

**2009 Pontiac G8**

2009 ENGINE Engine Mechanical - 3.6L - G8

**2009 ENGINE****Engine Mechanical - 3.6L - G8****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS**

| Application                                                | Specification    |           |
|------------------------------------------------------------|------------------|-----------|
|                                                            | Metric           | English   |
| A/C                                                        |                  |           |
| • Compressor Bolt - Front                                  | 22 N.m           | 17 lb ft  |
| • Compressor Bolt - Rear                                   | 22 N.m           | 17 lb ft  |
| • Compressor Bracket Bolt - Front                          | 58 N.m           | 43 lb ft  |
| • Compressor Hose Assembly Bolt                            | 9 N.m            | 80 lb in  |
| Alternator                                                 |                  |           |
| • Nut                                                      | 58 N.m           | 43 lb ft  |
| • Bracket Bolt - Side-M10                                  | 58 N.m           | 43 lb ft  |
| • Bracket Bolt - Front-M10                                 | 58 N.m           | 43 lb ft  |
| • Bracket Bolt - Side-M8                                   | 22 N.m           | 16 lb ft  |
| • Cable Nut                                                | 13 N.m           | 115 lb in |
| Camshaft Position Actuator                                 |                  |           |
| • Camshaft Bolt                                            | 58 N.m           | 43 lb ft  |
| • Oil Control Valve Bolt                                   | 10 N.m           | 89 lb in  |
| Camshaft Cap Bolt                                          | 10 N.m           | 89 lb in  |
| Camshaft Cover Bolt                                        | 10 N.m           | 89 lb in  |
| Camshaft Intermediate Drive Sprocket Bolt - Idler Sprocket | 58 N.m           | 43 lb ft  |
| Camshaft Position Sensor Bolt                              | 10 N.m           | 89 lb in  |
| Catalytic Converter                                        |                  |           |
| • Exhaust Manifold Nut                                     | 50 N.m           | 37 lb ft  |
| Close Out Cover Bolt                                       | 10 N.m           | 89 lb in  |
| Connecting Rod Bolt                                        |                  |           |
| • First Pass                                               | 30 N.m           | 22 lb ft  |
| • Second Pass - Counter Clockwise                          | Back Off to Zero |           |
| • Third Pass                                               | 25 N.m           | 18 lb ft  |
| • Final Pass                                               | 110 Degrees      |           |
| Coolant Outlet Bolt                                        | 10 N.m           | 89 lb in  |
| Crankshaft Balancer Bolt                                   |                  |           |

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|                                            |                               |          |
|--------------------------------------------|-------------------------------|----------|
| • First Pass                               | 100 N.m                       | 74 lb ft |
| • Final Pass                               | 150 Degrees                   |          |
| Crankshaft Main Bearing Bolt               |                               |          |
| Inner                                      |                               |          |
| • First Pass                               | 20 N.m                        | 15 lb ft |
| • Final Pass                               | 80 degrees                    |          |
| Outer                                      |                               |          |
| • First Pass                               | 15 N.m                        | 10 lb ft |
| • Final Pass                               | 110 Degrees                   |          |
| Side                                       |                               |          |
| • First Pass                               | 30 N.m                        | 22 lb ft |
| • Final Pass                               | 60 Degrees                    |          |
| Crankshaft Position Sensor Bolt            | 10 N.m                        | 89 lb in |
| Crankshaft Rear Oil Seal Housing Bolt      | 10 N.m                        | 89 lb in |
| Cylinder Head Bolt - M8                    |                               |          |
| • First Pass                               | 15 N.m                        | 10 lb ft |
| • Final Pass                               | 60 Degrees                    |          |
| Cylinder Head Bolt - M11                   |                               |          |
| • First Pass                               | 45 N.m                        | 33 lb ft |
| • Second Pass                              | Counter Clockwise 120 degrees |          |
| • Third Pass                               | 30 N.m                        | 22 lb ft |
| • Final Pass                               | 150 degrees                   |          |
| Cylinder Head Core Hole Plug               | 45 N.m                        | 33 lb ft |
| Drive Belt                                 |                               |          |
| • Idler Pulley Bolt                        | 58 N.m                        | 43 lb ft |
| • Tensioner Bolt                           | 22 N.m                        | 16 lb ft |
| ECM                                        |                               |          |
| • Bolt                                     | 10 N.m                        | 89 lb in |
| • Bracket Bolt - Front                     | 23 N.m                        | 17 lb ft |
| • Bracket Bolt - Side                      | 10 N.m                        | 89 lb in |
| • Grounding Bolt                           | 4.5 N.m                       | 40 lb in |
| ECT Sensor                                 | 25 N.m                        | 16 lb ft |
| Pressure Plate to Flywheel Retaining Bolts |                               |          |
| First Pass                                 | 15 N.m                        | 11 lb ft |
| Second Pass                                | 30 N.m                        | 22 lb ft |
| Third Pass                                 | 90° Degrees                   |          |
|                                            |                               |          |

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**Engine Front Cover Bolt**

|              |            |          |
|--------------|------------|----------|
| • First Pass | 20 N.m     | 15 lb ft |
| • Final Pass | 60 Degrees |          |

|                           |        |          |
|---------------------------|--------|----------|
| Engine Cover Bracket Bolt | 35 N.m | 26 lb ft |
|---------------------------|--------|----------|

**Engine Mount**

|                                      |        |          |
|--------------------------------------|--------|----------|
| • Bracket Bolt to Engine Block - M8  | 38 N.m | 28 lb ft |
| • Bracket Bolt to Engine Block - M10 | 50 N.m | 37 lb ft |
| • Nut to Engine Mount Bracket        | 80 N.m | 59 lb ft |
| • Nut to Frame                       | 80 N.m | 59 lb ft |

|                                              |        |          |
|----------------------------------------------|--------|----------|
| Evaporative Emission (EVAP) Purge Valve Bolt | 10 N.m | 89 lb in |
|----------------------------------------------|--------|----------|

**Engine Wiring Harness Bracket**

|                                          |        |          |
|------------------------------------------|--------|----------|
| • Bolt - Cylinder Head Rear              | 40 N.m | 30 lb ft |
| • Bolt - ECM Bracket Side                | 23 N.m | 17 lb ft |
| • Bolt - ECM Bracket Top                 | 10 N.m | 89 lb in |
| • Bolt - Oil Filter Adapter- M8          | 24 N.m | 18 lb ft |
| • Bolt - Oil Filter Adapter- M10         | 58 N.m | 43 lb ft |
| • Bolt - Oil Pan- M6                     | 10 N.m | 89 lb in |
| • Bolt - Oil Pan- M8                     | 22 N.m | 16 lb ft |
| • Bolt - Near Crankshaft Position Sensor | 10 N.m | 89 lb in |
| • Bolt - Right Side Block Front          | 23 N.m | 17 lb ft |
| • Bolt - Right Side Head Front           | 10 N.m | 89 lb in |

**Engine Wiring Harness Ground**

|                                   |        |          |
|-----------------------------------|--------|----------|
| • Bolt - ECM Bracket Top          | 10 N.m | 89 lb in |
| • Bolt - Left Cylinder Head Side  | 10 N.m | 89 lb in |
| • Bolt - Right Cylinder Head Rear | 10 N.m | 89 lb in |

**Exhaust Manifold**

|                    |        |          |
|--------------------|--------|----------|
| • Bolt             | 20 N.m | 15 lb ft |
| • Heat Shield Bolt | 10 N.m | 89 lb in |

|                |        |          |
|----------------|--------|----------|
| Fuel Rail Bolt | 10 N.m | 89 lb in |
|----------------|--------|----------|

|                   |        |          |
|-------------------|--------|----------|
| Ground Cable Bolt | 50 N.m | 37 lb ft |
|-------------------|--------|----------|

|                                        |        |          |
|----------------------------------------|--------|----------|
| Heater Inlet/Outlet Pipe Assembly Bolt | 10 N.m | 89 lb in |
|----------------------------------------|--------|----------|

|                    |        |          |
|--------------------|--------|----------|
| Ignition Coil Bolt | 10 N.m | 89 lb in |
|--------------------|--------|----------|

**Intake Manifold**

|                                             |        |          |
|---------------------------------------------|--------|----------|
| • Brace Bolt - Engine Front Cover M12       | 65 N.m | 48 lb ft |
| • Brace Bolt/Ball Stud - Intake Manifold M6 | 10 N.m | 89 lb in |

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|                                                                  |        |           |
|------------------------------------------------------------------|--------|-----------|
| • Engine Cover Ball Stud                                         | 9 N.m  | 80 lb in  |
| • Tuning Valve Bolt                                              | 10 N.m | 89 lb in  |
| • Upper-to-Cylinder Head Bolt - Long                             | 23 N.m | 17 lb ft  |
| • Upper-to-Cylinder Head Bolt - Short                            | 23 N.m | 17 lb ft  |
| • Upper-to-Lower Intake Manifold Bolt                            | 23 N.m | 17 lb ft  |
| Knock Sensor Bolt                                                | 23 N.m | 17 lb ft  |
| Oil Drain Plug                                                   | 25 N.m | 18 lb ft  |
| Oil Filter Cap                                                   | 25 N.m | 18 lb ft  |
| Oil Filter Adapter                                               |        |           |
| • Oil Filter Adapter to Cylinder Head Retaining Bolt - M10       | 65 N.m | 48 lb ft  |
| • Oil Filter Adapter to Cylinder Block Retaining Bolts - M8      | 23 N.m | 17 lb ft  |
| Oil Gallery Plug                                                 | 31 N.m | 23 lb ft  |
| Oil Level Indicator Tube Bracket to Cylinder Head Retaining Bolt | 10 N.m | 89 lb in  |
| Oil Level Sensor Bolt                                            | 10 N.m | 89 lb in  |
| Oil Pan                                                          |        |           |
| • Bolt - Block M8                                                | 23 N.m | 17 lb ft  |
| • Bolt - Crankshaft Rear Oil Seal Housing M6                     | 10 N.m | 89 lb in  |
| • oil pan baffle to oil pan retaining bolts                      | 10 N.m | 89 lb in  |
| • oil pan scraper to oil pan retaining bolts                     | 10 N.m | 89 lb in  |
| Oil Pressure Sender                                              | 20 N.m | 15 lb ft  |
| Oil Pump                                                         |        |           |
| • Bolt                                                           | 25 N.m | 18 lb ft  |
| • Cover Bolt                                                     | 13 N.m | 115 lb in |
| Oxygen Sensor                                                    |        |           |
| • Pump Converter Pipe                                            | 40 N.m | 30 lb ft  |
| PCV Tube Bracket Bolt                                            | 10 N.m | 89 lb in  |
| Piston Oil Cooling Nozzle Bolt                                   | 10 N.m | 89 lb in  |
| Power Steering Pump                                              |        |           |
| • Bracket to Engine Bolt                                         | 58 N.m | 43 lb ft  |
| • Pump to Bracket Bolt                                           | 22 N.m | 16 lb ft  |
| • Reservoir to Front Cover Bolt                                  | 9 N.m  | 80 lb in  |
| Primary Camshaft Drive Chain                                     |        |           |
| • Left Guide Bolt - Oil Pump                                     | 13 N.m | 115 lb in |
| • Tensioner Bolt                                                 | 23 N.m | 17 lb ft  |



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|                                        |         |           |
|----------------------------------------|---------|-----------|
| • Upper Guide Bolt                     | 23 N.m  | 17 lb ft  |
| Radiator Outlet Pipe                   |         |           |
| • Bolt - Alternator Bracket            | 23 N.m  | 17 lb ft  |
| • Bolt - Right Cylinder Head Rear      | 50 N.m  | 37 lb ft  |
| • Bolt - Thermostat Housing            | 10 N.m  | 89 lb in  |
| Secondary Camshaft Drive Chain         |         |           |
| • Guide Bolt                           | 23 N.m  | 17 lb ft  |
| • Shoe Bolt                            | 23 N.m  | 17 lb ft  |
| • Tensioner Bolt                       | 23 N.m  | 17 lb ft  |
| Spark Plug                             | 18 N.m  | 13 lb ft  |
| Starter Motor                          |         |           |
| • Bolt                                 | 50 N.m  | 37 lb ft  |
| • Cable Nut                            | 13 N.m  | 115 lb in |
| Suction Tube Bolt                      | 10 N.m  | 89 lb in  |
| Suction Screen Bolt                    | 10 N.m  | 89 lb in  |
| Thermostat Housing Bolt                | 10 N.m  | 89 lb in  |
| Throttle Body Bolt                     | 10 N.m  | 89 lb in  |
| Torque Converter Bolt                  | 60 N.m  | 44 lb ft  |
| Transmission                           |         |           |
| • Mount Bolt to Transmission - RPO M82 | 60 N.m  | 45 lb ft  |
| • Range Selector Lever Nut             | 9.5 N.m | 84 lb in  |
| • To Engine Bolt                       | 50 N.m  | 37 lb ft  |
| Water Pump                             |         |           |
| • Bolt                                 | 10 N.m  | 89 lb in  |
| • Pulley Bolt                          | 10 N.m  | 89 lb in  |

## ENGINE MECHANICAL SPECIFICATIONS

### LY7

| Application          | Specification  |                  |
|----------------------|----------------|------------------|
|                      | Metric         | English          |
| General              |                |                  |
| • Engine Type        | V-6            |                  |
| • Displacement       | 3564 cu cm     | 218 cu in        |
| • RPO                | LY7            |                  |
| • Engine Performance | 195 kW 340 N.m | 261 hp 250 lb ft |
| • Bore               | 94 mm          | 3.700 in         |

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|                                                                 |                          |                       |
|-----------------------------------------------------------------|--------------------------|-----------------------|
| • Stroke                                                        | 85.6 mm                  | 3.370 in              |
| • Compression Ratio                                             | 10.2:1                   |                       |
| • Cranking RPM - at 40° C (104°F)                               | 80 RPM                   |                       |
| • Idle Speed RPM                                                | 700 A/C Off - 700 A/C On |                       |
| • Firing Order                                                  | 1-2-3-4-5-6              |                       |
| • Spark Plug Gap                                                | 1.1 mm / 1.2 mm          | 0.0433 in / 0.0472 in |
| <b>Block</b>                                                    |                          |                       |
| • Crankshaft Main Bearing Bore Diameter                         | 72.867-72.881 mm         | 2.8688-2.8693 in      |
| • Cylinder Bore Diameter                                        | 94 mm                    | 3.7008 in             |
| • Cylinder Bore Out-of-Round - Production Max.                  | 0.013 mm                 | 0.0005 in             |
| <b>Camshaft</b>                                                 |                          |                       |
| • Camshaft Bearing Inside Diameter - Front Number 1             | 35.000-35.020 mm         | 1.3779-1.3787 in      |
| • Camshaft Bearing Inside Diameter - Middle and Rear Number 2-4 | 27.000-27.020 mm         | 1.0630-1.0638 in      |
| • Camshaft End Play                                             | 0.045-0.215 mm           | 0.0018-0.0085 in      |
| • Camshaft Journal Diameter - Front, 1                          | 34.936-34.960 mm         | 1.3754-1.3764 in      |
| • Camshaft Journal Diameter - Middle and Rear, 2-4              | 26.936-26.960 mm         | 1.0605-1.0614 in      |
| • Camshaft Journal Out-of-Round                                 | 0.006 mm                 | 0.0002 in             |
| • Camshaft Journal to Bore Clearance                            | 0.040-0.084 mm           | 0.0016-0.0033 in      |
| • Camshaft Lobe Duration - Exhaust @ 0.150 mm (0.0059 in) Lift  | 238 degrees              |                       |
| • Camshaft Lobe Duration - Intake @ 0.150 mm (0.0059 in) Lift   | 226 degrees              |                       |
| • Camshaft Lobe Lift - Exhaust                                  | 42.456-42.756 mm         | 1.6715-1.6833 in      |
| • Camshaft Lobe Lift - Intake                                   | 42.385-42.685 mm         | 1.6687-1.6805 in      |
| • Camshaft Lobe Overlap @ 0.150 mm (0.0059 in) Lift             | 0 degrees                |                       |
| • Camshaft Runout - Front and Rear, 1 and 4                     | 0.025 mm                 | 0.0010 in             |
| • Camshaft Runout - Middle 2 and 3                              | 0.050 mm                 | 0.0020 in             |
| • Camshaft Timing @ 0.15 mm (0.0059 in) Lift                    |                          |                       |
| • Valve Opens - Exhaust                                         | 229 degrees BTDC         |                       |
| • Valve Opens - Intake                                          | 14 degrees ATDC          |                       |
| • Centerline - Exhaust                                          | 111 degrees ATDC         |                       |
| • Centerline - Intake                                           | 132 degrees ATDC         |                       |
| • Valve Closes - Exhaust                                        | 9 degrees ATDC           |                       |

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|                                              |                         |                   |
|----------------------------------------------|-------------------------|-------------------|
| • Valve Closes - Intake                      | 252 degrees ATDC        |                   |
| • Valve Lift - Exhaust                       | 10.95 mm                | 0.431 in          |
| • Valve Lift - Intake                        | 10.95 mm                | 0.431 in          |
| Camshaft Phasing                             |                         |                   |
| Intake                                       | 0- -50° Crank (advance) |                   |
| Exhaust                                      | 0- +50° Crank (retard)  |                   |
| Cooling System                               |                         |                   |
| • Thermostat Start Opening Temperature       | 82°C +/- 2°C            | 179.6°F +/- 3.6°F |
| • Thermostat Full Open Temperature           | 95°C                    | 203°F             |
| Connecting Rod                               |                         |                   |
| • Connecting Rod Bearing Clearance           | 0.010-0.070 mm          | 0.0004-0.0028 in  |
| • Connecting Rod Bore Diameter - Bearing End | 59.620-59.636 mm        | 2.3472-2.3479 in  |
| • Connecting Rod Bore Diameter - Pin End     | 24.007-24.021 mm        | 0.9452-0.9457 in  |
| • Connecting Rod Length - Center to Center   | 150.4 mm                | 5.921 in          |
| • Connecting Rod Side Clearance              | 0.095-0.355 mm          | 0.0037-0.0140 in  |
| • Connecting Rod Width - Bearing End         |                         |                   |
| • Production                                 | 21.775 mm               | 0.8573 in         |
| • Service                                    | 21.770-21.780 mm        | 0.8571-0.8575 in  |
| • Connecting Rod Width - Pin End             |                         |                   |
| • Production                                 | 26.000 mm               | 1.0236 in         |
| • Service                                    | 25.950-26.050 mm        | 1.0217-1.0256 in  |
| Crankshaft                                   |                         |                   |
| • Connecting Rod Journal Diameter            | 55.992-56.008 mm        | 2.2044-2.2050 in  |
| • Connecting Rod Journal Out-of-Round        | 0.005 mm                | 0.0002 in         |
| • Connecting Rod Journal Taper               | 0.005 mm                | 0.0002 in         |
| • Connecting Rod Journal Width               |                         |                   |
| • Production                                 | 22.000 mm               | 0.8661 in         |
| • Service                                    | 21.920-22.080 mm        | 0.8630-0.8693 in  |
| • Crankshaft End Play                        | 0.100-0.330 mm          | 0.0039-0.0130 in  |
| • Crankshaft Main Bearing Clearance          | 0.010-0.060 mm          | 0.0004-0.0024 in  |
| • Crankshaft Main Journal Diameter           | 67.992-68.008 mm        | 2.676-2.677 in    |
| • Crankshaft Main Journal Out-of-Round       | 0.005 mm                | 0.0002 in         |
| • Crankshaft Main Journal Taper              | 0.005 mm                | 0.0002 in         |
| • Crankshaft Main Journal Thrust Wall        |                         |                   |
|                                              |                         |                   |

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|                                                  |                  |                  |
|--------------------------------------------------|------------------|------------------|
| • Runout                                         | 0.000-0.040 mm   | 0.0000-0.0016 in |
| • Square                                         | 0.000-0.010 mm   | 0.0000-0.0004 in |
| • Crankshaft Main Journal Width, #1, 2, 4        |                  |                  |
| • Production                                     | 24.000 mm        | 0.9449 in        |
| • Service                                        | 23.900-24.100 mm | 0.9409-0.9488 in |
| • Crankshaft Main Journal Width, #3              |                  |                  |
| • Production                                     | 24.400 mm        | 0.9606 in        |
| • Service                                        | 24.360-24.440 mm | 0.9591-0.9622 in |
| • Crankshaft Pilot Bearing Bore Diameter         | 20.965-20.995 mm | 0.8254-0.8266 in |
| • Crankshaft Rear Flange Runout                  | 0.025 mm         | 0.0010 in        |
| • Crankshaft Reluctor Ring Runout - Maximum      | 0.5 mm           | 0.0020 in        |
| • Crankshaft Runout                              | 0.030 mm         | 0.0012 in        |
| • Crankshaft Thrust Bearing Clearance            | 0.076-0.305 mm   | 0.0030-0.0120 in |
| • Crankshaft Thrust Surface - Height Diameter    | 95.000 mm        | 3.7401 in        |
| • Crankshaft Thrust Surface Runout               | 0.040 mm         | 0.0016 in        |
| Cylinder Head                                    |                  |                  |
| • Combustion Chamber Volume                      | 54.5 cc          | 3.325 cu in      |
| • Valve Guide Bore - Exhaust                     | 6.005-6.025 mm   | 0.2362-0.2370 in |
| • Valve Guide Bore - Intake                      | 6.005-6.025 mm   | 0.2362-0.2370 in |
| • Valve Guide Installed Height                   | 14.050-14.550 mm | 0.5531-0.5728 in |
| • Valve Lifter Bore Diameter                     | 12.008-12.030 mm | 0.4728-0.4736 in |
| Lubrication System                               |                  |                  |
| • Oil Capacity - Wet Fill With Oil Filter Change | 6.7 Liters       | 7.1 Quarts       |
| • Oil Pressure - Minimum @ Idle                  | 74 kPa           | 10 psi           |
| • Oil Pressure - Minimum @ 2,000 RPM             | 377 kPa          | 54 psi           |
| • Piston Cooling Jet Valve Opening Pressure      | 1.8-2.2 bar      | 26-32 psi        |
| Oil Pump                                         |                  |                  |
| • Gear Diameter - Outer                          | 87.095-87.175 mm | 3.4289-3.4321 in |
| • Gear Pocket - Depth                            | 15.565-15.600 mm | 0.6128-0.6142 in |
| • Gear Pocket - Diameter                         | 87.275-87.325 mm | 3.4360-3.4380 in |
| • Gear Thickness - Drive/Driven                  | 15.511-15.536 mm | 0.6107-0.6117 in |
| • Gear-to-Cover Clearance - Drive/Driven         | 0.030-0.085 mm   | 0.0012-0.0033 in |
| • Gear-to-Housing Clearance - Drive/Driven       | 0.100-0.230 mm   | 0.0039-0.0091 in |
| • Inner Gear Tip Clearance                       | 0.075-0.180 mm   | 0.0030-0.0071 in |

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|                                                      |                   |                  |
|------------------------------------------------------|-------------------|------------------|
| • Crankshaft Clearance to Housing                    | 0.040-0.130 mm    | 0.0016-0.0051 in |
| • Inner Gerotor Hub Diameter                         | 53.310-53.335 mm  | 2.0988-2.0998 in |
| • Housing Hub Diameter                               | 53.380-53.420 mm  | 2.1016-2.1031 in |
| • Inner Gerotor Hub Clearance to Housing             | 0.045-0.110 mm    | 0.0018-0.0043 in |
| • Piston Ring End Gap                                |                   |                  |
| • First Compression Ring                             | 0.150-0.300 mm    | 0.0059-0.0118 in |
| • Second Compression Ring                            | 0.280-0.480 mm    | 0.0110-0.0189 in |
| • Oil Control Ring                                   | 0.150-0.600 mm    | 0.0059-0.0236 in |
| • Piston Ring to Groove Clearance                    |                   |                  |
| • First Compression Ring                             | 0.030-0.065 mm    | 0.0012-0.0026 in |
| • Second Compression Ring                            | 0.015-0.060 mm    | 0.0006-0.0024 in |
| • Oil Control Ring                                   | 0.030-0.170 mm    | 0.0012-0.0669 in |
| • Piston Ring Thickness                              |                   |                  |
| • First Compression Ring                             | 1.175-1.190 mm    | 0.0463-0.0469 in |
| • Second Compression Ring                            | 1.470-1.495 mm    | 0.0579-0.0589 in |
| • Oil Control Ring                                   | 2.360-2.480 mm    | 0.0929-0.0976 in |
| Pistons and Pins                                     |                   |                  |
| • Piston Diameter                                    | 93.956-93.974 mm  | 3.5022-3.5029 in |
| • Piston Pin Bore Diameter                           | 24.005-24.009 mm  | 0.9452-0.9454 in |
| • Piston Ring Groove Width - First Compression Ring  | 1.220-1.240 mm    | 0.0480-0.0488 in |
| • Piston Ring Groove Width - Second Compression Ring | 1.510-1.530 mm    | 0.0595-0.0602 in |
| • Piston Ring Groove Width - Oil Control Ring        | 2.510-2.530 mm    | 0.0988-0.0996 in |
| • Piston to Bore Clearance                           | 0.026-0.052 mm    | 0.0008-0.0013 in |
| • Pin                                                |                   |                  |
| • Piston Pin Clearance to Connecting Rod Bore        | 0.007-0.024 mm    | 0.0003-0.0010 in |
| • Piston Pin Clearance to Piston Pin Bore            | 0.004-0.015 mm    | 0.0003-0.0006 in |
| • Piston Pin Diameter                                | 23.997-24.000 mm  | 0.9448-0.9449 in |
| • Piston Pin Length                                  | 60.6004-61.100 mm | 2.5685-2.5882 in |
| Valve System                                         |                   |                  |
| • Valve Face Angle                                   | 44.25 degrees     |                  |
| • Valve Face Runout                                  | 0.038 mm          | 0.0015 in        |
| • Valve Face Width - Exhaust                         | 2.750 mm          | 0.1083 in        |
| • Valve Face Width - Intake                          | 2.180 mm          | 0.0858 in        |

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|                                              |                  |                    |
|----------------------------------------------|------------------|--------------------|
| • Valve Head Diameter- Exhaust               | 30.470-30.730 mm | 1.199-1.209 in     |
| • Valve Head Diameter- Inlet                 | 36.830-37.090 mm | 1.45-1.46 mm       |
| • Valve Installed Height                     | 35.26-36.69 mm   | 1.3870-1.4445 in   |
| • Valve Length - Exhaust                     | 97.11 mm         | 3.8232 in          |
| • Valve Length - Intake                      | 101.23 mm        | 3.9854 in          |
| • Valve Seat Angle - Seating Surface         | 45 degrees       |                    |
| • Valve Seat Angle - Relief Surface          | 30 degrees       |                    |
| • Valve Seat Angle - Undercut Surface        | 60 degrees       |                    |
| • Valve Seat Runout - Maximum                | 0.080 mm         | 0.0031 in          |
| • Valve Seat Width - Exhaust Seating Surface | 1.400-1.800 mm   | 0.0551-0.0709 in   |
| • Valve Seat Width - Intake Seating Surface  | 1.000-1.400 mm   | 0.0394-0.0551 in   |
| • Valve Stem Diameter - Exhaust              | 5.955-5.975 mm   | 0.2344-0.2352 in   |
| • Valve Stem Diameter - Intake               | 5.955-5.975 mm   | 0.2344-0.2352 in   |
| • Valve Stem-to-Guide Clearance - Exhaust    | 0.040-0.08 mm    | 0.0014-0.0030 in   |
| • Valve Stem-to-Guide Clearance - Intake     | 0.030-0.070 mm   | 0.0010-0.0026 in   |
| • Valve Lifter Diameter                      | 11.986-12.000 mm | 0.4720-0.4724 in   |
| • Valve Lifter-to-Bore Clearance             | 0.037-0.041 mm   | 0.0015-0.0016 in   |
| • Rocker Arms                                |                  |                    |
| • Valve Rocker Arm Ratio                     | 1.68 to 1        |                    |
| • Valve Rocker Arm Roller Diameter           | 17.740-17.800 mm | 0.6987-0.7008 in   |
| • Valve Springs                              |                  |                    |
| • Valve Spring Coil Thickness                | 3.250 x 3.900 mm | 0.1280 x 0.1535 in |
| • Valve Spring Diameter - Inside Top         | 12.200-12.700 mm | 0.4760-0.4957 in   |
| • Valve Spring Diameter - Outside Top        | 18.00-18.450 mm  | 0.7087-0.7264 in   |
| • Valve Spring Diameter - Inside Bottom      | 17.950-20.500 mm | 0.7067-0.8071 in   |
| • Valve Spring Diameter - Outside Bottom     | 26.000 mm        | 1.0236 in          |
| • Valve Spring Free Length                   | 42.500-45.500 mm | 1.6555-1.7657 in   |
| • Valve Spring Installed Height - Closed     | 35.000 mm        | 1.3779 in          |
| • Valve Spring Installed Height - Open       | 24.000 mm        | 0.9449 in          |
| • Valve Spring Load - Closed                 | 247-273 N        | 56-61 lb           |
| • Valve Spring Load - Open                   | 598-662 N        | 134-149 lb         |
| • Valve Spring Total Number of Coils         | 7.1              |                    |

**ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS**

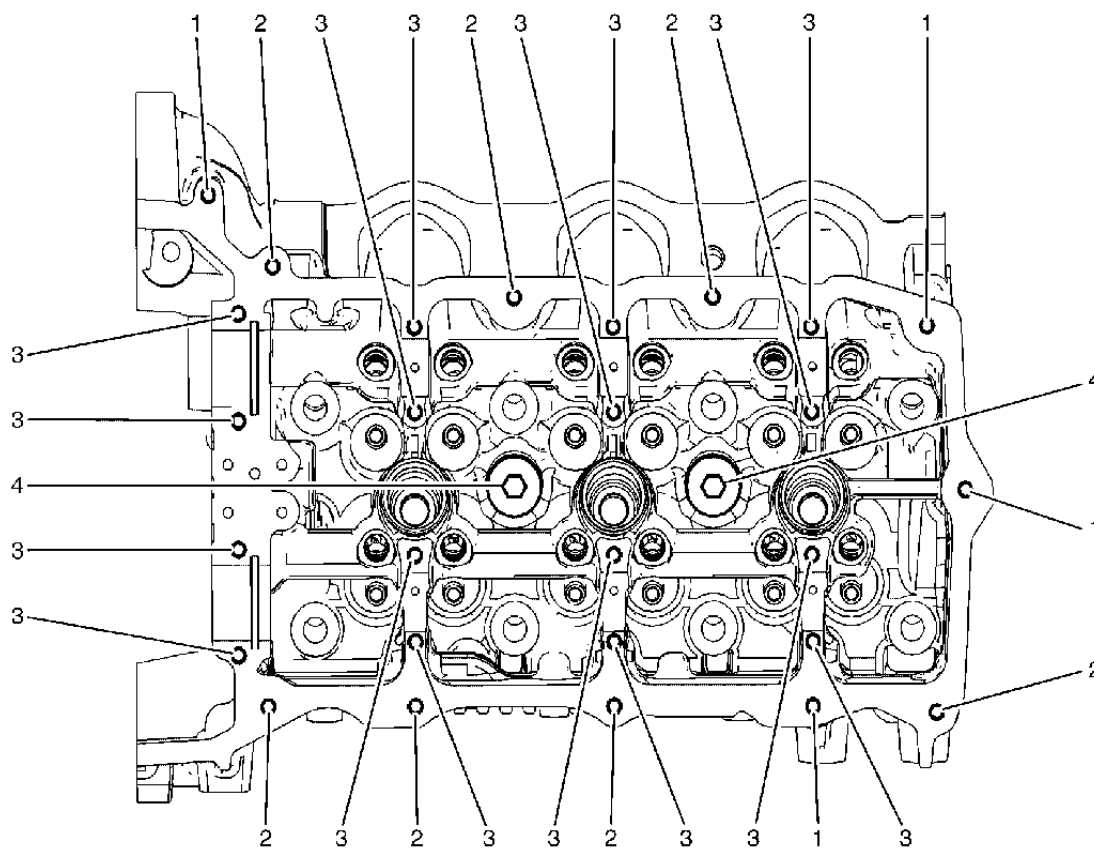
## 2009 Pontiac G8

2009 ENGINE Engine Mechanical - 3.6L - G8

| Application                                                                    | Type of Material                 |
|--------------------------------------------------------------------------------|----------------------------------|
| Coolant and Oil Plug Threads                                                   | LOCTITE 242™ or equivalent       |
| Oil Pan, Engine Front Cover, Crankshaft Rear Oil Seal Housing, Expansion Plugs | THREEBOND TB1207D™ or equivalent |

### THREAD REPAIR SPECIFICATIONS

#### Left Cylinder Head Camshaft Cover Face



**Fig. 1: Identifying Left Cylinder Head Camshaft Cover Face**  
Courtesy of GENERAL MOTORS CORP.

#### Left Cylinder Head Camshaft Cover Face

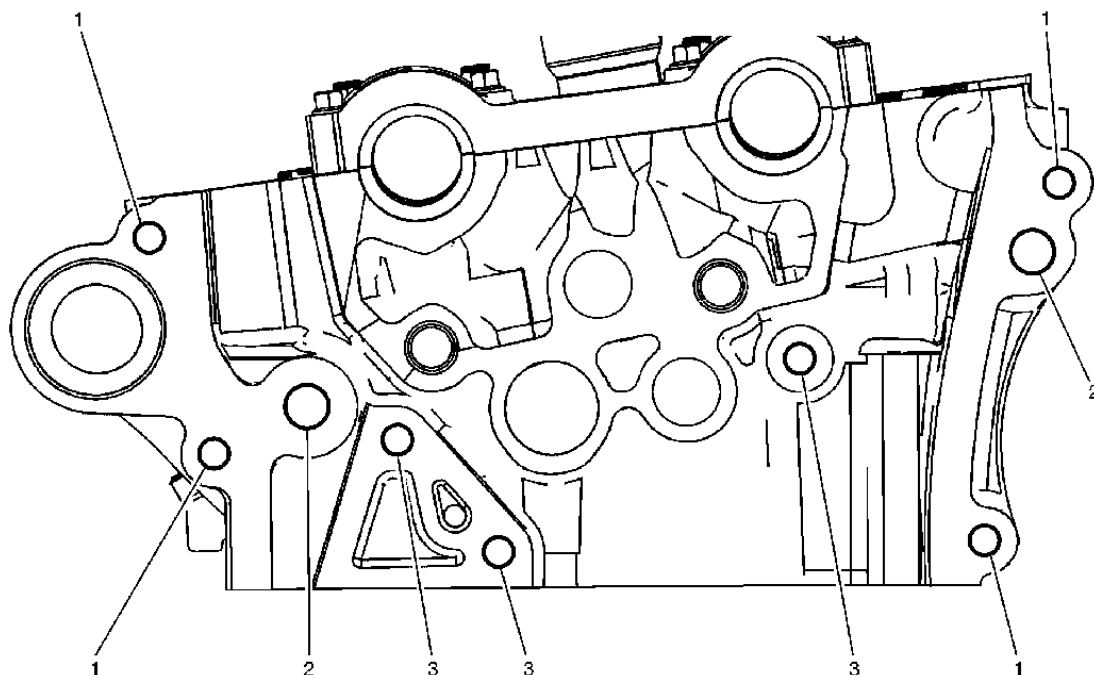
| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |
| 2             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  |        | THRU                |        |
| 3             | M6 x 1.0    | 701      | N/A               | N/A         | 203 | 204    | 205    | 28.5                  | 1.1220 | 24.0                | 0.9449 |
|               |             |          |                   |             |     |        |        |                       |        |                     |        |

## 2009 Pontiac G8

2009 ENGINE Engine Mechanical - 3.6L - G8

|   |           |     |     |     |     |     |     |      |        |      |        |
|---|-----------|-----|-----|-----|-----|-----|-----|------|--------|------|--------|
| 4 | M20 x 1.5 | 715 | 716 | N/A | 717 | 718 | 719 | 25.0 | 0.9842 | 17.0 | 0.6693 |
|---|-----------|-----|-----|-----|-----|-----|-----|------|--------|------|--------|

### Left Cylinder Head Front Face



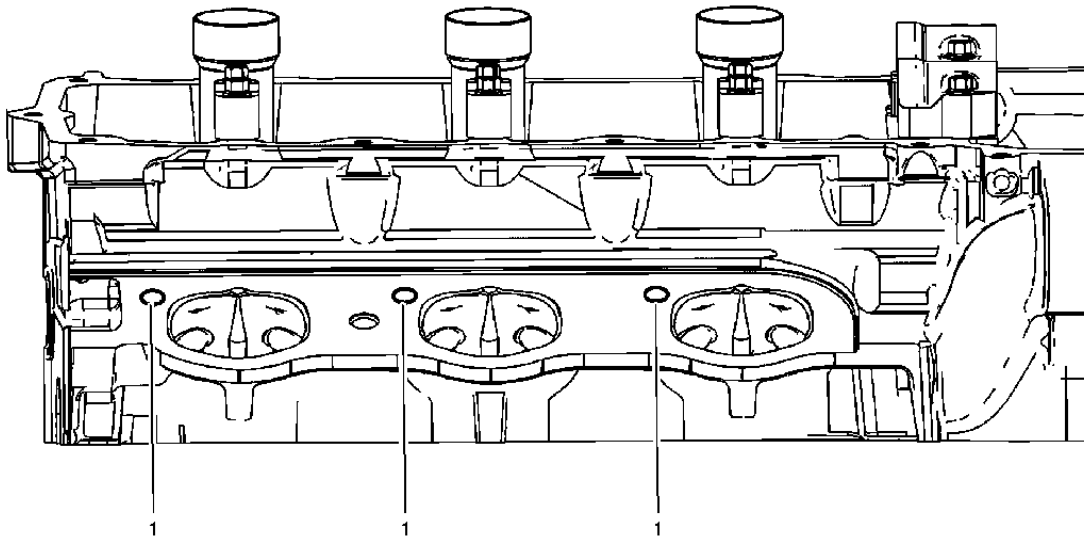
**Fig. 2: Identifying Left Cylinder Head Front Face**  
Courtesy of GENERAL MOTORS CORP.

### Left Cylinder Head Front Face

| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |       |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             |       |                   |             |     |        |        | J 42385-              |        |                     |        |
| 1             | M8 x 1.25   | 206   | 207               | N/A         | 208 | 209    | 210    | THRU                  |        | THRU                |        |
| 2             | M12 x 1.75  | 856   | 857               | N/A         | 858 | 859    | 416    | 40.0                  | 1.5748 | 32.5                | 1.2795 |
| 3             | M8 x 1.25   | 206   | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.122  | 23                  | 0.905  |

### Left Cylinder Head Intake Face



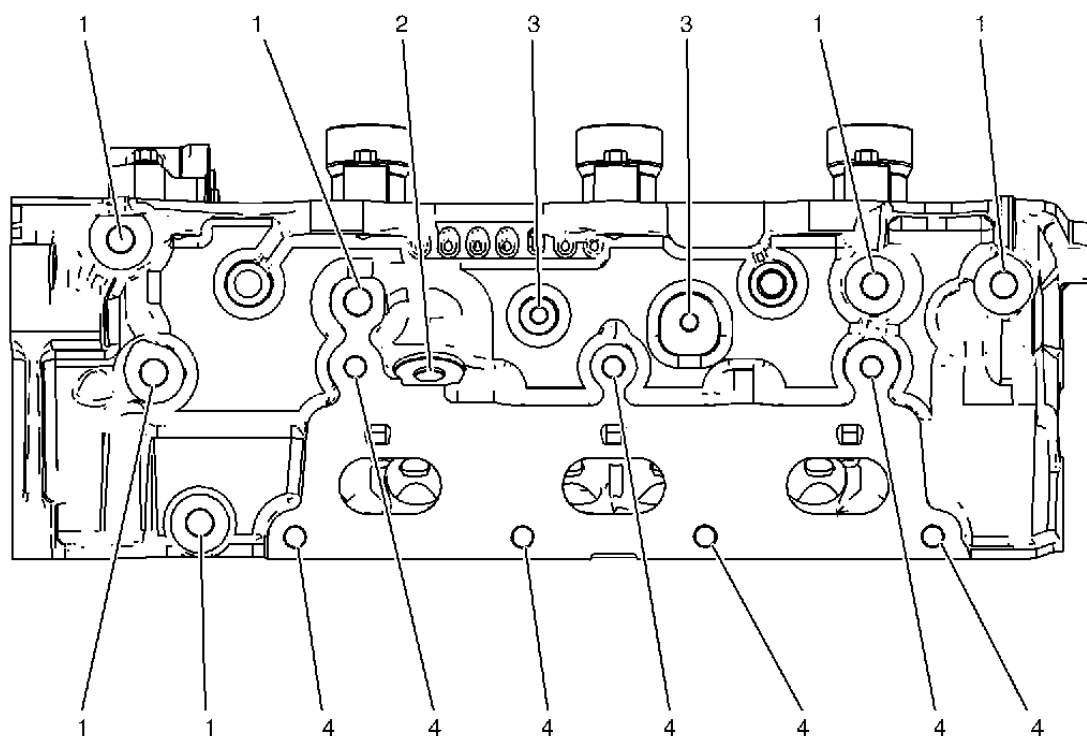


**Fig. 3: Identifying Left Cylinder Head Intake Face**  
Courtesy of GENERAL MOTORS CORP.

**Left Cylinder Head Intake Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

**Left Cylinder Head Exhaust Face**

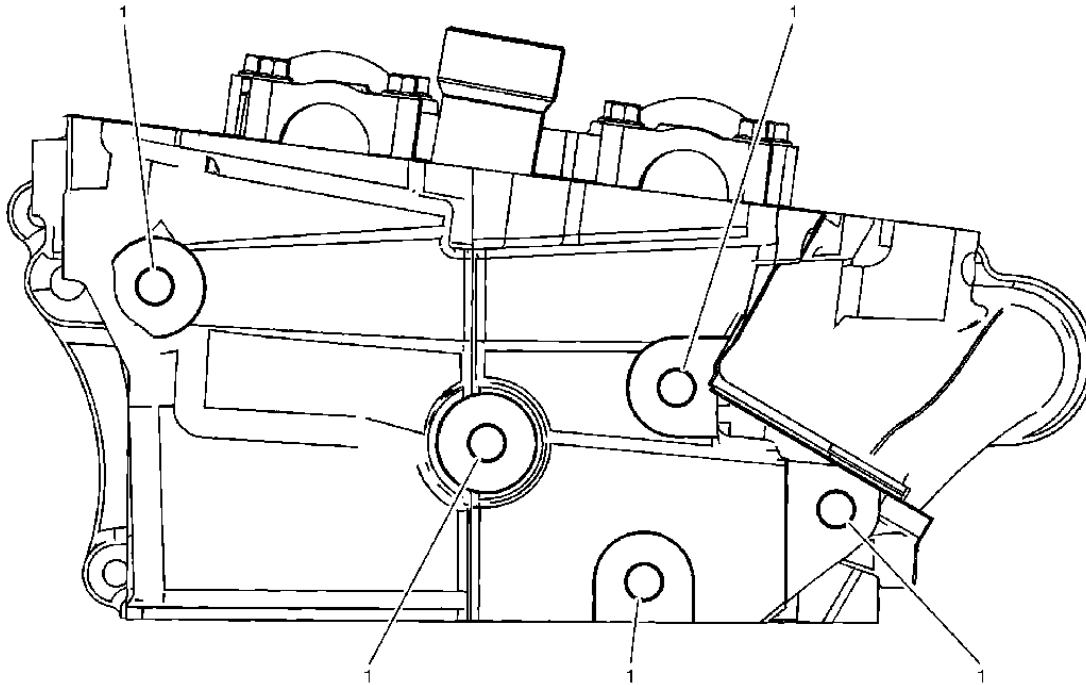


**Fig. 4: Identifying Left Cylinder Head Exhaust Face**  
Courtesy of GENERAL MOTORS CORP.

**Left Cylinder Head Exhaust Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3189 | 27.0                | 1.0630 |
| 2             | M12 x 1.5   | 705      | 706               | N/A         | 707 | 708    | 709    | 27.5                  | 1.0827 | 13.0                | 0.5118 |
| 3             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |
| 4             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

**Left Cylinder Head Rear Face**

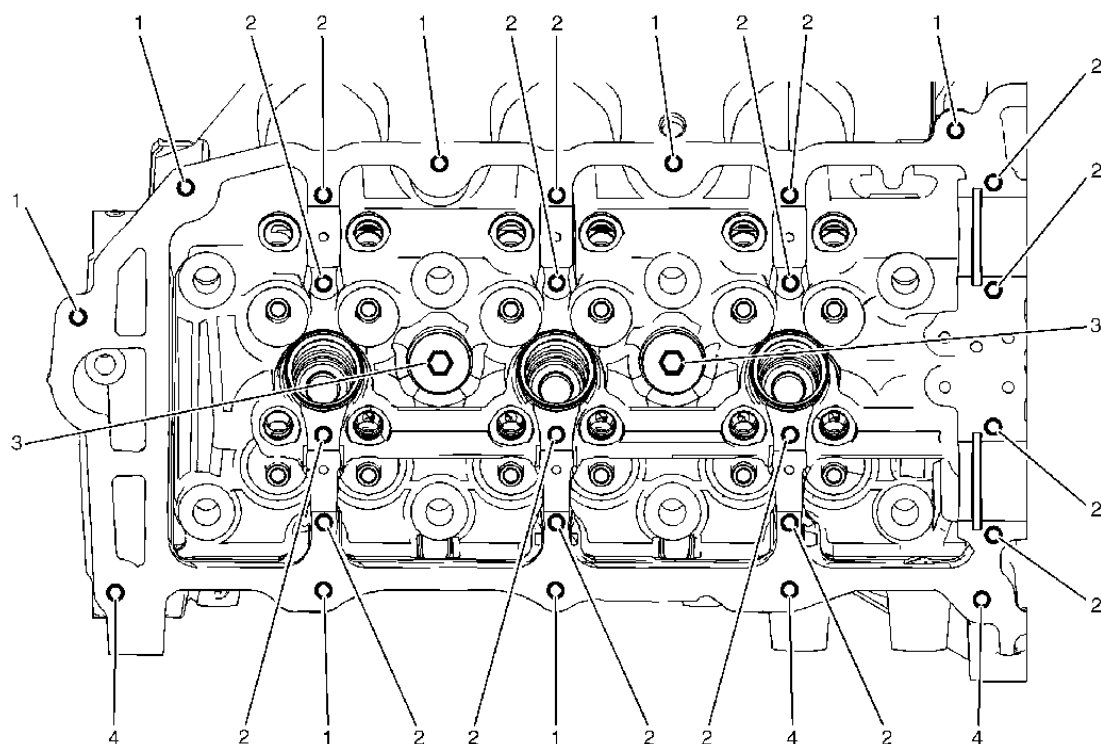


**Fig. 5: Identifying Left Cylinder Head Rear Face**  
Courtesy of GENERAL MOTORS CORP.

**Left Cylinder Head Rear Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3189 | 27.0                | 1.0630 |

**Right Cylinder Head Camshaft Cover Face**

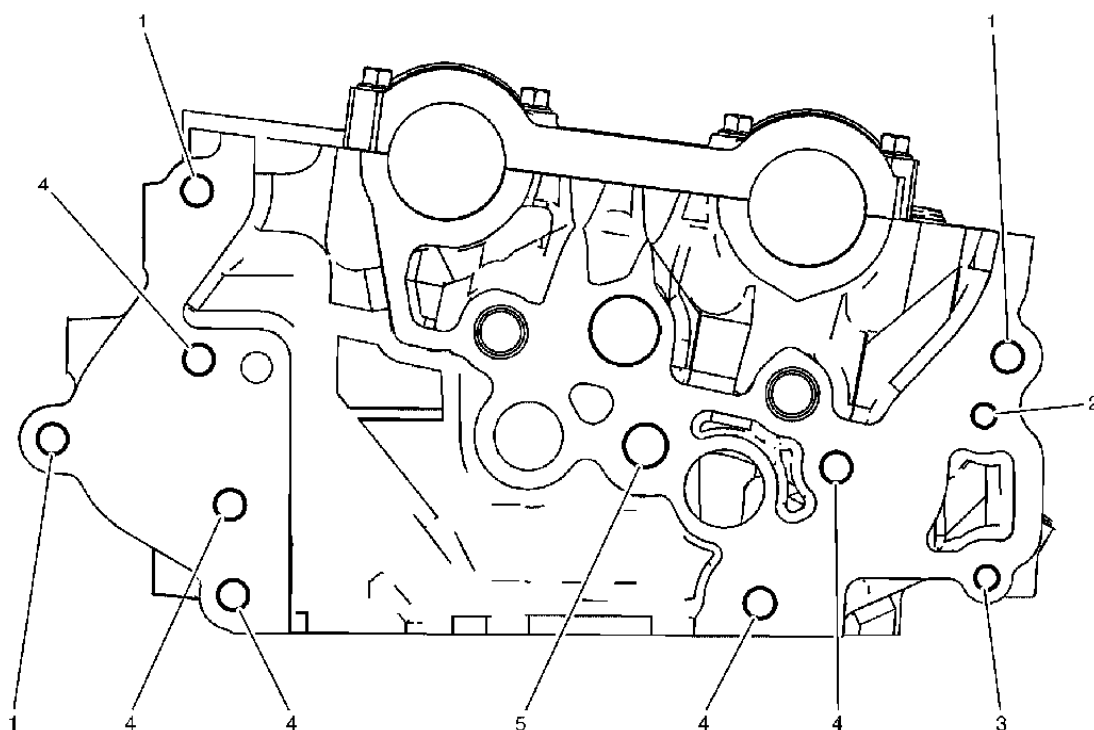


**Fig. 6: Identifying Right Cylinder Head Camshaft Cover Face**  
Courtesy of GENERAL MOTORS CORP.

**Right Cylinder Head Camshaft Cover Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  |        | THRU                |        |
| 2             | M6 x 1.0    | 701      | N/A               | N/A         | 203 | 204    | 205    | 28.5                  | 1.1220 | 24.0                | 0.9449 |
| 3             | M20 x 1.5   | 715      | 716               | N/A         | 717 | 718    | 719    | 25.0                  | 0.9842 | 17.0                | 0.6693 |
| 4             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |

**Right Cylinder Head Front Face**

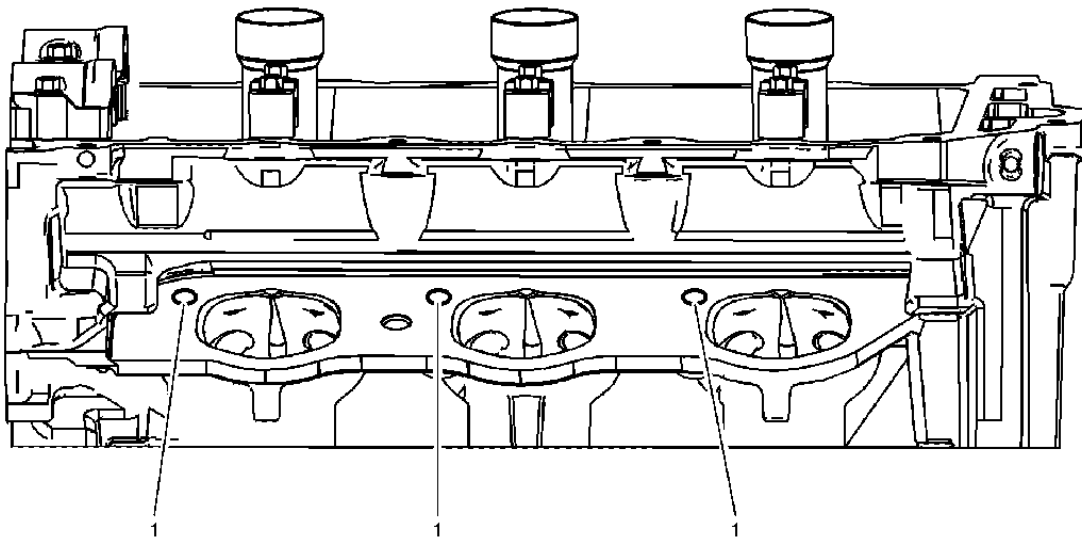


**Fig. 7: Identifying Right Cylinder Head Front Face**  
 Courtesy of GENERAL MOTORS CORP.

**Right Cylinder Head Front Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | THRU                  |        | THRU                |        |
| 2             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8880 | 18.0                | 0.7087 |
| 3             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  |        | THRU                |        |
| 4             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |
| 5             | M12 x 1.75  | 856      | 857               | N/A         | 858 | 859    | 416    | 40.0                  | 1.5748 | 32.5                | 1.2795 |

**Right Cylinder Head Intake Face**

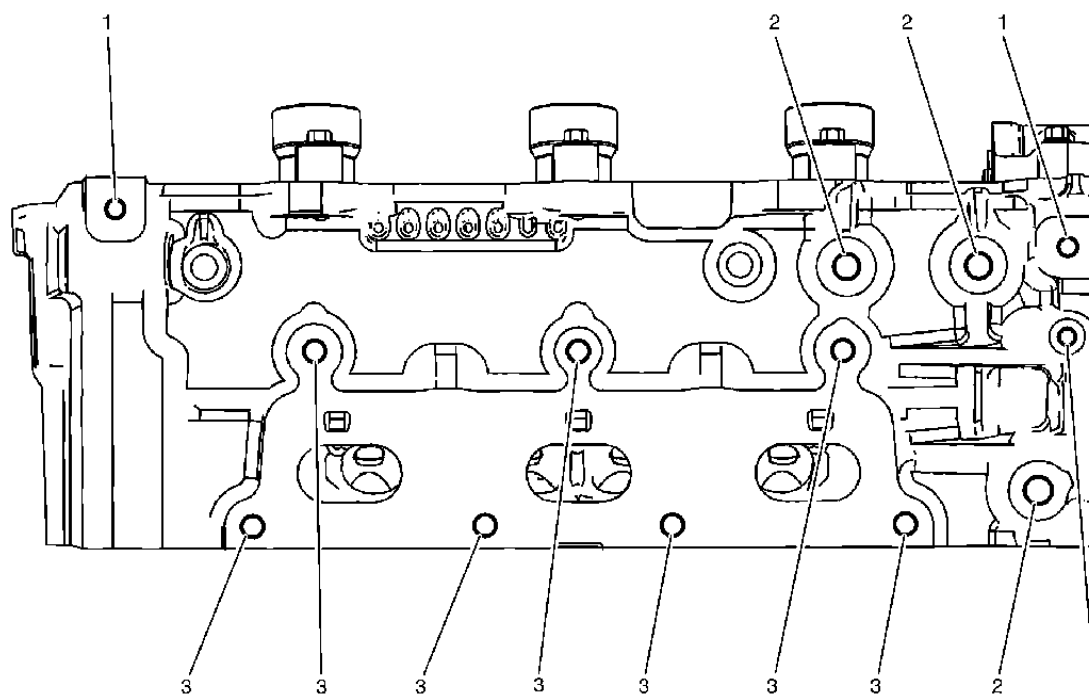


**Fig. 8: Identifying Right Cylinder Head Intake Face**  
Courtesy of GENERAL MOTORS CORP.

**Right Cylinder Head Intake Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

**Right Cylinder Head Exhaust Face**

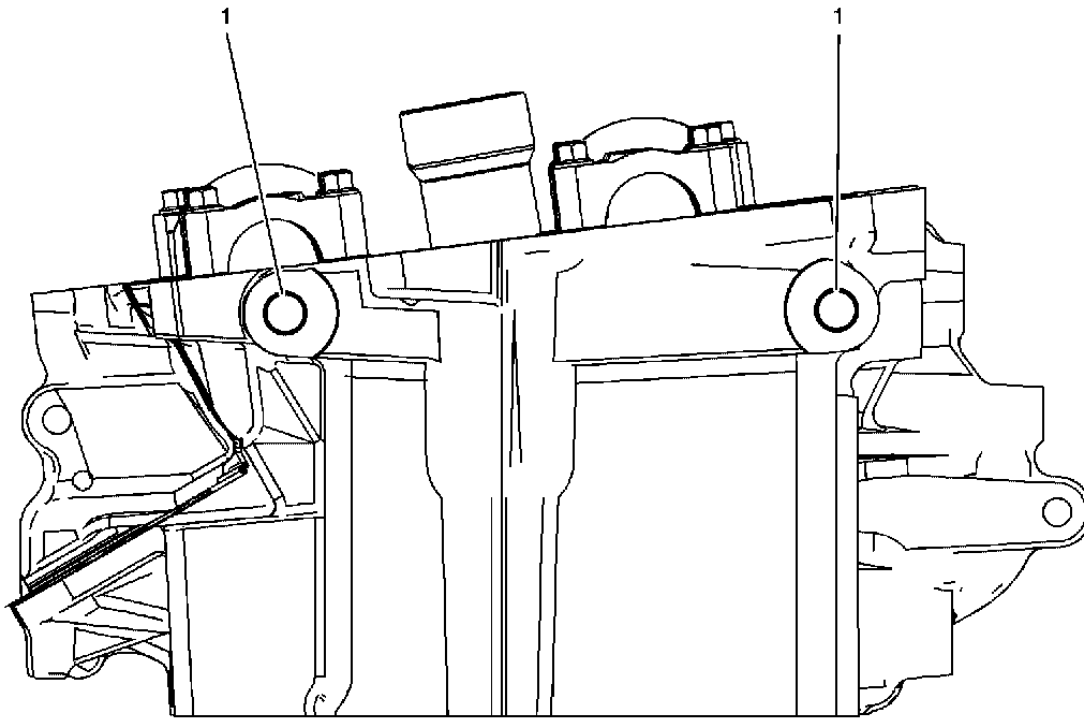


**Fig. 9: Identifying Right Cylinder Head Exhaust Face**  
Courtesy of GENERAL MOTORS CORP.

**Right Cylinder Head Exhaust Face**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |
| 2             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3189 | 27.0                | 1.0630 |
| 3             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

**Right Cylinder Head Rear Face**



**Fig. 10: Identifying Right Cylinder Head Rear Face**  
Courtesy of GENERAL MOTORS CORP.

**Right Cylinder Head Rear Face**

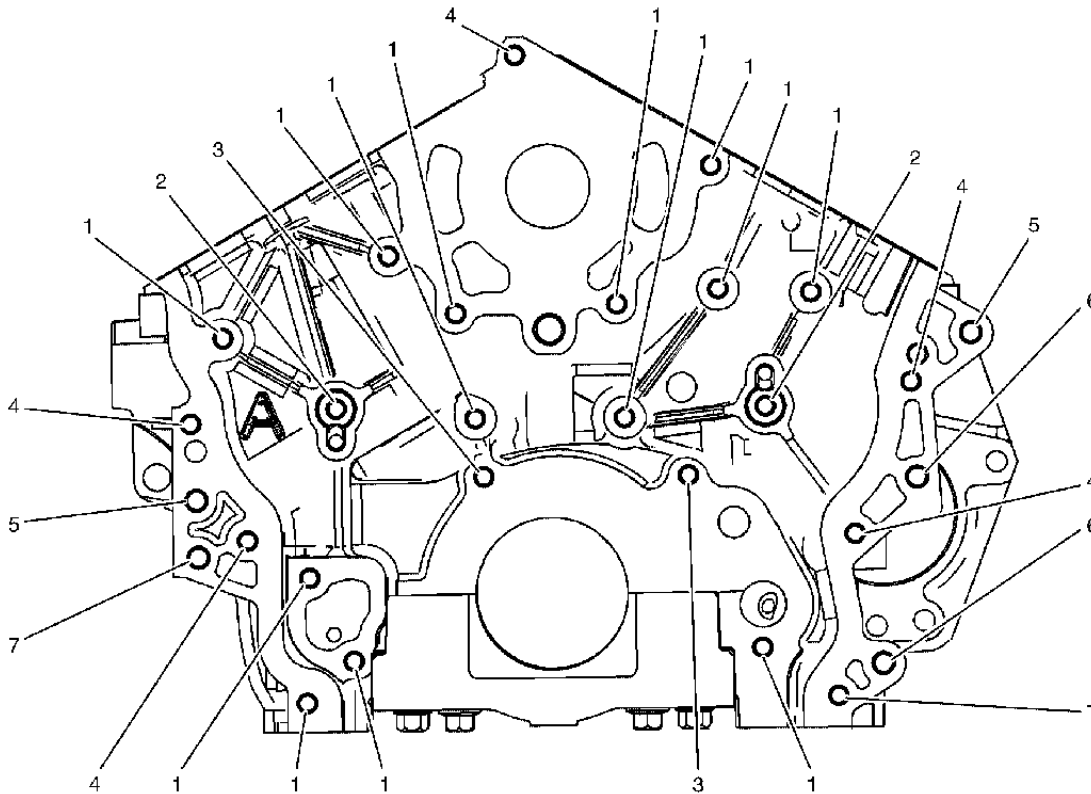
| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3189 | 27.0                | 1.0630 |

**Engine Block Front**



## 2009 Pontiac G8

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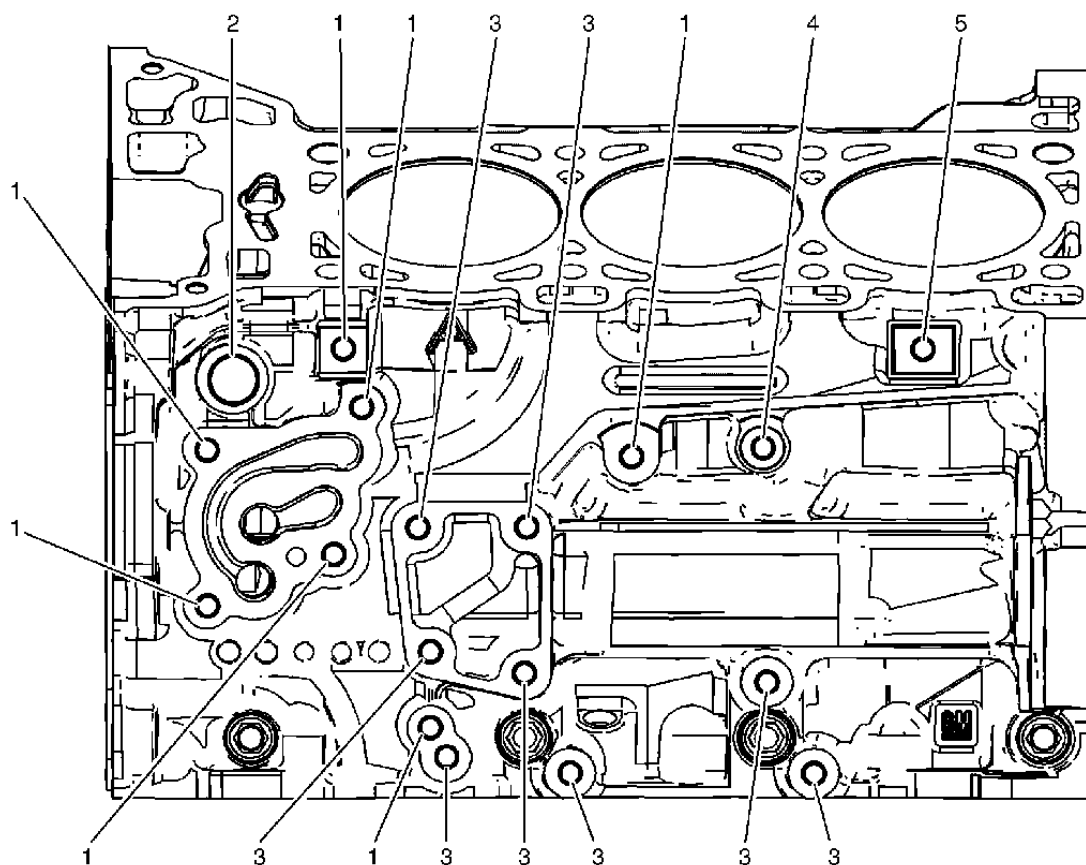


**Fig. 11: Identifying Engine Block Front**  
Courtesy of GENERAL MOTORS CORP.

### Engine Block Front

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |
| 2             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3189 | 27.0                | 1.0630 |
| 3             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | THRU                  |        | 23.0                | 0.9055 |
| 4             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | THRU                  |        | THRU                |        |
| 5             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | THRU                  |        | 28.0                | 1.1024 |
| 6             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | THRU                  |        | 20.0                | 0.7874 |

### Engine Block Left Side

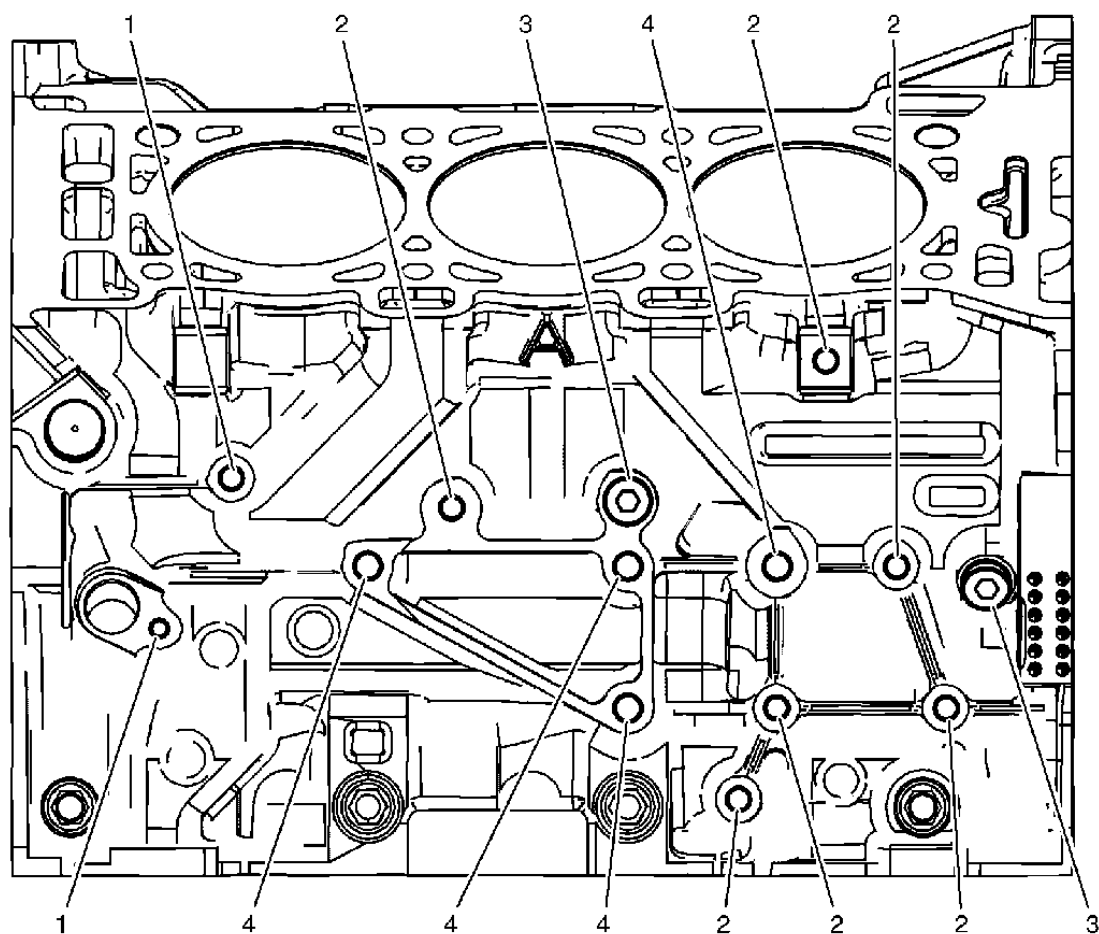


**Fig. 12: Identifying Engine Block Left Side**  
Courtesy of GENERAL MOTORS CORP.

**Engine Block Left Side**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |
| 2             | M20 x 1.5   | 715      | 716               | N/A         | 717 | 718    | 719    | 30.0                  | 1.1810 | 20.0                | 0.7874 |
| 3             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3190 | 27.0                | 1.0630 |
| 4             | M14 x 1.5   | 409      | 410               | N/A         | 411 | 412    | 735    | THRU                  |        | 15.0                | 0.5905 |
| 5             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 415    | 16.5                  | 0.6496 | 11.0                | 0.4331 |

**Engine Block Right Side**

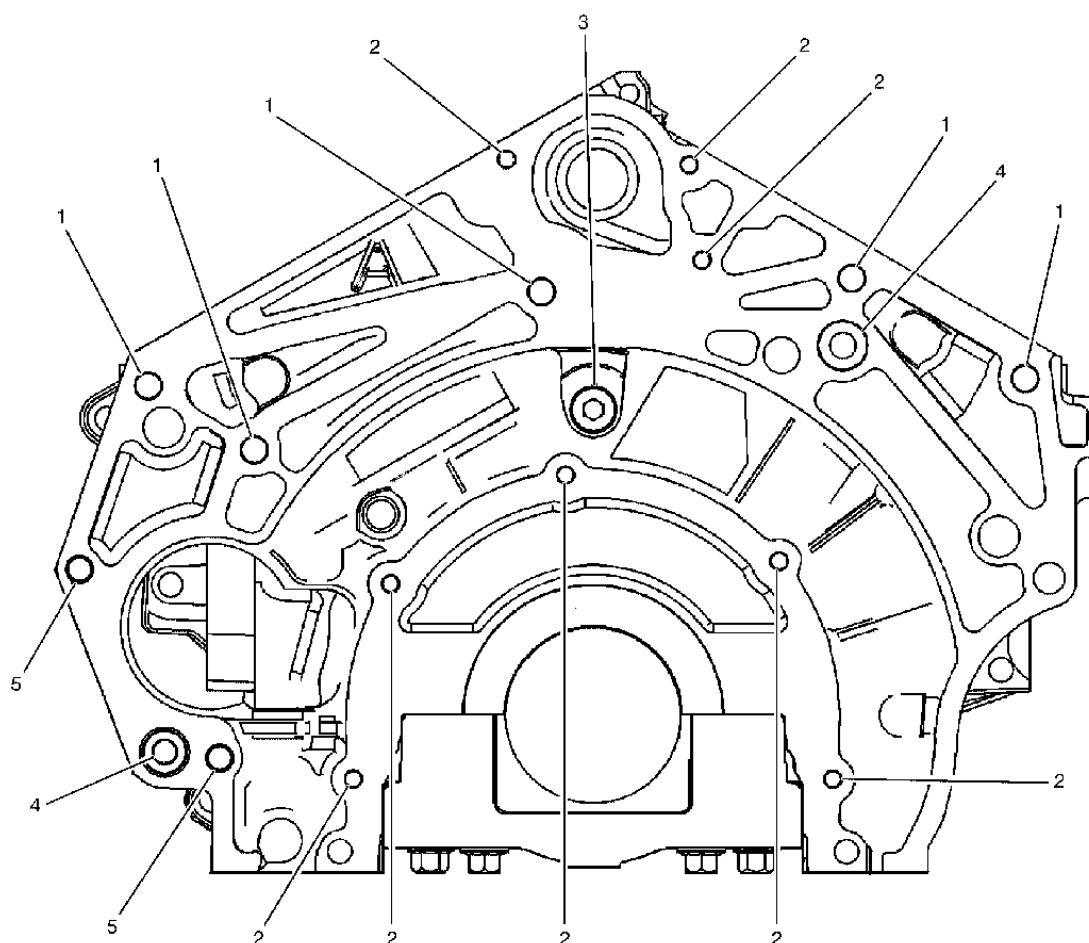


**Fig. 13: Identifying Engine Block Right Side**  
Courtesy of GENERAL MOTORS CORP.

#### Engine Block Right Side

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |
| 2             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |
| 3             | M14 x 1.5   | 409      | 410               | N/A         | 411 | 412    | 735    | THRU                  |        | 15.0                | 0.5905 |
| 4             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | 33.5                  | 1.3190 | 27.0                | 1.0630 |

#### Engine Block Rear

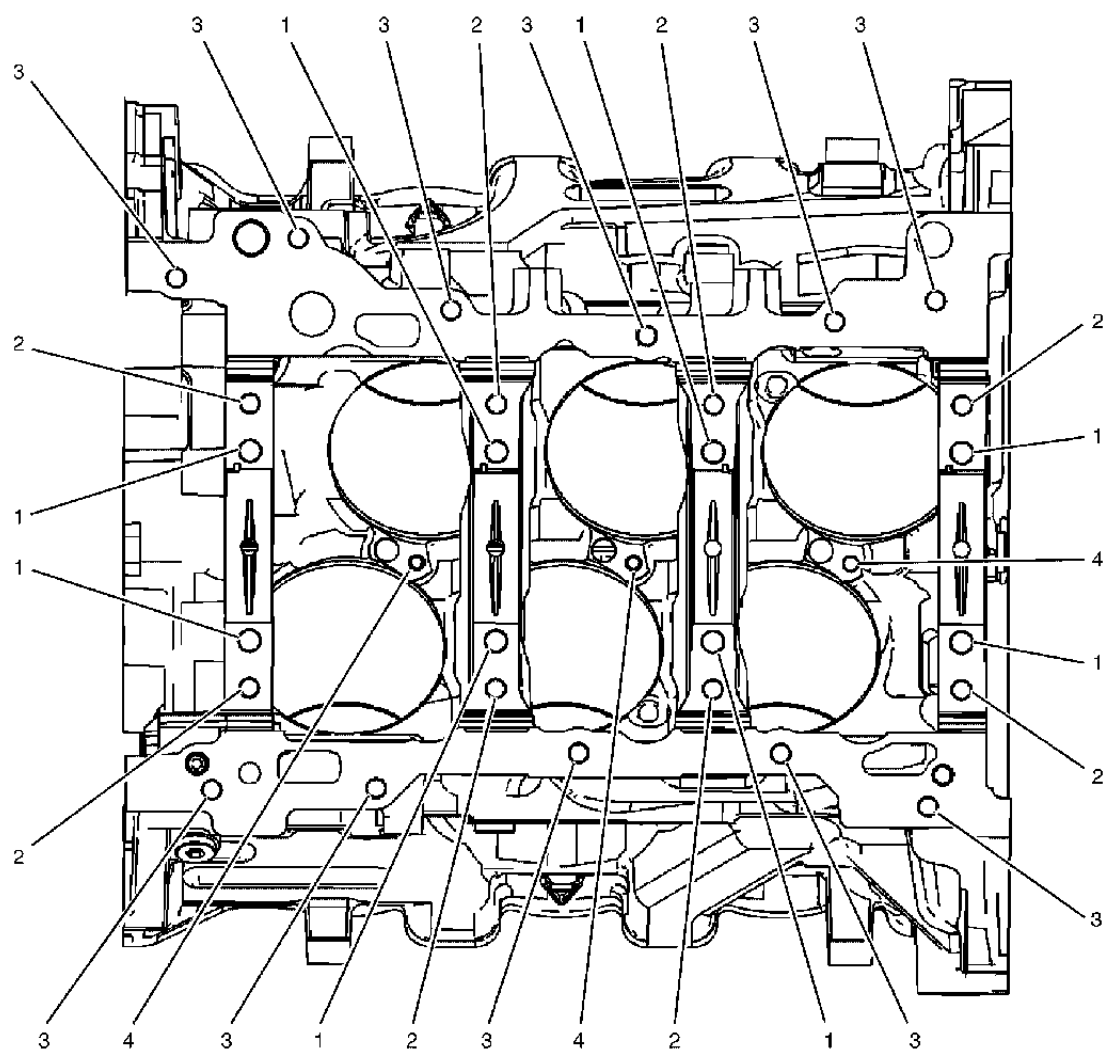


**Fig. 14: Identifying Engine Block Rear**  
Courtesy of GENERAL MOTORS CORP.

#### Engine Block Rear

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 420    | 33.5                  | 1.3190 | 27.0                | 1.0630 |
| 2             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |
| 3             | M14 x 1.5   | 409      | 410               | N/A         | 411 | 412    | 735    | THRU                  |        | 15.0                | 0.5905 |
| 4             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 216    | 39.5                  | 1.5551 | 33.0                | 1.2992 |
| 5             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 420    | THRU                  |        | THRU                |        |

# Engine Block Bottom



**Fig. 15: Identifying Engine Block Bottom**  
Courtesy of GENERAL MOTORS CORP.

## Engine Block Bottom

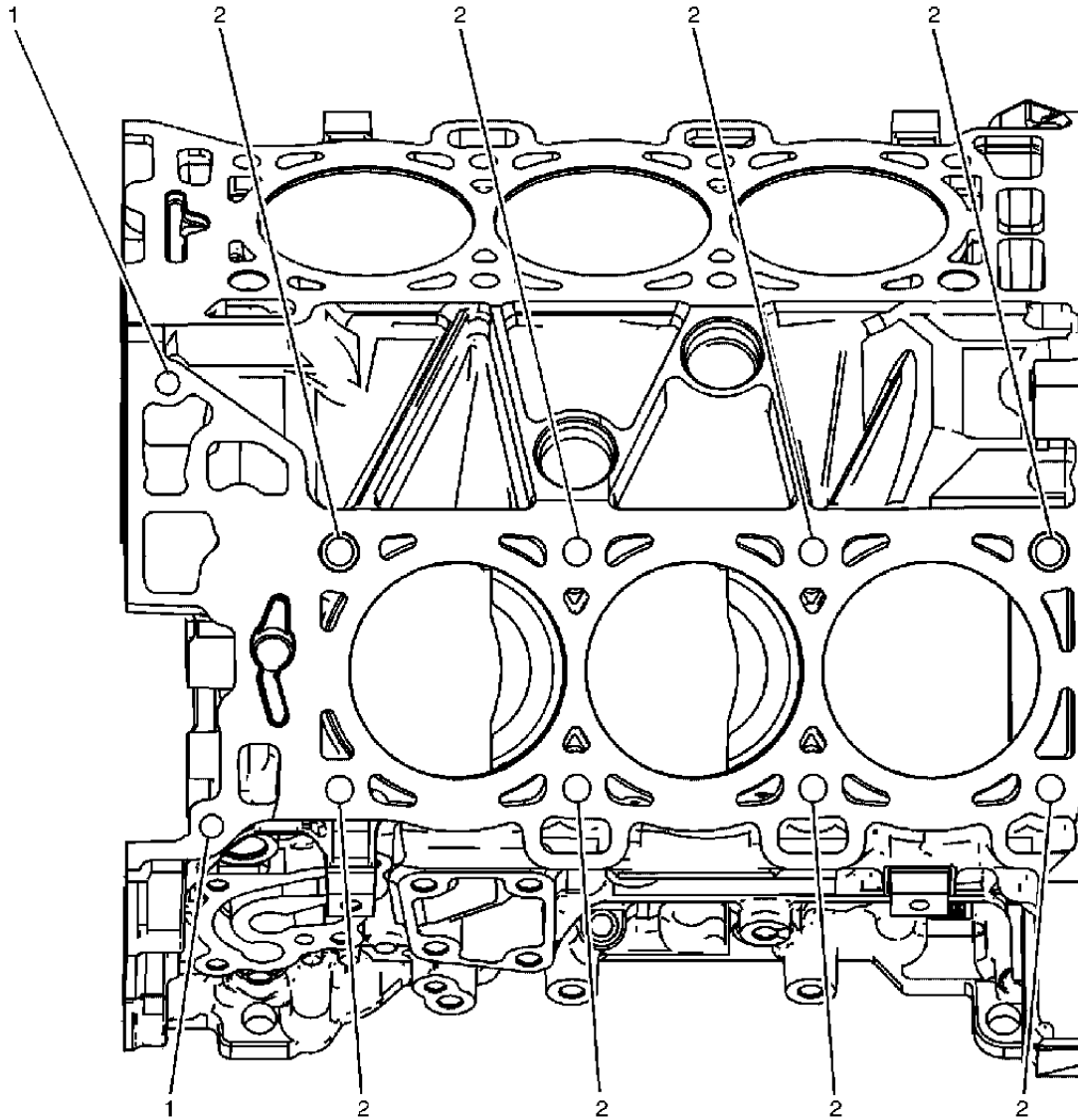
| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M10 x 2.0   | 720      | N/A               | N/A         | 721 | 722    | 104    | 56.0                  | 2.2047 | 49.0                | 1.9291 |
| 2             | M8 x 1.25   | 702      | N/A               | N/A         | 703 | 704    | 620    | 46.0                  | 1.8110 | 40.5                | 1.5945 |
| 3             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

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|   |          |     |     |     |     |     |     |      |      |
|---|----------|-----|-----|-----|-----|-----|-----|------|------|
| 4 | M6 x 1.0 | 201 | 202 | N/A | 203 | 204 | 205 | THRU | THRU |
|---|----------|-----|-----|-----|-----|-----|-----|------|------|

## Engine Block Left Deck Face



**Fig. 16: Identifying Engine Block Left Deck Face**  
Courtesy of GENERAL MOTORS CORP.

## Engine Block Left Deck Face

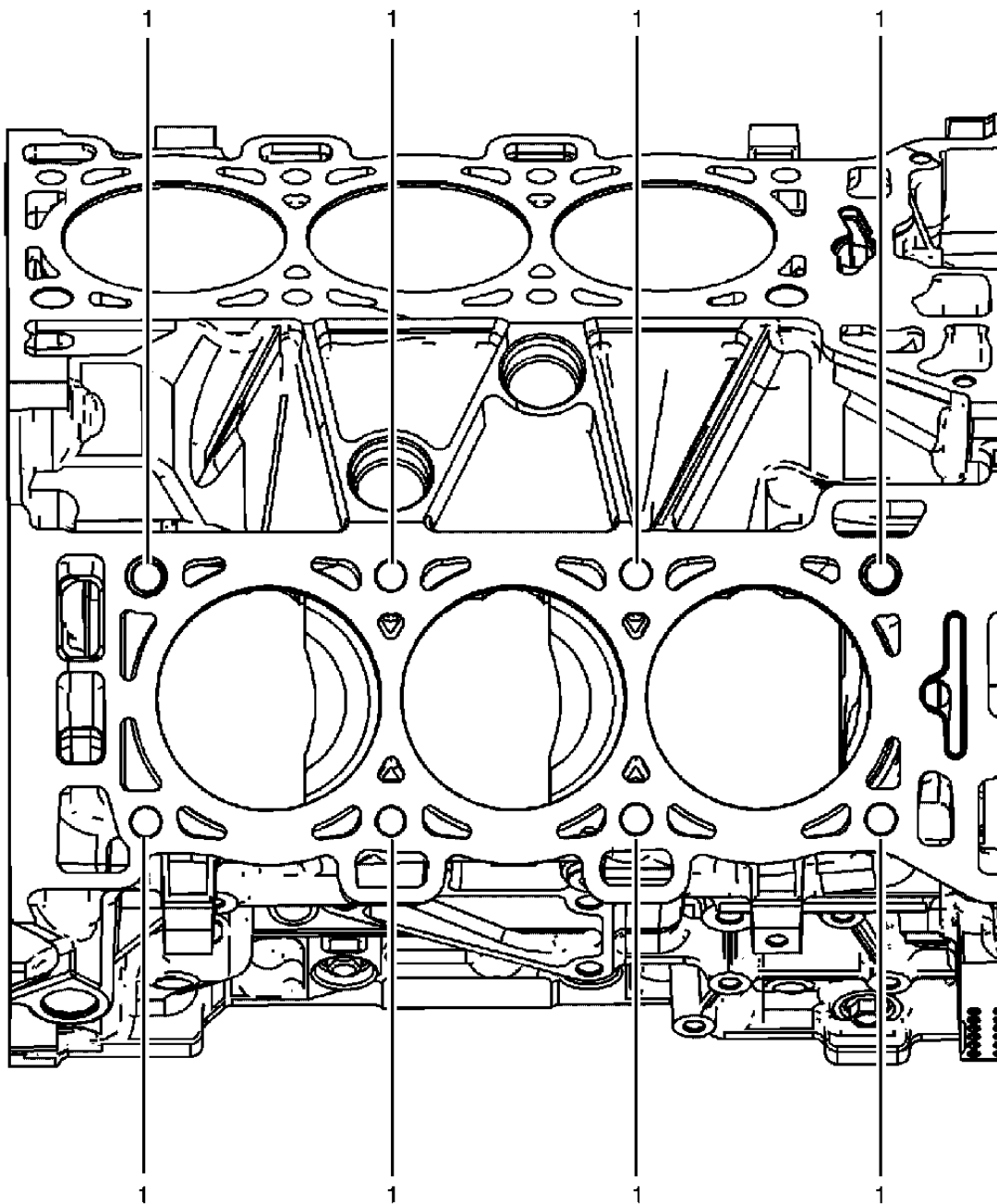
| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |       |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M8 x        | 206   | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |

## 2009 Pontiac G8

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|   |              |     |     |     |     |     |     |       |        |      |        |
|---|--------------|-----|-----|-----|-----|-----|-----|-------|--------|------|--------|
|   | 1.25         |     |     |     |     |     |     |       |        |      |        |
| 2 | M11 x<br>2.0 | 723 | N/A | N/A | 724 | 725 | 108 | 102.5 | 4.0354 | 94.0 | 3.7008 |

### Engine Block Right Deck Face



**Fig. 17: Identifying Engine Block Right Deck Face**  
Courtesy of GENERAL MOTORS CORP.

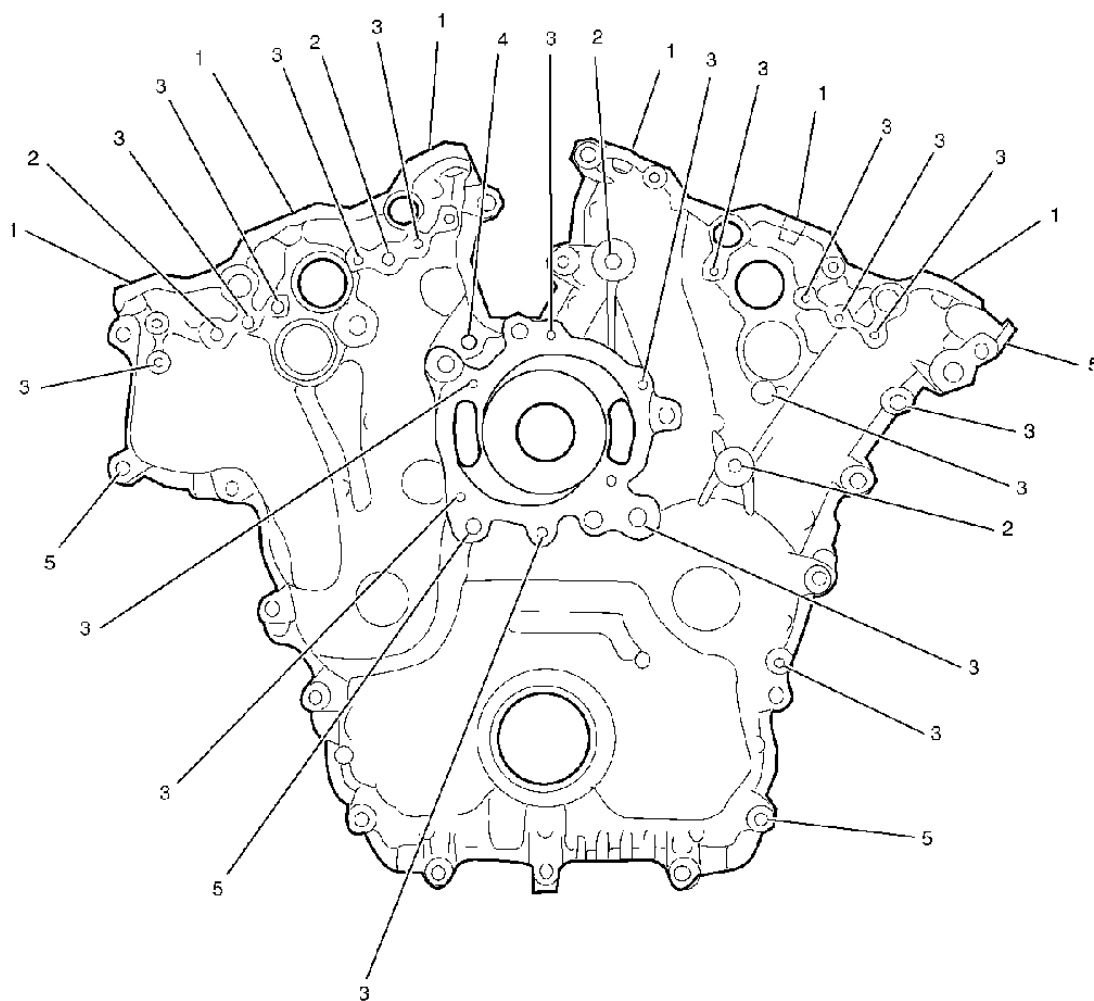
## 2009 Pontiac G8

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### Engine Block Right Deck Face

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M11 x 2.0   | 723      | N/A               | N/A         | 724 | 725    | 108    | 102.5                 | 4.0354 | 94.0                | 3.7008 |

### Engine Front Cover



**Fig. 18: Identifying Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

### Engine Front Cover

| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) | Tap Depth (Minimum) |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|---------------------|
|               |             |       |                   |             |     |        |        |                       |                     |

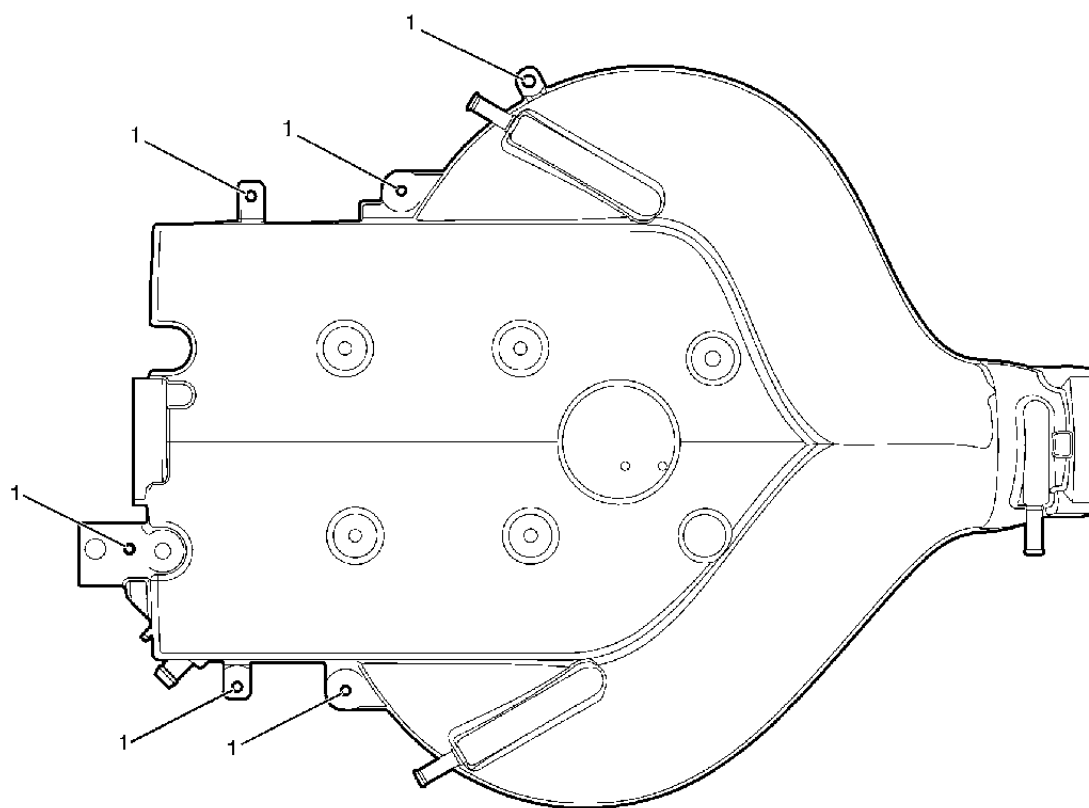


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|   |           | J 42385- |                   |             |     |        |        | MM (IN)               |                     | MM (IN)               |                     |
|---|-----------|----------|-------------------|-------------|-----|--------|--------|-----------------------|---------------------|-----------------------|---------------------|
|   |           | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) | Tap Depth (Minimum) | Drill Depth (Maximum) | Tap Depth (Minimum) |
| 1 | M6 x 1.0  | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  | THRU                |                       |                     |
| 2 | M8 x 1.25 | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5 1.1220           | 23.0 0.9055         |                       |                     |
| 3 | M6 x 1.0  | 201      | 202               | N/A         | 203 | 204    | 205    | 21.5 0.8465           | 18.0 0.7087         |                       |                     |
| 4 | M10 x 1.5 | 211      | 212               | N/A         | 213 | 214    | 215    | THRU                  | THRU                |                       |                     |
| 5 | M10 x 1.5 | 211      | 212               | N/A         | 213 | 214    | 420    | 32.5 1.2795           | 27.0 1.0630         |                       |                     |

### Upper Intake Manifold - Top

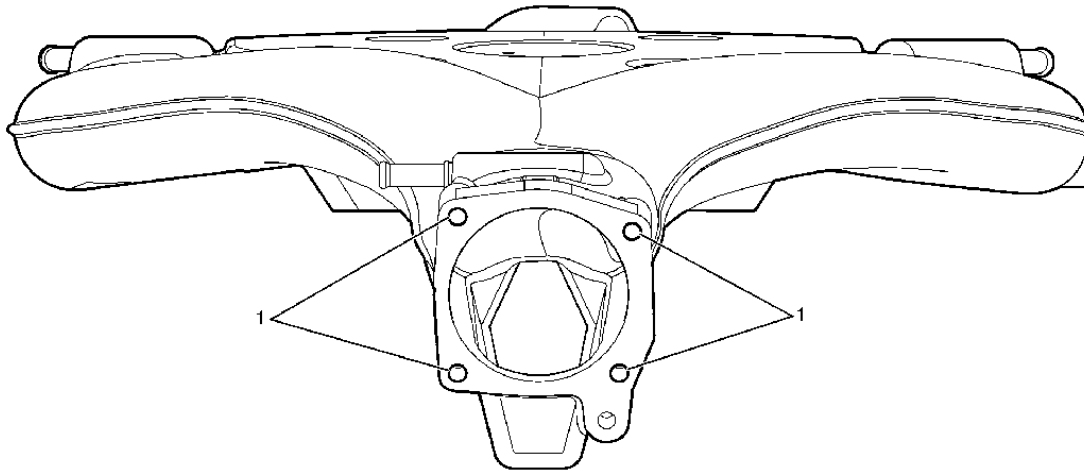


**Fig. 19: Identifying Upper Intake Manifold - Top**  
Courtesy of GENERAL MOTORS CORP.

### Upper Intake Manifold - Top

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |                     | Tap Depth (Minimum)   |                     |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|---------------------|-----------------------|---------------------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN)                | MM                    | (IN)                |
|               |             | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) | Tap Depth (Minimum) | Drill Depth (Maximum) | Tap Depth (Minimum) |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  | THRU                |                       |                     |

### Upper Intake Manifold - Front

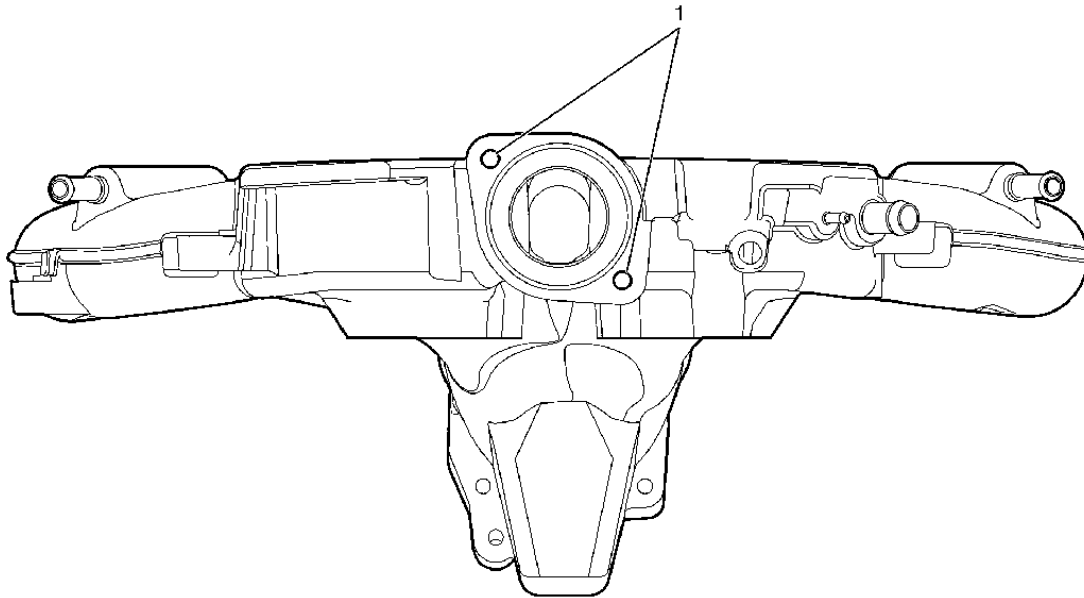


**Fig. 20: Identifying Upper Intake Manifold - Front**  
Courtesy of GENERAL MOTORS CORP.

### Upper Intake Manifold - Front

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |      | Tap Depth (Minimum) |      |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|------|---------------------|------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN) | MM                  | (IN) |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  |      | THRU                |      |

### Upper Intake Manifold - Rear

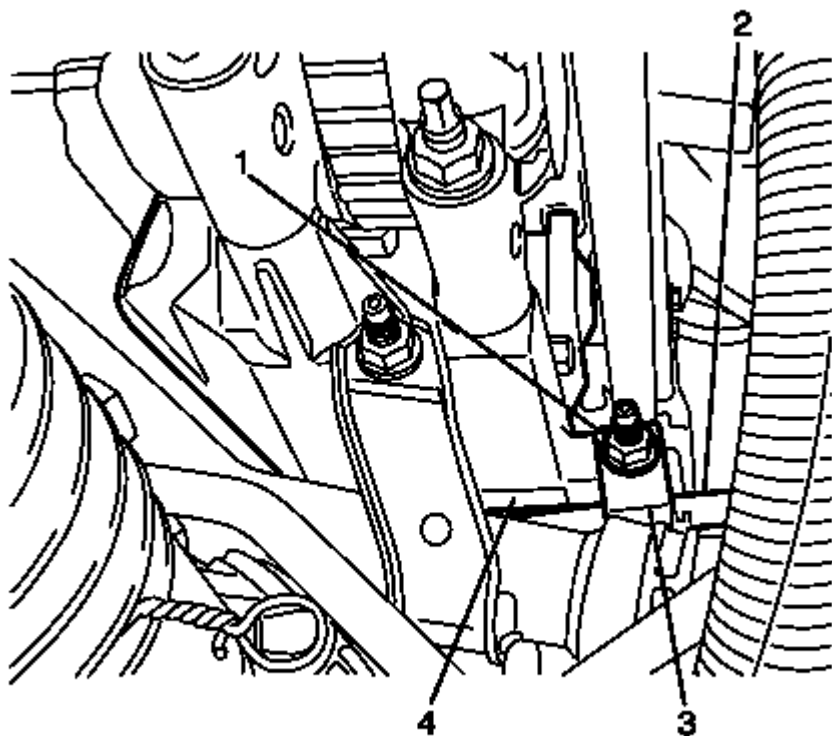


**Fig. 21: Identifying Upper Intake Manifold - Rear**  
 Courtesy of GENERAL MOTORS CORP.

**Upper Intake Manifold - Rear**

| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |      | Tap Depth (Minimum) |      |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|------|---------------------|------|
|               |             |       |                   |             |     |        |        | MM                    | (IN) | MM                  | (IN) |
|               |             |       |                   |             |     |        |        |                       |      |                     |      |
| 1             | M6 x 1.0    | 201   | 202               | N/A         | 203 | 204    | 205    | THRU                  |      | THRU                |      |

**Lower Intake Manifold - Top**

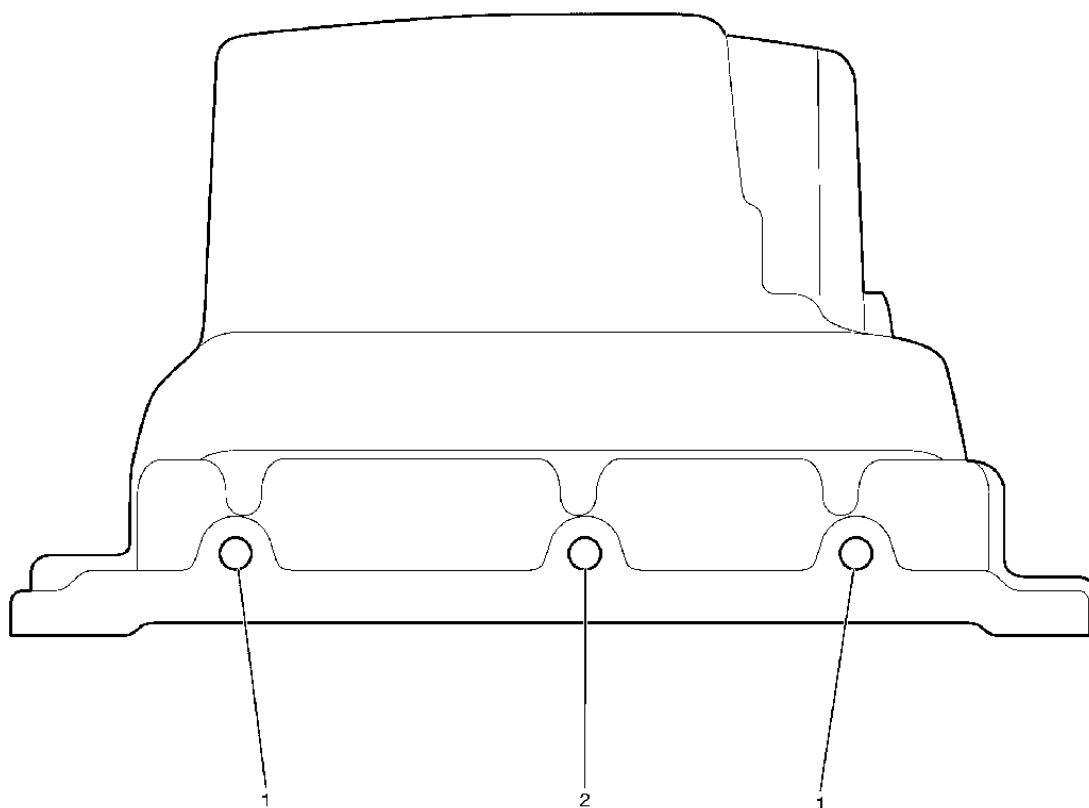


**Fig. 22: Identifying Transmission Cooler Line Clamp To Alternator Mounting Bracket Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

**Lower Intake Manifold - Top**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |      | Tap Depth (Minimum) |      |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|------|---------------------|------|
|               |             |          |                   |             |     |        |        | MM                    | (IN) | MM                  | (IN) |
|               |             | J 42385- |                   |             |     |        |        |                       |      |                     |      |
| 1             | M6 x 1.0    | 201      | 202               | N/A         | 203 | 204    | 205    | THRU                  |      | THRU                |      |
| 2             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | THRU                  |      | THRU                |      |

**Oil Pan Front**



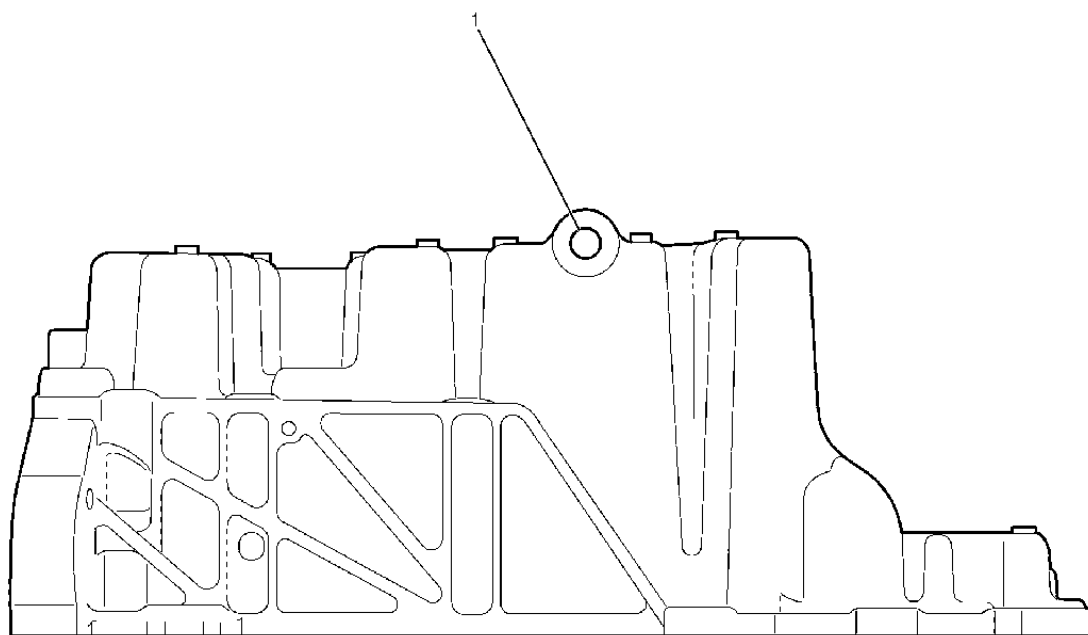
**Fig. 23: Identifying Oil Pan Front**

Courtesy of GENERAL MOTORS CORP.

**Oil Pan Front**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |          |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
|               |             | J 42385- |                   |             |     |        |        |                       |        |                     |        |
| 1             | M8 x 1.25   | 206      | 207               | N/A         | 208 | 209    | 210    | 28.5                  | 1.1220 | 23.0                | 0.9055 |
| 2             | M8 x 1.25   | 610      | N/A               | N/A         | 208 | 209    | 620    | 37.5                  | 1.4764 | 32.0                | 1.2598 |

**Oil Pan Left Side**

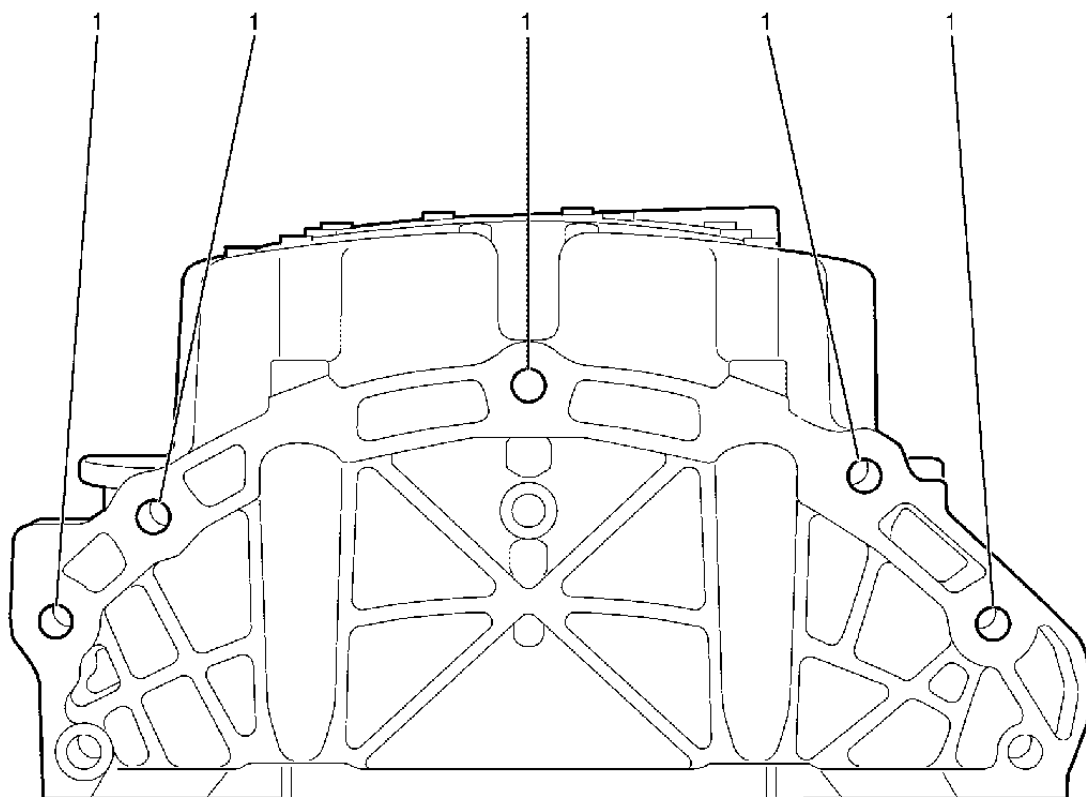


**Fig. 24: Identifying Oil Pan Left Side**  
 Courtesy of GENERAL MOTORS CORP.

#### Oil Pan Left Side

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |      | Tap Depth (Minimum) |      |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|------|---------------------|------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN) | MM                  | (IN) |
| 1             | M12 x 1.75  | 856      | 857               | N/A         | 858 | 859    | 416    | THRU                  |      | THRU                |      |

#### Oil Pan Rear

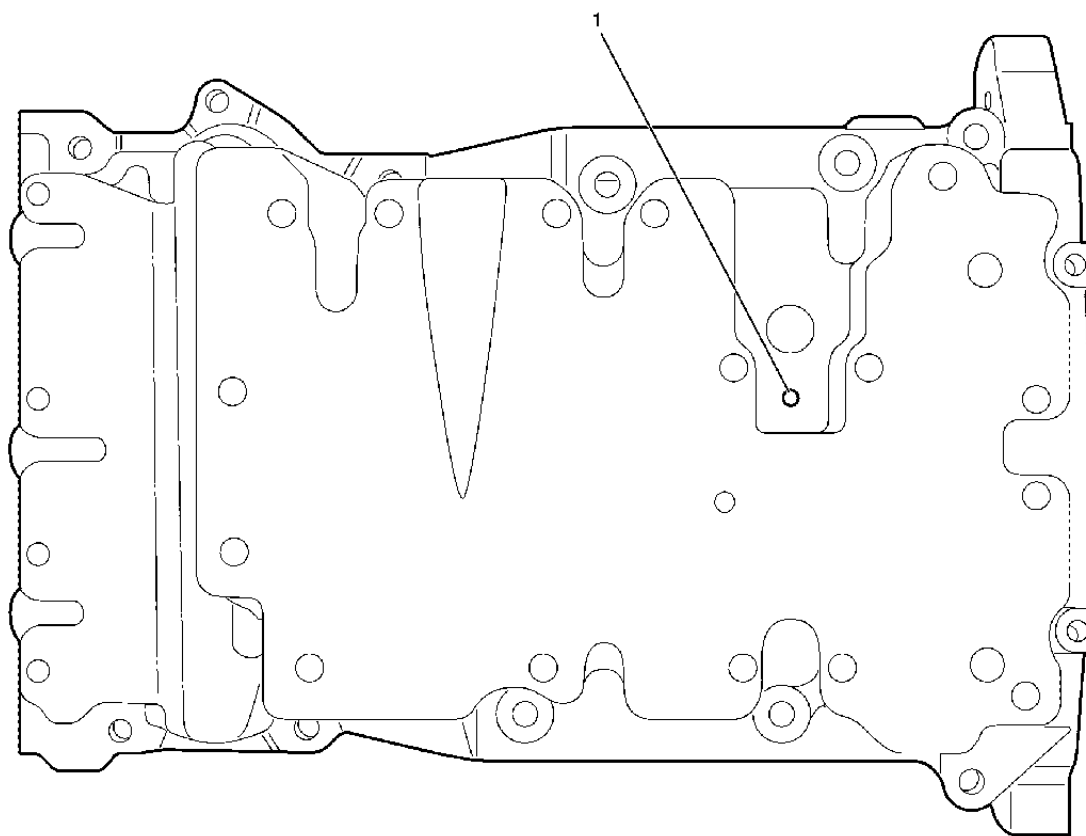


**Fig. 25: Identifying Oil Pan Rear**  
Courtesy of GENERAL MOTORS CORP.

**Oil Pan Rear**

| Hole Location | Thread Size | Drill    | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |      | Tap Depth (Minimum) |      |
|---------------|-------------|----------|-------------------|-------------|-----|--------|--------|-----------------------|------|---------------------|------|
|               |             | J 42385- |                   |             |     |        |        | MM                    | (IN) | MM                  | (IN) |
| 1             | M10 x 1.5   | 211      | 212               | N/A         | 213 | 214    | 215    | THRU                  |      | THRU                |      |

**Oil Pan Bottom**

**Fig. 26: Identifying Oil Pan Bottom**

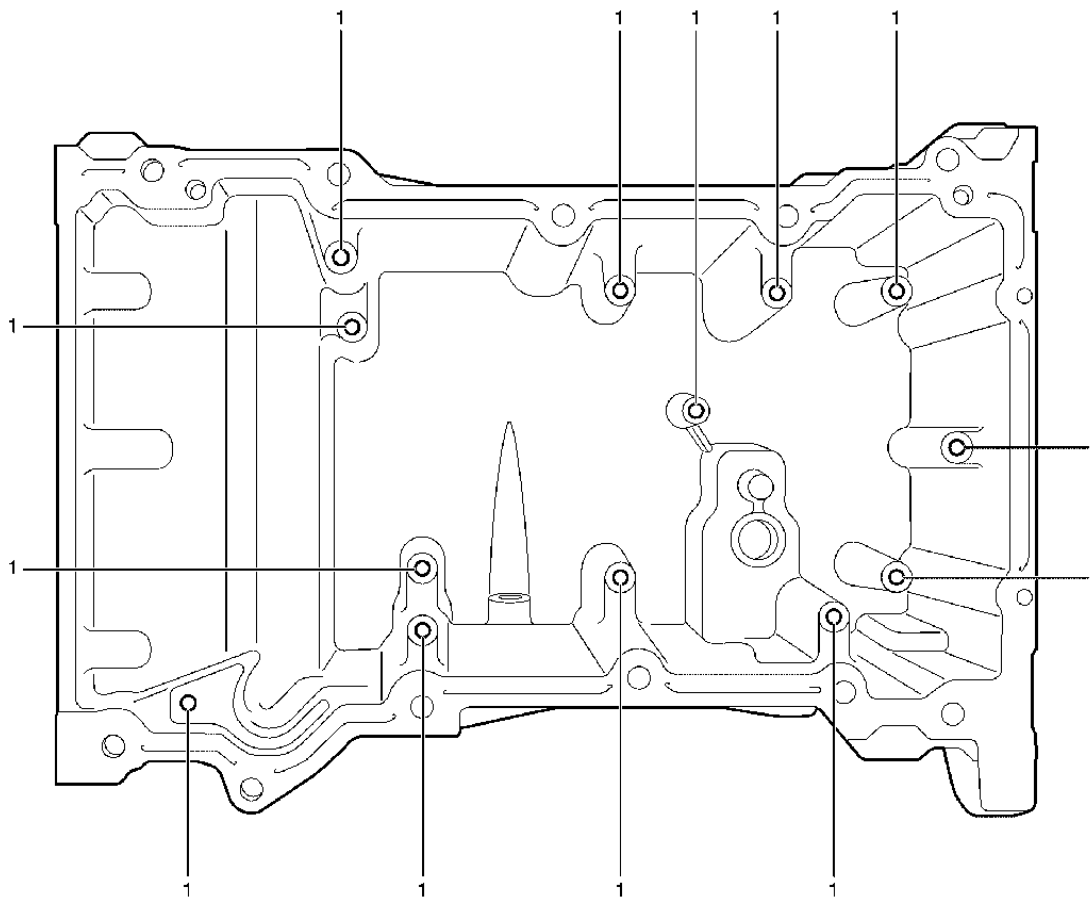
Courtesy of GENERAL MOTORS CORP.

**Oil Pan Bottom**

| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |       |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| 1             | M6 x 1.0    | 701   | N/A               | N/A         | 203 | 204    | 205    | 22.5                  | 0.8858 | 18.0                | 0.7087 |

**Oil Pan Top**





**Fig. 27: Identifying Oil Pan Top**  
 Courtesy of GENERAL MOTORS CORP.

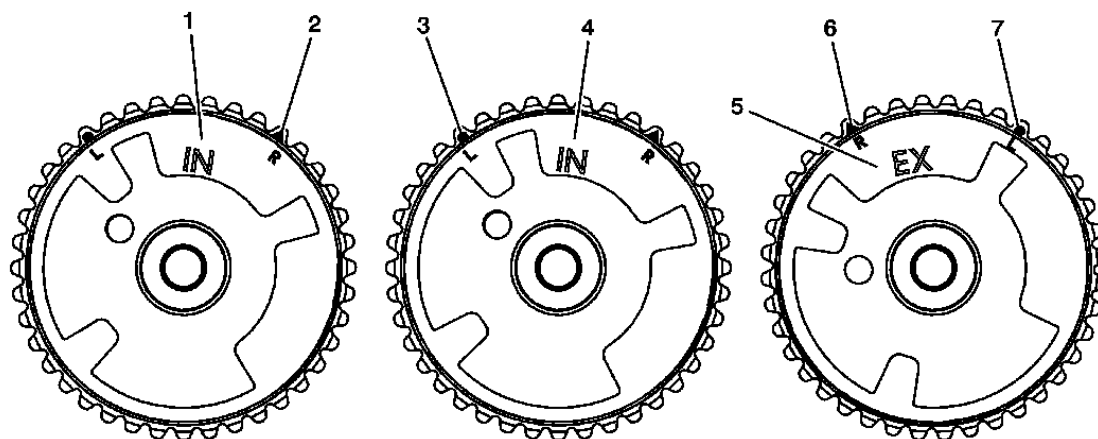
#### Oil Pan Top

| Hole Location | Thread Size | Drill | Counter Bore Tool | Stop Collar | Tap | Driver | Insert | Drill Depth (Maximum) |        | Tap Depth (Minimum) |        |
|---------------|-------------|-------|-------------------|-------------|-----|--------|--------|-----------------------|--------|---------------------|--------|
|               |             |       |                   |             |     |        |        | MM                    | (IN)   | MM                  | (IN)   |
| J 42385-      |             |       |                   |             |     |        |        |                       |        |                     |        |
| 1             | M6 x 1.0    | 701   | N/A               | N/A         | 203 | 204    | 205    | 28.0                  | 1.1024 | 23.5                | 0.9252 |

## SCHEMATIC AND ROUTING DIAGRAMS

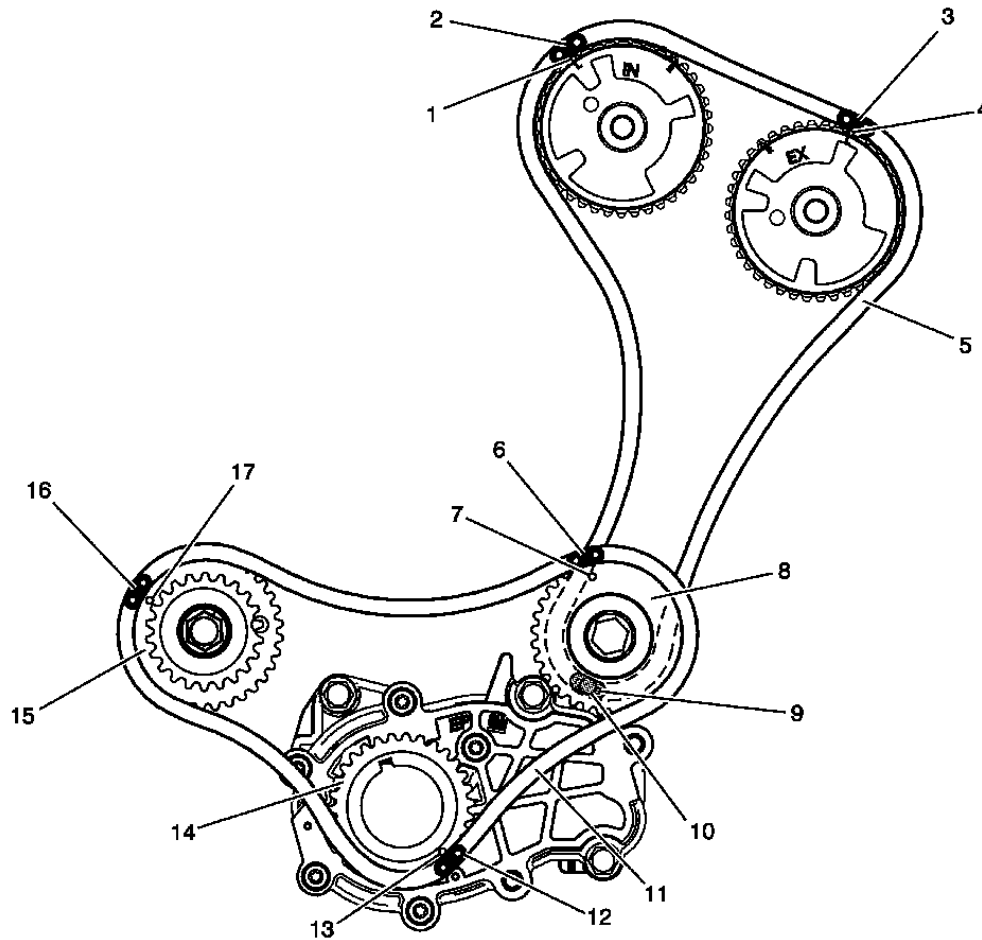
### ENGINE MECHANICAL SCHEMATICS





**Fig. 29: Camshaft Position Actuator Timing Marks**  
 Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                            |
|---------|---------------------------------------------------------------------------|
| 1       | Right Intake Camshaft Position Actuator Identifier                        |
| 2       | Right Intake Camshaft Position Actuator Right Side Timing Mark - Triangle |
| 3       | Left Intake Camshaft Position Actuator Left Side Timing Mark - Circle     |
| 4       | Left Intake Camshaft Position Actuator Identifier                         |
| 5       | Exhaust Camshaft Position Actuator Identifier                             |
| 6       | Exhaust Camshaft Position Actuator Right Side Timing Mark - Triangle      |
| 7       | Exhaust Camshaft Position Actuator Left Side Timing Mark - Circle         |



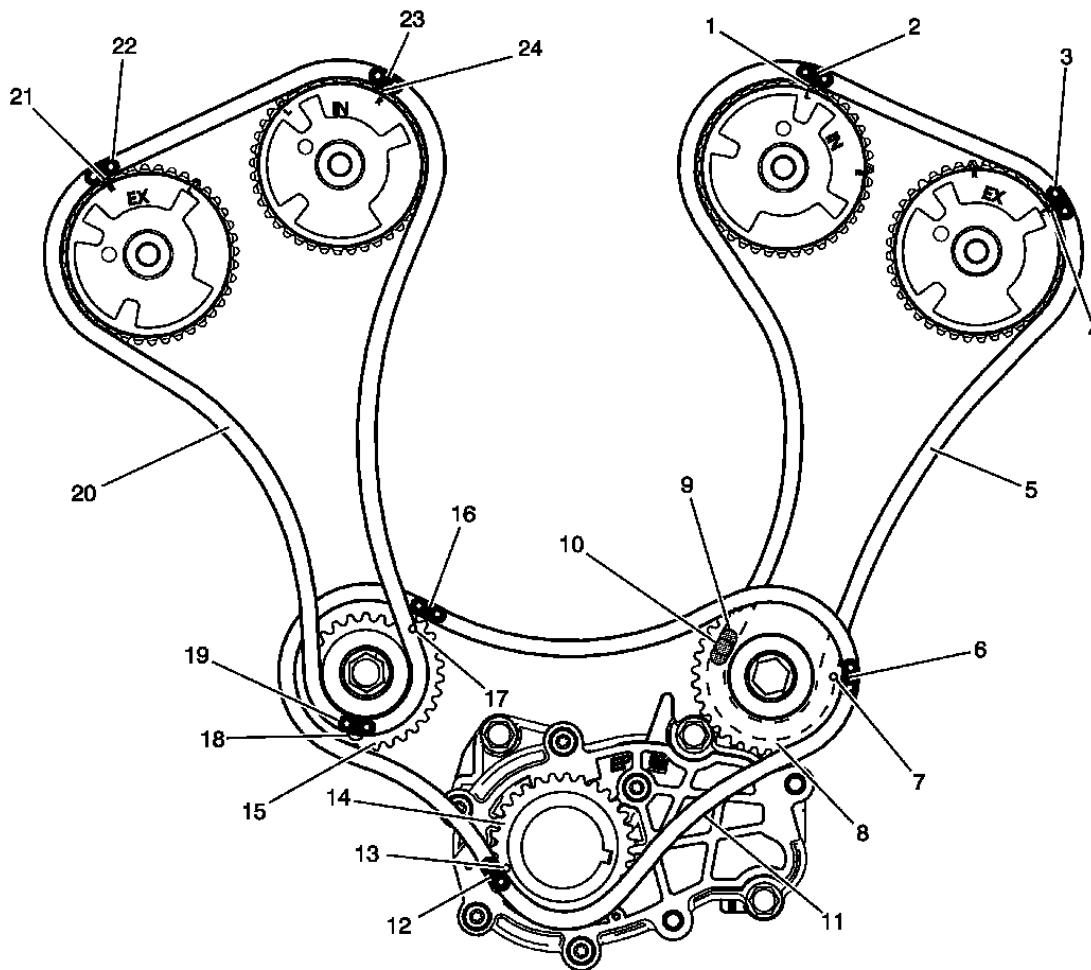
**Fig. 30: Stage One Component View**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                                                                                                  |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle                                                                               |
| 2       | Left Intake Secondary Camshaft Timing Drive Chain Timing Link                                                                                   |
| 3       | Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link                                                                                  |
| 4       | Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle                                                                              |
| 5       | Left Secondary Camshaft Timing Drive Chain                                                                                                      |
| 6       | Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket                                        |
| 7       | Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain                                        |
| 8       | Left Primary Camshaft Intermediate Drive Chain Sprocket                                                                                         |
| 9       | Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket, behind hole in sprocket |
| 10      | Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window for the Left Secondary Camshaft Timing Drive Chain Timing Link            |

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|    |                                                                                                           |
|----|-----------------------------------------------------------------------------------------------------------|
| 11 | Primary Camshaft Drive Chain                                                                              |
| 12 | Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket                                      |
| 13 | Crankshaft Sprocket Timing Mark                                                                           |
| 14 | Crankshaft Sprocket                                                                                       |
| 15 | Right Primary Camshaft Intermediate Drive Chain Sprocket                                                  |
| 16 | Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket |
| 17 | Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark                                      |



**Fig. 31: Stage Two Component View**  
Courtesy of GENERAL MOTORS CORP.

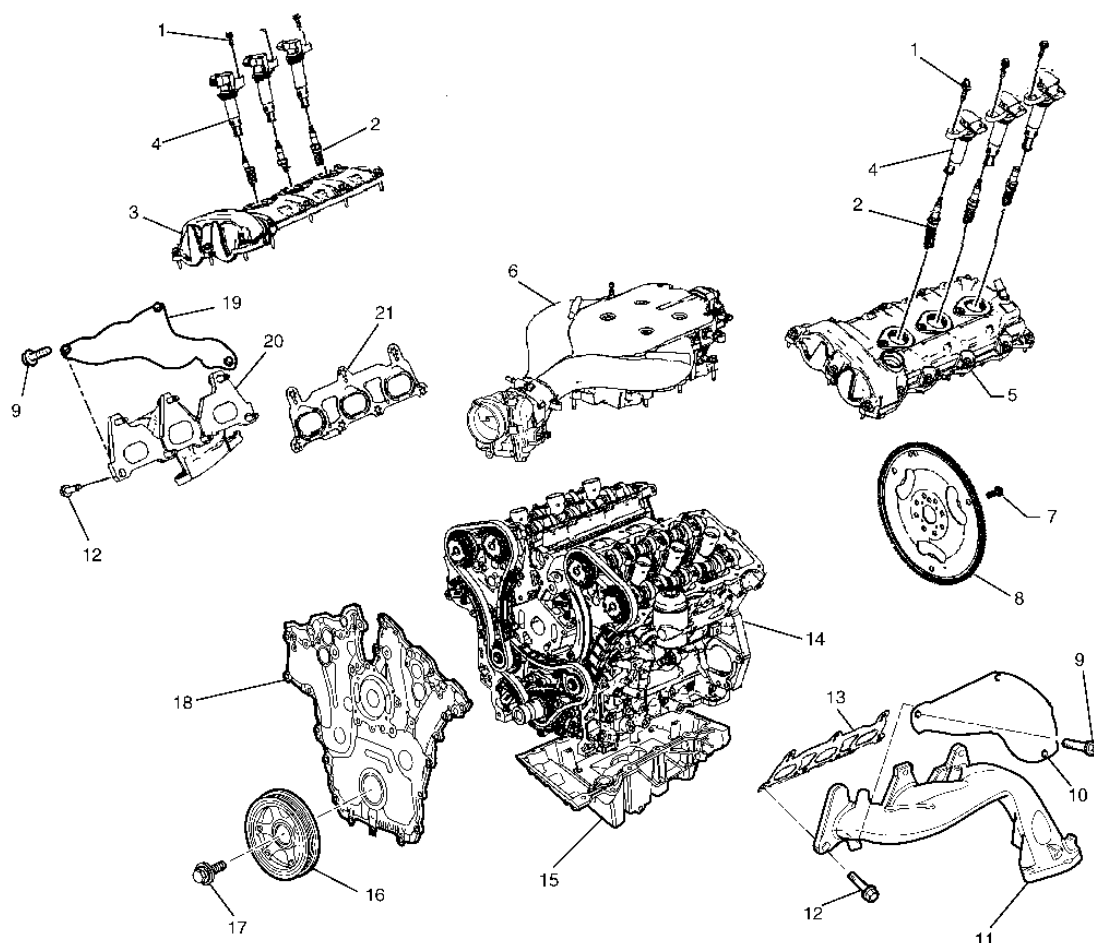
| Callout | Component Name                                                     |
|---------|--------------------------------------------------------------------|
| 1       | Left Intake Camshaft Position (CMP) Actuator Timing Mark - Circle  |
| 2       | Left Intake Secondary Camshaft Timing Drive Chain Timing Link      |
| 3       | Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link     |
| 4       | Left Exhaust Camshaft Position (CMP) Actuator Timing Mark - Circle |

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|    |                                                                                                                                                 |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 5  | Left Secondary Camshaft Timing Drive Chain                                                                                                      |
| 6  | Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket                                        |
| 7  | Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain                                        |
| 8  | Left Primary Camshaft Intermediate Drive Chain Sprocket                                                                                         |
| 9  | Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket, behind hole in sprocket |
| 10 | Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window                                                                           |
| 11 | Primary Camshaft Drive Chain                                                                                                                    |
| 12 | Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket                                                                            |
| 13 | Crankshaft Sprocket Timing Mark                                                                                                                 |
| 14 | Crankshaft Sprocket                                                                                                                             |
| 15 | Right Primary Camshaft Intermediate Drive Chain Sprocket                                                                                        |
| 16 | Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket                                       |
| 17 | Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain                                       |
| 18 | Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark/Window for the Right Secondary Camshaft Timing Drive Chain                 |
| 19 | Right Secondary Camshaft Timing Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket                        |
| 20 | Right Secondary Camshaft Timing Drive Chain                                                                                                     |
| 21 | Right Exhaust Camshaft Position (CMP) Actuator Timing Mark - Triangle                                                                           |
| 22 | Right Exhaust Secondary Camshaft Timing Drive Chain Timing Link                                                                                 |
| 23 | Right Intake Secondary Camshaft Timing Drive Chain Timing Link                                                                                  |
| 24 | Right Intake Camshaft Position (CMP) Actuator Timing Mark - Triangle                                                                            |

**COMPONENT LOCATOR****DISASSEMBLED VIEWS**



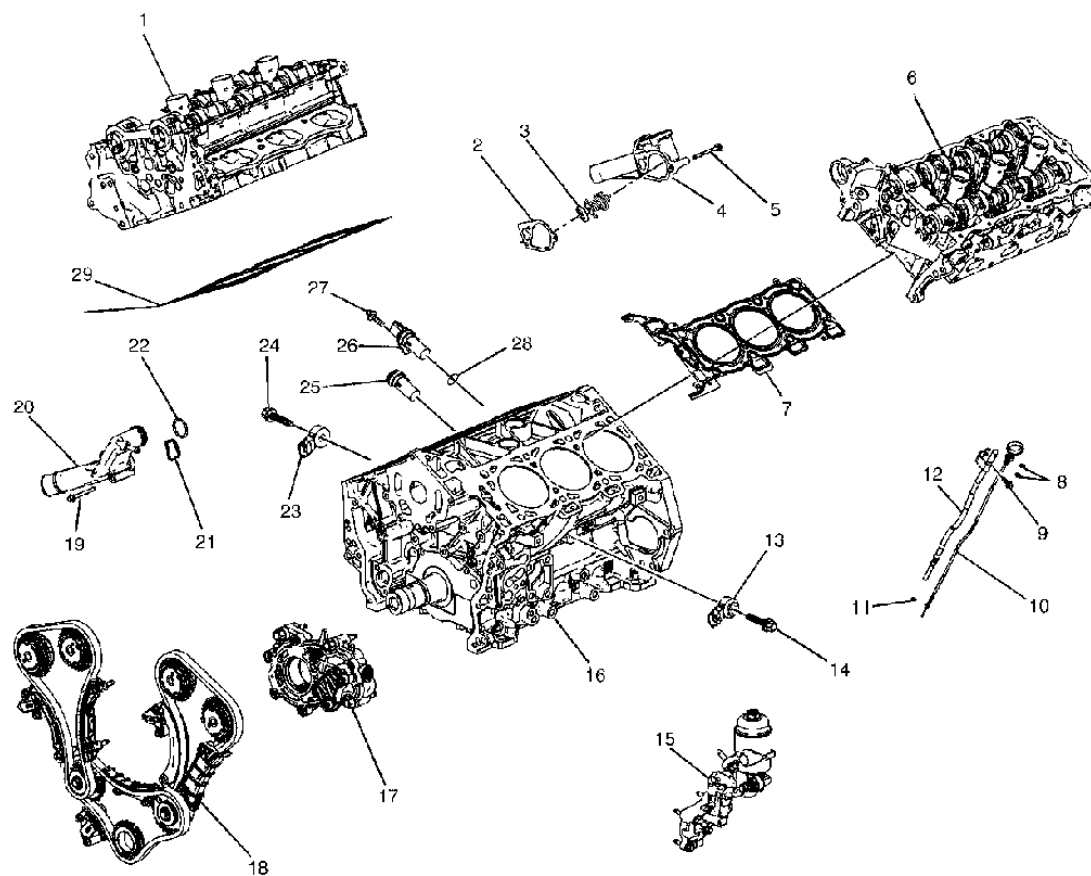
**Fig. 32: Engine Covers and Component Assemblies (1 of 2)**  
 Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                   |
|---------|------------------------------------------------------------------|
| 1       | Ignition Coil Assembly to Camshaft Cover Assembly Retaining Bolt |
| 2       | Spark Plug                                                       |
| 3       | Camshaft Cover Assembly - Right Side                             |
| 4       | Ignition Coil Assembly                                           |
| 5       | Camshaft Cover Assembly - Left Side                              |
| 6       | Intake Manifold Assembly                                         |
| 7       | Engine Flywheel to Crankshaft Retaining Bolt                     |
| 8       | Engine Flywheel                                                  |
| 9       | Exhaust Manifold Heat Shield to Exhaust Manifold Retaining Bolt  |
| 10      | Exhaust Manifold Heat Shield - Left Side                         |
| 11      | Exhaust Manifold - Left Side                                     |
| 12      | Exhaust Manifold to Cylinder Head Retaining Bolt                 |
| 13      | Exhaust Manifold Gasket - Left Side                              |

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|    |                                                  |
|----|--------------------------------------------------|
| 14 | Engine Assembly                                  |
| 15 | Oil Pan Assembly                                 |
| 16 | Crankshaft Balancer                              |
| 17 | Crankshaft Balancer to Crankshaft Retaining Bolt |
| 18 | Engine Front Cover Assembly                      |
| 19 | Exhaust Manifold Heat Shield - Right Side        |
| 20 | Exhaust Manifold - Right Side                    |
| 21 | Exhaust Manifold Gasket - Right Side             |



**Fig. 33: Engine Covers and Component Assemblies (2 of 2)**

Courtesy of GENERAL MOTORS CORP.

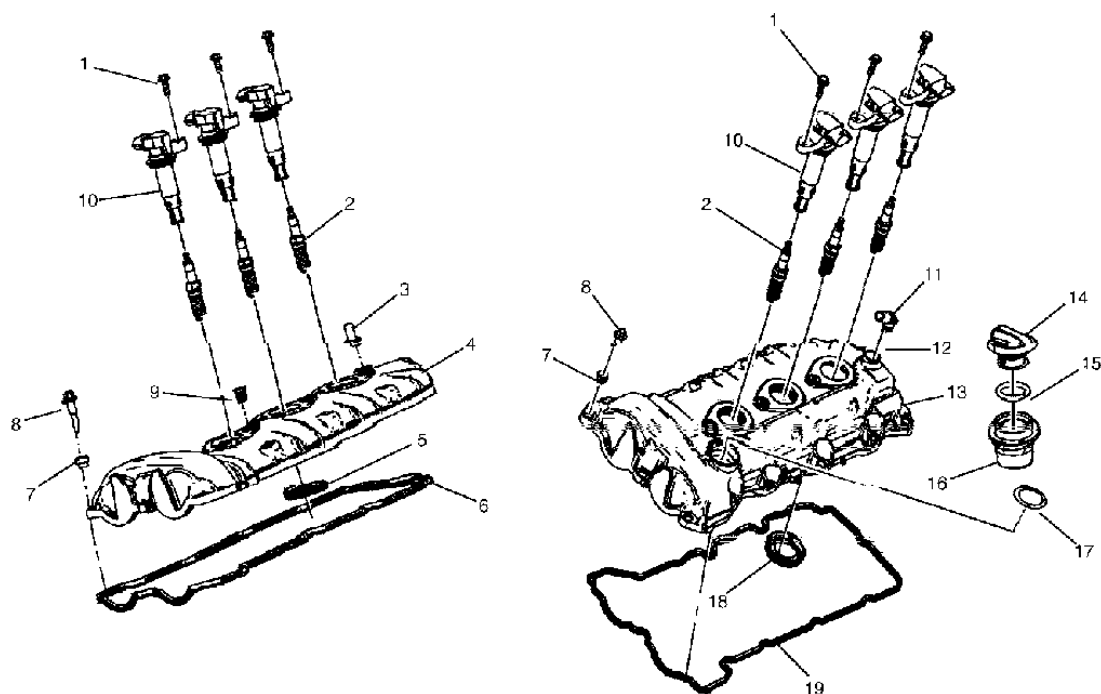
| Callout | Component Name                         |
|---------|----------------------------------------|
| 1       | Cylinder Head Assembly - Right Side    |
| 2       | Engine Cooling Thermostat Gasket       |
| 3       | Engine Cooling Thermostat              |
| 4       | Engine Cooling Thermostat Housing      |
| 5       | Engine Cooling Thermostat Housing Bolt |



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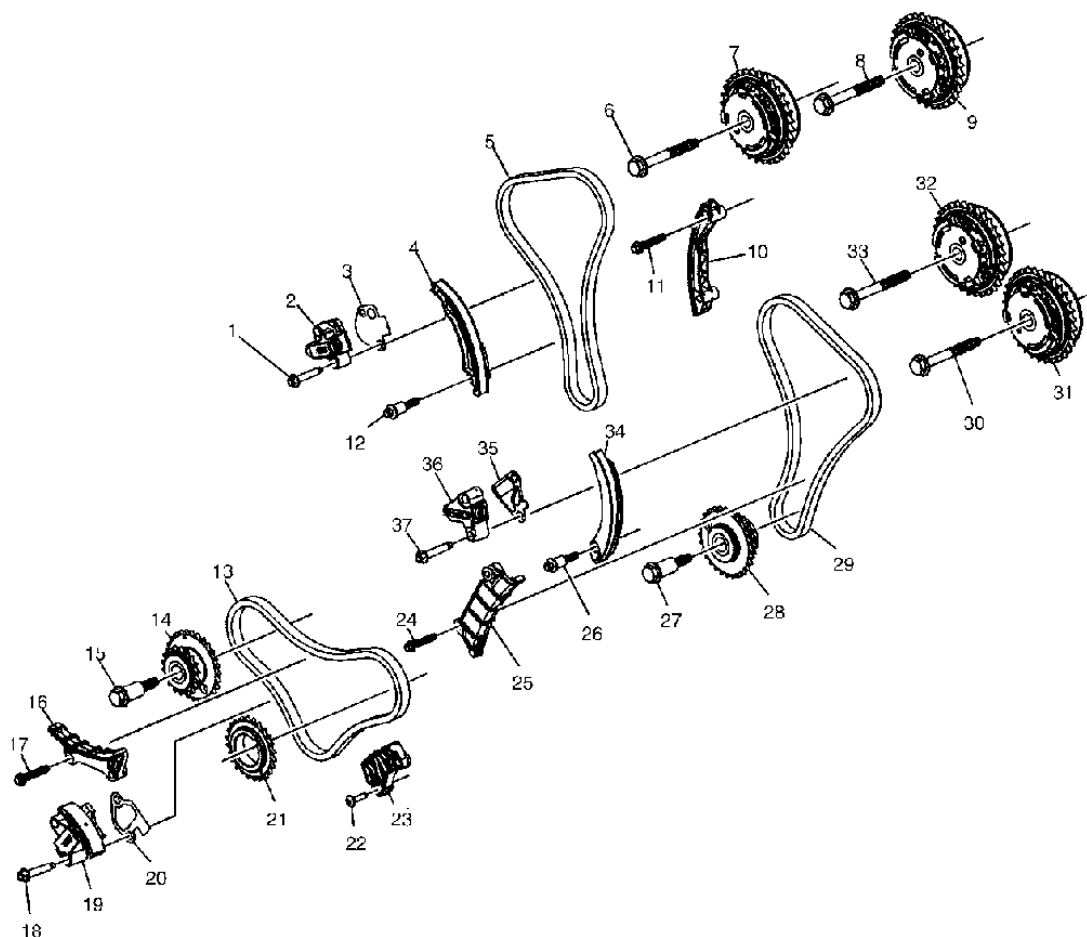
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|    |                                                             |
|----|-------------------------------------------------------------|
| 6  | Cylinder Head Assembly - Left Side                          |
| 7  | Cylinder Head Gasket - Left Side                            |
| 8  | Oil Level Indicator O-rings                                 |
| 9  | Oil Level Indicator Tube Bolt                               |
| 10 | Oil Level Indicator                                         |
| 11 | Oil Level Indicator Tube O-ring                             |
| 12 | Oil Level Indicator Tube                                    |
| 13 | Knock Sensor - Bank 1                                       |
| 14 | Knock Sensor to Cylinder Block Retaining Bolt - Bank 1      |
| 15 | Oil Filter Adapter Assembly                                 |
| 16 | Engine Short Block Assembly                                 |
| 17 | Oil Pump Assembly                                           |
| 18 | Timing Drive Assembly                                       |
| 19 | Water Outlet to Cylinder Block Retaining Bolt               |
| 20 | Water Outlet                                                |
| 21 | Water Outlet Seal                                           |
| 22 | Water Outlet O-ring                                         |
| 23 | Knock Sensor - Bank 2                                       |
| 24 | Knock Sensor to Cylinder Block Retaining Bolt - Bank 2      |
| 25 | Engine Coolant Heater                                       |
| 26 | Crankshaft Position Sensor                                  |
| 27 | Crankshaft Position Sensor to Cylinder Block Retaining Bolt |
| 28 | Crankshaft Position Sensor O-ring                           |
| 29 | Cylinder Head Gasket - Right Side                           |



**Fig. 34: Camshaft Cover Assembly**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                   |
|---------|--------------------------------------------------|
| 1       | Ignition Coil to Camshaft Cover Retaining Bolt   |
| 2       | Spark Plug                                       |
| 3       | Camshaft Cover PCV Fitting Orifice - Right Side  |
| 4       | Camshaft Cover - Right Side                      |
| 5       | Camshaft Cover Spark Plug Port Seal - Right Side |
| 6       | Camshaft Cover Gasket - Right Side               |
| 7       | Camshaft Cover Bolt Insulator                    |
| 8       | Camshaft Cover Bolt                              |
| 9       | Ignition Coil Bolt Thread Insert                 |
| 10      | Ignition Coil                                    |
| 11      | Camshaft Cover PCV Fitting - Left Side           |
| 12      | Camshaft Cover PCV Fitting - Left Side           |
| 13      | Camshaft Cover - Left Side                       |
| 14      | Oil Fill Cap                                     |
| 15      | Oil Fill O-Ring                                  |
| 16      | Oil Fill Tube                                    |
| 17      | Oil Fill O-Ring                                  |
| 18      | Camshaft Cover Spark Plug Port Seal - Left Side  |
| 19      | Camshaft Cover Gasket - Left Side                |



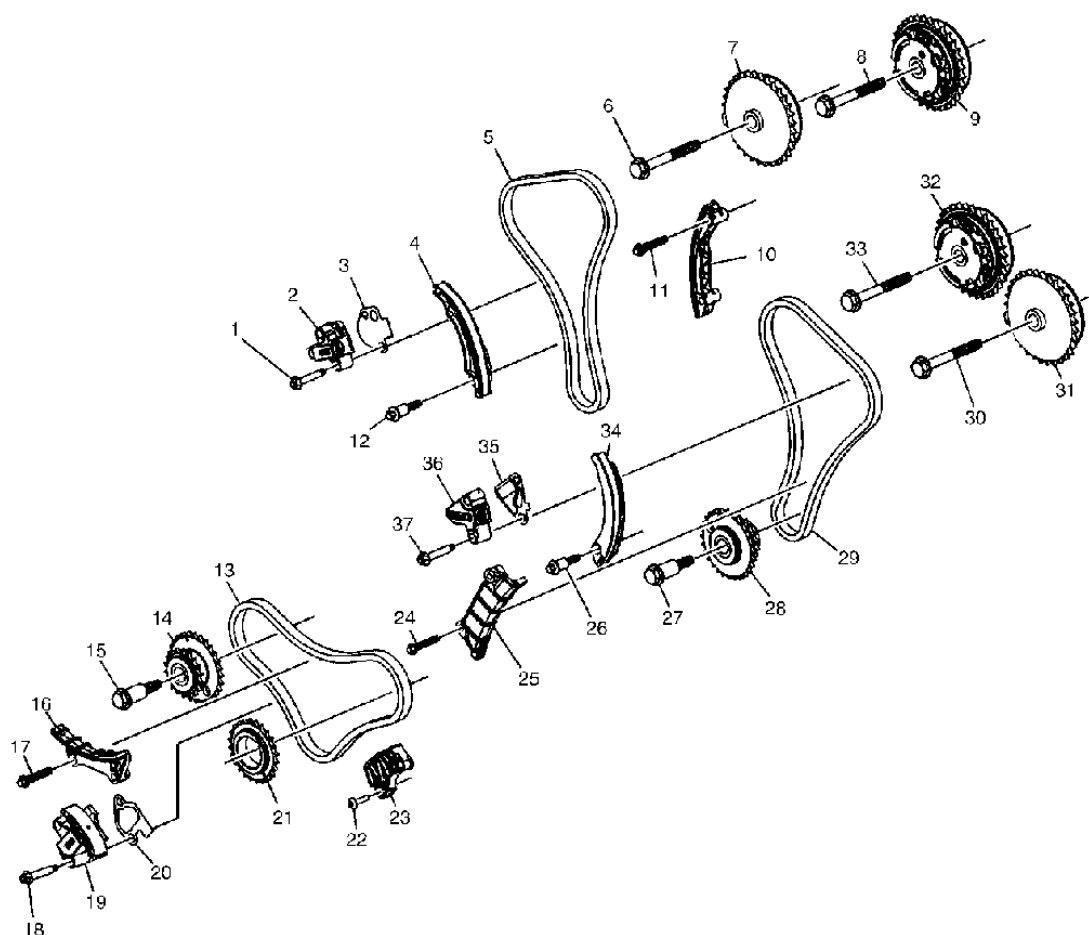
**Fig. 35: Camshaft Timing Components (LY7)**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                 |
|---------|----------------------------------------------------------------|
| 1       | Timing Chain Tensioner and Guide Bolt - Right Side             |
| 2       | Secondary Timing Chain Tensioner - Right Side                  |
| 3       | Secondary Timing Chain Tensioner Gasket - Right Side           |
| 4       | Secondary Timing Chain Shoe - Right Side                       |
| 5       | Secondary Timing Chain - Right Side                            |
| 6       | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 2 |
| 7       | Exhaust Camshaft Position Actuator - Bank 2                    |
| 8       | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 2 |
| 9       | Intake Camshaft Position Actuator - Bank 2                     |
| 10      | Secondary Timing Chain Guide Bolt - Right Side                 |
| 11      | Secondary Timing Chain Guide - Right Side                      |
| 12      | Secondary Timing Chain Shoe Bolt - Right Side                  |
| 13      | Primary Timing Chain                                           |

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|    |                                                                |
|----|----------------------------------------------------------------|
| 14 | Camshaft Intermediate Drive Chain Idler Sprocket               |
| 15 | Camshaft Intermediate Drive Chain Idler Sprocket Bolt          |
| 16 | Primary Timing Chain Upper Guide                               |
| 17 | Primary Timing Chain Guide Bolt                                |
| 18 | Primary Timing Chain Tensioner Bolt                            |
| 19 | Primary Timing Chain Tensioner                                 |
| 20 | Primary Timing Chain Tensioner Gasket                          |
| 21 | Crankshaft Sprocket                                            |
| 22 | Primary Timing Chain Lower Guide Bolt                          |
| 23 | Primary Timing Chain Lower Guide                               |
| 24 | Secondary Timing Chain Guide Bolt - Left Side                  |
| 25 | Secondary Timing Chain Guide - Left Side                       |
| 26 | Secondary Timing Chain Shoe Bolt - Left Side                   |
| 27 | Camshaft Intermediate Drive Shaft Sprocket Bolt - Left Side    |
| 28 | Camshaft Intermediate Drive Shaft Sprocket - Left Side         |
| 29 | Secondary Timing Chain - Left Side                             |
| 30 | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 1 |
| 31 | Exhaust Camshaft Position Actuator - Bank 1                    |
| 32 | Intake Camshaft Position Actuator - Bank 1                     |
| 33 | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 1 |
| 34 | Secondary Timing Chain Shoe - Left Side                        |
| 35 | Secondary Timing Chain Tensioner Gasket - Left Side            |
| 36 | Secondary Timing Chain Tensioner - Left Side                   |
| 37 | Timing Chain Tensioner Bolt - Left Side                        |



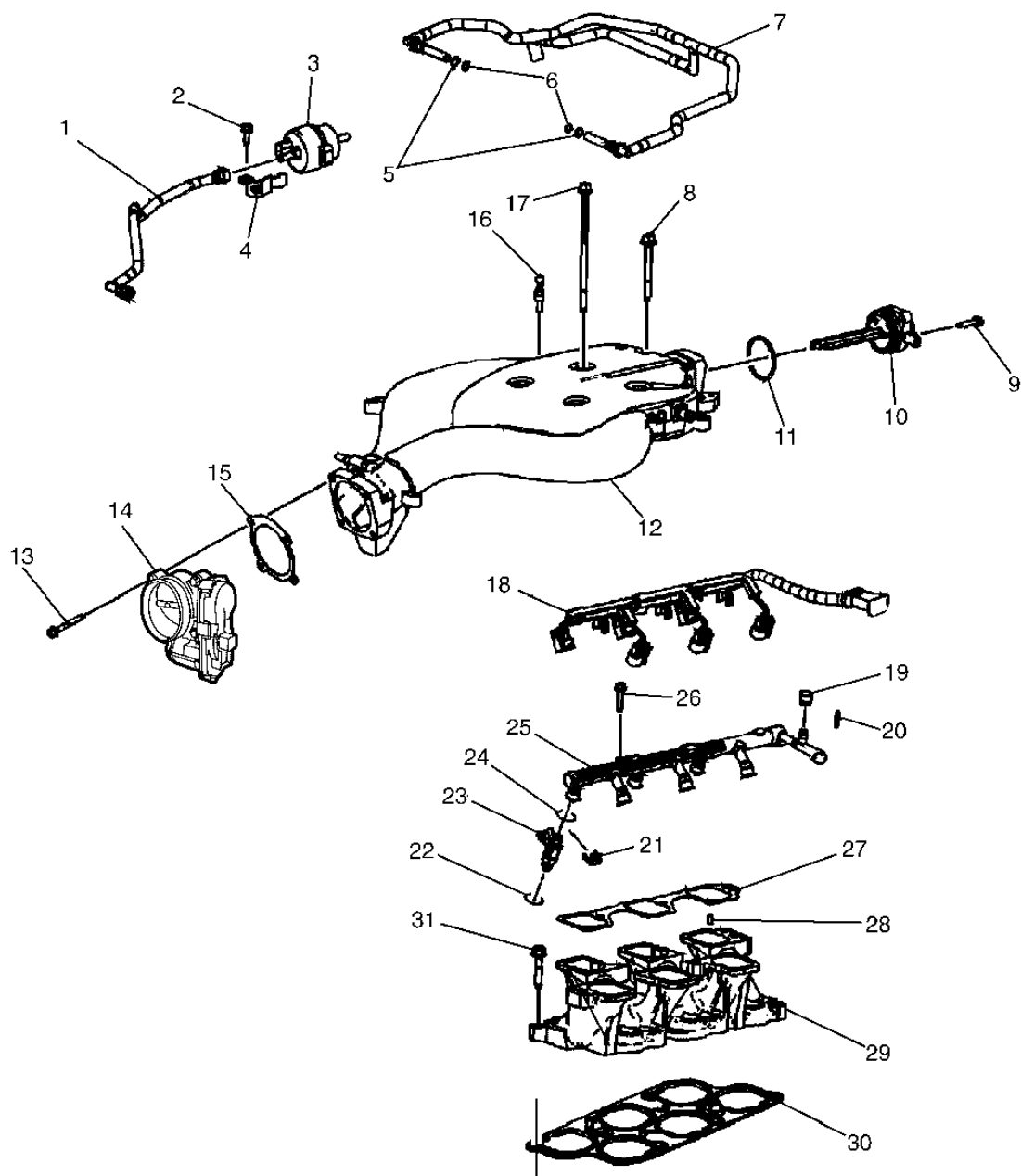
**Fig. 36: Camshaft Timing Components (LE0 & LW2)**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                 |
|---------|----------------------------------------------------------------|
| 1       | Timing Chain Tensioner and Guide Bolt - Right Side             |
| 2       | Secondary Timing Chain Tensioner - Right Side                  |
| 3       | Secondary Timing Chain Tensioner Gasket - Right Side           |
| 4       | Secondary Timing Chain Shoe - Right Side                       |
| 5       | Secondary Timing Chain - Right Side                            |
| 6       | Exhaust Camshaft Sprocket to Camshaft Retaining Bolt - Bank 2  |
| 7       | Exhaust Camshaft Sprocket - Bank 2                             |
| 8       | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 2 |
| 9       | Intake Camshaft Position Actuator - Bank 2                     |
| 10      | Secondary Timing Chain Guide Bolt - Right Side                 |
| 11      | Secondary Timing Chain Guide - Right Side                      |
| 12      | Secondary Timing Chain Shoe Bolt - Right Side                  |
| 13      | Primary Timing Chain                                           |

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|    |                                                                |
|----|----------------------------------------------------------------|
| 14 | Camshaft Intermediate Drive Chain Idler Sprocket               |
| 15 | Camshaft Intermediate Drive Chain Idler Sprocket Bolt          |
| 16 | Primary Timing Chain Upper Guide                               |
| 17 | Primary Timing Chain Guide Bolt                                |
| 18 | Primary Timing Chain Tensioner Bolt                            |
| 19 | Primary Timing Chain Tensioner                                 |
| 20 | Primary Timing Chain Tensioner Gasket                          |
| 21 | Crankshaft Sprocket                                            |
| 22 | Primary Timing Chain Lower Guide Bolt                          |
| 23 | Primary Timing Chain Lower Guide                               |
| 24 | Secondary Timing Chain Guide Bolt - Left Side                  |
| 25 | Secondary Timing Chain Guide - Left Side                       |
| 26 | Secondary Timing Chain Shoe Bolt - Left Side                   |
| 27 | Camshaft Intermediate Drive Shaft Sprocket Bolt - Left Side    |
| 28 | Camshaft Intermediate Drive Shaft Sprocket - Left Side         |
| 29 | Secondary Timing Chain - Left Side                             |
| 30 | Exhaust Camshaft Sprocket to Camshaft Retaining Bolt - Bank 1  |
| 31 | Exhaust Camshaft Sprocket - Bank 1                             |
| 32 | Intake Camshaft Position Actuator - Bank 1                     |
| 33 | Camshaft Position Actuator to Camshaft Retaining Bolt - Bank 1 |
| 34 | Secondary Timing Chain Shoe - Left Side                        |
| 35 | Secondary Timing Chain Tensioner Gasket - Left Side            |
| 36 | Secondary Timing Chain Tensioner - Left Side                   |
| 37 | Timing Chain Tensioner Bolt - Left Side                        |



**Fig. 37: Intake Manifold**

Courtesy of GENERAL MOTORS CORP.

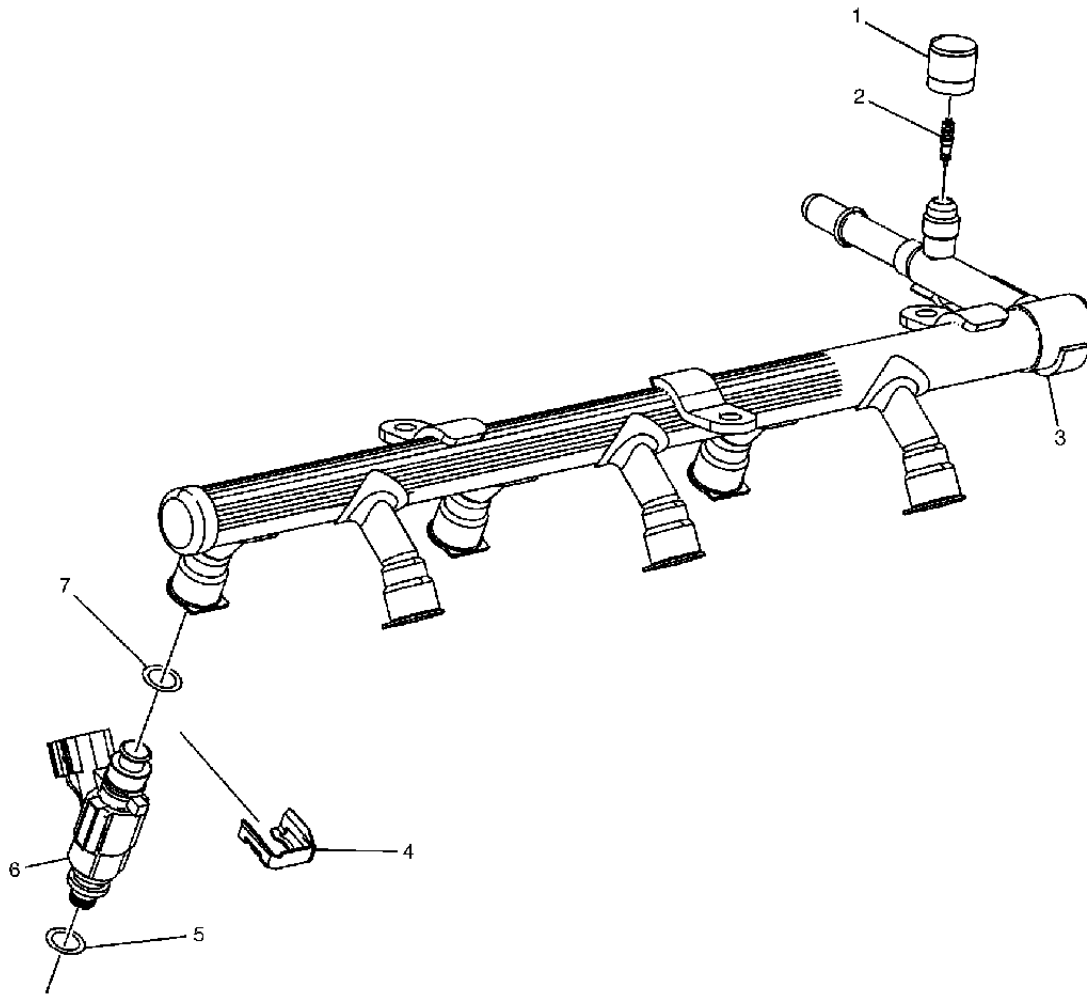
| Callout | Component Name                                                 |
|---------|----------------------------------------------------------------|
| 1       | Evaporative Emission (EVAP) Canister Purge Solenoid Valve Tube |
| 2       | EVAP Canister Purge Solenoid Valve Bolt                        |
| 3       | EVAP Canister Purge Solenoid Valve                             |
| 4       | EVAP Canister Purge Solenoid Valve Bracket                     |
| 5       | Positive Crankcase Ventilation (PCV) Hose O-Ring Outer/Larger  |

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|    |                                                          |
|----|----------------------------------------------------------|
| 6  | PCV Hose O-Ring Inner/Smaller                            |
| 7  | PCV Hose                                                 |
| 8  | Upper Intake Manifold Bolt - Short                       |
| 9  | Intake Manifold Runner Control Flap Retaining bolt       |
| 10 | Intake Manifold Runner Control Flap                      |
| 11 | Intake Manifold Runner Control Flap O-Ring               |
| 12 | Upper Intake Manifold Assembly                           |
| 13 | Throttle Body Retaining Bolt                             |
| 14 | Throttle Body                                            |
| 15 | Throttle Body Gasket                                     |
| 16 | Engine Cover Ball Stud                                   |
| 17 | Upper Intake Manifold Bolt - Long                        |
| 18 | Fuel Injector Wiring Harness                             |
| 19 | Fuel Pressure Service Valve Cap                          |
| 20 | Fuel Pressure Service Valve                              |
| 21 | Fuel Injector Retaining Clip                             |
| 22 | Fuel Injector Lower Seal                                 |
| 23 | Fuel Injector                                            |
| 24 | Fuel Injector Upper Seal                                 |
| 25 | Fuel Rail                                                |
| 26 | Fuel Rail Bolt                                           |
| 27 | Upper Intake Manifold Gasket                             |
| 28 | Lower Intake Manifold to Upper Intake Manifold Guide Pin |
| 29 | Lower Intake Manifold                                    |
| 30 | Lower Intake Manifold Gasket                             |
| 31 | Lower Intake Manifold Retaining Bolt                     |

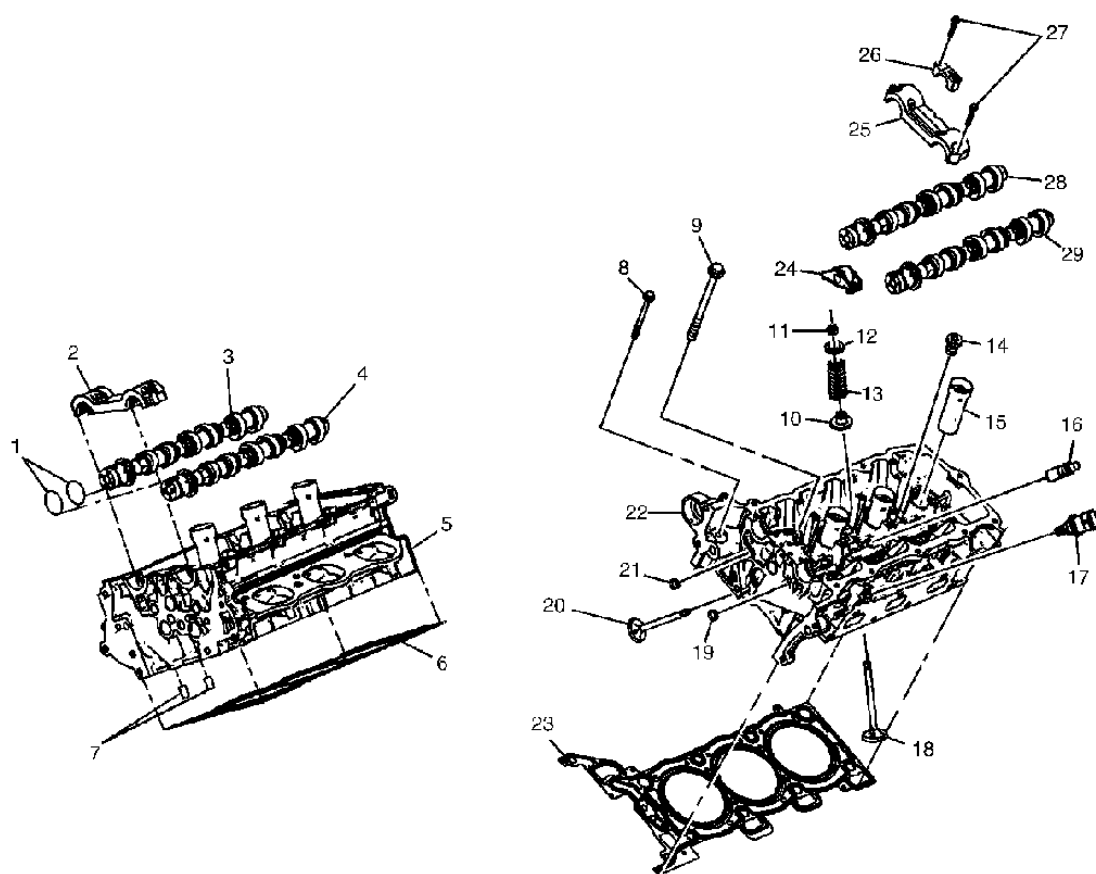




**Fig. 38: Fuel Rail**

Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                  |
|---------|---------------------------------|
| 1       | Fuel Pressure Service Valve Cap |
| 2       | Fuel Pressure Service Valve     |
| 3       | Fuel Rail                       |
| 4       | Fuel Injector Retainer          |
| 5       | Fuel Injector Lower Seal        |
| 6       | Fuel Injector                   |
| 7       | Fuel Injector Upper Seal        |



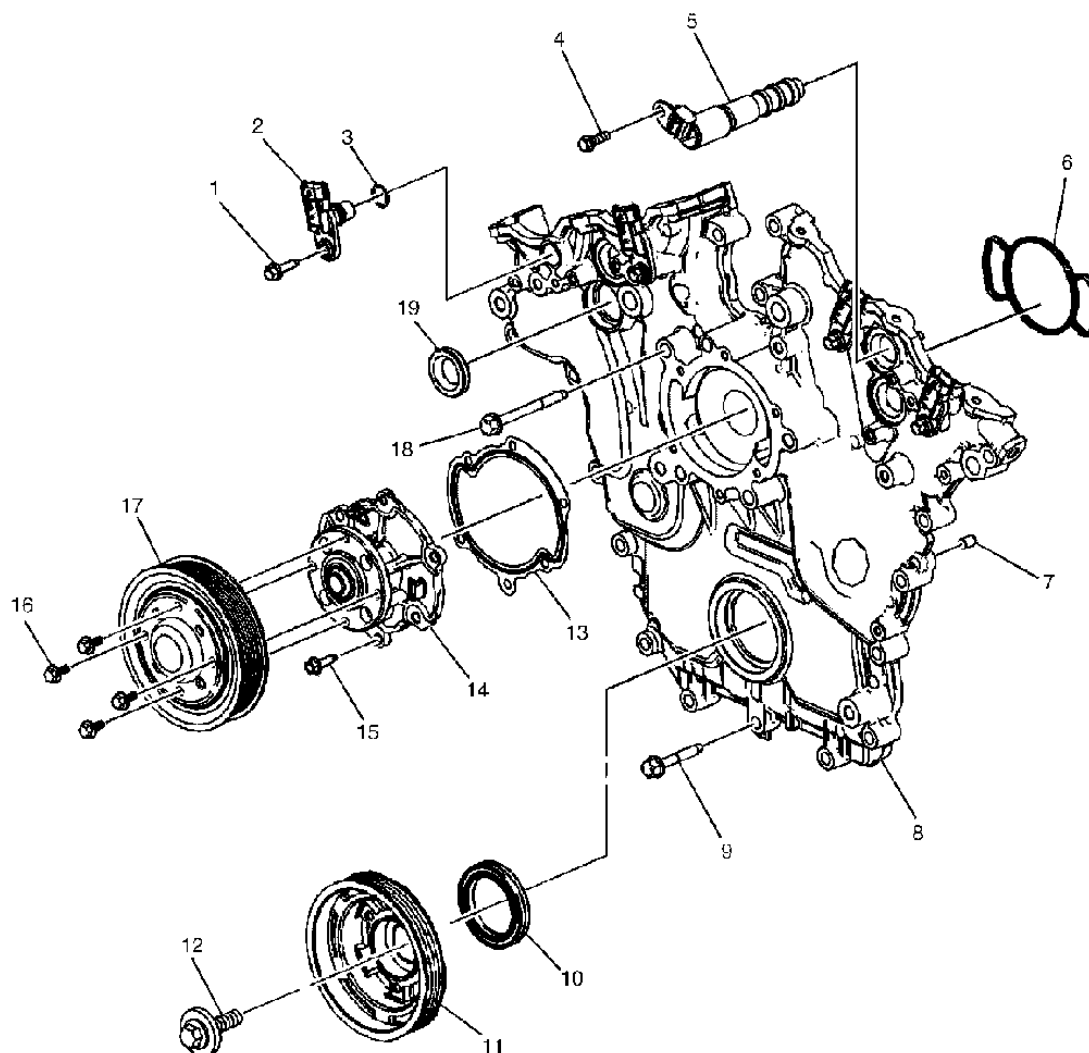
**Fig. 39: Cylinder Head Assemblies**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                  |
|---------|-------------------------------------------------|
| 1       | Camshaft Oil Seal Ring                          |
| 2       | Cylinder Head Camshaft Front Thrust Bearing Cap |
| 3       | Exhaust Camshaft - Right Side                   |
| 4       | Intake Camshaft - Right Side                    |
| 5       | Cylinder Head - Right Side                      |
| 6       | Cylinder Head Gasket - Right Side               |
| 7       | Cylinder Head Oil Gallery Check Valve           |
| 8       | Cylinder Head Front Bolt                        |
| 9       | Cylinder Head Bolt                              |
| 10      | Valve Stem Oil Seal                             |
| 11      | Valve Collets                                   |
| 12      | Valve Spring Cap                                |
| 13      | Valve Spring                                    |
| 14      | Cylinder Head Coolant Hole Threaded Plug        |
| 15      | Spark Plug Sleeve                               |

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|    |                                                  |
|----|--------------------------------------------------|
| 16 | Hydraulic Valve Lash Adjuster Assembly           |
| 17 | Engine Coolant Temperature Sensor                |
| 18 | Exhaust Valve                                    |
| 19 | Cylinder Head Oil Gallery Expansion Plug - 14 mm |
| 20 | Intake Valve                                     |
| 21 | Cylinder Head Oil Gallery Expansion Plug - 14 mm |
| 22 | Cylinder Head - Left Side                        |
| 23 | Cylinder Head Gasket - Left Side                 |
| 24 | Valve Rocker Arm Assembly                        |
| 25 | Cylinder Head Camshaft Front Thrust Bearing Cap  |
| 26 | Cylinder Head Camshaft Cap - Intermediate        |
| 27 | Cylinder Head Camshaft Cap Bolt                  |
| 28 | Intake Camshaft - Left Side                      |
| 29 | Exhaust Camshaft - Left Side                     |



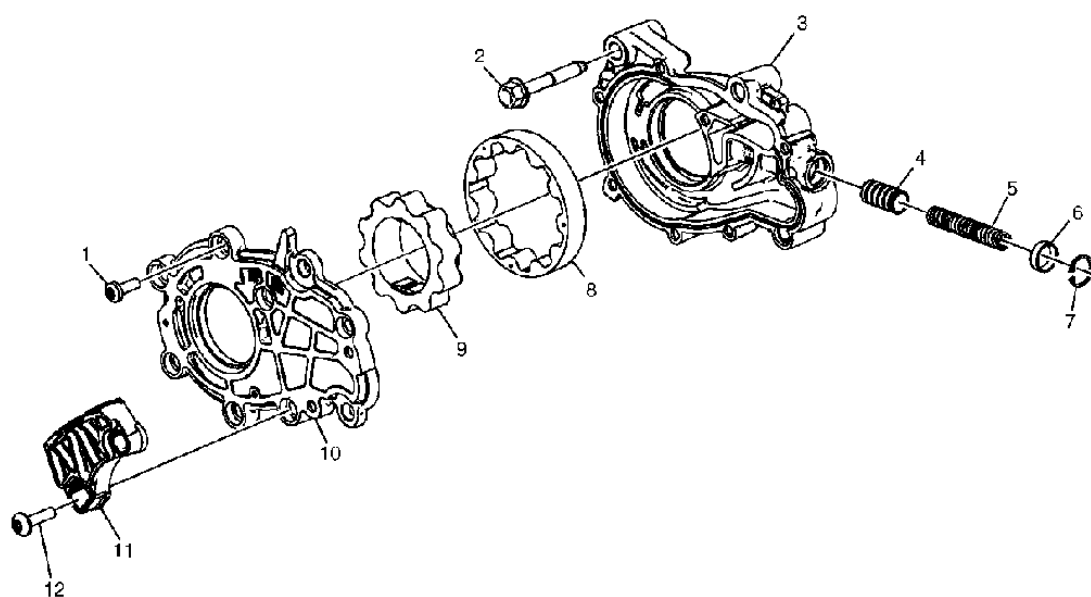
**Fig. 40: Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                                                 |
|---------|--------------------------------------------------------------------------------|
| 1       | Camshaft Position Sensor Bolt                                                  |
| 2       | Camshaft Position Sensor                                                       |
| 3       | Camshaft Position Sensor O-Ring                                                |
| 4       | Camshaft Position Actuator Solenoid Valve to Engine Front Cover Retaining Bolt |
| 5       | Camshaft Position Actuator Solenoid Valve                                      |
| 6       | Engine Front Cover to Cylinder Block Seal                                      |
| 7       | Engine Front Cover Guide Pin                                                   |
| 8       | Engine Front Cover                                                             |
| 9       | Engine Front Cover Retaining Bolt                                              |
| 10      | Crankshaft Front Oil Seal                                                      |

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|    |                                                |
|----|------------------------------------------------|
| 11 | Crankshaft Balancer                            |
| 12 | Crankshaft Balancer Bolt                       |
| 13 | Water Pump Gasket                              |
| 14 | Water Pump Assembly                            |
| 15 | Water Pump Bolt                                |
| 16 | Water Pump Pulley Bolt                         |
| 17 | Water Pump Pulley                              |
| 18 | Engine Front Cover Retaining Bolt              |
| 19 | Camshaft Position Actuator Solenoid Valve Seal |



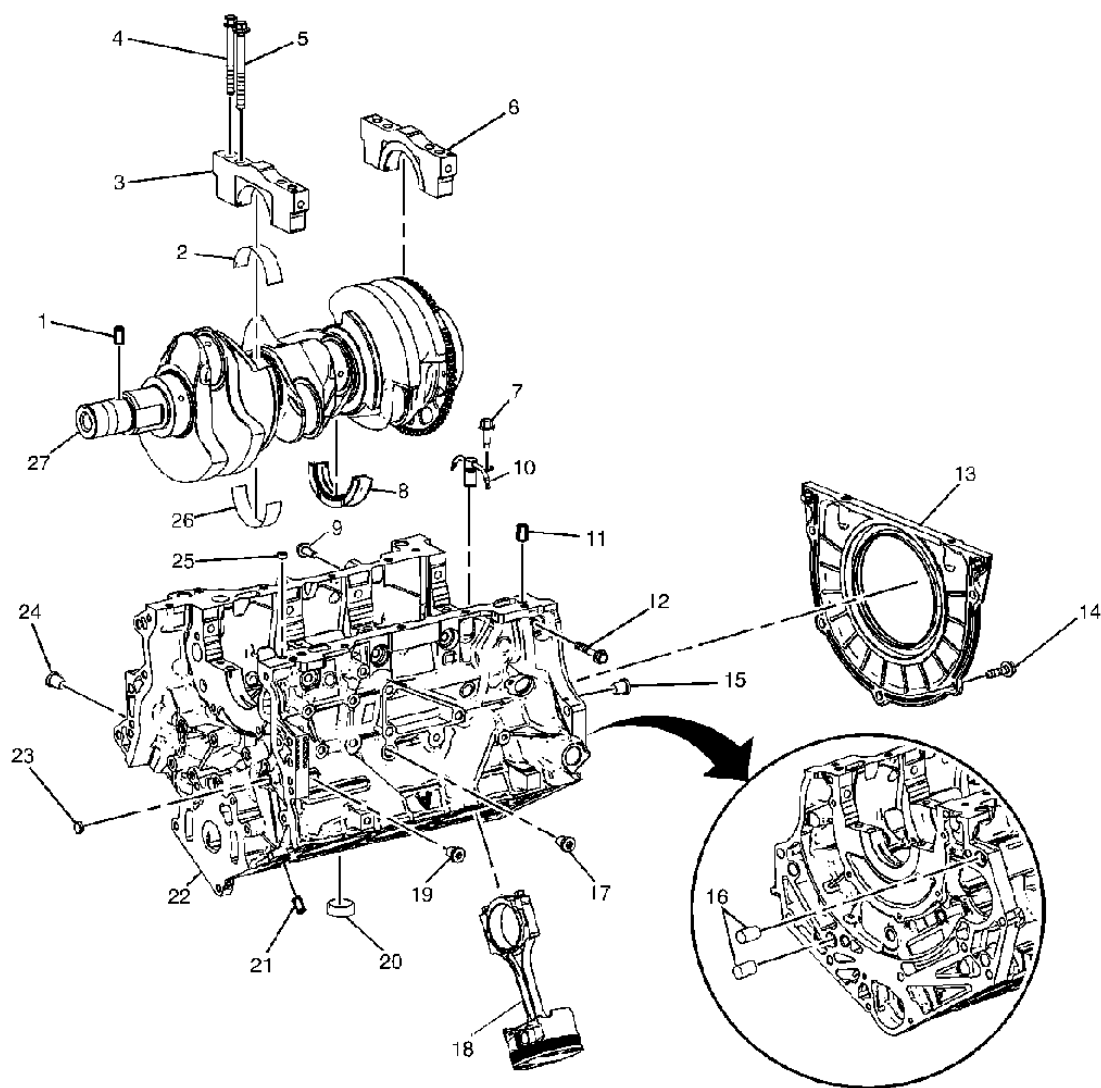
**Fig. 41: Oil Pump**

Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                                    |
|---------|---------------------------------------------------|
| 1       | Oil Pump Cover Retaining Bolt                     |
| 2       | Oil Pump Retaining Bolt                           |
| 3       | Oil Pump Housing                                  |
| 4       | Oil Pressure Relief Valve                         |
| 5       | Oil Pressure Relief Valve Spring                  |
| 6       | Oil Pressure Relief Valve Bore Plug               |
| 7       | Oil Pressure Relief Valve Bore Plug Retainer Clip |
| 8       | Oil Pump Driven Gear                              |
| 9       | Oil Pump Drive Gear                               |
| 10      | Oil Pump Cover                                    |
| 11      | Primary Camshaft Drive Chain Lower Guide          |

12

Primary Camshaft Drive Chain Lower Guide Retaining Bolt



**Fig. 42: Engine Block Assembly**

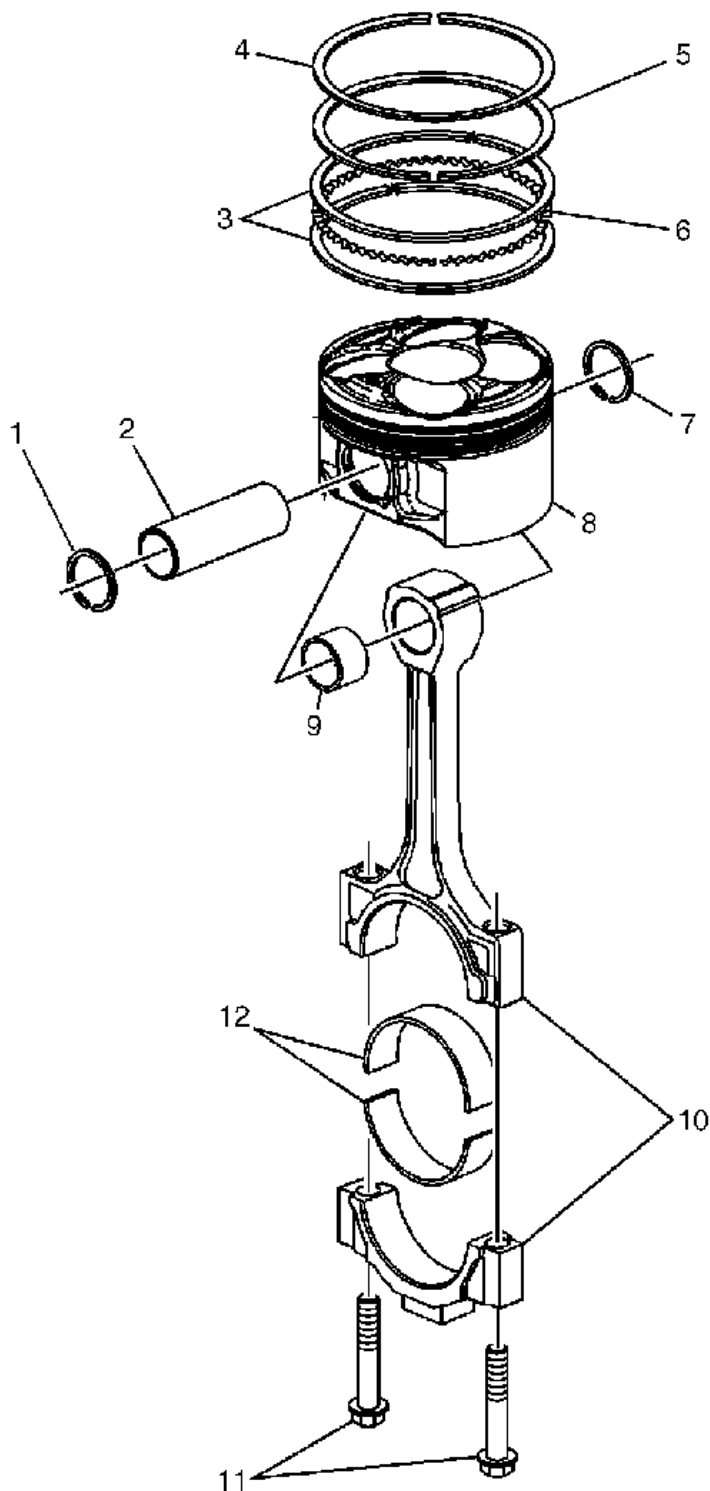
Courtesy of GENERAL MOTORS CORP.

| Callout | Component Name                       |
|---------|--------------------------------------|
| 1       | Crankshaft Sprocket Pin              |
| 2       | Crankshaft Lower Bearing             |
| 3       | Crankshaft Bearing Cap               |
| 4       | Crankshaft Bearing Cap Outboard Bolt |
| 5       | Crankshaft Bearing Cap Inboard Bolt  |
| 6       | Crankshaft Bearing Thrust Cap        |
| 7       | Oil Jet Retaining Bolt               |
|         |                                      |

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|    |                                                    |
|----|----------------------------------------------------|
| 8  | Oil Jet                                            |
| 9  | Crankshaft Upper Thrust Bearing #3                 |
| 10 | Cylinder Block-to-Oil Pan Alignment Dowels         |
| 11 | Crankshaft Bearing Cap Side Bolt - Long            |
| 12 | Engine Block Oil Gallery Threaded Plug - 14 mm     |
| 13 | Crankshaft Rear Oil Seal Housing Assembly          |
| 14 | Crankshaft Rear Oil Seal Housing Assembly Bolt     |
| 15 | Cylinder Block-to-Transmission Alignment Dowels    |
| 16 | Engine Block Coolant Drain Threaded Plug - 14 mm   |
| 17 | Piston and Connecting Rod Assembly                 |
| 18 | Engine Block Oil Gallery Threaded Plug - 14 mm     |
| 19 | Engine Block Core Coolant Expansion Plug - 34.3 mm |
| 20 | Cylinder Head Locating Pin                         |
| 21 | Engine Block                                       |
| 22 | Engine Block Oil Gallery Expansion Plug - 14 mm    |
| 23 | Engine Block Oil Gallery Threaded Plug - 20 mm     |
| 24 | Engine Block Oil Gallery Expansion Plug - 10 mm    |
| 25 | Crankshaft Bearing Cap Side Bolt - Short           |
| 26 | Crankshaft Upper Bearing                           |
| 27 | Crankshaft                                         |



**Fig. 43: Piston, Rings, Bearing and Connecting Rod**  
 Courtesy of GENERAL MOTORS CORP.

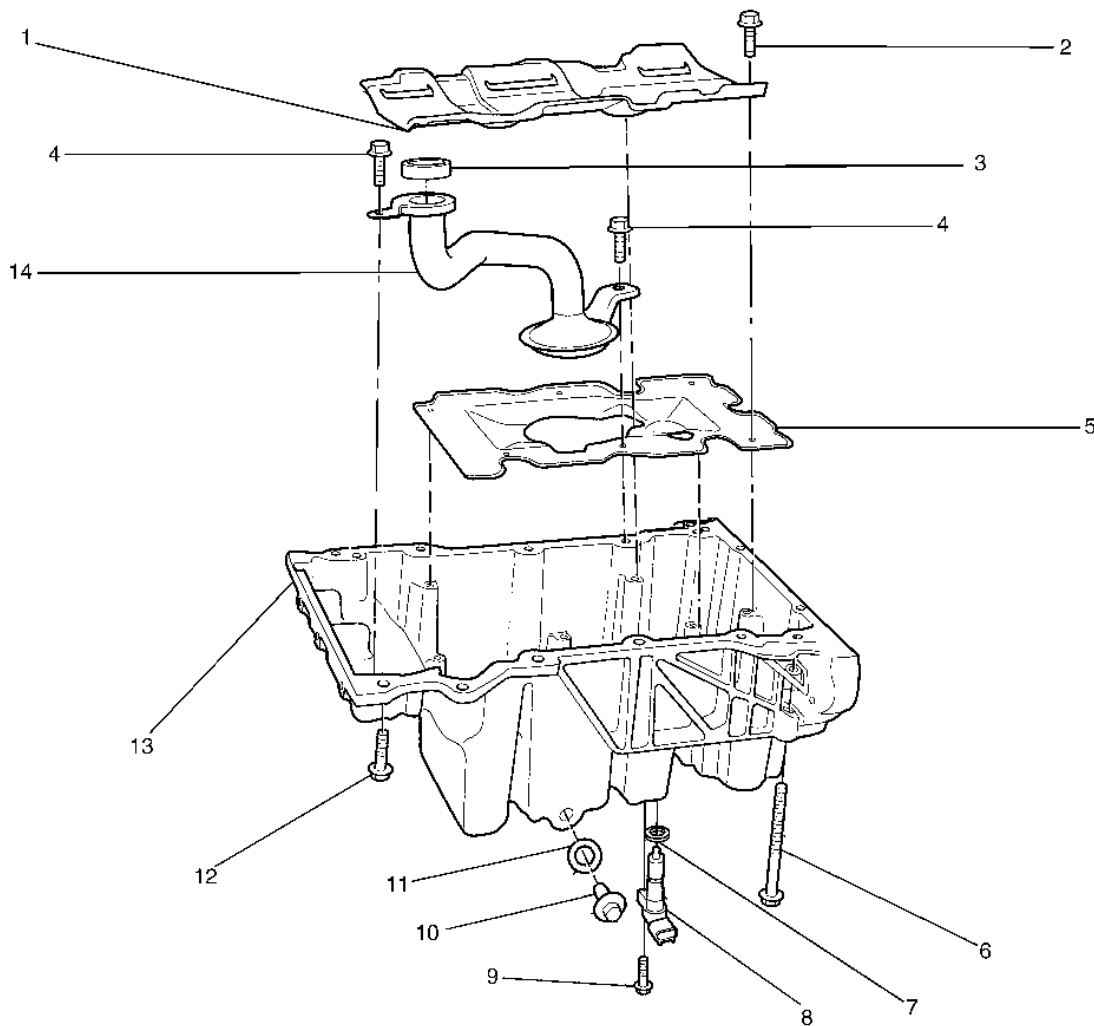
| Callout | Component Name |
|---------|----------------|
|         |                |



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|    |                                |
|----|--------------------------------|
| 1  | Piston Pin Retainer            |
| 2  | Piston Pin                     |
| 3  | Piston Oil Control Rail Ring   |
| 4  | Piston Upper Compression Ring  |
| 5  | Piston Lower Compression Ring  |
| 6  | Piston Oil Control Ring Spacer |
| 7  | Piston Pin Retainer            |
| 8  | Piston                         |
| 9  | Connecting Rod Bushing         |
| 10 | Connecting Rod                 |
| 11 | Connecting Rod Bolt            |
| 12 | Connecting Rod Bearing         |



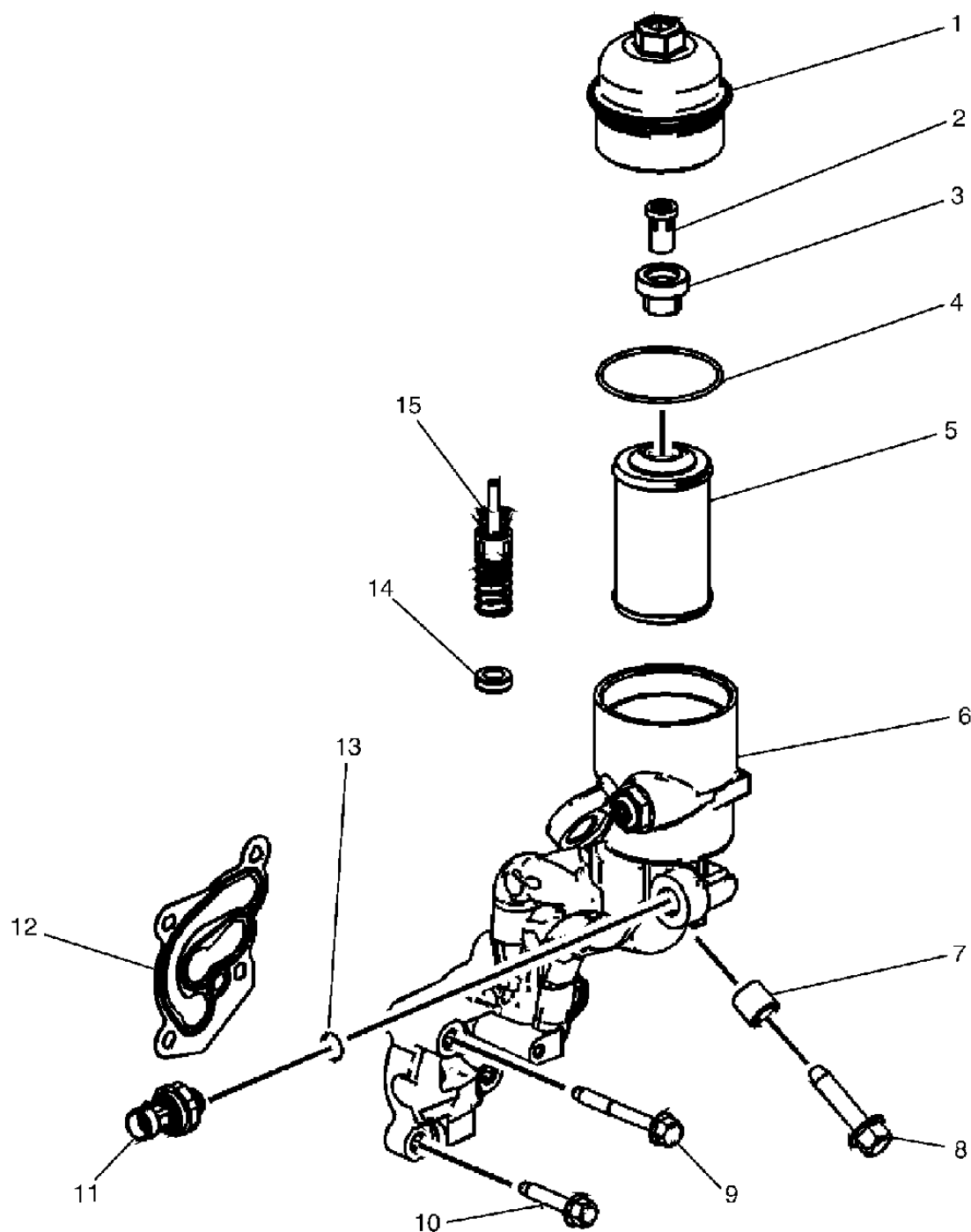
**Fig. 44: Oil Pan Assembly**

Courtesy of GENERAL MOTORS CORP.

