

## 2012 ENGINE

## Engine Mechanical - 2.4L - Verano

## SPECIFICATIONS

## FASTENER TIGHTENING SPECIFICATIONS (LEA)

## Fastener Tightening Specifications (LEA)

| Application                                       | Specification |           |
|---------------------------------------------------|---------------|-----------|
|                                                   | Metric        | English   |
| A/C Compressor to Block Bolt                      | 22 N.m        | 16 lb ft  |
| Air Pump Assembly Bolt                            | 22 N.m        | 16 lb ft  |
| Balance Shaft Bearing Carrier to Block Bolt       | 10 N.m        | 89 lb in  |
| Balance Shaft Chain Guide Bolt, Adjustable        | 10 N.m        | 89 lb in  |
| Balance Shaft Chain Guide Bolt, Fixed             | 12 N.m        | 106 lb in |
| Balance Shaft Chain Tensioner                     | 10 N.m        | 89 lb in  |
| Block Core Plug                                   | 35 N.m        | 26 lb ft  |
| Block Heater Bolt                                 | 10 N.m        | 89 lb in  |
| Cam Cover to Cylinder Head Bolt                   | 10 N.m        | 89 lb in  |
| Cam Cover to Ground Cable Bolt                    | 10 N.m        | 89 lb in  |
| Cam Cover to Ground Cable Stud                    | 10 N.m        | 89 lb in  |
| Camshaft                                          |               |           |
| • Camshaft Bearing Cap Bolt                       | 10 N.m        | 89 lb in  |
| • Camshaft Position Actuator Solenoid Valve Bolt  | 10 N.m        | 89 lb in  |
| • Camshaft Position Sensor Bolt                   | 10 N.m        | 89 lb in  |
| • Exhaust Camshaft Position Actuator - First Pass | 30 N.m        | 22 lb ft  |
| • Exhaust Camshaft Position Actuator - Final Pass | 100 degrees   |           |
| • Intake Camshaft Position Actuator - First Pass  | 30 N.m        | 22 lb ft  |
| • Intake Camshaft Position Actuator - Final Pass  | 100 degrees   |           |
| • Intake Camshaft Rear Cap Bolt                   | 10 N.m        | 89 lb in  |
| Connecting Rod Bolt                               |               |           |
| • First Pass                                      | 25 N.m        | 18 lb ft  |
| • Final Pass                                      | 100 degrees   |           |
| Crankshaft Balancer Bolt                          |               |           |
| • First Pass                                      | 150 N.m       | 111 lb ft |
| • Final Pass                                      | 100 degrees   |           |
| Crankshaft Position Reluctor Ring                 | 15 N.m        | 11 lb ft  |
| Crankshaft Position Sensor Bolt                   | 10 N.m        | 89 lb in  |
|                                                   |               |           |

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### Cylinder Head Bolt

|                                                                                                                                       |             |           |
|---------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------|
| • First Pass                                                                                                                          | 30 N.m      | 22 lb ft  |
| • Final Pass                                                                                                                          | 155 degrees |           |
| Cylinder Head Front Chaincase Bolt                                                                                                    | 35 N.m      | 26 lb ft  |
| Cylinder Head Oil Gallery Plug                                                                                                        | 35 N.m      | 26 lb ft  |
| Drive Belt Tensioner Bolt (LAF, LEA)                                                                                                  | 45 N.m      | 33 lb ft  |
| Drive Belt Tensioner Bolt (LUK) - OFF Vehicle                                                                                         |             |           |
| • First Pass                                                                                                                          | 50 N.m      | 37 lb ft  |
| • Final Pass                                                                                                                          | 90 degrees  |           |
| Drive Belt Tensioner Bolt (LUK) - ON Vehicle - Use <b>J 45025</b> Belt Tensioner Wrench in combination with a 3/8 drive torque wrench | 42 N.m      | 31 lb ft  |
| Engine Block Oil Gallery Plug                                                                                                         | 60 N.m      | 44 lb ft  |
| Engine Coolant Air Bleed Fitting                                                                                                      | 15 N.m      | 11 lb ft  |
| Engine Coolant Temperature Sensor                                                                                                     | 20 N.m      | 15 lb ft  |
| Engine Lift Bracket Bolt, Front                                                                                                       | 25 N.m      | 18 lb ft  |
| Engine Lift Bracket Bolt, Rear                                                                                                        | 25 N.m      | 18 lb ft  |
| Engine Lift Bracket Stud                                                                                                              | 25 N.m      | 18 lb ft  |
| Engine Mount Bracket to Body Bolts                                                                                                    | 62 N.m      | 46 lb ft  |
| Engine Mount Bracket to Engine Bolts                                                                                                  | 100 N.m     | 74 lb ft  |
| Engine to Transmission Bolts                                                                                                          | 75 N.m      | 55 lb ft  |
| EVAP Canister Valve Bolt                                                                                                              | 25 N.m      | 18 lb ft  |
| Exhaust Manifold Heat Shield Bolt                                                                                                     | 9 N.m       | 80 lb in  |
| Exhaust Manifold to Cylinder Head Nut - 2 passes                                                                                      | 14 N.m      | 124 lb in |
| Exhaust Manifold to Cylinder Head Stud                                                                                                | 15 N.m      | 11 lb ft  |
| Flywheel Bolt - Automatic Transmission                                                                                                |             |           |
| • First Pass                                                                                                                          | 53 N.m      | 39 lb ft  |
| • Final Pass                                                                                                                          | 25 degrees  |           |
| Front Cover to Block Bolt                                                                                                             | 25 N.m      | 18 lb ft  |
| Front Lift Bracket Bolt                                                                                                               | 25 N.m      | 18 lb ft  |
| Fuel Feed Intermediate Pipe                                                                                                           | 30 N.m      | 22 lb ft  |
| Fuel Pipe Bracket Bolt                                                                                                                | 10 N.m      | 89 lb in  |
| Fuel Pump Cover Bolt                                                                                                                  | 10 N.m      | 89 lb in  |
| Fuel Pump Cover Nut                                                                                                                   | 10 N.m      | 89 lb in  |
| Fuel Rail Assembly Bolt                                                                                                               | 25 N.m      | 18 lb ft  |
| Fuel Rail Harness Connector Bracket Bolt                                                                                              | 10 N.m      | 89 lb in  |
| Generator to Block Bolt                                                                                                               | 23 N.m      | 17 lb ft  |
| Generator Wiring Harness Nut                                                                                                          | 20 N.m      | 15 lb ft  |
| Ignition Coil Bolt                                                                                                                    | 10 N.m      | 89 lb in  |
| Intake Manifold Insulator Bolt                                                                                                        | 10 N.m      | 89 lb in  |

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|                                                                                                             |            |           |
|-------------------------------------------------------------------------------------------------------------|------------|-----------|
| Intake Manifold to Cylinder Head Bolt                                                                       | 25 N.m     | 18 lb ft  |
| Intake Manifold to Cylinder Head Nut                                                                        | 25 N.m     | 18 lb ft  |
| Intake Manifold to Cylinder Head Stud                                                                       | 15 N.m     | 11 lb ft  |
| Knock Sensor Bolt                                                                                           | 25 N.m     | 18 lb ft  |
| Lower Crankcase Bolts                                                                                       |            |           |
| <ul style="list-style-type: none"> <li>Crankshaft Bearings - Lower Crankcase to Block - Bedplate</li> </ul> |            |           |
| <ul style="list-style-type: none"> <li>First Pass</li> </ul>                                                | 20 N.m     | 15 lb ft  |
| <ul style="list-style-type: none"> <li>Final Pass</li> </ul>                                                | 70 Degrees |           |
| <ul style="list-style-type: none"> <li>Lower Crankcase Perimeter Bolt</li> </ul>                            | 25 N.m     | 18 lb ft  |
| Manifold Absolute Pressure (MAP) Sensor Bolt                                                                | 4 N.m      | 35 lb in  |
| Oil Filter Cap                                                                                              | 25 N.m     | 18 lb ft  |
| Oil Gallery Gerotor Cover - Rear Bolt                                                                       | 6 N.m      | 53 lb in  |
| Oil Level Indicator Tube to Intake Manifold Bolt                                                            | 10 N.m     | 89 lb in  |
| Oil Pan Baffle                                                                                              | 14 N.m     | 124 lb in |
| Oil Pan Drain Plug                                                                                          | 25 N.m     | 18 lb ft  |
| Oil Pan to Block Bolts                                                                                      | 25 N.m     | 18 lb ft  |
| Oil Pressure Switch                                                                                         | 26 N.m     | 19 lb ft  |
| Oil Pump Cover Bolt                                                                                         | 6 N.m      | 53 lb in  |
| Oil Pump Pressure Relief Valve Plug                                                                         | 40 N.m     | 30 lb ft  |
| Oxygen Sensor                                                                                               | 42 N.m     | 31 lb ft  |
| Piston Oil Nozzle Assembly                                                                                  | 15 N.m     | 11 lb ft  |
| Secondary Air Injection Assembly to Secondary Air Injection Pipe Assembly Bolt                              | 10 N.m     | 89 lb in  |
| Secondary Air Injection Pipe Assembly to Cylinder Head Bolt                                                 | 10 N.m     | 89 lb in  |
| Secondary Air Injection Assembly to Cylinder Head Bolt                                                      | 22Y        | 16 lb ft  |
| Secondary Air Injection Assembly Stud                                                                       | 10 N.m     | 89 lb in  |
| Secondary Air Injection Assembly Nut                                                                        | 22Y        | 16 lb ft  |
| Spark Plug                                                                                                  | 20 N.m     | 15 lb ft  |
| Thermostat Housing to Block Bolts                                                                           | 10 N.m     | 89 lb in  |
| Throttle Body Bolt                                                                                          | 10 N.m     | 89 lb in  |
| Throttle Body Nut                                                                                           | 10 N.m     | 89 lb in  |
| Throttle Body Stud                                                                                          | 6 N.m      | 53 lb in  |
| Timing Chain Guide Bolt, Adjustable                                                                         | 10 N.m     | 89 lb in  |
| Timing Chain Guide Bolt, Fixed                                                                              | 12 N.m     | 106 lb in |
| Timing Chain Guide Bolt, Upper                                                                              | 10 N.m     | 89 lb in  |
| Timing Chain Guide Bolt Access Hole Plug                                                                    | 75 N.m     | 55 lb ft  |
| Timing Chain Oil Nozzle Bolt                                                                                | 10 N.m     | 89 lb in  |
| Timing Chain Tensioner                                                                                      | 75 N.m     | 55 lb ft  |
| Transmission to Engine Brace Bolts                                                                          | 50 N.m     | 37 lb ft  |

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|                                                |        |          |
|------------------------------------------------|--------|----------|
| Transmission Torque Converter to Flywheel Bolt | 62 N.m | 46 lb ft |
| Vent Tube to Cylinder Head                     | 15 N.m | 11 lb ft |
| Water Jacket Drain Plug                        | 20 N.m | 15 lb ft |
| Water Pipe Support Bracket Bolt                | 10 N.m | 89 lb in |
| Water Pump Access Cover Bolt                   | 10 N.m | 89 lb in |
| Water Pump/Balance Shaft Chain Tensioner Bolt  | 10 N.m | 89 lb in |
| Water Pump Bolts                               | 25 N.m | 18 lb ft |
| Water Pump Cover Stud                          | 10 N.m | 89 lb in |
| Water Pump Sprocket Bolt                       | 10 N.m | 89 lb in |

**ENGINE MECHANICAL SPECIFICATIONS (LEA)****Engine Mechanical Specifications (LEA)**

| Application                                     | Specification                |                  |
|-------------------------------------------------|------------------------------|------------------|
|                                                 | Metric                       | English          |
| General Data                                    |                              |                  |
| • Engine Type                                   | Inline 4 Cylinder            |                  |
| • Displacement                                  | 2.4 L                        | 146 CID          |
| • RPO                                           | LEA                          |                  |
| • Liter (VIN)                                   | Passenger Car: C<br>Truck: W |                  |
| • Bore                                          | 87.992-88.008 mm             | 3.4642-3.4649 in |
| • Stroke                                        | 98 mm                        | 3.861 in         |
| • Compression Ratio                             | 10:01                        |                  |
| • Spark Plug Gap                                | 0.9 mm                       | 0.035 in         |
| Balance Shaft                                   |                              |                  |
| • Bearing Clearance                             | 0.030-0.060 mm               | 0.0012-0.0024 in |
| • Bearing Diameter - Inside - Carrier           | 20.050-20.063 mm             | 0.7894-0.7899 in |
| • Bearing Diameter - Outside - Carrier          | 41.975-41.995 mm             | 1.6526-1.6534 in |
| • Bearing Journal Diameter                      | 20.000-20.020 mm             | 0.7874-0.7882 in |
| • Bushing Clearance                             | 0.033-0.102 mm               | 0.0013-0.0040 in |
| • Bushing Diameter - Inside                     | 36.776-36.825 mm             | 1.4479-1.4498 in |
| • Bushing Journal Diameter                      | 36.723-36.743 mm             | 1.4458-1.4466 in |
| • End Play                                      | 0.050-0.300 mm               | 0.0020-0.0118 in |
| Block                                           |                              |                  |
| • Balance Shaft Bearing Bore Diameter - Carrier | 42.000-42.016 mm             | 1.6535-1.6542 in |
| • Balance Shaft Bushing Bore Diameter           | 40.763-40.776 mm             | 1.6048-1.6054 in |

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|                                                          |                  |                   |
|----------------------------------------------------------|------------------|-------------------|
| • Crankshaft Main Bearing Bore Diameter                  | 64.068-64.082 mm | 2.5224-2.5229 in  |
| • Cylinder Bore Diameter                                 | 87.992-88.008 mm | 3.4642-3.4649 in  |
| • Cylinder Bore Out-of-Round - Maximum                   | 0.010 mm         | 0.0004 in         |
| • Cylinder Bore Taper - Maximum                          | 0.010 mm         | 0.0004 in         |
| • Cylinder Head Deck Surface Flatness - Longitude        | 0.050 mm         | 0.002 in          |
| • Cylinder Head Deck Surface Flatness - Overall          | 0.08 mm          | 0.0031 in         |
| • Cylinder Head Deck Surface Flatness - Transverse       | 0.030 mm         | 0.0012 in         |
| Camshaft                                                 |                  |                   |
| • Camshaft End Play                                      | 0.040-0.144 mm   | 0.0016-0.0057 in  |
| • Camshaft Journal Diameter                              | 26.935-26.960 mm | 1.0604-1.0614 in  |
| • Camshaft Thrust Surface                                | 21.000-21.052 mm | 0.8268-0.8252 in  |
| Connecting Rod                                           |                  |                   |
| • Connecting Rod Bearing Clearance                       | 0.029-0.073 mm   | 0.0011-0.0029 in  |
| • Connecting Rod Bore Diameter - Bearing End             | 52.118-52.134 mm | 2.0519-2.05252 in |
| • Connecting Rod Bore Diameter - Pin End                 | 20.007-20.017 mm | 0.7877-0.7881 in  |
| • Connecting Rod Side Clearance                          | 0.070-0.370 mm   | 0.0028-0.0146 in  |
| • Connecting Rod Straightness - Bend - Maximum           | 0.021 mm         | 0.0083 in         |
| • Connecting Rod Straightness - Twist - Maximum          | 0.04 mm          | 0.0157 in         |
| Crankshaft                                               |                  |                   |
| • Connecting Rod Journal Diameter                        | 48.999-49.015 mm | 1.9291-1.9297 in  |
| • Crankshaft End Play                                    | 0.050-0.380 mm   | 0.0012-0.0150 in  |
| • Crankshaft Main Bearing Clearance                      | 0.031-0.067 mm   | 0.0012-0.0026 in  |
| • Crankshaft Main Journal Diameter                       | 55.993-56.009 mm | 2.2044-2.2051 in  |
| Cylinder Head                                            |                  |                   |
| • Overall Height - Minimum                               | 128.9 mm         | 5.07 in           |
| • Surface Flatness - Block Deck - Longitude              | 0.050 mm         | 0.002 in          |
| • Surface Flatness - Block Deck - Overall                | 0.1 mm           | 0.004 in          |
| • Surface Flatness - Block Deck - Transverse             | 0.030 mm         | 0.0012 in         |
| • Valve Guide Bore - Exhaust                             | 6.000-6.012 mm   | 0.2362-0.2367 in  |
| • Valve Guide Bore - Intake                              | 6.000-6.012 mm   | 0.2362-0.2367 in  |
| • Valve Lifter Bore Diameter - Stationary Lash Adjusters | 12.013-12.037 mm | 0.4730-0.4739 in  |
| • Valve Seat Angle - Relief Surface                      | 30 Degrees       |                   |
| • Valve Seat Angle - Seating Surface                     | 45 Degrees       |                   |

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|                                                             |                   |                  |
|-------------------------------------------------------------|-------------------|------------------|
| • Valve Seat Angle - Undercut Surface                       | 60 Degrees        |                  |
| • Valve Seat Roundness - Maximum                            | 0.025 mm          | 0.0010 in        |
| • Valve Seat Runout - Maximum                               | 0.080 mm          | 0.0031 in        |
| • Valve Seat Width - Exhaust Seating Surface                | 1.600 mm          | 0.0630 in        |
| • Valve Seat Width - Intake Seating Surface                 | 1.200 mm          | 0.0472 in        |
| Lubrication System                                          |                   |                  |
| • Oil Pressure - Minimum - @1000 RPM @ 90°C (194°F)         | 206.84-482.63 kPa | 30-70 psi        |
| • Oil Capacity                                              | 4.7L              | 5.0 quarts       |
| Piston Rings                                                |                   |                  |
| • Piston Ring End Gap - First Compression Ring              | 0.15-0.30 mm      | 0.006-0.012 in   |
| • Piston Ring End Gap - Second Compression Ring             | 0.20-0.45 mm      | 0.008-0.018 in   |
| • Piston Ring End Gap - Oil Control Ring - Rails            | 0.15-0.65 mm      | 0.006-0.026 in   |
| • Piston Ring to Groove Clearance - First Compression Ring  | 0.04-0.08 mm      | 0.0015-0.0031 in |
| • Piston Ring to Groove Clearance - Second Compression Ring | 0.030-0.070 mm    | 0.0012-0.0030 in |
| • Piston Ring to Groove Clearance - Oil Control Ring        | 0.058-0.207 mm    | 0.0023-0.0081 in |
| • Piston Ring Thickness - First Compression Ring            | 1.170-1.190 mm    | 0.0461-0.0469 in |
| • Piston Ring Thickness - Second Compression Ring           | 1.471-1.490 mm    | 0.0579-0.0587 in |
| • Piston Ring Thickness - Oil Control Ring - Rail - Maximum | 0.473 mm          | 0.0186 in        |
| • Piston Ring Thickness - Oil Control Ring - Spacer - Rail  | 0.929-1.006 mm    | 0.0366-0.0396 in |
| Pistons and Pins                                            |                   |                  |
| • Pin - Piston Pin Clearance to Connecting Rod Bore         | 0.007-0.020 mm    | 0.0003-0.0008 in |
| • Pin - Piston Pin Clearance to Piston Pin Bore             | 0.004-0.012 mm    | 0.0002-0.0005 in |
| • Pin - Piston Pin Diameter                                 | 19.997-20.000 mm  | 0.7873-0.7874 in |
| • Pin - Piston Pin End Play                                 | 0.410-1.266 mm    | 0.0161-0.0498 in |
| • Piston - Piston Diameter - @14.5 mm up                    | 87.967-87.982 mm  | 3.4633-3.4638 in |
| • Piston - Piston Pin Bore Diameter                         | 20.004-20.009 mm  | 0.7876-0.7878 in |
| • Piston - Piston Ring Groove Width - Oil Control           | 2.01-2.03 mm      | 0.0791-0.0799 in |
| • Piston - Piston Ring Groove Width - Second                | 1.52-1.54 mm      | 0.0598-0.0606 in |
| • Piston - Piston Ring Groove Width - Top                   | 1.23-1.25 mm      | 0.0484-0.0492 in |
| • Piston - Piston to Bore Clearance                         | 0.010-0.041 mm    | 0.0004-0.0016 in |

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### Valve System

|                                                                                           |                  |                  |
|-------------------------------------------------------------------------------------------|------------------|------------------|
| • Valves - Valve Face Angle                                                               | 45 Degrees       |                  |
| • Valves - Valve Face Runout - Maximum                                                    | 0.040 mm         | 0.0016 in        |
| • Valves - Valve Seat Runout - Maximum                                                    | 0.080 mm         | 0.0031 in        |
| • Valves - Valve Face Seat Width - Exhaust                                                | 1.6000 mm        | 0.06299 in       |
| • Valves - Valve Face Seat Width - Intake                                                 | 1.2000 mm        | 0.04724 in       |
| • Valves - Valve Head Diameter - Exhaust                                                  | 29.950-30.250 mm | 1.1791-1.1909 in |
| • Valves - Valve Head Diameter - Intake                                                   | 34.950-35.250 mm | 1.3760-1.4154 in |
| • Valves - Valve Head O.D. and Chamfer Height - Exhaust                                   | 1.1174 mm        | 0.04399 in       |
| • Valves - Valve Head O.D. and Chamfer Height - Intake                                    | 1.0526 mm        | 0.04144 in       |
| • Valves - Valve Stem Diameter - Exhaust                                                  | 5.935-5.950 mm   | 0.2337-0.2343 in |
| • Valves - Valve Stem Diameter - Intake                                                   | 5.955-5.970 mm   | 0.2344-0.2355 in |
| • Valves - Valve Stem Height - Closed                                                     | 32.500 mm        | 1.2795 in        |
| • Valves - Valve Stem to Guide Clearance - Exhaust                                        | 0.050-0.077 mm   | 0.0020-0.0026 in |
| • Valves - Valve Stem to Guide Clearance - Intake                                         | 0.030-0.057 mm   | 0.0012-0.0022 in |
| • Valve Lash Adjusters - Valve Lash Adjuster Diameter - Stationary Lash Adjuster          | 11.986-12.000 mm | 0.0005-0.0020 in |
| • Valve Lash Adjusters - Valve Lash-Adjuster-to-Bore Clearance - Stationary Lash Adjuster | 0.013-0.051 mm   | 3.2210-3.2299 in |
| • Valve Rocker Arms - Rocker Arm Ratio                                                    | 1.68 to 1        |                  |
| • Valve Rocker Arms - Rocker Arm Roller Diameter                                          | 17.740-17.800 mm | 0.6987-0.7008 in |
| • Valve Springs - Valve Spring Free Length                                                | 41.400-44.200 mm | 1.6299-1.7402 in |
| • Valve Springs - Valve Spring Installed Height - Closed                                  | 32.500 mm        | 1.2795 in        |
| • Valve Springs - Valve Spring Installed Height - Open                                    | 22.500 mm        | 0.8858 in        |
| • Valve Springs - Valve Spring Load - Closed - @32.5 mm                                   | 245.0-271.0 N    | 55-61 lb         |
| • Valve Springs - Valve Spring Load - Open - @22.5 mm                                     | 525.0-575.0 N    | 118-129 lb       |

## ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

### Adhesives, Fluids, Lubricants, and Sealers

| Application | Type of Material | GM Part Number |        |
|-------------|------------------|----------------|--------|
|             |                  | United States  | Canada |
|             |                  |                |        |

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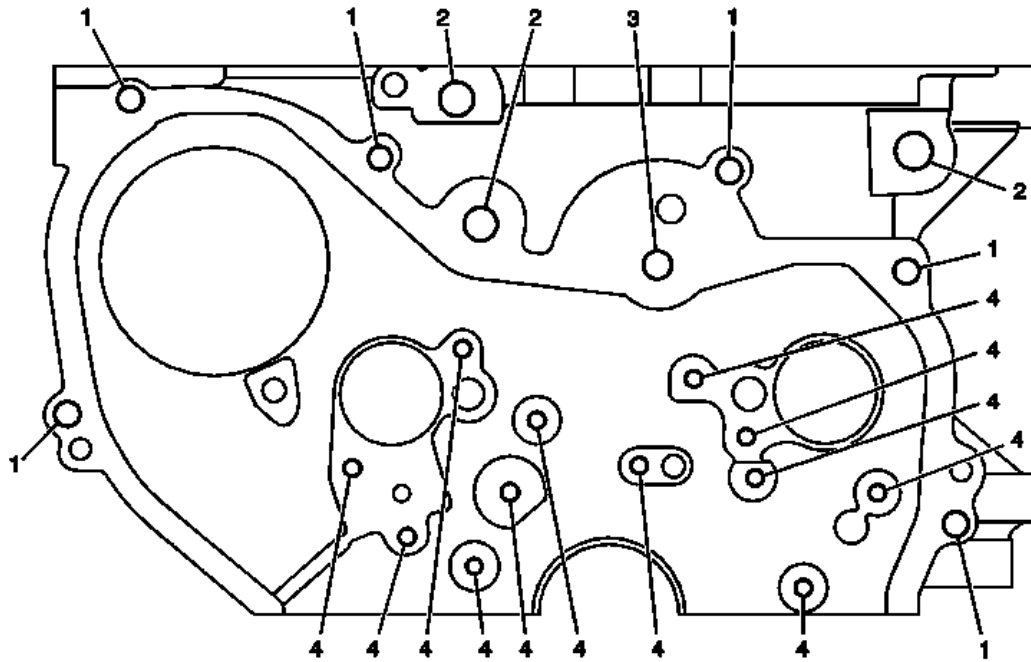
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|                                                                |                         |          |          |
|----------------------------------------------------------------|-------------------------|----------|----------|
| # 6 Intake Rear Camshaft Cap                                   | Sealant                 | 12378521 | 88901148 |
| Balance Shaft Bearings                                         | 5W-30                   | 19293000 | 19286321 |
| Cam Lobes                                                      | 5W-30                   | 19293000 | 19286321 |
| Crank Sensor O-ring                                            | 5W-30                   | 19293000 | 19286321 |
| Cylinder Bores                                                 | 5W-30                   | 19293000 | 19286321 |
| Cylinder Head Plugs                                            | Threadlocker            | 12345382 | 10953489 |
| Engine Block Threaded Plugs                                    | Sealant                 | 12346004 | 10953480 |
| Engine Block to Bedplate                                       | Sealant                 | 12378521 | 88901148 |
| Engine Oil                                                     | 5W-30                   | 19293000 | 19386321 |
| Fuel Injector O-rings                                          | 5W-30                   | 19293000 | 19386321 |
| Fuel Injector Tip Insulators, for Multiple Port Injection Only | 5W-30                   | 19293000 | 19386321 |
| Hydraulic Lash Adjusters                                       | Lubricant               | 88862586 | 88862827 |
| Ignition Coils                                                 | Lubricant               | 19260901 | 19260902 |
| Intake and Exhaust Valve Stems                                 | Lubricant               | 88862586 | 88862827 |
| Main Bearings                                                  | Lubricant               | 88862586 | 88862827 |
| Oil Filter Cap- Threads and O-ring Lead-in Chamfers            | 5W-30                   | 19293000 | 19286321 |
| Oil Level Indicator Tube O-ring                                | Lubricant               | 88862586 | 88862827 |
| Oil Pan to Bedplate Joint                                      | Sealant                 | 12378521 | 88901148 |
| Oil Pump- Pump Elements                                        | 5W-30                   | 19293000 | 19286321 |
| Oxygen Sensor Threads                                          | Anti-seize              | 88862477 | 88862478 |
| Piston Pin to Piston/Rod- Pin Bores of Piston and Rod          | 5W-30                   | 19293000 | 19286321 |
| Rod Bearings- Rod Pins of Crankshaft                           | 5W-30                   | 19293000 | 19286321 |
| Thread Repair Cutting Oil                                      | Lubricant               | 1052864  | 992881   |
| Thread Repair                                                  | Cleaner                 | 88862650 | 88901247 |
| Timing Chain Guide Bolt Access Hole Plug                       | Threadlocker            | 12345382 | 10953489 |
| Valves                                                         | Parts Immersion Solvent | 12345368 | 10953514 |
| Valve Rocker Arm/Valve Tip                                     | Lubricant               | 12345501 | 992704   |
| Water Feed Tube O-rings                                        | Lubricant               | 19260901 | 19260902 |
| Water Pump Drain Plug                                          | Sealant                 | 12346004 | 10953480 |

**THREAD REPAIR SPECIFICATIONS (LEA)****Engine Block- Front View**

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**Fig. 1: Identifying Bolt Size & Locations On Engine Block - Front View**  
Courtesy of GENERAL MOTORS COMPANY

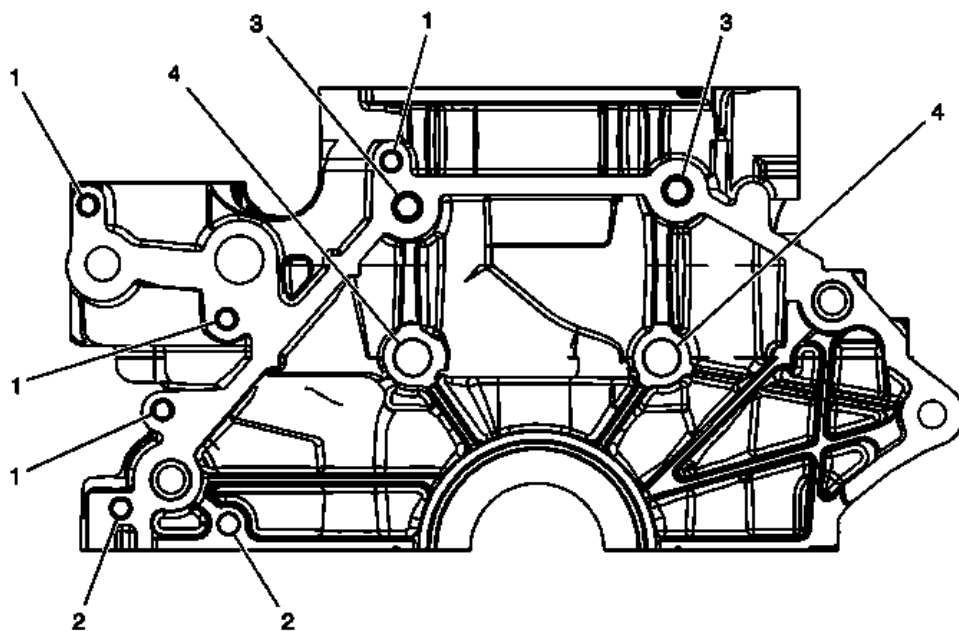
### Engine Block- Front View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |      |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN) |
| 1                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 23.5                  | 0.93  | 18.5                | 0.73 |
| 2                | M12 x 1.75  | 855    | 856   | 857              | 858 | 859    | 33.5                  | 1.32  | 26.5                | 1.04 |
| 3                | M10 x 1.5   | 215    | 211   | 212              | 213 | 214    | 24.5                  | 0.96  | 19.5                | 0.77 |
| 4                | M6 x 1      | 205    | 201   | 202              | 203 | 204    | 20                    | 0.787 | 16                  | 0.63 |

### Engine Block- Back View

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2012 ENGINE Engine Mechanical - 2.4L - Verano

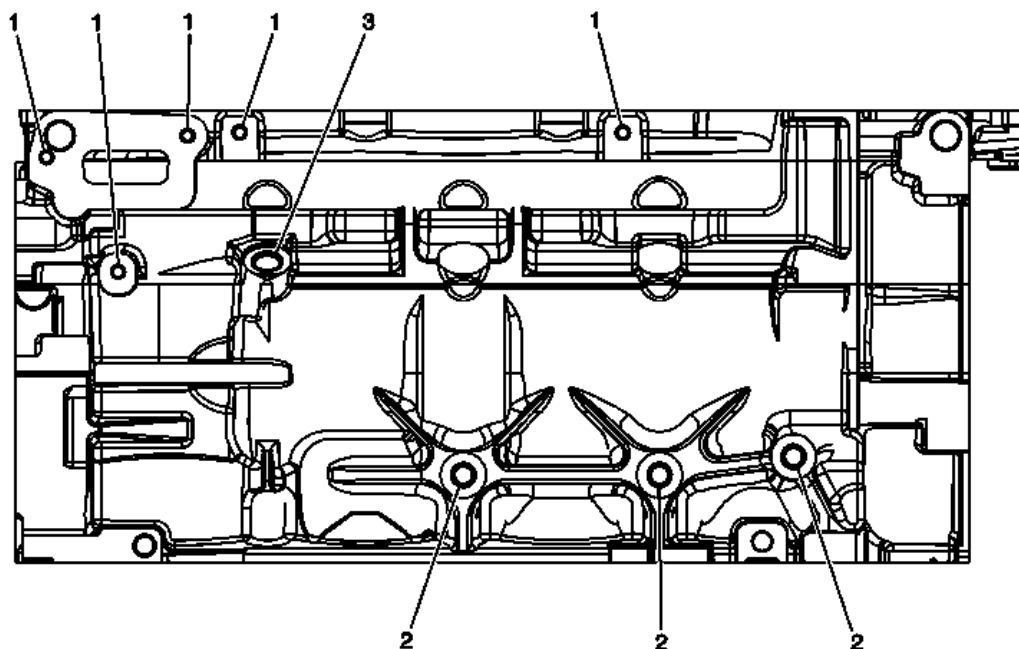


**Fig. 2: Identifying Bolt Size & Locations On Engine Block - Back View**  
Courtesy of GENERAL MOTORS COMPANY

### Engine Block- Back View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |      |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN) |
| 1                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 18                    | 0.709 | THRU                |      |
| 2                | M10 x 1.5   | 215    | 211   | 212              | 213 | 214    | 29                    | 1.161 | THRU                |      |
| 3                | M12 x 1.75  | 855    | 856   | 857              | 858 | 859    | 39                    | 1.535 | 33.5                | 1.32 |
| 4                | M16 x 1.5   | 860    | 861   | 862              | 863 | 864    | 21                    | 0.827 | 15                  | 0.59 |

### Engine Block- Right Side View

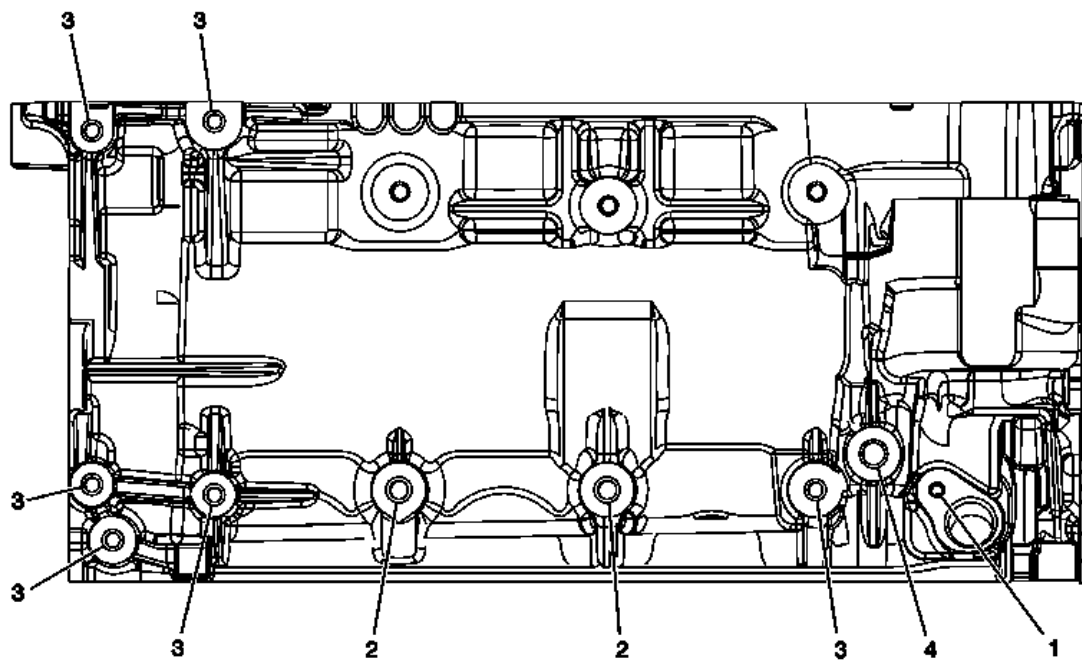


**Fig. 3: Locating Bolts On Engine Block - Right Side View**  
 Courtesy of GENERAL MOTORS COMPANY

**Engine Block- Right Side View**

| Service<br>Call<br>Out | Thread<br>Size | Insert | Drill | Counterbore<br>Tool | Tap | Driver | Drill Depth<br>(Maximum) |       | Tap Depth<br>(Maximum) |      |
|------------------------|----------------|--------|-------|---------------------|-----|--------|--------------------------|-------|------------------------|------|
| EN 42385-850           |                |        |       |                     |     |        | MM                       | (IN)  | MM                     | (IN) |
| 1                      | M6 x 1         | 205    | 201   | 202                 | 203 | 204    | 20.5                     | 0.807 | 16                     | 0.63 |
| 2                      | M10 x 1.5      | 215    | 211   | 212                 | 213 | 214    | 23.5                     | 0.925 | 18.5                   | 0.73 |
| 3                      | M12 x 1.75     | 865    | 856   | 857                 | 858 | 859    | 19.5                     | 0.768 | 12.5                   | 0.49 |

**Engine Block- Left Side View**

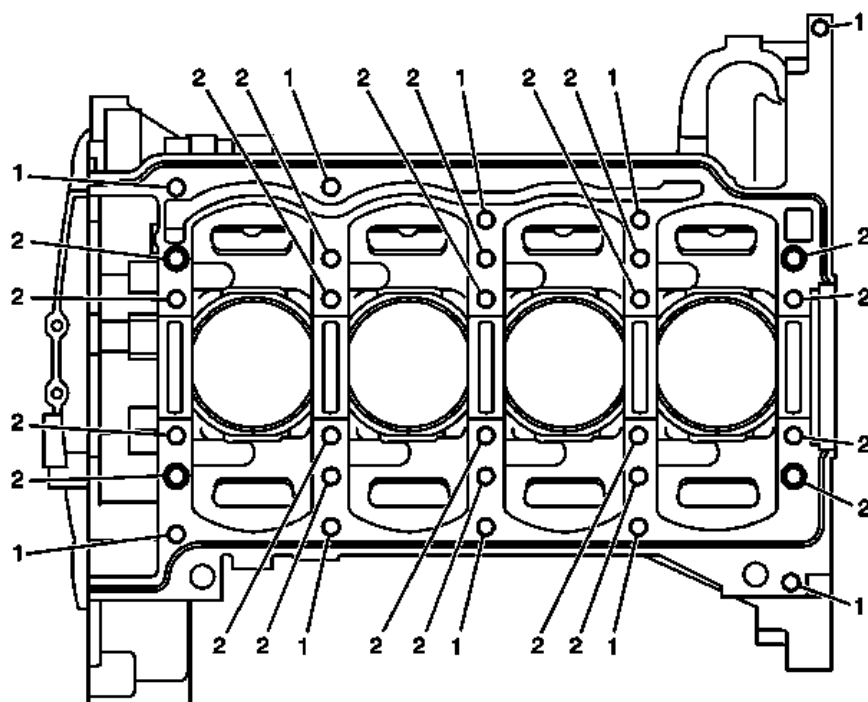


**Fig. 4: Locating Bolts On Engine Block - Left Side View**  
 Courtesy of GENERAL MOTORS COMPANY

#### Engine Block- Left Side View

| Service<br>Call<br>Out | Thread<br>Size | Insert | Drill | Counterbore<br>Tool | Tap | Driver | Drill Depth<br>(Maximum) |       | Tap Depth<br>(Maximum) |      |
|------------------------|----------------|--------|-------|---------------------|-----|--------|--------------------------|-------|------------------------|------|
| EN 42385-850           |                |        |       |                     |     |        | MM                       | (IN)  | MM                     | (IN) |
| 1                      | M6 x 1         | 205    | 201   | 202                 | 203 | 204    | 20.5                     | 0.807 | 16.5                   | 0.65 |
| 2                      | M10 x 1.5      | 215    | 211   | 212                 | 213 | 214    | 23.5                     | 0.925 | 18                     | 0.71 |
| 3                      | M8 x 1.25      | 210    | 206   | 2047                | 208 | 209    | 30.5                     | 1.201 | 22.5                   | 0.89 |
| 4                      | M12 x 1.75     | 865    | 856   | 857                 | 858 | 859    | 15.5                     | .061  | 12.5                   | 0.49 |

#### Engine Block- Bottom View

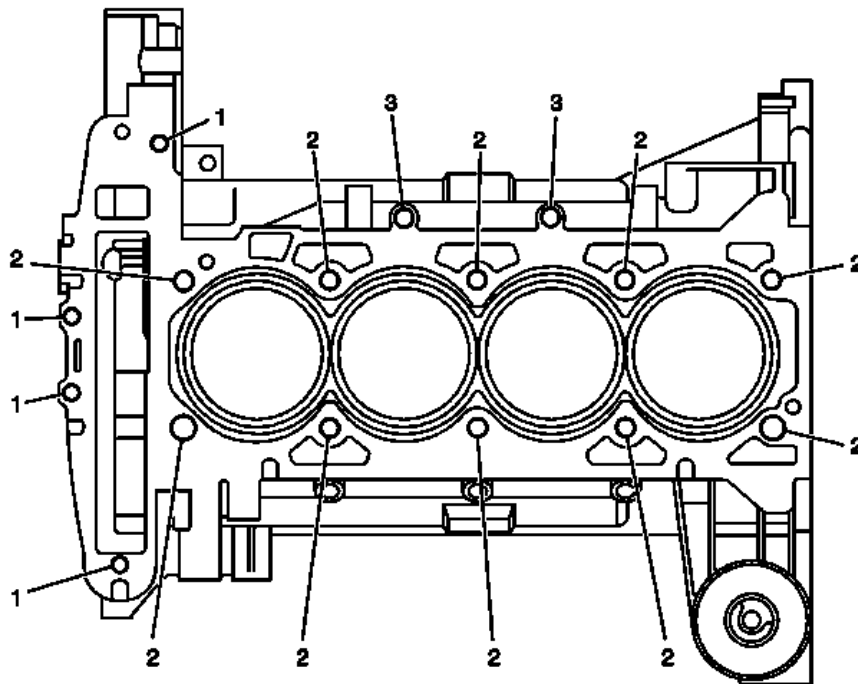


**Fig. 5: Identifying Bolt Size & Locations On Engine Block - Bottom**  
 Courtesy of GENERAL MOTORS COMPANY

#### Engine Block- Bottom View

| Service<br>Call<br>Out | Thread<br>Size | Insert | Drill | Counterbore<br>Tool | Tap | Driver | Drill Depth<br>(Maximum) |       | Tap Depth<br>(Maximum) |      |
|------------------------|----------------|--------|-------|---------------------|-----|--------|--------------------------|-------|------------------------|------|
| EN 42385-850           |                |        |       |                     |     |        | MM                       | (IN)  | MM                     | (IN) |
| 1                      | M8 x 1.25      | 210    | 206   | 207                 | 208 | 209    | 28                       | 1.102 | 22                     | 0.87 |
| 2                      | M10 x 1.5      | 514    | 511   | N/A                 | 512 | 513    | 60                       | 2.362 | 53.5                   | 2.11 |

#### Engine Block- Top View

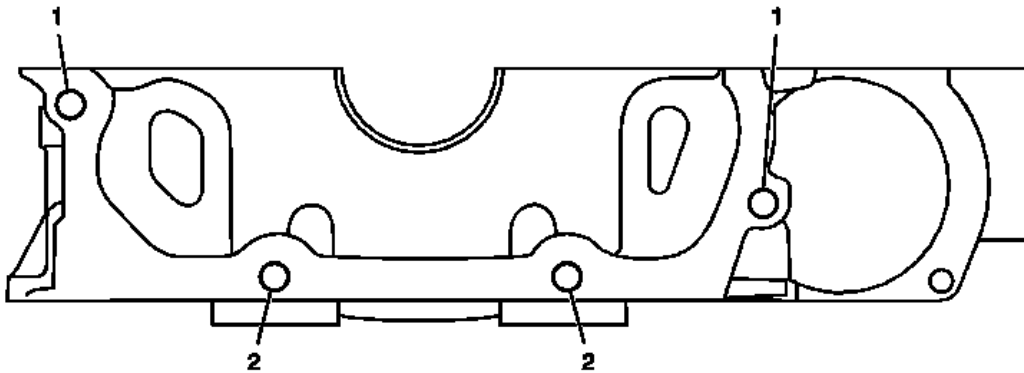


**Fig. 6: Identifying Bolt Size & Locations On Engine Block - Top**  
 Courtesy of GENERAL MOTORS COMPANY

**Engine Block- Top View**

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |      |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN) |
| 1                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 23.5                  | 0.925 | 18.5                | 0.73 |
| 2                | M11 x 1.5   | 507    | 504   | N/A              | 505 | 506    | 113.3                 | 4.461 | 107.3               | 4.22 |
| 3                | M12 x 1.75  | 865    | 856   | 857              | 858 | 859    | 13.5                  | 0.531 | 12.5                | 0.49 |

**Lower Crankcase- Front View**

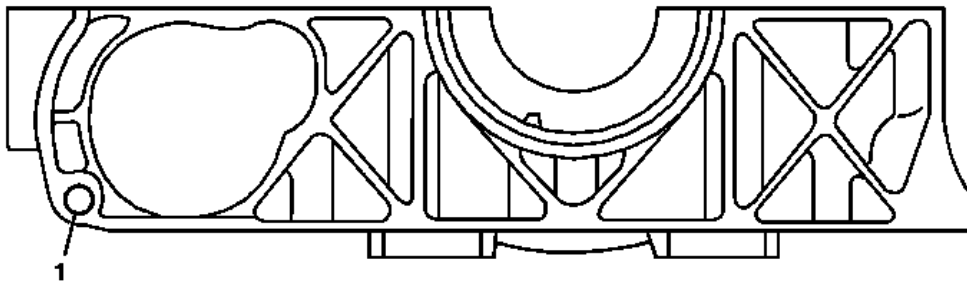


**Fig. 7: Identifying Bolt Size & Locations On Engine Block - Top**  
Courtesy of GENERAL MOTORS COMPANY

**Lower Crankcase- Front View**

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |      |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN) |
| 1                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 23.5                  | 0.925 | 18.5                | 0.73 |
| 2                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 30.5                  | 1.201 | 25.5                | 1.00 |

**Lower Crankcase- Back View**



**Fig. 8: Identifying Bolt Size & Locations On Lower Crankcase - Back**  
Courtesy of GENERAL MOTORS COMPANY

**Lower Crankcase- Back View**

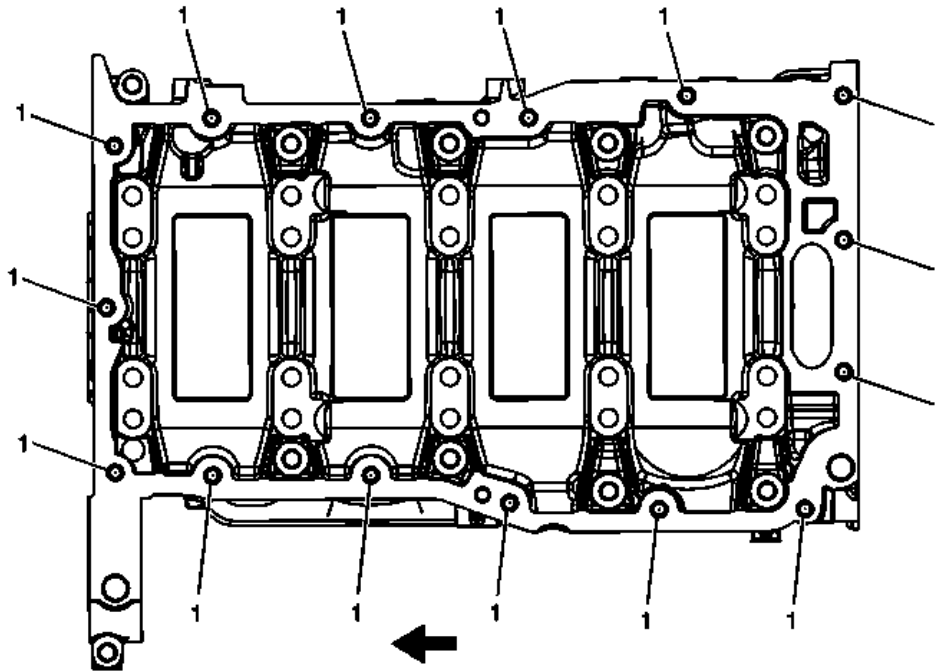
| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) | Tap Depth (Maximum) |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|---------------------|
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|---------------------|

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| EN 42385-850 |           |     |     |     |     |     | MM   | (IN)  | MM   | (IN) |
|--------------|-----------|-----|-----|-----|-----|-----|------|-------|------|------|
| 1            | M10 x 1.5 | 215 | 211 | 212 | 213 | 214 | 29.5 | 1.161 | THRU |      |

### Lower Crankcase- Bottom View



**Fig. 9: Locating Bolts On Lower Crankcase - Bottom View**  
Courtesy of GENERAL MOTORS COMPANY

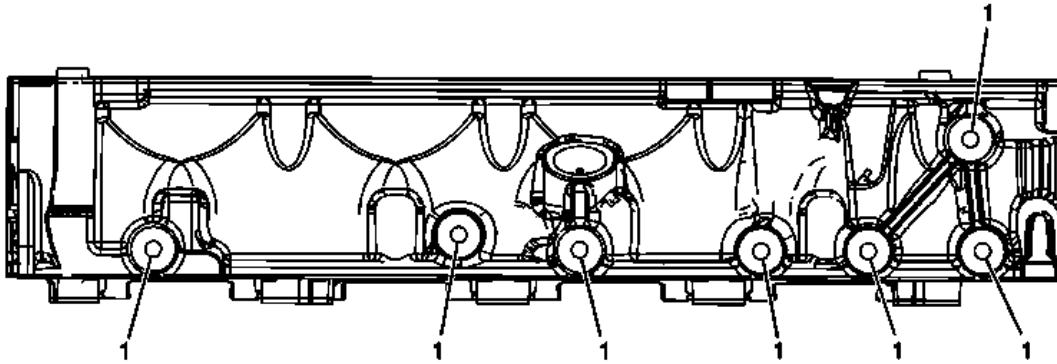
### Lower Crankcase- Bottom View

| Service<br>Call<br>Out | Thread<br>Size | Insert | Drill | Counterbore<br>Tool | Tap | Driver | Drill Depth<br>(Maximum) |       | Tap Depth<br>(Maximum) |      |
|------------------------|----------------|--------|-------|---------------------|-----|--------|--------------------------|-------|------------------------|------|
| EN 42385-850           |                |        |       |                     |     |        | MM                       | (IN)  | MM                     | (IN) |
| 1                      | M8 x 1.25      | 210    | 206   | 207                 | 208 | 209    | 23.5                     | 0.925 | 18.5                   | 0.73 |

### Lower Crankcase- Right View

## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

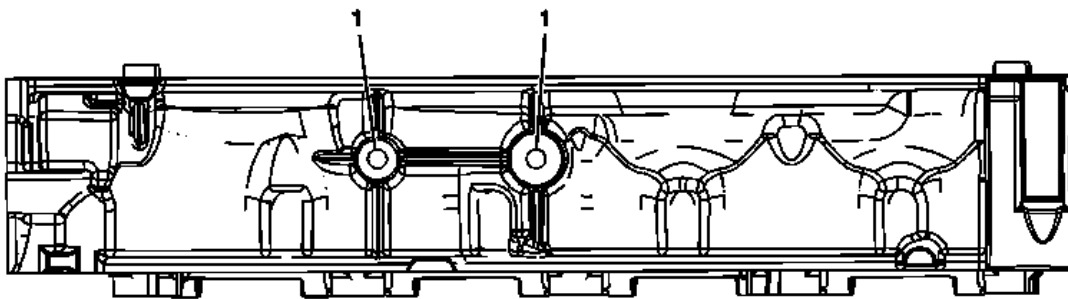


**Fig. 10: Identifying Bolt Size & Locations On Lower Crankcase - Right**  
Courtesy of GENERAL MOTORS COMPANY

### Lower Crankcase- Right View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |       |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|-------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN)  |
| 1                | M10 x 1.5   | 215    | 211   | 212              | 213 | 214    | 34                    | 1.339 | 27                  | 1.063 |

### Lower Crankcase- Left View



**Fig. 11: Identifying Bolt Size & Locations On Lower Crankcase - Left**  
Courtesy of GENERAL MOTORS COMPANY

### Lower Crankcase- Left View

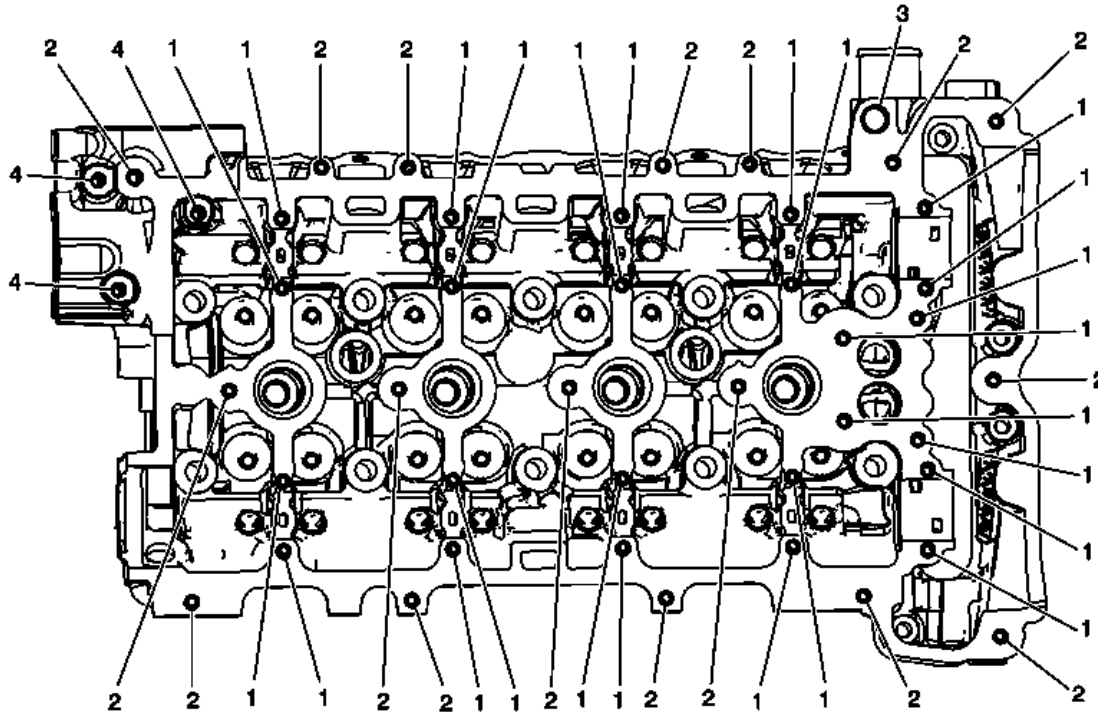
| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |      | Tap Depth (Maximum) |      |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|------|---------------------|------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN) | MM                  | (IN) |

## 2012 Buick Verano

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|   |           |     |     |     |     |     |    |       |    |       |
|---|-----------|-----|-----|-----|-----|-----|----|-------|----|-------|
| 1 | M8 x 1.25 | 210 | 211 | 212 | 213 | 214 | 34 | 1.339 | 27 | 1.063 |
|---|-----------|-----|-----|-----|-----|-----|----|-------|----|-------|

### Cylinder Head- Top View

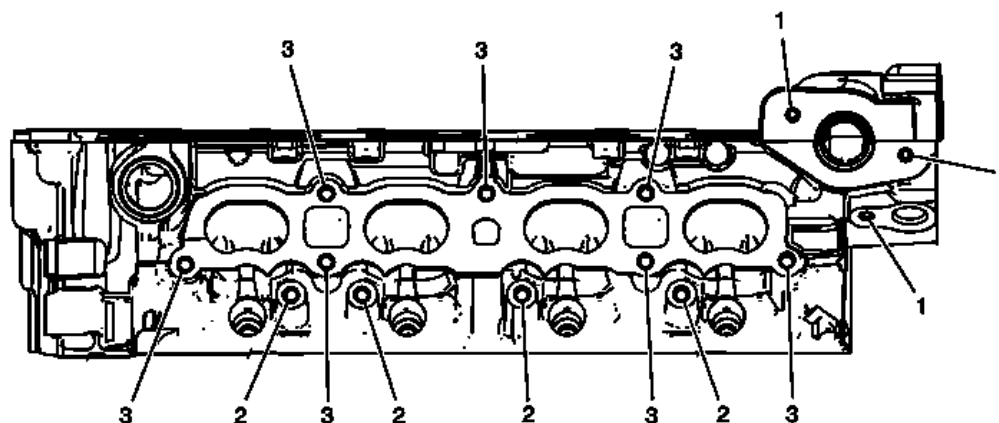


**Fig. 12: Locating Bolts On Cylinder Head - Top View**  
Courtesy of GENERAL MOTORS COMPANY

### Cylinder Head- Top View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |       |
|------------------|-------------|--------|-------|------------------|-----|--------|-----------------------|-------|---------------------|-------|
| EN 42385-850     |             |        |       |                  |     |        | MM                    | (IN)  | MM                  | (IN)  |
| 1                | M6 x 1      | 205    | 852   | N/A              | 203 | 204    | 24                    | 0.945 | 20                  | 0.787 |
| 2                | M6 x 1      | 205    | 201   | 202              | 203 | 204    | 20                    | 0.787 | 16                  | 0.63  |
| 3                | M14 x 1.75  | 854    | 857   | N/A              | 858 | 859    | THRU                  |       | THRU                |       |
| 4                | M8 x 1.25   | 854    | 853   | N/A              | 208 | 209    | 30                    | 1.182 | 27                  | 1.063 |

### Cylinder Head- Intake Manifold Deck View

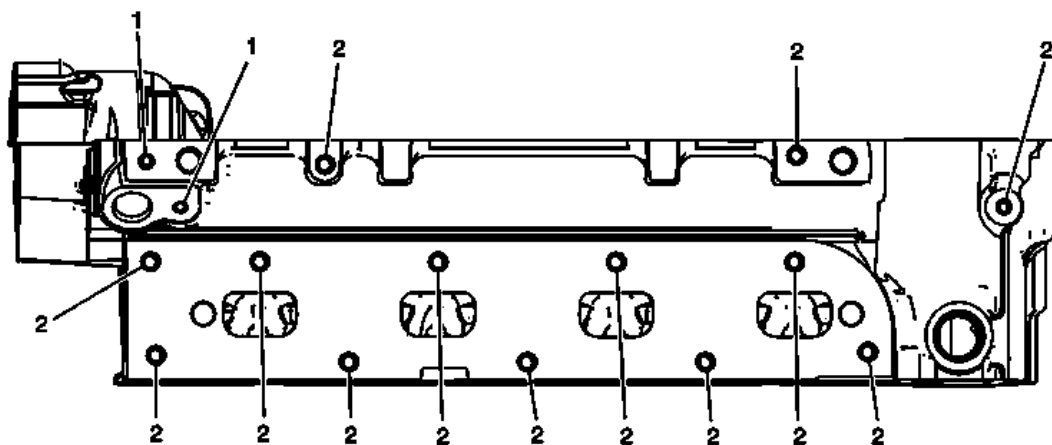


**Fig. 13: Identifying Bolt Size & Locations On Cylinder Head - Intake Manifold Deck**  
 Courtesy of GENERAL MOTORS COMPANY

#### Cylinder Head- Intake Manifold Deck View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth Maximum |       | Tap Depth Maximum |       |
|------------------|-------------|--------|-------|------------------|-----|--------|---------------------|-------|-------------------|-------|
| EN 42385-850     |             |        |       |                  |     |        | MM                  | IN    | MM                | IN    |
| 1                | M6 x 1      | 205    | 201   | 202              | 203 | 204    | 20                  | 0.787 | 16                | 0.63  |
| 2                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 20                  | 0.787 | 16                | 0.63  |
| 3                | M8 x 1.25   | 205    | 201   | 202              | 203 | 204    | 16                  | 0.630 | 12                | 0.473 |

#### Cylinder Head- Exhaust Manifold Deck View



**Fig. 14: Identifying Bolt Size & Locations On Cylinder Head - Exhaust Manifold Deck**  
 Courtesy of GENERAL MOTORS COMPANY

#### Cylinder Head- Exhaust Manifold Deck View

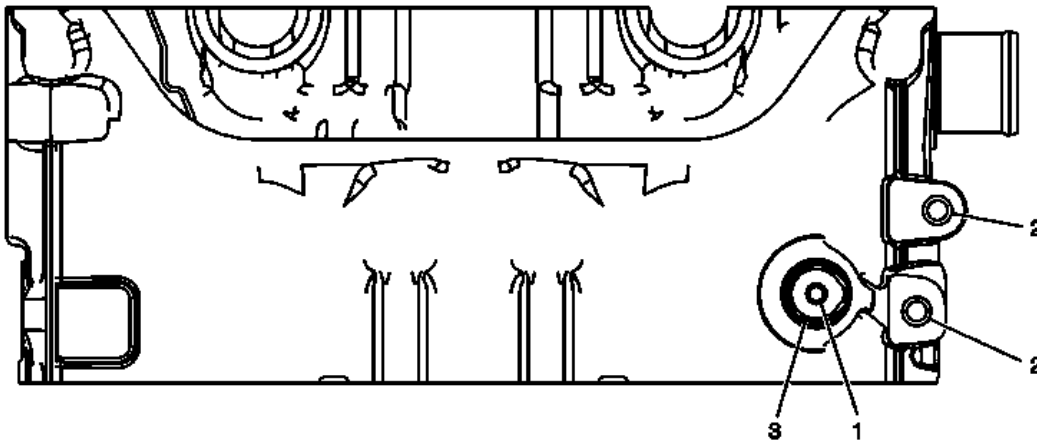
| Service Call | Thread |  | Counterbore |  | Drill Depth | Tap Depth |
|--------------|--------|--|-------------|--|-------------|-----------|
|--------------|--------|--|-------------|--|-------------|-----------|

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| Out          | Size      | Insert | Drill | Tool | Tap | Driver | (Maximum) |       | (Maximum) |      |
|--------------|-----------|--------|-------|------|-----|--------|-----------|-------|-----------|------|
| EN 42385-850 |           |        |       |      |     |        | MM        | (IN)  | MM        | (IN) |
| 1            | M6 x 1    | 205    | 201   | 202  | 203 | 204    | 20        | 0.78  | 16        | 0.63 |
| 2            | M8 x 1.25 | 210    | 206   | 207  | 208 | 209    | 25        | 0.984 | 20        | 0.78 |

### Cylinder Head- Front View



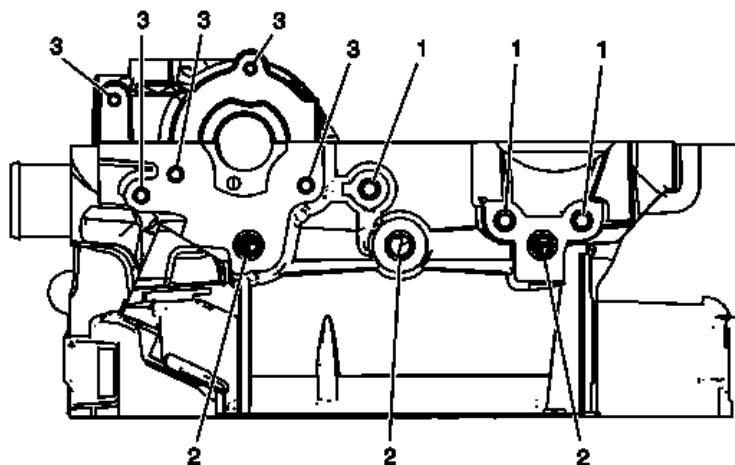
**Fig. 15: Locating Bolts On Cylinder Head - Front View**

Courtesy of GENERAL MOTORS COMPANY

### Cylinder Head- Front View

| Service Call Out | Thread Size | Insert                     | Drill | Counterbore Tool | Tap | Driver | Drill Depth (Maximum) |       | Tap Depth (Maximum) |       |
|------------------|-------------|----------------------------|-------|------------------|-----|--------|-----------------------|-------|---------------------|-------|
| EN 42385-850     |             |                            |       |                  |     |        | MM                    | (IN)  | MM                  | (IN)  |
| 1                | M6 x 1      | 205                        | 201   | 202              | 203 | 204    | 20                    | 0.787 | 16                  | 0.63  |
| 2                | M8 x 1.25   | 210                        | 206   | 207              | 208 | 209    | 25                    | 0.984 | 20                  | 0.787 |
| 3                | M22 x 1.5   | No Service Tools Available |       |                  |     |        | THRU                  |       | THRU                |       |

### Cylinder Head- Back View



**Fig. 16: Locating Bolts On Cylinder Head - Back View**  
 Courtesy of GENERAL MOTORS COMPANY

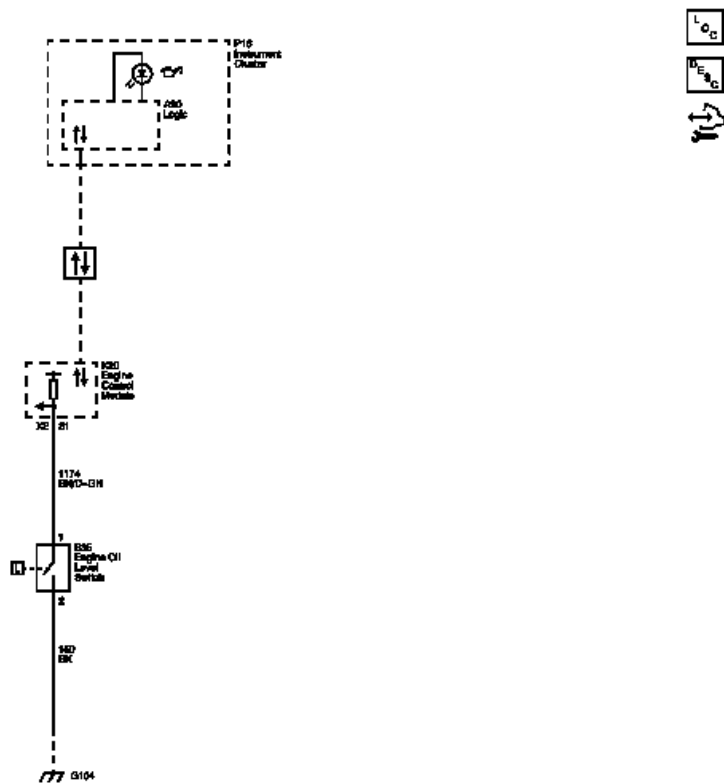
#### Cylinder Head- Back View

| Service Call Out | Thread Size | Insert | Drill | Counterbore Tool | Tap | Driver | Drill Depth Maximum |       | Tap Depth Maximum |       |
|------------------|-------------|--------|-------|------------------|-----|--------|---------------------|-------|-------------------|-------|
| EN 42385-850     |             |        |       |                  |     |        | MM                  | IN    | MM                | IN    |
| 1                | M8 x 1.25   | 210    | 206   | 207              | 208 | 209    | 25                  | 0.984 | 20                | 0.787 |
| 2                | M12 x 1.75  | 865    | 856   | 857              | 858 | 859    | 18                  | 0.709 | 14                | 0.551 |
| 3                | M6 x 1      | 205    | 201   | 202              | 203 | 204    | 20                  | 0.787 | 16                | 0.63  |

## WIRING SCHEMATICS

### ENGINE MECHANICAL WIRING SCHEMATICS

#### Oil Level Sensor

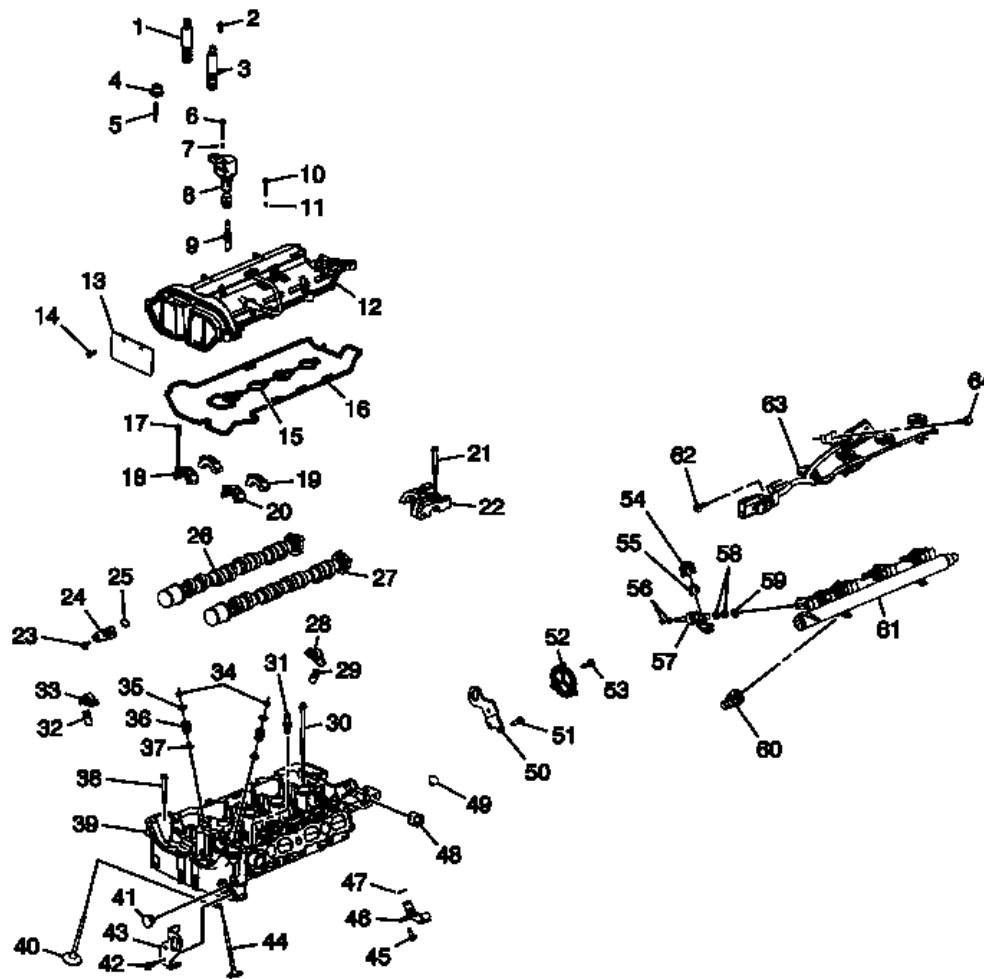


**Fig. 17: Oil Level Sensor Wiring Schematic**  
 Courtesy of GENERAL MOTORS COMPANY

## COMPONENT LOCATOR

### DISASSEMBLED VIEWS

#### Cylinder Head and Components



**Fig. 18: Exploded View Of Cylinder Head And Components**  
 Courtesy of GENERAL MOTORS COMPANY

| Callout | Component Name                                      |
|---------|-----------------------------------------------------|
| 1       | Camshaft Position Actuator Solenoid Valve - Exhaust |
| 2       | Camshaft Position Actuator Solenoid Valve Bolt      |
| 3       | Camshaft Position Actuator Solenoid Valve - Intake  |
| 4       | Upper Intake Manifold Sight Shield Grommet          |
| 5       | Ball Stud                                           |
| 6       | Ignition Coil Bolt                                  |
| 7       | Ignition Coil Bolt Retainer                         |
| 8       | Ignition Coil                                       |
| 9       | Spark Plug                                          |
| 10      | Camshaft Cover Bolt                                 |
| 11      | Camshaft Cover Bolt Retainer                        |
| 12      | Camshaft Cover                                      |
| 13      | Camshaft Housing Cover Insulator                    |

**2012 Buick Verano**

2012 ENGINE Engine Mechanical - 2.4L - Verano

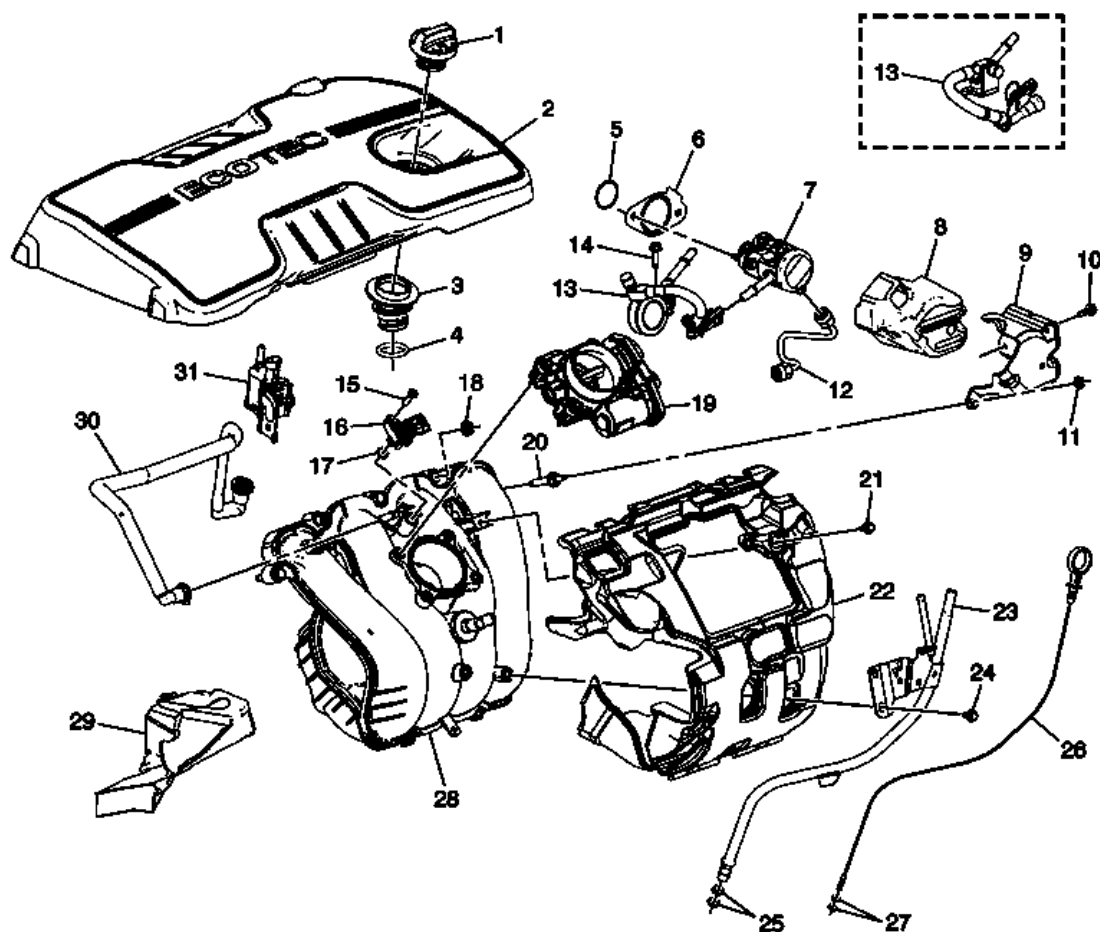
|    |                                          |
|----|------------------------------------------|
| 14 | Camshaft Housing Cover Insulator Bolt    |
| 15 | Camshaft Cover Seal                      |
| 16 | Camshaft Cover Seal                      |
| 17 | Camshaft Bearing Cap Bolt                |
| 18 | Camshaft Bearing Front Cap               |
| 19 | Camshaft Bearing Cap                     |
| 20 | Camshaft Bearing Front Cap               |
| 21 | Camshaft Rear Cap Bolt                   |
| 22 | Intake Camshaft Rear Cap                 |
| 23 | Camshaft Position Sensor Bolt            |
| 24 | Camshaft Position Sensor                 |
| 25 | Camshaft Position Sensor O-Ring          |
| 26 | Exhaust Camshaft                         |
| 27 | Intake Camshaft                          |
| 28 | Roller Finger Follower                   |
| 29 | Hydraulic Lash Adjuster                  |
| 30 | Cylinder Head Bolt                       |
| 31 | Engine Coolant Air Bleed Fitting         |
| 32 | Hydraulic Lash Adjuster                  |
| 33 | Roller Finger Follower                   |
| 34 | Valve Keys                               |
| 35 | Valve Spring Retainer                    |
| 36 | Valve Spring                             |
| 37 | Valve Stem Seal                          |
| 38 | Small Cylinder Head Bolt                 |
| 39 | Cylinder Head                            |
| 40 | Valve                                    |
| 41 | Timing Chain Guide Bolt Access Hole Plug |
| 42 | Front Lift Bracket Bolt                  |
| 43 | Front Lift Bracket                       |
| 44 | Valve                                    |
| 45 | Camshaft Position Sensor Bolt            |
| 46 | Camshaft Position Sensor                 |
| 47 | Camshaft Position Sensor O-Ring          |
| 48 | High Pressure Fuel Pump Roller Lifter    |
| 49 | Cylinder Head Gallery Plug               |
| 50 | Rear Lift Bracket                        |
| 51 | Rear Lift Bracket Bolt                   |
| 52 | Cylinder Head Cover Plate                |
| 53 | Cylinder Head Cover Plate Bolt           |
| 54 | Fuel Injector Retainer                   |
| -- |                                          |

## 2012 Buick Verano

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|    |                                              |
|----|----------------------------------------------|
|    | Fuel Injector Bushing                        |
| 56 | Fuel Injector Seal                           |
| 57 | Multiport Fuel Injector                      |
| 58 | Fuel Injector Spacer                         |
| 59 | Fuel Injector O-Ring                         |
| 60 | Fuel Injection Fuel Pressure Sensor Assembly |
| 61 | Multiport Fuel Injection Fuel Rail           |
| 62 | Fuel Injector Wiring Harness Bolt            |
| 63 | Fuel Injector Wiring Harness                 |
| 64 | Fuel Injector Wiring Harness Bolt            |

### Intake Manifold and Components



**Fig. 19: Exploded View Of Intake Manifold And Components**

Courtesy of GENERAL MOTORS COMPANY

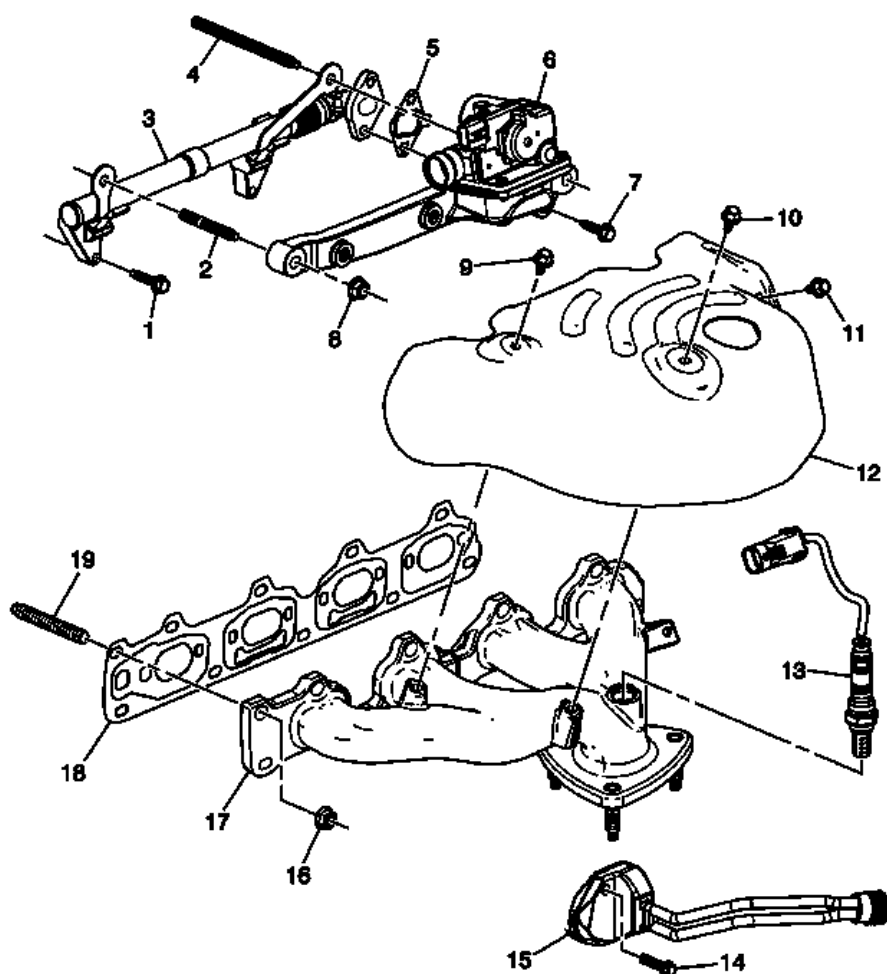
| Callout | Component Name |
|---------|----------------|
|         |                |

**2012 Buick Verano**

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|    |                                                          |
|----|----------------------------------------------------------|
| 1  | Oil Fill Cap                                             |
| 2  | Intake Manifold Cover                                    |
| 3  | Oil Fill Tube Assembly                                   |
| 4  | Oil Fill Cap O-Ring                                      |
| 5  | Fuel Pump Housing Seal                                   |
| 6  | Fuel Pump Gasket                                         |
| 7  | Fuel Pump Assembly                                       |
| 8  | Fuel Pump Insulator                                      |
| 9  | Fuel Pump Cover                                          |
| 10 | Fuel Pump Cover Bolt                                     |
| 11 | Fuel Pump Cover Nut                                      |
| 12 | Fuel Feed Intermediate Pipe                              |
| 13 | Low Pressure Fuel Pipe Assembly, model dependent         |
| 14 | Low Pressure Fuel Pipe Assembly Bolt                     |
| 15 | Manifold Absolute Pressure (MAP) Sensor Bolt             |
| 16 | MAP Sensor                                               |
| 17 | MAP Sensor O-Ring                                        |
| 18 | Intake Manifold Nut                                      |
| 19 | Throttle Body                                            |
| 20 | Intake Manifold Stud                                     |
| 21 | Intake Manifold Insulator Bolt                           |
| 22 | Intake Manifold Insulator                                |
| 23 | Oil Indicator Tube                                       |
| 24 | Oil Indicator Tube Bolt                                  |
| 25 | Oil Indicator Tube O-Ring                                |
| 26 | Oil Indicator                                            |
| 27 | Oil Indicator O-Ring                                     |
| 28 | Intake Manifold                                          |
| 29 | Fuel Injection Fuel Rail Noise Insulator                 |
| 30 | Evaporative (EVAP) Emission Canister Purge Tube Assembly |
| 31 | EVAP Emission Canister Purge Solenoid Valve              |

**Exhaust Manifold and Components**

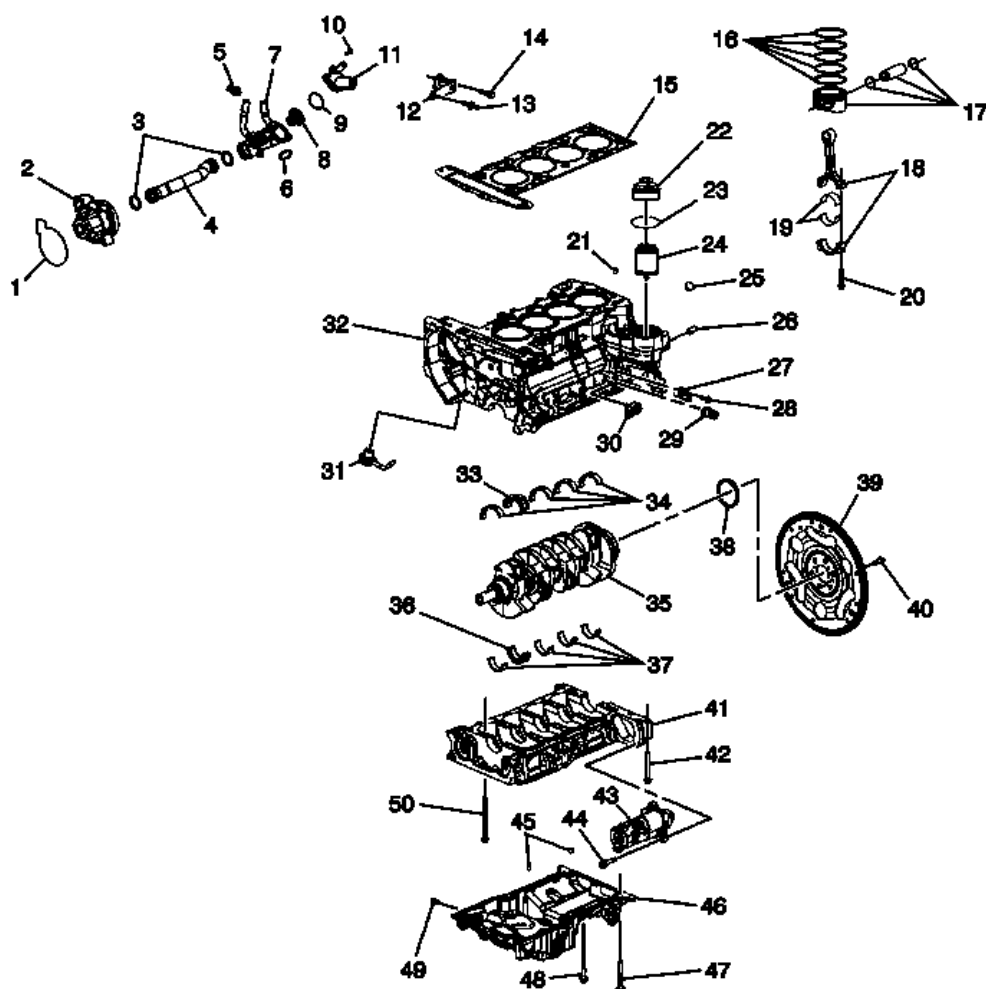


**Fig. 20: Exhaust Manifold and Components**  
 Courtesy of GENERAL MOTORS COMPANY

| Callout | Component Name                             |
|---------|--------------------------------------------|
| 1       | Secondary Air Injection Bolt               |
| 2       | Secondary Air Injection Check Stud         |
| 3       | Secondary Air Injection Pipe Assembly      |
| 4       | Secondary Air Injection Stud               |
| 5       | Secondary Air Injection Check Valve Gasket |
| 6       | Secondary Air Injection Assembly           |
| 7       | Secondary Air Injection Bolt               |
| 8       | Secondary Air Injection Assembly Nut       |
| 9       | Exhaust Manifold Heat Shield Bolt          |
| 10      | Exhaust Manifold Heat Shield Bolt          |
| 11      | Exhaust Manifold Heat Shield Bolt          |
| 12      | Exhaust Manifold Heat Shield               |
| 13      | Oxygen Sensor                              |

|    |                         |
|----|-------------------------|
| 14 | Block Heater Bolt       |
| 15 | Block Heater            |
| 16 | Exhaust Manifold Nut    |
| 17 | Exhaust Manifold        |
| 18 | Exhaust Manifold Gasket |
| 19 | Exhaust Manifold Stud   |

### Engine Block and Components



**Fig. 21: Exploded View Of Engine Block And Components**  
 Courtesy of GENERAL MOTORS COMPANY

| Callout | Component Name                   |
|---------|----------------------------------|
| 1       | Water Pump to Engine Block Seal  |
| 2       | Water Pump                       |
| 3       | Water Transfer Pipe O-ring Seals |
| 4       | Water Transfer Pipe              |

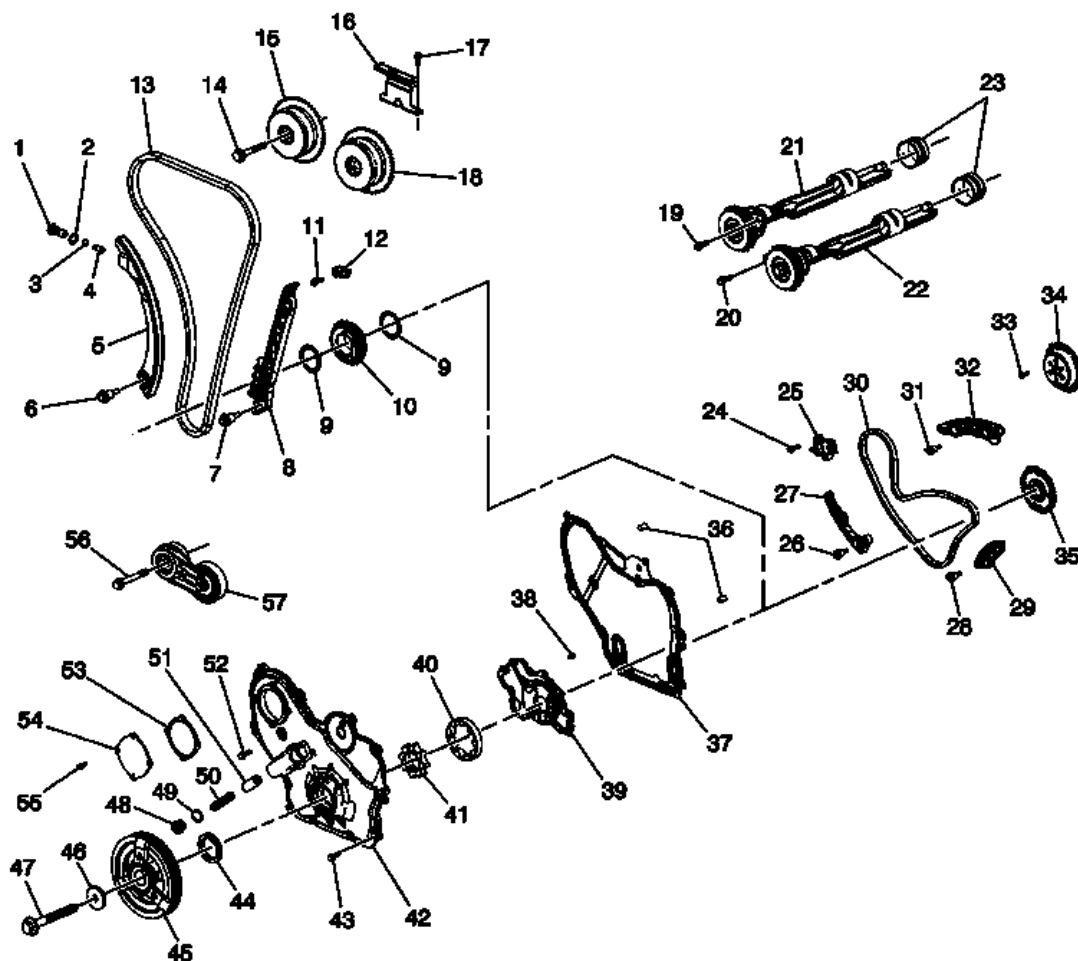
**2012 Buick Verano**

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|    |                                         |
|----|-----------------------------------------|
| 5  | Coolant Temperature Sensor              |
| 6  | Thermostat Housing to Block Gasket      |
| 7  | Thermostat Housing                      |
| 8  | Thermostat                              |
| 9  | Thermostat Gasket                       |
| 10 | Thermostat Housing Cap Bolt             |
| 11 | Thermostat Housing Cap                  |
| 12 | Water Pipe Support Bracket              |
| 13 | Water Pipe Support Bracket Bolt Stud    |
| 14 | Water Pipe Support Bracket Bolt         |
| 15 | Cylinder Head Gasket                    |
| 16 | Piston Ring Assembly                    |
| 17 | Piston Assembly                         |
| 18 | Connecting Rod                          |
| 19 | Connecting Rod Bearing                  |
| 20 | Connecting Rod Cap Bolt                 |
| 21 | Cylinder Head Alignment Pin             |
| 22 | Oil Filter Cap                          |
| 23 | Oil Filter Cap O-Ring                   |
| 24 | Oil Filter                              |
| 25 | Engine Block Gallery Plug               |
| 26 | Engine Block to Transaxle Alignment Pin |
| 27 | Crankshaft Position Sensor              |
| 28 | Crankshaft Position Sensor Bolt         |
| 29 | Oil Pressure Switch                     |
| 30 | Knock Sensor                            |
| 31 | Piston Oil Nozzle                       |
| 32 | Engine Block                            |
| 33 | Crankshaft Thrust Bearing - Upper       |
| 34 | Crankshaft Bearing - Upper              |
| 35 | Crankshaft                              |
| 36 | Crankshaft Thrust Bearing - Lower       |
| 37 | Crankshaft Bearing - Lower              |
| 38 | Crankshaft Rear Seal                    |
| 39 | Flywheel                                |
| 40 | Flywheel to Crankshaft Bolt             |
| 41 | Lower Crankcase                         |
| 42 | Lower Crankcase Perimeter Bolt          |
| 43 | Starter                                 |
| 44 | Starter Bolt                            |
| 45 | Engine Oil Pan Alignment Pins           |

|    |                                   |
|----|-----------------------------------|
|    | Engine Oil Pan                    |
| 47 | Engine Oil Pan Long Bolt          |
| 48 | Engine Oil Pan Bolt               |
| 49 | Engine Oil Pan Drain Plug         |
| 50 | Lower Crankcase Main Bearing Bolt |

### Timing Chain and Components



**Fig. 22: Timing Chain and Components**  
Courtesy of GENERAL MOTORS COMPANY

| Callout | Component Name                     |
|---------|------------------------------------|
| 1       | Timing Chain Tensioner Body        |
| 2       | Timing Chain Tensioner Washer      |
| 3       | Timing Chain Tensioner O-Ring Seal |
| 4       | Timing Chain Tensioner Plunger     |
| 5       | Adjustable Timing Chain Guide      |

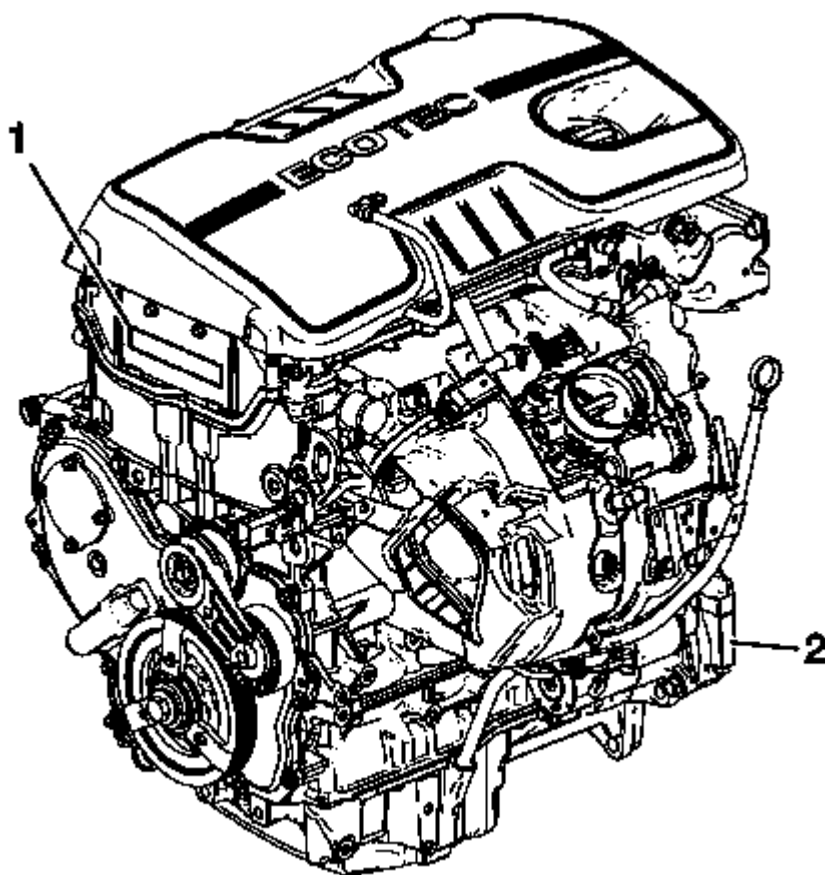
**2012 Buick Verano**

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|    |                                                   |
|----|---------------------------------------------------|
| 6  | Adjustable Timing Chain Guide Bolt                |
| 7  | Fixed Timing Chain Guide Bolt                     |
| 8  | Fixed Timing Chain Guide                          |
| 9  | Friction Washer                                   |
| 10 | Timing Chain Drive Sprocket                       |
| 11 | Timing Chain Oil Nozzle Bolt                      |
| 12 | Timing Chain Oil Nozzle                           |
| 13 | Timing Chain                                      |
| 14 | Camshaft Position Actuator Bolt                   |
| 15 | Exhaust Camshaft Position Actuator                |
| 16 | Upper Timing Chain Guide                          |
| 17 | Upper Timing Chain Guide Bolt                     |
| 18 | Intake Camshaft Position Actuator                 |
| 19 | Exhaust Balance Shaft Assembly Bolt               |
| 20 | Intake Balance Shaft Assembly Bolt                |
| 21 | Exhaust Balance Shaft Assembly                    |
| 22 | Intake Balance Shaft Assembly                     |
| 23 | Balance Shaft Rear Bearing                        |
| 24 | Balance Shaft Drive Chain Tensioner Assembly Bolt |
| 25 | Balance Shaft Drive Chain Tensioner Assembly      |
| 26 | Adjustable Balance Shaft Drive Chain Guide Bolt   |
| 27 | Adjustable Balance Shaft Drive Chain Guide        |
| 28 | Balance Shaft Drive Chain Guide Bolt              |
| 29 | Balance Shaft Drive Chain Guide                   |
| 30 | Balance Shaft Drive Chain                         |
| 31 | Balance Shaft Drive Chain Guide Bolt              |
| 32 | Balance Shaft Drive Chain Guide                   |
| 33 | Water Pump Drive Sprocket Bolt                    |
| 34 | Water Pump Drive Sprocket                         |
| 35 | Balance Shaft Drive Sprocket                      |
| 36 | Engine Front Cover Alignment Pins                 |
| 37 | Engine Front Cover Gasket                         |
| 38 | Oil Pump Cover Bolt                               |
| 39 | Oil Pump Cover                                    |
| 40 | Oil Pump Outer Gerotor                            |
| 41 | Oil Pump Inner Gerotor                            |
| 42 | Engine Front Cover                                |
| 43 | Engine Front Cover Bolt                           |
| 44 | Crankshaft Front Seal                             |
| 45 | Crankshaft Balancer                               |
| 46 | Crankshaft Balancer Washer                        |

|    |                                        |
|----|----------------------------------------|
|    | Crankshaft Balancer Bolt               |
| 48 | Oil Pressure Relief Valve Plug         |
| 49 | Oil Pressure Relief Valve O-Ring Seal  |
| 50 | Oil Pressure Relief Valve Spring       |
| 51 | Oil Pressure Relief Valve Plunger      |
| 52 | Water Pump Bolt                        |
| 53 | Engine Front Cover Access Plate Gasket |
| 54 | Engine Front Cover Access Plate        |
| 55 | Engine Front Cover Access Plate Bolt   |
| 56 | Belt Tensioner Bolt                    |
| 57 | Belt Tensioner                         |

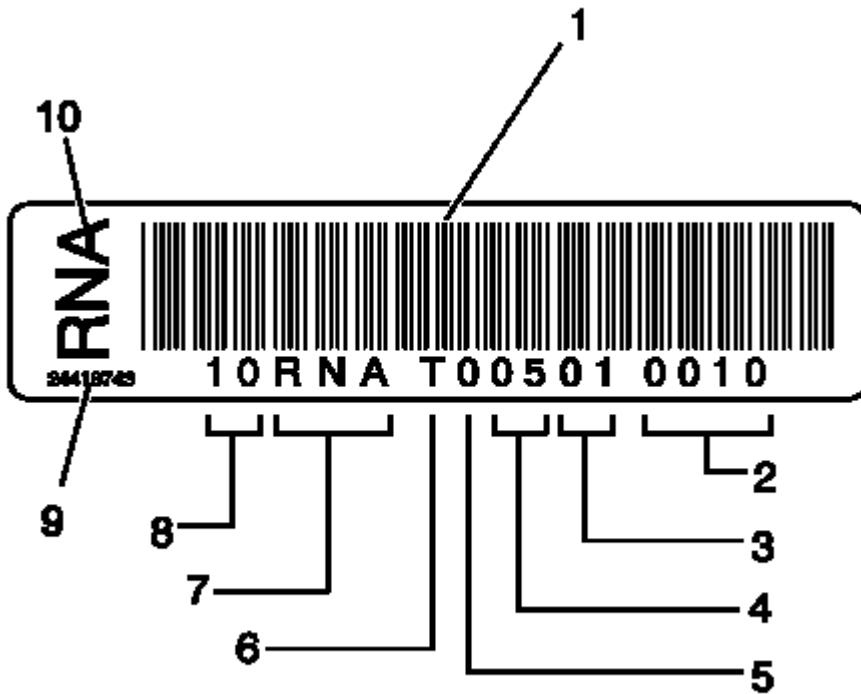
### ENGINE IDENTIFICATION (LEA)



**Fig. 23: Engine Identification (LAF)**

Courtesy of GENERAL MOTORS COMPANY

Identification can be made through the use of the Broadcast Code label on the engine (1) and the use of the partial VIN etched in one of two places - the primary location is on the starter motor flange (2). The secondary location is the oil filter bowl.



**Fig. 24: View Of Broadcast Code Label**  
Courtesy of GENERAL MOTORS COMPANY

- Barcode (1)
- Sequence Number (2)
- Day (3)
- Month (4)
- Year (5)
- Engine Assembly Plant (6)
- Broadcast Code (7)
- Part Designation (8)
- Engine Assembly Number (9)
- Broadcast Code (10)

The partial VIN identifies the specific vehicle by sequence number.

## DIAGNOSTIC INFORMATION AND PROCEDURES

### SYMPTOMS - ENGINE MECHANICAL

**Strategy Based Diagnostics**

1. Perform the **Diagnostic System Check - Vehicle** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, , **Engine Component Description (LEA)**, , and **Lubrication Description**.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary.

**Visual/Physical Inspection**

- Inspect for aftermarket devices which could affect the operation of the engine.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

**Intermittent**

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

**Symptom List**

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Engine Compression Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**

- Oil Leak Diagnosis
- Drive Belt Chirping, Squeal, and Whine Diagnosis
- Drive Belt Rumbling and Vibration Diagnosis
- Drive Belt Falls Off and Excessive Wear Diagnosis
- Drive Belt Tensioner Diagnosis

## BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

### Base Engine Misfire without Internal Engine Noises

| Cause                                                                                                                                                                                                                                                                              | Correction                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt<br>Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition. | Replace the drive belt.                                                                 |
| Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC.<br>A misfire code may be present without an actual misfire condition.                                                                                               | Inspect the components, and repair or replace as required.                              |
| A loose or improperly installed engine flywheel or crankshaft balancer<br>A misfire code may be present without an actual misfire condition.                                                                                                                                       | Repair or replace the flywheel and/or balancer as required.                             |
| Restricted exhaust system<br>A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.                       | Repair or replace as required.                                                          |
| Improperly installed or damaged vacuum hoses                                                                                                                                                                                                                                       | Repair or replace as required.                                                          |
| Improper sealing between the intake manifold and cylinder heads or throttle body.                                                                                                                                                                                                  | Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required. |
| Improperly installed or damaged MAP sensor<br>The sealing grommet of the MAP sensor should not be torn or damaged.                                                                                                                                                                 | Repair or replace the MAP sensor as required.                                           |
| Damage to the MAP sensor housing                                                                                                                                                                                                                                                   | Replace the intake manifold.                                                            |
| Worn or loose rocker arms<br>The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.                                                                                                                                                   | Replace the valve rocker arms as required.                                              |
| Stuck valves<br>Carbon buildup on the valve stem can cause the valve not to close properly.                                                                                                                                                                                        | Repair or replace as required.                                                          |
| Excessively worn or mis-aligned timing chain                                                                                                                                                                                                                                       | Replace the timing chain and sprockets as required.                                     |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn camshaft lobes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Replace the camshaft and valve lash adjusters.                                                                                                                                                                                                                                                                                           |
| Excessive oil pressure<br>A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li> <li>• Repair or replace the oil pump as required.</li> </ul>                                                                                                                                      |
| Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages<br>Coolant consumption may or may not cause the engine to overheat.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <ul style="list-style-type: none"> <li>• Inspect for spark plugs saturated by coolant.</li> <li>• Inspect the cylinder heads, engine block, and/or head gaskets.</li> <li>• Repair or replace as required.</li> </ul>                                                                                                                    |
| Worn piston rings<br>Oil consumption may or may not cause the engine to misfire.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>• Inspect the spark plugs for oil deposits.</li> <li>• Inspect the cylinders for a loss of compression. Refer to <b><u>Engine Compression Test</u></b>.</li> <li>• Perform cylinder leak down and compression testing to identify the cause.</li> <li>• Repair or replace as required.</li> </ul> |
| A damaged crankshaft reluctor wheel<br>A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. <ul style="list-style-type: none"> <li>• Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.</li> <li>• Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.</li> <li>• Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.</li> </ul> | Replace the sensor and/or crankshaft as required.                                                                                                                                                                                                                                                                                        |

### BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

#### Base Engine Misfire with Abnormal Internal Lower Engine Noises

| Cause                                                                                                                                    | Correction              |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt<br>Abnormalities in the accessory drive system and/or | Replace the drive belt. |

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|                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| components may cause engine RPM variations, noises similar to a faulty lower engine, and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.                      |                                                                                                                                                                                                                                                                                                                                      |
| Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout<br>A misfire code may be present without an actual misfire condition.                                                          | Inspect the components, repair or replace as required.                                                                                                                                                                                                                                                                               |
| Loose or improperly installed engine flywheel or crankshaft balancer<br>A misfire code may be present without an actual misfire condition.                                                                         | Repair or replace the flywheel and/or balancer as required.                                                                                                                                                                                                                                                                          |
| Worn piston rings<br>Oil consumption may or may not cause the engine to misfire.                                                                                                                                   | <ul style="list-style-type: none"><li>• Inspect the spark plugs for oil deposits.</li><li>• Inspect the cylinders for a loss of compression. Refer to <b><u>Engine Compression Test</u></b>.</li><li>• Perform cylinder leak down and compression testing to determine the cause.</li><li>• Repair or replace as required.</li></ul> |
| Worn crankshaft thrust bearings<br>Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft, and create a DTC without an actual misfire condition. | Replace the crankshaft and bearings as required.                                                                                                                                                                                                                                                                                     |

### BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

#### Base Engine Misfire with Abnormal Valve Train Noise

| Cause                                                                                                                             | Correction                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn or loose rocker arms<br>The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly. | Replace the valve rocker arms as required.                                                                                                                                                                                                                                     |
| Stuck valves<br>Carbon buildup on the valve stem can cause the valve to not close properly.                                       | Repair or replace as required.                                                                                                                                                                                                                                                 |
| Excessively worn or mis-aligned timing chain                                                                                      | Replace the timing chain and sprockets as required.                                                                                                                                                                                                                            |
| Worn camshaft lobes                                                                                                               | Replace the camshaft and valve lash adjusters.                                                                                                                                                                                                                                 |
| Sticking lifters                                                                                                                  | Replace as required.                                                                                                                                                                                                                                                           |
|                                                                                                                                   | <ol style="list-style-type: none"><li>1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li><li>2. Isolate the noise to a specific camshaft</li></ol> |

Malfunctioning camshaft position actuators - improper oil viscosity or contamination.

position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to **Camshaft Position Intake Actuator Replacement**, or **Camshaft Position Exhaust Actuator Replacement**.

## BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

### Base Engine Misfire with Coolant Consumption

| Cause                                                                                                                                                                                           | Correction                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Faulty cylinder head gasket and/or cracking, or other damage to the cylinder head and engine block cooling system passages.<br>Coolant consumption may or may not cause the engine to overheat. | <ul style="list-style-type: none"> <li>Inspect for spark plugs saturated by coolant.</li> <li>Perform a cylinder leak down test.</li> <li>Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket.</li> <li>Repair or replace as required.</li> </ul> |

## BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

### Base Engine Misfire with Excessive Oil Consumption

| Cause                                                                            | Correction                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn valves, valve guides and/or valve stem oil seals                            | <ul style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits.</li> <li>Repair or replace as required.</li> </ul>                                                                                                                                                                                               |
| Worn piston rings<br>Oil consumption may or may not cause the engine to misfire. | <ul style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits.</li> <li>Inspect the cylinders for a loss of compression. Refer to <b><u>Engine Compression Test</u></b>.</li> <li>Perform cylinder leak down and compression testing to determine the cause.</li> <li>Repair or replace as required.</li> </ul> |

## ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

### Engine Noise on Start-Up, but Only Lasting a Few Seconds

| Cause                                               | Correction                                                                                                   |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Incorrect oil filter without anti-drainback feature | Install the correct oil filter.                                                                              |
| Incorrect oil viscosity                             | <ol style="list-style-type: none"> <li>Drain the oil.</li> <li>Install the correct viscosity oil.</li> </ol> |
| High valve lash adjuster leak down rate             | Replace the lash adjusters as required.                                                                      |

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|                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn crankshaft thrust bearing                                                        | <ol style="list-style-type: none"><li>1. Inspect the thrust bearing and crankshaft.</li><li>2. Repair or replace as required.</li></ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Damaged or faulty oil filter by-pass valve                                            | <ol style="list-style-type: none"><li>1. Inspect the oil filter by-pass valve for proper operation.</li><li>2. Repair or replace as required.</li></ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Malfunctioning camshaft position actuators - improper oil viscosity or contamination. | <ol style="list-style-type: none"><li>1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li><li>2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to <b><u>Camshaft Position Intake Actuator Replacement</u></b>, or <b><u>Camshaft Position Exhaust Actuator Replacement</u></b>.</li></ol> |

**UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED****Upper Engine Noise, Regardless of Engine Speed**

| Cause                                                          | Correction                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low oil pressure                                               | <ul style="list-style-type: none"><li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li><li>• Repair or replace as required.</li></ul>                                                                                                          |
| Loose and/or worn valve rocker arm attachments                 | <ul style="list-style-type: none"><li>• Inspect the valve rocker arm stud, nut or bolt.</li><li>• Repair or replace as required.</li></ul>                                                                                                                                                   |
| Worn valve rocker arm                                          | Replace the valve rocker arm.                                                                                                                                                                                                                                                                |
| Improper lubrication to the valve rocker arms                  | Inspect the following components, and repair or replace as required: <ul style="list-style-type: none"><li>• The valve rocker arm</li><li>• The valve lifter</li><li>• The oil filter bypass valve</li><li>• The oil pump and pump screen</li><li>• The engine block oil galleries</li></ul> |
| Broken valve spring                                            | Replace the valve spring.                                                                                                                                                                                                                                                                    |
| Worn or dirty valve lash adjusters                             | Replace the valve lash adjusters.                                                                                                                                                                                                                                                            |
| Stretched or broken timing chain and/or damaged sprocket teeth | Replace the timing chain and sprockets.                                                                                                                                                                                                                                                      |
| Worn, damaged, or faulty timing chain tensioners               | Replace tensioners                                                                                                                                                                                                                                                                           |

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|                                                                                          |                                                                                                                                                           |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn engine camshaft lobes                                                               | <ul style="list-style-type: none"><li>• Inspect the engine camshaft lobes.</li><li>• Replace the camshaft and valve lash adjusters as required.</li></ul> |
| Worn valve guides or valve stems                                                         | Inspect the following components, and repair as required: <ul style="list-style-type: none"><li>• The valves</li><li>• The valve guides</li></ul>         |
| Stuck valves<br>Carbon on the valve stem or valve seat may cause the valve to stay open. | Inspect the following components, and repair as required: <ul style="list-style-type: none"><li>• The valves</li><li>• The valve guides</li></ul>         |

**LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED****Lower Engine Noise, Regardless of Engine Speed**

| <b>Cause</b>                                                                                                                                                                 | <b>Correction</b>                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low oil pressure                                                                                                                                                             | <ul style="list-style-type: none"><li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li><li>• Repair or replace damaged components as required.</li></ul> |
| Worn accessory drive components - abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components       | <ol style="list-style-type: none"><li>1. Inspect the accessory drive system.</li><li>2. Repair or replace as required.</li></ol>                                                                       |
| Loose or damaged crankshaft balancer                                                                                                                                         | <ol style="list-style-type: none"><li>1. Inspect the crankshaft balancer.</li><li>2. Repair or replace as required.</li></ol>                                                                          |
| Detonation or spark knock                                                                                                                                                    | Verify the correct operation of the ignition system. Refer to <b><u>Symptoms - Engine Controls</u></b> .                                                                                               |
| Loose torque converter bolts                                                                                                                                                 | <ol style="list-style-type: none"><li>1. Inspect the torque converter bolts and flywheel.</li><li>2. Repair or replace as required.</li></ol>                                                          |
| Loose or damaged flywheel                                                                                                                                                    | Repair or replace the flywheel.                                                                                                                                                                        |
| Damaged oil pan, contacting the oil pump screen - an oil pan that has been damaged, may improperly position the oil pump screen, preventing proper oil flow to the oil pump. | <ol style="list-style-type: none"><li>1. Inspect the oil pan.</li><li>2. Inspect the oil pump screen.</li><li>3. Repair or replace as required.</li></ol>                                              |
| Oil pump screen loose, damaged or restricted                                                                                                                                 | <ol style="list-style-type: none"><li>1. Inspect the oil pump screen.</li><li>2. Repair or replace as required.</li></ol>                                                                              |
| Excessive piston-to-cylinder bore clearance                                                                                                                                  | <ol style="list-style-type: none"><li>1. Inspect the piston and cylinder bore.</li><li>2. Repair as required.</li></ol>                                                                                |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Excessive piston pin-to-bore clearance                                                                                                                                                                                                   | <ol style="list-style-type: none"><li>1. Inspect the piston, piston pin, and the connecting rod.</li><li>2. Repair or replace as required.</li></ol>                                                                             |
| Excessive connecting rod bearing clearance                                                                                                                                                                                               | Inspect the following components, and repair as required: <ul style="list-style-type: none"><li>• The connecting rod bearings</li><li>• The connecting rods</li><li>• The crankshaft</li><li>• The crankshaft journals</li></ul> |
| Excessive crankshaft bearing clearance                                                                                                                                                                                                   | Inspect the following components, and repair as required: <ul style="list-style-type: none"><li>• The crankshaft bearings</li><li>• The crankshaft journals</li></ul>                                                            |
| Incorrect piston, piston pin, and connecting rod installation - pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore. | <ol style="list-style-type: none"><li>1. Verify the pistons, piston pins and connecting rods are installed correctly.</li><li>2. Repair as required.</li></ol>                                                                   |

**ENGINE NOISE UNDER LOAD****Engine Noise Under Load**

| <b>Cause</b>                               | <b>Correction</b>                                                                                                                                                                              |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low oil pressure                           | <ol style="list-style-type: none"><li>1. Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li><li>2. Repair or replace as required.</li></ol>          |
| Detonation or spark knock                  | Verify the correct operation of the ignition. Refer to <b><u>Symptoms - Engine Controls</u></b> .                                                                                              |
| Loose torque converter bolts               | <ol style="list-style-type: none"><li>1. Inspect the torque converter bolts and flywheel.</li><li>2. Repair as required.</li></ol>                                                             |
| Cracked flywheel, automatic transmission   | <ol style="list-style-type: none"><li>1. Inspect the flywheel bolts and flywheel.</li><li>2. Repair as required.</li></ol>                                                                     |
| Excessive connecting rod bearing clearance | Inspect the following components, and repair as required: <ul style="list-style-type: none"><li>• The connecting rod bearings</li><li>• The connecting rods</li><li>• The crankshaft</li></ul> |
| Excessive crankshaft bearing clearance     | Inspect the following components, and repair as                                                                                                                                                |

|                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                       | required: <ul style="list-style-type: none"> <li>• The crankshaft bearings</li> <li>• The crankshaft journals</li> <li>• The cylinder block crankshaft bearing bore</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Malfunctioning camshaft position actuators - improper oil viscosity or contamination. | <ol style="list-style-type: none"> <li>1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b>.</li> <li>2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to <b><u>Camshaft Position Intake Actuator Replacement</u></b>, or <b><u>Camshaft Position Exhaust Actuator Replacement</u></b>.</li> </ol> |

**ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE****Engine Will Not Crank - Crankshaft Will Not Rotate**

| Cause                                                                                                                                                                   | Correction                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Seized accessory drive system component                                                                                                                                 | <ol style="list-style-type: none"> <li>1. Remove accessory drive belts.</li> <li>2. Rotate crankshaft by hand at the balancer or flywheel location.</li> </ol>                                                                                                                                           |
| Hydraulically locked cylinder <ul style="list-style-type: none"> <li>• Coolant/antifreeze in cylinder</li> <li>• Oil in cylinder</li> <li>• Fuel in cylinder</li> </ul> | <ol style="list-style-type: none"> <li>1. Remove spark plugs and check for fluid.</li> <li>2. Inspect for broken head gasket.</li> <li>3. Inspect for cracked engine block or cylinder head.</li> <li>4. Inspect for a sticking fuel injector.</li> <li>5. Inspect for cracked cylinder wall.</li> </ol> |
| Seized automatic transmission torque converter                                                                                                                          | <ol style="list-style-type: none"> <li>1. Remove the torque converter bolts.</li> <li>2. Rotate crankshaft by hand at the balancer or flywheel location.</li> </ol>                                                                                                                                      |
| Seized manual transmission                                                                                                                                              | <ol style="list-style-type: none"> <li>1. Disengage the clutch.</li> <li>2. Rotate crankshaft by hand at the balancer or flywheel location.</li> </ol>                                                                                                                                                   |
| Broken timing chain and/or gears                                                                                                                                        | <ol style="list-style-type: none"> <li>1. Inspect timing chain and gears.</li> <li>2. Repair as required.</li> </ol>                                                                                                                                                                                     |
| Seized balance shaft                                                                                                                                                    | <ol style="list-style-type: none"> <li>1. Inspect balance shaft.</li> </ol>                                                                                                                                                                                                                              |

|                                                                                                                                                                               |                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                               | 2. Repair as required.                                                                                                                            |
| Material in cylinder <ul style="list-style-type: none"> <li>• Broken valve</li> <li>• Piston material</li> <li>• Foreign material</li> <li>• Cracked cylinder wall</li> </ul> | 1. Inspect cylinder for damaged components and/or foreign materials.<br>2. Inspect for fallen cylinder wall.<br>3. Repair or replace as required. |
| Seized crankshaft or connecting rod bearings                                                                                                                                  | 1. Inspect crankshaft and connecting rod bearings.<br>2. Inspect for fallen cylinder wall.<br>3. Repair as required.                              |
| Bent or broken connecting rod                                                                                                                                                 | 1. Inspect connecting rods.<br>2. Repair as required.                                                                                             |
| Broken crankshaft                                                                                                                                                             | 1. Inspect crankshaft.<br>2. Repair as required.                                                                                                  |

## COOLANT IN COMBUSTION CHAMBER

### Coolant in Combustion Chamber

| Cause                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Correction                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage.</p> <ol style="list-style-type: none"> <li>1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to <b><u>Engine Will Not Crank - Crankshaft Will Not Rotate</u></b>.</li> <li>2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore.</li> <li>3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component.</li> <li>4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to <b><u>Engine Compression Test</u></b>.</li> </ol> |                                                                                                                                                                        |
| Faulty cylinder head gasket                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Replace the head gasket and components as required. Refer to <b><u>Cylinder Head Cleaning and Inspection (LEA)</u></b> , and <b><u>Cylinder Head Replacement</u></b> . |
| Warped cylinder head                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Replace the cylinder head and gasket. Refer to <b><u>Cylinder Head Cleaning and Inspection (LEA)</u></b> .                                                             |
| Cracked cylinder head                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Replace the cylinder head and gasket.                                                                                                                                  |
| Cracked cylinder liner                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Replace the components as required.                                                                                                                                    |
| Cylinder head or block porosity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Replace the components as required.                                                                                                                                    |

## COOLANT IN ENGINE OIL

### Coolant in Engine Oil

| Cause                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Correction                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed.</p> <ol style="list-style-type: none"> <li>1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to <b><u>Lower Engine Noise, Regardless of Engine Speed.</u></b></li> <li>2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component.</li> <li>3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to <b><u>Engine Compression Test.</u></b></li> </ol> |                                                                                                                                                                       |
| Faulty cylinder head gasket                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Replace the head gasket and components as required. Refer to <b><u>Cylinder Head Cleaning and Inspection (LEA)</u></b> , and <b><u>Cylinder Head Replacement.</u></b> |
| Warped cylinder head                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Replace the cylinder head and gasket. Refer to <b><u>Cylinder Head Cleaning and Inspection (LEA).</u></b>                                                             |
| Cracked cylinder head                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Replace the cylinder head and gasket.                                                                                                                                 |
| Cracked cylinder liner                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Replace the components as required.                                                                                                                                   |
| Cylinder head or block porosity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Replace the components as required.                                                                                                                                   |

## ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gauge at zero and crank the engine through 4 compression strokes, 4 puffs.
8. Measure the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Measure the compression again and record the reading.
10. The minimum compression in any 1 cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ( $1\ 035 \times 70\% = 725$ ) ( $150 \times 70\% = 105$ ).

- Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
- Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
- Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
- If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

## CYLINDER LEAKAGE TEST

### Special Tools

**EN 35667-A** Cylinder Head Leakdown Tester

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

**NOTE:**      **A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High leakage may indicate one or more of the following:**

- Worn or burnt valves
- Broken valve springs
- Stuck valve lash adjusters
- Incorrect valve lash/adjustment
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

**WARNING:** Unless directed otherwise, the ignition and start switch must be in the OFF or LOCK position, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

**For Vehicles equipped with OnStar® (UE1) with Back Up Battery:**

**The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power**

disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power (RAP) should be allowed to time out or be disabled (simply opening the driver door should disable RAP) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with RAP activated may cause activation of the OnStar® Back-Up Battery (BUB) system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The BUB is not rechargeable and once activated the BUB must be replaced.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to [Spark Plug Replacement](#).
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install the **EN 35667-A** tester or equivalent.

**NOTE:** It may be necessary to hold the crankshaft balancer bolt to prevent the engine from rotating.

5. Apply shop air pressure to the **EN 35667-A** tester and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
  - Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
  - Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
  - Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
  - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

## OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 0.9 L (1 qt) or greater of engine oil within 3 200 kilometers (2,000 miles). The causes of excessive oil consumption include the following conditions:

- External oil leaks

Tighten bolts and/or replace gaskets and oil seals as necessary.

- Incorrect oil level or improper reading of oil level indicator

With the vehicle on a level surface, allow adequate drain down time and inspect for the correct oil level.

- Improper oil viscosity

Use recommended SAE viscosity for the prevailing temperatures.

- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, or the seal omitted

Ream guides and install oversize service valves and/or new valve stem oil seals.

- Piston rings broken, improperly installed, worn, or not seated properly

Allow adequate time for rings to seat. Replace broken or worn rings, as necessary.

- Piston improperly installed or mis-fitted

## **OIL PRESSURE DIAGNOSIS AND TESTING**

### **Special Tools**

- **CH-48027** Digital Pressure Gauge
- **EN-21867-850** Oil Pressure Gauge Adapter

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

1. With the vehicle on a level surface, allow adequate drain down time of 2-3 minutes and measure for a low oil level.

Add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.

2. Run the engine, and verify low, or no oil pressure on the vehicle gauge or light.

Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
  - Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
  - Oil diluted by moisture or unburned fuel mixtures
  - Improper oil viscosity for the expected temperature
  - Incorrect or malfunctioning oil pressure sender
  - Incorrect or malfunctioning oil pressure gauge

- Plugged oil filter
  - Malfunctioning oil bypass valve
4. Remove the oil pressure sender or another engine block oil gallery plug.
  5. Install **EN-21867-850** adapter and **CH-48027** gauge and measure the engine oil pressure.
  6. Compare the readings to specifications. Refer to **Engine Mechanical Specifications (LEA)**.
  7. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
    - Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
    - Oil pump worn or dirty

Refer to **Oil Pump Disassemble**.

- Oil pump-to-engine front cover bolts loose

Refer to **Engine Front Cover and Oil Pump Installation**.

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Malfunctioning oil pump pressure regulator valve
- Excessive bearing clearance

Refer to **Crankshaft and Bearing Cleaning and Inspection**.

- Cracked, porous or restricted oil galleries
- Oil gallery plugs missing or incorrectly installed

Refer to **Engine Block Assemble**.

- Broken lash adjusters

## OIL LEAK DIAGNOSIS

### Oil Leak Diagnosis

| Step                                                                                                                                                                                                                                                                               | Action                                                                                                                                                                                                                                                                                                                                                    | Yes | No |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----|
| DEFINITION: You can repair most fluid leaks by first, visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself. |                                                                                                                                                                                                                                                                                                                                                           |     |    |
| 1                                                                                                                                                                                                                                                                                  | <ol style="list-style-type: none"> <li>1. Operate the vehicle until it reaches normal operating temperature. Refer to <b><u>Engine Mechanical Specifications (LEA)</u></b>.</li> <li>2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface.</li> <li>3. Wait 15 minutes.</li> <li>4. Check for drippings.</li> </ol> |     |    |

## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                      |                     |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------|
|   | Are drippings present?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Go to <b>Step 2</b>  | System OK           |
| 2 | Can you identify the type of fluid and the approximate location of the leak?                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Go to <b>Step 10</b> | Go to <b>Step 3</b> |
| 3 | <ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                               | Go to <b>Step 10</b> | Go to <b>Step 4</b> |
| 4 | <ol style="list-style-type: none"> <li>1. Completely clean the entire engine and surrounding components.</li> <li>2. Operate the vehicle for several miles at normal operating temperature and at varying speeds.</li> <li>3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface.</li> <li>4. Wait 15 minutes.</li> <li>5. Identify the type of fluid, and the approximate location of the leak.</li> </ol> <p>Can you identify the type of fluid and the approximate location of the leak?</p> | Go to <b>Step 10</b> | Go to <b>Step 5</b> |
| 5 | <ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                               | Go to <b>Step 10</b> | Go to <b>Step 6</b> |
| 6 | <ol style="list-style-type: none"> <li>1. Completely clean the entire engine and surrounding components.</li> <li>2. Apply an aerosol-type powder, for example, baby powder or foot powder, to the suspected area.</li> <li>3. Operate the vehicle for several miles at normal operating temperature and at varying speeds.</li> <li>4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the</li> </ol>                                                                              |                      |                     |

## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                      |                     |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------|
|    | <p>powder surface.</p> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Go to <b>Step 10</b> | Go to <b>Step 7</b> |
| 7  | <ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                                                                                                                                                  | Go to <b>Step 10</b> | Go to <b>Step 8</b> |
| 8  | <p>Use <b>EN 28428-E</b> Dye and Light Kit , in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool.</p> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                                                                                                                                                                                                                                                                                                    | Go to <b>Step 10</b> | Go to <b>Step 9</b> |
| 9  | <ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> <p>Can you identify the type of fluid and the approximate location of the leak?</p>                                                                                                                                                                                                                  | Go to <b>Step 10</b> | System OK           |
| 10 | <ol style="list-style-type: none"> <li>1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: <ul style="list-style-type: none"> <li>• Higher than recommended fluid levels</li> <li>• Higher than recommended fluid pressures</li> <li>• Plugged or malfunctioning fluid filters or pressure bypass valves</li> <li>• Plugged or malfunctioning engine ventilation system</li> <li>• Improperly tightened or damaged fasteners</li> <li>• Cracked or porous components</li> <li>• Improper sealants or gaskets where required</li> <li>• Improper sealant or gasket installation</li> </ul> </li> </ol> |                      |                     |

|    |                                                                                                                                                                                                                                                                       |                      |           |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------|
|    | <ul style="list-style-type: none"> <li>• Damaged or worn gaskets or seals</li> <li>• Damaged or worn sealing surfaces</li> </ul> <p>2. Inspect the engine for customer modifications.</p> <p>Is there mechanical damage, or customer modifications to the engine?</p> | Go to <b>Step 11</b> | System OK |
| 11 | <p>Repair or replace all damaged or modified components.</p> <p>Did you complete the repair?</p>                                                                                                                                                                      | Go to <b>Step 1</b>  | -         |

## CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS (WITHOUT TURBOCHARGER)

### Special Tools

#### EN 23951 Valve Manometer

1. Remove the oil level indicator. Install a **EN 23951** valve manometer or equivalent.
2. Start the engine.
3. Check for slight vacuum. The vacuum level should be less than 3.377 kPa (1 in Hg).
4. If vacuum is higher, inspect and verify that the clean air hose from cam cover to air intake is not blocked or kinked.
5. If vacuum is in the normal range, block or pinch off the clean air hose. The clean air hose is the hose between the cam cover and air intake system. Vacuum should increase on the manometer. If held too long, vacuum will be drawn through the crankshaft seals creating a sucking sound.
6. If vacuum does not increase, the orifice in the intake manifold could be plugged.
7. If there is zero vacuum or pressure, verify compression of the engine.
8. If compression is normal, check for a blocked orifice at the intake manifold. Clean the orifice.

## DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

### Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

### Test Description

The numbers below refer to the step numbers on the diagnostic table.

**2**

The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.

**3**

The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

**4**

Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.

**6**

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

**10**

Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.

**12**

Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

**14**

This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.

**15**

This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from

working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

16

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

17

This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

19

Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

**Drive Belt Chirping, Squeal, and Whine Diagnosis**

| Step                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Action                                                                                 | Yes                 | No                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------|--------------------------------------------------|
| <b>CAUTION:</b><br><b>Refer to <u>Belt Dressing Caution</u> .</b>                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                        |                     |                                                  |
| <b>DEFINITION:</b> The following items are indications of chirping: <ul style="list-style-type: none"> <li>• A high pitched noise that is heard once per revolution of the drive belt or a pulley.</li> <li>• Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp.</li> </ul>                                                                                                                                               |                                                                                        |                     |                                                  |
| <b>DEFINITION:</b> The following items are indications of drive belt squeal: <ul style="list-style-type: none"> <li>• A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs.</li> <li>• The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.</li> </ul> |                                                                                        |                     |                                                  |
| <b>DEFINITION:</b> The following items are indications of drive belt whine: <ul style="list-style-type: none"> <li>• A high pitched continuous noise.</li> <li>• The noise may be caused by an accessory drive component failed bearing.</li> </ul>                                                                                                                                                                                                                               |                                                                                        |                     |                                                  |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Did you review the Drive Belt Symptom operation and perform the necessary inspections? | Go to <b>Step 2</b> | Go to <b><u>Symptoms - Engine Mechanical</u></b> |

## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

|    |                                                                                                                                                                                                                                                                                                                                                                               |                                           |                       |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-----------------------|
| 2  | Verify that there is a chirping, squeal or whine noise.<br>Does the engine make the chirping squeal or whine noise?                                                                                                                                                                                                                                                           | Go to <b>Step 3</b>                       | Go to Diagnostic Aids |
| 3  | <p>1. Remove the drive belt.</p> <p>If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed.</p> <p>2. Operate the engine for no longer than 30-40 seconds.</p> <p>3. Repeat this test if necessary by removing the remaining belt(s).</p> <p>Does the chirping, squeal or whine noise still exist?</p> | Go to <b>Symptoms - Engine Mechanical</b> | Go to <b>Step 4</b>   |
| 4  | <p>If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth.</p> <p>If diagnosing a squeal or whine noise, proceed to step 13.</p> <p>Do the belt grooves have pilling?</p>                                                                                                                                                          | Go to <b>Step 5</b>                       | Go to <b>Step 6</b>   |
| 5  | Clean the drive belt pulleys with a suitable wire brush.<br>Did you complete the repair?                                                                                                                                                                                                                                                                                      | Go to <b>Step 20</b>                      | Go to <b>Step 6</b>   |
| 6  | Inspect for misalignment of the pulleys.<br>Are any of the pulleys misaligned?                                                                                                                                                                                                                                                                                                | Go to <b>Step 7</b>                       | Go to <b>Step 8</b>   |
| 7  | Replace or repair any misaligned pulleys.<br>Did you complete the repair?                                                                                                                                                                                                                                                                                                     | Go to <b>Step 20</b>                      | Go to <b>Step 8</b>   |
| 8  | Inspect for bent or cracked brackets.<br>Did you find any bent or cracked brackets?                                                                                                                                                                                                                                                                                           | Go to <b>Step 9</b>                       | Go to <b>Step 10</b>  |
| 9  | Replace any bent or cracked brackets.<br>Did you complete the repair?                                                                                                                                                                                                                                                                                                         | Go to <b>Step 20</b>                      | Go to <b>Step 10</b>  |
| 10 | Inspect for improper, loose or missing fasteners.<br>Did you find the condition?                                                                                                                                                                                                                                                                                              | Go to <b>Step 11</b>                      | Go to <b>Step 12</b>  |
| 11 | <p><b>CAUTION:</b><br/><b>Refer to <u>Fastener Caution</u> .</b></p> <p>1. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications (LEA)</u></b>.</p> <p>2. Replace any improper or missing fasteners.</p> <p>Did you complete the repair?</p>                                                                                                         | Go to <b>Step 20</b>                      | Go to <b>Step 12</b>  |
| 12 | Inspect for a bent pulley.<br>Did you find the condition?                                                                                                                                                                                                                                                                                                                     | Go to <b>Step 18</b>                      | Go to <b>Step 19</b>  |
| 13 | Inspect for an accessory drive component seized bearing or a faulty accessory drive component.<br>If diagnosing a whine noise and the condition still                                                                                                                                                                                                                         |                                           |                       |

|           |                                                                                                                                                        |                      |                       |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------|
|           | exist, proceed to Diagnostic Aids.<br>Did you find and correct the condition?                                                                          | Go to <b>Step 20</b> | Go to <b>Step 14</b>  |
| <b>14</b> | Test the drive belt tensioner for proper operation. Refer to <b><u>Drive Belt Tensioner Diagnosis</u></b> .<br>Did you find and correct the condition? | Go to <b>Step 20</b> | Go to <b>Step 15</b>  |
| <b>15</b> | Inspect for the correct drive belt length.<br>Did you find and correct the condition?                                                                  | Go to <b>Step 20</b> | Go to <b>Step 16</b>  |
| <b>16</b> | Inspect for misalignment of a pulley.<br>Did you find and correct the condition?                                                                       | Go to <b>Step 20</b> | Go to <b>Step 17</b>  |
| <b>17</b> | Inspect for the correct pulley size.<br>Did you find and correct the condition?                                                                        | Go to <b>Step 20</b> | Go to Diagnostic Aids |
| <b>18</b> | Replace the bent pulley.<br>Did you complete the repair?                                                                                               | Go to <b>Step 20</b> | Go to <b>Step 19</b>  |
| <b>19</b> | Replace the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you complete the repair?                                                | Go to <b>Step 20</b> | Go to Diagnostic Aids |
| <b>20</b> | Operate the system in order to verify the repair.<br>Did you correct the condition?                                                                    | System OK            | Go to <b>Step 3</b>   |

## DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

### Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

### Test Description

The numbers below refer to the step numbers on the diagnostic table.

**2**

This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.

**3**

This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

4

Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plies of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

5

Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

9

Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.

11

This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.

12

Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

### Drive Belt Rumbling and Vibration Diagnosis

| Step                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Action | Yes | No |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|----|
| <b>CAUTION:</b><br>Refer to <b><u>Belt Dressing Caution</u></b> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |        |     |    |
| <b>DEFINITION:</b> The following items are indications of drive belt rumbling: <ul style="list-style-type: none"> <li>• A low pitch tapping, knocking, or thumping noise heard at or just above idle.</li> <li>• Heard once per revolution of the drive belt or a pulley.</li> <li>• Rumbling may be caused from: <ul style="list-style-type: none"> <li>○ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove</li> <li>○ The separation of the drive belt</li> </ul> </li> </ul> |        |     |    |

- A damaged drive belt

DEFINITION: The following items are indications of drive belt vibration:

- The vibration is engine-speed related.
- The vibration may be sensitive to accessory load.

|   |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                           |                                                  |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| 1 | Did you review the Drive Belt Symptom operation and perform the necessary inspections?                                                                                                                                                                                                                                                                       | Go to <b>Step 2</b>                                                                                       | Go to <b><u>Symptoms - Engine Mechanical</u></b> |
| 2 | Verify that there is a rumbling noise or that the vibration is engine related.<br>Does the engine make the rumbling noise or vibration?                                                                                                                                                                                                                      | Go to <b>Step 3</b>                                                                                       | Go to Diagnostic Aids                            |
| 3 | 1. Remove the drive belt.<br><br>If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed.<br><br>2. Operate the engine for no longer than 30-40 seconds.<br><br>3. Repeat this test if necessary by removing the remaining belt(s).<br><br>Does the rumbling or vibration still exist? | Go to <b><u>Symptoms - Engine Mechanical</u></b><br>or<br>Go to <b><u>Vibration Analysis - Engine</u></b> | Go to <b>Step 4</b>                              |
| 4 | Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up.<br>Did you find any of these conditions?                                                                                                                                                                                                                | Go to <b>Step 7</b>                                                                                       | Go to <b>Step 5</b>                              |
| 5 | Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves.<br>Did you find severe pilling?                                                                                                                                                                                                                                                | Go to <b>Step 6</b>                                                                                       | Go to <b>Step 7</b>                              |
| 6 | 1. Clean the drive belt pulleys using a suitable wire brush.<br><br>2. Reinstall the drive belts. Refer to <b><u>Drive Belt Replacement</u></b> .<br><br>Did you correct the condition?                                                                                                                                                                      | Go to <b>Step 8</b>                                                                                       | Go to <b>Step 7</b>                              |
| 7 | Install a new drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you complete the replacement?                                                                                                                                                                                                                                               | Go to <b>Step 8</b>                                                                                       | Go to <b>Step 9</b>                              |
| 8 | Operate the system in order to verify the repair.<br>Did you correct the condition?                                                                                                                                                                                                                                                                          | System OK                                                                                                 | Go to <b>Step 9</b>                              |
| 9 | Inspect for improper, loose or missing fasteners.<br>Did you find any of these conditions?                                                                                                                                                                                                                                                                   | Go to <b>Step 10</b>                                                                                      | Go to <b>Step 11</b>                             |
|   | 1. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications (LEA)</u></b> .                                                                                                                                                                                                                                                            |                                                                                                           |                                                  |

|    |                                                                                                                                 |                      |                       |
|----|---------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------|
| 10 | 2. Replace improper or missing fasteners.<br>Did you complete the repair?                                                       | Go to <b>Step 13</b> | Go to <b>Step 11</b>  |
| 11 | Inspect for a bent water pump shaft. Refer to <b><u>Water Pump Replacement</u></b> .<br>Did you find and correct the condition? | Go to <b>Step 13</b> | Go to <b>Step 12</b>  |
| 12 | Inspect for bent or cracked brackets.<br>Did you find and correct the condition?                                                | Go to <b>Step 13</b> | Go to Diagnostic Aids |
| 13 | Operate the system in order to verify the repair.<br>Did you correct the condition?                                             | System OK            | Go to <b>Step 3</b>   |

## DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

### Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

### Test Description

The numbers below refer to the step numbers on the diagnostic table.

#### 2

This inspection is to verify the condition of the drive belt. Damage may of occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.

#### 4

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper

installation procedure of that pulley.

5

Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

6

Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

7

Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut , spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

13

The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

14

The installation of a drive belt that is two wide or two narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

15

This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

#### Drive Belt Falls Off and Excessive Wear Diagnosis

| Step                                                                                                                                                                                                        | Action                                                                                                        | Yes                 | No                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|--------------------------------------------------|
| <b>CAUTION:</b><br><b>Refer to <u>Belt Dressing Caution</u> .</b>                                                                                                                                           |                                                                                                               |                     |                                                  |
| <b>DEFINITION:</b> The drive belt falls off the pulleys or may not ride correctly on the pulleys. <b>DEFINITION:</b> Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt. |                                                                                                               |                     |                                                  |
| 1                                                                                                                                                                                                           | Did you review the Drive Belt Symptom operation and perform the necessary inspections?                        | Go to <b>Step 2</b> | Go to <b><u>Symptoms - Engine Mechanical</u></b> |
| 2                                                                                                                                                                                                           | If diagnosing excessive wear, proceed to step 13.<br>If diagnosing a drive belt that falls off, inspect for a |                     |                                                  |

## 2012 Buick Verano

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|    |                                                                                                                                                                                                                                                                     |                      |                       |
|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------|
|    | damaged drive belt.<br>Did you find the condition?                                                                                                                                                                                                                  | Go to <b>Step 3</b>  | Go to <b>Step 4</b>   |
| 3  | Install a new drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Does the drive belt continue to fall off?                                                                                                                                              | Go to <b>Step 4</b>  | System OK             |
| 4  | Inspect for misalignment of the pulleys.<br>Did you find and repair the condition?                                                                                                                                                                                  | Go to <b>Step 12</b> | Go to <b>Step 5</b>   |
| 5  | Inspect for a bent or dented pulley.<br>Did you find and repair the condition?                                                                                                                                                                                      | Go to <b>Step 12</b> | Go to <b>Step 6</b>   |
| 6  | Inspect for a bent or a cracked bracket.<br>Did you find and repair the condition?                                                                                                                                                                                  | Go to <b>Step 12</b> | Go to <b>Step 7</b>   |
| 7  | Inspect for improper, loose or missing fasteners.<br>Did you find loose or missing fasteners?                                                                                                                                                                       | Go to <b>Step 8</b>  | Go to <b>Step 9</b>   |
| 8  | <b>CAUTION:</b><br><b>Refer to <u>Fastener Caution</u> .</b><br><br>1. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications (LEA)</u></b> .<br>2. Replace improper or missing fasteners.<br><br>Does the drive belt continue to fall off? | Go to <b>Step 9</b>  | System OK             |
| 9  | Test the drive belt tensioner for operating correctly.<br>Refer to <b><u>Drive Belt Tensioner Diagnosis</u></b> .<br>Does the drive belt tensioner operate correctly?                                                                                               | Go to <b>Step 11</b> | Go to <b>Step 10</b>  |
| 10 | Replace the drive belt tensioner. Refer to <b><u>Drive Belt Tensioner Replacement</u></b> .<br>Does the drive belt continue to fall off?                                                                                                                            | Go to <b>Step 11</b> | System OK             |
| 11 | Inspect for failed drive belt idler and drive belt tensioner pulley bearings.<br>Did you find and repair the condition?                                                                                                                                             | Go to <b>Step 12</b> | Go to Diagnostic Aids |
| 12 | Operate the system in order to verify the repair.<br>Did you correct the condition?                                                                                                                                                                                 | System OK            | Go to <b>Step 2</b>   |
| 13 | Inspect the drive belt for the proper installation. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you find this condition?                                                                                                                                 | Go to <b>Step 16</b> | Go to <b>Step 14</b>  |
| 14 | Inspect for the proper drive belt.<br>Did you find this condition?                                                                                                                                                                                                  | Go to <b>Step 16</b> | Go to <b>Step 15</b>  |
| 15 | Inspect for the drive belt rubbing against a bracket, hose, or wiring harness.<br>Did you find and repair the condition?                                                                                                                                            | Go to <b>Step 17</b> | Go to Diagnostic Aids |
| 16 | Replace the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you complete the replacement?                                                                                                                                                        | Go to <b>Step 17</b> | -                     |
| 17 | Operate the system in order to verify the repair.<br>Did you correct the condition?                                                                                                                                                                                 | System OK            | -                     |

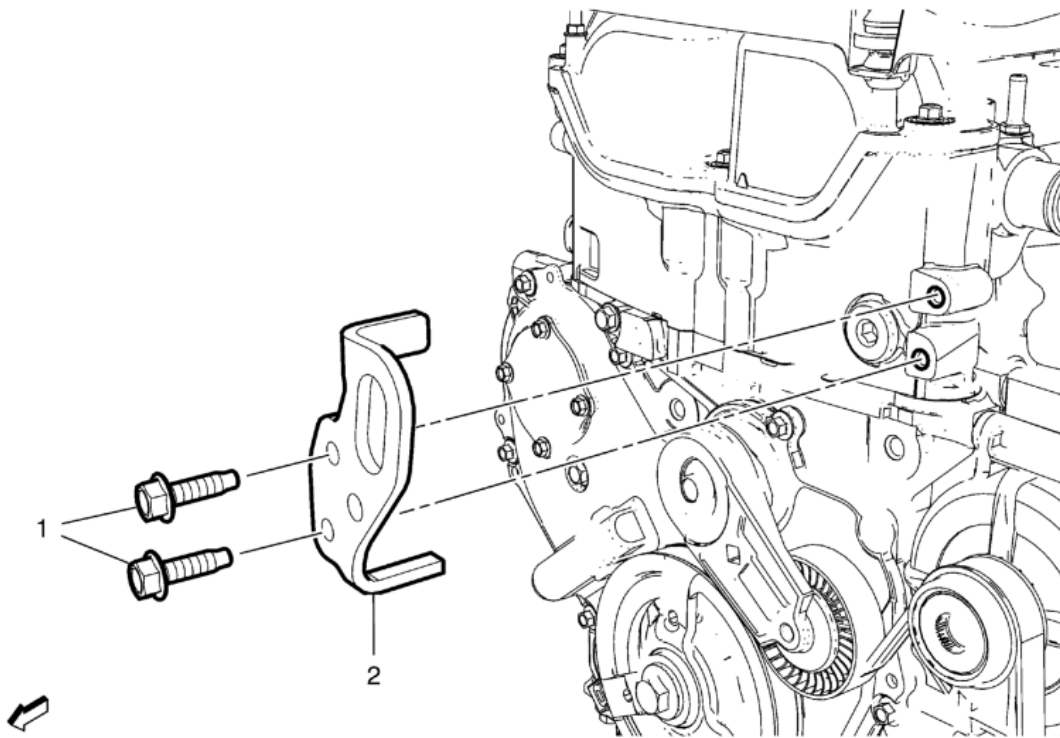
## DRIVE BELT TENSIONER DIAGNOSIS

### Drive Belt Tensioner Diagnosis

| Step | Action                                                                                                                                                                                                                                                                                                                                                                          | Yes                 | No                  |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|
| 1    | Remove the drive belt and inspect the drive belt tensioner pulley.<br>Is the drive belt tensioner pulley loose or misaligned?                                                                                                                                                                                                                                                   | Go to <b>Step 4</b> | Go to <b>Step 2</b> |
| 2    | Rotate the drive belt tensioner.<br>Does the tensioner rotate without any unusual resistance or binding?                                                                                                                                                                                                                                                                        | Go to <b>Step 3</b> | Go to <b>Step 4</b> |
| 3    | <ol style="list-style-type: none"> <li>1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop.</li> <li>2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop.</li> </ol><br>Is the first torque reading within 10 percent of the second torque reading? | System OK           | Go to <b>Step 4</b> |
| 4    | Replace the drive belt tensioner.<br>Is the repair complete?                                                                                                                                                                                                                                                                                                                    | System OK           | -                   |

## REPAIR INSTRUCTIONS - ON VEHICLE

### ENGINE LIFT FRONT BRACKET REPLACEMENT

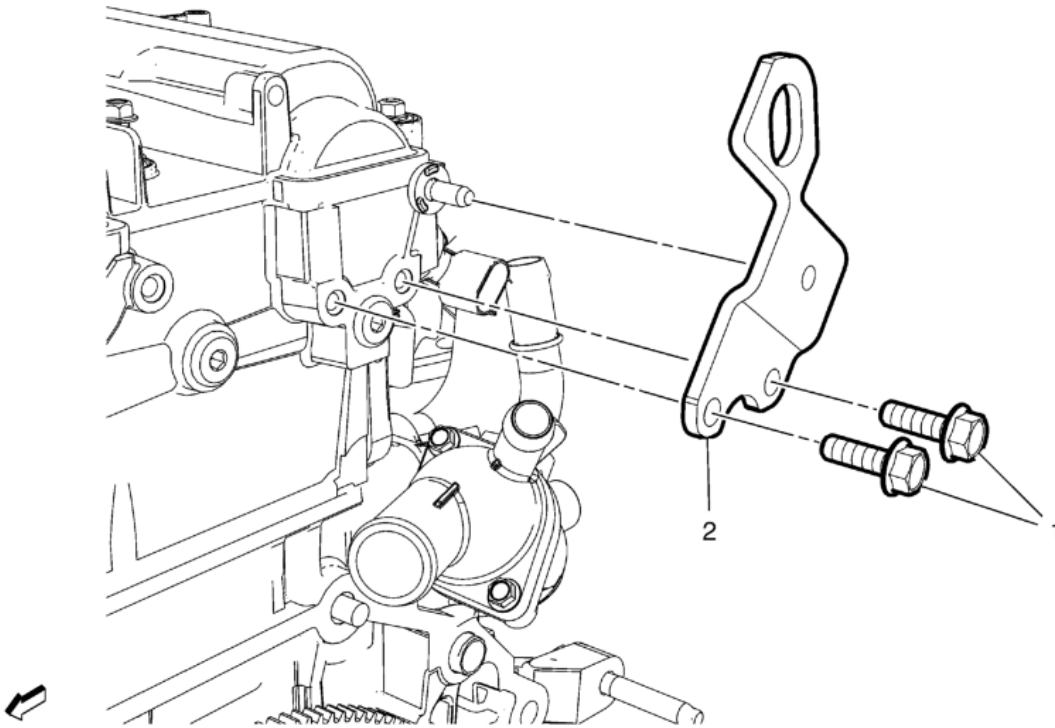


**Fig. 25: Engine Lift Front Bracket & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

### Engine Lift Front Bracket Replacement

| Callout                                                                                                                                                                                            | Component Name                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                                                                                                                                                      |                                                                                                                                                          |
| 1. Remove the air cleaner assembly. Refer to <a href="#">Air Cleaner Assembly Replacement</a> .<br>2. Remove the engine mount bracket. Refer to <a href="#">Engine Mount Bracket Replacement</a> . |                                                                                                                                                          |
| 1                                                                                                                                                                                                  | Engine Lift Bracket Front Bolt (Qty: 2)<br><br><b>CAUTION:</b><br>Refer to <a href="#">Fastener Caution</a> .<br><br><b>Tighten</b><br>25 N.m (18 lb ft) |
| 2                                                                                                                                                                                                  | Engine Lift Bracket - Front                                                                                                                              |

### ENGINE LIFT REAR BRACKET REPLACEMENT



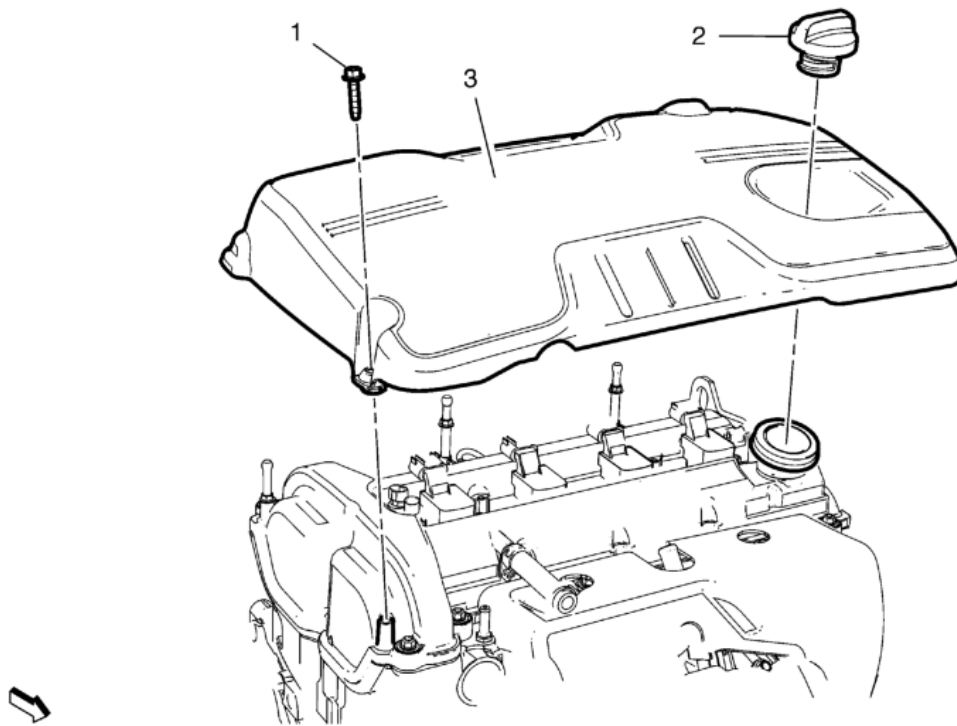
**Fig. 26: Engine Lift Rear Bracket & Bolts**

Courtesy of GENERAL MOTORS COMPANY

### Engine Lift Rear Bracket Replacement

| Callout                                                               | Component Name                                                                                                                                   |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                         |                                                                                                                                                  |
| Unclip the engine wiring harness from the engine lift bracket - rear. |                                                                                                                                                  |
| 1                                                                     | Engine Lift Bracket Bolt (Qty: 2)<br><br><b>CAUTION:</b><br><b>Refer to <u>Fastener Caution</u> .</b><br><br><b>Tighten</b><br>25 N.m (18 lb ft) |
| 2                                                                     | Engine Lift Bracket - Rear                                                                                                                       |

### INTAKE MANIFOLD COVER REPLACEMENT



**Fig. 27: Intake Manifold Cover, Bolt & Engine Oil Filler Cap**  
 Courtesy of GENERAL MOTORS COMPANY

### Intake Manifold Cover Replacement

| Callout | Component Name                                                                                                                    |
|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| 1       | Intake Manifold Cover Bolt<br><br><b>CAUTION:</b><br>Refer to <u>Fastener Caution</u> .<br><br><b>Tighten</b><br>9 N.m (80 lb in) |
| 2       | Engine Oil Filler Cap                                                                                                             |
| 3       | Intake Manifold Cover                                                                                                             |

### DRIVE BELT REPLACEMENT

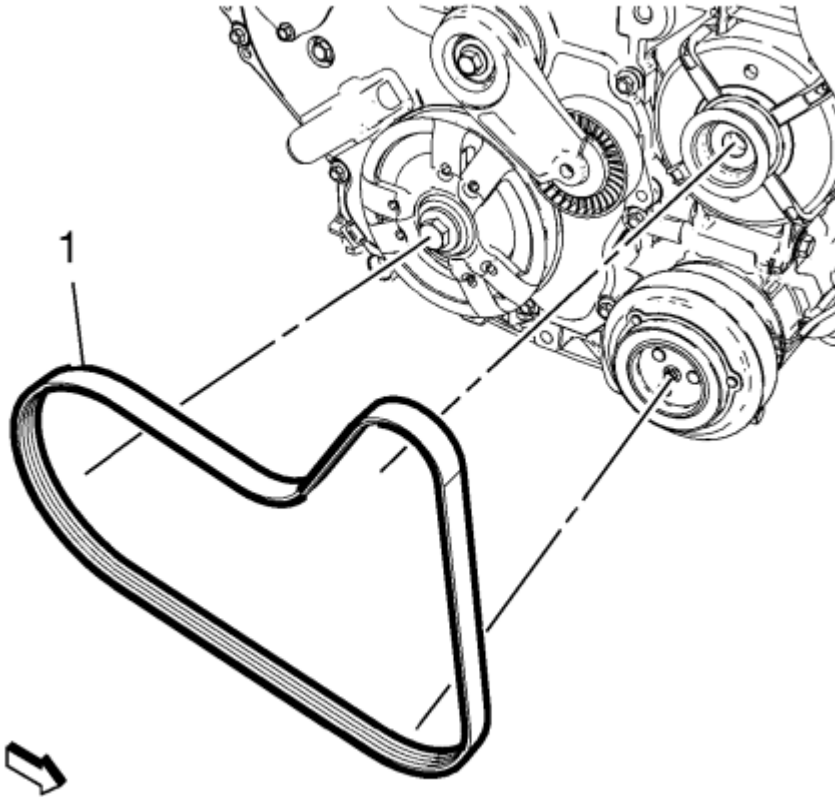
#### Special Tools

**EN-44811** Accessory Belt Tensioner Unloader

For equivalent regional tools, refer to Special Tools.

#### Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)** .
2. Remove the front compartment insulator. Refer to **Front Compartment Insulator Replacement** .
3. Remove the front part of the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
4. Install the **EN-44811** tensioner unloader.
5. Tension the drive belt tensioner counterclockwise and hold tension.

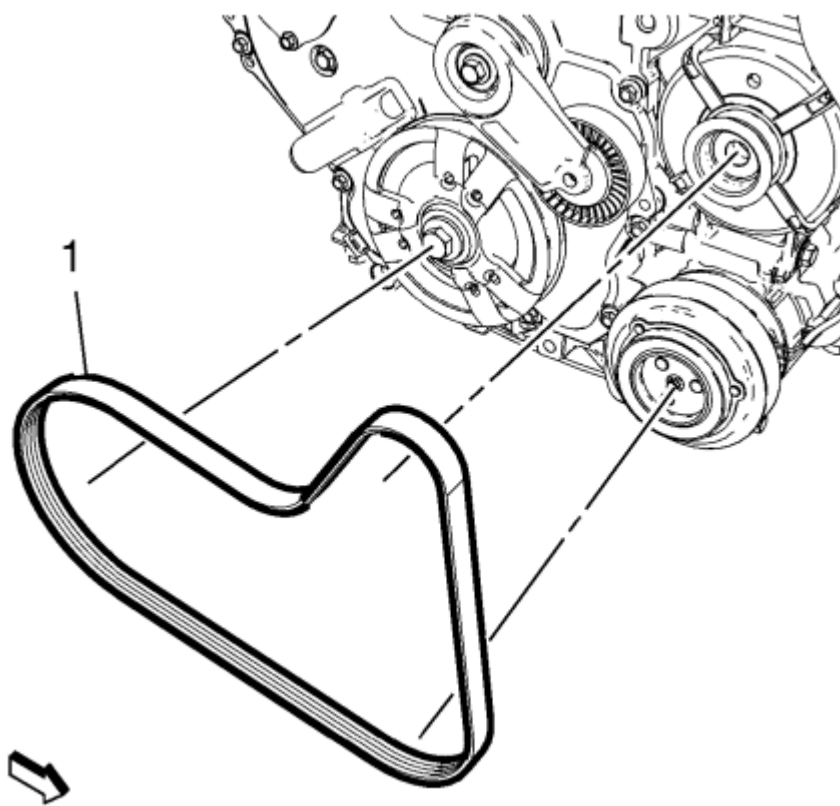


**Fig. 28: Drive Belt Routing**

Courtesy of GENERAL MOTORS COMPANY

6. Remove the drive belt (1).
7. Release tension from the drive belt tensioner and allow the tensioner to slide back slowly.

#### **Installation Procedure**



**Fig. 29: Drive Belt Routing**

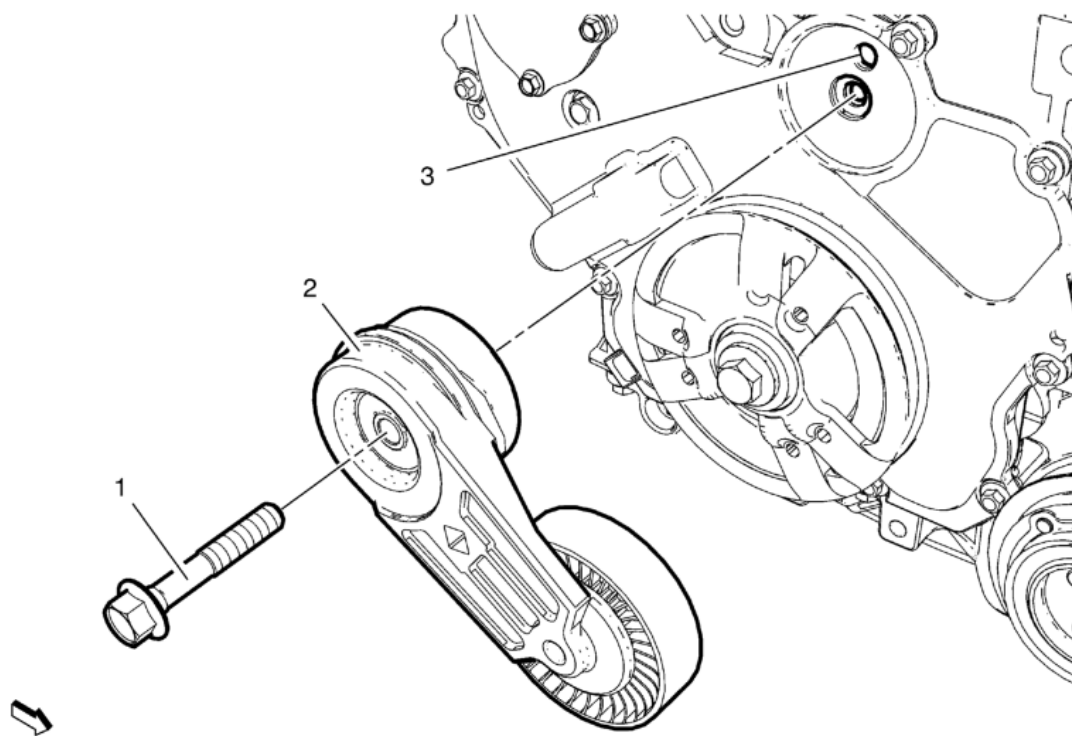
Courtesy of GENERAL MOTORS COMPANY

1. Apply tension to the drive belt tensioner using the **EN-44811** tensioner unloader by rotating counterclockwise and hold tension.
2. Install the drive belt (1).
3. Release tension from the drive belt tensioner and allow the tensioner to slide back slowly.
4. Remove the **EN-44811** tensioner unloader.
5. Inspect the drive belt for proper seat.
6. Install the front part of the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement**.
7. Install the front compartment insulator. Refer to **Front Compartment Insulator Replacement**.
8. Lower the vehicle.

## DRIVE BELT TENSIONER REPLACEMENT

### Removal Procedure

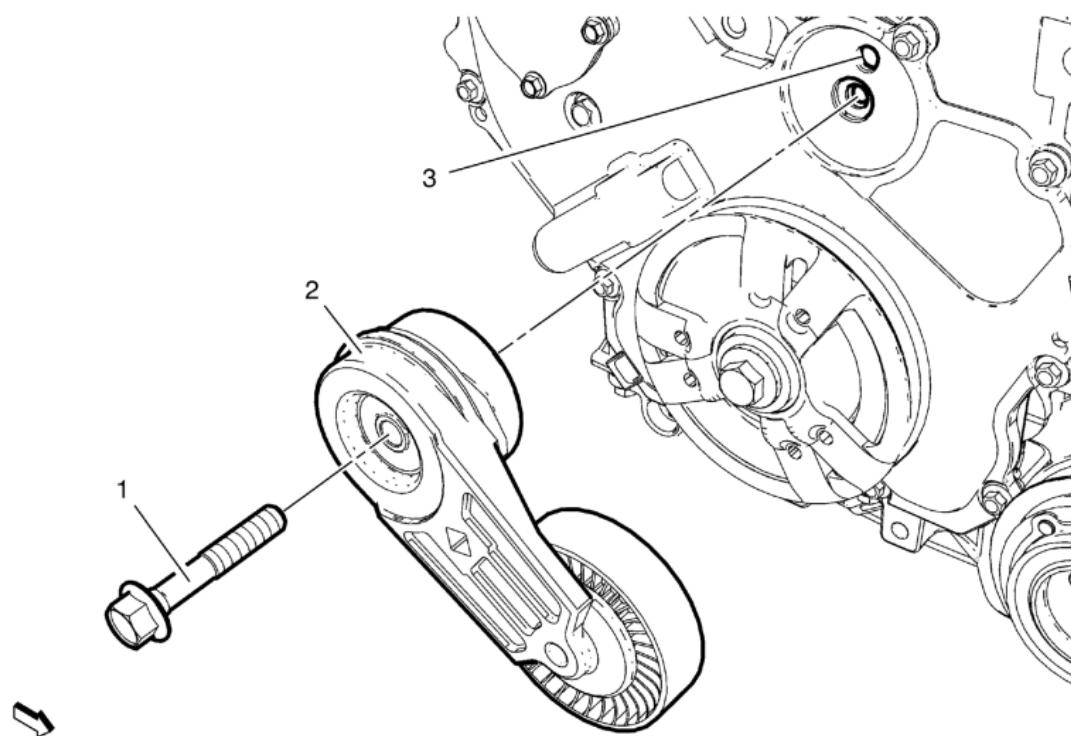
1. Remove the drive belt. Refer to **Drive Belt Replacement**.



**Fig. 30: Drive Belt Tensioner & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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

#### **Installation Procedure**



**Fig. 31: Drive Belt Tensioner & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

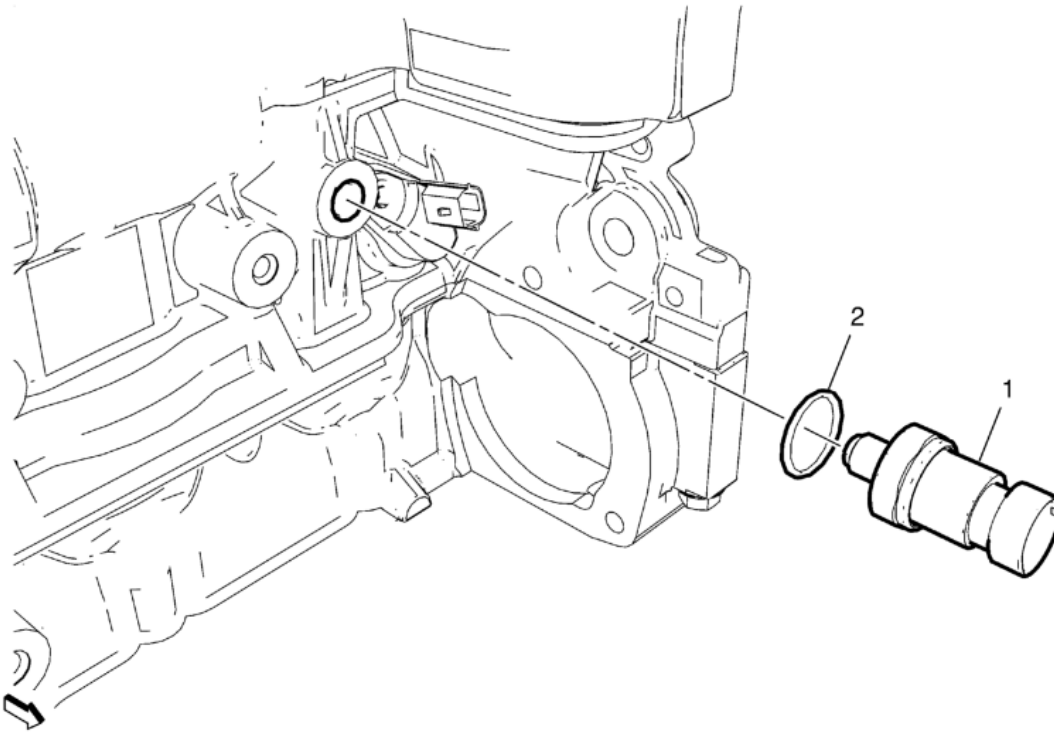
**NOTE:** Ensure that the drive belt tensioner notch fits into the engine front cover hole (3).

1. Install the drive belt tensioner (2).

**CAUTION:** Refer to Fastener Caution .

2. Install the drive belt tensioner bolt (1) and tighten to 45 N.m (33 lb ft).
3. Install the drive belt. Refer to Drive Belt Replacement.

## ENGINE OIL PRESSURE SWITCH REPLACEMENT



**Fig. 32: Engine Oil Pressure Switch & Seal Ring**  
 Courtesy of GENERAL MOTORS COMPANY

### Engine Oil Pressure Switch Replacement

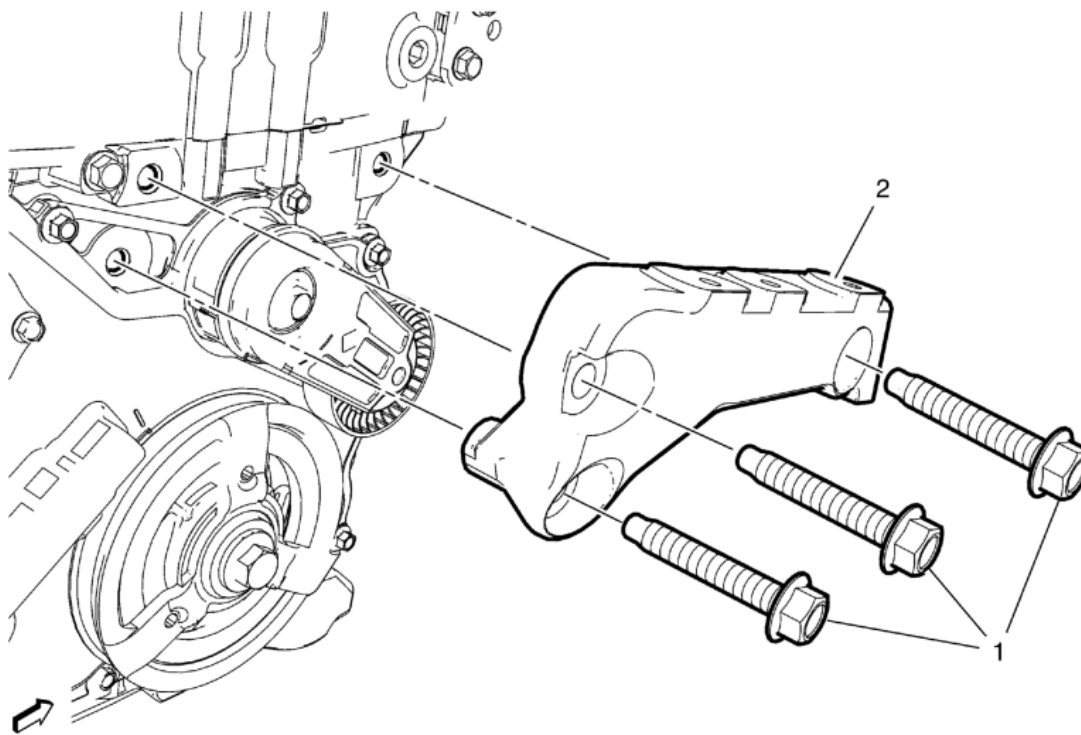
| Callout                                                                                                                                                                                                                         | Component Name                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                          |
| 1. Disconnect the negative battery cable. Refer to <b><u>Battery Negative Cable Disconnection and Connection</u></b> .<br>2. Raise and support the vehicle. Refer to <b><u>Lifting and Jacking the Vehicle (Standard)</u></b> . |                                                                                                                                                                                                                                                                                          |
| 1                                                                                                                                                                                                                               | Engine Oil Pressure Switch<br><br><b>CAUTION:</b><br>Refer to <b><u>Fastener Caution</u></b> .<br><br><b>Tighten</b><br>35 N.m (26 lb ft)<br><b>Special Tools</b><br><b>EN-35749</b> Oil Pressure Sensor Socket<br>For equivalent regional tools, refer to <b><u>Special Tools</u></b> . |
| 2                                                                                                                                                                                                                               | Engine Oil Pressure Switch Seal Ring                                                                                                                                                                                                                                                     |

### 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. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
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



**Fig. 33: Engine Mount Bracket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

### Engine Mount Bracket Replacement

| Callout                       | Component Name                                                                      |
|-------------------------------|-------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b> |                                                                                     |
| 1.                            | Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u> . |

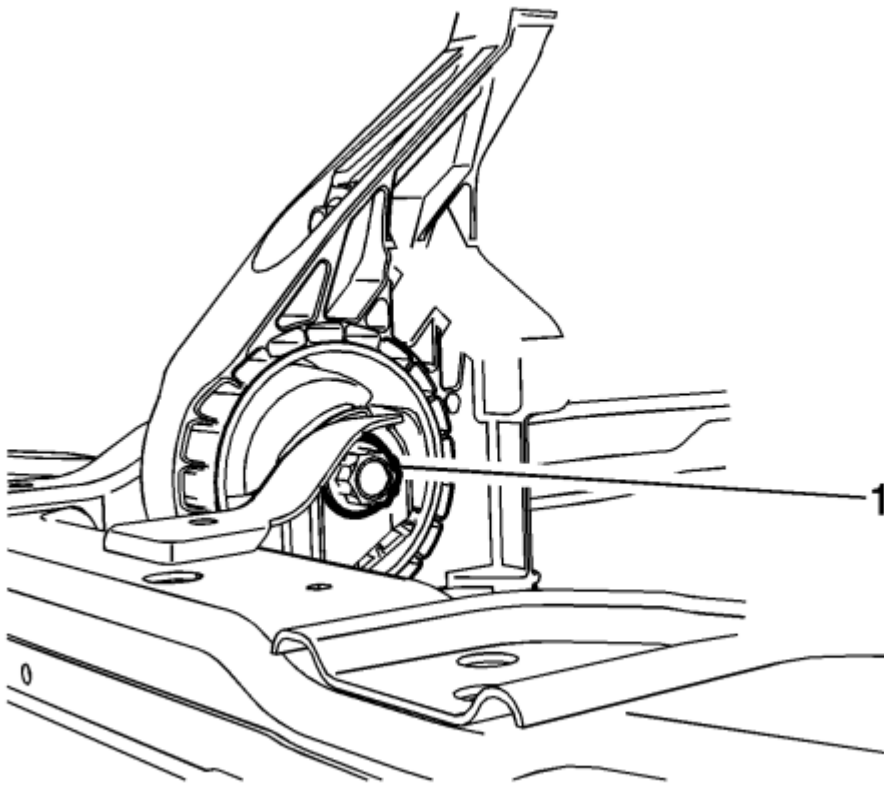
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
3. Support the engine with engine lifter.
4. Remove the engine mount. Refer to **Engine Mount Replacement**.

|   |                                                                                                                                                                                                                                                   |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Engine Mount Bracket Bolt (Qty: 3)<br><br><b>CAUTION:</b><br><b>Refer to <u>Fastener Caution</u> .</b><br><br><b>Procedure</b><br>Raise the engine until mount engine mount bracket bolts are accessible.<br><b>Tighten</b><br>100 N.m (74 lb ft) |
| 2 | Engine Mount Bracket                                                                                                                                                                                                                              |

## POWERTRAIN MOUNT BALANCING

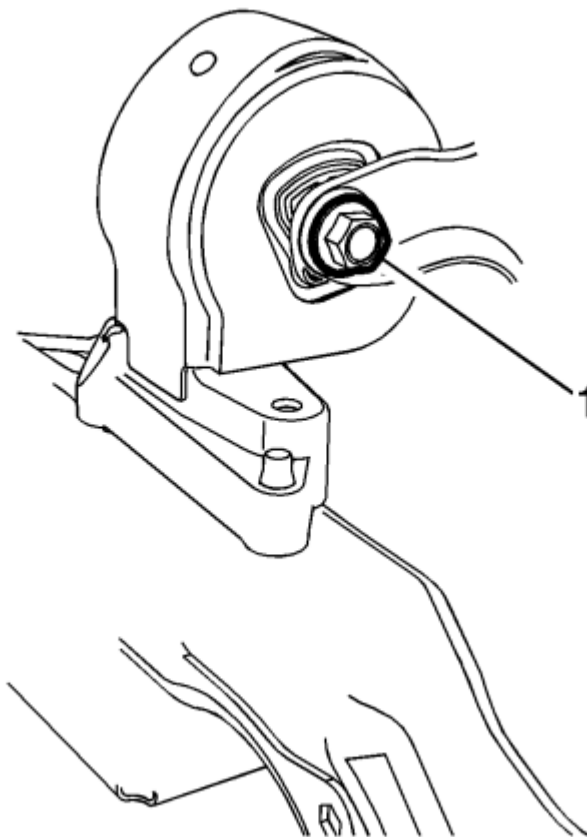
**NOTE:** Follow the balance procedure steps listed below when no starting point has been established such as in a collision repair.

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



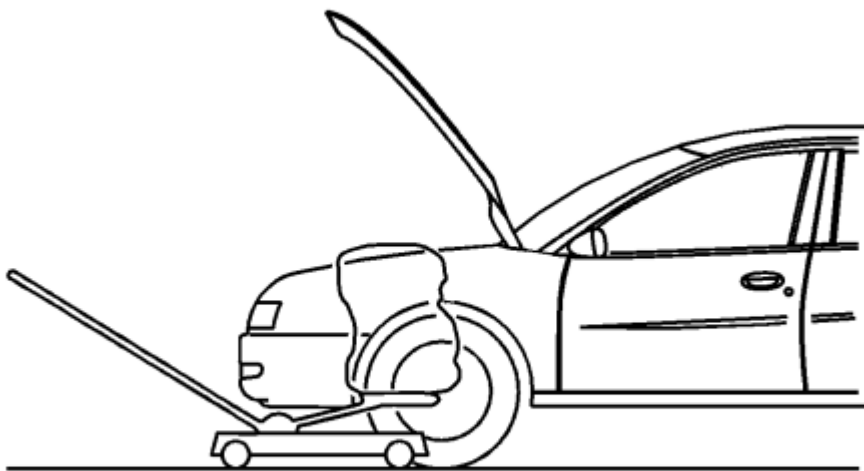
**Fig. 34: Front Transaxle Mount Through Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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



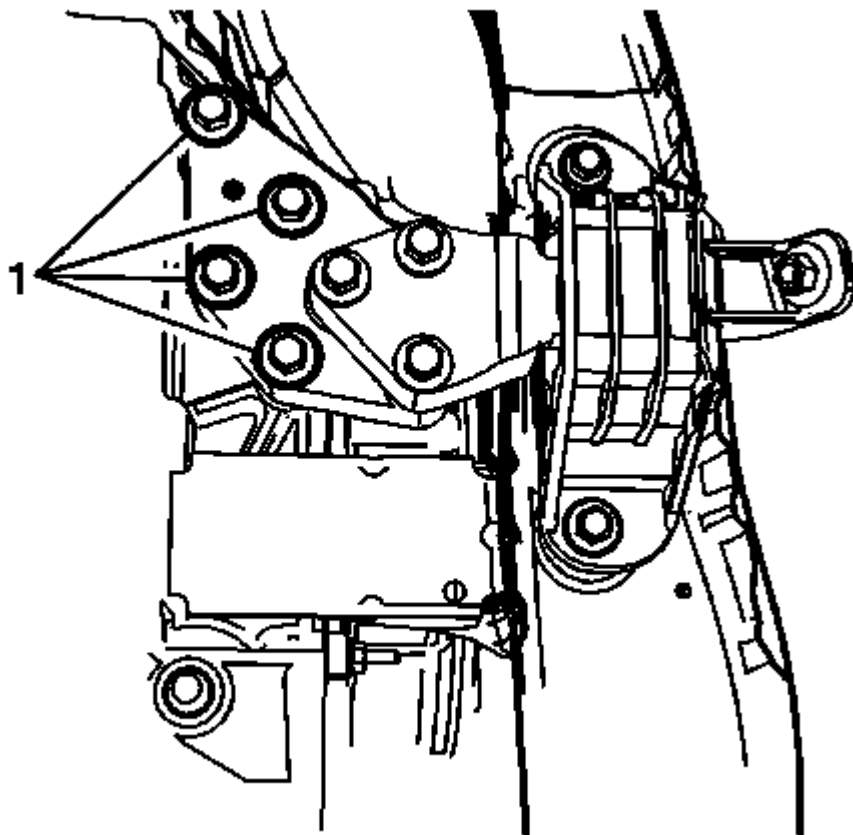
**Fig. 35: Rear Transaxle Mount Through Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 36: Supporting Engine/Transmission With Hydraulic Floor Jack**  
**Courtesy of GENERAL MOTORS COMPANY**

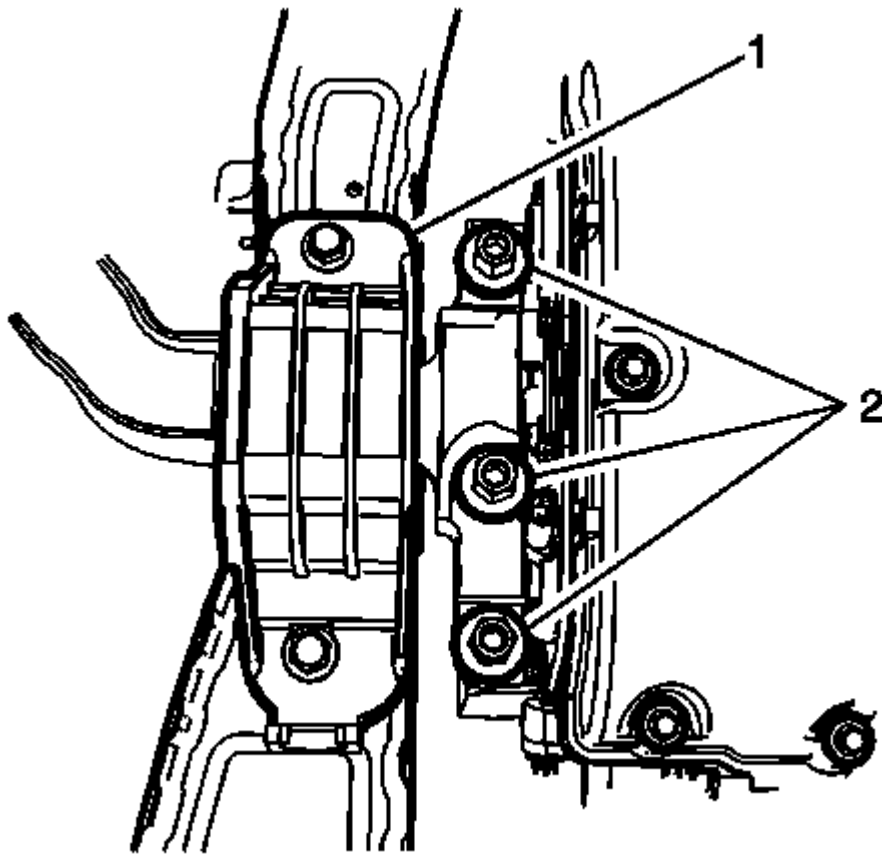
5. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.



**Fig. 37: Transaxle Bolts**

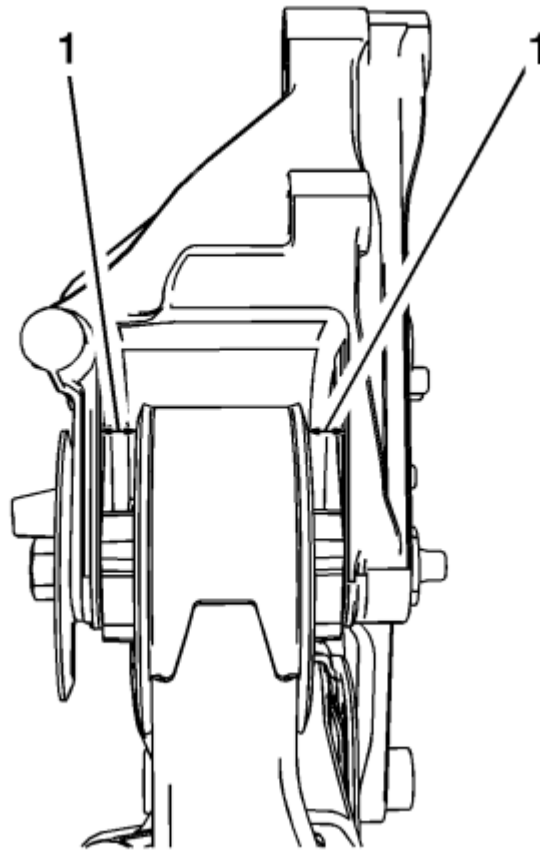
Courtesy of GENERAL MOTORS COMPANY

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



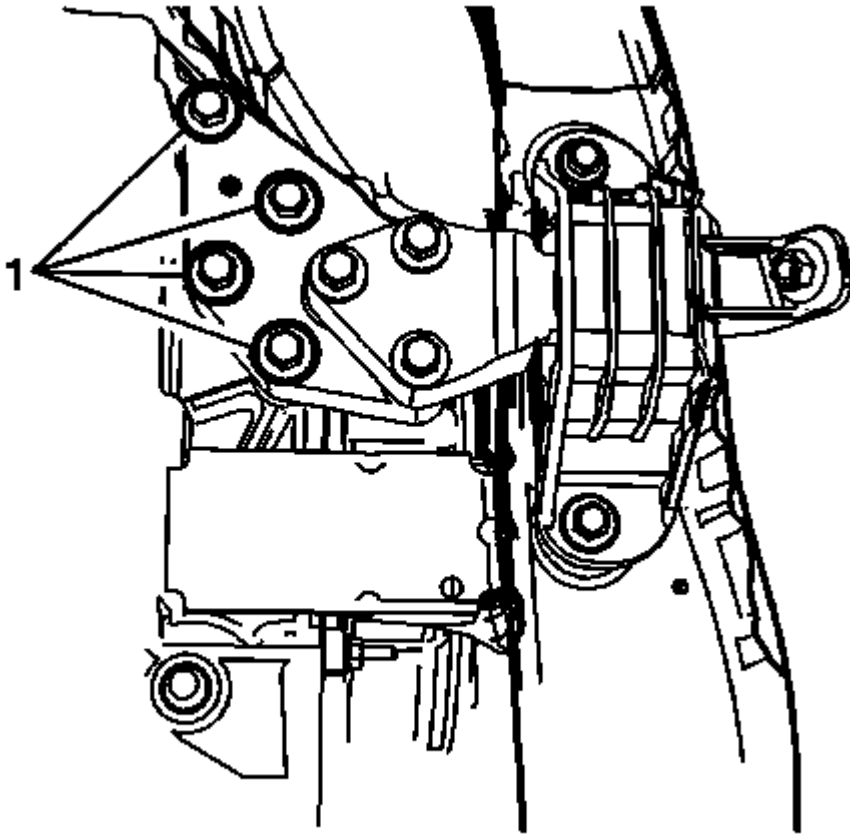
**Fig. 38: Engine Mount And Bracket Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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. 39: Front And Rear Powertrain Mounts**  
**Courtesy of GENERAL MOTORS COMPANY**

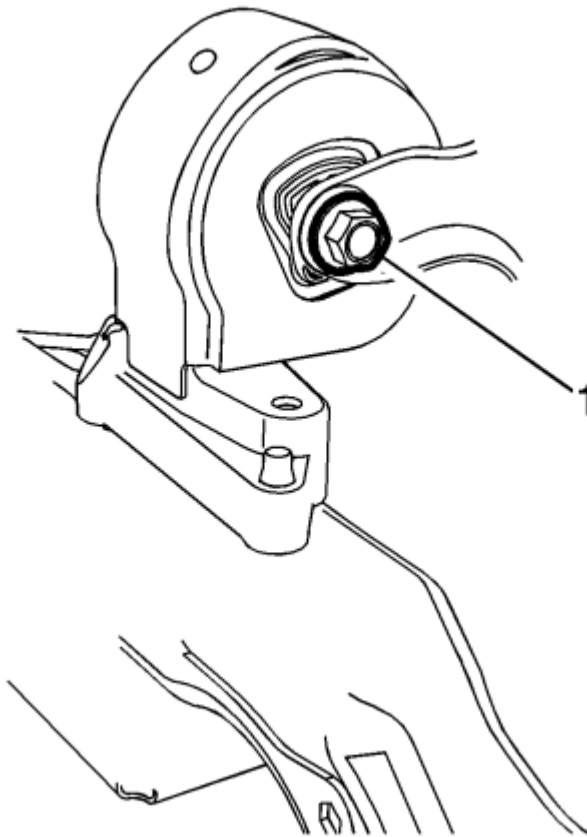
9. Check that the front and rear mounts are centered (1) in the mount brackets, adjust if necessary.
10. Tighten the left hand (transaxle side) mount bolts, starting with the bolt nearest to the center of the mount. See the appropriate transmission mount replacement procedure for the fastener tightening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



**Fig. 40: Transaxle Bolts**

**Courtesy of GENERAL MOTORS COMPANY**

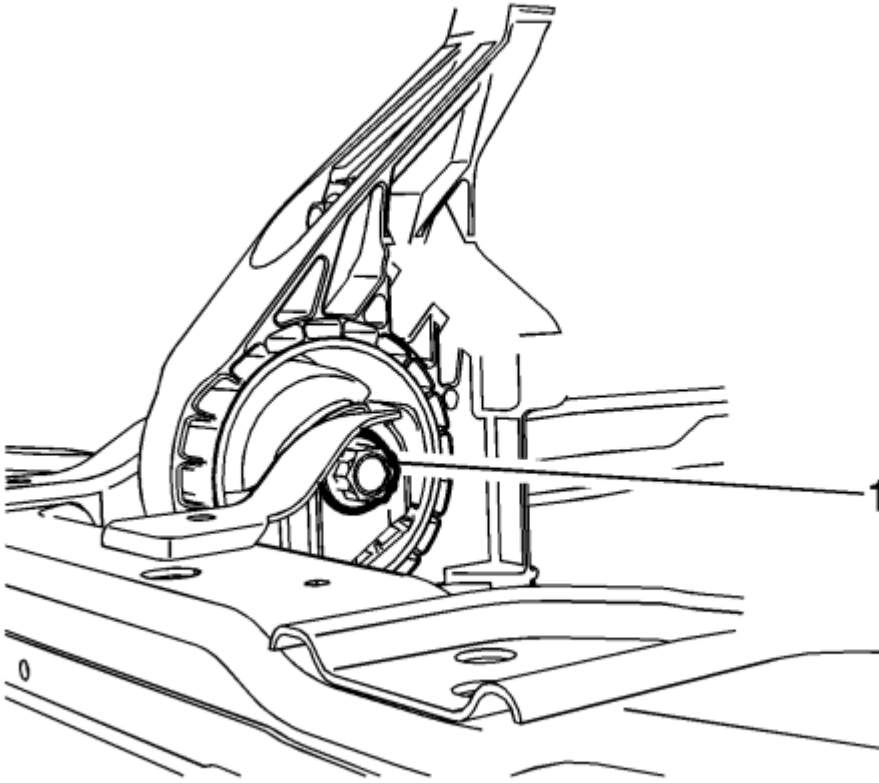
11. Tighten the right hand (engine side) mount bolts (1), starting with the bolt nearest to the center of the mount. See the appropriate engine mount replacement procedure for the fastener tightening specifications.
12. Remove the floor jacks from under the oil pan and transmission.
13. Raise the vehicle.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



**Fig. 41: Rear Transaxle Mount Through Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**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.



