lb in).
4. Install the intake manifold insulator.
5. Install the fuel pump cover.
6. Connect the fuel feed line to the chassis fuel line.
7. Install the engine wire harness clip to the intake manifold.
8. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
9. Connect the MAP sensor connector.
10. Connect the engine harness electrical connector to the fuel injector inline electrical connector.
11. Install the fuel injector inline connector clip to the intake manifold.

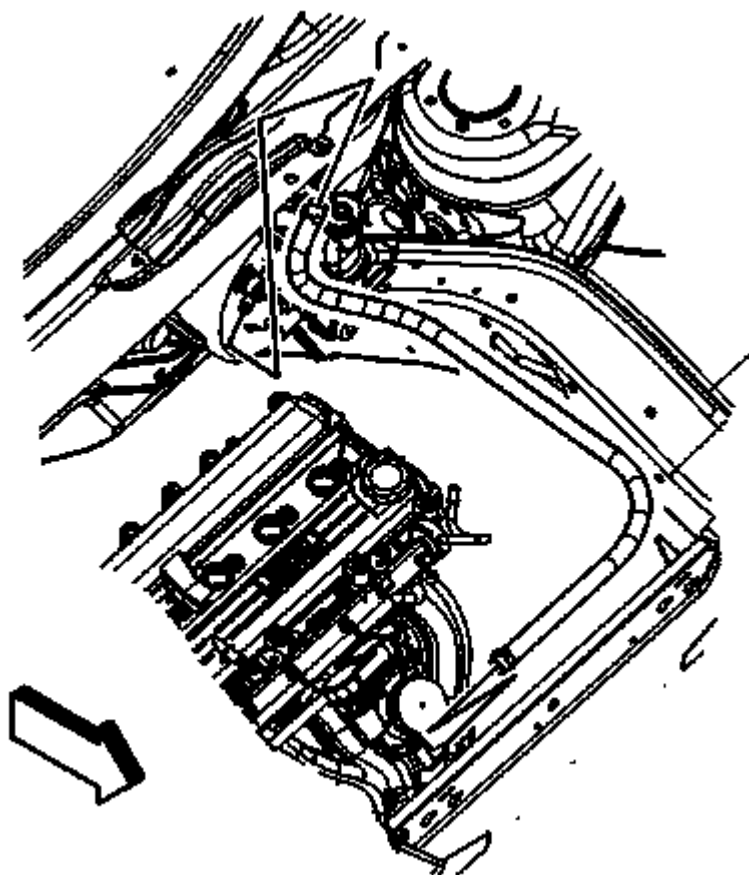


Fig. 40: Brake Booster Vacuum Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

12. Install the brake booster hose to the intake manifold.
13. Position the brake booster vacuum hose clamp at the intake manifold.
14. Install the EVAP canister purge solenoid valve tube. Refer to **Plastic Collar Quick Connect Fitting Service** .
15. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .
16. Install the positive crankcase ventilation hose/pipe/tube. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.

CRANKSHAFT BALANCER REPLACEMENT

SPECIAL TOOLS

- **EN-38122A:** Crankshaft Holding Tool
- **EN-45059:** Angle Meter

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

REMOVAL PROCEDURE

1. Remove the front wheelhouse front liner. Refer to **Front Wheelhouse Front Liner Replacement** .
2. Remove the power brake booster pump. Refer to **Power Brake Booster Pump Replacement (2.4L)** .

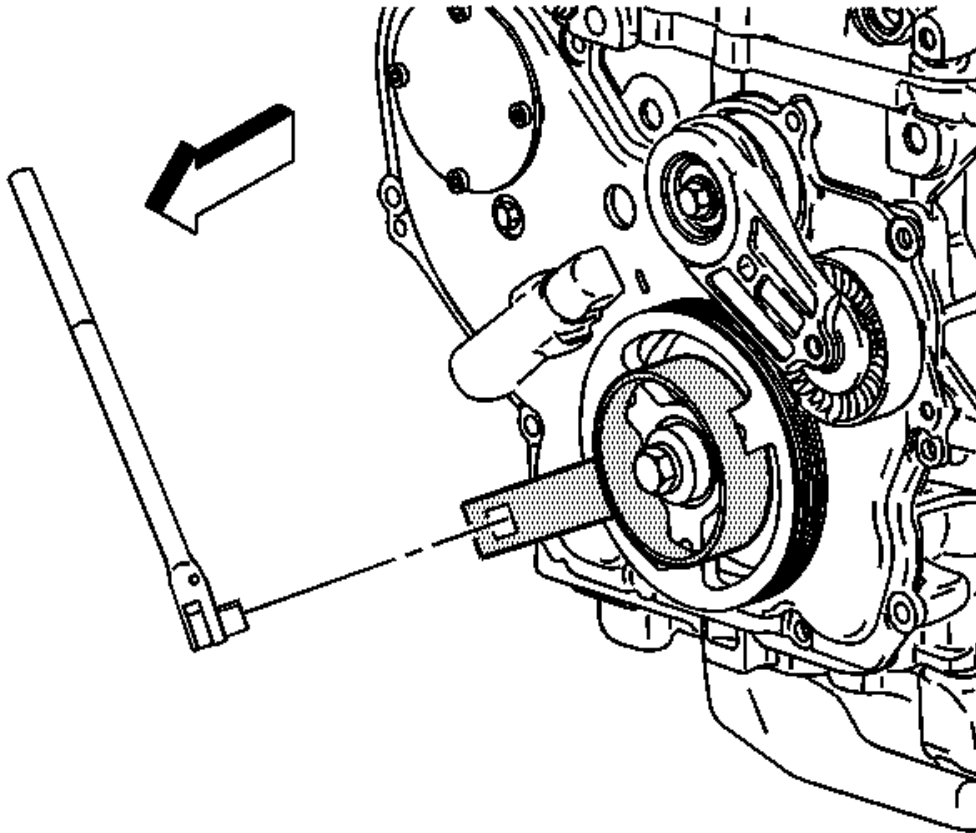


Fig. 41: Harmonic Balancer Holder
Courtesy of GENERAL MOTORS CORP.

3. Remove the drive belt. Refer to **Drive Belt Replacement**.
4. Use **EN-38122A**: holding tool to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt.
5. Remove and discard the crankshaft balancer bolt.

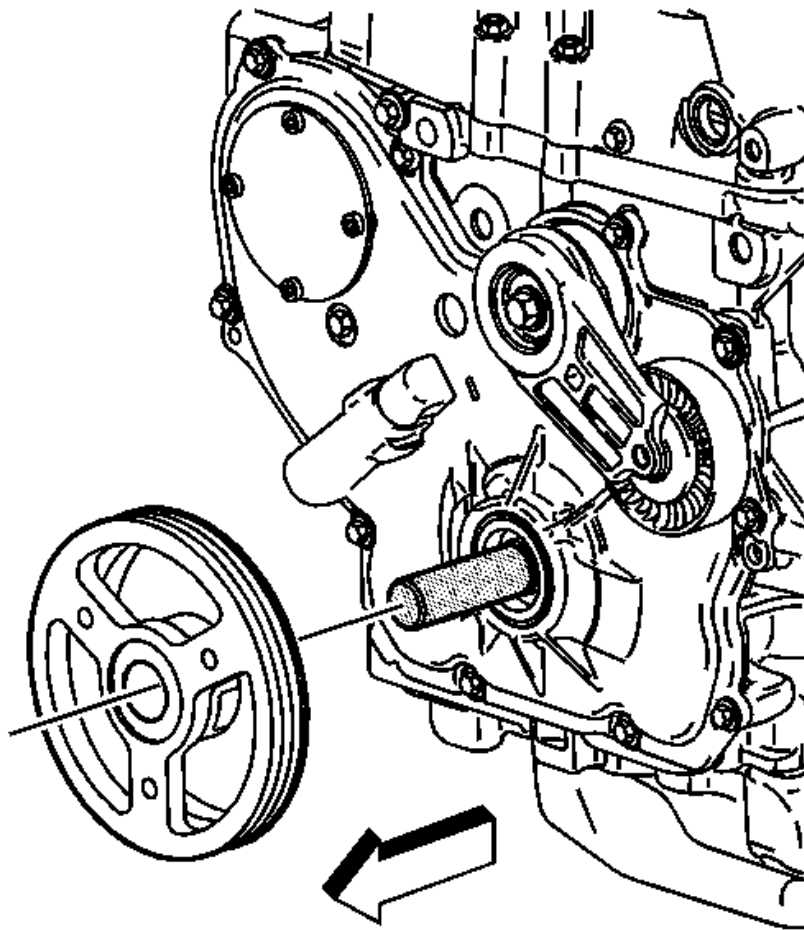


Fig. 42: Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft balancer.

INSTALLATION PROCEDURE

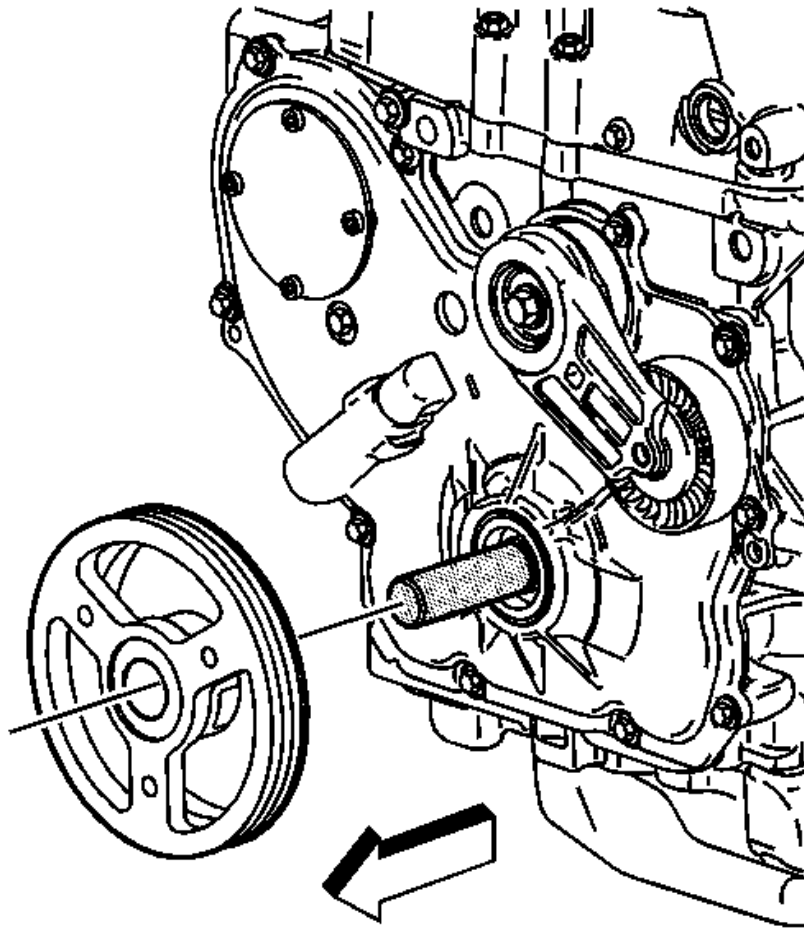


Fig. 43: Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer.
2. Install a NEW crankshaft balancer bolt.

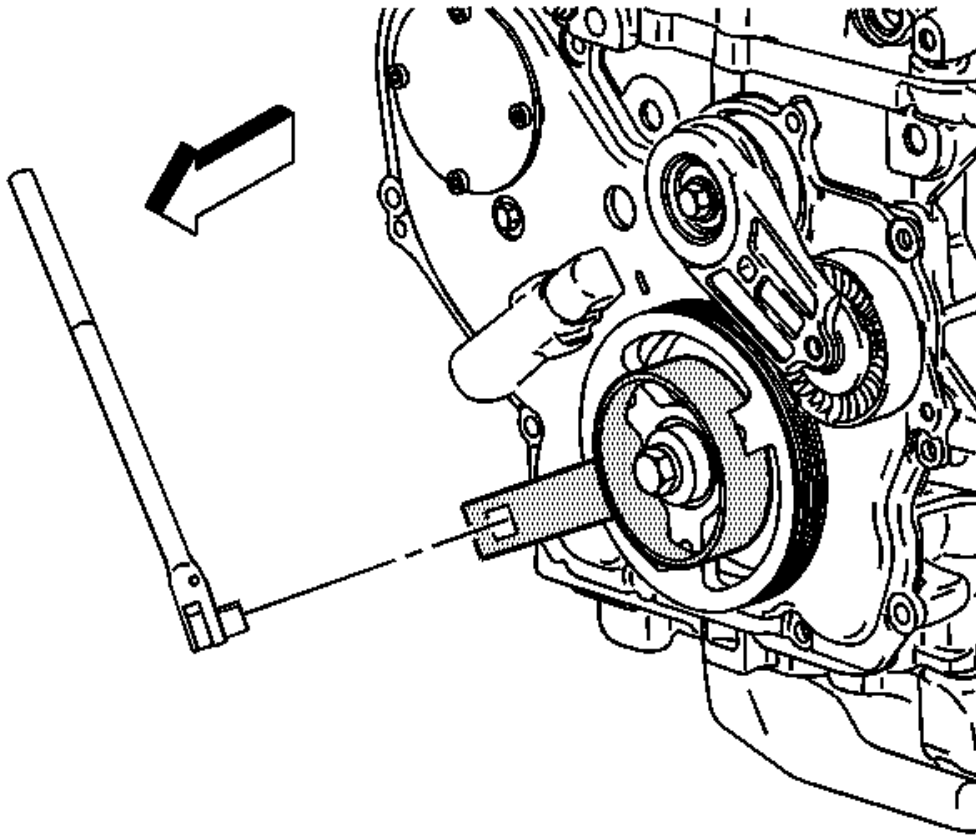


Fig. 44: Harmonic Balancer Holder
Courtesy of GENERAL MOTORS CORP.

3. Use the **EN-38122A**: holding tool to hold the crankshaft balancer in order to prevent the balancer from rotating while tightening the bolt.

CAUTION: Refer to **Fastener Caution** .

4. Tighten the crankshaft balancer bolt to 100 N.m (74 lb ft) plus an additional 125 degrees using the **EN-45059**: meter.
5. Install the drive belt. Refer to **Drive Belt Replacement**.
6. Install the power brake booster pump. Refer to **Power Brake Booster Pump Replacement (2.4L)** .
7. Install the front wheelhouse front liner. Refer to **Front Wheelhouse Front Liner Replacement** .

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

SPECIAL TOOLS

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

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

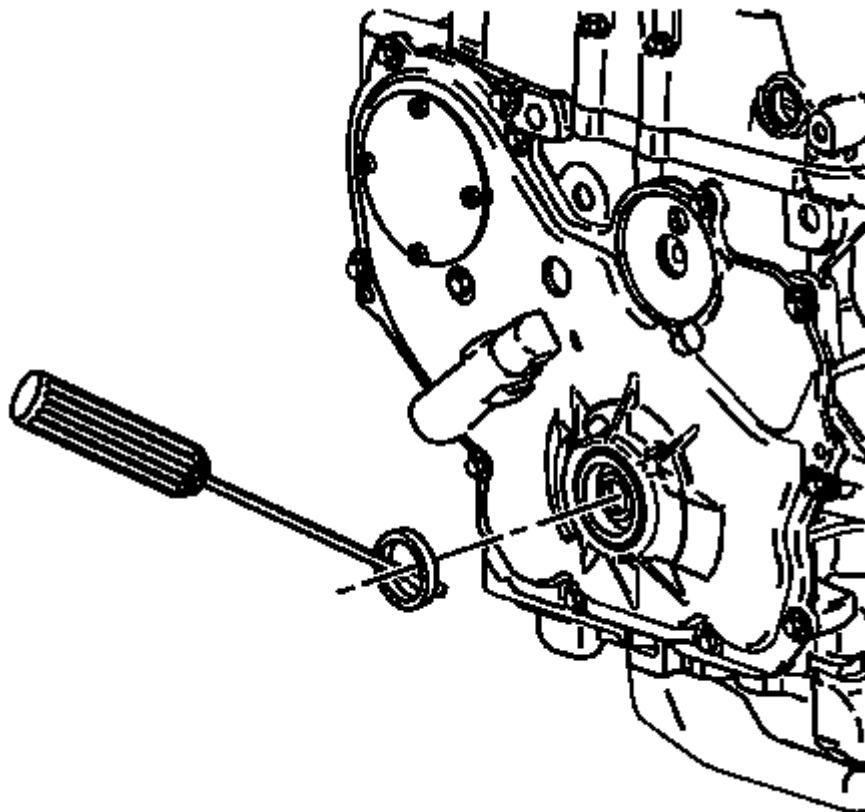
REMOVAL PROCEDURE

Fig. 45: Front Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Use a flat-bladed tool to remove the seal from the front cover.

INSTALLATION PROCEDURE

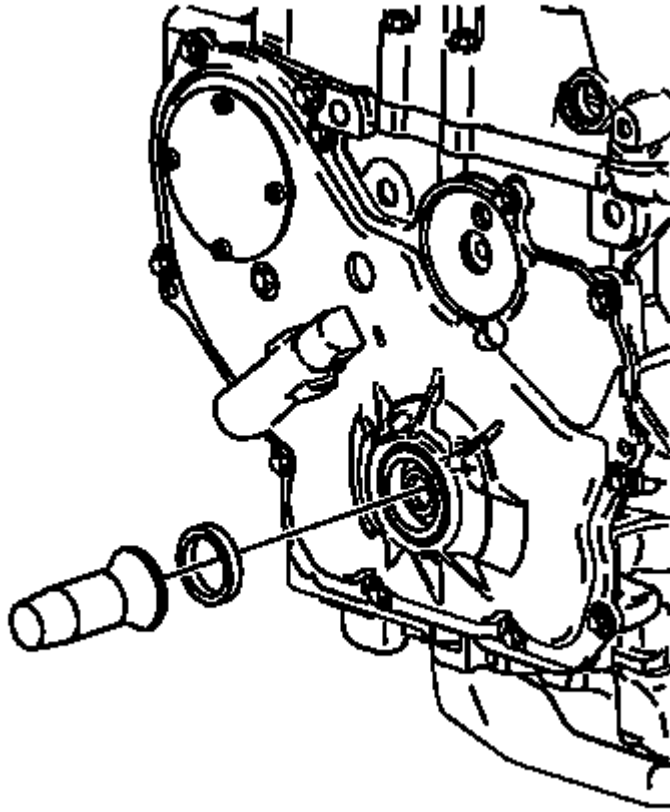


Fig. 46: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **EN-35268-A**: installer in order to install the crankshaft front oil seal to the engine front cover.
2. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

REMOVAL PROCEDURE

1. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

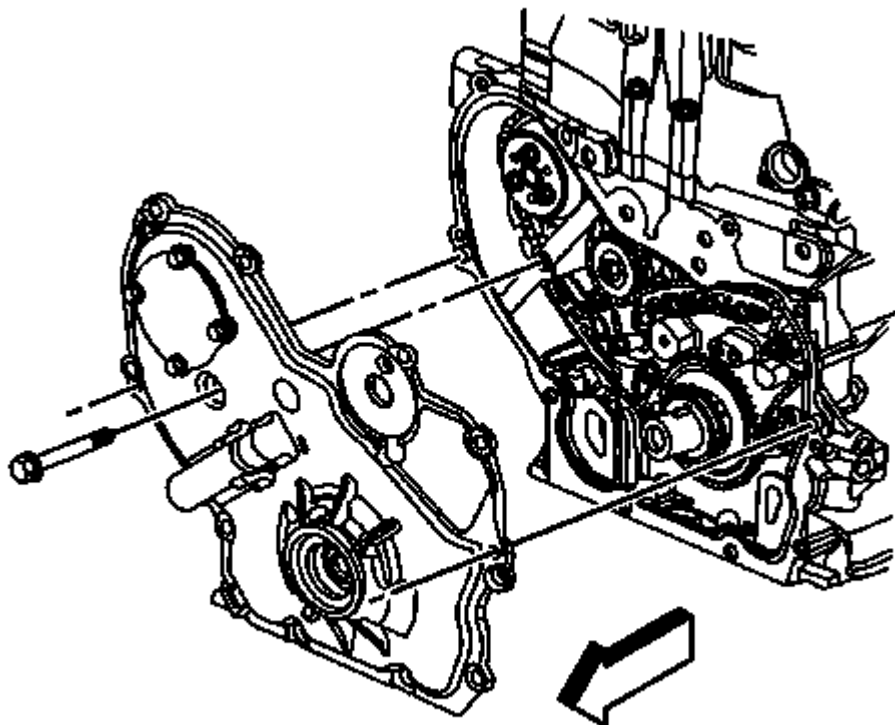


Fig. 47: Engine Front Cover

Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover to water pump bolt.

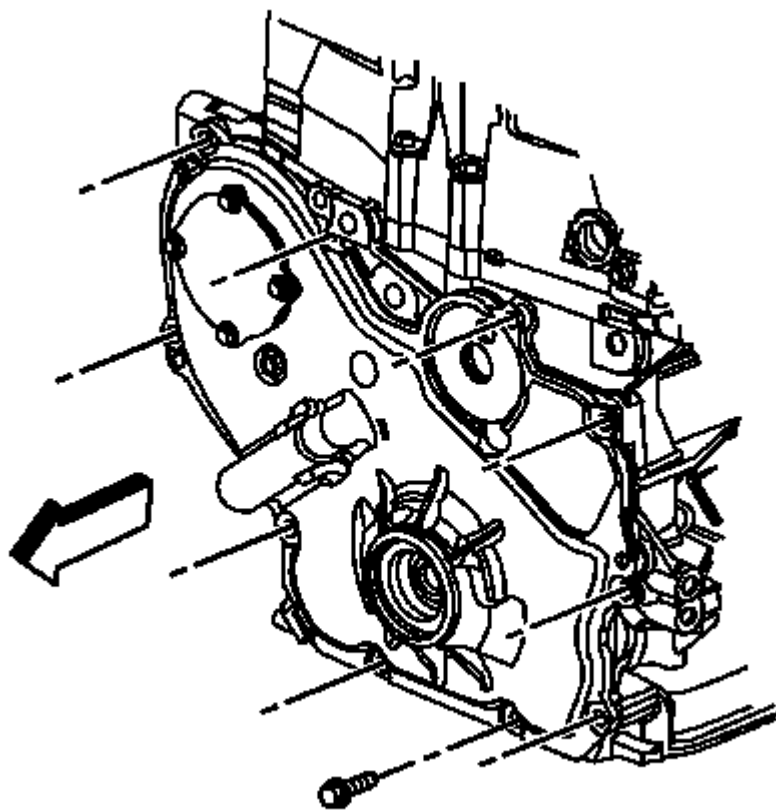


Fig. 48: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the engine front cover bolts.
6. Remove the engine front cover.

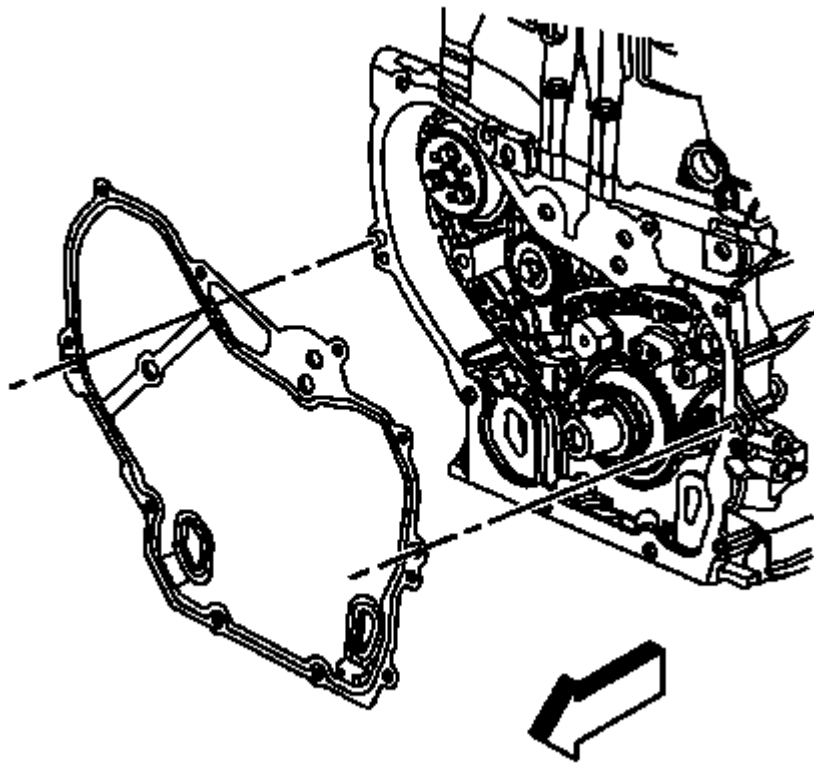


Fig. 49: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the engine front cover gasket.

INSTALLATION PROCEDURE

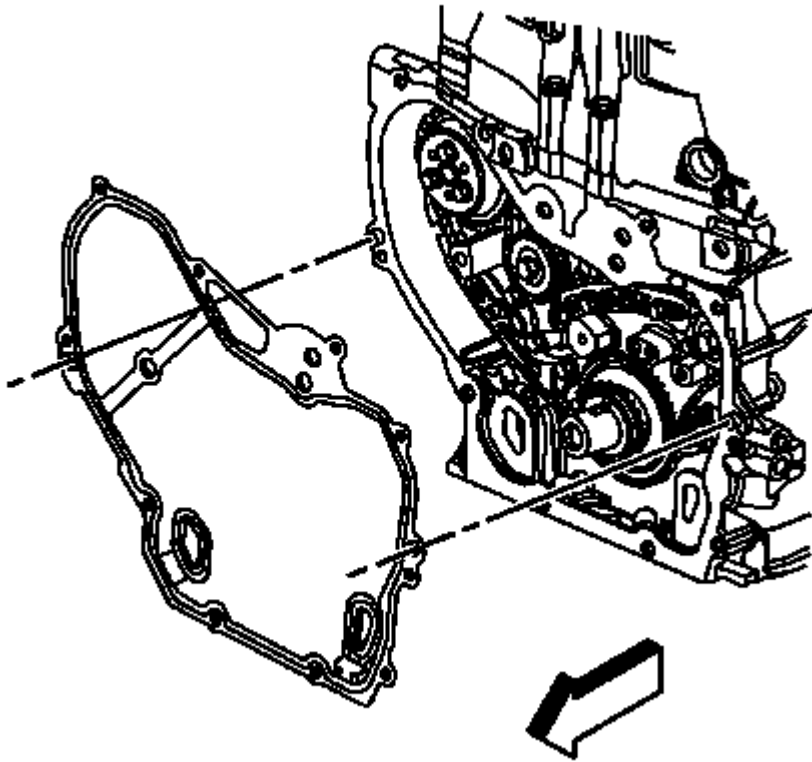


Fig. 50: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW engine front cover gasket to the dowel pins.
2. Install the engine front cover.

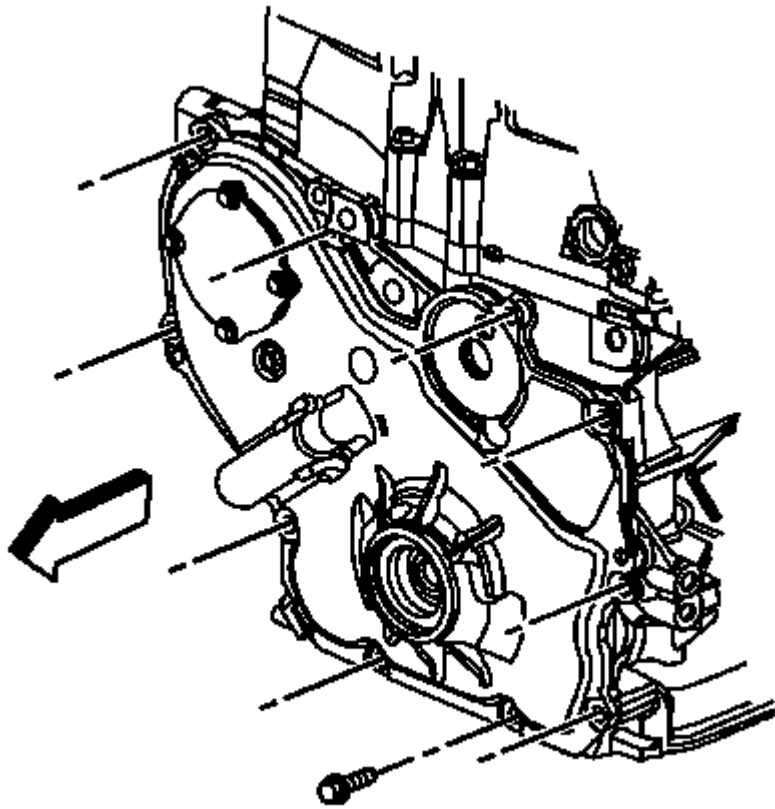


Fig. 51: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
4. Lower the vehicle.

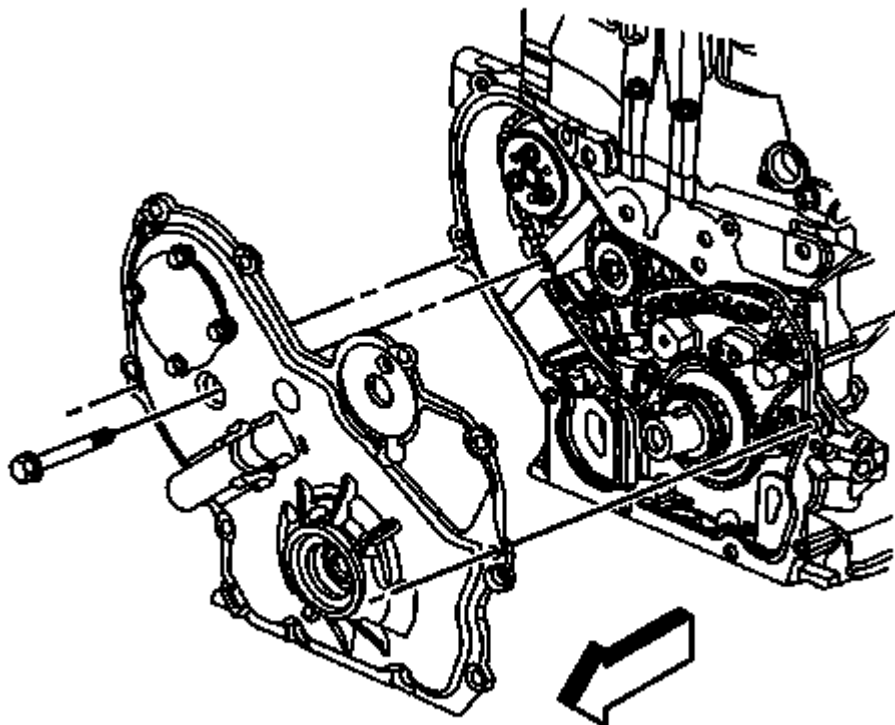


Fig. 52: Engine Front Cover

Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover to water pump bolt and tighten to 25 N.m (18 lb ft).

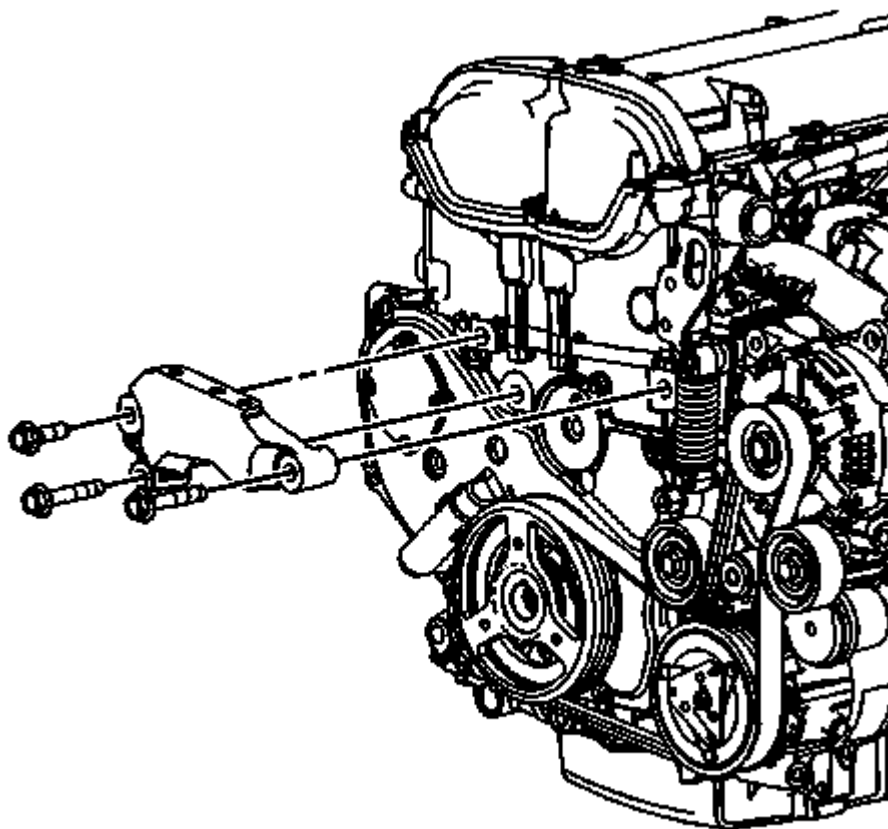


Fig. 53: Engine Mount Bracket And Engine Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
7. Install the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

SPECIAL TOOLS

- **EN-45027:** Tensioner Tool
- **EN-45059:** Angle Meter

For equivalent regional tools, refer to Special Tools .

REMOVAL PROCEDURE

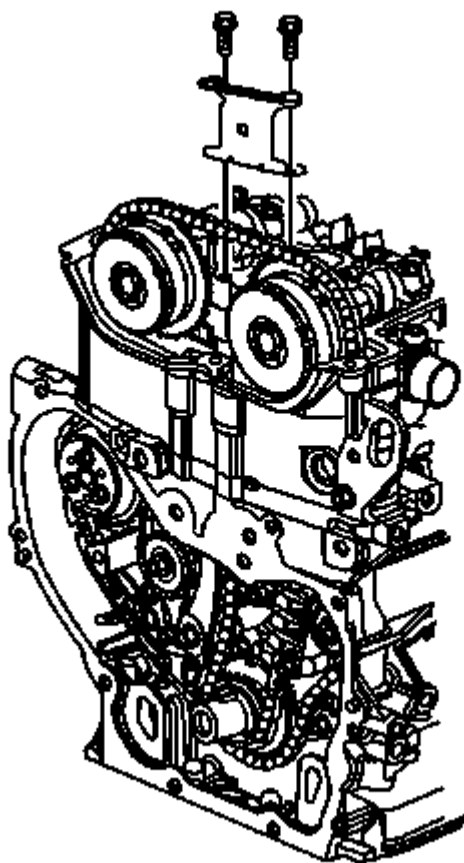


Fig. 54: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the number 1 cylinder spark plug. Refer to [Spark Plug Replacement](#) .
2. Rotate the crankshaft in the engine rotational direction clockwise, until the number 1 piston is at top dead center (TDC) on the exhaust stroke.
3. Remove the camshaft cover. Refer to [Camshaft Cover Replacement](#).
4. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).
5. Remove the upper timing chain guide bolts and guide.

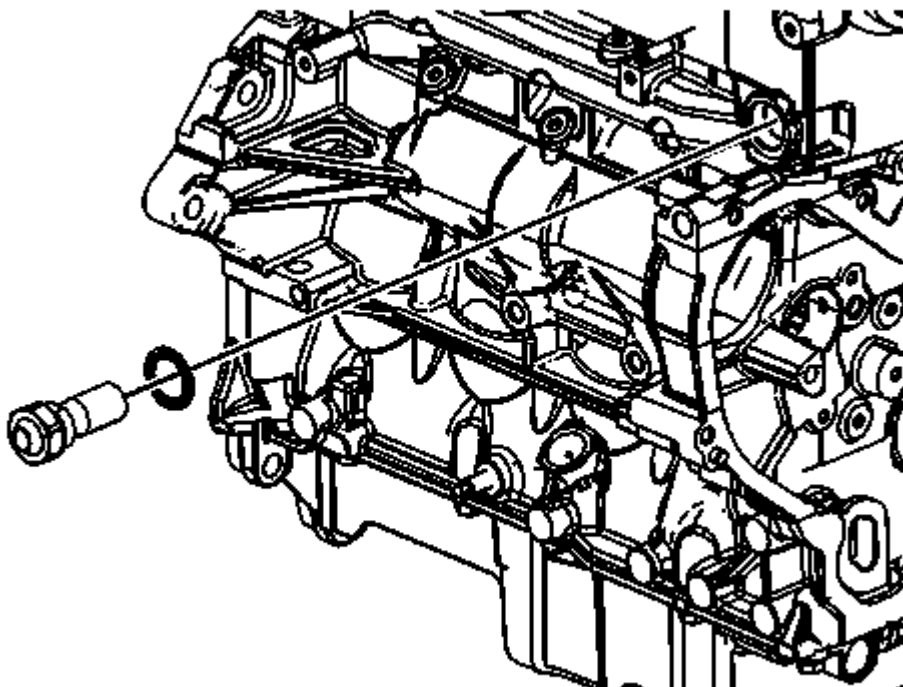


Fig. 55: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

6. Remove the timing chain tensioner.

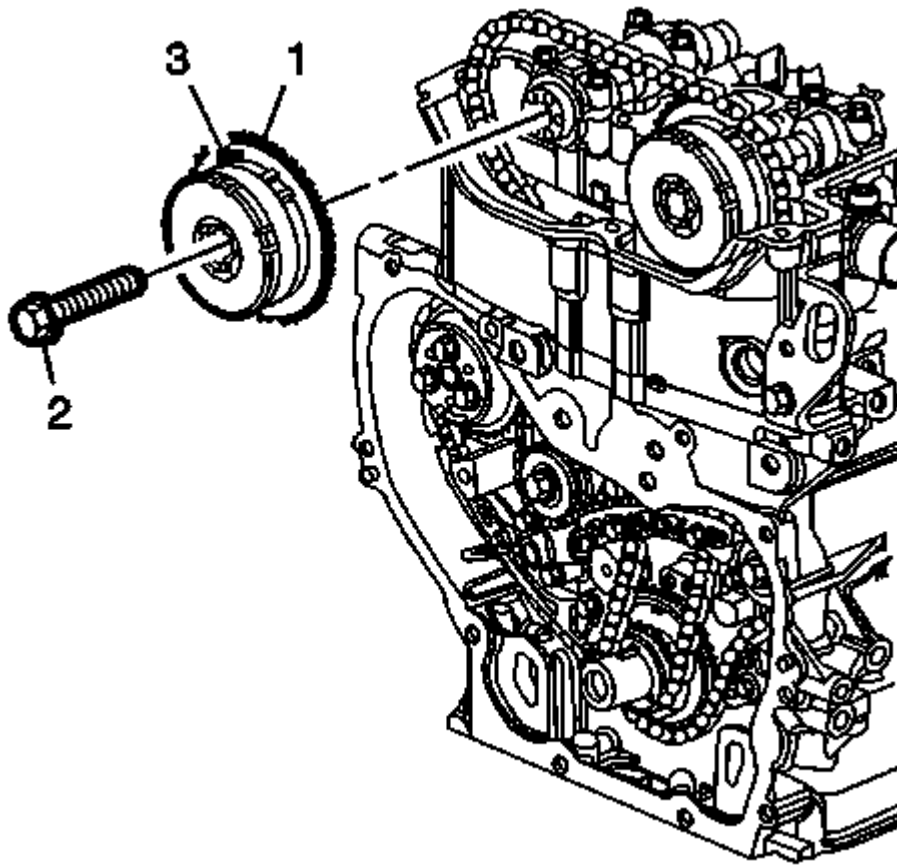


Fig. 56: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

7. Install a 24 mm wrench on the hex on the exhaust camshaft in order to hold the camshaft.
8. Remove and discard the exhaust camshaft actuator bolt (2).
9. Remove the exhaust camshaft actuator (1, 3) from the camshaft and timing chain.

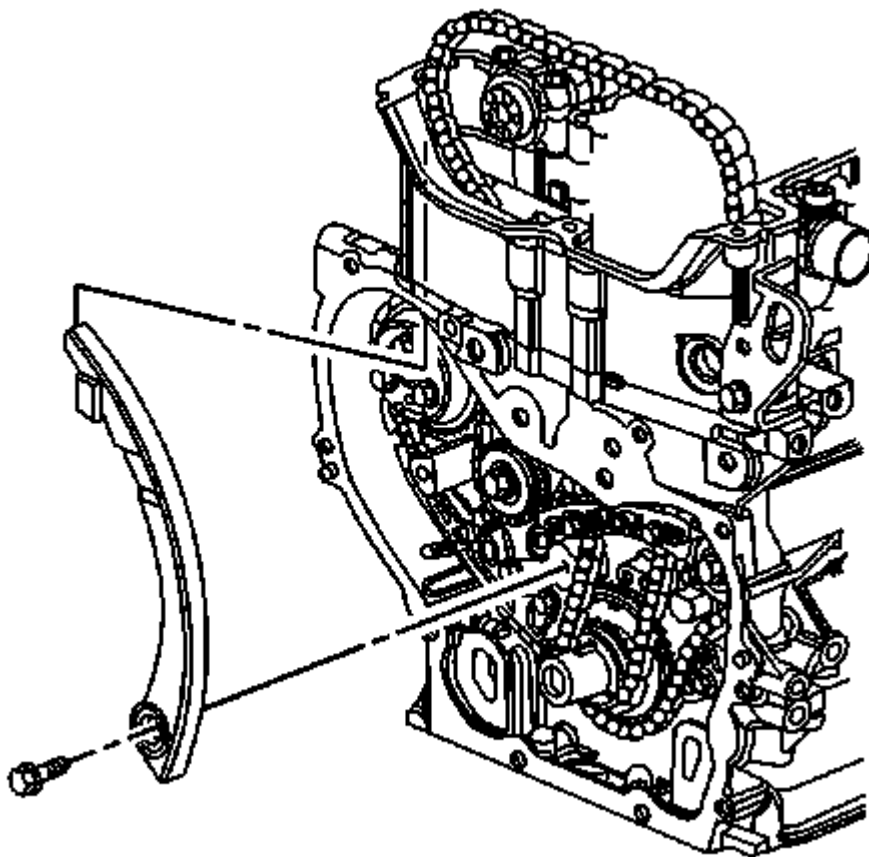


Fig. 57: Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner guide bolt and guide.

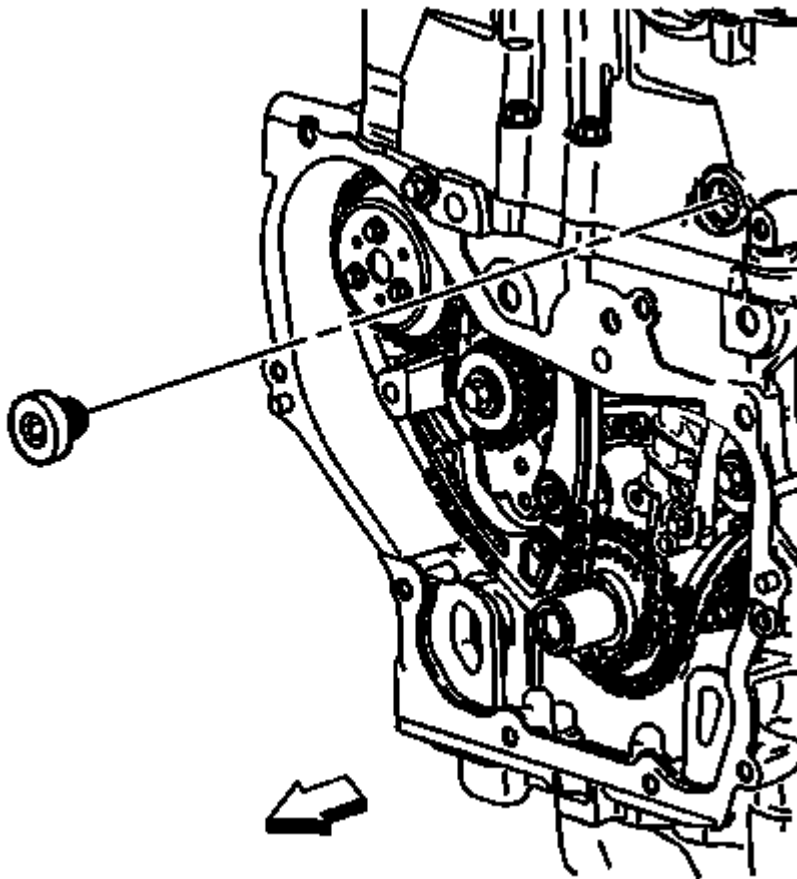


Fig. 58: Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

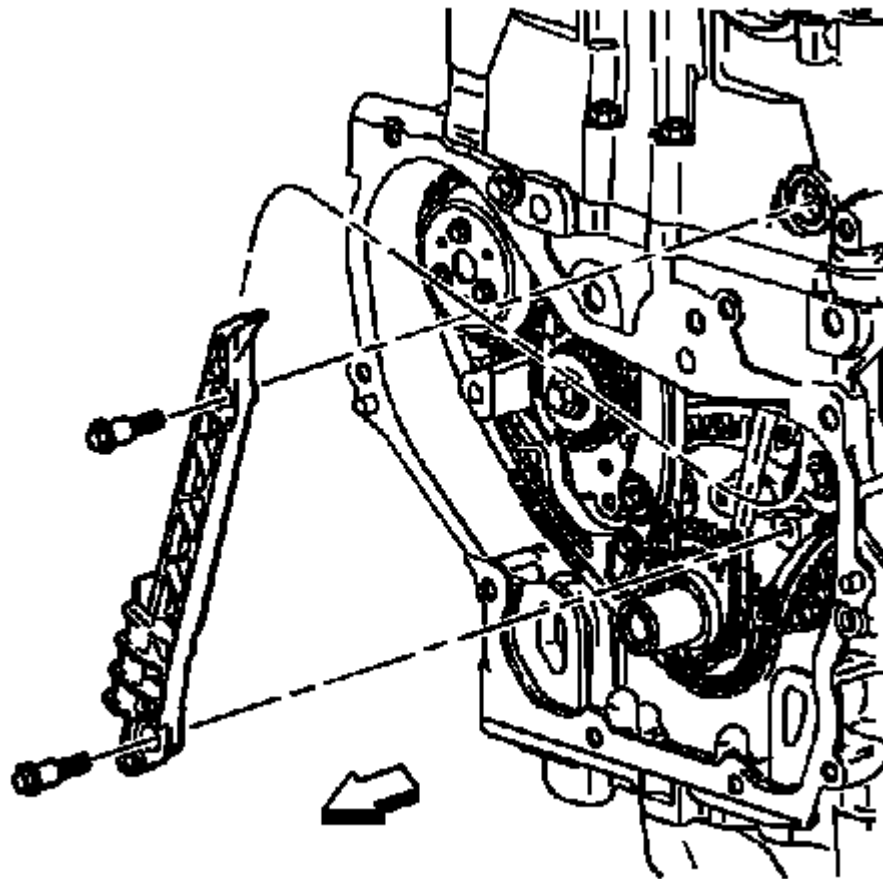


Fig. 59: Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Remove the fixed timing chain guide bolts and guide.

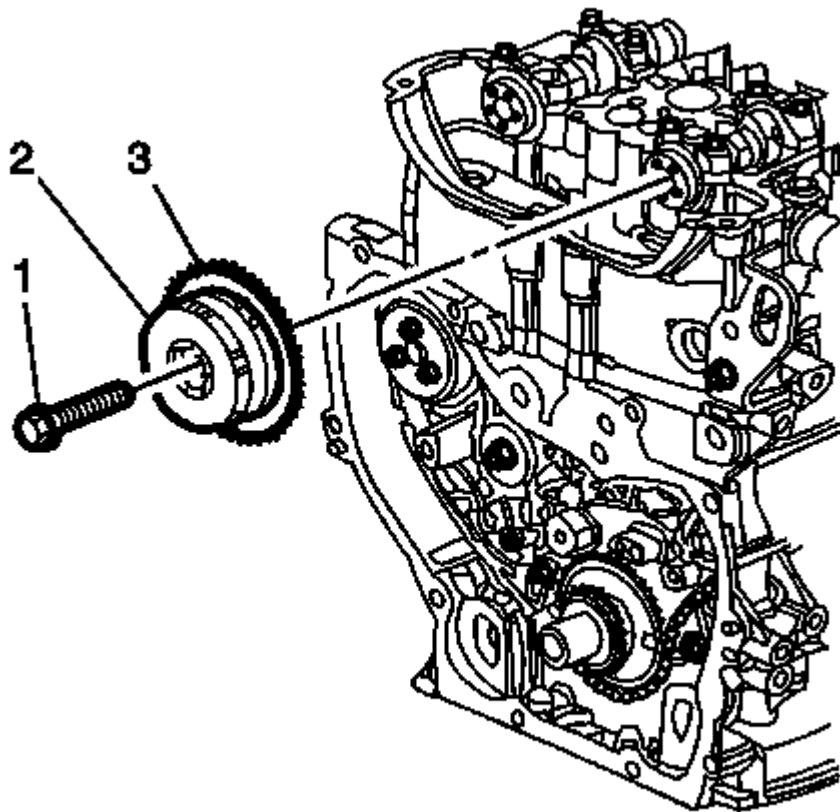


Fig. 60: Intake Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

13. Install a 24 mm wrench on the hex on the intake camshaft in order to hold the camshaft.
14. Remove and discard the intake camshaft actuator bolt (2).
15. Remove the intake camshaft actuator (3), and the timing chain through the top of the cylinder head.