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| <b>Callout</b> | <b>Component Name</b>                      |
|----------------|--------------------------------------------|
| 1              | Oil Pan Baffle Scraper                     |
| 2              | Oil Pan Scraper to Oil Pan Retaining Bolt  |
| 3              | Oil Pump Suction Pipe Seal                 |
| 4              | Oil Suction Pipe to Oil Pan Retaining Bolt |
| 5              | Oil Pan Baffle                             |
| 6              | Oil Pan Bolt - Long                        |
| 7              | Engine Oil Level Sensor O-Ring             |
| 8              | Engine Oil Level Sensor                    |
| 9              | Engine Oil Level Sensor Bolt               |
| 10             | Oil Pan Drain Plug                         |
| 11             | Oil Pan Drain Plug O-Ring                  |
| 12             | Oil Pan Bolt - Short                       |
| 13             | Oil Pan                                    |
| 14             | Oil Pump Suction Pipe                      |



**Fig. 45: Oil Filter Adapter**

Courtesy of GENERAL MOTORS CORP.

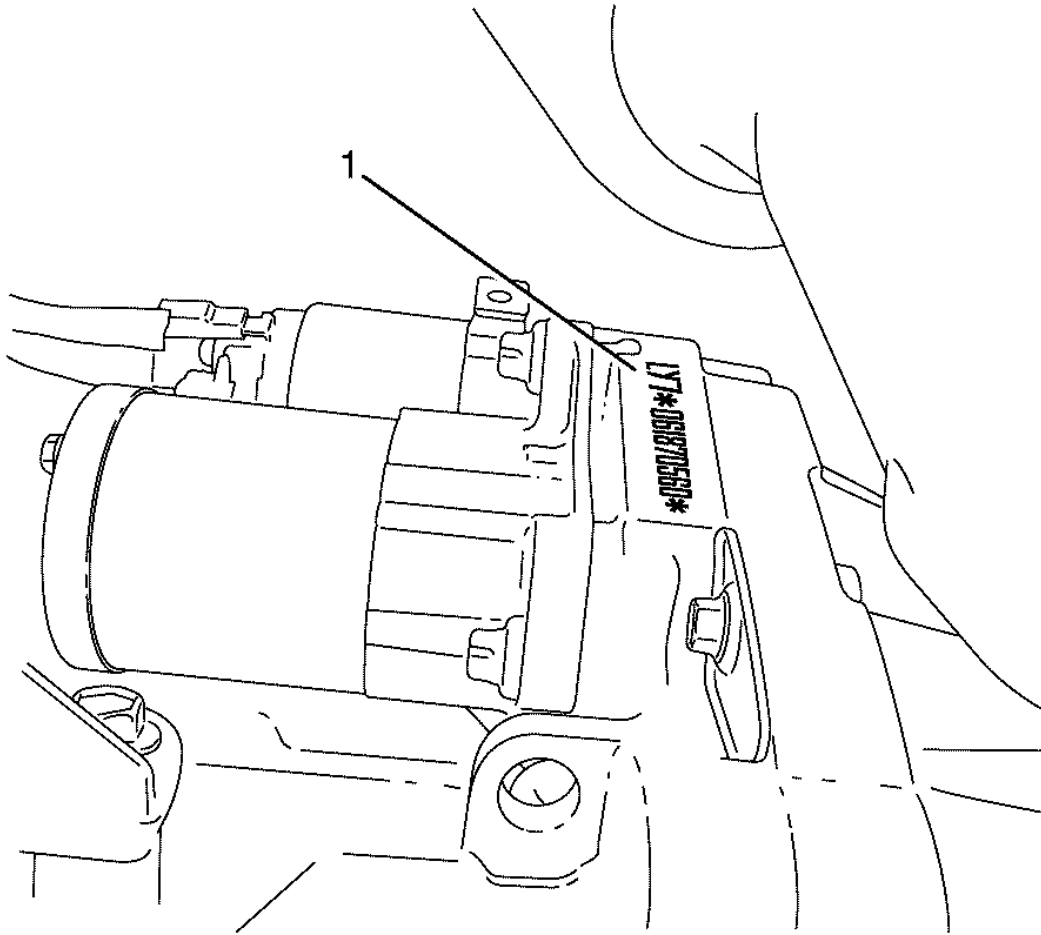
| Callout | Component Name          |
|---------|-------------------------|
| 1       | Oil Filter AdapterCap   |
| 2       | Oil Filter Bypass Valve |

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|    |                                   |
|----|-----------------------------------|
| 3  | Drain Valve Assembly              |
| 4  | Oil Filter Cap O-ring             |
| 5  | Oil Filter Cartridge              |
| 6  | Oil Filter Adapter                |
| 7  | Oil Filter Adapter Bolt Sleeve    |
| 8  | Oil Filter Adapter Bolt - Large   |
| 9  | Oil Filter Adapter Bolt - Long    |
| 10 | Oil Filter Adapter Bolt           |
| 11 | Engine Oil Pressure Sensor        |
| 12 | Oil Filter Adapter Gasket         |
| 13 | Engine Oil Pressure Sensor O-ring |
| 14 | Drain Valve Assembly Seal         |
| 15 | Oil Filter Bypass Valve Body      |

### ENGINE IDENTIFICATION



**Fig. 46: Locating Engine Serial Number**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The location of the Engine Serial Number has changed from the previous model. The vehicle must be raised to view the Engine Serial Number as it can only be seen from underneath the vehicle.

The Engine Serial Number is located on the left-hand side at the rear of the engine cylinder block (1) and is stamped or laser etched onto the block at the assembly plant. When reading the Engine Serial Number the following information can be obtained:

Engine Serial Number LY7061870560 is used as an example:

- The first three digits, LY7, identify the engine model by its Regular Production Option (RPO) code as an LY7 engine.
- The next digit, 0, is a number limiter and has no meaning.

- The next two digits, 06, identify the build year as 2006.
- The next three digits, 187, identify the Julian date the engine was manufactured as day 187.
- The next four digits, 0560, identify the assembly plant sequence number as 0560.
- The next digit, , is a number limiter and has no meaning.

## DIAGNOSTIC INFORMATION AND PROCEDURES

### DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, **Drive Belt System Description** and **Lubrication Description**. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to **Symptoms - Engine Mechanical** to identify the correct procedure for diagnosing the system and where the procedure is located.

### SYMPTOMS - ENGINE MECHANICAL

#### Strategy Based Diagnostics

1. Perform a **Diagnostic System Check - Vehicle** , before using the symptom tables, if applicable.
2. Review the system operations in order to familiarise yourself with the system functions. Refer to **Disassembled Views** and **Engine Component Description** and **Drive Belt System Description** 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. For a detailed explanation, refer to **Strategy Based Diagnosis** .

#### Visual/Physical Inspection

- Inspect for aftermarket devices which may affect the operation of the engine. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which may cause the symptom.
- Check for the correct oil level, correct 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

correctly.

### 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.**

### BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

| Cause                                                                                                                                                                                                                                                                                 | Correction                                                                                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Abnormalities, extreme 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. Refer to <b><u>Drive Belt Replacement</u></b> .                                                                                           |
| Worn, damaged, or mis-aligned accessory drive components or pulley runout above acceptable tolerances may lead to a misfire DTC.<br>A misfire code may be present without an actual misfire condition.                                                                                | Inspect the components:<br>Repair or replace as required.                                                                                                         |
| Loose or incorrectly 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. Refer to <b><u>Engine Flywheel Replacement</u></b> or <b><u>Crankshaft Balancer Replacement</u></b> . |
| Restricted exhaust system.<br>An extreme restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include                                                                                                  | Repair or replace as required. Refer to <b><u>ENGINE EXHAUST</u></b> for the required procedure.                                                                  |

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|                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| collapsed or dented pipes or plugged mufflers and/or catalytic converters.                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                         |
| Incorrectly installed or damaged vacuum hoses.                                                                                                                                                                                                                         | Repair or replace as required.                                                                                                                                                                                                                                                                                                                                                          |
| Incorrect sealing between the intake manifold and cylinder heads, intake manifold and throttle body and/or pressure relief valve and intake manifold.                                                                                                                  | Replace the intake manifold, plenum duct, cylinder heads, throttle body, pressure relief valve or gaskets as required.                                                                                                                                                                                                                                                                  |
| Incorrectly installed or damaged EVAP purge solenoid and/or O-ring seal.                                                                                                                                                                                               | Repair or replace the EVAP purge solenoid as required.                                                                                                                                                                                                                                                                                                                                  |
| Worn or loose Stationary Hydraulic Lash Adjusters (SHLAs), valve rocker arms.<br>The stationary hydraulic lash adjusters (SHLAs), valve rocker arm, roller bearing should be intact and in the correct position                                                        | Replace the SHLAs, valve rocker arms, as required.                                                                                                                                                                                                                                                                                                                                      |
| Sticking valves.<br>Carbon buildup on the valve stem can cause the valve not to close correctly.                                                                                                                                                                       | Repair or replace as required.                                                                                                                                                                                                                                                                                                                                                          |
| Timing chain or chains worn or mis-aligned above acceptable tolerances.                                                                                                                                                                                                | Replace the timing chain or chains and sprockets as required.                                                                                                                                                                                                                                                                                                                           |
| Worn camshaft lobes.                                                                                                                                                                                                                                                   | Replace the camshaft or camshafts and high Stationary Hydraulic Lash Adjusters (SHLAs), valve lifters.                                                                                                                                                                                                                                                                                  |
| Oil pressure above acceptable tolerances.<br>A lubrication system with oil pressure above acceptable tolerances may lead to valve lifter pump-up above acceptable tolerances 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 cylinder block cooling system passages. Refer to <b><u>Diagnostic Starting Point - Engine Cooling</u></b> .<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. Refer to <b><u>Spark Plug Inspection</u></b> .</li> <li>• Inspect the cylinder heads, cylinder 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. Refer to <b><u>Spark Plug Inspection</u></b> .</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.                                                                                                     | Replace the crankshaft as required.                                                                                                                                                                                                                                                                                                                                                     |



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- Systems with EXTREME reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.
- Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.

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

| Cause                                                                                                                                                                                                                                                                                                                                    | Correction                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Abnormalities, extreme 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, 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. | Replace the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .                                                                                                                                                                                                                                                                                                             |
| Worn, damaged, or mis-aligned accessory drive components or pulley runout above acceptable tolerances.<br>A misfire code may be present without an actual misfire condition.                                                                                                                                                             | Inspect the components, repair or replace as required.                                                                                                                                                                                                                                                                                                                              |
| Loose or incorrectly installed engine flywheel or crankshaft balancer.<br>A misfire code may be present without an actual misfire condition.                                                                                                                                                                                             | Repair or replace the engine flywheel and/or crankshaft balancer as required. Refer to <b><u>Engine Flywheel Replacement</u></b> or <b><u>Crankshaft Balancer Replacement</u></b> .                                                                                                                                                                                                 |
| Worn or broken 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. Refer to <b><u>Spark Plug Inspection</u></b> .</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**

| Cause | Correction |
|-------|------------|
|-------|------------|

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|                                                                                                                                                                            |                                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Worn or loose Stationary Hydraulic Lash Adjusters (SHLAs), valve rocker arms.<br>The SHLAs, valve rocker arm, roller bearing should be intact and in the correct position. | Replace the SHLAs, valve rocker arms, as required.               |
| Sticking valves.<br>Carbon buildup on the valve stem can cause the valve not to close correctly.                                                                           | Repair or replace as required.                                   |
| Worn or mis-aligned above acceptable tolerances timing chain or chains.                                                                                                    | Replace the timing chain or chains and sprockets as required.    |
| Worn camshaft lobes.                                                                                                                                                       | Replace the camshaft or camshafts and high SHLAs, valve lifters. |
| Sticking SHLAs, lifters.                                                                                                                                                   | Replace the SHLAs as required.                                   |

**BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION**

| Cause                                                                                                                                                                                                                                                                  | Correction                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and cylinder block cooling system passages. Refer to <b><u>Diagnostic Starting Point - Engine Cooling</u></b> .<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. Refer to <b><u>Spark Plug Inspection</u></b> .</li> <li>Perform a cylinder leak down test. Refer to <b><u>Cylinder Leakage Test</u></b></li> <li>Inspect the cylinder heads and cylinder 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**

| Cause                                                                             | Correction                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Worn valves, valve guides and/or valve stem oil seals.                            | <ol style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits. Refer to <b><u>Spark Plug Inspection</u></b> .</li> <li>Repair or replace as required.</li> </ol>                                                                                                                                                                                             |
| Worn piston rings.<br>Oil consumption may or may not cause the engine to misfire. | <ol style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits. Refer to <b><u>Spark Plug Inspection</u></b></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> </ol> |

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

| Cause | Correction |
|-------|------------|
|-------|------------|

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|                                                                               |                                                                                                                                                             |
|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Incorrect oil filter.                                                         | Install the correct oil filter.                                                                                                                             |
| Incorrect oil viscosity.                                                      | Drain the engine oil and replace with the correct viscosity oil.                                                                                            |
| High Stationary Hydraulic Lash Adjuster (SHLA), valve lifter, leak down rate. | Replace the SHLAs, valve lifters, as required.                                                                                                              |
| Worn crankshaft thrust bearing.                                               | <ul style="list-style-type: none"><li>• Inspect the thrust bearing and crankshaft.</li><li>• Repair or replace as required.</li></ul>                       |
| Damaged or faulty oil filter by-pass valve.                                   | <ul style="list-style-type: none"><li>• Inspect the oil filter by-pass valve for correct operation.</li><li>• Replace the oil filter as required.</li></ul> |

**UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED**

| <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>                                                                                                                                                                   |
| Loose and/or worn Stationary Hydraulic Lash Adjuster (SHLA), valve rocker arm. | <ol style="list-style-type: none"><li>1. Inspect the SHLA, valve rocker arm.</li><li>2. Repair or replace as required.</li></ol>                                                                                                                                                                                                                        |
| Incorrect lubrication to the SHLAs, valve rocker arms.                         | Inspect the following components, and repair or replace as required: <ul style="list-style-type: none"><li>• The SHLA, valve rocker arm</li><li>• The high stationary SHLA, valve lifter</li><li>• The oil filter</li><li>• The oil pump and pump screen</li><li>• The cylinder head oil galleries</li><li>• The cylinder block oil galleries</li></ul> |
| Broken valve spring                                                            | Replace the valve spring.                                                                                                                                                                                                                                                                                                                               |
| Worn or dirty SHLAs, valve lifters                                             | Replace the SHLAs, valve lifters.                                                                                                                                                                                                                                                                                                                       |
| Stretched or broken timing chain or chains and/or damaged sprocket teeth       | Replace the timing chain or chains and sprockets.                                                                                                                                                                                                                                                                                                       |
| Worn timing chain tensioner or tensioners                                      | Replace the timing chain tensioner or tensioners as required.                                                                                                                                                                                                                                                                                           |
| Worn timing chain shoe or shoes                                                | Replace the timing chain shoe or shoes as required.                                                                                                                                                                                                                                                                                                     |
| Worn timing chain guide or guides                                              | Replace the timing chain guide or guides as required.                                                                                                                                                                                                                                                                                                   |
| Worn engine camshaft lobes                                                     | <ol style="list-style-type: none"><li>1. Inspect the engine camshaft lobes.</li><li>2. Replace the camshaft or camshafts and SHLAs, valve lifters, as required.</li></ol>                                                                                                                                                                               |
| Worn valve guides or valve stems                                               | Inspect the following components, and repair as                                                                                                                                                                                                                                                                                                         |

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|                                                                                                                                                     |                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                     | required:                                                                                                                                            |
|                                                                                                                                                     | <ul style="list-style-type: none"> <li>• The valves</li> <li>• The valve guides</li> </ul>                                                           |
| <ul style="list-style-type: none"> <li>• Stuck valves</li> <li>• Carbon on the valve stem or valve seat may cause the valve to stay open</li> </ul> | 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**

| <b>Cause</b>                                                                                                                                                                                                                                | <b>Correction</b>                                                                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low oil pressure.                                                                                                                                                                                                                           | 1. Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b> .<br>2. Repair or replace damaged components as required. |
| <ul style="list-style-type: none"> <li>• Worn accessory drive components.</li> <li>• Abnormalities such as extreme cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.</li> </ul>        | 1. Inspect the accessory drive system.<br>2. Repair or replace as required.                                                                          |
| Loose or damaged crankshaft balancer.                                                                                                                                                                                                       | 1. Inspect the crankshaft balancer.<br>2. Repair or replace as required.                                                                             |
| Detonation or spark knock.                                                                                                                                                                                                                  | Verify the correct operation of the ignition controls system. Refer to <b><u>Electronic Ignition System Diagnosis</u></b> .                          |
| Loose torque converter bolts.                                                                                                                                                                                                               | 1. Inspect the torque converter bolts and engine flywheel.<br>2. Repair or replace as required.                                                      |
| Loose or damaged engine flywheel.                                                                                                                                                                                                           | Repair or replace the engine flywheel.                                                                                                               |
| <ul style="list-style-type: none"> <li>• Damaged oil pan, contacting the oil pump screen.</li> <li>• An oil pan that has been damaged may incorrectly position the oil pump screen, preventing correct oil flow to the oil pump.</li> </ul> | 1. Inspect the oil pan.<br>2. Inspect the oil pump screen.<br>3. Repair or replace as required.                                                      |
| Oil pump screen loose, damaged or restricted.                                                                                                                                                                                               | 1. Inspect the oil pump screen.<br>2. Repair or replace as required.                                                                                 |
| Piston-to-cylinder bore clearance above acceptable tolerances.                                                                                                                                                                              | 1. Inspect the piston and cylinder bore.<br>2. Repair as required.                                                                                   |
| Piston pin-to-bore clearance above acceptable                                                                                                                                                                                               | 1. Inspect the piston, piston pin, and the                                                                                                           |

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|                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| tolerances.                                                                                                                                                                                                                                                                                          | connecting rod.<br>2. Repair or replace as required.                                                                                                                                                                                  |
| Connecting rod bearing clearance above acceptable tolerances.                                                                                                                                                                                                                                        | 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> |
| Crankshaft bearing clearance above acceptable tolerances.                                                                                                                                                                                                                                            | 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>                                                              |
| <ul style="list-style-type: none"> <li>• Incorrect piston, piston pin and connecting rod installation.</li> <li>• 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.</li> </ul> | 1. Verify the pistons, piston pins and connecting rods are installed correctly.<br>2. Repair as required.                                                                                                                             |

**ENGINE NOISE UNDER LOAD**

| <b>Cause</b>                                                  | <b>Correction</b>                                                                                                                                                                                  |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low oil pressure.                                             | 1. Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b> .<br>2. Repair or replace as required.                                                                  |
| Detonation or spark knock.                                    | Verify the correct operation of the ignition controls. Refer to <b><u>Electronic Ignition System Diagnosis</u></b> .                                                                               |
| Loose torque converter bolts.                                 | 1. Inspect the torque converter bolts and engine flywheel.<br>2. Repair as required.                                                                                                               |
| Cracked engine flywheel.                                      | 1. Inspect the engine flywheel and bolts.<br>2. Repair as required.                                                                                                                                |
| Connecting rod bearing clearance above acceptable tolerances. | 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> |
| Crankshaft bearing clearance above acceptable tolerances.     | Inspect the following components, and repair as required:                                                                                                                                          |

- The crankshaft bearings
- The crankshaft journals
- The cylinder block crankshaft bearing bore

## ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

| Cause                                                                                                                                                                       | Correction                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Seized accessory drive system component.                                                                                                                                    | <ol style="list-style-type: none"> <li>1. Remove the accessory drive belt or belts.</li> <li>2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location.</li> <li>3. Repair or replace as required.</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 the spark plugs and check for fluid.</li> <li>2. Inspect for broken head gasket or gaskets.</li> <li>3. Inspect for cracked cylinder block or cylinder head.</li> <li>4. Inspect for a sticking fuel injector.</li> <li>5. Repair or replace as required.</li> </ol> |
| Seized automatic transmission torque converter.                                                                                                                             | <ol style="list-style-type: none"> <li>1. Remove the torque converter bolts.</li> <li>2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location.</li> <li>3. Repair or replace as required.</li> </ol>                                                                              |
| Material in cylinder. <ul style="list-style-type: none"> <li>• Broken valve.</li> <li>• Piston material.</li> <li>• Foreign material.</li> </ul>                            | <ol style="list-style-type: none"> <li>1. Inspect the cylinder for damaged components and/or foreign materials.</li> <li>2. Repair or replace as required.</li> </ol>                                                                                                                                                 |
| Seized crankshaft or connecting rod bearings.                                                                                                                               | <ol style="list-style-type: none"> <li>1. Inspect the crankshaft and the connecting rod bearings.</li> <li>2. Repair as required.</li> </ol>                                                                                                                                                                          |
| Bent or broken connecting rod.                                                                                                                                              | <ol style="list-style-type: none"> <li>1. Inspect the connecting rods.</li> <li>2. Repair as required.</li> </ol>                                                                                                                                                                                                     |
| Broken crankshaft.                                                                                                                                                          | <ol style="list-style-type: none"> <li>1. Inspect the crankshaft.</li> <li>2. Repair as required.</li> </ol>                                                                                                                                                                                                          |
| Seized or broken camshaft.                                                                                                                                                  | <ol style="list-style-type: none"> <li>1. Inspect the camshaft or camshafts.</li> <li>2. Inspect the cylinder head camshaft journals for damage.</li> <li>3. Repair as required.</li> </ol>                                                                                                                           |

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Seized or broken camshaft timing components.

1. Inspect the following sprockets:
  - The crankshaft sprocket.
  - The exhaust sprockets.
  - The intake sprockets.
2. Inspect the following chains:
  - The primary camshaft drive chain.
  - The secondary camshaft drive chains.
3. Inspect the following guides:
  - The lower primary camshaft drive chain guide.
  - The upper primary camshaft drive chain guides.
4. Inspect the secondary camshaft drive chain shoe.
5. Inspect the following tensioners:
  - The primary camshaft drive chain tensioner.
  - The secondary camshaft drive chain tensioners.
6. Repair as required.

Seized or broken valve train components.

1. Inspect the Stationary Hydraulic Lash Adjusters (SHLAs), rocker arms.
2. Inspect the lifters.
3. Inspect the valves.
4. Inspect the valve springs.
5. Repair as required.

### COOLANT IN COMBUSTION CHAMBER

| Cause                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Correction |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <p>DEFINITION: White smoke and/or coolant type odor above acceptable tolerances 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 leakage test. Refer to <b><u>Cylinder Leakage Test</u></b>. During this test, above acceptable air bubbles within the coolant may indicate a faulty gasket or damaged</li></ol> |            |

component.

4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the cylinder block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.

|                                           |                                                                                                                                                                                                                                           |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cracked intake manifold or failed gasket. | Replace the components as required.                                                                                                                                                                                                       |
| Faulty cylinder head gasket.              | Replace the head gasket and components as required. Refer to <b><u>Cylinder Head Cleaning and Inspection</u></b> . Refer to <b><u>Cylinder Head Replacement - Left Side</u></b> or <b><u>Cylinder Head Replacement - Right Side</u></b> . |
| Warped cylinder head.                     | Machine the cylinder head to the correct flatness, if applicable and replace the cylinder head gasket. Refer to <b><u>Cylinder Head Cleaning and Inspection</u></b> .                                                                     |
| Cracked cylinder head.                    | Replace the cylinder head and gasket.                                                                                                                                                                                                     |
| Cracked cylinder liner or cylinder block. | Replace the components as required.                                                                                                                                                                                                       |
| Cylinder head or cylinder block porosity. | Replace the components as required.                                                                                                                                                                                                       |

## 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 above acceptable foaming or an overfill condition. Oil diluted by coolant may not correctly 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 leakage test. Refer to <b><u>Cylinder Leakage Test</u></b>. During this test, 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 cylinder block with low compression may indicate a failed cylinder head gasket. Refer to <b><u>Engine Compression Test</u></b>.</li> </ol> |                                                                                                                                                                                                                                           |
| Faulty external engine oil cooler.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Replace the components as required.                                                                                                                                                                                                       |
| Faulty cylinder head gasket.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Replace the head gasket and components as required. Refer to <b><u>Cylinder Head Cleaning and Inspection</u></b> . Refer to <b><u>Cylinder Head Replacement - Left Side</u></b> or <b><u>Cylinder Head Replacement - Right Side</u></b> . |
| Warped cylinder head.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Machine the cylinder head to correct flatness, if applicable, and replace the cylinder head gasket. Refer to <b><u>Cylinder Head Cleaning and Inspection</u></b> .                                                                        |
| Cracked cylinder head.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Replace the cylinder head and gasket.                                                                                                                                                                                                     |
| Cracked cylinder liner or cylinder block.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Replace the components as required.                                                                                                                                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                           |



Cylinder head, block, or manifold porosity.

Replace the components as required.

## ENGINE COMPRESSION TEST

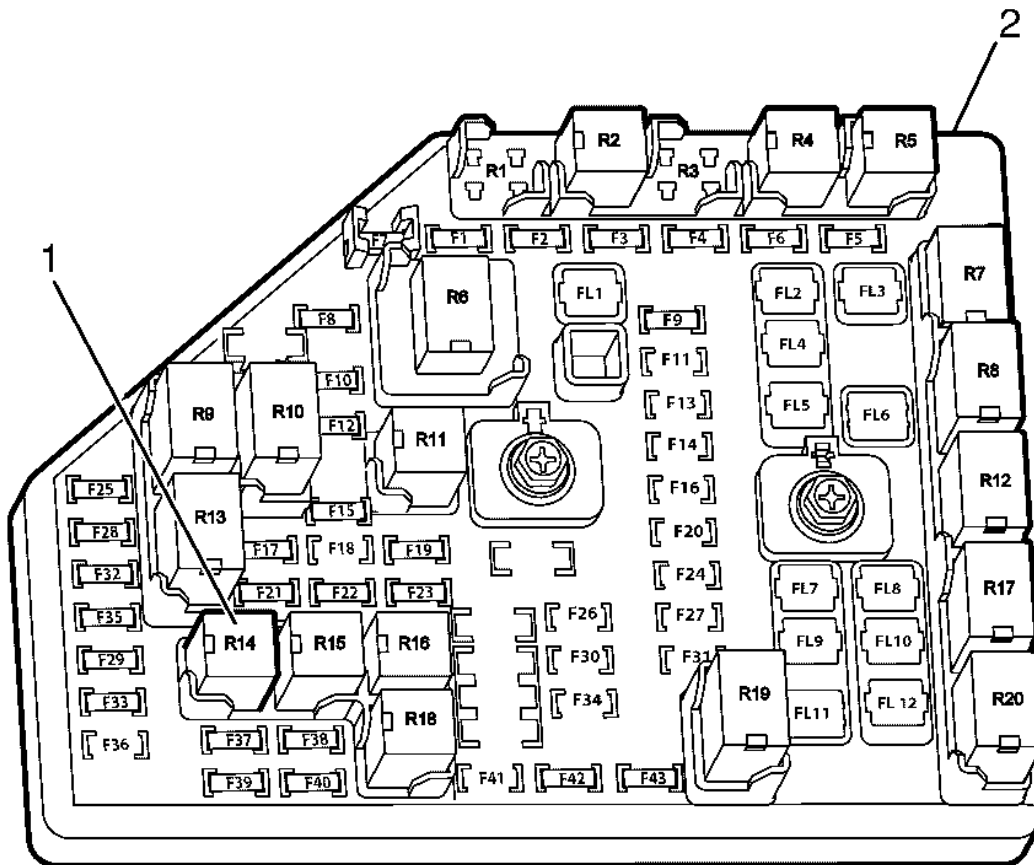
### Tools Required

**J 39313** Spark Plug Port Adapter. See **Special Tools**.

A compression pressure test of the engine cylinders determines the condition of the rings, the valves and the head gasket.

### Test

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge.
2. Charge the battery if the battery is not fully charged.
3. Turn the engine to the OFF position.

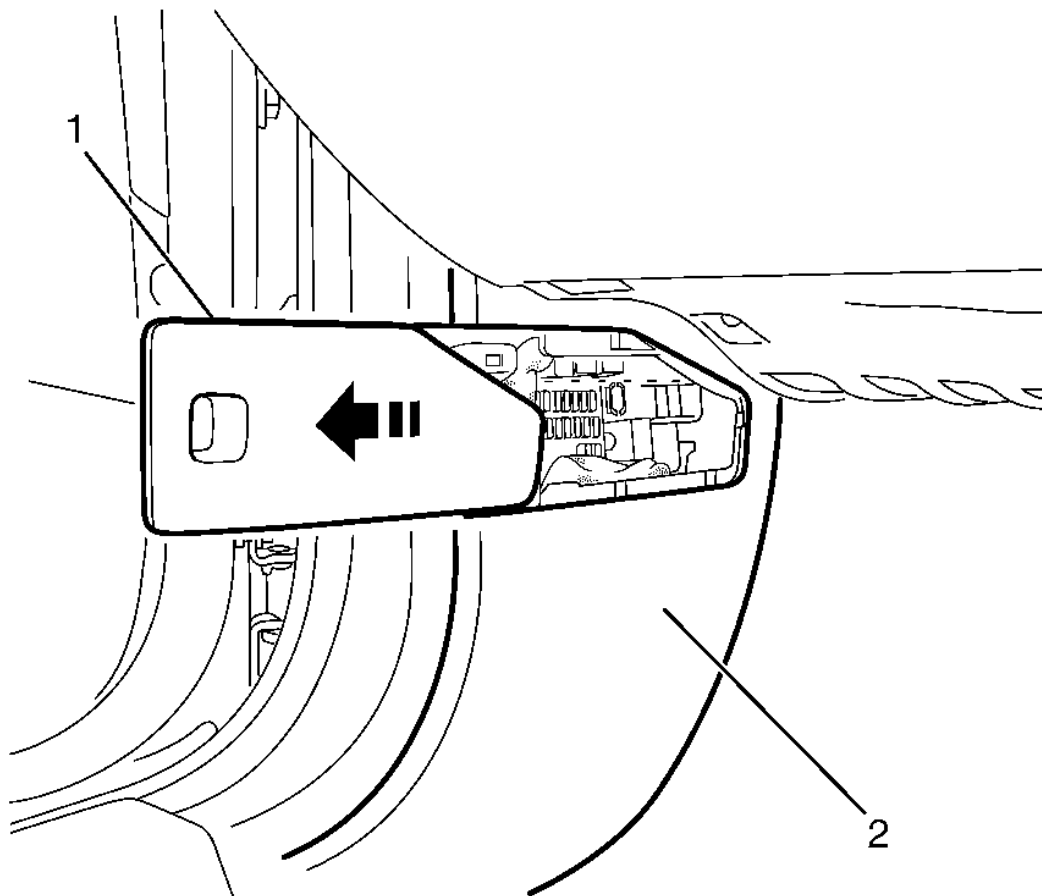


**Fig. 47: Identifying Ignition Relay & Under Hood Body Electrical Center**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Remove the ignition relay (1) from the under hood body electrical centre (2).

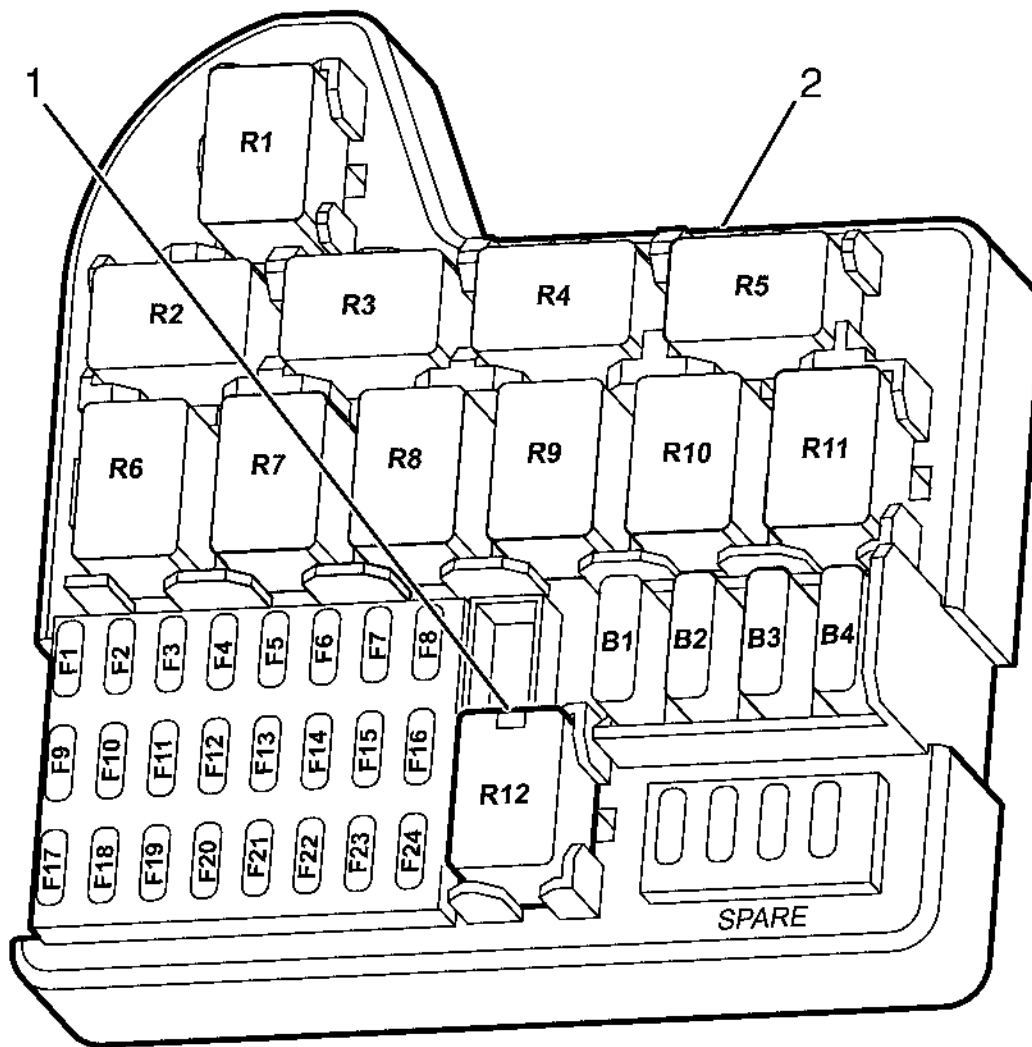
4. Disable the ignition system.



**Fig. 48: Identifying Instrument Panel Fuse Block Cover**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Pull the instrument panel fuse block cover (1) rearward to disengage it from the left hand hinge pillar trim (2).

5. Remove the instrument panel fuse block cover (1).



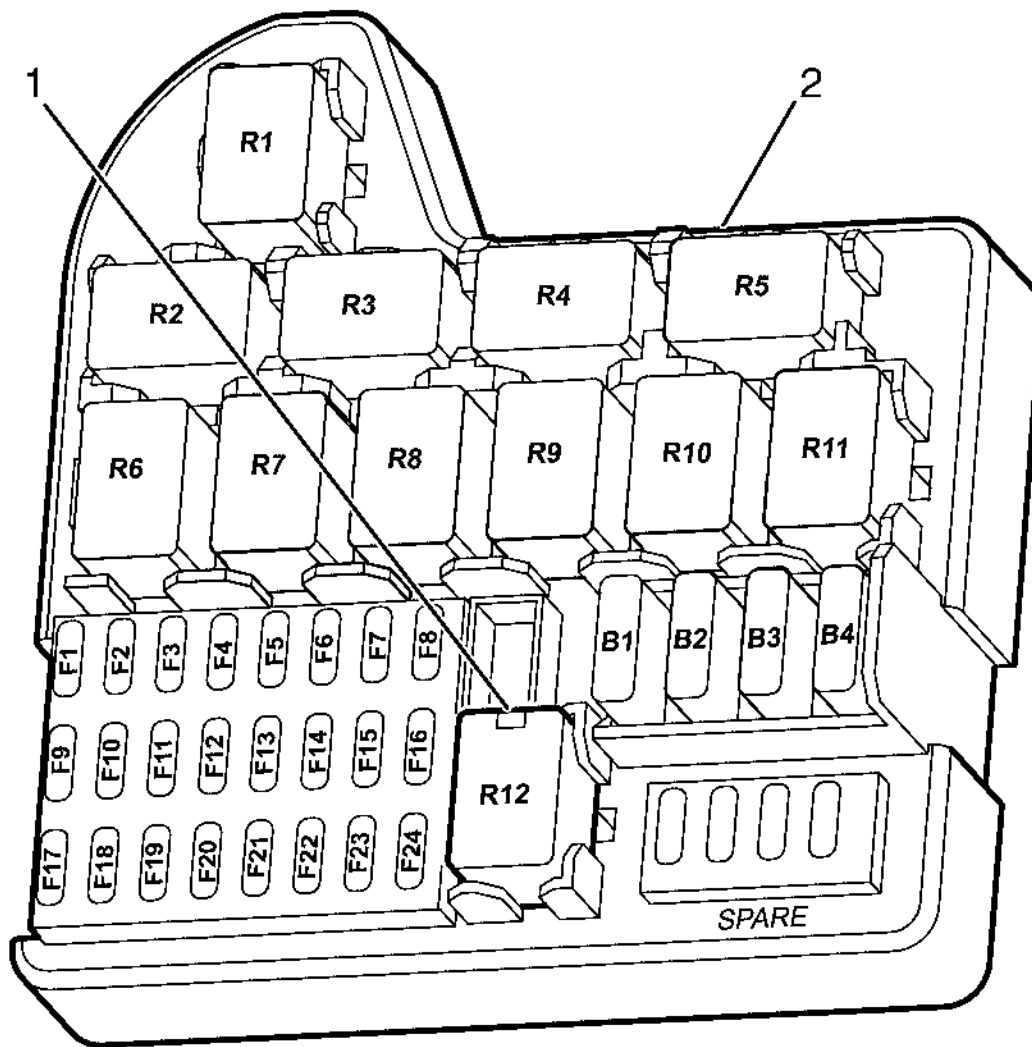
**Fig. 49: Identifying Fuel Pump Relay & Instrument Panel Fuse Block**  
 Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Remove the fuel pump relay (1) from the instrument panel fuse block (2).

6. Disable the fuel injection system.
7. Remove the spark plugs from all cylinders. Refer to **Spark Plug Replacement** .
8. Measure the engine compression, using the following procedure:
  1. Thread the **J 39313** into the spark plug hole. See **Special Tools**.
  2. Thread the compression gauge onto the **J 39313** . See **Special Tools**.
  3. Have an assistant depress the accelerator to the wide open throttle position and crank the engine

through, at least 4 compression strokes, in the testing cylinder.

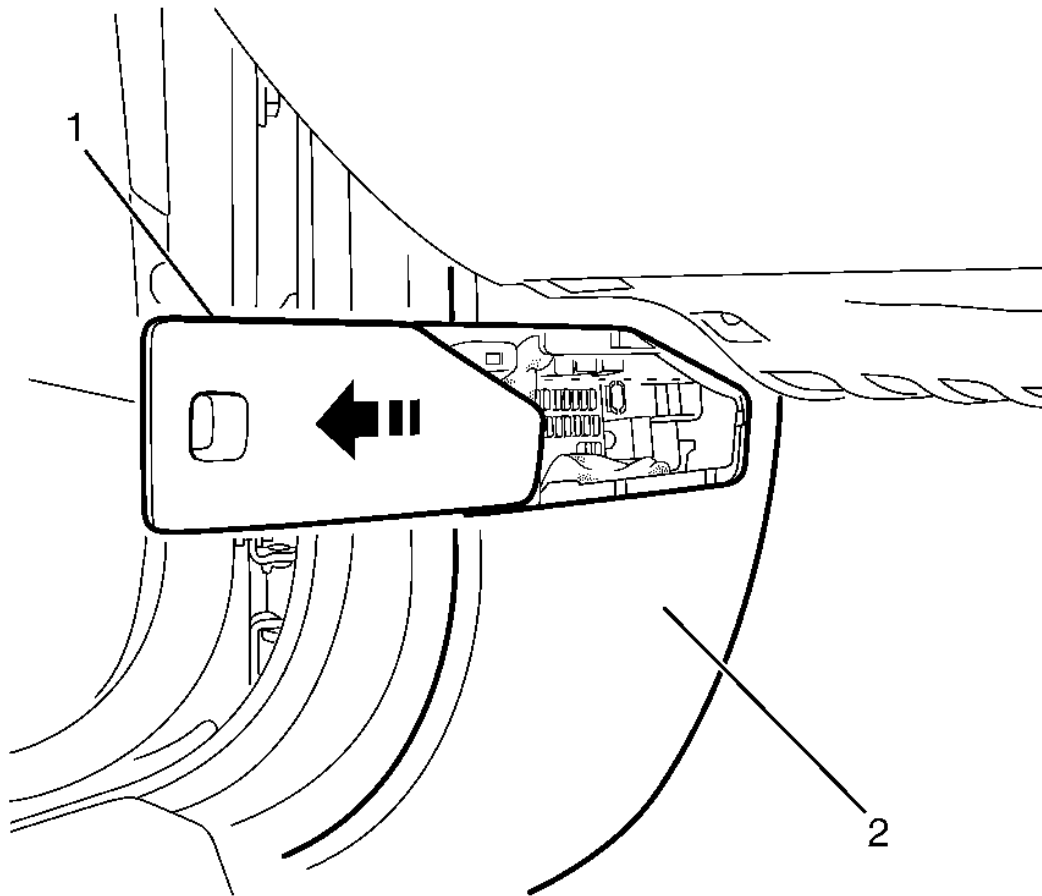
4. Check and record the readings on the gauge at each stroke.
5. Remove the compression gauge from the **J 39313** . See **Special Tools**.
6. Remove the **J 39313** from the spark plug hole. See **Special Tools**.
7. Repeat the compression test for each cylinder.
9. Record the compression readings from all of the cylinders.
  - The lowest reading should not be less than 70 percent of the highest reading.
  - No cylinder reading should be less than 965 kPa (140 psi).
10. 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.
  - 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.



**Fig. 50: Identifying Fuel Pump Relay & Instrument Panel Fuse Block**  
 Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Install the fuel pump fuse to the rear fuse and relay centre fuse block.

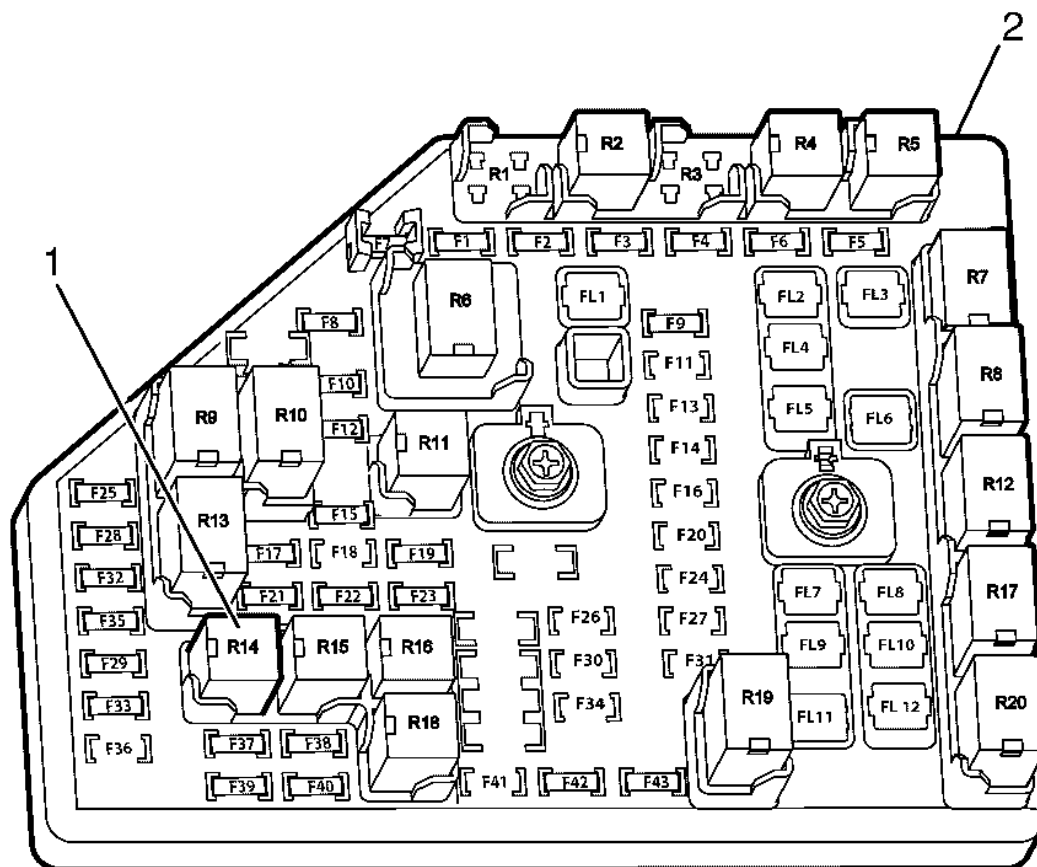
11. Enable the fuel injection system.



**Fig. 51: Identifying Instrument Panel Fuse Block Cover**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Push the fuse block access cover (1) forward to engage it to the left hand hinge pillar trim (2).

12. Install the left hand hinge pillar trim fuse block access cover (1).



**Fig. 52: Identifying Ignition Relay & Under Hood Body Electrical Center**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Install the ignition relay (1) to the under bonnet fuse block (2).

13. Enable the ignition system.
14. Install the spark plugs to all cylinders. Refer to [Spark Plug Replacement](#) .

## CYLINDER LEAKAGE TEST

### Special Tools

- **J 35667-A:** Cylinder Head Leakdown Tester
- **J 39313:** Spark Plug Port Adapter

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

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

- Worn or burnt valves.
- Broken valve springs.
- Stuck valve lifters.
- Incorrect valve lash.
- Damaged piston.
- Worn piston rings.
- Worn or scored cylinder bore.
- Damaged cylinder head gasket.
- Cracked or damaged cylinder head.
- Cracked or damaged cylinder 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.

1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .
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. Thread the **J 39313**: adapter into the spark plug hole.
5. Install the **J 35667-A**: tester or equivalent.

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

6. Apply air pressure to the **J 35667-A**: tester J 35667-A and adjust according to the manufacturers instructions.
7. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered above acceptable and may require component service. In above acceptable leakage situations, inspect for the following conditions:
  - Air leakage sounds at the throttle body or air inlet hose may indicate a worn or burnt intake valve or a broken valve spring.
  - Air leakage sounds at the exhaust extension pipe 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 may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged cylinder block or a damaged cylinder head.
- Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

8. Perform the leakage test on the remaining cylinders and record the values.

## OIL CONSUMPTION DIAGNOSIS

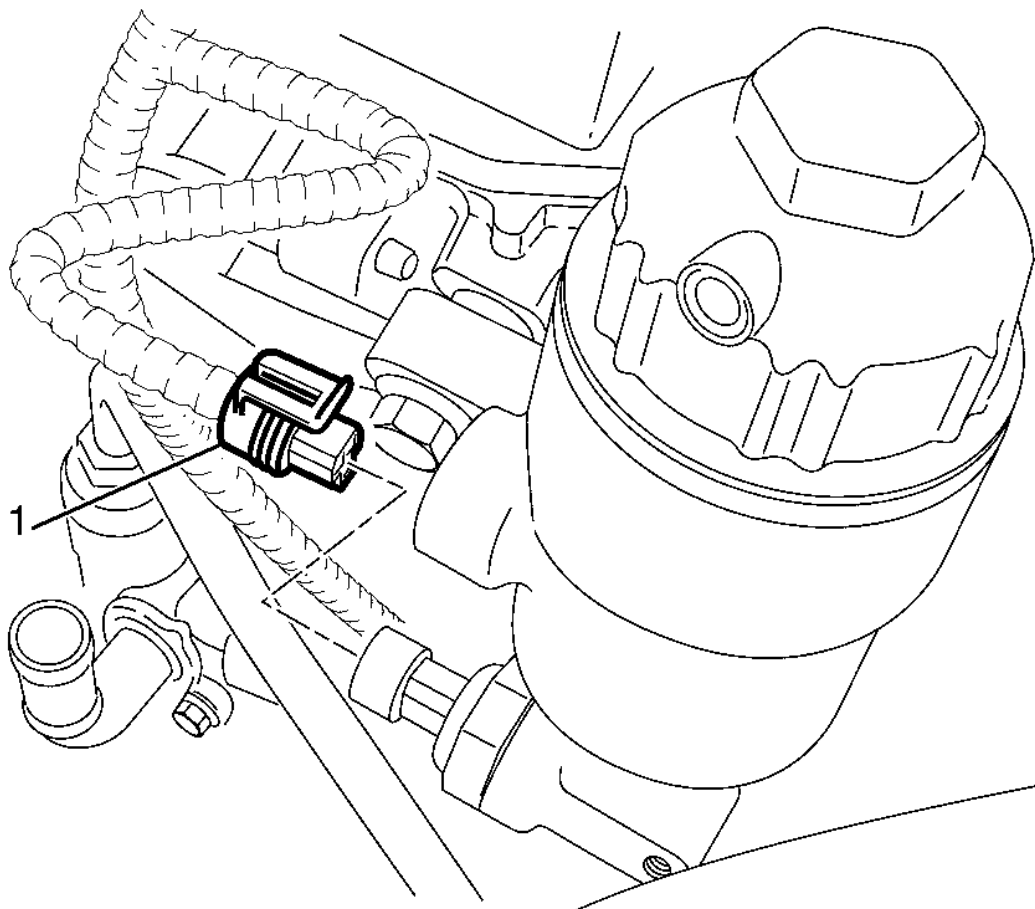
| Checks                                                                                                                                                                                                                                                             | Causes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DEFINITION:</b> Oil consumption (not due to leaks) above acceptable tolerances is the use of 1.9 L (2 qts) or more of engine oil within 3 200 km (2,000 mi).<br>The causes of oil consumption above acceptable tolerances may include the following conditions: |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Preliminary                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>• External oil leaks - Refer to <b>Oil Leak Diagnosis</b>.</li> <li>• Incorrect oil level or incorrect reading of the oil level indicator.<br/><br/>Position the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2-3 minutes) and check for the correct engine oil level.</li> <li>• Incorrect oil viscosity.<br/><br/>Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.</li> <li>• Continuous high speed driving and/or extreme usage.</li> <li>• Crankcase ventilation system restrictions or malfunctioning components.</li> <li>• Worn valve guides and/or valve stems.</li> <li>• Worn, missing or incorrectly installed valve stem oil seals.</li> <li>• Piston rings not seated correctly.<br/><br/>Allow adequate time for the rings to seat.</li> <li>• Piston rings broken or worn</li> <li>• Piston and rings incorrectly installed or miss-fitted to the cylinder bore</li> </ul> |

## OIL PRESSURE DIAGNOSIS AND TESTING

### Tools Required

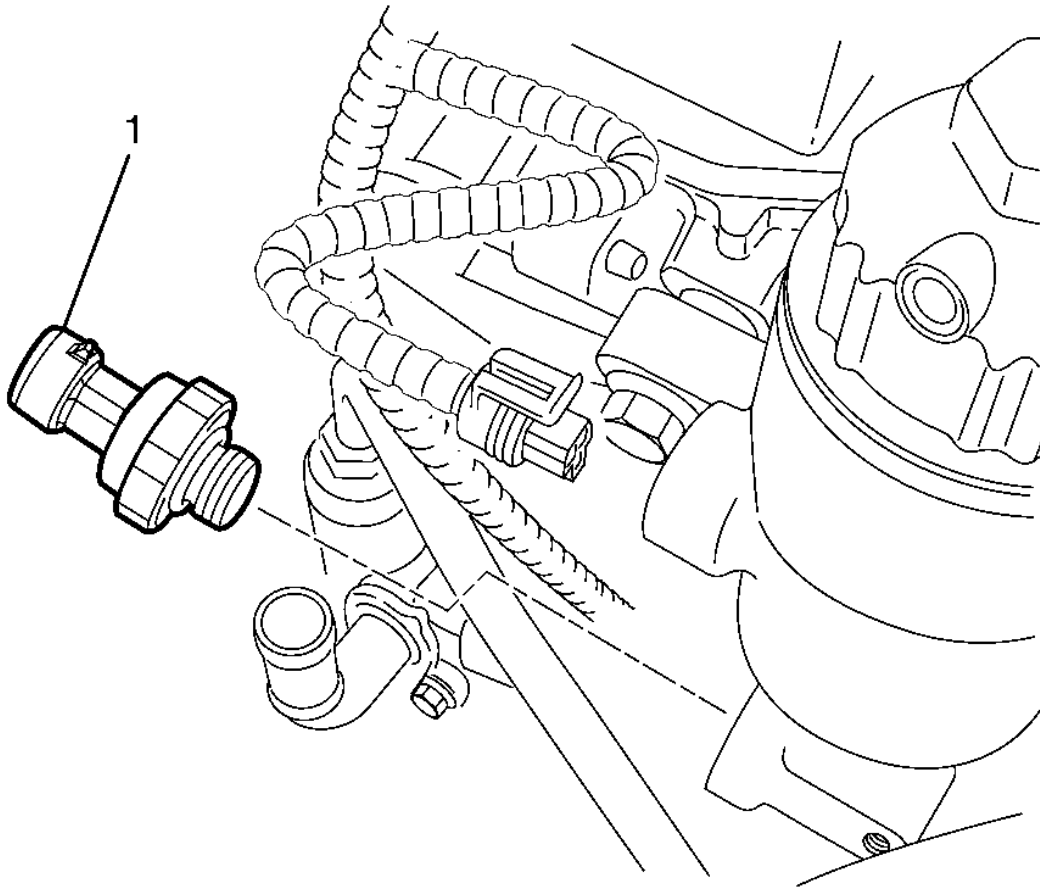
- **J 21867** Pressure Gauge. See **Special Tools**.
- **J-21867-6** Oil Pressure Adapter Fitting. See **Special Tools**.

1. Position the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time (2-3 minutes), and measure for a low oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following:
  - Foamy oil
  - Slow idle speed
  - Plugged oil filter
  - Oil diluted by the following:
    - Water
    - Engine coolant
    - Unburned fuel mixtures
  - Malfunctioning oil filter bypass valve
  - Incorrect or faulty oil pressure gauge
  - Incorrect or faulty oil pressure gauge sensor
  - incorrect engine oil viscosity for the expected temperature



**Fig. 53: Identifying Oil Pressure Sensor Connector**  
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the oil pressure sensor connector (1).



**Fig. 54: Identifying Oil Pressure Sensor**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pressure sensor (1).
8. Install the **J 21867** with the **J-21867-6** to the oil filter adapter (2). See **Special Tools**.
9. Measure the engine oil pressure.
10. Compare the readings to the **Engine Mechanical Specifications**.
11. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
  - Loose oil filter adapter bolts.
  - Missing or damaged oil filter adapter O-ring seal or seals.
  - Worn or dirty oil pump.
  - Loose oil pump-to-cylinder block bolts.
  - Loose, plugged or damaged oil pump screen.
  - Missing or damaged oil pump screen O-ring seal.
  - Damage or leak in the oil pump screen suction tube.

- Malfunctioning oil pump pressure regulator valve.
- Missing or incorrectly installed oil gallery plugs.
- Loose camshaft intermediate drive shaft bolts.
- Bearing clearance above acceptable tolerances for the following:
  - Connecting rod or rods.
  - Crankshaft.
  - Camshaft or camshafts.
  - Camshaft intermediate drive shaft sprocket.
- Cracked, porous or restricted oil galleries.
- Broken valve lifters.

12. Repair or replace components as necessary.

## OIL LEAK DIAGNOSIS

| Checks                                                                                                                                                                                                                                                                                                                                                                        | Action                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CAUTION:</b><br>It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Most fluid leaks can be repaired 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.                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Locating and identifying the leak                                                                                                                                                                                                                                                                                                                                             | To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid, or some other fluid, use the visual inspection method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Visual Inspection Method                                                                                                                                                                                                                                                                                                                                                      | <ol style="list-style-type: none"> <li>1. Bring the vehicle to normal operating temperature.</li> <li>2. Park the vehicle over a clean surface.</li> <li>3. Wait several minutes, then check for drips.</li> <li>4. Identify the type of fluid, and the approximate location of the leak.</li> <li>5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components.</li> <li>7. If you cannot locate the leak, do the following:                             <ol style="list-style-type: none"> <li>1. Completely clean the entire engine and surrounding components.</li> <li>2. Operate the vehicle for several kilometres at normal operation temperature and at varying speeds.</li> </ol> </li> </ol> |

|                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                            | <ol style="list-style-type: none"> <li>Park the vehicle over a clean surface.</li> <li>Wait several minutes, then check for drips.</li> <li>Identify the type of fluid, and the approximate location of the leak.</li> <li>Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>See possible causes for leaks.</li> <li>If you still cannot locate the leak, use the powder method or the black light and dye method.</li> </ol>                                                                                                                                    |
| Powder Method              | <ol style="list-style-type: none"> <li>Completely clean the entire engine and surrounding components.</li> <li>Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area.</li> <li>Operate the vehicle for several miles at normal operation temperature and at varying speeds.</li> <li>Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.</li> <li>Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>See possible causes for leaks.</li> </ol>                     |
| Black Light and Dye Method | <ol style="list-style-type: none"> <li>A dye and light kit is available for finding leaks. Use the <b>J 28428-E</b> High-Intensity Black Light Kit or equivalent. See <b>Special Tools</b>. Refer to the manufacturer's instructions when using the tool.</li> <li>Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>See possible causes for leaks.</li> </ol>                                                                                                                                                                                                   |
| Possible Causes for Leaks  | <p>Check for the following conditions:</p> <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>Incorrectly tightened or damaged fasteners.</li> <li>Cracked or porous components.</li> <li>Incorrect sealants or gaskets where required.</li> <li>Incorrect sealant or gasket installation.</li> <li>Damaged or worn gaskets or seals.</li> <li>Damaged or worn sealing surfaces.</li> </ul> |

## CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

**Crankcase Ventilation (CV) System Inspection**

- Test for vacuum at the vacuum hose where it connects to the crankcase ventilation housing. There should be manifold vacuum present at the hose. If there is no vacuum, inspect for a plugged hose, leaking hose or a plugged vent adapter.
- Plug the end of the vacuum hose while the engine is running. Inspect the hose for any areas that collapse when the end of the hose is blocked. Replace the hose if it collapses when blocked.
- If oil has accumulated in the intake air duct, inspect for the following conditions:
  - Plugged vacuum orifice in the crankcase ventilation housing.
  - Plugged or restricted crankcase ventilation housing.
  - Crankcase pressure or blow-by above acceptable tolerances. Refer to **Oil Consumption Diagnosis**.
- Additional items to inspect:
  - Plugged or leaking fresh air vent hose assembly or vent adapter.
  - Plugged or restricted passages in the throttle body.
  - Missing or damaged O-ring seals on the vent adapter.
  - Inspect the cam covers, the oil pan gasket, and other sealing areas for leaks.

**Results of Incorrect Operation**

A plugged crankcase ventilation housing or hose may contribute to the following conditions:

- A rough idle.
- Stalling or a slow idle speed.
- Oil leaks.
- Oil accumulation in the intake air duct.
- Sludge in the engine.

A leaking housing or hose may contribute to the following conditions:

- A rough idle.
- Stalling.
- Unstable idle speed.

**DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS****Diagnostic Aids**

The drive belts will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items, but not limited to, may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the alternator failing.

**Test Description**

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

**3:** This test is to verify that the noise is being caused by the drive belts or the accessory drive components. When removing the drive belt, the water pump will not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

**4:** The inspection should include checking the drive belt tensioners and the drive belt idler pulley bearings. The drive belts may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the correct inspection and replacement procedure.

| Step                                                                                                                  | Action                                                                                                                                                                                                                                                                                                        | Yes                                              | No                                               |
|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| <b>CAUTION:</b><br>Refer to <b><u>Belt Dressing Caution</u></b> .                                                     |                                                                                                                                                                                                                                                                                                               |                                                  |                                                  |
| <b>DEFINITION:</b> A high pitched continuous noise that may be caused by an accessory drive component failed bearing. |                                                                                                                                                                                                                                                                                                               |                                                  |                                                  |
| 1                                                                                                                     | Did you review the Symptoms - Engine Mechanical diagnostic information, 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 whine noise. Does the engine make the whine noise?                                                                                                                                                                                                                                     | Go to <b>Step 3</b>                              | Go to Diagnostic Aids                            |
| 3                                                                                                                     | <b>NOTE:</b><br><b>When removing the drive belt the water pump will not be operating and the engine may overheat.</b><br><br>1. Remove the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>2. Operate the engine for no longer than 30 to 40 seconds.<br><br>Does the whine noise still exist? | Go to <b><u>Symptoms - Engine Mechanical</u></b> | Go to <b>Step 4</b>                              |
| 4                                                                                                                     | Inspect for a failed accessory drive component bearing. Did you find and repair the condition?                                                                                                                                                                                                                | Go to <b>Step 5</b>                              | Go to Diagnostic Aids                            |
| 5                                                                                                                     | Operate the system in order to verify the repair. Did you correct the condition?                                                                                                                                                                                                                              | System OK                                        | -                                                |

## DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

### Diagnostic Aids



Vibration from the engine operating may cause a body component or another part of the vehicle to make a rumbling noise.

The drive belt may have a 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 belt is installed, there might be an inoperative accessory drive component. 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 the drive belt is causing the rumbling noise. A rumbling noise may be confused with an internal engine noise due to the similarity in the description. When removing the drive belt the water pump will 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 belt is to ensure that it is 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 extreme the drive belt does not have a smooth surface for correct operation.

| Step                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Action                                                                                                         | Yes                 | No                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|---------------------|--------------------------------------------------|
| <b>CAUTION:</b><br><b>Refer to <u>Belt Dressing Caution</u> .</b><br><br><b>DEFINITION:</b> <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> <li>○ A damaged drive belt.</li> </ul> </li> </ul> |                                                                                                                |                     |                                                  |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Did you review the Symptoms - Engine Mechanical diagnostic information, 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.<br>Does the engine make the rumbling                                    |                     |                                                  |

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|   | noise?                                                                                                                                                                                                                                                                                                                                                             | Go to <b>Step 3</b>                              | Go to Diagnostic Aids |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-----------------------|
| 3 | <p><b>NOTE:</b><br/>When removing the drive belt the water pump will not be operating and the engine may overheat.</p> <ol style="list-style-type: none"> <li>1. Remove the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .</li> <li>2. Operate the engine for no longer than 30 to 40 seconds.</li> </ol> <p>Does the rumbling noise still exist?</p> | Go to <b><u>Symptoms - Engine Mechanical</u></b> | Go to <b>Step 4</b>   |
| 4 | <p>Inspect the drive belt for damage, separation, or sections of missing ribs. Did you find any of these conditions?</p>                                                                                                                                                                                                                                           | Go to <b>Step 7</b>                              | Go to <b>Step 5</b>   |
| 5 | <p>Inspect for extreme pilling of more than 1/3 of the drive belt pulley grooves. Did you find extreme pilling?</p>                                                                                                                                                                                                                                                | Go to <b>Step 6</b>                              | Go to <b>Step 7</b>   |
| 6 | <ol style="list-style-type: none"> <li>1. Clean the drive belt pulleys using a suitable wire brush.</li> <li>2. Reinstall the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .</li> </ol> <p>Did you complete the repair?</p>                                                                                                                           | Go to <b>Step 8</b>                              | -                     |
| 7 | <p>Install a new drive belt. Refer to <b><u>Drive Belt Replacement</u></b> . Did you complete the replacement?</p>                                                                                                                                                                                                                                                 | Go to <b>Step 8</b>                              | -                     |
| 8 | <p>Operate the system in order to verify the repair. Did you correct the condition?</p>                                                                                                                                                                                                                                                                            | System OK                                        | Go to Diagnostic Aids |

### 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 or released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate correctly.

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

#### 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 have occurred to the drive belt when the drive belt fell off. The drive belt may have been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plies.

**4:** Misalignment of the pulleys may be caused from incorrect 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 2 or 3 pulleys. If a misaligned pulley is found, refer to that accessory drive component for the correct 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 may prevent the drive belt from not seating correctly 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 the fasteners can address the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or wrong fasteners, may cause pulley misalignment due to the bracket moving under load. Over tightening the fasteners may cause misalignment of the accessory drive component bracket.

| Step                                                                                       | Action                                                                                                          | Yes                  | No                                        |
|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------------|
| <b>CAUTION:</b><br>Refer to <u>Belt Dressing Caution</u> .                                 |                                                                                                                 |                      |                                           |
| DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys. |                                                                                                                 |                      |                                           |
| 1                                                                                          | Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?  | Go to <b>Step 2</b>  | Go to <u>Symptoms - Engine Mechanical</u> |
| 2                                                                                          | Inspect for a 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 <u>Drive Belt Replacement</u> .<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 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 incorrect, loose or missing fasteners.<br>Did you find incorrect, loose or missing fasteners?       | Go to <b>Step 8</b>  | Go to <b>Step 9</b>                       |
|                                                                                            | <b>CAUTION:</b><br>Refer to <u>Fastener Caution</u> .                                                           |                      |                                           |

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|    |                                                                                                                                                                                                  |                      |                       |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------|
| 8  | <ol style="list-style-type: none"> <li>1. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications</u></b>.</li> <li>2. Replace incorrect or missing fasteners.</li> </ol> |                      |                       |
|    | 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. 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 a 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>   |

**DRIVE BELT EXCESSIVE WEAR DIAGNOSIS****Diagnostic Aids**

Wear on a drive belt above acceptable tolerances 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 wear above acceptable tolerances, but will probably cause the drive belt to make a noise or to fall off.

Misalignment of the drive belt pulleys above acceptable tolerances will cause wear above acceptable tolerances and may also make the drive belt fall off.

**Test Description**

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

**2:** 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 miss-positioning the drive belt by one groove on a pulley.

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

**4:** 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

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snapping the throttle.

| Step                                                                                                      | Action                                                                                                                              | Yes                 | No                                               |
|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------------------------------|
| <b>CAUTION:</b><br><b>Refer to <u>Belt Dressing Caution</u> .</b>                                         |                                                                                                                                     |                     |                                                  |
| <b>DEFINITION:</b> Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt. |                                                                                                                                     |                     |                                                  |
| 1                                                                                                         | Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?                      | Go to <b>Step 2</b> | Go to <b><u>Symptoms - Engine Mechanical</u></b> |
| 2                                                                                                         | Inspect the drive belt for the correct installation. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you find the condition? | Go to <b>Step 5</b> | Go to <b>Step 3</b>                              |
| 3                                                                                                         | Confirm the drive belt is the correct specification for the engine.<br>Did you find the condition?                                  | Go to <b>Step 5</b> | Go to <b>Step 4</b>                              |
| 4                                                                                                         | 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 6</b> | Go to Diagnostic Aids                            |
| 5                                                                                                         | Replace the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> .<br>Did you complete the replacement?                        | Go to <b>Step 6</b> | -                                                |
| 6                                                                                                         | Operate the system in order to verify the repair.<br>Did you correct the condition?                                                 | System OK           | -                                                |

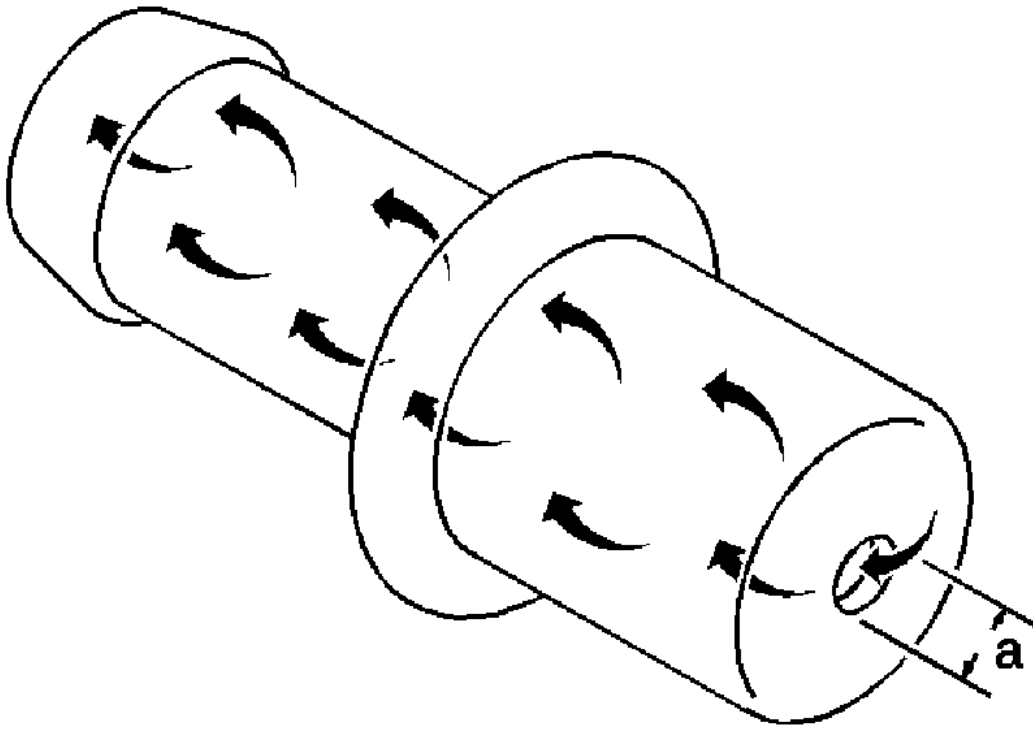
### DRIVE BELT TENSIONER DIAGNOSIS

| Step | Action                                                                                                                                                                                                                                   | Yes                 | No                  |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|
| 1    | Remove the drive belt. Refer to <b><u>Drive Belt Replacement</u></b> . 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    | 1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop.<br>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. |                     |                     |

|   |                                                                                                                        |           |                     |
|---|------------------------------------------------------------------------------------------------------------------------|-----------|---------------------|
|   | Is the first torque reading within 10% of the second torque reading?                                                   | System OK | Go to <b>Step 4</b> |
| 4 | Replace the drive belt tensioner. Refer to <b><u>Drive Belt Tensioner Replacement</u></b> .<br>Is the repair complete? | System OK | -                   |

## DESCRIPTION AND OPERATION

### CRANKCASE VENTILATION SYSTEM DESCRIPTION



**Fig. 55: Identifying Description Of Crankcase Ventilation System**  
 Courtesy of GENERAL MOTORS CORP.

A crankcase ventilation system is used to consume crankcase vapours created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using a 3 mm (0.118 in) (a) orifice located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow amounts of blow-by

gases above acceptable tolerances to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

## **DRIVE BELT SYSTEM DESCRIPTION**

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
  - The power steering pump
  - The alternator
  - The A/C compressor
  - The water pump

The drive belt system uses 1 belt. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM, and have different layers or plies containing either fibre cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys.

## **ENGINE COMPONENT DESCRIPTION**

The High Feature V6 RPO LY7 is a 3.6L engine incorporating two intake and two exhaust valves per cylinder. Individual intake and exhaust camshafts with camshaft position actuators are mounted on each cylinder head. The cylinder bore is 94 mm (3.7008 in) and the piston stroke is 85.6 mm (3.3701 in). The cylinders are arranged in two banks of three with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6. The engine firing order is 1-2-3-4-5-6.

### **Crankcase**

The cylinder block is constructed of aluminium alloy by precision sand-casting with cast in place iron cylinder liners. Each copper-infiltrated sintered steel main bearing cap incorporates six bolts bolting the cap into the cylinder block. Along with two outer and two inner bolts, two side bolts are used in the deep skirt block. To

prevent aeration, oil return from the valvetrain and cylinder heads is channelled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and cylinder block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. A knock sensor is located on the each side of the exterior of the cylinder block. The crankshaft position sensor is located on the left side of the exterior of the cylinder block.

### **Crankshaft**

The crankshaft is a forged steel design with four main bearings. Crankshaft thrust is controlled by the number three main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. The crankshaft is internally balanced with an integral oil pump drive machined into the nose in front of the front main journal.

### **Connecting Rods and Pistons**

The connecting rods are sinterforged steel and have full floating piston pins. The piston pins are a slip fit in the bronze bushed connecting rod. Round wire retainers are used to retain the piston pin into the piston. The cast aluminium pistons incorporate a polymer-coated skirt to reduce friction. The piston uses two low tension compression rings and one multi-piece oil control ring. The top compression ring is plasma sprayed. The second compression ring is cast iron napier. The oil control ring incorporates a steel expander and two chrome plated steel rails.

### **Camshaft Drive System**

The camshaft drive system uses Inverted Tooth (IT) timing drive chains and consists of one primary timing drive chain driven by the crankshaft sprocket. The primary timing drive chain drives two intermediate drive shaft sprockets. Each oil pressure fed intermediate drive shaft sprocket drives separate secondary timing drive chains. Each secondary timing drive chain drives the respective cylinder head's intake and exhaust camshaft position actuators.

The primary timing drive chain uses two stationary timing drive chain guides and an oil pressure hydraulically actuated tensioner with built-in shoe. The tensioners minimize timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioners incorporate a plunger that adjusts out with wear allowing only a minimal amount of backlash. The tensioners are equipped with oiling jets to spray oil onto the timing components during engine operation. The secondary timing drive chains use a stationary timing drive chain guide and movable timing drive chain shoe. The secondary timing drive chain shoe is under tension from an oil pressure hydraulically actuated tensioner. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

The primary timing drive system also uses an IT timing drive chain. The primary timing drive chain connects the crankshaft sprocket with the left and right side intermediate drive shaft sprockets.

### **Camshaft Position Actuator System**

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes the inlet and exhaust valve timing within a range of 25 camshaft degrees as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions



without compromising overall engine response and driveability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and addresses the need for an Exhaust Gas Recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator, rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains this position during start-up conditions. Under other engine operating conditions, the camshaft position actuator is controlled by the Engine Control Module (ECM) to deliver optimal intake and exhaust valve timing for performance, driveability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover to accurately determine the position of each camshaft. Each camshaft position actuator has a specific timing drive mark for right or left bank application, as the camshaft position actuators are common bank to bank. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

The camshaft front journal has several drilled oil holes to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. The center camshaft bolt hole is counterbored to allow oil to flow around the camshaft bolt and to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position. Radially outward from the center of the journal is a set of four drilled camshaft position actuator oil holes. Oil in this group of oil holes is used to move the camshaft from the default position to a specific set position as determined by the ECM. Seal rings are used at the front and rear of the front camshaft journal to prevent oil leakage from the camshaft position actuator hydraulic system. The seal is made from a plastic compound that resists wear and has a diagonal end gap to enhance sealing. The camshaft position actuator is mounted to the front end of the camshaft and the timing notch in the nose of the camshaft aligns with the dowel pin in the camshaft position actuator to ensure correct cam timing and camshaft position actuator oil hole alignment.

### **Cylinder Heads**

The cylinder heads are semi permanent mould cast aluminium with powdered metal valve seat inserts and valve guides. Two 36.96 mm (1.4551 in) intake valves and two 30.60 mm (1.2047 in) exhaust valves are actuated by roller finger valve rocker arms pivoting on a Stationary Hydraulic Lash Adjuster (SHLA). Separate exhaust and intake camshafts are supported by four bearings machined into the cylinder head. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The Engine Coolant Temperature (ECT) sensor is threaded into the left cylinder head.

### **Induction System**

A dual-stage variable intake manifold is achieved through the use of a Intake Manifold Runner Control (IMRC) flap. The Engine Control Module (ECM) controlled valve changes the plenum volume available for resonance tuning of the inlet flow path. With the IMRC flap shut, the intake manifold is using dual plane flow with the cylinders feeding from two separate plenums. In this mode the system boosts cylinder charging in the low to mid speed range. At higher engine speeds the IMRC flap opens creating a single plane flow with the cylinders all feeding from a common large plenum. In this mode the system boosts charging in the high speed range. An electronically controlled throttle (ETC), through the ECM, coordinates the input from the driver with various control components.

### **Right and Left Bank Designation**

Right side and left side designation through the engine mechanical section are viewed from the rear of the engine or from inside the vehicle.

## **LUBRICATION DESCRIPTION**

A structural diecast aluminium oil pan incorporates an oil suction pipe, a baffle, a windage tray, and an oil level sensor. The oil suction pipe is bolted into the oil pan and seals to the bottom of the block with O-ring gasket. The baffle is mounted to the lower portion of the 6.5 litre (6.9 quart) capacity oil pan sump and ensures oil supply to the oil suction pickup. The windage tray is bolted to the upper portion of the oil pan and reduces friction losses at high speed. The oil level sensor is mounted through the bottom of the oil pan.

A crankshaft driven gerotor oil pump with internal pressure-relief valve is mounted to the front of the cylinder block and pulls oil from the oil suction pipe through the lower passage in the cylinder block. The oil pump then directs the flow of pressurized oil back through the upper passage in the block to the left side of the cylinder block where the oil filter adapter is mounted.

An oil filter adapter is mounted with a gasket to the left side of the cylinder block. The oil filter adapter incorporates a top-access, cartridge style oil filter. The filter is accessed through a screw on cap with an O-ring gasket. The oil filter adapter cap has a built-in oil bypass valve. The oil filter adapter housing incorporates a drain back control valve and a threaded oil pressure sending unit. Oil flows through the lower passage in the oil filter adapter up to and through the oil filter cartridge. Filtered oil travels back through the upper passage of the oil filter adapter and back into the cylinder block.

Oil is directed up and across the cylinder block front through several drilled passages. These front passages feed oil to each cylinder head, oil to the passage for the main bearings and piston oil jets, oil to the right and left secondary idler sprockets, and oil to the primary timing drive chain tensioner.

Each cylinder head passage directs oil into the cylinder head where it is directed to oiling circuits for the Stationary Hydraulic Lifter assemblies (SHLAs) and the camshaft bearing journals. Oil is also directed through 2 passages each with a spring-loaded check-ball valve to the 2 chambers where the camshaft position actuator oil control solenoid valves are mounted. Each chamber contains a camshaft position actuator oil control solenoid valve with built-in oil filter screen. One camshaft position actuator oil control solenoid valve is used to control the exhaust camshaft position actuator and 1 camshaft position actuator oil control solenoid valve is used to control the intake camshaft position actuator. The Engine Control Module (ECM) electrically controls each camshaft position actuator oil control solenoid valve. When energized by the ECM the camshaft position actuator oil control solenoid valve directs oil to pass up through the cylinder head front camshaft bearing cap. Oil passes through the camshaft bearing cap passage into oil holes drilled into the side of the front camshaft

journal and onto the front of the camshaft mounting surface. Oil passes through to matching passages in the camshaft position actuator. Oil is directed by the camshaft position actuator oil control solenoid valve to the appropriate passage in the system to pressurize oil on the vanes on the inside of the of the camshaft position actuator. Oil acting on the vanes rotates the camshaft mounted to the inner camshaft position actuator rotor relative to the sprocket mounted to the outer camshaft position actuator housing. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains the camshaft position actuator in the home or default position during start-up conditions. Oil pressure directed by the camshaft position actuator oil control solenoid valve unlocks the pin and allows the camshaft position actuator to function. An additional passage in the cylinder head also directs oil to the secondary timing drive chain tensioner mounted to each cylinder head.

The oil passage that supplies oil to the main bearings also supplies oil to pressure-actuated piston-cooling oil jets. Each oil jet is mounted between opposing cylinder bores and directs oil to the 2 bores to provide extra cooling and control piston temperatures.

Oil is directed from the front passages to the front of the block where the right and left secondary idler sprockets and the primary timing drive chain tensioner are mounted. Each camshaft timing drive chain tensioner relies on a gasket in order to maintain an oil reserve after the engine is turned OFF. All camshaft timing drive chain tensioners incorporate a small oil jet to supply an oil spray onto the camshaft timing drive chain components.

Oil returns to the oil pan sump either through the camshaft timing drive chain area or through the cast oil drain back passages on the outboard walls of the cylinder heads and cylinder block.

## **CLEANLINESS AND CARE**

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice correct cleaning and protection procedures to the machined surfaces and to the friction areas.

**CAUTION: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.**

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

**WARNING: Refer to Battery Disconnect Warning .**

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to **BATTERY NEGATIVE CABLE DISCONNECTION AND CONNECTION** in Engine Electrical.

## **SEPARATING PARTS**

In addition to the Room Temperature Vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. If possible, bump the components sideways rather than using prying tools in order to remove the components. This technique prevents damage when the bonding strength of the RTV sealant is stronger than the component itself. Perform bumping at the bends or at the reinforced areas in order to prevent part distortion.

## **REPLACING ENGINE GASKETS**

### **Gasket Reuse and Applying Sealant**

- 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 specified in the service procedure.

### **Separating Components**

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

### **Cleaning Gasket Surfaces**

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

DO NOT use any other method or technique to remove the sealant or the 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 engine oil.

This fine grit is an abrasive and can cause internal engine damage.

### **Assembling Components**

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must 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.
- Apply only the amount of sealant specified in the service procedure to a component.
- DO NOT allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping correctly or cause component damage when tightened.

**IMPORTANT: DO NOT overtighten the fasteners.**

- Tighten the fasteners to the correct specifications.

## **USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT**

### **Sealant Types**

**NOTE:** The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Anaerobic sealant room temperature vulcanizing (RTV)
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

### **Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant**

Anaerobic type room temperature vulcanizing (RTV) sealant cures in the absence of air. This type of sealant is used where 2 components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

**CAUTION: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause**

hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

**NOTE: Do not wait for the RTV sealant to skin over.**

- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes.

**NOTE: Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

#### **Anaerobic Type Gasket Eliminator Sealant**

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.

The surfaces to be sealed must be clean and dry.

**CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.**

**NOTE:**

- Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.
- Do not overtighten the fasteners.
  - Apply the gasket eliminator sealant evenly to get a uniform thickness

**of the gasket eliminator sealant on the sealing surface.**

- **Tighten the fasteners in sequence, if specified, and to the proper torque specifications.**
- **After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.**

#### **Anaerobic Type Threadlock Sealant**

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

**NOTE:**

- **Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than 5 minutes, may result in incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

#### **Anaerobic Type Pipe Sealant**

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

**CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to**

**component failure.**

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

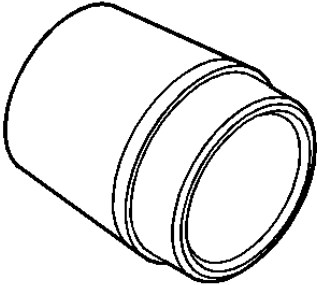
**NOTE:**        **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

**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 correct tightening of various fasteners.
- To correctly 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

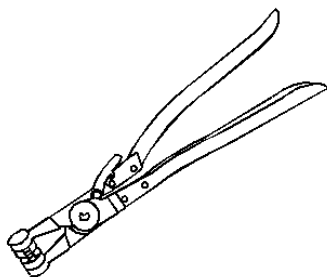
**SPECIAL TOOLS AND EQUIPMENT****SPECIAL TOOLS**

| Illustration                                                                        | Tool Number/Description                        |
|-------------------------------------------------------------------------------------|------------------------------------------------|
|  | <p>EN 46101<br/>Spark Plug Tube Seal Guide</p> |
|                                                                                     |                                                |

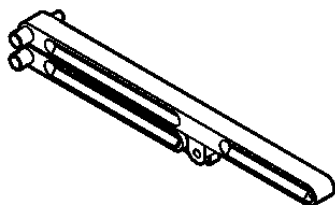


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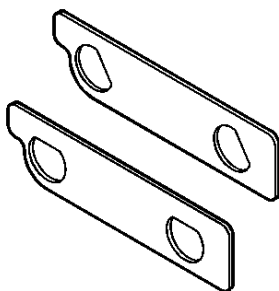
2009 ENGINE Engine Mechanical - 3.6L - G8



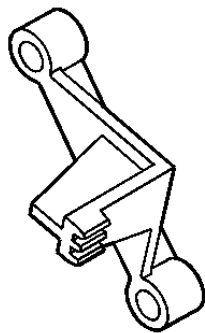
EN 46103  
Camshaft Actuator Valve Seal Remover/Installer



EN 46104  
Water Pump Pulley Holding Tool



EN 46105-1  
EN 46105-2  
Camshaft Locking Tools

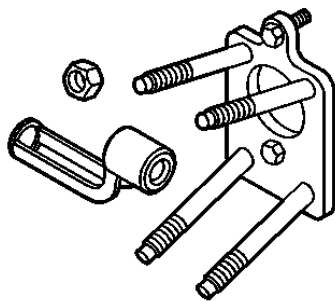
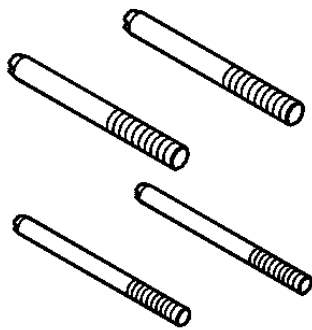


EN 46106  
Flywheel Holding Tool

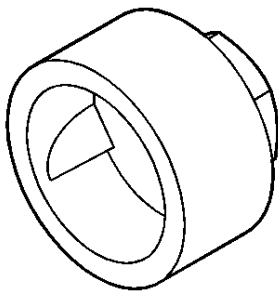
EN 46109  
Guide Pins

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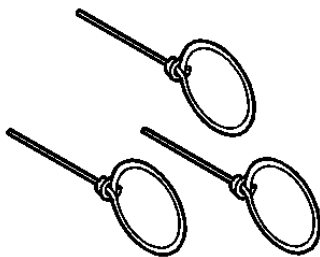
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EN 46110  
On-Vehicle Valve Spring Compressor



EN 46111  
Crankshaft Rotation Socket

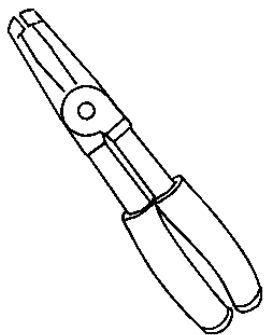
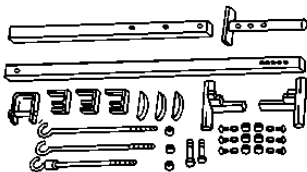


EN 46112  
Tensioner Retraction Pins

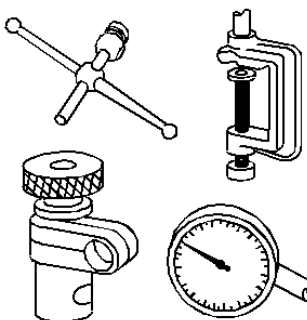
EN 46114  
Engine Lift Brackets

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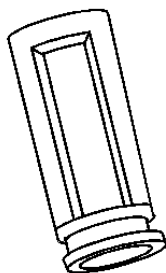
2009 ENGINE Engine Mechanical - 3.6L - G8



EN 46116  
Valve Stem Seal Remover/Installer

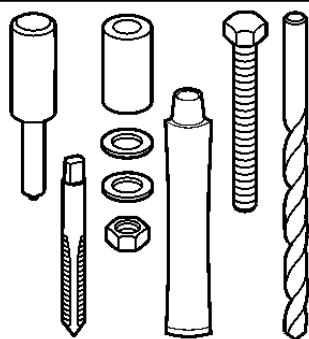
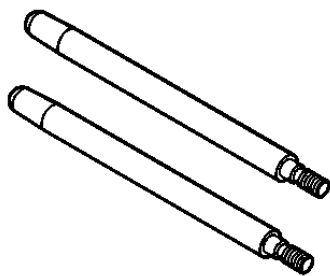


EN 46117  
Valve Stem Key Remover/Installer

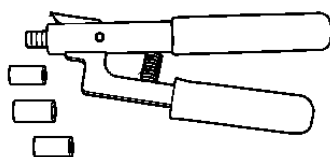


EN 46119  
Off-Vehicle Valve Spring Compressor Adapter

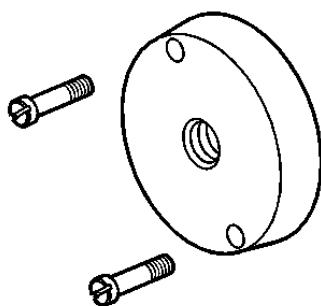
EN 46121  
Connecting Rod Guide Pin Set



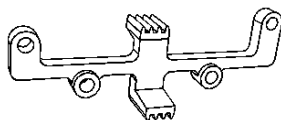
EN 46122  
Camshaft Position Actuator Check-Ball Valve  
Remover/Installer



EN 46745  
Piston Pin Clip Remover/Installer



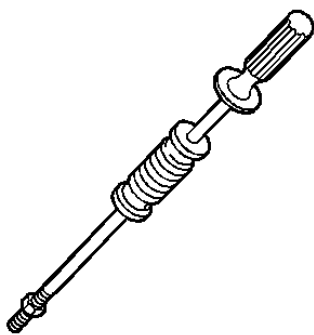
EN 47839  
Crankshaft Rear Oil Seal Installation Tool



EN 48018  
Flywheel Holding Tool

## 2009 Pontiac G8

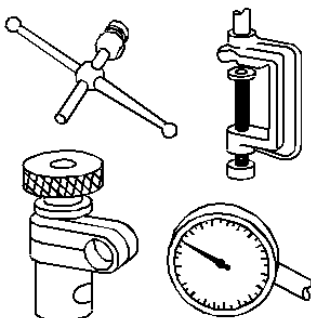
2009 ENGINE Engine Mechanical - 3.6L - G8



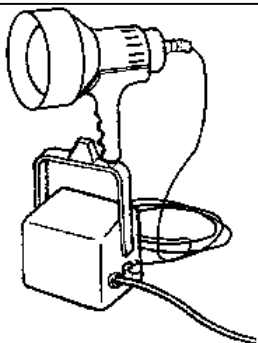
J 6125-1B  
Slide Hammer with Adapter



J 7872  
Magnetic Base Dial Indicator



J 8001  
Dial Indicator Set

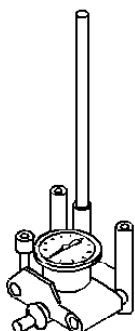
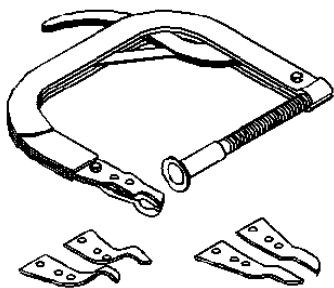


J 8037  
Ring Compressor

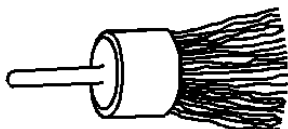
J 8062  
Valve Spring Compressor - Head Off

## 2009 Pontiac G8

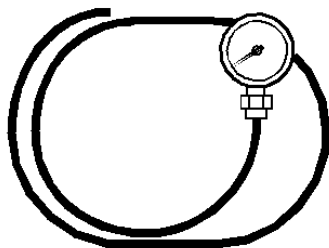
2009 ENGINE Engine Mechanical - 3.6L - G8



J 8087  
Cylinder Bore Gage

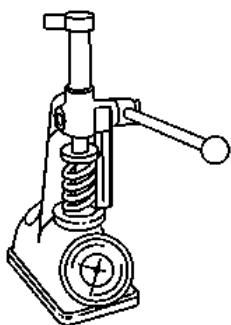
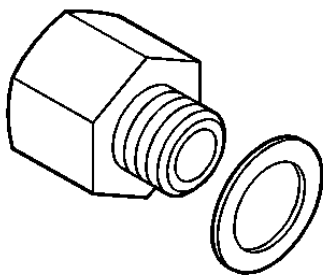


J 8358  
Carbon Removal Brush

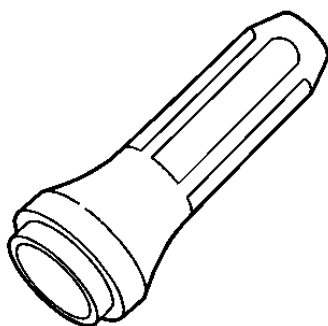


J 21867  
Pressure Gage

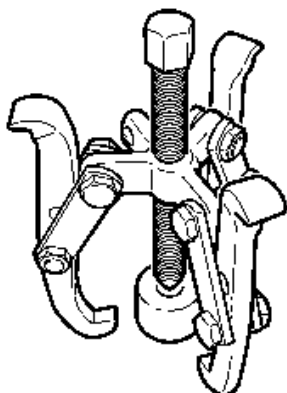
J 21867-6  
Oil Pressure Adapter Fitting



J 22738-B  
Valve Spring Tester



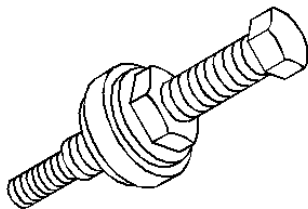
J 24254  
Oil Seal Installer



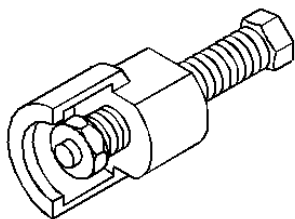
303-642  
Crankshaft Balancer Puller

## 2009 Pontiac G8

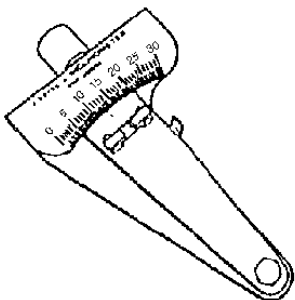
2009 ENGINE Engine Mechanical - 3.6L - G8



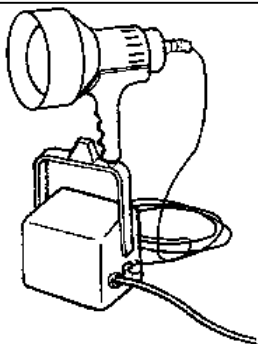
J 25033-C  
Pulley Installer



J 25034-C  
Pulley Remover



J 28410  
Gasket Remover (Aluminium Components)



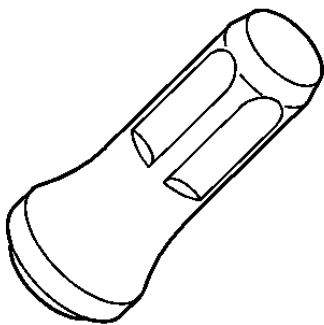
J 28428-E  
High Intensity Black Light Kit

J 29184  
Oil Seal Installer



## 2009 Pontiac G8

2009 ENGINE Engine Mechanical - 3.6L - G8



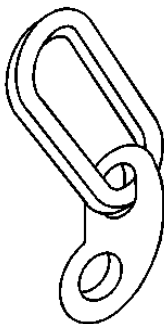
J 33169  
Clutch Alignment Arbor



J 35667-A  
Cylinder Head Leakdown Tester



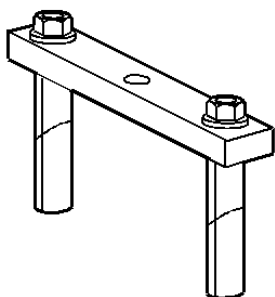
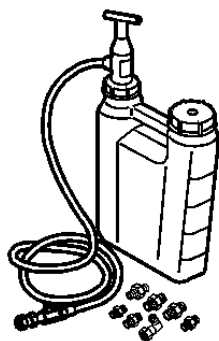
J 36857  
Engine Lift Bracket



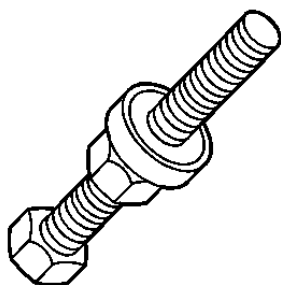
J 39313  
Spark Plug Port Adapter

## 2009 Pontiac G8

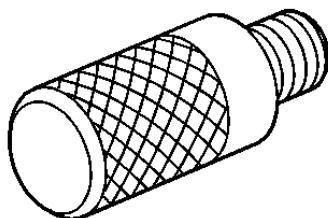
2009 ENGINE Engine Mechanical - 3.6L - G8



J 41818  
Crankshaft Bearing Cap Remover



J 41998-B  
Crankshaft Balancer Installer

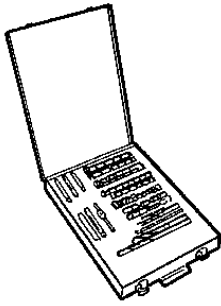


J 42183  
Handle

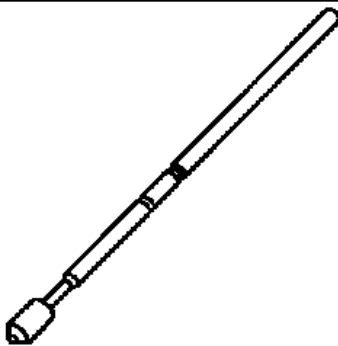
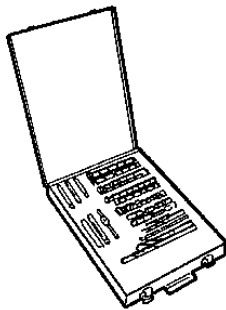
J 42385-700  
High Feature Thread Repair Kit

## 2009 Pontiac G8

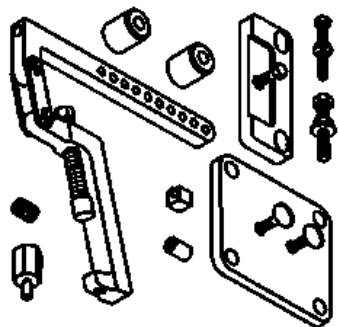
2009 ENGINE Engine Mechanical - 3.6L - G8



J 42385-2000  
Thread Insert Kit



J 42640  
Steering Column Anti-Rotation Pin

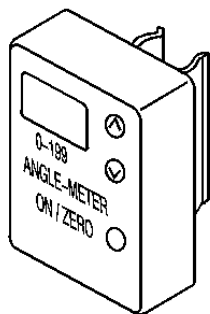
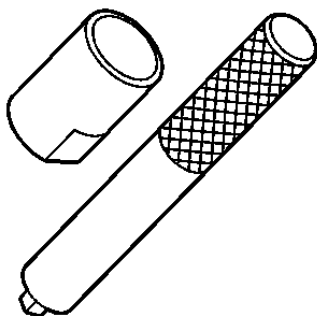
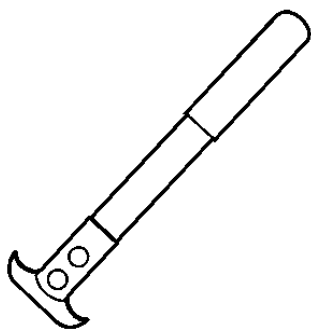
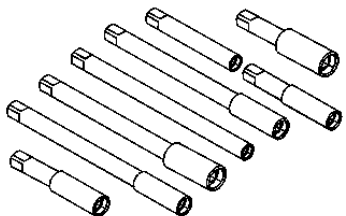


J 43690-100  
Rod Bearing Clearance Checking Tool - Adapter  
Kit

J 43965  
Thread Repair Extension Kit

## 2009 Pontiac G8

2009 ENGINE Engine Mechanical - 3.6L - G8



J 45000  
Seal Remover

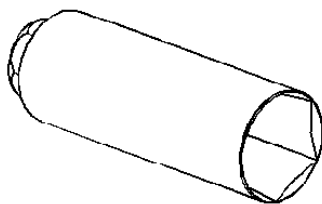
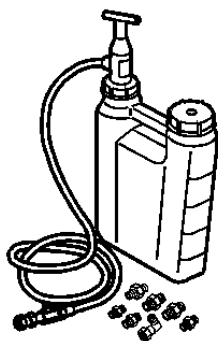
J 45027  
Tensioner Tool

J 45059  
Angle Meter

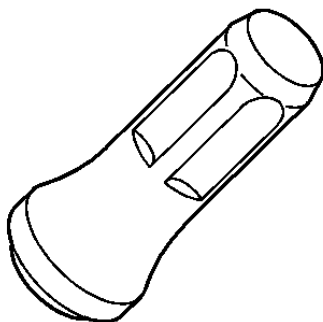
J 45299  
Engine Preluber

## 2009 Pontiac G8

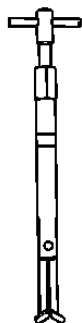
2009 ENGINE Engine Mechanical - 3.6L - G8



J 41712  
Oil Pressure Sensor Socket



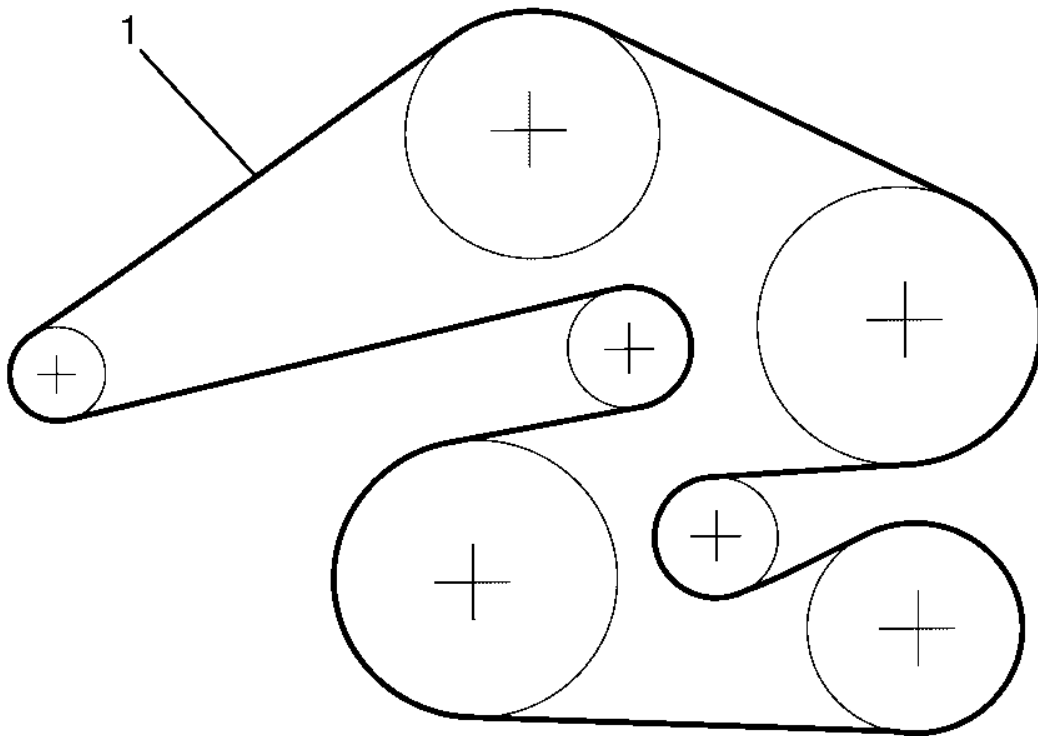
J 29184  
Crankshaft Front Oil Seal Installer



EN 48313  
Timing Chain Retention Tool

**2009 ENGINE****Engine Mechanical - 3.6L - G8****REPAIR INSTRUCTIONS - ON VEHICLE****DRIVE BELT REPLACEMENT****Removal Procedure**

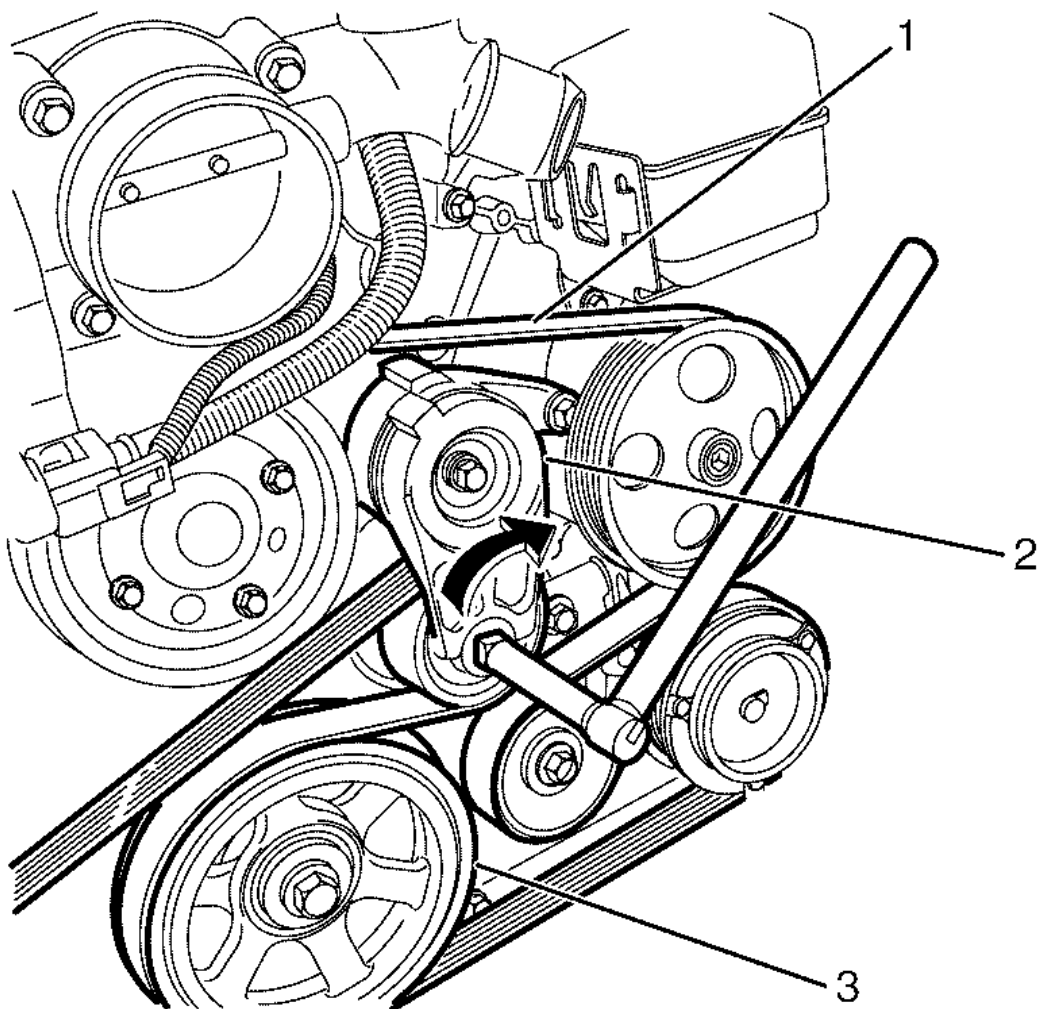
1. Remove the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .



**Fig. 1: Drive Belt Routing**

Courtesy of GENERAL MOTORS CORP.

2. Note the routing of the drive belt (1).

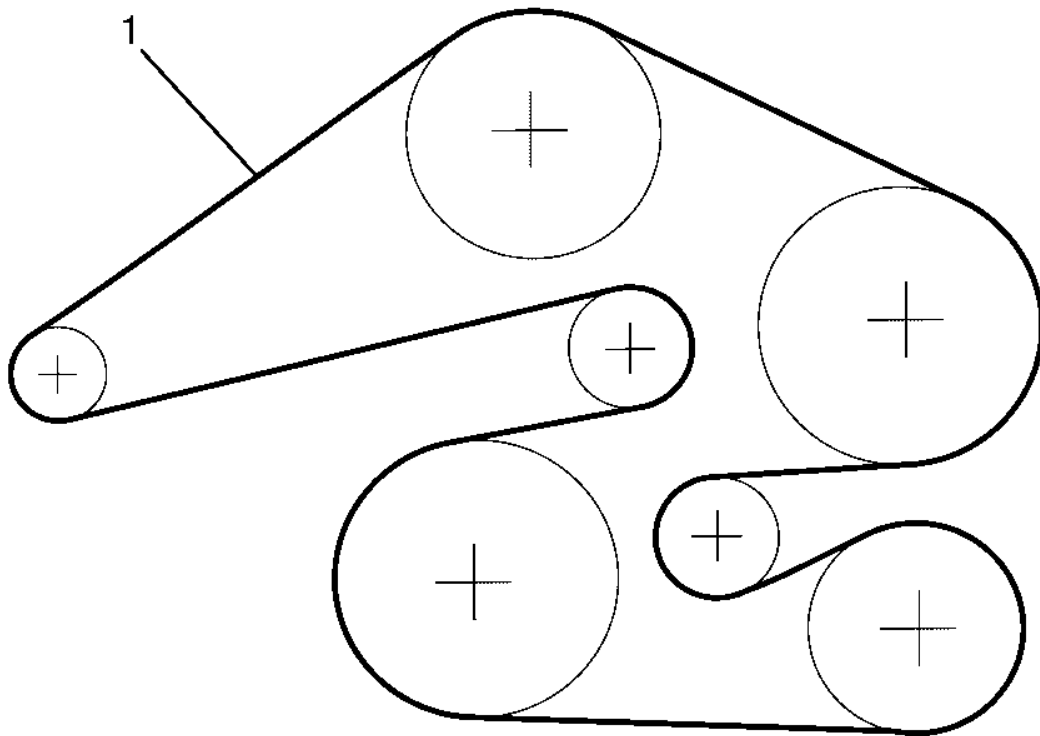


**Fig. 2: Identifying Drive Belt Tensioner Rotation (Clockwise)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Using a suitable tool rotate the drive belt tensioner (2) clockwise.

3. Rotate the drive belt tensioner (2) clockwise in order to release tension on the drive belt (1).
4. Remove the drive belt (1) from the crankshaft pulley (3).
5. Slowly release the drive belt tensioner (2).
6. Remove the drive belt (1).

#### Installation Procedure

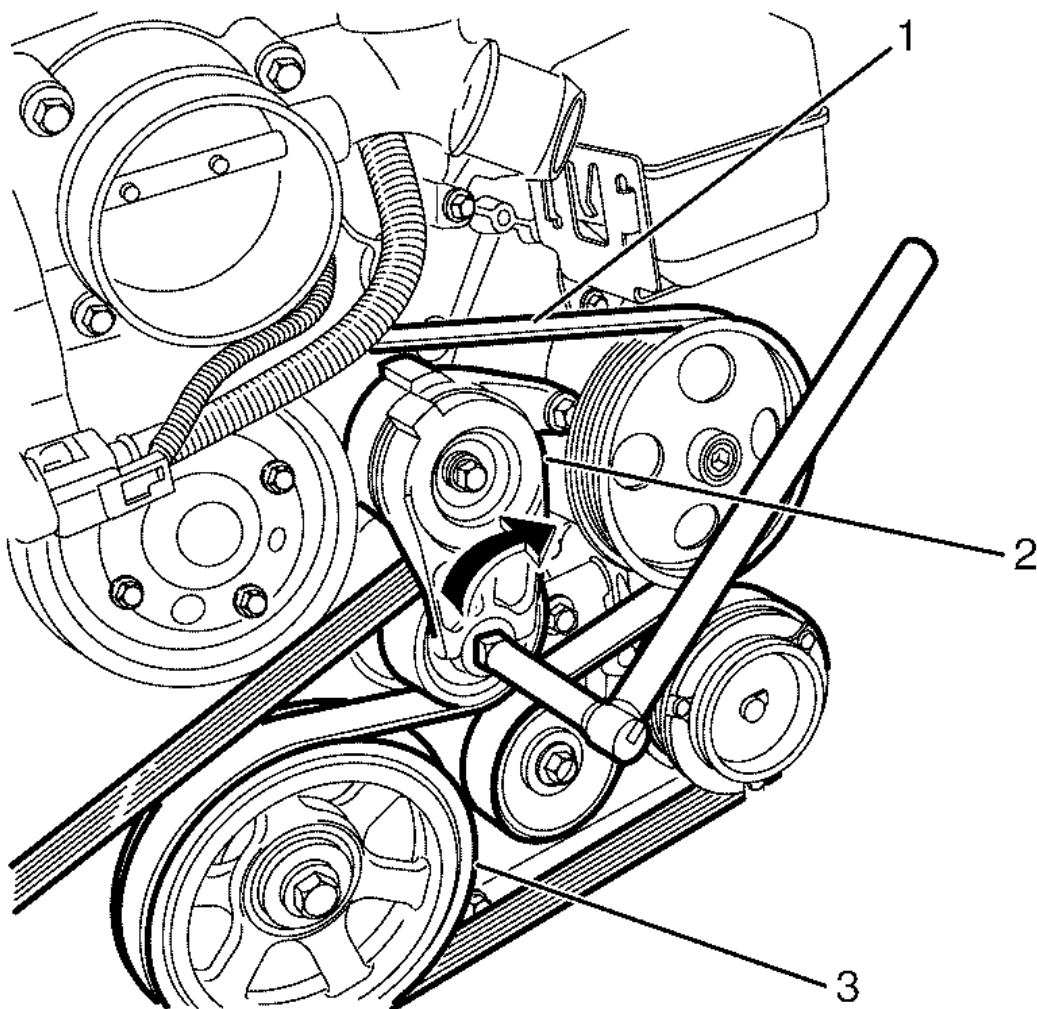


**Fig. 3: Drive Belt Routing**

Courtesy of GENERAL MOTORS CORP.

1. Install and correctly route the drive belt (1) around the following:
  - Water pump pulley
  - Generator
  - Drive belt tensioner
  - Crankshaft balancer
  - Air conditioning compressor
  - Power steering pump





**Fig. 4: Identifying Drive Belt Tensioner Rotation (Clockwise)**  
Courtesy of GENERAL MOTORS CORP.

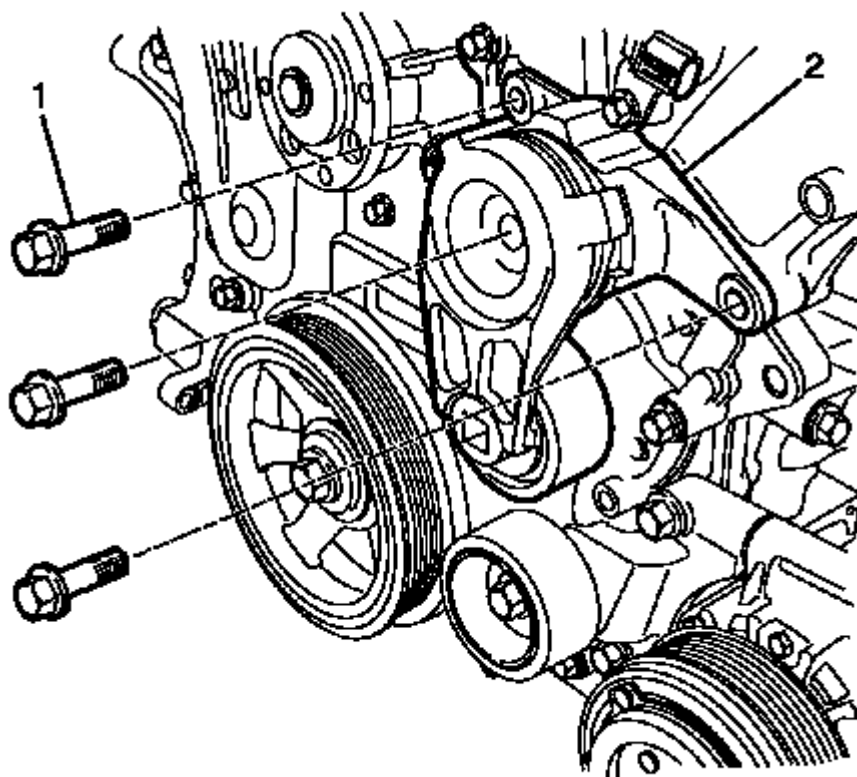
2. Using a suitable tool rotate the drive belt tensioner (2) clockwise.
3. Install the drive belt (1) to the crankshaft pulley (3).

**IMPORTANT: Make sure the drive belt (1) is correctly aligned and seated into the grooves of the accessory drive pulleys.**

4. Slowly release the drive belt tensioner (2).
5. Remove the suitable tool from the drive belt tensioner (2).
6. Install the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement**.

**DRIVE BELT TENSIONER REPLACEMENT****Removal Procedure**

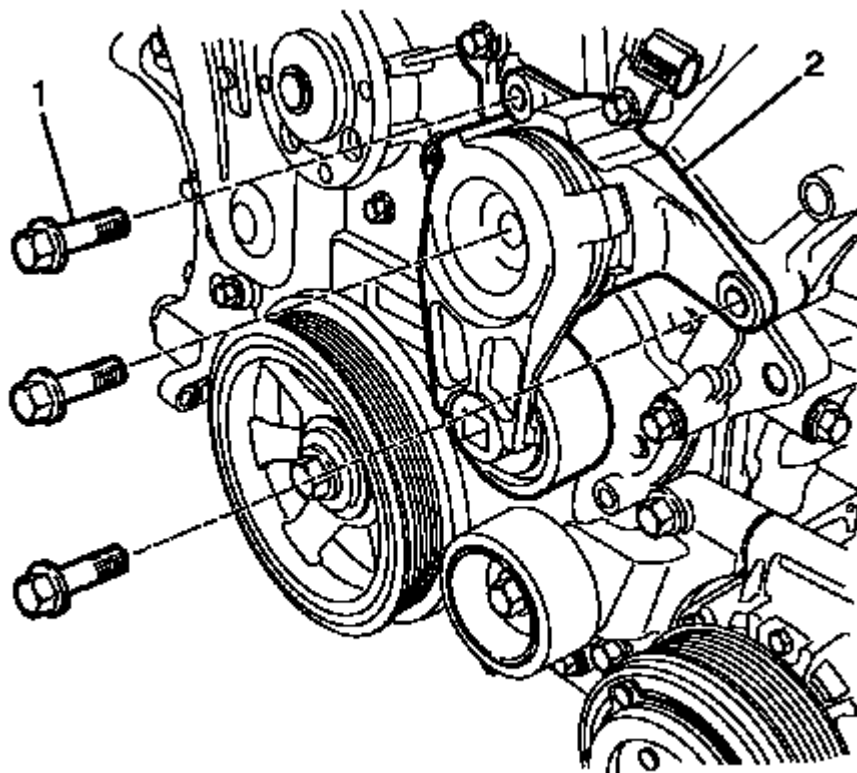
1. Remove the air intake duct. Refer to [Air Cleaner Inlet Duct Replacement](#) .
2. Remove the drive belt. Refer to [Drive Belt Replacement](#).



**Fig. 5: Identifying Drive Belt Tensioner To Engine Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the drive belt tensioner to engine front cover retaining bolts (1).
4. Remove the drive belt tensioner (2).

**Installation Procedure**



**Fig. 6: Identifying Drive Belt Tensioner To Engine Front Cover Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner (2) to the engine front cover.

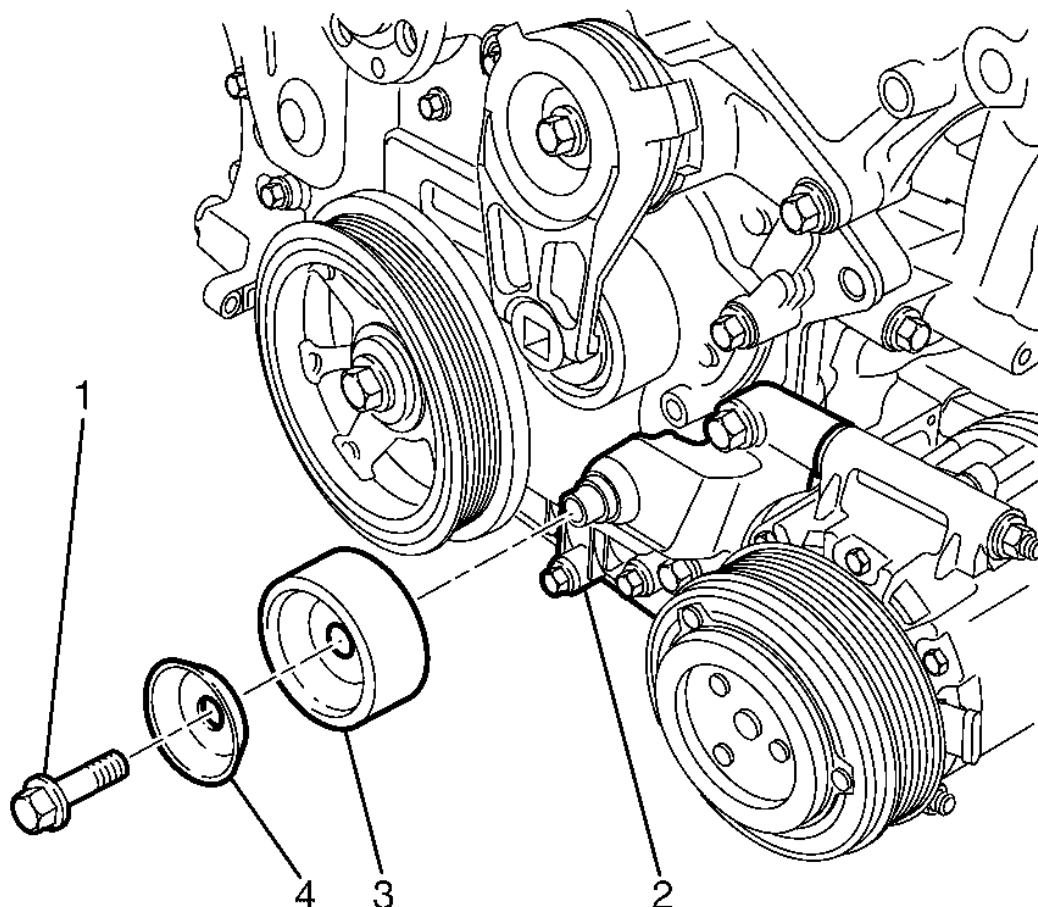
**CAUTION:** Refer to Fastener Caution .

2. Install the drive belt tensioner to the engine front cover retaining bolts (1) and tighten to 22 N.m (17 lb ft).
3. Install the drive belt. Refer to Drive Belt Replacement.
4. Install the air intake duct. Refer to Air Cleaner Inlet Duct Replacement .

## DRIVE BELT IDLER PULLEY REPLACEMENT

### Removal Procedure

1. Remove the air intake duct. Refer to Air Cleaner Inlet Duct Replacement .
2. Remove the drive belt. Refer to Drive Belt Replacement.

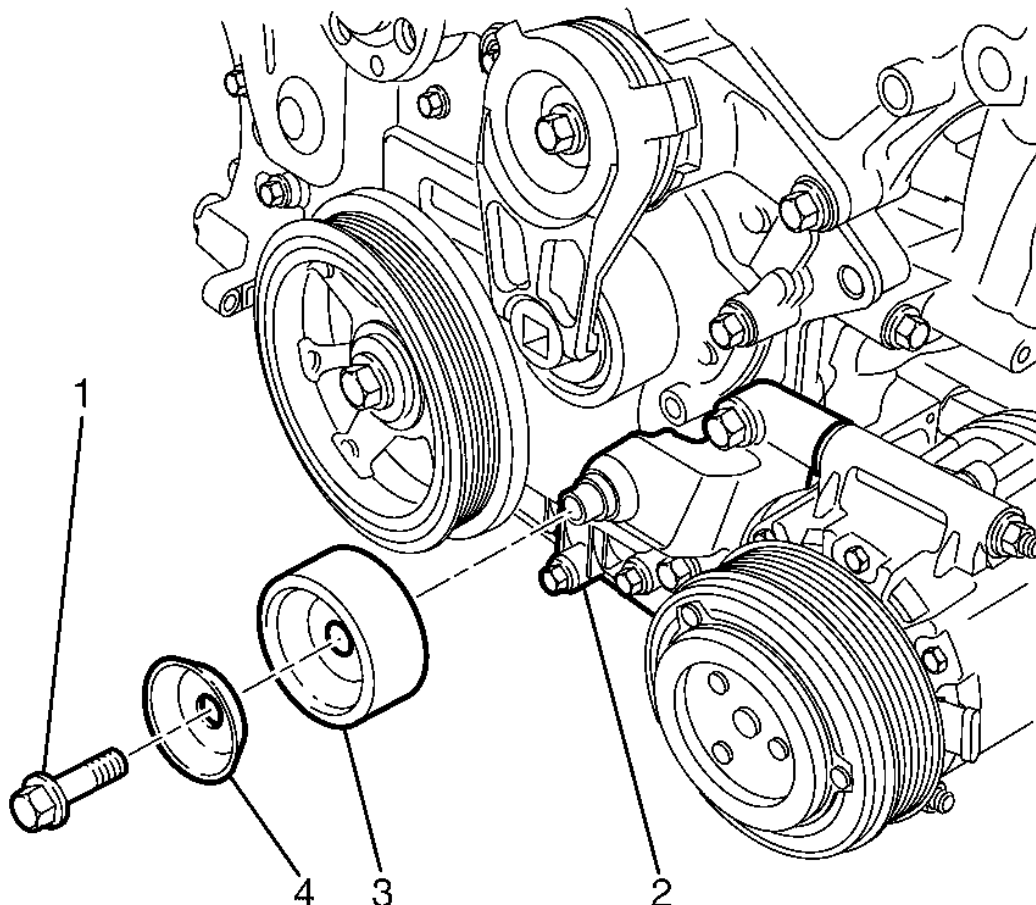


**Fig. 7: View Of Dished Washer, Drive Belt Idler Pulley, Accessory Drive Mounting Bracket & Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

3. Remove the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).
4. Remove the dished washer (4) and drive belt idler pulley (3) from the accessory drive mounting bracket (2).

#### Installation Procedure



**Fig. 8: View Of Dished Washer, Drive Belt Idler Pulley, Accessory Drive Mounting Bracket & Retaining Bolt**

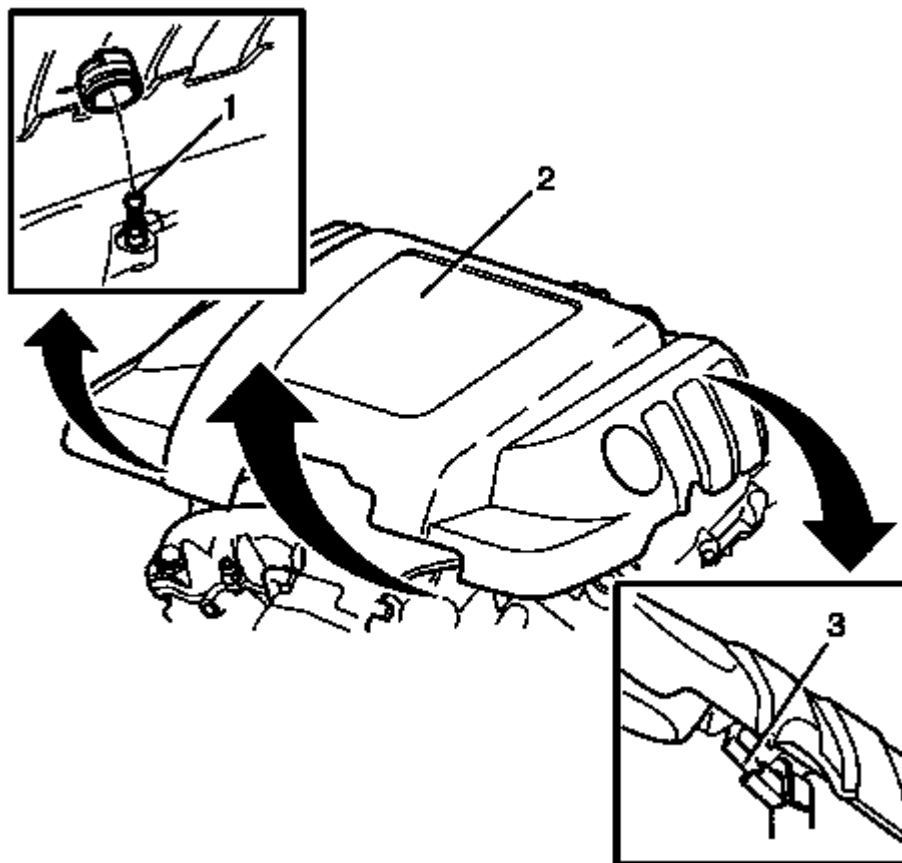
Courtesy of GENERAL MOTORS CORP.

1. Install the dished washer (4) and drive belt idler pulley (3) to the accessory drive mounting bracket (2).
2. Hand tighten the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).

**CAUTION:** Refer to Fastener Caution .

3. Install the drive belt idler pulley with the accessory drive mounting bracket retaining bolt and tighten to 58 N.m (43 lb ft).
4. Install the drive belt. Refer to Drive Belt Replacement.
5. Install the air intake duct. Refer to Air Cleaner Inlet Duct Replacement .

## ENGINE COVER REPLACEMENT

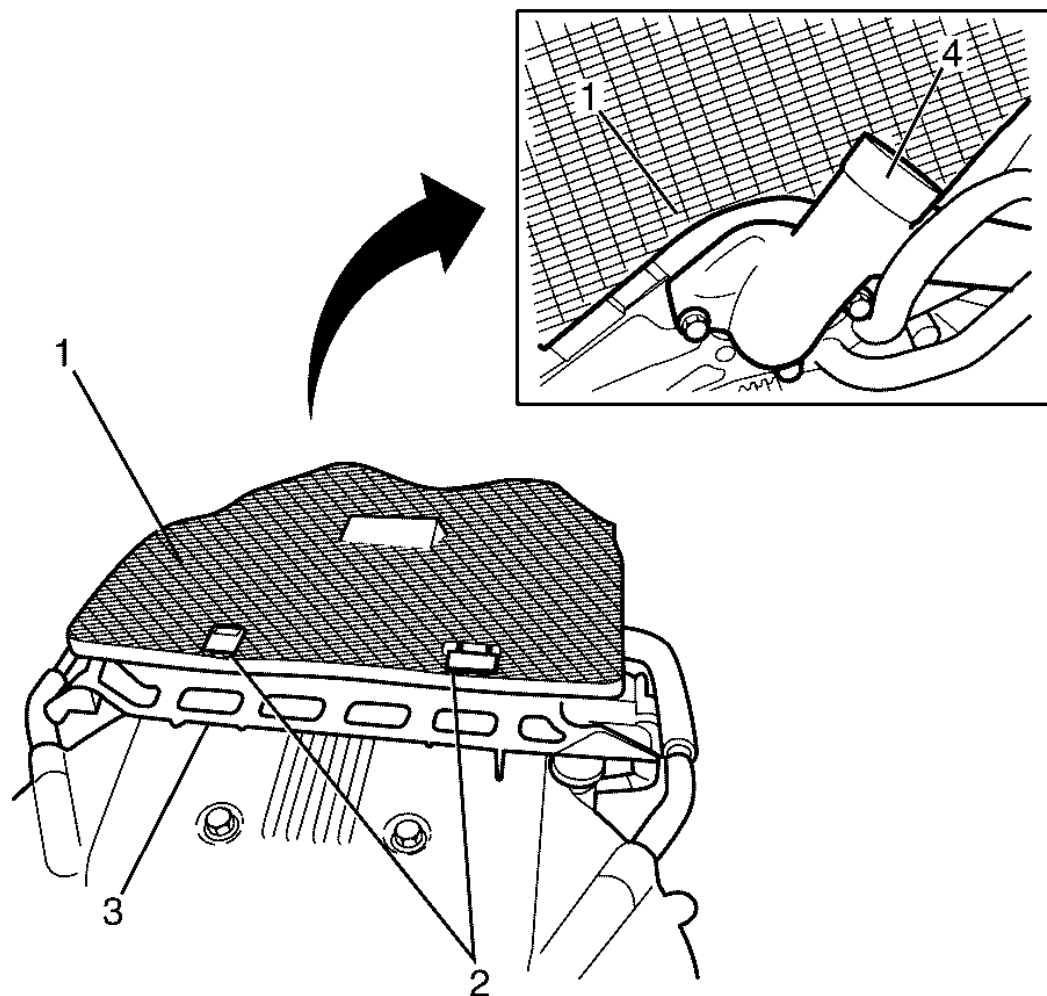
**Removal Procedure**

**Fig. 9: Engine Cover, Locator Legs & Retention Hooks**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Apply suitable pressure on the front edge of the engine cover (2) to disengage the locator legs (1).

**NOTE:** Disengage the engine cover insulator legs (1) by raising the engine cover (2) upwards and moving it suitably forward to release the retention hooks (3).

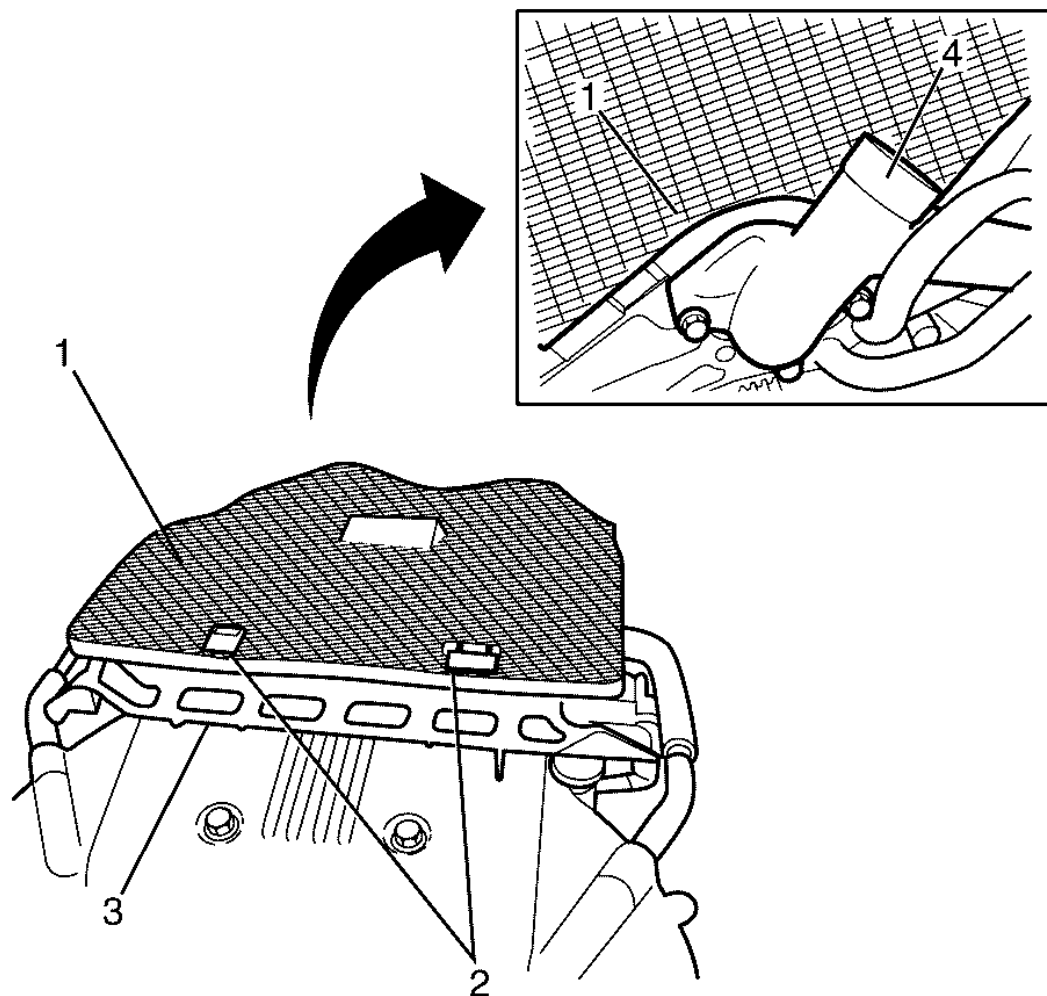
1. Remove the engine cover (2).



**Fig. 10: Sound Insulator, Hooks & Intake Manifold Sight Shield Bracket**  
Courtesy of GENERAL MOTORS CORP.

2. Disengage the sound insulator (1) from the two hooks (2) on the intake manifold sight shield bracket (3).
3. Remove the sound insulator (1) ensuring it safely releases from behind the water outlet housing (4).

#### Installation Procedure

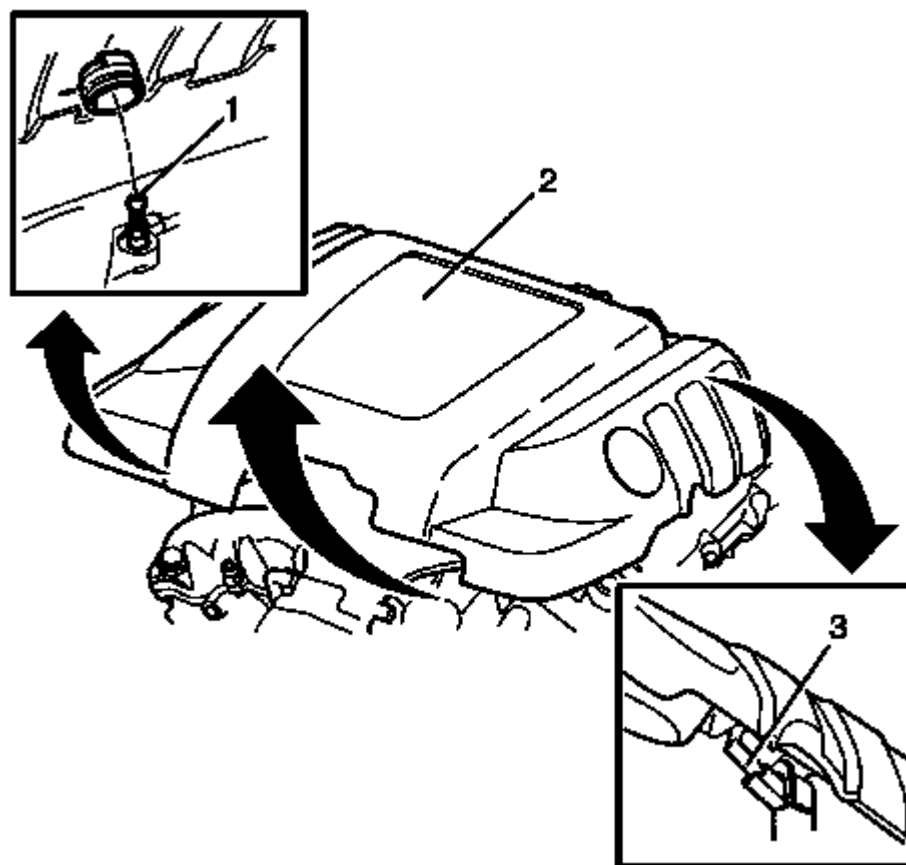


**Fig. 11: Sound Insulator, Hooks & Intake Manifold Sight Shield Bracket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the sound insulator (1) correctly locates behind the water outlet housing (4).

1. Install the sound insulator (1).
2. Engage the sound insulator (1) onto the two retention hooks (2) on the intake manifold sight shield bracket (3).



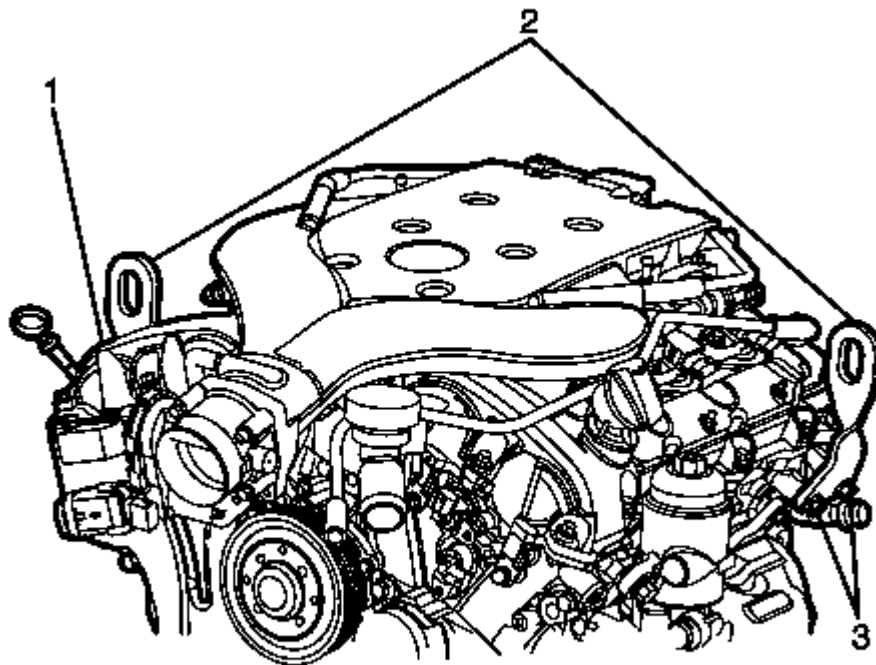


**Fig. 12: Engine Cover, Locator Legs & Retention Hooks**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** When installing the engine cover (2) onto the engine assembly, make sure to correctly engage the retention hooks (3).

3. Install the engine cover (2) onto the engine assembly, engaging the engine cover insulator legs (1).

#### ENGINE MOUNT INSPECTION



**Fig. 13: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

1. Position the EN 46114 (2) on the engine (1).

**CAUTION:** Refer to Fastener Caution .

2. Install the EN 46114 to cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).

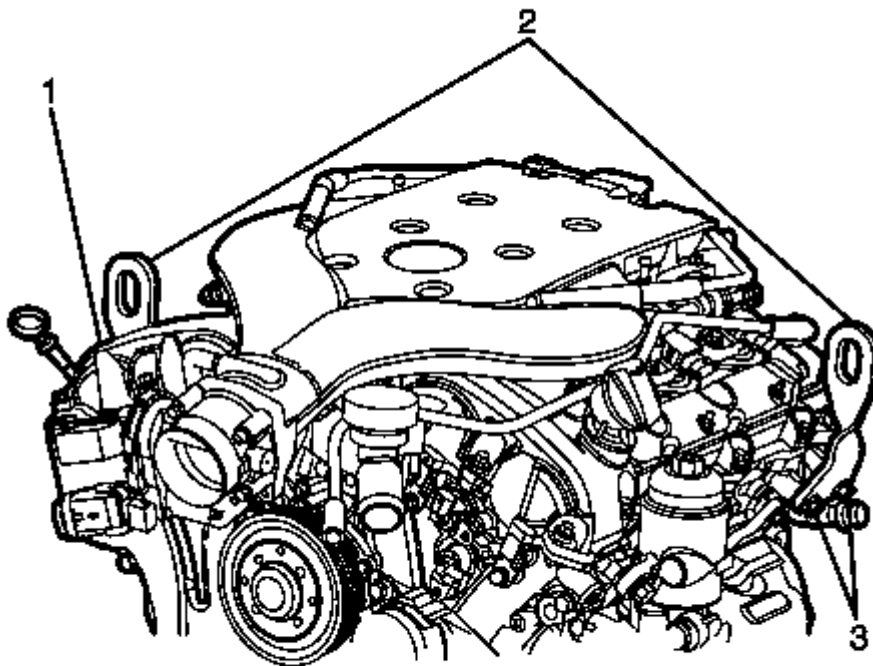
**CAUTION:** Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

**NOTE:** Raising the engine, will remove the weight from the engine mount and create a slight tension in the rubber mount.

3. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the engine mounts.

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

4. Observe the engine mount while raising the engine. Replace the engine mount if the mount exhibits any of the following conditions:
  - The hard rubber surface 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 GLYCOL™ fluid is leaking from the engine mount.
5. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket. Refer to **Engine Mount Replacement - Left Side** or **Engine Mount Replacement - Right Side**.



**Fig. 14: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the EN 46114 to cylinder head retaining bolts (3).
7. Remove the EN 46114 (2) from the engine (1).

**ENGINE MOUNT REPLACEMENT - LEFT SIDE****Special Tools**

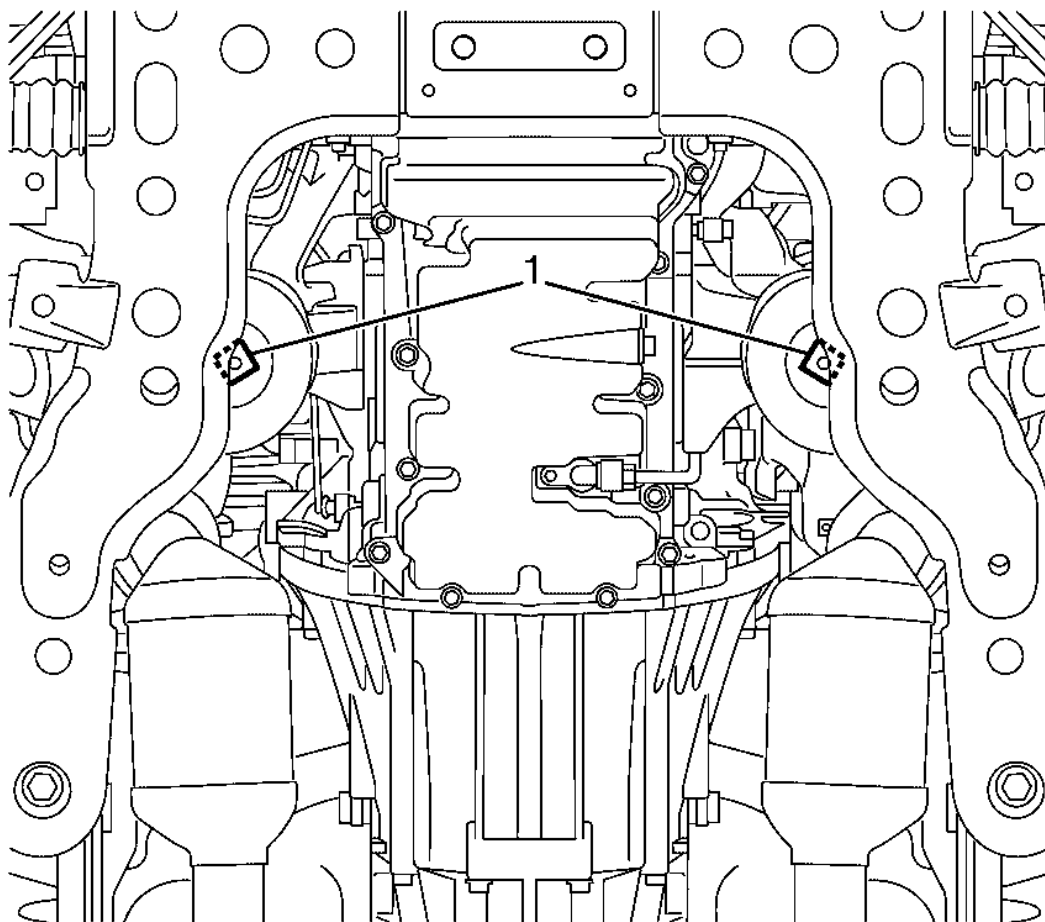
**EN 46114** Engine Lift Brackets.

**Removal Procedure**

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

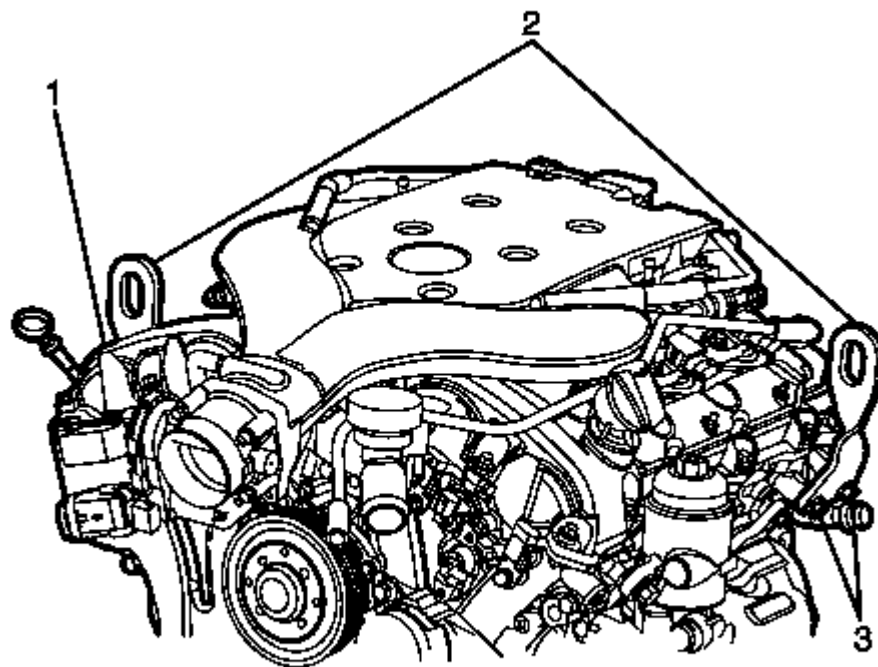
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Remove the engine splash shield. Refer to Engine Splash Shield Replacement .



**Fig. 15: Identifying Engine Mount To Front Subframe Retaining Nut**  
**Courtesy of GENERAL MOTORS CORP.**

3. Remove the engine mount to front subframe retaining nuts (1).
4. Lower the vehicle.



**Fig. 16: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

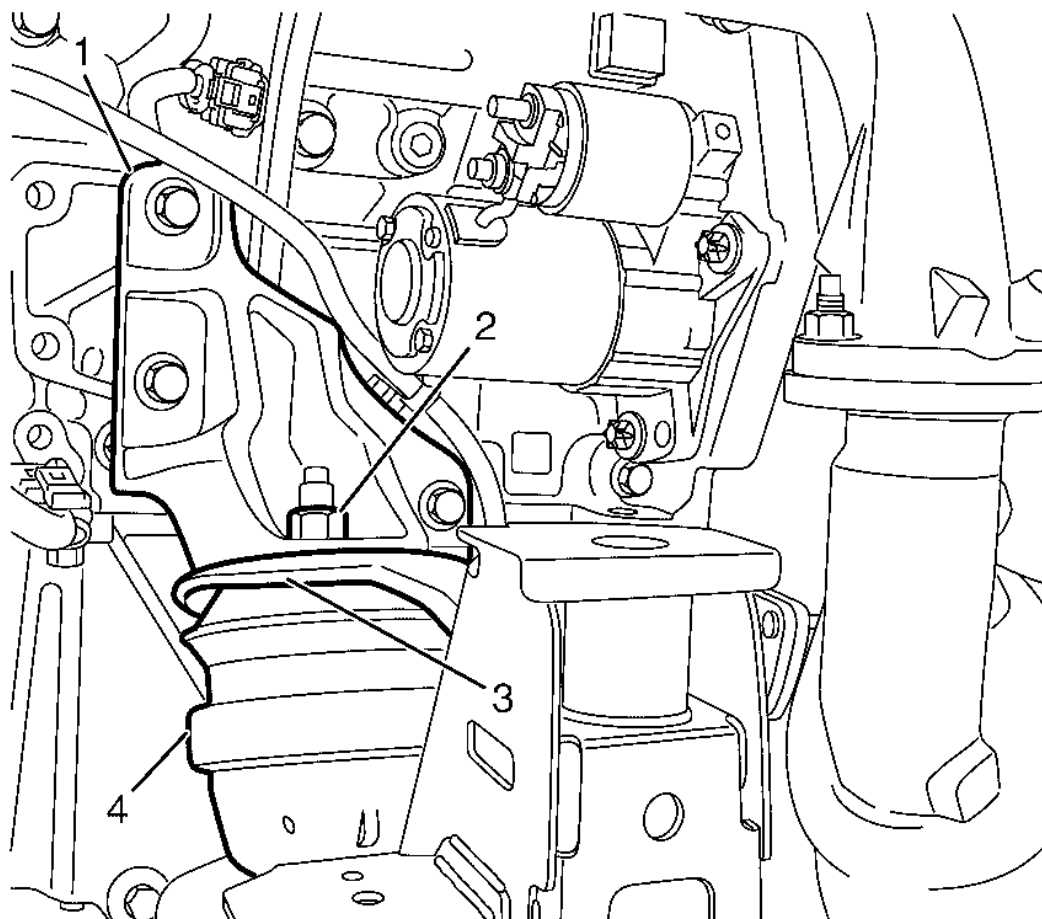
5. Position the EN 46114 (2) on the engine (1).

**CAUTION:** Refer to Fastener Caution .

6. Install the EN 46114 using the cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

7. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the left hand engine mount.



**Fig. 17: Identifying Left Hand Engine Mount To Engine Mount Bracket Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the left hand engine mount to engine mount bracket retaining nut (2).

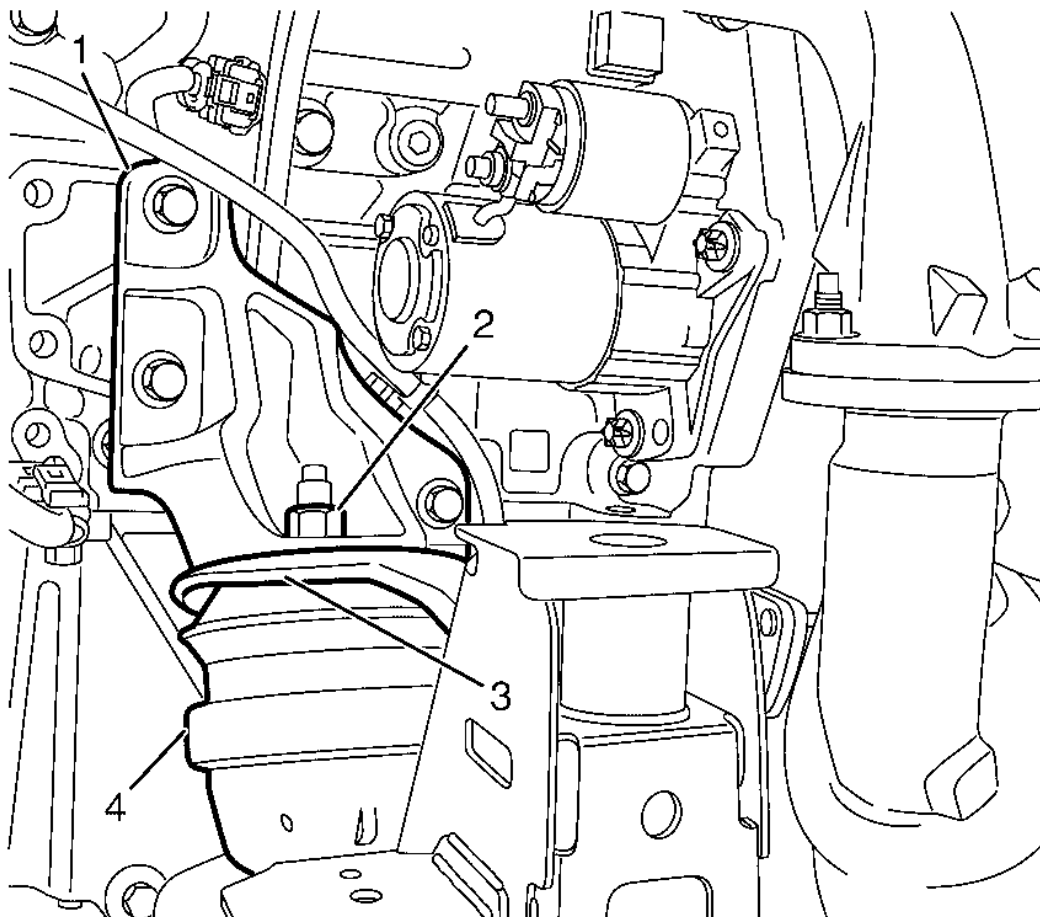
**NOTE:** If required raise the engine further to provide adequate space.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

**NOTE:** DO NOT distort or bend the left hand engine mount heat shield (3).

9. Remove the left hand engine mount (4) from the left hand engine mount bracket (1).

#### Installation Procedure



**Fig. 18: Identifying Left Hand Engine Mount To Engine Mount Bracket Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT distort or bend the left hand engine mount heat shield (3).

1. Position the left hand engine mount (4) on the left hand engine mount bracket (1).

**CAUTION:** Refer to Fastener Caution .

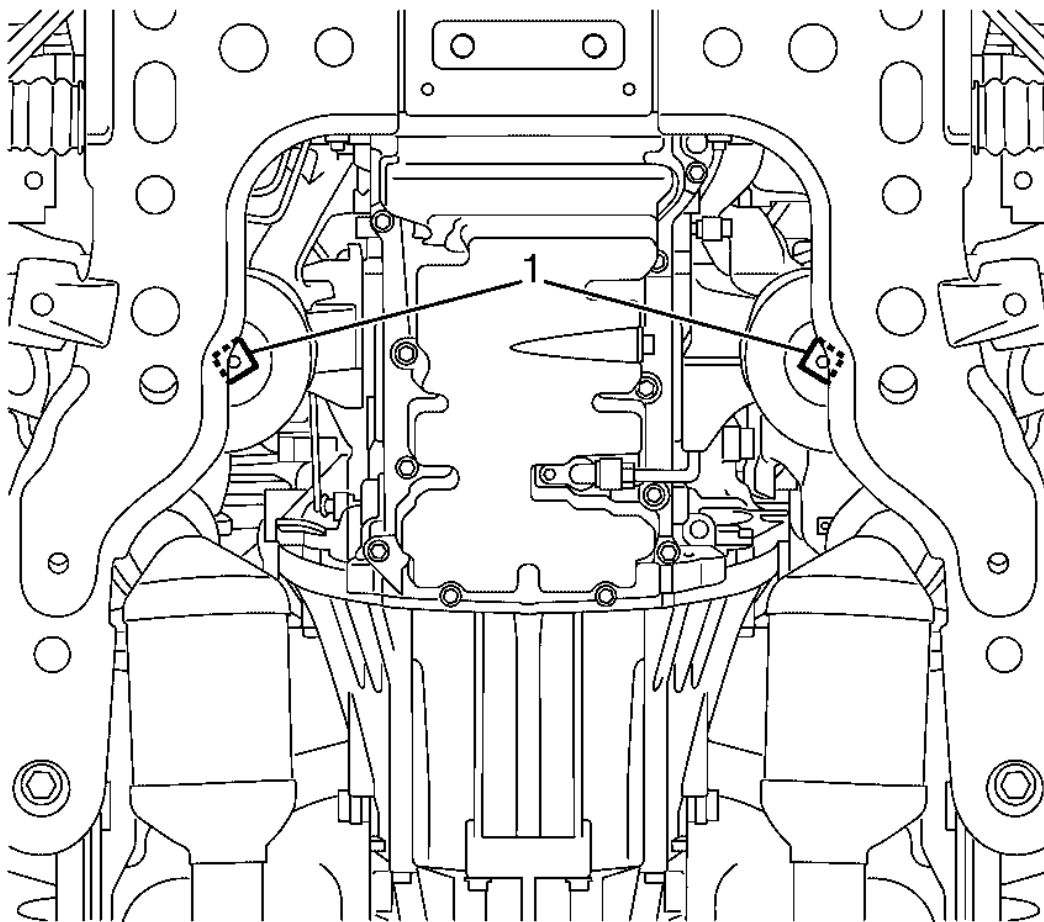
2. Install the left hand engine mount using the engine mount bracket retaining nut (2) and tighten to 80 N.m (59 lb ft).
3. Lower the engine until the weight is resting on the left hand engine mount.

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



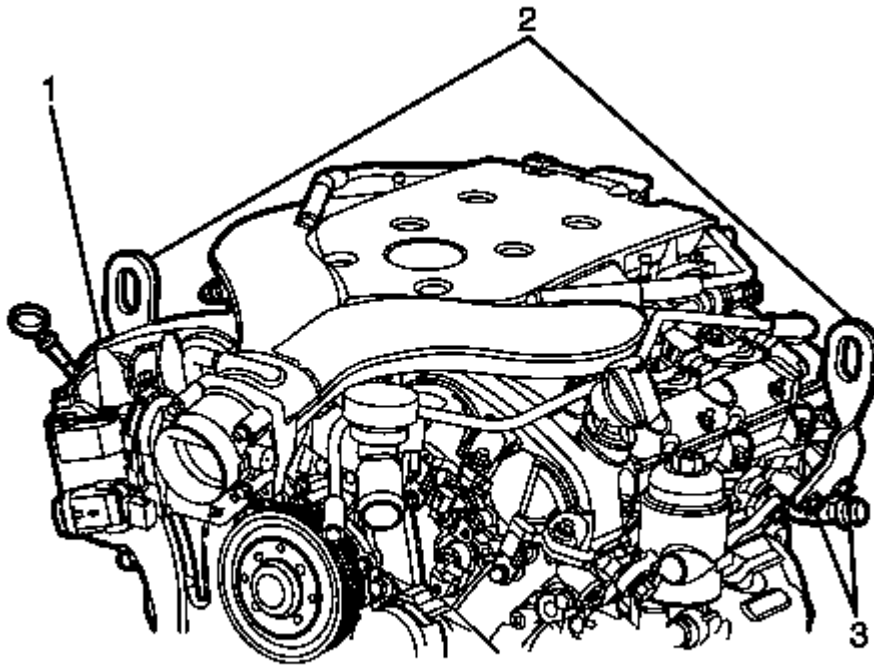
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

4. Raise the vehicle.



**Fig. 19: Identifying Engine Mount To Front Subframe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount using the front subframe retaining nuts (1) and tighten to 80 N.m (59 lb ft).
6. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
7. Lower the vehicle to the ground.



**Fig. 20: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the EN 46114 to cylinder head retaining bolts (3).
9. Remove the EN 46114 (2) from the engine (1).

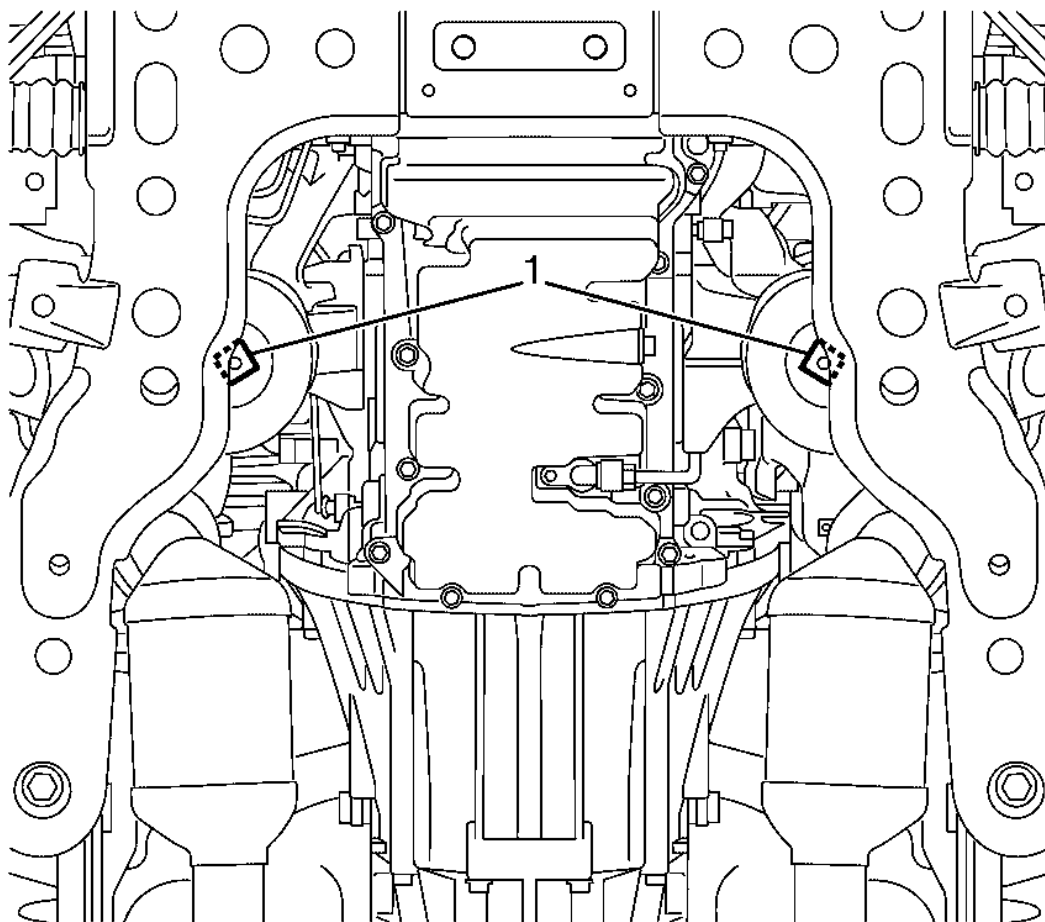
## ENGINE MOUNT REPLACEMENT - RIGHT SIDE

### Removal Procedure

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

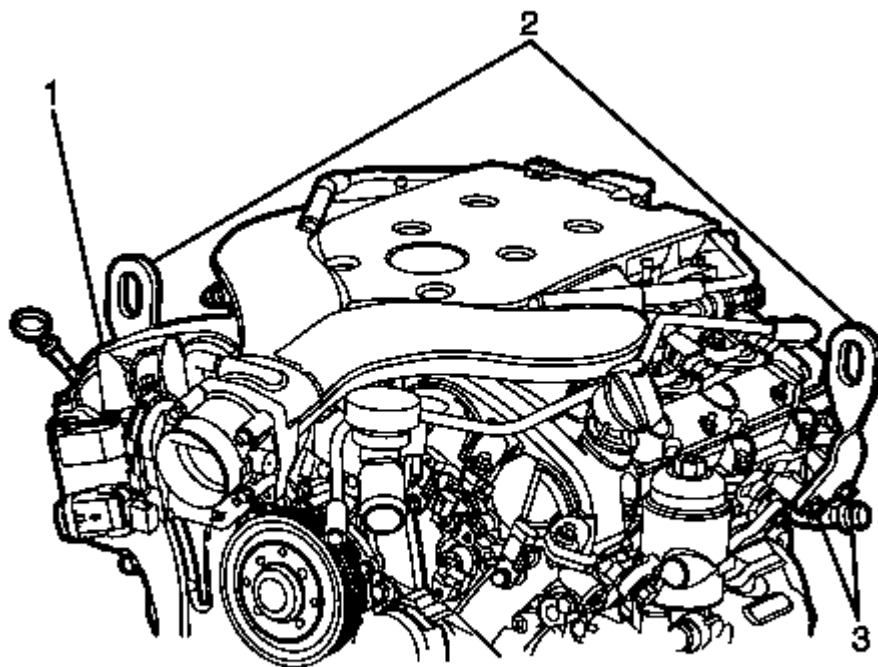
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Remove the engine splash shield. Refer to Engine Splash Shield Replacement .



**Fig. 21: Identifying Engine Mount To Front Subframe Retaining Nut**  
**Courtesy of GENERAL MOTORS CORP.**

3. Remove the engine mount to front subframe retaining nuts (1).
4. Lower the vehicle.



**Fig. 22: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

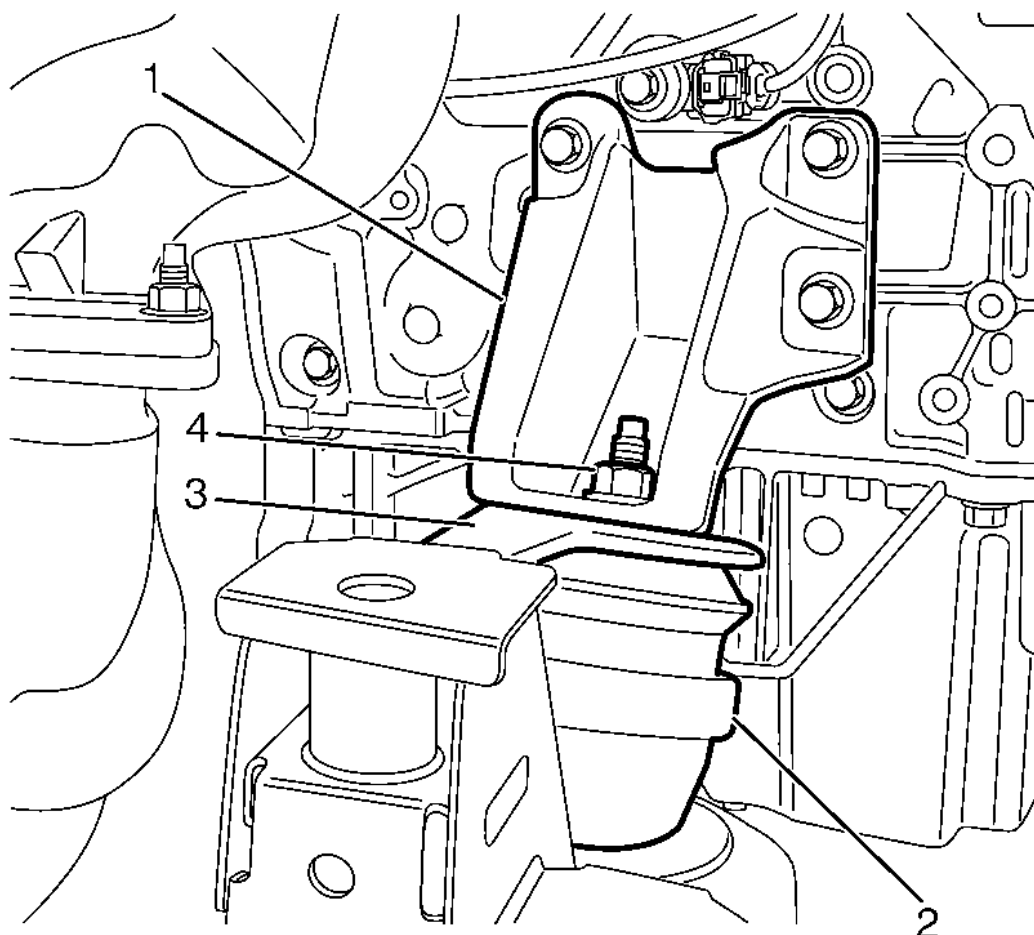
5. Position the **EN 46114** (2) on the engine (1).

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

6. Install the **EN 46114** using the cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).

**NOTE:**      **When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.**

7. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the right hand engine mount.



**Fig. 23: Identifying Right Hand Engine Mount To Engine Mount Bracket Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the right hand engine mount to engine mount bracket retaining nut (4).

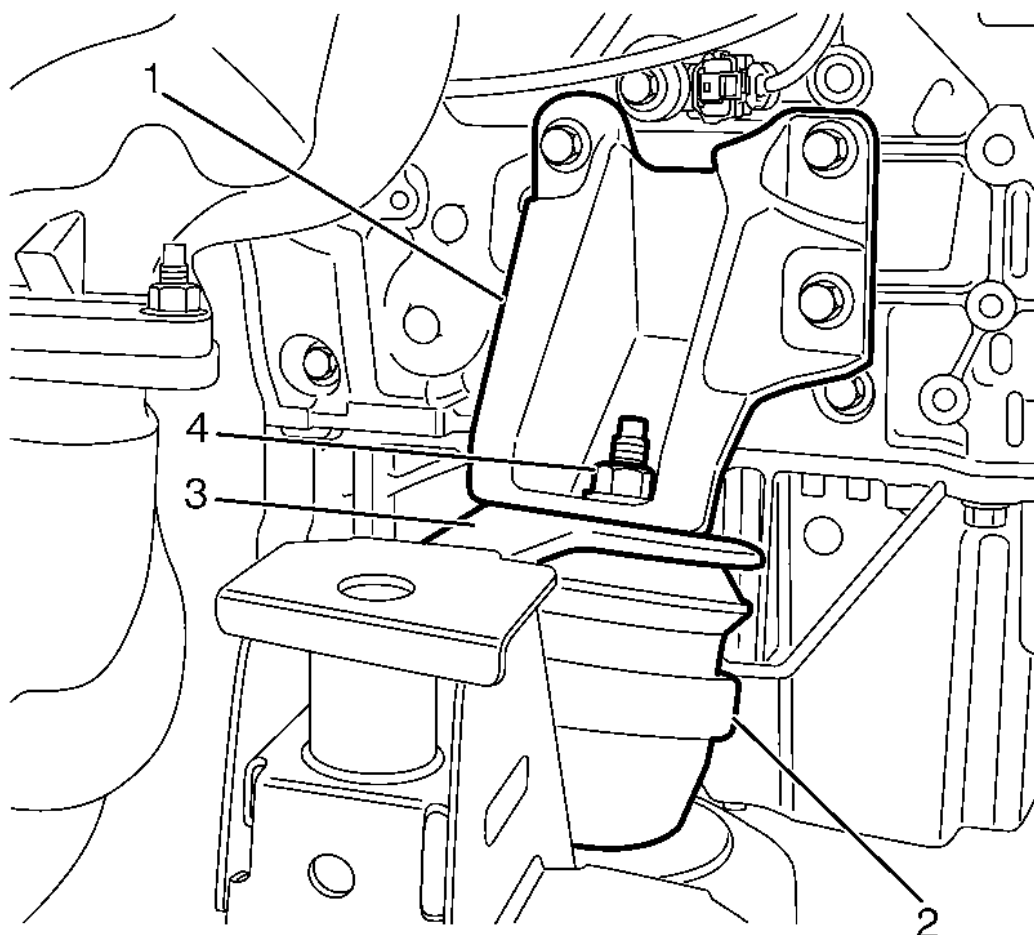
**NOTE:** If required raise the engine further to provide adequate space.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

**NOTE:** DO NOT distort or bend the right hand engine mount heat shield (3).

9. Remove the right hand engine mount (2) from the right hand engine mount bracket (1).

#### Installation Procedure



**Fig. 24: Identifying Right Hand Engine Mount To Engine Mount Bracket Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT distort or bend the right hand engine mount heat shield (3).

1. Position the right hand engine mount (2) on the right hand engine mount bracket (1).

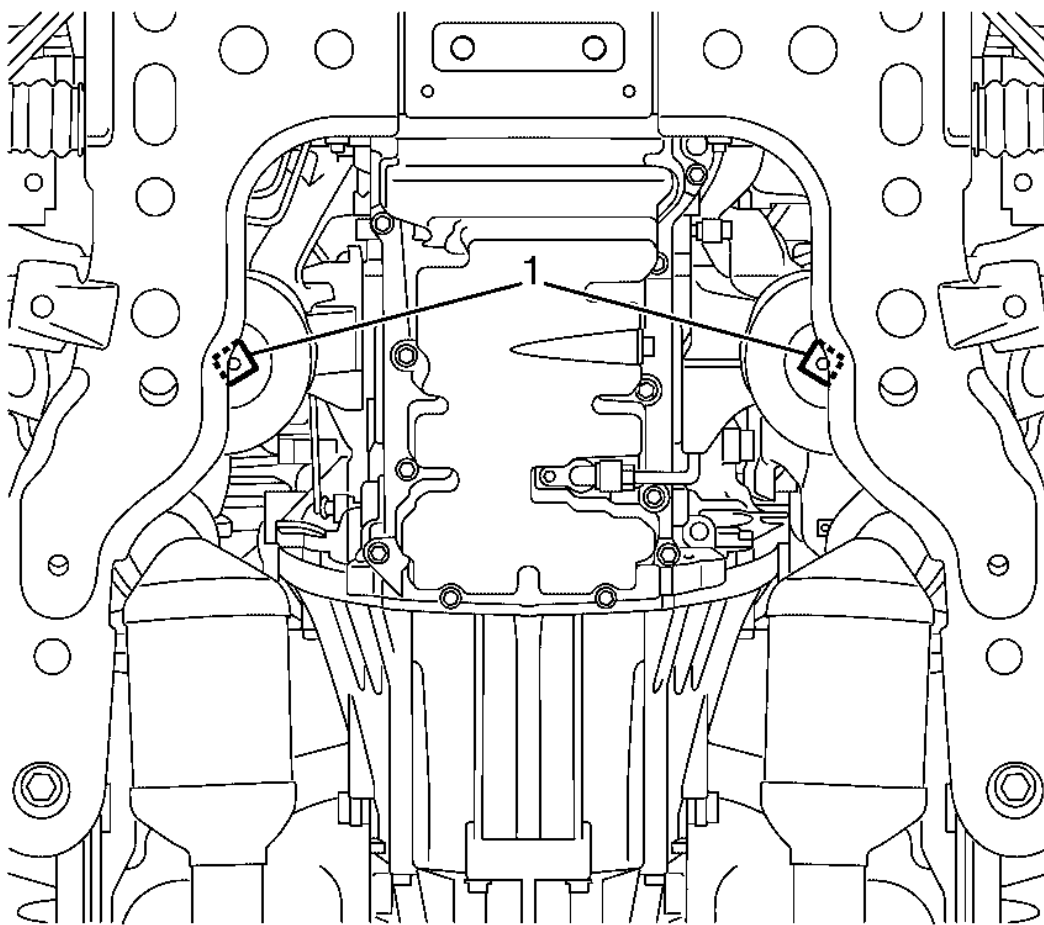
**CAUTION:** Refer to Fastener Caution .

2. Install the right hand engine mount using the engine mount bracket retaining nut (4) and tighten to 80 N.m (59 lb ft).
3. Lower the engine until the weight is resting on the right hand engine mount.

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

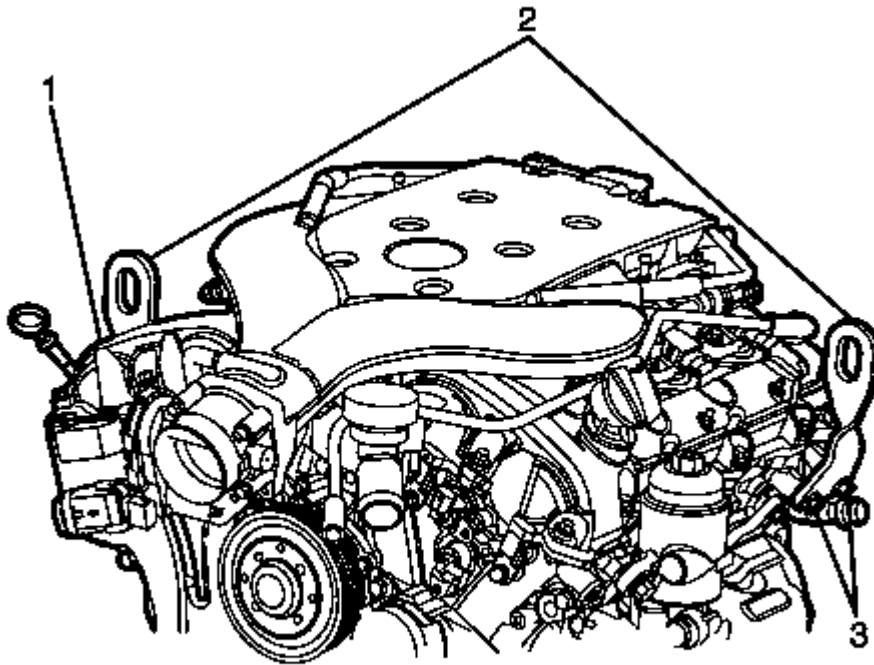
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

4. Raise the vehicle.



**Fig. 25: Identifying Engine Mount To Front Subframe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount using the front subframe retaining nuts (1) and tighten to 80 N.m (59 lb ft).
6. Install the engine splash shield. Refer to **Engine Splash Shield Replacement**.
7. Lower the vehicle to the ground.



**Fig. 26: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

8. Remove the EN 46114 to cylinder head retaining bolts (3).
9. Remove the EN 46114 (2) from the engine (1).

## ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE

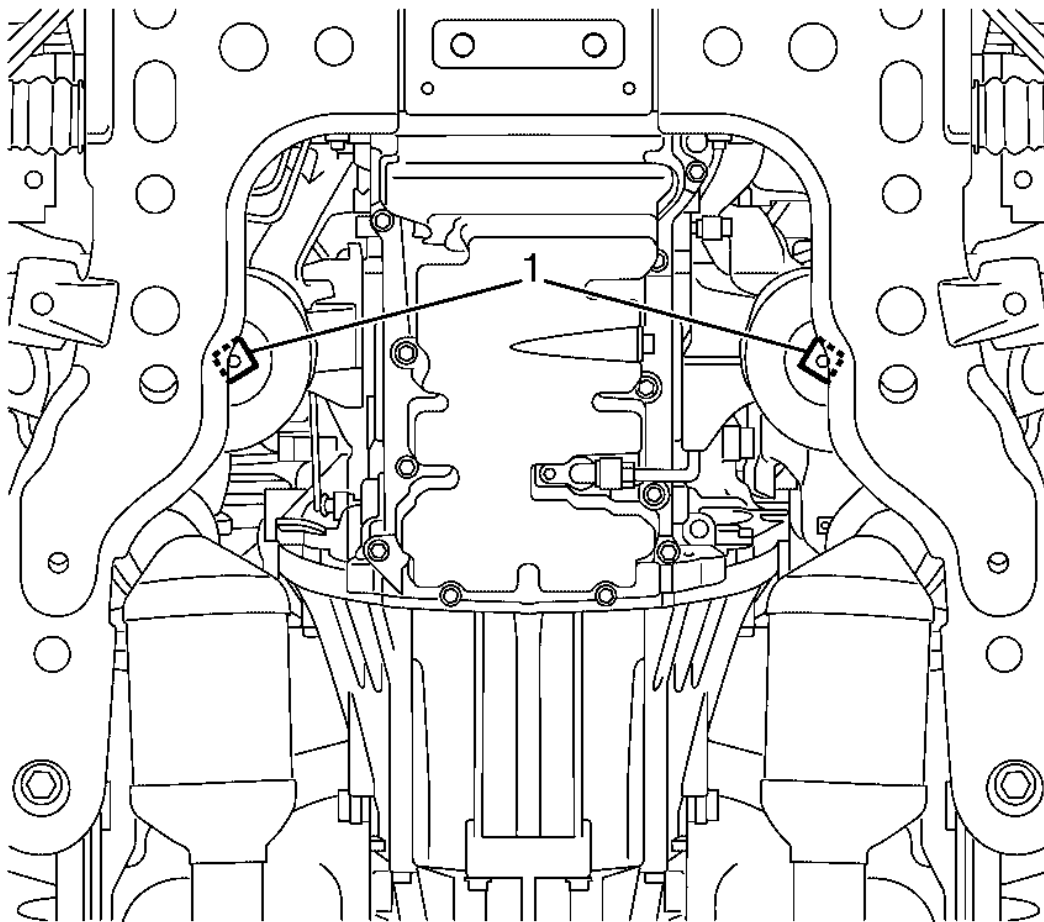
### Removal Procedure

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

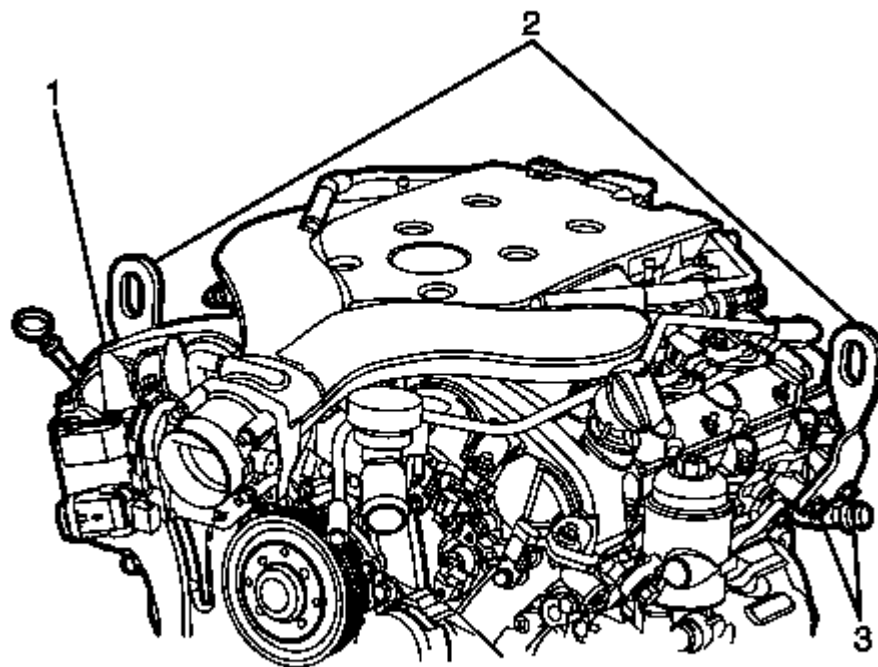
1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Remove the engine splash shield. Refer to Engine Splash Shield Replacement .





**Fig. 27: Identifying Engine Mount To Front Subframe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the lower engine mount retaining nuts (1).
4. Lower the vehicle.



**Fig. 28: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

5. Position the EN 46114 (2) on the engine (1).

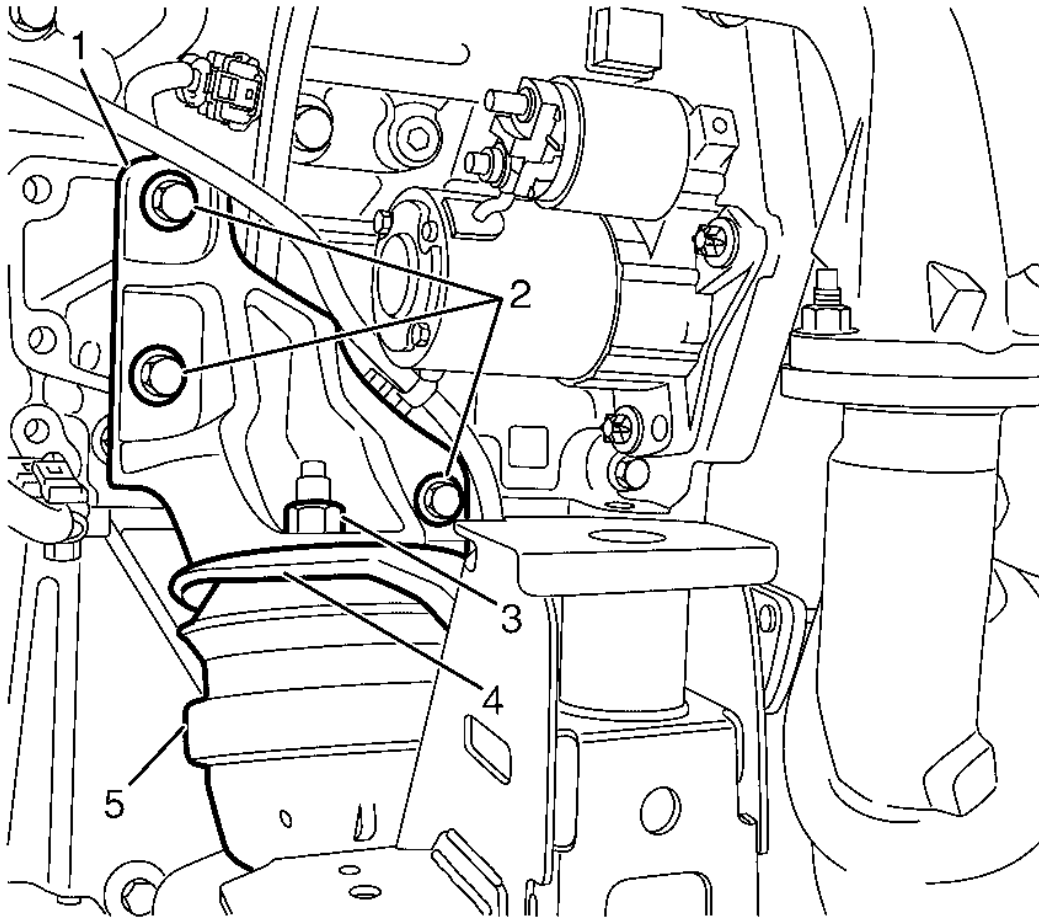
**CAUTION:** Refer to Fastener Caution .

6. Install the EN 46114 using the cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).

**NOTE:** Use a suitable tool to raise the engine.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

7. Raise the engine until the weight of the engine is removed from the left hand engine mount.



**Fig. 29: Identifying Right Hand Engine Mount Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the left hand engine mount to engine mount bracket retaining nut (3).

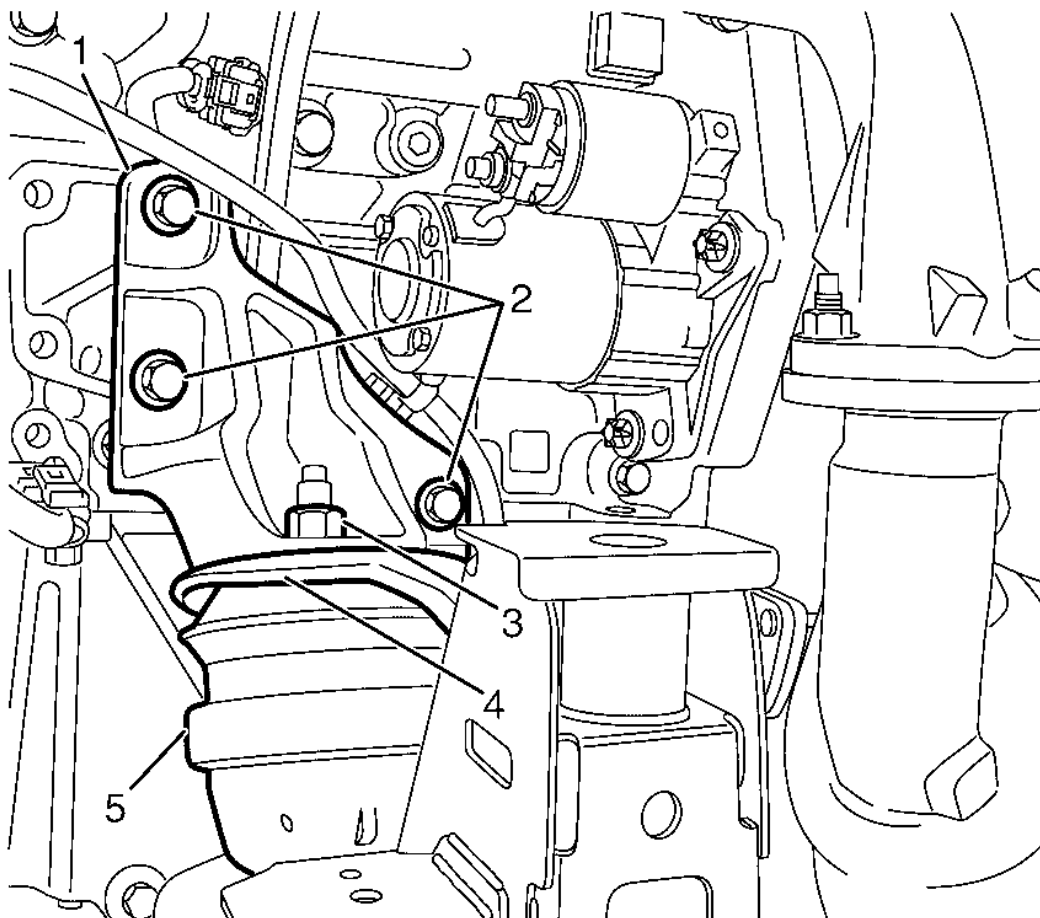
**NOTE:** If required raise the engine further to provide adequate space.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

9. Remove the left hand engine mount (5) from the left hand engine mount bracket (1).

**NOTE:** DO NOT distort or bend the left hand engine mount heat shield (4).

10. Remove the left hand engine mount bracket to cylinder block retaining bolts (2).
11. Remove the left hand engine mount bracket (1).

**Installation Procedure**

**Fig. 30: Identifying Right Hand Engine Mount Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT distort or bend the left hand engine mount heat shield (4).

1. Install the left hand engine mount bracket (1).

**CAUTION:** Refer to Fastener Caution .

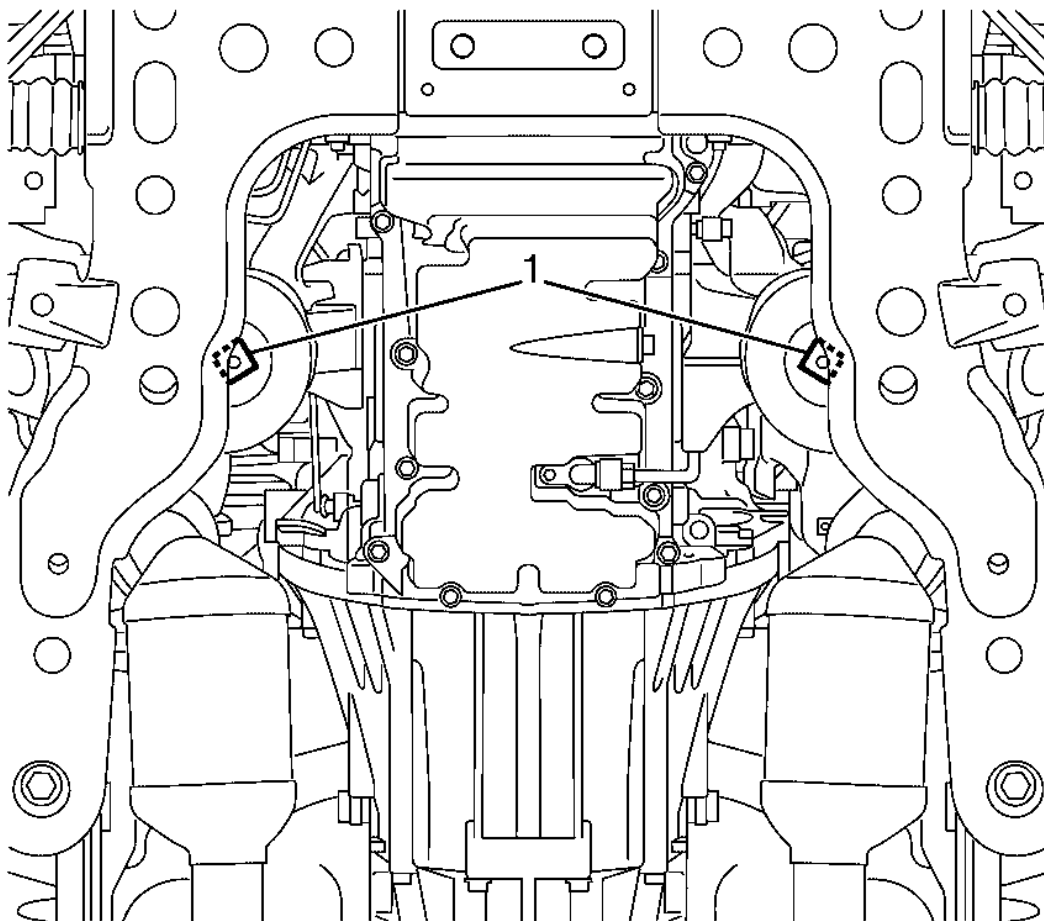
2. Install the left hand engine mount bracket using the cylinder block retaining bolts (2) and tighten to 60 N.m (44 lb ft).
3. Position the left hand engine mount (5) on the left hand engine mount bracket (1).