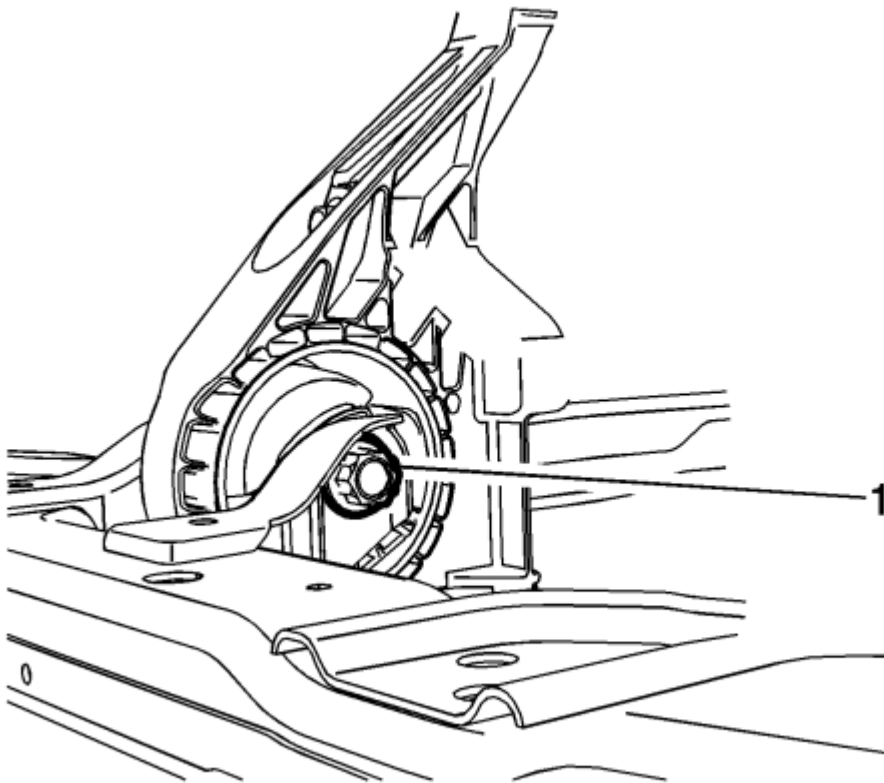
**Fig. 42: Front Transaxle Mount Through Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

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

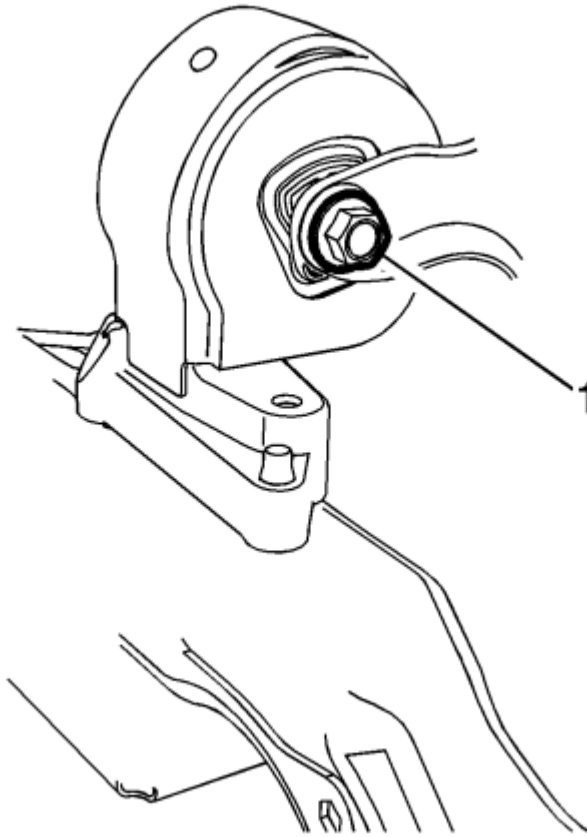
**NOTE:** Follow the balance procedure steps listed below when front or rear mounts through bolts are loosened or removed during a repair procedure.

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



**Fig. 43: Front Transaxle Mount Through Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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

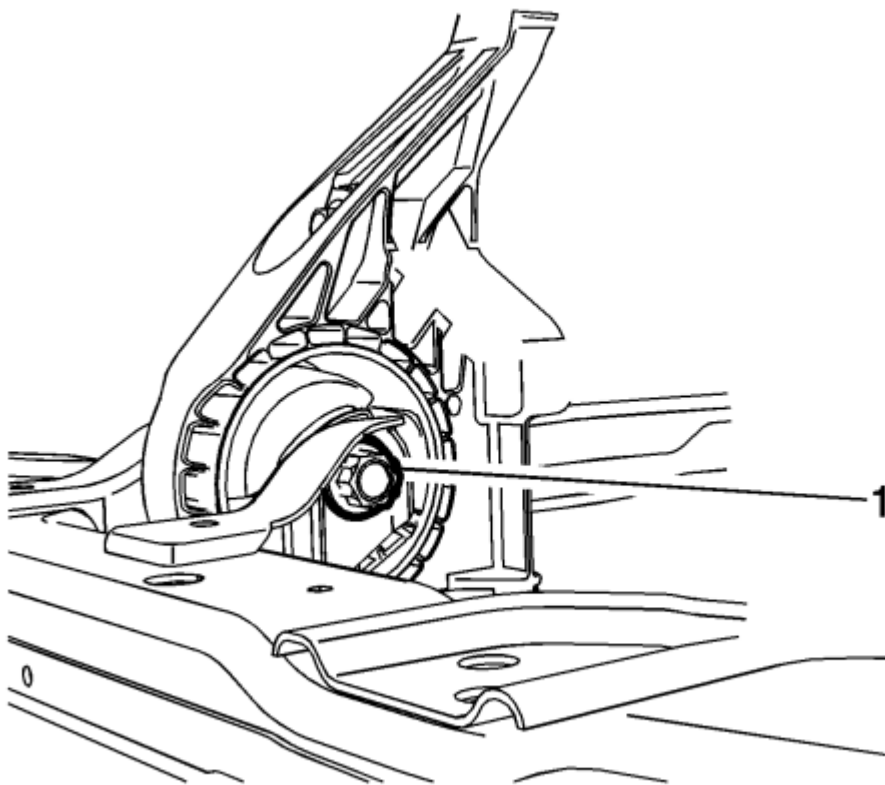


**Fig. 44: Rear Transaxle Mount Through Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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.

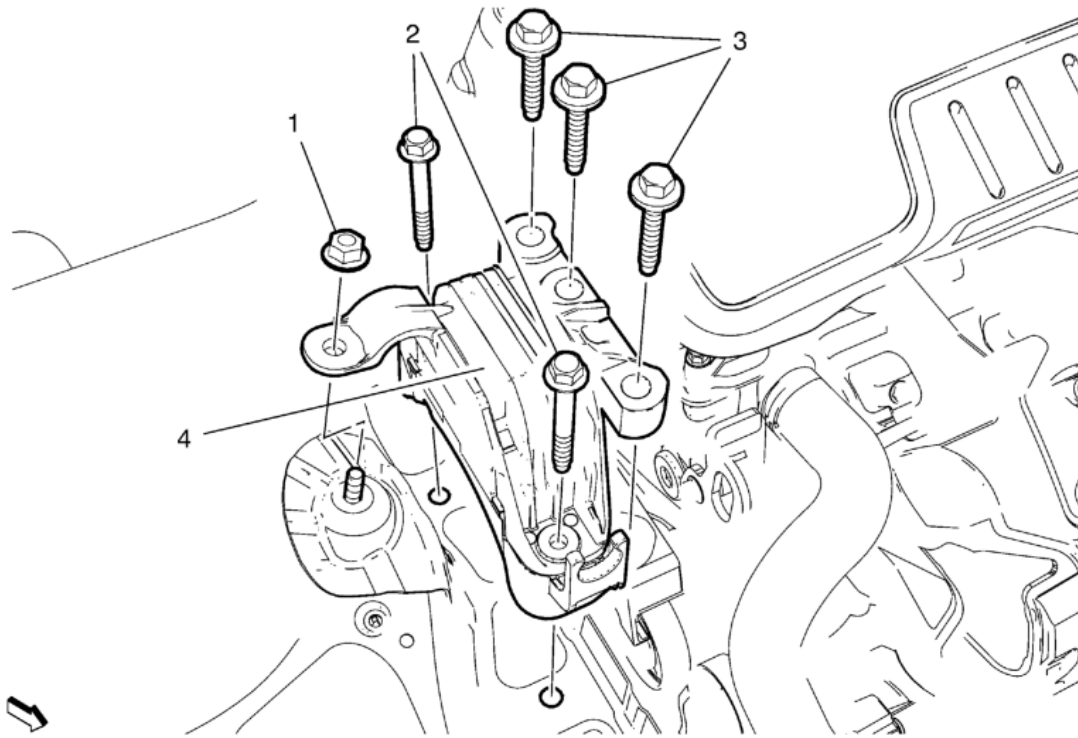
5. Tighten the rear transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.



**Fig. 45: Front Transaxle Mount Through Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

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. 46: Engine Mount & Components**

Courtesy of GENERAL MOTORS COMPANY

**Engine Mount Replacement**

| Callout                                                                                                                                                                                                                                   | Component Name                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                                                                                                                                                                                             |                                                                                                                                 |
| 1. Remove the air cleaner assembly. Refer to <b><u>Air Cleaner Assembly Replacement</u></b> .<br>2. Remove intake manifold cover. Refer to <b><u>Intake Manifold Cover Replacement</u></b> .<br>3. Support the engine with engine lifter. |                                                                                                                                 |
| 1                                                                                                                                                                                                                                         | Engine Mount Nut<br><br><b>CAUTION:</b><br><b>Refer to <u>Fastener Caution</u> .</b><br><br><b>Tighten</b><br>62 N.m (46 lb ft) |
| 2                                                                                                                                                                                                                                         | Engine Mount Bolt (Qty: 2)<br><b>Tighten</b><br>62 N.m (46 lb ft)                                                               |
|                                                                                                                                                                                                                                           | Engine Mount Bracket Bolt (Qty: 3)<br><br><b>CAUTION:</b>                                                                       |

Refer to Torque-to-Yield Fastener Caution .

### Procedure

Install NEW bolts. DO NOT reuse the old bolts.

### Tighten

- First pass: 50 N.m (37 lb ft)
- Final pass: 60 - 75 degrees

### Special Tools

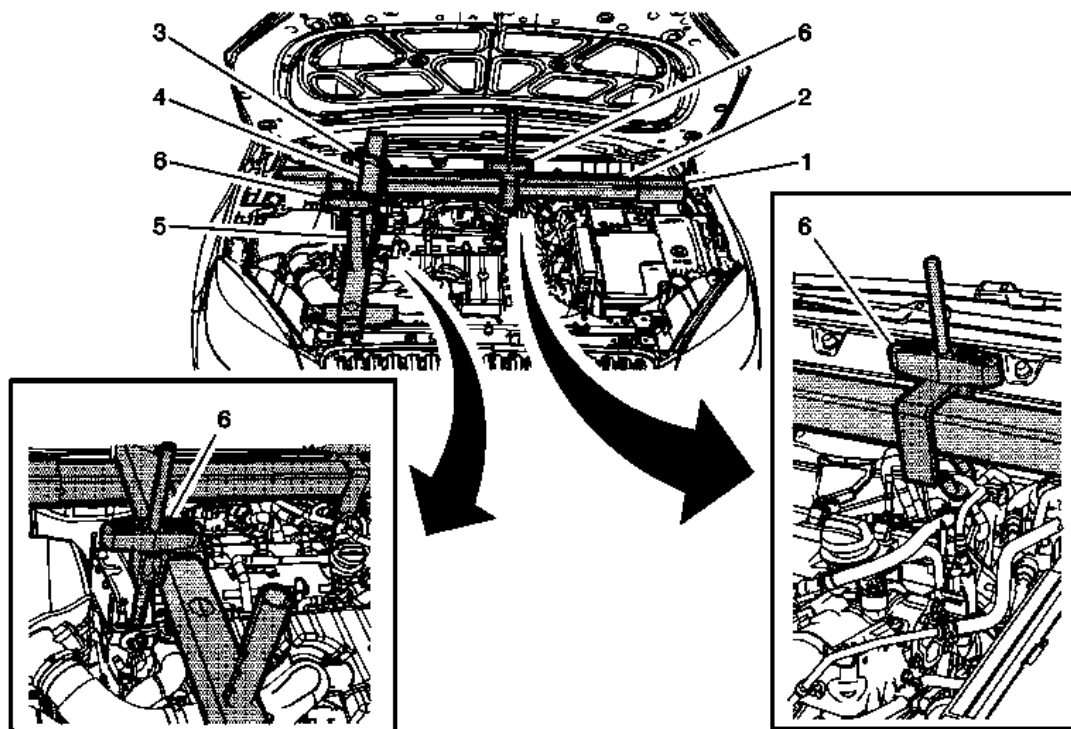
EN-45059 Angle Meter

For equivalent regional tools, refer to Special Tools.

3

Engine Mount

## ENGINE SUPPORT FIXTURE



**Fig. 47: Engine Support Fixture & Components**  
Courtesy of GENERAL MOTORS COMPANY

### Engine Support Fixture

| Callout               | Component Name |
|-----------------------|----------------|
| Preliminary Procedure |                |

1. Remove the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement** .
2. Remove the Intake Manifold Cover. Refer to **Intake Manifold Cover Replacement**

### Special Tools

- **EN-28467** Engine Support Fixture Adapter Legs
- **J-28467-518** Main Support Beam
- **J-28467-23A** Cross Bracket
- **J-28467-2A** Strut Tower Support Assembly
- **J-28467-14A** Radiator Tube Shelf Assembly
- **J-36857** Engine Lift Bracket.
- **J-28467-8A** Hook Assembly

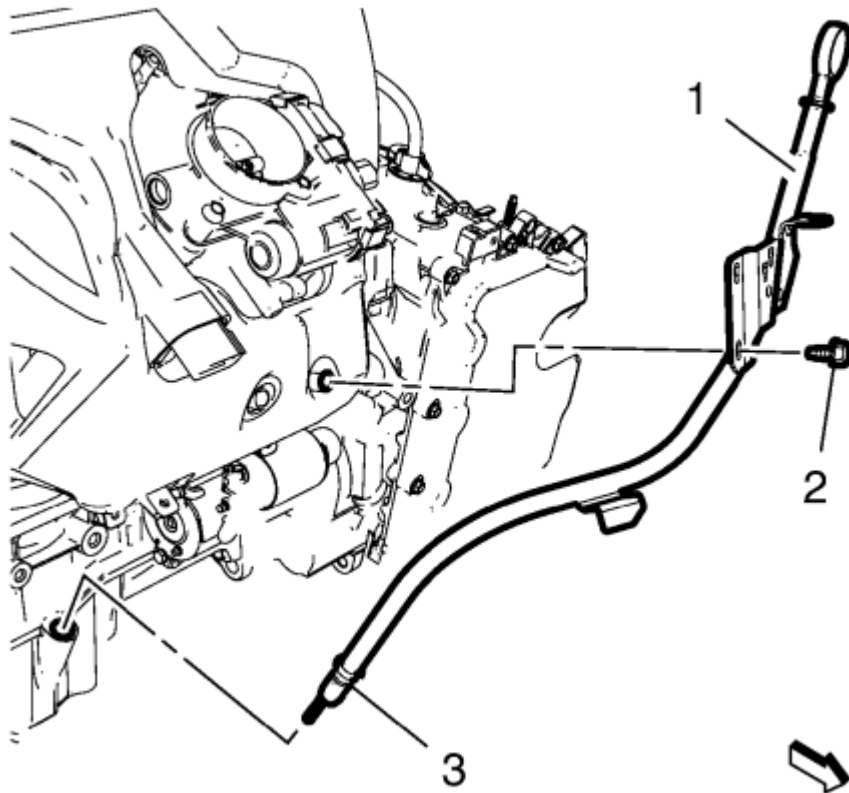
For equivalent regional tools. Refer to **Special Tools**.

|   |                                                                                                                                        |
|---|----------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Engine Support Fixture Adapter Leg (Qty: 2)                                                                                            |
| 2 | Main Support Beam                                                                                                                      |
| 3 | Cross Bracket                                                                                                                          |
| 4 | Strut Tower Support Assembly<br><b>Procedure</b><br>Adjust the length of the strut tower support assembly.                             |
| 5 | Radiator Tube Shelf Assembly                                                                                                           |
| 6 | Hook Assembly (Qty: 2)<br><br><b>NOTE:</b><br><b>If the engine is not equipped with engine lift bracket, install J-36857 in place.</b> |

## OIL LEVEL INDICATOR TUBE REPLACEMENT

### Removal Procedure

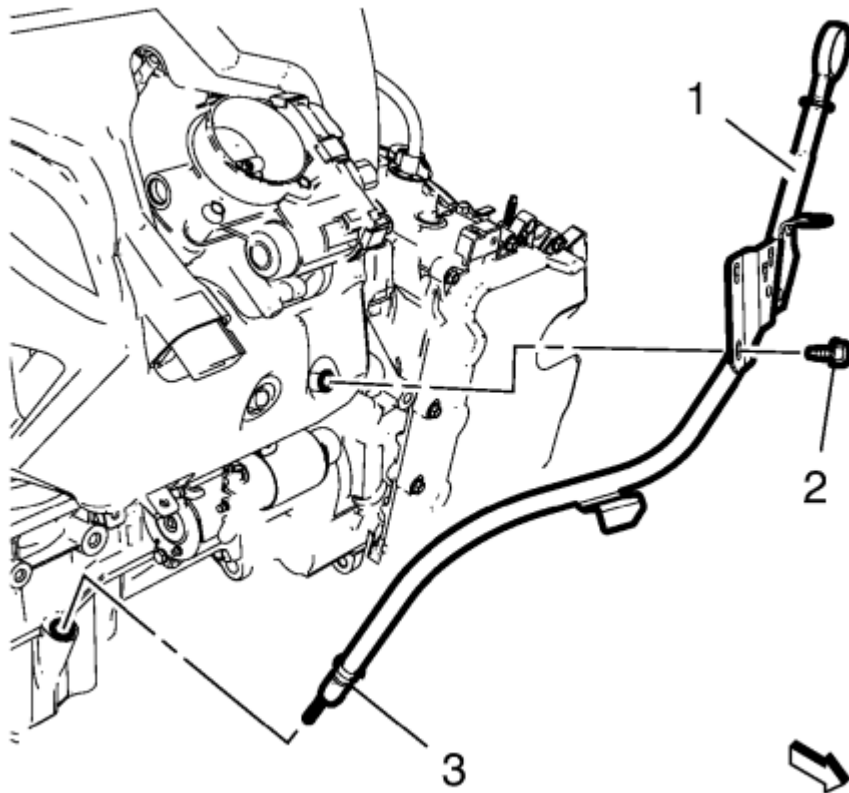
1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Unclip the ECM wiring harness from the oil level indicator tube bracket.



**Fig. 48: Oil Level Indicator Tube, Seal Ring & Bracket Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

3. Remove the oil level indicator tube bracket bolt (2).
4. Remove the oil level indicator tube (1) from the oil pan.
5. Remove and DISCARD the oil level indicator tube seal ring (3).

#### Installation Procedure



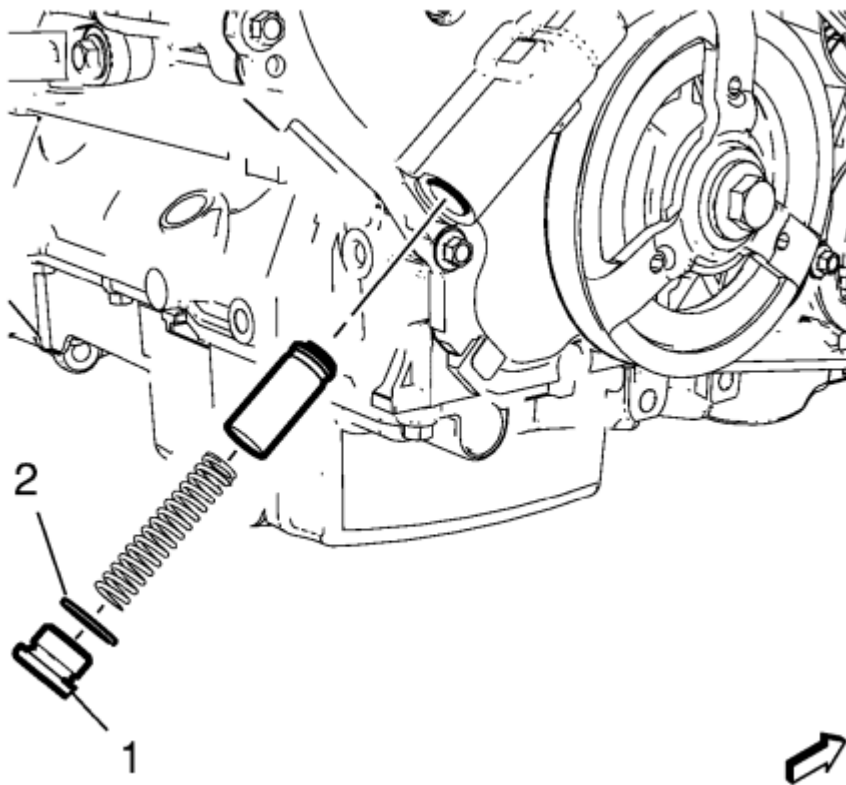
**Fig. 49: Oil Level Indicator Tube, Seal Ring & Bracket Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

1. Install the oil level indicator tube (1) to the oil pan along with a NEW seal ring (3).

**CAUTION: Refer to Fastener Caution .**

2. Install the oil level indicator tube bracket bolt (2) and tighten to 10 N.m (89 lb in).
3. Clip the ECM wiring harness to the oil level indicator tube bracket.
4. Install the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement .

## OIL PRESSURE RELIEF VALVE REPLACEMENT



**Fig. 50: Oil Pressure Relief Valve & Seal Ring**  
 Courtesy of GENERAL MOTORS COMPANY

### Oil Pressure Relief Valve Replacement

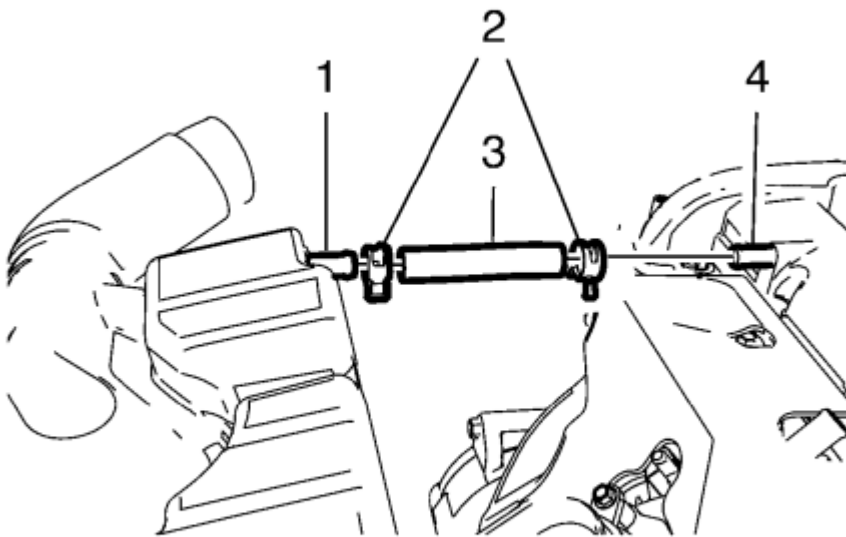
| Callout                                                                                                                                                                                                                                                                                                                           | Component Name                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedure</b>                                                                                                                                                                                                                                                                                                      |                                                                                                                                   |
| 1. Remove front wheelhouse liner right side. Refer to <u>Front Wheelhouse Liner Replacement</u> .<br>2. Remove front compartment splash shield right side. Refer to <u>Front Compartment Splash Shield Replacement</u> .<br>3. Remove right wheel drive shaft. Refer to <u>Front Wheel Drive Shaft Replacement - Right Side</u> . |                                                                                                                                   |
| 1                                                                                                                                                                                                                                                                                                                                 | Oil Pressure Relief Valve<br><br><b>CAUTION:</b><br>Refer to <u>Fastener Caution</u> .<br><br><b>Tighten</b><br>40 N.m (30 lb ft) |
| 2                                                                                                                                                                                                                                                                                                                                 | Oil Pressure Relief Valve Seal Ring<br><b>Procedure</b>                                                                           |

DISCARD the seal ring and use NEW only.

## **POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT**

### **Removal Procedure**

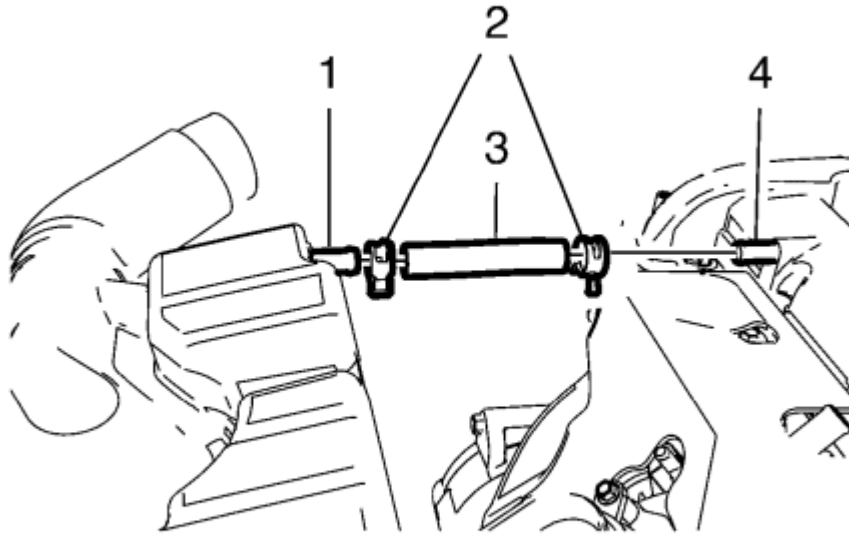
1. Remove intake manifold cover. Refer to **Intake Manifold Cover Replacement**.



**Fig. 51: Positive Crankcase Ventilation Hose/Pipe/Tube & Components**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove 2 positive crankcase ventilation hose clamps (2).
3. Remove the positive crankcase ventilation hose (3) from the camshaft cover (4) and the air cleaner outlet duct - rear (1).

### **Installation Procedure**



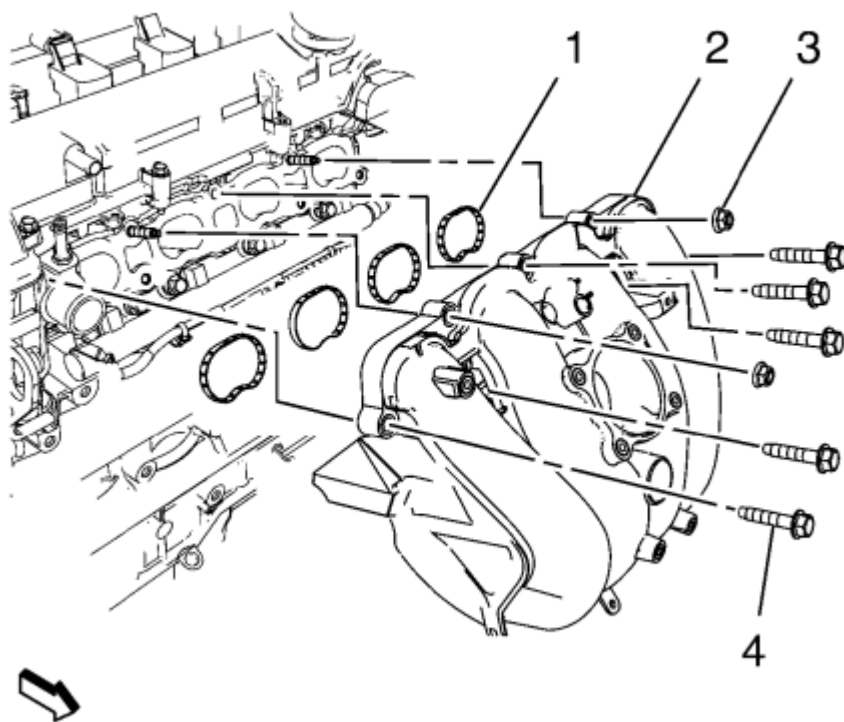
**Fig. 52: Positive Crankcase Ventilation Hose/Pipe/Tube & Components**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the positive crankcase ventilation hose (3) to the camshaft cover (4) and the air cleaner outlet duct - rear (1).
2. Install 2 positive crankcase ventilation hose clamps (2).
3. Install intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

## INTAKE MANIFOLD REPLACEMENT

### Removal Procedure

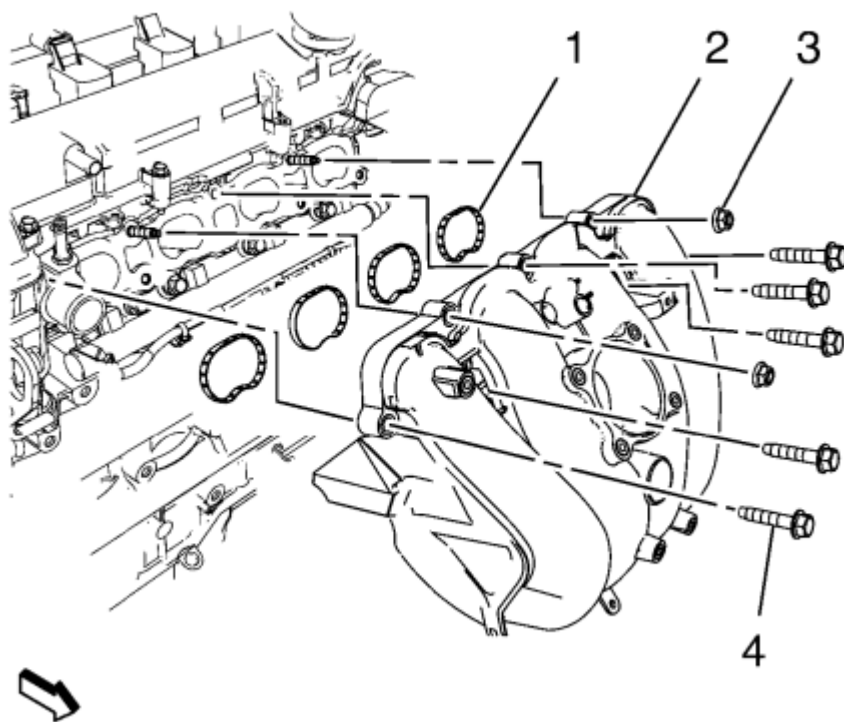
1. Remove the intake manifold insulator. Refer to **Intake Manifold Insulator Replacement**.
2. Remove the manifold absolute pressure sensor from the intake manifold. Refer to **Manifold Absolute Pressure Sensor Replacement**.
3. Remove the fuel pump cover only from the fuel pump. Refer to **Fuel Pump Replacement**.



**Fig. 53: Intake Manifold & Mounting Components**  
**Courtesy of GENERAL MOTORS COMPANY**

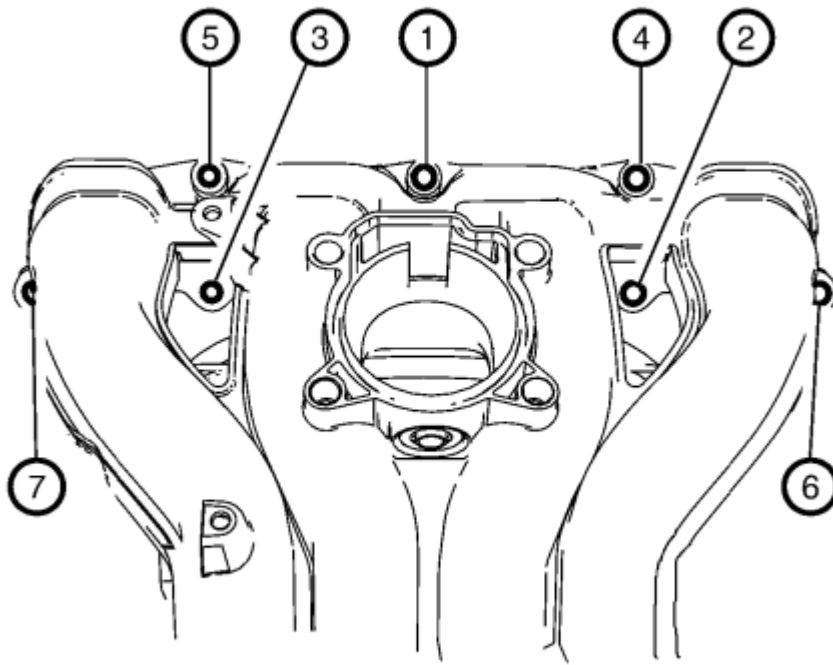
4. Remove the 2 intake manifold nuts (3) and the 5 intake manifold bolts (4).
5. Remove the intake manifold (2) and the 4 intake manifold gaskets (1).

#### Installation Procedure



**Fig. 54: Intake Manifold & Mounting Components**  
 Courtesy of GENERAL MOTORS COMPANY

1. Install the intake manifold (2) and the 4 NEW intake manifold gaskets (1).
2. Install the 2 intake manifold nuts (4) and the 5 intake manifold bolts (4) to the intake manifold (2).



**Fig. 55: Intake Manifold Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

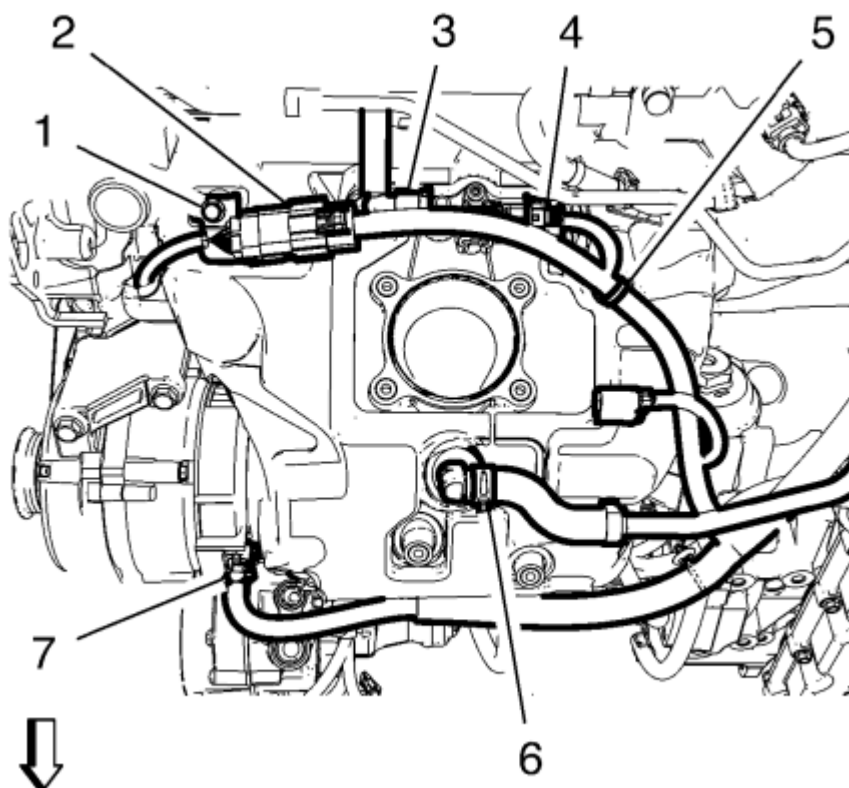
3. Tighten the intake manifold nuts and the intake manifold bolts in sequence as shown to 10 N.m (89 lb in).
4. Install the fuel pump cover only to the fuel pump. Refer to Fuel Pump Replacement .
5. Install the manifold absolute pressure sensor. Refer to Manifold Absolute Pressure Sensor Replacement .
6. Install the intake manifold insulator. Refer to Intake Manifold Insulator Replacement.

## INTAKE MANIFOLD INSULATOR REPLACEMENT

### Removal Procedure

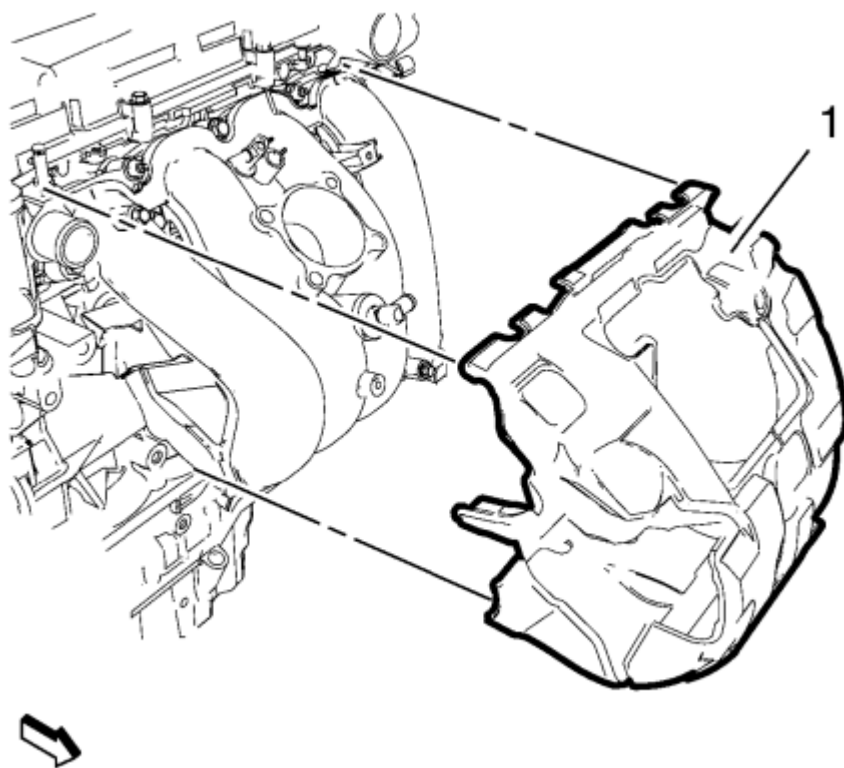
1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection .
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.
3. Remove the throttle body assembly. Refer to Throttle Body Assembly Replacement .
4. Remove the brake booster vacuum pipe from the intake manifold.

5. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
6. Remove the A/C compressor and condenser hose from the compressor and reposition. Refer to **Air Conditioning Compressor and Condenser Hose Replacement**.



**Fig. 56: Intake Manifold Insulator & Components**  
Courtesy of GENERAL MOTORS COMPANY

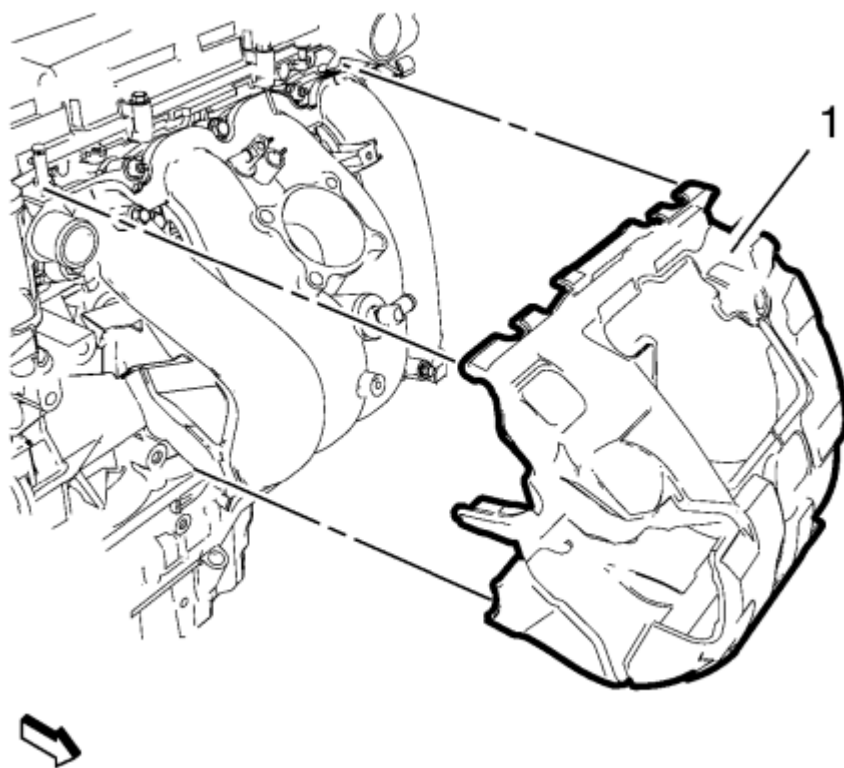
7. Disconnect the ECM wiring harness plug (2) from the fuel injector wiring harness plug.
8. Remove the fuel injector wiring harness plug bracket bolt (1) and the fuel injector wiring harness plug bracket from the intake manifold.
9. Disconnect the ECM wiring harness plug (4) from the manifold absolute pressure sensor.
10. Remove the ECM wiring harness clip from the intake manifold and reposition the ECM wiring harness.
11. Remove the evaporative emission canister purge tube (3) from the intake manifold stud and reposition.
12. Remove the brake booster vacuum pipe (6), remove the brake booster vacuum pipe from the intake manifold stud and reposition.
13. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)**.
14. Pull the intake manifold insulator over the lower intake manifold brackets.
15. Lower the vehicle completely.



**Fig. 57: Intake Manifold Insulator**  
Courtesy of GENERAL MOTORS COMPANY

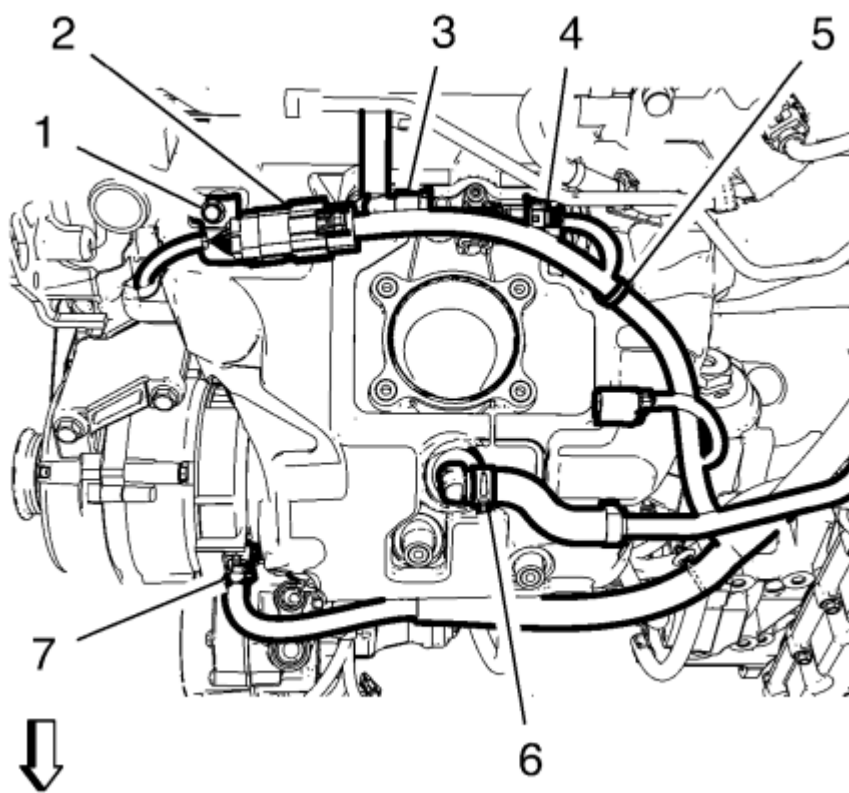
16. Remove the intake manifold insulator (1).

**Installation Procedure**



**Fig. 58: Intake Manifold Insulator**  
**Courtesy of GENERAL MOTORS COMPANY**

1. Install the intake manifold insulator (1).
2. Raise the vehicle.
3. Pull the intake manifold insulator over the lower intake manifold brackets.
4. Lower the vehicle.



**Fig. 59: Intake Manifold Insulator & Components**  
**Courtesy of GENERAL MOTORS COMPANY**

5. Install the brake booster vacuum pipe to the intake manifold stud and install the brake booster vacuum pipe clamp (6).
6. Install the evaporative emission canister purge tube (3) to the intake manifold stud.
7. Position the ECM wiring harness and clip in the ECM wiring harness clip (5) to the intake manifold.
8. Connect the ECM wiring harness plug (4) to the manifold absolute pressure sensor.

**CAUTION: Refer to Fastener Caution .**

9. Install the fuel injector wiring harness plug bracket to the intake manifold and tighten the fuel injector wiring harness plug bracket bolt (1) to 10 N.m (89 lb in).
10. Connect the ECM wiring harness plug (2) to the fuel injector wiring harness plug.
11. Install the A/C compressor and condenser hose to the compressor. Refer to **Air Conditioning Compressor and Condenser Hose Replacement** .
12. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
13. Install the brake booster vacuum pipe to the intake manifold.
14. Clip the radiator surge inlet hose/pipe to the fuel rail.

15. Install the throttle body assembly. Refer to **Throttle Body Assembly Replacement** .
16. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
17. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .

## CRANKSHAFT BALANCER REPLACEMENT

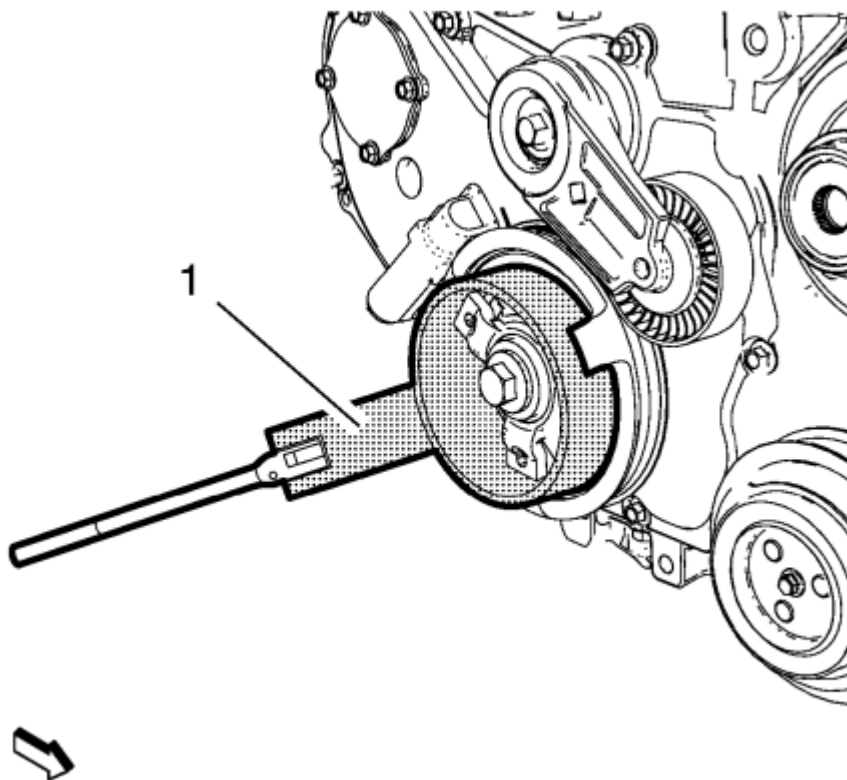
### Special Tools

- **EN-38122-A** Crankshaft Balancer Holder
- **EN-45059** Angle Meter

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

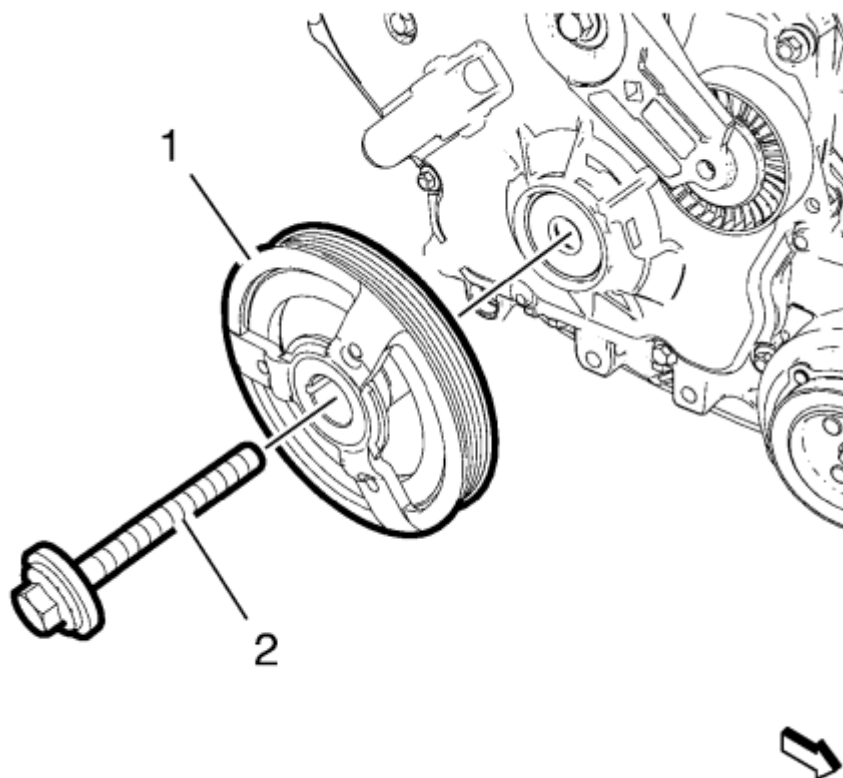
### Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)** .
2. Remove the wheel - front right side. Refer to **Tire and Wheel Removal and Installation** .
3. Remove front wheelhouse liner - right side. Refer to **Front Wheelhouse Liner Replacement** .
4. Remove the front compartment splash shield . Refer to **Front Compartment Splash Shield Replacement** .



**Fig. 60: Crankshaft Balancer Holder**  
Courtesy of GENERAL MOTORS COMPANY

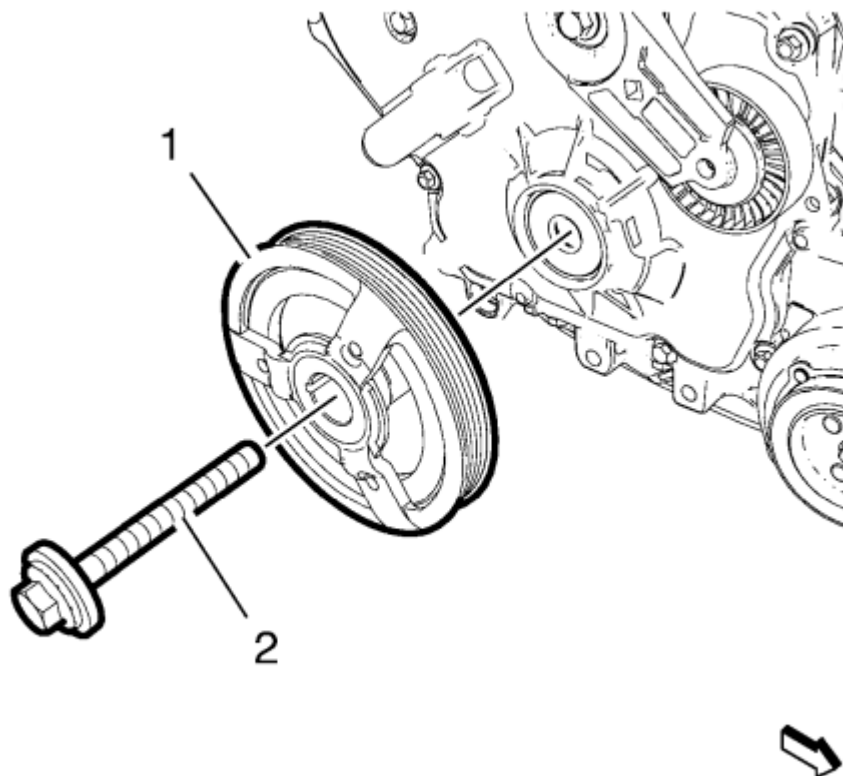
5. Use the EN-38122-A holder (1) to counterhold the crankshaft.



**Fig. 61: Crankshaft Balancer & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

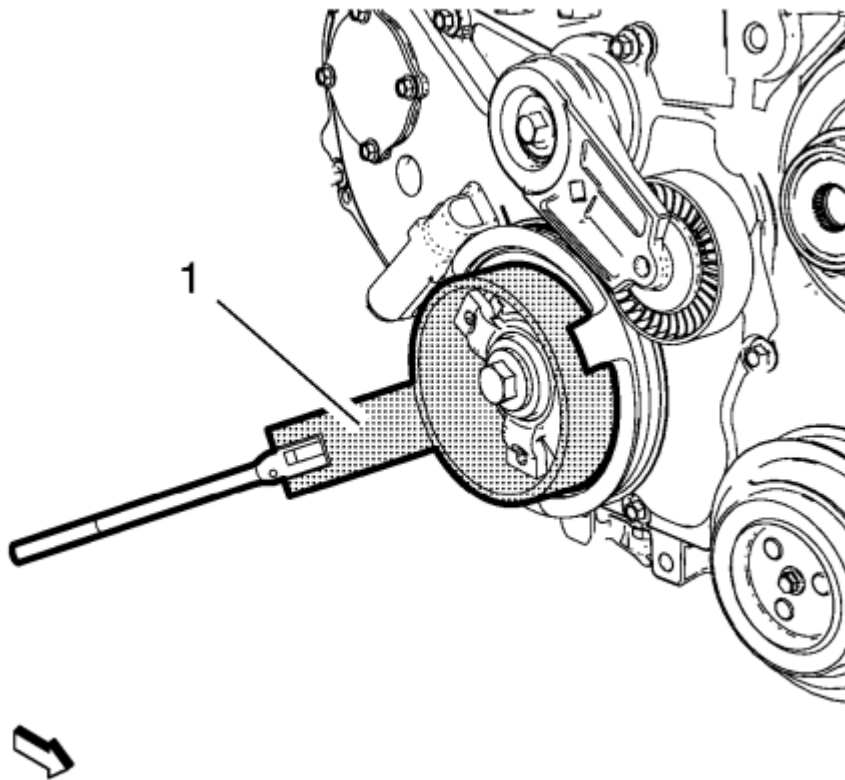
6. Remove the crankshaft balancer bolt (2) while counter hold the crankshaft.
7. Remove the crankshaft balancer (1).

#### **Installation Procedure**



**Fig. 62: Crankshaft Balancer & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft balancer (1).



**Fig. 63: Crankshaft Balancer Holder**  
 Courtesy of GENERAL MOTORS COMPANY

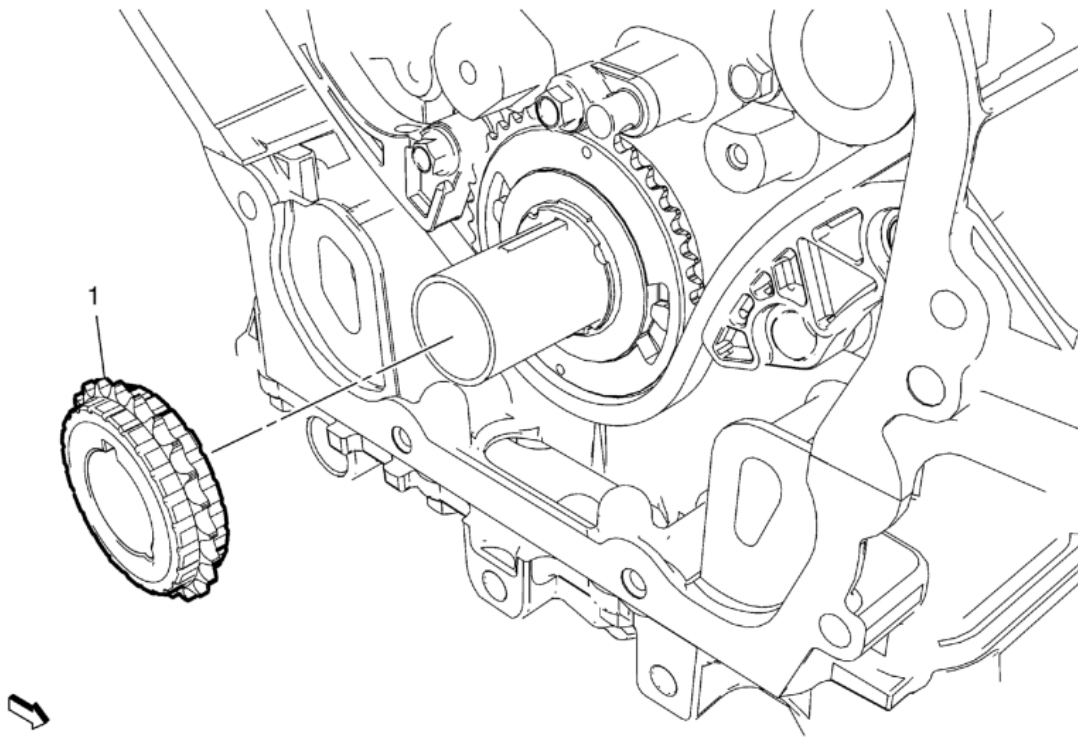
**CAUTION: Refer to Fastener Caution .**

2. Install the crankshaft balancer bolt and tighten a first pass to 150Y(111 lb ft). Use the **EN-38122-A** crankshaft balancer holder (1) to counterhold the crankshaft.

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

3. Tighten the crankshaft balancer bolt a final pass to an additional 100 degrees, using the **EN-45059** meter. Use the **EN-38122-A** crankshaft balancer holder (1) to counterhold the crankshaft.
4. Install the engine splash shield - right side. Refer to **Front Compartment Splash Shield Replacement** .
5. Install front wheelhouse liner - right side. Refer to **Front Wheelhouse Liner Replacement** .
6. Install the wheel - front right side. Refer to **Tire and Wheel Removal and Installation** .
7. Lower the vehicle.

## **TIMING CHAIN CRANKSHAFT SPROCKET REPLACEMENT**



**Fig. 64: Timing Chain Crankshaft Sprocket**  
 Courtesy of GENERAL MOTORS COMPANY

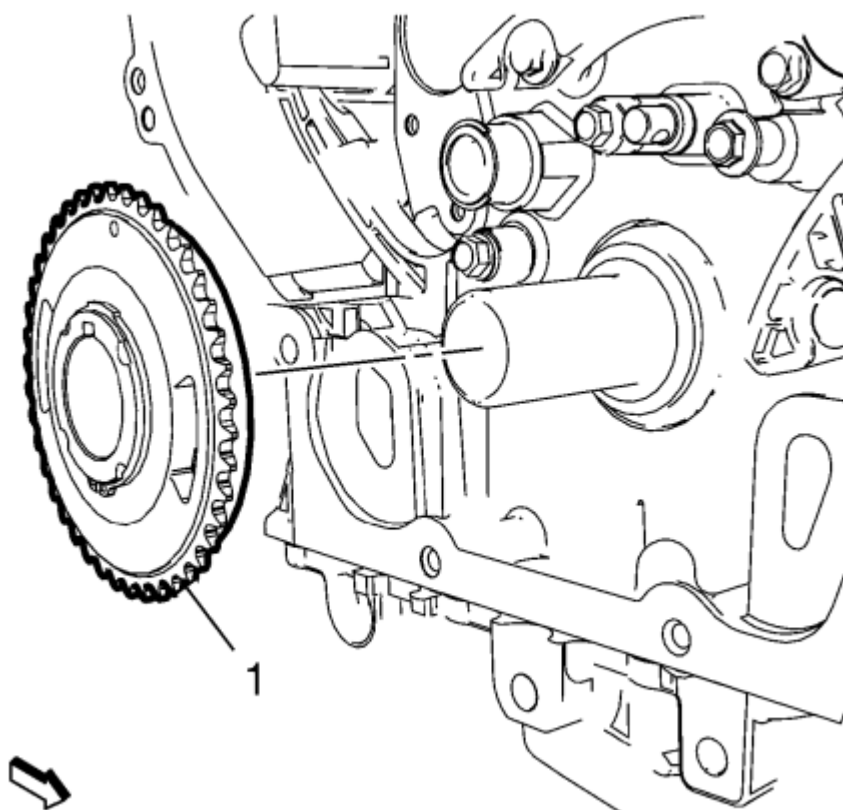
#### Timing Chain Crankshaft Sprocket Replacement

| Callout                                                                                                      | Component Name                            |
|--------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| <b>Preliminary Procedure</b>                                                                                 |                                           |
| Remove the timing chain. Refer to <b><u>Camshaft Timing Chain, Sprocket, and Tensioner Replacement</u></b> . |                                           |
| 1                                                                                                            | Camshaft Timing Chain Crankshaft Sprocket |

#### WATER PUMP AND BALANCE SHAFT CHAIN CRANKSHAFT SPROCKET REPLACEMENT

##### Removal Procedure

1. Remove the water pump and balance shaft timing chain. Refer to **Water Pump and Balance Shaft Chain Replacement**.

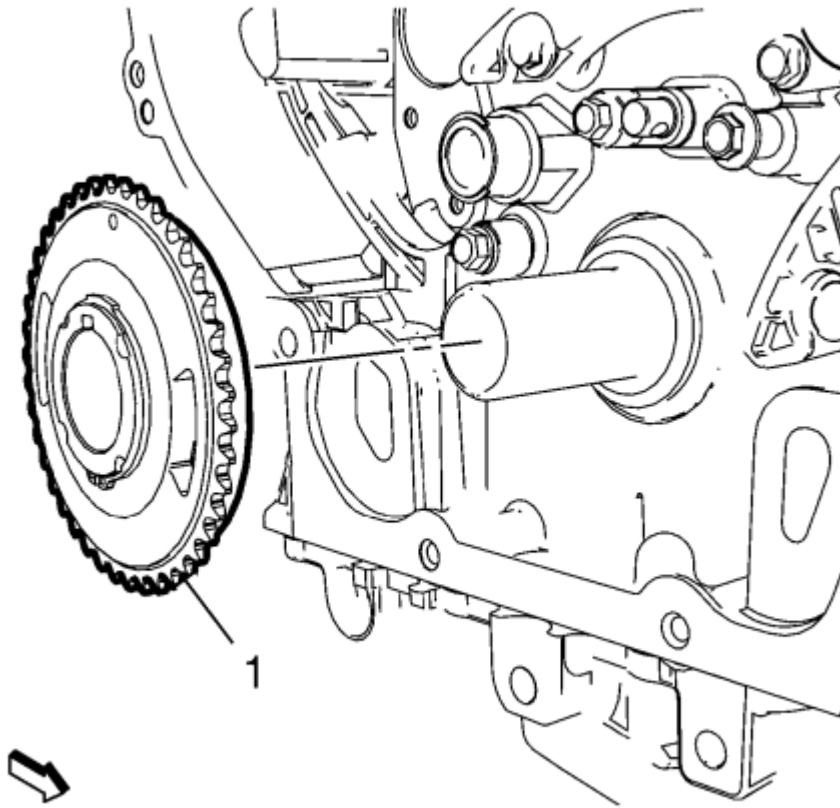


**Fig. 65: Water Pump & Balance Shaft Chain Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** The cam is only plugged into the recess and may fall down.

2. Remove the water pump and balance shaft timing chain crankshaft sprocket (1).

**Installation Procedure**

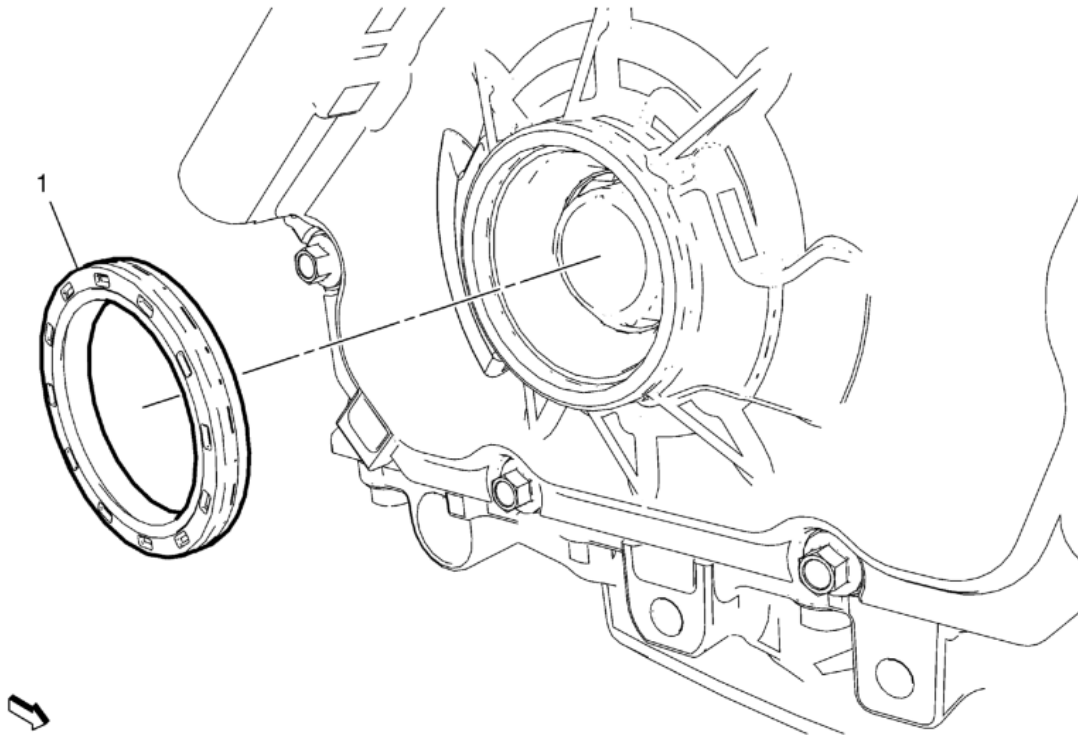


**Fig. 66: Water Pump & Balance Shaft Chain Crankshaft Sprocket**  
 Courtesy of GENERAL MOTORS COMPANY

**NOTE:** The cam and the sprocket groove must align.

1. Install the water pump and balance shaft timing chain crankshaft sprocket (1).
2. Check the correct seat of the sprocket. The sprocket must not turn independent of the crankshaft.
3. Install the water pump and balance shaft timing chain. Refer to **Water Pump and Balance Shaft Chain Replacement**.

## CRANKSHAFT FRONT OIL SEAL REPLACEMENT

**Fig. 67: Crankshaft Front Oil Seal**

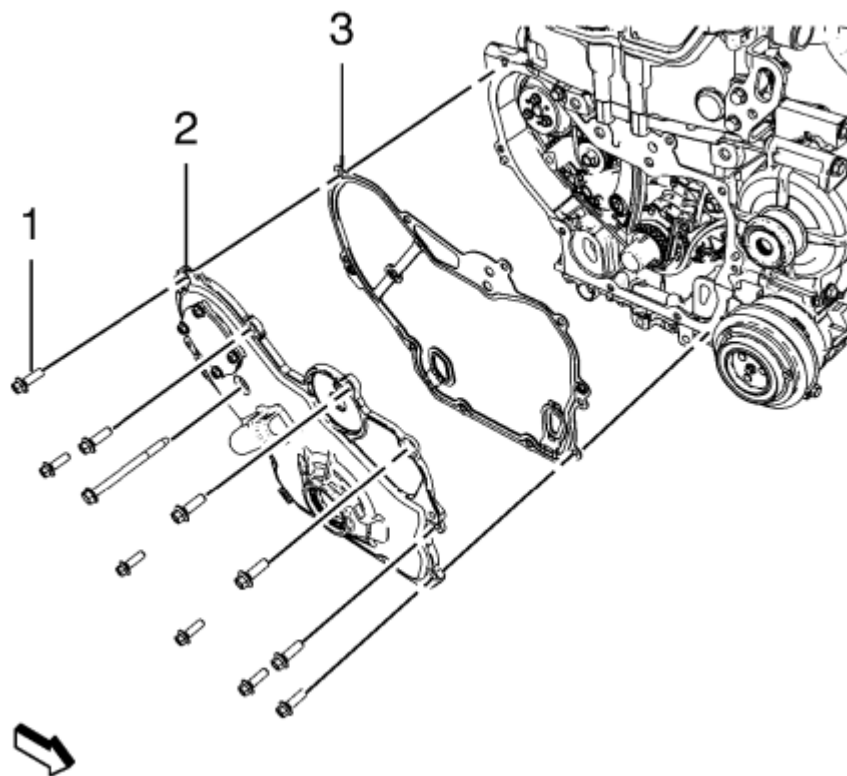
Courtesy of GENERAL MOTORS COMPANY

**Crankshaft Front Oil Seal Replacement**

| Callout                                                                           | Component Name                                                                                                                                                         |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedure</b>                                                      |                                                                                                                                                                        |
| Remove the crankshaft balancer, refer to <b>Crankshaft Balancer Replacement</b> . |                                                                                                                                                                        |
| 1                                                                                 | Crankshaft Front Oil Seal<br><b>Special Tools</b><br><b>EN-34115</b> Front Crankshaft Seal Installer<br>For equivalent regional tools, refer to <b>Special Tools</b> . |

**ENGINE FRONT COVER REPLACEMENT****Removal Procedure**

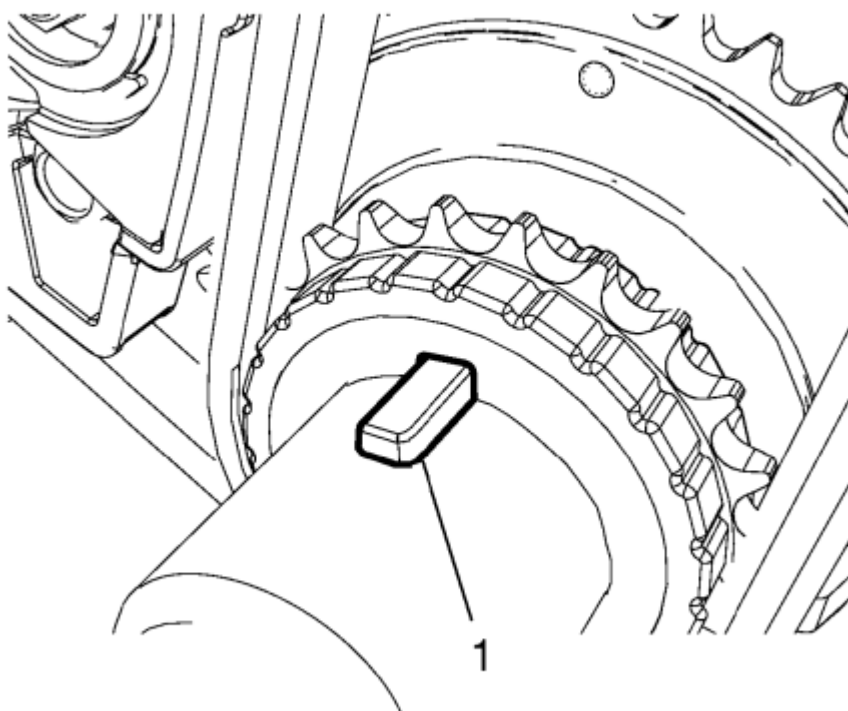
1. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
2. Set crankshaft to TDC of combustion stroke 1. cylinder.
3. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Remove the engine mount bracket. Refer to **Engine Mount Bracket Replacement**.
6. Lower the engine as deep as necessary to remove the engine front cover bolts/water pump bolt.



**Fig. 68: Engine Front Cover, Gasket & Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

7. Remove the 11 engine front cover bolts (1).
8. Remove the engine front cover (2) and the gasket (3).

#### **Installation Procedure**

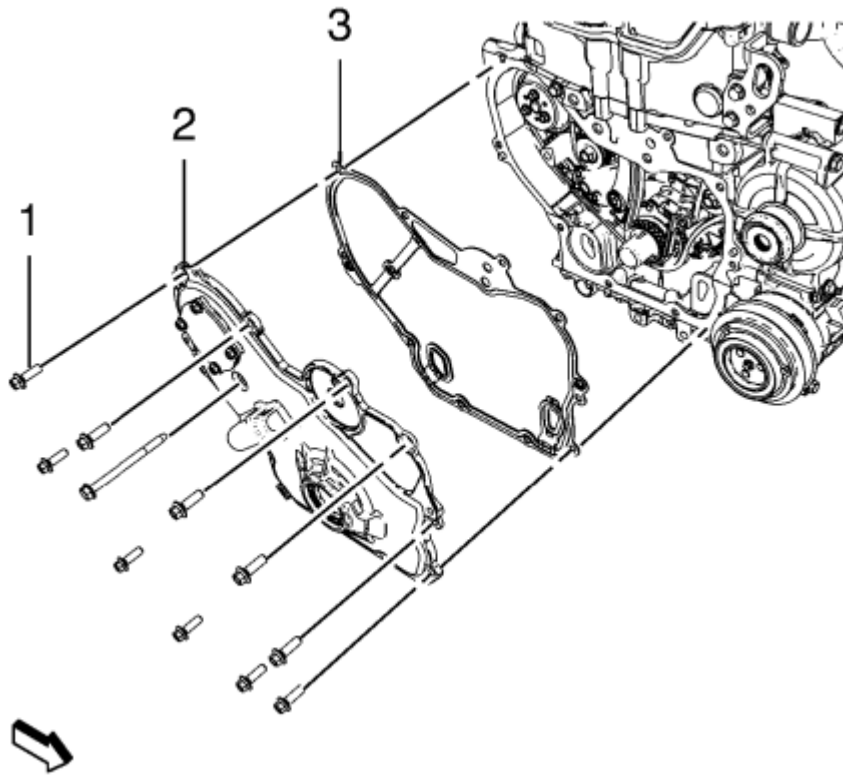


**Fig. 69: Oil Pump Driven Gear Cam**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** The cam (1) is only plugged into the recess.

1. The cam (1) and the groove in the oil pump driven gear must align. Rotate the oil pump driven gear to match cam (1) and the groove in the oil pump driven gear.
2. Clean the sealing surfaces.



**Fig. 70: Engine Front Cover, Gasket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

3. Install the engine front cover (2) and a NEW gasket (3).

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Remind the longer water pump bolt.

4. Install the engine front cover bolts (1) and tighten the bolts to 28 N.m (21 lb ft).
5. Install the engine mount bracket. Refer to Engine Mount Bracket Replacement.
6. Remove the engine support fixture. Refer to Engine Support Fixture.
7. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
8. Install the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.

## INTAKE CAMSHAFT REPLACEMENT

### Special Tools

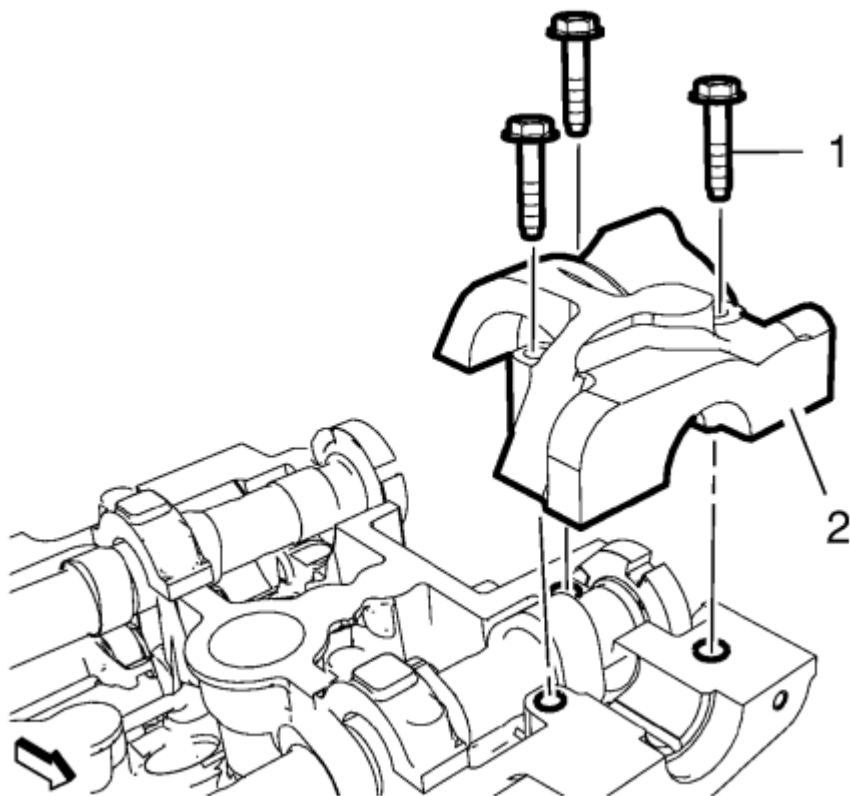
- EN-45059 Angle Meter

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

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

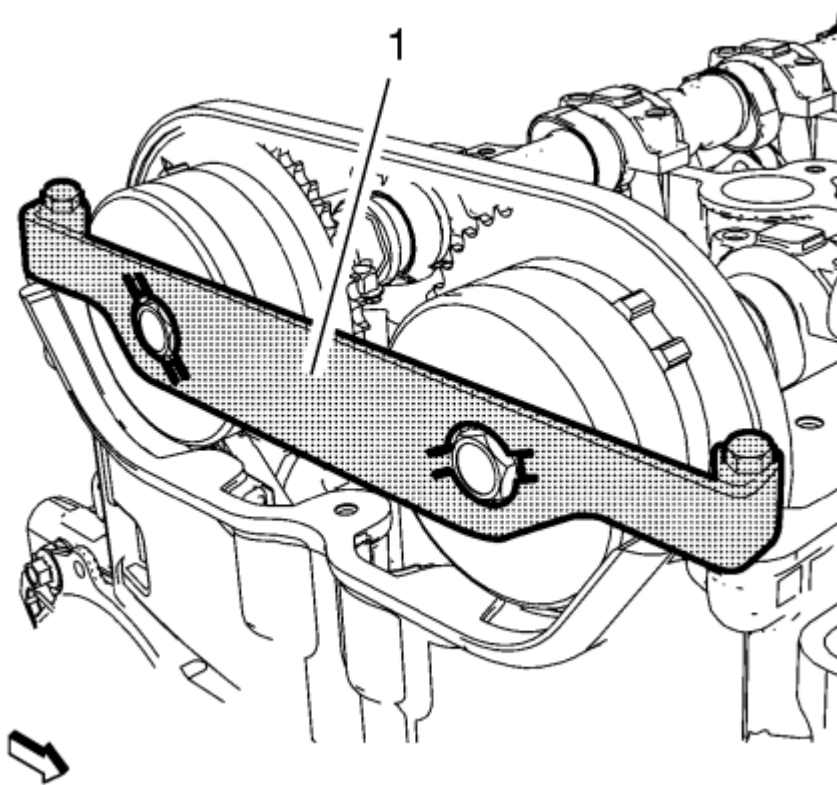
#### **Removal Procedure**

1. Remove the spark plugs. Refer to **Spark Plug Replacement**.
2. Remove the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
3. Remove the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement**.
4. Remove the Fuel Pump. Refer to **Fuel Pump Replacement**.



**Fig. 71: Rear Bearing Block & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

5. Remove the 3 rear bearing block bolts (1) and remove the rear bearing block (2).



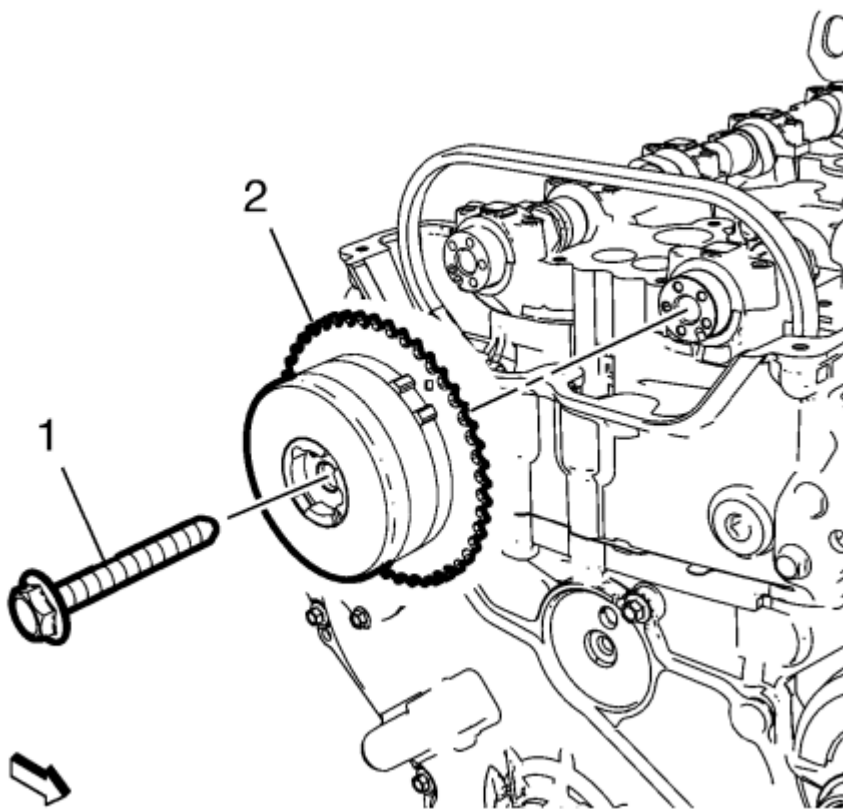
**Fig. 72: Crankshaft Locking Tool**

Courtesy of GENERAL MOTORS COMPANY

6. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.

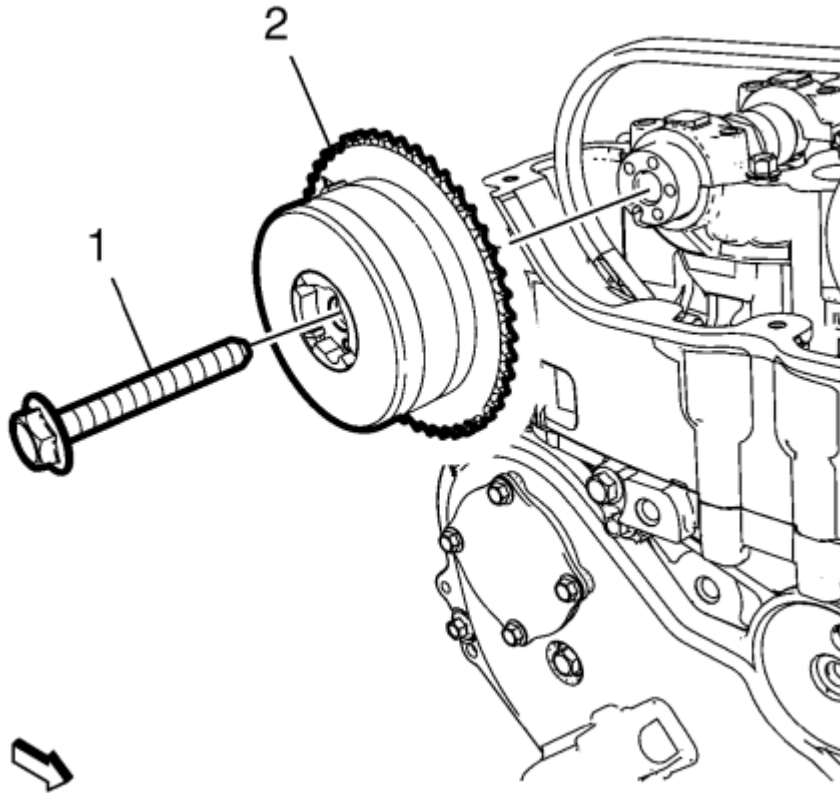
**CAUTION: Refer to Fastener Caution .**

7. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).



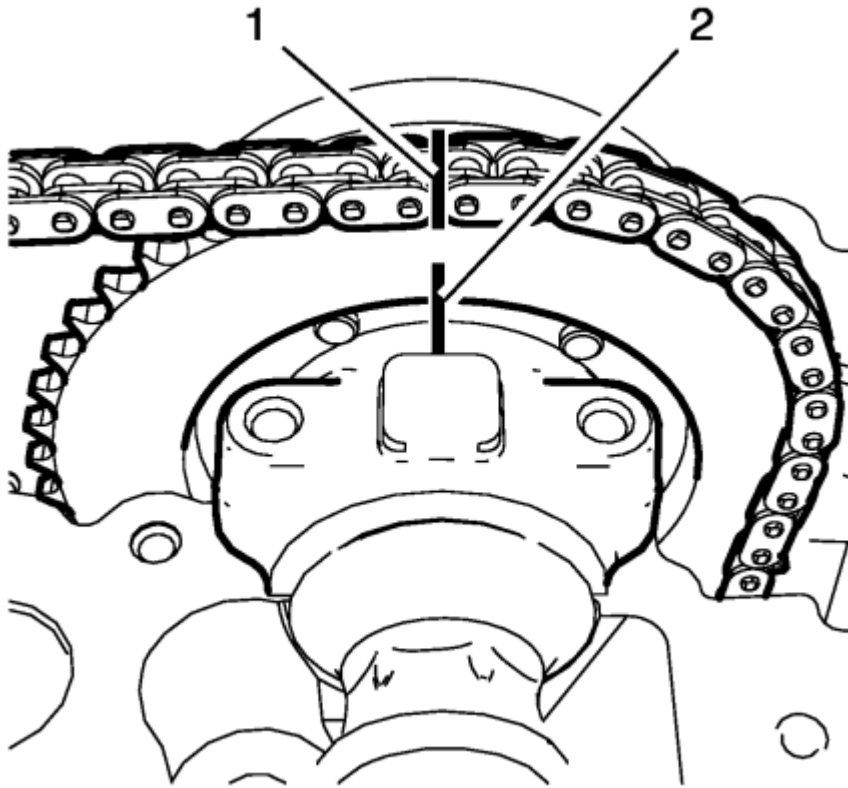
**Fig. 73: Camshaft Intake Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

8. Loosen, but DO NOT remove, the camshaft position intake actuator bolt (1).



**Fig. 74: Camshaft Position Exhaust Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

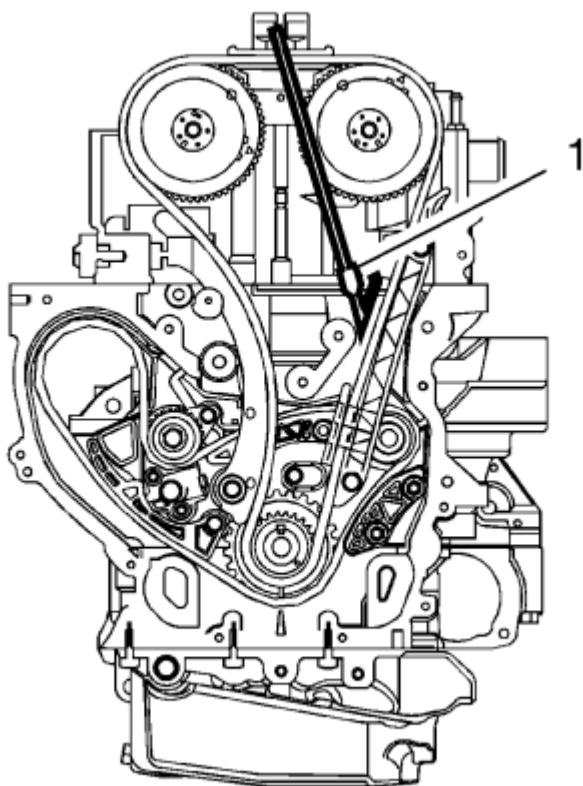
9. Loosen, but DO NOT remove, the camshaft position exhaust actuator bolt (1) from the exhaust camshaft actuator (2).
10. Remove the **EN-48953** locking tool.
11. Rotate the crankshaft clockwise at the crankshaft balancer bolt to the TDC of combustion stroke of cylinder 1.



**Fig. 75: Timing Chain & Camshaft Bearing Cover Marks**  
Courtesy of GENERAL MOTORS COMPANY

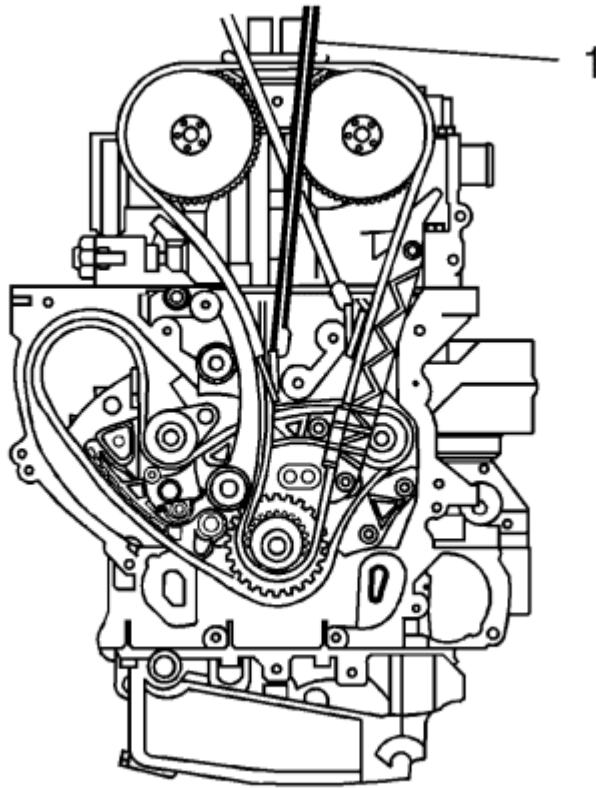
**NOTE:** Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

12. Mark both camshaft actuators and their respective locations on the timing chain (1). Mark additional the position from the camshaft actuator to the camshaft bearing cover (2).
13. Remove the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



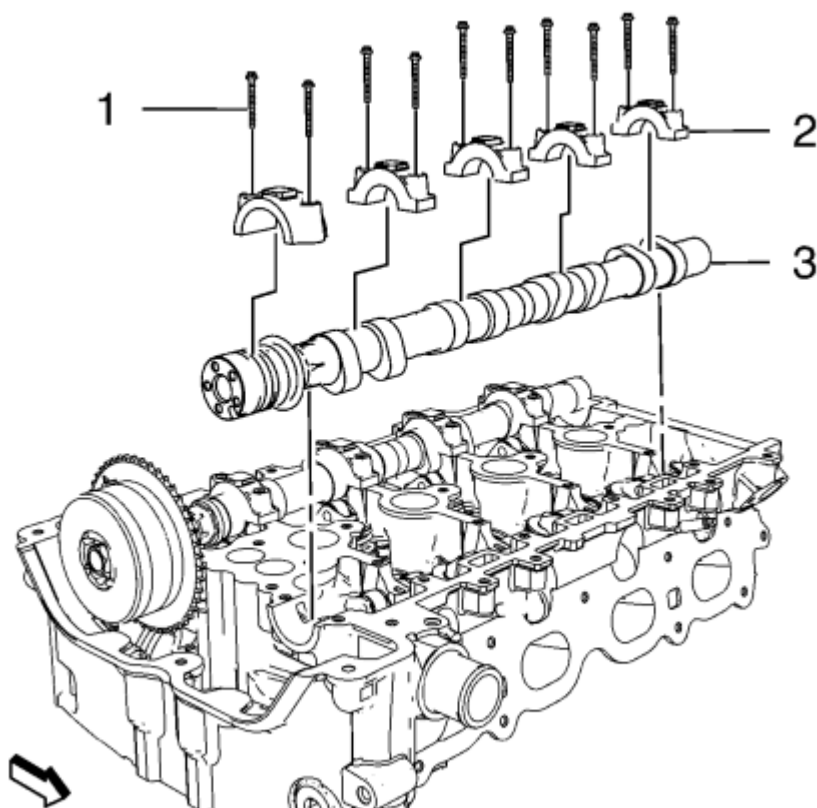
**Fig. 76: Timing Chain Retention Tool On Intake Side**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 77: Timing Chain Retention Tool On Exhaust Side**  
**Courtesy of GENERAL MOTORS COMPANY**

15. Install the **EN-48749** retention tool (1) to the exhaust side of the timing chain.
16. Remove and DISCARD the camshaft position intake actuator bolt (1).
17. Remove the intake camshaft actuator from the camshaft while also removing the actuator from the timing chain.
18. Remove and DISCARD the camshaft position exhaust actuator bolt.
19. Remove the exhaust camshaft actuator from the camshaft while also removing the actuator from the timing chain.
20. Mark the bearing caps to ensure they are installed in the original position.

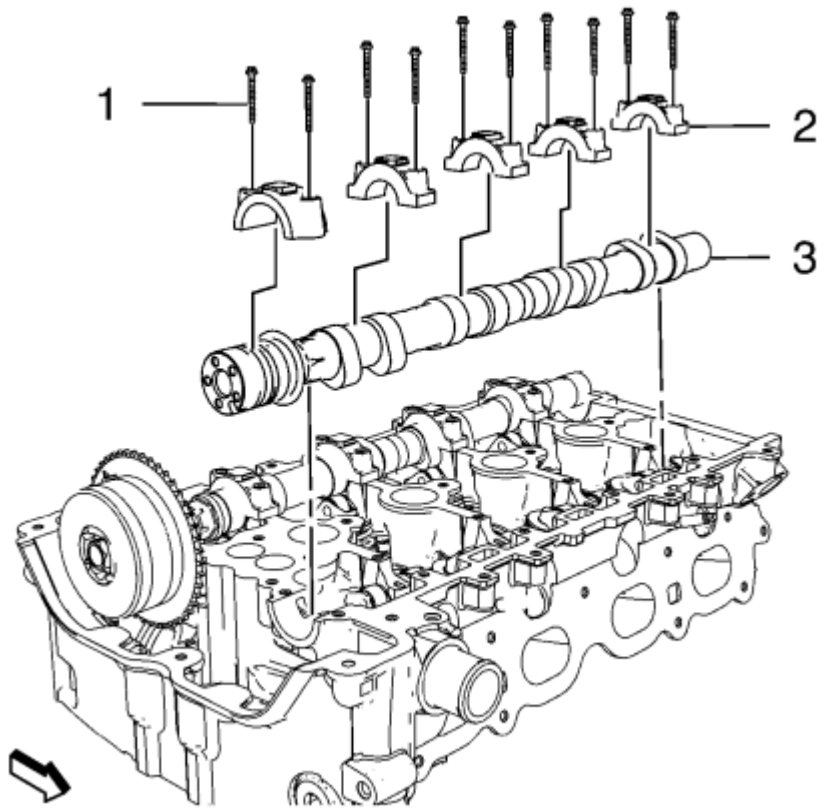


**Fig. 78: Intake Camshaft, Bearing Cap & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

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

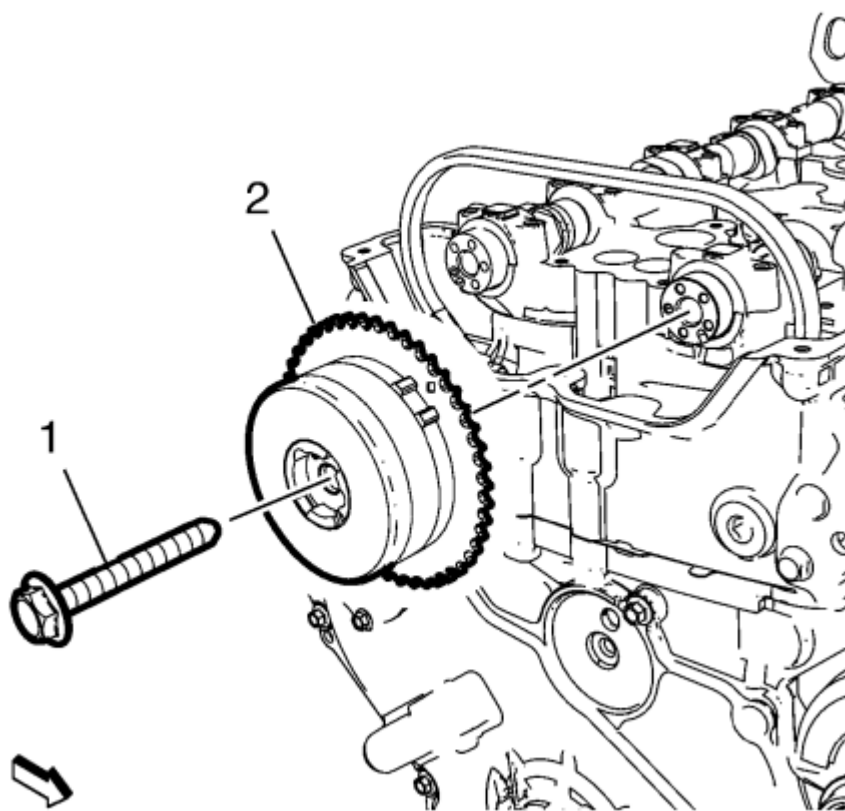
21. Remove the 10 bearing cap bolts (1).
22. Remove the 5 bearing caps (2).
23. Remove the intake camshaft (3).

**Installation Procedure**



**Fig. 79: Intake Camshaft, Bearing Cap & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

1. Install the intake camshaft (3).
2. Install the 5 bearing caps (2).
3. Install the 10 bearing cap bolts (1) and hand tighten.
4. Tighten the bearing cap bolts in increments of 3 turns until they are seated.
5. When all the bearing caps are seated, tighten the bolts to 10 N.m (89 lb in).

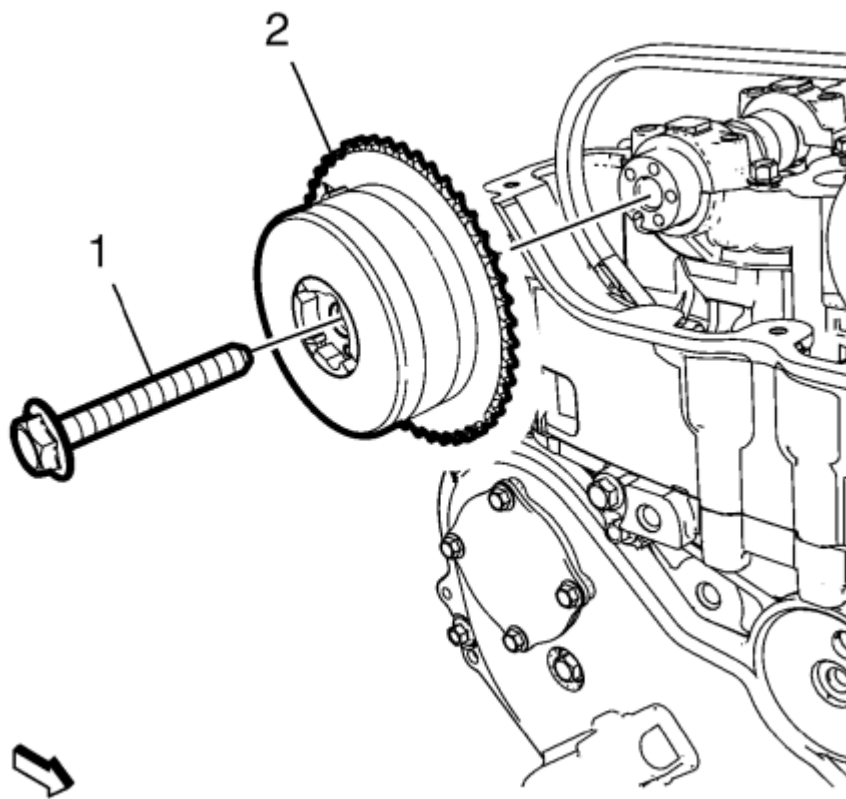


**Fig. 80: Camshaft Intake Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ensure the timing chain and the camshaft position actuators are on their marked points.

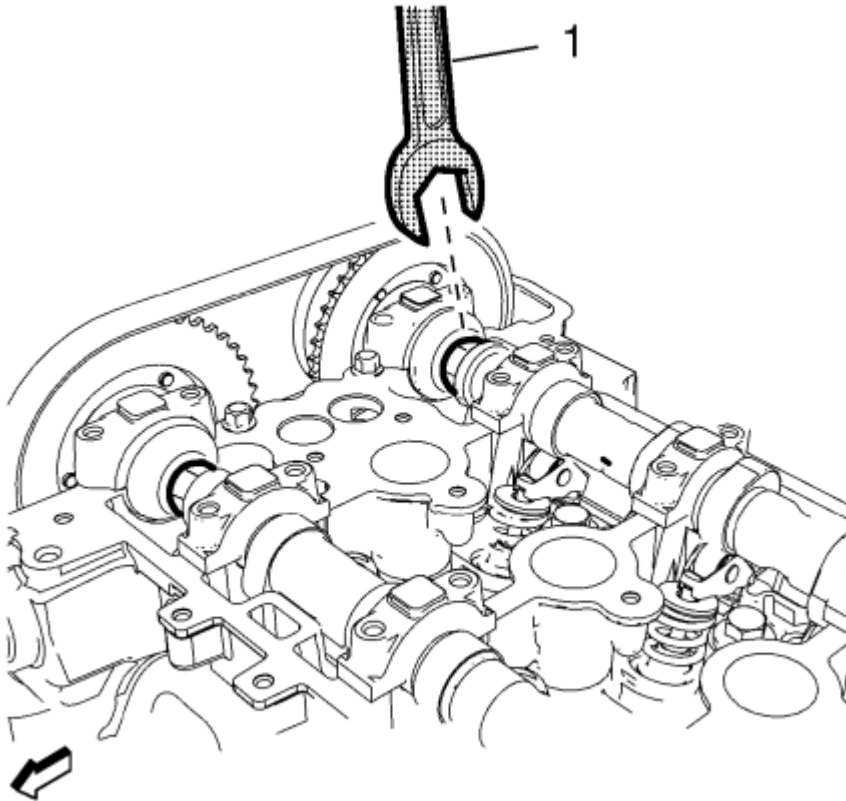
Ensure that the exhaust camshaft actuator fully fits in the exhaust camshaft.

6. Install the intake camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.



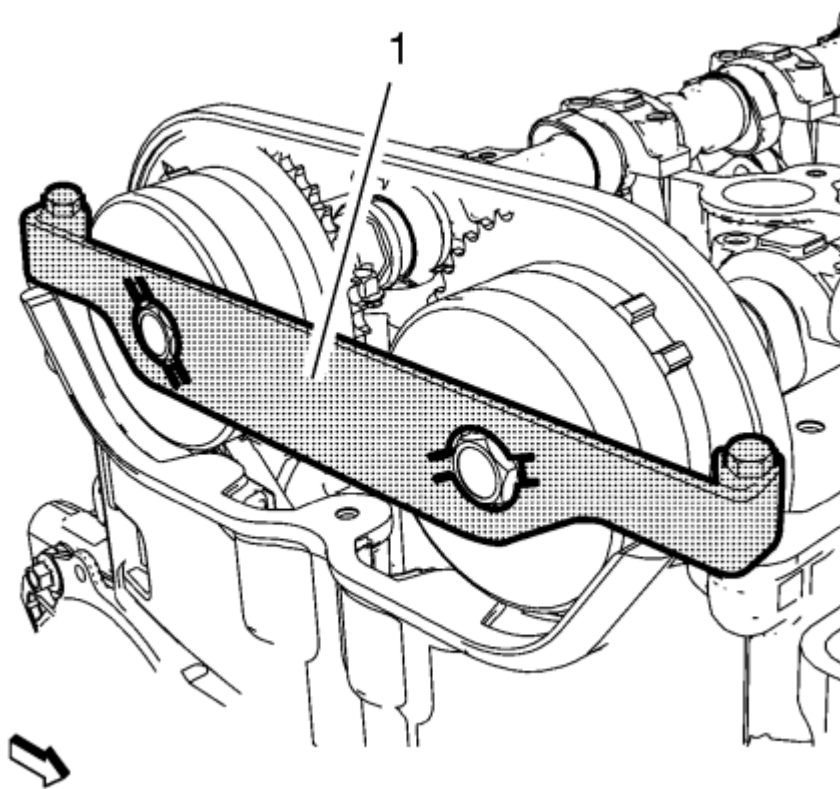
**Fig. 81: Camshaft Position Exhaust Actuator & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

7. Install the exhaust camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.



**Fig. 82: Open Ended Wrench & Actuator Bolt**  
Courtesy of GENERAL MOTORS COMPANY

8. Rotate the intake camshaft with a open ended wrench to install the camshaft intake actuator on the marked points.
9. Install the NEW camshaft position intake actuator bolt (1) and hand tighten.
10. Rotate the exhaust camshaft with a open ended wrench (1) to install the camshaft exhaust actuator on the marked points.
11. Install the NEW camshaft position exhaust actuator bolt handtighten.
12. Remove both **EN-48749** retention tool from the timing chain.
13. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



**Fig. 83: Crankshaft Locking Tool**

Courtesy of GENERAL MOTORS COMPANY

14. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.

**CAUTION: Refer to Fastener Caution .**

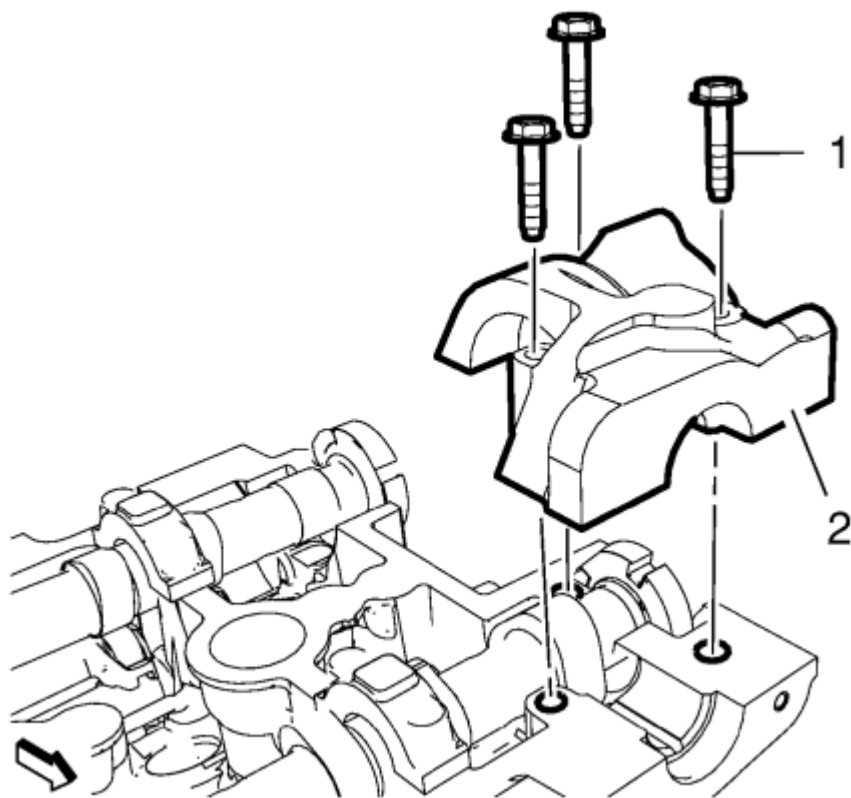
15. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

16. Tighten the intake camshaft actuator bolt a first pass to 30 N.m (22 lb ft).
17. Tighten the intake camshaft actuator bolt a final pass to an additional 100 degrees, using the **EN-45059** meter.

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

18. Tighten the exhaust camshaft actuator bolt a first pass to 30 N.m (22 lb ft).
19. Tighten the exhaust camshaft actuator bolt a final pass to an additional 100 degrees, using the **EN-45059** meter.
20. Remove the **EN-48953** locking tool.



**Fig. 84: Rear Bearing Block & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

21. Install the rear bearing block (2) and tighten the 3 rear bearing block bolts (1) to 12 N.m (106 lb in).
22. Rotate the crankshaft clockwise at the crankshaft balancer bolt to 720 degrees and ensure that the marks are still fit. If the marks are not fit, refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.
23. Install the Fuel Pump. Refer to **Fuel Pump Replacement** .
24. Install the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
25. Install the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
26. Install the spark plugs. Refer to **Spark Plug Replacement** .
27. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

## EXHAUST CAMSHAFT REPLACEMENT

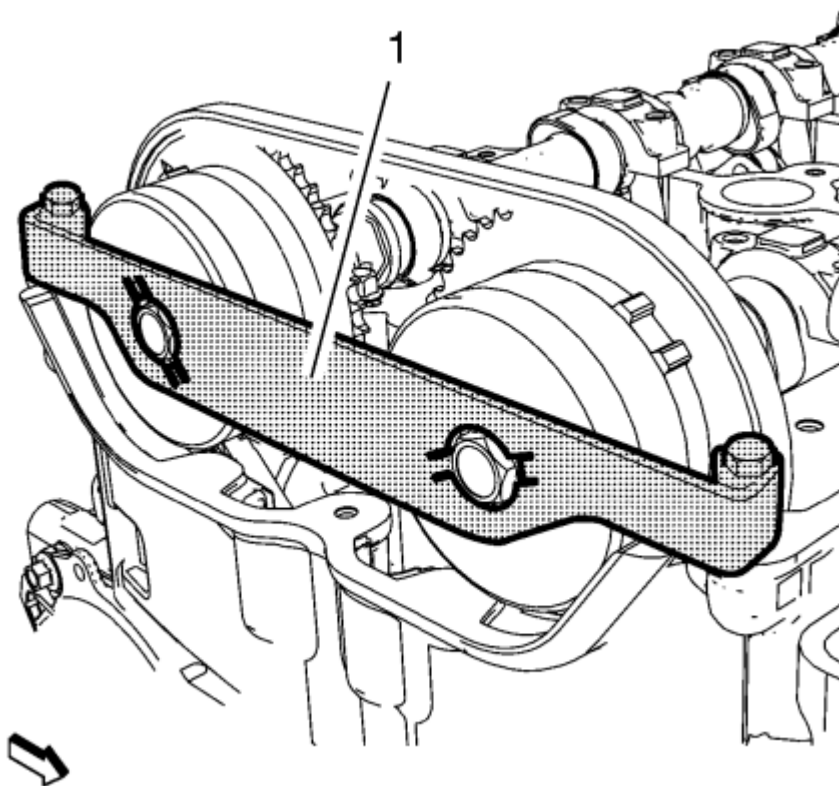
### Special Tools

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

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

#### Removal Procedure

1. Remove the spark plugs. Refer to **Spark Plug Replacement** .
2. Remove the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
3. Remove the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .



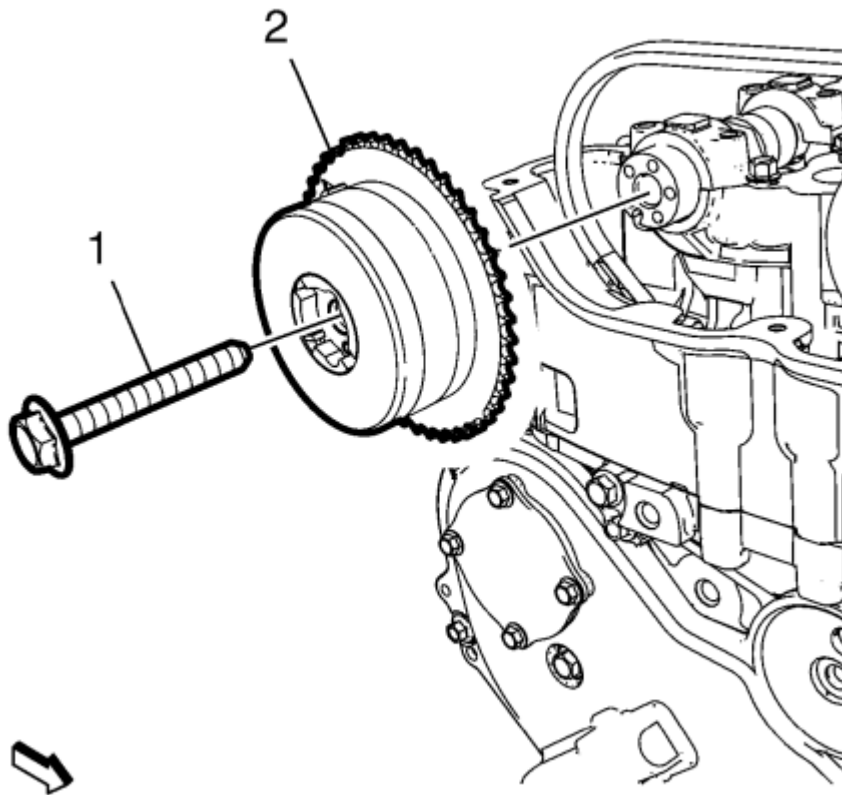
**Fig. 85: Crankshaft Locking Tool**

Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.

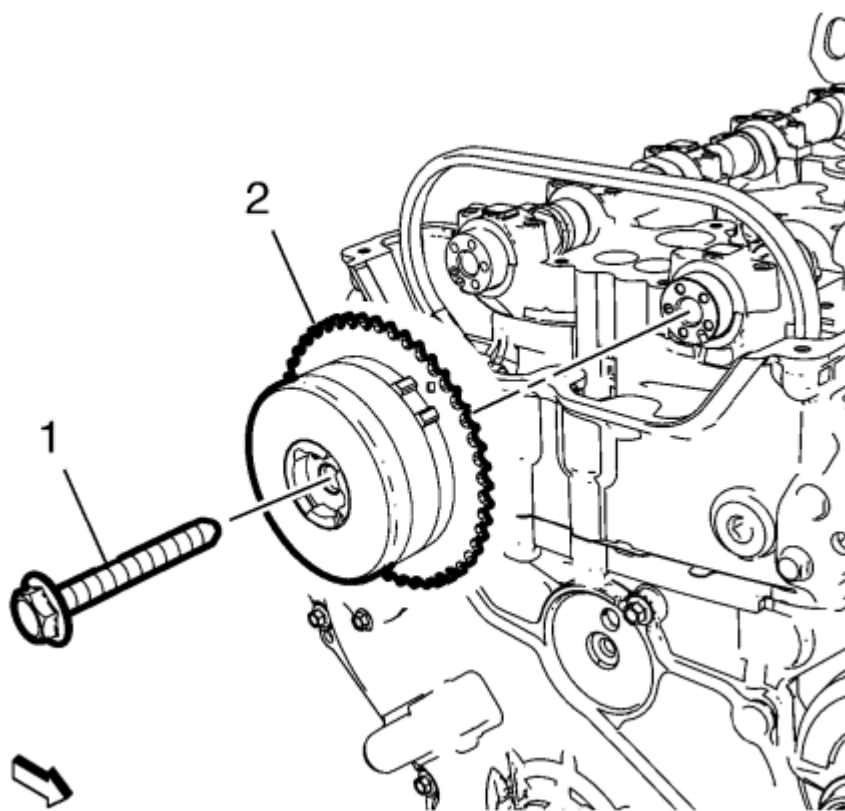
**CAUTION:** Refer to **Fastener Caution** .

5. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).



**Fig. 86: Camshaft Position Exhaust Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

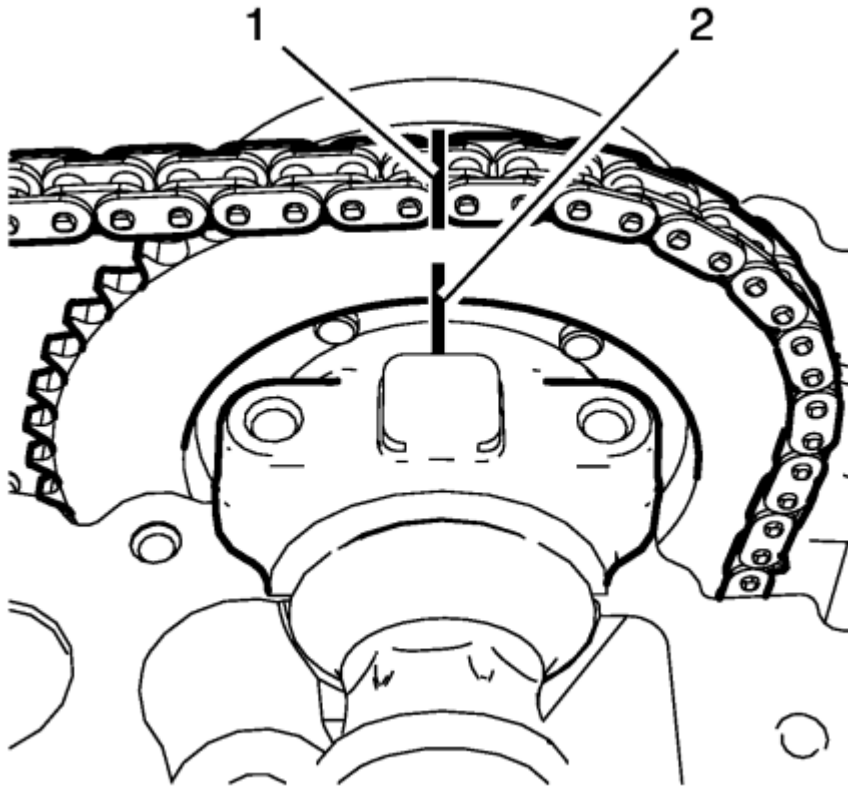
6. Loosen, but DO NOT remove, the camshaft position exhaust actuator bolt (1) from the exhaust camshaft actuator (2).



**Fig. 87: Camshaft Intake Actuator & Bolt**

Courtesy of GENERAL MOTORS COMPANY

7. Loosen, but DO NOT remove, the camshaft position intake actuator bolt (1) from the camshaft position intake actuator (2).
8. Remove the **EN-48953** locking tool.
9. Rotate the crankshaft clockwise at the crankshaft balancer bolt to the TDC of the combustion stroke of cylinder 1.

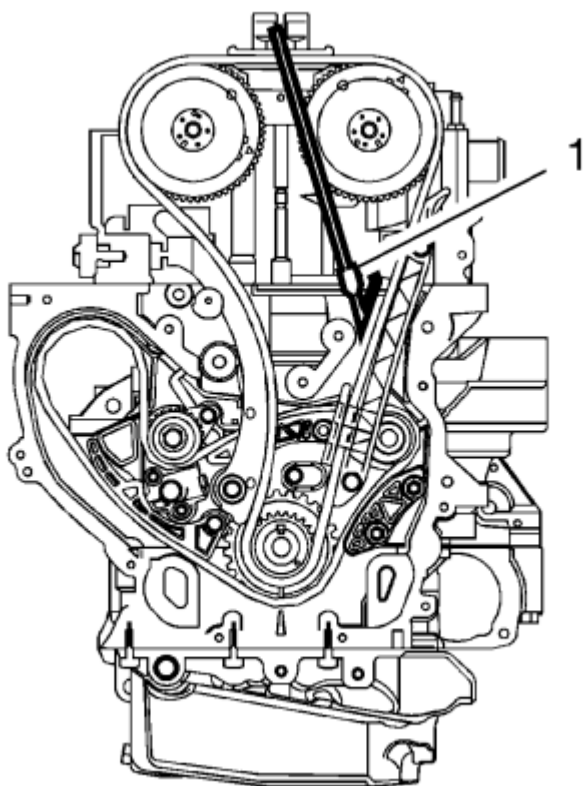


**Fig. 88: Timing Chain & Camshaft Bearing Cover Marks**

Courtesy of GENERAL MOTORS COMPANY

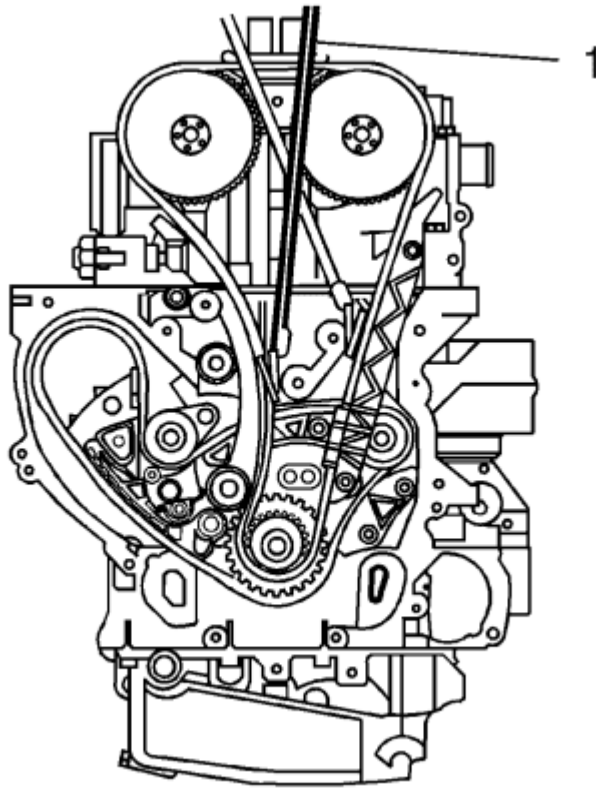
**NOTE:** Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

10. Mark both camshaft actuators and their respective locations on the timing chain (1). Mark additional the position from the camshaft actuator to the camshaft bearing cover (2).
11. Remove the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



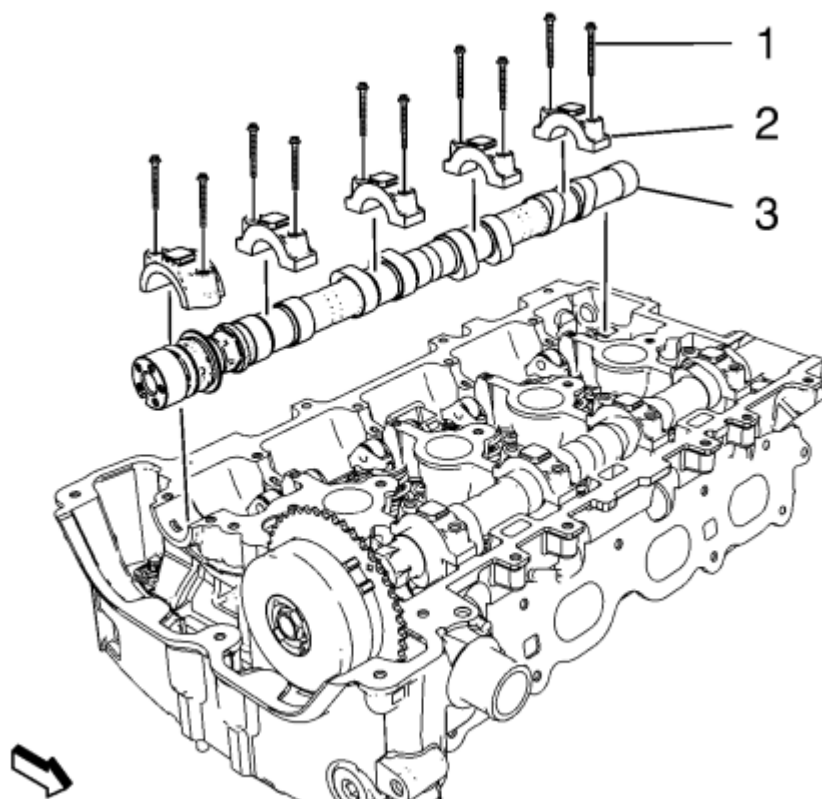
**Fig. 89: Timing Chain Retention Tool On Intake Side**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 90: Timing Chain Retention Tool On Exhaust Side**  
**Courtesy of GENERAL MOTORS COMPANY**

13. Install the **EN-48749** retention tool (1) to the exhaust side of the timing chain.
14. Remove and DISCARD the camshaft position exhaust actuator bolt.
15. Remove the exhaust camshaft actuator from the camshaft while also removing the actuator from the timing chain.
16. Remove and DISCARD the camshaft position intake actuator bolt.
17. Remove the intake camshaft actuator from the camshaft while also removing the actuator from the timing chain.
18. Mark the bearing caps to ensure they are installed in the original position.

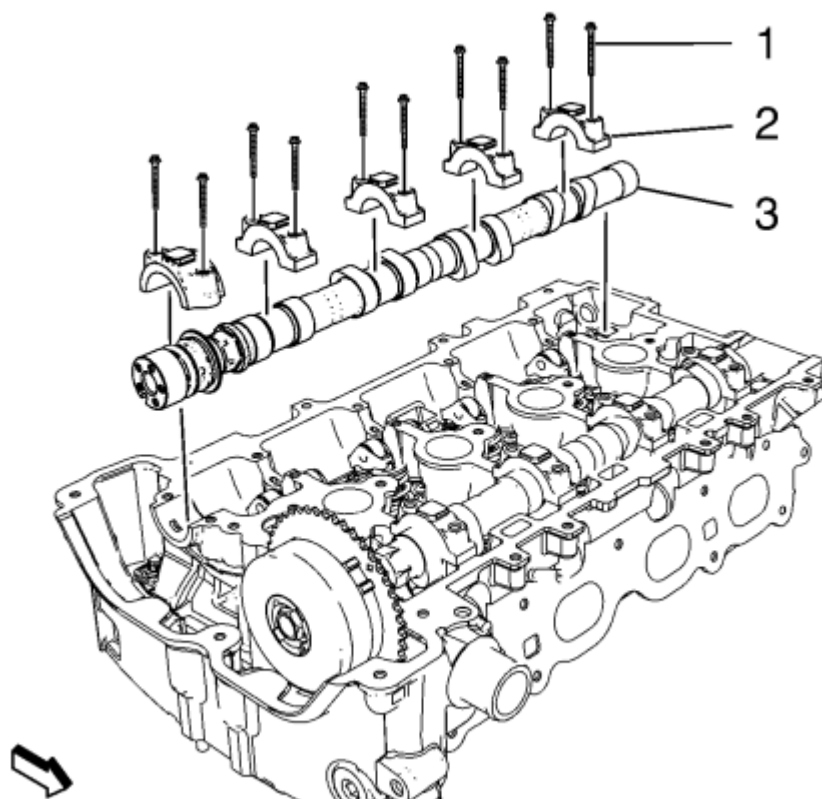


**Fig. 91: Exhaust Camshaft, Bearing Caps & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

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

19. Remove the 10 bearing cap bolts (1)
20. Remove the 5 bearing caps (2)
21. Remove the exhaust camshaft (3).

#### Installation Procedure

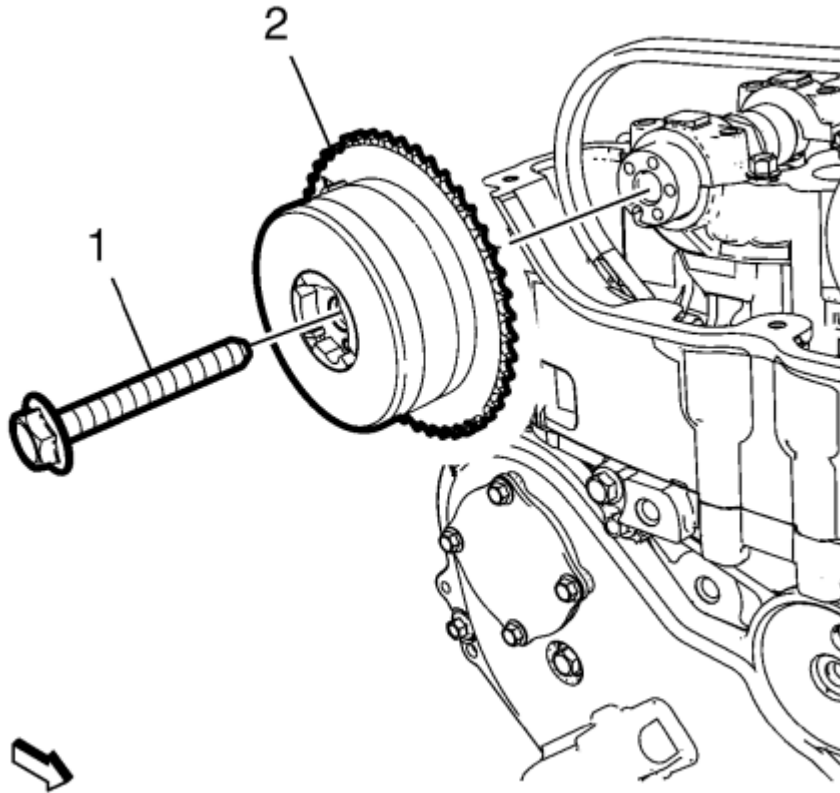


**Fig. 92: Exhaust Camshaft, Bearing Caps & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust camshaft (3).
2. Install the 5 bearing caps (2).
3. Install the 10 bearing cap bolts (1) hand tighten.

**CAUTION: Refer to Fastener Caution .**

4. Tighten the bearing cap bolts in increments of 3 turns until they are seated.
5. When all the bearing caps are seated, tighten the bolts to 10 N.m (89 lb in).

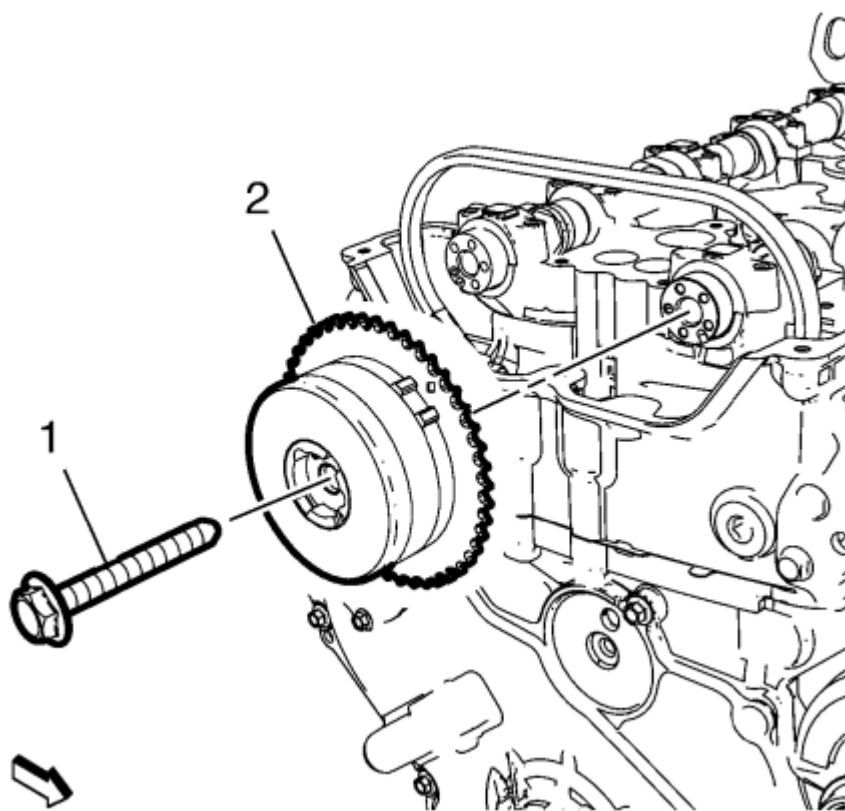


**Fig. 93: Camshaft Position Exhaust Actuator & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

**NOTE:** Ensure the timing chain and the camshaft position actuators are on their marked points.

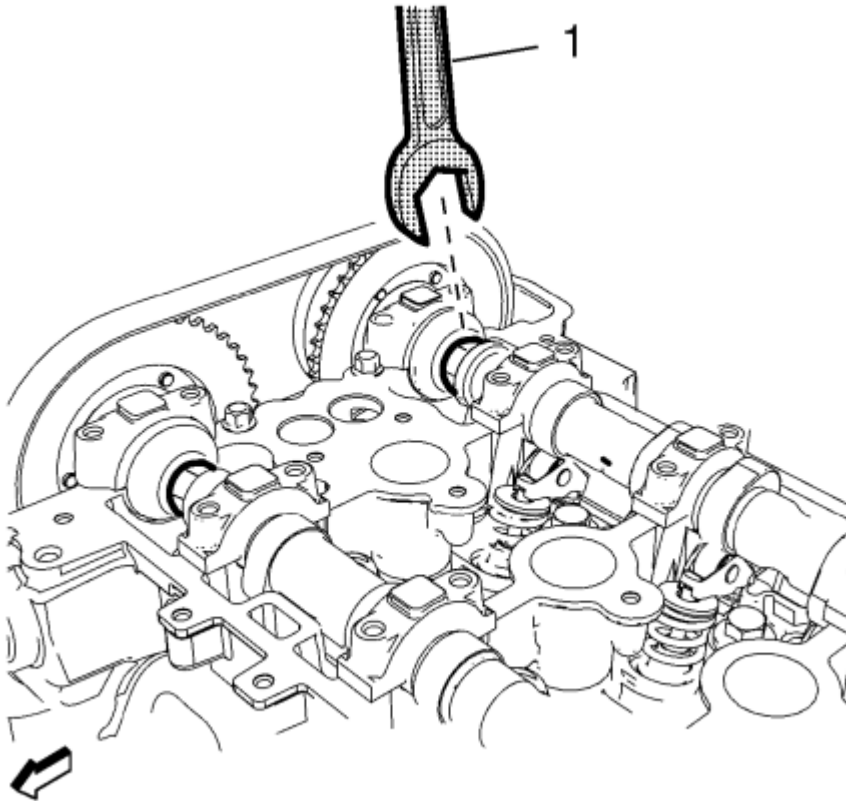
**Ensure that the exhaust camshaft actuator fully fits in the exhaust camshaft.**

6. Install the exhaust camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.



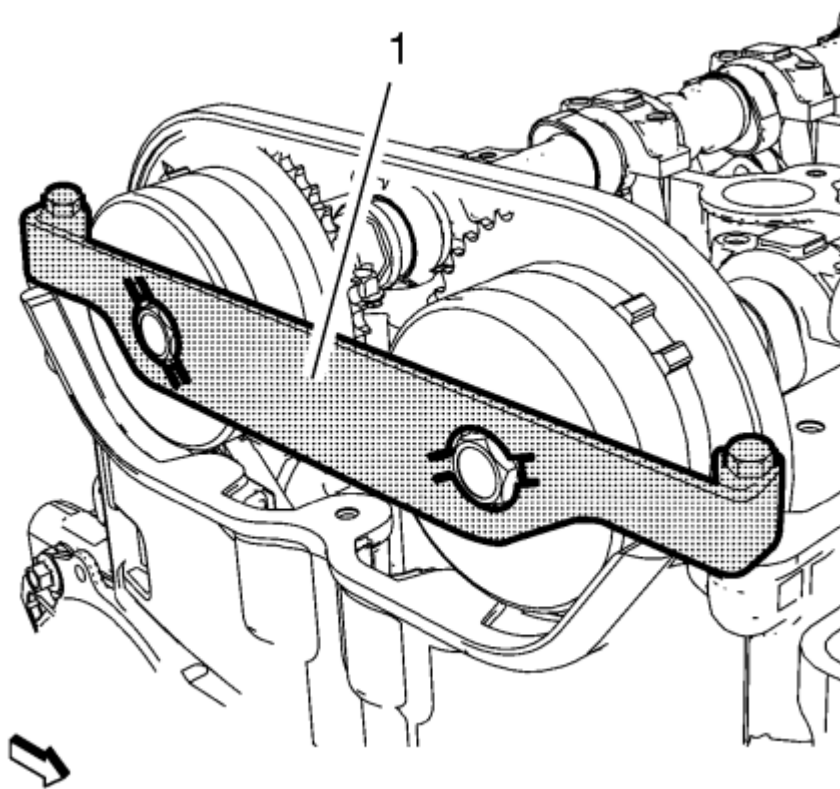
**Fig. 94: Camshaft Intake Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

7. Install the intake camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.



**Fig. 95: Open Ended Wrench & Actuator Bolt**  
Courtesy of GENERAL MOTORS COMPANY

8. Rotate the exhaust camshaft with a open ended wrench (1) to install the camshaft exhaust actuator on the marked points.
9. Install the NEW camshaft position exhaust actuator bolt handtighten.
10. Rotate the intake camshaft with a open ended wrench (1) to install the camshaft intake actuator on the marked points.
11. Install the NEW camshaft position intake actuator bolt handtighten.
12. Remove both **EN-48749** retention tool from the timing chain.
13. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



**Fig. 96: Crankshaft Locking Tool**

Courtesy of GENERAL MOTORS COMPANY

14. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.
15. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

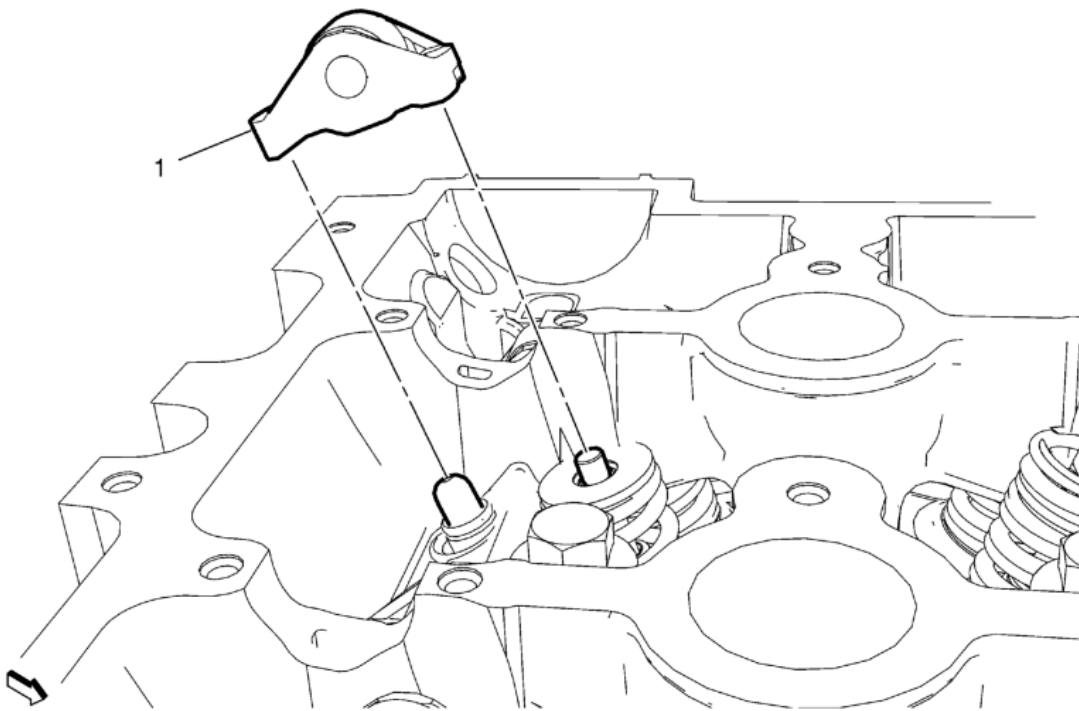
16. Tighten the NEW exhaust camshaft actuator bolt a first pass to 30 N.m (22 lb ft).
17. Tighten the exhaust camshaft actuator bolt a final pass to an additional 100 degrees, using the **EN-45059** meter.

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

18. Tighten the NEW intake camshaft actuator bolt a first pass to 30 N.m (22 lb ft).
19. Tighten the intake camshaft actuator bolt a final pass to an additional 100 degrees, using the **EN-45059** meter.

20. Remove the **EN-48953** locking tool.
21. Rotate the crankshaft clockwise at the crankshaft balancer bolt to 720 degrees and ensure that the marks are still fit. If the marks are not fit, refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.
22. Install the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement**.
23. Install the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
24. Install the spark plugs. Refer to **Spark Plug Replacement**.

## VALVE ROCKER ARM REPLACEMENT



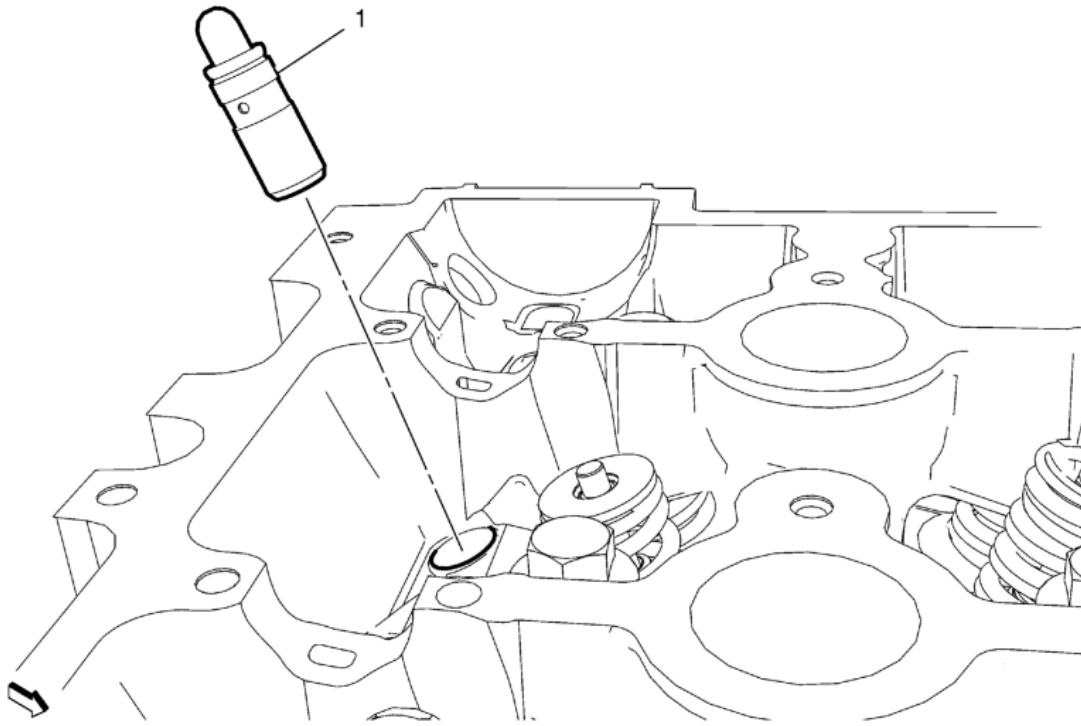
**Fig. 97: Valve Rocker Arms**

Courtesy of GENERAL MOTORS COMPANY

### Valve Rocker Arm Replacement

| Callout                                                                               | Component Name             |
|---------------------------------------------------------------------------------------|----------------------------|
| <b>Preliminary Procedures</b>                                                         |                            |
| 1. Remove the exhaust camshaft. Refer to <b><u>Exhaust Camshaft Replacement</u></b> . |                            |
| 2. Remove the intake camshaft. Refer to <b><u>Intake Camshaft Replacement</u></b> .   |                            |
| 1                                                                                     | Valve Rocker Arm (Qty: 16) |

## HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT



**Fig. 98: Hydraulic Valve Lash Adjusters**  
 Courtesy of GENERAL MOTORS COMPANY

### Hydraulic Valve Lash Adjuster Replacement

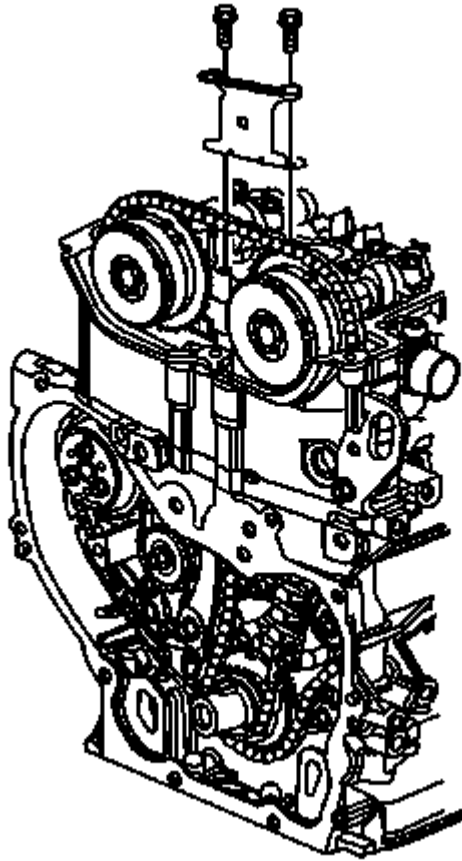
| Callout                                                                                                                                                                                                                                                                      | Component Name                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                                                                                                                                                                                                                                |                                                                                                                              |
| 1. Remove the exhaust camshaft. Refer to <a href="#">Exhaust Camshaft Replacement</a> .<br>2. Remove the intake camshaft. Refer to <a href="#">Intake Camshaft Replacement</a> .<br>3. Remove the valve rocker arms. Refer to <a href="#">Valve Rocker Arm Replacement</a> . |                                                                                                                              |
| 1                                                                                                                                                                                                                                                                            | Hydraulic Valve Lash Adjuster (Qty: 16)<br><b>Procedure</b><br>Install the new hydraulic valve lash adjuster with engine oil |

### CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

#### Special Tools

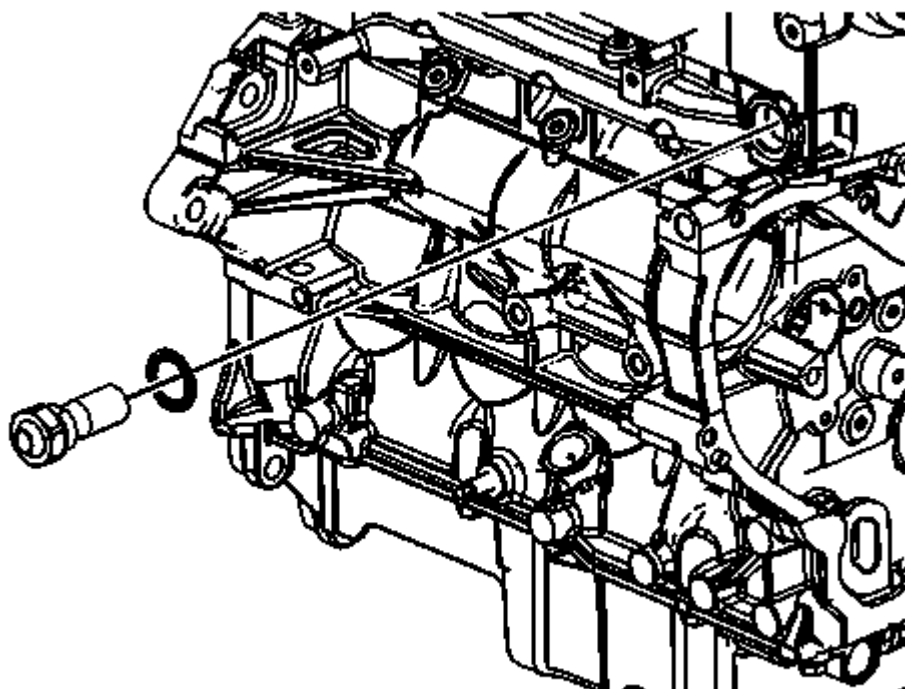
- **EN-45027** Tensioner Tool
- **EN-45059** Angle Meter
- **EN-48953** Camshaft Actuator Locking Tool

For equivalent regional tools, refer to [Special Tools](#).

**Removal Procedure**

**Fig. 99: View Of Upper Timing Chain Guide & Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

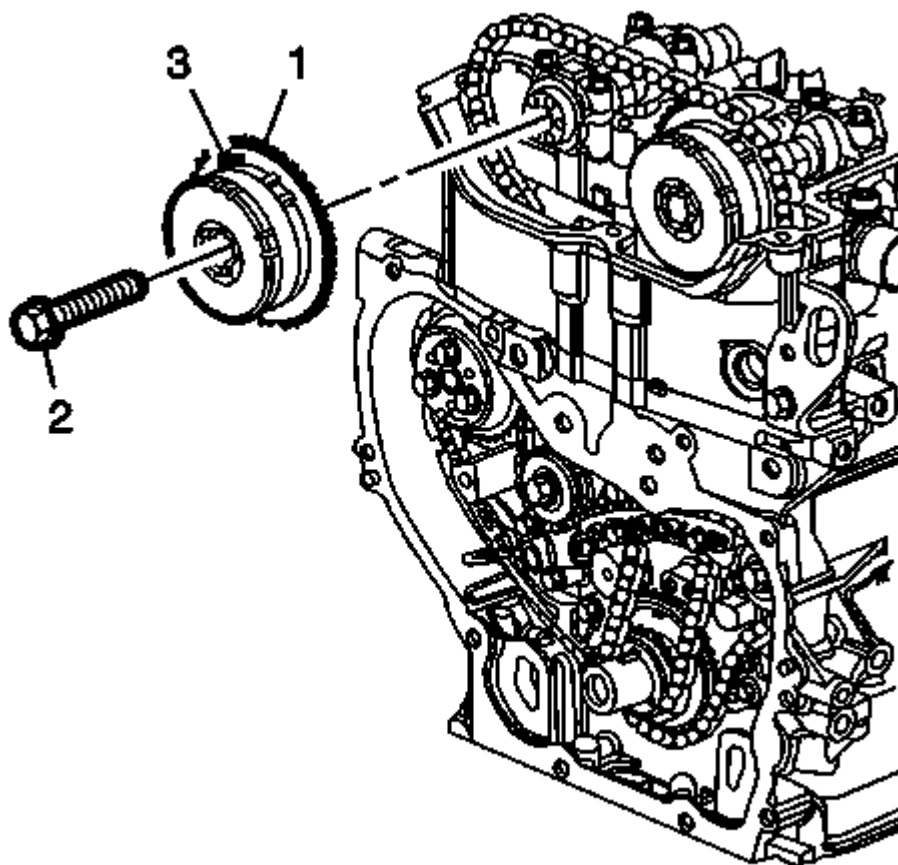
1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the number 1 cylinder spark plug. Refer to **Spark Plug Replacement**.
3. Rotate the crankshaft in the engine rotational direction clockwise, until the number 1 piston is at top dead center (TDC) on the exhaust stroke.
4.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



**Fig. 100: View Of Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS COMPANY

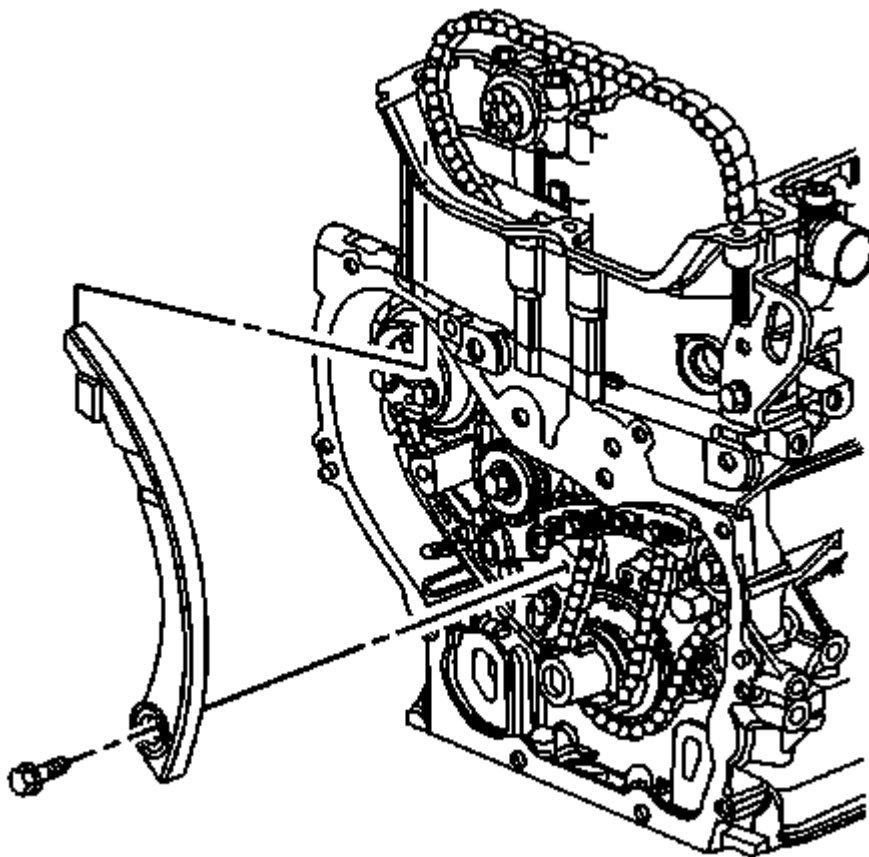
**NOTE:** The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

6. Remove the timing chain tensioner.



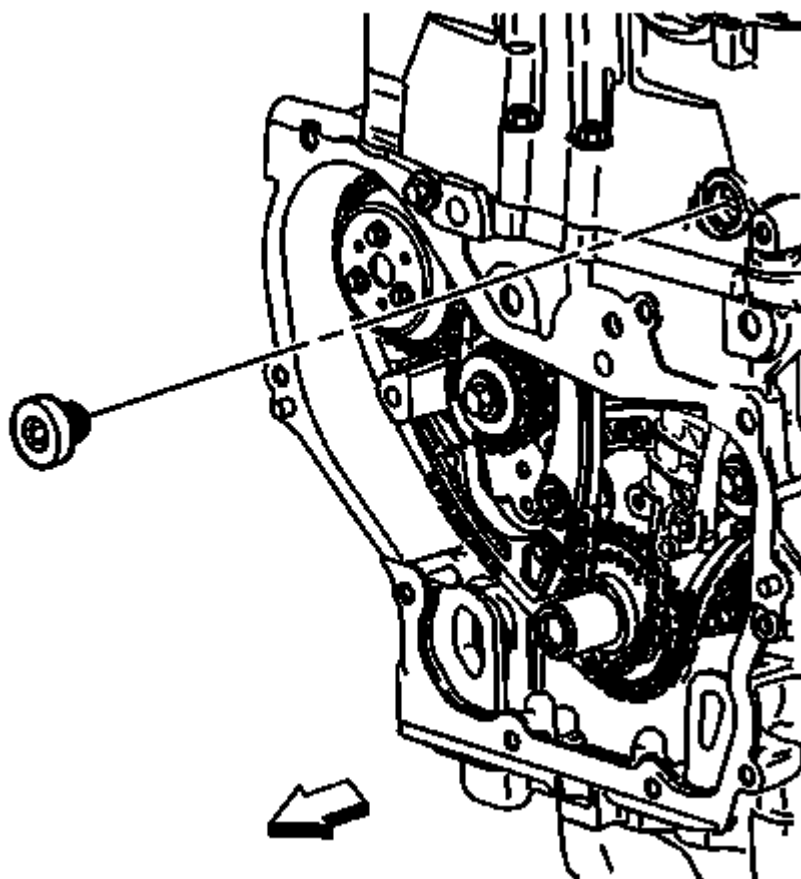
**Fig. 101: Exhaust Camshaft Sprocket**  
**Courtesy of GENERAL MOTORS COMPANY**

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.



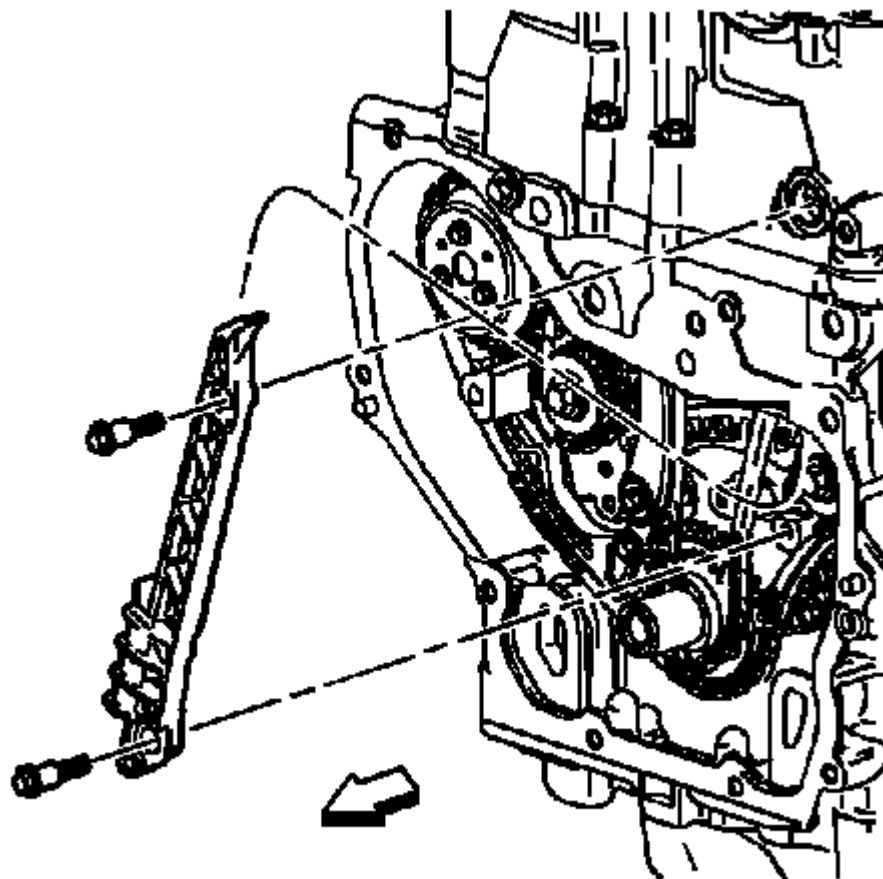
**Fig. 102: Timing Chain Tensioner Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



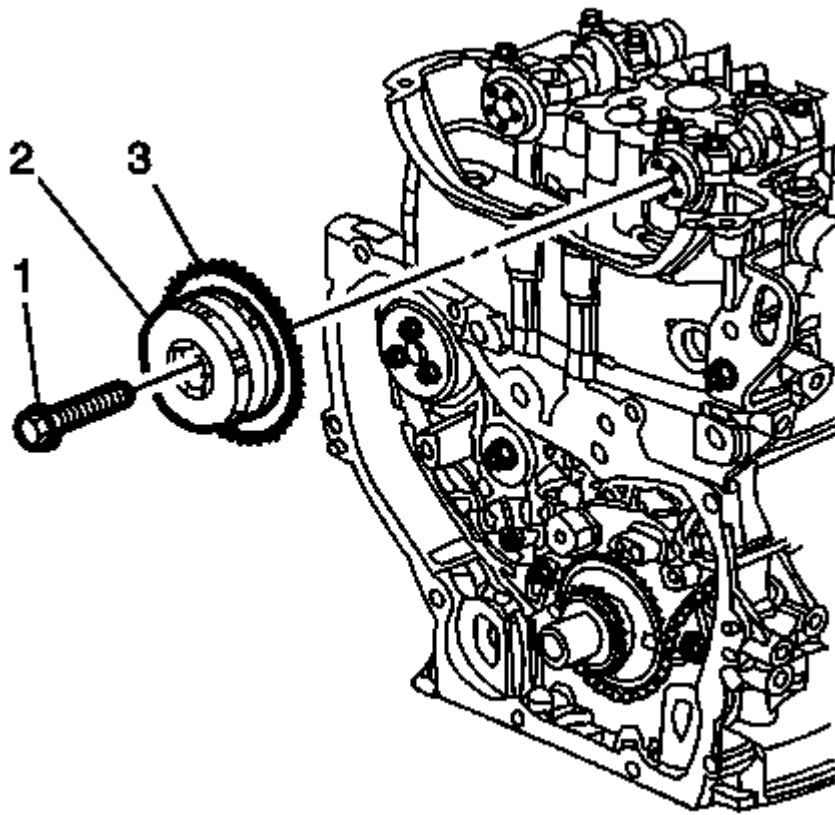
**Fig. 103: View Of Fixed Timing Chain Guide Access Plug**  
Courtesy of GENERAL MOTORS COMPANY

11. Remove the fixed timing chain guide access plug.



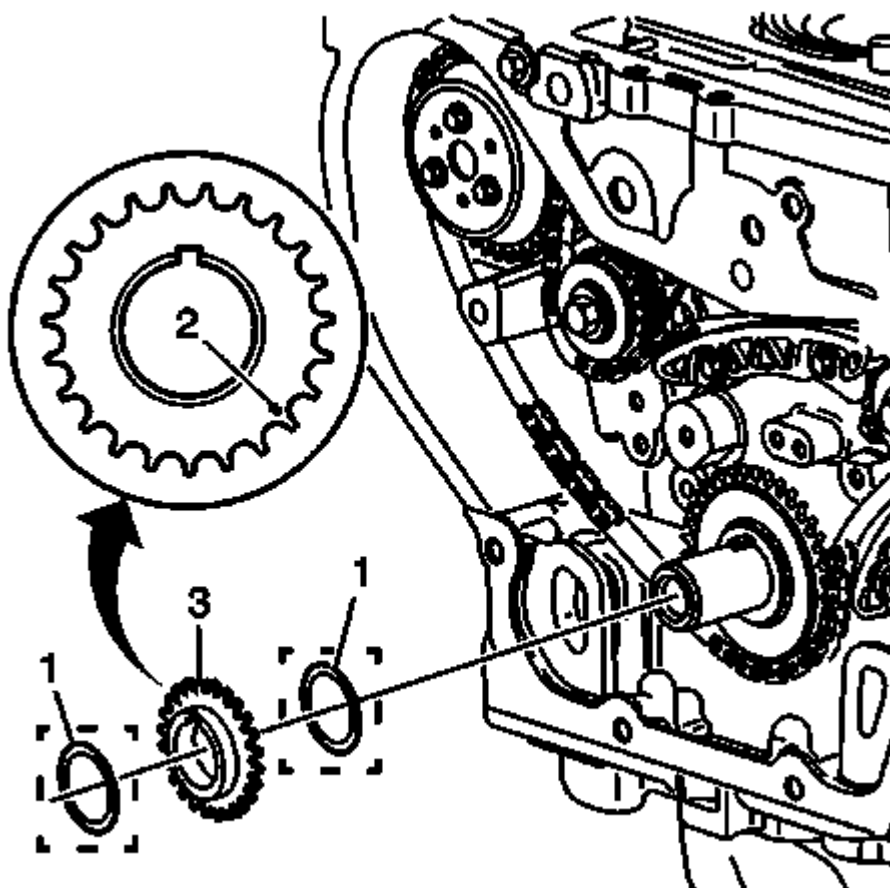
**Fig. 104: View Of Fixed Timing Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 105: Timing Chain & Camshaft Position Actuator**  
**Courtesy of GENERAL MOTORS COMPANY**

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.

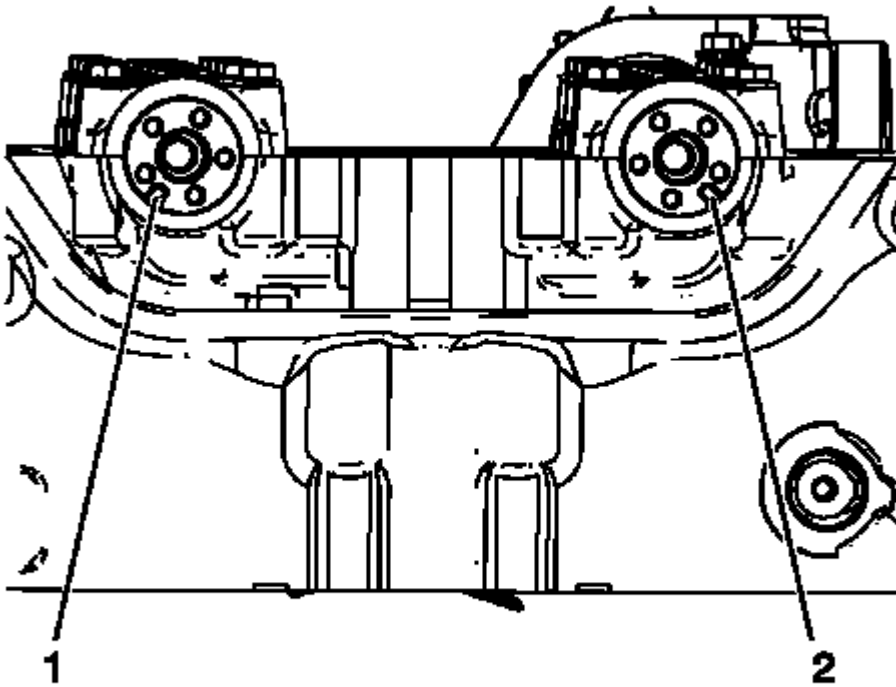


**Fig. 106: View of Friction Washer & Timing Chain Drive Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ecotec 4 cylinder engines with SIDI-Direct Injection, the lower timing chain crank gear may be equipped with a second spacing washer installed in front of the lower timing chain crank gear. The outer spacer/washer is in between the crank/balancer pulley and the lower timing gear and may remain in place when the pulley is removed. The spacer/washer has a dot/mark on its surface that may be mistaken for the lower timing mark. If applicable, the washer must be removed in order to view the correct timing mark on the lower crank gear.

16. Remove the outer friction washer (1) if equipped.
17. Ensure the crankshaft gear timing mark (2) is in the 5 o'clock position and crankshaft key is in the 12 o'clock position.
18. Remove the crankshaft sprocket (3).
19. Remove the inner friction washer (1).

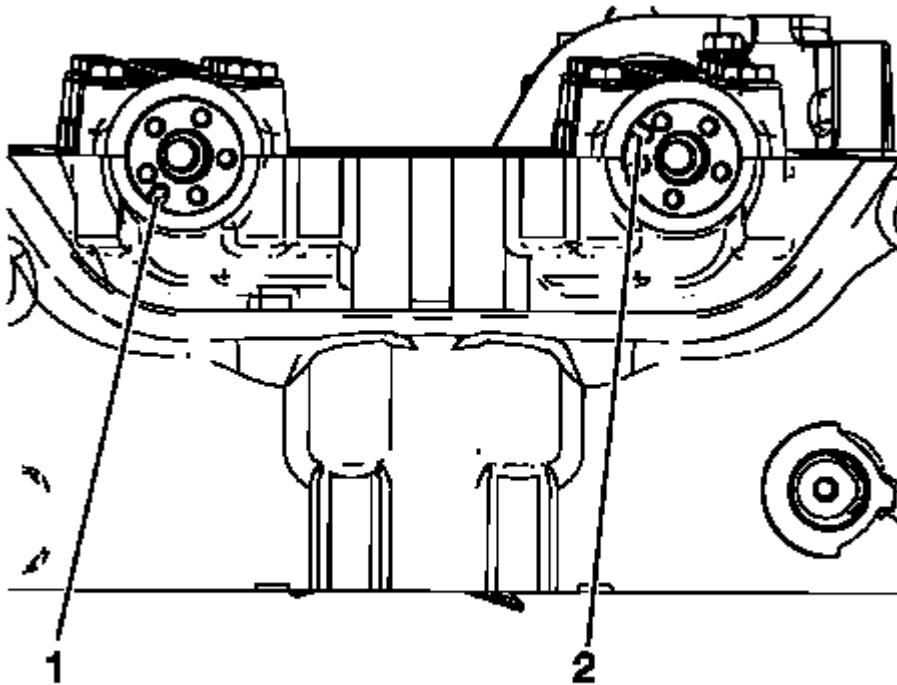
#### Installation Procedure



**Fig. 107: Identifying Proper Exhaust/Intake Camshaft Alignment positions**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** If equipped with the following engine; LE5, LE9, LAT, LNF, LDK, LHU, LTD, LBN, or 2010 LAF, ensure the intake camshaft notch is in the 5 o'clock position and the exhaust camshaft notch is in the 7 o'clock position.

1. 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 top dead center (TDC), crankshaft key at 12 o'clock.

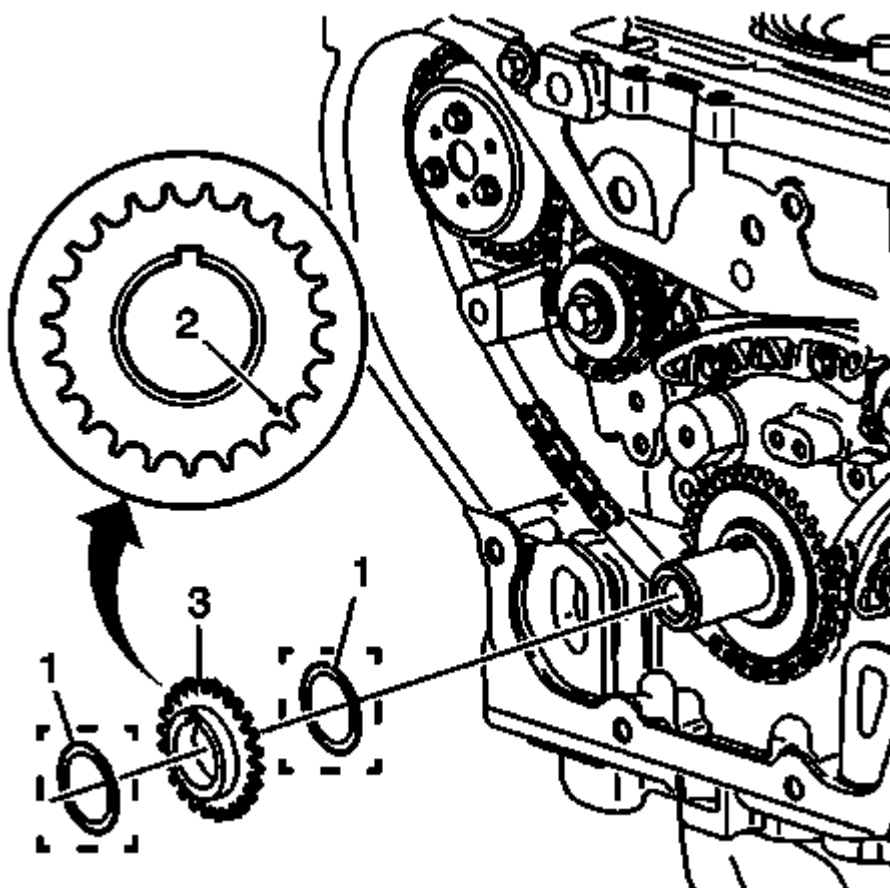


**Fig. 108: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** If equipped with following engine; LAP, LE8, LEA, LUK , or 2011 LAF, ensure the intake camshaft notch is in the 10 o'clock position and the exhaust camshaft notch is in the 7 o'clock position.

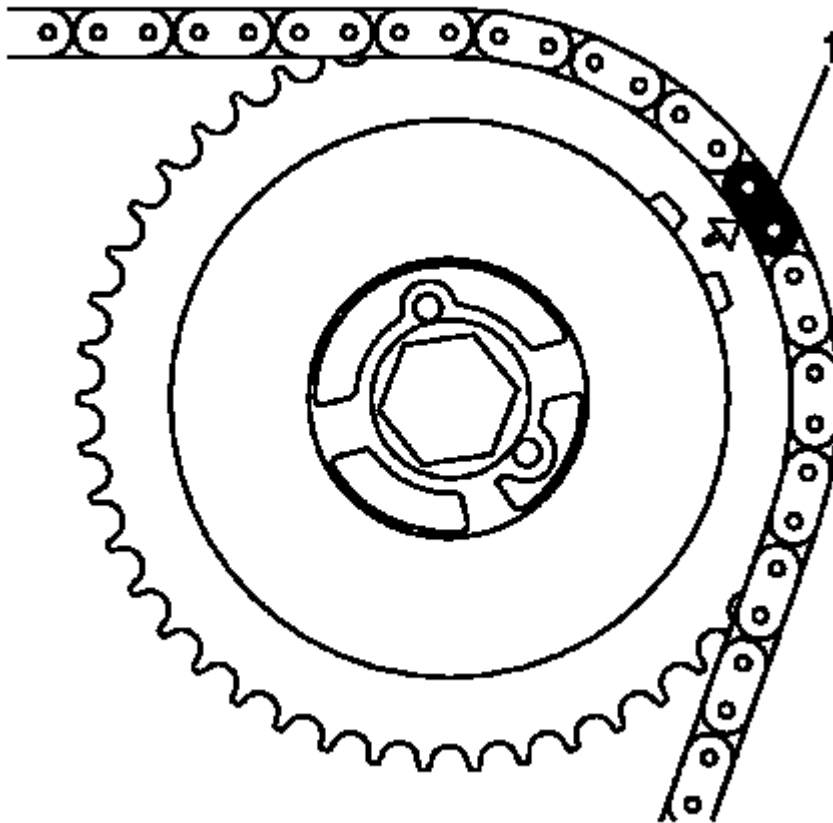
2. Ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.



**Fig. 109: View of Friction Washer & Timing Chain Drive Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ecotec 4 cylinder engines with SIDI-Direct Injection, the lower timing chain crank gear may be equipped with a second spacing washer installed in front of the lower timing chain crank gear. The outer spacer/washer is in between the crank/balancer pulley and the lower timing gear and may remain in place when the pulley is removed. The spacer/washer has a dot/mark on its surface that may be mistaken for the lower timing mark. If applicable, the washer must be removed in order to view the correct timing mark on the lower crank gear.

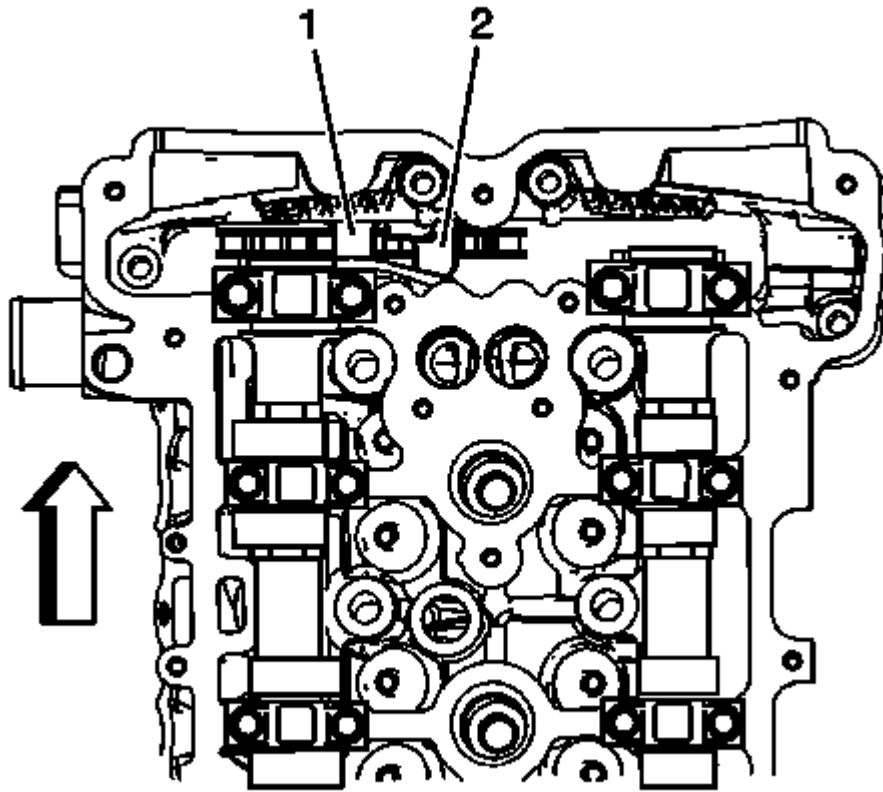
3. Install the inner friction washer (1).
4. Install the crankshaft sprocket with the timing mark (2) is in the 5 o'clock position and facing outward.
5. Install the outer friction washer (1) if equipped.



**Fig. 110: Identifying Colored Links On Timing Chain**  
Courtesy of GENERAL MOTORS COMPANY

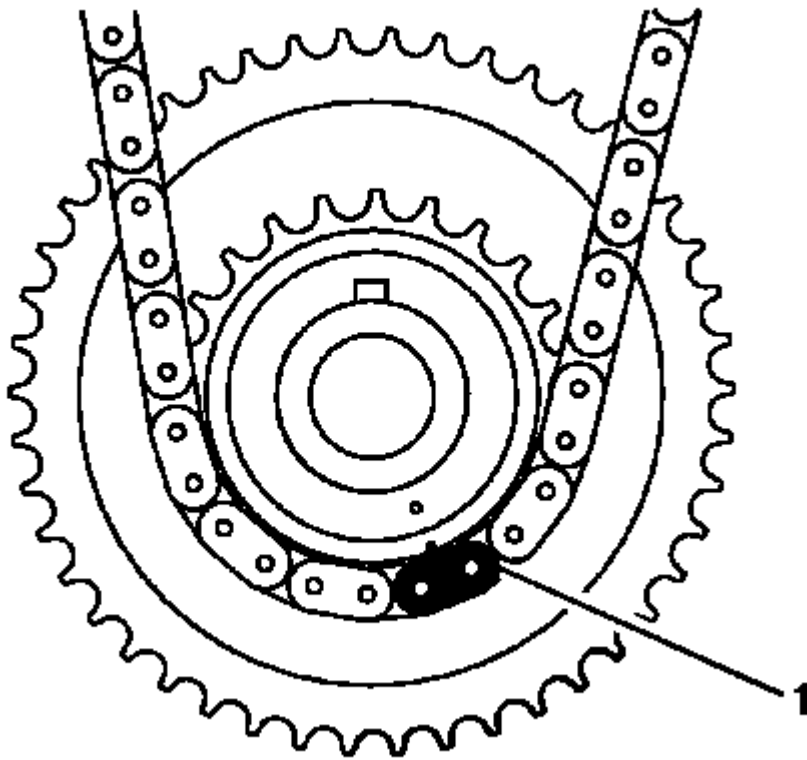
**NOTE:**

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



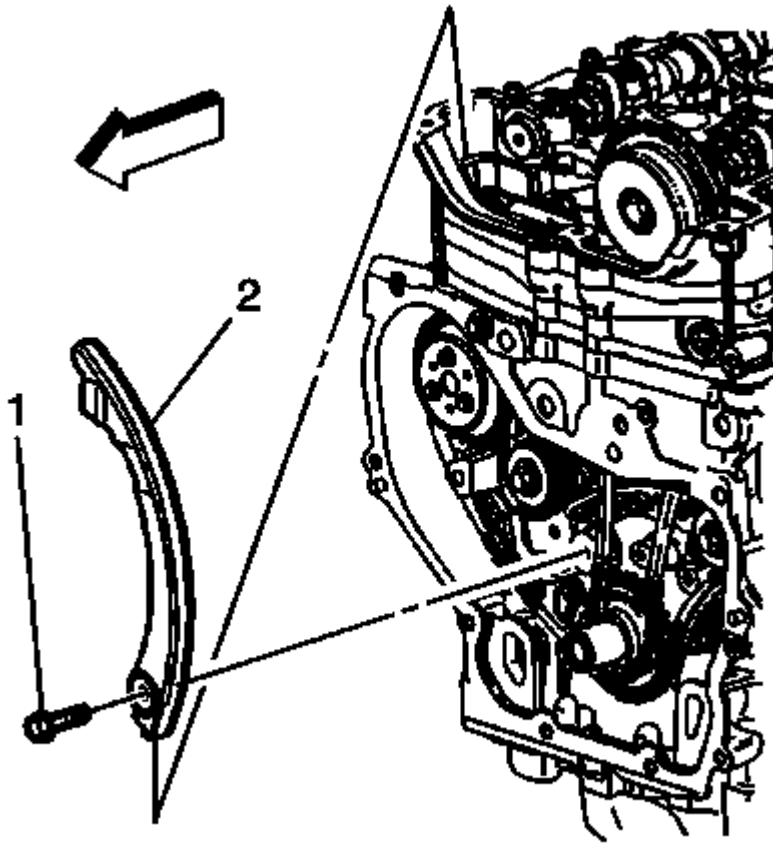
**Fig. 111: Identifying Cylinder Head Opening**  
Courtesy of GENERAL MOTORS COMPANY

7. 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).
8. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
9. Hand tighten the new intake camshaft actuator bolt.



**Fig. 112: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

10. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (1) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.
11. Install the friction washer, if applicable.

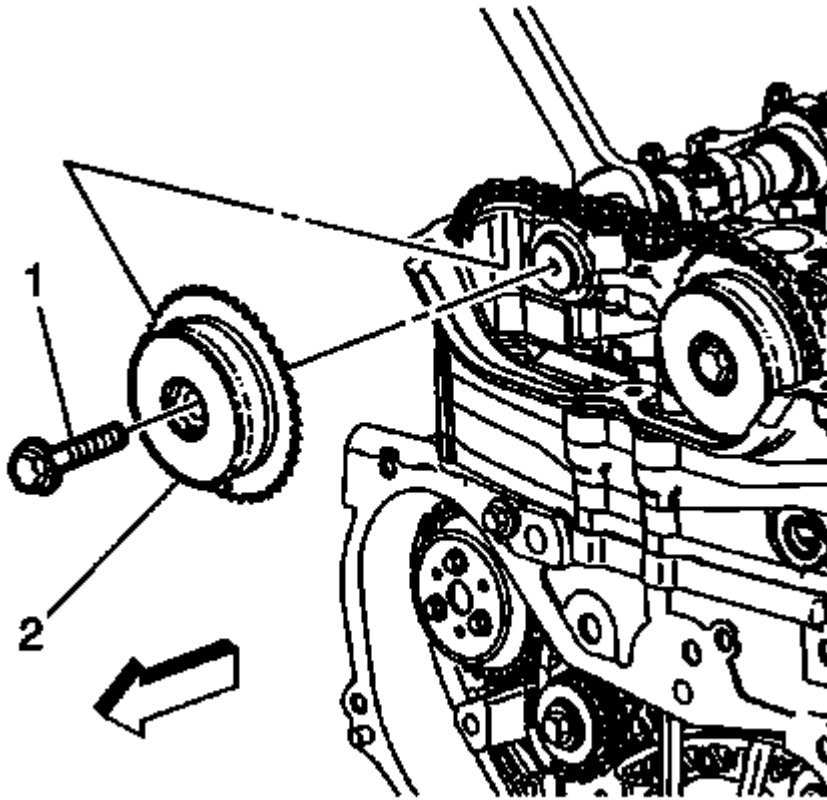


**Fig. 113: Adjustable Timing Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

13. Install the adjustable timing chain guide (2) down through the opening in the cylinder head and install the adjustable timing chain bolt (1). Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

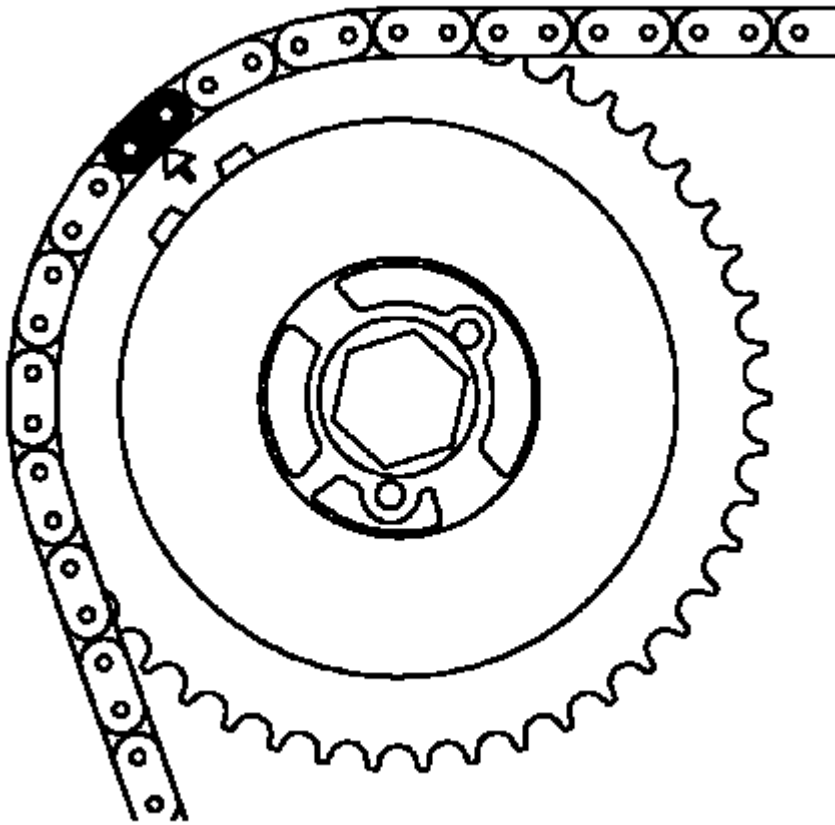


**Fig. 114: Camshaft Actuator**

Courtesy of GENERAL MOTORS COMPANY

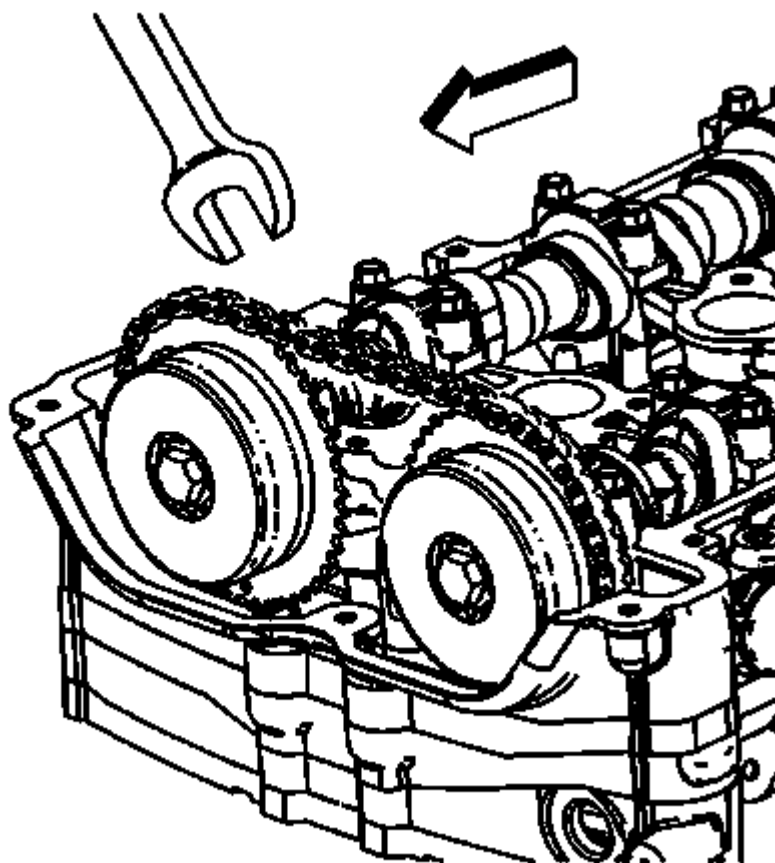
**NOTE:** Always install NEW actuator bolts (1).

14. Install the exhaust camshaft actuator (2) into the timing chain with the timing mark lined up with the second matching colored link.



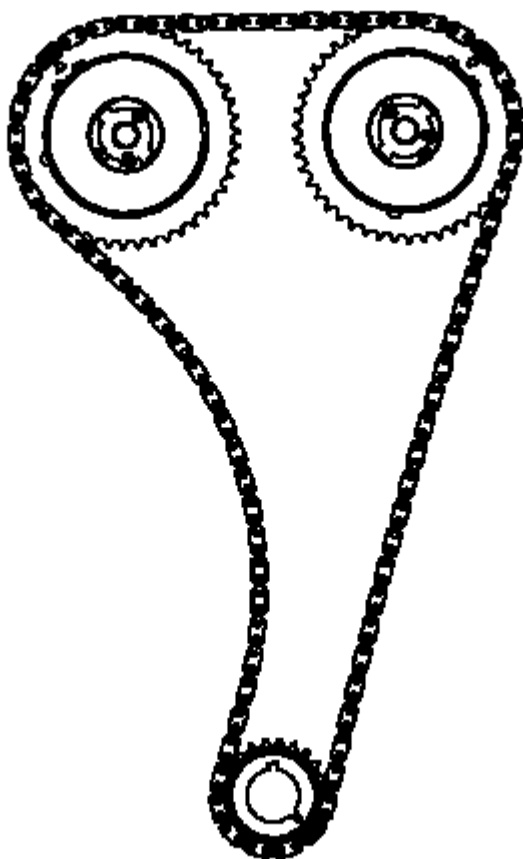
**Fig. 115: Aligning Timing Mark On Actuator With Last Pink Colored Link**  
Courtesy of GENERAL MOTORS COMPANY

15. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
16. 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.



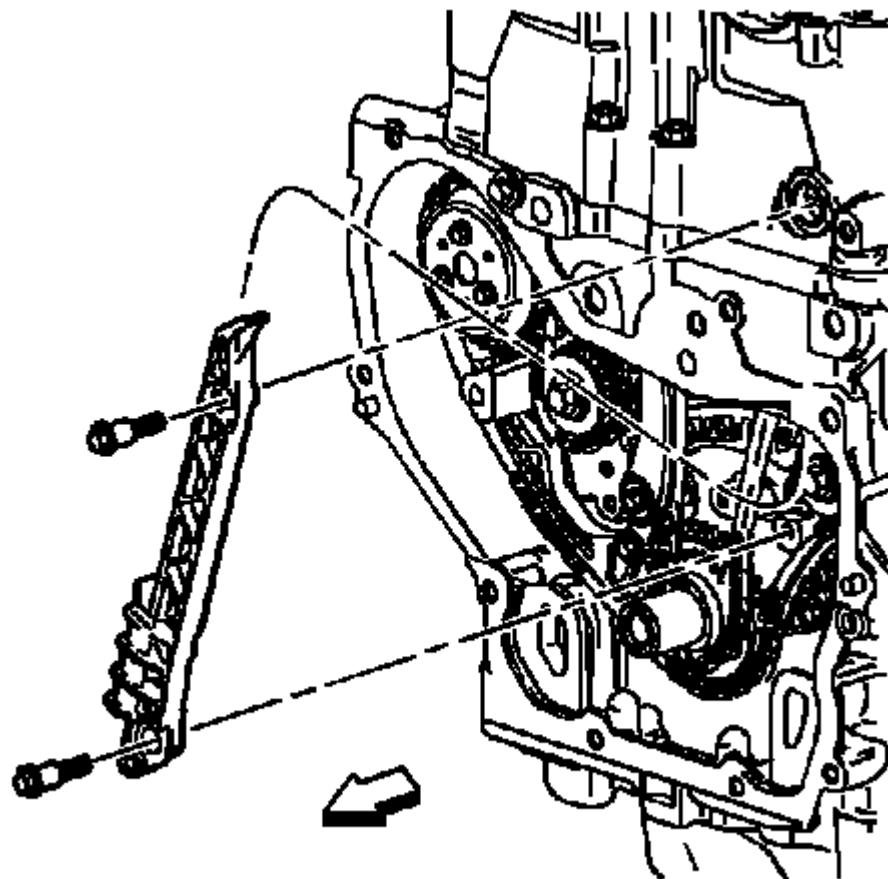
**Fig. 116: Identifying Cam Actuator, Camshaft & Chain**  
Courtesy of GENERAL MOTORS COMPANY

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



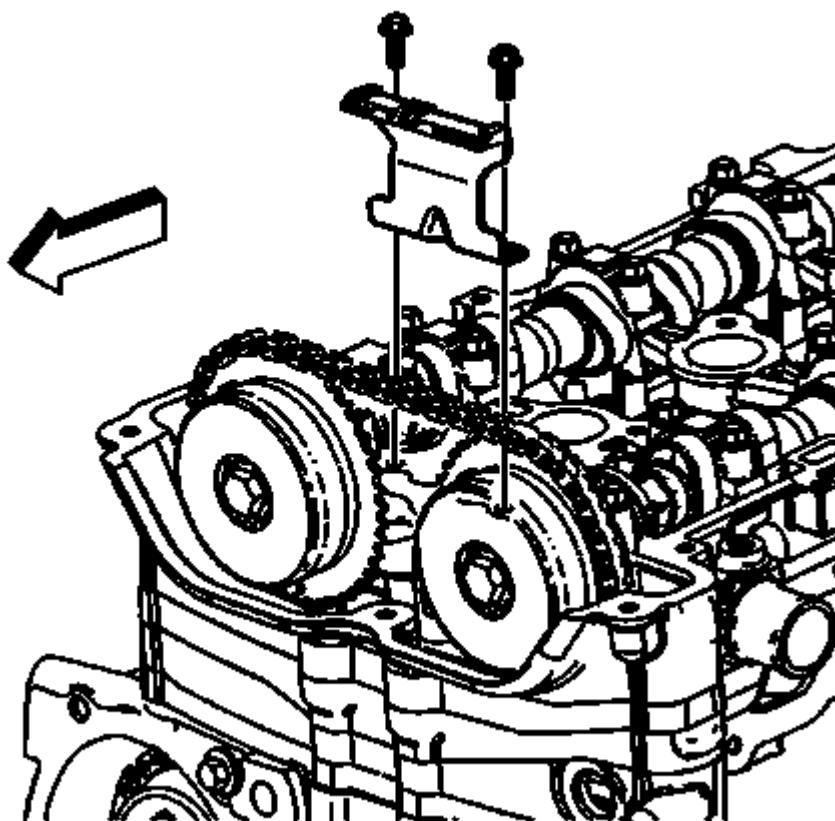
**Fig. 117: Identifying Chain & Sprockets**  
**Courtesy of GENERAL MOTORS COMPANY**

18. 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.