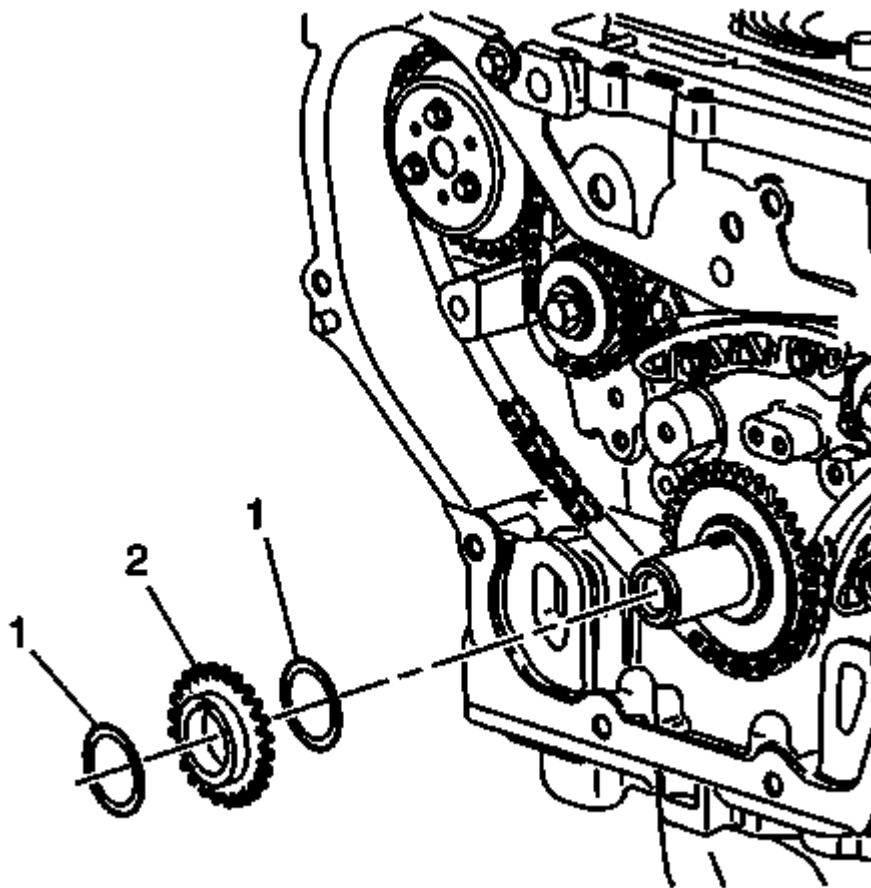


Fig. 61: Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

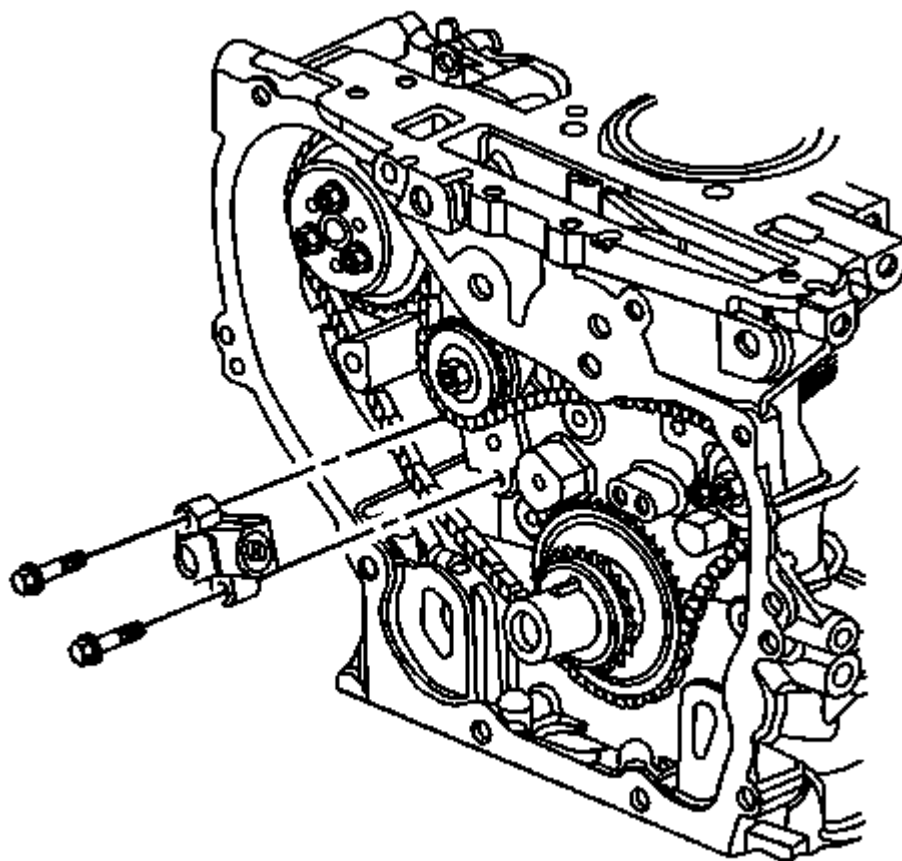


Fig. 62: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

17. If replacing the balance shaft timing chain and sprocket, perform the following steps, if not proceed to step 10 in the installation procedure.
18. Remove the balance shaft drive chain tensioner bolts and tensioner.

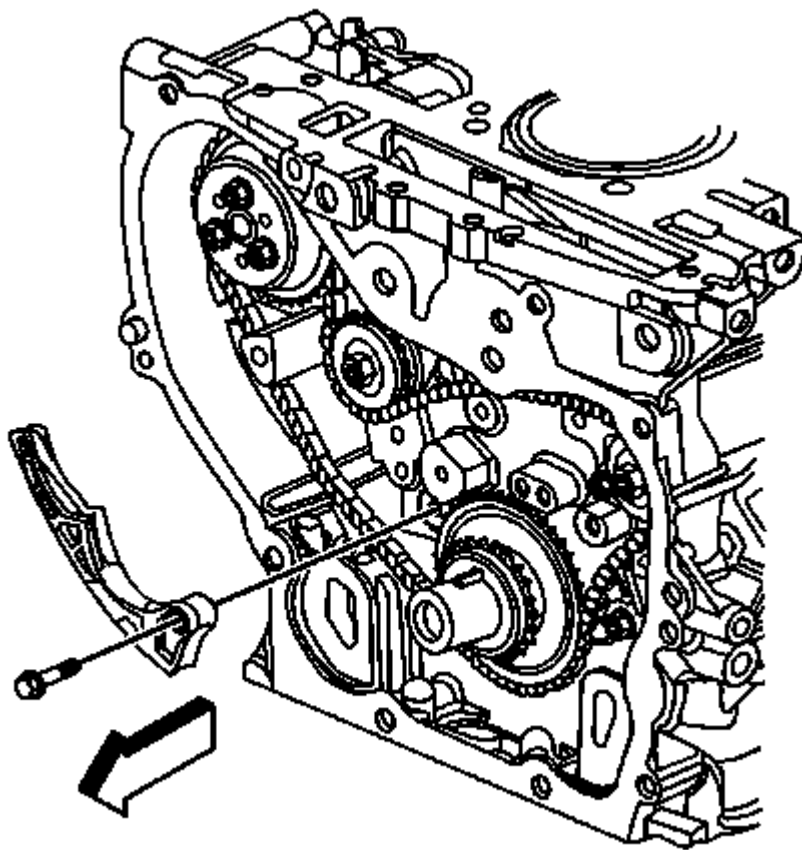


Fig. 63: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

19. Remove the adjustable balance shaft chain guide bolt and guide.

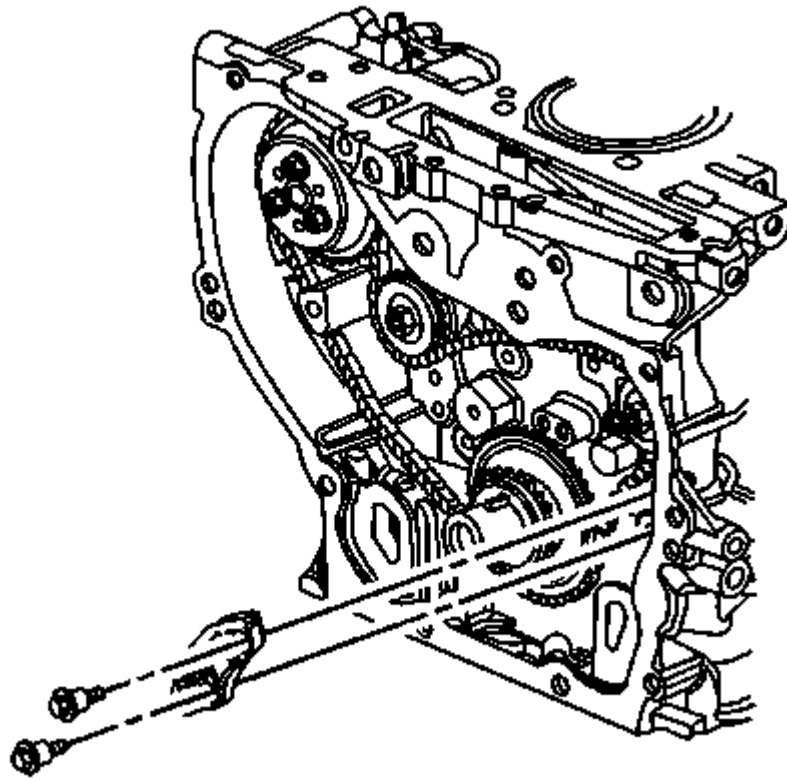


Fig. 64: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Remove the small balance shaft drive chain guide bolts and guide.

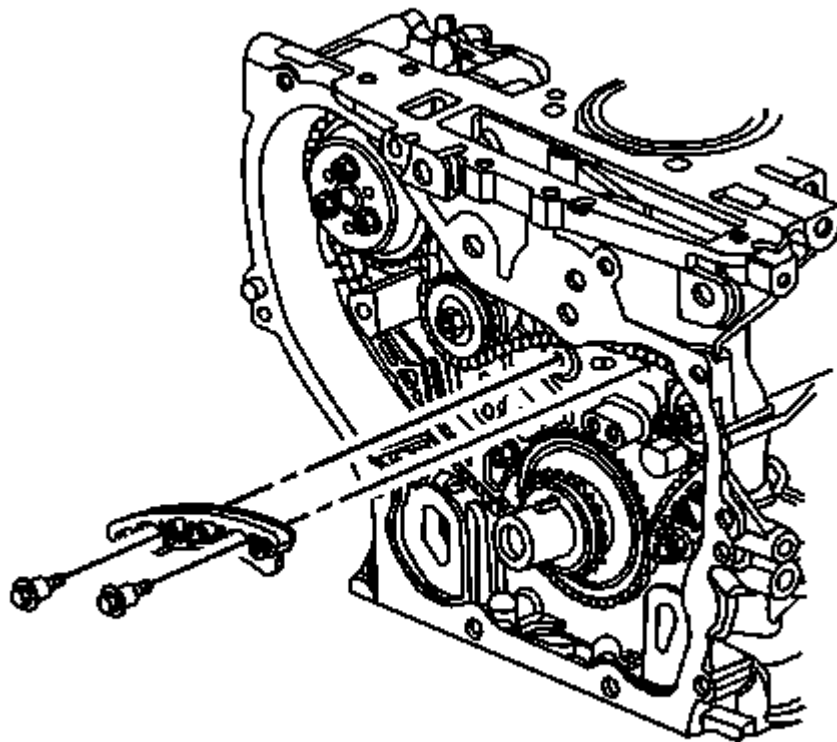


Fig. 65: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

21. Remove the upper balance shaft drive chain guide bolts and guide.

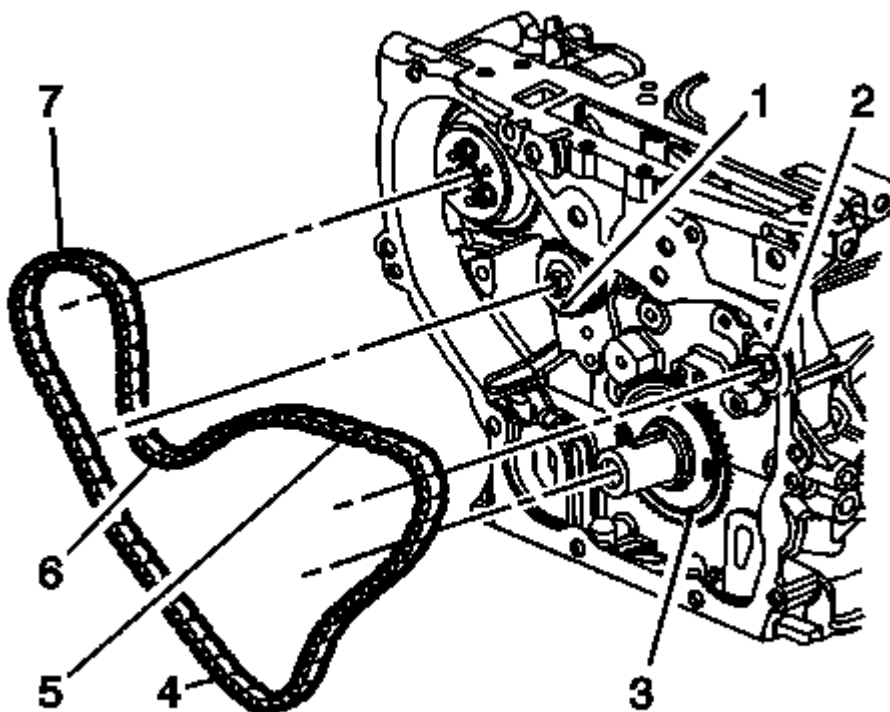


Fig. 66: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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

22. Remove the balance shaft drive chain (7).
23. Remove the balance shaft drive sprocket.

INSTALLATION PROCEDURE

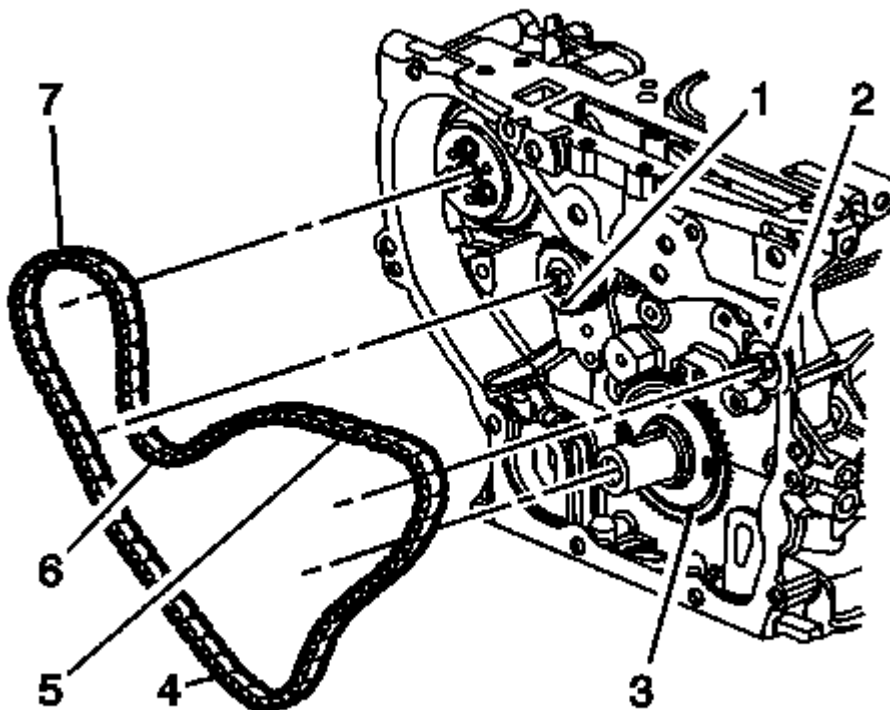


Fig. 67: Balance Shaft Drive Chain
 Courtesy of GENERAL MOTORS CORP.

1. If replacing the balance shaft timing chain, perform the following steps, if not proceed to step 10.
2. Install the balance shaft drive sprocket.

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

3. Install the balance shaft drive chain (7) with the colored link lined up with the marks on the balance shaft sprockets and the balance shaft drive sprocket. There are 3 colored links on the chain. Two are chrome and one is copper. Use the following steps in order to line up the links with the sprockets.
 1. Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft sprocket.
 2. Working clockwise around the chain, place the chrome link (4) in line with the timing mark (3) on the balance shaft drive sprocket (approximately 6 o'clock position on the sprocket).
 3. Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
 4. Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

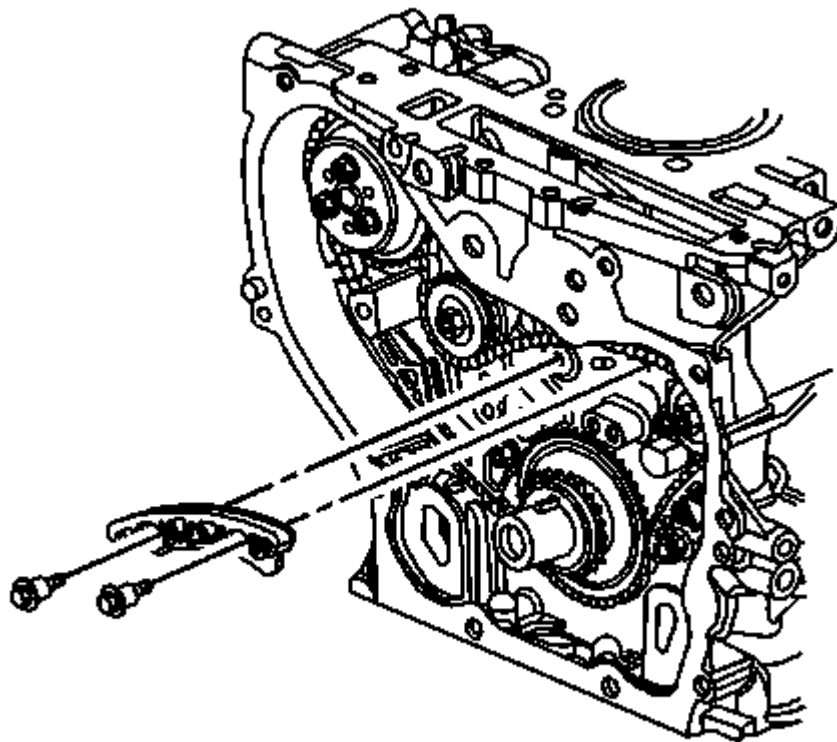


Fig. 68: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the upper balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

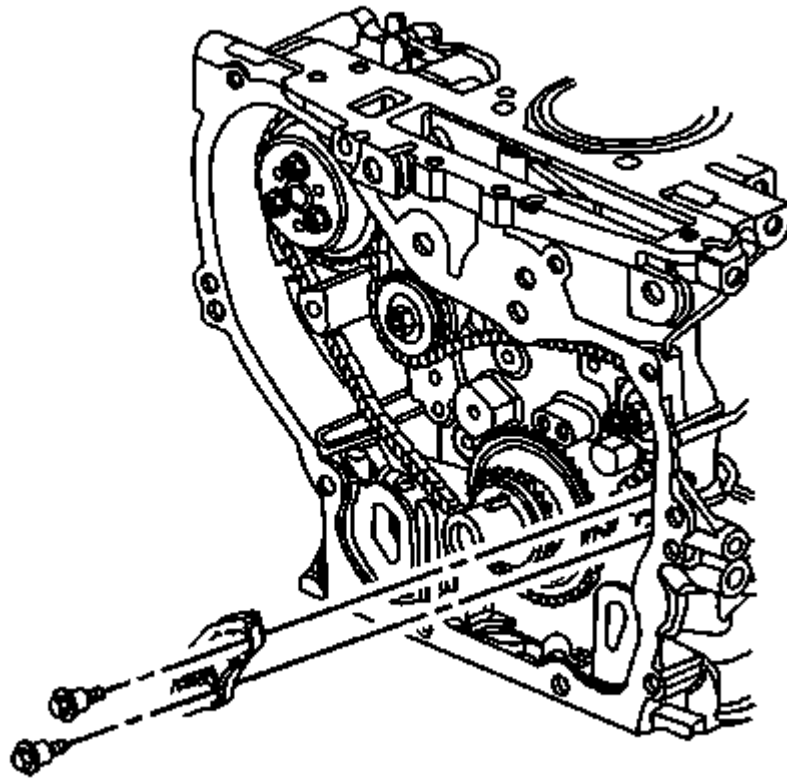


Fig. 69: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

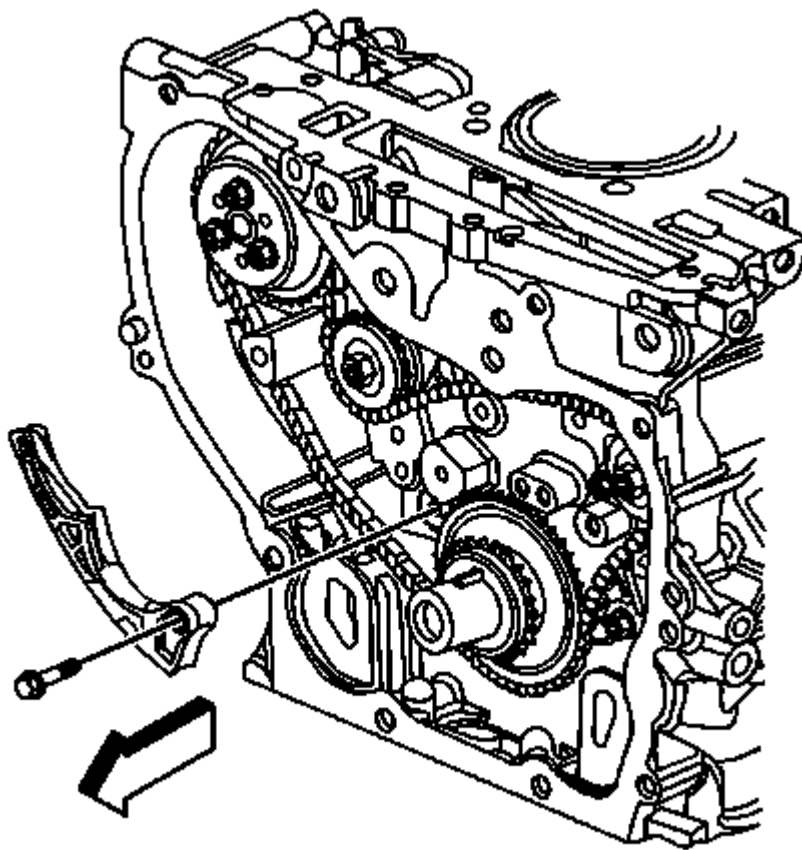


Fig. 70: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt and tighten to 10 N.m (89 lb in).

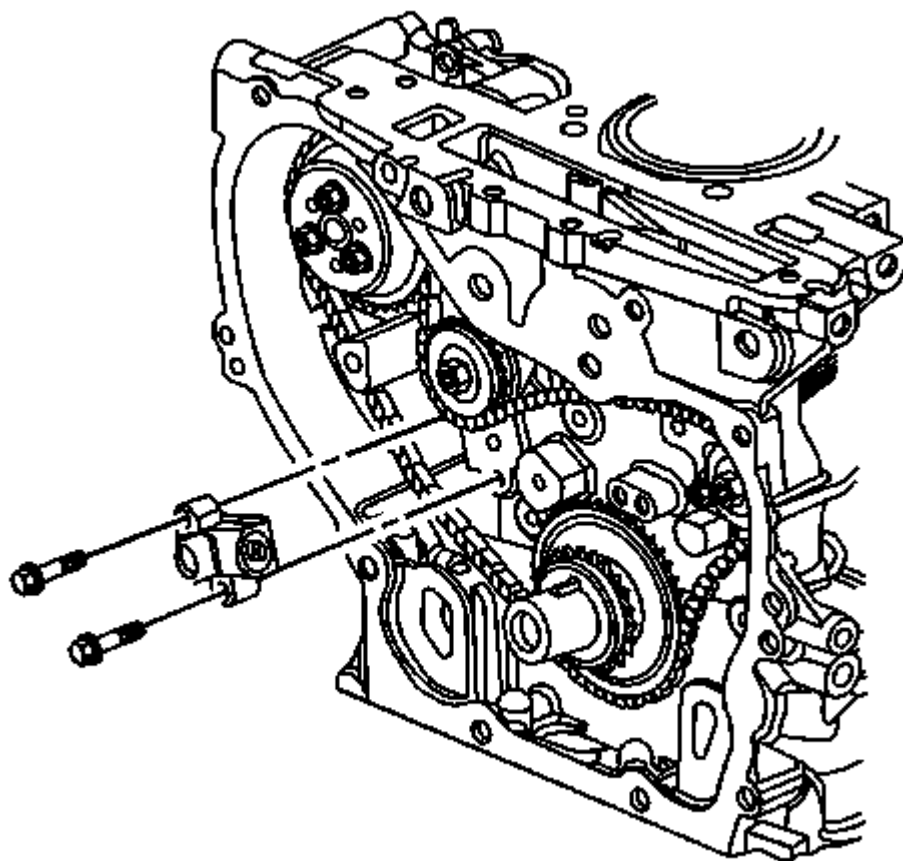


Fig. 71: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

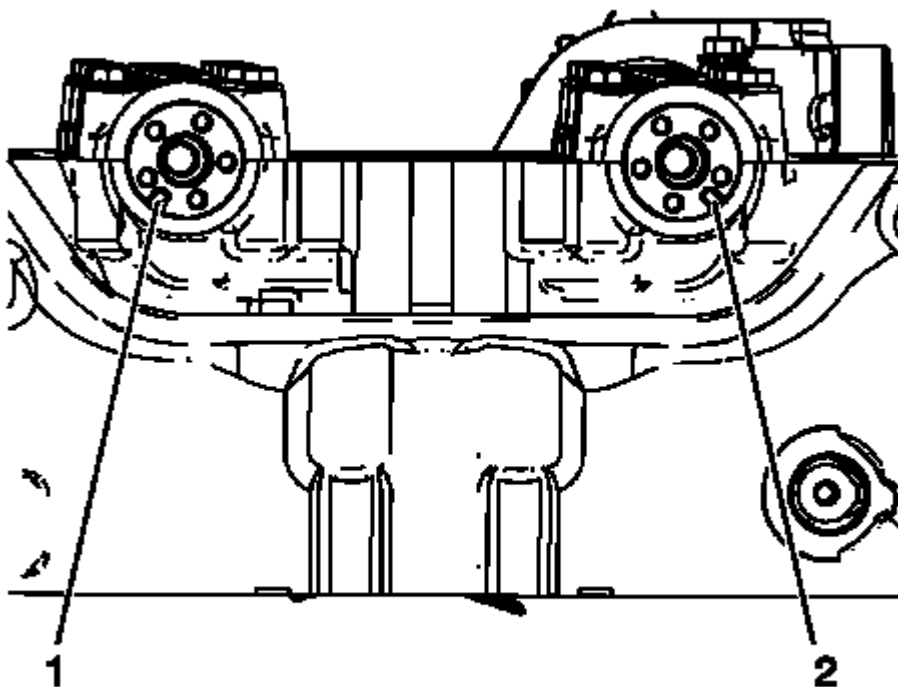


Fig. 72: Proper Exhaust/Intake Camshaft Alignment Positions
Courtesy of GENERAL MOTORS CORP.

10. Ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

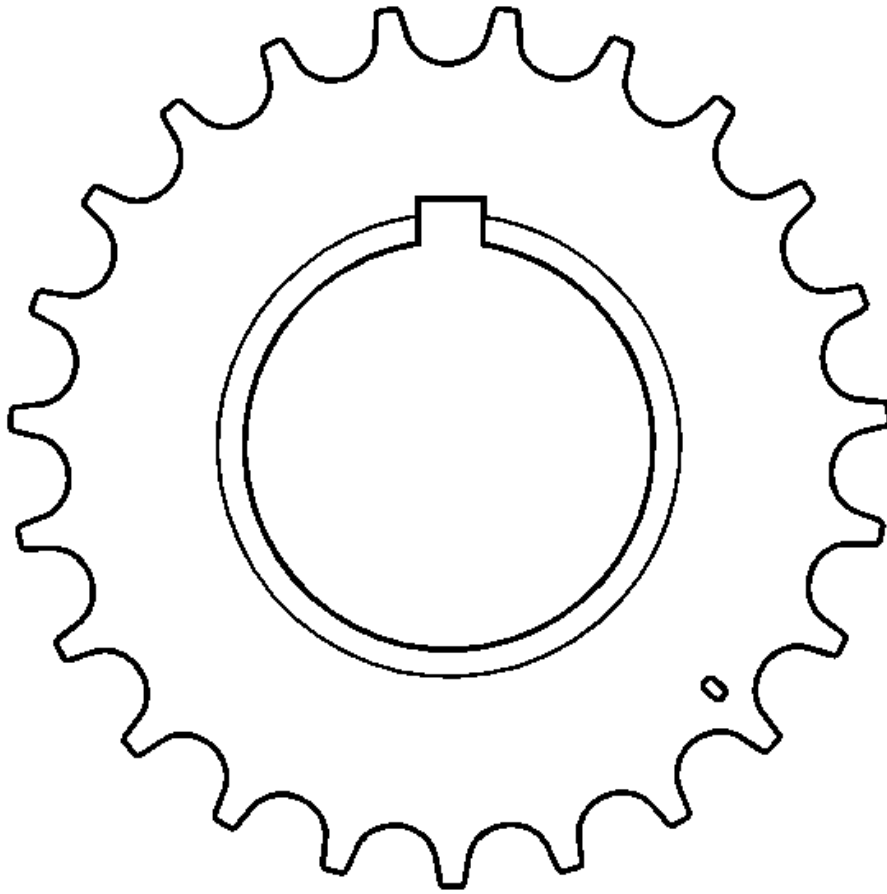


Fig. 73: Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

11. Install the friction washer, if applicable.
12. Install the timing chain drive sprocket to the crankshaft with the timing mark in the 5 o'clock position and the front of the sprocket facing.

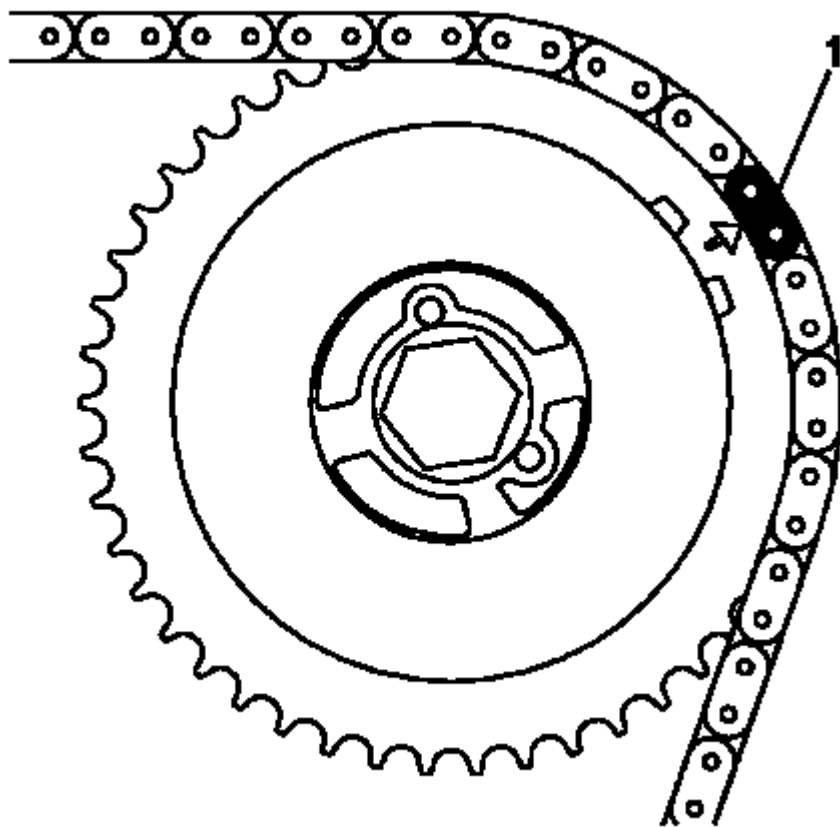


Fig. 74: Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE:

- There are 3 colored links on the timing chain. Two links are of matching color, and 1 link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.
- Always use new actuator bolts.

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

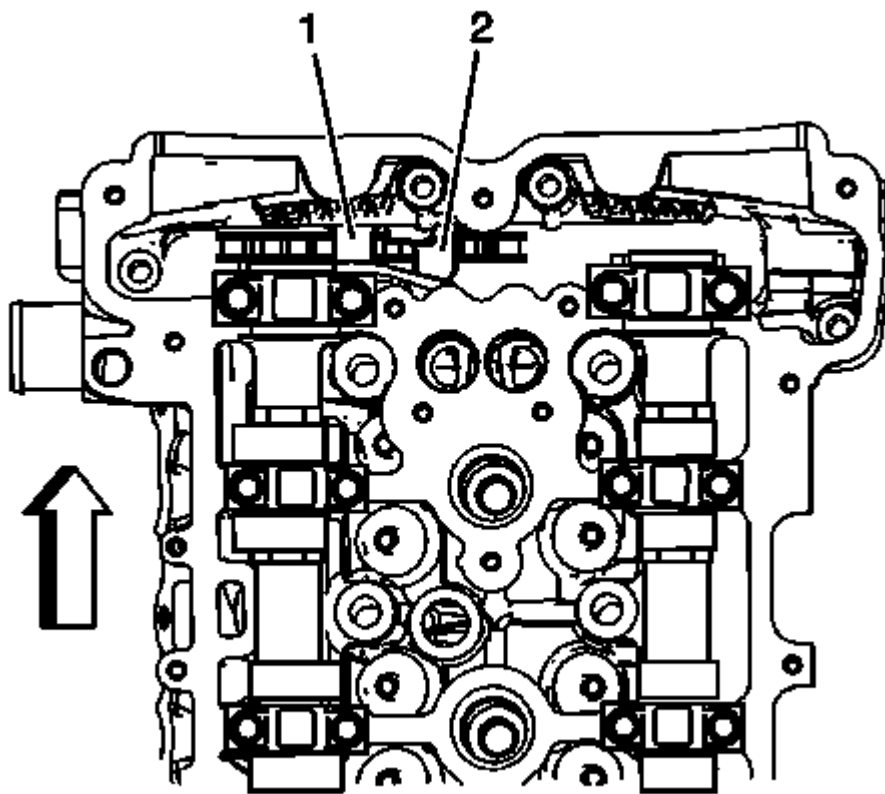


Fig. 75: Cylinder Block Bosses

Courtesy of GENERAL MOTORS CORP.

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

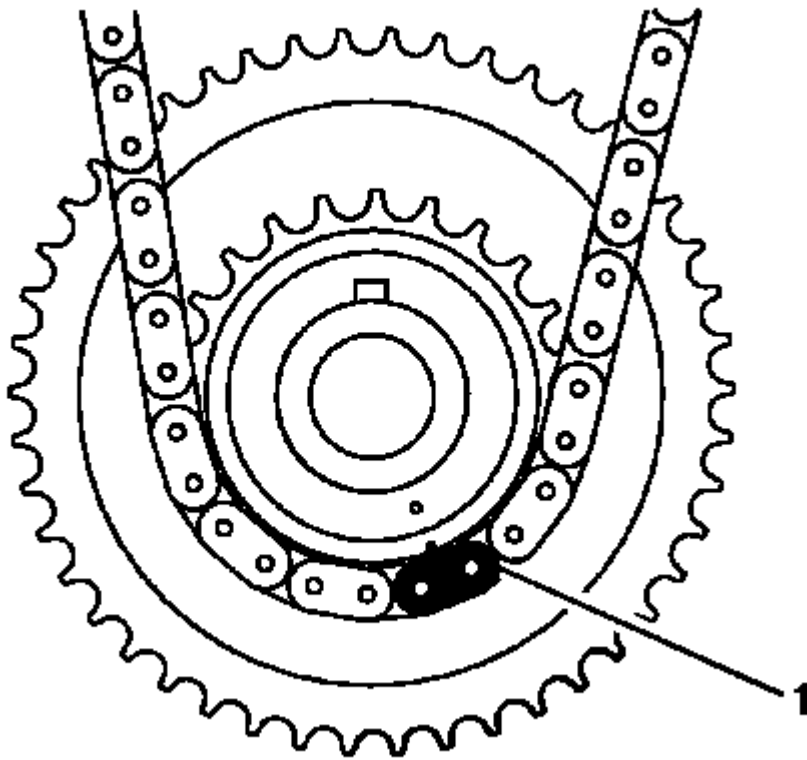


Fig. 76: Lining Up Colored Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

17. Route the timing chain around the crankshaft sprocket and line up the first matching colored link with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.
18. Install the friction washer, if applicable.

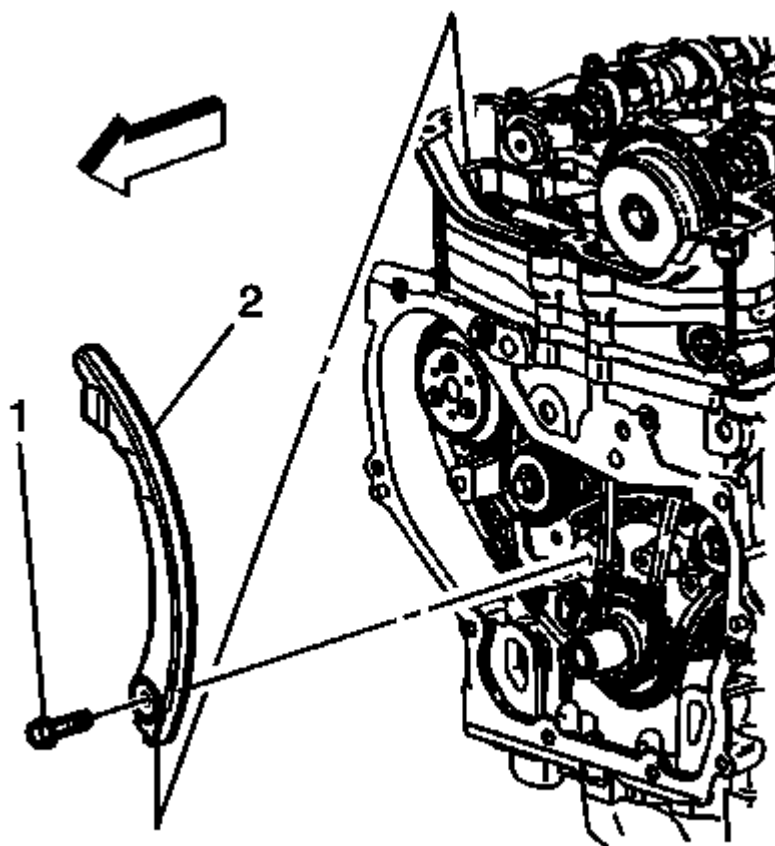


Fig. 77: Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

19. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.
20. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt. Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

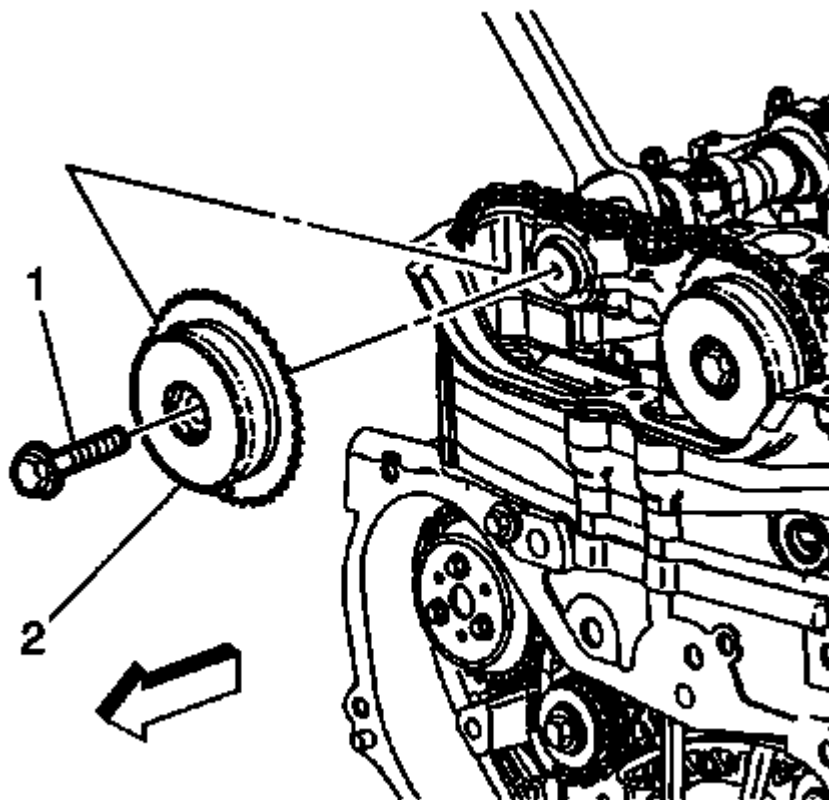


Fig. 78: Camshaft Actuator

Courtesy of GENERAL MOTORS CORP.

NOTE: Always install NEW actuator bolts.

21. Install the exhaust camshaft actuator into the timing chain with the timing mark lined up with the second matching colored link.

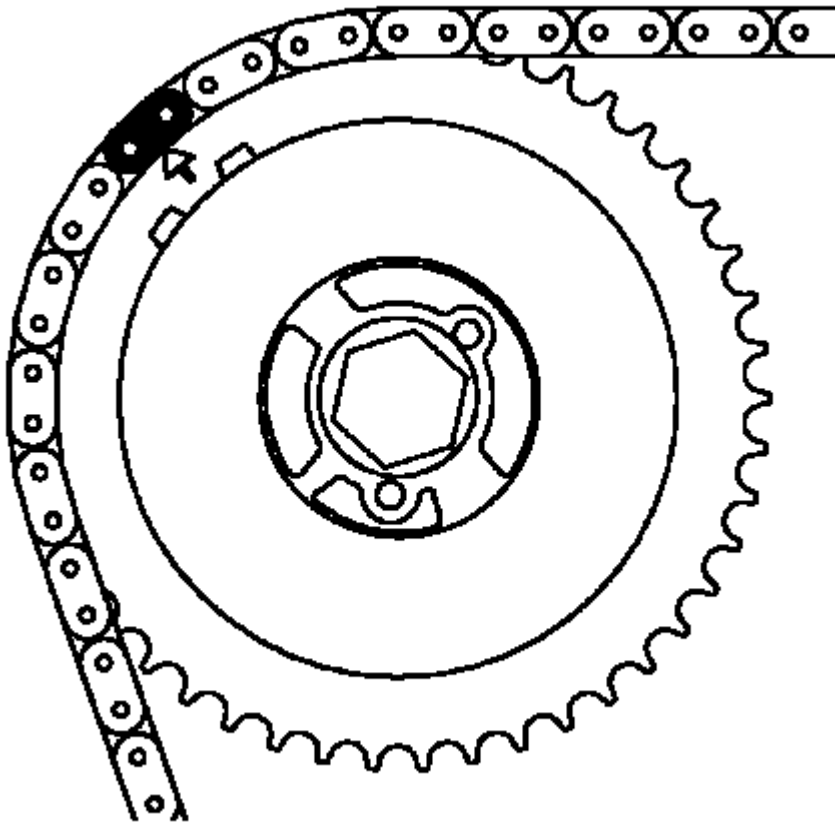


Fig. 79: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

22. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
23. Use 24 mm open ended wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

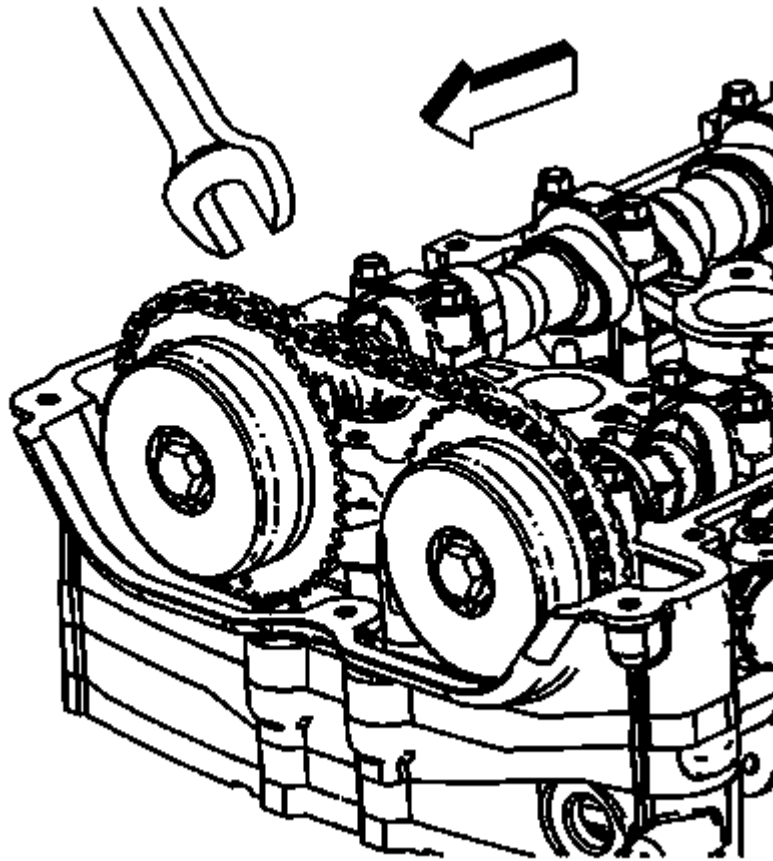


Fig. 80: Rotating Camshaft

Courtesy of GENERAL MOTORS CORP.

24. When the actuator seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.

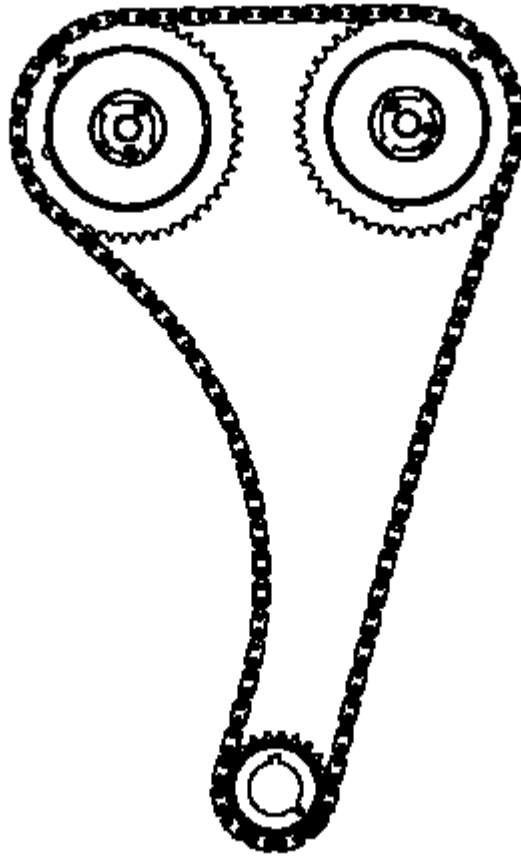


Fig. 81: Chain And Sprockets

Courtesy of GENERAL MOTORS CORP.

25. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not aligned, repeat the portion of the procedure necessary to align the timing marks.

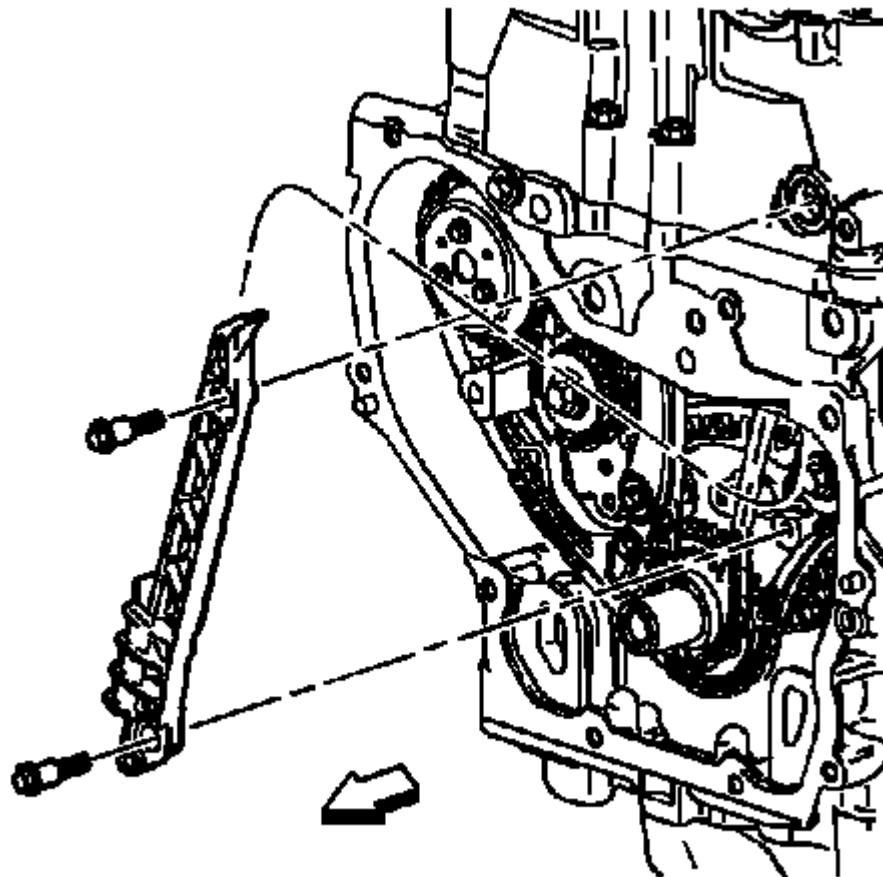


Fig. 82: Fixed Timing Chain Guide

Courtesy of GENERAL MOTORS CORP.