4. Install the left hand engine mount using the engine mount bracket retaining nut (3) and tighten to 80 N.m (59 lb ft).
5. Lower the engine until the weight is resting on the left hand engine mount.

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

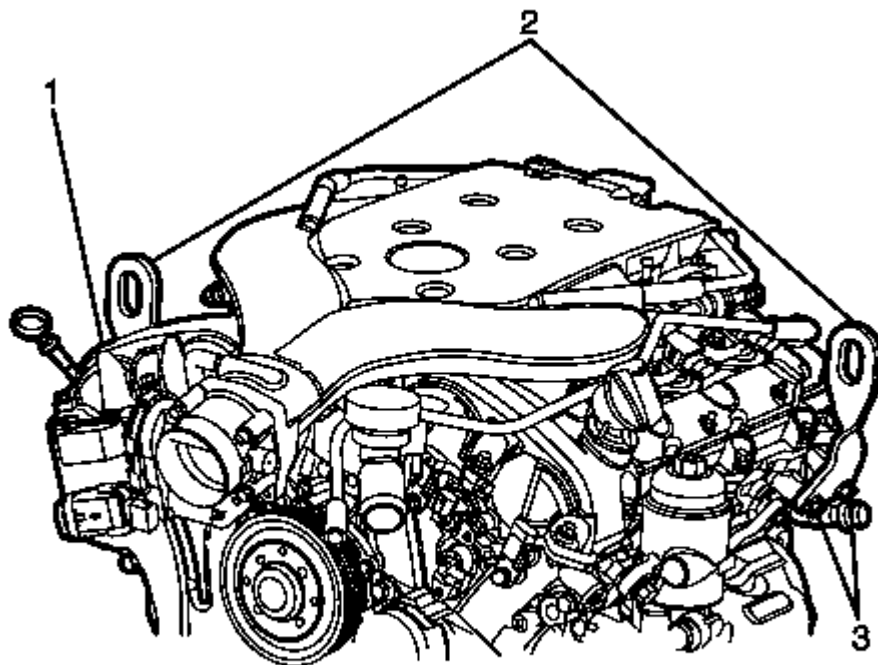
6. Raise the vehicle.



**Fig. 31: Identifying Engine Mount To Front Subframe Retaining Nut**

Courtesy of GENERAL MOTORS CORP.

7. Install the engine mount using the front subframe retaining nut (1) and tighten to 80 N.m (59 lb ft).
8. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
9. Lower the vehicle to the ground.



**Fig. 32: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the EN 46114 to cylinder head retaining bolts (3).
11. Remove the EN 46114 (2) from the engine (1).

#### **ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE**

##### **Special Tools**

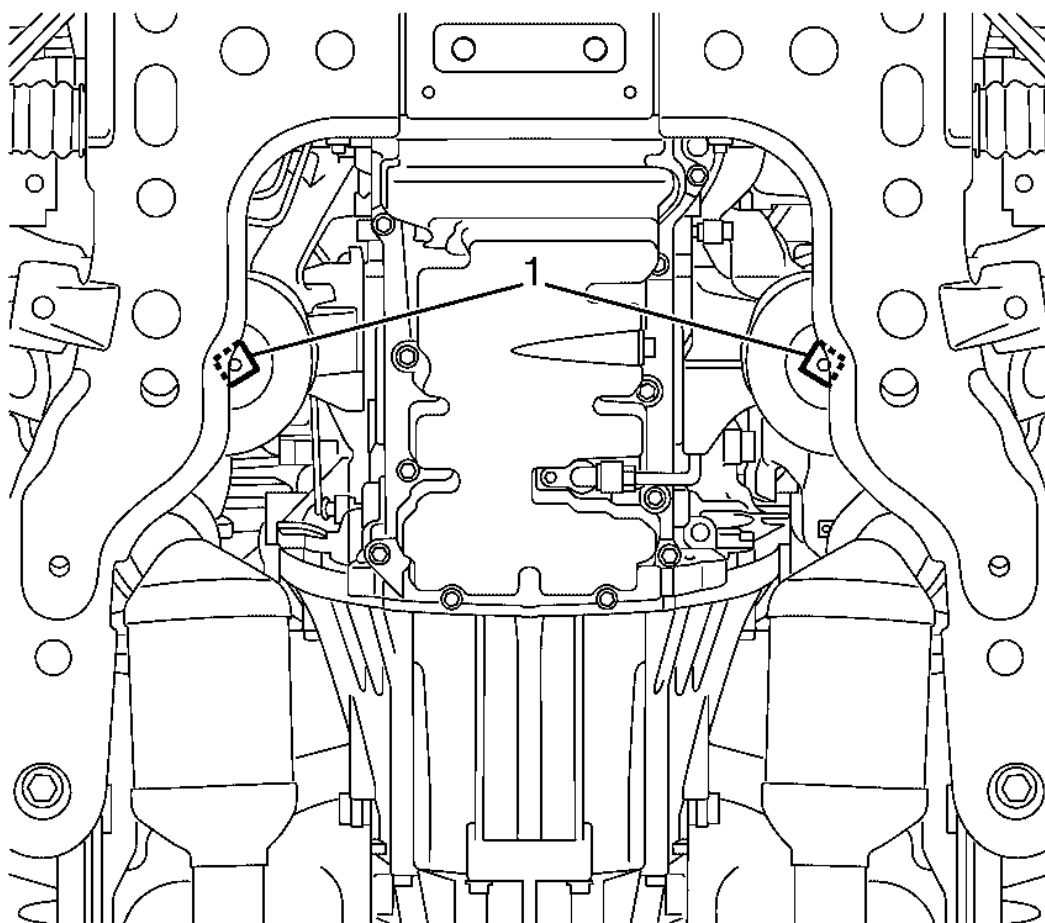
EN 46114 Engine Lift Brackets.

##### **Removal Procedure**

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

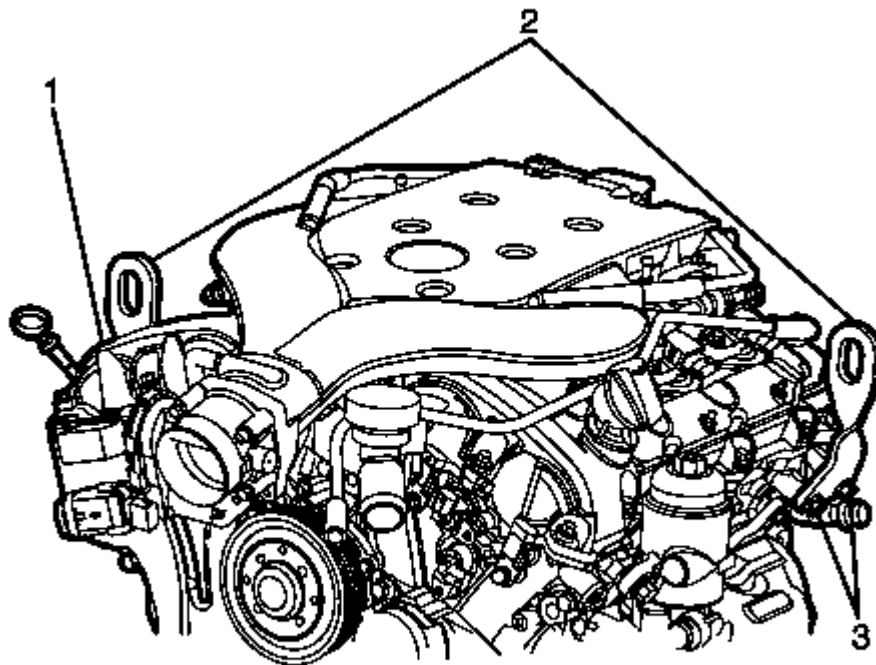
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Remove the engine splash shield. Refer to Engine Splash Shield Replacement .



**Fig. 33: Identifying Engine Mount To Front Subframe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the lower engine mount retaining nuts (1).
4. Lower the vehicle.



**Fig. 34: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

5. Position the **EN 46114** (2) on the engine (1).

**CAUTION:** Refer to Fastener Caution .

6. Install the **EN 46114** to cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).

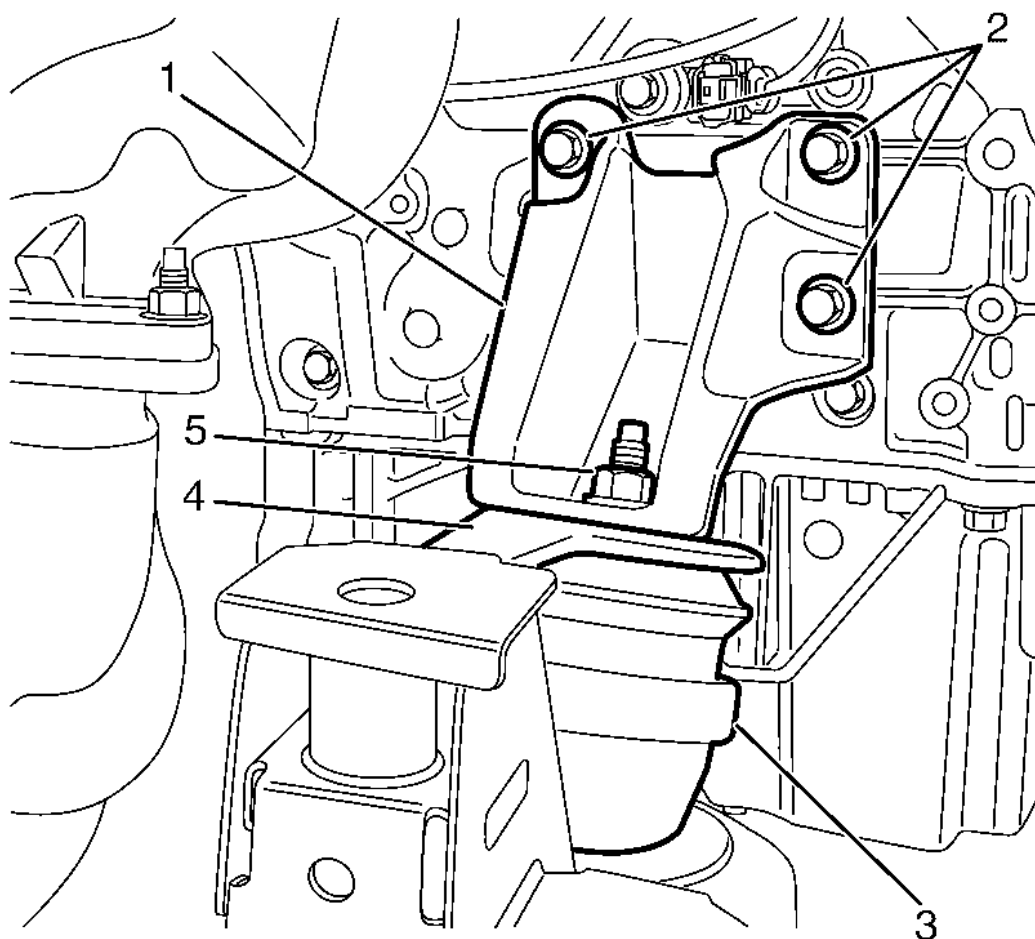
**Tighten:** Tighten the bolts to.

**NOTE:** Use a suitable tool to raise the engine.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

7. Raise the engine until the weight of the engine is removed from the right hand engine mount.





**Fig. 35: Identifying Right Hand Engine Mount Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the right hand engine mount to engine mount bracket retaining nut (5).

**NOTE:** If required raise the engine further to provide adequate space.

**NOTE:** When lifting the engine assembly, observe the clearance between the rear of the engine assembly and the dash panel.

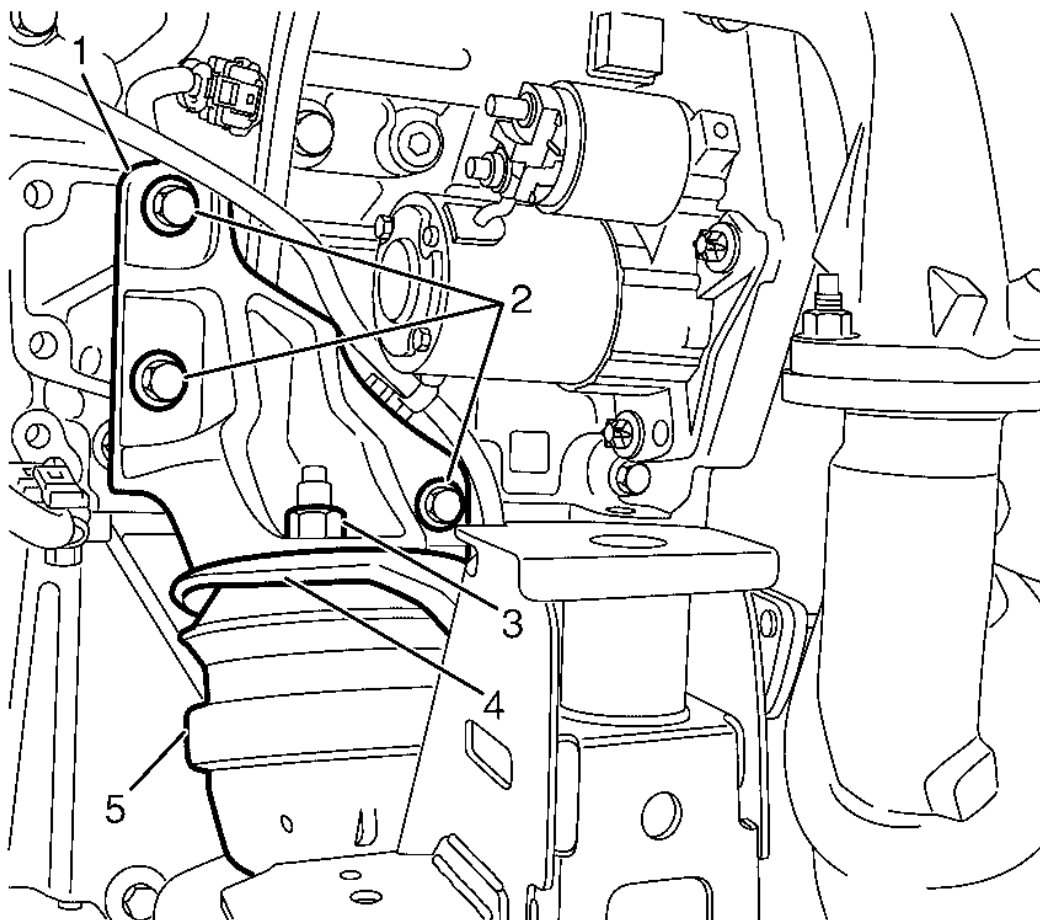
9. Remove the right hand engine mount (3) from the right hand engine mount bracket (1).

**NOTE:** DO NOT distort or bend the right hand engine mount heat shield (4).

10. Remove the right hand engine mount bracket to cylinder block retaining bolts (2).

11. Remove the right hand engine mount bracket (1).

#### Installation Procedure



**Fig. 36: Identifying Right Hand Engine Mount Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT** distort or bend the right hand engine mount heat shield (4).

1. Install the right hand engine mount bracket (1).

**CAUTION: Refer to Fastener Caution .**

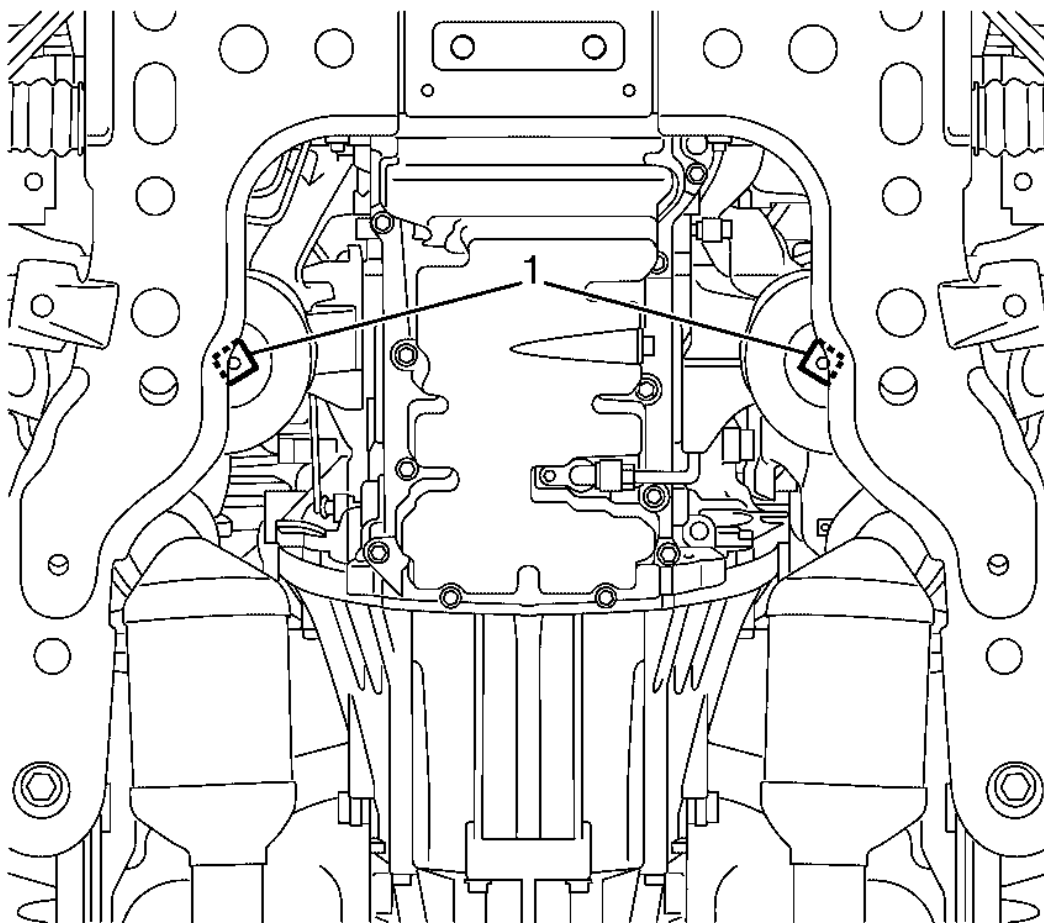
2. Install the right hand engine mount bracket using the cylinder block retaining bolts (2) and tighten to 60 N.m (44 lb ft).

3. Position the right hand engine mount (3) on the right hand engine mount bracket (1).
4. Install the right hand engine mount using the engine mount bracket retaining nut (5) and tighten to 80 N.m (59 lb ft).
5. Lower the engine until the weight is resting on the right hand engine mount.

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

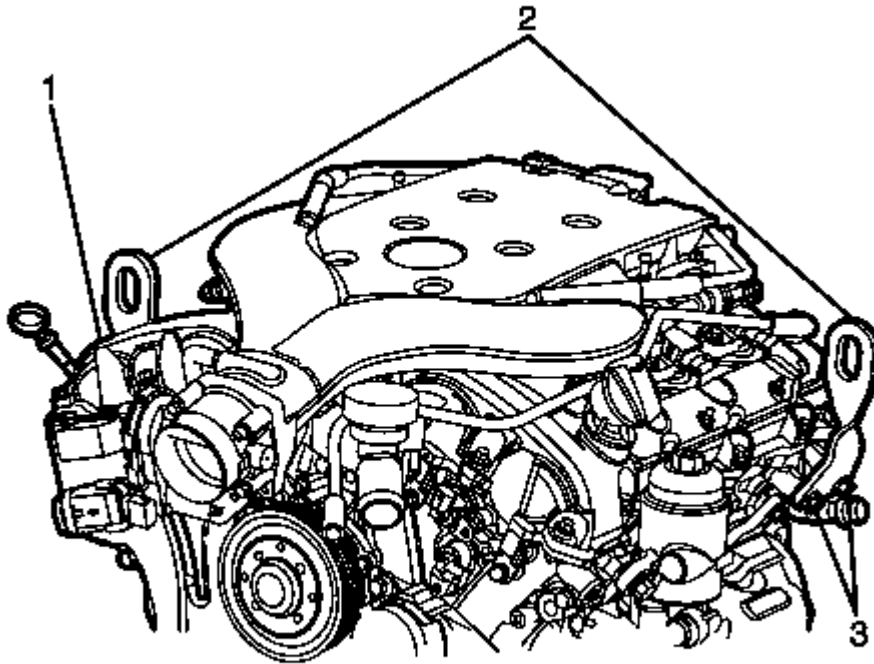
**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

6. Raise the vehicle.



**Fig. 37: Identifying Engine Mount To Front Subframe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

7. Install the engine mount using the front subframe retaining nut (1) and tighten to 80 N.m (59 lb ft).
8. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
9. Lower the vehicle to the ground.



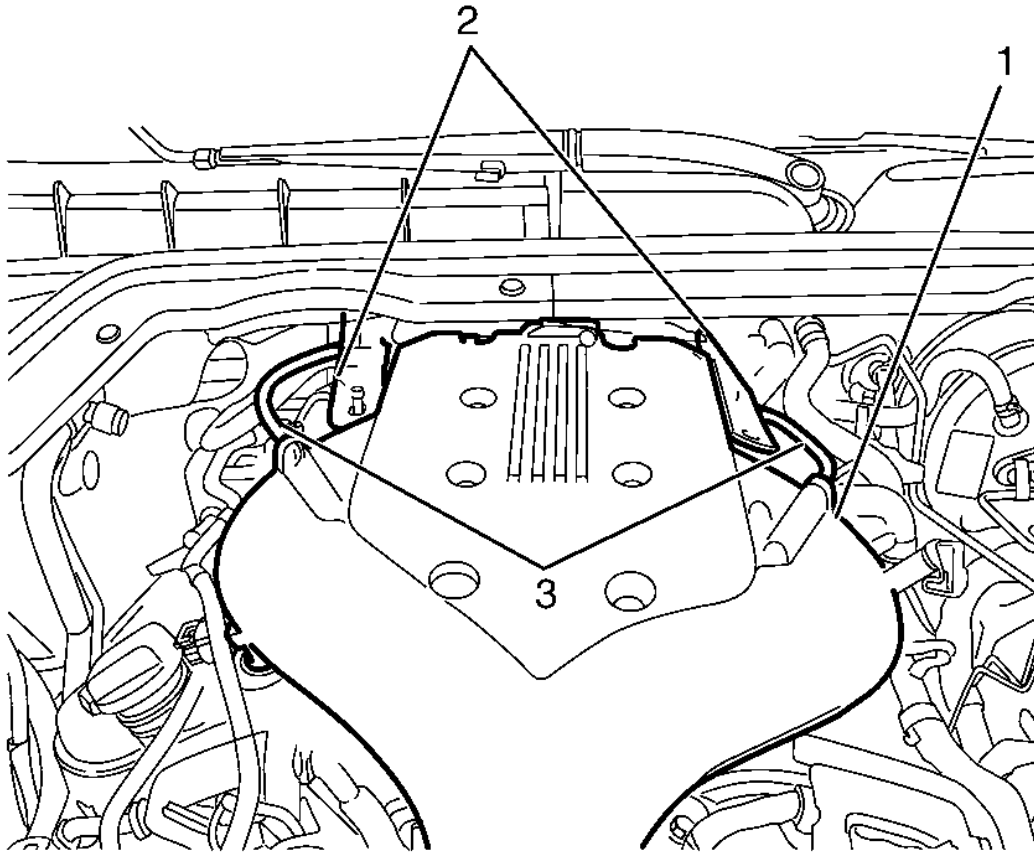
**Fig. 38: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN 46114** to cylinder head retaining bolts (3).
11. Remove the **EN 46114** (2) from the engine (1).

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

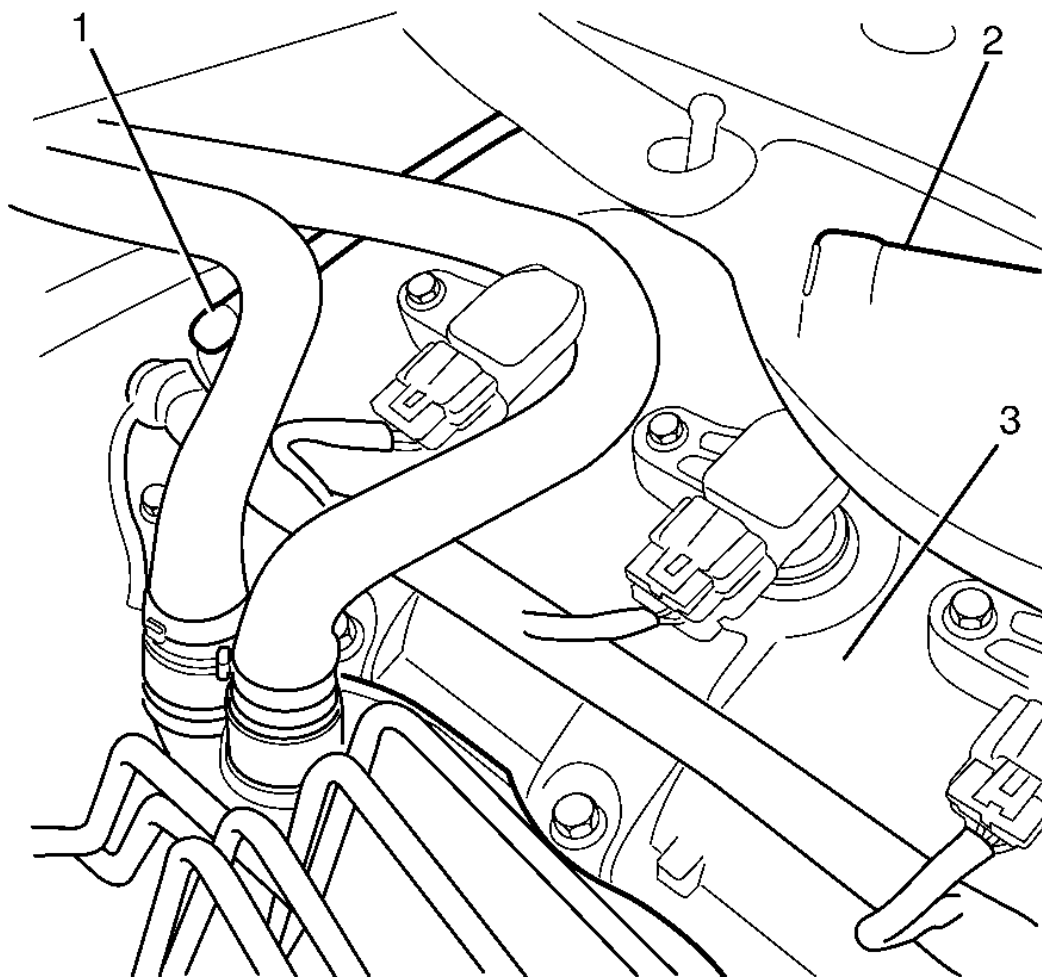
### **Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.



**Fig. 39: Identifying Noise Insulation, Intake Manifold Assembly & PCV Tube**  
Courtesy of GENERAL MOTORS CORP.

2. Detach and reposition the noise insulation panel (3) from the engine cover ball studs on the intake manifold assembly (1).
3. Disconnect the PCV tube (2) from both sides of the upper intake manifold assembly (1).

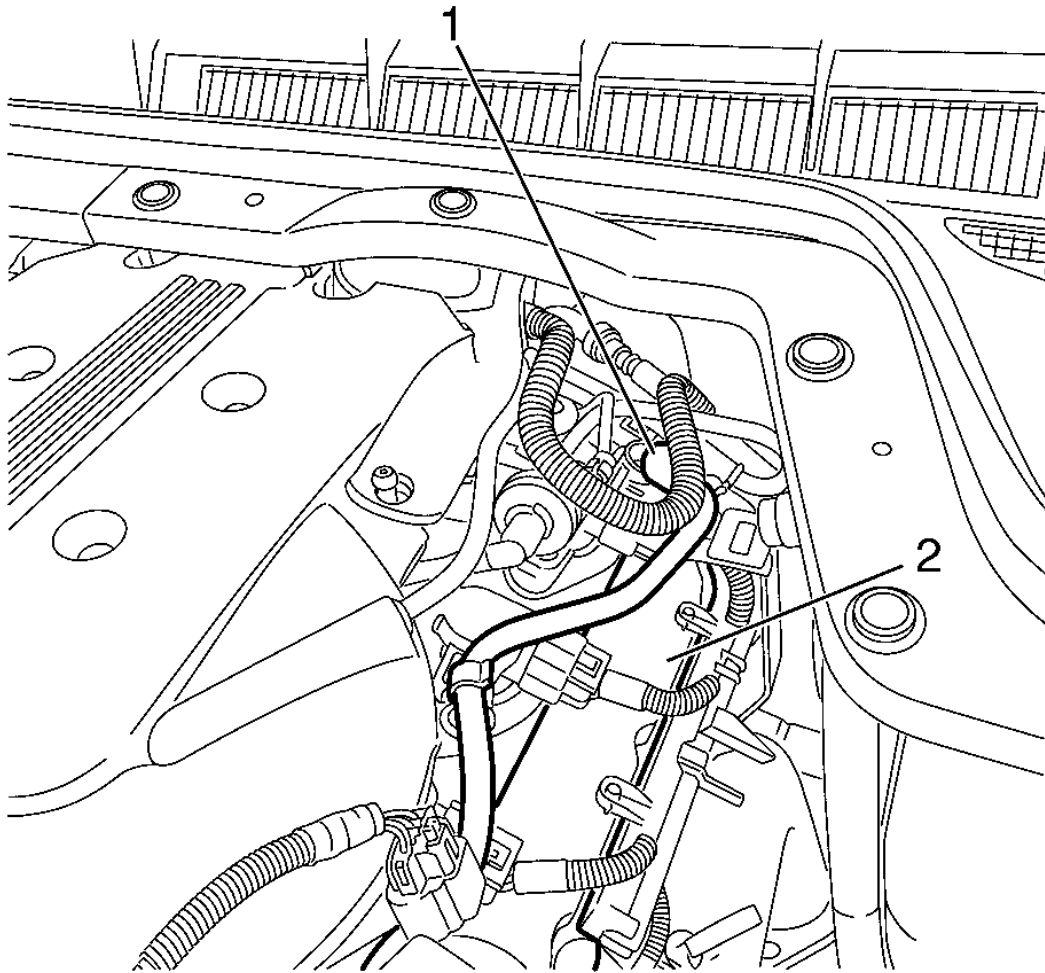


**Fig. 40: Identifying PCV Tube, Intake Manifold Assembly & Right Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the PCV tube (1) from the right camshaft cover (3).

**IMPORTANT:** Install a rubber cap or plug to the right hand camshaft cover (3) to prevent dust and dirt entry.

5. Plug the right hand camshaft cover (3).
6. Remove the PCV tube (1) from the intake manifold assembly (2).

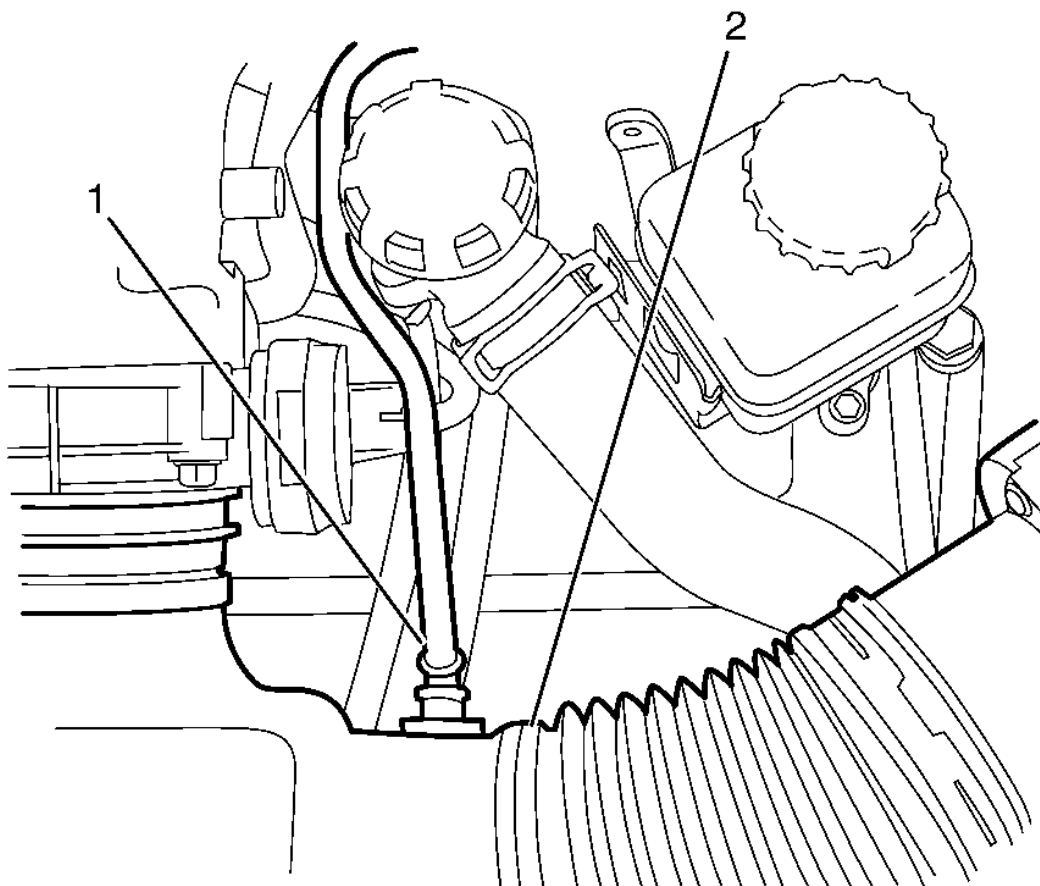


**Fig. 41: Identifying PCV Tube & Left Hand Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the PCV tube (1) from the left hand camshaft cover (2).

**IMPORTANT: Install a rubber cap or plug to the left hand camshaft cover (2) to prevent dust and dirt entry.**

8. Plug the left hand camshaft cover (2).

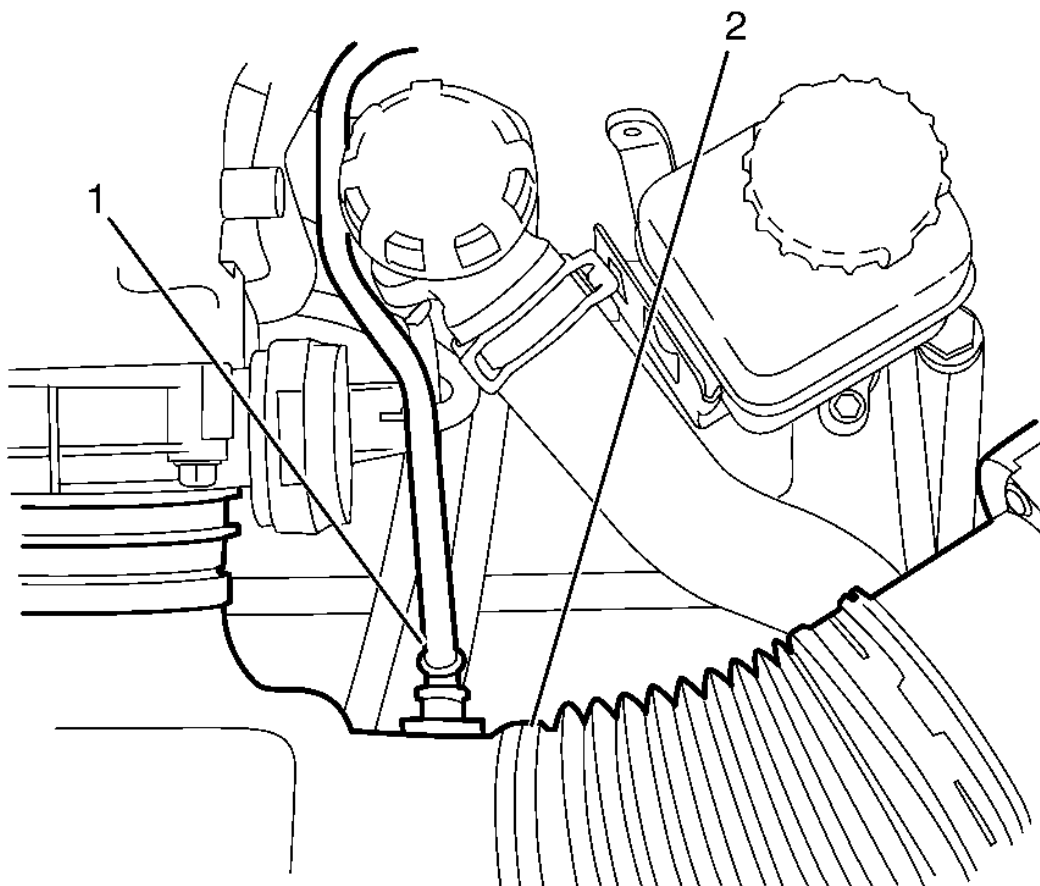


**Fig. 42: Identifying PCV Tube & Air Intake Assembly**  
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the PCV tube (1) from the air intake assembly (2).

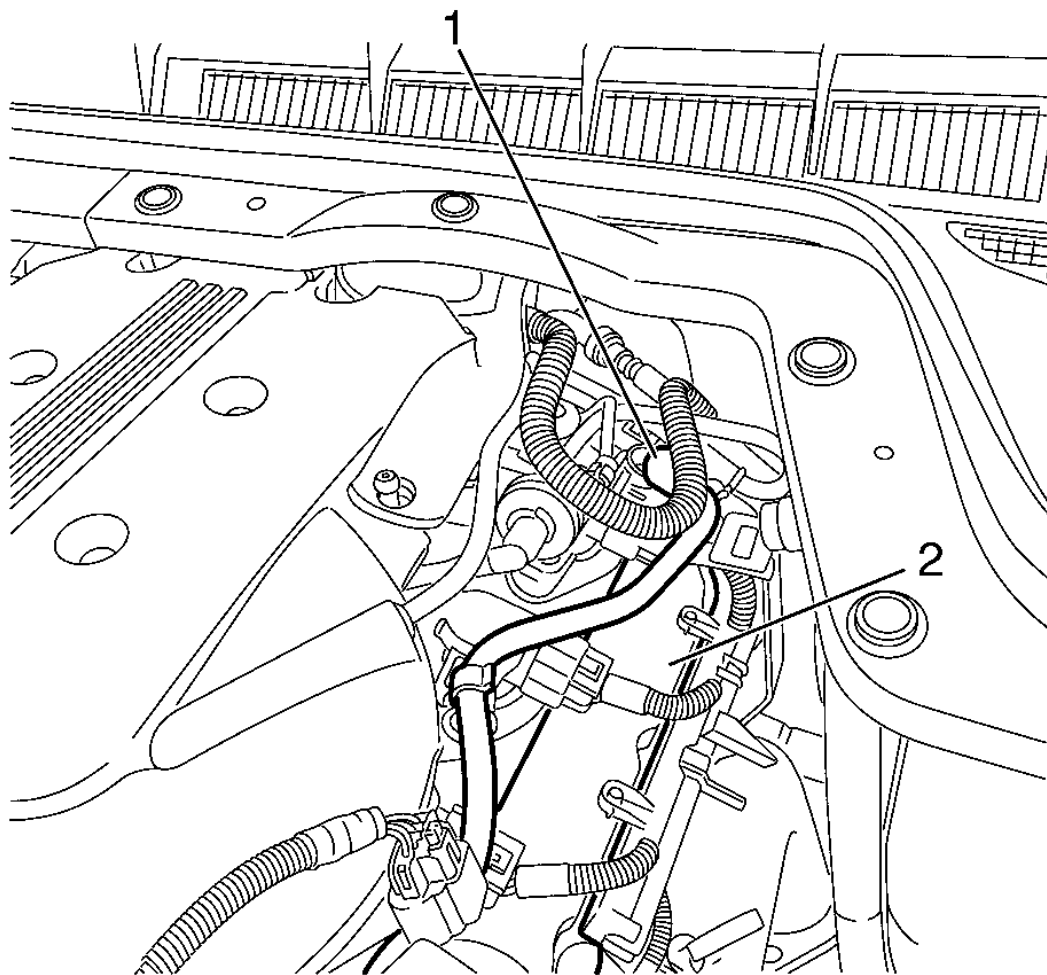
#### **Installation Procedure**





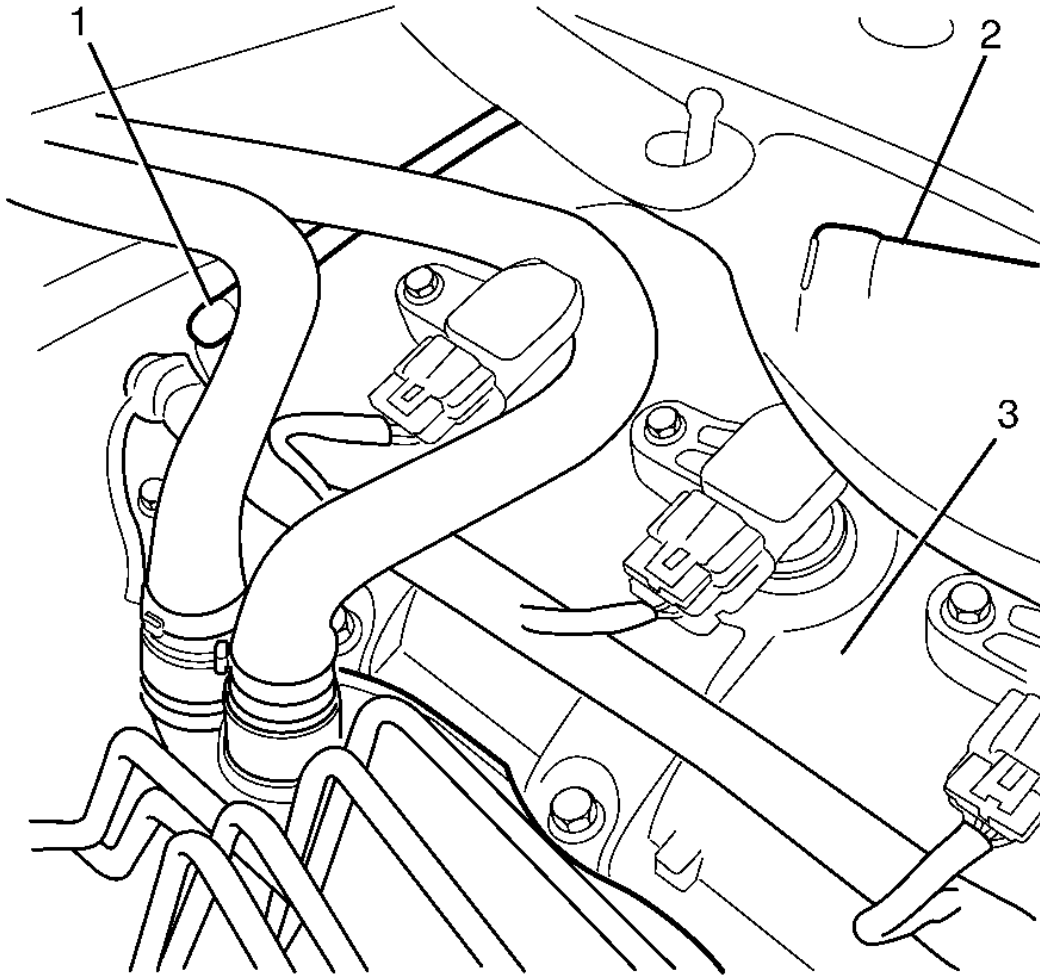
**Fig. 43: Identifying PCV Tube & Air Intake Assembly**  
**Courtesy of GENERAL MOTORS CORP.**

1. Connect the PCV tube (1) to the air intake assembly (2).



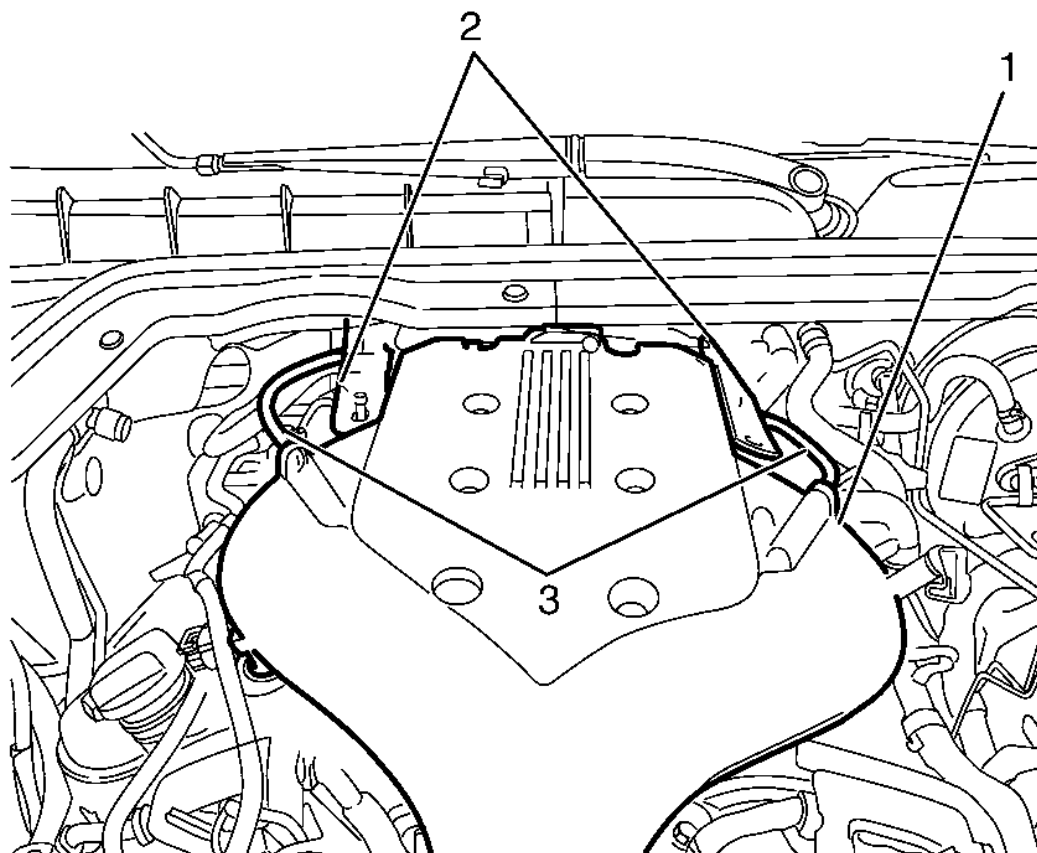
**Fig. 44: Identifying PCV Tube & Left Hand Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the plug from the left hand camshaft cover (2).
3. Connect the PCV tube (1) to the left hand camshaft cover (2).



**Fig. 45: Identifying PCV Tube, Intake Manifold Assembly & Right Camshaft Cover**  
**Courtesy of GENERAL MOTORS CORP.**

4. Install the PCV tube (1) to the intake manifold assembly (2).
5. Remove the plug from the right hand camshaft cover (3).
6. Connect the PCV tube (1) to the right camshaft cover (3).



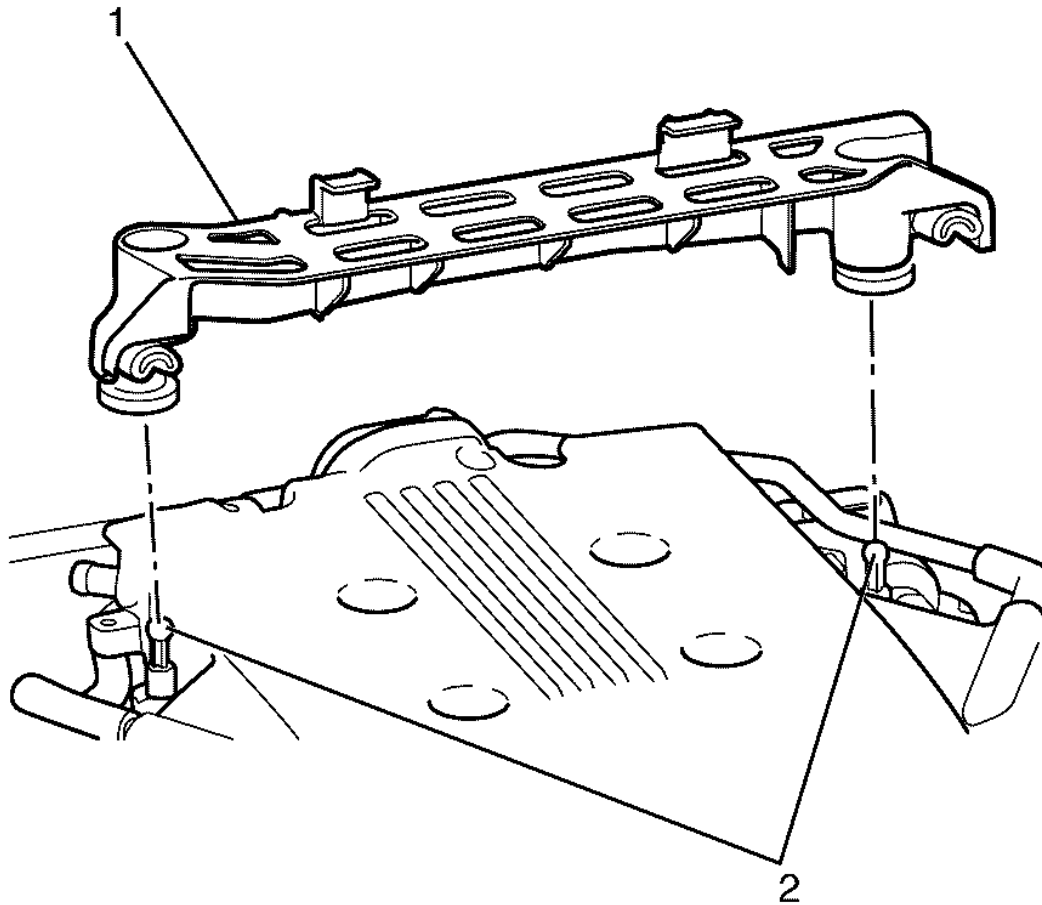
**Fig. 46: Identifying Noise Insulation, Intake Manifold Assembly & PCV Tube**  
Courtesy of GENERAL MOTORS CORP.

7. Connect the PCV tube (3) from both sides of the upper intake manifold assembly (2).
8. Attach the noise insulation panel (1) to the engine cover ball studs on the intake manifold assembly (2).
9. Install the engine covers. Refer to **Engine Cover Replacement**.

## INTAKE MANIFOLD SIGHT SHIELD BRACKET REPLACEMENT

### Removal Procedure

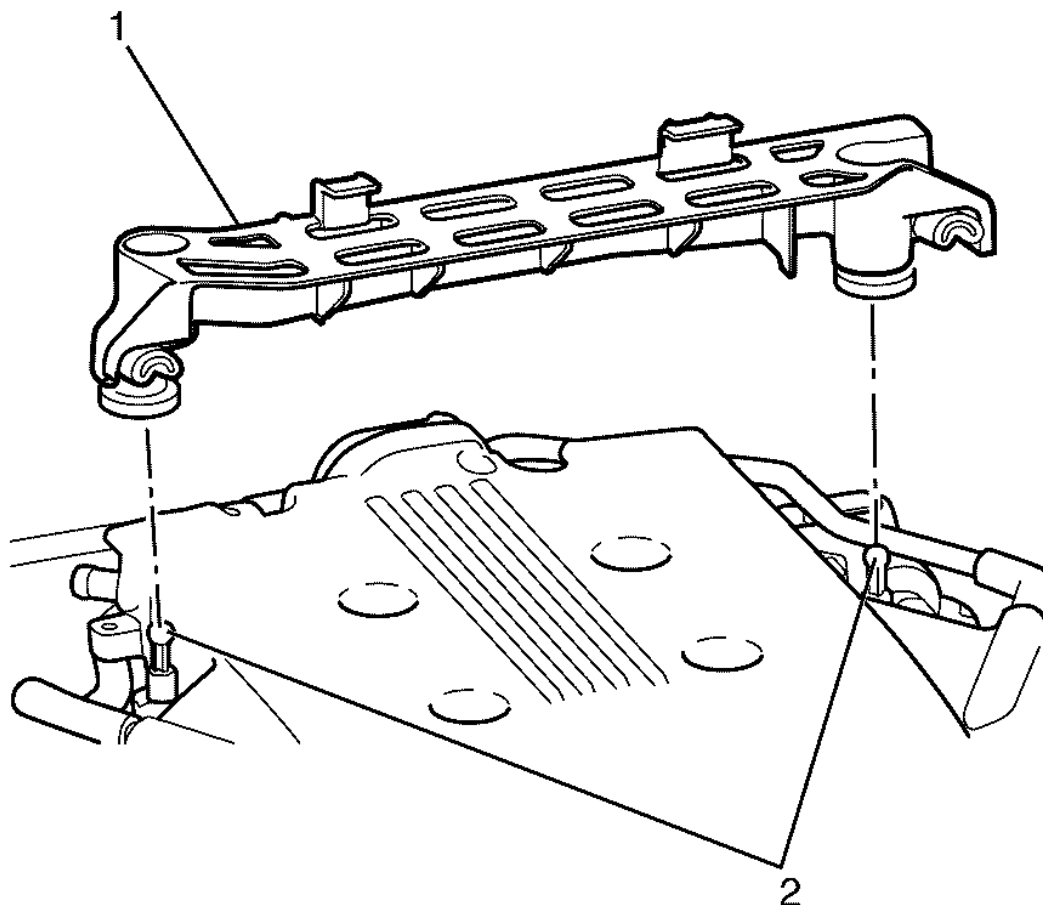
1. Remove the engine cover. Refer to **Engine Cover Replacement**.



**Fig. 47: Intake Manifold Sight Shield Bracket**  
**Courtesy of GENERAL MOTORS CORP.**

2. Apply suitable upward pressure at both ends of the intake manifold sight shield bracket (1).
3. Remove the intake manifold sight shield bracket (1) from the intake manifold sight shield bracket supports (2).

#### **Installation Procedure**



**Fig. 48: Intake Manifold Sight Shield Bracket**  
Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold sight shield bracket (1) to the intake manifold sight shield bracket supports (2).

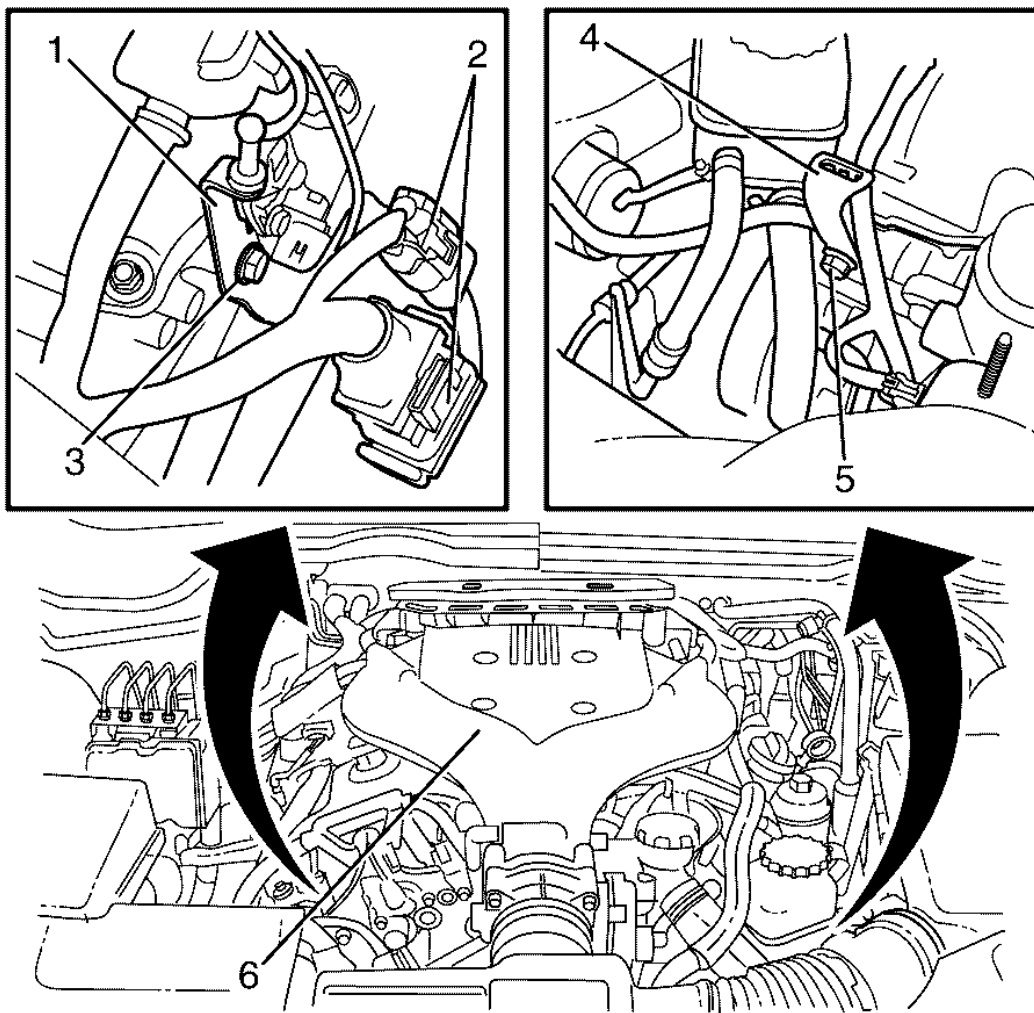
**NOTE:** Apply equal pressure at both ends of the intake manifold sight shield bracket (1). Failure to comply may result in damage to the intake manifold sight shield bracket (1)

2. Apply equal suitable downward pressure at both ends of the intake manifold sight shield bracket (1) to engage the intake manifold sight shield bracket (1) to the intake manifold sight shield bracket supports (2).
3. Install the engine cover. Refer to **Engine Cover Replacement**.

## UPPER INTAKE MANIFOLD SIGHT SHIELD BRACKET REPLACEMENT

### Removal Procedure

1. Remove the engine cover. Refer to **Engine Cover Replacement**.
2. Remove the intake manifold sight shield bracket. Refer to **Intake Manifold Sight Shield Bracket Replacement**.
3. Remove the intake air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**.

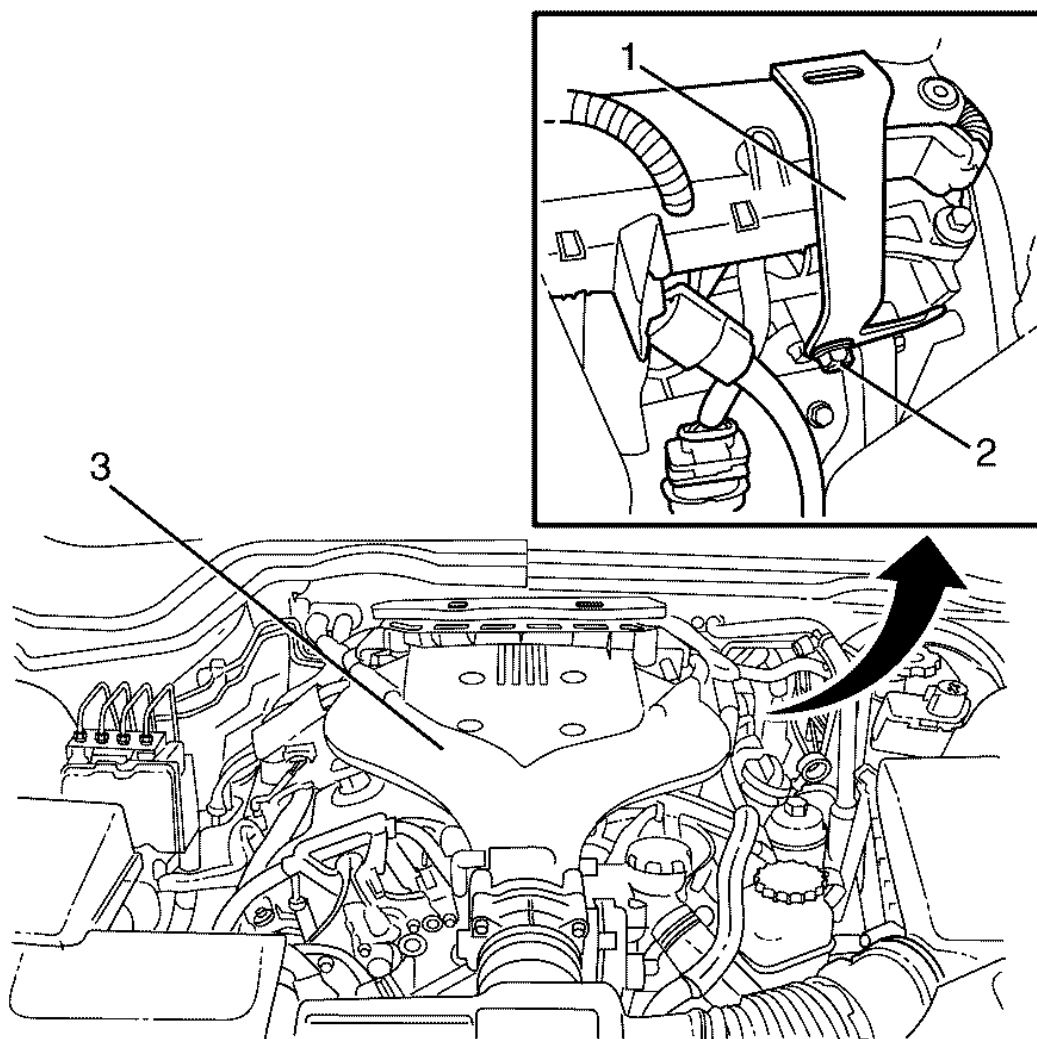


**Fig. 49: Identifying Upper Intake Manifold Sight Shield Bracket & Components**  
 Courtesy of GENERAL MOTORS CORP.

4. Detach the wiring harness connectors (2) from the upper intake manifold sight shield bracket (1).
5. Remove the upper intake manifold sight shield bracket to engine assembly bolt (3) from the upper intake manifold sight shield bracket (1).
6. Remove the upper intake manifold sight shield bracket (1) from the engine assembly (6).
7. Remove the upper intake manifold sight shield bracket to engine assembly bolt (5) from the upper intake

manifold sight shield bracket (4).

8. Remove the upper intake manifold sight shield bracket (4) from the engine assembly (6).

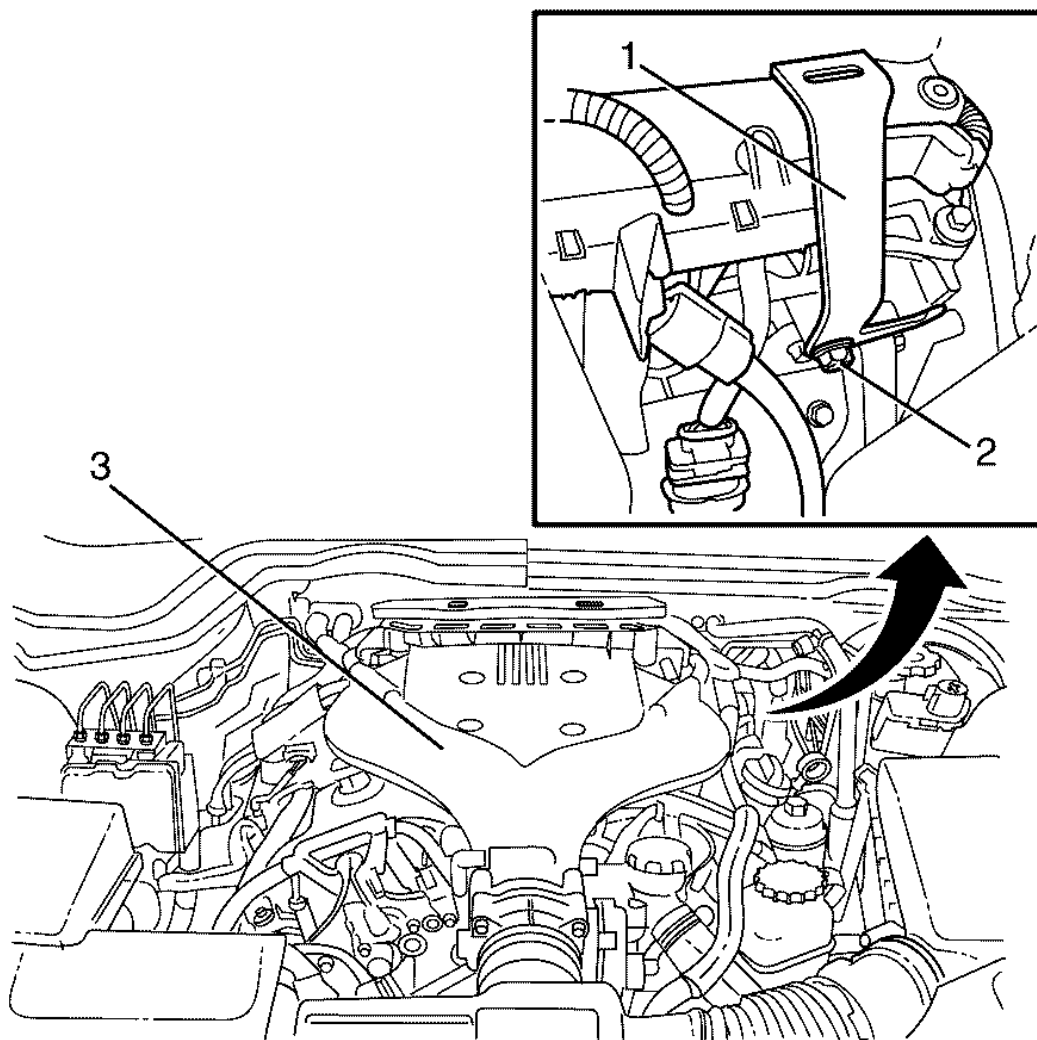


**Fig. 50: Upper Intake Manifold Sight Shield Bracket To Engine Assembly Bolt**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper intake manifold sight shield bracket to engine assembly bolt (2) from the upper intake manifold sight shield bracket (1).
10. Remove the upper intake manifold sight shield bracket (1) from the engine assembly (3).

#### Installation Procedure



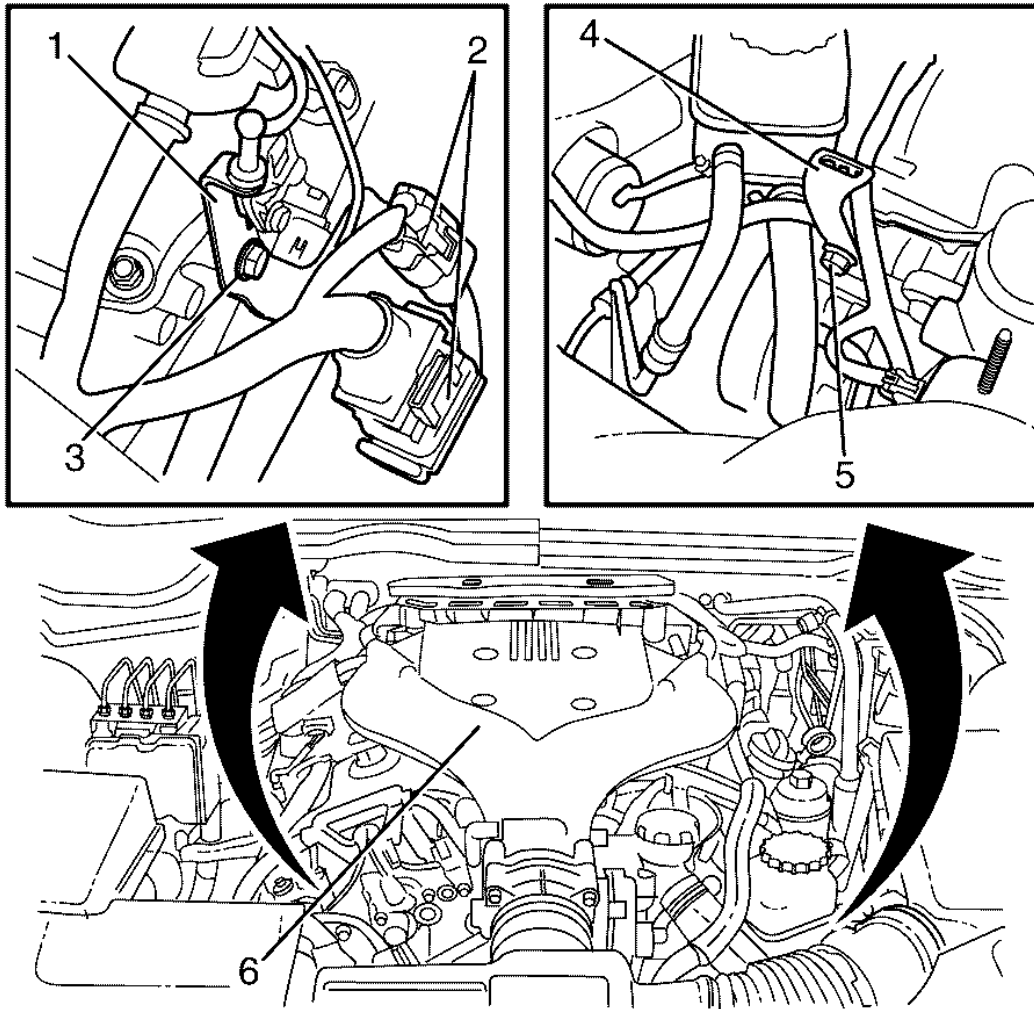


**Fig. 51: Upper Intake Manifold Sight Shield Bracket To Engine Assembly Bolt**  
 Courtesy of GENERAL MOTORS CORP.

1. Install the upper intake manifold sight shield bracket (1) to the engine assembly (3).

**CAUTION: Refer to Fastener Caution .**

2. Install the upper intake manifold sight shield bracket to engine assembly bolt (2) to the upper intake manifold sight shield bracket (1) and tighten to 35 N.m (26 lb in).



**Fig. 52: Identifying Upper Intake Manifold Sight Shield Bracket & Components**  
**Courtesy of GENERAL MOTORS CORP.**

3. Install the upper intake manifold sight shield bracket (4) to the engine assembly (6).
4. Install the upper intake manifold sight shield bracket to engine assembly bolt (5) to the upper intake manifold sight shield bracket (4) and tighten to 35 N.m (26 lb in).
5. Install the upper intake manifold sight shield bracket (1) to the engine assembly (6).
6. Install the upper intake manifold sight shield bracket to engine assembly bolt (3) to the upper intake manifold sight shield bracket (1) and tighten to 35 N.m (26 lb in).
7. Attach the wiring harness connectors (2) to the upper intake manifold sight shield bracket (1).
8. Install the intake air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**.
9. Install the intake manifold sight shield bracket. Refer to **Intake Manifold Sight Shield Bracket Replacement**.

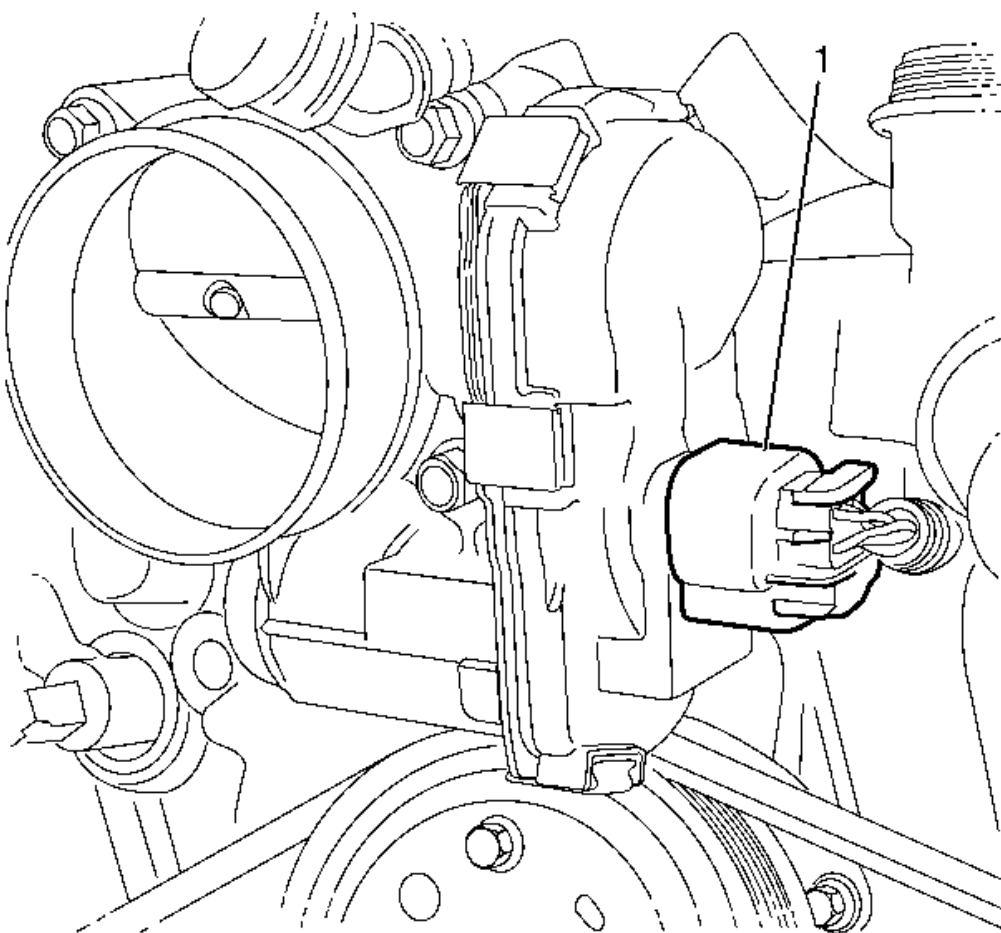
10. Install the engine cover. Refer to **Engine Cover Replacement**.

## UPPER INTAKE MANIFOLD REPLACEMENT

### Removal Procedure

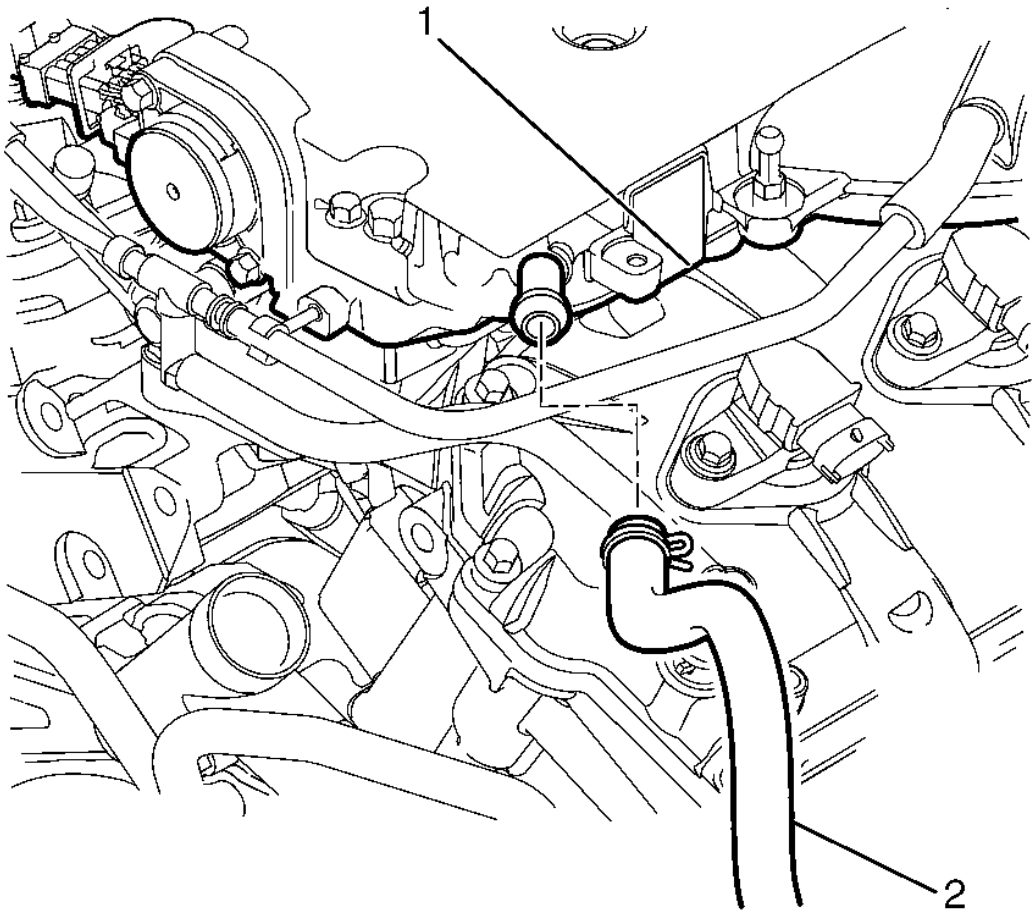
**WARNING:** Refer to **Battery Disconnect Warning** .

1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the engine covers. Refer to **Engine Cover Replacement**.
3. Remove the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .



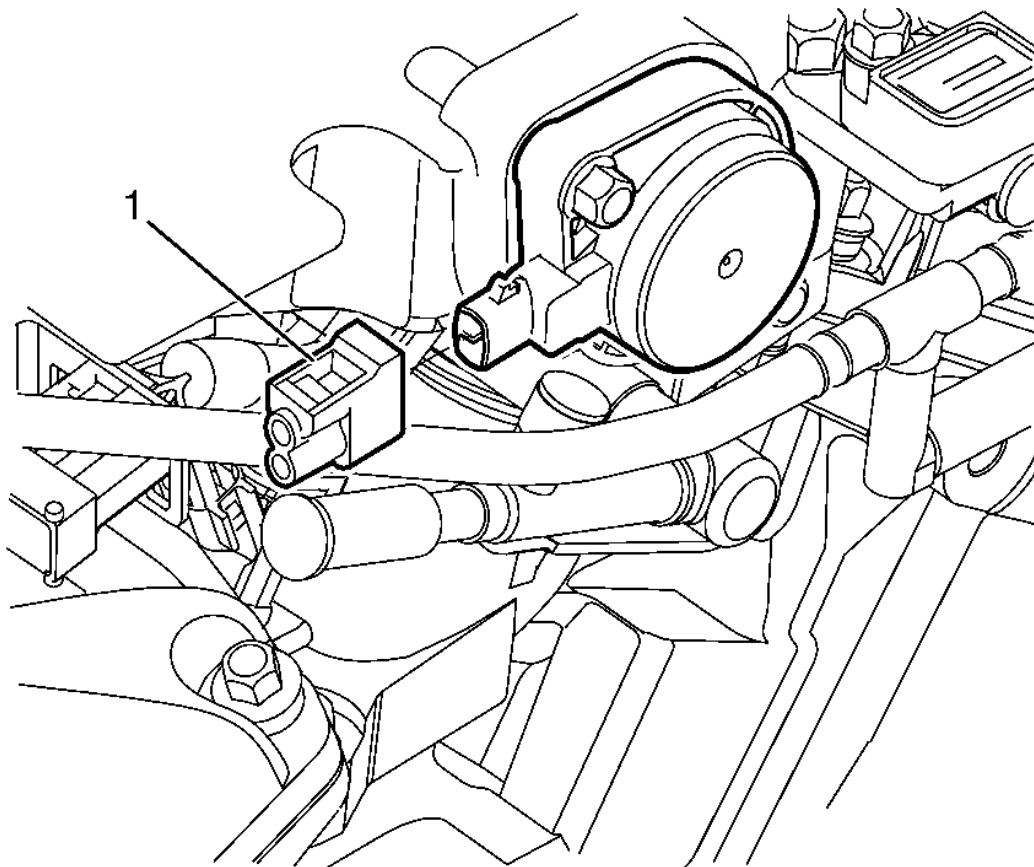
**Fig. 53: Identifying Throttle Body Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the throttle body electrical connector (1).



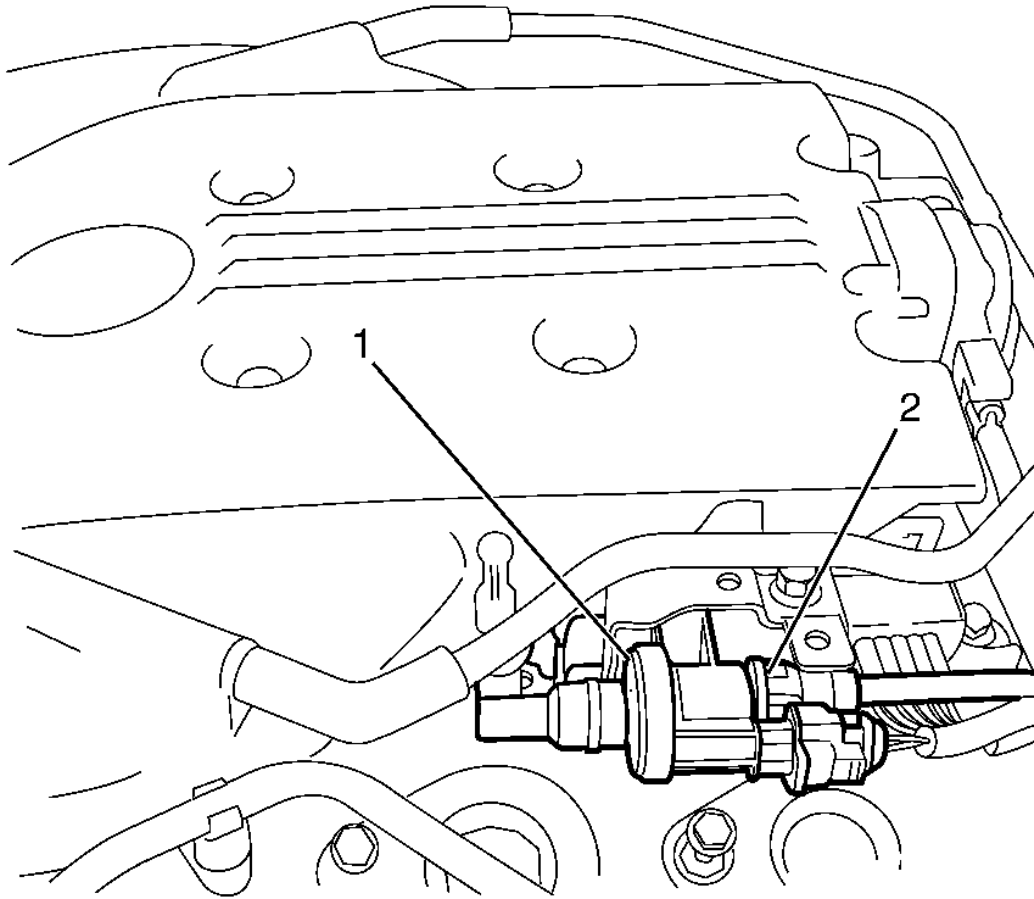
**Fig. 54: Identifying Brake Booster Vacuum Hose & Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the brake booster vacuum hose (2) from the intake manifold (1).



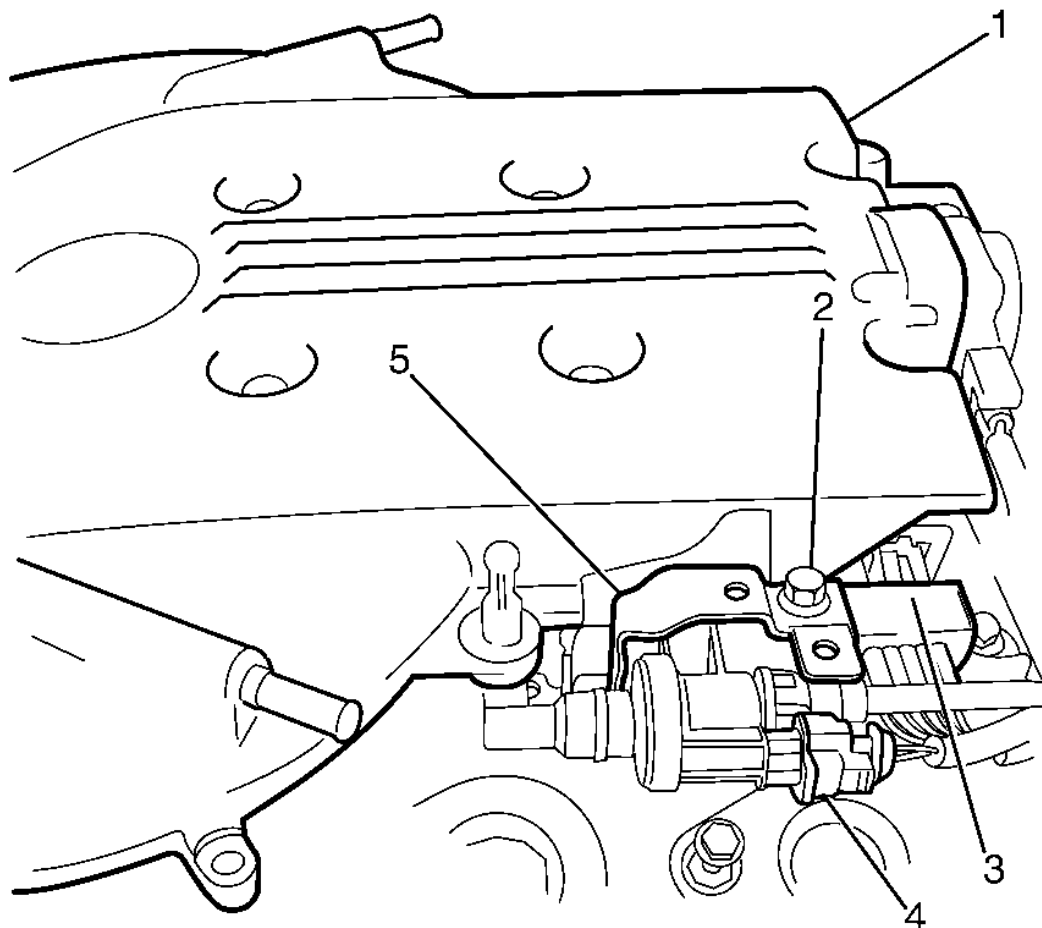
**Fig. 55: Identifying IMRC Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the Inlet Manifold Runner Control (IMRC) electrical connector (1).



**Fig. 56: Identifying EVAP Purge Line & Purge Solenoid**  
Courtesy of GENERAL MOTORS CORP.

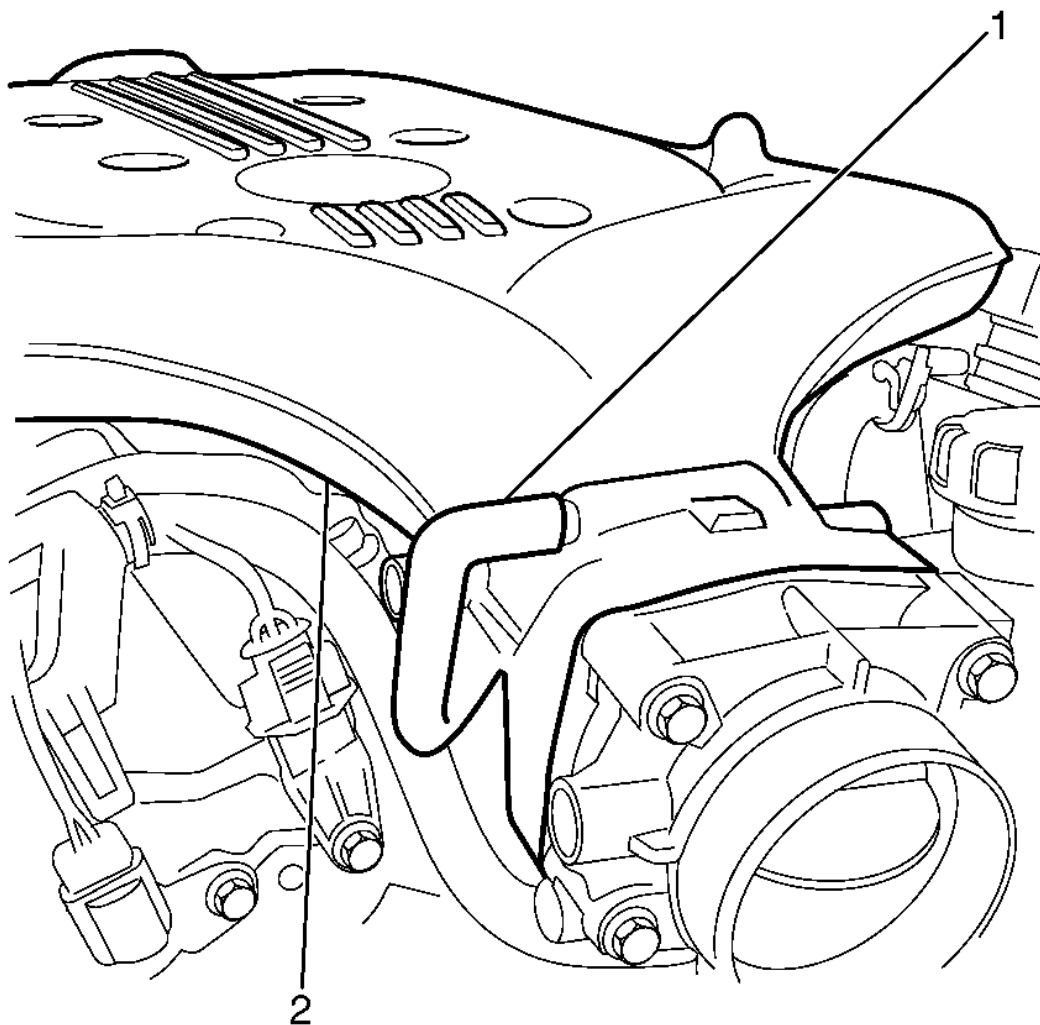
7. Disconnect the evaporative emission (EVAP) purge line (1) from the purge solenoid (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .
8. Plug or cap the (EVAP) purge line (1) and the purge solenoid (2) ends.



**Fig. 57: Identifying Fuel Injector Harness Electrical Connector/EVAP Valve Mounting Bracket To Intake Manifold Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

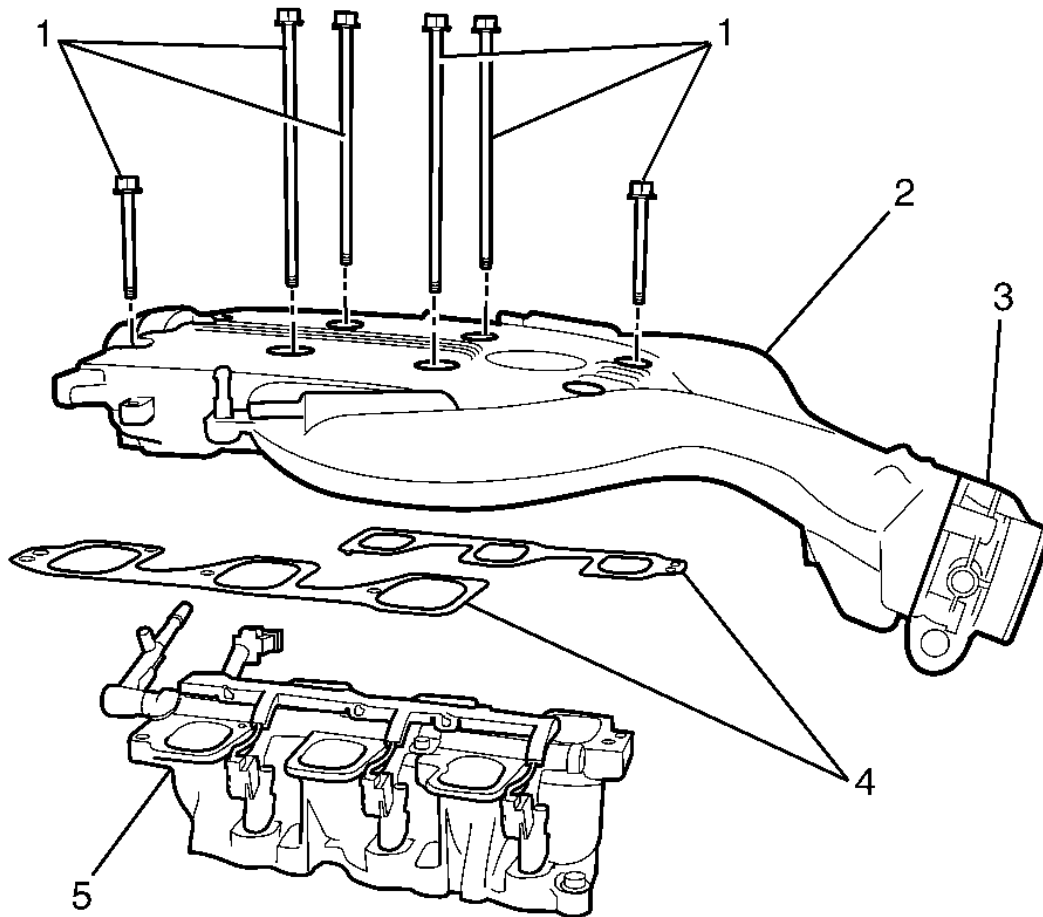
9. Disconnect the EVAP valve electrical connector (4)
10. Disconnect the fuel injector harness electrical connector (3)
11. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
12. Reposition the fuel injector harness electrical connector/EVAP valve mounting bracket (5) away from the intake manifold (1).
13. Remove the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.



**Fig. 58: View Of EVAP Hose & Upper Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

14. Disconnect the EVAP hose (1) from the intake manifold (2).





**Fig. 59: Identifying Upper Intake Manifold Bolts**  
 Courtesy of GENERAL MOTORS CORP.

15. Remove the upper intake manifold bolts (1).
16. Remove the upper intake manifold (2) and the throttle body (3) as an assembly.

**NOTE:** The upper intake manifold gaskets (4) must be discarded after removal.

17. Remove the upper intake manifold gaskets (4).

Discard the gaskets

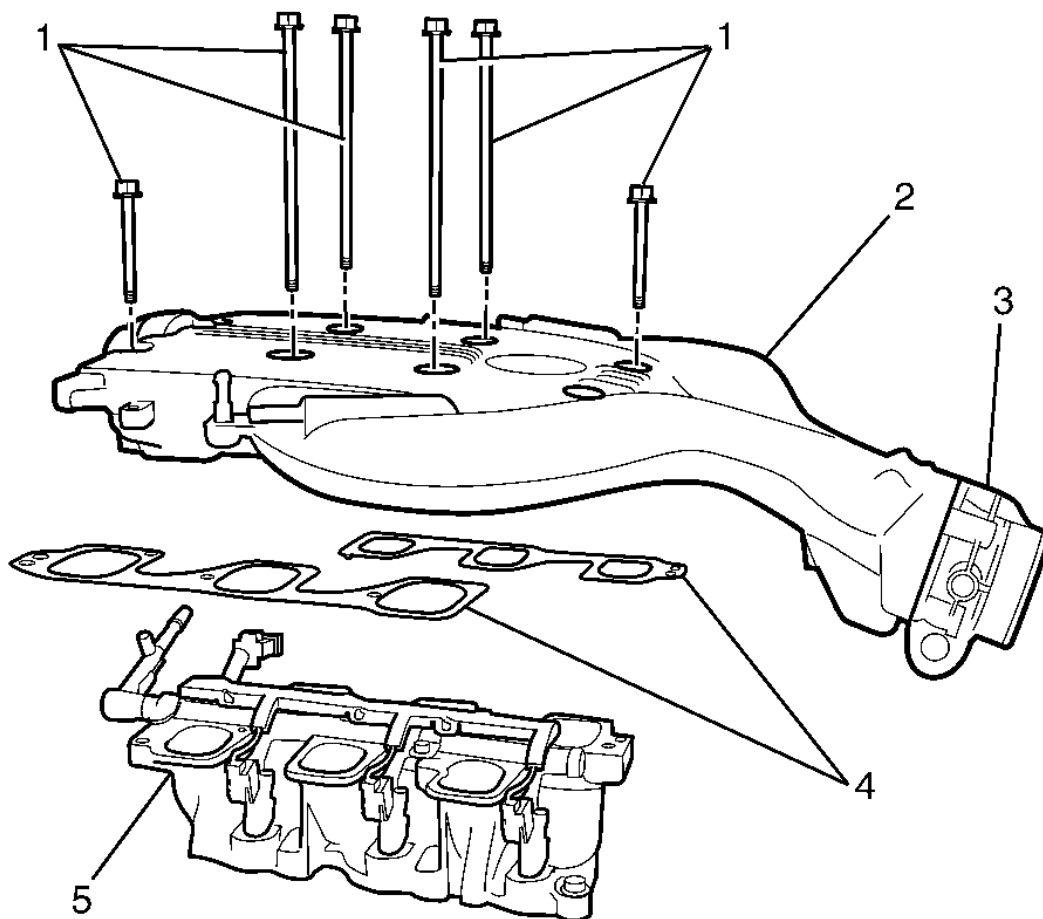
**NOTE:** The lower intake manifold (5) must be plugged with a clean lint free cloth to prevent foreign matter entry into the engine.

18. Plug the lower intake manifold (5) with a clean lint free cloth.

19. If the upper intake manifold is being replaced, disassemble the intake manifold. Refer to **Intake Manifold Disassemble** .
20. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection** .

#### Installation Procedure

1. If the upper intake manifold is being replaced, assemble the intake manifold. Refer to **Intake Manifold Assemble** .



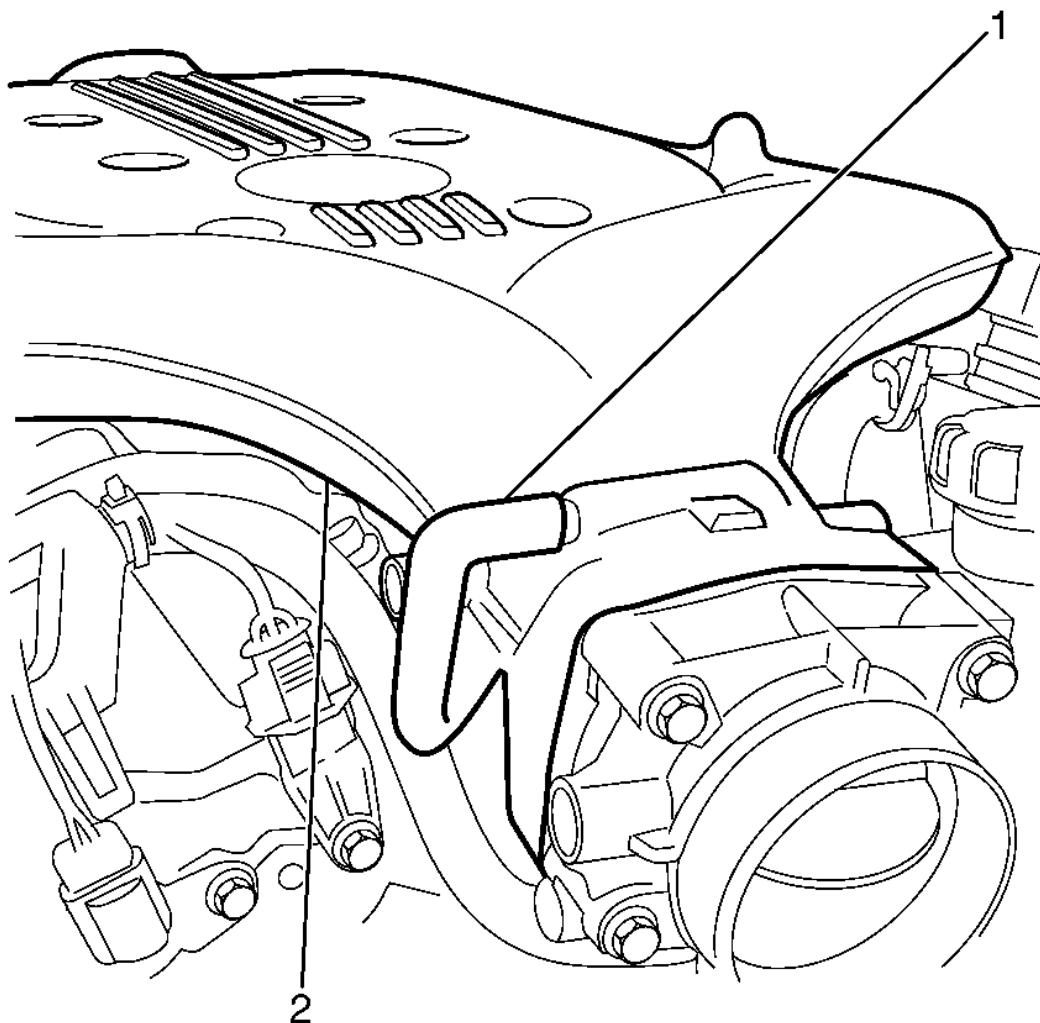
**Fig. 60: Identifying Upper Intake Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the clean lint free cloth from the lower intake manifold (5)
3. Install NEW upper intake manifold gaskets (4).
4. Install the upper intake manifold (2) and the throttle body (3) as an assembly.

**CAUTION:** Refer to Fastener Caution .

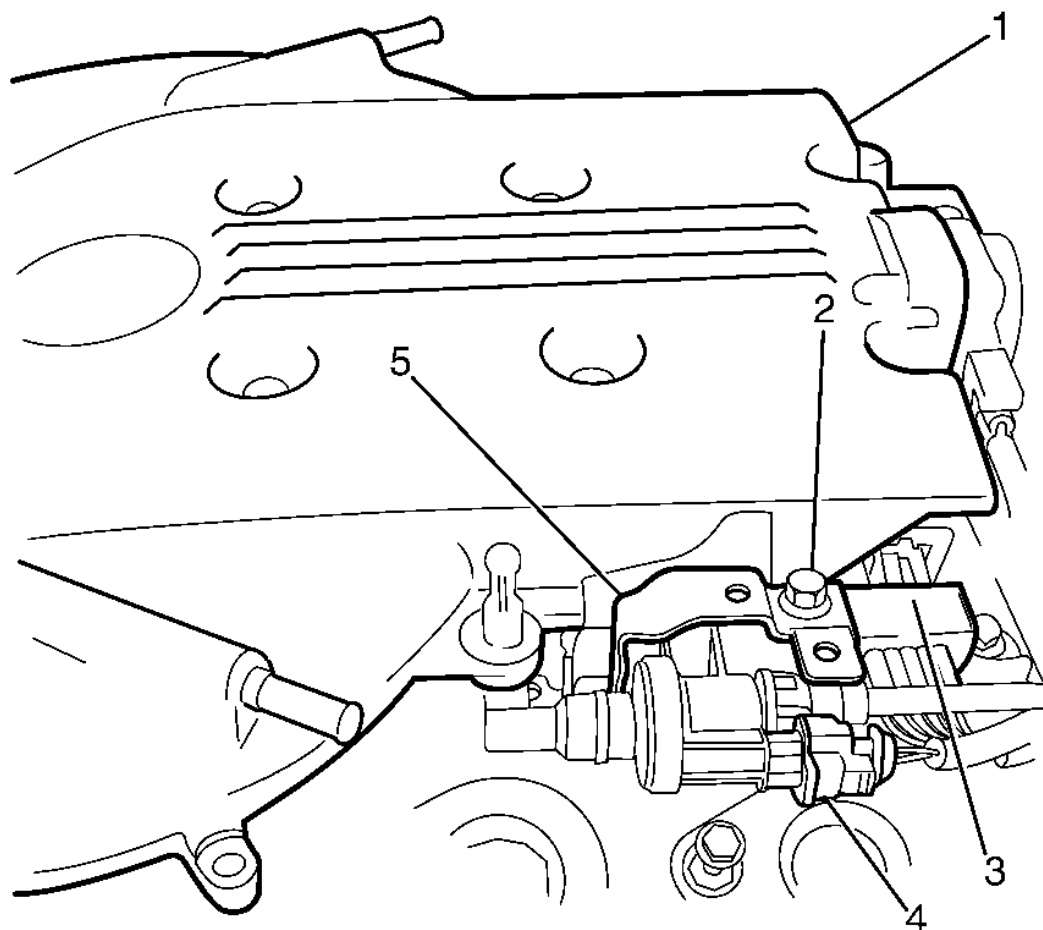
**NOTE:** Tighten the intake manifold bolts (1) in a circular pattern starting at the center (long bolts) and moving outward.

5. Install the upper intake manifold bolts (1) and tighten to 23 N.m (17 lb ft).



**Fig. 61: View Of EVAP Hose & Upper Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

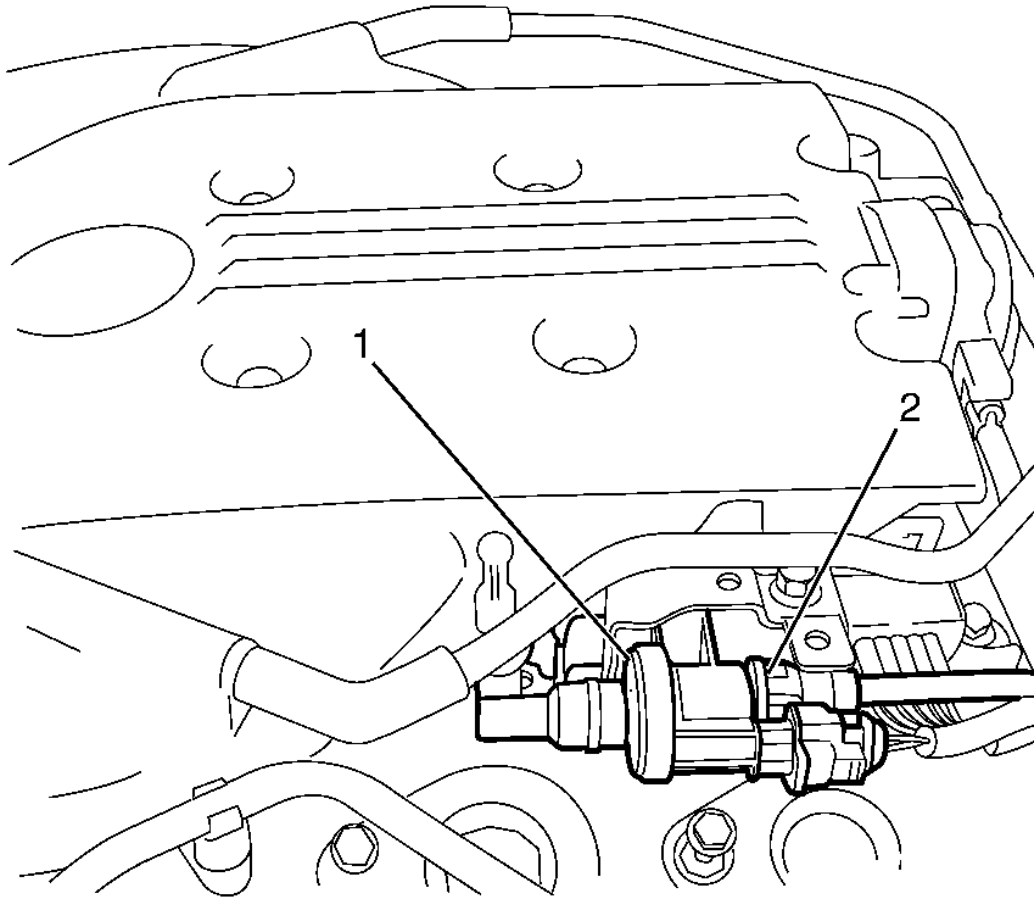
6. Connect the EVAP line (1) to the intake manifold (2).



**Fig. 62: Identifying Fuel Injector Harness Electrical Connector/EVAP Valve Mounting Bracket To Intake Manifold Retaining Bolt**

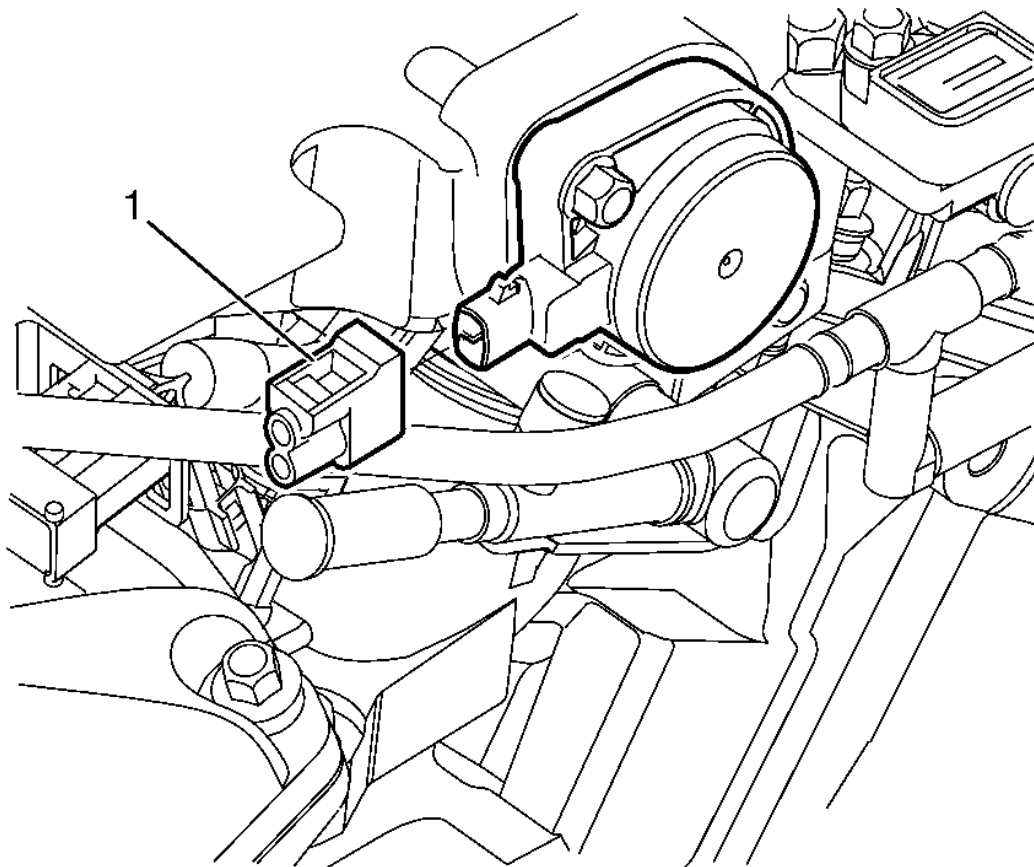
Courtesy of GENERAL MOTORS CORP.

7. Install the fuel injector harness electrical connector/EVAP valve mounting bracket (5) to the intake manifold (1).
8. Install the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
9. Connect the fuel injector harness electrical connector (3)
10. Connect the EVAP valve electrical connector (4)
11. Install the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.



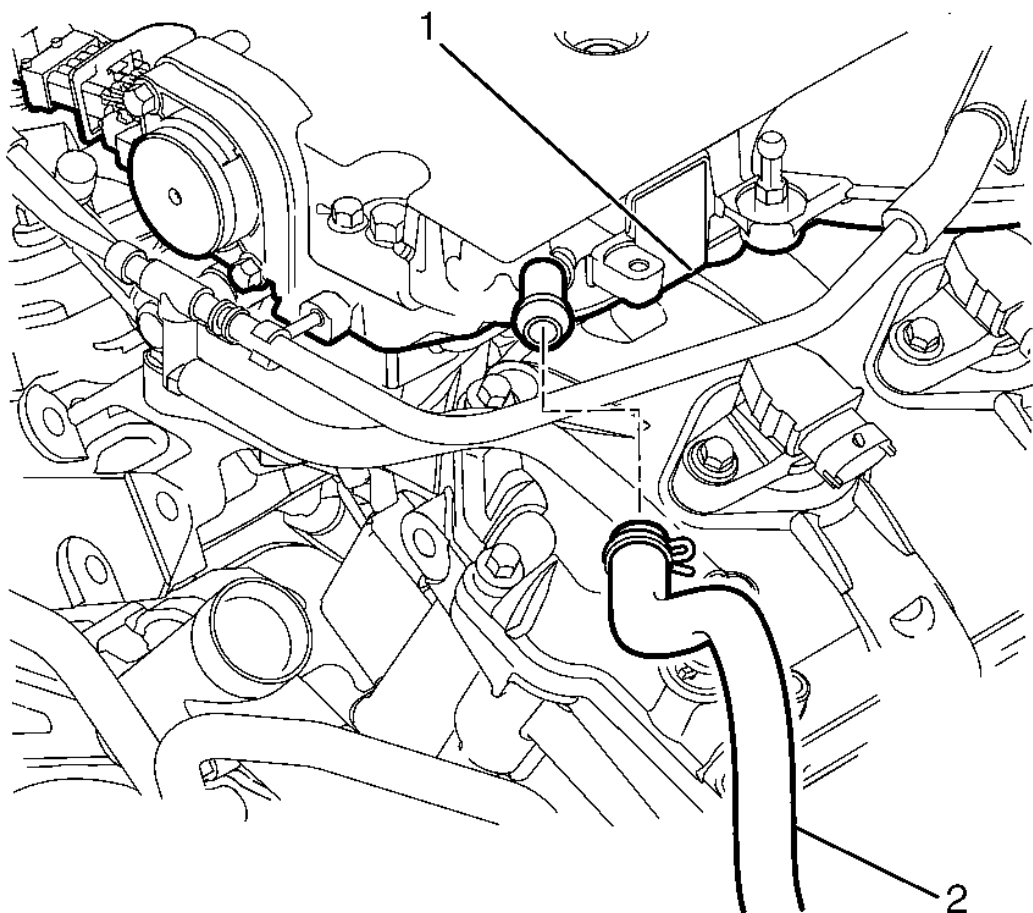
**Fig. 63: Identifying EVAP Purge Line & Purge Solenoid**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the plug or cap from the (EVAP) purge line (1) and the purge solenoid (2) ends.
13. Connect the evaporative emission (EVAP) purge line (1) from the purge solenoid (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .



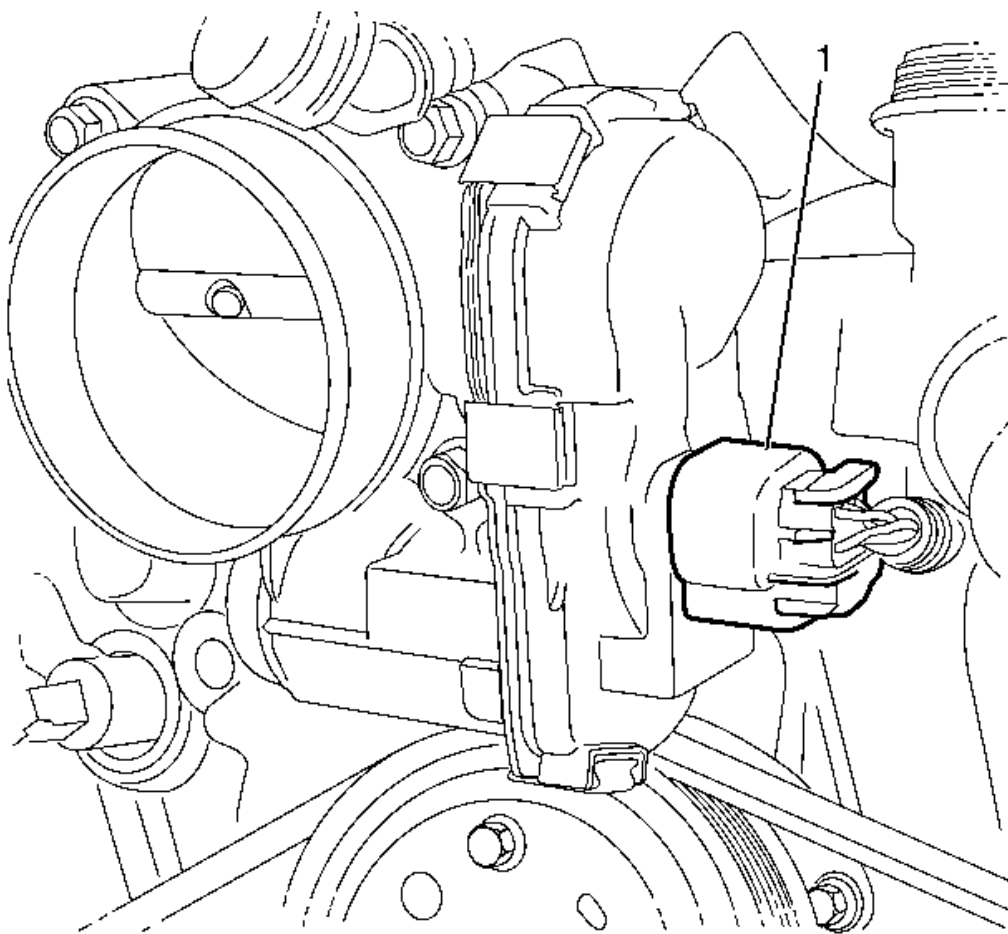
**Fig. 64: Identifying IMRC Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

14. Connect the Inlet Manifold Runner Control (IMRC) electrical connector (1).



**Fig. 65: Identifying Brake Booster Vacuum Hose & Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

15. Connect the brake booster vacuum hose (2) to the intake manifold (1).



**Fig. 66: Identifying Throttle Body Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

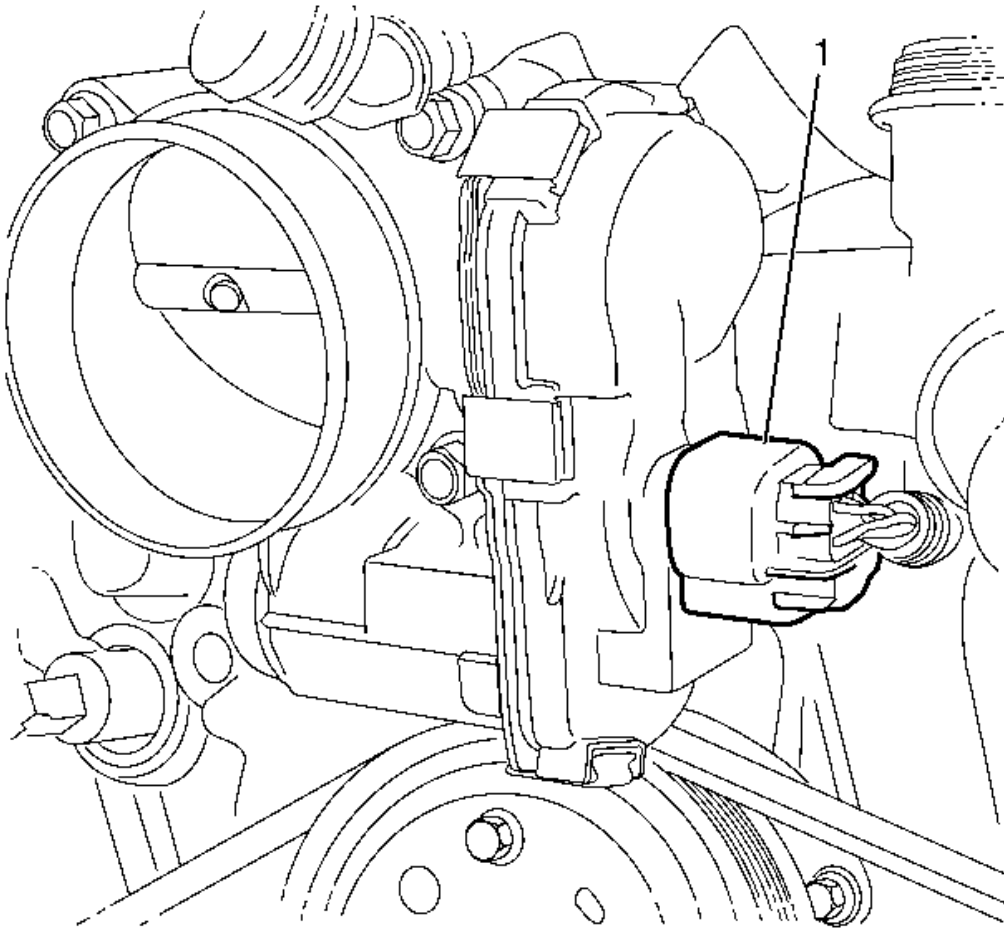
16. Connect the throttle body electrical connector (1).
17. Install the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .
18. Install the engine covers. Refer to **Engine Cover Replacement**.
19. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .

## **LOWER INTAKE MANIFOLD REPLACEMENT**

**WARNING:** Refer to **Battery Disconnect Warning** .

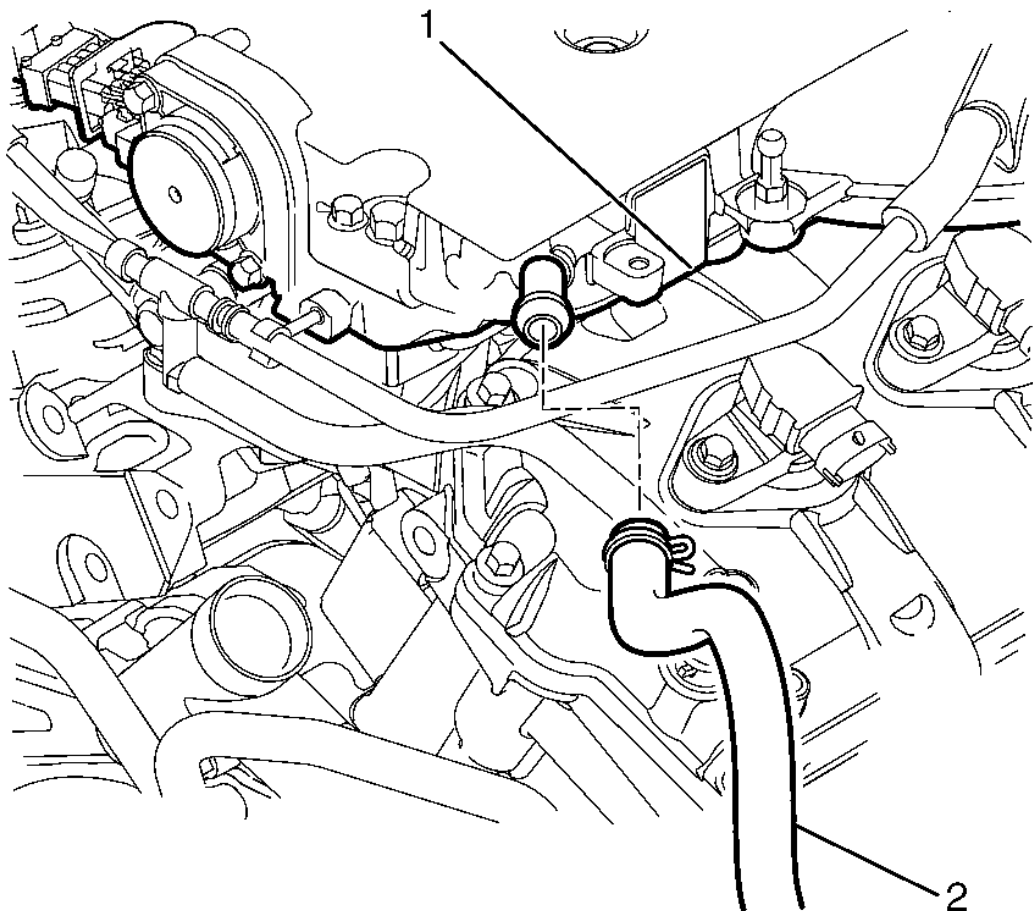


1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the engine covers. Refer to **Engine Cover Replacement**.
3. Remove the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .



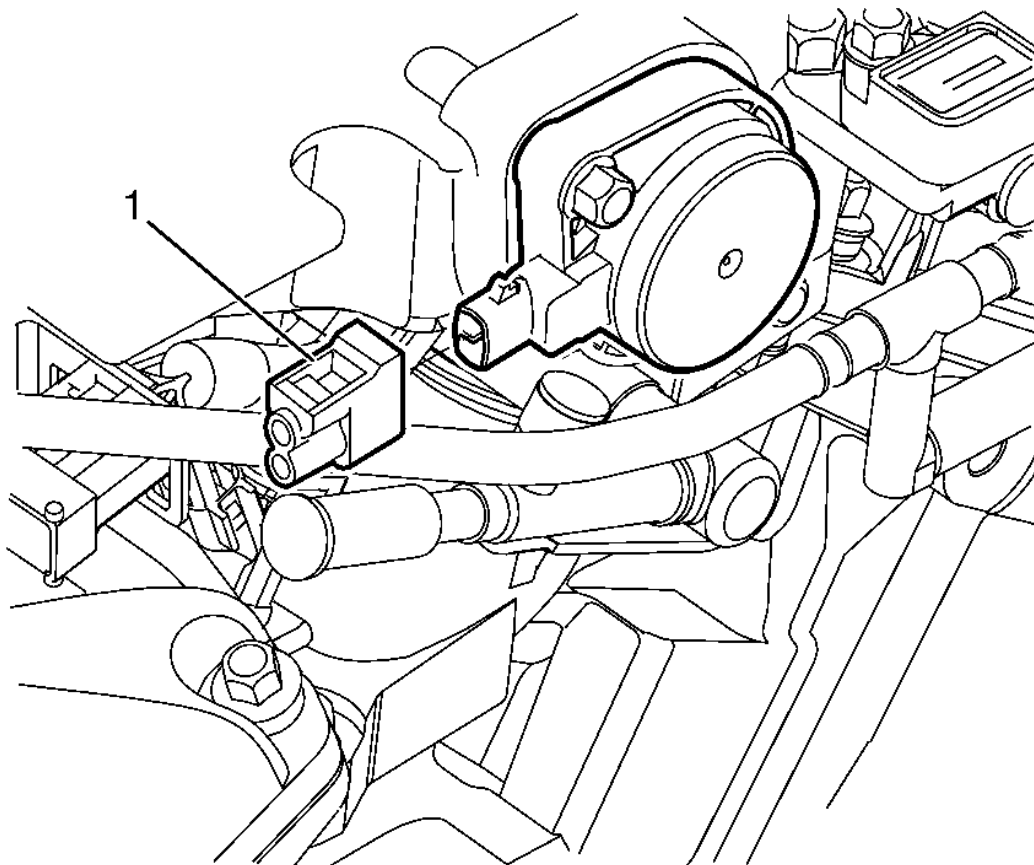
**Fig. 67: Identifying Throttle Body Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the throttle body electrical connector (1).



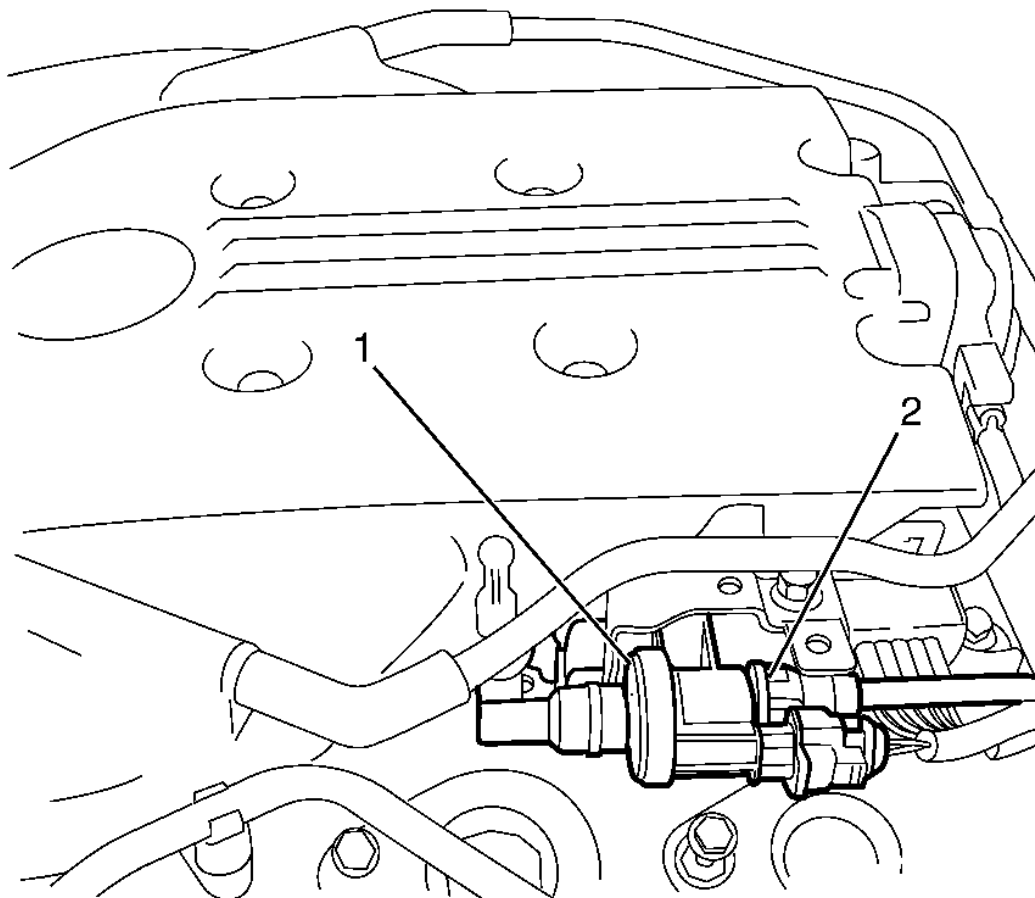
**Fig. 68: Identifying Brake Booster Vacuum Hose & Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

5. Disconnect the brake booster vacuum hose (2) from the intake manifold (1).



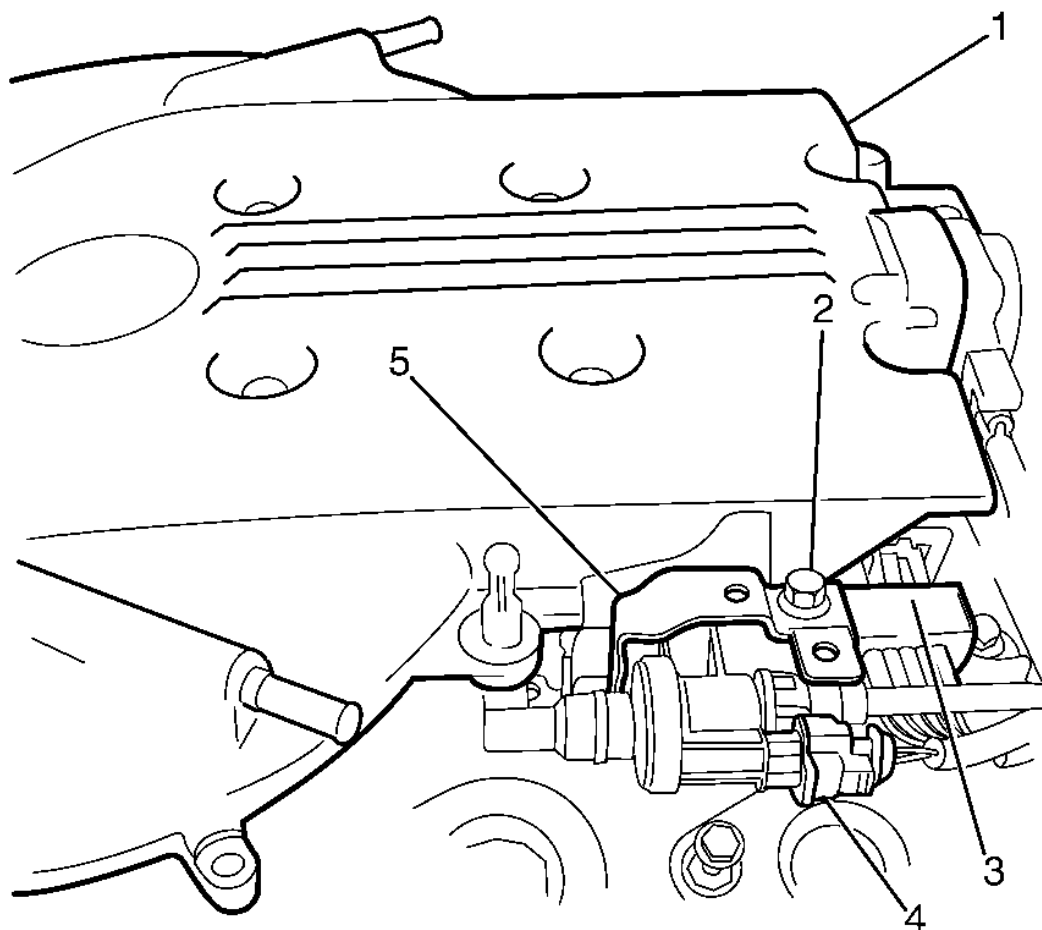
**Fig. 69: Identifying IMRC Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the Inlet Manifold Runner Control (IMRC) solenoid connector (1).



**Fig. 70: Identifying EVAP Purge Line & Purge Solenoid**  
Courtesy of GENERAL MOTORS CORP.

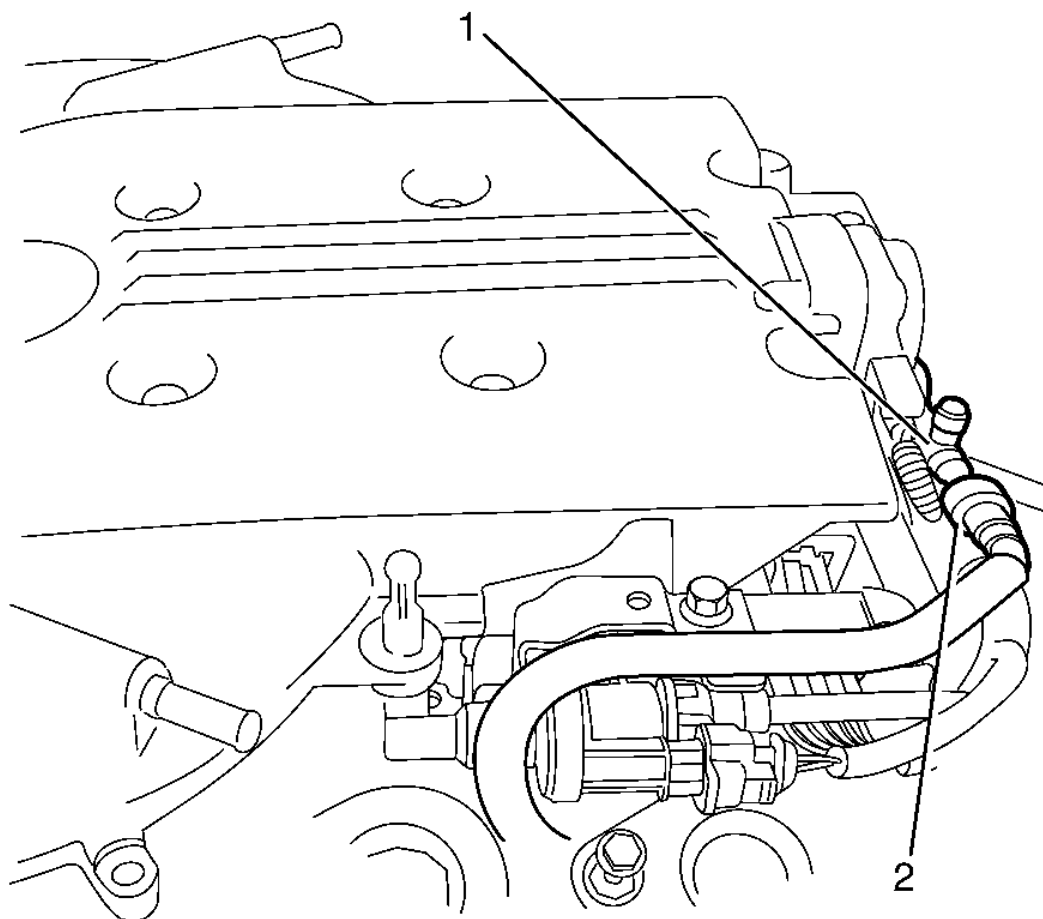
7. Disconnect the evaporative emission (EVAP) purge line (1) from the purge solenoid (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .
8. Plug or cap the (EVAP) purge line (1) and the purge solenoid (2) ends.
9. Remove the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.



**Fig. 71: Identifying Fuel Injector Harness Electrical Connector/EVAP Valve Mounting Bracket To Intake Manifold Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

10. Disconnect the EVAP valve electrical connector (4)
11. Disconnect the fuel injector harness electrical connector (3)
12. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
13. Reposition the fuel injector harness electrical connector/EVAP valve mounting bracket (5) away from the intake manifold (1).

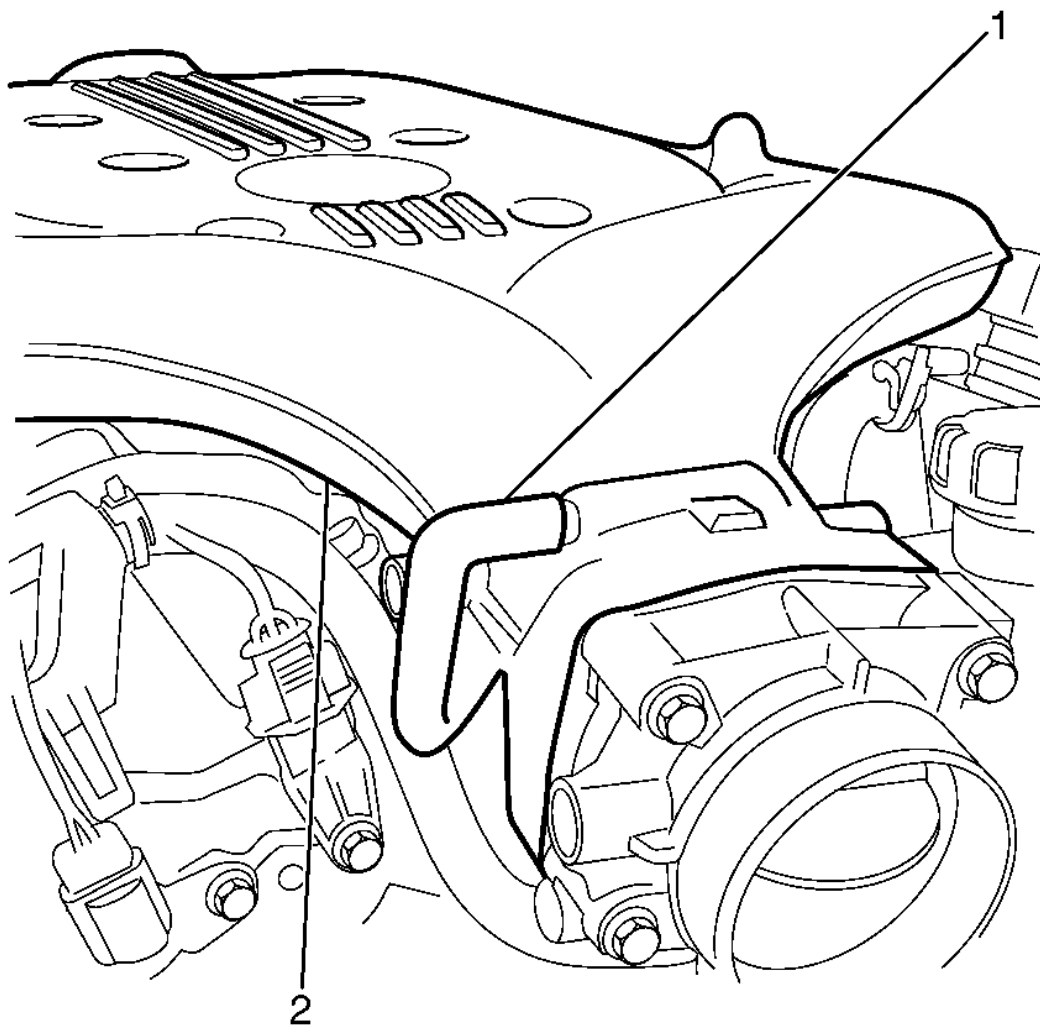


**Fig. 72: Identifying Fuel Feed Pipe & Fuel Rail**  
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the fuel feed pipe (2) from the fuel rail (1). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .

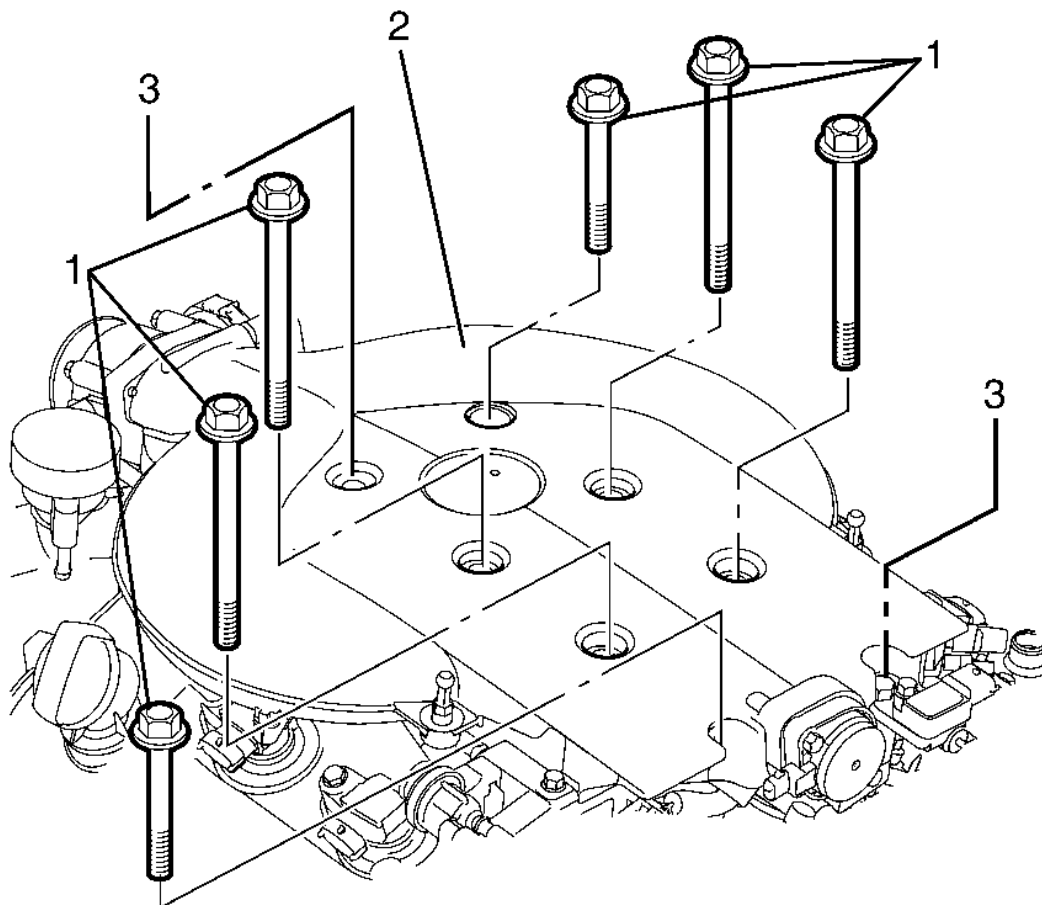
**NOTE:** Plug or cap the fuel feed pipe (2) and fuel rail (1) ends to prevent fuel leaks and/or contamination.

15. Plug or cap the fuel feed pipe (2) and fuel rail (1) ends.



**Fig. 73: View Of EVAP Hose & Upper Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

16. Disconnect the EVAP line (1) from the intake manifold (2).



**Fig. 74: Identifying Throttle Body, Intake Manifold & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- DO NOT remove the upper intake manifold to lower intake manifold retaining bolts (3).
- DO NOT kink or damage the fuel pipe.

17. Remove the intake manifold to cylinder head retaining bolts (1).
18. Remove the intake manifold assembly (2).

**NOTE:**

The cylinder heads and engine valley must be plugged with a clean lint free cloth to prevent foreign matter entry into the engine.

19. Plug the cylinder heads and engine valley with a clean lint free cloth.
20. Disassemble the intake manifold as to replace the lower intake manifold. Refer to **Intake Manifold**

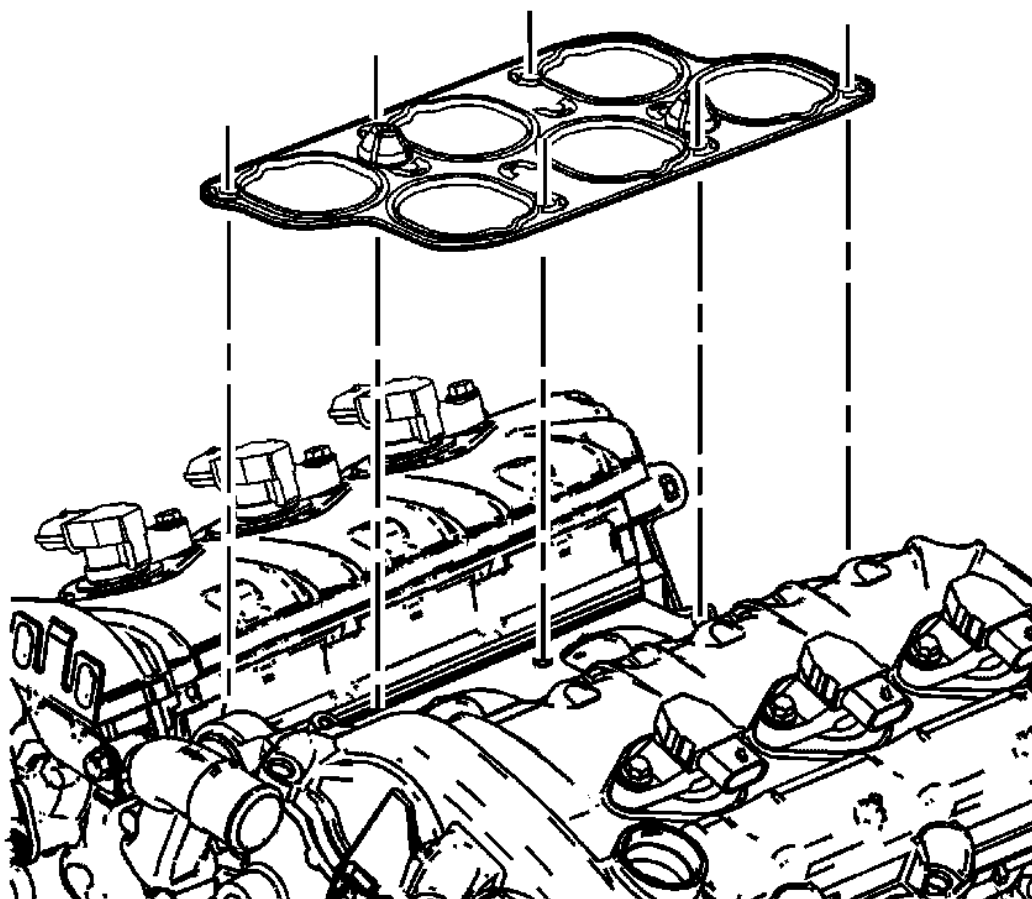


**Disassemble .**

21. Clean and inspect the intake manifold and the sealing surfaces. Refer to **Intake Manifold Cleaning and Inspection .**

**Installation Procedure**

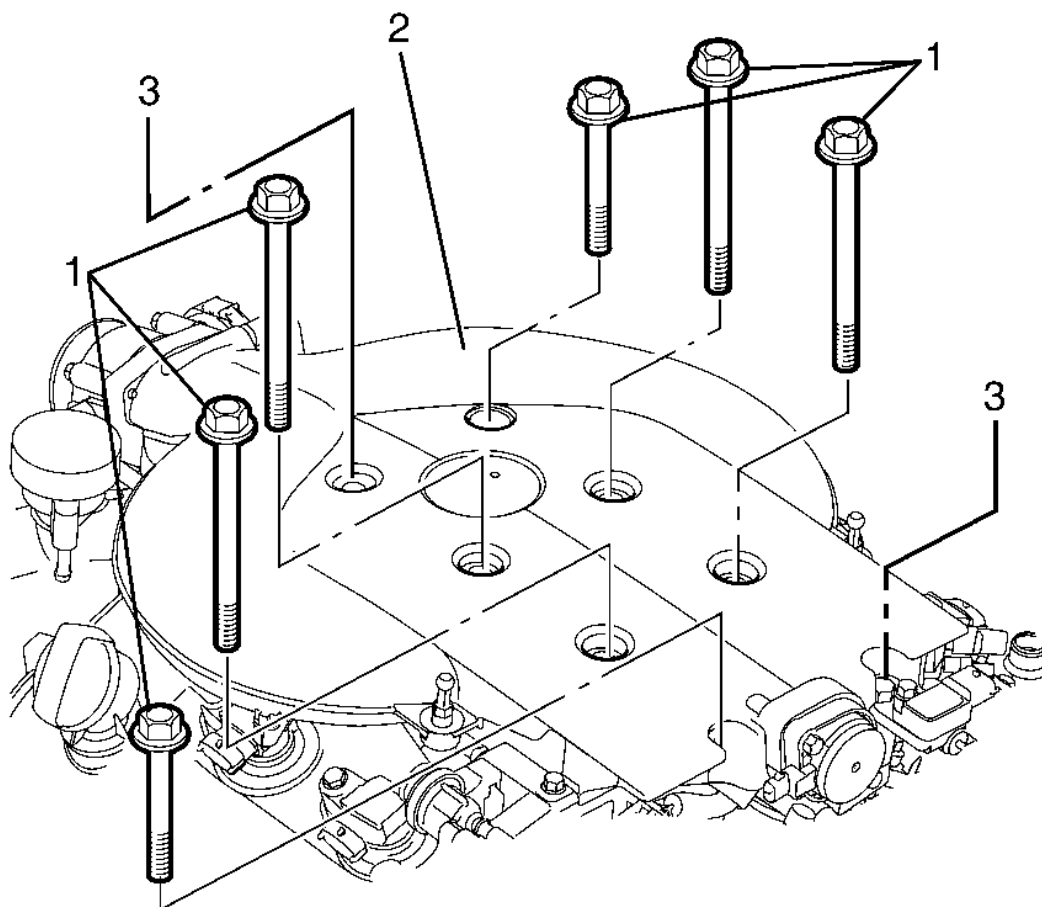
1. Assemble the intake manifold as necessary. Refer to **Intake Manifold Assemble .**
2. Remove the clean lint free cloth from the cylinder heads and engine valley.



**Fig. 75: Identifying Lower Intake Manifold Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **Inspect and replace the lower intake manifold gasket only if the gasket is worn or damaged.**

3. Install the lower intake manifold gasket.



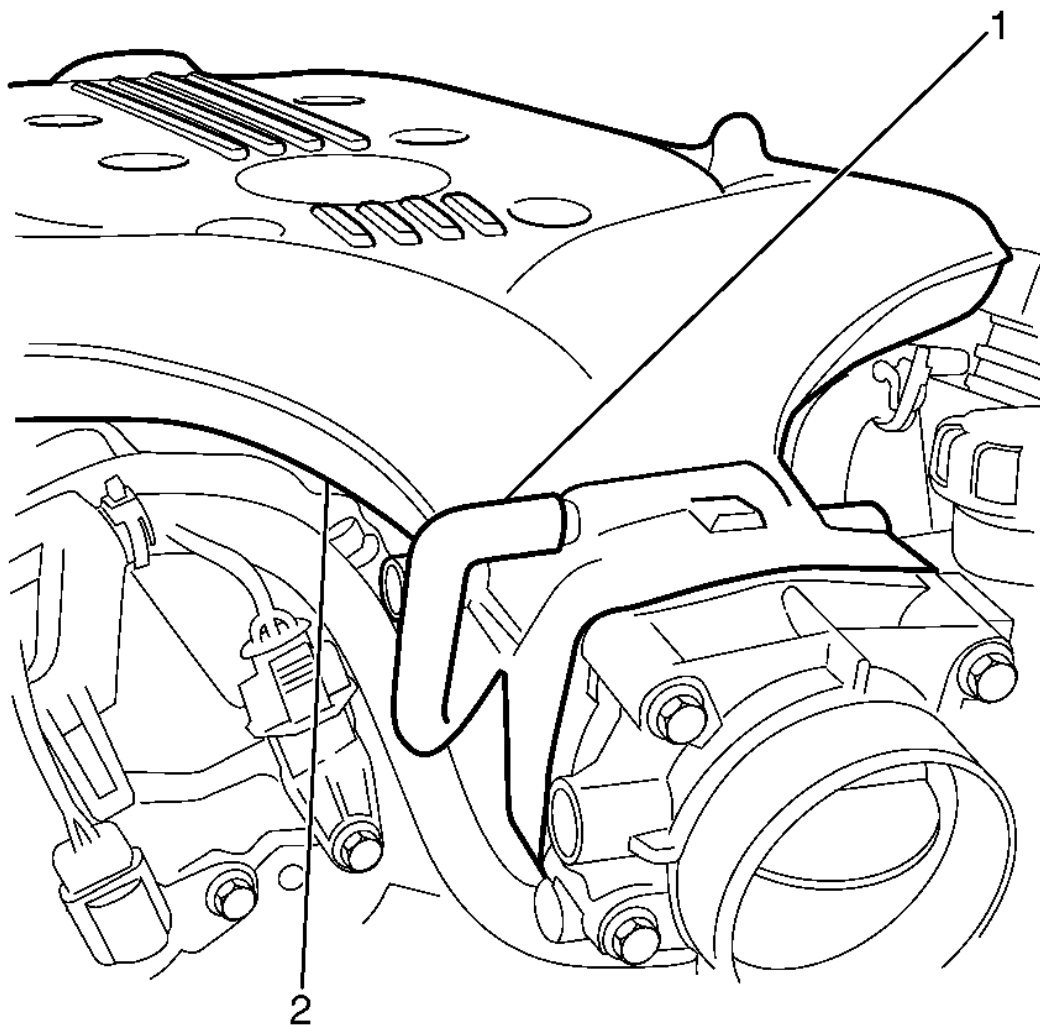
**Fig. 76: Identifying Throttle Body, Intake Manifold & Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold assembly (2).

**CAUTION:** Refer to Fastener Caution .

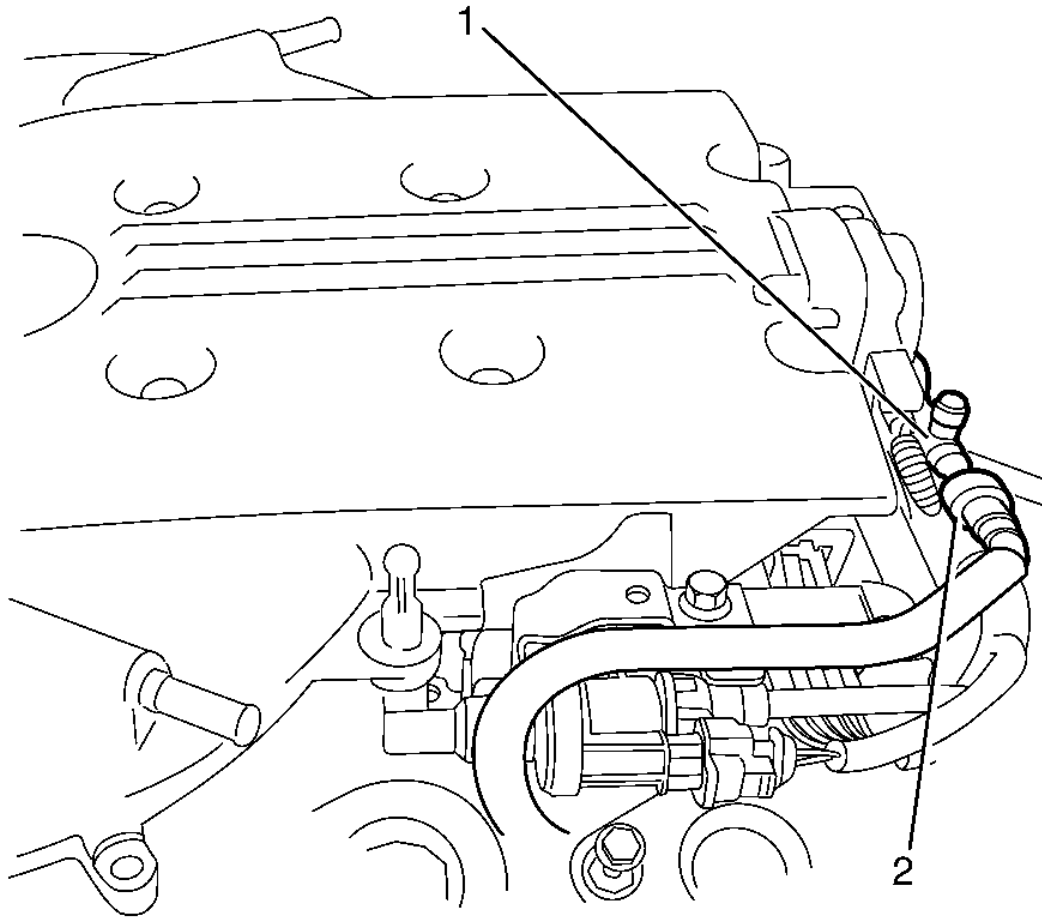
**NOTE:** Tighten the intake manifold to cylinder head retaining bolts (1) in a circular pattern starting at the center (long bolts) and moving outward.

5. Install the intake manifold using the cylinder head retaining bolts (1) and tighten to 23 N.m (17 lb ft).



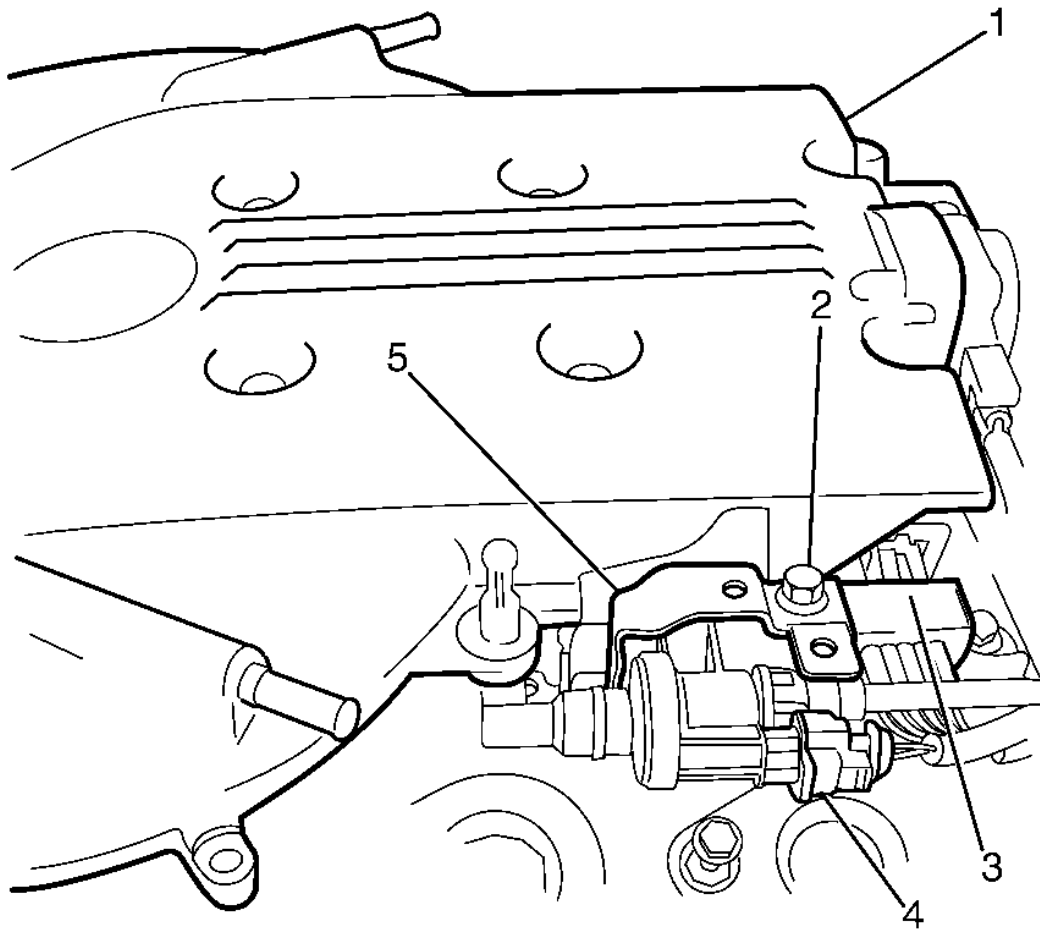
**Fig. 77: View Of EVAP Hose & Upper Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

6. Connect the EVAP line (1) to the intake manifold (2).



**Fig. 78: Identifying Fuel Feed Pipe & Fuel Rail**  
Courtesy of GENERAL MOTORS CORP.

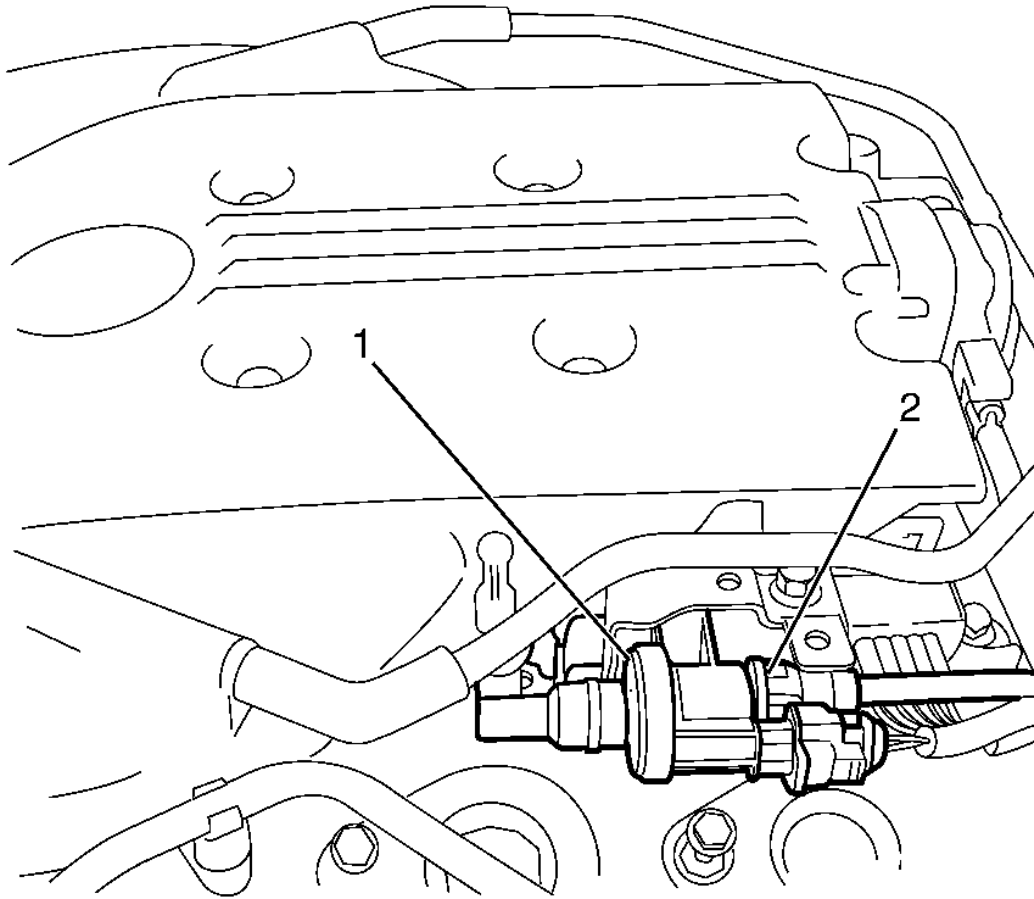
7. Remove the plug or cap at the fuel feed pipe (1) and fuel rail (2) ends
8. Connect the fuel feed pipe (1) to the fuel rail (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .



**Fig. 79: Identifying Fuel Injector Harness Electrical Connector/EVAP Valve Mounting Bracket To Intake Manifold Retaining Bolt**

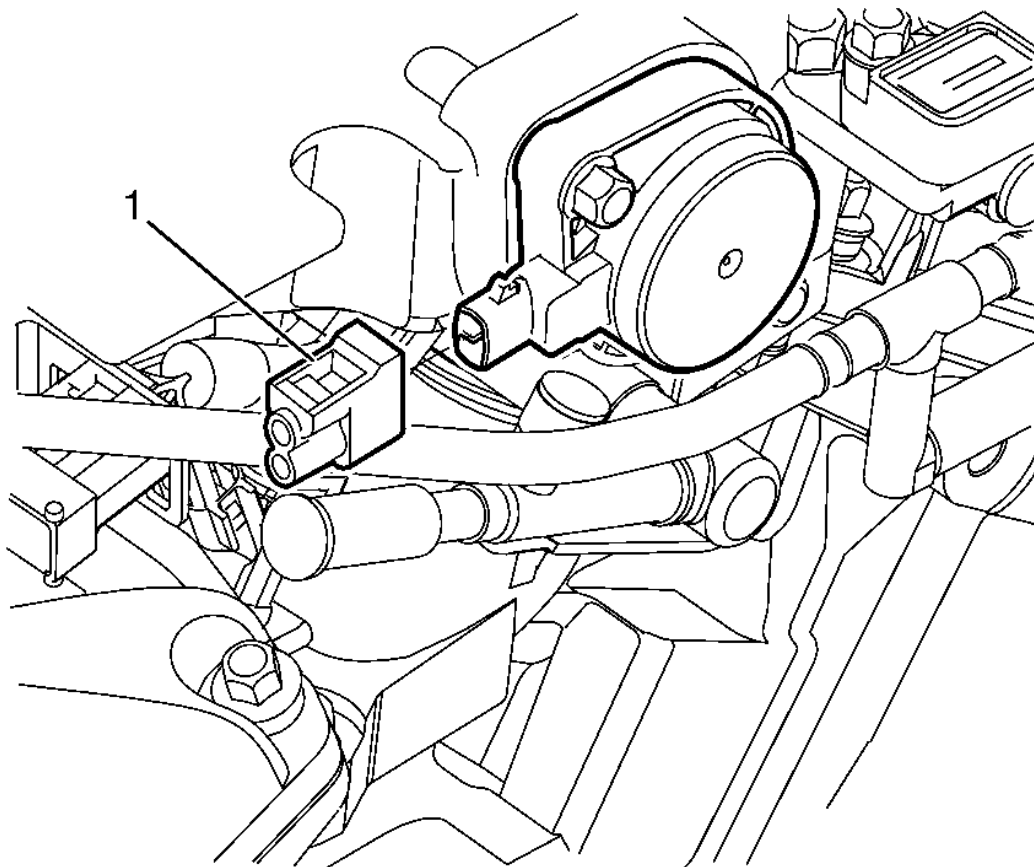
Courtesy of GENERAL MOTORS CORP.

9. Install the fuel injector harness electrical connector/EVAP valve mounting bracket (5) to the intake manifold (1).
10. Install the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
11. Connect the fuel injector harness electrical connector (3)
12. Connect the EVAP valve electrical connector (4)
13. Install the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**.



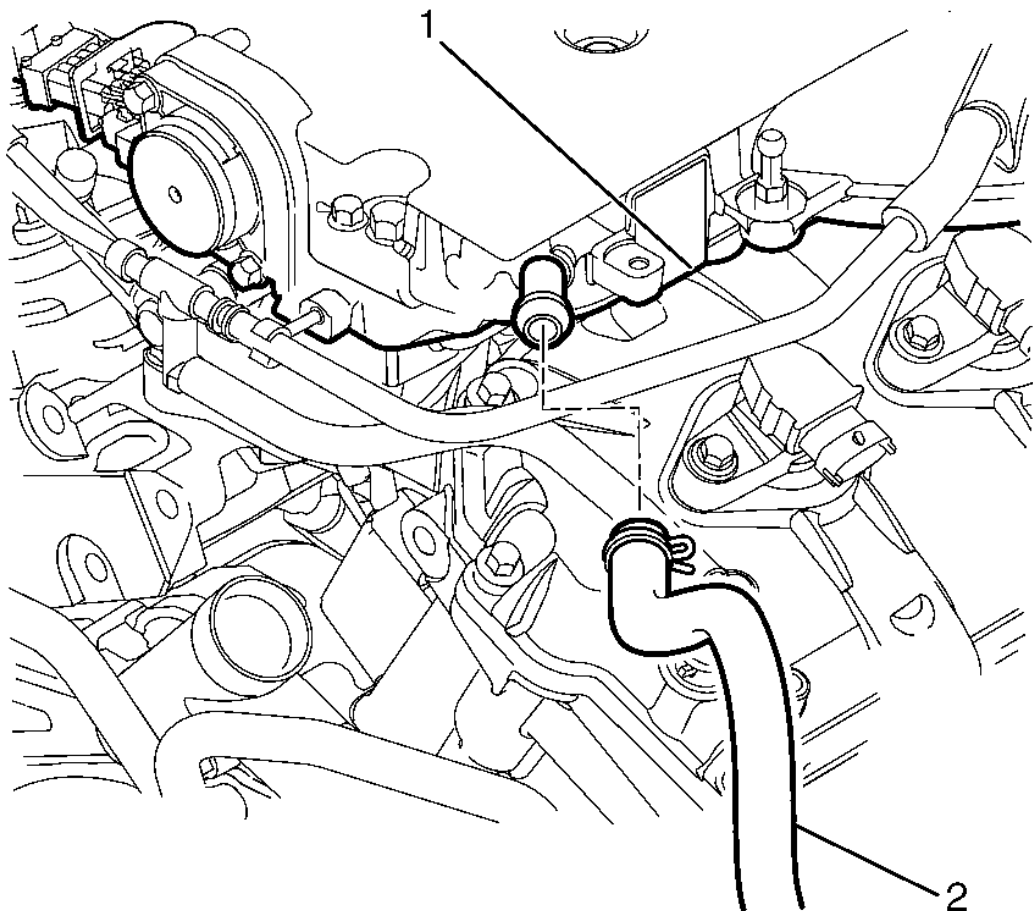
**Fig. 80: Identifying EVAP Purge Line & Purge Solenoid**  
Courtesy of GENERAL MOTORS CORP.

14. Remove the plug or cap from the (EVAP) purge line (2) and the purge solenoid (1) ends.
15. Connect the evaporative emission (EVAP) purge line (2) from the purge solenoid (1). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .



**Fig. 81: Identifying IMRC Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

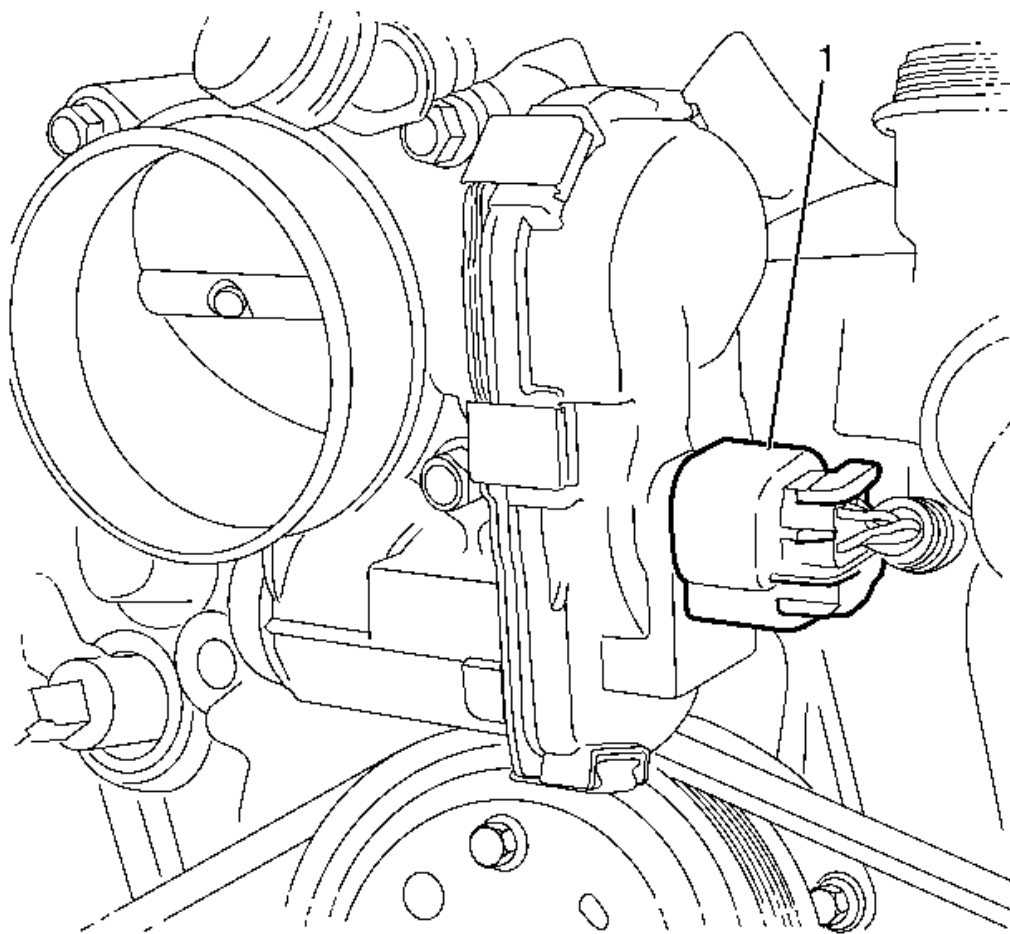
16. Connect the Inlet Manifold Runner Control (IMRC) electrical connector (1).



**Fig. 82: Identifying Brake Booster Vacuum Hose & Intake Manifold**  
**Courtesy of GENERAL MOTORS CORP.**

17. Connect the brake booster vacuum hose (2) to the intake manifold (1).





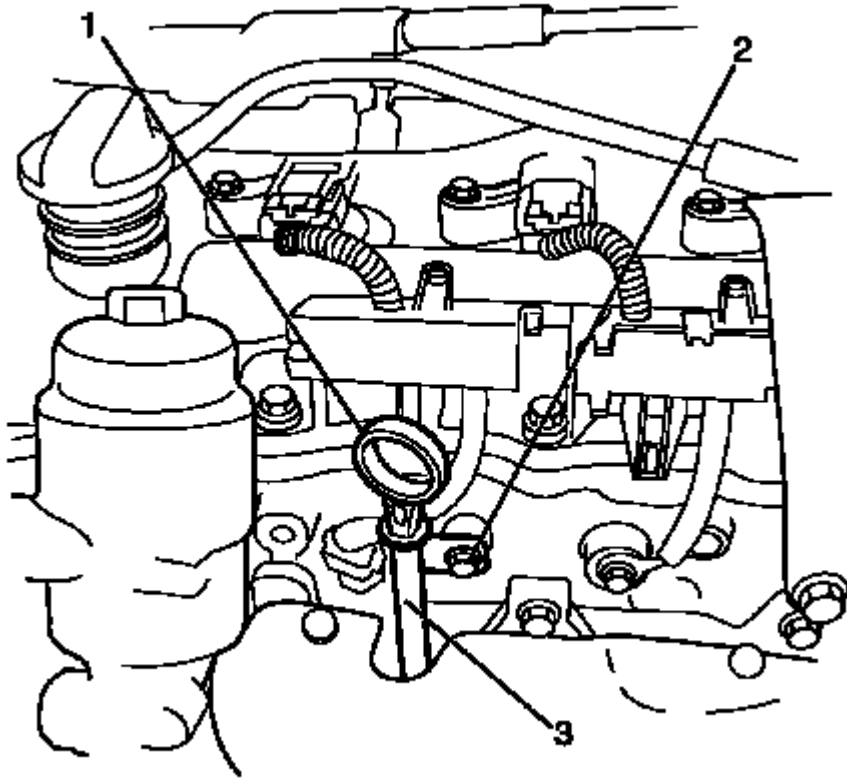
**Fig. 83: Identifying Throttle Body Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

18. Connect the throttle body electrical connector (1).
19. Install the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .
20. Install the engine covers. Refer to **Engine Cover Replacement**.
21. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .

## **OIL LEVEL INDICATOR TUBE REPLACEMENT**

### **Removal Procedure**

1. Turn the ignition OFF.



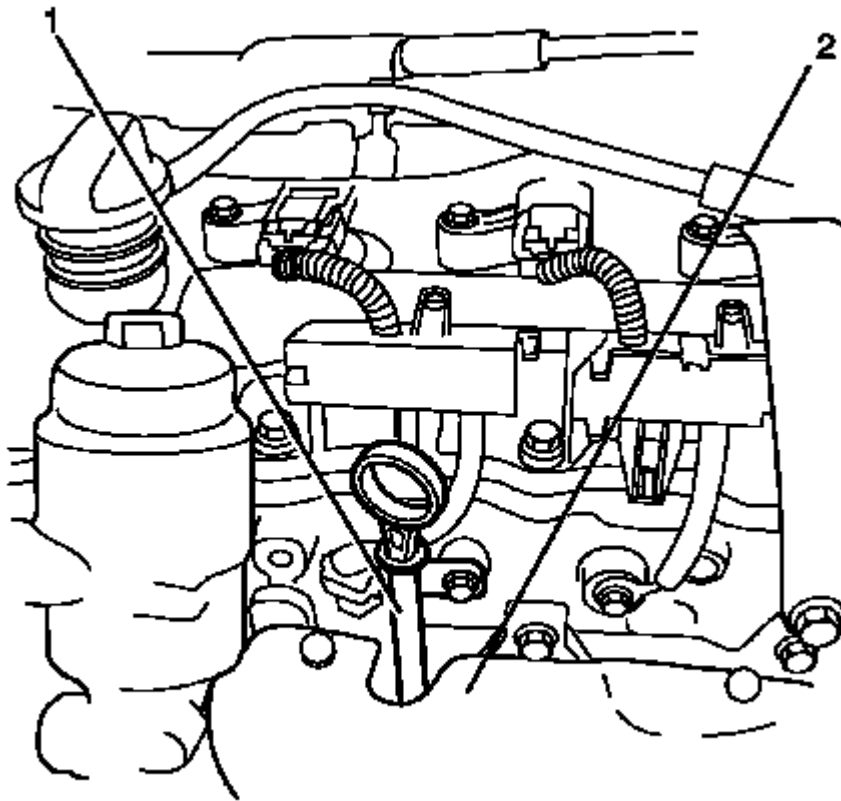
**Fig. 84: Identifying Oil Level Indicator Tube Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube bracket to cylinder head retaining bolt (2).
3. Remove the oil level indicator (1) from the oil level indicator tube (3).

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
5. Remove the knock sensor. Refer to Knock Sensor Replacement - Bank 2 .
6. Lower the vehicle.



**Fig. 85: Identifying Oil Level Indicator Tube & Exhaust Manifold**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil level indicator tube (1) up through the exhaust manifold (2).
8. If you are replacing only the oil level indicator tube seal, remove and discard the old seal.

#### Installation Procedure

1. Install the oil level indicator and tube. Refer to Oil Level Indicator and Tube Installation .

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

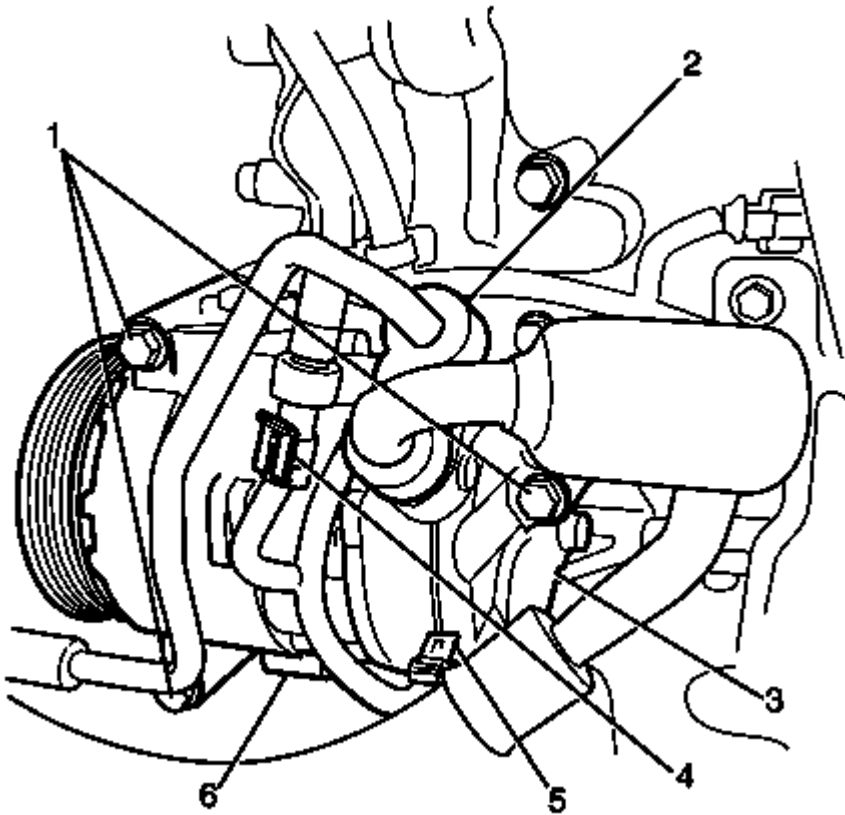
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
3. Install the knock sensor. Refer to Knock Sensor Replacement - Bank 2 .

4. Lower the vehicle.

## OIL FILTER ADAPTER REPLACEMENT

### Removal Procedure

1. Remove the engine covers. Refer to Engine Cover Replacement.
2. Remove the oil filter. Refer to Engine Oil and Oil Filter Replacement.
3. Remove the drive belt. Refer to Drive Belt Replacement - Accessory.



**Fig. 86: Identifying Compressor To Compressor Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the A/C pressure transducer electrical connector (4).
5. Disconnect the A/C compressor electrical connector (5).

**IMPORTANT: DO NOT disconnect the A/C pipes (2) from the A/C compressor (6).**

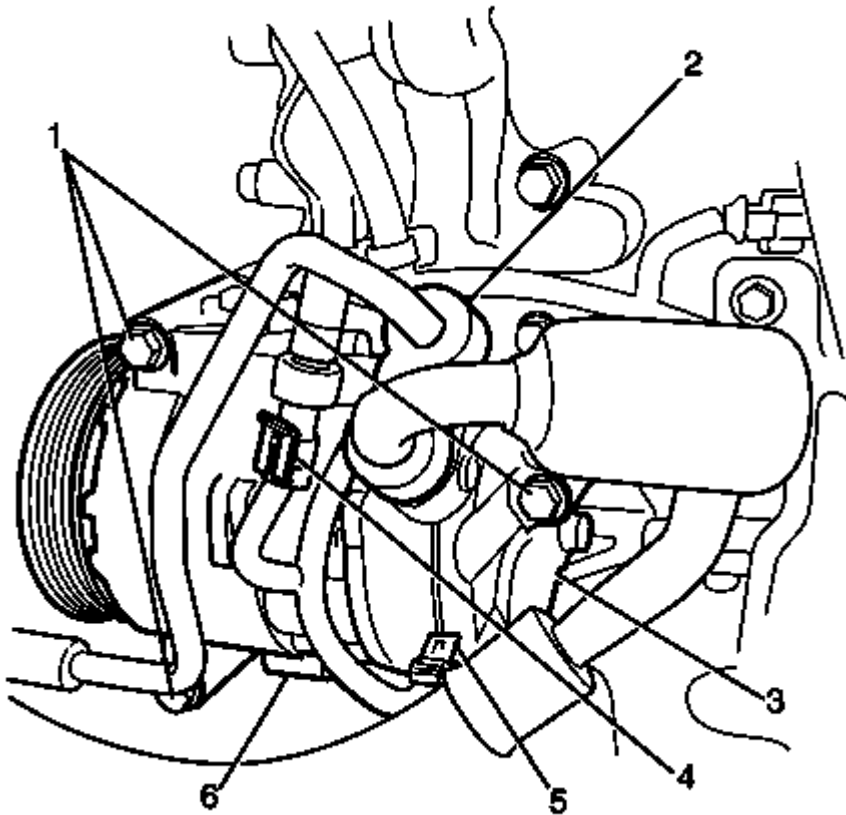
6. Remove the A/C compressor to A/C compressor/power steering pump mounting bracket retaining bolts (1).
7. Secure and reposition the A/C compressor (6) away from the A/C compressor mounting bracket (3) in

order to gain access to the oil filter adapter to cylinder block retaining bolts.

8. Remove the oil filter adapter. Refer to **Oil Filter Adapter Removal**.

#### Installation Procedure

1. Install the oil filter adapter. Refer to **Oil Filter Adapter Installation**.



**Fig. 87: Identifying Compressor To Compressor Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Make sure the A/C pipes (2) are not twisted or kinked upon compressor installation.

2. Install the A/C compressor (6) with the A/C pipes (2) to the A/C compressor mounting bracket (3).
3. Install the A/C compressor to A/C compressor mounting bracket retaining bolts (1).
4. Connect the A/C pressure transducer electrical connector (4).
5. Connect the A/C compressor electrical connector (5).
6. Install the drive belt. Refer to **Drive Belt Replacement**.
7. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

#### CRANKSHAFT BALANCER REPLACEMENT

**Special Tools**

- **EN 46106** Flywheel Holding Tool. See Special Tools .
- **J 45059** Angle Meter. See Special Tools .

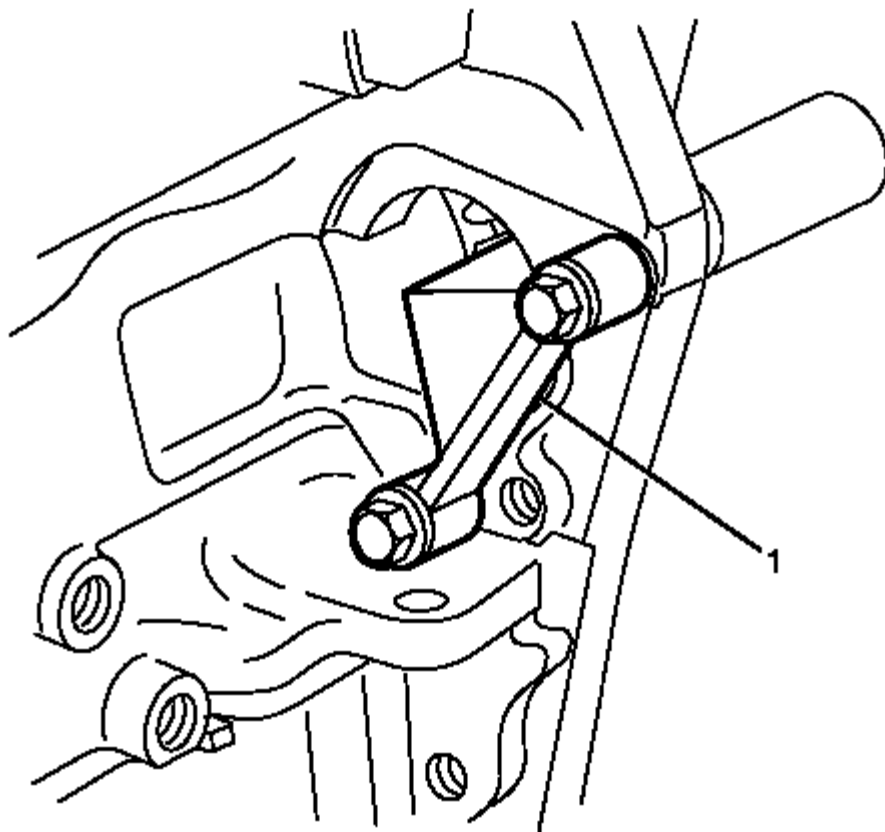
**Removal Procedure**

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

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
3. Remove the starter motor. Refer to Starter Replacement (3.6L) .



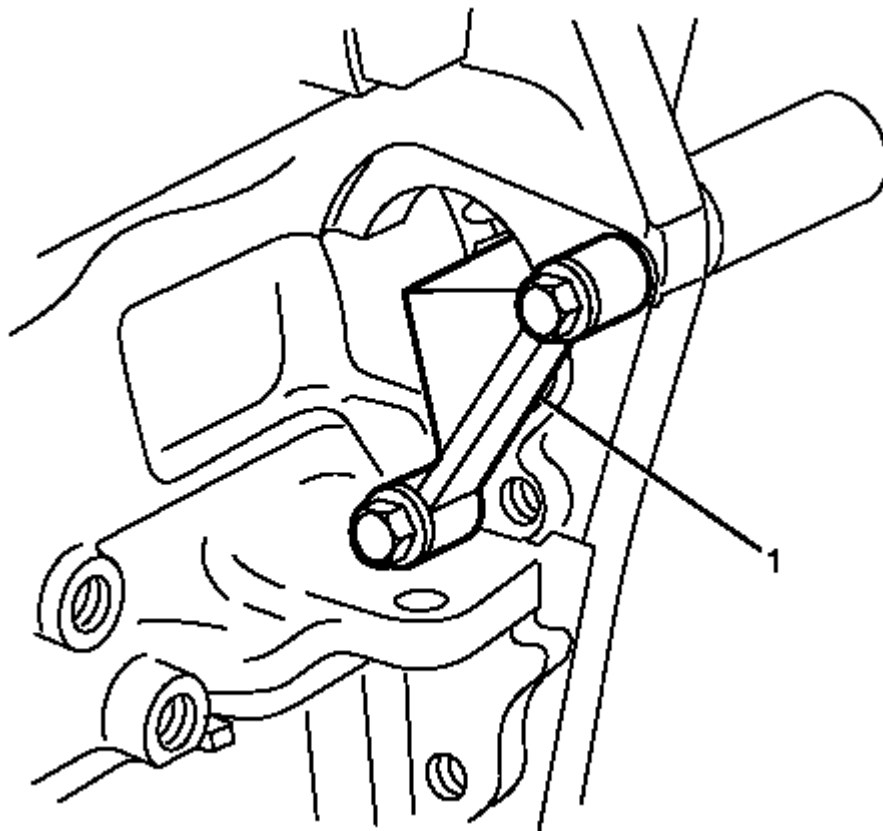
**Fig. 88: View Of EN 46106**

**Courtesy of GENERAL MOTORS CORP.**

4. Install the **EN 46106** (1) through the starter mounting hole. See **Special Tools** .
5. Lower the vehicle.
6. Remove the front air deflector. Refer to **Front Air Deflector Replacement** .
7. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal** .

**Installation Procedure**

1. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation** .
2. Install the front air deflector. Refer to **Front Air Deflector Replacement** .
3. Raise the vehicle.

**Fig. 89: View Of EN 46106****Courtesy of GENERAL MOTORS CORP.**

4. Remove **EN 46106** (1) from the starter mounting hole. See **Special Tools** .
5. Remove the starter motor. Refer to **Starter Replacement (3.6L)** .
6. Install the drive belt. Refer to **Drive Belt Replacement** .