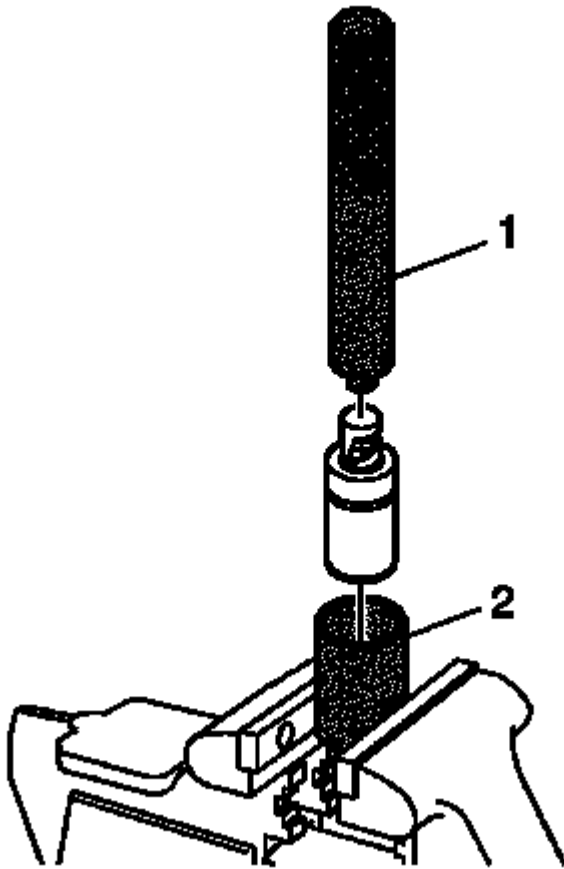
**Fig. 118: View Of Fixed Timing Chain Guide**  
**Courtesy of GENERAL MOTORS COMPANY**

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



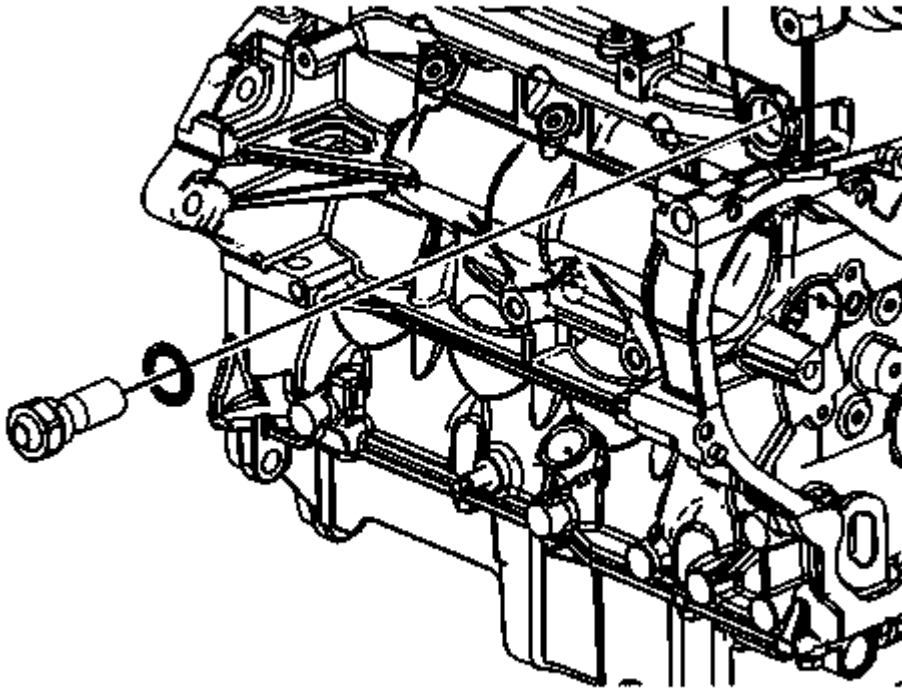
**Fig. 119: Upper Timing Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 120: Compressing Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS COMPANY

21. 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. Remove the sealing collar from the piston assembly.
  4. Install the **EN-45027-2** tool (2) into a vise.
  5. Install the notch end of the piston assembly into the **EN-45027-2** tool (2).
  6. Using the **EN-45027-1** tool (1), turn the ratchet cylinder into the piston.
  7. Reinstall the sealing collar to the piston assembly.
  8. Reinstall the piston assembly into the body of the tensioner.
  9. Install the snap ring.

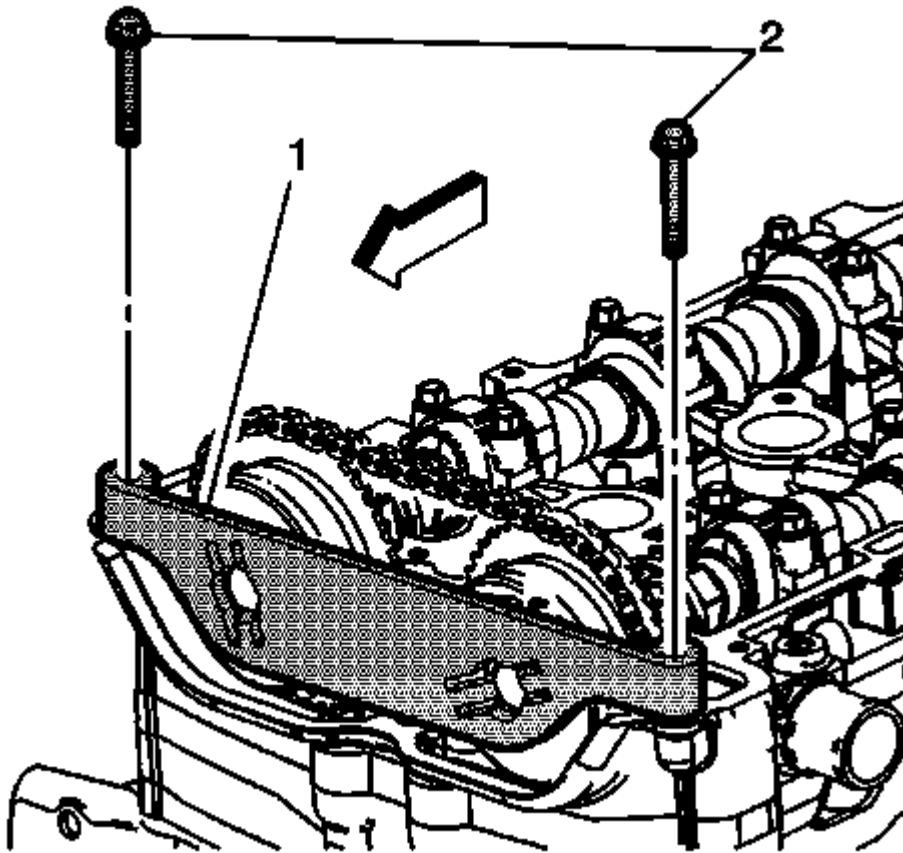


**Fig. 121: View Of Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS COMPANY

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

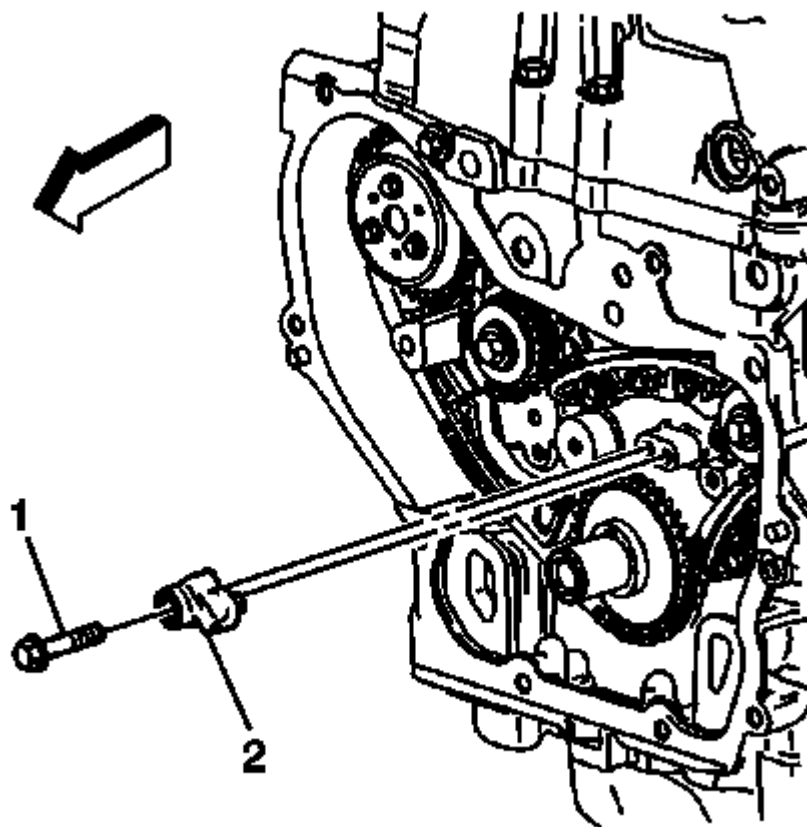
**NOTE:**        **Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.**

24. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
25. 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. 122: Camshaft Actuator Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

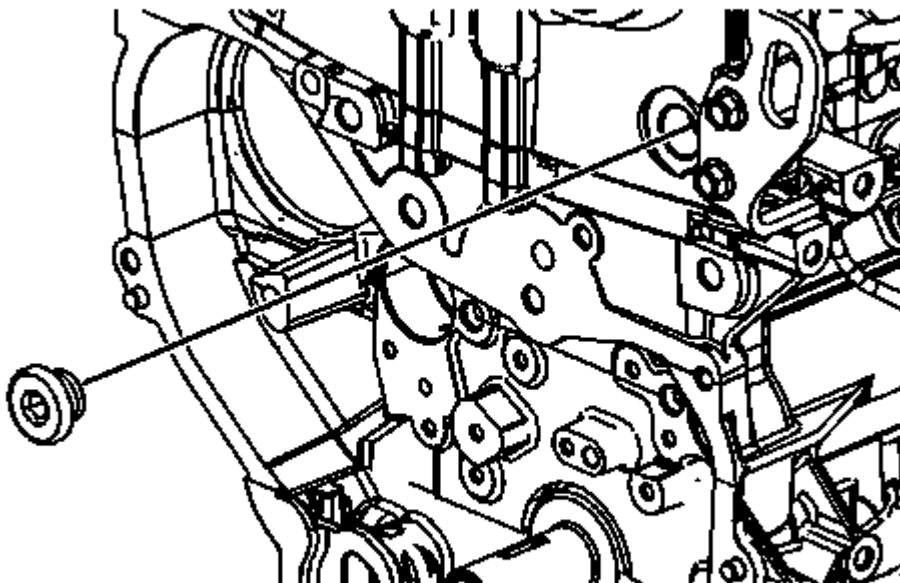
26. Install **EN-48953** locking tool (1) and tighten the bolts into the cylinder head to 10 N.m (89 lb in).
27. Using a torque wrench, tighten the camshaft actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059** meter.
28. Remove the **EN-48953** locking tool.



**Fig. 123: View Of Oil Nozzle & Bolt**

Courtesy of GENERAL MOTORS COMPANY

29. Install the timing chain oiling nozzle (2). Tighten the timing chain oiling nozzle (1) bolt to 10 N.m (89 lb in).



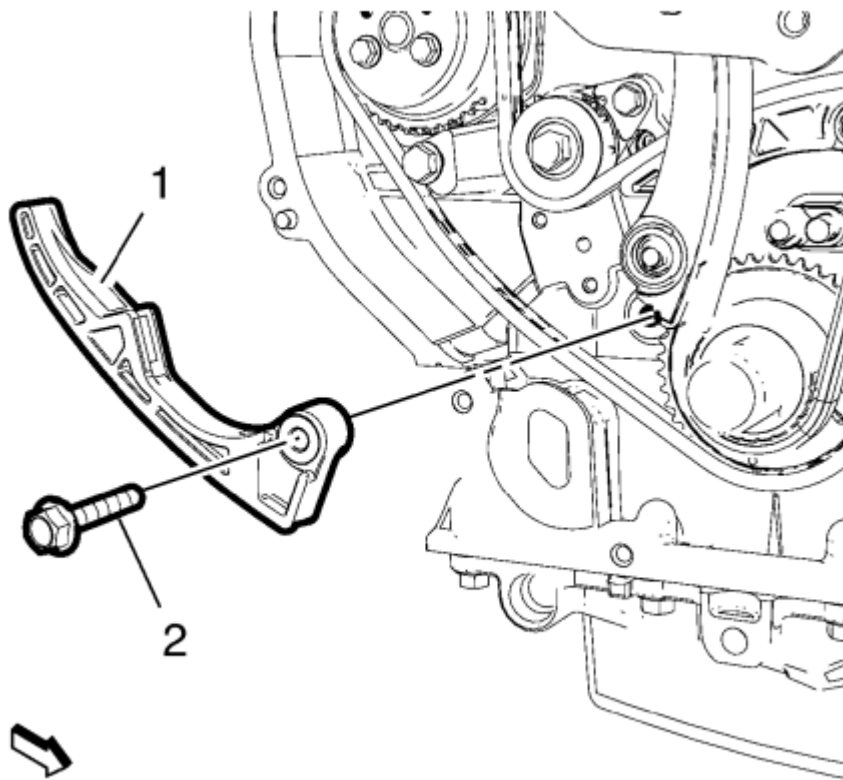
**Fig. 124: View Of Timing Chain Guide Bolt Access Hole & Plug**  
Courtesy of GENERAL MOTORS COMPANY

30. Apply sealant compound to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
31. Install the timing chain guide bolt access hole plug. Tighten the access hole plug to 90 N.m (66 lb ft).
32. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
33. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
34. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement**.

## **BALANCER CHAIN ADJUST GUIDE REPLACEMENT**

### **Removal Procedure**

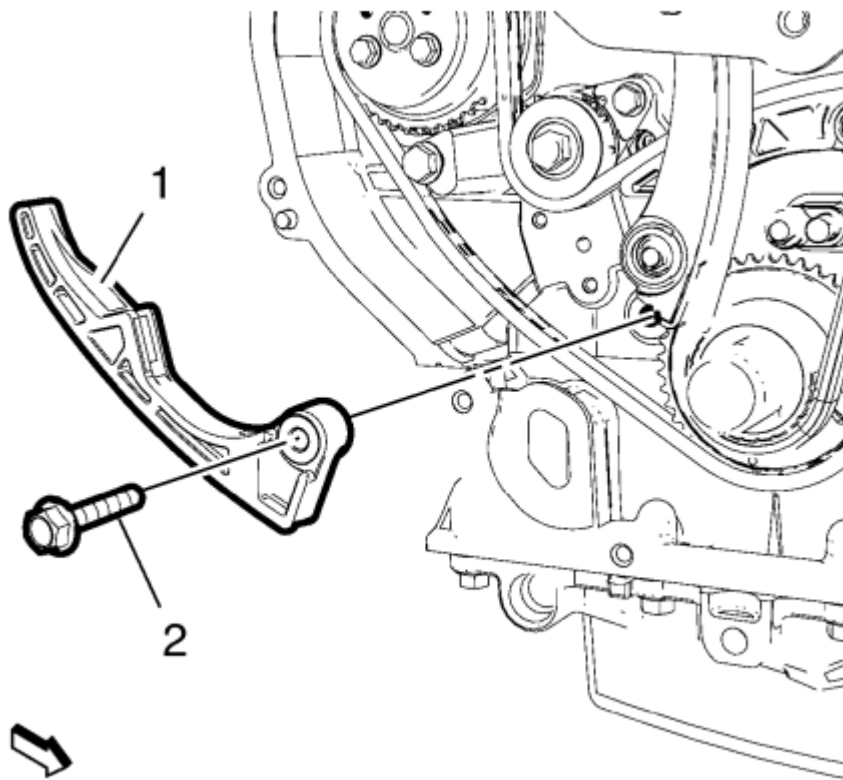
1. Remove the water pump and balance shaft chain tensioner. Refer to **Water Pump and Balance Shaft Chain Tensioner Replacement**.



**Fig. 125: Balancer Chain Adjust Guide & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the balancer chain guide bolt (2) and the balancer chain guide (1).

#### **Installation Procedure**



**Fig. 126: Balancer Chain Adjust Guide & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

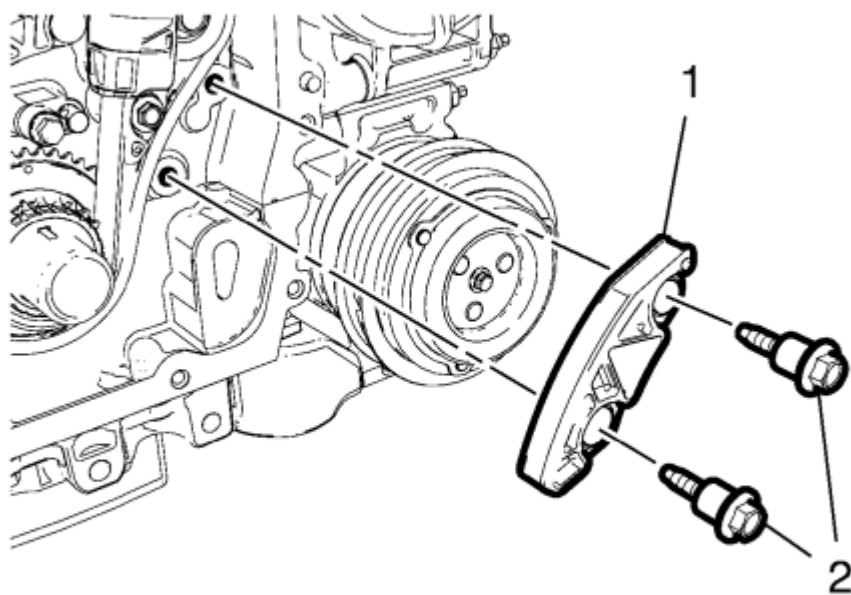
**CAUTION:** Refer to Fastener Caution .

1. Install the balancer chain guide (1) and the balancer chain guide bolt (2) and tighten to 12 N.m (106 lb in).
2. Install the water pump and balance shaft chain tensioner. Refer to Water Pump and Balance Shaft Chain Tensioner Replacement.

## BALANCER CHAIN GUIDE REPLACEMENT - LOWER

### Removal Procedure

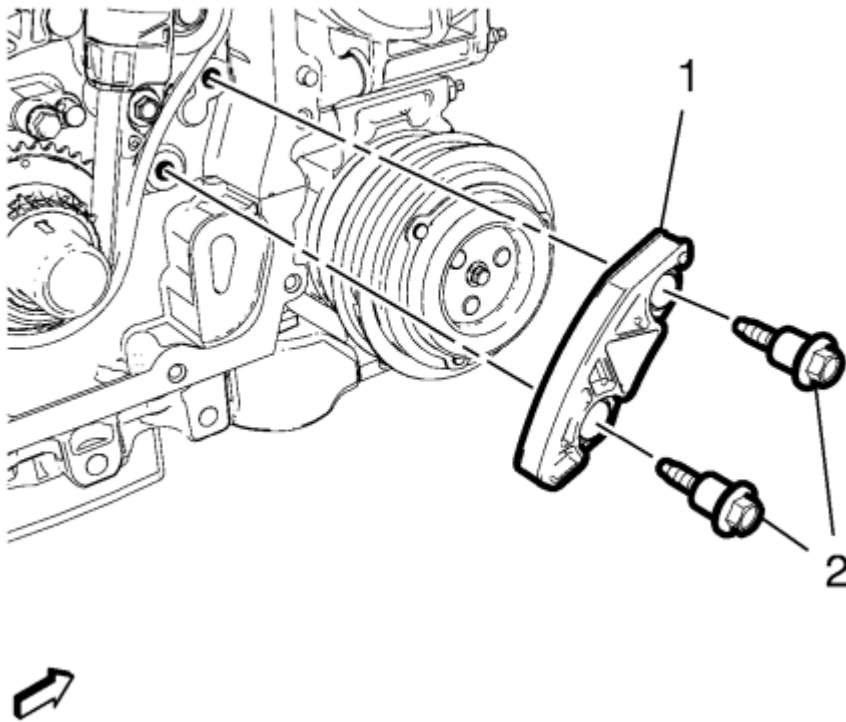
1. Remove the water pump and balance shaft chain tensioner. Refer to Water Pump and Balance Shaft Chain Tensioner Replacement.



**Fig. 127: Balancer Chain Guide & Bolts - Lower**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the 2 balancer chain guide bolts (2) and the balancer chain guide (1).

#### **Installation Procedure**



**Fig. 128: Balancer Chain Guide & Bolts - Lower**  
 Courtesy of GENERAL MOTORS COMPANY

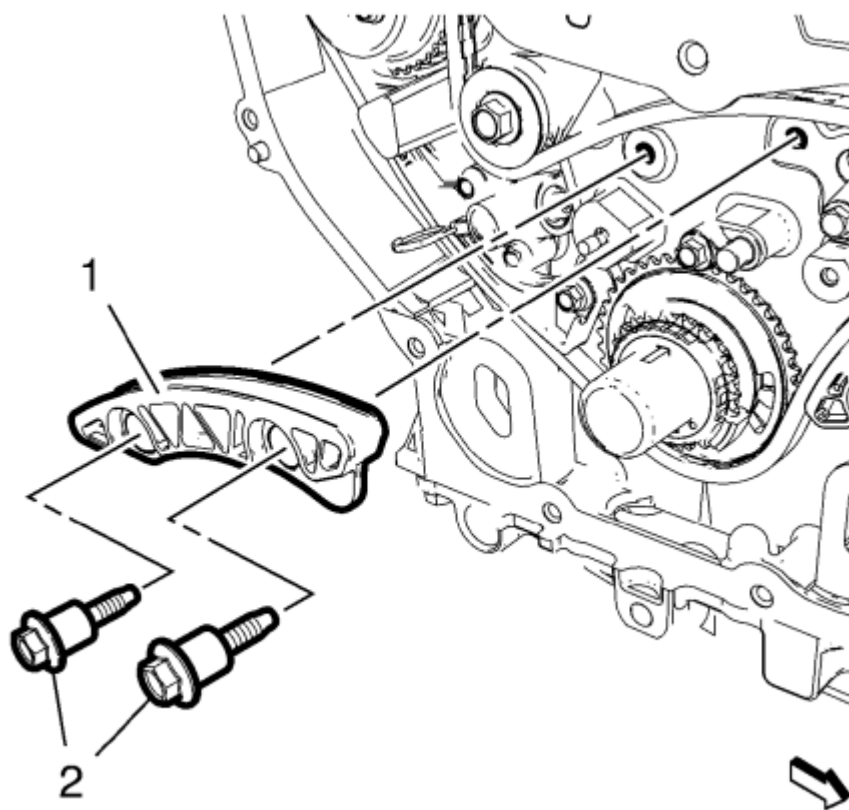
**CAUTION:** Refer to Fastener Caution .

1. Install the balancer chain guide (1) and the 2 balancer chain guide bolts (2) and tighten to 12 N.m (106 lb in).
2. Install the water pump and balance shaft chain tensioner. Refer to Water Pump and Balance Shaft Chain Tensioner Replacement.

## BALANCER CHAIN GUIDE REPLACEMENT - UPPER

### Removal Procedure

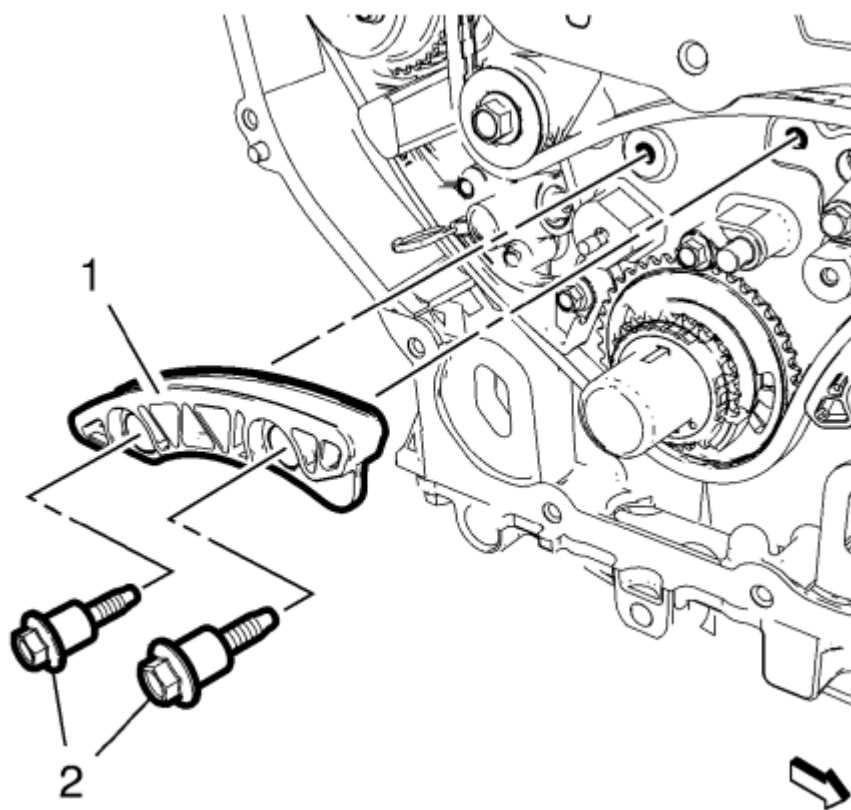
1. Remove the water pump and balance shaft chain. Refer to Water Pump and Balance Shaft Chain Replacement.



**Fig. 129: Balancer Chain Guide & Bolts - Upper**  
**Courtesy of GENERAL MOTORS COMPANY**

2. Remove the 2 balancer chain guide bolts (2) and the upper balancer chain guide (1).

#### **Installation Procedure**



**Fig. 130: Balancer Chain Guide & Bolts - Upper**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

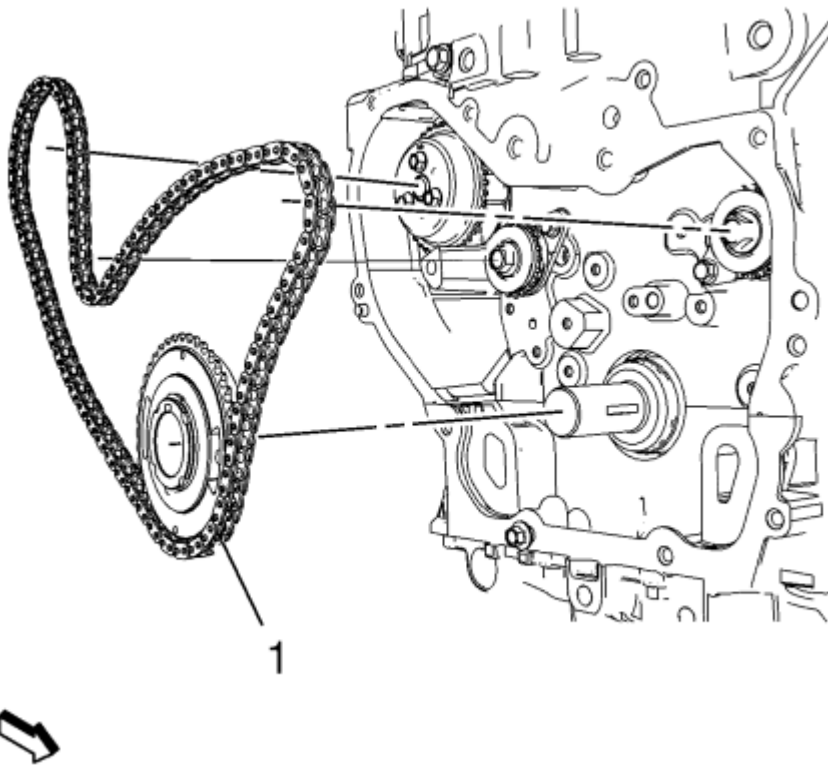
1. Install the upper balancer chain guide (1) and the 2 balancer chain guide bolts (2) and tighten to 12 N.m (106 lb in).
2. Install the water pump and balance shaft chain. Refer to Water Pump and Balance Shaft Chain Replacement.

## WATER PUMP AND BALANCE SHAFT CHAIN REPLACEMENT

### Removal Procedure

1. Remove the camshaft timing chain. Refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.
2. Remove the water pump and balance shaft timing chain tensioner. Refer to Water Pump and Balance Shaft Chain Tensioner Replacement.
3. Remove the water pump and balance shaft timing chain guide - upper. Refer to Balancer Chain Guide Replacement - Upper.

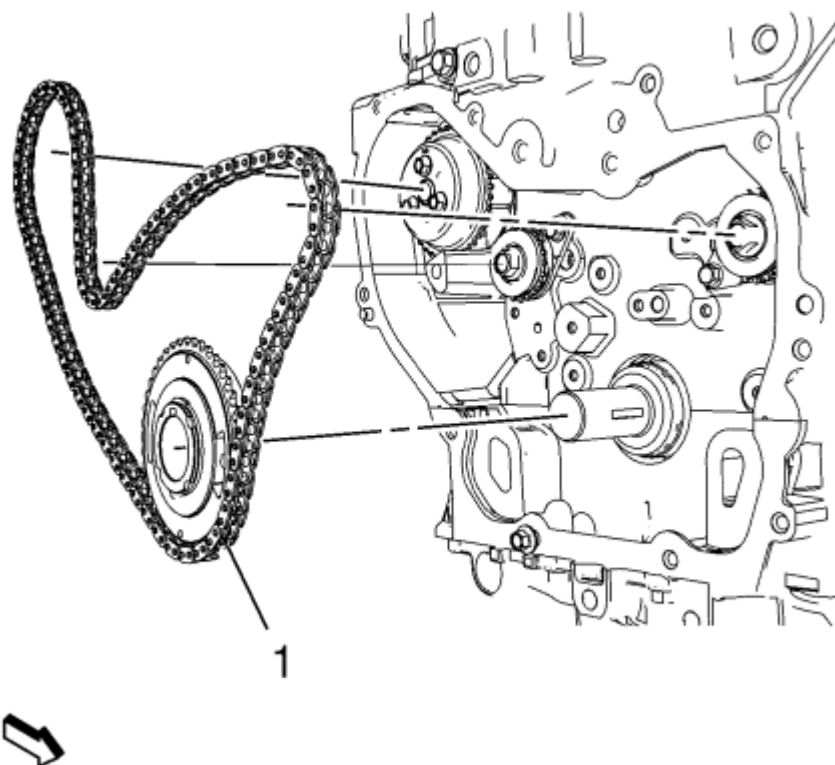
4. Remove the water pump and balance shaft timing chain guide - lower. Refer to **Balancer Chain Guide Replacement - Lower**.
5. Remove the water pump and balance shaft timing chain adjustable guide. Refer to **Balancer Chain Adjust Guide Replacement**.



**Fig. 131: Water Pump and Balance Shaft Chain & Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

6. Remove the water pump and balance shaft timing chain with the sprocket (1).

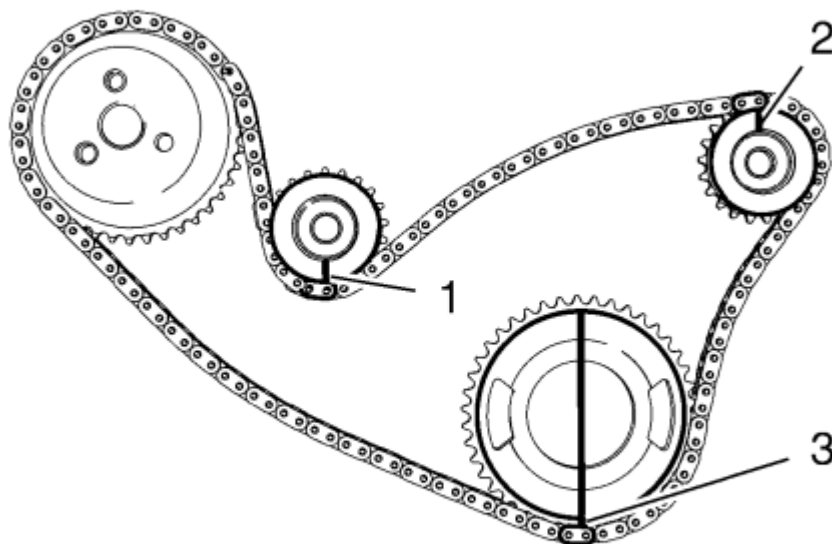
#### **Installation Procedure**



**Fig. 132: Water Pump & Balance Shaft Chain & Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ensure that the crankshaft is still on TDC combustion stroke of 1 cylinder.

1. Install the water pump and balance shaft timing chain and the crankshaft sprocket (1).



**Fig. 133: Sprocket Timing Marks**

Courtesy of GENERAL MOTORS COMPANY

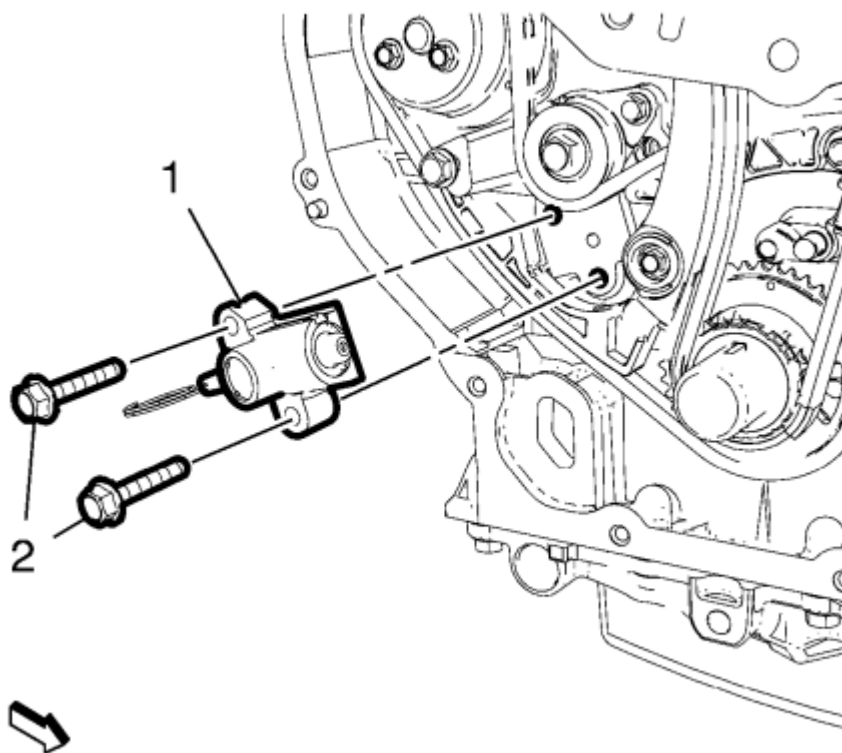
2. Use the following procedure to line up the links with the sprockets:
  1. Ensure that the balance shaft exhaust side timing mark is at 6 o'clock and the balance shaft intake side is at 12 o'clock.
  2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are 3 colored links on the chain. 2 links are a matching color, and 1 link is a unique color.
  3. Place the uniquely colored link so that it lines up with the timing mark on the intake side balance shaft sprocket (2).
  4. Working clockwise around the chain, place the first matching colored link in line with the timing mark on the crankshaft drive sprocket - approximately at the 6 o'clock position on the crank sprocket (3).
  5. Place the timing chain on the water pump sprocket. There is no timing mark.
  6. Align the last matching colored link with the timing mark on the exhaust side balance shaft drive sprocket (1).
3. Install the water pump and balance shaft timing chain guide - lower. Refer to **Balancer Chain Guide Replacement - Lower**.
4. Install the water pump and balance shaft timing chain guide - upper. Refer to **Balancer Chain Guide Replacement - Upper**.

5. Install the water pump and balance shaft timing chain adjustable guide. Refer to **Balancer Chain Adjust Guide Replacement**.
6. Install the water pump and balance shaft timing chain tensioner. Refer to **Water Pump and Balance Shaft Chain Tensioner Replacement**.
7. Install the camshaft timing chain. Refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.

## WATER PUMP AND BALANCE SHAFT CHAIN TENSIONER REPLACEMENT

### Removal Procedure

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.



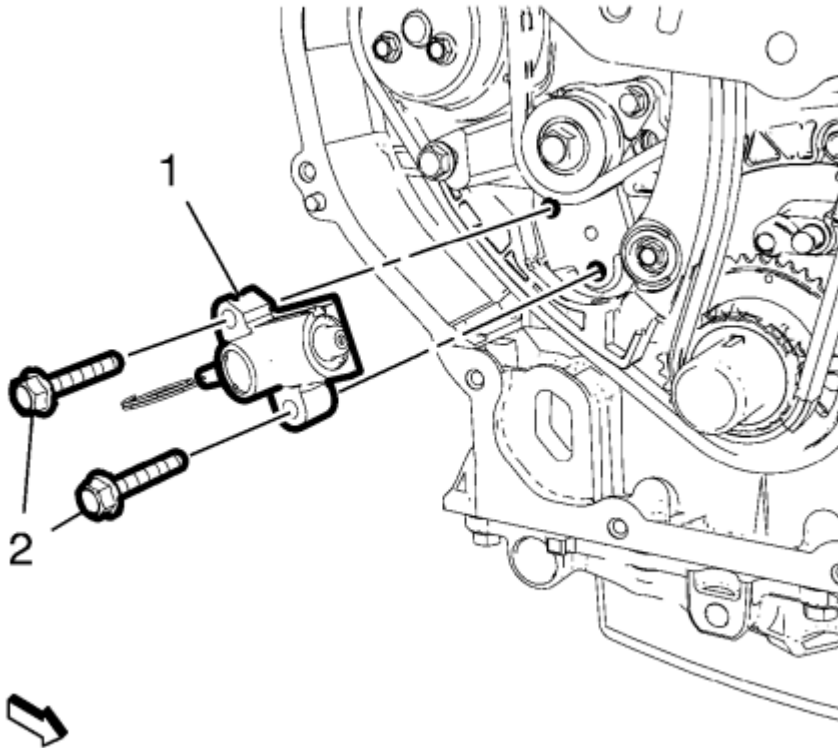
**Fig. 134: Water Pump & Balance Shaft Chain Tensioner & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the 2 tensioner bolts (2) and the water pump and balance shaft chain tensioner (1).

### Installation Procedure

1. Reset the water pump and balance shaft chain tensioner by performing the following steps:
  1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.

2. Turn the tensioner back to the original 12 o'clock position and insert a paper pin through the hole in the plunger body and into the hole in the tensioner plunger.
2. Clean the water pump and balance shaft chain tensioner sealing surface.

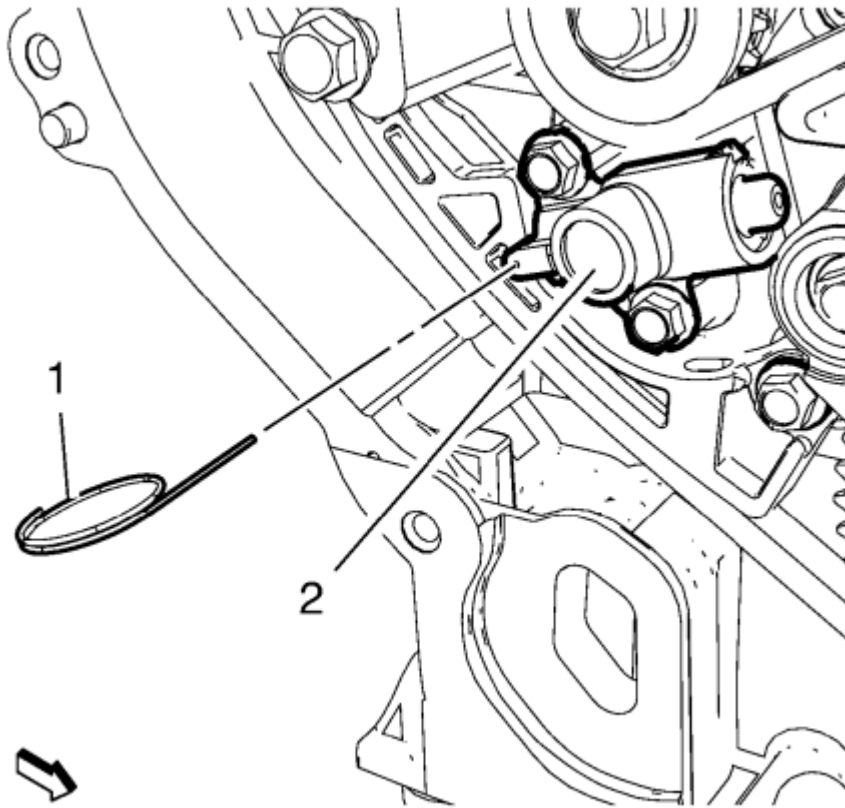


**Fig. 135: Water Pump & Balance Shaft Chain Tensioner & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

3. Install the water pump and balance shaft chain tensioner (1).

**CAUTION: Refer to Fastener Caution .**

4. Install the 2 water pump and balance shaft chain tensioner bolts (2) and tighten the bolts to 10 N.m (89 lb in).



**Fig. 136: Paper Pin & Tensioner**

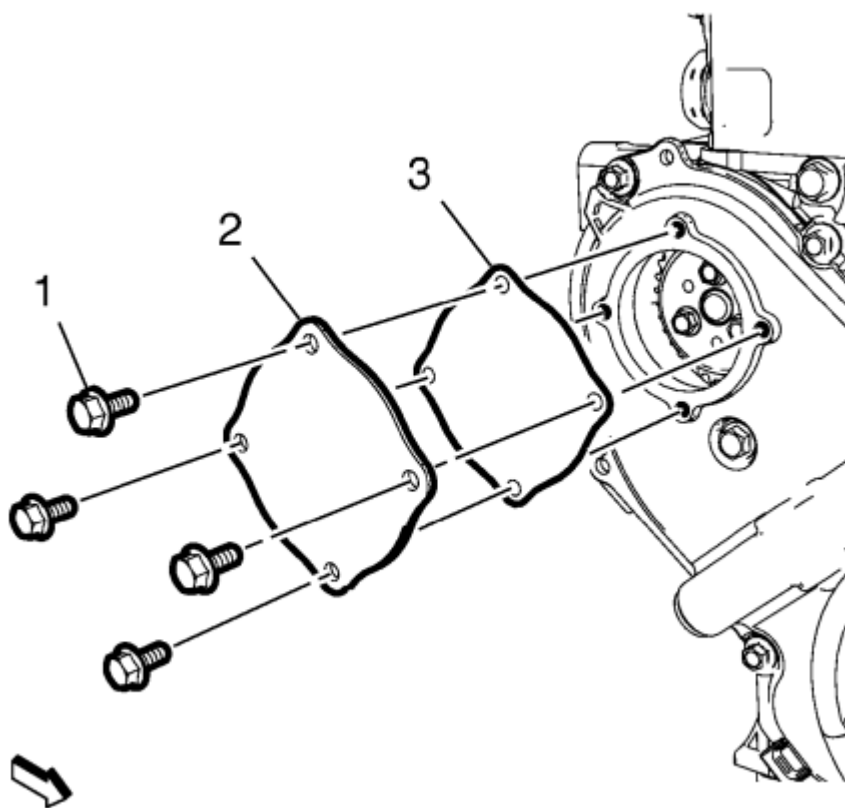
Courtesy of GENERAL MOTORS COMPANY

5. Remove the paper pin (1) from the tensioner (2).
6. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

## WATER PUMP COVER REPLACEMENT

### Removal Procedure

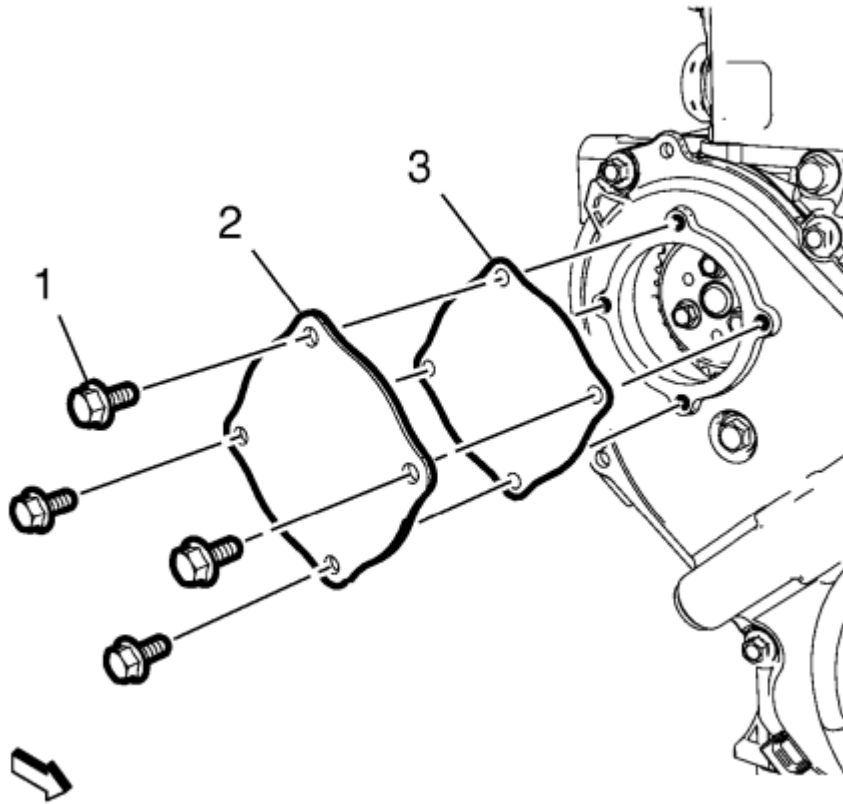
1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)** .
2. Remove the front wheelhouse liner right side. Refer to **Front Wheelhouse Liner Replacement** .
3. Remove the front compartment insulator. Refer to **Front Compartment Insulator Replacement** .



**Fig. 137: Water Pump Cover, Gasket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

4. Remove the 4 water pump cover bolts (1) and the water pump cover (2) along with the gasket (3).

#### Installation Procedure



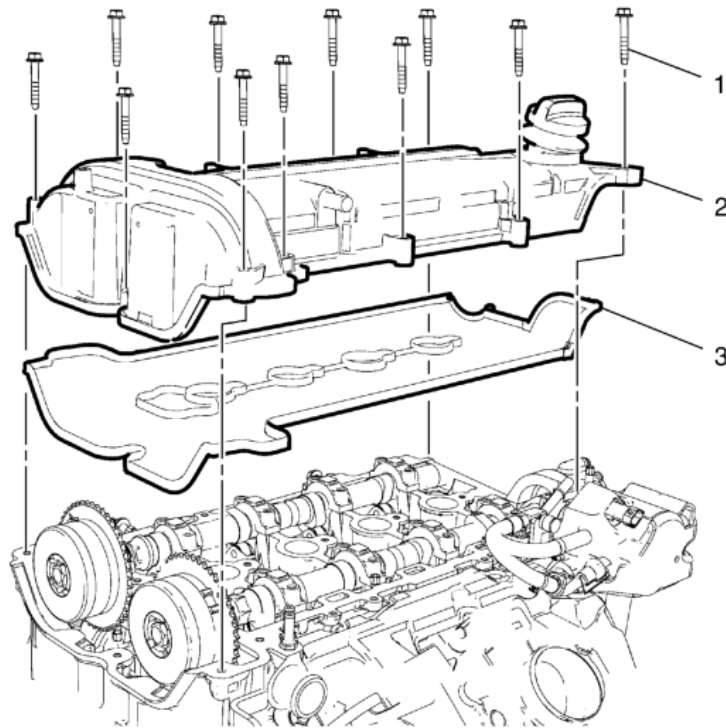
**Fig. 138: Water Pump Cover, Gasket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Use a **NEW** water pump cover gasket (3).

1. Install the water pump cover (2) and the 4 water pump bolts (1) and tighten to 10 (89 lb in).
2. Install the front compartment insulator. Refer to **Front Compartment Insulator Replacement** .
3. Install the front wheelhouse liner right side. Refer to **Front Wheelhouse Liner Replacement** .
4. Lower the vehicle.

## CAMSHAFT COVER REPLACEMENT



**Fig. 139: Camshaft Cover & Components**  
Courtesy of GENERAL MOTORS COMPANY

### Camshaft Cover Replacement

| Callout                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Component Name                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b> <ol style="list-style-type: none"> <li>1. Remove the intake manifold cover. Refer to <b><u>Intake Manifold Cover Replacement</u></b>.</li> <li>2. Remove evaporative emission canister tube. Refer to <b><u>Evaporative Emission Canister Purge Tube Replacement</u></b>.</li> <li>3. Disconnect the ECM wiring harness from the camshaft position actuator solenoid valves.</li> <li>4. Unclip the engine wiring harness and fuel line from the camshaft cover.</li> <li>5. Remove the 4 ignition coils. Refer to <b><u>Ignition Coil Replacement</u></b>.</li> </ol> |                                                                                                                                              |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Camshaft Cover Bolt (Qty: 11)<br><br><b>CAUTION:</b><br>Refer to <b><u>Fastener Caution</u></b> .<br><br><b>Tighten</b><br>10 N.m (89 lb in) |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Camshaft Cover                                                                                                                               |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Camshaft Cover Gasket                                                                                                                        |
| <b>Procedure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                              |

Use a NEW camshaft cover gasket.

## **TIMING CHAIN TENSIONER REPLACEMENT**

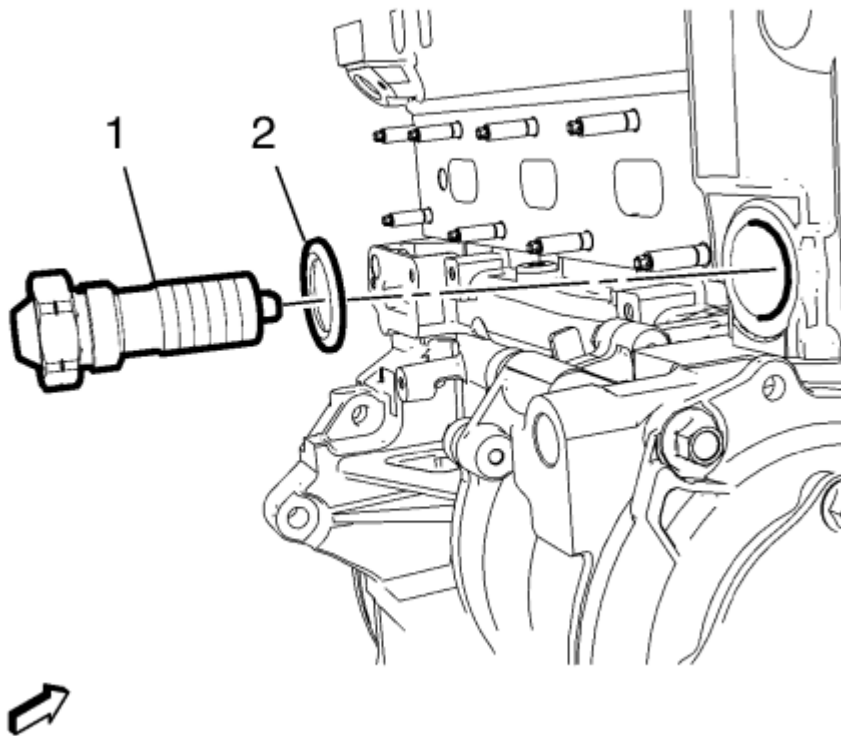
### **Special Tools**

- **EN-45027-1** Tensioner Tool.
- **EN-45027-2** Tensioner Tool.

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

### **Removal Procedure**

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the dash upper extension panel opening cover. Refer to **Dash Upper Extension Panel Opening Cover Replacement**.

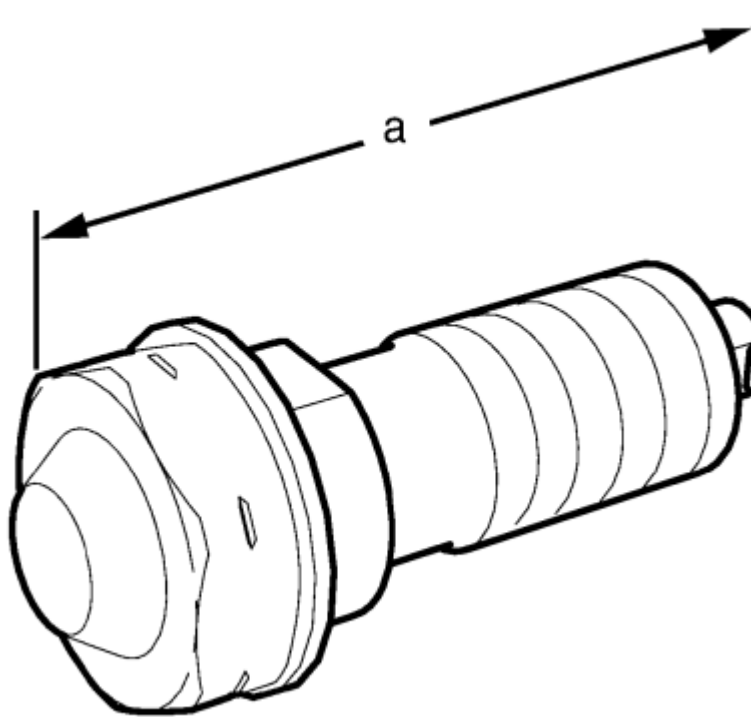


**Fig. 140: Timing Chain Tensioner & Seal Ring**  
Courtesy of GENERAL MOTORS COMPANY

3. Remove the timing chain tensioner (1) and the timing chain tensioner seal ring (2).

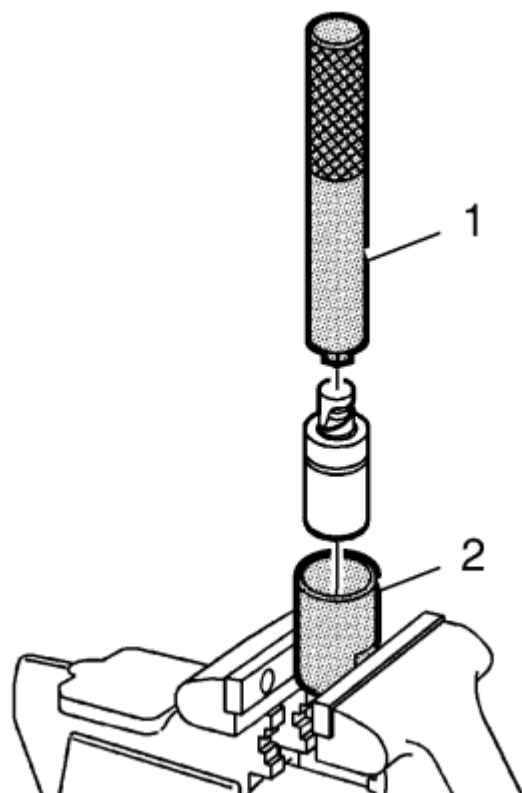
**Installation Procedure**

1. Inspect the timing chain tensioner. If the timing chain tensioner is damaged, replace the timing chain tensioner.



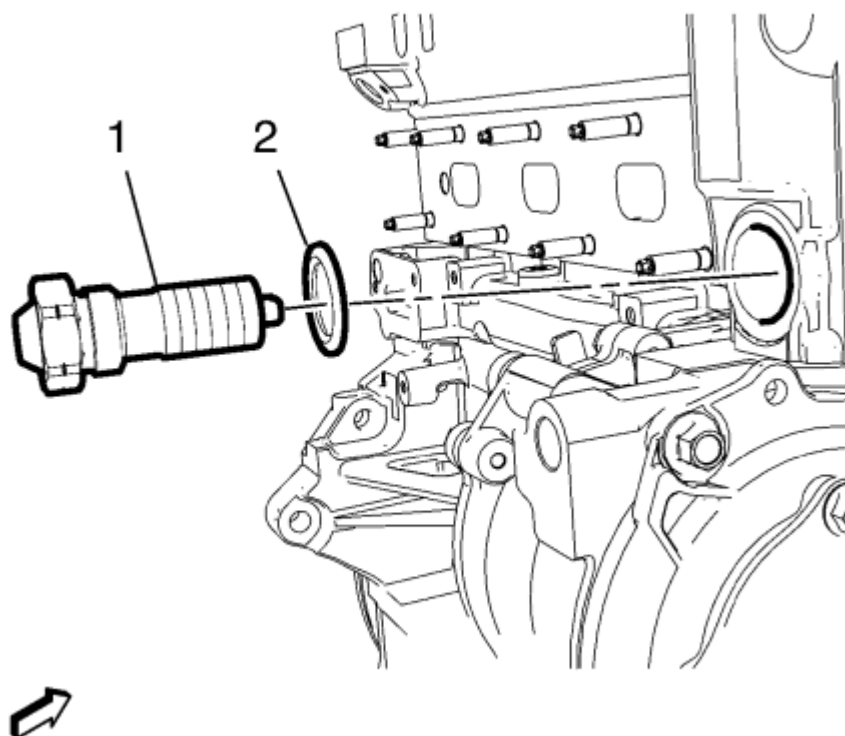
**Fig. 141: Timing Chain Tensioner Length**  
Courtesy of GENERAL MOTORS COMPANY

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. 142: Timing Chain Tensioner & Compression Tools**  
Courtesy of GENERAL MOTORS COMPANY

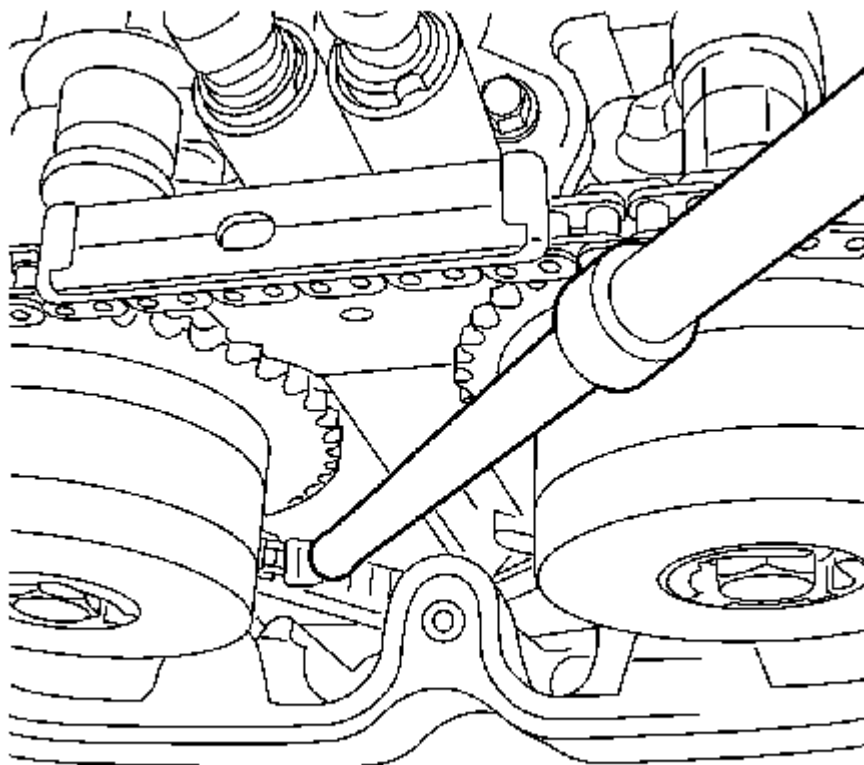
3. If the timing chain tensioner is not in the compressed state, perform the following steps:
  1. Remove the locking ring from the tensioner body.
  2. Remove the piston assembly from the tensioner body of the timing chain tensioner by pulling it out.
  3. Install the **EN-45027-2** tensioner (2) into a vise.
  4. Install the notch end of the piston assembly into the **EN-45027-1** tensioner (2).
  5. Using the **EN-45027-1** tensioner (1), turn the ratchet cylinder into the piston.
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. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.



**Fig. 143: Timing Chain Tensioner & Seal Ring**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

6. Install the timing chain tensioner (1) with a NEW seal ring (2) and tighten to 75 N.m (55 lb ft).



**Fig. 144: Timing Chain Tensioner Release Tool**

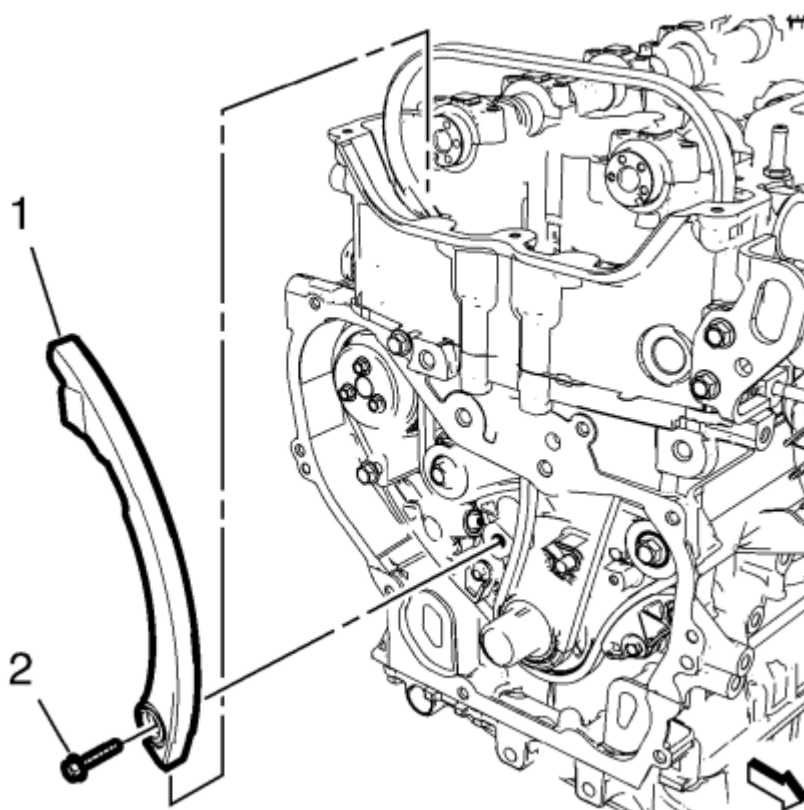
Courtesy of GENERAL MOTORS COMPANY

7. 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.
8. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
9. Install the dash upper extension panel opening cover. Refer to **Dash Upper Extension Panel Opening Cover Replacement**.

## ADJUSTABLE TIMING CHAIN GUIDE REPLACEMENT

### Removal Procedure

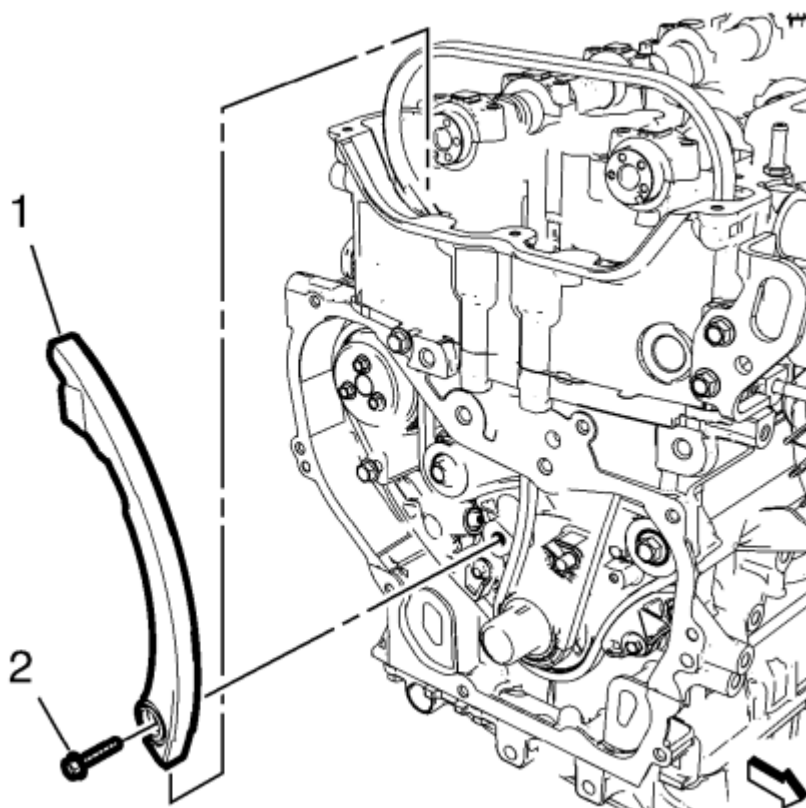
1. Remove the camshaft position exhaust actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.
2. Remove the camshaft position intake actuator. Refer to **Camshaft Position Intake Actuator Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.



**Fig. 145: Adjustable Timing Chain Guide & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

4. Remove the timing chain adjustable guide bolt (2) and the timing chain adjustable guide (1).

#### **Installation Procedure**



**Fig. 146: Adjustable Timing Chain Guide & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

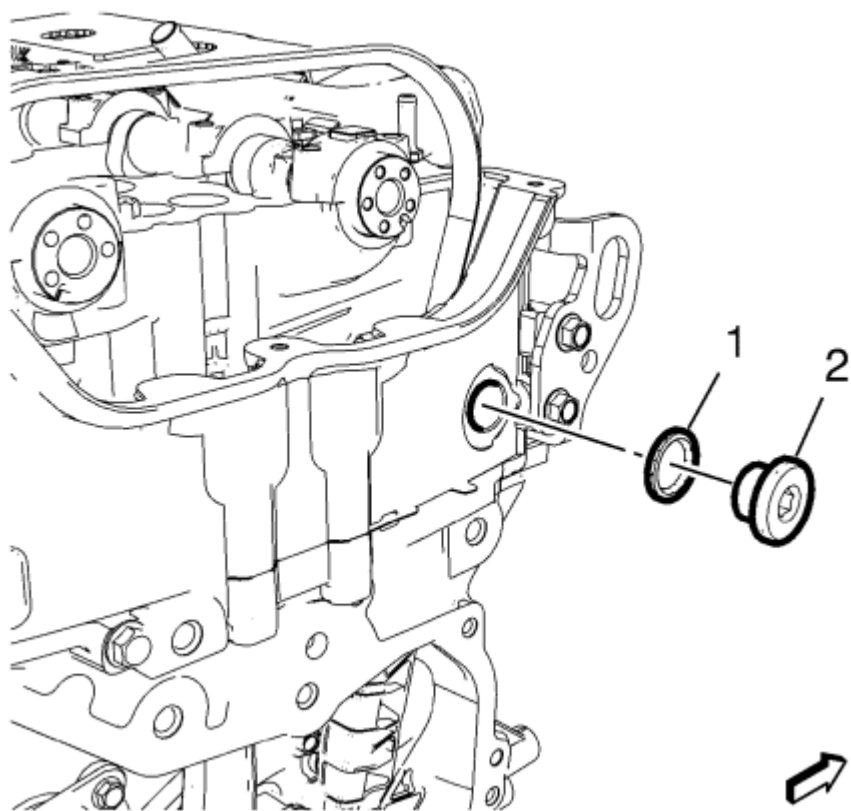
**CAUTION:** Refer to Fastener Caution .

1. Install the timing chain adjustable guide (1) and the timing chain adjustable guide bolt (2) and tighten to 12 N.m (106 lb in).
2. Install the engine front cover. Refer to Engine Front Cover Replacement.
3. Install the camshaft position intake actuator. Refer to Camshaft Position Intake Actuator Replacement.
4. Install the camshaft position exhaust actuator. Refer to Camshaft Position Exhaust Actuator Replacement.

## TIMING CHAIN GUIDE REPLACEMENT

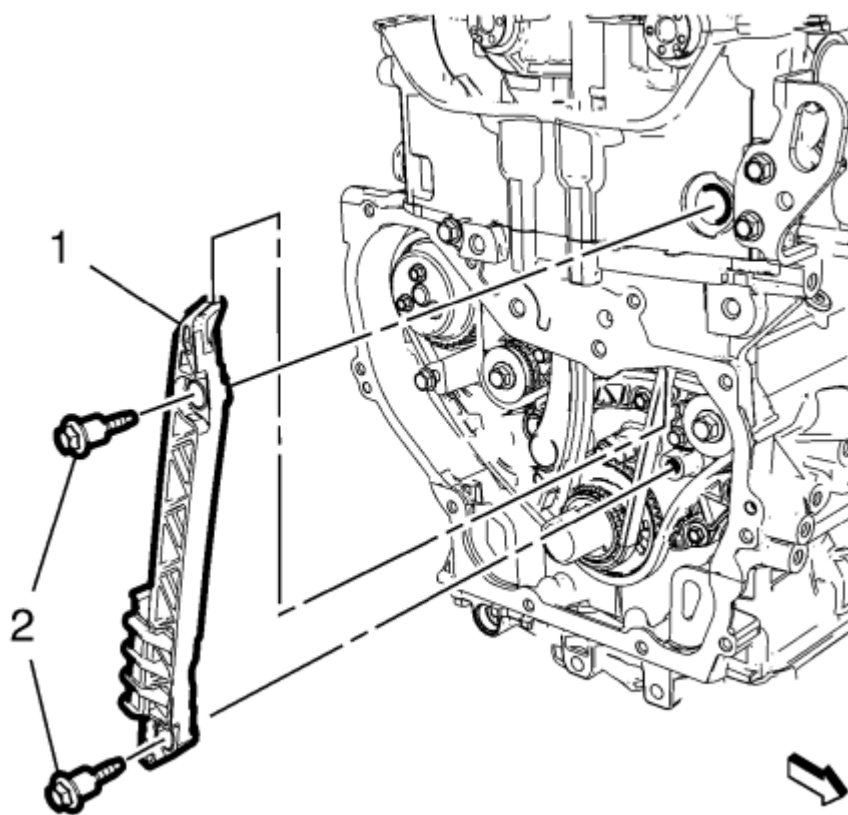
### Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.



**Fig. 147: Timing Chain Guide Access Hole Plug & Washer**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the timing chain guide access hole plug (1) and the washer (2).

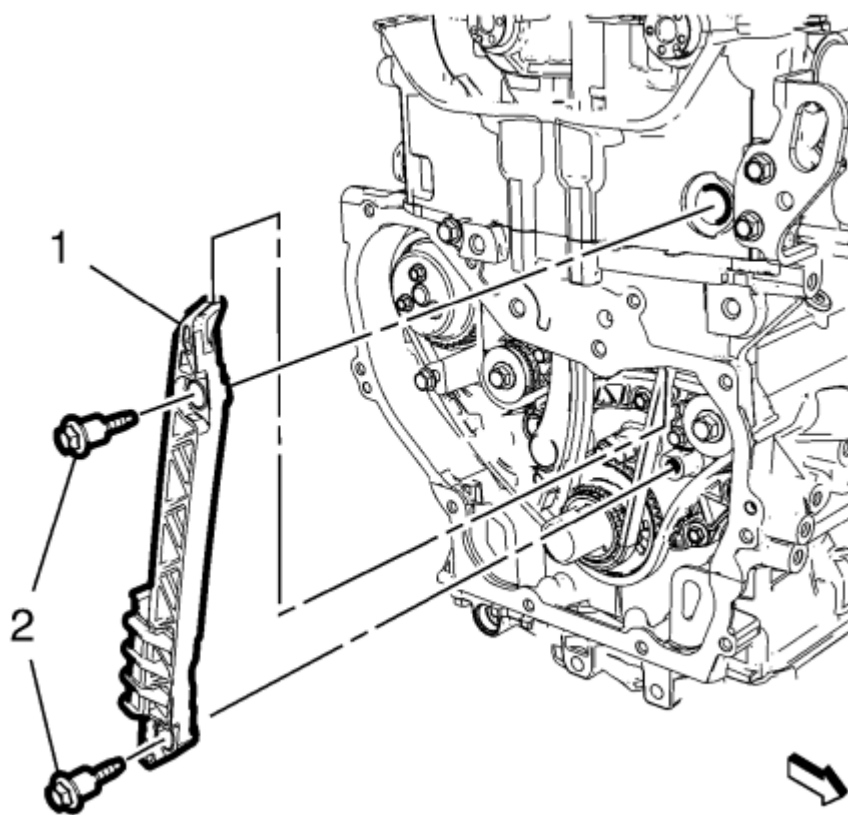


**Fig. 148: Timing Chain Guide & Bolts**

Courtesy of GENERAL MOTORS COMPANY

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

#### Installation Procedure

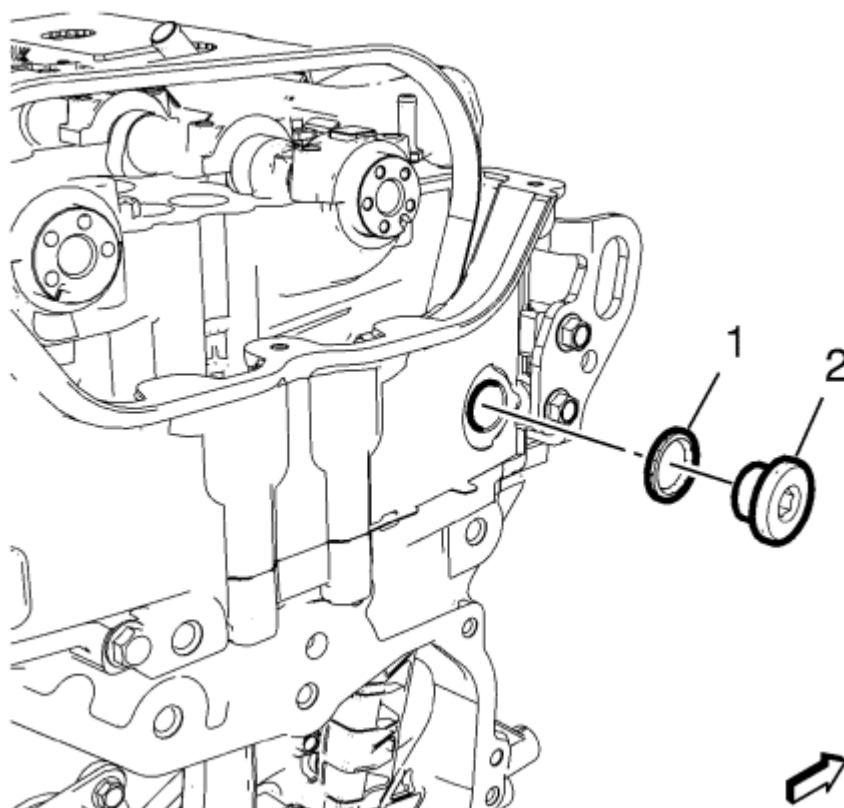


**Fig. 149: Timing Chain Guide & Bolts**

Courtesy of GENERAL MOTORS COMPANY

**CAUTION: Refer to Fastener Caution .**

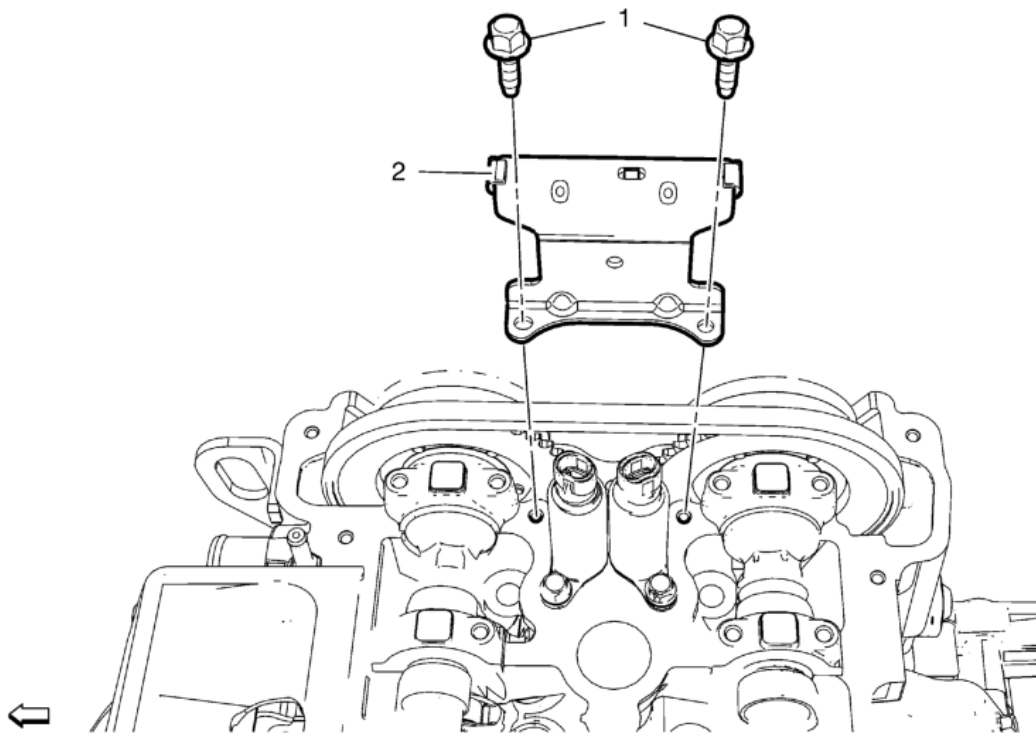
1. Install the timing chain guide (1) and the timing chain guide bolts (2) and tighten to 12 N.m (106 lb in).



**Fig. 150: Timing Chain Guide Access Hole Plug & Washer**  
 Courtesy of GENERAL MOTORS COMPANY

2. Install the timing chain guide access hole plug (1) and the NEW washer (2) and tighten to 75 N.m (55 lb ft).
3. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

## **TIMING CHAIN UPPER GUIDE REPLACEMENT**

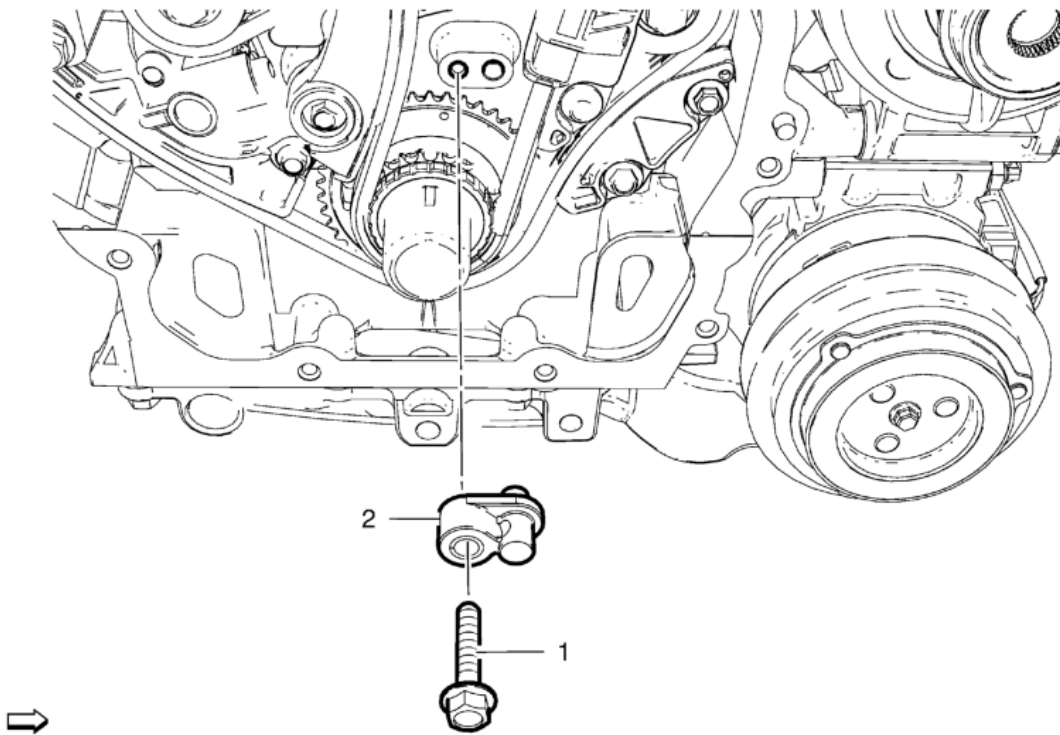


**Fig. 151: Timing Chain Upper Guide & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

### Timing Chain Upper Guide Replacement

| Callout                                                                 | Component Name                                                                                                                           |
|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedure</b>                                            |                                                                                                                                          |
| Remove the camshaft cover. Refer to <u>Camshaft Cover Replacement</u> . |                                                                                                                                          |
| 1                                                                       | Timing Chain Guide Bolt (Qty: 2)<br><br><b>CAUTION:</b><br>Refer to <u>Fastener Caution</u> .<br><br><b>Tighten</b><br>10 N.m (89 lb in) |
| 2                                                                       | Timing Chain Guide - Upper                                                                                                               |

### TIMING CHAIN OIL NOZZLE REPLACEMENT



**Fig. 152: Timing Chain Oil Nozzle & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

### Timing Chain Oil Nozzle Replacement

| Callout                                                                         | Component Name                                                                                                                       |
|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>Preliminary Procedures</b>                                                   |                                                                                                                                      |
| Remove the engine front cover. Refer to <b>Engine Front Cover Replacement</b> . |                                                                                                                                      |
| 1                                                                               | Timing Chain Oil Nozzle Bolt<br><br><b>CAUTION:</b><br>Refer to <b>Fastener Caution</b> .<br><br><b>Tighten</b><br>10 N.m (89 lb in) |
| 2                                                                               | Timing Chain Oil Nozzle                                                                                                              |

### CAMSHAFT POSITION INTAKE ACTUATOR REPLACEMENT

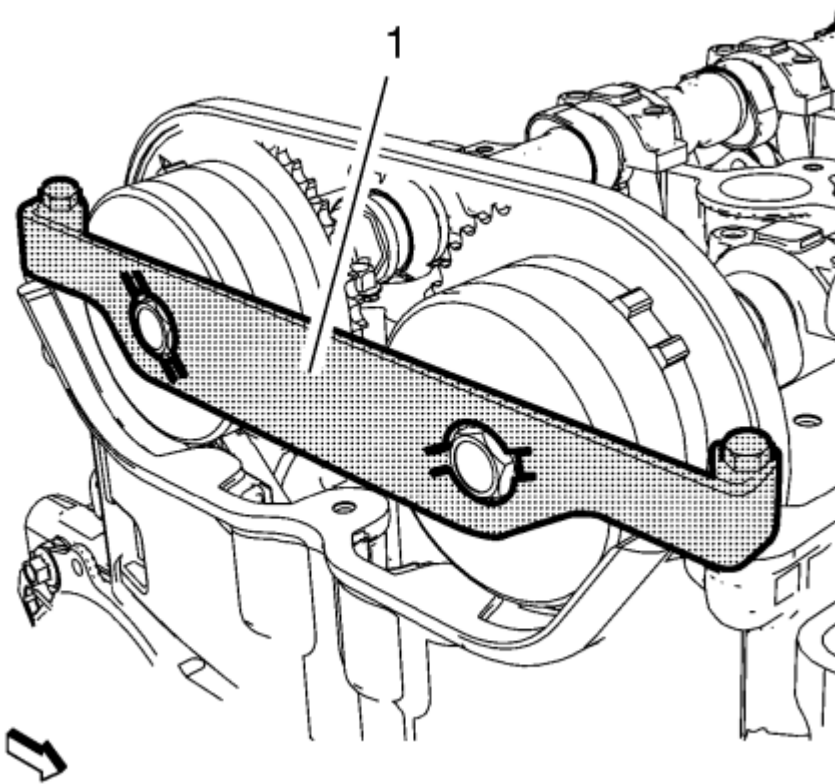
#### Special Tools

- **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 spark plugs. Refer to Spark Plug Replacement .
2. Remove the upper timing chain guide. Refer to Timing Chain Upper Guide Replacement.
3. Remove the front wheelhouse liner. Refer to Front Wheelhouse Liner Replacement .

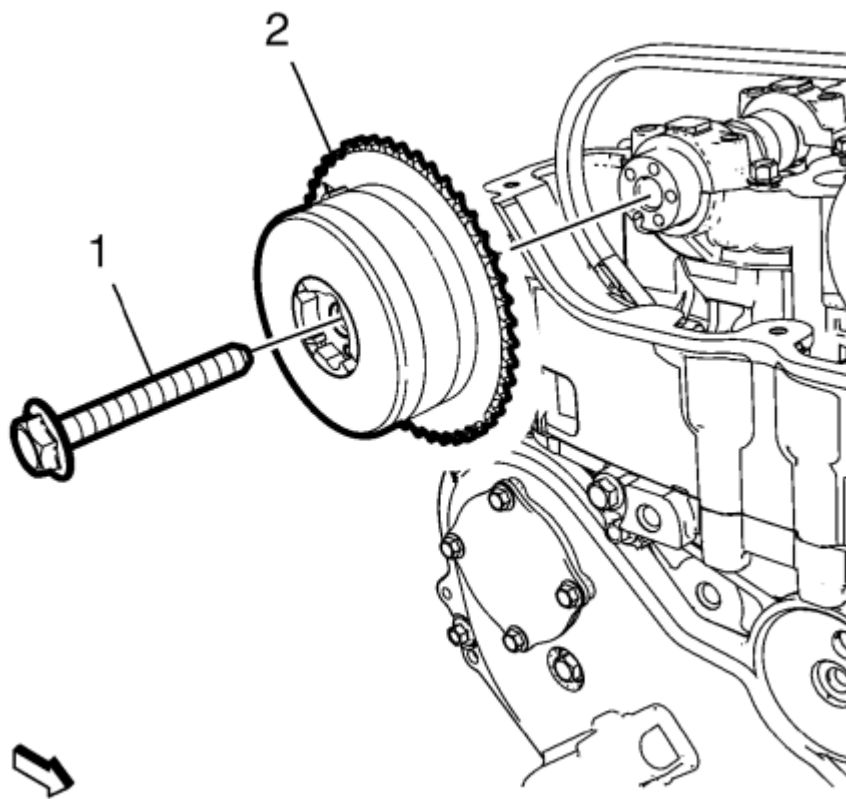


**Fig. 153: Crankshaft Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.

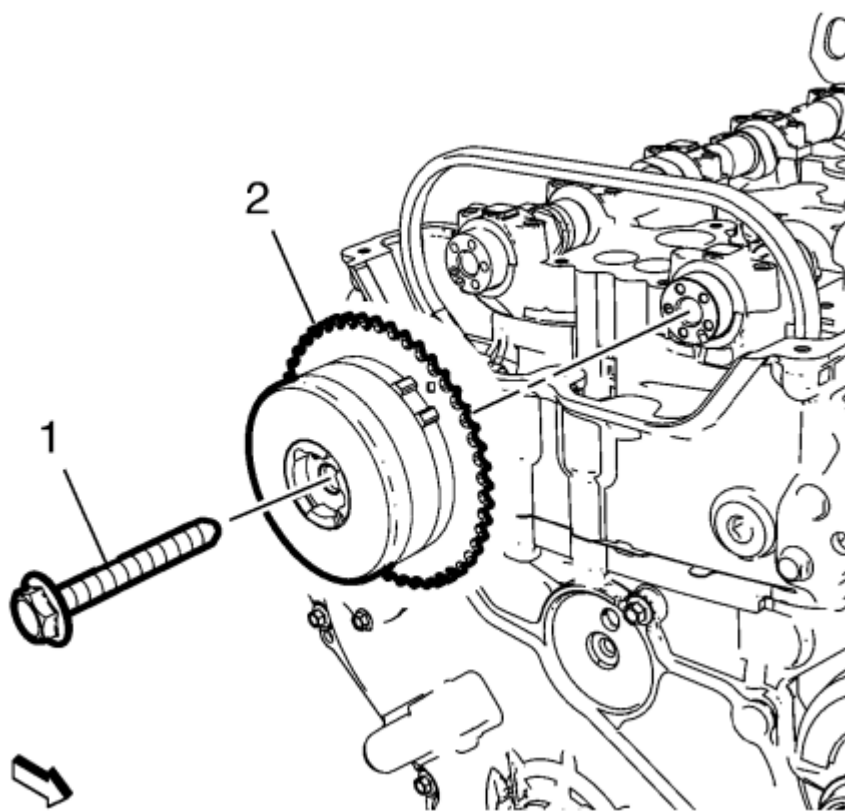
**CAUTION:** Refer to Fastener Caution .

5. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).



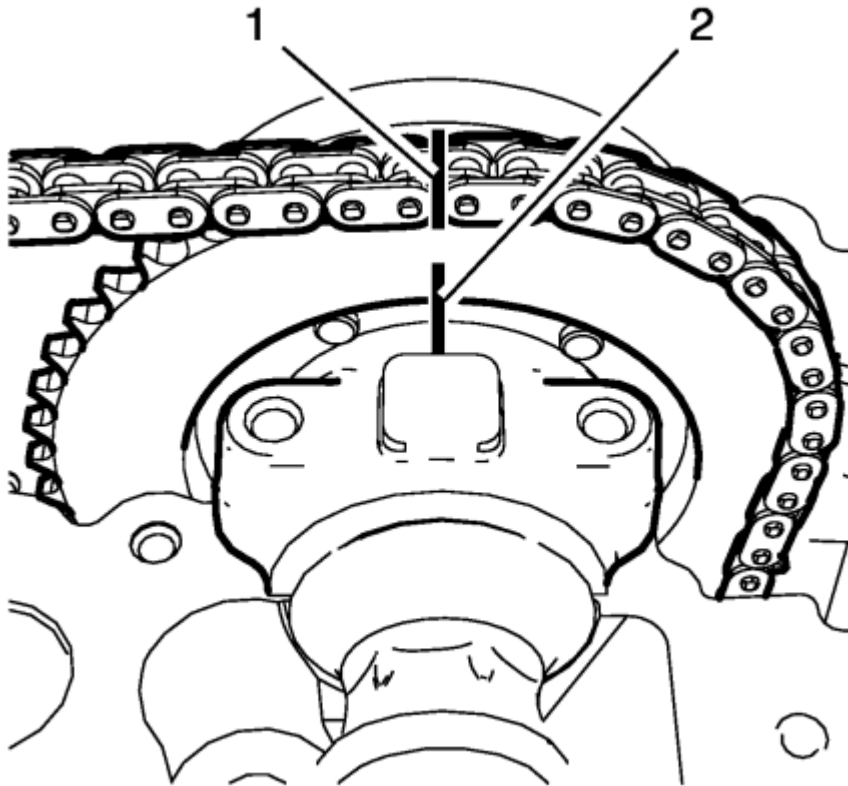
**Fig. 154: Camshaft Position Exhaust Actuator & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

6. Loosen, but DO NOT remove, the camshaft position exhaust actuator bolt (1).



**Fig. 155: Camshaft Intake Actuator & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

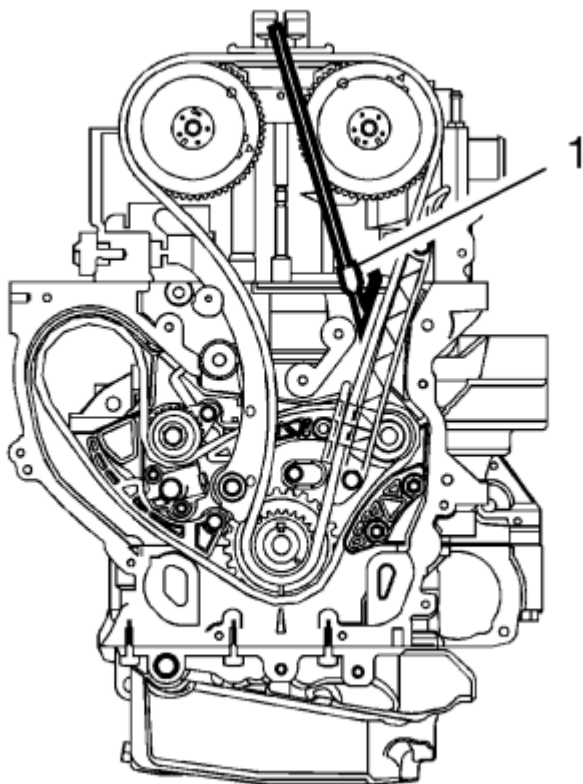
7. Loosen, but DO NOT remove, the camshaft position intake actuator bolt (1).
8. Remove the **EN-48953** locking tool.



**Fig. 156: Timing Chain & Camshaft Bearing Cover Marks**  
Courtesy of GENERAL MOTORS COMPANY

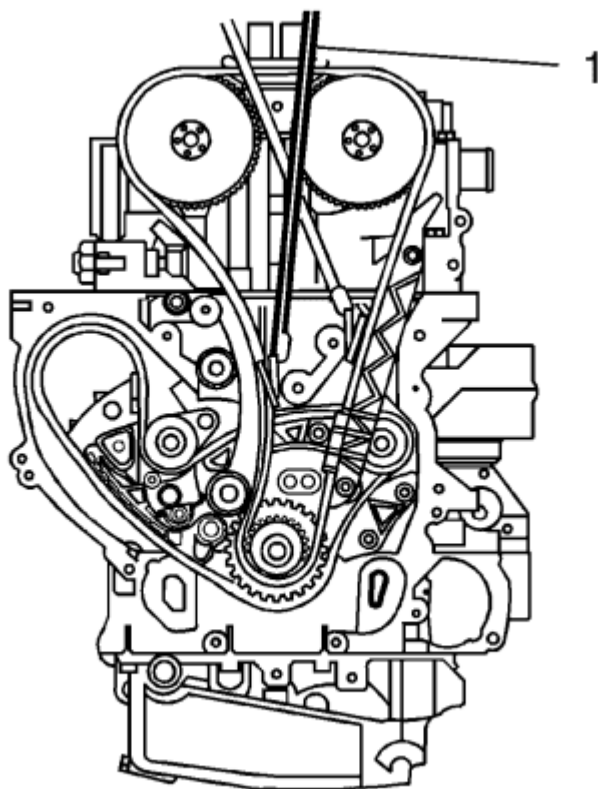
**NOTE:** Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

9. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain (1). Mark additional the position from each camshaft actuator to the camshaft bearing cover (2).
10. Remove the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



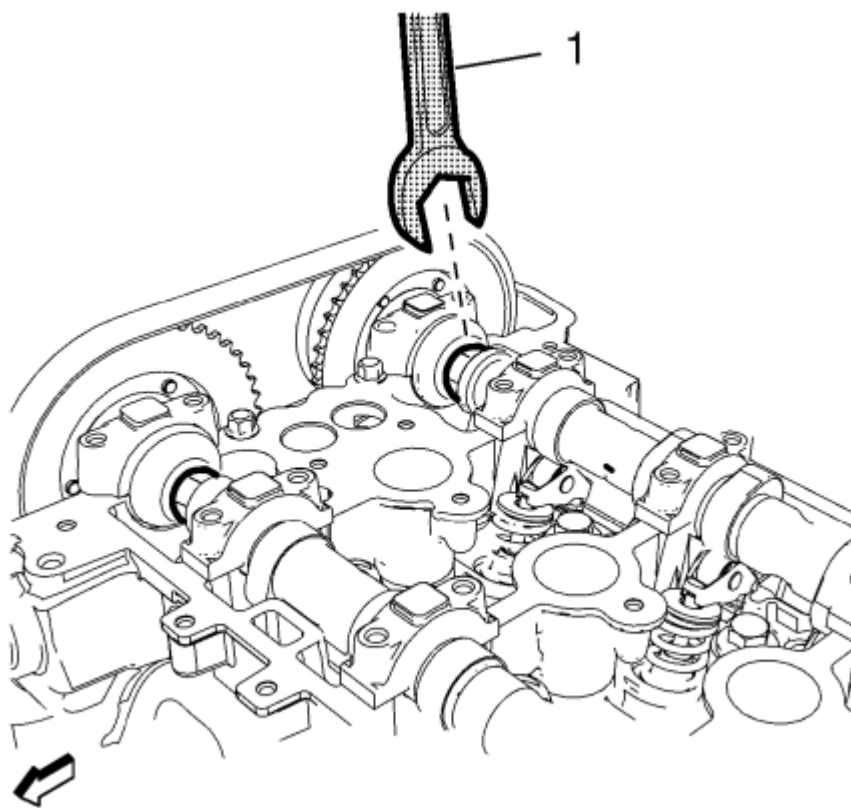
**Fig. 157: Timing Chain Retention Tool On Intake Side**  
**Courtesy of GENERAL MOTORS COMPANY**

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



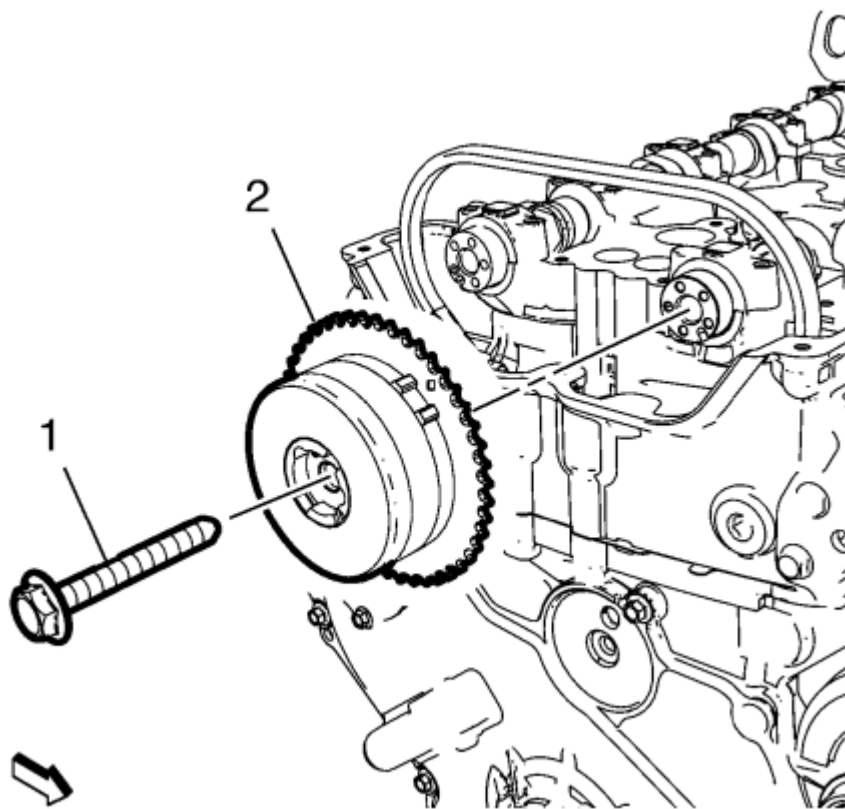
**Fig. 158: Timing Chain Retention Tool On Exhaust Side**  
**Courtesy of GENERAL MOTORS COMPANY**

12. Install the **EN-48749** retention tool (1) to the exhaust side of the timing chain.
13. Remove and DISCARD the camshaft position exhaust actuator bolt (1).



**Fig. 159: Open Ended Wrench & Actuator Bolt**  
Courtesy of GENERAL MOTORS COMPANY

14. Rotate the exhaust camshaft clockwise with an open ended wrench slightly to take the tension off of the timing chain.
15. Remove the exhaust camshaft actuator (2) from the camshaft while also removing the actuator from the timing chain.
16. Release tension from the exhaust camshaft and allow the exhaust camshaft to slide back slowly.



**Fig. 160: Camshaft Intake Actuator & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

17. Remove and DISCARD the camshaft position intake actuator bolt (1).
18. Remove the intake camshaft actuator (2) from the camshaft while also removing the actuator from the timing chain.

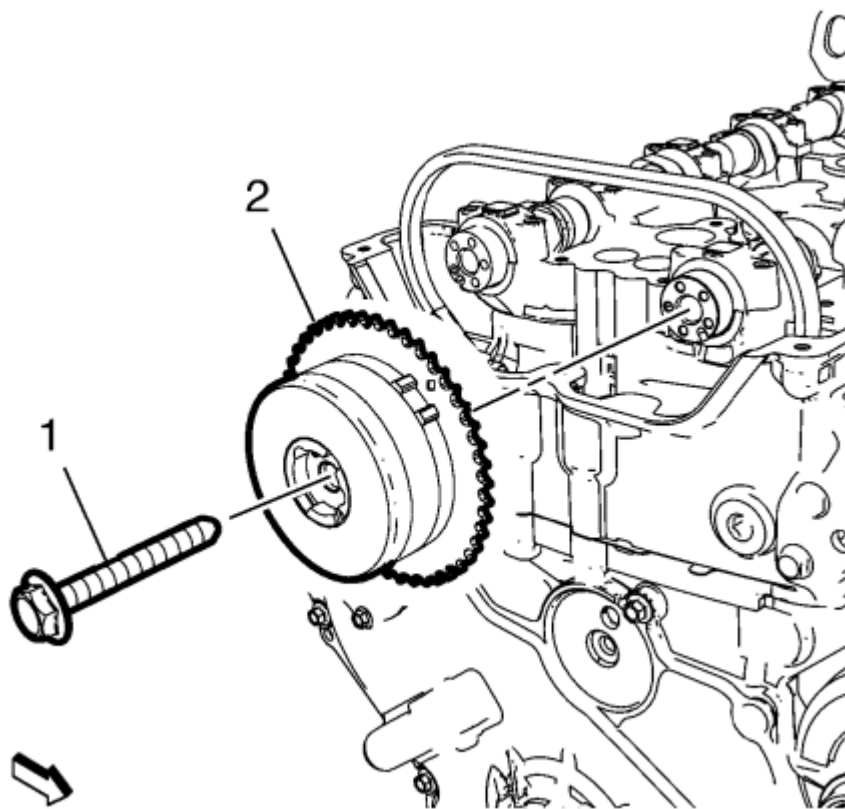
#### Installation Procedure

1. Mark the new intake camshaft actuator at the same point as the old intake camshaft actuator.

**NOTE:**        **Ensure the timing chain and the camshaft position actuator is the marked point.**

**Ensure that the intake camshaft actuator fully fits in the intake camshaft.**

2. Rotate the intake camshaft clockwise with a open ended wrench slightly to fit the intake camshaft actuator in the intake camshaft.



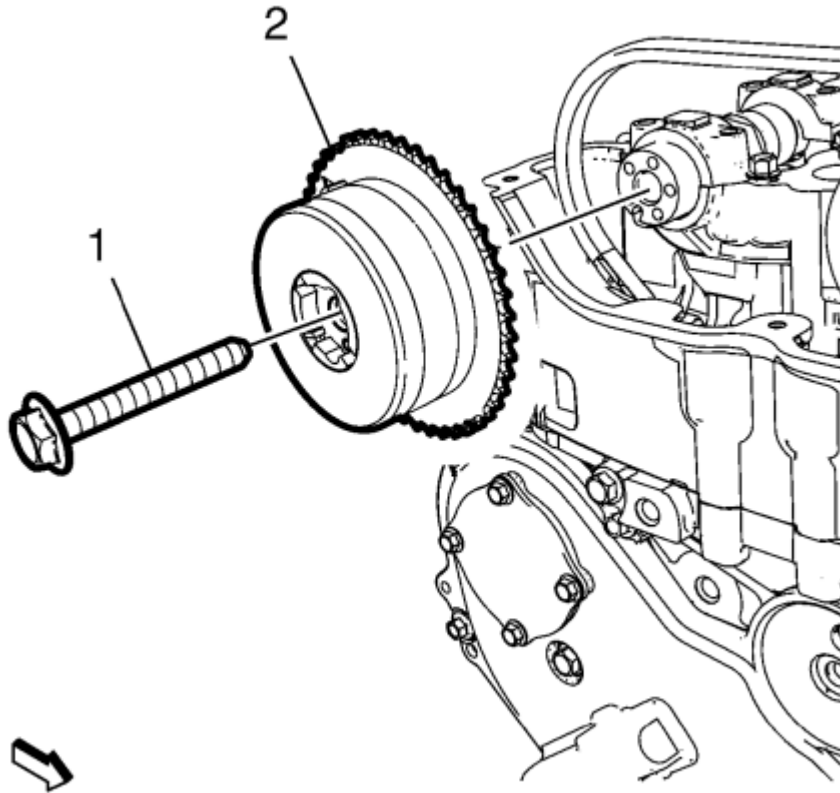
**Fig. 161: Camshaft Intake Actuator & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

3. Install the intake camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.
4. Release tension slowly from the intake camshaft.
5. Install the NEW camshaft position intake actuator bolt (1) handtighten.
6. Mark the new camshaft exhaust actuator at the same point as the old camshaft exhaust actuator.

**NOTE:**      **Ensure the timing chain and the camshaft position actuators are on their marked points.**

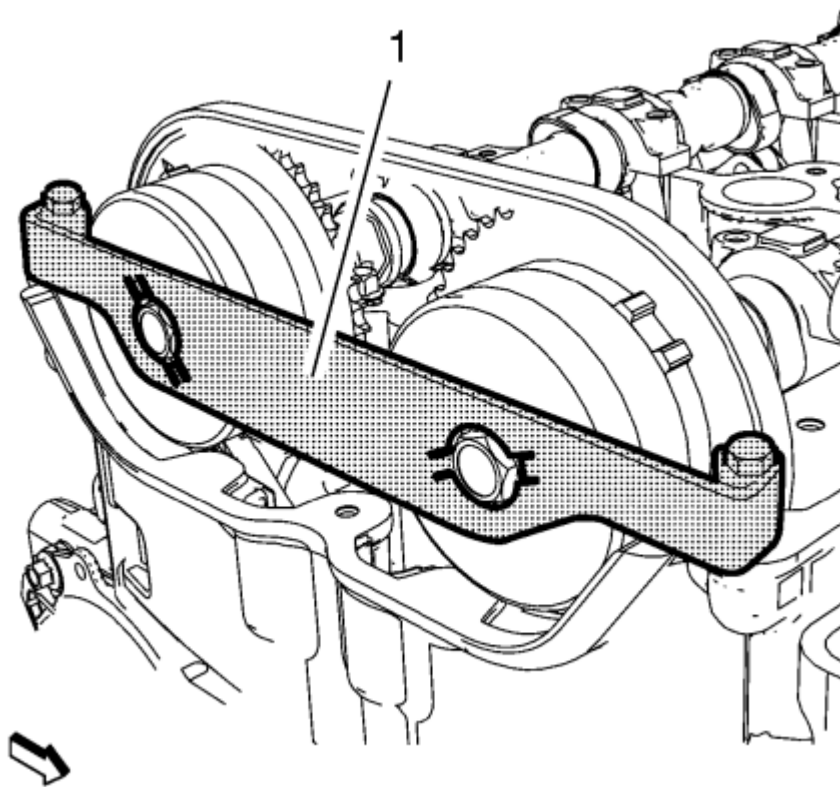
**Ensure that the exhaust camshaft actuator fully fits in the exhaust camshaft.**

7. Rotate the exhaust camshaft clockwise with an open ended wrench slightly to fit the exhaust camshaft actuator in the exhaust camshaft.



**Fig. 162: Camshaft Position Exhaust Actuator & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

8. Install the exhaust camshaft actuator (2) to the exhaust camshaft while also installing the actuator at the timing chain.
9. Release tension slowly from the exhaust camshaft.
10. Install the NEW camshaft position exhaust actuator bolt (1) handtighten.
11. Remove both **EN-48749** retention tool from the timing chain.
12. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



**Fig. 163: Crankshaft Locking Tool**  
**Courtesy of GENERAL MOTORS COMPANY**

13. Install the **EN-48953** locking tool (1) to the camshafts.
14. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).
15. Tighten the exhaust camshaft actuator (2) a first pass to 30 N.m (22 lb ft).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

16. Tighten the exhaust camshaft actuator a final pass to an additional 100 degrees, using the **EN-45059** meter.
17. Tighten the intake camshaft actuator (2) a first pass to 30 N.m (22 lb ft).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

18. Tighten the intake camshaft actuator a final pass to an additional 100 degrees, using the **EN-45059** meter.
19. Remove the **EN-48953** locking tool.
20. Rotate the crankshaft clockwise at the crankshaft balancer bolt to 720 degrees and ensure that the marks

are still fit. If the marks are not fit, refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.

21. Install the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
22. Install the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
23. Install the spark plugs. Refer to **Spark Plug Replacement** .

## **CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT**

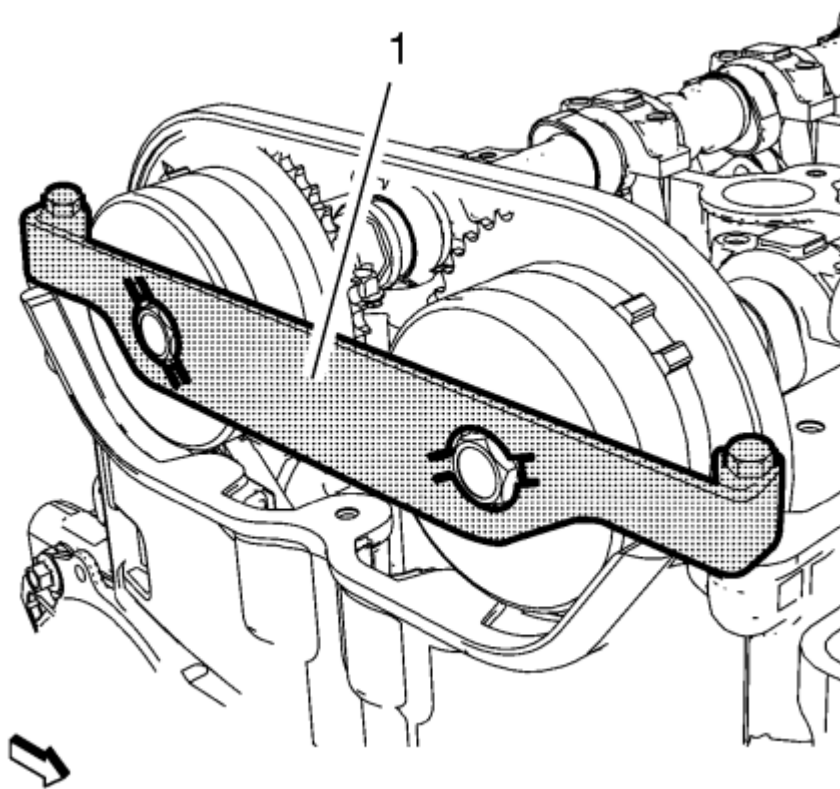
### **Special Tools**

- **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** .
3. Remove the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
4. Remove the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .

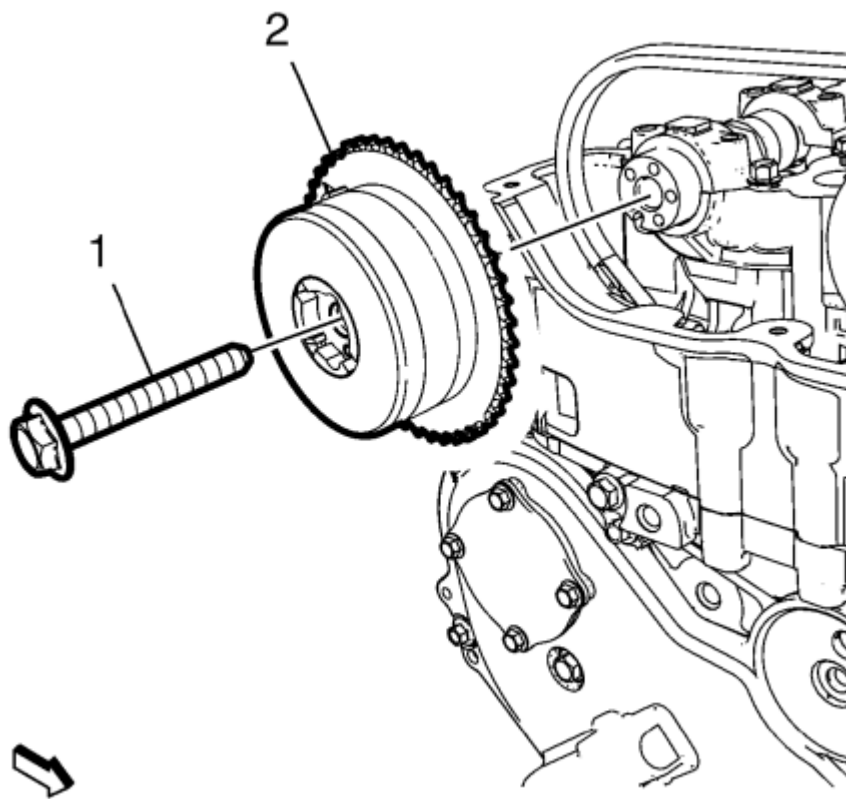


**Fig. 164: Crankshaft Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

5. Rotate the crankshaft clockwise at the crankshaft balancer bolt and install the **EN-48953** locking tool (1) to the camshafts.

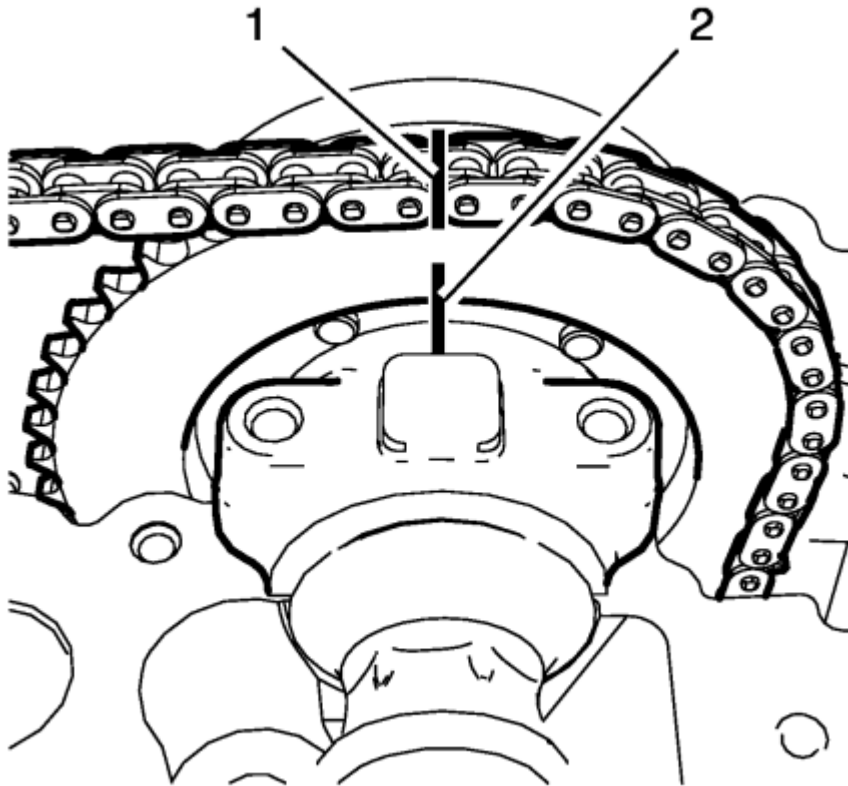
**CAUTION: Refer to Fastener Caution .**

6. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).



**Fig. 165: Camshaft Position Exhaust Actuator & Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

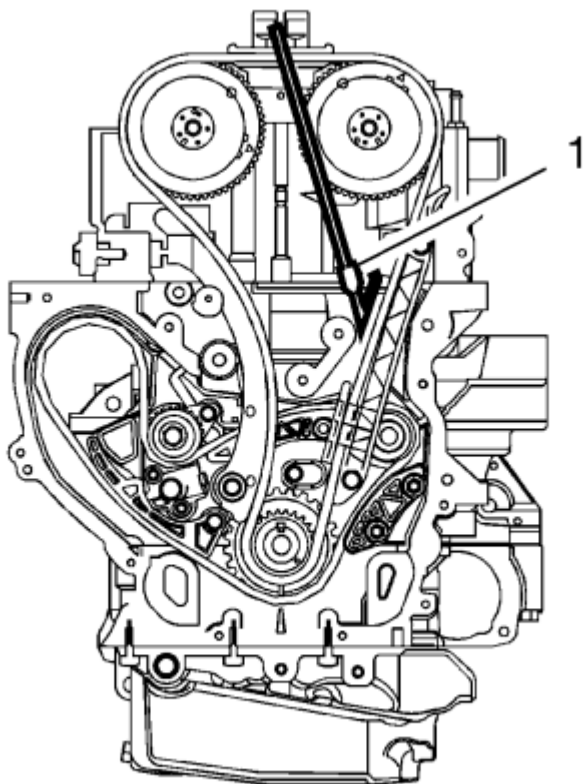
7. Loosen, but DO NOT remove, the camshaft position exhaust actuator bolt (1).
8. Remove the **EN-48953** locking tool.



**Fig. 166: Timing Chain & Camshaft Bearing Cover Marks**  
Courtesy of GENERAL MOTORS COMPANY

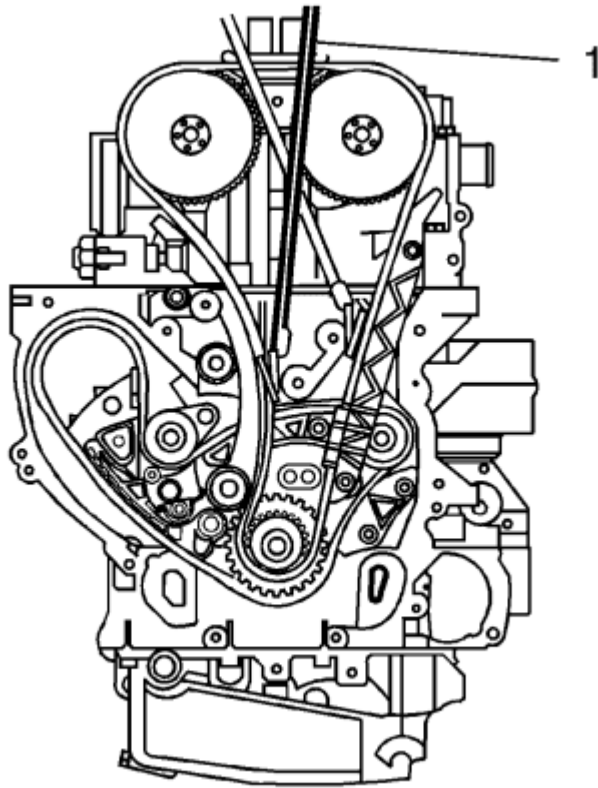
**NOTE:** Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

9. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain (1). Mark additional the position from each camshaft actuator to the camshaft bearing cover (2).
10. Remove the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



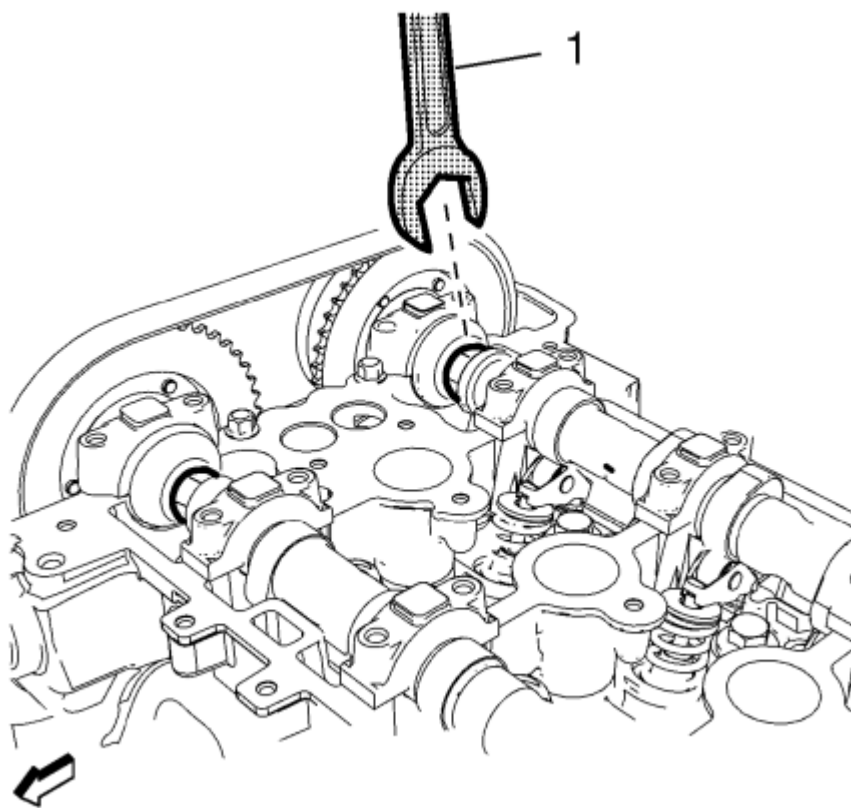
**Fig. 167: Timing Chain Retention Tool On Intake Side**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 168: Timing Chain Retention Tool On Exhaust Side**  
**Courtesy of GENERAL MOTORS COMPANY**

12. Install the **EN-48749** retention tool (1) to the exhaust side of the timing chain.
13. Remove and DISCARD the camshaft position exhaust actuator bolt (1).



**Fig. 169: Open Ended Wrench & Actuator Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

14. Rotate the exhaust camshaft clockwise with an open ended wrench slightly to take the tension off of the timing chain on the intake actuator.
15. Remove the exhaust camshaft actuator (2) from the camshaft while also removing the actuator from the timing chain.
16. Release tension from the exhaust camshaft and allow the exhaust camshaft to slide back slowly.

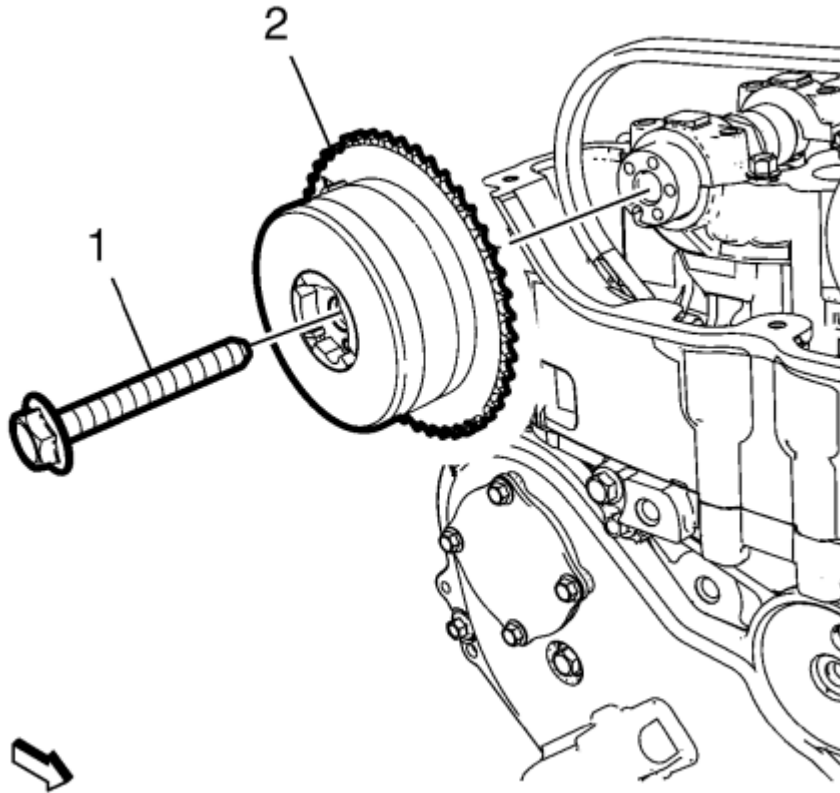
#### Installation Procedure

1. Mark the new exhaust camshaft actuator at the same point as the old exhaust camshaft actuator.

**NOTE:**      **Ensure the timing chain and the camshaft position actuators are on their marked points.**

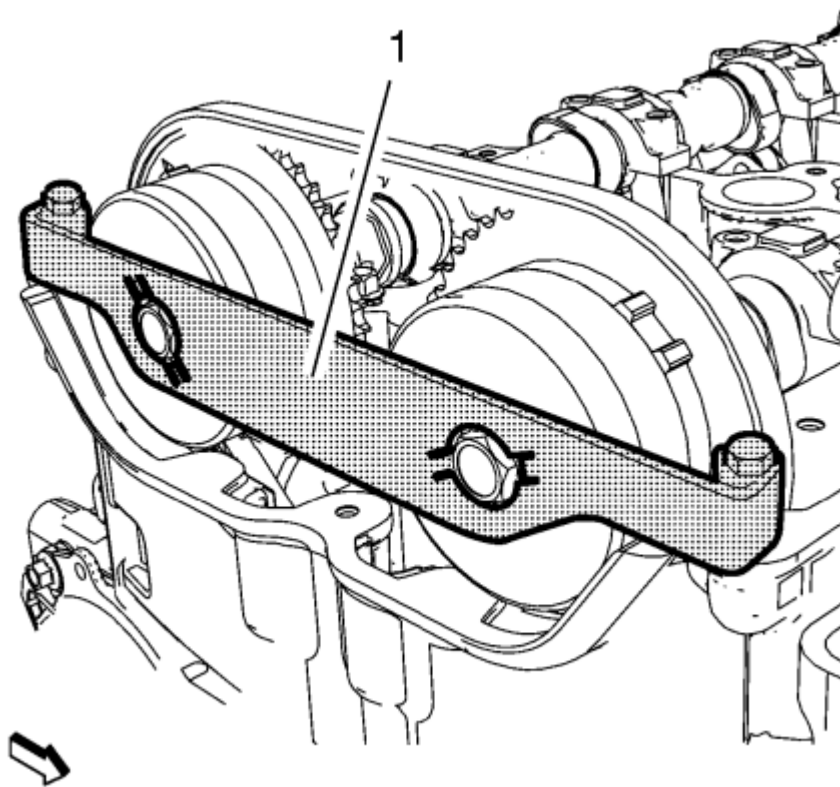
**Ensure that the exhaust camshaft actuator fully fits in the exhaust camshaft.**

2. Rotate the exhaust camshaft clockwise with an open ended wrench slightly to fit the exhaust camshaft actuator in the exhaust camshaft.



**Fig. 170: Camshaft Position Exhaust Actuator & Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

3. Install the exhaust camshaft actuator (2) to the camshaft while also installing the actuator at the timing chain.
4. Release tension slowly from the exhaust camshaft.
5. Install the NEW camshaft position exhaust actuator bolt (1) handtighten.
6. Remove both **EN-48749** retention tool from the timing chain.
7. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.



**Fig. 171: Crankshaft Locking Tool**  
**Courtesy of GENERAL MOTORS COMPANY**

8. Install the **EN-48953** locking tool (1) to the camshafts.
9. Install the **EN-48953** locking tool bolts and tighten to 10 N.m (89 lb in).
10. Tighten the exhaust camshaft actuator (2) a first pass to 30 N.m (22 lb in).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

11. Tighten the exhaust camshaft actuator a final pass to an additional 100 degrees, using the **EN-45059** meter.
12. Remove the **EN-48953** locking tool.
13. Rotate the crankshaft clockwise at the crankshaft balancer bolt to 720 degrees and ensure that the marks are still fit. If the marks are not fit, refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.
14. Install the front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
15. Install the upper timing chain guide. Refer to **Timing Chain Upper Guide Replacement**.
16. Install the spark plugs. Refer to **Spark Plug Replacement** .
17. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

## VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

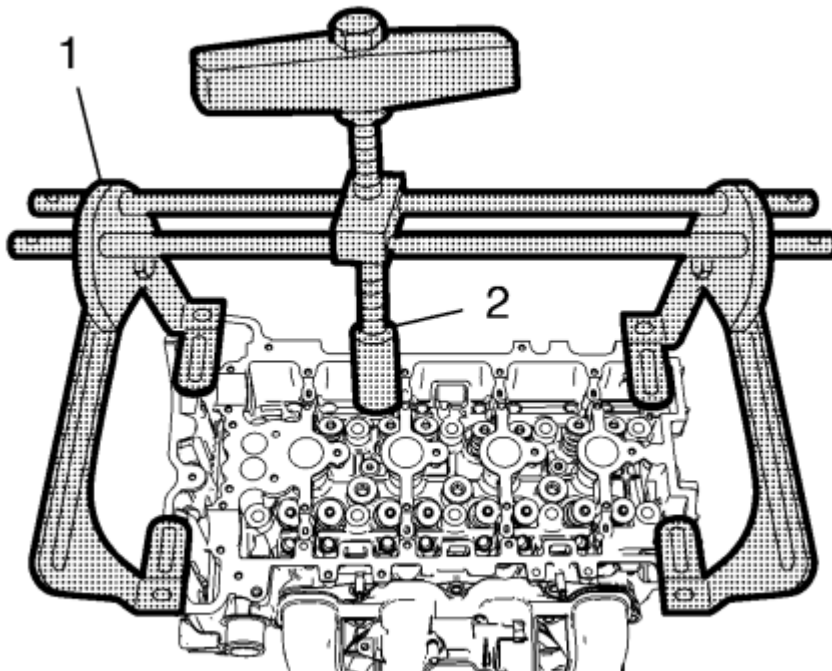
### Special Tools

- **EN-36017** Valve Guide Seal Remover
- **EN-43649** Valve Spring Compressor
- **EN-43653** Flywheel Holding Tool

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

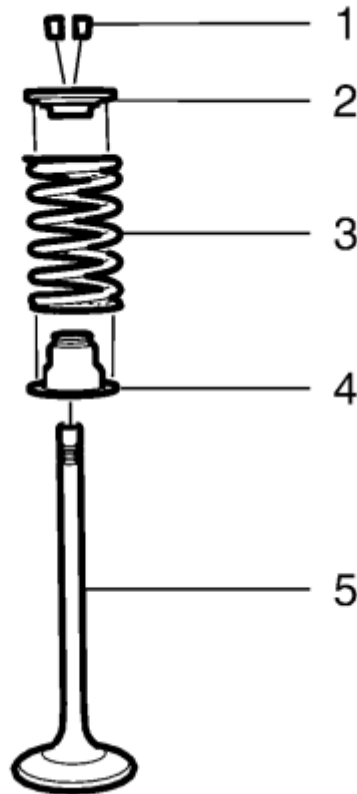
### Removal Procedure

1. Remove the starter. Refer to **Starter Replacement** .
2. Remove the exhaust camshaft. Refer to **Exhaust Camshaft Replacement**.
3. Remove the intake camshaft. Refer to **Intake Camshaft Replacement**.
4. Install the **EN-43653** holding tool.
5. Remove the valve rocker arms. Refer to **Valve Rocker Arm Replacement**.
6. Remove the spark plugs. Refer to **Spark Plug Replacement** .



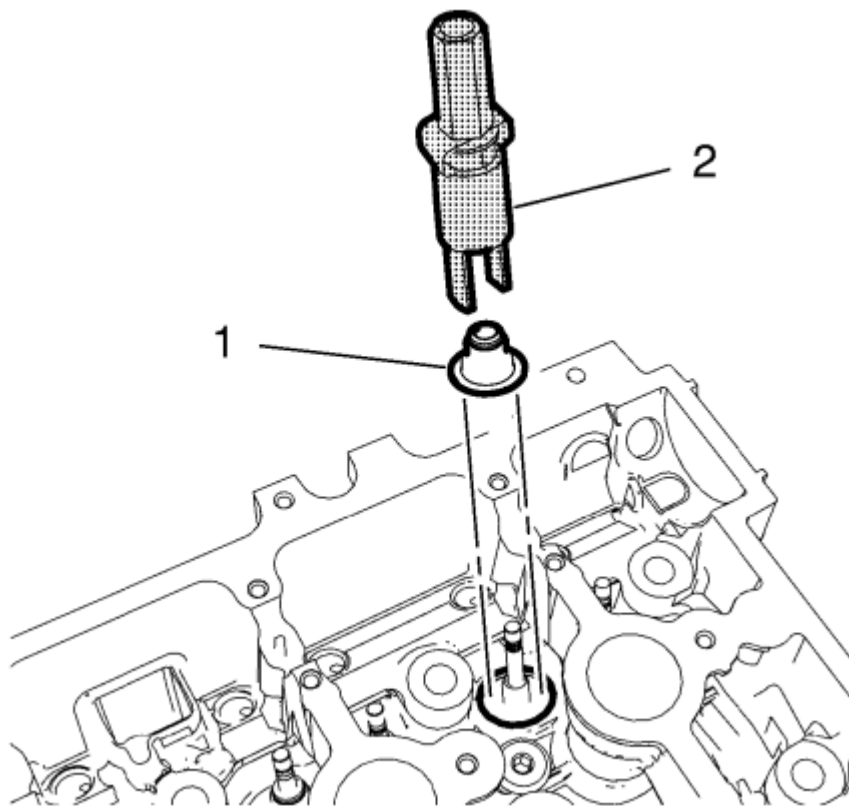
**Fig. 172: Valve Spring Compressor**  
Courtesy of GENERAL MOTORS COMPANY

7. Install the **EN-43649** compressor (1) to the cylinder head.
8. Install an air hose adapter into the spark plug hole.
9. Attach an air hose to the adapter and pressurize the cylinder to 6.9 bar (100 psi).
10. Compress the valve spring using the valve spring compressor (2).



**Fig. 173: Valve Spring, Keys & Retainer**  
Courtesy of GENERAL MOTORS COMPANY

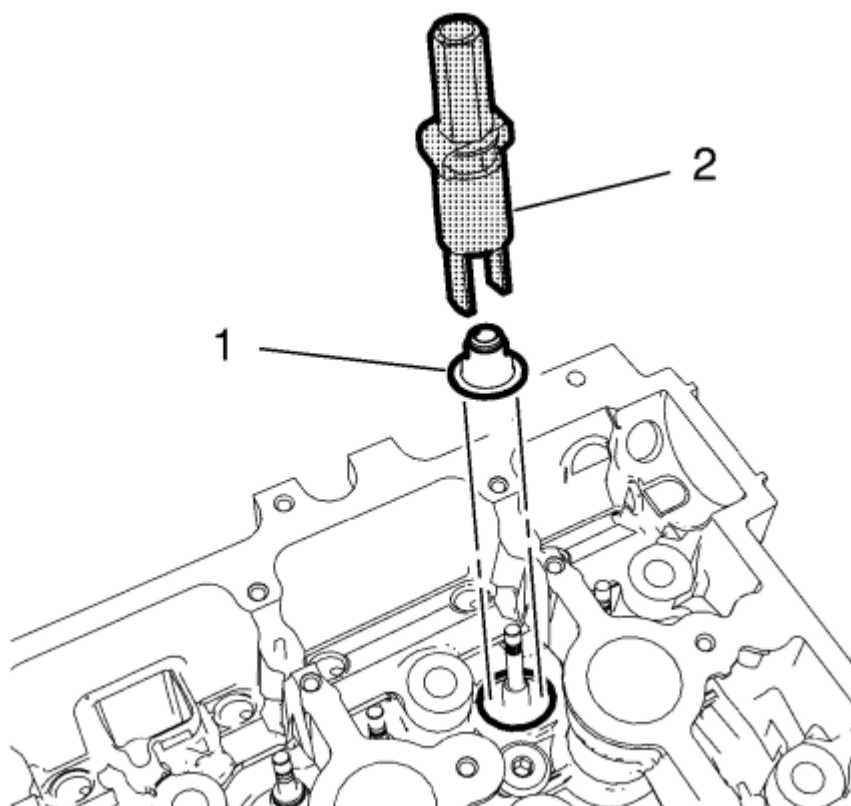
11. Remove the valve spring keys (1)
12. Remove the valve spring retainer (2) and the valve spring (3).



**Fig. 174: Valve Seal & Removal Tool**  
Courtesy of GENERAL MOTORS COMPANY

13. Use the **EN-36017** remover (2) to remove the valve seal (1).

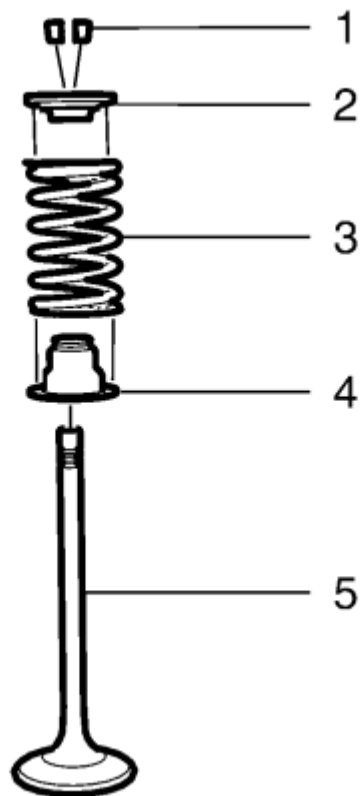
#### **Installation Procedure**



**Fig. 175: Valve Seal & Removal Tool**

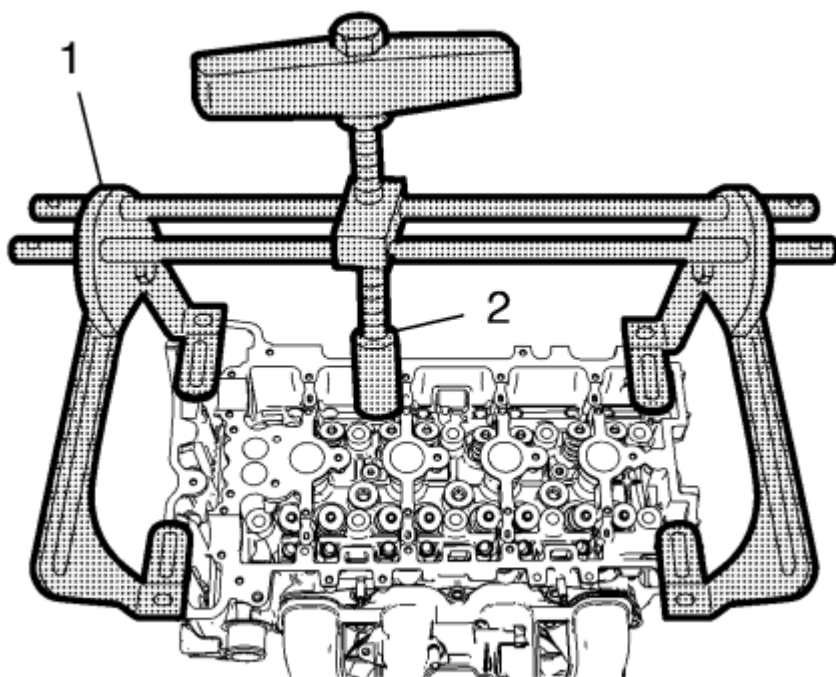
Courtesy of GENERAL MOTORS COMPANY

1. Use the **EN-36017** remover (2) to install a NEW valve seal (1).



**Fig. 176: Valve Spring, Keys & Retainer**  
**Courtesy of GENERAL MOTORS COMPANY**

2. Install the valve spring retainer (2) and the valve spring (3) to the valve (5).



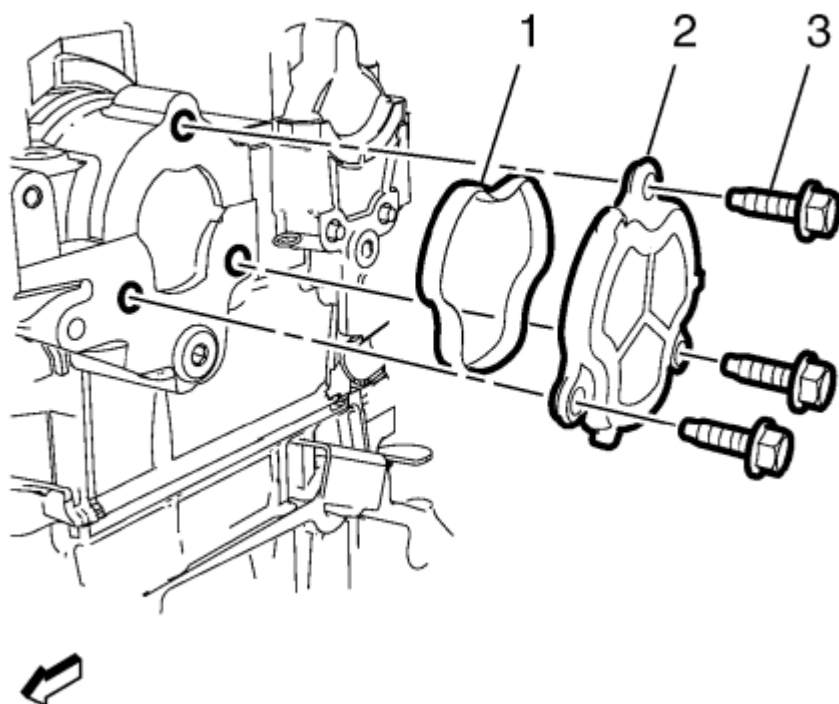
**Fig. 177: Valve Spring Compressor**

Courtesy of GENERAL MOTORS COMPANY

3. Compress the valve spring using the valve spring compressor (2).
4. Install the valve spring keys.
5. Disconnect the air hose and remove the air hose adapter from the spark plug hole.
6. Remove the **EN-43649** compressor.
7. Install the spark plugs. Refer to **Spark Plug Replacement** .
8. Remove the **EN-43653** holding tool.
9. Install the valve rocker arms. Refer to **Valve Rocker Arm Replacement**.
10. Install the intake camshaft. Refer to **Intake Camshaft Replacement**.
11. Install the exhaust camshaft. Refer to **Exhaust Camshaft Replacement**.
12. Install the starter. Refer to **Starter Replacement** .

## CYLINDER HEAD OPENING PLATE REPLACEMENT

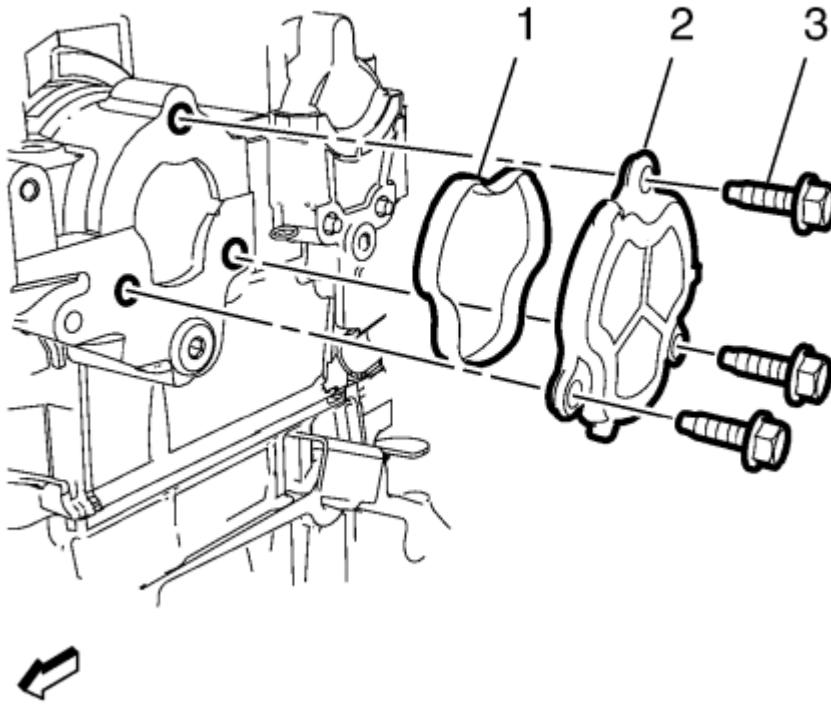
### Removal Procedure



**Fig. 178: Cylinder Head Opening Plate, Gasket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the cylinder head opening plate bolts (3).
2. Remove the cylinder head opening plate (2) along with the cylinder head opening plate gasket (1).

#### Installation Procedure



**Fig. 179: Cylinder Head Opening Plate, Gasket & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the cylinder head opening plate (2) with the NEW cylinder head opening plate gasket (1).

**CAUTION:** Refer to Fastener Caution .

2. Install the cylinder head opening plate bolts (3) and tighten to 10 N.m (89 lb in).

## CYLINDER HEAD REPLACEMENT

### Special Tools

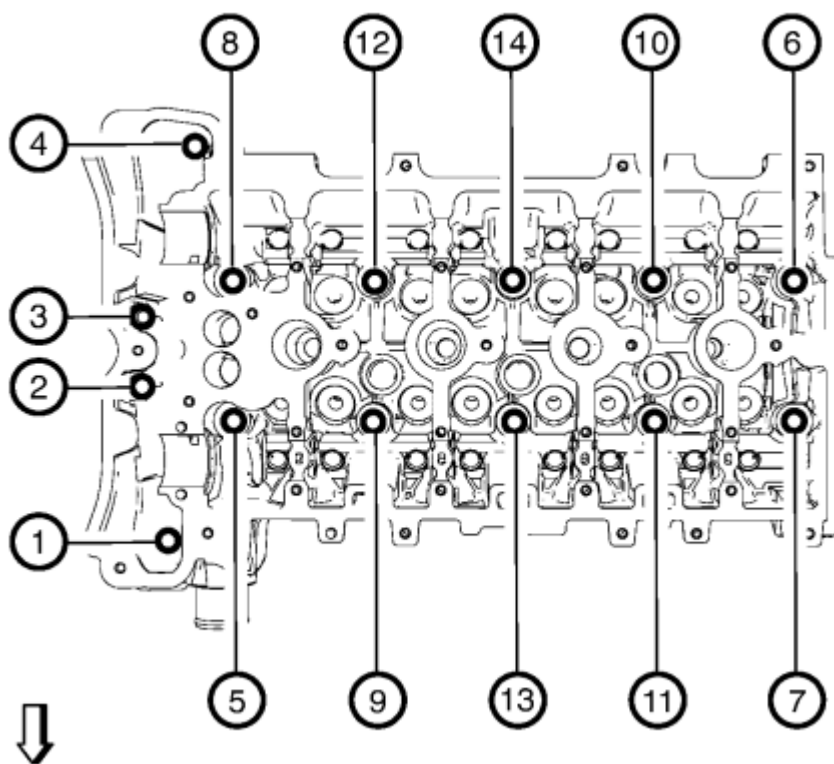
**EN-45059** Angle Meter

For equivalent regional tools, refer to Special Tools.

### Removal Procedure

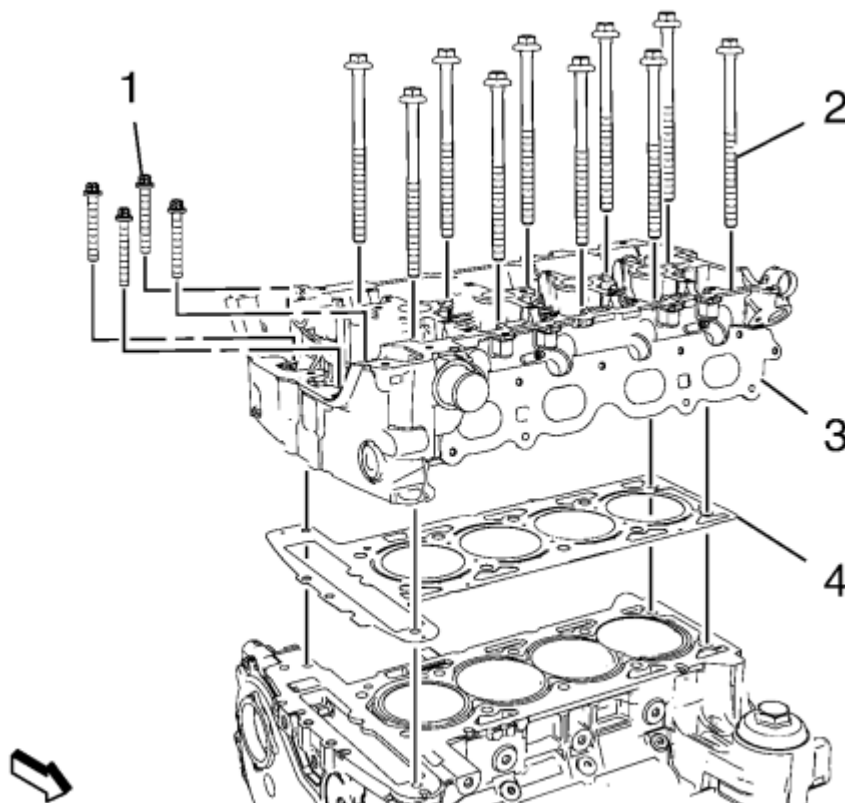
1. Remove the radiator surge tank inlet hose. Refer to Radiator Surge Tank Inlet Hose/Pipe Replacement .

2. Remove the three-way catalytic converter. Refer to **Three-Way Catalytic Converter Replacement** .
3. Remove the exhaust camshaft. Refer to **Exhaust Camshaft Replacement**.
4. Remove the intake camshaft. Refer to **Intake Camshaft Replacement**.
5. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
6. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement** .
7. Remove the fuel injection fuel rail assembly. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
8. Remove the hydraulic valve lash adjuster. Refer to **Hydraulic Valve Lash Adjuster Replacement**.



**Fig. 180: Cylinder Head Bolt Loosening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

9. Loosen the cylinder head bolts in sequence as shown.

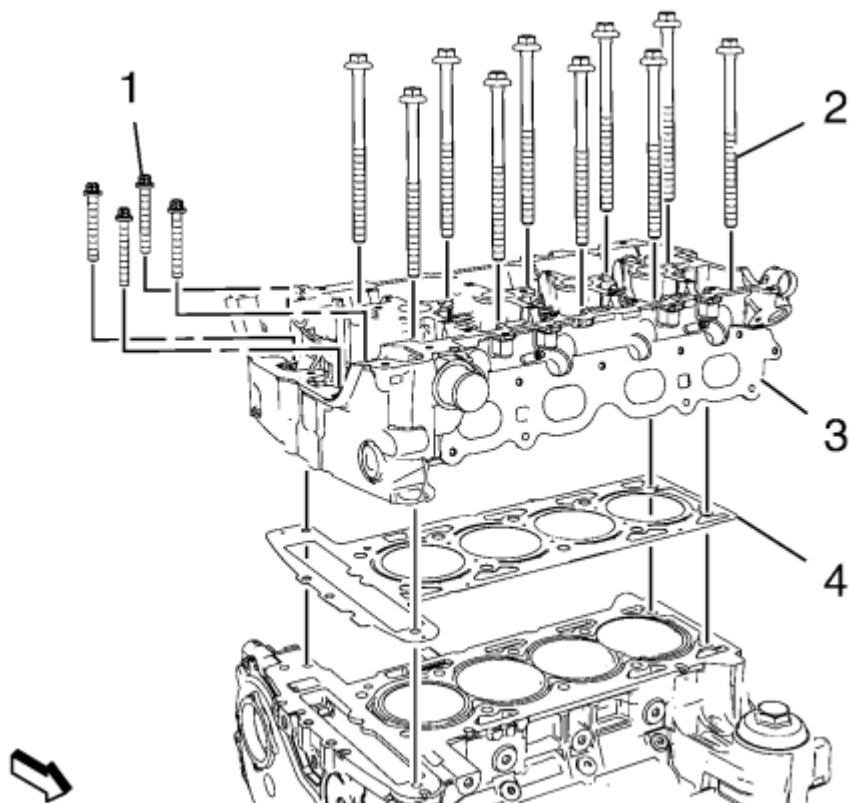


**Fig. 181: Cylinder Head, Gasket & Bolts**

Courtesy of GENERAL MOTORS COMPANY

10. Remove and DISCARD the 14 cylinder head bolts (1) and (2).
11. Remove the cylinder head (3) with the cylinder head gasket (4).

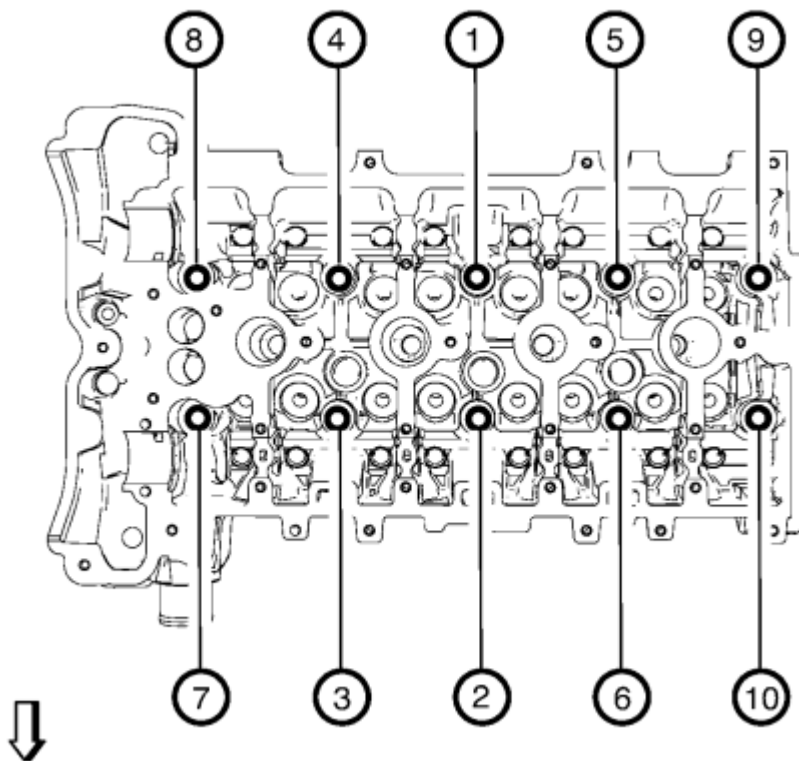
#### Installation Procedure



**Fig. 182: Cylinder Head, Gasket & Bolts**

Courtesy of GENERAL MOTORS COMPANY

1. Install the cylinder head (3) and the NEW cylinder head gasket (4).
2. Install the 14 cylinder head bolts (1) and (2).



**Fig. 183: Cylinder Head Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

3. Fasten the cylinder head bolts hand-tighten in sequence as shown.

**CAUTION: Refer to Fastener Caution .**

4. Tighten the NEW cylinder head bolts a first pass in the sequence as shown to 30 N.m (22 lb ft).

**CAUTION: Refer to Torque-to-Yield Fastener Caution .**

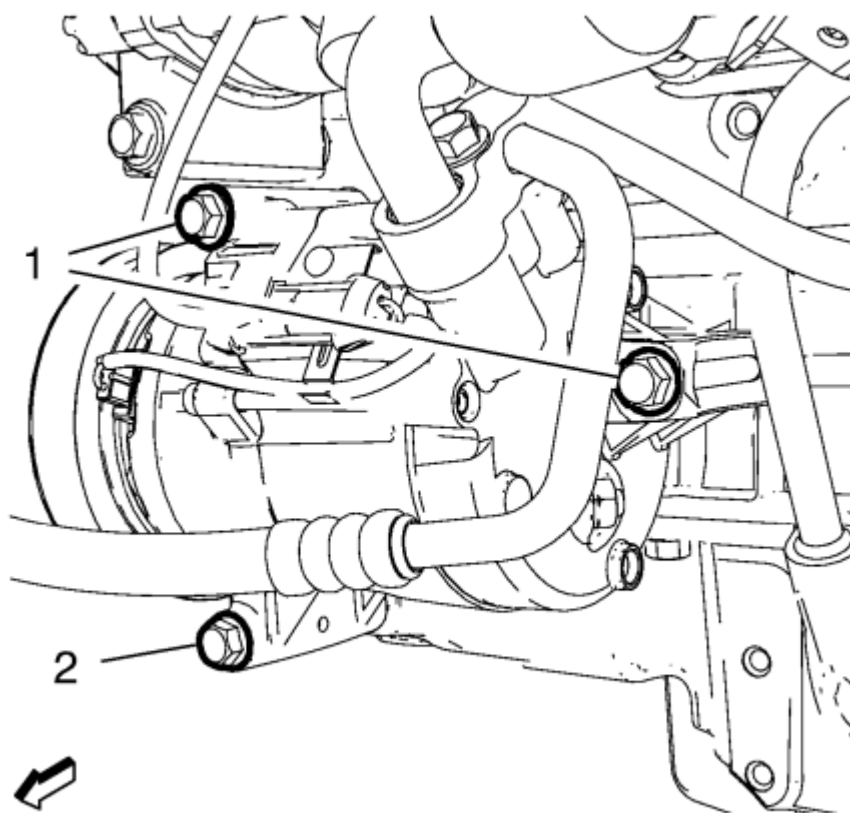
5. Tighten the cylinder head bolts a final pass in the sequence shown an additional 155 degrees, using the **EN-45059** meter.
6. Tighten the 4 cylinder head front bolts to 35 N.m (26 lb ft).
7. Install the hydraulic valve lash adjuster. Refer to **Hydraulic Valve Lash Adjuster Replacement**.
8. Install the fuel injection fuel rail assembly. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
9. Install the intake manifold. Refer to **Intake Manifold Replacement**.
10. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement** .

11. Install the intake camshaft. Refer to **Intake Camshaft Replacement**.
12. Install the exhaust camshaft. Refer to **Exhaust Camshaft Replacement**.
13. Install the radiator surge tank inlet hose. Refer to **Radiator Surge Tank Inlet Hose/Pipe Replacement**.
14. Install the three-way catalytic converter. Refer to **Three-Way Catalytic Converter Replacement**.
15. Replace the engine oil filter and the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

## OIL PAN REPLACEMENT

### Removal Procedure

1. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)**.
3. Remove the drive belt. Refer to **Drive Belt Replacement**.
4. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

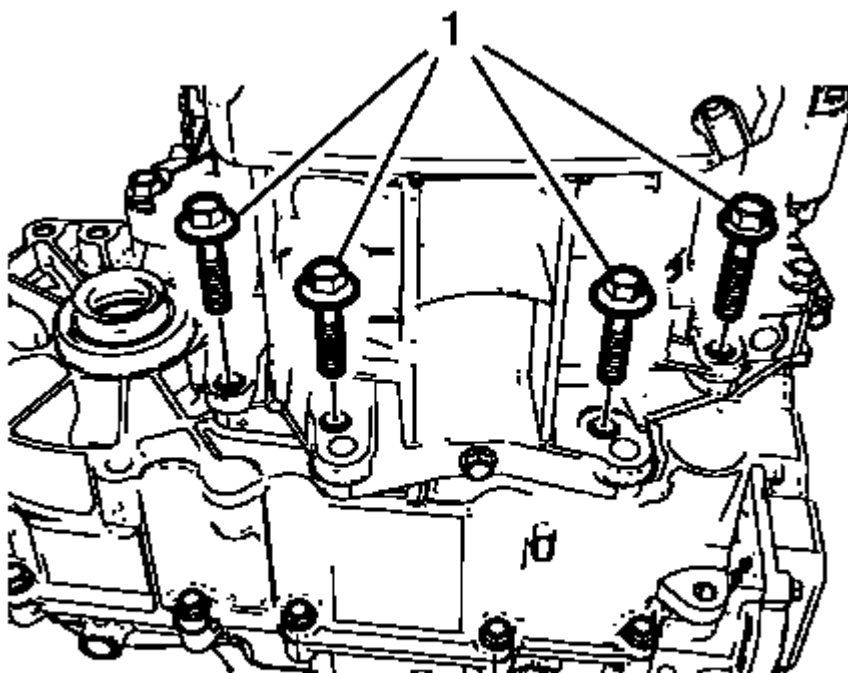


**Fig. 184: A/C Compressor Bolts**  
Courtesy of GENERAL MOTORS COMPANY

5. Loosen the 3 A/C compressor bolts (1, 2).
6. Remove the A/C compressor bolt (2) completely.

**NOTE:** Do not remove the A/C compressor.

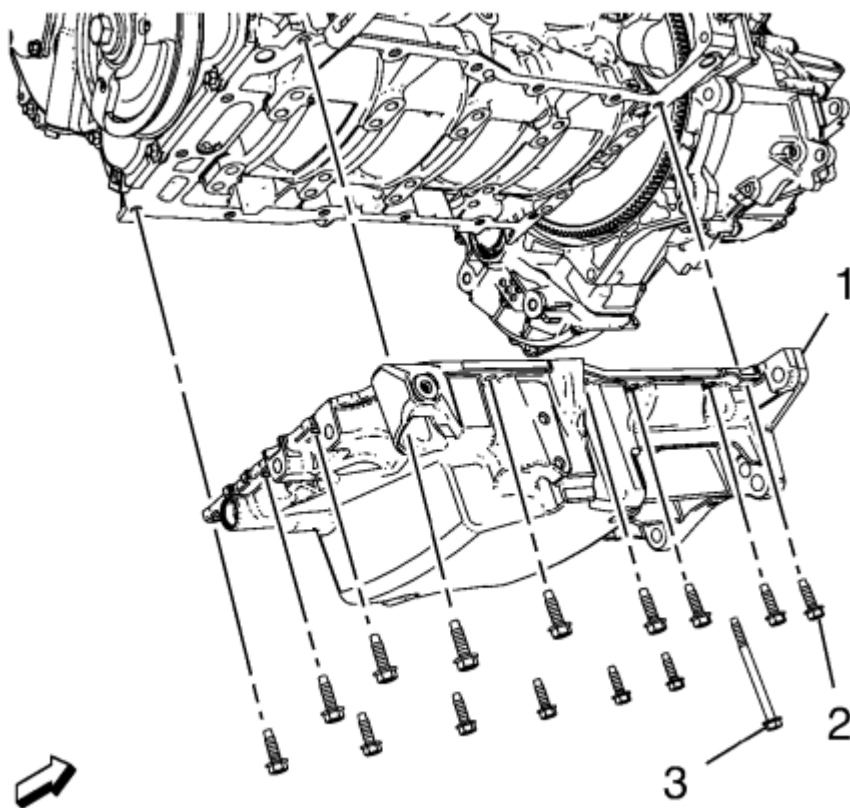
7. Pull the A/C compressor away from the engine block and oil pan in order to gain access to the oil pan.



**Fig. 185: Transmission Bolts**

Courtesy of GENERAL MOTORS COMPANY

8. Remove the 4 transmission bolts (1) from the transmission.



**Fig. 186: Oil Pan & Bolts**

Courtesy of GENERAL MOTORS COMPANY

9. Remove the long oil pan bolt (3).
10. Remove the 14 short oil pan bolts (2).

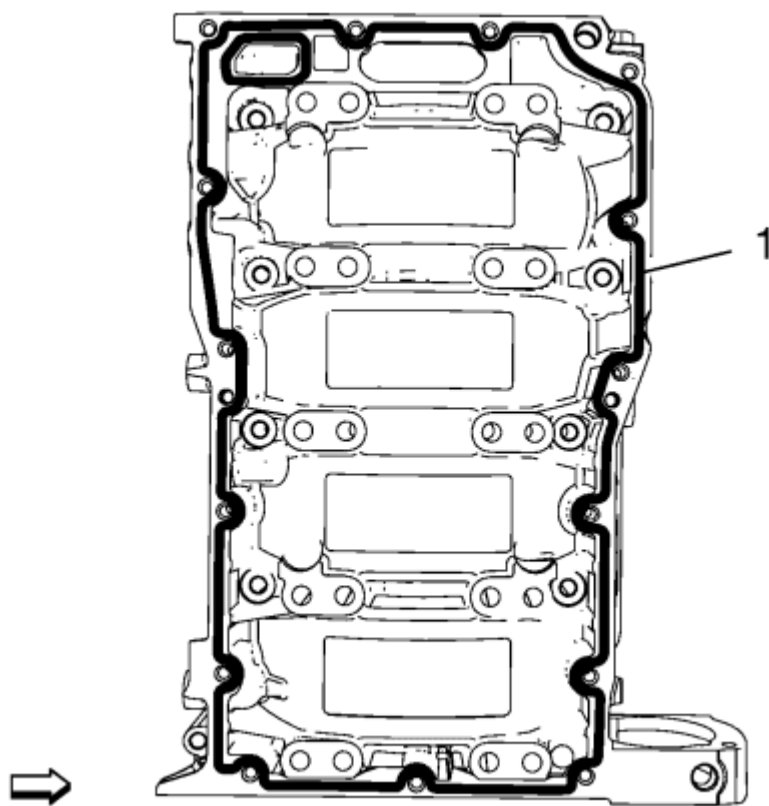
**CAUTION:** Pry the oil pan carefully in order to prevent damage to the transaxle case or the oil pan sealing surfaces.

11. Remove the oil pan (1).

#### Installation Procedure

1. Clean the sealing surfaces.

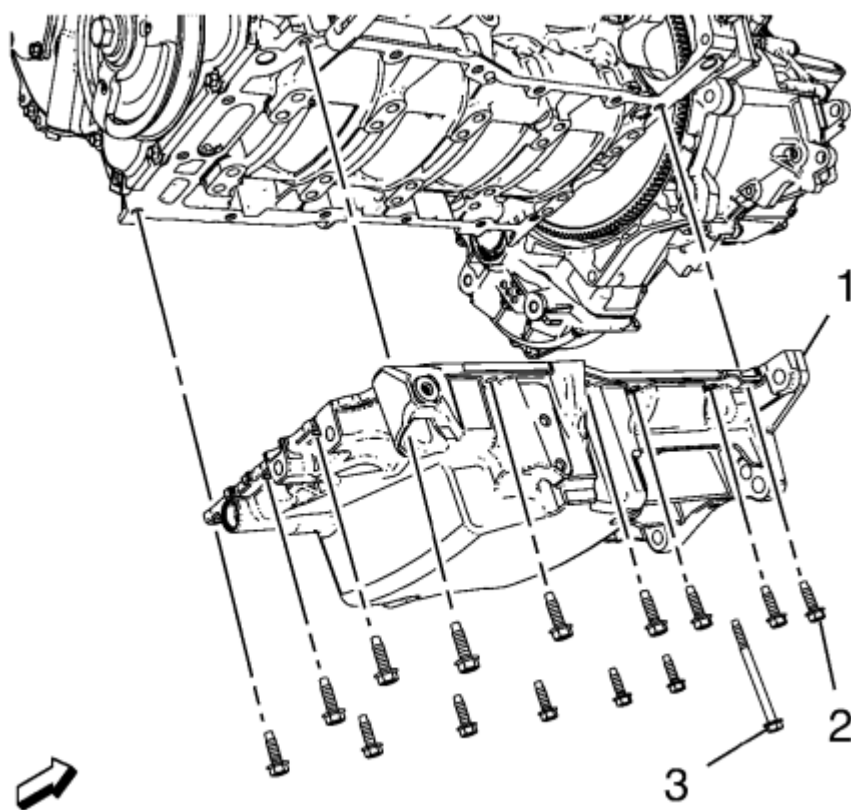
**NOTE:** The complete installation procedure of the lower oil pan should be done in 10 minutes. Do not coat sealing compound on the oil pan bolt bores and threads.



**Fig. 187: Oil Pan Sealant Bead**

Courtesy of GENERAL MOTORS COMPANY

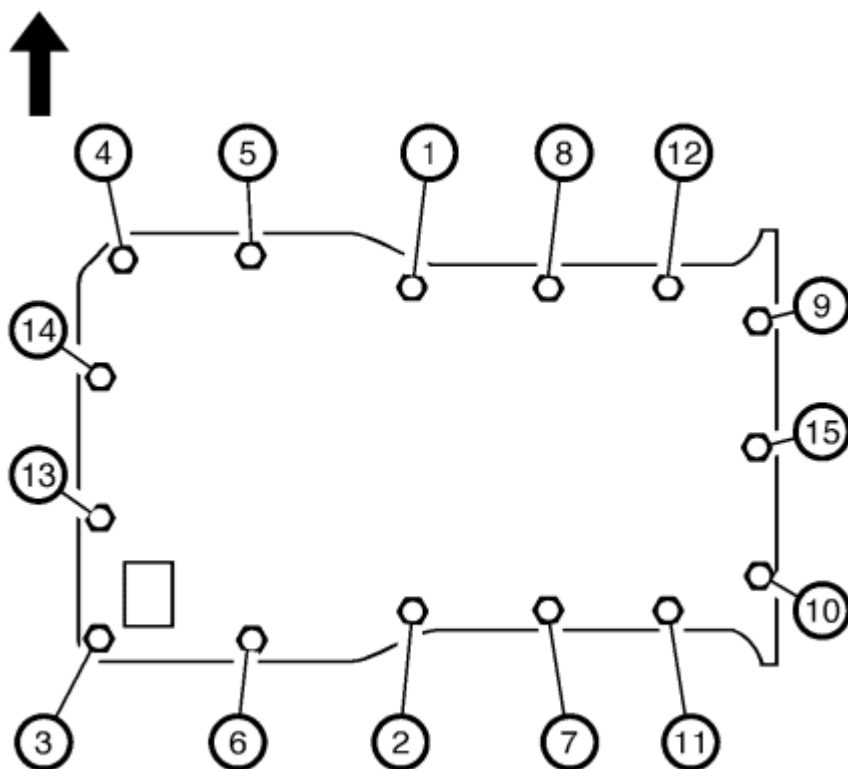
2. Ensure that the oil pan and the sealing surface on the lower crankcase are free of all oil and debris.
3. Apply a 2 mm (0.079 in) bead of suitable sealant (1) around the perimeter of the oil pan and the oil suction port opening. DO NOT over apply the sealant. More than a 2 mm (0.079 in) bead is not required.



**Fig. 188: Oil Pan & Bolts**

Courtesy of GENERAL MOTORS COMPANY

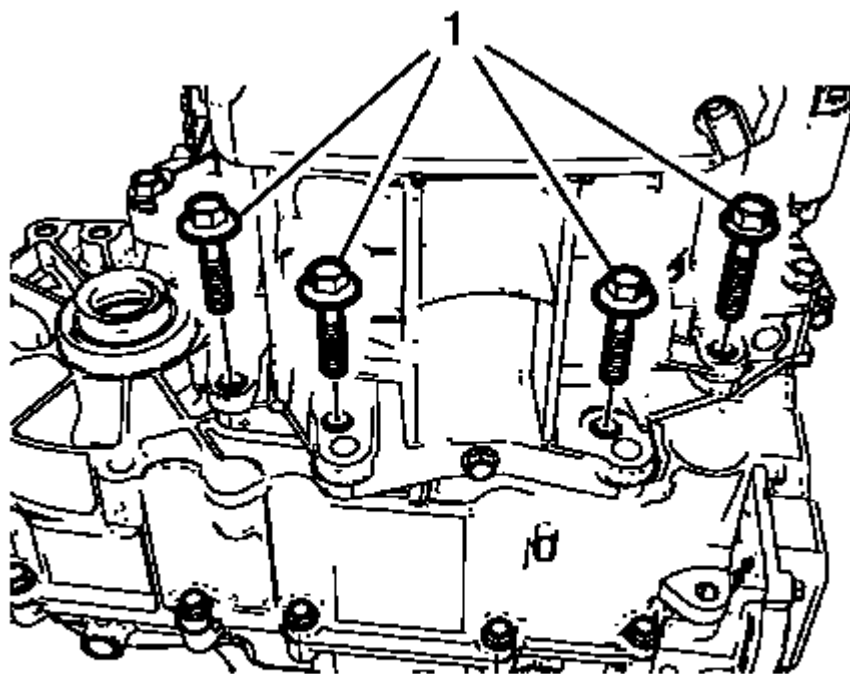
4. Install the oil pan (1).
5. Loosely tighten the 14 short oil pan bolts (2).
6. Loosely tighten the long oil pan bolt (3).



**Fig. 189: Oil Pan Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

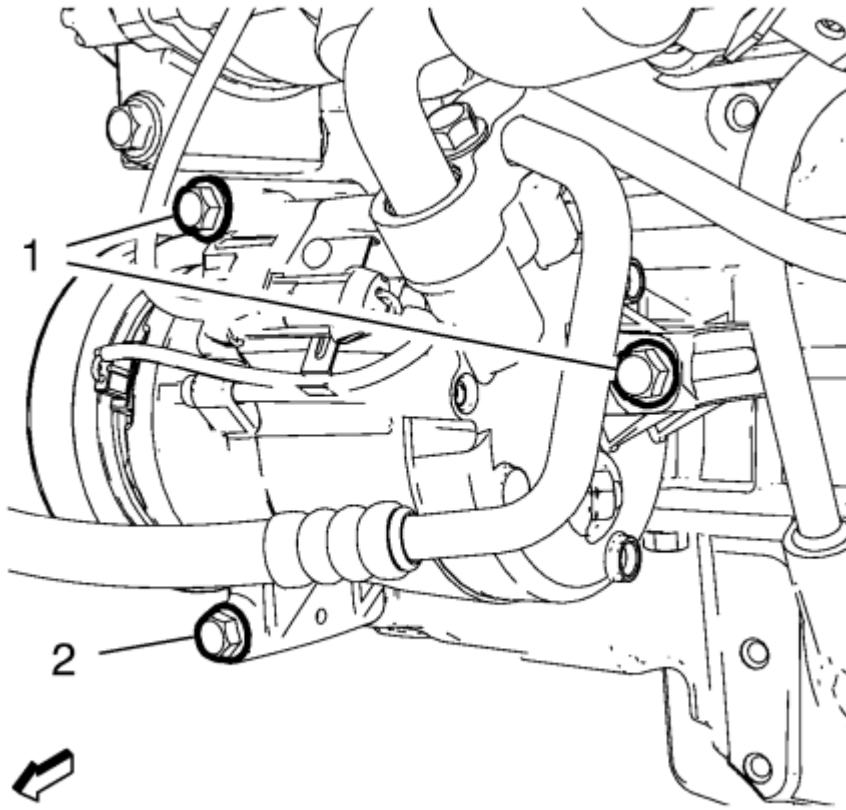
7. Tighten the oil pan bolts in a sequence as shown in the graphic above to 25 N.m (18 lb ft).



**Fig. 190: Transmission Bolts**

Courtesy of GENERAL MOTORS COMPANY

8. Tighten the 4 transmission bolts (1) to 45 N.m (33 lb ft).



**Fig. 191: A/C Compressor Bolts**

Courtesy of GENERAL MOTORS COMPANY

9. Reposition the A/C compressor and tighten the 3 A/C compressor bolts (1, 2) to 22 N.m (16 lb ft).
10. Install the drive belt. Refer to **Drive Belt Replacement**.
11. Lower the vehicle.
12. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
13. Fill up the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

## PISTON, CONNECTING ROD, AND BEARING REPLACEMENT

### Special Tools

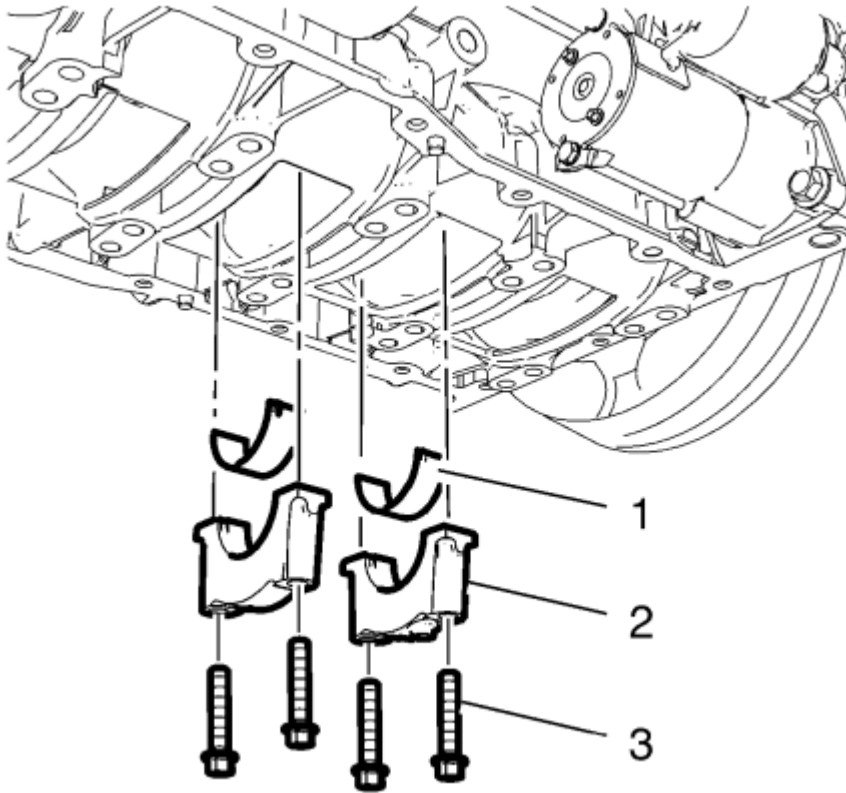
- EN-43953 Ring Compressor
- EN-43966-1 Connecting Rod Guides
- EN-45059 Angle Meter

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

### Removal Procedure

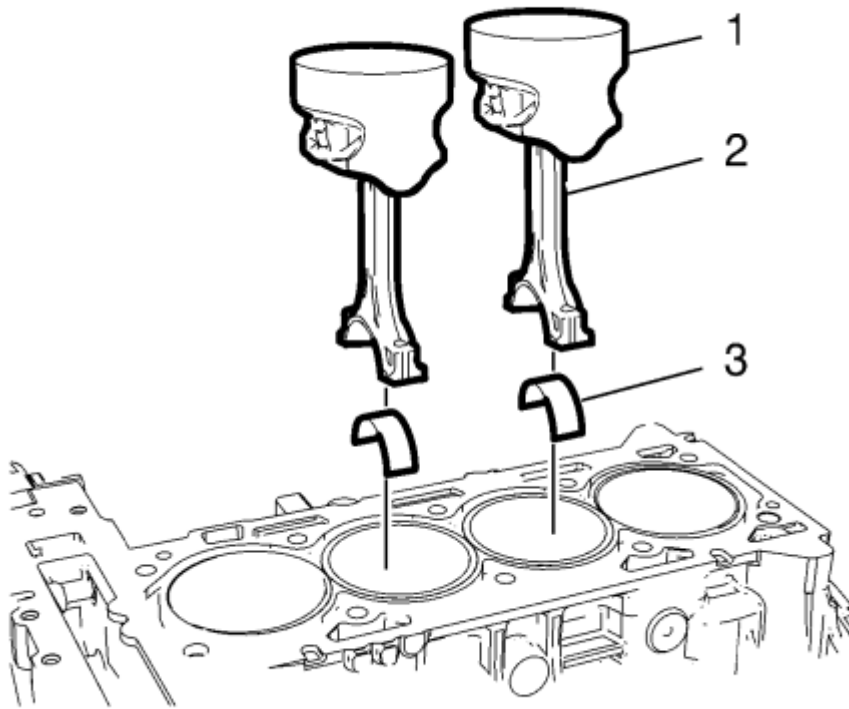
1. Remove the cylinder head. Refer to **Cylinder Head Replacement**.

2. Remove the oil pan. Refer to **Oil Pan Replacement**.
3. Rotate the crankshaft to a position where the connecting rod fasteners are the most accessible.
4. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
5. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.



**Fig. 192: Lower Piston Bearing, Bearing Caps & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

6. Remove the 4 bearing cap bolts (3) and the 2 bearing caps (2) and remove and DISCARD the lower bearing (1).
7. Install the **EN-43966-1** guides on the connecting rod threads before removing the piston and connecting the rod assembly.

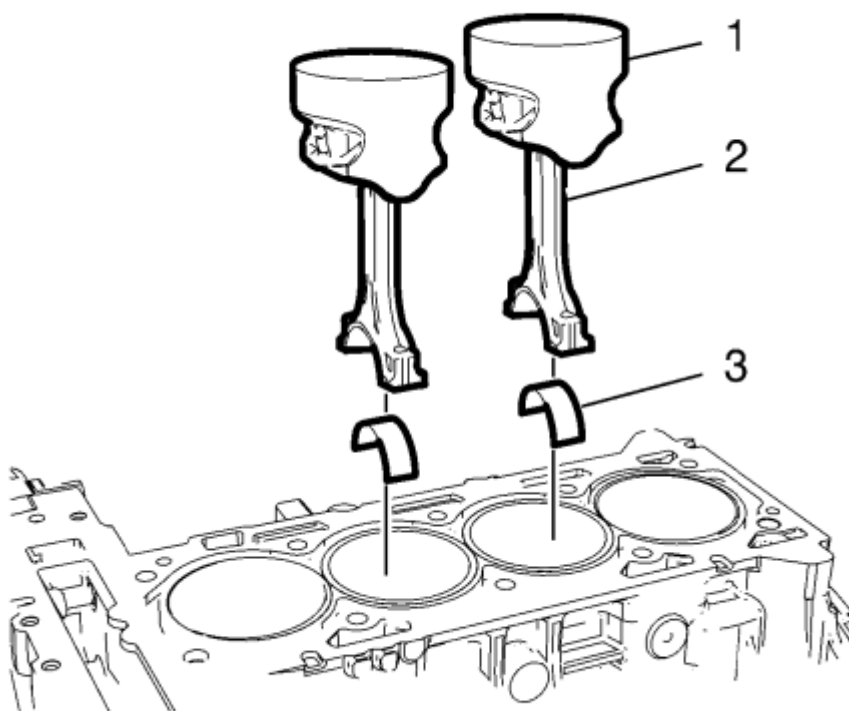


**Fig. 193: Upper Piston Bearing, Piston & Connecting Rod**  
Courtesy of GENERAL MOTORS COMPANY

8. Remove the piston (1) with the connecting rod (2) and remove and DISCARD the upper bearing (3).
9. Remove the **EN-43966-1** guides.

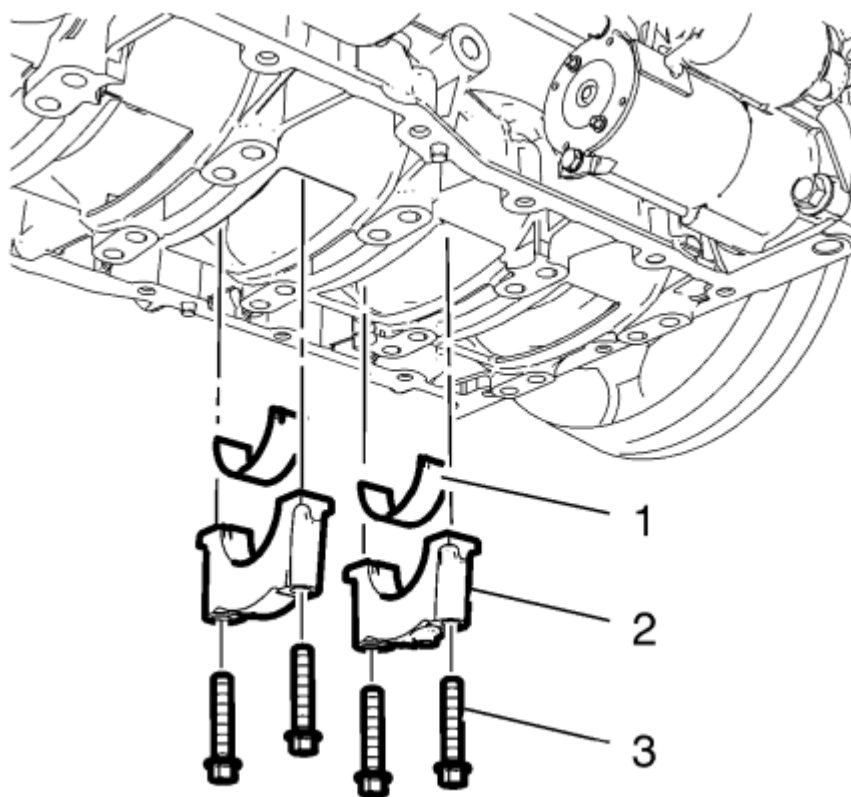
#### Installation Procedure

1. Install the **EN-43966-1** guides on the connecting rod threads. This protects the crankshaft journal during piston and connecting rod installation.
2. Install the **EN-43953** compressor to the piston and the connecting rod to the correct bore.



**Fig. 194: Upper Piston Bearing, Piston & Connecting Rod**  
Courtesy of GENERAL MOTORS COMPANY

3. Install the piston (1) with the connecting rod (2) and the NEW upper bearing (3).
4. Hold the **EN-43953** compressor against the engine block until all the rings have entered the cylinder bore.
5. Remove the **EN-43966-1** guides.



**Fig. 195: Lower Piston Bearing, Bearing Caps & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Ensure that the bearing caps are on the same places than before.

6. Install the NEW lower bearing (1) with the 2 bearing caps (2).

**CAUTION:** Refer to Fastener Caution .

7. Install the 4 bearing caps bolts (3) and tighten a first pass to 25 N.m (18 lb ft).

**CAUTION:** Refer to Torque-to-Yield Fastener Caution .

8. Tighten the 4 bearing caps bolts (3) a final pass to an additional 100 degrees, using the **EN-45059** meter.
9. Install the oil pan. Refer to Oil Pan Replacement.
10. Install the cylinder head. Refer to Cylinder Head Replacement.

#### **AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT**

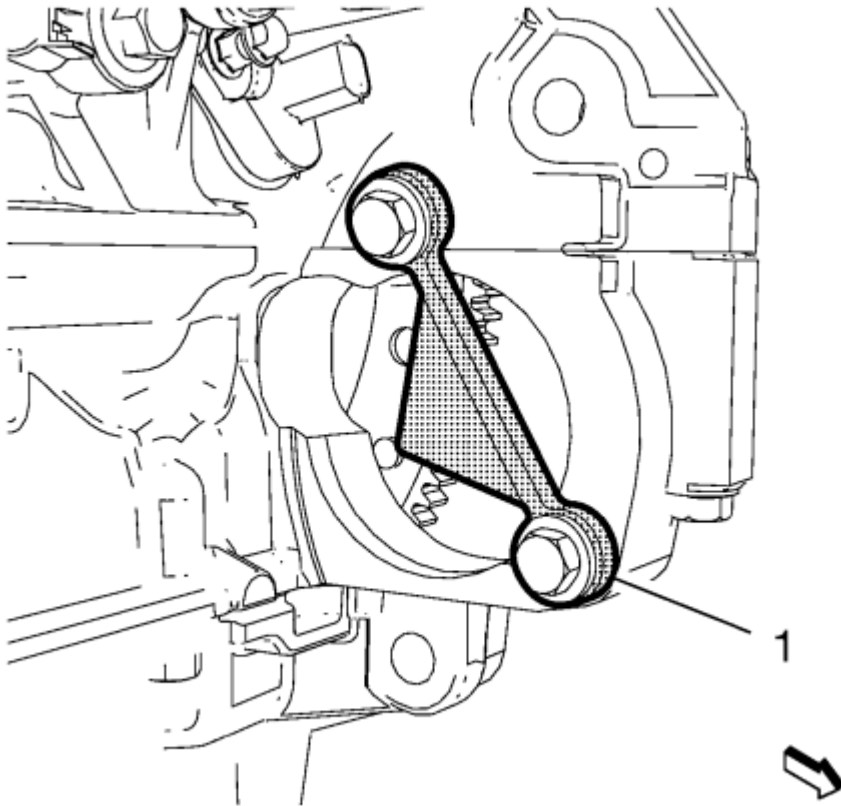
**Special Tools**

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

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

**Removal Procedure**

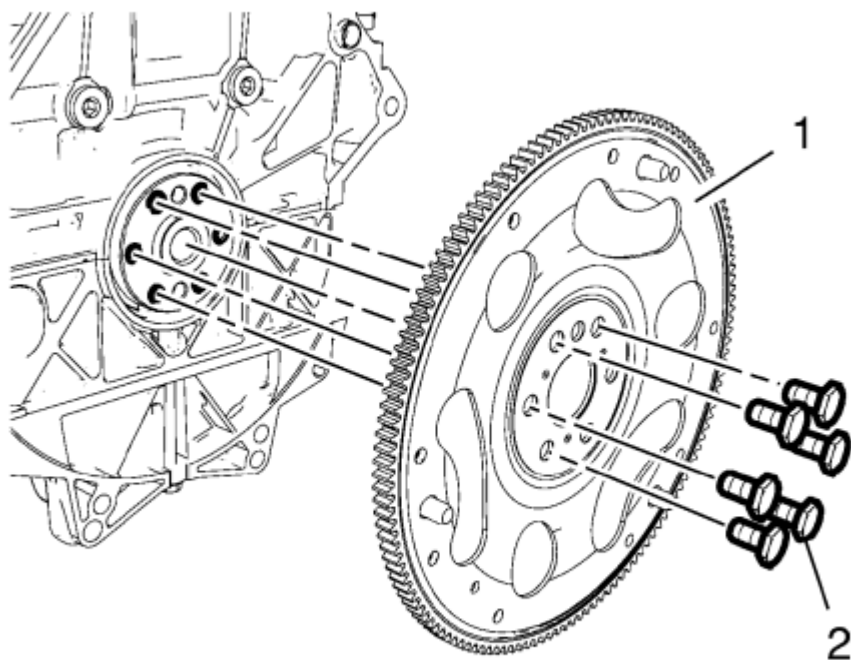
1. Remove the automatic transmission. Refer to **Transmission Replacement** .



**Fig. 196: Flywheel Holding Tool**

Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-43653** holding tool (1) in the starter assembly location, engaging the automatic flex plate, in order to prevent crankshaft rotation.