26. Install the fixed timing chain guide and bolts. Tighten the fixed timing chain guide bolts to 12 N.m (106 lb in).

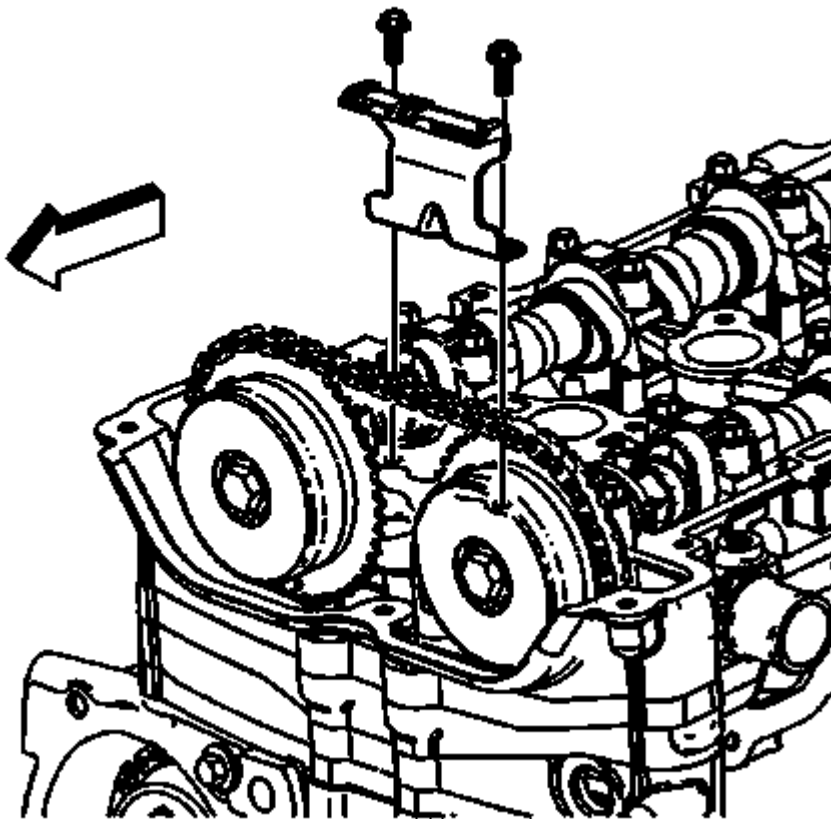


Fig. 83: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

27. Install the upper timing chain guide and bolts. Tighten the upper timing chain guide bolts to 10 N.m (89 lb in).

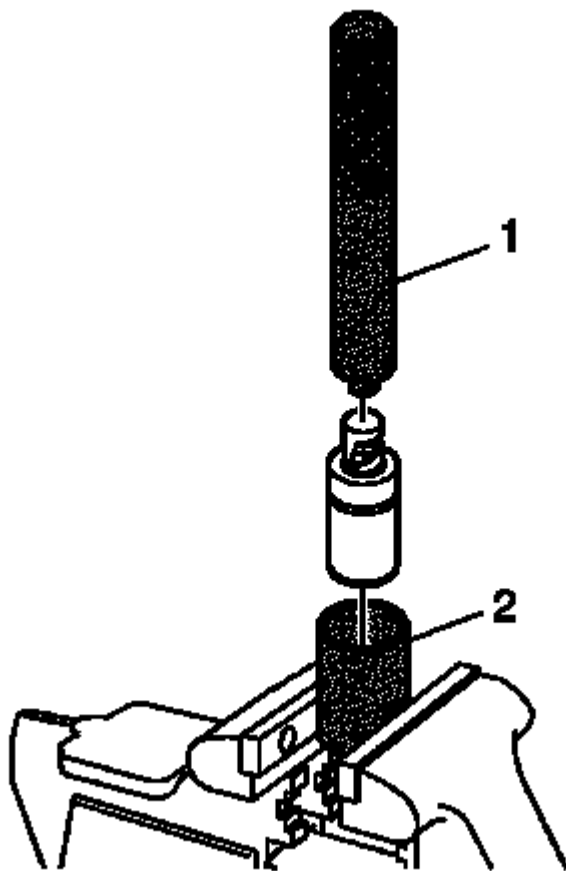


Fig. 84: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

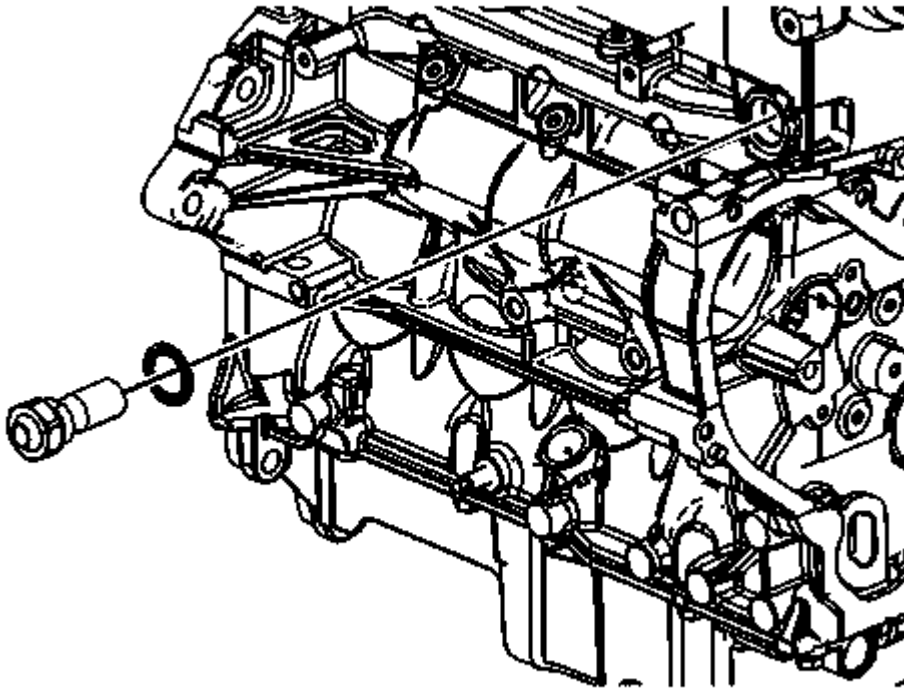


Fig. 85: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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

31. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
32. The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.

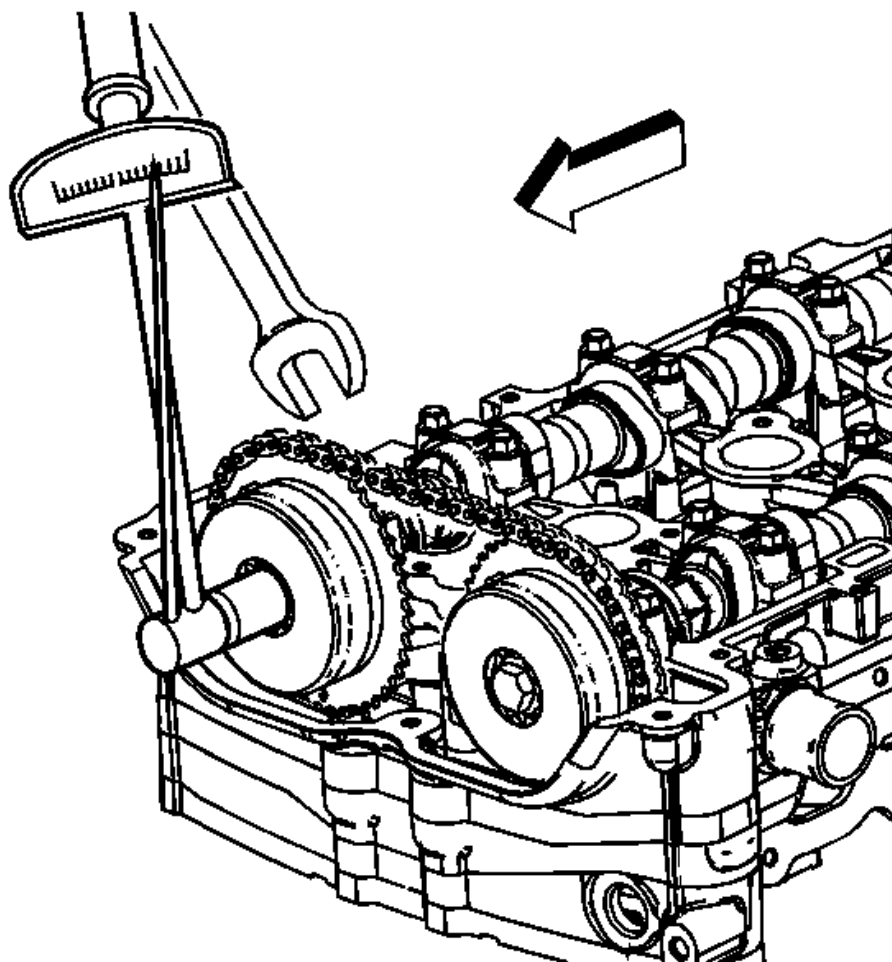


Fig. 86: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

33. Using a 24 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059**: meter.
34. Using a 24 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059**: meter.

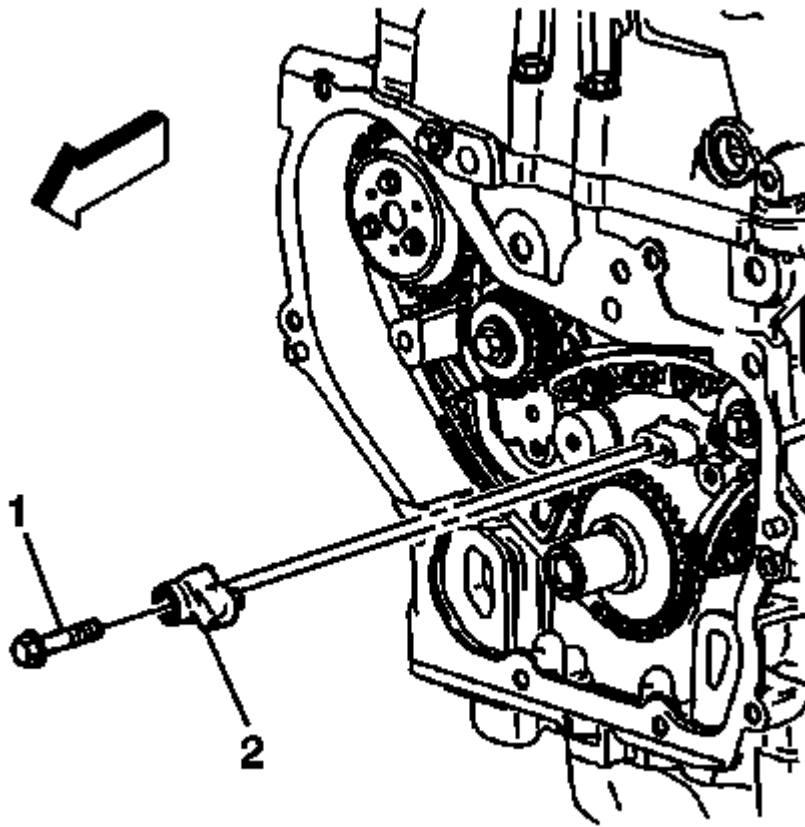


Fig. 87: Timing Chain Oiling Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

35. Install the timing chain oiling nozzle. Tighten the timing chain oiling nozzle bolt to 10 N.m (89 lb in).

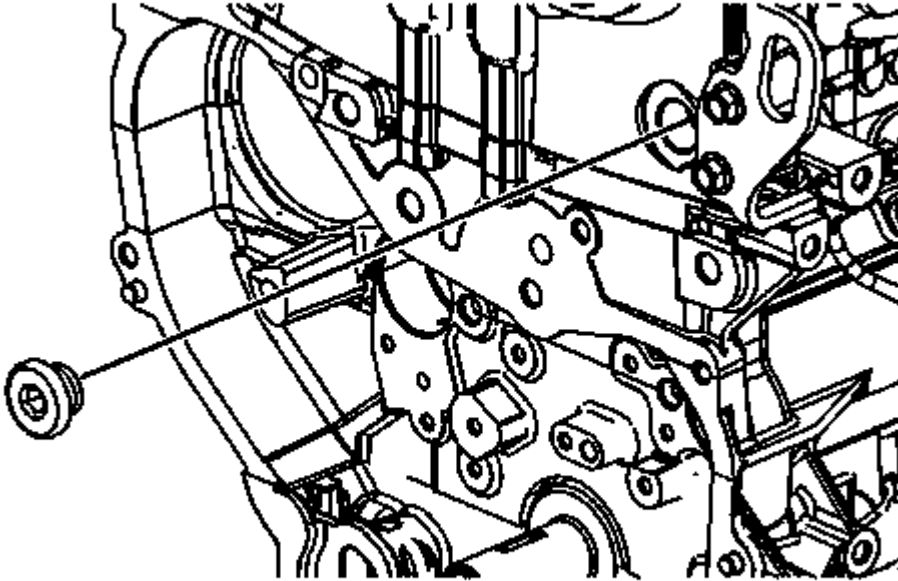
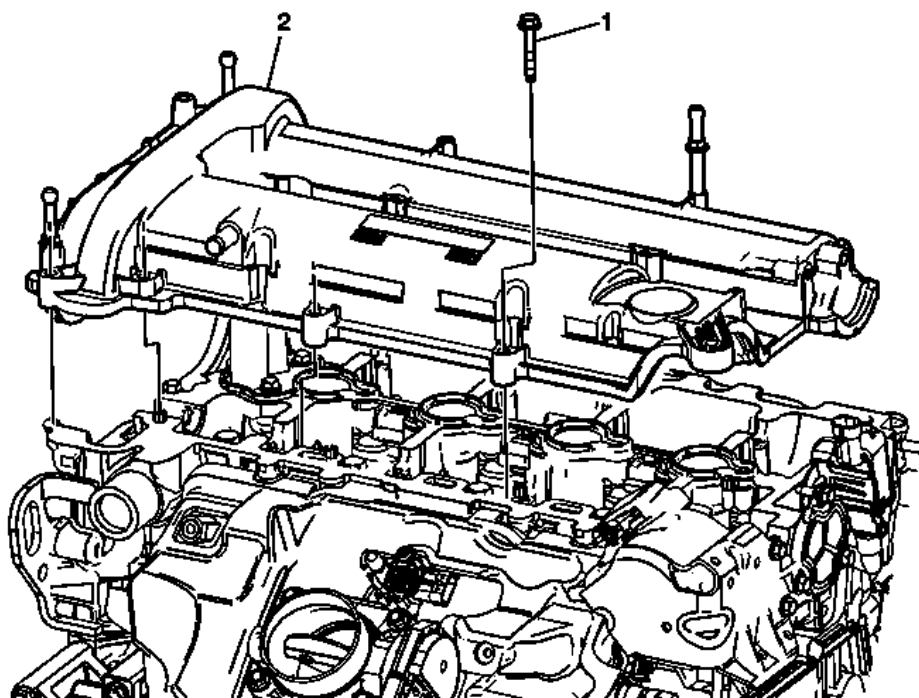


Fig. 88: Timing Chain Guide Bolt Access Hole Plug
Courtesy of GENERAL MOTORS CORP.

36. Apply sealant compound to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** for the recommended sealant.
37. Install the timing chain guide bolt access hole plug. Tighten the access hole plug to 90 N.m (66 lb ft).
38. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
39. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
40. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement**.

CAMSHAFT COVER REPLACEMENT

**Fig. 89: Camshaft Cover**

Courtesy of GENERAL MOTORS CORP.

Callous	Component Name
Preliminary Procedures 1. Remove the air cleaner outlet duct. Refer to <u>Air Cleaner Outlet Duct Replacement</u> . 2. Remove the ignition coils. Refer to <u>Ignition Coil Replacement (LE5, LE9, or LAF)</u> . 3. Remove the Camshaft Position Sensor intake. Refer to <u>Camshaft Position Sensor Replacement - Intake (LE5, LE9, or LAF)</u> 4. Remove the Camshaft Position Sensor Exhaust. Refer to <u>Camshaft Position Sensor Replacement - Exhaust (LE5, LE9 or LAF)</u>	
1	Camshaft Cover Fastener (Qty: 11) CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 10 N.m (89 lb in)
2	Camshaft Cover Procedure 1. Do not reuse camshaft gasket. Also use a new gasket when removing or replacing camshaft cover.

2. Remove ignition coil wiring harness clips from the camshaft cover.
3. Remove the fuel line bracket from the camshaft cover.
4. Transfer components as necessary.

TIMING CHAIN TENSIONER REPLACEMENT

SPECIAL TOOLS

EN-45027: Tensioner Tool

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

REMOVAL PROCEDURE

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

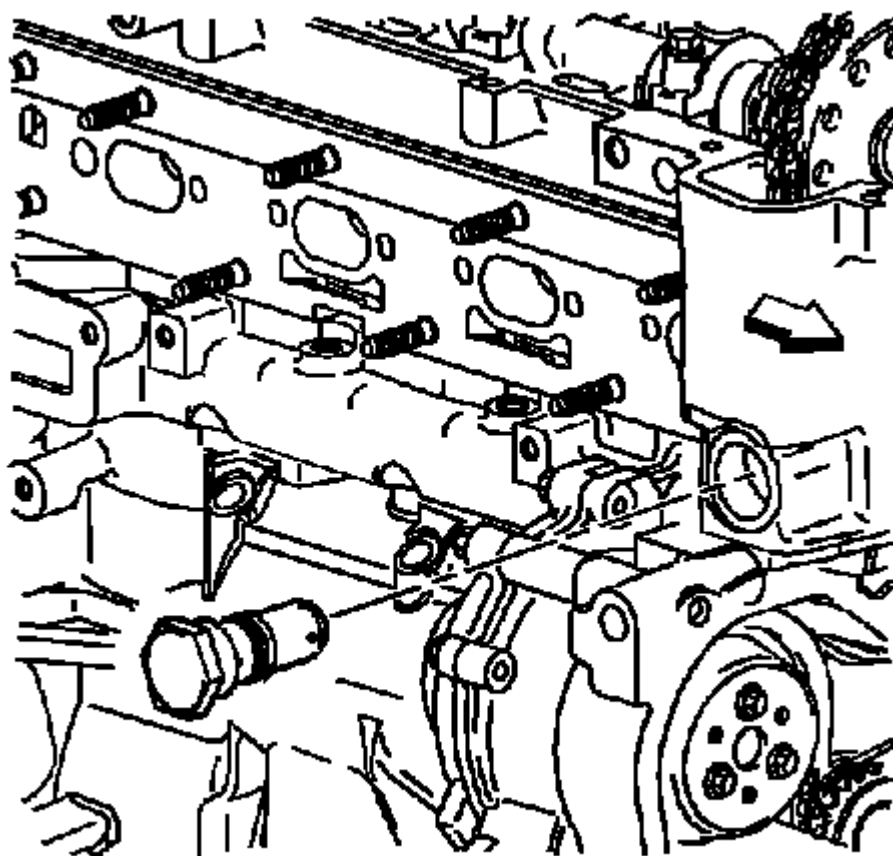


Fig. 90: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain tensioner.
4. Remove the seal from the tensioner.

INSTALLATION PROCEDURE

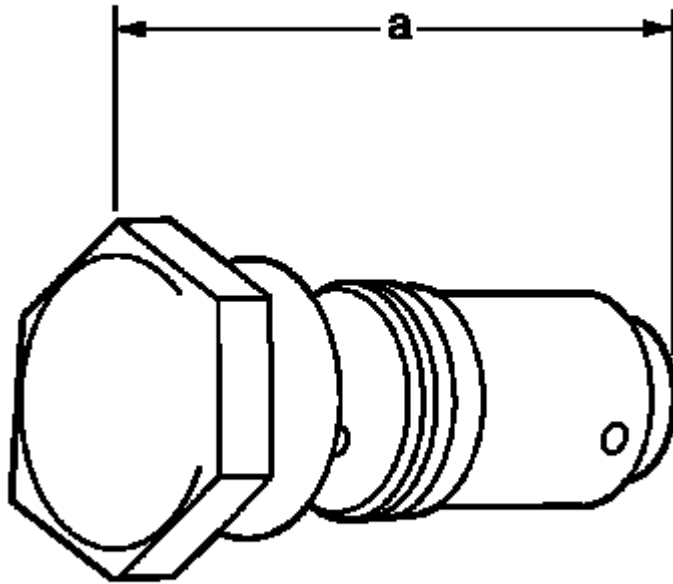


Fig. 91: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner or O-ring seal as applicable.
2. Measure the timing chain tensioner assembly from end to end. If the timing chain tensioner is to be replaced, a new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

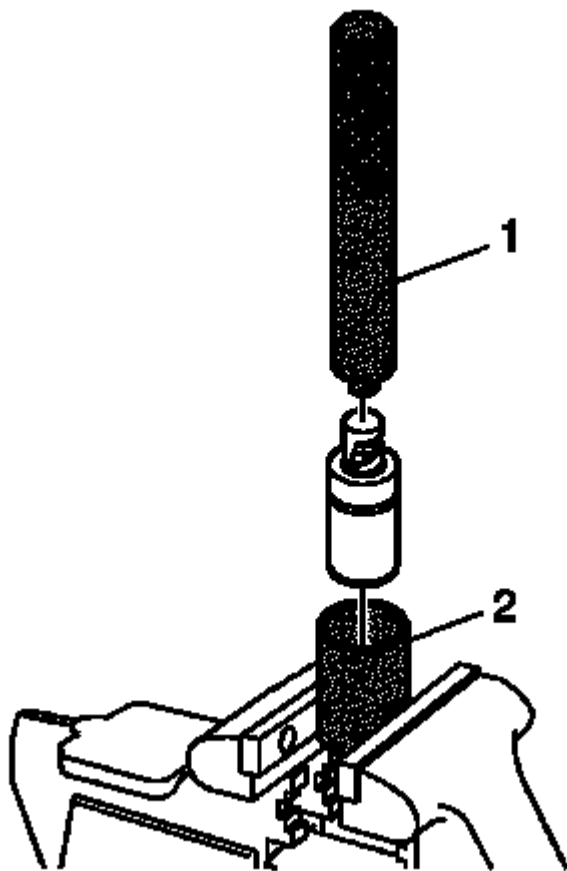


Fig. 92: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. If the timing chain tensioner is not in the compressed state, perform the following steps:
 1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
 2. Install the **EN-45027-2:** tool (2) into a vise.
 3. Install the notch end of the piston assembly into the **EN-45027-2:** tool (2).
 4. Using the **EN-45027-1:** tool (1), turn the ratchet cylinder into the piston.

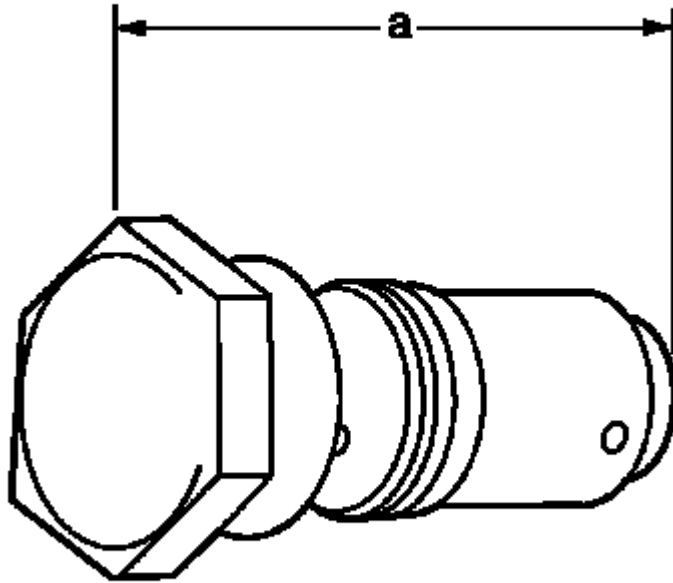


Fig. 93: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

4. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris out with a lint-free cloth.
5. Install the compressed piston assembly back into the timing chain tensioner body until it stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, it will activate the tensioner, which will then need to be reset again.
6. At this point the tensioner should measure approximately 72 mm (2.83 in) (a) from end to end. If the tensioner does not read 72 mm (2.83 in) (a) from end to end, repeat steps 3-5.

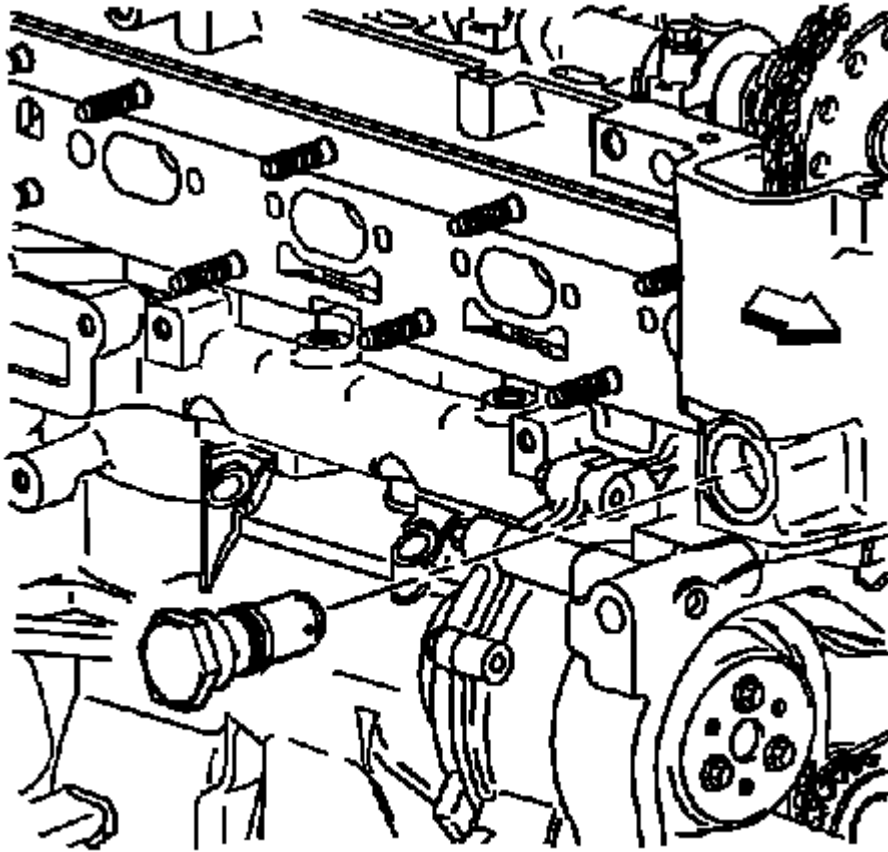


Fig. 94: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

CAUTION: Refer to Fastener Caution .

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

8. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
9. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.
10. Install the camshaft cover. Refer to Camshaft Cover Replacement.
11. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection .

INTAKE CAMSHAFT AND VALVE LIFTER REPLACEMENT

REMOVAL PROCEDURE

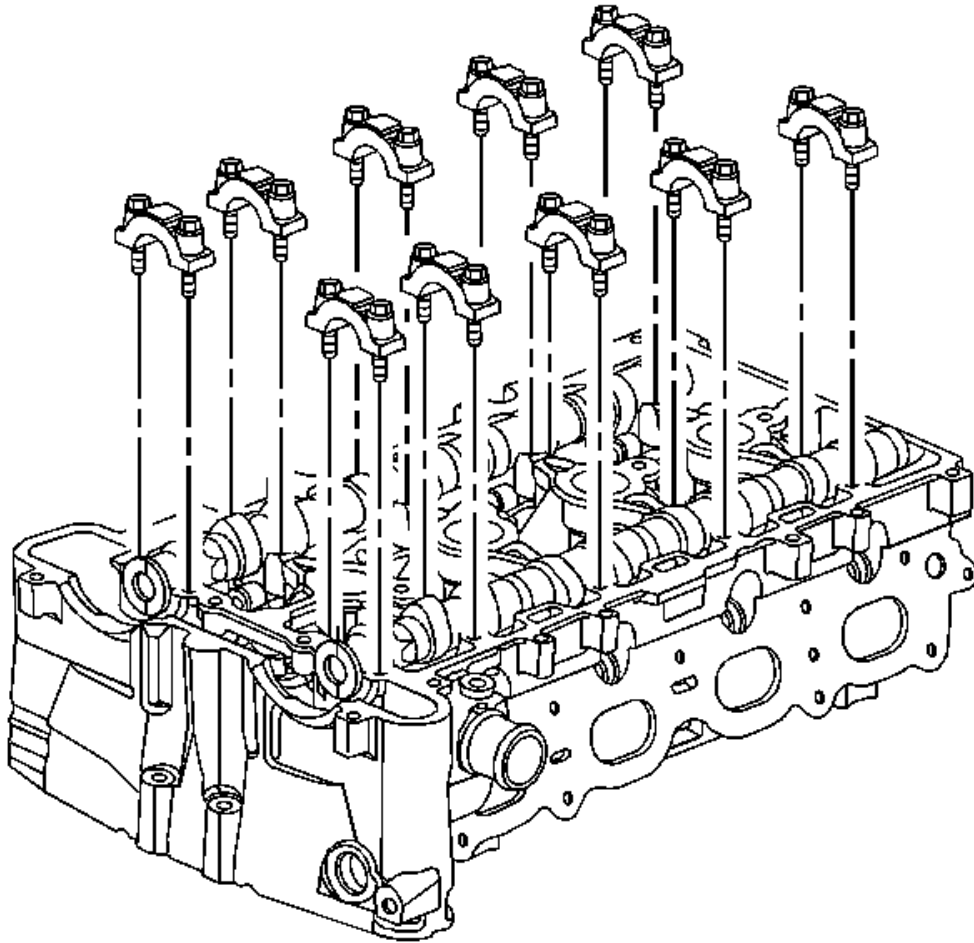


Fig. 95: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position actuator. Refer to [Camshaft Position Intake Actuator Replacement](#).

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

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

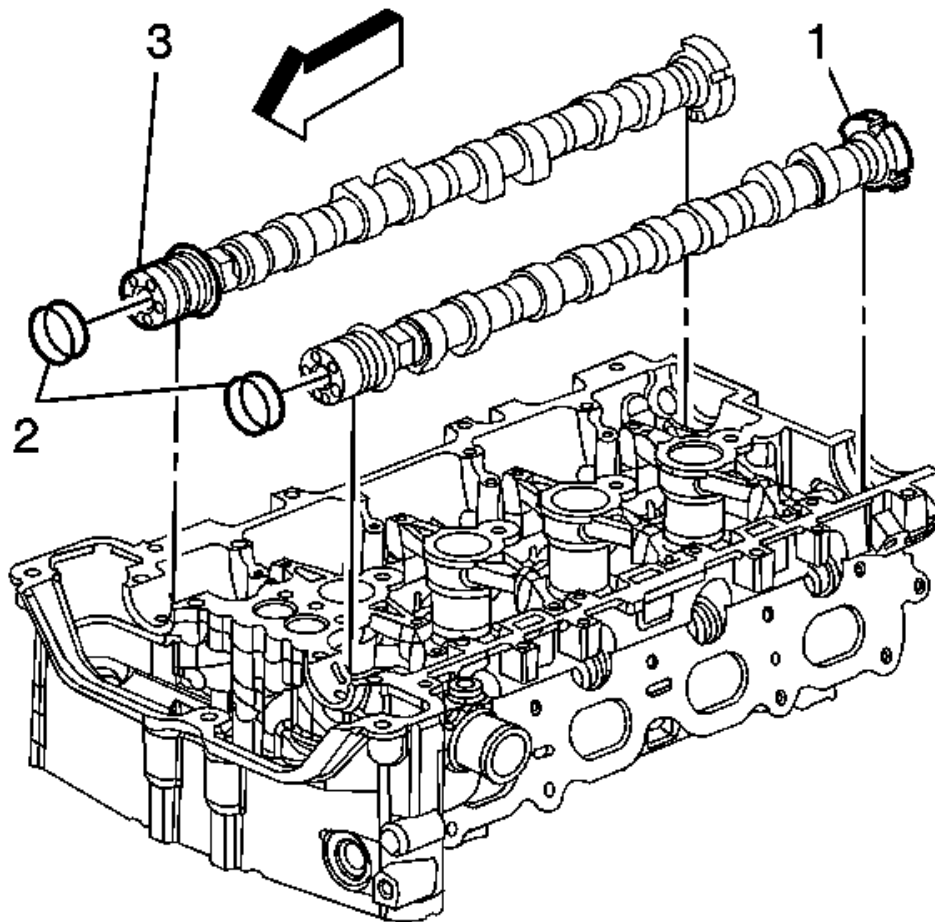


Fig. 96: Intake & Exhaust Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake camshaft (1).

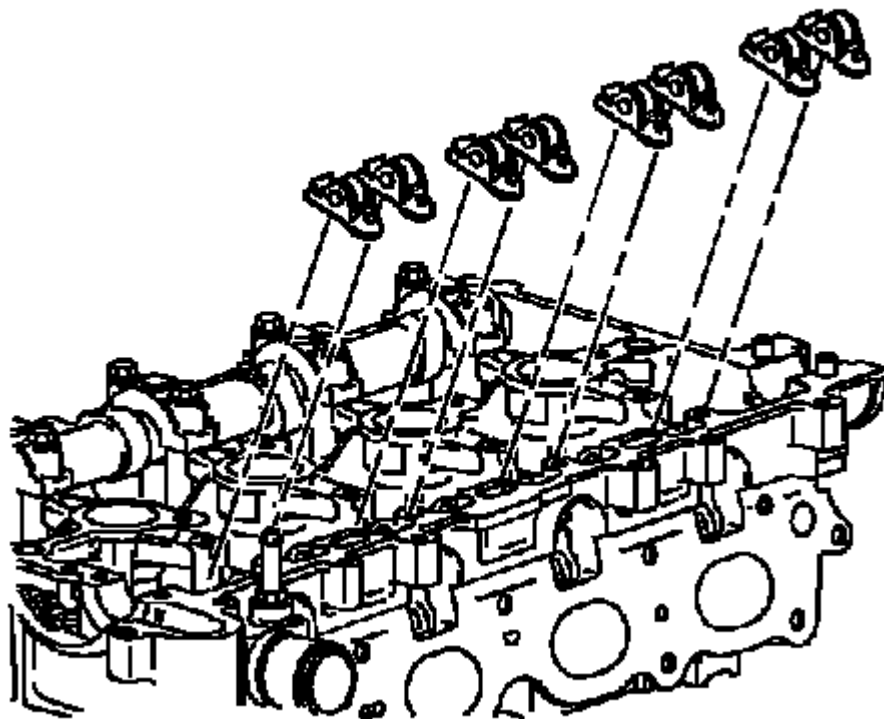


Fig. 97: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

6. Remove the camshaft roller followers.

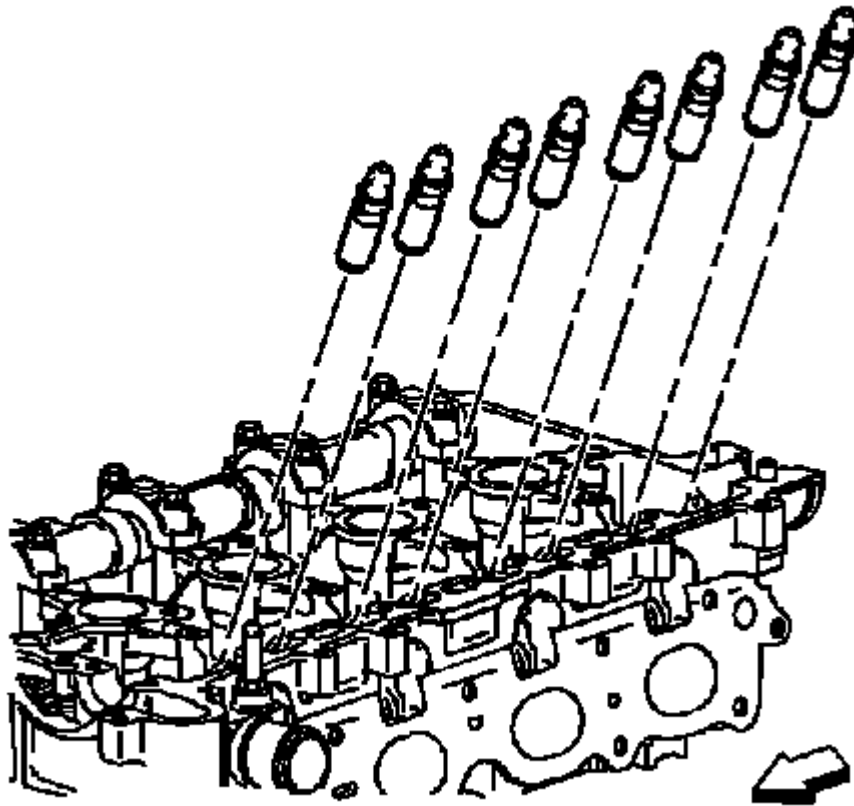


Fig. 98: Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

INSTALLATION PROCEDURE

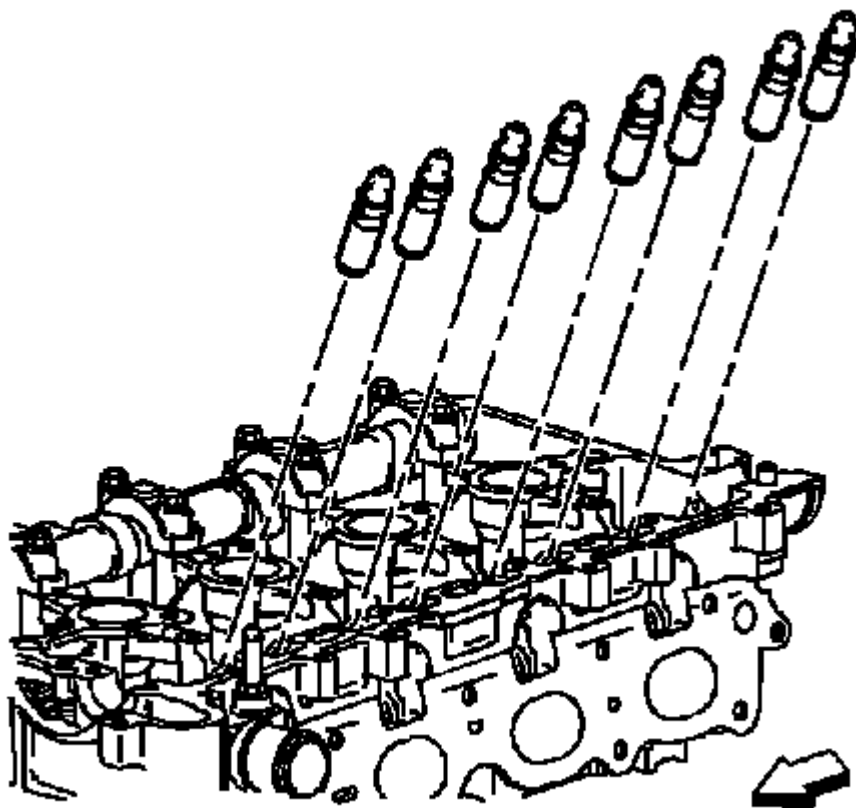


Fig. 99: Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** for the recommended lubricant.

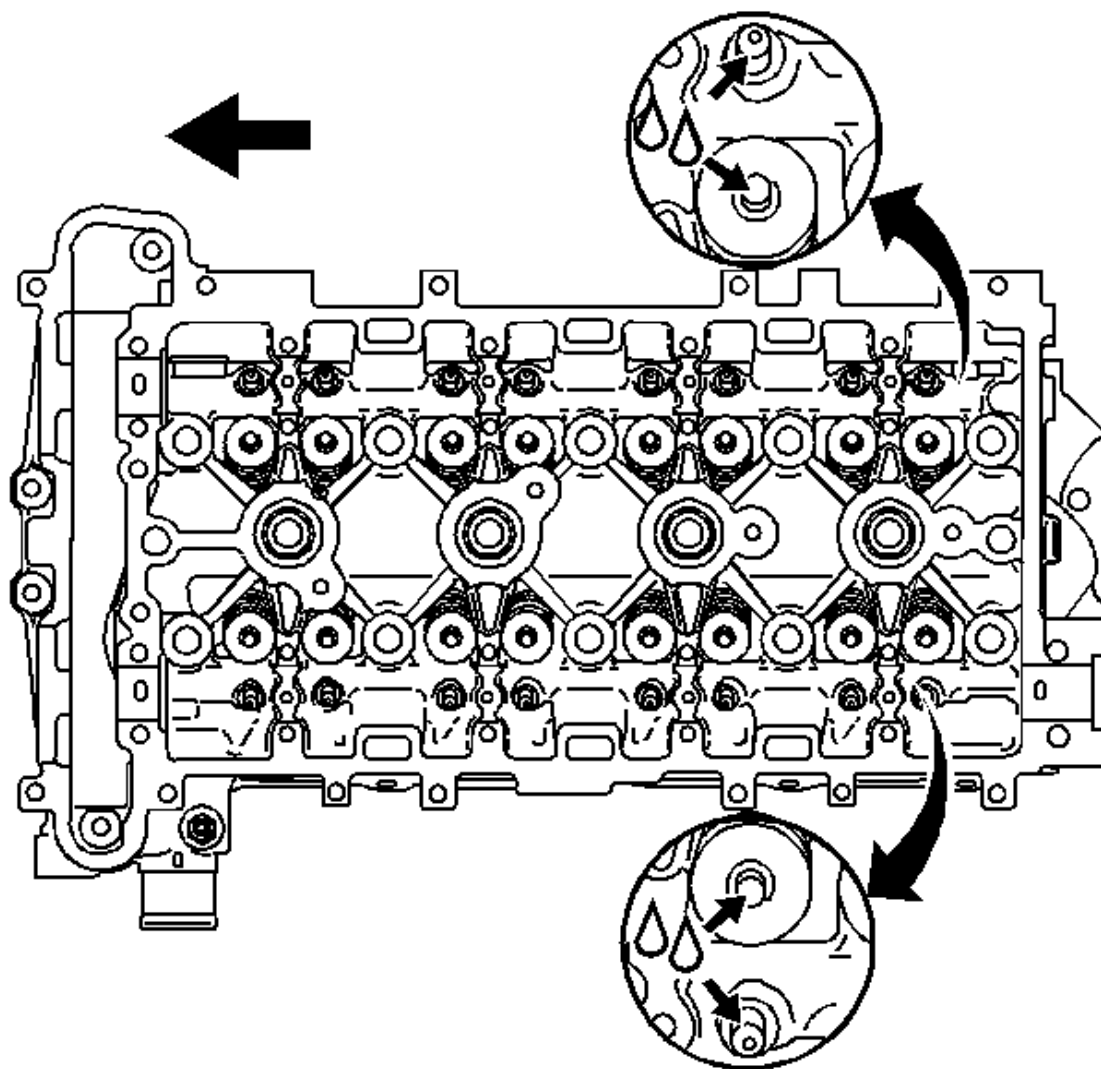


Fig. 100: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** for the recommended lubricant.

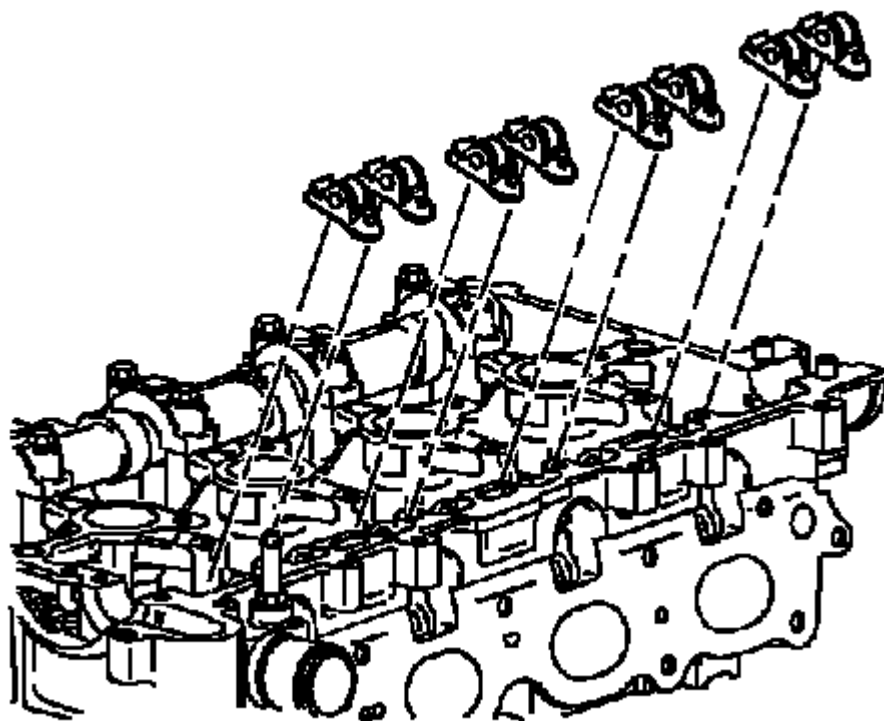


Fig. 101: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

4. Position the camshaft roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** for the recommended lubricant.

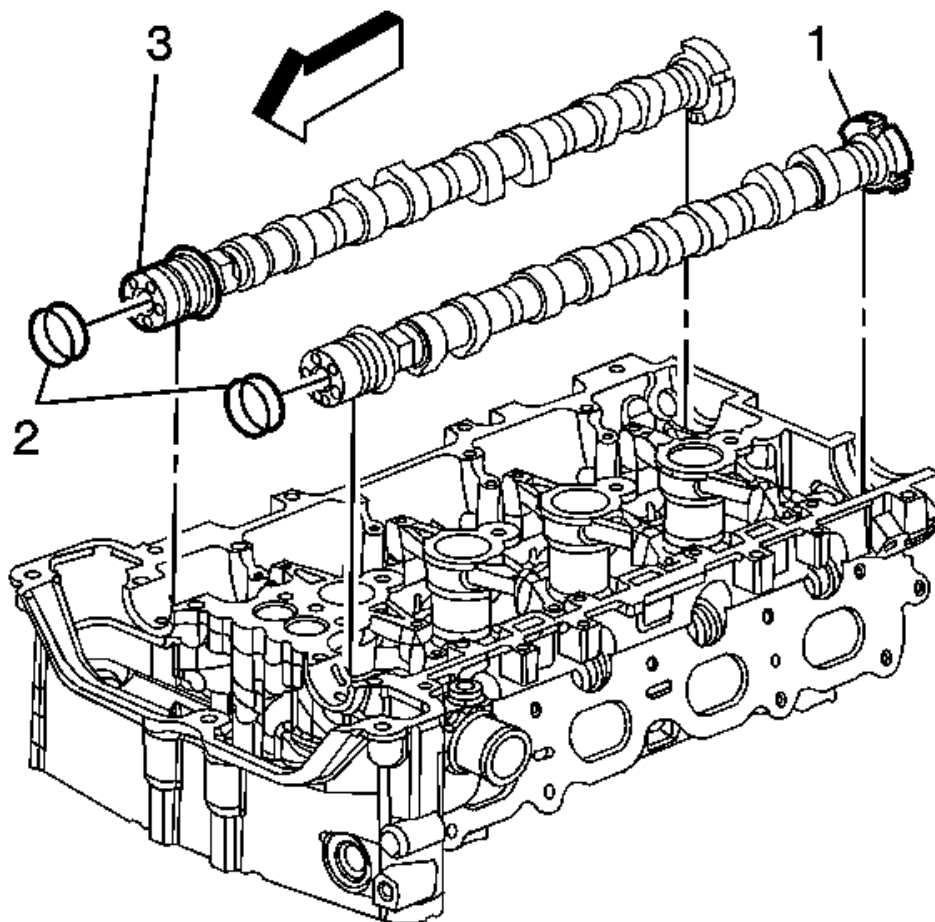


Fig. 102: Intake & Exhaust Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft (1) and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** for the recommended lubricant.

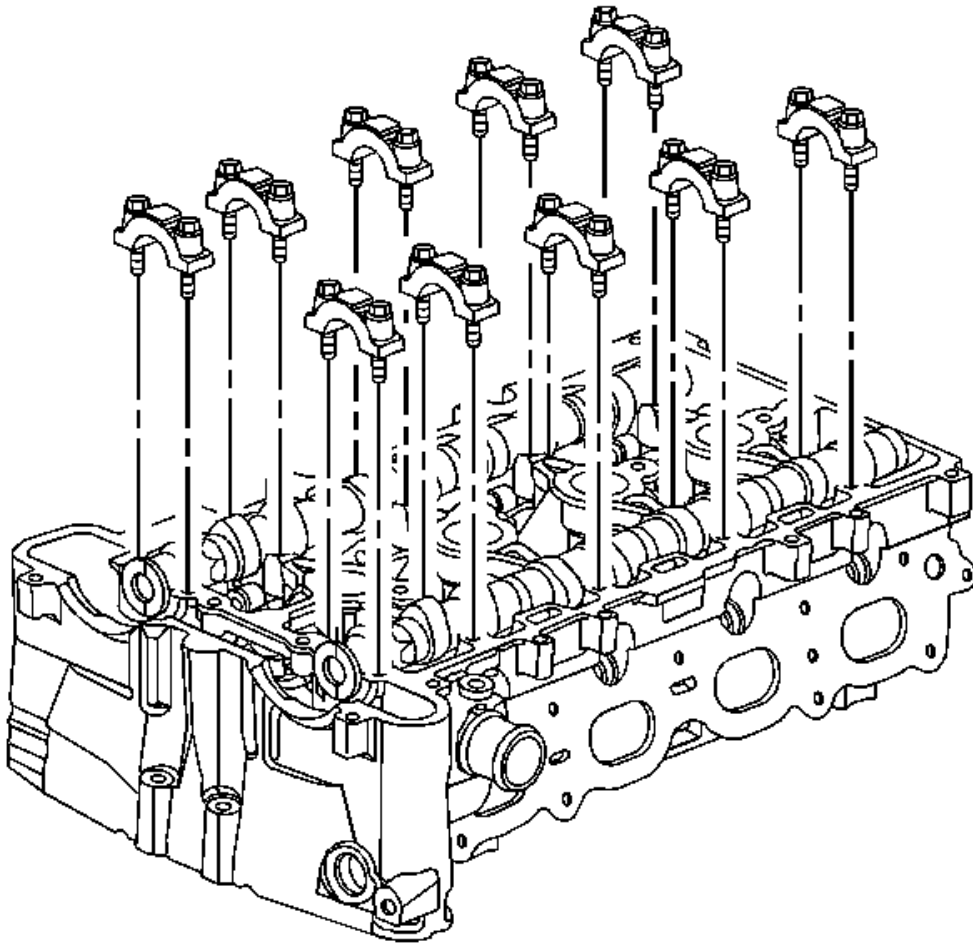


Fig. 103: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to **Fastener Caution** .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

EXHAUST CAMSHAFT AND VALVE LIFTER REPLACEMENT

REMOVAL PROCEDURE

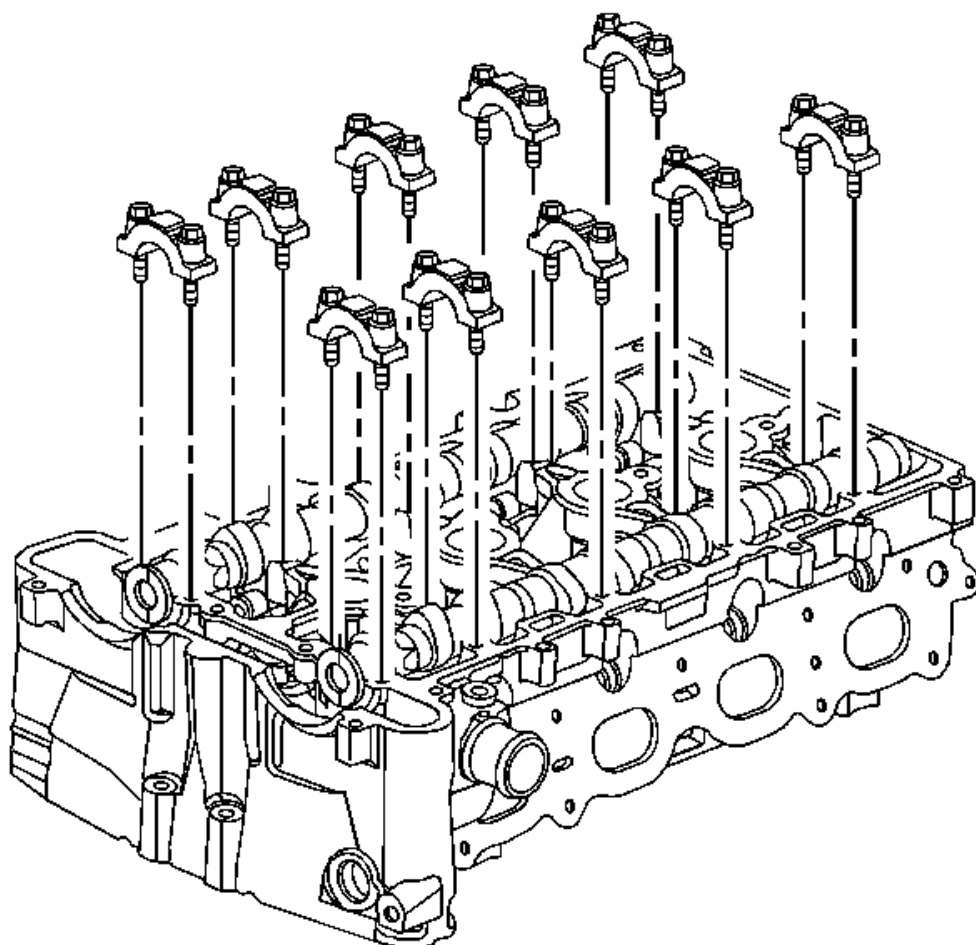


Fig. 104: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator. Refer to Camshaft Position Exhaust Actuator Replacement.