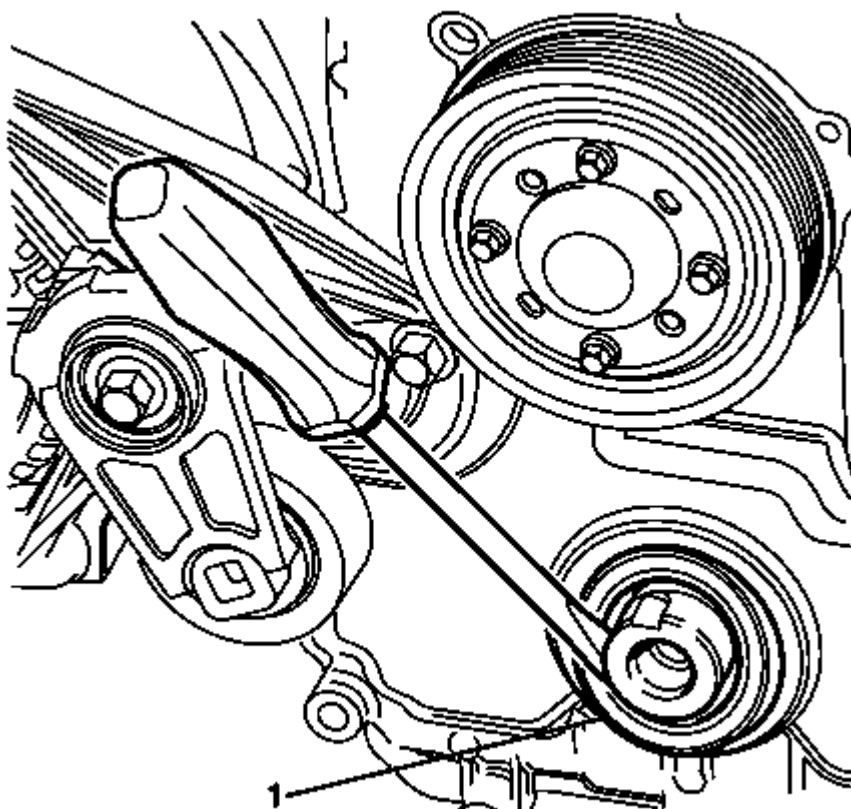
**CRANKSHAFT FRONT OIL SEAL REPLACEMENT**

**Tools Required**

**J 29184** Oil Seal Installer. See Special Tools .

**Removal Procedure**

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



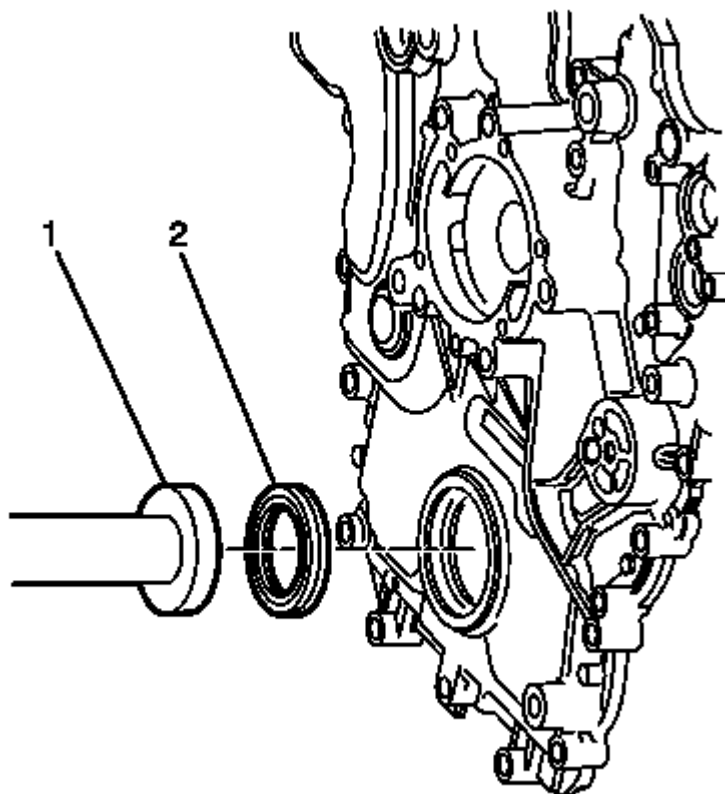
**Fig. 90: Identifying Crankshaft Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT** damage the sealing surfaces of the front cover or the crankshaft when prying the crankshaft front oil seal for removal. Damaging the sealing surface may cause leakage or require replacement of the damaged component.

3. Use a flat-bladed tool in order to remove the crankshaft oil seal (1).

**Installation Procedure**





**Fig. 91: View Of J 29184 & Crankshaft Front Oil Seal**  
 Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT lubricate the crankshaft front oil seal or the crankshaft balancer sealing surfaces.**

1. Use the **J 29184** (1) or equivalent to install the crankshaft front oil seal (2). See Special Tools .
2. Install the crankshaft balancer. Refer to Crankshaft Balancer Installation .
3. Install the drive belt. Refer to Drive Belt Replacement.

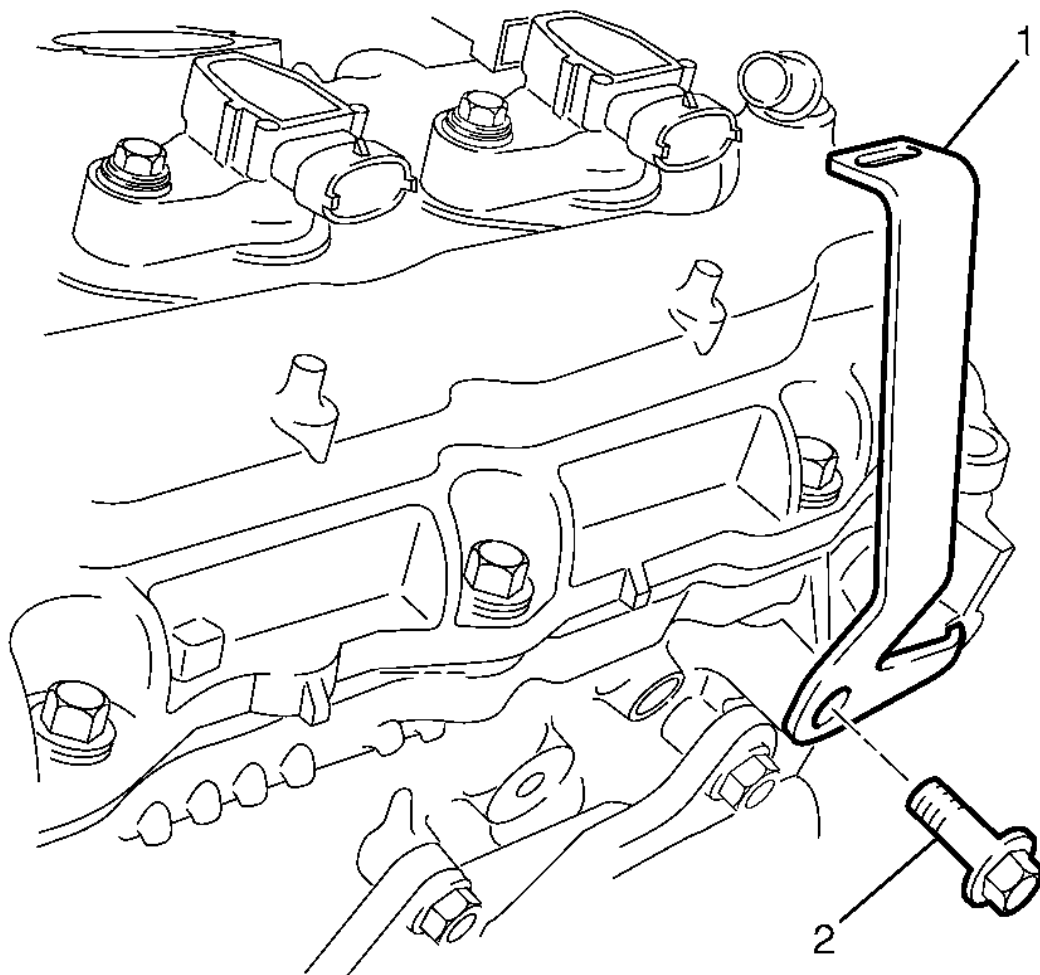
## **CAMSHAFT COVER REPLACEMENT - LEFT SIDE**

### **Special Tools**

**EN 46101** Spark Plug Tube Plugs. See Special Tools .

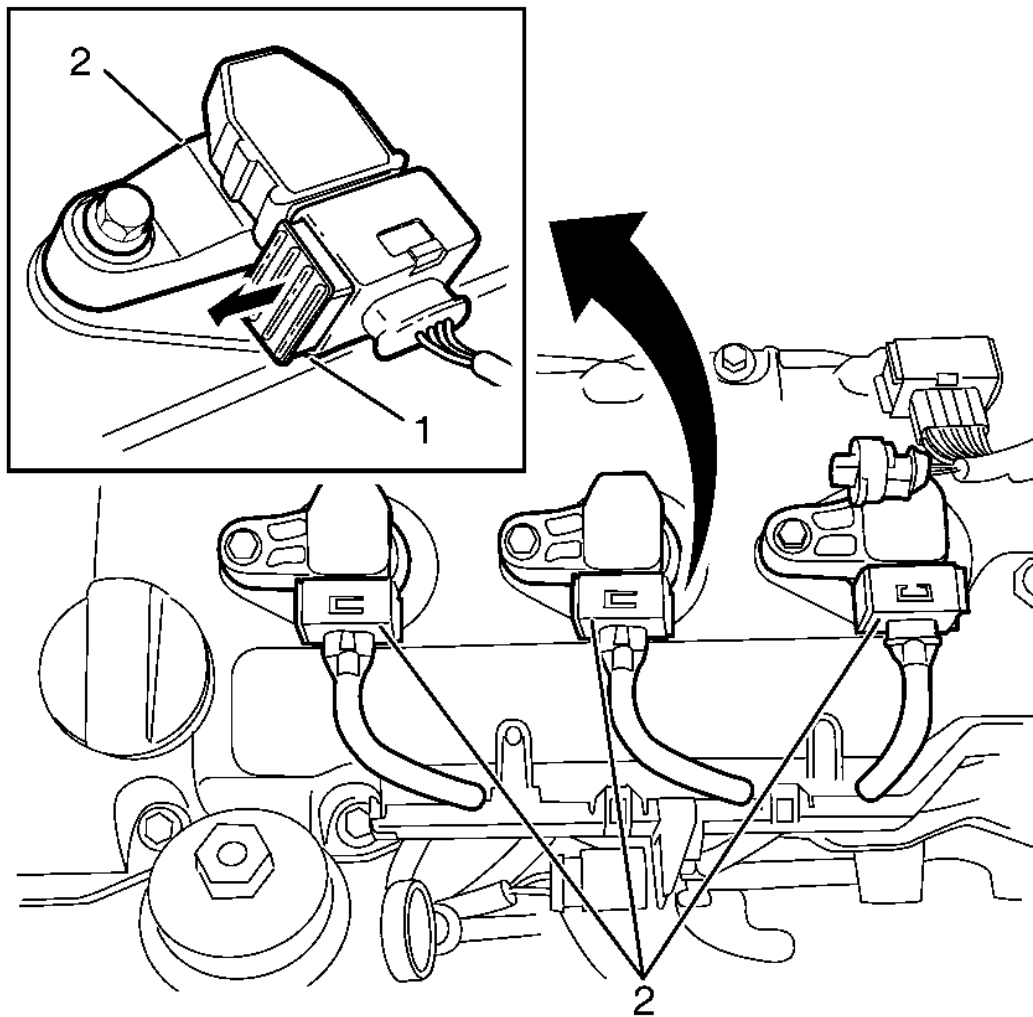
### **Removal Procedure**

1. Remove the engine covers. Refer to Engine Cover Replacement.
2. Remove the upper intake manifold with the lower intake manifold. Refer to Lower Intake Manifold Replacement.



**Fig. 92: Identifying Left Engine Cover Mounting Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

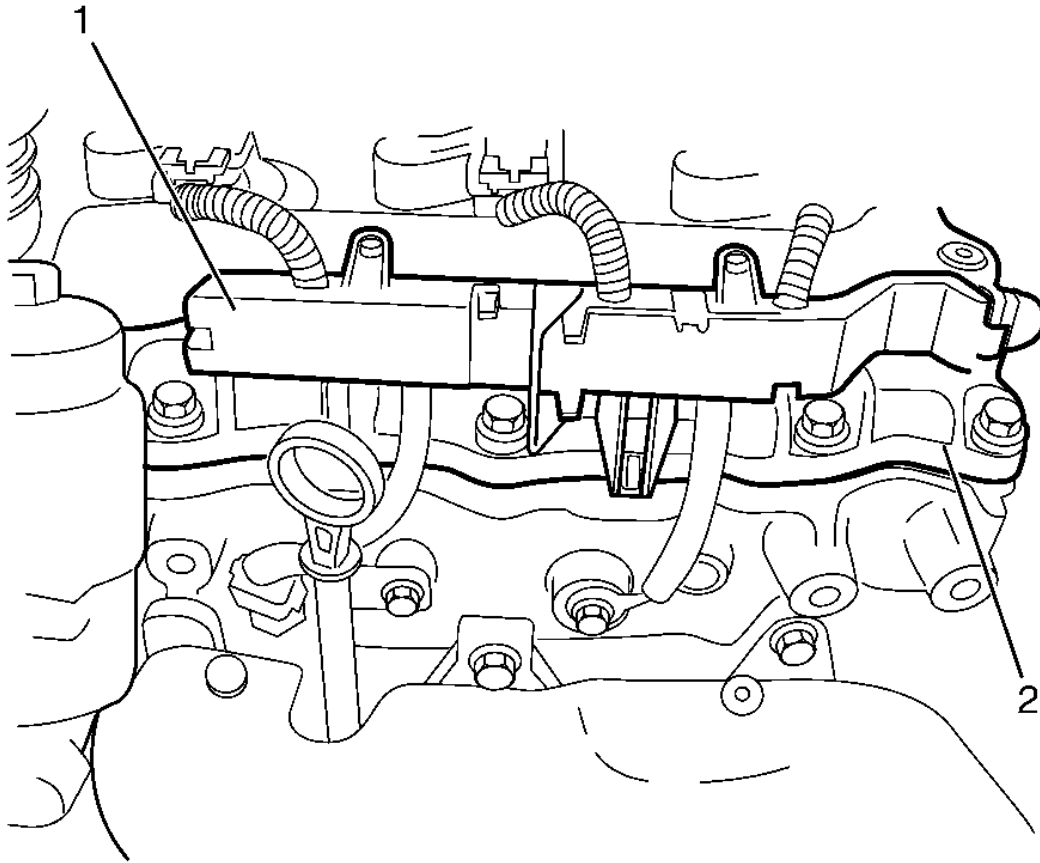
3. Remove the engine covers mounting bracket to cylinder head retaining bolt (2).
4. Remove the engine covers mounting bracket (1).



**Fig. 93: Identifying Ignition Coil Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Use a suitable tool to slide the connector retaining latch (1) in the direction of the arrow.

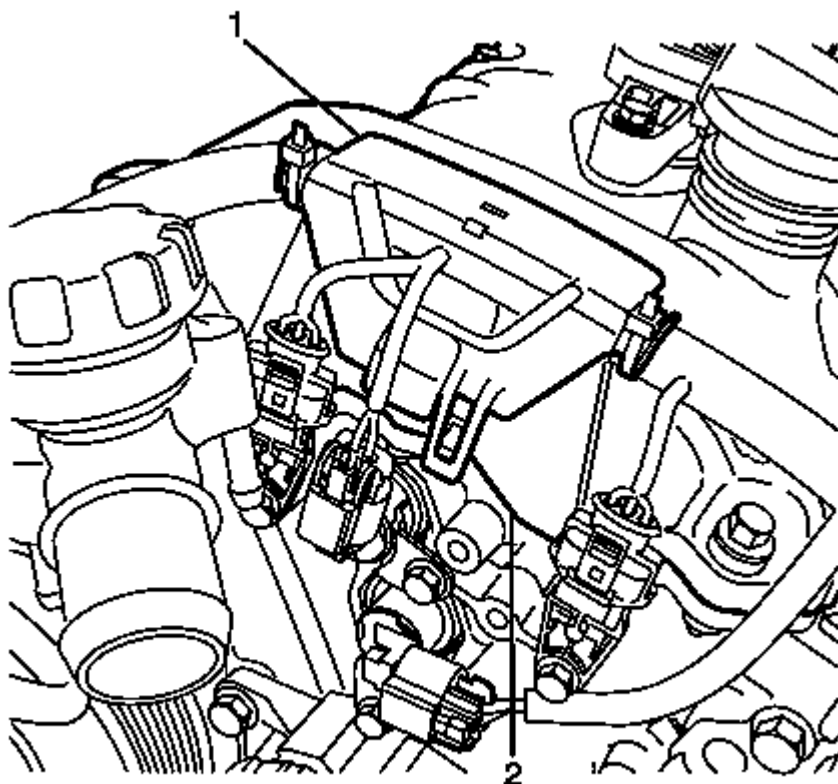
5. Disconnect the ignition coil electrical connectors (2).



**Fig. 94: Identifying Wiring Harness & Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Use a suitable tool to detach the wiring harness (1) clips from the camshaft cover (2), then lift the wiring harness (1) upwards to detach from the camshaft cover (2).

6. Remove the wiring harness (1) from the camshaft cover (2).

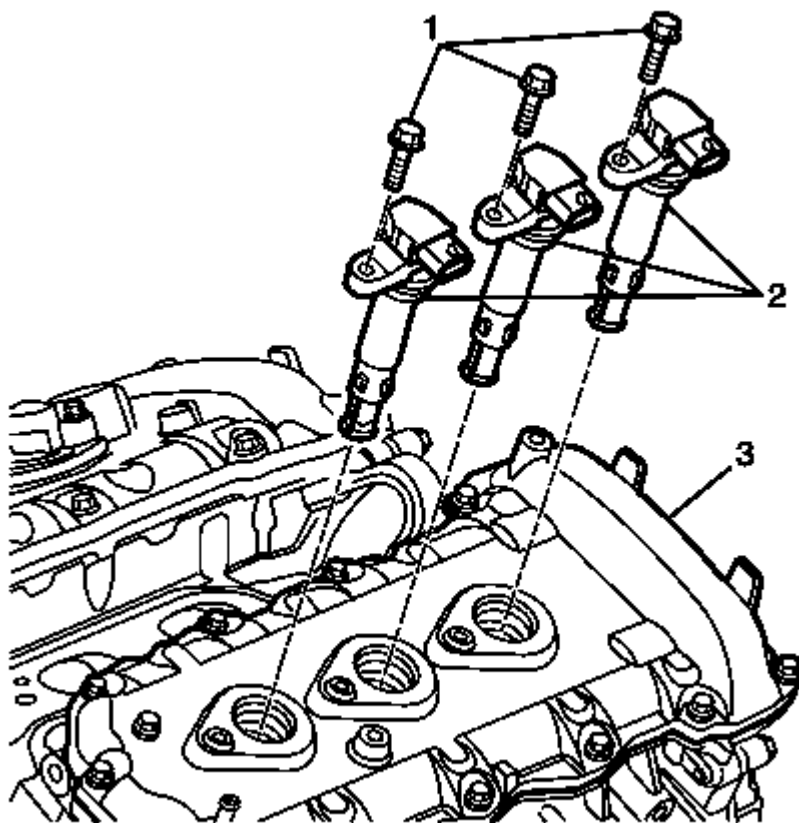


**Fig. 95: View Of Wiring Harness & Camshaft Cover**  
 Courtesy of GENERAL MOTORS CORP.

**NOTE:** It is not necessary to disconnect the engine front cover electrical connectors.

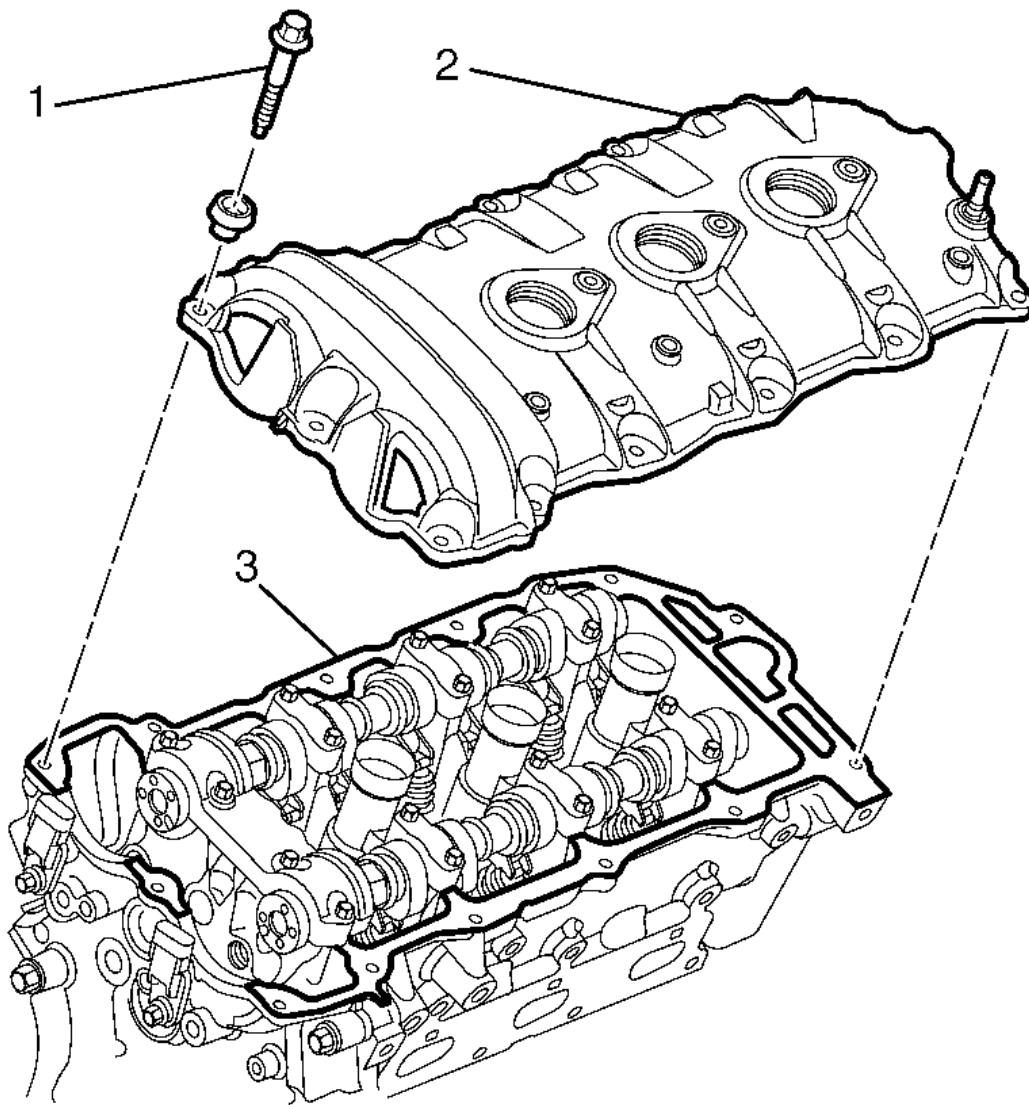
**NOTE:** Use a suitable tool to detach the wiring harness (1) clip from the camshaft cover (2), then lift the wiring harness (1) upwards to detach from the camshaft cover (2).

7. Remove the wiring harness (1) from the front of the camshaft cover (2).
8. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).



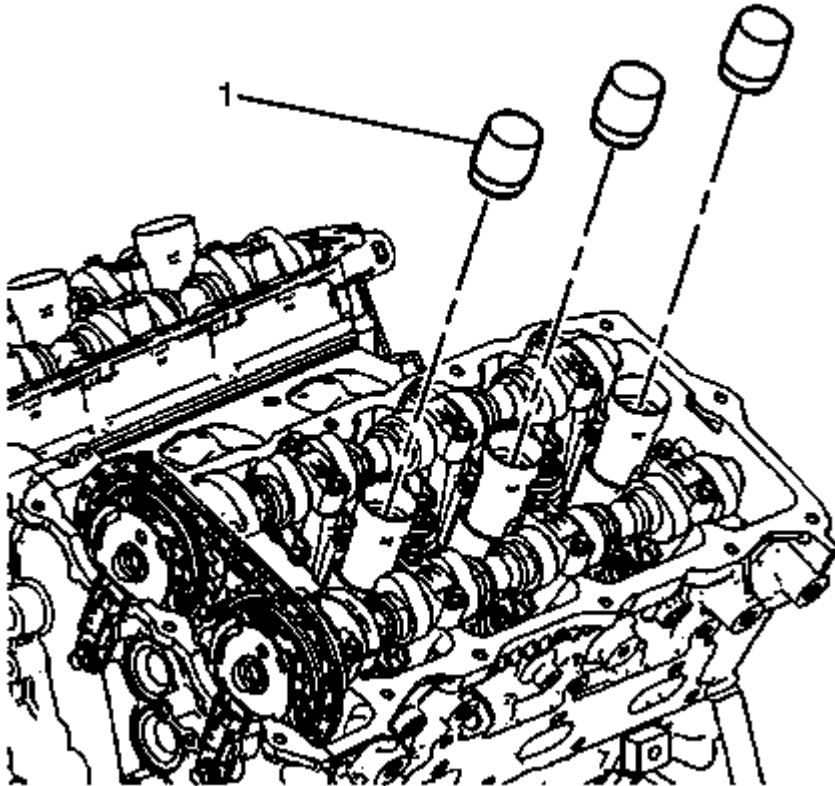
**Fig. 96: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the ignition coil to camshaft cover retaining bolts (1).
10. Remove the ignition coils (2) from the camshaft cover (3).



**Fig. 97: Identifying Left Camshaft Cover To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the camshaft cover to cylinder head retaining bolts (1).
12. Remove the camshaft cover (2) from the cylinder head (3).
13. Remove and discard the camshaft cover seal and grommets.



**Fig. 98: View Of EN-46101**

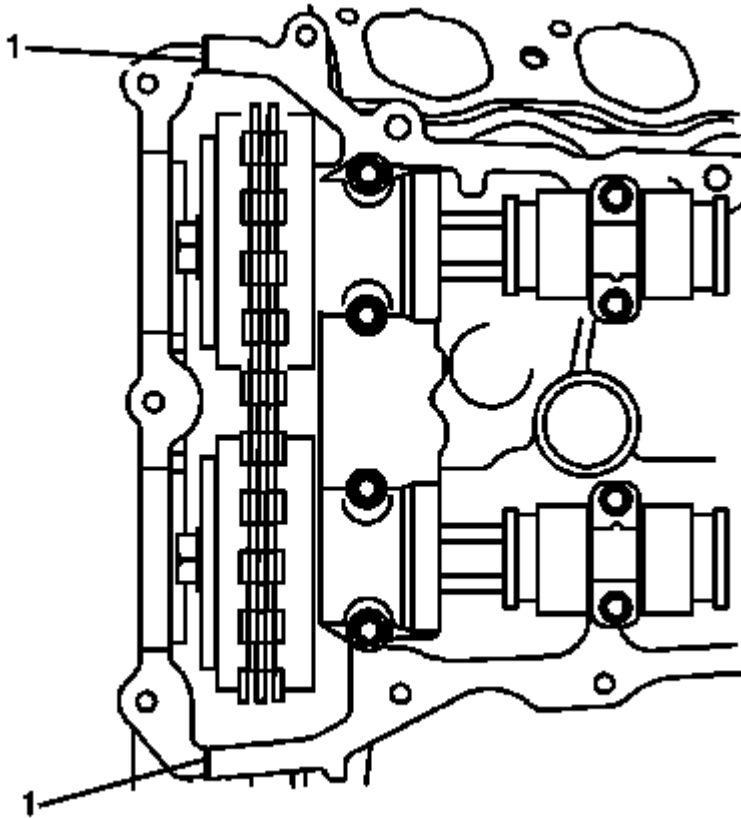
**Courtesy of GENERAL MOTORS CORP.**

14. Install the EN-46101 (1) to the spark plug tubes to prevent dirt and other contaminants from entering the cylinders.

#### **Installation Procedure**

1. Install a NEW camshaft cover seal and NEW grommets.

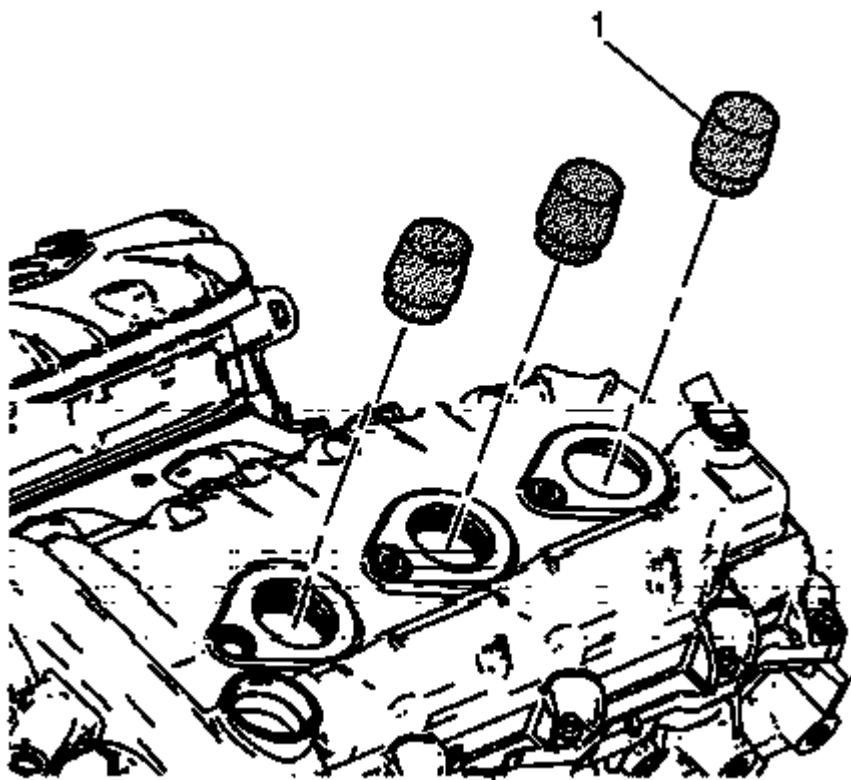




**Fig. 99: View Of Engine Front Cover Split Lines**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.

2. Place a 3mm bead of RTV sealant (1) on the join line between the engine front cover and the cylinder head.

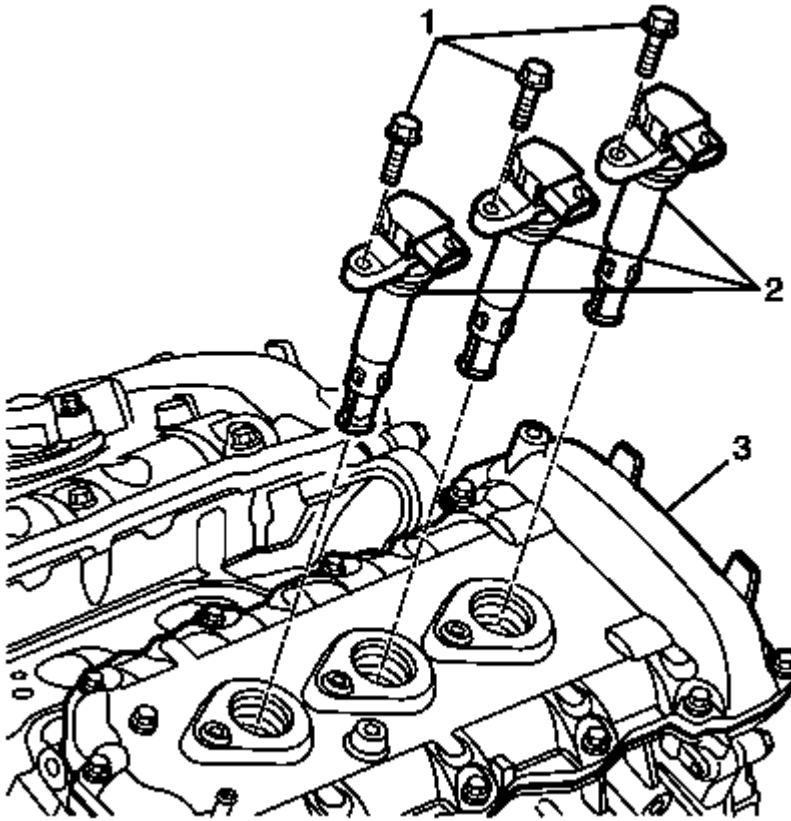


**Fig. 100: View Of EN 46101**

Courtesy of GENERAL MOTORS CORP.

3. Remove the **EN 46101** EN 46101 (1) from the spark plug tubes of the left cylinder head. See **Special Tools** .

Install the camshaft cover. Refer to **Camshaft Cover Installation - Left Side** .

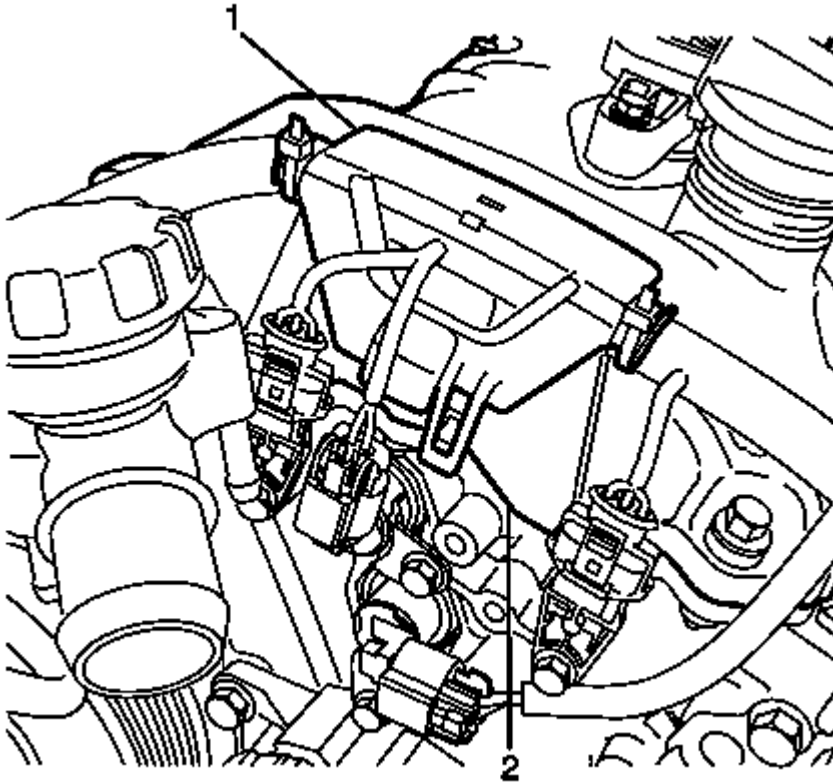


**Fig. 101: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the ignition coils (2) to the camshaft cover (3).

**CAUTION:** Refer to Fastener Caution .

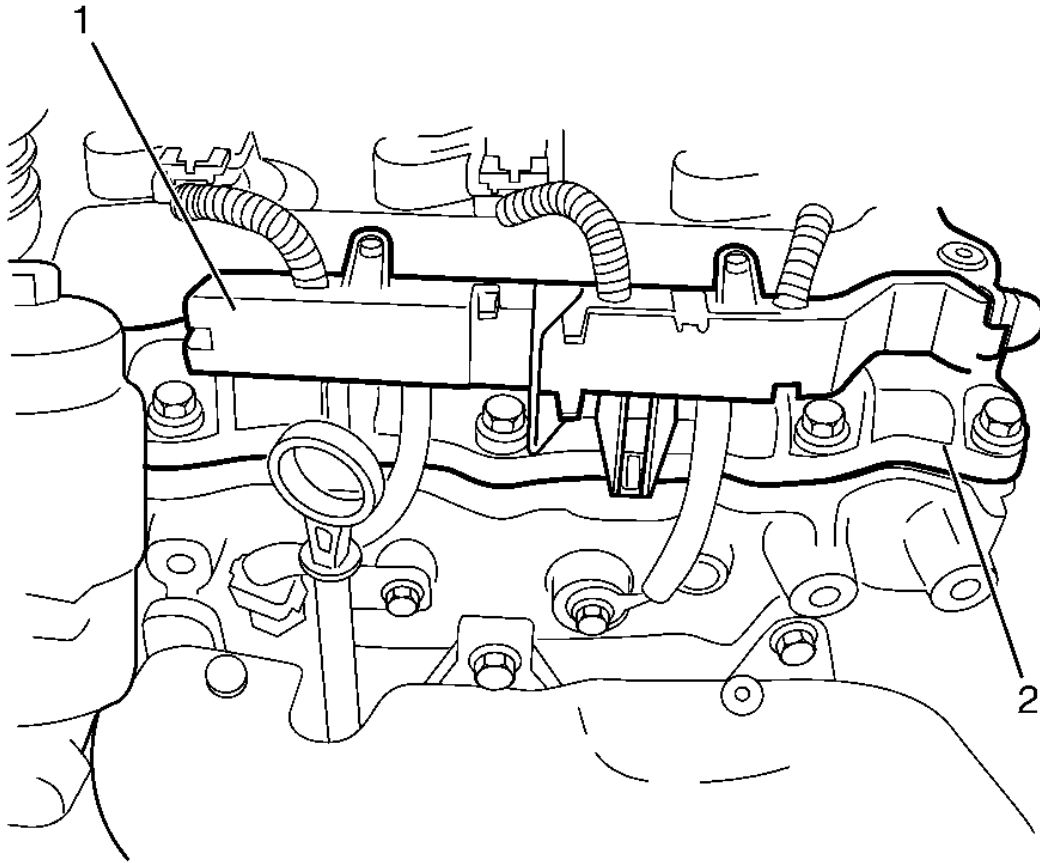
5. Install the ignition coil to the camshaft cover retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 102: View Of Wiring Harness & Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the wiring harness (1) is located on the camshaft cover (2) locating lugs and the clips are engaged.

6. Install the wiring harness (1) to the front of the camshaft cover (2).

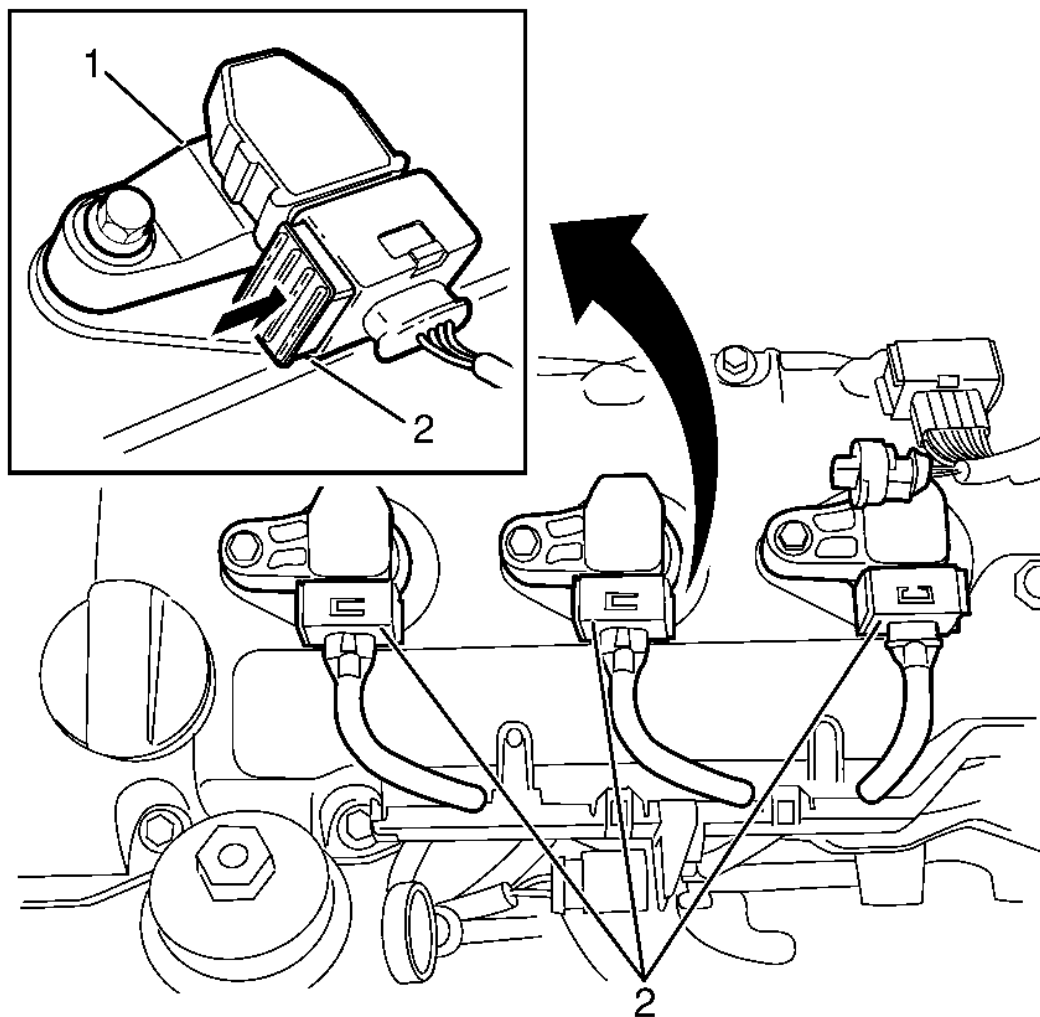


**Fig. 103: Identifying Wiring Harness & Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the wiring harness (1) is located on the camshaft cover (2) locating lugs and the clips are engaged.

**NOTE:** Install the wiring harness from the side of the camshaft cover by sliding the conduit up and inboard.

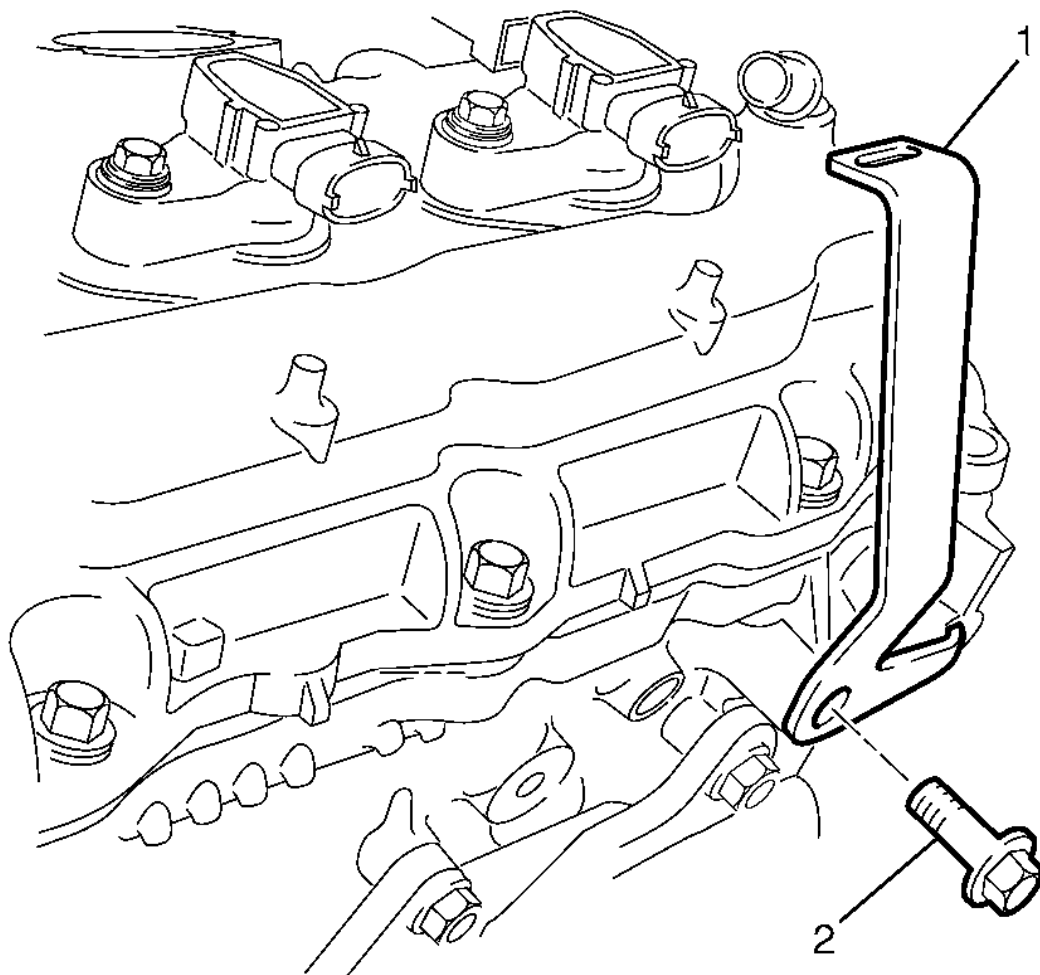
7. Install the wiring harness (1) to the camshaft cover (2).



**Fig. 104: Identifying Ignition Coil Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Slide the connector retaining latch (2) in the direction of the arrow.

8. Connect the ignition coil electrical connectors (1).



**Fig. 105: Identifying Left Engine Cover Mounting Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

9. Install the engine covers mounting bracket using the cylinder head retaining bolt (1) and tighten to 5 N.m (26 lb ft).
10. Install the engine covers mounting bracket (2).
11. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
12. Install the engine covers. Refer to **Engine Cover Replacement**.

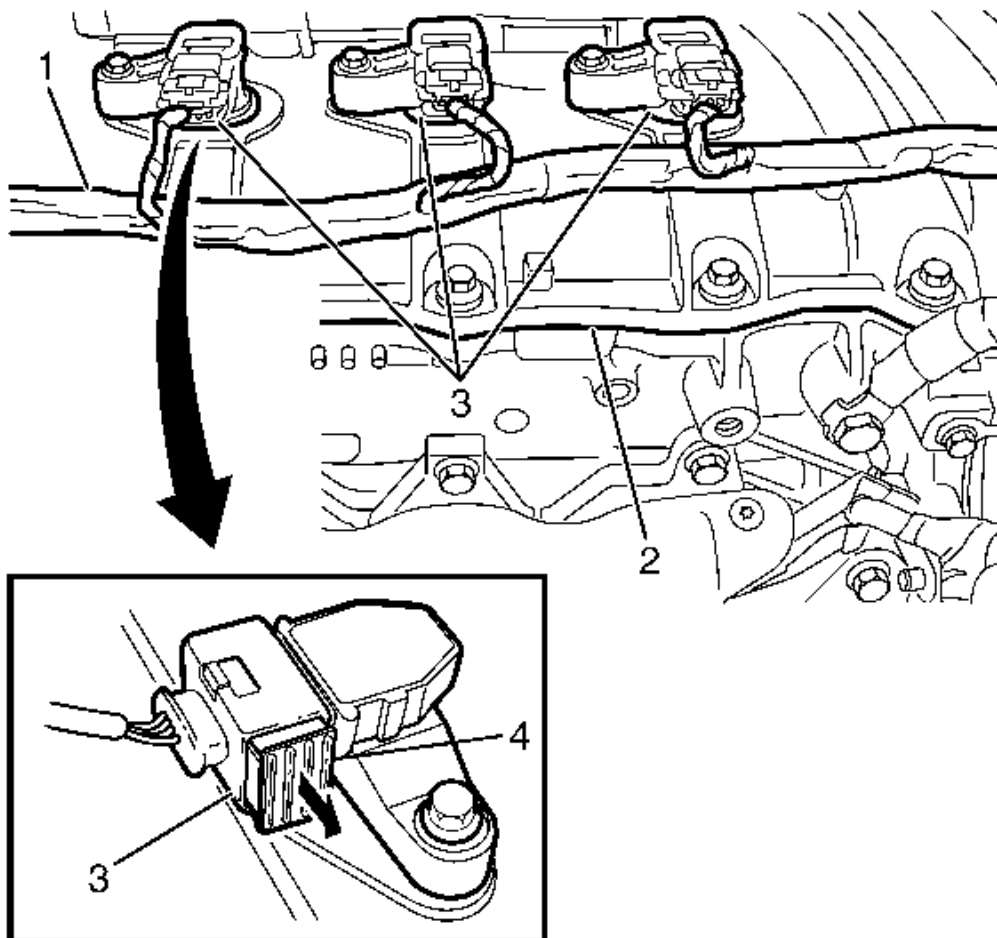
## CAMSHAFT COVER REPLACEMENT - RIGHT SIDE

### Special Tools

**EN 46101** Spark Plug Tube Plugs. See Special Tools .

#### Removal Procedure

1. Remove the engine covers. Refer to Engine Cover Replacement.
2. Remove the upper intake manifold with the lower intake manifold. Refer to Lower Intake Manifold Replacement.



**Fig. 106: Identifying Ignition Coil Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

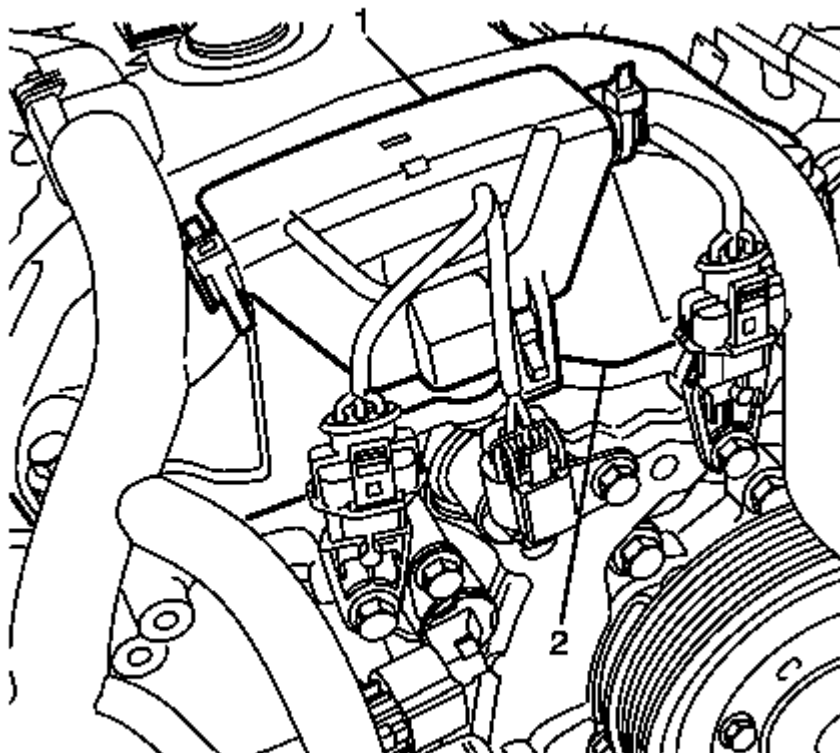
**NOTE:** Use a suitable tool to slide the connector retaining latch (4) in the direction of the arrow.



3. Disconnect the ignition coil electrical connectors (3).

**NOTE:** Use a suitable tool to detach the wiring harness (1) clips from the camshaft cover (2).

4. Remove the wiring harness (1) from the camshaft cover (2).

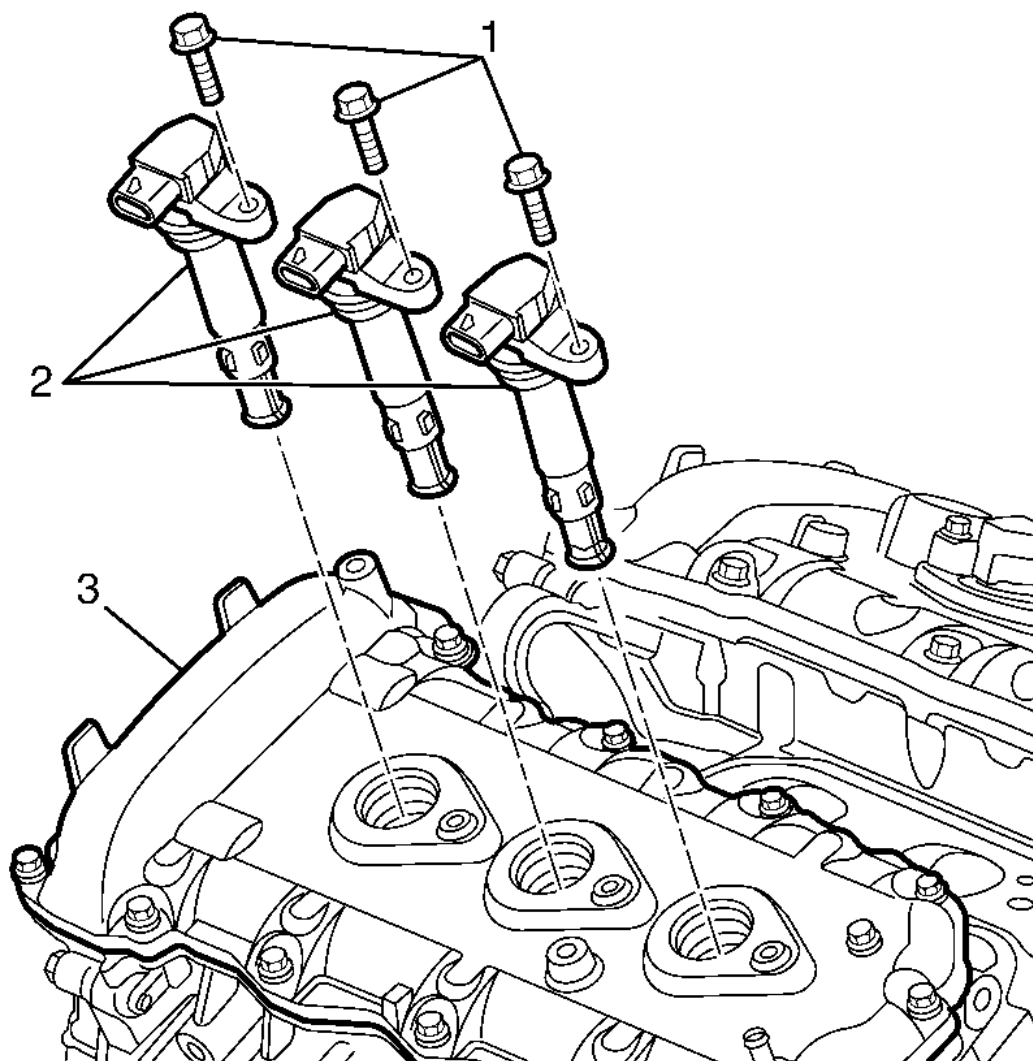


**Fig. 107: Identifying Wiring Harness & Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** It is not necessary to disconnect the engine front cover electrical connectors.

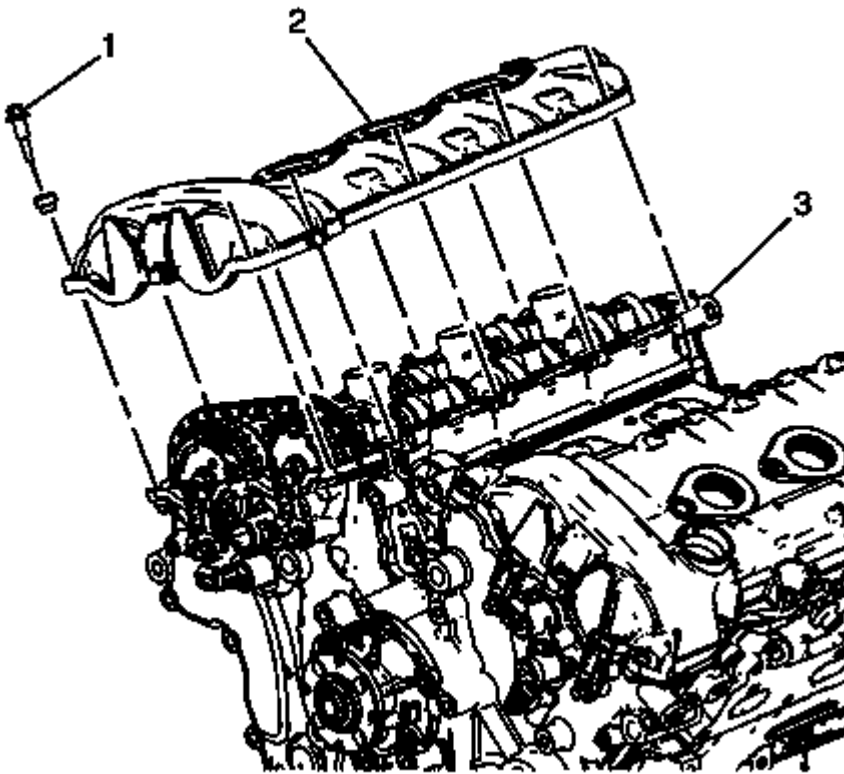
**NOTE:** Use a suitable tool to detach the wiring harness (1) clip from the camshaft cover (2), then lift the wiring harness (1) upwards to detach from the camshaft cover (2).

5. Remove the wiring harness (1) from the front of the camshaft cover (2).
6. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).



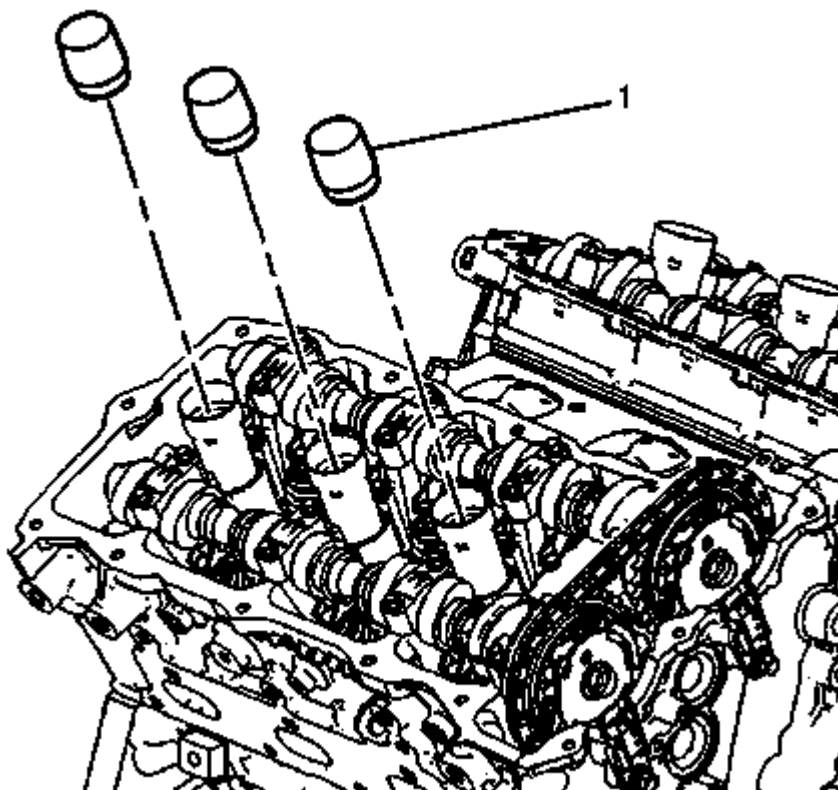
**Fig. 108: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

7. Remove the ignition coil to camshaft cover retaining bolts (1).
8. Remove the ignition coils (2) from the camshaft cover (3).



**Fig. 109: Identifying Right Camshaft Cover With Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft cover to cylinder head retaining bolts (1).
10. Remove the camshaft cover (2) from the cylinder head (3).
11. Remove and discard the camshaft cover seal and grommets.

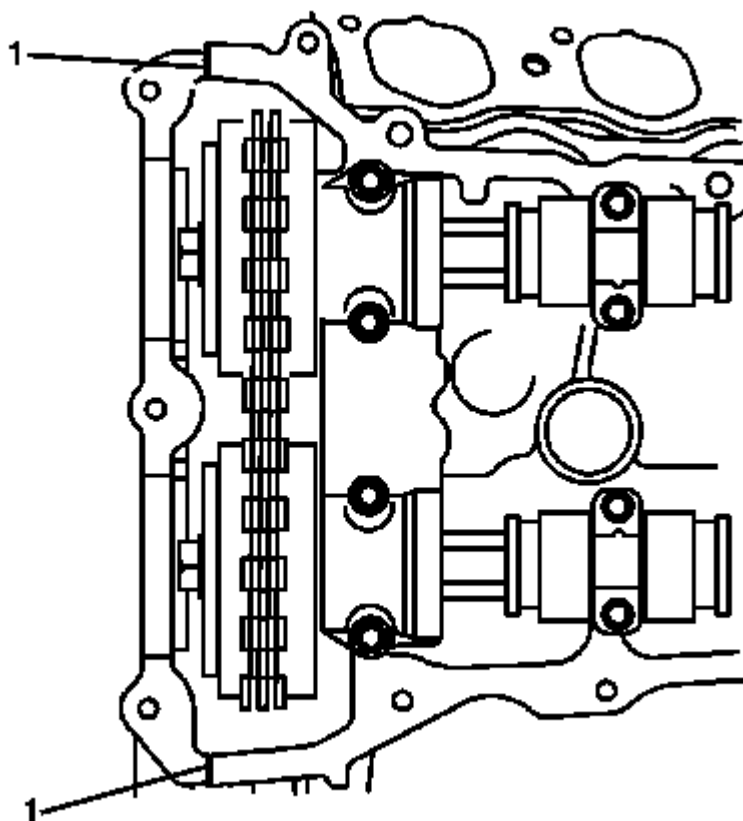


**Fig. 110: View Of EN-46101**

**Courtesy of GENERAL MOTORS CORP.**

12. Install the EN-46101 (1) to the spark plug tubes to prevent dirt and other contaminants from entering the cylinders.

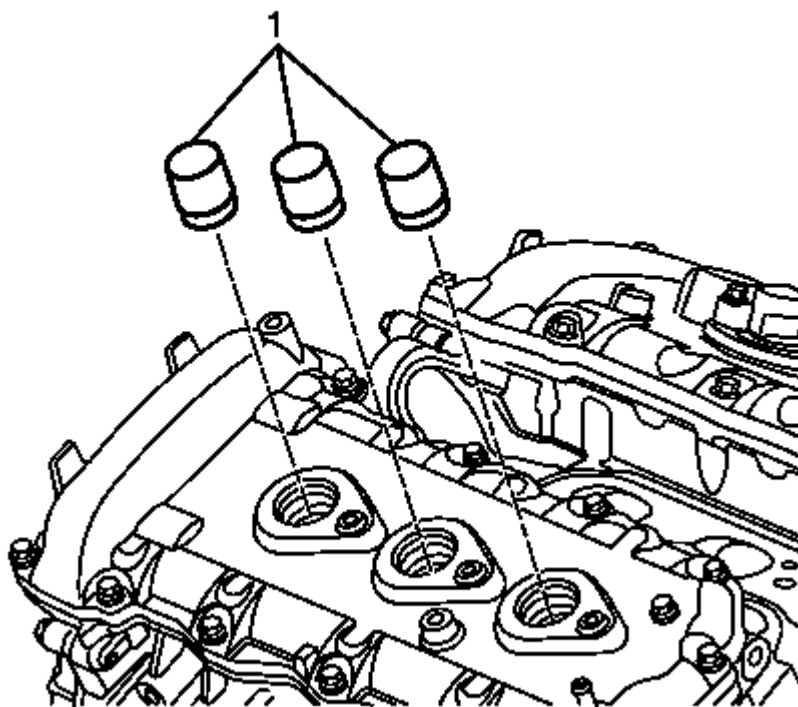
#### **Installation Procedure**



**Fig. 111: View Of Engine Front Cover Split Lines**  
 Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.**

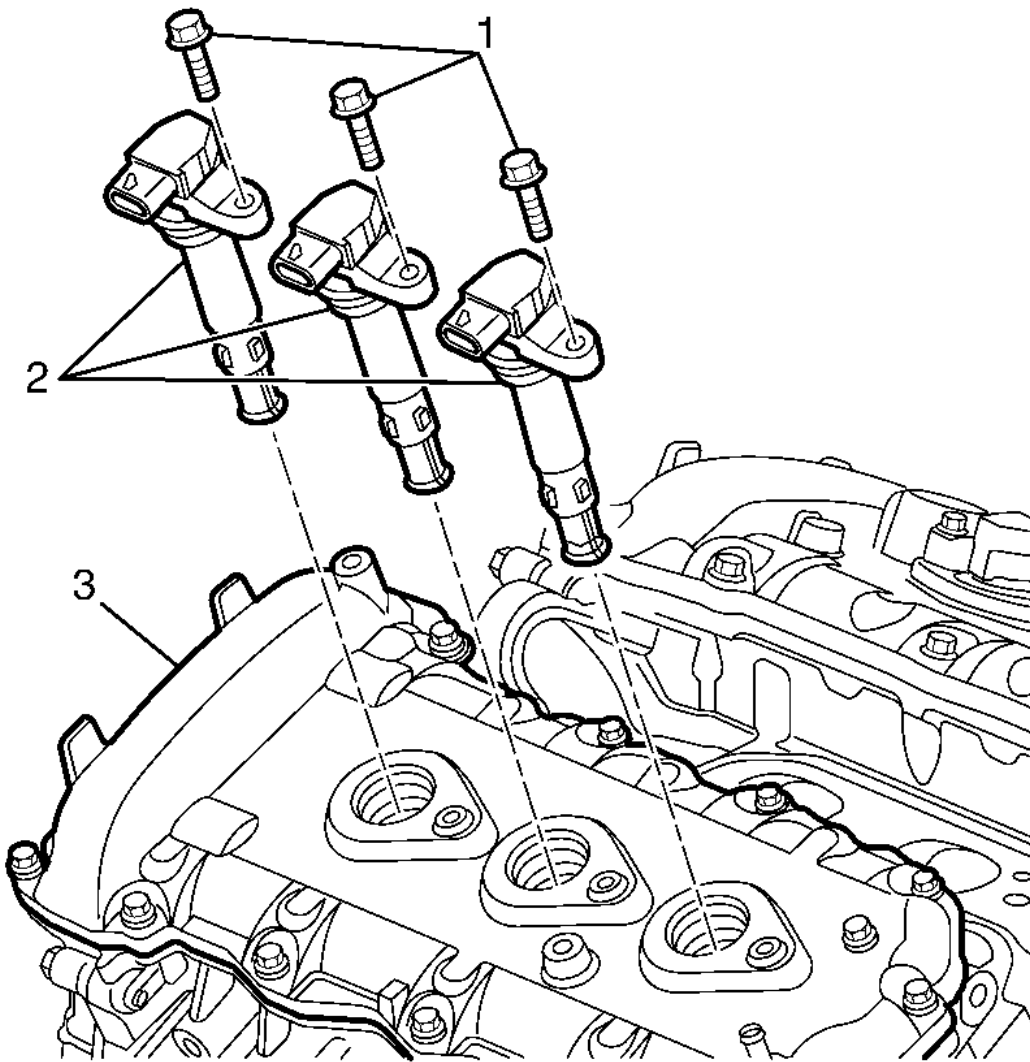
1. Place a 3mm bead of RTV sealant (1) on the join line between the engine front cover and the cylinder head.
2. Install a NEW camshaft cover seal and NEW grommets.
3. Install the camshaft cover. Refer to **Camshaft Cover Installation - Right Side** .



**Fig. 112: View Of EN-46101**

Courtesy of GENERAL MOTORS CORP.

4. Remove the EN-46101 (1).

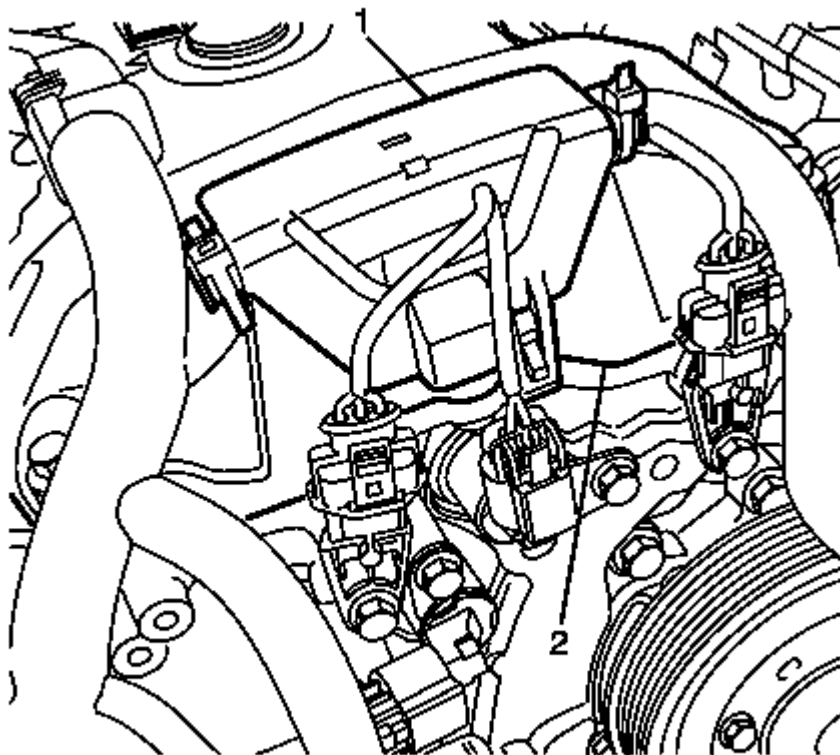


**Fig. 113: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

5. Install the ignition coils (2) to the camshaft cover (3).

**CAUTION: Refer to Fastener Caution .**

6. Install the ignition coil using the camshaft cover retaining bolts (1) and tighten to 10 N.m (89 lb in).

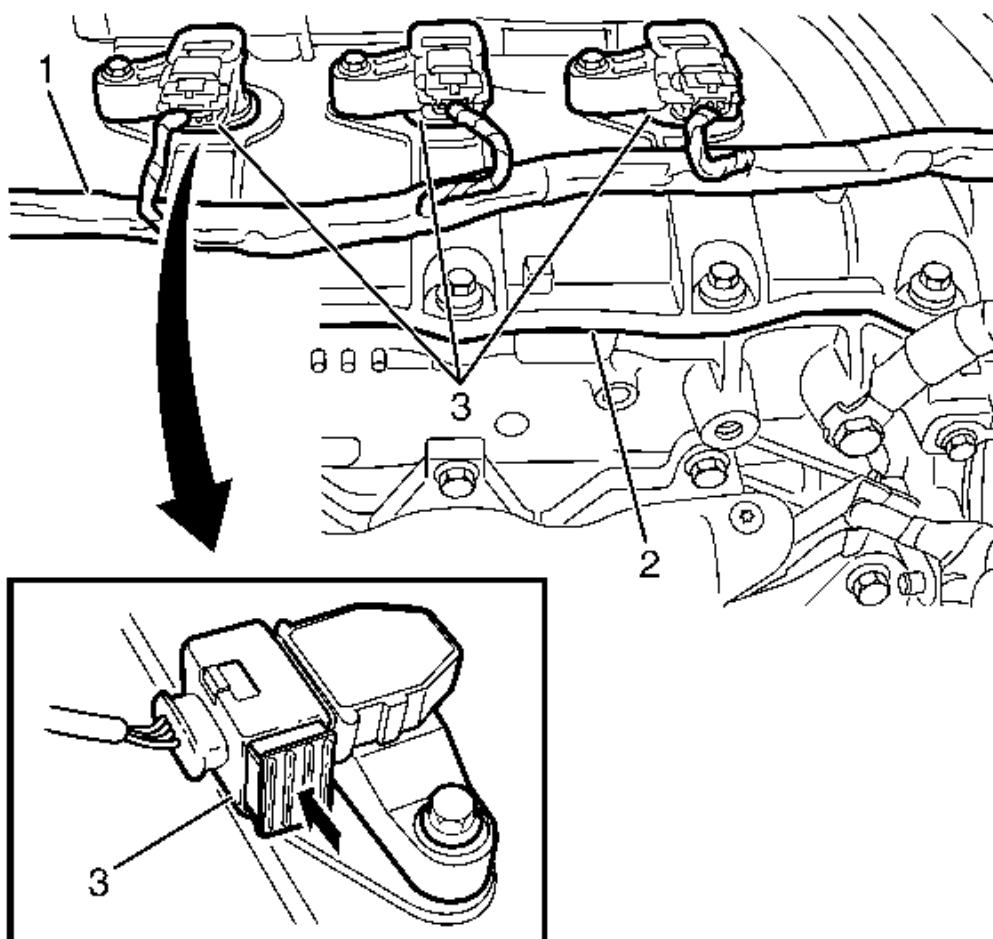


**Fig. 114: Identifying Wiring Harness & Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the wiring harness (1) is located on the camshaft cover (2) locating lugs and the clips are engaged.

7. Install the wiring harness (1) to the front of the camshaft cover (2).





**Fig. 115: Identifying Ignition Coil Electrical Connectors**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the wiring harness (1) is located on the camshaft cover (2) locating lugs and the clips are engaged.

8. Install the wiring harness (1) to the camshaft cover (2).

**NOTE:** Slide the connector retaining latch (4) in the opposite direction of the arrow.

9. Connect the ignition coil electrical connectors (1).
10. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold**

**Replacement.**

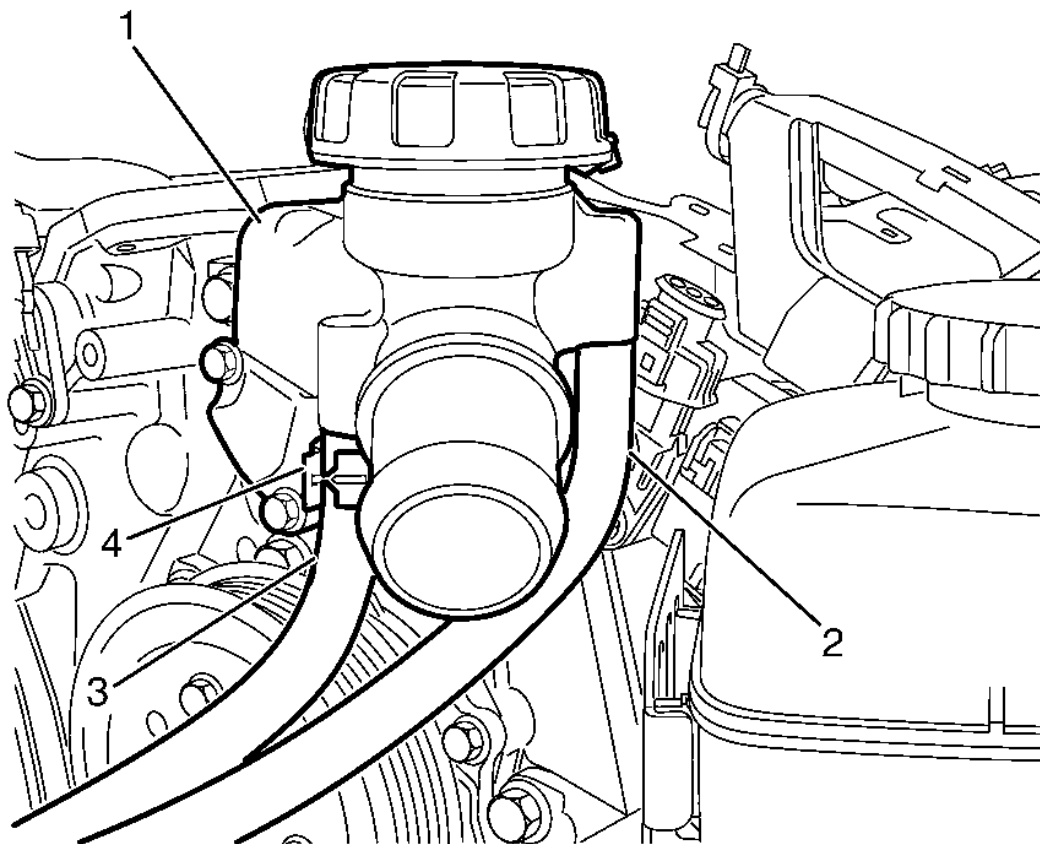
11. Install the engine covers. Refer to **Engine Cover Replacement**.

**ENGINE FRONT COVER REPLACEMENT****Special Tools**

**EN 46109** Engine Front Cover Installation Guide Pins. See **Special Tools** .

**Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
3. Remove the camshaft covers. Refer to **Camshaft Cover Replacement - Left Side** and **Camshaft Cover Replacement - Right Side**.
4. Drain the engine coolant. Refer to **Cooling System Draining and Filling (3.6 L)** .
5. Remove the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (3.6L)** .



**Fig. 116: View Of Outlet Housing, Coolant Recovery Hose, Coolant Bleed Hose & Retaining Clamp**  
 Courtesy of GENERAL MOTORS CORP.

6. Compress the coolant bleed hose retaining clamp (4) at the outlet housing (1) end and slide 50 mm (2 in) along the coolant bleed hose (3).
7. Remove the coolant bleed hose (3) from the outlet housing (1).

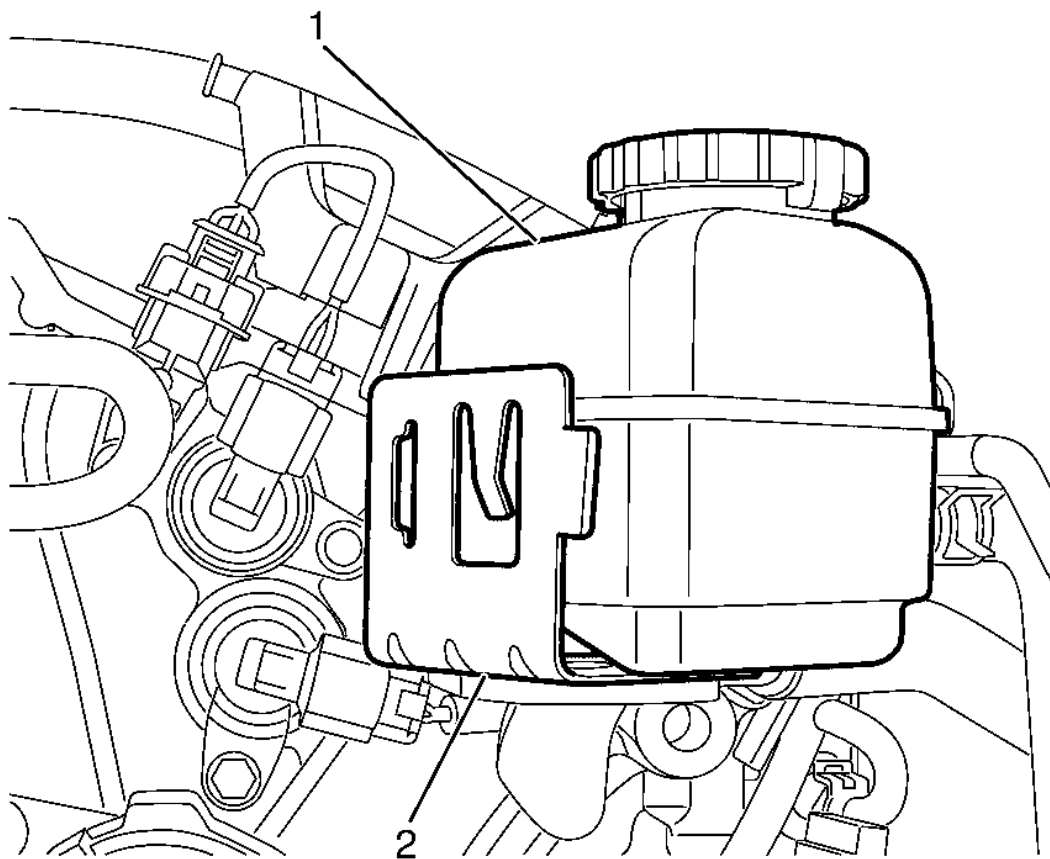
**NOTE:** Twist and pull the coolant recovery hose (2) to remove from the outlet housing (1).

8. Disconnect the coolant recovery hose (2) from the outlet housing (1).

**NOTE:** Plug or cap the hoses and inlets when separating the cooling system components, this prevents dirt and other contaminants from entering the cooling system.

9. Plug or cap the cooling system hoses and inlets
10. Remove the water outlet housing. Refer to **Water Outlet Replacement** .

11. Remove the drive belt. Refer to **Drive Belt Replacement**.
12. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
13. Remove the alternator bracket with the alternator. Refer to **Generator Bracket Replacement (3.6L)**.



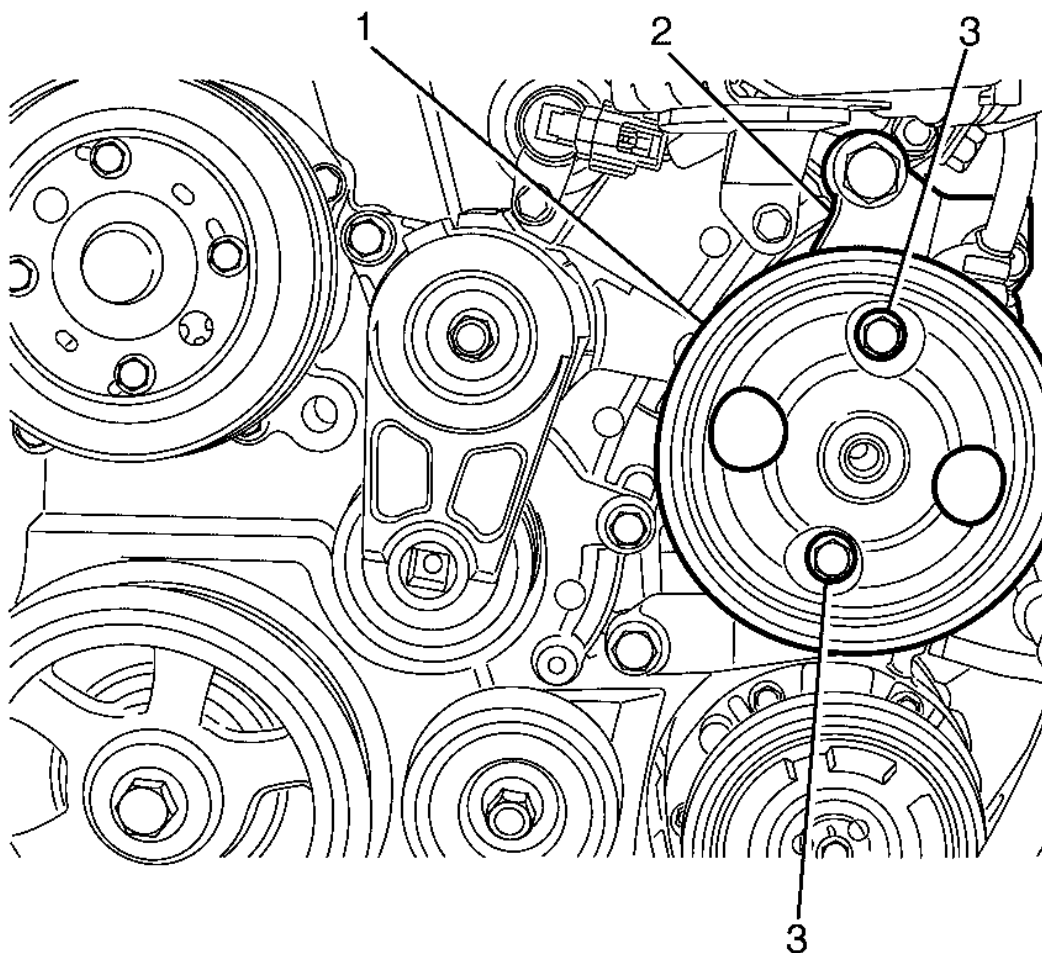
**Fig. 117: Identifying Power Steering Fluid Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT disconnect the power steering pipes or drain the power steering fluid.

**NOTE:** The locking tang on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1). Release the locking tang on the power steering reservoir bracket (2) with a suitable tool.

14. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).

15. Reposition and secure the power steering fluid reservoir away from the power steering fluid reservoir (1) bracket (2).

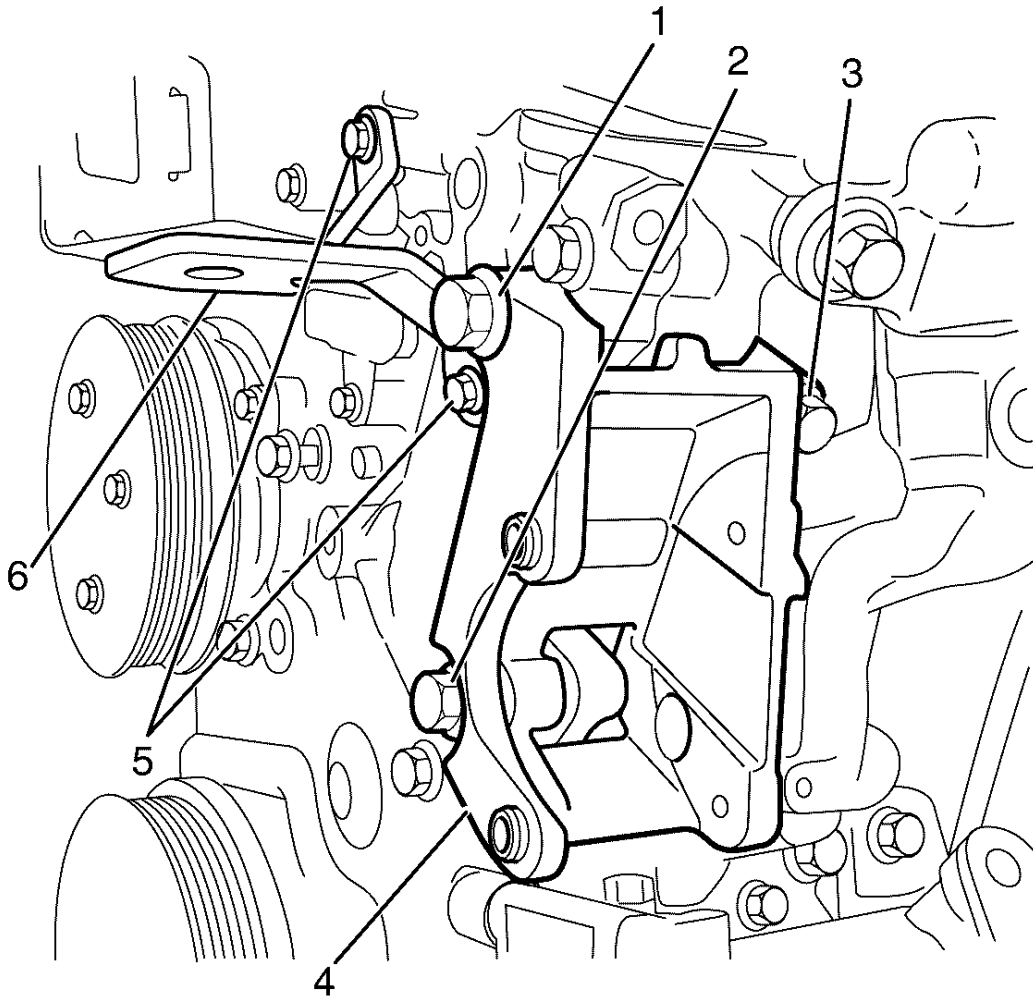


**Fig. 118: Identifying Power Steering Pump To Power Steering Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

- NOTE:** DO NOT disconnect the power steering pipes/hoses.
- NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.
- NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

16. Remove the power steering pump to power steering bracket retaining bolts (3).
- Discard the bolts.

- Clean the bolt holes.
17. Remove the power steering pump (1) from the power steering bracket (2).
  18. Secure and reposition the power steering pump (1) away from the power steering bracket (2).



**Fig. 119: Identifying Power Steering Fluid Reservoir Bracket To Engine Front Cover Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

19. Remove the power steering fluid reservoir bracket to engine front cover retaining bolts (5).
  - Discard the bolts.

- Clean the bolt holes.

20. Remove the power steering fluid reservoir bracket (6).

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

21. Remove the power steering bracket to cylinder head retaining bolt (3).

- Discard the bolt.
- Clean the bolt hole.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

22. Remove the power steering bracket to engine front cover retaining bolt (1).

- Discard the bolt.
- Clean the bolt hole.

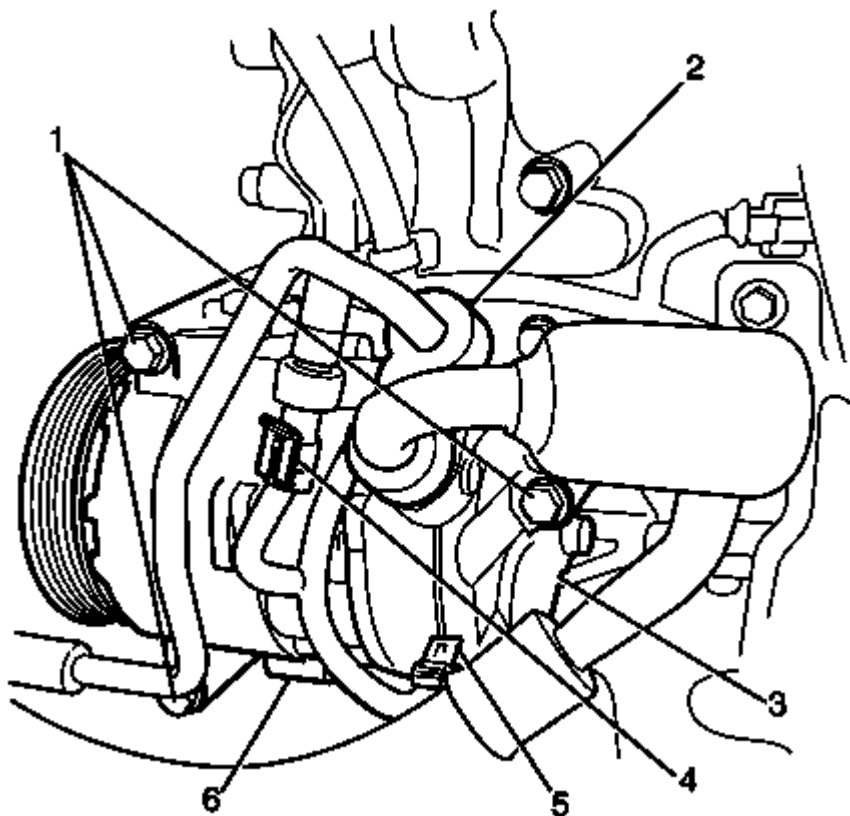
**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

23. Remove the power steering bracket to cylinder block retaining bolt (2).

- Discard the bolt.
- Clean the bolt hole.

24. Remove the power steering pump bracket (4).



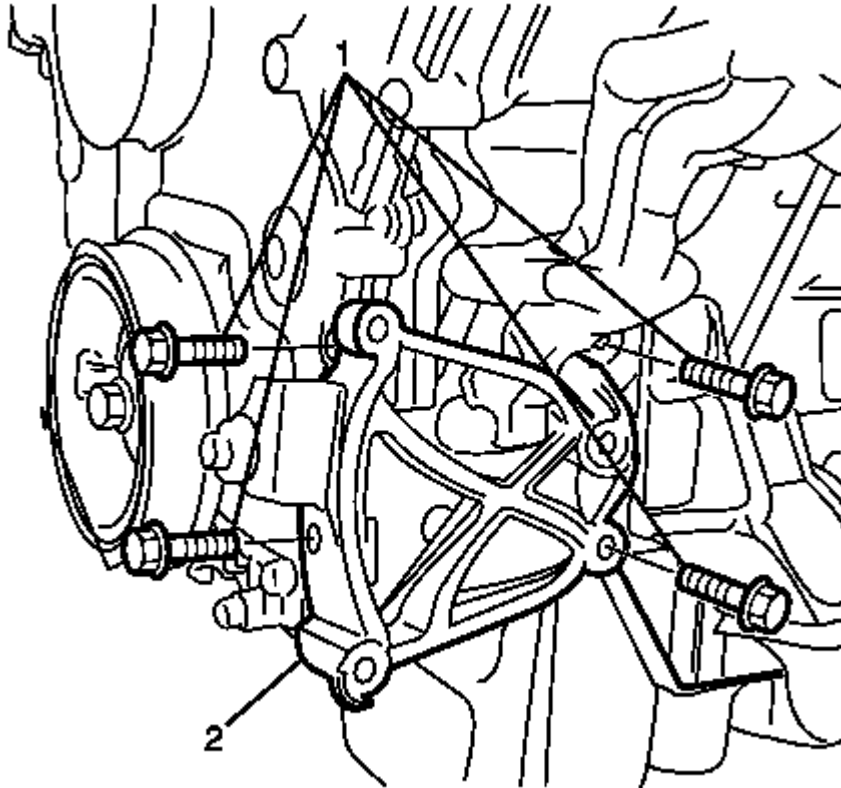
**Fig. 120: Identifying Compressor To Compressor Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

- 25. Disconnect the A/C pressure transducer electrical connector (4).
- 26. Disconnect the A/C compressor electrical connector (5).

**NOTE:**        **DO NOT disconnect the A/C pipes (2) from the A/C compressor (6).**

- 27. Remove the A/C compressor to A/C compressor/power steering pump mounting bracket retaining bolts (1).
- 28. Secure and reposition the A/C compressor (6) away from the A/C compressor mounting bracket (3).





**Fig. 121: Identifying A/C Compressor Bracket To Cylinder Block Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

29. Remove the compressor bracket mounting bolts (1).
30. Remove the compressor bracket (2).
31. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
32. Remove the camshaft position sensors. Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** . Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** . Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
33. Remove the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake** (if fitted) **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake** .
34. Remove the engine front cover with the water pump. Refer to **Engine Front Cover Removal** .
35. Disassemble the engine front cover as necessary. Refer to **Engine Front Cover Disassemble** .

**NOTE:**        **DO NOT** use sharp and/or metal gasket scrapers in order to clean the sealing surfaces.

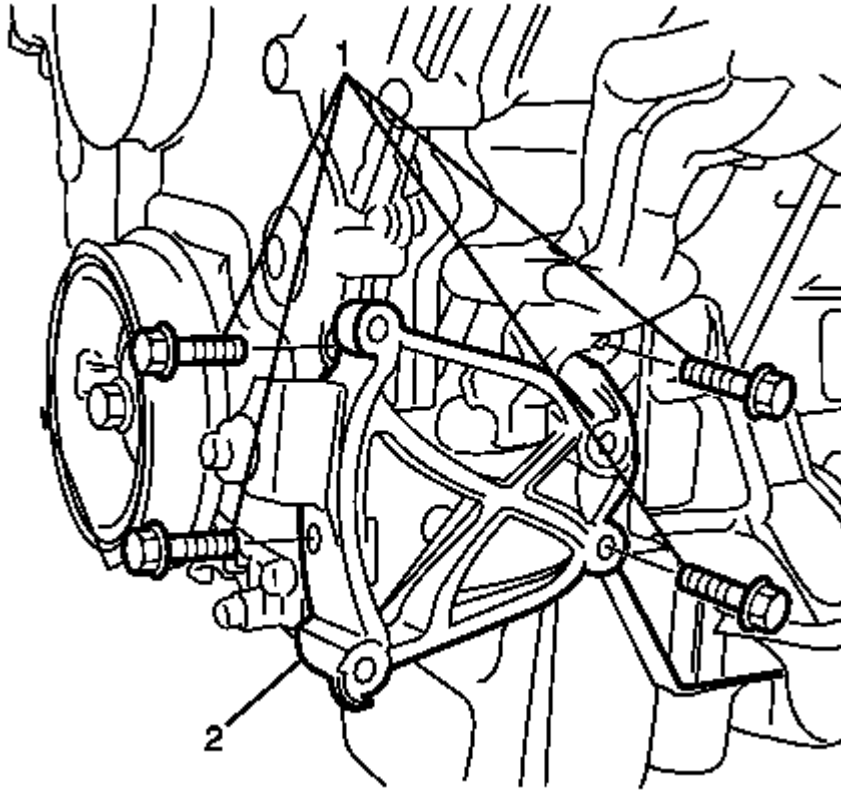
36. Carefully clean the engine front cover sealing surfaces. Refer to **Engine Front Cover Cleaning and Inspection** .

**NOTE:**        **Insert a piece of cardboard between the oil pan front and the oil pump in order to prevent any contaminants from falling into the oil pan.**

37. Carefully clean the engine front cover sealing surfaces. Refer to **Engine Front Cover Cleaning and Inspection** .
38. Use compressed air in order to remove any engine coolant from the engine cooling passages and from the top of the oil pan scraper (windage tray).

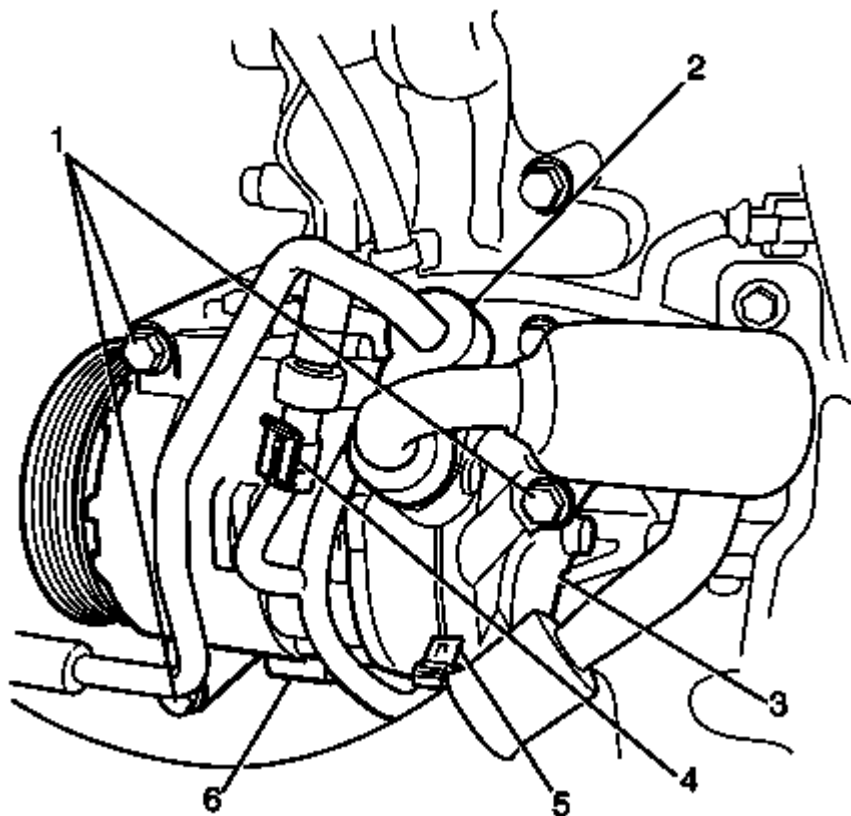
#### **Installation Procedure**

1. Assemble the engine front cover as necessary. Refer to **Engine Front Cover Assemble** .
2. Use the **EN 46109** to install the engine front cover. See **Special Tools** . Refer to **Engine Front Cover Installation** .
3. Install the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake** . Refer to (if fitted) **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake** .
4. Install the camshaft position sensors. Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** . Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
5. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .



**Fig. 122: Identifying A/C Compressor Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. install the compressor bracket (2).
7. Install the compressor bracket mounting bolts (1).



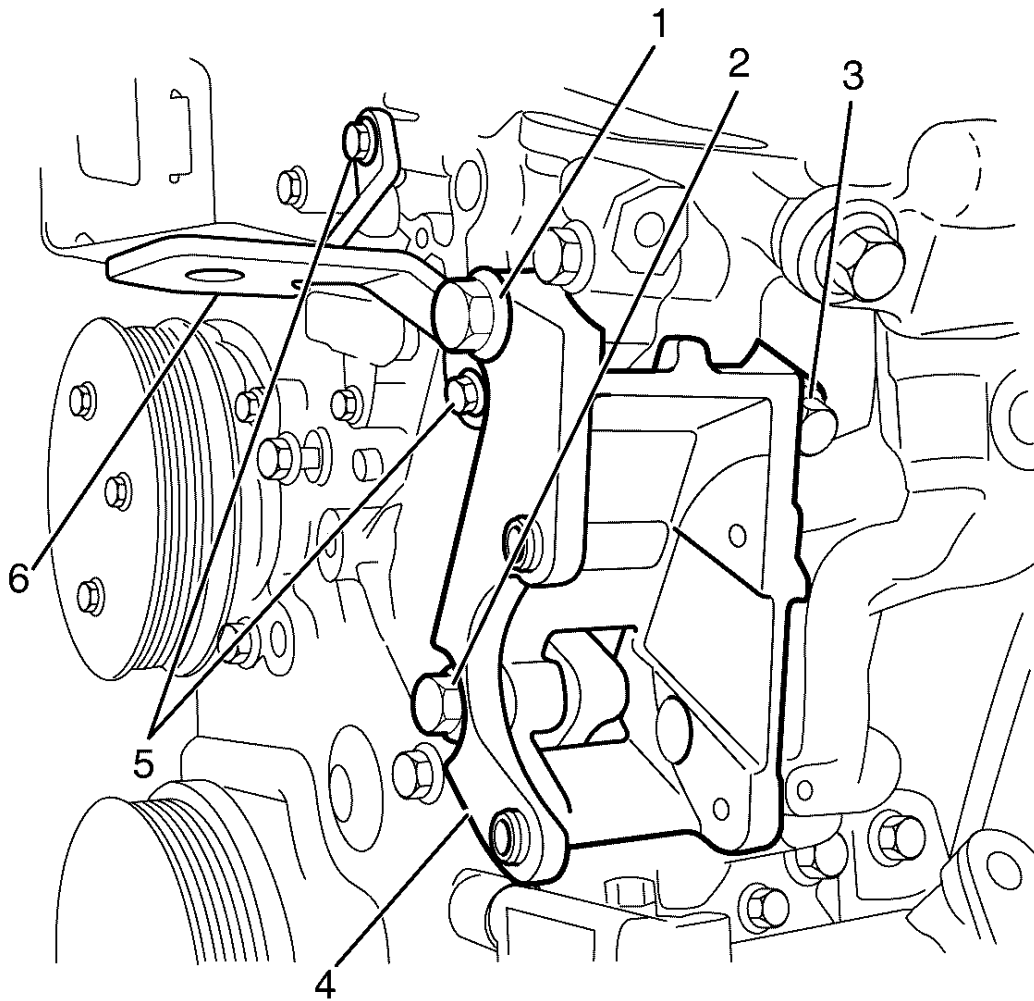
**Fig. 123: Identifying Compressor To Compressor Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the A/C pipes (2) are not twisted or kinked upon compressor installation.

8. Install the A/C compressor (6) with the A/C pipes (2) to the A/C compressor mounting bracket (3).

**CAUTION:** Refer to Fastener Caution .

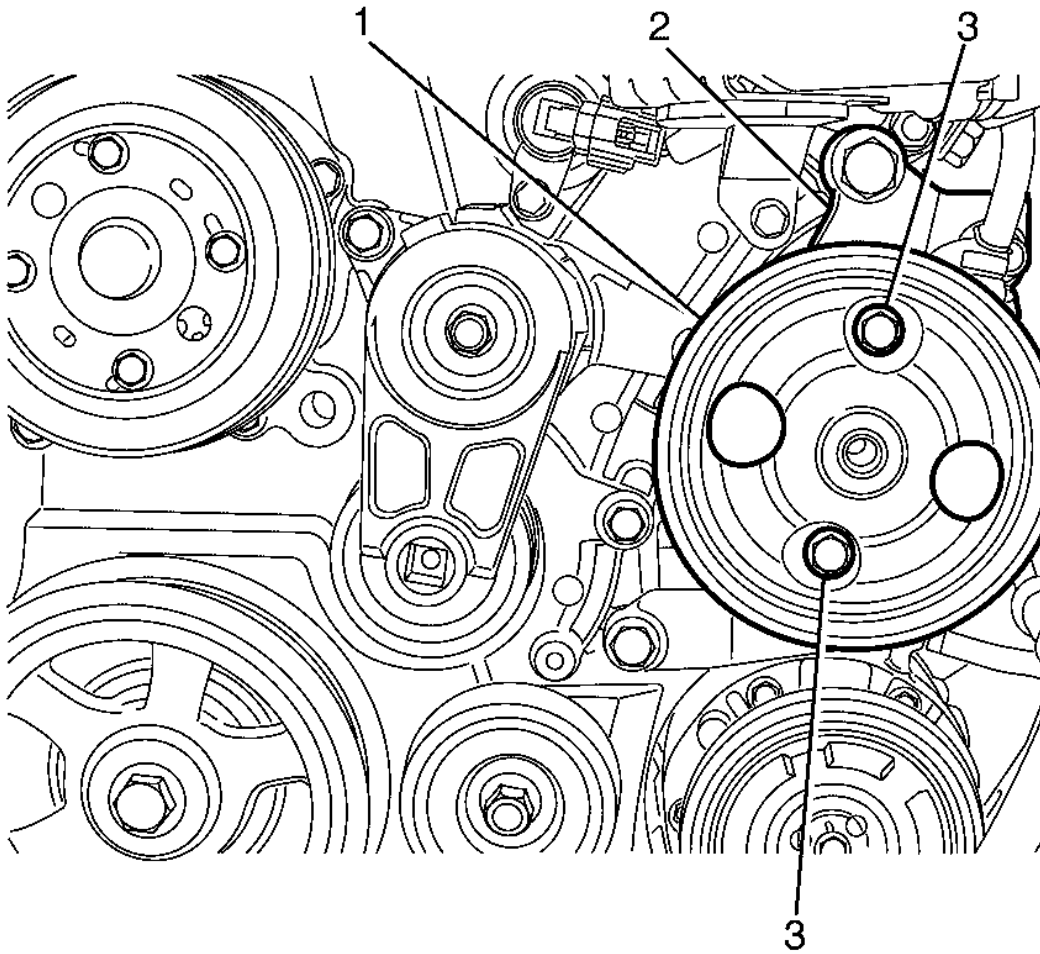
9. Install the compressor to the compressor mounting bracket retaining bolts (1) and tighten to 22 N.m (16 lb ft)
10. Connect the A/C pressure transducer electrical connector (4).
11. Connect the A/C compressor electrical connector (5).



**Fig. 124: Identifying Power Steering Fluid Reservoir Bracket To Engine Front Cover Retaining Bolts**

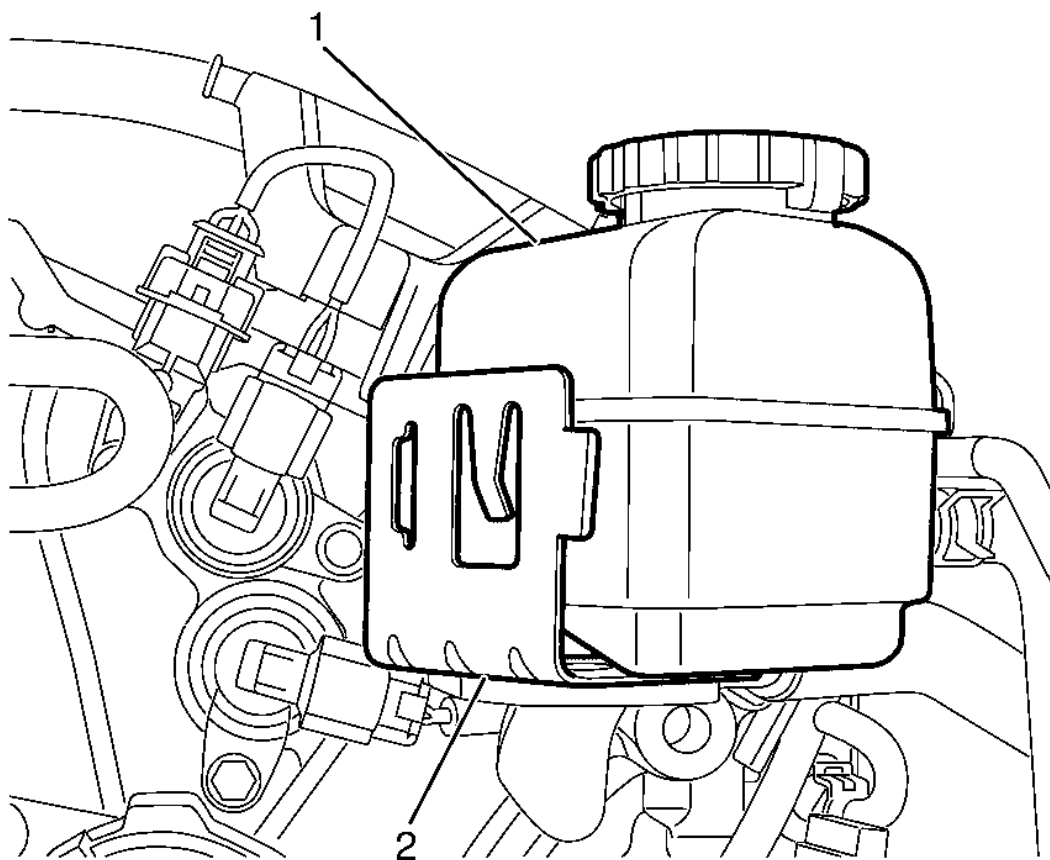
Courtesy of GENERAL MOTORS CORP.

12. Install the power steering pump bracket (4).
13. Install a NEW power steering bracket to the cylinder head retaining bolt (3) and tighten to 58 N.m (43 lb ft).
14. Install a NEW power steering bracket to the engine front cover retaining bolts (1) and tighten to 58 N.m (43 lb ft).
15. Install a NEW power steering bracket to the cylinder block retaining bolt (2) and tighten to 58 N.m (43 lb ft).
16. Install the power steering fluid reservoir bracket (6).
17. Install the NEW power steering fluid reservoir bracket to the engine front cover retaining bolts (5) and tighten to 9 N.m (80 lb ft).



**Fig. 125: Identifying Power Steering Pump To Power Steering Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

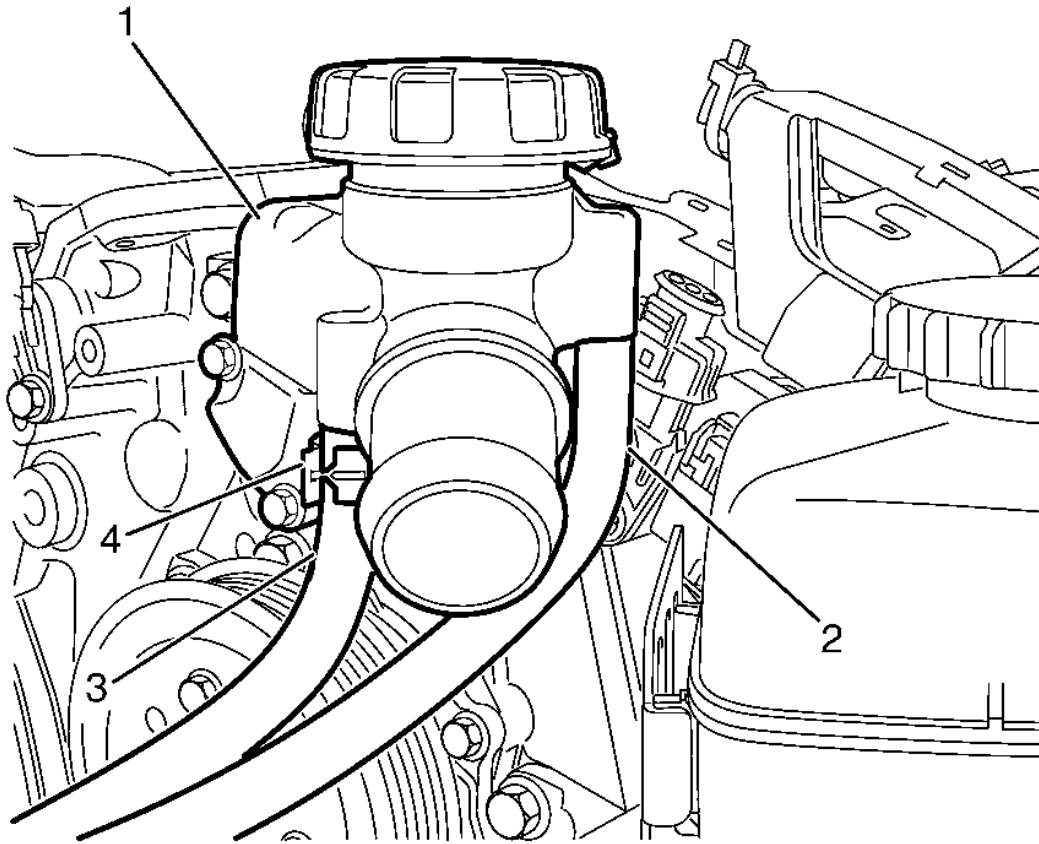
18. Install the power steering pump (2) to the power steering pump bracket (1).
19. Install the NEW power steering pump to the power steering pump bracket retaining bolts (3) and tighten to 27 N.m (22 lb ft).



**Fig. 126: Identifying Power Steering Fluid Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the power steering reservoir (1) and the locking tang on the power steering reservoir bracket (2) are engaged to avoid an induced rattle condition.

20. Install the power steering fluid reservoir (1) to the power steering fluid reservoir bracket (2).
21. Install the alternator bracket with the alternator. Refer to **Generator Bracket Replacement (3.6L)** **Generator Bracket Replacement (6.0L)** .
22. Install the belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
23. Install the drive belt. Refer to **Drive Belt Replacement**.
24. Install the water outlet housing. Refer to **Water Outlet Replacement** .



**Fig. 127: View Of Outlet Housing, Coolant Recovery Hose, Coolant Bleed Hose & Retaining Clamp**  
Courtesy of GENERAL MOTORS CORP.

25. Remove the plug or cap at the cooling system hoses and inlets
26. Install the coolant bleed hose (3) to the outlet housing (1).
27. Compress the coolant bleed hose retaining clamp (4) and position back to its original location on the coolant bleed hose (3).
28. Connect the coolant recovery hose (2) from the outlet housing (1).
29. Install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (3.6L)** .
30. Install the camshaft covers. Refer to **Camshaft Cover Replacement - Left Side** and **Camshaft Cover Replacement - Right Side**.
31. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
32. Install the engine covers. Refer to **Engine Cover Replacement**.
33. Fill the cooling system. Refer to **Cooling System Draining and Filling (3.6 L)** .
34. Change the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .



**SECONDARY CAMSHAFT DRIVE CHAIN REPLACEMENT - LEFT SIDE****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side**.
5. Remove the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Removal - Right Side**.
6. Remove the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Removal - Right Side**.
7. Remove the right bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Removal - Right Side**.
8. Remove the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.
9. Remove the primary upper camshaft drive chain guide. Refer to **Primary Timing Chain Guide Removal - Upper**.
10. Remove the primary camshaft drive chain. Refer to **Primary Camshaft Intermediate Drive Chain Removal**.
11. Remove the right bank camshaft intermediate drive chain idler. Refer to **Camshaft Intermediate Drive Chain Idler Removal - Right Side**.
12. Remove the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Left Side**.
13. Remove the left bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Removal - Left Side**.
14. Remove the left bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Removal - Left Side**.
15. Remove the left bank camshaft intermediate drive chain idler. Refer to **Camshaft Intermediate Drive Chain Idler Removal - Left Side**.
16. Remove the left bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Removal - Left Side**.
17. Clean and inspect all of the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection**.

**Installation Procedure**

1. Install the left bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Installation - Left Side (LY7 or LP1)**.
2. Install the left bank camshaft intermediate drive chain idler. Refer to **Camshaft Intermediate Drive Chain Idler Installation - Left Side**.
3. Install the left bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain**

**Guide Installation - Left Side .**

4. Install the left bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Left Side .**
5. Install the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Left Side .**
6. Install the right bank camshaft intermediate drive chain idler. Refer to **Camshaft Intermediate Drive Chain Idler Installation - Right Side .**
7. Install the primary camshaft drive chain. Refer to **Primary Camshaft Intermediate Drive Chain Installation .**
8. Install the primary upper camshaft drive chain guide. Refer to **Primary Timing Chain Guide Installation - Upper .**
9. Install the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal .**
10. Install the right bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Installation - Right Side .**
11. Install the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Installation - Right Side .**
12. Install the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side .**
13. Install the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side .**
14. Install the spark plugs. Refer to **Spark Plug Replacement .**
15. Install the engine front cover. Refer to **Engine Front Cover Replacement.**
16. Install the engine covers. Refer to **Engine Cover Replacement.**

**SECONDARY CAMSHAFT DRIVE CHAIN REPLACEMENT - RIGHT SIDE****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement.**
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement .**
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement.**
4. Remove the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side .**
5. Remove the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Removal - Right Side .**
6. Remove the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Removal - Right Side .**
7. Remove the right bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Removal - Right Side .**

**Installation Procedure**

1. Install the right bank secondary camshaft drive chain. Refer to **Secondary Camshaft Drive Chain Installation - Right Side** .
2. Install the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Installation - Right Side** .
3. Install the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side** .
4. Install the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side** .
5. Install the spark plugs. Refer to **Spark Plug Replacement** .
6. Install the engine front cover. Refer to **Engine Front Cover Replacement** .
7. Install the engine covers. Refer to **Engine Cover Replacement** .

## **SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - LEFT SIDE**

### **Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement** .
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement** .
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement** .
4. Remove the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Left Side** .

### **Installation Procedure**

1. Install the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Left Side** .
2. Install the spark plugs. Refer to **Spark Plug Replacement** .
3. Install the engine front cover. Refer to **Engine Front Cover Replacement** .
4. Install the engine covers. Refer to **Engine Cover Replacement** .

## **SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - RIGHT SIDE**

### **Removal Procedure**

1. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement** .
2. Remove the engine front cover. Refer to **Engine Front Cover Replacement** .
3. Remove the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side** .

### **Installation Procedure**

1. Install the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side** .
2. Install the spark plugs. Refer to **Spark Plug Replacement** .

3. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Install the engine covers. Refer to **Engine Cover Replacement**.

**SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - LEFT SIDE****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the left bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Removal - Left Side**.

**Installation Procedure**

1. Install the left bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Left Side**.
2. Install the spark plugs. Refer to **Spark Plug Replacement**.
3. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Install the engine covers. Refer to **Engine Cover Replacement**.

**SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - RIGHT SIDE****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side**.
5. Remove the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Removal - Right Side**.

**Installation Procedure**

1. Install the right bank secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Installation - Right Side**.
2. Install the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side**.
3. Install the spark plugs. Refer to **Spark Plug Replacement**.
4. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Install the engine covers. Refer to **Engine Cover Replacement**.

**SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - LEFT SIDE**

**Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Left Side**.
5. Remove the left bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Removal - Left Side**.

**Installation Procedure**

1. Install the left bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Installation - Left Side**.
2. Install the left bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Left Side**.
3. Install the spark plugs. Refer to **Spark Plug Replacement**.
4. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Install the engine covers. Refer to **Engine Cover Replacement**.

**SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - RIGHT SIDE****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side**.
5. Remove the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Removal - Right Side**.

**Installation Procedure**

1. Install the right bank secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Installation - Right Side**.
2. Install the right bank secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Removal - Right Side**.
3. Install the spark plugs. Refer to **Spark Plug Replacement**.
4. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Install the engine covers. Refer to **Engine Cover Replacement**.

**PRIMARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT**

**Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

**IMPORTANT: If the entire camshaft timing system is not in Stage 2, refer to Camshaft Timing Drive Chain Alignment Diagram, mark the timing chain and sprockets in order to ensure correct reassembly.**

4. Remove the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.

**Installation Procedure**

1. Install the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.
2. Install the spark plugs. Refer to **Spark Plug Replacement**.
3. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Install the engine covers. Refer to **Engine Cover Replacement**.

**PRIMARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - LOWER**

The primary camshaft drive chain guide is not serviceable separately. If the guide is worn or damaged, the guide must be replaced with the oil pump.

**PRIMARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - UPPER****Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to **Spark Plug Replacement**.
3. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
4. Remove the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.
5. Remove the primary upper camshaft drive chain guide. Refer to **Primary Timing Chain Guide Removal - Upper**.

**Installation Procedure**

1. Install the primary upper camshaft drive chain guide. Refer to **Primary Timing Chain Guide Installation - Upper**.
2. Install the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.
3. Install the spark plugs. Refer to **Spark Plug Replacement**.

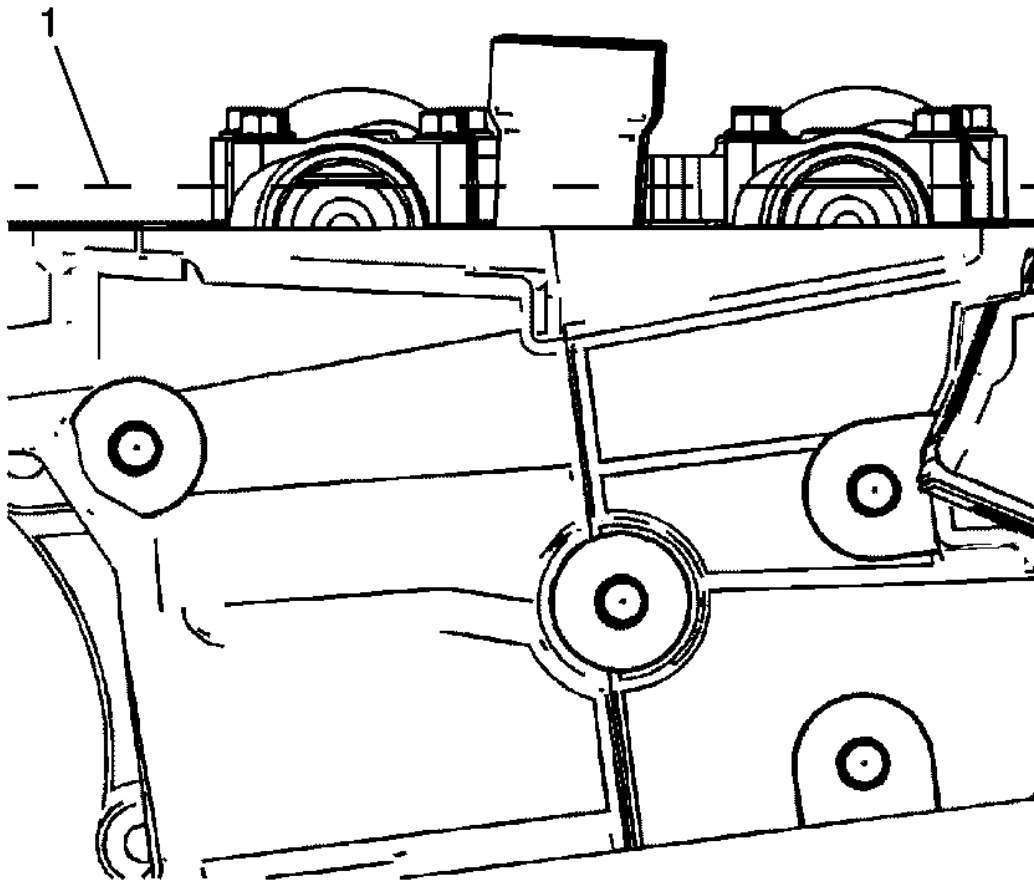
4. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Install the engine covers. Refer to **Engine Cover Replacement**.

**CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST****Special Tools**

- **EN 46105** Camshaft Locking Tools. See **Special Tools** .
- **EN-48313** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46111** Crankshaft Rotation Socket. See **Special Tools** .

**Removal Procedure**

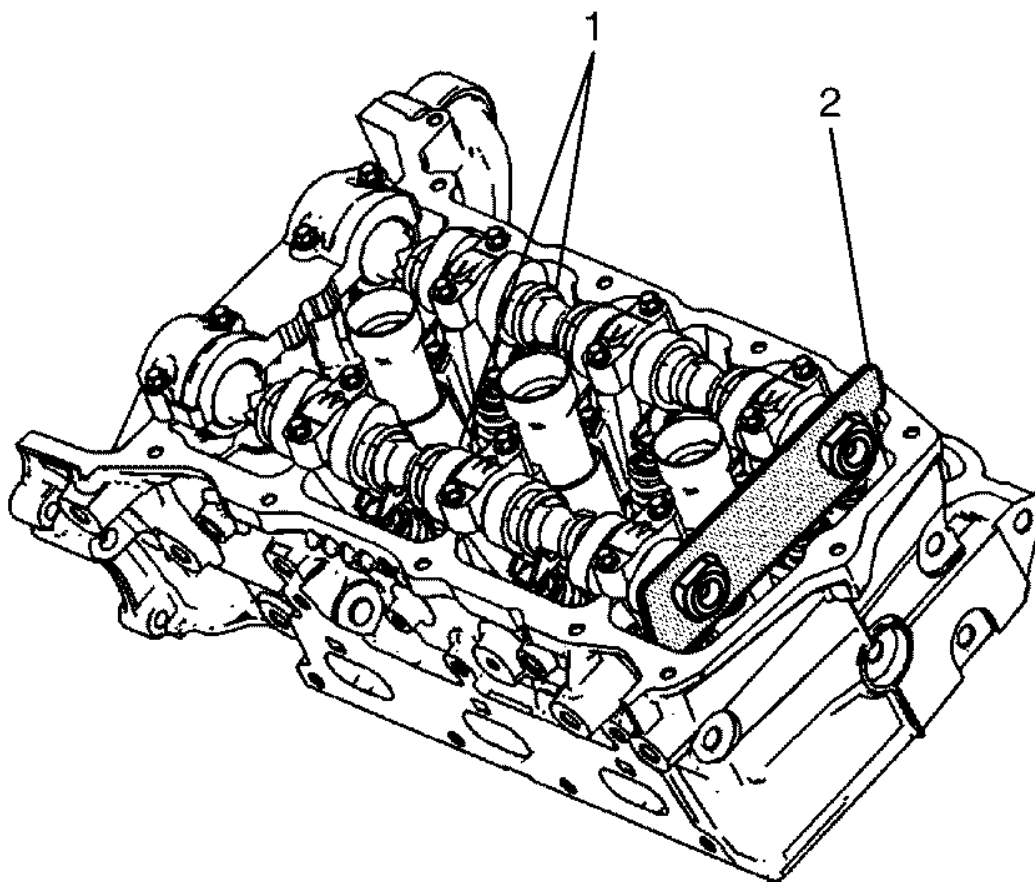
1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
3. Remove the left side camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
4. Remove the camshaft position sensors. Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** .
5. Remove the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake** .
6. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal** .



**Fig. 128: Identifying Camshaft Cover Rail**  
Courtesy of GENERAL MOTORS CORP.

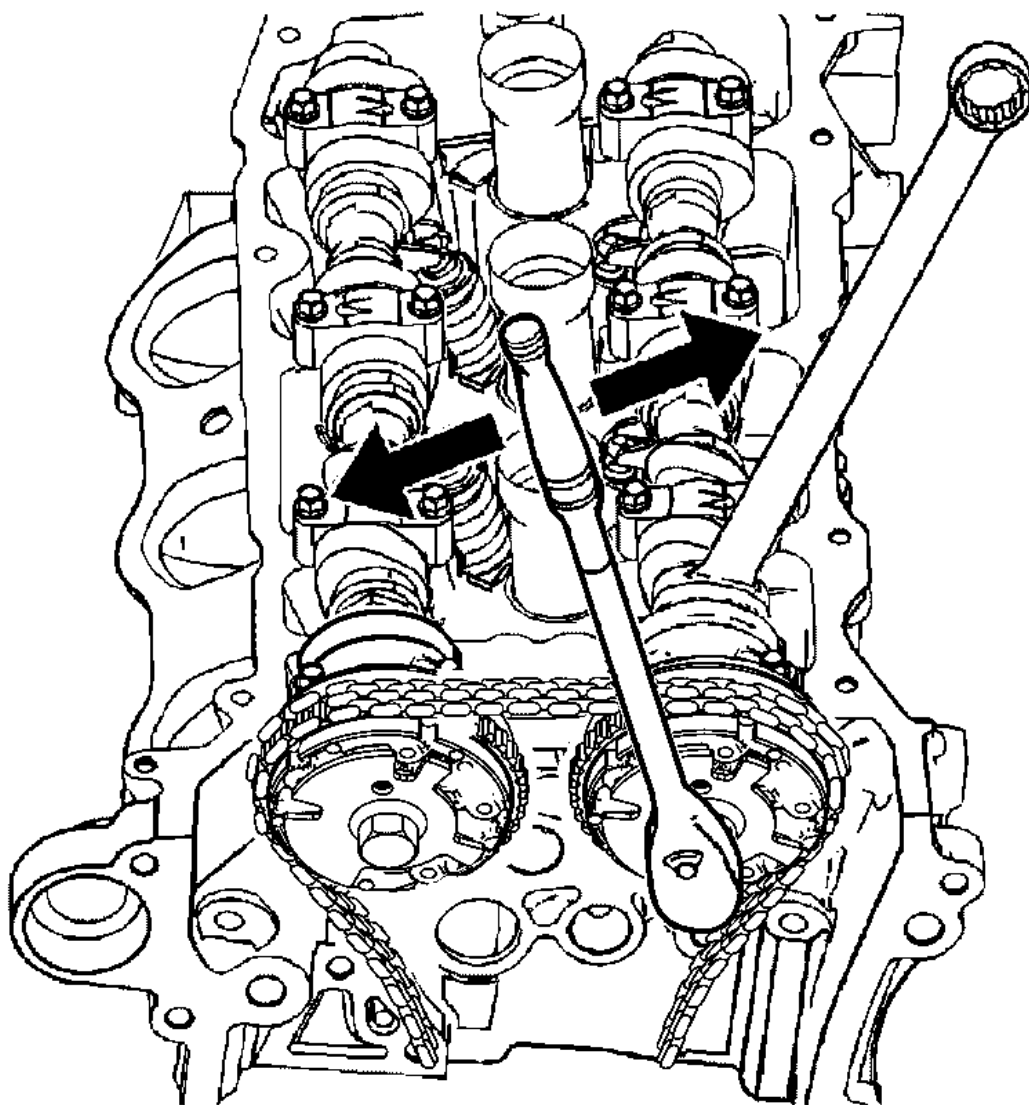
7. Rotate the crankshaft with the **EN 46111** until the camshafts are in a neutral (low tension) position. See **Special Tools** . The camshaft flats will be parallel with the camshaft cover rail (1).





**Fig. 129: View Of EN 46105 & Left Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN 46105** (2) onto the rear of the left side camshafts (1). See **Special Tools** .



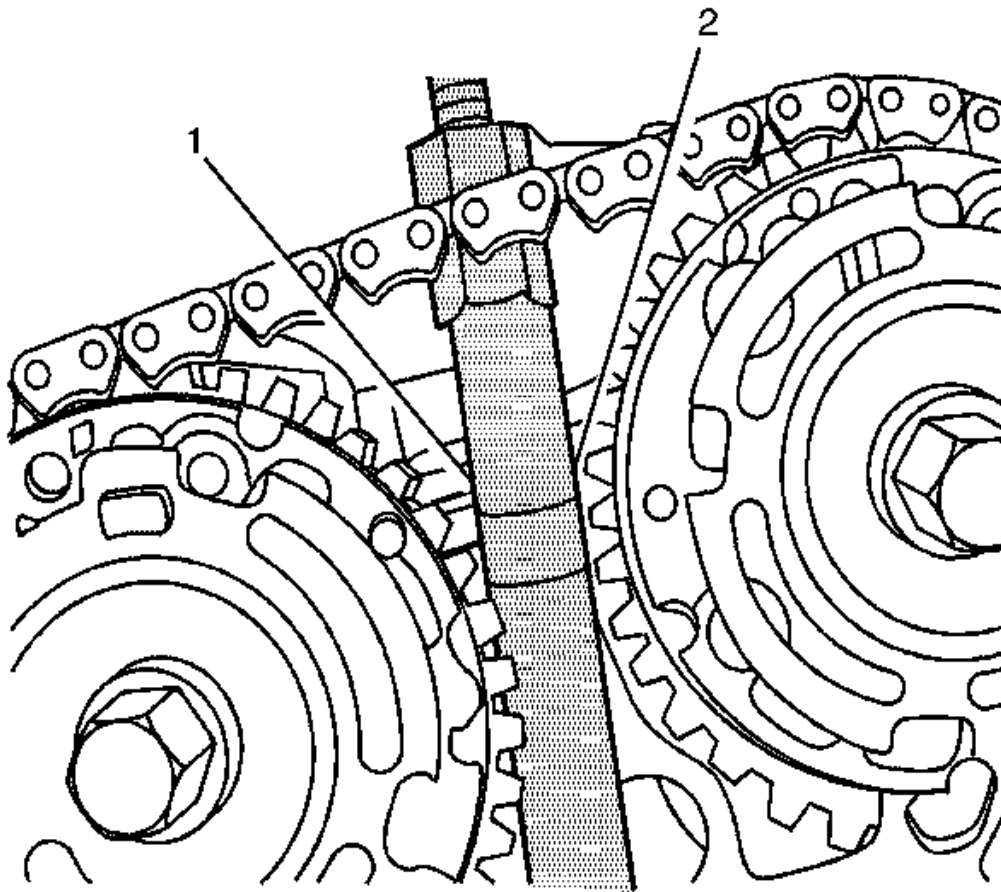
**Fig. 130: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**NOTE:**

- Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.
- DO NOT remove the camshaft position actuator to camshaft retaining bolt at this time.

9. Loosen the left side exhaust camshaft position actuator to camshaft retaining bolt.
10. Loosen the **EN-48313** so that the legs are retracted. See **Special Tools** .

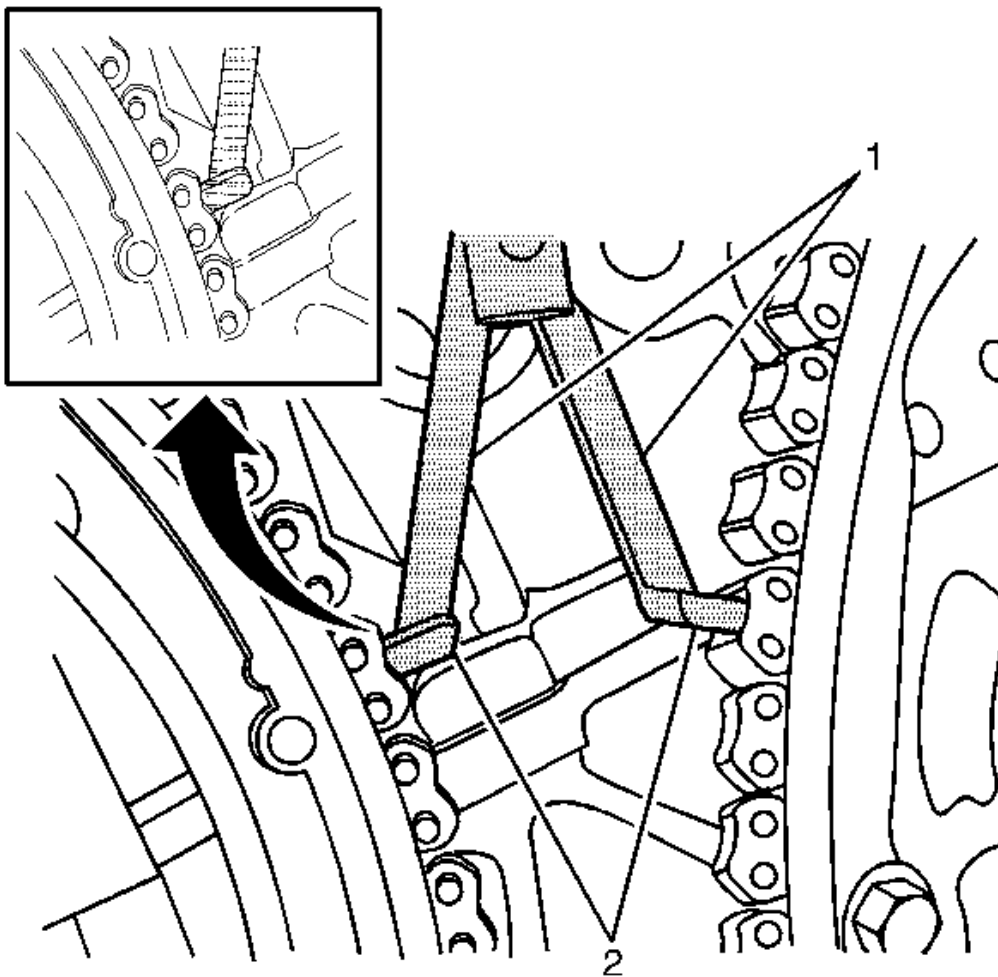


**Fig. 131: View Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The front engine cover is removed in the following graphics for illustration purposes and is not required to perform the procedure.

11. Insert the **EN-48313** between the camshaft actuators, rearward of the timing chain until the top line that is scribed in the body of the tool (1) is adjacent to the top surface of the cylinder head (2). See **Special Tools** . This is the approximate installed position.



**Fig. 132: Identifying Feet & Legs Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

12. Make sure that the feet (2) on the legs (1) of the EN-48313 are facing the front of the engine. See **Special Tools** .

**NOTE:** DO NOT tighten the EN-48313 at this stage. See **Special Tools** .

13. Partially expand the legs (1) of EN-48313 by turning the T-shaped handle clockwise. See **Special Tools** .

**NOTE:** Make sure that the feet (2) of the EN-48313 are correctly engaged into one of the link pockets to prevent chain slipping during tightening. See **Special Tools** .

14. Continue expanding the **EN-48313** until the feet (2) contact the timing chain. See **Special Tools** .

**CAUTION:** Refer to **Torque Reaction Against Timing Drive Chain Caution** .

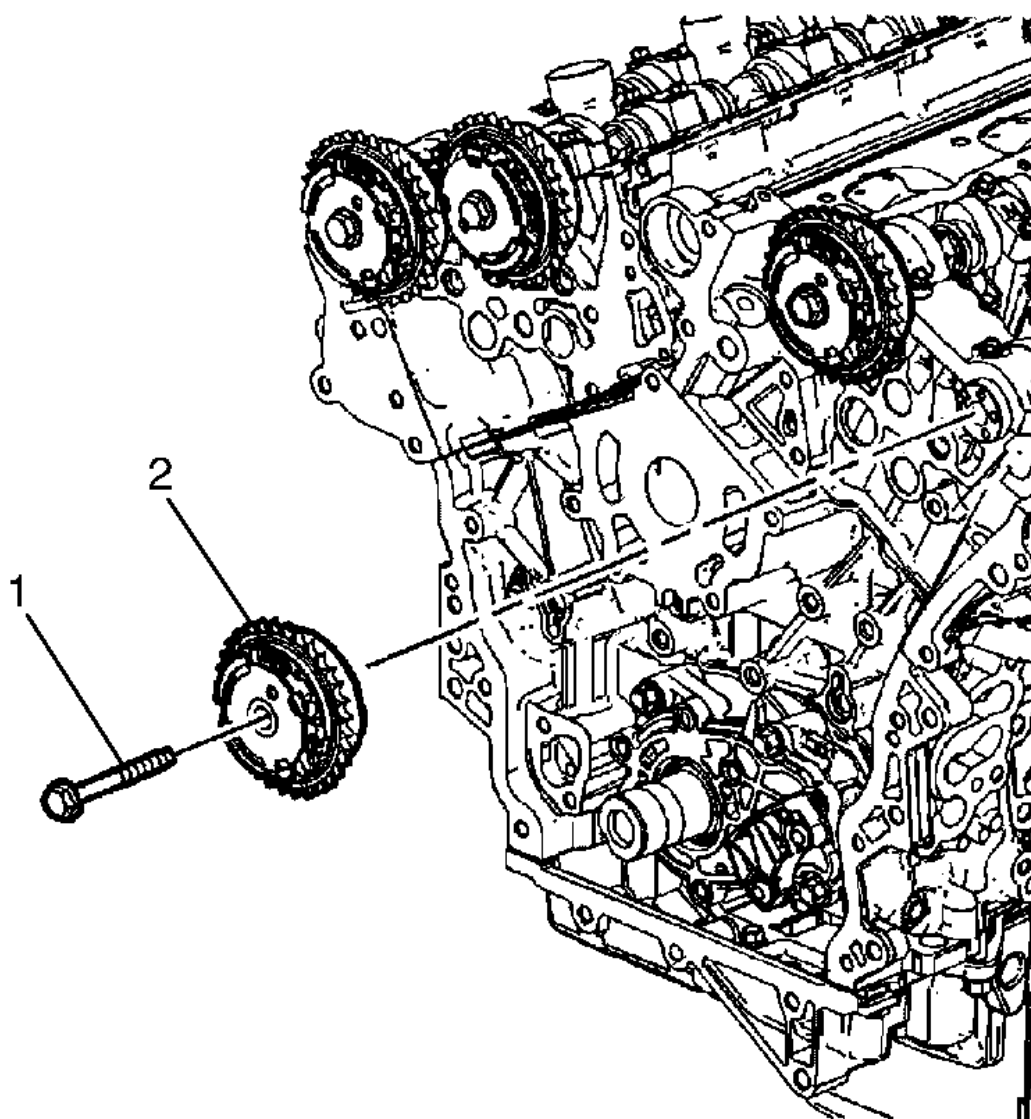
15. Hand tighten the **EN-48313** . See **Special Tools** .

**NOTE:**        **DO NOT allow the body of the EN-48313 to rotate when tightening the T-handle. See Special Tools .**

16. Use an open-end wrench on the hex cast into the body of the **EN-48313** and hand tighten the T-handle. See **Special Tools** .
17. Use an open-end wrench on the hex cast of the left side intake and exhaust camshafts and rotate the camshafts towards each other in order create slack in the chain between the actuators.
18. The **EN-48313** is now correctly installed to hold the timing chain in position. See **Special Tools** .

**NOTE:**        **Make sure that the camshaft timing chain and the camshaft position actuators are marked for correct assembly.**

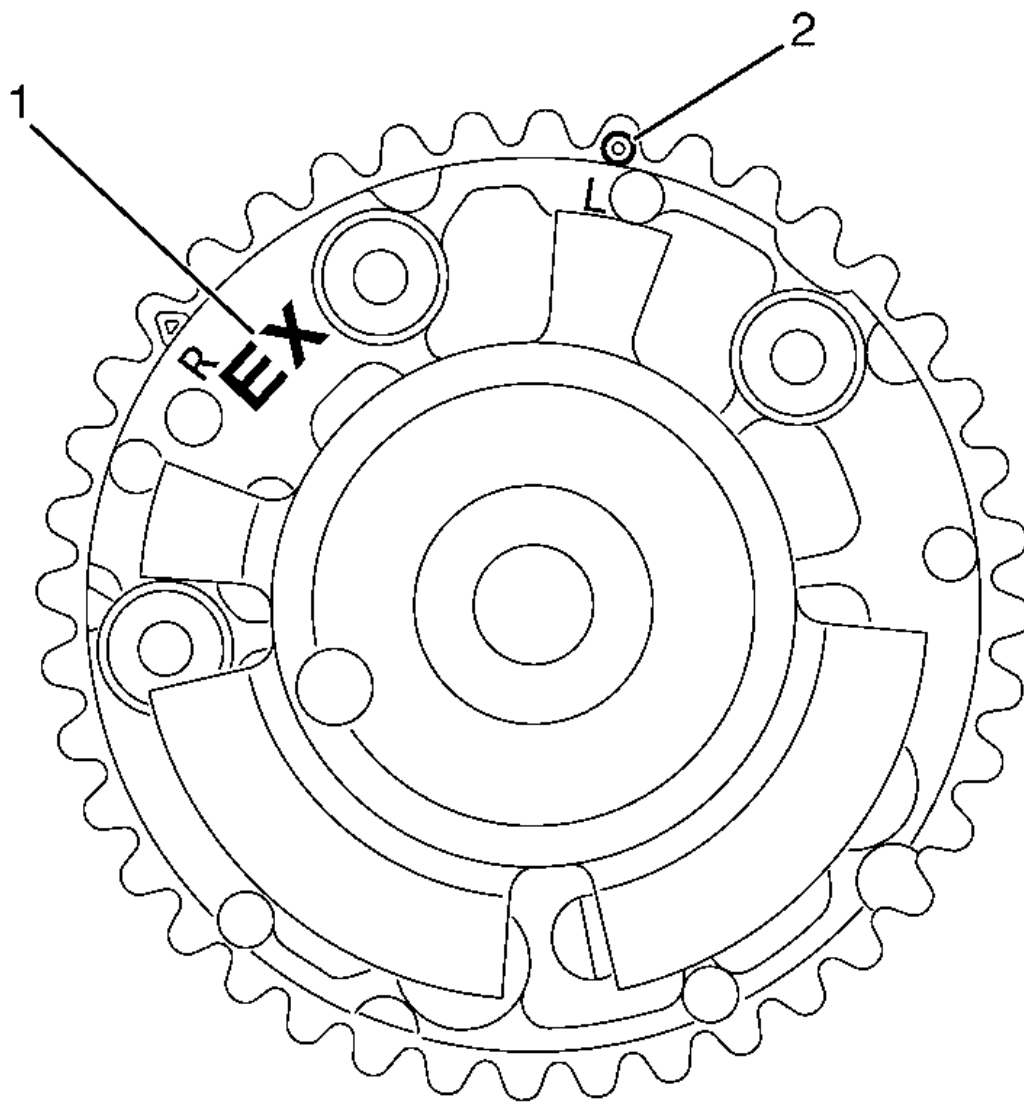
19. Mark the timing chain and the camshaft position actuators.



**Fig. 133: Identifying Left Side Exhaust Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

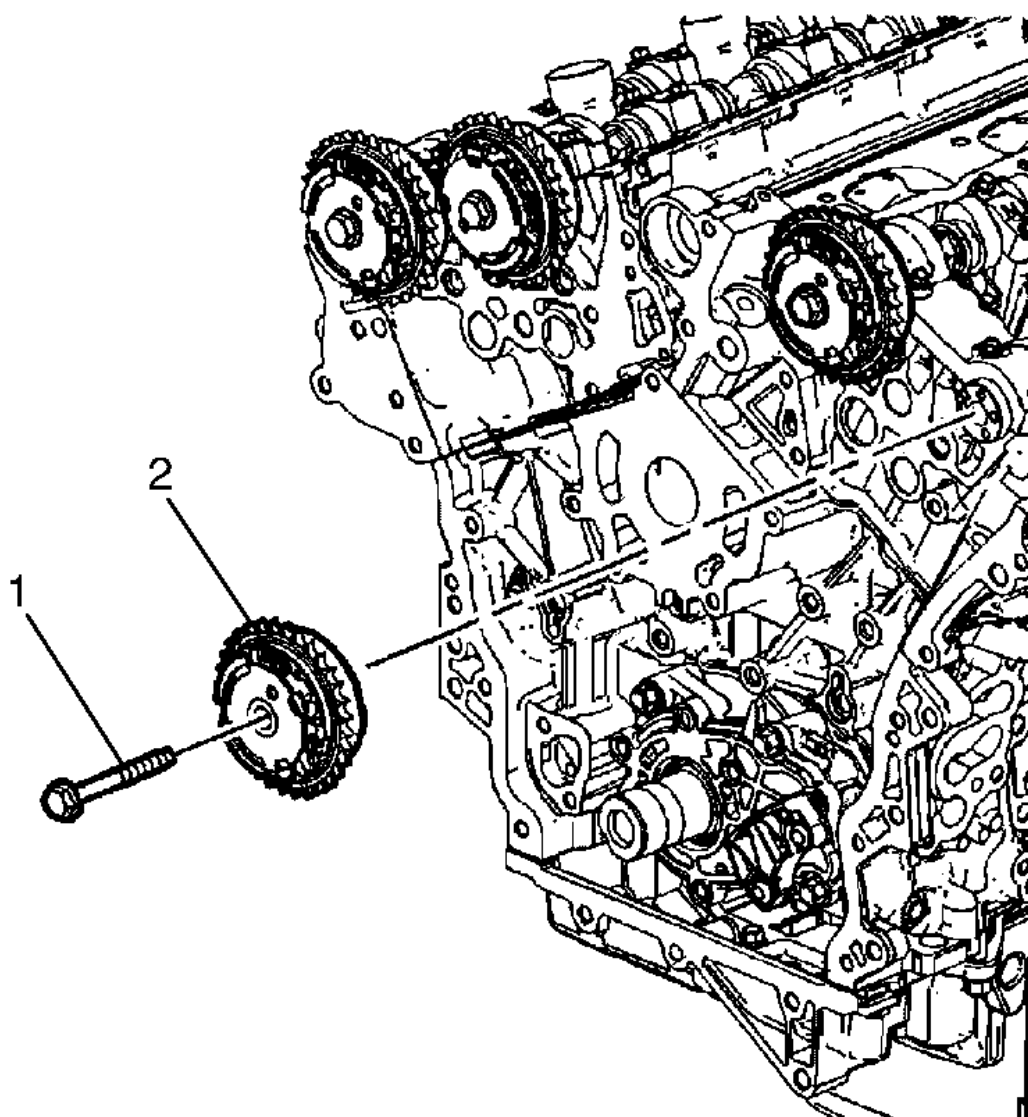
20. Remove the left side exhaust camshaft position actuator to camshaft retaining bolt (1).
21. Remove the left side exhaust camshaft position actuator (2).

#### Installation Procedure



**Fig. 134: View Of "EX", "L" & Circle Markings**  
**Courtesy of GENERAL MOTORS CORP.**

1. Make sure the correct camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.
2. Make sure the correct timing mark is used. Observe the outer ring of the camshaft position actuator for the "L" and circle marking (2). The marking is for alignment to the highlighted timing chain link on the left side of the engine.



**Fig. 135: Identifying Left Side Exhaust Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

3. Install the left side exhaust camshaft position actuator (2).

**NOTE:**

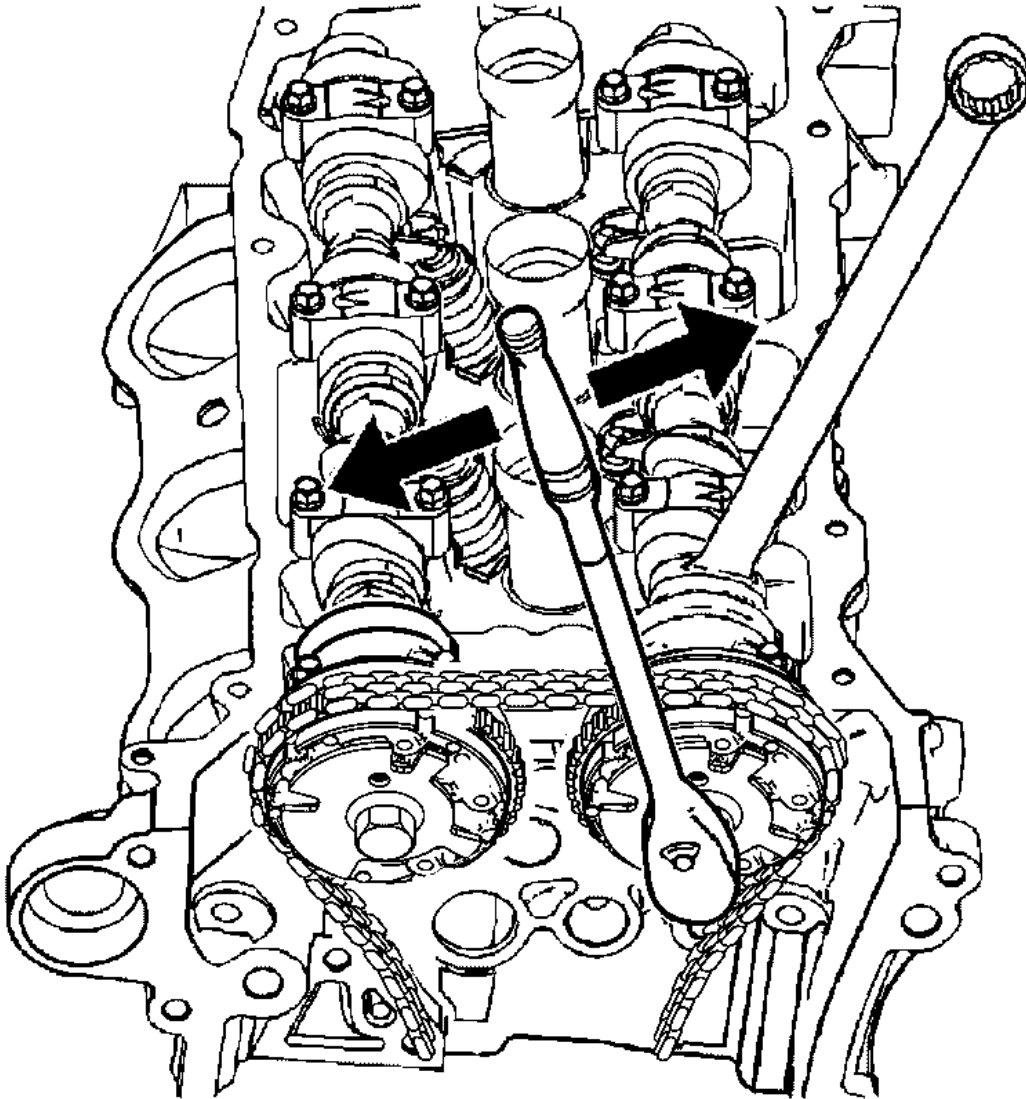
- Make sure that the marks on the camshaft position actuators and the timing chain are aligned.
- DO NOT tighten the left side exhaust camshaft position actuator to camshaft retaining bolt (1) at this time.



4. Install the camshaft position actuator to camshaft retaining bolt (1).

DO NOT fully tighten at this stage.

5. Remove **EN-48313** . See **Special Tools** .



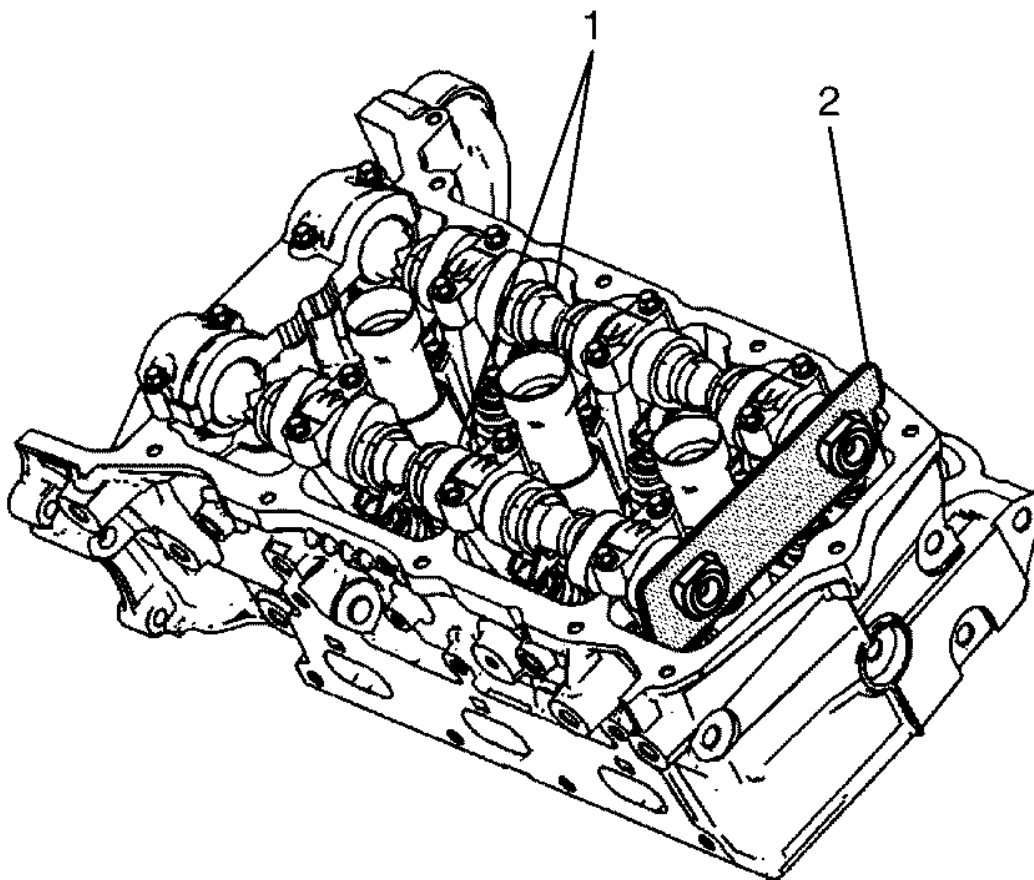
**Fig. 136: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

6. Install the camshaft position actuator using the camshaft retaining bolt and tighten to 58 N.m (43 lb ft).



**Fig. 137: View Of EN 46105 & Left Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46105** (2) from the rear of the left side camshafts (1). See Special Tools .
8. Install the camshaft position (CMP) actuator solenoids. Refer to (if fitted) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake

9. Install the camshaft position sensors. Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** .
10. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation** .
11. Install the left bank camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
12. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
13. Install the engine covers. Refer to **Engine Cover Replacement**.

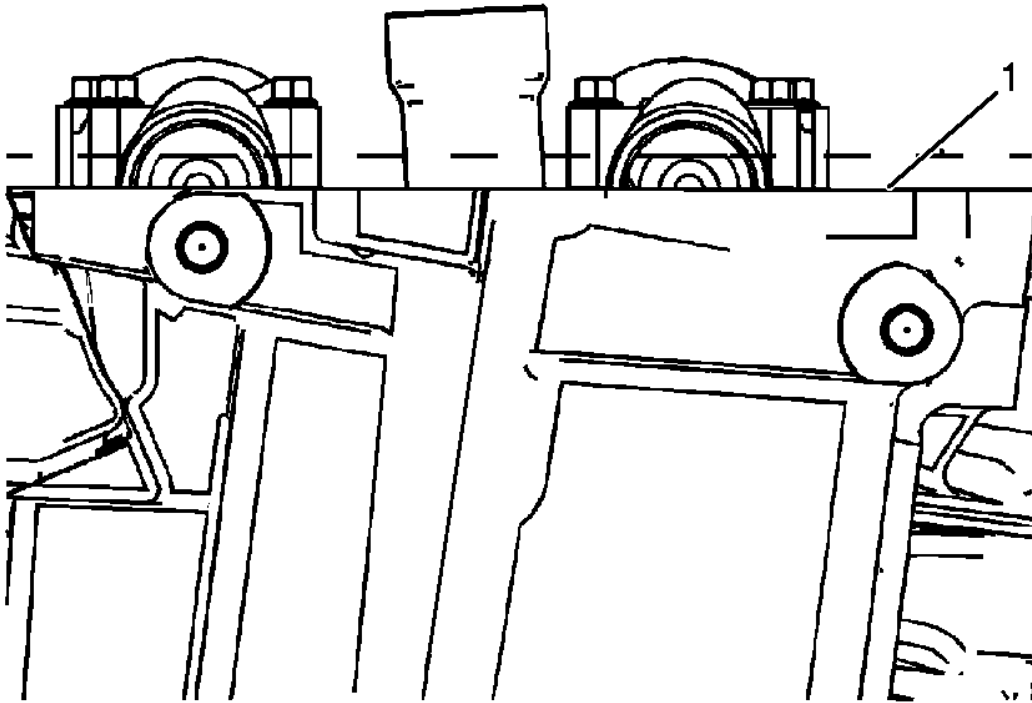
## **CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST**

### **Tools Required**

- **EN 46105** Camshaft Locking Tools. See **Special Tools** .
- **EN-48313** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46111** Crankshaft Rotation Socket. See **Special Tools** .

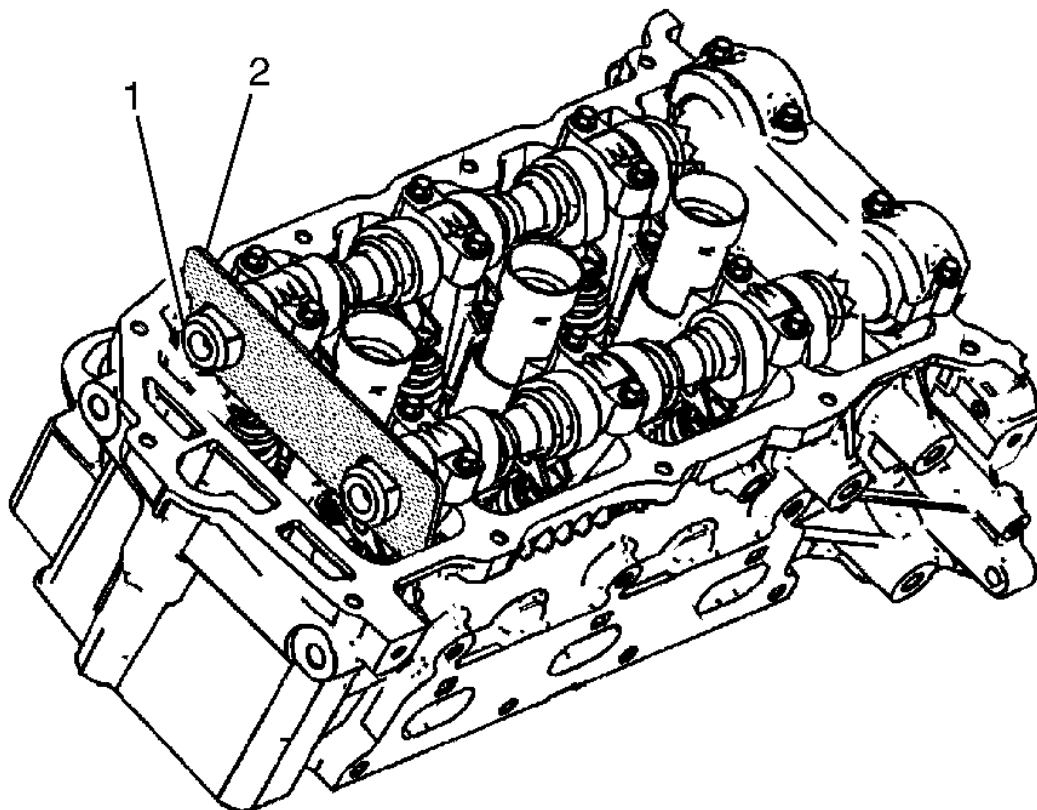
### **Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement**.
2. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
3. Remove the right side camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
4. Remove the camshaft position sensors. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
5. Remove the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake**.
6. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal** .



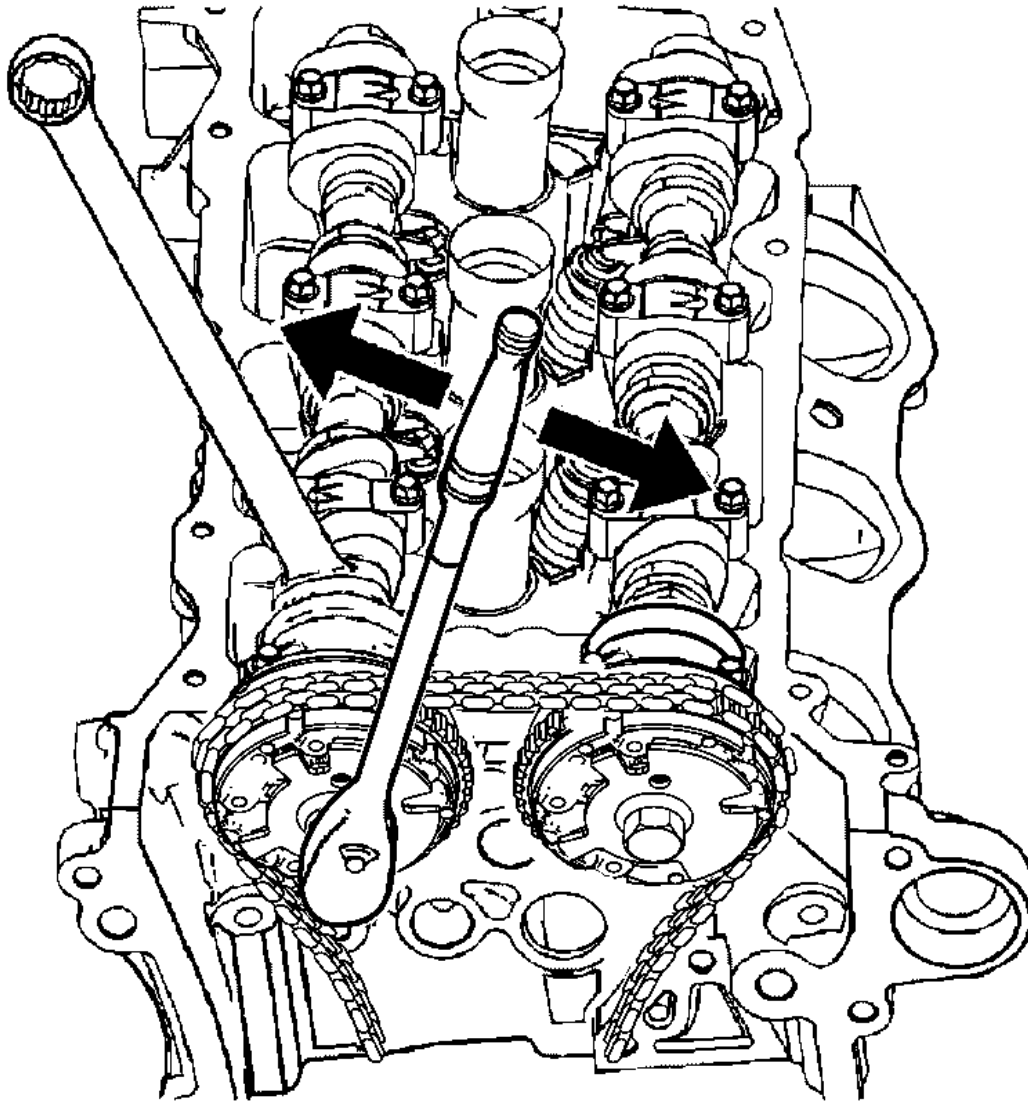
**Fig. 138: Identifying Camshaft Cover Rail**  
Courtesy of GENERAL MOTORS CORP.

7. Rotate the crankshaft with the **EN 46111** until the camshafts are in a neutral (low tension) position. See **Special Tools** . The camshaft flats will be parallel with the camshaft cover rail (1).



**Fig. 139: View Of EN 46105 & Right Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN 46105** (1) onto the rear of the right side camshafts (2). See **Special Tools** .



**Fig. 140: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

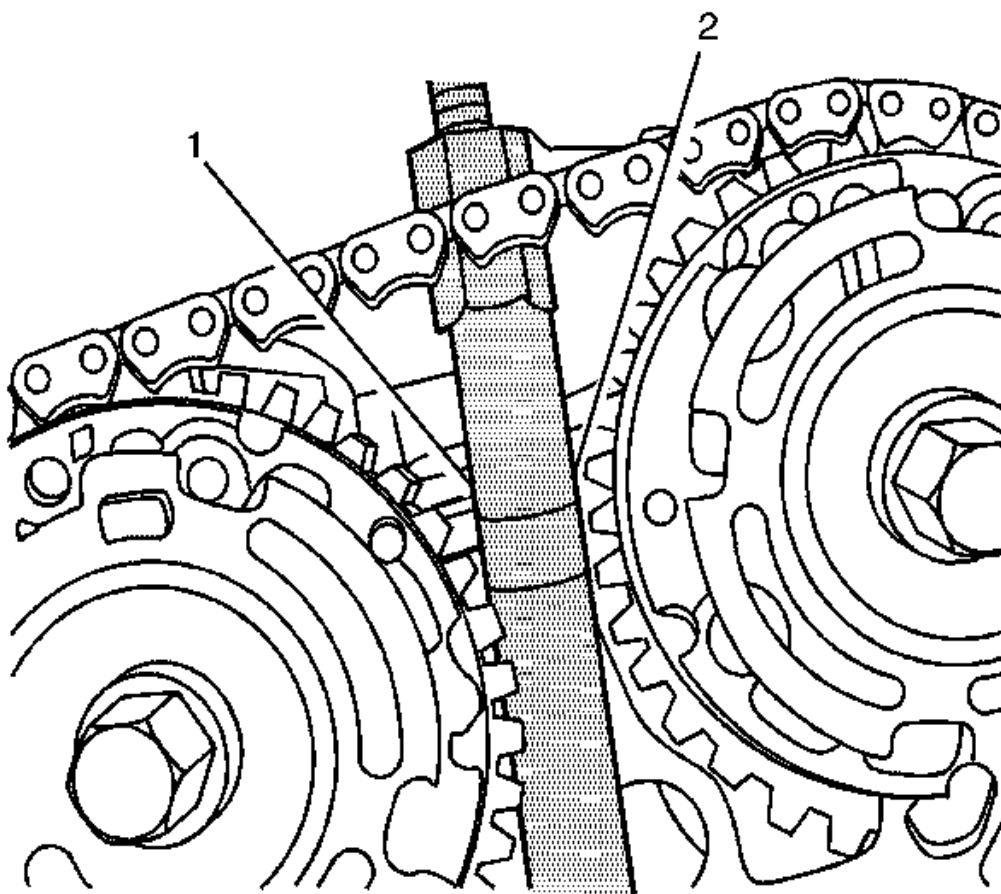
**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**NOTE:**

- Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.
- DO NOT remove the camshaft position actuator to camshaft retaining

**bolt at this time.**

9. Loosen the right side exhaust camshaft position actuator to camshaft retaining bolt.

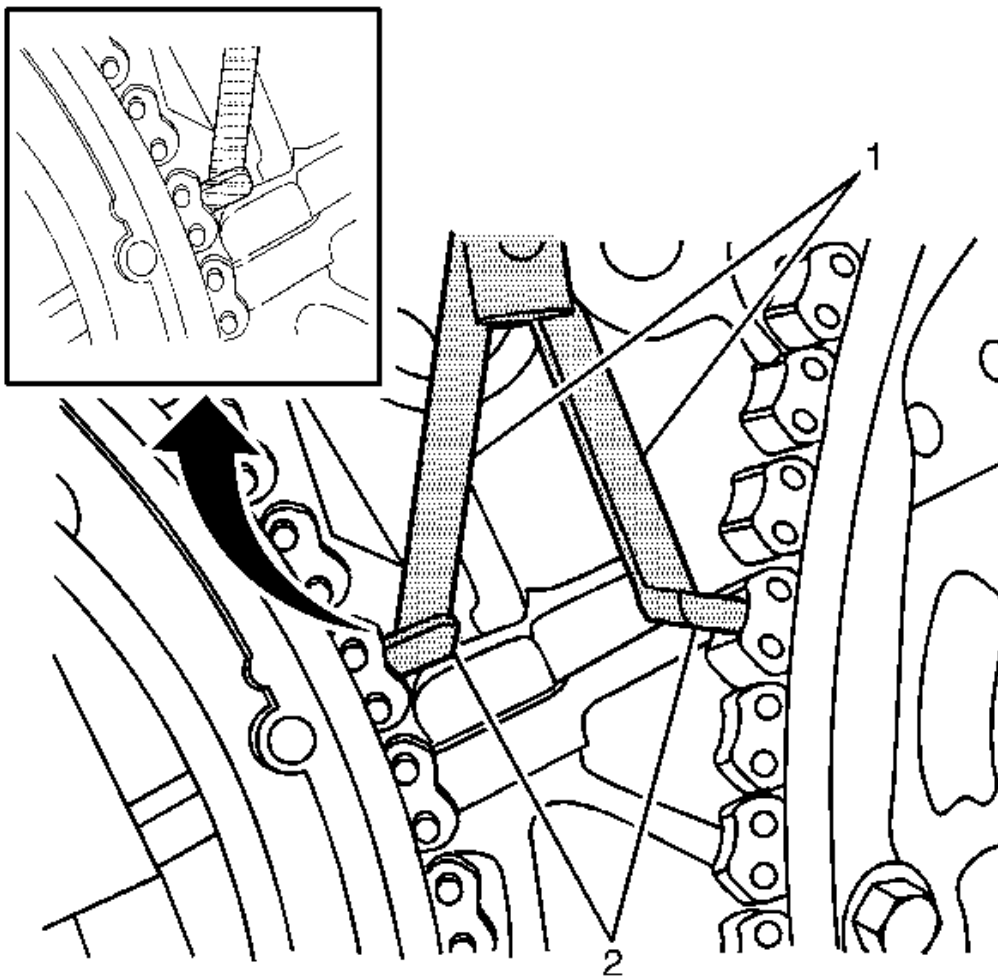


**Fig. 141: View Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The front engine cover is removed in the following graphics for illustration purposes and is not required to perform the procedure.

10. Loosen the **EN-48313** so that the legs are retracted. See **Special Tools**.
11. Insert the **EN-48313** between the camshaft actuators, rearward of the timing chain until the top line that is scribed in the body of the tool (1) is adjacent to the top surface of the cylinder head (2). See **Special Tools**. This is the approximate installed position.



**Fig. 142: Identifying Feet & Legs Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

12. Make sure that the feet (2) on the legs (1) of the EN-48313 are facing the front of the engine. See **Special Tools** .

**NOTE:** DO NOT tighten EN-48313 at this stage. See **Special Tools** .

13. Partially expand the legs (1) of the EN-48313 by turning the T-shaped handle clockwise. See **Special Tools** .

**NOTE:** Make sure that the feet (2) of the EN-48313 are correctly engaged into one of the link pockets to prevent chain slipping during tightening. See **Special**



**Tools .**

14. Continue expanding the **EN-48313** until the feet (2) contact the timing chain. See **Special Tools** .

**CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .**

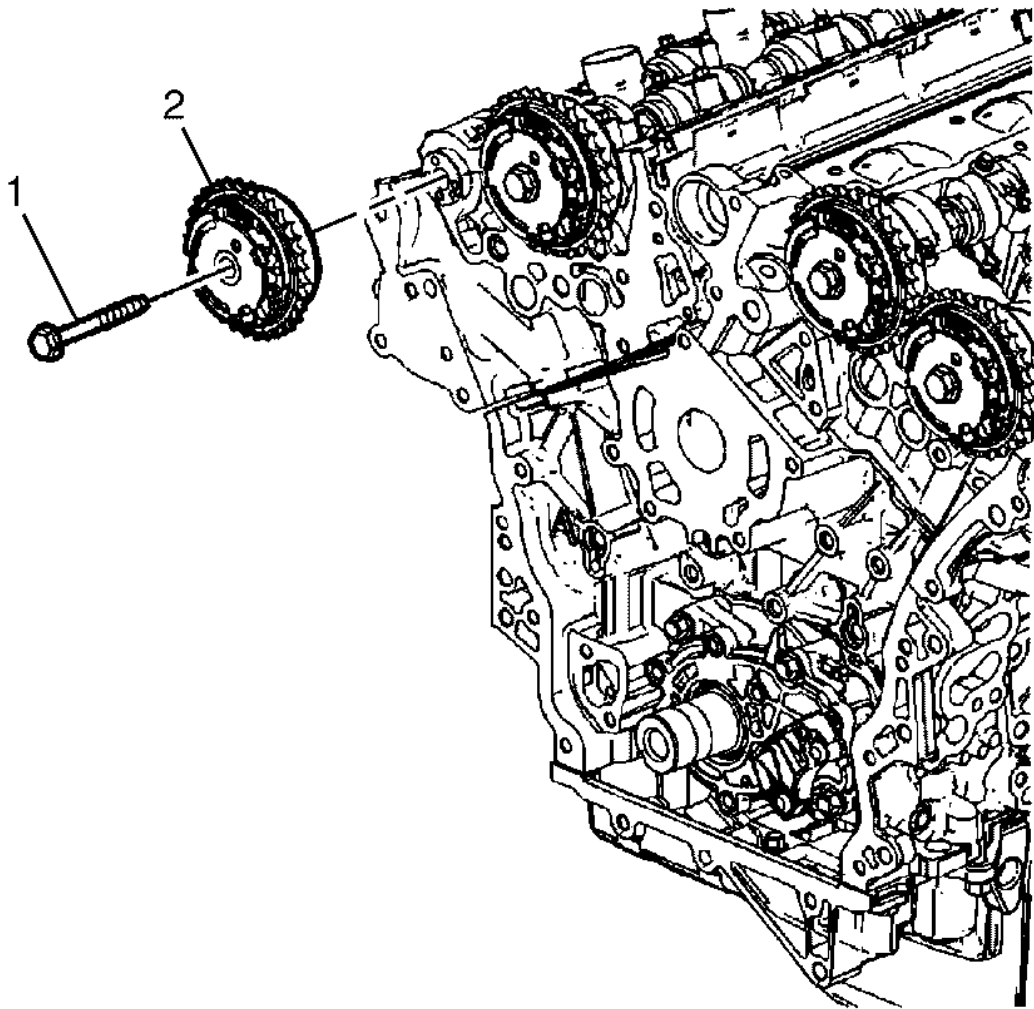
15. Hand tighten the **EN-48313** . See **Special Tools** .

**NOTE: DO NOT allow the body of the EN-48313 to rotate when tightening the T-handle. See Special Tools .**

16. Use an open-end wrench on the hex cast into the body of the **EN-48313** and hand tighten the T-handle. See **Special Tools** .
17. Use an open-end wrench on the hex cast into the right intake and exhaust camshafts and rotate the camshafts towards each other in order create slack in the chain between the actuators.
18. The **EN-48313** is now correctly installed to hold the timing chain in position. See **Special Tools** .

**NOTE: Make sure that the camshaft timing chain and the camshaft position actuators are marked for correct assembly.**

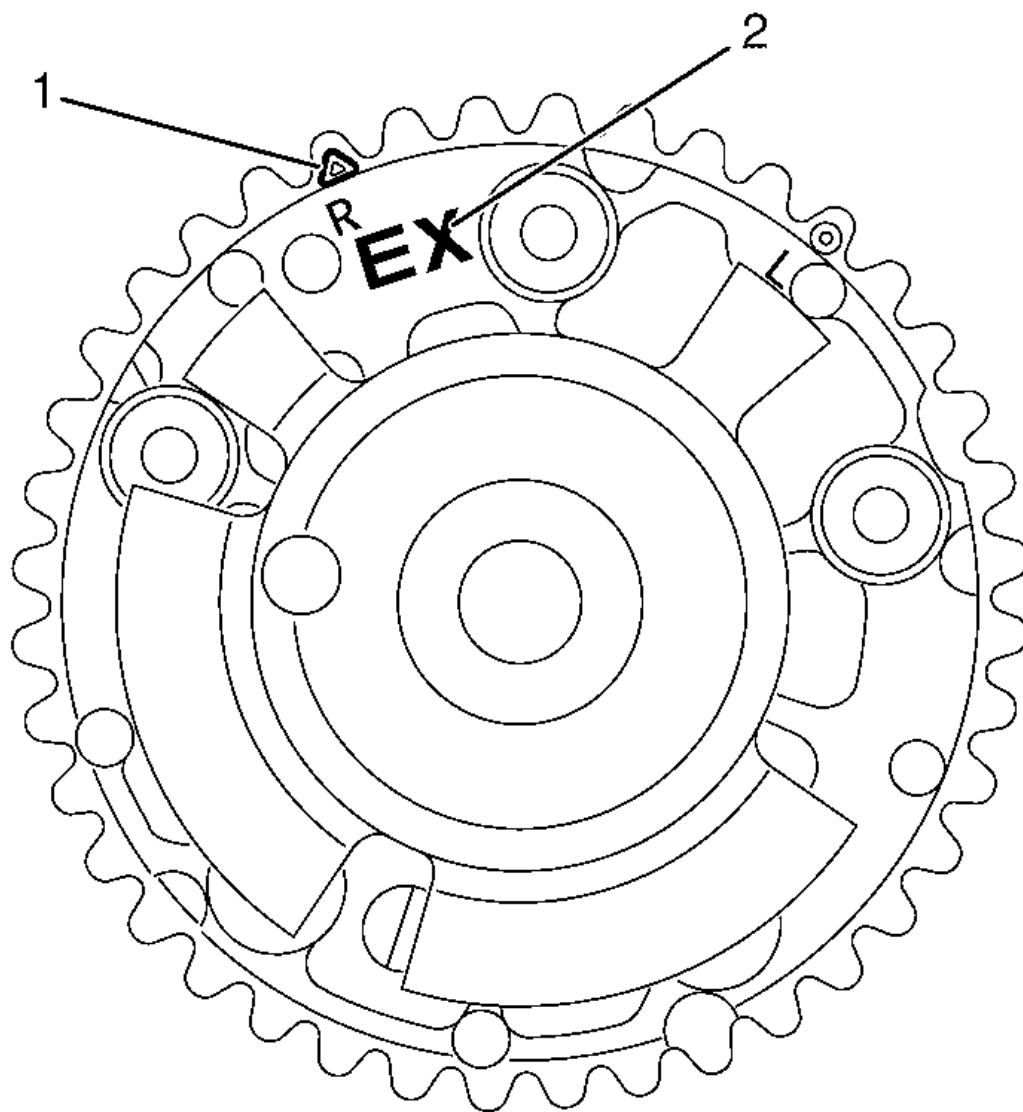
19. Mark the timing chain and the camshaft position actuators.



**Fig. 143: Identifying Right Side Exhaust Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

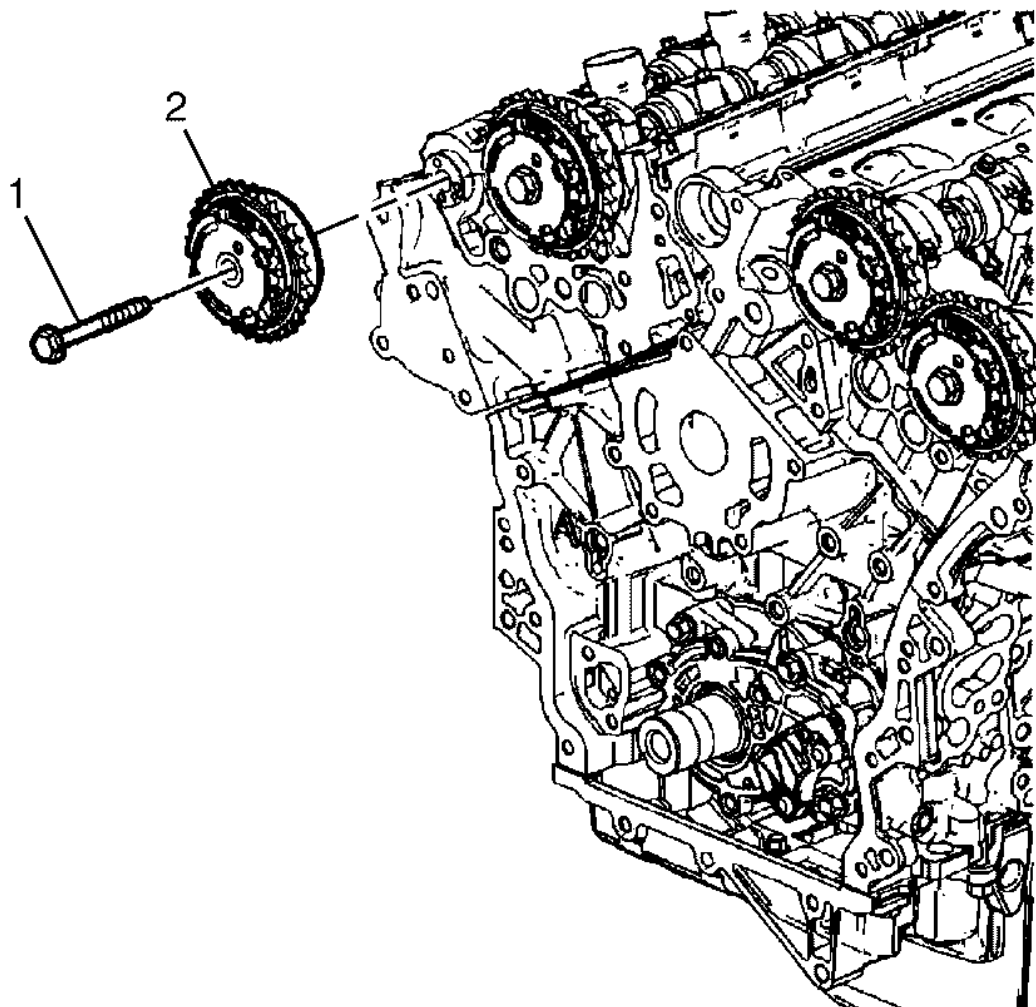
20. Remove the right side exhaust camshaft position actuator to camshaft retaining bolt (1).
21. Remove the right side exhaust camshaft position actuator (2).

#### **Installation Procedure**



**Fig. 144: View Of "EX", "R" & Triangle Markings**  
**Courtesy of GENERAL MOTORS CORP.**

1. Make sure the correct camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.
2. Make sure the correct timing mark is used. Observe the outer ring of the camshaft position actuator for the "R" and triangle marking (2). The marking is for alignment to the highlighted timing chain link on the right side of the engine.



**Fig. 145: Identifying Right Side Exhaust Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

3. Install the right side exhaust camshaft position actuator (2).

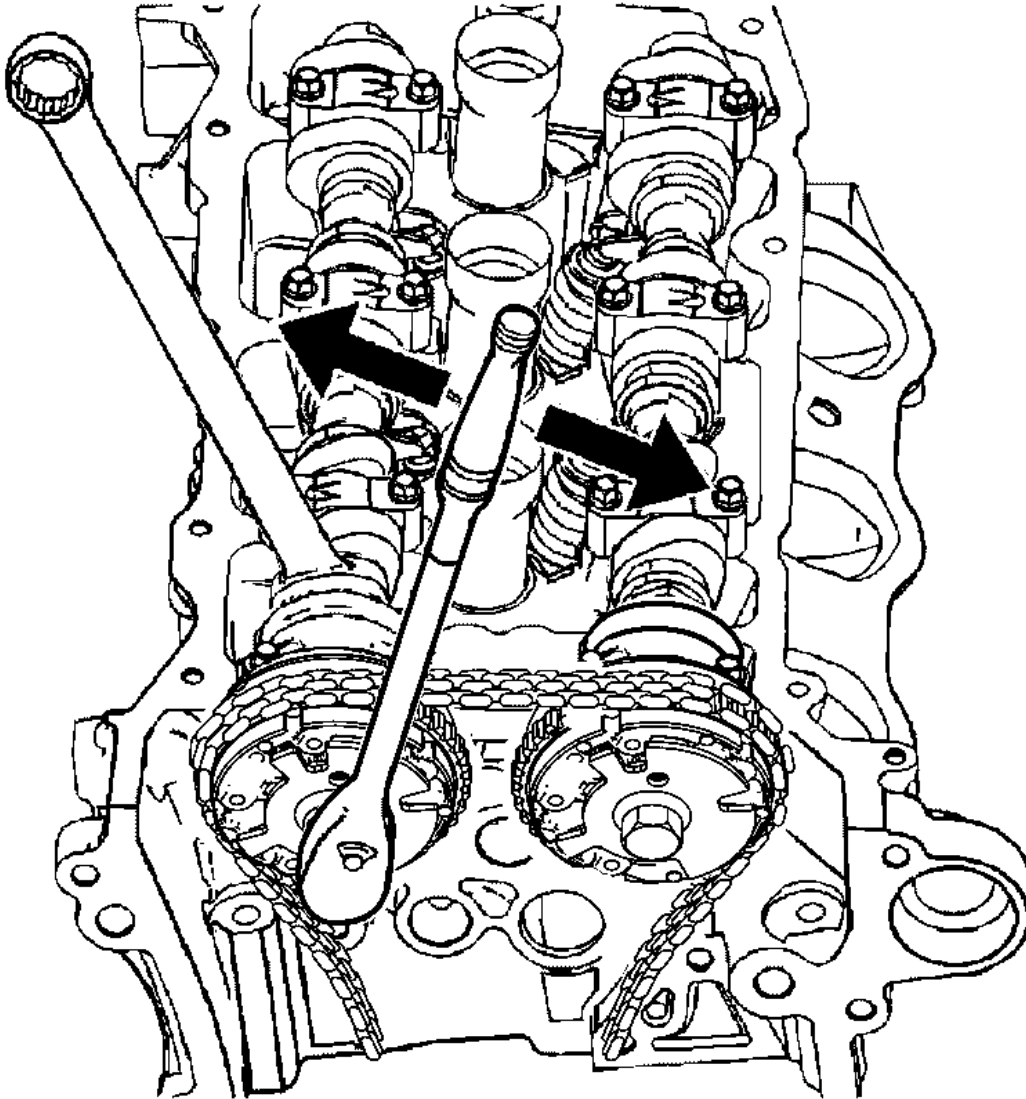
**NOTE:**

- Make sure that the marks on the camshaft position actuators and the timing chain are aligned.
- DO NOT tighten the right intake camshaft position actuator to camshaft retaining bolt (1) at this time.

4. Install the right side camshaft position actuator to camshaft retaining bolt (1).

DO NOT fully tighten at this stage.

5. Remove EN-48313 . See Special Tools .



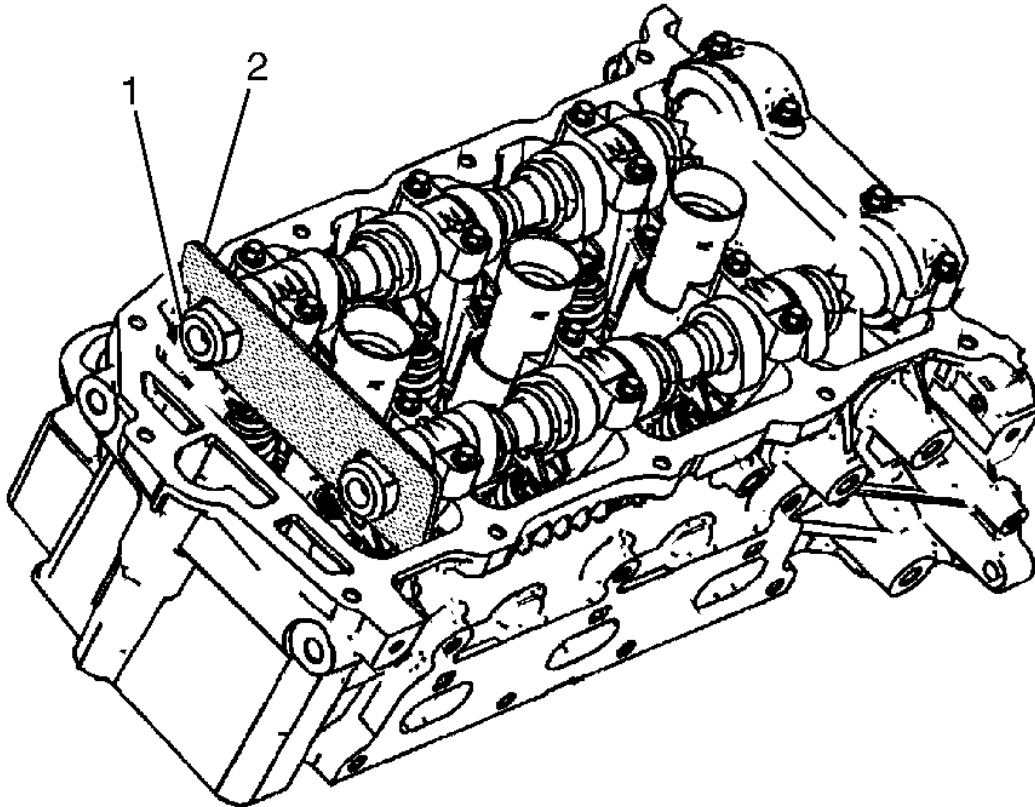
**Fig. 146: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

6. Install the camshaft position actuator using the camshaft retaining bolt and tighten to 58 N.m (43 lb ft).



**Fig. 147: View Of EN 46105 & Right Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46105** (2) from the rear of the right side camshafts (1). See **Special Tools** .
8. Install the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake** .
9. Install the camshaft position sensors. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake** .
10. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation** .
11. Install the right side camshaft cover. Refer to **Camshaft Cover Replacement - Right Side** .
12. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold** .

**Replacement.**

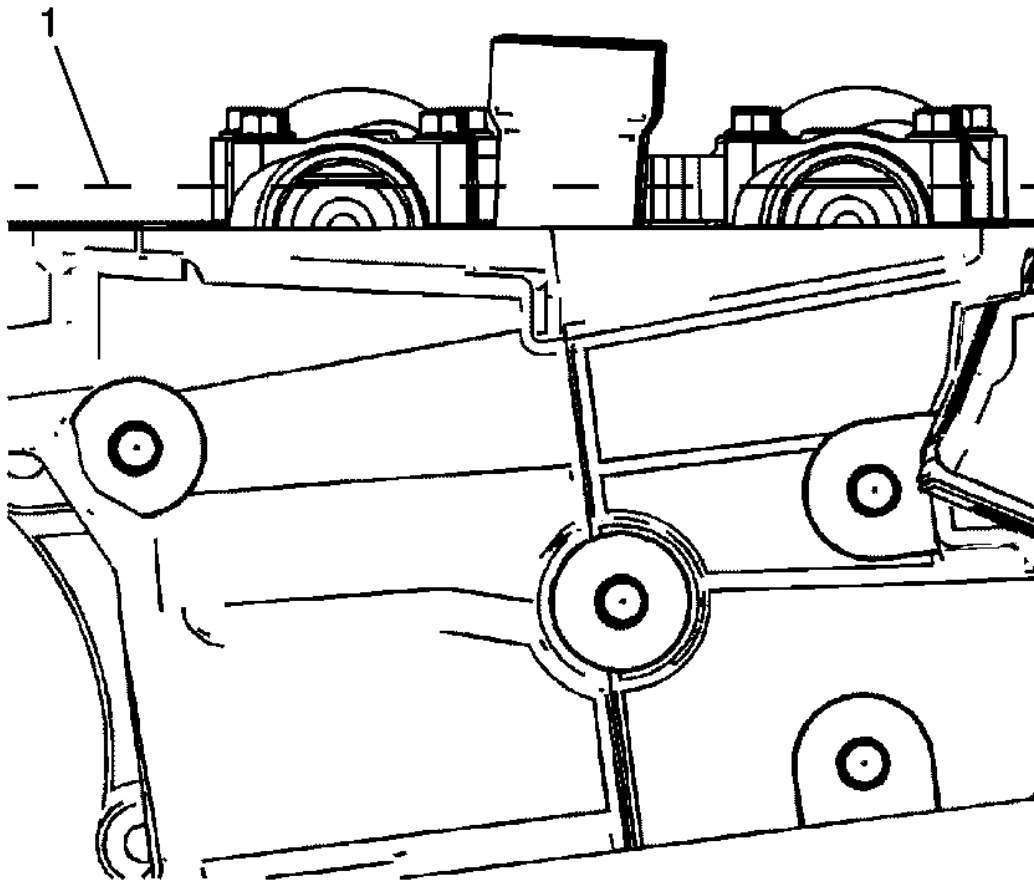
13. Install the engine covers. Refer to **Engine Cover Replacement.**

**CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE****Tools Required**

- **EN 46105** Camshaft Locking Tools. See **Special Tools** .
- **EN-48313** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46111** Crankshaft Rotation Socket. See **Special Tools** .