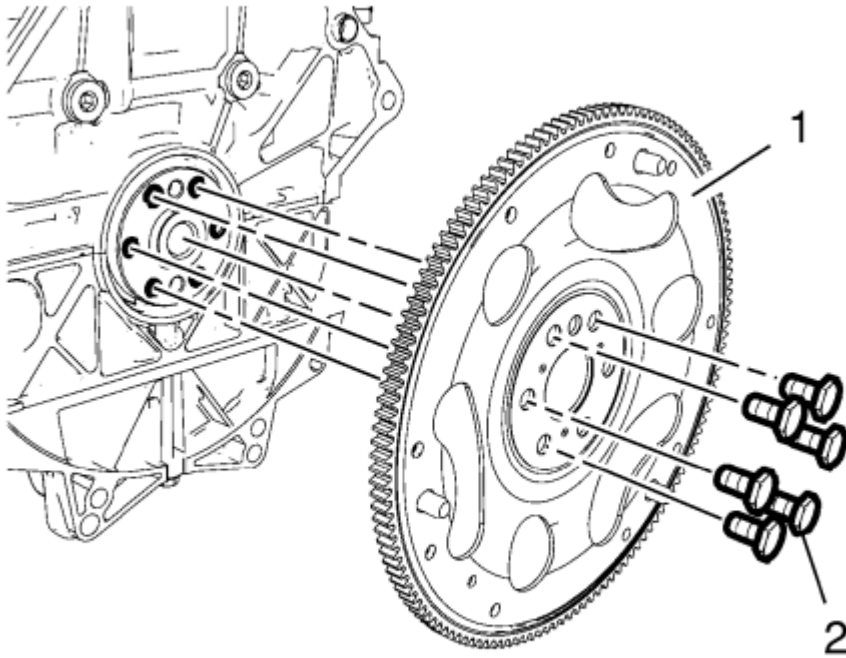
**Fig. 197: Automatic Flex Plate & Bolts**

**Courtesy of GENERAL MOTORS COMPANY**

3. Remove and DISCARD the 6 automatic transmission flex plate bolts (2) and the automatic flex plate (1).

#### **Installation Procedure**

1. Re-cut the 8 automatic transmission flex plate bolt threads in the crankshaft.

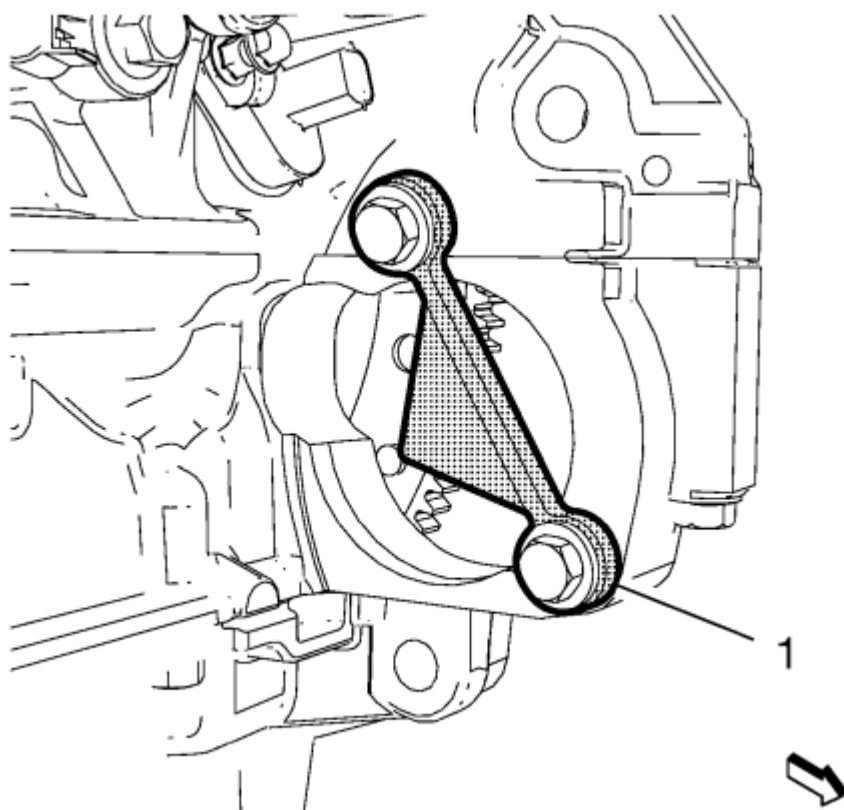


**Fig. 198: Automatic Flex Plate & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

**CAUTION:** Refer to Torque-to-Yield Fastener Caution .

2. Install the 6 automatic flex plate (1) and 6 NEW automatic transmission flex plate bolts (2) handtighten.
3. Tighten the automatic transmission flex plate bolts a first pass to 53 N.m (39 lb ft)
4. Tighten the automatic transmission flex plate bolts a final pass to an additional 25 degrees, using the **EN-45059** meter.



**Fig. 199: Flywheel Holding Tool**

Courtesy of GENERAL MOTORS COMPANY

5. Remove the **EN-43653** holding tool (1) from the starter assembly location.
6. Install the automatic transmission. Refer to **Transmission Replacement**.

## CRANKSHAFT REAR OIL SEAL REPLACEMENT

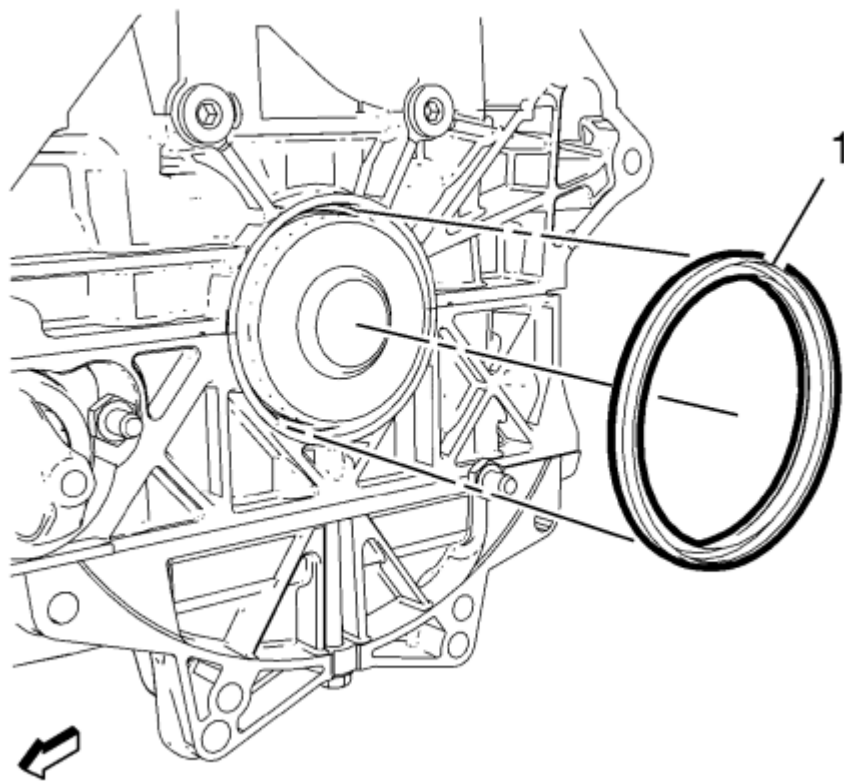
### Special Tools

**EN-42067** Rear Main Seal Installer.

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

### Removal Procedure

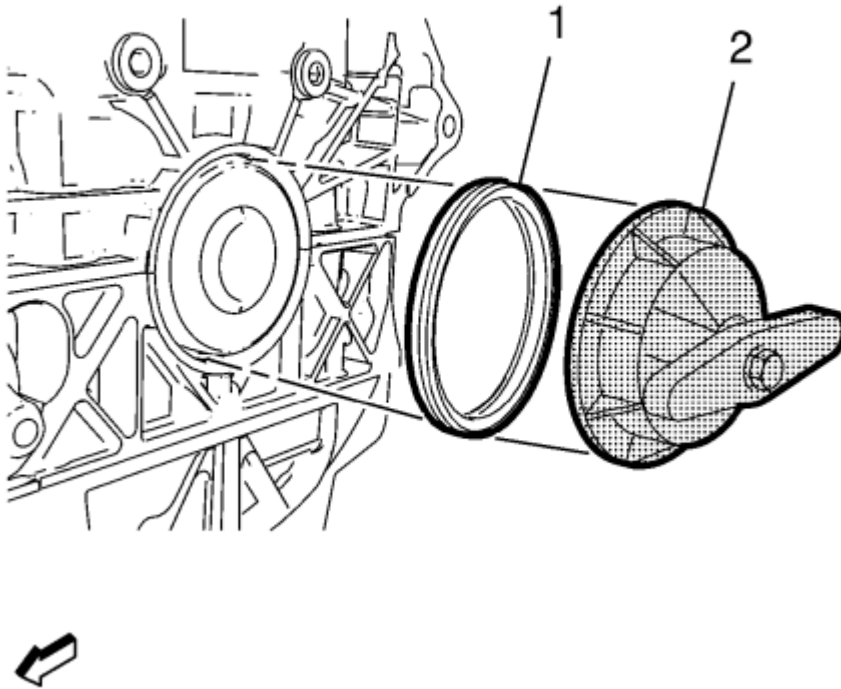
1. Remove the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement**.



**Fig. 200: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft rear oil seal (1) with a suitable tool.

**Installation Procedure**



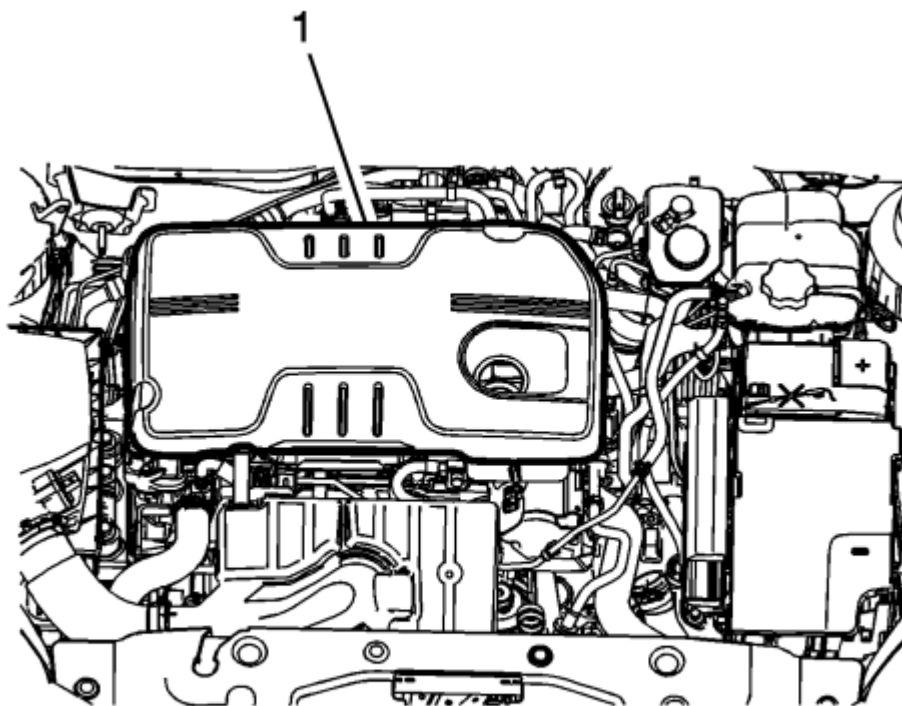
**Fig. 201: Crankshaft Rear Oil Seal & Installer**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft rear oil seal (1) with the **EN-42067** installer.
2. Install the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement**.

## ENGINE REPLACEMENT

### Removal Procedure

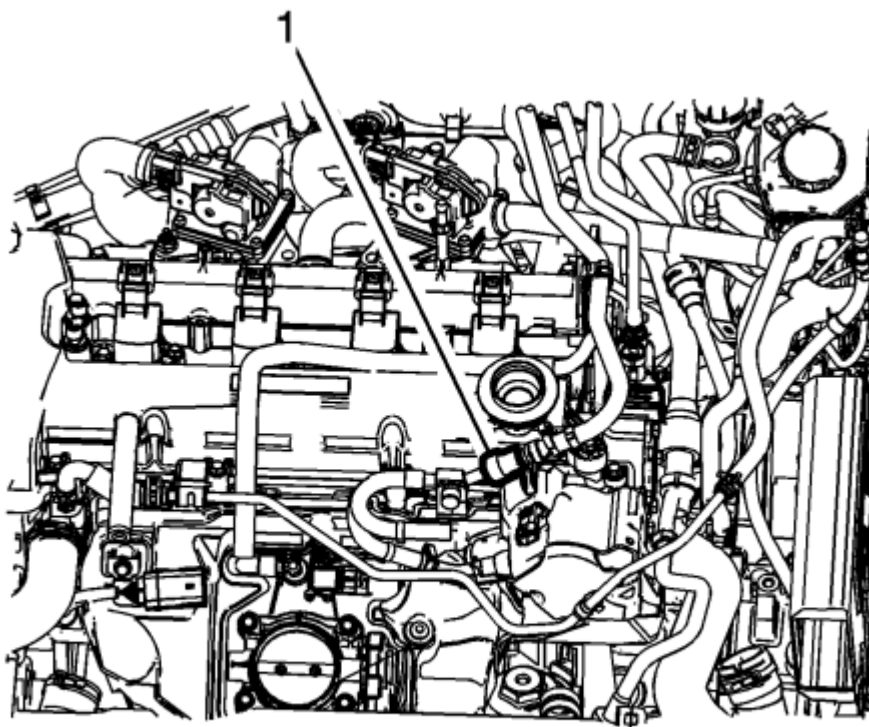
1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging** .
3. Drain the cooling system. Refer to **Cooling System Draining and Filling (GE 47716)** .
4. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
5. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
6. Remove the front bumper fascia. **Front Bumper Fascia Replacement** .



**Fig. 202: Intake Manifold Cover**

Courtesy of GENERAL MOTORS COMPANY

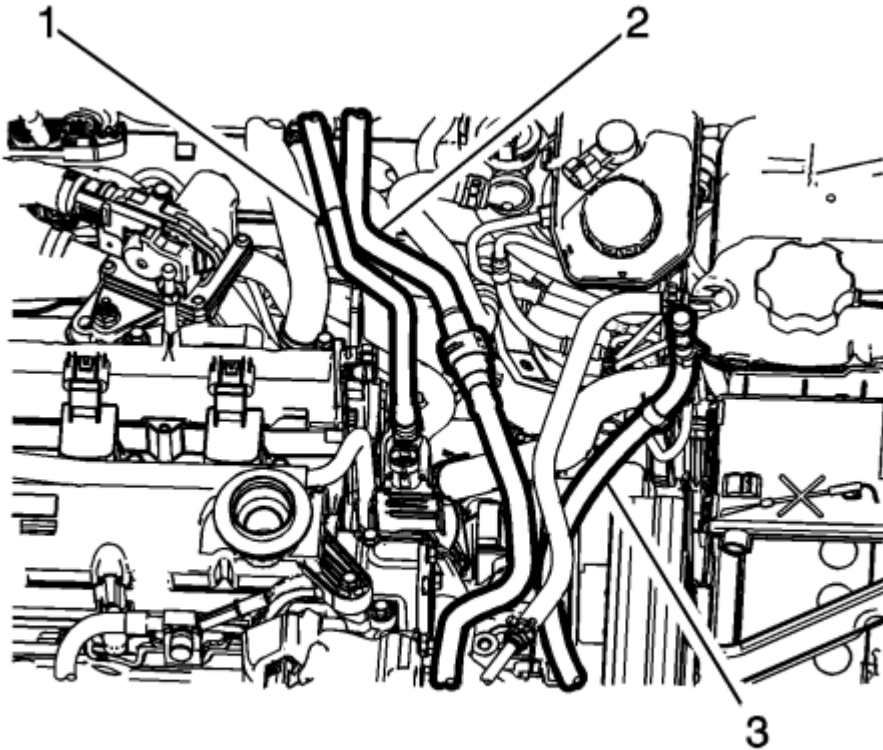
7. Remove the Intake Manifold Cover. Refer to **Intake Manifold Cover Replacement**
8. Remove the air conditioning compressor and the condenser hose. Refer to **Air Conditioning Compressor and Condenser Hose Replacement** .



**Fig. 203: Fuel Feed Line**

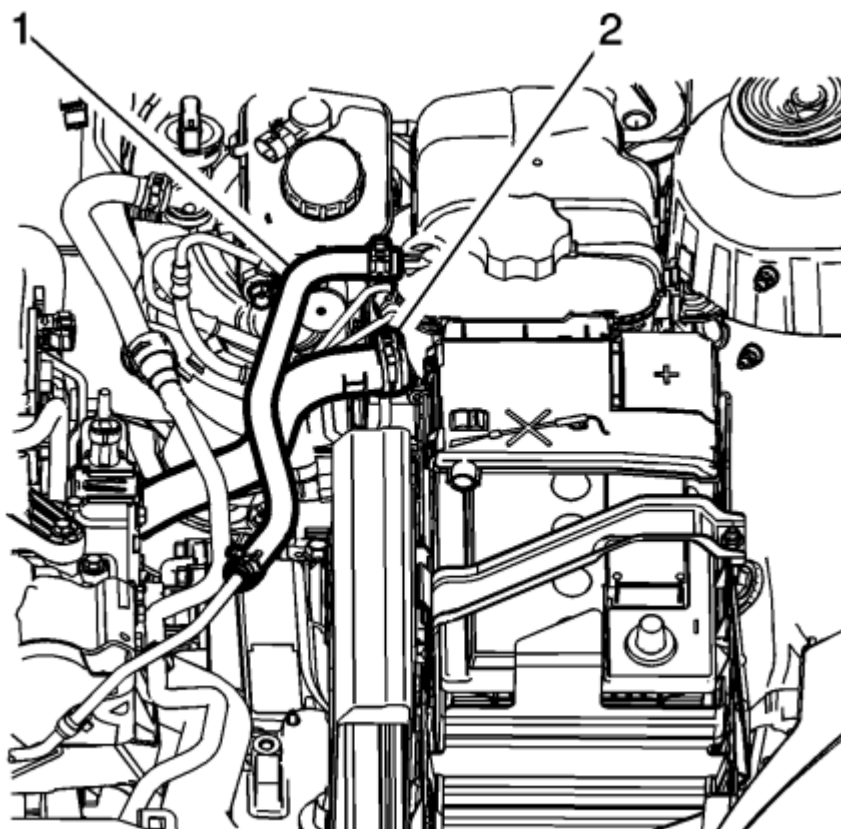
Courtesy of GENERAL MOTORS COMPANY

9. Disconnect the fuel feed line (1) and reposition away from the engine. Refer to **Plastic Collar Quick Connect Fitting Service** .



**Fig. 204: EVAP Hose, Brake Booster Vacuum Pipe & Transmission Vent Hose**  
Courtesy of GENERAL MOTORS COMPANY

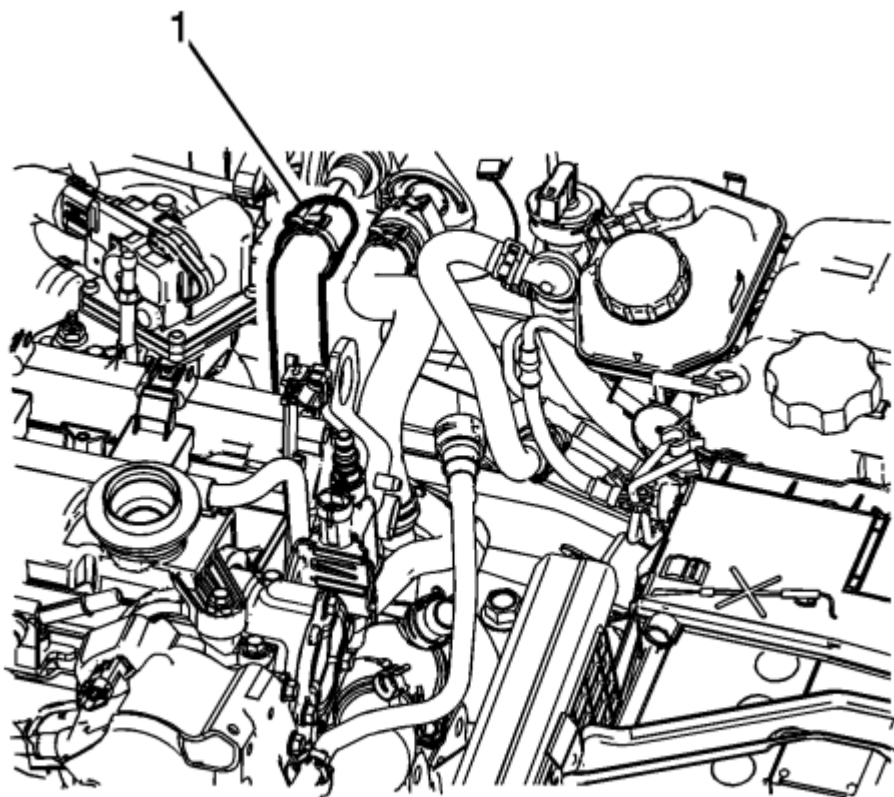
10. Disconnect the EVAP hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
11. Disconnect the power brake booster vacuum pipe (2). Refer to **Power Brake Booster Vacuum Pipe Replacement (Engine Side)** , **Power Brake Booster Vacuum Pipe Replacement (Booster Side)** .
12. Disconnect the transmission vent hose (3) from the coolant surge tank.



**Fig. 205: Radiator Surge Tank Hose**

**Courtesy of GENERAL MOTORS COMPANY**

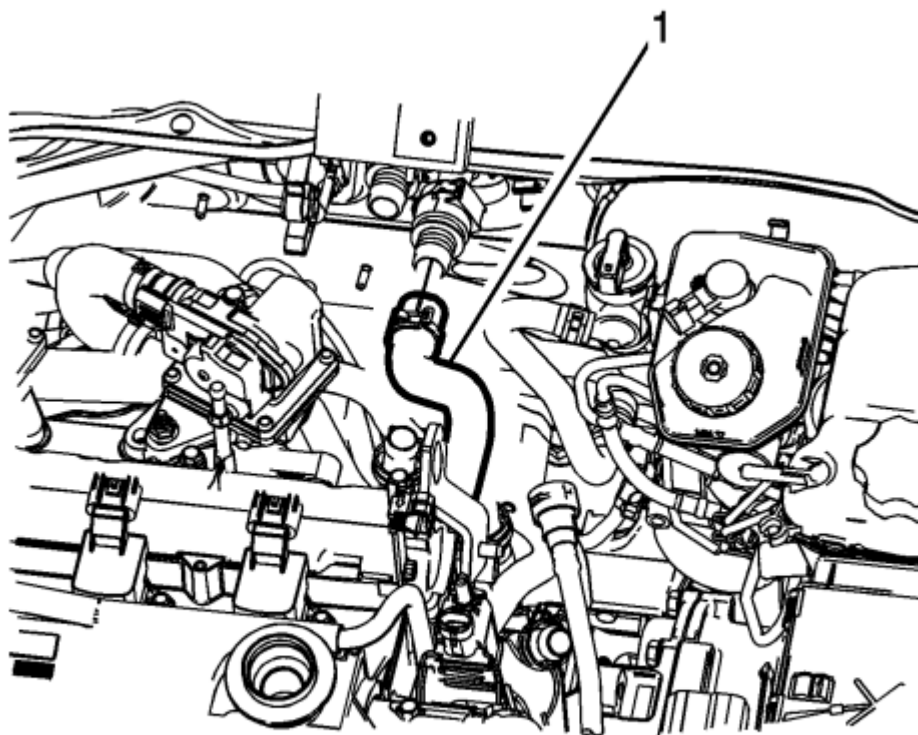
13. Remove the radiator surge tank hose (1, 2) lay on top of engine.



**Fig. 206: Inlet Heater Core Hose**

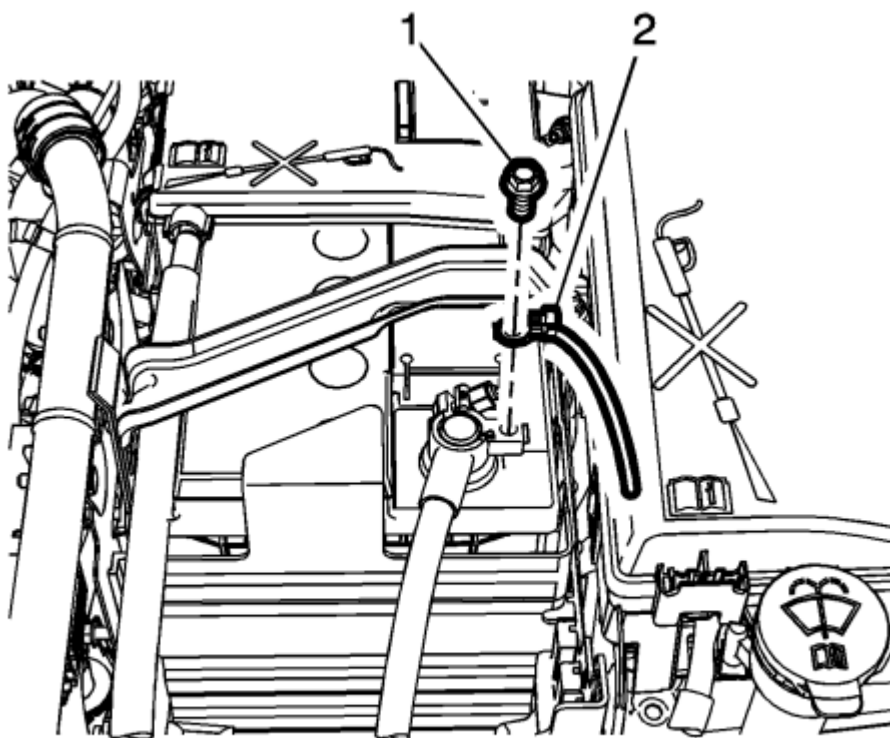
Courtesy of GENERAL MOTORS COMPANY

14. Disconnect the inlet (1) heater core hoses. Refer to **Heater Inlet Hose Replacement** .



**Fig. 207: Outlet Heater Core Hose**  
Courtesy of GENERAL MOTORS COMPANY

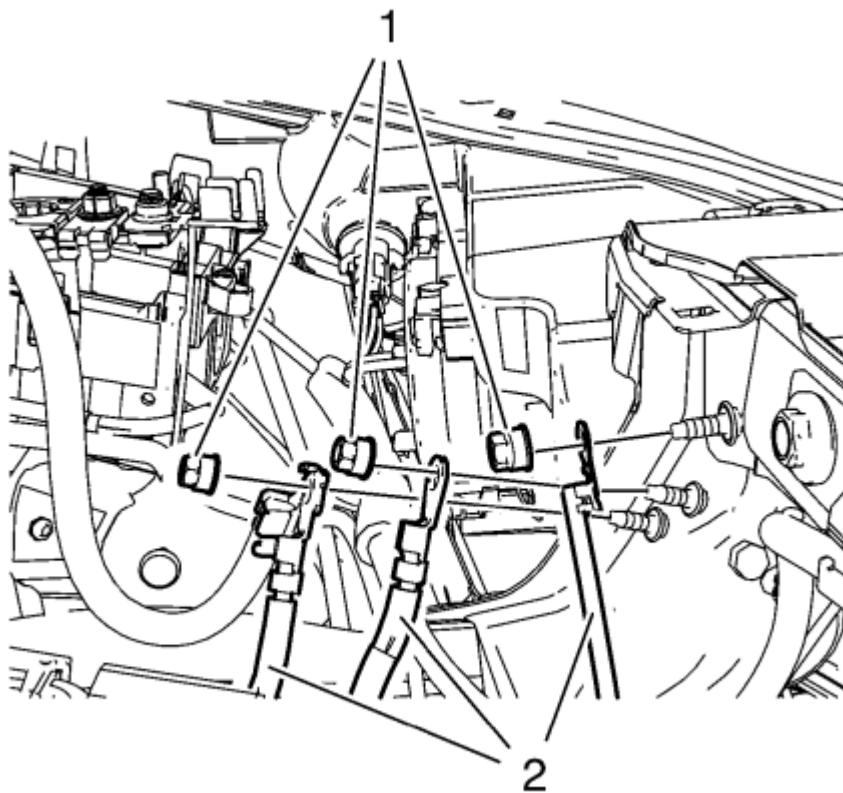
15. Disconnect the outlet (1) heater core hoses. Refer to **Heater Outlet Hose Replacement** .



**Fig. 208: Ground Strap & Bolt**

Courtesy of GENERAL MOTORS COMPANY

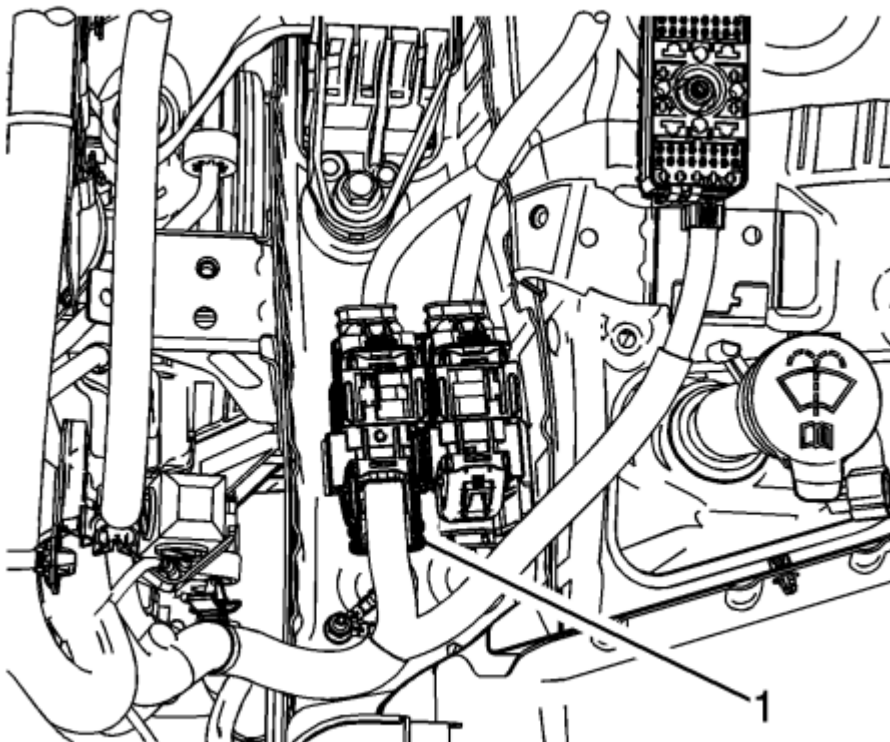
16. Remove the ground strap bolt (1) from the battery cable and reposition the strap (2) aside.
17. Remove the battery tray. Refer to **Battery Tray Replacement** .



**Fig. 209: Wiring Harness & Ground Nuts**

Courtesy of GENERAL MOTORS COMPANY

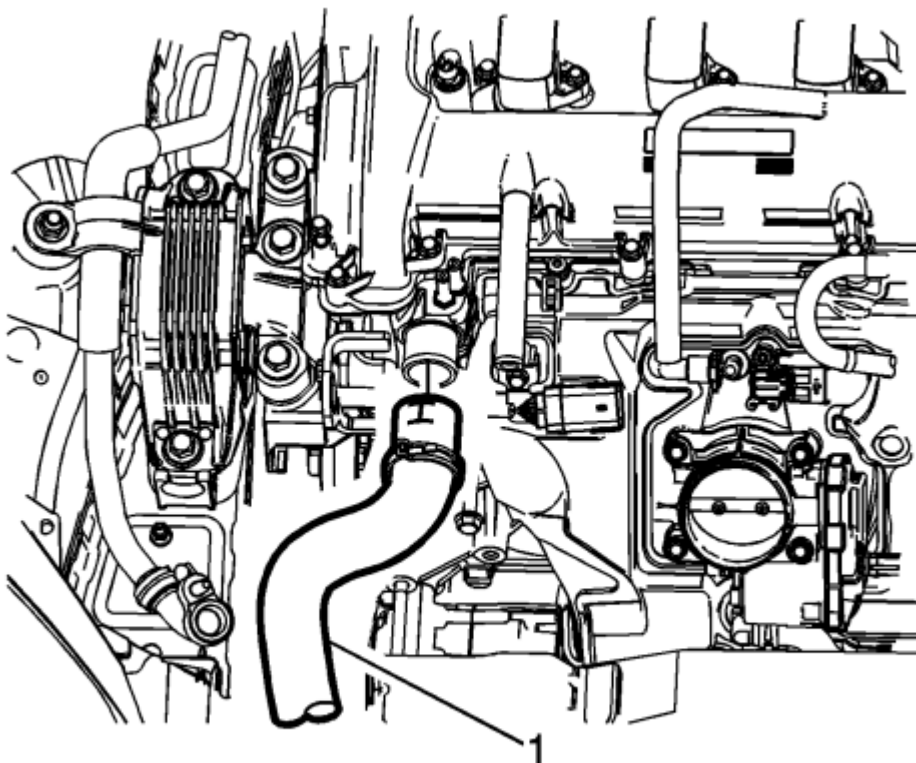
18. Remove the ground nuts (1) and put the wiring harness (2) aside.
19. Disconnect the electrical connectors from the engine control module (ECM). Refer to **Engine Control Module Replacement** .
20. Disconnect the wiring harness from the accessory wiring junction block.



**Fig. 210: Junction Connector**

**Courtesy of GENERAL MOTORS COMPANY**

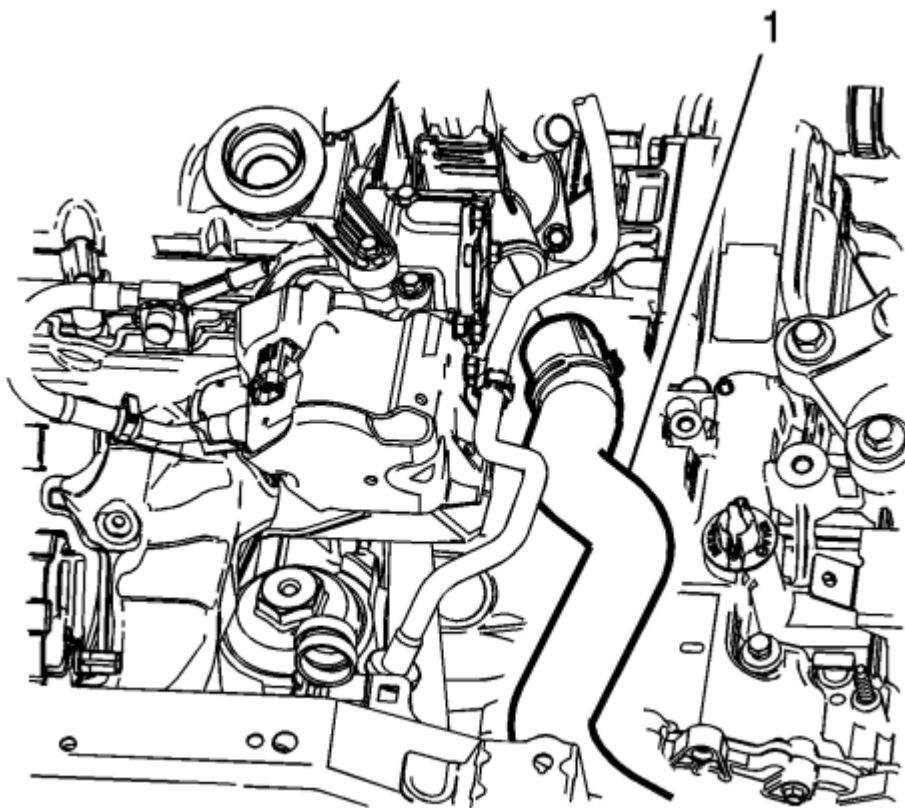
21. Disconnect the wiring harness from the junction connector (1).
22. Place the ECM, transmission and the accessory wiring junction block wiring harnesses on the top of the engine assembly.



**Fig. 211: Radiator Inlet Hose**

Courtesy of GENERAL MOTORS COMPANY

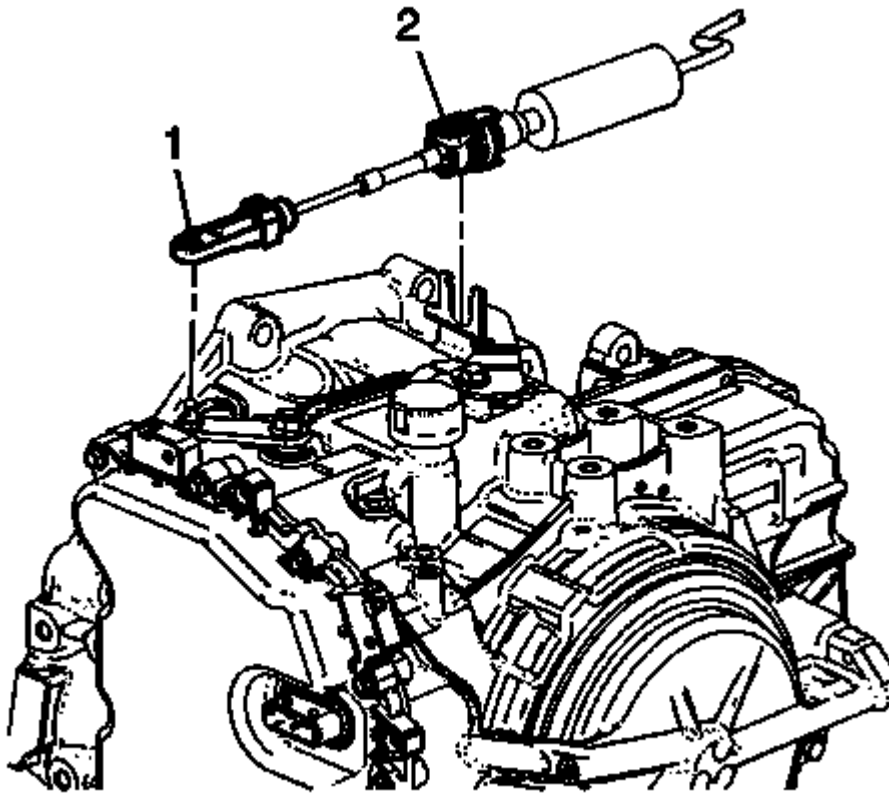
23. Remove the radiator inlet hose (1). Refer to **Radiator Inlet Hose Replacement** .



**Fig. 212: Radiator Outlet Hose**

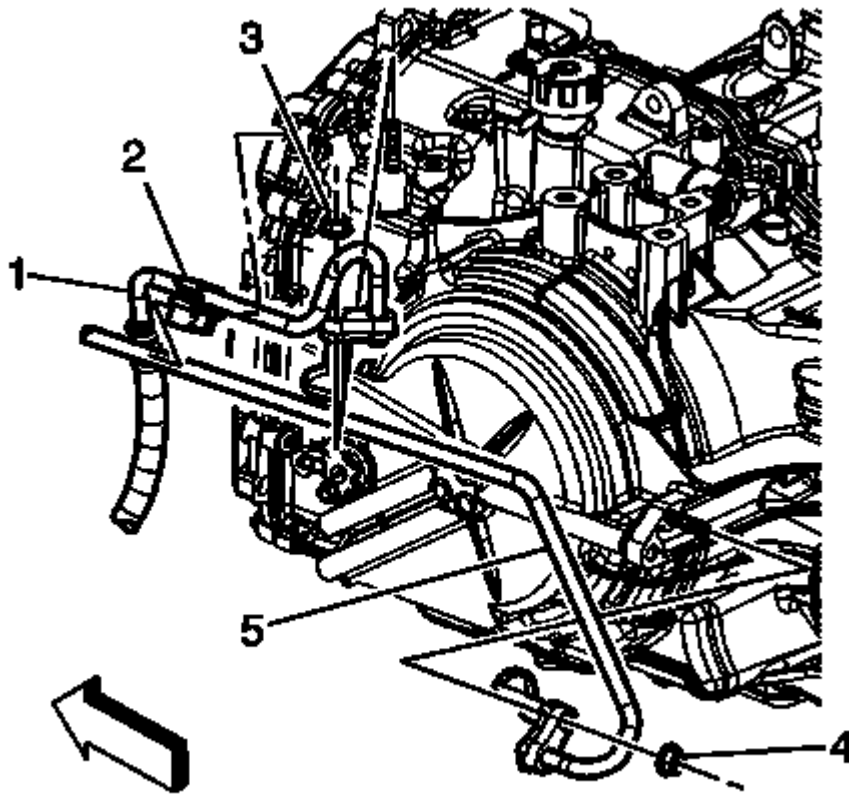
Courtesy of GENERAL MOTORS COMPANY

24. Remove the radiator outlet hose (1). Refer to **Radiator Outlet Hose Replacement** .



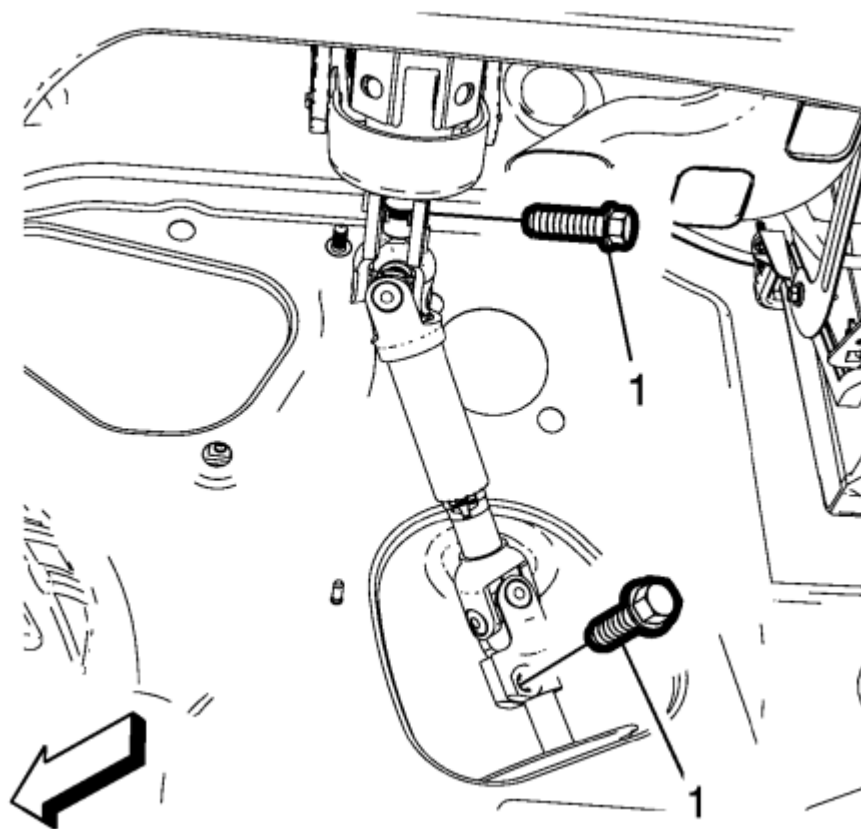
**Fig. 213: View Of Transmission Range Selector Lever & Cable Connection**  
Courtesy of GENERAL MOTORS COMPANY

25. Disconnect the transmission range selector lever cable terminal (1) from the transmission manual shift lever pin.
26. Press the locking tabs inward in order to release the transmission range selector lever cable (2) from the cable bracket.



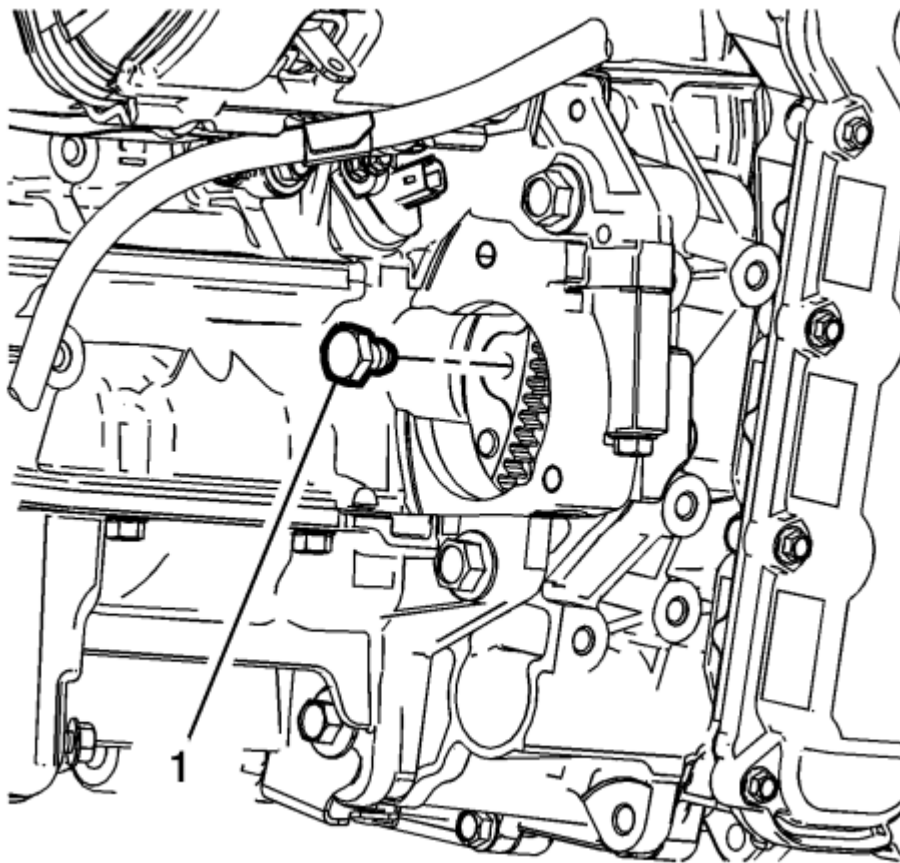
**Fig. 214: Identifying Cooler Inlet & Outlet Hoses**  
**Courtesy of GENERAL MOTORS COMPANY**

27. Remove the oil cooler inlet (1) and outlet (5) hoses from the retainer (2) on the control valve body cover.
28. Remove the transmission fluid cooler inlet hose nut (3) from the transmission.
29. Remove the transmission fluid cooler inlet hose (1) from the transmission.
30. Remove the transmission fluid cooler outlet hose nut (4) from the transmission.
31. Remove the transmission fluid cooler outlet hose (5) from the transmission.
32. Plug and/or cap the hose and transmission to prevent contamination.



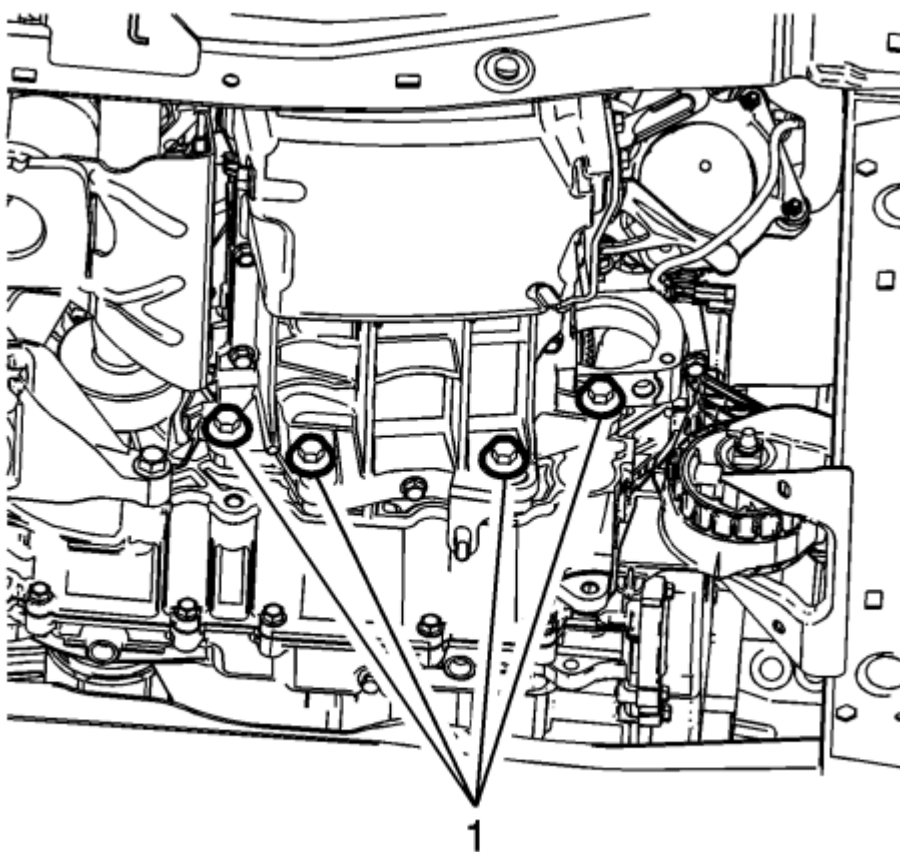
**Fig. 215: Lower Steering Intermediate Shaft Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

33. Remove and DISCARD the lower steering intermediate shaft bolt (1).
34. Install the engine support fixture. Refer to **Engine Support Fixture**.
35. Remove the starter motor. Refer to **Starter Replacement**.
36. Remove the air deflector.



**Fig. 216: Torque Converter To Flywheel Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

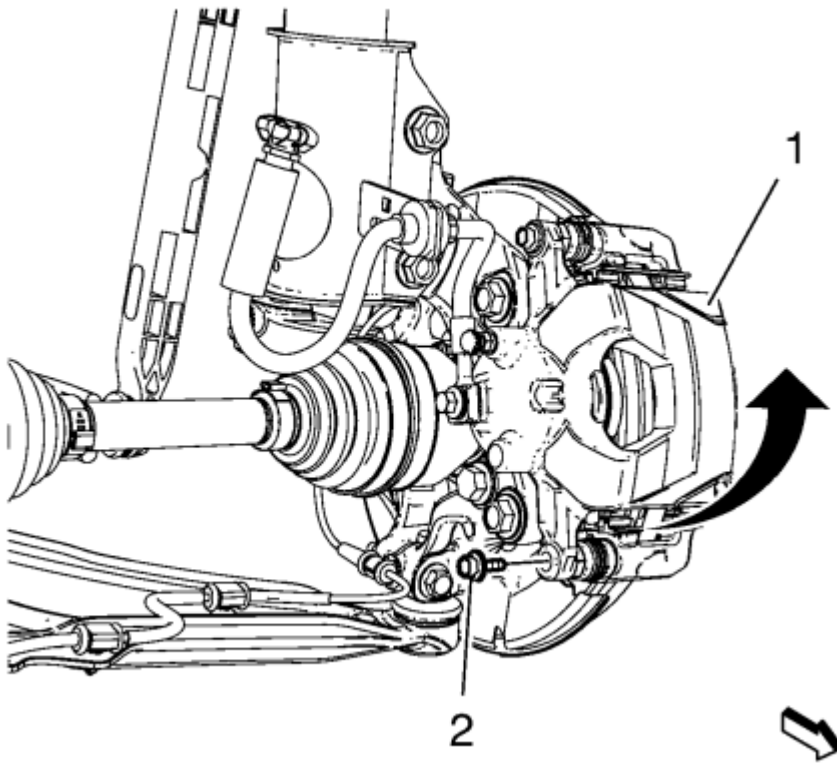
37. Mark the relationship of the flywheel to the torque converter for reassembly.
38. Remove the torque converter to flywheel bolts (1).



**Fig. 217: Lower Transmission Bolts**

Courtesy of GENERAL MOTORS COMPANY

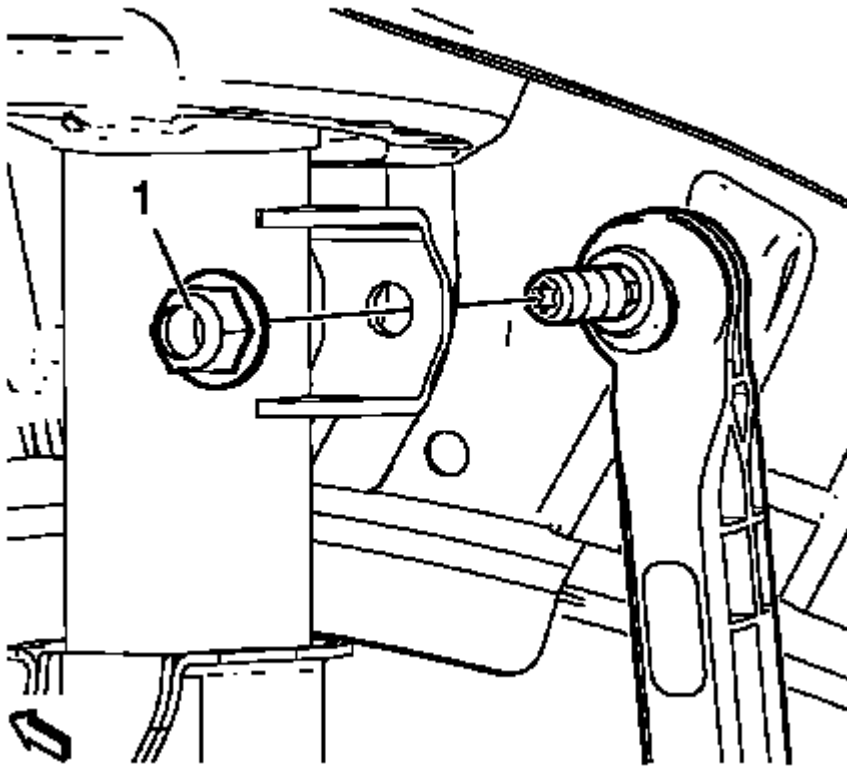
39. Remove the lower oil pan to transmission lower bolts (1).



**Fig. 218: View Of Brake Caliper And Brake Caliper Guide Pin Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Do Not disconnect the brake hoses from the calipers.

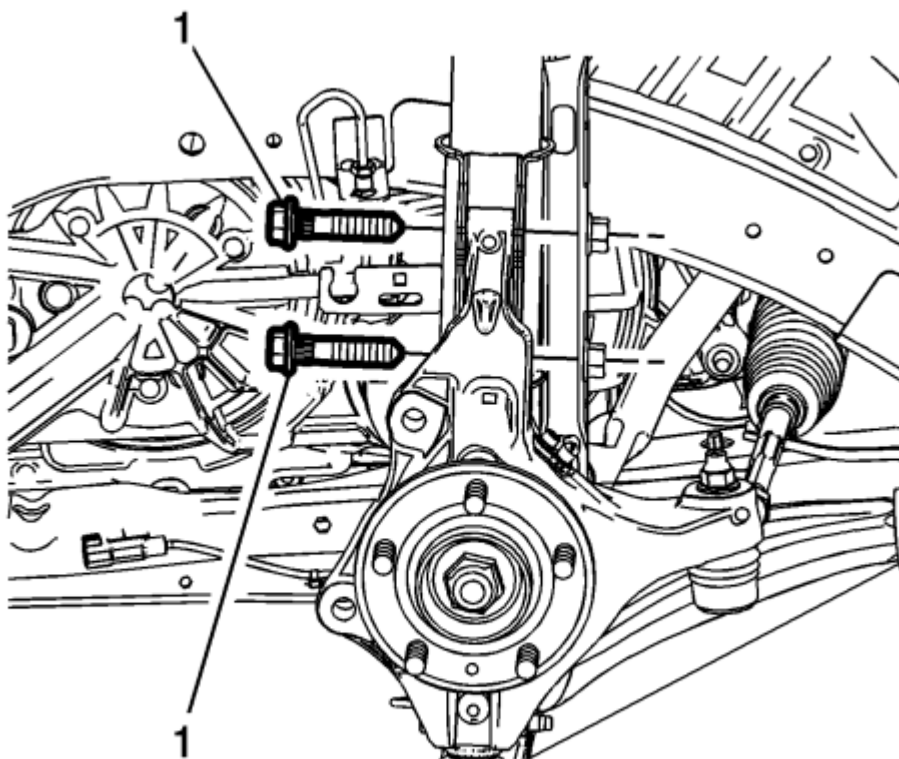
40. Remove the front brake calipers (1) and caliper bolts (2) from the caliper brackets, and then suspend the calipers with mechanics wire to the body.
41. Remove the exhaust system. Refer to Exhaust System Replacement .



**Fig. 219: Stabilizer Link Nut**

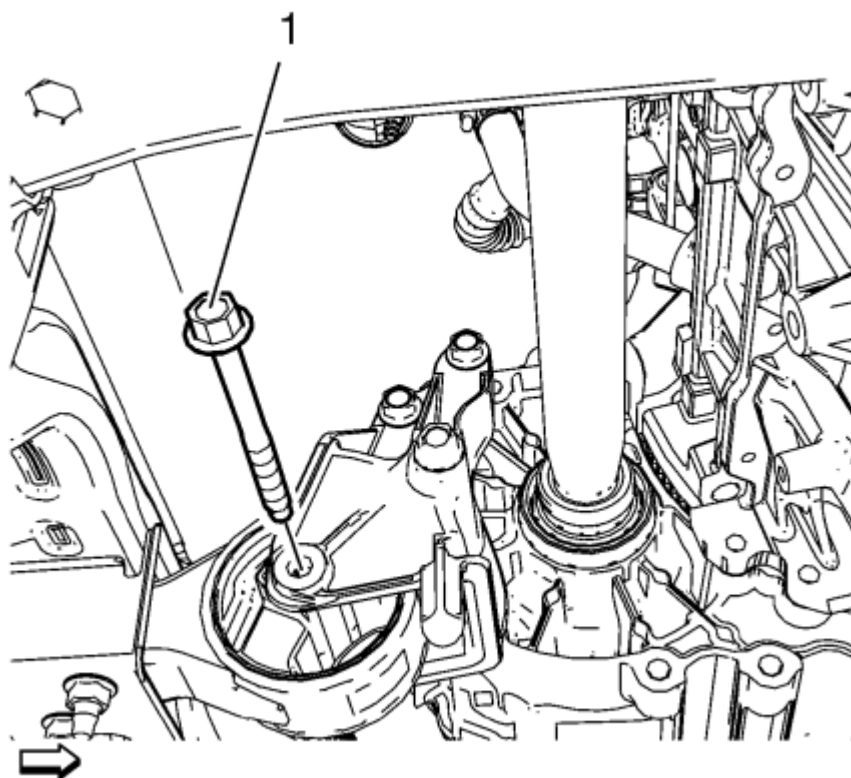
Courtesy of GENERAL MOTORS COMPANY

42. Remove and DISCARD the stabilizer link nut (1) from the strut assemblies. Refer to **Stabilizer Shaft Link Replacement**.
43. Disconnect the right wheel drive shaft from the intermediate shaft.



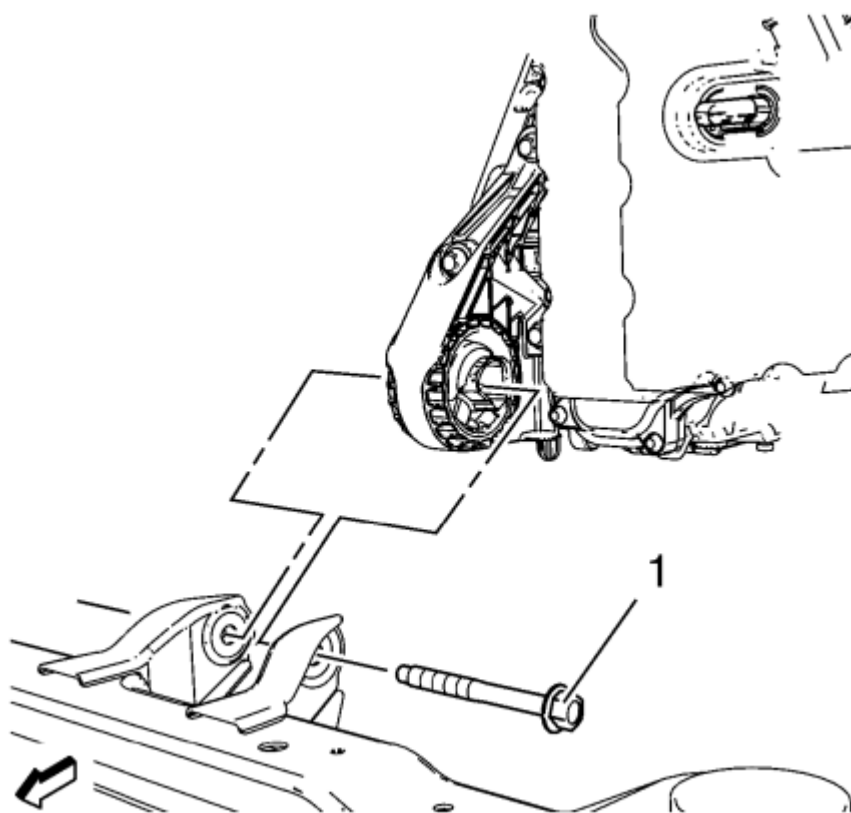
**Fig. 220: Front Steering Knuckle Bolts**  
Courtesy of GENERAL MOTORS COMPANY

44. Disconnect the front steering knuckles bolts (1) from the strut assemblies. Refer to **Steering Knuckle Replacement** .
45. Disconnect the electronic power steering connectors from the electronic power steering assembly. Refer to **FEP Connectors (Steering Gear)** .



**Fig. 221: Rear Transmission Mount Bracket Bolt**  
Courtesy of GENERAL MOTORS COMPANY

46. Remove the rear transmission mount bracket to rear mount through bolt (1).

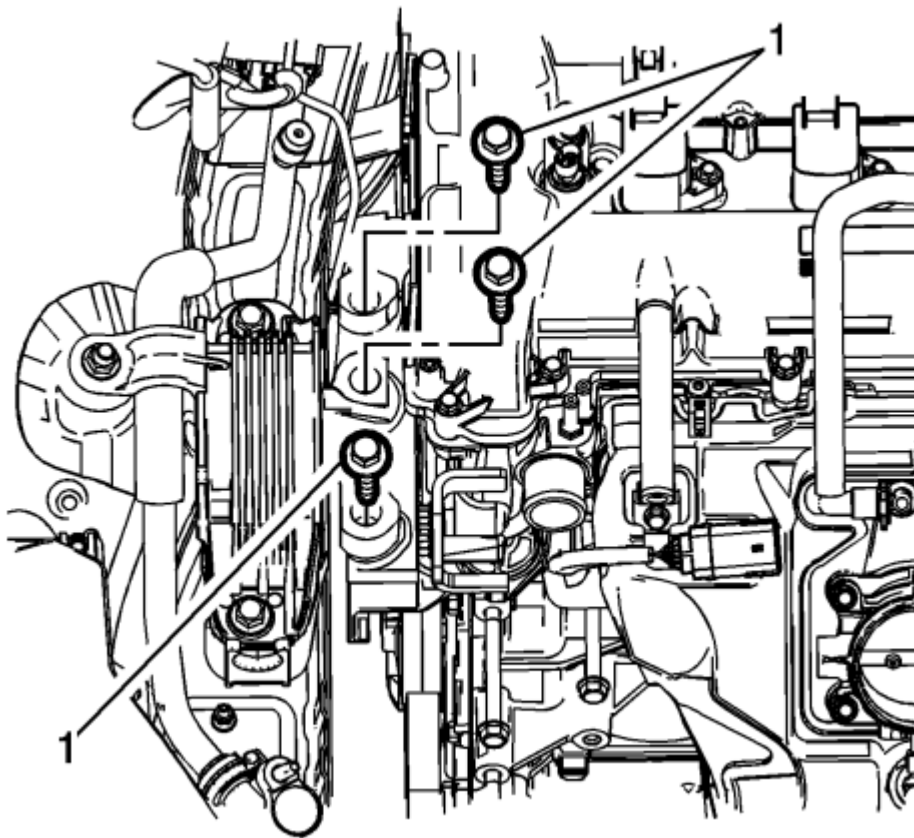


**Fig. 222: Front Transmission Mount Through Bolt**  
Courtesy of GENERAL MOTORS COMPANY

47. Remove the transmission front mount through bolt (1).
48. Using suitable straps or chains, secure the front of vehicle to the hoist arms.

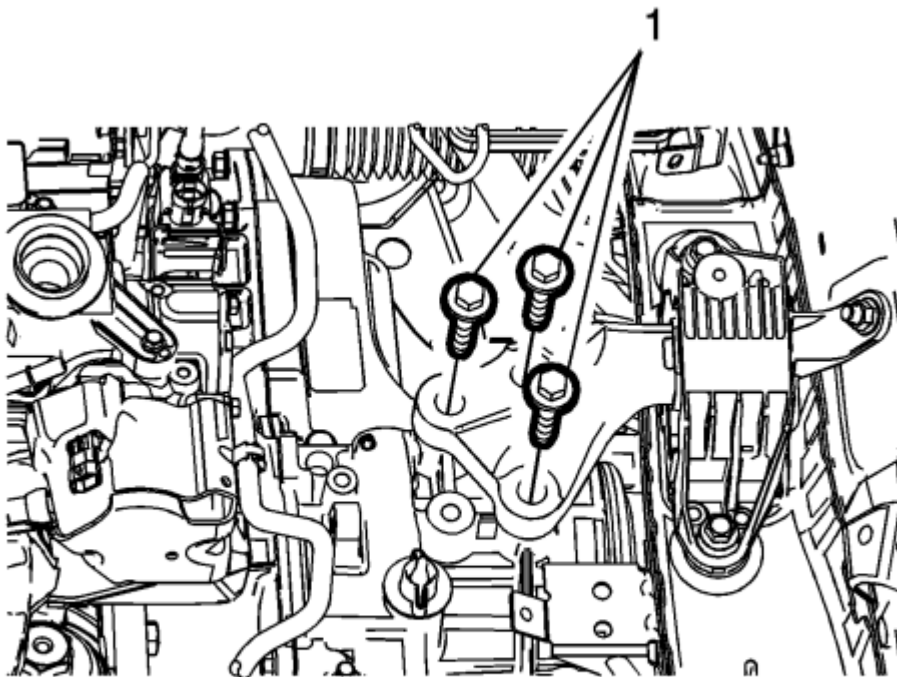
**NOTE:** Use the engine support fixture to slightly raise the powertrain assembly to aid in the removal of the engine and transmission mount bolts.

49. Use the engine support fixture to slightly raise the powertrain assembly to aid in the removal of the engine and transmission mount bolts.



**Fig. 223: Right Side Engine Mount Bolts**  
Courtesy of GENERAL MOTORS COMPANY

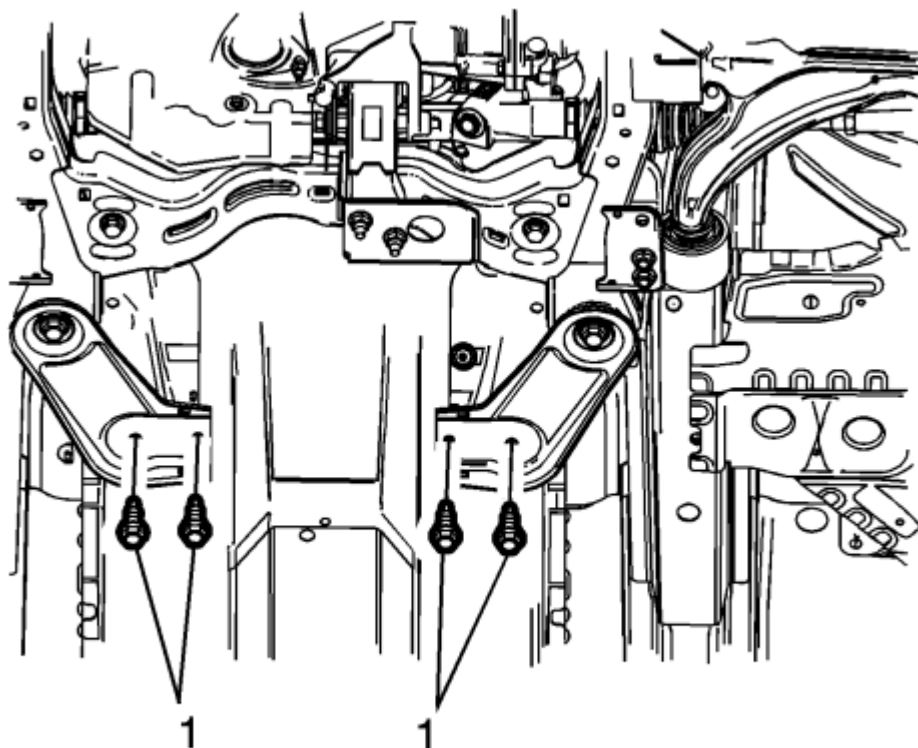
50. Mark the location of the bolts (1) before removing.
51. Remove the right side engine mount bolts (1). Refer to **Engine Mount Replacement**.



**Fig. 224: Transmission Mount & Bolts**

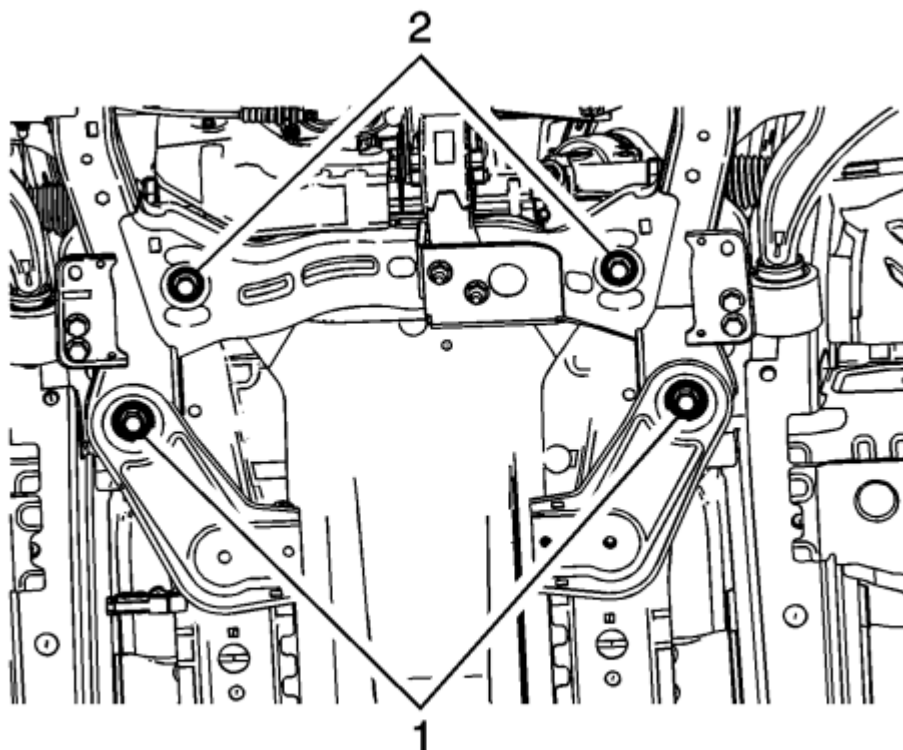
Courtesy of GENERAL MOTORS COMPANY

52. Mark the location of the bolts (1) before removing.
53. Remove the transmission mount bolts (1), left side. Refer to **Transmission Mount Replacement - Left Side** .
54. Using a suitable engine support table, lower the vehicle until the drivetrain and front suspension frame contacts the engine support table.
55. Position blocks of wood below the oil pan and transmission to stabilize the powertrain on the support table.
56. Using the engine support fixture, lower the powertrain down until it is resting on the engine support table.
57. Remove the engine support fixture. Refer to **Engine Support Fixture**.



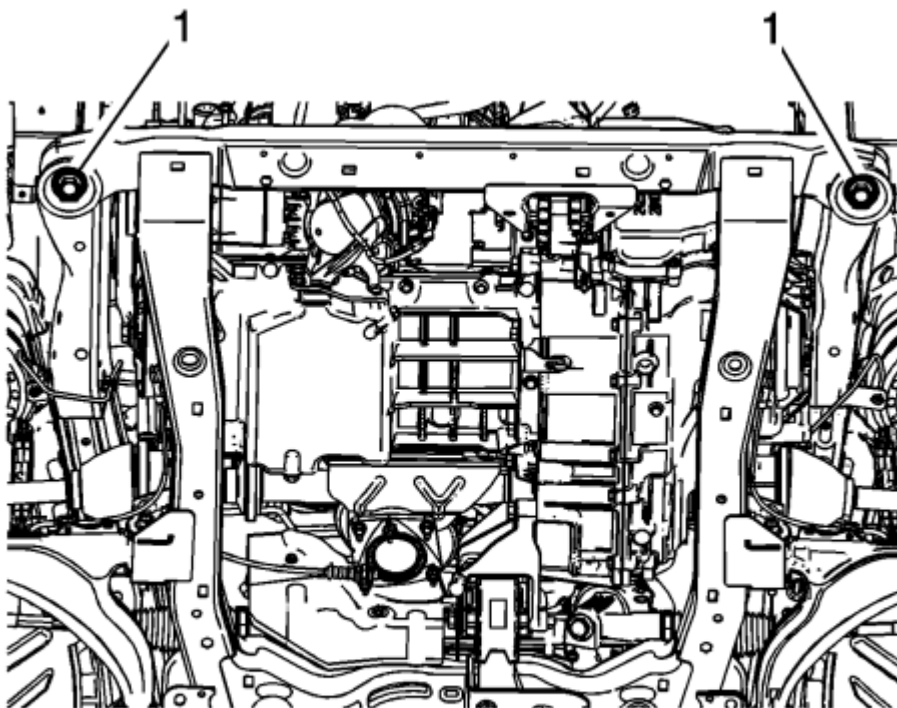
**Fig. 225: Rear Frame Reinforcement & Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

58. Remove and DISCARD the rear frame reinforcement bolts (1) and reinforcement.



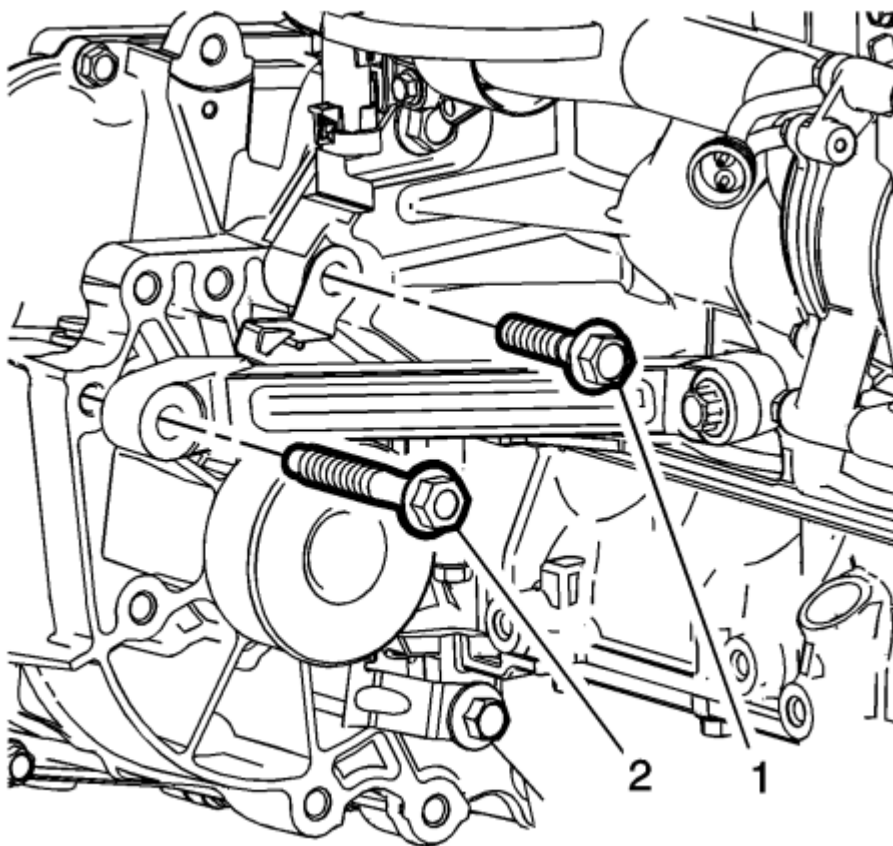
**Fig. 226: Rear Frame Reinforcement Bolts**  
Courtesy of GENERAL MOTORS COMPANY

59. Remove the rear frame reinforcement bolts (1, 2).



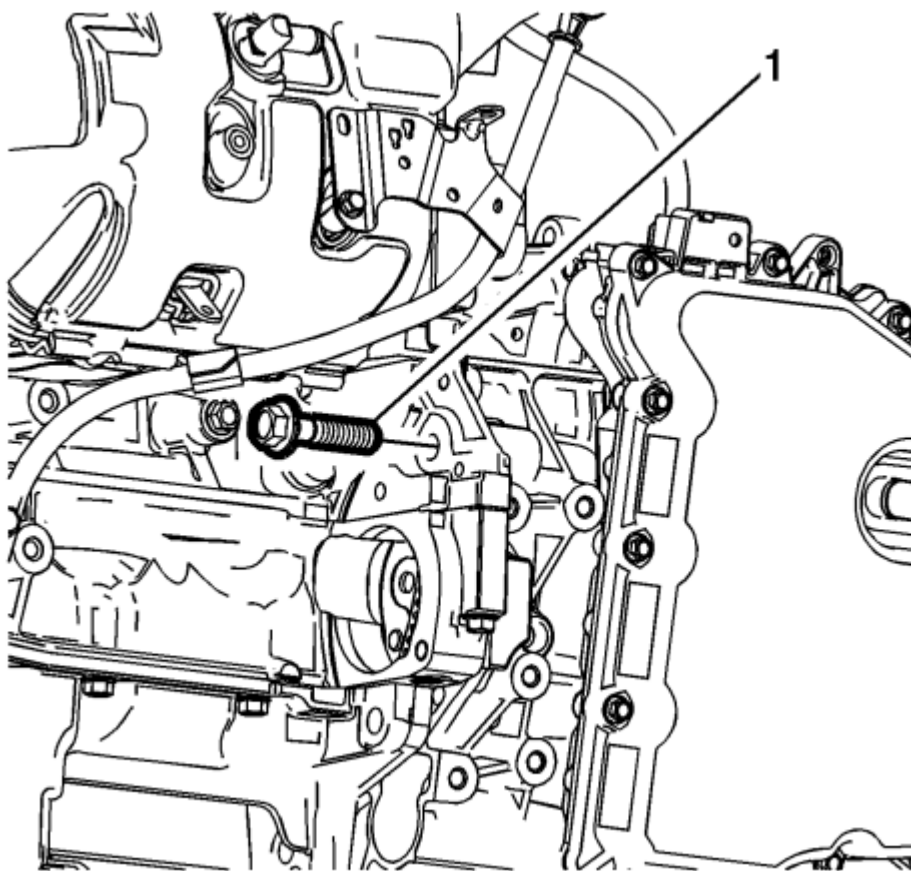
**Fig. 227: Front Frame Reinforcement Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

60. Remove the front frame reinforcement bolts (1).
61. Slowly and carefully raise the vehicle, ensure the engine, transmission, radiator assembly and drivetrain suspension frame are free from wiring, hoses and other engine compartment components.
62. Disconnect engine coolant hoses as necessary.
63. Disconnect electrical connectors as necessary.



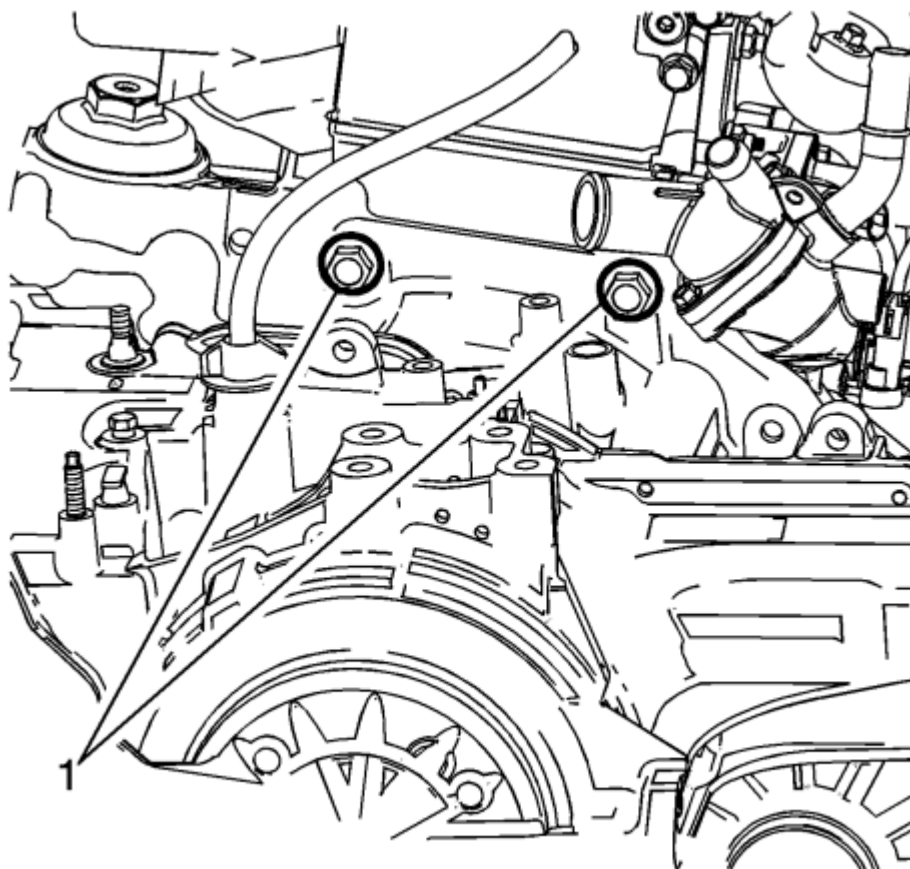
**Fig. 228: Lower Cylinder Head To Transmission Bolts**  
Courtesy of GENERAL MOTORS COMPANY

64. Remove the lower cylinder head to transmission lower bolts (1, 2).



**Fig. 229: Lower Engine Case To Transmission Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

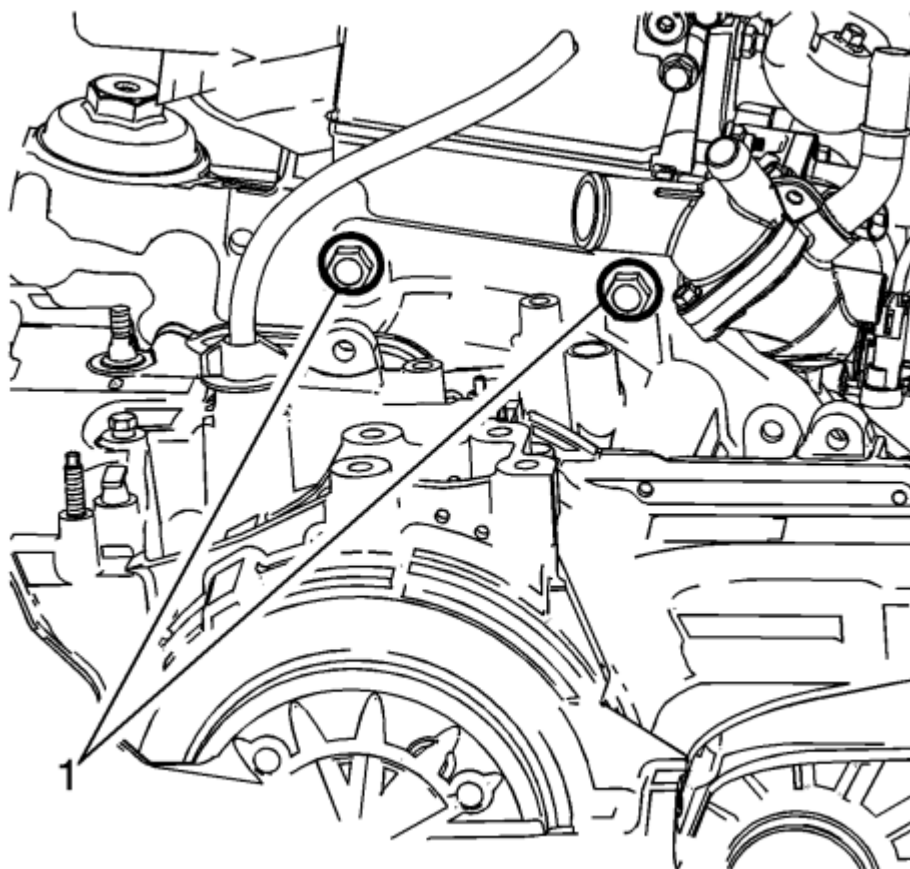
65. Remove the lower engine case to transmission lower bolts (1).



**Fig. 230: Upper Transmission To Engine Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

66. Remove the upper transmission to engine bolts (1) and separate the engine and transmission.
67. Install the engine to the engine stand.
68. Transfer parts as needed.

#### **Installation Procedure**

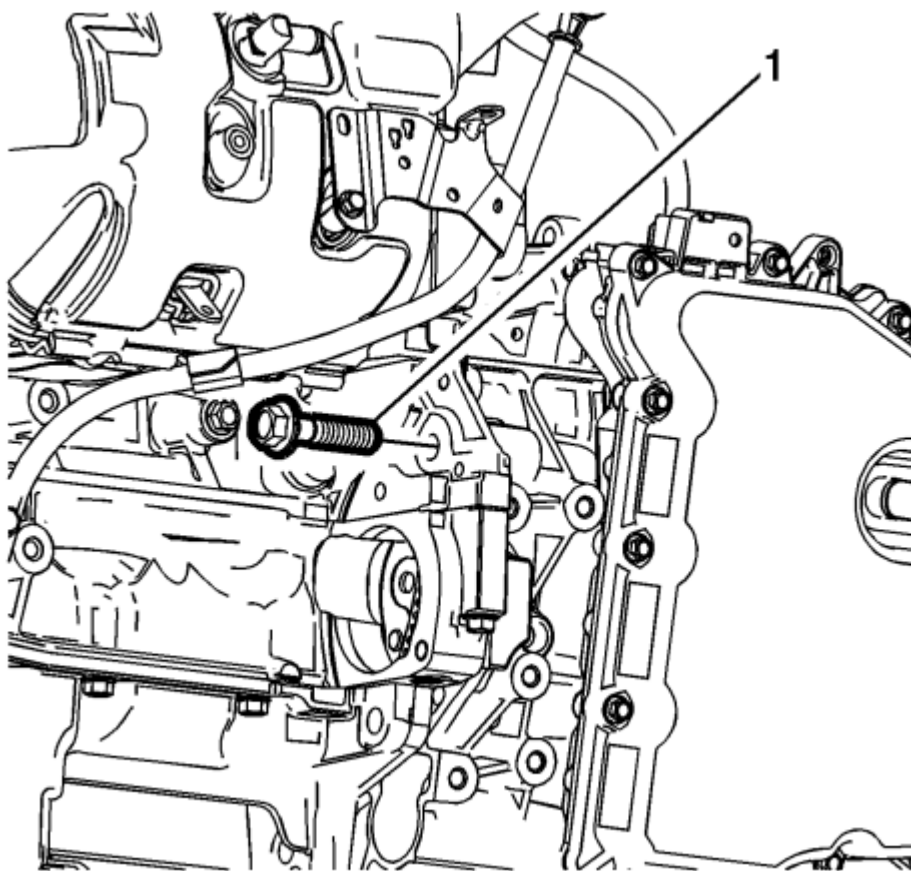


**Fig. 231: Upper Transmission To Engine Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine from the engine stand.
2. Install the transmission to the engine.

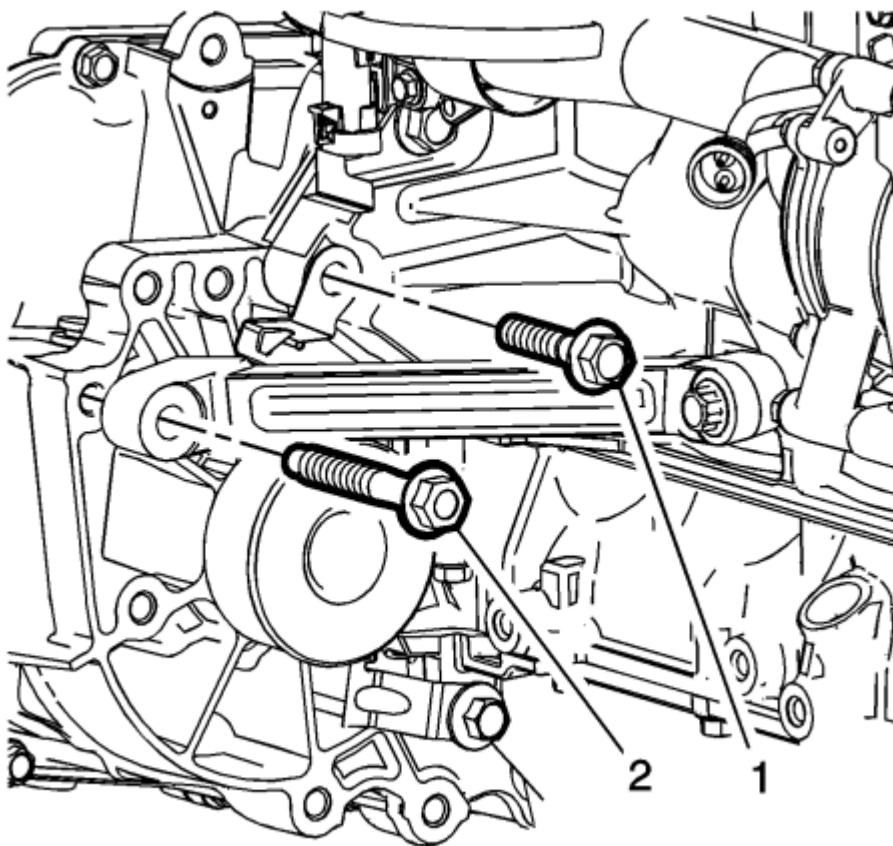
**CAUTION: Refer to Fastener Caution .**

3. Install the upper transmission to engine bolts (1) and tighten to 75 N.m (55 lb ft).



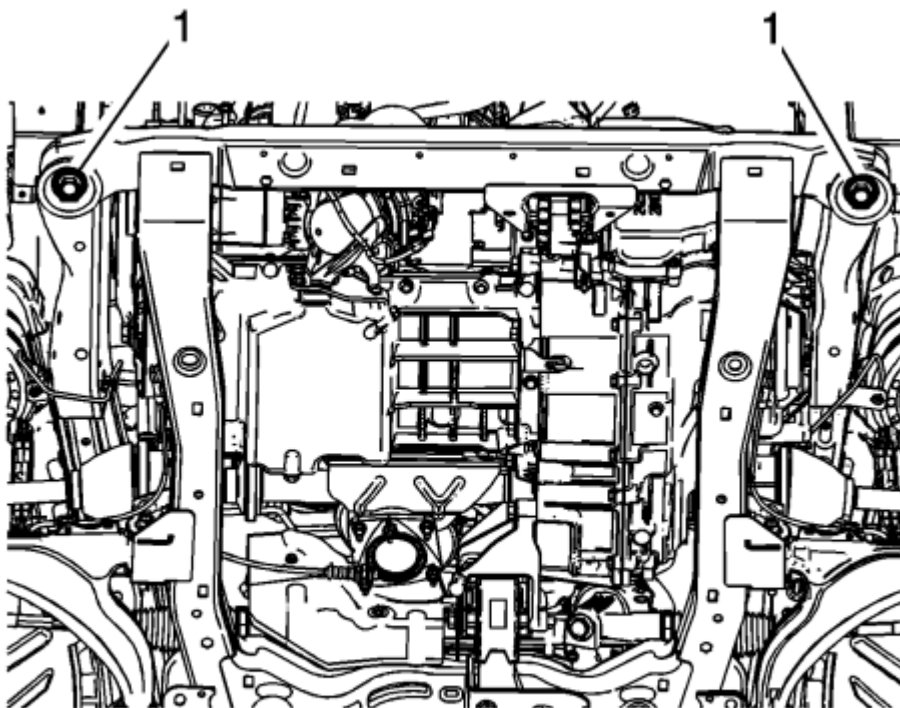
**Fig. 232: Lower Engine Case To Transmission Bolts**  
Courtesy of GENERAL MOTORS COMPANY

4. Install the lower engine case to transmission lower bolts (1) and tighten to 75 N.m (55 lb ft).



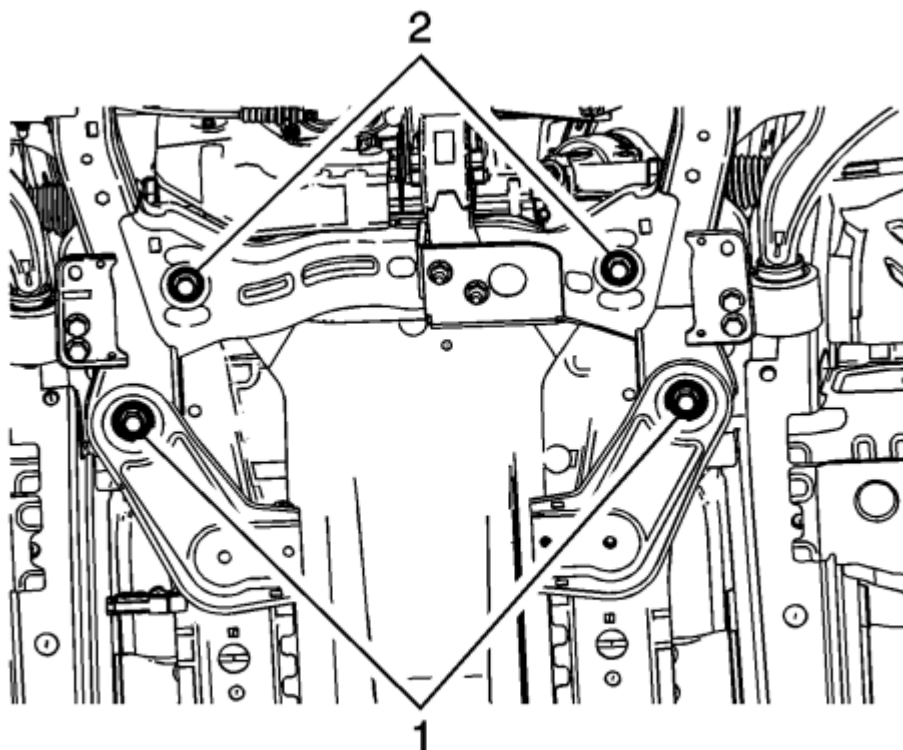
**Fig. 233: Lower Cylinder Head To Transmission Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

5. Install the lower cylinder head to transmission lower bolts (1, 2) and tighten to 75 N.m (55 lb ft).
6. Position the engine, transmission, radiator assembly and drivetrain suspension frame under the vehicle.
7. Slowly and carefully lower the vehicle, ensure the engine, transmission, radiator assembly and drivetrain suspension frame are free from wiring, hoses and other engine compartment components.



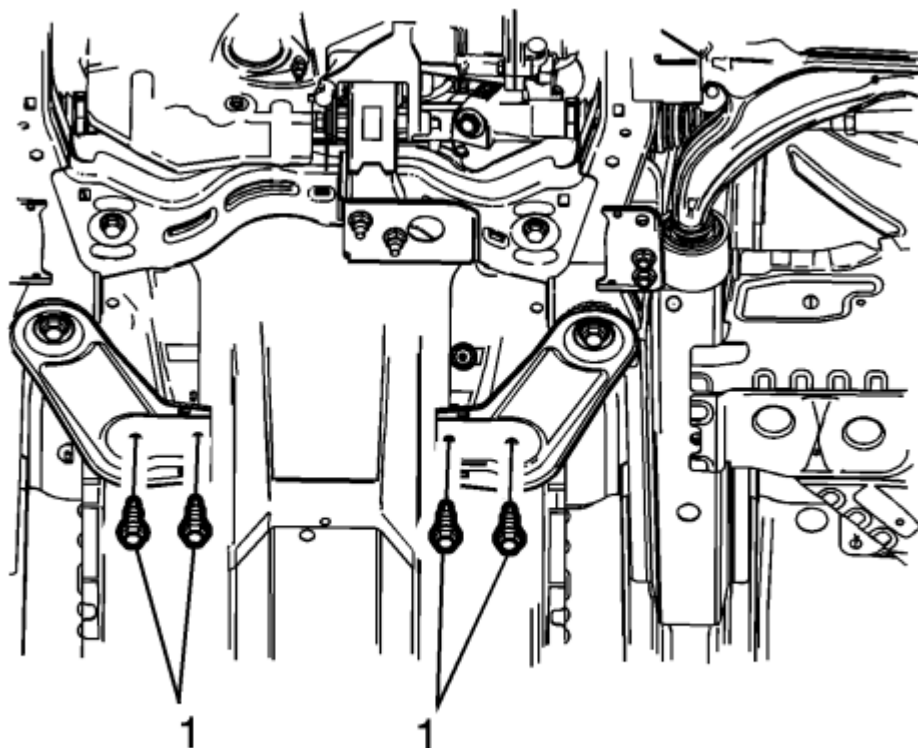
**Fig. 234: Front Frame Reinforcement Bolts**  
Courtesy of GENERAL MOTORS COMPANY

8. Install the front frame reinforcement bolts (1) and tighten to 160 N.m (118 lb ft).



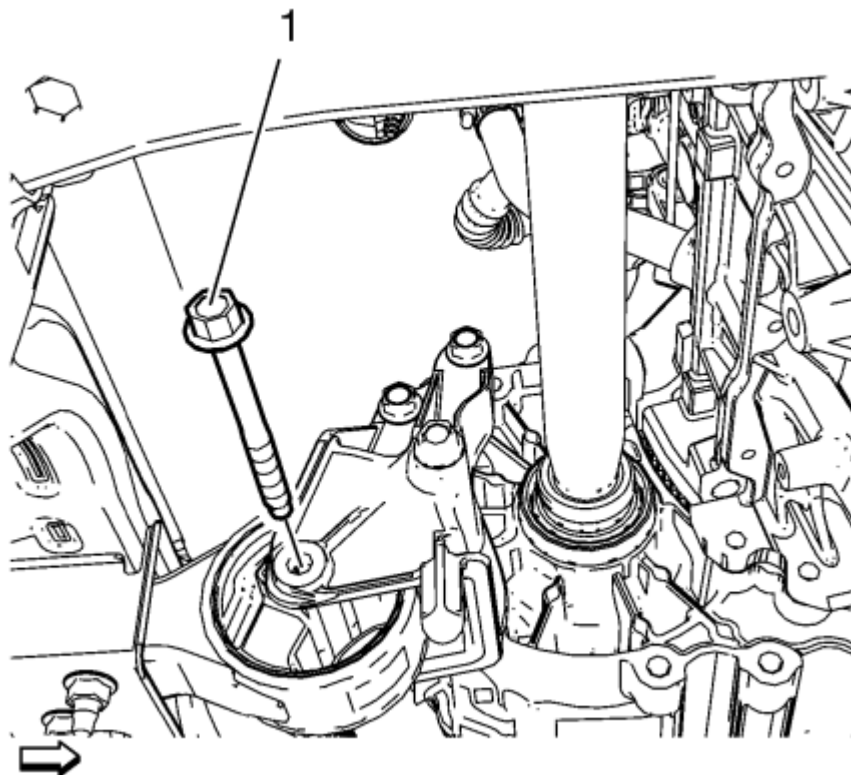
**Fig. 235: Rear Frame Reinforcement Bolts**  
Courtesy of GENERAL MOTORS COMPANY

9. Install the rear frame reinforcement bolts (1, 2) and tighten to 160 N.m (118 lb ft).



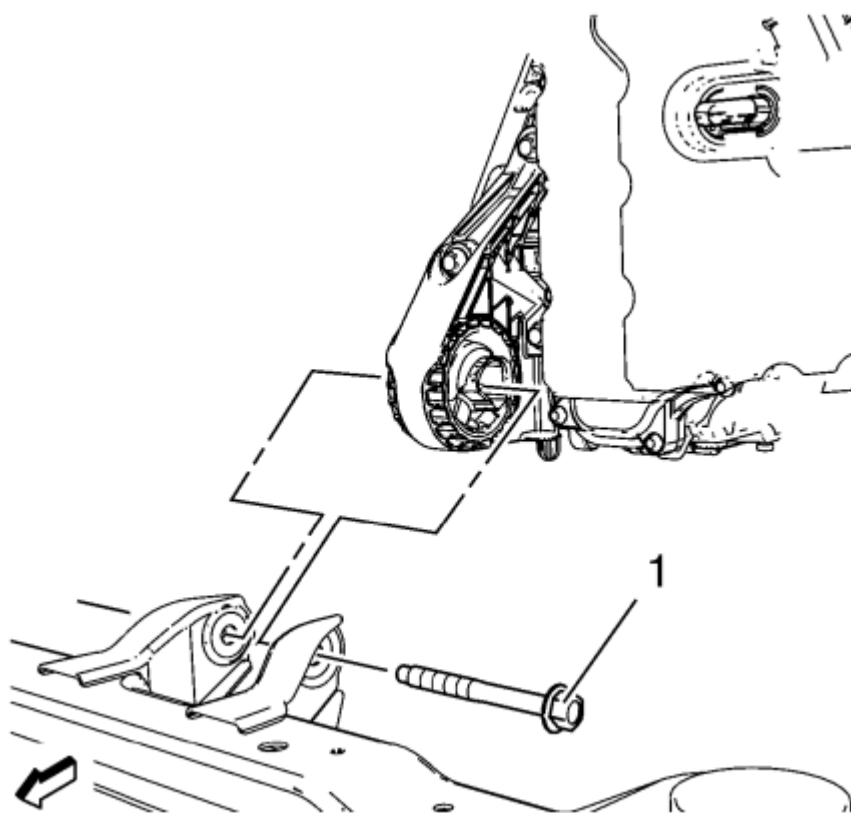
**Fig. 236: Rear Frame Reinforcement & Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

10. Install NEW rear frame reinforcement and bolts (1) and tighten to 60 N.m (44 lb ft) plus 45 degrees.
11. Install the engine support fixture. Refer to **Engine Support Fixture**.



**Fig. 237: Rear Transmission Mount Bracket Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

12. Install the transmission bracket mount to mount through bolt (1) and tighten to 100 N.m (74 lb ft).

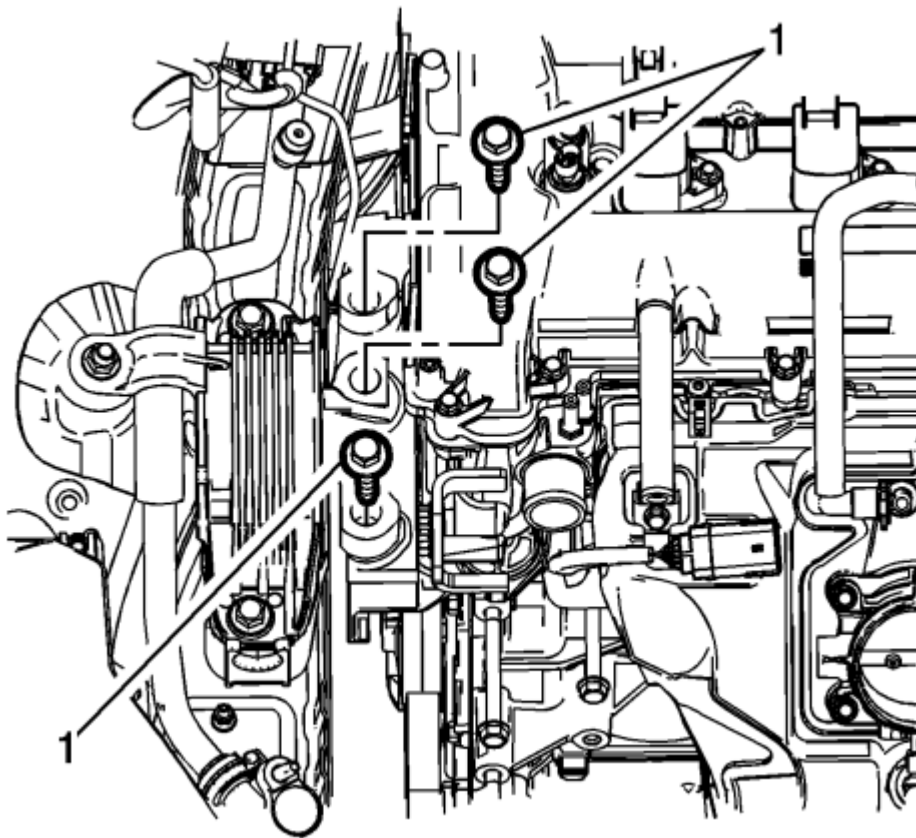


**Fig. 238: Front Transmission Mount Through Bolt**  
 Courtesy of GENERAL MOTORS COMPANY

13. Install the transmission mount through bolt (1) and tighten to 58 N.m (43 lb ft).

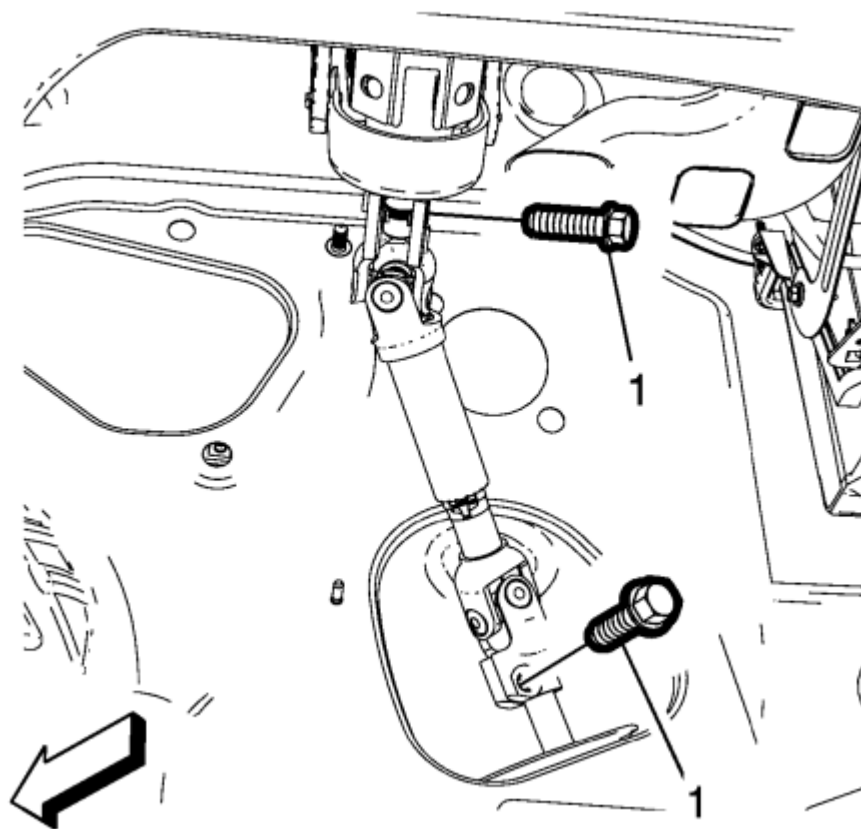
**WARNING: Refer to Torque-to-Yield Fastener Warning .**

14. Install the NEW left transmission mount to transmission bolts (1) and tighten to 50 N.m (37 lb ft) plus 60-75 degrees.



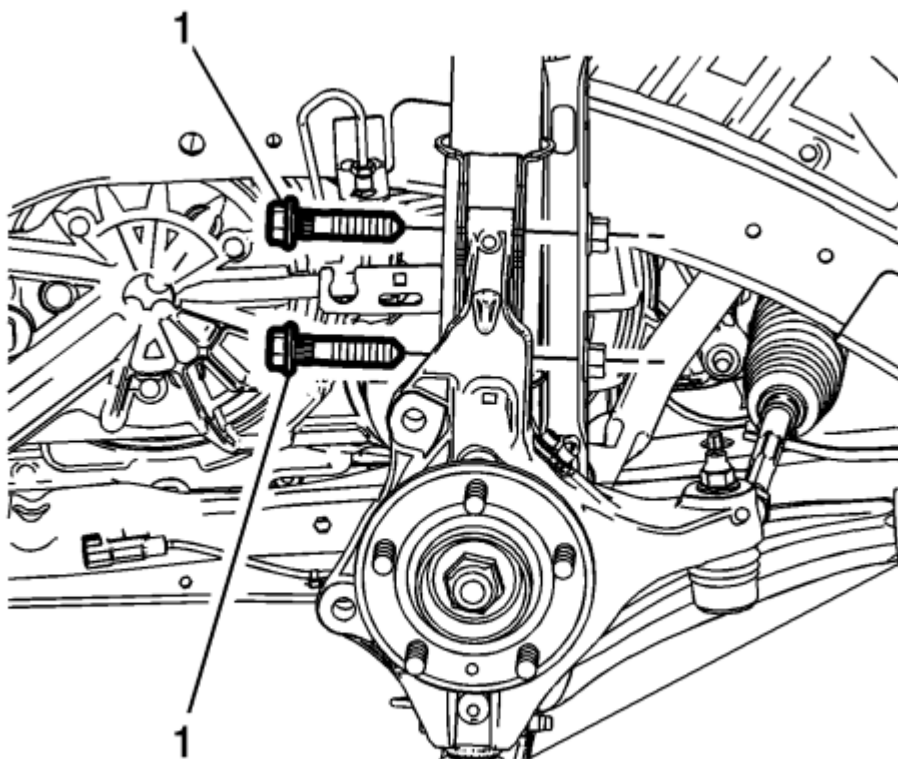
**Fig. 239: Right Side Engine Mount Bolts**  
Courtesy of GENERAL MOTORS COMPANY

15. Install the right side engine mount bolts (1) and tighten to 50 N.m (37 lb ft) plus 70 degrees.



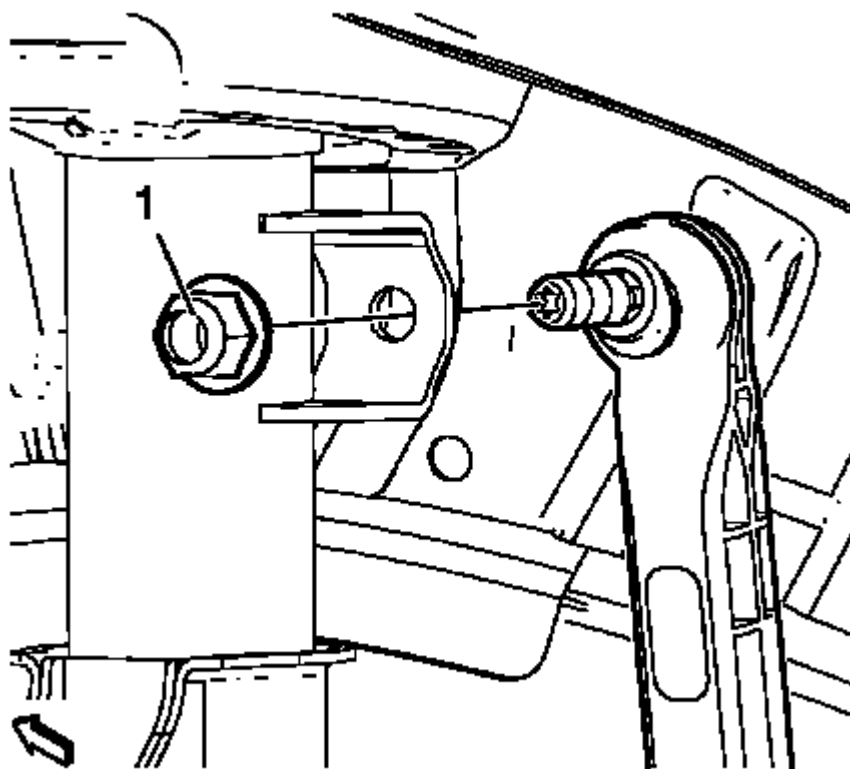
**Fig. 240: Lower Steering Intermediate Shaft Bolt**  
Courtesy of GENERAL MOTORS COMPANY

16. Install the NEW lower steering intermediate shaft (1) bolt and tighten to 34 N.m (25 lb ft).
17. Connect the electronic power steering connectors to the electronic power steering assembly. Refer to **FEP Connectors (Steering Gear)** .



**Fig. 241: Front Steering Knuckle Bolts**  
Courtesy of GENERAL MOTORS COMPANY

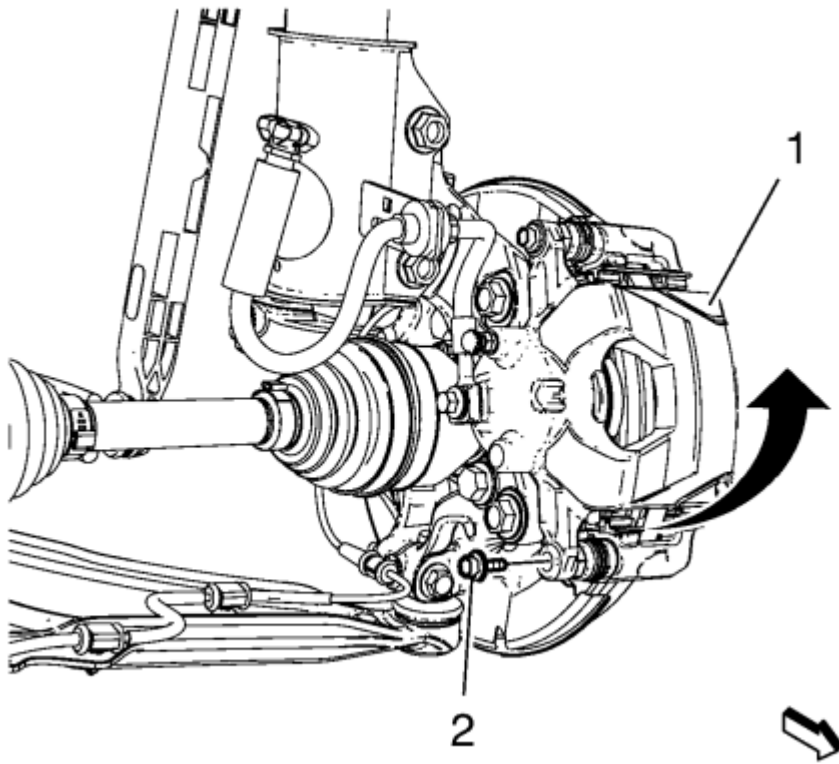
18. Connect the front steering knuckles bolts (1) to the strut assemblies. Refer to **Steering Knuckle Replacement** .



**Fig. 242: Stabilizer Link Nut**

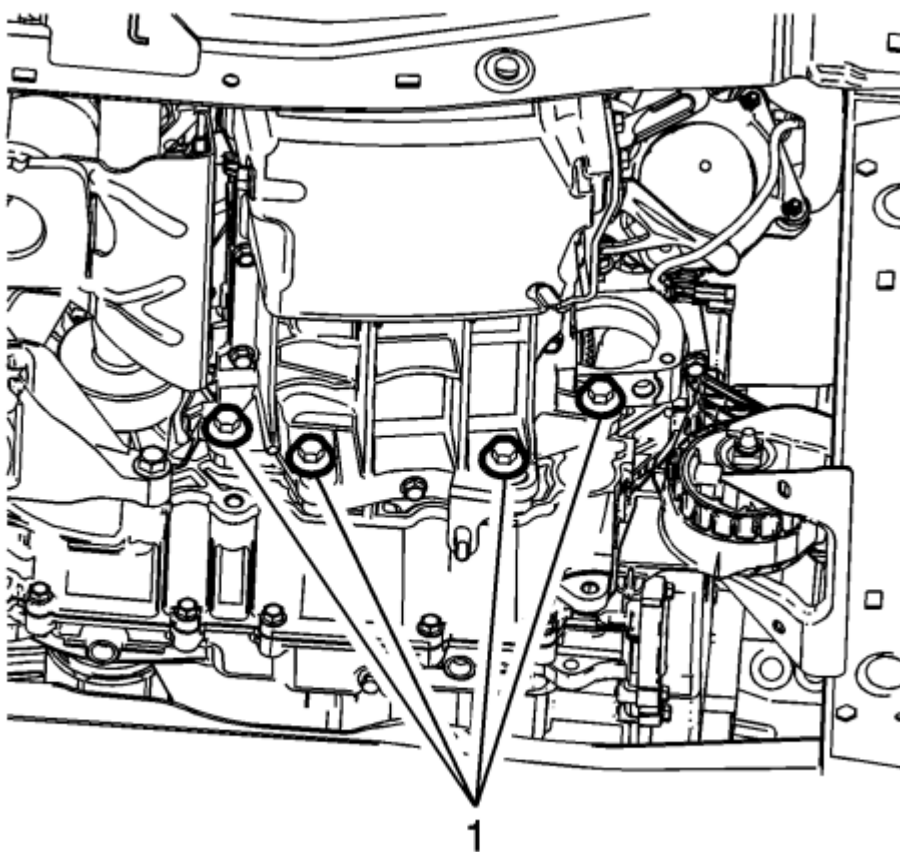
Courtesy of GENERAL MOTORS COMPANY

19. Install the NEW the stabilizer link nut (1) to the strut assemblies. Refer to **Stabilizer Shaft Link Replacement** .
20. Connect the right wheel drive shaft from the intermediate shaft.



**Fig. 243: View Of Brake Caliper And Brake Caliper Guide Pin Bolt**  
Courtesy of GENERAL MOTORS COMPANY

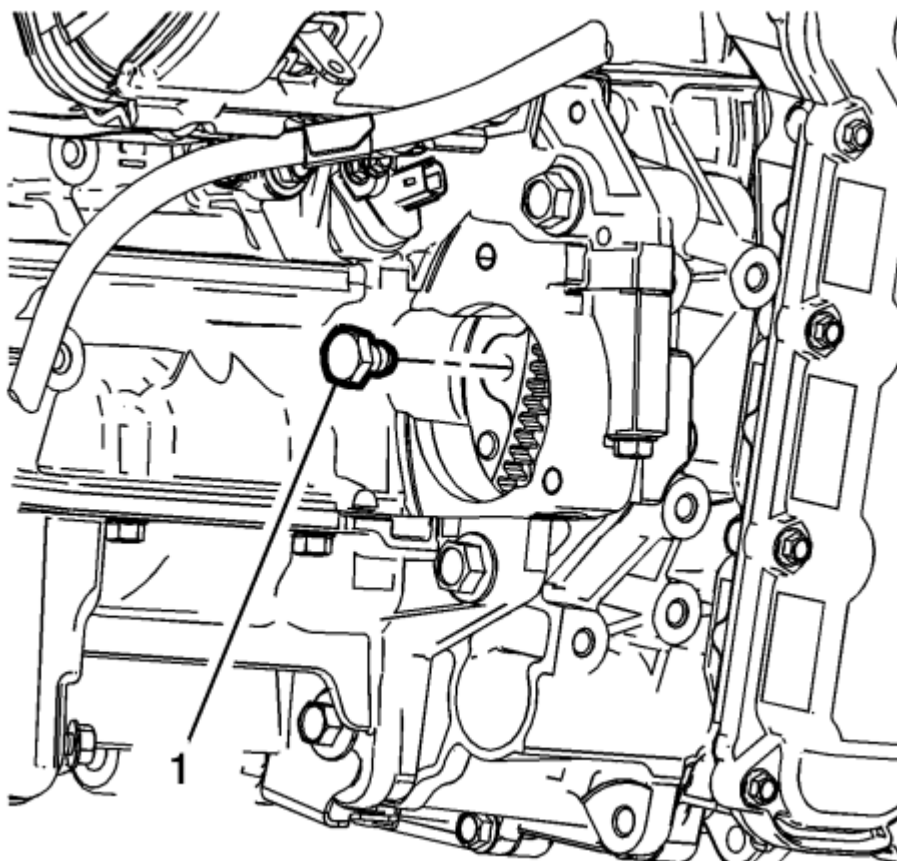
21. Install the front brake caliper (1) and tighten the brake caliper guide pin bolt (2) to 28 N.m (21 lb ft).
22. Install the exhaust system. Refer to **Exhaust System Replacement** .
23. Connect the wheel speed connectors to the steering knuckles.



**Fig. 244: Lower Transmission Bolts**

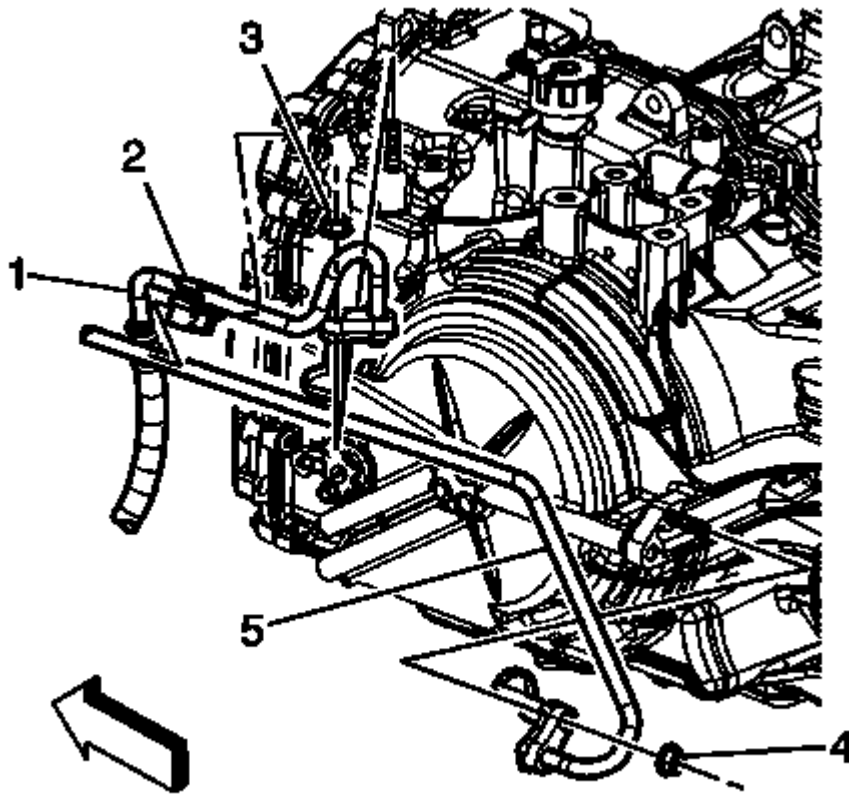
Courtesy of GENERAL MOTORS COMPANY

24. Install the lower oil pan to transmission lower bolts (1). and tighten to 75 N.m (55 lb ft).



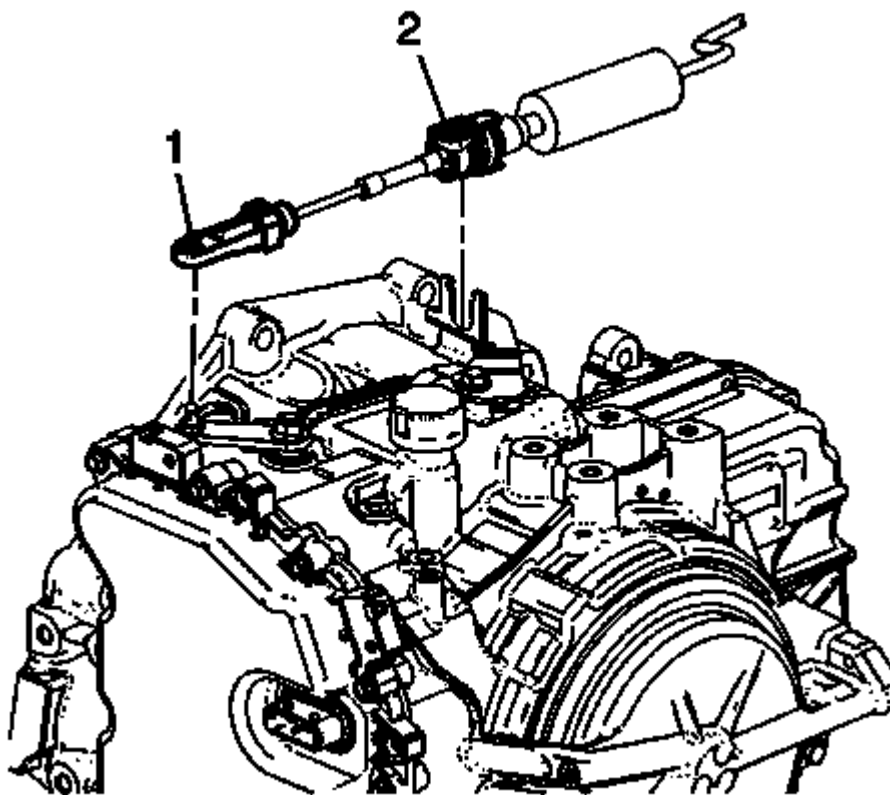
**Fig. 245: Torque Converter To Flywheel Bolts**  
**Courtesy of GENERAL MOTORS COMPANY**

25. Install the torque converter to flywheel bolts (1) and tighten to 62 N.m (46 lb ft).
26. Install the starter. Refer to **Starter Replacement** .
27. Lower the vehicle.
28. Remove the engine support fixture.



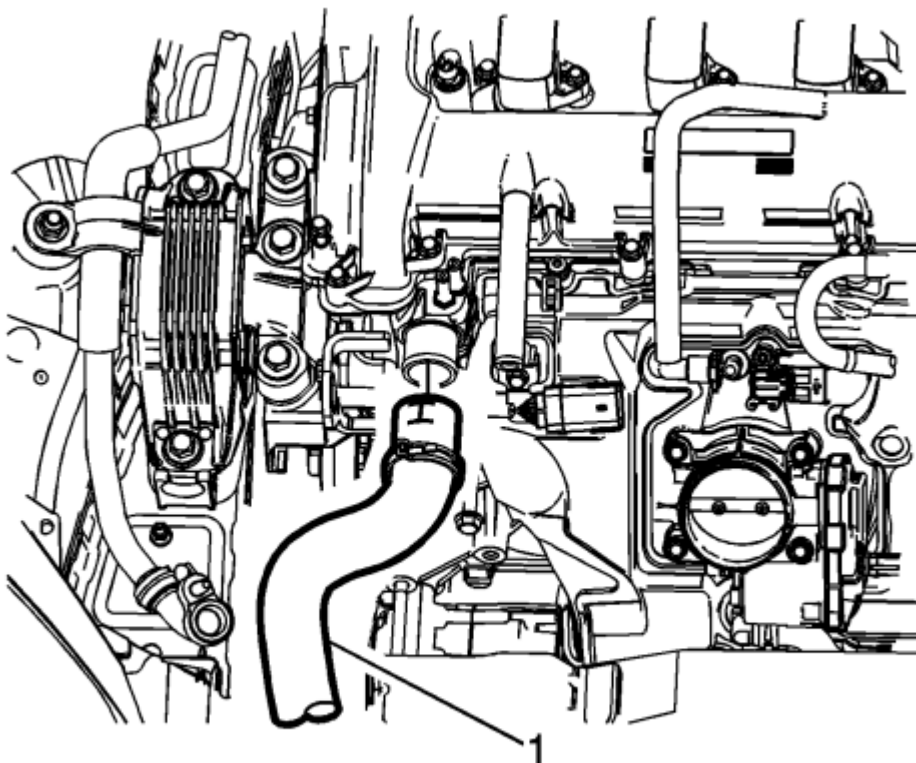
**Fig. 246: Identifying Cooler Inlet & Outlet Hoses**  
**Courtesy of GENERAL MOTORS COMPANY**

29. Install the transmission fluid cooler outlet hose (5) to the transmission.
30. Install the transmission fluid cooler outlet hose retainer nut (4) and tighten to 22 N.m (16 lb ft).
31. Install the transmission fluid cooler inlet hose (1) to the transmission.
32. Install the transmission fluid cooler inlet hose retainer nut (3).
33. Install the oil cooler inlet (1) and outlet (5) hoses to the retainer (2) on the control valve body cover.



**Fig. 247: View Of Transmission Range Selector Lever & Cable Connection**  
Courtesy of GENERAL MOTORS COMPANY

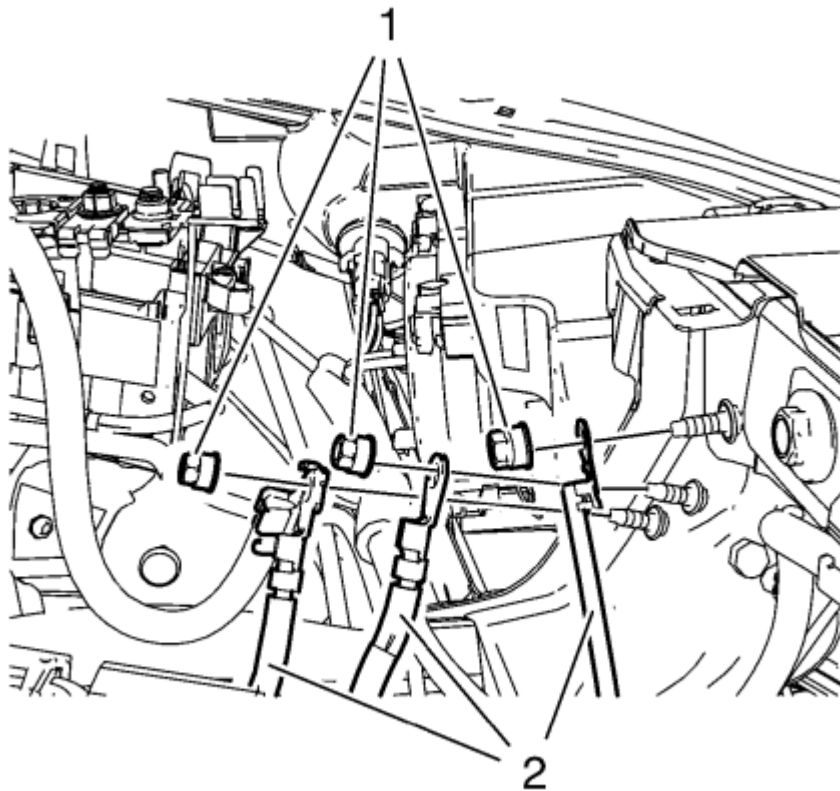
34. Connect the range selector cable (2) to the range selector cable bracket.
35. Connect the range selector cable end (1) to the range selector lever.



**Fig. 248: Radiator Inlet Hose**

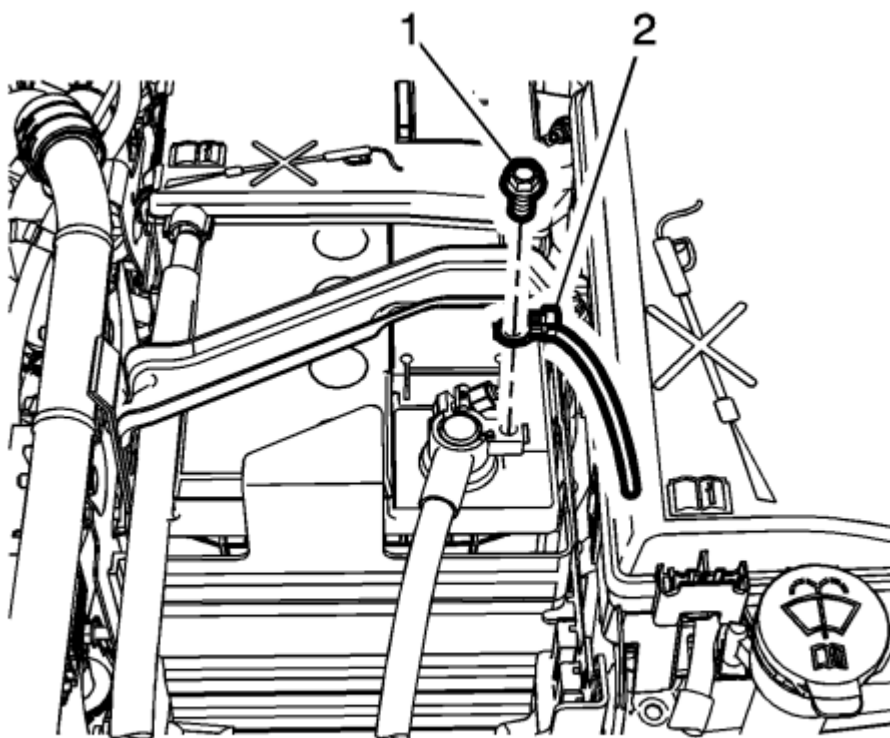
Courtesy of GENERAL MOTORS COMPANY

36. Install the radiator inlet hose (1). Refer to **Radiator Inlet Hose Replacement** .
37. Install the radiator outlet hose (1). Refer to **Radiator Outlet Hose Replacement** .



**Fig. 249: Wiring Harness & Ground Nuts**  
Courtesy of GENERAL MOTORS COMPANY

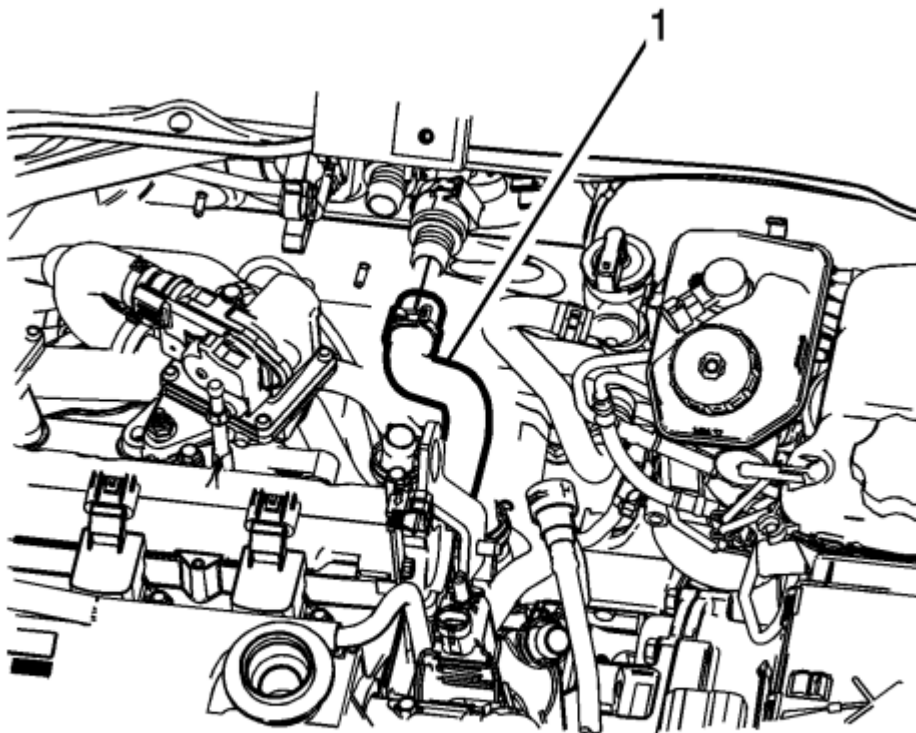
38. Install the wiring harnesses (2).
39. Install the ground nuts (1) and tighten to 9 N.m (80 lb in).
40. Connect the wiring connectors and ground strap to the transmission.
41. Install the battery tray. Refer to **Battery Tray Replacement**
42. Connect the wiring harness to the accessory wiring junction block.



**Fig. 250: Ground Strap & Bolt**

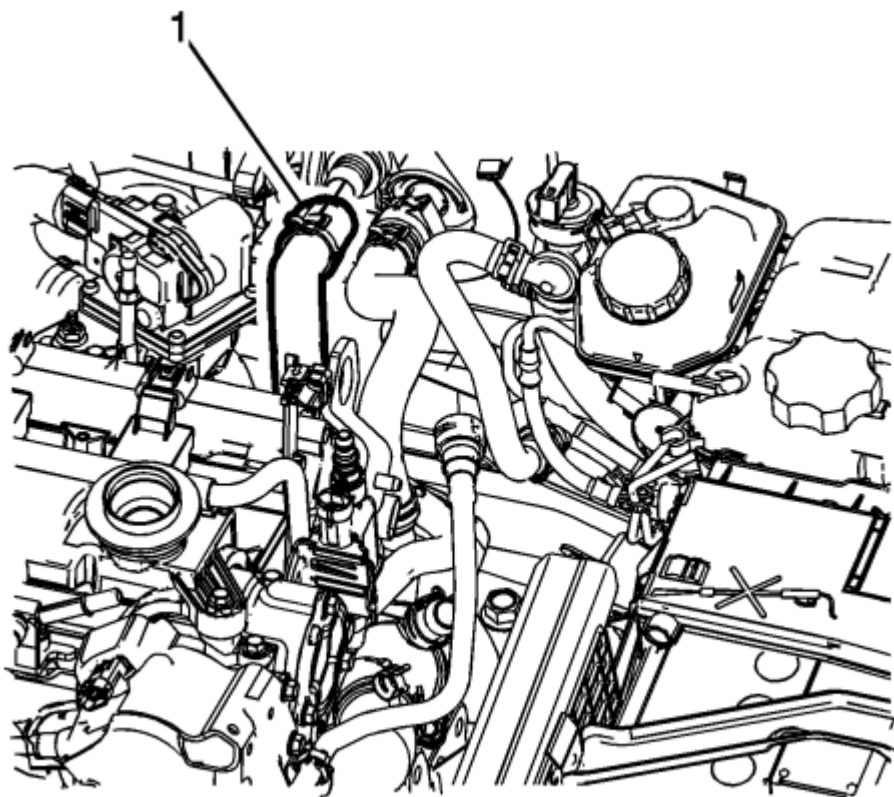
Courtesy of GENERAL MOTORS COMPANY

43. Connect the wiring harness plugs (1).



**Fig. 251: Outlet Heater Core Hose**  
Courtesy of GENERAL MOTORS COMPANY

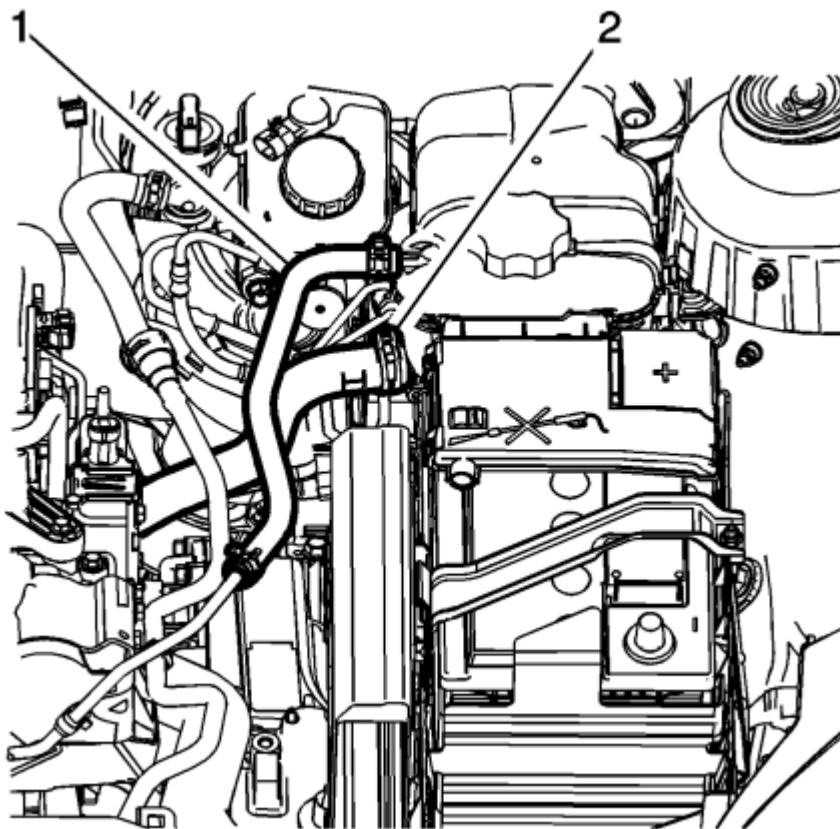
44. Connect the outlet (1) heater core hoses. Refer to **Heater Outlet Hose Replacement** .



**Fig. 252: Inlet Heater Core Hose**

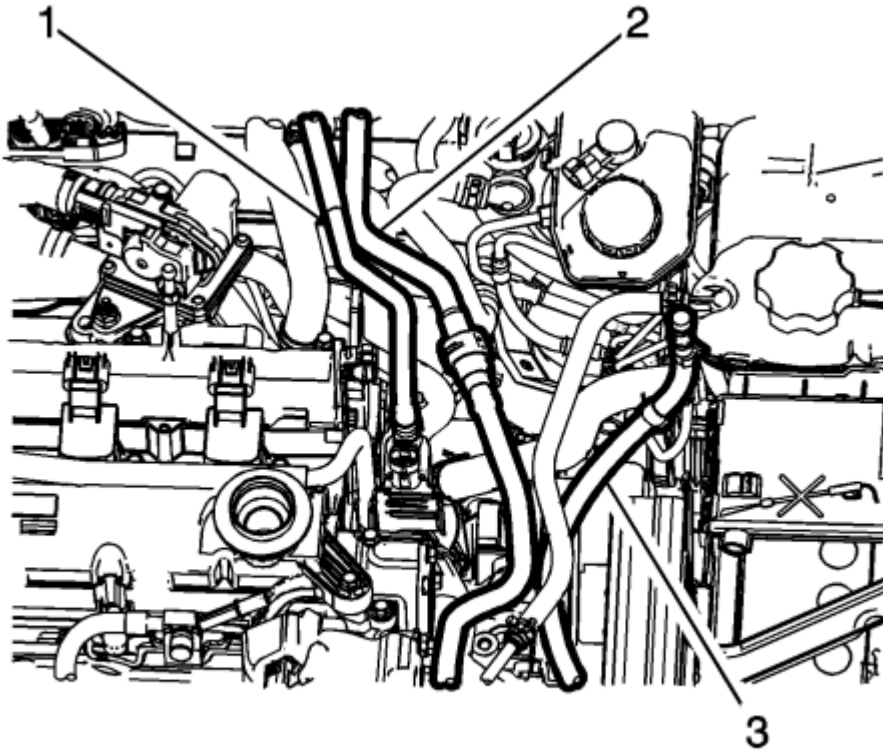
Courtesy of GENERAL MOTORS COMPANY

45. Connect the inlet (1) heater core hoses. Refer to **Heater Inlet Hose Replacement** .



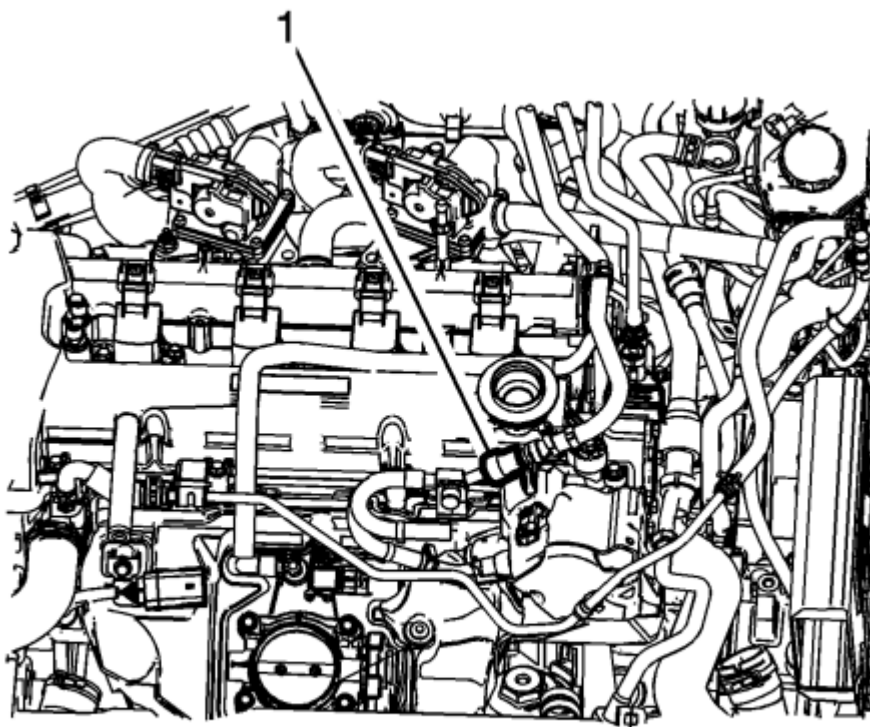
**Fig. 253: Radiator Surge Tank Hose**  
**Courtesy of GENERAL MOTORS COMPANY**

46. Connect the coolant hose (2, 1) to radiator surge tank.



**Fig. 254: EVAP Hose, Brake Booster Vacuum Pipe & Transmission Vent Hose**  
**Courtesy of GENERAL MOTORS COMPANY**

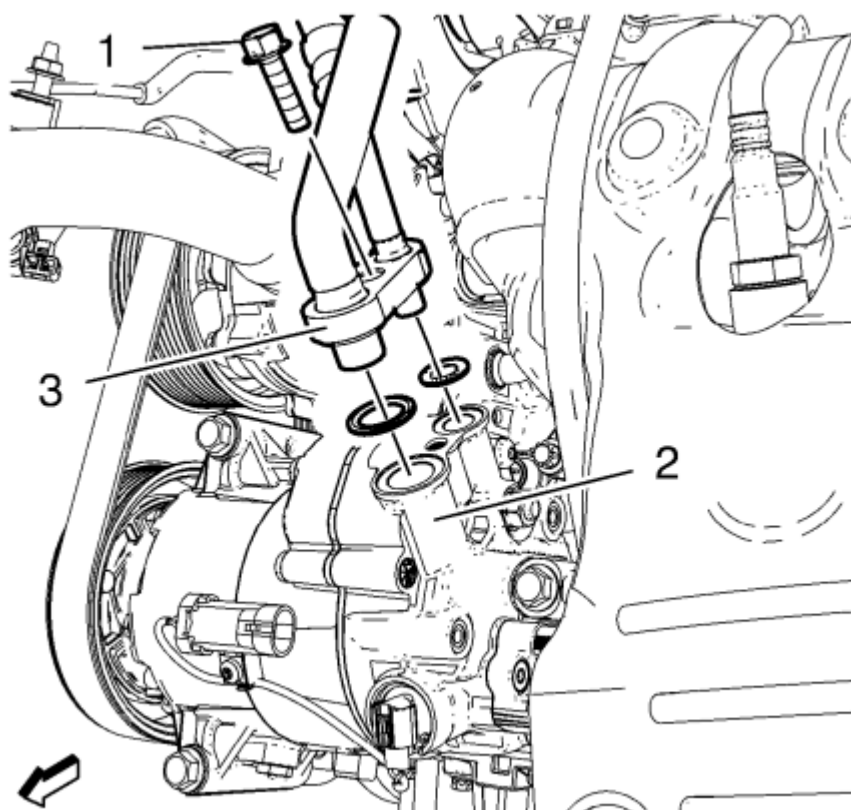
47. Connect the EVAP hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
48. Connect the power brake booster vacuum pipe (2). Refer to **Power Brake Booster Vacuum Pipe Replacement (Engine Side)** , **Power Brake Booster Vacuum Pipe Replacement (Booster Side)** .
49. Connect the transmission vent hose (3) from the coolant surge tank.



**Fig. 255: Fuel Feed Line**

**Courtesy of GENERAL MOTORS COMPANY**

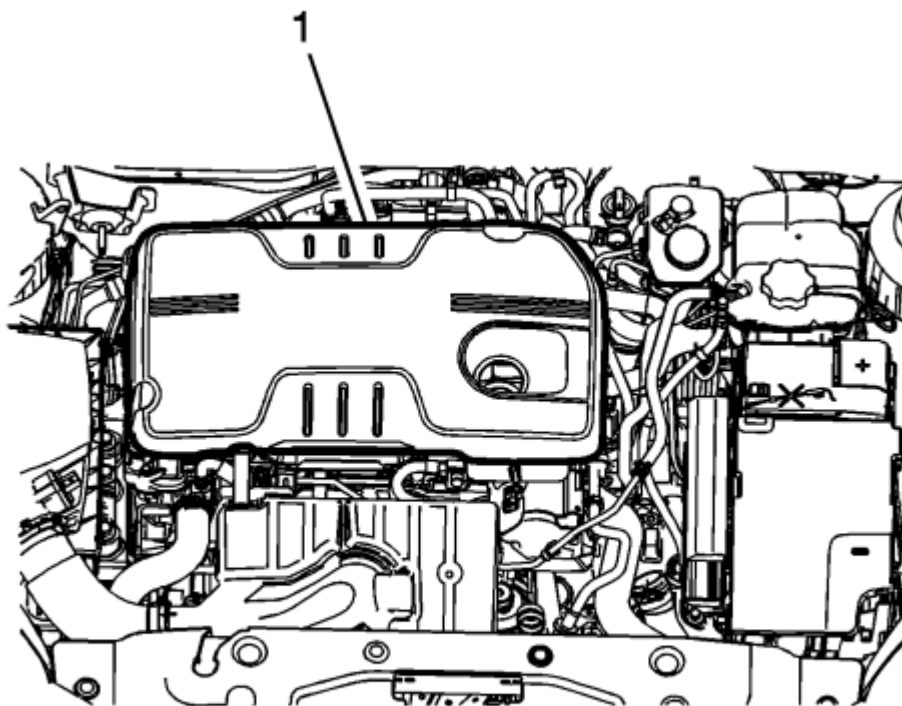
50. Connect the fuel feed line (1) to the engine. Refer to **Plastic Collar Quick Connect Fitting Service** .



**Fig. 256: A/C Compressor And Condenser Hose And Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Use **NEW O-ring seals**. Refer to **Air Conditioning O-Ring Seal Replacement** .

51. Install the air conditioning compressor and the condenser hose (3).
52. Install the air conditioning compressor and the condenser hose bolt (1) to the A/C compressor (2) and tighten to 22 N.m (16 lb ft).
53. Install the air conditioning compressor and the condenser hose. Refer to **Air Conditioning Compressor and Condenser Hose Replacement**
54. Install the front bumper fascia. Refer to **Front Bumper Fascia Replacement** .
55. Install the air deflector.
56. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
57. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
58. Evacuate and charge the refrigerant system. Refer to **Refrigerant Recovery and Recharging** .
59. Fill the engine cooling system. Refer to **Cooling System Draining and Filling (GE 47716)** .



**Fig. 257: Intake Manifold Cover**

Courtesy of GENERAL MOTORS COMPANY

60. Install the Intake Manifold Cover. Refer to **Intake Manifold Cover Replacement**.
61. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnection and Connection**.

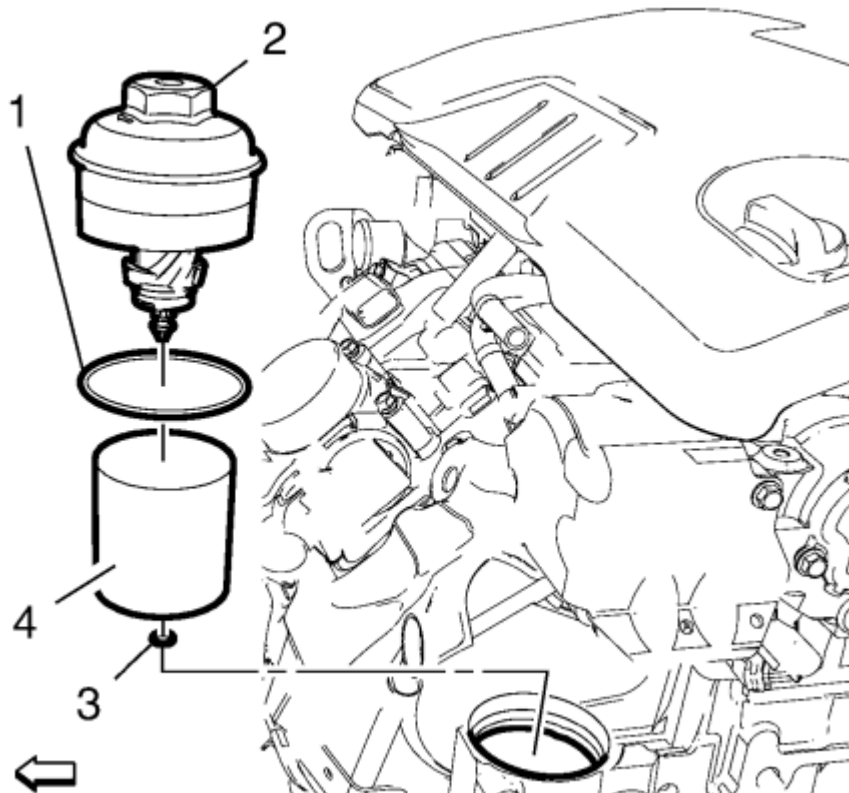
## **ENGINE OIL AND OIL FILTER REPLACEMENT**

### **Special Tools**

**EN-44887** Oil Filter Wrench

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

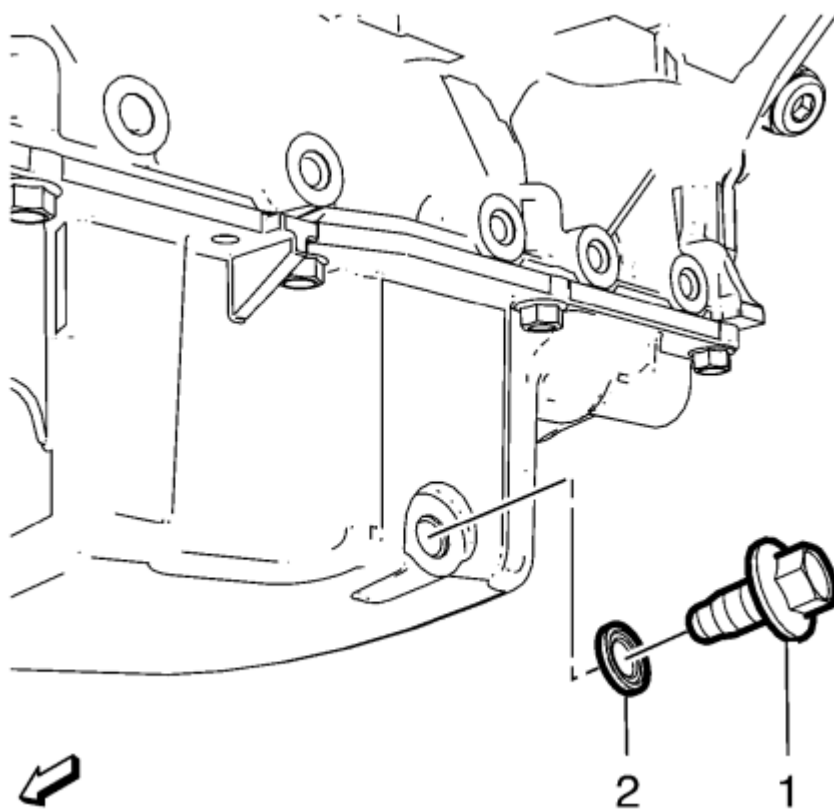
### **Removal Procedure**



**Fig. 258: Oil Filter Components**

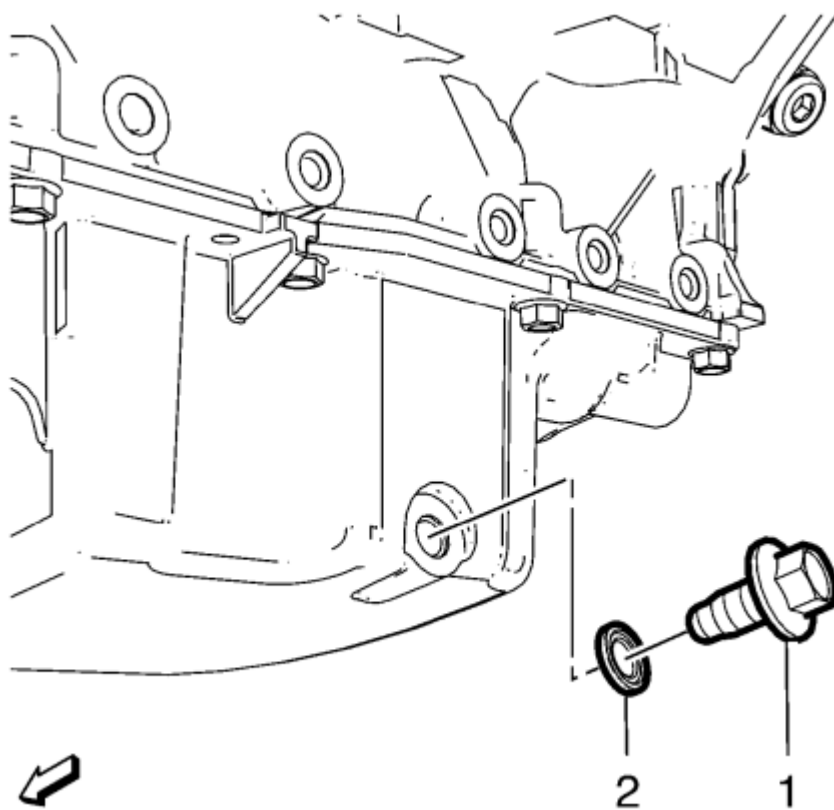
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter cap (2) with the **EN-44887** wrench.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle (Standard)** .
3. Place a drain pan under the oil drain plug.

**Fig. 259: Drain Plug & Seal Ring****Courtesy of GENERAL MOTORS COMPANY**

4. Remove the oil drain plug (1) and the oil drain plug seal ring (2).

**Installation Procedure**

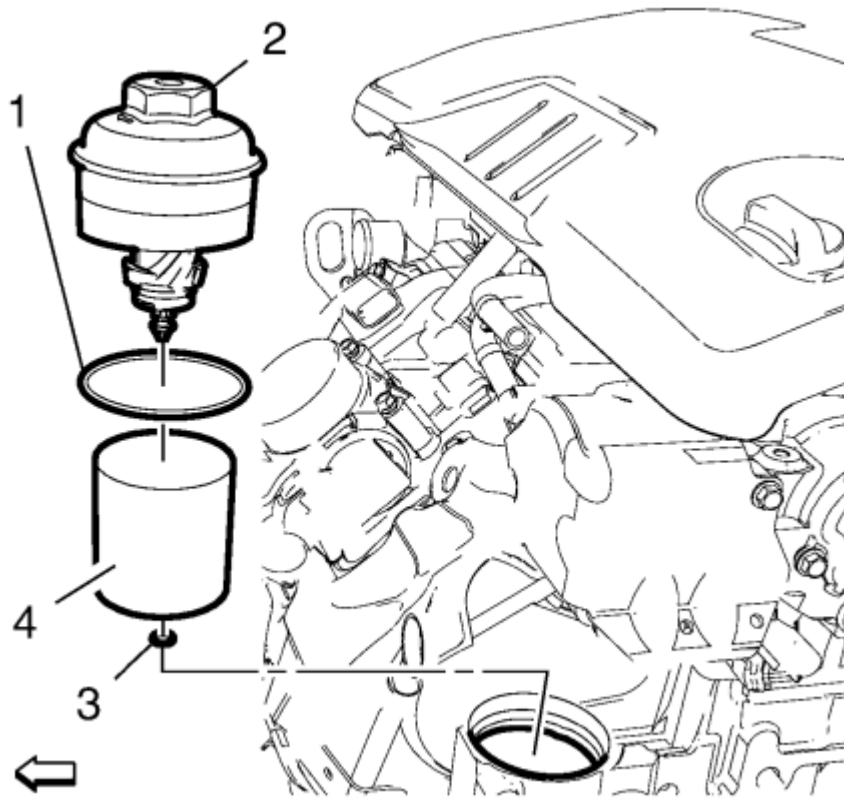


**Fig. 260: Drain Plug & Seal Ring**

Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

1. Install the oil drain plug (1) with the oil drain plug seal ring (2) and tighten to 25 N.m (18 lb ft).
2. Remove the oil drain pan.
3. Lower and unsupport the vehicle.



**Fig. 261: Oil Filter Components**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:** Install a NEW oil filter (4) and a NEW oil filter cap seal (1) and (3) to the oil filter cap (2).

4. Install the oil filter cap (2) with the **EN-44887** wrench and tighten to 25 N.m (18 lb ft).
5. Fill the engine with engine oil. Refer to **Engine Mechanical Specifications (LEA)**.
6. Reset the oil life monitor.

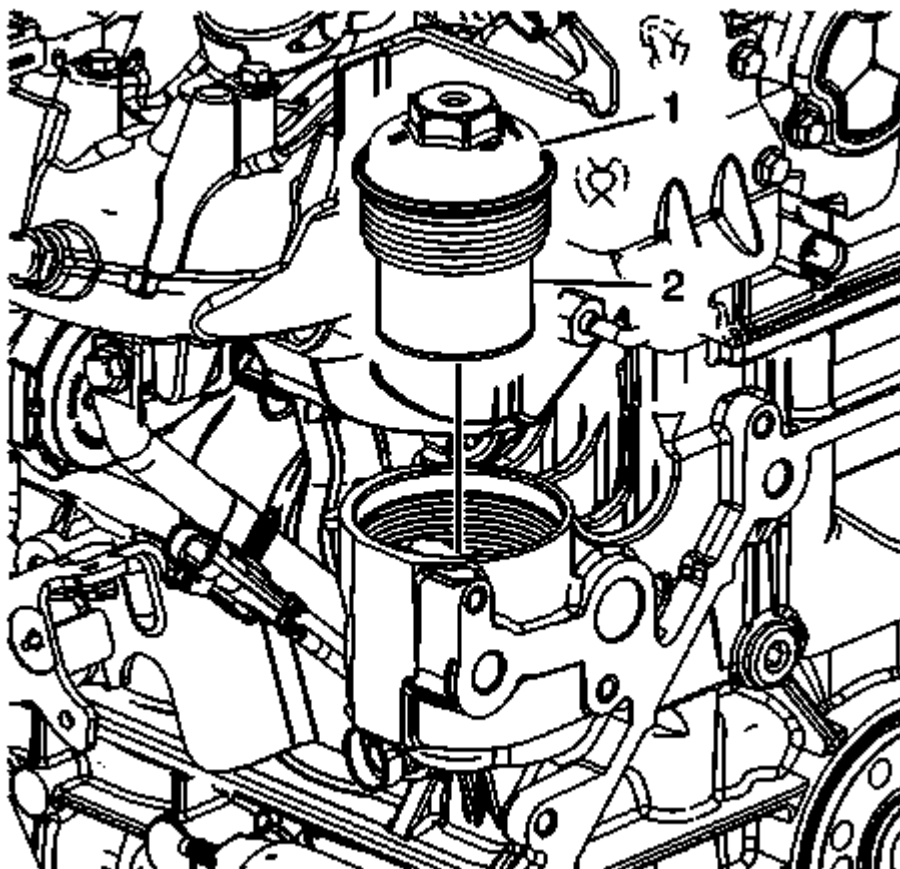
## REPAIR INSTRUCTIONS - OFF VEHICLE

### DRAINING FLUIDS AND OIL FILTER REMOVAL

#### Special Tools

**EN-44887** Oil Filter Wrench

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



**Fig. 262: Identifying Oil Filter & Cap**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

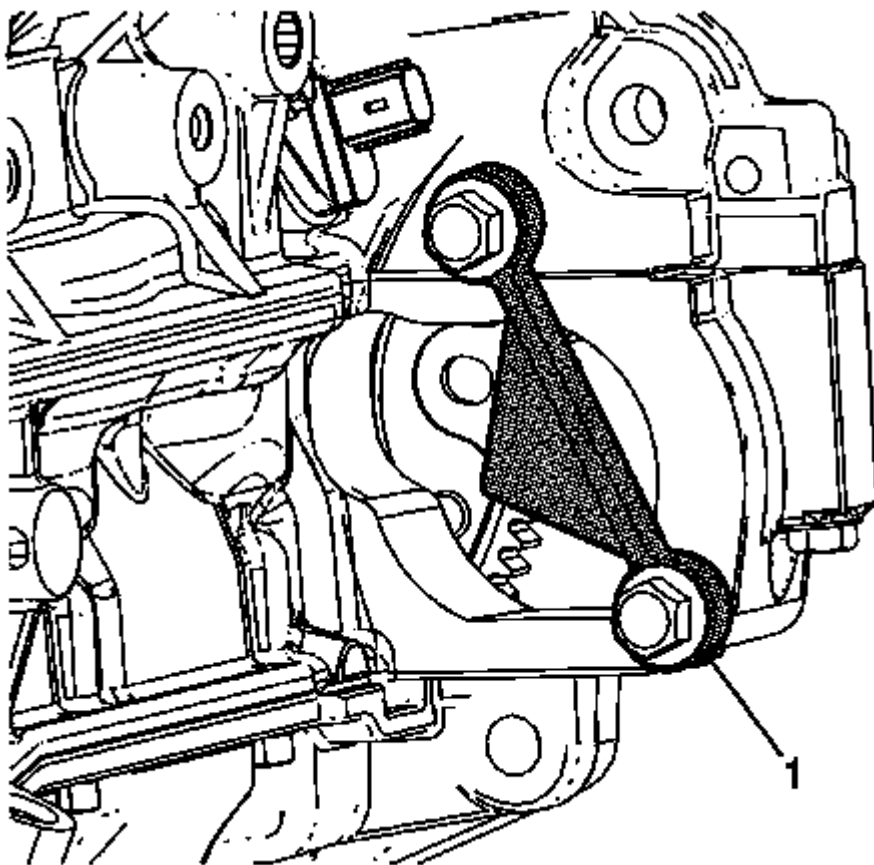
4. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
5. Remove the water pump drain plug from the water pump and allow the coolant to drain from the water jacket.
6. Apply sealant to the water pump drain plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. Install the water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

## CRANKSHAFT BALANCER REMOVAL

## Special Tools

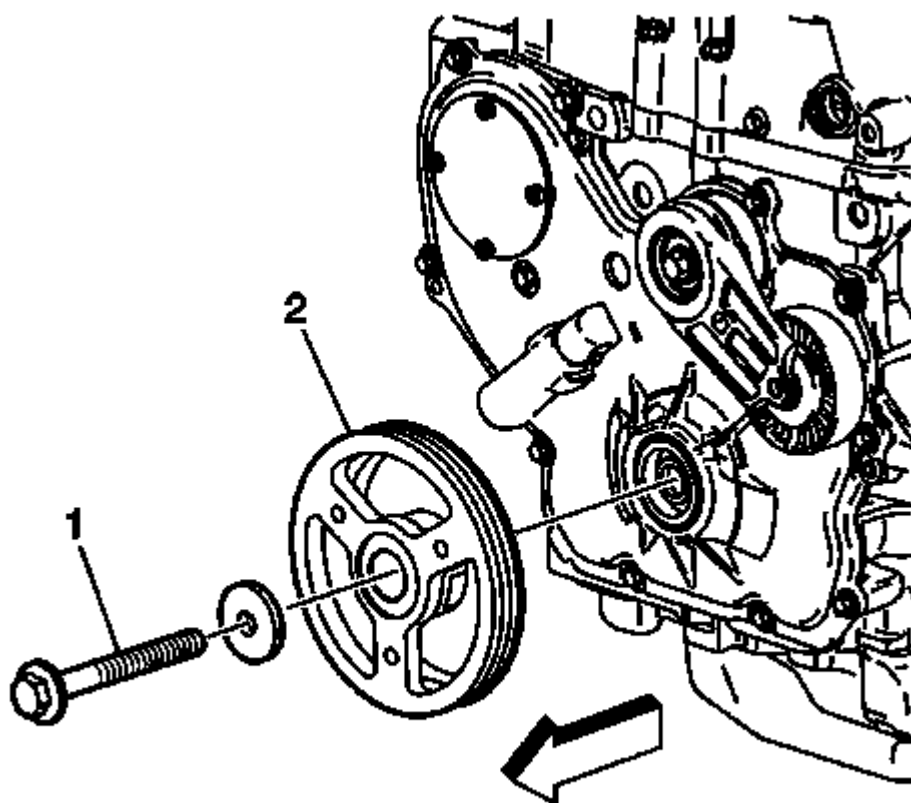
### EN 43653 Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools



**Fig. 263: View of Engine Flywheel**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 264: Balancer & Retaining Bolt**  
Courtesy of GENERAL MOTORS COMPANY

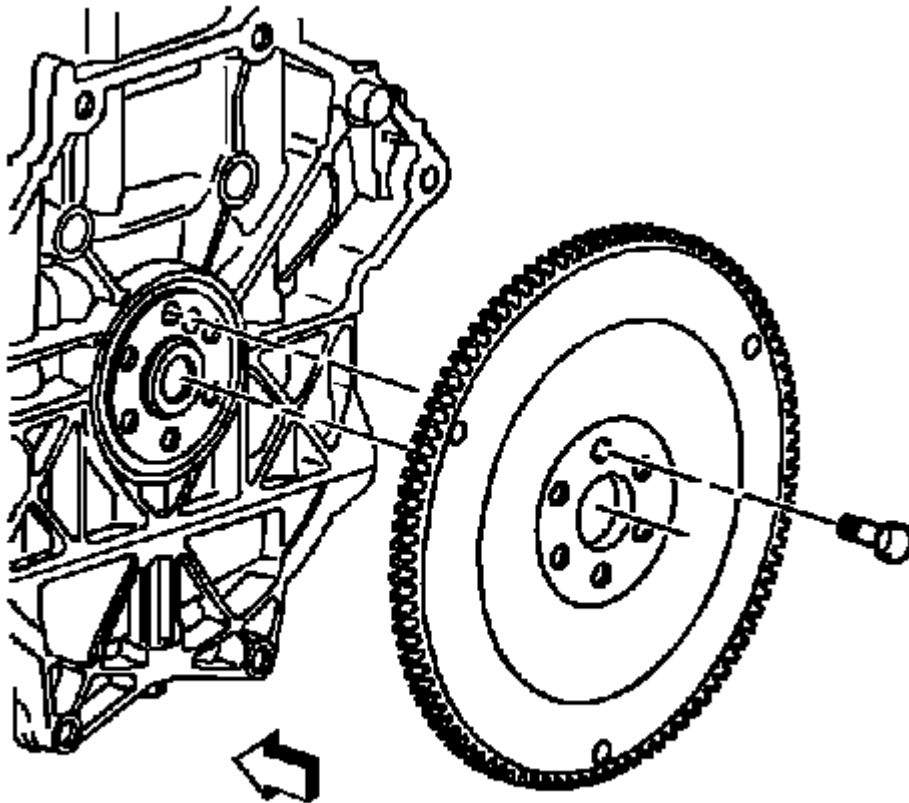
2. Remove the balancer retaining bolt (1) and washer. Discard the bolt.
3. Remove the balancer (2) using a universal removal tool.

## ENGINE FLYWHEEL REMOVAL

### Special Tools

**EN 43653** Flywheel Holding Tool

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

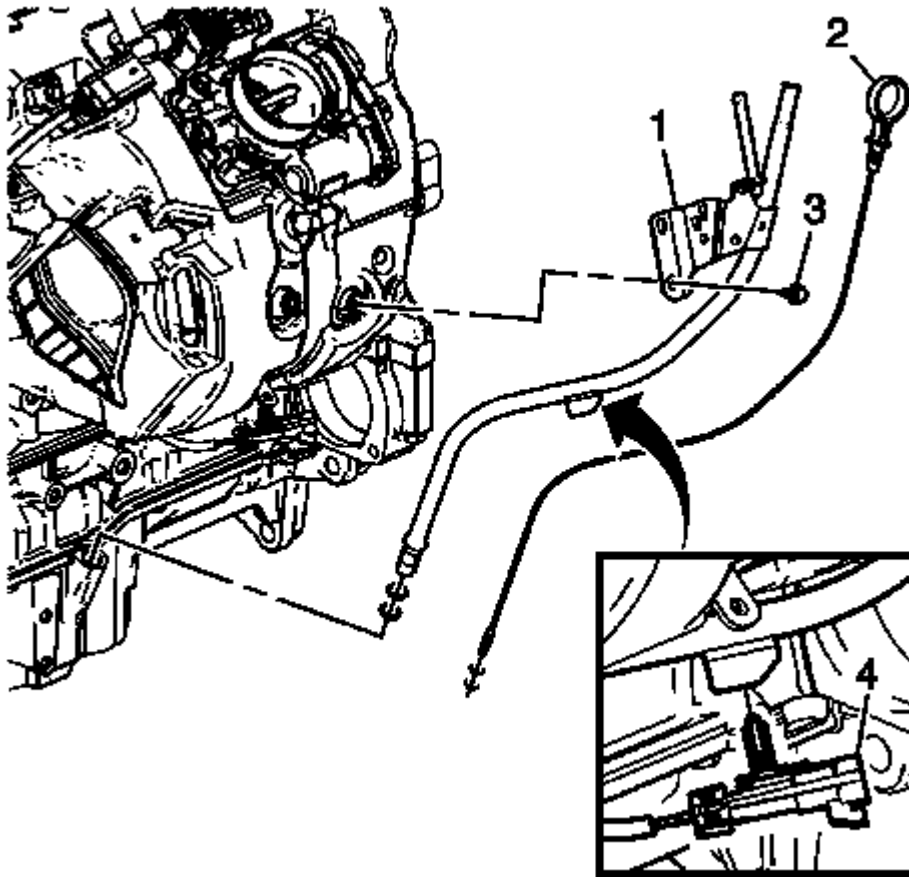


**Fig. 265: View Of Flywheel**

Courtesy of GENERAL MOTORS COMPANY

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

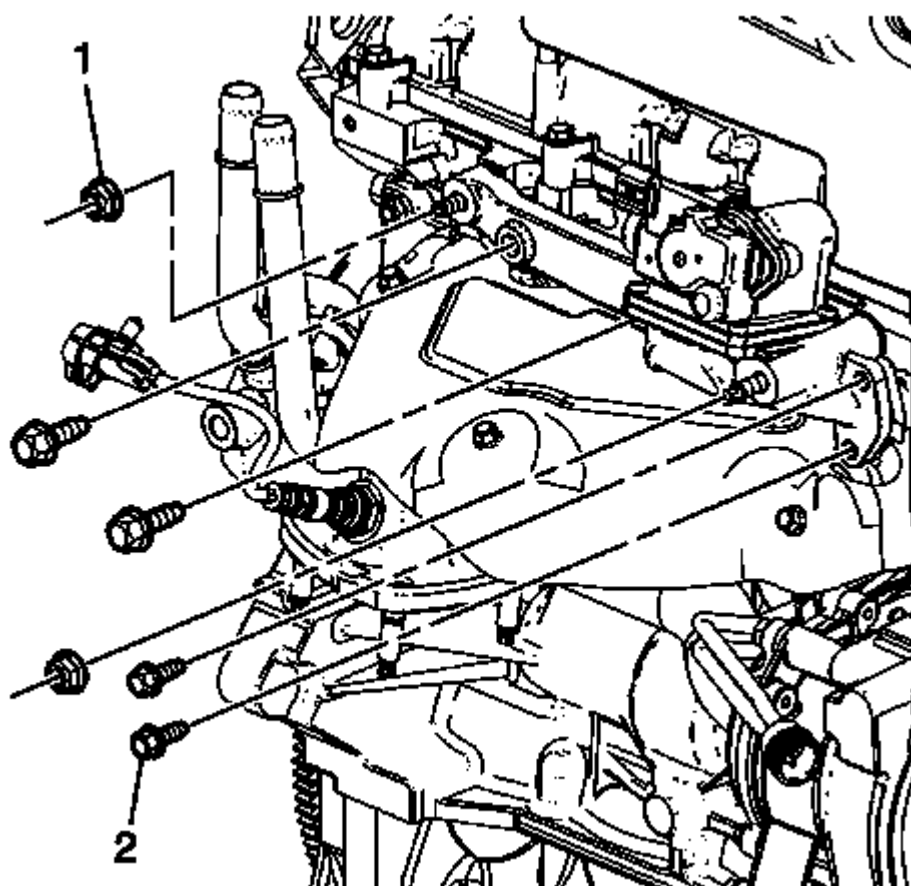
#### **OIL LEVEL INDICATOR AND TUBE REMOVAL (LEA)**



**Fig. 266: Oil Level Indicator Tube Components**  
Courtesy of GENERAL MOTORS COMPANY

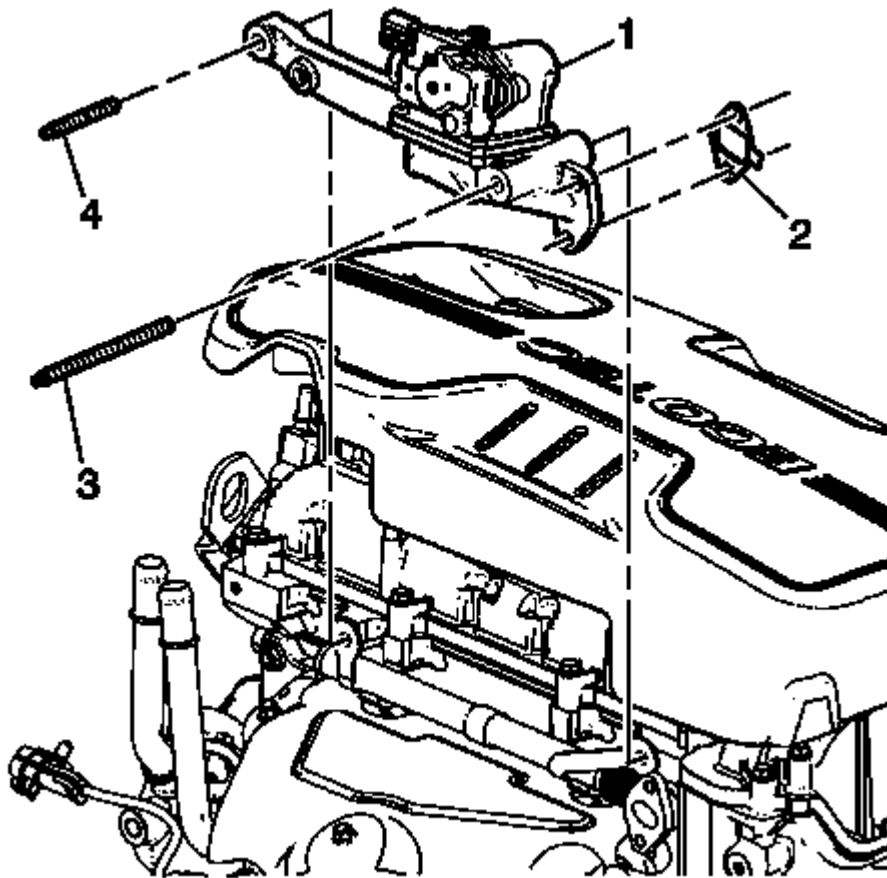
1. Remove knock sensor connector (4) from the oil level indicator tube.
2. Remove the electrical wiring harness from the oil level indicator tube.
3. Remove the oil level indicator tube bracket bolt (3).
4. Remove the oil level indicator (2) and the oil level indicator tube (1) from the oil pan.
5. Inspect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

#### **EXHAUST MANIFOLD REMOVAL (LEA)**



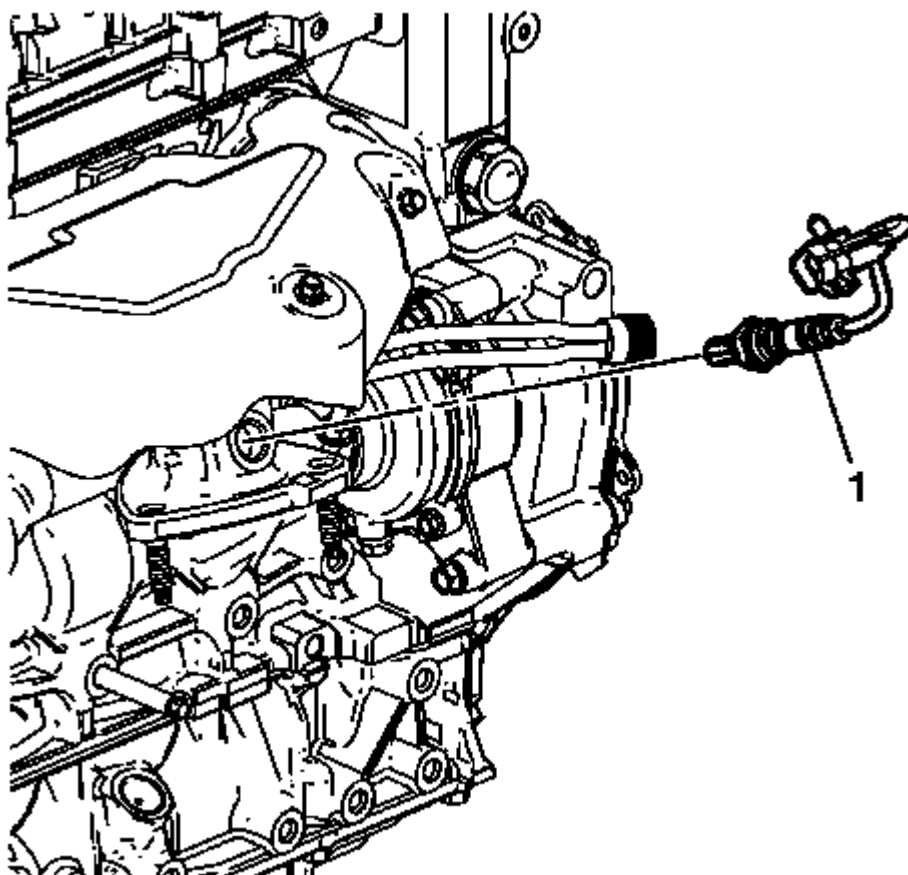
**Fig. 267: Secondary Air Injection Bolts And Nuts**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 268: Secondary Air Injection Studs**  
 Courtesy of GENERAL MOTORS COMPANY

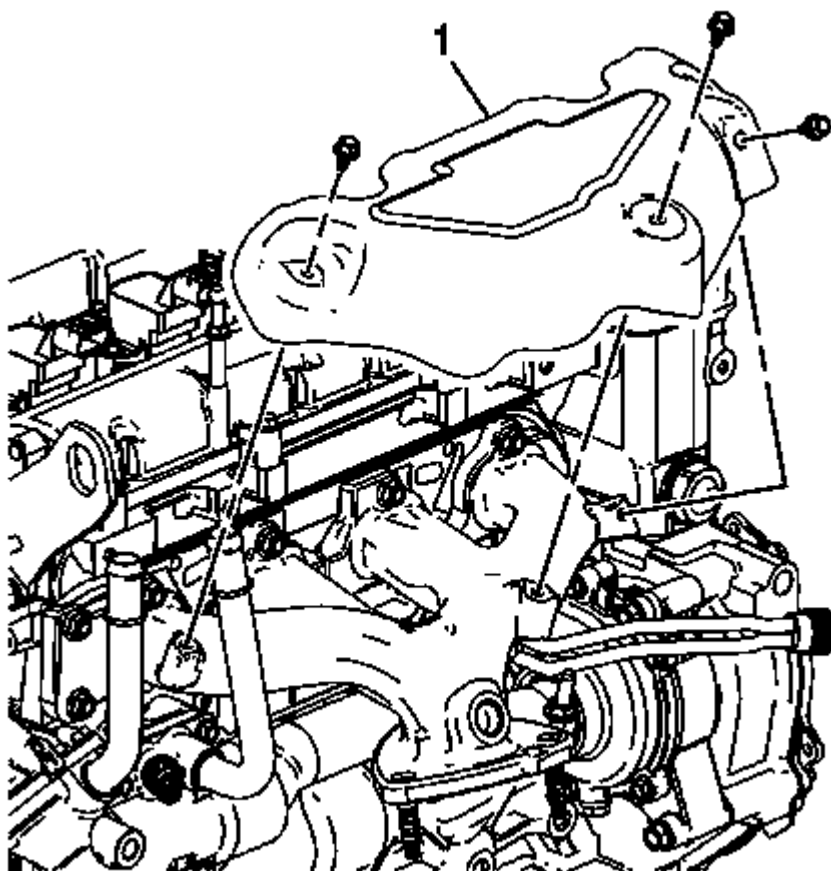
2. Remove the secondary air injection studs (3 and 4).
3. Remove the secondary air injection valve assembly (1).
4. Remove the secondary air injection gasket (2) and discard.



**Fig. 269: Oxygen Sensor**

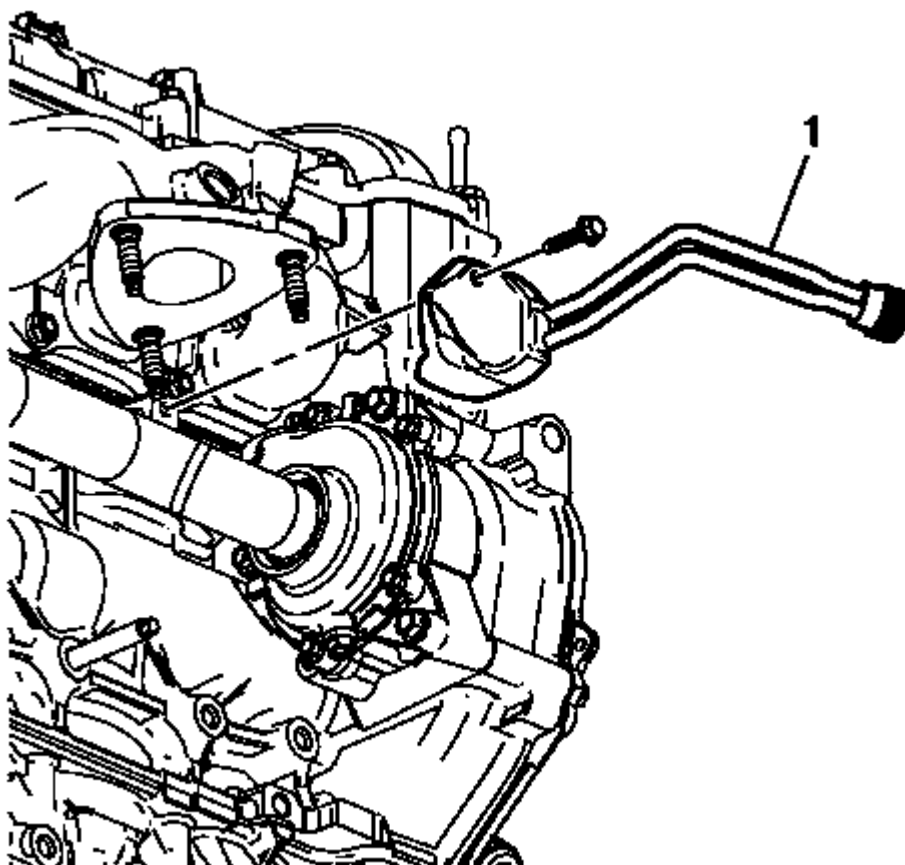
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oxygen sensor (1).



**Fig. 270: Exhaust Manifold Heat Shield**  
Courtesy of GENERAL MOTORS COMPANY

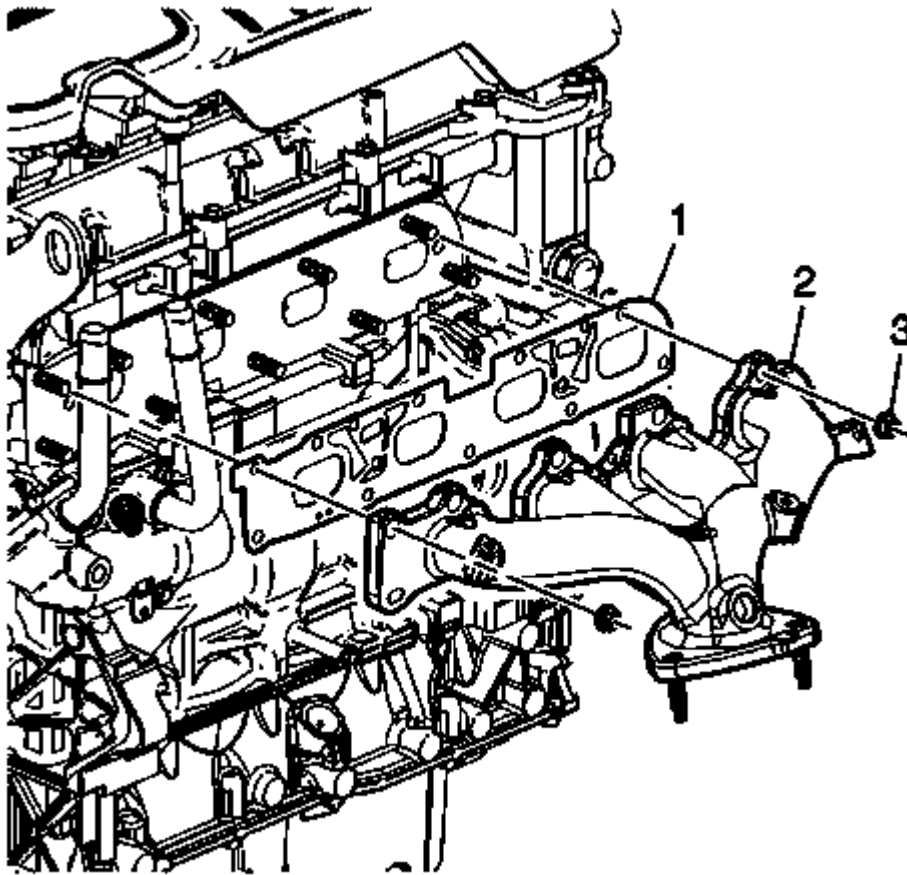
6. Remove the exhaust manifold heat shield bolts.
7. Remove the exhaust manifold heat shield (1).