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

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

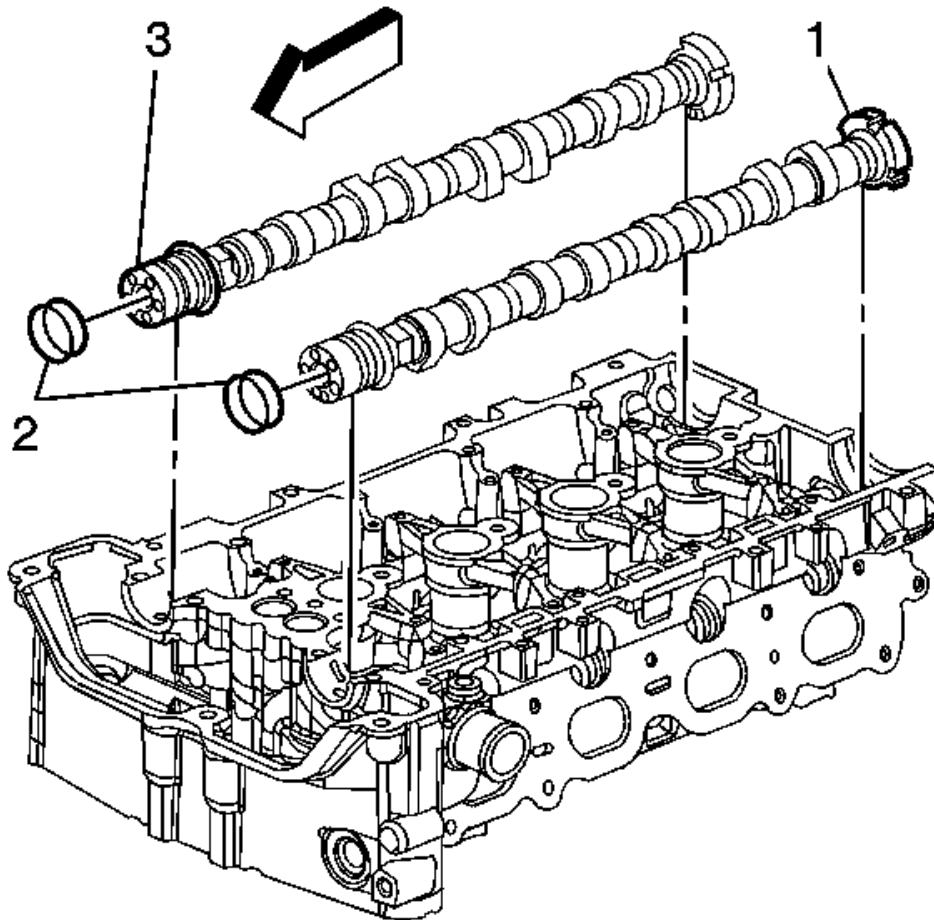


Fig. 105: Intake & Exhaust Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft (3).

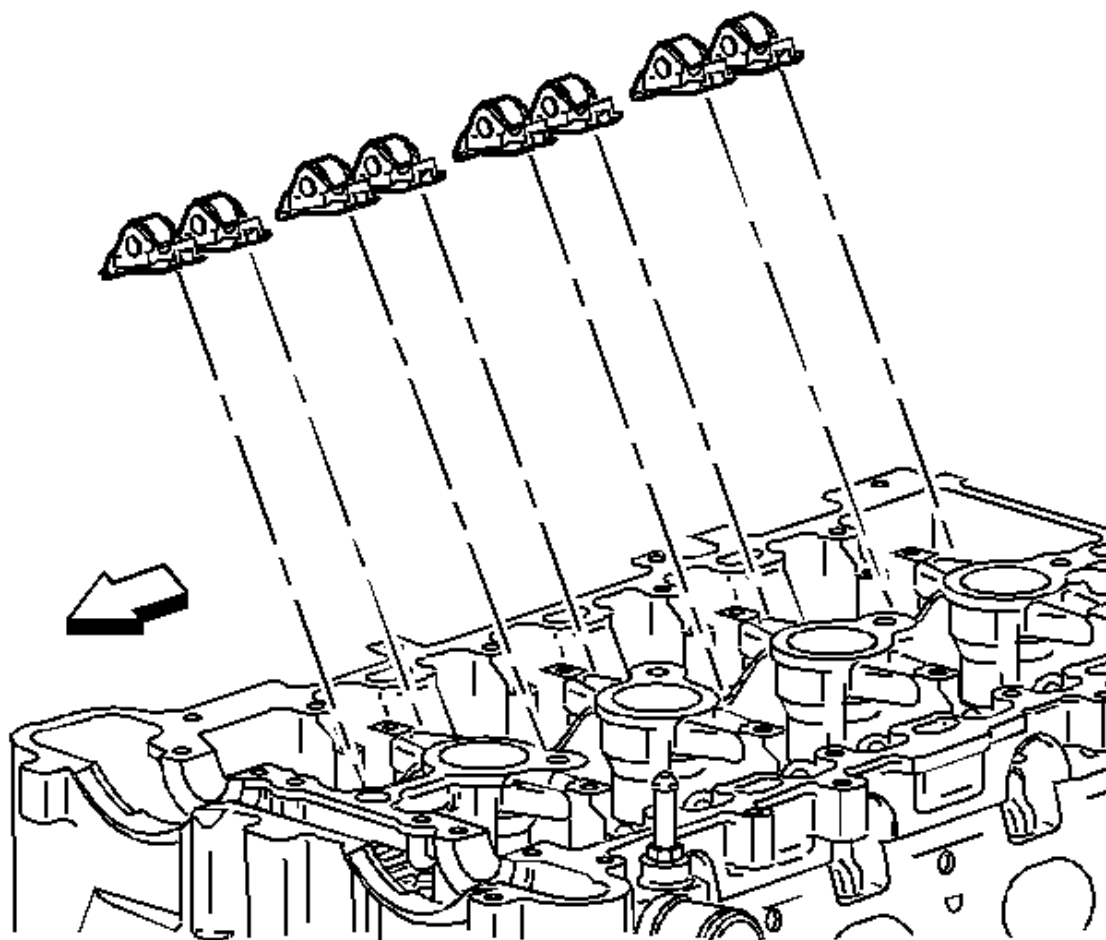


Fig. 106: Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

6. Remove the camshaft roller followers.

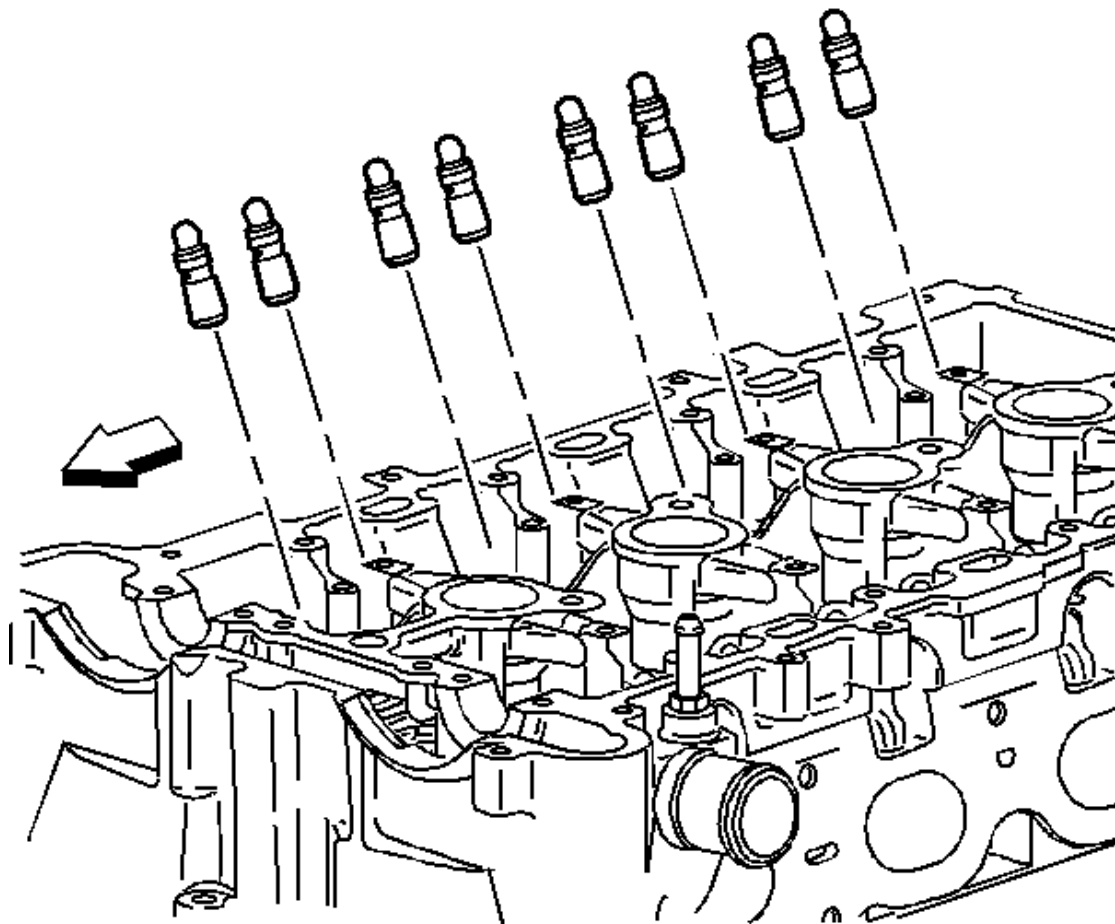


Fig. 107: Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

INSTALLATION PROCEDURE

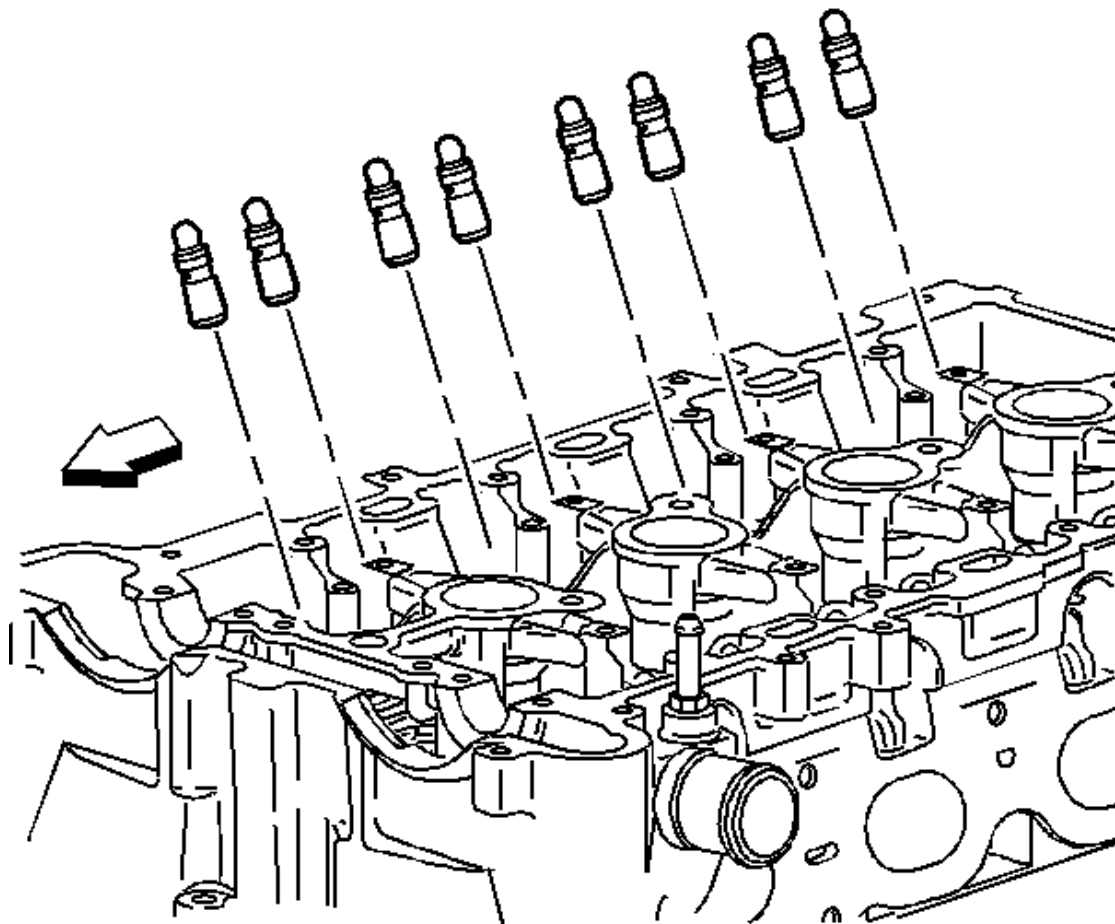


Fig. 108: Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

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

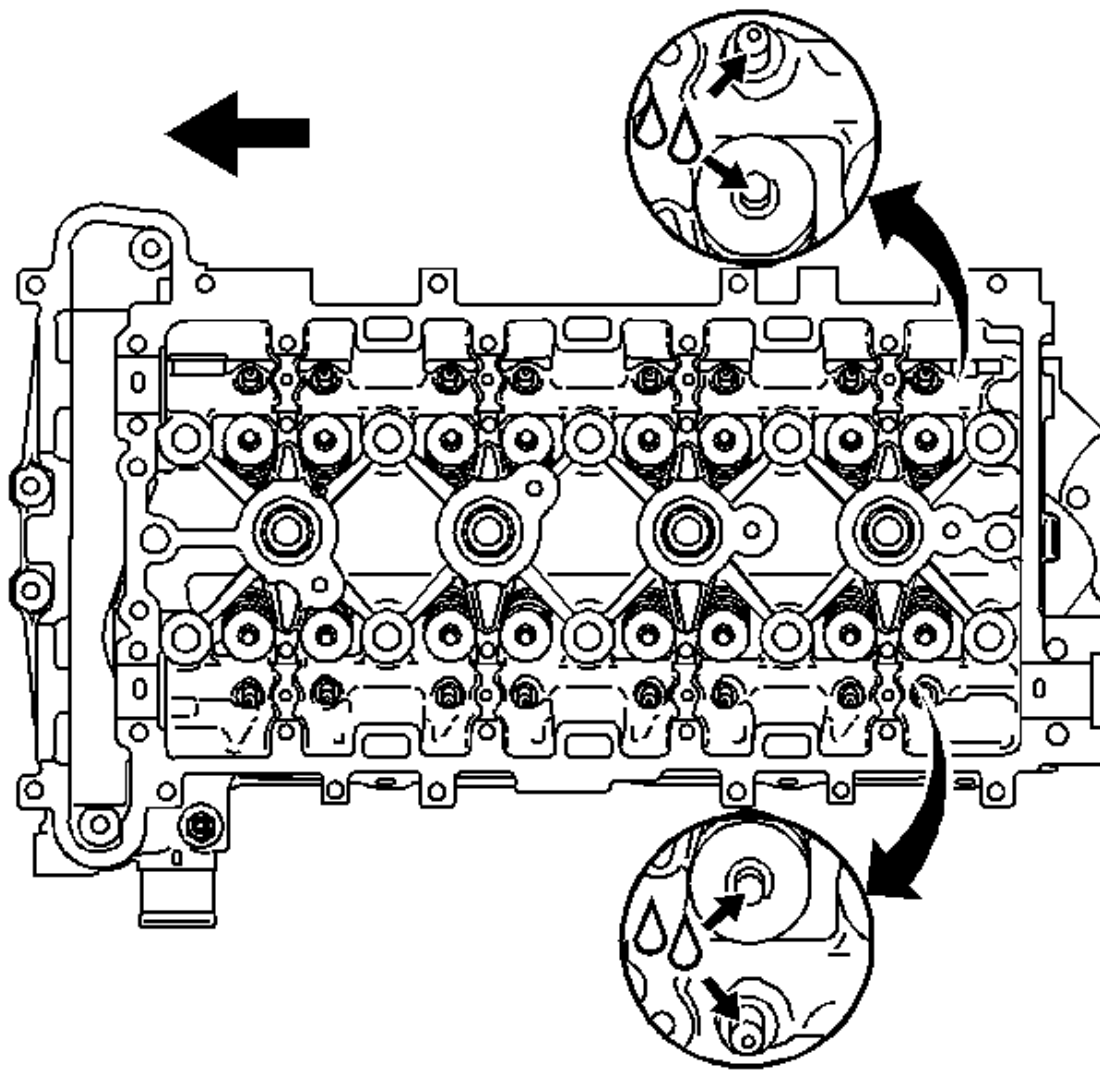


Fig. 109: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with Adhesives, Fluids, Lubricants, and Sealers (LAF) .

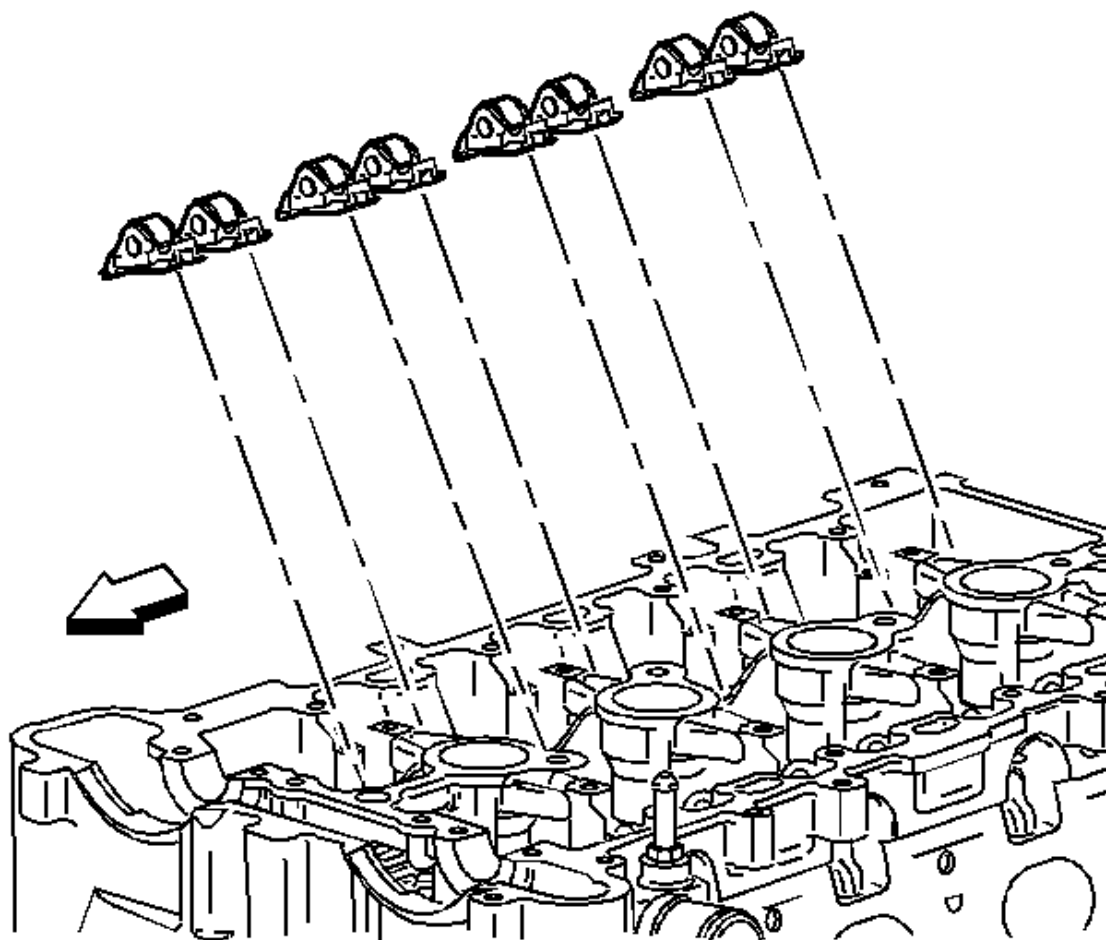


Fig. 110: Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

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

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

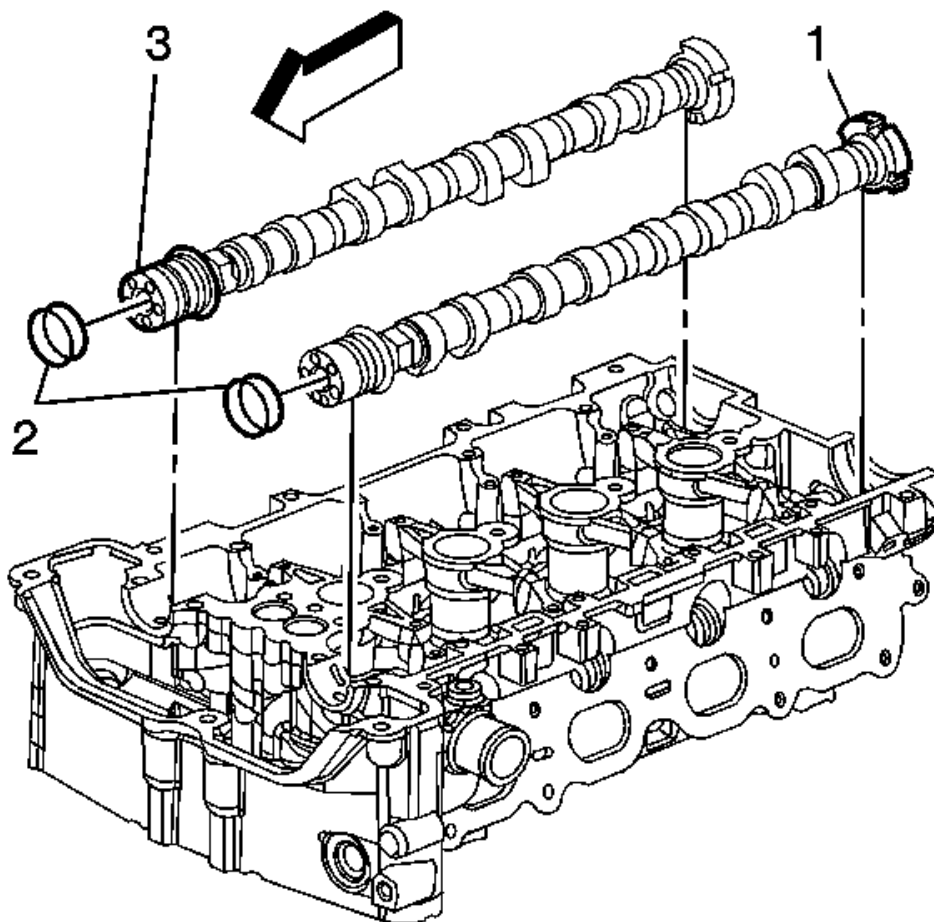


Fig. 111: Intake & Exhaust Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft (3). Lubricate with Adhesives, Fluids, Lubricants, and Sealers (LAF) .

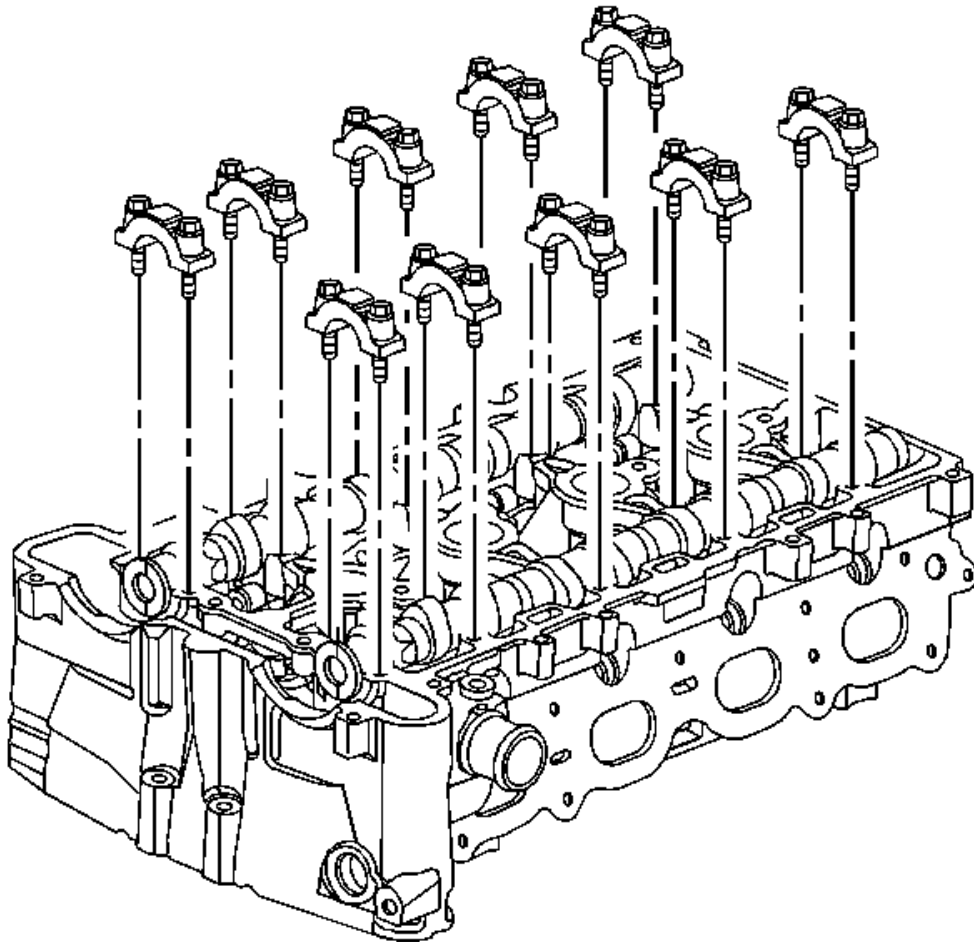


Fig. 112: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the exhaust camshaft position actuator. Refer to Camshaft Position Exhaust Actuator Replacement.

CAMSHAFT POSITION INTAKE ACTUATOR REPLACEMENT

SPECIAL TOOLS

- **EN-45059:** Angle Meter

- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

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

REMOVAL PROCEDURE

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

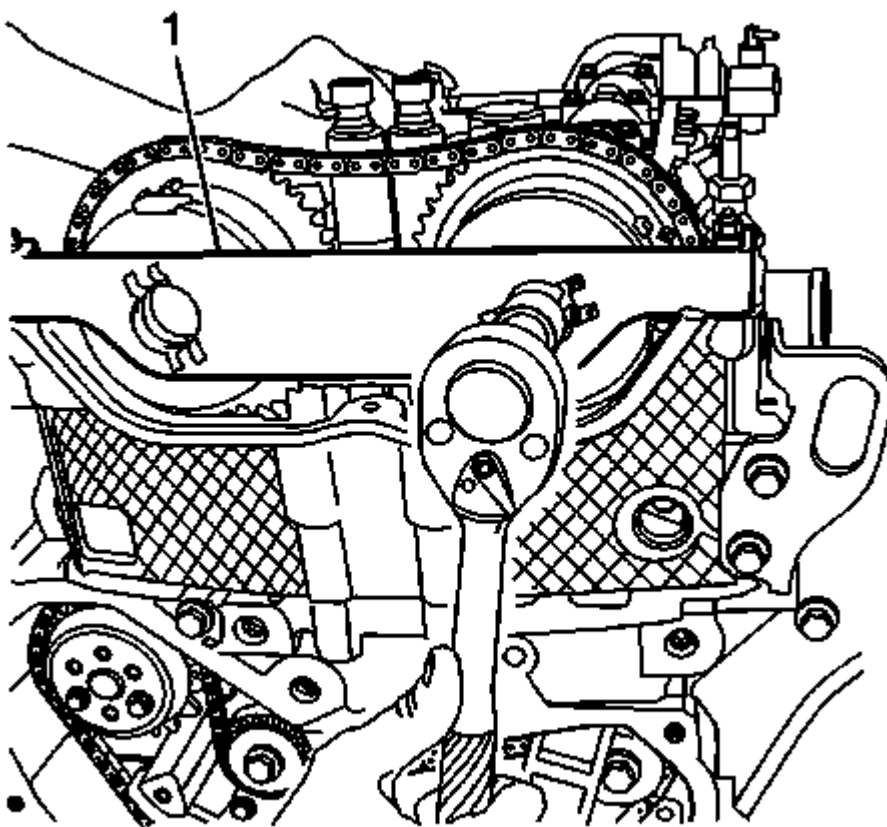


Fig. 113: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953:** retention tool (1).

CAUTION: Refer to **Fastener Caution** .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but DO NOT remove the intake camshaft actuator bolt.

6. Remove the **EN-48953**: locking tool (1).
7. Clean the timing chain and gears with solvent.

NOTE: **Ensure the timing chain and the camshaft position actuators are marked for proper assembly.**

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

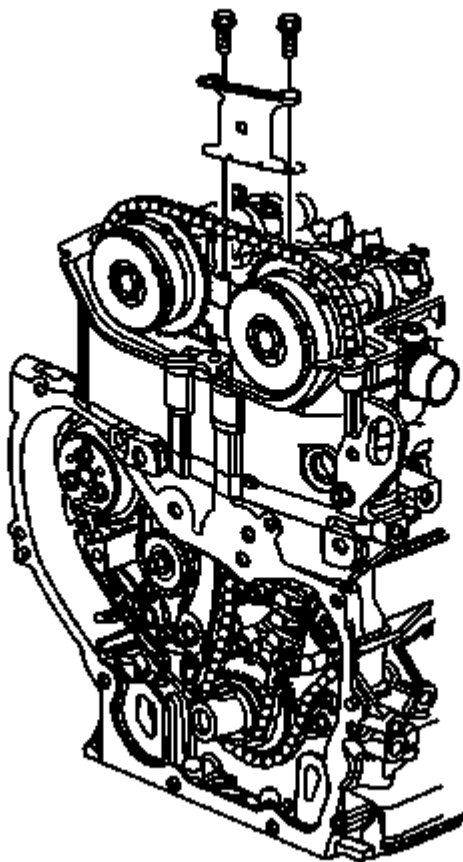


Fig. 114: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

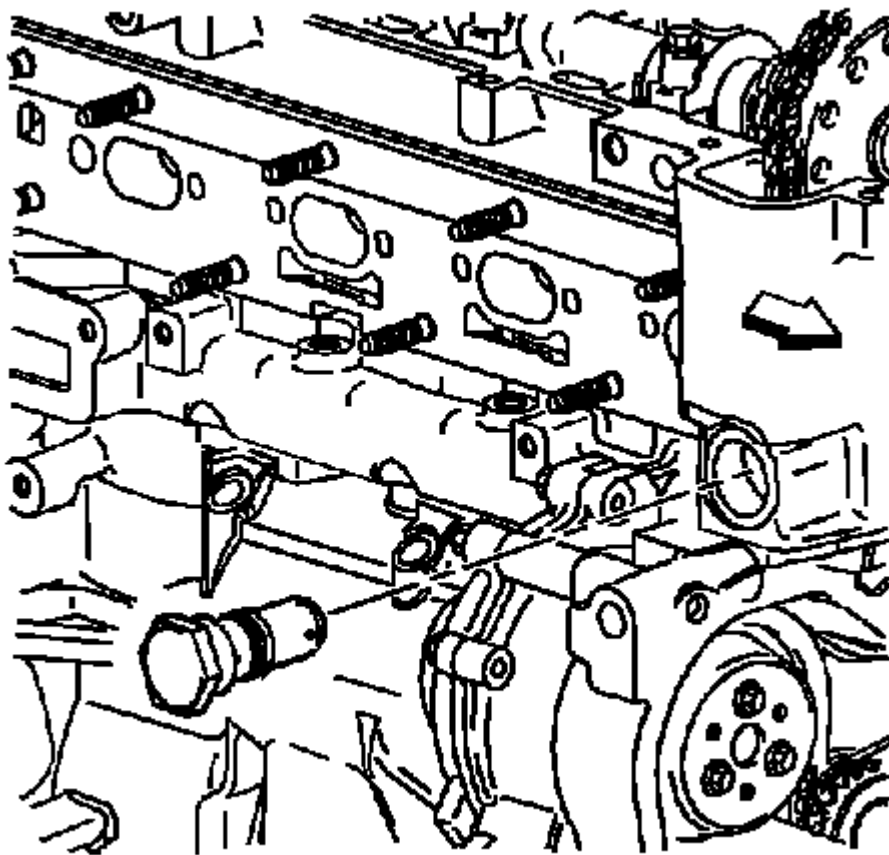


Fig. 115: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

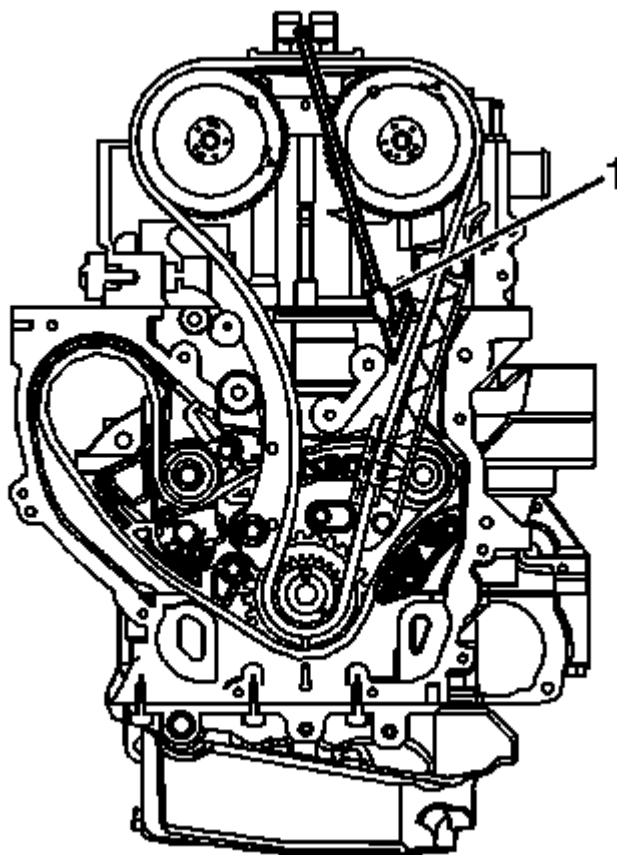


Fig. 116: Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The intake camshaft actuator should not rotate during the removal or installation.
- Ensure the tips of the tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.

11. Install the **EN-48749**: retention tool (1) to the intake side of the timing chain.

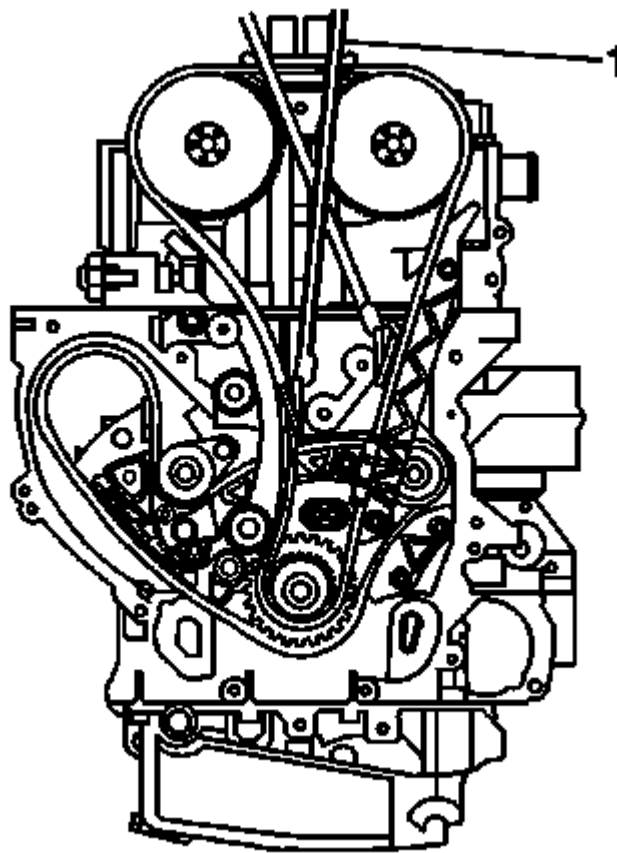


Fig. 117: Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN-48749**: retention tool (1) to the exhaust side of the timing chain.

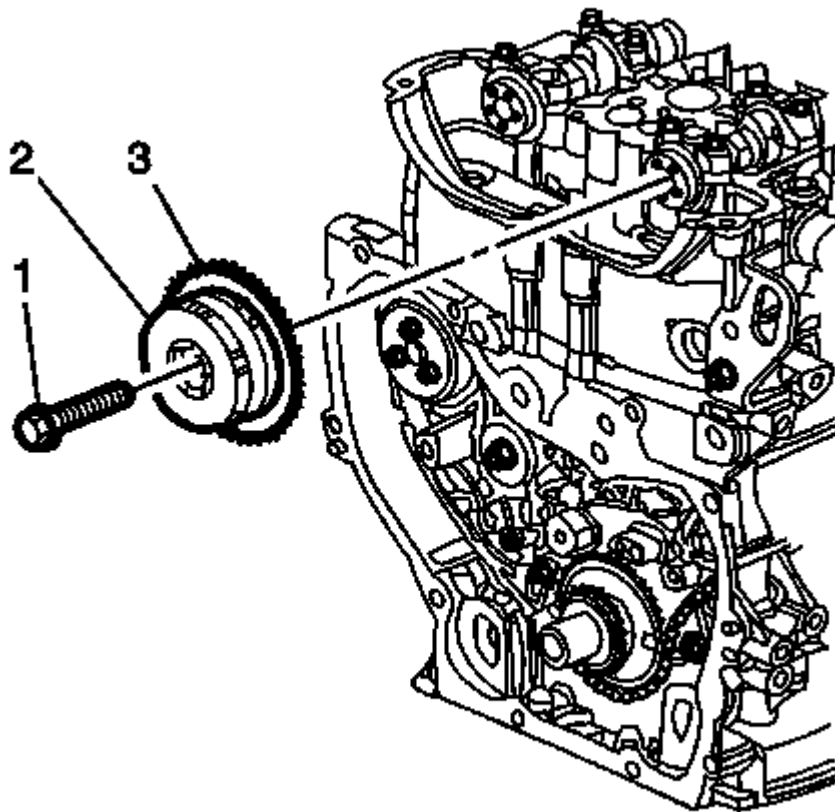


Fig. 118: Intake Camshaft Actuator
 Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the intake camshaft actuator bolt (1).
14. Rotate the exhaust camshaft clockwise slightly to take the tension off of the timing chain on the intake actuator.
15. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

INSTALLATION PROCEDURE

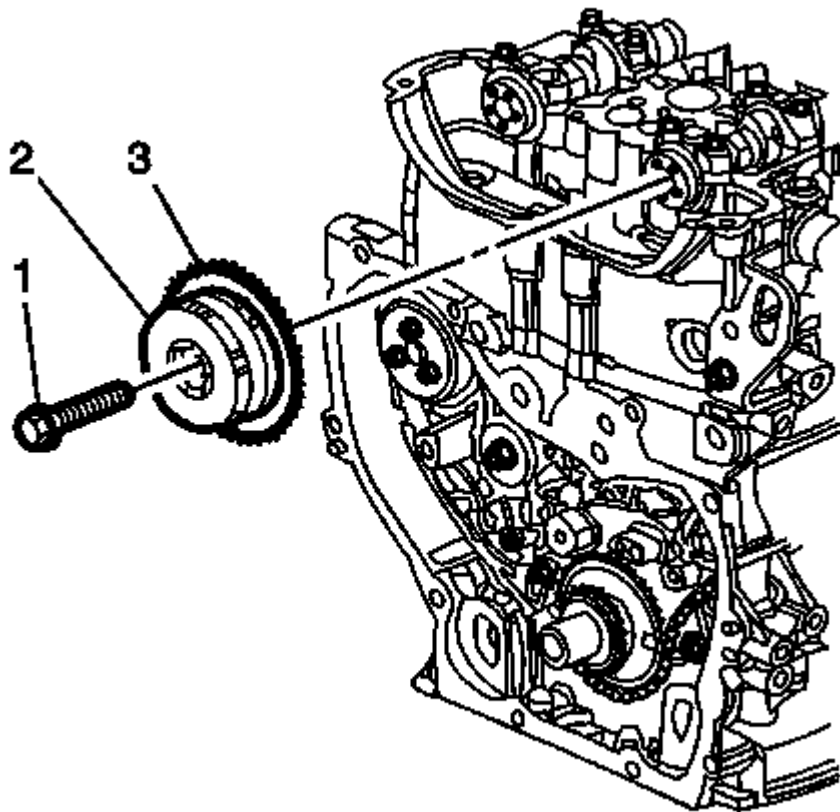


Fig. 119: Intake Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

1. Install the timing chain onto the intake camshaft actuator.
2. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft rotating the exhaust camshaft clockwise, if required.
3. Install a NEW intake camshaft actuator bolt (1) until snug.

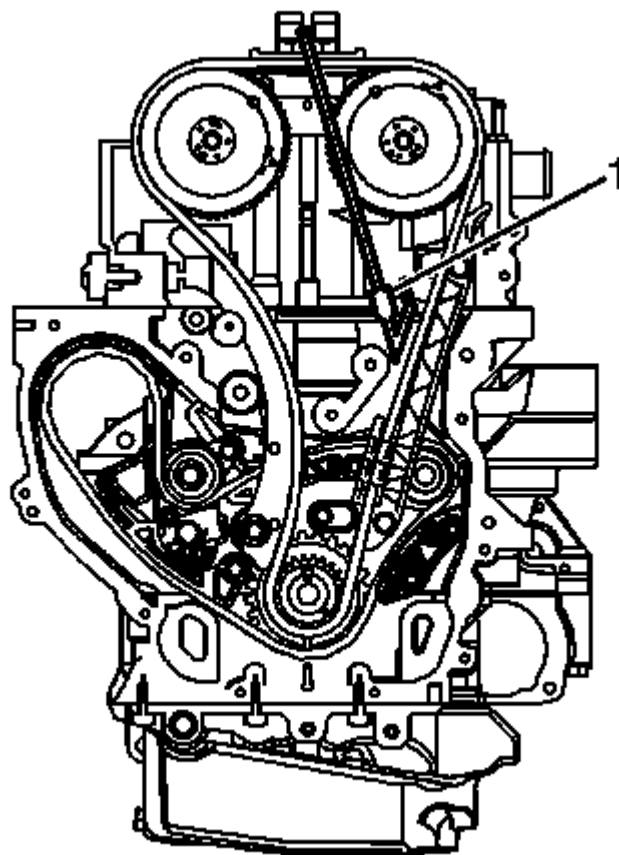


Fig. 120: Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain retention tool (1) from the intake side of the timing chain.

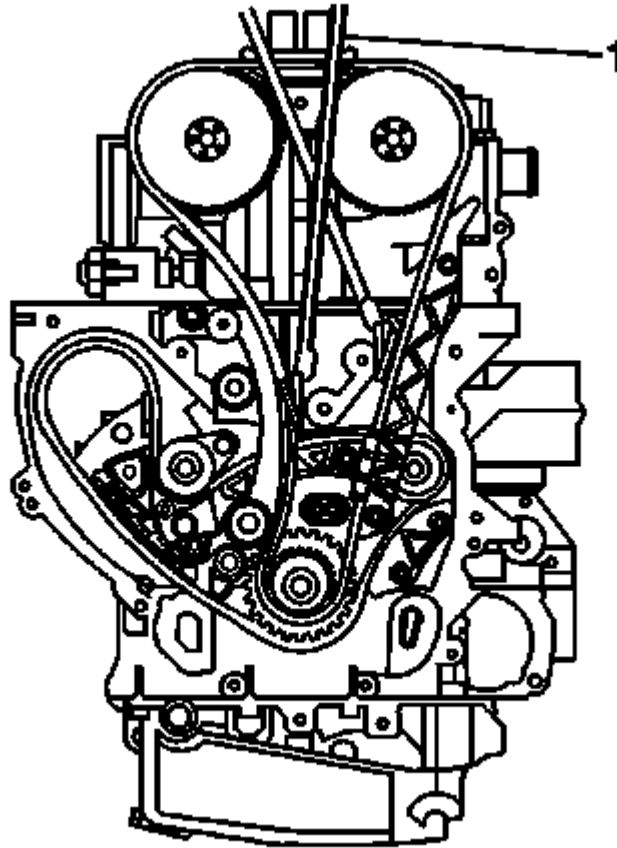


Fig. 121: Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the intake camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

5. Remove the timing chain retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend, limiting the timing chain life.

6. Reset and install the timing chain tensioner. Refer to Timing Chain Tensioner Replacement.

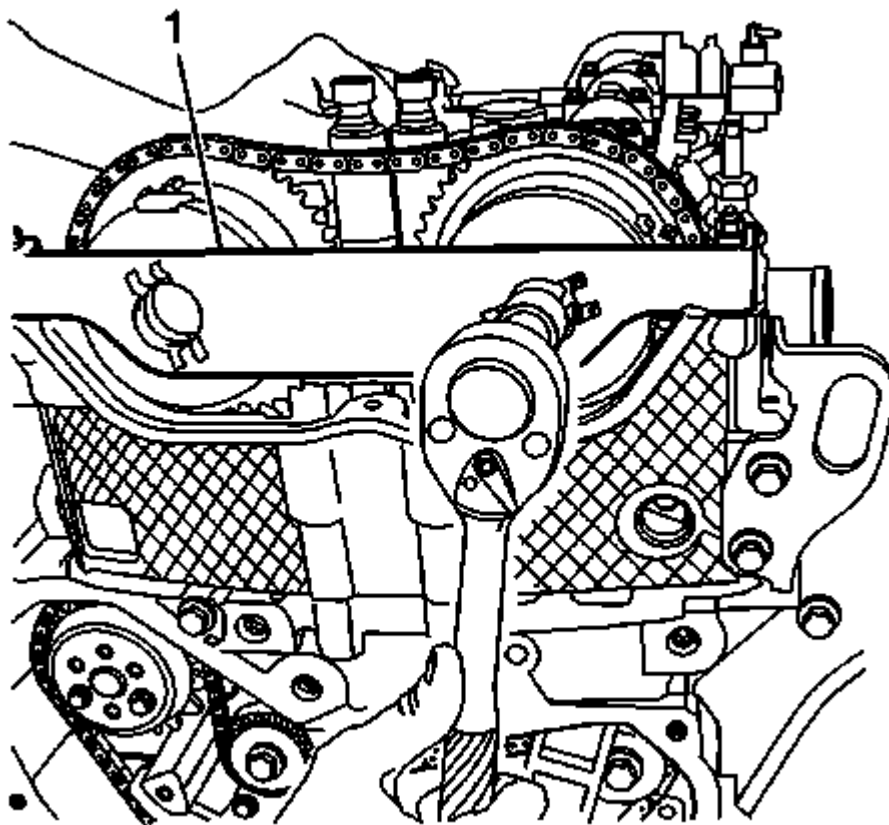


Fig. 122: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

7. Install the **EN-48953**: retention tool (1).
8. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
9. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059**: meter.

NOTE: **You must have the EN-48953: retention tool installed to perform this procedure.**

10. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).
11. Remove the **EN-48953**: retention tool (1).

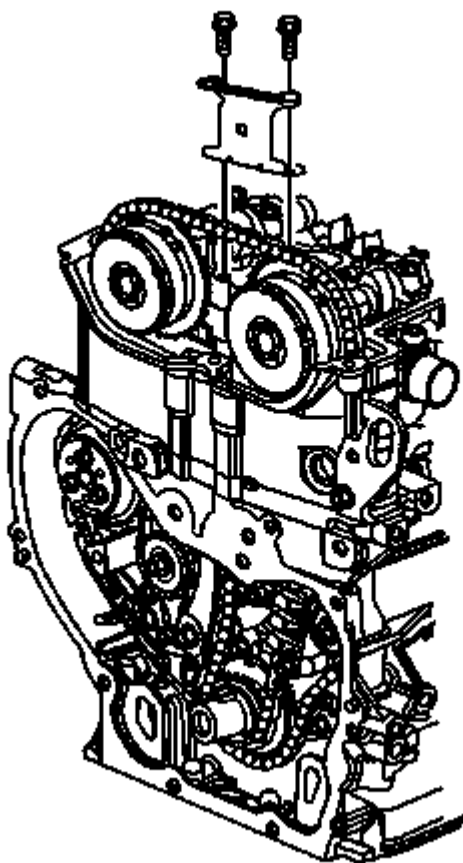


Fig. 123: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

SPECIAL TOOLS

- **EN-45059:** Angle Meter
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

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

REMOVAL PROCEDURE

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

2. Remove the spark plugs. Refer to Spark Plug Replacement .

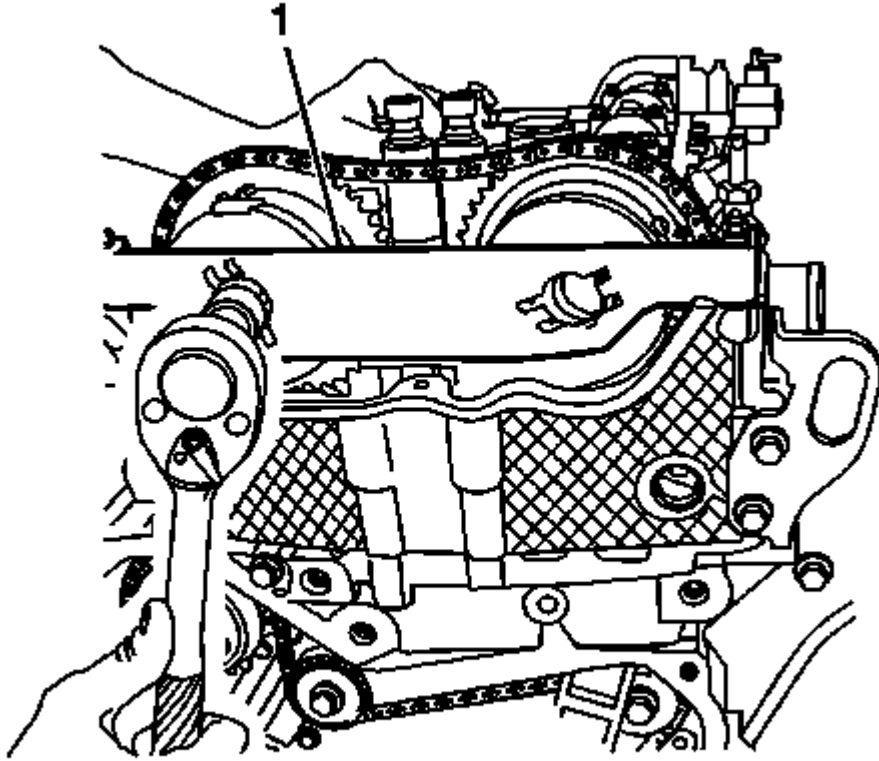


Fig. 124: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953**: locking tool (1).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but do not remove the exhaust camshaft actuator bolt.
6. Remove the **EN-48953**: locking tool (1).
7. Clean the timing chain and gears with solvent.