**Removal Procedure**

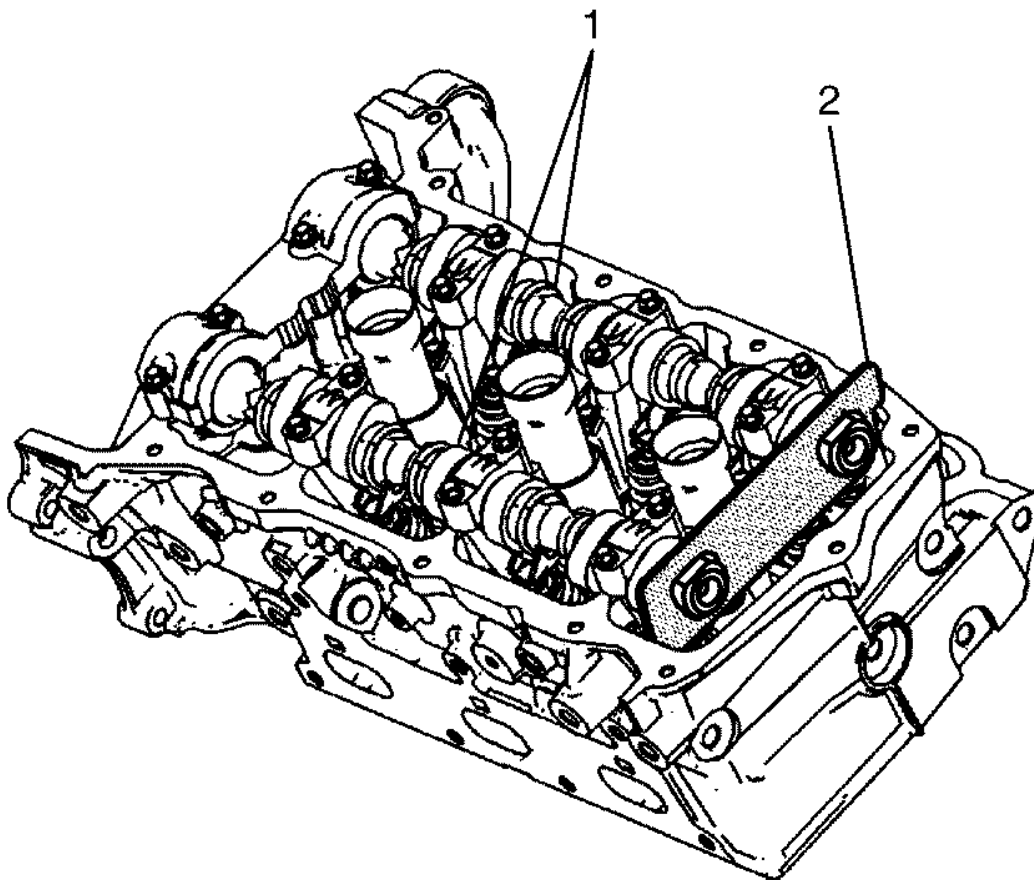
1. Remove the engine covers. Refer to **Engine Cover Replacement.**
2. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement.**
3. Remove the left side camshaft cover. Refer to **Camshaft Cover Replacement - Left Side.**
4. Remove the camshaft position sensors. Refer to (if fitted) **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake** .
5. Remove the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake** .
6. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal** .



**Fig. 148: Identifying Camshaft Cover Rail**  
Courtesy of GENERAL MOTORS CORP.

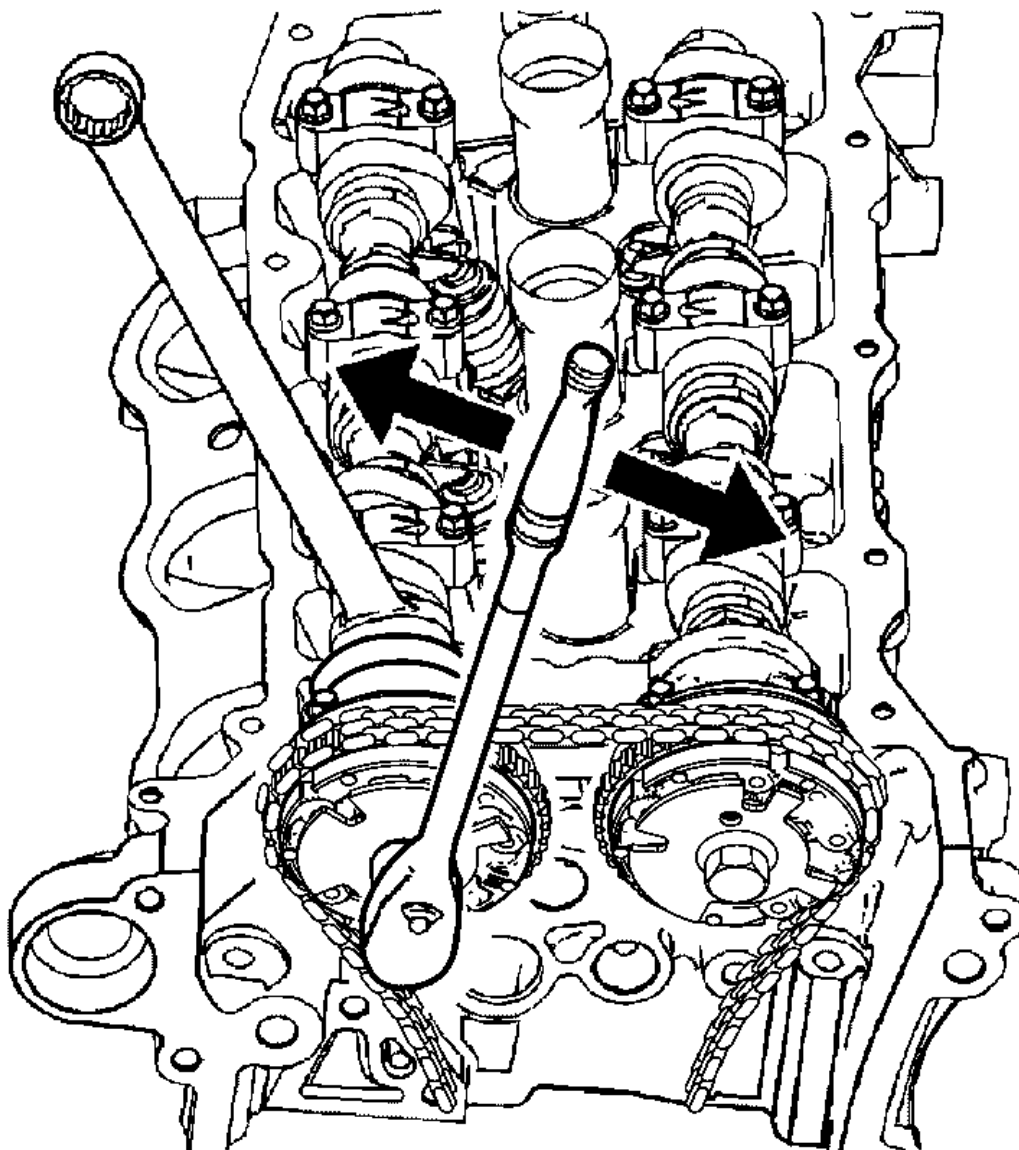
7. Rotate the crankshaft with the **EN 46111** until the camshafts are in a neutral (low tension) position. See **Special Tools** . The camshaft flats will be parallel with the camshaft cover rail (1).





**Fig. 149: View Of EN 46105 & Left Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN 46105** (2) onto the rear of the left side camshafts (1). See **Special Tools** .



**Fig. 150: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

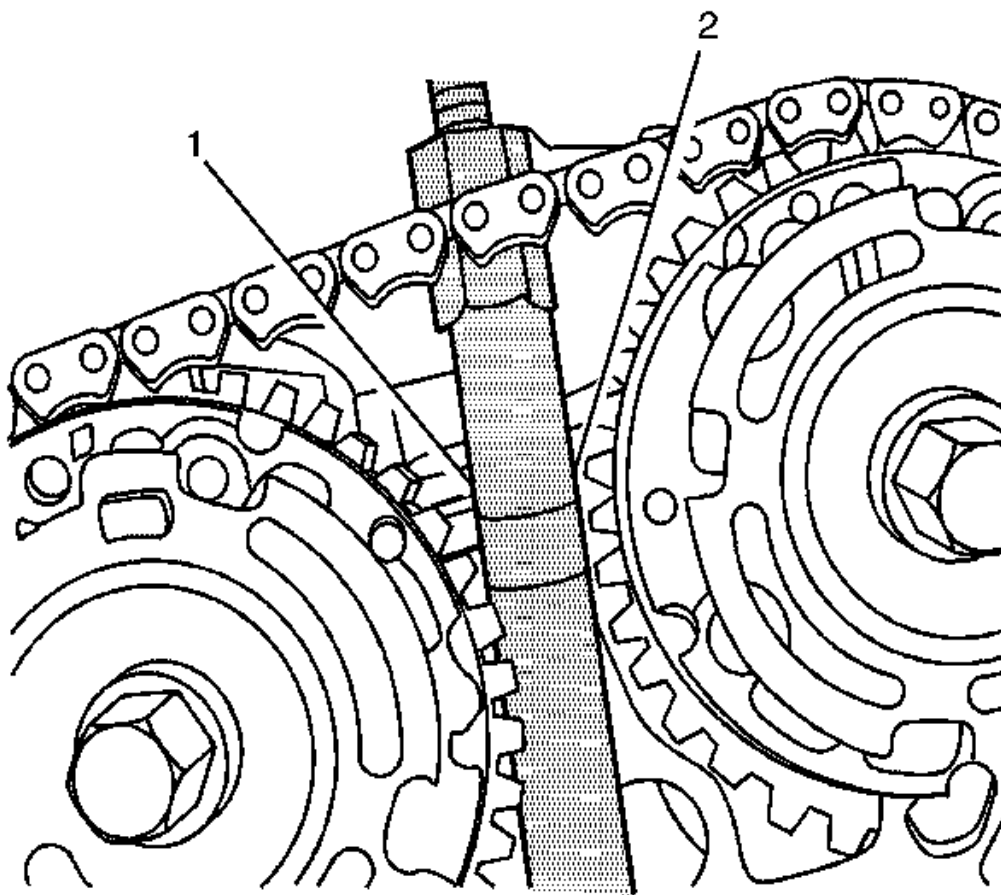
**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**NOTE:**

- Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

- **DO NOT** remove the camshaft position actuator to camshaft retaining bolt at this time.

9. Loosen the left side intake camshaft position actuator to camshaft retaining bolt.



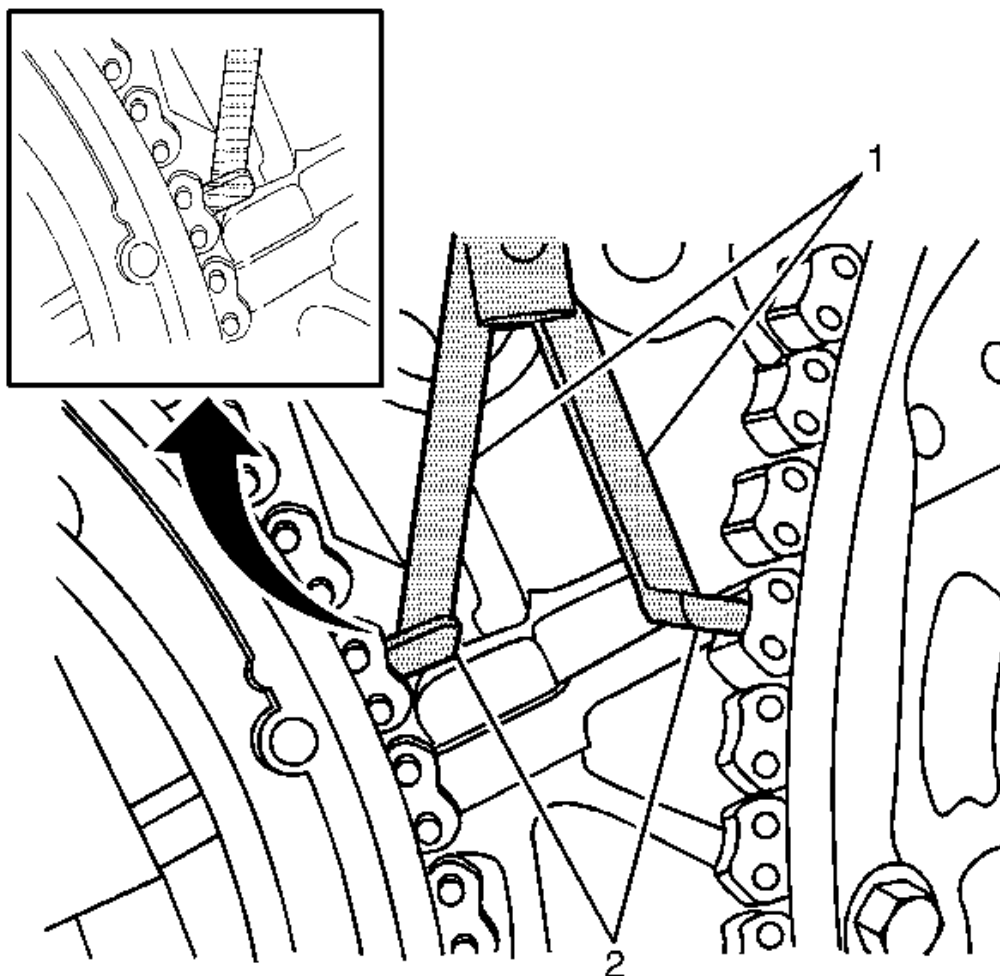
**Fig. 151: View Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The front engine cover is removed in the following graphics for illustration purposes and is not required to perform the procedure.

10. Insert the **EN-48313** between the camshaft actuators, rearward of the timing chain until the top line that is scribed in the body of the tool (1) is adjacent to the top surface of the cylinder head (2). See **Special Tools** . This is the approximate installed position.

11. Loosen the **EN-48313** so that the legs are retracted. See **Special Tools** .



**Fig. 152: Identifying Feet & Legs Of EN-48313**  
Courtesy of GENERAL MOTORS CORP.

12. Make sure that the feet (2) on the legs (1) of the **EN-48313** are facing the front of the engine. See **Special Tools** .

**NOTE:**        **DO NOT tighten EN-48313 at this stage. See Special Tools .**

13. Partially expand the legs (1) of the **EN-48313** by turning the T-shaped handle clockwise. See **Special Tools** .

**NOTE:** Make sure that the feet (2) of the EN-48313 are correctly engaged into one of the link pockets to prevent chain slipping during tightening. See Special Tools .

14. Continue expanding the EN-48313 until the feet (2) contact the timing chain. See Special Tools .

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

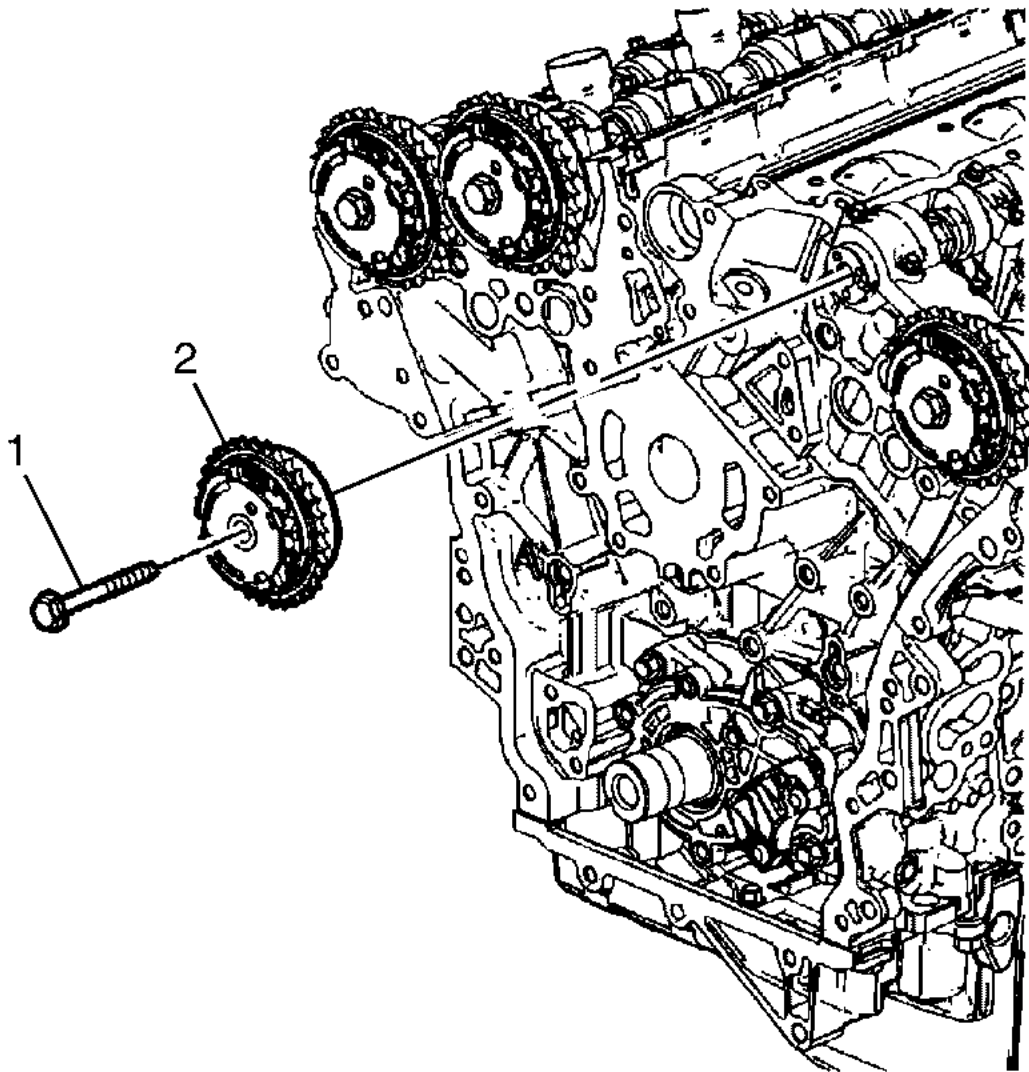
15. Hand tighten the EN-48313 . See Special Tools .

**NOTE:** DO NOT allow the body of the EN-48313 to rotate when tightening the T-handle. See Special Tools .

16. Use an open-end wrench on the hex cast into the body of the EN-48313 and hand tighten the T-handle. See Special Tools .
17. Use an open-end wrench on the hex cast of the left side intake and exhaust camshafts and rotate the camshafts towards each other in order create slack in the chain between the actuators.
18. The EN-48313 is now correctly installed to hold the timing chain in position. See Special Tools .

**NOTE:** Make sure that the camshaft timing chain and the camshaft position actuators are marked for correct assembly.

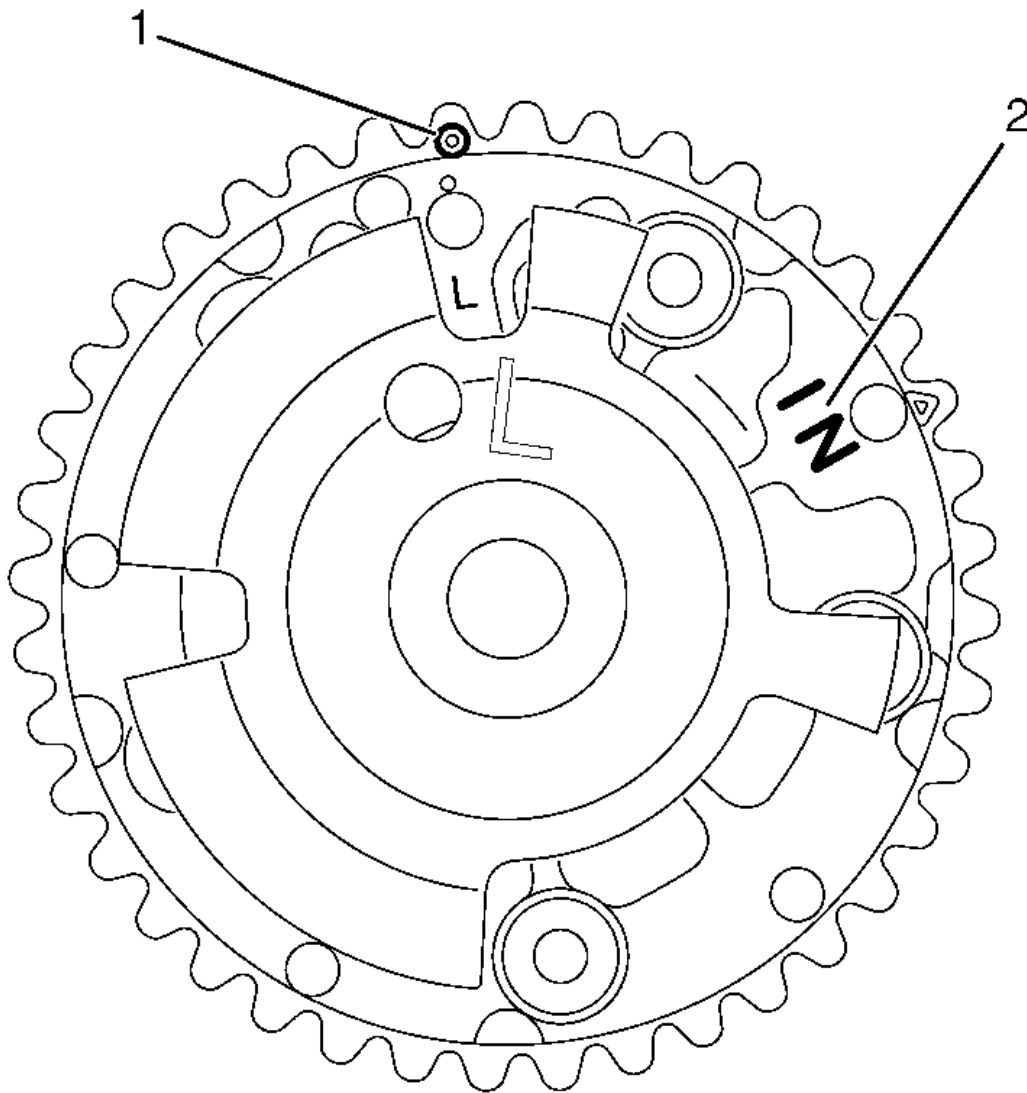
19. Mark the timing chain and the camshaft position actuators.



**Fig. 153: Identifying Left Intake Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

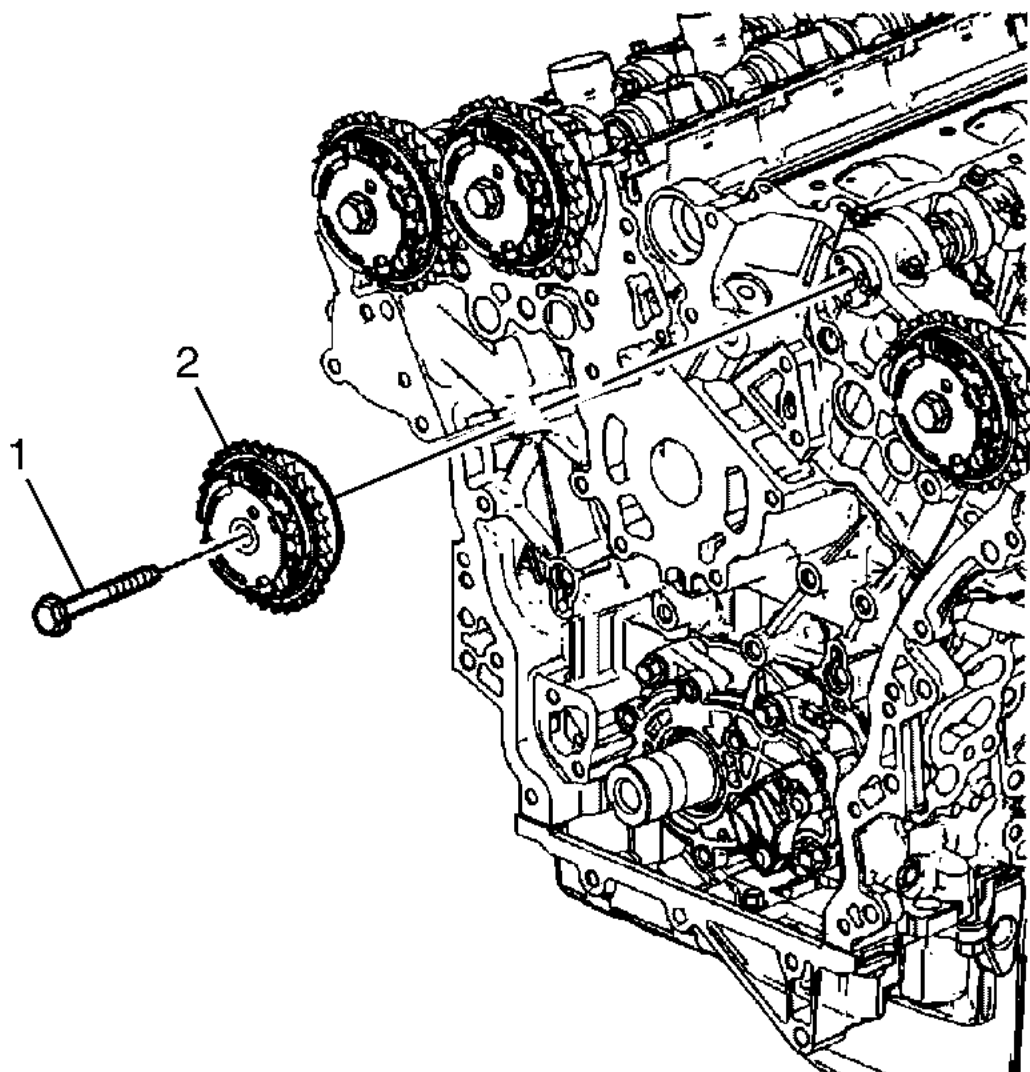
20. Remove the left side intake camshaft position actuator to camshaft retaining bolt (1).
21. Remove the left side intake camshaft position actuator (2).

#### **Installation Procedure**



**Fig. 154: View Of "IN", "L" & Circle Markings**  
Courtesy of GENERAL MOTORS CORP.

1. Make sure the correct camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (2). The marking is for an intake camshaft position actuator.
2. Make sure the correct timing mark is used. Observe the outer ring of the camshaft position actuator for the "L" and circle marking (1). The marking is for alignment to the highlighted timing chain link on the left side of the engine.



**Fig. 155: Identifying Left Intake Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

3. Install the left side intake camshaft position actuator (2).

**NOTE:**

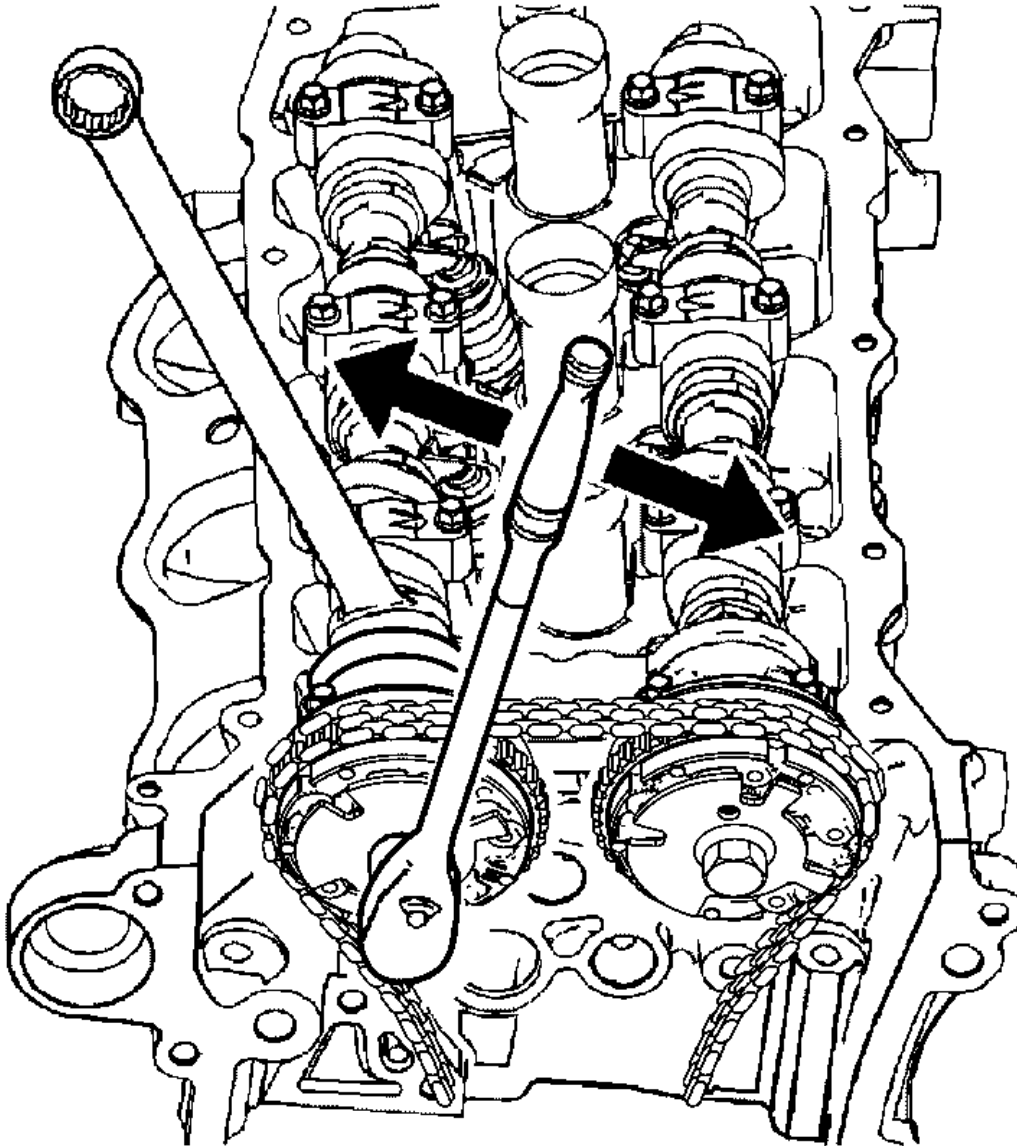
- Make sure that the marks on the camshaft position actuators and the timing chain are aligned.
- DO NOT tighten the right intake camshaft position actuator to camshaft retaining bolt (1) at this time.

4. Install the camshaft position actuator to camshaft retaining bolt (1).



DO NOT fully tighten at this stage.

5. Remove **EN-48313** . See **Special Tools** .



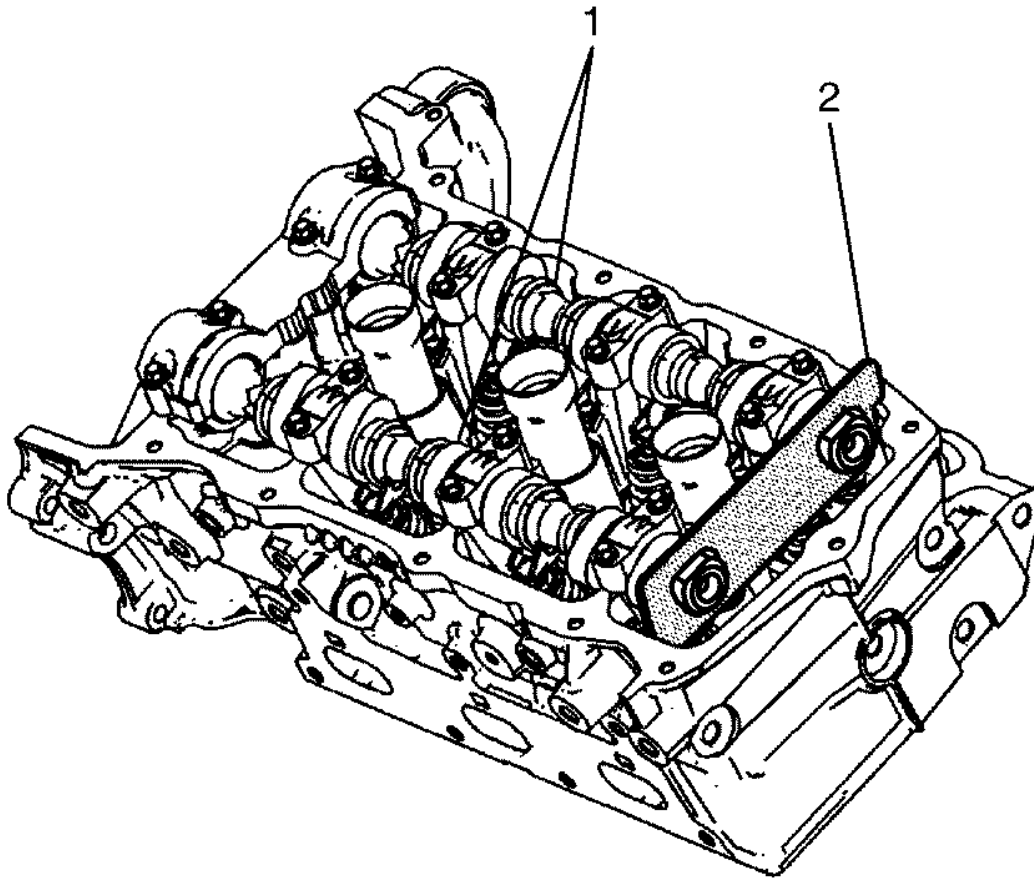
**Fig. 156: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to **Torque Reaction Against Timing Drive Chain Caution** .

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

6. Install the camshaft position actuator using the camshaft retaining bolt and tighten to 58 N.m (43 lb ft).



**Fig. 157: View Of EN 46105 & Left Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46105** (2) from the rear of the left side camshafts (1). See Special Tools .
8. Install the camshaft position (CMP) actuator solenoids. Refer to (if fitted) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake .
9. Install the camshaft position sensors. Refer to (if fitted) Camshaft Position Sensor Replacement - Bank

**2 (Left Side) Exhaust and Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake .**

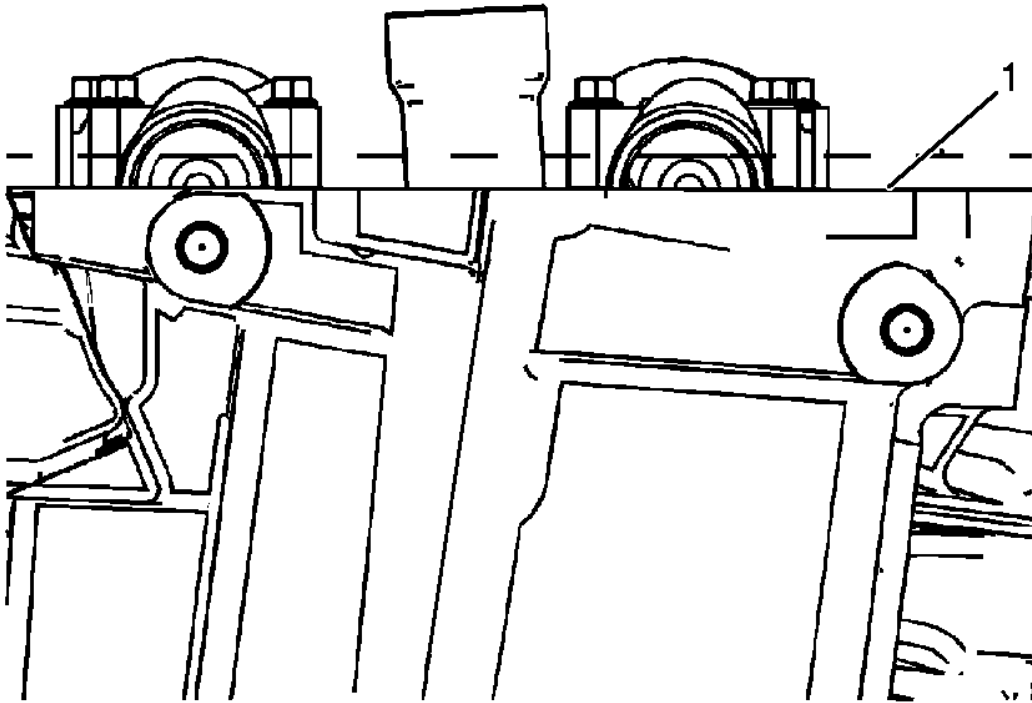
10. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation** .
11. Install the left bank camshaft cover. Refer to **Camshaft Cover Replacement - Left Side.**
12. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement.**
13. Install the engine covers. Refer to **Engine Cover Replacement.**

**CAMSHAFT POSITION ACTUATOR REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE****Tools Required**

- **EN 46105** Camshaft Locking Tools. See **Special Tools** .
- **EN-48313** Timing Chain Retention Tool. See **Special Tools** .
- **EN 46111** Crankshaft Rotation Socket. See **Special Tools** .

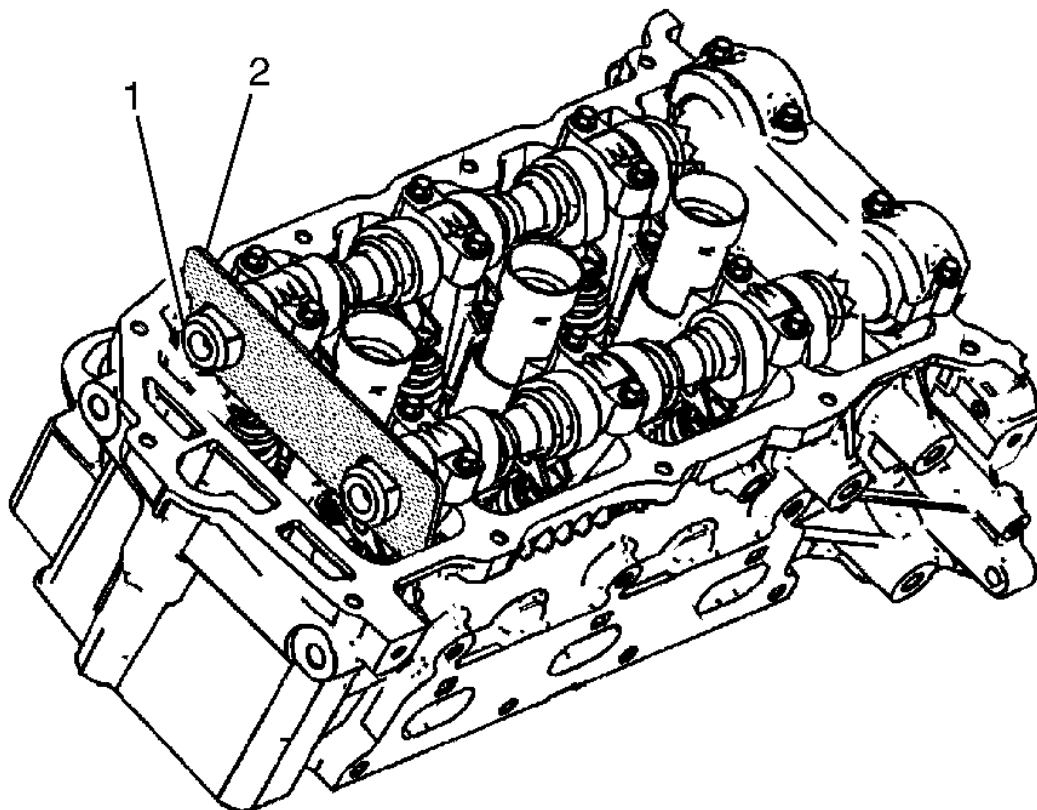
**Removal Procedure**

1. Remove the engine covers. Refer to **Engine Cover Replacement.**
2. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement.**
3. Remove the right side camshaft cover. Refer to **Camshaft Cover Replacement - Right Side.**
4. Remove the camshaft position sensors. Refer to **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake .**
5. Remove the camshaft position (CMP) actuator solenoids. Refer to (if fitted) **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake .**
6. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal** .



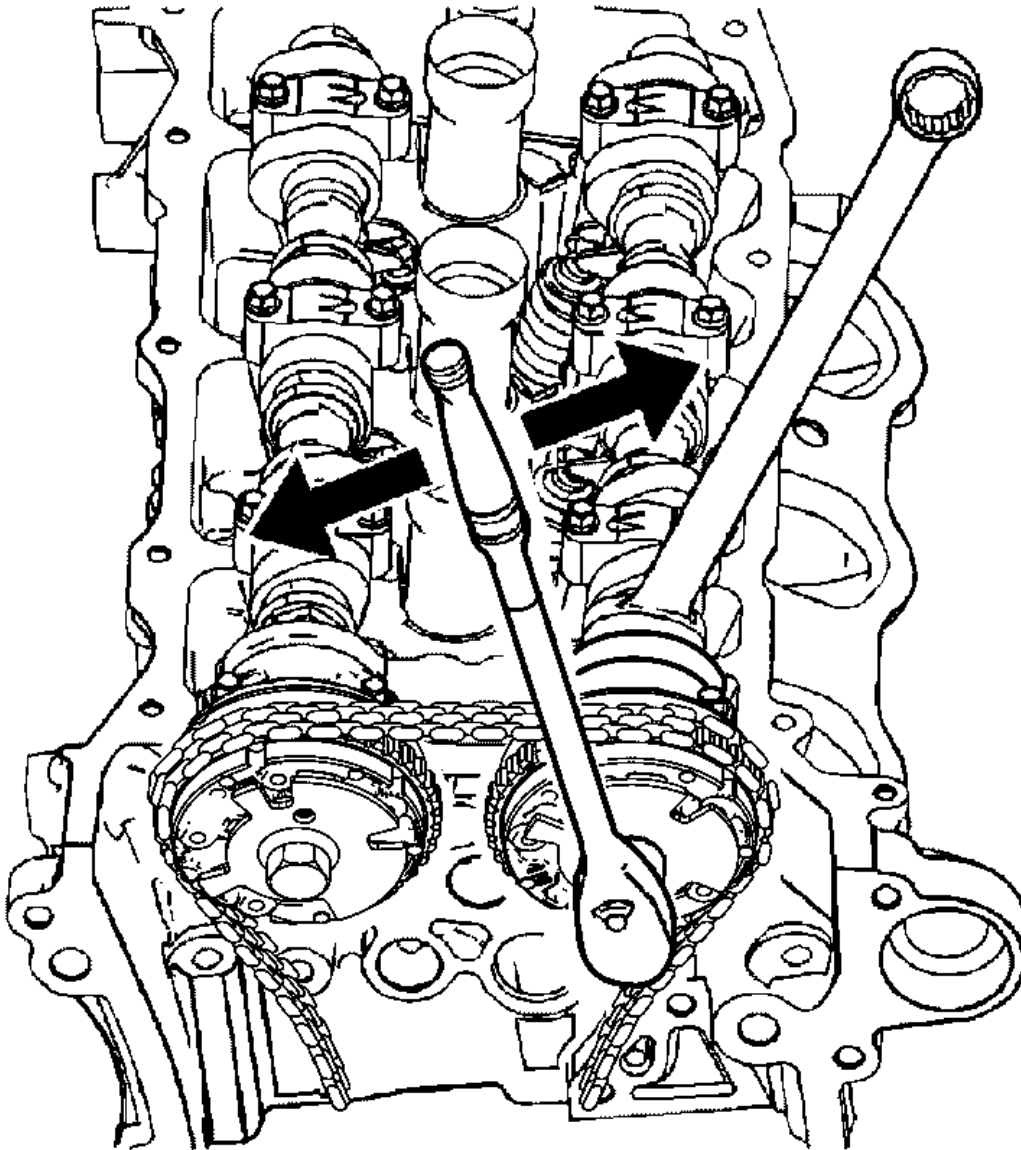
**Fig. 158: Identifying Camshaft Cover Rail**  
Courtesy of GENERAL MOTORS CORP.

7. Rotate the crankshaft with the **EN 46111** until the camshafts are in a neutral (low tension) position. See **Special Tools** . The camshaft flats will be parallel with the camshaft cover rail (1).



**Fig. 159: View Of EN 46105 & Right Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN 46105** (2) onto the rear of the right side camshafts (1). See **Special Tools** .



**Fig. 160: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

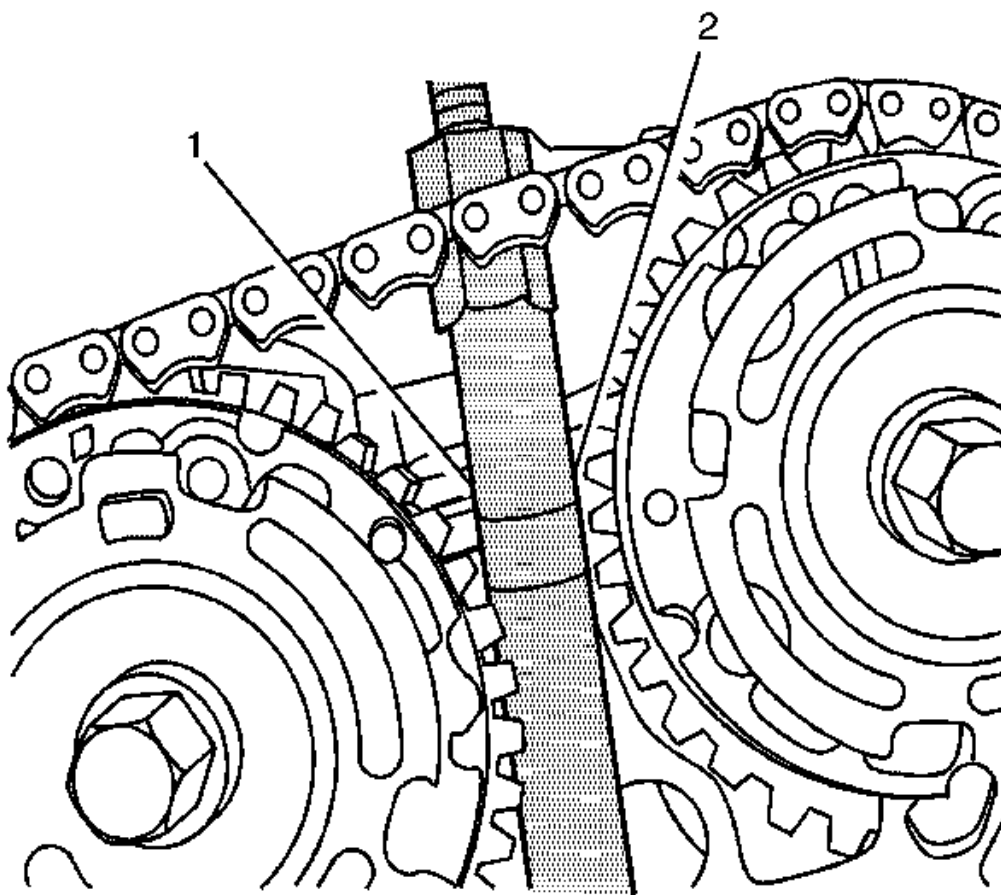
**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**NOTE:**

- Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

- **DO NOT** remove the camshaft position actuator to camshaft retaining bolt at this time.

9. Loosen the right side intake camshaft position actuator to camshaft retaining bolt.
10. Loosen the **EN-48313** so that the legs are retracted. See **Special Tools** .



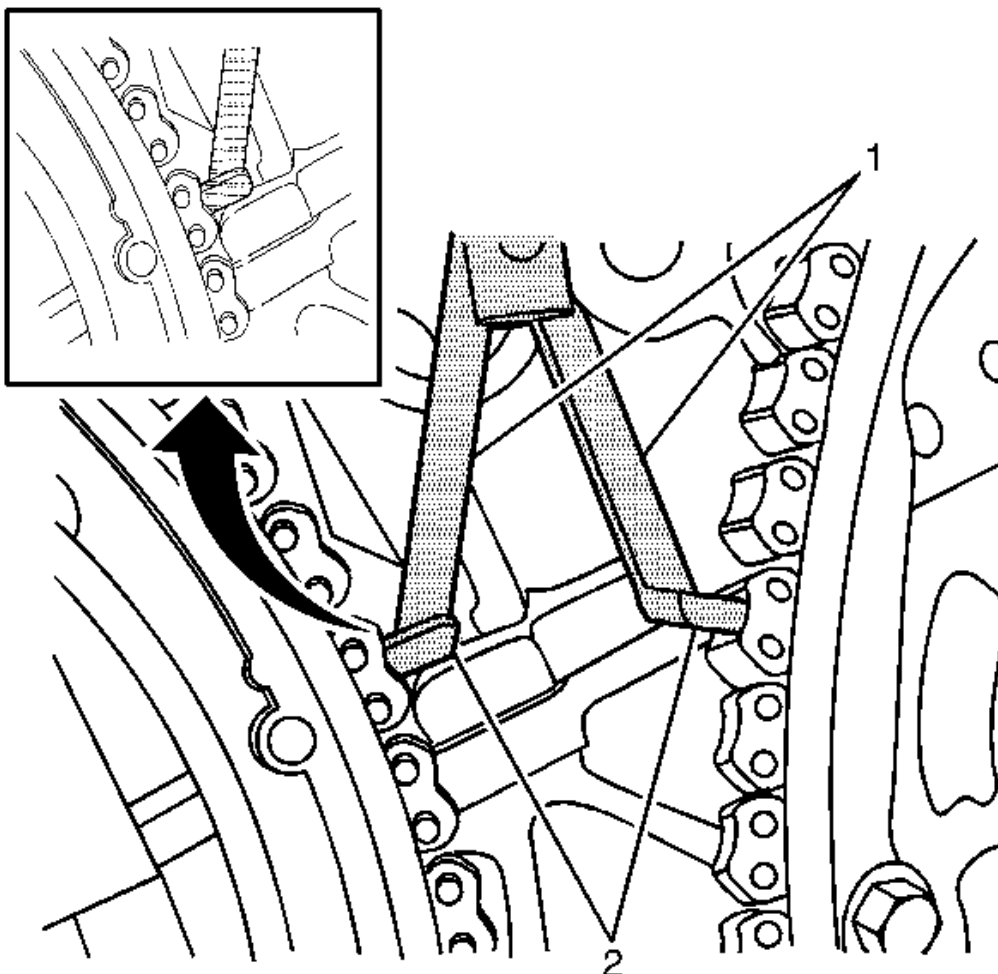
**Fig. 161: View Of EN-48313**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The front engine cover is removed in the following graphics for illustration purposes and is not required to perform the procedure.

11. Insert the **EN-48313** between the camshaft actuators, rearward of the timing chain until the top line that is scribed in the body of the tool (1) is adjacent to the top surface of the cylinder head (2). See **Special**

**Tools** . This is the approximate installed position.



**Fig. 162: Identifying Feet & Legs Of EN-48313**  
Courtesy of GENERAL MOTORS CORP.

12. Make sure that the feet (2) on the legs (1) of the **EN-48313** are facing the front of the engine. See **Special Tools** .

**NOTE:**        **DO NOT** tighten **EN-48313** at this stage. See **Special Tools** .

13. Partially expand the legs (1) of the **EN-48313** by turning the T-shaped handle clockwise. See **Special Tools** .



**NOTE:** Make sure that the feet (2) of the EN-48313 is correctly engaged into one of the link pockets to prevent chain slipping during tightening. See Special Tools .

14. Continue expanding the EN-48313 until the feet (2) contact the timing chain. See Special Tools .

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

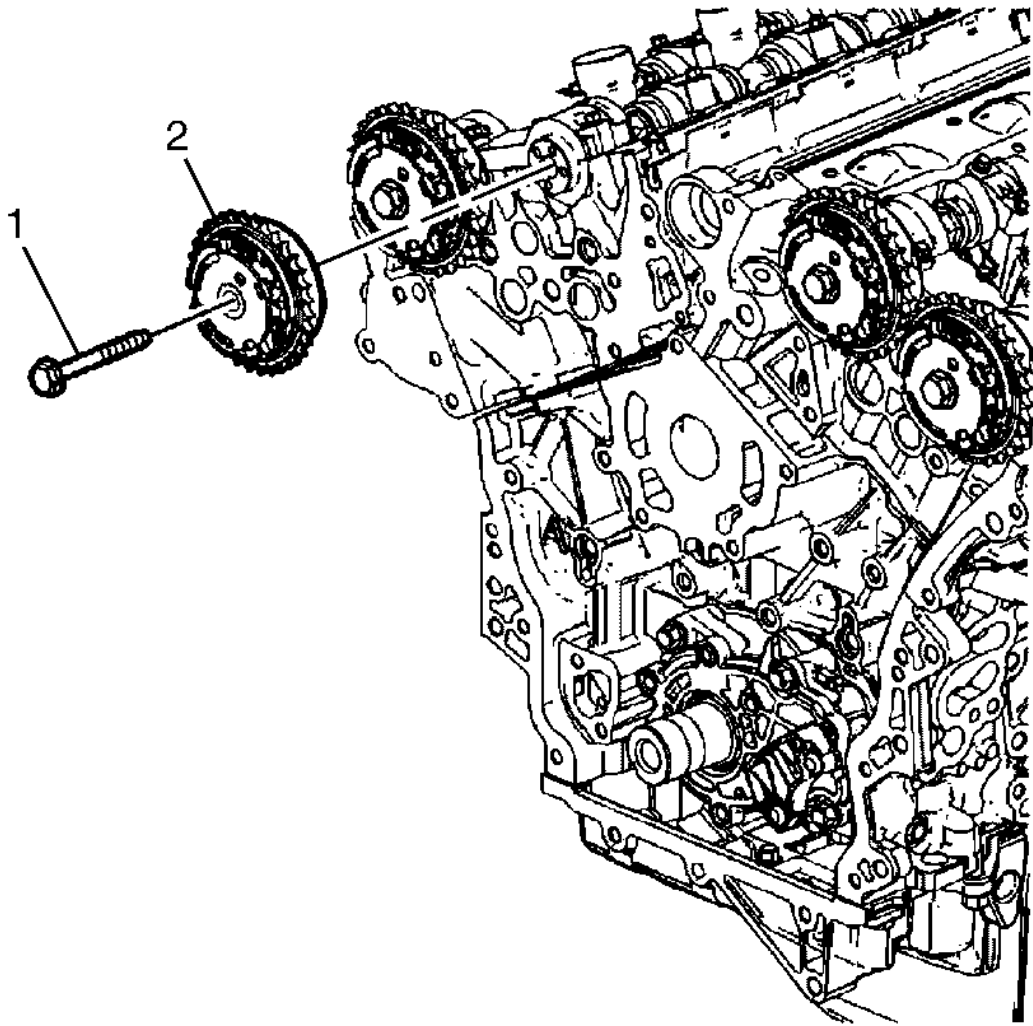
15. Hand tighten the EN-48313 . See Special Tools .

**NOTE:** DO NOT allow the body of the tool to rotate when tightening the T-handle.

16. Use an open-end wrench on the hex cast into the body of the EN-48313 and hand tighten the T-handle. See Special Tools .
17. Use an open-end wrench on the hex cast into the right intake and exhaust camshafts and rotate the camshafts towards each other in order create slack in the chain between the actuators.
18. The EN-48313 is now correctly installed to hold the timing chain in position. See Special Tools .

**NOTE:** Make sure that the camshaft timing chain and the camshaft position actuators are marked for correct assembly.

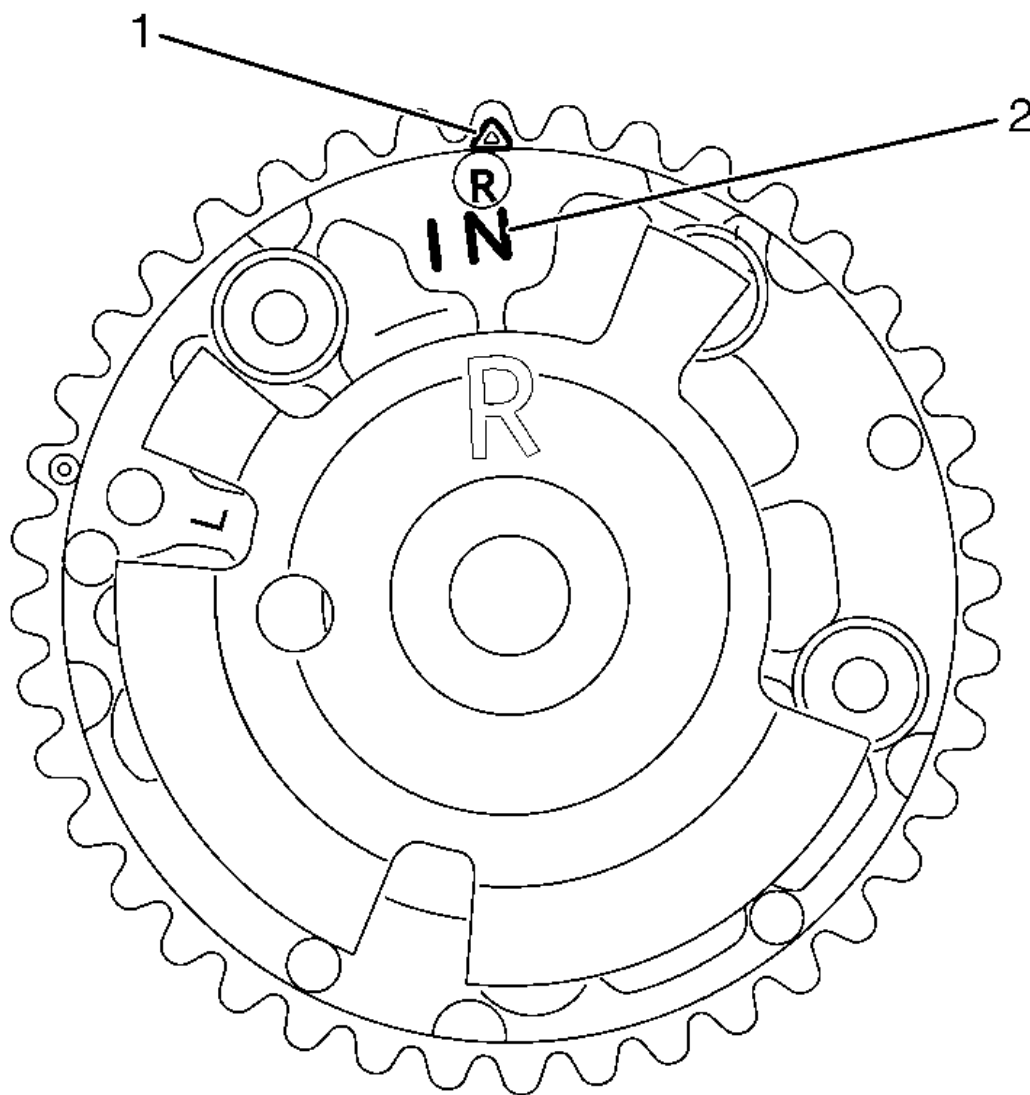
19. Mark the timing chain and the camshaft position actuators.



**Fig. 163: Identifying Right Intake Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

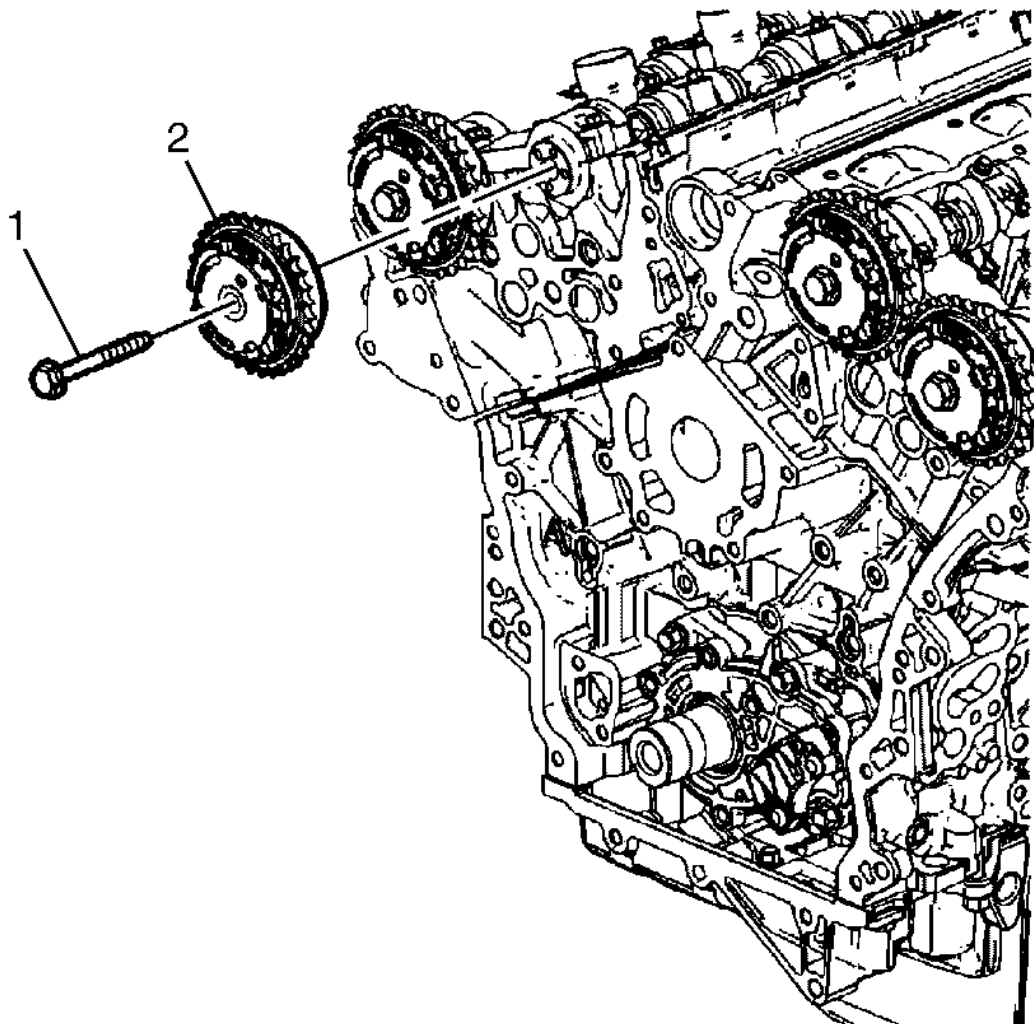
20. Remove the right side intake camshaft position actuator to camshaft retaining bolt (1).
21. Remove the right side intake camshaft position actuator (2).

#### **Installation Procedure**



**Fig. 164: Identifying "IN", "R" & Triangle Markings**  
Courtesy of GENERAL MOTORS CORP.

1. Make sure the correct camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (2). The marking is for an intake camshaft position actuator.
2. Make sure the correct timing mark is used. Observe the outer ring of the camshaft position actuator for the "R" and triangle marking (1). The marking is for alignment to the highlighted timing chain link on the right side of the engine.



**Fig. 165: Identifying Right Intake Camshaft Position Actuator To Camshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

3. Install the right side intake camshaft position actuator (2).

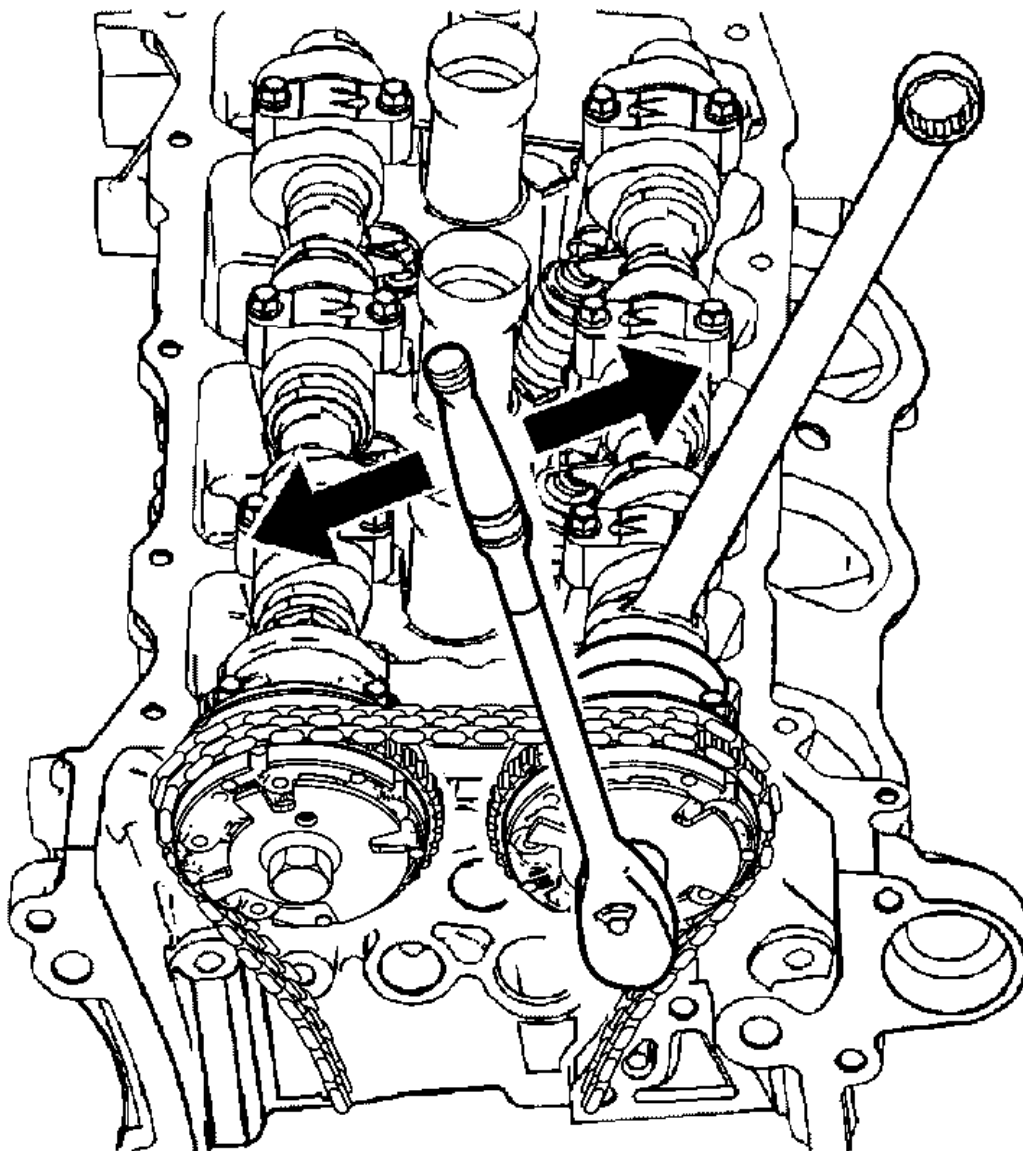
**NOTE:**

- Make sure that the marks on the camshaft position actuators and the timing chain are aligned.
- DO NOT tighten the right intake camshaft position actuator to camshaft retaining bolt (1) at this time.

4. Install the right side intake camshaft position actuator to camshaft retaining bolt (1).

DO NOT fully tighten at this stage.

5. Remove the **EN 46108** EN 48313.



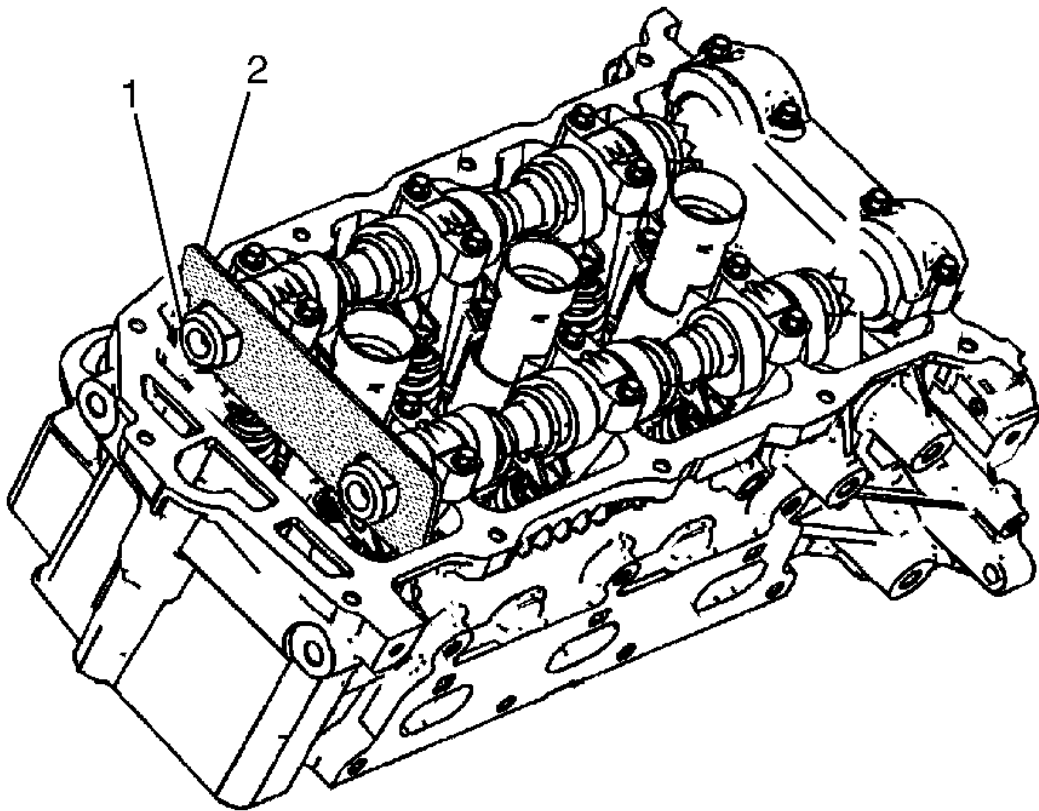
**Fig. 166: View Of Open-End Wrench**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Torque Reaction Against Timing Drive Chain Caution .

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Use an open-end wrench at the camshaft hex to prevent camshaft/engine rotation.

6. Install the camshaft position actuator using the camshaft retaining bolt and tighten to 58 N.m (43 lb ft).



**Fig. 167: View Of EN 46105 & Right Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46105** (2) from the rear of the right side camshafts (1). See Special Tools .
8. Install the camshaft position (CMP) actuator solenoids. Refer to (if fitted) Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake .
9. Install the camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust and Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake .
10. Install the crankshaft balancer. Refer to Crankshaft Balancer Installation .
11. Install the right side camshaft cover. Refer to Camshaft Cover Replacement - Right Side .

12. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
13. Install the engine covers. Refer to **Engine Cover Replacement**.

## **SETTING CAMSHAFT TIMING**

**IMPORTANT:** Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the relationship between any chain and sprocket has been lost. Even when only one sprocket is involved, multiple crankshaft rotations will not produce conditions where correct timing can be confirmed.

If necessary, follow the left bank secondary camshaft drive chain replacement procedures to reset the camshaft timing. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side**.

## **CAMSHAFT REPLACEMENT - LEFT SIDE**

### **Removal Procedure**

1. Remove the left side camshaft position actuators. Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Intake**.
2. Remove the left side camshafts. Refer to **Camshaft Removal - Left Side**.

### **Installation Procedure**

1. Install the left side camshafts. Refer to **Camshaft Removal - Left Side**.
2. Install the left side camshaft position actuators. Refer to **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 2 (Left Side) Intake**.

## **CAMSHAFT REPLACEMENT - RIGHT SIDE**

### **Removal Procedure**

1. Remove the right side camshaft position actuators. Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake**.
2. Remove the right side camshafts. Refer to **Camshaft Removal - Right Side**.

### **Installation Procedure**

1. Install the right side camshafts. Refer to **Camshaft Installation - Right Side**.
2. Install the right side camshaft position actuators. Refer to **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Exhaust** and **Camshaft Position Actuator Replacement - Bank 1 (Right Side) Intake**.

**VALVE ROCKER ARM REPLACEMENT - LEFT SIDE****Removal Procedure**

1. Remove the applicable camshaft(s). Refer to **Camshaft Replacement - Left Side**.
2. Remove the rocker arms. Refer to **Valve Rocker Arm Removal - Left Side**.
3. Clean and inspect the camshaft(s) and the rocker arm(s). Repair or replace as necessary. Refer to **Camshaft Cleaning and Inspection** and **Valve Lifters Cleaning and Inspection**.

**Installation Procedure**

1. Install the rocker arms. Refer to **Valve Rocker Arm Installation - Left Side**.
2. Install the applicable camshaft(s). Refer to **Camshaft Replacement - Left Side**.

**VALVE ROCKER ARM REPLACEMENT - RIGHT SIDE****Removal Procedure**

1. Remove the applicable camshaft(s). Refer to **Camshaft Replacement - Right Side**.
2. Remove the rocker arms. Refer to **Valve Rocker Arm Removal - Right Side**.
3. Clean and inspect the camshaft(s) and the rocker arm(s). Repair or replace as necessary. Refer to **Camshaft Cleaning and Inspection** and **Valve Lifters Cleaning and Inspection**.

**Installation Procedure**

1. Install the rocker arms. Refer to **Valve Rocker Arm Installation - Right Side**.
2. Install the applicable camshaft(s). Refer to **Camshaft Installation - Right Side**.

**VALVE LIFTER REPLACEMENT - LEFT SIDE****Removal Procedure**

1. Remove the applicable camshaft(s). **Camshaft Replacement - Left Side**.
2. Remove the rocker arms. Refer to **Valve Rocker Arm Removal - Left Side**.
3. Remove the lifters. Refer to **Valve Lifter Removal - Left Side**.
4. Clean and inspect the camshaft(s), rocker arm(s) and lifter(s). Repair or replace as necessary. Refer to **Camshaft Cleaning and Inspection** and **Valve Rocker Arm Cleaning and Inspection** and **Valve Lifters Cleaning and Inspection**.

**Installation Procedure**

1. Install the lifters. Refer to **Valve Lifter Installation - Left Side**.
2. Install the rocker arms. Refer to **Valve Rocker Arm Installation - Left Side**.
3. Install the applicable camshaft(s). Refer to **Camshaft Replacement - Left Side**.



**VALVE LIFTER REPLACEMENT - RIGHT SIDE****Removal Procedure**

1. Remove the applicable camshaft(s). Refer to **Camshaft Replacement - Right Side**.
2. Remove the rocker arms. Refer to **Valve Rocker Arm Removal - Right Side** .
3. Remove the lifters. Refer to **Valve Lifter Removal - Right Side** .
4. Clean and inspect the camshaft(s), rocker arm(s) and lifter(s). Repair or replace as necessary. Refer to **Camshaft Cleaning and Inspection** and **Valve Rocker Arm Cleaning and Inspection** and **Valve Lifters Cleaning and Inspection** .

**Installation Procedure**

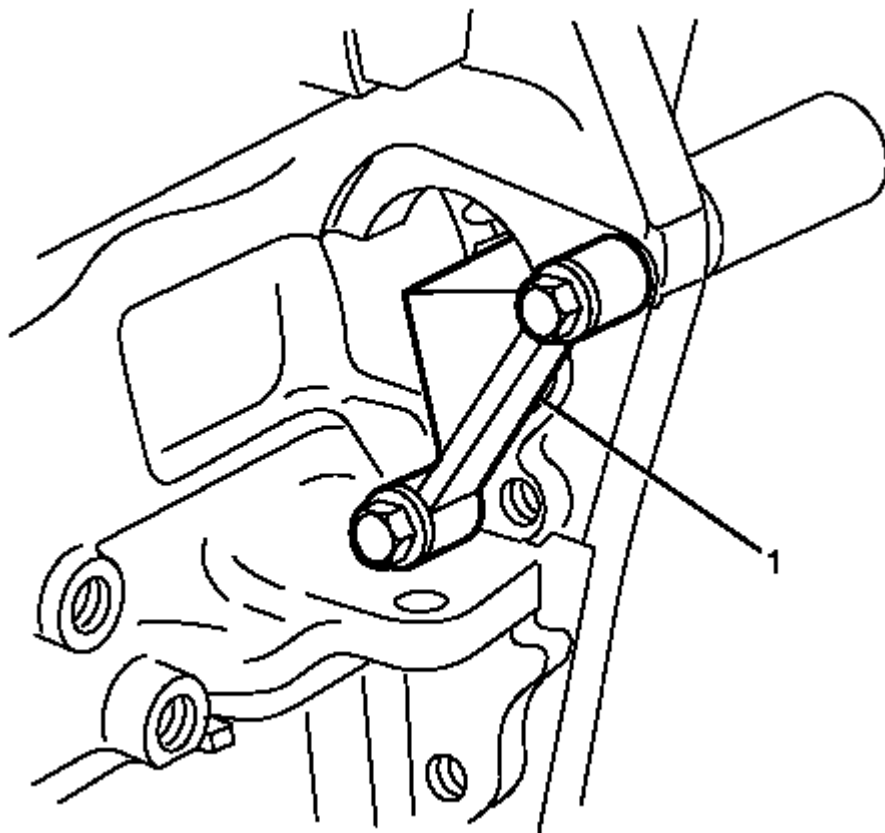
1. Install the lifters. Refer to **Valve Lifter Installation - Right Side** .
2. Install the rocker arms. Refer to **Valve Rocker Arm Installation - Right Side** .
3. Install the applicable camshaft(s). Refer to **Camshaft Installation - Right Side** .

**VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - LEFT SIDE****Tools Required**

- **EN 46106** Flywheel Holding Tool. See **Special Tools** .
- **EN 46110** On-Vehicle Valve Spring Compressor. See **Special Tools** .
- **EN 46116** Valve Stem Seal Remover/Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .
- **EN 46117** Valve Collet Remover/Installer. See **Special Tools** .

**Removal Procedure**

1. Remove the starter motor. Refer to **Starter Replacement (3.6L)** .

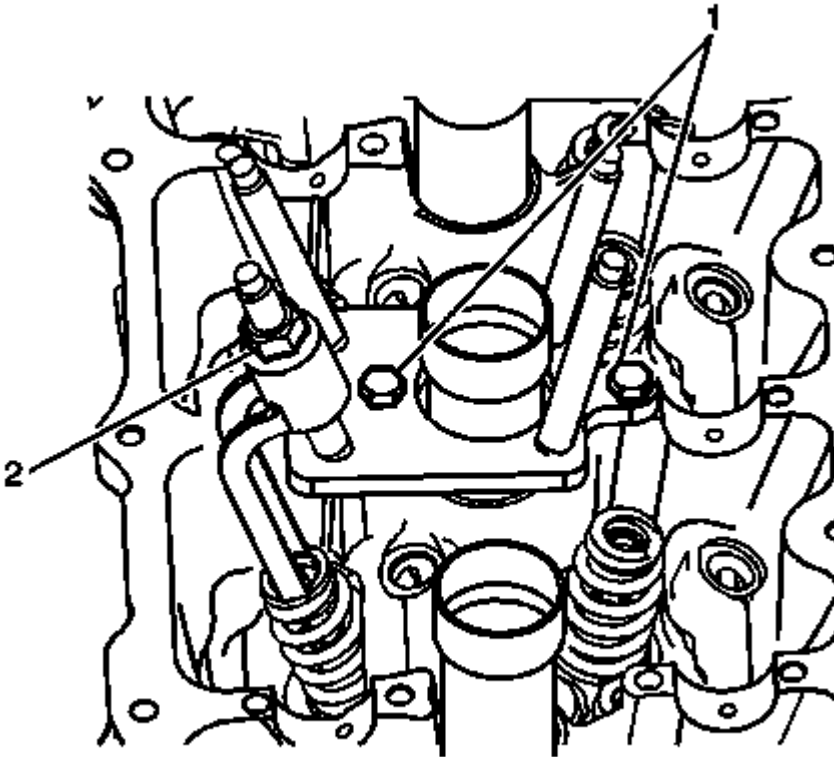


**Fig. 168: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

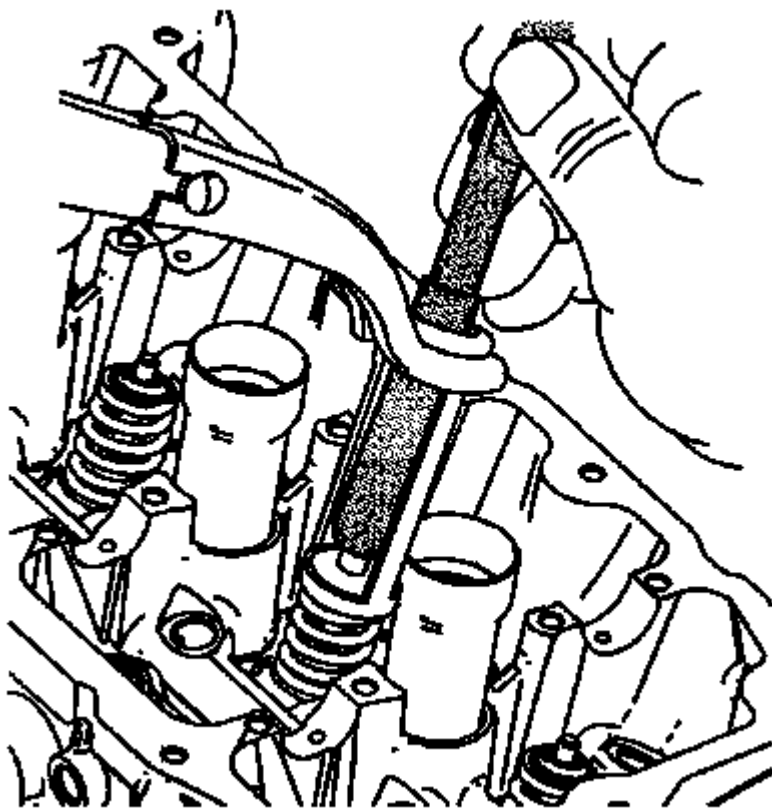
**IMPORTANT:** If the EN 46106 (1) is not installed, the crankshaft may rotate. See Special Tools . If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.

2. Install the EN 46106 (1) in order to prevent crankshaft rotation. See Special Tools .
3. Remove the camshafts and rocker arms. Refer to Camshaft Replacement - Left Side.
4. Remove the spark plug from the applicable cylinder. Refer to Spark Plug Replacement .
5. Install the J 39313 to the applicable cylinder. See Special Tools .
6. Connect the J 39313 to a compressed air source. See Special Tools .
7. Install the EN 46110 above the applicable cylinder. See Special Tools .



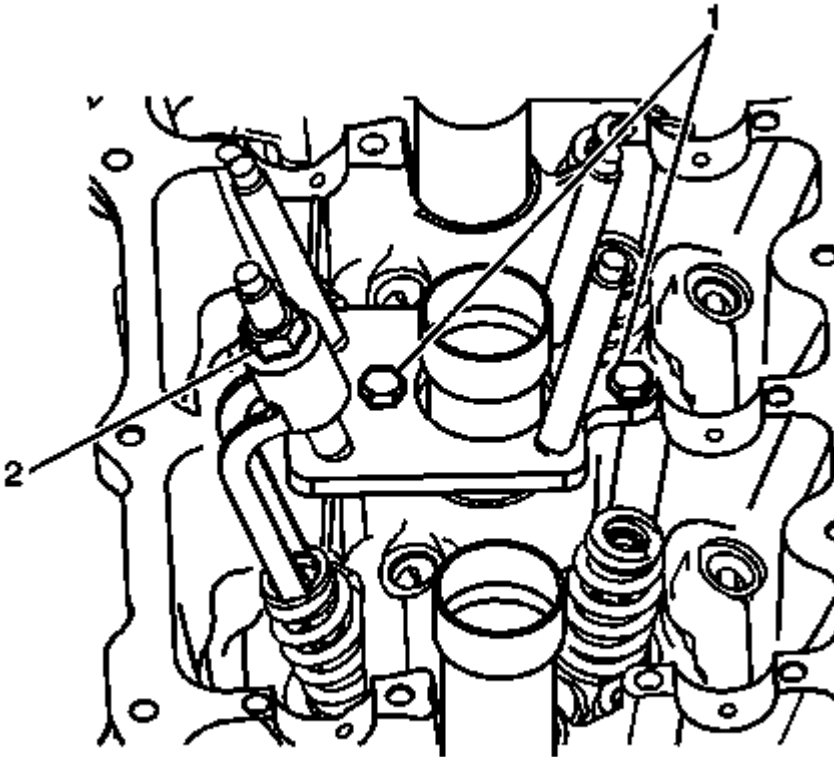
**Fig. 169: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
9. Tighten the **EN 46110** valve spring compressor nut (2). See **Special Tools** .



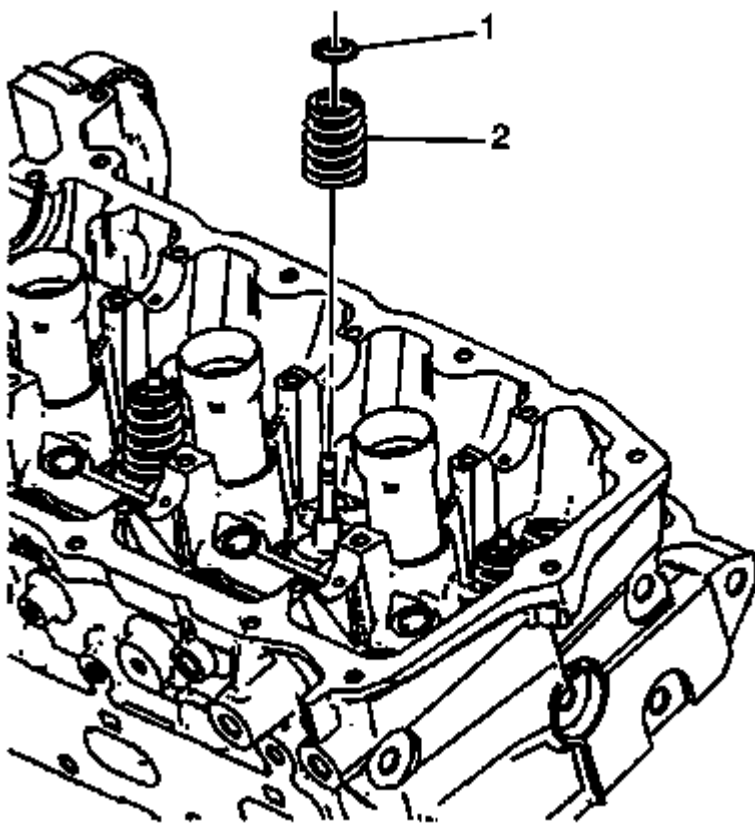
**Fig. 170: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve collets using the **EN 46117** . See **Special Tools** .



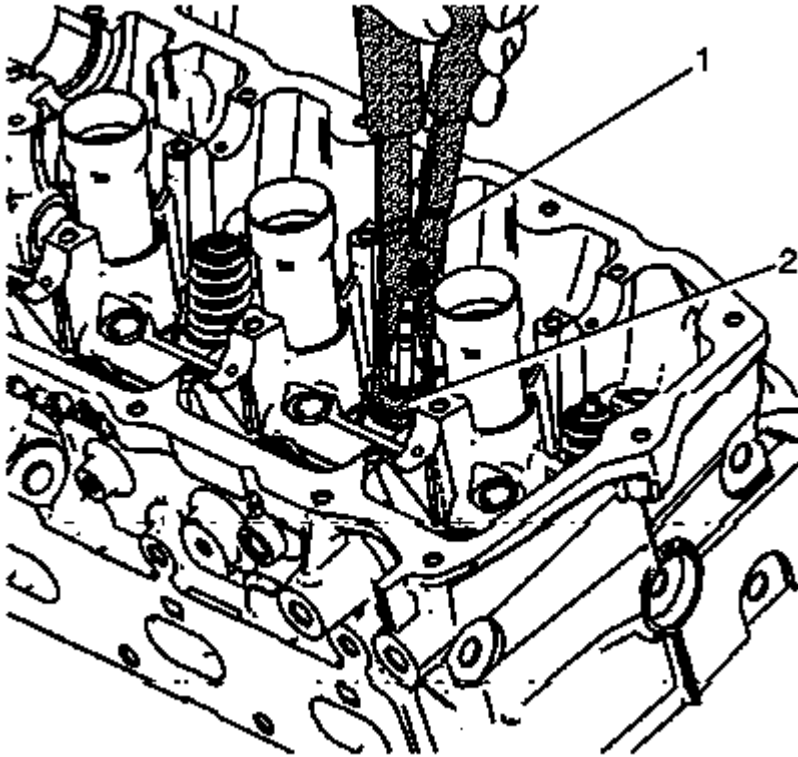
**Fig. 171: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

11. Loosen the **EN 46110** valve spring compressor nut (2). See **Special Tools** .
12. Remove the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
13. Remove the **EN 46110** . See **Special Tools** .



**Fig. 172: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

14. Remove the valve spring retainer (1).
15. Remove the valve spring (2).



**Fig. 173: View Of EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

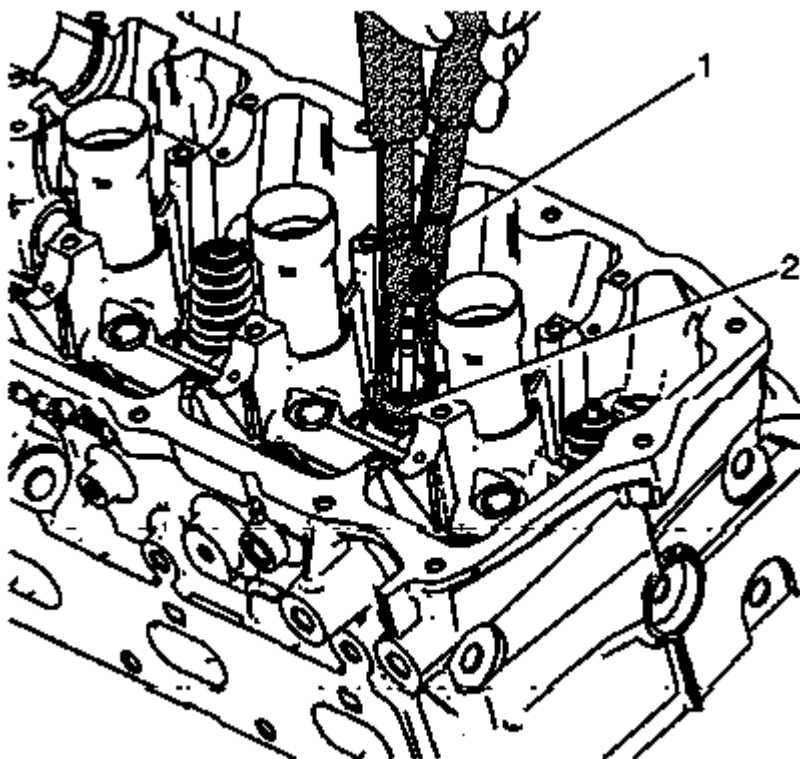
**IMPORTANT: NEVER reuse a valve stem oil seal.**

16. Remove the valve stem oil seal (2) using the EN 46116 (1). See **Special Tools** .

Discard the valve stem oil seals.

17. Repeat these procedures for the remaining valves.

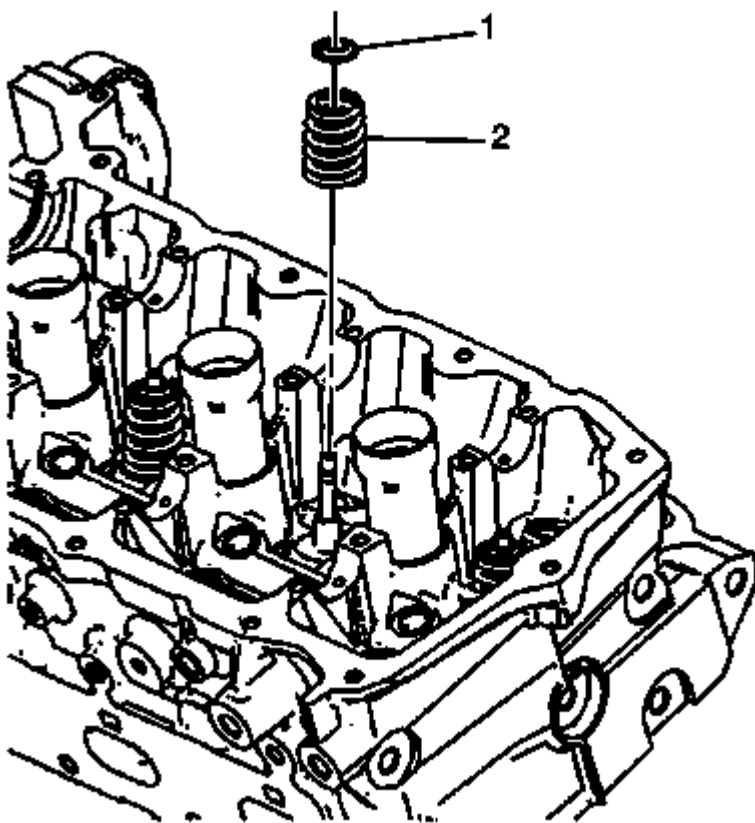
#### **Installation Procedure**



**Fig. 174: View Of EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

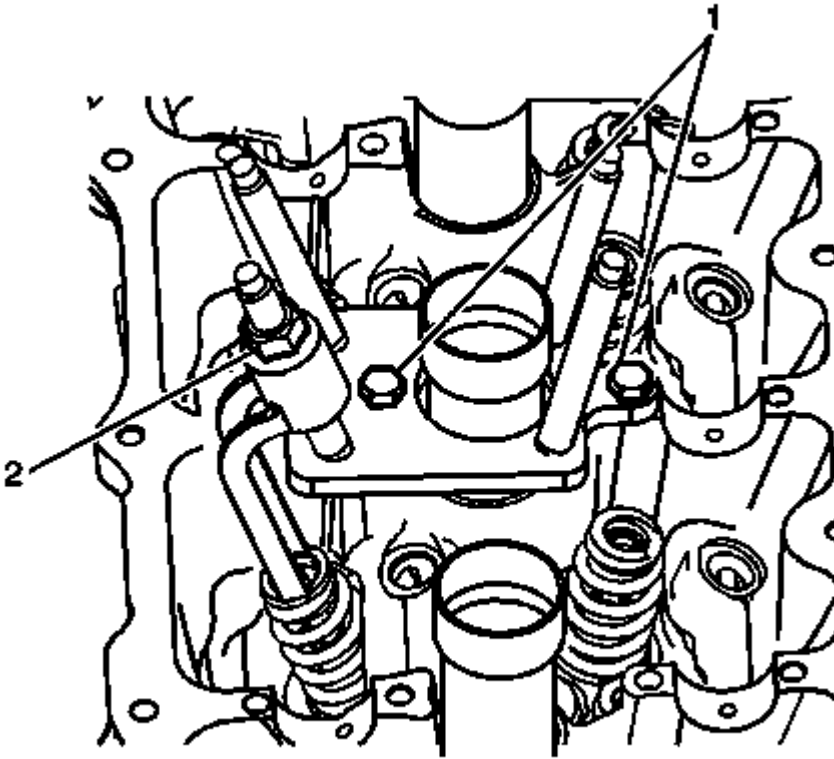
1. Use the EN 46116 (1) in order to install the NEW valve stem seal (2). See **Special Tools** .





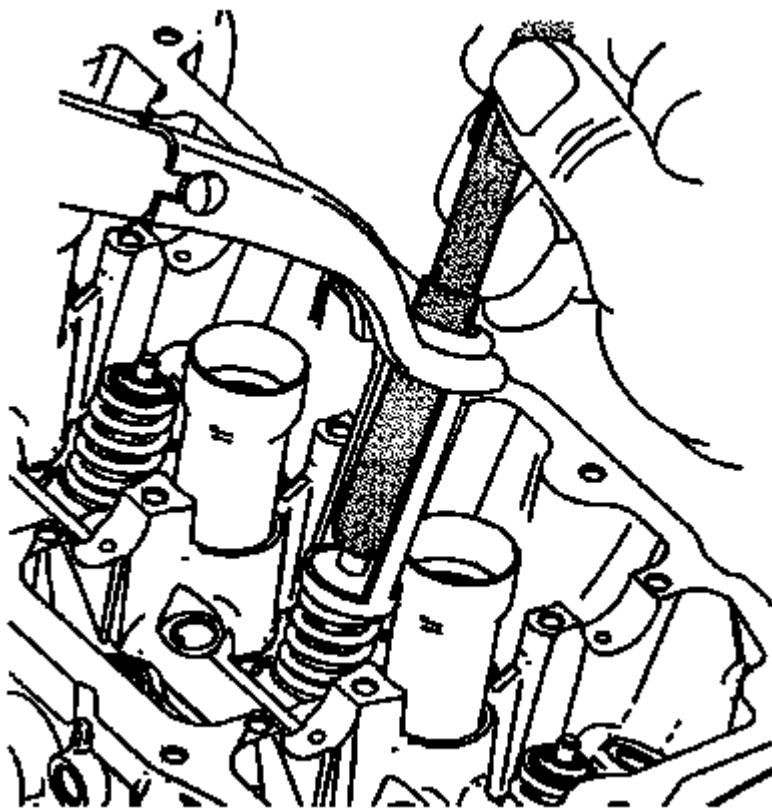
**Fig. 175: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (2).
3. Install the valve spring retainer (1).



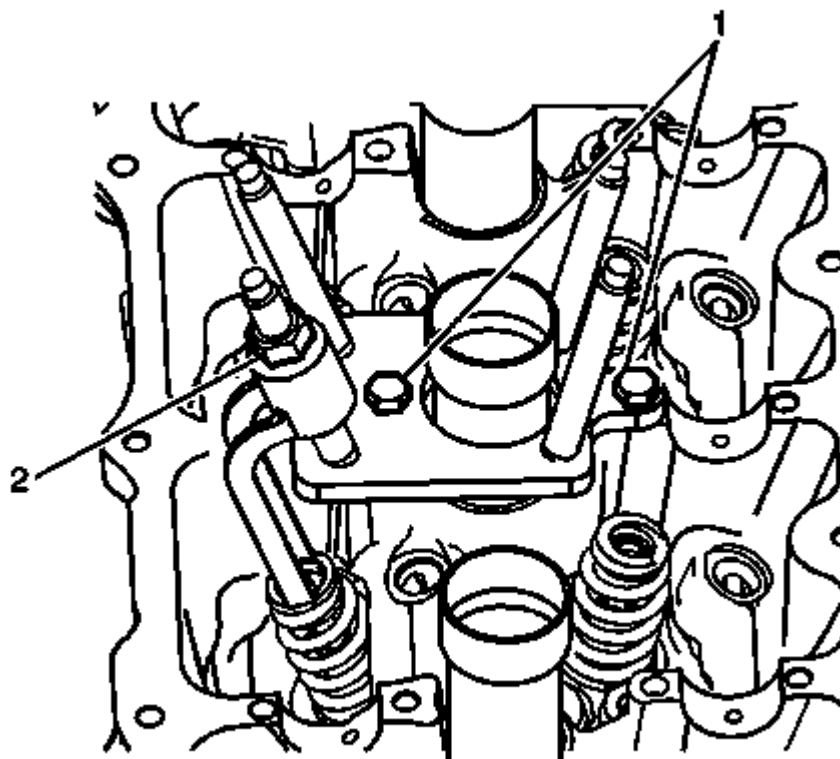
**Fig. 176: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46110** above the applicable valve spring. See **Special Tools** .
5. Install the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
6. Tighten the **EN 46110** valve spring compressor nut (2). See **Special Tools** .



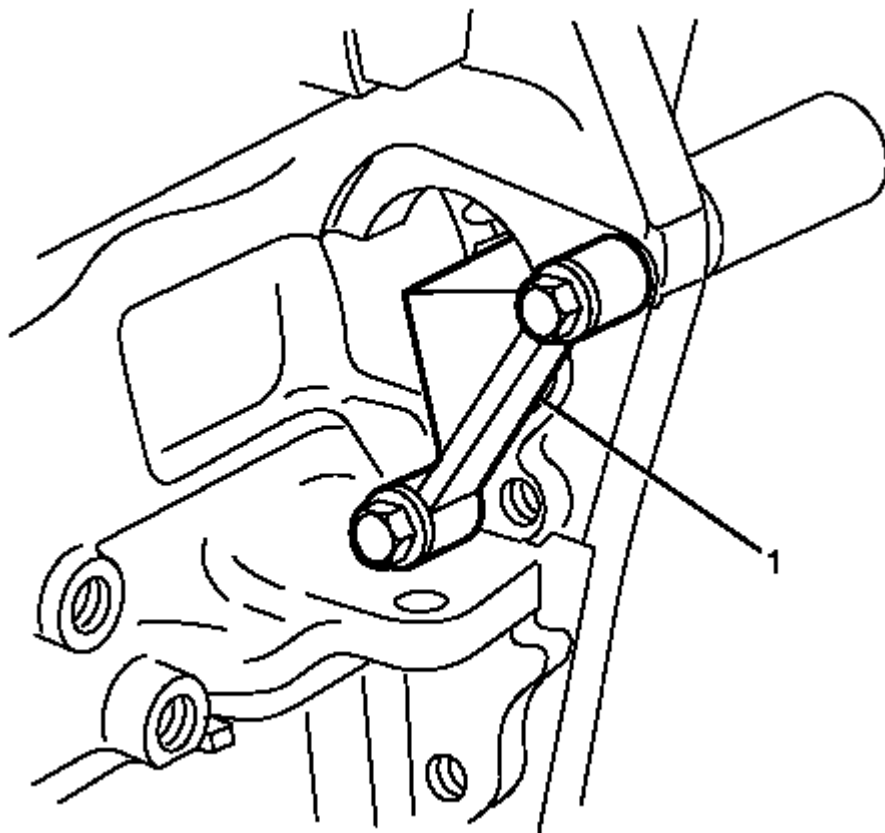
**Fig. 177: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

7. Install the valve collets using the EN 46117 (1). See **Special Tools** .



**Fig. 178: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

8. Loosen the **EN 46110** valve spring compressor nut (2). See **Special Tools** .
9. Remove the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
10. Remove the **EN 46110** . See **Special Tools** .
11. Disconnect the **J 39313** from the compressed air source. See **Special Tools** .
12. Remove the **J 39313** . See **Special Tools** .
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the rocker arms and camshafts. Refer to **Camshaft Replacement - Left Side**.



**Fig. 179: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

15. Remove the **EN 46106** (1). See **Special Tools** .
16. Install the starter motor. Refer to **Starter Replacement (3.6L)** .

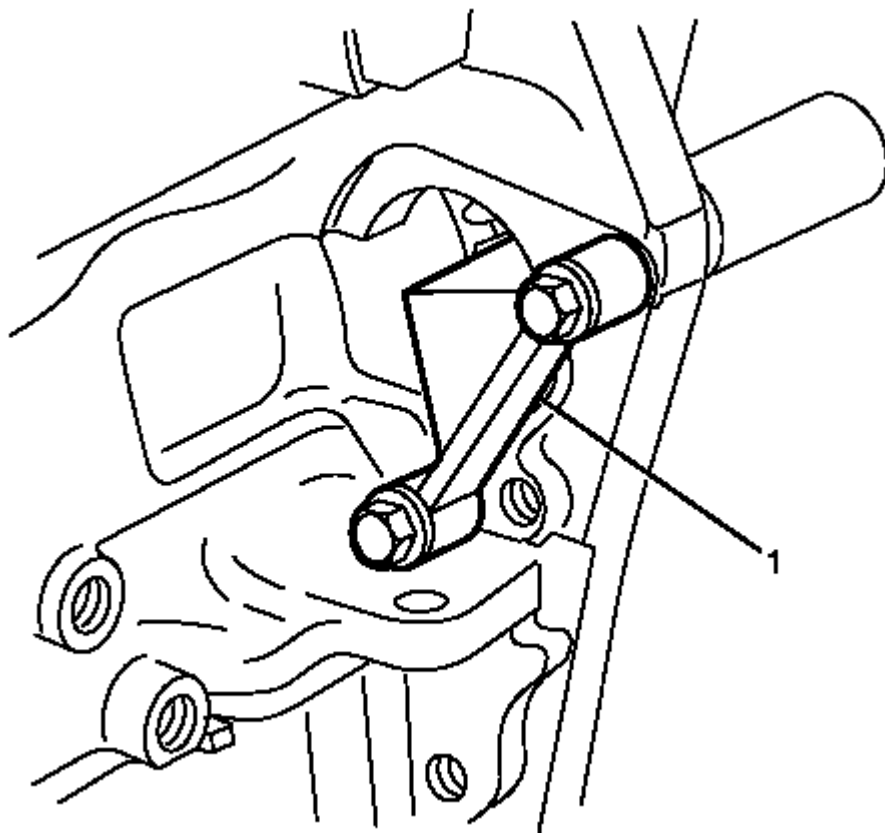
## VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - RIGHT SIDE

### Tools Required

- **EN 46106** 6 Flywheel Holding Tool. See **Special Tools** .
- **EN 46110** On-Vehicle Valve Spring Compressor. See **Special Tools** .
- **EN 46116** Valve Stem Seal Remover/Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .
- **EN 46117** Valve Collet Remover/Installer. See **Special Tools** .

### Removal Procedure

1. Remove the starter motor. Refer to **Starter Replacement (3.6L)** .

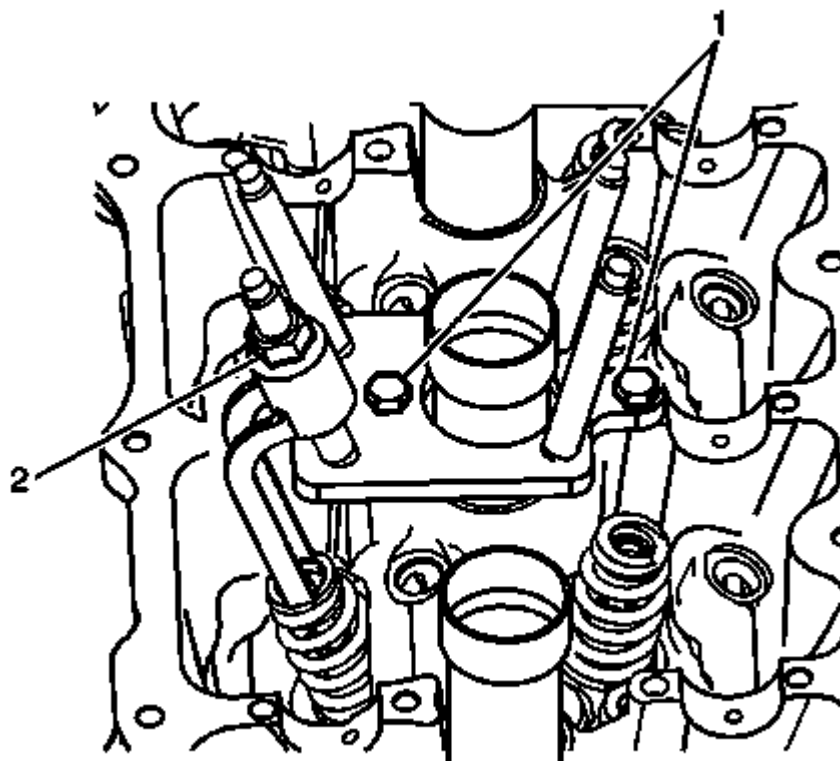


**Fig. 180: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

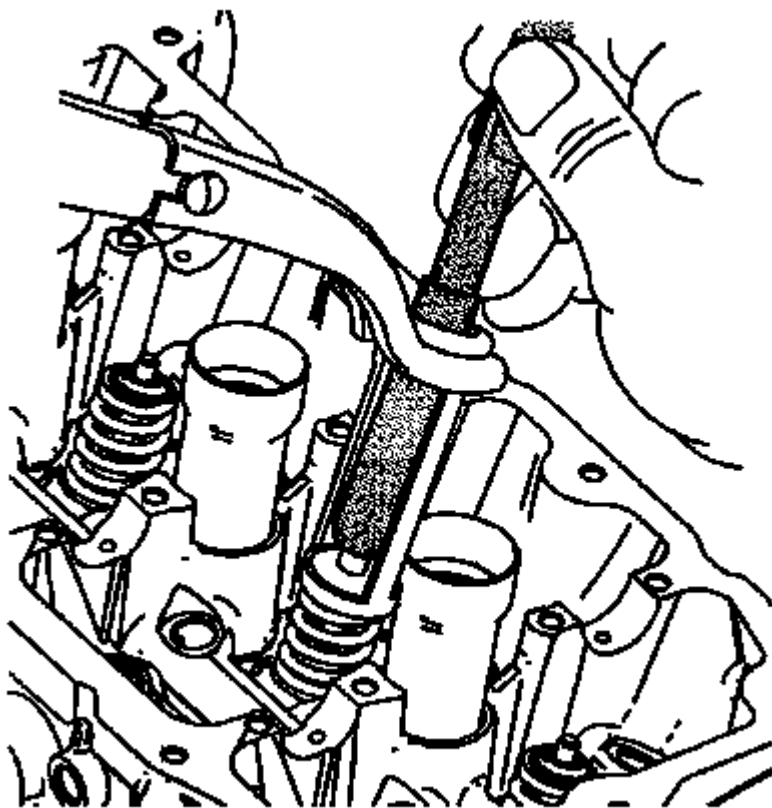
**IMPORTANT:** If the EN 46106 is not installed, the crankshaft may rotate. See Special Tools . If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.

2. Install the EN 46106 (1). See Special Tools .
3. Remove the camshafts and rocker arms. Refer to Camshaft Replacement - Left Side.
4. Remove the spark plug from the applicable cylinder. Refer to Spark Plug Replacement .
5. Install the J 39313 to the applicable cylinder. See Special Tools .
6. Connect the J 39313 to a compressed air source. See Special Tools .
7. Install the EN 46110 above the applicable cylinder. See Special Tools .



**Fig. 181: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

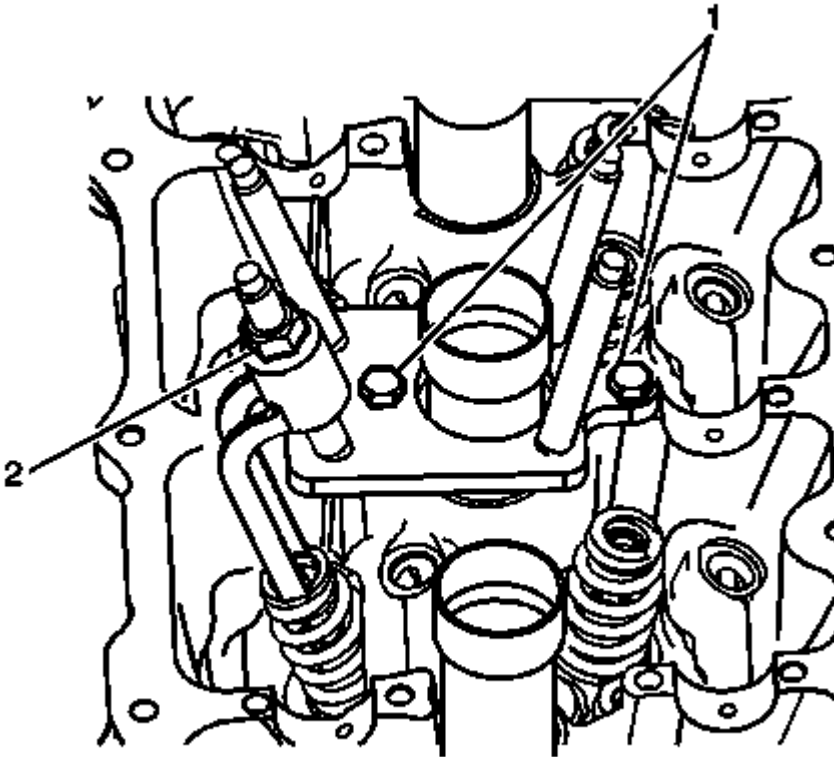
8. Install the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
9. Tighten the **EN 46110** valve spring compressor nut (2). See **Special Tools** .



**Fig. 182: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

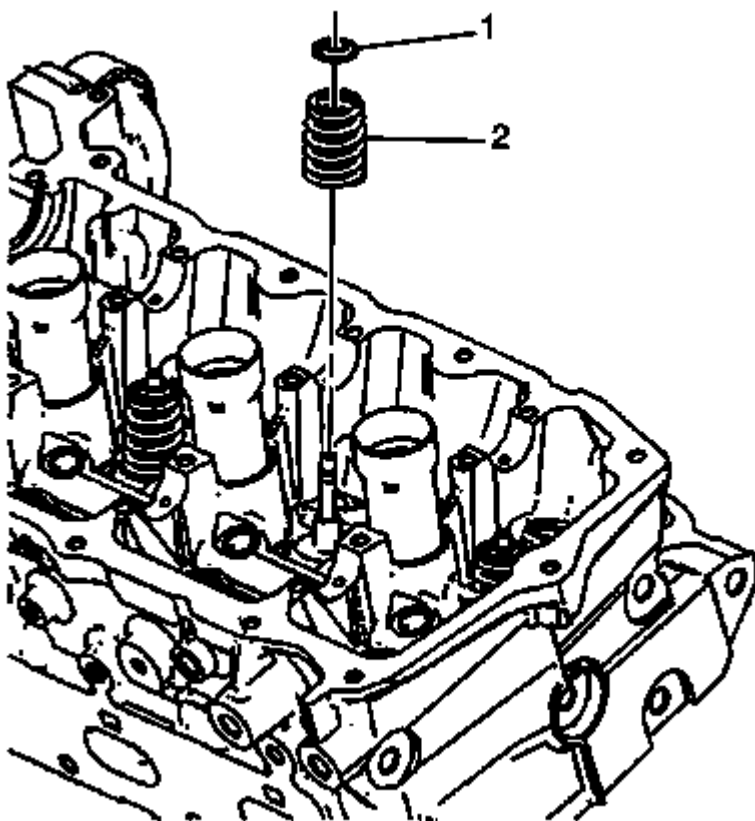
10. Remove the valve collets using the **EN 46117** . See **Special Tools** .





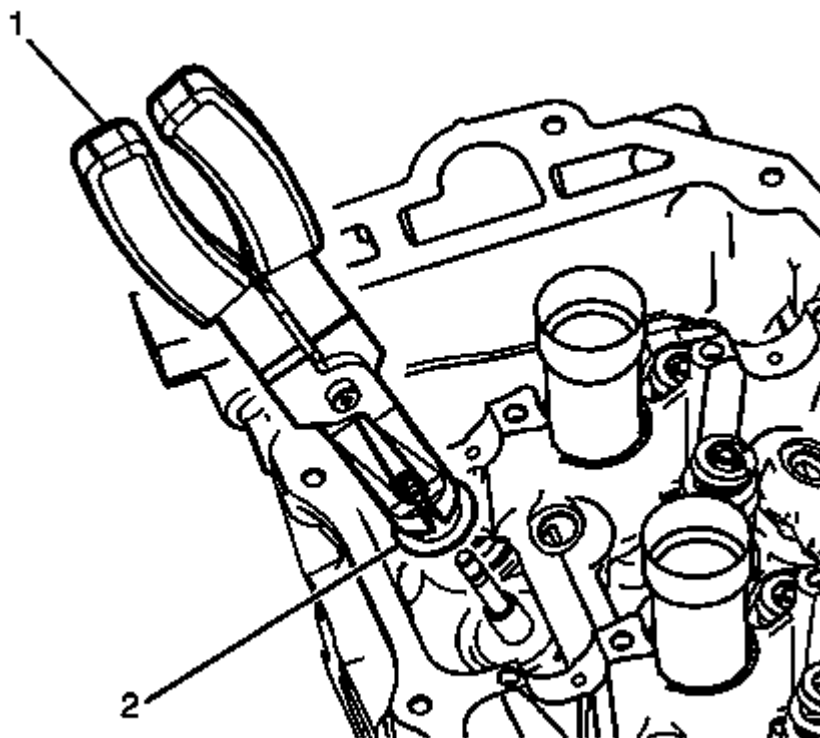
**Fig. 183: View Of EN 46110 Valve Spring Compressor Nut**  
 Courtesy of GENERAL MOTORS CORP.

11. Loosen the **EN 46110** valve spring compressor nut (2). See **Special Tools** .
12. Remove the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
13. Remove the **EN 46110** . See **Special Tools** .



**Fig. 184: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

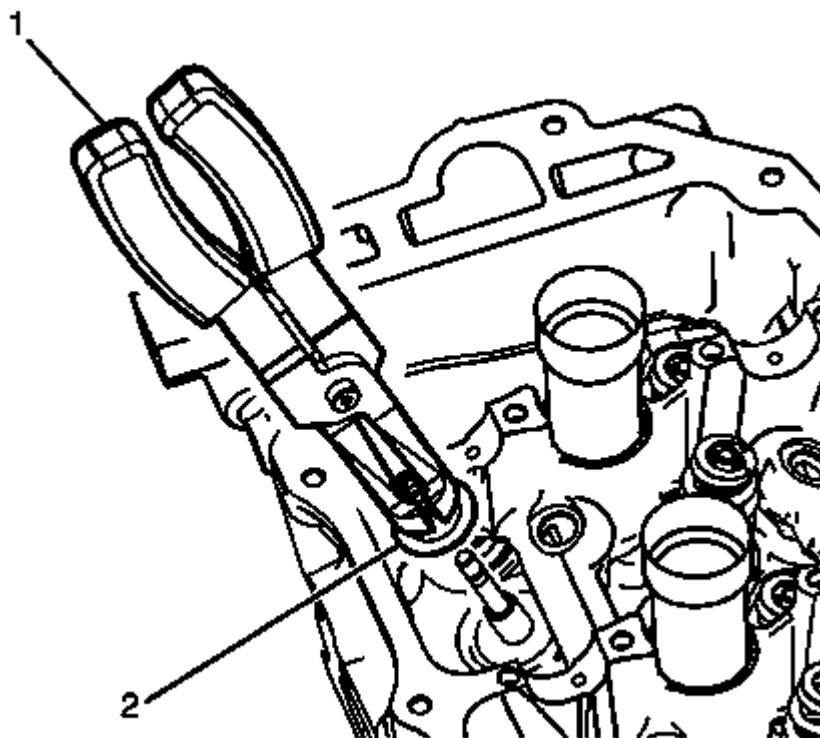
14. Remove the valve spring retainer (1).
15. Remove the valve spring (2).



**Fig. 185: Identifying EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

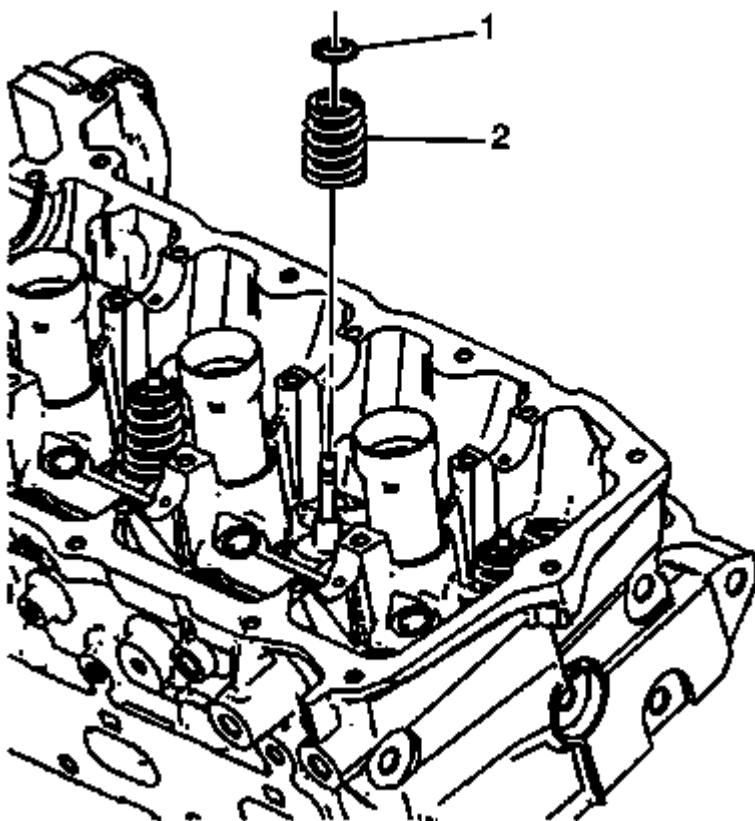
16. Use the EN 46116 (1) in order to remove the valve stem seal (2). See **Special Tools** .

#### **Installation Procedure**



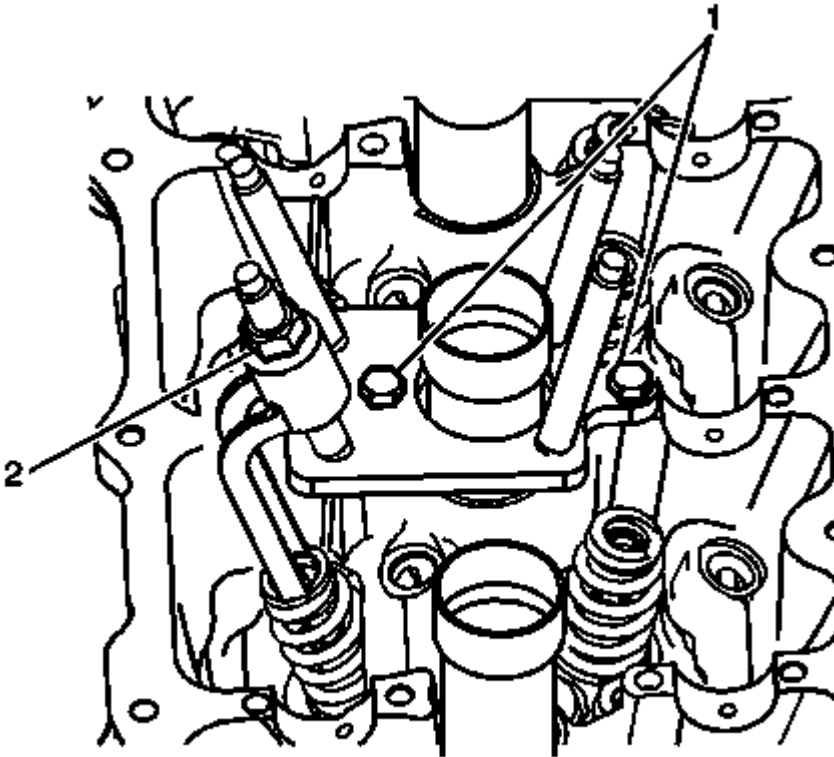
**Fig. 186: Identifying EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Use the EN 46116 (1) in order to install the valve stem seal (2). See **Special Tools** .



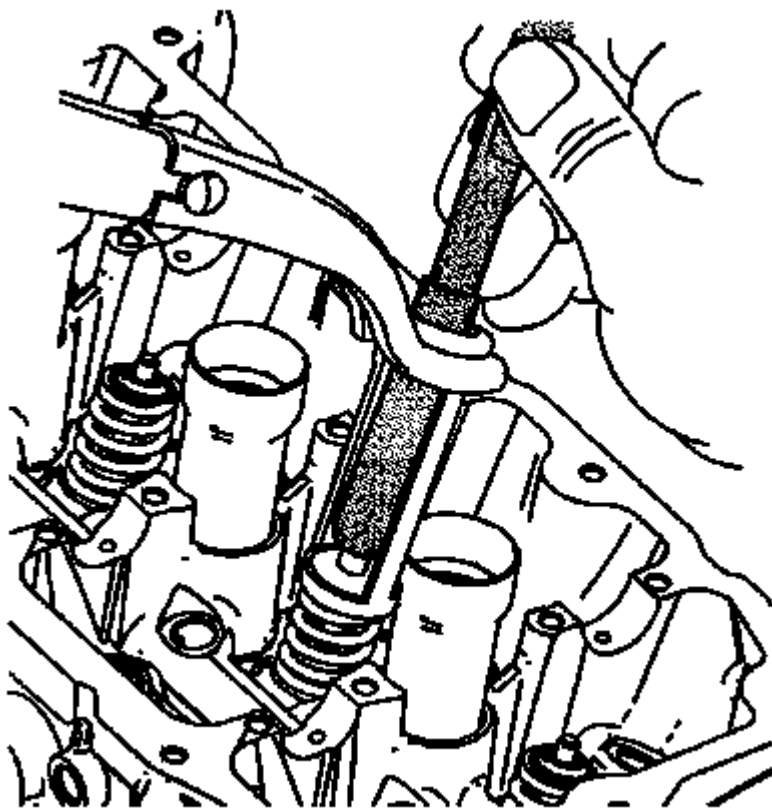
**Fig. 187: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (2).
3. Install the valve spring retainer (1).



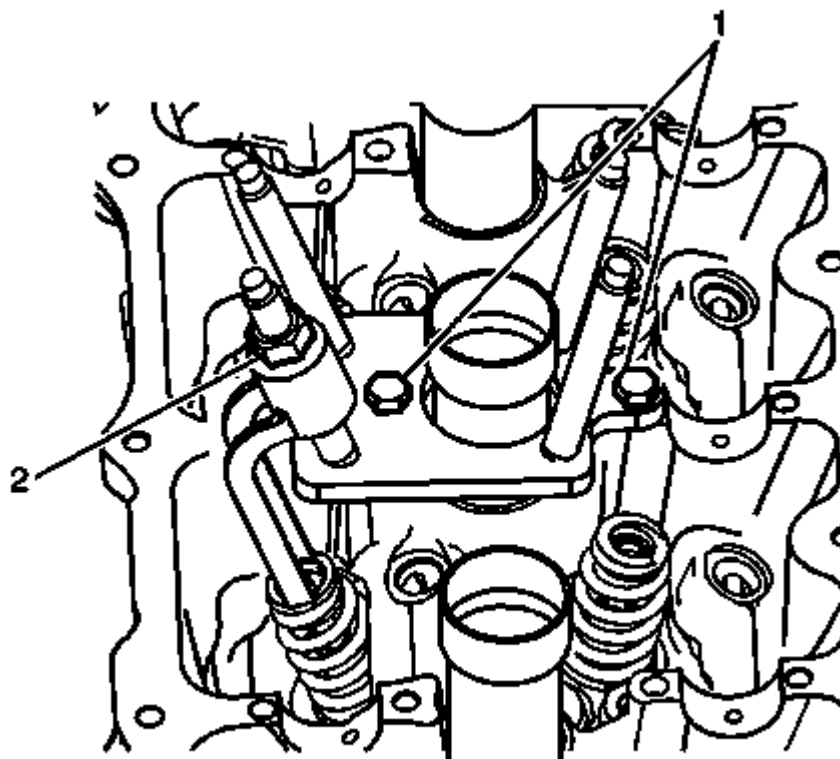
**Fig. 188: View Of EN 46110 Valve Spring Compressor Nut**  
Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46110** above the applicable valve spring. See **Special Tools** .
5. Install the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
6. Tighten the **EN 46110** valve spring compressor nut (2). See **Special Tools** .



**Fig. 189: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

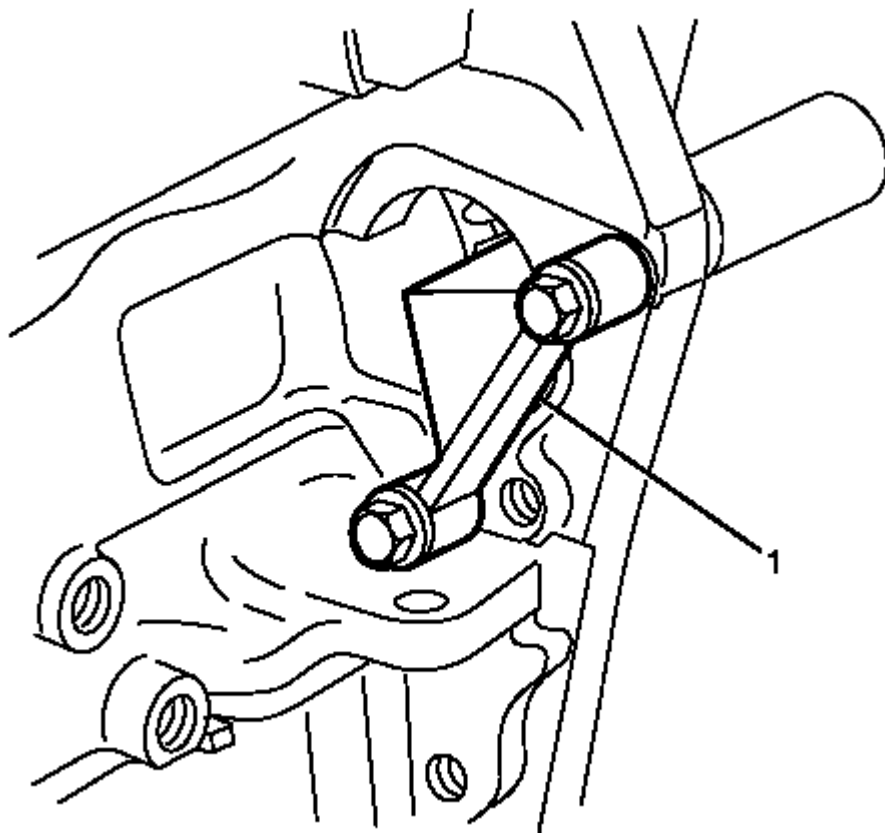
7. Install the valve collets using the EN 46117 . See **Special Tools** .



**Fig. 190: View Of EN 46110 Valve Spring Compressor Nut**  
 Courtesy of GENERAL MOTORS CORP.

8. Loosen the **EN 46110** valve spring compressor nut (2). See **Special Tools** .
9. Remove the **EN 46110** to cylinder head retaining bolts (1). See **Special Tools** .
10. Remove the **EN 46110** . See **Special Tools** .
11. Disconnect the **J 39313** from the compressed air source. See **Special Tools** .
12. Remove the **J 39313** . See **Special Tools** .
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the rocker arms and camshafts. Refer to **Camshaft Replacement - Left Side**.





**Fig. 191: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

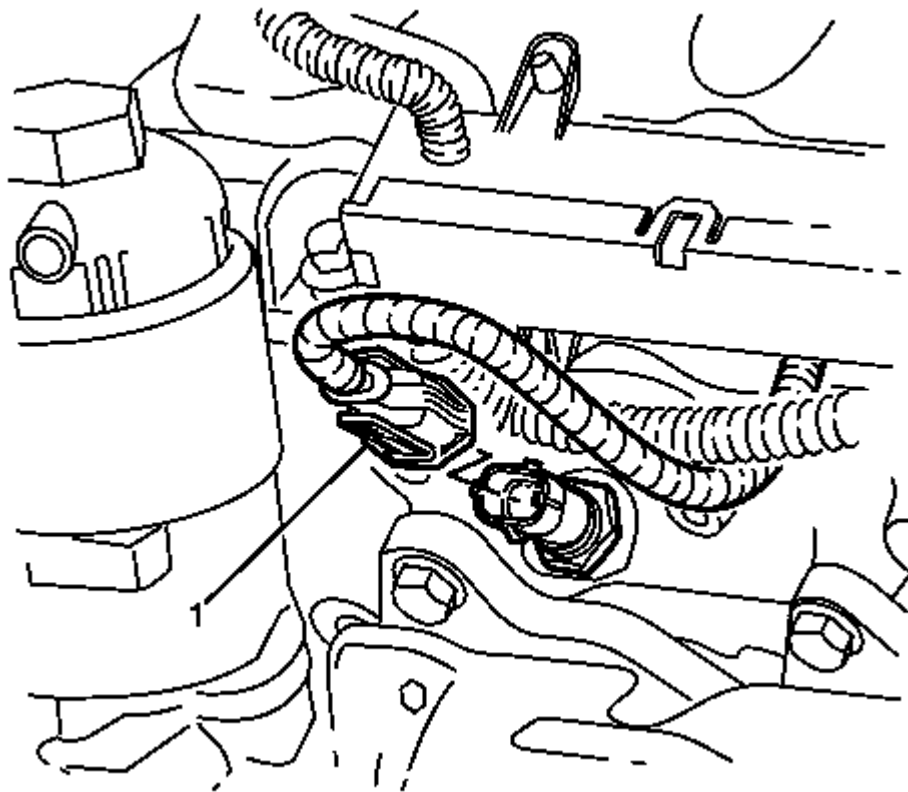
15. Remove the **EN 46106 (1)**. See **Special Tools** .
16. Install the starter motor. Refer to **Starter Replacement (3.6L)** .

## CYLINDER HEAD REPLACEMENT - LEFT SIDE

### Removal Procedure

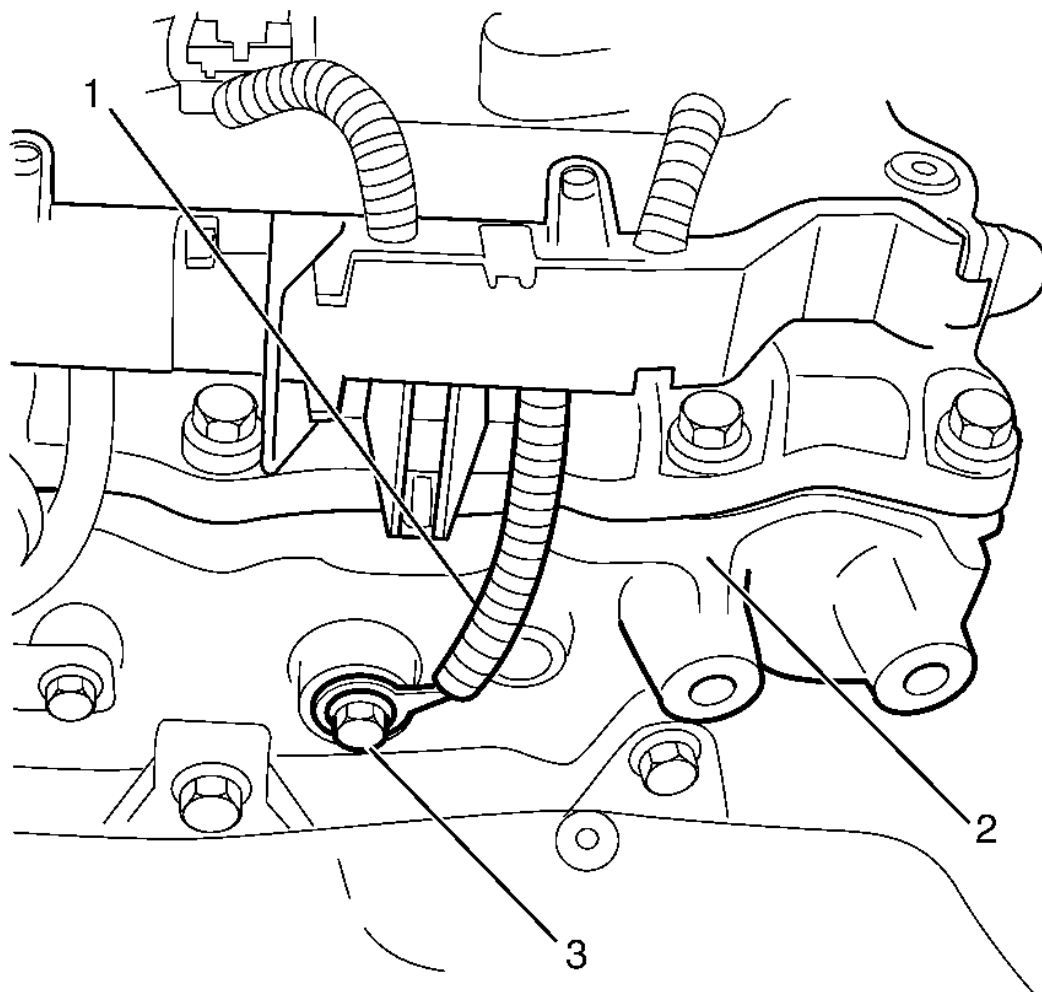
**WARNING:** Refer to **Battery Disconnect Warning** .

1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the engine covers. Refer to **Engine Cover Replacement**.
3. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
4. Remove the left bank secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side**.
5. Remove the oil level indicator. Refer to **Oil Level Indicator Tube Replacement**.



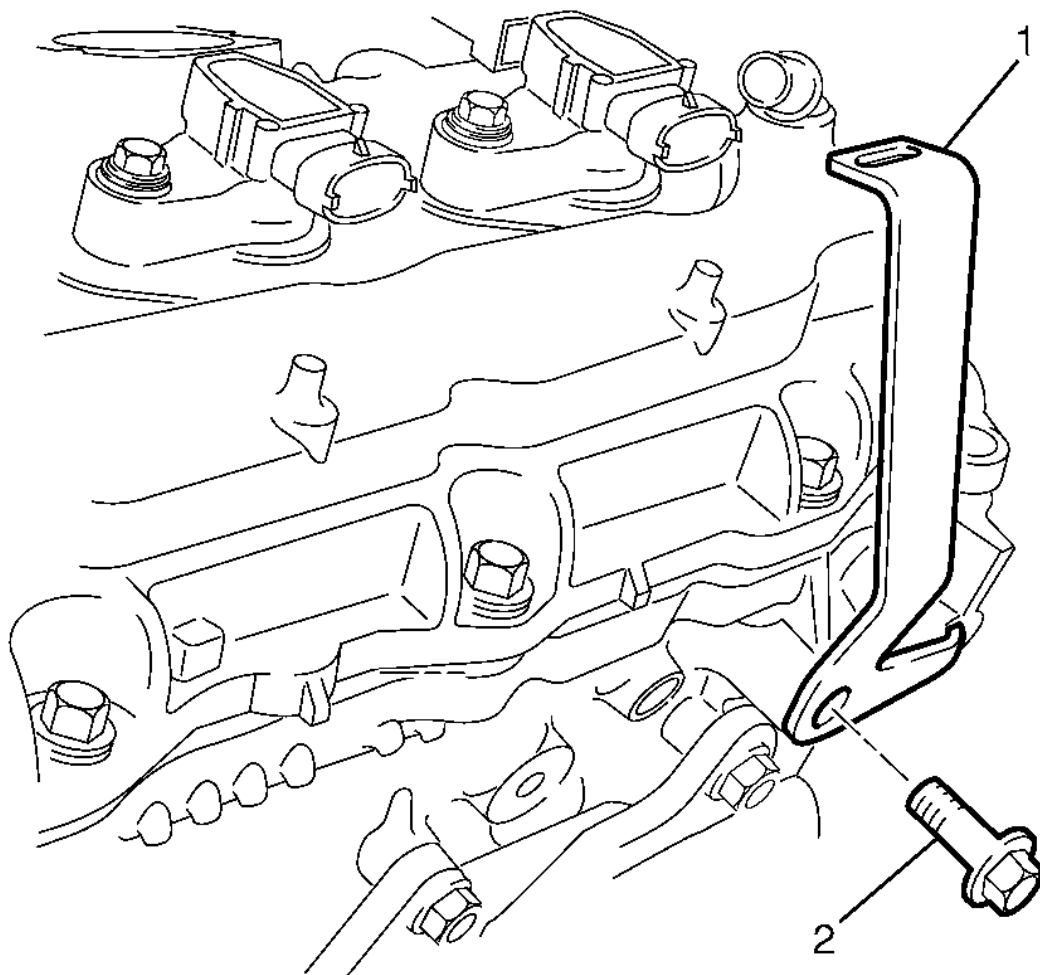
**Fig. 192: Identifying Coolant Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the coolant temperature sensor electrical connector (1).



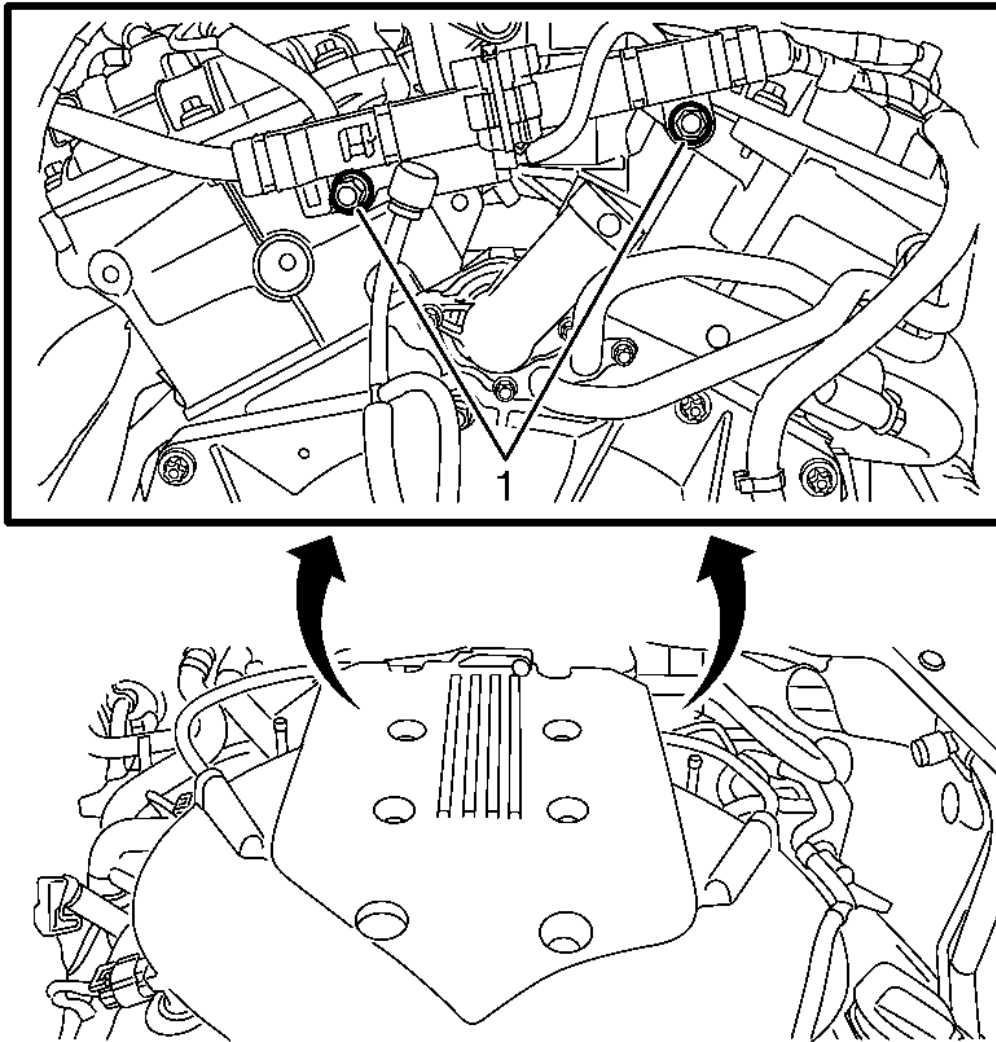
**Fig. 193: Identifying Wiring Harness Ground To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the wiring harness ground to cylinder head retaining bolt (3).
8. Remove the wiring harness ground (1) from the cylinder head (2).
9. Remove the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.



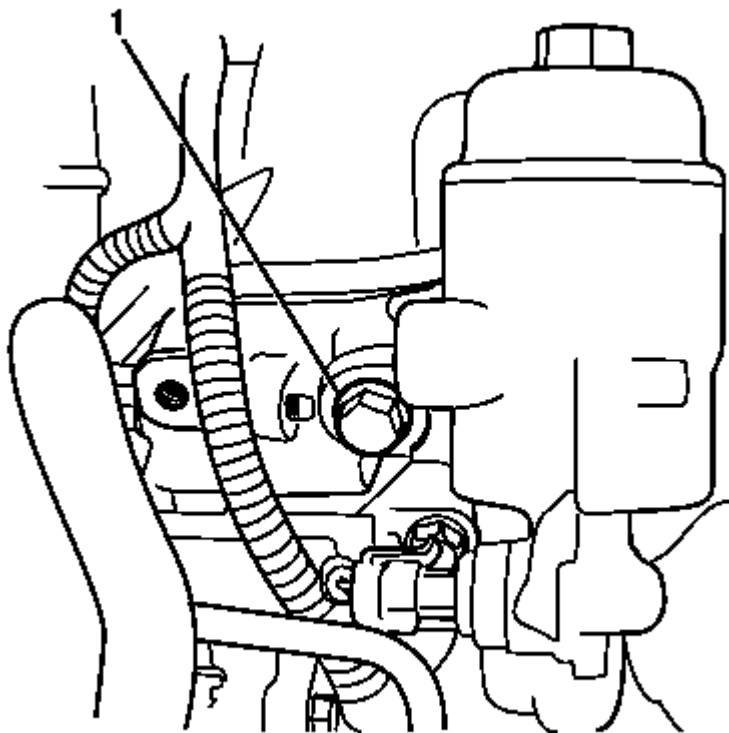
**Fig. 194: Identifying Left Engine Cover Mounting Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the left engine cover mounting bracket to cylinder head retaining bolt (2).
11. Remove the left engine cover mounting bracket (2) from the cylinder head.



**Fig. 195: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

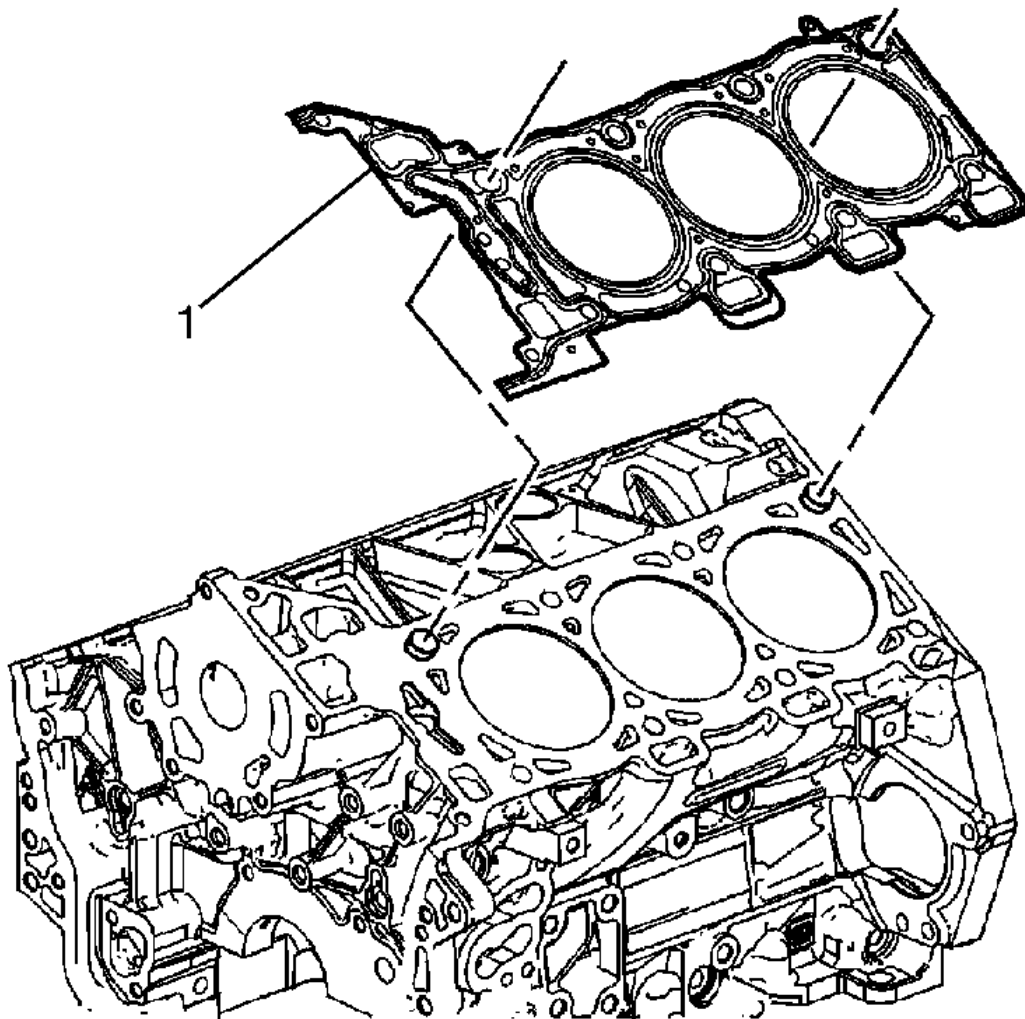
12. Remove the engine wiring harness bracket to cylinder head retaining bolts (1).
13. Remove the catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (V6)** .



**Fig. 196: Identifying Oil Filter Adapter Upper Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT remove the oil filter adapter.**

14. Remove the oil filter adapter upper bolt (1).
15. Remove the cylinder head with the exhaust manifold. Refer to Cylinder Head Removal - Left Side .



**Fig. 197: View Of Left Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Cylinder head gaskets must be discarded whenever the cylinder head has been removed from the cylinder block.

16. Remove the cylinder head gasket (1).

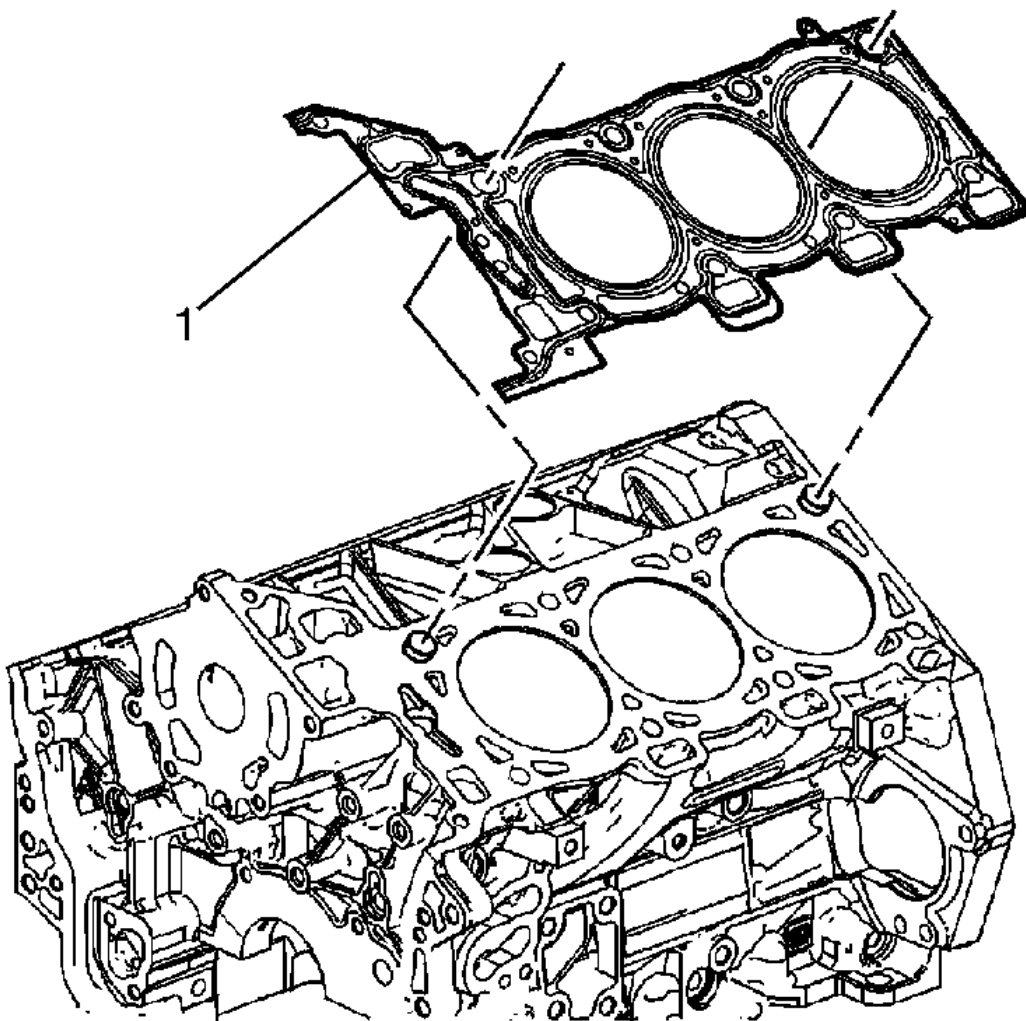
Discard the gasket.

17. Clean and inspect the cylinder head and the cylinder block sealing surfaces. Refer to Cylinder Head Cleaning and Inspection and Engine Block Cleaning and Inspection.
18. If necessary, perform the following steps:

- Remove the exhaust manifold from the cylinder head. Refer to [Exhaust Manifold Removal - Left Side](#).
- Disassemble the cylinder head. Refer to [Cylinder Head Disassemble](#).

#### Installation Procedure

1. If necessary, perform the following steps:
  - Assemble the cylinder head. Refer to [Cylinder Head Assemble](#).
  - Install the exhaust manifold to the cylinder head. Refer to [Exhaust Manifold Installation - Left Side](#).

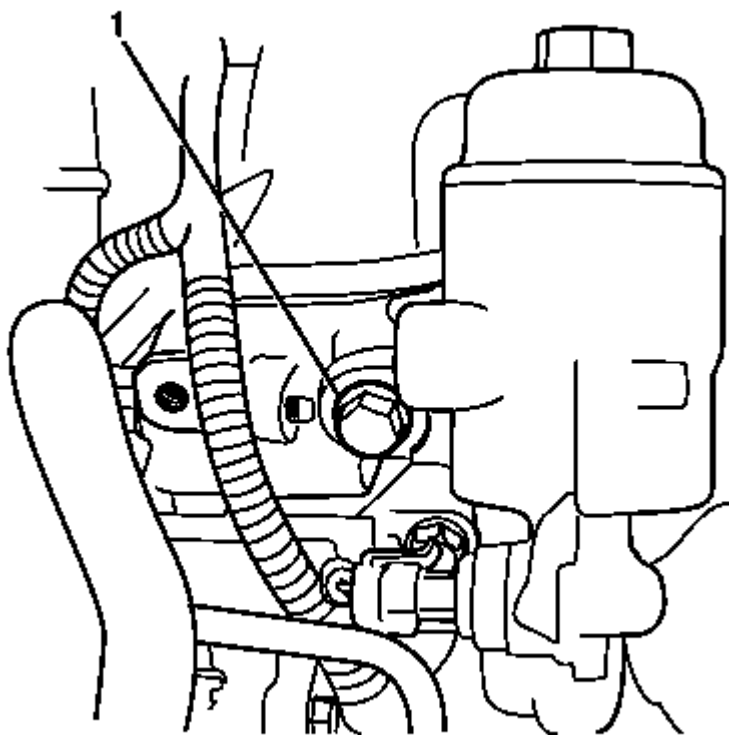


**Fig. 198: View Of Left Cylinder Head Gasket**



Courtesy of GENERAL MOTORS CORP.

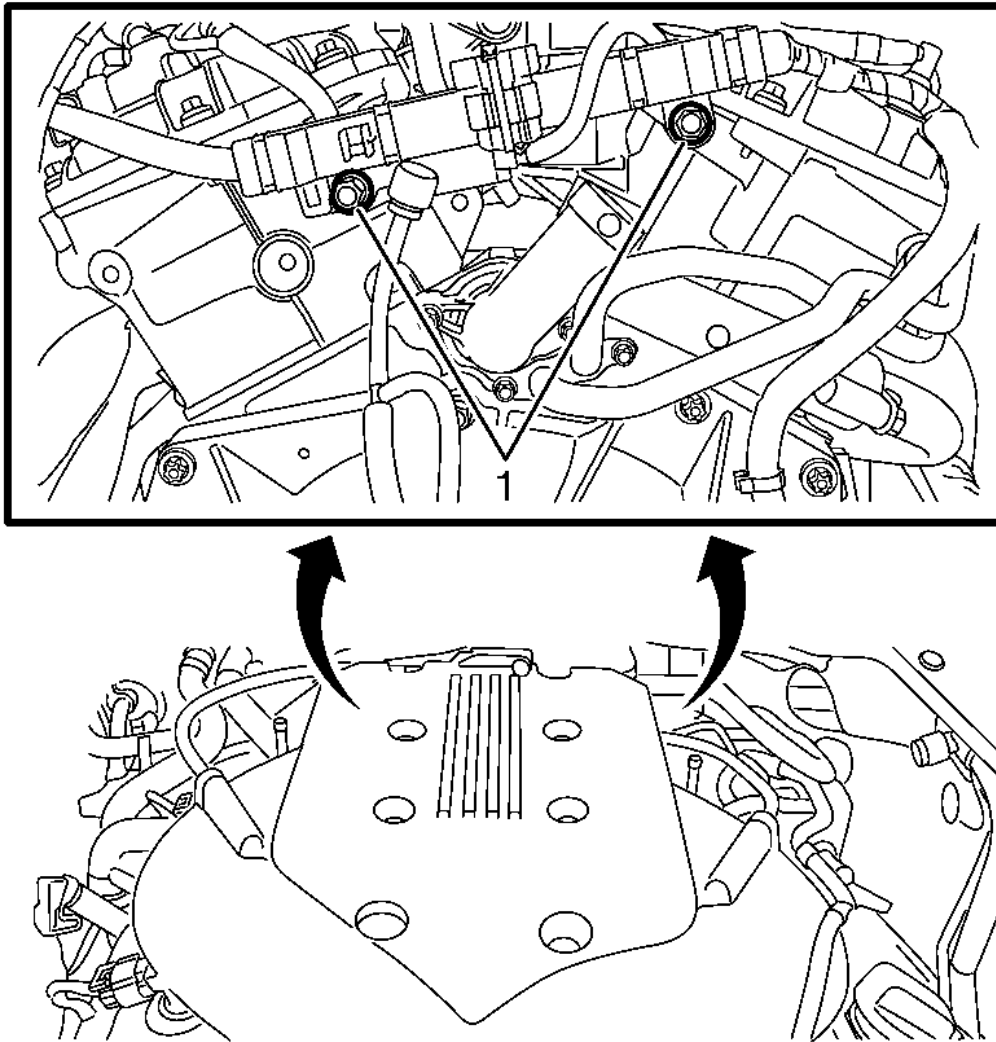
2. Install a NEW cylinder head gasket (1).
3. Install the cylinder head with the exhaust manifold to the engine. Refer to **Cylinder Head Installation - Left Side** .



**Fig. 199: Identifying Oil Filter Adapter Upper Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

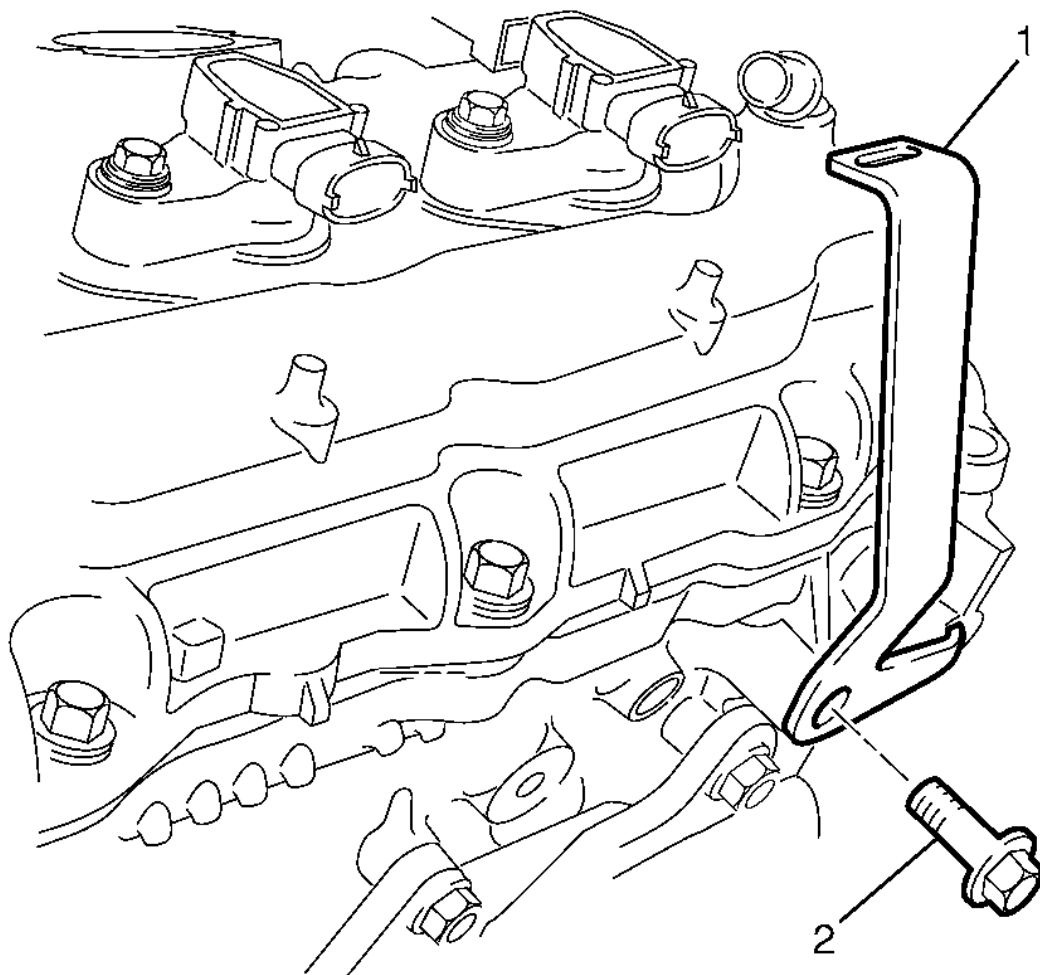
**CAUTION:** Refer to **Fastener Caution** .

4. Install the oil filter adapter upper retaining bolt (1) and tighten to 65 N.m (48 lb in).
5. Install the catalytic converter to the exhaust manifold. Refer to **Catalytic Converter Replacement - Left Side (V6)** .



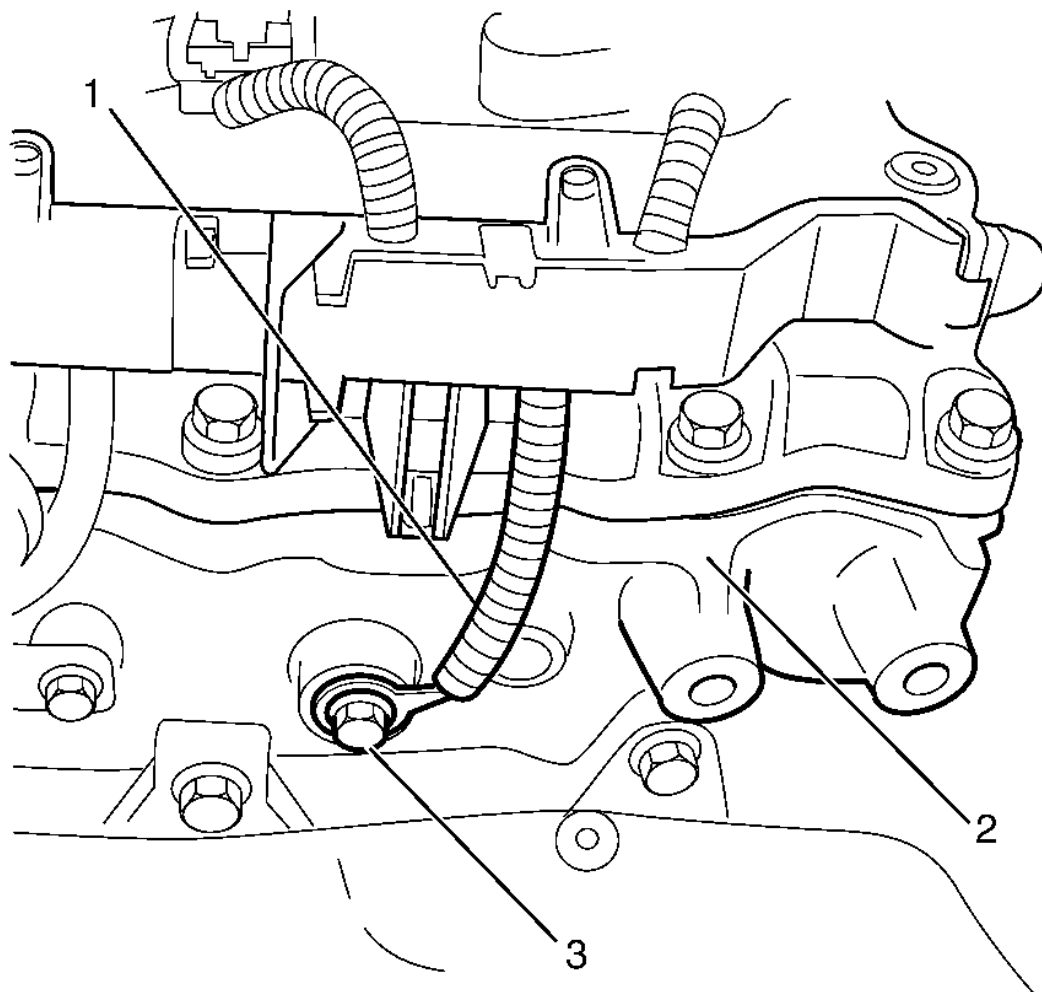
**Fig. 200: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Install the wiring harness bracket (2) to the rear of the cylinder head (3).
7. Install the wiring harness bracket using the cylinder head retaining bolts (1) and tighten to 10 N.m (89 lb in).



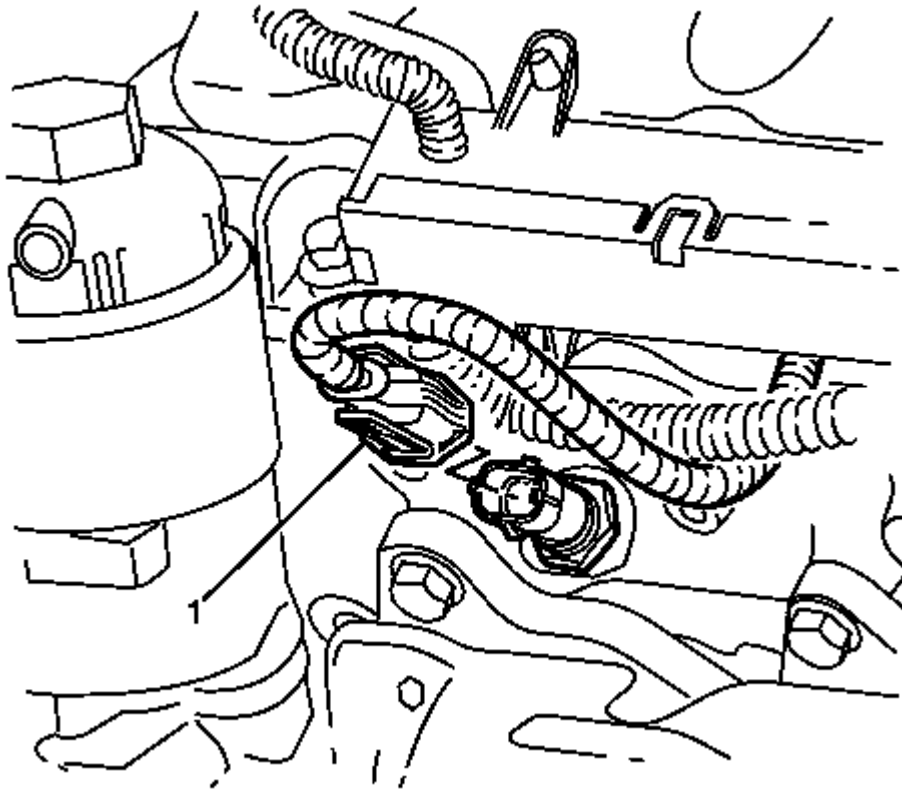
**Fig. 201: Identifying Left Engine Cover Mounting Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

8. Install the left engine cover mounting bracket (2) to the cylinder head.
9. Install the left engine cover mounting bracket using the cylinder head retaining bolt (2) and tighten to 35 N.m (26 lb in).
10. Install the left engine cover mounting bracket to cylinder head retaining bolt (2).
11. Install the upper intake manifold with the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.



**Fig. 202: Identifying Wiring Harness Ground To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

12. Install the wiring harness ground (1) to the cylinder head (2).
13. Install the wiring harness ground to the cylinder head retaining bolt (3) and tighten to 10 N.m (89 lb in).



**Fig. 203: Identifying Coolant Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

14. Connect the coolant temperature sensor electrical connector (1).
15. Install the oil level indicator. Refer to **Oil Level Indicator Tube Replacement**.
16. Install the left bank secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side**.
17. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
18. Install the engine covers. Refer to **Engine Cover Replacement**.
19. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection**.

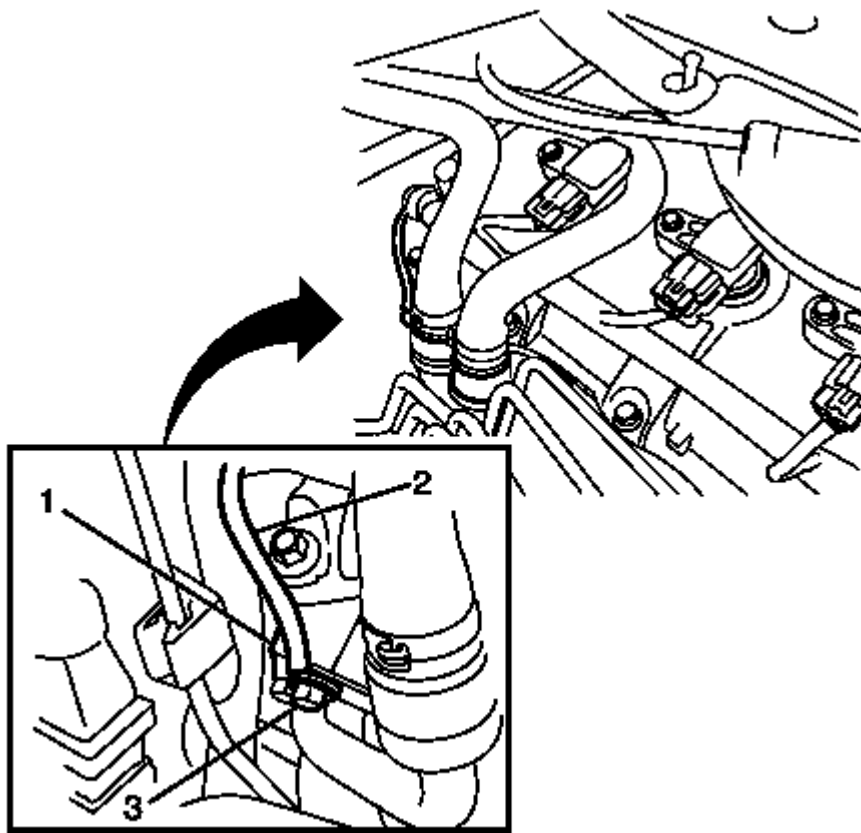
## **CYLINDER HEAD REPLACEMENT - RIGHT SIDE**

### **Removal Procedure**

**WARNING:** Refer to **Battery Disconnect Warning**.

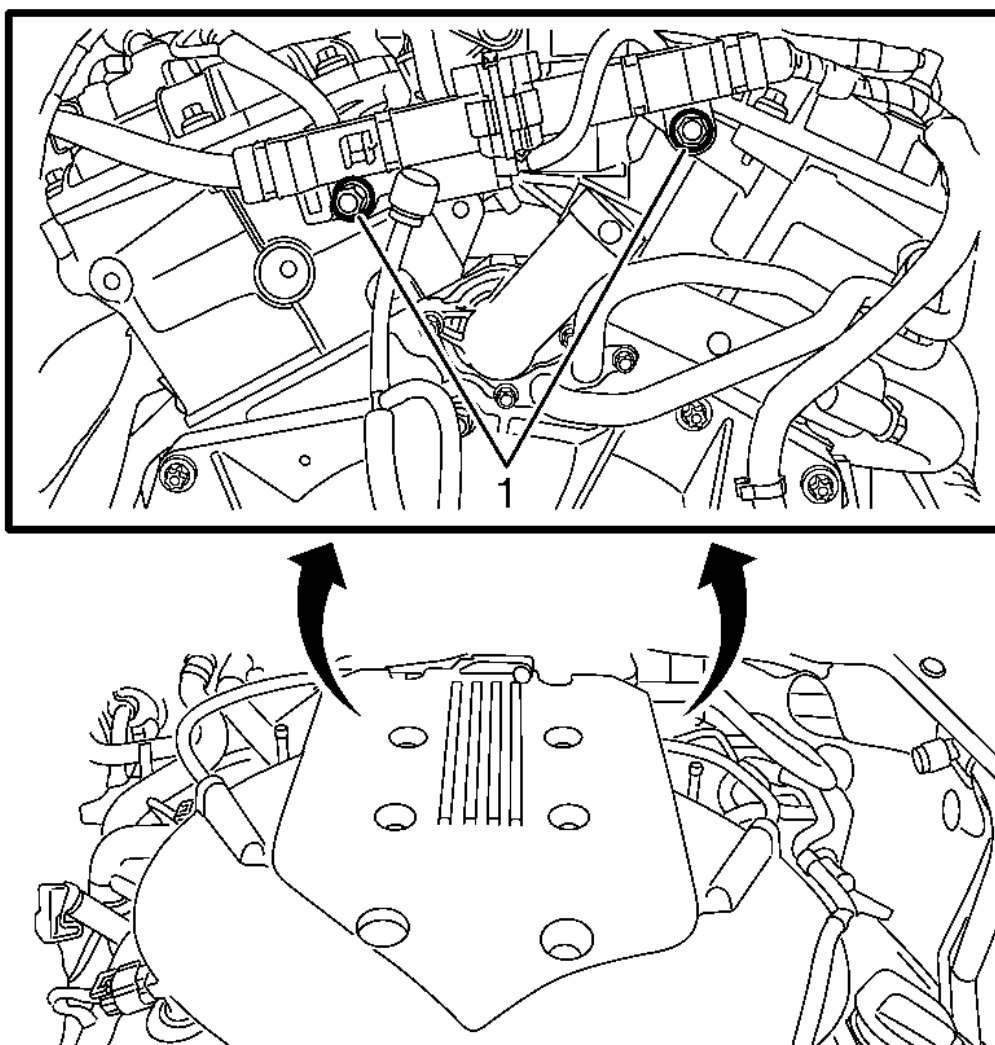
1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Remove the engine covers. Refer to **Engine Cover Replacement**.

3. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side.**
4. Remove the left bank secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Left Side.**



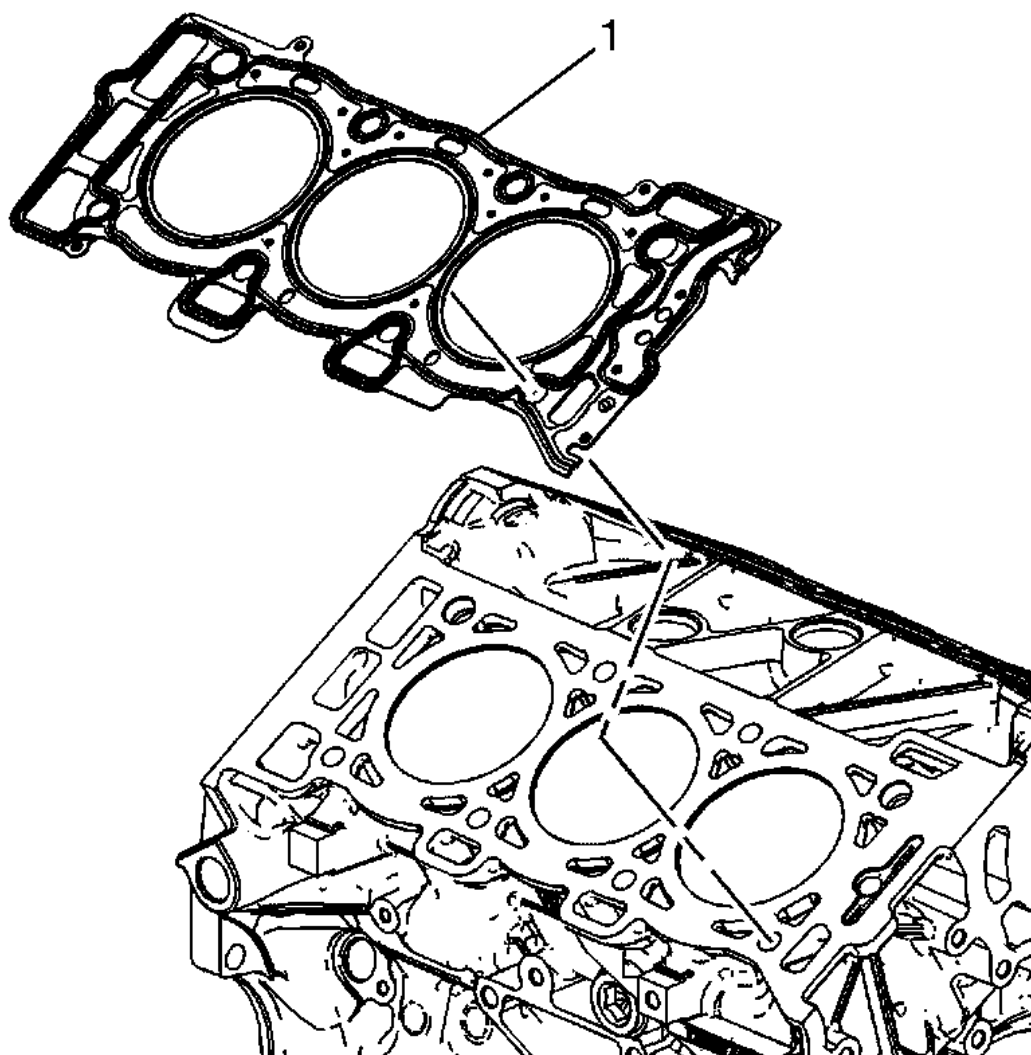
**Fig. 204: Identifying Wiring Harness Ground To Right Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the wiring harness ground to cylinder head retaining bolts (1).
6. Remove the wiring harness ground (2) from the side of the cylinder head (3).
7. Remove the coolant inlet pipe. Refer to **Engine Coolant Inlet Pipe Replacement .**



**Fig. 205: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine wiring harness bracket to cylinder head retaining bolts (1).
9. Remove the catalytic converter. Refer to **Catalytic Converter Replacement - Right Side (V6)** .
10. Remove the cylinder head with the exhaust manifold. Refer to **Cylinder Head Removal - Right Side** .



**Fig. 206: View Of Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **Cylinder head gaskets must be discarded whenever the cylinder head has been removed from the cylinder block**

11. Remove and discard the cylinder head gasket (1).

Discard the gasket

12. Clean and inspect the cylinder head and the cylinder block sealing surfaces. Refer to **Cylinder Head Cleaning and Inspection** and **Engine Block Cleaning and Inspection** .



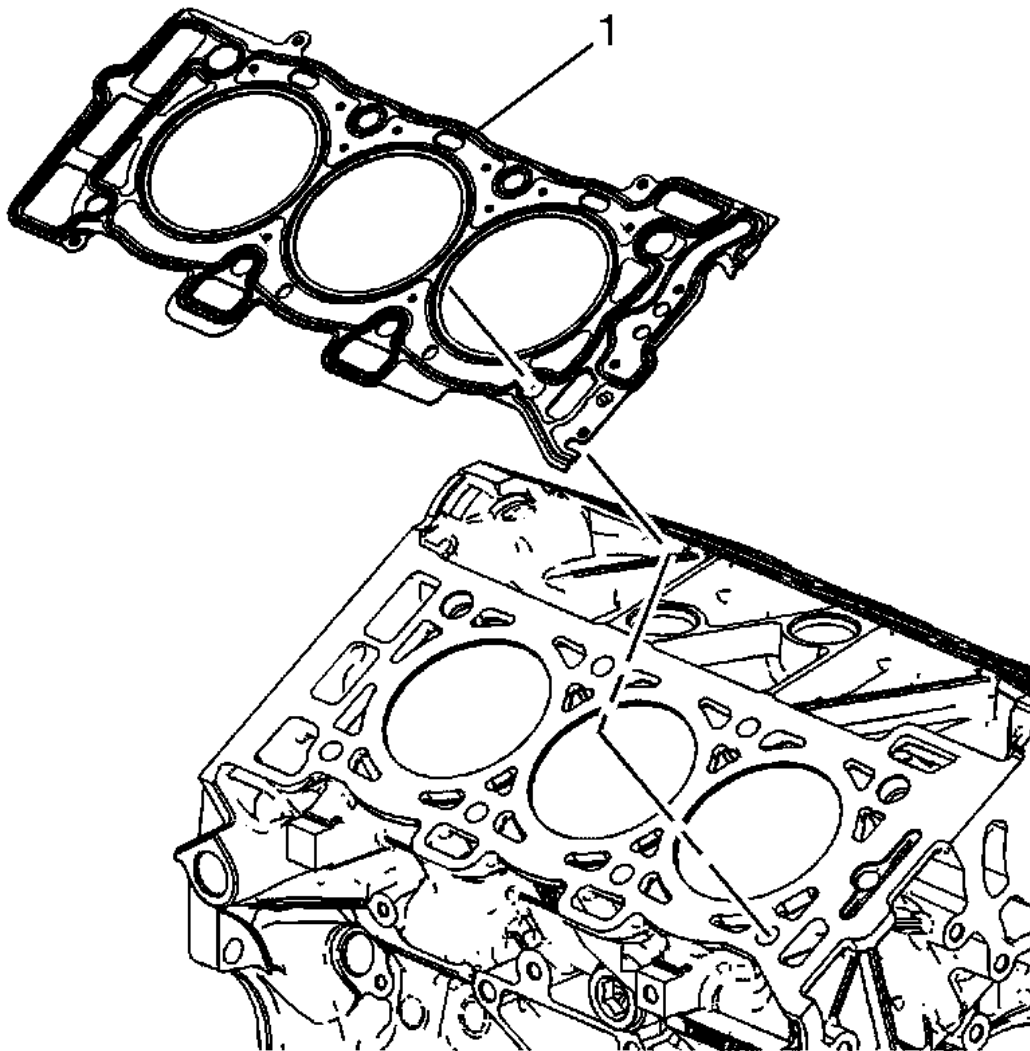
13. If necessary, perform the following steps:

- Remove the exhaust manifold from the cylinder head. Refer to **Exhaust Manifold Removal - Right Side**.
- Disassemble the cylinder head. Refer to **Cylinder Head Disassemble**.

#### Installation Procedure

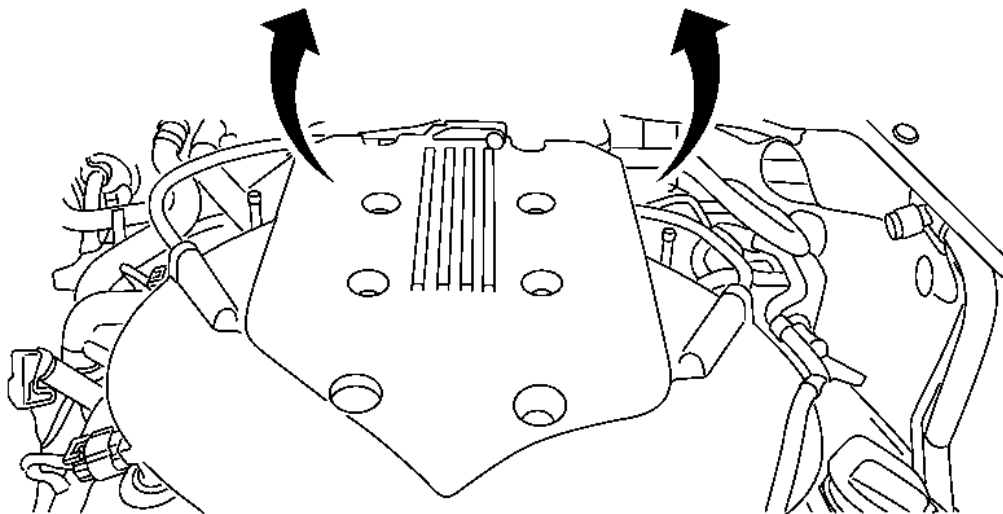
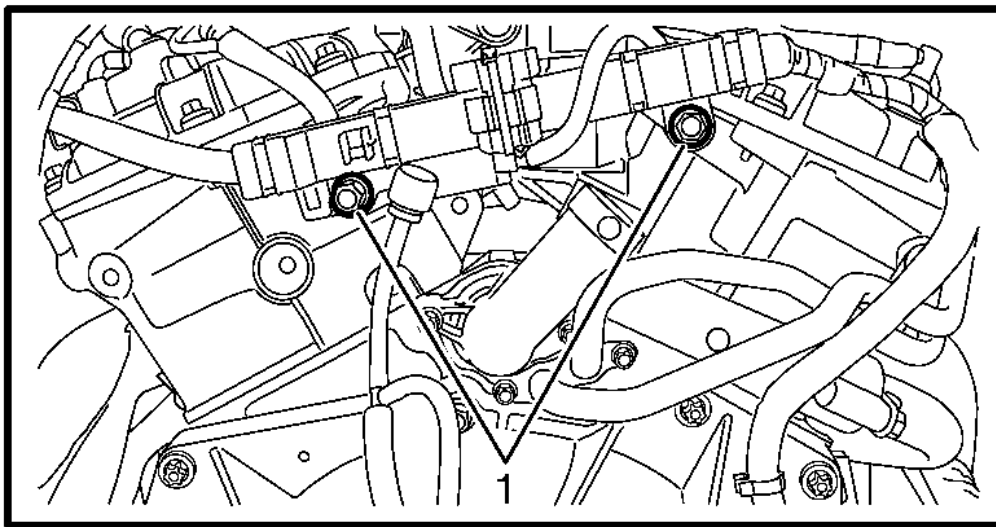
1. If necessary, perform the following steps:

- Assemble the cylinder head. Refer to **Cylinder Head Assemble**.
- Install the exhaust manifold to the cylinder head. Refer to **Exhaust Manifold Installation - Right Side**.



**Fig. 207: View Of Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW cylinder head gasket (1).
3. Install the cylinder head with the exhaust manifold to the engine. Refer to **Cylinder Head Installation - Right Side**.
4. Install the catalytic converter to the exhaust manifold. Refer to **Catalytic Converter Replacement - Right Side (V6)**.

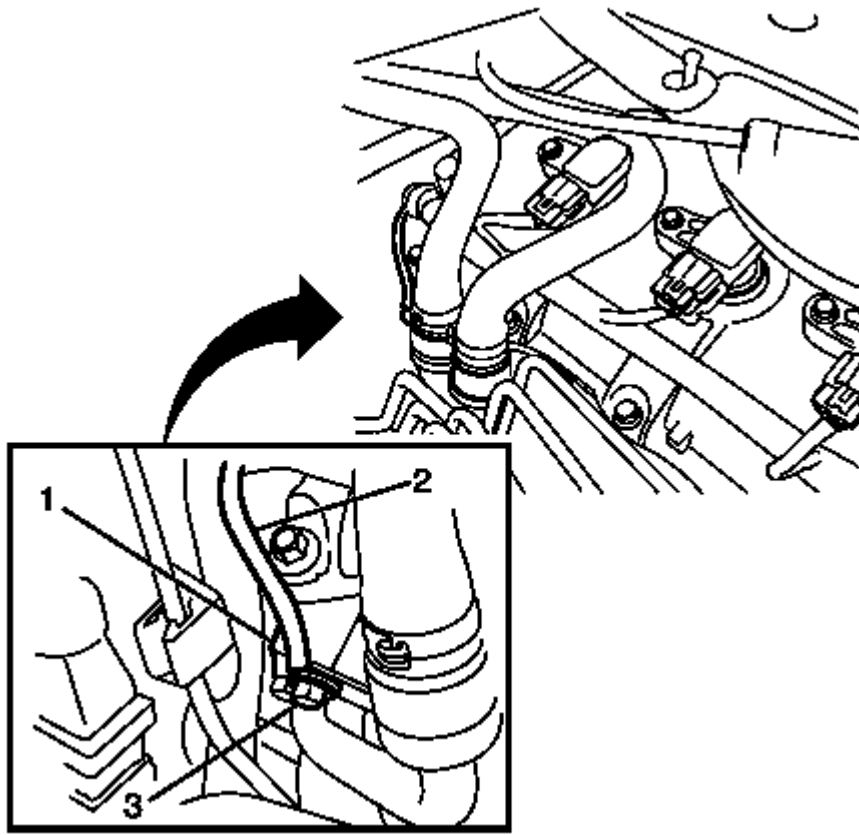


**Fig. 208: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

5. Install the engine wiring harness bracket to cylinder head retaining bolts (1).

**CAUTION:** Refer to Fastener Caution .

6. Install the wiring harness bracket using the cylinder head retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 209: Identifying Wiring Harness Ground To Right Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

7. Install the wiring harness ground to the side of the cylinder head.
8. Install the wiring harness ground to the right cylinder head retaining bolt (3) and tighten to 10 N.m (89 lb in).
9. Install the coolant inlet pipe. Refer to Engine Coolant Inlet Pipe Replacement .
10. Install the left bank secondary timing chain. Refer to Secondary Camshaft Drive Chain Replacement - Left Side.
11. Install the right camshaft cover. Refer to Camshaft Cover Replacement - Right Side.
12. Install the engine covers. Refer to Engine Cover Replacement.
13. Connect the battery ground cable. Refer to Battery Negative Cable Disconnection and Connection .

## ENGINE FLYWHEEL REPLACEMENT

**Removal Procedure**

1. Remove the transmission. Refer to [Transmission Replacement](#)
2. Remove the engine flywheel. Refer to [Engine Flywheel Removal](#)

**Installation Procedure**

1. Install the engine flywheel. Refer to [Engine Flywheel Installation](#)
2. Install the transmission. Refer to [Transmission Replacement](#)

**CRANKSHAFT REAR OIL SEAL AND HOUSING REPLACEMENT****Removal Procedure**

1. Remove the engine flywheel. Refer to [Engine Flywheel Replacement](#).
2. Remove the oil pan. Refer to [Oil Pan Replacement](#).
3. Remove the crankshaft rear oil seal and housing. Refer to [Crankshaft Rear Oil Seal and Housing Removal](#).

**Installation Procedure**

1. Install the crankshaft rear oil seal and housing. Refer to [Crankshaft Rear Oil Seal and Housing Installation](#).
2. Install the oil pan. Refer to [Oil Pan Replacement](#).
3. Install the engine flywheel. Refer to [Engine Flywheel Replacement](#).

**OIL PUMP REPLACEMENT****Removal Procedure**

1. Remove the engine covers. Refer to [Engine Cover Replacement](#).
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to [Spark Plug Replacement](#).
3. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).

**IMPORTANT: DO NOT remove the left bank idler sprocket.**

4. Remove the primary timing chain. Refer to [Primary Camshaft Intermediate Drive Chain Removal](#).
5. Remove the crankshaft sprocket. Refer to [Crankshaft Sprocket Removal](#).
6. Remove the oil pump bolts and the oil pump. Refer to [Oil Pump Removal](#).
7. Perform the following steps as necessary:
  - Disassemble the oil pump. Refer to [Oil Pump Disassemble](#).
  - Clean and inspect the oil pump. Refer to [Oil Pump Disassemble](#).

**Installation Procedure**

1. Assemble the oil pump as necessary. Refer to **Oil Pump Assemble** .
2. Install the oil pump. Refer to **Oil Pump Installation** .
3. Install the crankshaft sprocket. Refer to **Crankshaft Sprocket Installation** .
4. Install the primary timing chain. Refer to **Primary Camshaft Intermediate Drive Chain Installation** .
5. Install the spark plugs. Refer to **Spark Plug Replacement** .
6. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
7. Install the engine covers. Refer to **Engine Cover Replacement**.

**2009 ENGINE**

**Engine Mechanical - 3.6L - G8**

**REPAIR INSTRUCTIONS - ON VEHICLE**

**OIL PAN REPLACEMENT**

**Removal Procedure**

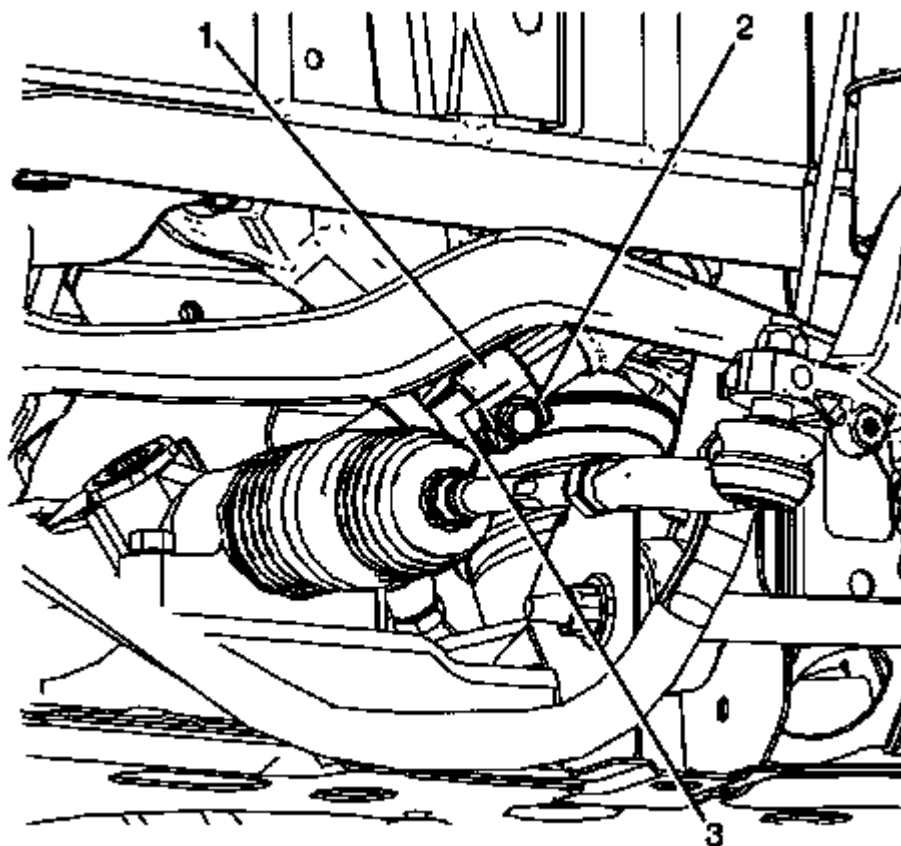
**WARNING:** Refer to Battery Disconnect Warning .