**Fig. 271: Block Heater**

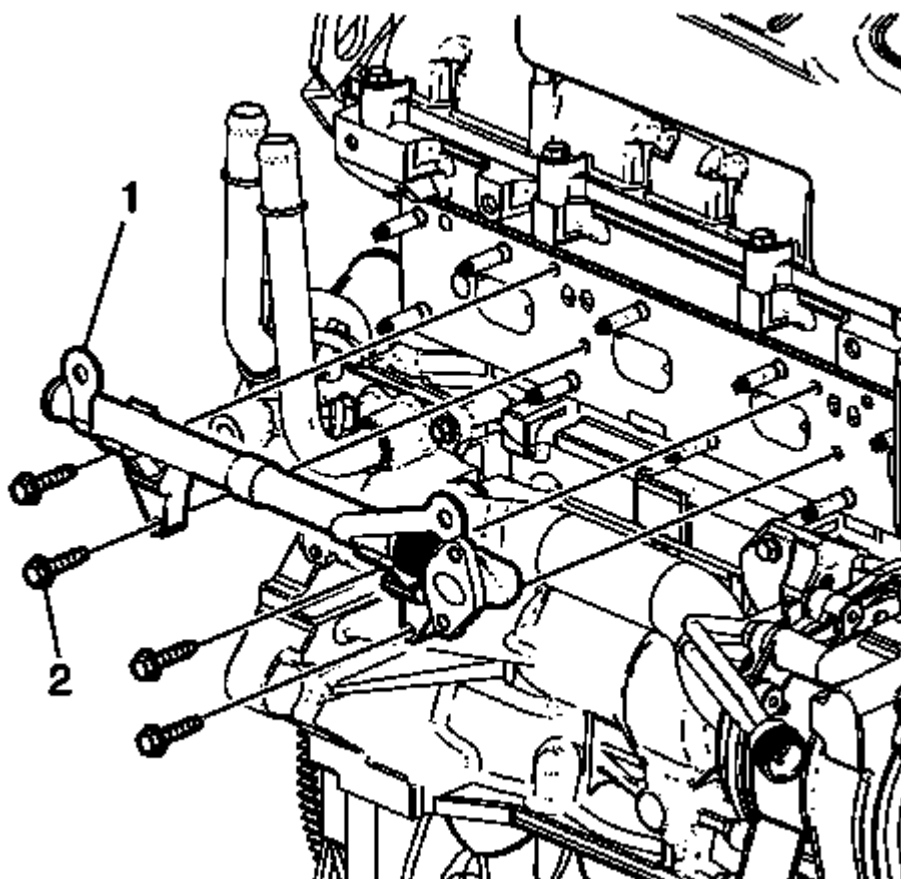
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 272: Exhaust Manifold Components**  
Courtesy of GENERAL MOTORS COMPANY

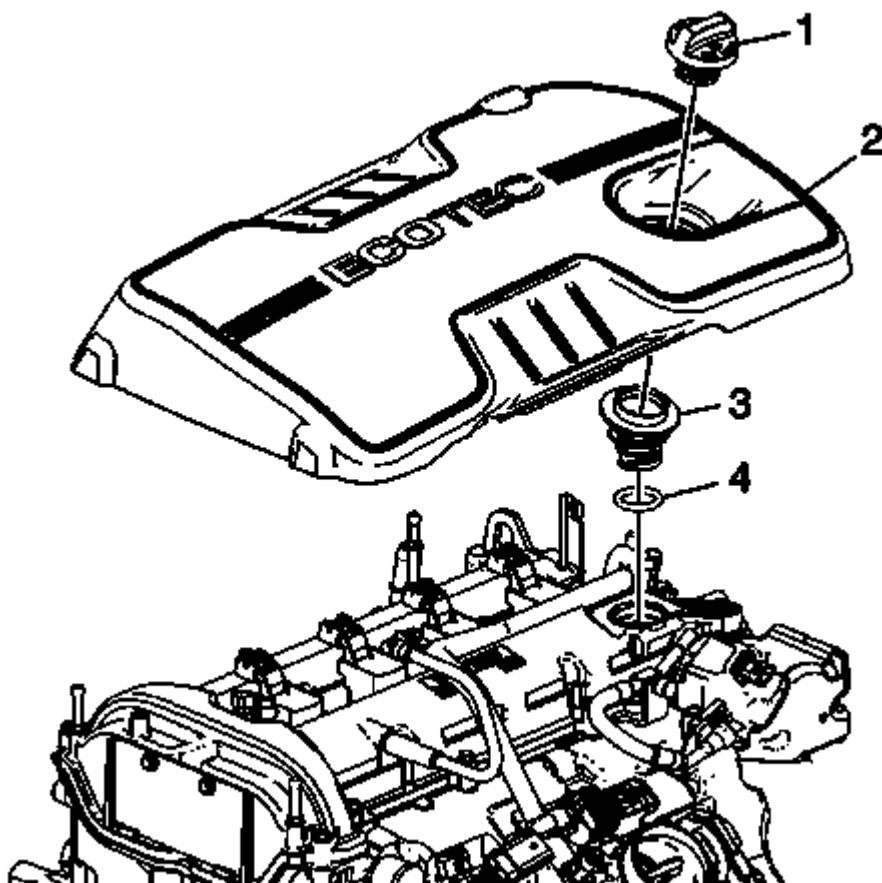
9. Remove and discard the exhaust manifold to cylinder head retaining nuts (1).
10. Remove the exhaust manifold (2).
11. Remove the exhaust manifold gasket (3).
12. Clean all of the sealing surfaces.
13. If the exhaust manifold is being replaced, transfer the following parts:
  - The exhaust manifold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



**Fig. 273: Secondary Air Injection Pipe Assembly**  
Courtesy of GENERAL MOTORS COMPANY

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

## INTAKE MANIFOLD REMOVAL

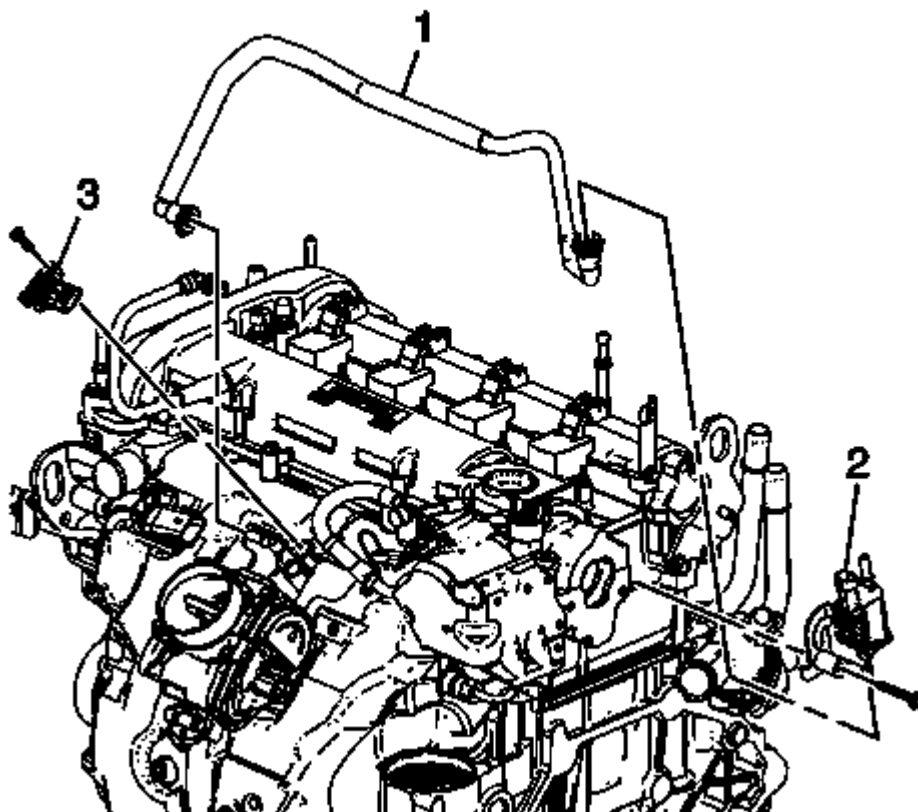


**Fig. 274: Oil Fill Cap Components**

Courtesy of GENERAL MOTORS COMPANY

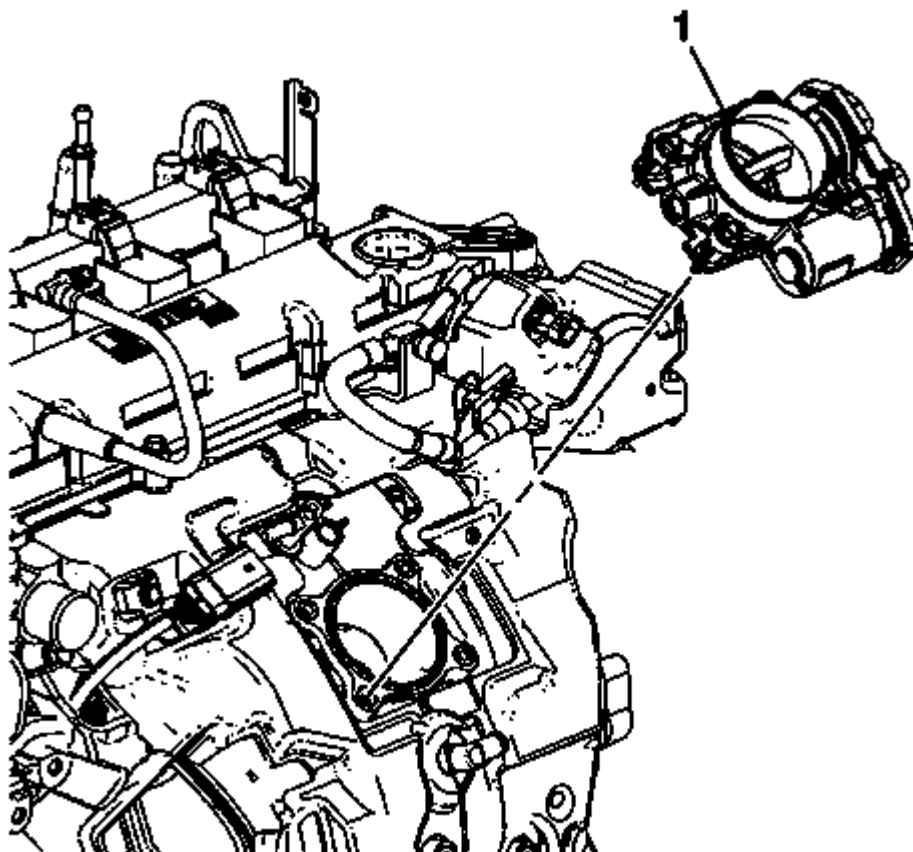
**CAUTION:** Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold can be damaged if it is removed when the engine is hot.

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



**Fig. 275: EVAP Canister Valve, Tube & MAP Sensor**  
Courtesy of GENERAL MOTORS COMPANY

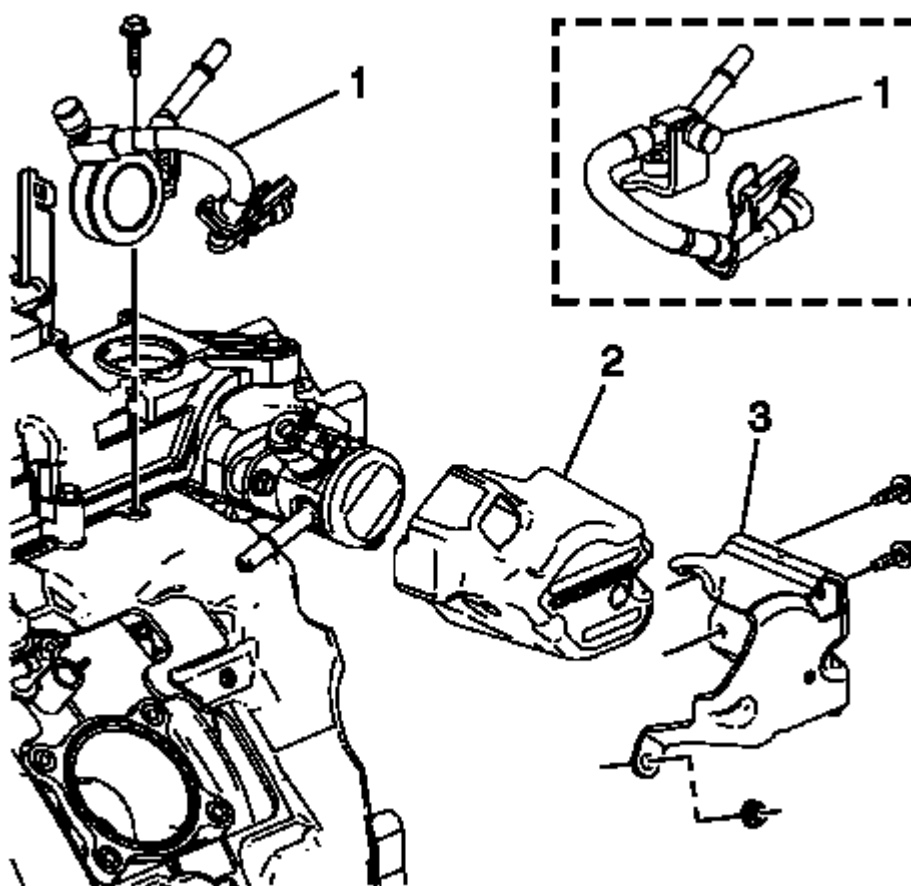
4. Remove the evaporative (EVAP) emission canister valve tube (1).
5. Remove the EVAP canister valve (2).
6. Remove the MAP sensor (3).



**Fig. 276: Throttle Body**

Courtesy of GENERAL MOTORS COMPANY

7. Remove the throttle body (1).



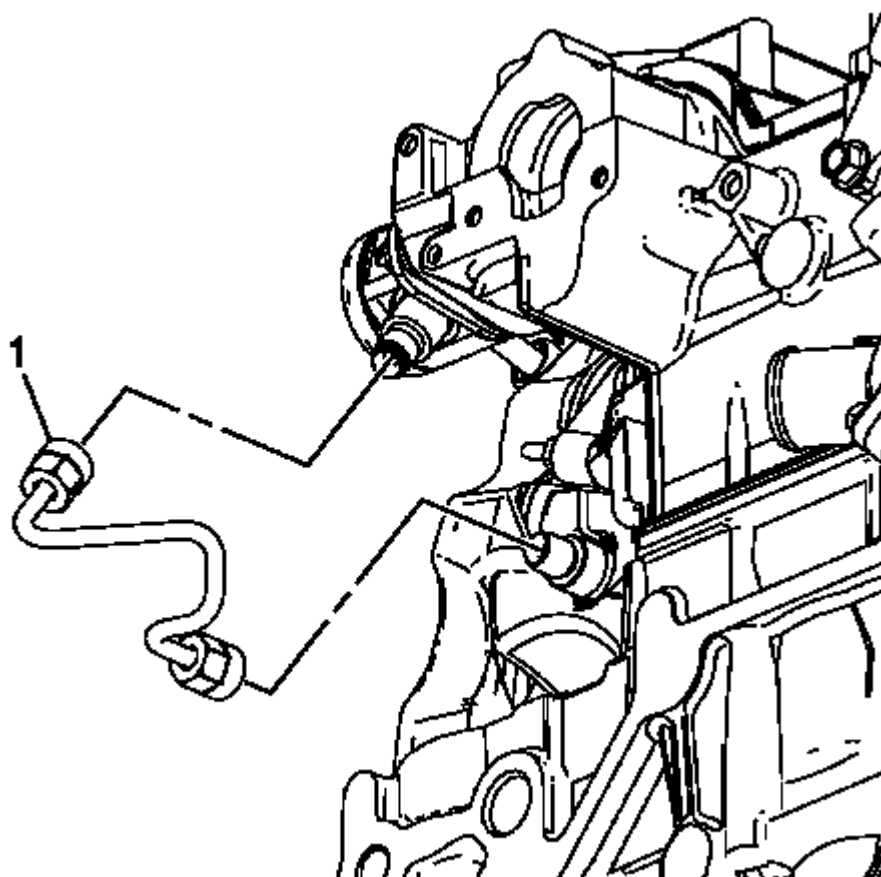
**Fig. 277: Fuel Pump Components**

Courtesy of GENERAL MOTORS COMPANY

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

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

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

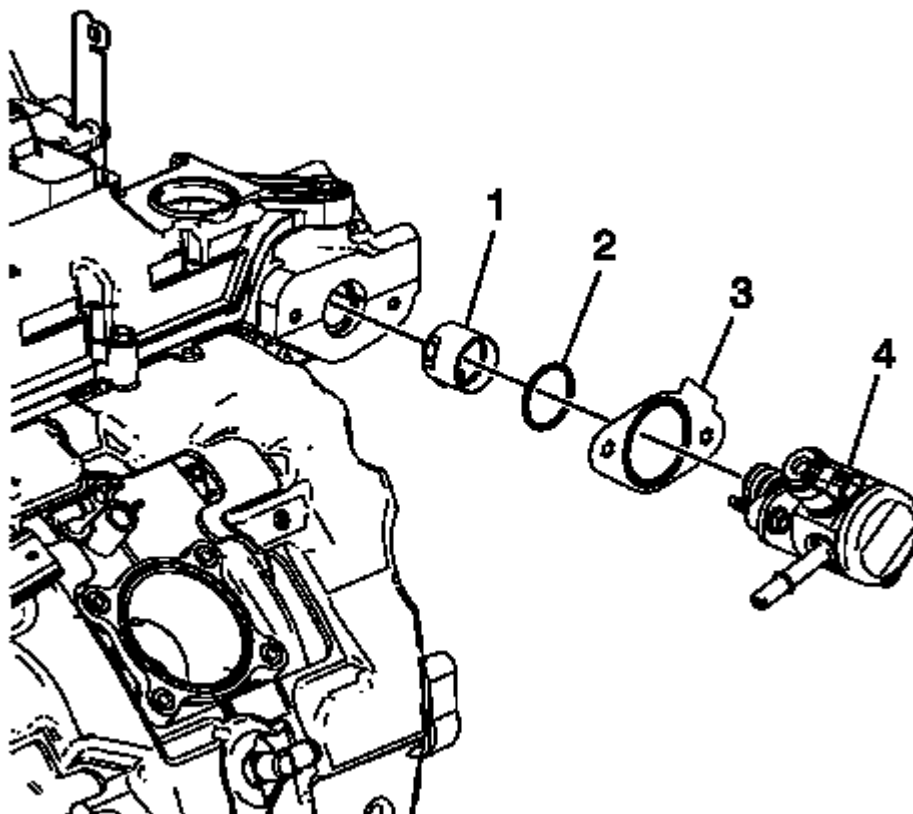


**Fig. 278: High Pressure Fuel Line**

Courtesy of GENERAL MOTORS COMPANY

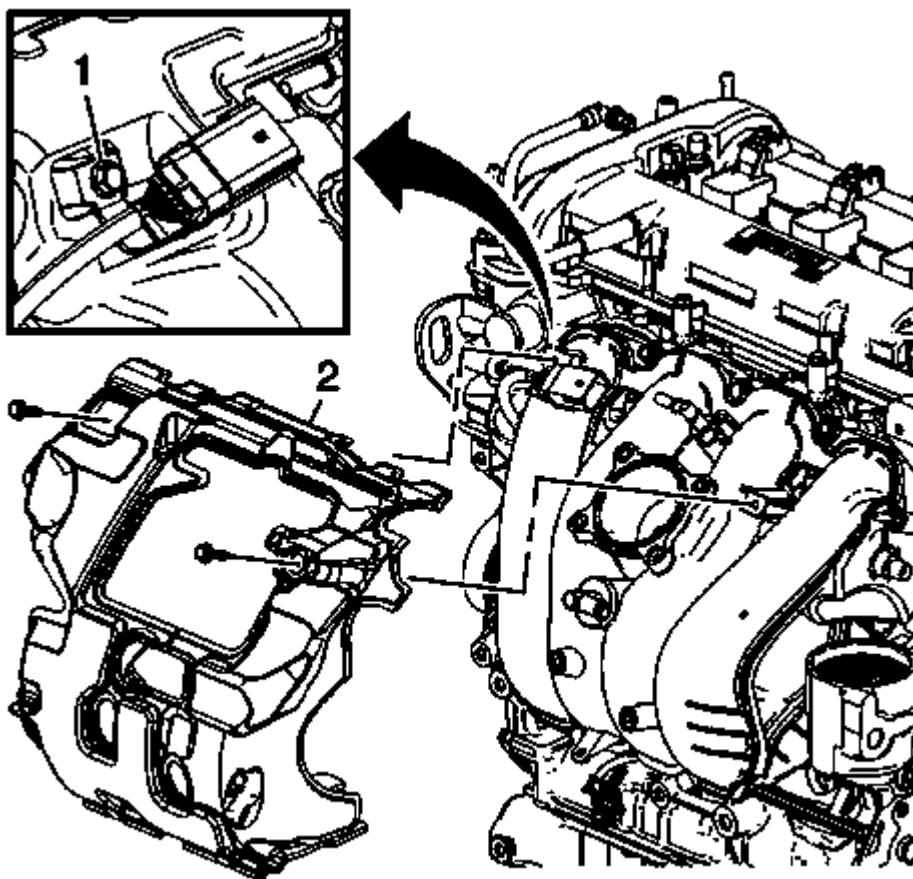
**WARNING:** Fuel that flows out at high pressure can cause serious injury to the skin and eyes. **ALWAYS** depressurize the fuel system before removing components that are under high fuel pressure.

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



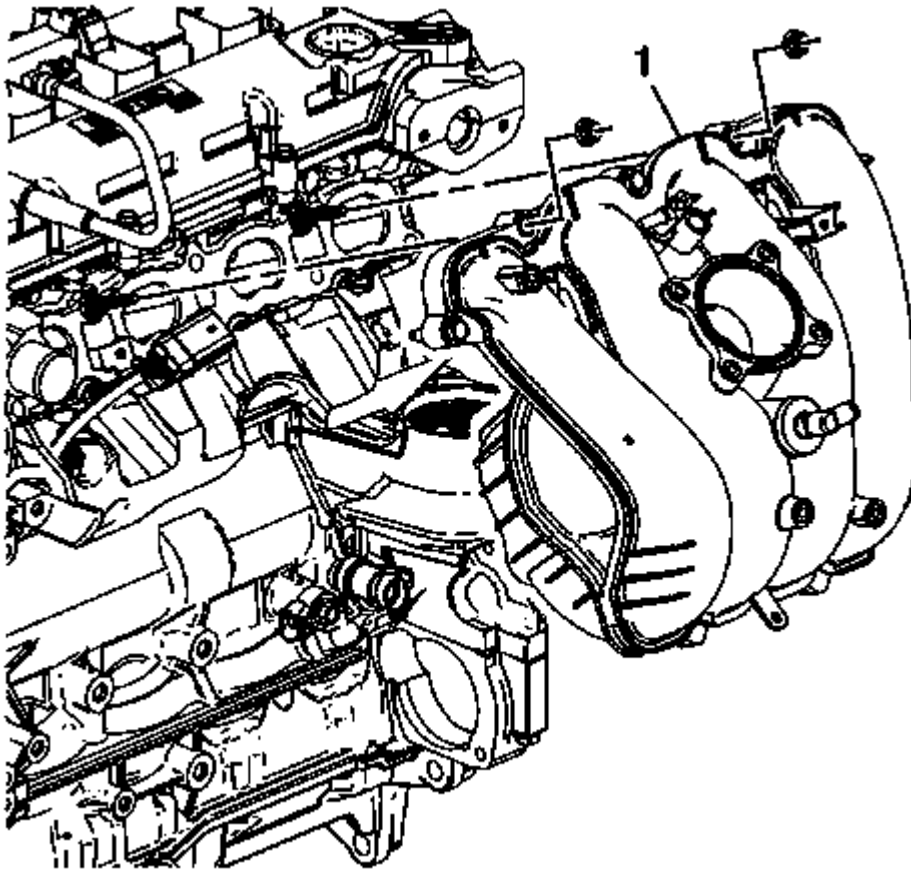
**Fig. 279: Fuel Pump Assembly Components**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 280: Fuel Rail Harness Connector Bracket And Intake Manifold Insulator**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 281: Intake Manifold Retaining Nuts And Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

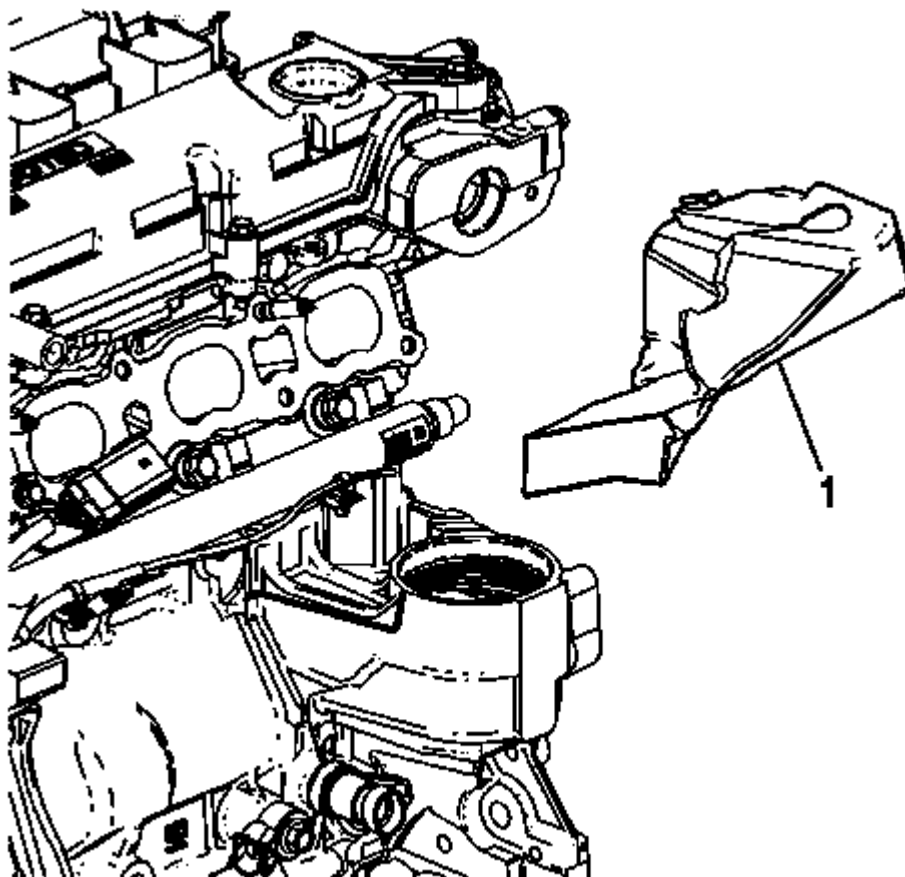
17. Remove the intake manifold retaining nuts and bolts.
18. Remove the intake manifold (1).
19. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

## FUEL RAIL AND INJECTORS REMOVAL

### Special Tools

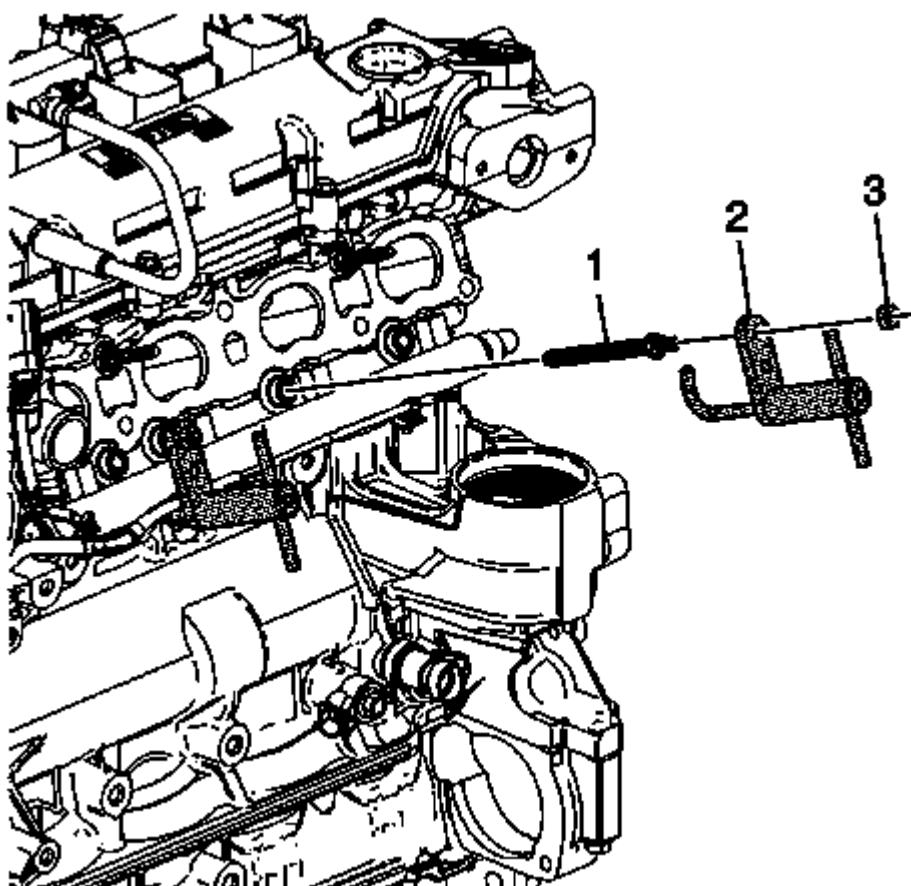
**EN-49248** Fuel Rail Assembly Remover

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



**Fig. 282: Fuel Injection Fuel Rail Noise Shield**  
**Courtesy of GENERAL MOTORS COMPANY**

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

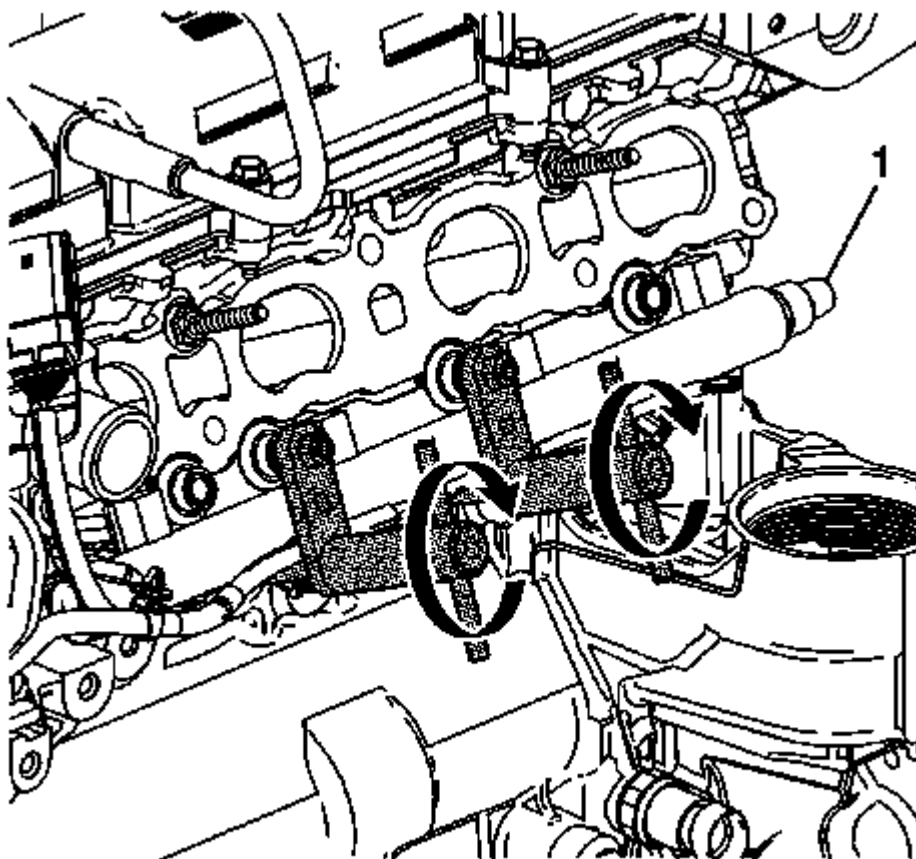


**Fig. 283: Electrical Harness And Fuel Rail Harness**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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



**Fig. 284: Fuel Rail Assembly Remover**

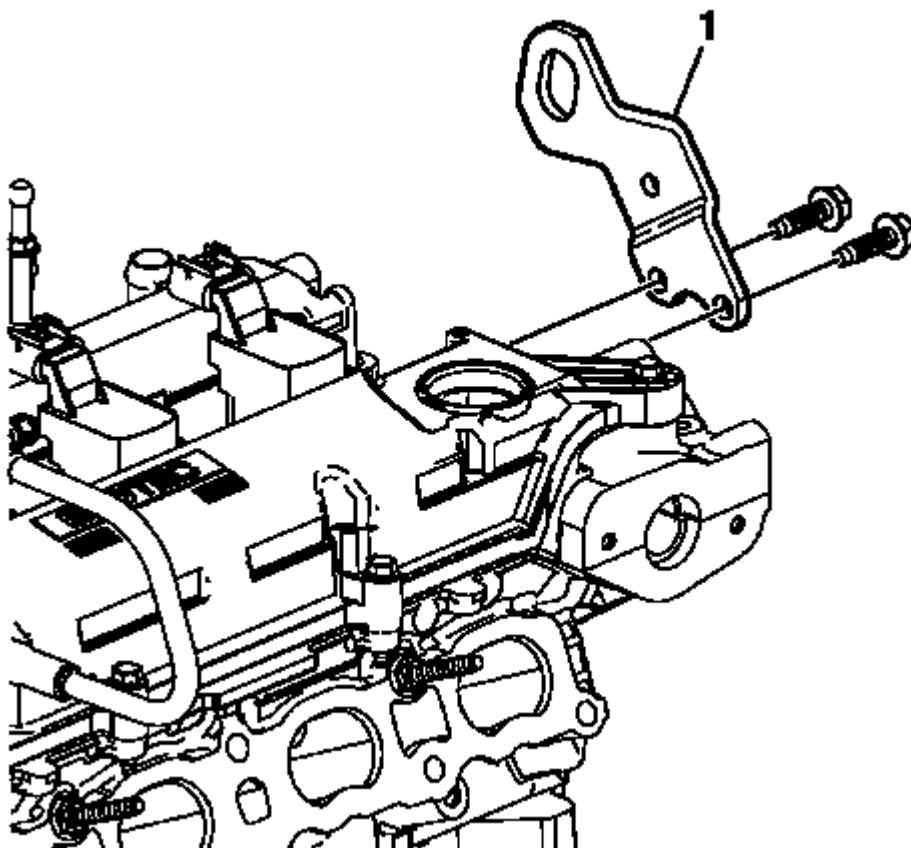
Courtesy of GENERAL MOTORS COMPANY

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

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

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

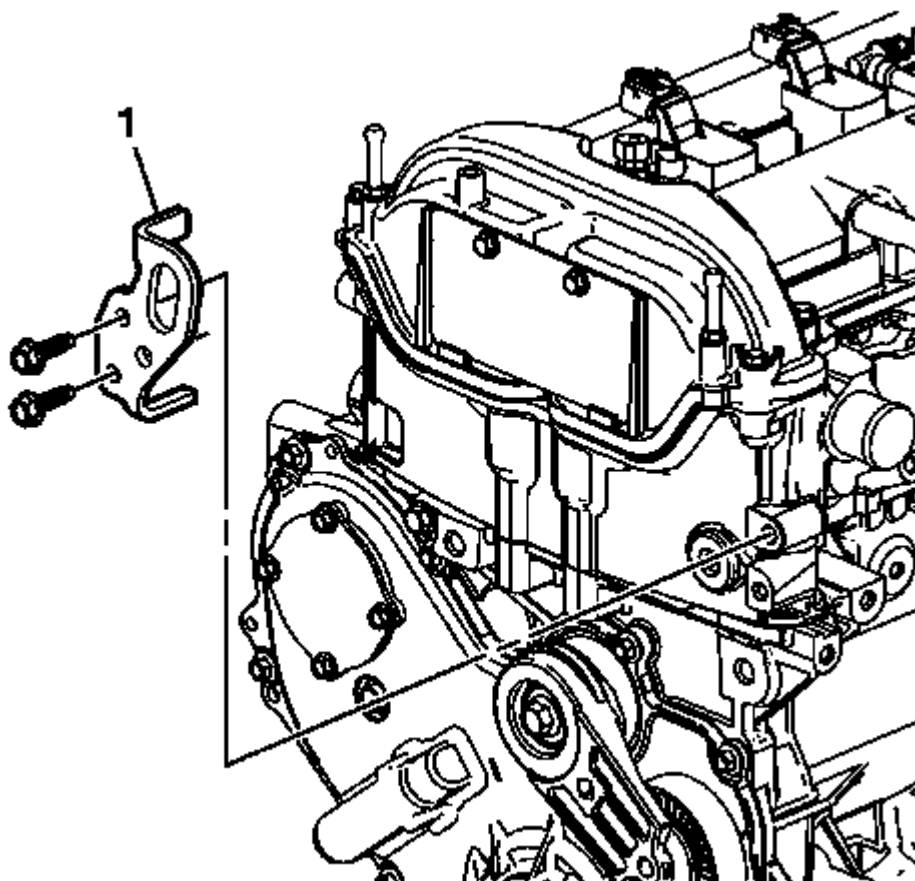
#### **CAMSHAFT COVER REMOVAL (LEA)**



**Fig. 285: Rear Lift Bracket**

Courtesy of GENERAL MOTORS COMPANY

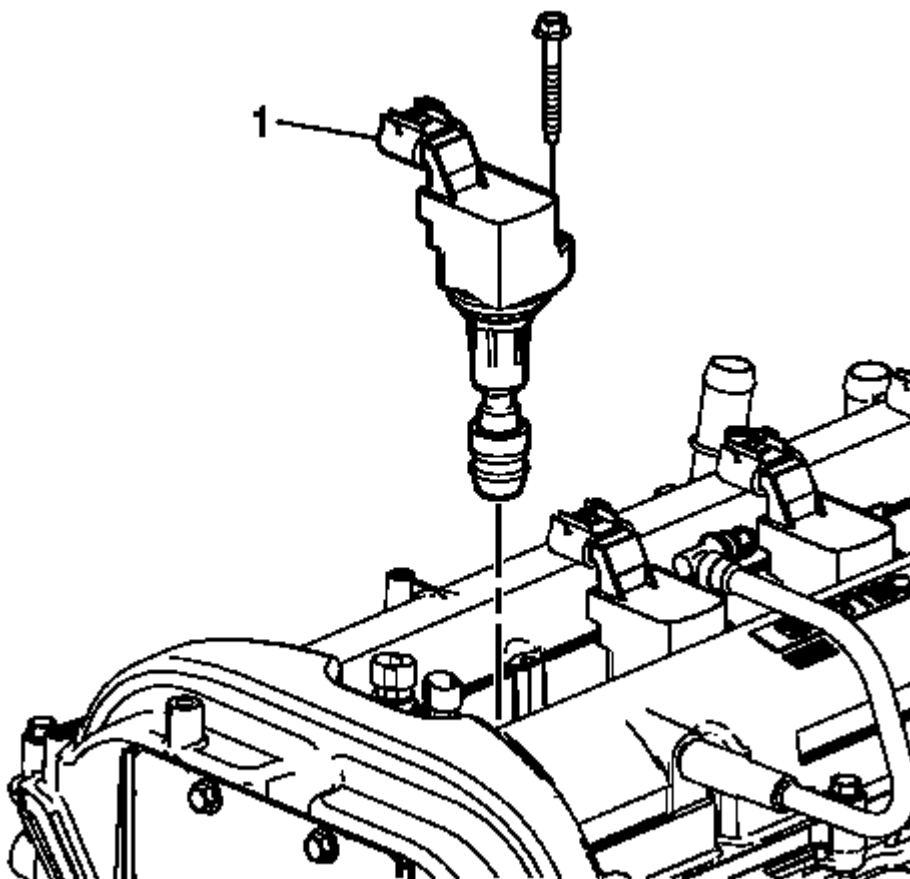
1. Remove the rear lift bracket (1).



**Fig. 286: Front Lift Bracket**

Courtesy of GENERAL MOTORS COMPANY

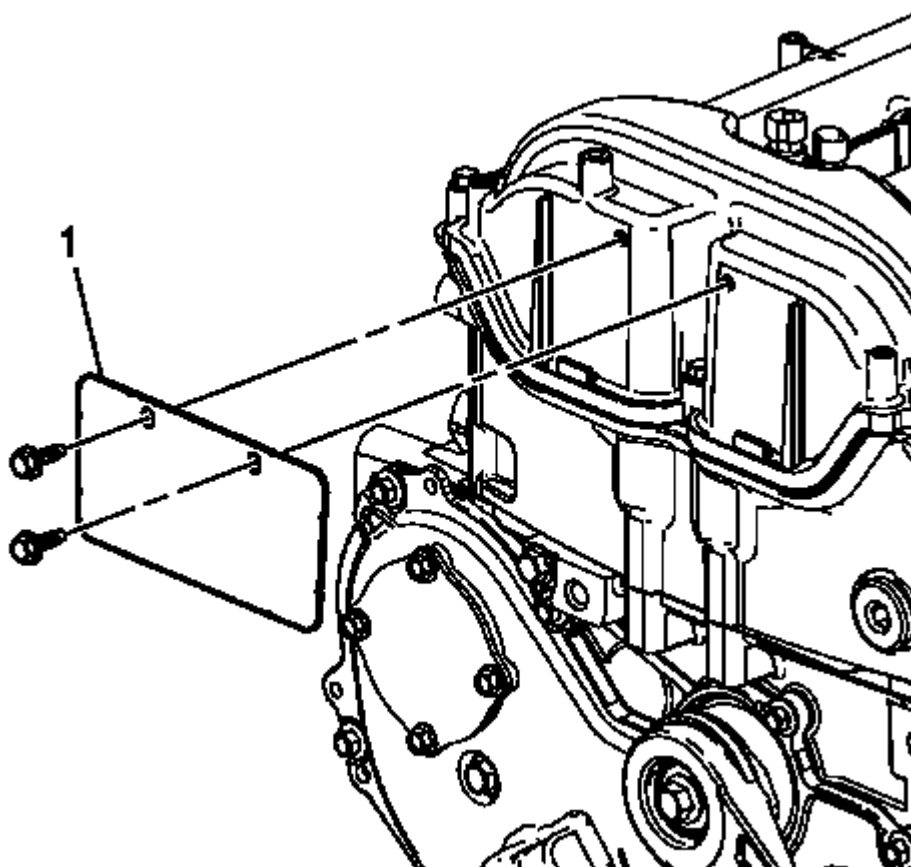
2. Remove the front lift bracket (1).



**Fig. 287: Ignition Coil**

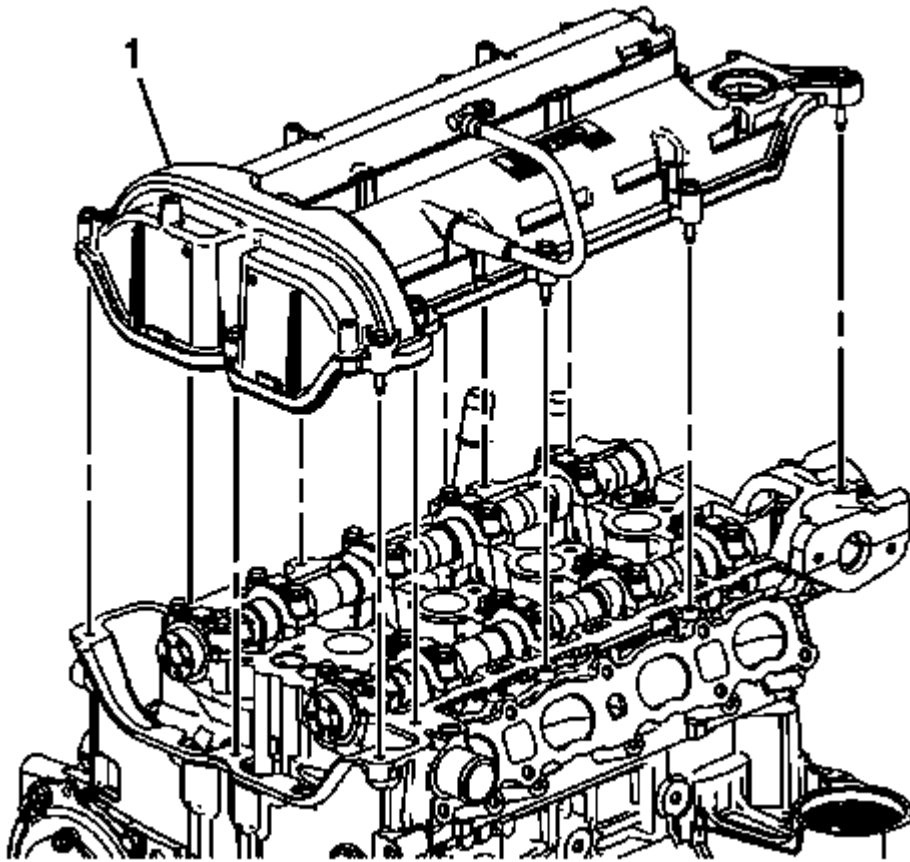
Courtesy of GENERAL MOTORS COMPANY

3. Remove the ignition coil (1).



**Fig. 288: Camshaft Housing Cover Insulator**  
Courtesy of GENERAL MOTORS COMPANY

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

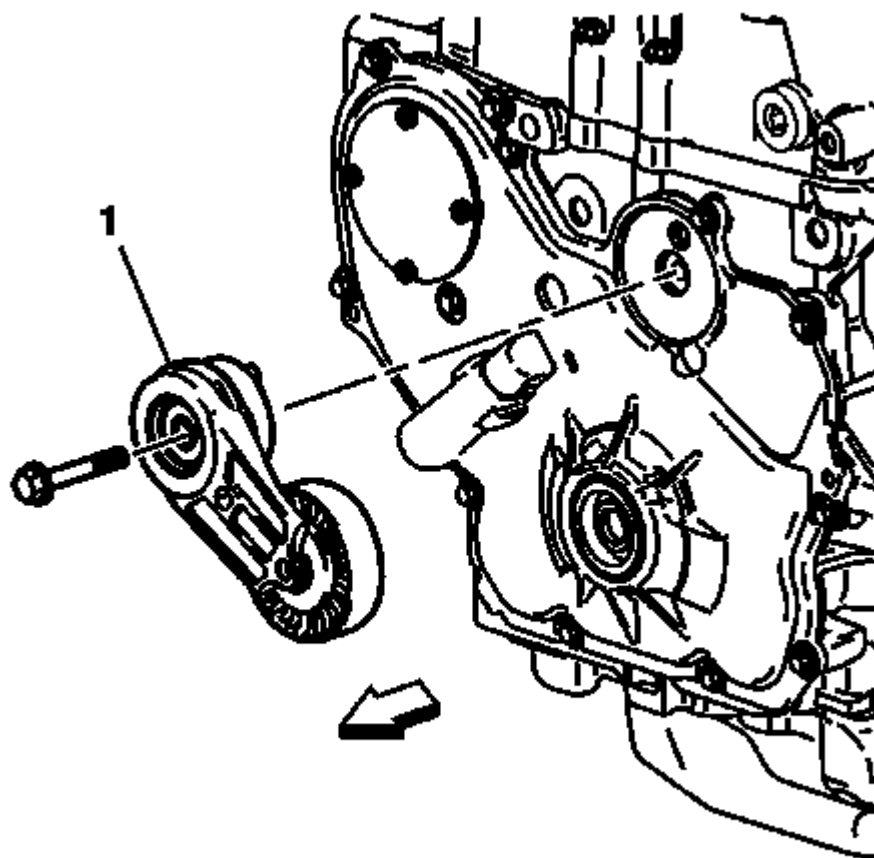


**Fig. 289: Camshaft Cover Assembly**  
Courtesy of GENERAL MOTORS COMPANY

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

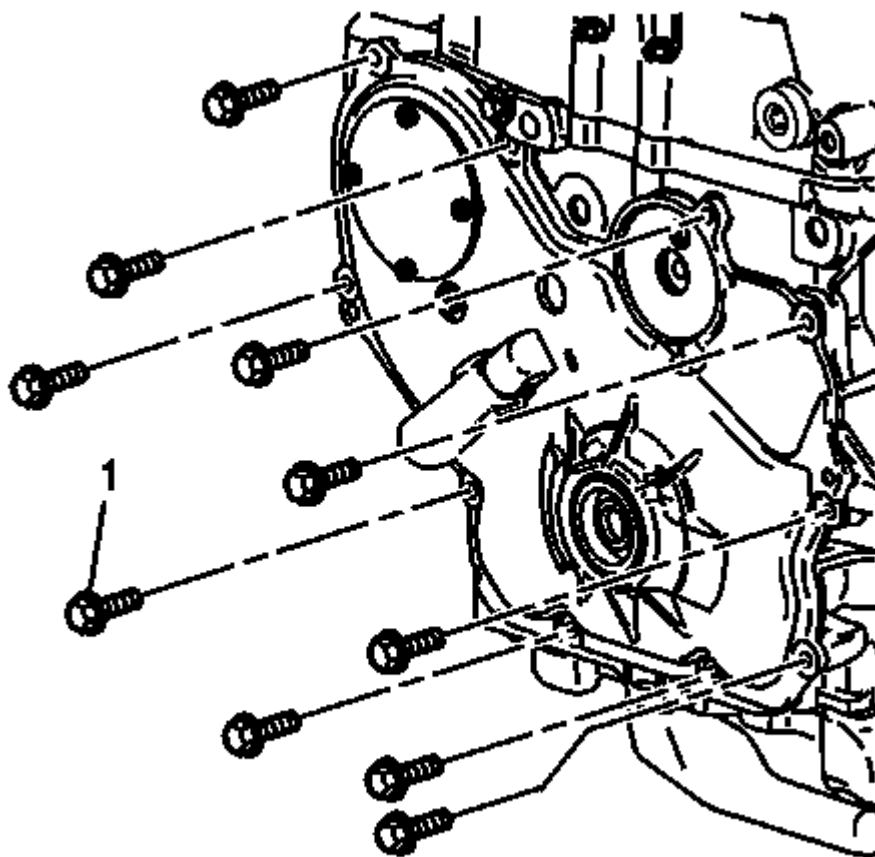
5. Remove the camshaft cover assembly (1).
6. Remove and discard the camshaft cover gasket, camshaft cover grommets, and camshaft cover bolts if they are serviced with the grommet.

## ENGINE FRONT COVER AND OIL PUMP REMOVAL



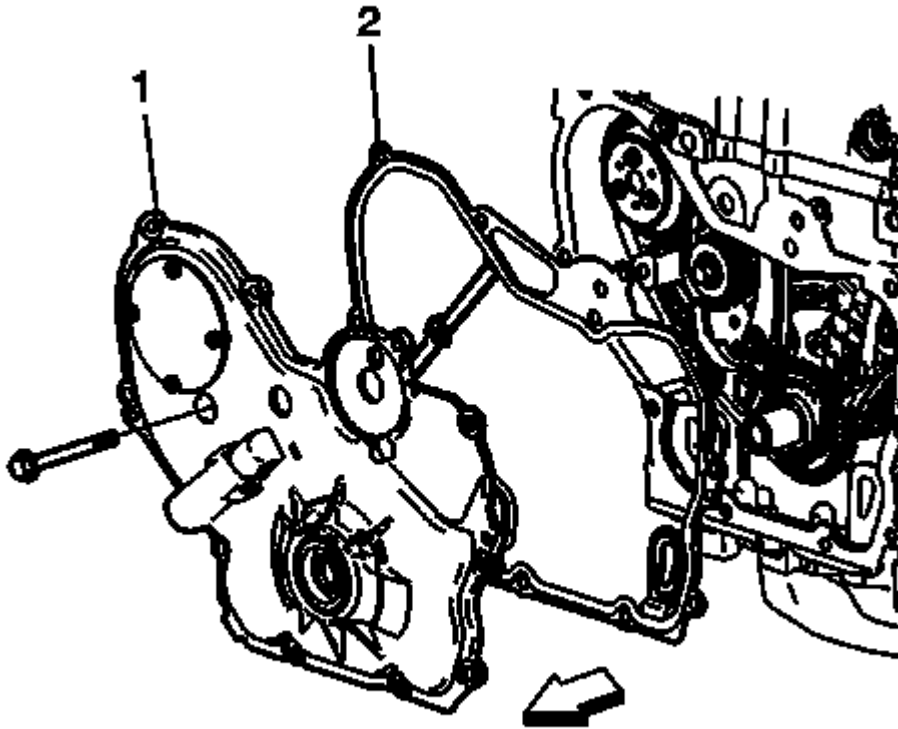
**Fig. 290: Accessory Drive Belt Tensioner And Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 291: Engine Front Cover Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 292: Long Water Pump Bolt And Engine Front Cover**  
Courtesy of GENERAL MOTORS COMPANY

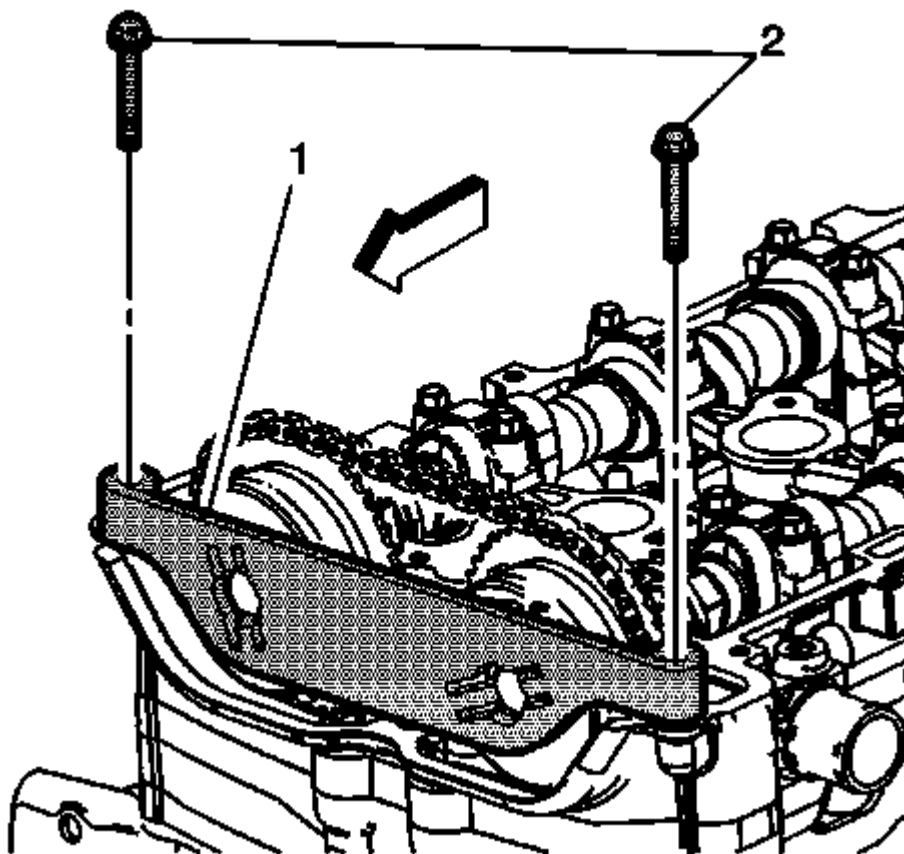
4. Remove the long water pump bolt.
5. Remove the engine front cover (1) and gaskets (2).
6. Remove the crankshaft front cover oil seal with an appropriate tool.

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

### **Special Tools**

**EN-48953** Camshaft Actuator Locking Tool

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

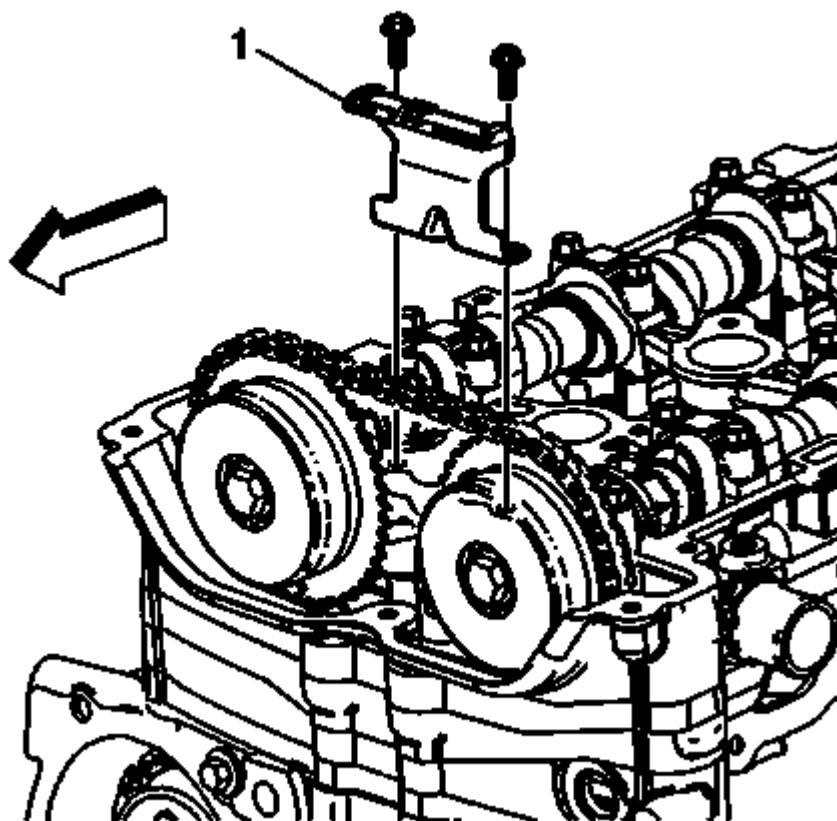


**Fig. 293: Camshaft Actuator Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

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

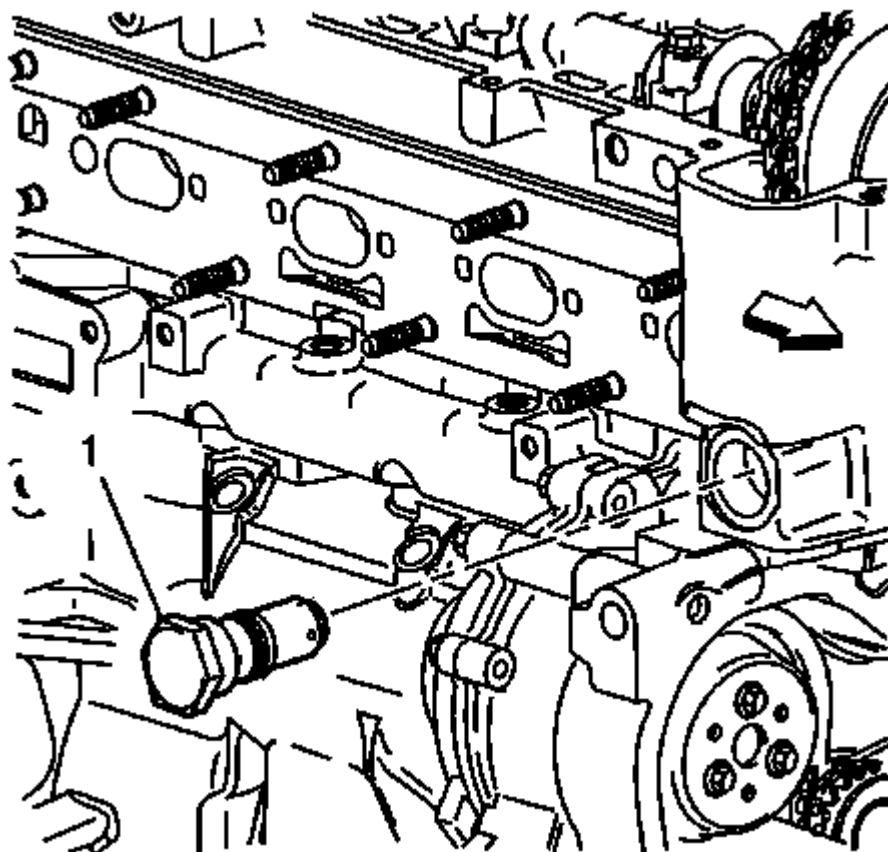
**NOTE:** Marking the chain and actuators is crucial to procedures operation. The camshaft actuator and timing chain must have oil removed from the surface prior to marking both actuators and chain.

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



**Fig. 294: Identifying Upper Timing Chain Guide & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

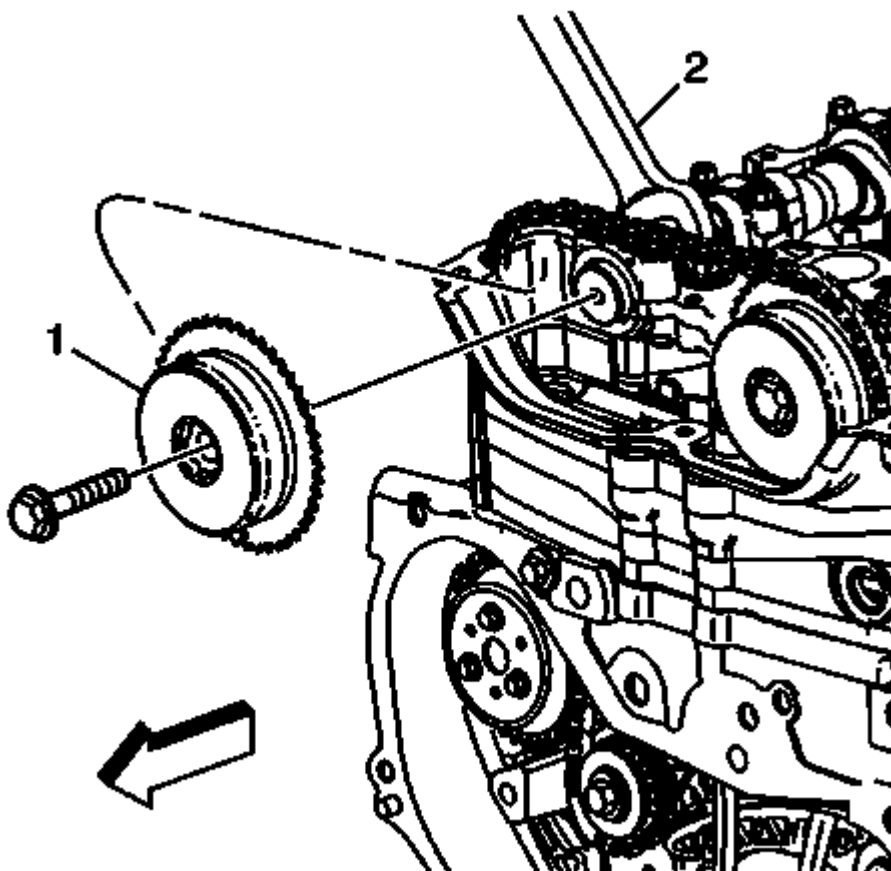
6. Remove the upper timing chain guide bolts.
7. Remove the upper timing chain guide (1).



**Fig. 295: Identifying Timing Chain Tensioner Plunger**  
Courtesy of GENERAL MOTORS COMPANY

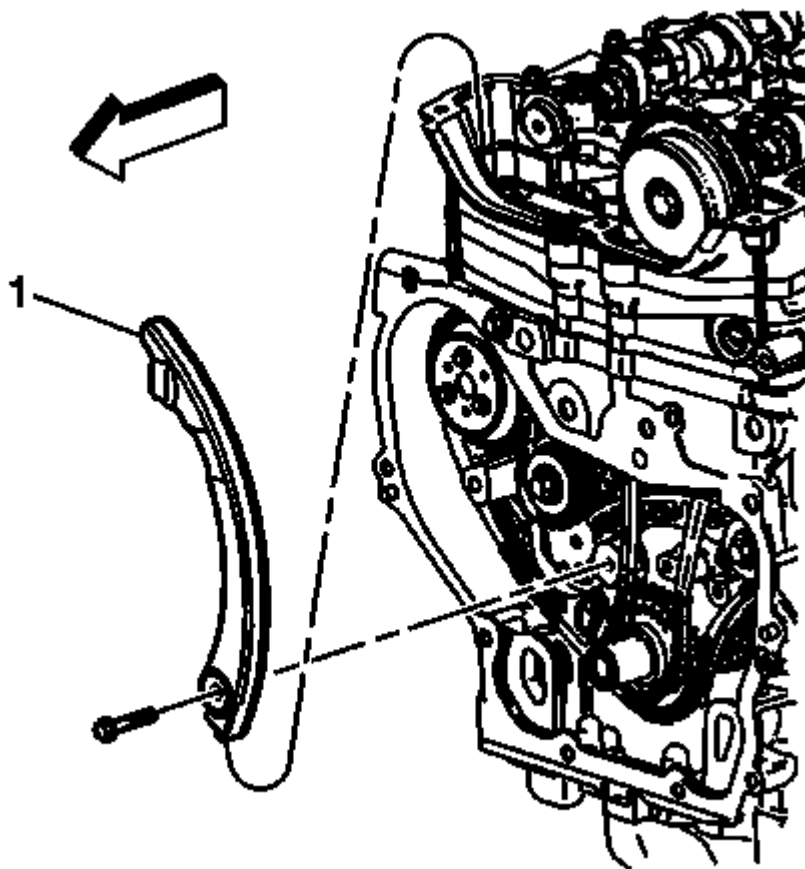
**NOTE:** The timing chain tensioner must be removed to unload chain tension before the timing chain is removed.

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



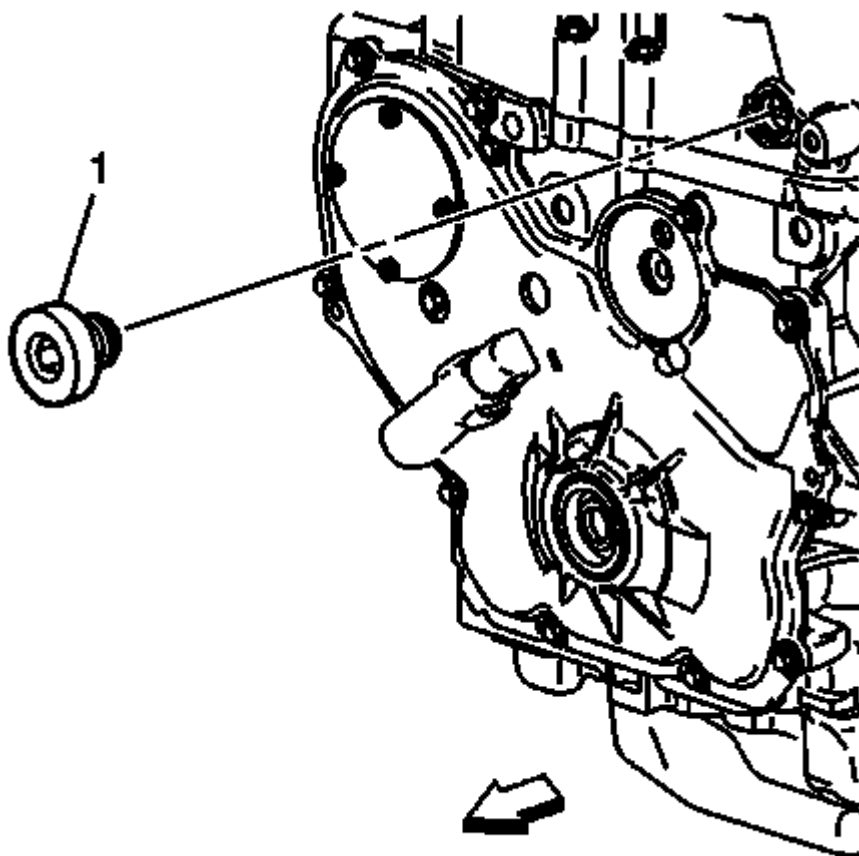
**Fig. 296: Identifying Exhaust Camshaft Actuator**  
Courtesy of GENERAL MOTORS COMPANY

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



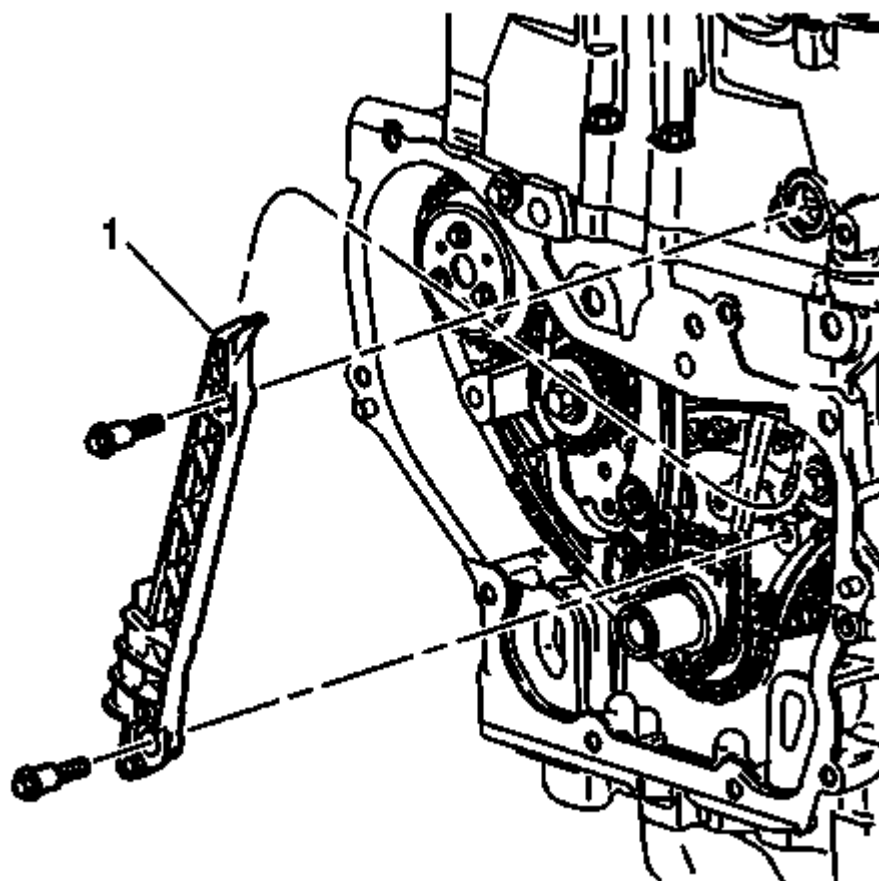
**Fig. 297: View of Adjustable Timing Chain Guide Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

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



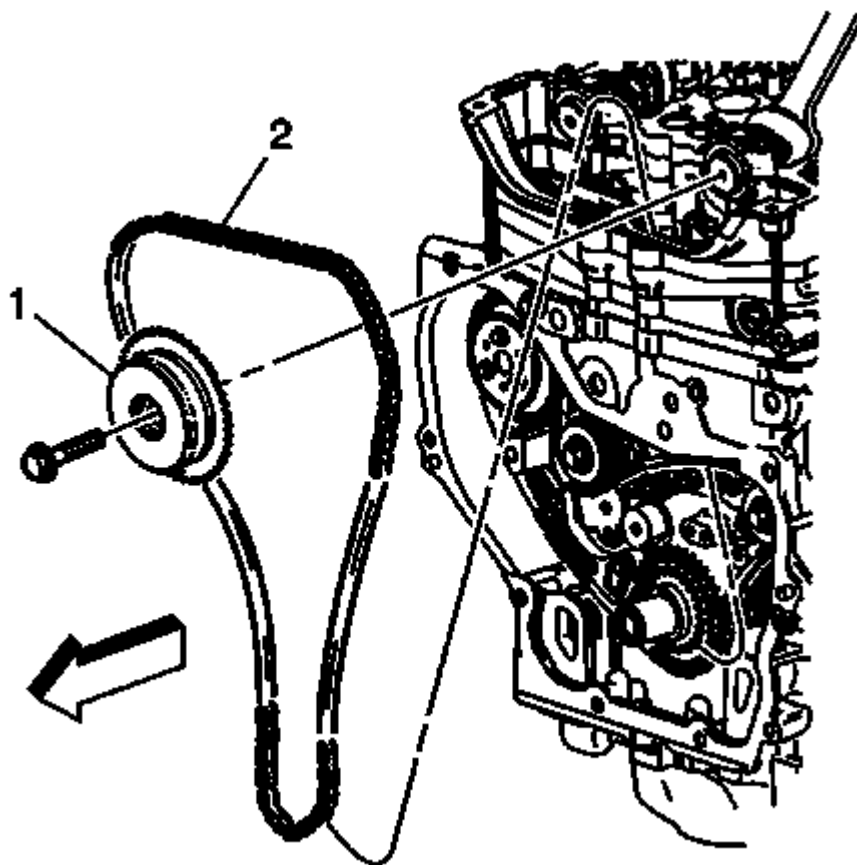
**Fig. 298: Identifying Fixed Timing Chain Guide Bolt Plug**  
Courtesy of GENERAL MOTORS COMPANY

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



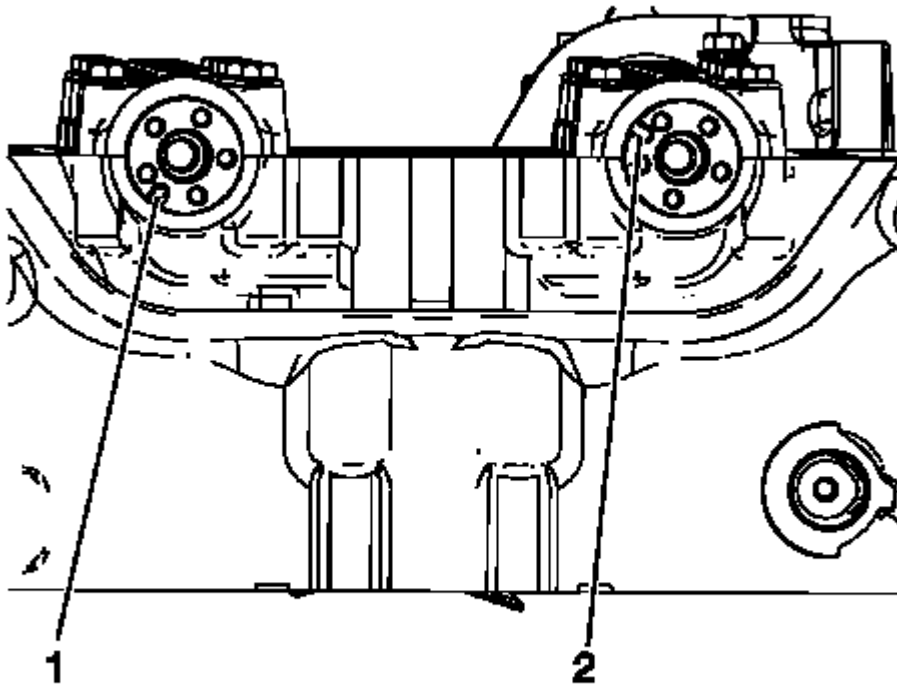
**Fig. 299: View of Fixed Timing Chain Guide**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 300: Identifying Intake Camshaft Actuator & Timing Chain**  
Courtesy of GENERAL MOTORS COMPANY

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



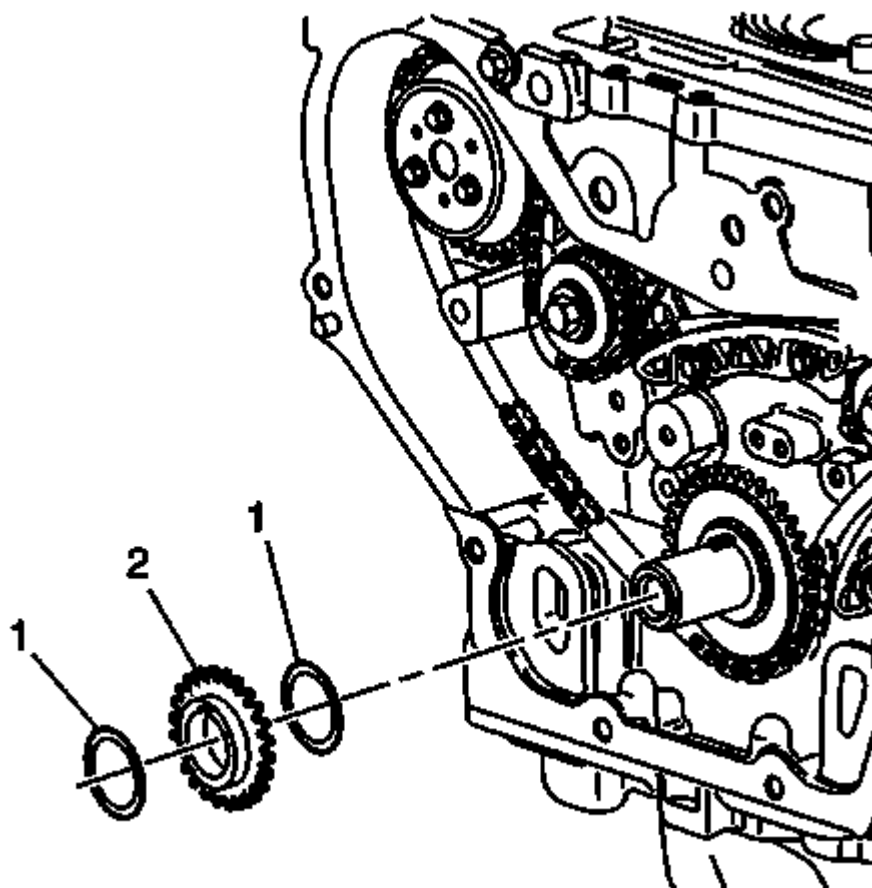
**Fig. 301: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

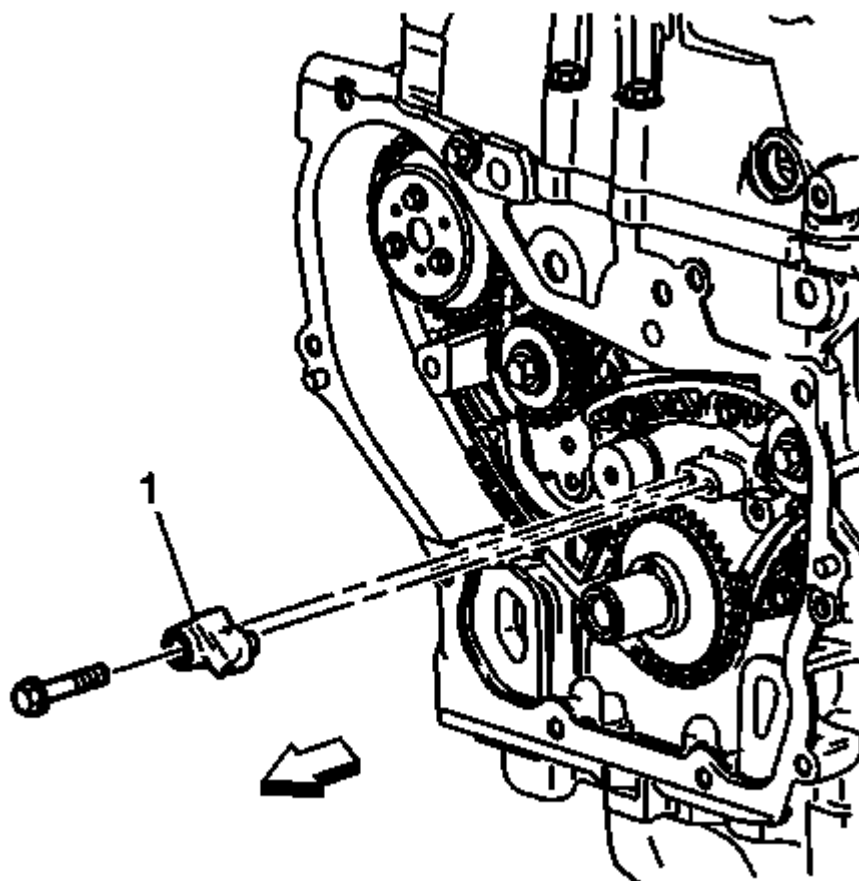
- The number 3 exhaust valves are open.
- Note the position and direction of the camshafts before removal. Mark the cylinder head in relation to the locking notches before component removal.

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



**Fig. 302: View Of Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

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

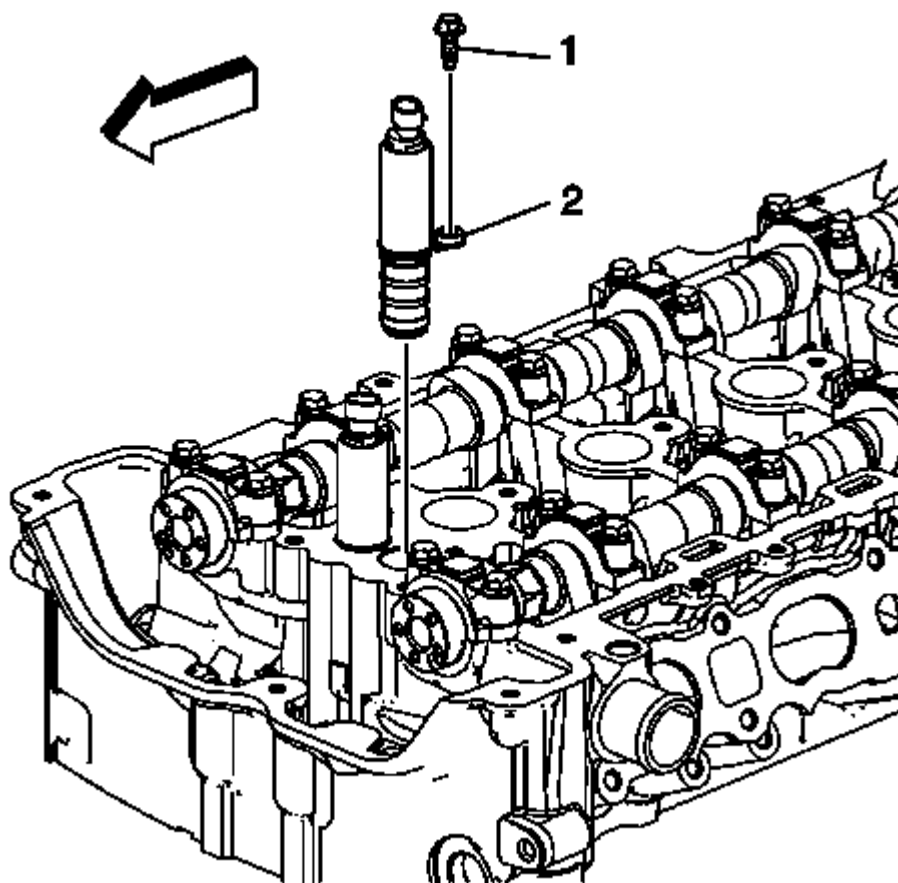


**Fig. 303: View of Timing Chain Oil Nozzle**  
Courtesy of GENERAL MOTORS COMPANY

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

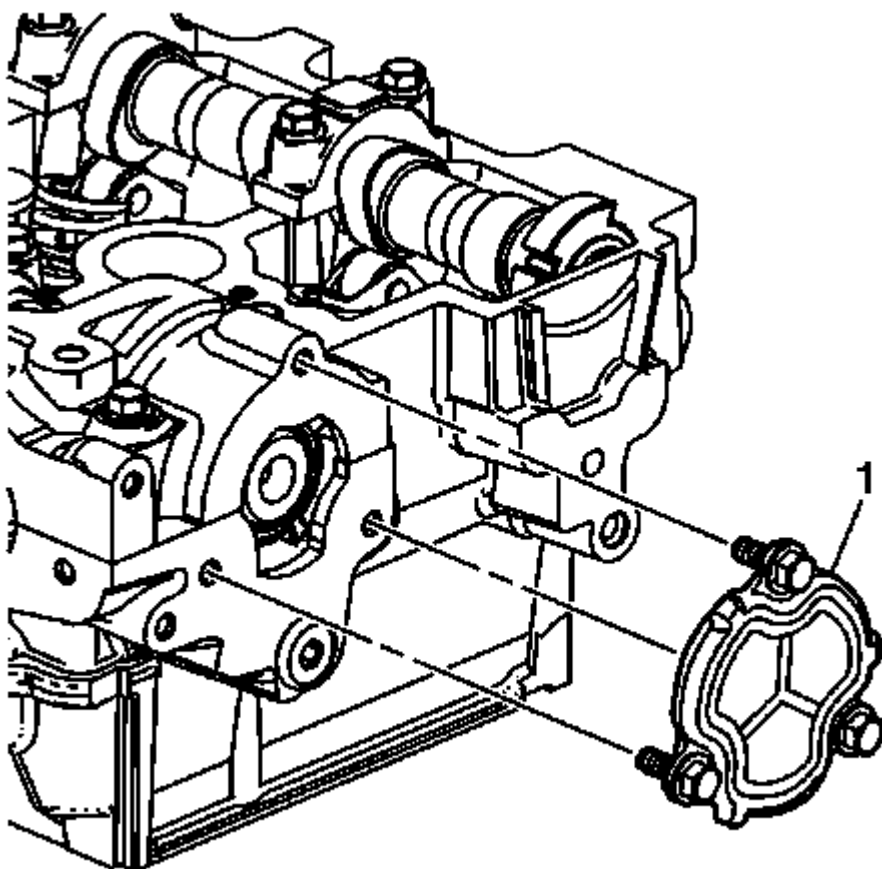
## INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL (LEA)

### Intake Camshaft and Components Removal



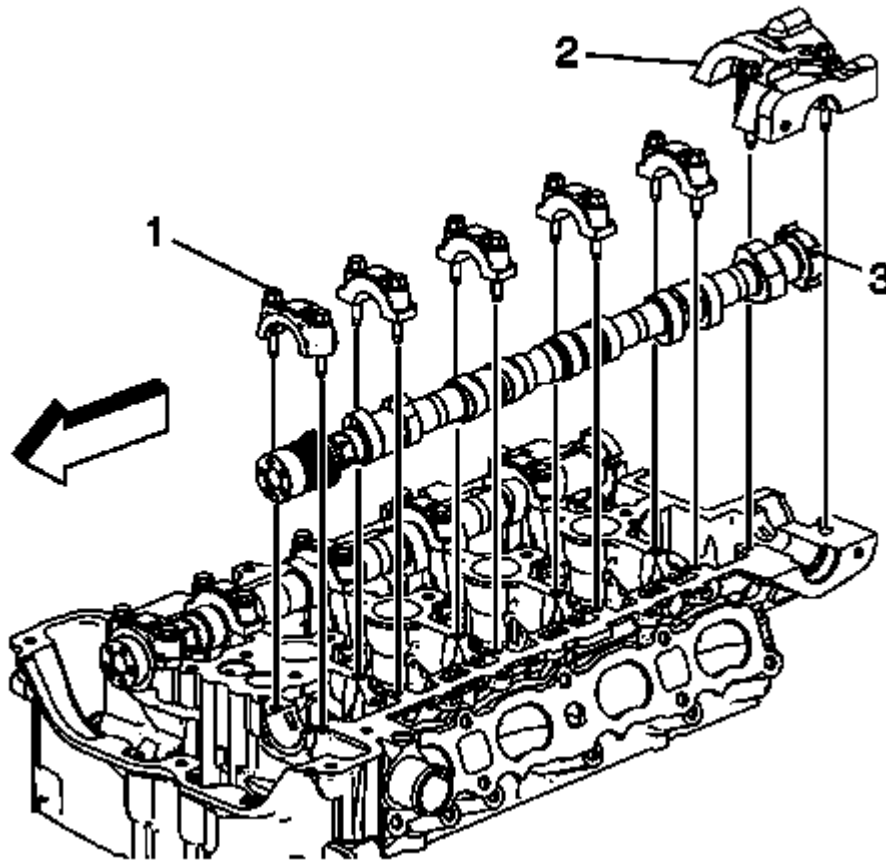
**Fig. 304: Intake Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 305: Rear Cylinder Head Cover Plate**  
Courtesy of GENERAL MOTORS COMPANY

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

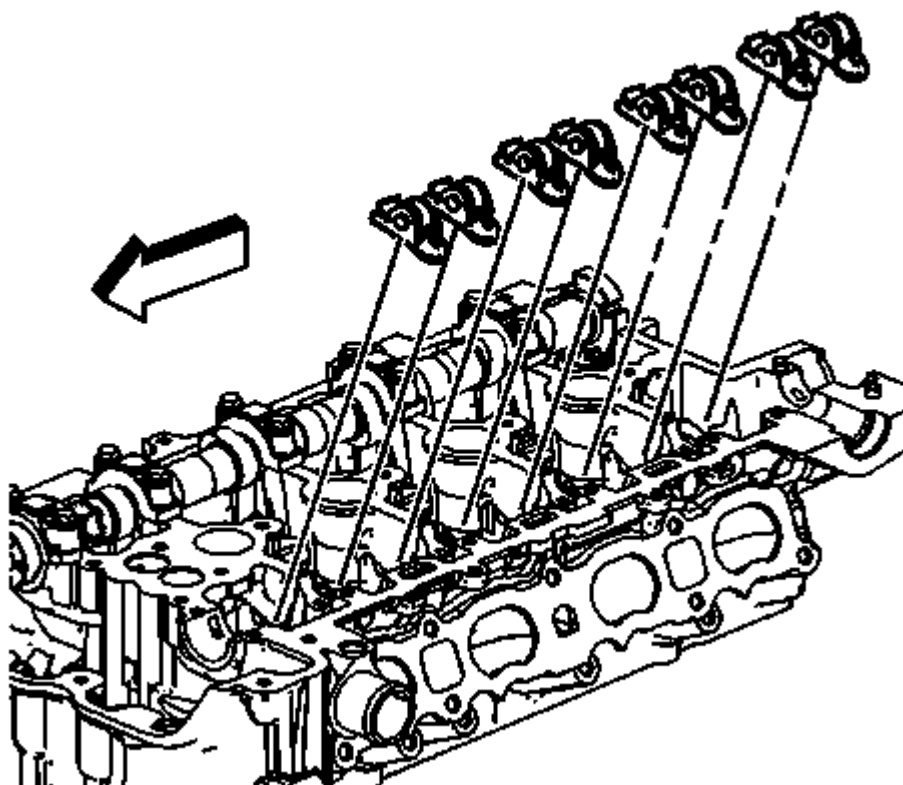


**Fig. 306: Intake Camshaft Bearing Rear Cap & Bolts**  
 Courtesy of GENERAL MOTORS COMPANY

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

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

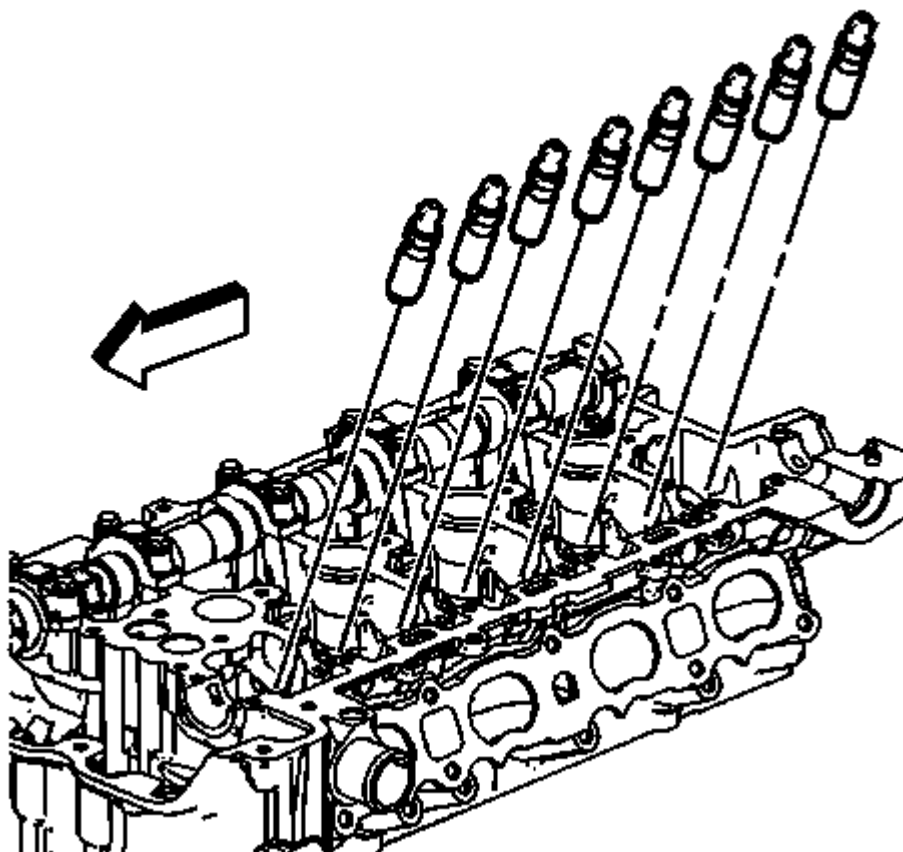
4. Mark camshaft caps to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts.
6. Remove the camshaft caps (1).
7. Remove the intake camshaft (3).



**Fig. 307: Intake Camshaft Roller Finger Followers**  
Courtesy of GENERAL MOTORS COMPANY

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

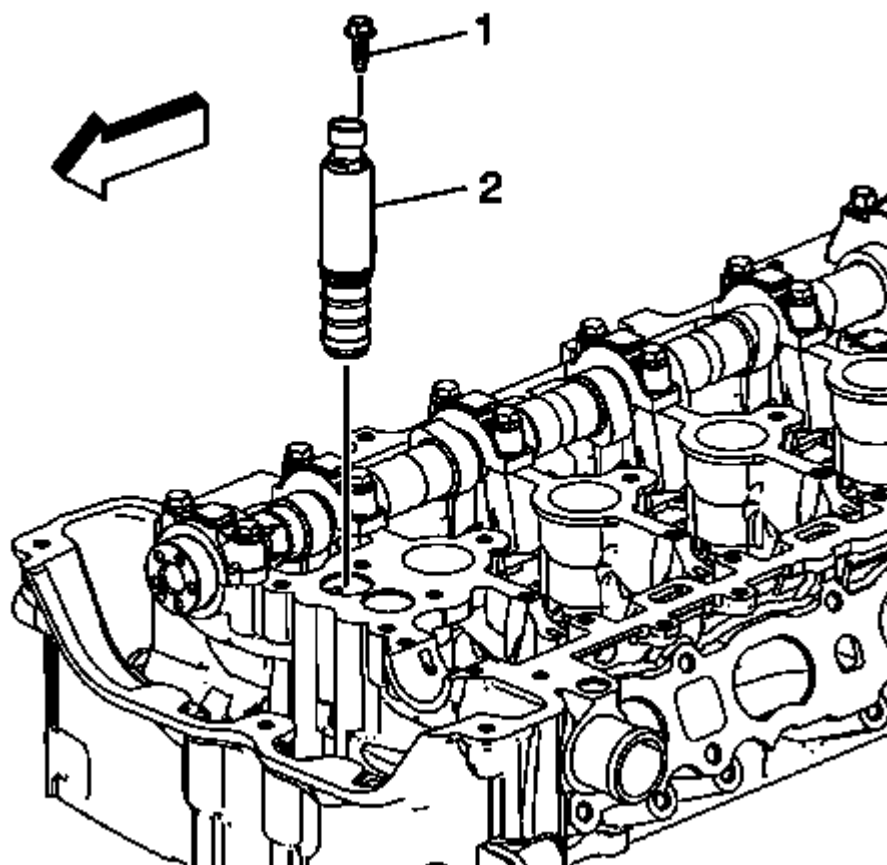
8. Remove the intake camshaft roller finger followers.



**Fig. 308: Hydraulic Lash Adjusters**  
Courtesy of GENERAL MOTORS COMPANY

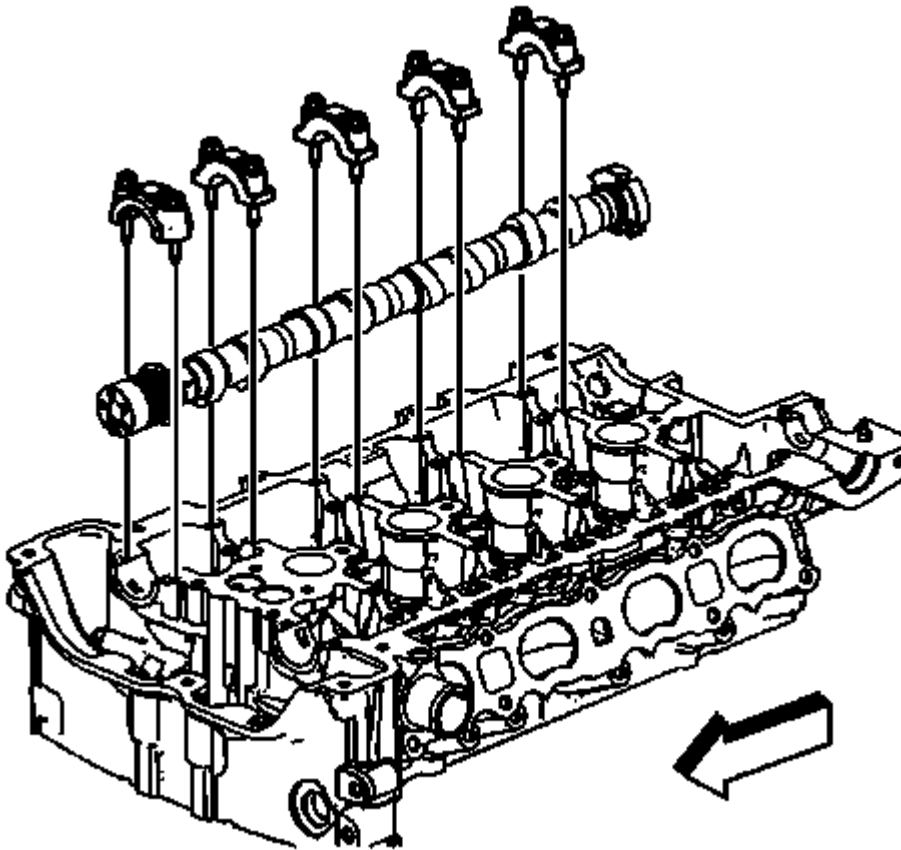
9. Remove the hydraulic lash adjusters.

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



**Fig. 309: Exhaust Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

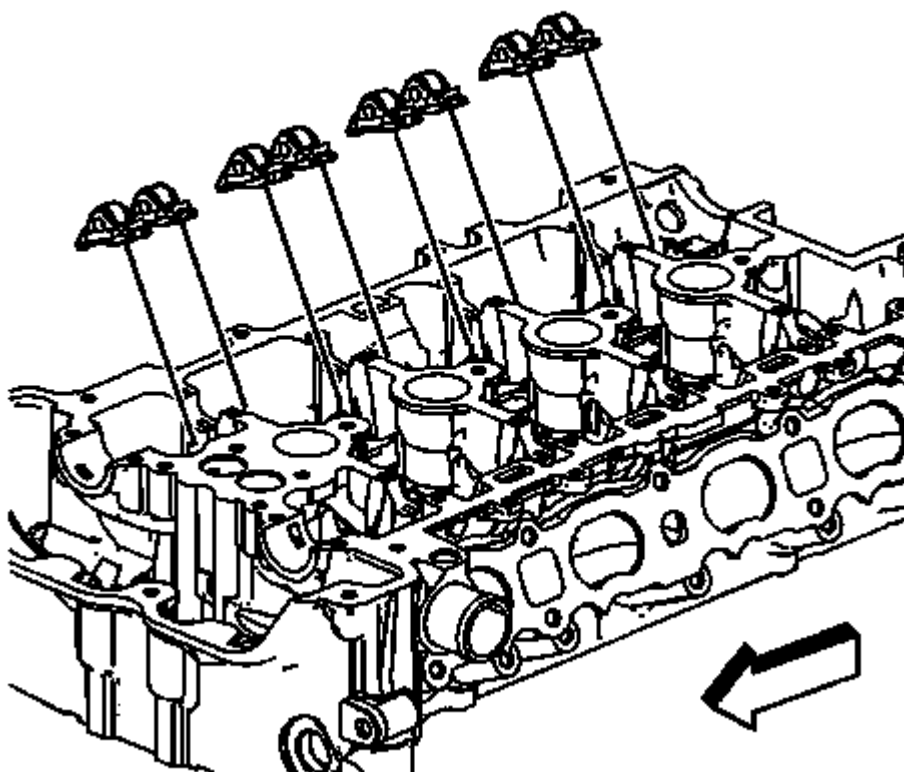
1. Remove the exhaust camshaft position actuator solenoid valve bolt (1) and valve (2).



**Fig. 310: Exhaust Camshaft & Caps**  
 Courtesy of GENERAL MOTORS COMPANY

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

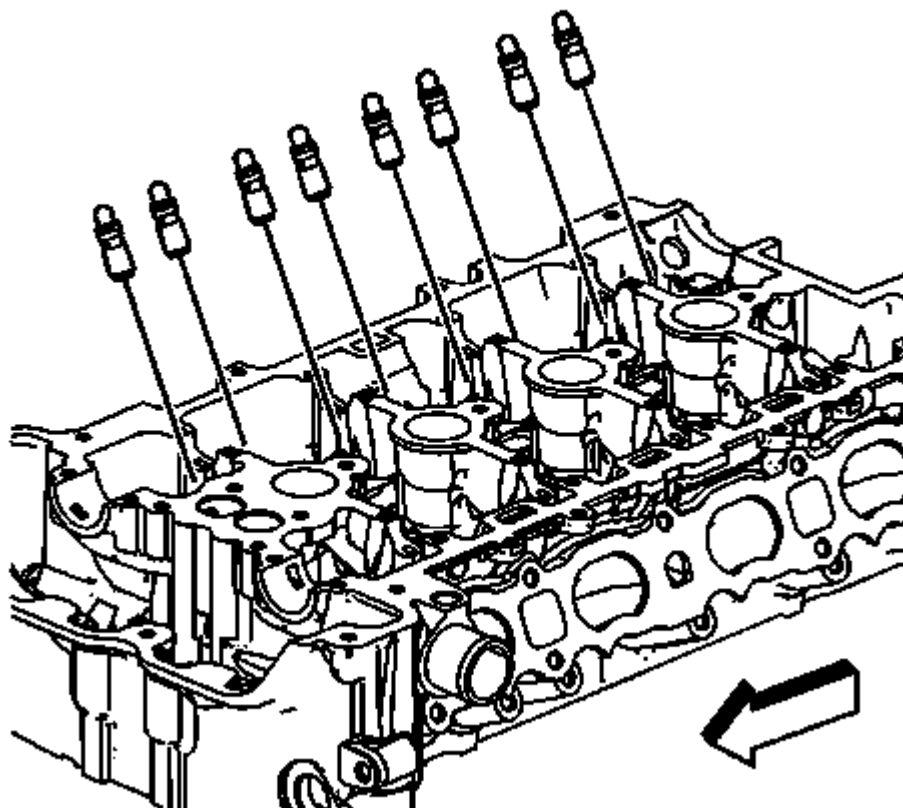
2. Mark camshaft caps to ensure they are installed in the same position.
3. Remove the exhaust camshaft cap bolts.
4. Remove the camshaft caps ensuring they are marked and refitted in same position on assembly.
5. Remove the exhaust camshaft.



**Fig. 311: Exhaust Camshaft Roller Finger Followers**  
Courtesy of GENERAL MOTORS COMPANY

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

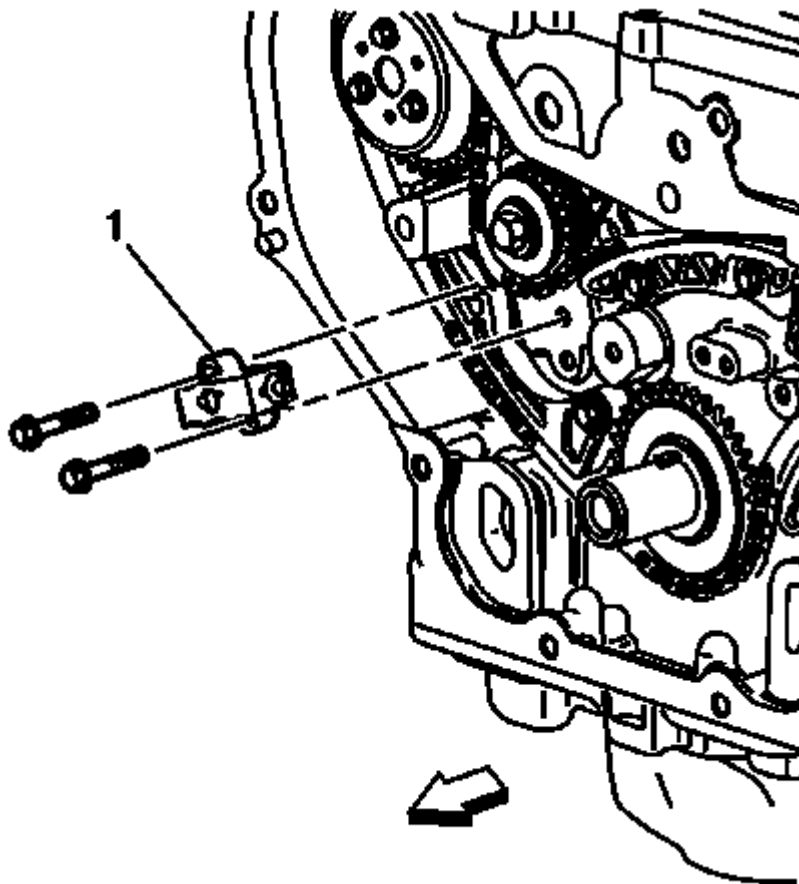
6. Remove the exhaust camshaft roller finger followers.



**Fig. 312: Hydraulic Lash Adjusters**  
Courtesy of GENERAL MOTORS COMPANY

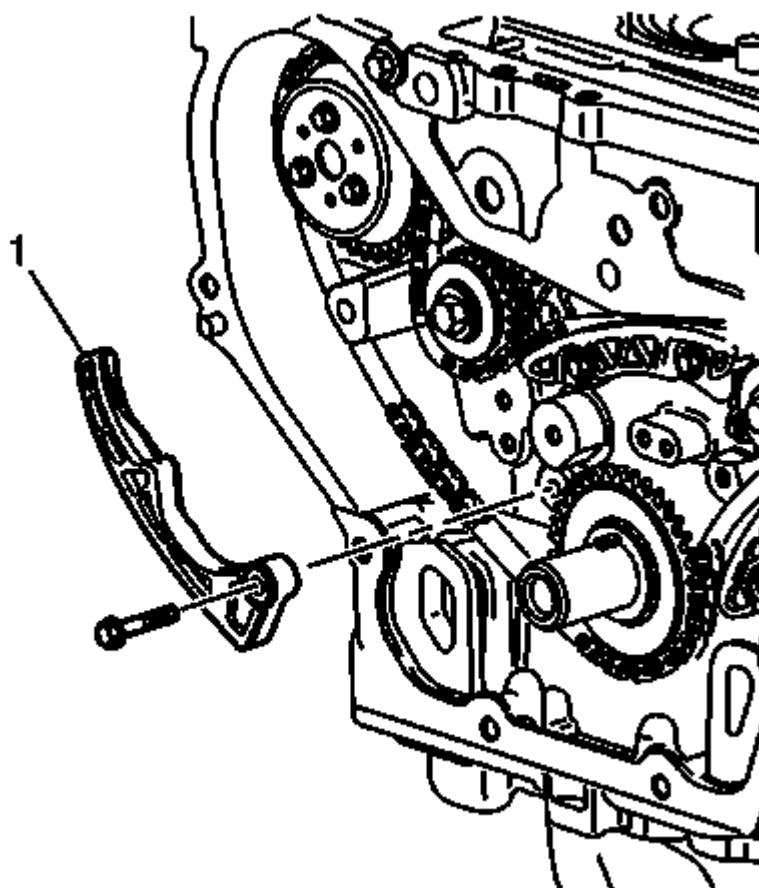
7. Remove the hydraulic lash adjusters.

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



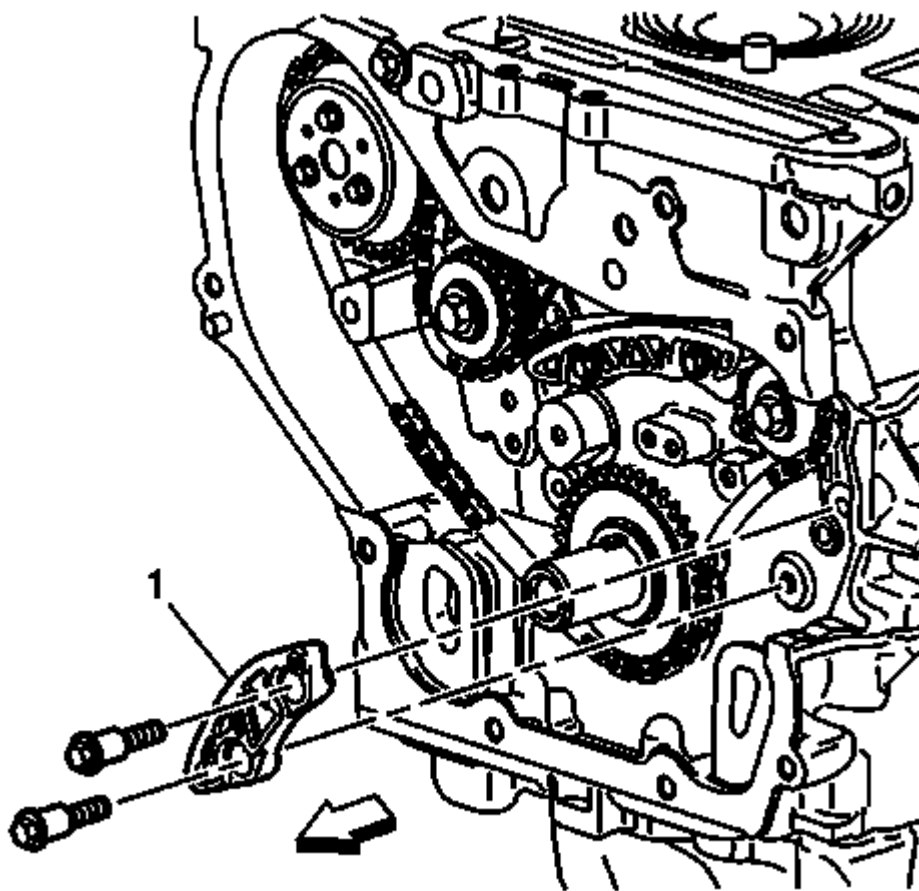
**Fig. 313: Balance Shaft Drive Chain Tensioner & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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



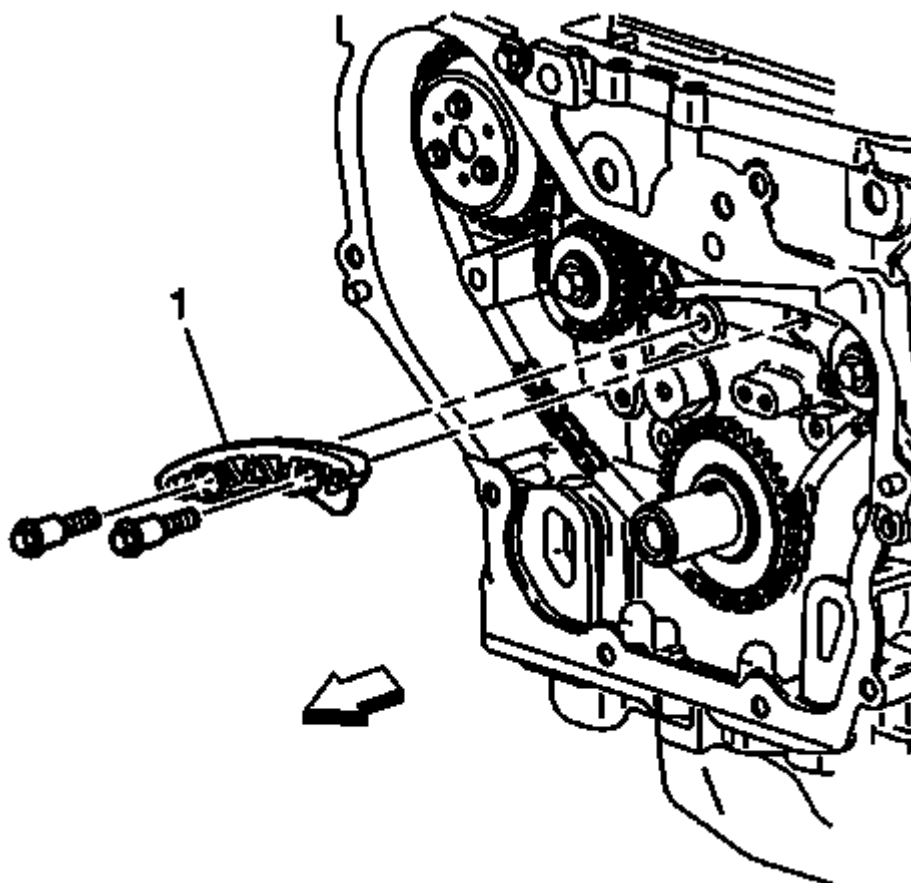
**Fig. 314: Adjustable Balance Shaft Drive Chain Guide**  
**Courtesy of GENERAL MOTORS COMPANY**

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



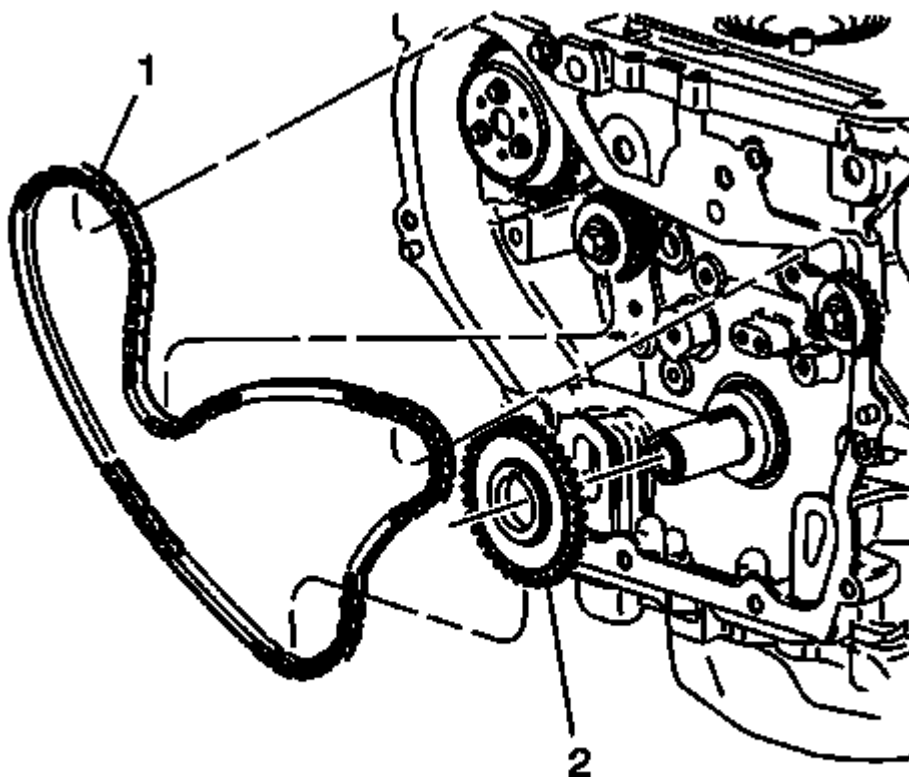
**Fig. 315: Small Balance Shaft Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 316: Upper Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 317: Balance Shaft Drive Chain & Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

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

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

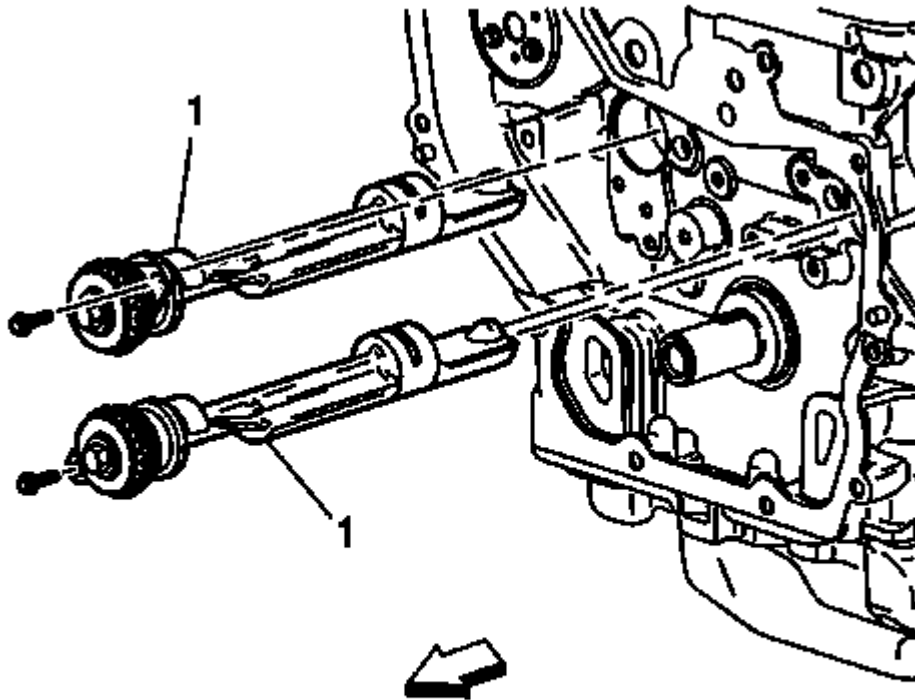
## BALANCE SHAFT REMOVAL

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

### Special Tools

EN-43650 Balancer Shaft Bearing Remover and Installer

For equivalent regional tools, refer to Special Tools.



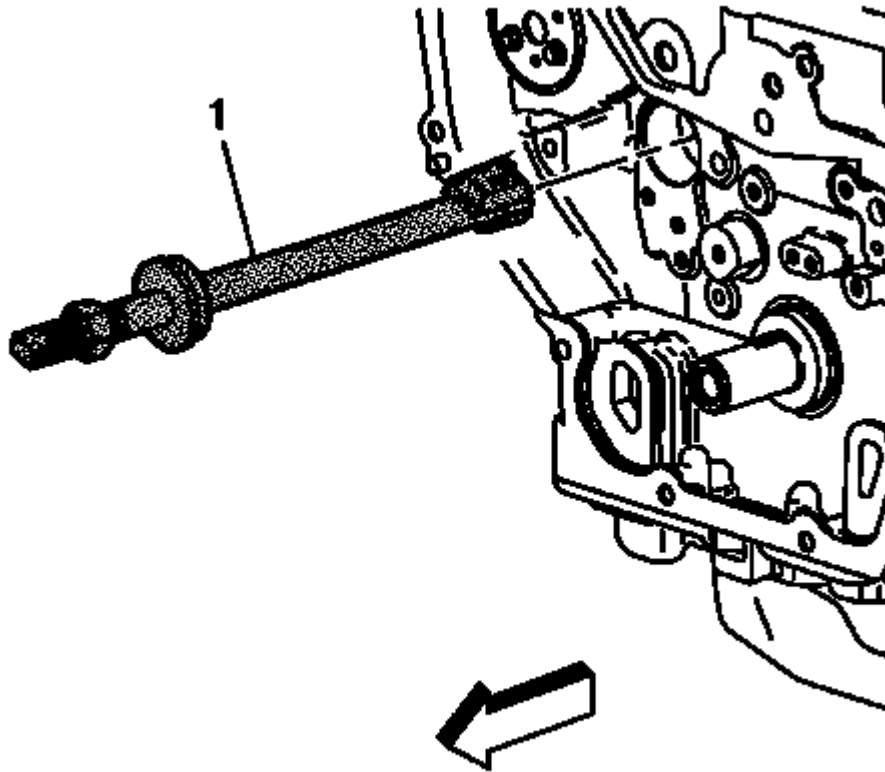
**Fig. 318: View of Balance Shaft Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balance shaft bearing carrier bolts.

**NOTE:**

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

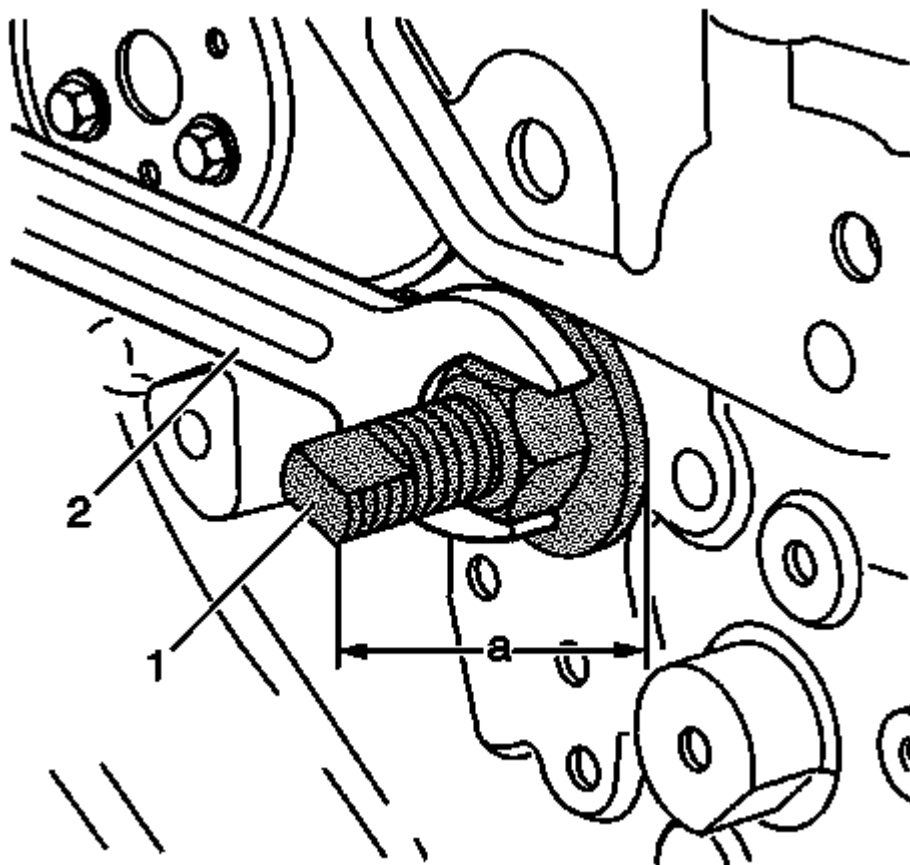
2. Remove the balance shaft assemblies (1).



**Fig. 319: Balance Shaft Bushing Remover**  
Courtesy of GENERAL MOTORS COMPANY

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

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

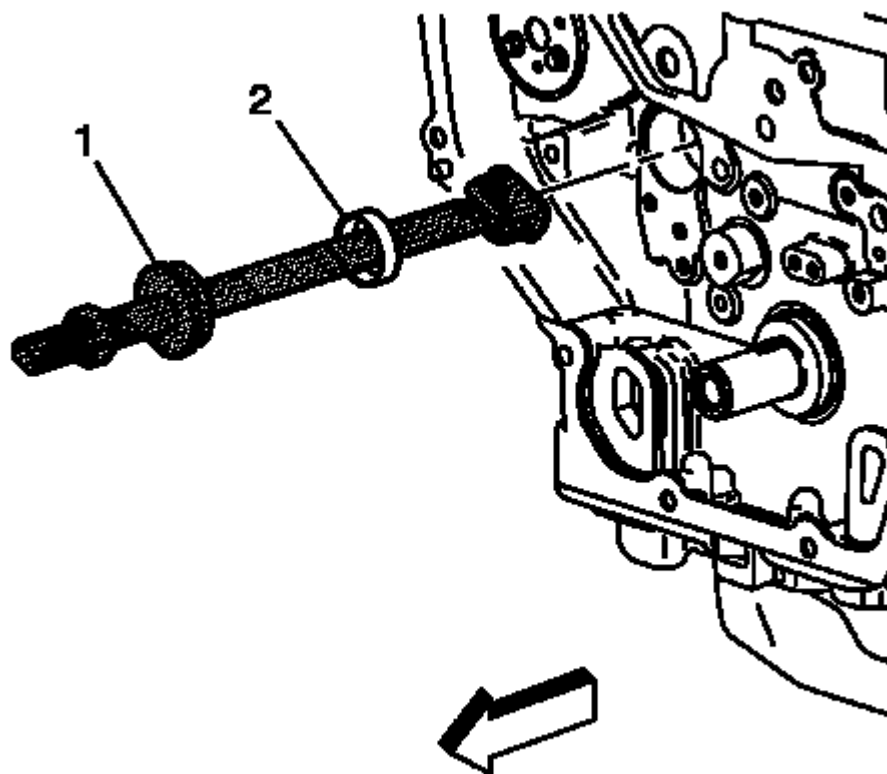


**Fig. 320: Identifying Properly Installed Remover**  
Courtesy of GENERAL MOTORS COMPANY

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

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

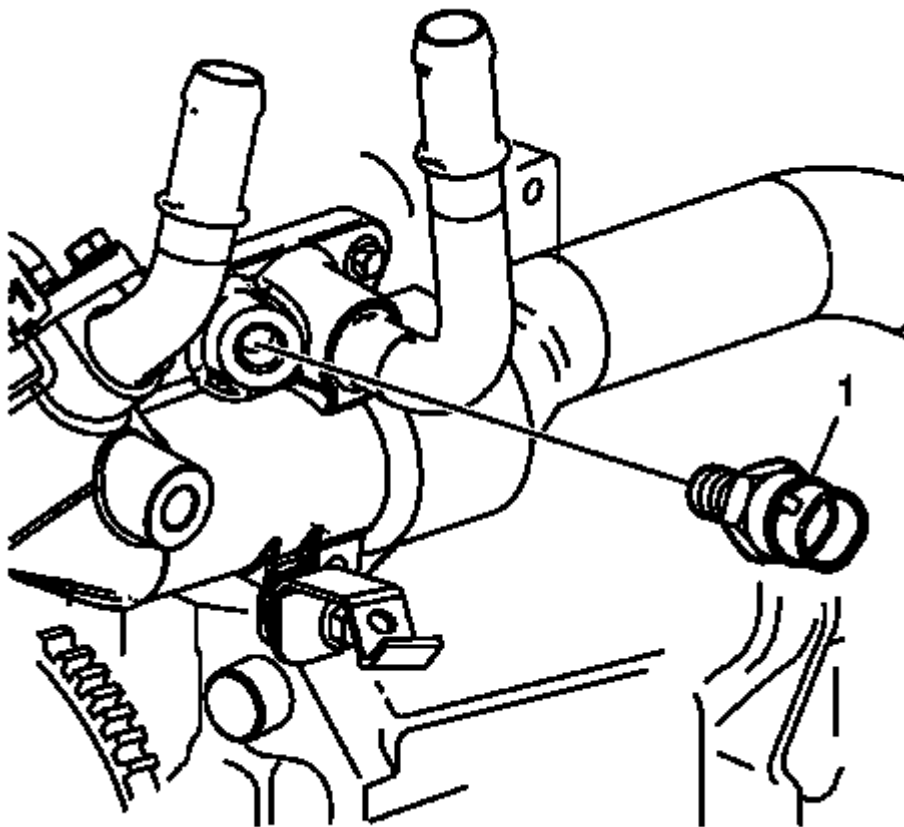
If the **EN-43650** remover is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.



**Fig. 321: Remover & Balance Shaft Bushing**  
Courtesy of GENERAL MOTORS COMPANY

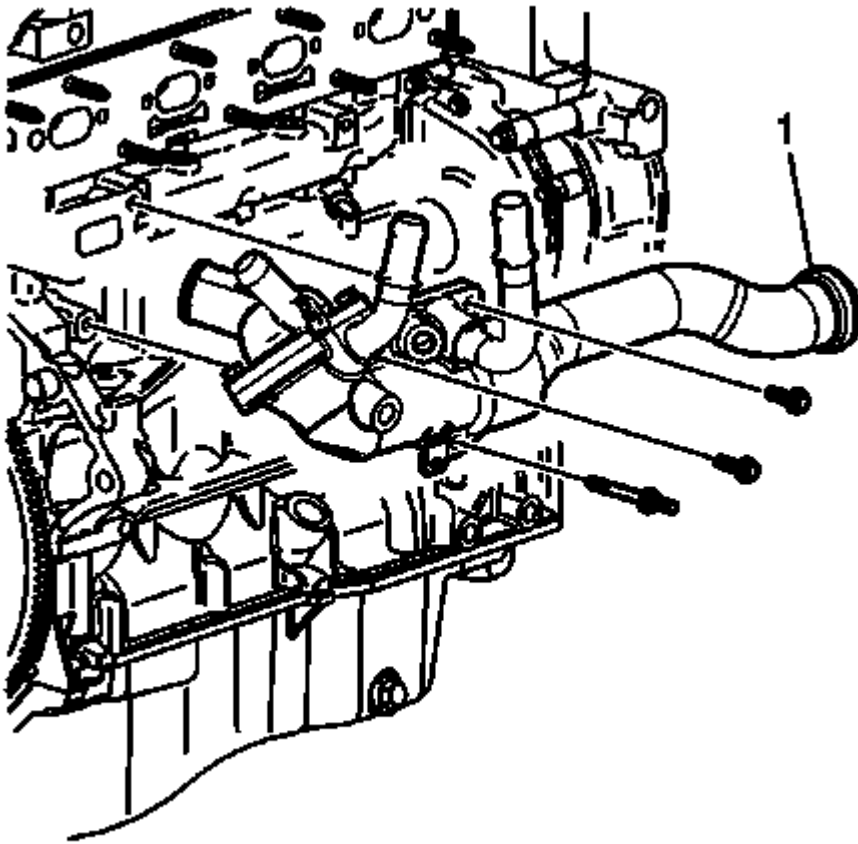
7. Tighten the nut on the **EN-43650** remover (1) until the tension releases. When the tension releases, remove the **EN-43650** remover and the balance shaft bushing (2).

## WATER PUMP REMOVAL



**Fig. 322: Engine Coolant Temperature Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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

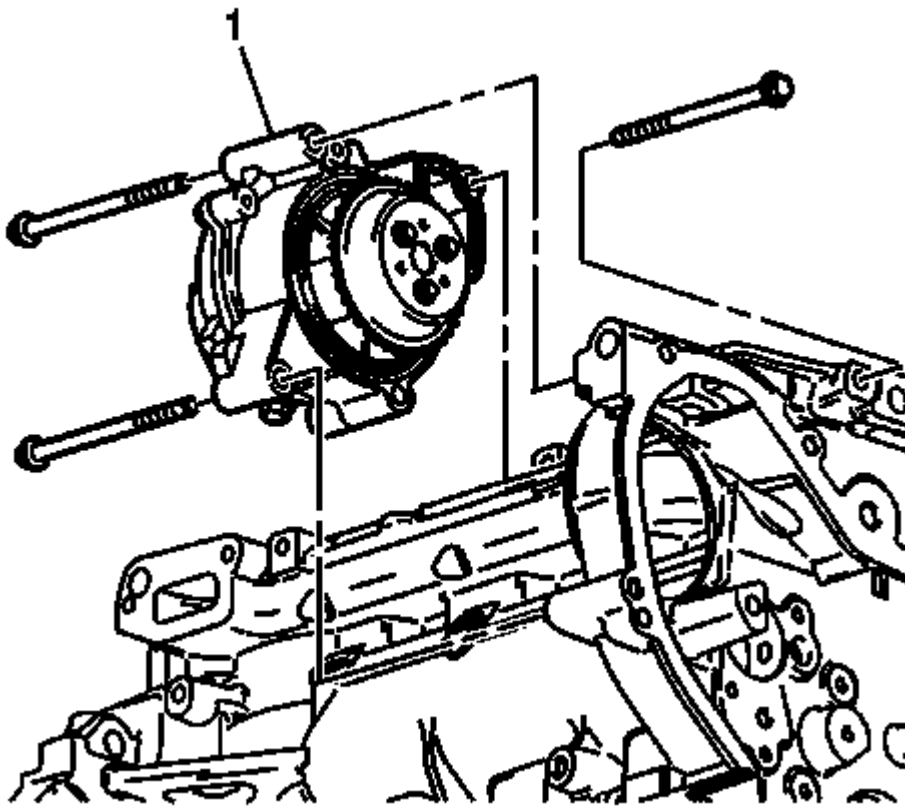


**Fig. 323: Thermostat Housing, Water Feed Pipe & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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



**Fig. 324: Water Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

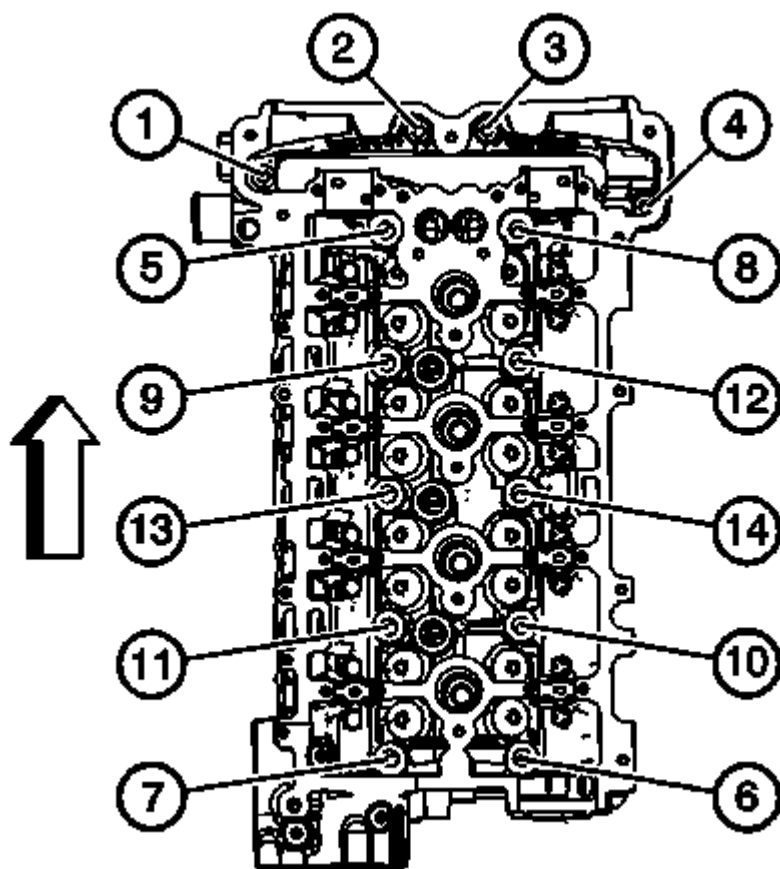
4. Remove the water pump retaining bolts. Be sure to remove the bolt that goes through the front of the engine block.
5. Remove the water pump assembly (1).

## CYLINDER HEAD REMOVAL (LEA)

### Special Tools

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

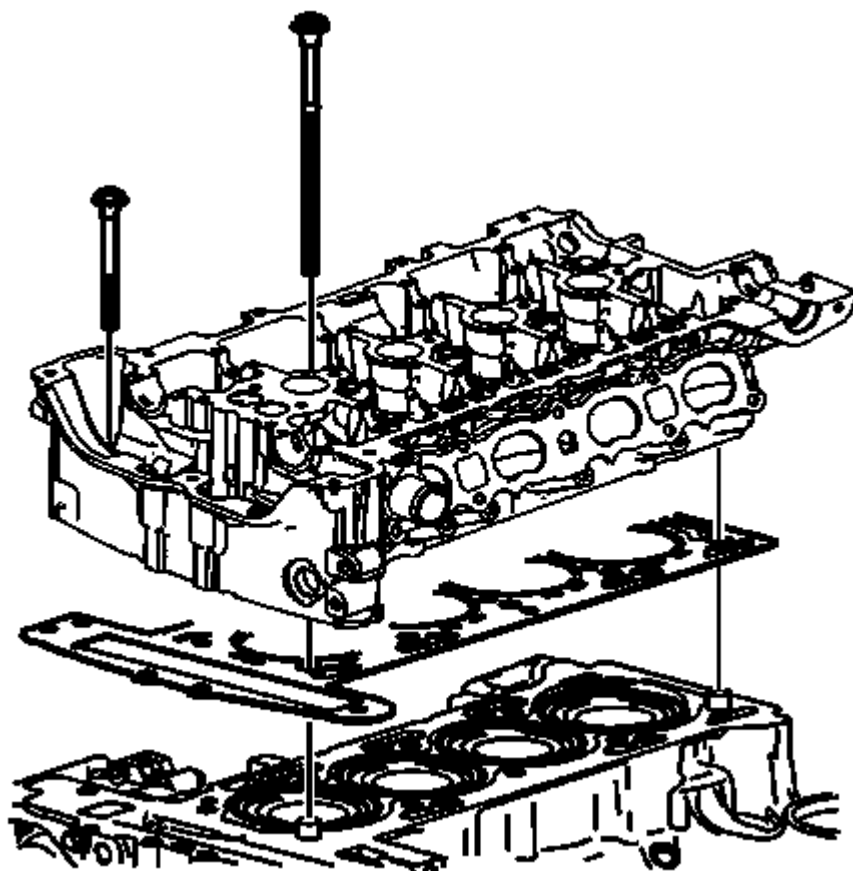
For equivalent regional tools, refer to **Special Tools**



**Fig. 325: Cylinder Head-To-Block Bolt Sequence**  
Courtesy of GENERAL MOTORS COMPANY

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

Discard the bolts.



**Fig. 326: Cylinder Head**

Courtesy of GENERAL MOTORS COMPANY

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

2. Remove the cylinder head.
3. Remove the cylinder head gasket.
4. Clean all of the gasket surfaces.
5. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:
  - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

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

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

**NOTE:** Be careful not to gouge or scratch the gasket surfaces. Do not gouge

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

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

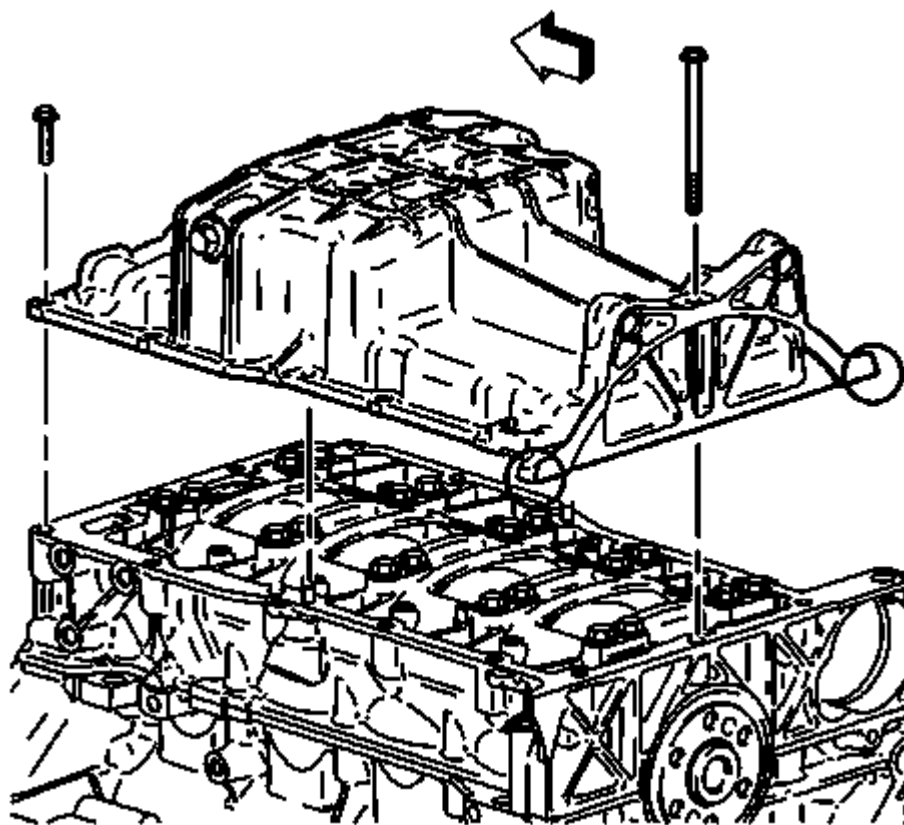
**NOTE:** Do not use a tap to clean the cylinder head bolt holes.

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

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

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

## **OIL PAN REMOVAL**



**Fig. 327: View Of Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

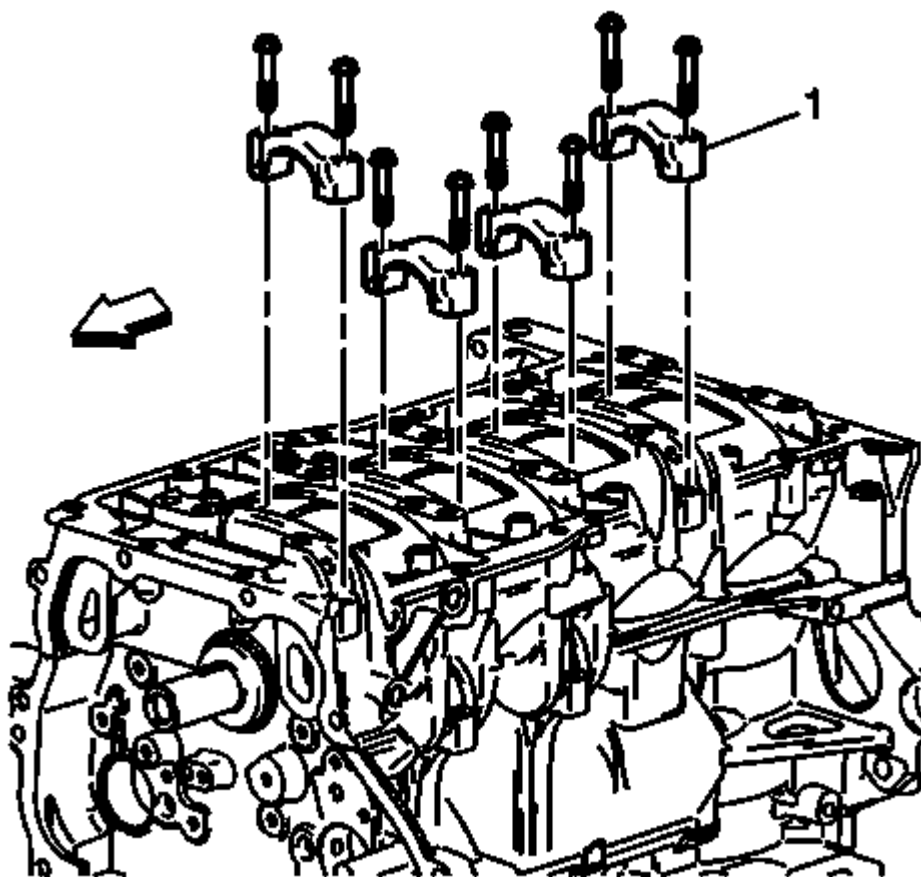
1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

## PISTON, CONNECTING ROD, AND BEARING REMOVAL

### Special Tools

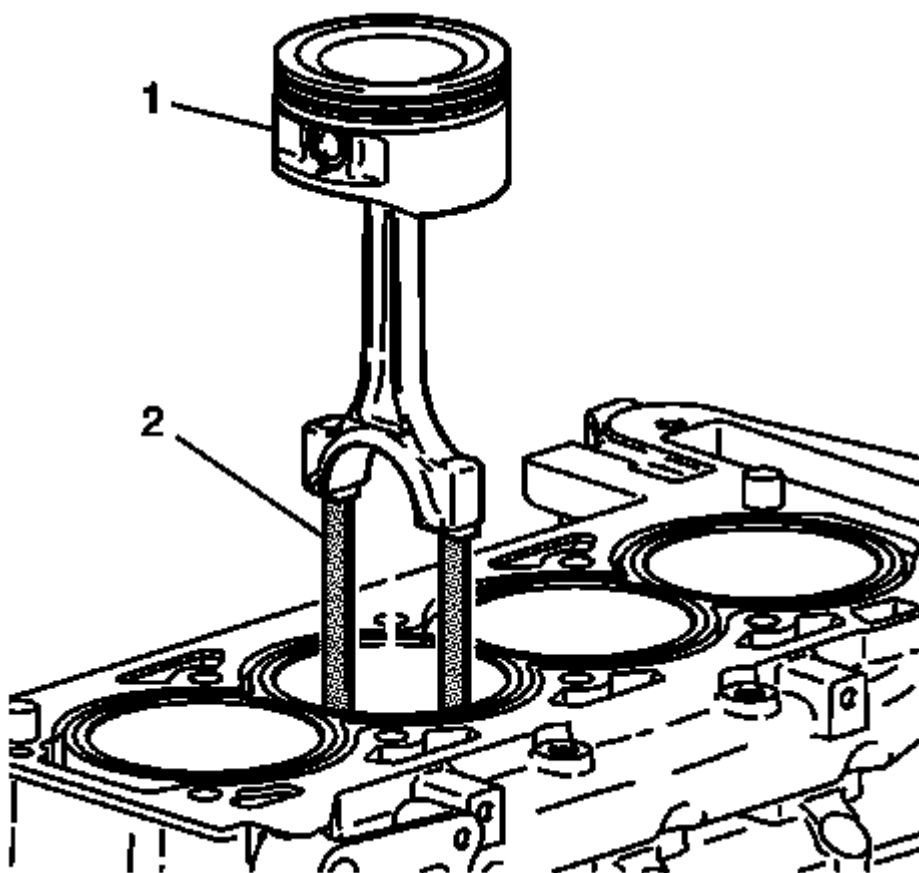
**EN-43966-1** Connecting Rod Guides

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



**Fig. 328: View of Connecting Rod Cap**  
Courtesy of GENERAL MOTORS COMPANY

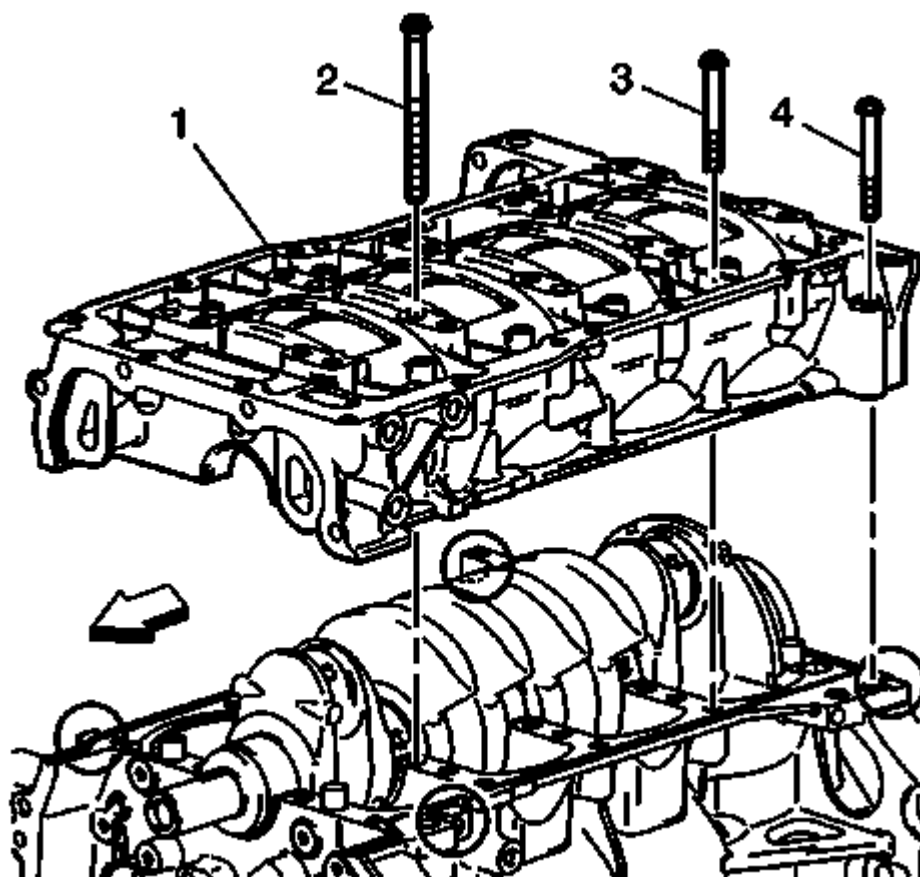
1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder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



**Fig. 329: View Of Connecting Rod Guides**  
Courtesy of GENERAL MOTORS COMPANY

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

## LOWER CRANKCASE REMOVAL



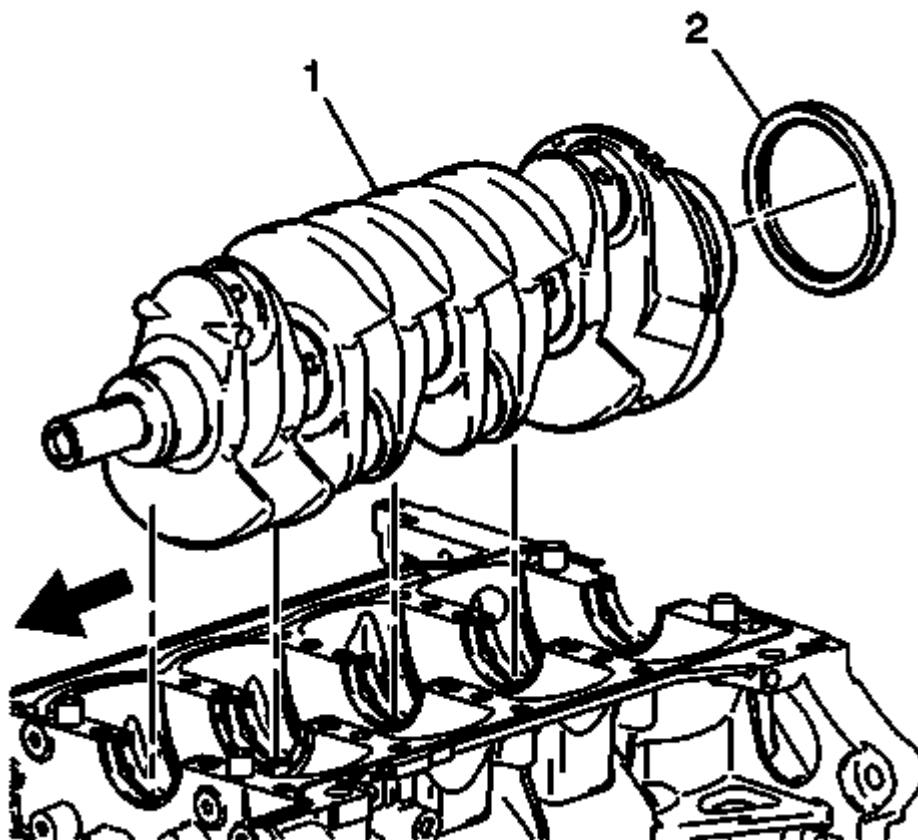
**Fig. 330: Upper & Lower Crankcase With Bolts**  
Courtesy of GENERAL MOTORS COMPANY

1. Remove the bedplate perimeter bolts (3).

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

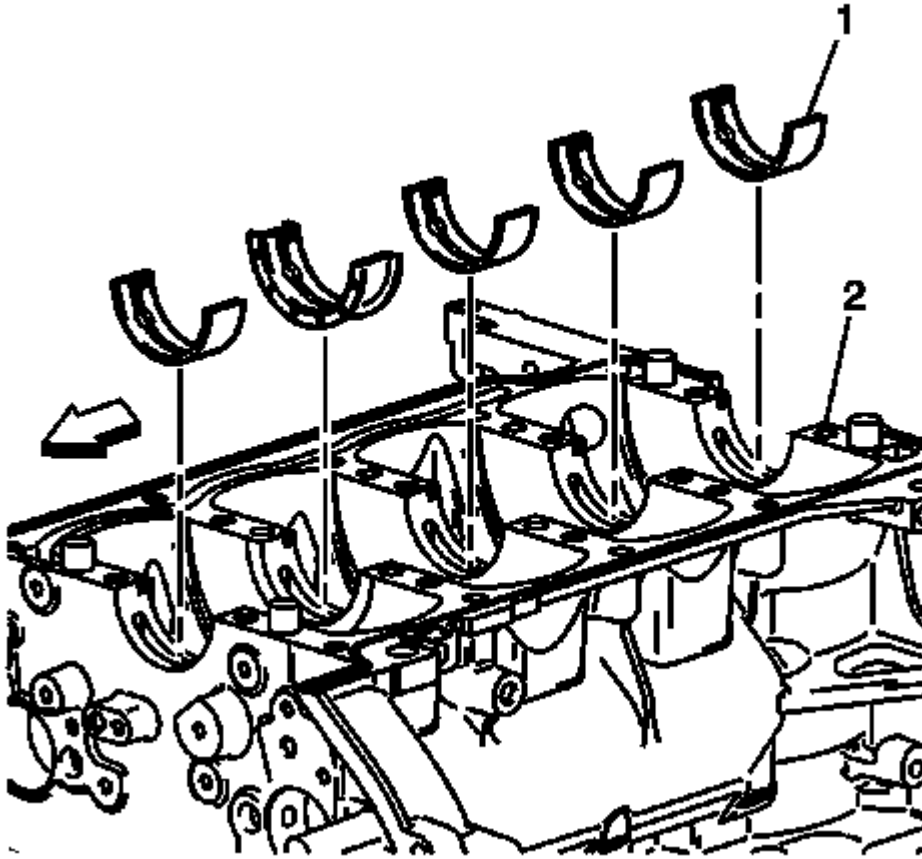
2. Remove and discard the crankshaft bearing bolts (2).
3. Using the pry-points and an appropriate prying tool, gently separate the upper and lower crankcase (1).

## CRANKSHAFT AND BEARING REMOVAL



**Fig. 331: Crankshaft & Rear Oil Seal**  
**Courtesy of GENERAL MOTORS COMPANY**

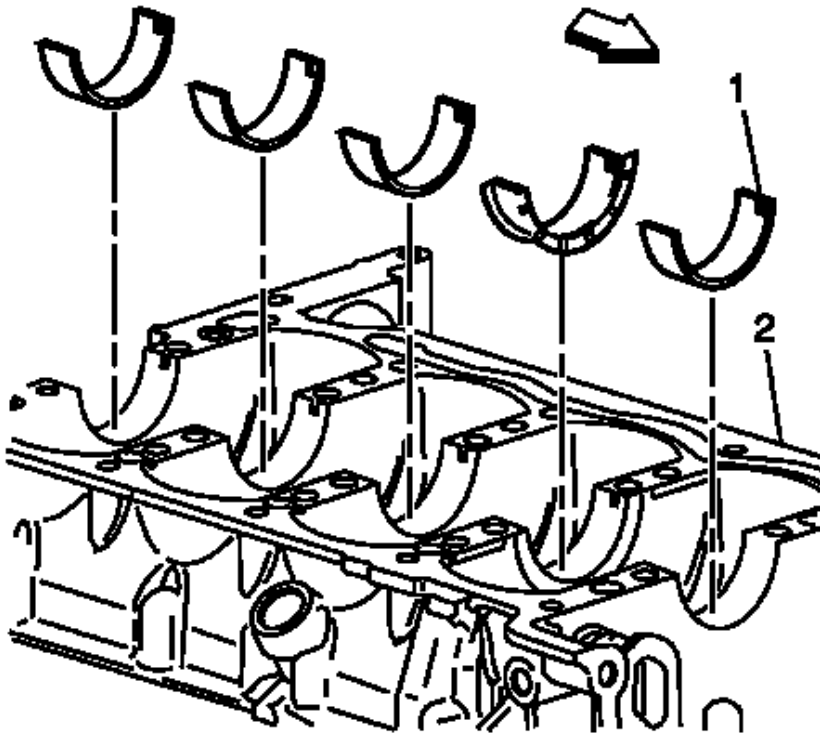
1. Remove the crankshaft (1) from the block.
2. Remove the crankshaft rear oil seal (2) from the block.



**Fig. 332: View of Upper Crankshaft Bearings**  
 Courtesy of GENERAL MOTORS COMPANY

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

3. Remove the bearing inserts (1) from the block (2).



**Fig. 333: View of Lower Bearing Halves**  
Courtesy of GENERAL MOTORS COMPANY

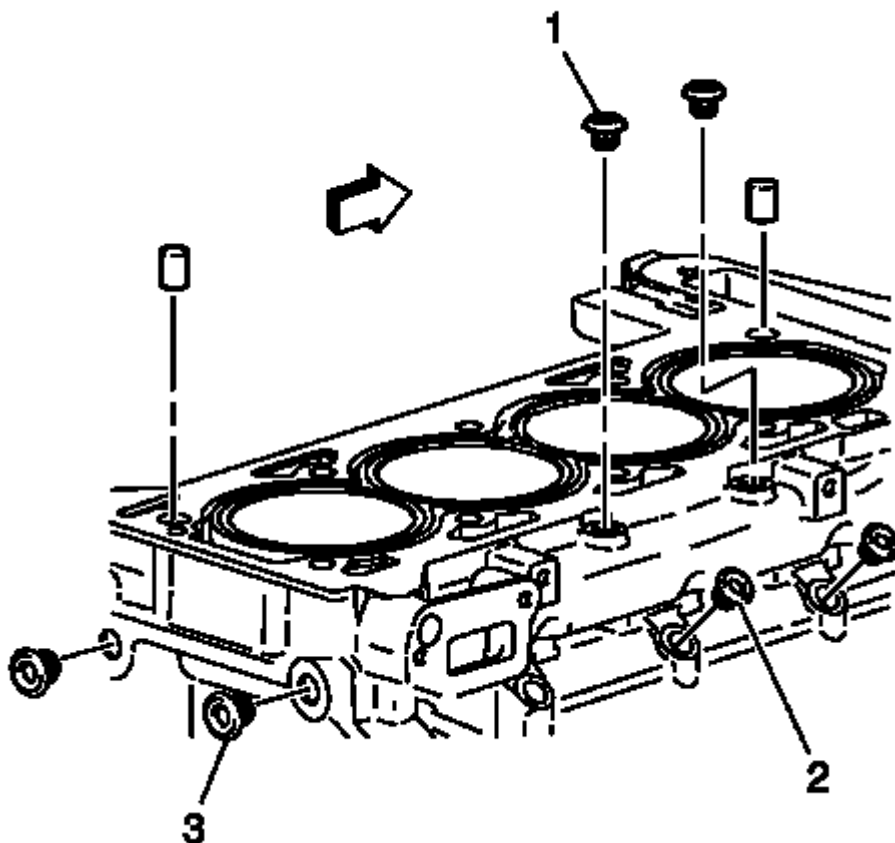
4. Remove the bearing inserts (1) from the bed plate (2).
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
  - Cracks
  - Chips
  - Gouges
  - Roughness
  -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

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

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

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

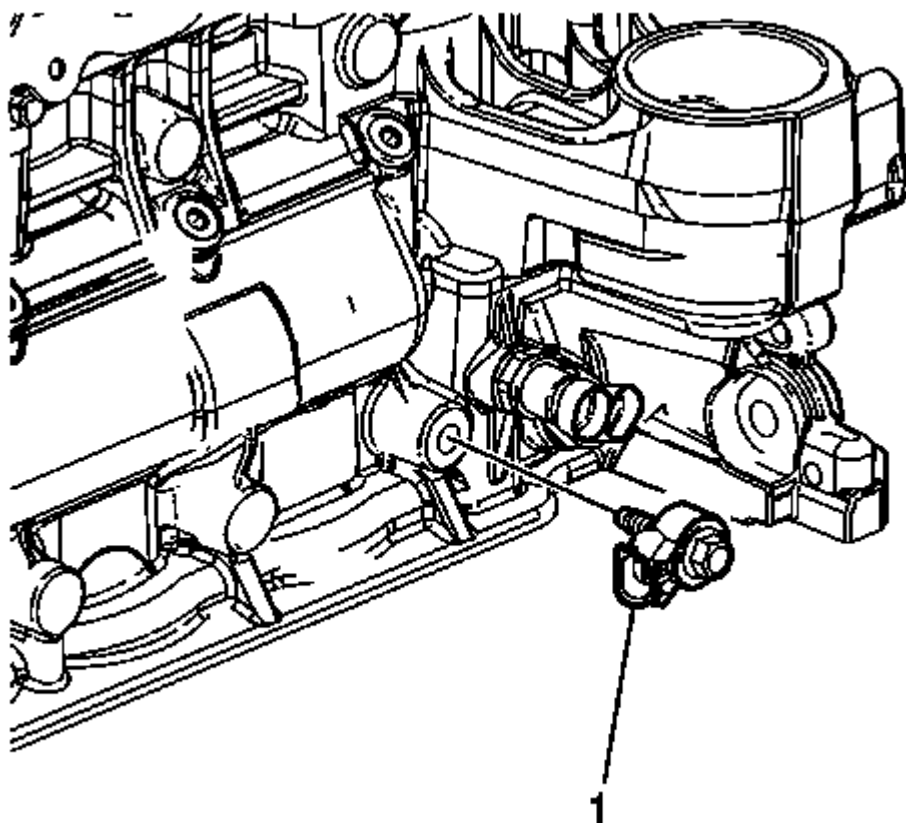
## ENGINE BLOCK DISASSEMBLE



**Fig. 334: Locating Block Plugs**

Courtesy of GENERAL MOTORS COMPANY

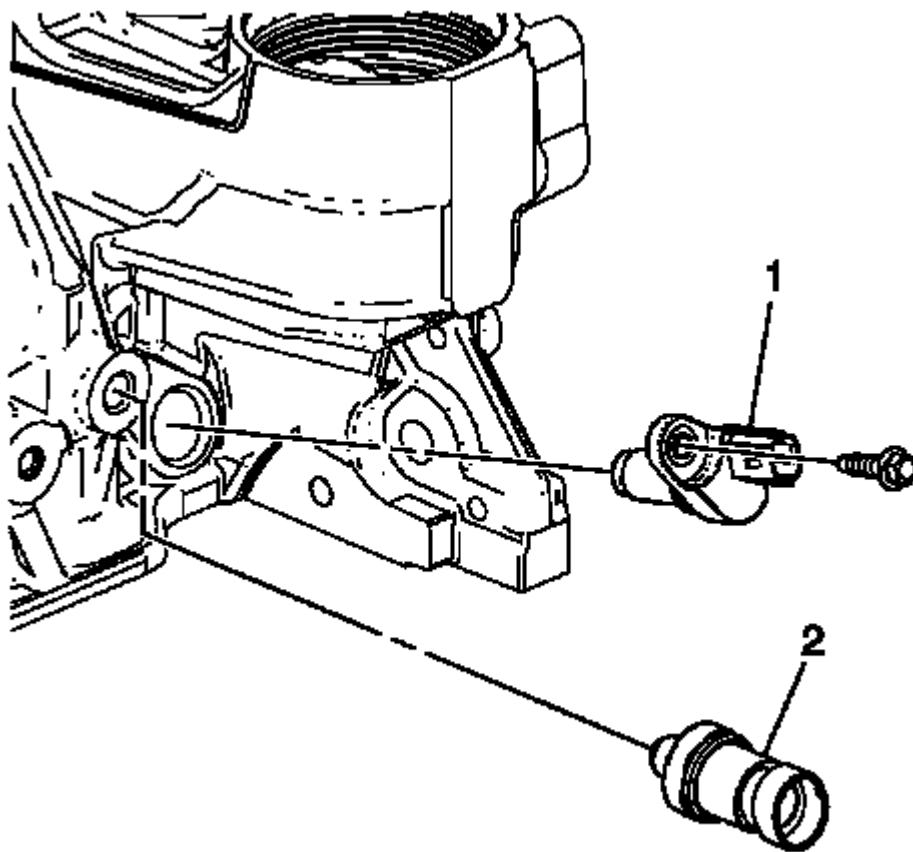
1. Remove the engine block coolant drain plug.
2. Remove the oil flow check valve.
3. Remove the rear oil passage plugs (3).
4. Remove the 3 oil passage plugs on each side of the block (2).
5. Remove the 2 water passage plugs on the top of the block (1).
6. Remove the 2 front oil passage plugs.



**Fig. 335: Knock Sensor**

**Courtesy of GENERAL MOTORS COMPANY**

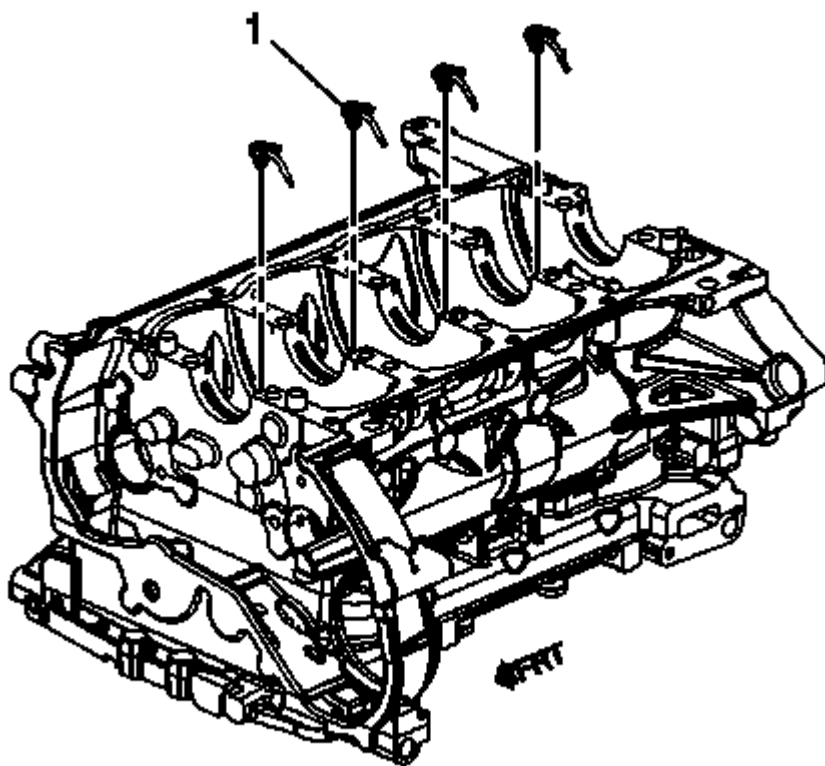
7. Remove the knock sensor (1) and bolt.



**Fig. 336: Oil Pressure Switch**

**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 337: Piston Oil Nozzle Assembly**  
Courtesy of GENERAL MOTORS COMPANY

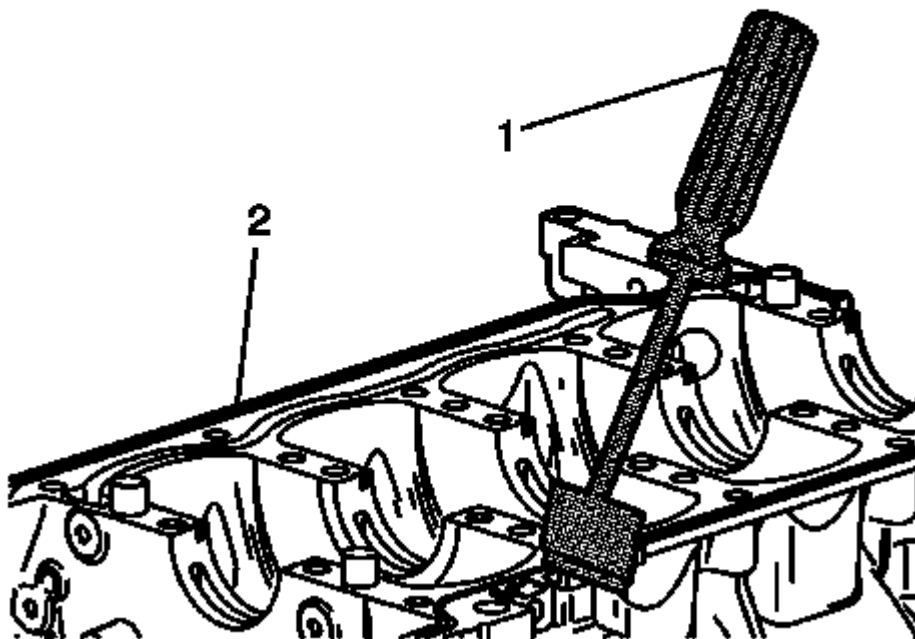
10. If equipped, loosen the piston oil nozzle assembly (1) bolt and remove the piston oil nozzle assembly.

## ENGINE BLOCK CLEANING AND INSPECTION

### Special Tools

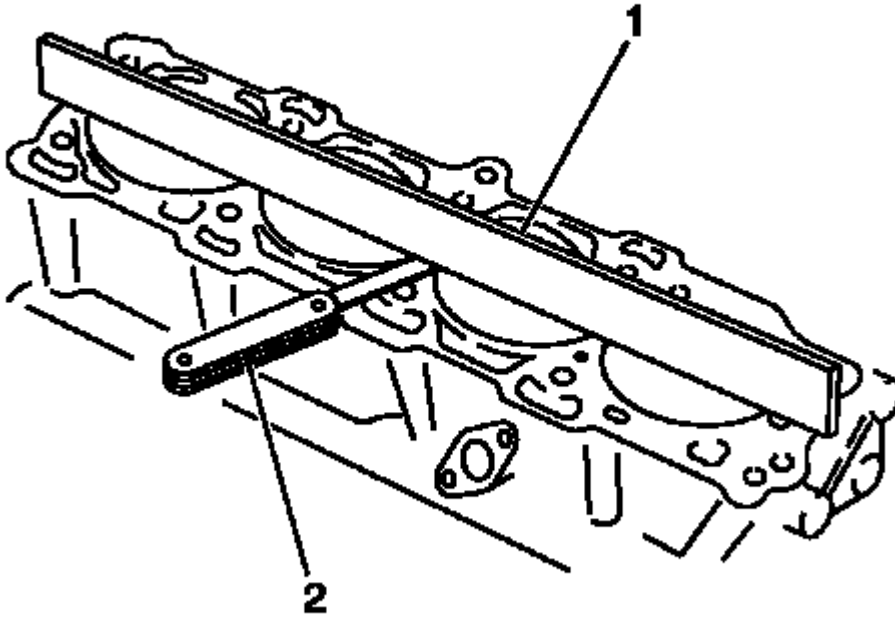
- EN-8087 Cylinder Bore Gauge
- GE-7872 Magnetic Base Dial Indicator

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



**Fig. 338: Cleaning Sealing Material From Gasket Mating Surfaces**  
Courtesy of GENERAL MOTORS COMPANY

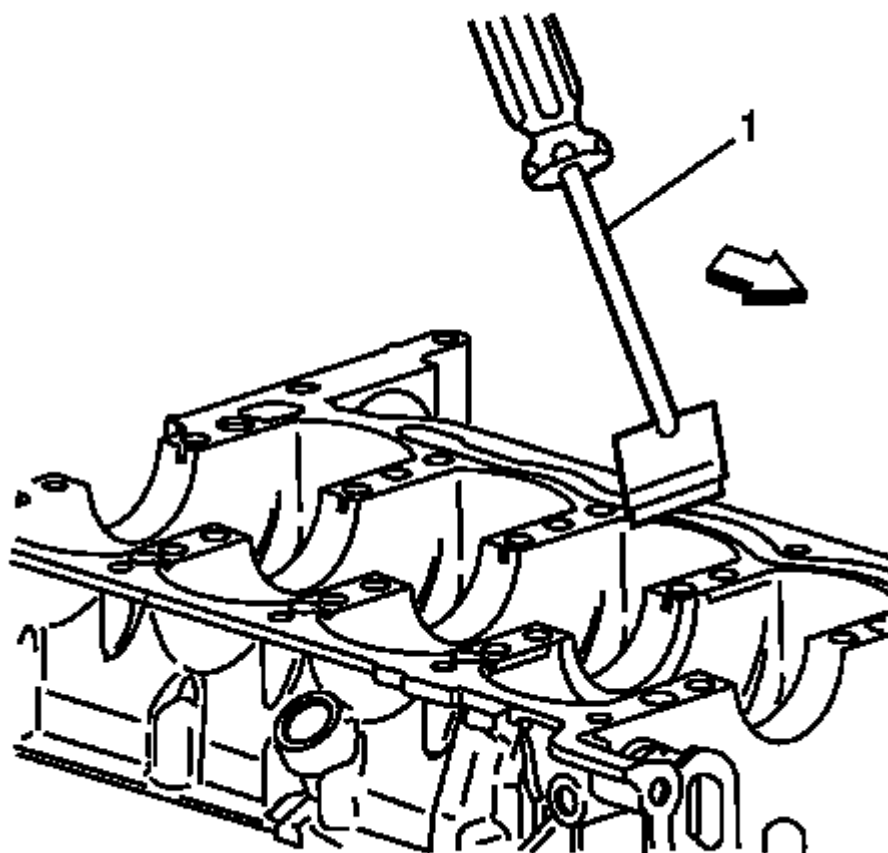
1. Clean the sealing material from the gasket mating surfaces (2) with a suitable tool (1).
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.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



**Fig. 339: Checking Deck Surface For Flatness**  
Courtesy of GENERAL MOTORS COMPANY

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

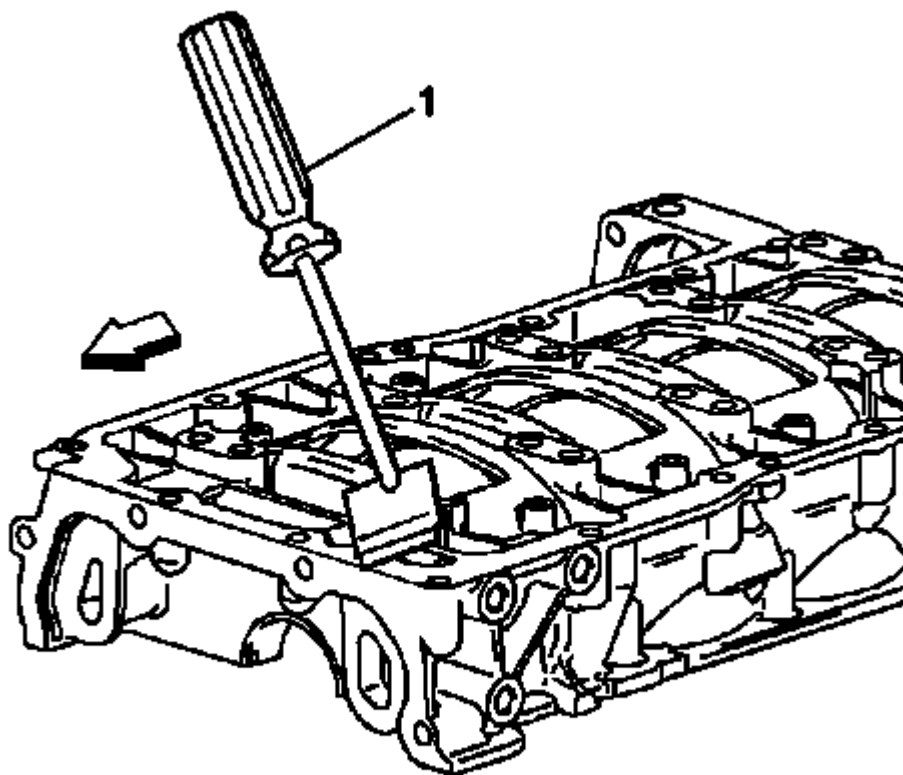
9. Use a straight edge (1) and a feeler gauge (2) to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill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



**Fig. 340: Cleaning Sealing Material From Gasket Mating Surfaces On Lower Crankcase Engine Block Side**

Courtesy of GENERAL MOTORS COMPANY

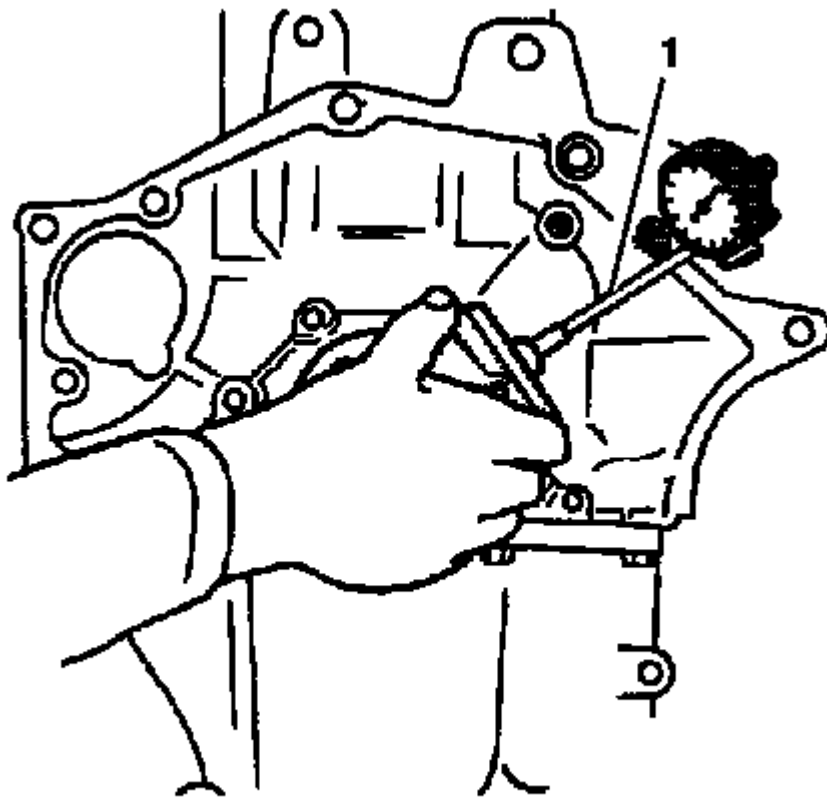
11. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side with a suitable tool (1).



**Fig. 341: Cleaning Sealing Material From Gasket Mating Surfaces On Lower Crankcase Oil Pan Side**

**Courtesy of GENERAL MOTORS COMPANY**

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

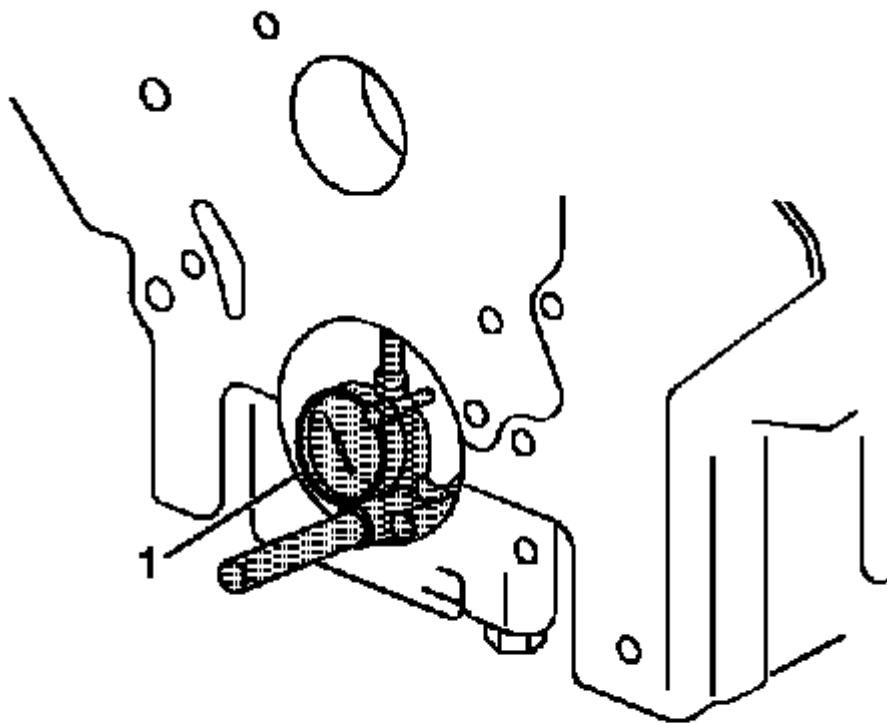


**Fig. 342: Inspecting Mating Surfaces Of Transmission Face**  
Courtesy of GENERAL MOTORS COMPANY

13. Inspect the mating surfaces of the transmission face.

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

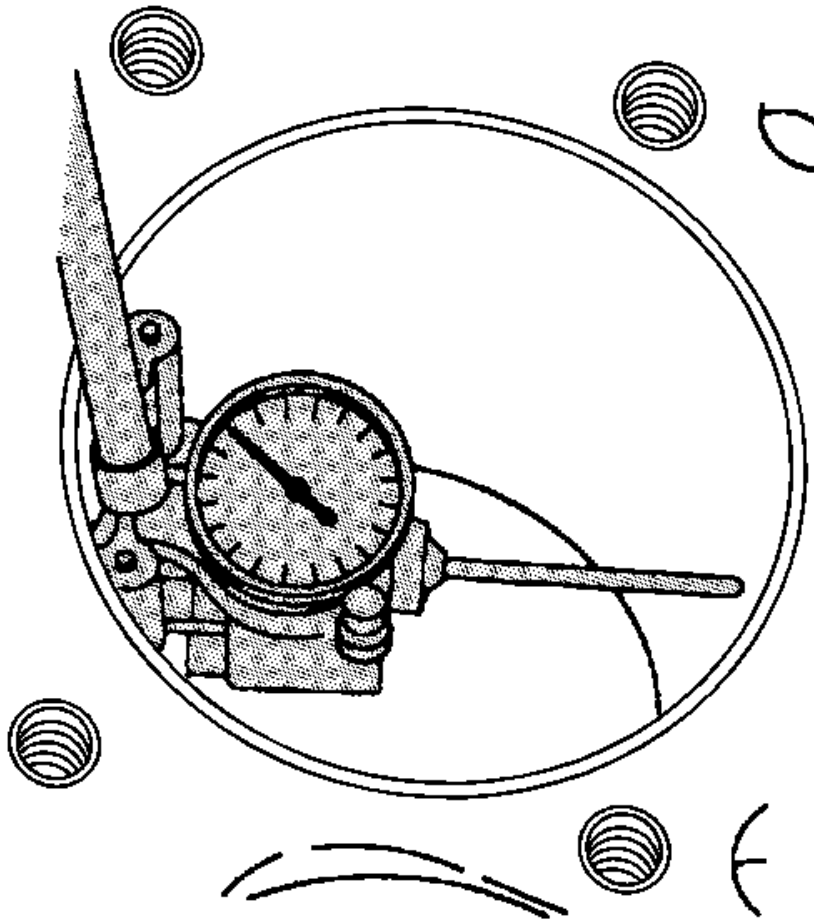
14. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
  1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **GE-7872** dial indicator (1)
  2. Hold the gauge plate flat against the crankshaft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



**Fig. 343: Measuring Bearing Bore**  
Courtesy of GENERAL MOTORS COMPANY

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

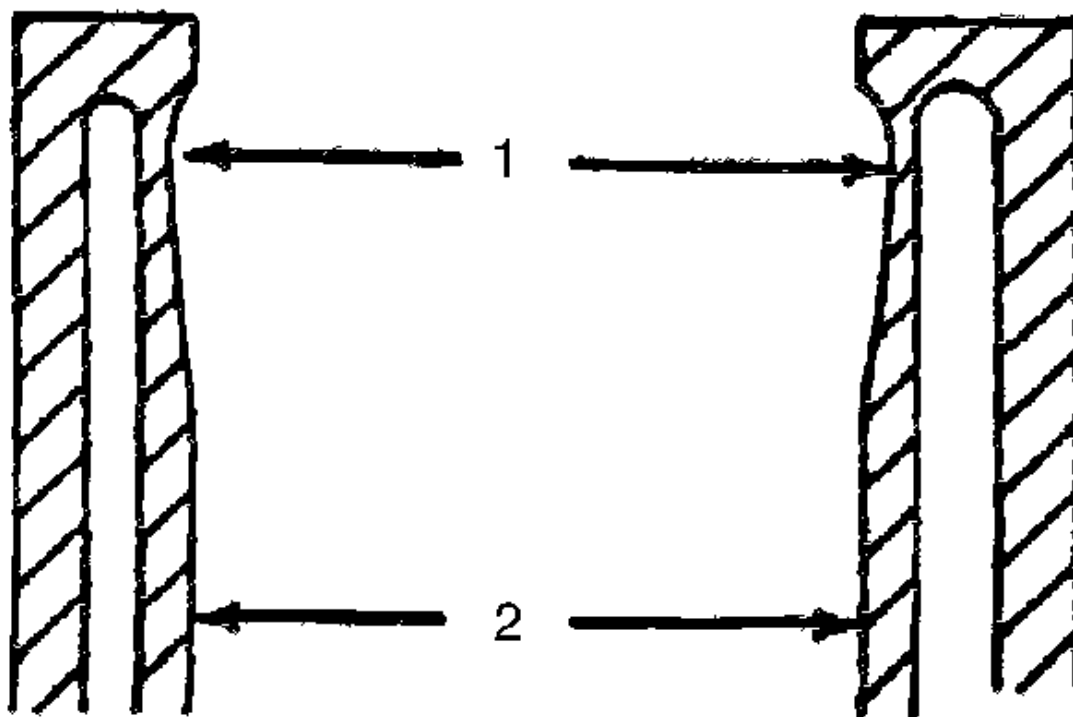
#### Measuring Cylinder Bore Diameter



**Fig. 344: Measuring Cylinder Bore**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN-8087** gauge.
2. Compare your results with the **Engine Mechanical Specifications (LEA)**. If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing (LEA)**.

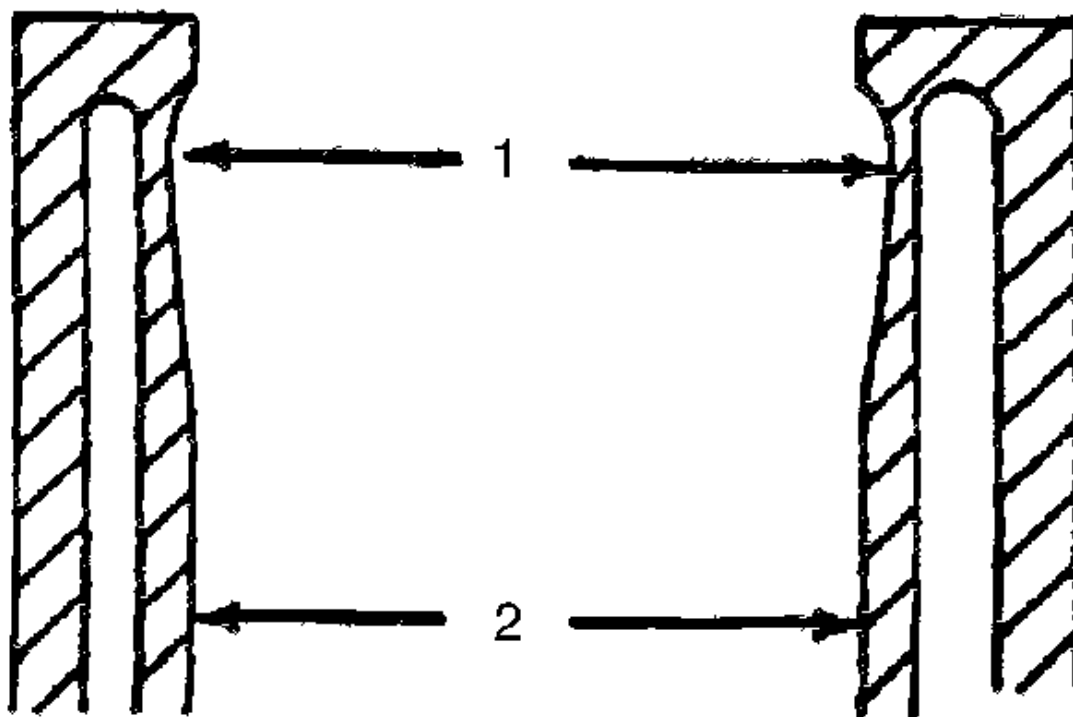
#### Measuring Cylinder Bore Taper



**Fig. 345: Measuring Head Gasket Dimensions**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 13 mm (0.510 in) below the deck surface (1) and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.938 in) below the deck surface (2) and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications (LEA)**. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing (LEA)**.

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



**Fig. 346: Measuring Head Gasket Dimensions**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure both the thrust and non-thrust cylinder diameter at 13 mm (0.510 in) below the deck surface (1). Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.938 in) below the deck surface (2). Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications (LEA)**. If the cylinders exceed these specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing (LEA)**.

## CYLINDER BORING AND HONING (LEA)

### Boring Procedure

1. Measure all pistons with a micrometer to determine the cylinder bore diameter. Refer to **Engine Block Cleaning and Inspection**.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block, removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

### Honing Procedure

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

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

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

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

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

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

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

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

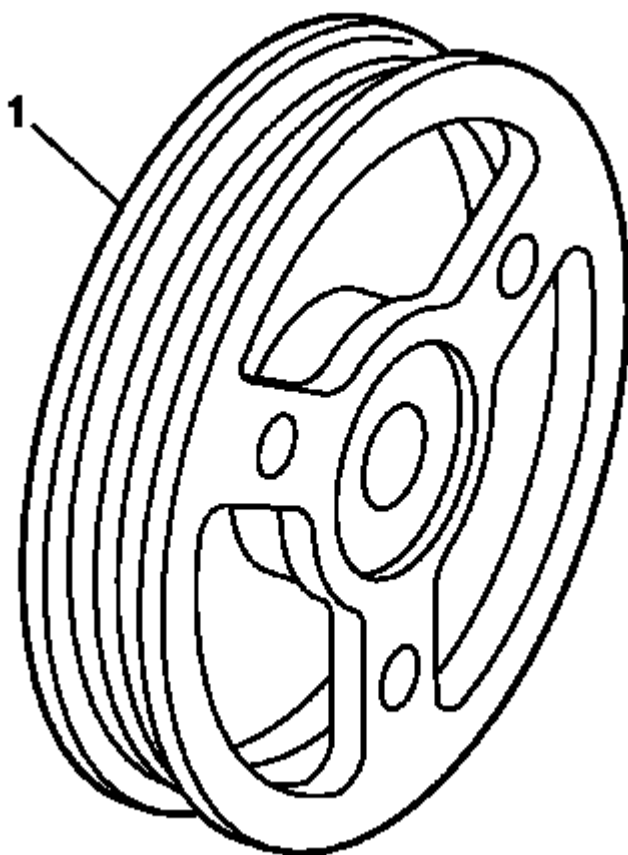
#### Deglazing Procedure

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

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

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

#### CRANKSHAFT BALANCER CLEANING AND INSPECTION



**Fig. 347: Crankshaft Balancer**

Courtesy of GENERAL MOTORS COMPANY

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

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

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

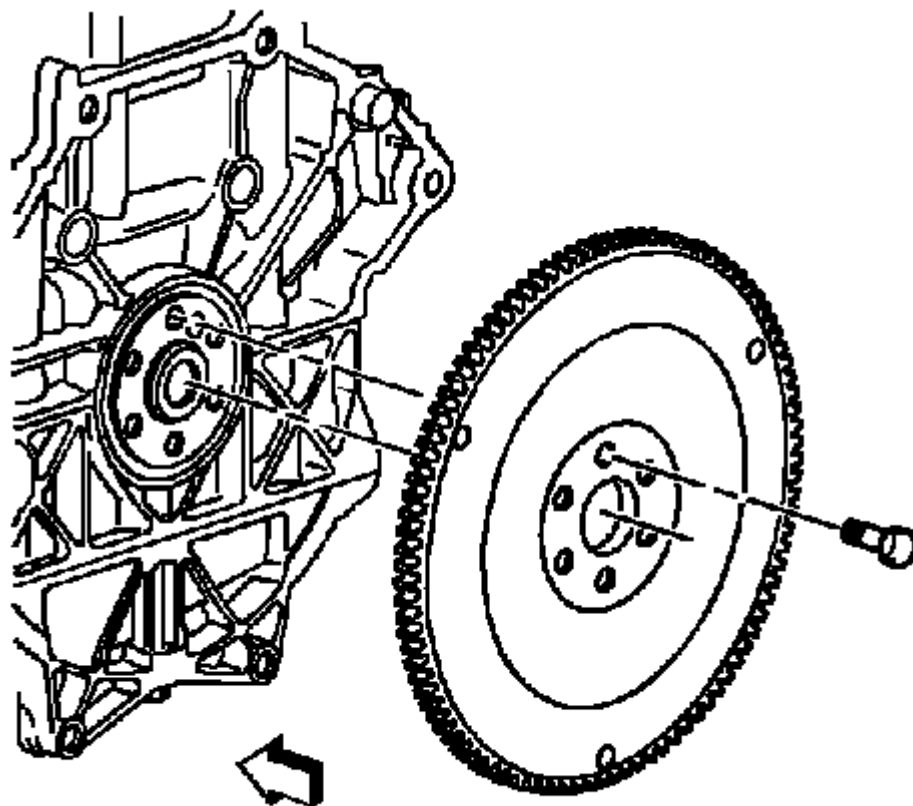
**NOTE:** In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves

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

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

## ENGINE FLYWHEEL CLEANING AND INSPECTION



**Fig. 348: View Of Flywheel**

Courtesy of GENERAL MOTORS COMPANY

1. Clean the flywheel in solvent.

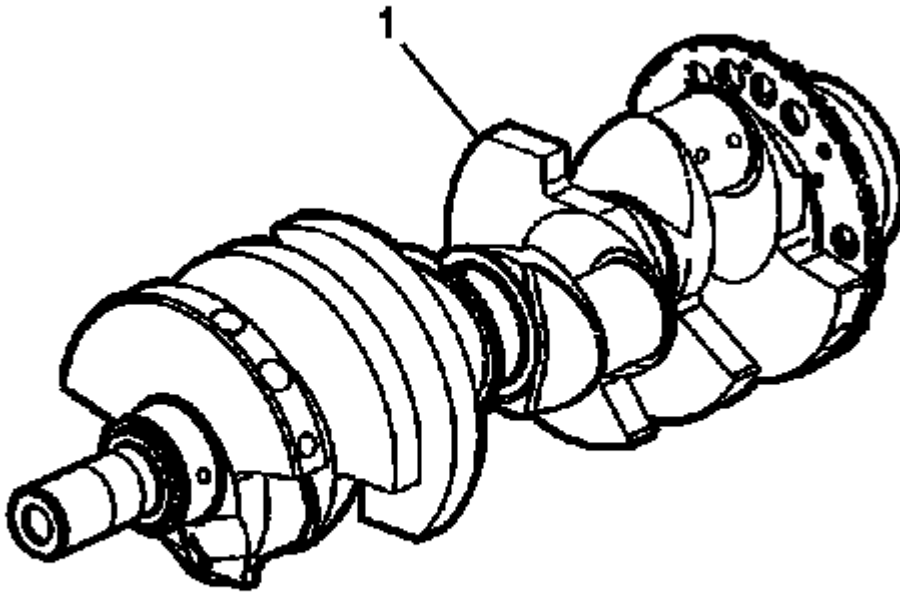
**WARNING:** Refer to Safety Glasses Warning .