NOTE: Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

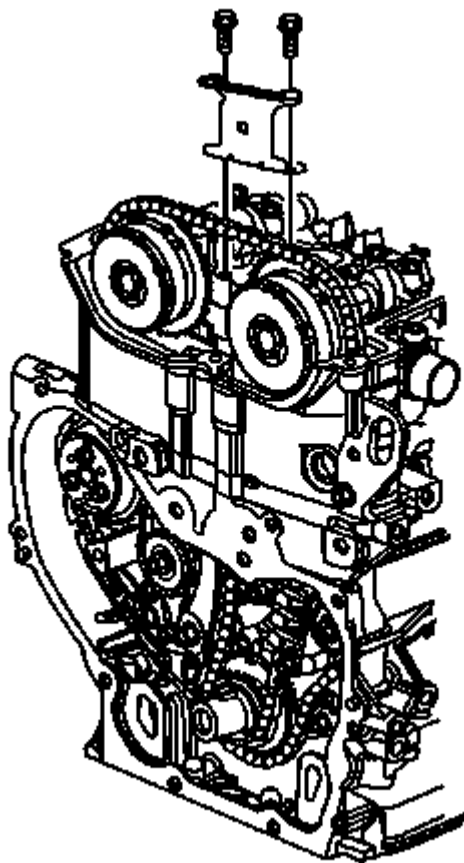


Fig. 125: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

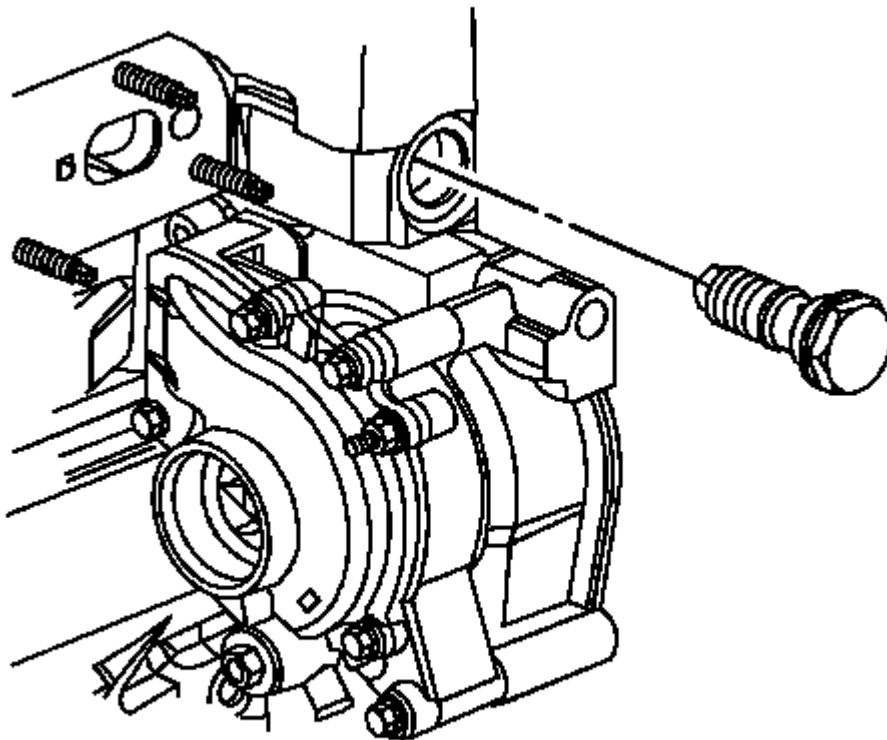


Fig. 126: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

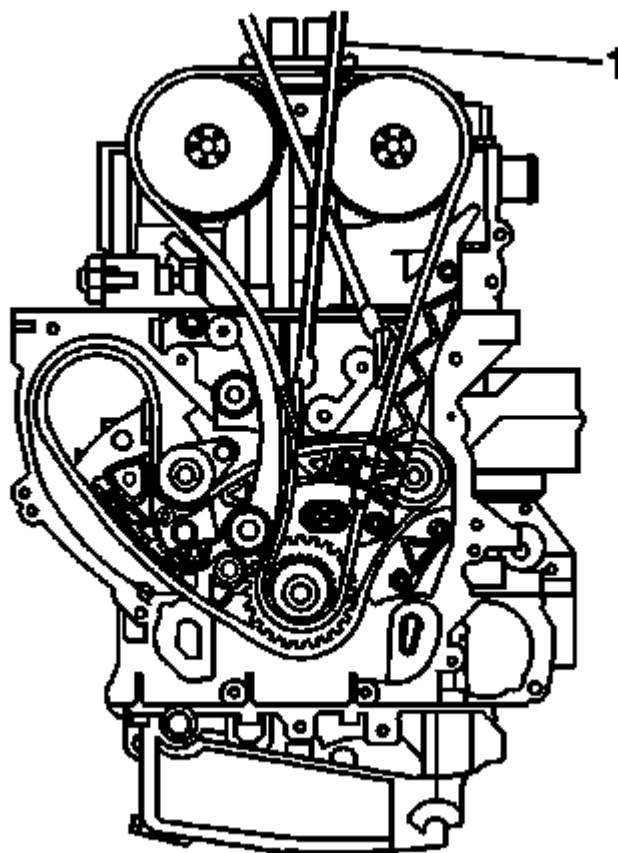


Fig. 127: Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The camshaft actuators should not rotate during the removal or installation.
- Ensure the tips of the EN-48749: retention tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.

11. Install the **EN-48749:** retention tool (1) to the exhaust side of the timing chain.

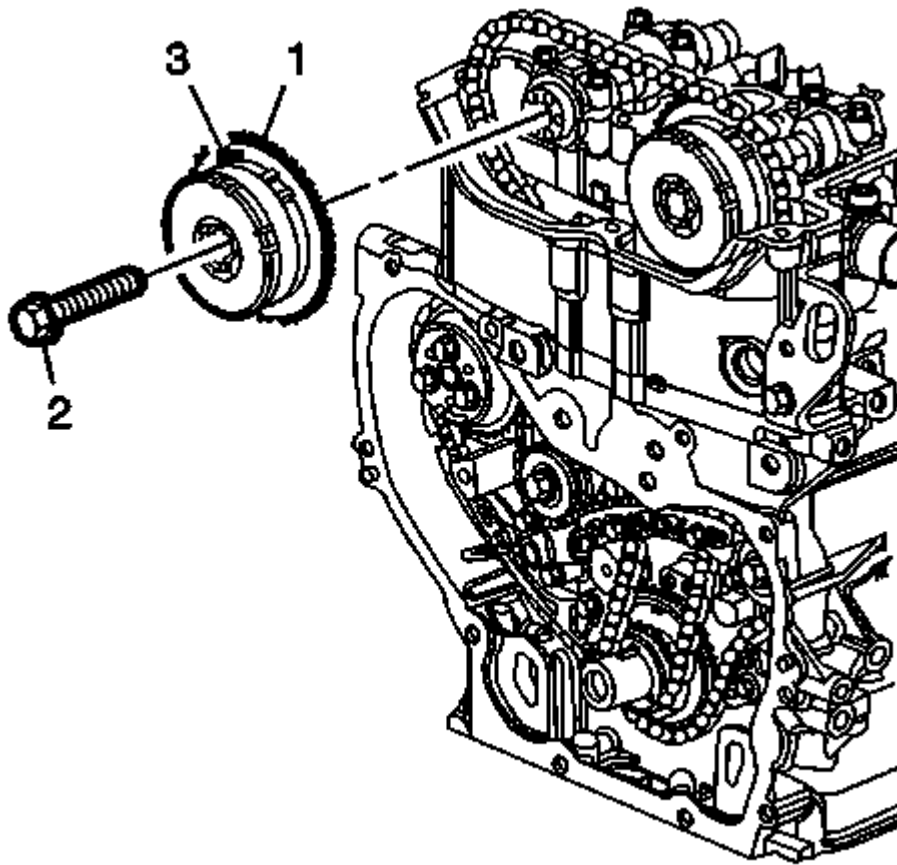


Fig. 128: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

12. Remove and discard the exhaust camshaft actuator bolt (2).
13. Remove the exhaust camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

INSTALLATION PROCEDURE

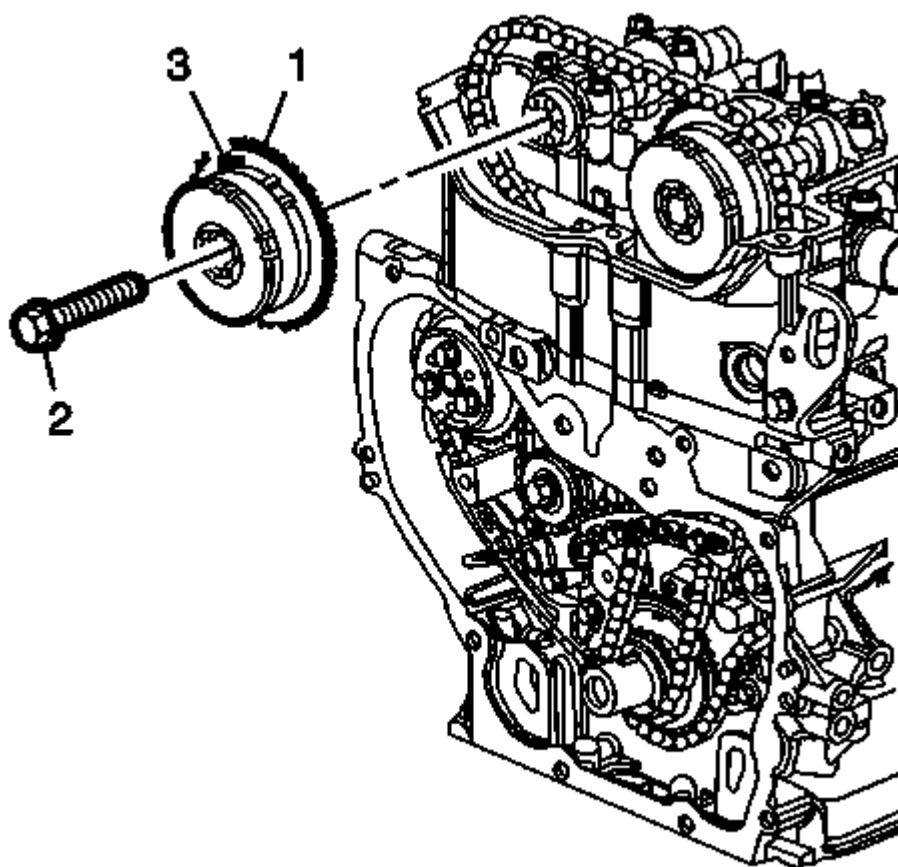


Fig. 129: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.
- The exhaust camshaft may need to be rotated clockwise to fully set the camshaft actuator.

1. Install the timing chain onto the exhaust camshaft actuator.
2. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
3. Install a NEW exhaust camshaft actuator bolt (2) until snug.

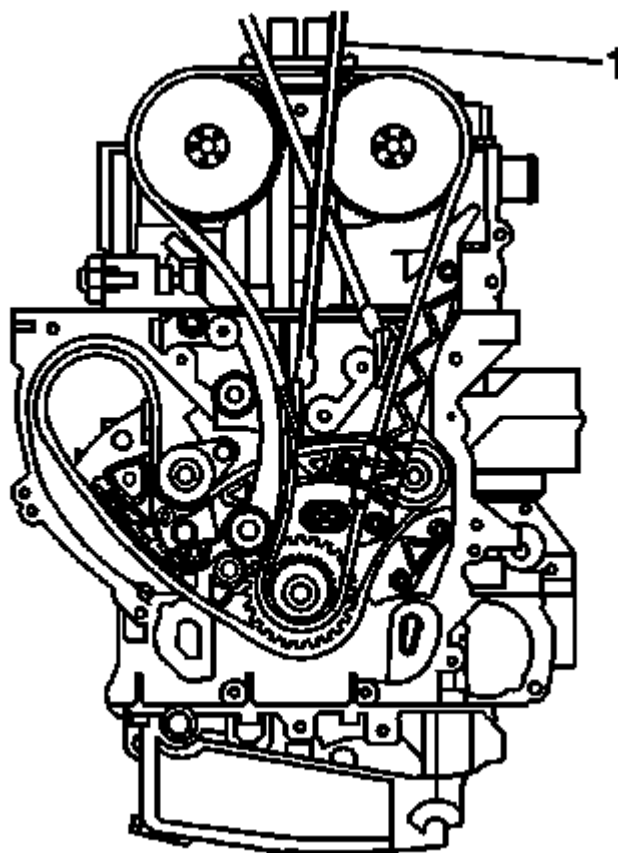


Fig. 130: Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the exhaust camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

4. Remove the **EN-48749:** retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend, limiting the timing chain life.

5. Reset and install the timing chain tensioner. Refer to Timing Chain Tensioner Replacement.

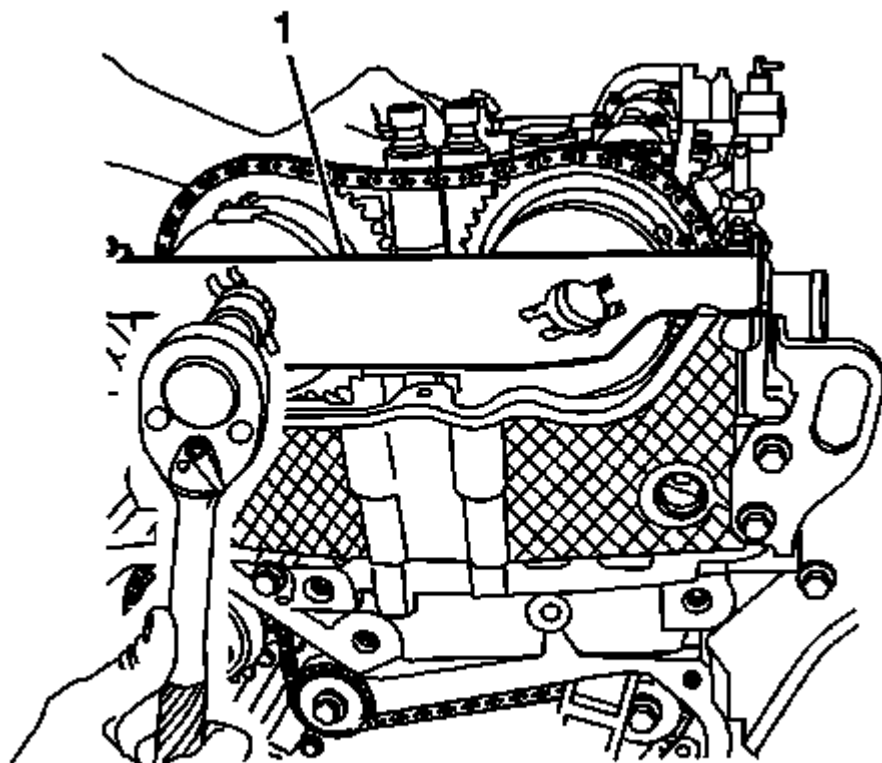


Fig. 131: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-48953**: locking tool (1).
7. Install the camshaft actuator retainer bolts and tighten 10 N.m (89 lb in).
8. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059**: meter.

NOTE: You must have the **EN-48953**: locking tool installed to perform this procedure.

9. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).

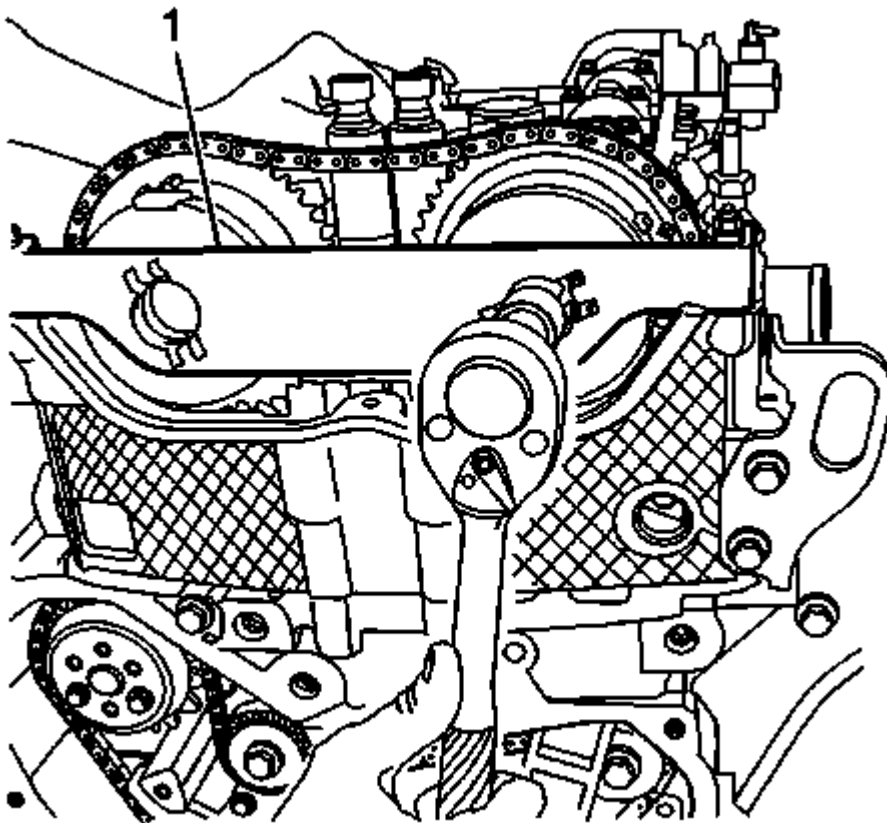


Fig. 132: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft actuator retainer **EN-48953**: locking tool (1).

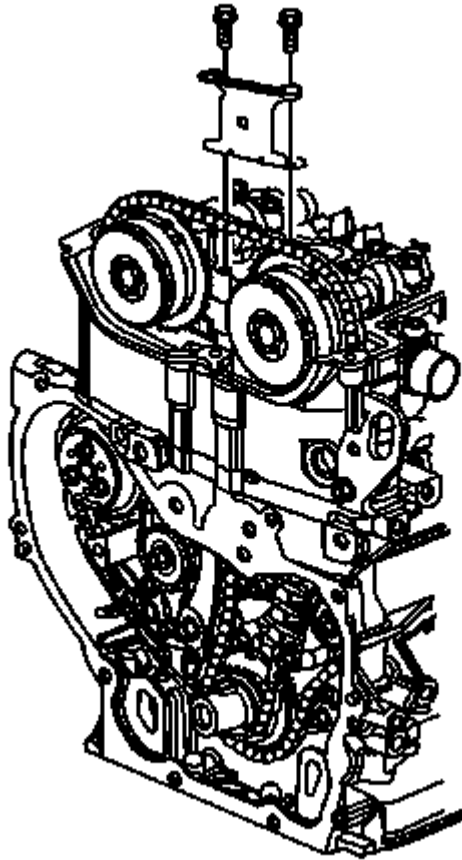


Fig. 133: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
12. Install the camshaft cover. Refer to Camshaft Cover Replacement.
13. Install the spark plugs. Refer to Spark Plug Replacement.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

SPECIAL TOOLS

- **EN-36017:** Valve Guide Seal Remover
- **EN-43649:** Valve Spring Compressor
- **EN-43649-10:** Valve Spring Compressor Adaptor Set
- **EN-43653:** Flywheel Holding Tool

For equivalent regional tools refer to Special Tools.

REMOVAL PROCEDURE

NOTE: Prevent the crankshaft from rotating clockwise or counterclockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-43653: holding tool.

1. If equipped, with a manual transmission leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped, with an automatic transmission, remove the starter. Refer to **Starter Replacement (L4)** .
3. Install EN-43653: holding tool.
4. Remove the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.

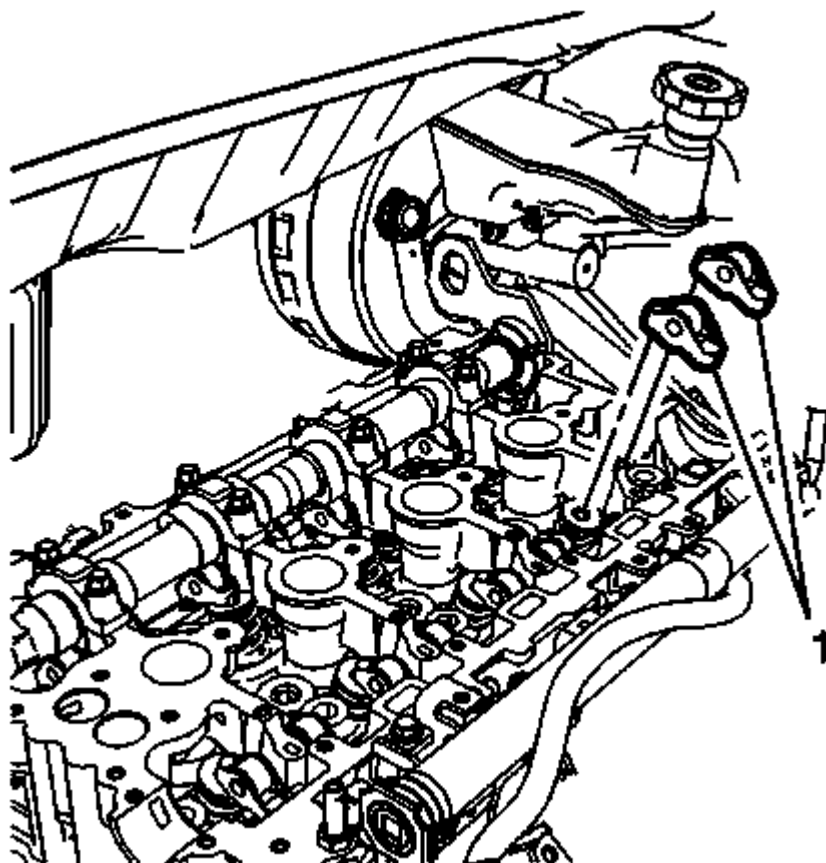


Fig. 134: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft roller followers (1).

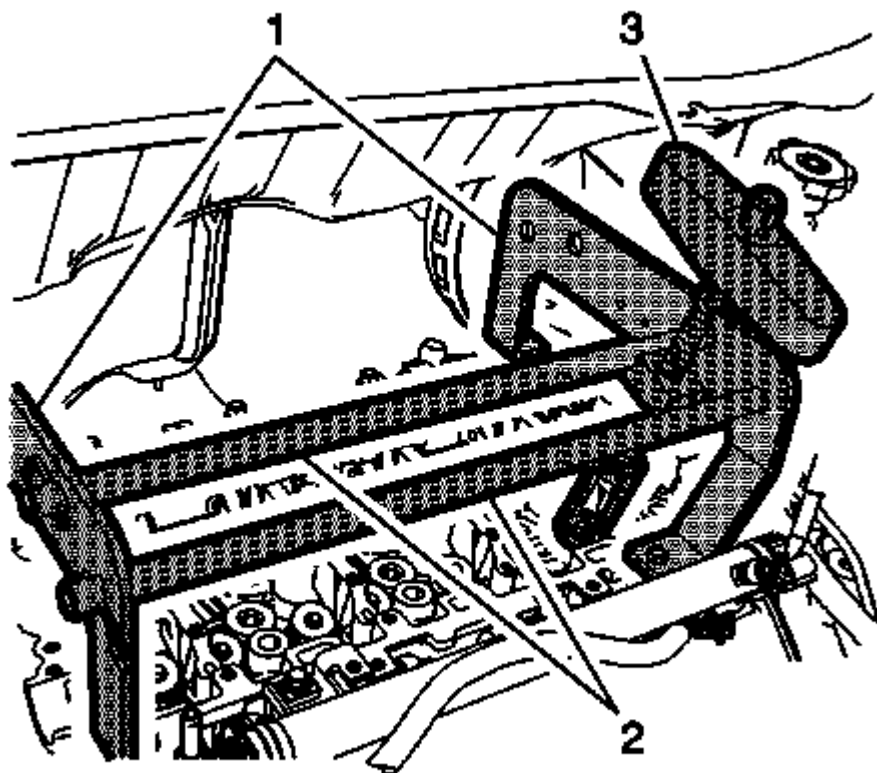


Fig. 135: Valve Spring Compressor Adaptor Set
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-43649-10:** adaptor set (1) to the front and rear of the cylinder head.
7. Install the cross bars and locks (2) of the **EN-43649:** compressor to the valve spring compressor adaptors.
8. Remove the spark plugs. Refer to **Spark Plug Replacement** .
9. Install an air hose adapter into the spark plug hole.
10. Attach an air hose to the adapter and pressurize the cylinder to 690 kPa (100 psi).
11. Compress the valve spring using the valve spring compressor (3).

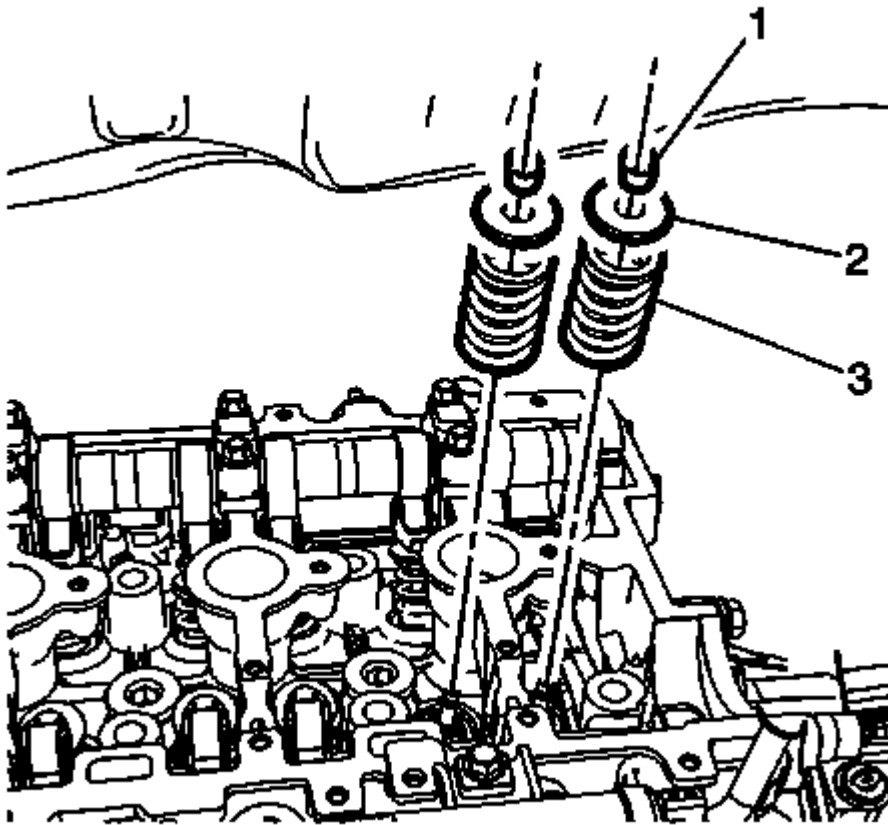


Fig. 136: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve spring keepers (1).
13. Remove the valve spring (3) and retainer (2).

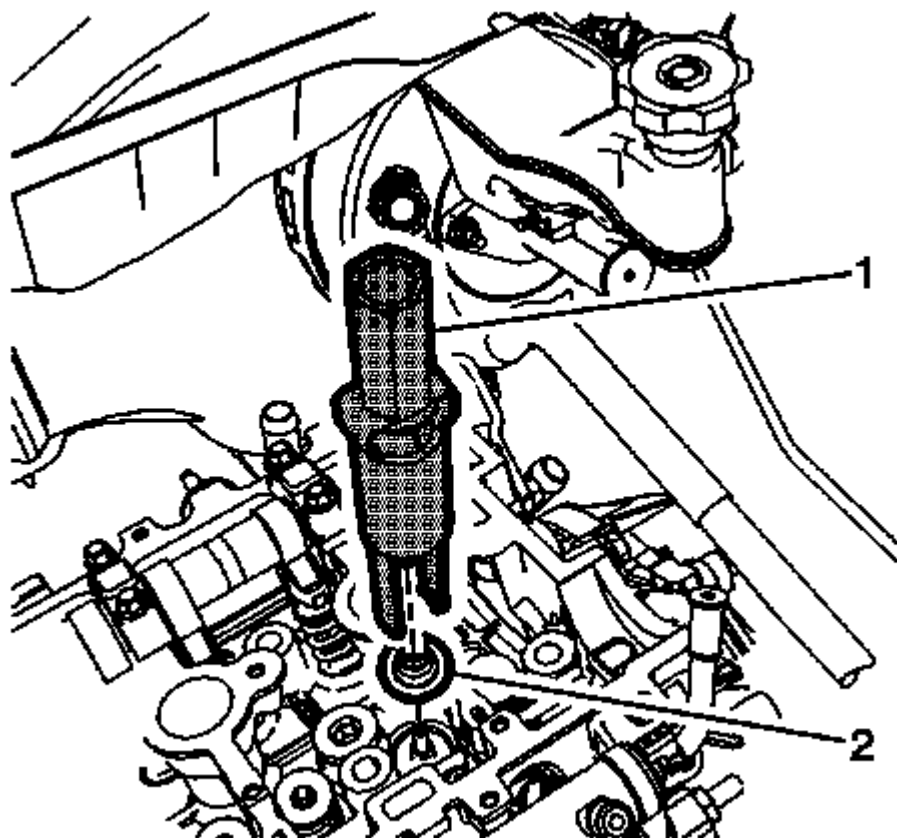


Fig. 137: View Of Valve Guide Seal Remover/Installer
Courtesy of GENERAL MOTORS CORP.

14. Use the **EN-36017**: seal remover (1) to remove the valve seal.

INSTALLATION PROCEDURE

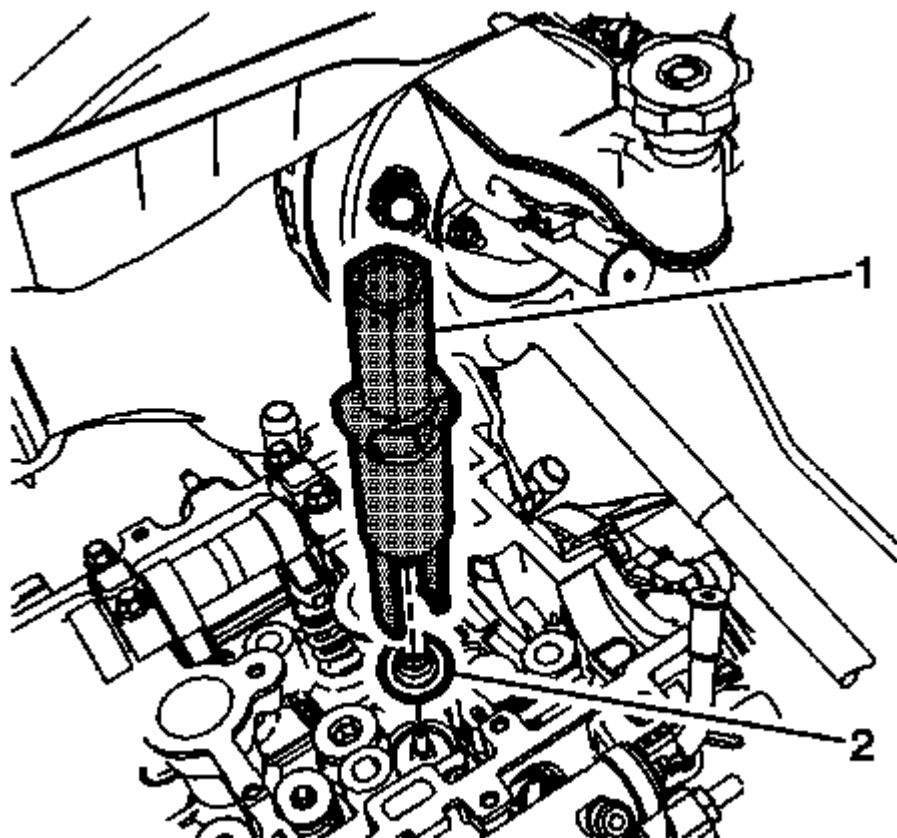


Fig. 138: View Of Valve Guide Seal Remover/Installer
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-36017**: seal remover (1) install the NEW valve seal. Fully seat the seal onto the valve guide.

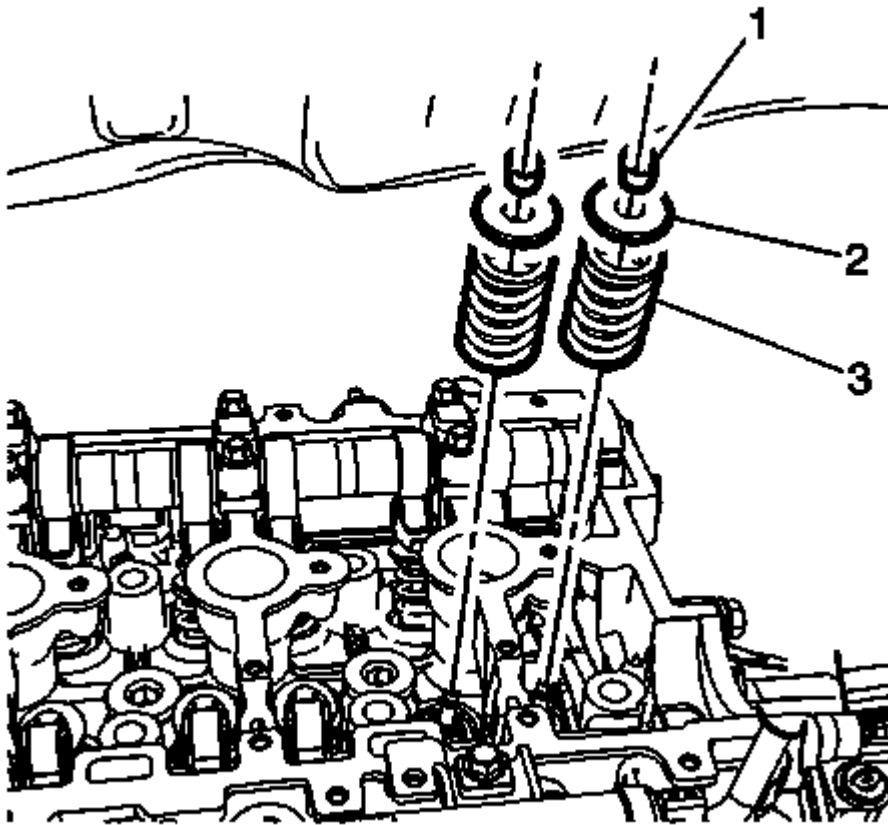


Fig. 139: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (3) and retainer (2).
3. Compress the valve spring using the valve spring compressor.
4. Install the valve spring keepers (1).
5. Disconnect the air hose and air hose adapter.

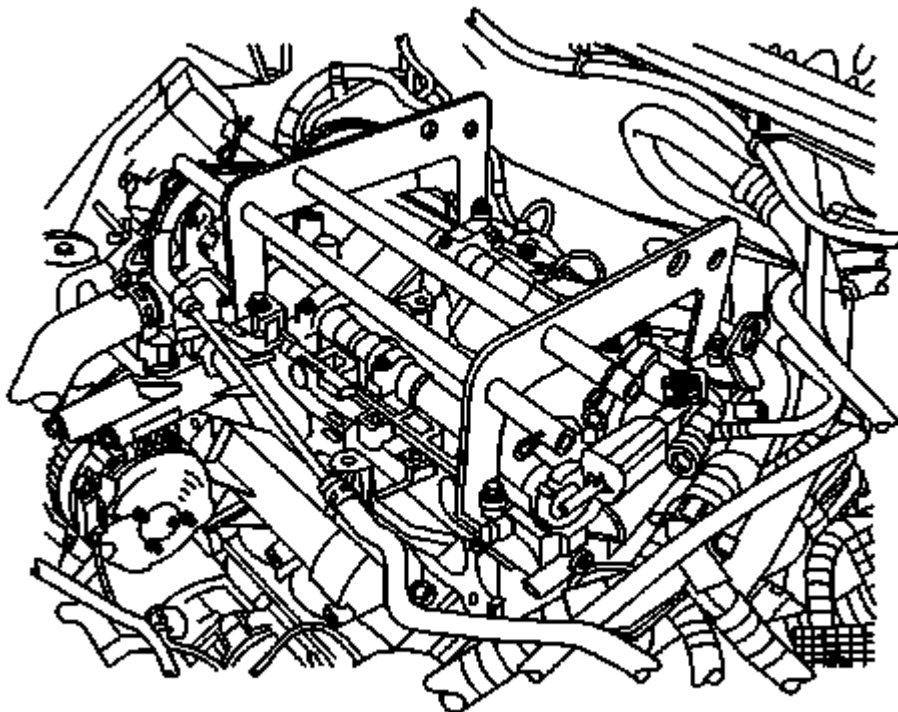


Fig. 140: Valve Spring Compressor At Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN-43649:** compressor and **EN-43649-10:** adaptor set from the cylinder head.
7. Install the spark plugs. Refer to **Spark Plug Replacement** .

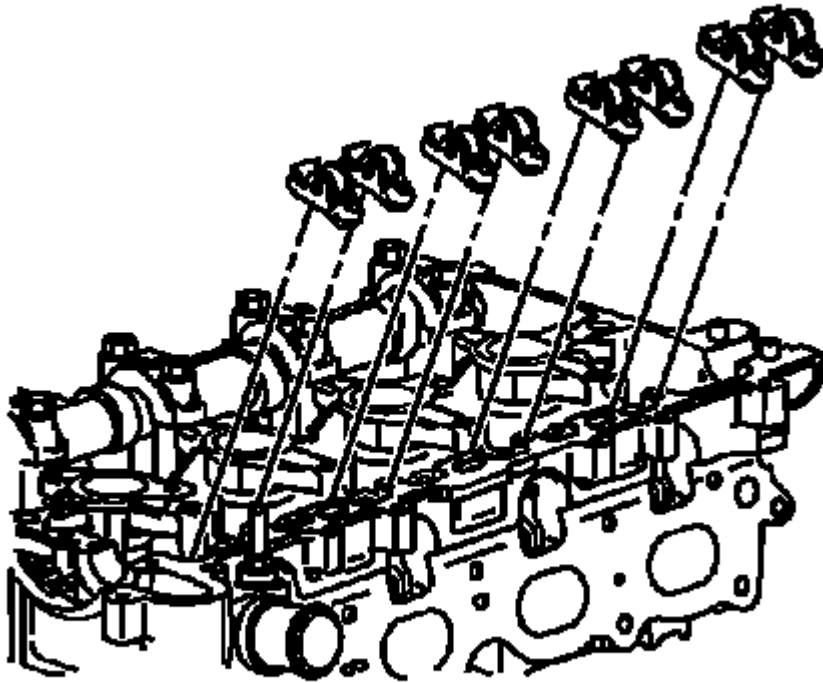


Fig. 141: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers.
9. Install the camshaft. Refer to Intake Camshaft and Valve Lifter Replacement or Exhaust Camshaft and Valve Lifter Replacement.
10. If used, remove the EN-43653: holding tool.
11. If removed, install the starter. Refer to Starter Replacement (L4) .

CYLINDER HEAD REPLACEMENT (LAF)

SPECIAL TOOLS

- **EN-45059:** Angle Meter
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

For equivalent regional tools, refer to Special Tools

REMOVAL PROCEDURE

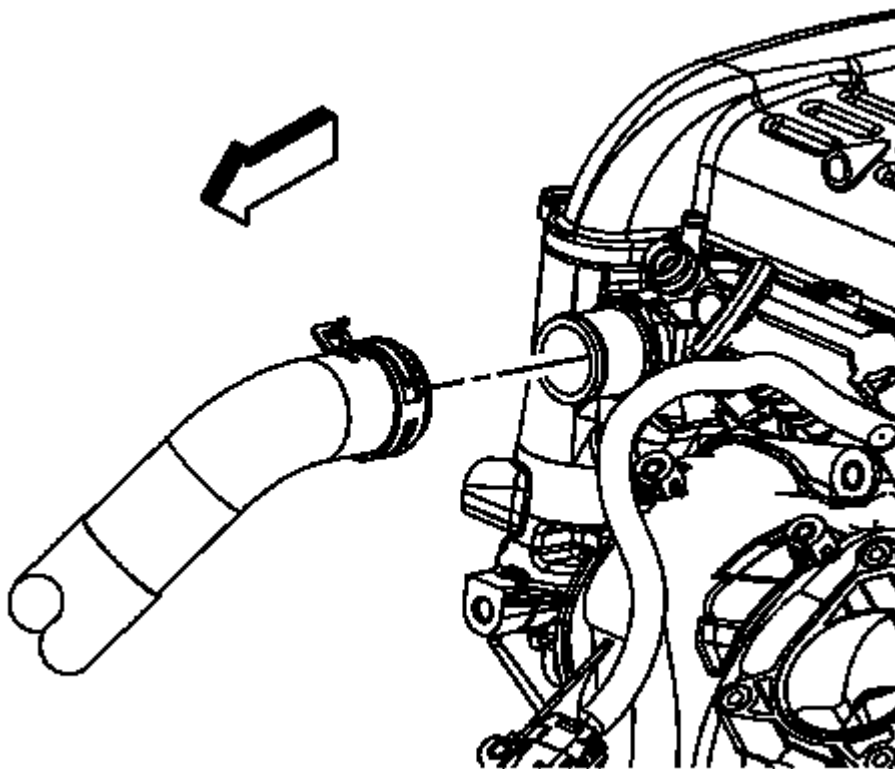


Fig. 142: Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to Cooling System Draining and Filling (GE 47716) or Cooling System Draining and Filling (Static Fill)
2. Remove the exhaust manifold. Refer to Exhaust Manifold Replacement (L4)
3. Remove the intake manifold. Refer to Intake Manifold Replacement
4. Reposition the radiator surge tank air bleed hose clamp.
5. Remove the radiator surge tank air bleed hose from the cylinder head.
6. Reposition the radiator inlet hose clamp.
7. Remove the radiator inlet hose from the cylinder head.
8. Disconnect all electrical connectors as necessary.
9. Remove the camshaft cover. Refer to Camshaft Cover Replacement

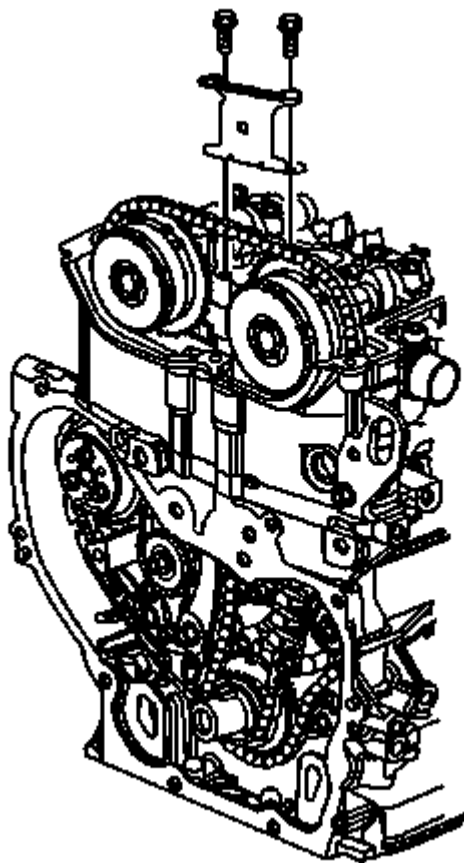


Fig. 143: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the upper timing chain guide bolts and guide.

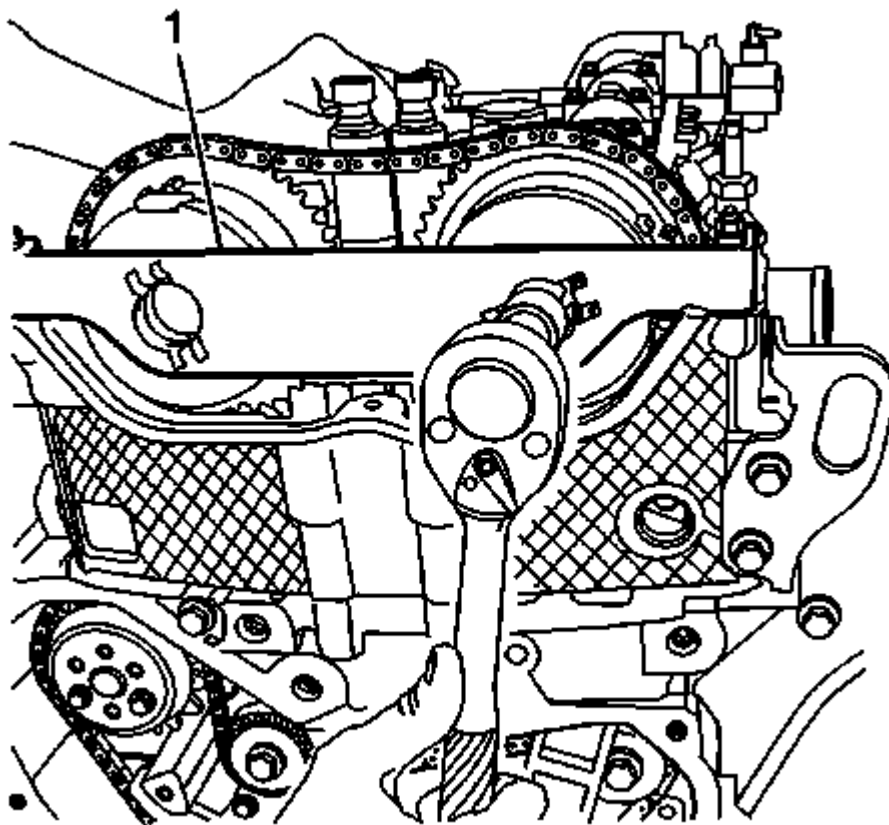


Fig. 144: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE:

- If the intake camshaft actuator is moving independently of the camshaft, this means the camshaft is not locked to the actuator. Rotate the camshaft counterclockwise while the holding tool is installed and this will lock the camshaft to the actuator.
- Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

11. Rotate the intake camshaft clockwise and install the **EN-48953**: locking tool (1) to the actuators.

CAUTION: Refer to Fastener Caution

12. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
13. Clean the timing chain and gears with solvent.
14. Mark the timing gear sprockets and the timing chain. It is recommended that the paint marks are located in the 12 o'clock position.

15. Loosen, but do not remove the intake and exhaust camshaft actuator bolts.
16. Remove the **EN-48953**: locking tool.

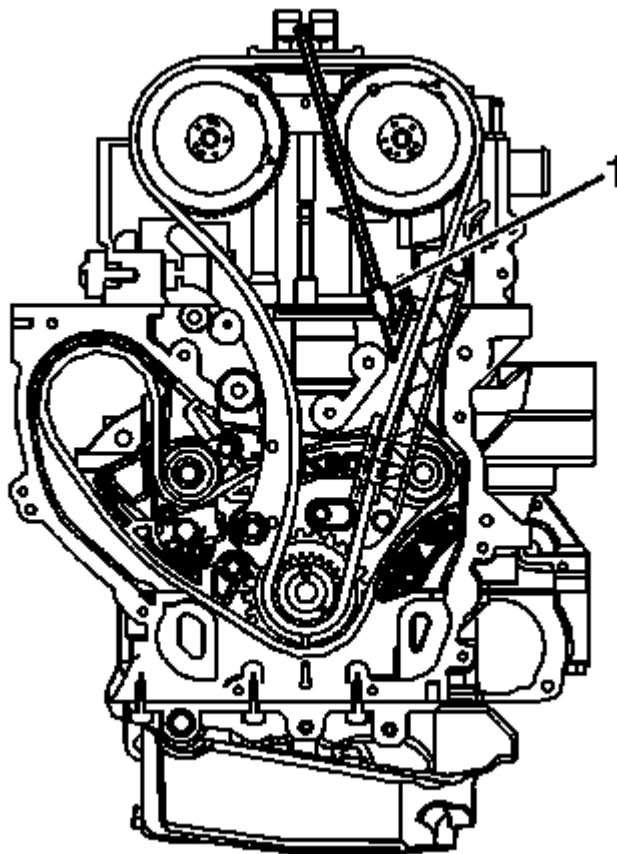


Fig. 145: Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the tips of the **EN-48749**: retention tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.

17. Install the **EN-48749**: retention tool (1) to the intake side of the timing chain.

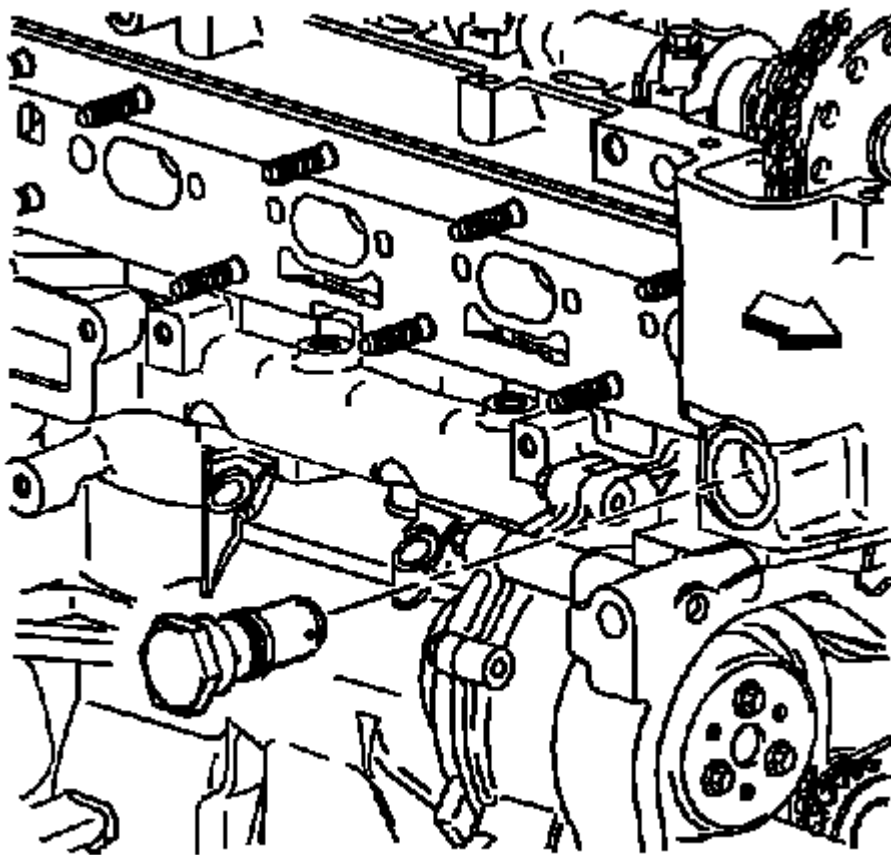


Fig. 146: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

18. Remove the timing chain tensioner.

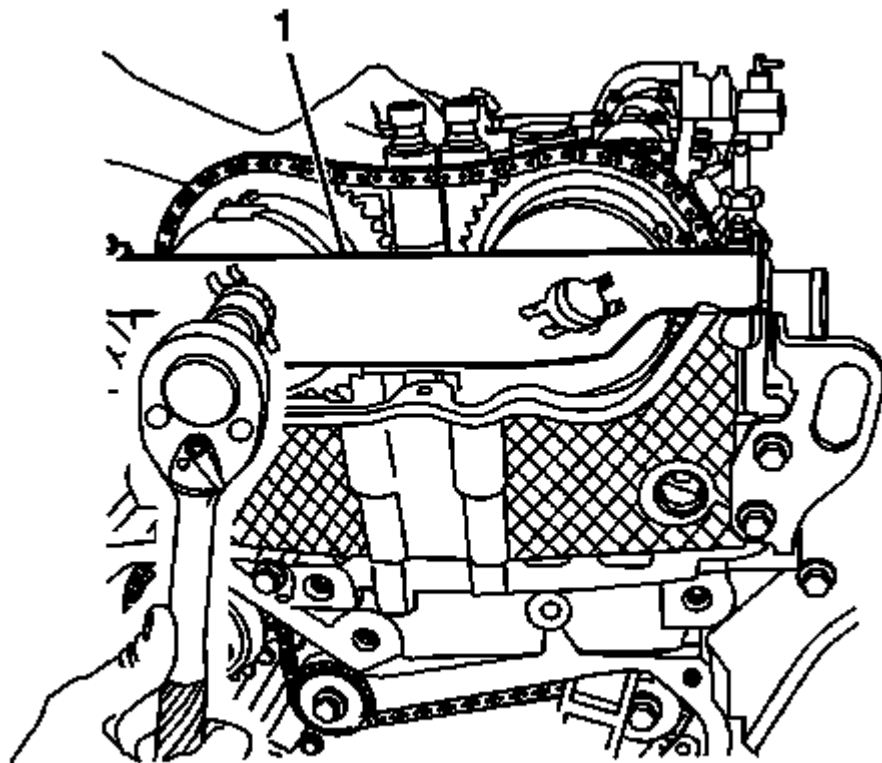


Fig. 147: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft actuators should not rotate during the removal of installation.