1. Disconnect the battery ground cable. Refer to Battery Negative Cable Disconnection and Connection .

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
3. Drain the engine oil. Refer to Engine Oil and Oil Filter Replacement.
4. Remove the engine splash shield. Refer to Engine Splash Shield Replacement .
5. Remove the front air deflector. Refer to Front Air Deflector Replacement .



**Fig. 1: Identifying Intermediate Steering Shaft To Pinion Shaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Observing the orientation of the intermediate steering shaft (1) with reference to the pinion shaft (3) will minimise the potential of incorrect steering column assembly alignment.

6. Mark the intermediate steering shaft (1) in relation to the pinion shaft (3).

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

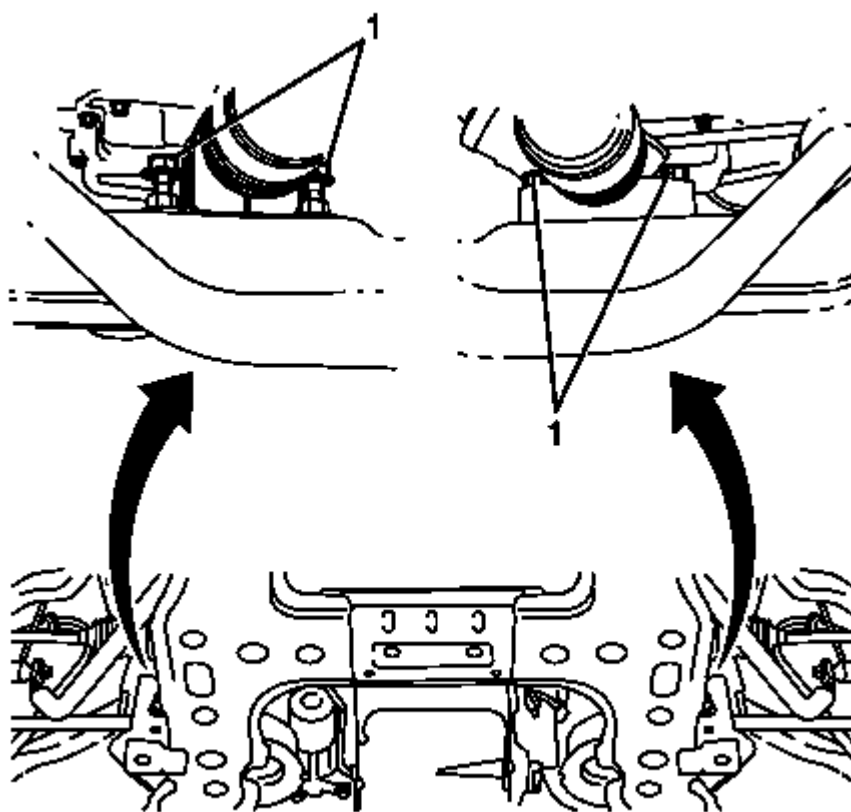
7. Remove the intermediate steering shaft to pinion shaft retaining bolt (2) and discard.

Discard the bolt.

**NOTE:** Make sure all the bolt hole is thoroughly cleaned and all micro-encapsulated thread sealant is removed.

8. Disconnect the intermediate shaft (2) from the pinion shaft (3).

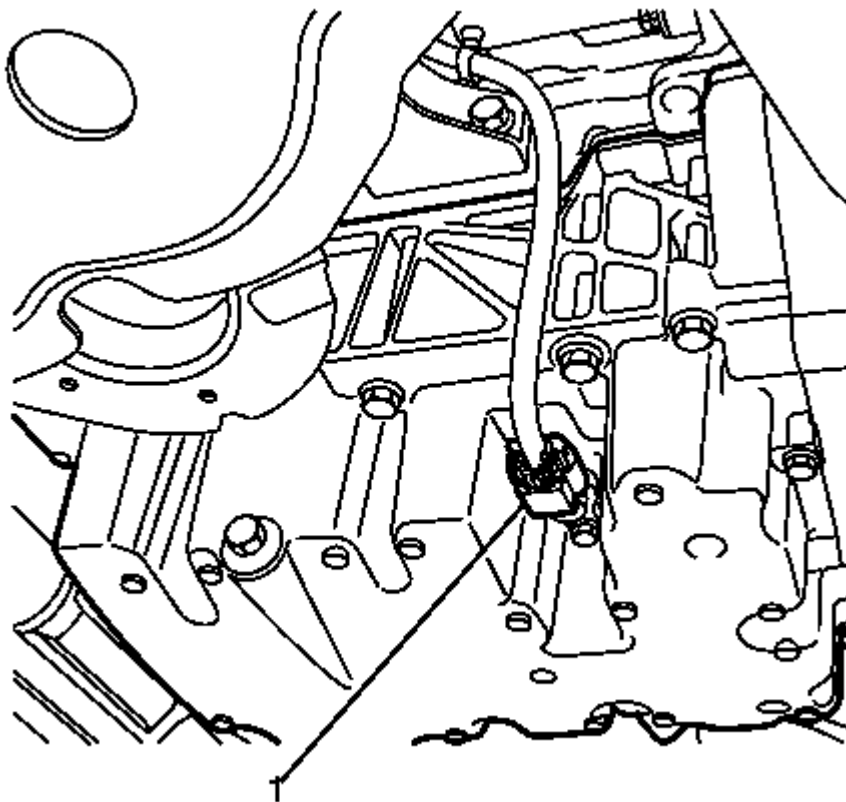
Clean the bolt hole.



**Fig. 2: Identifying Steering Gear To Subframe Retaining Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

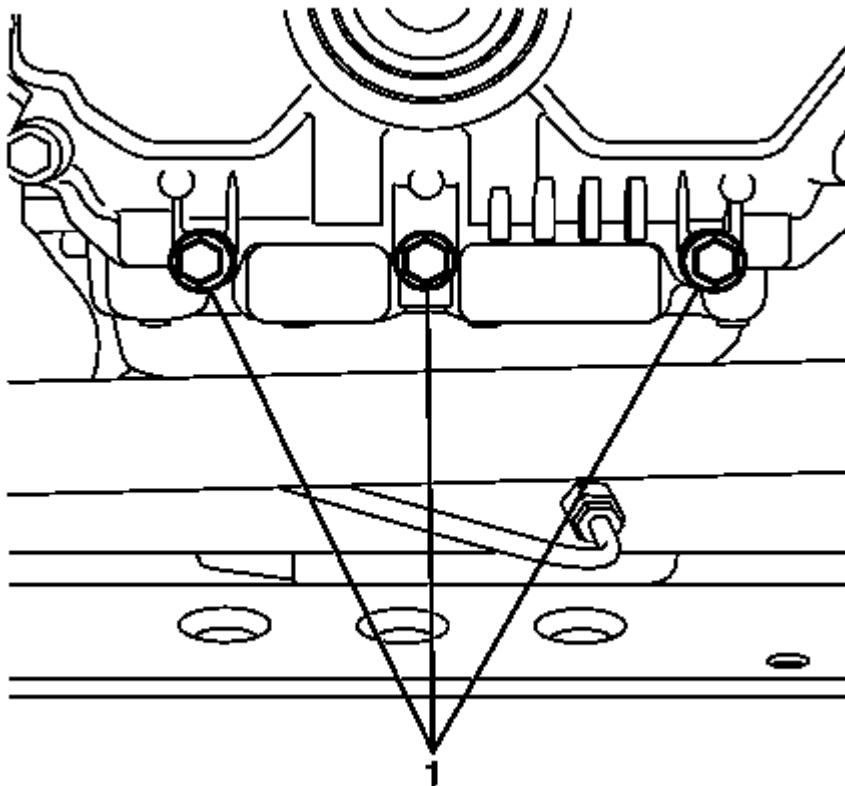
9. Remove the steering gear to subframe retaining bolts (1).
10. Slide the steering gear forward to gain full access to the sump.





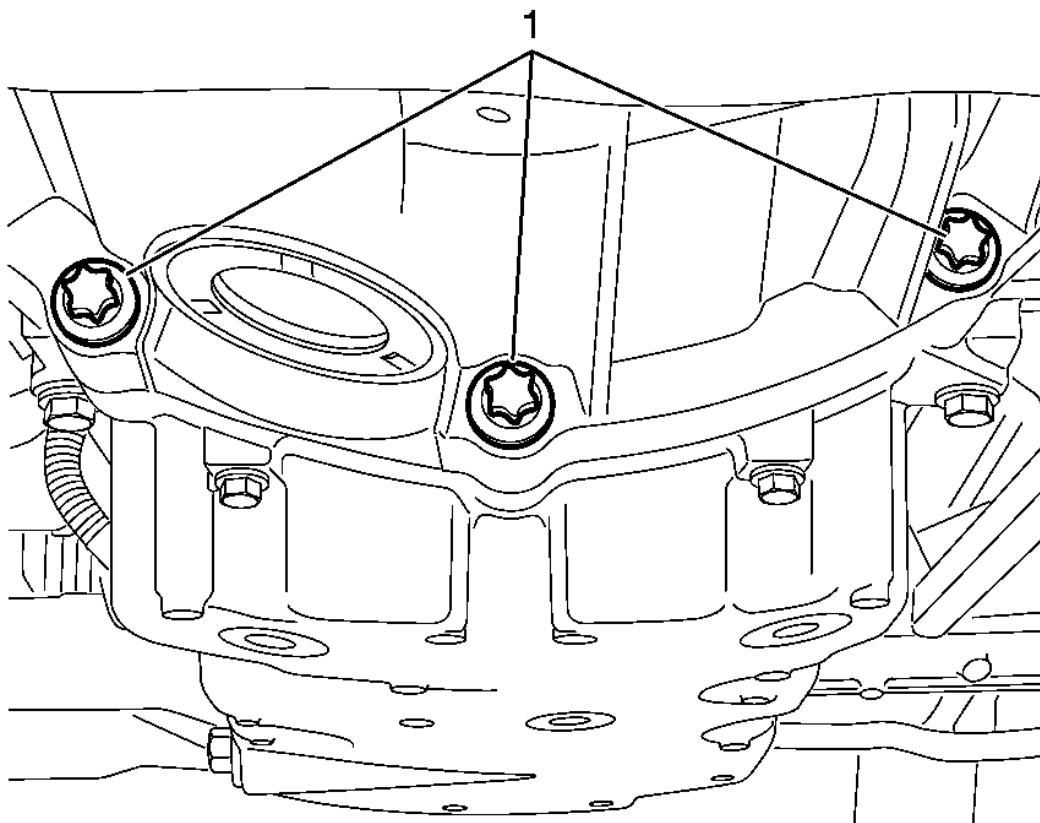
**Fig. 3: Identifying Oil Level/Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the oil level/temperature sensor electrical connector (1) from the oil level/temperature sensor.



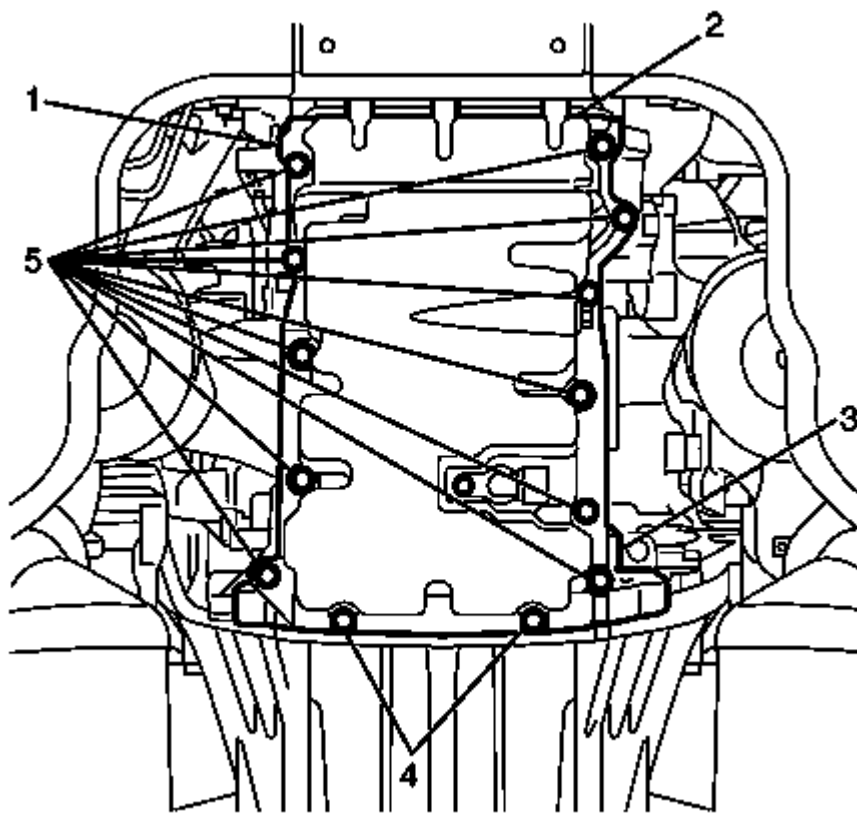
**Fig. 4: Identifying Front Cover To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the front cover to oil pan retaining bolts (1).



**Fig. 5: Identifying Transmission To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

13. Remove the transmission to oil pan retaining bolts (1).



**Fig. 6: Identifying Rear Oil Pan To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

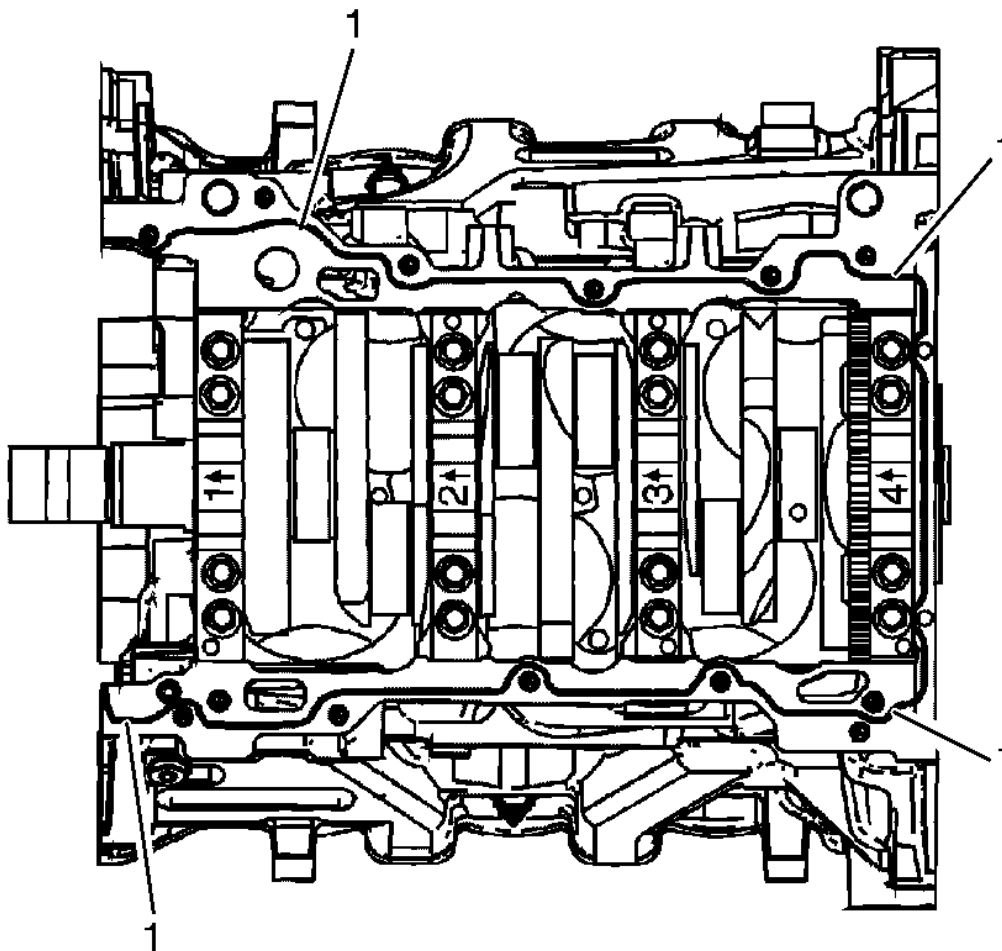
14. Remove the rear oil pan to cylinder block retaining bolts (4).
15. Remove the oil pan to cylinder block retaining bolts (5).

**NOTE:** Using the pry points (1 and 3) to shear the RTV sealant.

16. Remove the oil pan (2) from the engine block.
17. Perform the following steps as necessary.
  - Disassemble the oil pan. Refer to Oil Pan Disassemble .
  - Clean and inspect the oil pan. Refer to Oil Pan Cleaning and Inspection .

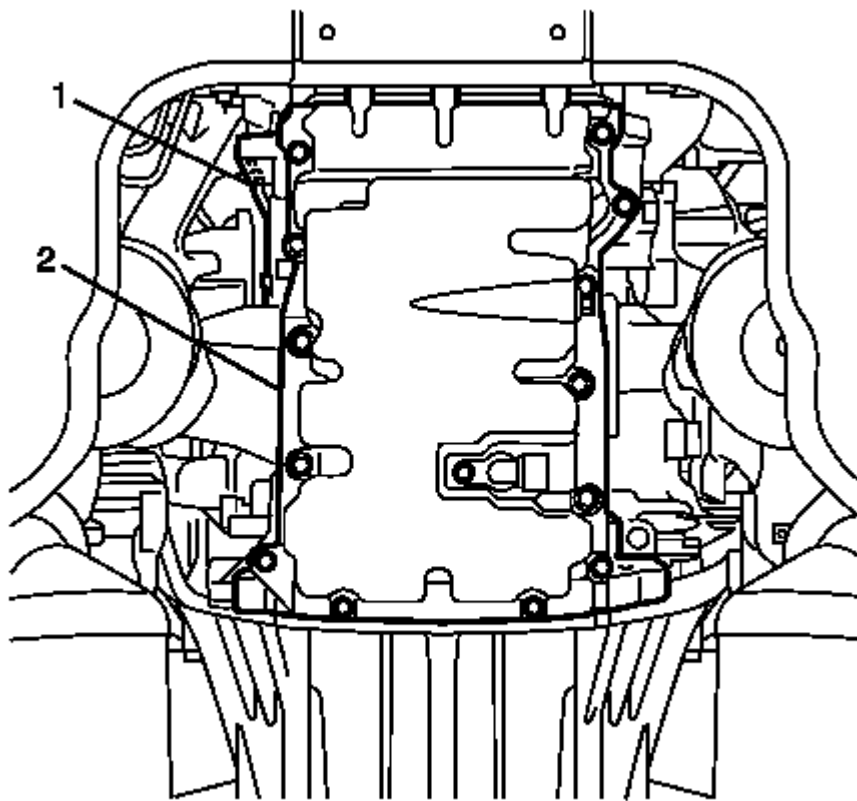
#### Installation Procedure

1. Assemble the oil pan as necessary. Refer to Oil Pan Assemble .



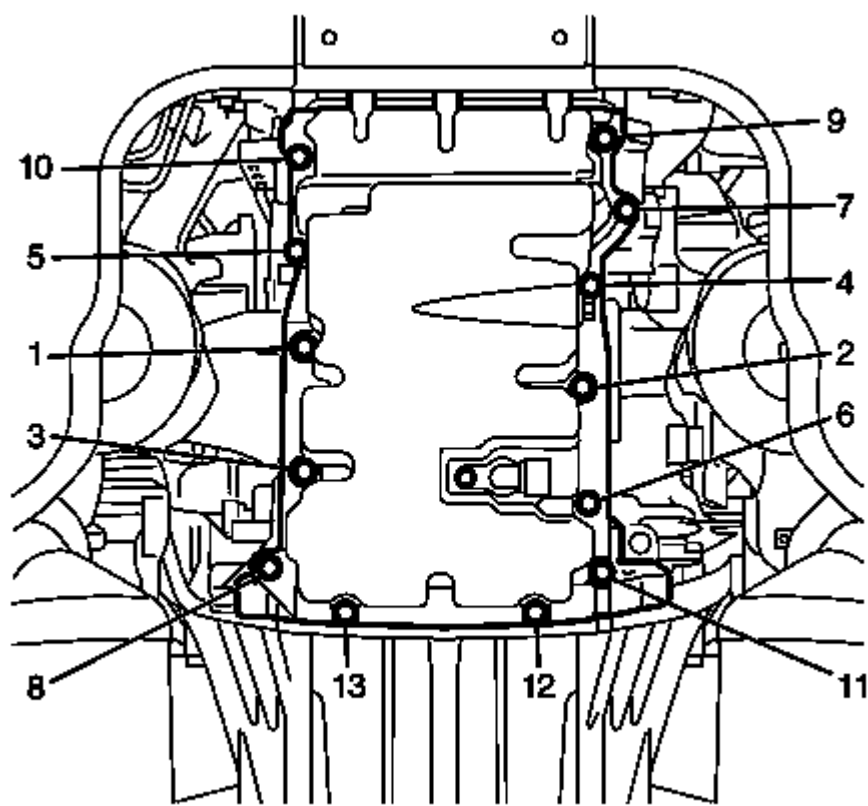
**Fig. 7: View Of RTV Sealant Application Areas**  
Courtesy of GENERAL MOTORS CORP.

2. Place a three mm (0.118 in) bead of RTV sealant (1) on the block pan rail and the crankshaft rear oil seal housing.



**Fig. 8: Identifying Oil Pan & Engine Block**  
Courtesy of GENERAL MOTORS CORP.

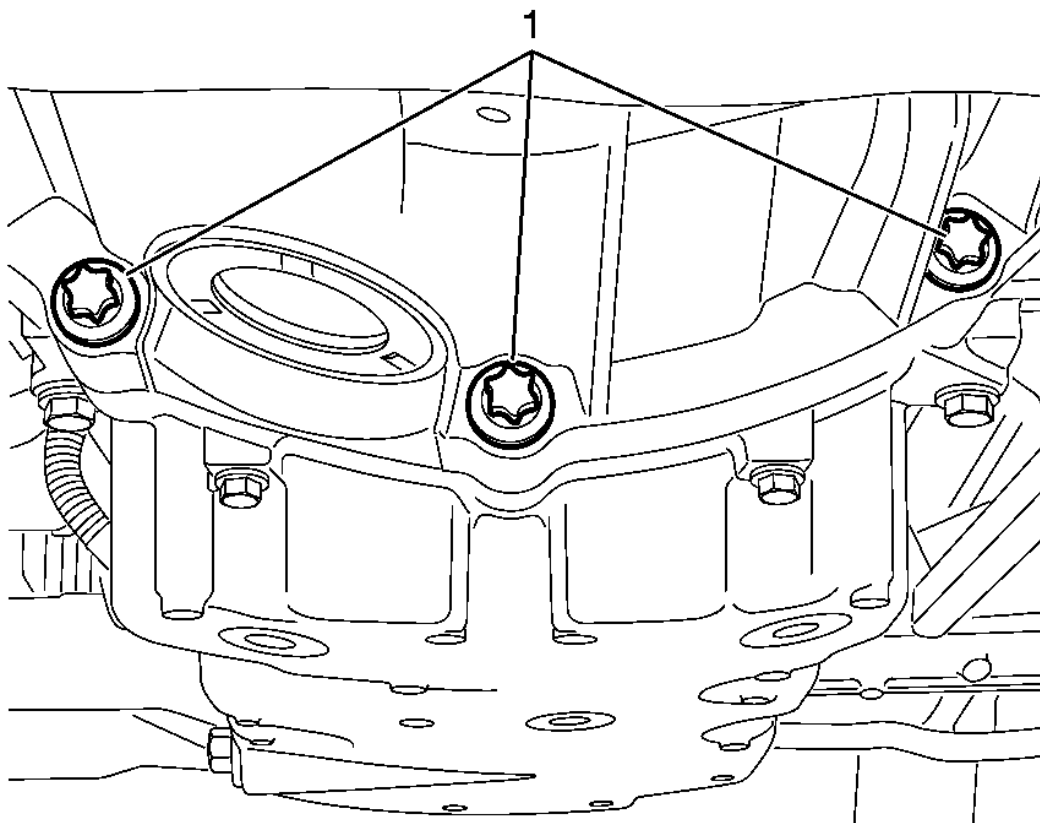
3. Position the oil pan (1) onto the engine block (2).



**Fig. 9: Identifying Oil Pan To Cylinder Block Retaining Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

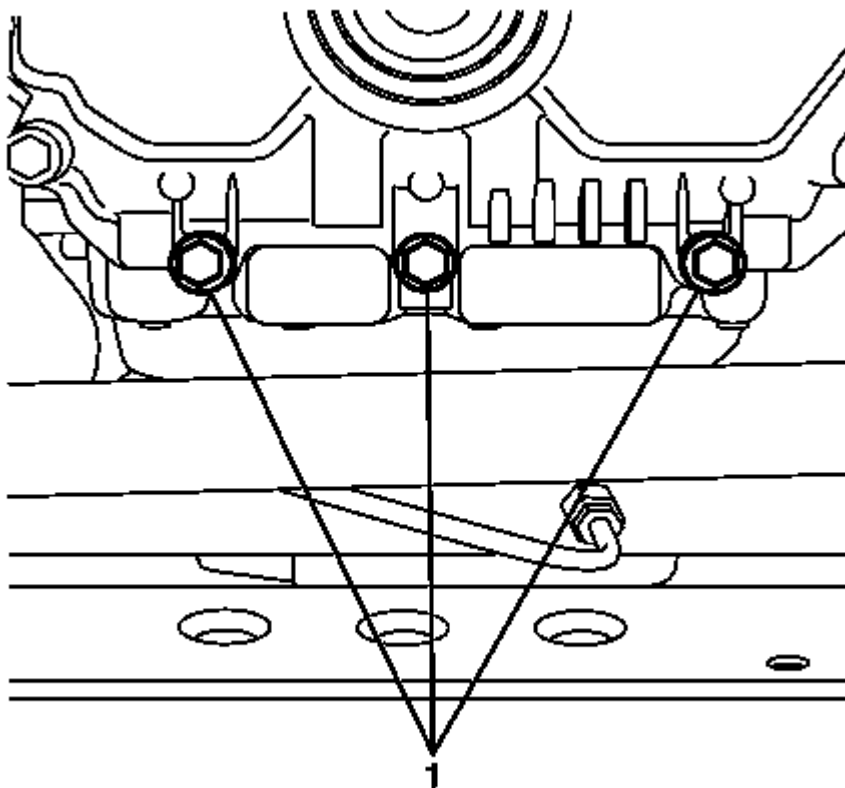
4. Install the oil pan to cylinder block retaining bolts in the sequence shown and tighten..
  - the eight mm bolts (1-11) to 23 N.m (17 lb ft)
  - the six mm bolts (12, 13) to 10 N.m (89 lb in)



**Fig. 10: Identifying Transmission To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

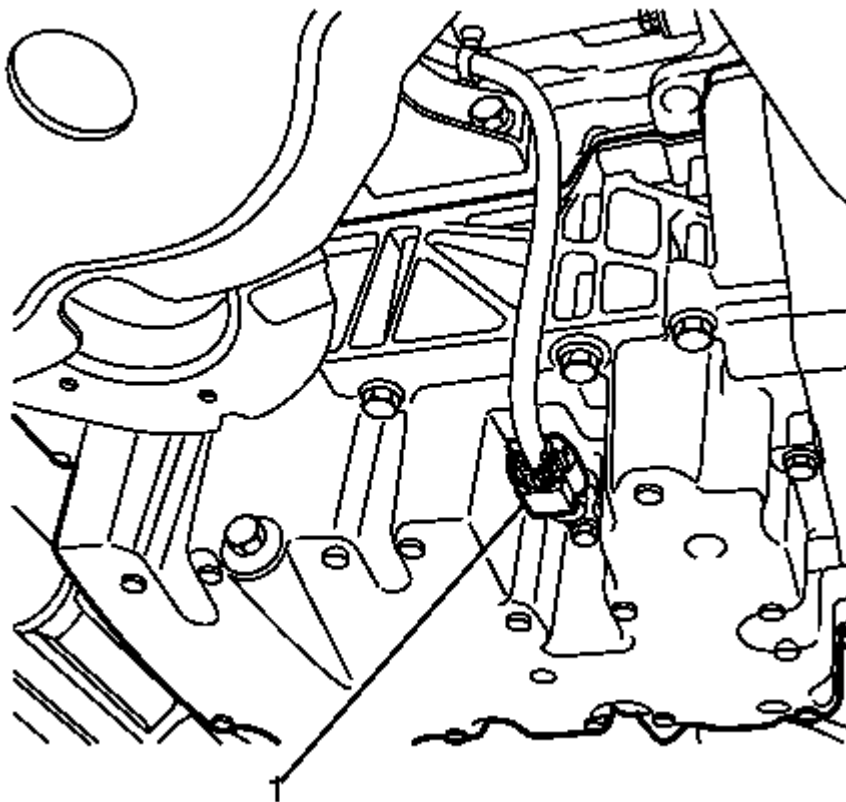
5. Install the transmission to the oil pan retaining bolts (1) and tighten to 48 N.m (17 lb ft).





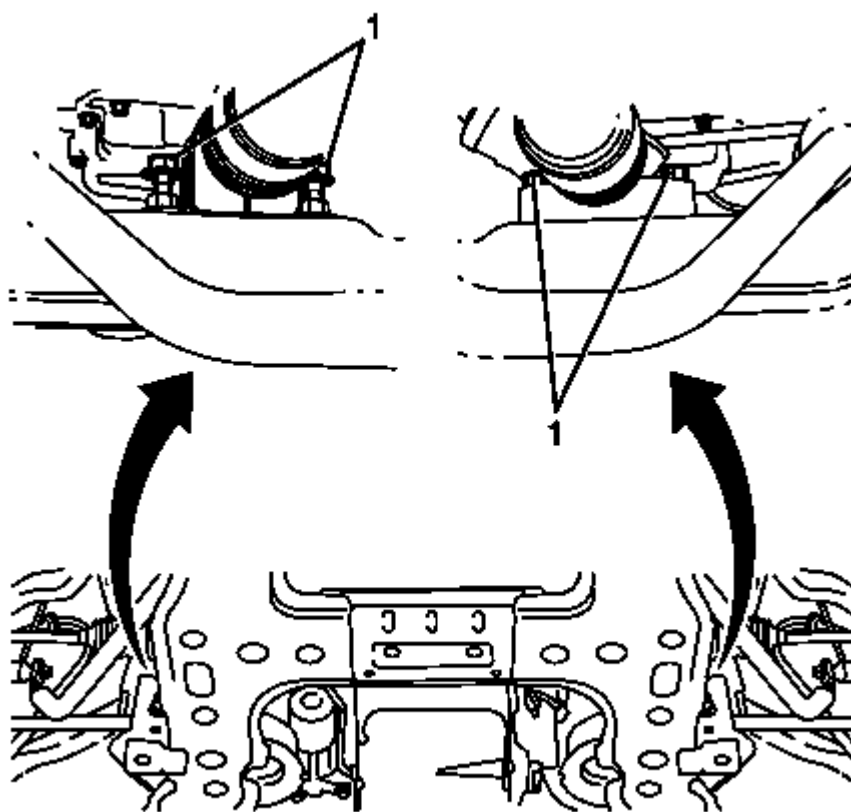
**Fig. 11: Identifying Front Cover To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Install the front cover using the oil pan retaining bolts (1) and tighten to 23 N.m (17 lb ft).



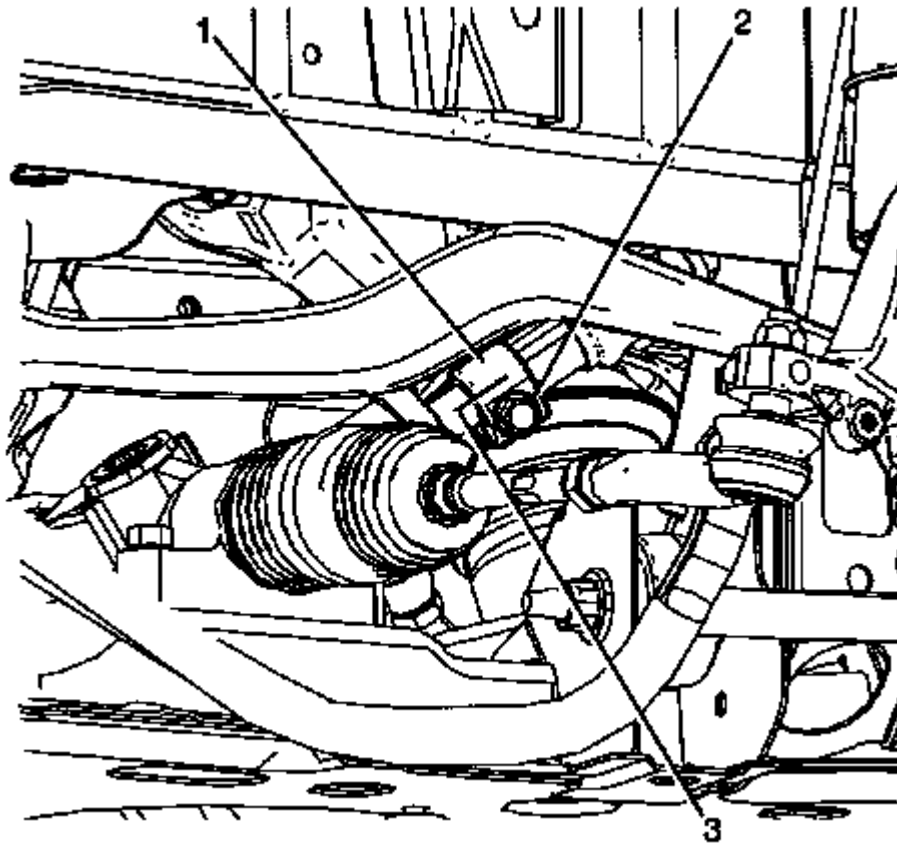
**Fig. 12: Identifying Oil Level/Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

7. Connect the oil level/temperature sensor electrical connector (1) to the oil level/temperature sensor.
8. Position the steering gear in the correct location.



**Fig. 13: Identifying Steering Gear To Subframe Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Install the steering gear using the subframe retaining bolts (1) and tighten to 65 N.m (48 lb ft).



**Fig. 14: Identifying Intermediate Steering Shaft To Pinion Shaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The intermediate steering shaft and pinion shaft splines must be installed in the position recorded during removal and aligned with the marks previously made.

10. Connect the intermediate steering shaft (1) to the pinion shaft (3).
11. Install the NEW intermediate steering shaft to the pinion shaft retaining bolt (2) and tighten to 25 N.m (16 lb ft).
12. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
13. Install the front air deflector. Refer to **Front Air Deflector Replacement** .
14. Lower the vehicle to the ground
15. Fill the engine with new engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
16. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .

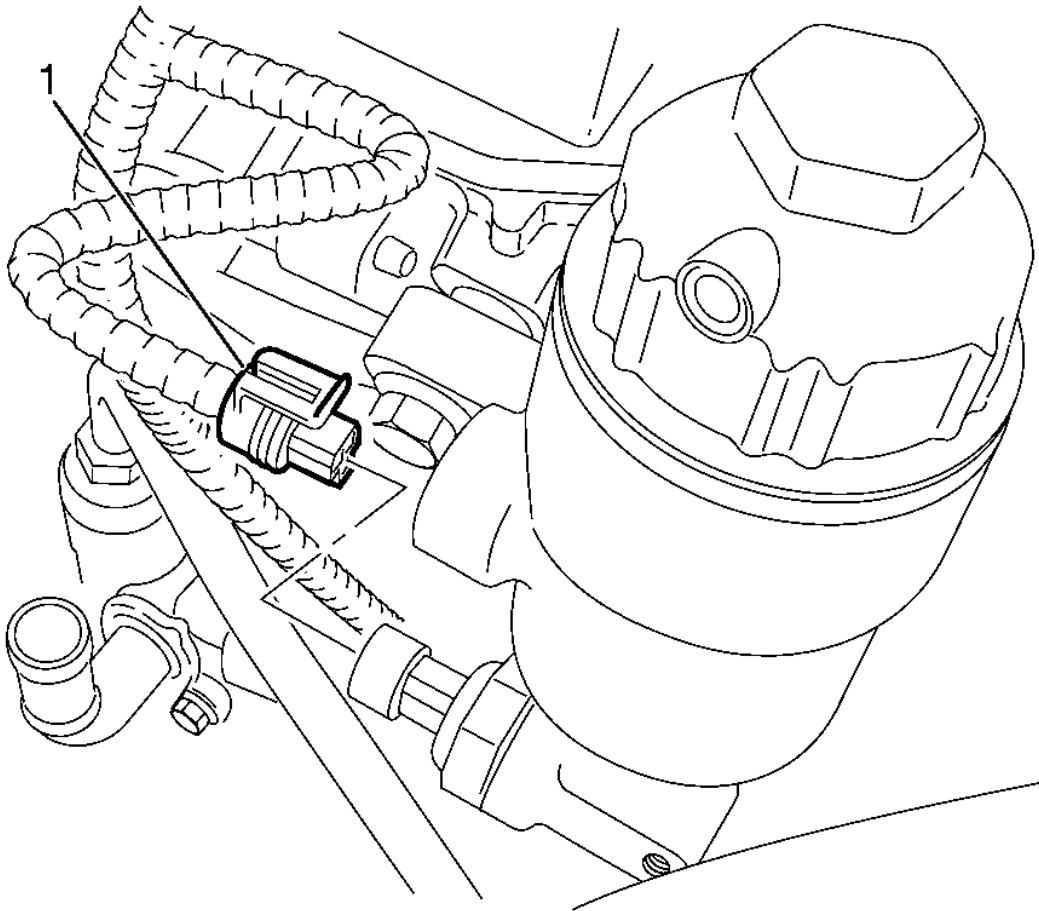
## ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

### Special Tools

**J 41712** Oil Pressure Sensor Socket. See **Special Tools** .

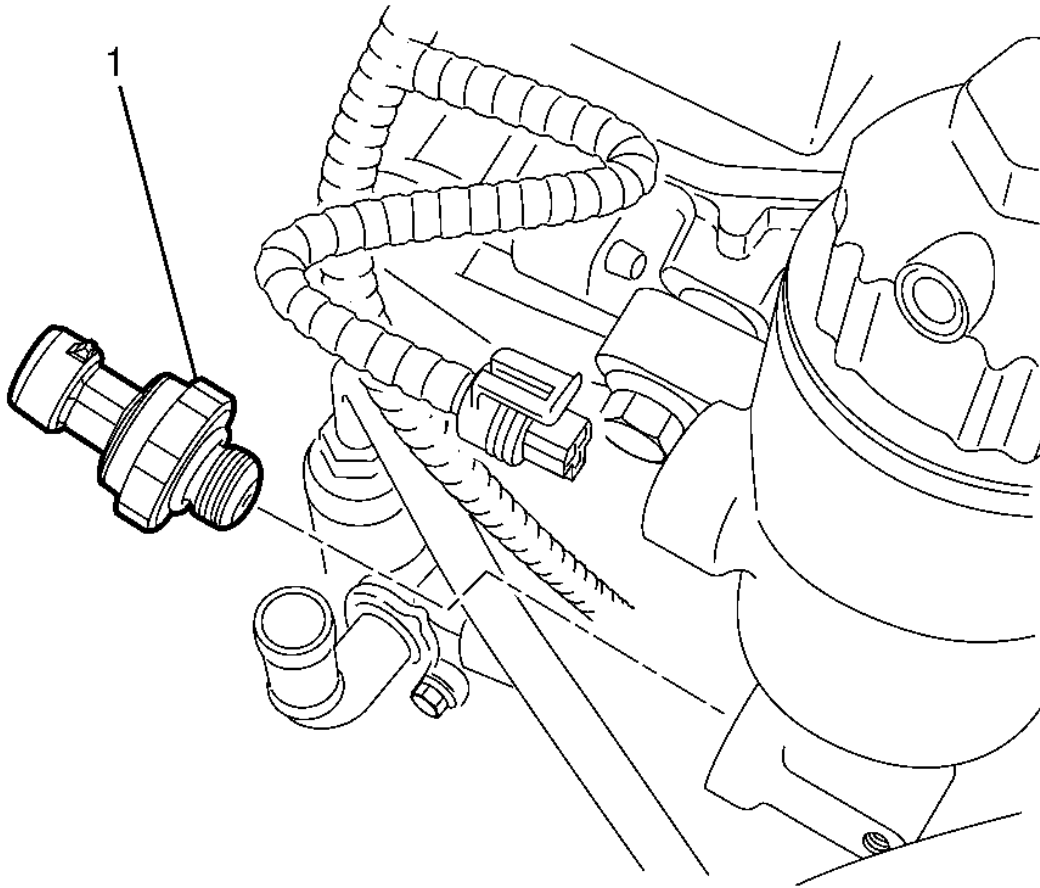
**Removal Procedure**

1. Turn the ignition OFF.
2. Remove the left hand engine cover. Refer to **Engine Cover Replacement** .



**Fig. 15: Identifying Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the oil pressure sensor electrical connector (1).

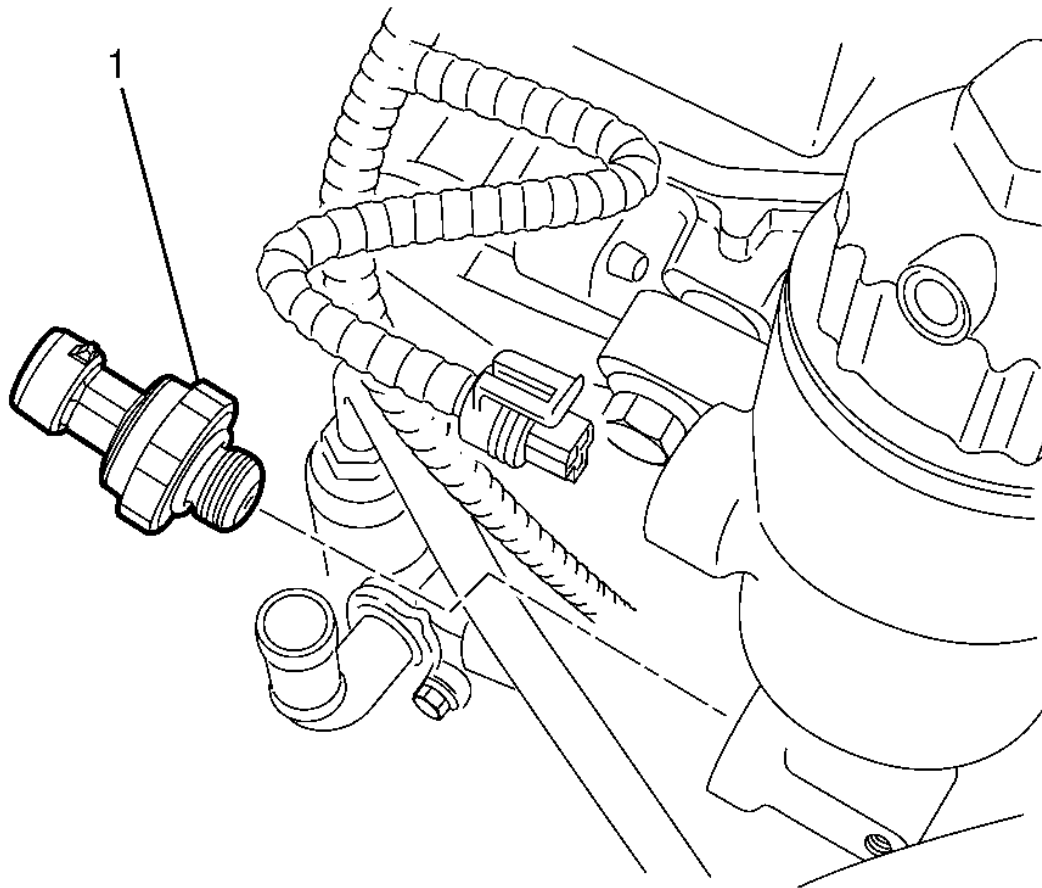


**Fig. 16: Identifying Oil Pressure Sensor**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** A small amount of oil will drain out of the oil filter housing when the oil pressure sensor is removed. Use a shop towel to absorb the oil.

4. Use the **J 41712** in order to remove the oil pressure sensor (1). See **Special Tools** .

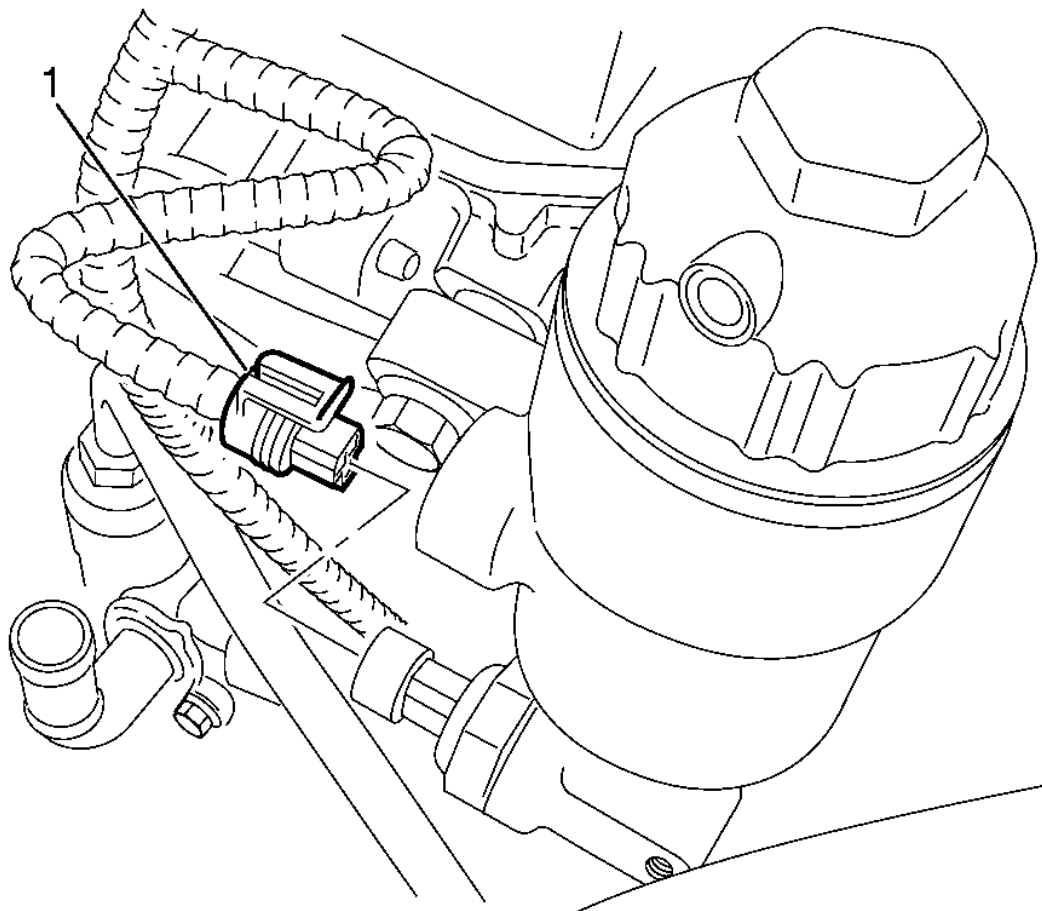
#### **Installation Procedure**



**Fig. 17: Identifying Oil Pressure Sensor**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

1. Use the **J 41712** in order to install the oil pressure sensor (1) and tighten to 20 N. See Special Tools .m (15 lb ft).



**Fig. 18: Identifying Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

2. Connect the oil pressure sensor electrical connector (1).
3. Install the left hand engine cover. Refer to **Engine Cover Replacement** .

## **ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT**

### **Removal Procedure**

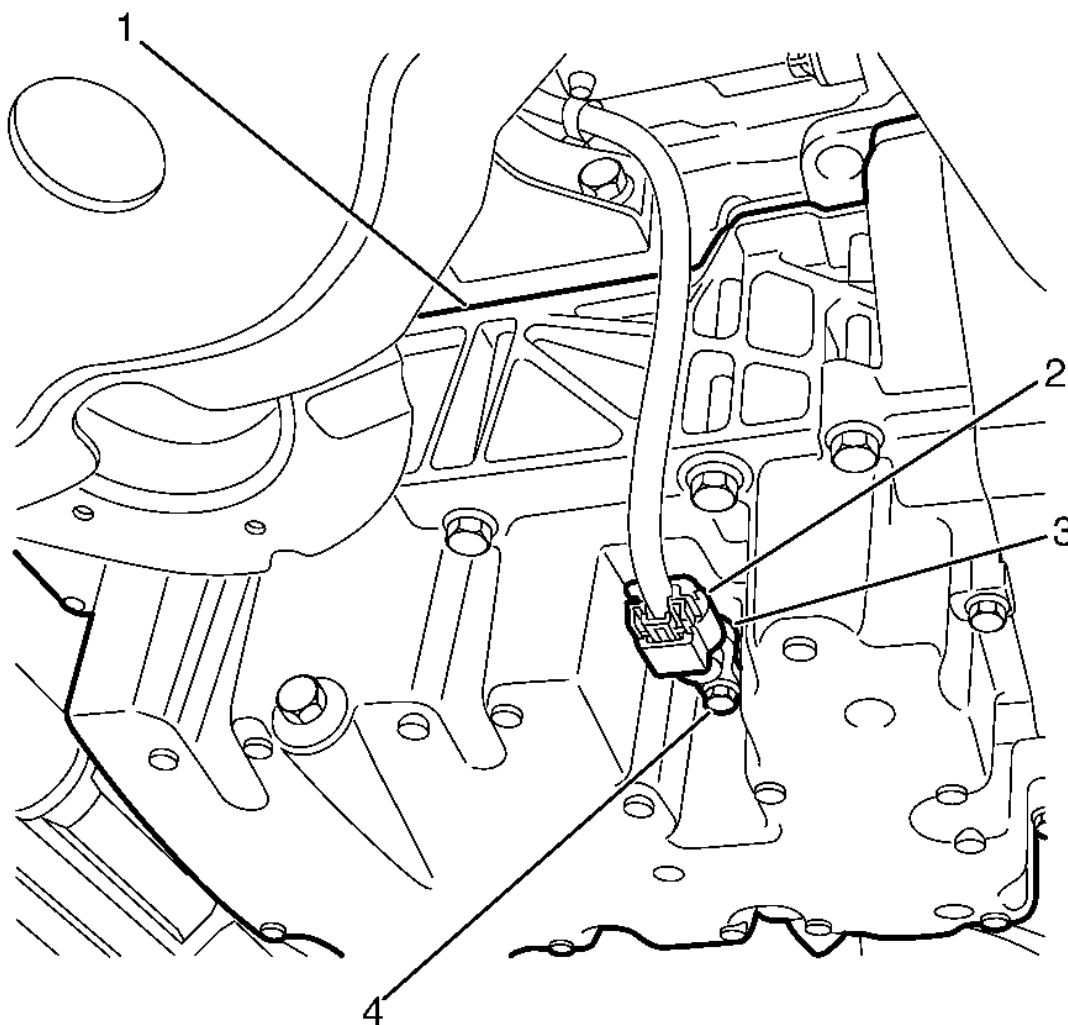
**WARNING:** Refer to **Safety Glasses Warning** .

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the



opposite end from which the components are being removed and strap the vehicle to the hoist.

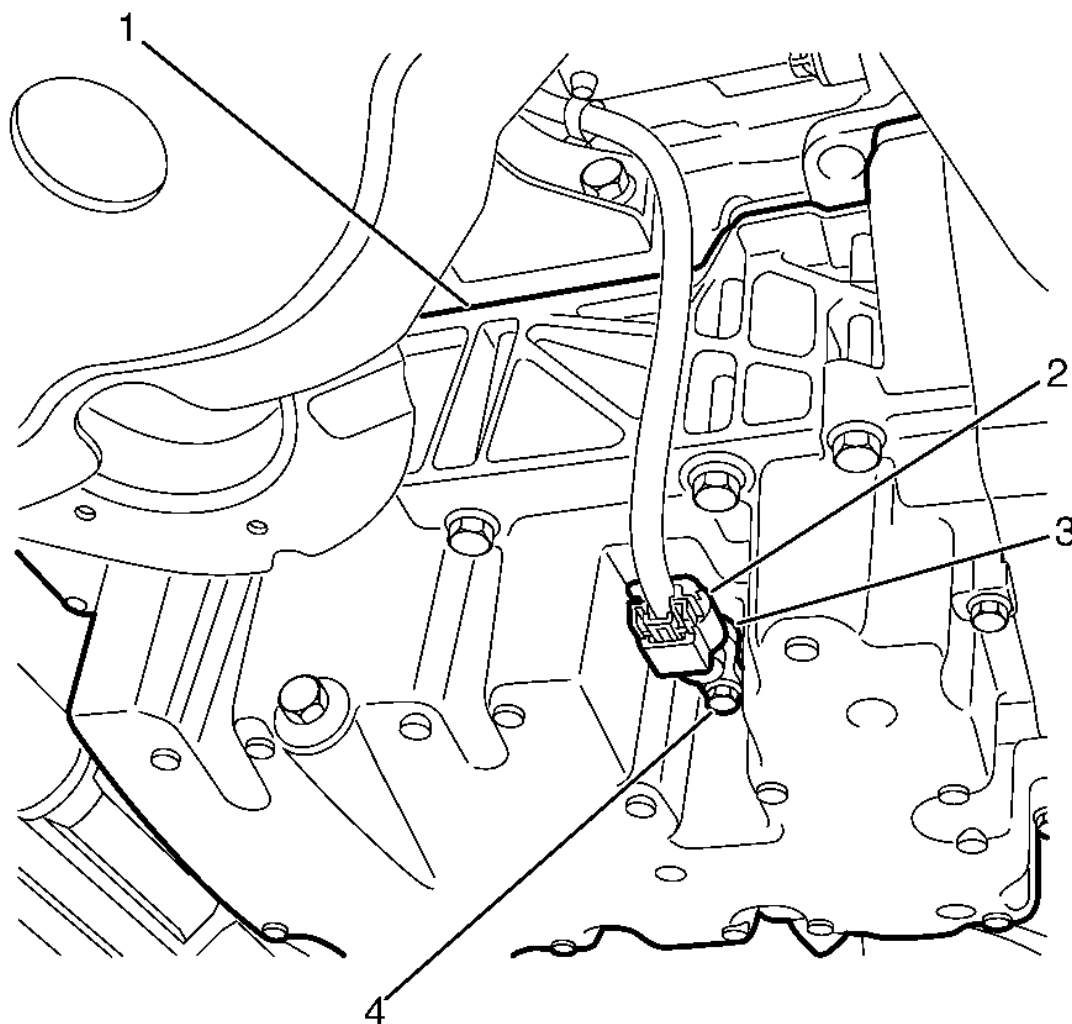
1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Remove the Engine Splash Shield. Refer to Engine Splash Shield Replacement .



**Fig. 19: Identifying Engine Oil Level Switch To Oil Pan Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

3. Drain the engine oil. Refer to Engine Oil and Oil Filter Replacement.
4. Disconnect the engine oil level switch electrical connector (2).
5. Remove the engine oil level switch to oil pan retaining bolt (4).
6. Remove the engine oil level switch (3) from the oil pan (1).

#### Installation Procedure



**Fig. 20: Identifying Engine Oil Level Switch To Oil Pan Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

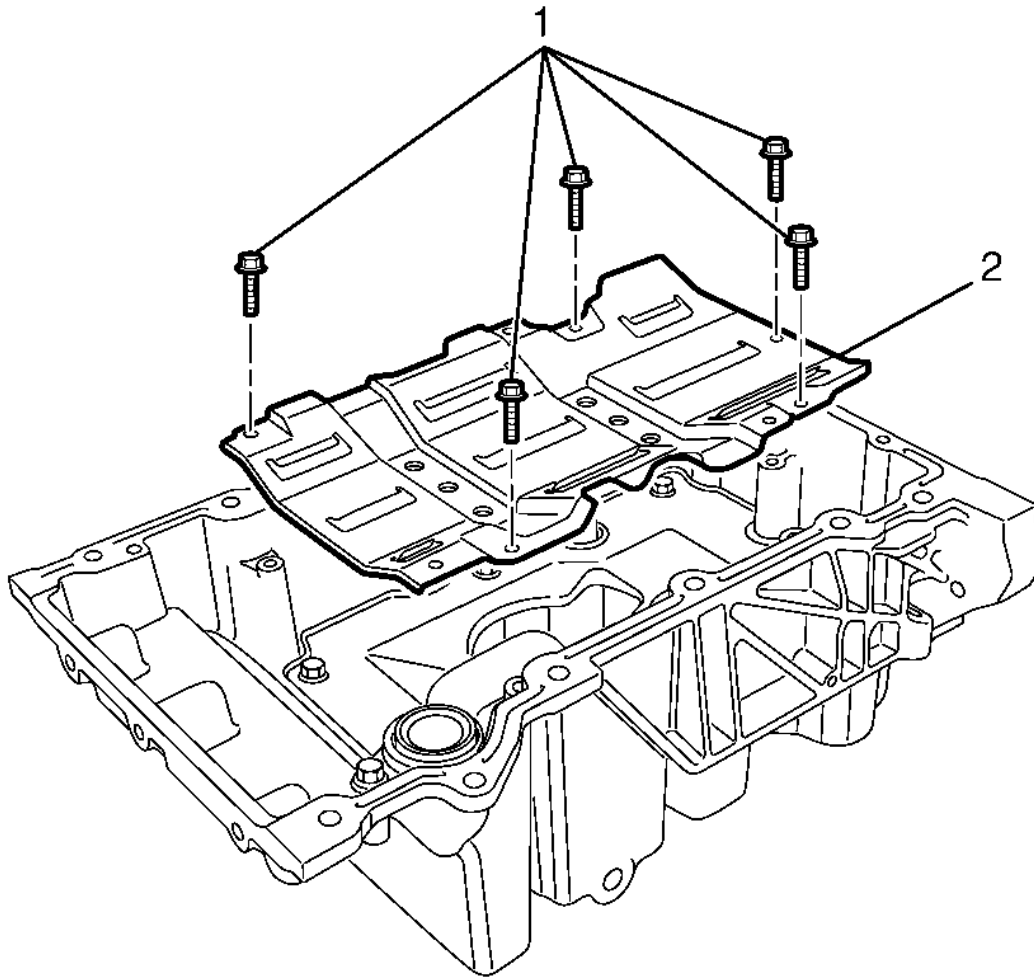
**CAUTION:** Refer to Fastener Caution .

1. Install the engine oil level switch bolt (2) to the oil pan (3) and tighten to 20 N.m (15 lb ft).
2. Connect the engine oil level switch electrical connector (1).
3. Install the front air deflector. Refer to Front Air Deflector Replacement .
4. Lower the vehicle.
5. Fill the engine oil. Refer to Engine Oil and Oil Filter Replacement.
6. Inspect for oil leaks after engine start up.
7. Reset the GM Oil Life System. Refer to GM Oil Life System Resetting .

#### OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY REPLACEMENT

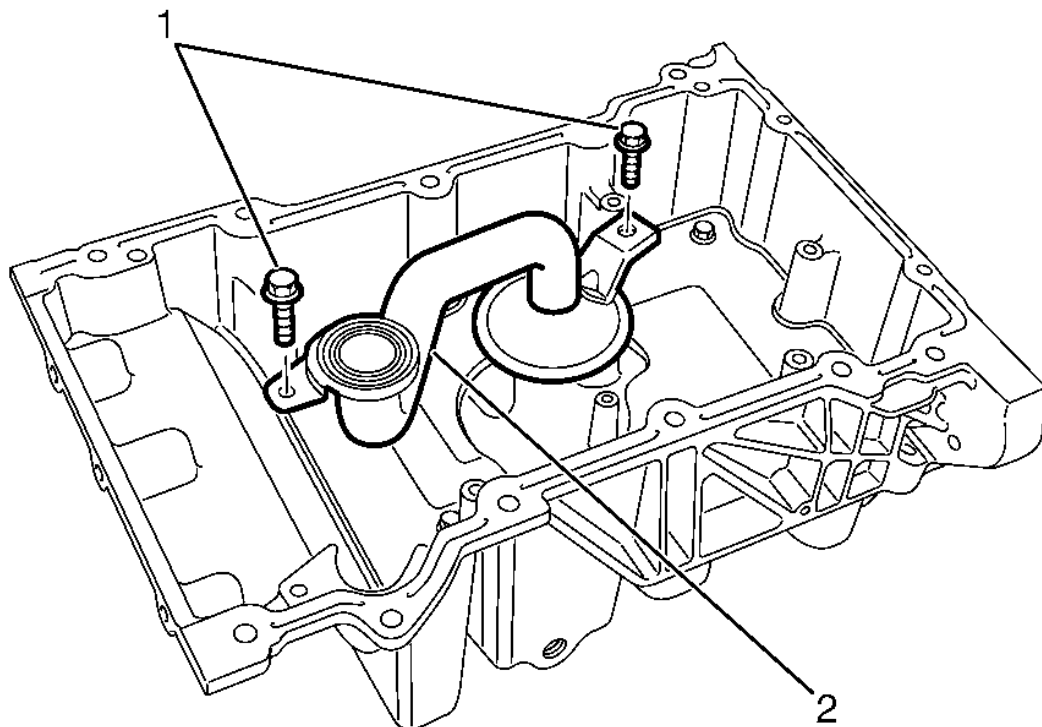
**Removal Procedure**

1. Remove the oil pan. Refer to **Oil Pan Replacement**.



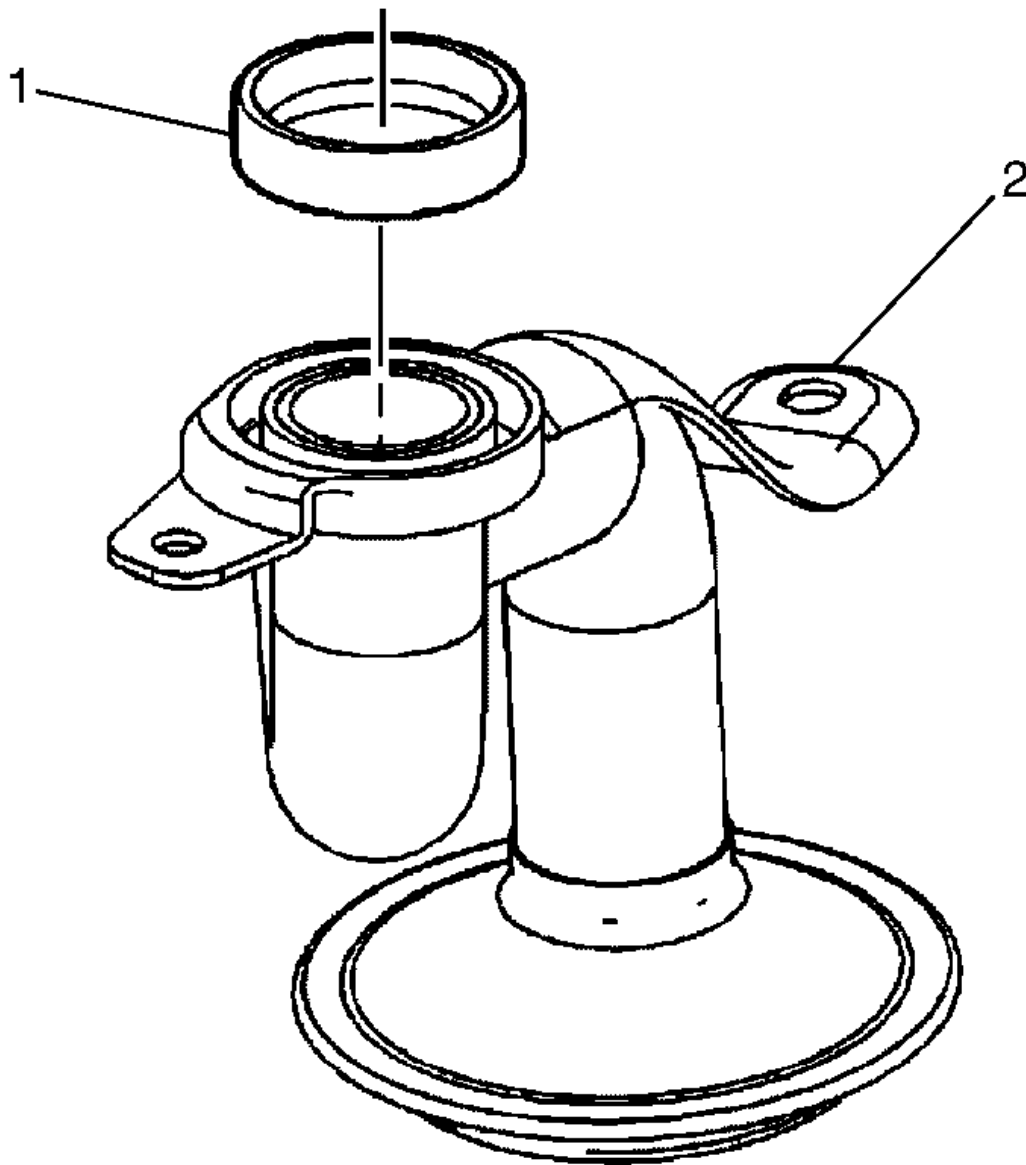
**Fig. 21: Identifying Oil Pan Scraper To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan scraper bolts (1).
3. Remove the oil pan scraper (2).



**Fig. 22: Identifying Oil Suction Pipe To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil suction pipe to oil pan retaining bolts (1).
5. Remove the oil suction pipe (2).

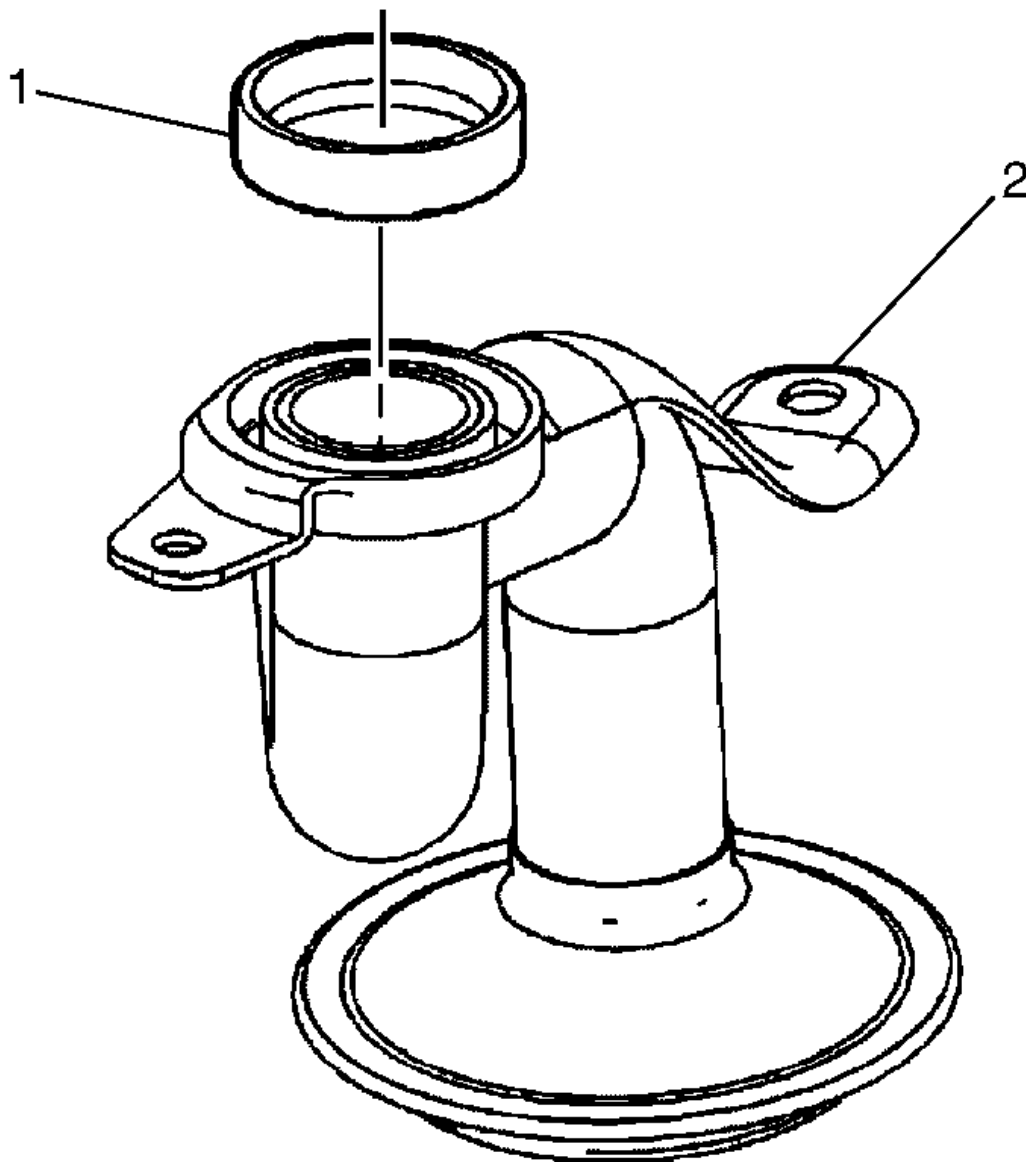


**Fig. 23: Identifying Oil Suction Pipe & Seal**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The oil suction pipe seal (1) is a single use component and must be discarded whenever the oil suction pipe (2) is removed.

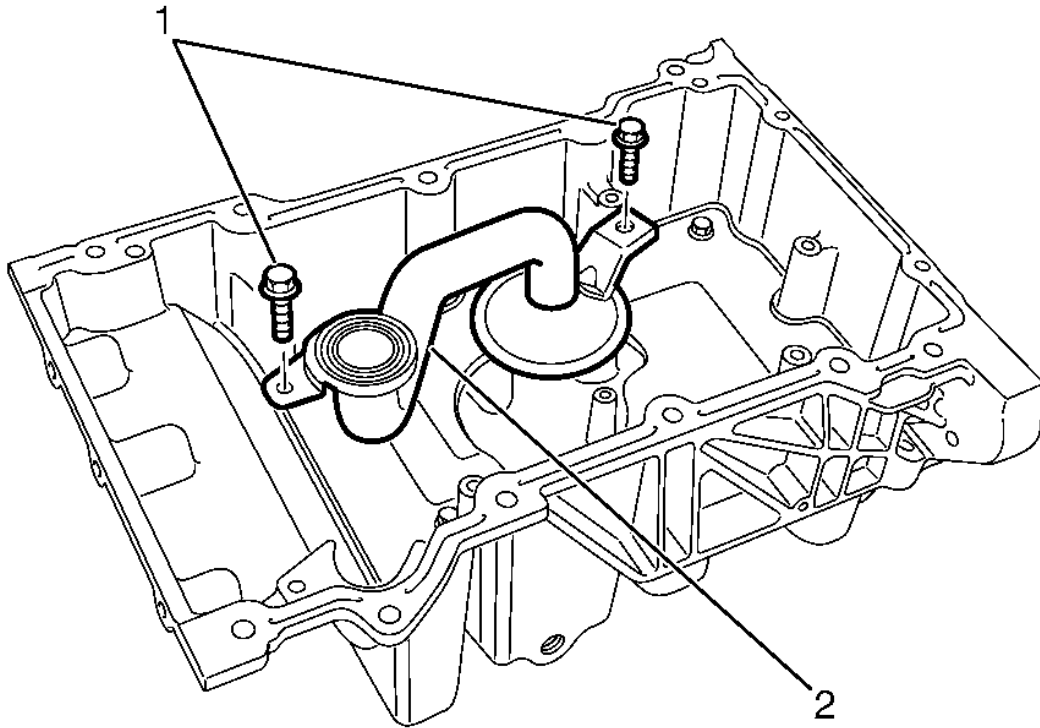
6. Remove the oil suction pipe seal (1) from the oil suction pipe (2).

Discard the oil suction pipe seal (1).

**Installation Procedure**

**Fig. 24: Identifying Oil Suction Pipe & Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil suction pipe seal (1) onto the oil suction pipe (2).

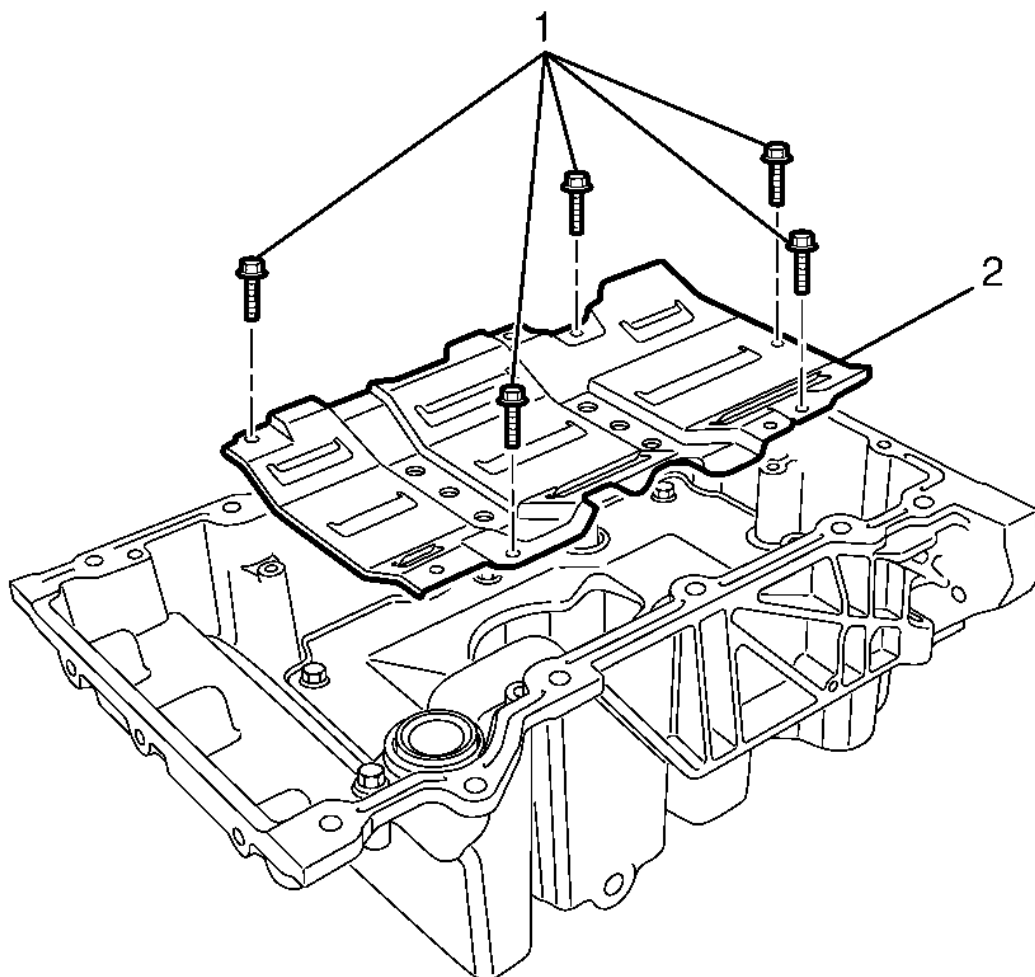


**Fig. 25: Identifying Oil Suction Pipe To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

2. Install the oil suction pipe (2).

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

3. Install the oil suction pipe using the oil pan retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 26: Identifying Oil Pan Scraper To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan scraper (2).
5. Install the oil pan scraper to the oil pan retaining bolts (1) and tighten to 10 N.m (89 lb in).
6. Install the oil pan. Refer to **Oil Pan Replacement**.

## ENGINE REPLACEMENT

### Special Tools

EN 46114 Engine Lifting Brackets

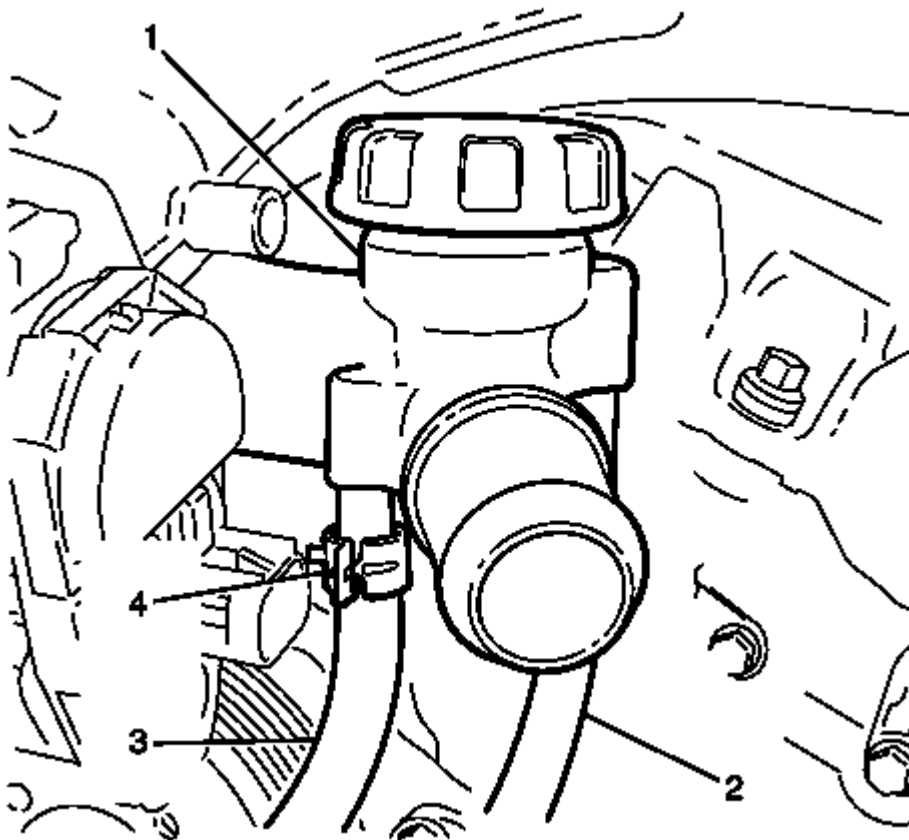
### Removal Procedure



1. Turn the ignition key to the LOCK position.

**WARNING:** Refer to Battery Disconnect Warning .

2. Disconnect the battery ground cable. Refer to Battery Negative Cable Disconnection and Connection .
3. Remove the engine covers. Refer to Engine Cover Replacement .
4. Remove the radiator air intake baffle. Refer to Cooling Fan and Shroud Replacement .
5. Recover the air conditioning (A/C) refrigerant. Refer to Refrigerant Recovery and Recharging .
6. Remove the air intake duct. Refer to Air Cleaner Inlet Duct Replacement .
7. Depressurise the fuel system. Refer to Fuel Pressure Relief .
8. Drain the cooling system. Refer to Cooling System Draining and Filling (3.6 L) .
9. Remove the radiator outlet hose. Refer to Radiator Outlet Hose Replacement (3.6L) .



**Fig. 27: View Of Outlet Housing, Coolant Recovery Hose & Coolant Bleed Hose With Retaining Clamp**

Courtesy of GENERAL MOTORS CORP.

10. Compress the coolant bleed hose retaining clamp (4) at the outlet housing (1) end and slide 50 mm (2 in) along the coolant bleed hose (3).

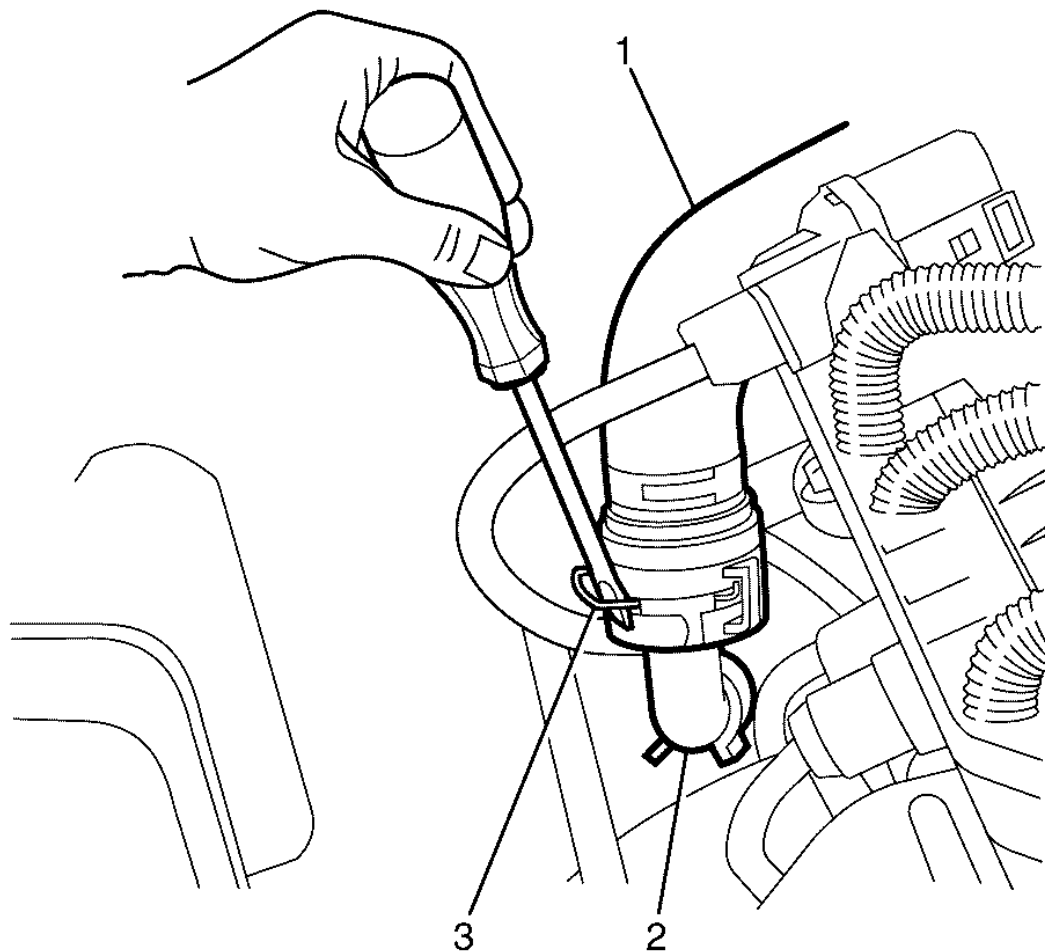
11. Remove the coolant bleed hose (3) from the outlet housing (1).

**NOTE:** Twist and pull the coolant recovery hose (2) to remove from the outlet housing (1).

12. Disconnect the coolant recovery hose (2) from the outlet housing (1).

**NOTE:** Plug or cap the hoses and inlets when separating the cooling system components, this prevents dirt and other contaminants from entering the cooling system.

13. Plug or cap the cooling system hoses and inlets



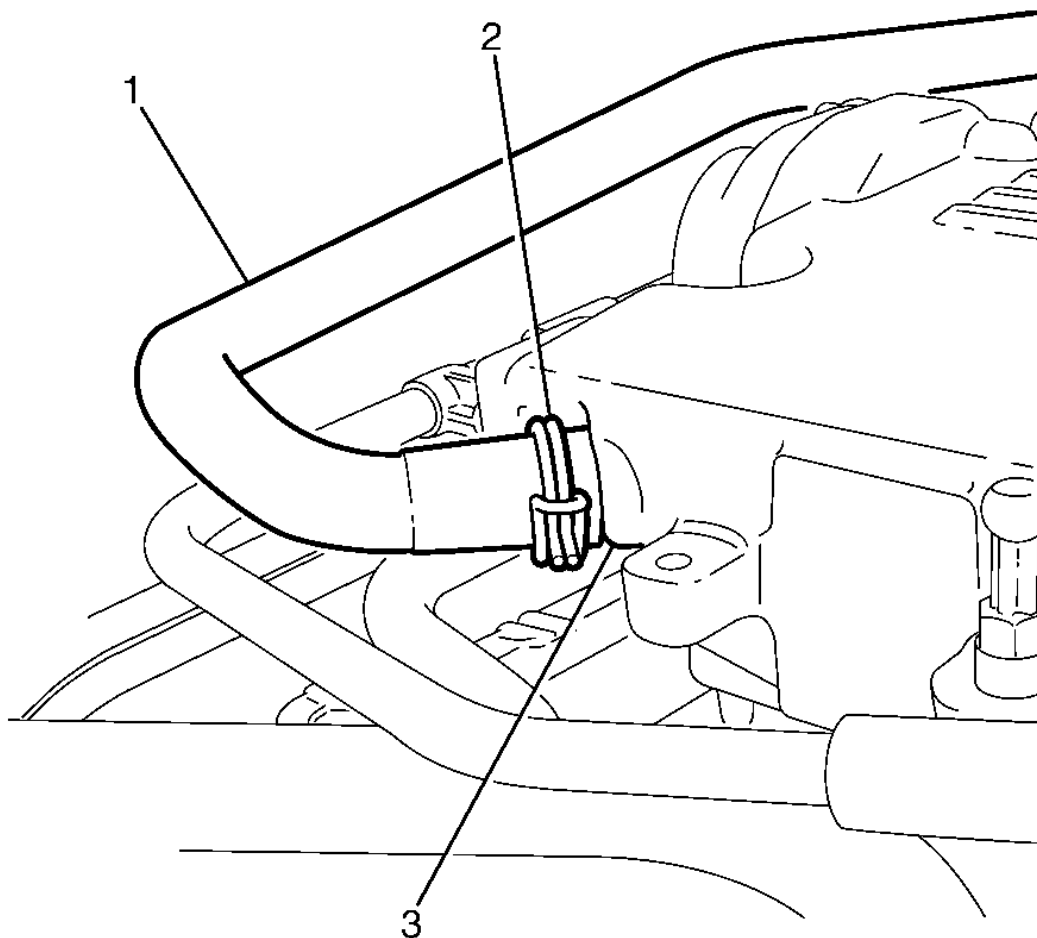
**Fig. 28: Identifying Heater Outlet Hose, Heater Outlet Pipe Quick Connect Fitting & Retaining Clip**

Courtesy of GENERAL MOTORS CORP.

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

**NOTE:** The inlet and outlet heater hoses (1) are retained to the heater pipes (2) by quick connect fittings. Disconnect the heater hose (1) quick connect fittings by releasing the retaining clips (3) with a suitable tool.

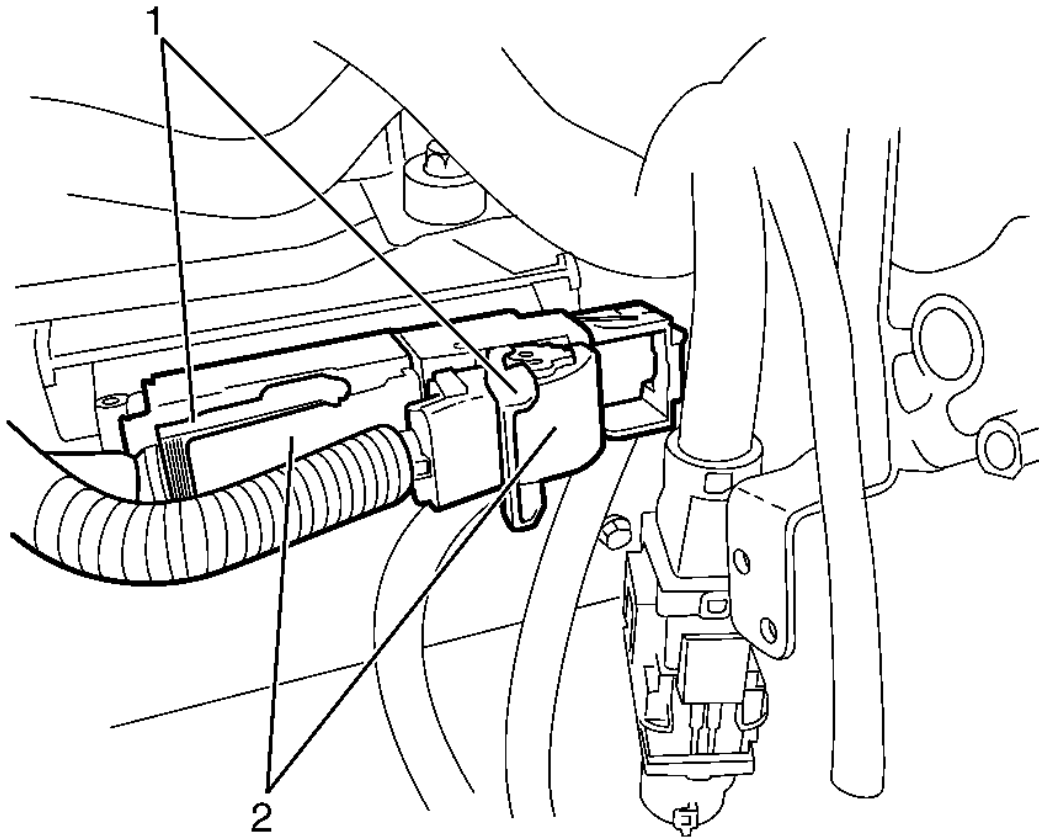
14. Disconnect the heater hose (1) from the heater pipe (2) in two places.



**Fig. 29: Identifying Intake Manifold Vacuum Port & Vacuum Hose With Retaining Clamp**  
Courtesy of GENERAL MOTORS CORP.

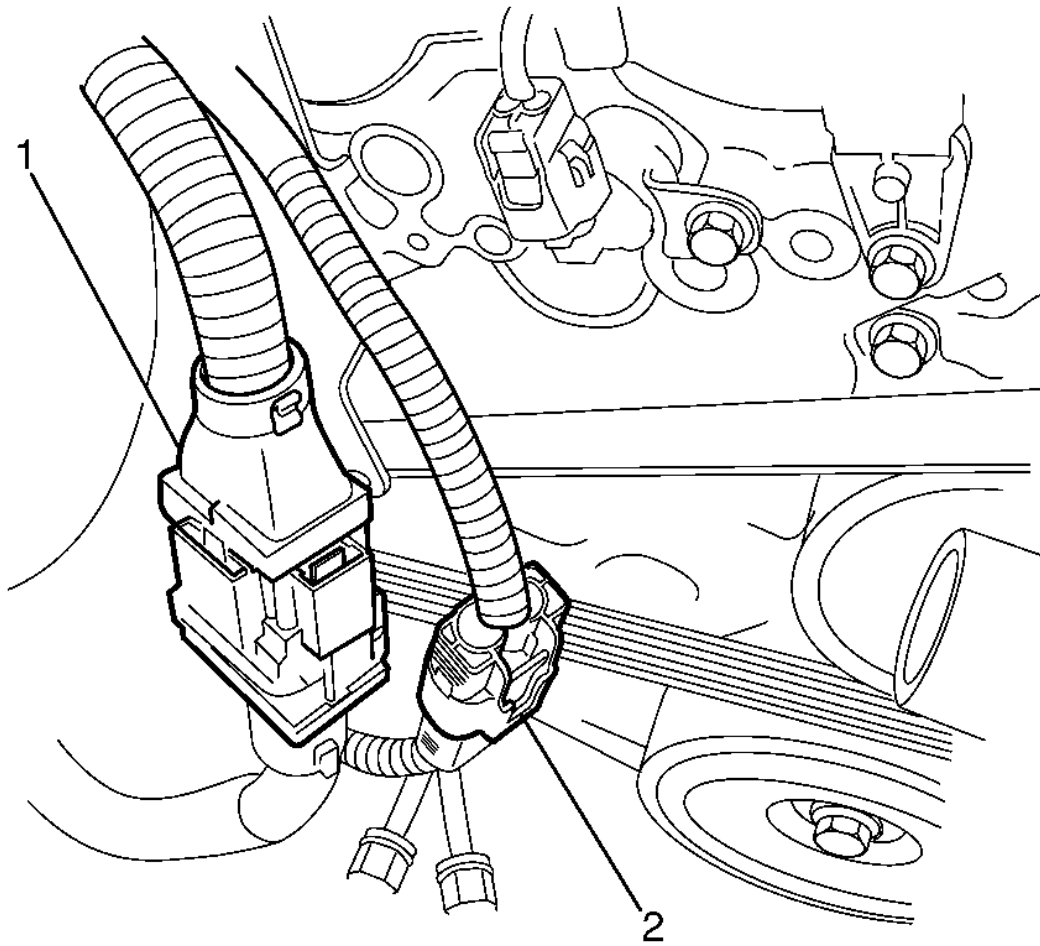
15. Compress the vacuum hose retaining clamp (2) at the intake manifold vacuum port (3) and slide 50 mm

- (2 in) back along the vacuum hose (1).
16. Disconnect the vacuum hose (1) from the intake manifold vacuum port (3) and secure away from the engine.
  17. Remove the engine coolant heater cord if fitted. Refer to **Coolant Heater Cord Replacement (3.6L)** .



**Fig. 30: Identifying ECM Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

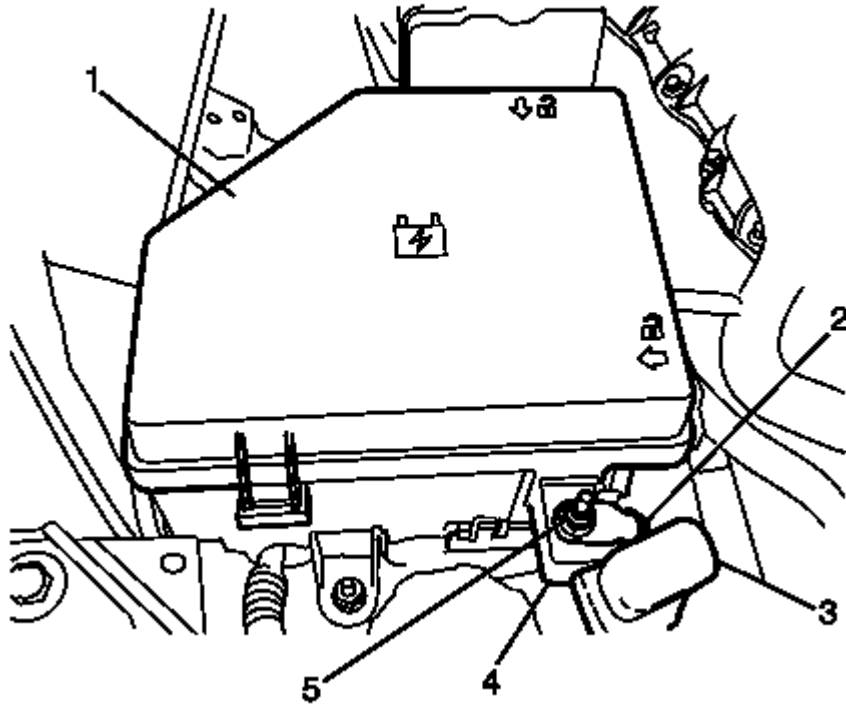
18. Rotate the engine control module (ECM) electrical connector levers (1) up to the unlocked position.
19. Disconnect ECM electrical connectors (2) from the ECM.



**Fig. 31: Identifying 56 & 2 Pin Engine Wiring Harness To Main Wiring Harness Electrical Connectors**

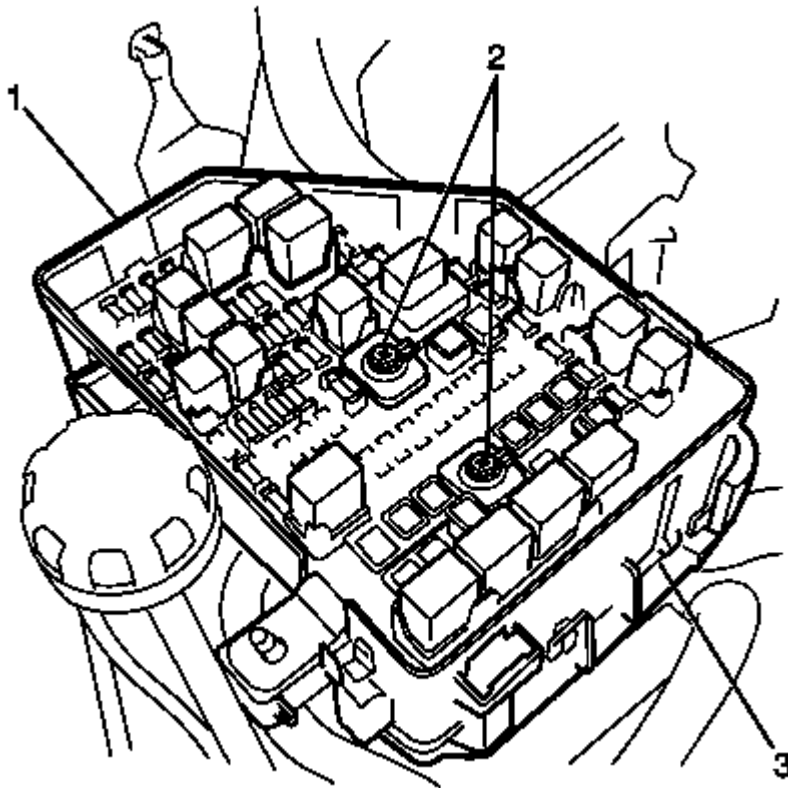
**Courtesy of GENERAL MOTORS CORP.**

20. Disconnect the 56 pin engine wiring harness to main wiring harness electrical connector (1).
21. Disconnect the two pin engine wiring harness to main wiring harness electrical connector (2).



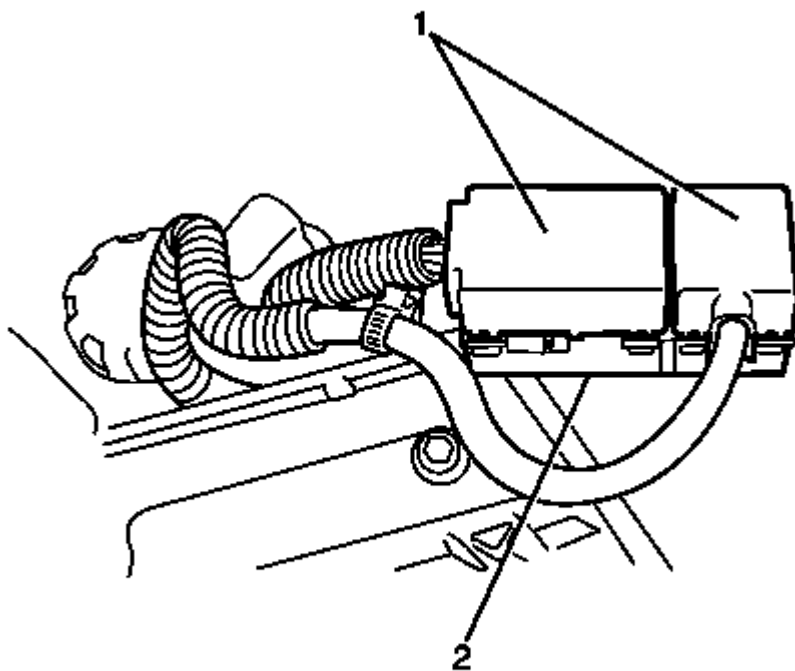
**Fig. 32: Identifying Positive Cable To Under Hood BEC Plate Retaining Bolt**  
 Courtesy of GENERAL MOTORS CORP.

22. Remove the under hood body electrical centre (BEC) cover (1).
23. Remove the positive cable protective cover (3).
24. Remove the positive cable to under hood BEC plate retaining bolt (5).
25. Disconnect the positive cable (2) from the upper under hood BEC plate (4).



**Fig. 33: Identifying Under Hood BEC Upper Plate To Lower Plate Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

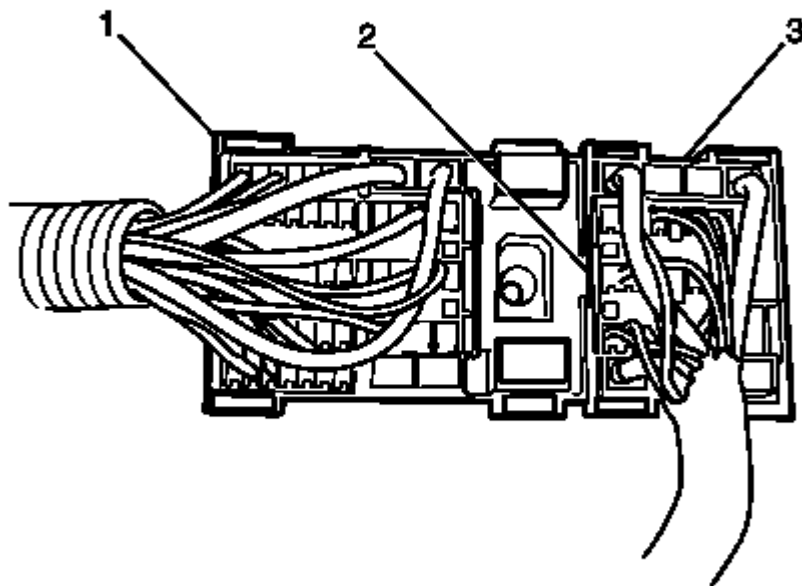
26. Remove the under hood BEC upper plate to lower plate retaining bolts (2).
27. Raise the upper under hood BEC plate (1) from the lower under hood BEC plate (3).



**Fig. 34: Identifying Under Hood BEC Connector With Protector**  
Courtesy of GENERAL MOTORS CORP.

28. Detach the protector (1) from the base of the under hood BEC connector (2).

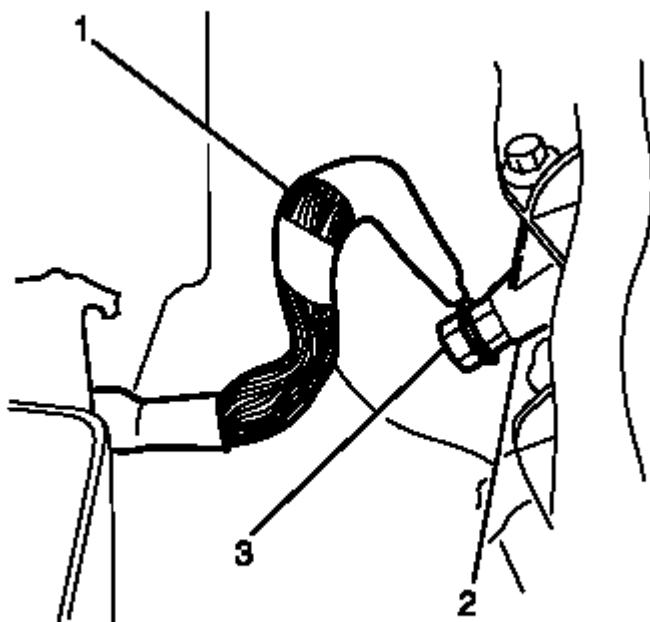




**Fig. 35: Identifying Engine Connector, Locking Tang & Body Harness Connector**  
Courtesy of GENERAL MOTORS CORP.

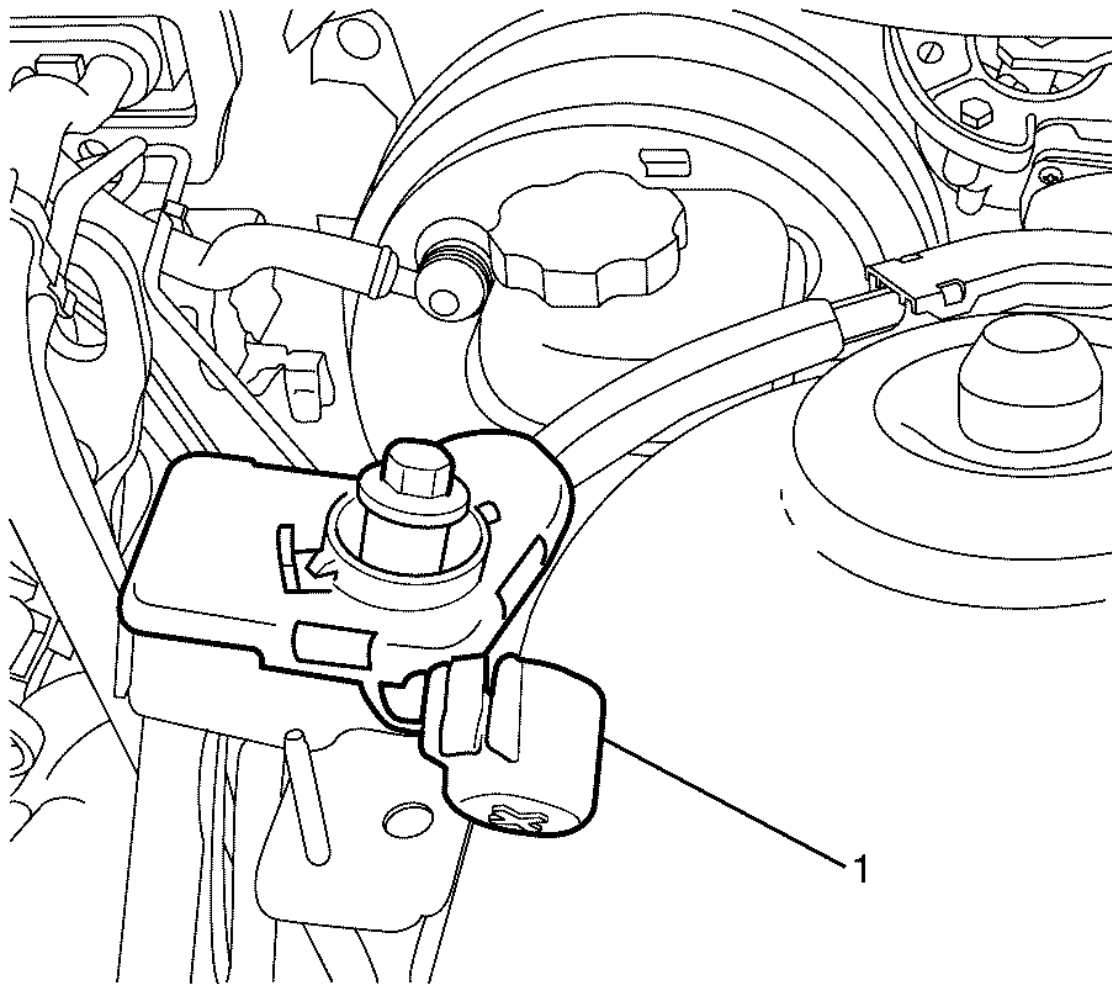
**NOTE:** Use a suitable tool to depress the connector locking tang (2), then pull the body harness connector (1) upward and the engine connector (3) downward to separate the body harness connector (1) from the engine connector (3).

29. Separate the body harness connector (1) from the engine connector (3).
30. Reposition and secure the engine wiring harness and connector (3) on the engine.



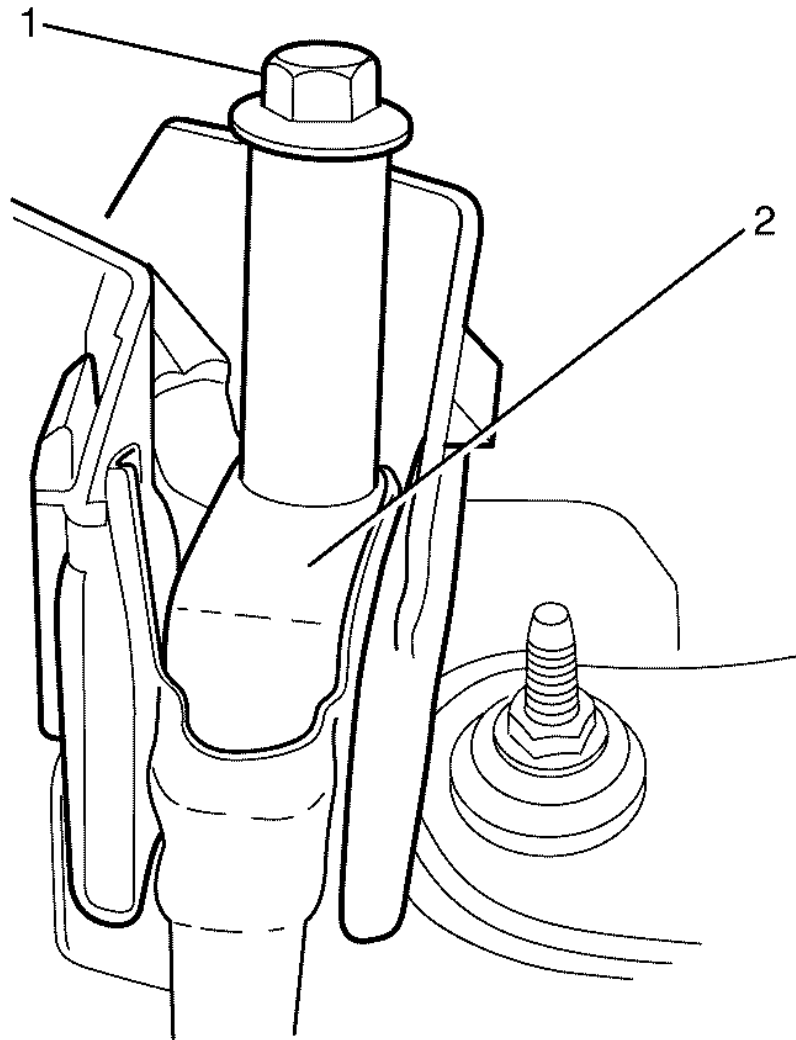
**Fig. 36: Identifying Vehicle Body Ground Cable To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

31. Remove the vehicle body ground cable to cylinder head retaining bolt (3)
32. Disconnect the vehicle body ground cable (1) from the cylinder head (2).



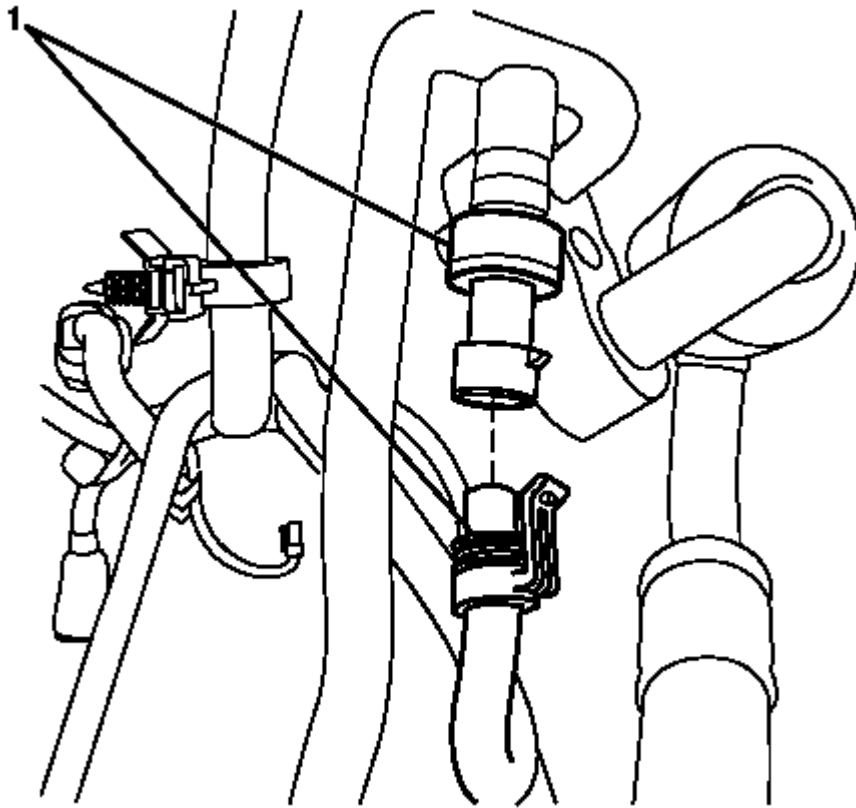
**Fig. 37: Identifying Remote Battery Positive Post Cover**  
Courtesy of GENERAL MOTORS CORP.

33. Remove the remote positive battery post cover (1) from the remote positive battery post.



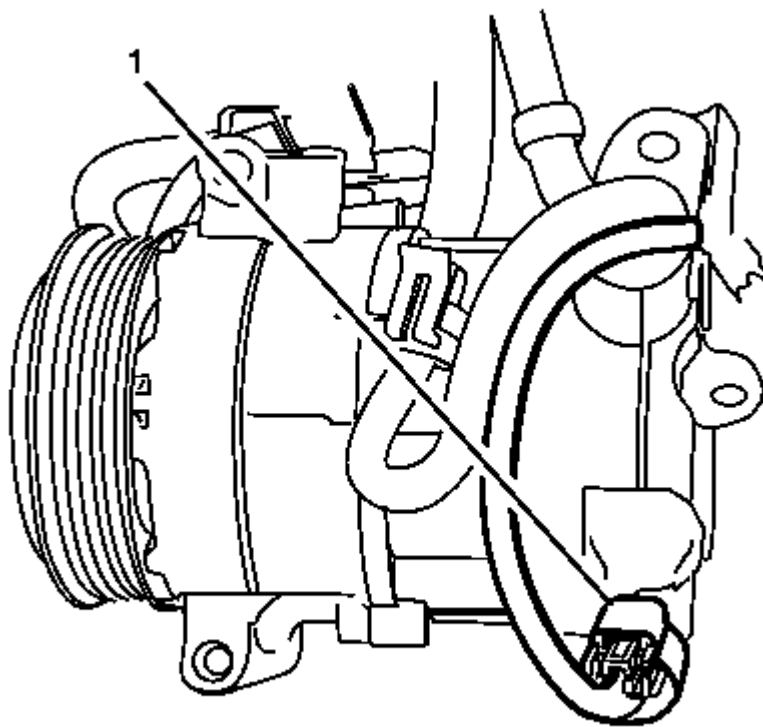
**Fig. 38: Identifying Remote Battery Positive Post To Wiring Harness Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

34. Remove the remote positive battery post to wiring harness retaining bolt (1).
35. Remove the wiring harness (2) from the remote positive battery post.



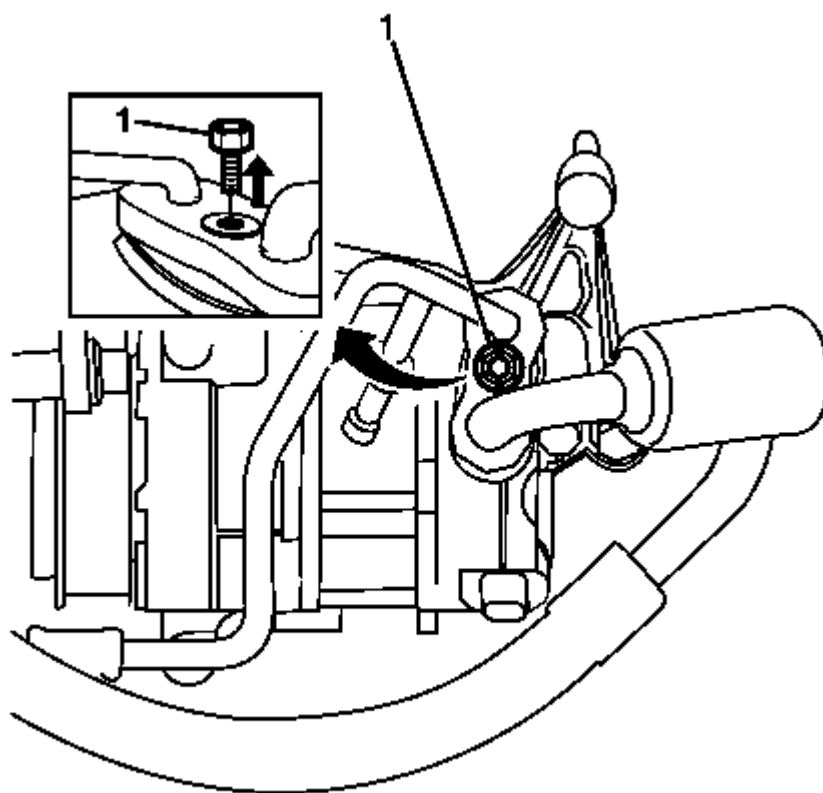
**Fig. 39: Identifying A/C Refrigerant Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

36. Disconnect the A/C pressure transducer electrical connector (1).



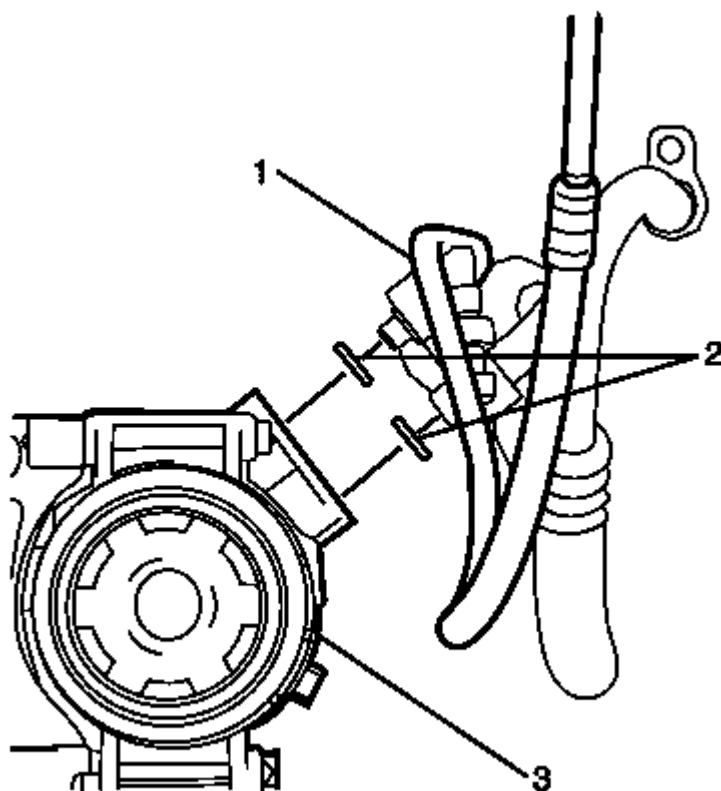
**Fig. 40: Identifying A/C Compressor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

37. Disconnect the A/C compressor electrical connector (1).



**Fig. 41: Identifying Suction/Discharge Pipe Pad To Compressor Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

38. Remove the suction/discharge line pad to A/C compressor retaining nut (1).



**Fig. 42: View Of A/C Suction/Discharge Pipe**  
 Courtesy of GENERAL MOTORS CORP.

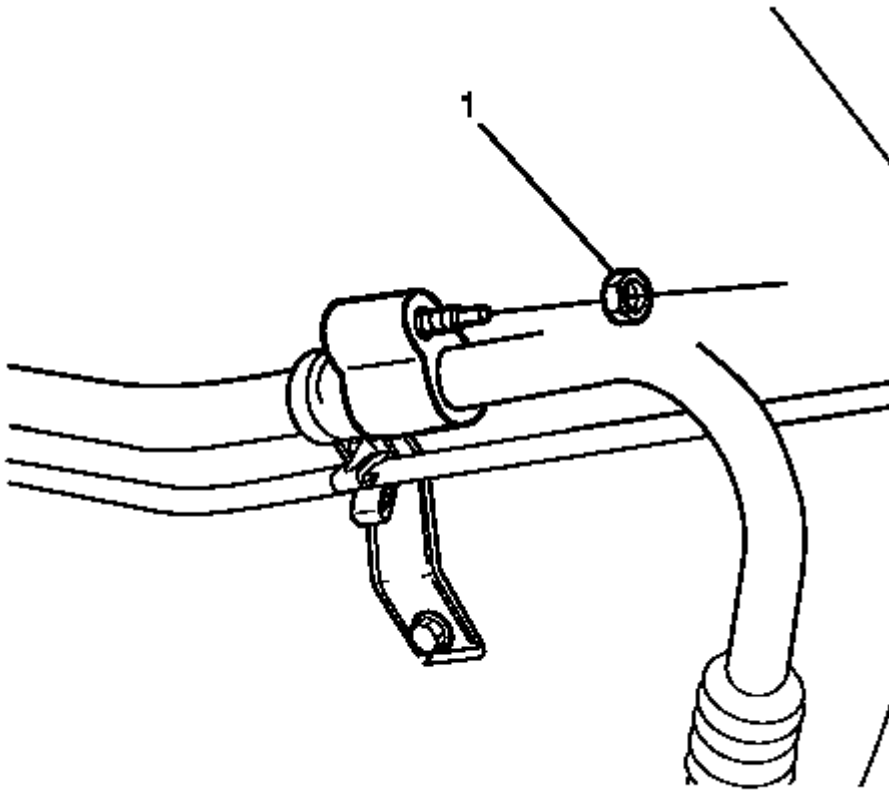
39. Disconnect the A/C suction/discharge line pad (1) from the A/C compressor (3).

**NOTE:** Plug or cap the A/C suction/discharge pipe ends and the compressor ports immediately to prevent contamination and absorption of moisture from the atmosphere.

40. Plug or cap the A/C suction/discharge pipe (1) ends and the compressor (3) ports.

**NOTE:** The A/C sealing O-rings (2) are a single use component and will not reseal. Install NEW A/C sealing O-rings (2) whenever the A/C suction/discharge line pad (1) is removed from the A/C compressor (3).



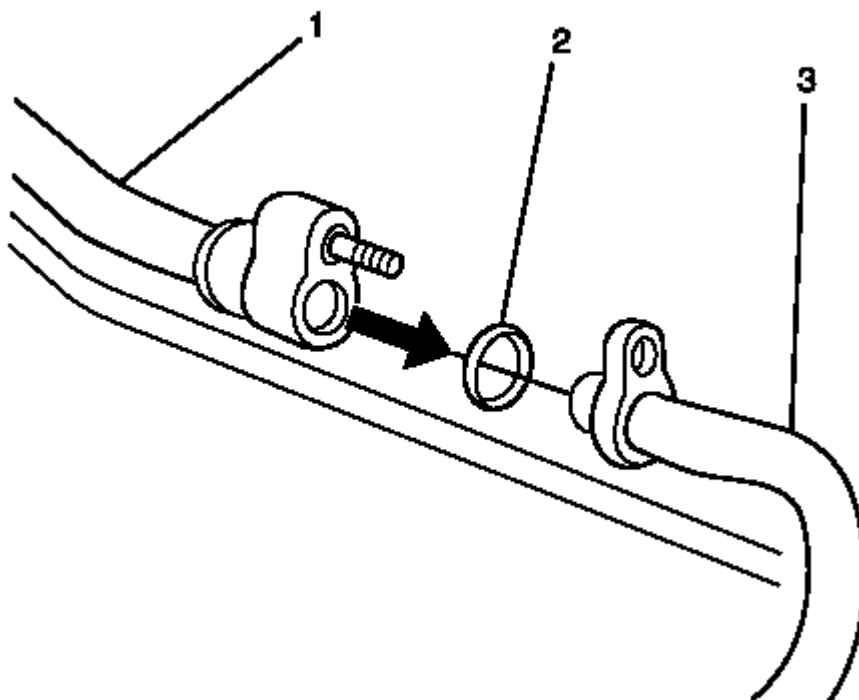


**Fig. 43: Identifying A/C Suction Pipe Pad To Lower A/C Suction Pipe Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

41. Remove and discard the A/C suction/discharge pipe sealing O-rings (2).

Discard the O-rings (2).

Remove the A/C suction pipe pad to A/C suction pipe retaining nut (1).



**Fig. 44: Identifying Upper & Lower A/C Suction Pipe With Sealing O-Ring**  
Courtesy of GENERAL MOTORS CORP.

42. Disconnect the upper A/C suction pipe (1) from the lower A/C suction tube (3).

**NOTE:** Plug or cap the A/C suction pipe ends (1 and 3) immediately to prevent contamination and absorption of moisture from the atmosphere.

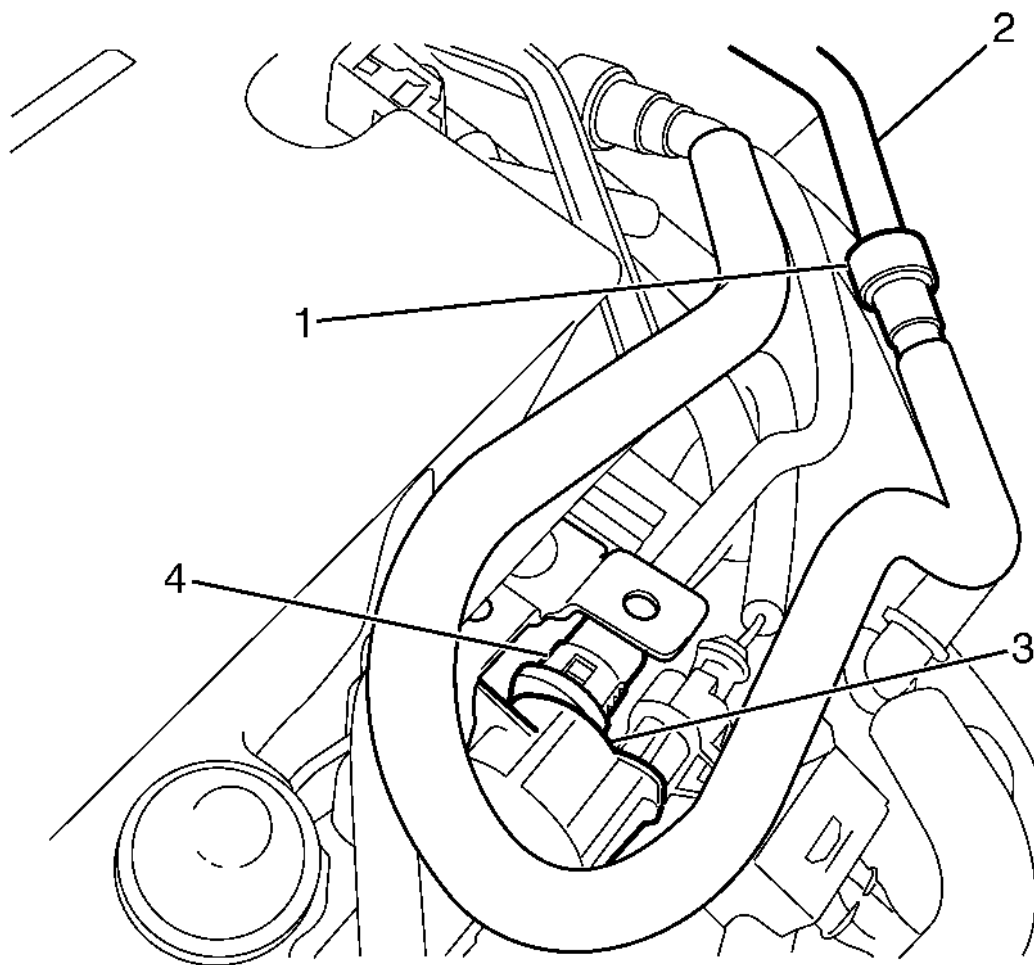
43. Plug or cap the A/C suction pipe ends.

**NOTE:** The A/C suction pipe sealing O-ring (2) is a single use component and will not reseal. Install a NEW A/C suction pipe sealing O-ring (2) whenever the upper A/C suction pipe (1) is removed from the lower A/C suction pipe (3).

44. Remove and discard the A/C suction pipe sealing O-ring (2).

Discard the O-ring (2).

45. Reposition and retain the A/C suction/discharge pipes away from the engine.



**Fig. 45: View Of EVAP Purge Line, Purge Solenoid, Fuel Feed Hose & Pipe**  
Courtesy of GENERAL MOTORS CORP.

46. Disconnect the fuel feed hose (1) from the fuel feed pipe (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .

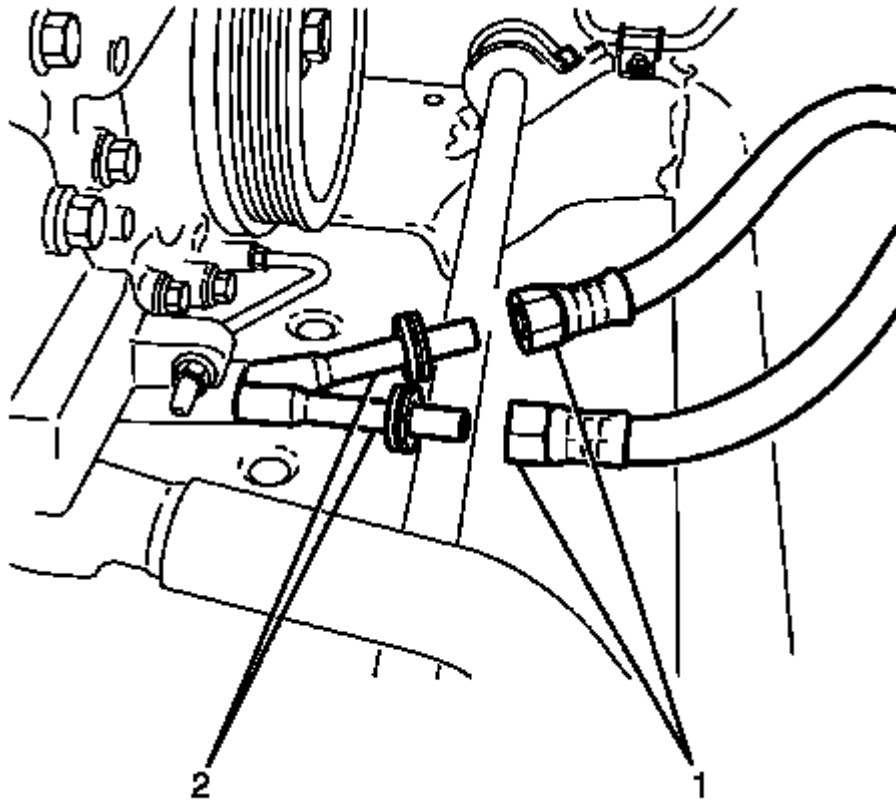
**NOTE:**      **Plug or cap the fuel feed pipe (2) and fuel feed hose (1) ends to prevent fuel leaks and/or contamination.**

47. Plug or cap the fuel feed pipe (2) and fuel feed hose (1) ends.
48. Disconnect the evaporative emission (EVAP) purge line (4) from the purge solenoid (3). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .
49. Plug or cap the (EVAP) purge line (4) and the purge solenoid (3) ends.

**NOTE:** The flexible hoses are not serviced separately. Therefore if the hose's require replacement, then the hose and radiator to hose cooler hose assembly must be fitted.

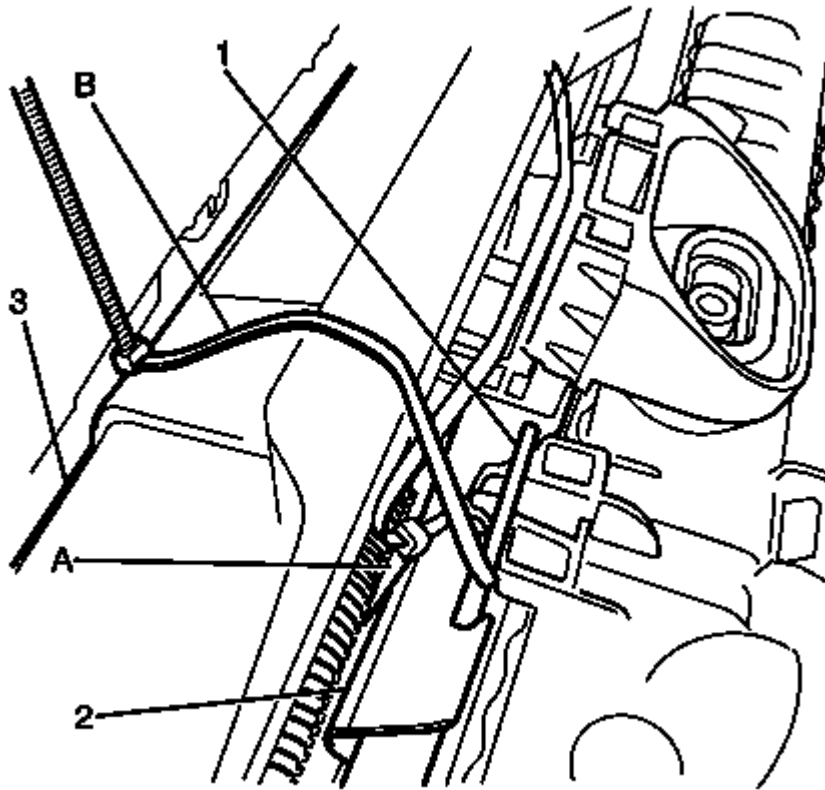
**NOTE:** When removal is complete plug hose openings with a clean lint free cloth to prevent foreign matter entry.

50. Place a suitable container beneath the radiator and engine.



**Fig. 46: Identifying Transmission Cooler Lines & Flexible Hoses**  
Courtesy of GENERAL MOTORS CORP.

51. Disconnect the transmission cooler line (2) from the flexible hose (1) at the quick connect fitting using tool. AU525.
- Open release tool AU525 then close and clip around the hose to be disconnected.
  - While holding the flexible hose (1) push the hose inwards with one hand, then pull back to separate from the steel hose piping (2).
  - Repeat for the second fitting.
52. Reposition and secure the flexible hoses (1) away from the engine and subframe.



**Fig. 47: Identifying Front End, Radiator & Condenser Assembly**  
Courtesy of GENERAL MOTORS CORP.

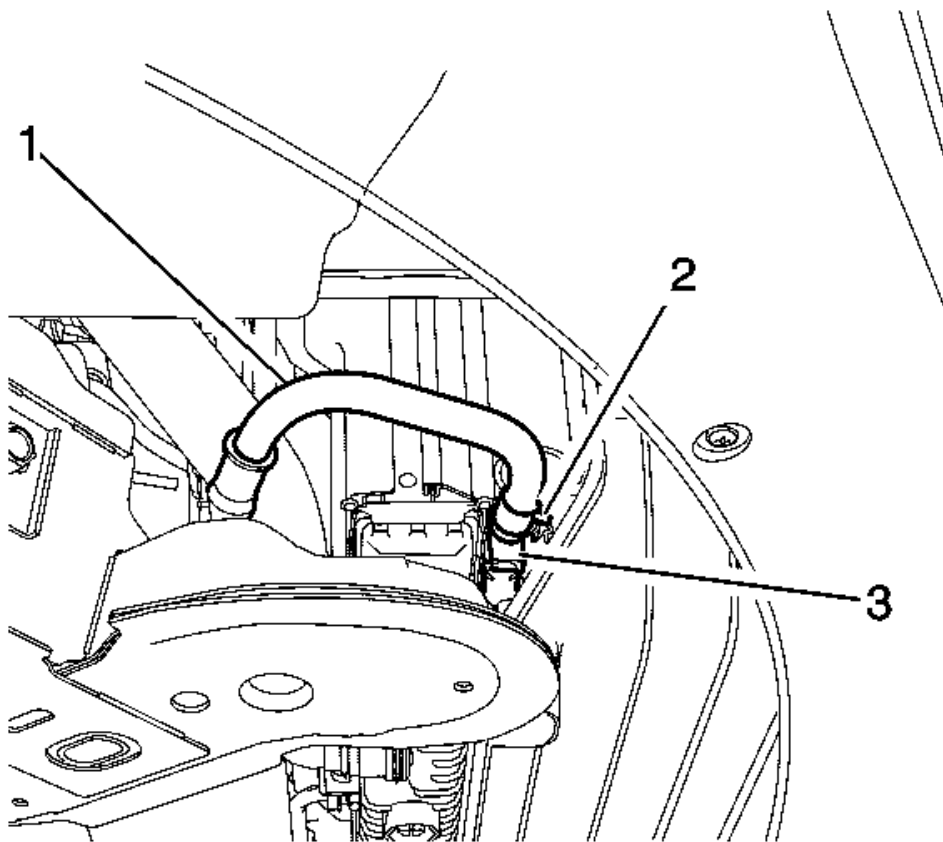
- NOTE:** It is necessary to secure the radiator and condenser assembly (2) to the front end assembly (3) as the radiator and condenser assembly is supported to the subframe.
- NOTE:** Thread zip tie A around the front end assembly and zip tie B through the radiator and condenser mount (1). Insert zip tie A into the retainer of zip tie B and insert zip tie B into the retainer of zip tie A.

53. Secure radiator and condenser assembly (2) to the front end assembly (3) with large zip ties or equivalent.

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

**WARNING:** To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

54. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
55. Remove the front air deflector. Refer to Front Air Deflector Replacement .
56. Remove the Engine Splash Shield. Refer to Engine Splash Shield Replacement .
57. Disconnect the radiator inlet hose. Refer to Radiator Inlet Hose Replacement (3.6L) .



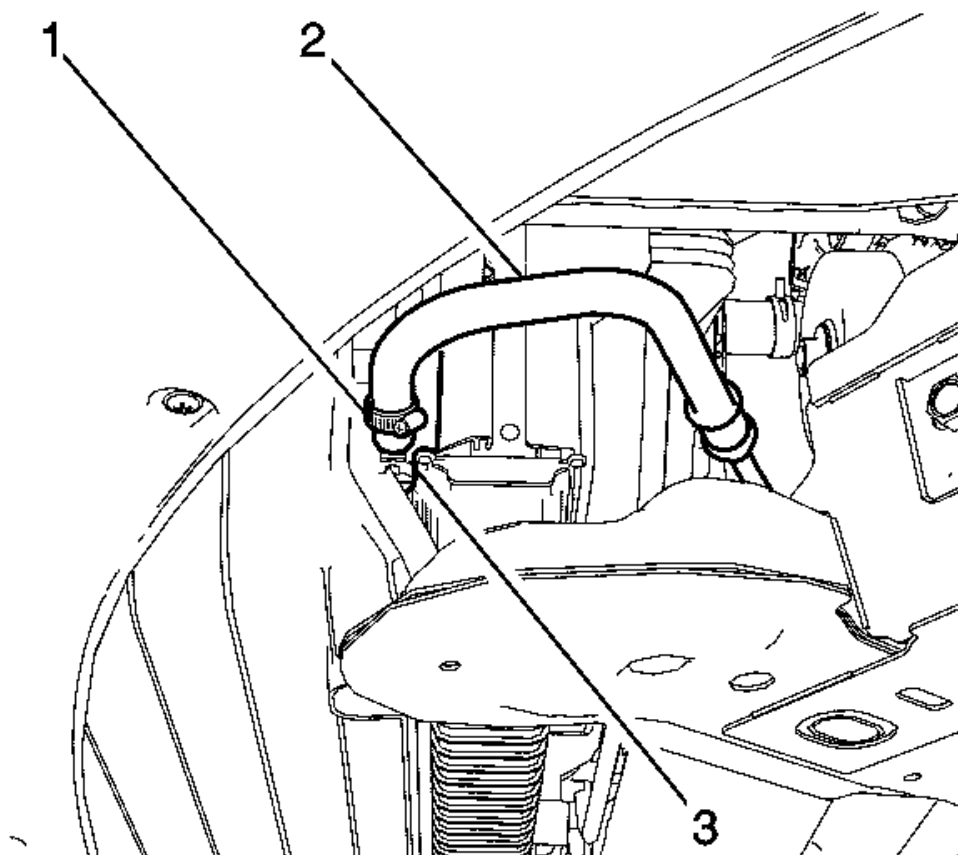
**Fig. 48: View Of Power Steering Cooler & Power Steering Gear Outlet Pipe/Hose With Spring Clamp**  
Courtesy of GENERAL MOTORS CORP.

58. Place a suitable container under the power steering cooler.

**NOTE:** The power steering cooler (3) must be plugged to prevent the entry of foreign particles into the power steering system.

59. Release the power steering gear outlet hose spring clamp (2) and disconnect the power steering gear outlet hose (1) from the power steering cooler (3).

Plug the power steering cooler (3) and power steering gear outlet hose (1).



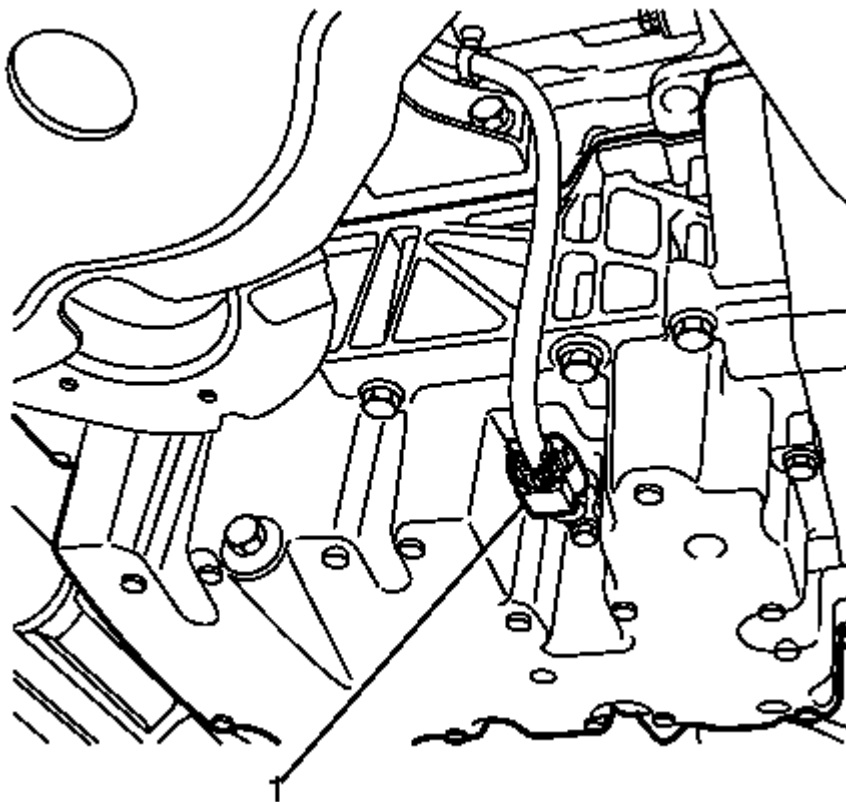
**Fig. 49: View Of Power Steering Cooler & Power Steering Fluid Reservoir Inlet Pipe/Hose & Spring Clamp**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The power steering cooler (3) must be plugged to prevent the entry of foreign particles into the power steering system.

60. Release the power steering reservoir inlet hose spring clamp (1) and disconnect the power steering reservoir inlet hose (2) from the power steering cooler (3).

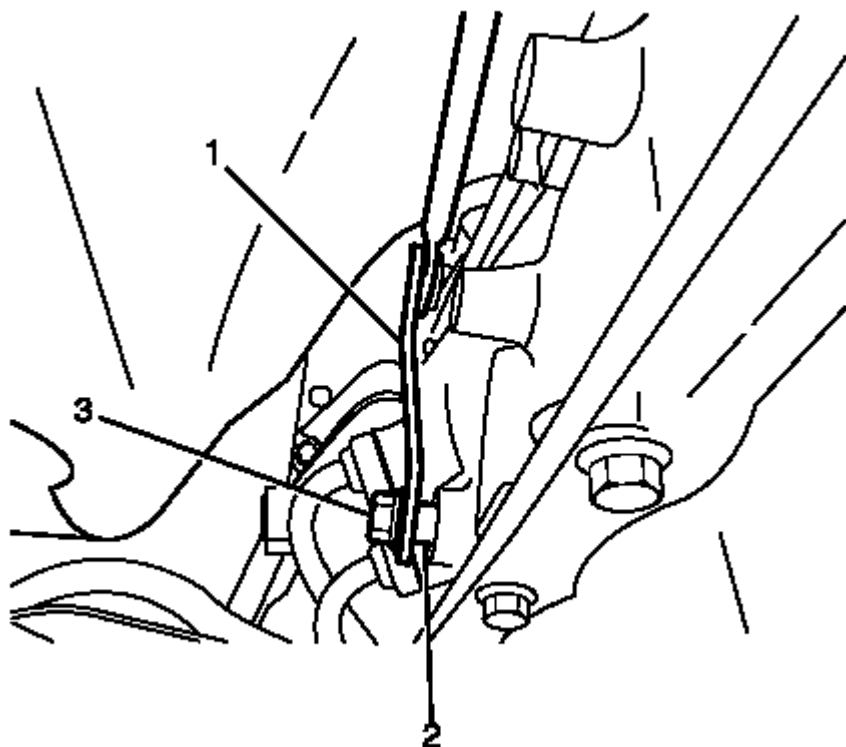
Plug the power steering cooler (3) and power steering reservoir inlet hose (2).



**Fig. 50: Identifying Oil Level/Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

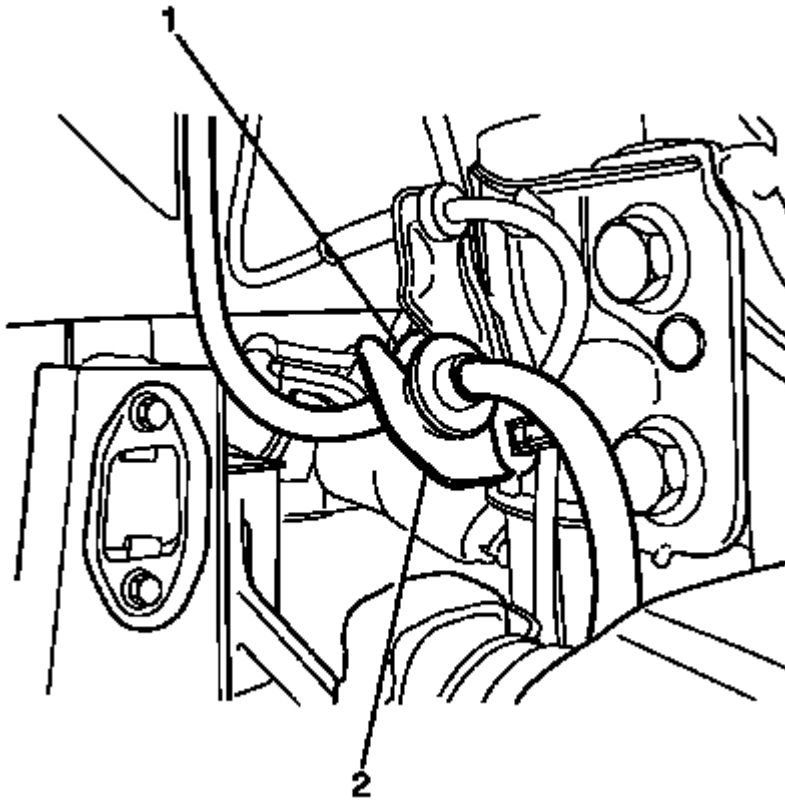
61. Disconnect the oil level/temperature sensor electrical connector (1).
62. Remove the exhaust system. Refer to **Exhaust System Replacement (V6 - For Access)** or **Exhaust System Replacement (V6 - Complete)** or **Exhaust System Replacement (V6 - For Access)** or **Exhaust System Replacement (V6 - Complete)** .
63. Remove the centre exhaust heat shield. Refer to **Exhaust Heat Shield Replacement - Center** .
64. Remove the propeller shaft. Refer to **Propeller Shaft Replacement** .





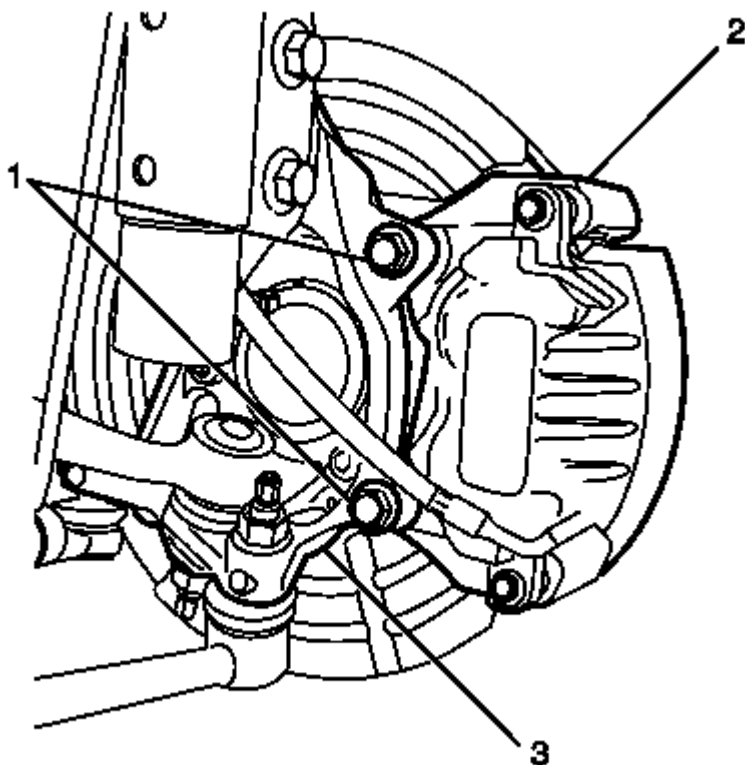
**Fig. 51: Identifying Shift Selector Linkage Rod To Shift Selector Shaft Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

65. Remove the shift selector linkage rod to shift selector shaft retaining nut (3).
66. Remove the shift selector linkage rod (1) from the shift selector shaft (2).
67. Remove the starter motor. Refer to **Starter Replacement (3.6L)** .
68. Partially lower the vehicle.
69. Remove the front wheels. Refer to **Tire and Wheel Removal and Installation** .



**Fig. 52: Identifying Front Brake Hose & Strut Mounted Brake Hose Retaining Bracket**  
Courtesy of GENERAL MOTORS CORP.

70. Detach the front brake hose (1) from the strut mounted brake hose retaining bracket (2). Repeat for opposite side.



**Fig. 53: Identifying Front Brake Caliper Anchor Plate To Front Steering Knuckle Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

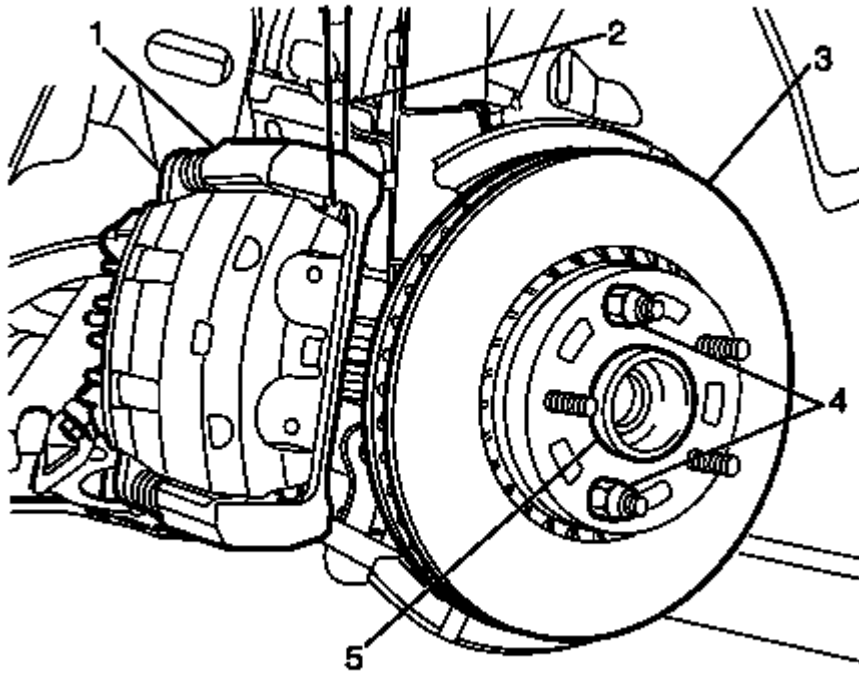
**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

71. Remove the front brake caliper anchor plate to knuckle retaining bolts (1). Repeat for opposite side.
- Discard the bolts.
  - Clean the bolt holes.

**IMPORTANT:** DO NOT disconnect the hydraulic brake flexible hose from the brake caliper otherwise complete bleeding of the braking system will be necessary.

72. Remove the front brake caliper (2) from the front steering knuckle (3). Repeat for opposite side.



**Fig. 54: View Of Hub, Wheel Nuts, Front Brake Disc, Heavy Mechanic's Wire & Front Brake Caliper**

Courtesy of GENERAL MOTORS CORP.

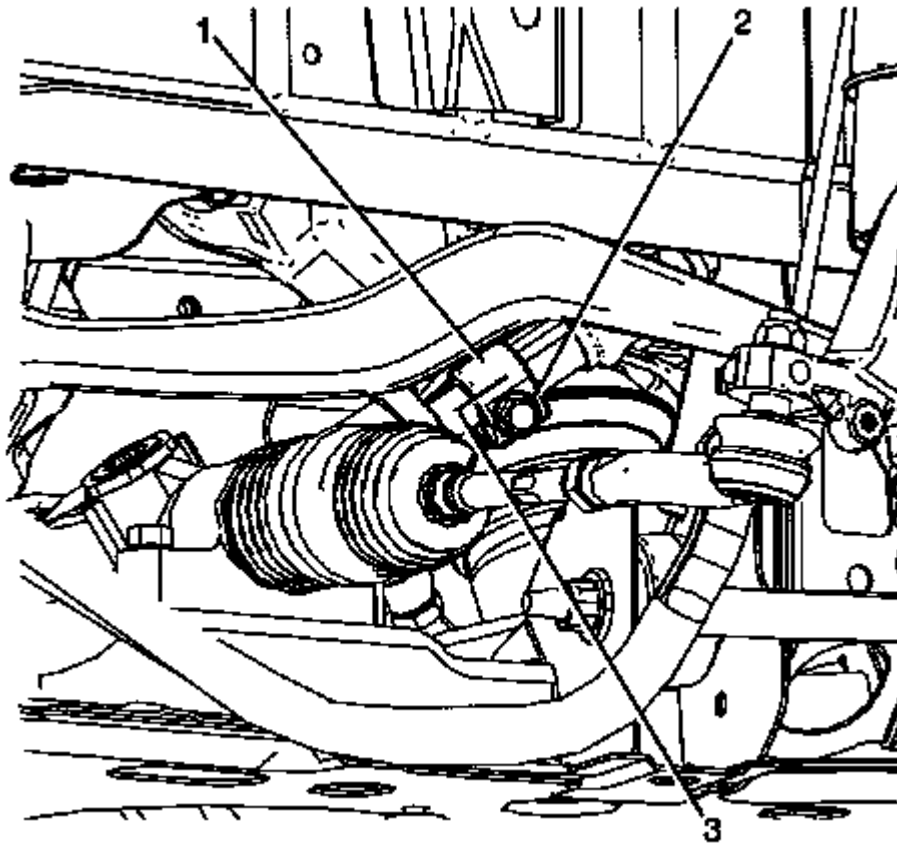
**CAUTION:** Support the brake caliper with heavy mechanic wire, or equivalent, whenever it is separated from its mount and the hydraulic flexible brake hose is still connected. Failure to support the caliper in this manner will cause the flexible brake hose to bear the weight of the caliper, which may cause damage to the brake hose and in turn may cause a brake fluid leak.

73. Support the front brake caliper (1) with heavy mechanic's wire, or equivalent (2). Repeat for opposite side.
74. Install two wheel nuts (4) to retain the front brake disc (3) to the hub (5). Repeat for opposite side.



**Fig. 55: Identifying Front Wheel Speed Sensor Jumper Harness Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

75. Disconnect the front wheel speed sensor jumper harness electrical connector (1) and secure away from the subframe and suspension components. Repeat for opposite side.



**Fig. 56: Identifying Intermediate Steering Shaft To Pinion Shaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The front wheels of the vehicle must be maintained in the straight ahead position and the steering column must be in the LOCK position before disconnecting the steering column or intermediate shaft. If these procedures are not followed incorrect alignment of some components during installation will result and damage to the SIR coil assembly will occur.

**NOTE:** Observing the orientation of the intermediate steering shaft (1) with reference to the pinion shaft (3) will minimize the potential of incorrect steering column assembly alignment.

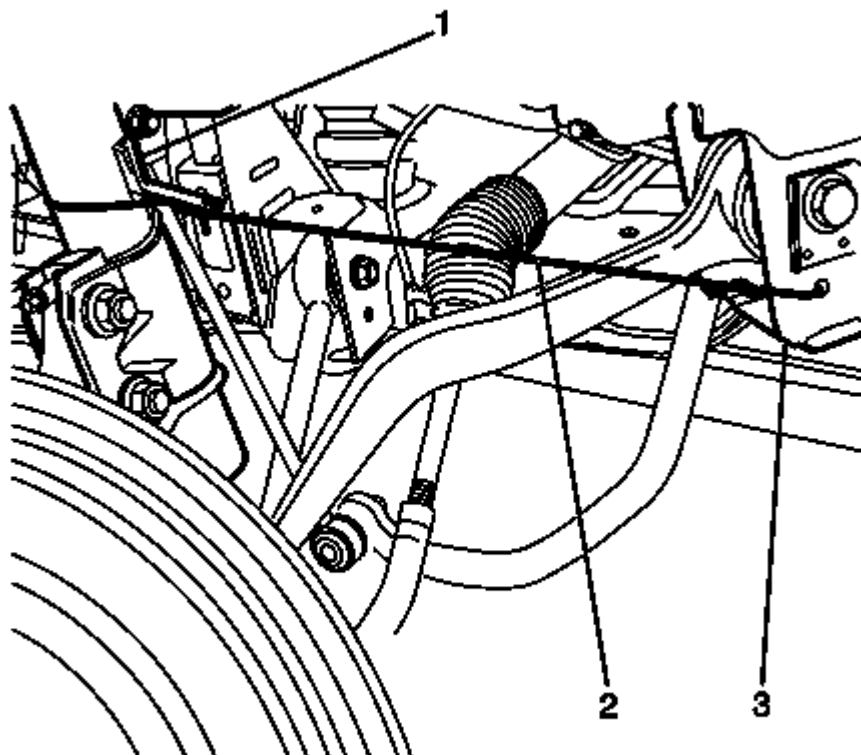
76. Mark the intermediate steering shaft (1) in relation to the pinion shaft (3).
77. Remove the intermediate steering shaft to pinion shaft retaining bolt (2).

**IMPORTANT:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**IMPORTANT:** Make sure the bolt hole is thoroughly cleaned and all micro-encapsulated

**thread sealant is removed.**

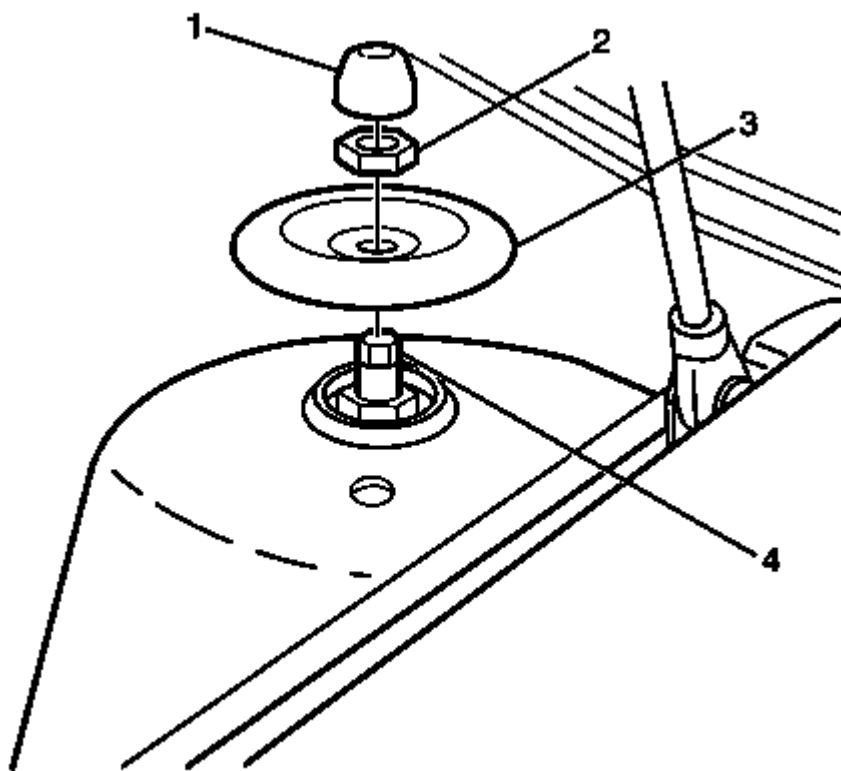
78. Disconnect the intermediate shaft (2) from the pinion shaft (3).
  - Discard the bolt.
  - Clean the bolt hole.
79. Lower the vehicle.



**Fig. 57: View Of Subframe, Heavy Mechanic's Wire & Strut Assembly**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The strut assembly (1) must be secured to the subframe (3) to prevent damage to the front wheelhouse liner, fenders and suspension components.

80. Retain the front strut assembly (1) to the front subframe (3) using heavy mechanics wire or equivalent (2). Repeat for opposite side.



**Fig. 58: View Of Strut Piston Shaft, Stud Dust Cover, Front Wheelhouse Retaining Plate & Nut**  
Courtesy of GENERAL MOTORS CORP.

81. Remove the stud dust cover (1) from the strut assembly to front wheelhouse retaining nut (2).

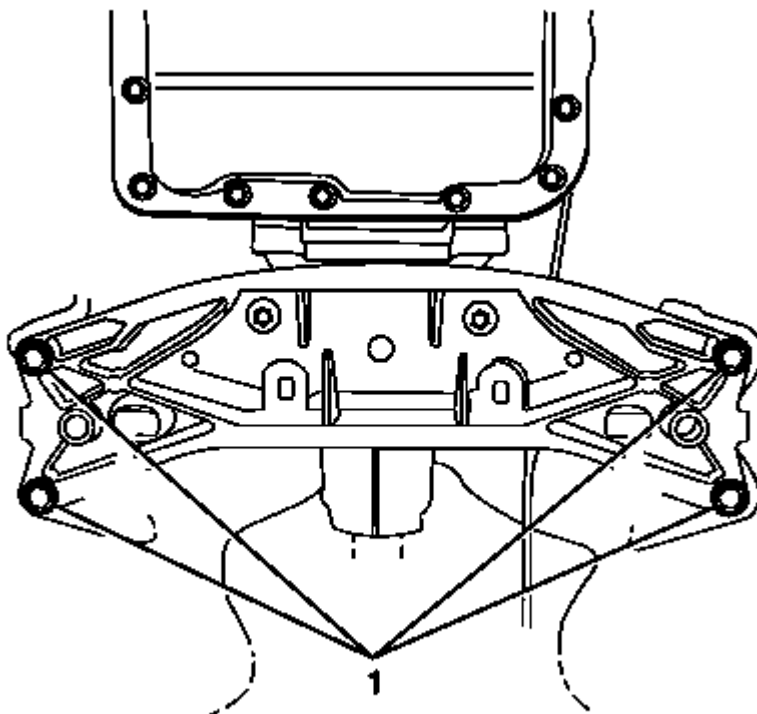
**NOTE:** The strut assembly (4) must be supported from underneath before the strut assembly to front wheelhouse retaining nut (2) is removed.

82. Remove the strut assembly to front wheelhouse retaining nut (2) while holding the strut piston shaft (4) with a suitable tool.

Discard the nut.

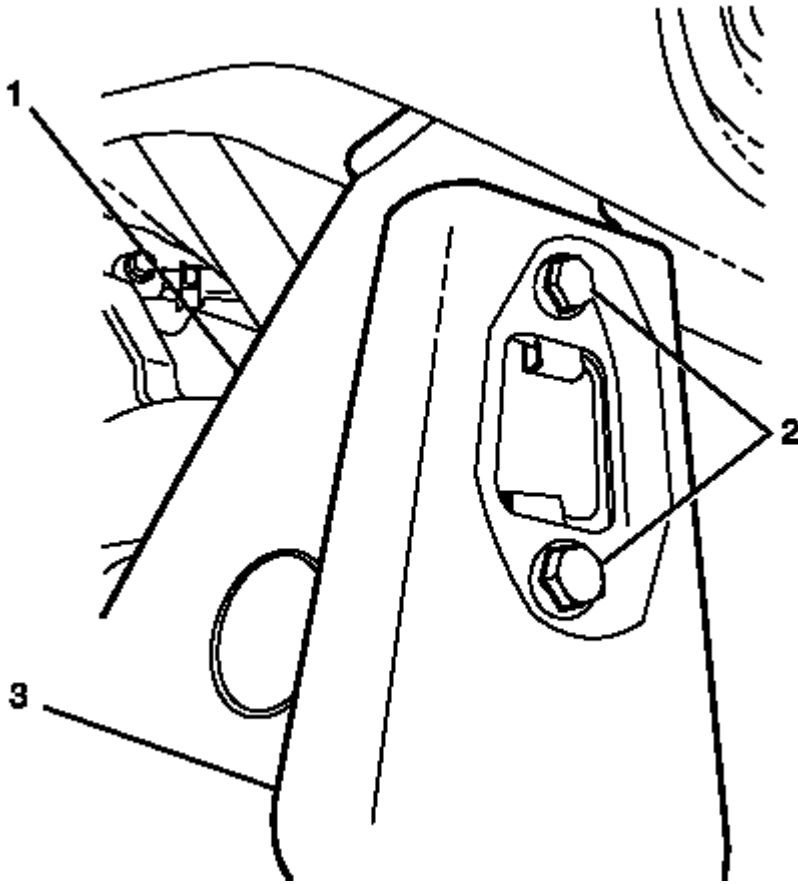
83. Remove the strut assembly to front wheelhouse retaining plate (3).  
84. Position a suitable powertrain and/or engine lift table below the frame, engine and transmission.  
85. Raise the lift table and/or lower the vehicle to support the frame, engine and transmission.





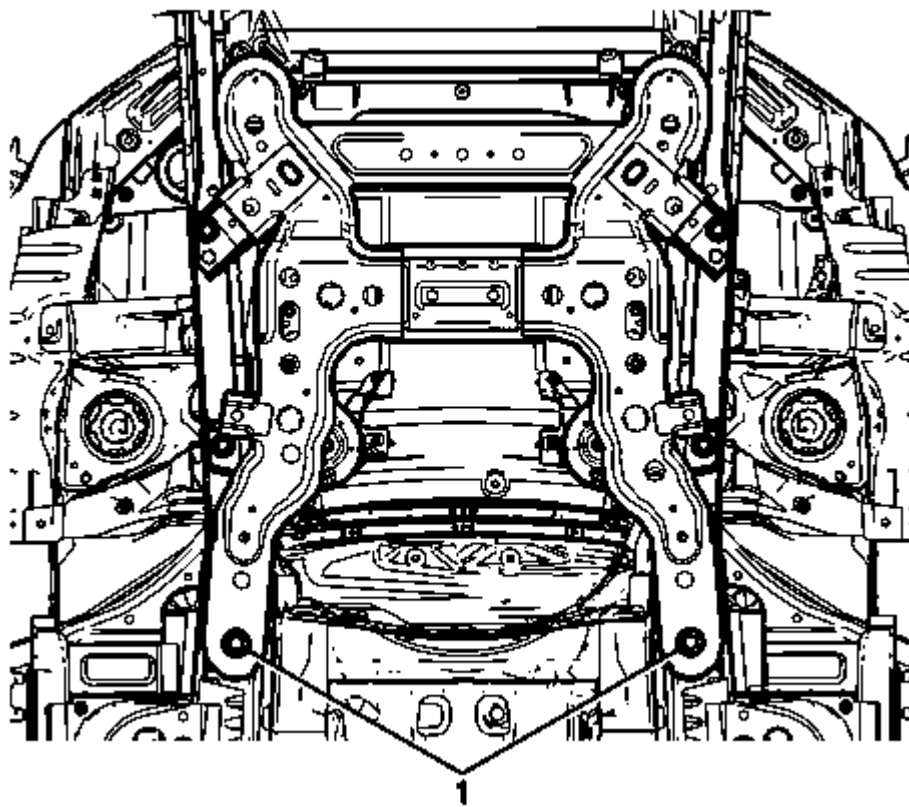
**Fig. 59: Identifying Transmission Support To Body Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

86. Remove the transmission support to body retaining bolts (1).



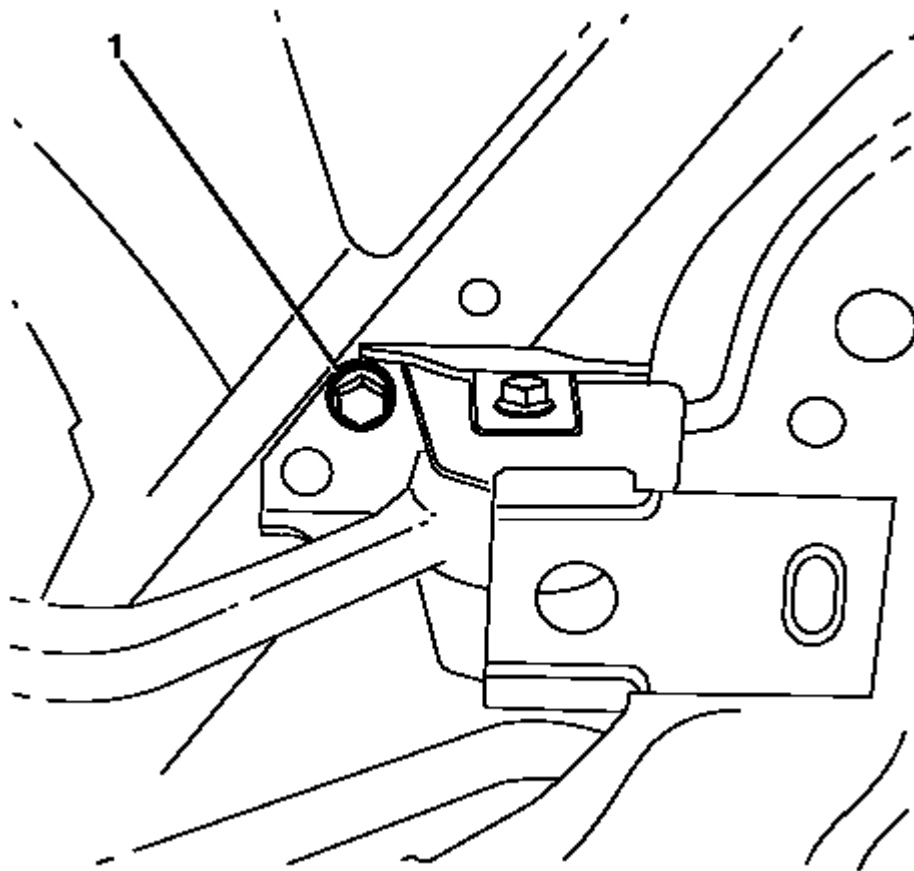
**Fig. 60: Identifying Subframe Reinforcement Plate To Subframe Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

87. Remove the subframe reinforcement plate to subframe retaining bolts (2).
88. Remove the subframe reinforcement plate (3) from the subframe (1).



**Fig. 61: Identifying Subframe To Body Rear Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

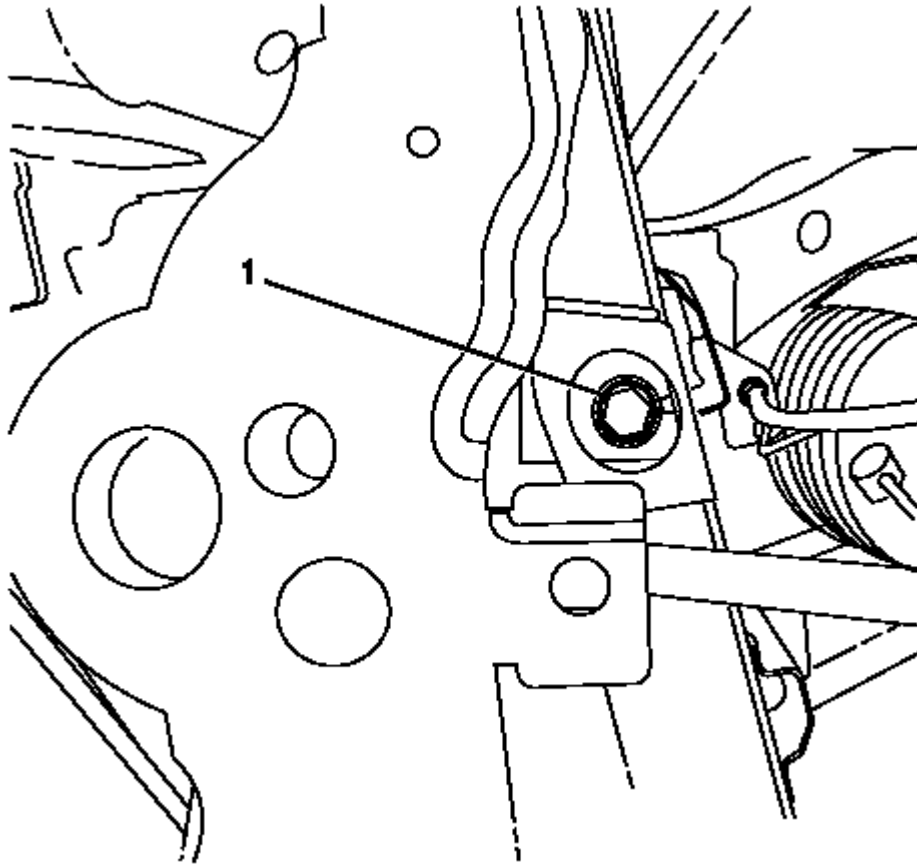
89. Remove the subframe to body rear retaining bolts (1).



**Fig. 62: Identifying Subframe To Body Front Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Only right side depicted in graphic, left side similar.

90. Remove the subframe to body front retaining bolt (1). Repeat for opposite side.



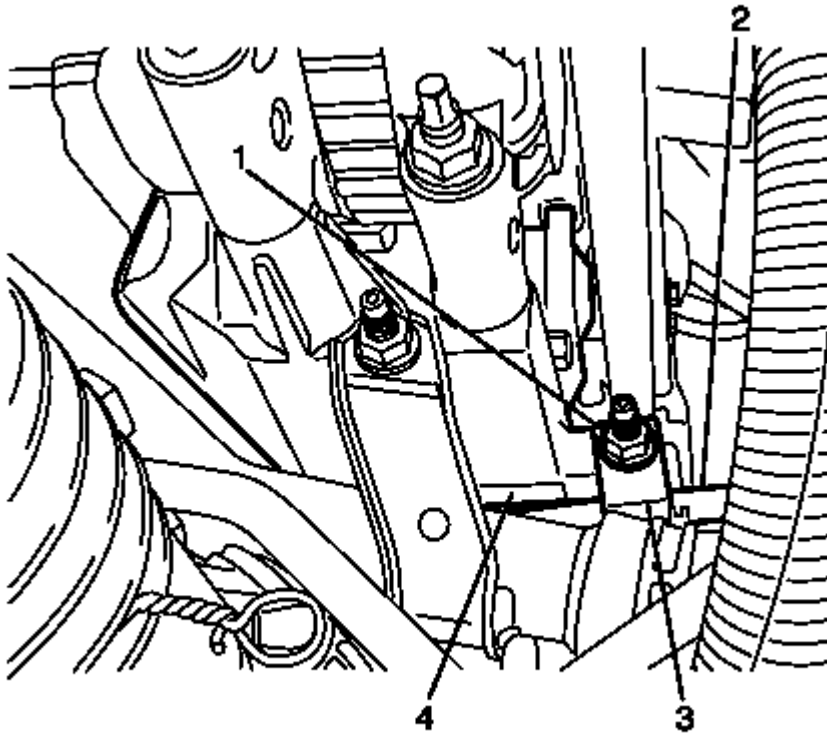
**Fig. 63: Identifying Subframe To Body Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

**NOTE:** Only right side depicted in graphic, left side similar.

91. Remove the subframe to body retaining bolt (1). Repeat for opposite side.

**NOTE:** Make sure that all the hoses, wires, pipes and front struts clear the vehicle during the removal process.

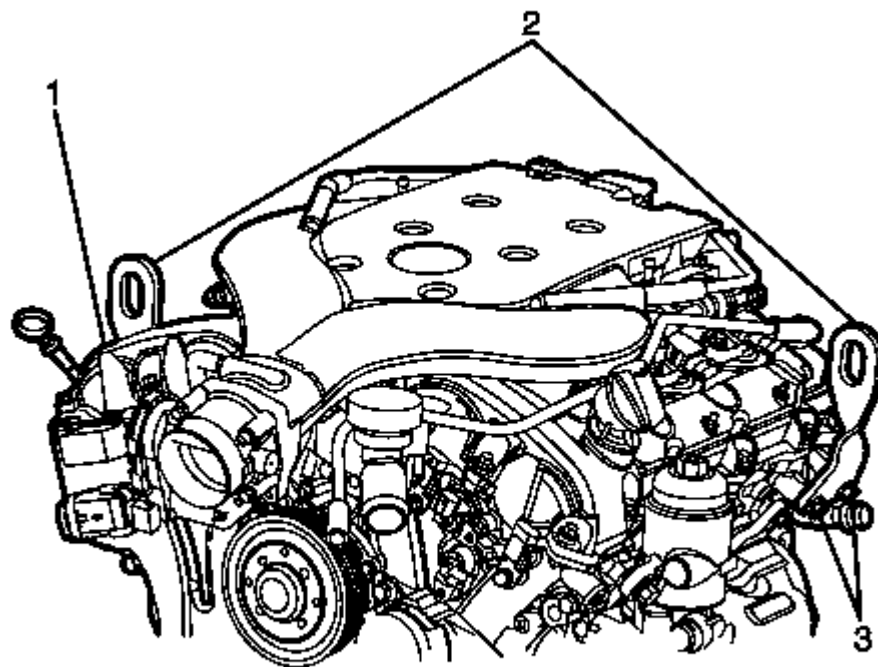
92. With the aid of an assistant, lower the table and/or raise the vehicle to remove the engine, transmission, front suspension and subframe assembly from the vehicle.
93. Remove the engine and transmission wiring harness and related components. Refer to **Engine Wiring Harness Assembly Removal**.



**Fig. 64: Identifying Transmission Cooler Line Clamp To Alternator Mounting Bracket Retaining Nut**

**Courtesy of GENERAL MOTORS CORP.**

94. Remove the transmission cooler line clamp to alternator mounting bracket retaining nut (1).
95. Remove the transmission cooler line clamp (3) and transmission cooler lines (2) from the alternator mounting bracket (4).

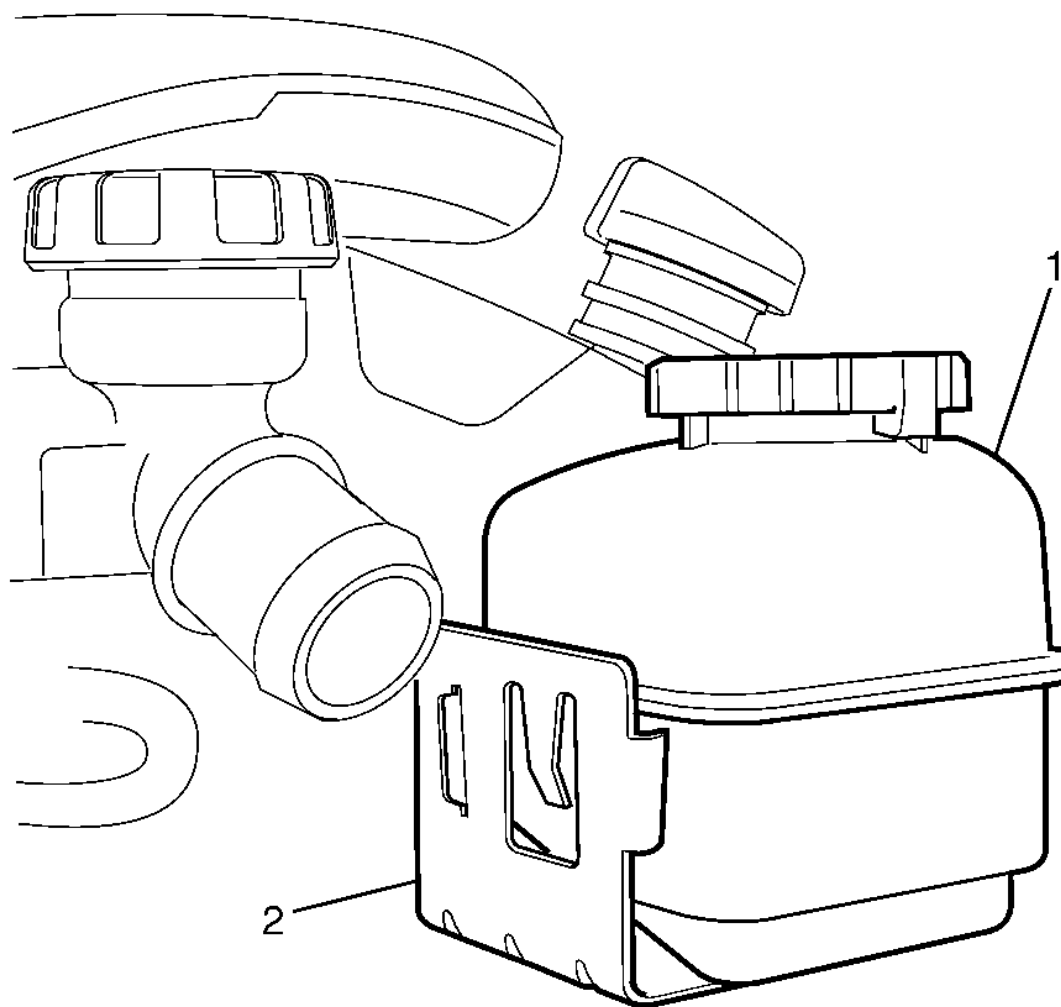


**Fig. 65: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

96. Position the **EN 46114** (2) on the engine (1).

**CAUTION: Refer to Fastener Caution .**

97. Install the **J 41798** to the cylinder head retaining bolts (3) and tighten to 50 N.m (36 lb ft).
98. Connect a suitable lifting crane to the engine lift brackets and raise the suitable lifting crane to support the engine.
99. Position a second powertrain lift table below the transmission.
100. Remove the transmission. Refer to **Transmission Replacement** .
101. Remove the engine flywheel. Refer to **Engine Flywheel Removal**.
102. Remove the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side (V6)** and **Catalytic Converter Replacement - Right Side (V6)** .
103. Remove the drive belt. Refer to **Drive Belt Replacement** .

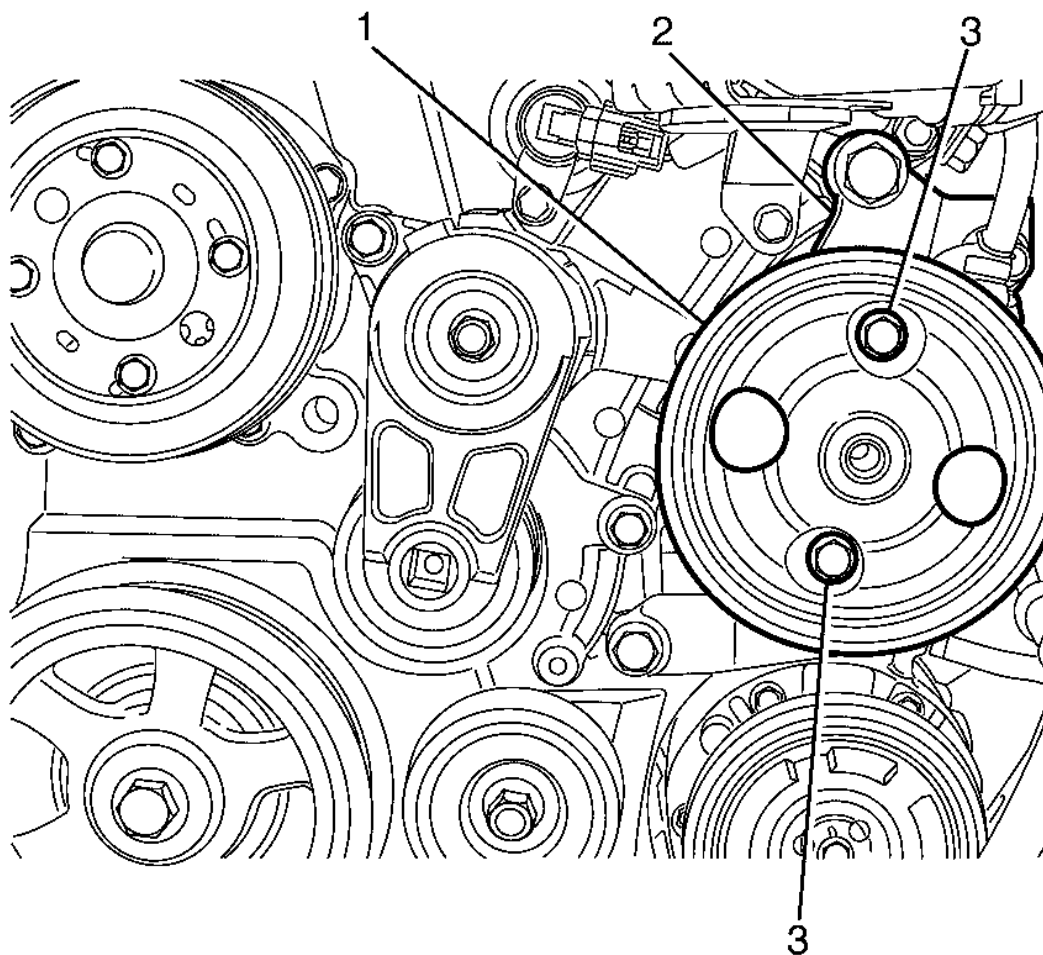


**Fig. 66: View Of Power Steering Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The locking tang on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1). Release the locking tang on the power steering reservoir bracket (2) with a suitable tool.

104. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).





**Fig. 67: Identifying Power Steering Pump To Power Steering Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT disconnect the power steering pipes/hoses.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**NOTE:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

105. Remove the power steering pump to power steering pump bracket retaining bolts (3).

- Discard the bolts.
- Clean the bolt hole.

106. Remove the power steering pump (1) from the power steering pump bracket (2) position the power steering pump aside.

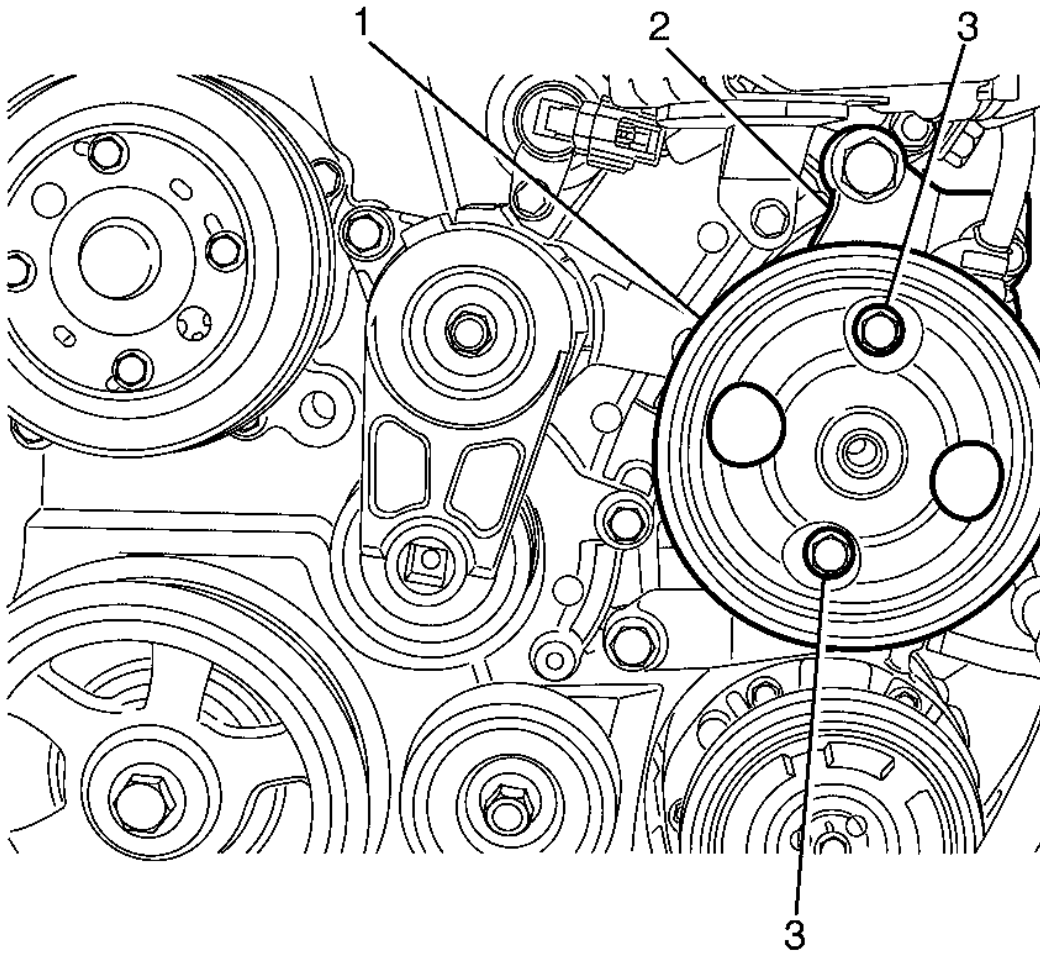
107. Remove the A/C compressor. Refer to **Air Conditioning Compressor Replacement (3.6L Engine)** .
108. Remove the A/C compressor mounting bracket. Refer to **Air Conditioning Compressor Bracket Replacement** .
109. Remove the alternator. Refer to **Generator Replacement (3.6L)** .
110. Attach a suitable lifting chain and hooks to the **EN 46114** .
111. Using a suitable lifting crane, raise the engine to clear the engine mount stud.
112. Remove the engine mount brackets with the engine mounts. Refer to **Engine Mount Bracket Replacement - Left Side** and **Engine Mount Bracket Replacement - Right Side** .
113. Remove the engine from the subframe

If required mount the engine on a suitable engine stand.

114. Remove the alternator bracket. Refer to **Generator Bracket Replacement (3.6L)** .

#### **Installation Procedure**

1. Use a floor crane in order to install the engine to the frame.
2. Install the engine mount brackets with the engine mounts. Refer to **Engine Mount Bracket Replacement - Left Side** and **Engine Mount Bracket Replacement - Right Side** .
3. Raise the floor crane to partially support the engine
4. Install the alternator bracket. Refer to **Generator Bracket Replacement (3.6L)** .
5. Install the alternator. Refer to **Generator Replacement (3.6L)** .
6. Install the A/C compressor mounting bracket. Refer to **Air Conditioning Compressor Bracket Replacement** .
7. Install the A/C compressor. Refer to **Air Conditioning Compressor Replacement (3.6L Engine)** .

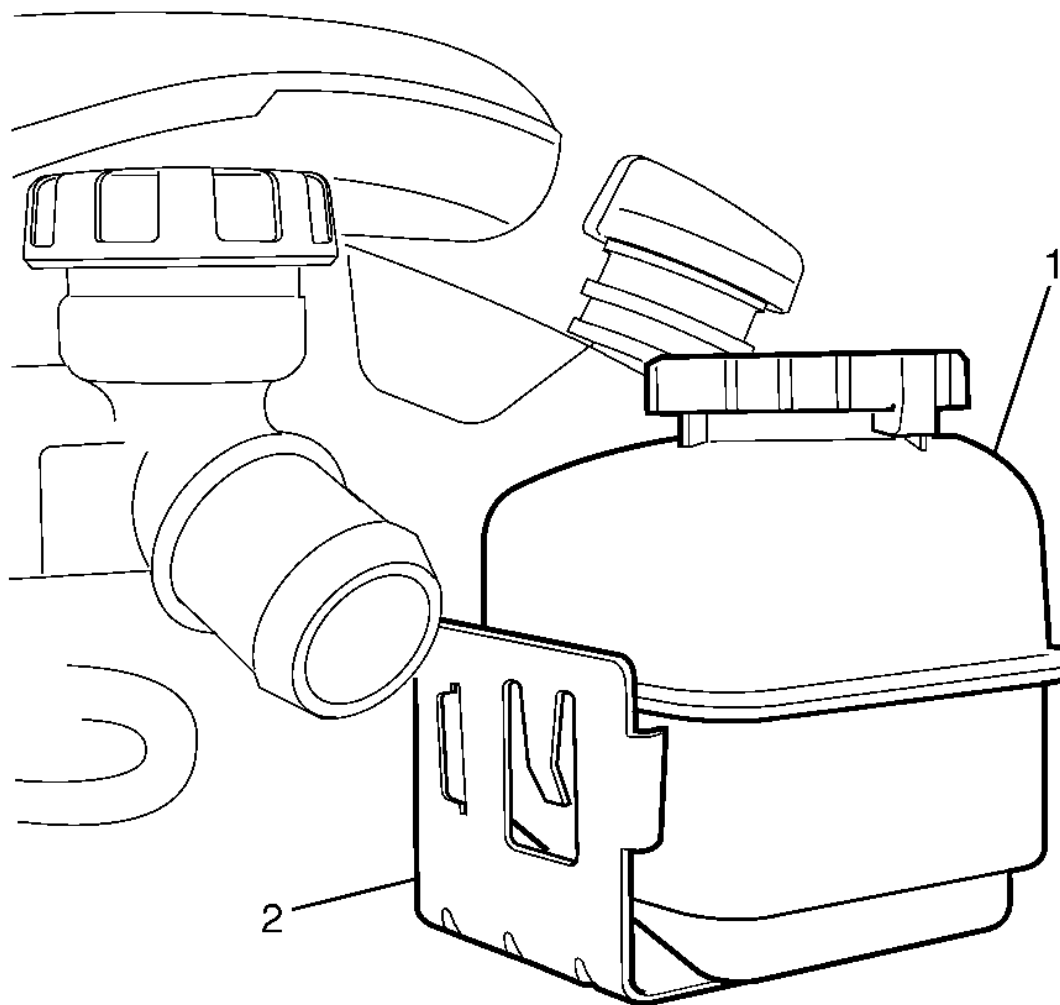


**Fig. 68: Identifying Power Steering Pump To Power Steering Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Install the power steering pump (1) to the power steering pump bracket (2).