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

**CRANKSHAFT AND BEARING CLEANING AND INSPECTION****Special Tools**

**GE-7872** Magnetic Base Dial Indicator Set

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



**Fig. 349: View Of Crankshaft**

Courtesy of GENERAL MOTORS COMPANY

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

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

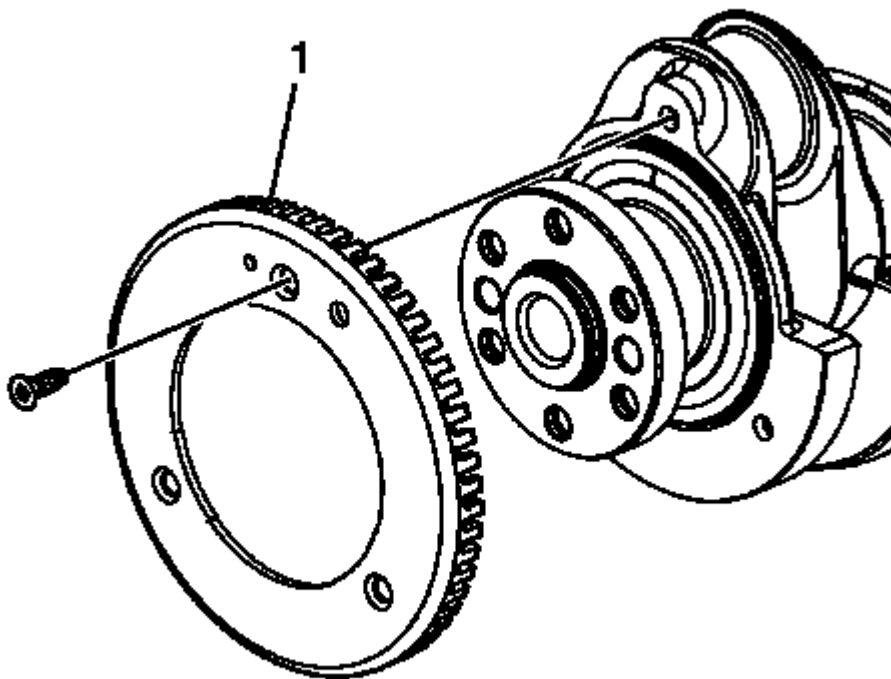
**WARNING:** Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

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

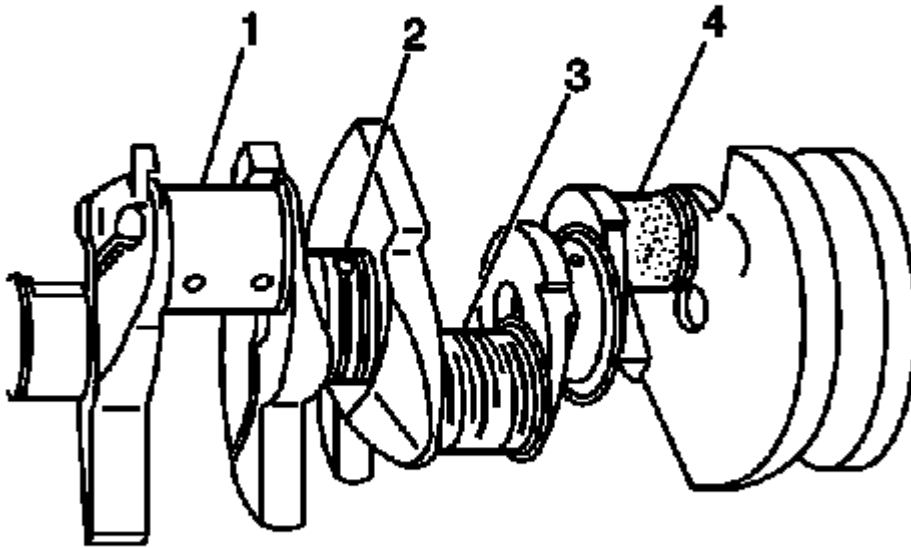
Imperfections of the reluctor ring teeth may effect OBD II system performance.

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



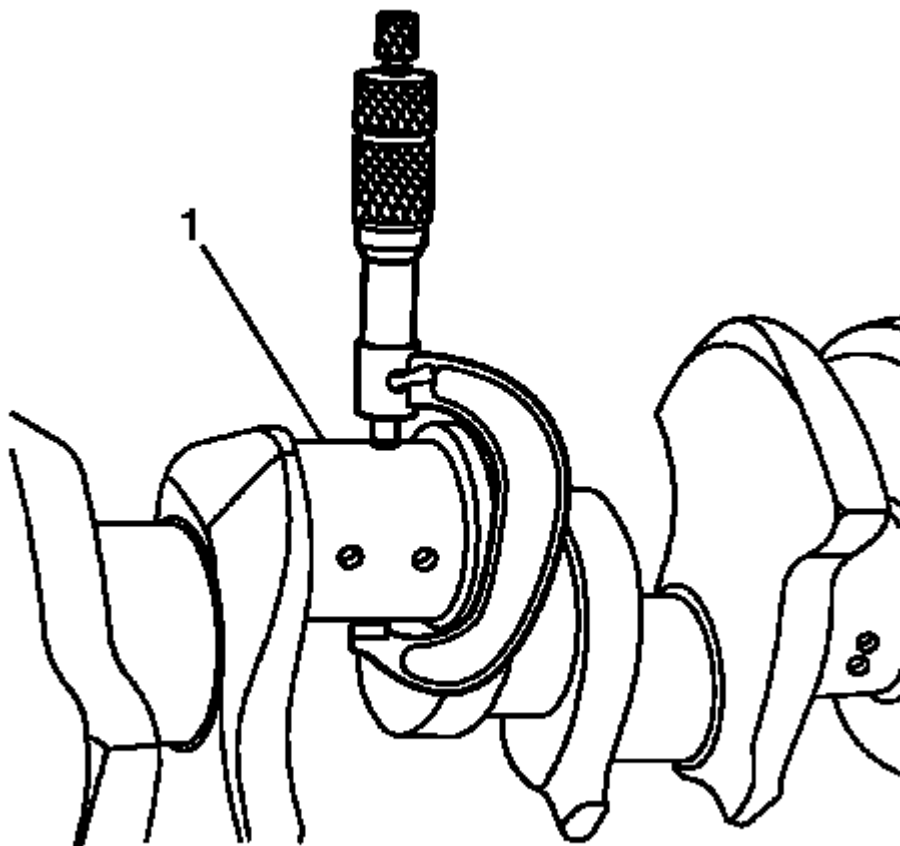
**Fig. 350: View of Crankshaft Position Reluctor Ring**  
Courtesy of GENERAL MOTORS COMPANY

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



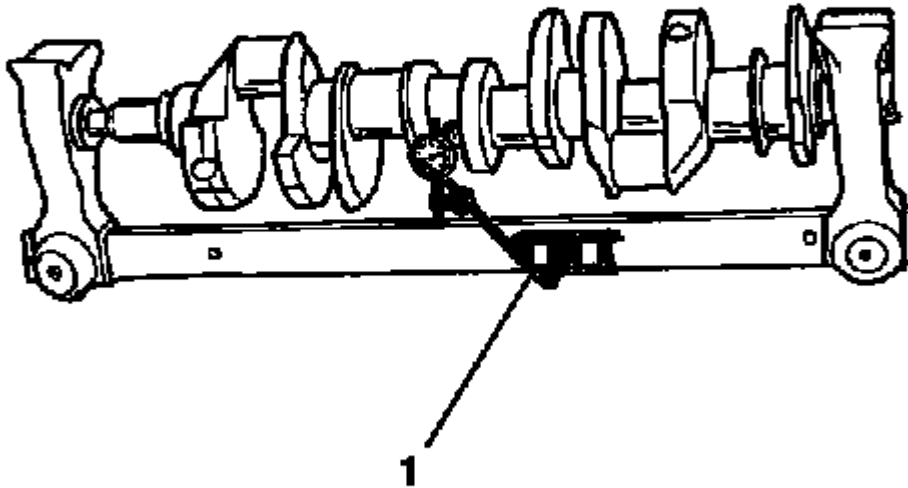
**Fig. 351: Identifying Different Crankshaft Journal Wear Patterns**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 352: Measure Crankshaft Journals For Out-Of-Round**  
Courtesy of GENERAL MOTORS COMPANY

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

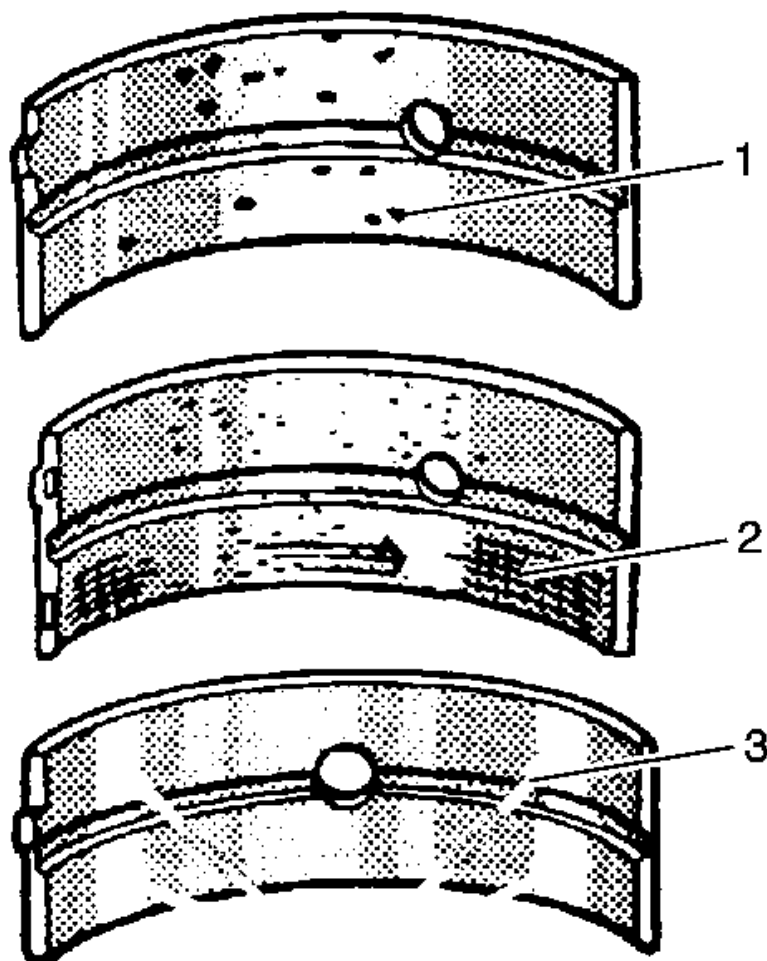


**Fig. 353: Measuring The Crankshaft Runout**  
**Courtesy of GENERAL MOTORS COMPANY**

12. Measure the crankshaft runout.

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

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



**Fig. 354: Identifying Crankshaft Bearings For Craters Or Pockets**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

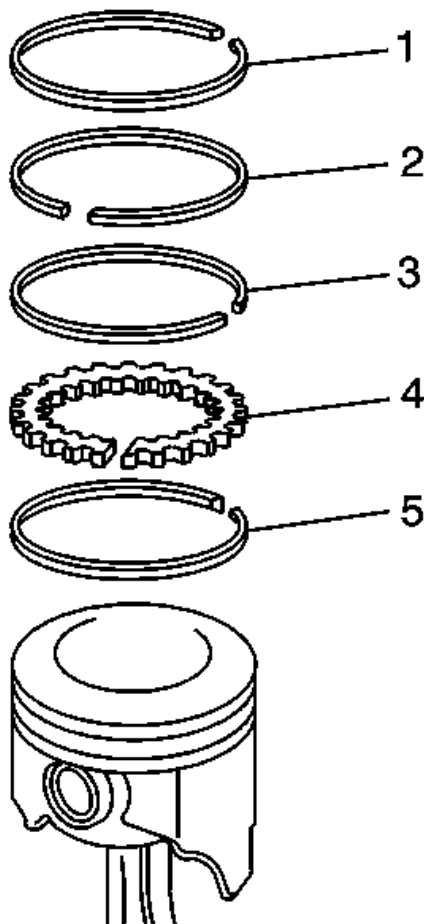
Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

## PISTON AND CONNECTING ROD DISASSEMBLE

### Special Tools

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

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

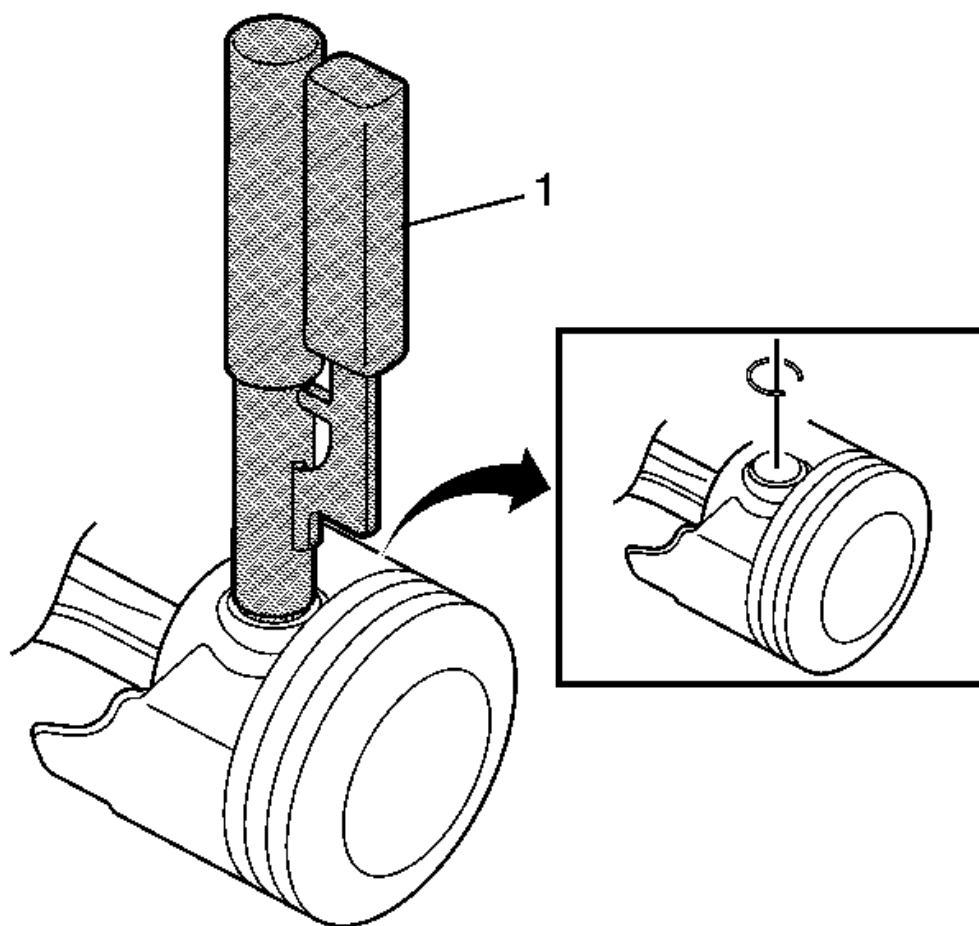


**Fig. 355: Identifying Piston Rings**

Courtesy of GENERAL MOTORS COMPANY

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

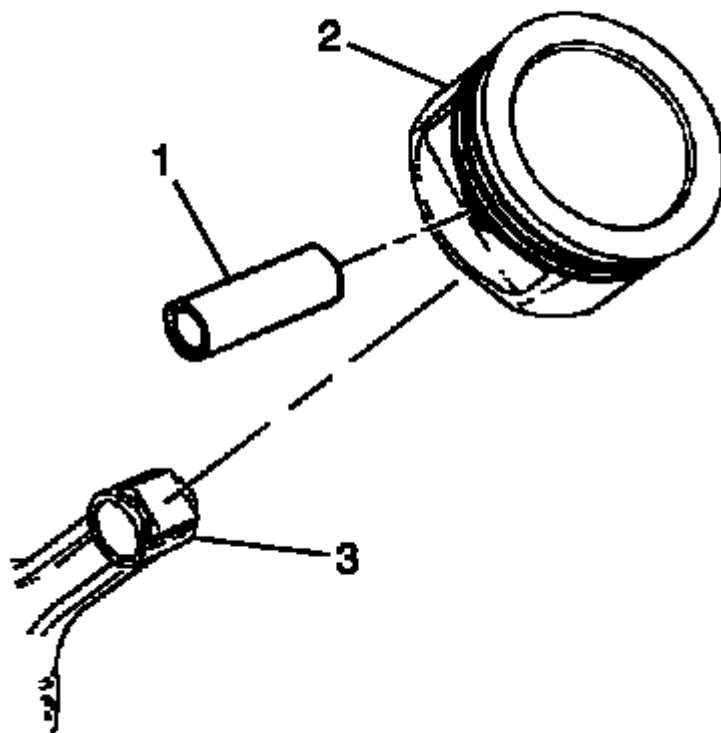
1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.



**Fig. 356: View of Piston Pin Retainers**  
Courtesy of GENERAL MOTORS COMPANY

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

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



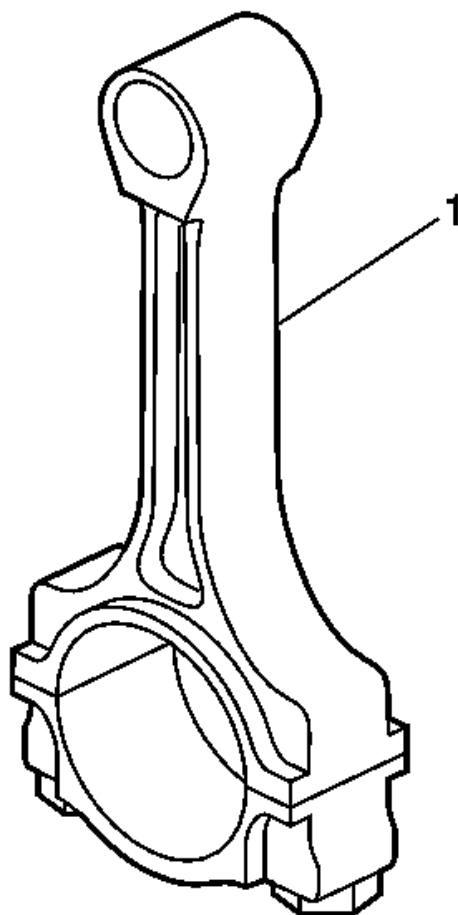
**Fig. 357: Identifying Piston Pin And Connecting Rod**

Courtesy of GENERAL MOTORS COMPANY

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

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

### **Connecting Rod Measurement**



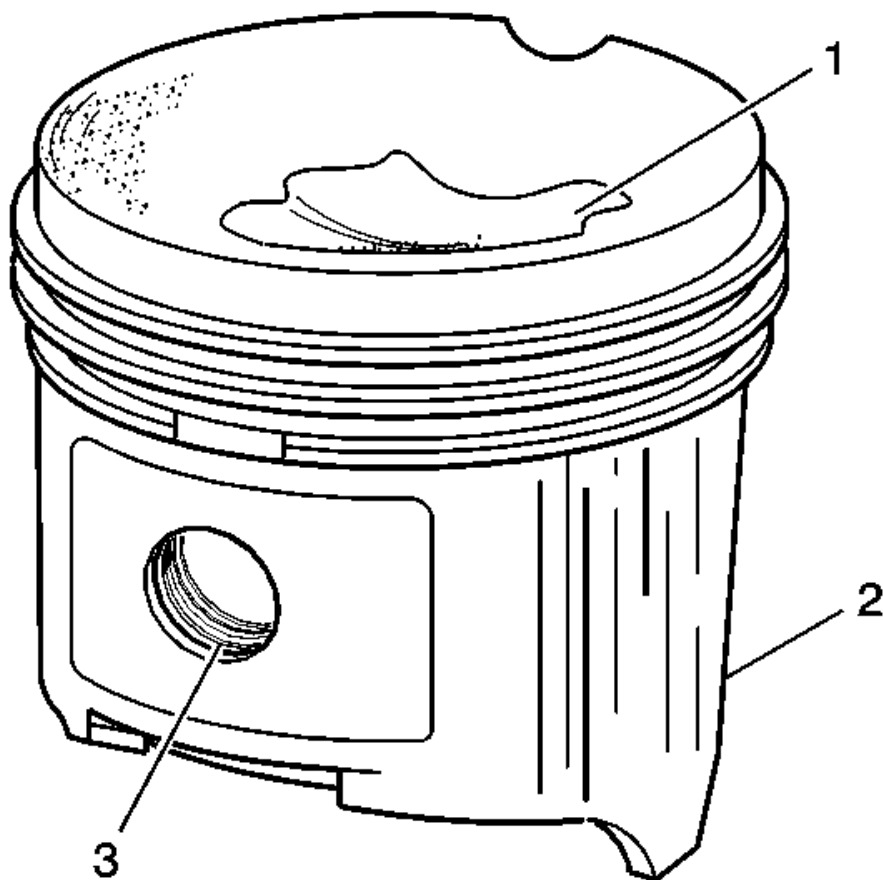
**Fig. 358: Connecting Rod**

Courtesy of GENERAL MOTORS COMPANY

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

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

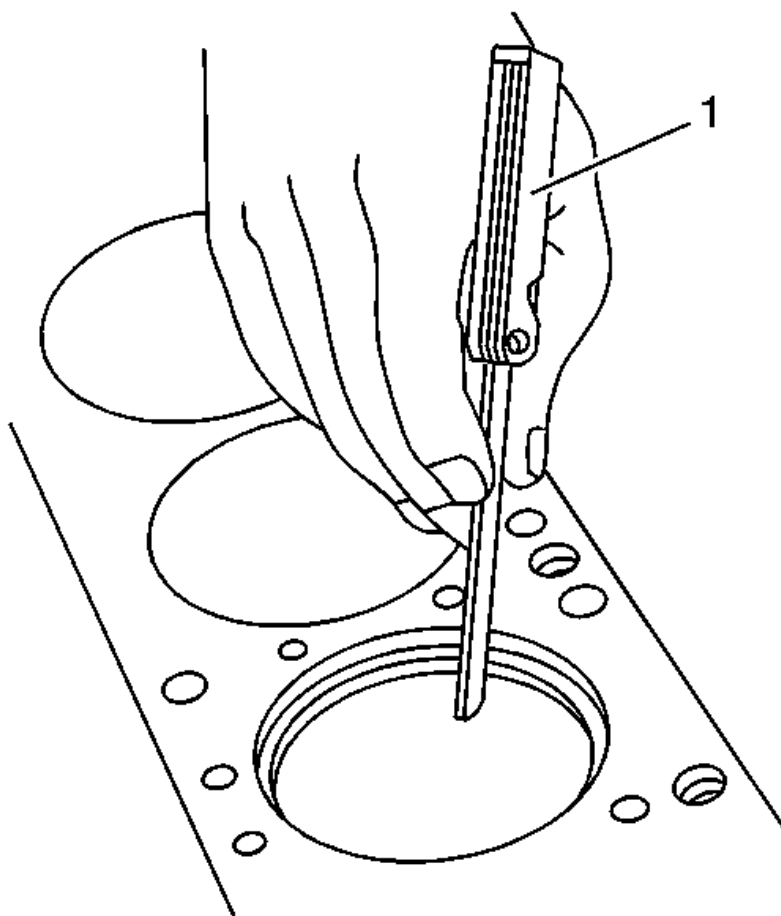
#### Piston Measurement



**Fig. 359: Identifying Piston Damage Inspection Areas**  
Courtesy of GENERAL MOTORS COMPANY

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

- Worn piston pin bores (3)
4. Replace pistons that show any signs or damage or excessive wear.
  5. Measure the piston pin bore to piston pin clearances using the following procedure:
    1. Piston pin bores and pins must be free of varnish or scuffing.
    2. Use an outside micrometer to measure the piston pin in the piston contact areas.
    3. Using an inside micrometer, measure the piston pin bore.
    4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002-0.012 mm (0.00007-0.00047 in).
    5. If the clearance is excessive, determine which component is out of specification.

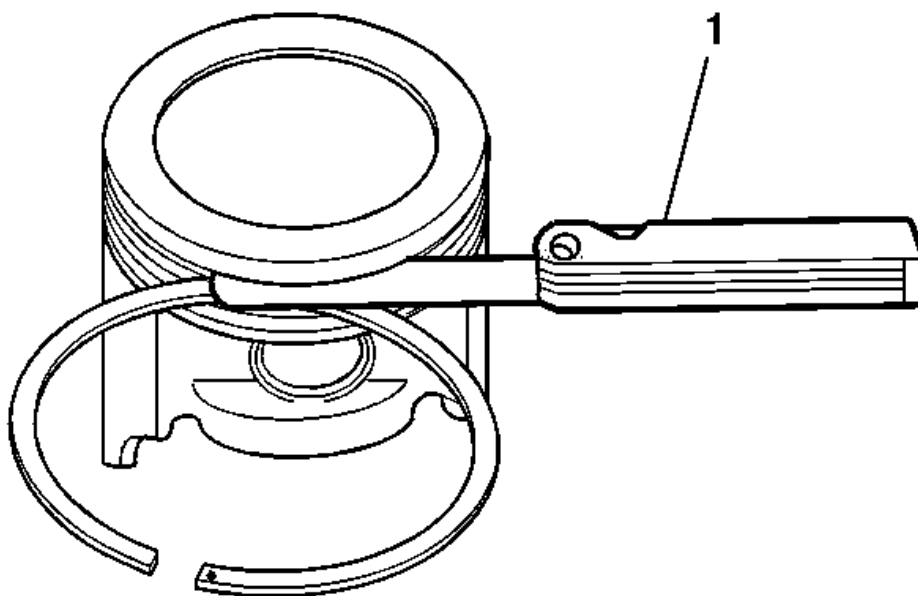


**Fig. 360: Measuring Piston Ring End Gap**  
Courtesy of GENERAL MOTORS COMPANY

6. Measure the piston ring end gap using the following procedure:
  1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by

positioning the ring with the piston head.

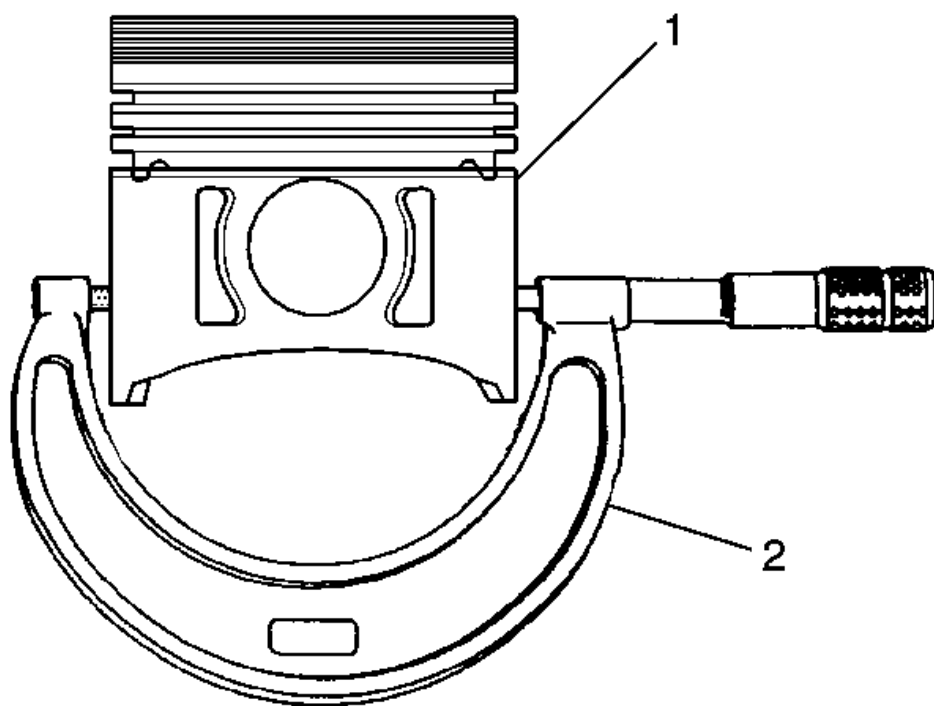
2. Measure the end gap of the piston ring with feeler gauges (1). Compare the measurements with those provided below:
  - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
  - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
  - The oil ring end gap should be 0.25-0.76 mm (0.0098-0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.



**Fig. 361: Measuring Piston Ring Side Clearance**  
Courtesy of GENERAL MOTORS COMPANY

7. Measure the piston ring side clearance using the following procedure:
  1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
  2. With the piston ring on the piston, use feeler gauges (1) to check clearance at multiple locations.

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



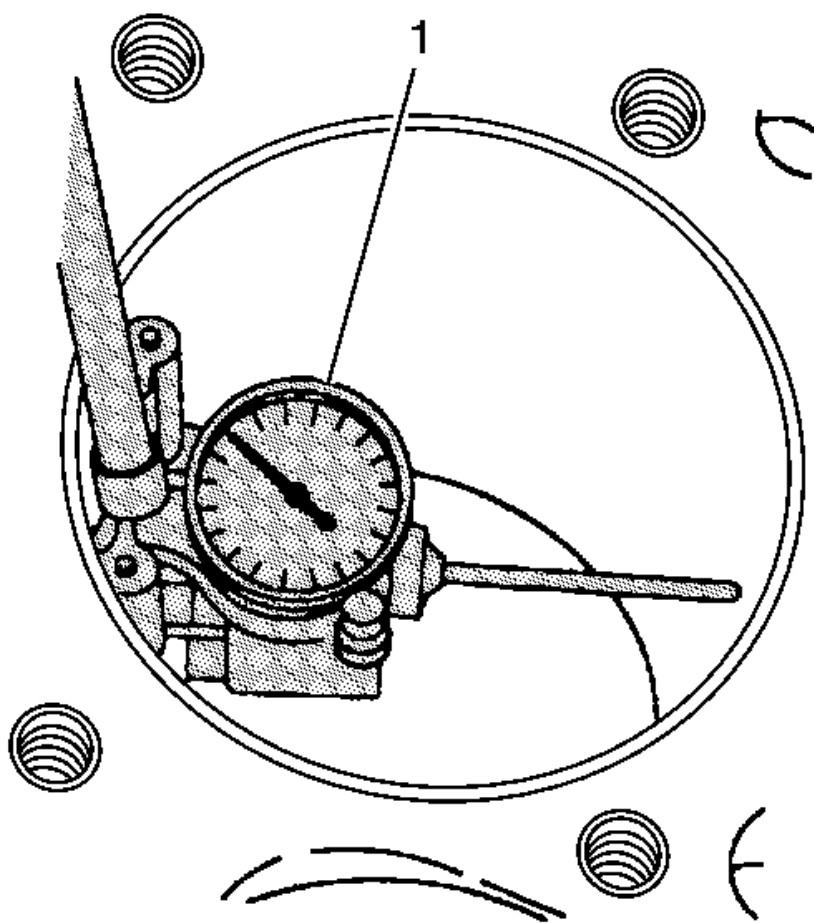
**Fig. 362: Measuring Piston Width**

Courtesy of GENERAL MOTORS COMPANY

11. Measure piston width using the following procedure:

1. Using an outside micrometer (2), measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
  2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
  3. The proper clearance specification for the piston is 0.010-0.041 mm (0.0006-0.0016 in).
12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston (1).

#### Piston Selection



**Fig. 363: Measuring Cylinder Bore**

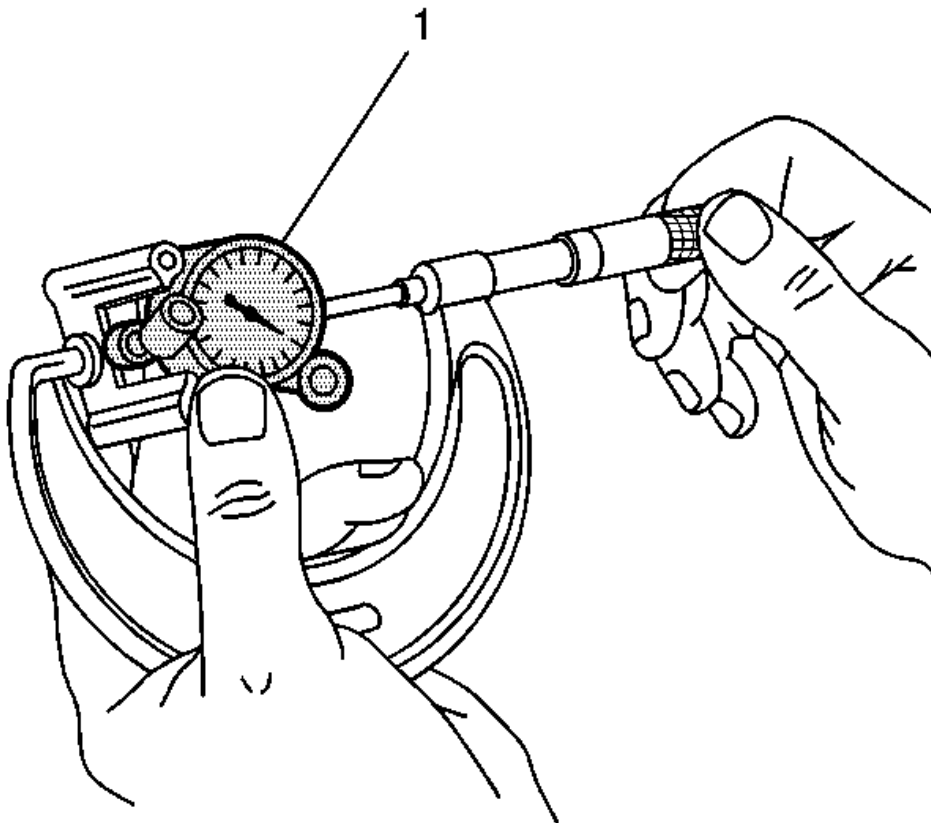
Courtesy of GENERAL MOTORS COMPANY

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

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

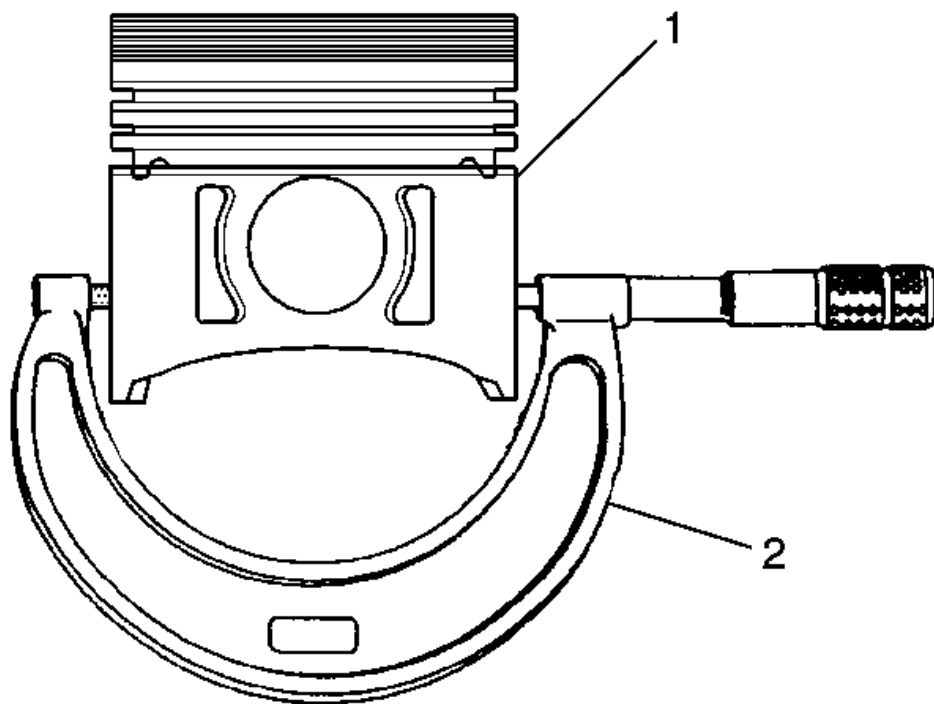
**A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.**

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



**Fig. 364: Measuring Bore Gauge**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 365: Measuring Piston Width**

Courtesy of GENERAL MOTORS COMPANY

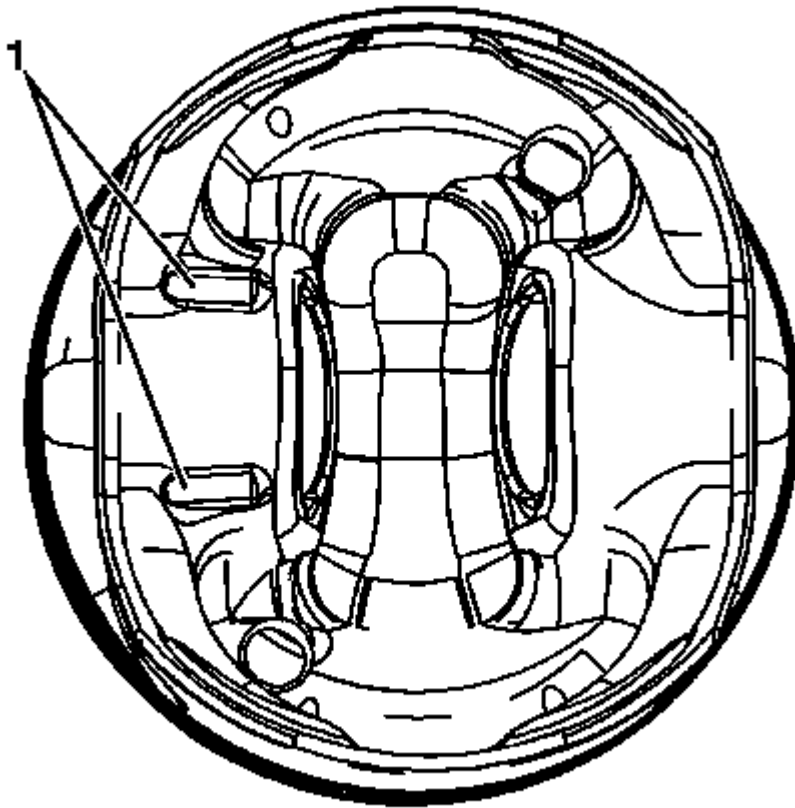
5. With a micrometer (2) or caliper at a right angle to the piston (1), measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine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

## PISTON AND CONNECTING ROD ASSEMBLE

### Special Tools

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

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

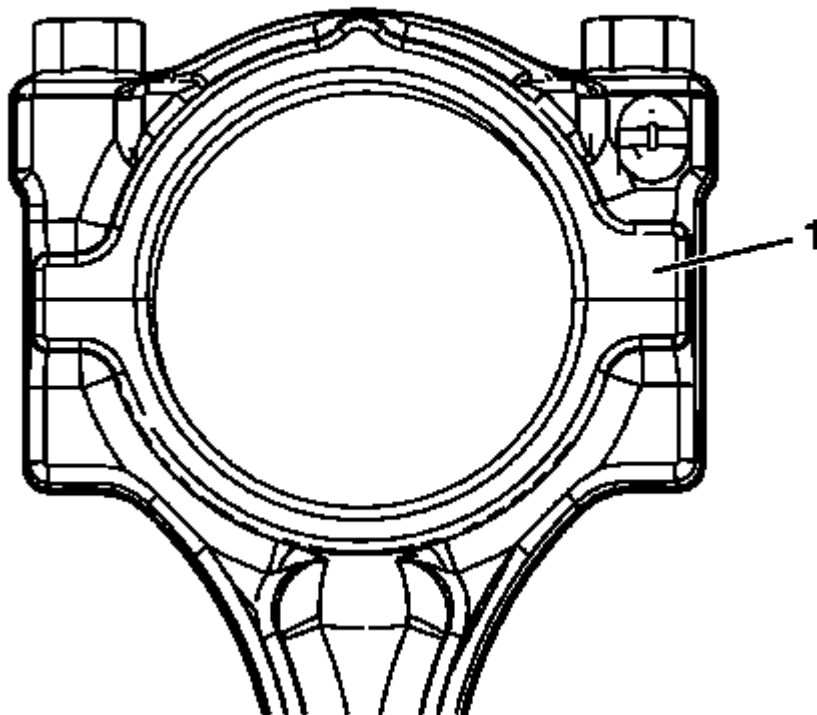


**Fig. 366: Locating "Cast Boss" On Underside of Piston**  
Courtesy of GENERAL MOTORS COMPANY

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

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

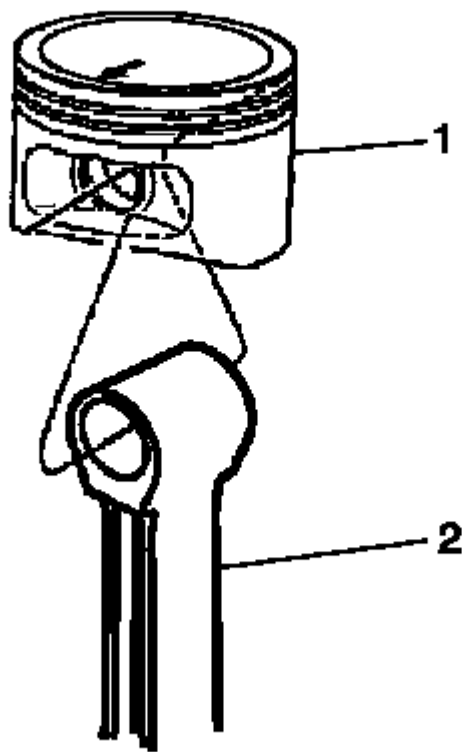
1. The cast boss (1), on the underside of the piston, must go to the rear of the block.



**Fig. 367: Identifying Cast Mark**

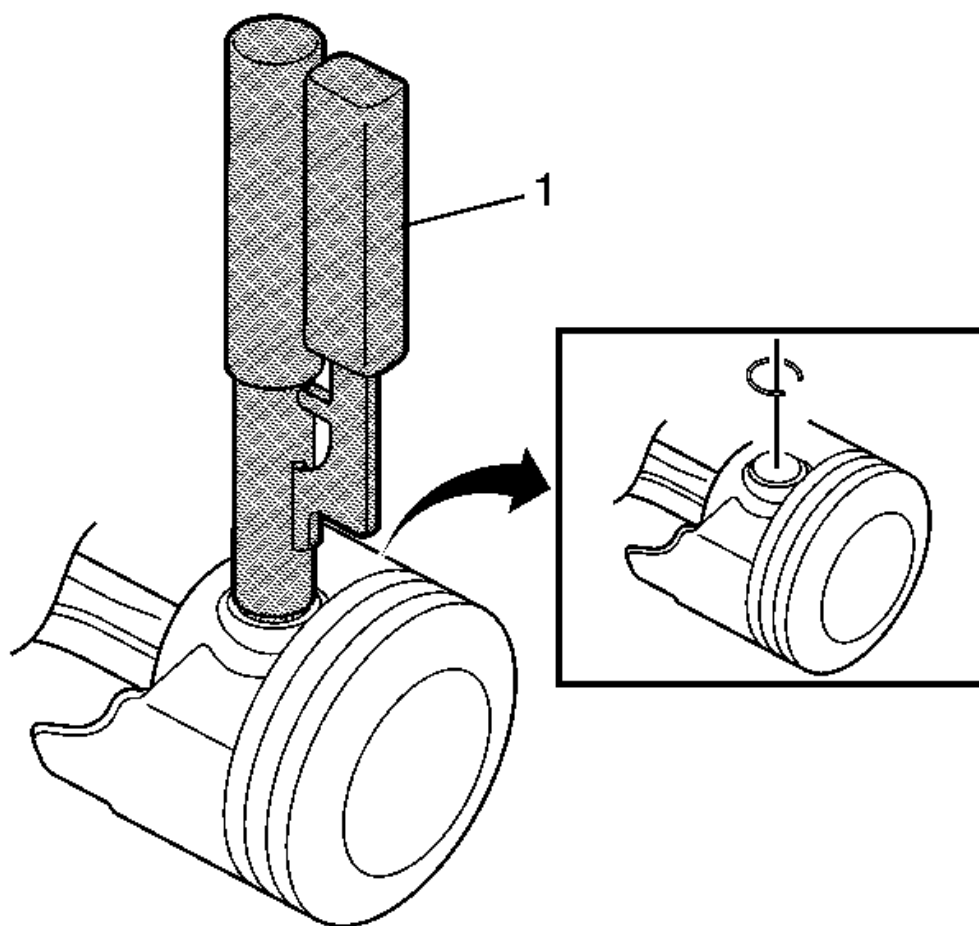
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 368: View of Connecting Rod and Piston**  
**Courtesy of GENERAL MOTORS COMPANY**

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



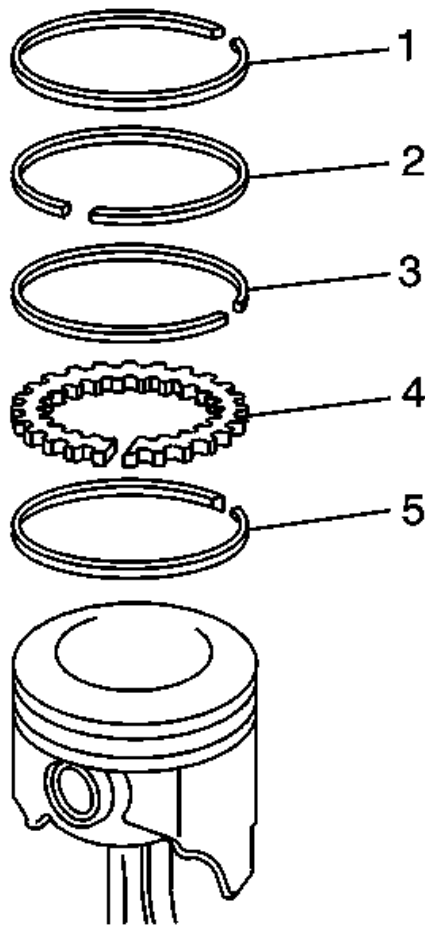
**Fig. 369: View of Piston Pin Retainers**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

4. Install the second piston pin retainer, using **EN-46745** installer (1) .
5. Ensure that the piston moves freely.



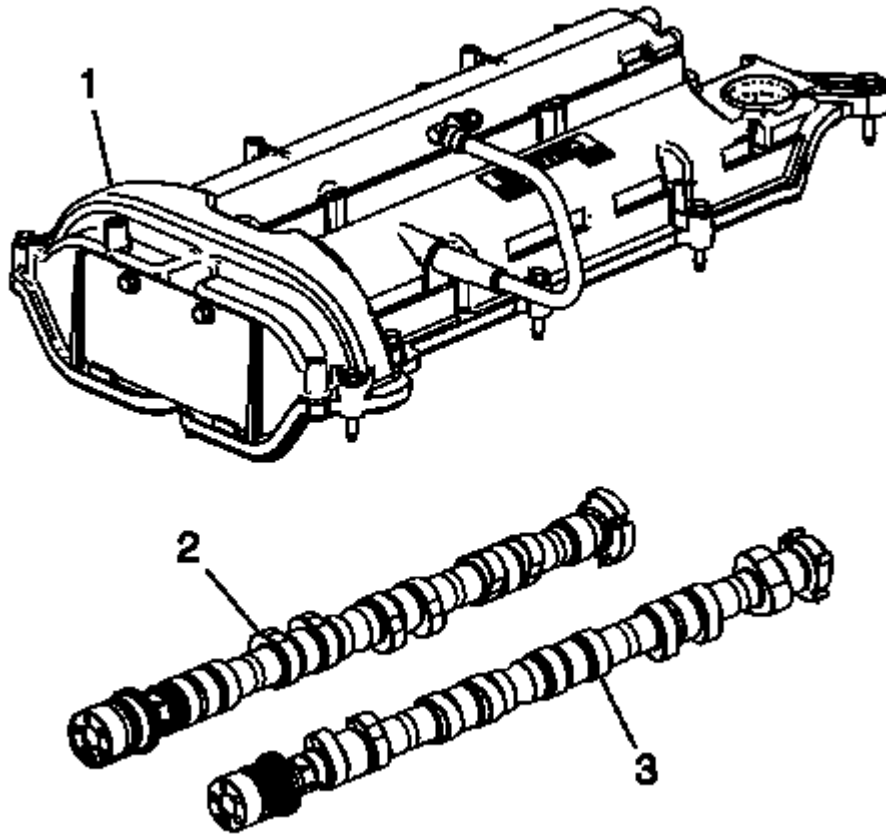
**Fig. 370: Identifying Piston Rings**

Courtesy of GENERAL MOTORS COMPANY

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

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

## CAMSHAFT CLEANING AND INSPECTION (LEA)

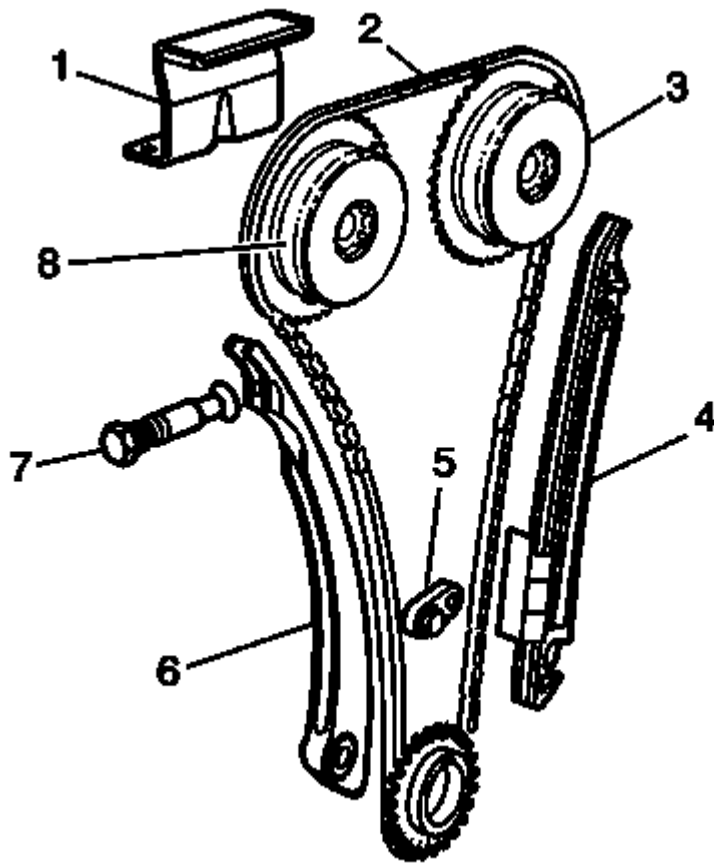


**Fig. 371: Camshaft Cover And Camshafts**

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft journals and lobes for wear or scoring.
2. Inspect the camshaft sprocket alignment notch for damage.
3. Inspect the camshaft cover (1) for damage or loose oil control baffles.
4. Clean the camshaft cover.
5. Wash the camshafts (2, 3) in solvent.
6. Oil the camshafts.
7. Inspect the camshaft cover for cracks or other signs of damage.

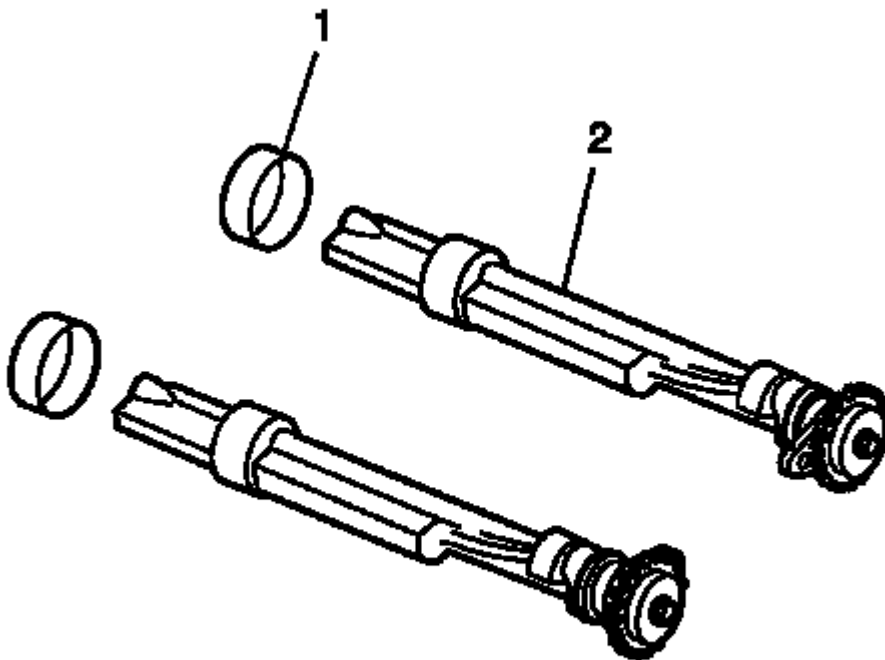
## CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION



**Fig. 372: Locating Timing Chain Guides**

Courtesy of GENERAL MOTORS COMPANY

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

**BALANCE SHAFT CLEANING AND INSPECTION****Fig. 373: Balance Shafts**

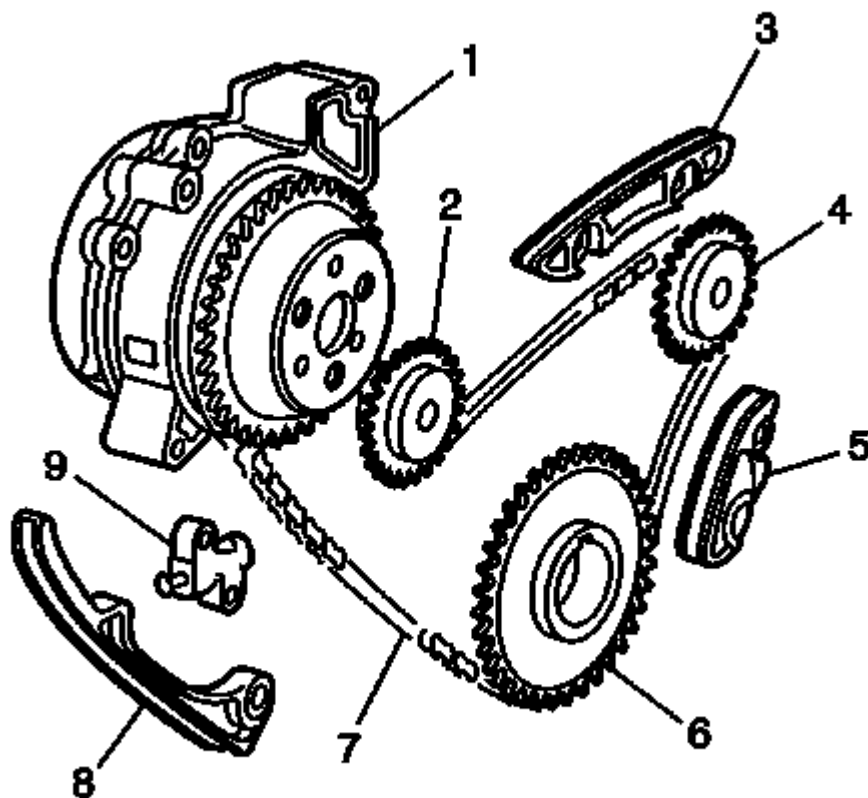
Courtesy of GENERAL MOTORS COMPANY

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

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

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

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



**Fig. 374: Water Pump, Balance Shaft Chain And Sprocket**  
 Courtesy of GENERAL MOTORS COMPANY

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

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

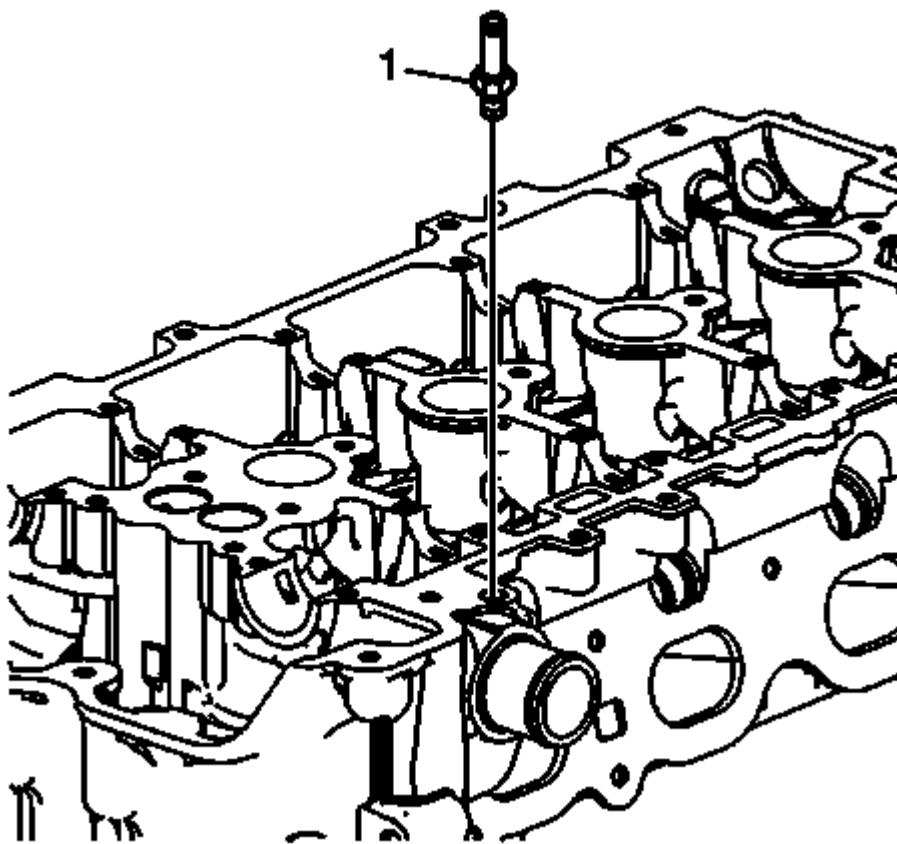
4. Inspect the balance shaft drive chain (7) and sprockets (2, 4) for wear.
5. Inspect the crankshaft sprocket (6) faces for signs of movement.
6. Inspect the alignment notch in the balance shaft for cracking or damage.
7. Inspect the water pump (1), crankshaft, and balance shaft sprocket teeth and chain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

#### CYLINDER HEAD DISASSEMBLE (LEA)

### Special Tools

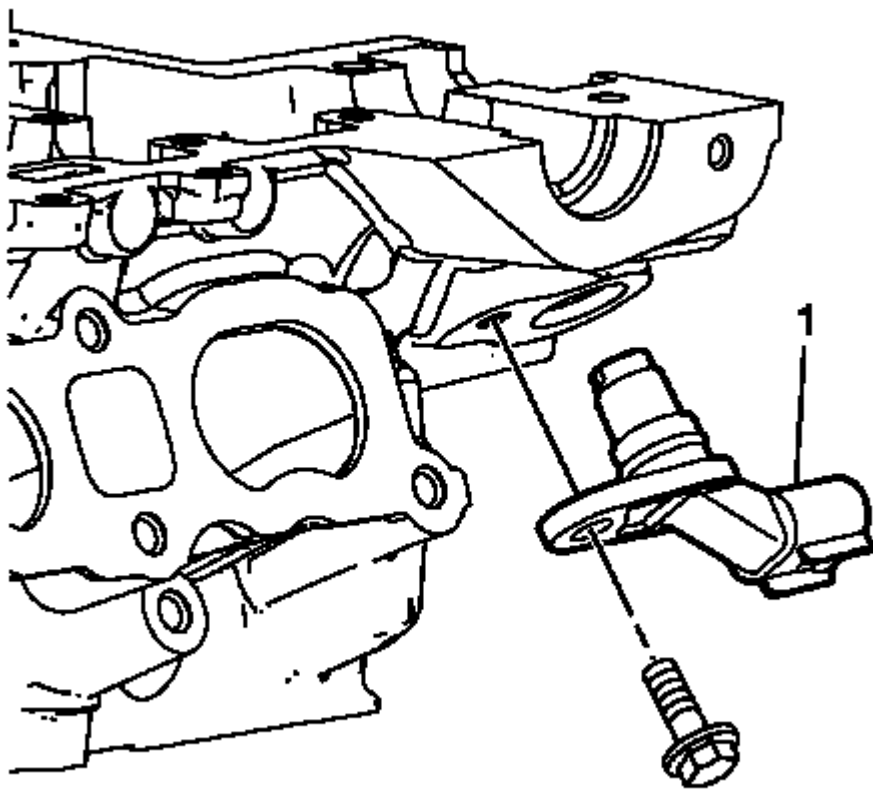
- **EN-8062** Valve Spring Compressor
- **EN-36017** Valve Seal Remover
- **EN-43963** Valve Spring Compressor (off car)

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



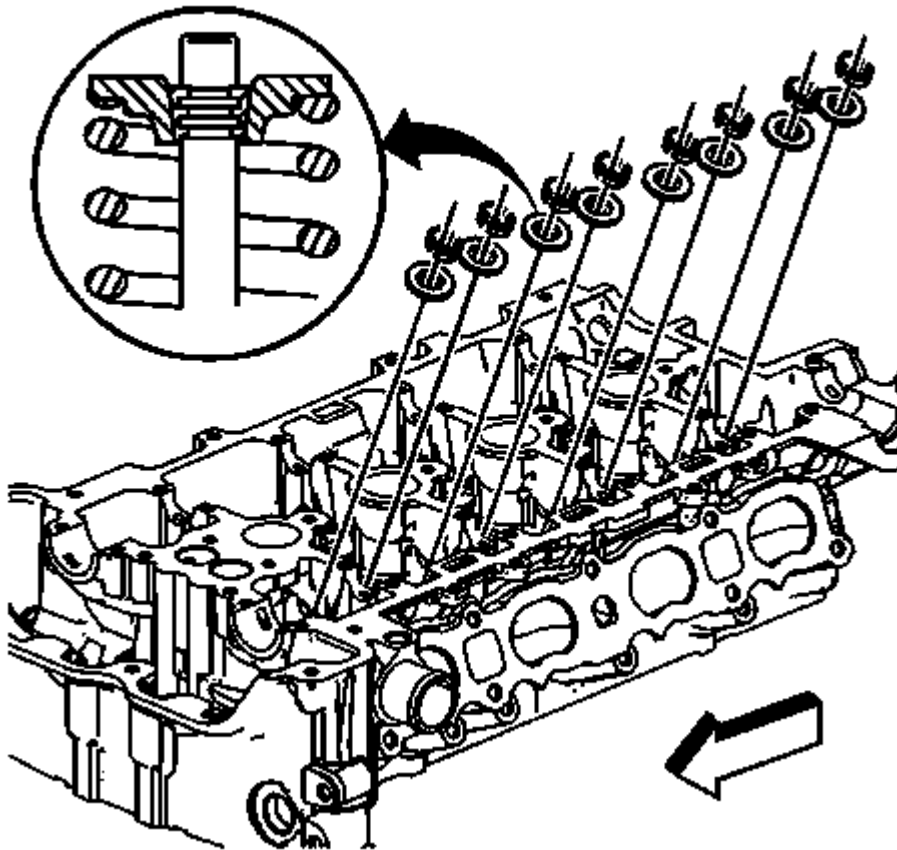
**Fig. 375: Identifying Coolant Air Bleed Hose Fitting**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 376: Intake Camshaft Position Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 377: Valve Train Components**  
Courtesy of GENERAL MOTORS COMPANY

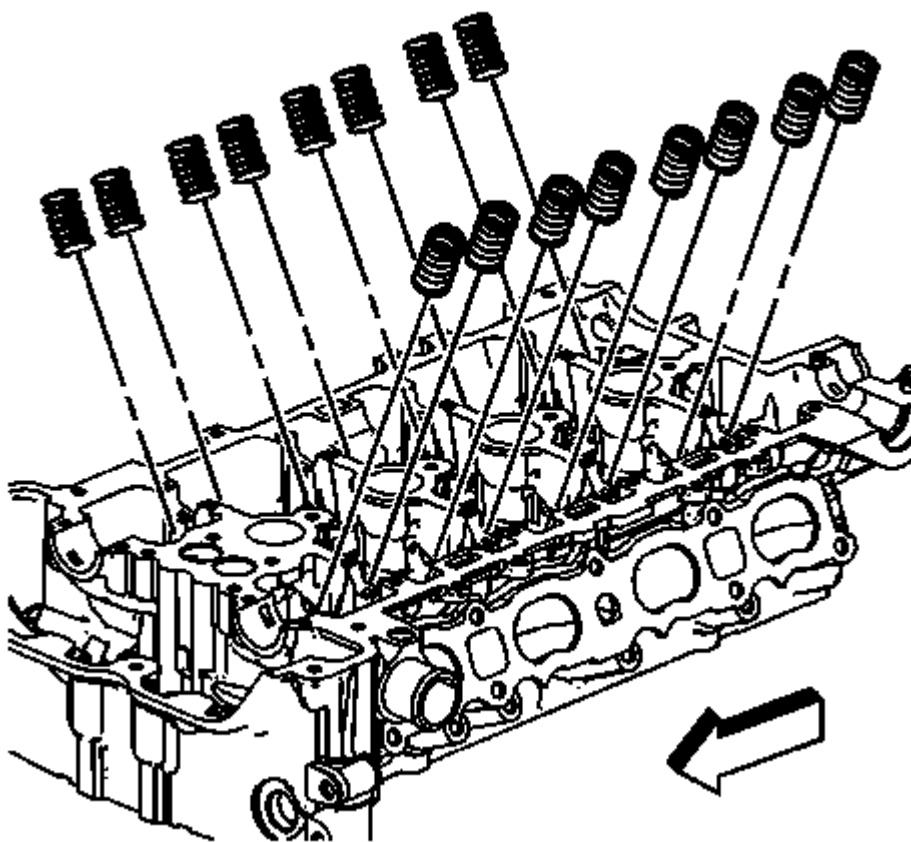
**WARNING:** Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

**CAUTION:** Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

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

3. Perform the following procedure to remove the valve keys, springs, and retainers:
  1. Using the **EN-8062** compressor and the **EN-43963** compressor , compress the valve spring.

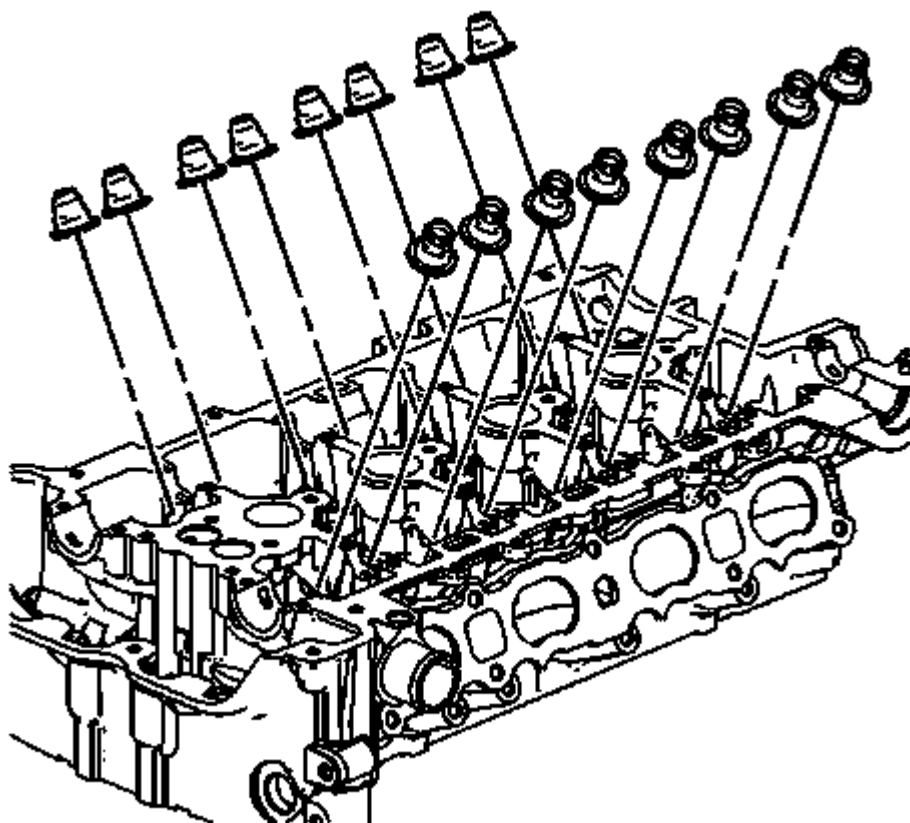
2. Remove the valve keys.
3. Slowly release the **EN-8062** compressor and the **EN-43963** compressor from the valve spring assembly.
4. Remove the retainer.



**Fig. 378: Valve Springs**

Courtesy of GENERAL MOTORS COMPANY

4. Remove the springs.

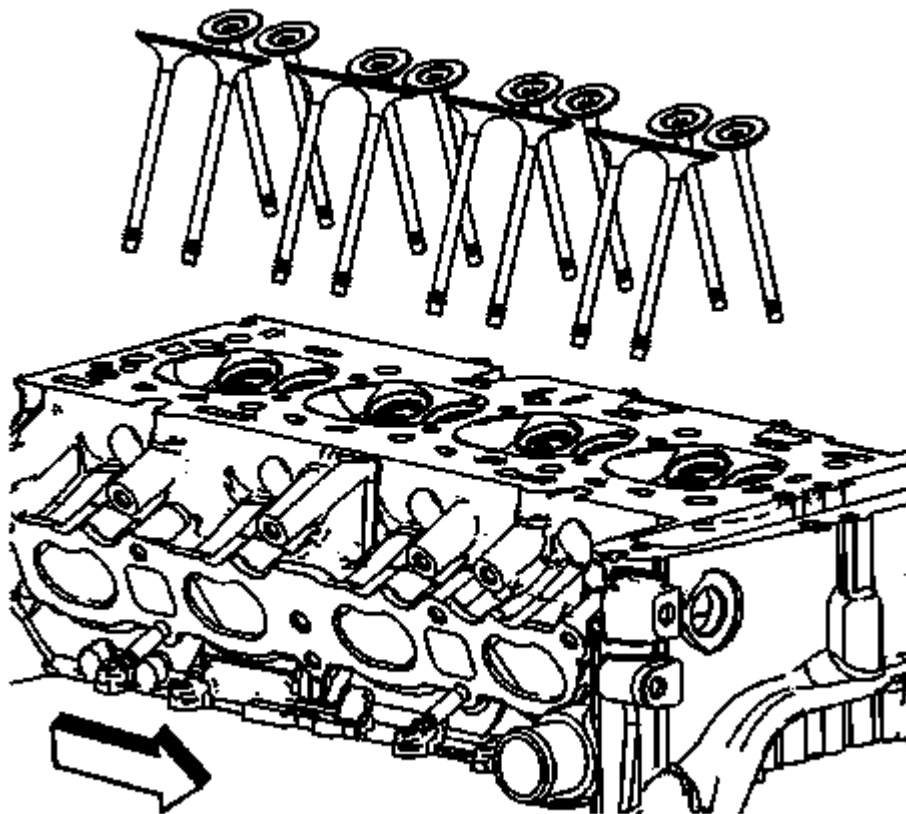


**Fig. 379: Valve Guides**

Courtesy of GENERAL MOTORS COMPANY

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

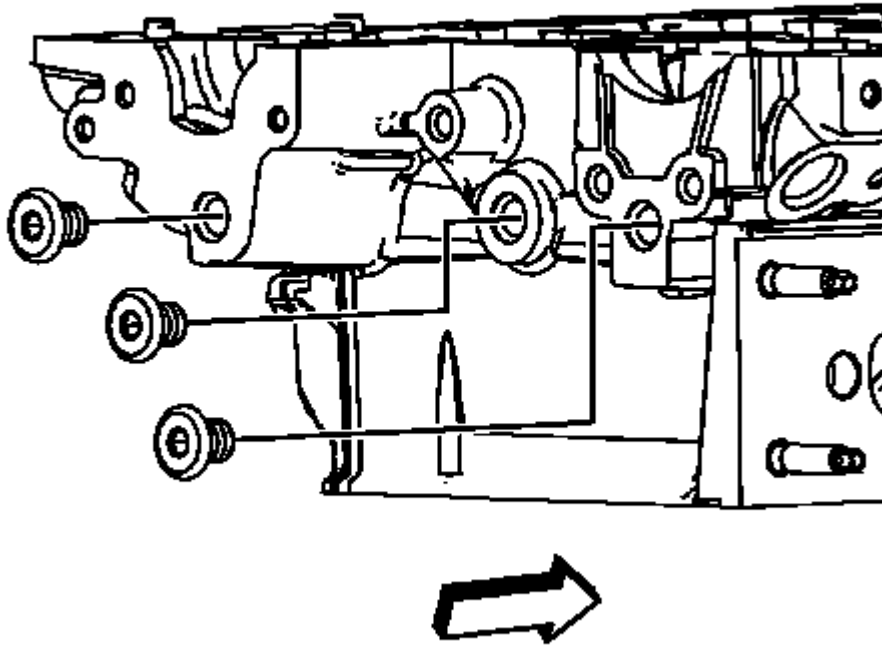
5. Using **EN-36017** remover , remove the valve seals. Discard the seals, do not reuse.



**Fig. 380: View Of Valves**

Courtesy of GENERAL MOTORS COMPANY

6. Remove the valves.



**Fig. 381: Cylinder Head Plugs**

Courtesy of GENERAL MOTORS COMPANY

7. Remove the cylinder head plugs.

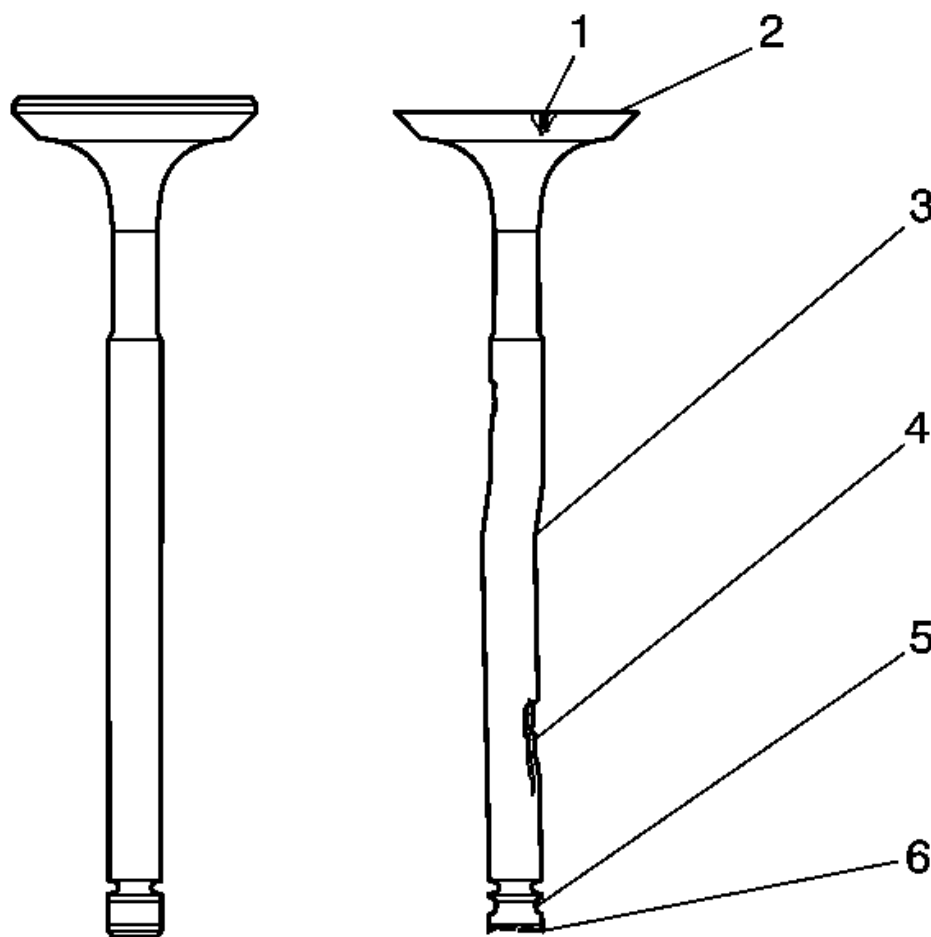
## CYLINDER HEAD CLEANING AND INSPECTION (LEA)

### Special Tools

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

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

### Valve Cleaning and Inspection



**Fig. 382: Valve Inspection Areas**

Courtesy of GENERAL MOTORS COMPANY

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

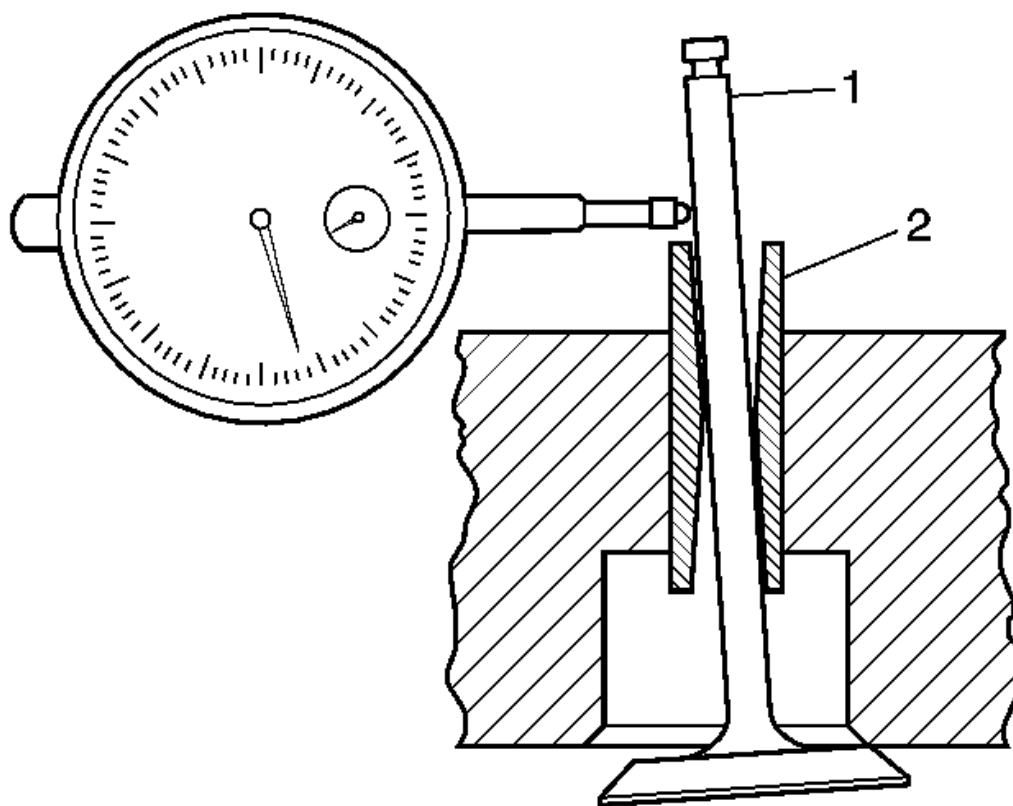
**NOTE:** Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

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

stone.

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

#### Valve Guide Measurement



**Fig. 383: Inspecting For Excessive Valve Stem To Guide Clearance**  
Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **GE 7872** dial indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications (LEA)** for proper clearance.

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

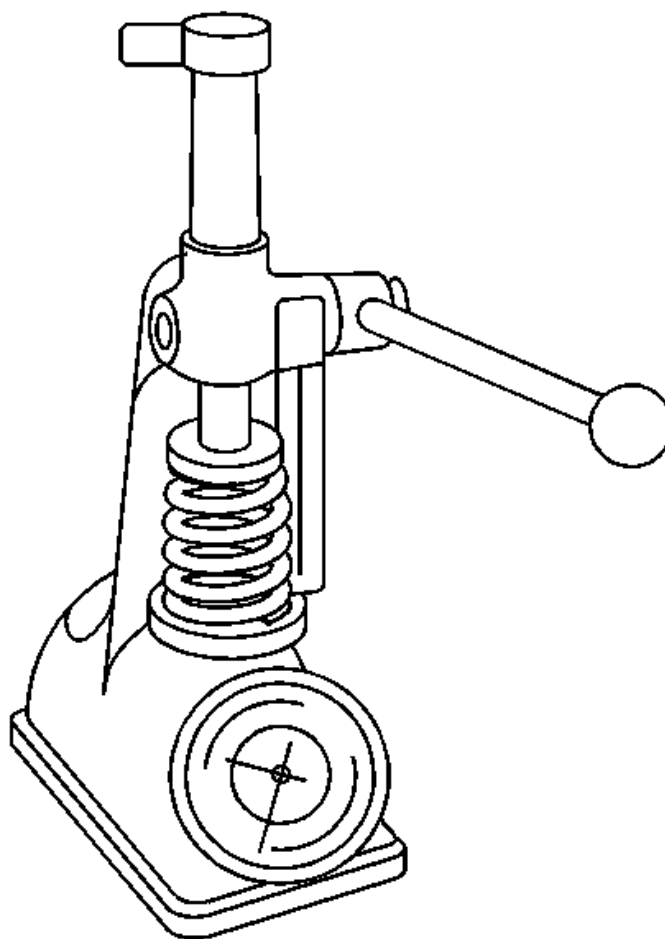
6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

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

1. Clean the valve springs in solvent.

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

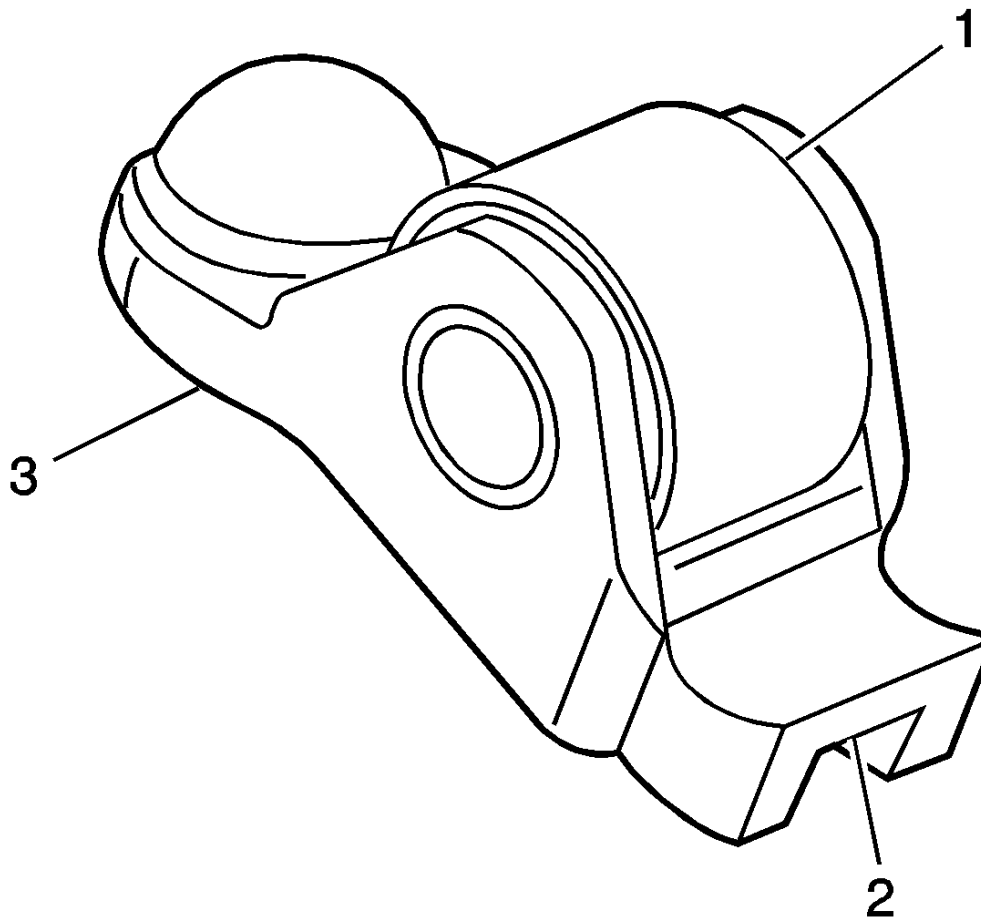
2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.



**Fig. 384: Measuring Valve Spring Tension**  
Courtesy of GENERAL MOTORS COMPANY

4. Measure the valve spring tension using the **EN 22738-B** tester. Refer to **Engine Mechanical Specifications (LEA)**
5. If low valve spring load is found, replace the valve springs. **DO NOT** use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

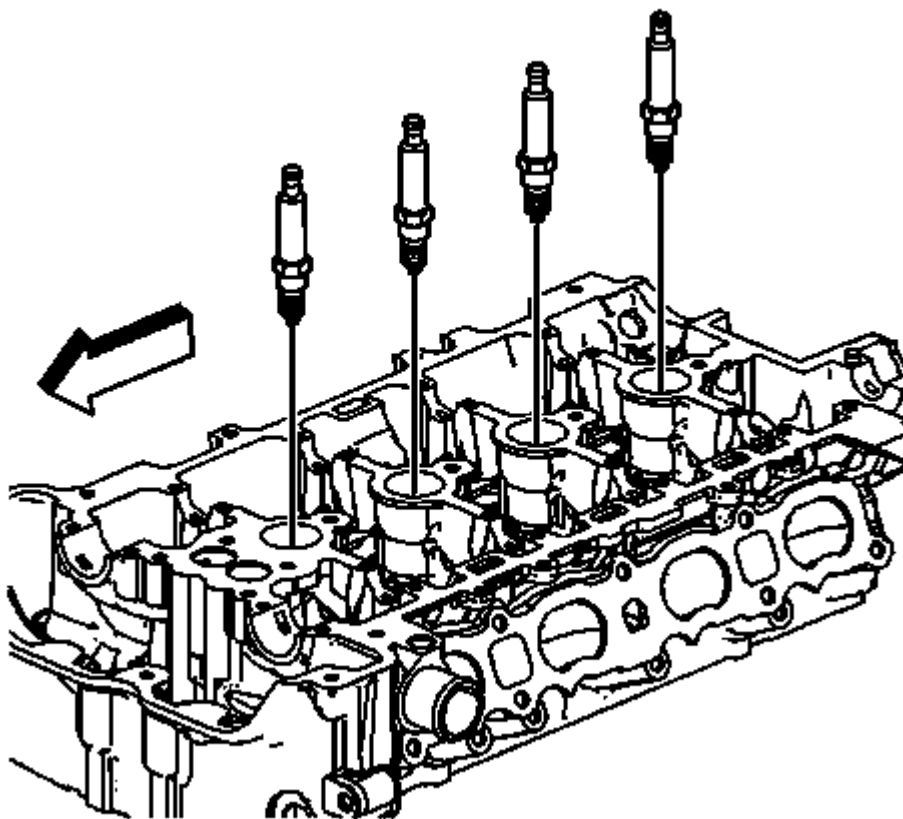
#### **Valve Rocker Arm Cleaning and Inspection**



**Fig. 385: Inspecting Valve Rocker Arms**  
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft follower roller (1) for the following:
  - Flat spots
  - Excessive scoring and pitting
  - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

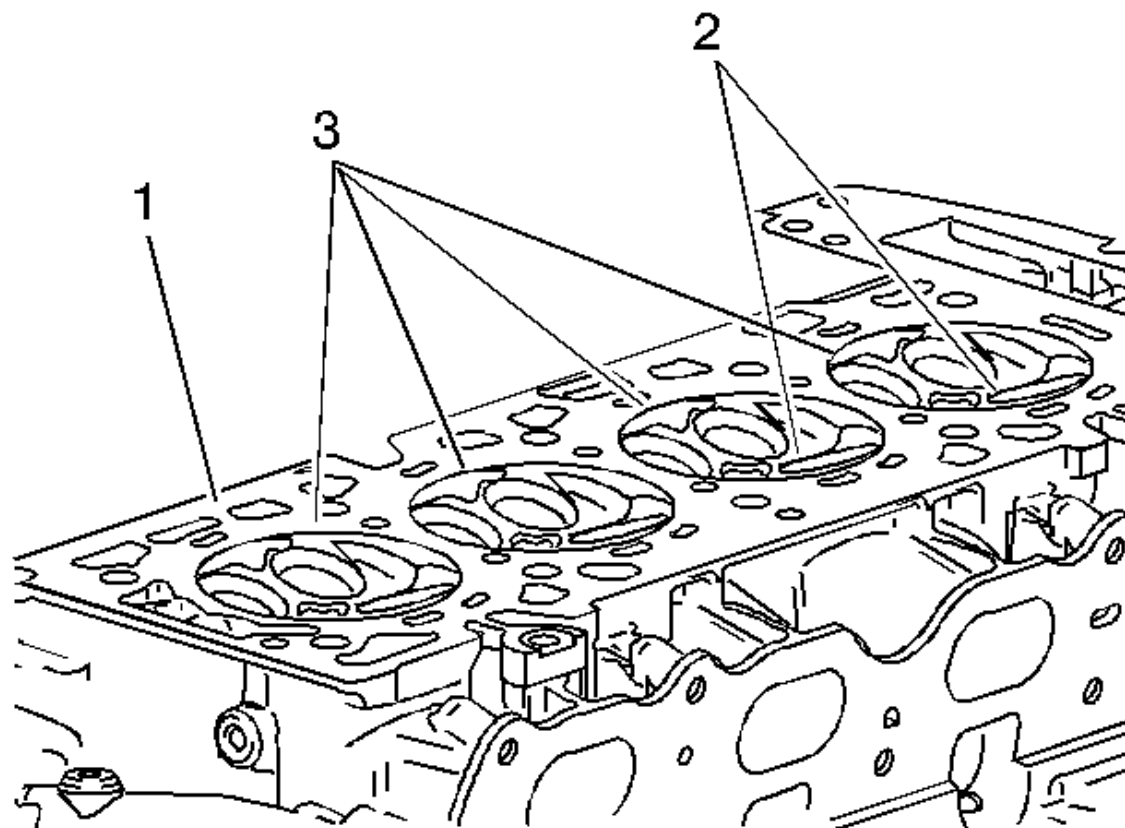
#### Cylinder Head and Gasket Surface Cleaning and Inspection



**Fig. 386: Spark Plugs**

Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 387: Locating Combustion Chambers**  
Courtesy of GENERAL MOTORS COMPANY

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

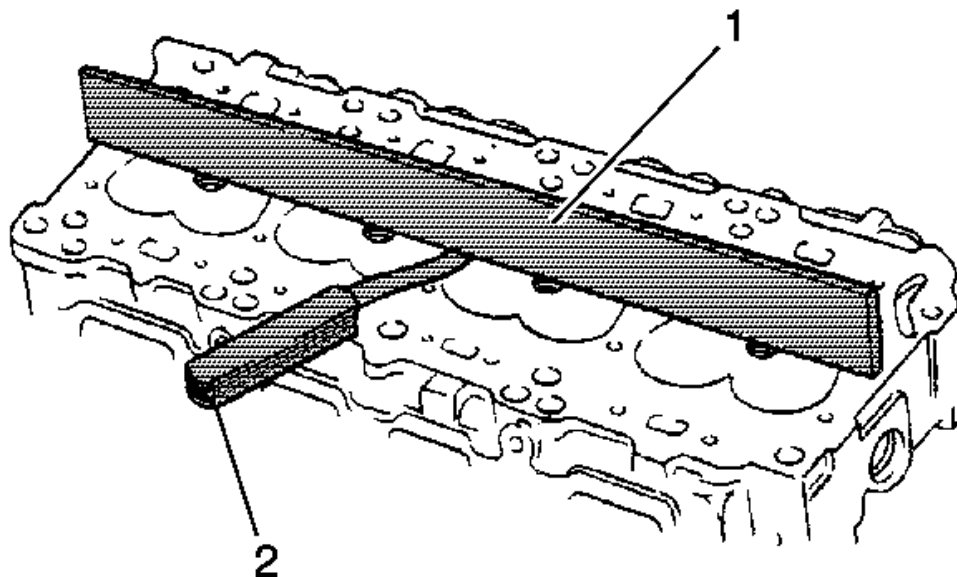
**NOTE:** Do not use a wire brush on any gasket sealing surface.

5. Remove the sealant from the rear cap mating surface with **EN-28410** remover. Care must be used to avoid gouging or scraping the sealing surfaces.

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

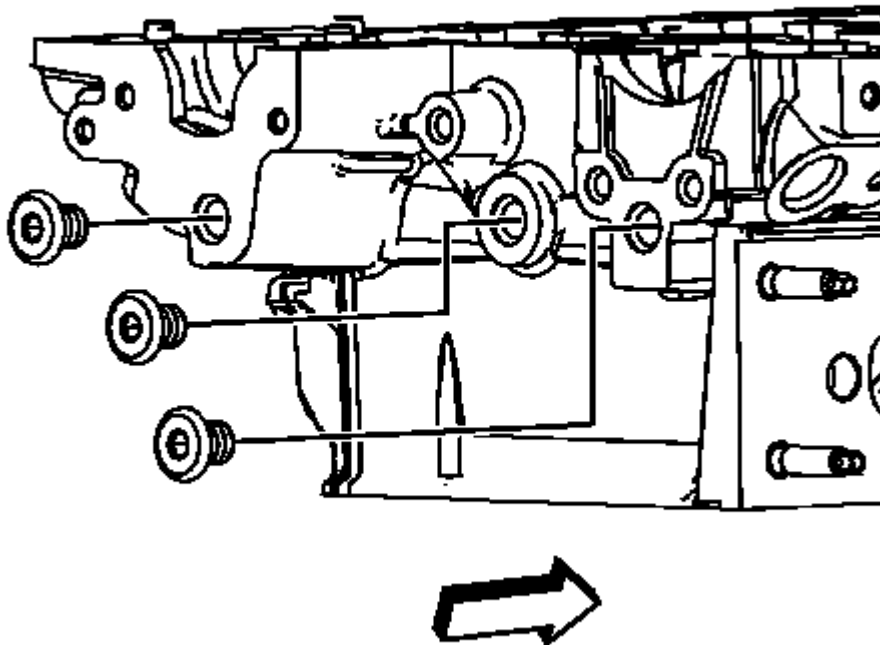
**NOTE:** Do not attempt to weld the cylinder head, replace it.

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



**Fig. 388: Checking Cylinder Head Deck Surface For Flatness**  
Courtesy of GENERAL MOTORS COMPANY

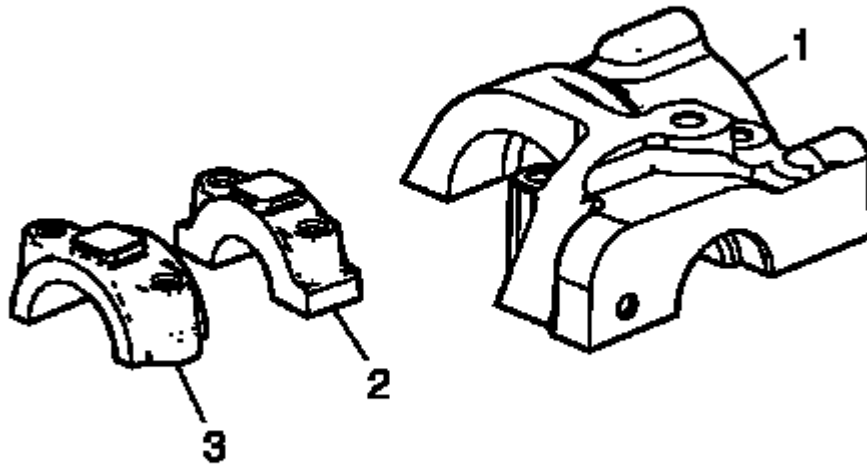
14. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications (LEA)**. If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
15. Inspect all the threaded holes for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



**Fig. 389: Cylinder Head Plugs**

Courtesy of GENERAL MOTORS COMPANY

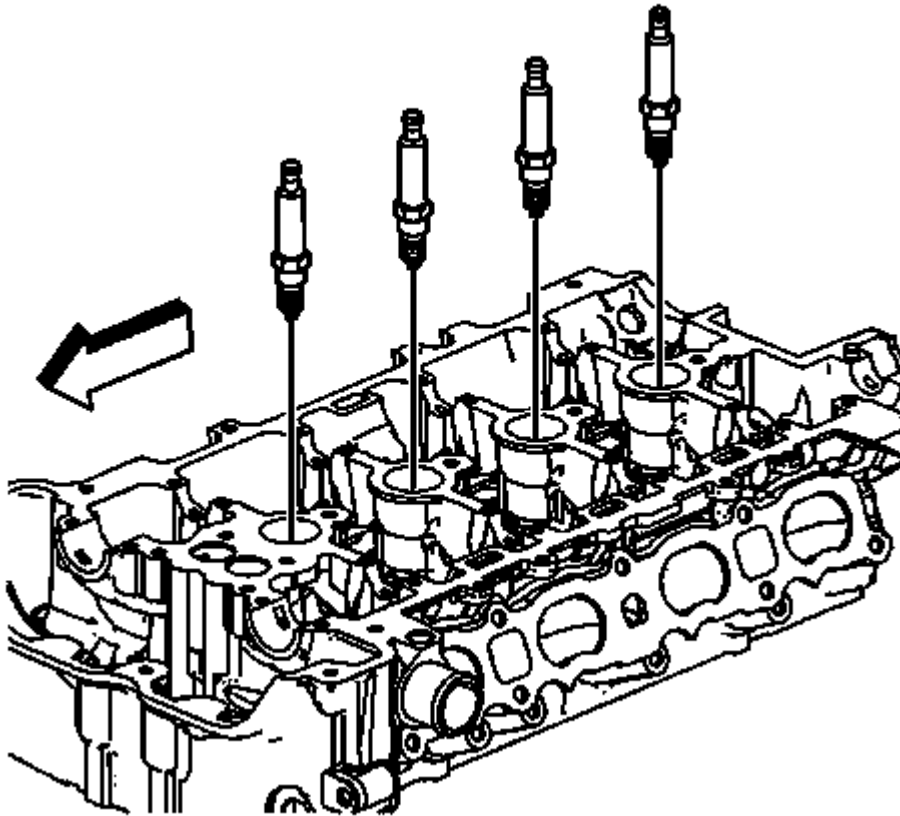
17. Inspect the cylinder head plugs and verify the oil orifice is clear and free of debris.



**Fig. 390: Bearing Caps**

Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 391: Spark Plugs**

Courtesy of GENERAL MOTORS COMPANY

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

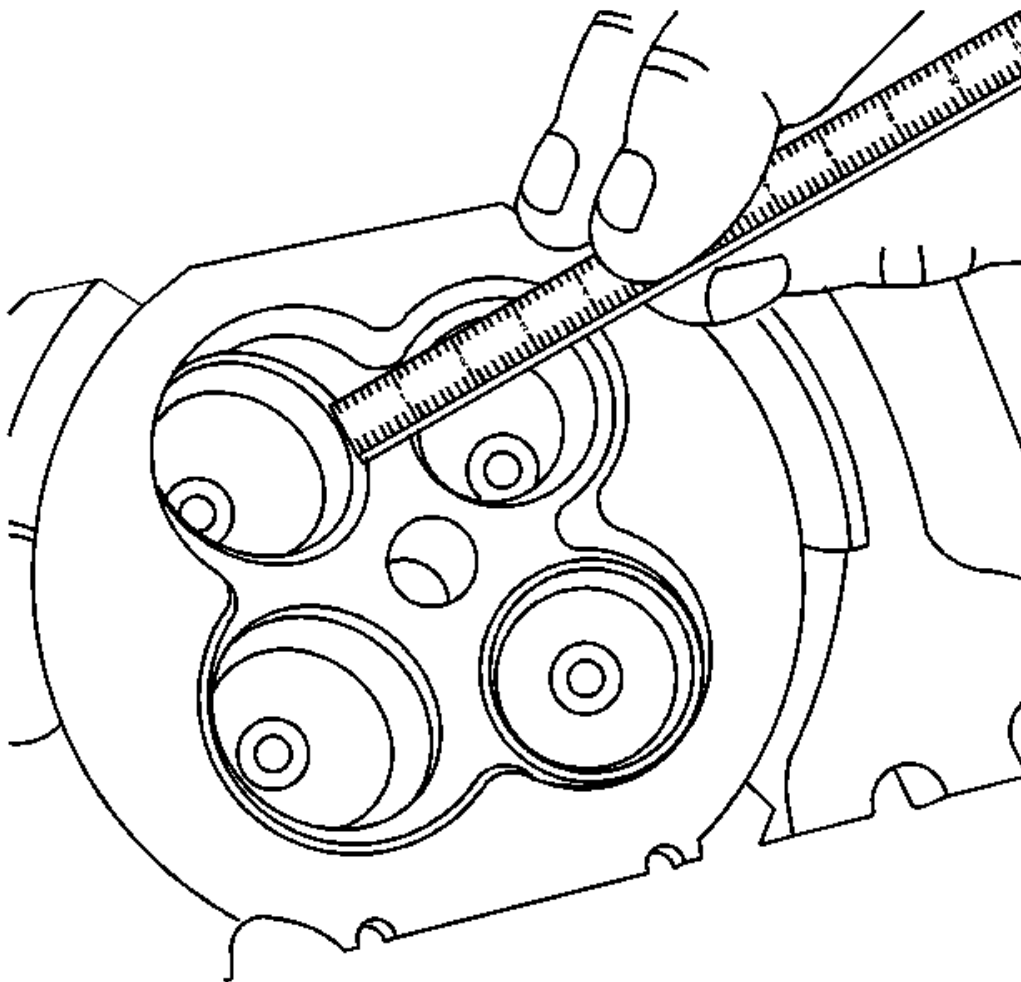
23. Install the spark plugs. Tighten the plugs to 20 N.m (15 lb ft).

## VALVE AND SEAT GRINDING

### Valve Measurement and Reconditioning Overview

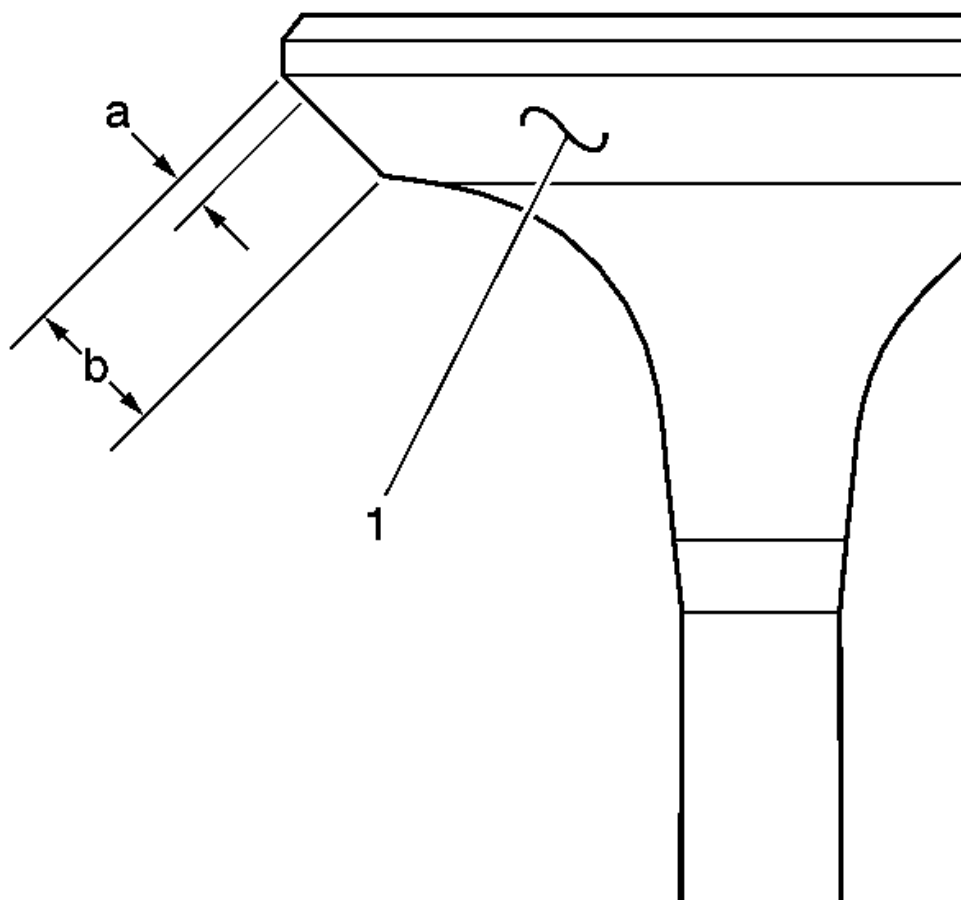
- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement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

### Valve Seat Width Measurement Procedure



**Fig. 392: Checking Valve Seat Width**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 393: Valve Face Seat Width**

Courtesy of GENERAL MOTORS COMPANY

2. Measure the seat width (b) on the valve face (1) using a proper scale.

**NOTE:** The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in Engine Mechanical Specifications (LEA).
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

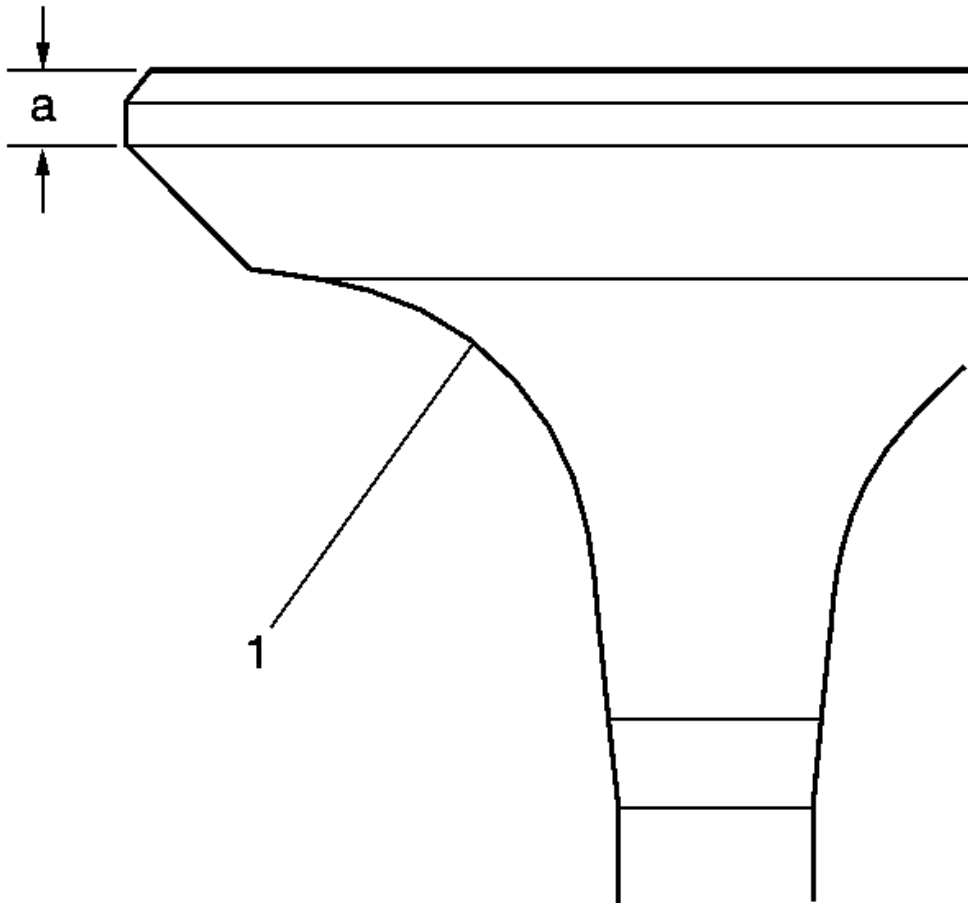
#### Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

**CAUTION:** The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

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

#### Valve Head O.D. and Chamfer Measurement Procedure



**Fig. 394: View Of Valve Head O.D. & Chamfer**  
Courtesy of GENERAL MOTORS COMPANY

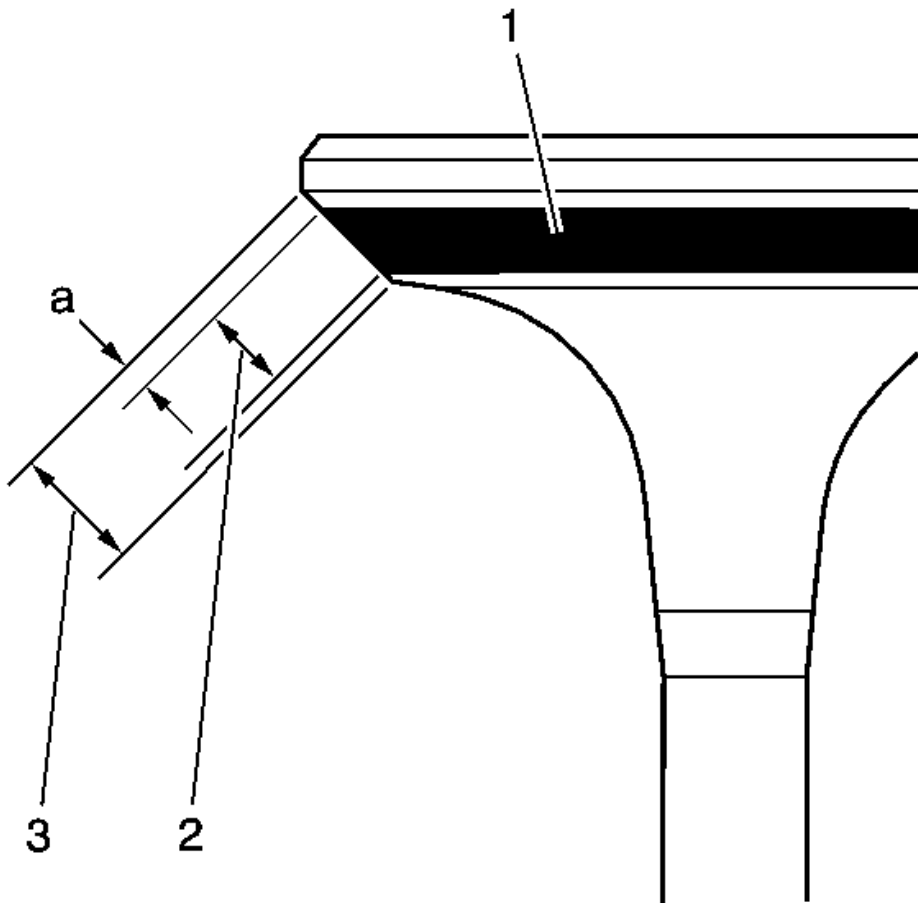
1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to Engine Mechanical Specifications (LEA).

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

#### Valve-to-Seat Concentricity Measurement Procedure

**NOTE:**

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.



**Fig. 395: Inspecting Valve Face**

Courtesy of GENERAL MOTORS COMPANY

1. Coat the valve face (3) lightly with blue dye (1).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.

4. Remove the valve from the cylinder head.

5. Inspect the valve face.

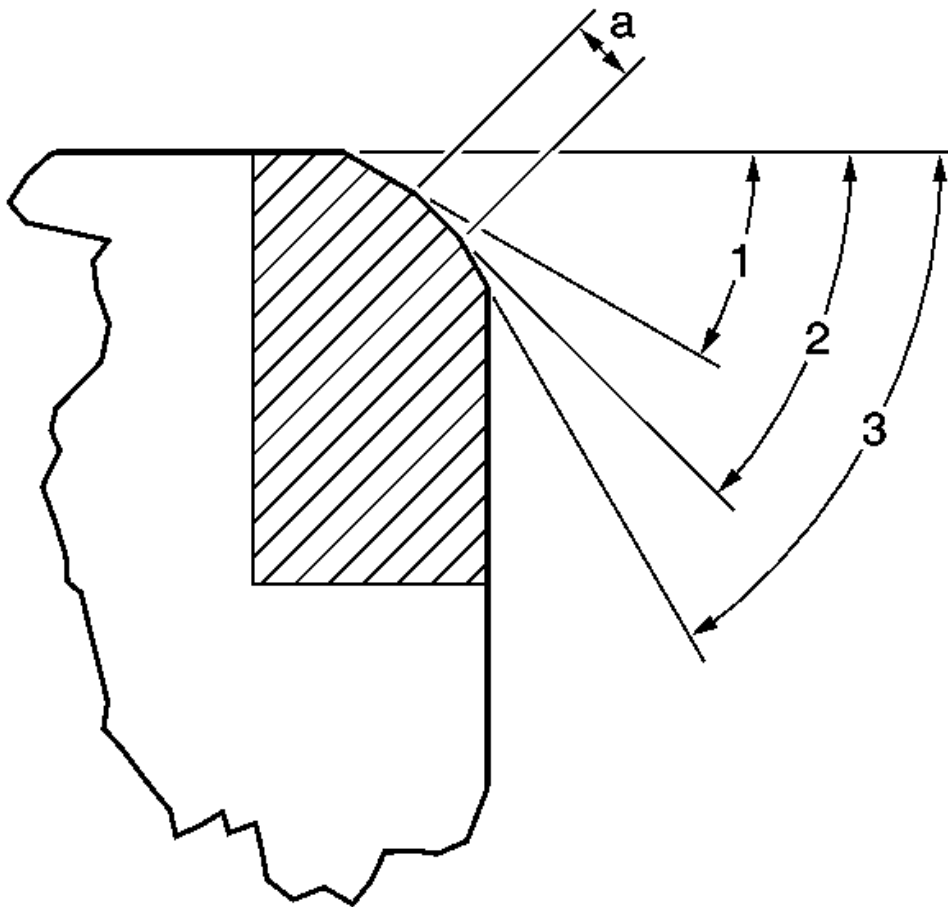
- If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

**NOTE:** The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

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

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

#### **Valve and Seat Reconditioning Procedure**



**Fig. 396: Valve Seating Surface Angle**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

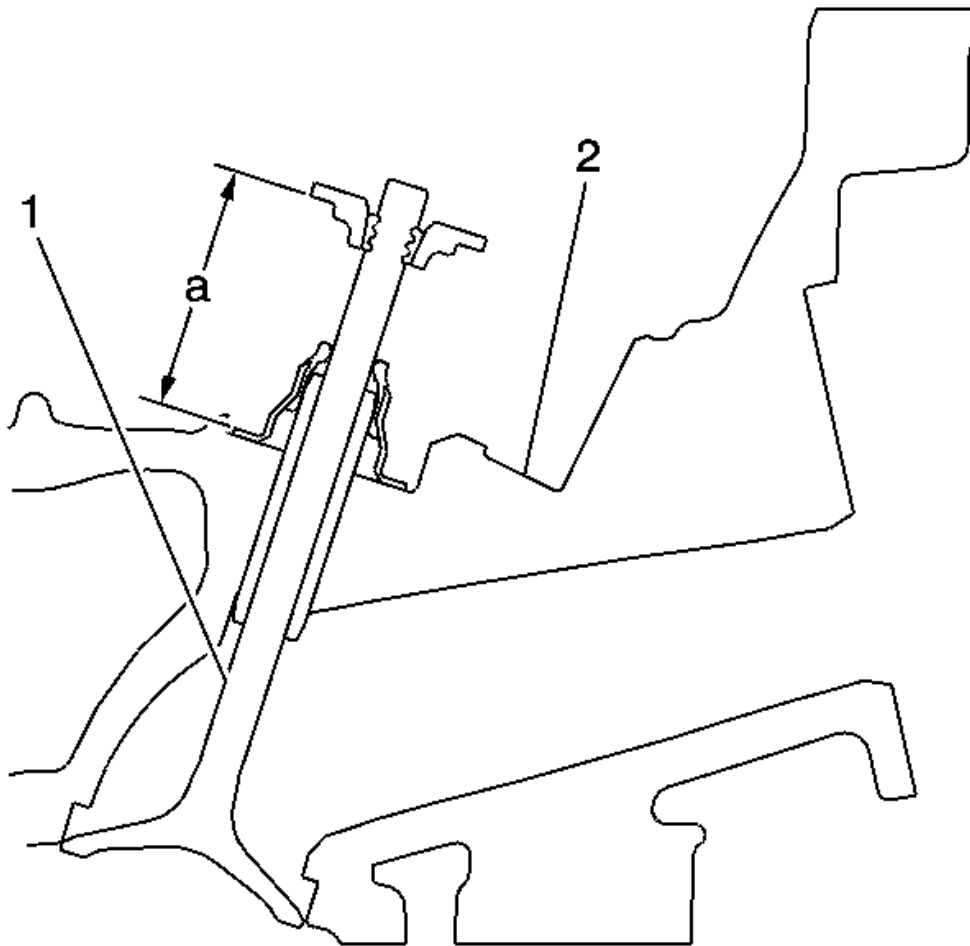
- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

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

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

4. Replace the intake valve if it is out of specification. Refer to **Engine Mechanical Specifications (LEA)**.
5. If the original exhaust valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications (LEA)**. Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
  - If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.
  - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

#### **Valve Stem Height Measurement Procedure**



**Fig. 397: Valve Stem Height Measurement**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

premature wear and possible engine damage.

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

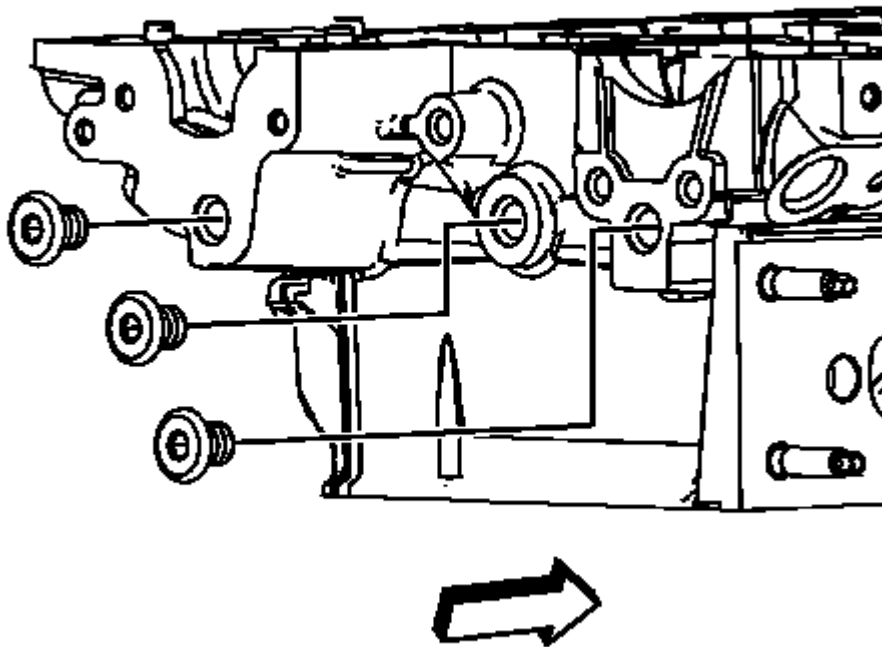
7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

## CYLINDER HEAD ASSEMBLY (LEA)

### Special Tools

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

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

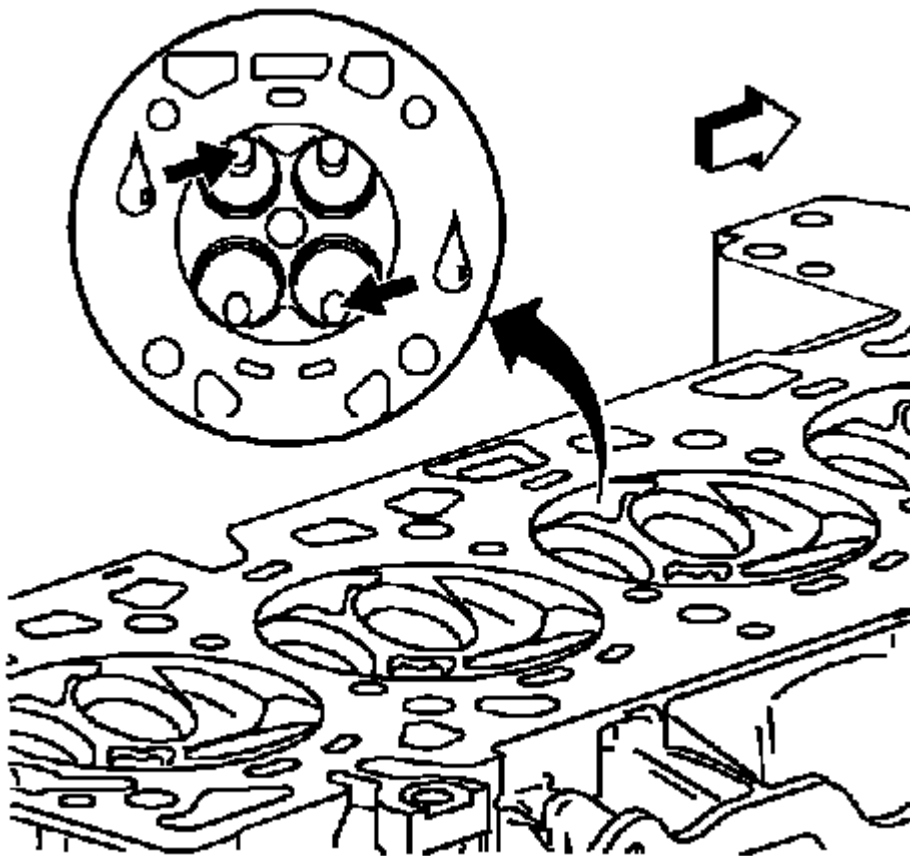


**Fig. 398: Cylinder Head Plugs**  
Courtesy of GENERAL MOTORS COMPANY

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

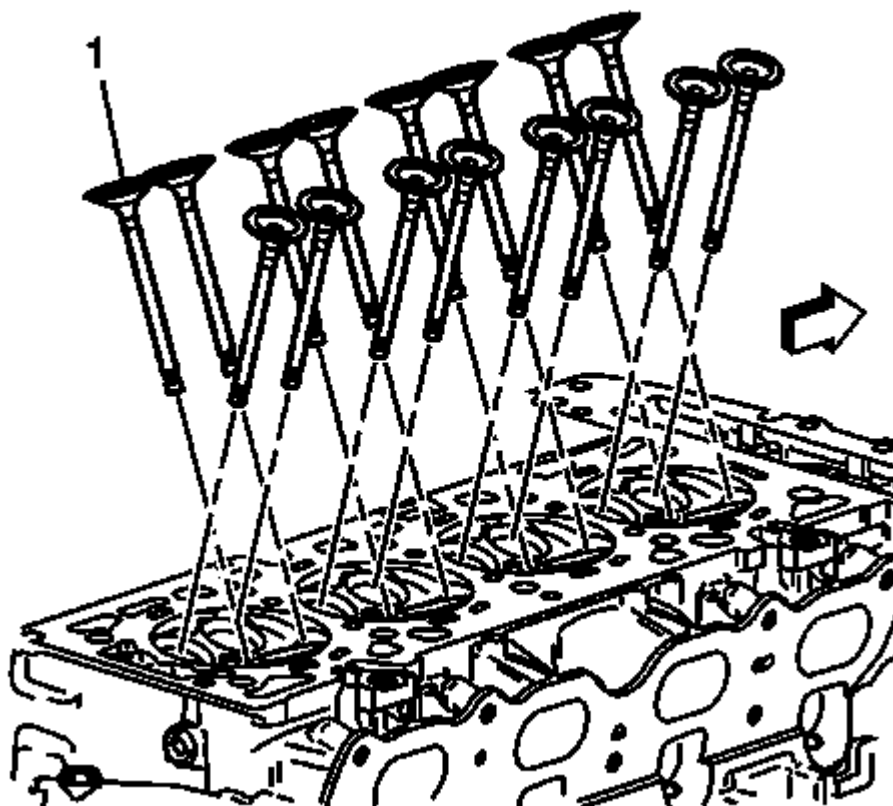
**CAUTION:** Refer to Component Fastener Tightening Caution .

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



**Fig. 399: Applying Prussian Blue**  
Courtesy of GENERAL MOTORS COMPANY

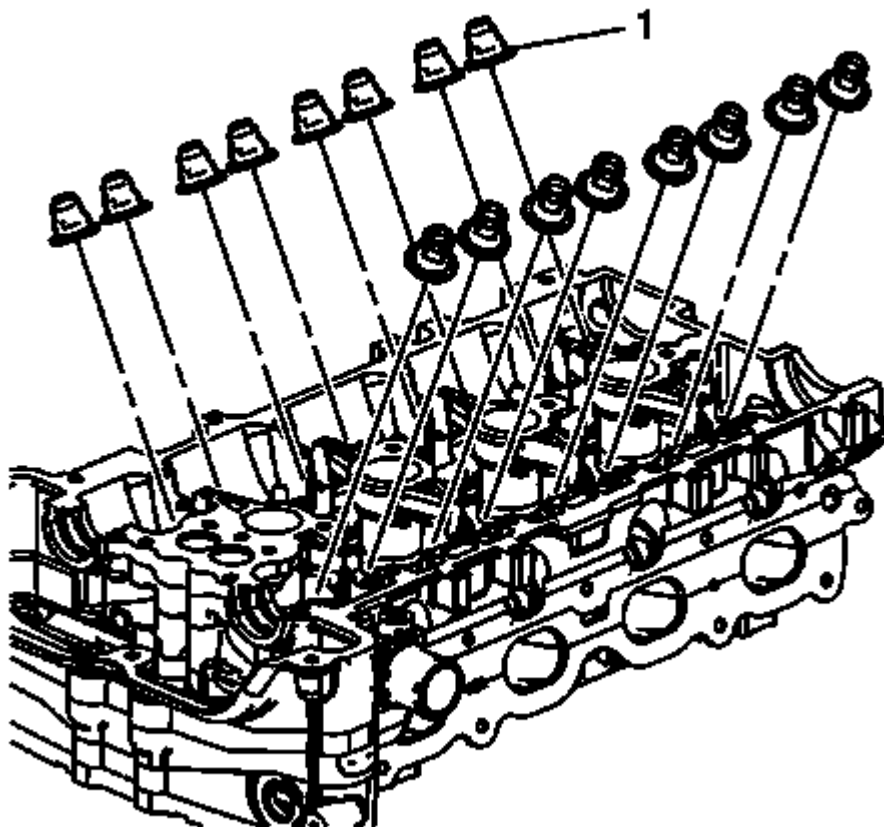
3. Inspect the valves and the valve seats. Refer to Valve and Seat Grinding.



**Fig. 400: View of Valves**

Courtesy of GENERAL MOTORS COMPANY

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

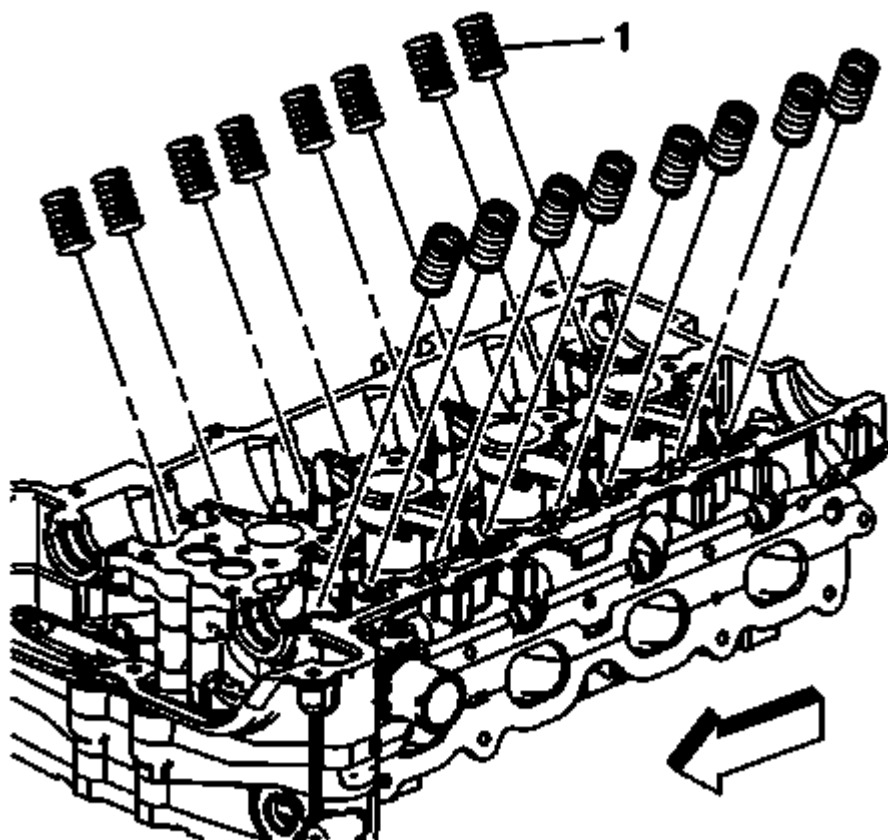


**Fig. 401: View of Valve Seals**

Courtesy of GENERAL MOTORS COMPANY

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

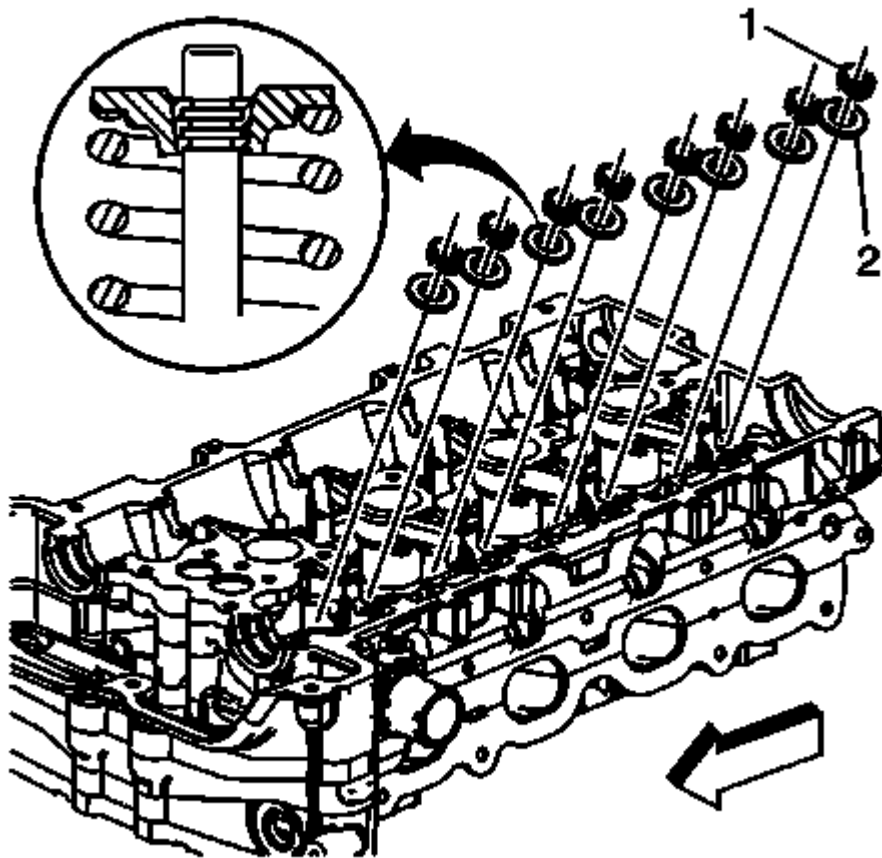
5. Install the NEW valve seals (1). Fully seat the seals on the valve guides.



**Fig. 402: View of Valve Springs**

Courtesy of GENERAL MOTORS COMPANY

6. Install the springs (1).



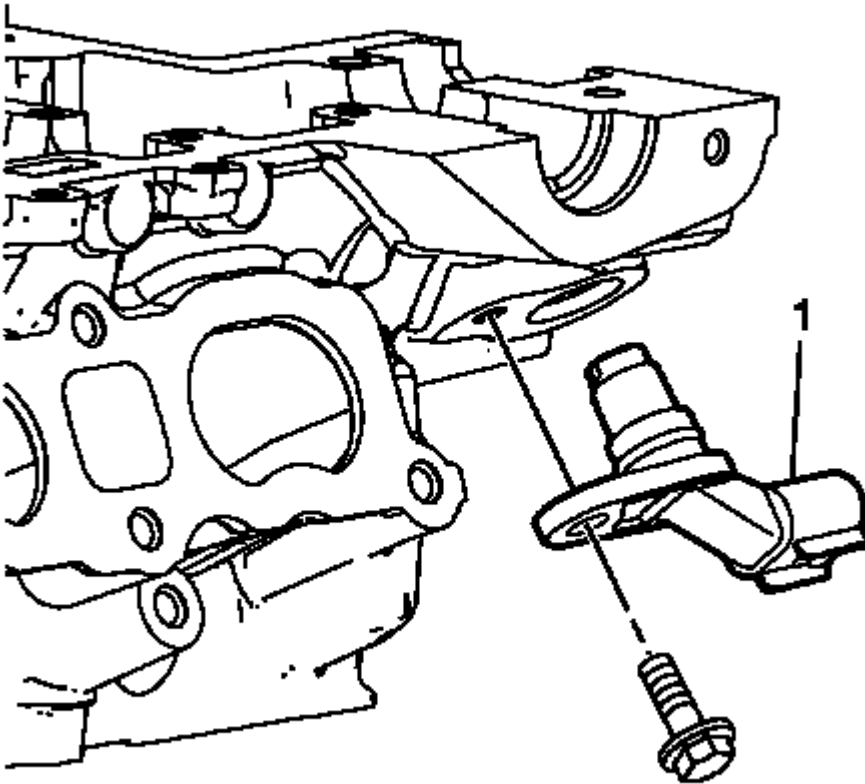
**Fig. 403: View of Valve Keys and Retainer**  
Courtesy of GENERAL MOTORS COMPANY

**WARNING:** Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

**CAUTION:** Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

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

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

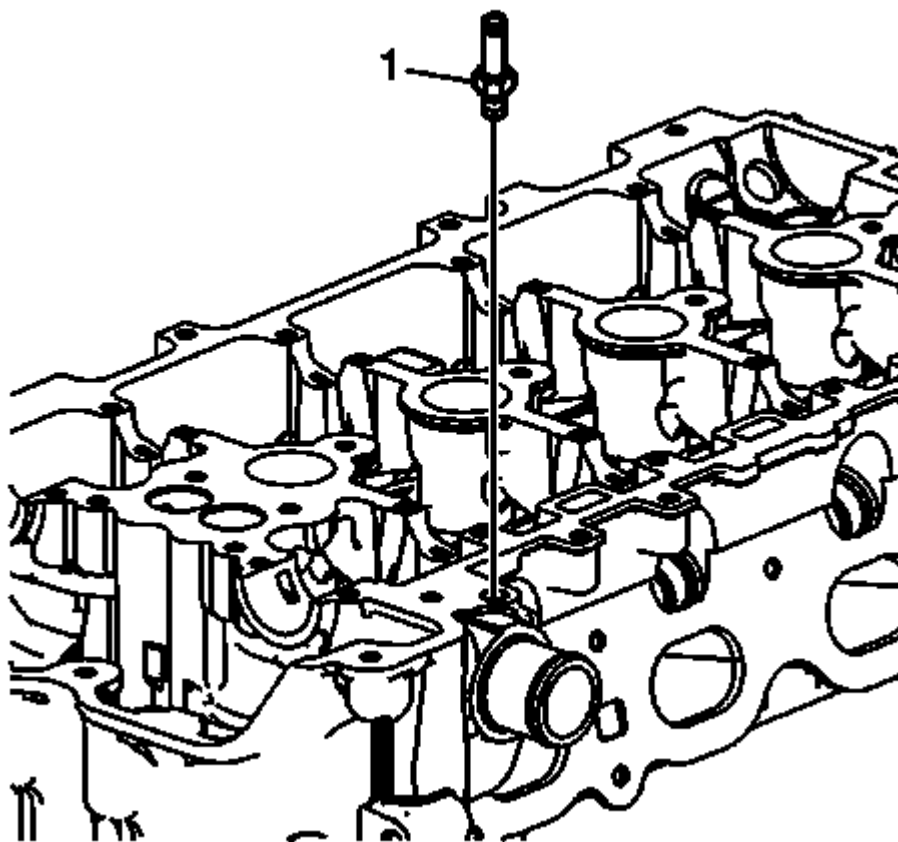


**Fig. 404: Intake Camshaft Position Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

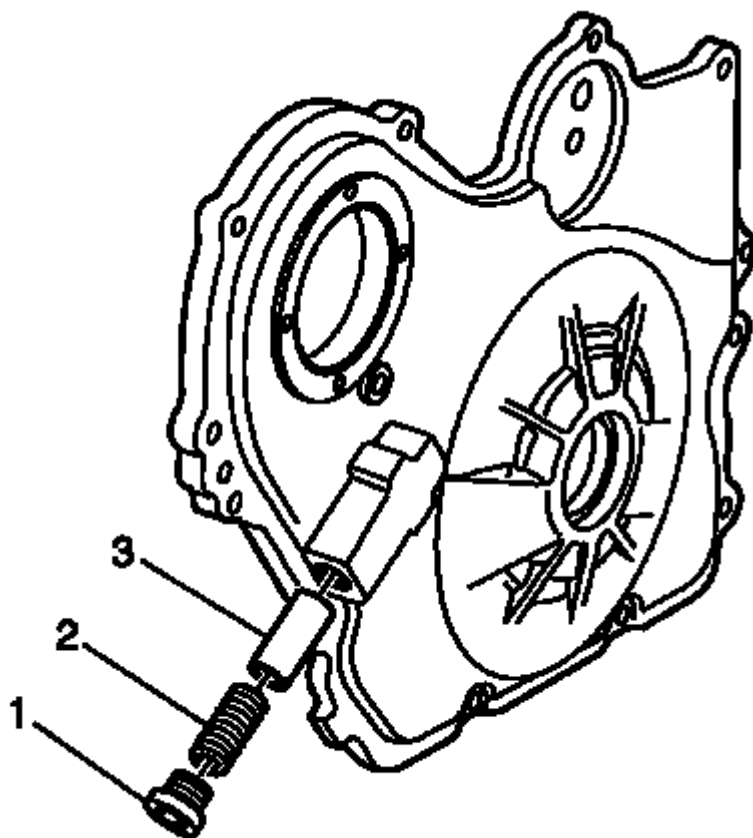
9. Install the intake camshaft position sensor (1) and bolt. Tighten the bolt to 10 N.m (89 lb in).



**Fig. 405: Identifying Coolant Air Bleed Hose Fitting**  
Courtesy of GENERAL MOTORS COMPANY

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

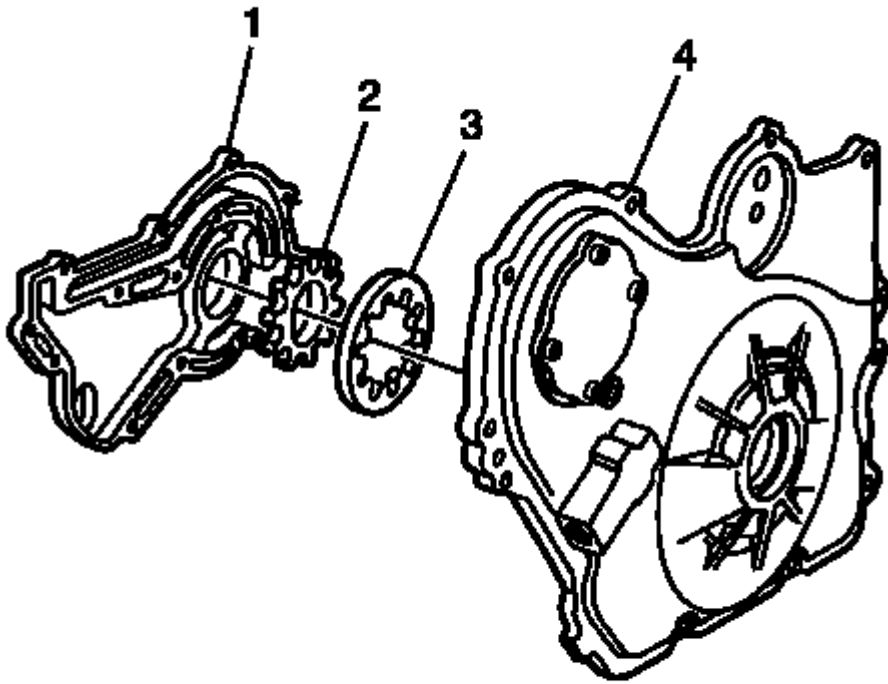
#### **OIL PUMP DISASSEMBLE**



**Fig. 406: Pressure Relief Valve**

Courtesy of GENERAL MOTORS COMPANY

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



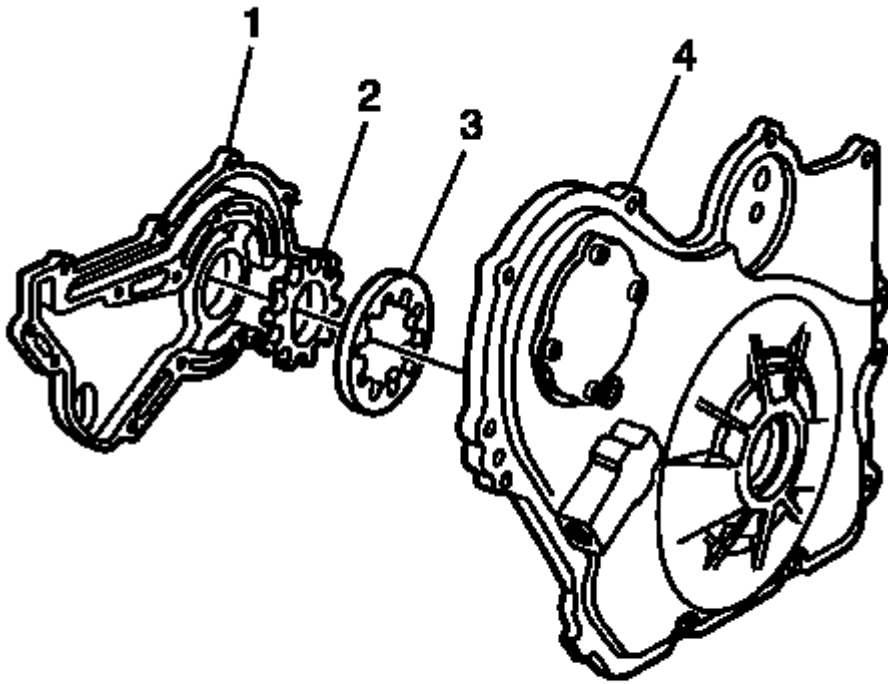
**Fig. 407: Oil Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

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

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

## OIL PUMP ASSEMBLE



**Fig. 408: Oil Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

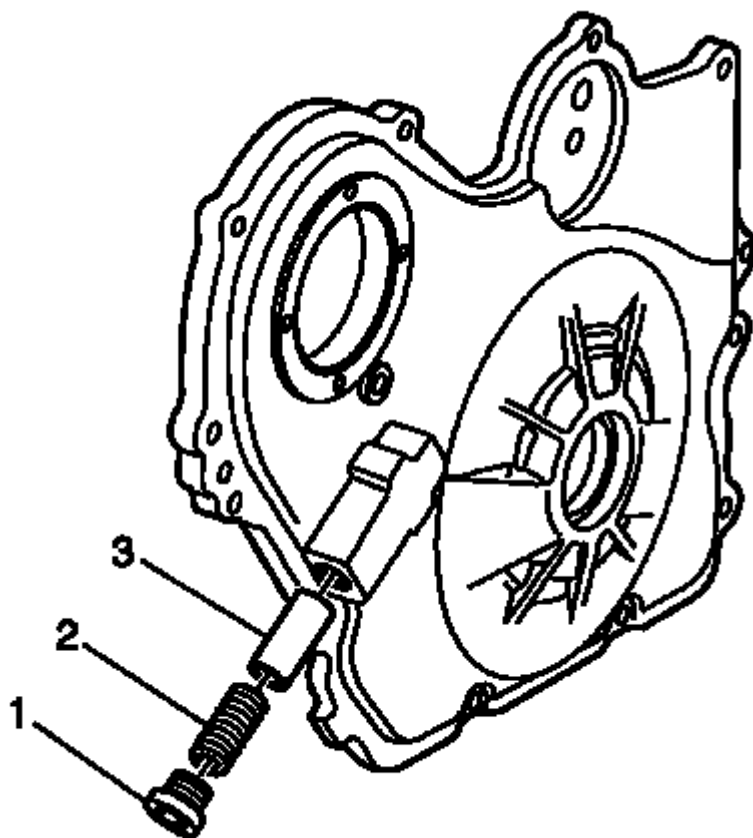
1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear (2) into the outer gear (3).

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

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

**CAUTION:** Refer to Fastener Caution .

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



**Fig. 409: Pressure Relief Valve**

Courtesy of GENERAL MOTORS COMPANY

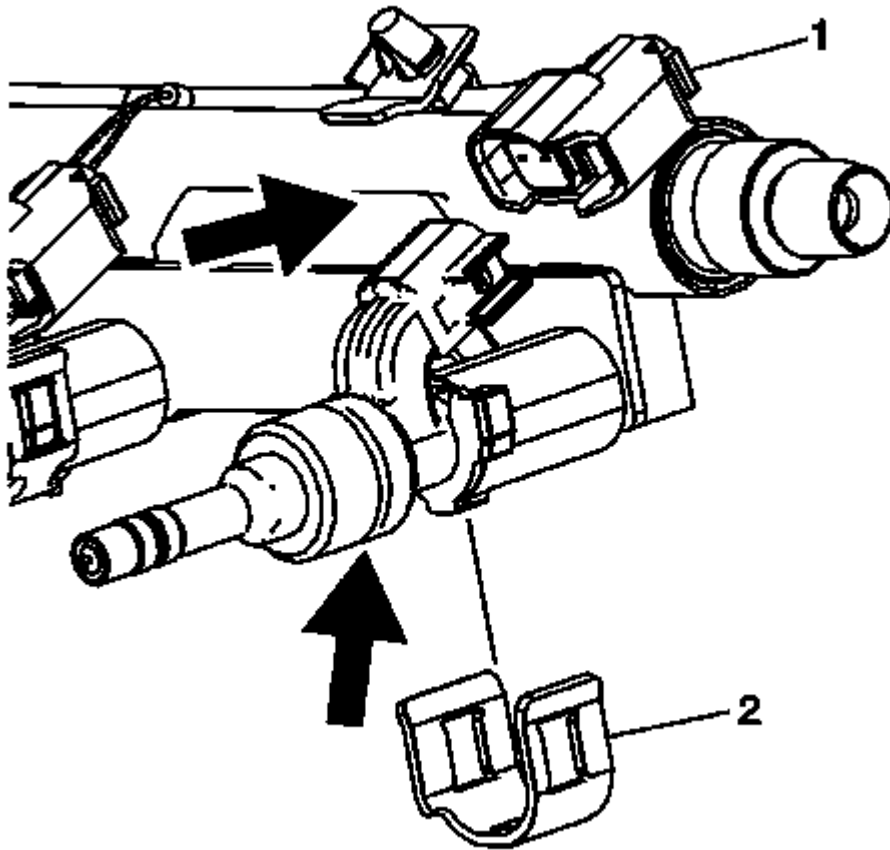
5. Install the pressure relief valve plunger (3).
6. Install the pressure relief valve spring (2).
7. Install and tighten the pressure relief valve plug (1) to 40 N.m (30 lb ft).

## FUEL RAIL AND INJECTORS CLEANING AND INSPECTION (LEA)

### Special Tools

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

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



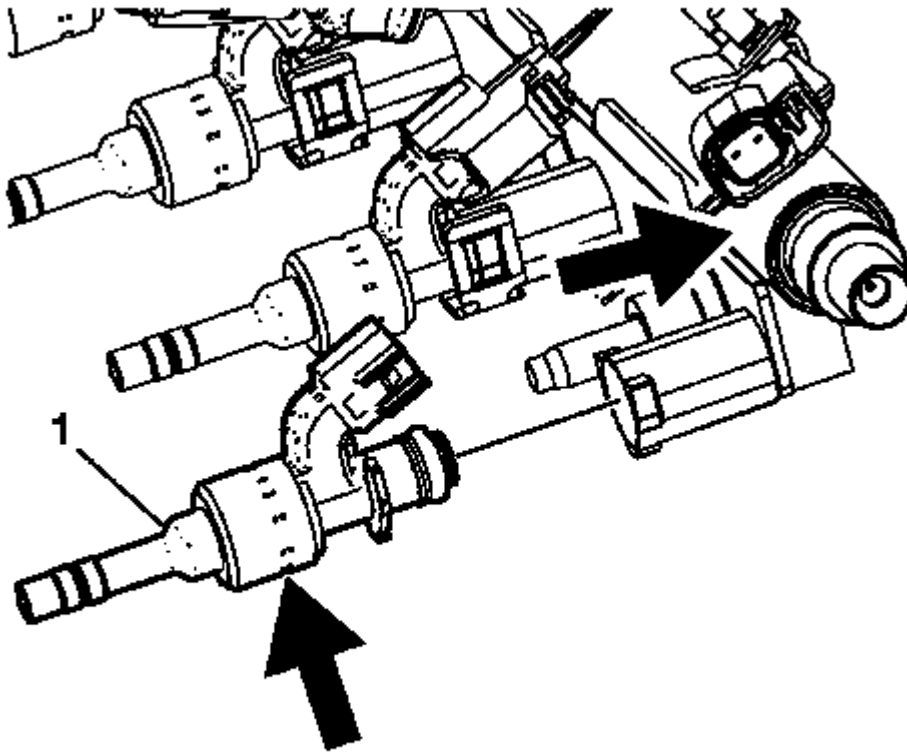
**Fig. 410: Fuel Injectors & Retainers**

Courtesy of GENERAL MOTORS COMPANY

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

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

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

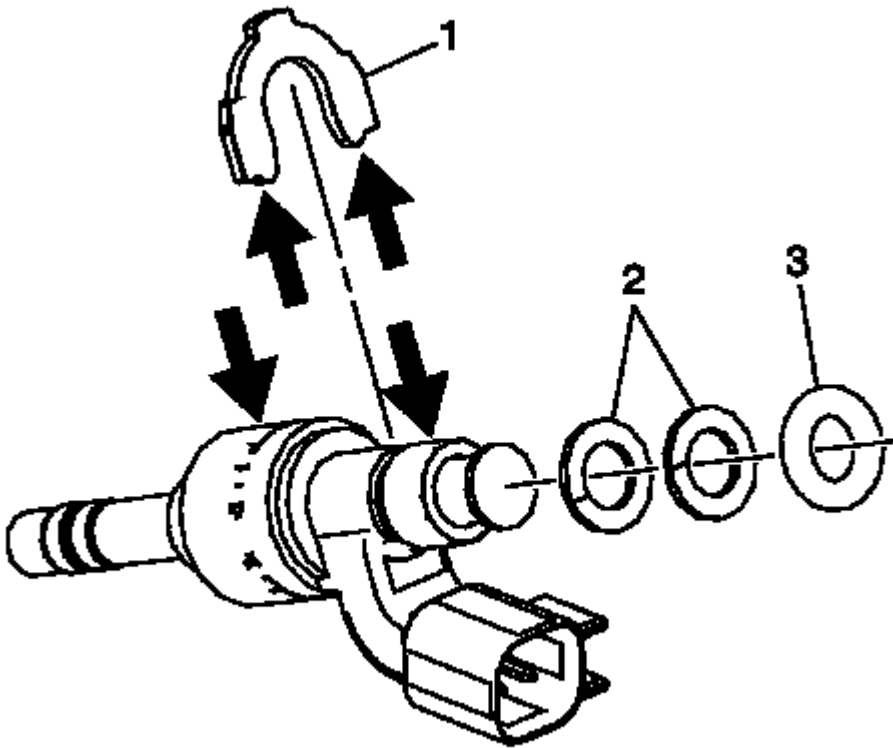


**Fig. 411: Supporting Fuel Injector**  
Courtesy of GENERAL MOTORS COMPANY

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

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

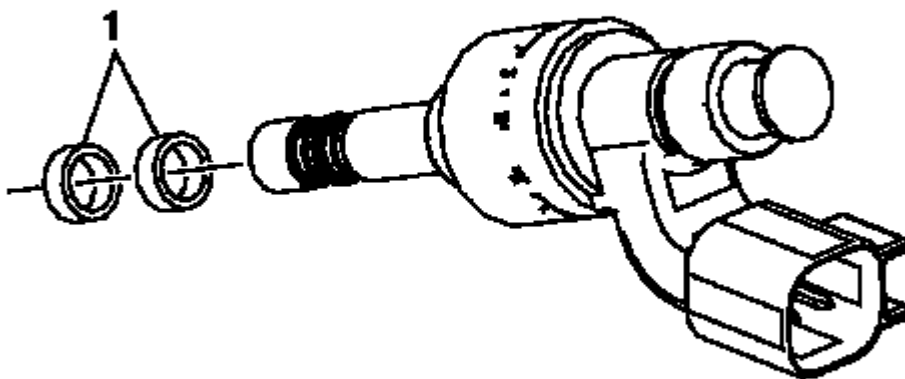
3. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable.



**Fig. 412: Fuel Injector Bushing, O-Ring & Spacers**  
Courtesy of GENERAL MOTORS COMPANY

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

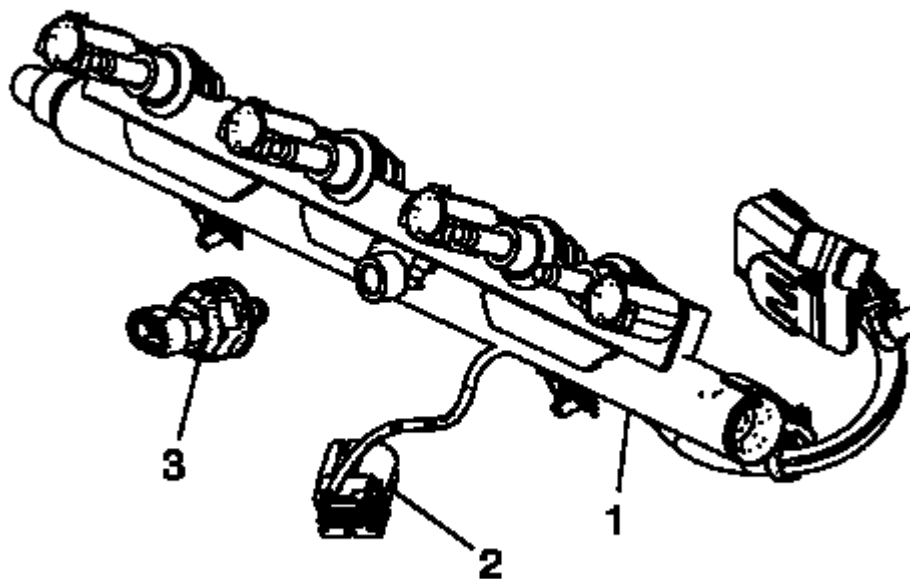
4. Using a suitable tool, remove the fuel injector bushing (1) by pushing straight off at the bushing tabs, indicated by the arrows. Discard the bushing.
5. Remove and discard the fuel injector O-ring (3) and plastic spacers (2).



**Fig. 413: Fuel Injector Seals**

**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 414: Fuel Rail, Connector & Pressure Sensor**  
 Courtesy of GENERAL MOTORS COMPANY

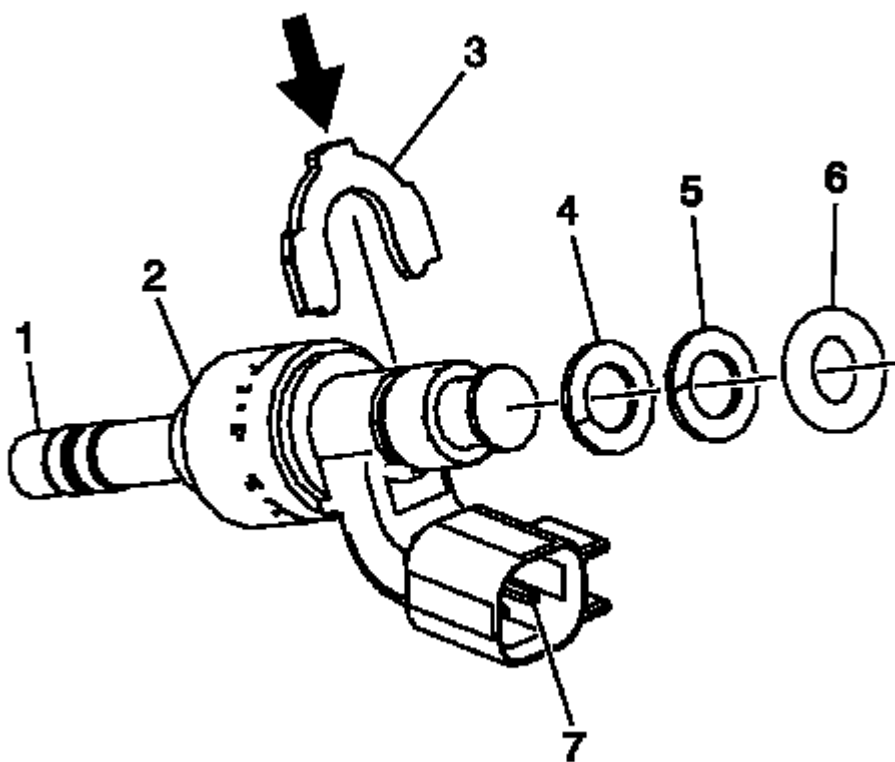
**NOTE:** Do not soak or submerge the fuel rail or injectors in solvent.

7. Clean the exterior of the fuel rail (1) and injectors in solvent.
8. Inspect the fuel rail and components for the following conditions:
  - Damage, debris, or restrictions to the fuel rail
  - Damage, debris, or restrictions to the fuel ports in the fuel rail
  - Damage to the mounting area for the fuel rail
  - Damage to the fuel rail mounting bolts
  - Damage to the threads on the fuel rail fuel feed fitting
9. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

**CAUTION:** Refer to Fastener Caution .

10. Inspect the fuel pressure sensor (3) for damage.
  1. Disconnect the harness connector (2) from the fuel pressure sensor.

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



**Fig. 415: Fuel Injector Components**

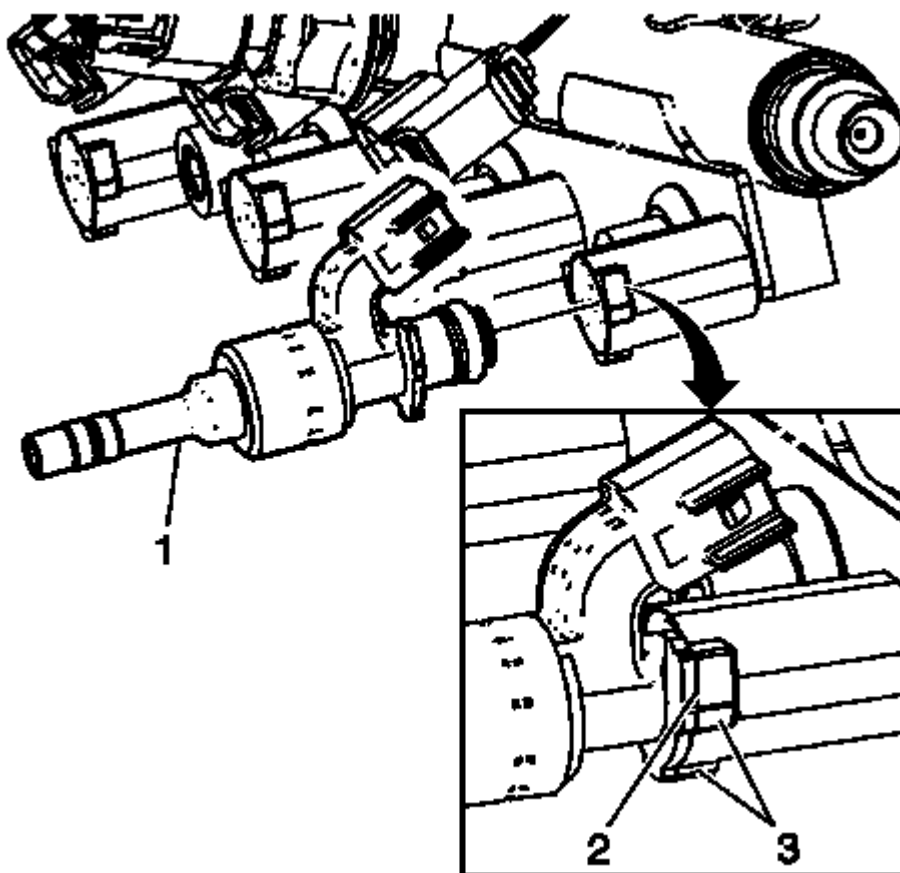
Courtesy of GENERAL MOTORS COMPANY

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

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

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

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

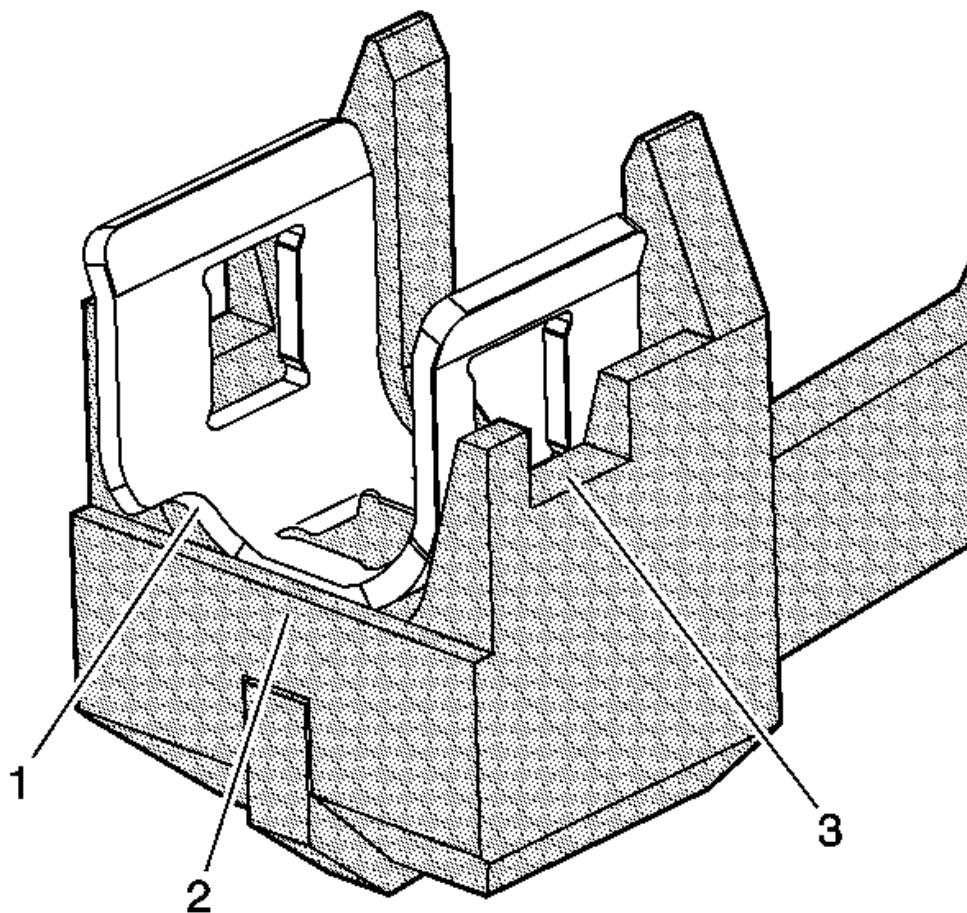


**Fig. 416: Fuel Injectors**

Courtesy of GENERAL MOTORS COMPANY

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

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



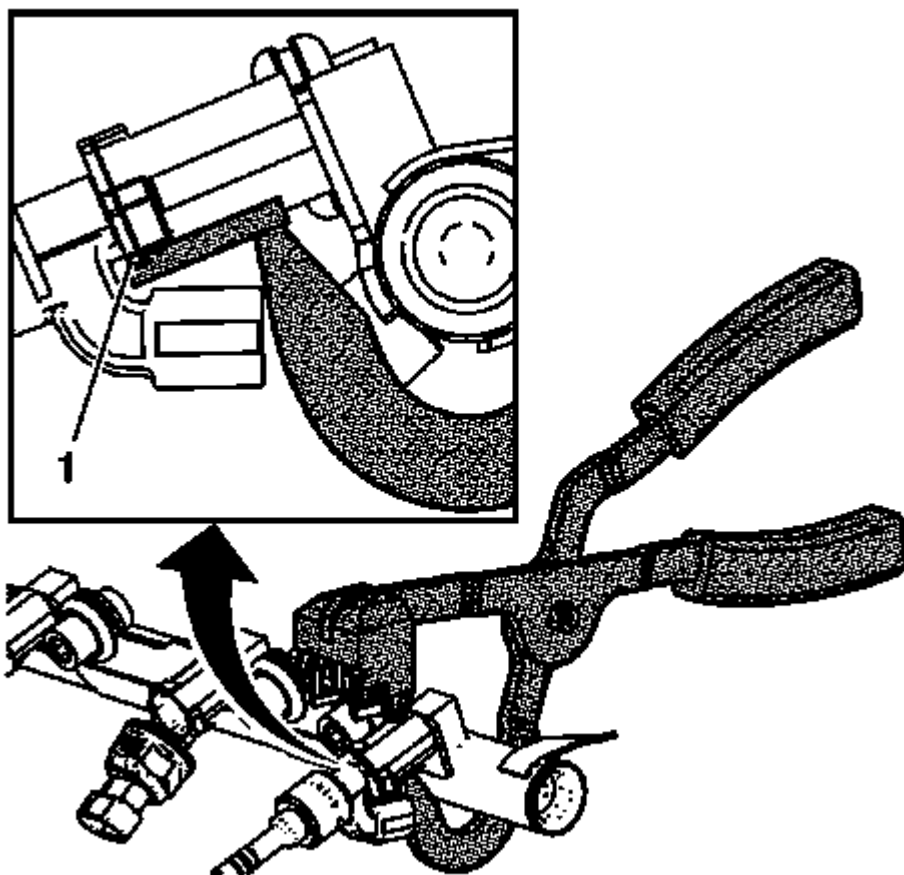
**Fig. 417: Retainer Installer**

Courtesy of GENERAL MOTORS COMPANY

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

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

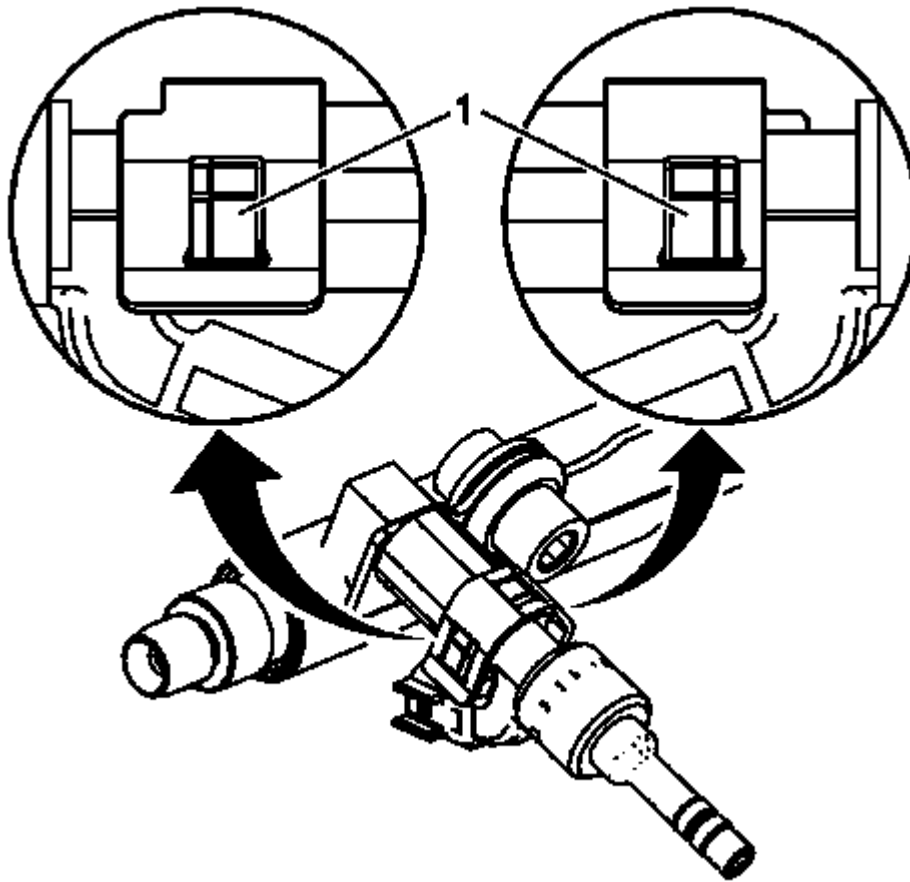
19. Install the fuel injector retainer onto the **EN-49247** installer.



**Fig. 418: Installing Fuel Injector Retainer**  
 Courtesy of GENERAL MOTORS COMPANY

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

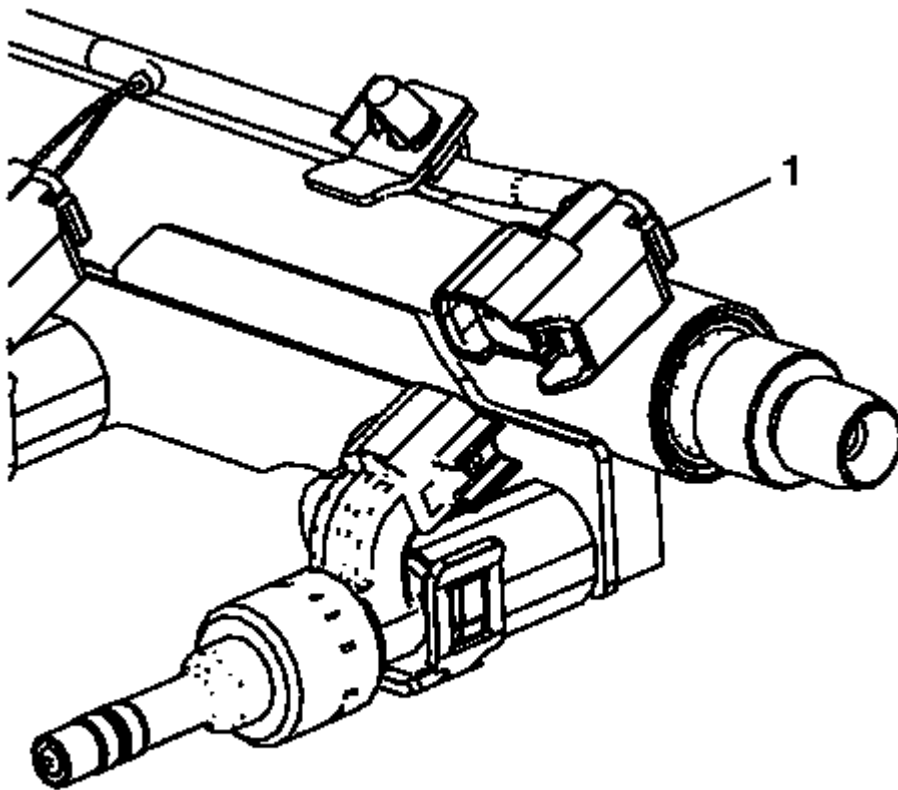
20. Using **EN-49247** installer , install the fuel injector retainer.



**Fig. 419: Proper Injector Retainer Installation**  
Courtesy of GENERAL MOTORS COMPANY

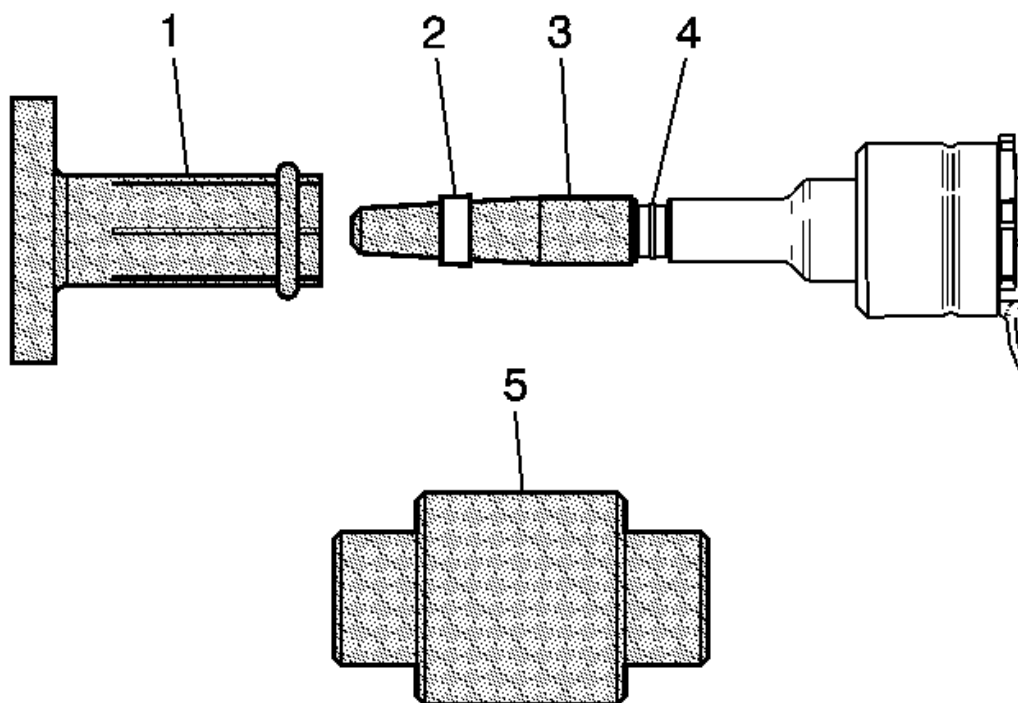
**CAUTION:** Ensure the fuel injector retainer is properly installed. Failure to completely install the retainers may degrade fuel injection system performance or cause system malfunction.

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



**Fig. 420: Fuel Rail Harness Connector**  
Courtesy of GENERAL MOTORS COMPANY

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



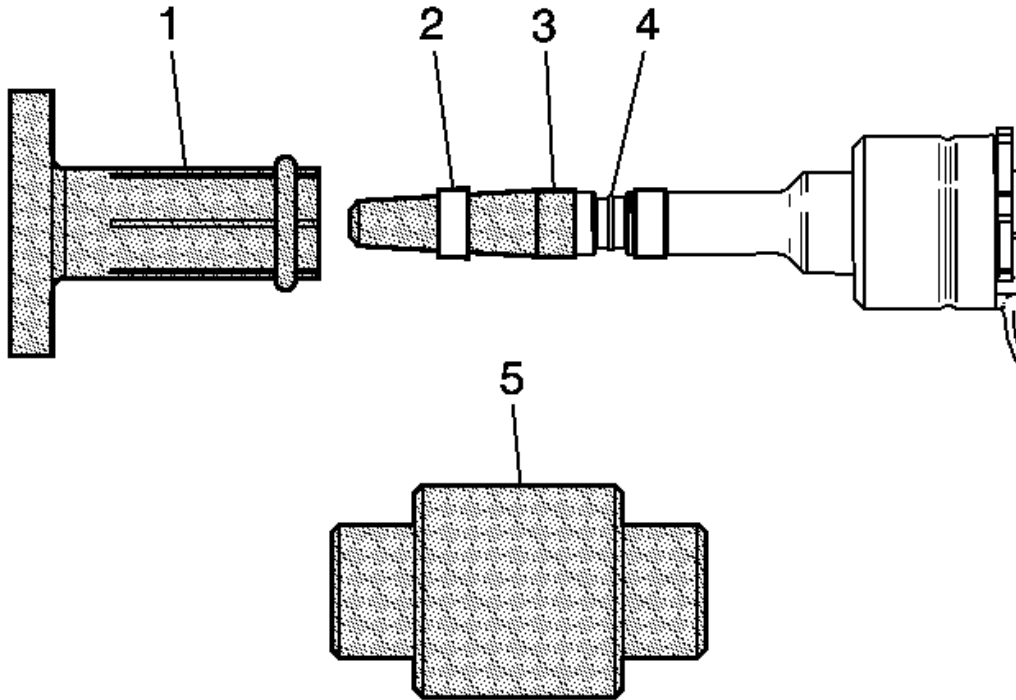
**Fig. 421: Identifying Fuel Injector Tip & Seals - Long**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

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



**Fig. 422: Identifying Fuel Injector Tip & Seals - Short**  
 Courtesy of GENERAL MOTORS COMPANY

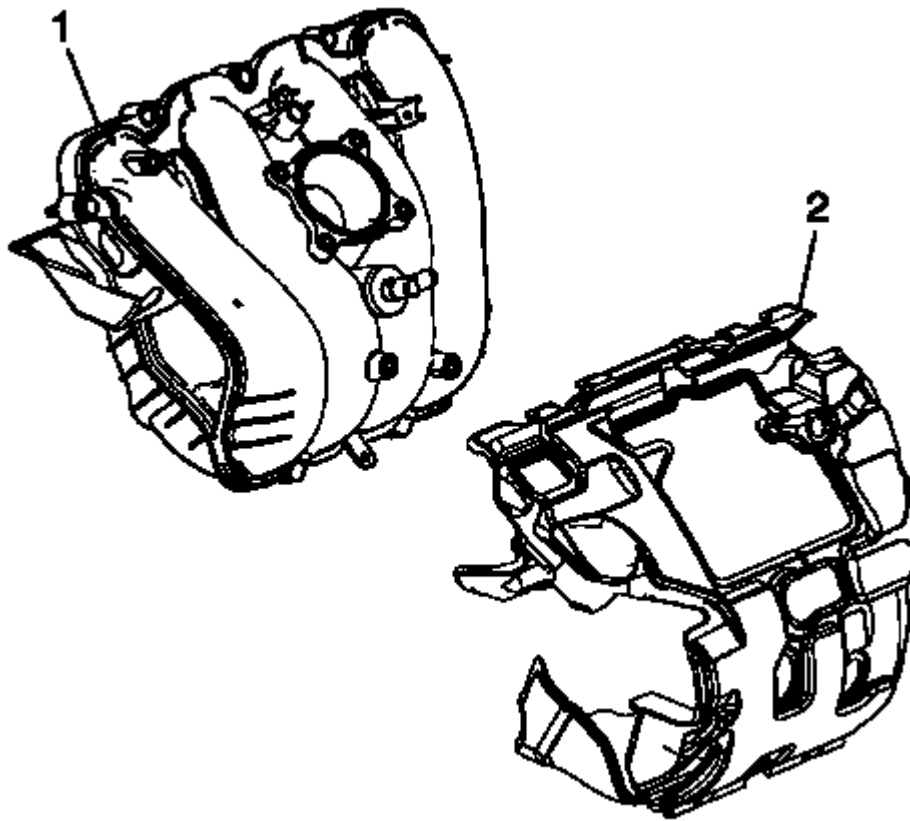
**NOTE:** Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

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

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

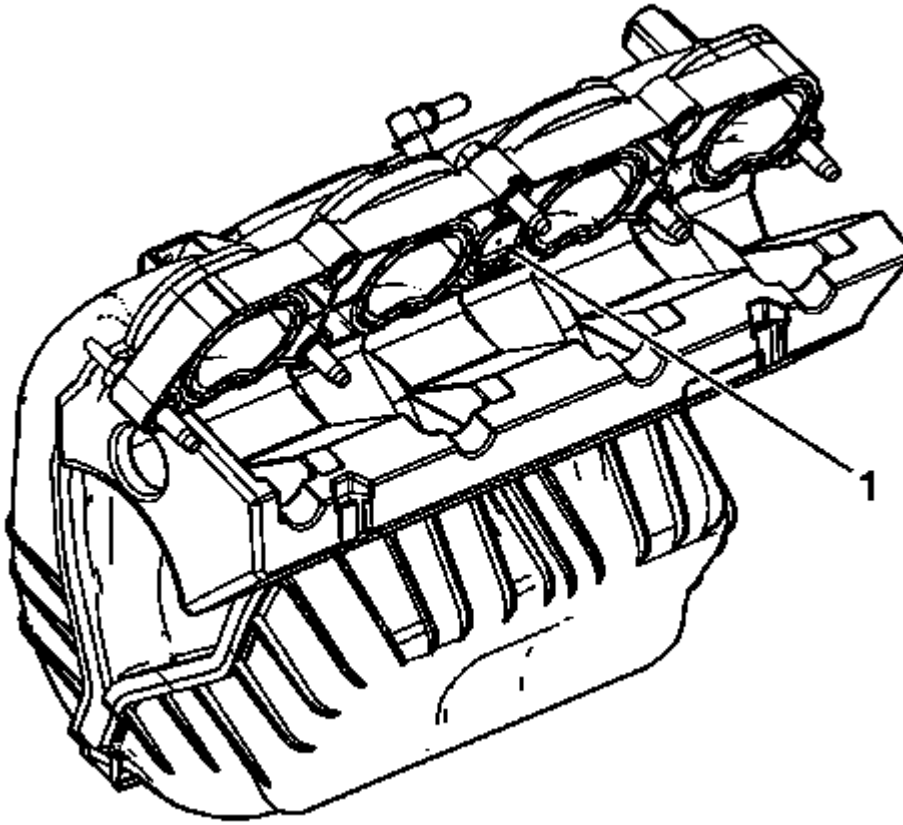
29. Compress the seal with your fingers, then resize the seal using the EN-49245-4 sizer (5).

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



**Fig. 423: Intake Manifold & Insulator**  
Courtesy of GENERAL MOTORS COMPANY

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



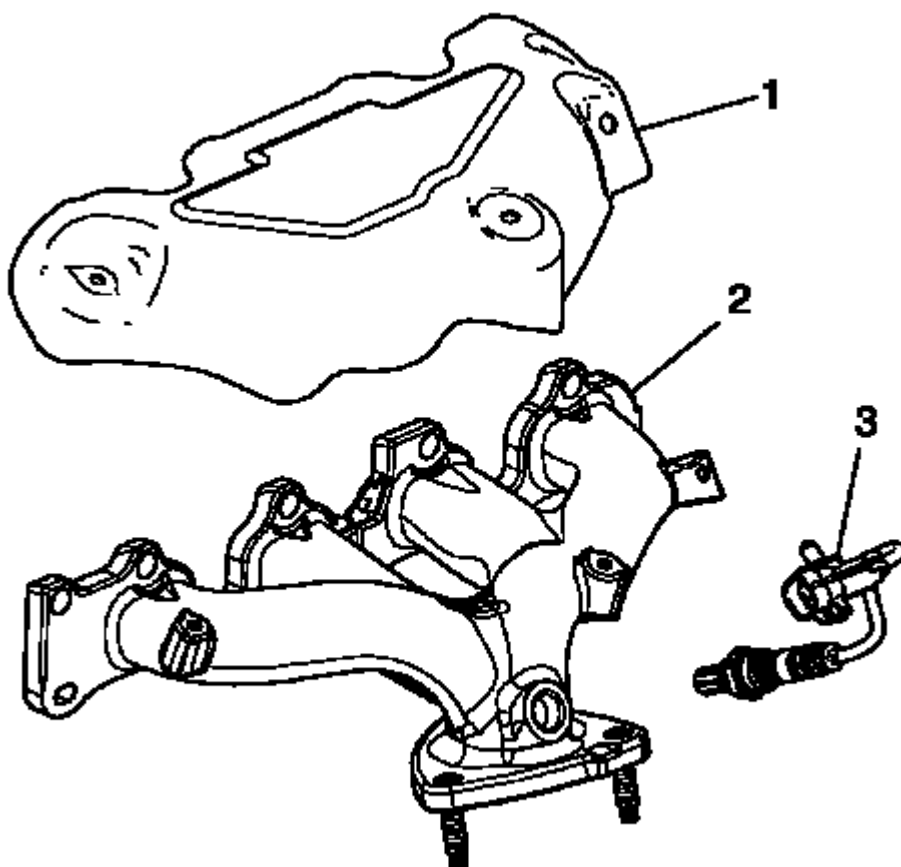
**Fig. 424: Crankcase Ventilation Passages**  
Courtesy of GENERAL MOTORS COMPANY

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

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

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

#### **EXHAUST MANIFOLD CLEANING AND INSPECTION (LEA)**



**Fig. 425: Exhaust Manifold, Oxygen Sensor & Heat Shield**  
Courtesy of GENERAL MOTORS COMPANY

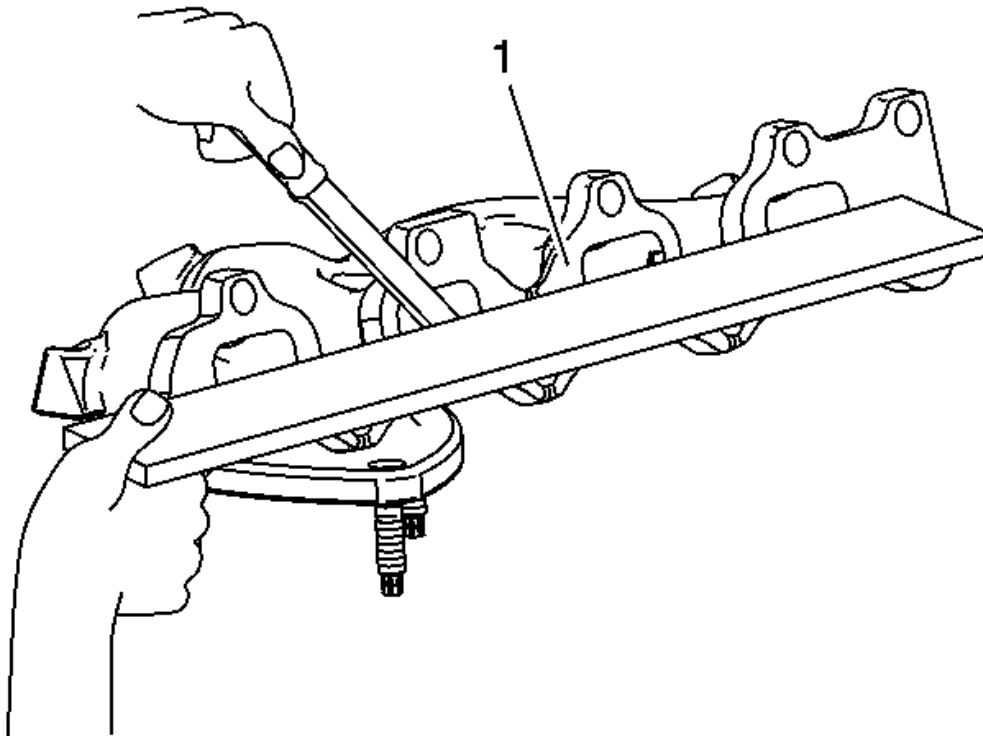
**NOTE:**

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

1. Remove the oxygen sensor (3) from the manifold.
2. Clean the exhaust manifold (2) in solvent.

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

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

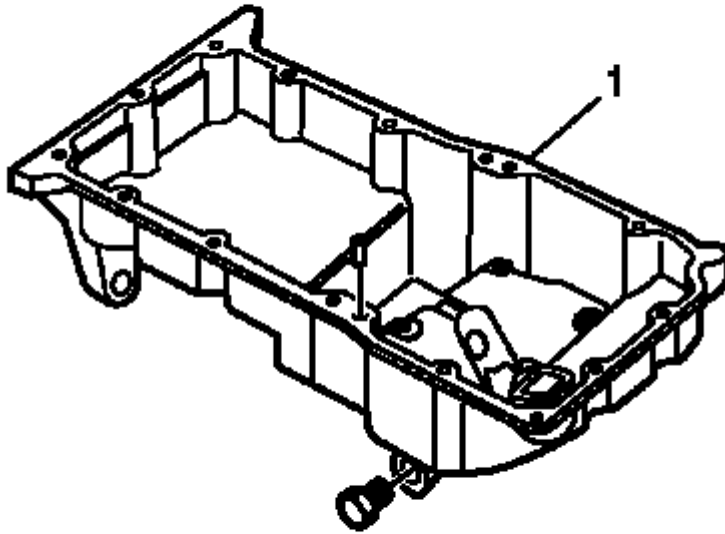


**Fig. 426: Measuring Exhaust Manifold Mounting Face**  
Courtesy of GENERAL MOTORS COMPANY

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

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

## OIL PAN CLEANING AND INSPECTION



**Fig. 427: Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

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

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

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

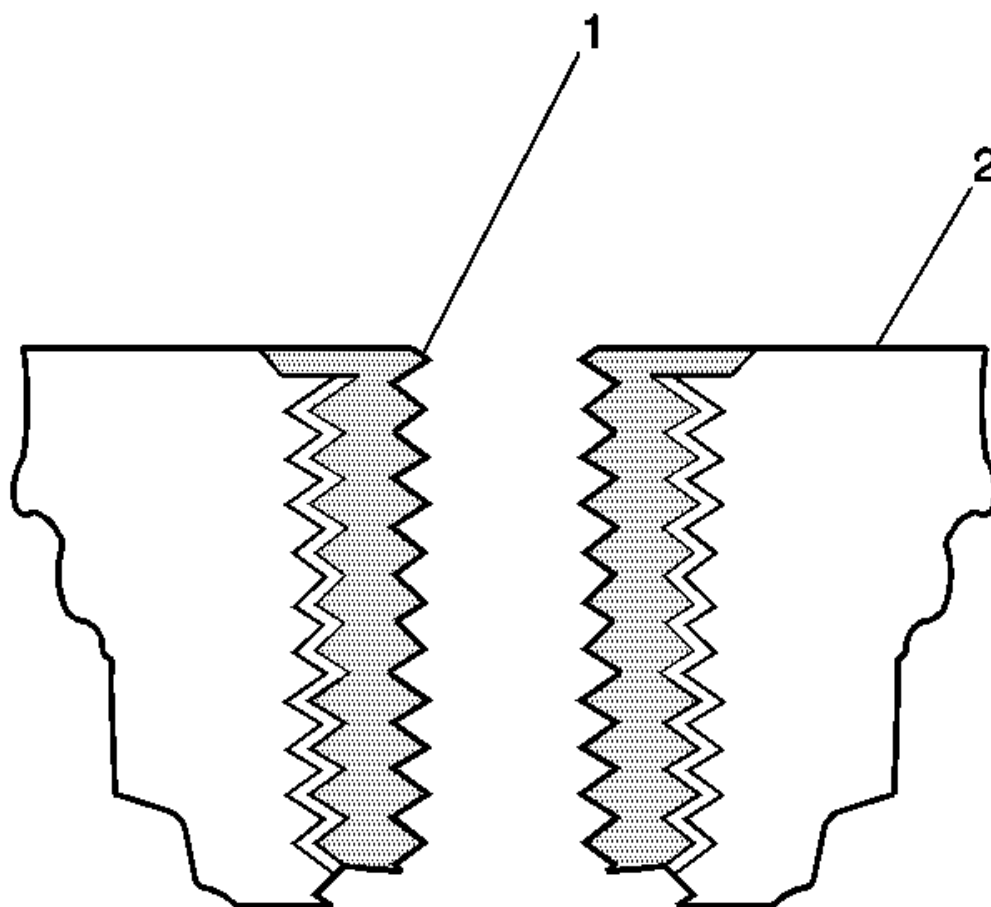
## THREAD REPAIR

### Special Tools

**EN 42385-850** Thread Repair Kit

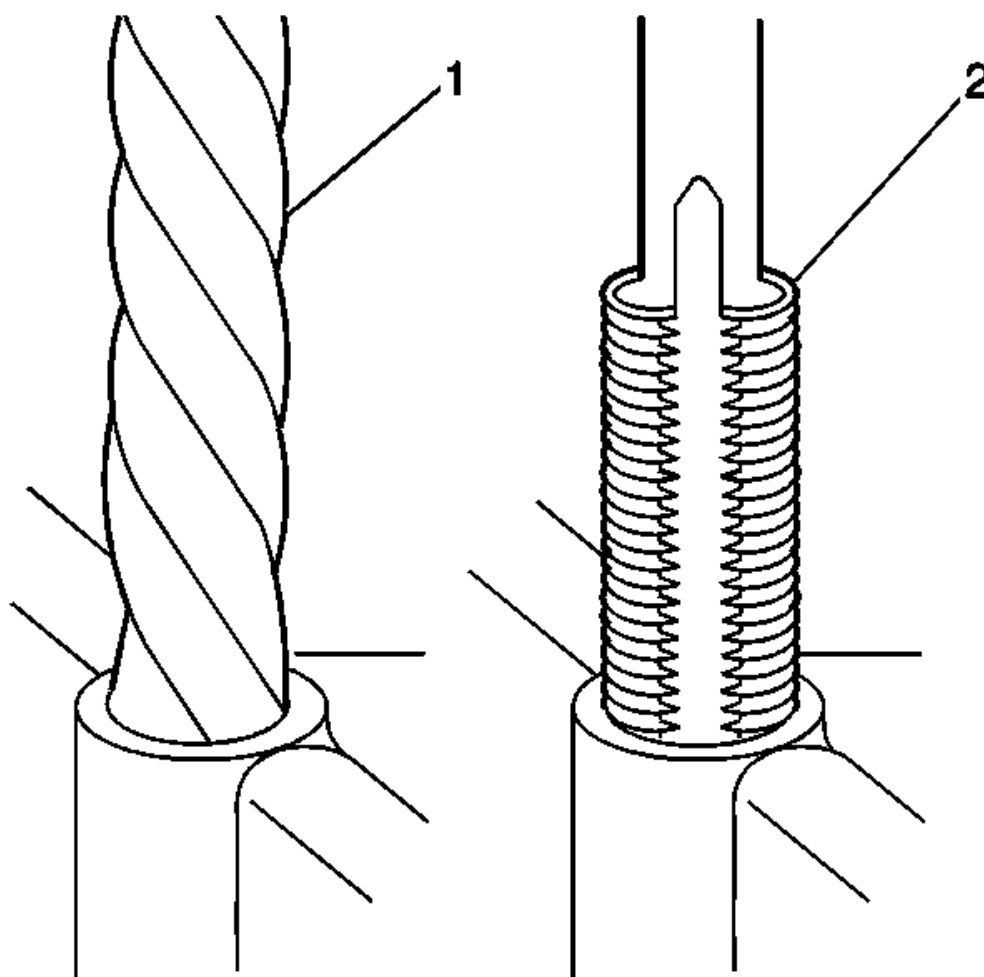
For equivalent regional tools, refer to **Special Tools**.