19. Install the **EN-48749:** retention tool (1) to the exhaust side of the timing chain.

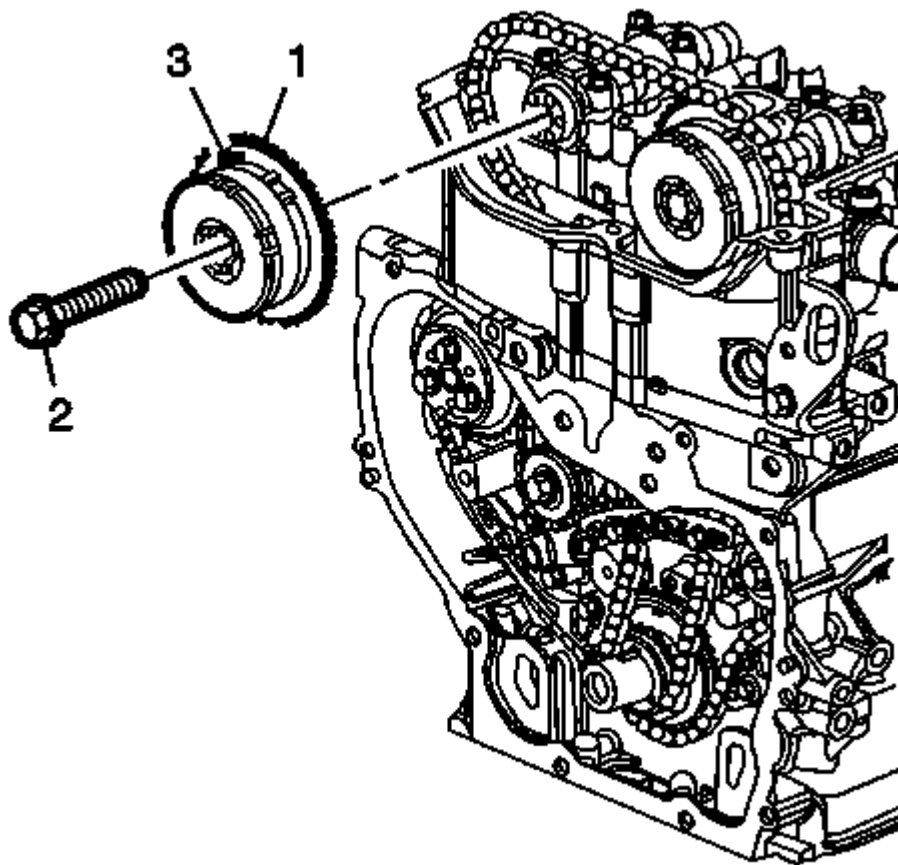


Fig. 148: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

20. Remove and discard the exhaust camshaft actuator bolt (2).

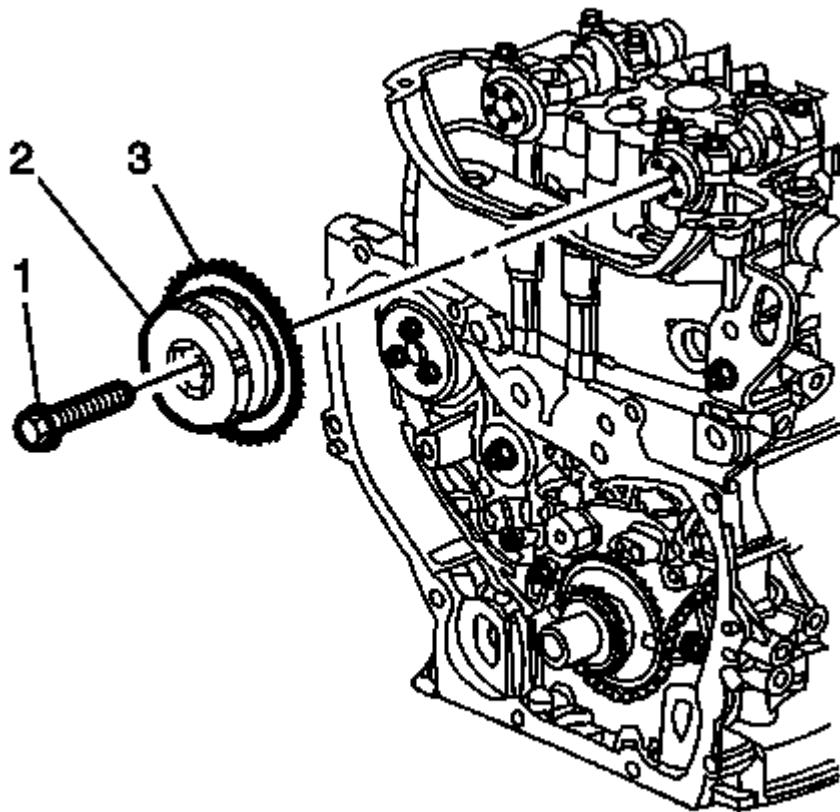


Fig. 149: Intake Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

21. Remove and discard the intake camshaft actuator bolt (2).
22. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

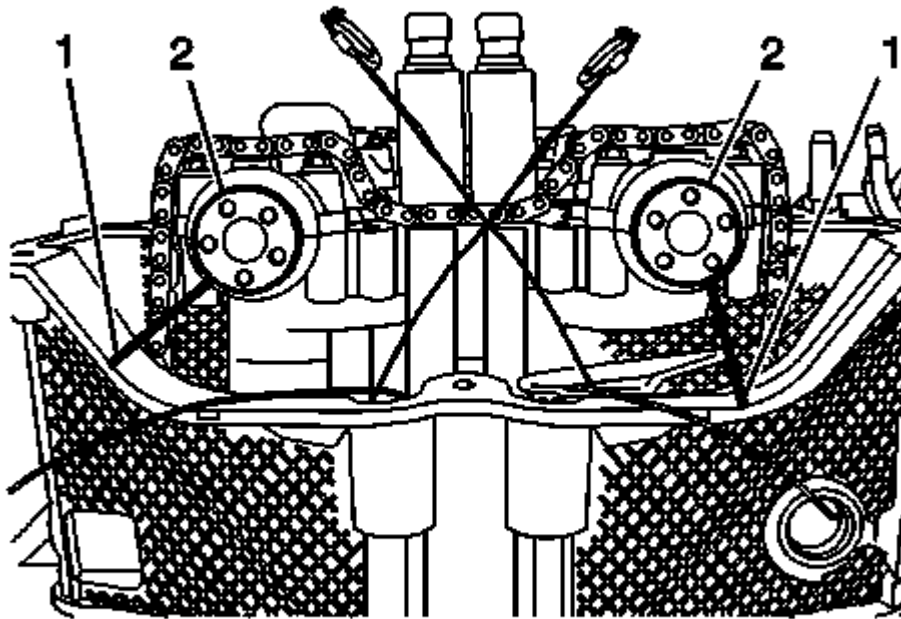


Fig. 150: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

23. Mark the cylinder head (1) in relationship to the camshaft actuator notch is on the camshaft (2).

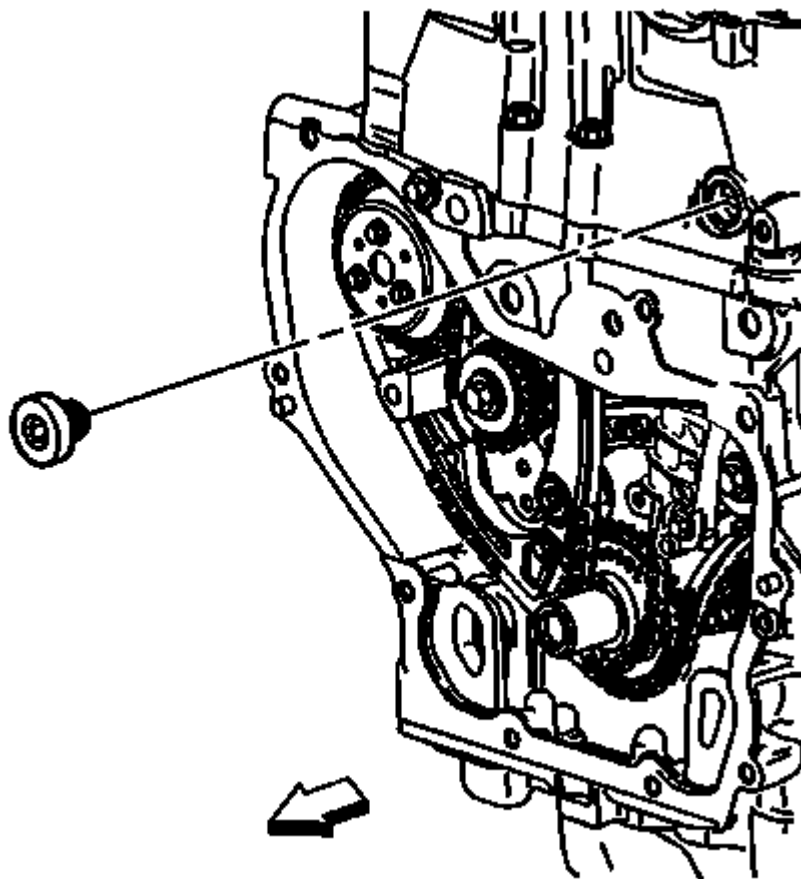


Fig. 151: Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

24. Remove the fixed timing chain guide access plug.

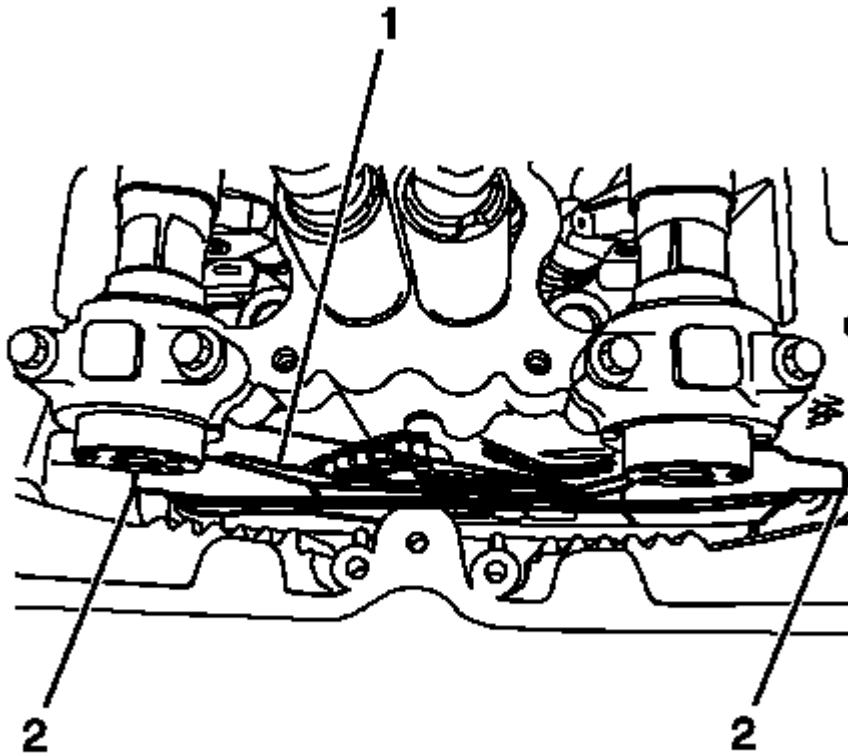


Fig. 152: Pulling Guides Together
Courtesy of GENERAL MOTORS CORP.

NOTE: The threaded rod from the timing chain retention tool can be used to help feed the rubber band around the chain guides.

25. Install a rubber band (1) around the top of the upper timing chain guides (2) in order to pull the guides together.

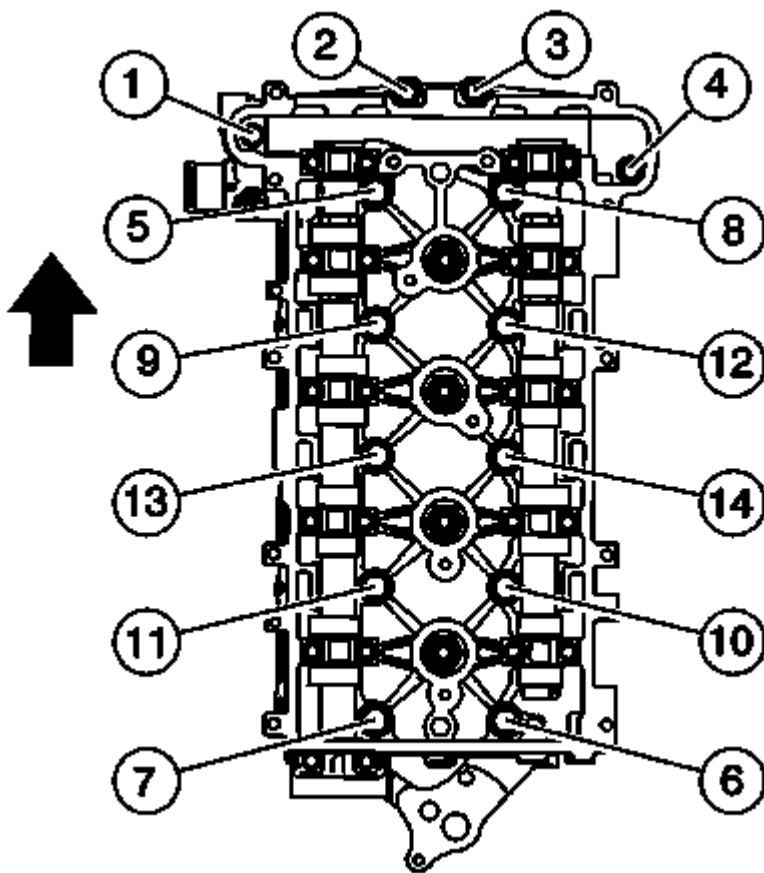


Fig. 153: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

26. Remove the cylinder head bolts in the sequence shown. Discard the bolts.

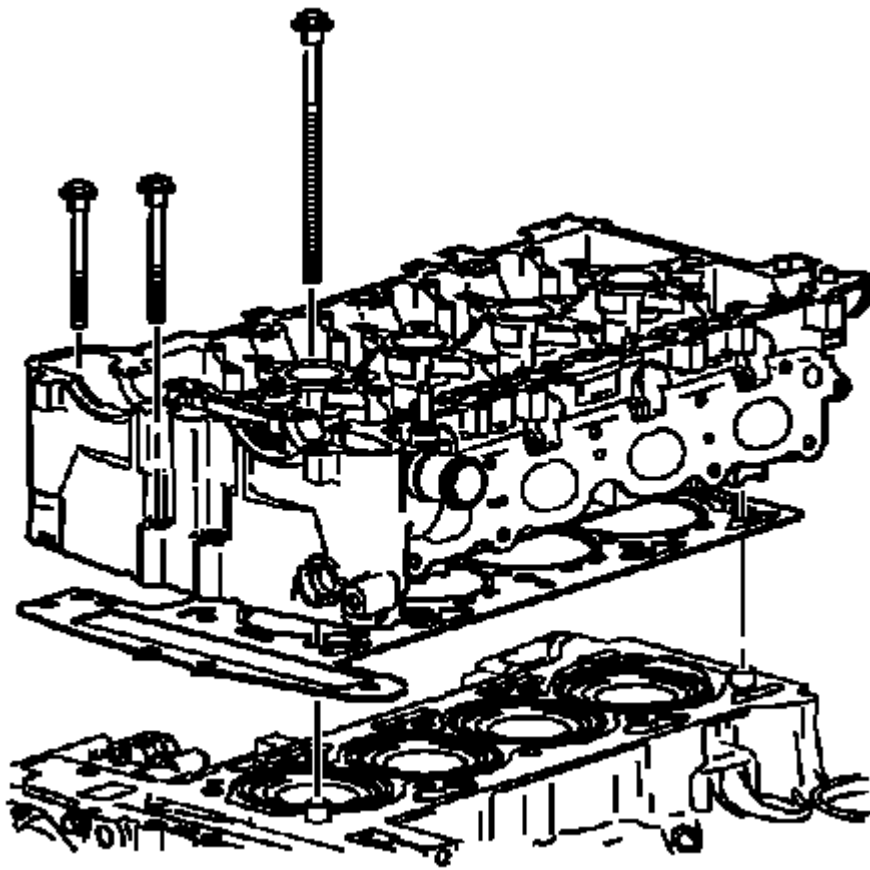


Fig. 154: Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

27. Remove the cylinder head.
28. Remove the cylinder head gasket.
29. Clean all of the gasket surfaces.
30. Use the following steps when cleaning the cylinder head and cylinder block surfaces:
 - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge either surface.

NOTE: **DO NOT use any other method or technique to clean these gasket surfaces.**

- Use a NEW razor blade on the cylinder head and a NEW blade on the cylinder block.

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

by the NEW gasket.

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

31. Clean the old sealer/lube and any dirt from around the bolt holes.

NOTE: DO NOT use a tap to clean the cylinder head bolt holes.

32. Clean the bolts holes with a nylon bristle brush.

33. When cleaning the cylinder head bolt holes use suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun in order to reach the bottom of the holes.

34. If replacing the cylinder head, transfer all parts as necessary.

INSTALLATION PROCEDURE

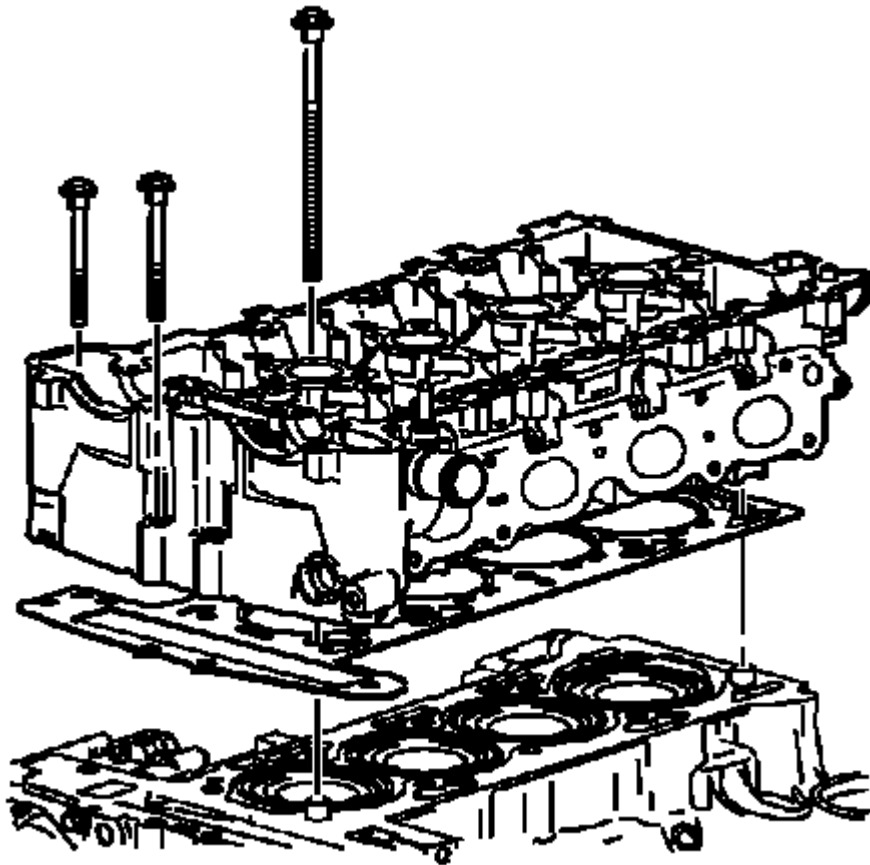


Fig. 155: Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use any sealing material.

1. Install the cylinder head gasket.

2. Install the cylinder head.
3. Install NEW cylinder head bolts.

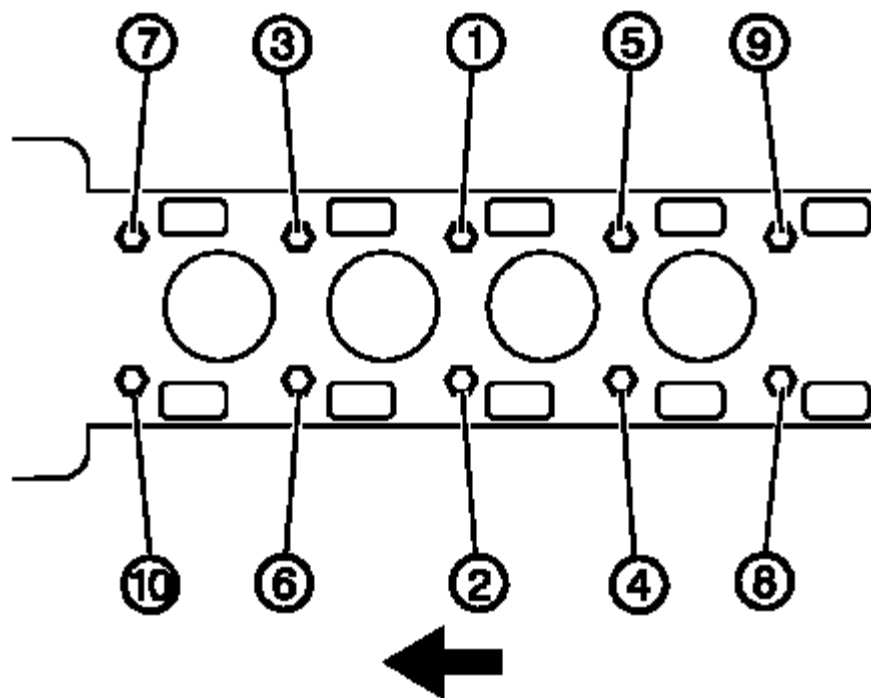


Fig. 156: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown. Tighten the bolts to 30 N.m (22 lb ft) plus an additional 155 degrees using the **EN-45059** meter.

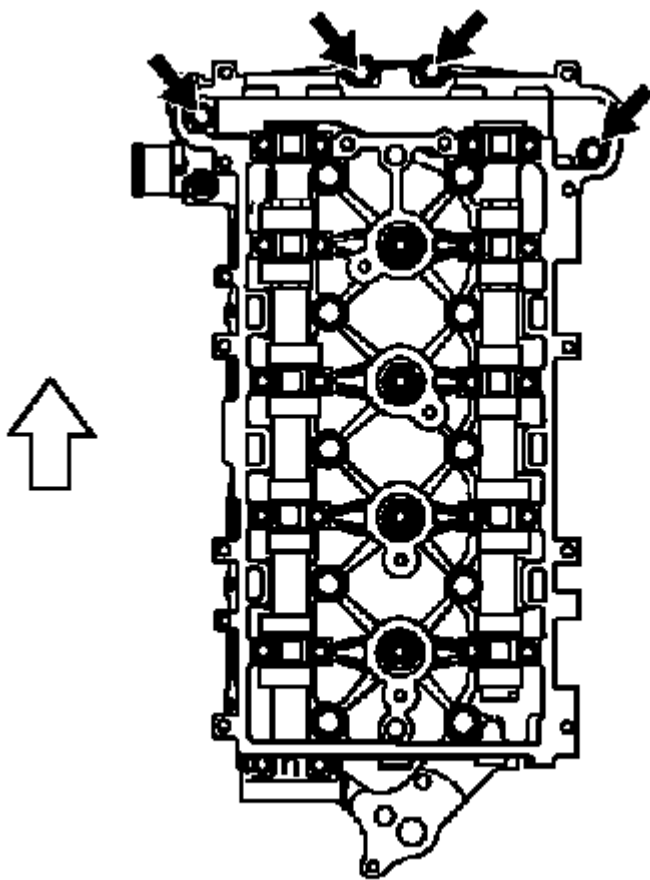


Fig. 157: Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts and tighten to 35 N.m (26 lb ft).

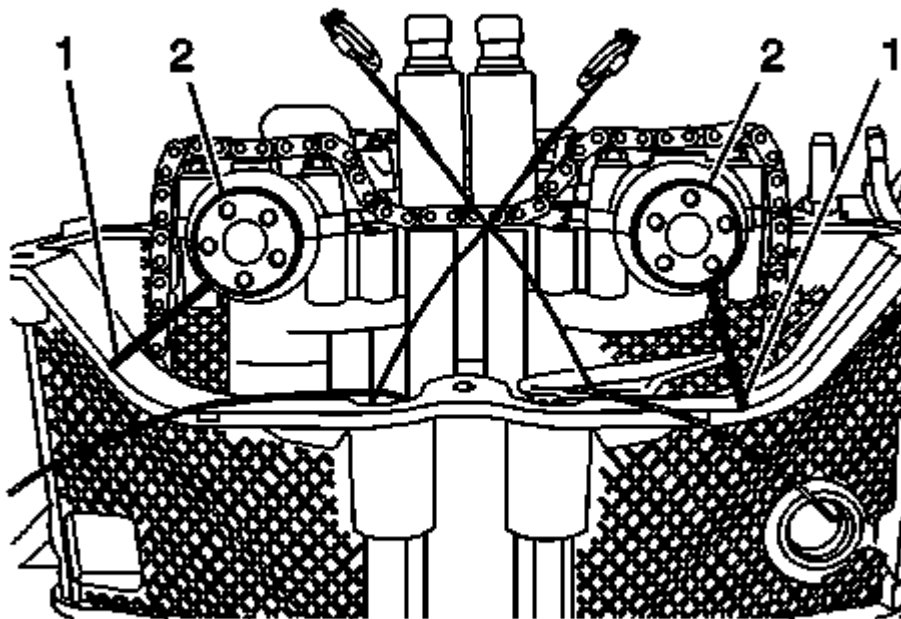


Fig. 158: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

6. Ensure the cylinder head (1) and the camshaft (2) are correctly aligned.

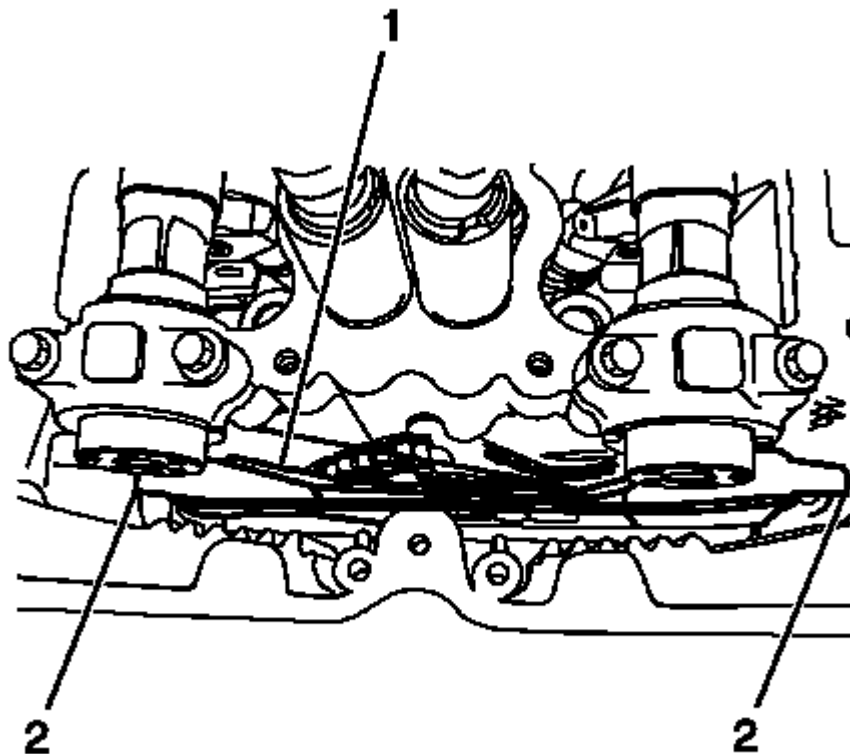


Fig. 159: Pulling Guides Together
Courtesy of GENERAL MOTORS CORP.

7. Remove the rubber band (1) from around the top of the upper timing chain guides (2).
8. Install the fixed guide bolt into the cylinder bolt and tighten to 12 N.m (106 lb in).

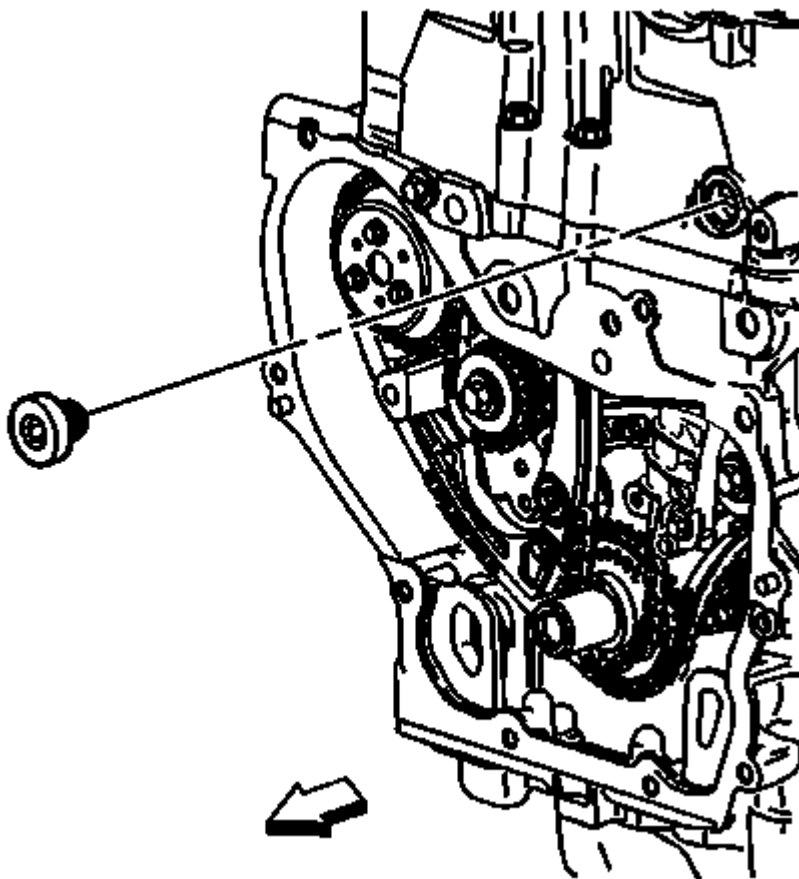


Fig. 160: Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant compound to thread and install the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)**
10. Install the fixed timing chain guide access plug. Tighten the chain guide plug to 90 N.m (59 lb ft).

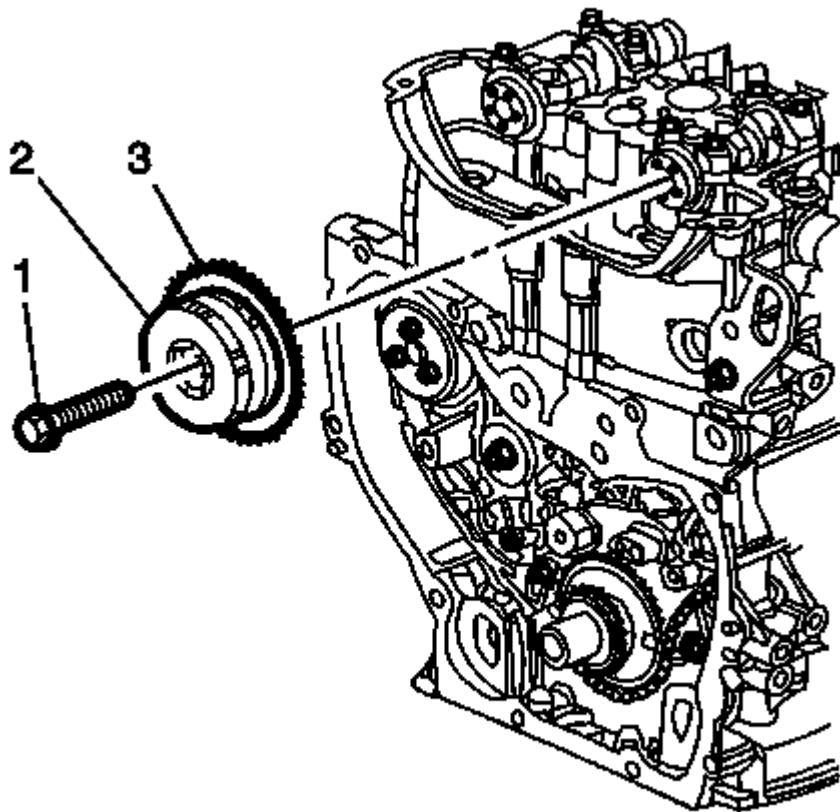


Fig. 161: Intake Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the exhaust camshaft actuator is still aligned properly with the mark on the timing chain.

11. Install the timing chain onto the intake camshaft actuator.
12. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
13. Install a NEW intake camshaft actuator bolt (2) until snug.

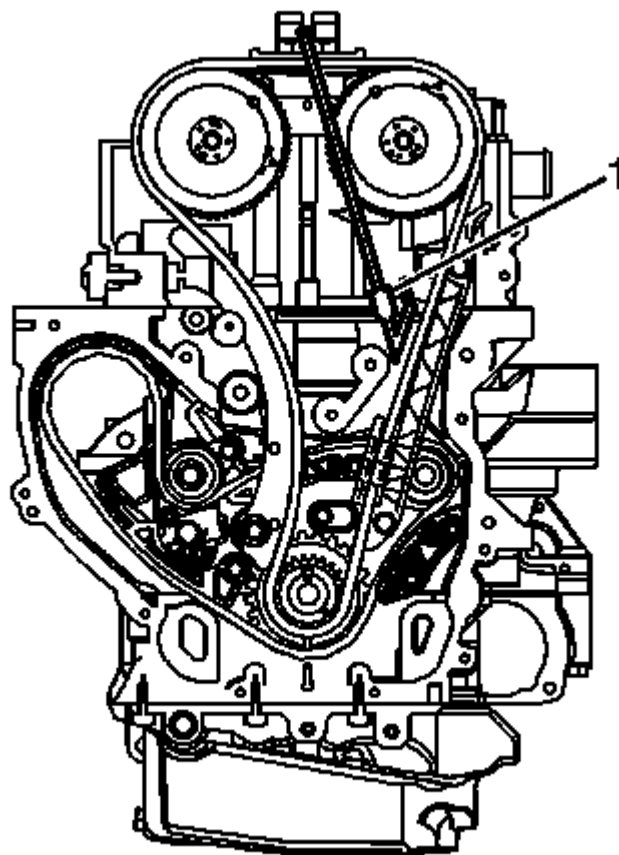


Fig. 162: Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

14. Remove the **EN-48749:** retention tool (1) from the intake side of the timing chain.

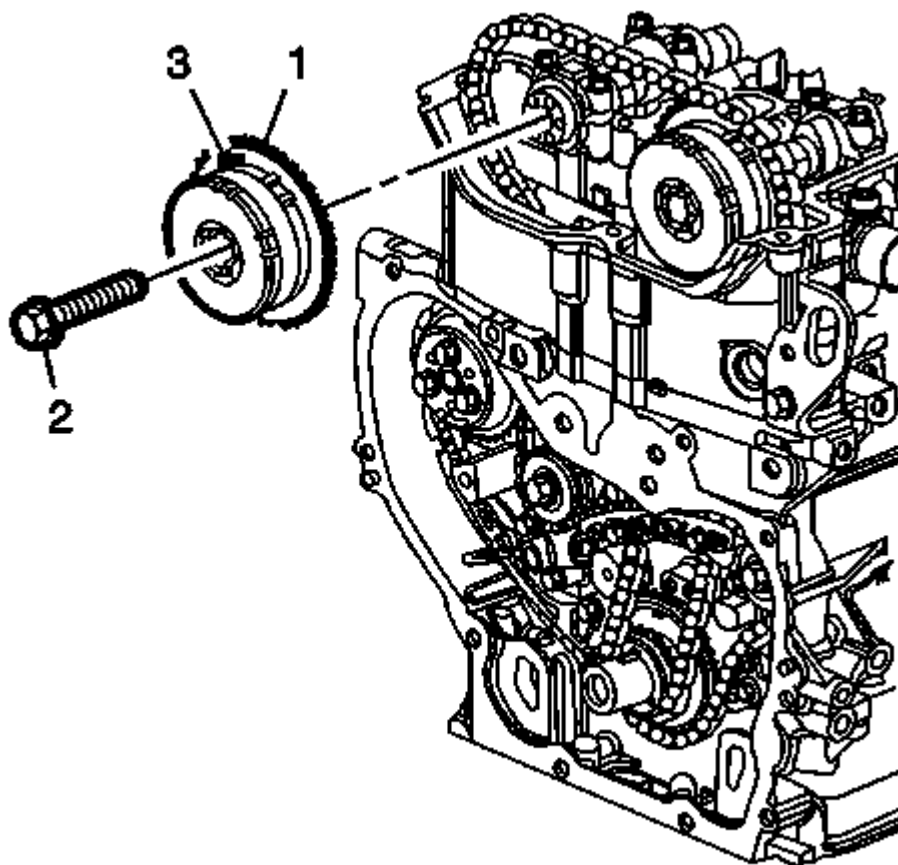


Fig. 163: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

15. Install the timing chain onto the exhaust camshaft actuator.
16. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
17. Install a NEW exhaust camshaft actuator bolt (2) until snug.

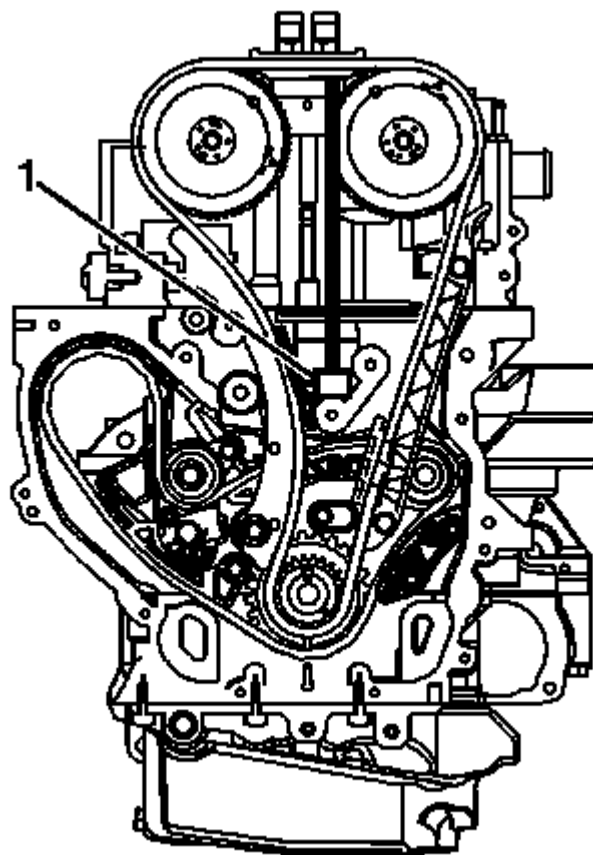


Fig. 164: Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

18. Remove the **EN-48749:** retention tool (1) from the exhaust side of the timing chain.
19. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**

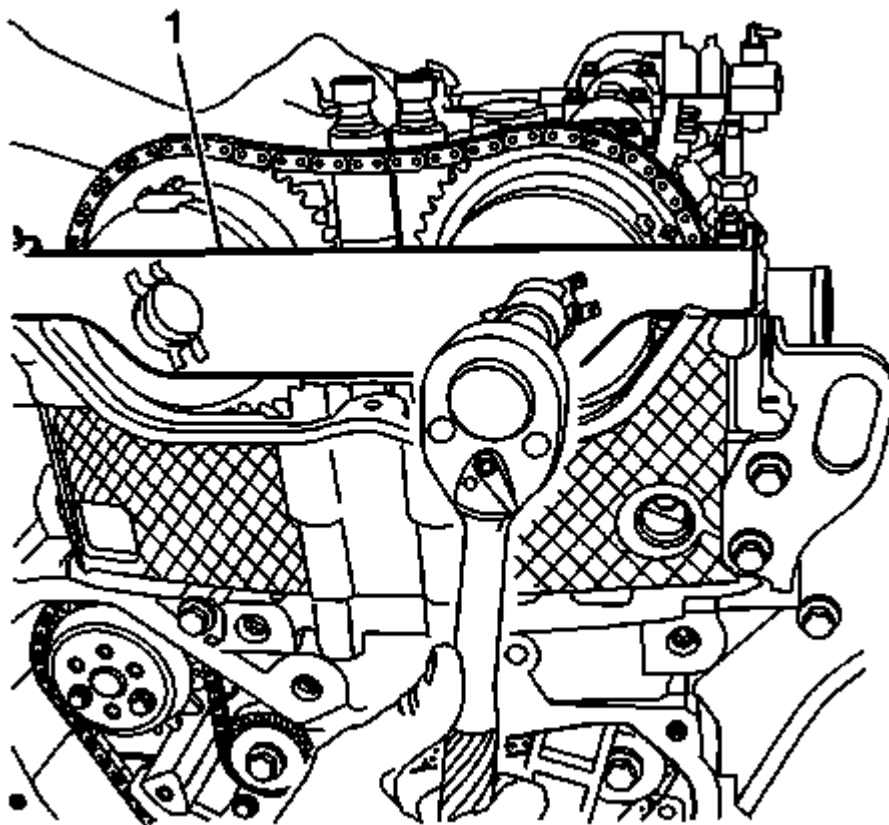


Fig. 165: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

20. Install the **EN-48953**: locking tool (1) to the actuators.
21. Install the camshaft actuator locking tool bolts and tighten to 10 N.m (89 lb in).
22. Release the tensioner by applying a counterclockwise torque on the harmonic balancer bolt and tighten the bolt to 45 N.m (33 lb ft).
23. Tighten the NEW camshaft actuator bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **EN-45059**: meter.
24. Remove the camshaft actuator locking tool, **EN-48953**: locking tool.

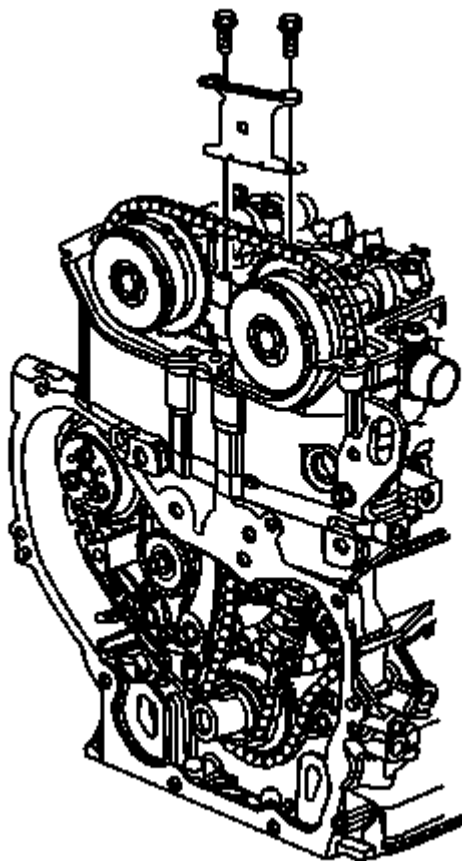


Fig. 166: Upper Timing Chain Guide And Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the upper timing chain guide bolts and guide. Tighten the bolts to 10 N.m (89 lb in).
26. Install the camshaft cover. Refer to **Camshaft Cover Replacement**

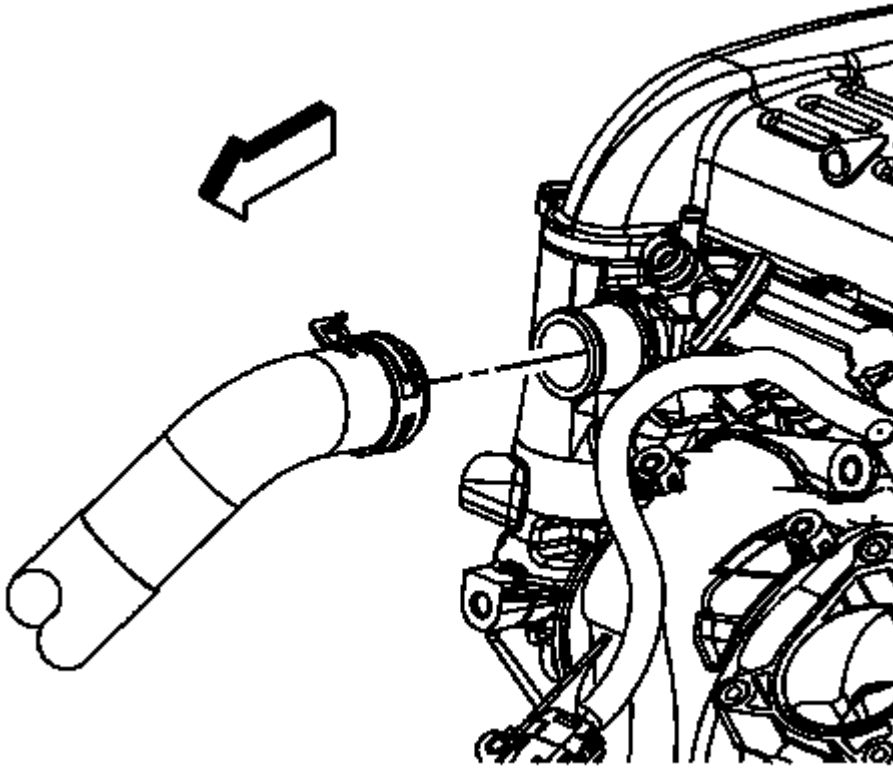


Fig. 167: Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

27. Connect all electrical connectors as necessary.
28. Install the radiator inlet hose to the cylinder head.
29. Position the radiator inlet hose clamp.
30. Install the radiator surge tank air bleed hose to the cylinder head.
31. Position the radiator surge tank air bleed hose clamp.
32. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (L4)**
33. Install the intake manifold. Refer to **Intake Manifold Replacement**
34. Fill the cooling system. Refer to **Cooling System Draining and Filling (GE 47716)** or **Cooling System Draining and Filling (Static Fill)**

OIL PAN REPLACEMENT

REMOVAL PROCEDURE

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.

NOTE: The support fixture bar must be installed to provide enough access to remove and properly tighten the oil pan bolts.

3. Install the engine support fixture. Refer to Engine Support Fixture.
4. Remove engine mount. Refer to Engine Mount Replacement.
5. Using the engine support fixture, raise the engine approximately 76 mm (3 in).
6. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.

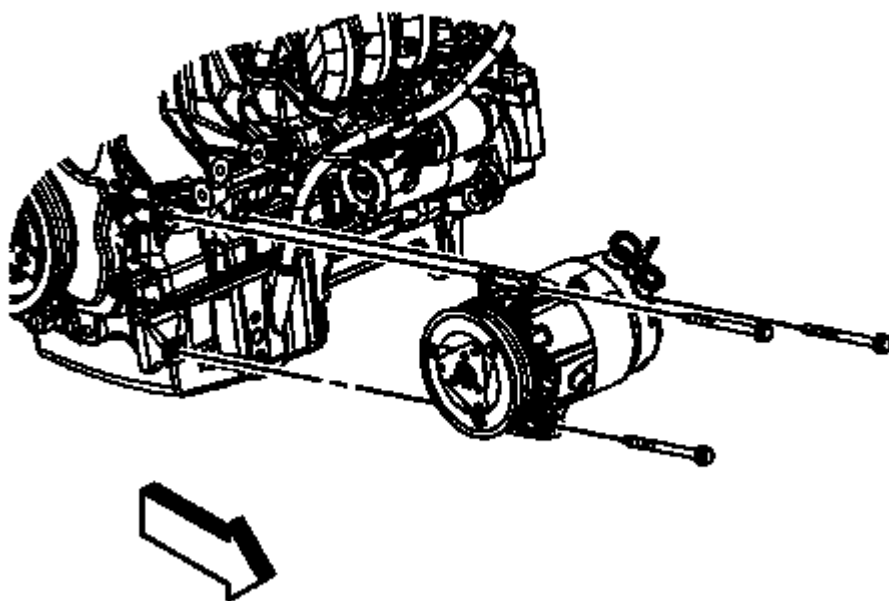


Fig. 168: A/C Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the upper air conditioning (A/C) compressor bolts.
8. Remove the lower A/C compressor bolt.