**CAUTION:** Refer to Fastener Caution .

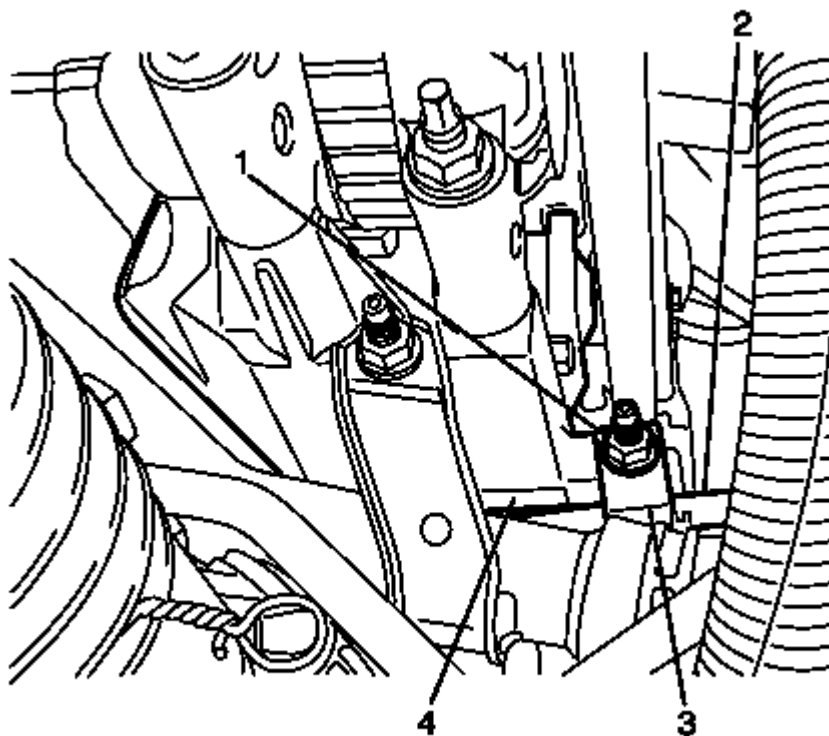
9. Install the NEW power steering pump to the power steering pump bracket retaining bolts (3) and tighten to 27 N.m (22 lb ft).



**Fig. 69: View Of Power Steering Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the power steering reservoir (2) and the power steering reservoir bracket locking tang (1) are engaged to avoid an induced rattle condition.

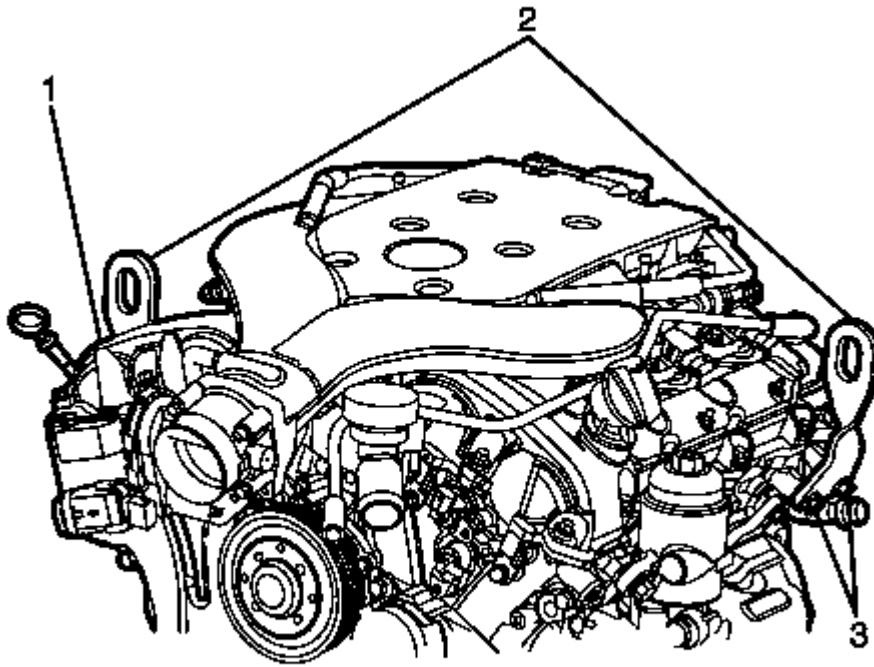
10. Install the power steering fluid reservoir to the power steering fluid reservoir bracket.
11. Install the drive belt. Refer to **Drive Belt Replacement** .
12. Install the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side (V6)** and **Catalytic Converter Replacement - Right Side (V6)** .
13. Install the flywheel. Refer to **Engine Flywheel Removal**.
14. Install the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 5L40-E/5L50-E.



**Fig. 70: Identifying Transmission Cooler Line Clamp To Alternator Mounting Bracket Retaining Nut**

Courtesy of GENERAL MOTORS CORP.

15. Install the transmission cooler line clamp (3) and transmission cooler lines (2) to the alternator mounting bracket (4).
16. Install the transmission cooler line clamp to the alternator mounting bracket retaining nut (1) and tighten to 22 N.m (16 lb ft).
17. Install the engine and transmission wiring harness and related components. Refer to **Engine Wiring Harness Assembly Removal**.

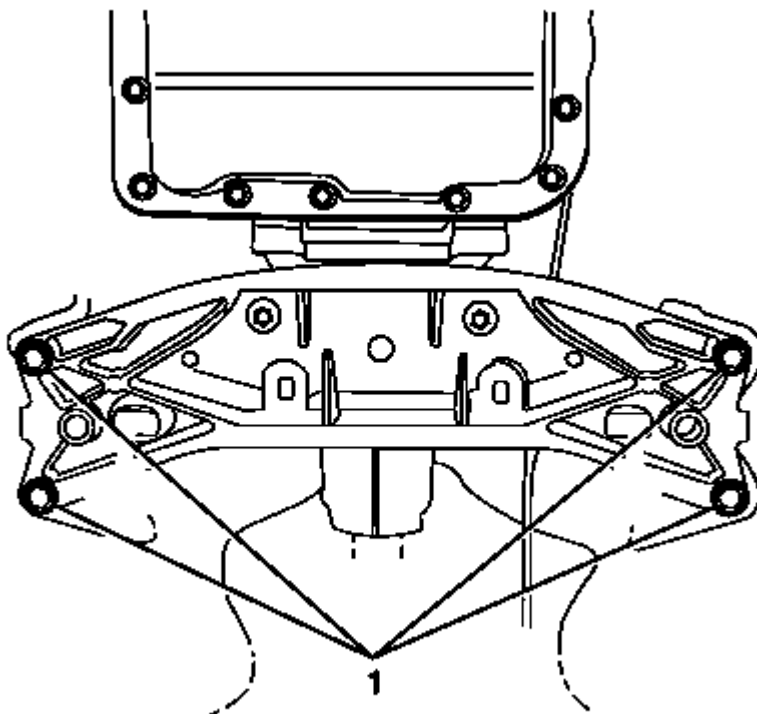


**Fig. 71: View Of EN 46114, Engine & Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

18. Remove the EN 46114 (2) on the engine (1).

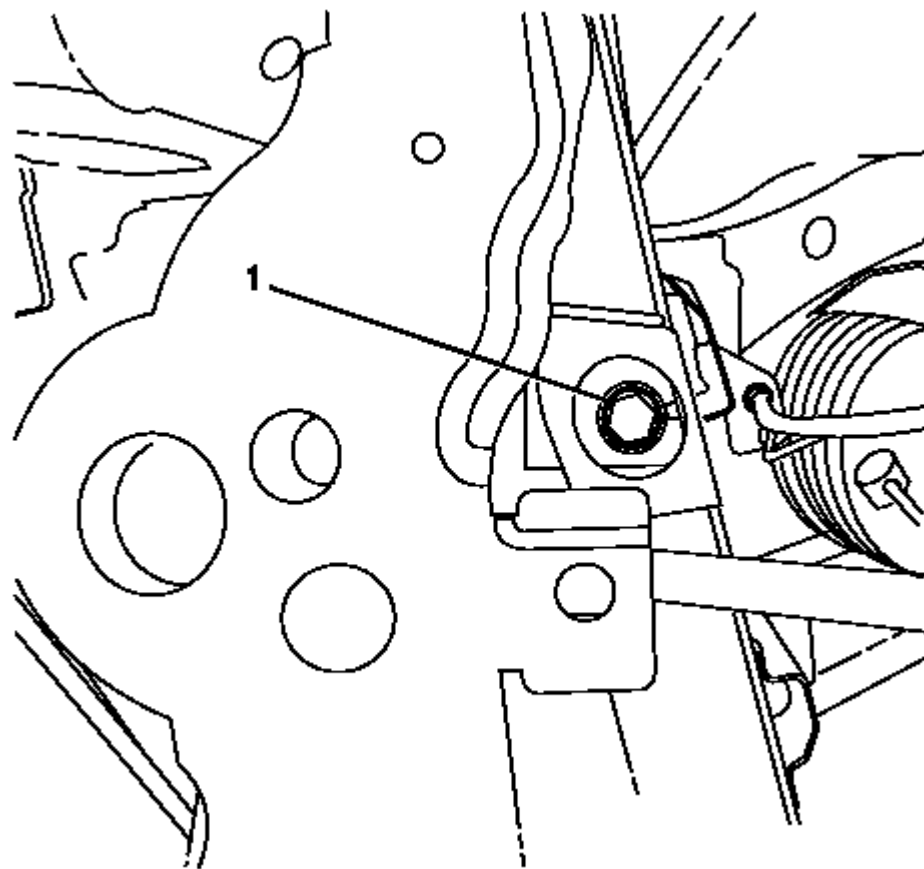
**NOTE:** Make sure that all the hoses, wires, pipes and shock modules clear the vehicle during the installation process.

19. With the aid of an assistant, raise the table and/or lower the vehicle to install the engine, transmission, front suspension and subframe assembly to the vehicle.



**Fig. 72: Identifying Transmission Support To Body Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

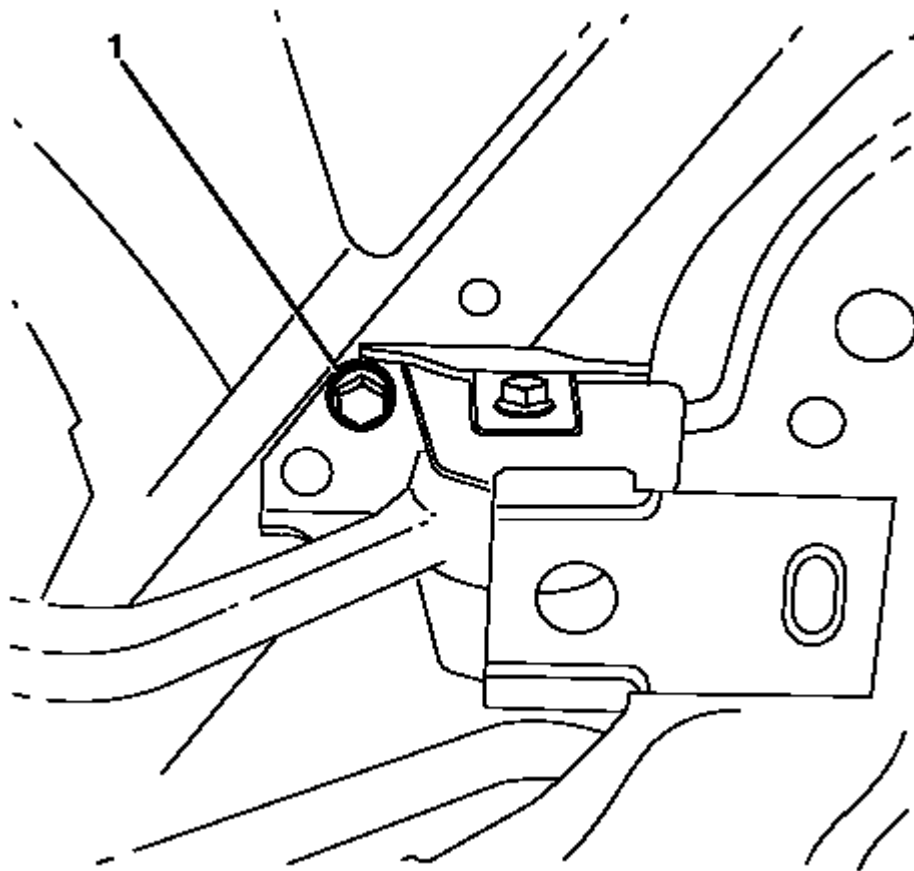
20. Install the transmission support to the body retaining bolts (1) and tighten to 58 N.m (43 lb ft).



**Fig. 73: Identifying Subframe To Body Retaining Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

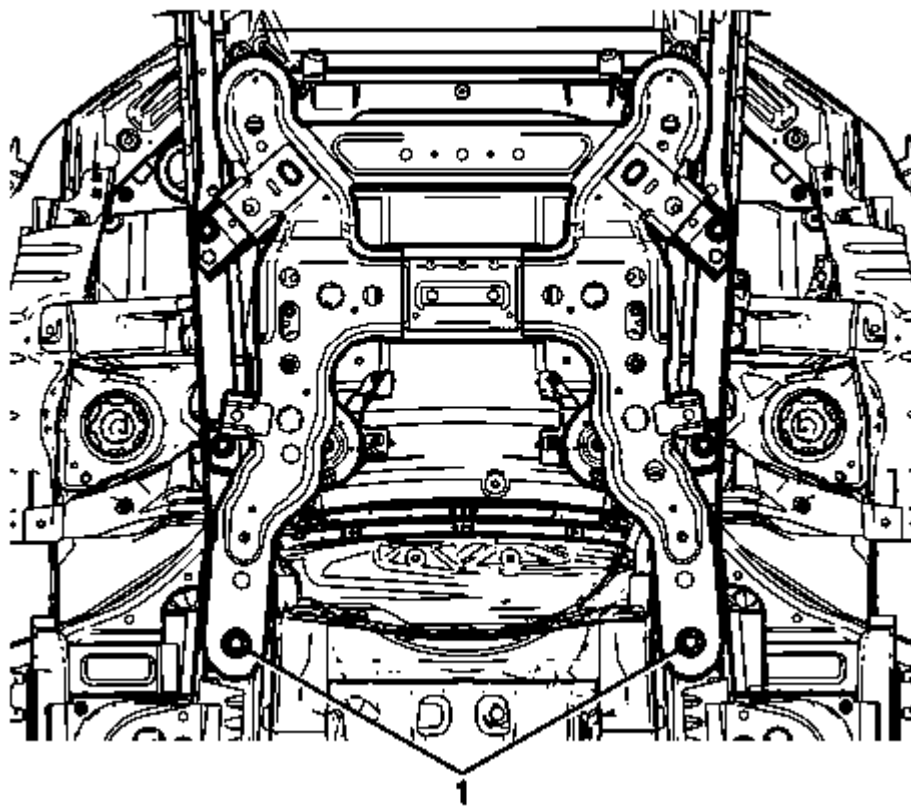
21. Install the subframe to the body retaining bolts (1) and tighten to 160 N.m (118 lb ft).





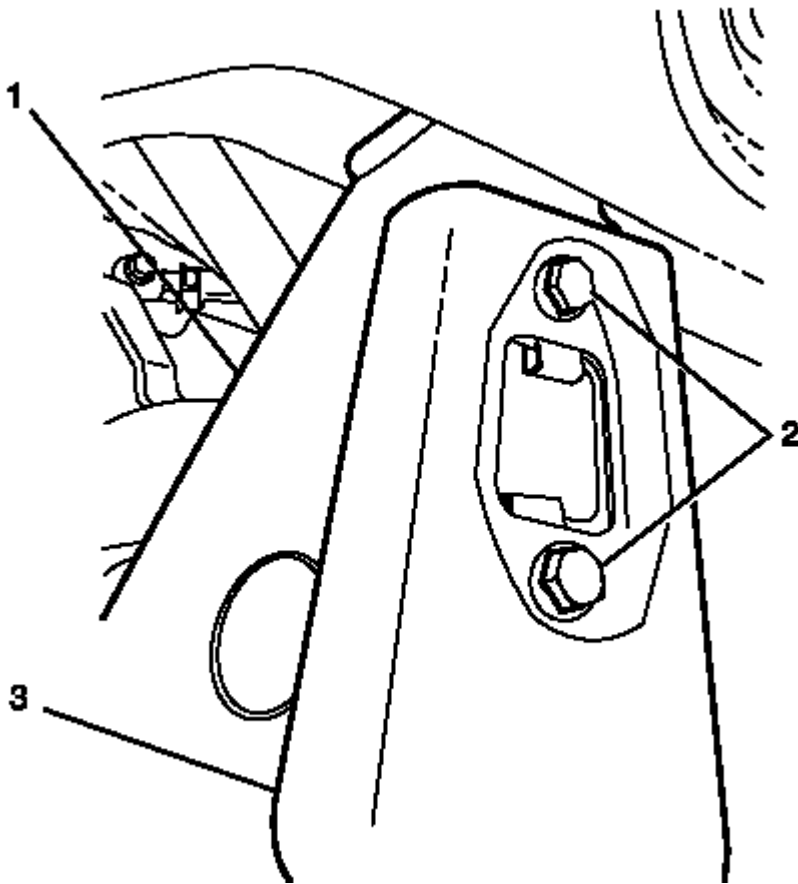
**Fig. 74: Identifying Subframe To Body Front Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

22. Install the subframe to the body front retaining bolts (1) and tighten to 160 N.m (118 lb ft).



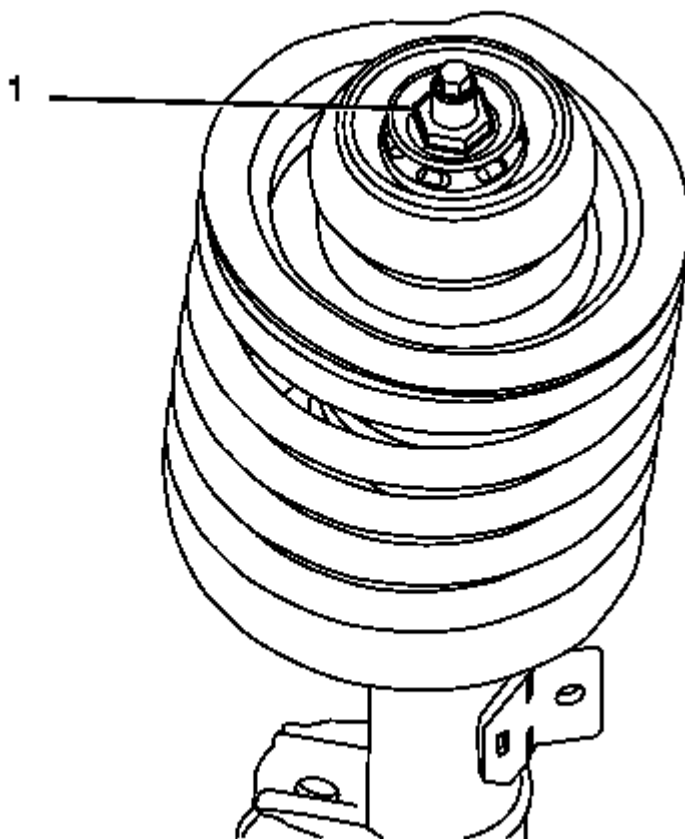
**Fig. 75: Identifying Subframe To Body Rear Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

23. Install the subframe to the body rear retaining bolts (1) and tighten to 240 N.m (177 lb ft).



**Fig. 76: Identifying Subframe Reinforcement Plate To Subframe Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

24. Install the subframe reinforcement plate (3) to the subframe (1).
25. Install the subframe reinforcement plate to the subframe retaining bolts (2) and tighten to 17 N.m (13 lb ft)..
26. Lower the lift table and/or raise the vehicle to remove the support from the frame, engine and transmission.
27. Remove the powertrain and/or engine lift table from the frame, engine and transmission.
28. Partially lower the vehicle.

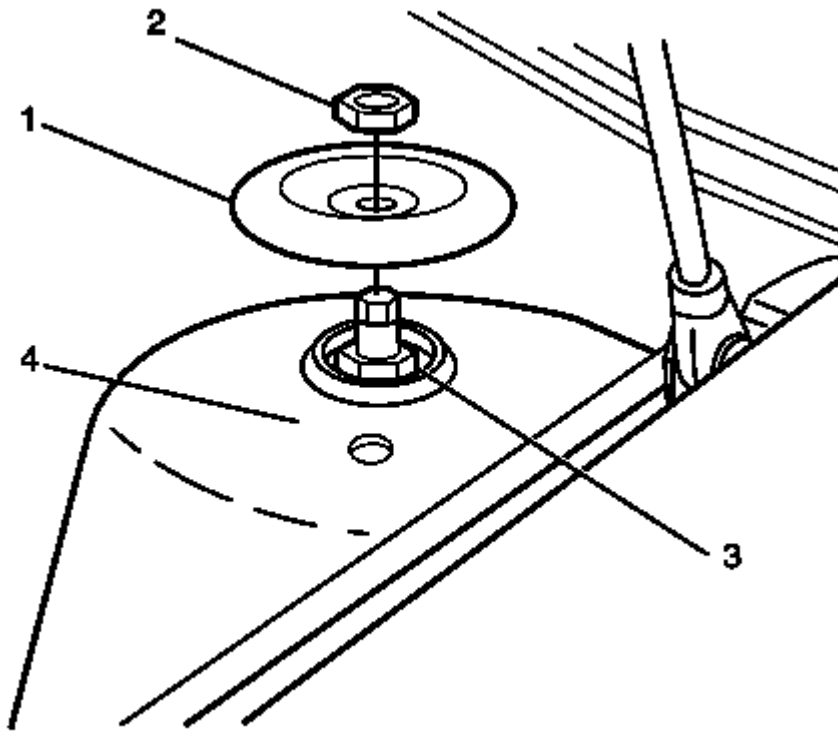


**Fig. 77: Identifying Strut Assembly Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

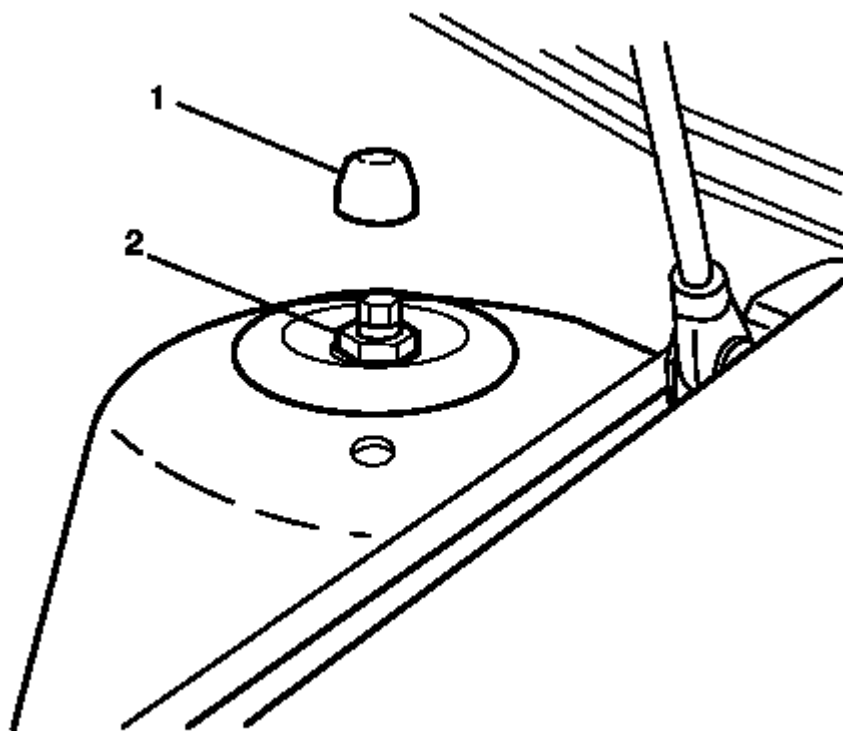
**NOTE:** The strut assembly retaining nut (1) must be checked for correct torque before installing the strut assembly into the vehicle. The strut assembly retaining nut torque must be 75 N.m (55 lb ft).

29. Check the torque of the strut assembly retaining nut (1), correct if necessary.



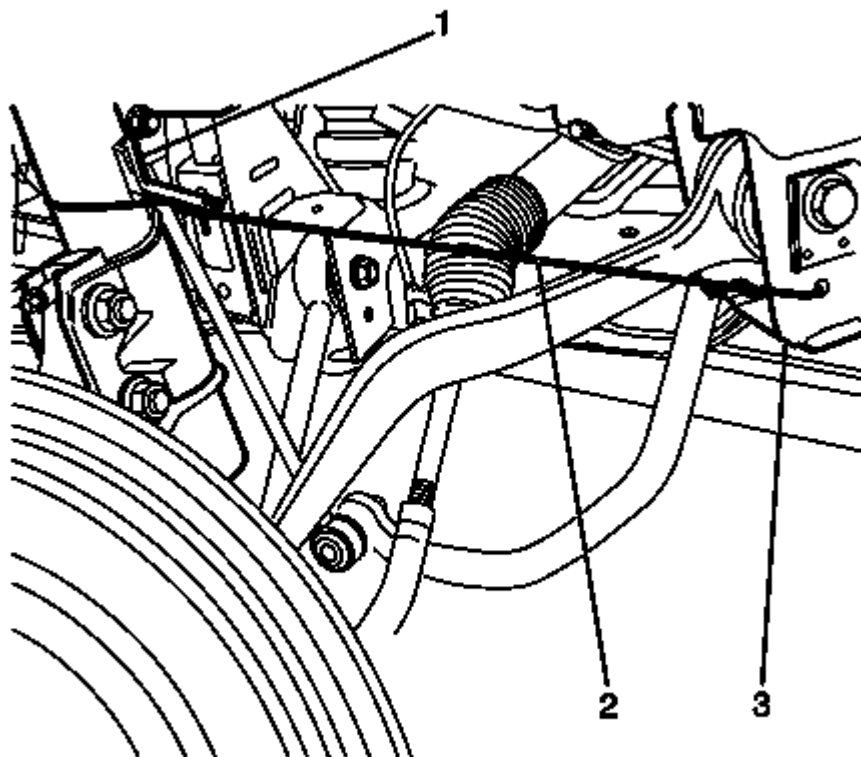
**Fig. 78: Identifying Front Strut Assembly To Front Wheelhouse Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

30. Install the strut assembly (3) to the vehicle (4).
31. Install the strut assembly to the body retaining plate (1).
32. Install the NEW strut assembly to the body retaining nut (2) and tighten to 55 N.m (40 lb ft).



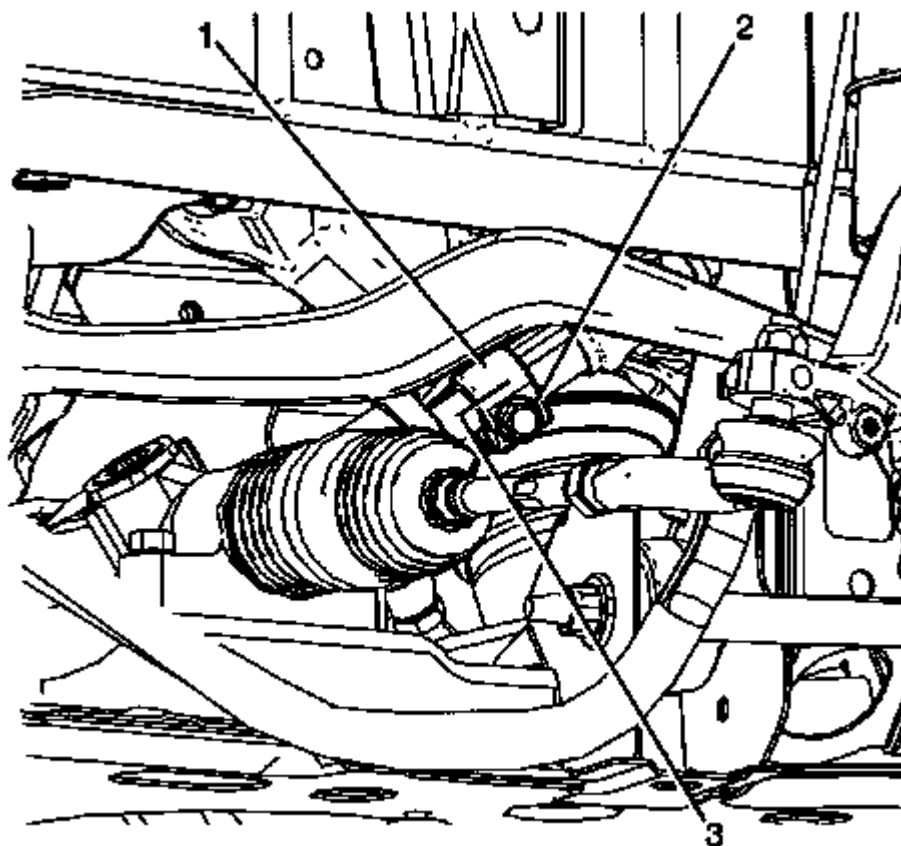
**Fig. 79: Identifying Front Strut Assembly To Front Wheelhouse Retaining Nut With Dust Cover**  
Courtesy of GENERAL MOTORS CORP.

33. Install the dust cover (1) to the strut assembly to body retaining nut (2).
34. Partially raise the vehicle.



**Fig. 80: View Of Subframe, Heavy Mechanic's Wire & Strut Assembly**  
Courtesy of GENERAL MOTORS CORP.

35. Remove the heavy mechanics wire or equivalent (2) retaining the strut assembly (1) to the subframe (3).

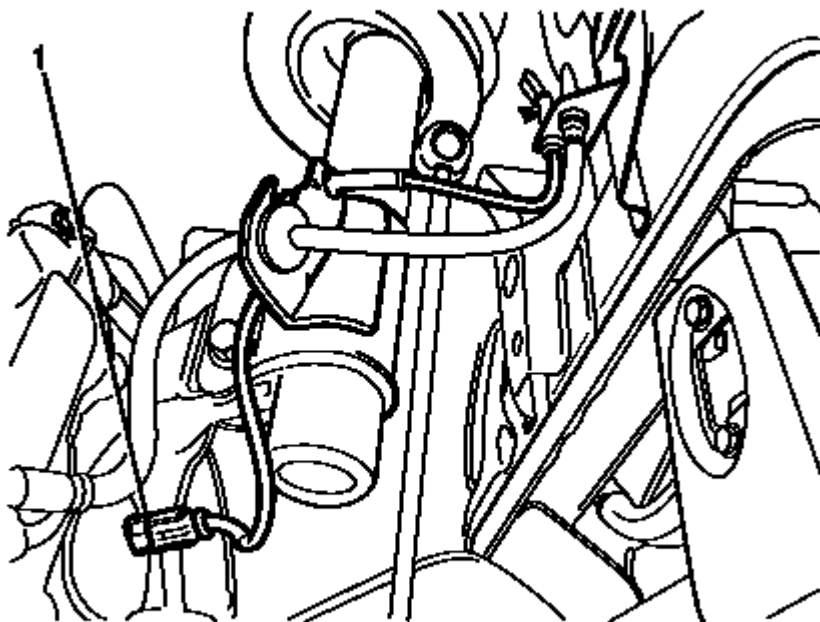


**Fig. 81: Identifying Intermediate Steering Shaft To Pinion Shaft Retaining Bolt**  
 Courtesy of GENERAL MOTORS CORP.

**NOTE:** The intermediate steering shaft and pinion shaft splines must be installed in the position recorded during removal and aligned with the marks previously made.

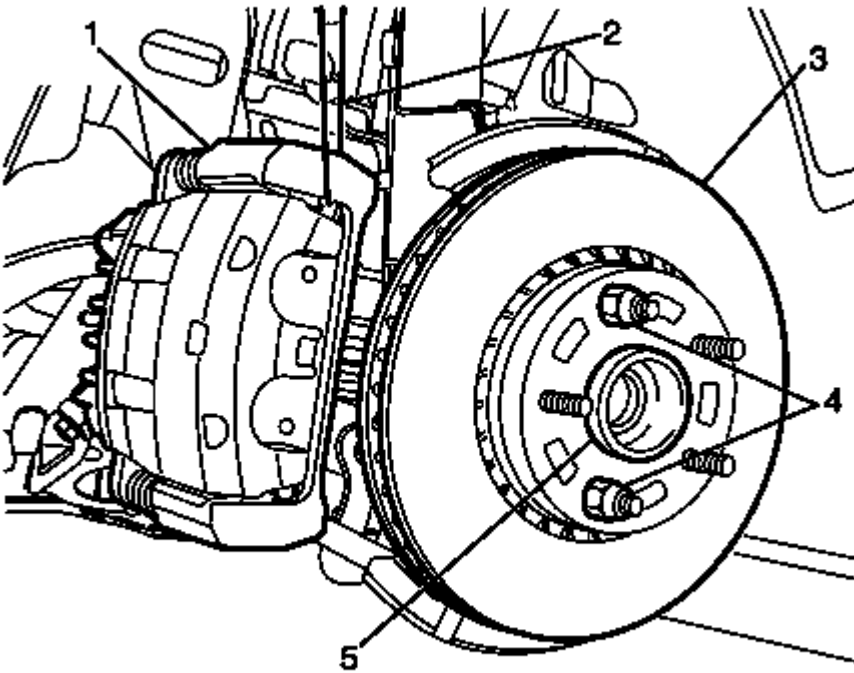
36. Connect the intermediate steering shaft (1) to the pinion shaft (3).
37. Install the NEW intermediate steering shaft to the pinion shaft retaining bolt (2) and tighten to 25 N.m (18 lb ft).





**Fig. 82: Identifying Front Wheel Speed Sensor Jumper Harness Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

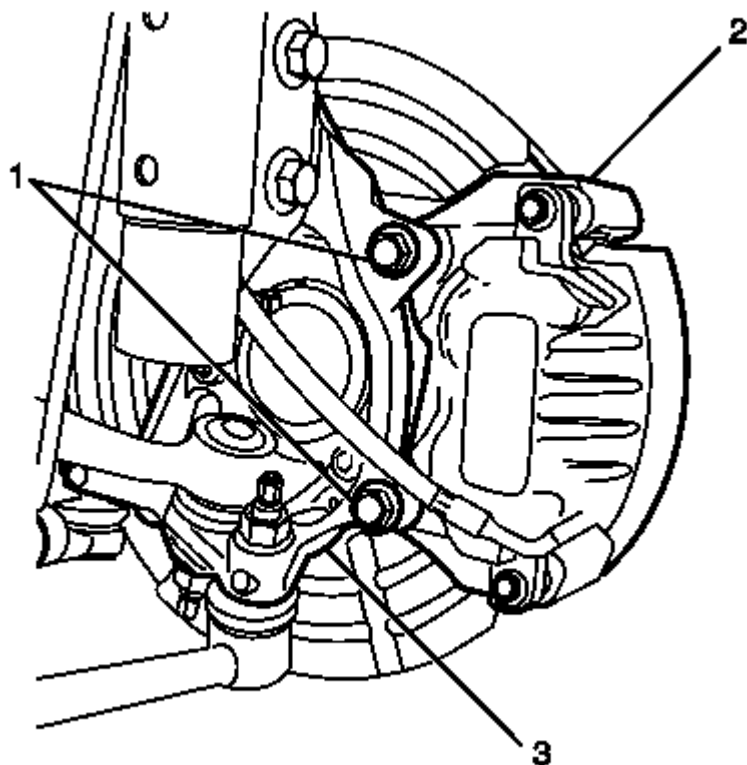
38. Connect the wheel speed sensor jumper harness electrical connector (1).



**Fig. 83: View Of Hub, Wheel Nuts, Front Brake Disc, Heavy Mechanic's Wire & Front Brake Caliper**

**Courtesy of GENERAL MOTORS CORP.**

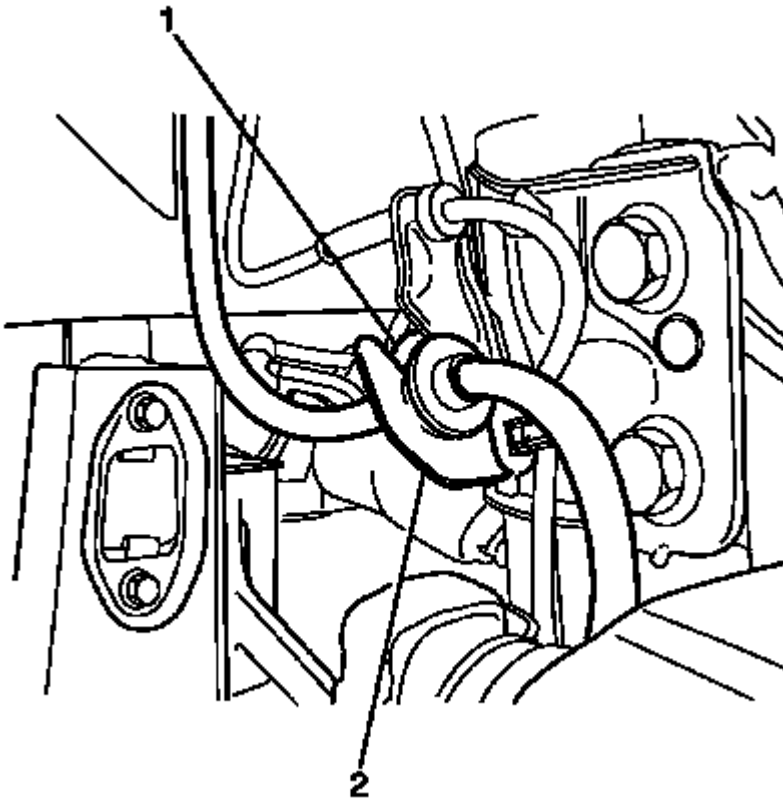
39. Remove the heavy mechanic's wire, or equivalent support (2) from the brake caliper (1).
40. Remove the wheel nuts (4) retaining the brake disc (3) to the hub (5).



**Fig. 84: Identifying Front Brake Caliper Anchor Plate To Front Steering Knuckle Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Make sure the brake hose is not twisted or kinked after installation.  
Damage to the hose could result.

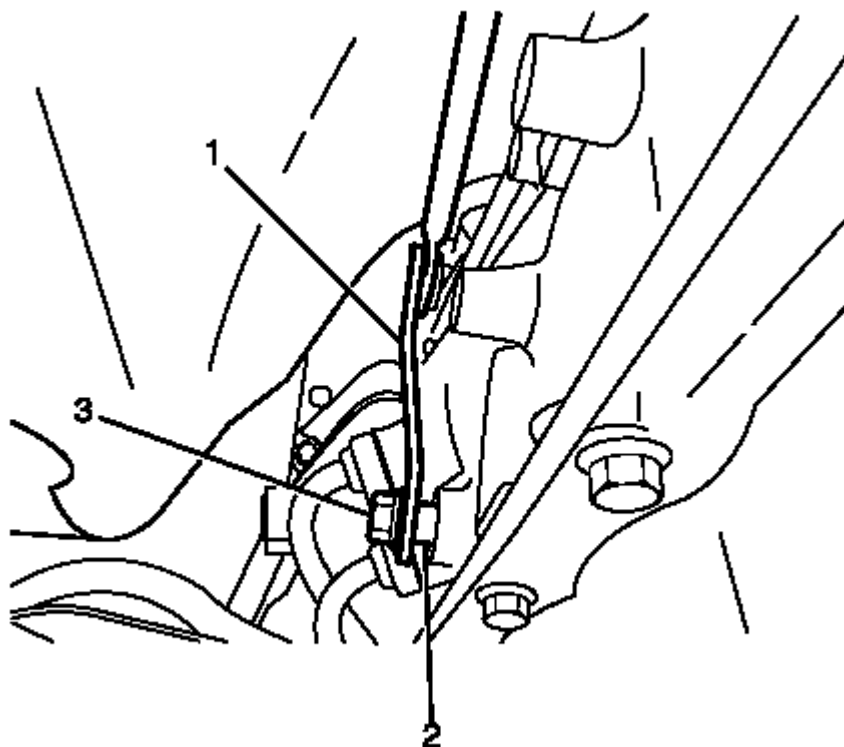
41. Install the brake caliper assembly (2) to the steering knuckle (3).
42. Install the NEW brake caliper anchor plate to the knuckle retaining bolts (1) and tighten to 60 N.m +120° (44 lb in +120°).



**Fig. 85: Identifying Front Brake Hose & Strut Mounted Brake Hose Retaining Bracket**  
Courtesy of GENERAL MOTORS CORP.

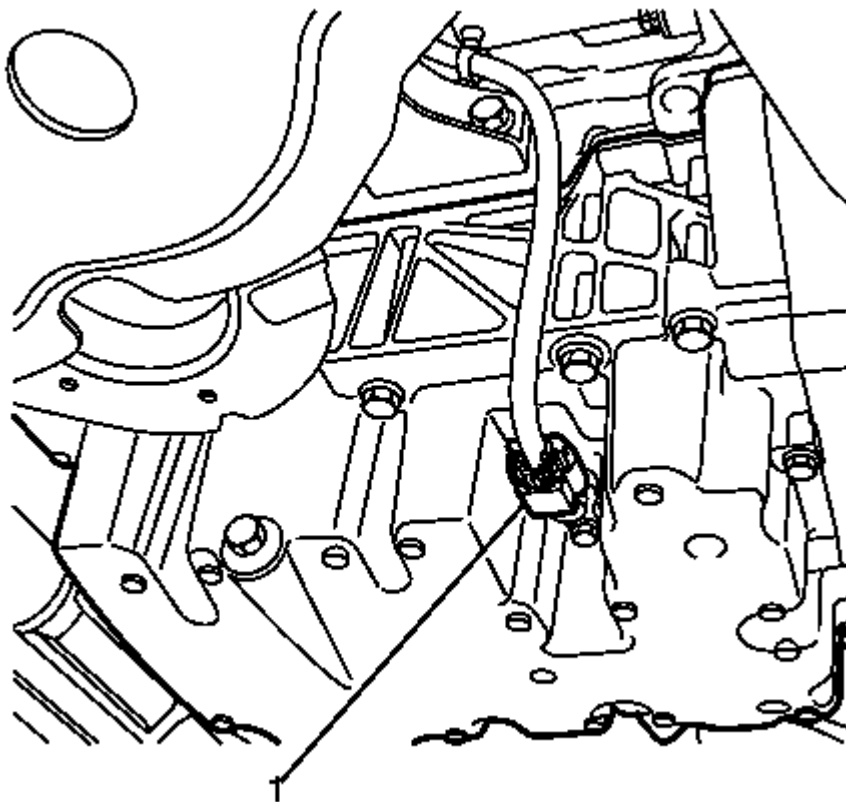
**CAUTION:** Make sure the brake hose is not twisted or kinked after installation.  
Damage to the hose could result.

43. Attach the brake hose (1) to the strut mounted brake hose retaining bracket (2).
44. Install the front wheels. Refer to **Tire and Wheel Removal and Installation** .



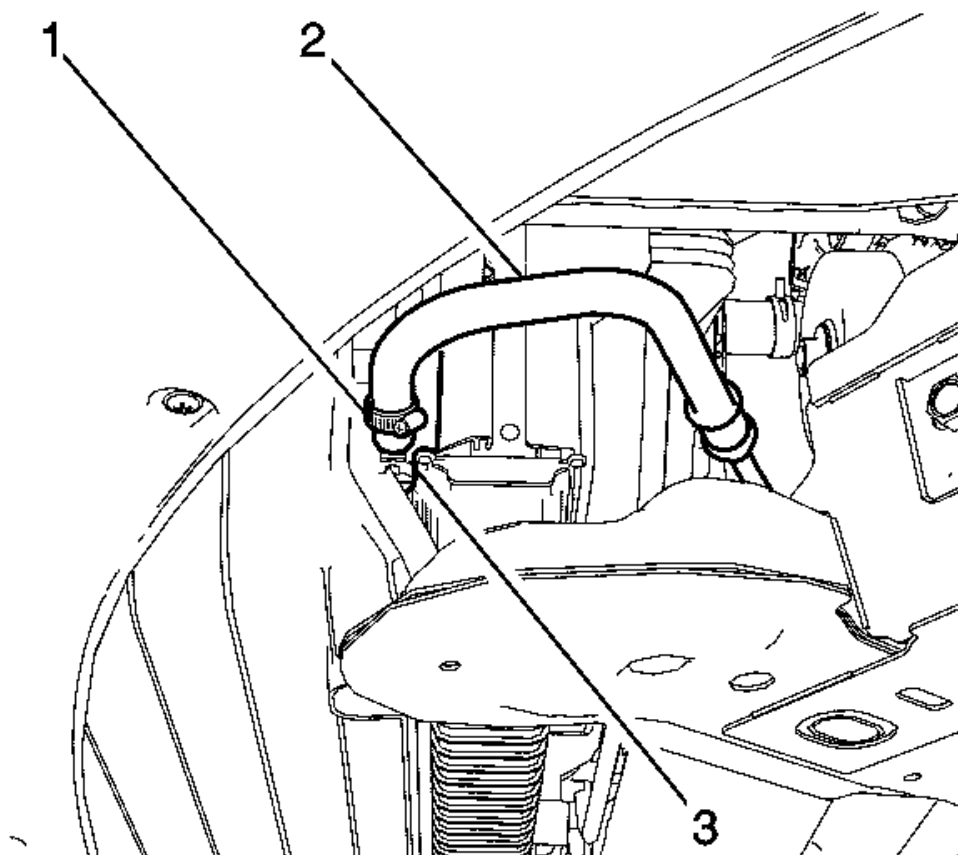
**Fig. 86: Identifying Shift Selector Linkage Rod To Shift Selector Shaft Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

45. Install the shift selector linkage rod (1) to the shift selector shaft (2).
46. Install the shift selector linkage rod using the shift selector shaft retaining nut (3) and tighten to 9 N.m (80 lb in).
47. Install the starter motor. Refer to **Starter Replacement (3.6L)** .
48. Install the propeller shaft. Refer to **Propeller Shaft Replacement** .
49. Install the centre exhaust heat shield. Refer to **Exhaust Heat Shield Replacement - Center** .
50. Install the Exhaust system. Refer to **Exhaust System Replacement (V6 - For Access)** or **Exhaust System Replacement (V6 - Complete)** .



**Fig. 87: Identifying Oil Level/Temperature Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

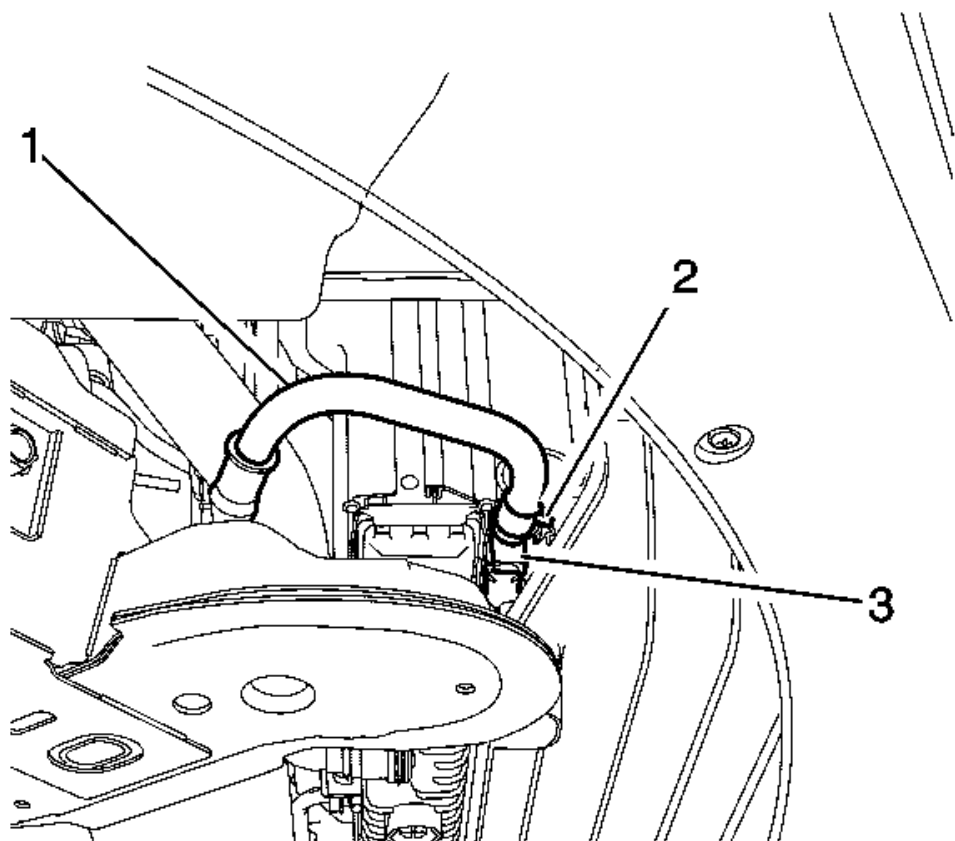
51. Connect the low oil level sensor electrical connector (1).



**Fig. 88: View Of Power Steering Cooler & Power Steering Fluid Reservoir Inlet Pipe/Hose & Spring Clamp**

Courtesy of GENERAL MOTORS CORP.

52. Remove the plug from the power steering cooler (3) and power steering reservoir inlet hose (2).
53. Connect the power steering reservoir inlet hose (2) to the power steering cooler (3).
54. Install the power steering reservoir inlet hose spring clamp (1) to its original location

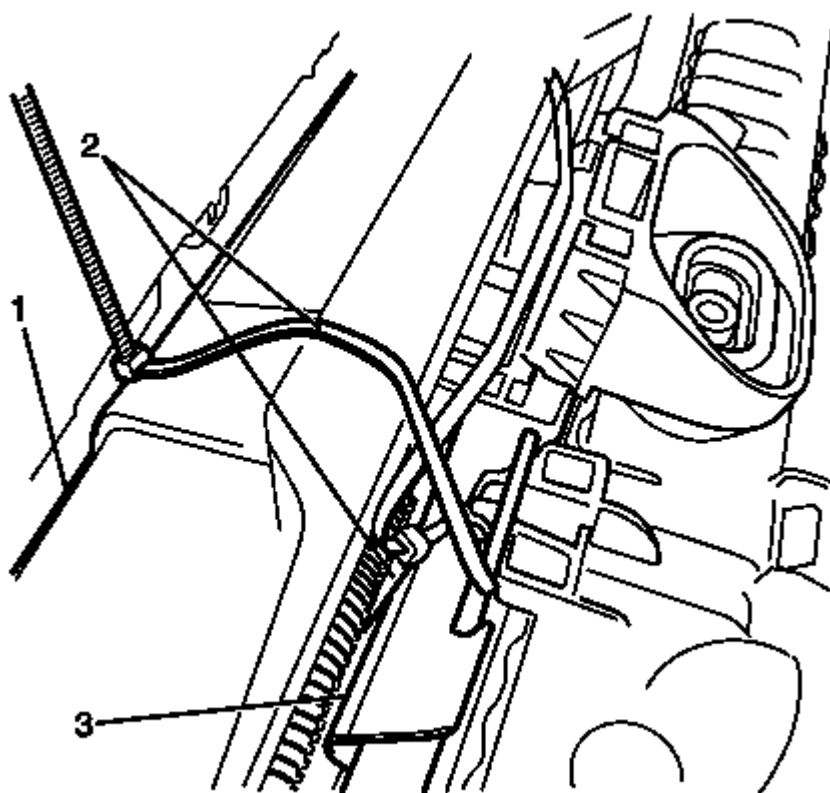


**Fig. 89: View Of Power Steering Cooler & Power Steering Gear Outlet Pipe/Hose With Spring Clamp**

Courtesy of GENERAL MOTORS CORP.

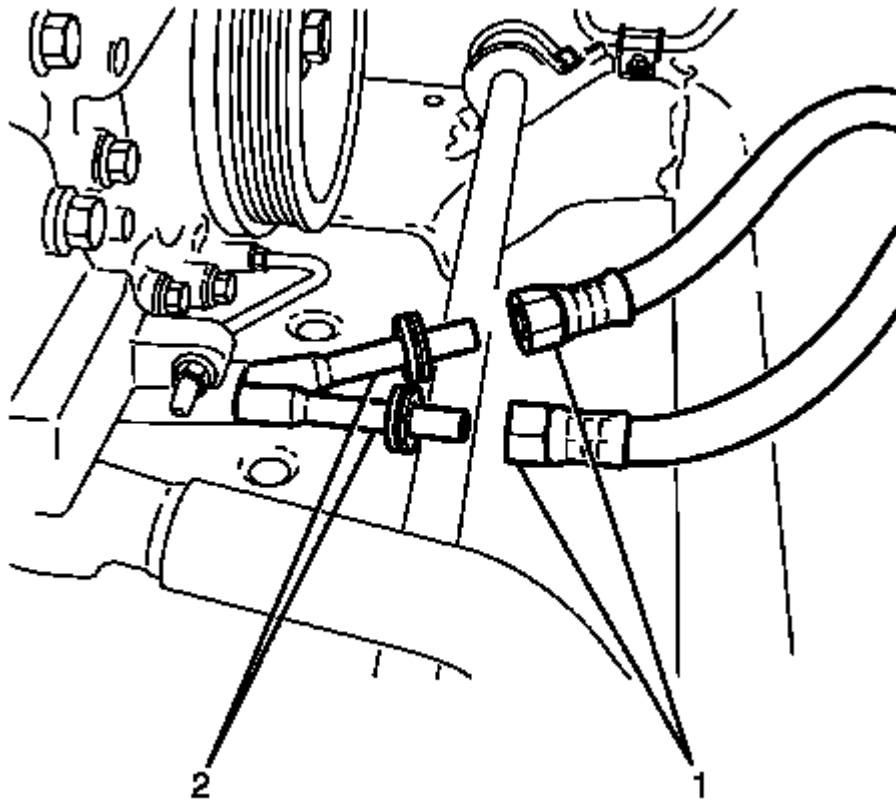
55. Remove the plug from the power steering cooler (3) and power steering reservoir inlet hose (1).
56. Connect the power steering reservoir inlet hose (1) to the power steering cooler (3).
57. Install the power steering reservoir inlet hose spring clamp (2) to its original location
58. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
59. Install the front air deflector. Refer to **Front Air Deflector Replacement** .
60. Lower the vehicle.





**Fig. 90: View Of Front End, Radiator & Condenser Assembly**  
Courtesy of GENERAL MOTORS CORP.

61. Remove the zip ties (2) or equivalent securing the radiator and condenser assembly (3) to the front end assembly (1).



**Fig. 91: Identifying Transmission Cooler Lines & Flexible Hoses**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The AU-525 is not required for installation.

62. Remove the clean lint free cloth at the transmission cooler lines (2) and the flexible hoses (1).

**NOTE:** The flexible hoses are not serviced separately. Therefore if the hose's require replacement, then the hose and radiator to hose cooler hose assembly must be fitted.

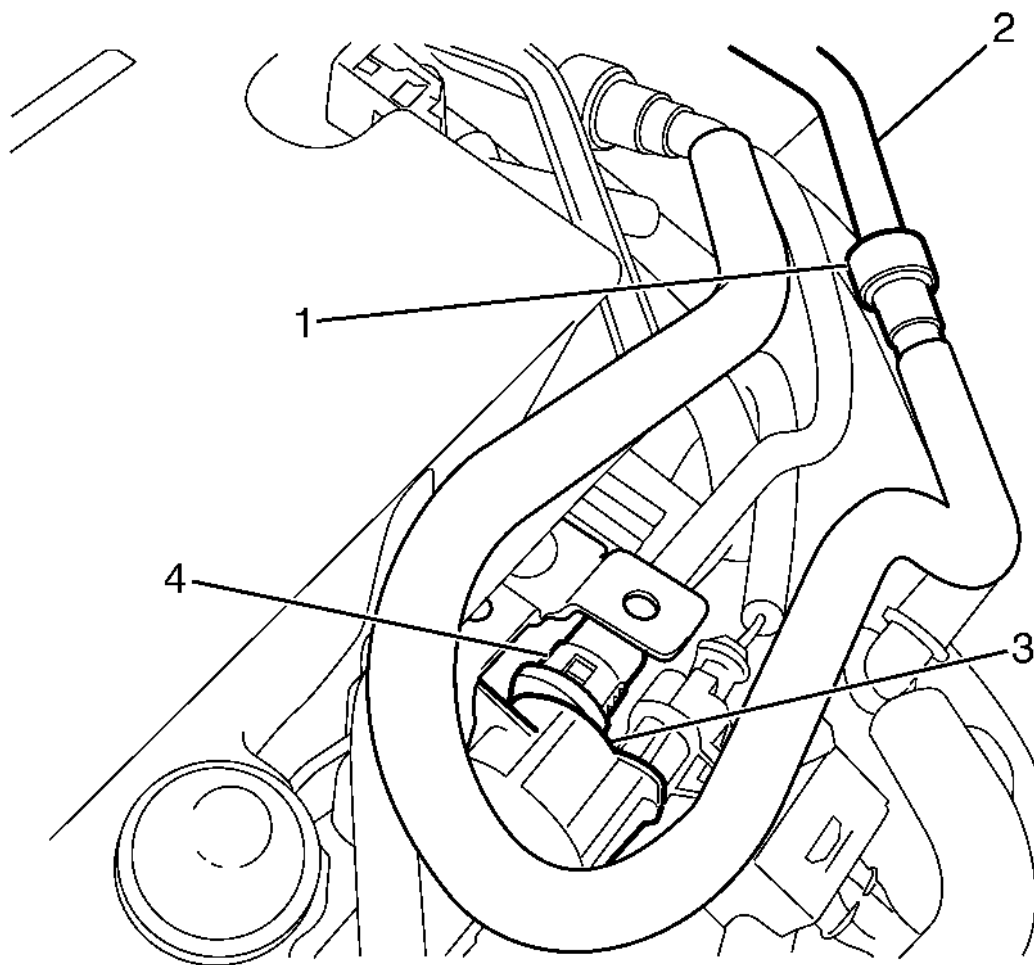
63. Align both flexible hose's with both steel cooler lines.

**NOTE:** Listen for an audible click to confirm fitting.

64. Hold the cooler line (2) and connect the flexible hose (1) by pushing together. Repeat procedure for other hose.

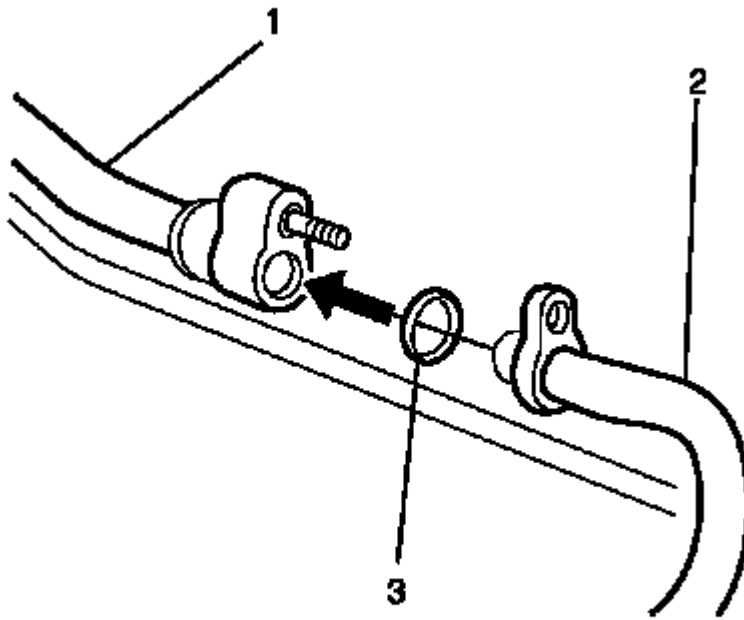
**NOTE:** When adding or changing transmission fluid use only recommended automatic transmission fluid.

65. Check and top up transmission fluid level if required.



**Fig. 92: View Of EVAP Purge Line, Purge Solenoid, Fuel Feed Hose & Pipe**  
Courtesy of GENERAL MOTORS CORP.

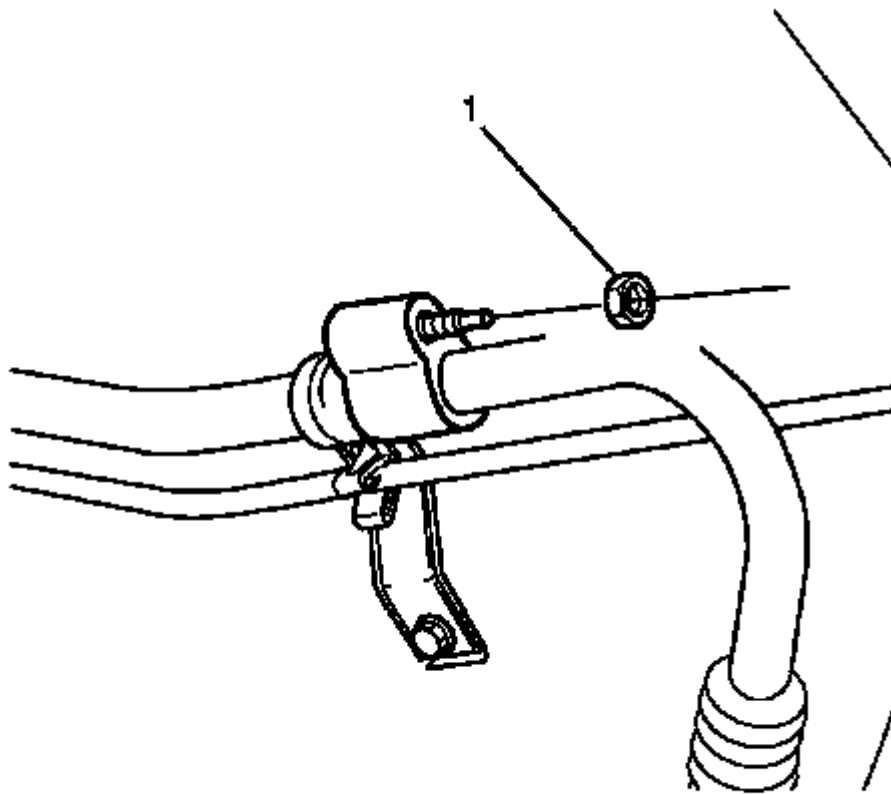
66. Remove the plug or cap at the fuel feed hose (1) and fuel feed pipe (2) ends.
67. Connect the fuel feed hose (1) to the fuel feed pipe (2). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .
68. Remove the plug or cap at the EVAP purge line (4) and the purge solenoid (3) ends.
69. Connect the EVAP purge line (4) to the purge solenoid (3). Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .



**Fig. 93: View Of Upper & Lower Suction Pipe With Sealing Washer**  
Courtesy of GENERAL MOTORS CORP.

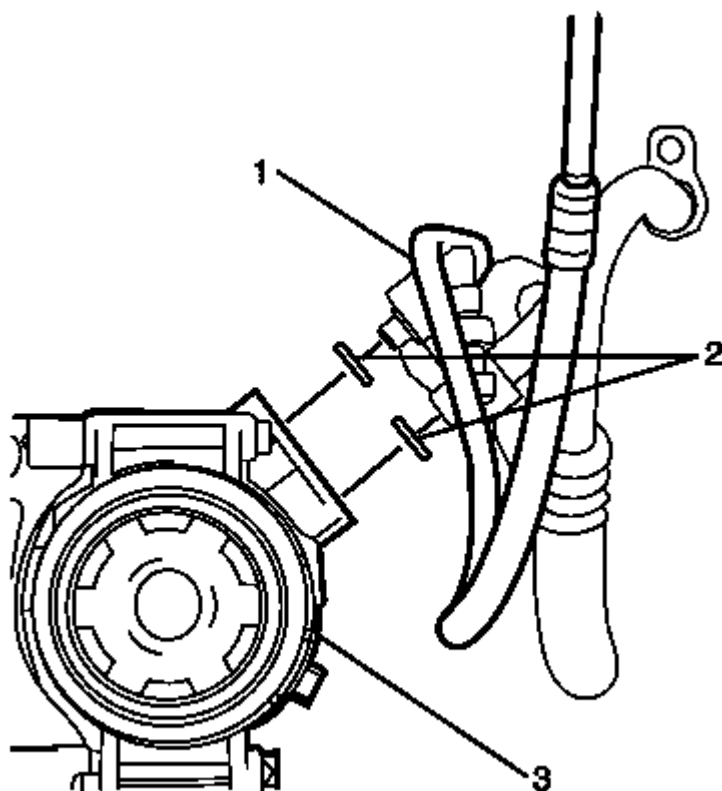
**NOTE:**      **DO NOT** coat the new sealing washer with oil. They must be fitted dry. The use of mineral oil will render the washer useless, as the washer **WILL** swell causing refrigerant to leak out.

70. Install a NEW sealing washer (3) to suction pipe joint.
71. Position the upper suction pipe (1) to the lower suction pipe (2).



**Fig. 94: Identifying Suction Pipe Upper To Suction Pipe Lower Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

72. Install the A/C suction pipe pad to the A/C suction pipe retaining nut (1) and tighten to 22 N.m(16 lb ft).

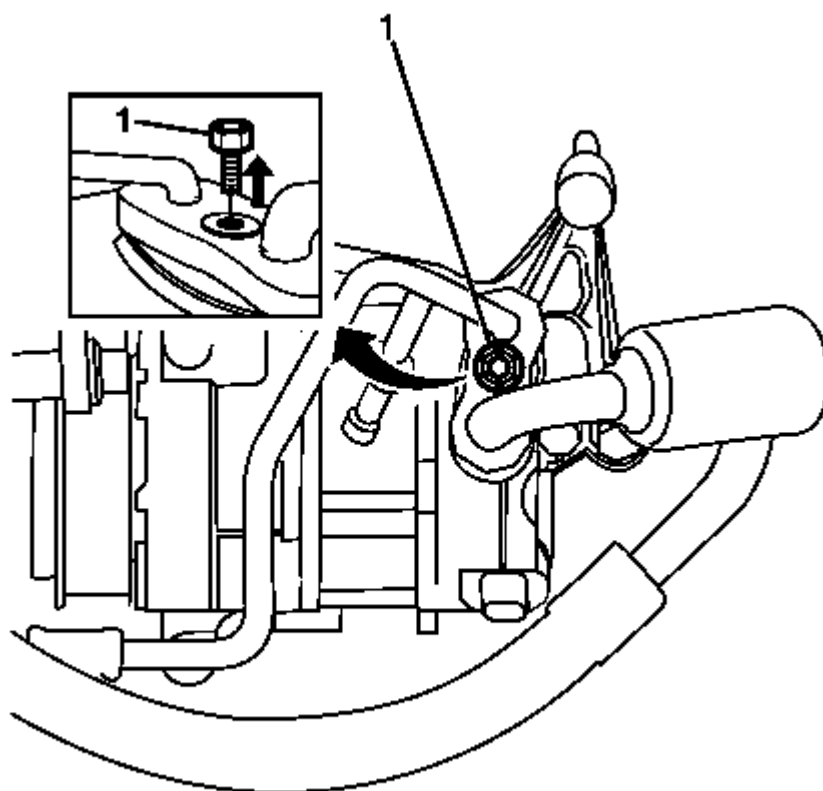


**Fig. 95: View Of A/C Suction/Discharge Pipe**  
 Courtesy of GENERAL MOTORS CORP.

73. Remove the plug or cap at the A/C suction/discharge pipe (1) ends and the compressor (2) ports.

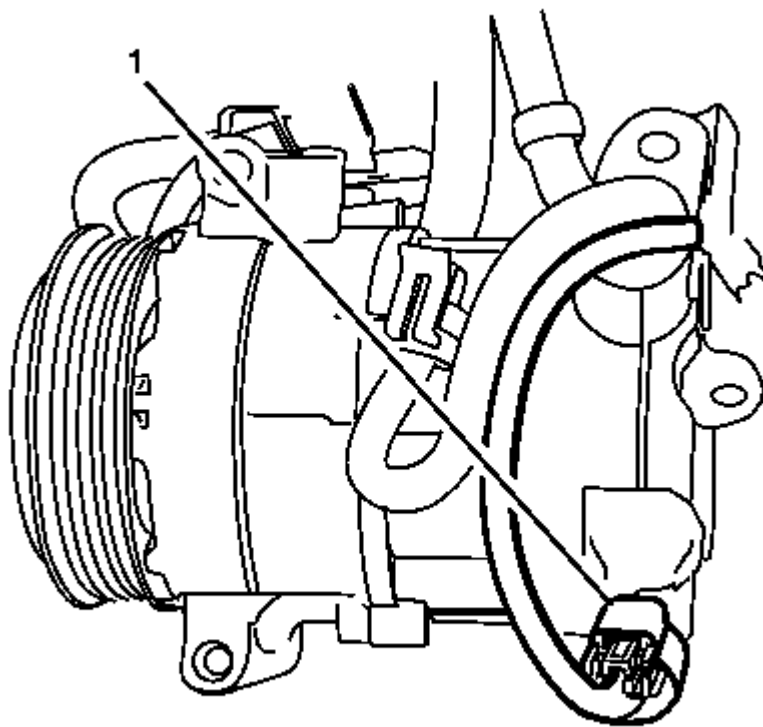
**NOTE:** The A/C sealing O-rings must be fitted dry. DO NOT lubricate the A/C sealing O-rings.

74. Fit the NEW A/C suction/discharge pipe sealing O-ring (2) to the suction pipe.
75. Connect the A/C suction/discharge line pad (1) to the A/C compressor (2).



**Fig. 96: Identifying Suction/Discharge Pipe Pad To Compressor Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

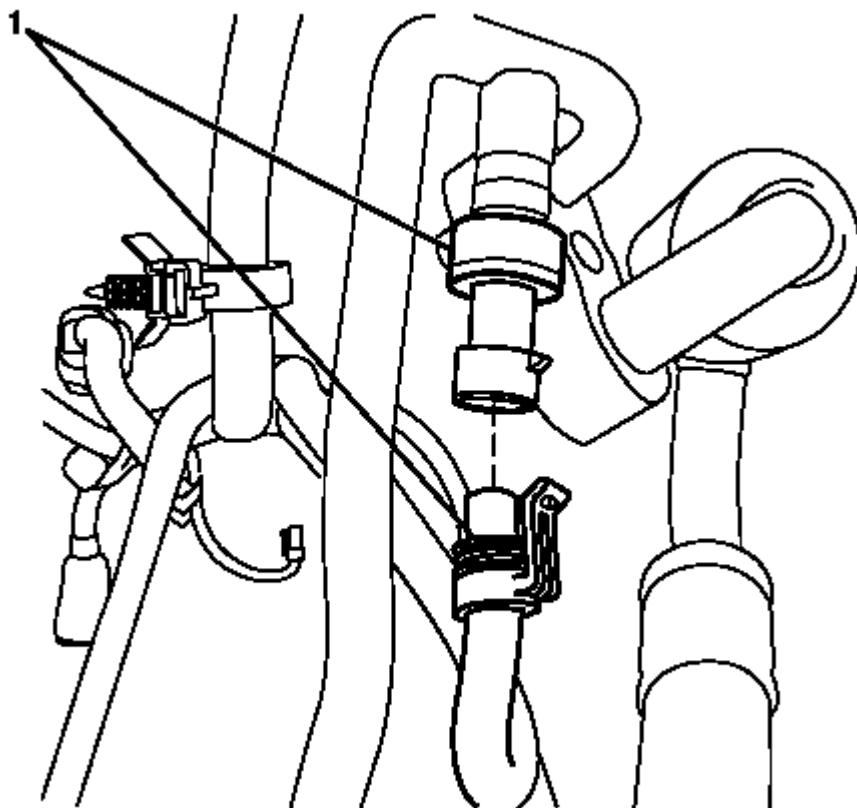
76. Install the suction/discharge line pad to A/C compressor retaining nut (1).



**Fig. 97: Identifying A/C Compressor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

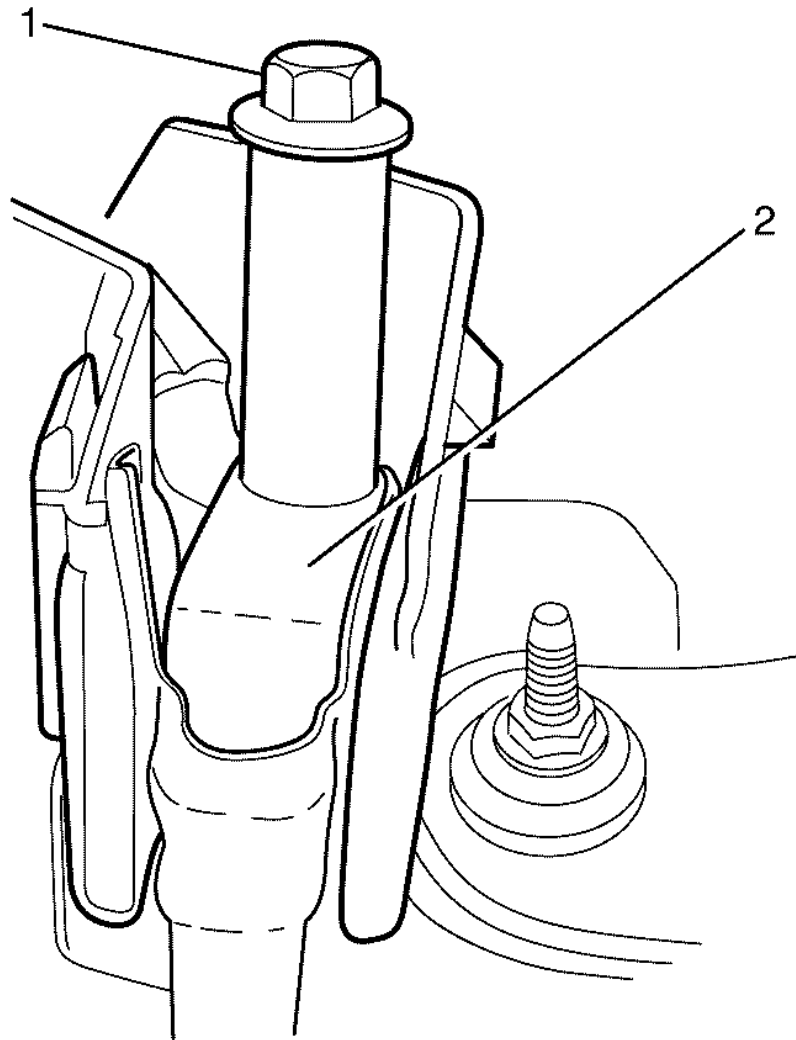
77. Connect the A/C compressor electrical connector (1).





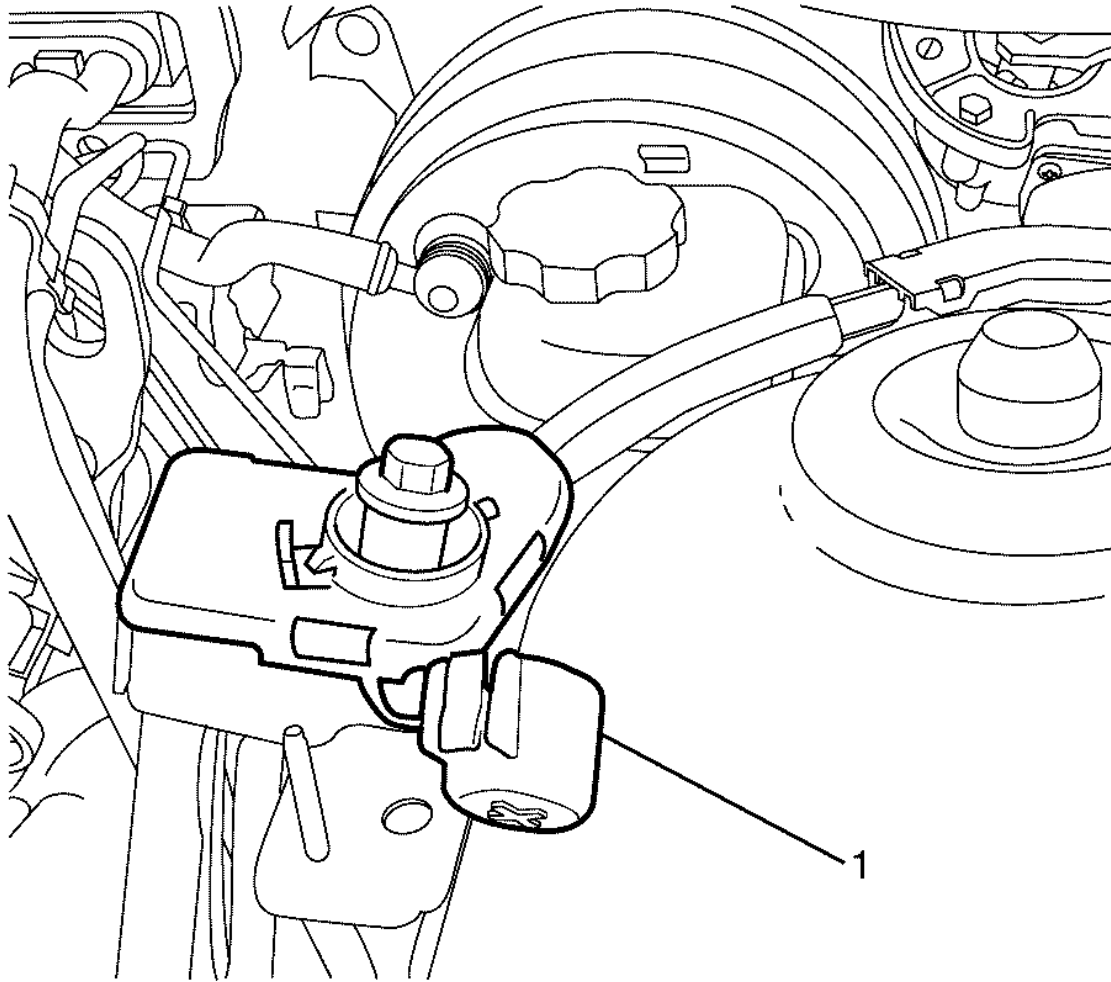
**Fig. 98: Identifying A/C Refrigerant Pressure Sensor Electrical Connector**  
**Courtesy of GENERAL MOTORS CORP.**

78. Connect the A/C pressure transducer electrical connector (1).



**Fig. 99: Identifying Remote Battery Positive Post To Wiring Harness Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

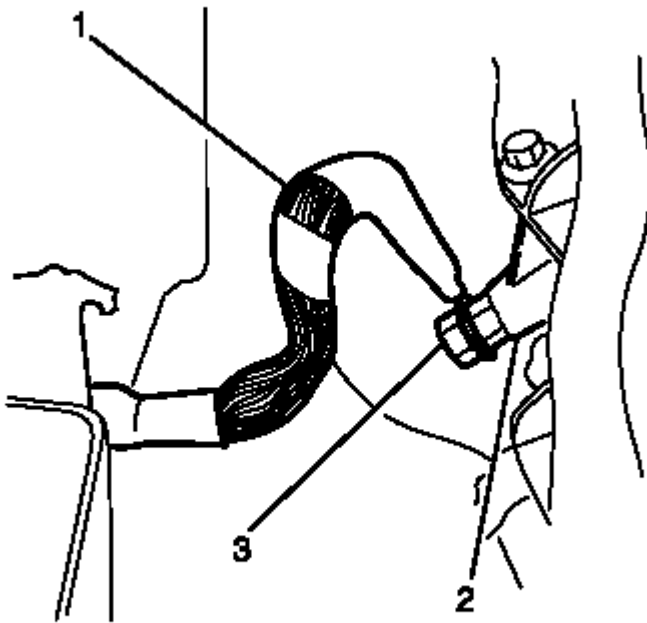
79. Install the wiring harness (2).
80. Install the remote battery positive post to the wiring harness retaining bolt (1) and tighten to 15 N.m (11 lb ft).



**Fig. 100: Identifying Remote Battery Positive Post Cover**  
Courtesy of GENERAL MOTORS CORP.

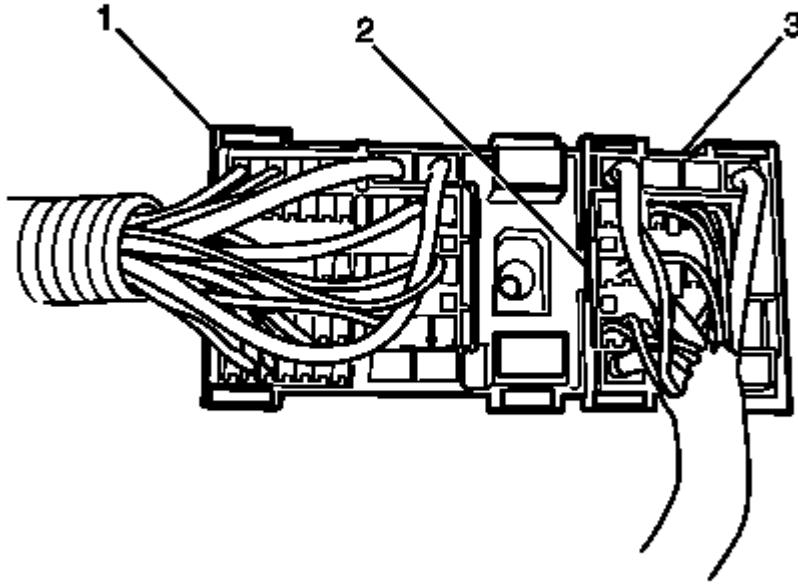
**NOTE:** Make sure the clips on the remote battery positive post cover (1) are engaged to avoid an induced rattle condition.

81. Install the remote battery positive post cover (1).



**Fig. 101: Identifying Vehicle Body Ground Cable To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

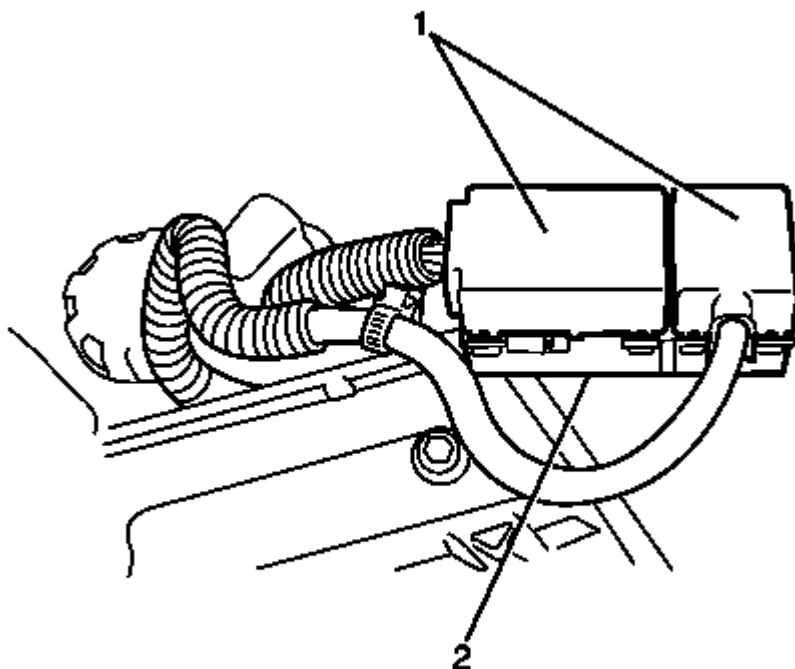
82. Connect the vehicle body ground cable (1) to the cylinder head (2).
83. Install the vehicle body ground cable to the cylinder head retaining bolt (3) and tighten to 10 N.m(89 lb in)



**Fig. 102: Identifying Engine Connector, Locking Tang & Body Harness Connector**  
Courtesy of GENERAL MOTORS CORP.

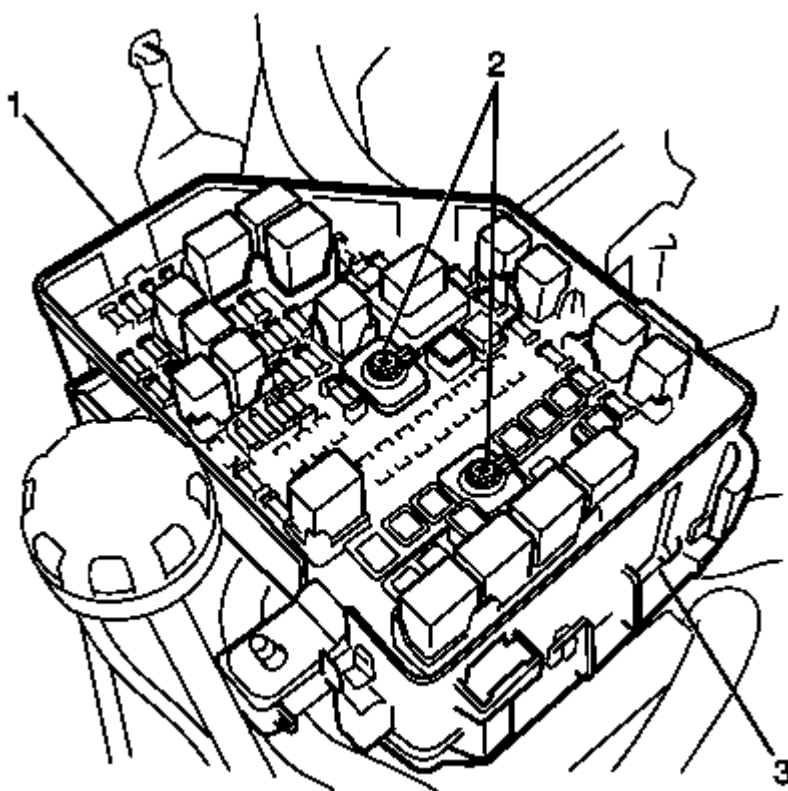
**NOTE:** Listen for a audible click from the locking tang (2) to confirm fitting.

84. Slide the engine connector (3) into the body harness connector (1) to join.



**Fig. 103: Identifying Under Hood BEC Connector With Protector**  
Courtesy of GENERAL MOTORS CORP.

85. Attach the protector (1) to the base of the under hood BEC connector (2).

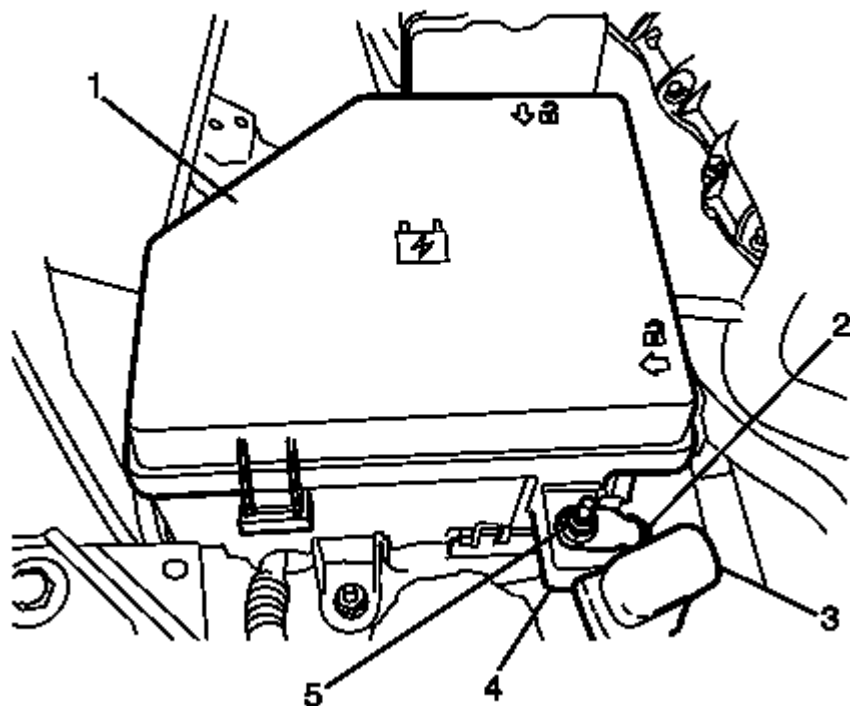


**Fig. 104: Identifying Under Hood BEC Upper Plate To Lower Plate Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

86. Install the upper under hood BEC plate (1) to the lower under hood BEC plate (3).

**NOTE:** The under hood BEC upper plate to lower plate retaining bolts (2) **DO NOT** have a torque specification. Listen for an audible clicking sound whilst tightening the under hood BEC upper plate to lower plate retaining bolts (2) to confirm correct fitting.

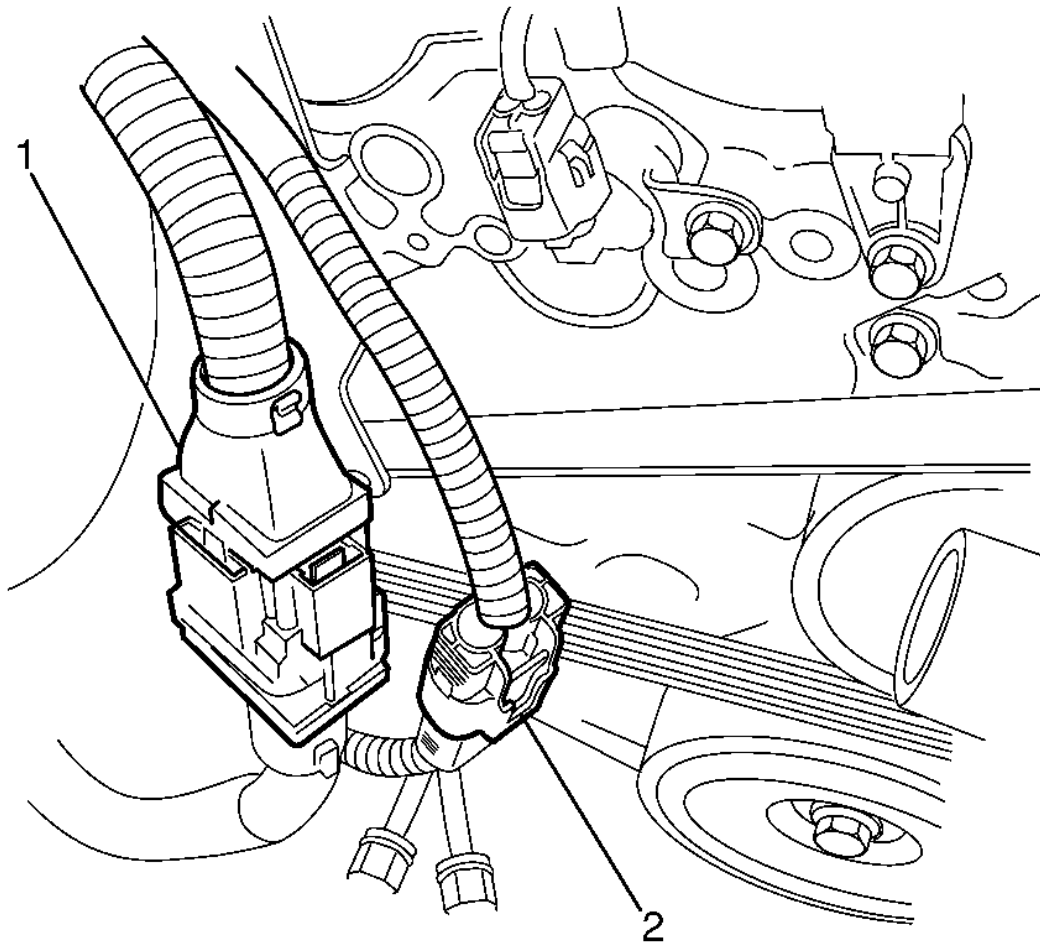
87. Install the under hood BEC upper plate to lower plate retaining bolts (2).



**Fig. 105: Identifying Positive Cable To Under Hood BEC Plate Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

88. Connect the positive cable (2) to the upper under hood BEC plate (4).
89. Install the positive cable to the under hood BEC plate retaining bolt (5) and tighten to 10 N.m(89 lb ft).
90. Install the positive cable protective cover (3).
91. Install the under hood body electrical centre (BEC) lid (1).

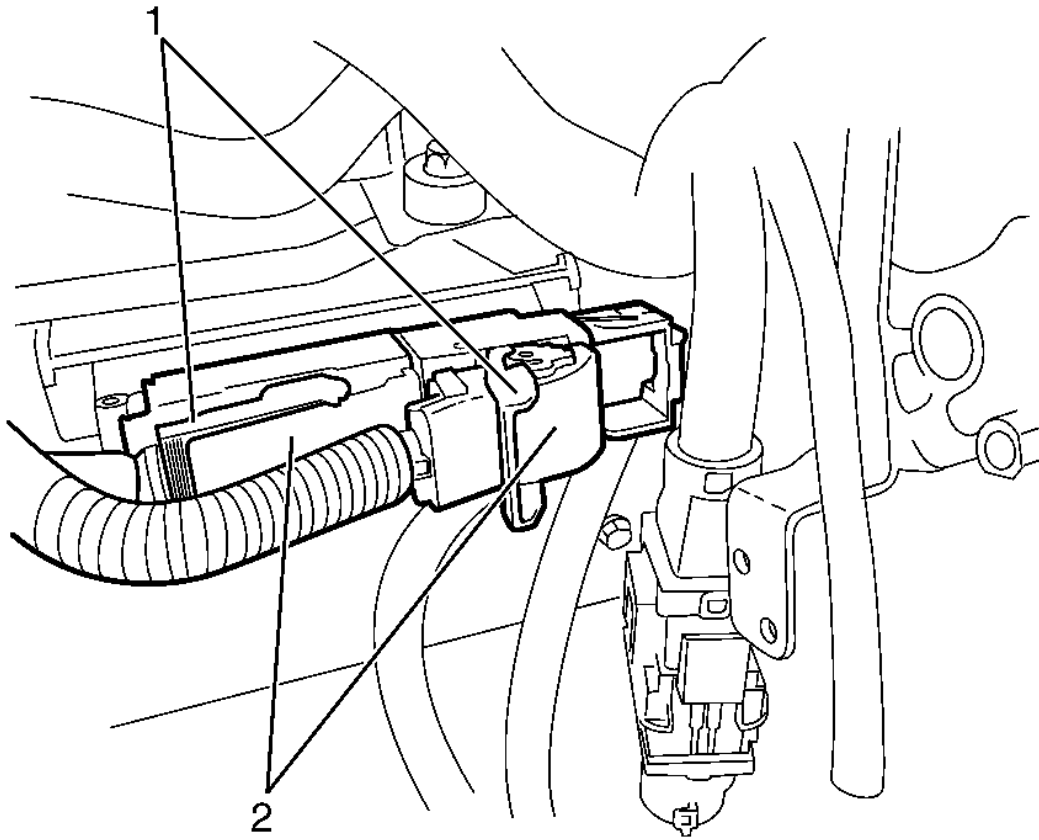




**Fig. 106: Identifying 56 & 2 Pin Engine Wiring Harness To Main Wiring Harness Electrical Connectors**

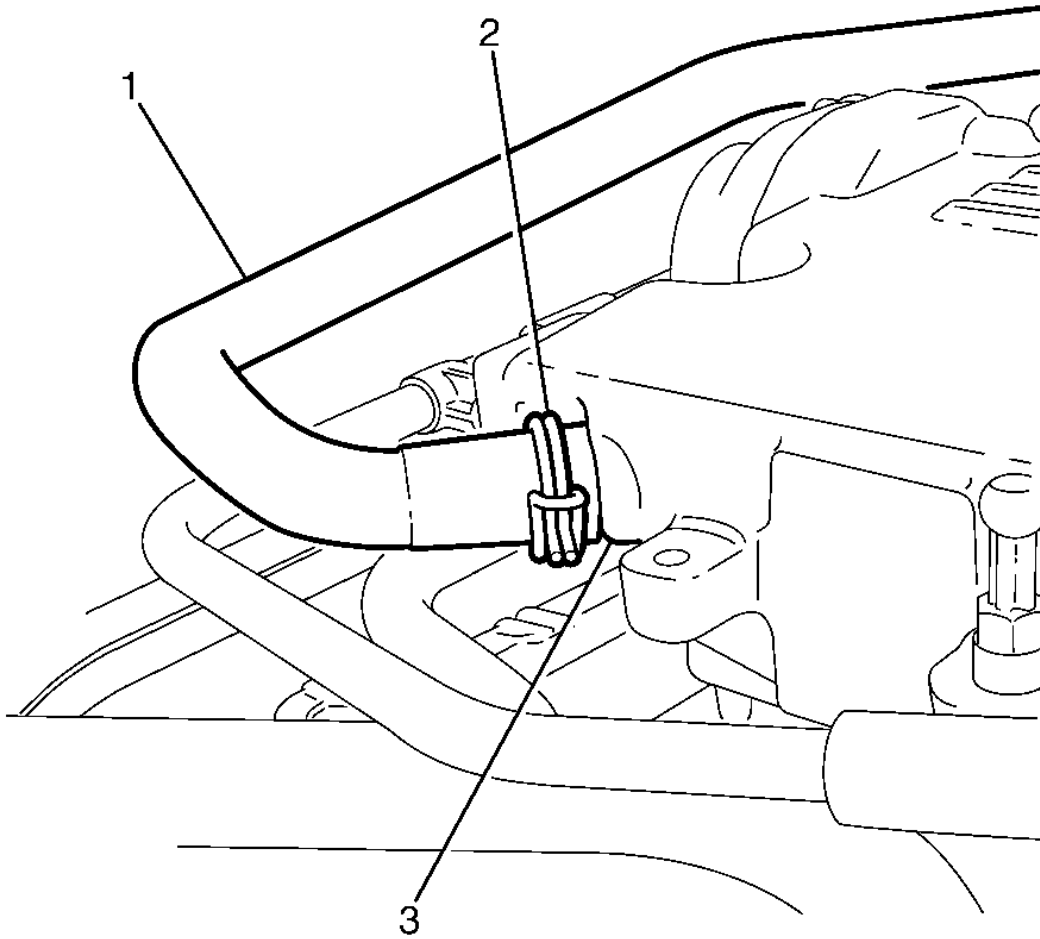
**Courtesy of GENERAL MOTORS CORP.**

92. Connect the 56 pin engine wiring harness to main wiring harness electrical connector (1).
93. Connect the 2 pin engine wiring harness to main wiring harness electrical connector (2).



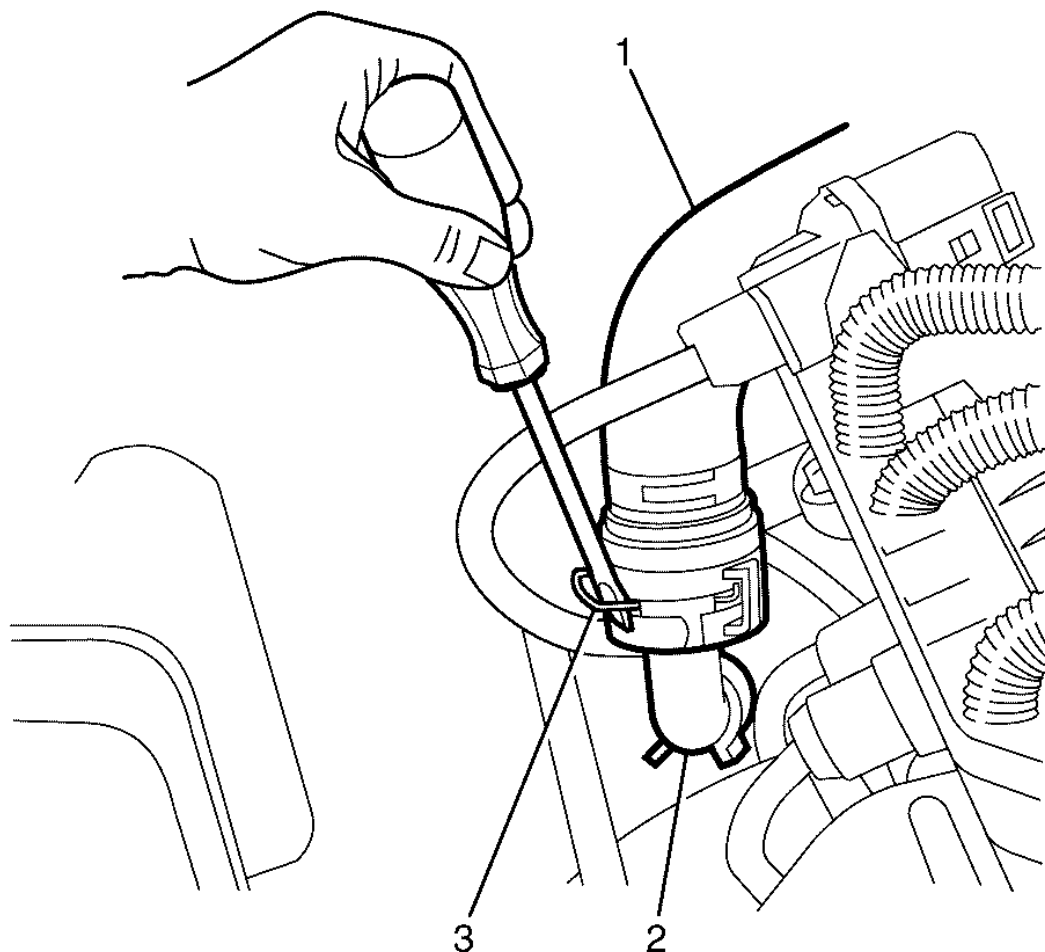
**Fig. 107: Identifying ECM Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

94. Connect ECM electrical connectors (2).
95. Rotate the engine control module (ECM) electrical connector levers (1) to the locked position.
96. Install the engine coolant heater cord if fitted. Refer to **Coolant Heater Cord Replacement (3.6L)** .



**Fig. 108: Identifying Intake Manifold Vacuum Port & Vacuum Hose With Retaining Clamp**  
Courtesy of GENERAL MOTORS CORP.

97. Connect the vacuum hose (1) to the intake manifold vacuum port (3).
98. Compress the vacuum hose retaining clamp (2) and slide along the vacuum hose (1) to the correct location to secure the vacuum hose (1) to the intake manifold vacuum port (3).



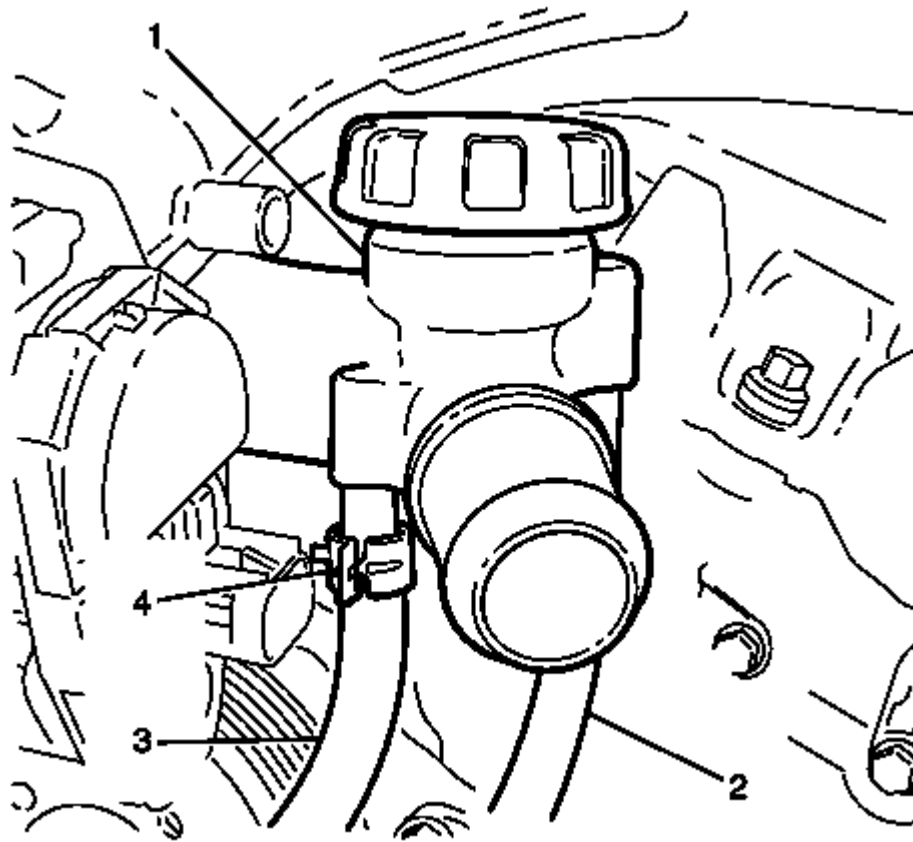
**Fig. 109: Identifying Heater Outlet Hose, Heater Outlet Pipe Quick Connect Fitting & Retaining Clip**

Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Installing Hoses without Twists or Bends Caution .

**NOTE:** Listen for a audible click to confirm fitting in two places

99. Attach the heater hose (1) quick connect fitting (3) by pushing the hose onto the heater pipe (2).



**Fig. 110: View Of Outlet Housing, Coolant Recovery Hose & Coolant Bleed Hose With Retaining Clamp**

**Courtesy of GENERAL MOTORS CORP.**

100. Remove the plug or cap at the cooling system hoses and inlets
101. Install the coolant bleed hose (3) to the outlet housing (1).
102. Compress the coolant bleed hose retaining clamp (4) and position back to its original location on the coolant bleed hose (3).
103. Connect the coolant recovery hose (2) from the outlet housing (1).
104. Install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (3.6L)** .
105. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection** .
106. Refill the cooling system. Refer to **Cooling System Draining and Filling (3.6 L)** .
107. Install the air intake duct. Refer to **Air Cleaner Inlet Duct Replacement** .
108. Recharge the air conditioning (A/C) system. Refer to **Refrigerant Recovery and Recharging** .
109. Install the radiator air intake baffle. Refer to **Radiator Air Upper Baffle and Deflector Replacement** .
110. Install the engine covers. Refer to **Engine Cover Replacement** .
111. Disable the ignition system.
112. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
113. Enable the ignition system.

114. Start the engine and listen for unusual noises.
115. Check the vehicle oil pressure gauge and confirm that the engine has acceptable oil pressure.

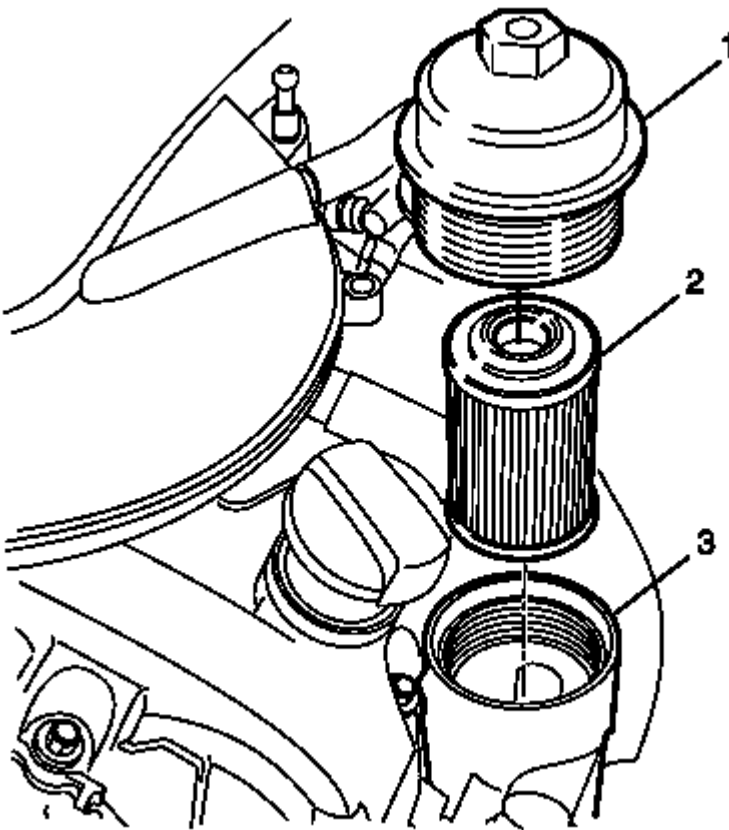
If necessary, install an oil pressure gauge and measure the engine oil pressure.

116. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
117. Listen for sticking stationary hydraulic lash adjuster, (SHLAs) (valve lifters) and other unusual noises.
118. Inspect for fuel, oil, and/or other coolant leaks while the engine is running.

## ENGINE OIL AND OIL FILTER REPLACEMENT

### Removal Procedure

1. Turn the ignition OFF.



**Fig. 111: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Use a six-point socket to remove the oil filter cap (1).

2. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).

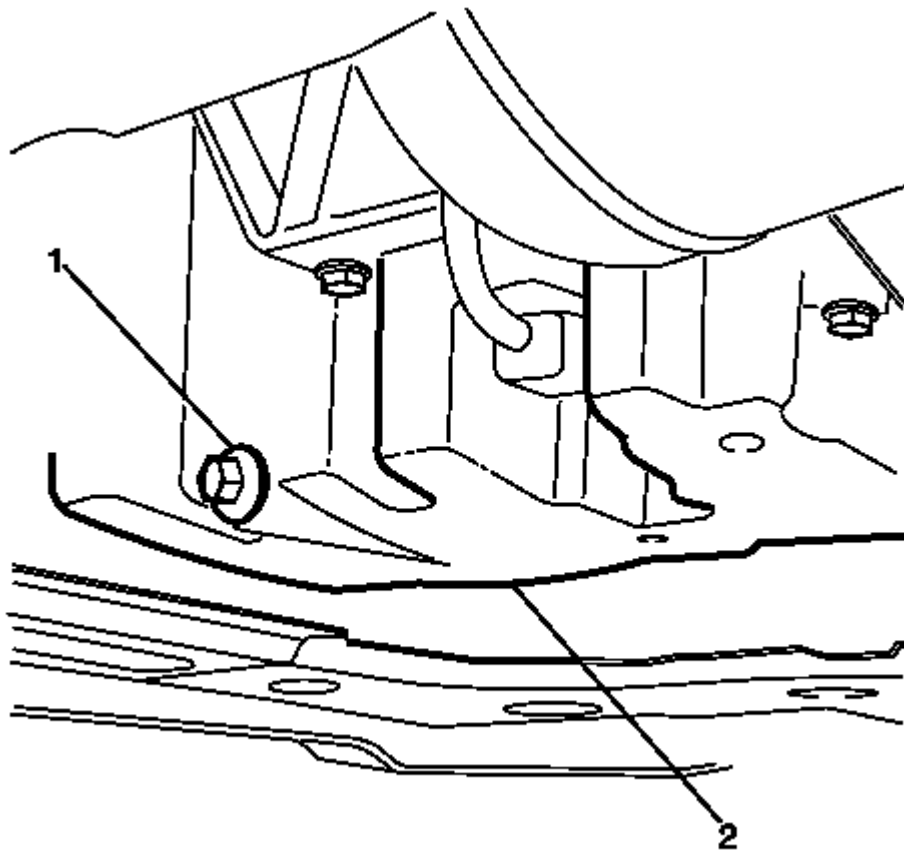
**NOTE:** The oil filter cartridge (2) must be replaced at every service interval.

3. Remove the oil filter cartridge (2).

Discard the oil filter cartridge (2).

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

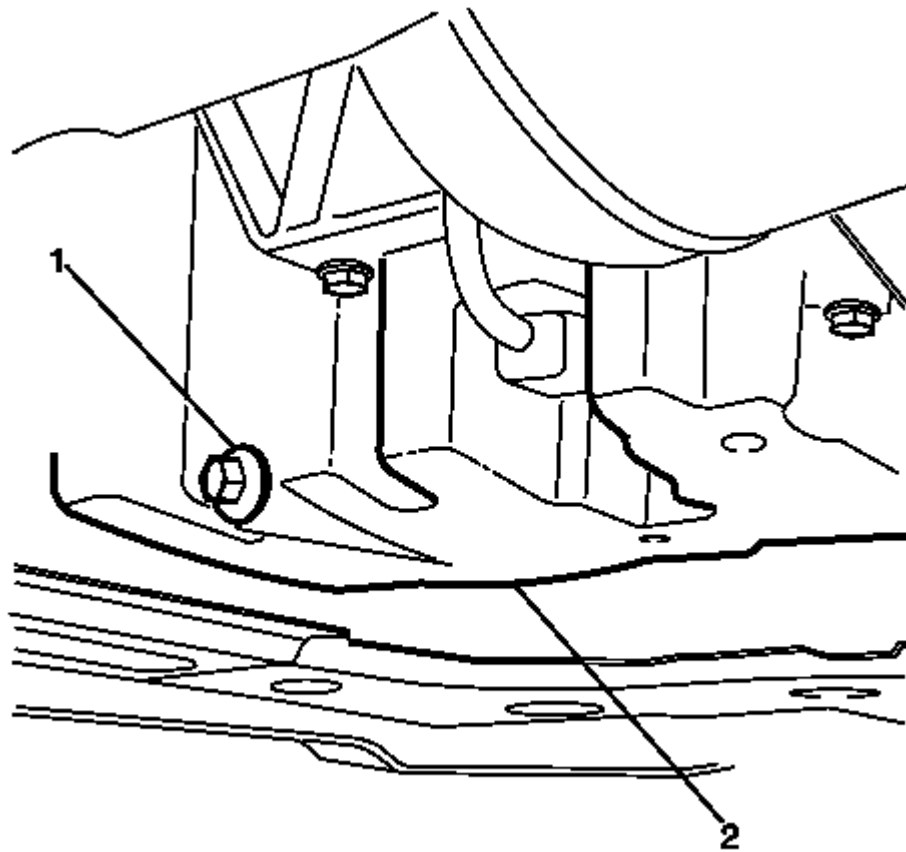
4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .



**Fig. 112: Identifying Oil Pan & Drain Plug**  
Courtesy of GENERAL MOTORS CORP.

5. Place a suitable container below the oil pan drain plug (1).
6. Remove the oil pan drain plug (1) from the oil pan (2).
7. Allow the oil to drain completely.

#### Installation Procedure

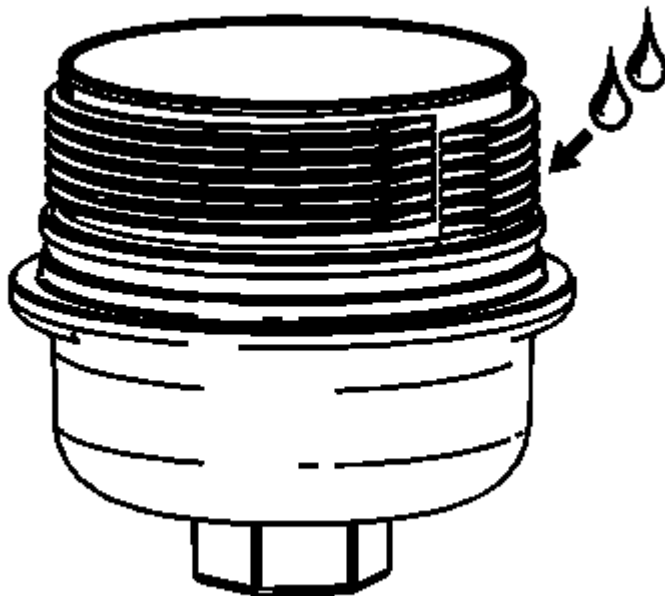


**Fig. 113: Identifying Oil Pan & Drain Plug**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

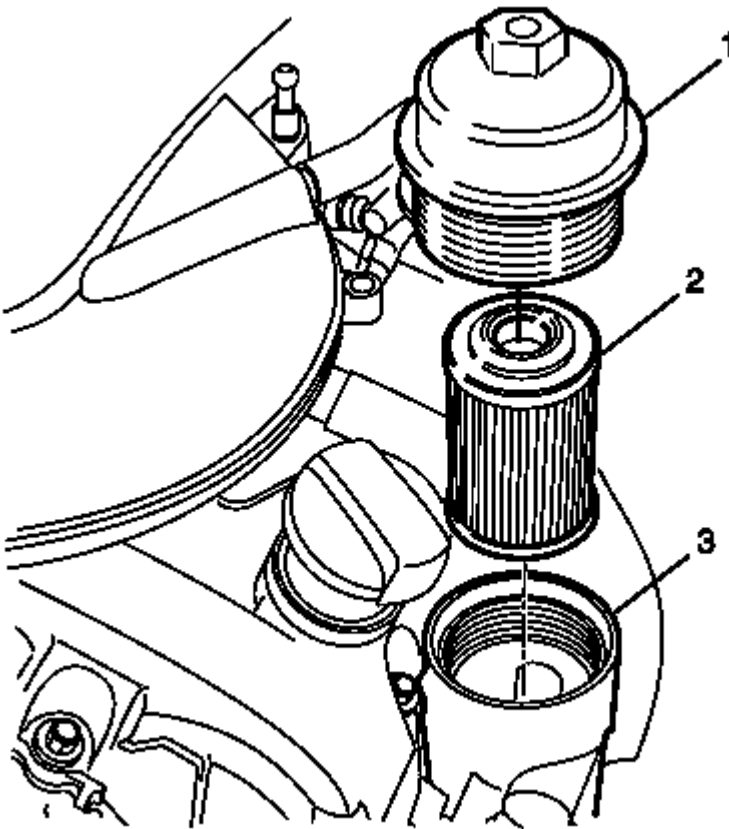
1. Install the oil pan drain plug (1) to the oil pan (2) and tighten to 25 N.m (18 lb ft).
2. Lower the vehicle.





**Fig. 114: Identifying Oil Filter Cap Thread Lubrication**  
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the oil filter cap threads with clean engine oil.



**Fig. 115: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW oil filter cartridge (2).

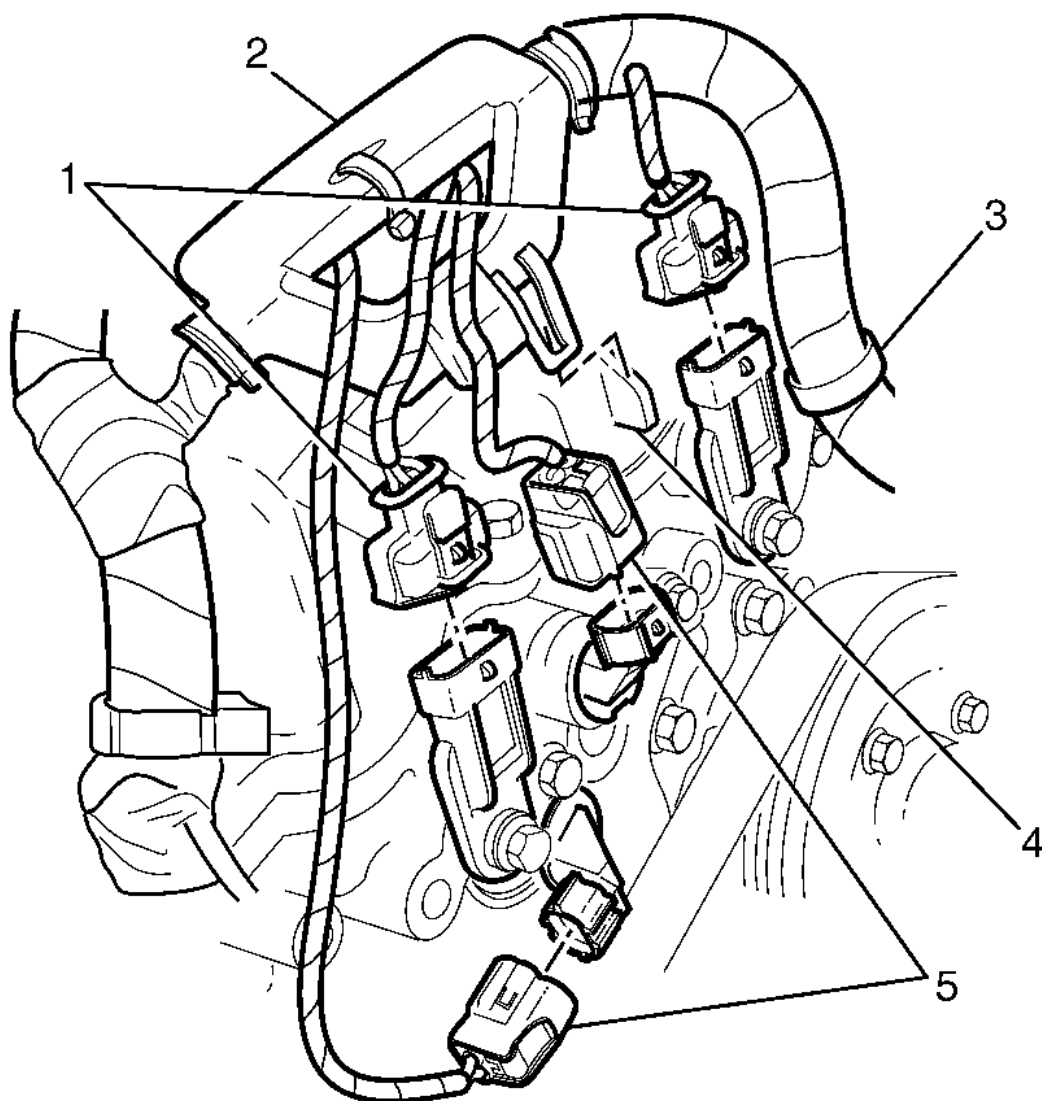
**NOTE:** Use a six-point socket to install the oil filter cap.

5. Install the oil filter cap (1) to the engine oil filter adapter (3) and tighten to 25 N.m (18 lb ft).
6. Fill the engine with the appropriate oil type and quantity. Refer to **Fluid and Lubricant Recommendations** and **Approximate Fluid Capacities**.
7. Reset the service reminder display. Refer to **Service Display Reminders**.

## REPAIR INSTRUCTIONS - OFF VEHICLE

### ENGINE WIRING HARNESS ASSEMBLY REMOVAL

1. Remove the engine covers. Refer to **Engine Cover Replacement**.



**Fig. 116: Identifying Right Camshaft Position Sensors Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

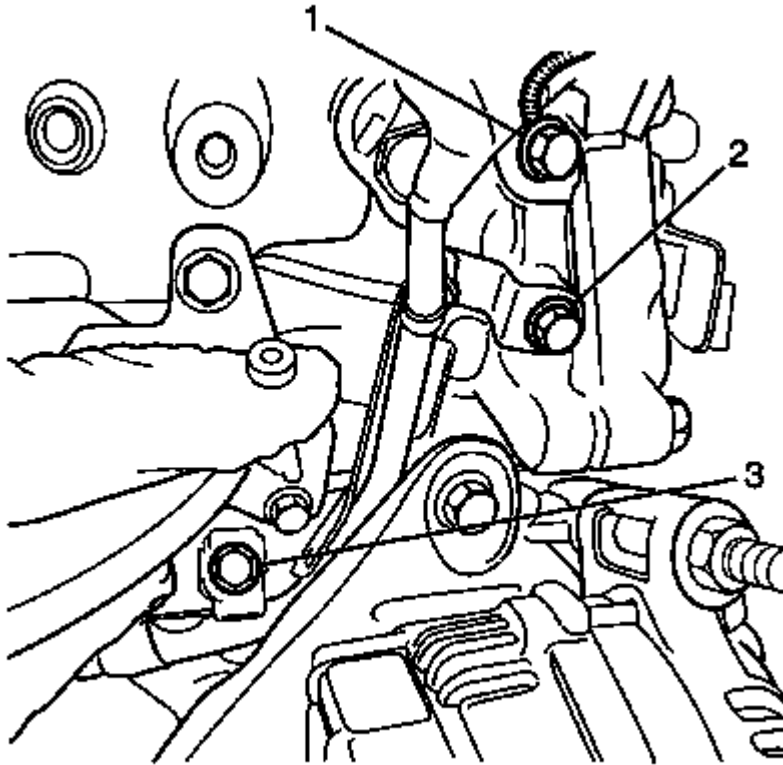
2. Disconnect the right camshaft position sensors electrical connectors (1).

**IMPORTANT: LE0 and LW2 engines only have an intake camshaft position actuator valve.**

3. Disconnect the right bank intake and exhaust camshaft position actuator valve electrical connectors (5).
4. Detach the engine wiring harness to cylinder head retaining lug (3).

**IMPORTANT:** Use a suitable tool to detach the engine wiring harness bracket (2) from the locating clip lug on the right bank camshaft cover (4) then slide the engine wiring harness bracket (2) upwards to detach from the right bank camshaft cover (4).

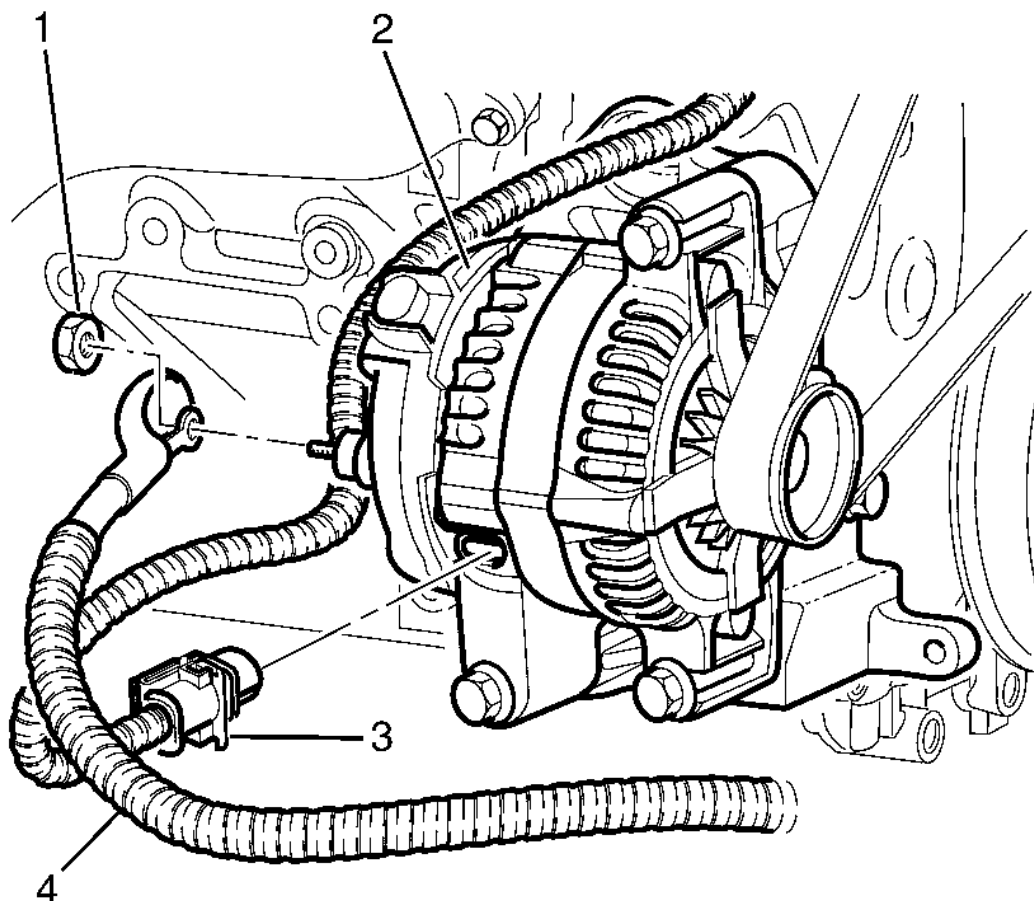
5. Detach the engine wiring harness bracket (2) from the right bank camshaft cover (4).



**Fig. 117: Identifying Engine Wiring Harness Bracket To Right Bank Cylinder Head Retaining Bolts**

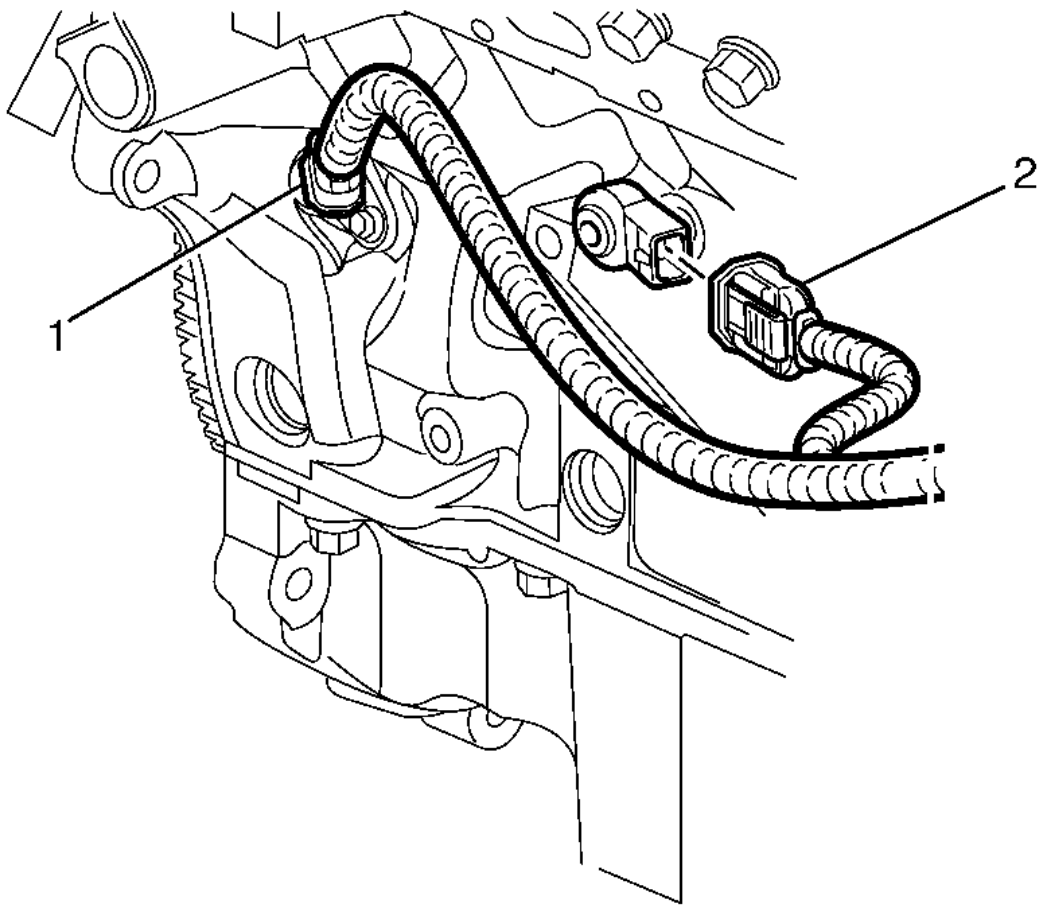
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
7. Remove the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
8. Remove the engine wiring harness bracket to cylinder block retaining bolt (3).



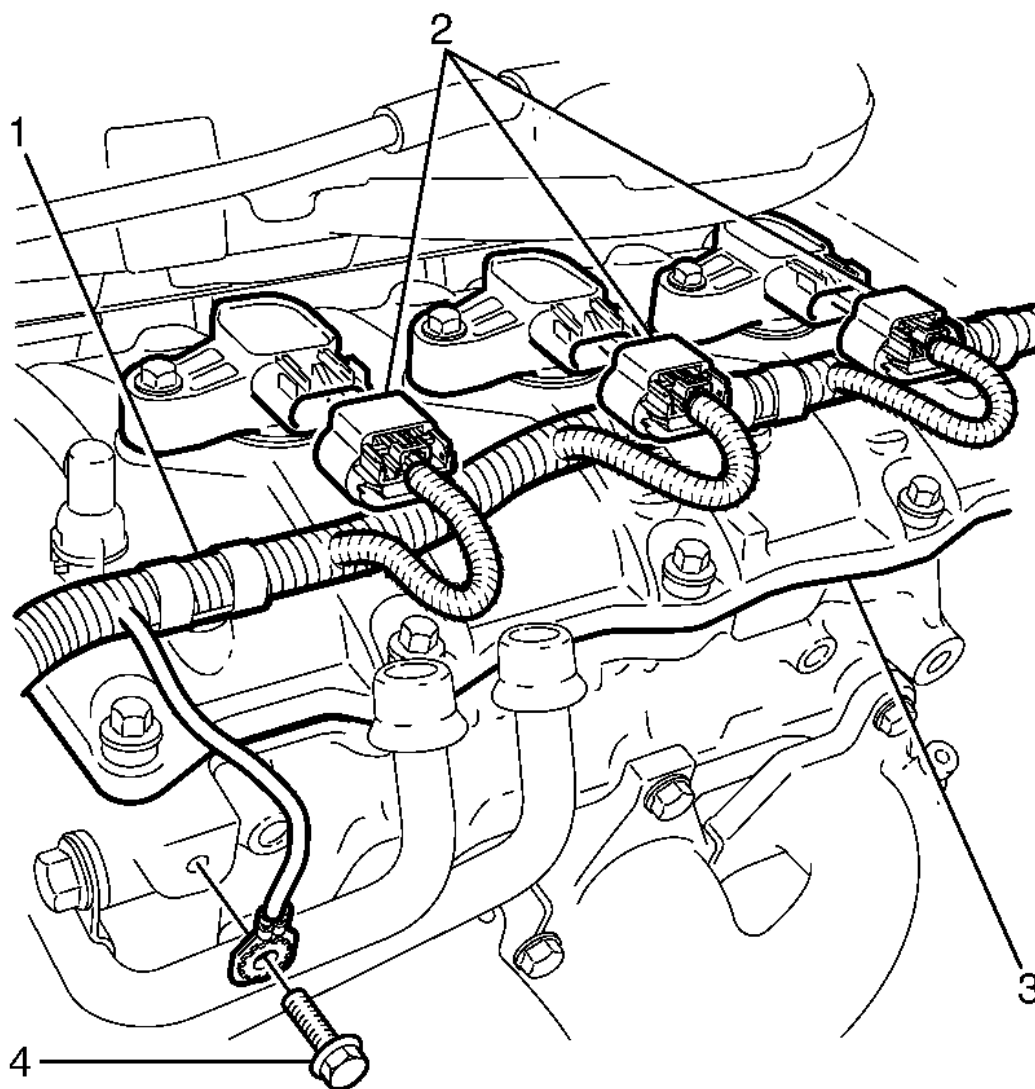
**Fig. 118: Identifying Alternator, Battery Positive Cable & Alternator Battery Harness Connector**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the battery positive cable to alternator retaining nut (1).
10. Disconnect the battery positive cable (2) from the alternator (3).
11. Disconnect the alternator battery harness connector (4).
12. Remove the alternator and mounting bracket. Refer to **Generator Removal**.



**Fig. 119: Identifying Crankshaft Position & Right Bank Knock Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the right bank knock sensor electrical connector (2).
14. Disconnect the crankshaft position sensor electrical connector (1).



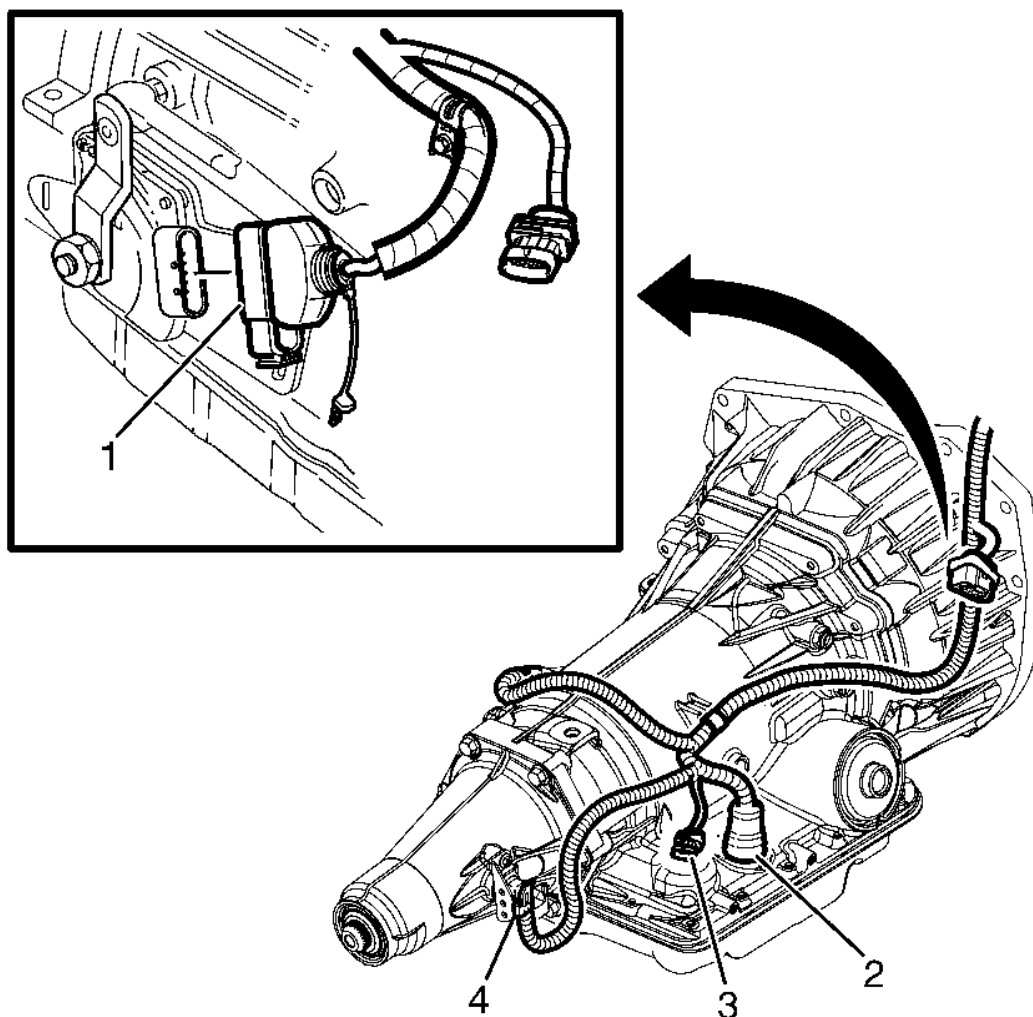
**Fig. 120: View Of Engine Wiring Harness, Right Bank Camshaft Cover & Right Bank Ignition Coil Electrical Connectors**

Courtesy of GENERAL MOTORS CORP.

15. Disconnect the right bank ignition coil electrical connectors (2).
16. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (4).

**IMPORTANT: Use a suitable tool to detach the engine wiring harness (1) clips from the right bank camshaft cover (4).**

17. Detach the engine wiring harness (1) from the right bank camshaft cover (3).

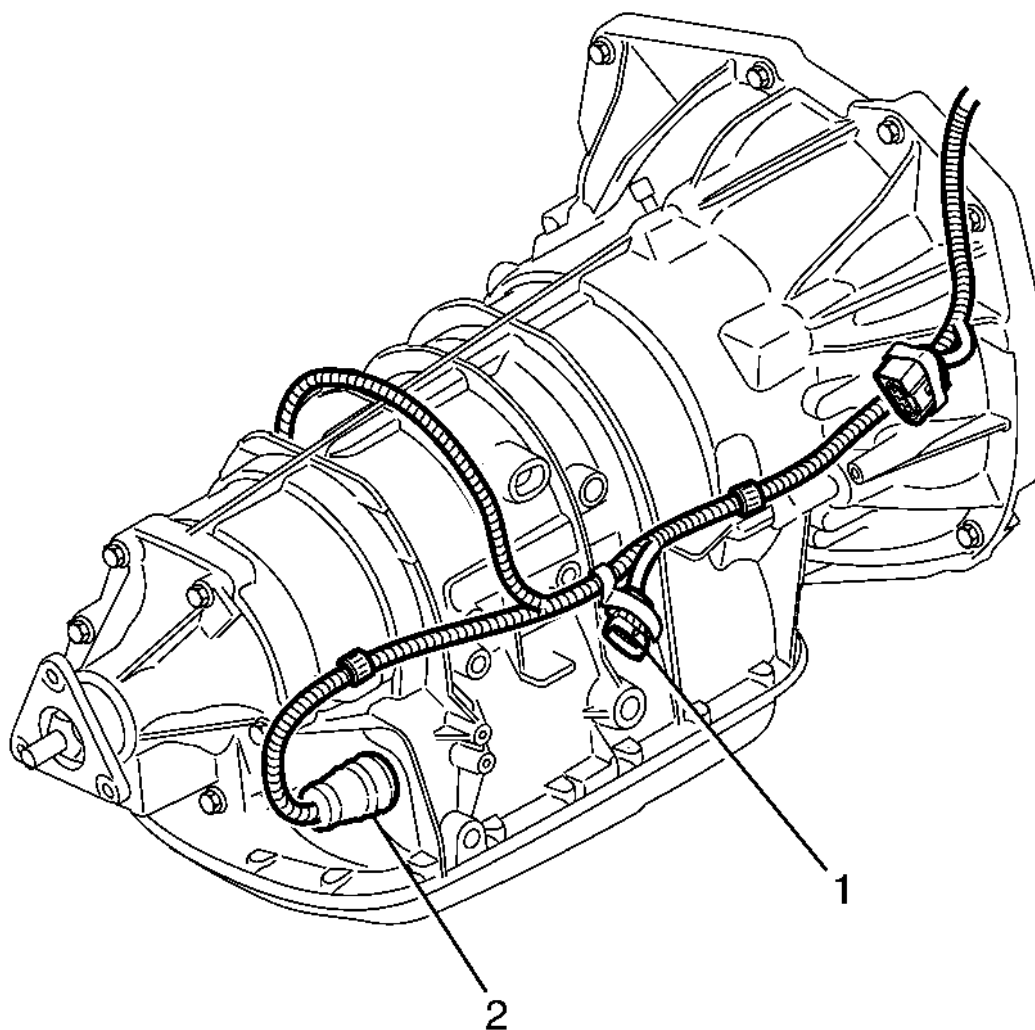


**Fig. 121: Identifying Park/Neutral Switch Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Steps 19 - 22 refer to the 4L60E 4 speed automatic transmission only.**

18. Disconnect the right hand Heated Oxygen Sensor 1 electrical connector (2) if still connected after engine removal.
19. Disconnect the main transmission electrical connector (3).
20. Disconnect the vehicle speed sensor electrical connector (4)
21. Disconnect the park/neutral switch electrical connector (1).



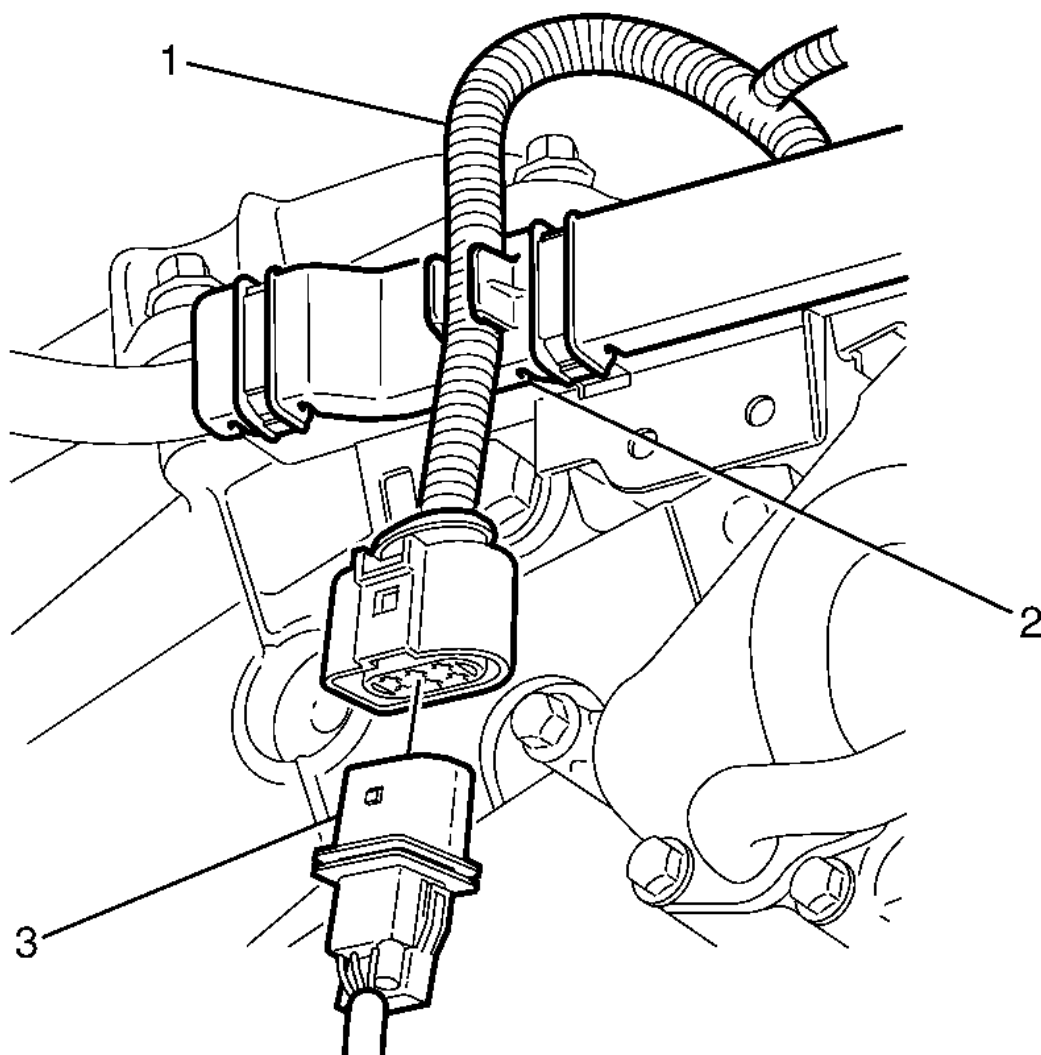


**Fig. 122: View Of Right Hand Heated Oxygen Sensor 1 & Main Transmission Electrical Connectors**

Courtesy of GENERAL MOTORS CORP.

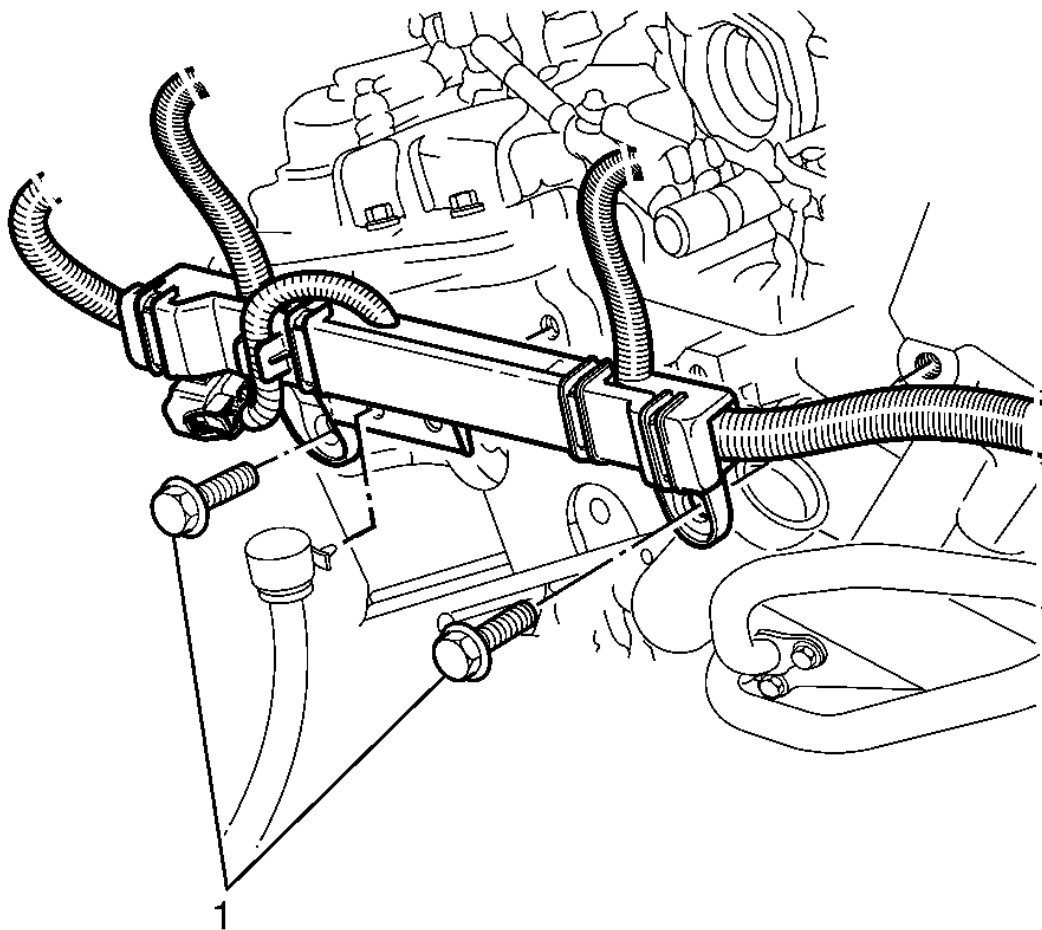
**IMPORTANT: Steps 24 and 25 refer to the 5L40E 5 speed automatic transmission only.**

22. Disconnect the right hand Heated Oxygen Sensor 1 electrical connector (1) if still connected after engine removal.
23. Disconnect the main transmission electrical connector (2).



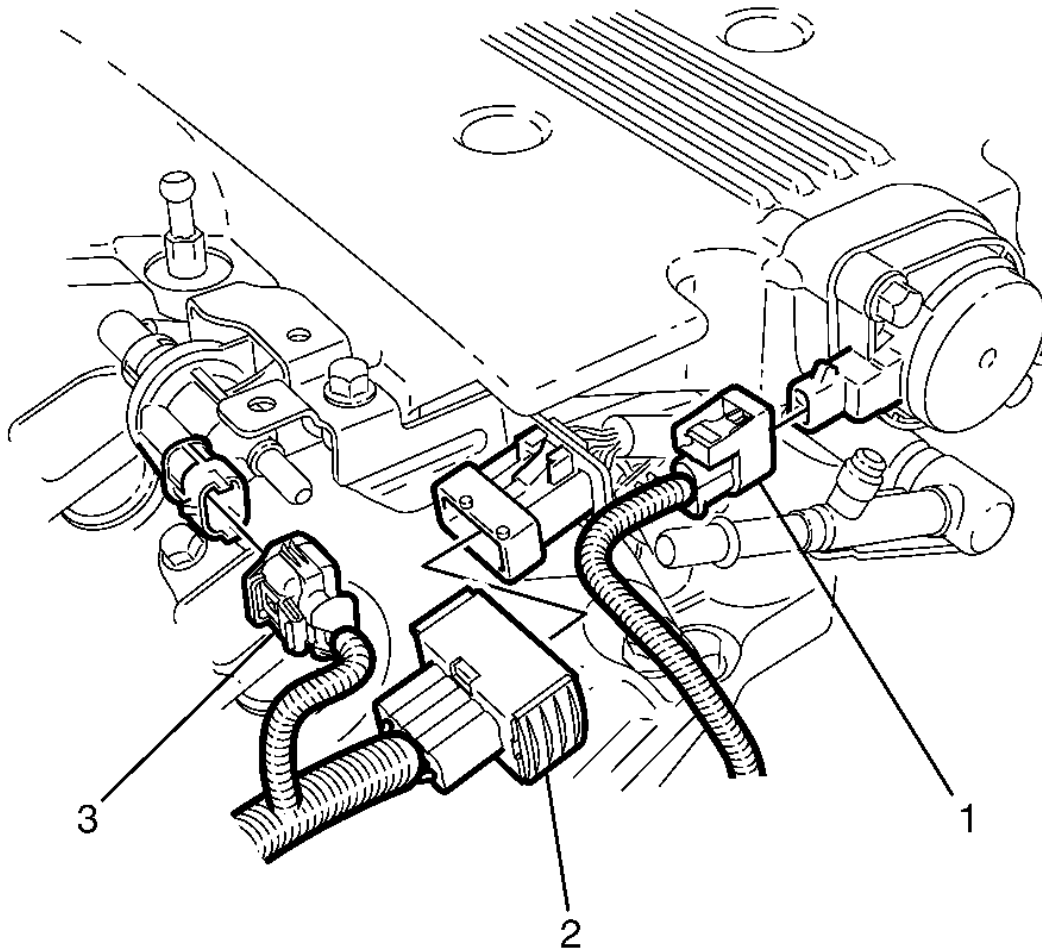
**Fig. 123: View Of Left Hand Heated Oxygen Sensor 1 Electrical Harness & Connector**  
**Courtesy of GENERAL MOTORS CORP.**

24. Disconnect the left hand Heated Oxygen Sensor 1 electrical connector (3) if still connected after engine removal.
25. Detach the left hand Heated Oxygen Sensor 1 electrical harness (1) from the engine wiring harness bracket (2).



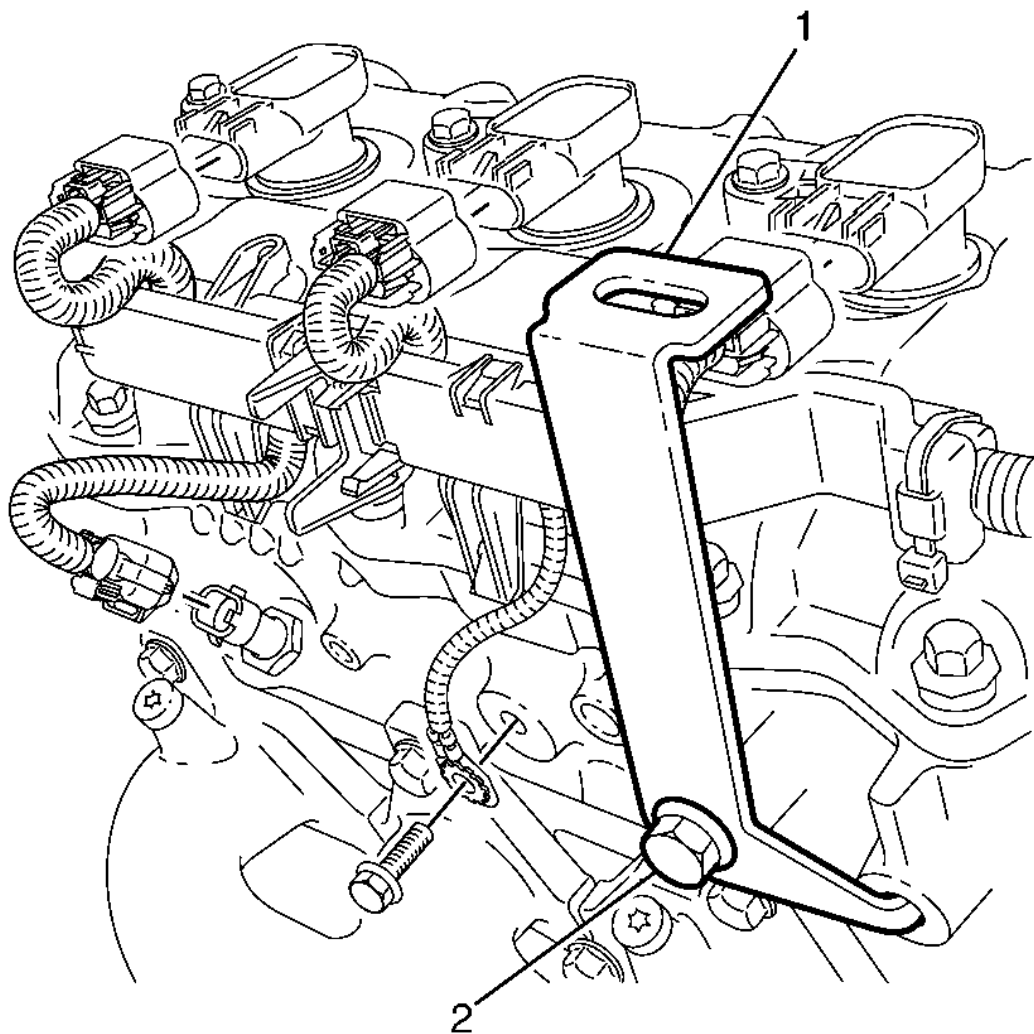
**Fig. 124: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

26. Remove the engine wiring harness bracket to cylinder head retaining bolts (1).



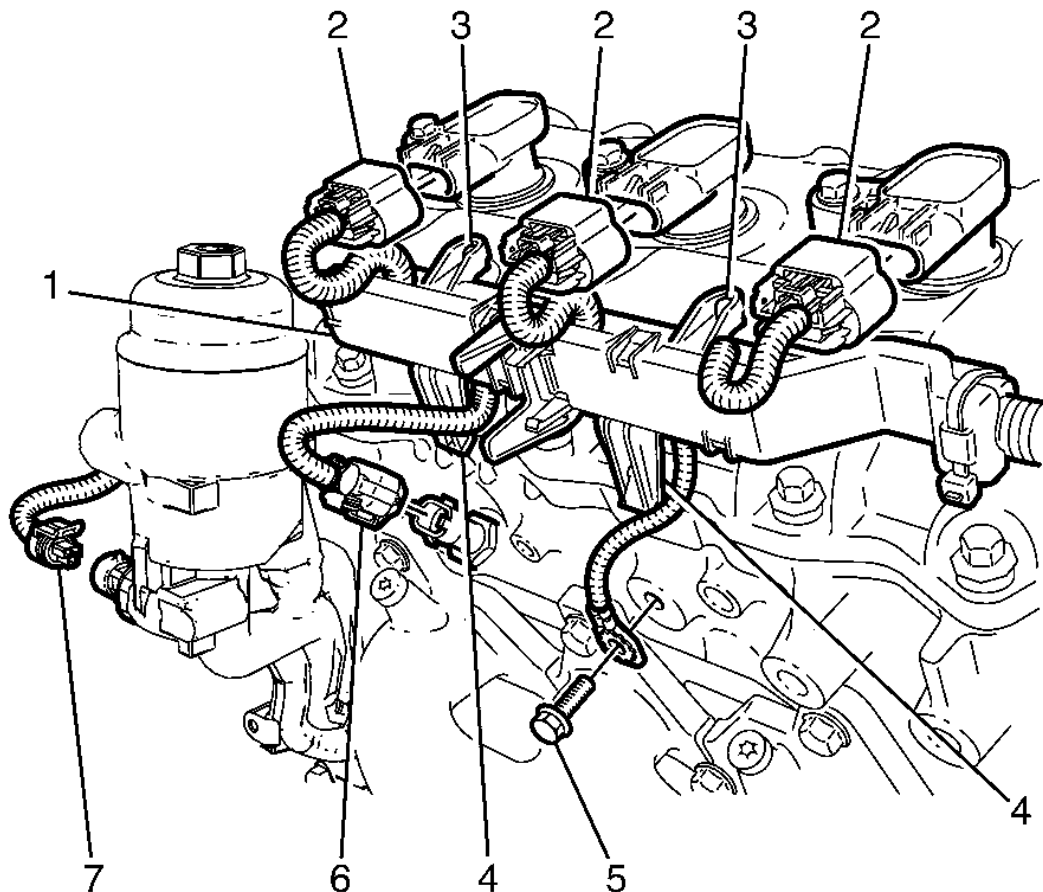
**Fig. 125: View Of IMRC, Injector Harness & Purge Solenoid Electrical Connectors**  
**Courtesy of GENERAL MOTORS CORP.**

27. Disconnect the Intake Manifold Runner Control (IMRC) electrical connector (1).
28. Disconnect the injector harness electrical connector (2).
29. Disconnect the purge solenoid electrical connector (3).



**Fig. 126: Identifying Engine Cover Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

30. Remove the engine cover bracket to cylinder head retaining bolt (2).
31. Remove the engine cover bracket (1).



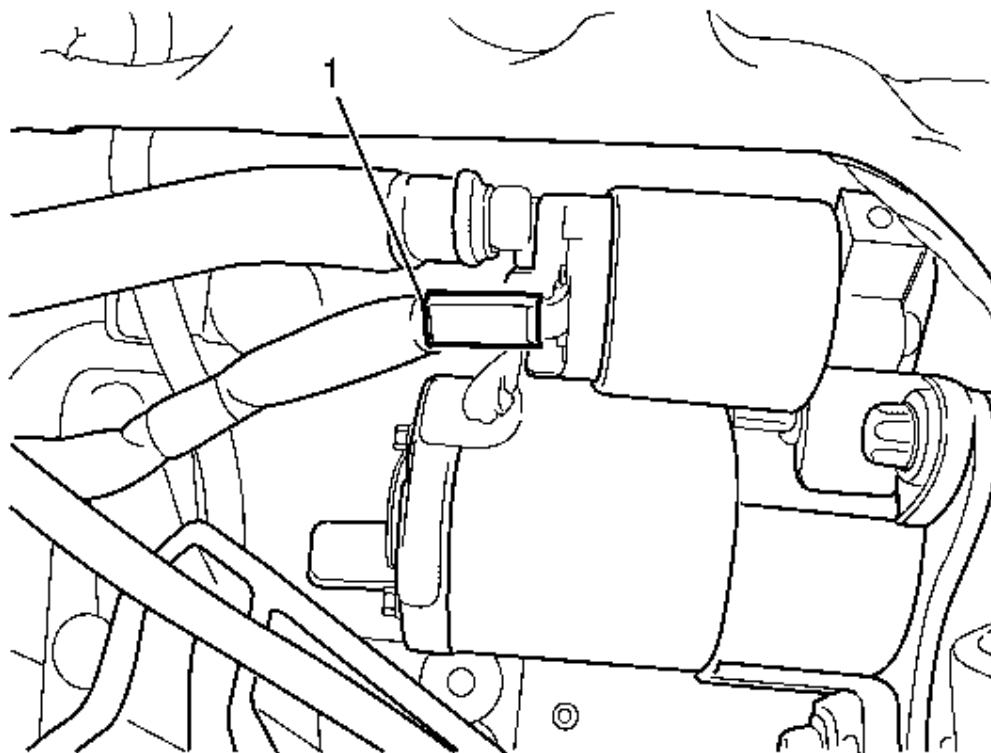
**Fig. 127: View Of Left Bank Ignition Coil Electrical Connectors & Right Bank Camshaft Cover Lugs**

Courtesy of GENERAL MOTORS CORP.

32. Disconnect the left bank ignition coil electrical connectors (2).
33. Remove the engine wiring harness ground to left bank cylinder head retaining bolt (5).
34. Disconnect the coolant temperature sensor electrical connector (6).
35. Disconnect the oil pressure sensor electrical connector (7).

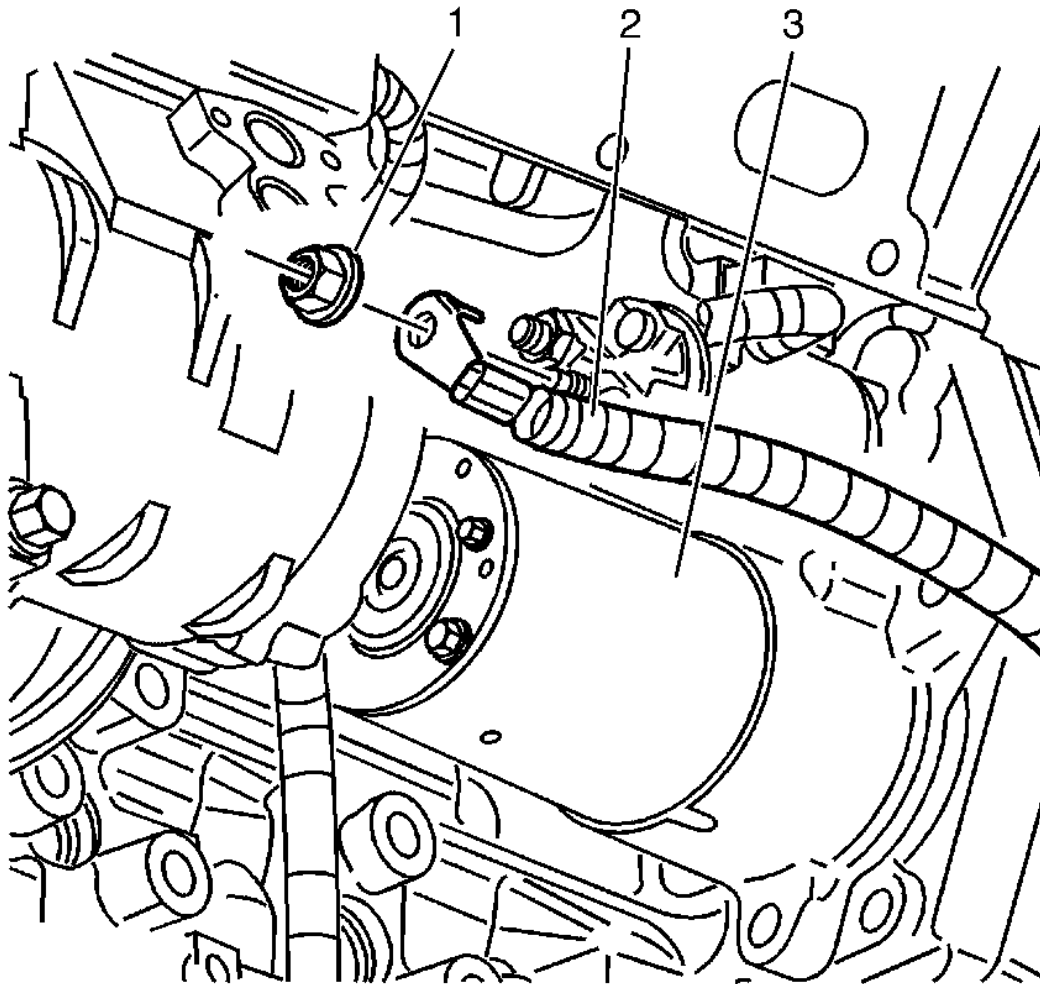
**IMPORTANT:** Use a suitable tool to detach the engine wiring harness (1) clips from the right bank camshaft cover clips (4) then lift upwards to detach the engine wiring harness (1) from the right bank camshaft cover lugs (3).

36. Detach the engine wiring harness bracket (1) from the right bank camshaft cover lugs (3) and position aside.



**Fig. 128: View Of Starter Motor Electrical Connector**  
**Courtesy of GENERAL MOTORS CORP.**

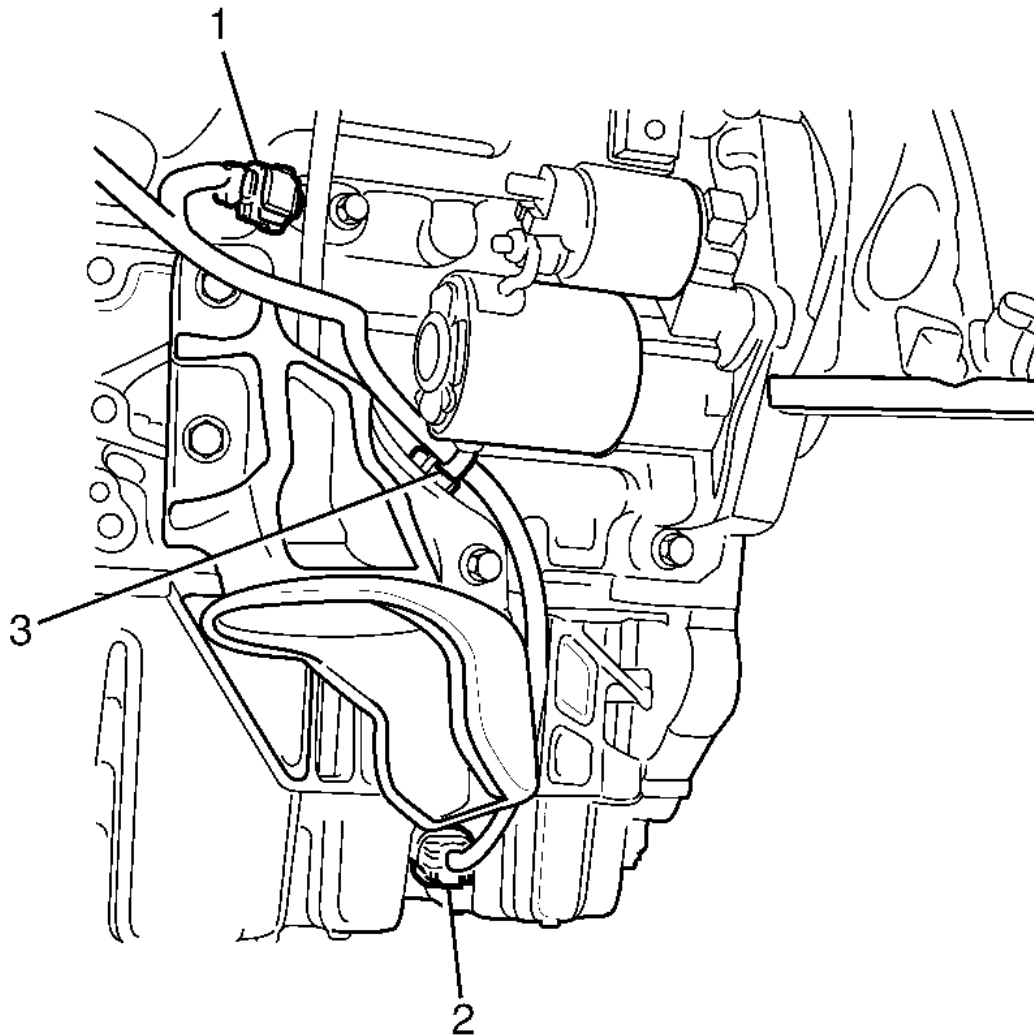
37. Disconnect the starter motor electrical connector (1).



**Fig. 129: Identifying Battery Cable Harness To Starter Motor Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

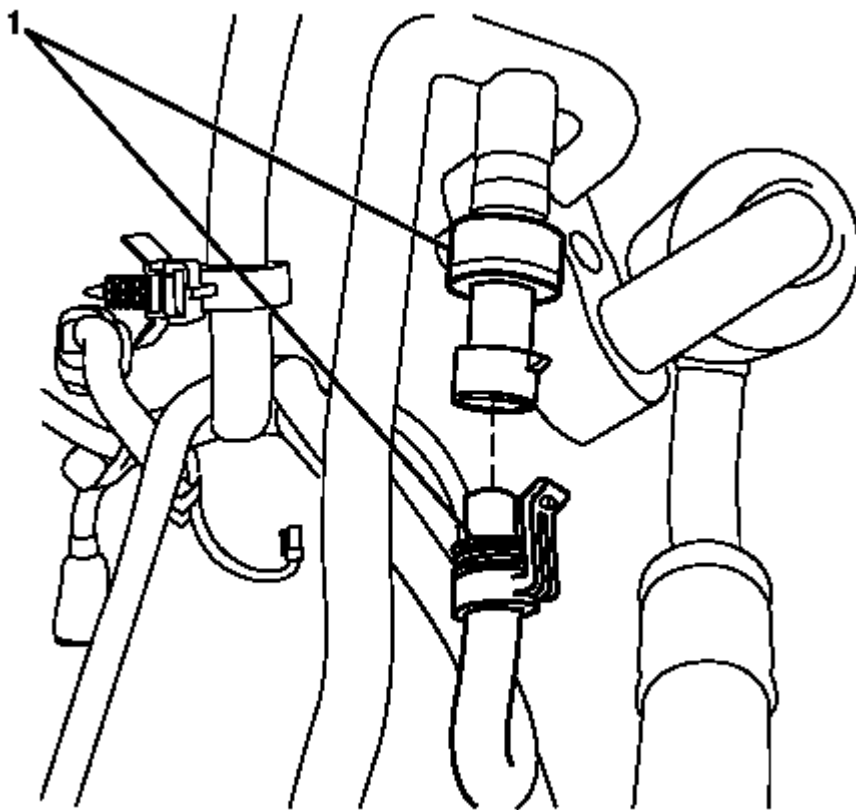
38. Disconnect the battery cable harness (2) from the starter motor (3).
39. Remove the battery cable harness to starter motor retaining nut (1).





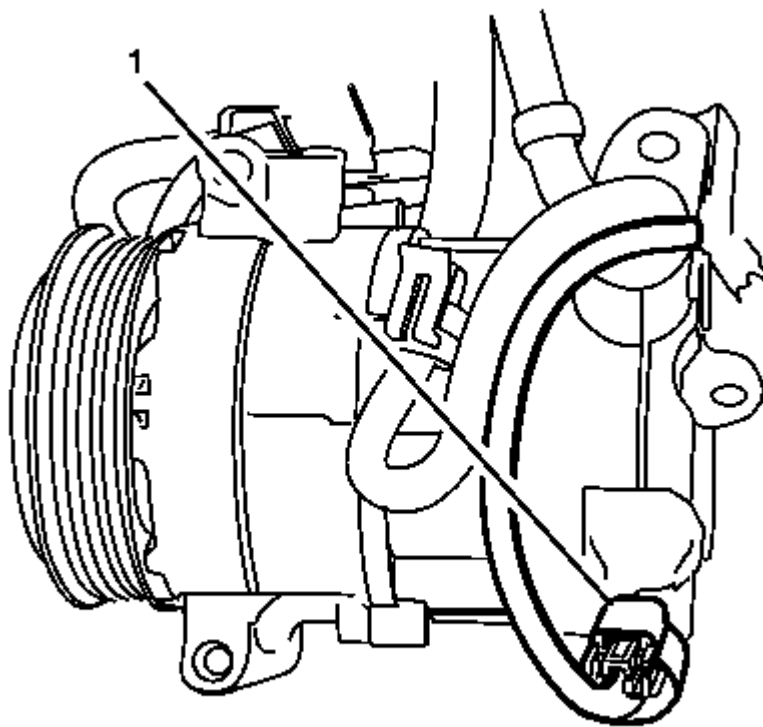
**Fig. 130: Identifying Left Bank Knock Sensor & Oil Level Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

40. Disconnect the left bank knock sensor electrical connector (1).
41. Disconnect the oil level sensor electrical connector (2).
42. Detach the engine wiring harness to cylinder block retaining lug (3).



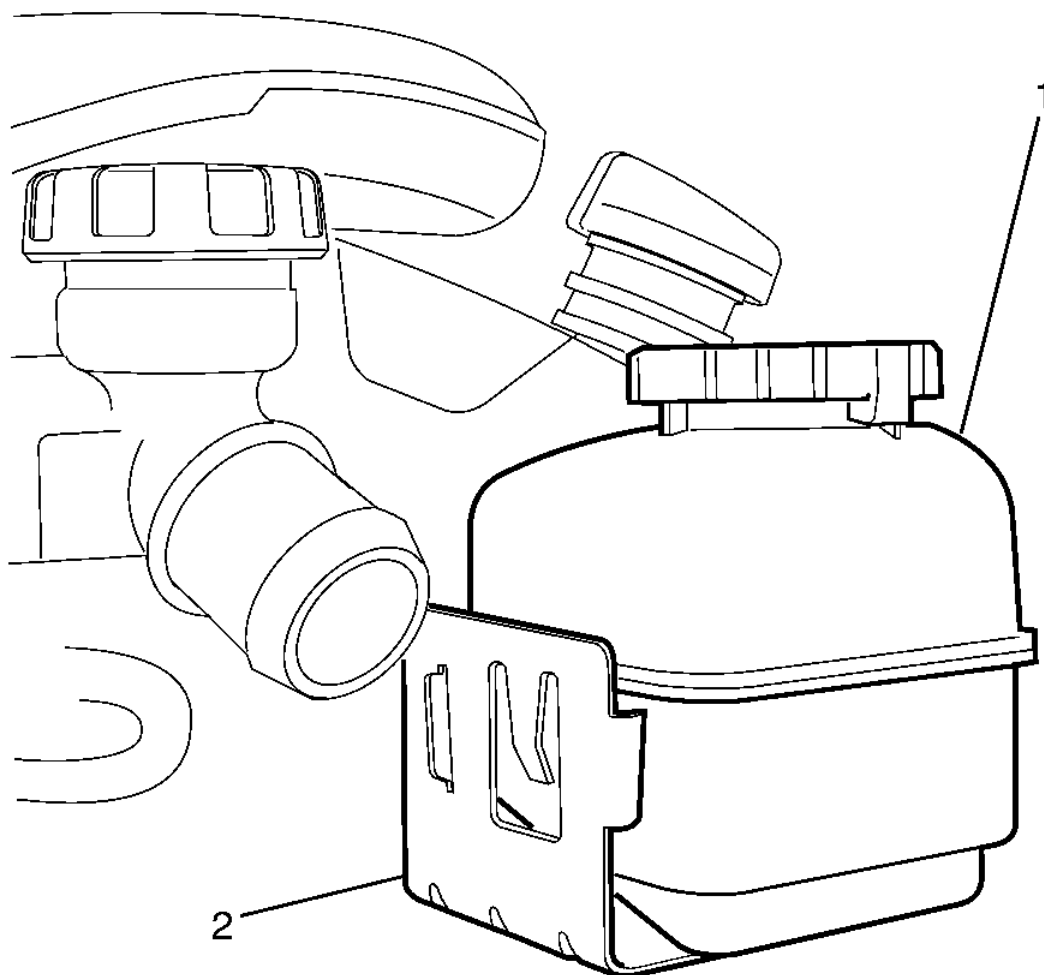
**Fig. 131: Identifying A/C Refrigerant Pressure Sensor Electrical Connector**  
**Courtesy of GENERAL MOTORS CORP.**

43. Disconnect the A/C pressure transducer electrical connector (1).



**Fig. 132: Identifying A/C Compressor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

44. Disconnect the A/C compressor electrical connector (1).

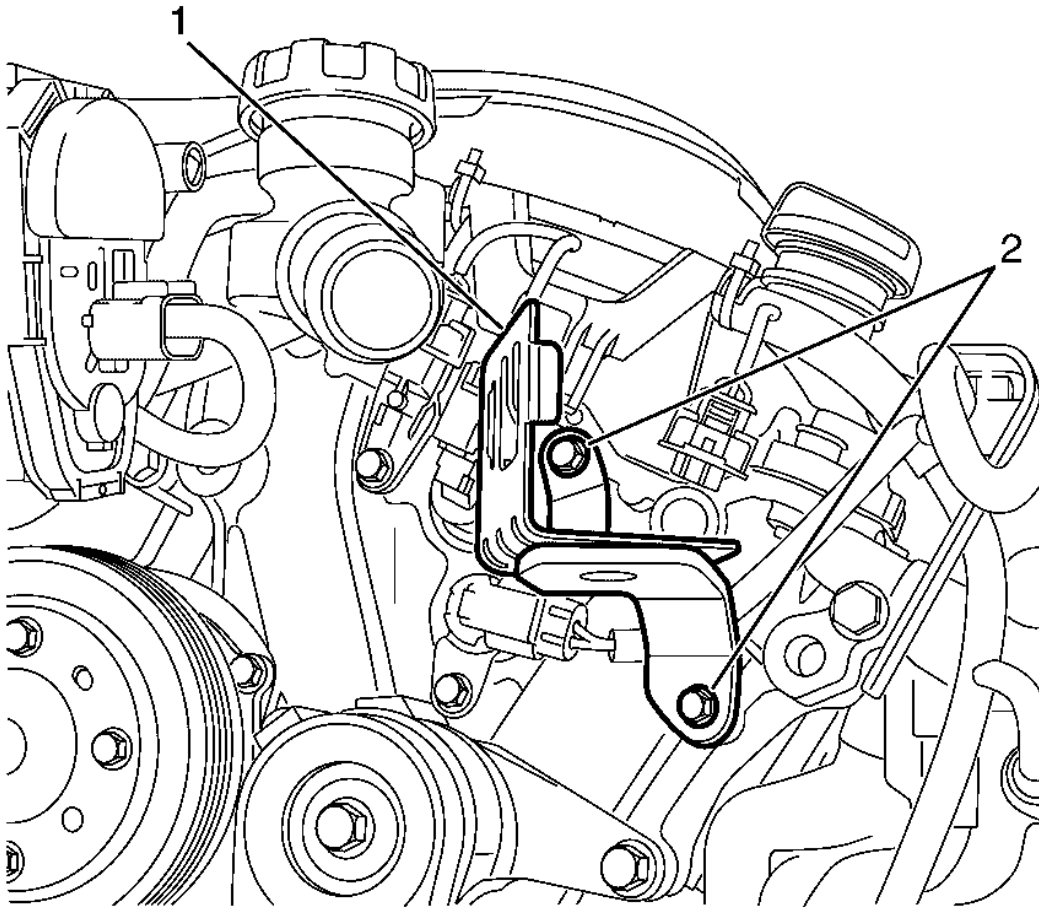


**Fig. 133: Identifying Power Steering Fluid Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** DO NOT disconnect the power steering pipes or drain the power steering fluid.

**IMPORTANT:** The locking tang on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1). Release the locking tang on the power steering reservoir bracket (2) with a suitable tool.

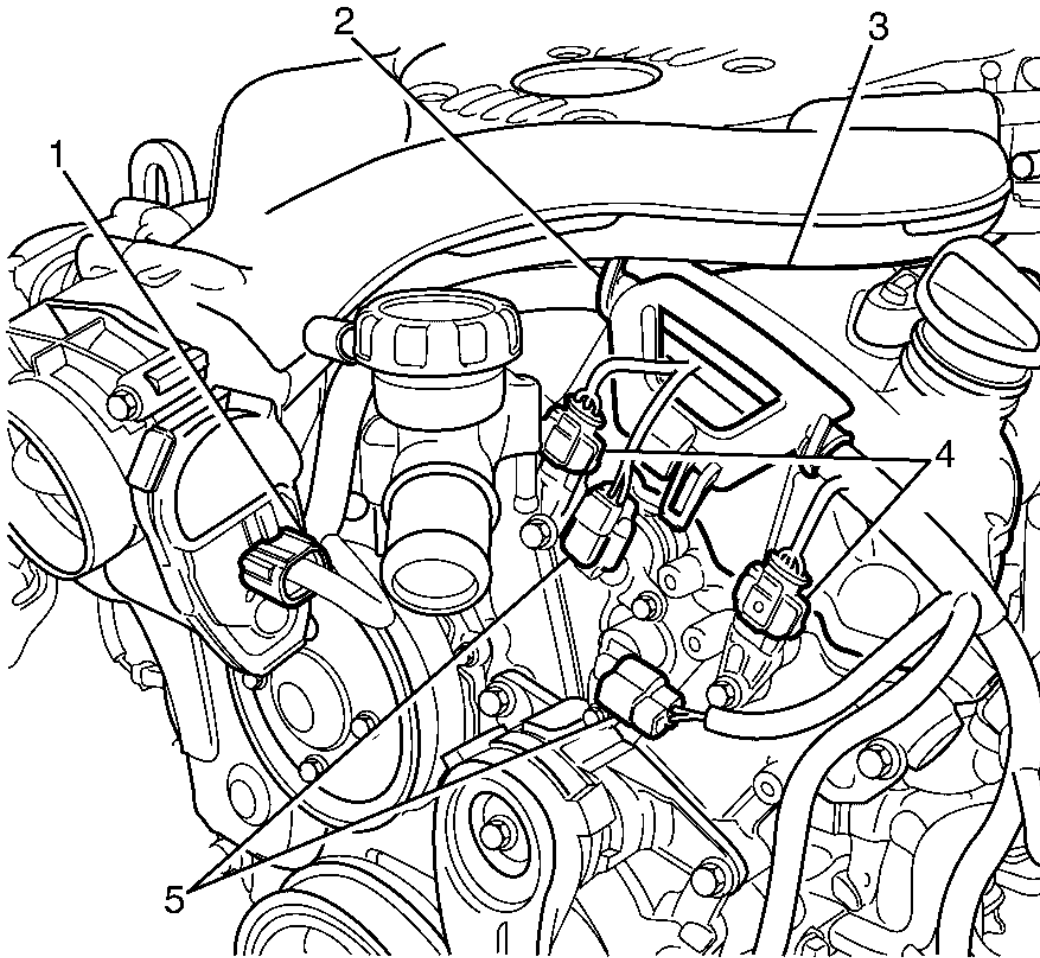
45. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).
46. Reposition and secure the power steering fluid reservoir away from the power steering fluid reservoir (1) bracket (2).



**Fig. 134: Identifying Power Steering Fluid Reservoir Bracket To Engine Front Cover Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

47. Remove the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
48. Remove the power steering fluid reservoir bracket (1).



**Fig. 135: View Of Throttle Position Sensor Electrical Connector, Engine Wiring Harness Bracket & Left Bank Camshaft Cover**

Courtesy of GENERAL MOTORS CORP.

49. Disconnect the left camshaft position sensors electrical connectors (4).

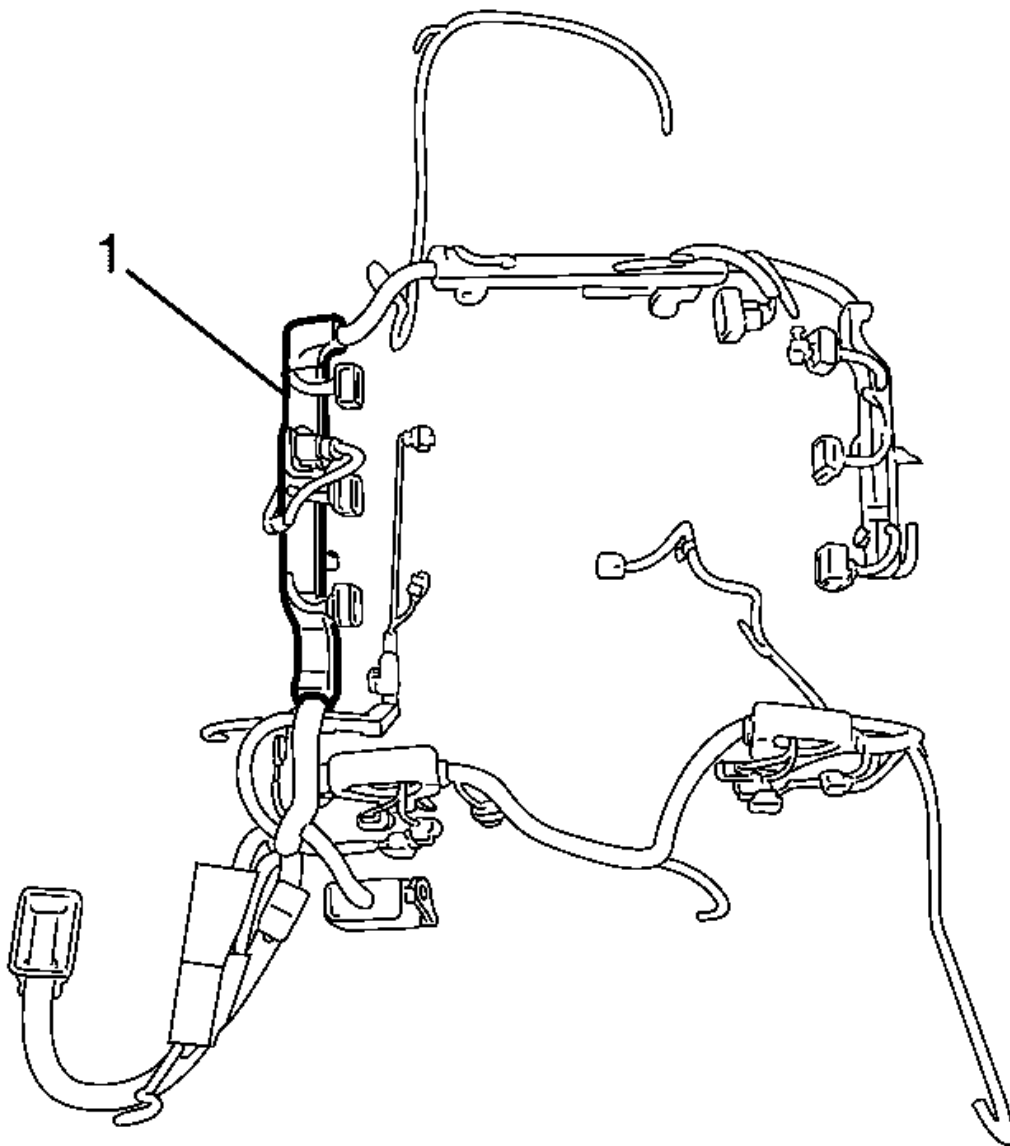
**IMPORTANT:** LE0 and LW2 engines only have an intake camshaft position actuator valve.

50. Disconnect the left bank intake and exhaust camshaft position actuator valve electrical connectors (5).
51. Disconnect the throttle position sensor electrical connector (1).

**IMPORTANT:** Use a suitable tool to detach the engine wiring harness bracket (2) from the locating clip lug on the left bank camshaft cover (3) then slide the engine wiring harness bracket (2) upwards to detach from the left bank

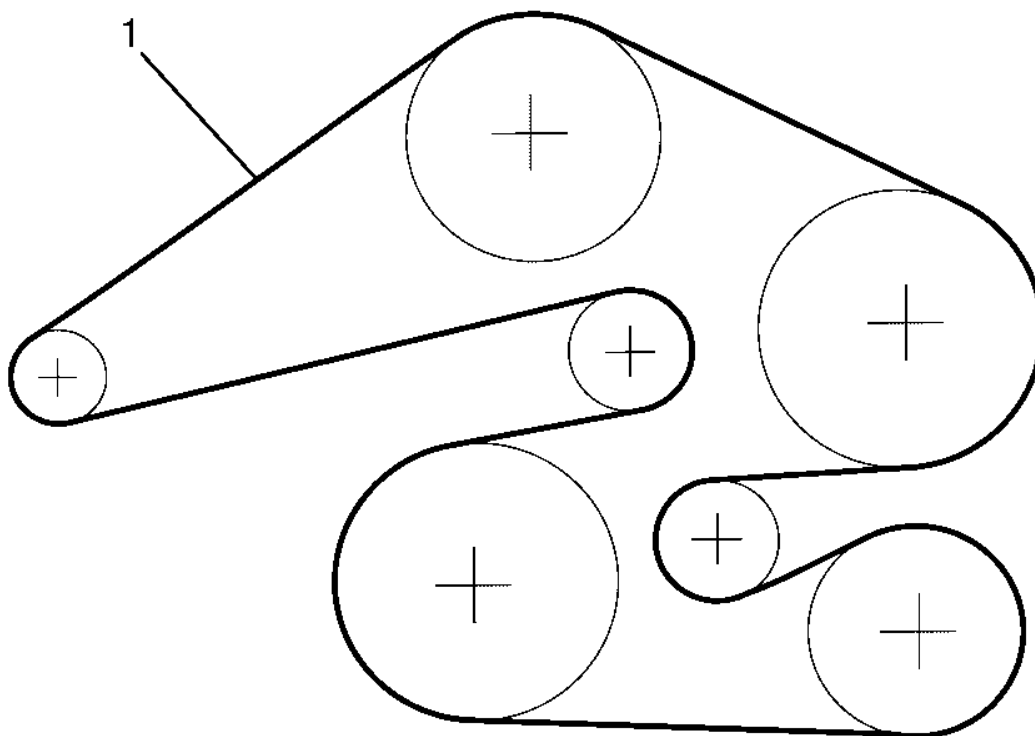
**camshaft cover (3).**

52. Detach the engine wiring harness bracket (2) from the left bank camshaft cover (3).



**Fig. 136: Identifying Engine Wiring Harness**  
Courtesy of GENERAL MOTORS CORP.

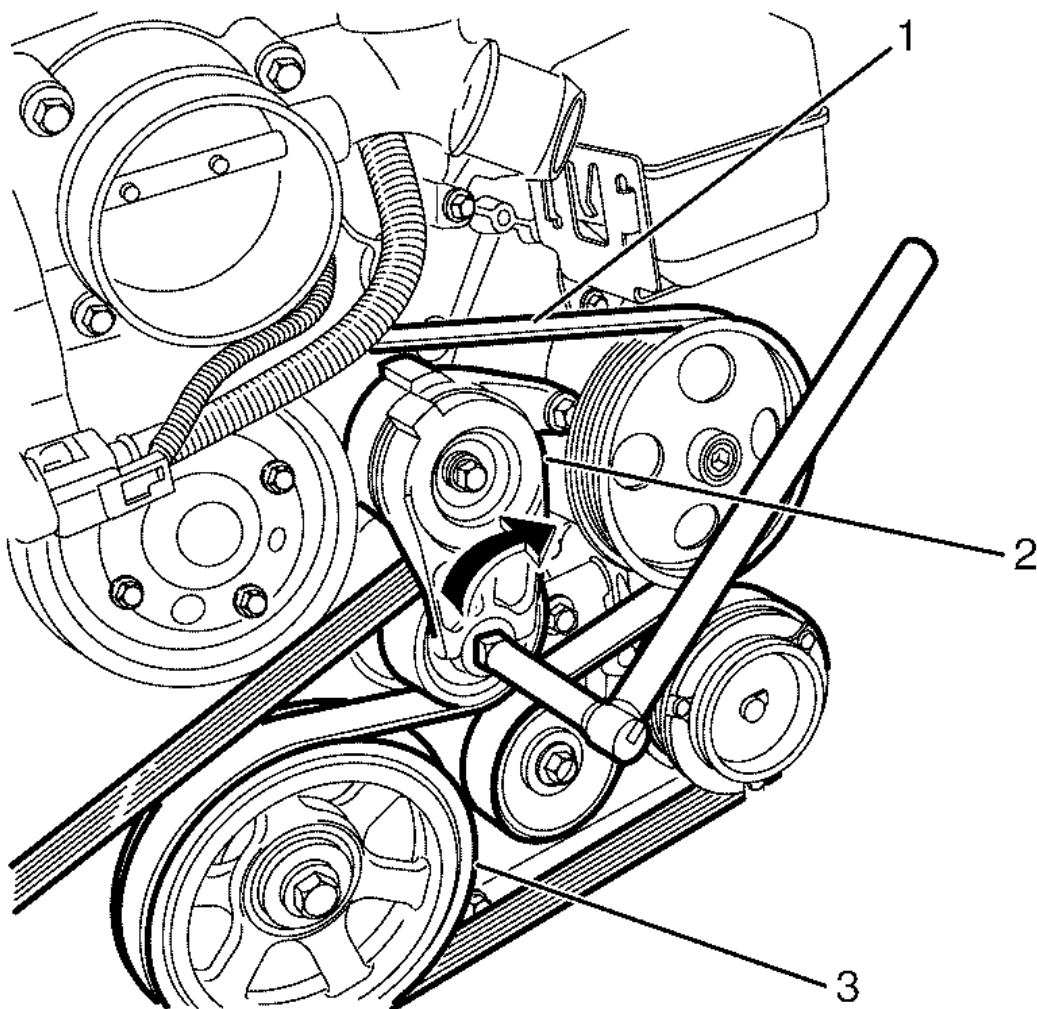
53. Remove the engine wiring harness (1).