### General Thread Repair



**Fig. 428: View Of Bushing Type Insert & Base Material**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 429: Drilling & Tapping Threads**

Courtesy of GENERAL MOTORS COMPANY

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

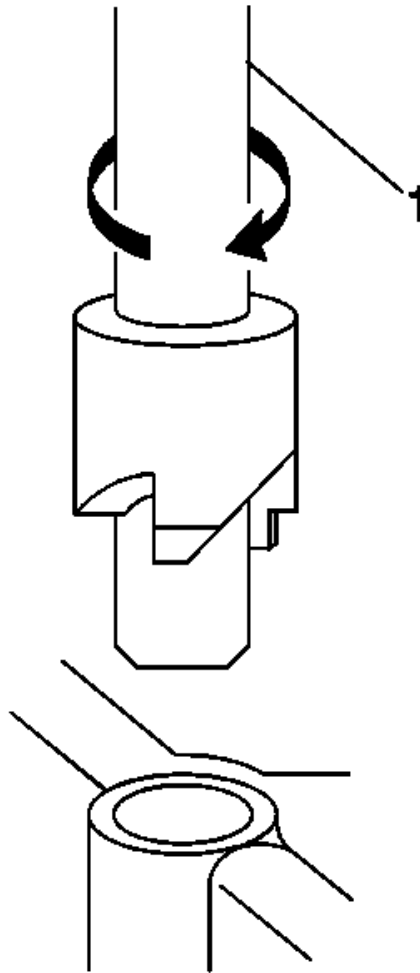
**Driver oil MUST be used on the installer driver tool.**

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

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

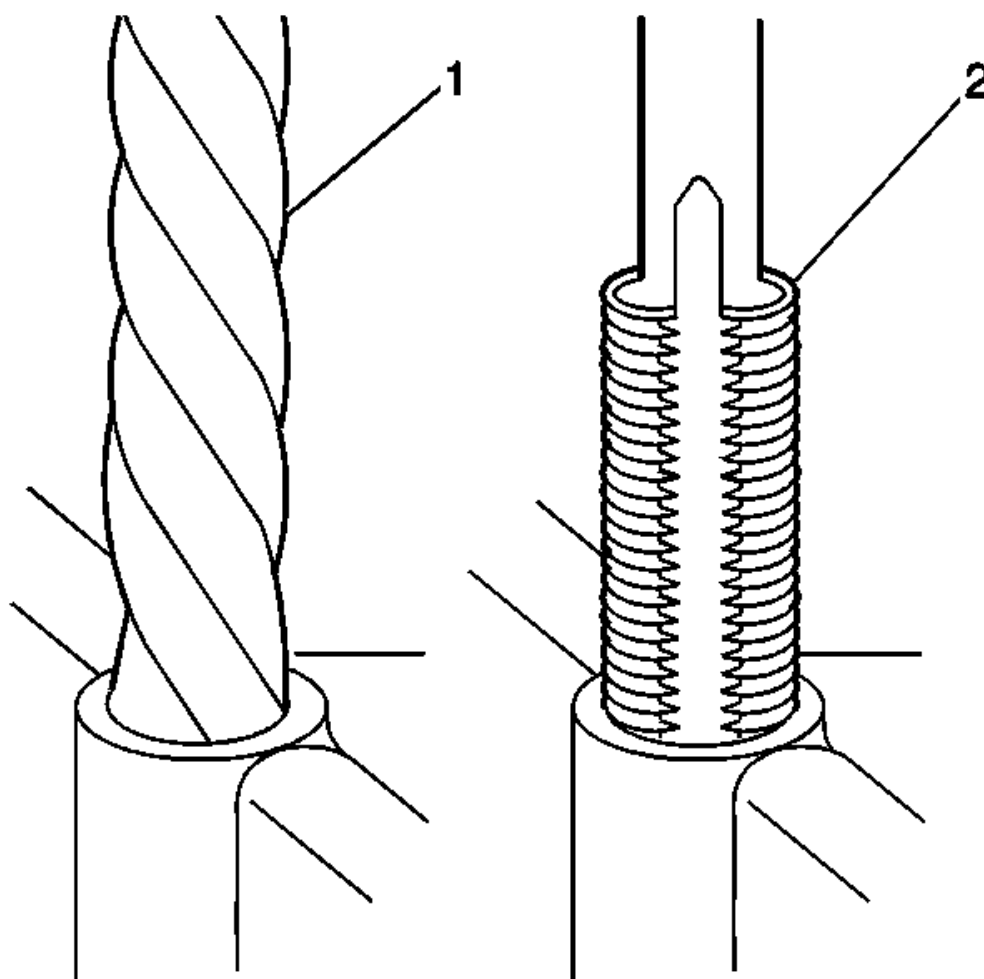
**WARNING:** Refer to Safety Glasses and Compressed Air Warning .

2. Using compressed air, clean out any chips.



**Fig. 430: Identifying Counterbore Drill**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 431: Drilling & Tapping Threads**

Courtesy of GENERAL MOTORS COMPANY

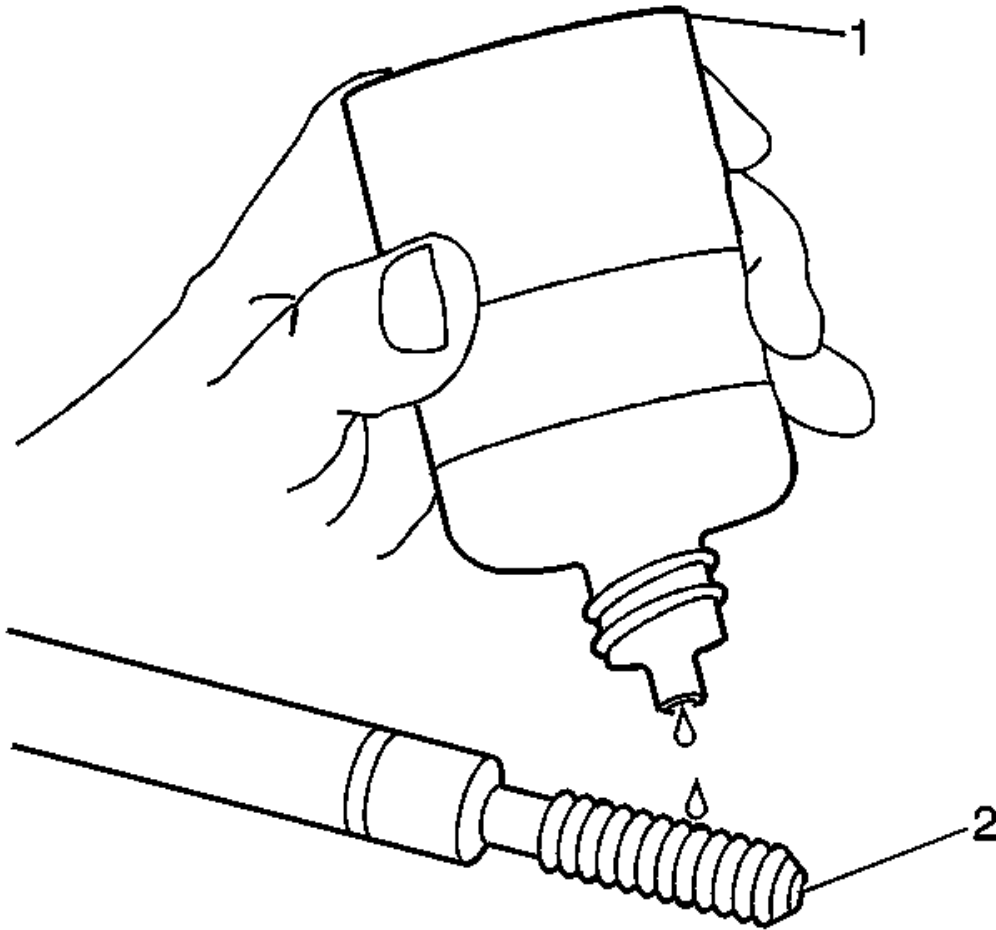
5. Using a tap wrench (2), tap the threads of the drilled hole.
  - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
  - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
  - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

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

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

6. Using compressed air, clean out any chips.

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

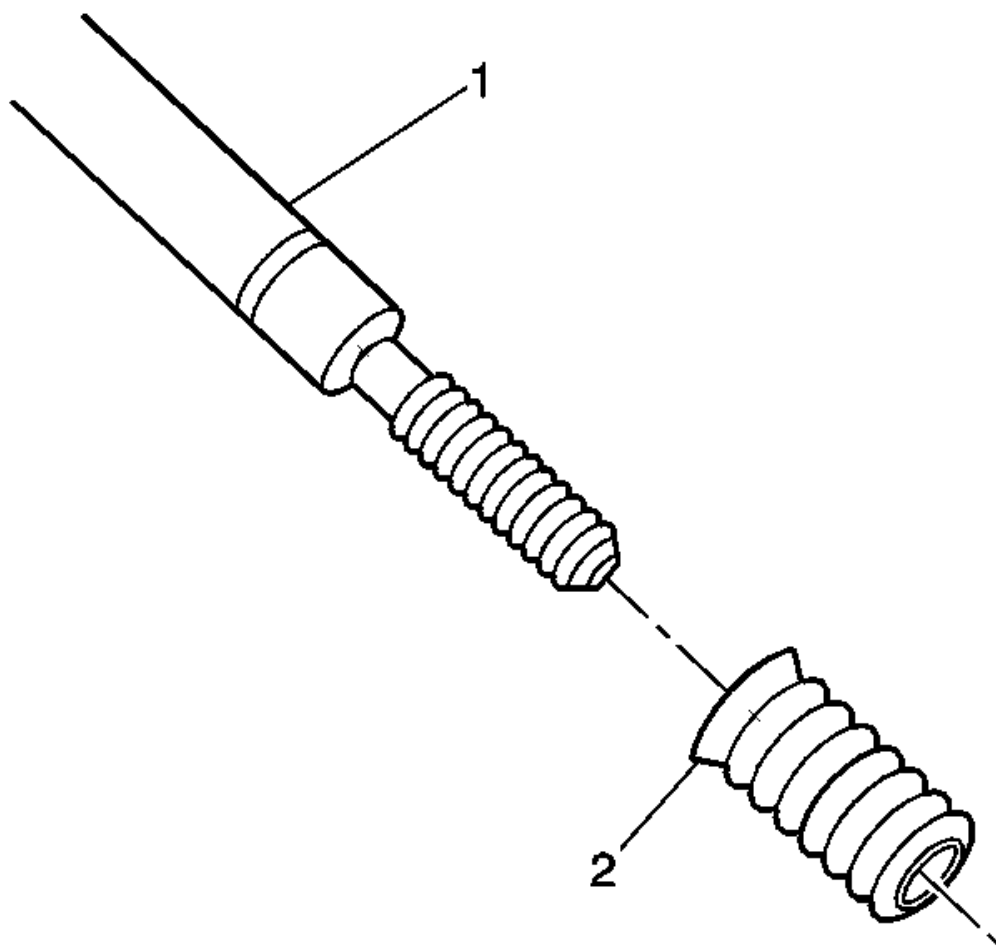


**Fig. 432: Lubricating Installer Tool Using Driver Oil**

Courtesy of GENERAL MOTORS COMPANY

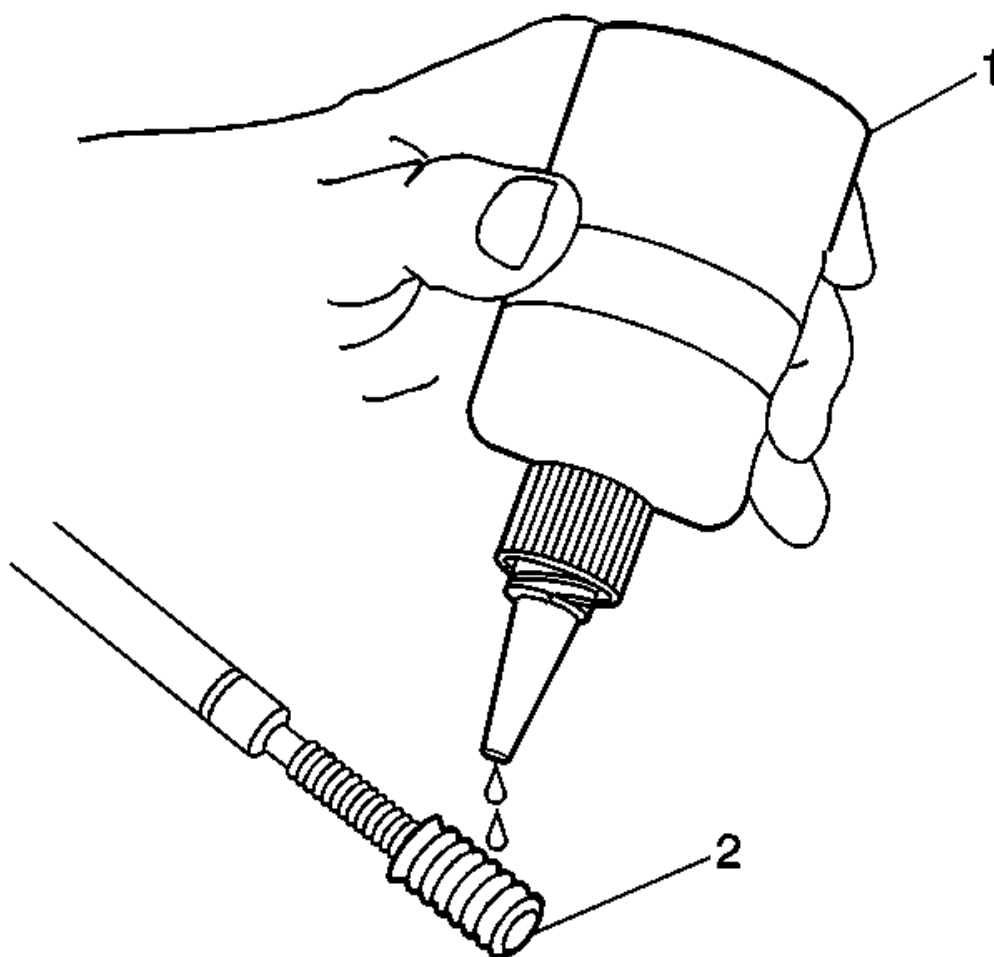
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



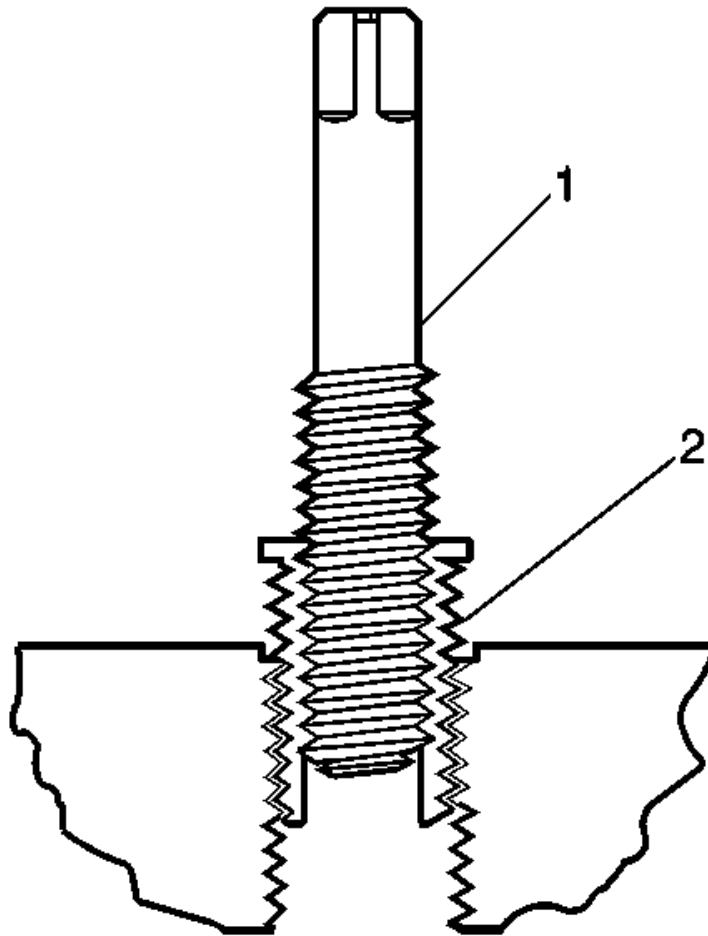
**Fig. 433: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 434: Applying Threadlock To Insert**  
Courtesy of GENERAL MOTORS COMPANY

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

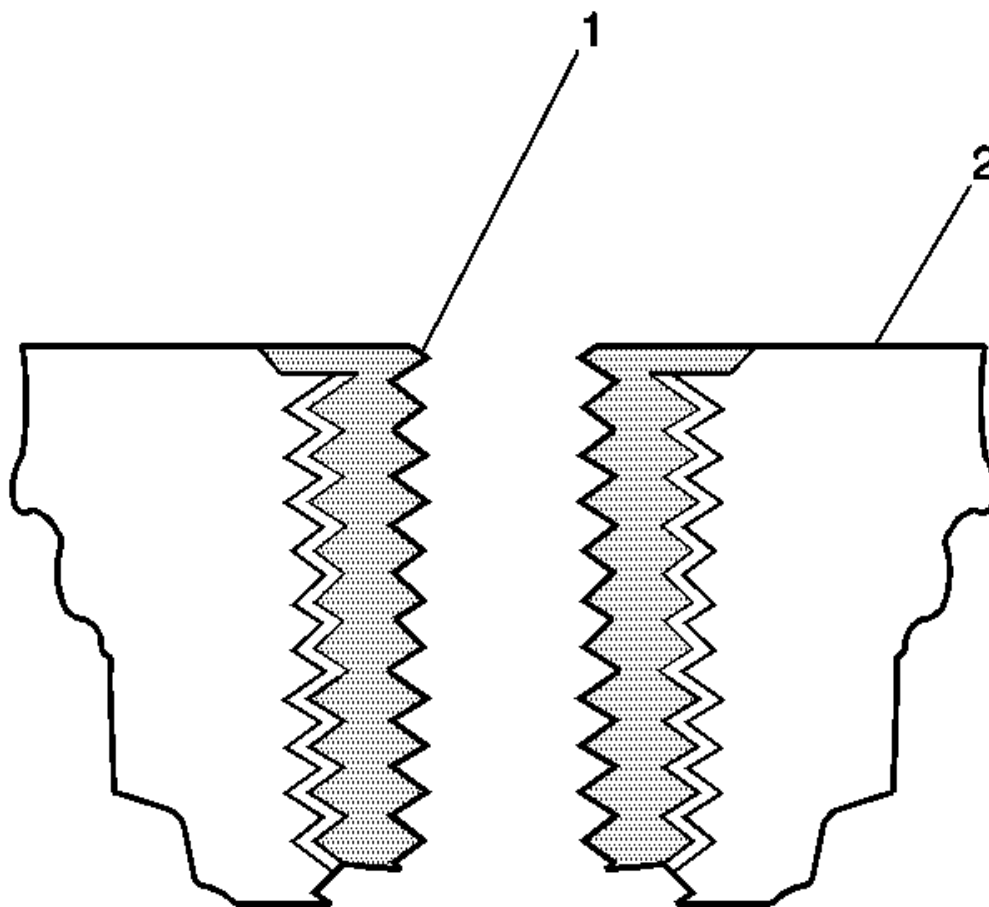


**Fig. 435: View Of Insert In Tapped Bolt Hole**  
**Courtesy of GENERAL MOTORS COMPANY**

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

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

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

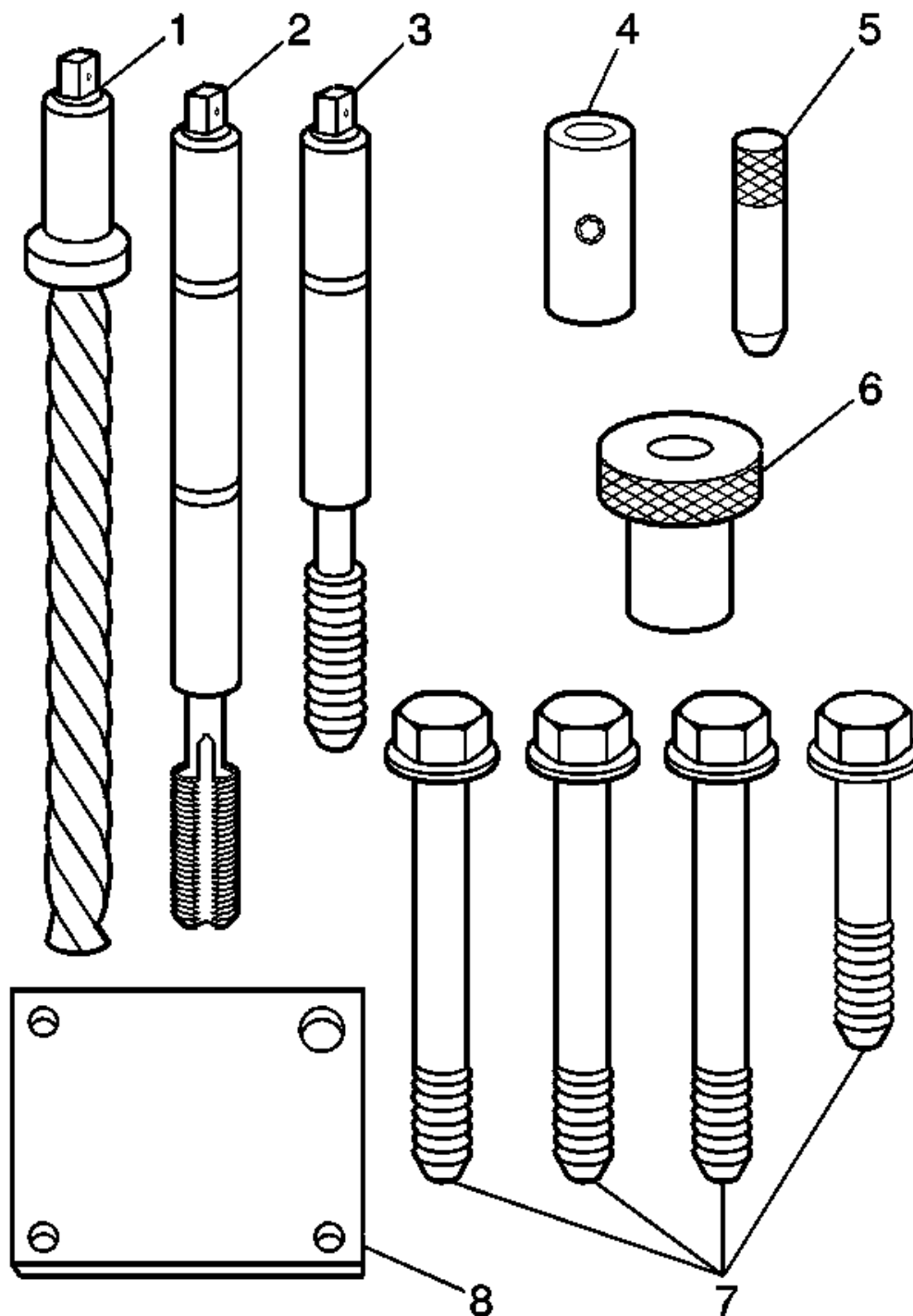


**Fig. 436: View Of Bushing Type Insert & Base Material**  
Courtesy of GENERAL MOTORS COMPANY

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

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

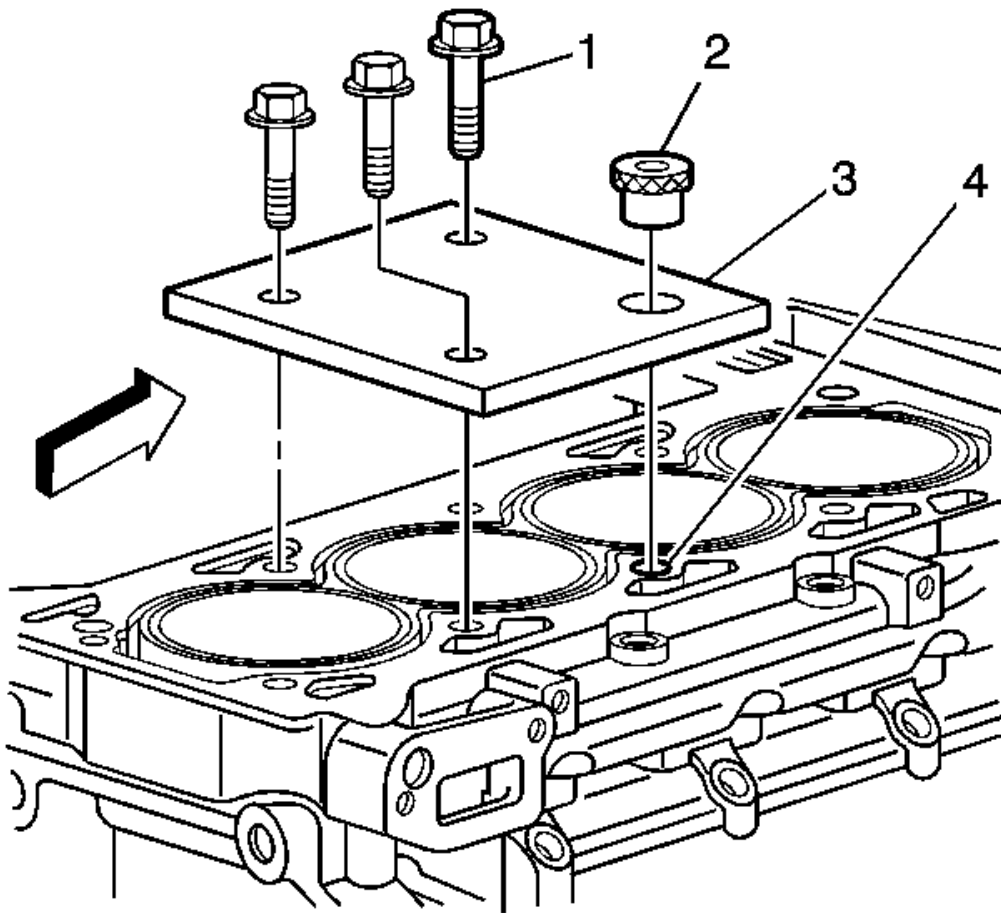
#### **Cylinder Head Bolt Hole Thread Repair**



**Fig. 437: Identifying Thread Repair Kit Components**  
 Courtesy of GENERAL MOTORS COMPANY

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

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



**Fig. 438: Installing Fixture Plate, Bolts, & Bushing**  
Courtesy of GENERAL MOTORS COMPANY

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

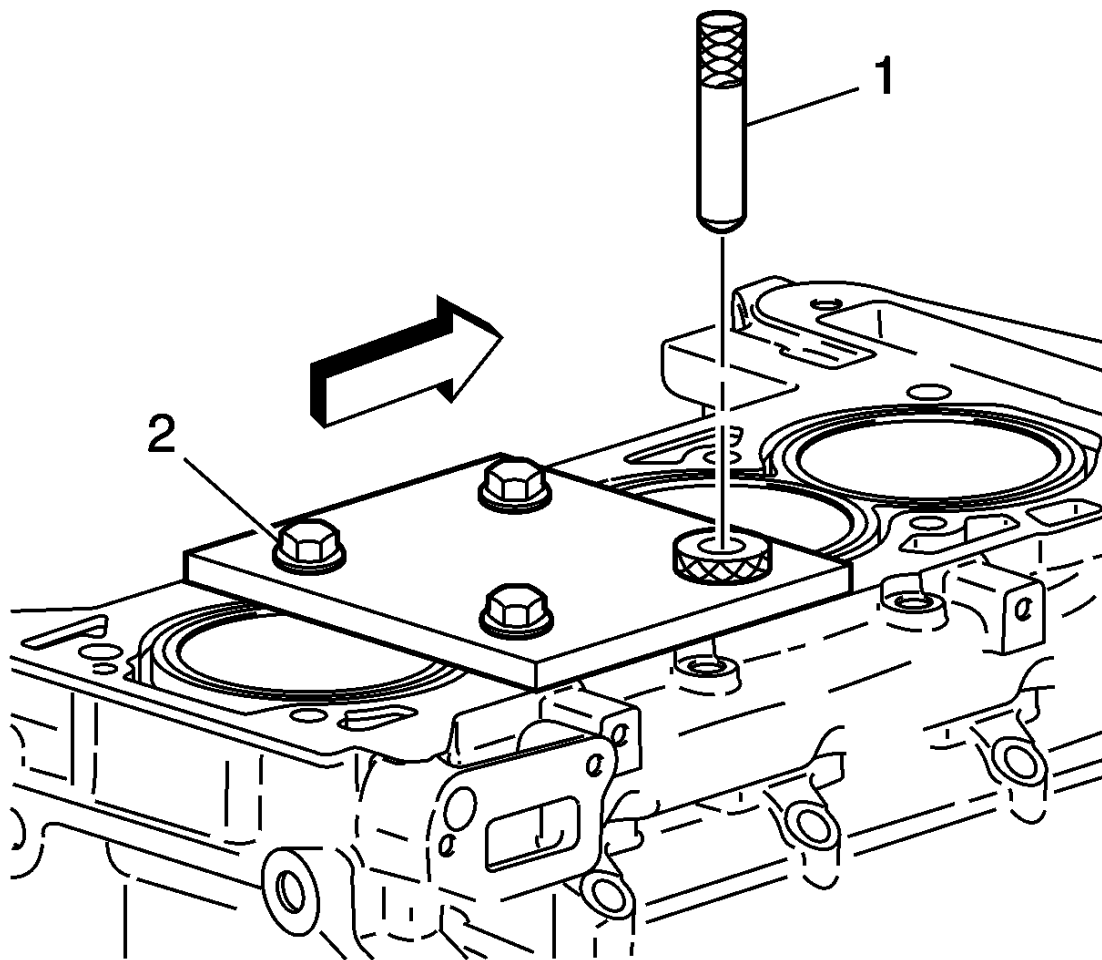
**NOTE:** The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.

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

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

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

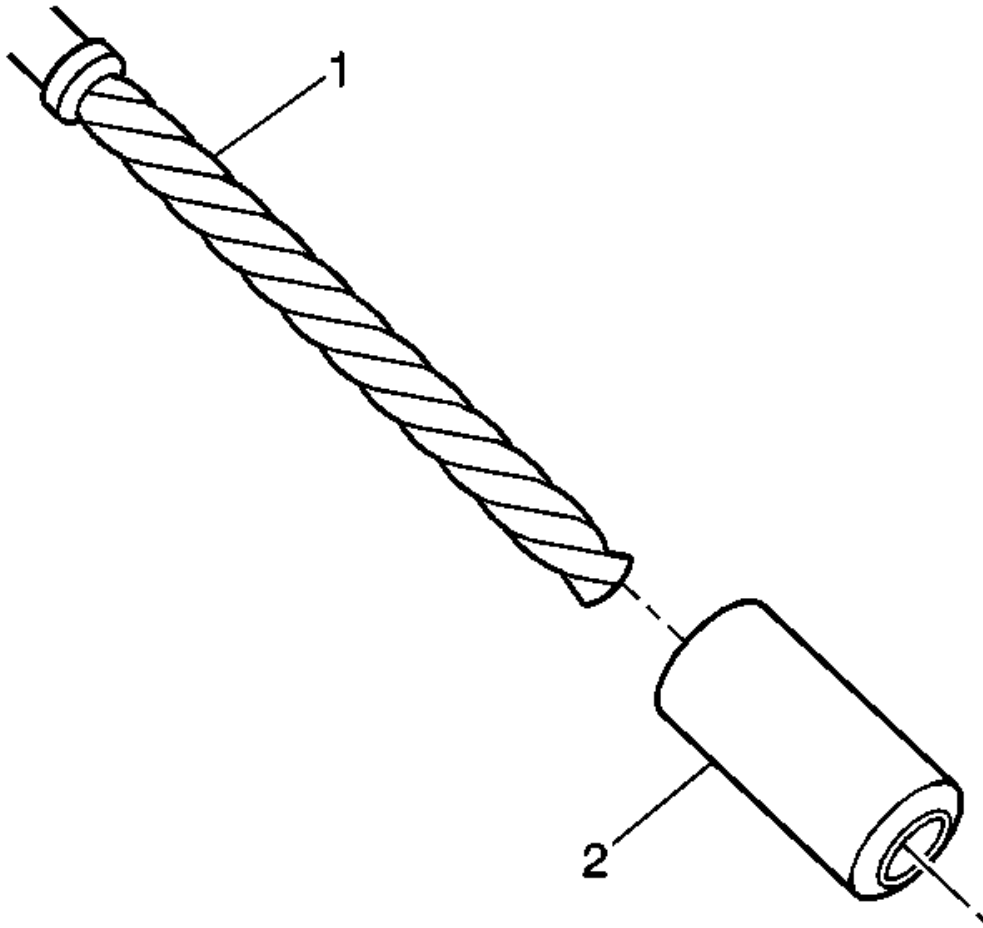
Position the fixture plate and bushing over the hole that is to be repaired (4).



**Fig. 439: Identifying Alignment Pin**  
Courtesy of GENERAL MOTORS COMPANY

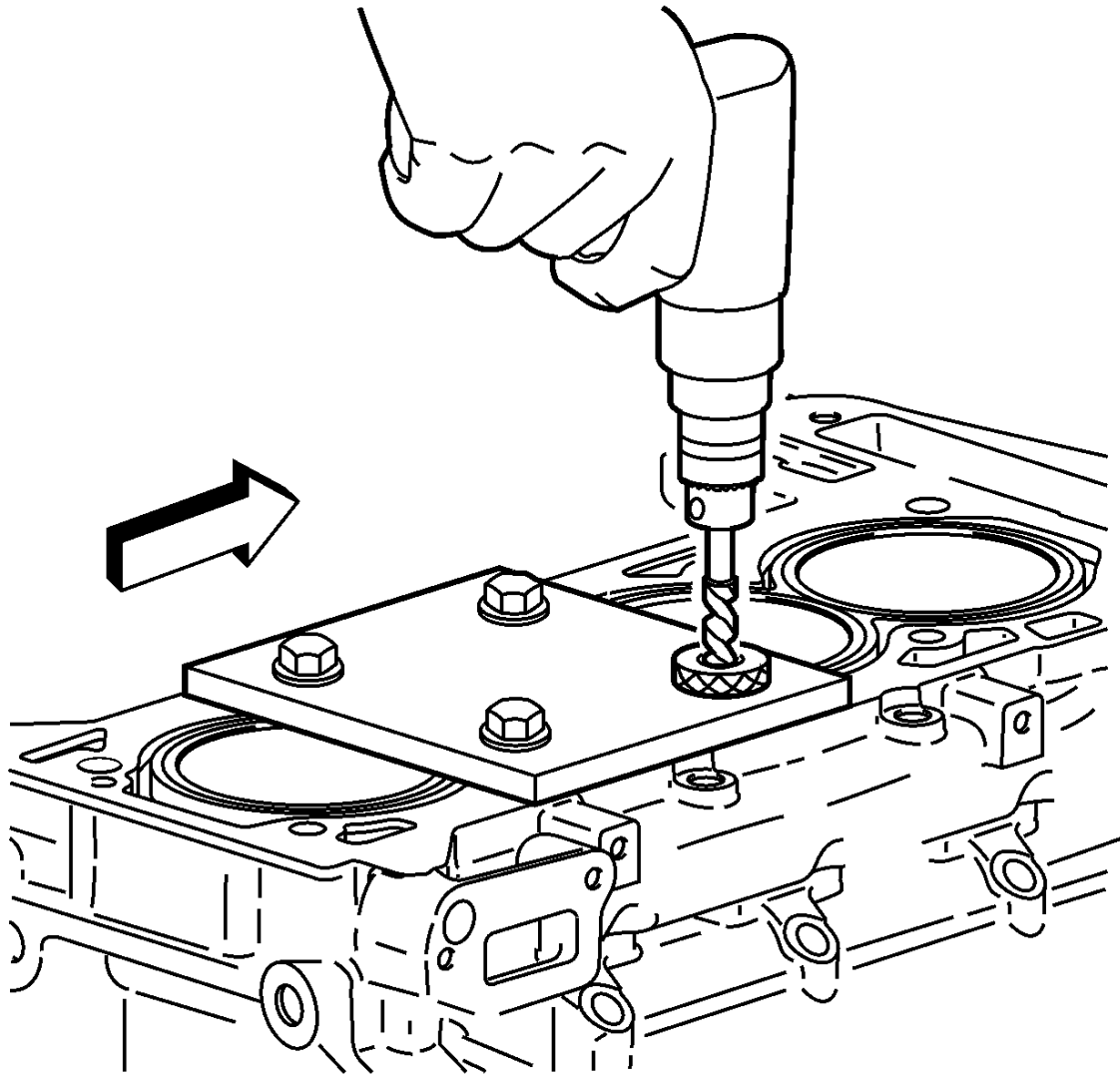
3. Position the alignment pin (1) through the bushing and into the hole.

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



**Fig. 440: View Of Stop Collar & Counterbore Drill**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 441: Drilling Out Threads Of Damaged Hole**  
Courtesy of GENERAL MOTORS COMPANY

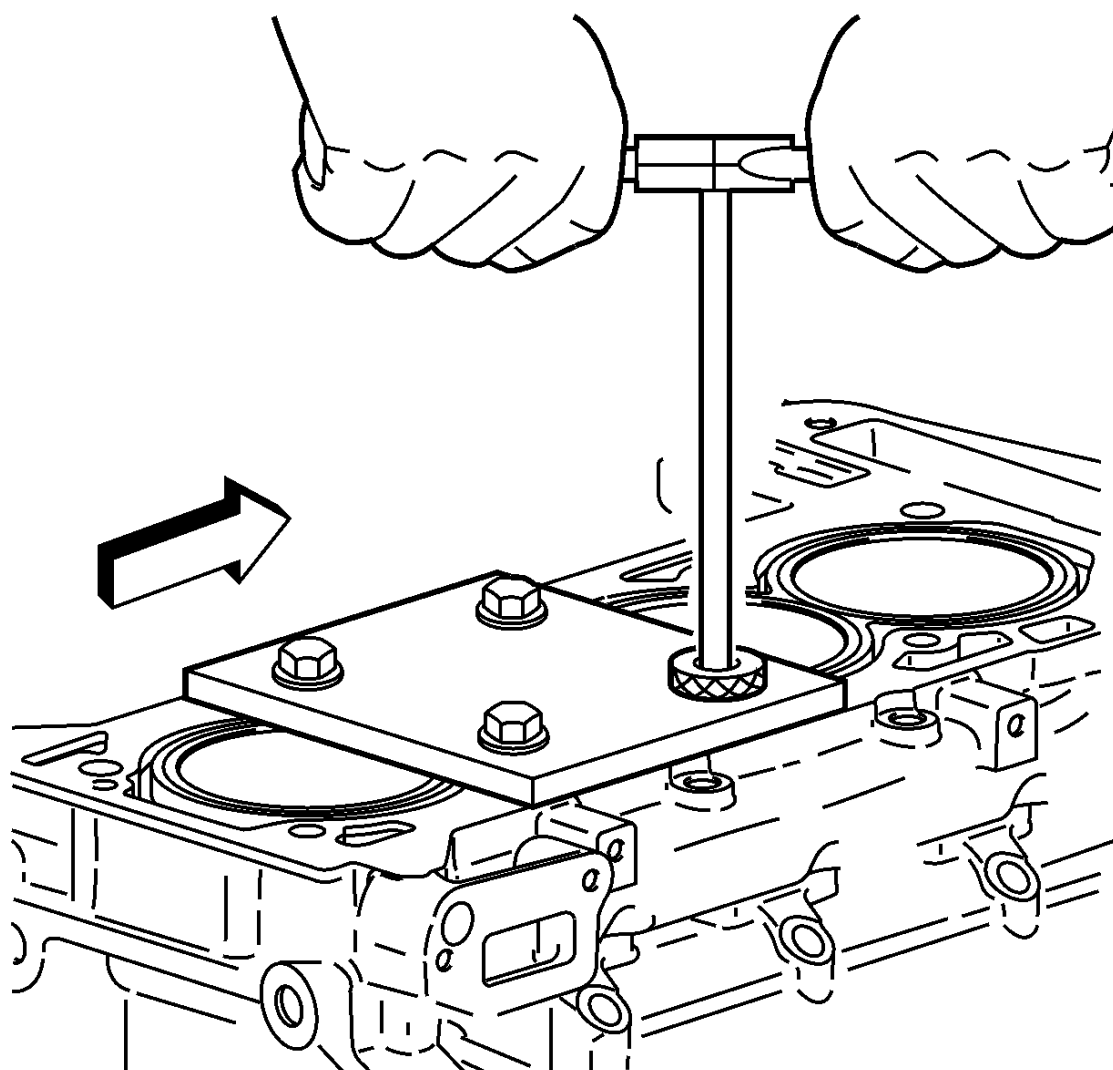
**NOTE:** During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

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

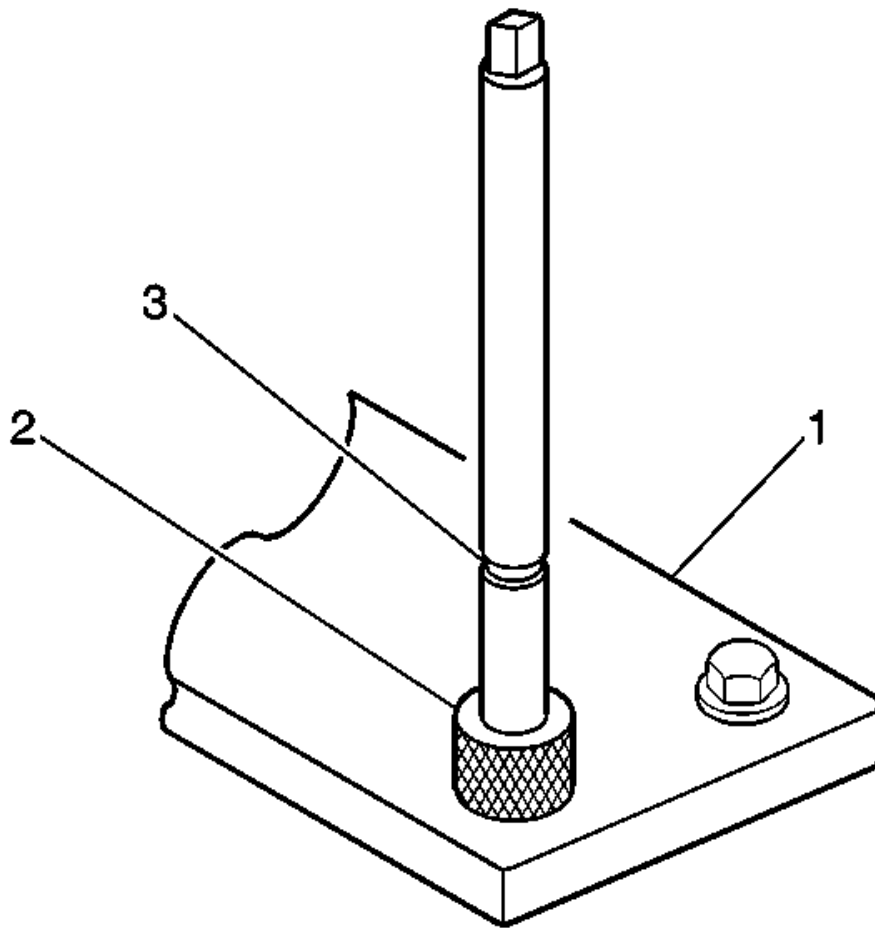
**WARNING:** Refer to Safety Glasses and Compressed Air Warning .

8. Using compressed air, clean out any chips.



**Fig. 442: Tapping Threads Of Drilled Hole With Tap Wrench**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 443: View Of Fixture Plate, Drill Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS COMPANY

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

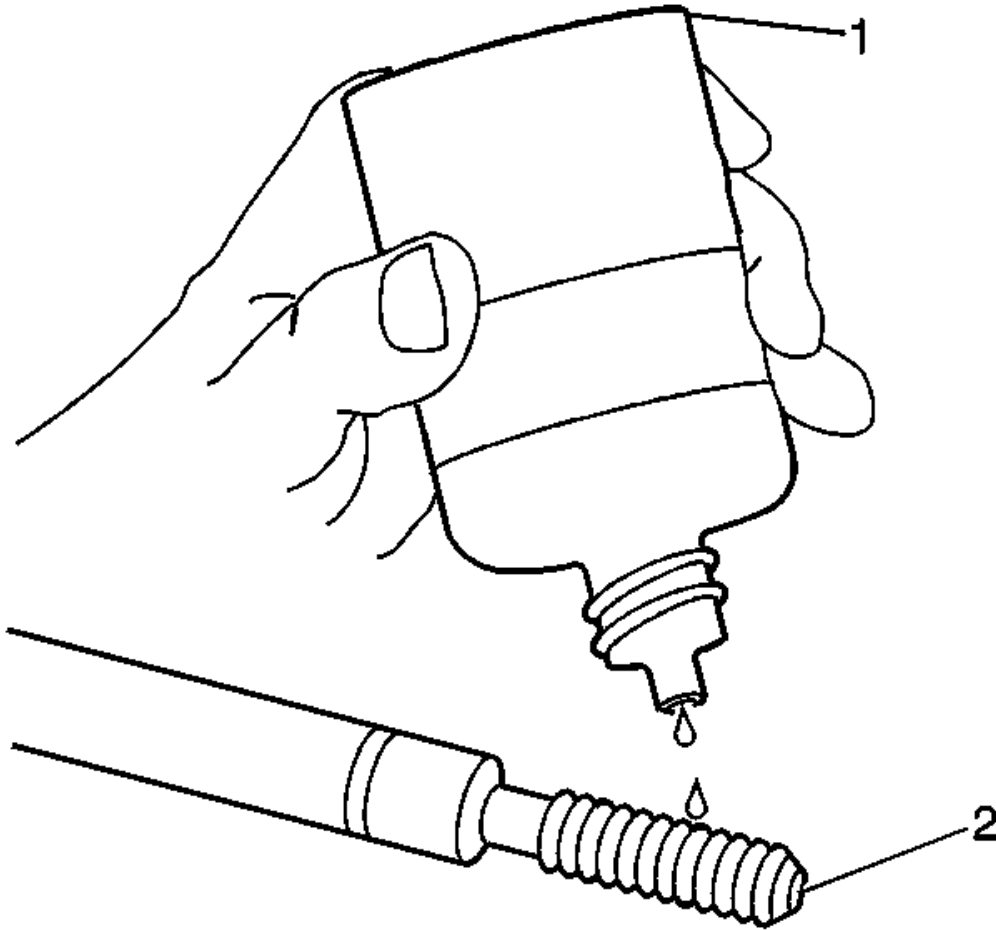
In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

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

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

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

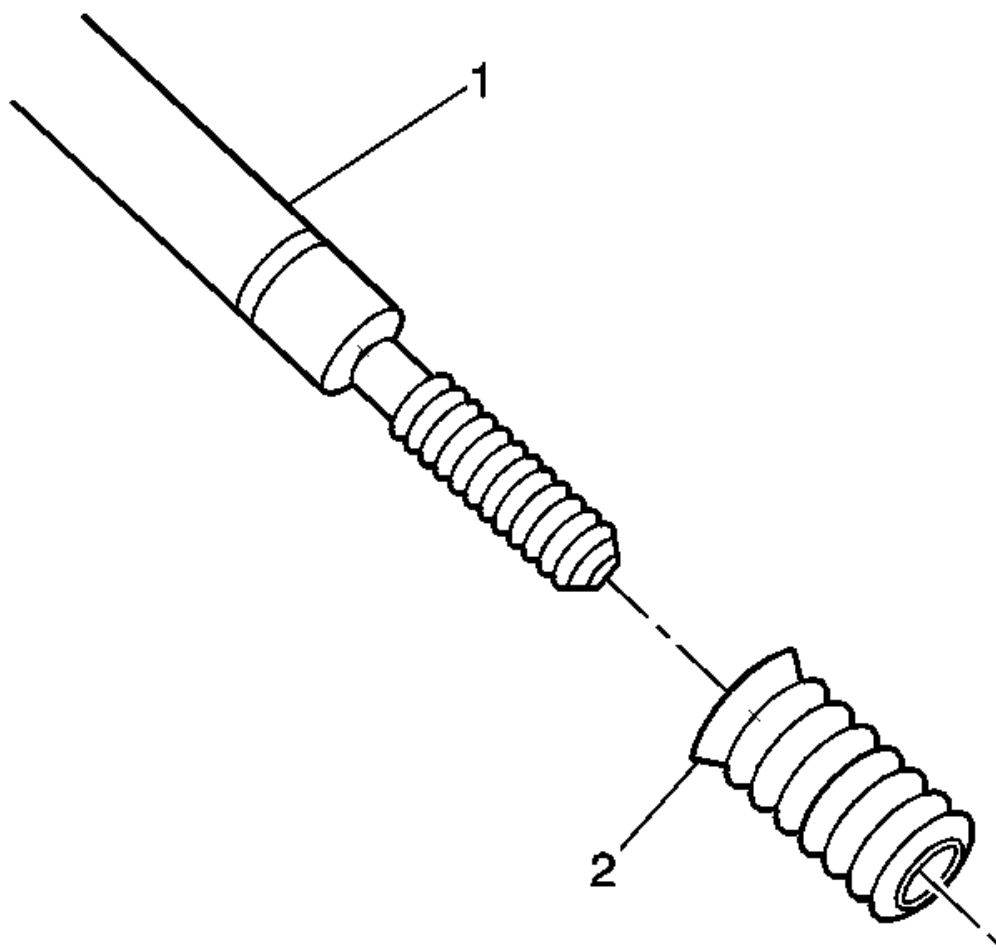
12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
14. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 444: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS COMPANY

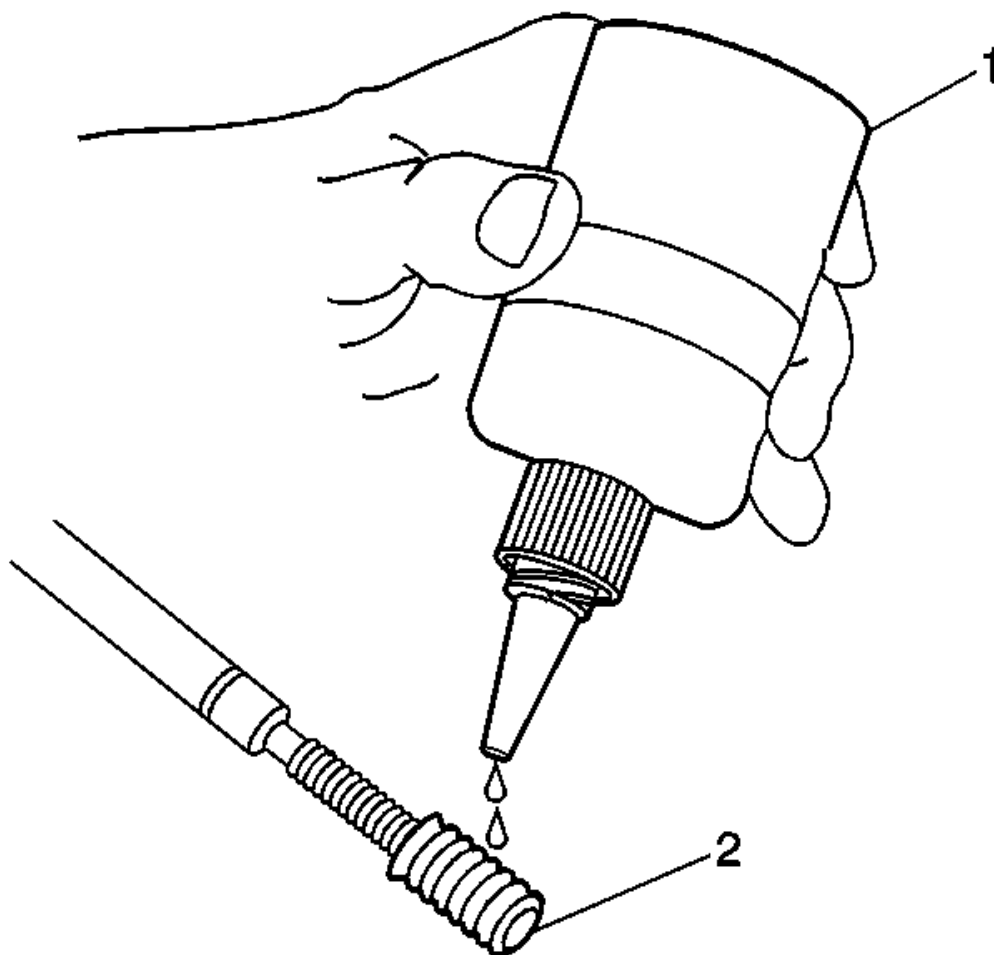
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



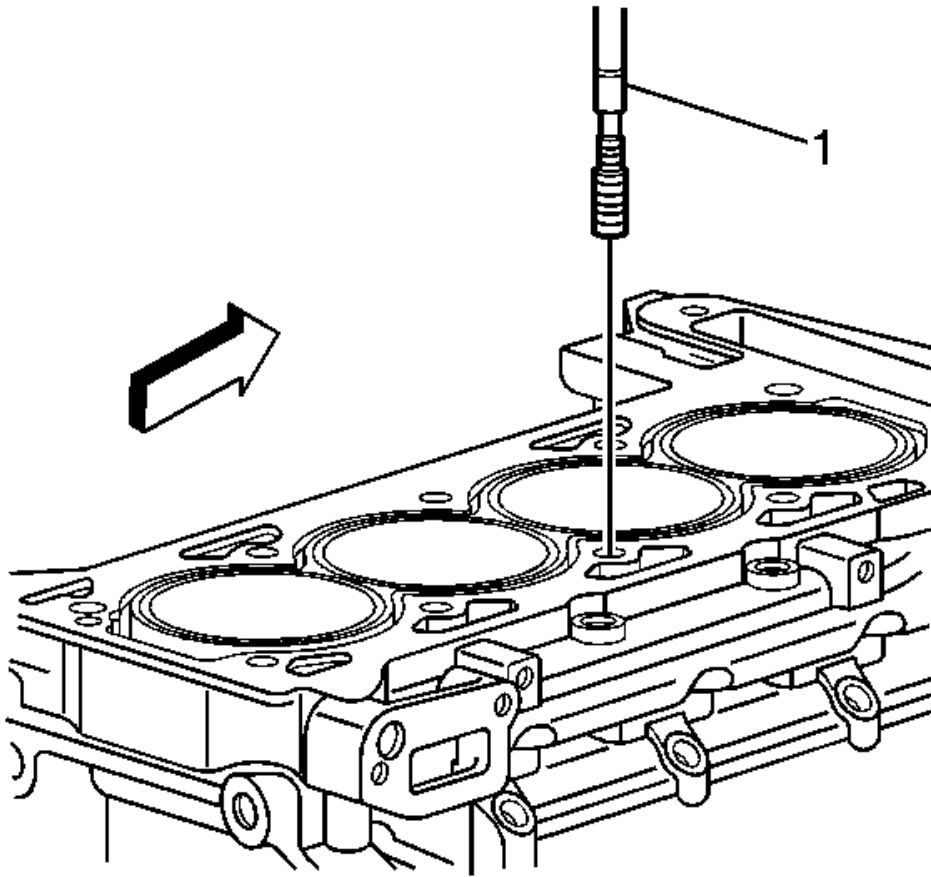
**Fig. 445: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 446: Applying Threadlock To Insert**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 447: View of Driver Tool**

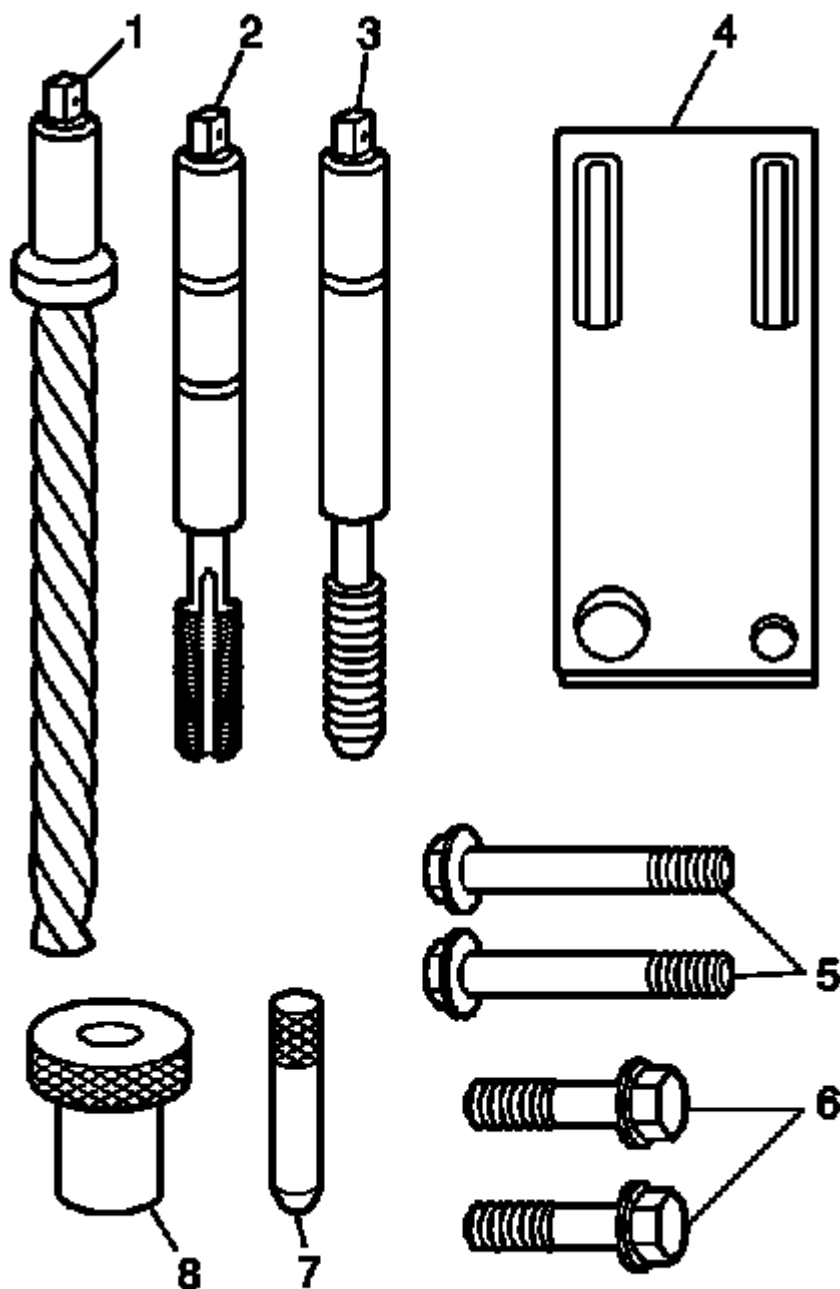
Courtesy of GENERAL MOTORS COMPANY

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

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

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

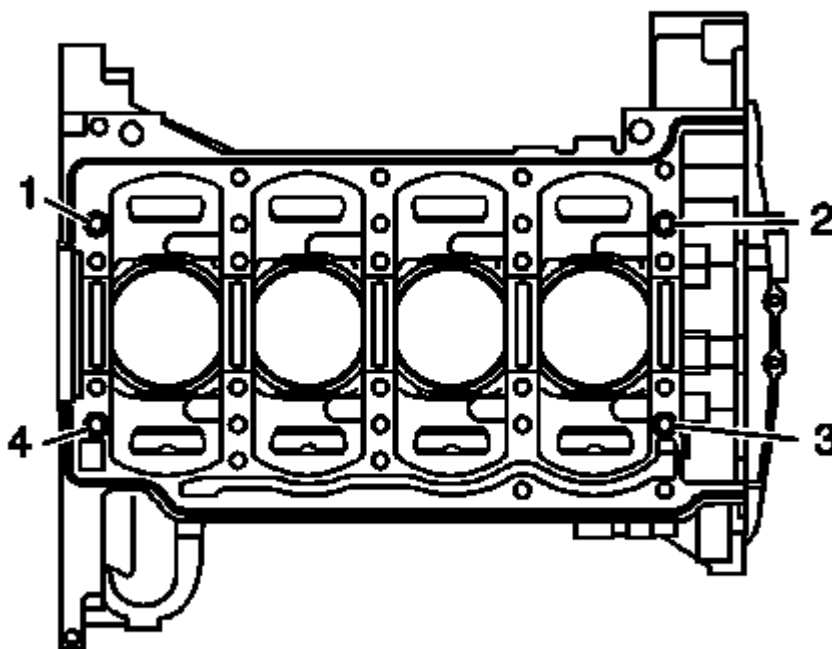
#### **Main Cap Bolt Hole Thread Repair**



**Fig. 448: Identifying Thread Repair Kit Components**  
Courtesy of GENERAL MOTORS COMPANY

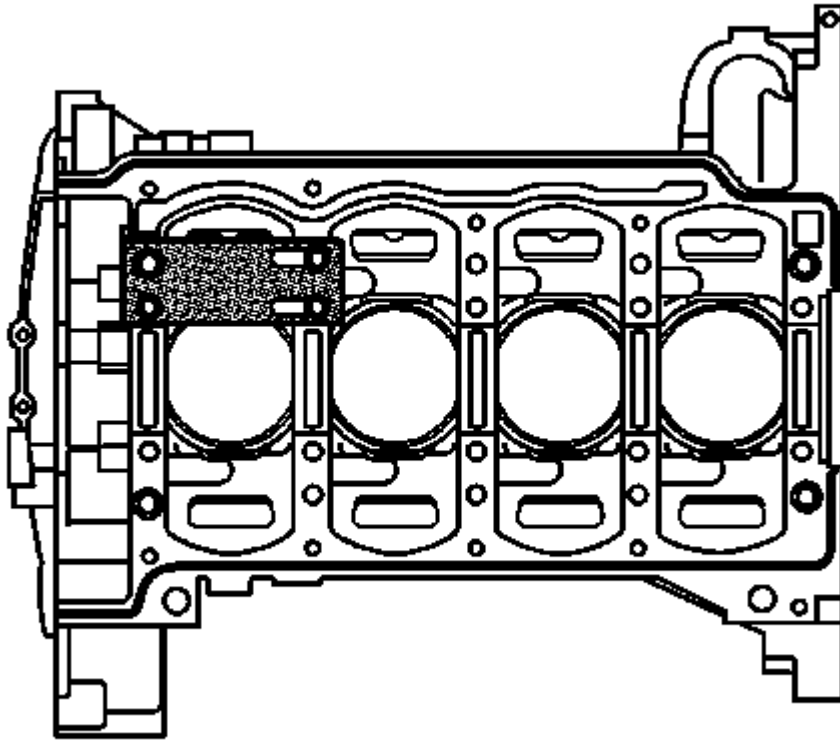
1. The main cap bolt hole thread repair kit consists of the following items:
  - Drill (1)
  - Tap (2)
  - Installer (3)

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



**Fig. 449: Identifying Alignment Dowel Pins**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 450: View of Fixture Plate on Engine Block**  
Courtesy of GENERAL MOTORS COMPANY

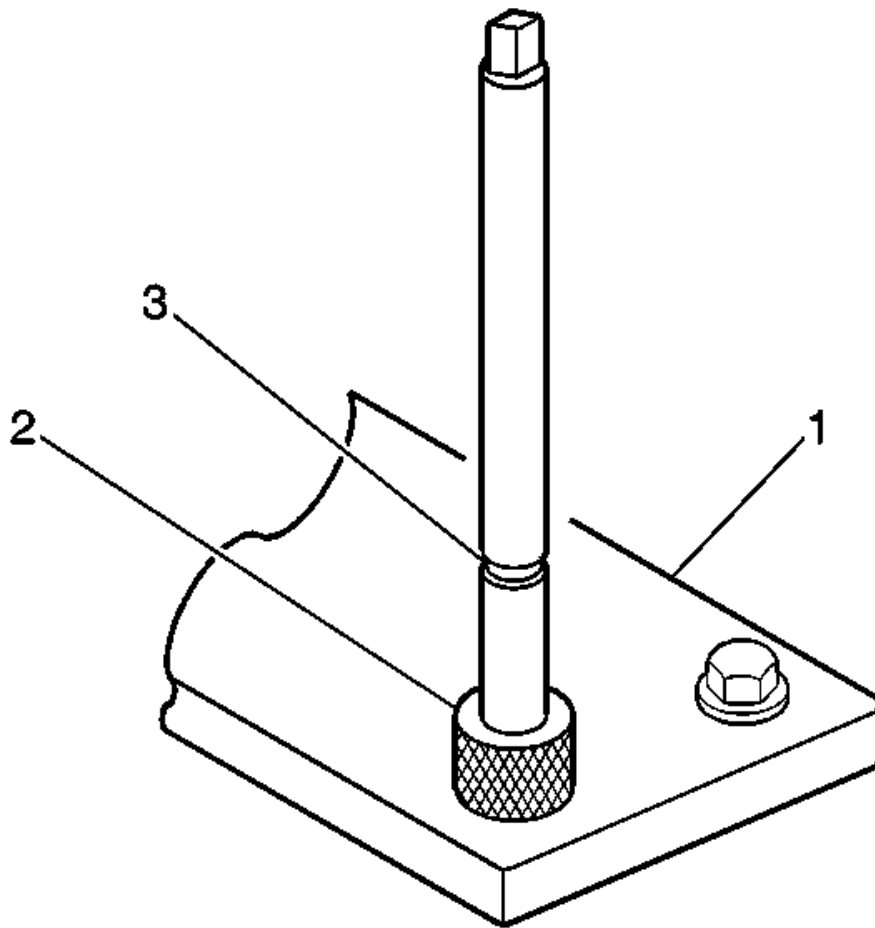
3. Install the fixture plate, bolt, and bushing, onto the engine block.

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

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

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

6. Using compressed air, clean out any chips.



**Fig. 451: View Of Fixture Plate, Drill Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS COMPANY

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

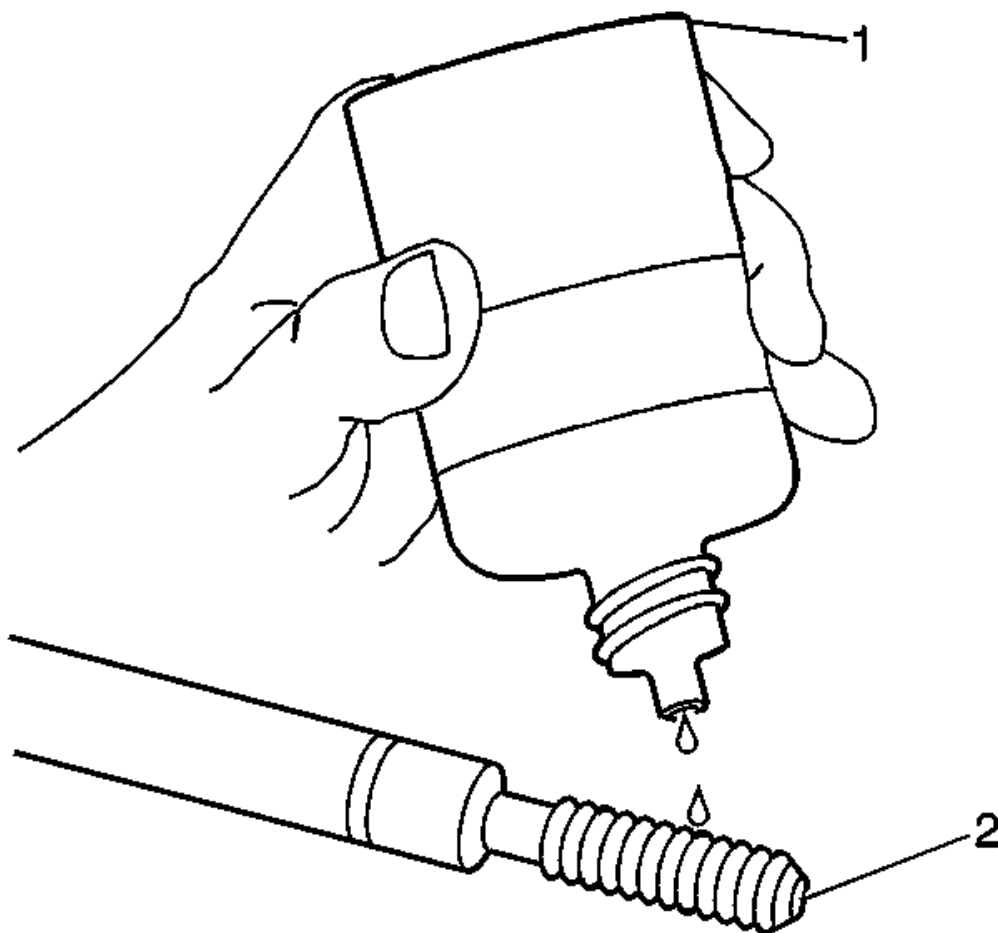
In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap aligns with the top of the bushing (2).

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

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

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

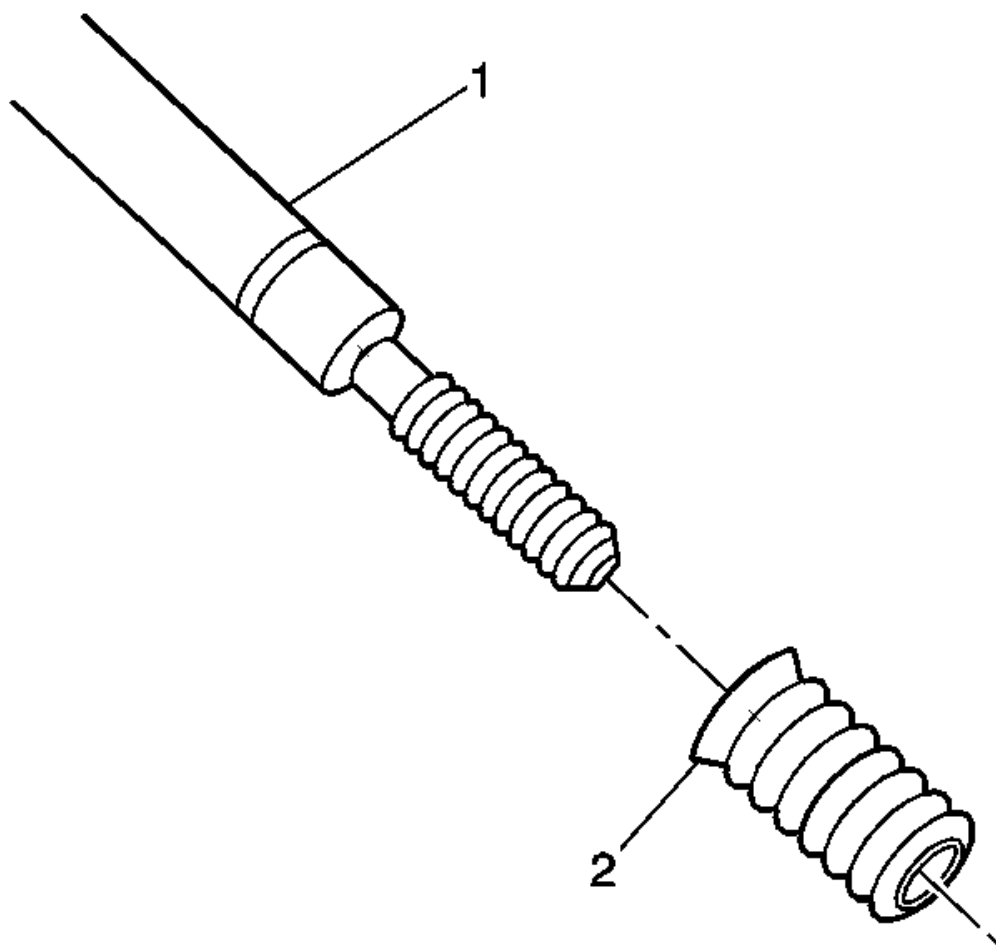
10. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 452: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS COMPANY

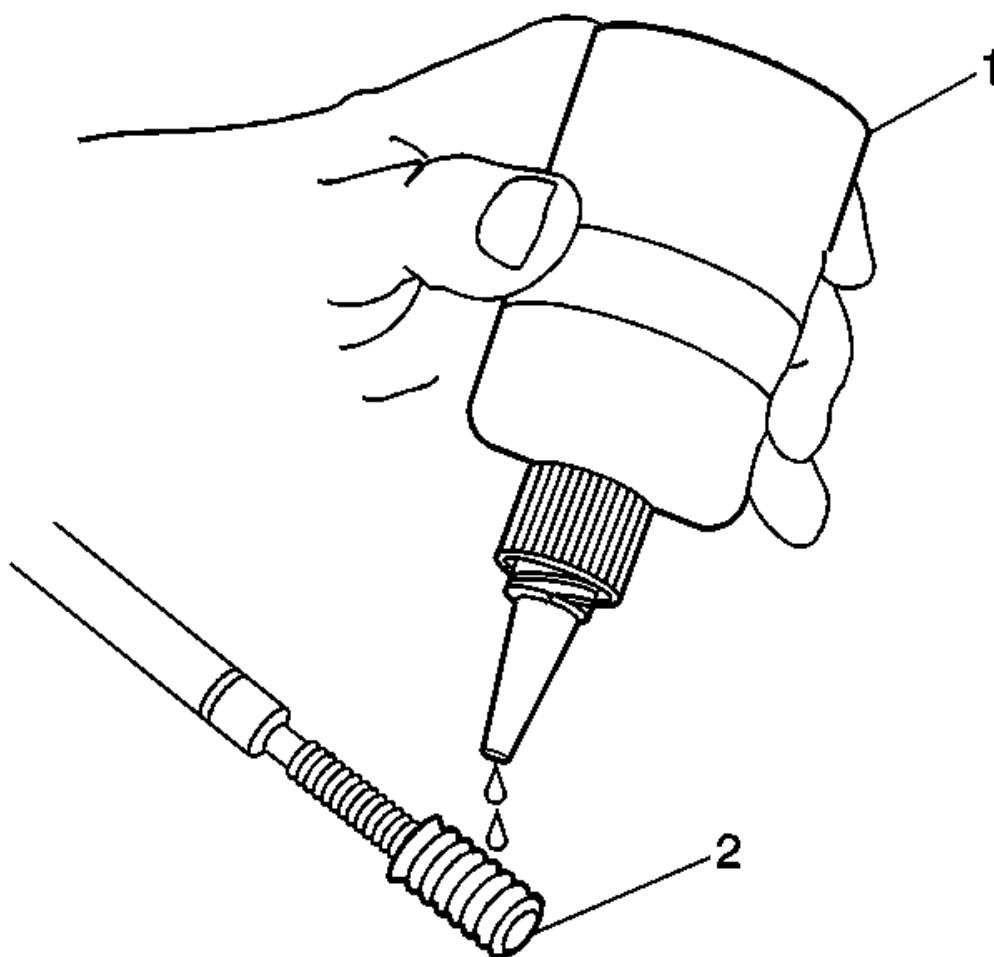
**NOTE:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



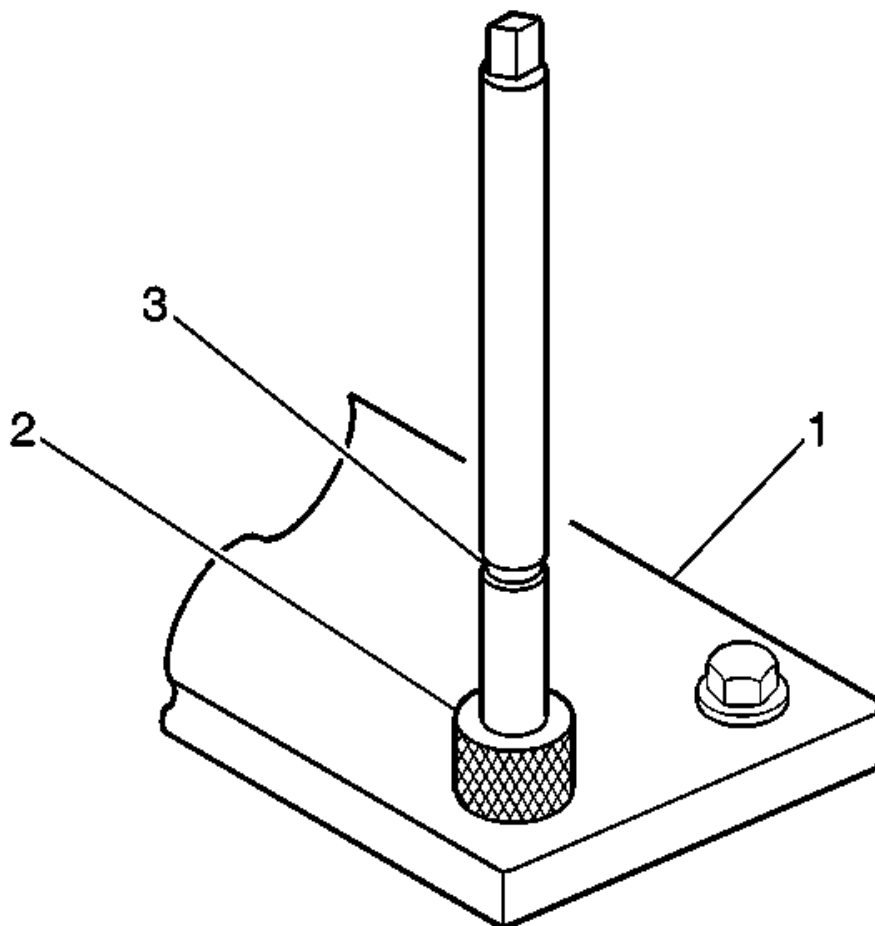
**Fig. 453: View of Bushing Type Insert**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 454: Applying Threadlock To Insert**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 455: View Of Fixture Plate, Drill Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS COMPANY

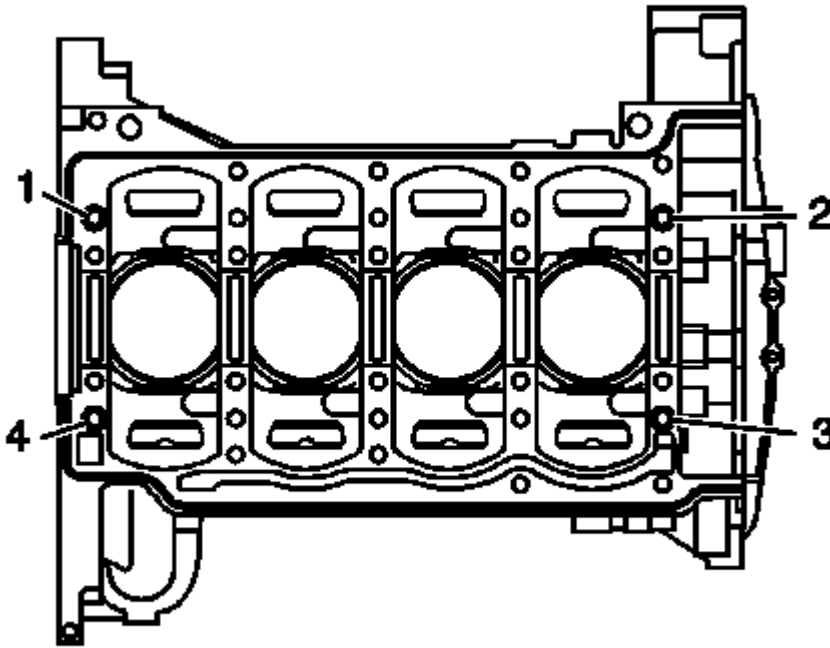
**NOTE:** The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

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

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

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

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



**Fig. 456: Identifying Alignment Dowel Pins**  
Courtesy of GENERAL MOTORS COMPANY

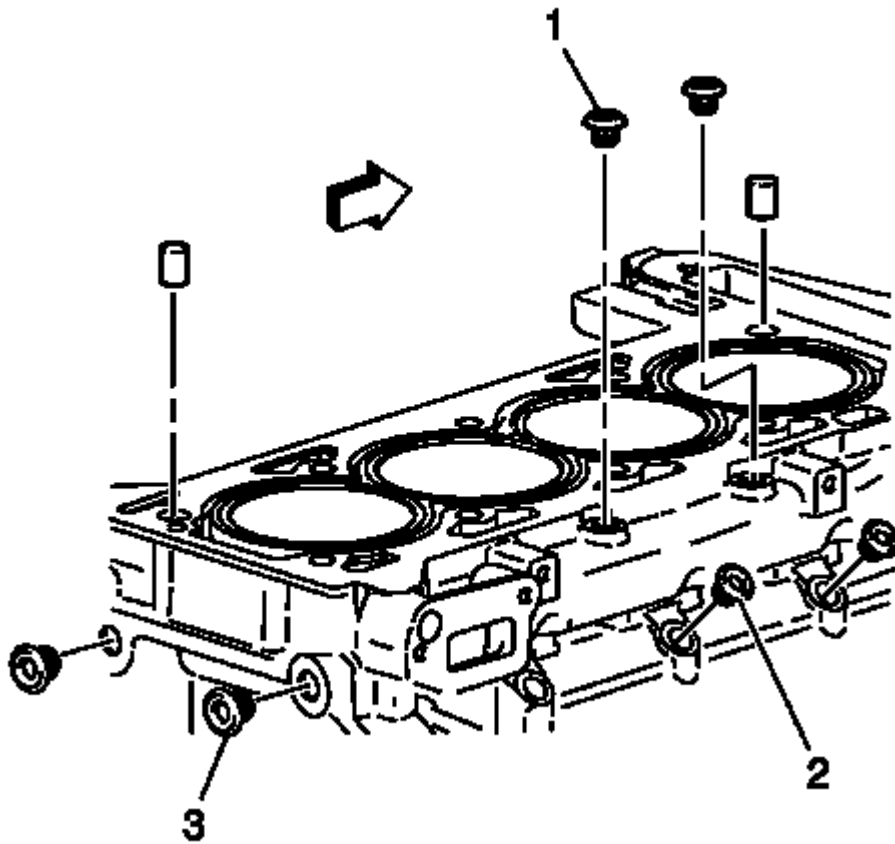
16. Install the alignment dowel pins in holes (1-4), if necessary.

### SERVICE PRIOR TO ASSEMBLY

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

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

### ENGINE BLOCK ASSEMBLE



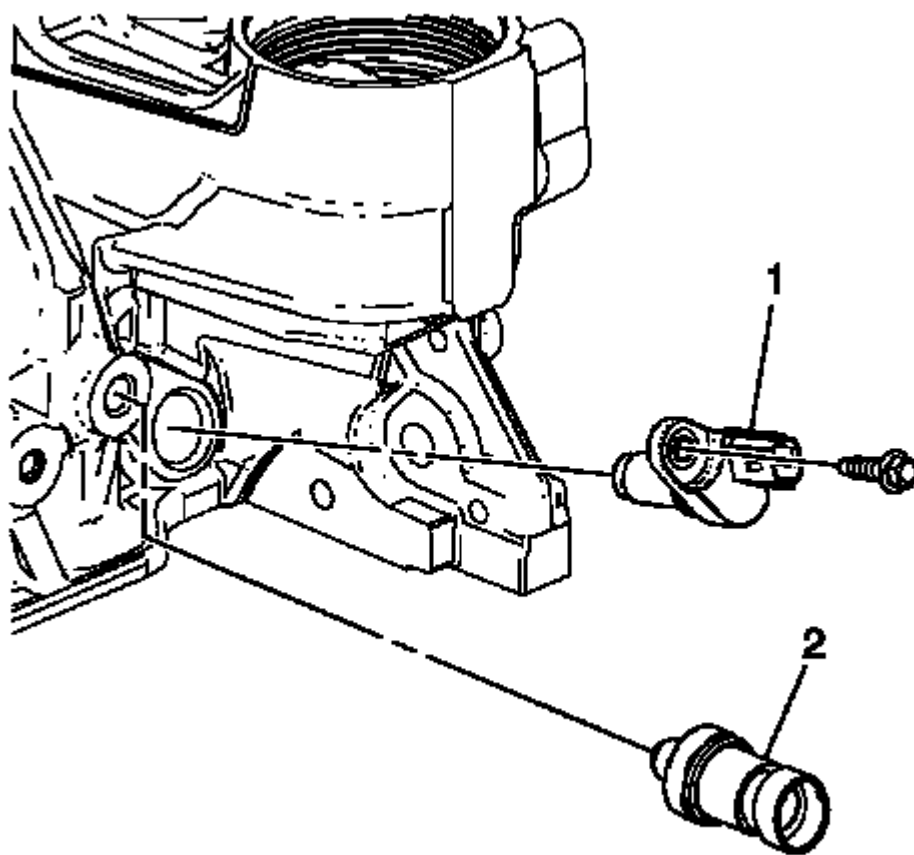
**Fig. 457: Locating Block Plugs**

Courtesy of GENERAL MOTORS COMPANY

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

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

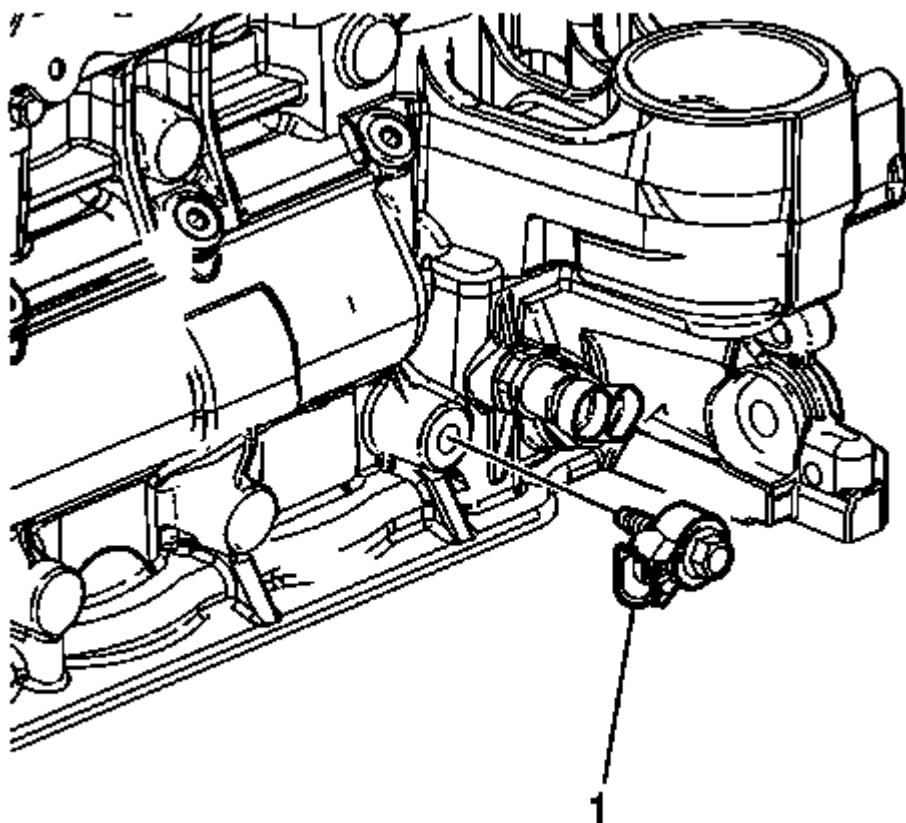
3. Install the coolant jacket plugs, with sealant, and tighten to 35 N.m (26 lb ft).
4. Install the rear oil passage plugs, with sealant, and tighten to 60 N.m (44 lb ft).
5. Install the other oil passage plugs, with sealant, and tighten to 35 N.m (26 lb ft).



**Fig. 458: Oil Pressure Switch**

Courtesy of GENERAL MOTORS COMPANY

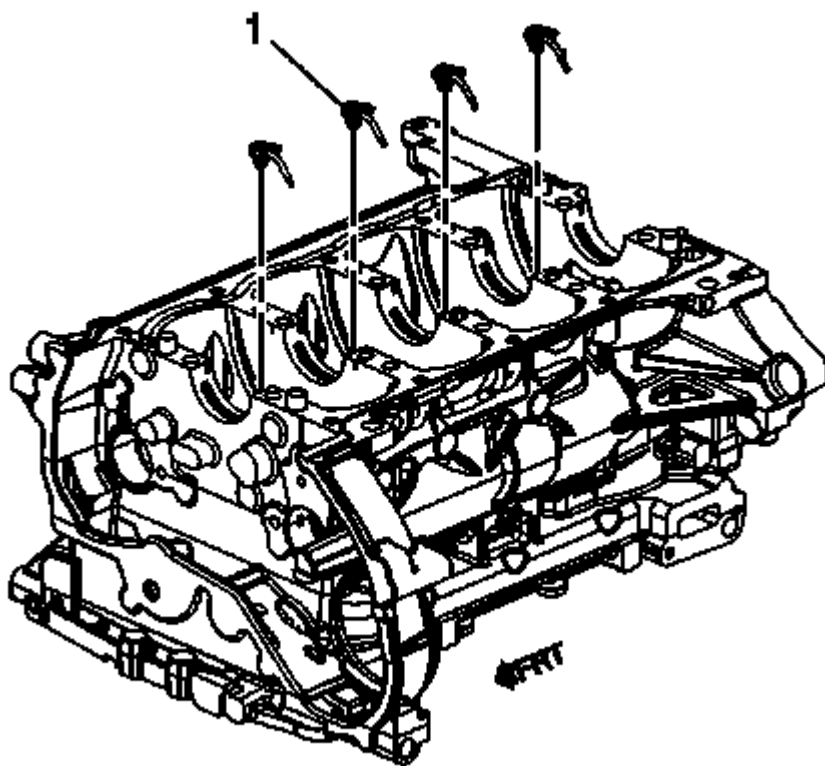
6. Lubricate the crankshaft position sensor O-ring with engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. Install the crankshaft position sensor (1) and bolt and tighten to 10 N.m (89 lb in).
8. Install the oil pressure switch (2) and tighten to 26 N.m (19 lb ft).



**Fig. 459: Knock Sensor**

Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 460: Piston Oil Nozzle Assembly**  
Courtesy of GENERAL MOTORS COMPANY

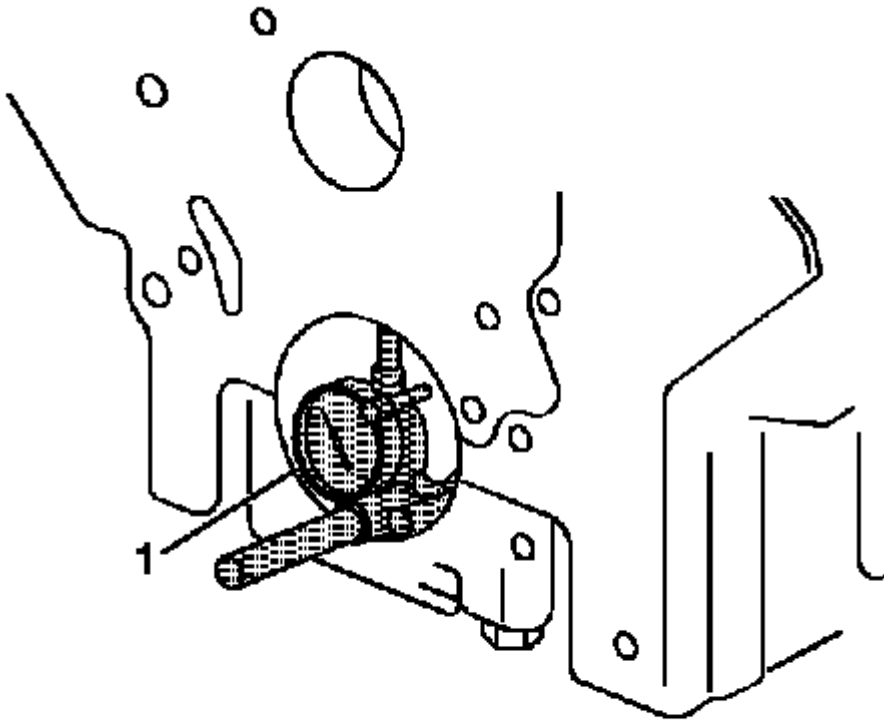
10. Install the piston oil nozzle assemblies (1), if equipped.
11. Install the piston oil nozzle assembly bolts and tighten to 15 N.m (11 lb ft).

## CRANKSHAFT AND BEARING INSTALLATION

### Special Tools

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

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



**Fig. 461: Measuring Bearing Bore**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

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

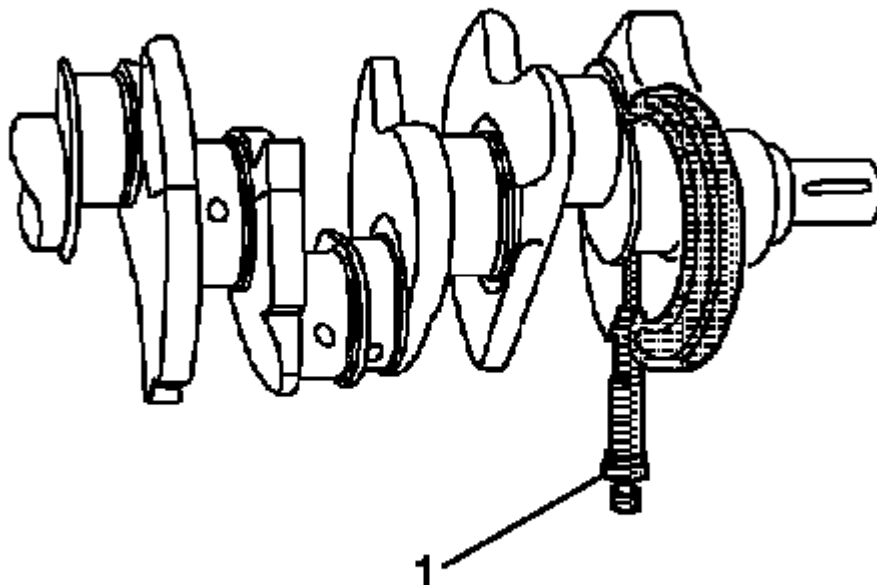
Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

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

**Bearing Selection**

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are 2 methods to measure bearing clearance. Method A gives more reliable results and is preferred.

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

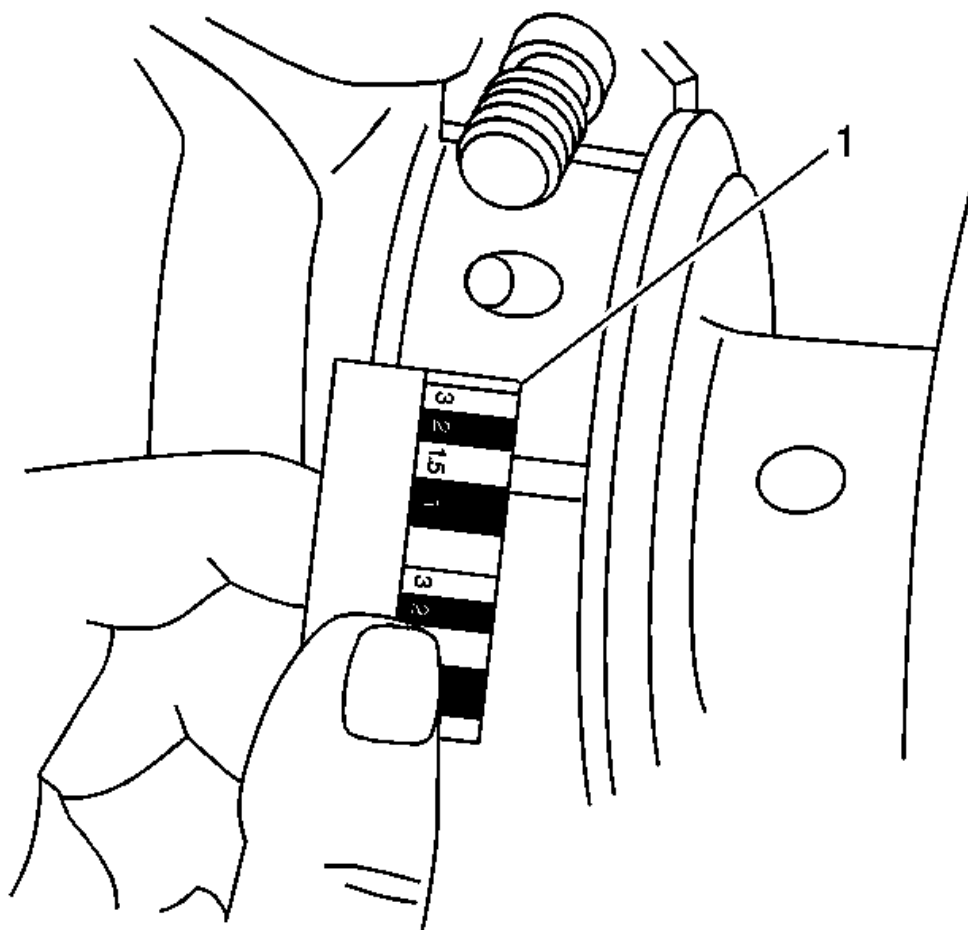


**Fig. 462: Measuring Bearing Clearance Using Method A**  
Courtesy of GENERAL MOTORS COMPANY

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

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

8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
9. Measure the crankshaft main bearing inside diameter with an inside micrometer.



**Fig. 463: Measuring Bearing Clearance Using Method B**  
Courtesy of GENERAL MOTORS COMPANY

3. To measure bearing clearance using Method B, use the following procedure:
  1. Clean the used bearing inserts.
  2. Install the used bearing inserts.
  3. Place a piece of gaging plastic across the entire bearing width.
  4. Install the bearing caps.

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

**use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.**

5. Install the bearing cap bolts to specification.

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

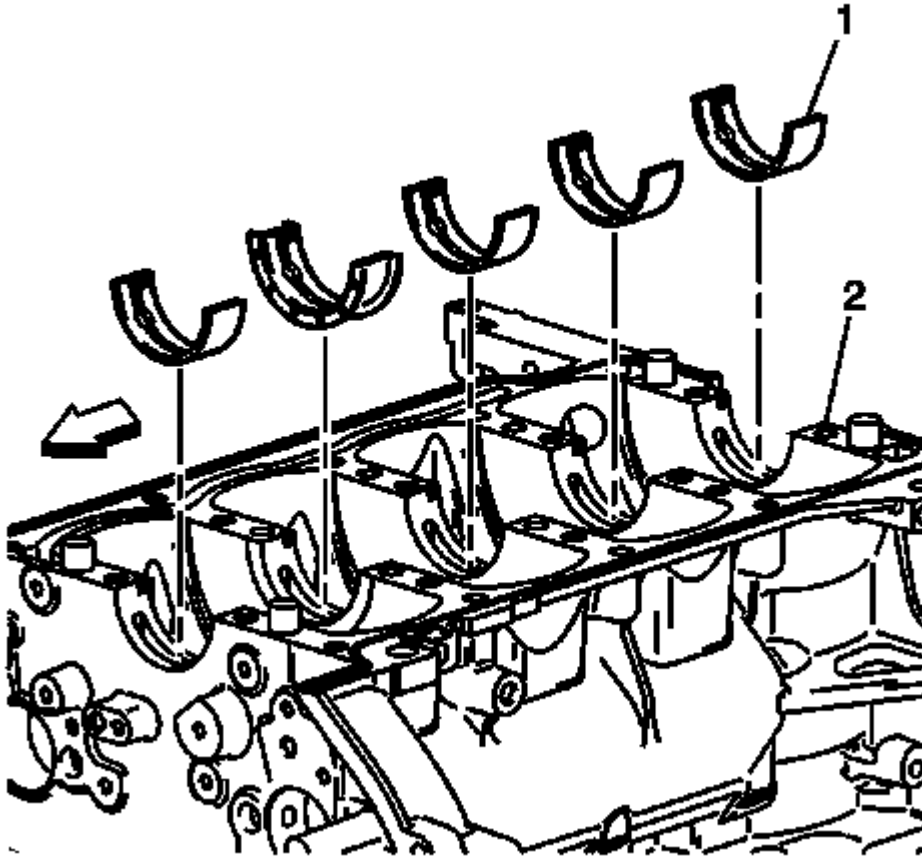
6. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or to the bearing cap.
7. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
8. Remove the gauging plastic.

## **LOWER CRANKCASE INSTALLATION**

### **Special Tools**

**EN 45059** Angle Meter

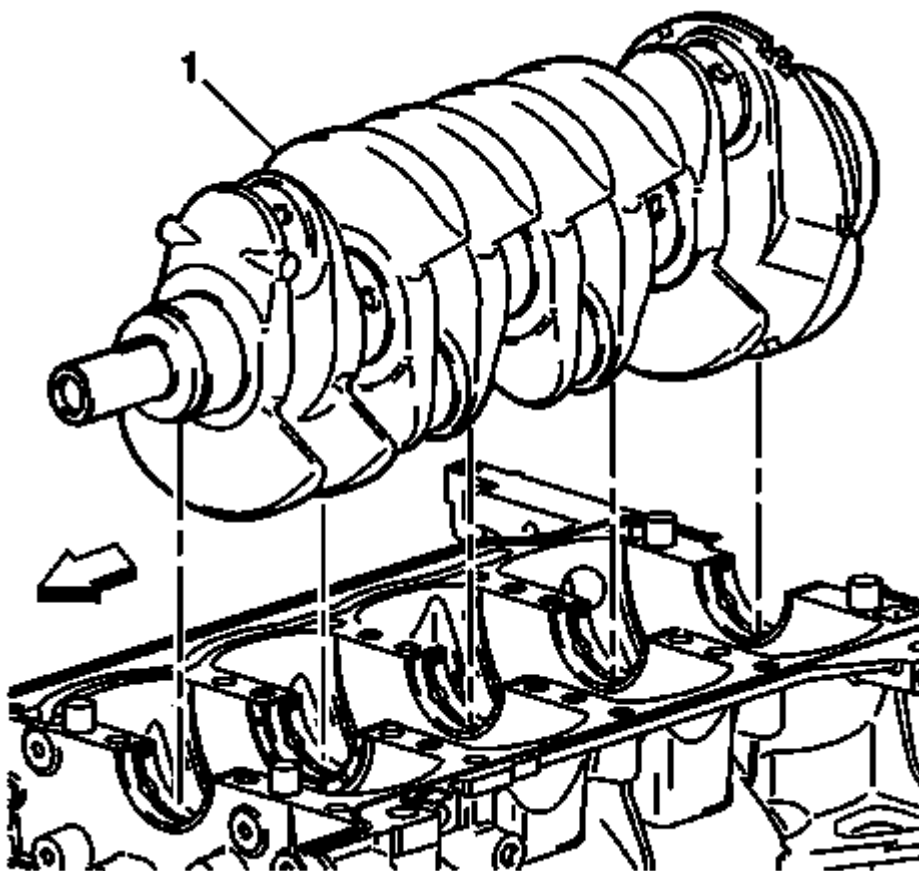
For equivalent regional tools, refer to **Special Tools**.



**Fig. 464: View of Upper Crankshaft Bearings**  
Courtesy of GENERAL MOTORS COMPANY

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

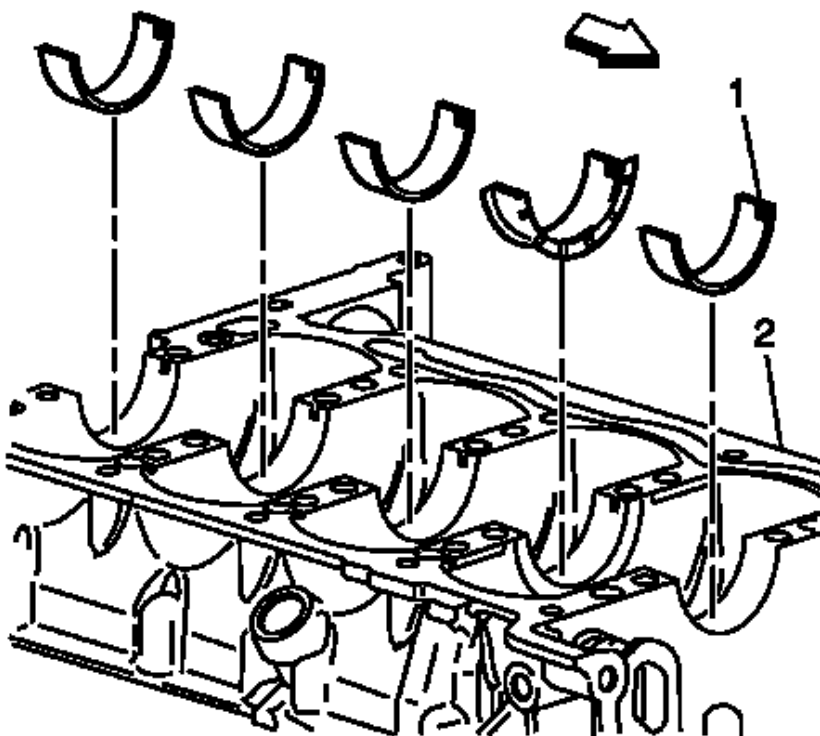
1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.



**Fig. 465: View of Crankshaft**

**Courtesy of GENERAL MOTORS COMPANY**

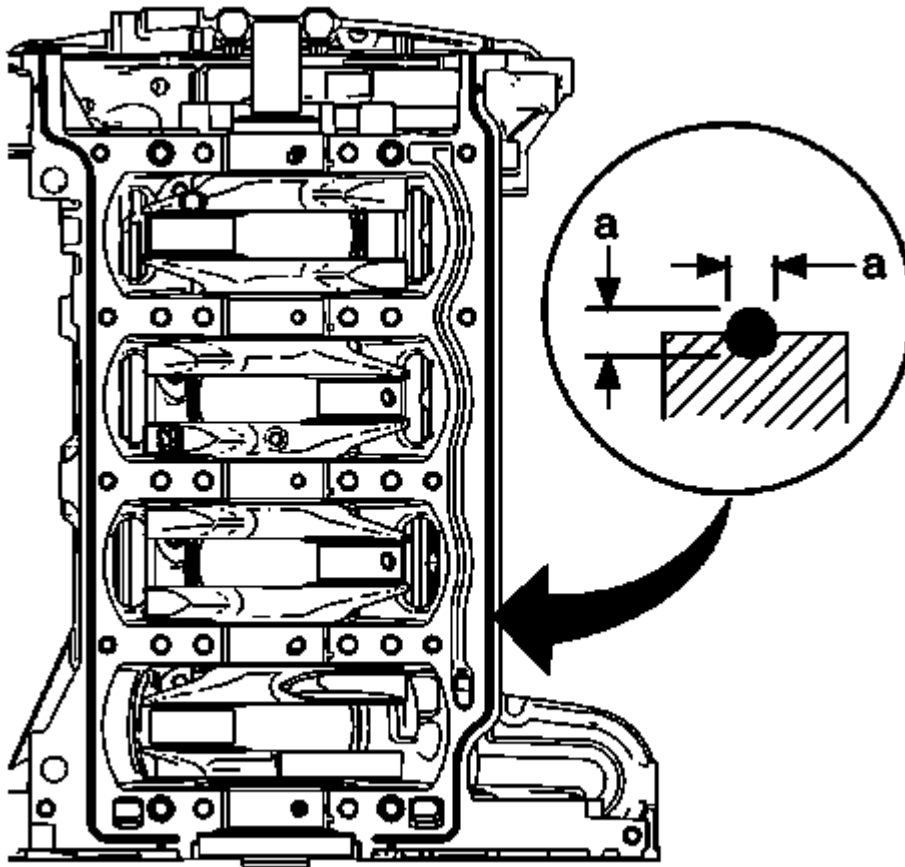
2. Install the crankshaft (1) on the journals.



**Fig. 466: View of Lower Bearing Halves**

Courtesy of GENERAL MOTORS COMPANY

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



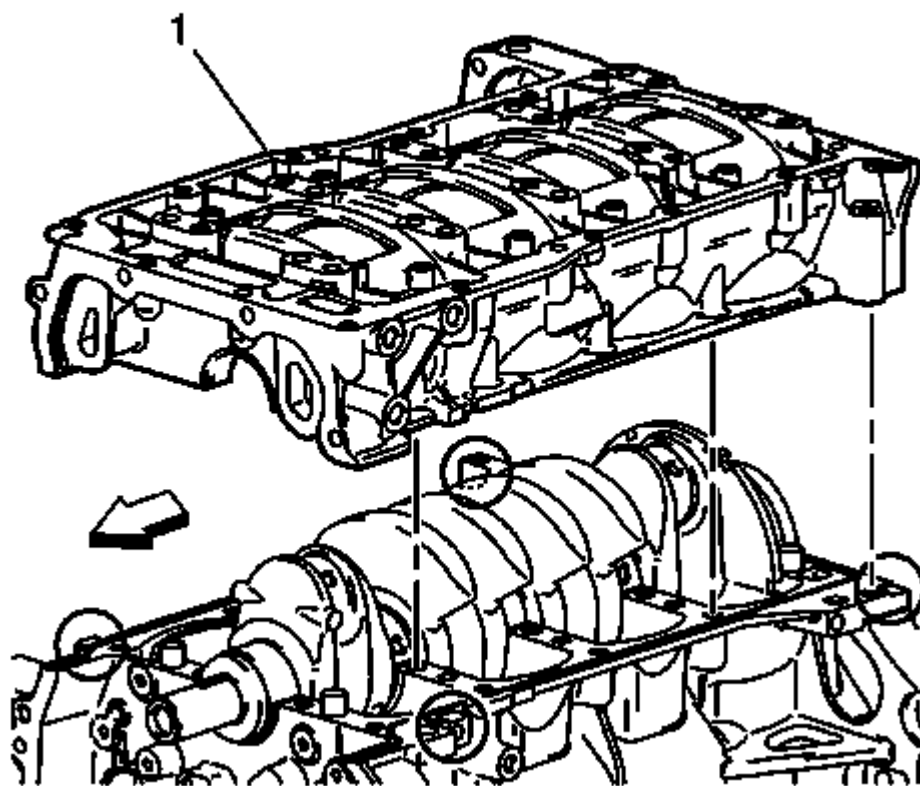
**Fig. 467: Applying Sealer**

Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

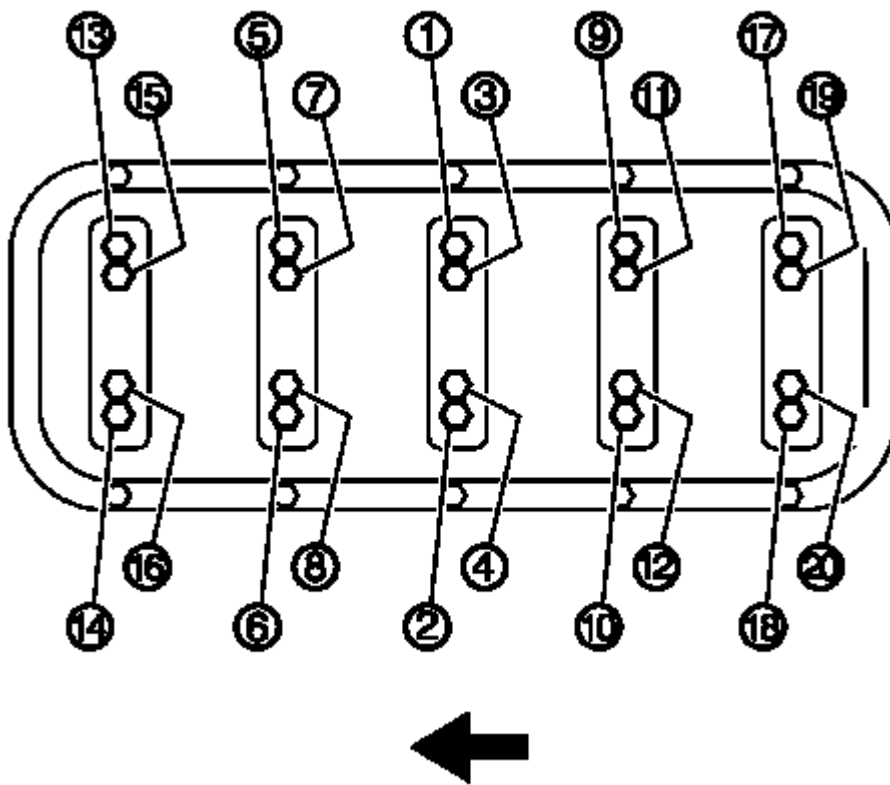
- The block assembly surface must be free of contamination prior to applying the sealer.
- Install and align the bedplate to block within 20 minutes of applying the sealer.
- The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.

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



**Fig. 468: View of Lower Crankcase**  
**Courtesy of GENERAL MOTORS COMPANY**

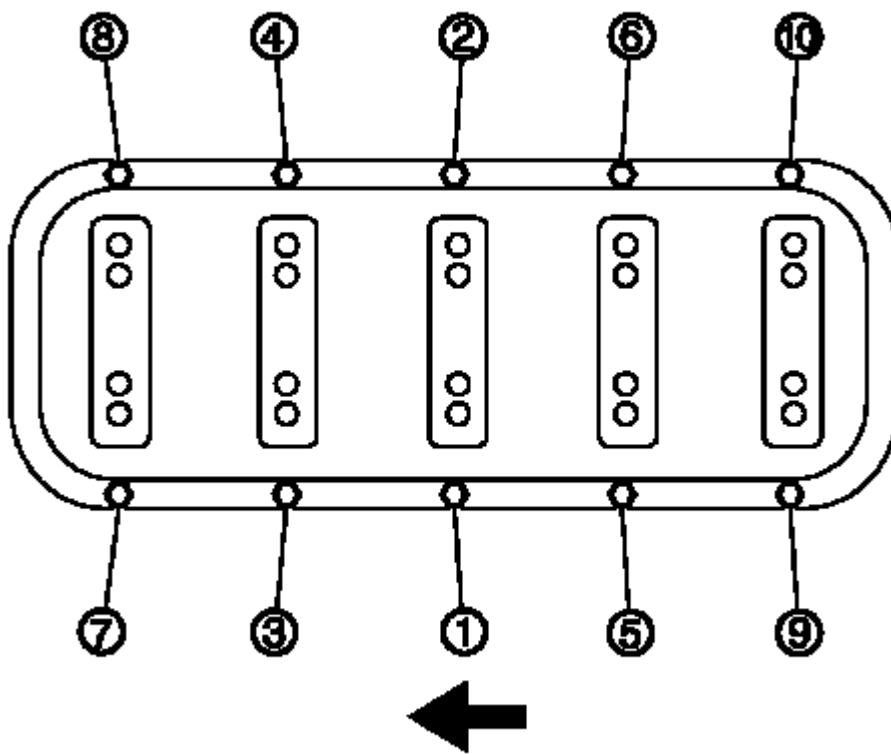
5. Install the lower crankcase (1). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.



**Fig. 469: Identifying Crankshaft Bearing Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

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



**Fig. 470: Lower Crankcase Perimeter Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

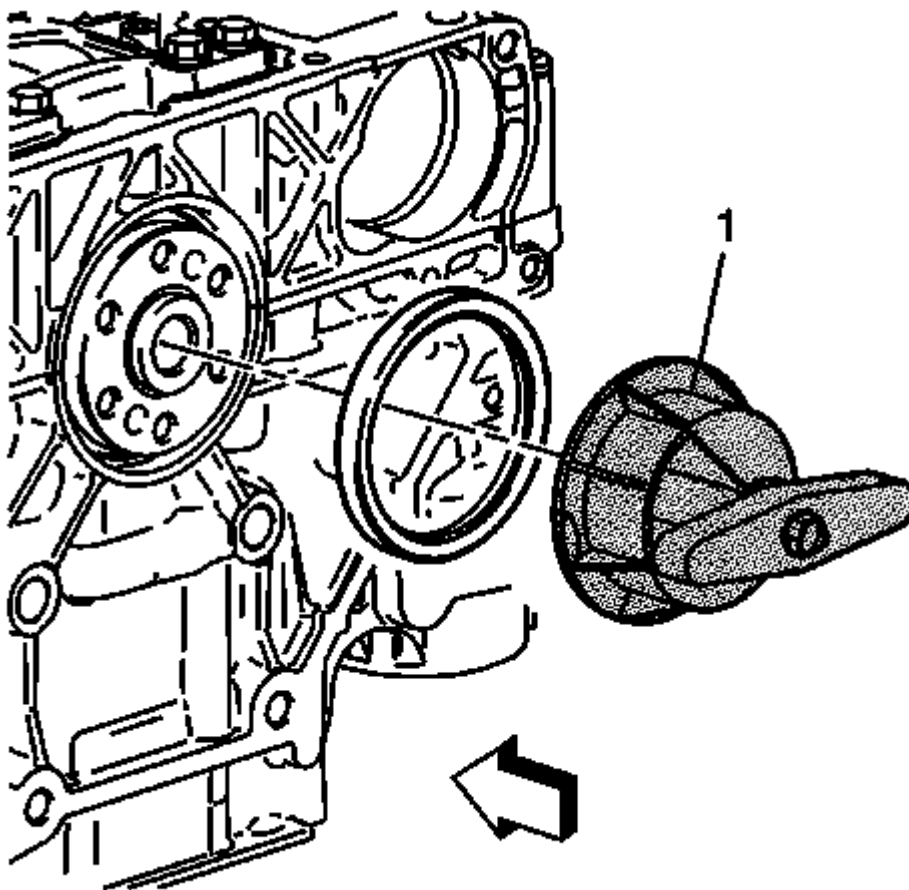
7. Tighten the lower crankcase perimeter bolts in sequence to 25 N.m (18 lb ft).

## CRANKSHAFT REAR OIL SEAL INSTALLATION

### Special Tools

**EN-42067** Rear Main Seal Installer

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



**Fig. 471: Rear Crankshaft Seal & Installer**  
Courtesy of GENERAL MOTORS COMPANY

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

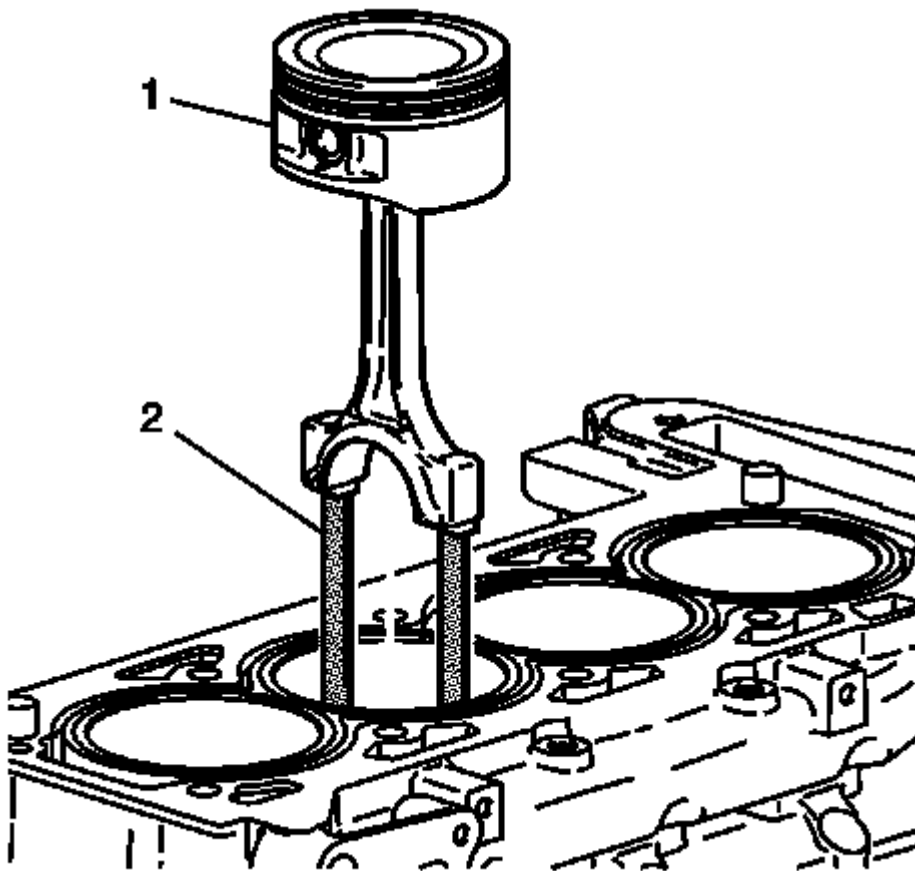
## PISTON, CONNECTING ROD, AND BEARING INSTALLATION (LEA)

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

### Special Tools

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

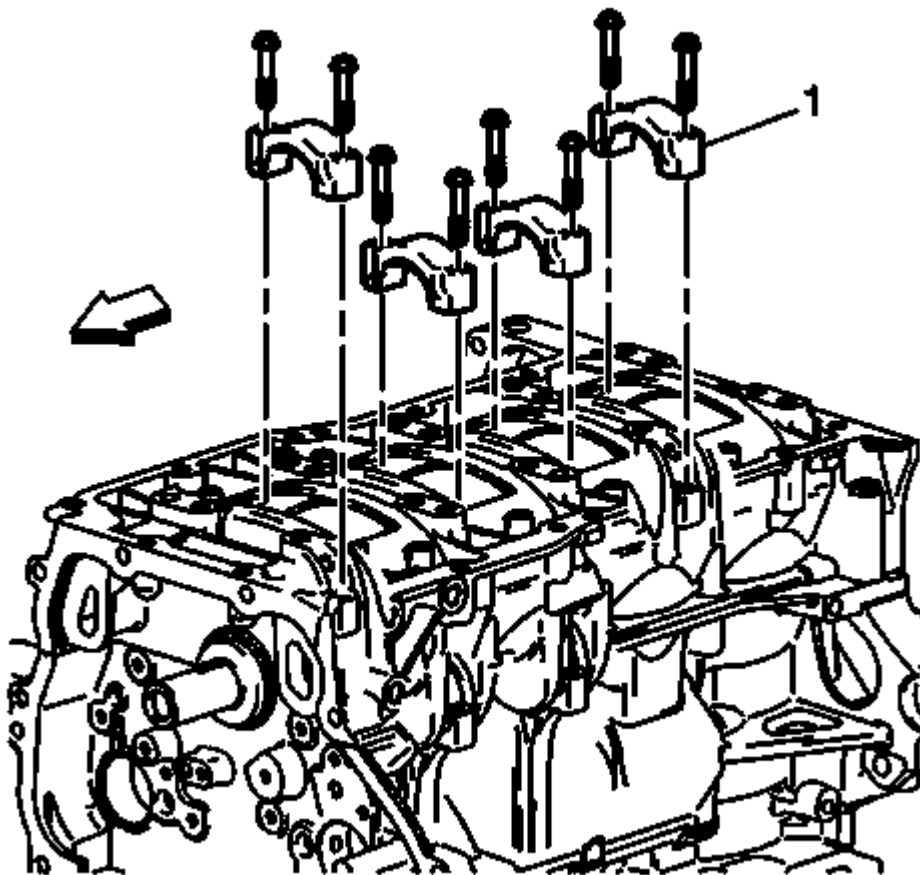
For equivalent regional tools, refer to **Special Tools**.



**Fig. 472: View Of Connecting Rod Guides**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the connecting rod bearings. Use NEW bearings.
  1. Install the bearing inserts into the connecting rod and the connecting rod cap.
  2. Lubricate the connecting rod bearings with engine oil.
2. Install the **EN-43966** guides (1) into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.
3. Install **EN-47836** compressor , piston, and the connecting rod to the correct bore.
  1. Stagger each piston ring end gap equally around the piston.
  2. Lubricate the piston and the piston rings with engine oil.
  3. Do not disturb the piston ring end gap location.
  4. The piston must be installed so that the mark on the top of the piston faces the front of the engine.
  5. Place the piston in its matching bore.
  6. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
  7. Hold the **EN-47836** compressor against the engine block until all the rings have entered the cylinder bore.

8. Remove the connecting rod guides from the connecting rod bolt holes.



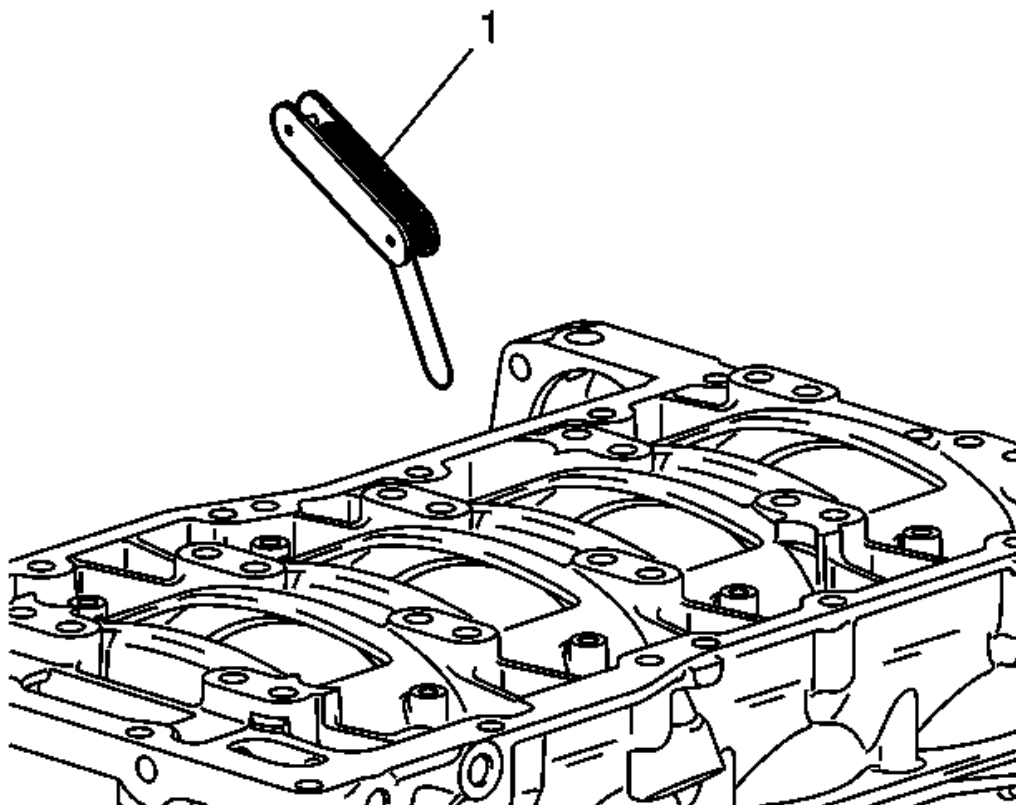
**Fig. 473: View of Connecting Rod Cap**  
Courtesy of GENERAL MOTORS COMPANY

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

4. Install the connecting rod cap (1).

**CAUTION:** Refer to Fastener Caution .

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



**Fig. 474: Measuring Connecting Rod Side Clearance**  
Courtesy of GENERAL MOTORS COMPANY

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

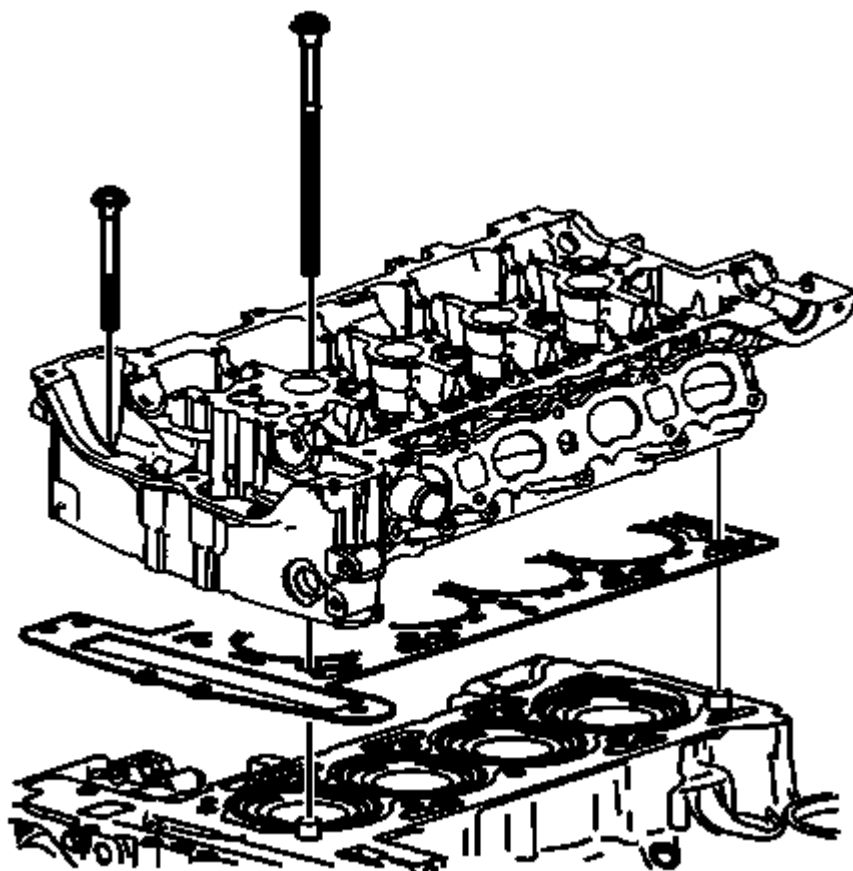
The correct clearance is 0.07-0.37 mm (0.0027-0.0145 in).

## CYLINDER HEAD INSTALLATION (LEA)

### Special Tools

**EN 45059** Angle Meter

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

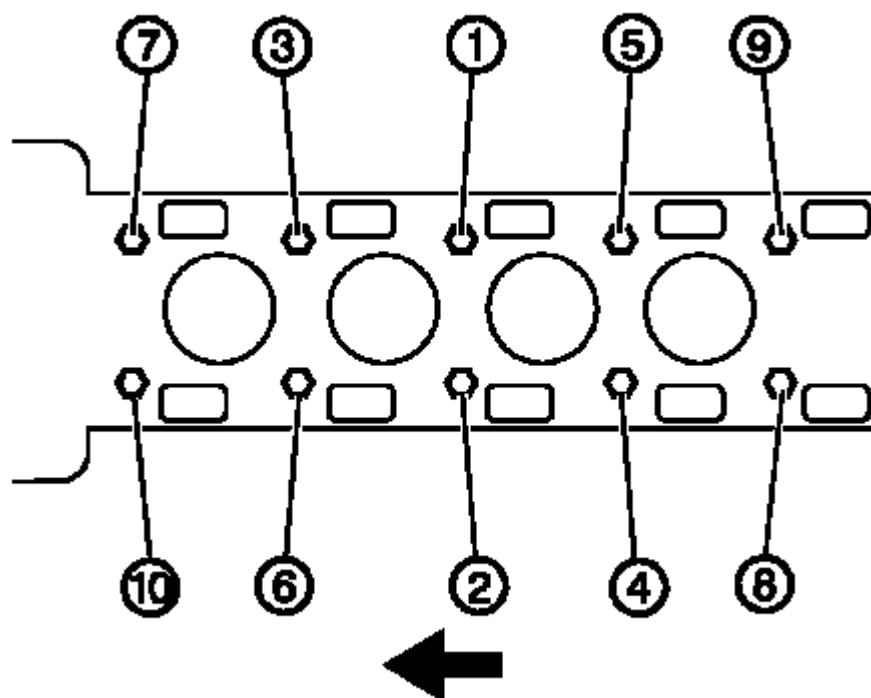


**Fig. 475: Cylinder Head**

Courtesy of GENERAL MOTORS COMPANY

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

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

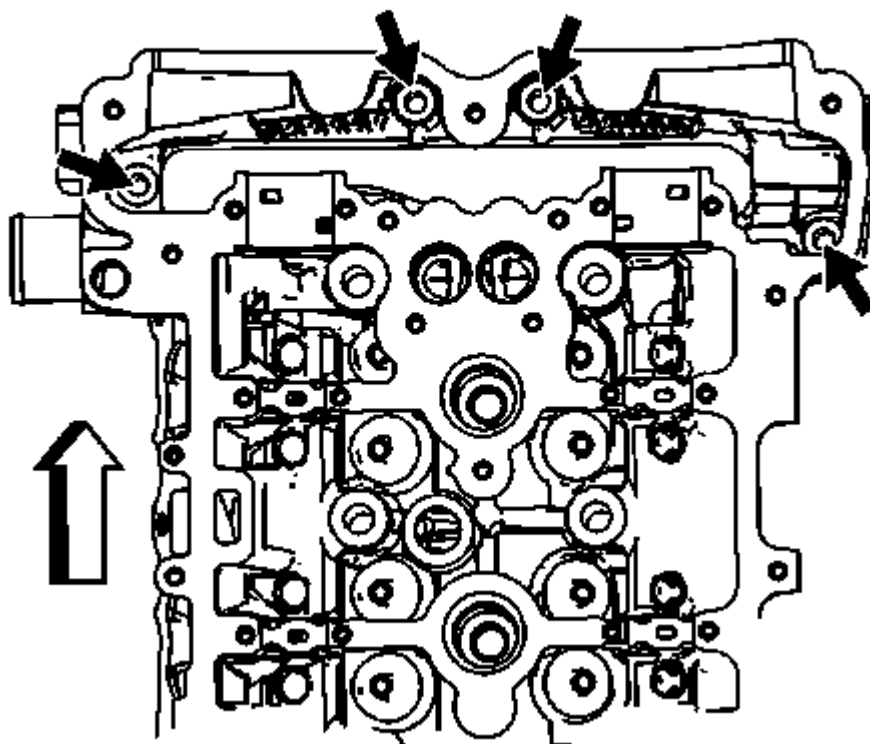


**Fig. 476: Identifying Cylinder Head Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

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

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

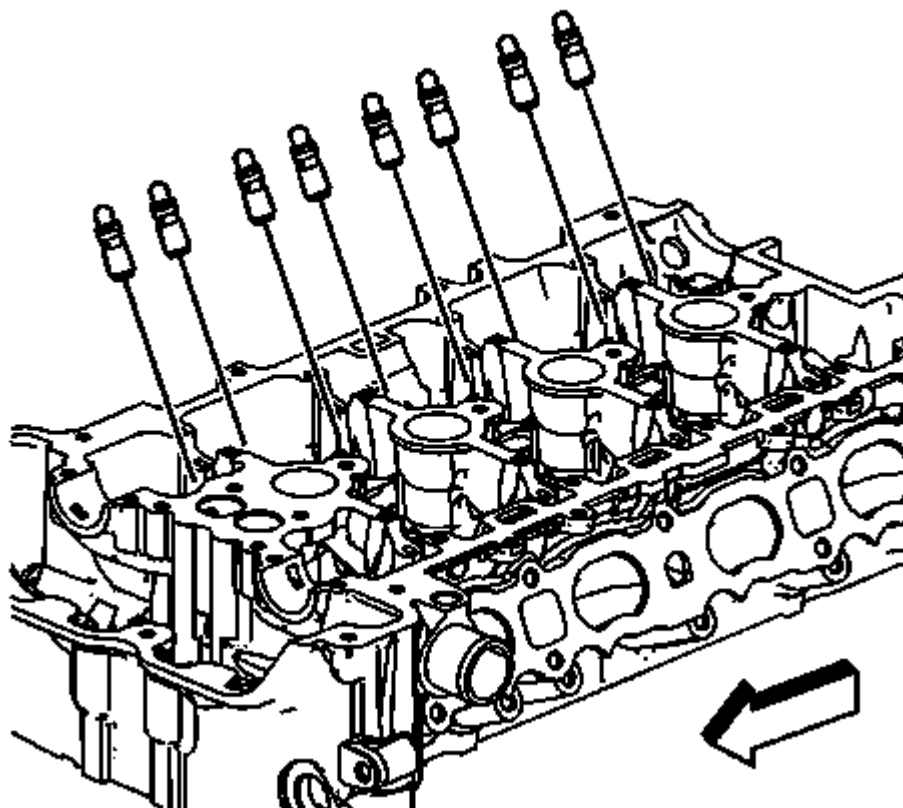


**Fig. 477: Locating Front Cylinder Head Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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

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

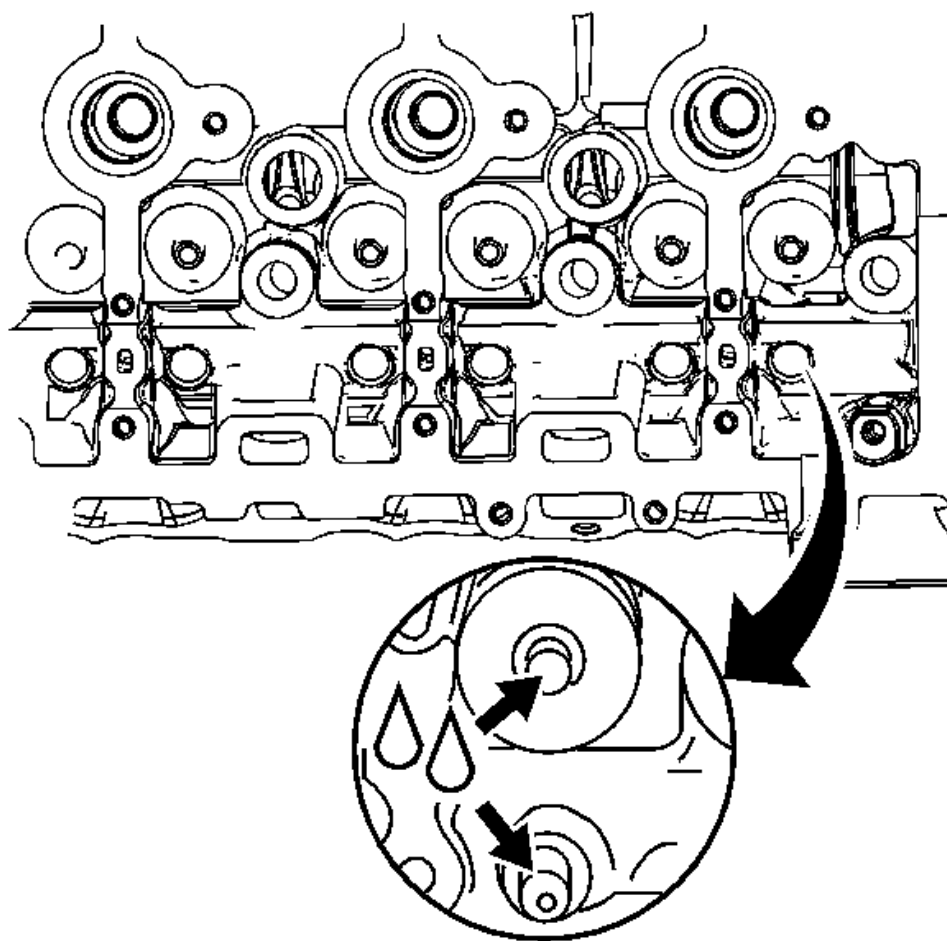
##### **Exhaust Camshaft Installation**



**Fig. 478: Hydraulic Lash Adjusters**

Courtesy of GENERAL MOTORS COMPANY

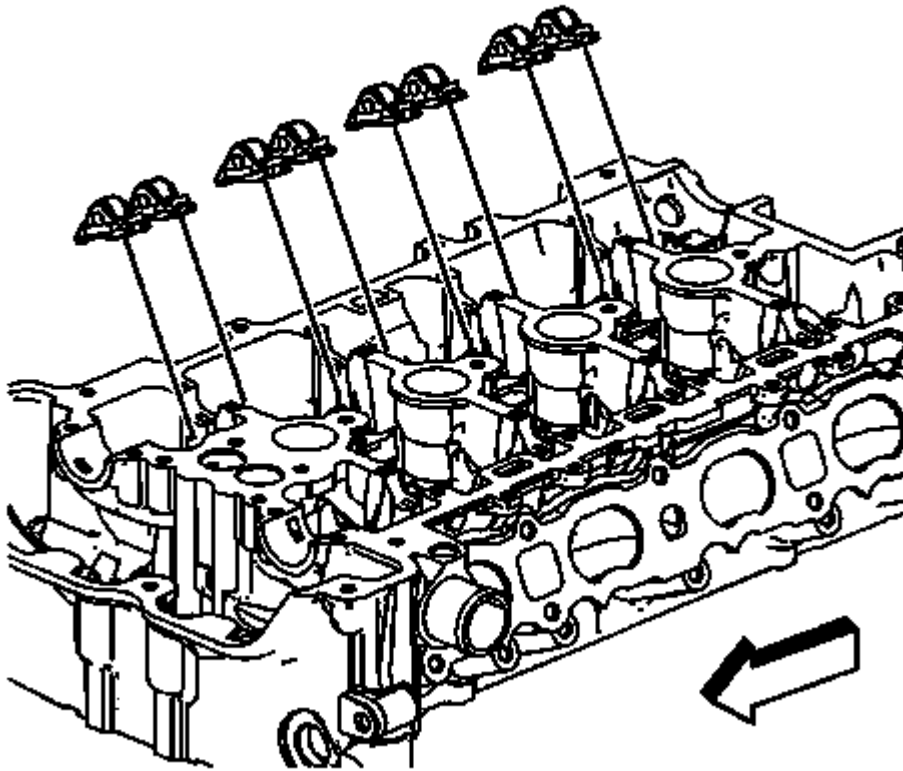
1. Install the hydraulic lash adjusters into their bores in the cylinder head and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.



**Fig. 479: Valve Tips**

Courtesy of GENERAL MOTORS COMPANY

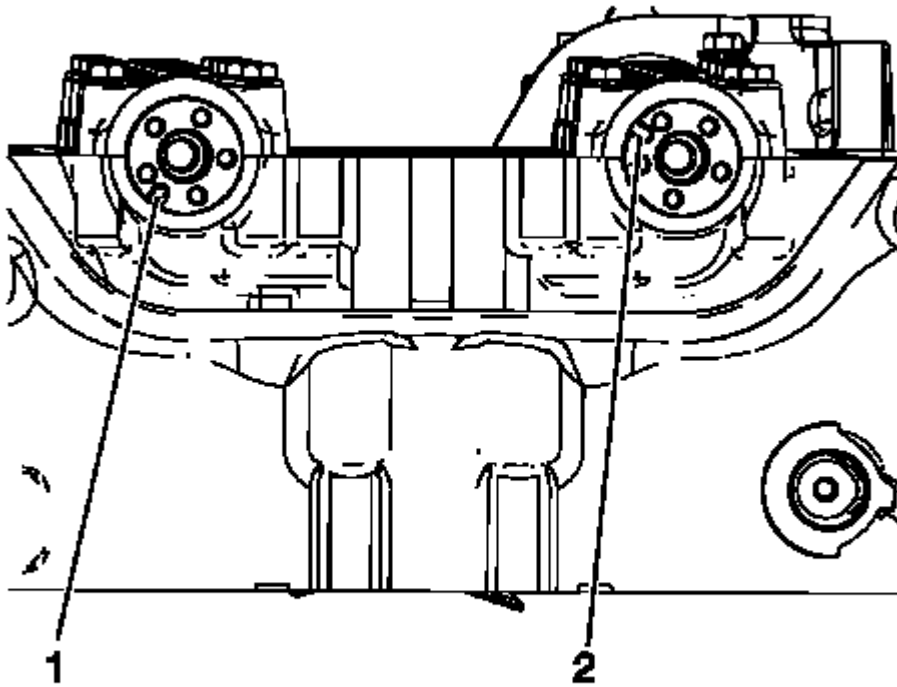
2. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers.



**Fig. 480: Exhaust Camshaft Roller Finger Followers**  
Courtesy of GENERAL MOTORS COMPANY

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

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

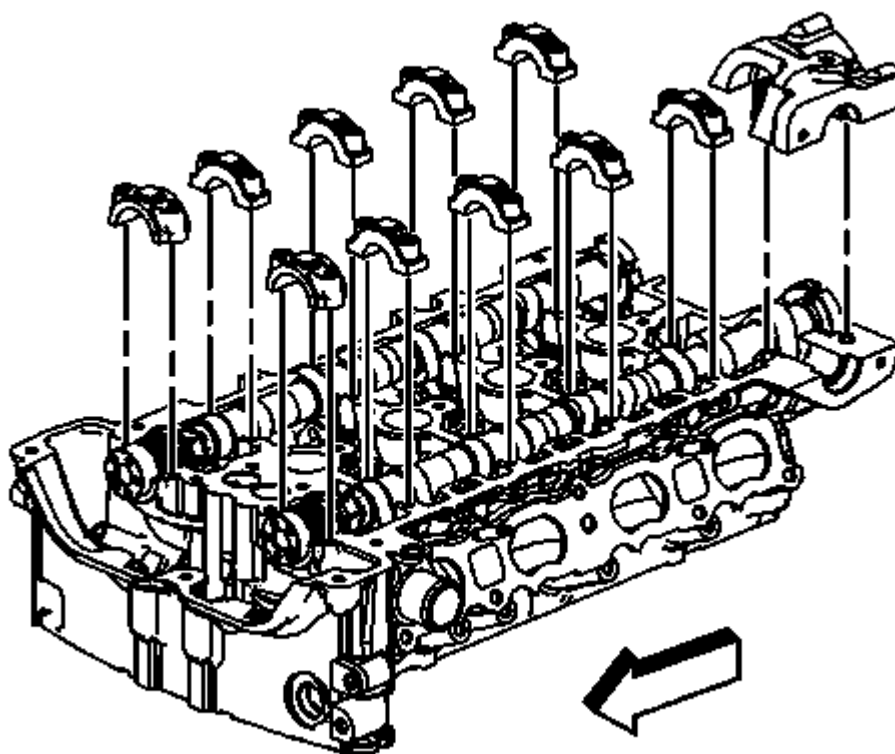


**Fig. 481: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

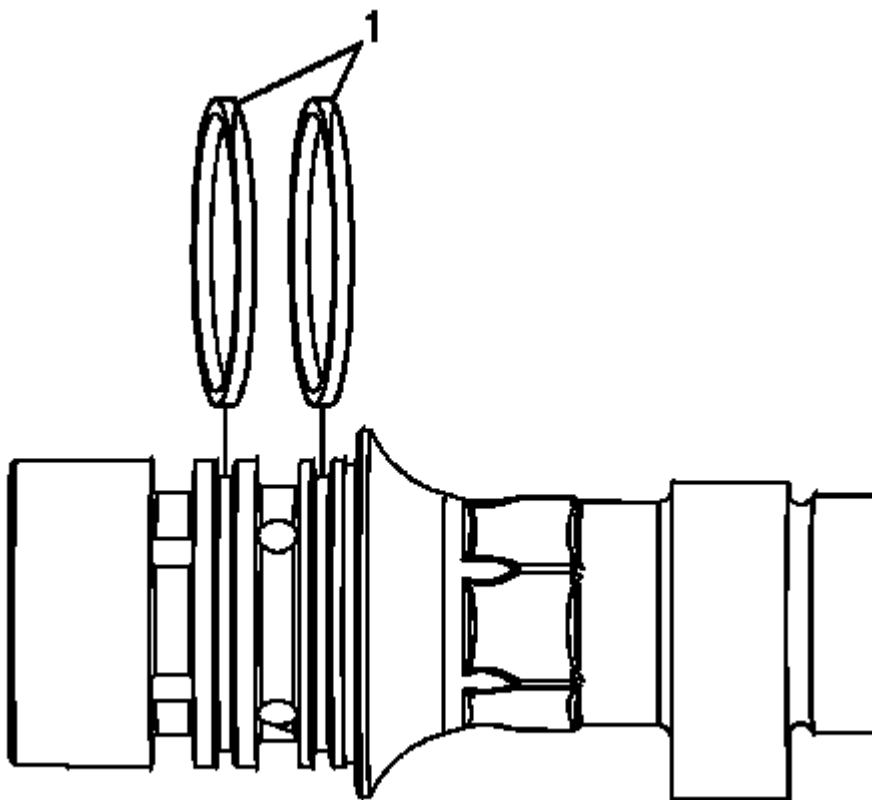
**NOTE:** The engine is timed top-dead center exhaust stroke.

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

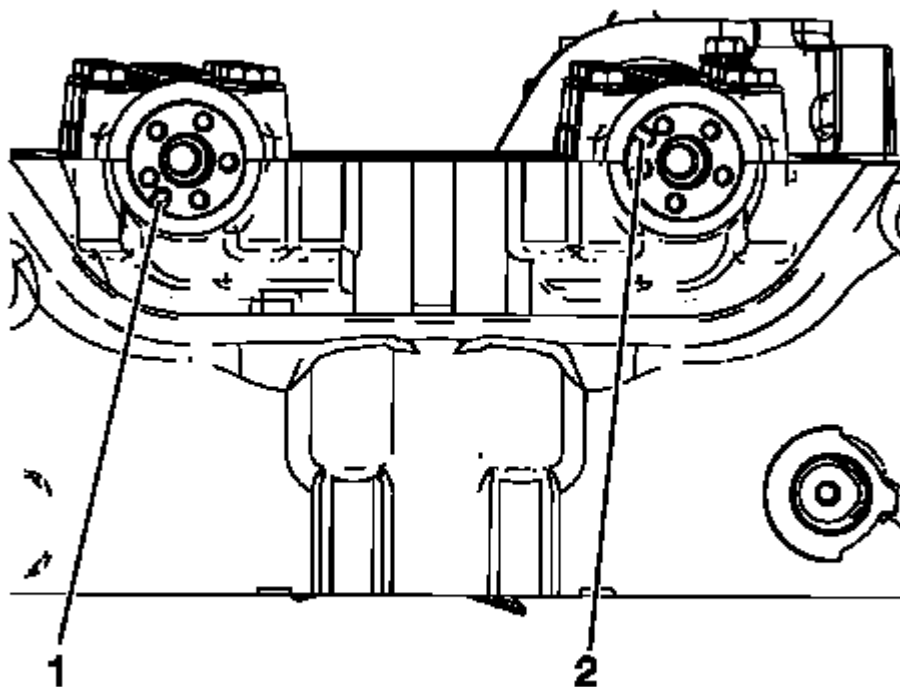


**Fig. 482: Intake Camshaft & Caps**  
Courtesy of GENERAL MOTORS COMPANY

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

**Fig. 483: Oil Seals****Courtesy of GENERAL MOTORS COMPANY**

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



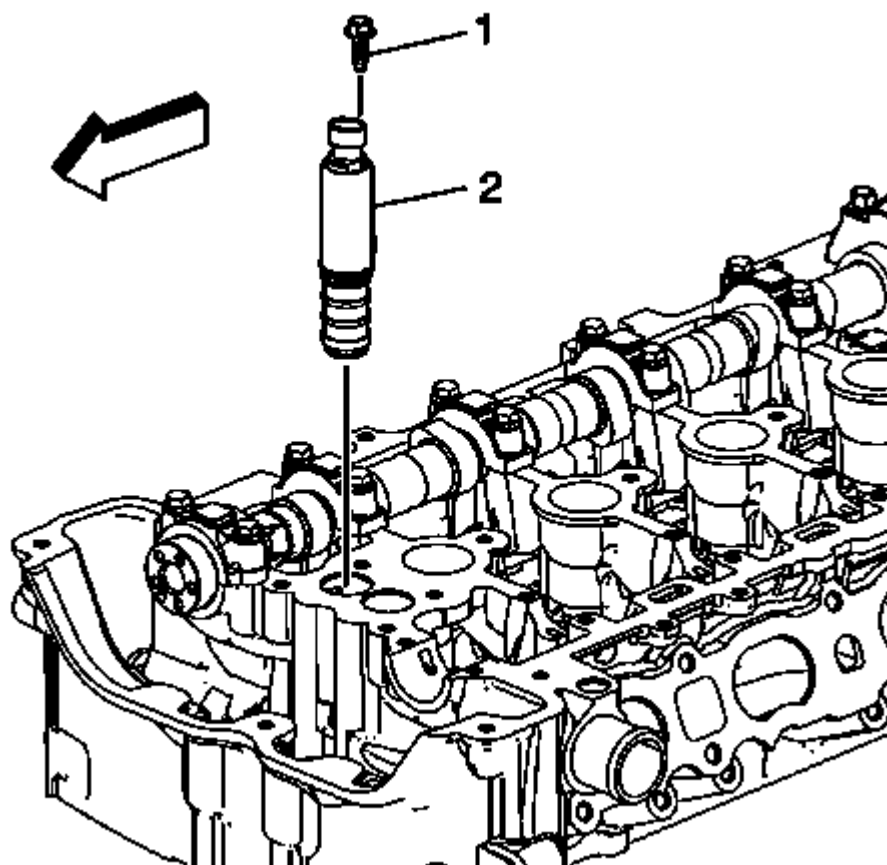
**Fig. 484: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

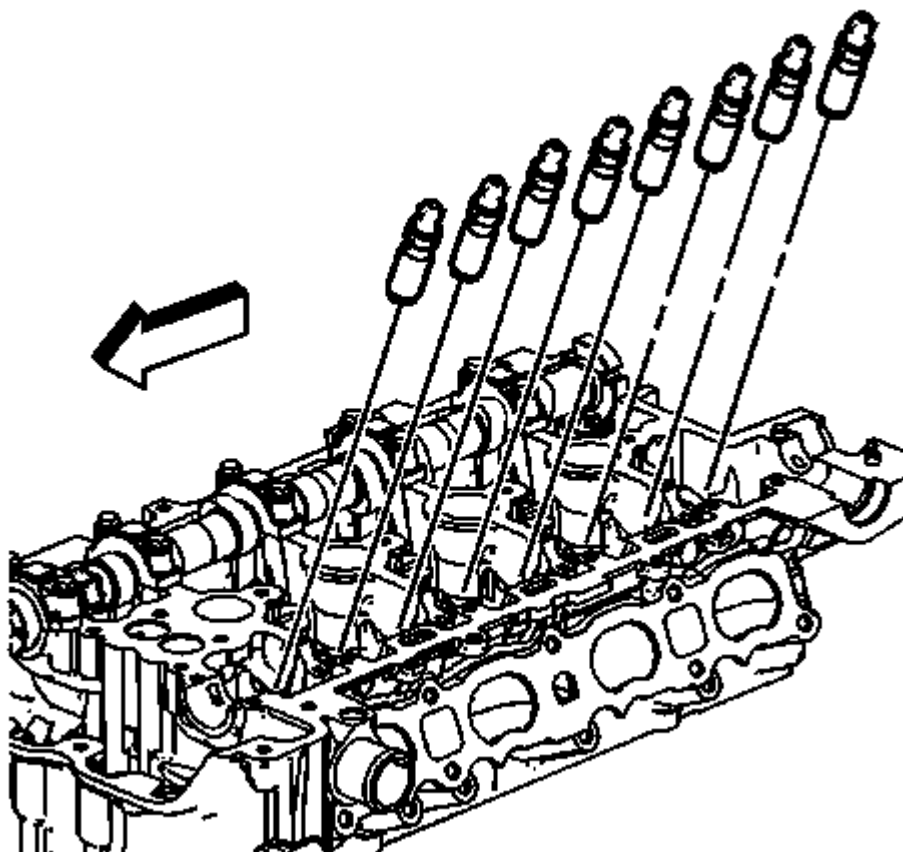
9. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).



**Fig. 485: Exhaust Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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

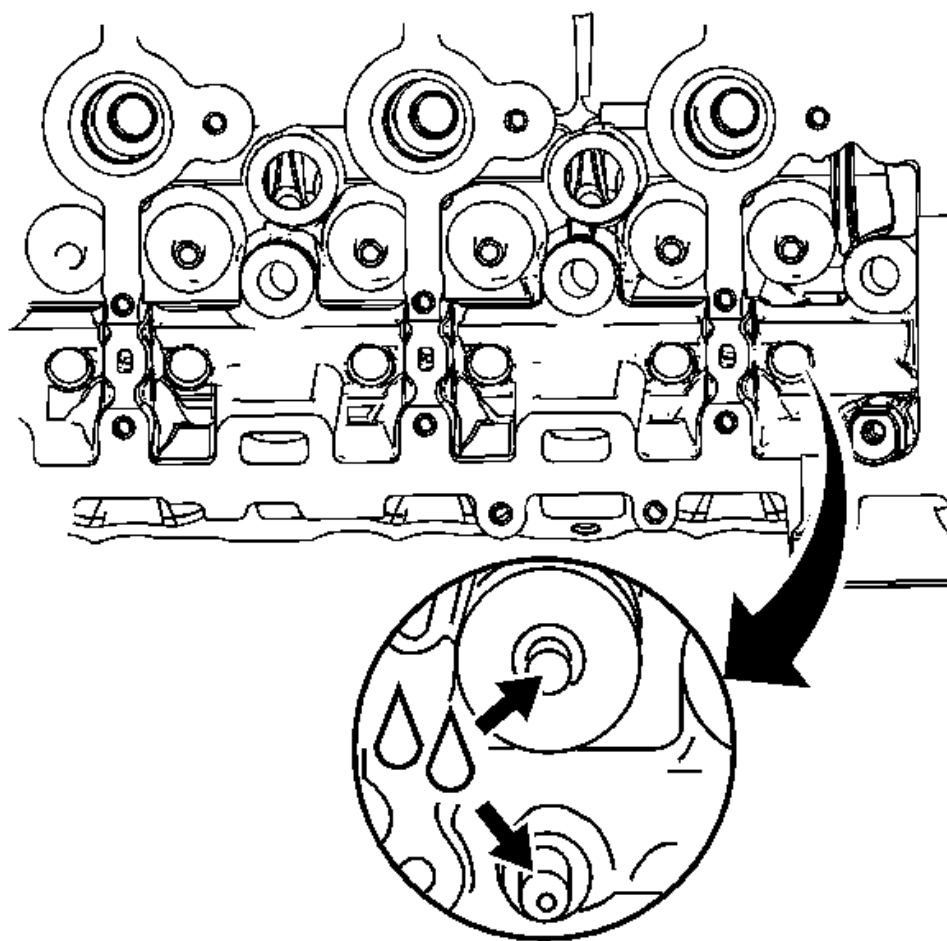
#### **Intake Camshaft Installation**



**Fig. 486: Hydraulic Lash Adjusters**

Courtesy of GENERAL MOTORS COMPANY

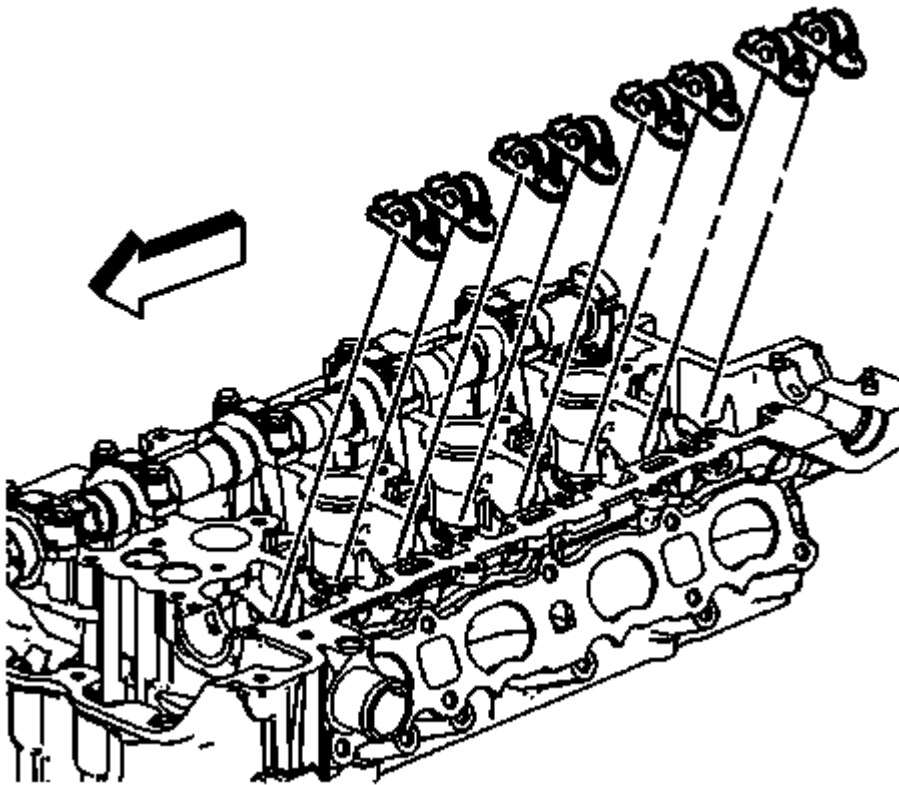
1. Install the hydraulic lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.



**Fig. 487: Valve Tips**

Courtesy of GENERAL MOTORS COMPANY

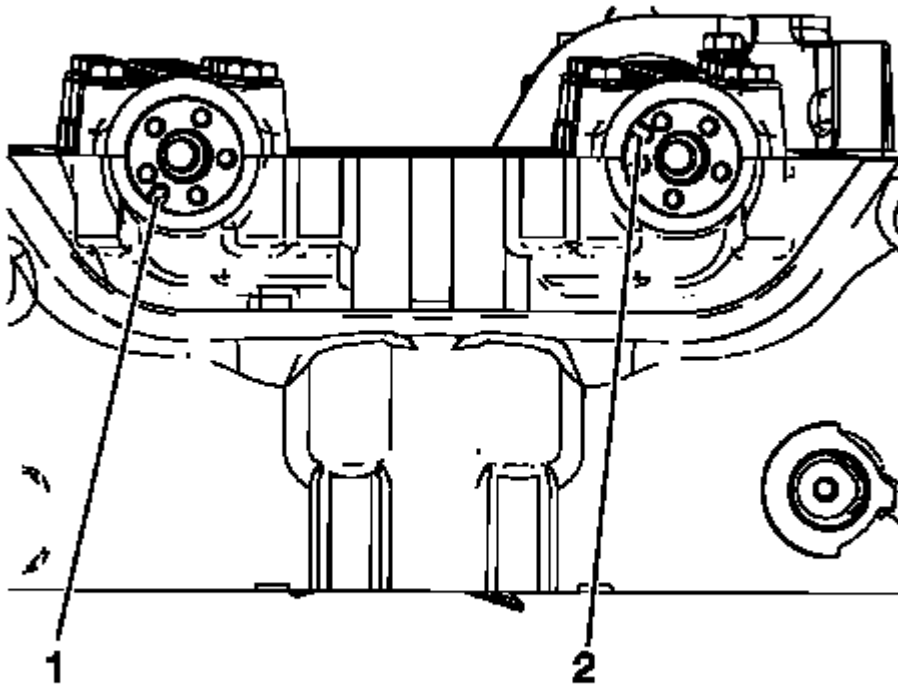
3. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers.



**Fig. 488: Intake Camshaft Roller Finger Followers**  
Courtesy of GENERAL MOTORS COMPANY

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

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

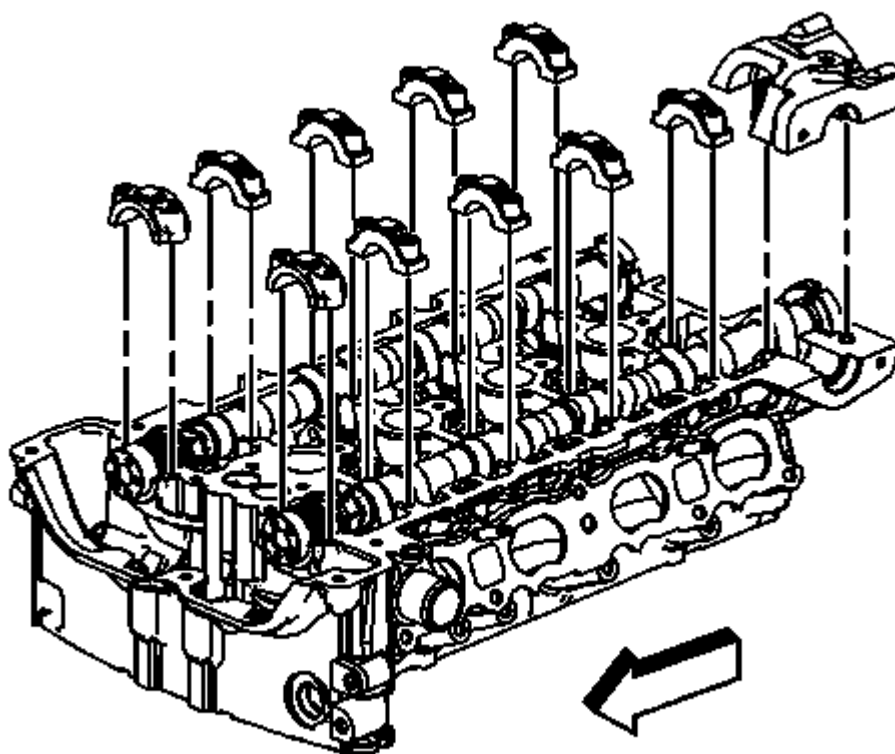


**Fig. 489: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

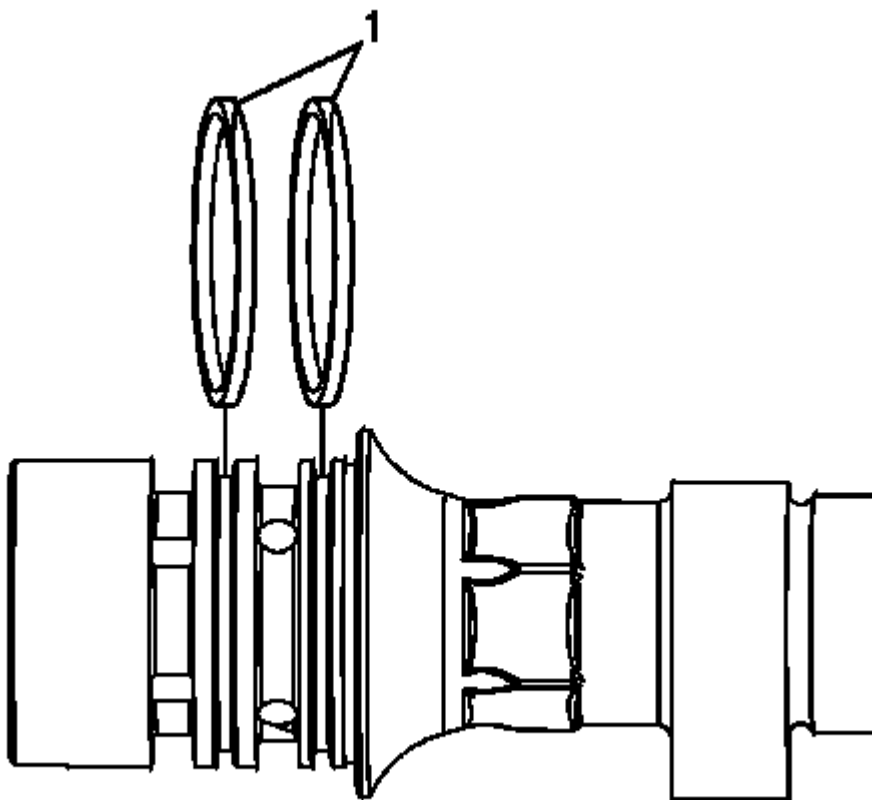
**NOTE:** The engine is timed top-dead center exhaust stroke.

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

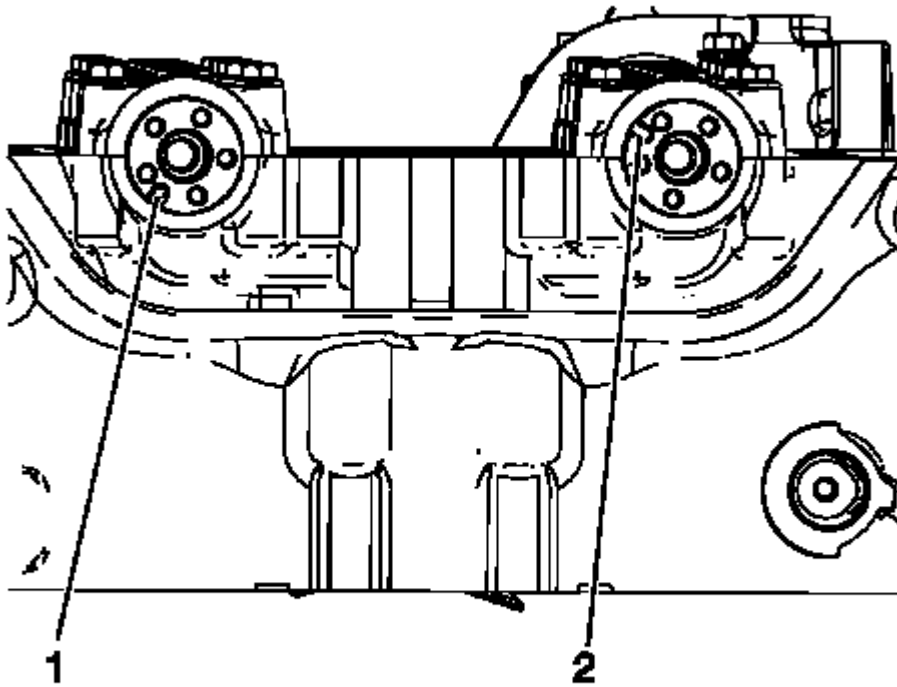


**Fig. 490: Intake Camshaft & Caps**  
Courtesy of GENERAL MOTORS COMPANY

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

**Fig. 491: Oil Seals****Courtesy of GENERAL MOTORS COMPANY**

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

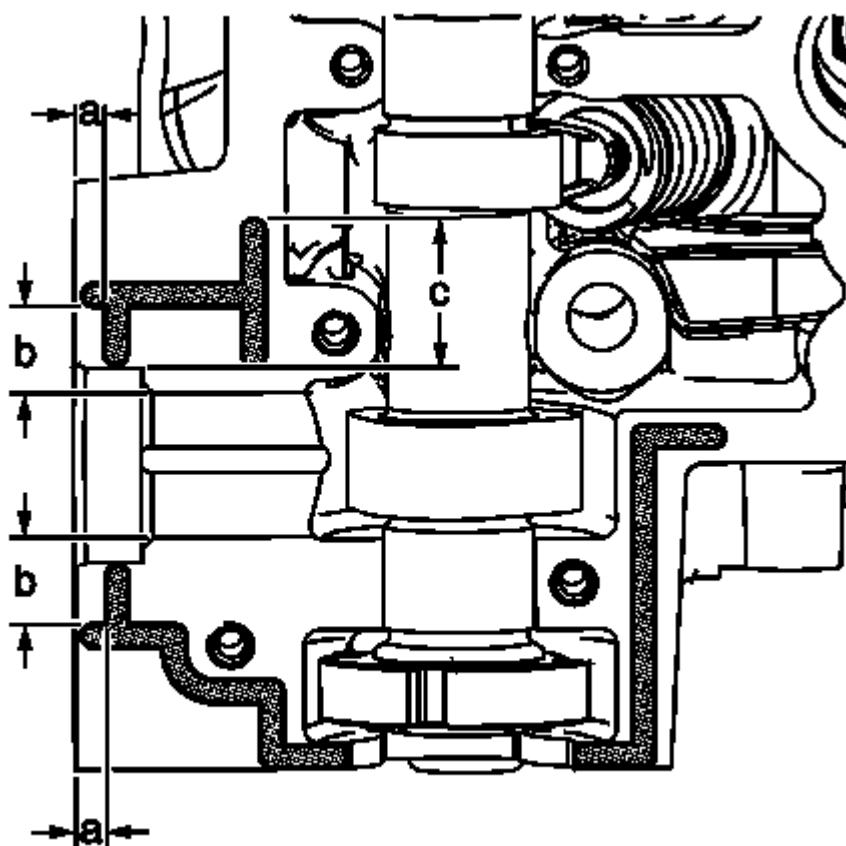


**Fig. 492: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

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

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

**Fig. 493: Sealer Application Areas**

Courtesy of GENERAL MOTORS COMPANY

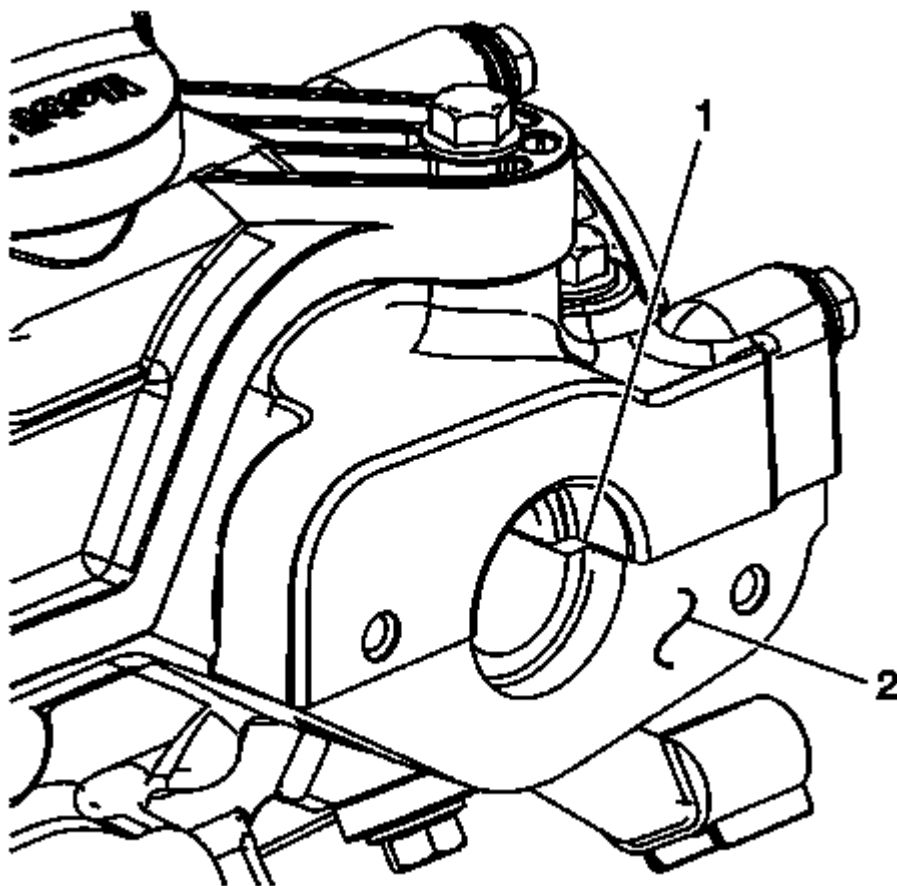
**NOTE:** It is critical during installation to ensure the bearing rear cap and cylinder head alignment is correct and the mating surfaces are flush.

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

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

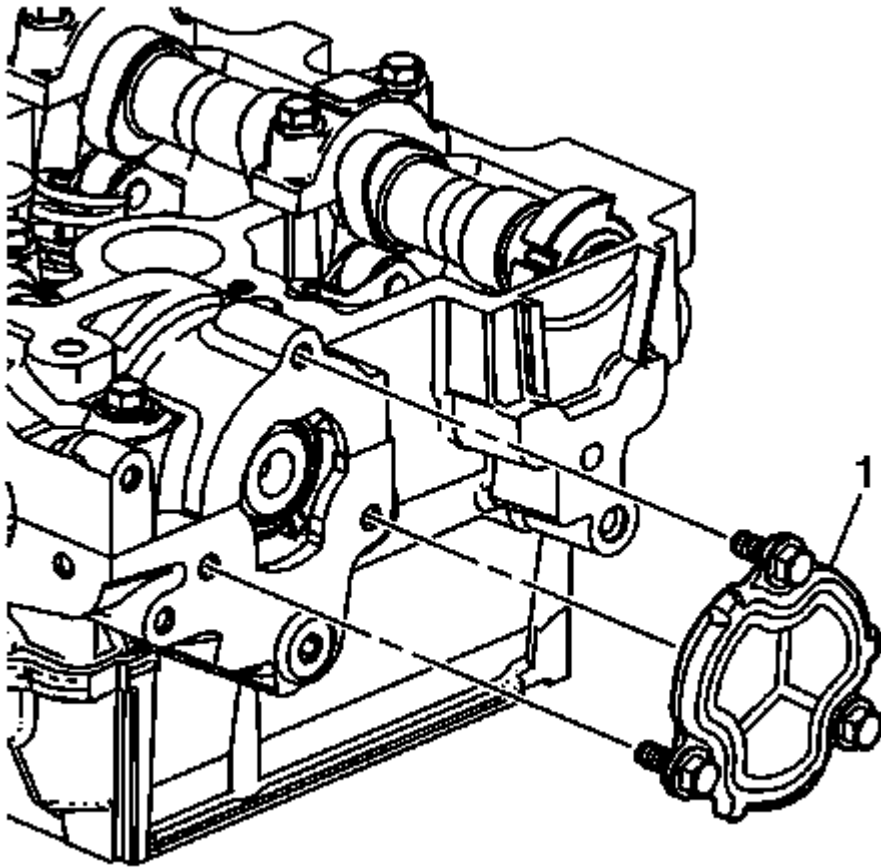
- Run bead to 5.0 mm, dimension a, as shown.
- Where the cap ends on the perimeter rail, extend bead approximately 4.0 mm beyond edge of cap.
- Run bead, dimension c, 32 mm from the edge of the cylinder head as shown.
- Run beads, dimension b, 20 mm from edge of cylinder head as shown.

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



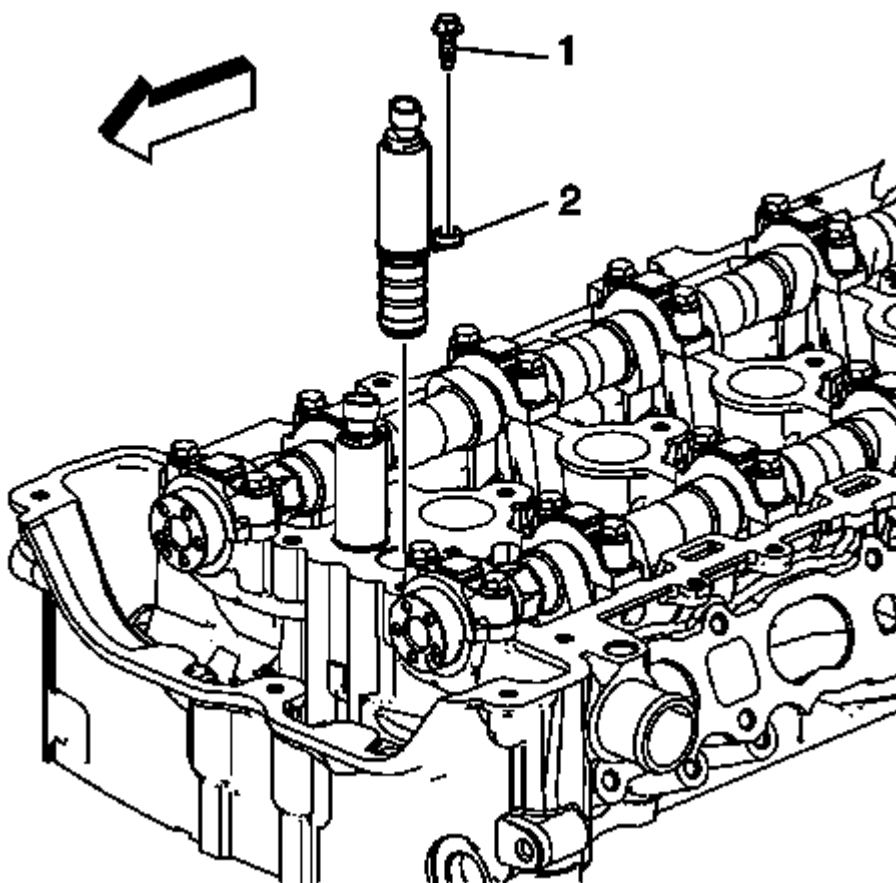
**Fig. 494: Identifying Fuel Pump Roller Lifter Orifice**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 495: Rear Cylinder Head Cover Plate**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 496: Intake Camshaft Position Actuator Solenoid Valve & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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

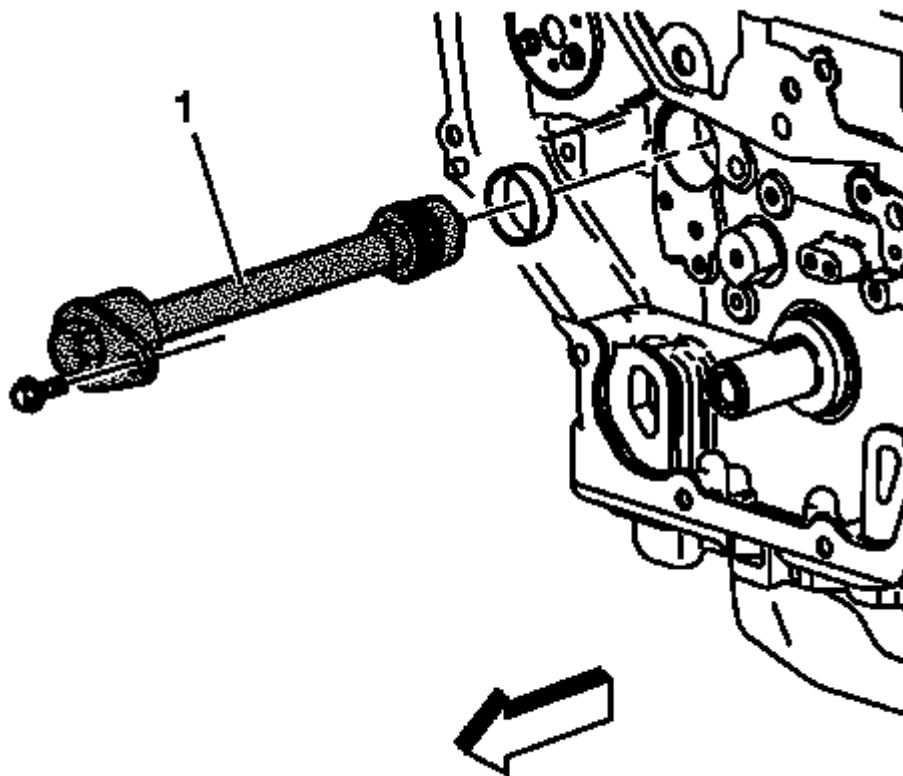
## BALANCE SHAFT INSTALLATION

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

### Special Tools

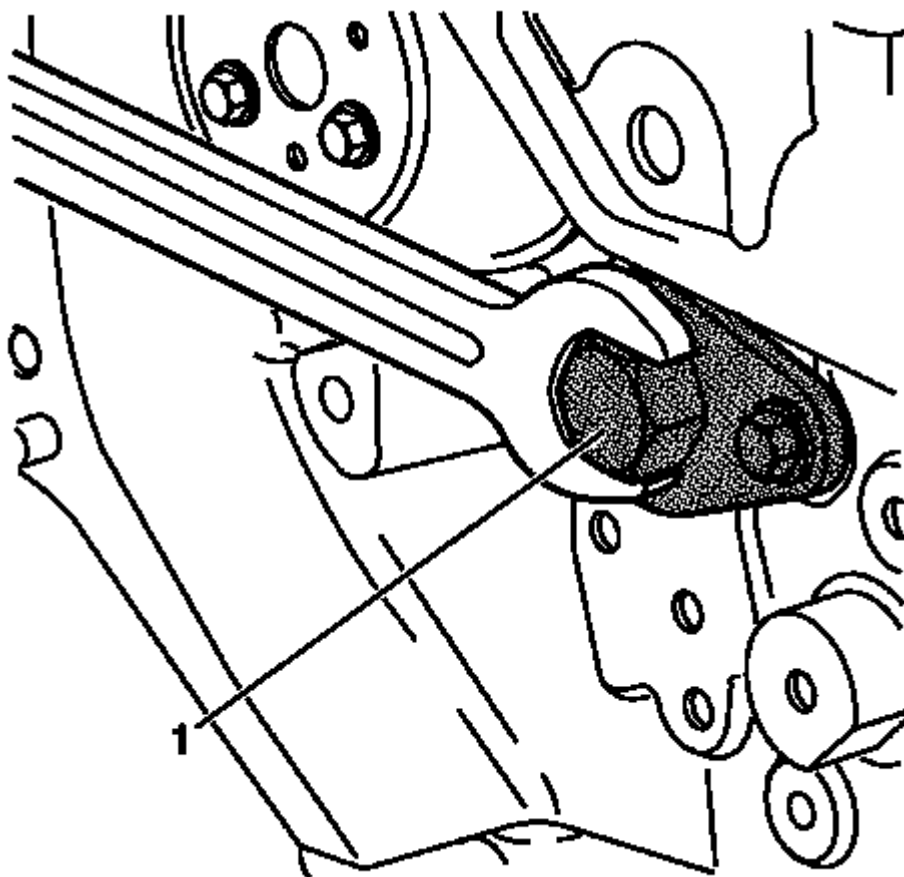
**EN-43650** Balance Shaft Bushing Remover/Installer

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



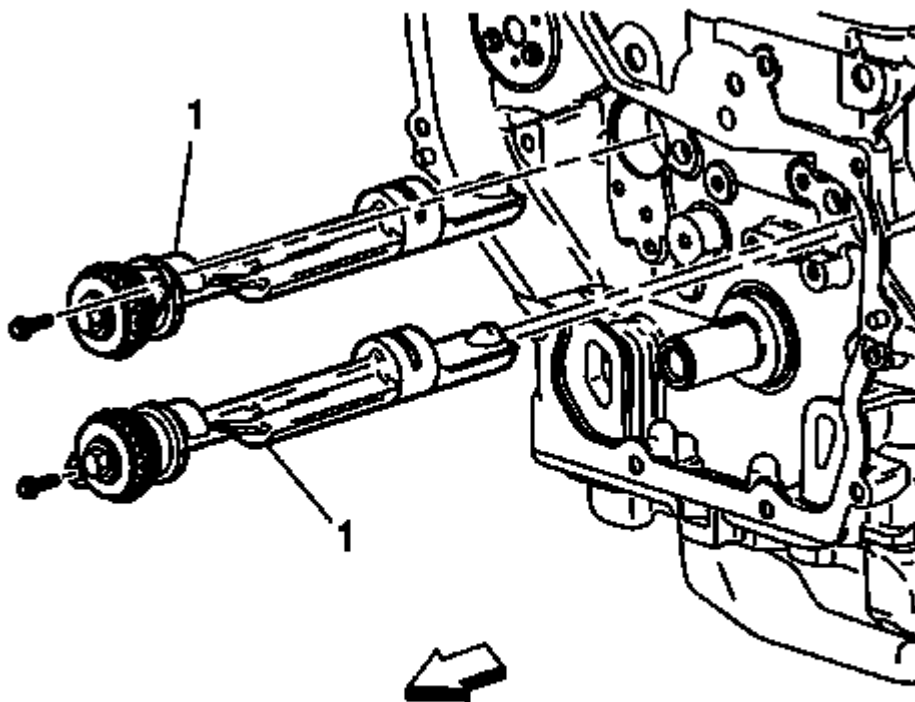
**Fig. 497: View of Balance Shaft Bushing and EN-43650 Installer**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 498: Seat Balance Shaft Bushing Into Bore Using EN-43650**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 499: View of Balance Shaft Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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

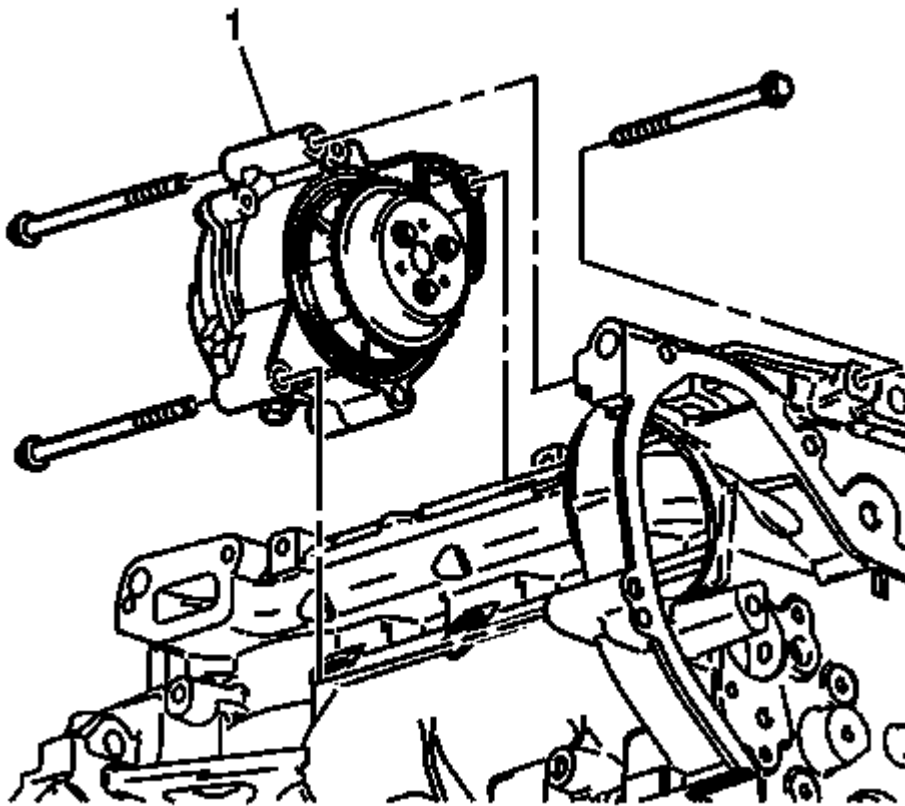
4. Place the number one piston at top dead center (TDC).
5. Lubricate the balance shaft lobes with engine oil.
6. Install the balance shafts (1) into their bores.