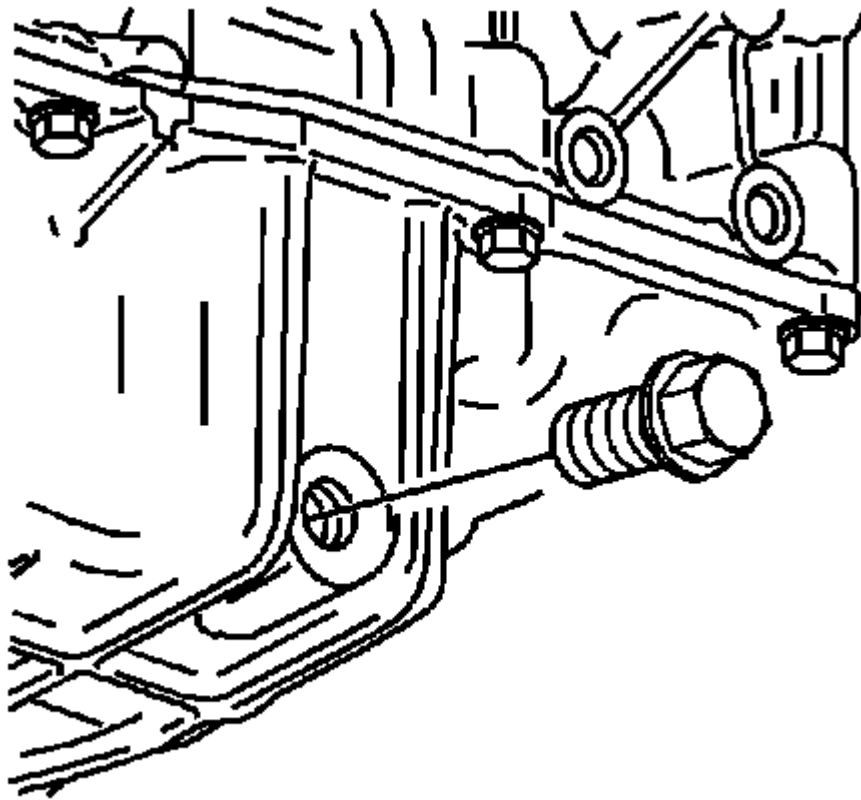


Fig. 169: Oil Pan Drain Plug

Courtesy of GENERAL MOTORS CORP.

9. Place a suitable drain pan under the oil pan drain plug.
10. Remove the oil pan drain plug.
11. Drain the engine oil.
12. Reinstall the oil pan drain plug until snug.

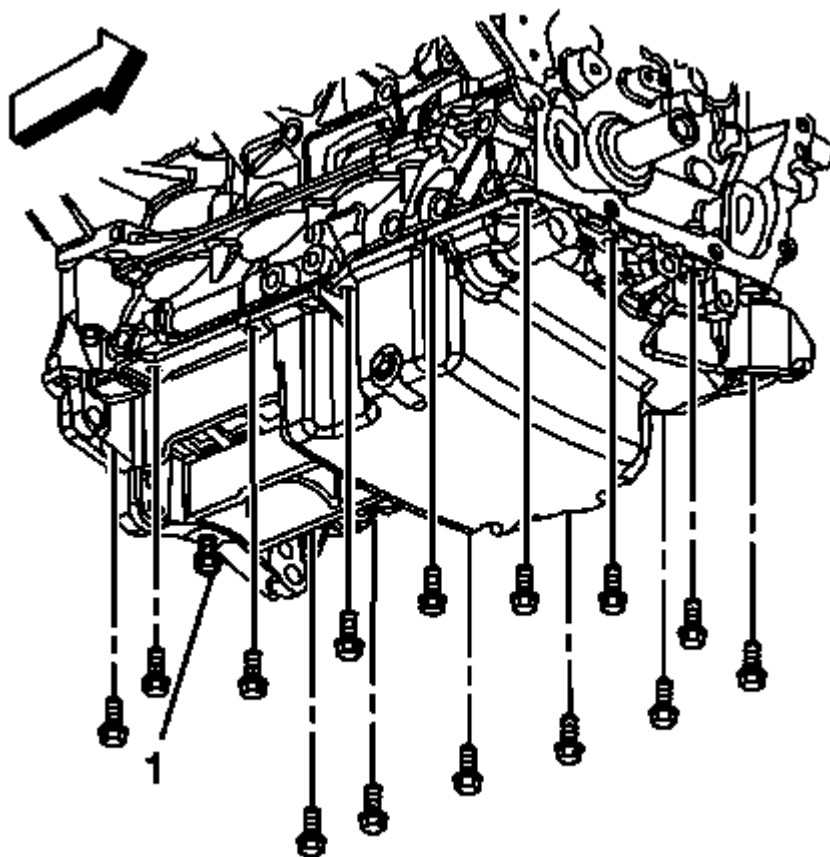


Fig. 170: Oil Pan Bolts

Courtesy of GENERAL MOTORS CORP.

13. Remove the 4 oil pan to transaxle bolts.
14. Remove the oil pan bolts.

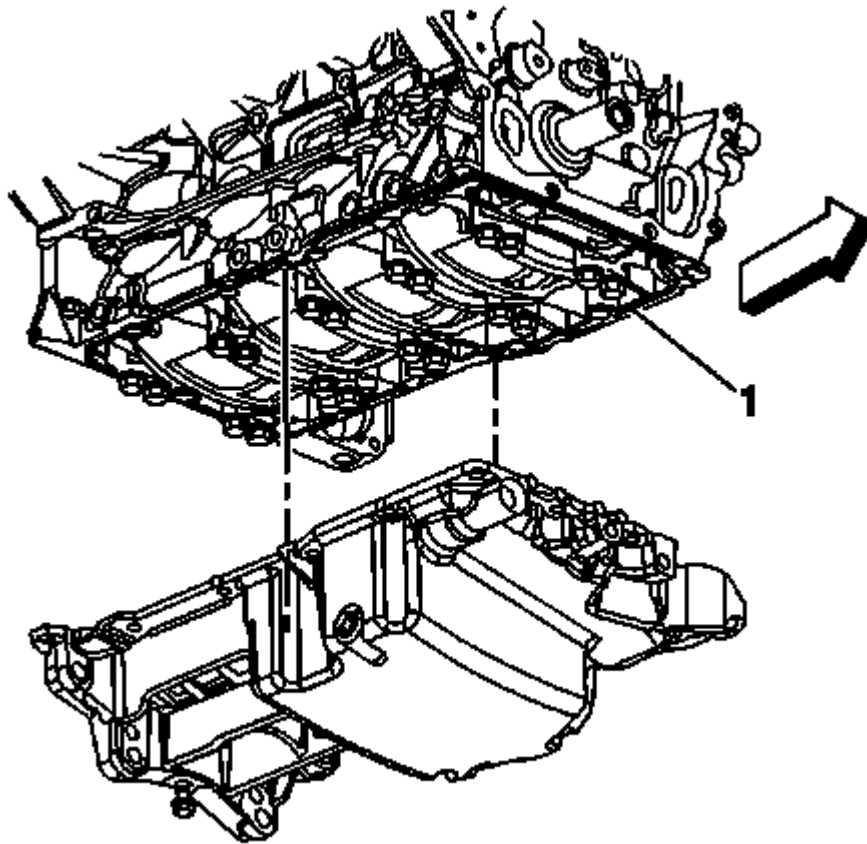


Fig. 171: Oil Pan

Courtesy of GENERAL MOTORS CORP.

15. Remove the oil pan
16. Remove any old oil pan sealant (1).

INSTALLATION PROCEDURE

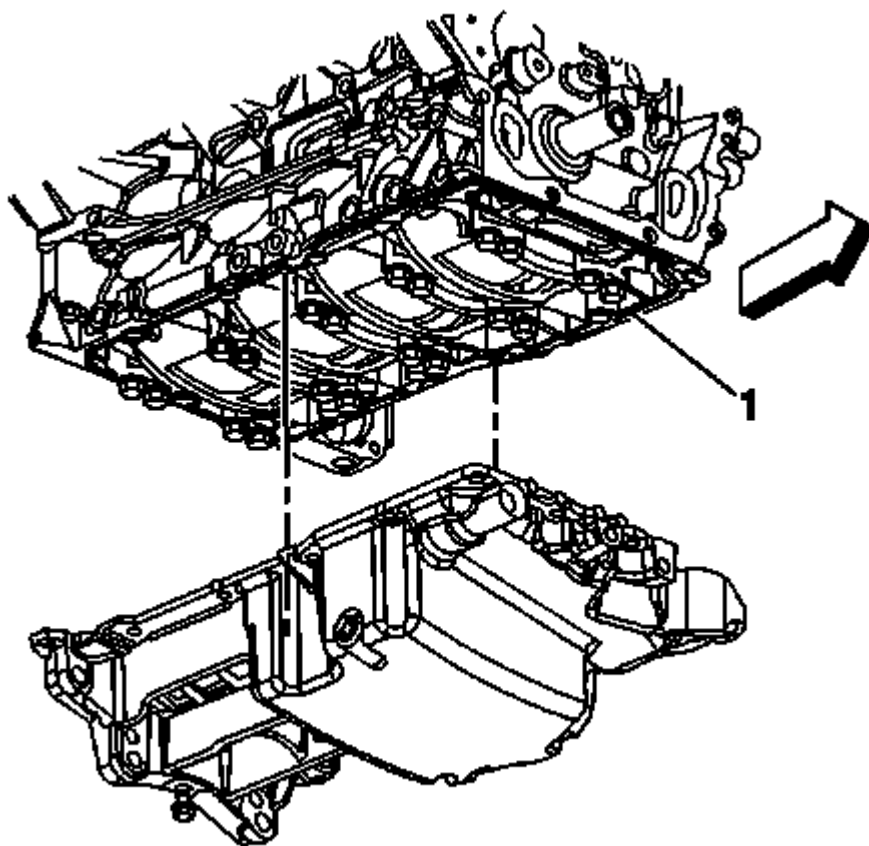


Fig. 172: Oil Pan

Courtesy of GENERAL MOTORS CORP.

1. Ensure that the oil pan and the sealing surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of sealant (1) around the perimeter of the oil pan and the oil suction port opening. DO NOT over apply the sealant. More than a 2 mm bead is not required. Refer to **Adhesives, Fluids, Lubricants, and Sealers (LAF)** .
3. Install the oil pan.

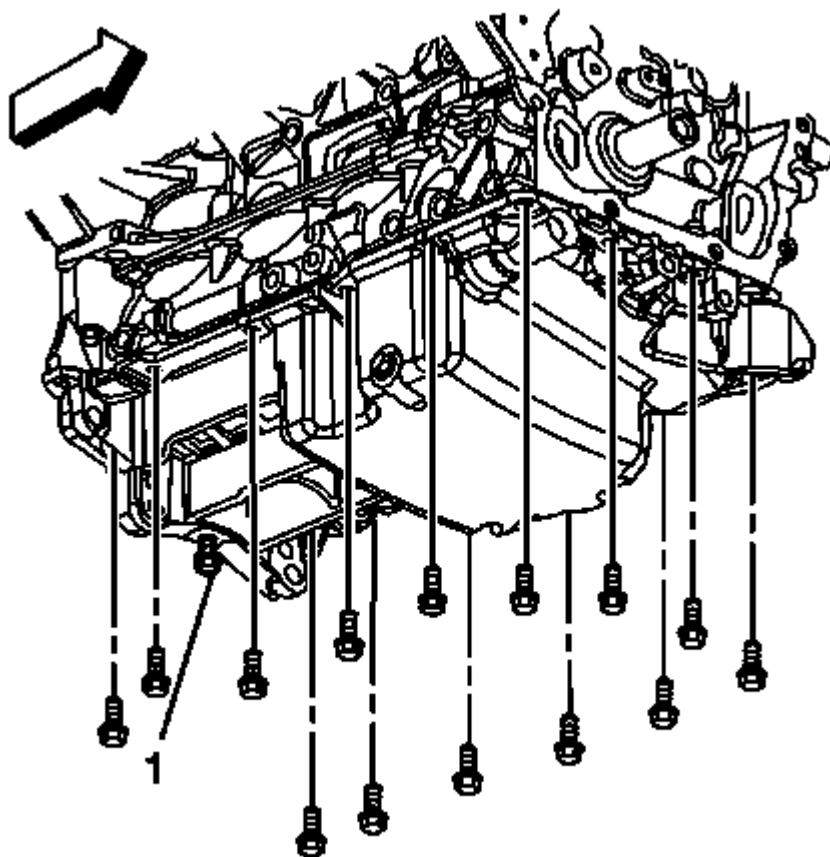


Fig. 173: Oil Pan Bolts

Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

CAUTION: Refer to Fastener Caution .

5. Install the 4 oil pan to transaxle bolts and tighten to 75 N.m (55 lb ft).

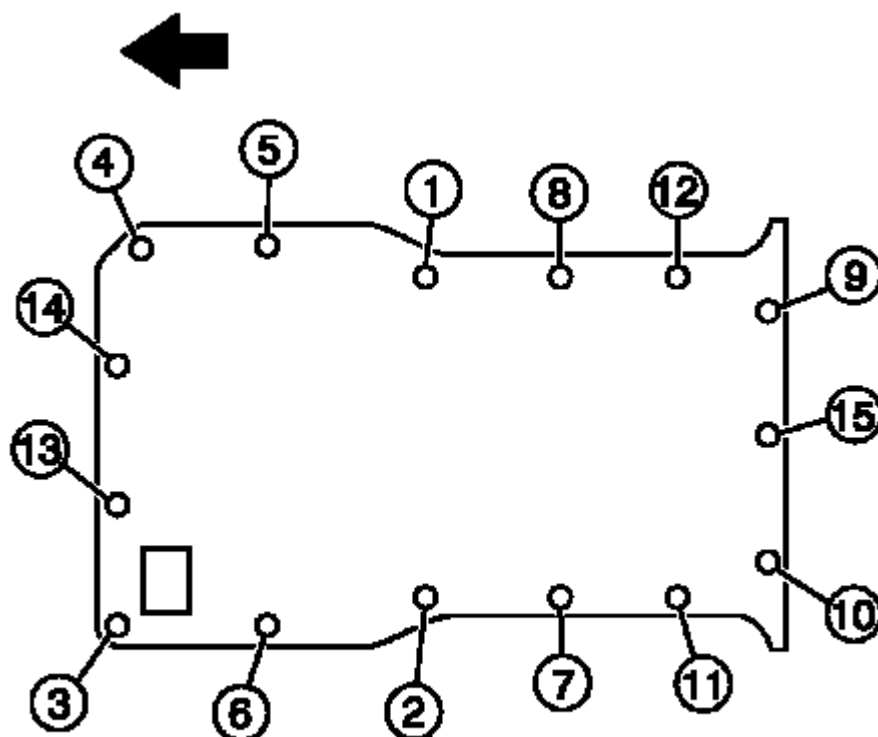


Fig. 174: Oil Pan Bolt Tightening Sequence

Courtesy of GENERAL MOTORS CORP.

6. Tighten the oil pan bolts in the sequence shown to 25 N.m (18 lb ft).
7. Lower the vehicle.
8. Using the engine support fixture, lower the engine.
9. Install the engine mount. Refer to **Engine Mount Replacement**.
10. Remove the engine support fixture.
11. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
12. Install the drive belt. Refer to **Drive Belt Replacement**.
13. Fill the engine oil to the proper level.

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT (LAF)

SPECIAL TOOLS

- **EN-8037:** Ring Compressor
- **EN-24270:** Cylinder Bore Ridge Reamer
- **EN-43966-1:** Connecting Rod Guides

- **EN-45059:** Angle Meter

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

REMOVAL PROCEDURE

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the cylinder head. Refer to **Cylinder Head Replacement (LAF)**.

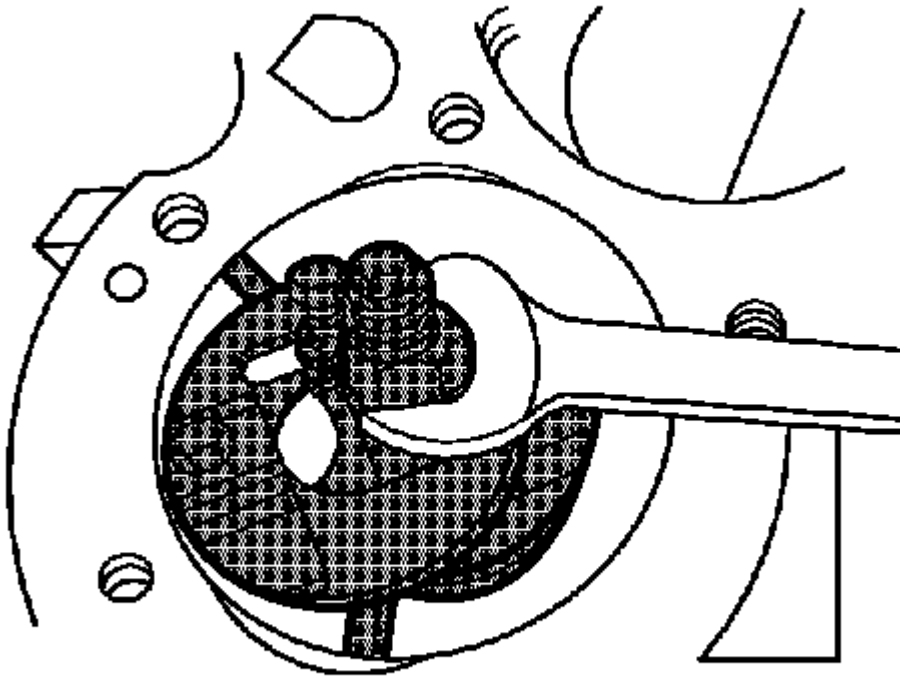


Fig. 175: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

3. If a ring ridge is present, remove the ring ridge as follows:
 1. Turn the crankshaft until the piston is at the bottom of the stroke.
 2. Place a cloth on top of the piston.
 3. Use a **EN-24270:** reamer to remove the ring ridge.
 4. Turn the crankshaft so the piston is at top of the stroke.
 5. Remove the cloth and cutting debris.

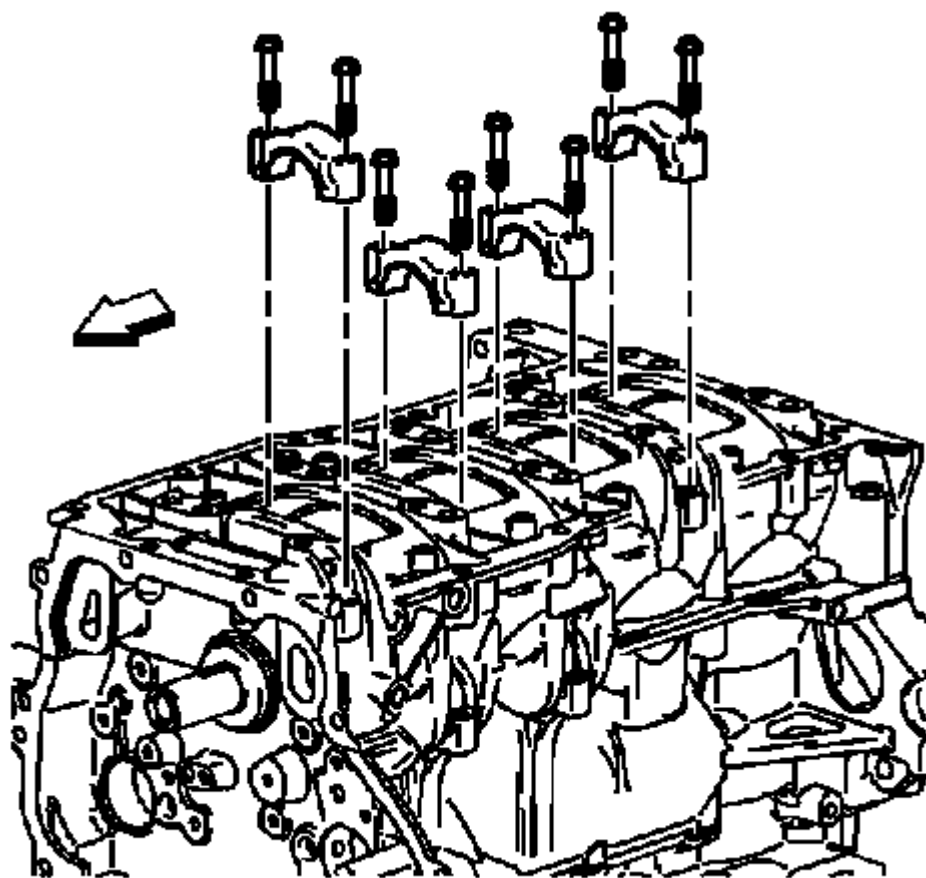


Fig. 176: Connecting Rod Bolts & Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Place the numbers on connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

4. Remove the connecting rod nuts and the connecting rod cap.

Discard the bolts and nuts.

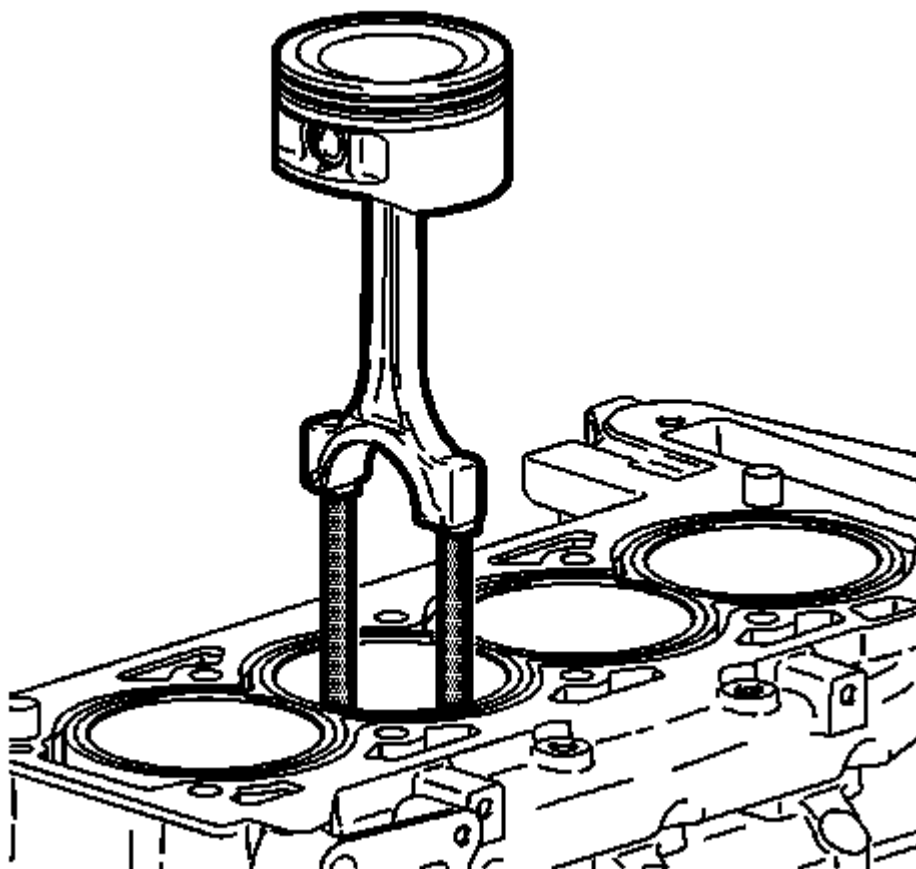


Fig. 177: Connecting Rod And Piston
Courtesy of GENERAL MOTORS CORP.

5. Remove the connecting rod and the piston out of the top of the engine block using the **EN-43966-1:** guides.
6. Clean the cylinder bores with hot water and detergent or with a light honing.
7. Swab the bores with the engine oil and a clean, dry cloth.

INSTALLATION PROCEDURE

1. Coat the following parts with engine oil:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces

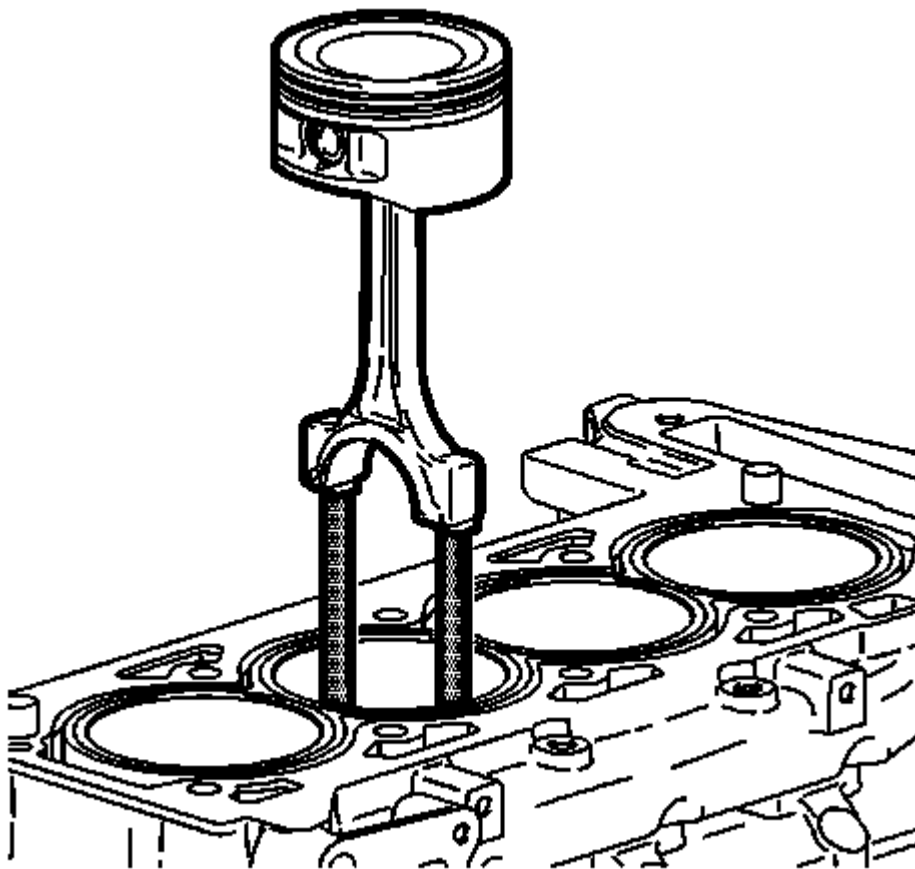


Fig. 178: Connecting Rod And Piston
Courtesy of GENERAL MOTORS CORP.

2. Install the piston into its original bore using the **EN-43966-1**: guides.

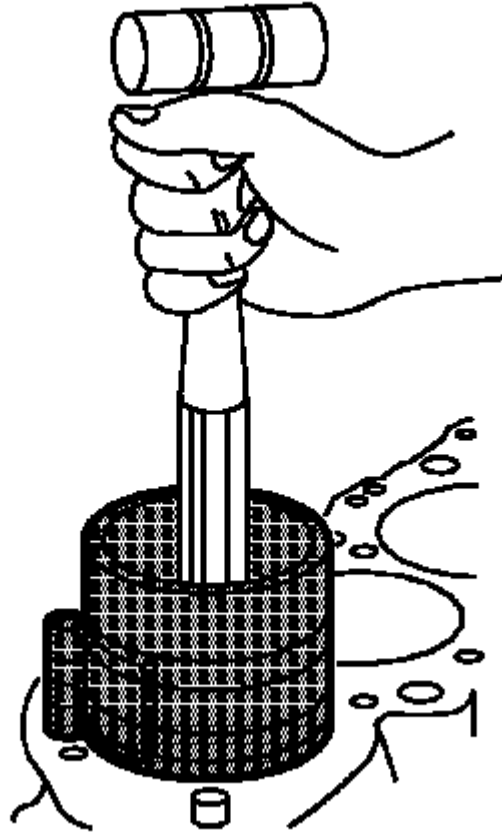


Fig. 179: Tapping Top Of Piston With Wooden Hammer Handle
Courtesy of GENERAL MOTORS CORP.

3. Lightly tap the top of the piston with a wooden hammer handle.
4. When installing the piston and the connecting rod, the stamped mark on the piston must point to the front of the engine.
5. Hold the **EN-8037**: compressor firmly against the engine block until all the piston rings have entered the cylinder bore.
6. Install the connecting rod caps onto their original connecting rods.
7. Align the numbers placed on the connecting rod and the connecting rod cap during removal.

CAUTION: Refer to Fastener Caution .

8. Install the new connecting rod bolts and nuts.
 - On the first pass, tighten the nuts evenly to 25 N.m (18 lb ft).
 - On the final pass, use the **EN-45059**: meter in order to tighten the nuts an additional 100 degrees.

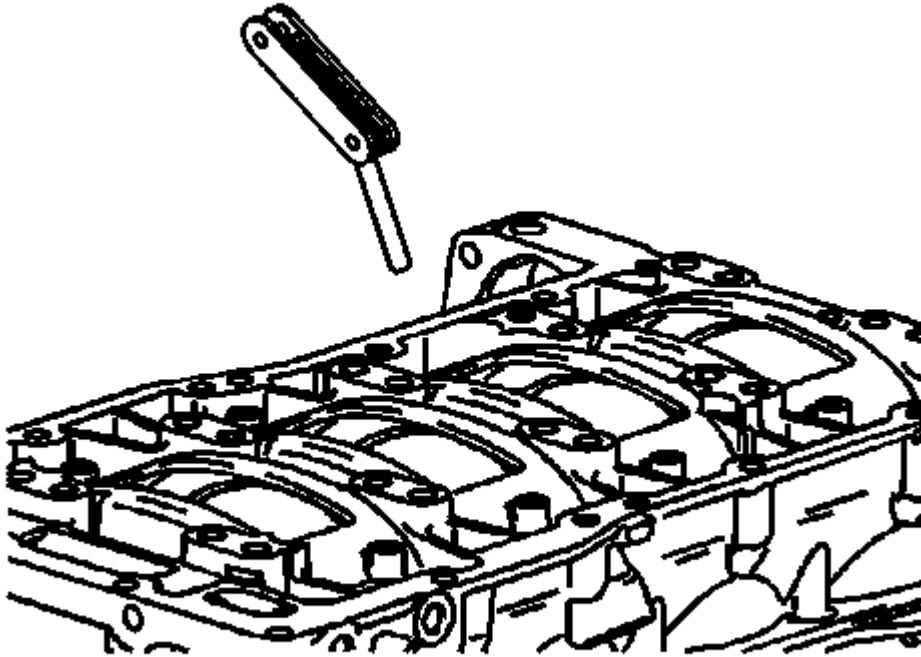


Fig. 180: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

9. Measure the connecting rod side clearance with a feeler gauge.

The correct clearance is 0.070-0.370 mm (0.0027-0.0145 in).

10. Install the cylinder head. Refer to **Cylinder Head Replacement (LAF)**.
11. Install the oil pan. Refer to **Oil Pan Replacement**.

ENGINE FLYWHEEL REPLACEMENT

SPECIAL TOOLS

- **EN-43653:** Flywheel Holding Tool
- **EN-45059:** Angle Meter

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

REMOVAL PROCEDURE

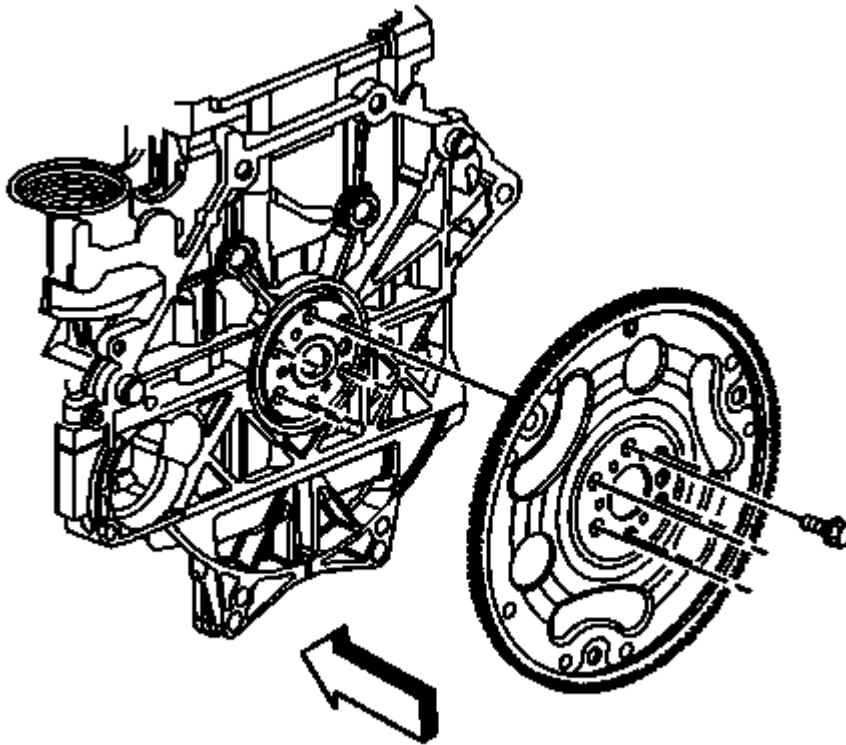


Fig. 181: Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Remove the transaxle. Refer to [Transmission Replacement](#) .
2. Install the **EN-43653**: tool in order to prevent the flywheel from rotating when loosening the flywheel bolts.

NOTE: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full engagement on the thin-headed flywheel bolts.

3. Loosen, remove and discard the flywheel bolts.

NOTE: Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

4. Remove the flywheel.
5. Remove the **EN-43653**: tool.
6. Clean the thread adhesive from the flywheel bolt holes. Use a nylon bristle brush to clean the holes in the crankshaft.

INSTALLATION PROCEDURE

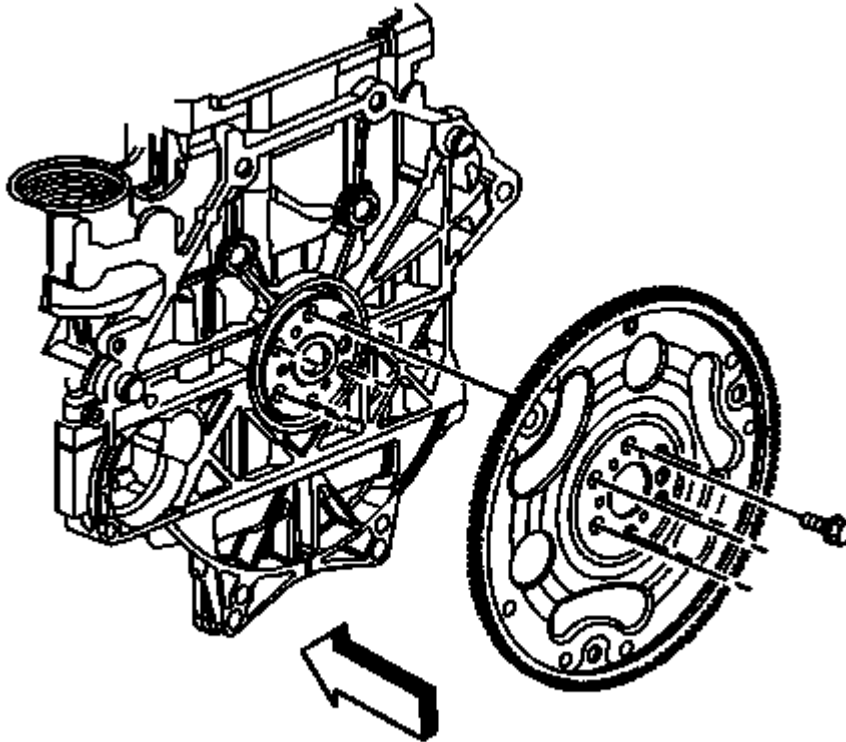


Fig. 182: Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel to the crankshaft.
2. Install the NEW flywheel bolts until snug.
3. Install the **EN-43653**: tool in order to prevent the flywheel from rotating when tightening the flywheel bolts.

CAUTION: Refer to **Fastener Caution** .

4. Tighten the flywheel bolts to 53 N.m (39 lb ft) plus an additional 25 degrees using the **EN-45059**: meter.
5. Remove the **EN-43653**: tool.
6. Install the transaxle. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

SPECIAL TOOLS

EN-42067: Rear Main Seal Installer

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

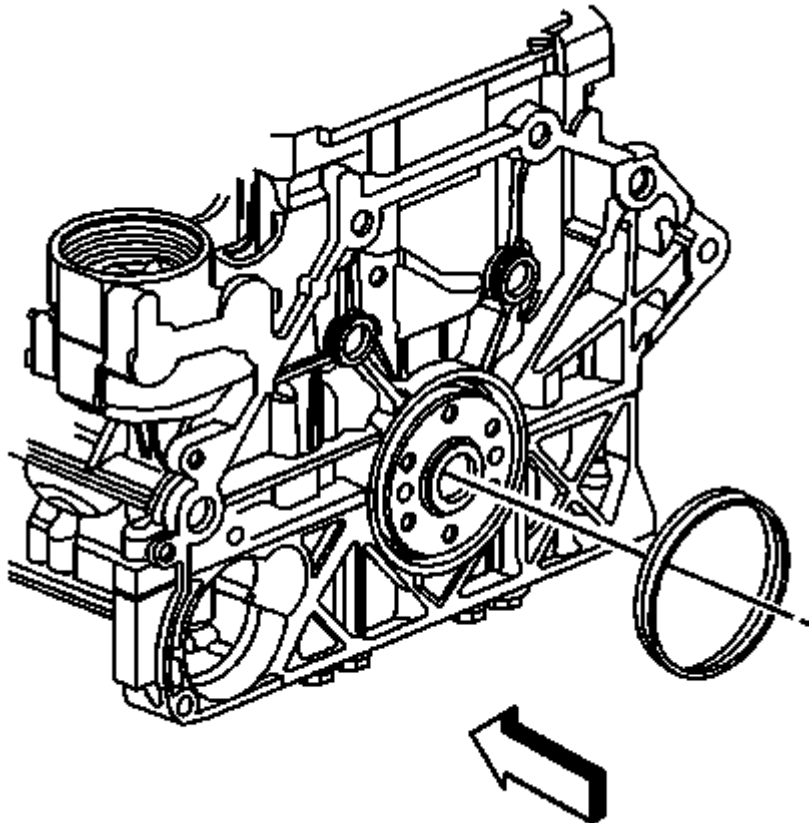
REMOVAL PROCEDURE

Fig. 183: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

NOTE: Do not damage the outside diameter of the crankshaft or chamber with any tool.

2. Pry out the crankshaft rear oil seal using a flat-bladed tool.

INSTALLATION PROCEDURE

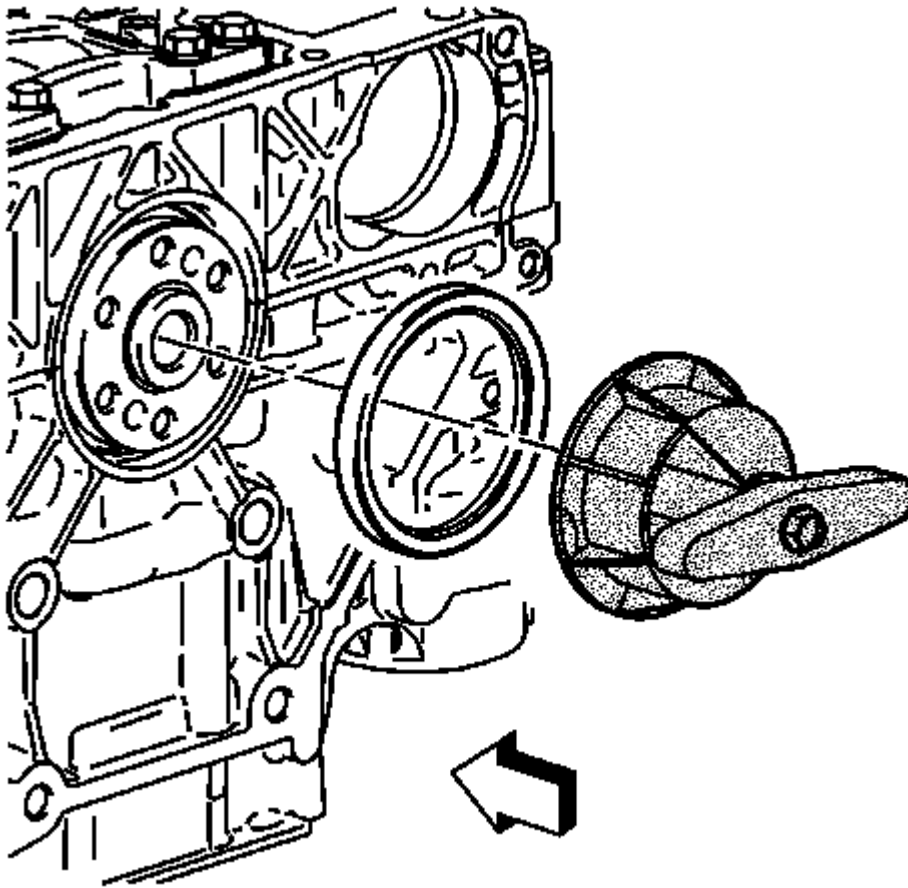


Fig. 184: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-42067**: installer, install a NEW crankshaft rear oil seal.
2. Install the flywheel. Refer to **Engine Flywheel Replacement**.

ENGINE REPLACEMENT

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**.
3. Disconnect the fuel feed pipe quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service**.
4. Disconnect the evaporative emission (EVAP) line quick connect fitting from the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Remove the fuel feed pipe clip from the fuel line bracket.
6. Remove the transaxle shift cable clip from the fuel line bracket.
7. Remove the battery tray. Refer to **Battery Tray Replacement**.

8. Remove the vacuum brake booster hose from the intake manifold.
9. Remove the coolant recovery inlet pipe clip from the fuel rail.
10. Remove the coolant recovery inlet hose from the cylinder head.
11. Remove the radiator inlet hose from the cylinder head.
12. Remove the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LAF)** .

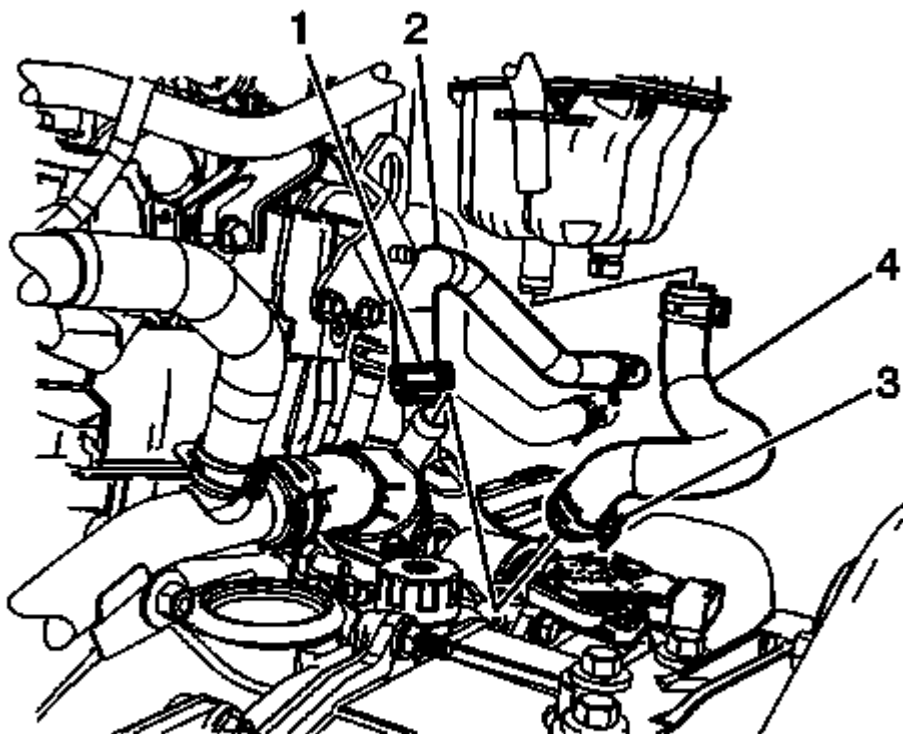


Fig. 185: Inlet Hoses

Courtesy of GENERAL MOTORS CORP.

13. Remove the heater inlet hose (2) from the thermostat housing.
14. Remove the coolant recovery reservoir/heater inlet hose (4) from the thermostat housing.
15. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
16. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement (LAF)**.
17. Disconnect the engine wiring harness electrical connector from the air conditioning (A/C) compressor.

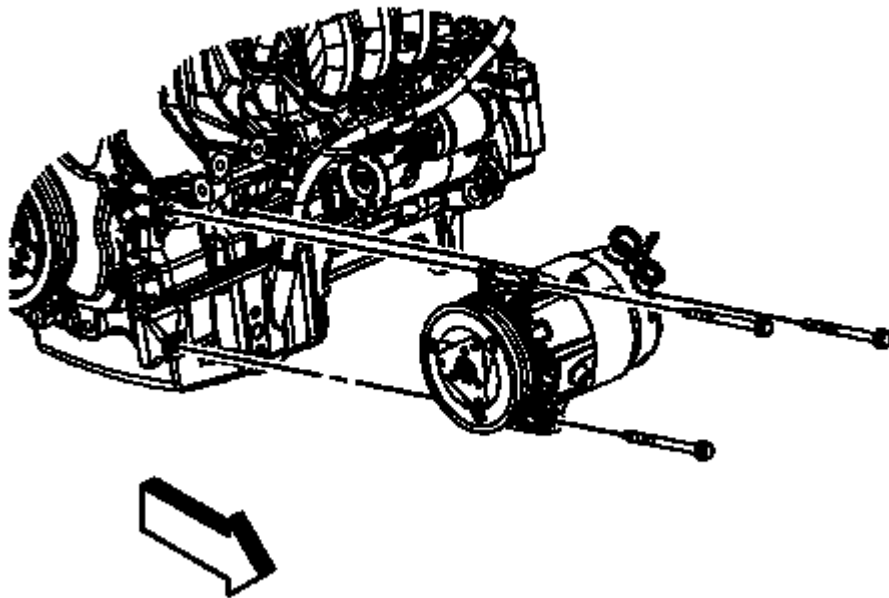


Fig. 186: A/C Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

18. Unbolt the A/C compressor and reposition out of the way.
19. Remove the positive battery cable from the starter motor.
20. Disconnect the generator electrical connectors.
21. Lower the vehicle.

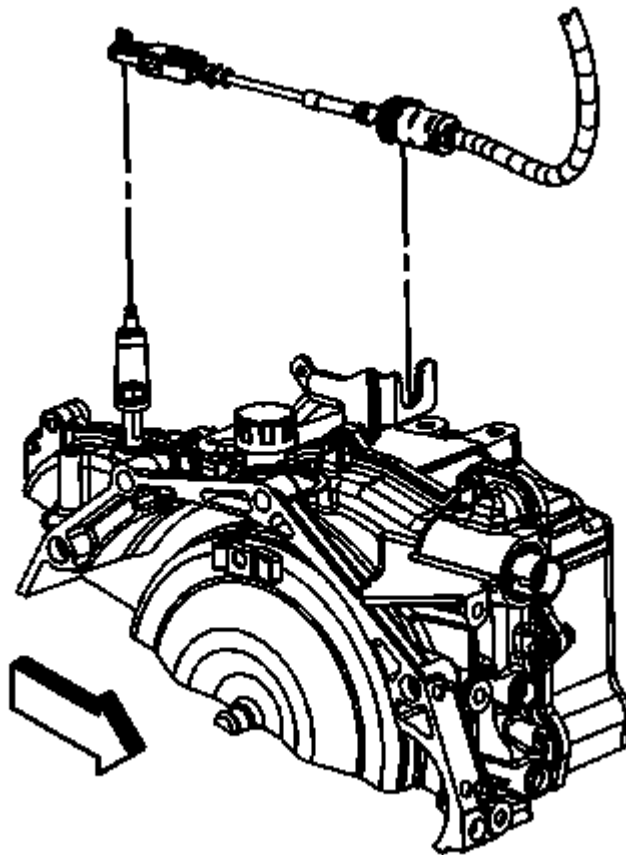


Fig. 187: Transaxle Shift Cable And Range Select Lever
Courtesy of GENERAL MOTORS CORP.

22. Remove the transaxle shift cable from the range select lever.
23. Release the shift control cable retaining clip and remove the cable from the shift control cable bracket.

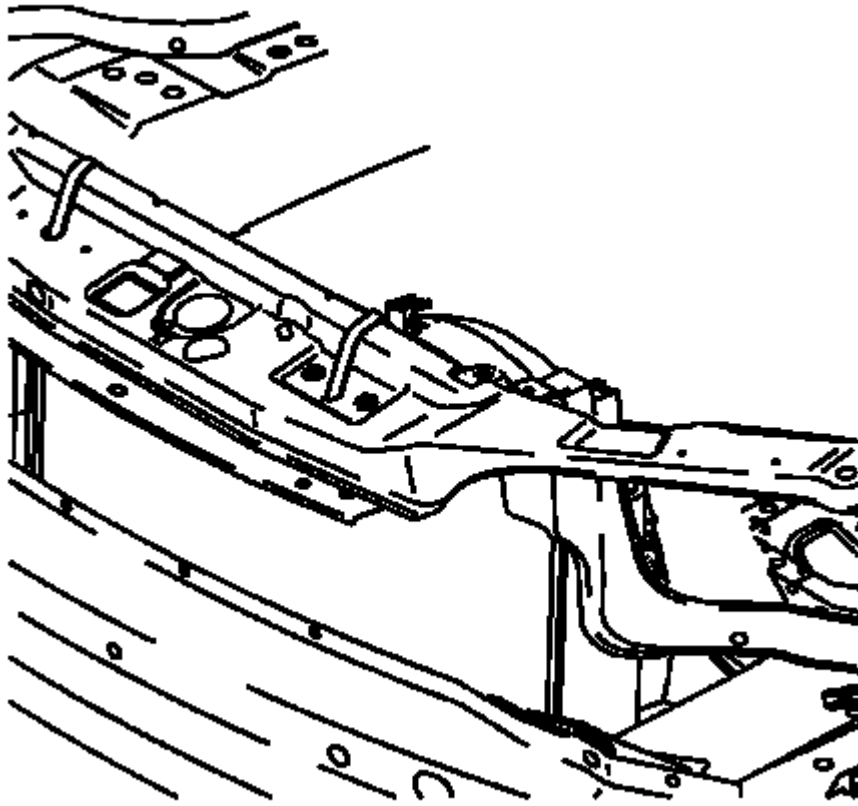


Fig. 188: Securing Radiator/Condenser/Fan Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: The radiator/condenser/fan assembly will stay in the vehicle during engine removal.

24. Using long tie straps, secure the radiator/condenser/fan assembly to the radiator support.
25. Raise the vehicle.
26. Remove the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
27. Remove the front wheelhouse panel.
28. Drain the transaxle fluid.
29. Remove the fluid cooler lines at the transmission. Refer to **Fluid Cooler Inlet Hose Replacement** and **Fluid Cooler Outlet Hose Replacement** .
30. Remove the catalytic converter.