**CAUTION:** Refer to Fastener Caution .

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

## WATER PUMP INSTALLATION

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



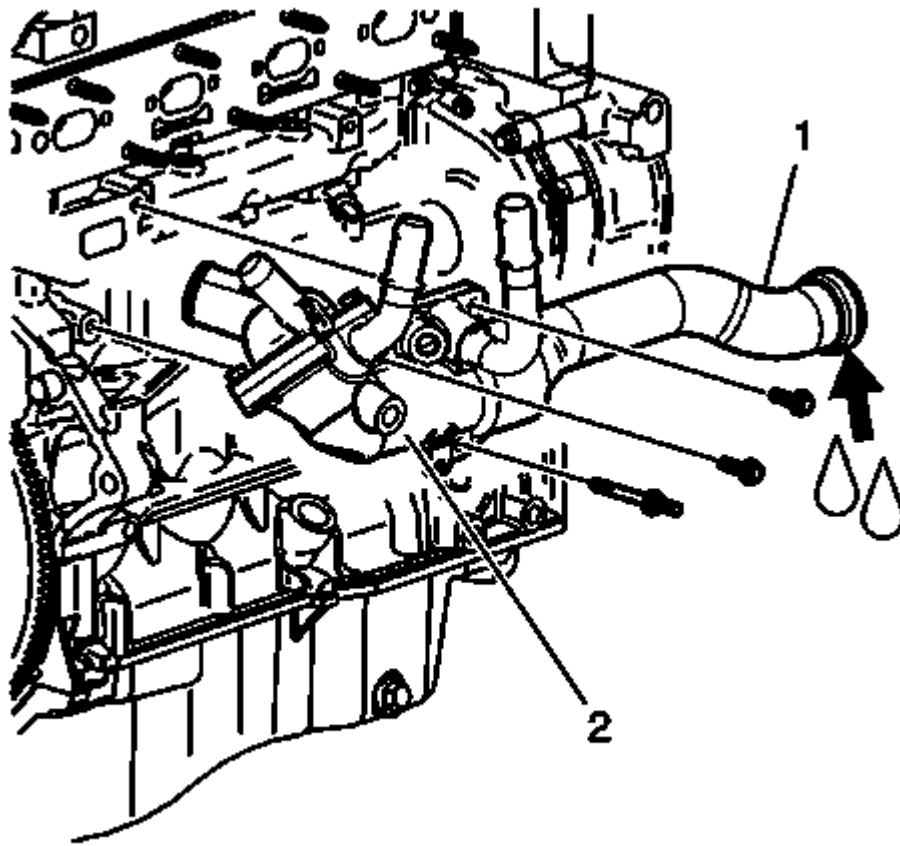
**Fig. 500: Water Pump Assembly**

Courtesy of GENERAL MOTORS COMPANY

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

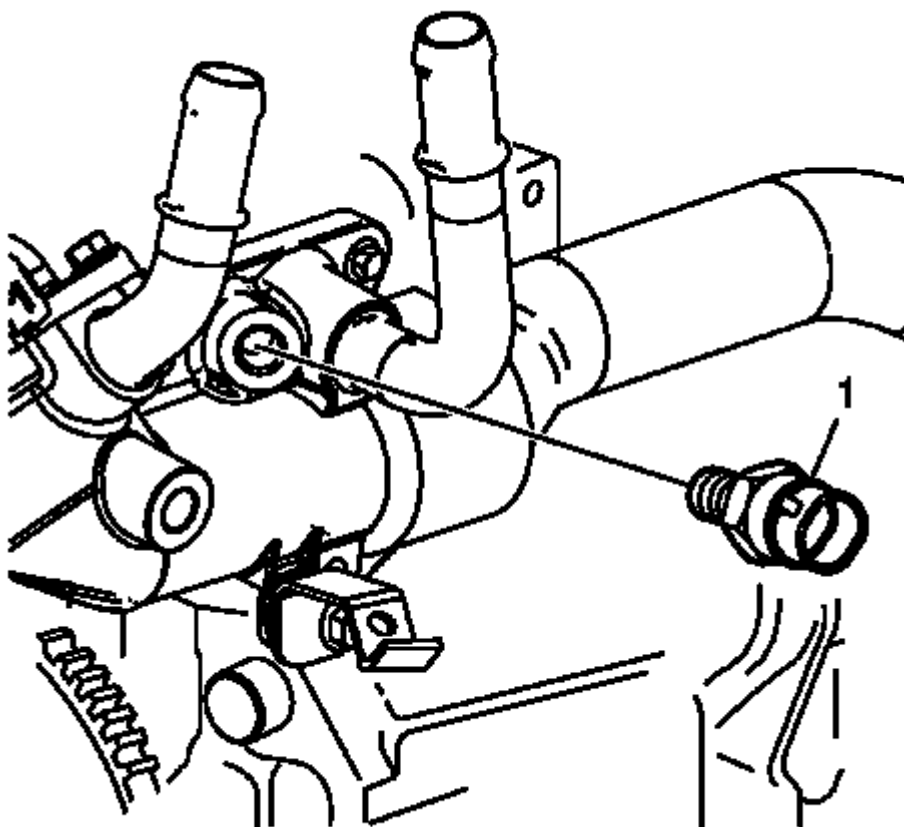
**CAUTION: Refer to Fastener Caution .**

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



**Fig. 501: Water Feed Tube & Thermostat Housing**  
Courtesy of GENERAL MOTORS COMPANY

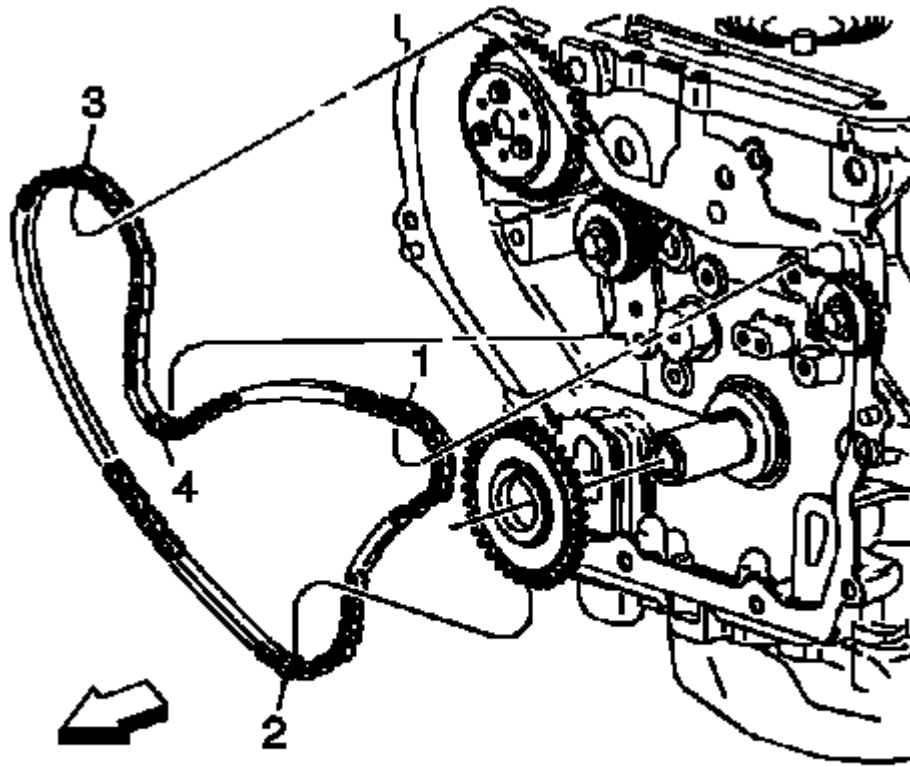
6. Install the water feed tube (1).
7. Lubricate the feed tube O-ring with antifreeze.
8. Install the water feed tube by twisting and pushing toward the water pump. Take care not to tear or damage the O-ring.
9. Install the thermostat housing (2) to block bolts and stud and tighten to 10 N.m (89 lb in).



**Fig. 502: Engine Coolant Temperature Sensor**  
Courtesy of GENERAL MOTORS COMPANY

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

#### **BALANCE SHAFT TO ENGINE TIMING (LEA)**



**Fig. 503: Aligning Balance Shaft Drive Chain**  
Courtesy of GENERAL MOTORS COMPANY

1. Install the balance shaft drive sprocket.

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

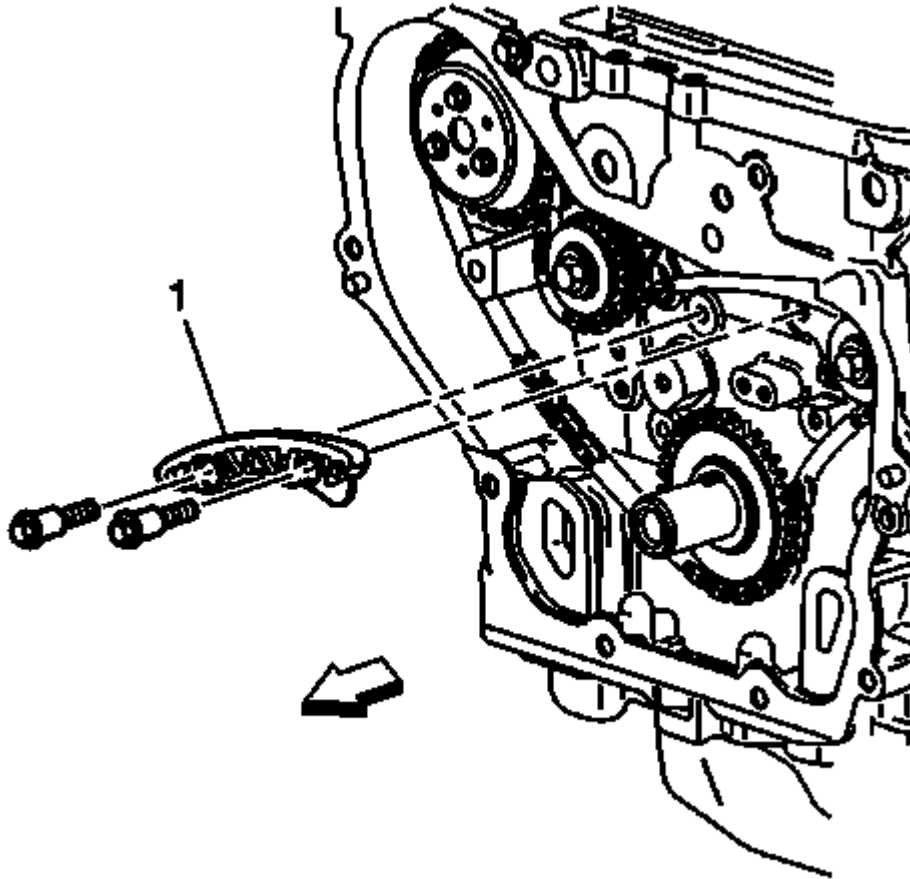
2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three colored links on the chain. Two links are of matching colors, and one link is of a unique color. Use the following procedure to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

Orient the chain so that the colored links are visible.

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

sprocket.

## WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER INSTALLATION

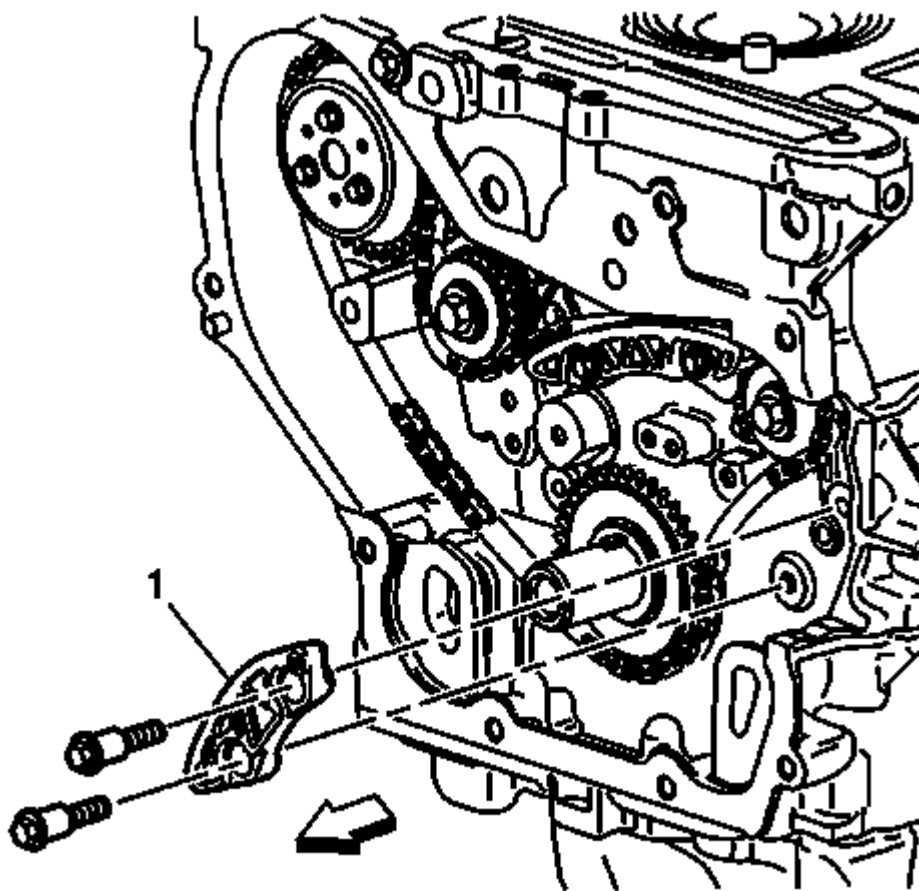


**Fig. 504: Upper Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

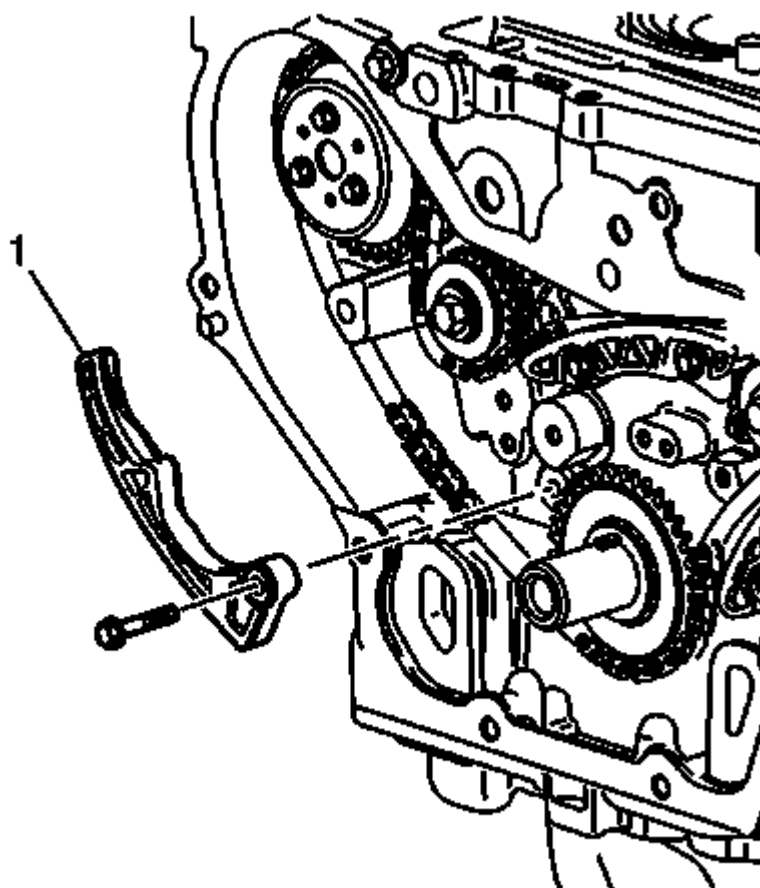
**NOTE:** If the balance shafts are not properly timed to the engine, the engine may vibrate and make noise.

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



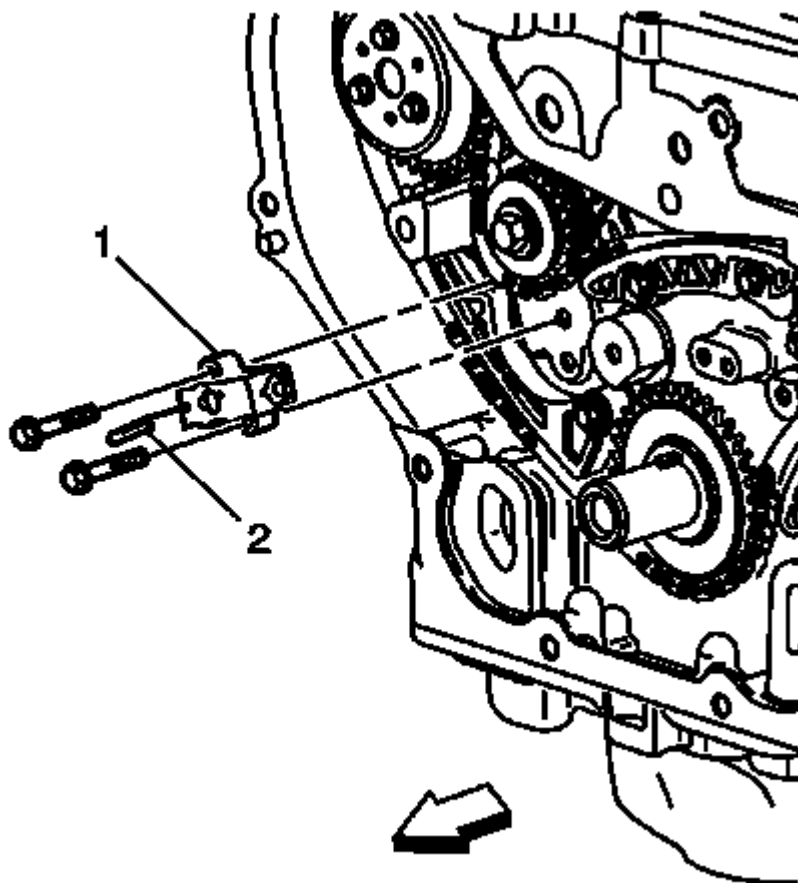
**Fig. 505: Small Balance Shaft Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 506: Adjustable Balance Shaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 507: Timing Chain Tensioner**

Courtesy of GENERAL MOTORS COMPANY

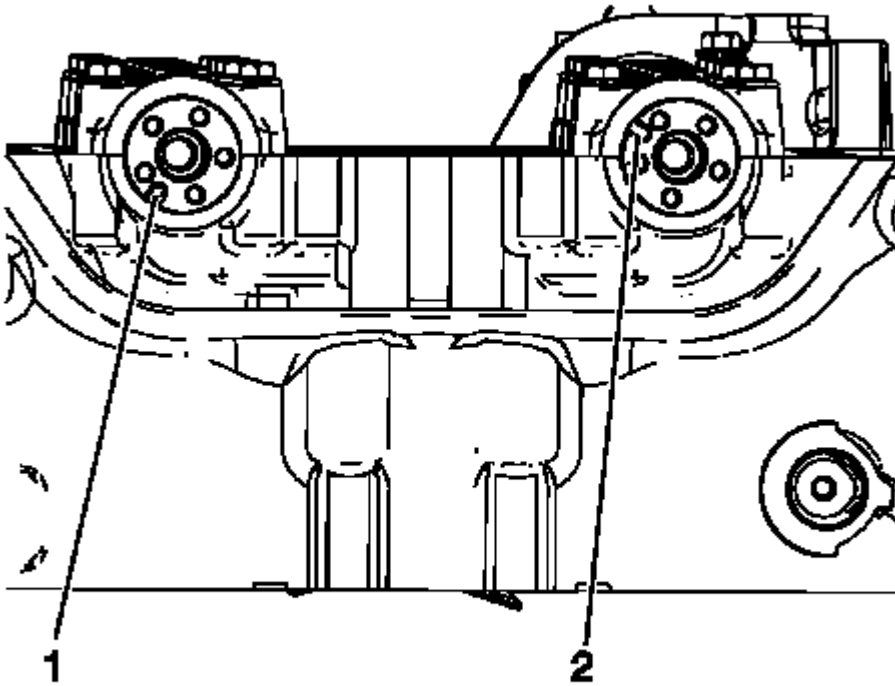
6. Reset the timing chain tensioner (1) by performing the following steps:
  1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.
  2. Turn the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hole in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

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

### Special Tools

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

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

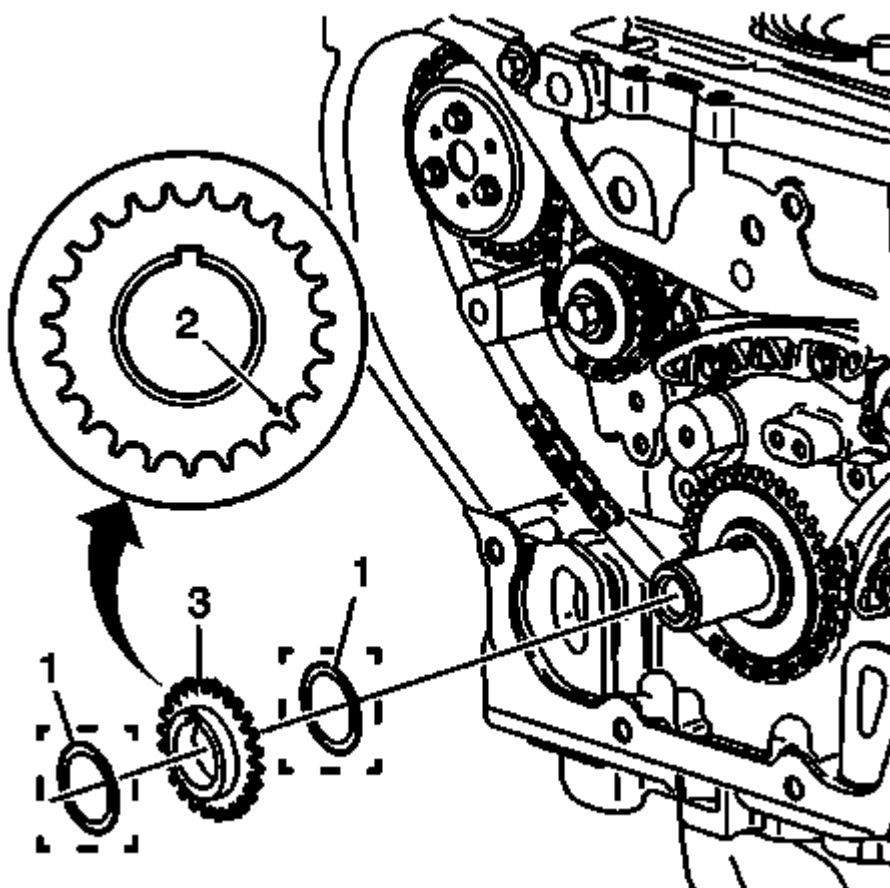


**Fig. 508: Camshaft Notches**

Courtesy of GENERAL MOTORS COMPANY

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

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

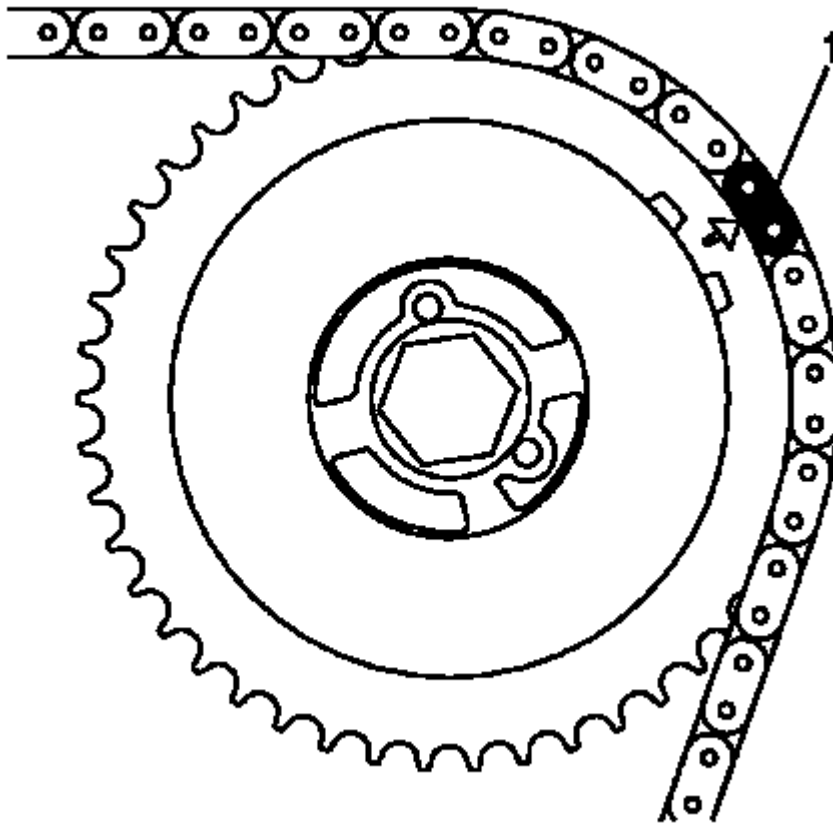


**Fig. 509: View of Friction Washer and Timing Chain Drive Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

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

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

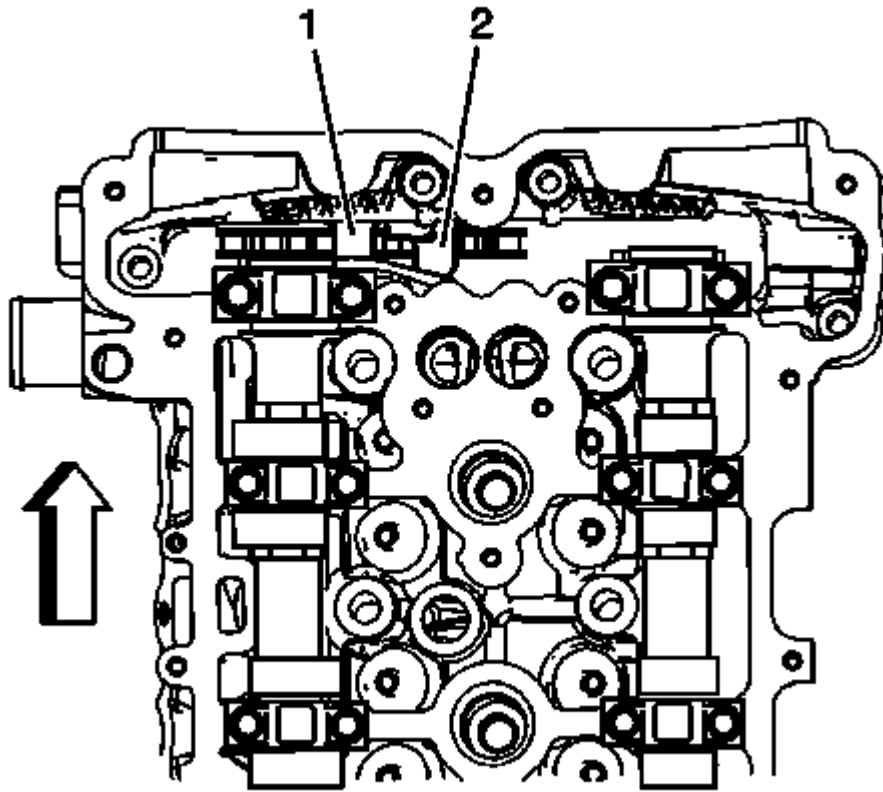
4. Install a second friction washer (1), if equipped.



**Fig. 510: Identifying Colored Links On Timing Chain**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** There are three colored links on the timing chain. Two links are of matching color, and one link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

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

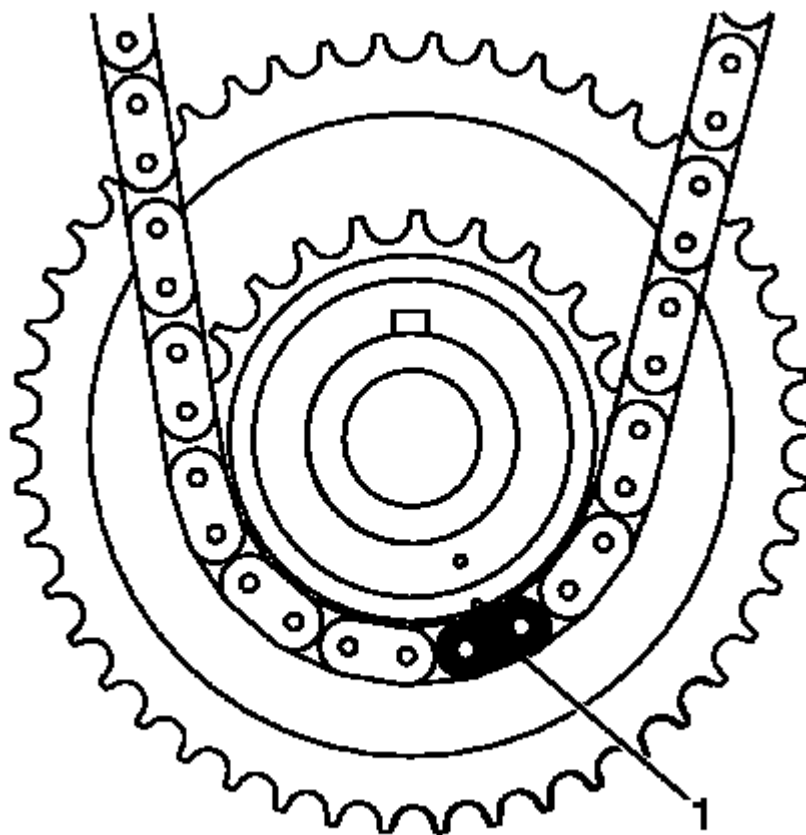


**Fig. 511: Identifying Cylinder Head Opening**  
Courtesy of GENERAL MOTORS COMPANY

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

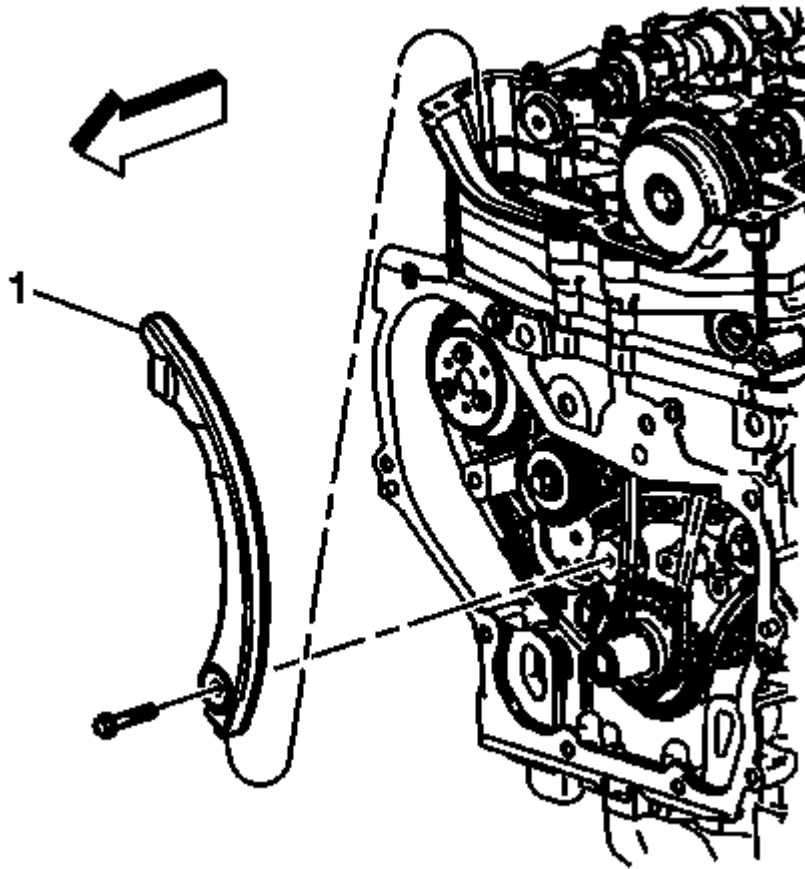
**NOTE:** Always use NEW actuator bolts.

8. Hand tighten the new intake camshaft actuator bolt.



**Fig. 512: Aligning Timing Chain & Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS COMPANY

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

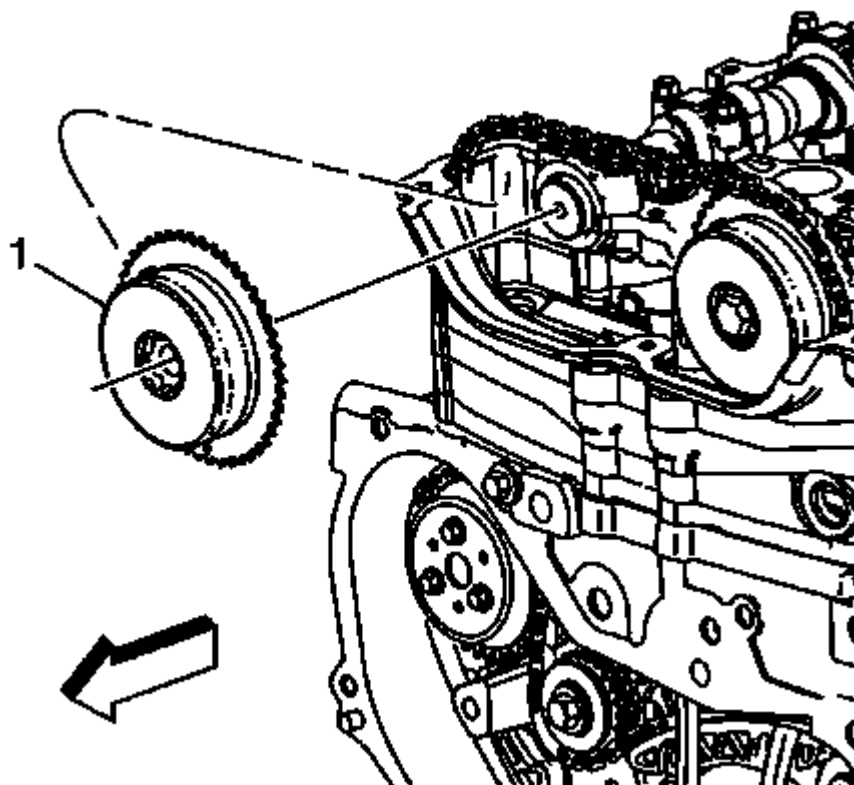


**Fig. 513: View of Adjustable Timing Chain Guide Bolt**  
**Courtesy of GENERAL MOTORS COMPANY**

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

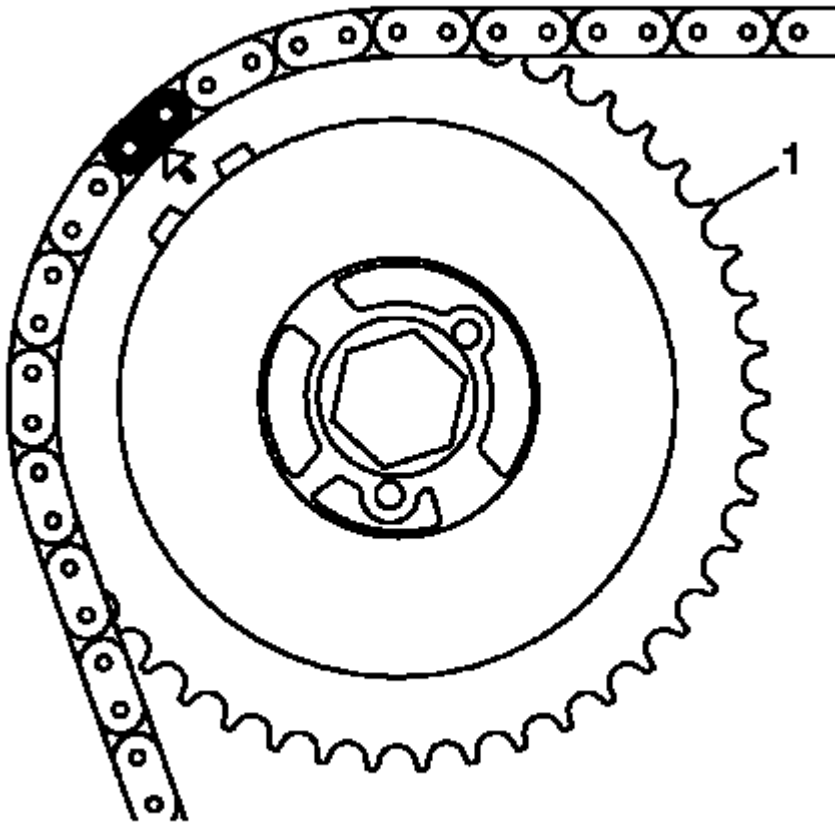
**CAUTION: Refer to Fastener Caution .**

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



**Fig. 514: View of Exhaust Camshaft Actuator**  
**Courtesy of GENERAL MOTORS COMPANY**

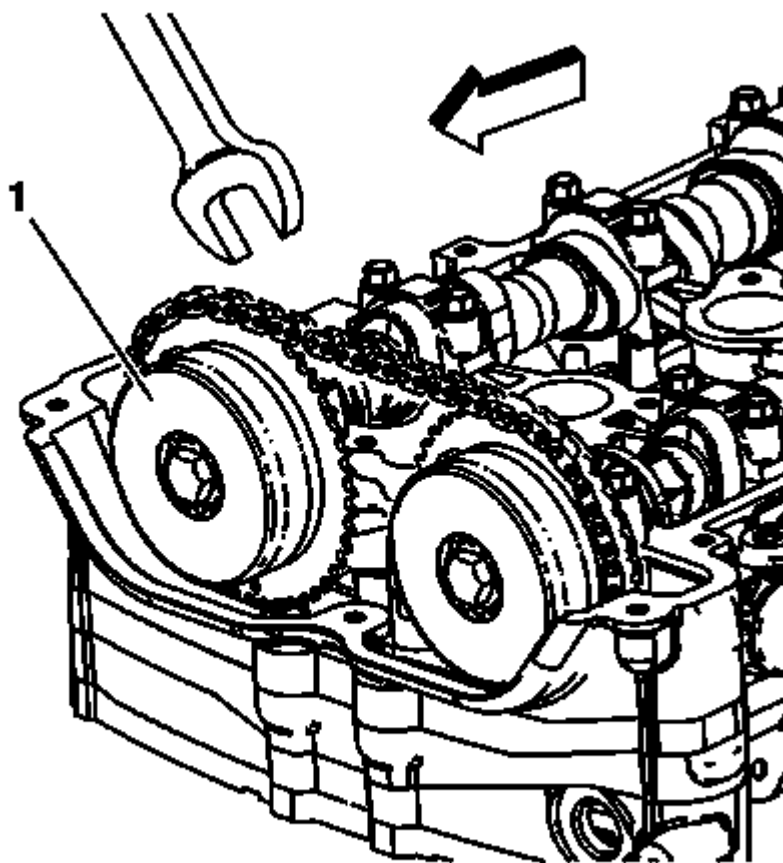
12. Install the exhaust camshaft actuator (1) into the timing chain with the timing mark lined up with the second matching colored link.



**Fig. 515: Aligning Dowel Pin Onto Exhaust Camshaft Actuator**  
Courtesy of GENERAL MOTORS COMPANY

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

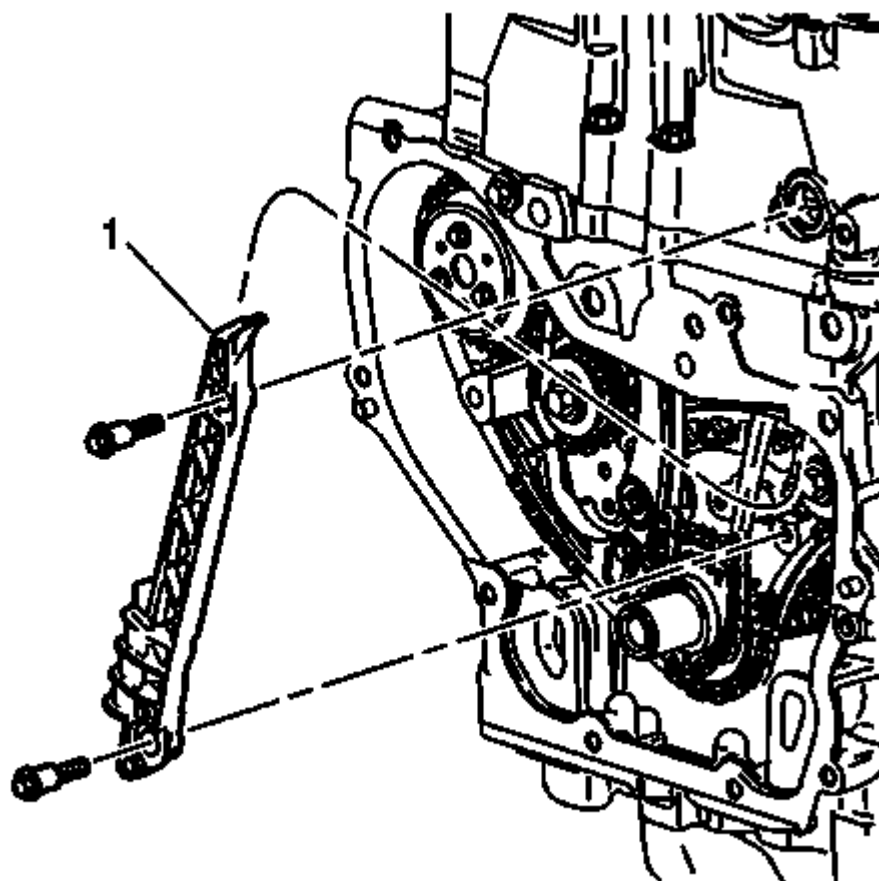
13. Install the exhaust camshaft actuator (1) onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
14. Using a 23-24 mm open end wrench, rotate the exhaust camshaft clockwise until the dowel pin in the camshaft actuator goes into the camshaft slot.



**Fig. 516: View of Actuator**

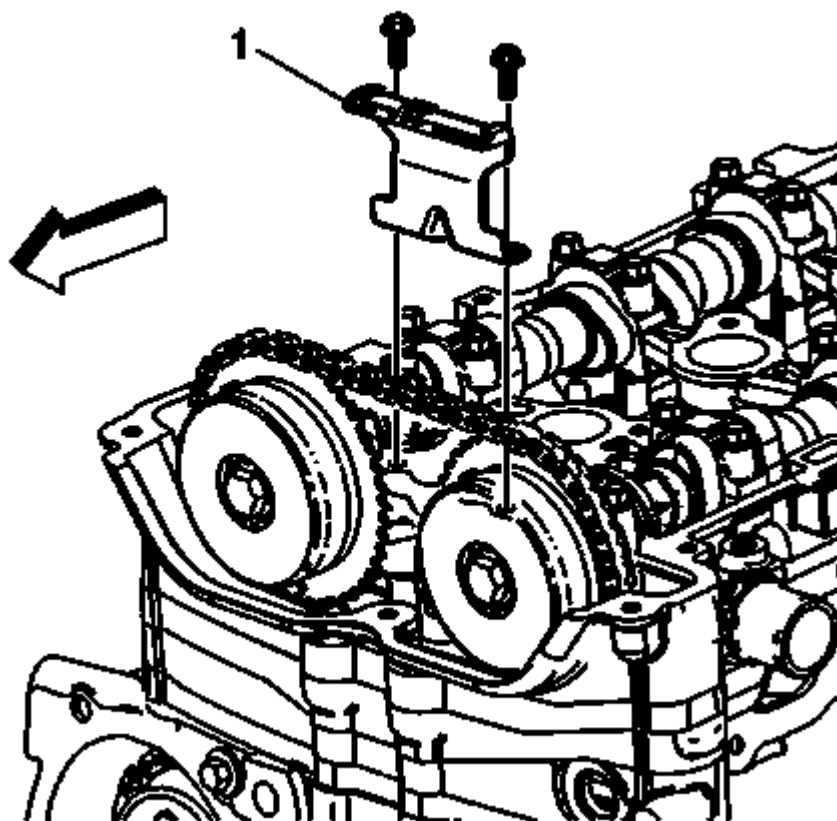
**Courtesy of GENERAL MOTORS COMPANY**

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



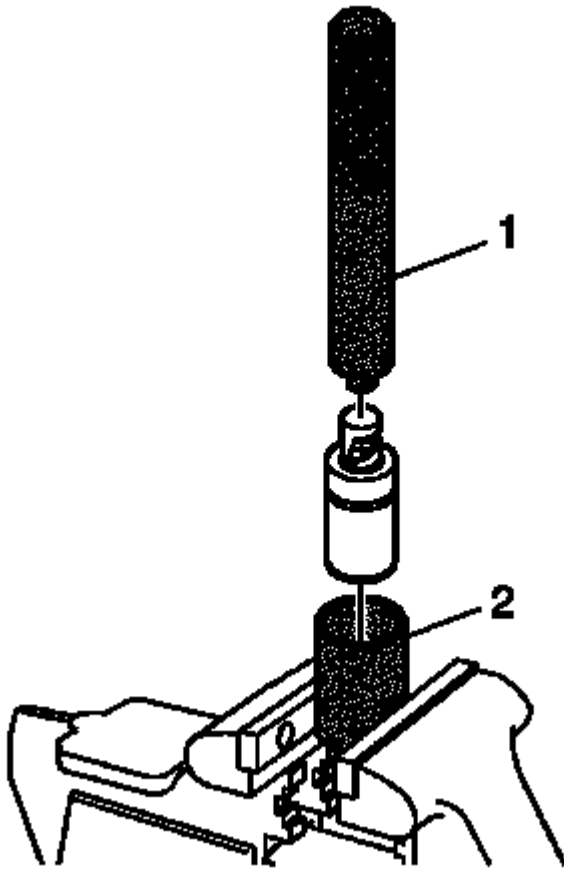
**Fig. 517: View of Fixed Timing Chain Guide**  
**Courtesy of GENERAL MOTORS COMPANY**

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



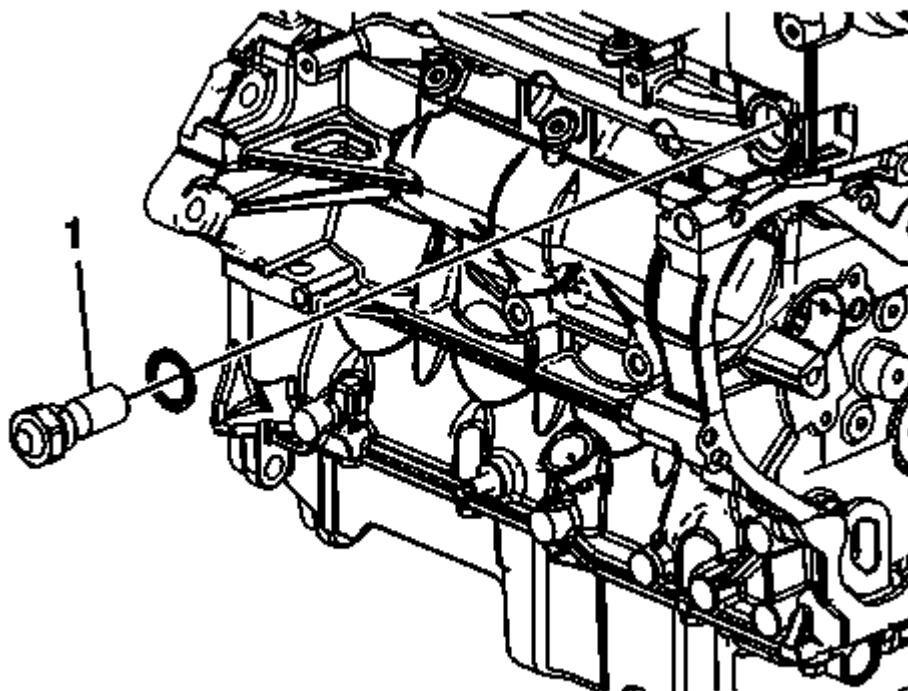
**Fig. 518: Identifying Upper Timing Chain Guide & Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 519: Compressing Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 520: View of Timing Chain Tensioner Seal**  
Courtesy of GENERAL MOTORS COMPANY

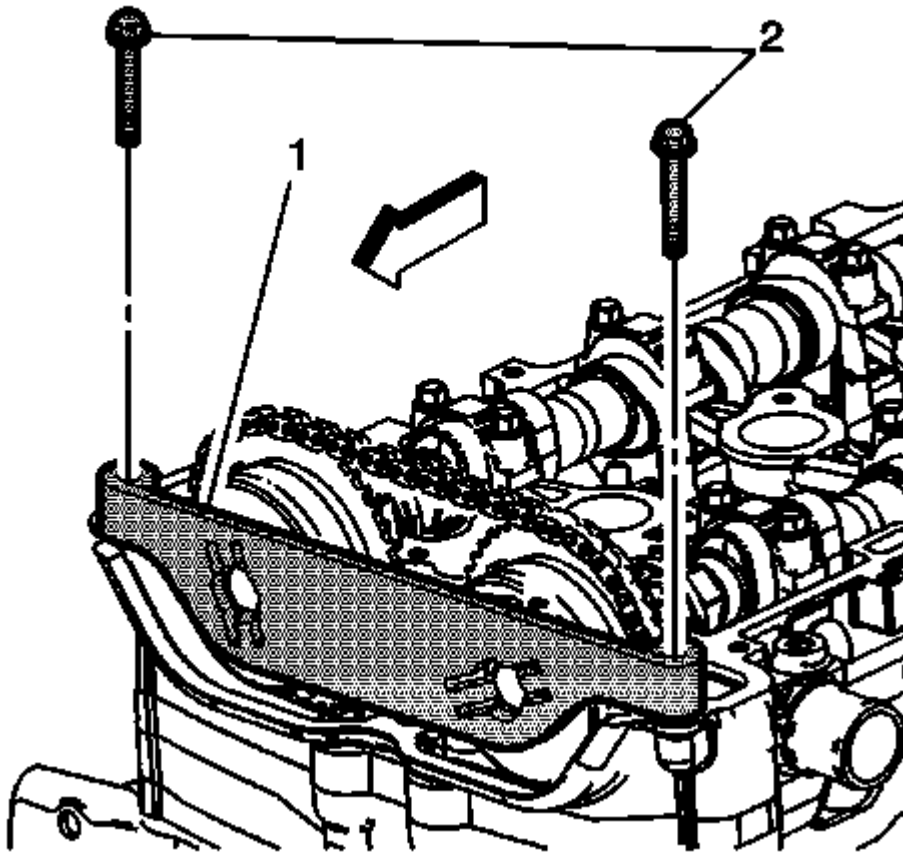
20. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
21. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

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

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

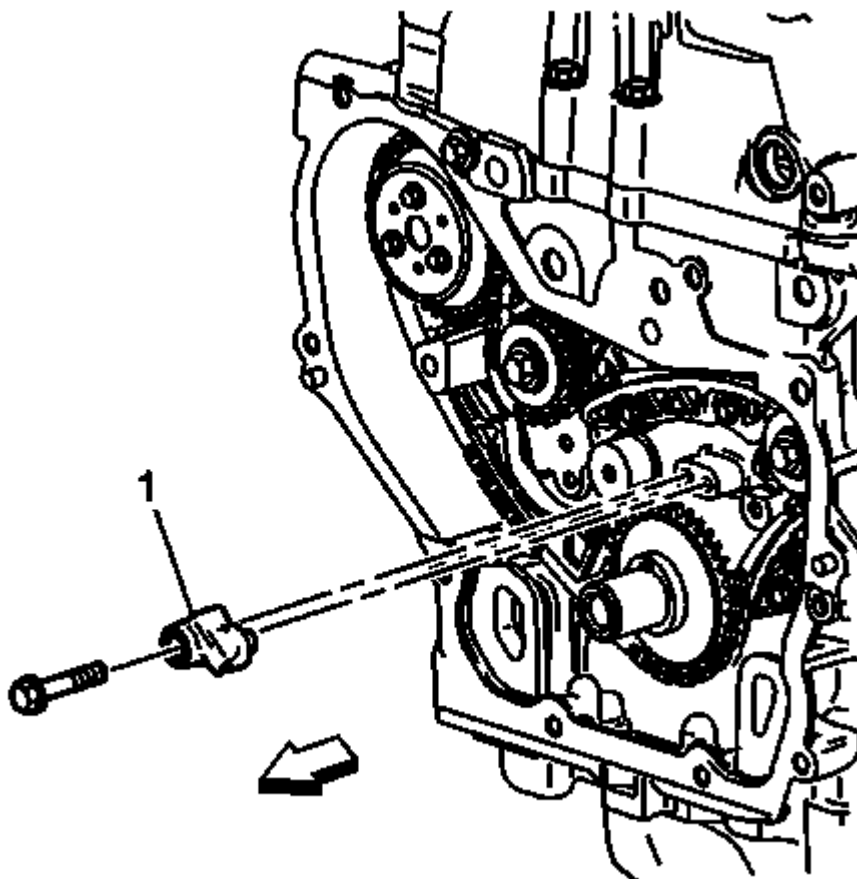
**NOTE:** The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet.

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



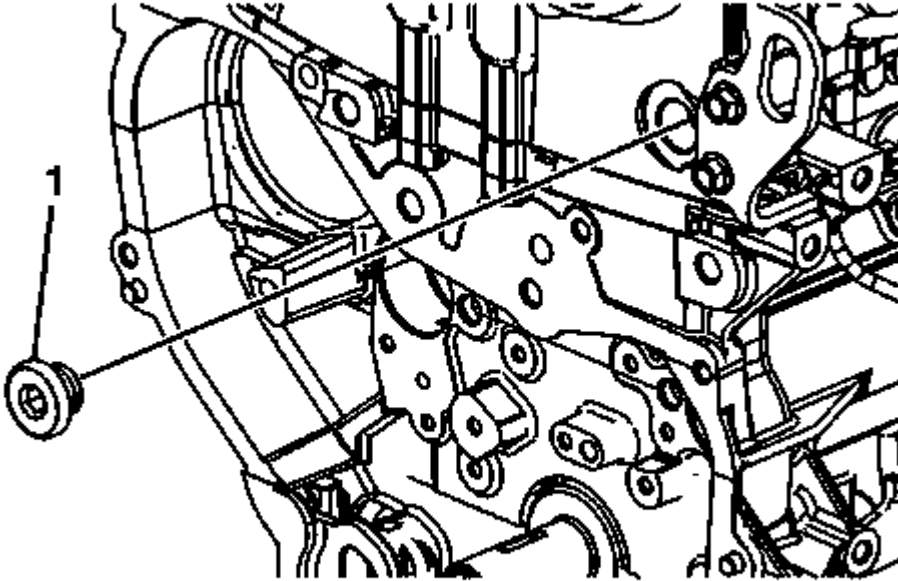
**Fig. 521: Camshaft Actuator Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 522: View of Timing Chain Oil Nozzle**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 523: Identifying Timing Chain Guide Bolt Access Hole Plug**  
Courtesy of GENERAL MOTORS COMPANY

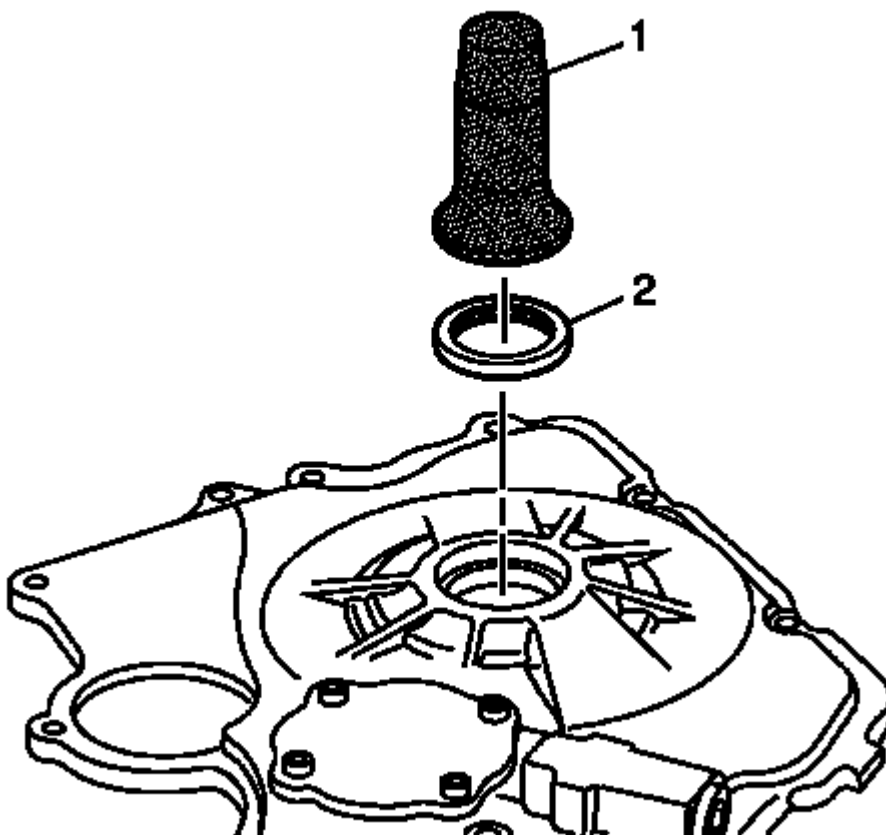
29. Apply sealant to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
30. Install the timing chain guide bolt access hole plug (1) and tighten to 75 N.m (55 lb ft).

## CRANKSHAFT FRONT OIL SEAL INSTALLATION

### Special Tools

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

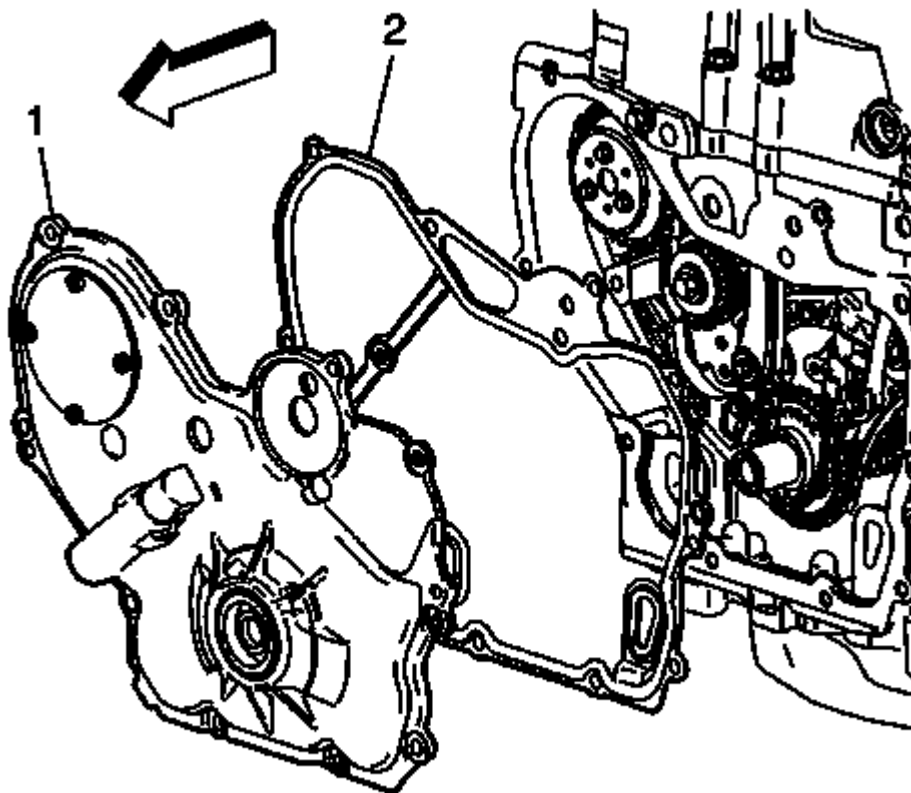
For equivalent regional tools, refer to **Special Tools**.



**Fig. 524: Crankshaft Front Oil Seal & Installer**  
Courtesy of GENERAL MOTORS COMPANY

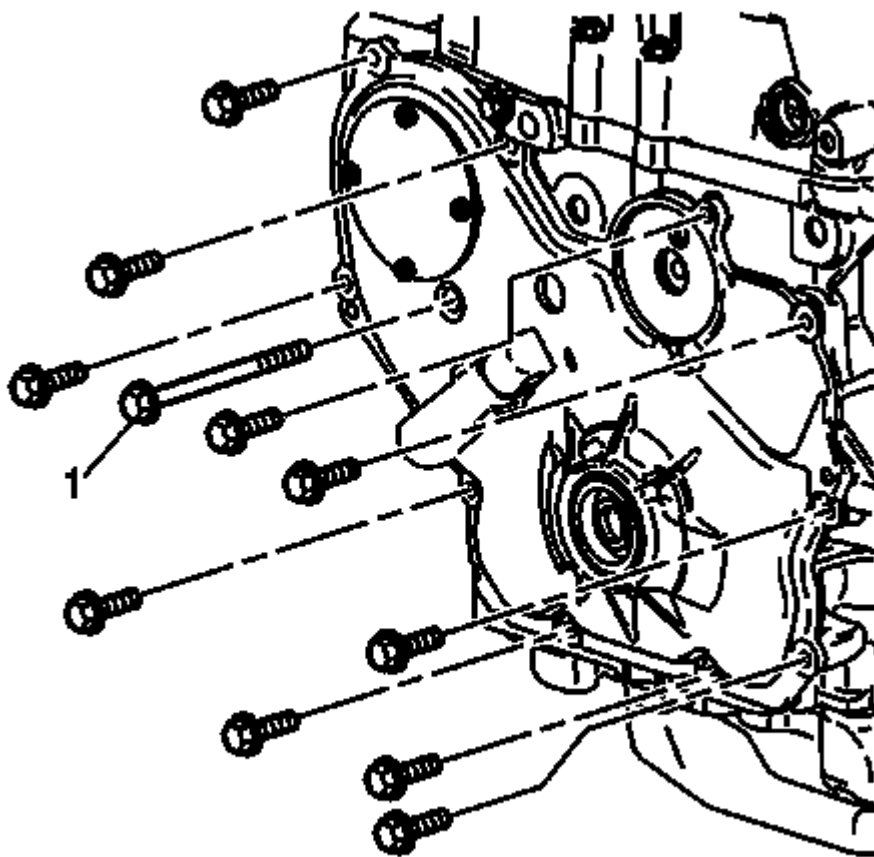
1. Install the seal (2) into the front cover using the EN-35268-A installer (1).
2. Ensure that the engine front cover is properly supported when installing the seal.

## ENGINE FRONT COVER AND OIL PUMP INSTALLATION



**Fig. 525: View Of Engine Front Cover & Gasket**  
**Courtesy of GENERAL MOTORS COMPANY**

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

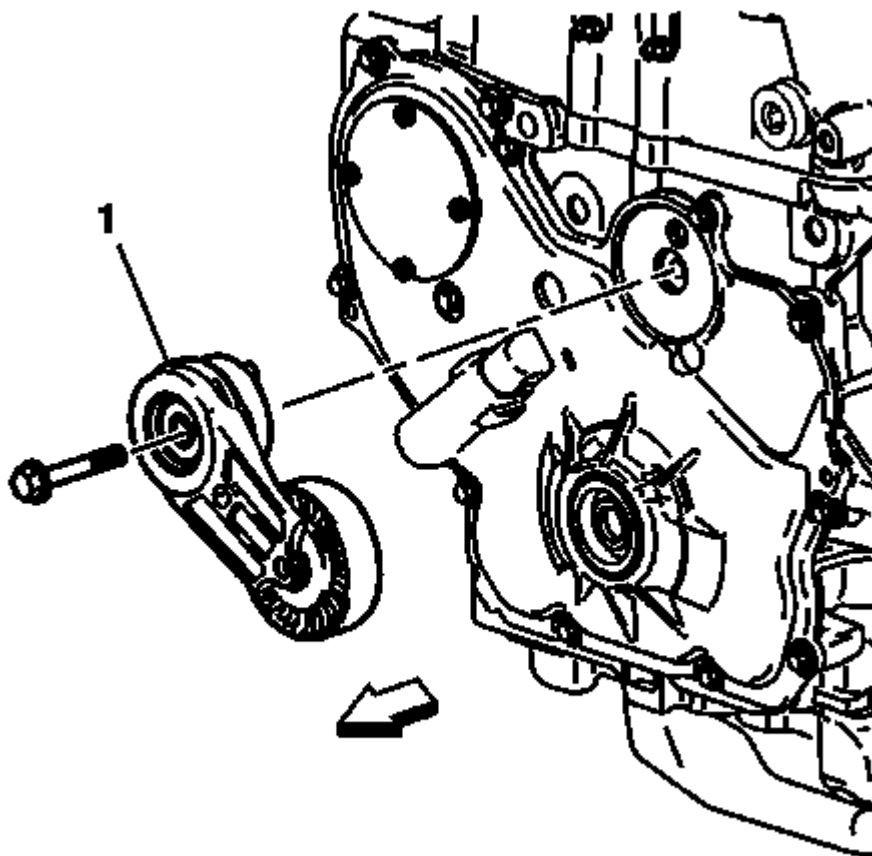


**Fig. 526: Engine Front Cover Bolts & Long Water Pump Bolt**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

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

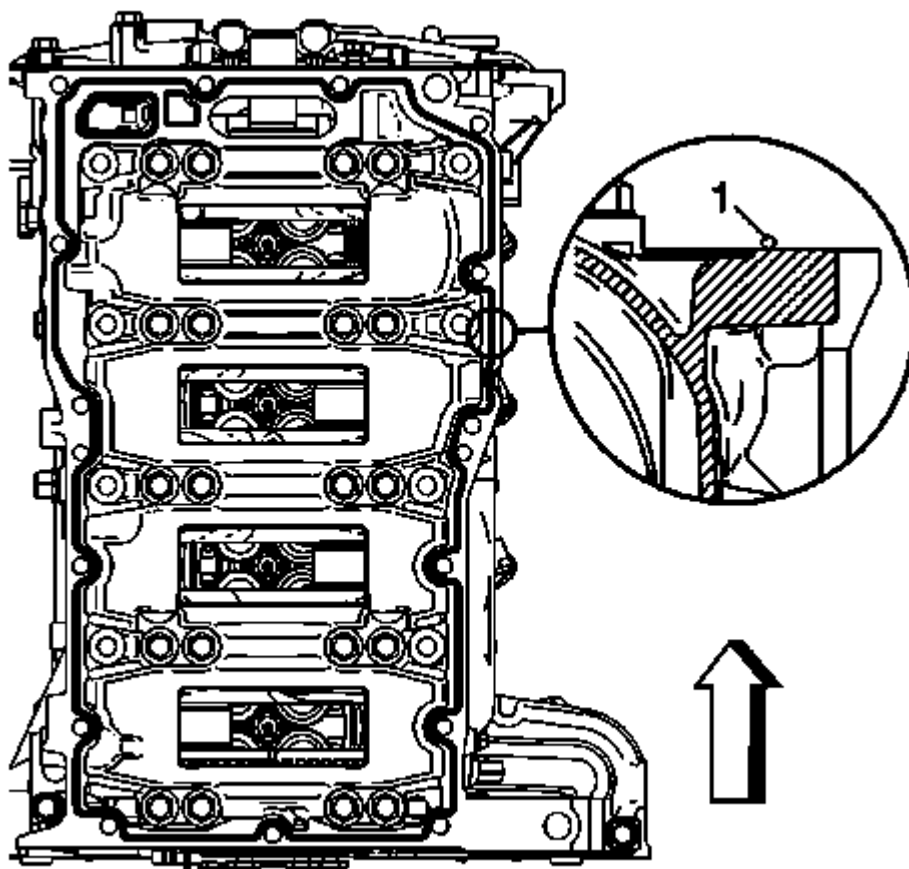
2. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
3. Install the long water pump bolt (1) and tighten to 25 N.m (18 lb ft).



**Fig. 527: Accessory Drive Belt Tensioner & Bolt**  
Courtesy of GENERAL MOTORS COMPANY

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

## OIL PAN INSTALLATION

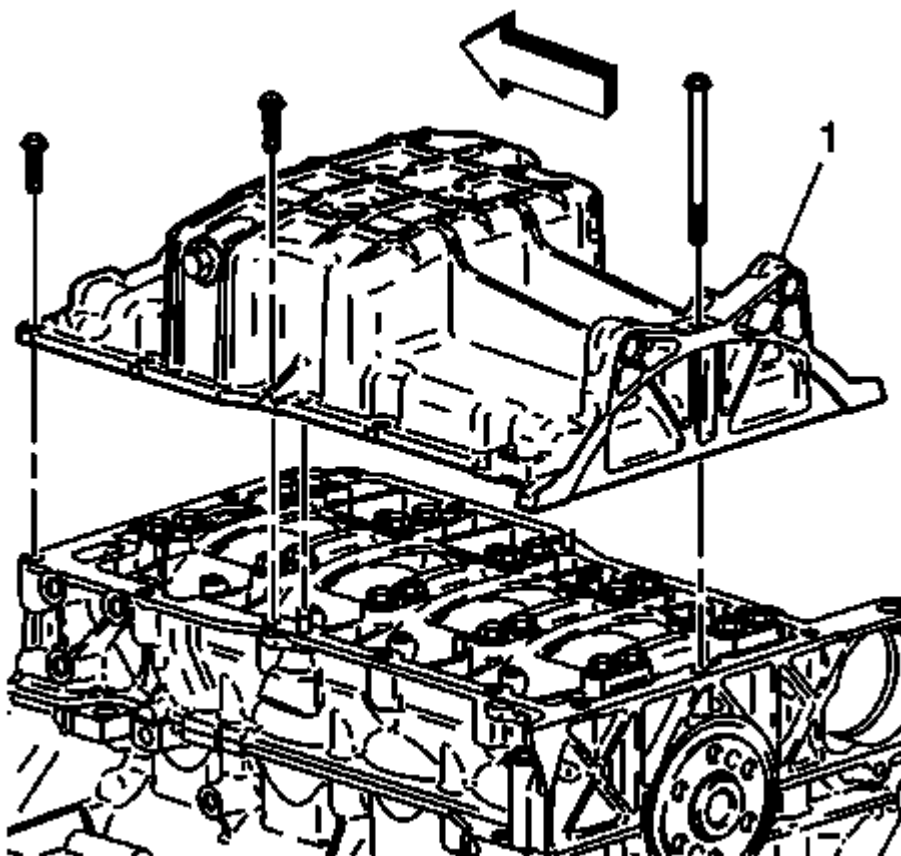


**Fig. 528: Identifying Bead of Sealer on Oil Pan**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:**

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

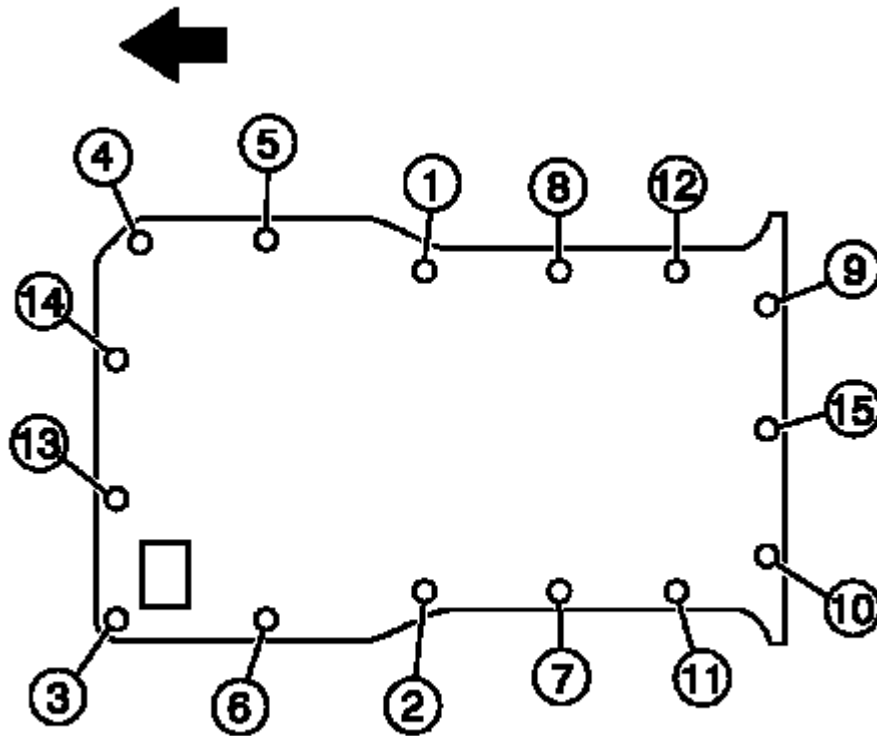
1. Apply a 2.25 mm bead of sealer (1) on the level part of the flange next to the chamfer around the perimeter of the oil pan and the oil suction port opening. Refer to **Adhesives, Fluids, Lubricants, and Sealers.**



**Fig. 529: Oil Pan**

Courtesy of GENERAL MOTORS COMPANY

2. Install the oil pan (1).



**Fig. 530: Identifying Oil Pan Bolts Removal & Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

**CAUTION:** Refer to Fastener Caution .

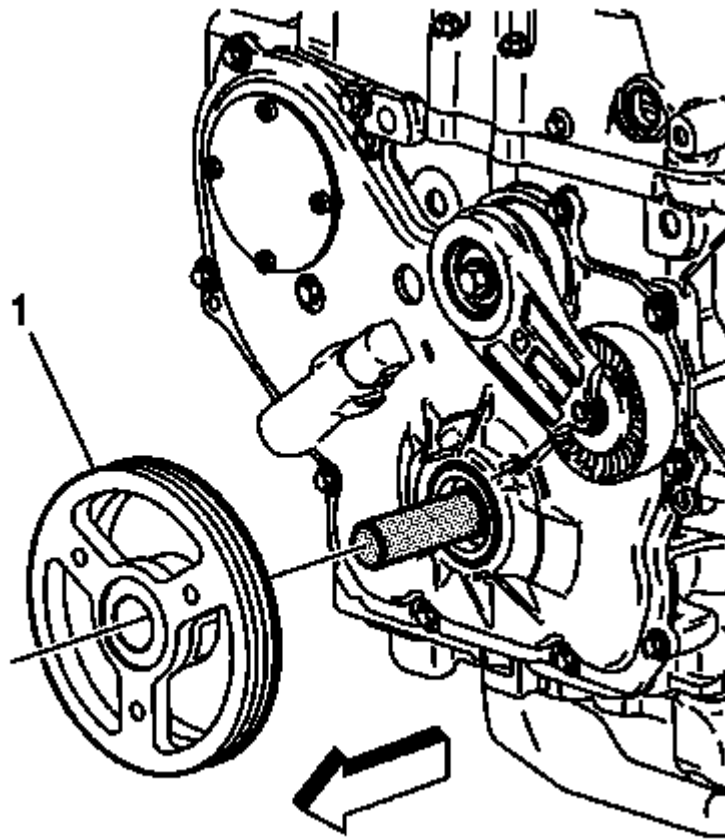
3. Install the oil pan bolts and tighten to 25 N.m (18 lb ft) in sequence.

## CRANKSHAFT BALANCER INSTALLATION

### Special Tools

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

For equivalent regional tools, refer to Special Tools.

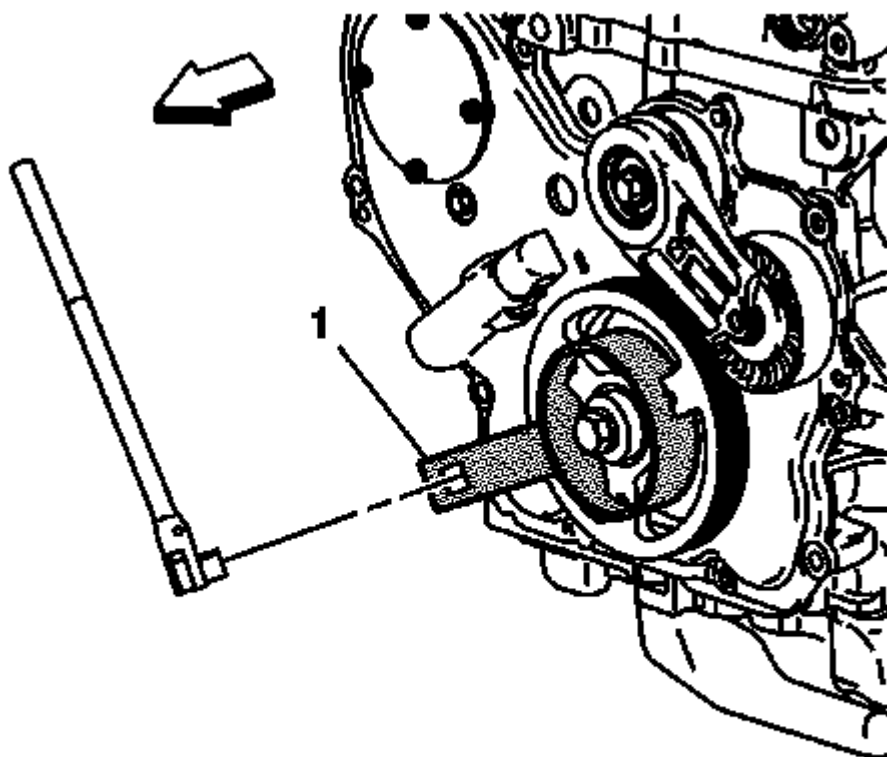


**Fig. 531: Identifying Balancer**

Courtesy of GENERAL MOTORS COMPANY

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

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



**Fig. 532: Crankshaft Balancer Holder**  
Courtesy of GENERAL MOTORS COMPANY

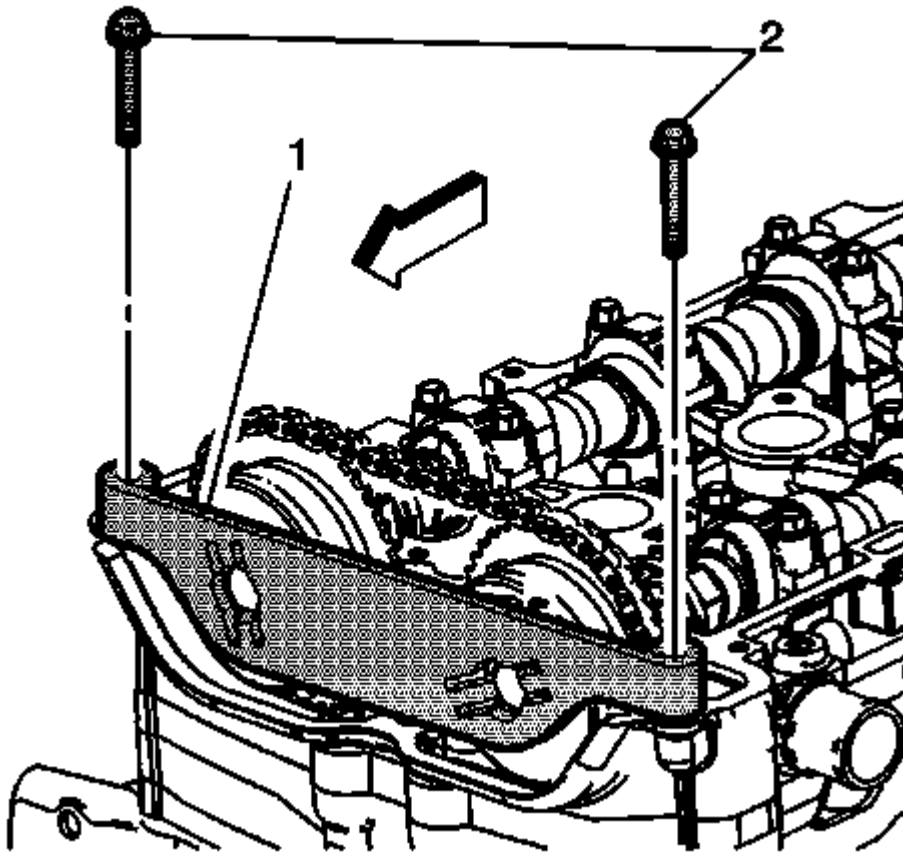
**NOTE:** EN 43653 locking tool may be used instead of EN 38122-A holder to prevent crankshaft rotation.

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

**CAUTION:** Refer to Fastener Caution .

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

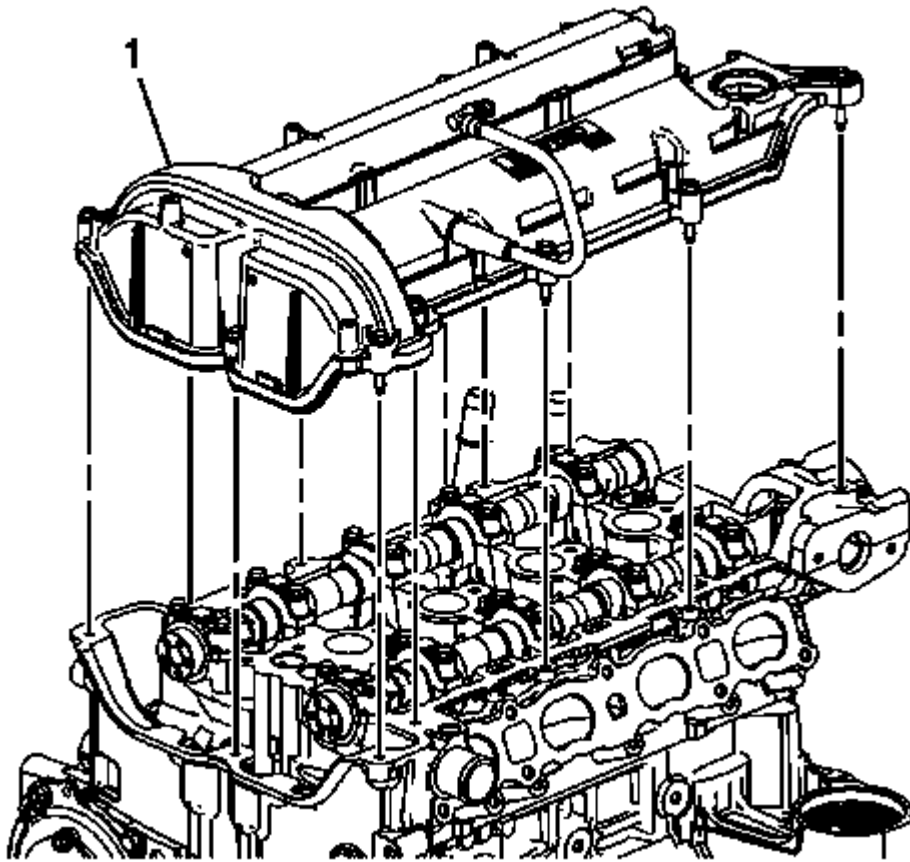
4. Install a new retaining bolt and washer. Use the EN 38122-A holder and a breaker bar to prevent the crankshaft from rotating when tightening the bolt. Tighten the bolt to 150 N.m (111 lb ft) plus 100 degrees using the EN 45059 meter.



**Fig. 533: Camshaft Actuator Locking Tool**  
Courtesy of GENERAL MOTORS COMPANY

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

#### **CAMSHAFT COVER INSTALLATION (LEA)**

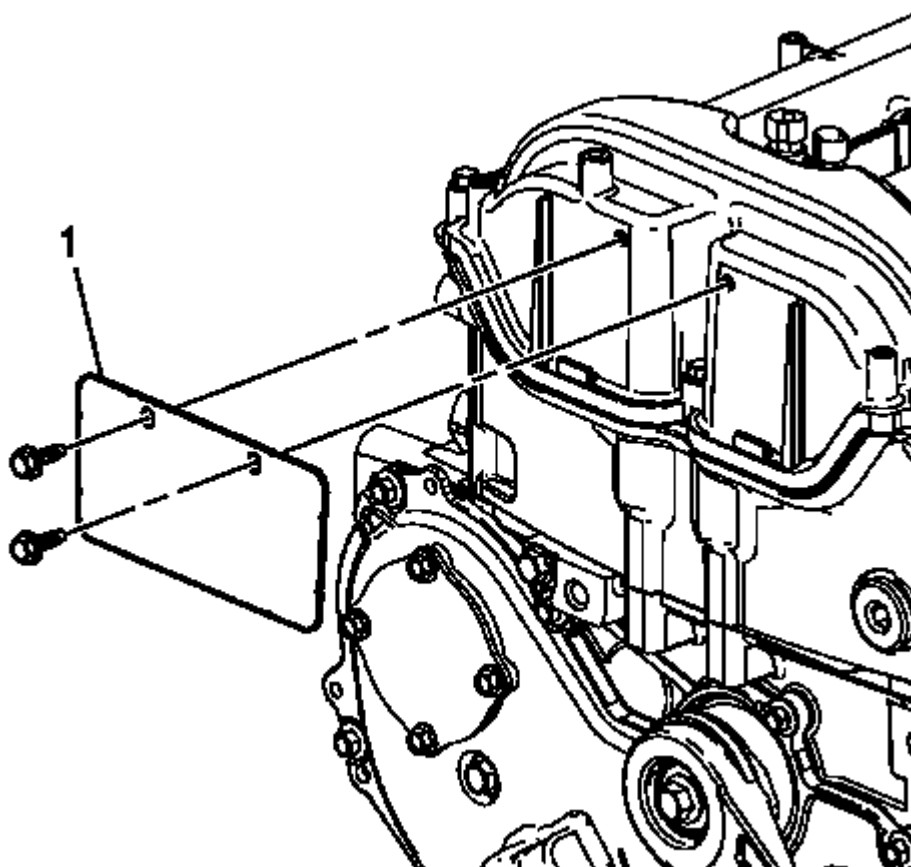


**Fig. 534: Camshaft Cover Assembly**  
Courtesy of GENERAL MOTORS COMPANY

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

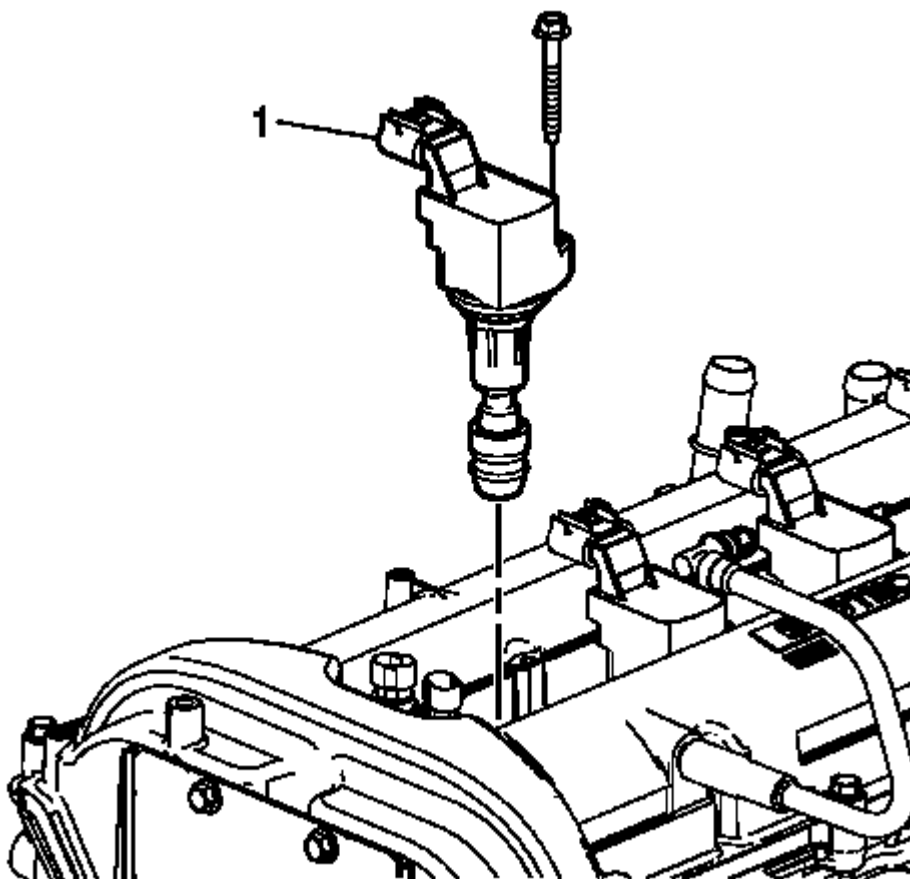
**CAUTION: Refer to Fastener Caution .**

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



**Fig. 535: Camshaft Housing Cover Insulator**  
**Courtesy of GENERAL MOTORS COMPANY**

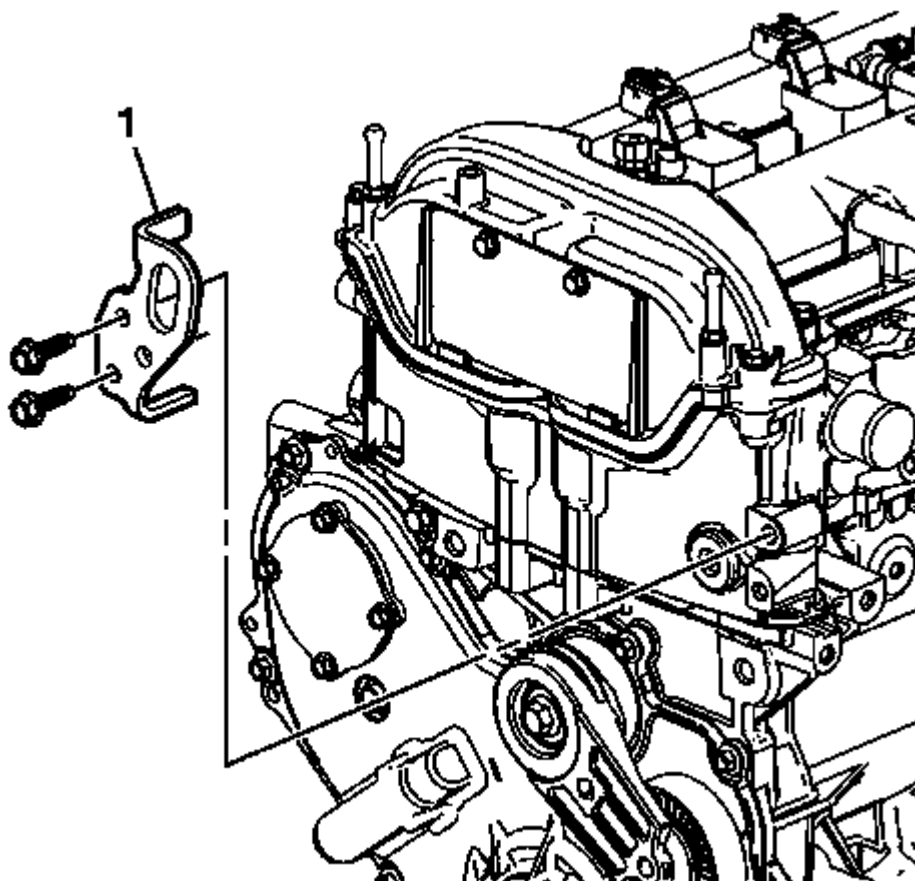
4. Install the camshaft housing cover insulator (1). Tighten the bolts to 10 N.m (89 lb in).



**Fig. 536: Ignition Coil**

Courtesy of GENERAL MOTORS COMPANY

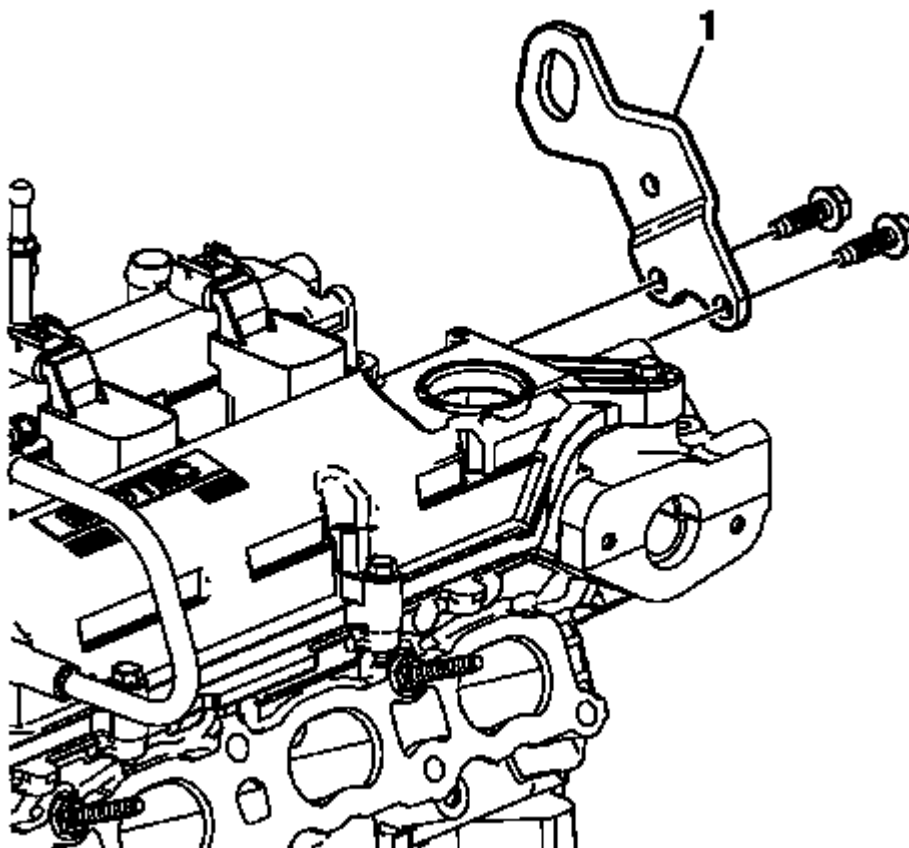
5. Install the ignition coil (1). Tighten the bolt to 10 N.m (89 lb in).



**Fig. 537: Front Lift Bracket**

**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 538: Rear Lift Bracket**

Courtesy of GENERAL MOTORS COMPANY

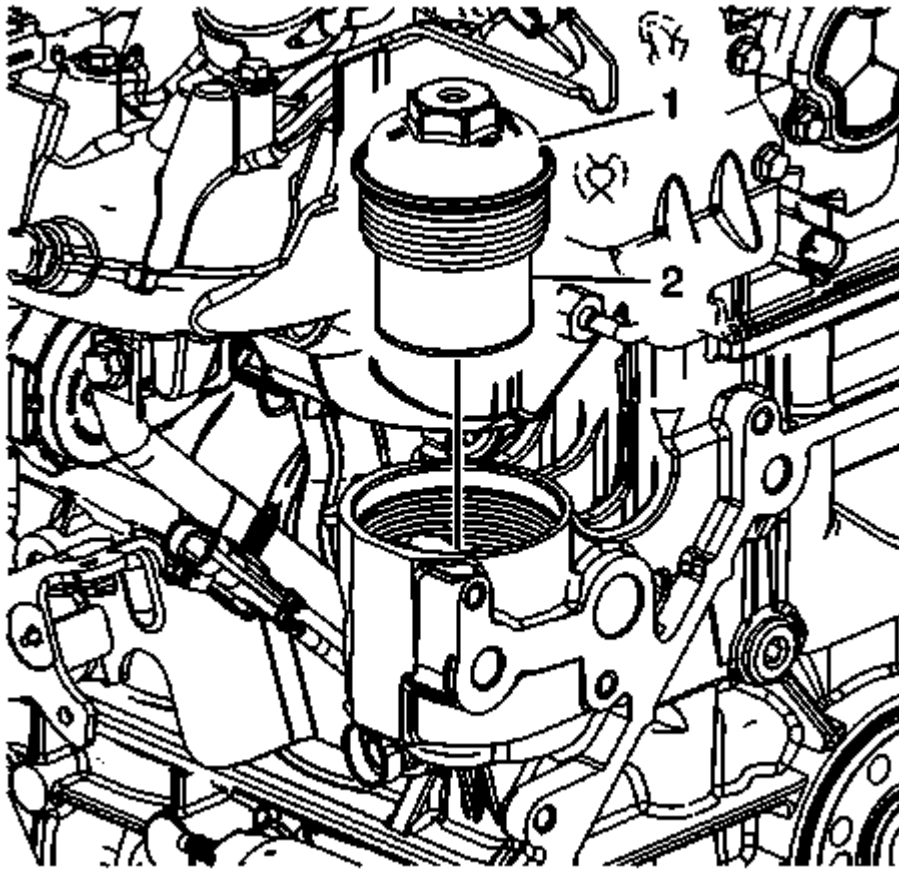
8. Install the rear lift bracket (1).
9. Install the rear lift bracket bolts and tighten to 25 N.m (18 lb ft).

## OIL FILTER WITH CAP AND SEAL INSTALLATION

### Special Tools

**EN-44887** Oil Filter Wrench

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



**Fig. 539: Identifying Oil Filter & Cap**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

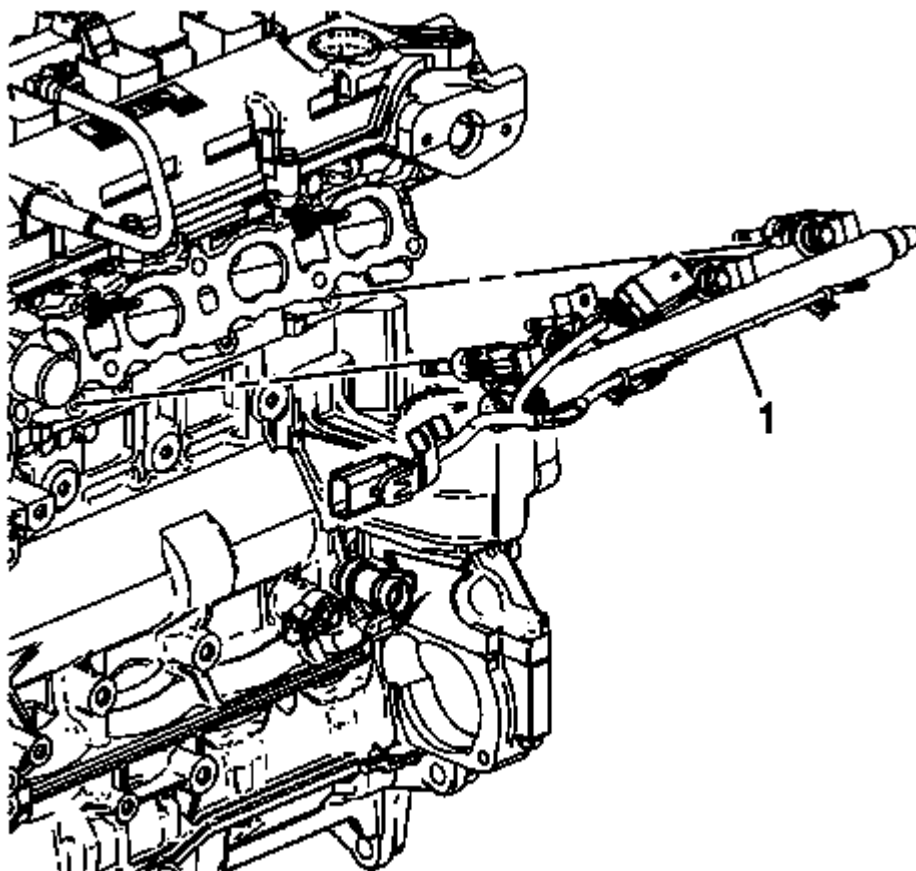
3. Use **EN-44887** wrench to install the oil filter cap. Tighten the oil filter cap to 25 N.m (18 lb ft).

## FUEL RAIL AND INJECTORS INSTALLATION

### Special Tools

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

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



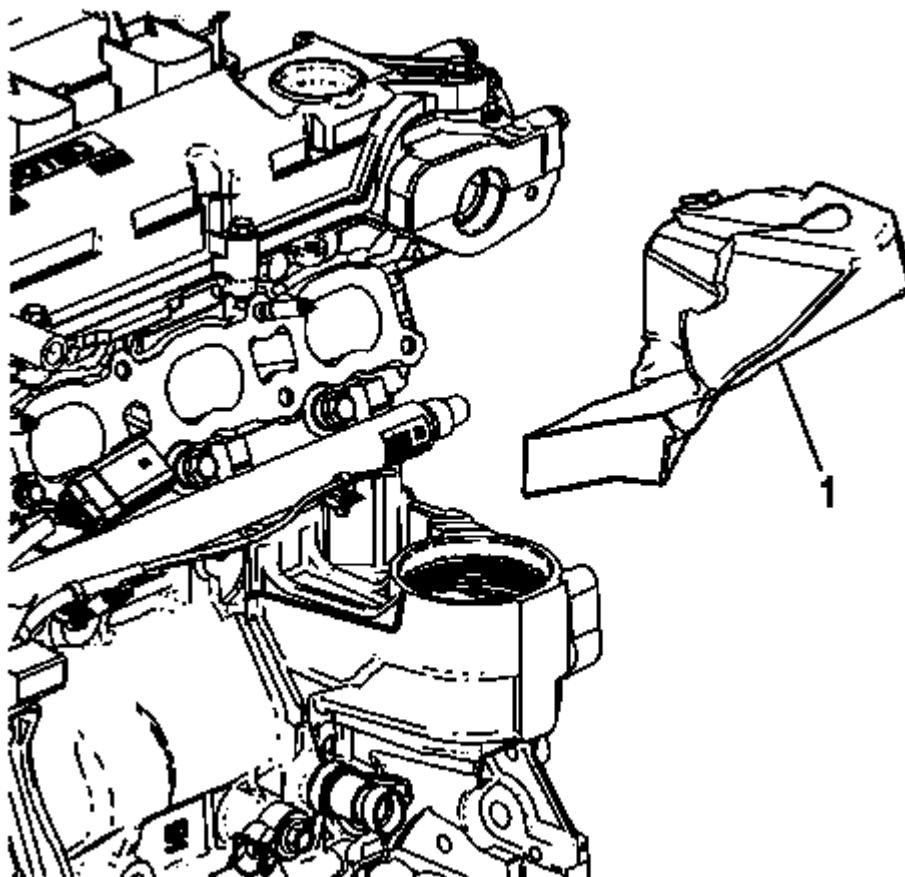
**Fig. 540: Fuel Rail**

Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION: Refer to Fastener Caution .**

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



**Fig. 541: Fuel Injection Fuel Rail Noise Shield**  
Courtesy of GENERAL MOTORS COMPANY

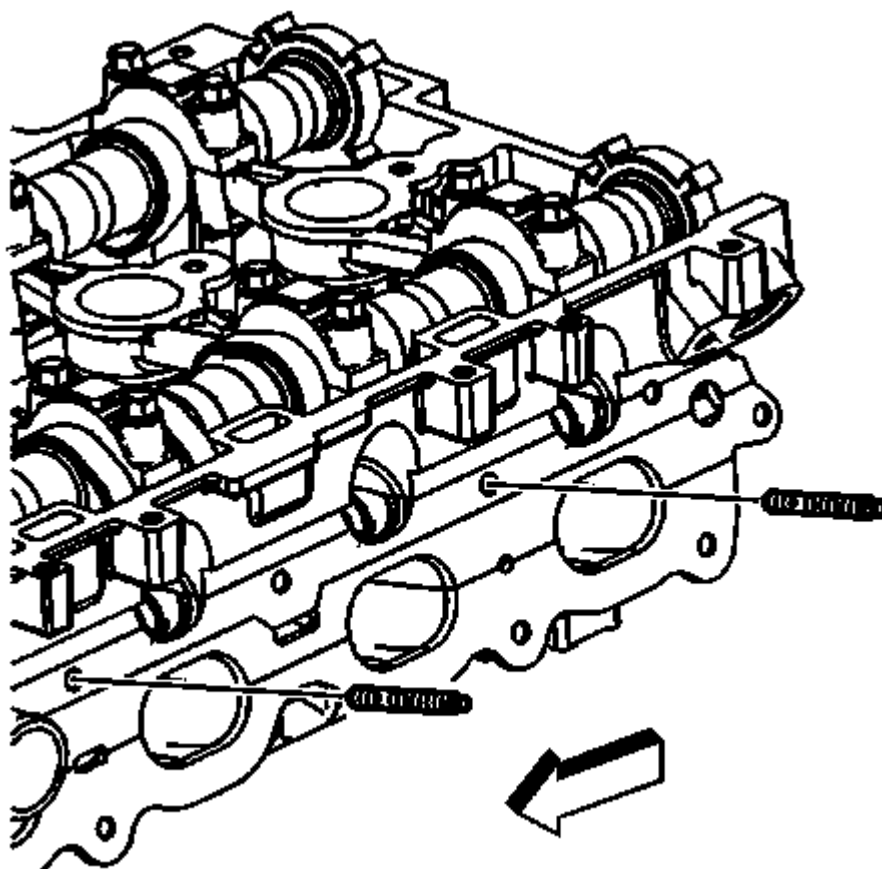
6. Install the fuel injection fuel rail noise shield (1).

## INTAKE MANIFOLD INSTALLATION

### Special Tools

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

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

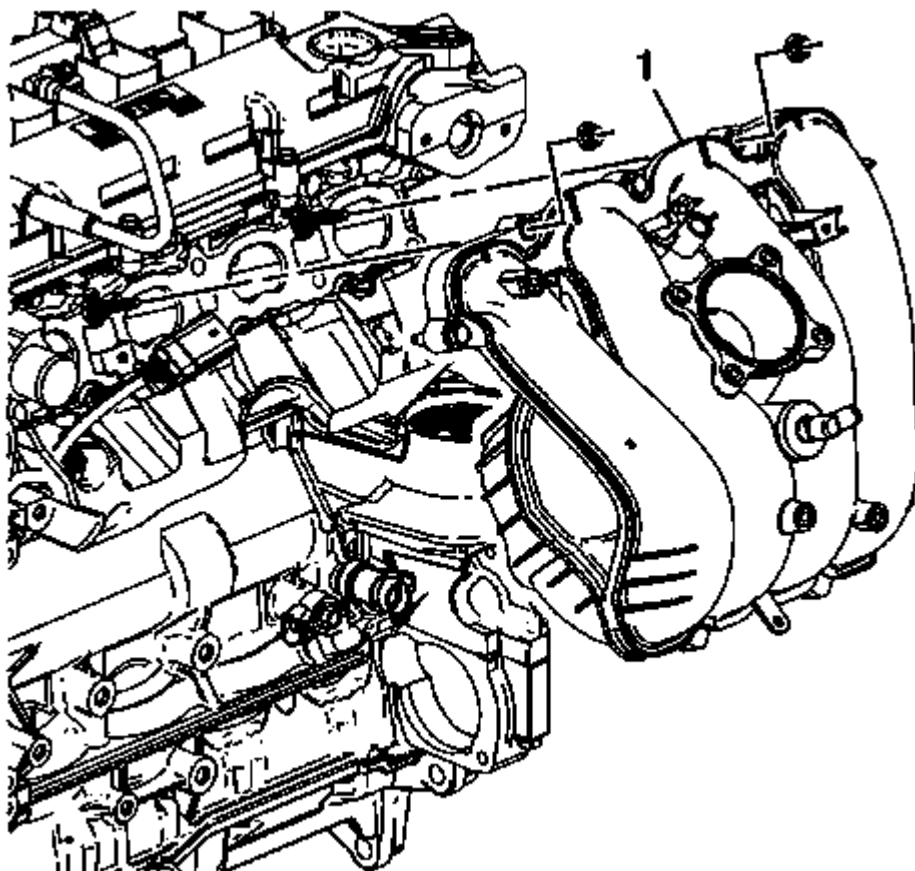


**Fig. 542: Intake Manifold Studs**

Courtesy of GENERAL MOTORS COMPANY

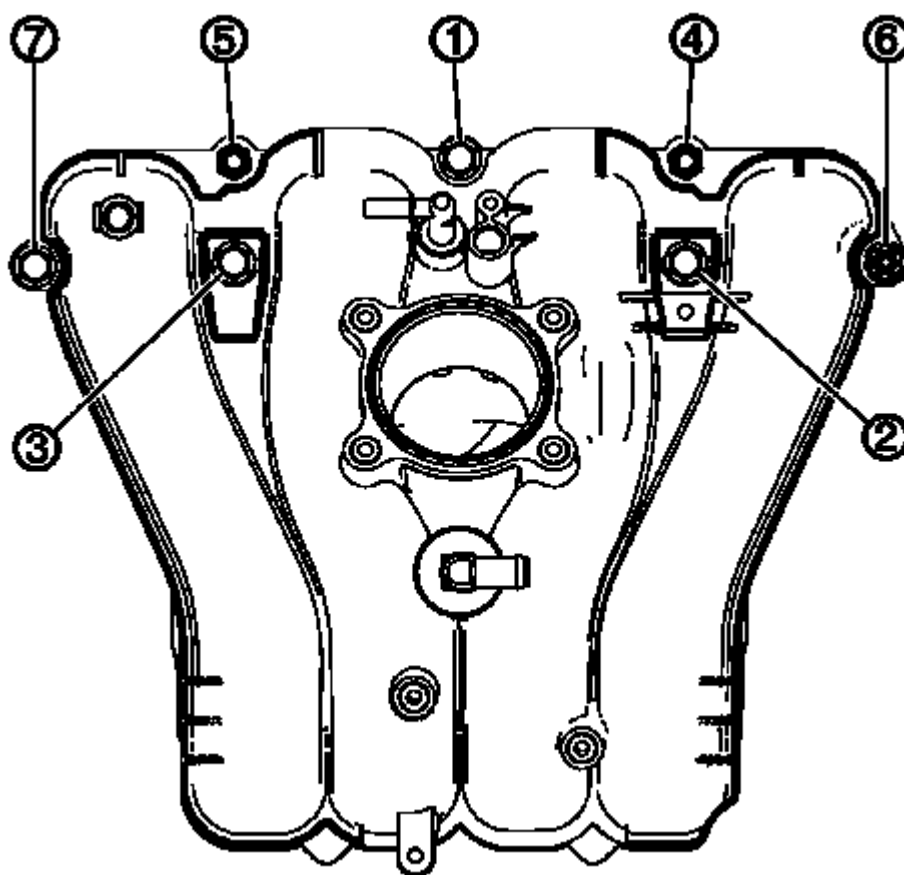
**CAUTION:** Refer to Fastener Caution .

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



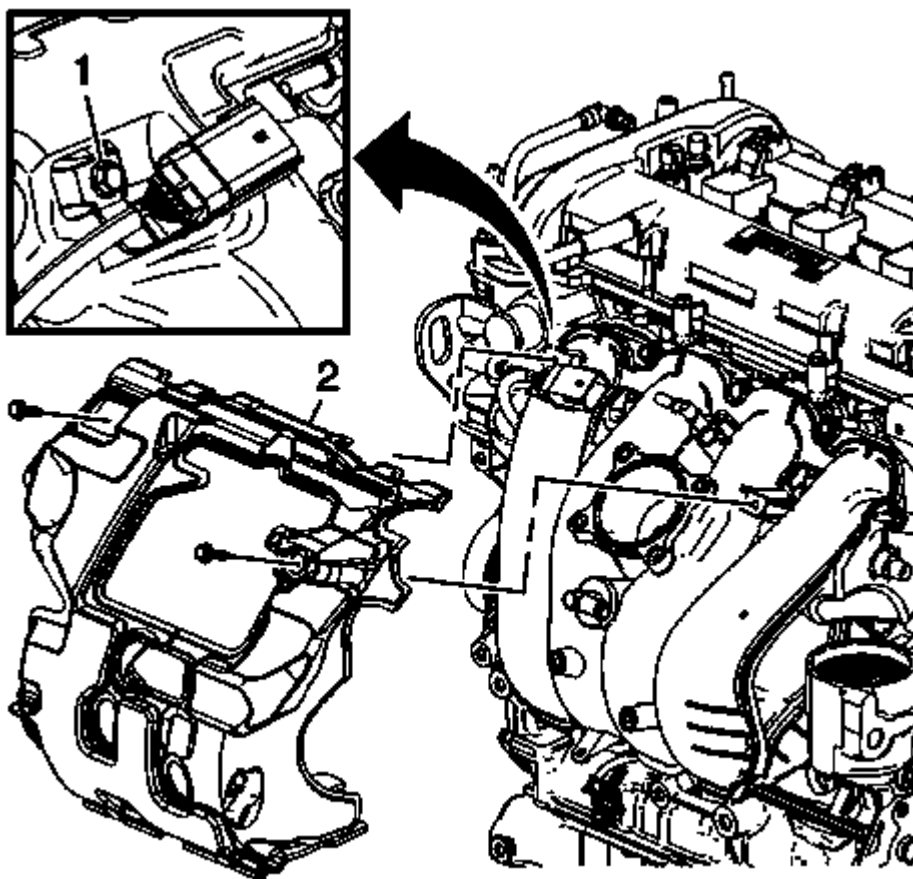
**Fig. 543: Intake Manifold Retaining Nuts And Bolts**  
Courtesy of GENERAL MOTORS COMPANY

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



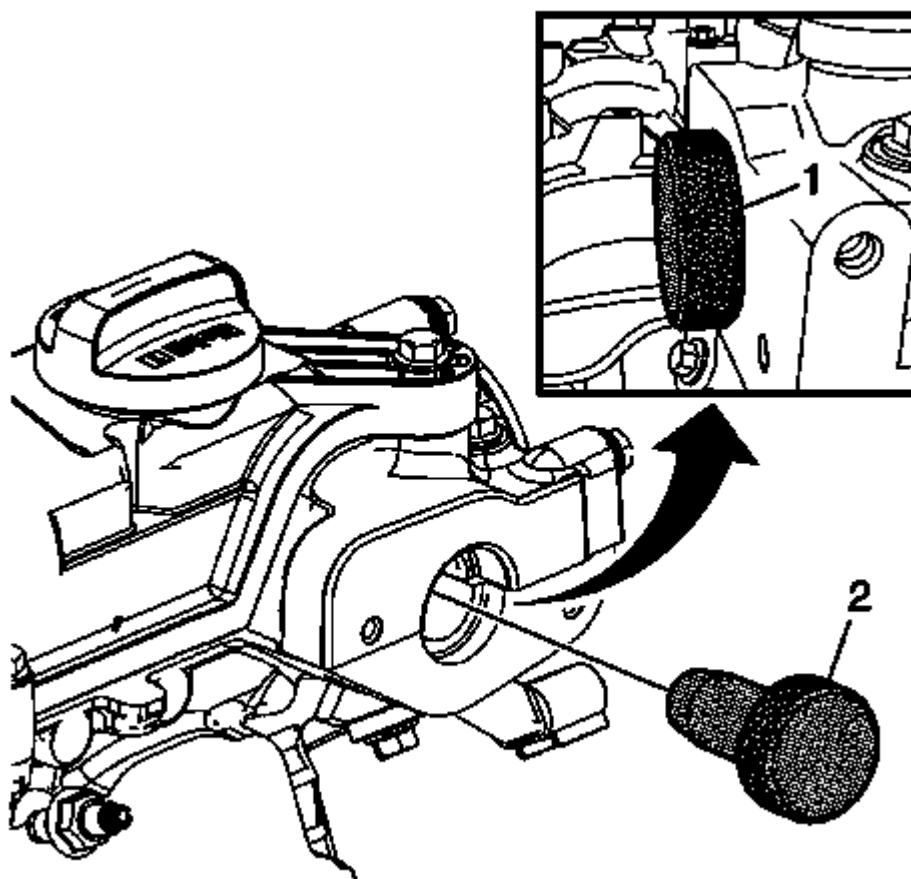
**Fig. 544: Identifying Intake Manifold Bolts And Nuts**  
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 545: Fuel Rail Harness Connector Bracket & Intake Manifold Insulator**  
Courtesy of GENERAL MOTORS COMPANY

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

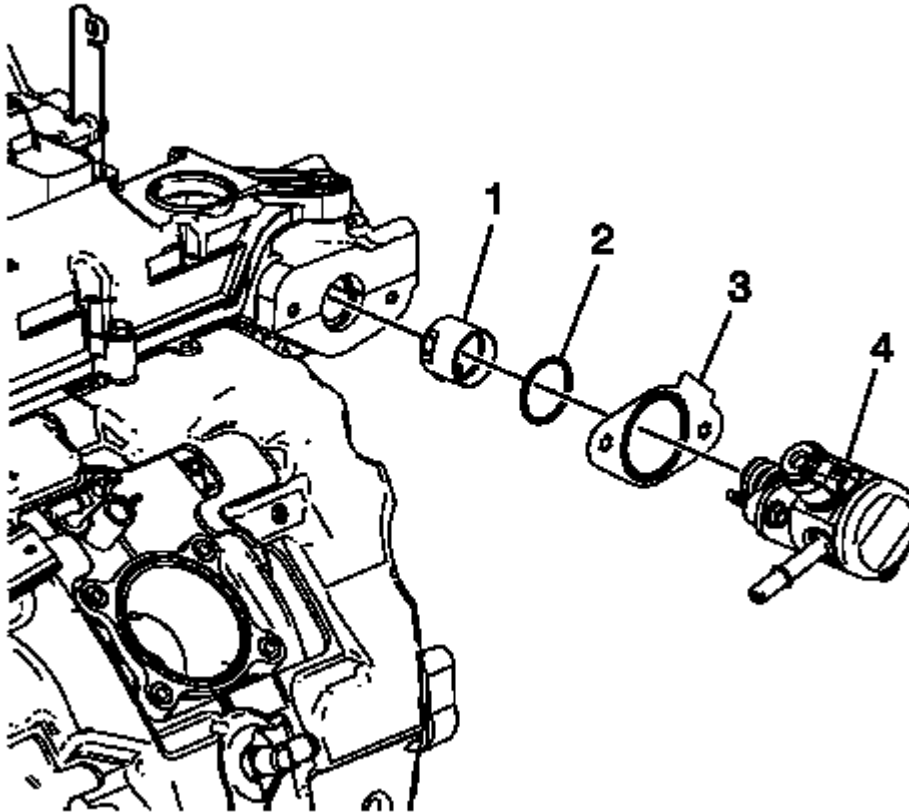


**Fig. 546: Using Alignment Gage**

Courtesy of GENERAL MOTORS COMPANY

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

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



**Fig. 547: Fuel Pump Assembly Components**  
Courtesy of GENERAL MOTORS COMPANY

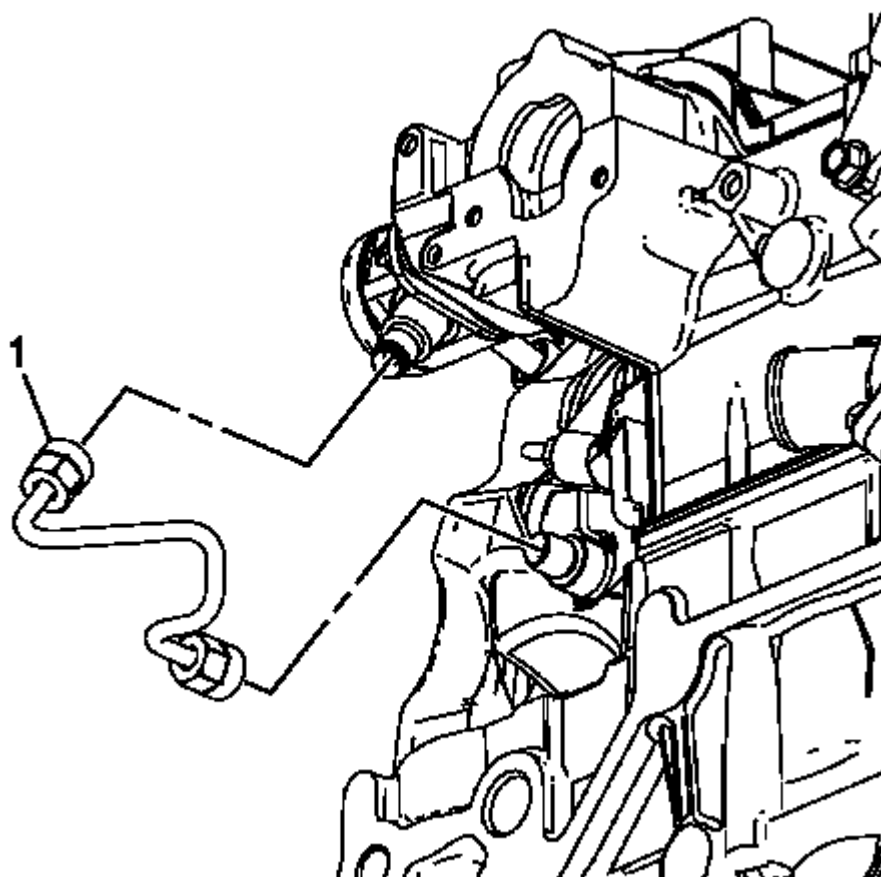
8. Lubricate the high pressure fuel pump cylinder head bore with 5W30 engine oil.

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

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

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

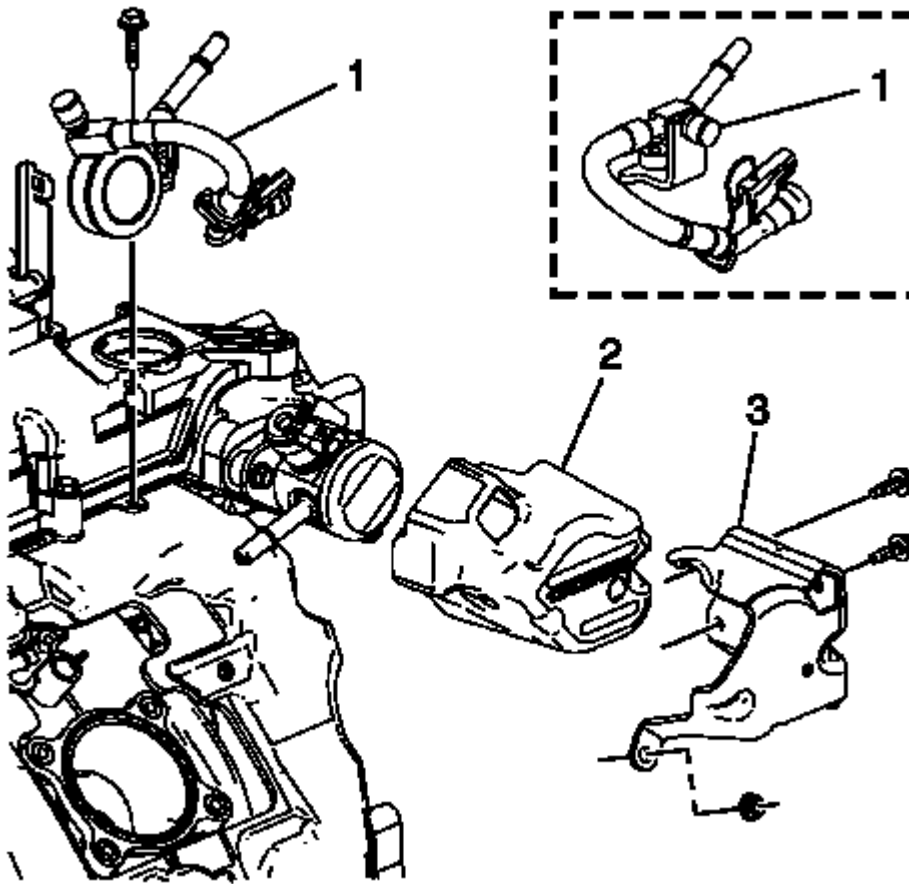
11. Install the fuel pump assembly (4).
12. Start and hand-tighten the fuel pump assembly bolts evenly. Tighten the fuel pump bolts evenly to 15 N.m (11 lb ft).



**Fig. 548: High Pressure Fuel Line**

**Courtesy of GENERAL MOTORS COMPANY**

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



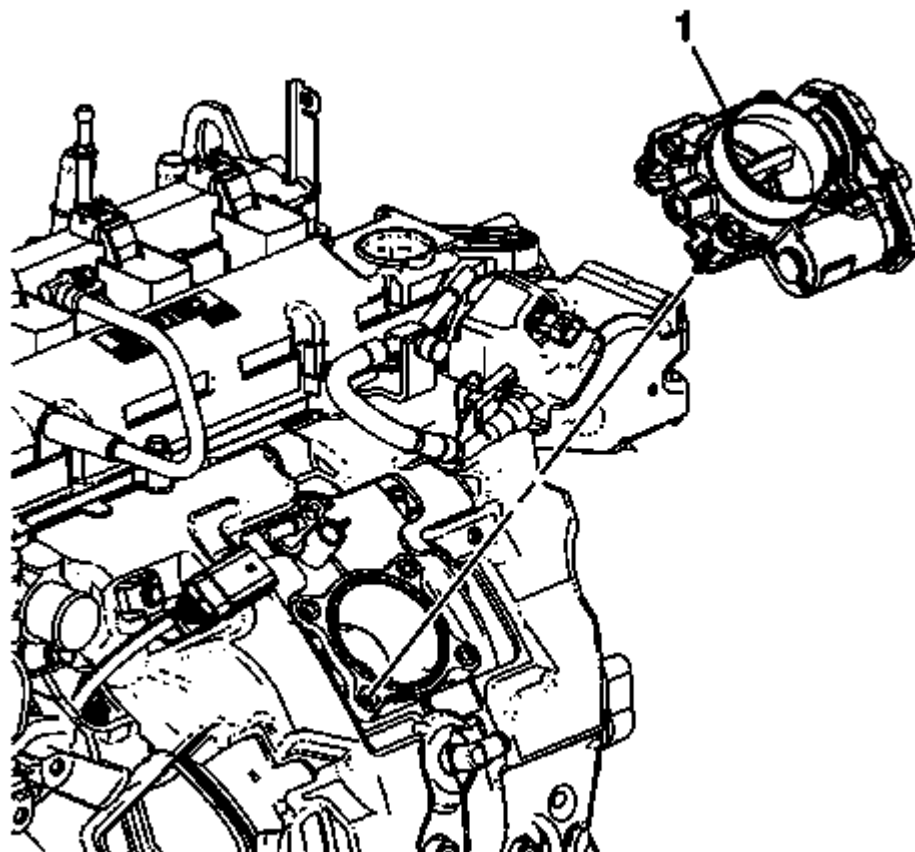
**Fig. 549: Fuel Pump Components**

Courtesy of GENERAL MOTORS COMPANY

14. Install the fuel pump insulator (2).

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

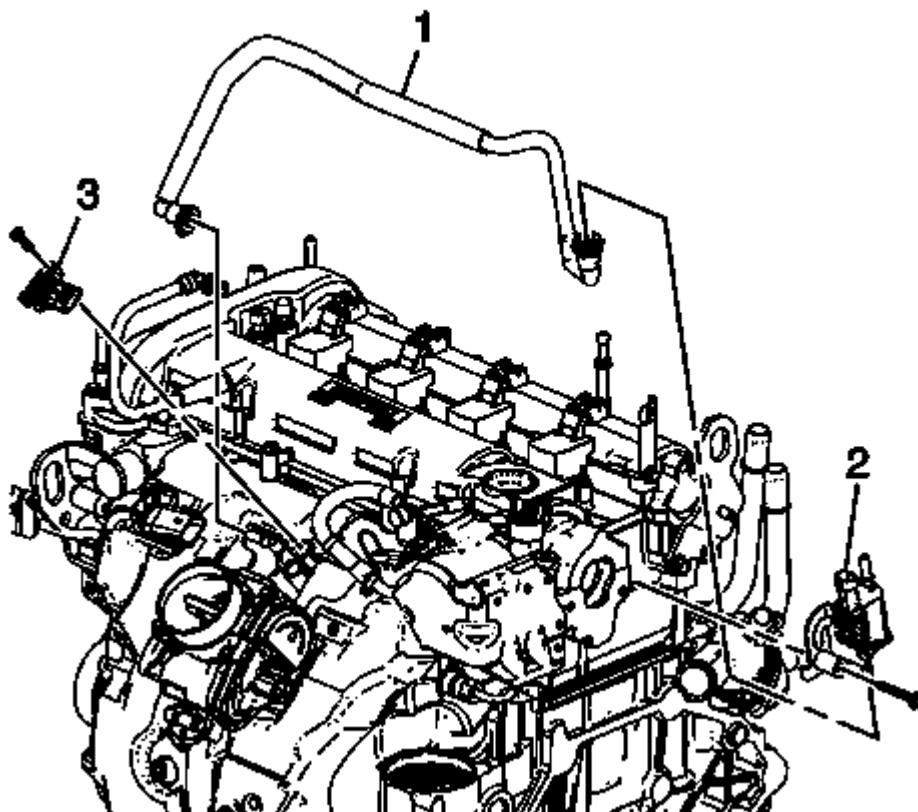
15. Install the low pressure fuel pipe assembly (1).  
16. Install the fuel pump cover (3) and nut. Tighten the nut to 10 N.m (89 lb in).  
17. Install the fuel pump cover bolts. Tighten the bolts to 10 N.m (89 lb in).



**Fig. 550: Throttle Body**

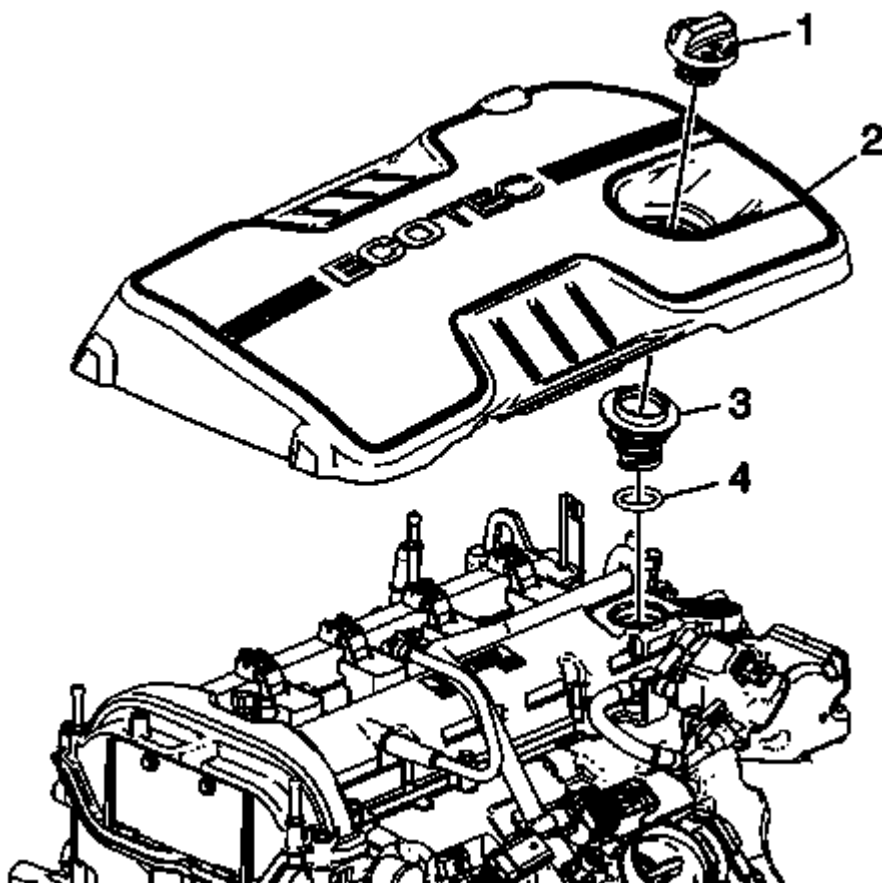
Courtesy of GENERAL MOTORS COMPANY

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



**Fig. 551: EVAP Canister Valve, Tube & MAP Sensor**  
**Courtesy of GENERAL MOTORS COMPANY**

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

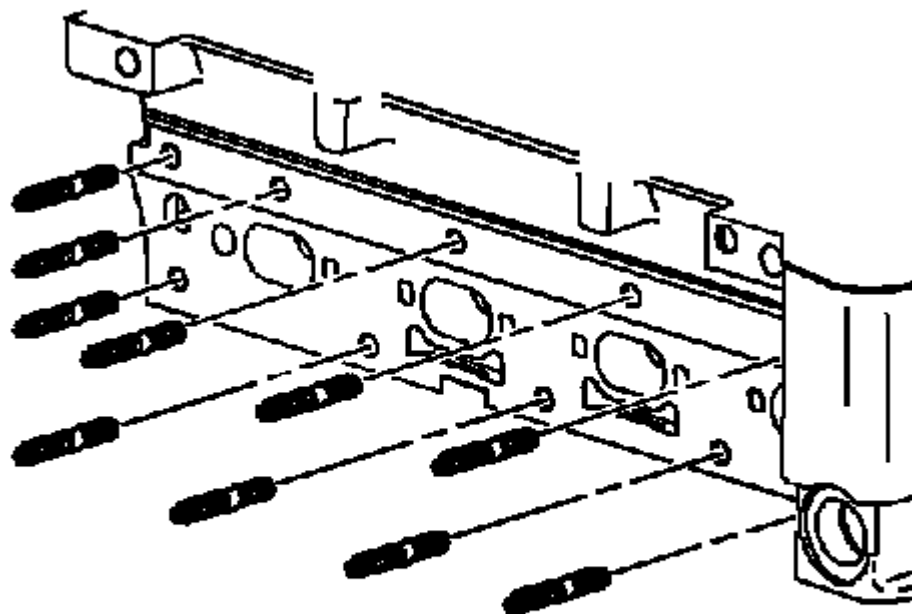


**Fig. 552: Oil Fill Cap Components**

Courtesy of GENERAL MOTORS COMPANY

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

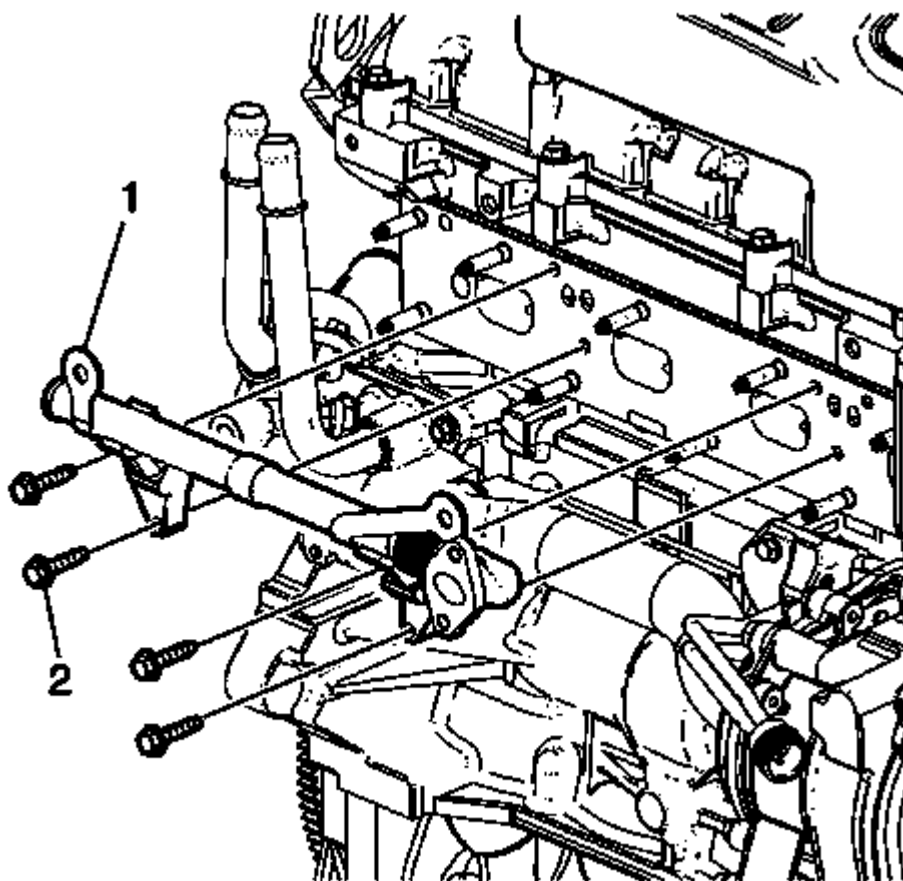
#### **EXHAUST MANIFOLD INSTALLATION (LEA)**



**Fig. 553: View Of Exhaust Manifold Studs**  
 Courtesy of GENERAL MOTORS COMPANY

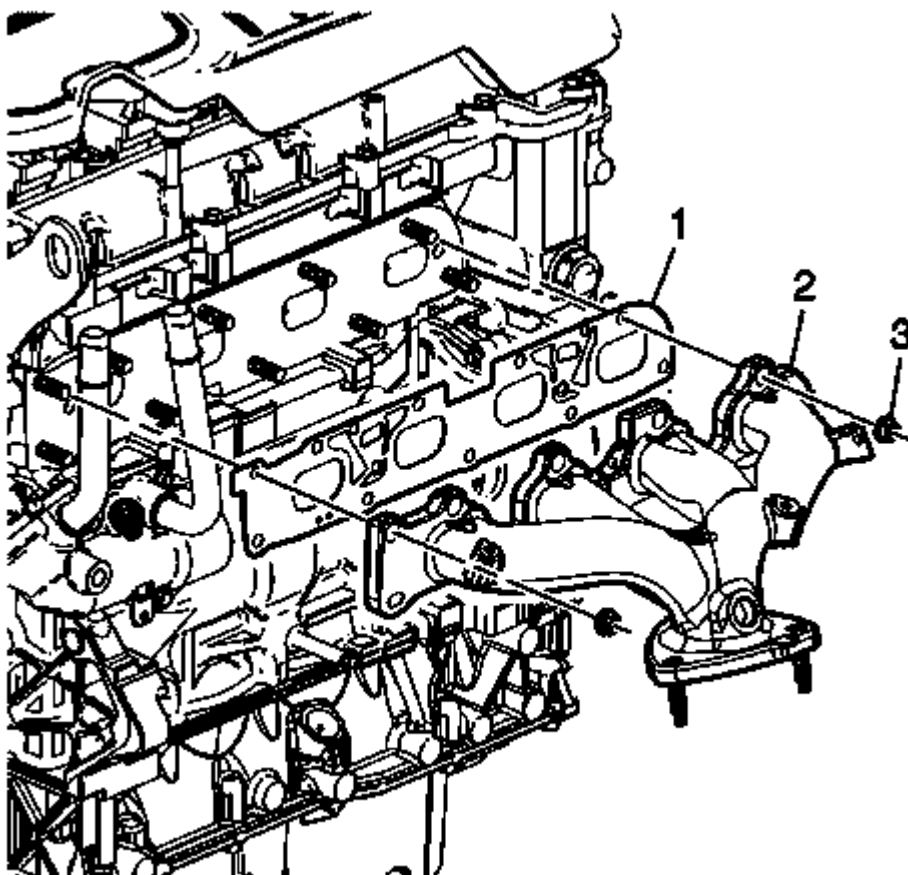
**CAUTION:** Refer to Fastener Caution .

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



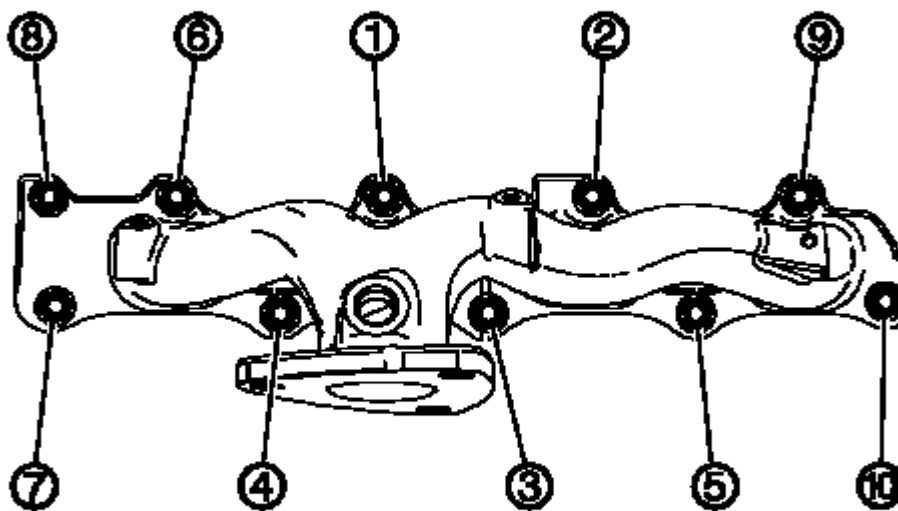
**Fig. 554: Secondary Air Injection Pipe Assembly**  
**Courtesy of GENERAL MOTORS COMPANY**

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



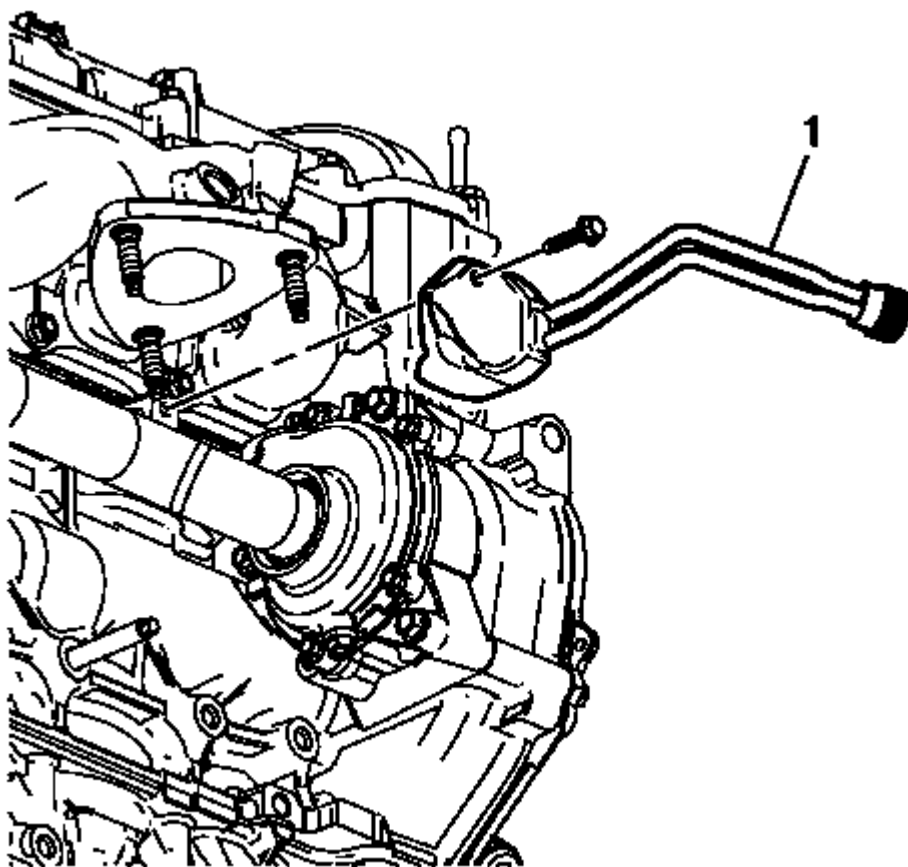
**Fig. 555: Exhaust Manifold Components**  
**Courtesy of GENERAL MOTORS COMPANY**

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



**Fig. 556: Exhaust Manifold Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS COMPANY

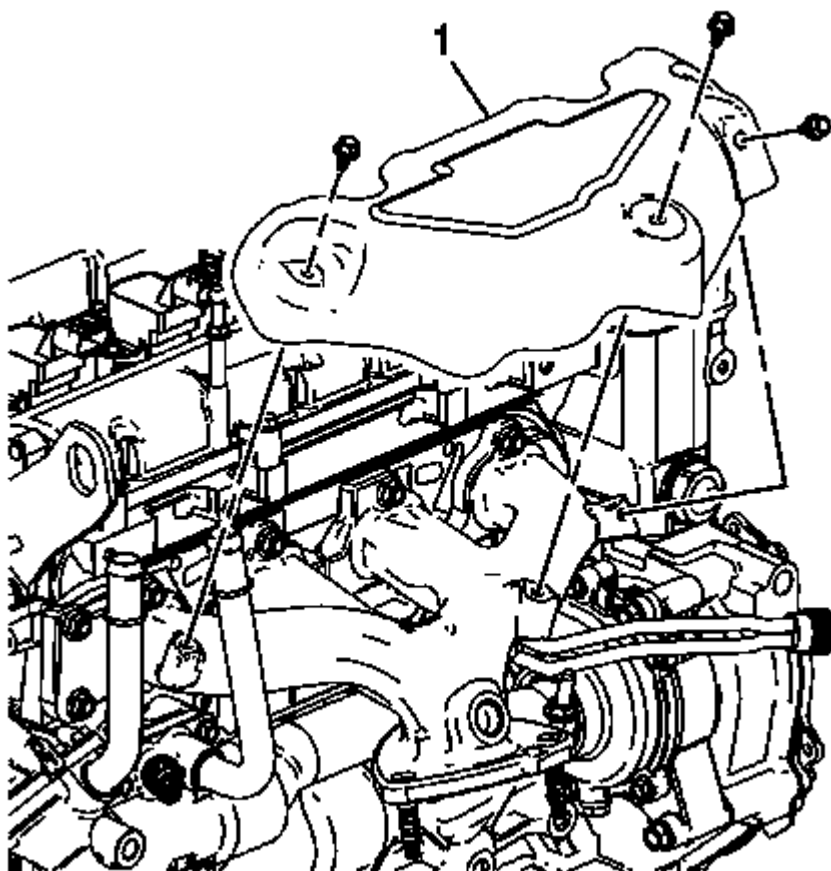
7. Tighten the NEW exhaust manifold to cylinder head retaining nuts two passes in sequence:
  1. Tighten first pass in sequence to 14 N.m (124 lb in).
  2. Tighten final pass in sequence to 14 N.m (124 lb in).



**Fig. 557: Block Heater**

Courtesy of GENERAL MOTORS COMPANY

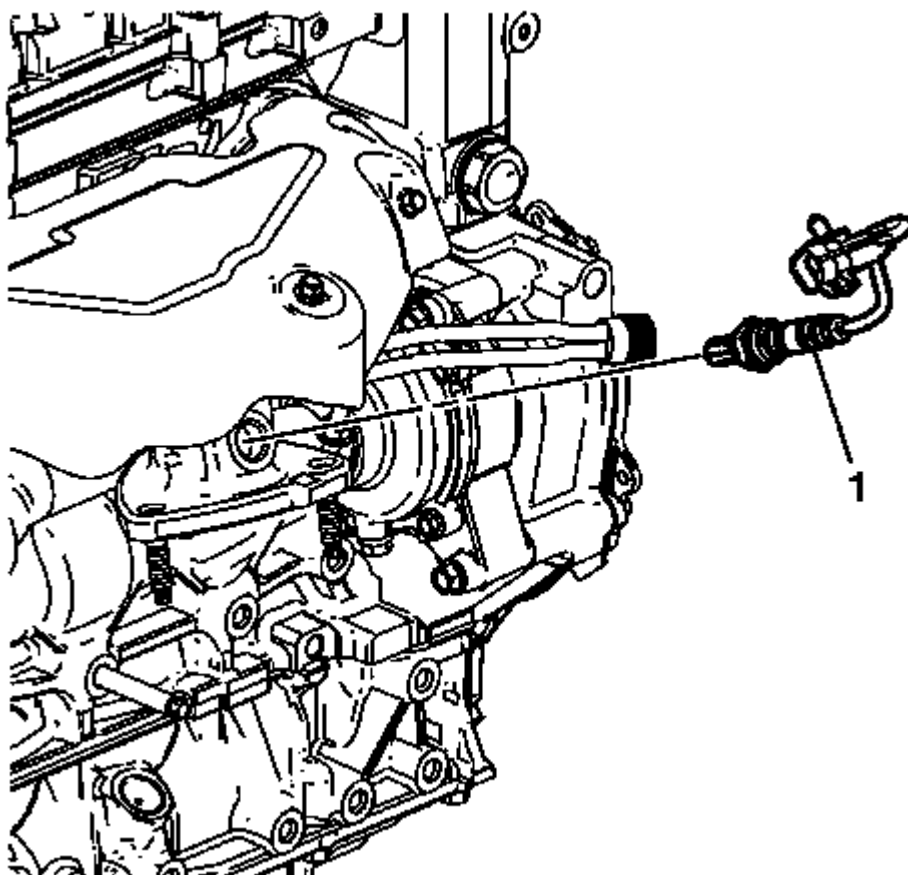
8. Install the block heater (1). Tighten the bolt to 10 N.m (89 lb in).



**Fig. 558: Exhaust Manifold Heat Shield**

**Courtesy of GENERAL MOTORS COMPANY**

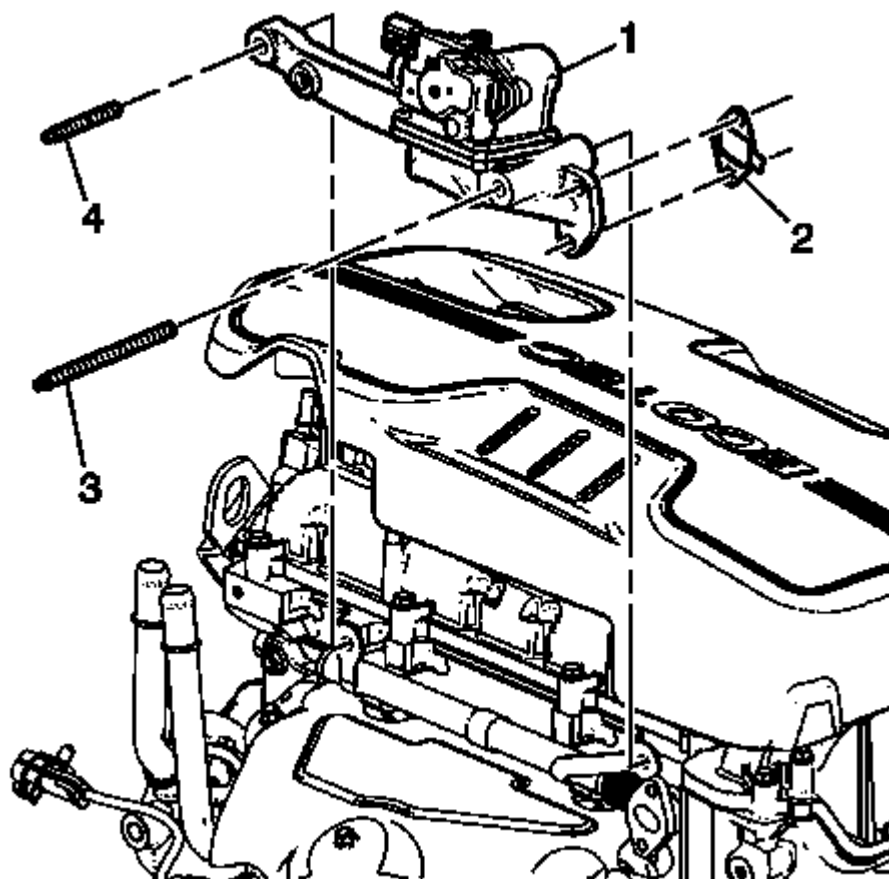
9. Install the exhaust manifold heat shield (1).
10. Install the exhaust manifold heat shield bolts and tighten to 9 N.m (80 lb in).



**Fig. 559: Oxygen Sensor**

Courtesy of GENERAL MOTORS COMPANY

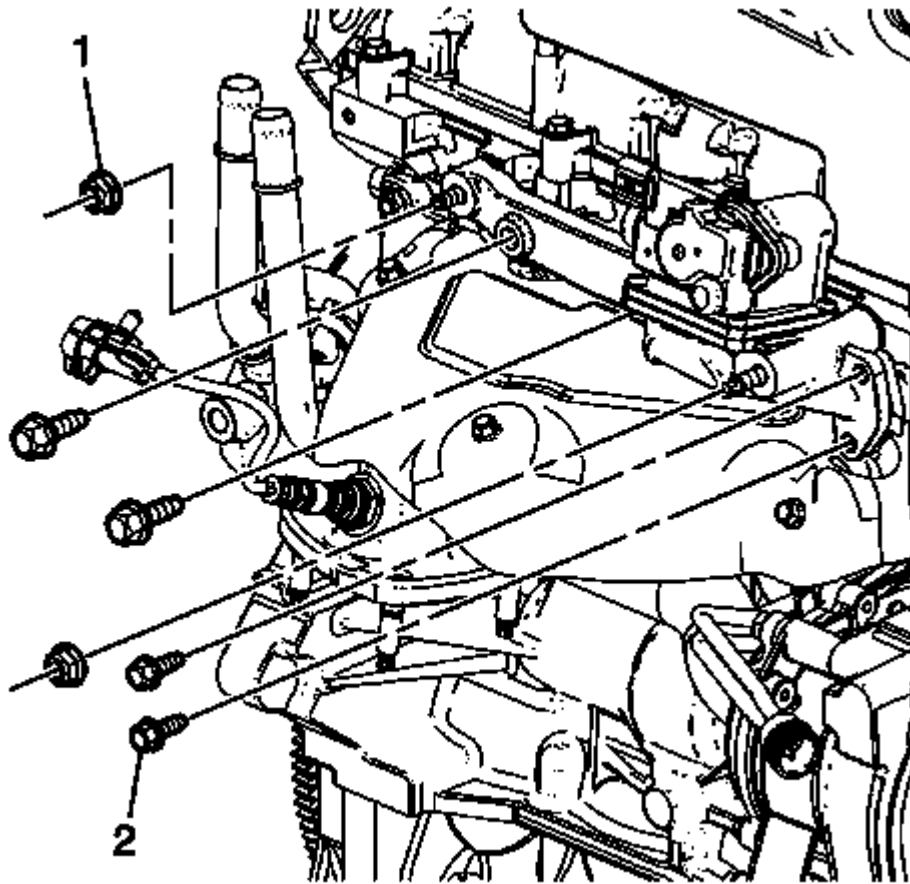
11. Coat the threads of the oxygen sensor (1) with anti-seize. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
12. Install the oxygen sensor and tighten to 42 N.m (31 lb ft).



**Fig. 560: Secondary Air Injection Studs**

Courtesy of GENERAL MOTORS COMPANY

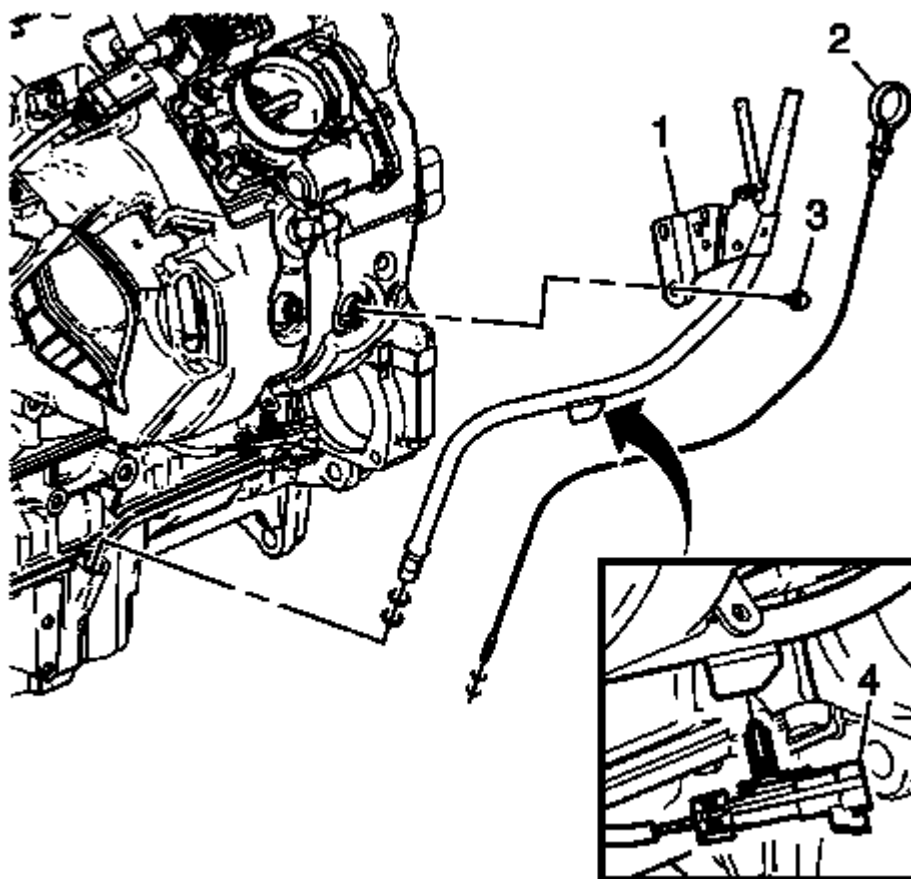
13. Install the secondary air injection studs (3 and 4) and tighten to 10 N.m(89 lb in).
14. Install the secondary air injection valve assembly (1) with a NEW gasket (2).



**Fig. 561: Secondary Air Injection Bolts And Nuts**  
Courtesy of GENERAL MOTORS COMPANY

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

#### OIL LEVEL INDICATOR AND TUBE INSTALLATION (LEA)



**Fig. 562: Oil Level Indicator Tube Components**  
Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION:** Refer to Fastener Caution .

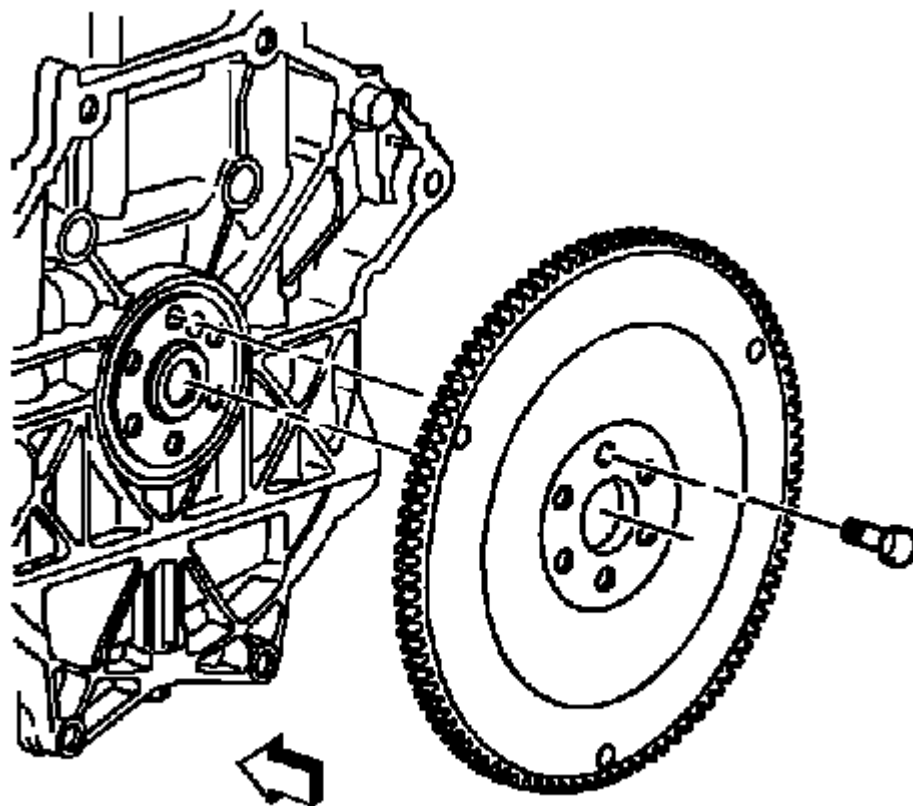
3. Install the oil level indicator tube bracket bolt (3) to the intake manifold and tighten to 10 N.m (89 lb in).
4. Install the electrical wiring harness to the oil level indicator tube.
5. Install the knock sensor wiring clip (4) into the oil level indicator tube.

## ENGINE FLYWHEEL INSTALLATION

### Special Tools

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

For equivalent regional tools, refer to Special Tools.



**Fig. 563: View Of Flywheel**

Courtesy of GENERAL MOTORS COMPANY

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

**CAUTION:** Refer to Fastener Caution .

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

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

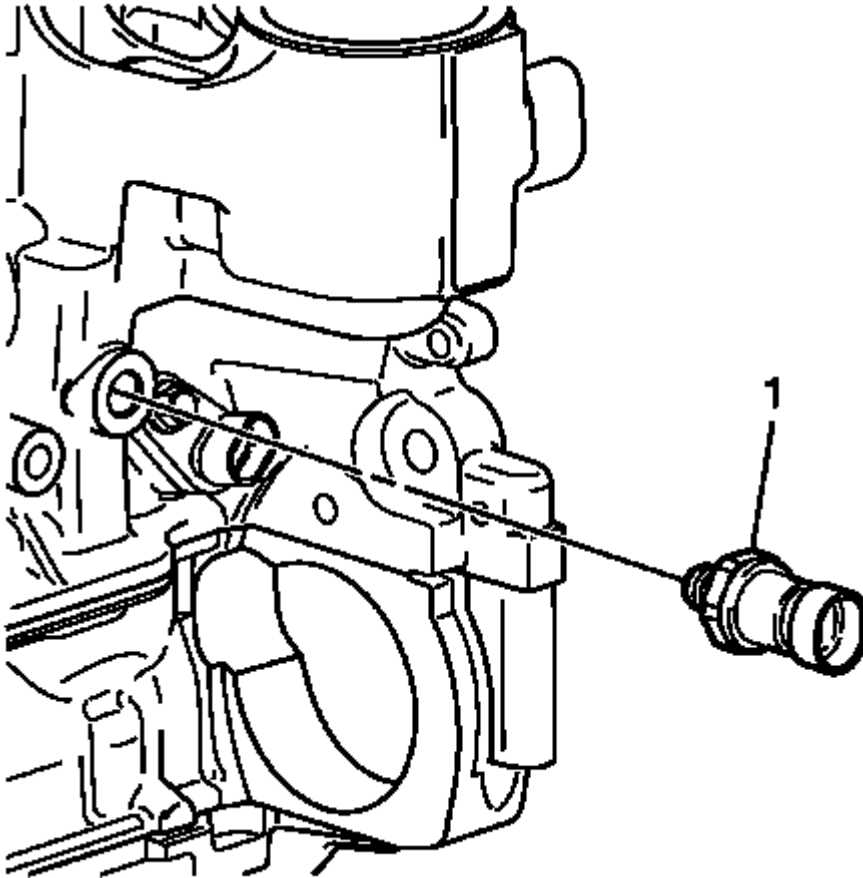
## ENGINE PRELUBING

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

## Special Tools

### EN-45299 Engine Preluber

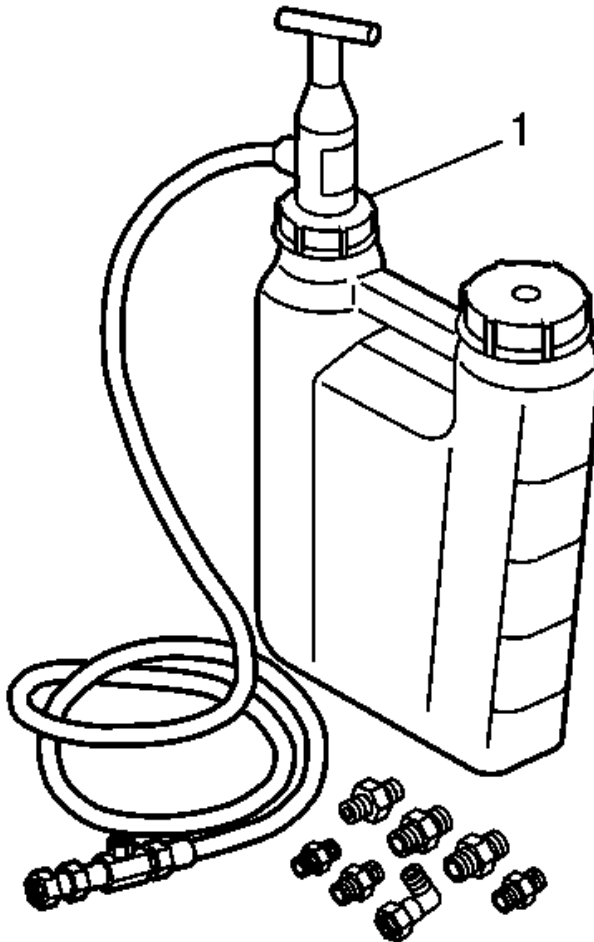
For equivalent regional tools, refer to Special Tools.



**Fig. 564: Identifying the M12 x 1.75 Adapter**  
Courtesy of GENERAL MOTORS COMPANY

**NOTE:** A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

1. Remove the oil pressure switch.
2. Install the M12 x 1.75 adapter (1) P/N 509376.



**Fig. 565: View of Flexible Hose, Adapter and Preluber**  
Courtesy of GENERAL MOTORS COMPANY

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **EN-45299** preluber (1) in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
5. Close the valve and remove the flexible hose and adapter from the engine.

**CAUTION: Refer to Fastener Caution .**

6. Install the oil pressure switch to the engine and tighten to 22 N.m (16 lb ft).
7. Top-off the engine oil to the proper level.

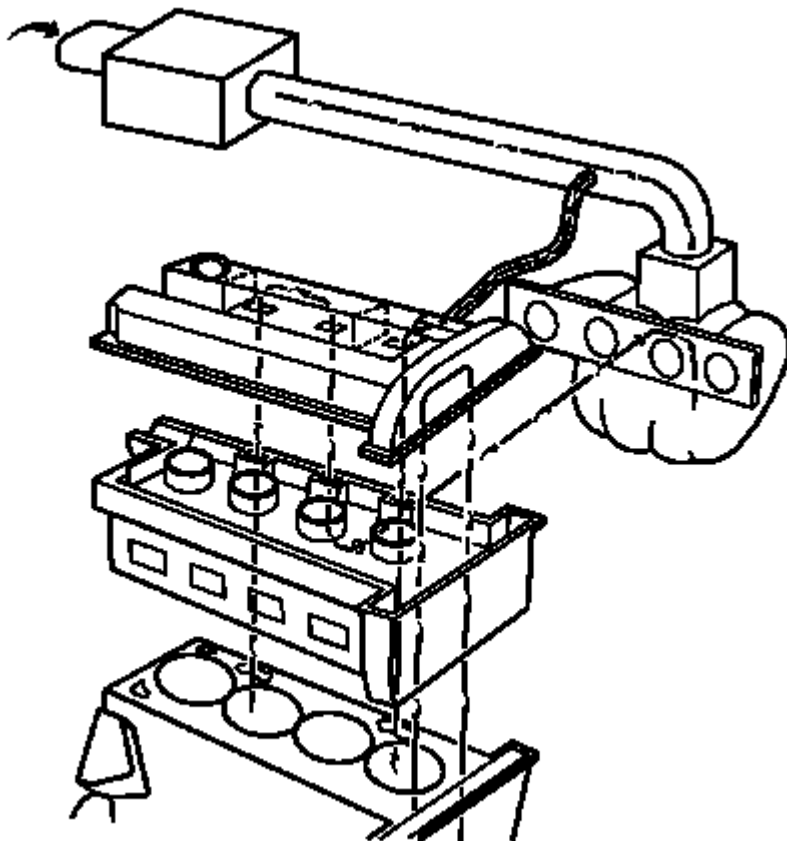
## DESCRIPTION AND OPERATION

### CRANKCASE VENTILATION SYSTEM DESCRIPTION

## General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

## Operation



**Fig. 566: Identifying Crankcase Ventilation System**

Courtesy of GENERAL MOTORS COMPANY

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the camshaft cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

## Results of Incorrect Operation

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed

- Oil leaks
- Sludge in engine

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

## **ENGINE COMPONENT DESCRIPTION (LEA)**

### **Engine Description**

#### **Cylinder Block**

The cylinder block is constructed of aluminum alloy by precision sand-casting with 4 cast-in-place iron cylinder liners arranged in-line. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the front of the engine. The cylinder block incorporates a bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

#### **Crankshaft**

The crankshaft is cast nodular iron with 8 counterweights. The number 8 counterweight is also the ignition system reluctor wheel. The main bearing journals are cross-drilled, and the upper bearings are grooved. The crankshaft has a slip fit balance shaft drive sprocket. Number 2 main bearing is the thrust bearing. The crankshaft balancer is used to control torsional vibration.

#### **Connecting Rod and Piston**

The connecting rods are powdered metal. The connecting rod incorporates the floating piston pin. The pistons are cast aluminum. The piston rings are of a low tension type to reduce friction. The top compression ring is ductile iron with a molybdenum facing and phosphate coated sides. The second compression ring is gray iron. The oil ring is a 3-piece spring construction with chromium plating.

#### **Oil Pan**

The oil pan is die cast aluminum. The oil pan includes an attachment to the transmission to provide additional structural support.

#### **Balance Shaft Assembly**

There are 2 block mounted balance shafts located on each side of the crankcase at the bottom of the cylinder bores. The balance shafts are driven by a single roller chain that also drives the water pump. The chain is tensioned by a hydraulic tensioner that is supplied pressure by the engine oil pump. This design promotes the maximum effectiveness of the balance shaft system and reduces noise and vibration.

## **Cylinder Head**

The cylinder head is a semi-permanent mold. Pressed-in powdered metal valve guides and valve seat insets are used. The fuel injection nozzle is located in the intake port. The cylinder head incorporates camshaft journals and camshaft caps.

## **Valves**

There are 2 intake and 2 exhaust valves per cylinder. Rotators are used on all of the intake valves. The rotators are located at the bottom of the valve spring to reduce valve train reciprocating mass. Positive valve stem seals are used on all valves.

## **Camshaft**

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron.

## **Valve Lash Adjusters**

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

## **Camshaft Cover**

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

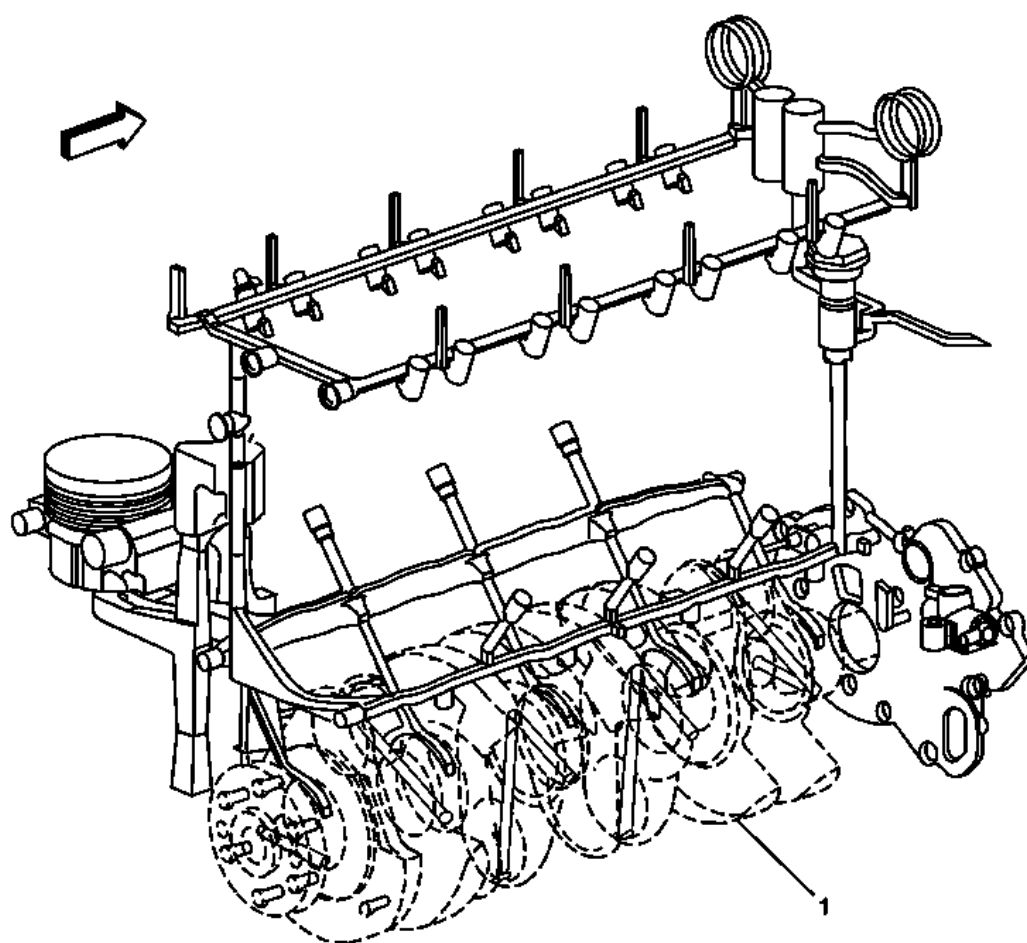
## **Camshaft Drive**

A roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

## **Intake and Exhaust Manifold**

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

## **LUBRICATION DESCRIPTION**

**Fig. 567: Lubrication System**

Courtesy of GENERAL MOTORS COMPANY

Oil is applied under pressure to the crankshaft (1), connecting rods, balance shaft assembly, camshaft bearing surfaces, valve lash adjusters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the gerotor type oil pump through a fixed inlet screen. The oil pump is driven by the crankshaft. The oil pump body is within the engine front cover. The pressurized oil from the pump passes through the oil filter. The oil filter is located on the right (front) side of the engine block. The oil filter is housed in a casting that is integrated with the engine block. The oil filter is a disposable cartridge type. A by-pass valve in the filter cap allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

## CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

## SEPARATING PARTS

### NOTE:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **Many internal engine components will develop specific wear patterns on their friction surfaces.**
- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lash adjusters
- Valve lash adjusters, lash adjuster guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

## REPLACING ENGINE GASKETS

**Special Tools****EN-28410** Gasket Remover

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

**Gasket Reuse and Applying Sealants**

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

**Separating Components**

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

**Cleaning Gasket Surfaces**

- Remove all gasket and sealing material from the part using the **EN-28410** remover or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
  - This grit is abrasive and has been known to cause internal engine damage.

**Assembling Components**

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

**USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT**

Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil

leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

#### Room Temperature Vulcanizing (RTV) Sealer

- RTV sealant hardens when exposed to air. This type sealer is used where 2 rigid parts, such as the lower crankcase and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet, within 3 minutes. Do not wait for RTV to skin over.
- Tighten bolts to specifications. Do not overtighten.

#### Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.
- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.
- Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when tightened.

**NOTE:**      **Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.**

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

#### Pipe Joint Compound

- Pipe joint compound is a pliable sealer that does not completely harden.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include:

exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.

- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when the bolt is tightened.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

## TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

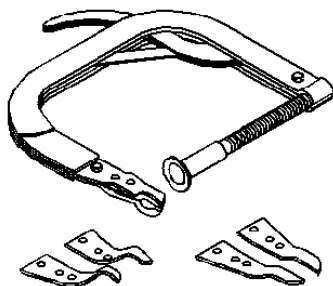
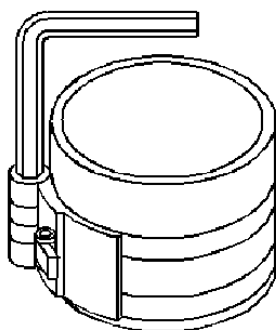
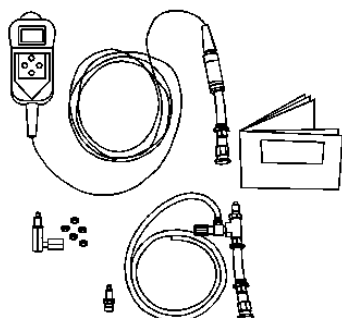
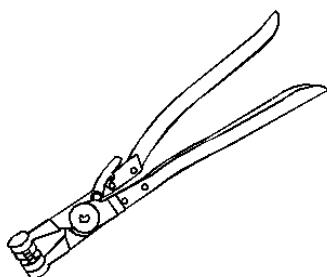
## SPECIAL TOOLS AND EQUIPMENT

### SPECIAL TOOLS

| Illustration | Tool Number/Description                                                        |
|--------------|--------------------------------------------------------------------------------|
|              | BO-38185<br>J-38185<br>Hose Clamp Pliers<br>South America Use Local Equivalent |

## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano



CH-48027  
Digital Pressure Gauge  
South America Use Local Equivalent

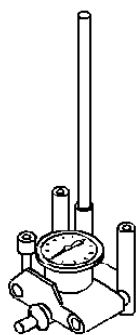
EN-8037  
J-8037  
Ring Compressor  
South America Use Local Equivalent

EN-8062  
J 8062  
KM-348  
09916-14510  
7-0006798  
Valve Spring Compressor- Head Off

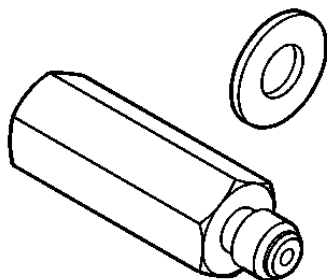
EN-8087  
J 8087  
Cylinder Bore Gauge

## 2012 Buick Verano

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South America Use Local Equivalent



EN-21867-850

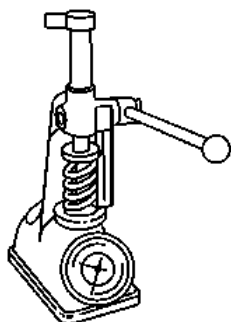
J-21867-850

KM-498-B

KM-6106

7-0006833

Oil Pressure Gauge Adapter



EN 22738-B

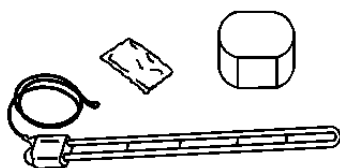
GE 22738-B

J 22738-B

J 9666

Valve Spring Tester

South America Use Local Equivalent



EN 23951

J 23951

Valve Manometer

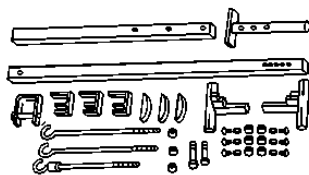
South America Use Local Equivalent

EN 28410  
J 28410  
Gasket Remover

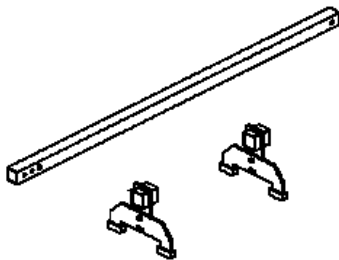
## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

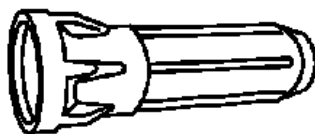
South America Use Local Equivalent



EN 28467-B  
J 28467-B  
X-0206951  
L-0906004  
Universal Engine Support Fixture



EN 28467-500B  
J 28467-500B  
Engine Support Fixture

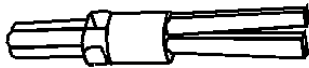


EN 35268-A  
J 35268-A  
Camshaft/Front Main Seal Installer

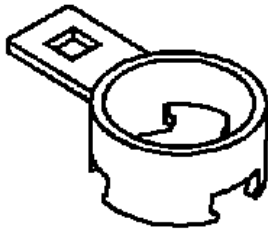
EN 35667-A  
J 35667-A  
Cylinder Head Leakdown Tester  
South America Use Local Equivalent

## 2012 Buick Verano

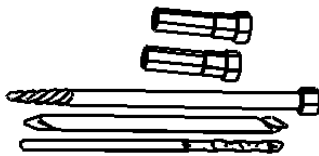
2012 ENGINE Engine Mechanical - 2.4L - Verano



EN-36017  
J 36017  
KM-840- Removal  
KM-6152- Installation  
V-0506032  
Valve Seal Remover



EN-38122-A  
J 38122-A  
KM-J-38122-A  
KM-956-1  
Crankshaft Balancer Holder



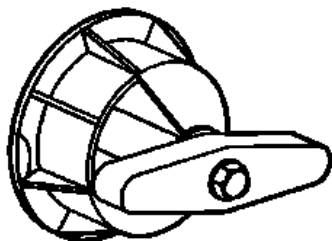
EN-38188  
J 38188  
Cylinder Head Broken Bolt Extractor Kit  
South America Use Local Equivalent

EN-42067  
J 42067  
KM-J-42067

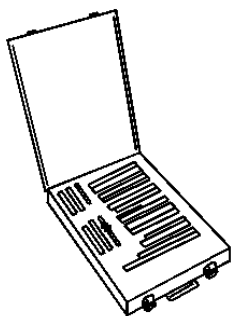
## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

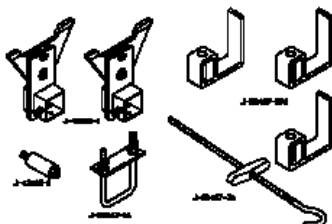
Rear Main Seal Installer



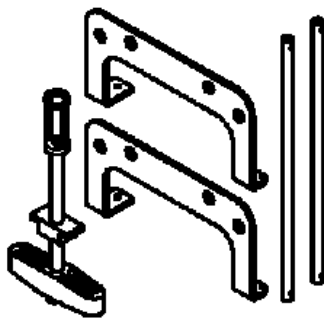
EN-42385-850  
J 42385-850  
Thread Repair Kit  
South America Use Local Equivalent



EN 43405  
J 43405  
Engine Support Fixture Adapter



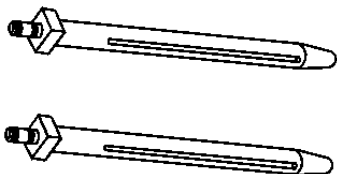
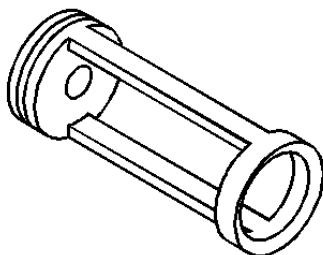
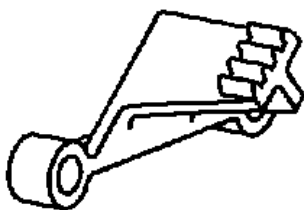
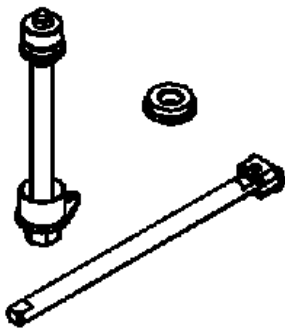
EN-43649  
J 43649  
Valve Spring Compressor  
South America Use Local Equivalent



EN-43650  
J 43650  
Balance Shaft Bearing Remover and Installer

## 2012 Buick Verano

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EN 43653  
J 43653  
KM-652  
Flywheel Holding Tool  
South America Use Local Equivalent

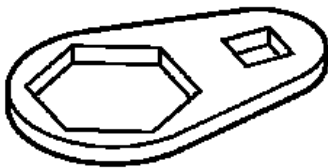
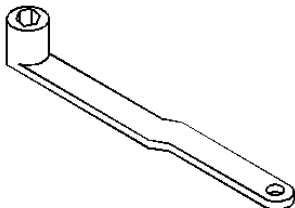
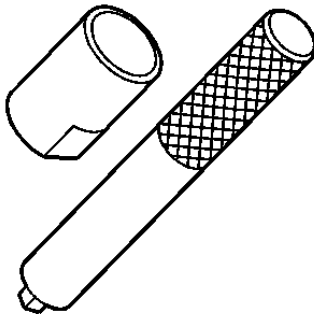
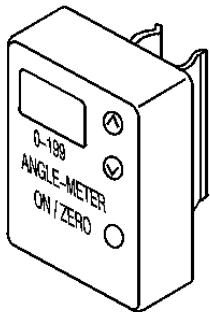
EN-43963  
J 43963  
KM-6149  
V-0306983  
Valve Spring Compressor (off car)

EN-43966  
J 43966  
V-0506030  
Connecting Rod Guides

EN-44887  
J 44887  
KM-6150

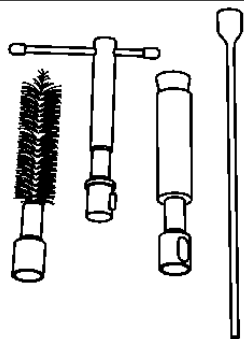
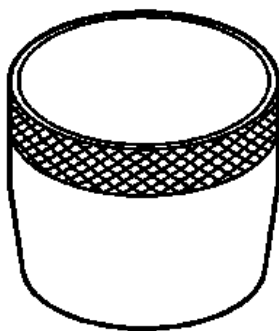
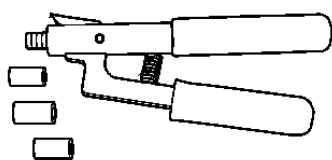
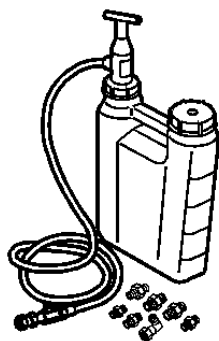
## 2012 Buick Verano

2012 ENGINE Engine Mechanical - 2.4L - Verano

|                                                                                     |                                                                                      |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|    | Oil Filter Wrench                                                                    |
|    | EN 45025<br>J 45025<br>Belt Tensioner Wrench                                         |
|   | EN-45027<br>J 45027<br>Tensioner Tool<br>South America Use Local Equivalent          |
|  | EN-45059<br>J 45059<br>KM-470-B<br>Angle Meter<br>South America Use Local Equivalent |
|                                                                                     | EN-45299<br>J 45299<br>Engine Pre-Luber<br>South America Use Local Equivalent        |

## 2012 Buick Verano

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EN 46745

J 43654

Piston Pin Clip Remover/Installer  
South America Use Local Equivalent

EN 47836

Piston Ring Compressor  
South America Use Local Equivalent

EN-47909

Injector Bore and Sleeve Cleaning Kit

EN 48366

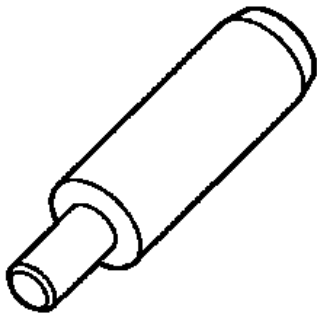
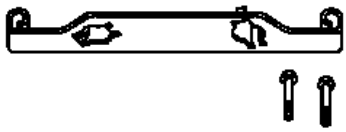
EN 48368

EN 48953

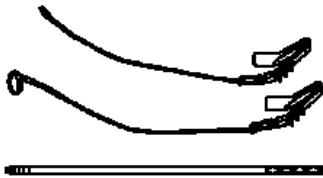
Camshaft Actuator Locking Tool  
South America Use Local Equivalent

## 2012 Buick Verano

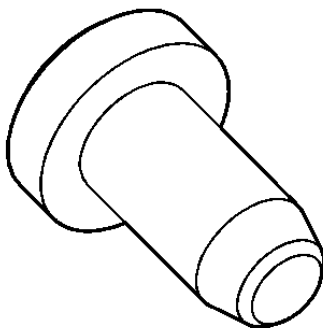
2012 ENGINE Engine Mechanical - 2.4L - Verano



EN 48585  
Crankshaft Balancer Guide  
South America Use Local Equivalent



EN 48749  
J 44217  
Timing Chain Retention Tool Kit  
South America Use Local Equivalent

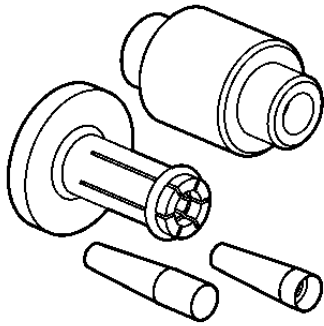


EN 48896  
HP Fuel Pump Installation Alignment Gauge

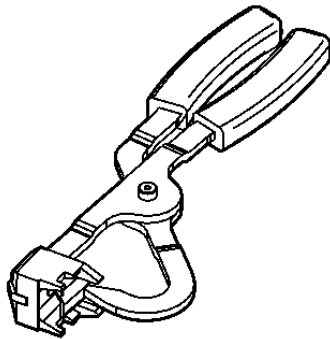
EN 49245  
EN-48266 and EN-49245-1  
Fuel Injector Seal Installer/Sizer

## 2012 Buick Verano

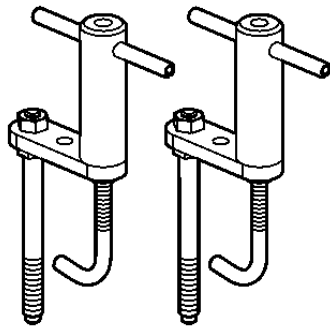
2012 ENGINE Engine Mechanical - 2.4L - Verano



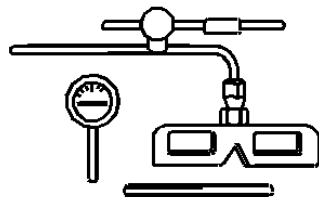
EN 49247  
Injector Retaining Clip Installer



EN 49248  
Fuel Rail Assembly Remover



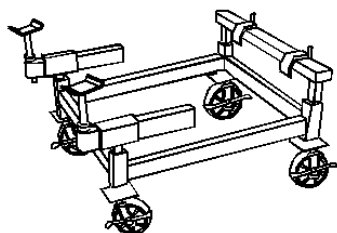
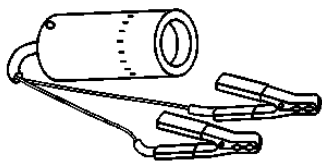
GE-7872  
J 7872  
Magnetic Base Dial Indicator Set  
South America Use Local Equivalent



GE-42220  
J 28428-E  
J 42220  
Universal 12V Leak Detection Lamp  
South America Use Local Equivalent

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J-39580  
J-9703386  
J-9703392  
L-0806003  
L-0906001  
L-0906002  
L-0906003  
L-0906004  
Engine Support Table