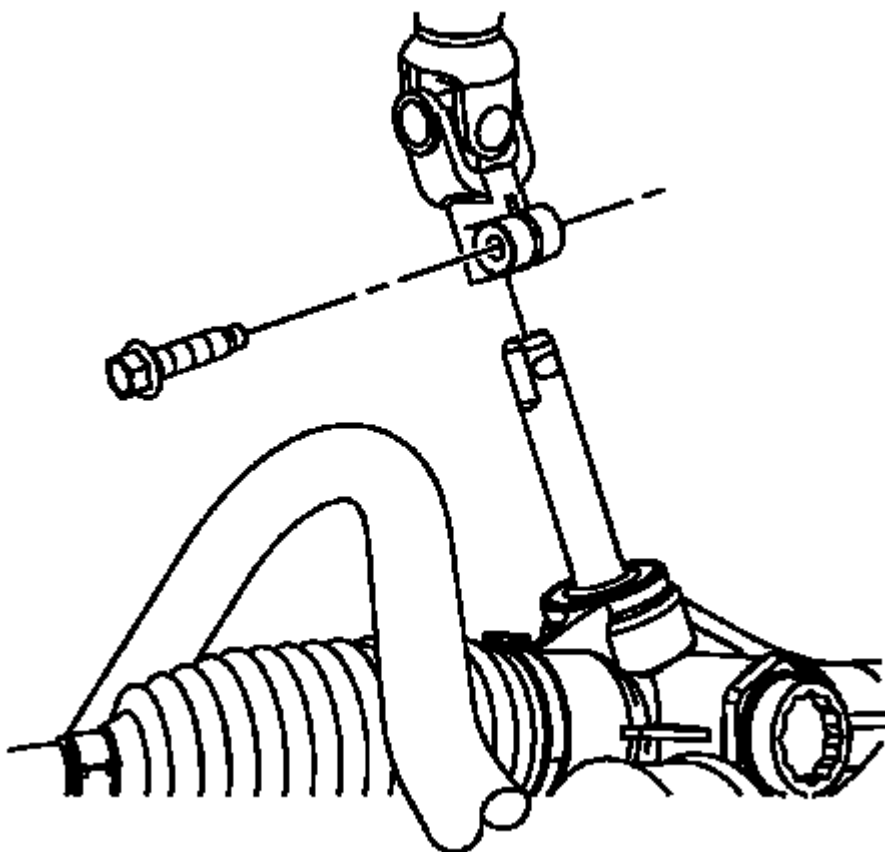


Fig. 189: Intermediate Shaft To Steering Gear Pinch Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: **Secure the steering wheel in the straight forward position before separating the intermediate shaft from the steering gear, or damage to the SIR coil will occur.**

31. Remove the intermediate to steering gear pinch bolt and disconnect the intermediate shaft from the steering gear. Discard the pinch bolt.
32. Separate the tie rods from the steering knuckles.
33. Remove the wheel drive shafts.
34. Lower the vehicle.

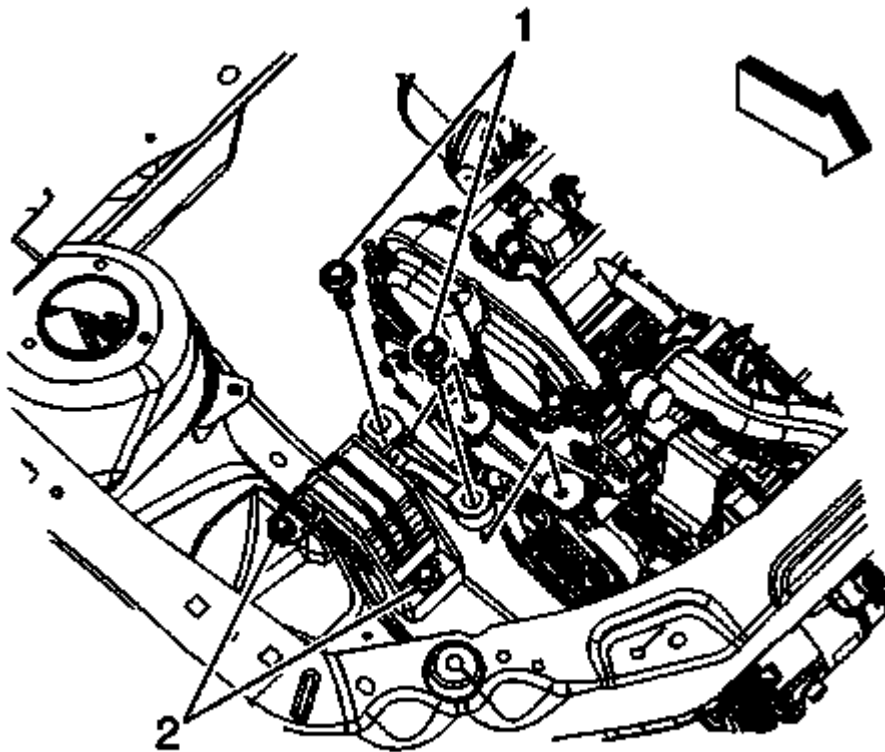


Fig. 190: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

35. Remove the engine mount to bracket bolts (1).

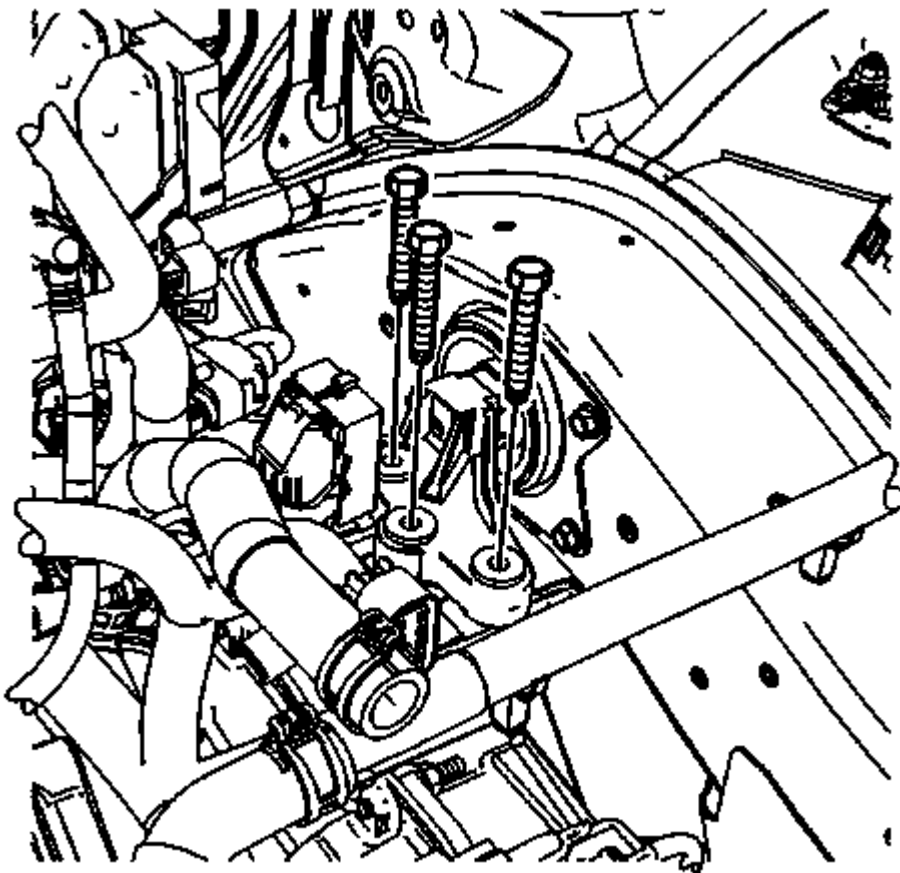


Fig. 191: Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

36. Remove the transaxle mount to transaxle bolts.
37. Raise the vehicle.

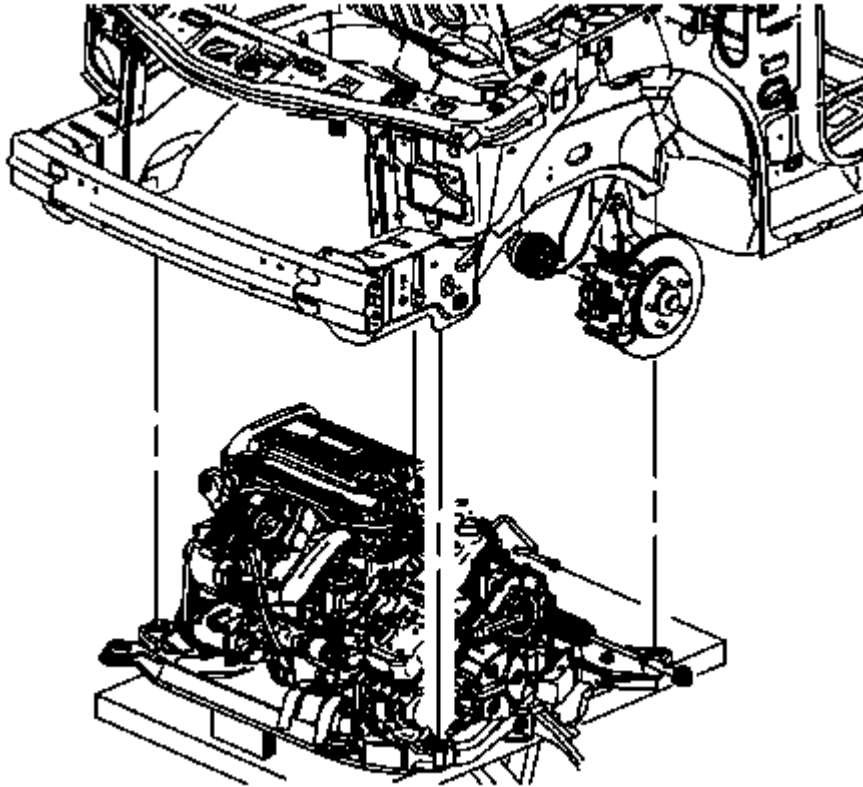


Fig. 192: Raising Powertrain Assembly Into Position
Courtesy of GENERAL MOTORS CORP.

NOTE: During the powertrain removal support the vehicle body by placing a jack at the rear of the vehicle.

38. Position a engine support table under the powertrain assembly.

NOTE: Blocks of wood can be used between the front of the frame and the oil pan to table in order to level the powertrain during the removal.

39. With the table positioned, fully raise the table to contact the powertrain assembly.
40. Remove the frame to body bolts. Discard the bolts.

NOTE: When lowering the engine/transaxle assembly, verify all brake lines, shifter cables and other components are free during removal.

41. Lower the engine table and raise the body on the hoist until the engine/transaxle and frame are free from the vehicle.
42. Disconnect the engine wiring harness electrical connectors as necessary.

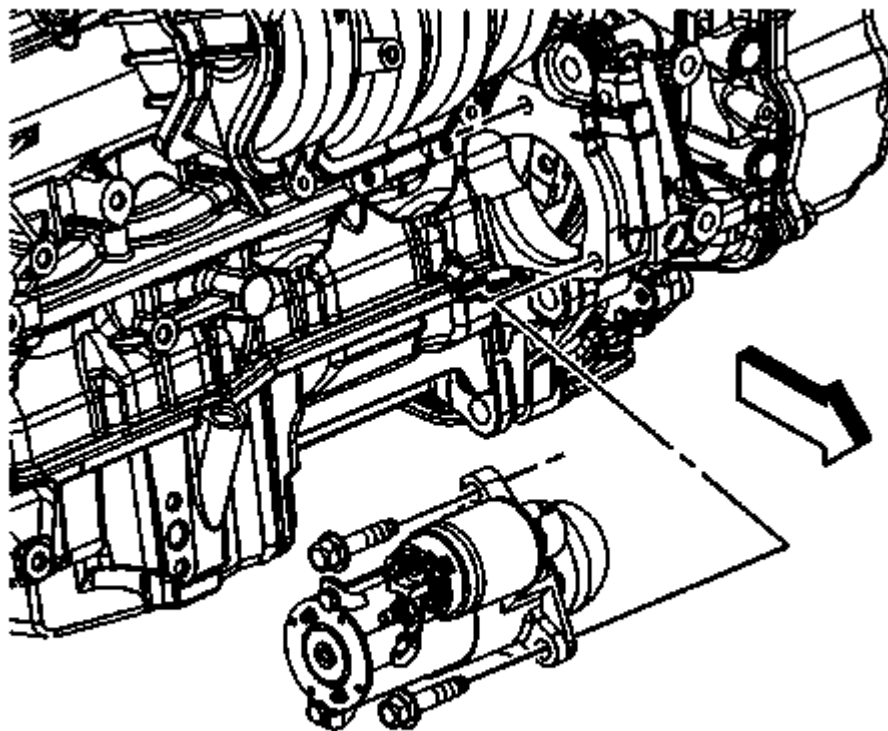


Fig. 193: Starter Motor Bolts And Starter
Courtesy of GENERAL MOTORS CORP.

43. Remove the starter motor bolts and starter.

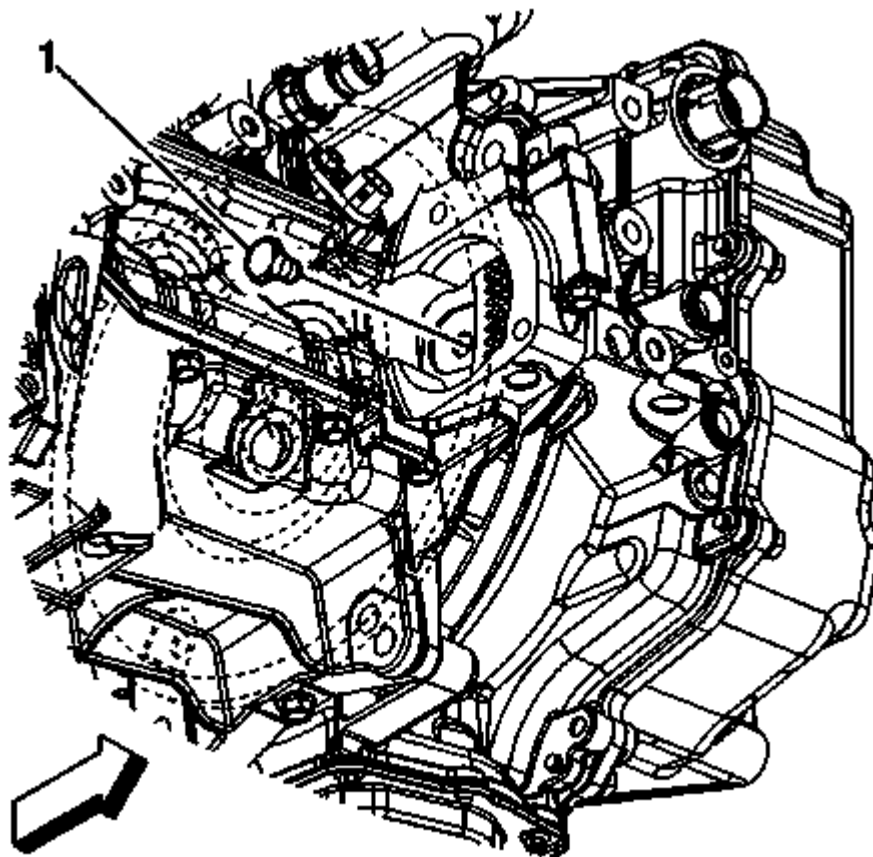


Fig. 194: Torque Converter To Flexplate Bolts
Courtesy of GENERAL MOTORS CORP.

44. Remove the torque converter to flexplate bolts (1).
45. Install a suitable lifting device to the engine.

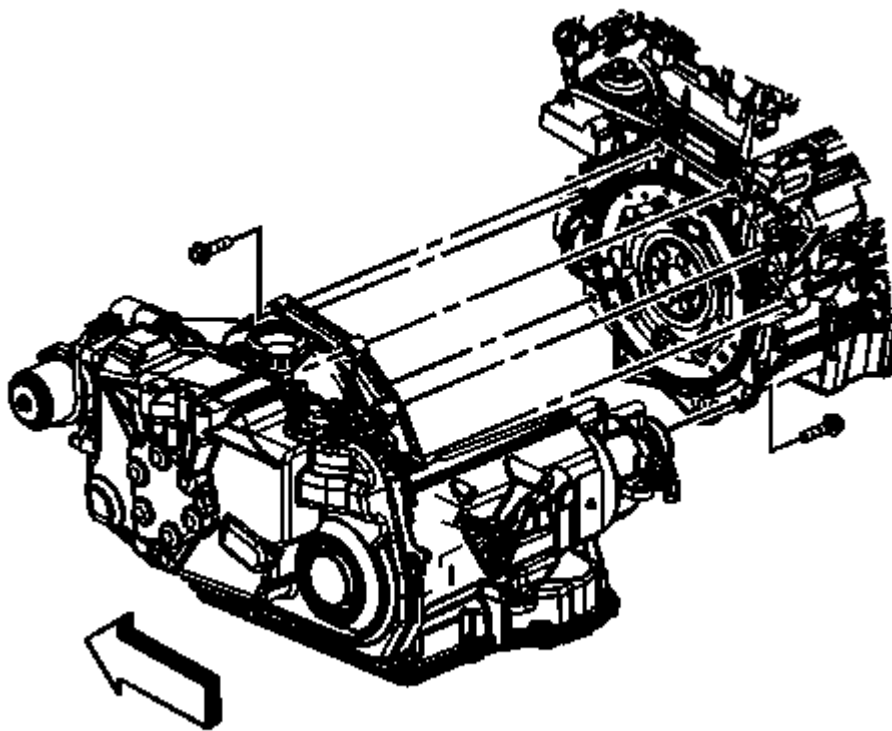


Fig. 195: Transaxle To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

46. Remove the transaxle bolts from the engine.
47. Separate the engine from the transaxle.
48. Install the engine to a suitable engine stand.

INSTALLATION PROCEDURE

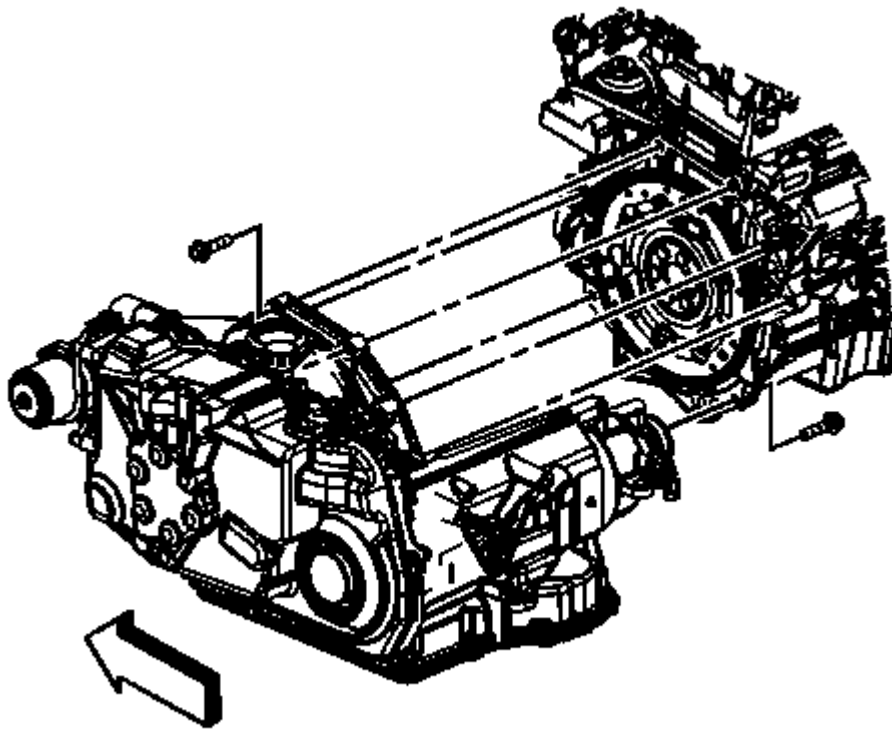


Fig. 196: Transaxle To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a suitable lifting device to the engine.
2. Using the lifting device, position and install the engine to the transaxle.

CAUTION: Refer to Fastener Caution .

3. Install the transaxle bolts to the engine and tighten to 75 N.m (55 lb ft).

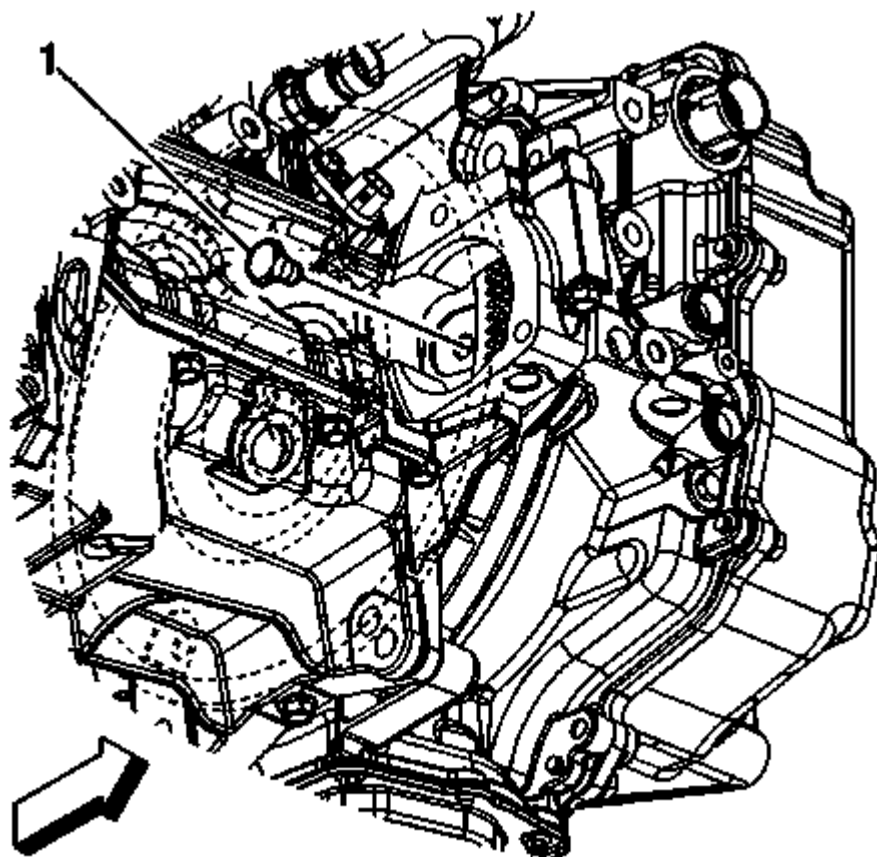


Fig. 197: Torque Converter To Flexplate Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the torque converter to flexplate bolts (1) and tighten to 60 N.m (44 lb ft).
5. Remove the engine lifting device.

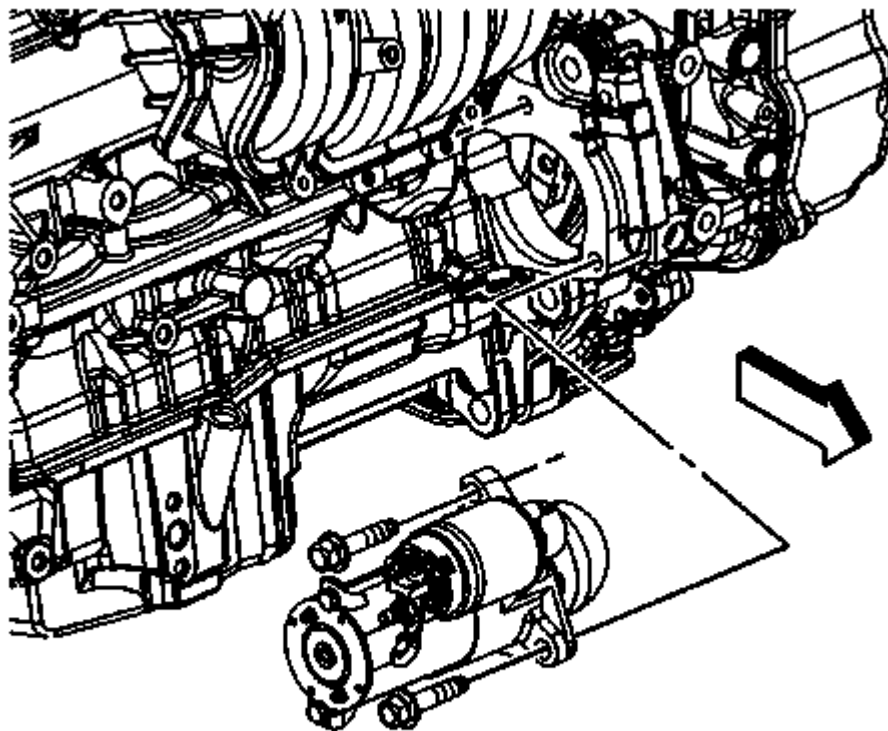


Fig. 198: Starter Motor Bolts And Starter
Courtesy of GENERAL MOTORS CORP.

6. Install the starter motor and bolts and tighten to 53 N.m (39 lb ft).
7. Connect the engine wiring harness electrical connectors as necessary.

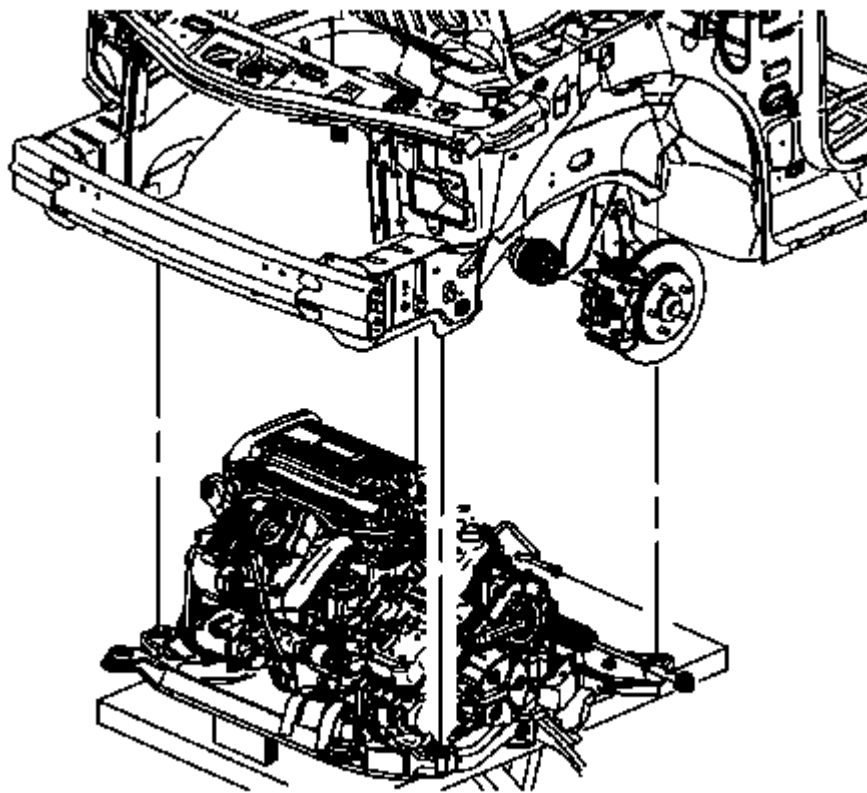


Fig. 199: Raising Powertrain Assembly Into Position
Courtesy of GENERAL MOTORS CORP.

8. Position the powertrain and support table under the vehicle.
9. Raise the powertrain into position under the vehicle.
10. With the table positioned, if required, lower the vehicle over the powertrain.
11. Align the lower radiator pins with the frame. Ensure all hoses and electrical harnesses are correctly routed and free from the loading path of the powertrain.
12. Install the NEW frame to body bolts and tighten to 155 N.m (114 lb ft).
13. Lower the vehicle.

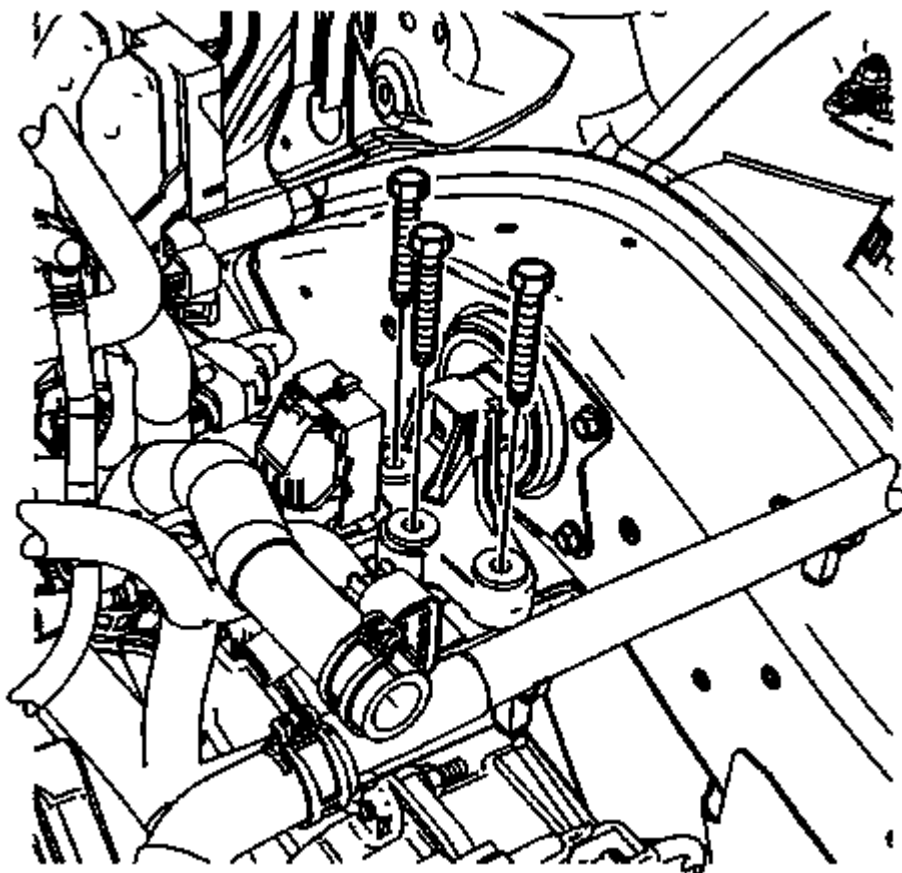


Fig. 200: Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the transaxle mount to transaxle bolts and tighten to 55 N.m (41 lb ft).

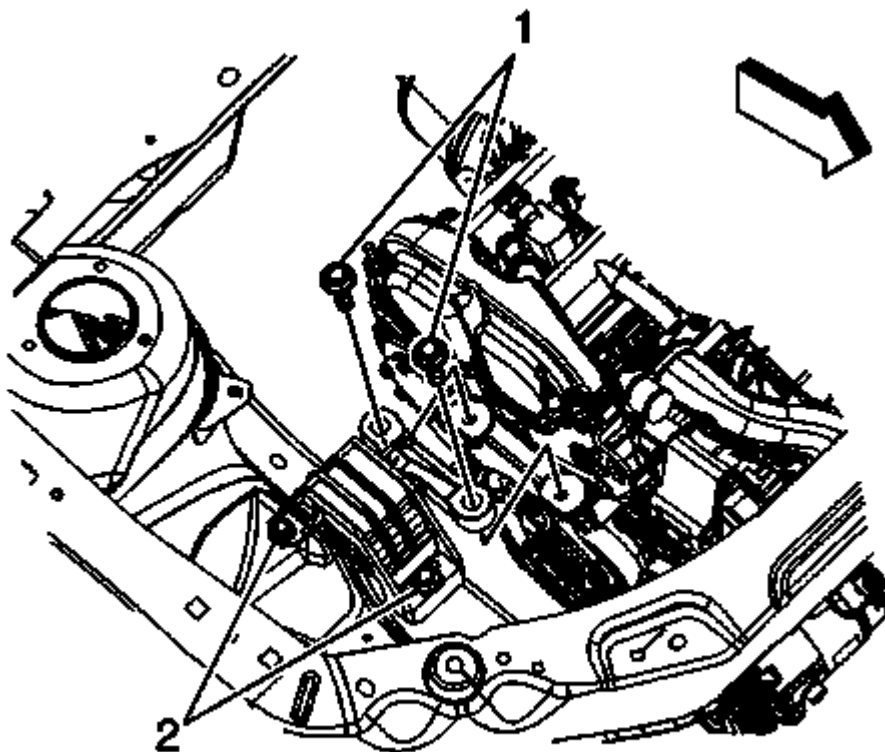


Fig. 201: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine mount to bracket bolts must be hand started. Do not pry the engine mount to align the holes.

15. Install the engine mount to bracket bolts (1) and tighten to 50 N.m (37 lb ft).
16. Raise and support the vehicle.
17. Install the wheel drive shafts.

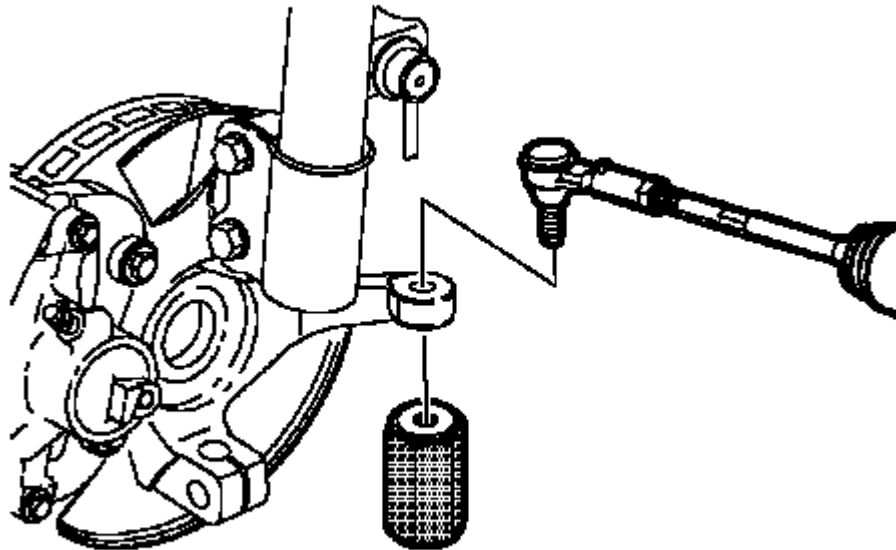


Fig. 202: Outer Tie Rod & Steering Knuckle
Courtesy of GENERAL MOTORS CORP.

18. Connect the outer tie rods to the steering knuckles.

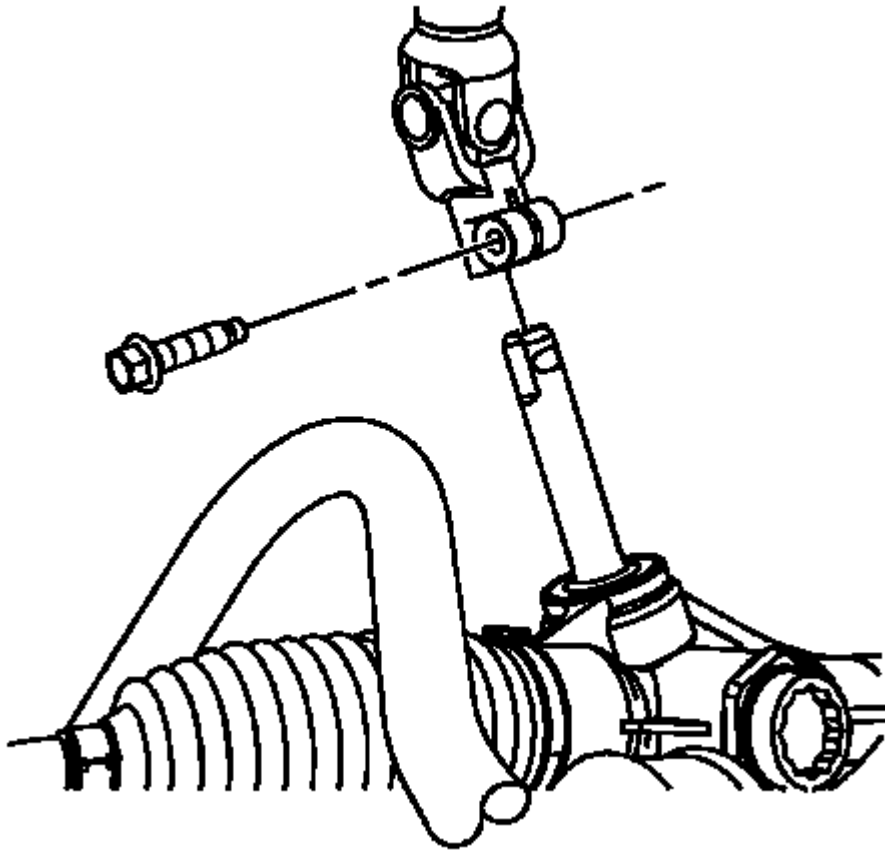


Fig. 203: Intermediate Shaft To Steering Gear Pinch Bolt
 Courtesy of GENERAL MOTORS CORP.

19. Position the intermediate shaft to the steering gear and install a NEW pinch bolt and tighten to 34 N.m (25 lb ft).
20. Install the catalytic converter.
21. Install the fluid cooler lines at the transaxle. Refer to **Fluid Cooler Inlet Hose Replacement** and **Fluid Cooler Outlet Hose Replacement** .
22. Install the front wheelhouse panel.
23. Install the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
24. Lower the vehicle.

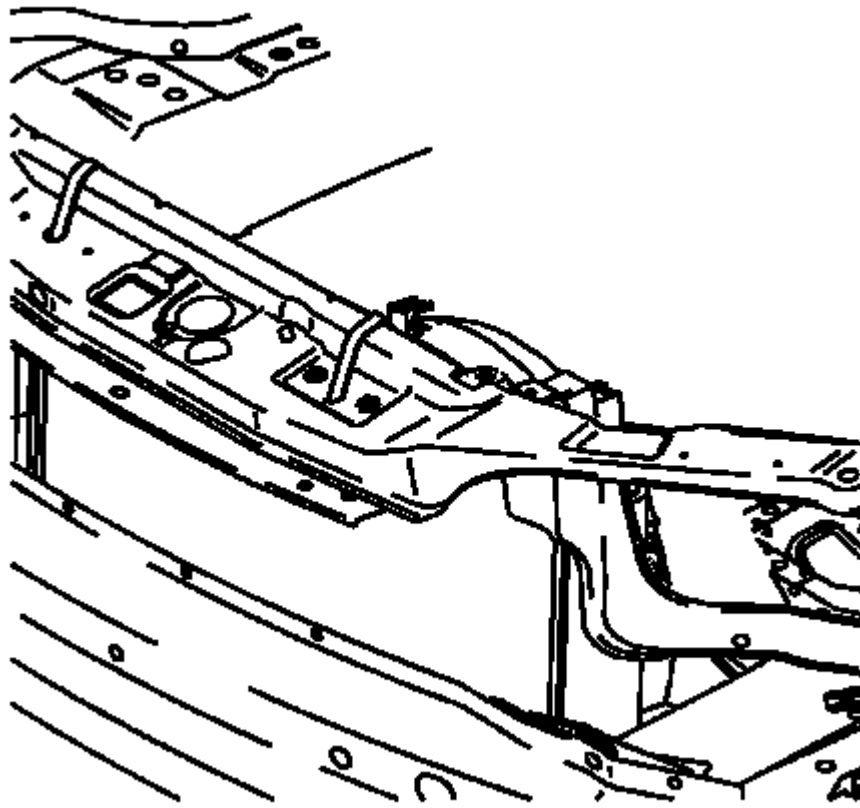


Fig. 204: Securing Radiator/Condenser/Fan Assembly
Courtesy of GENERAL MOTORS CORP.

25. Un-secure and position the radiator/condenser/fan assembly.

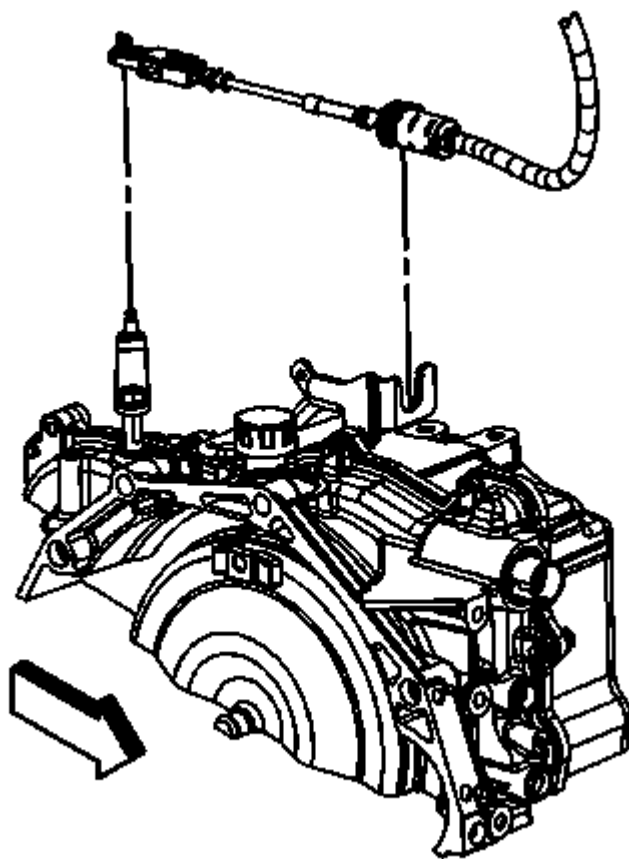


Fig. 205: Transaxle Shift Cable And Range Select Lever
Courtesy of GENERAL MOTORS CORP.

26. Install the shift control cable to the shift control cable bracket and engage the shift control cable retaining clip.
27. Install the transaxle shift cable to the range select lever.
28. Raise and support the vehicle.
29. Connect the generator electrical connectors.
30. Install the positive battery cable to the starter motor, tighten to 9 N.m (80 lb in)

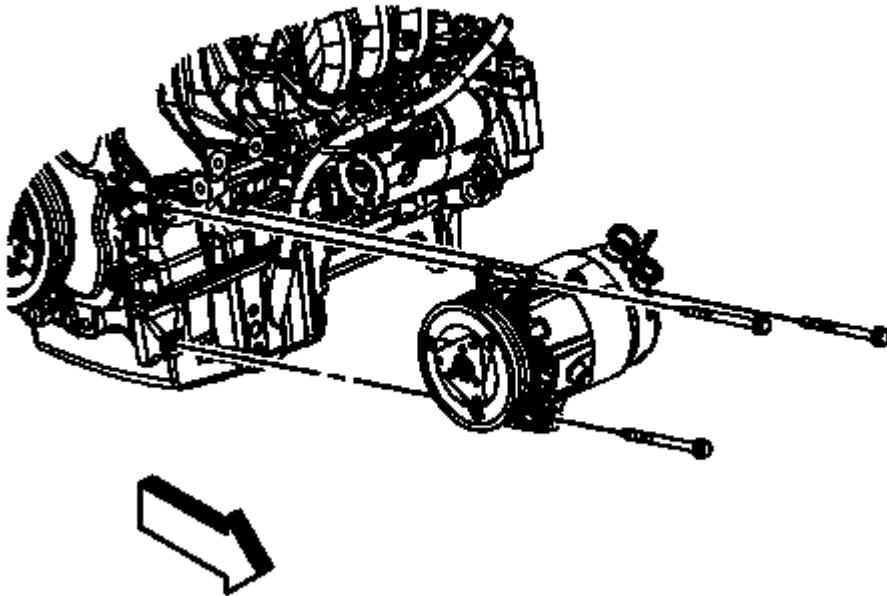


Fig. 206: A/C Compressor Bolts
 Courtesy of GENERAL MOTORS CORP.

31. Position the A/C compressor and install the bolts and tighten to 50 N.m (37 lb ft).
32. Connect the engine wiring harness electrical connector to the A/C compressor.
33. Lower the vehicle.
34. Install the coolant recovery reservoir/heater inlet hose to the thermostat housing.
35. Install the heater inlet hose to the thermostat housing.
36. Install the radiator inlet hose from the cylinder head.
37. Install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LAF)** .
38. Position and install the coolant recovery inlet hose to the cylinder head.
39. Install the coolant recovery inlet pipe clip to the fuel rail.
40. Position and install the vacuum brake booster hose to the intake manifold.
41. Install the battery tray. Refer to **Battery Tray Replacement** .
42. Install the transaxle shift cable clip to the fuel line bracket.
43. Install the fuel feed pipe clip to the fuel line bracket.
44. Connect the EVAP line quick connect fitting to the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

45. Connect the fuel feed pipe quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
46. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
47. Fill the transaxle with fluid. Refer to **Transmission Fluid Level and Condition Check** .
48. Refill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement (LAF)**.
49. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .
50. Start the engine and allow the engine to run, inspect for leaks. Correct as necessary.

ENGINE OIL AND OIL FILTER REPLACEMENT (LAF)

REMOVAL PROCEDURE

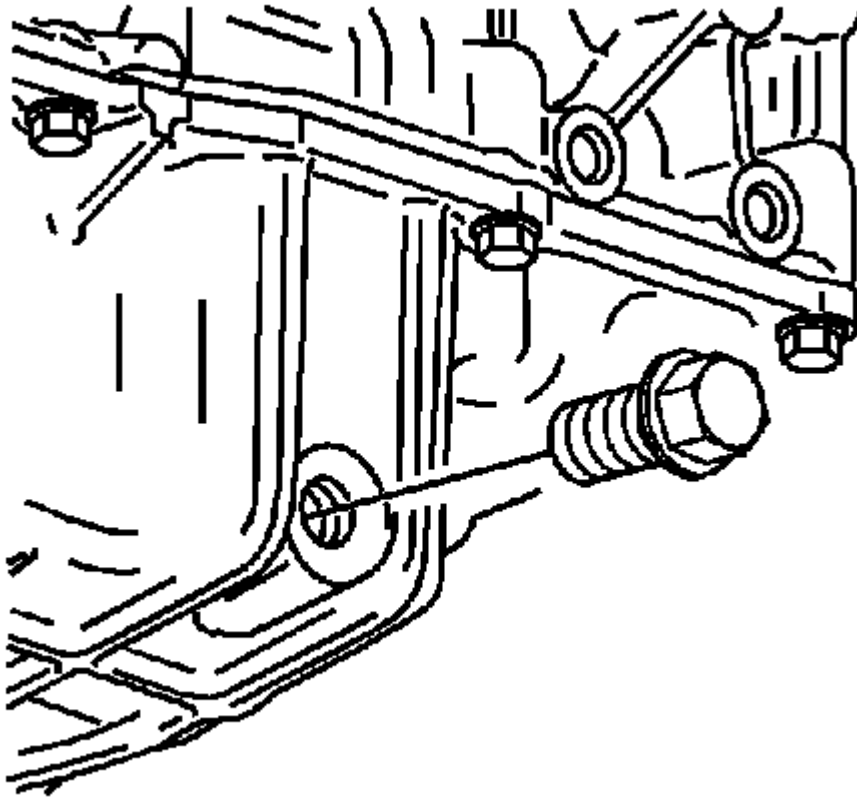


Fig. 207: Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil drain plug.
3. Remove the oil pan drain plug.

4. Allow the oil to drain completely.

CAUTION: Refer to Fastener Caution .

5. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
6. Lower the vehicle.

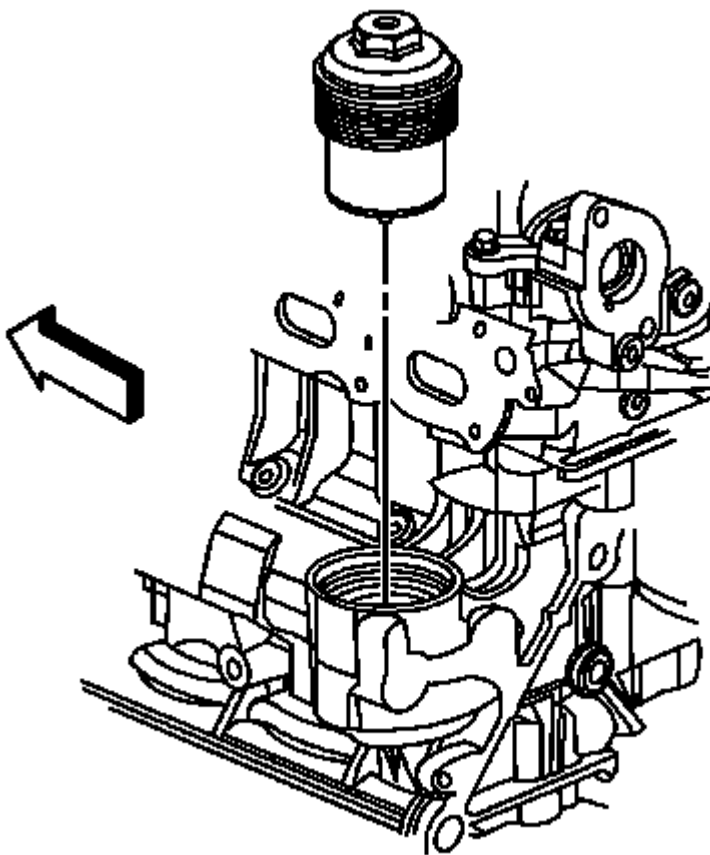


Fig. 208: Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

7. use an oil filter wrench on the outside diameter of the oil filter cap.
8. Remove the oil filter cap and filter.
9. Remove the filter from the cap.

INSTALLATION PROCEDURE

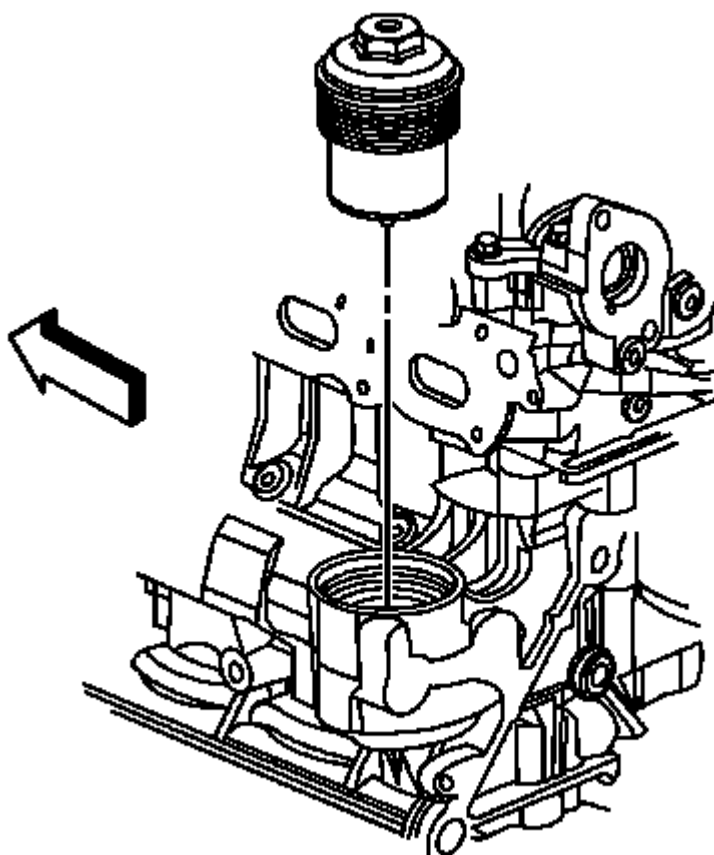


Fig. 209: Oil Filter Cap

Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter to the cap.
2. Install the oil filter cap and filter.

CAUTION: Over torquing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

3. use an oil filter wrench on the outside diameter of the oil filter cap. Tighten the oil filter cap until fully seated. DO NOT exceed 25 N.m (18 lb ft).
4. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations** .