**DRIVE BELT REMOVAL**

**Fig. 137: Drive Belt Routing**  
Courtesy of GENERAL MOTORS CORP.

1. Note the routing of the drive belt (1).





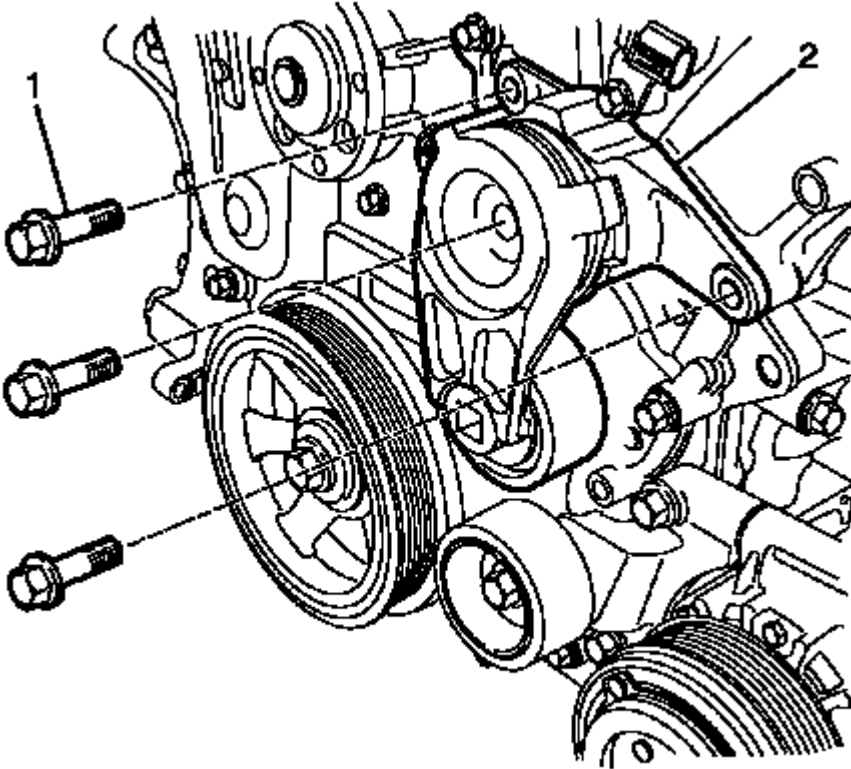
**Fig. 138: Identifying Drive Belt Tensioner Rotation (Clockwise)**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Using a suitable tool rotate the drive belt tensioner (2) clockwise.

2. Rotate the drive belt tensioner (2) clockwise in order to release tension on the drive belt (1).
3. Remove the drive belt (1) from the crankshaft pulley (3).
4. Slowly release the drive belt tensioner (2).
5. Remove the drive belt (1).

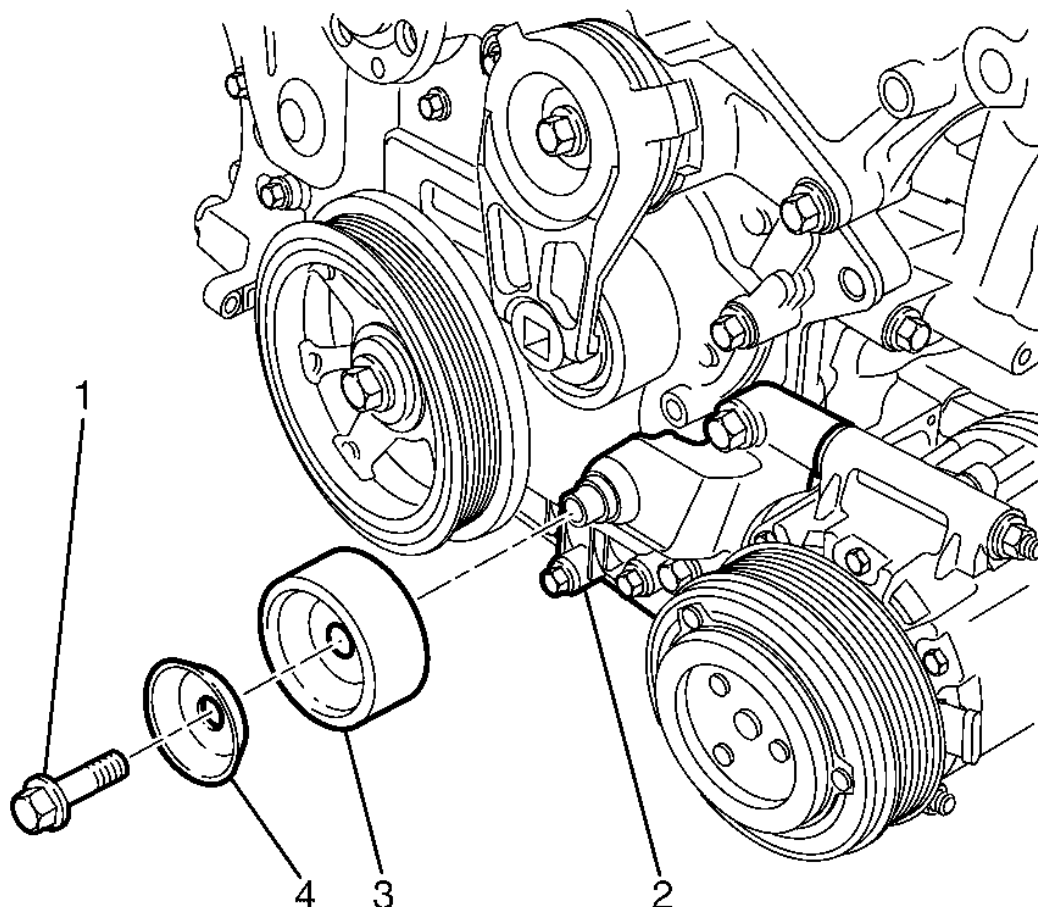
#### **DRIVE BELT TENSIONER REMOVAL**



**Fig. 139: Identifying Drive Belt Tensioner To Engine Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner to engine front cover retaining bolts (1).
2. Remove the drive belt tensioner (2).

#### **DRIVE BELT IDLER PULLEY REMOVAL**

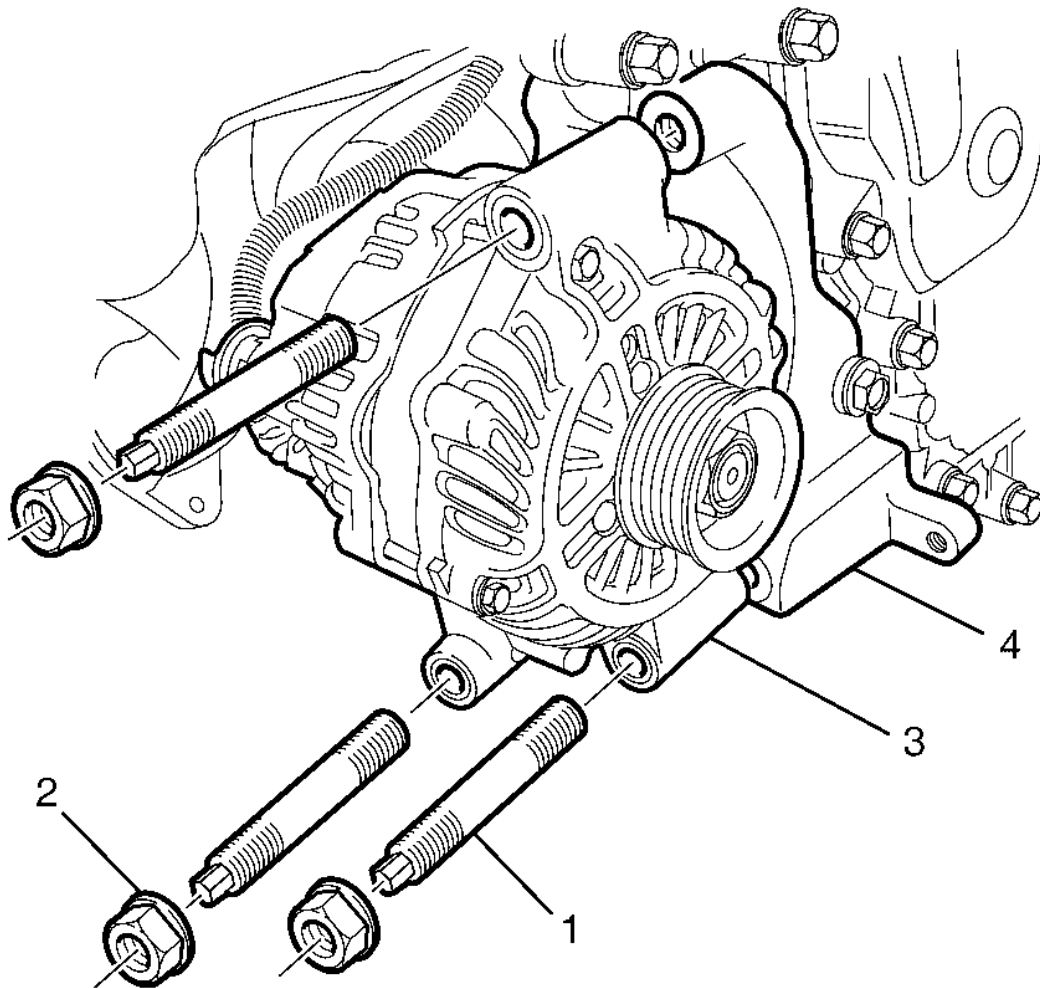


**Fig. 140: View Of Dished Washer, Drive Belt Idler Pulley, Accessory Drive Mounting Bracket & Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

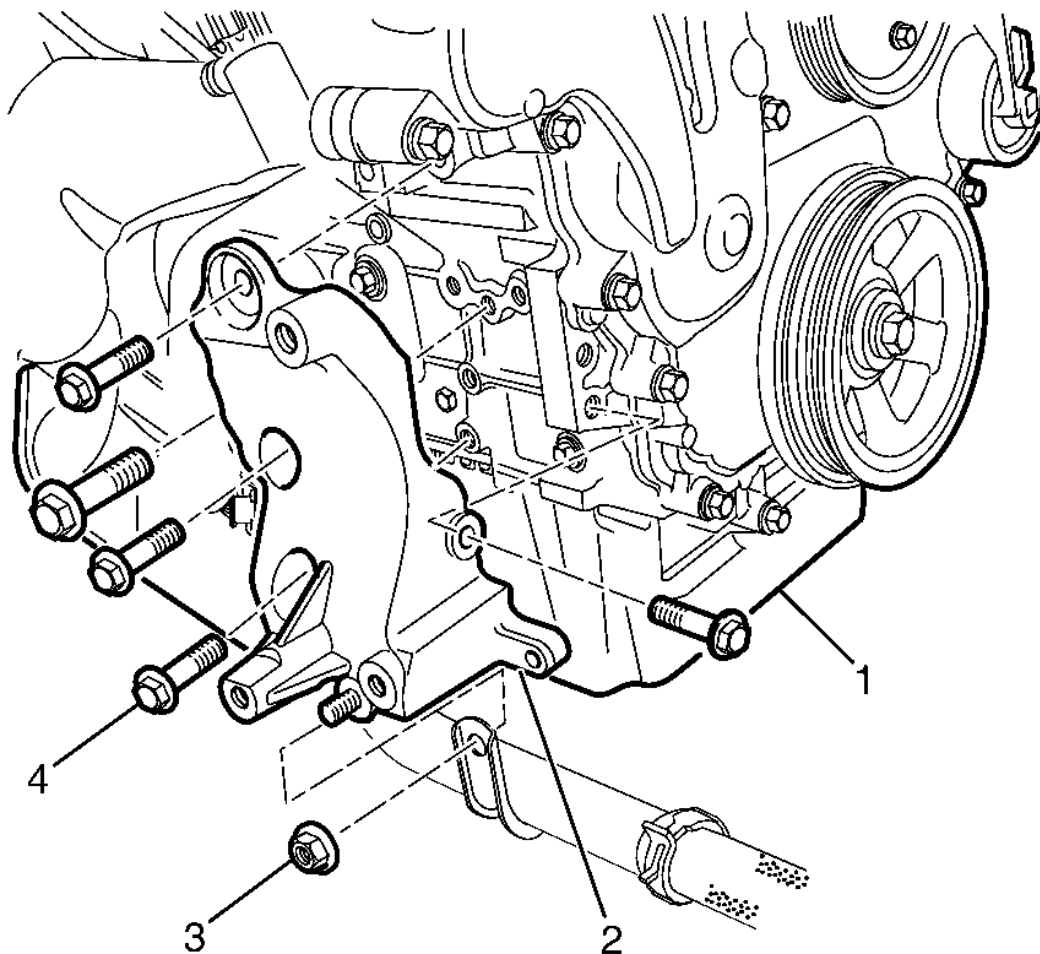
1. Remove the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).
2. Remove the dished washer (4) and drive belt idler pulley (3) from the accessory drive mounting bracket (2).

## GENERATOR REMOVAL



**Fig. 141: Identifying Alternator Bracket Retaining Nuts & Studs**  
Courtesy of GENERAL MOTORS CORP.

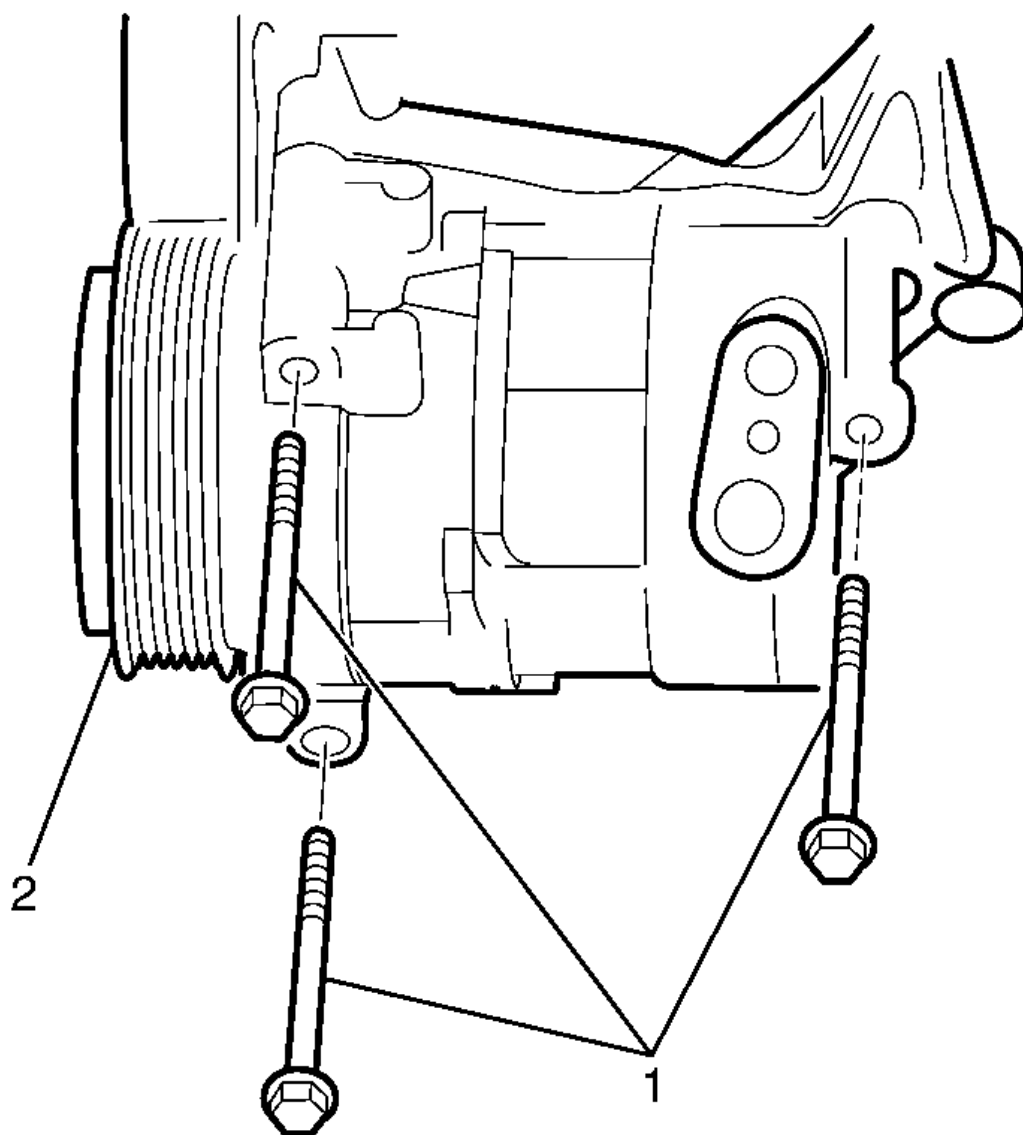
1. Remove the alternator to alternator bracket retaining nuts (2).
2. Remove the alternator to alternator bracket retaining studs (1).
3. Remove the alternator (3) from the alternator bracket (4).



**Fig. 142: Identifying Alternator Mounting Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the coolant inlet pipe to alternator mounting bracket retaining nut (3)
5. Remove the alternator mounting bracket to cylinder block retaining bolts (4).
6. Remove the alternator mounting bracket (2) from the cylinder block (1).

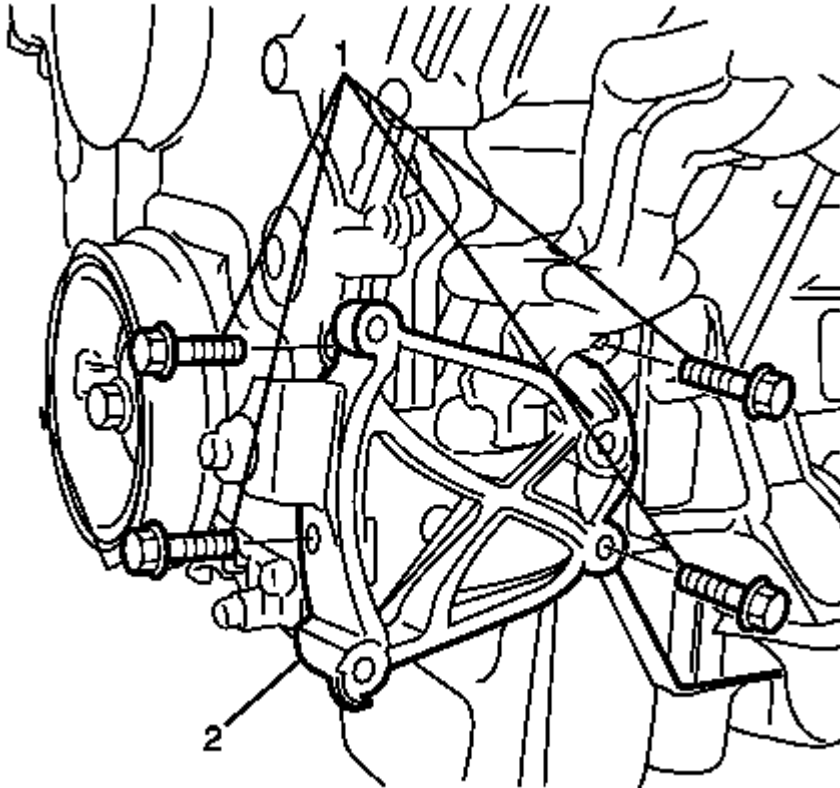
#### **AIR CONDITIONING (A/C) COMPRESSOR REMOVAL**



**Fig. 143: Identifying A/C Compressor To A/C Compressor Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The compressor must be supported before removing the compressor to compressor mounting bracket retaining bolts (1).

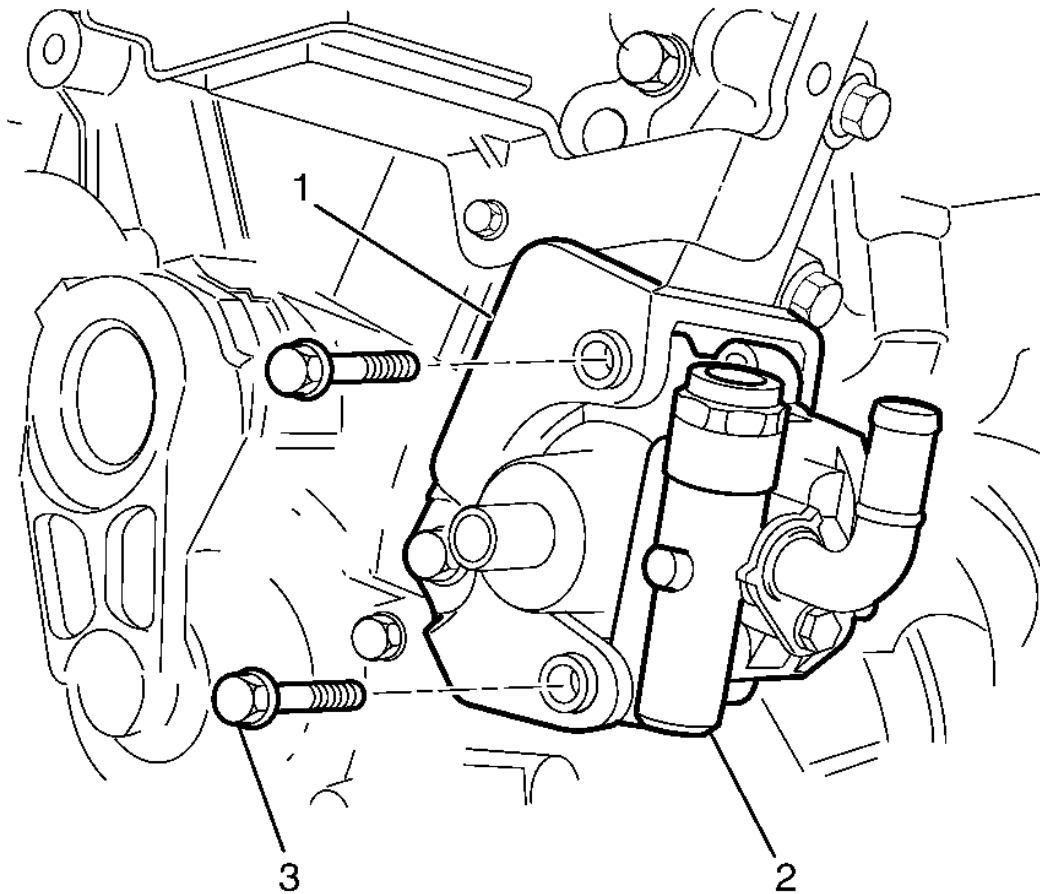
1. Remove the compressor to compressor mounting bracket retaining bolts (1).
2. Remove the compressor (2) by sliding forwards and upwards.



**Fig. 144: Identifying A/C Compressor Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the compressor mounting bracket to engine retaining bolts (1).
4. Remove the compressor mounting bracket (2).

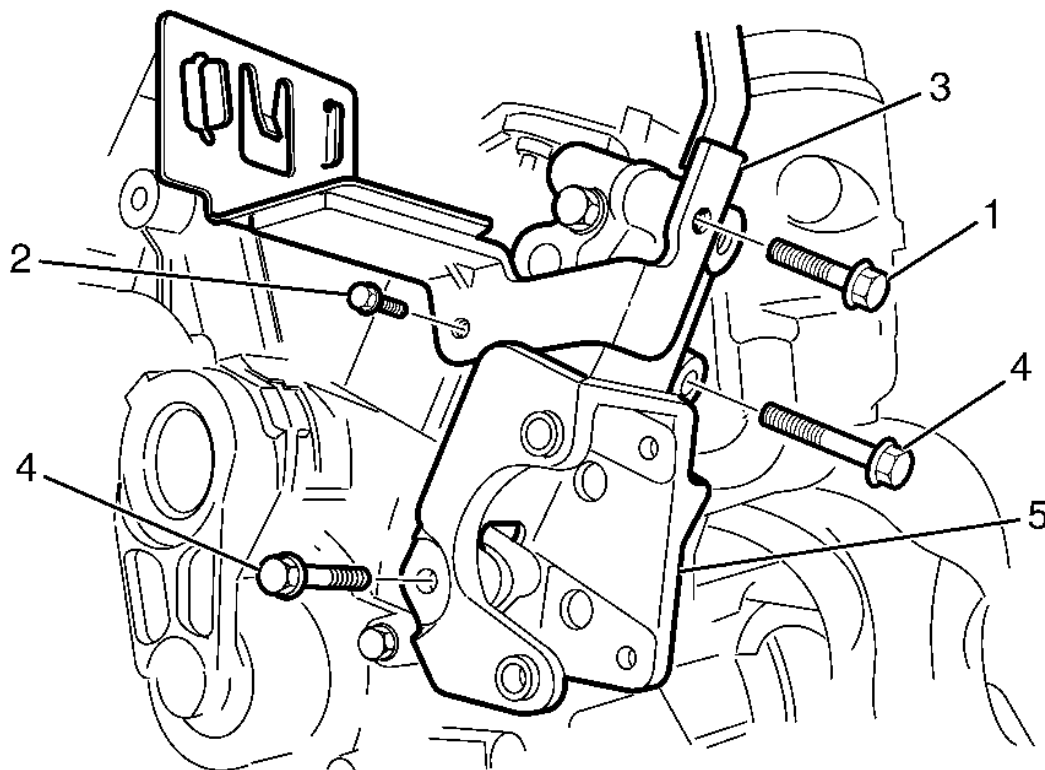
#### **POWER STEERING PUMP REMOVAL**



**Fig. 145: Identifying Power Steering Pump To Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the power steering pump to mounting bracket retaining bolts (3).
2. Remove the power steering pump (2) from the power steering pump mounting bracket (1).

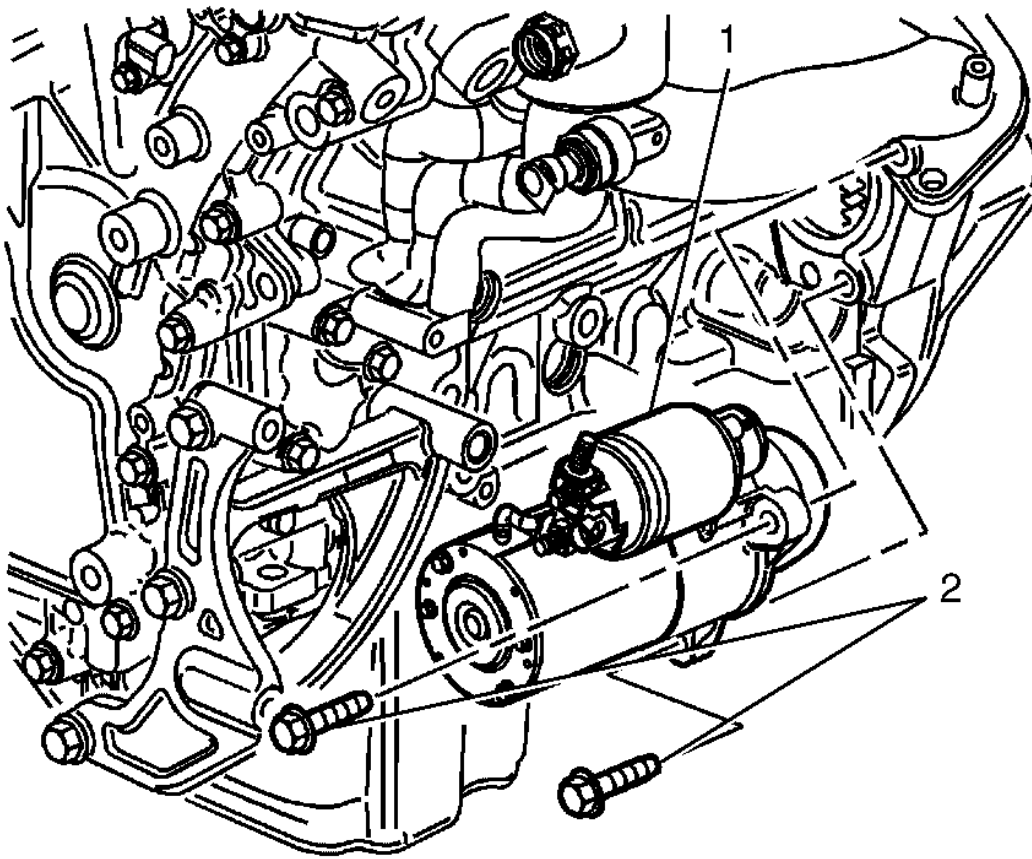




**Fig. 146: Identifying Power Steering Pump Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the power steering reservoir bracket to cylinder head retaining bolt (1).
4. Remove the power steering reservoir bracket to engine front cover retaining bolt (2).
5. Remove the power steering reservoir bracket (3).
6. Remove the power steering pump bracket to cylinder head retaining bolts (4).
7. Remove the power steering pump bracket (5).

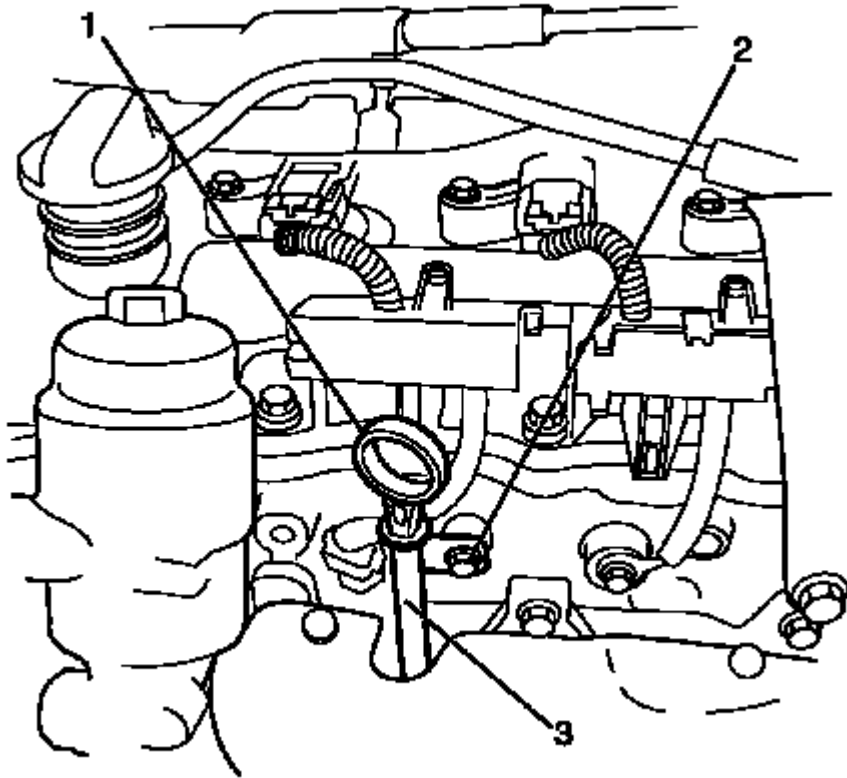
## STARTER REMOVAL



**Fig. 147: Identifying Starter Motor To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

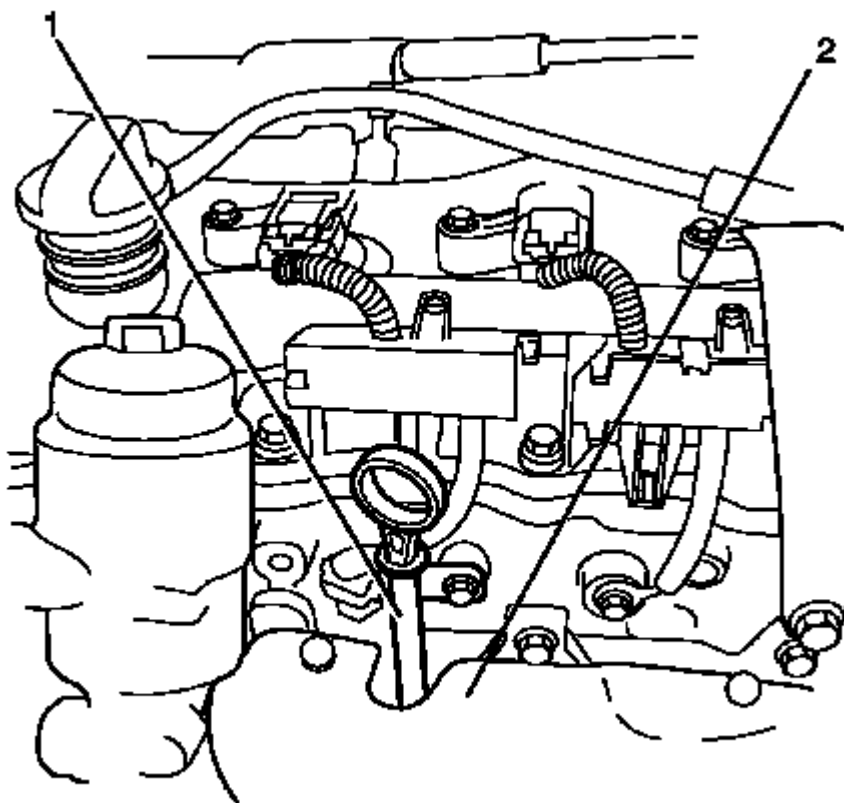
1. Remove the starter motor to cylinder block retaining bolts (2).
2. Remove the starter motor (1).

#### **OIL LEVEL INDICATOR AND TUBE REMOVAL**



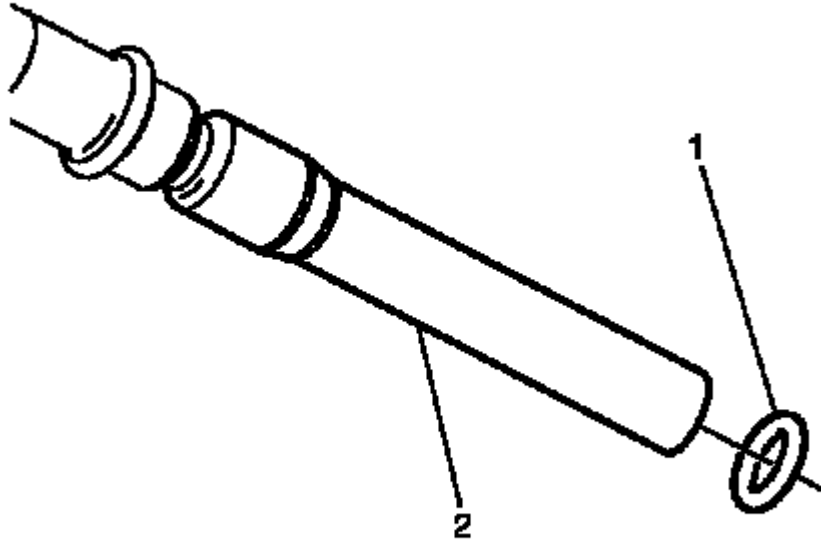
**Fig. 148: Identifying Oil Level Indicator Tube Bracket To Cylinder Head Retaining Bolt**  
 Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator tube bracket to cylinder head retaining bolt (2).
2. Remove the oil level indicator (1) from the oil level indicator tube (3).
3. Remove the knock sensor. Refer to **Knock Sensor Replacement - Bank 2** .



**Fig. 149: Identifying Oil Level Indicator Tube & Exhaust Manifold**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level indicator tube (1) up through the exhaust manifold (2).

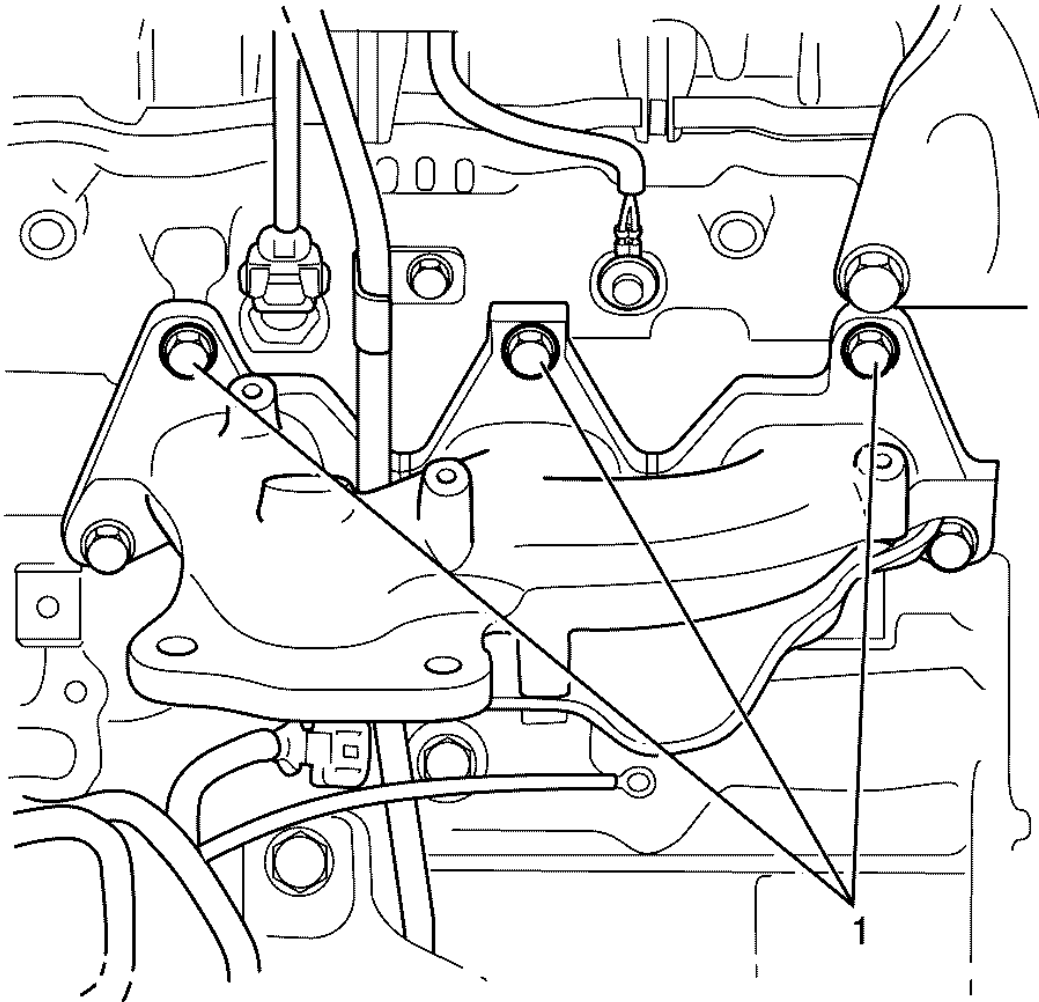


**Fig. 150: Identifying Oil Level Indicator Tube & O-Ring**  
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the O-ring (1) from the oil level indicator tube (2) if damaged.

## **EXHAUST MANIFOLD REMOVAL - LEFT SIDE**

### **Removal Procedure**

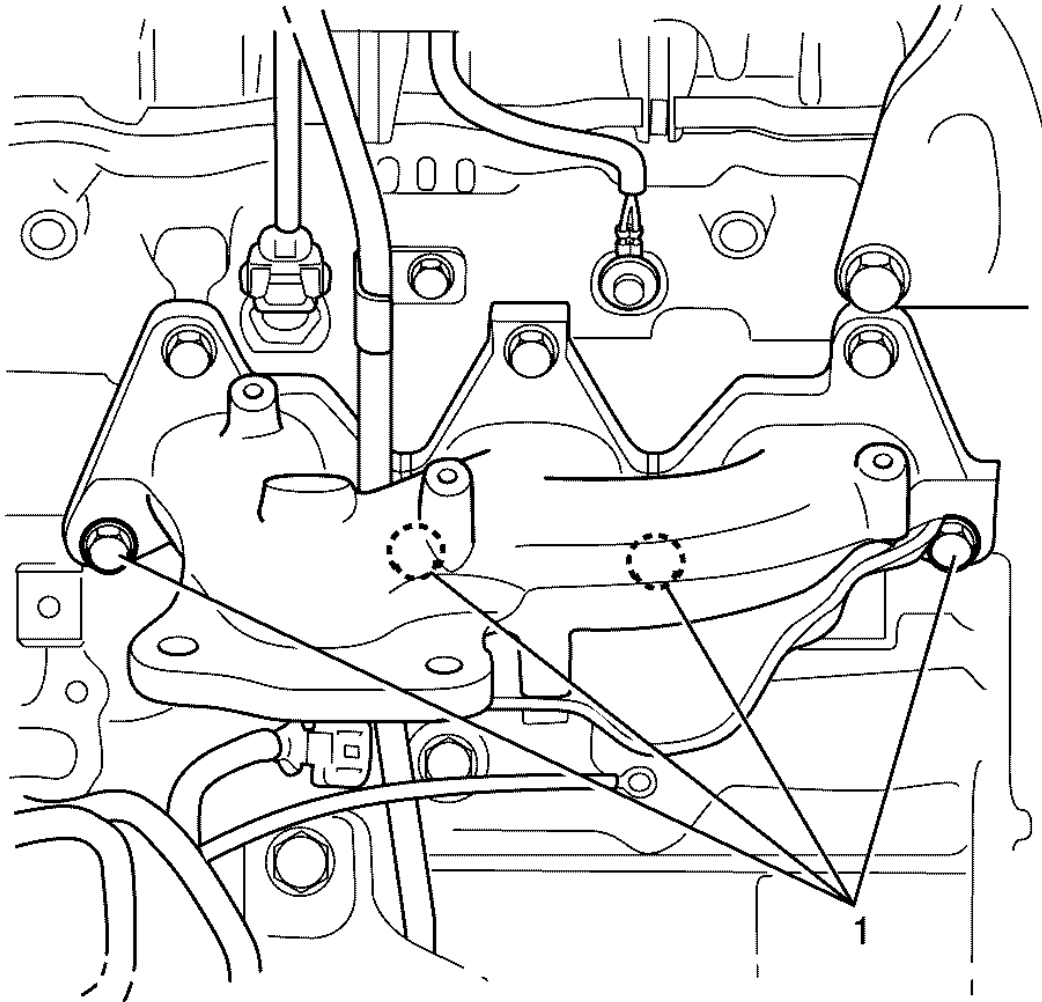


**Fig. 151: Upper Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

1. Remove the exhaust manifold to cylinder head retaining bolts (1).

Discard the bolts.

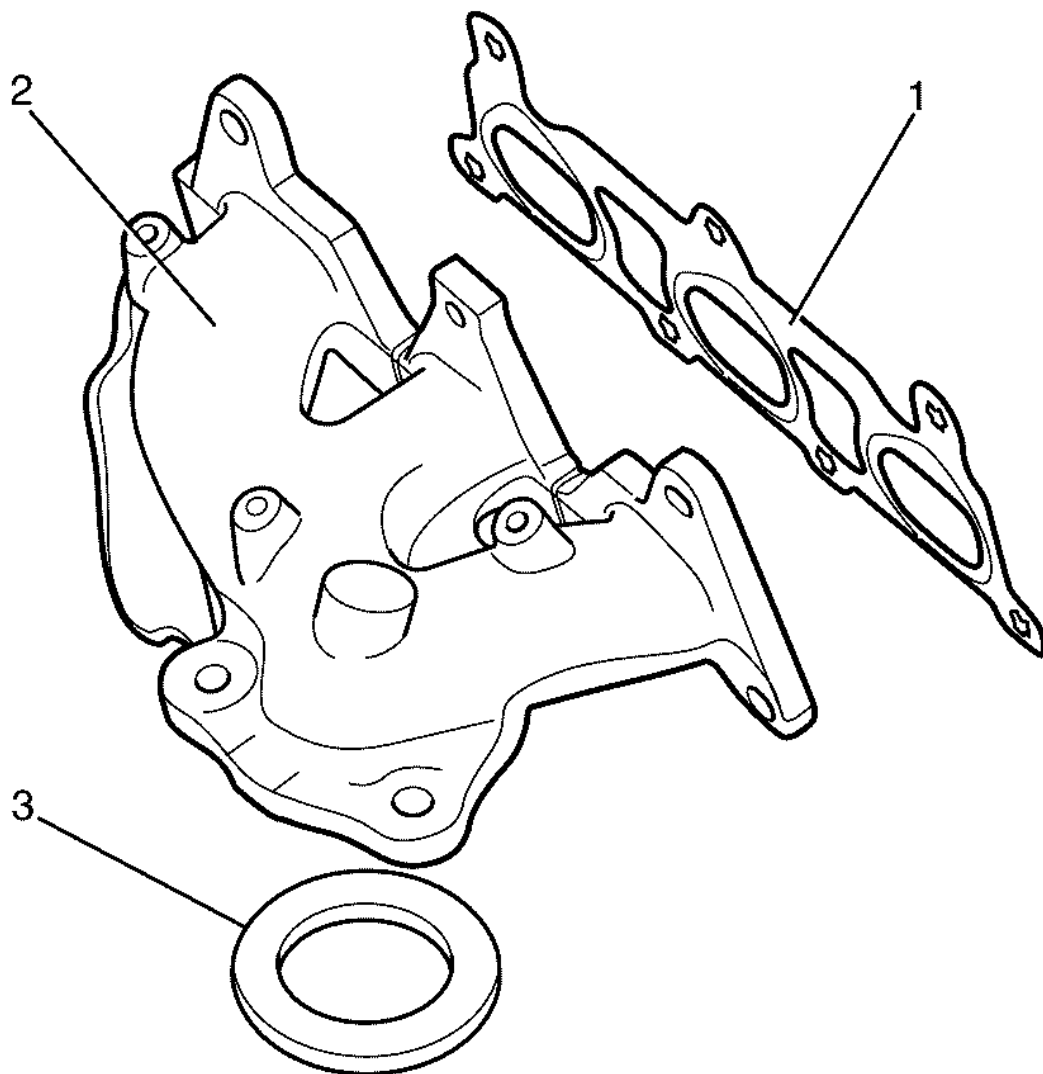


**Fig. 152: Lower Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

2. Remove the exhaust manifold to cylinder head retaining bolts (1).

Discard the bolts.



**Fig. 153: Identifying Sealing Ring & Exhaust Manifold With Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure that the surrounding wiring harness and electrical connectors are not damaged when removing the exhaust manifold (2).

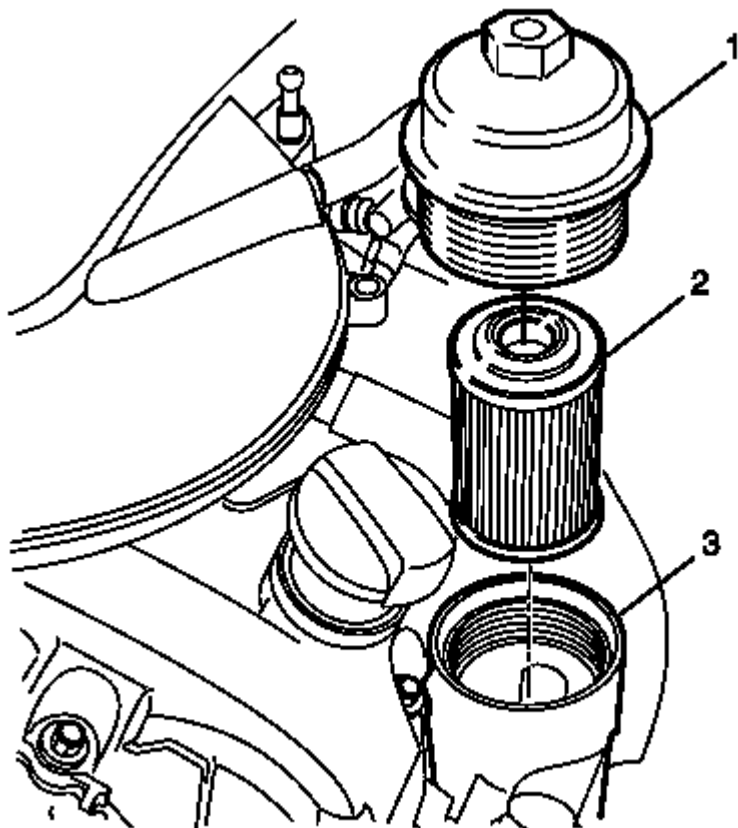
**NOTE:** The exhaust manifold gasket (1) and sealing ring (3) are single use parts. They must be discarded after removal.

3. Remove the exhaust manifold (2) from the engine assembly.
4. Separate the exhaust manifold (2) from the exhaust manifold gasket (1) and sealing ring (3).



5. Discard the exhaust manifold gasket (1) and sealing ring (3).

## OIL FILTER ADAPTER REMOVAL



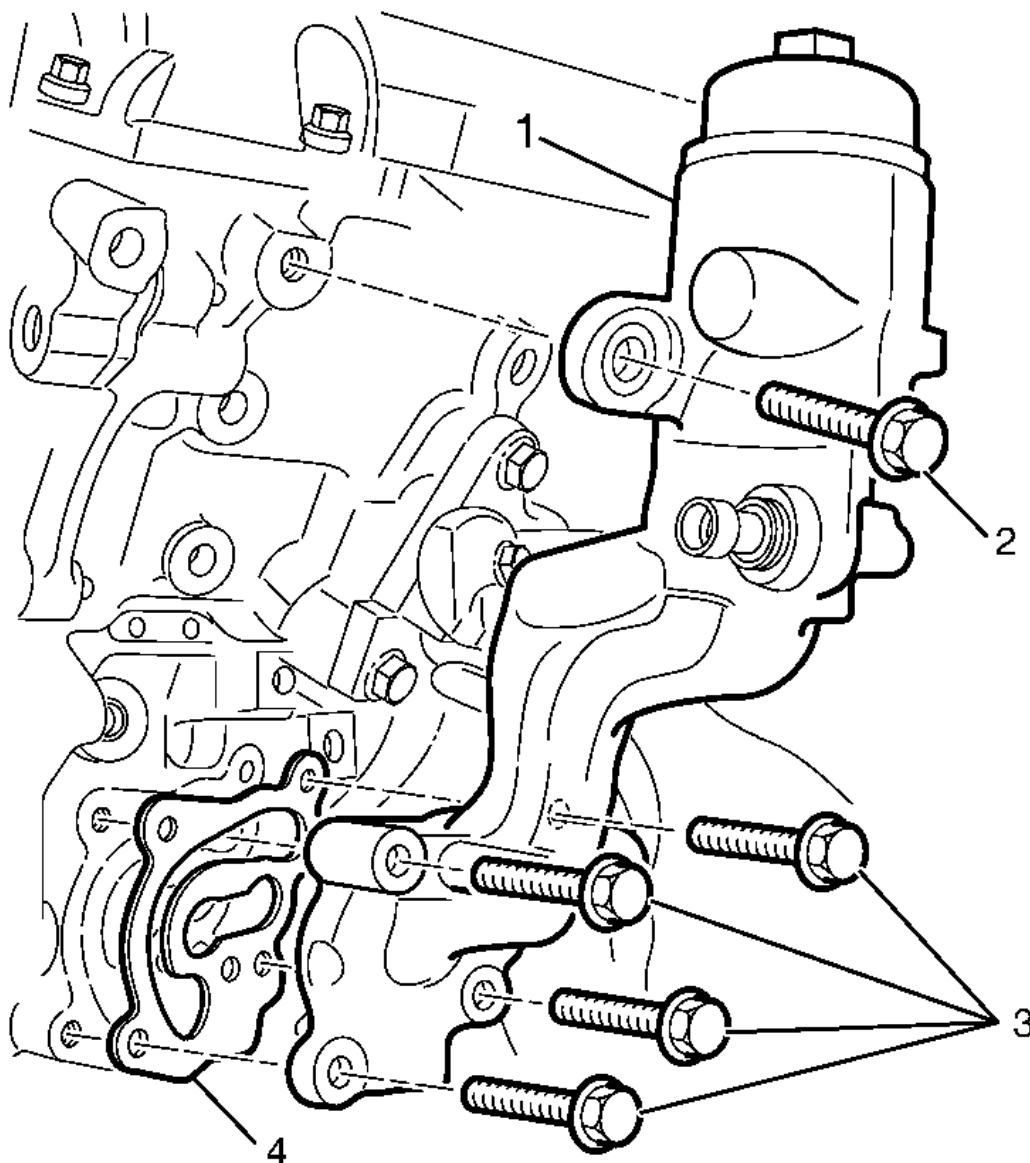
**Fig. 154: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Use a six-point socket to remove the oil filter cap (1).

1. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).
2. Remove the oil filter cartridge (2).

Discard the oil filter cartridge (2).

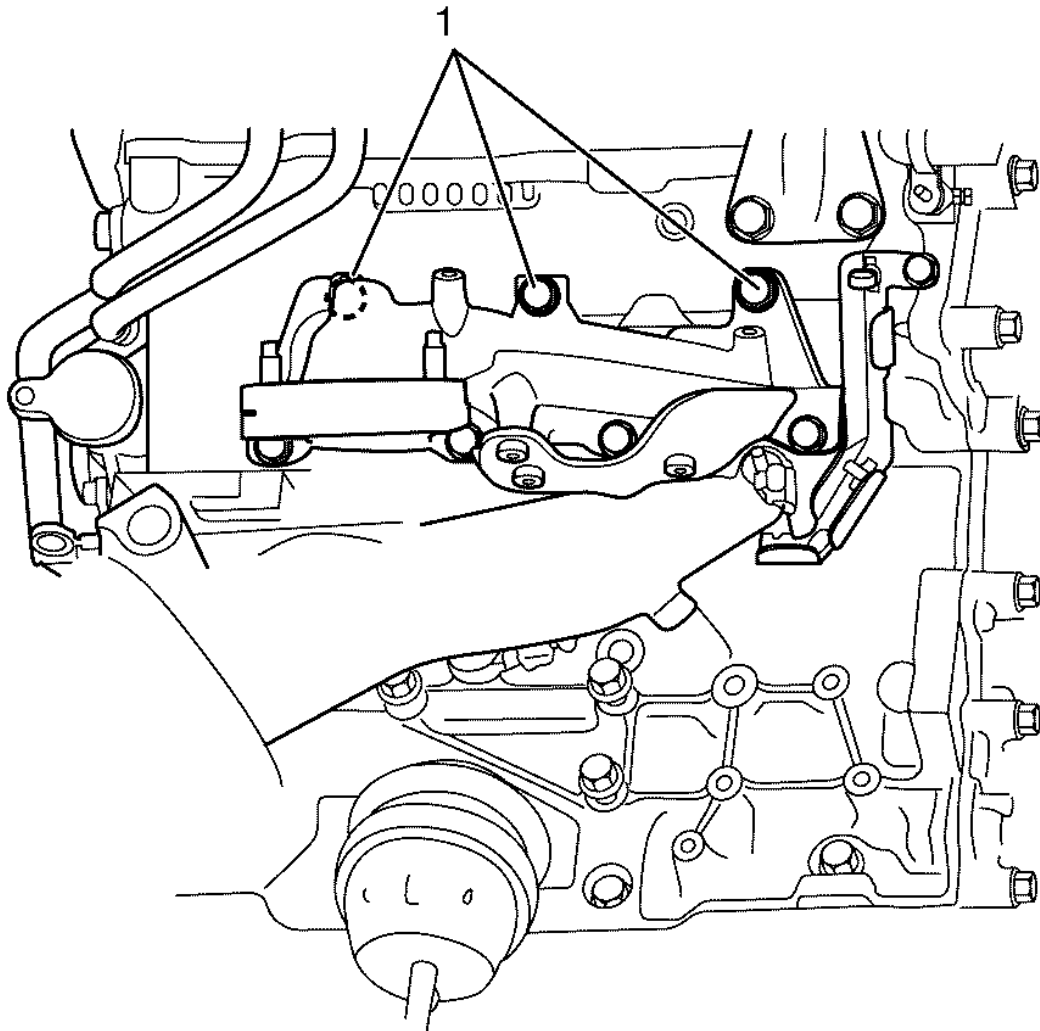
3. Re-install the oil filter cap.



**Fig. 155: Identifying M8 & M10 Oil Filter Adapter Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the M8 oil filter adapter to cylinder block retaining bolts (3).
5. Remove the M10 oil filter adapter to cylinder head retaining bolt (2).
6. Remove the oil filter adapter (1).
7. Remove and discard the oil filter adapter gasket (4).

#### EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

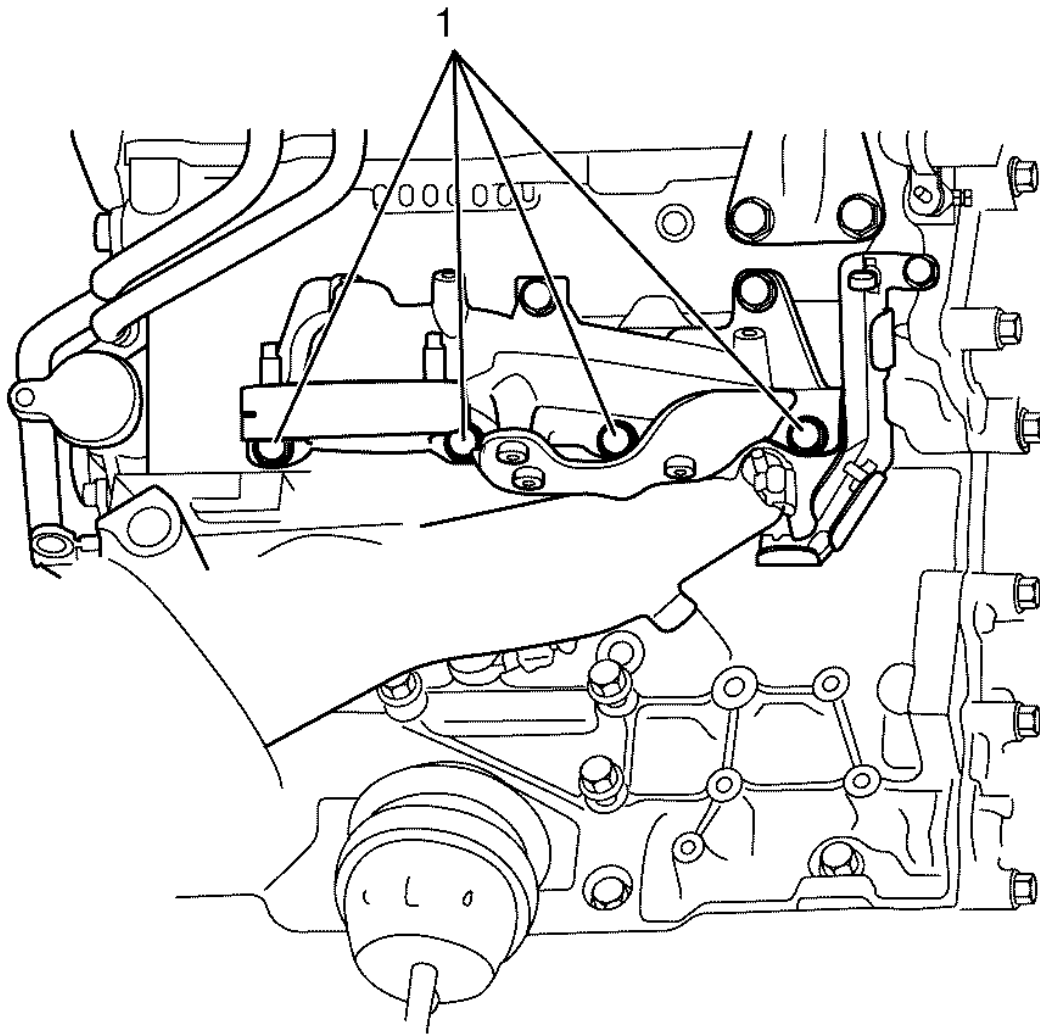
**Removal Procedure**

**Fig. 156: Upper Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

1. Remove the exhaust manifold to cylinder head retaining bolts (1).

Discard the bolts.

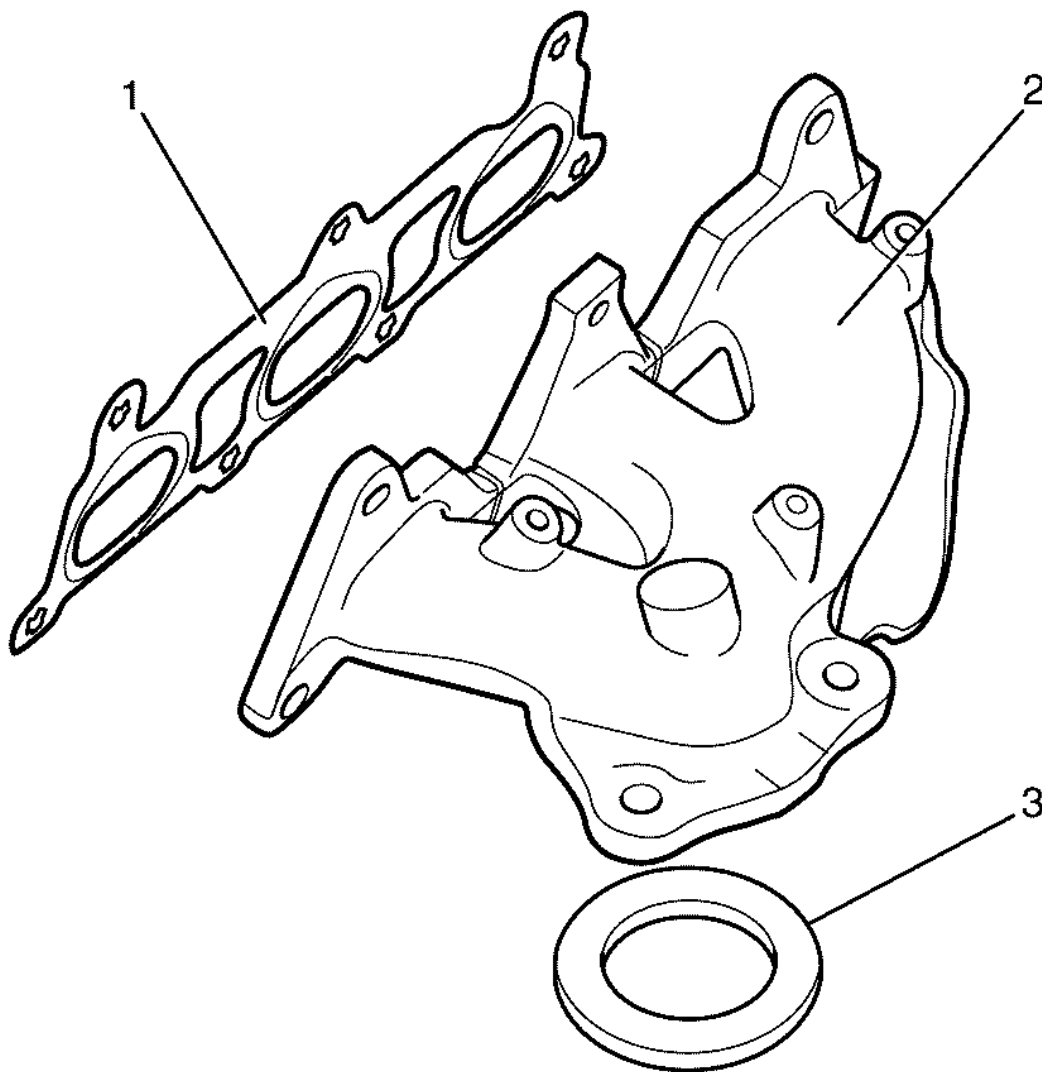


**Fig. 157: Lower Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

2. Remove the exhaust manifold to cylinder head retaining bolts (1).

Discard the bolts.



**Fig. 158: Identifying Sealing Ring, Exhaust Manifold & Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure that the surrounding wiring harness and electrical connectors are not damaged when removing the exhaust manifold (2).

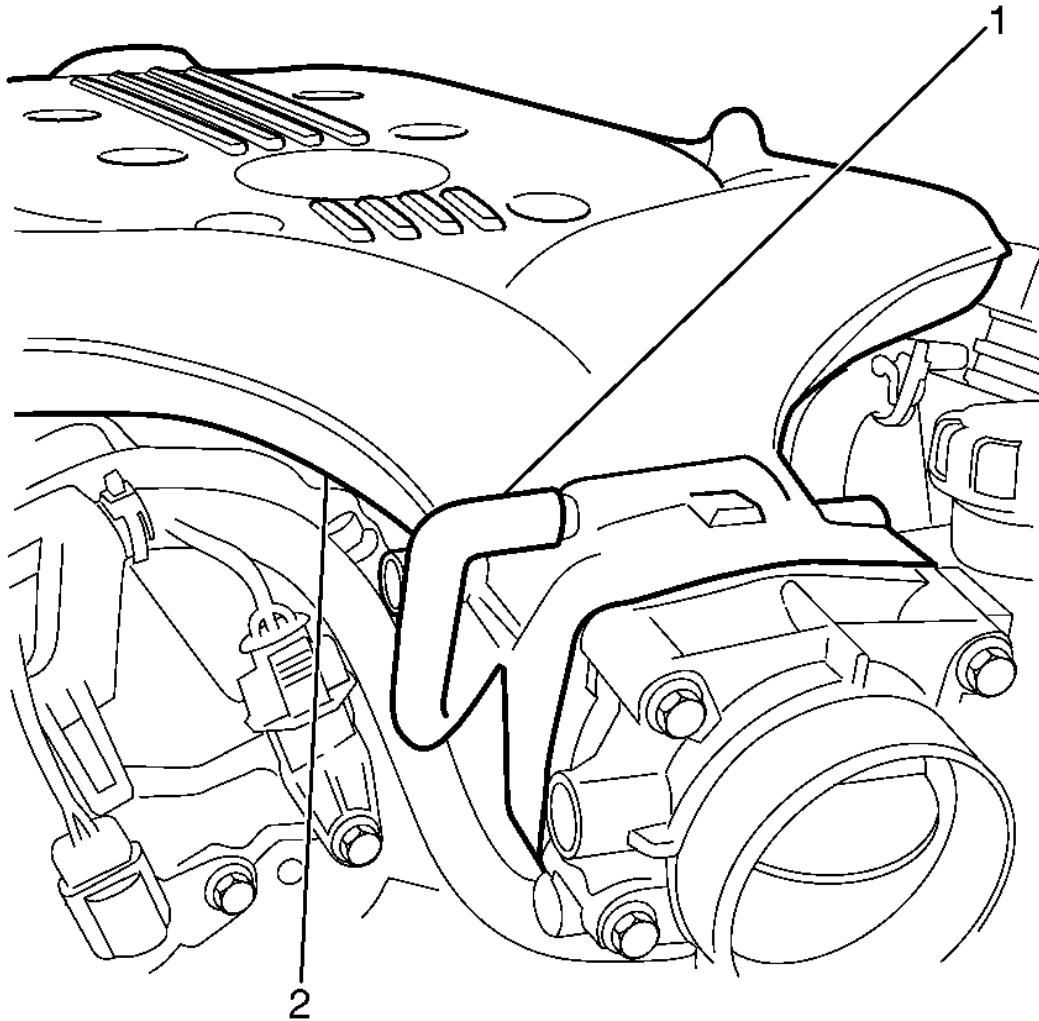
**NOTE:** The exhaust manifold gasket (1) and sealing ring (3) are single use parts. They must be discarded after removal.

3. Remove the exhaust manifold (2) from the engine assembly.
4. Separate the exhaust manifold (2) from the exhaust manifold gasket (1) and sealing ring (3).

5. Discard the exhaust manifold gasket (1) and sealing ring (3).

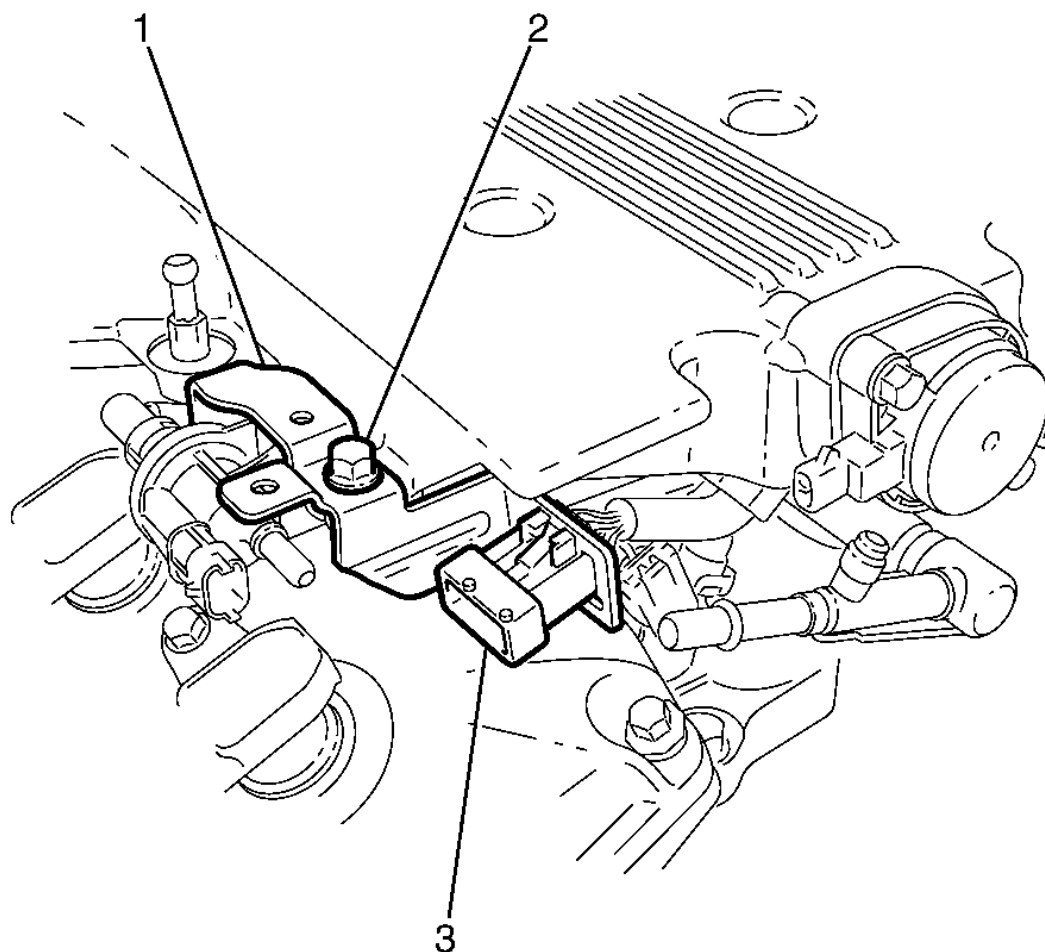
## INTAKE MANIFOLD REMOVAL

1. Remove the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement** .



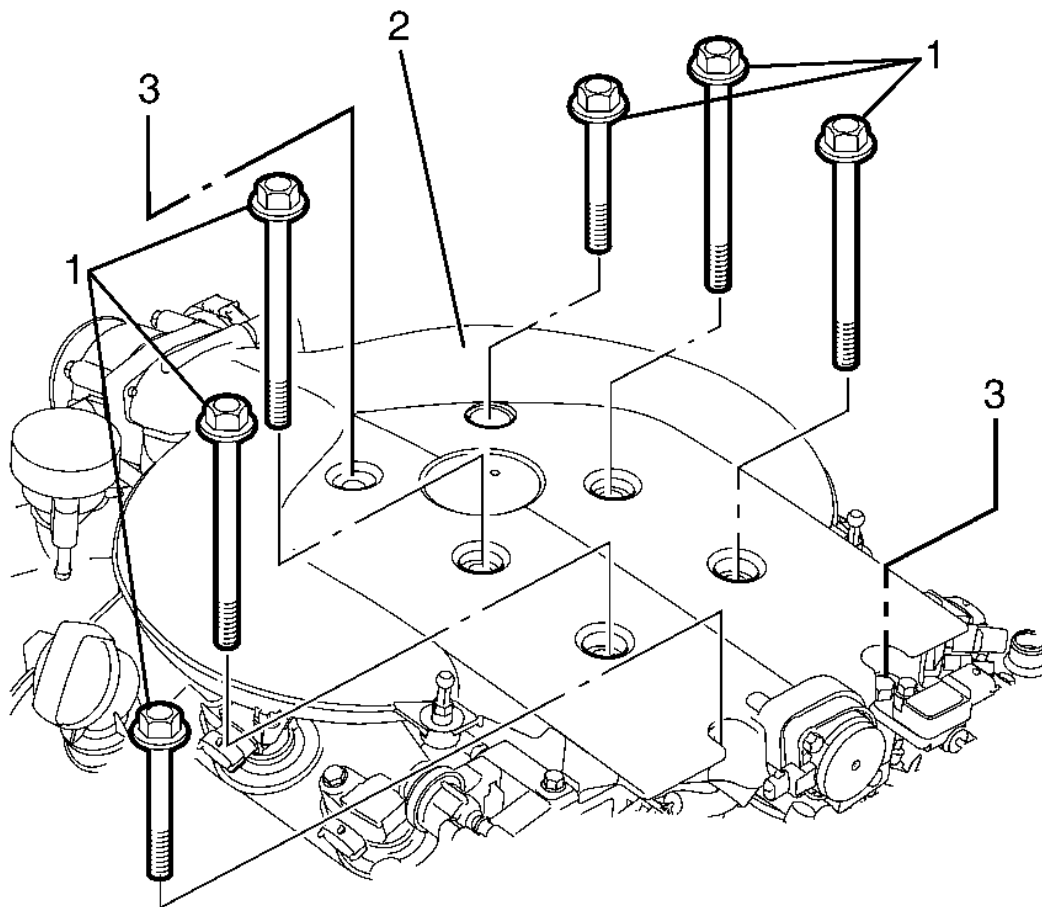
**Fig. 159: View Of EVAP Hose & Upper Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the EVAP hose (1) from the intake manifold (2).



**Fig. 160: Identifying Fuel Injector Harness Electrical Connector & EVAP Valve Mounting Bracket**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2).
4. Detach the fuel injector harness electrical connector (3) from the fuel injector harness electrical connector/EVAP valve mounting bracket (1).
5. Remove the fuel injector harness electrical connector/EVAP valve mounting bracket (1).



**Fig. 161: Identifying Throttle Body, Intake Manifold & Bolts**  
 Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

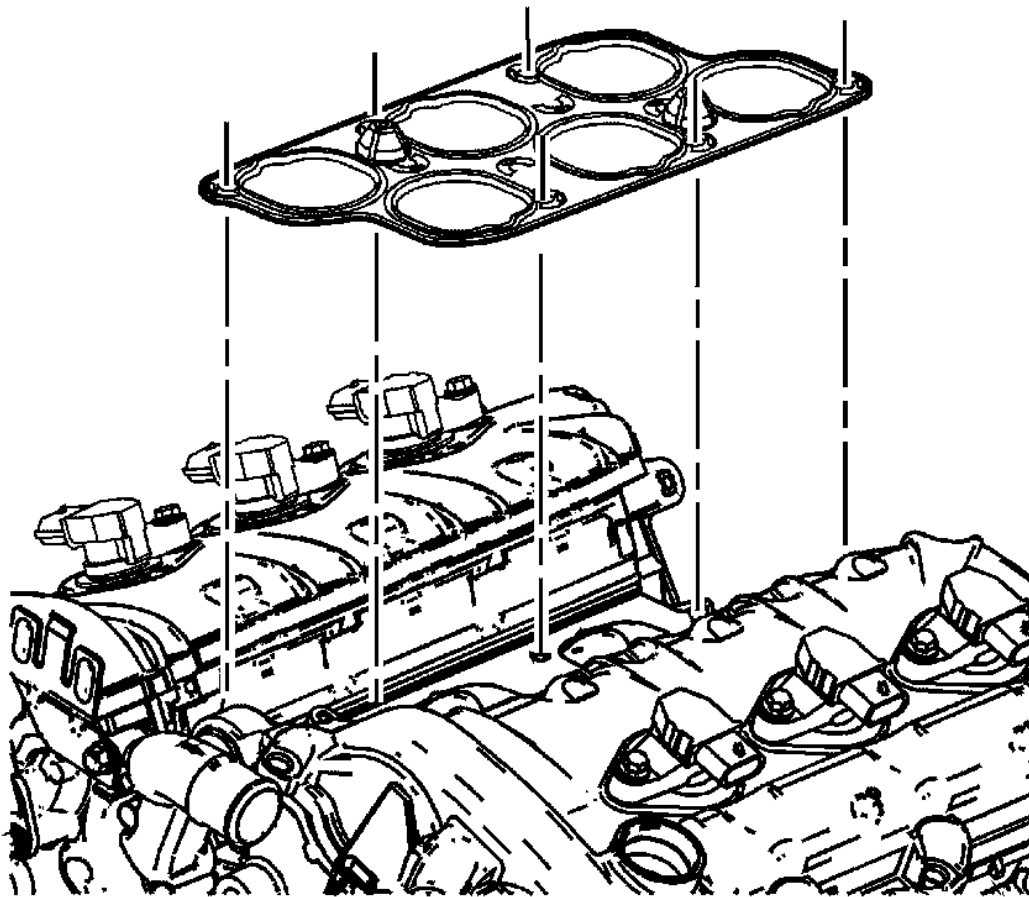
- **DO NOT** remove the upper intake manifold to lower intake manifold retaining bolts.
- **DO NOT** kink or damage the fuel pipe.

6. Remove the intake manifold bolts (1).
7. Remove the intake manifold (2) and the throttle body (3) as an assembly.

**IMPORTANT:** The cylinder heads and engine valley must be plugged with a clean lint free cloth to prevent foreign matter entry into the engine.

8. Plug the cylinder heads and engine valley with a clean lint free cloth.

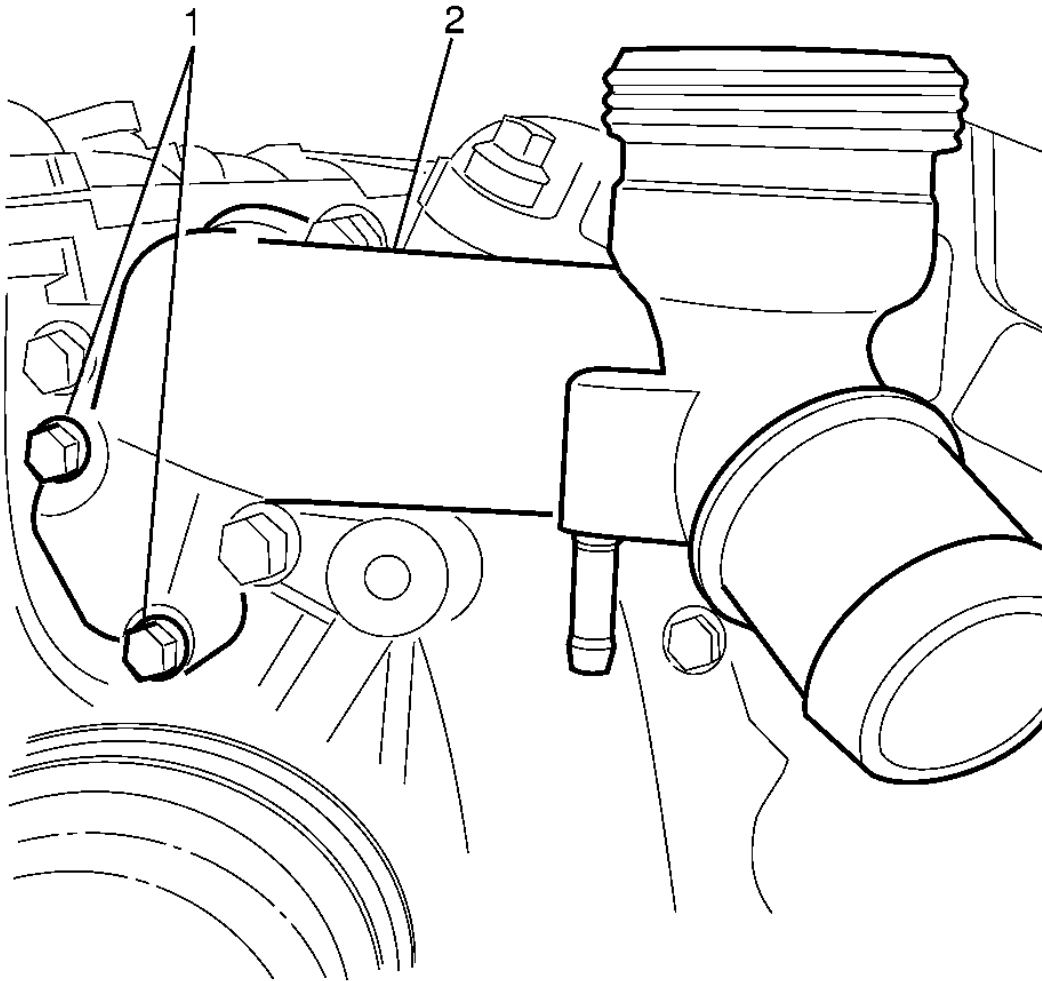




**Fig. 162: View Of Lower Intake Manifold Gasket**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the lower intake manifold gasket.

## **WATER OUTLET REMOVAL**



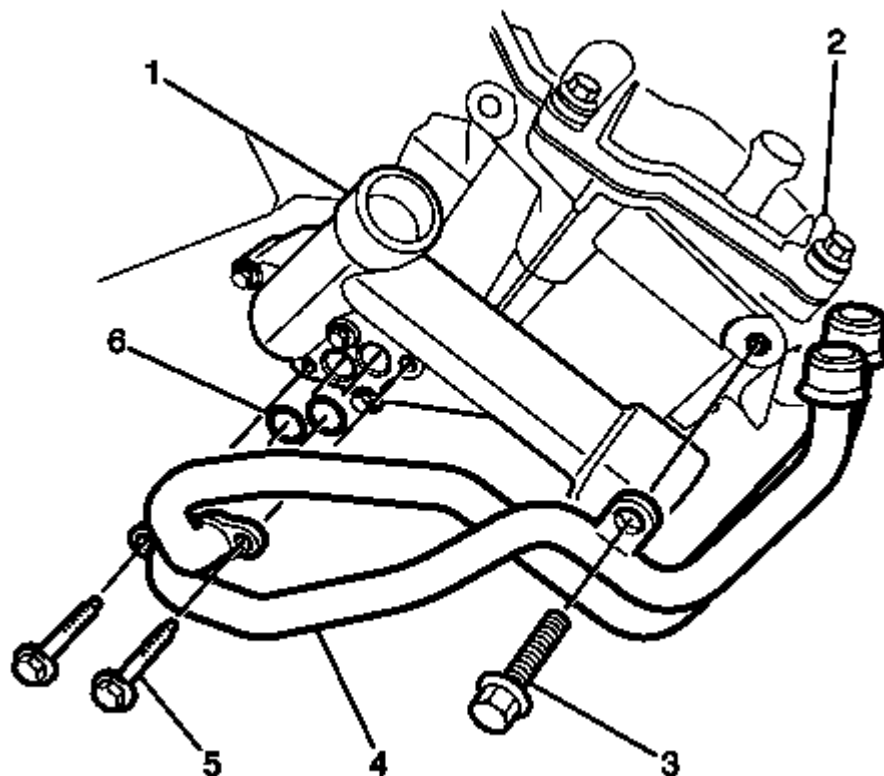
**Fig. 163: Identifying Coolant Outlet Housing To Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant outlet housing to intake manifold retaining bolts (1).

**IMPORTANT:** Use of a soft hammer will aid in the removal of the coolant outlet housing.

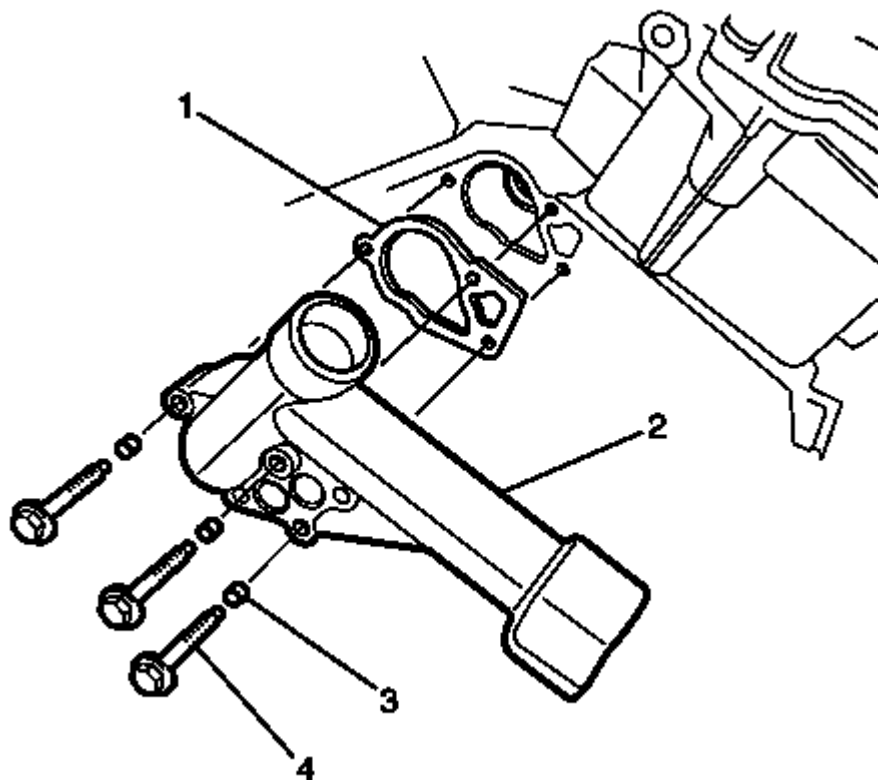
2. Remove the coolant outlet housing (2).
3. Remove the rubber O-ring and seal.

#### ENGINE COOLANT THERMOSTAT HOUSING REMOVAL



**Fig. 164: Identifying Heater Hose Assembly To Right Bank Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater hose assembly to right bank cylinder head retaining bolt (3).
2. Remove the heater hose assembly to thermostat housing retaining bolts (5).
3. Remove the heater hose assembly (4) from the right bank cylinder head (3) and thermostat housing (1).
4. Remove the O-ring seals (6).



**Fig. 165: Identifying Thermostat Housing To Cylinder Block Retaining Bolts & Rubber Grommets**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The thermostat housing has one longer bolt which is located in the upper left of the housing.

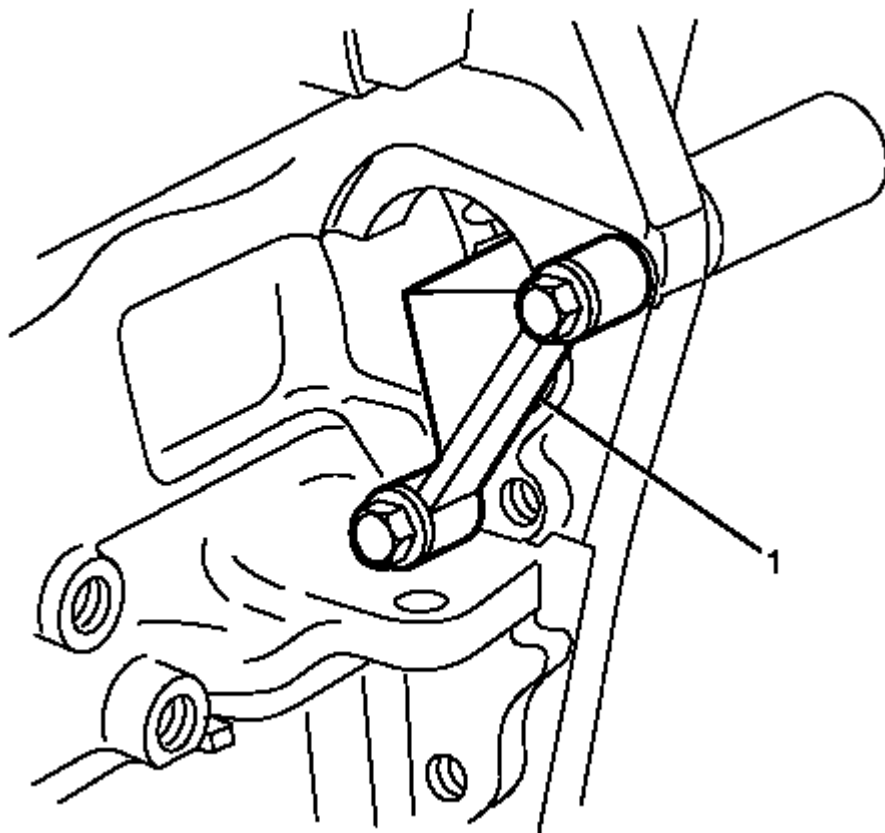
**IMPORTANT:** When replacing thermostat housing always renew the block gasket (1).

5. Remove thermostat housing to cylinder block retaining bolts (4) and rubber grommets (3).
6. Remove thermostat housing (2).
7. Remove thermostat housing gasket (1).

## CRANKSHAFT BALANCER REMOVAL

### Tools Required

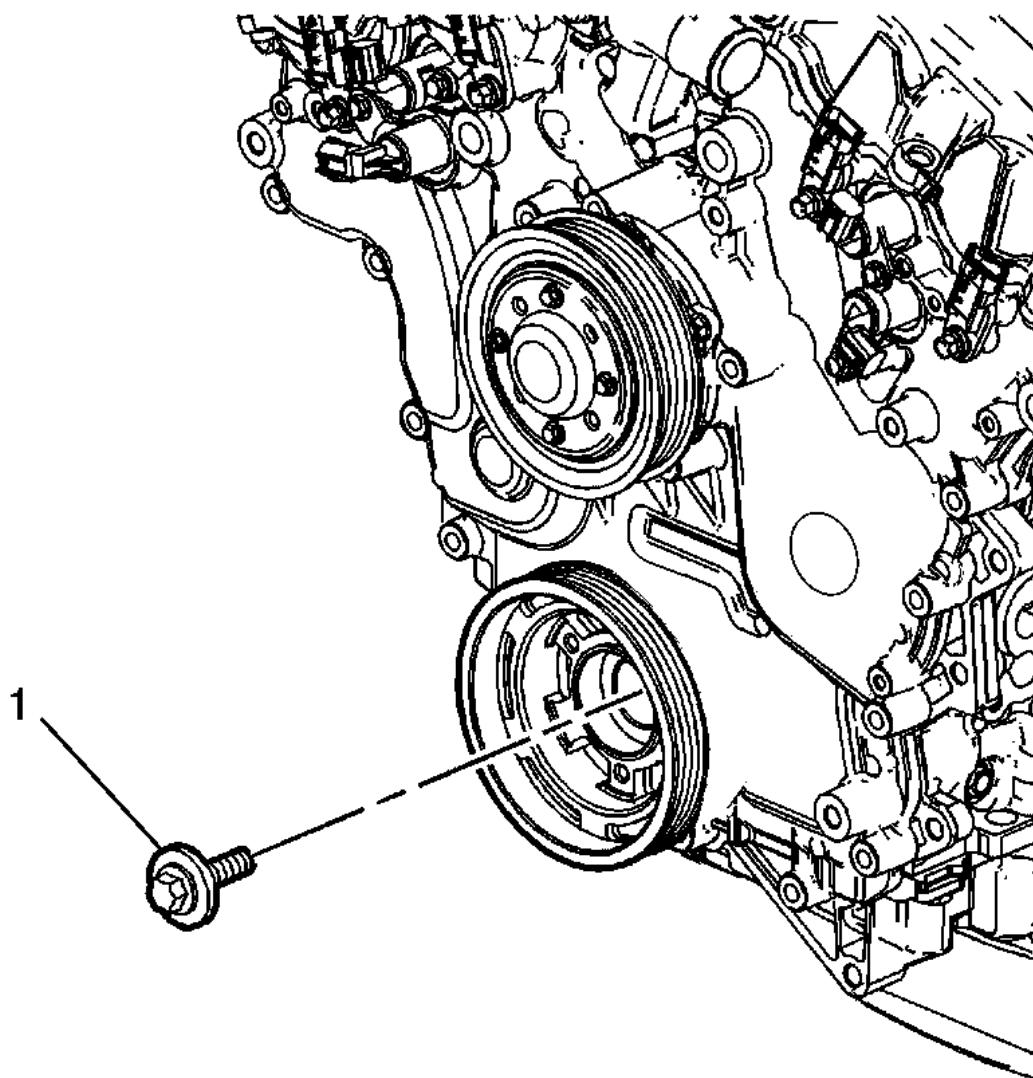
- **EN 46106** Flywheel Holding Tool. See **Special Tools** .
- **303-642** Harmonic Balancer Puller. See **Special Tools** .



**Fig. 166: View Of EN 46106**

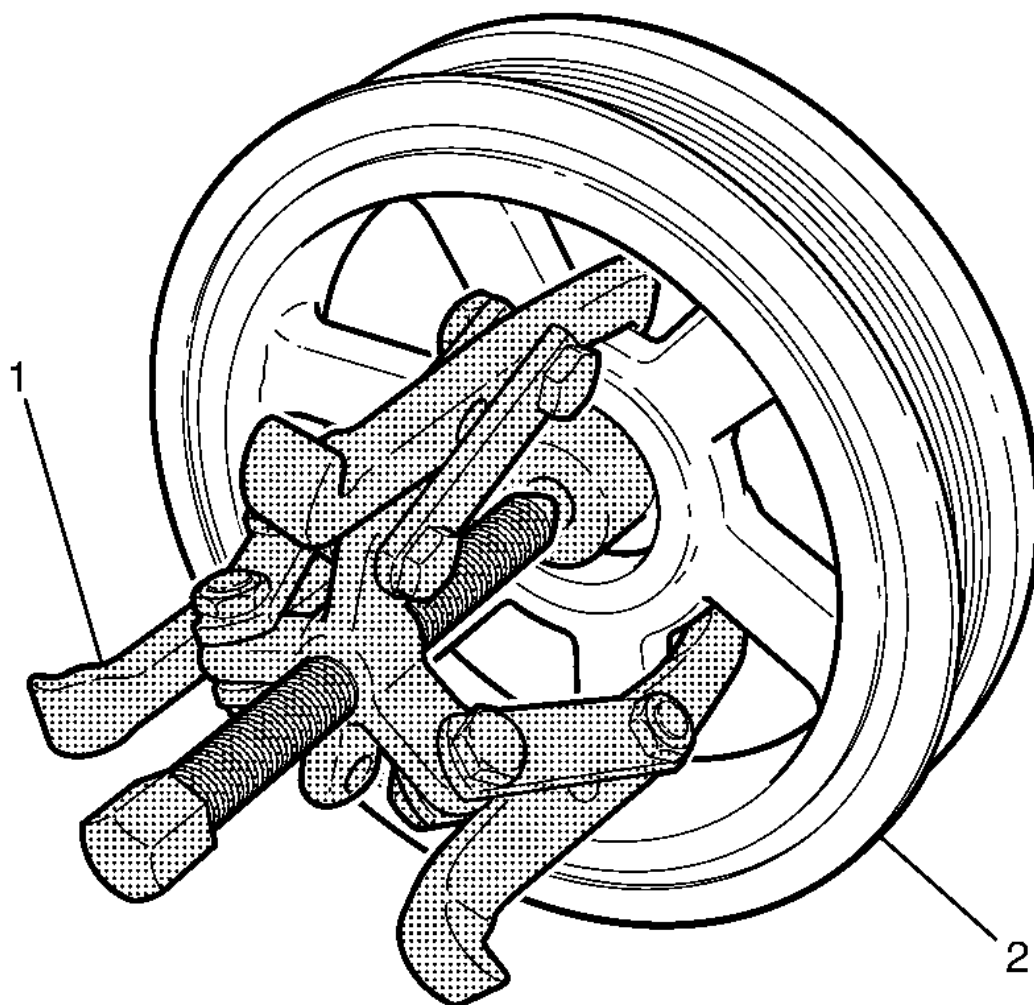
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46106** (1) through the starter mounting hole. See **Special Tools** .



**Fig. 167: Identifying Crankshaft Balancer To Crankshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer to crankshaft retaining bolt (1).



**Fig. 168: View Of 303-642 & Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

3. Install the 303-642 (1). See Special Tools .

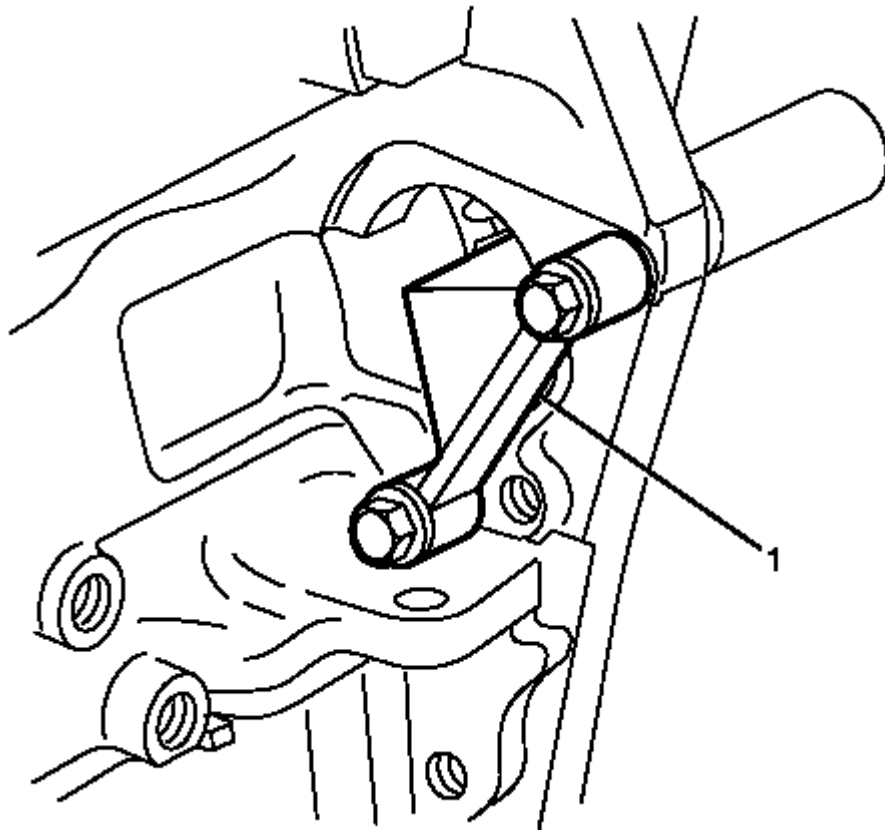
**IMPORTANT:** Remove the crankshaft balancer off by tightening the center bolt on the 303-642 (1) until the crankshaft balancer (2) is removed from the crankshaft. See Special Tools .

4. Remove the crankshaft balancer (2).
5. Remove the 303-642 (1) from the crankshaft balancer. See Special Tools .

## ENGINE FLYWHEEL REMOVAL

**Tools Required**

**EN 46106** Flywheel Holding Tool. See **Special Tools** .

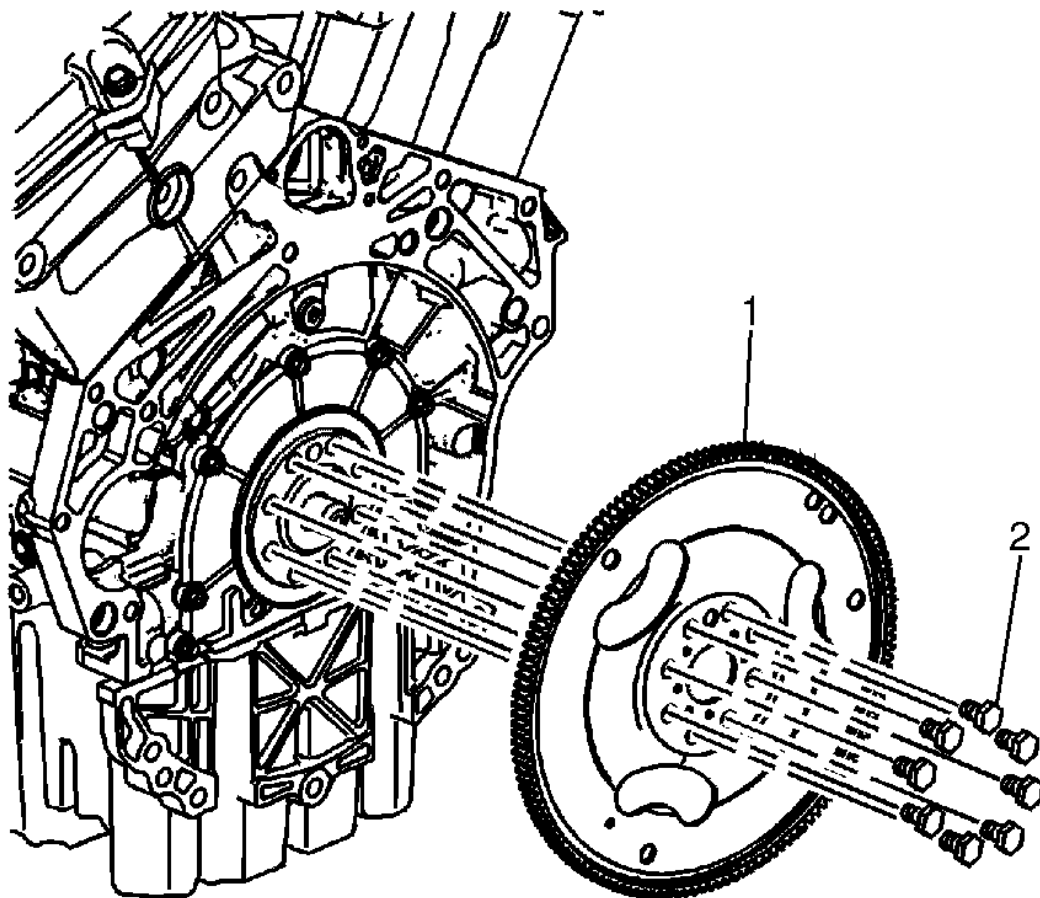


**Fig. 169: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46106** (1) through the starter mounting hole. See **Special Tools** .





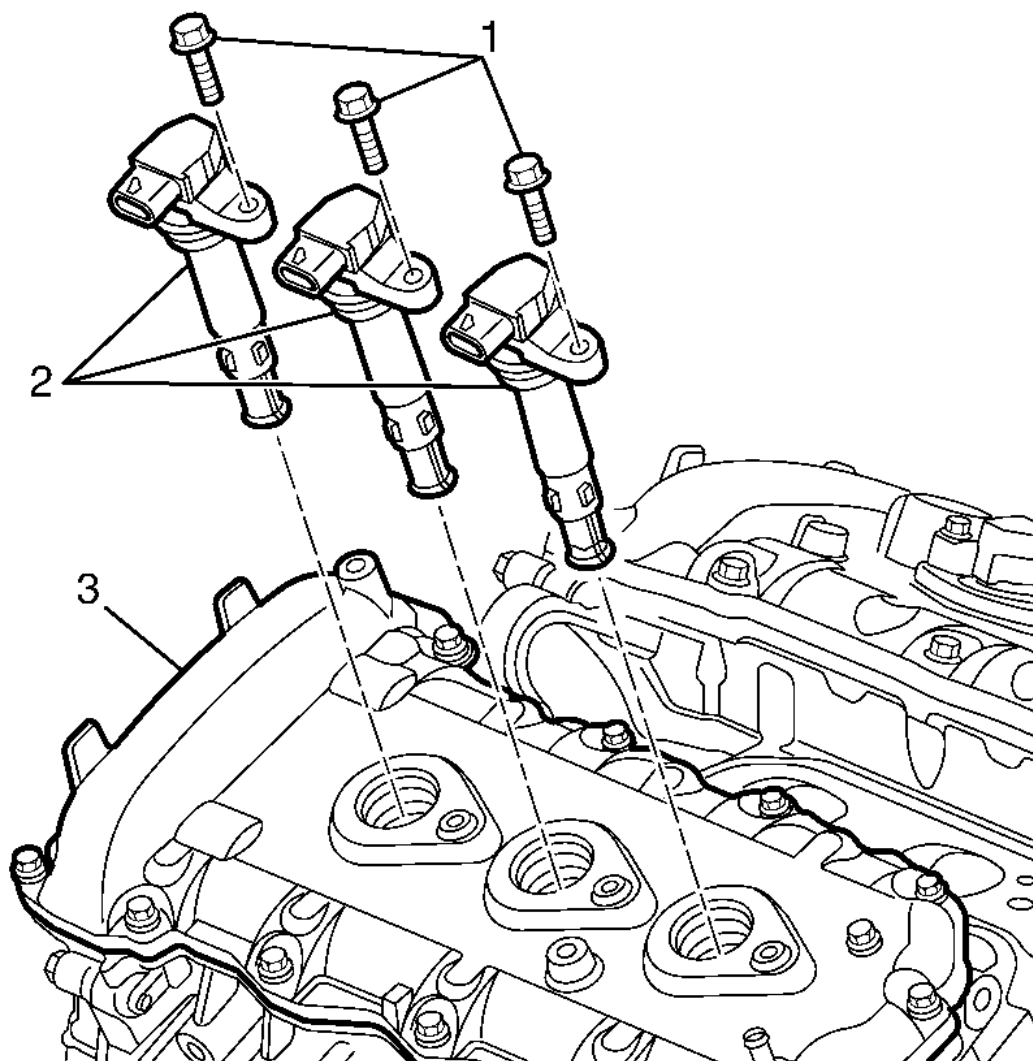
**Fig. 170: Identifying Automatic Transmission Flex Plate To Crankshaft Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Bolts with micro-encapsulated thread sealant must be discarded after removal.

**IMPORTANT:** Make sure all the bolt holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

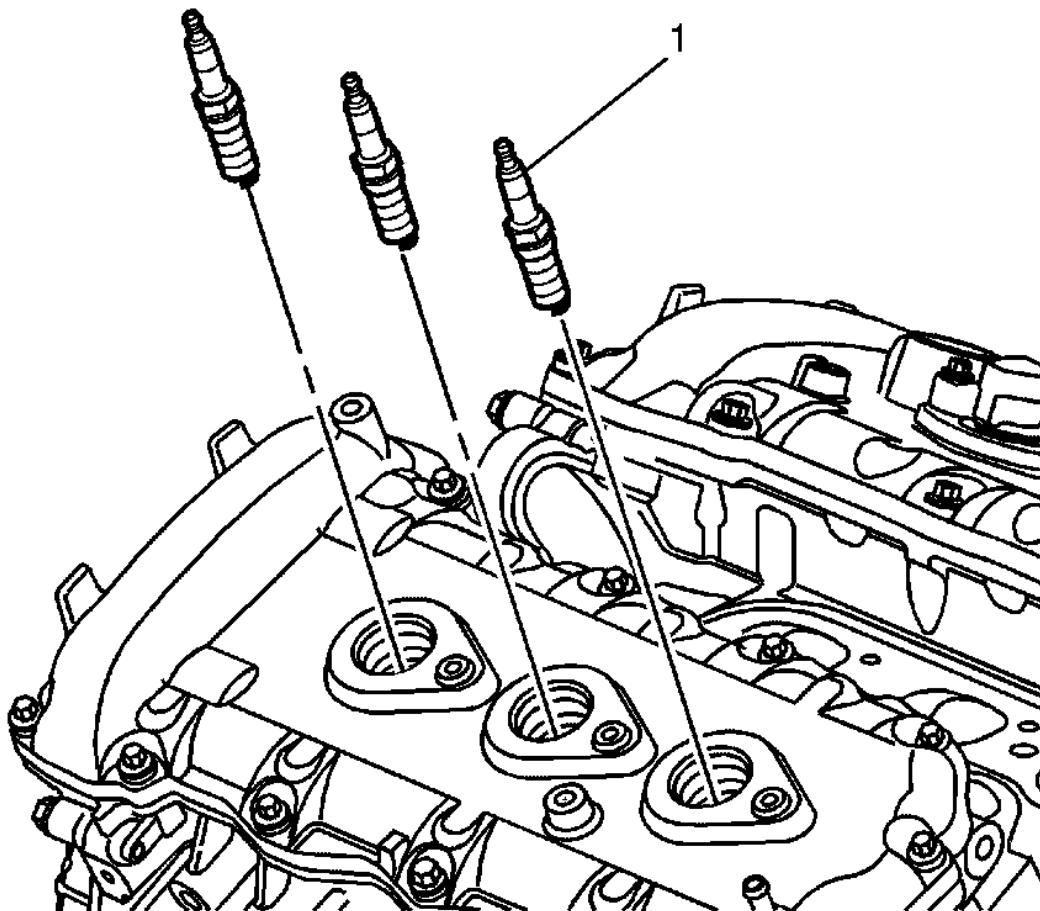
2. Remove the engine flywheel to crankshaft retaining bolts (1).
  - Discard the bolts.
  - Clean the bolt holes.
3. Remove the engine flywheel (2).

#### CAMSHAFT COVER REMOVAL - LEFT SIDE



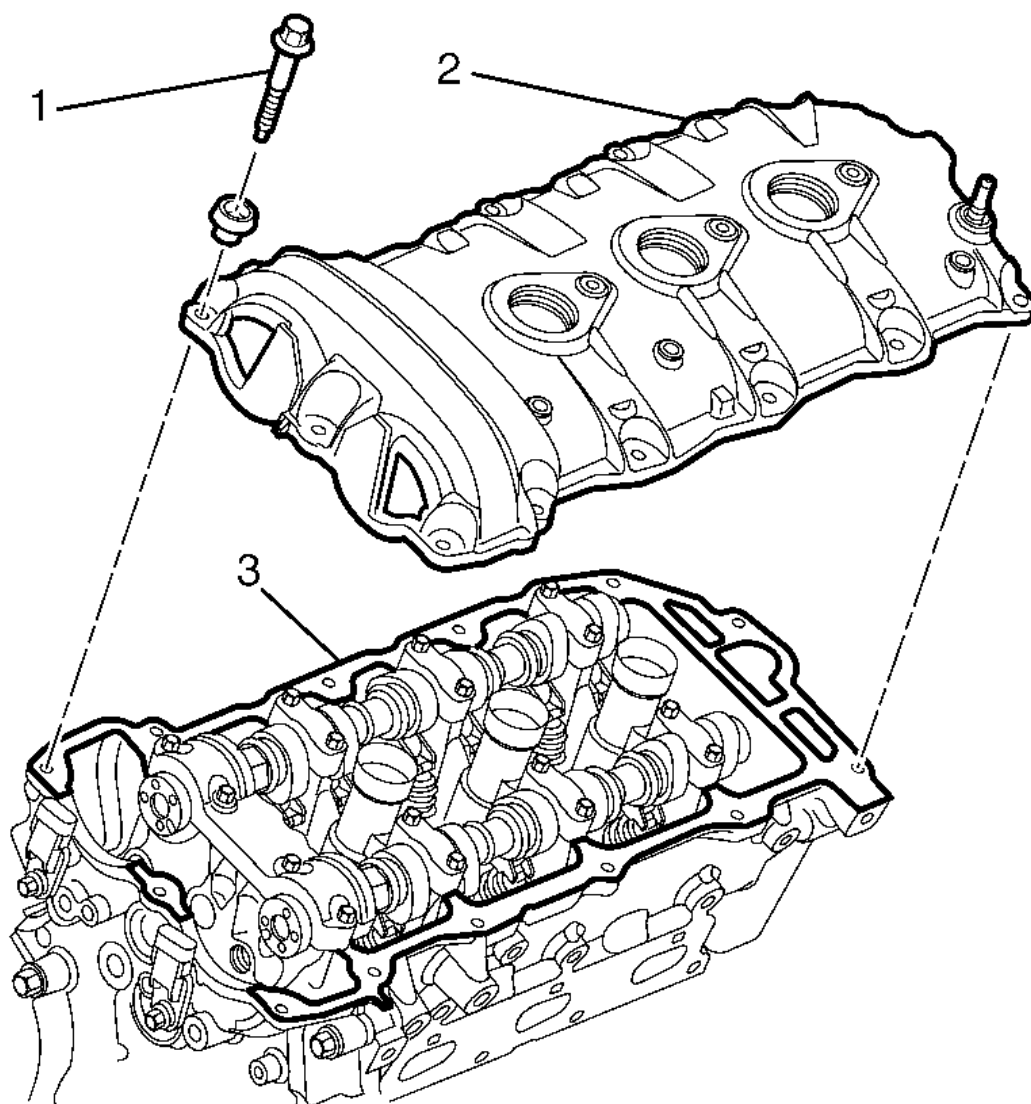
**Fig. 171: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil to camshaft cover retaining bolts (1).
2. Remove the ignition coils (2) from the camshaft cover (3).



**Fig. 172: View Of Spark Plugs**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs (1).



**Fig. 173: Identifying Left Camshaft Cover To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

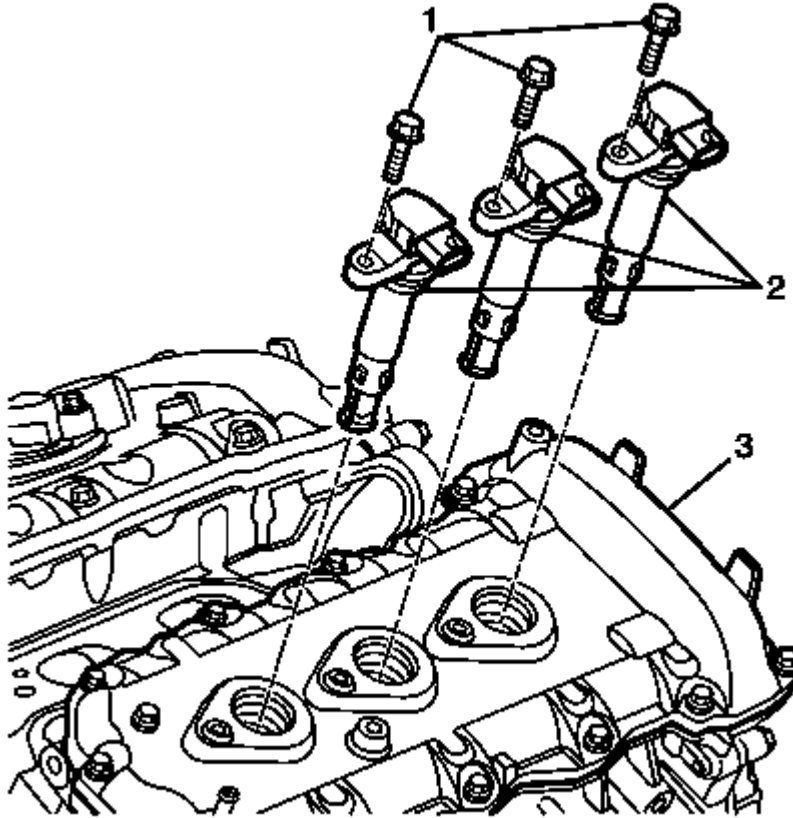
4. Remove the camshaft cover to cylinder head retaining bolts (1).
5. Remove the camshaft cover (2) from the cylinder head (3).

**IMPORTANT:** The camshaft cover seal and grommets must be discarded whenever the camshaft cover has been removed from the cylinder head (2).

6. Remove the camshaft cover seal and grommets.

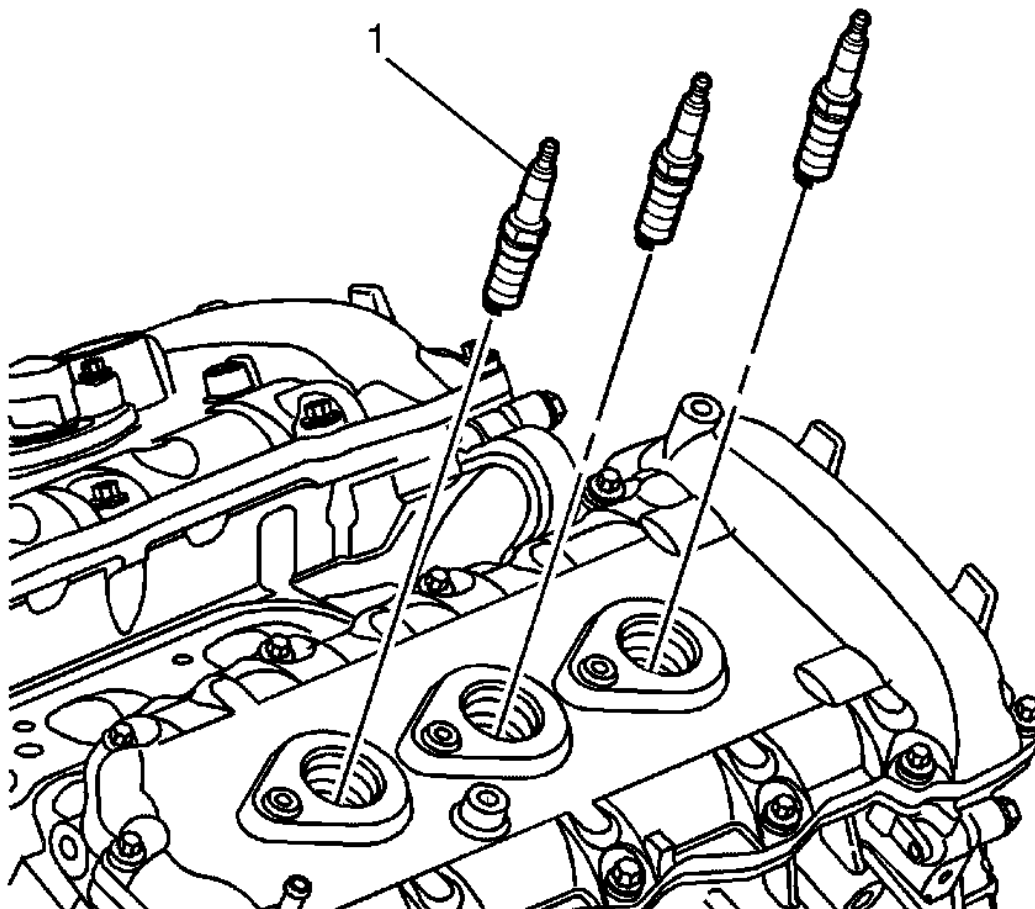
Discard the seal and grommets

### CAMSHAFT COVER REMOVAL - RIGHT SIDE



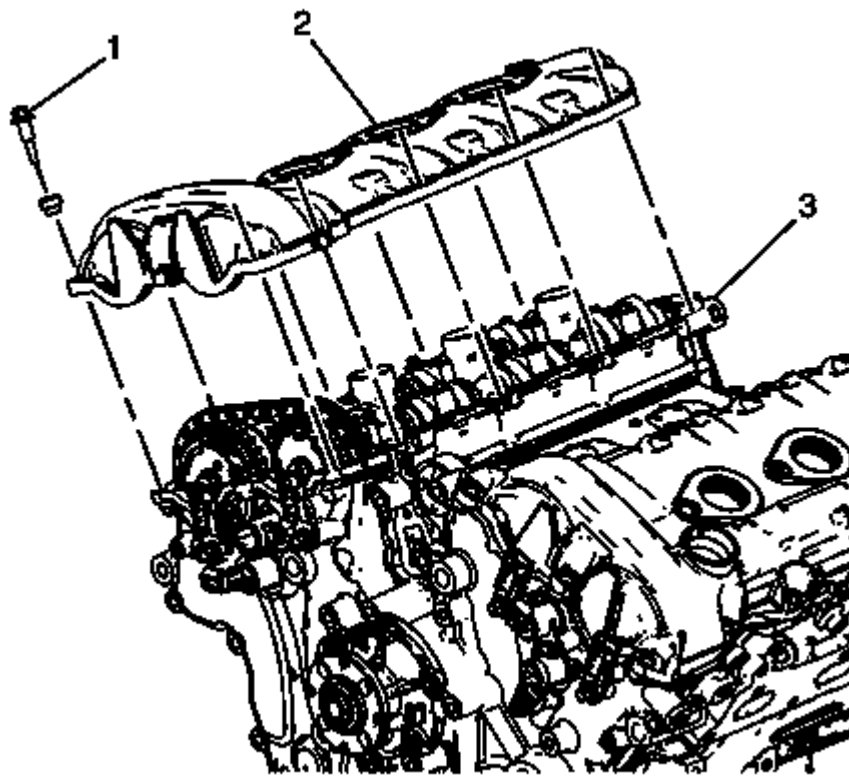
**Fig. 174: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil to camshaft cover retaining bolts (1).
2. Remove the ignition coils (2) from the camshaft cover (3).



**Fig. 175: View Of Spark Plugs**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs (1).



**Fig. 176: Identifying Right Camshaft Cover With Bolts**  
 Courtesy of GENERAL MOTORS CORP.

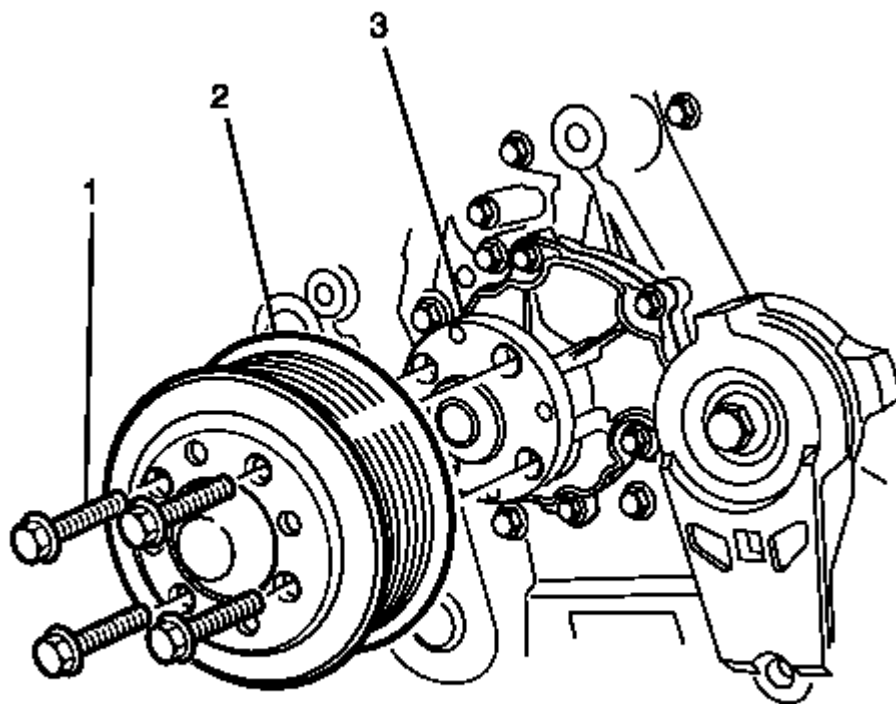
4. Remove the camshaft cover to cylinder head retaining bolts (1).
5. Remove the camshaft cover (2) from the cylinder head (3).

**IMPORTANT:** The camshaft cover seal and grommets must be discarded whenever the camshaft cover has been removed from the cylinder head (2).

6. Remove the camshaft cover seal and grommets.

Discard the seal and grommets

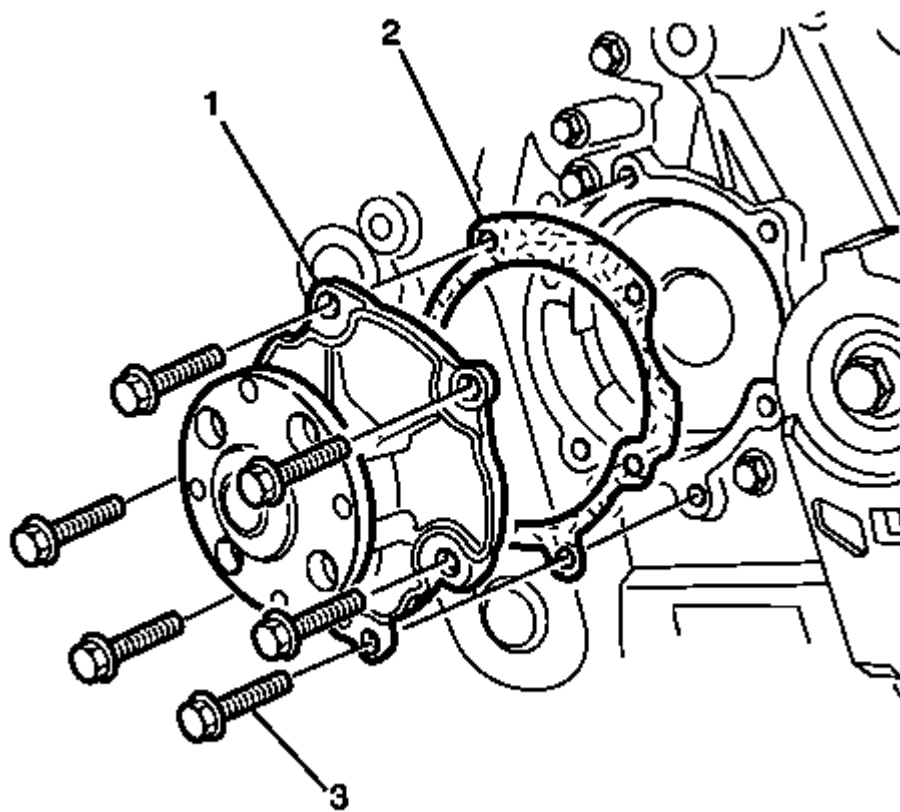
## WATER PUMP REMOVAL



**Fig. 177: Identifying Water Pump Pulley To Water Pump Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump pulley to water pump retaining bolts (1).
2. Remove the water pump pulley (2) from the water pump (3).





**Fig. 178: Identifying Water Pump To Engine Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Use a soft hammer to separate the water pump from the engine cover.

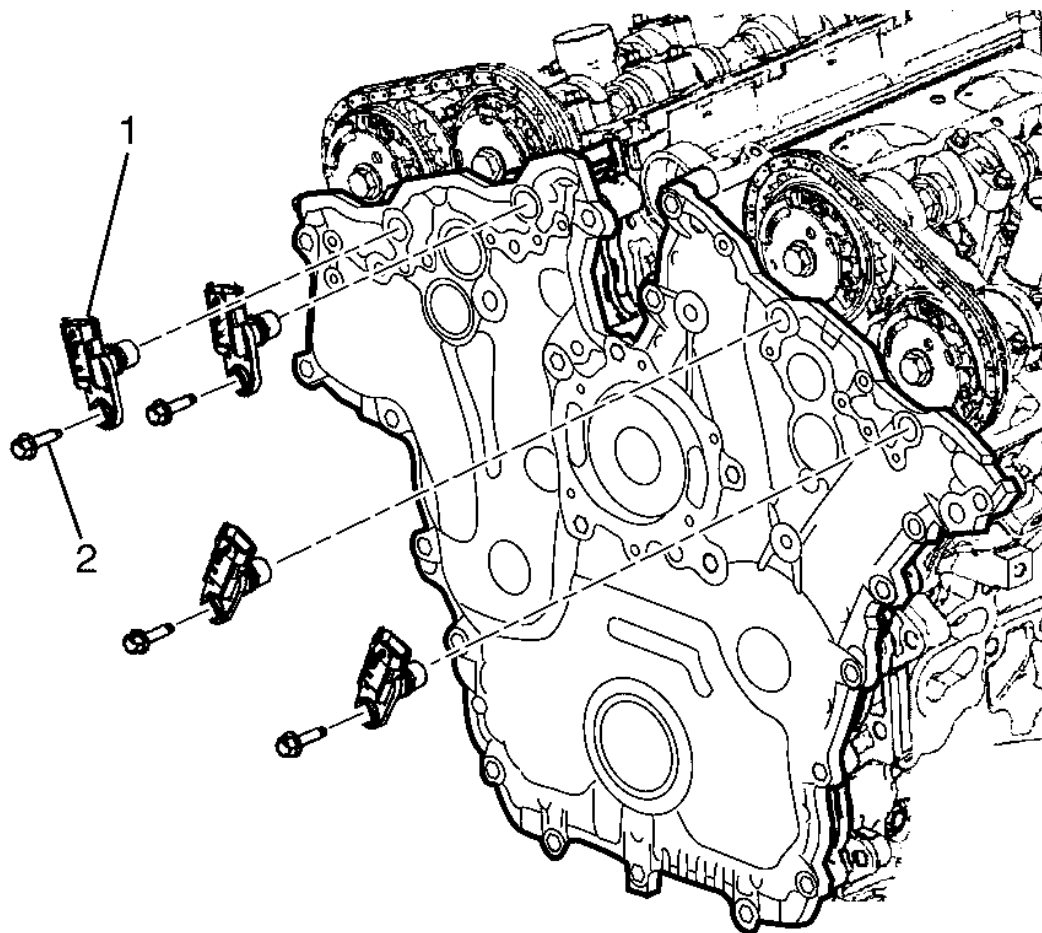
3. Remove the water pump to engine front cover retaining bolts (3).
4. Remove the water pump (1).
5. Remove the water pump gasket (2).

Discard the gasket.

## ENGINE FRONT COVER REMOVAL

### Tools Required

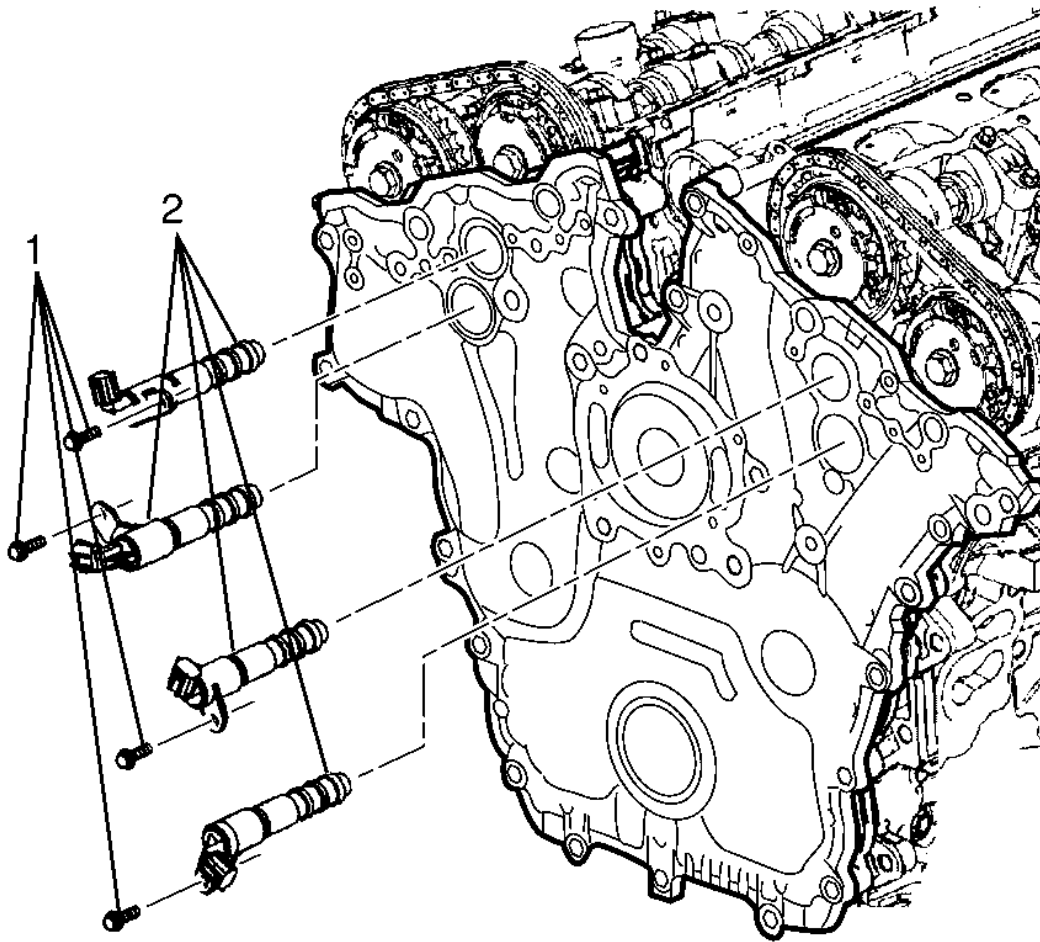
- **EN 46105** Camshaft Locking Tools. See **Special Tools** .
- **EN 46111** Crankshaft Rotation Socket. See **Special Tools** .



**Fig. 179: Identifying Camshaft Position Sensor To Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

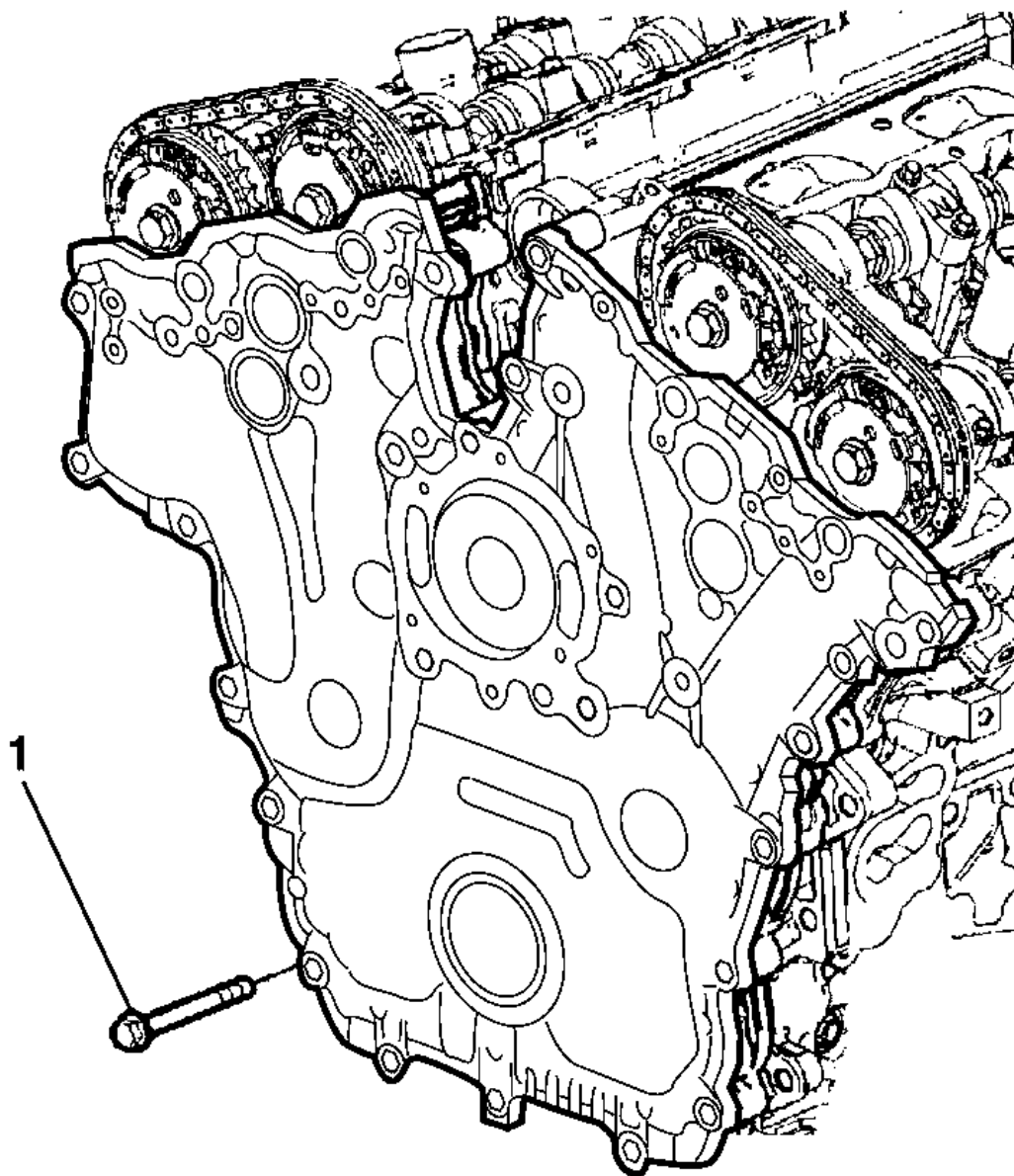
**CAUTION:** The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.

1. Remove the camshaft position actuator sensor to engine front cover retaining bolts (2).
2. Remove the camshaft position sensors (1).



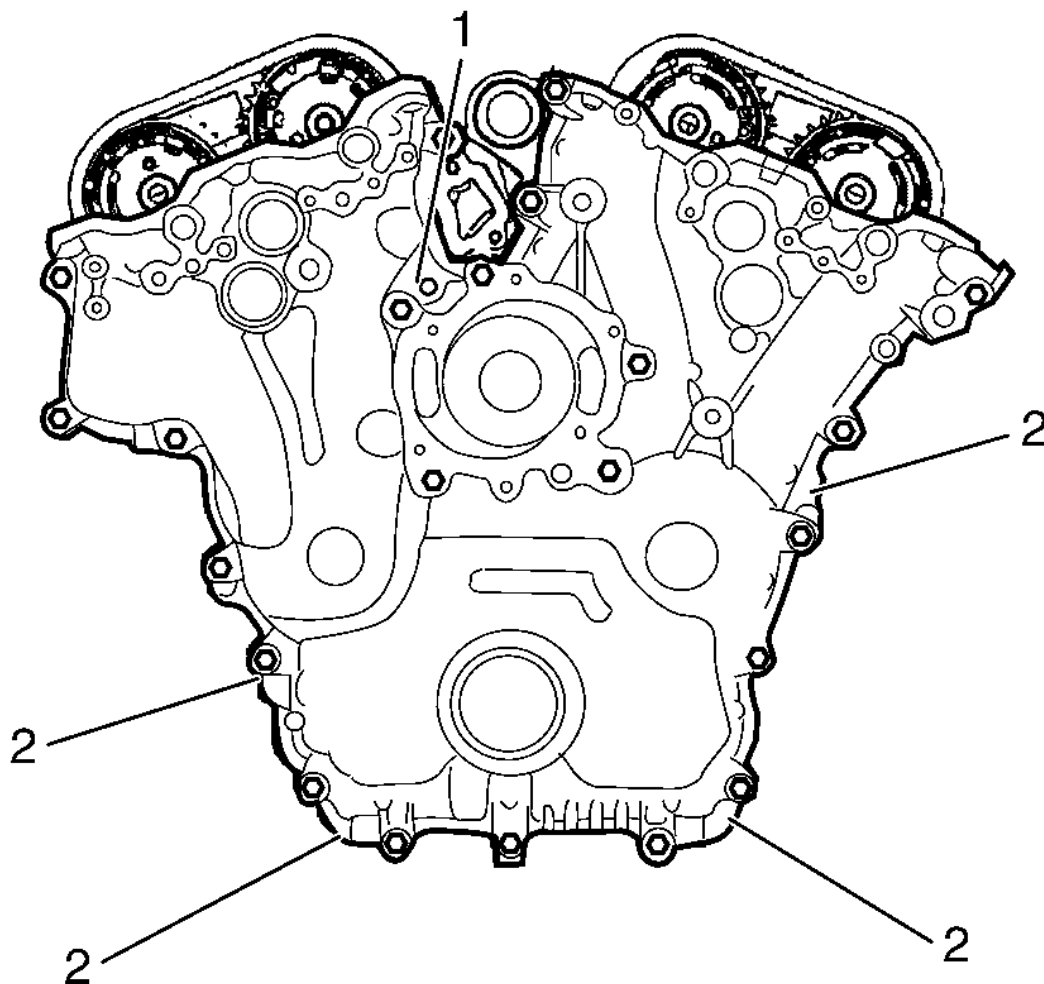
**Fig. 180: Identifying Camshaft Position Actuator Solenoid To Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft position actuator valve to engine front cover retaining bolts (1).
4. Remove the camshaft position actuator valves (2).



**Fig. 181: Identifying Engine Front Cover To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

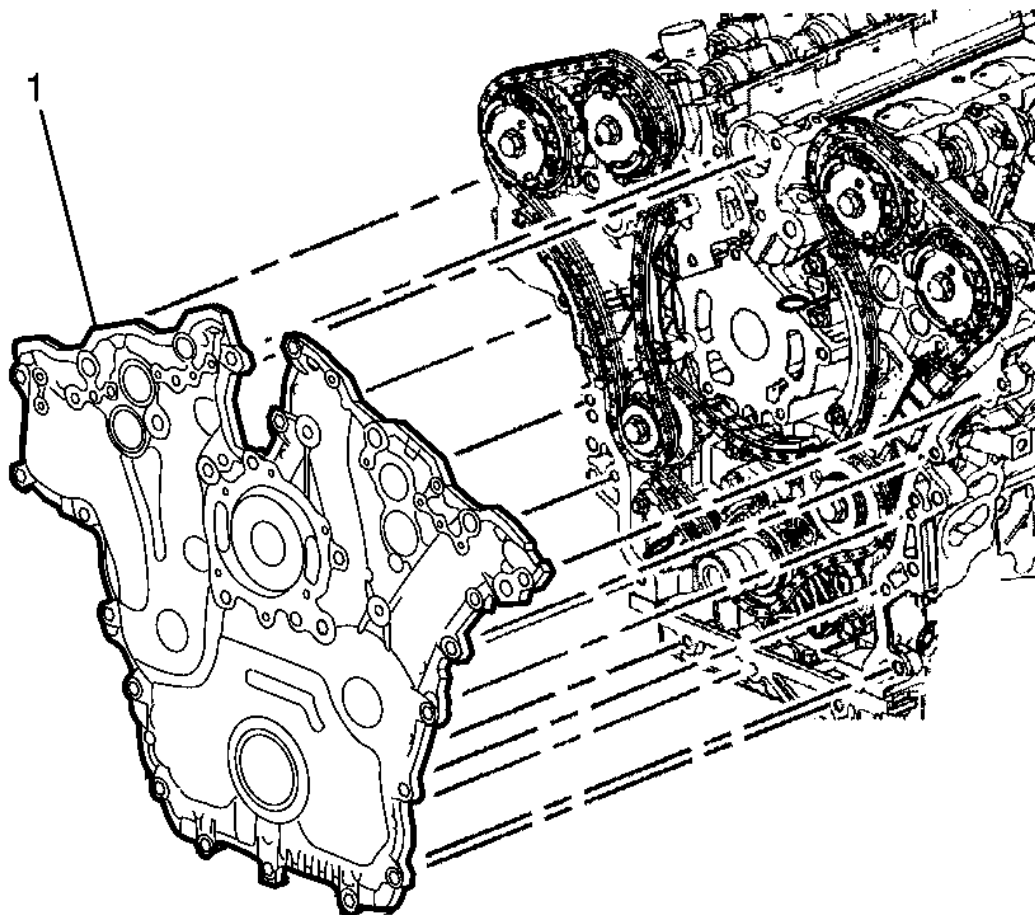
5. Remove the engine front cover to cylinder block retaining bolts (1).



**Fig. 182: Identifying Jackscrew Hole And Pry Points**  
Courtesy of GENERAL MOTORS CORP.

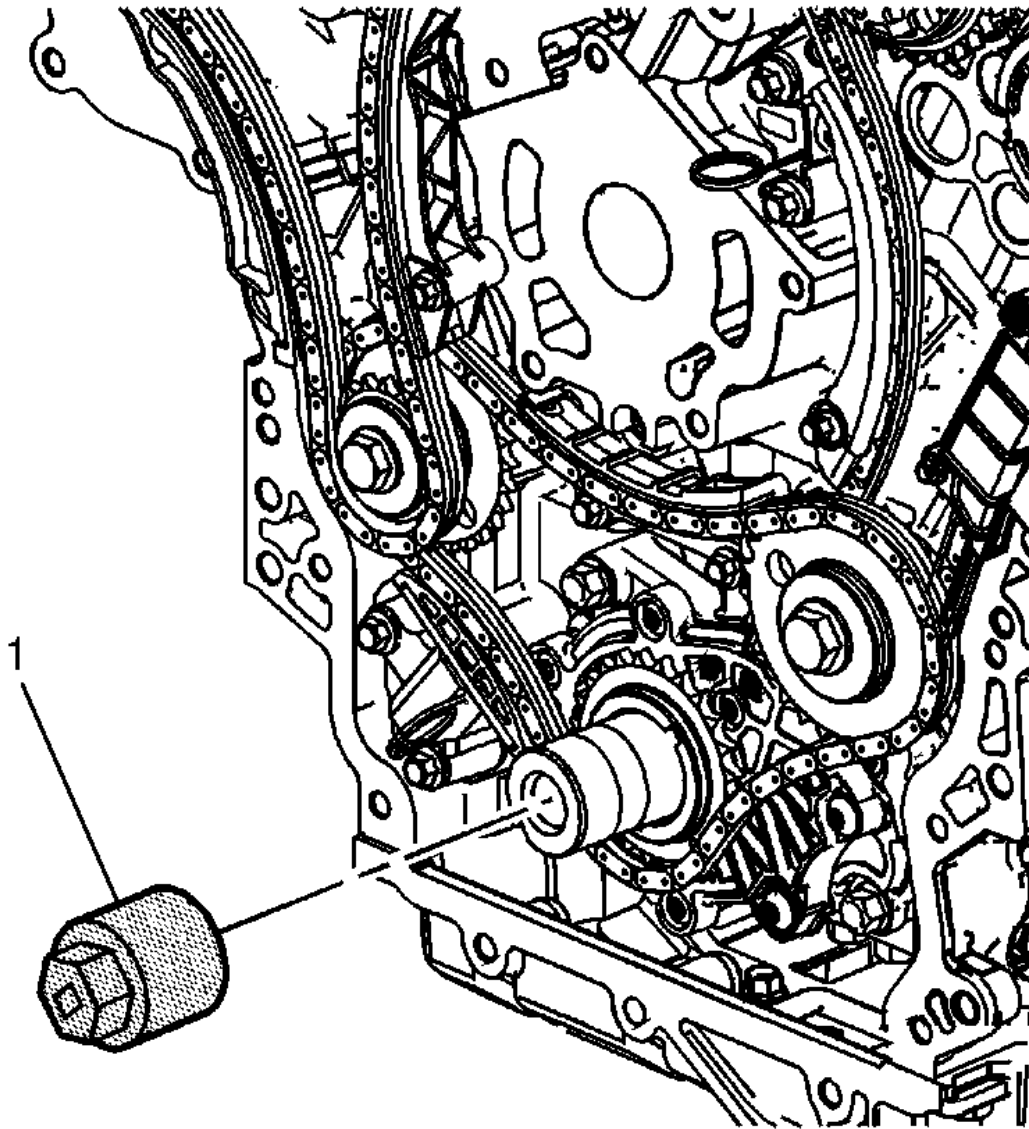
**CAUTION:** Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position actuators are used to pry against in order to remove the engine front cover.

6. Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1).
7. Using the pry points (2) located at the edge of the front cover and the jackscrew, shear the Room Temperature Vulcanizing (RTV) sealant.



**Fig. 183: Identifying Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

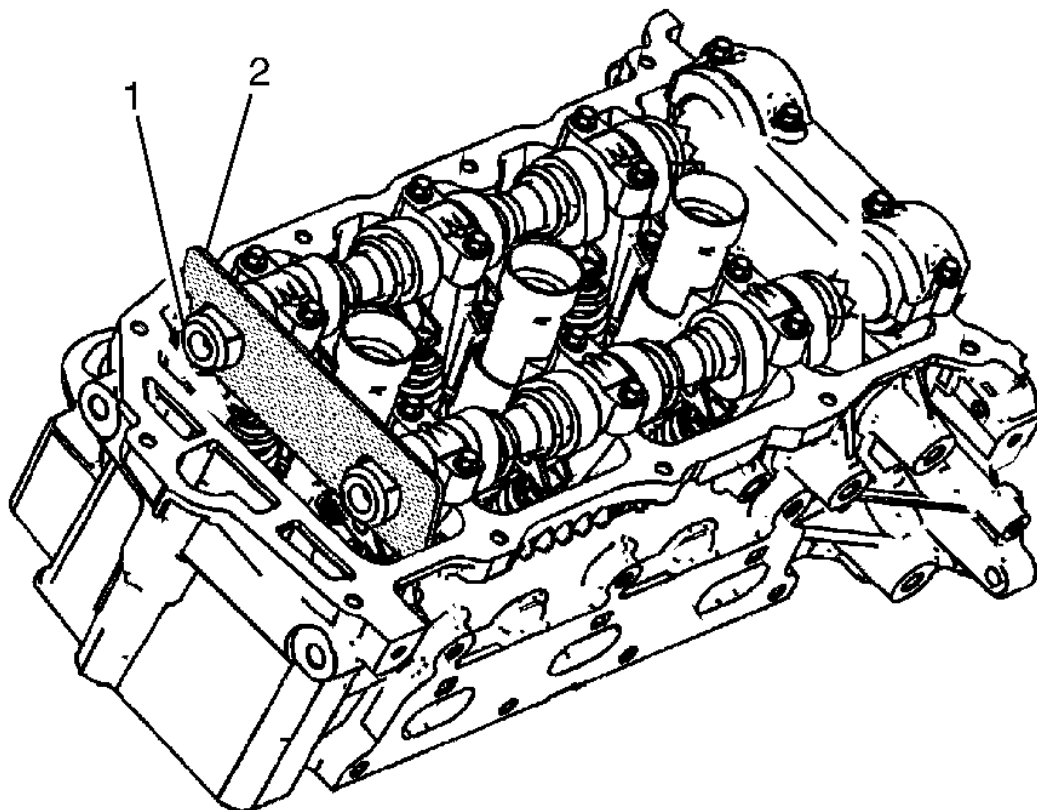
8. Remove the engine front cover (1).



**Fig. 184: View Of EN 46111**

Courtesy of GENERAL MOTORS CORP.

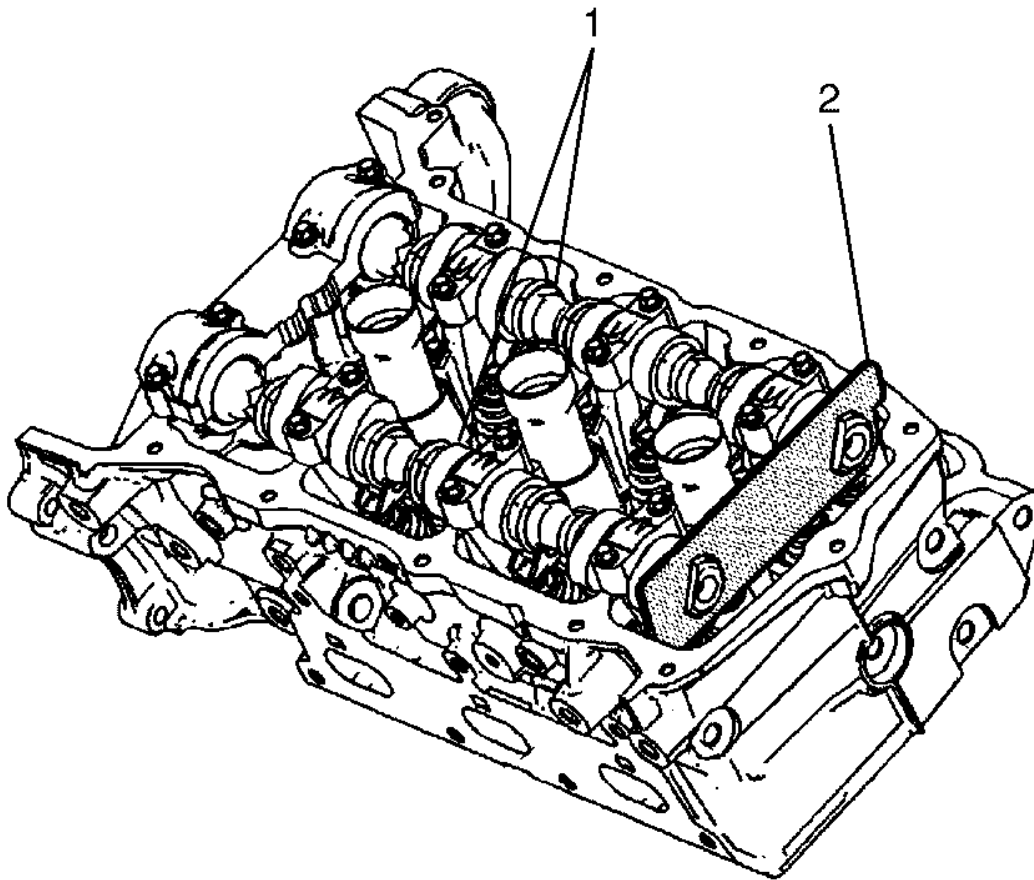
9. Using the EN 46111 (1), rotate the crankshaft until the left cylinder head camshafts align with the EN 46105 and the right cylinder head camshafts align with the EN 46105 . See Special Tools .



**Fig. 185: View Of EN 46105 & Right Side Camshafts**  
**Courtesy of GENERAL MOTORS CORP.**

10. Install the **EN 46105** (2) onto the rear of the right hand camshafts (1). See **Special Tools** .

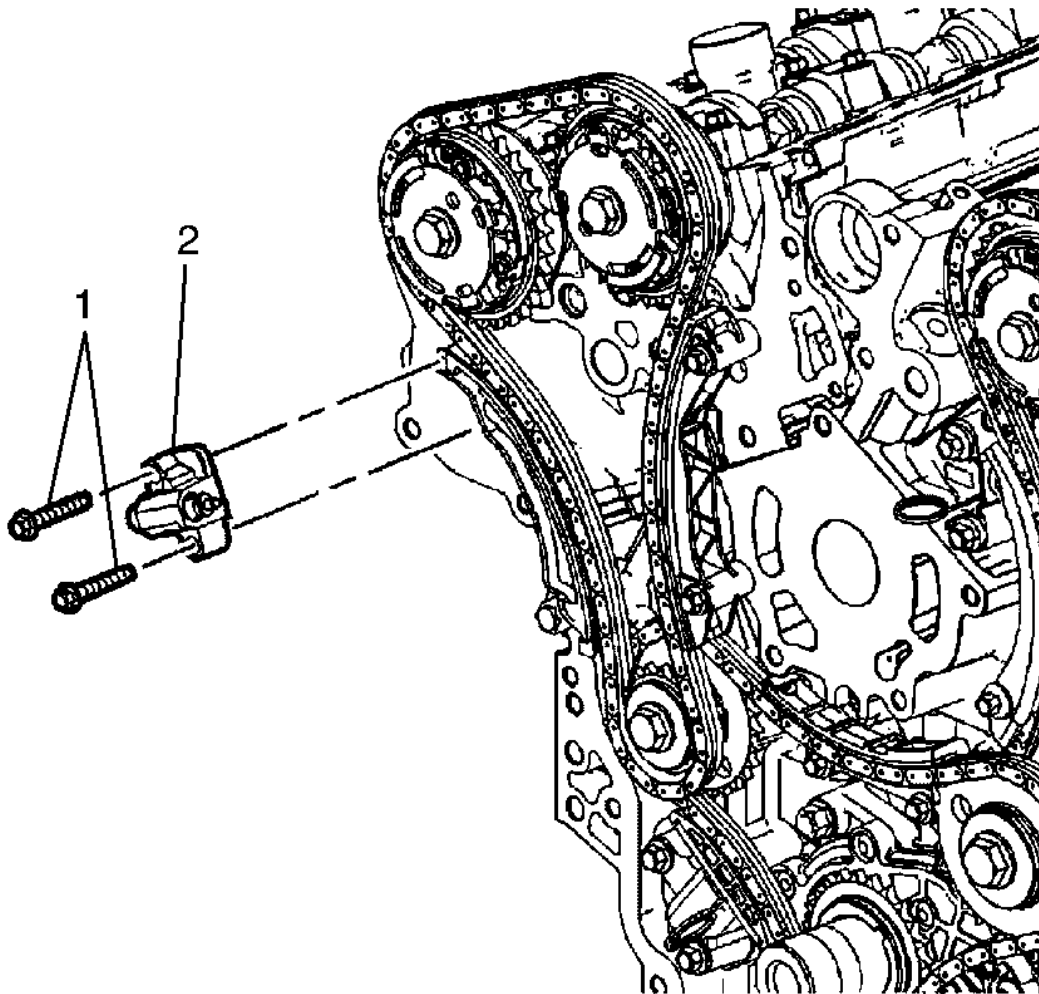




**Fig. 186: View Of EN 46105 & Left Hand Camshafts**  
Courtesy of GENERAL MOTORS CORP.

11. Install the **EN 46105** (2) onto the rear of the left hand camshafts (1). See **Special Tools** .

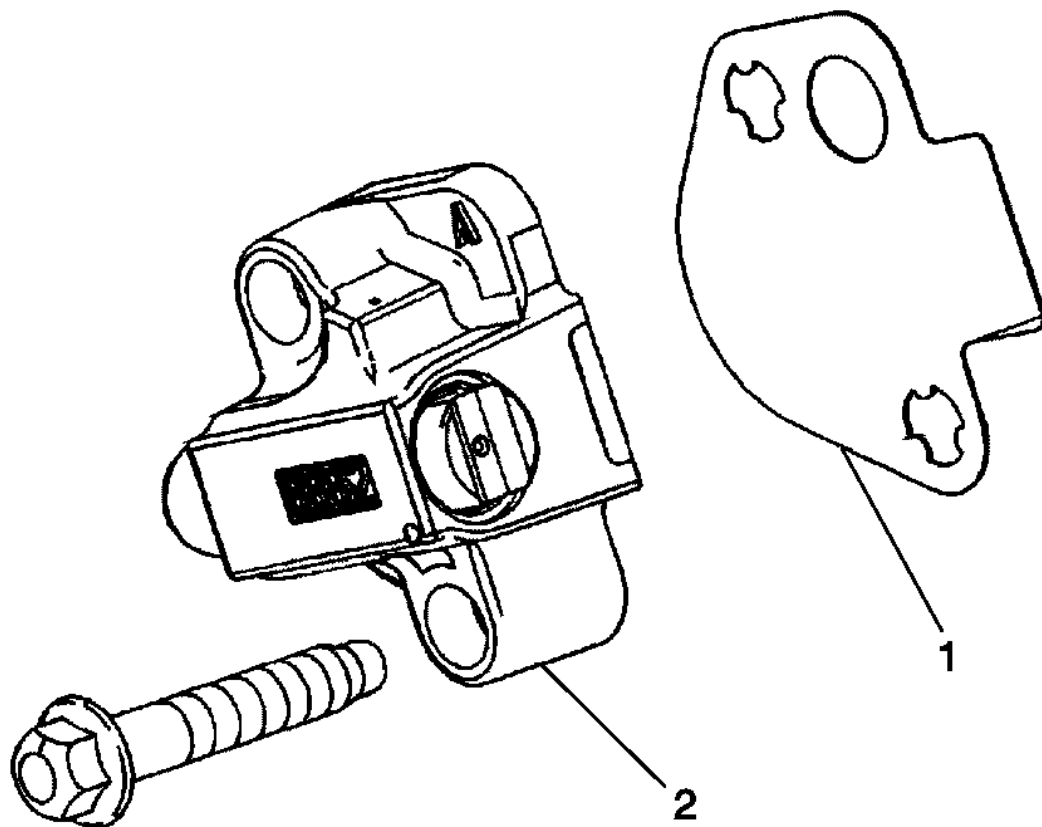
#### **SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REMOVAL - RIGHT SIDE**



**Fig. 187: Identifying Right Secondary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the right secondary camshaft drive chain tensioner (2).



**Fig. 188: Identifying Right Secondary Camshaft Drive Chain Tensioner & Gasket**  
Courtesy of GENERAL MOTORS CORP.

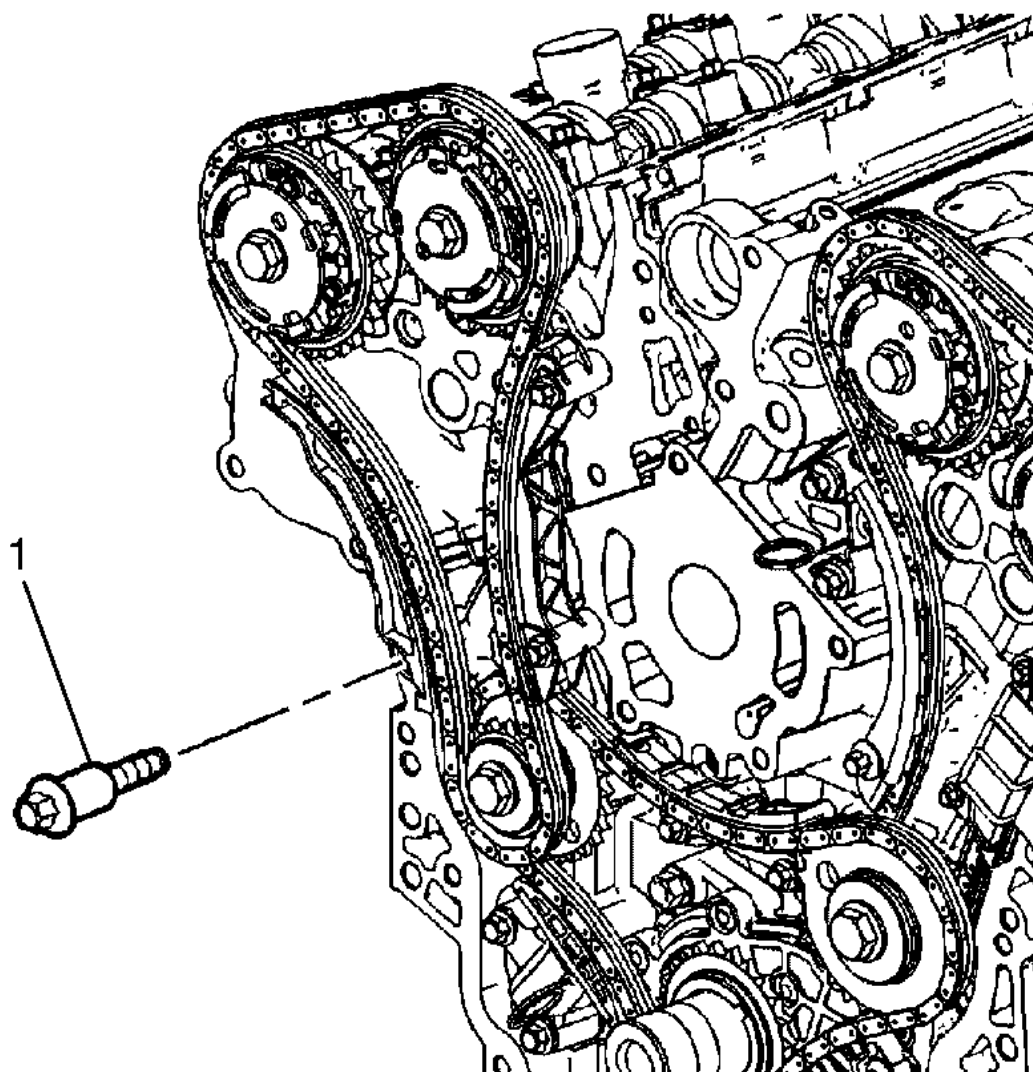
**IMPORTANT:** The right secondary camshaft drive chain tensioner gasket (2) must be discarded whenever the right secondary camshaft drive chain tensioner (1) has been removed from the cylinder block.

3. Remove the right secondary camshaft drive chain tensioner gasket (1) from the right secondary camshaft drive chain tensioner (2).

Discard the gasket.

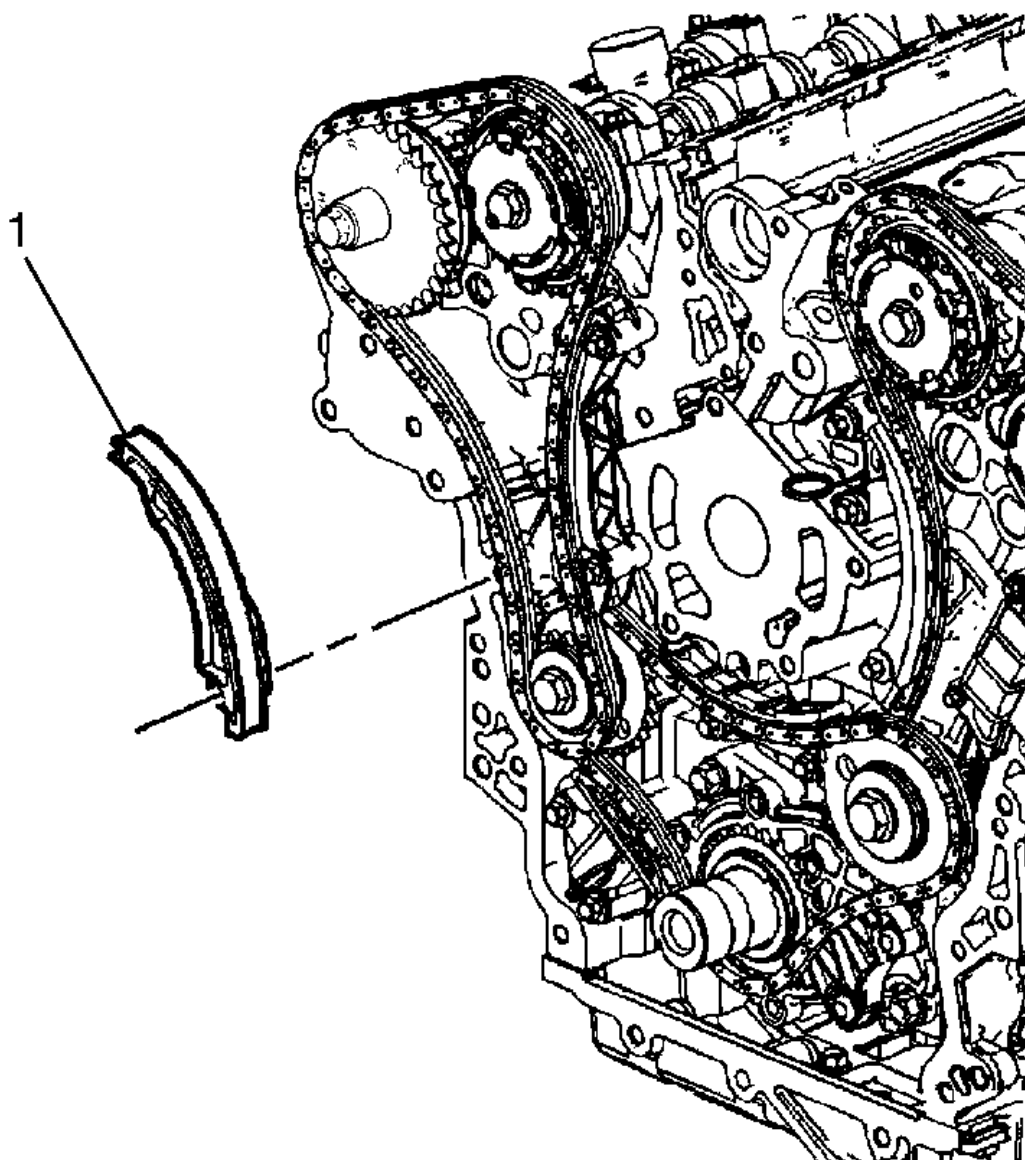
4. Inspect the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head for burrs or any defects that may degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.

## SECONDARY CAMSHAFT DRIVE CHAIN SHOE REMOVAL - RIGHT SIDE



**Fig. 189: Identifying Right Secondary Camshaft Drive Chain Shoe To Cylinder Block Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

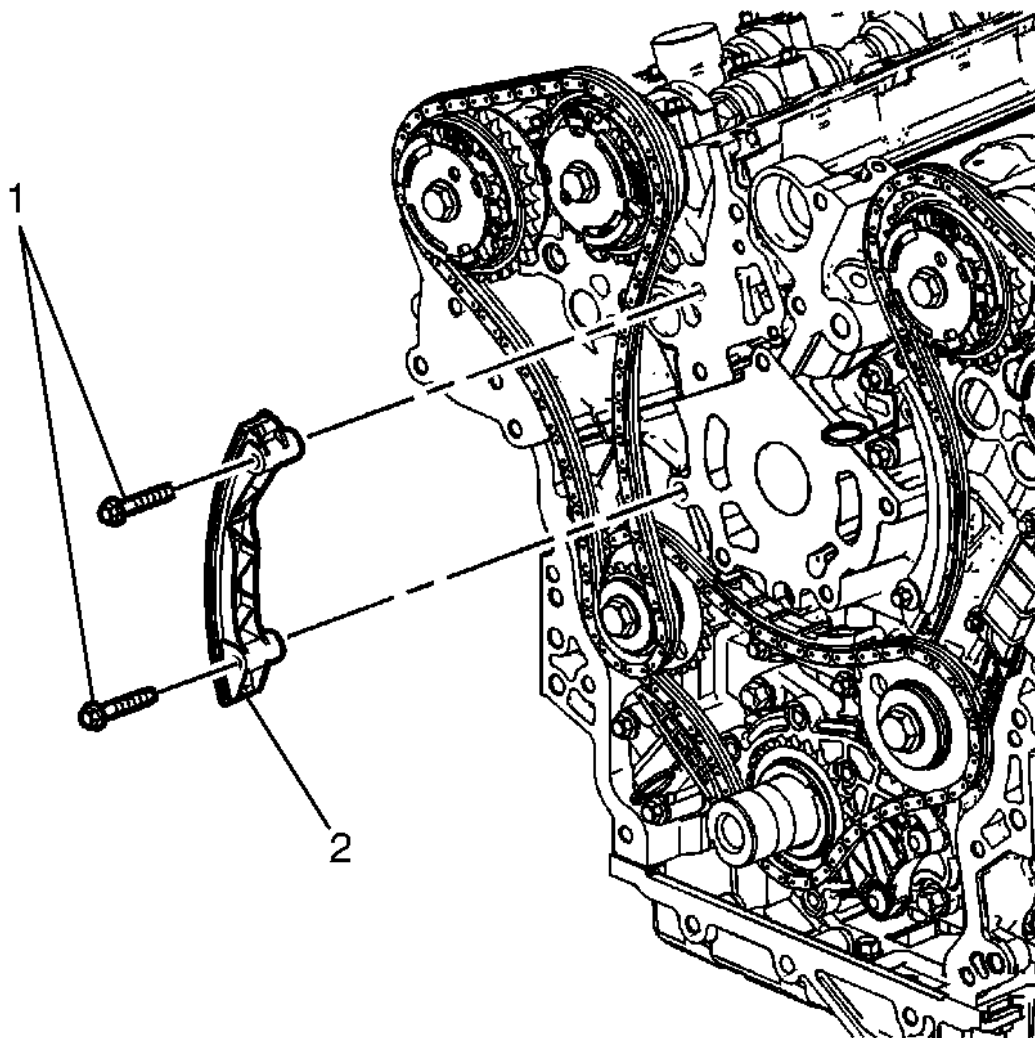
1. Remove the right secondary camshaft drive chain shoe to cylinder block retaining bolt (1).



**Fig. 190: View Of Right Secondary Camshaft Drive Chain Shoe**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the right secondary camshaft drive chain shoe (1).

#### **SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REMOVAL - RIGHT SIDE**

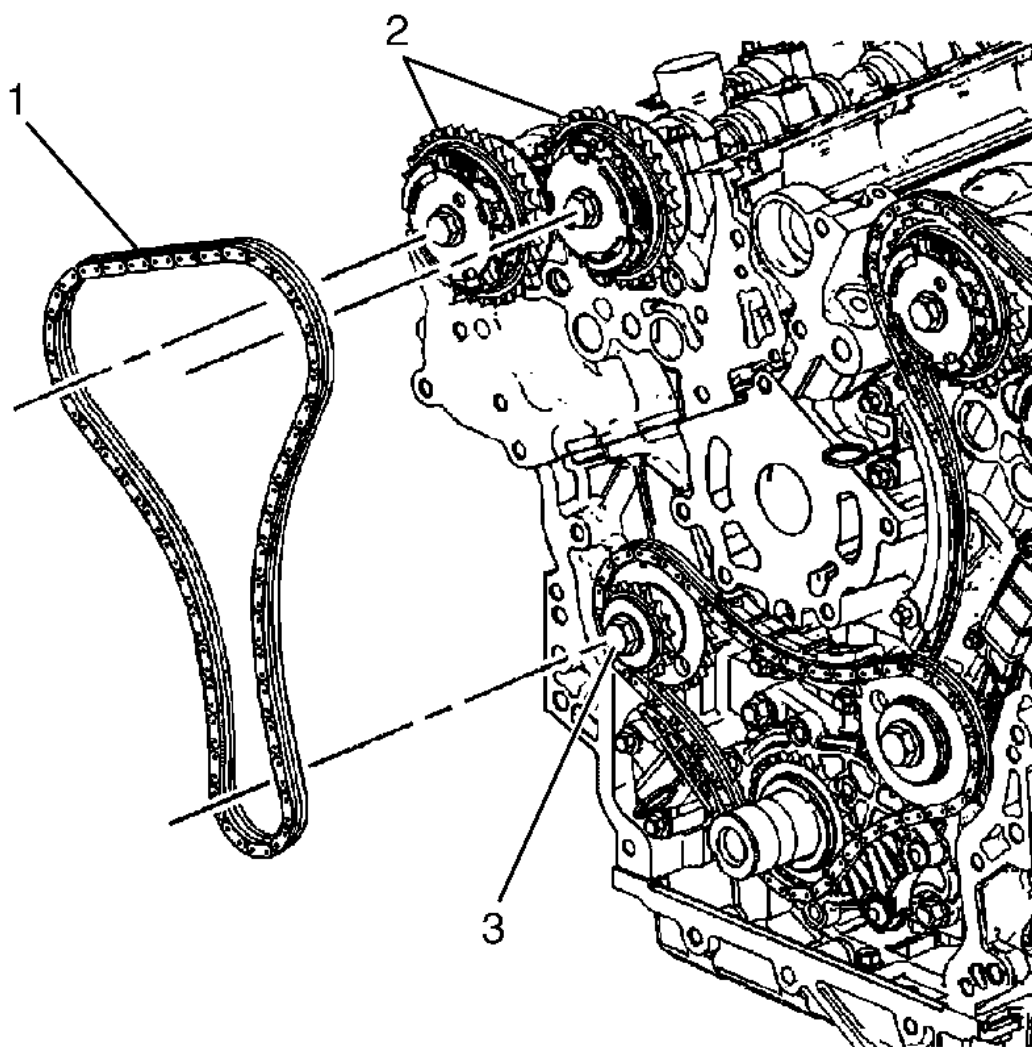


**Fig. 191: Identifying Right Secondary Camshaft Drive Chain Guide To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft drive chain guide to cylinder block retaining bolts (1).
2. Remove the right secondary camshaft drive chain guide (2).

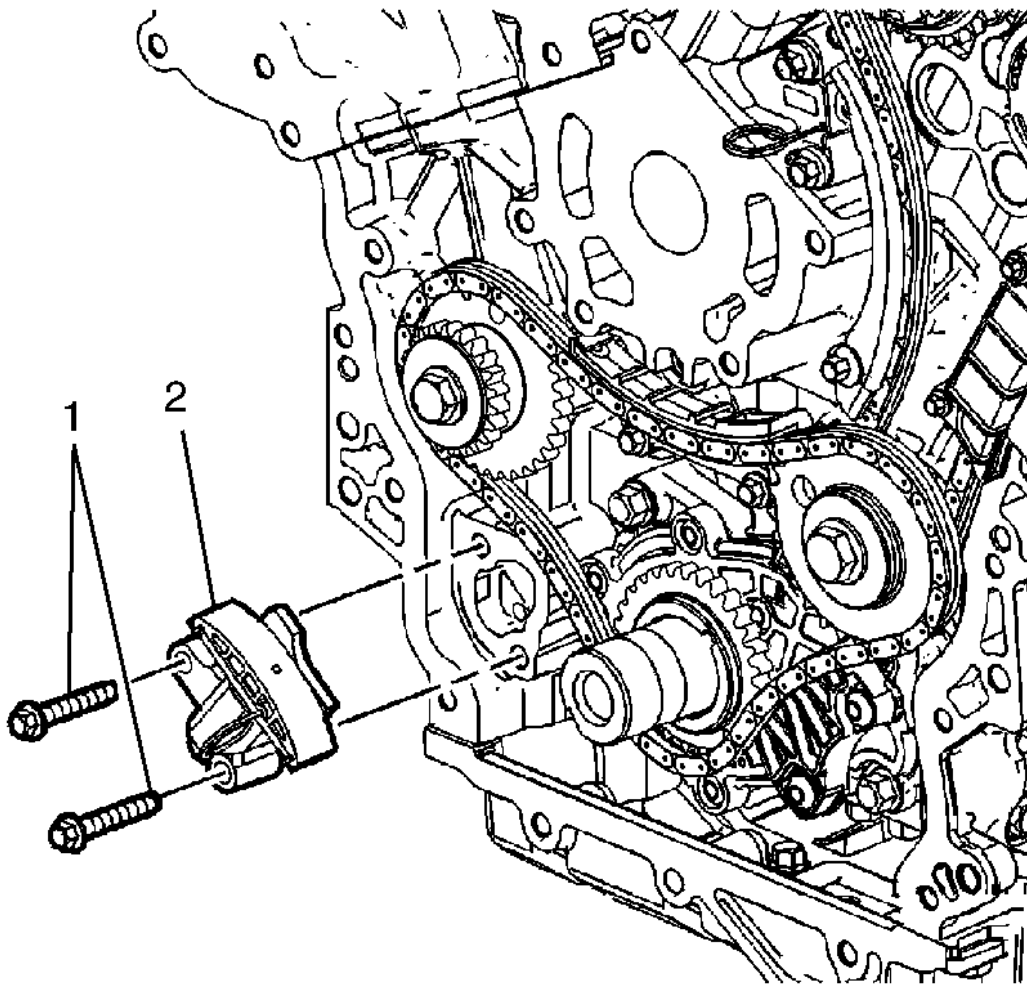
#### **SECONDARY CAMSHAFT DRIVE CHAIN REMOVAL - RIGHT SIDE**



**Fig. 192: View Of Right Secondary Camshaft Drive Chain, Right Camshaft Position Actuators & Intermediate Drive Chain Idler Sprocket**  
Courtesy of GENERAL MOTORS CORP.

Remove the right secondary camshaft drive chain (1) from the right camshaft position actuators (2) and the right camshaft intermediate drive chain idler sprocket (3).

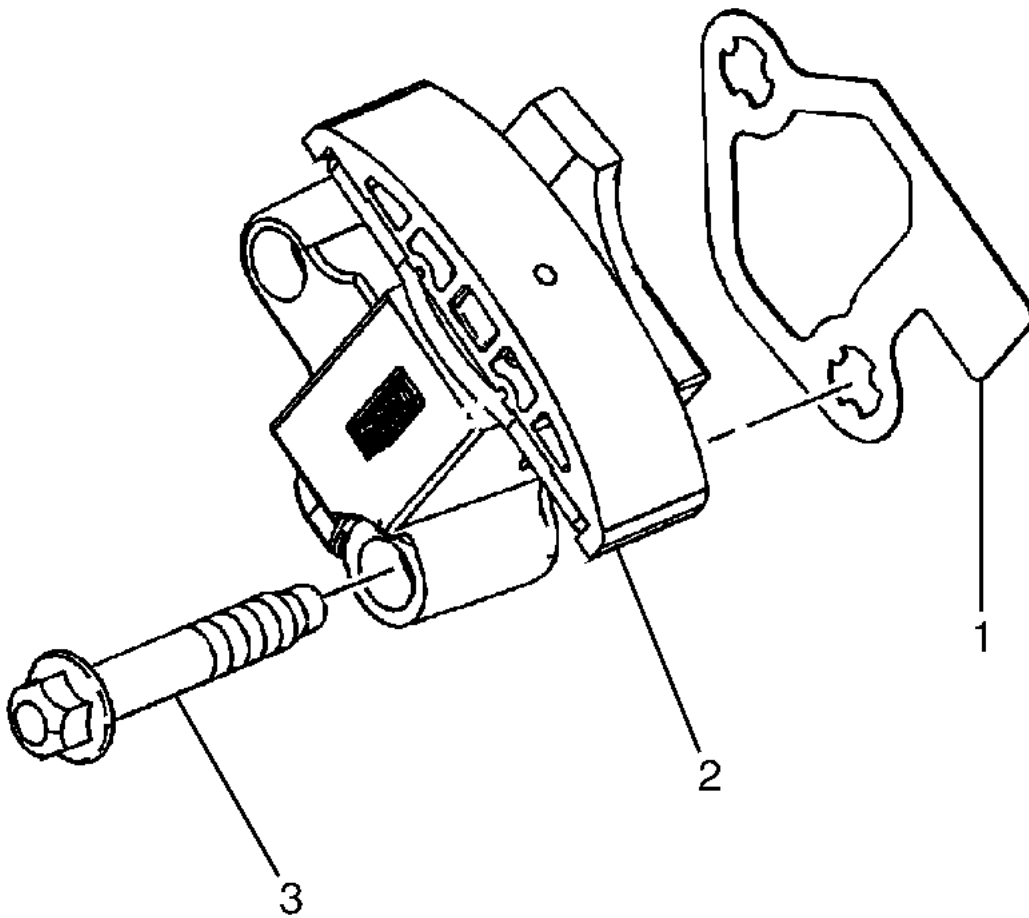
#### **PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER REMOVAL**



**Fig. 193: Identifying Primary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the primary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the primary camshaft drive chain tensioner (2).





**Fig. 194: View Of Primary Camshaft Drive Chain Tensioner, Gasket & Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the primary camshaft drive chain tensioner bolts (3) from the primary camshaft drive chain tensioner (2) and gasket (1).

**IMPORTANT:** The primary camshaft drive chain tensioner gasket (1) must be discarded whenever the primary camshaft drive chain tensioner (2) has been removed from the cylinder block.

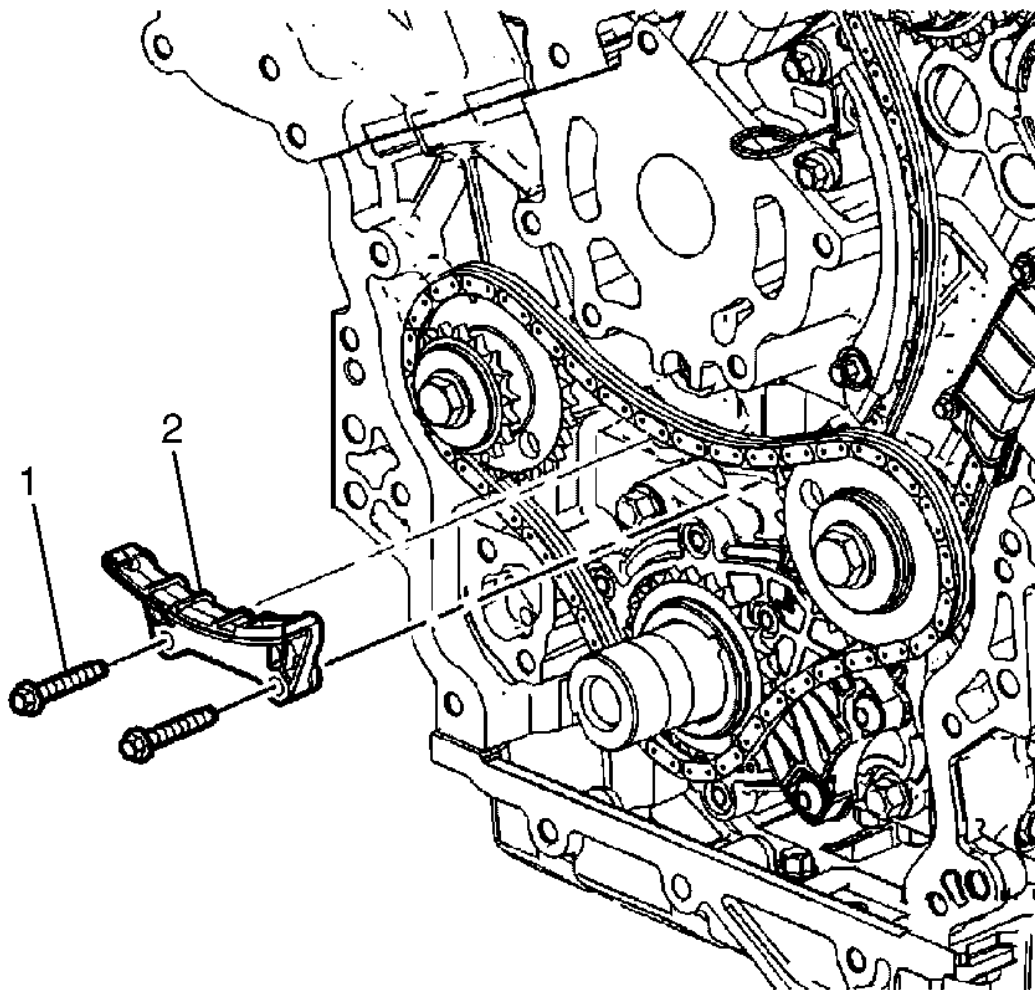
4. Remove the primary camshaft drive chain tensioner gasket (1) from the primary camshaft drive chain tensioner (2).

Discard the gasket.

5. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any

defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.

### PRIMARY TIMING CHAIN GUIDE REMOVAL - UPPER

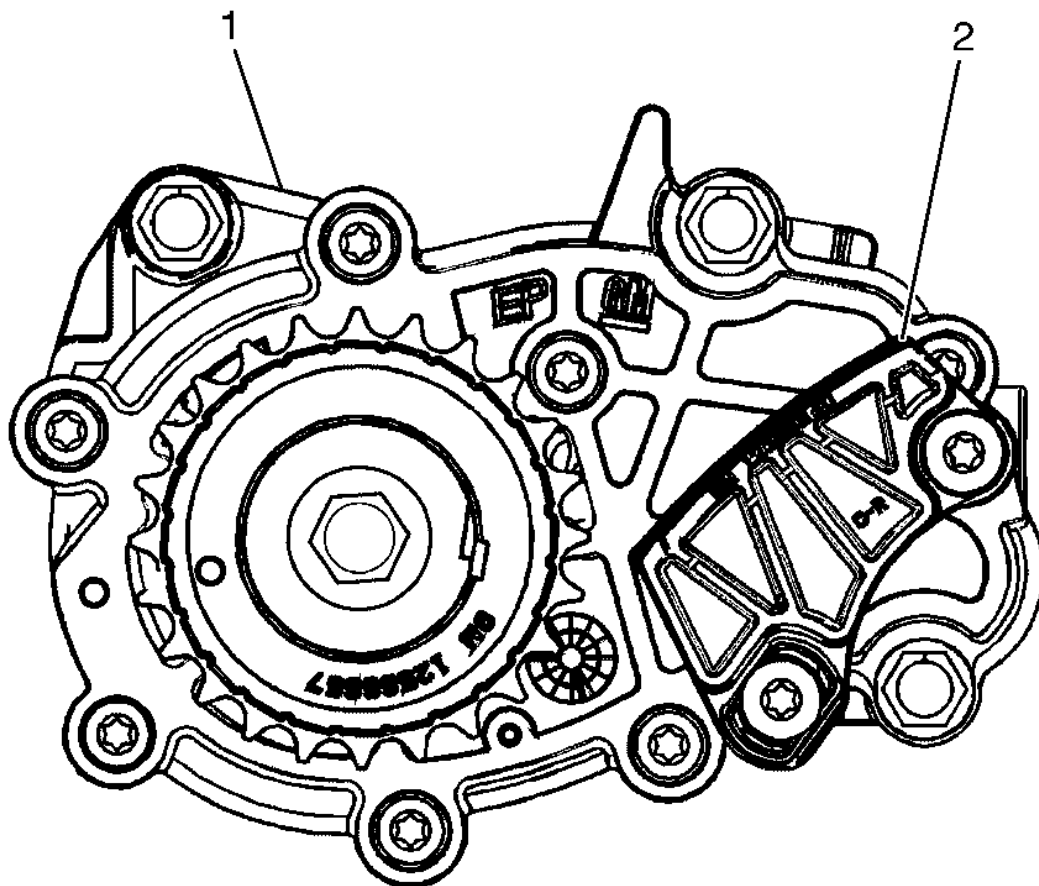


**Fig. 195: Identifying Primary Camshaft Drive Chain Upper Guide To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Remove the primary camshaft drive chain upper guide to cylinder block retaining bolts (1).
2. Remove the primary camshaft drive chain upper guide (2).

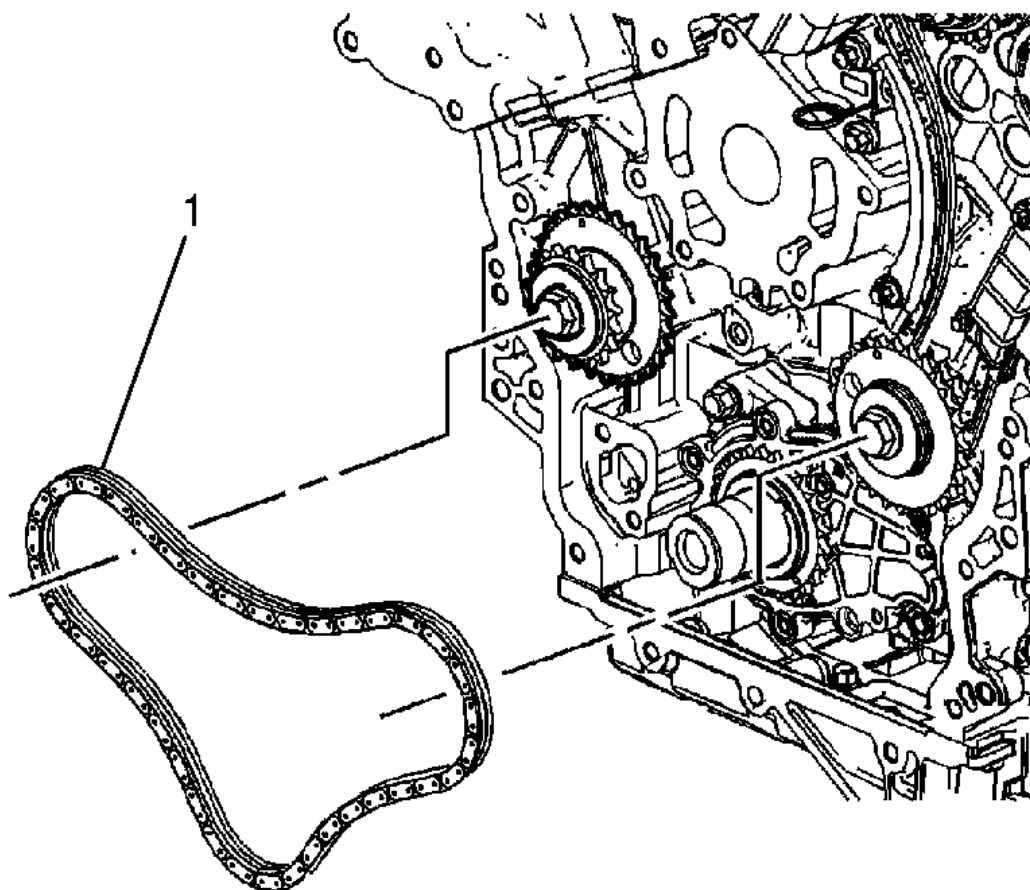
### PRIMARY TIMING CHAIN GUIDE REMOVAL - LOWER



**Fig. 196: View Of Oil Pump & Primary Camshaft Drive Chain Lower Guide**  
Courtesy of GENERAL MOTORS CORP.

DO NOT remove the primary camshaft drive chain lower guide (2). The primary camshaft drive chain lower guide (2) is not serviceable separately. If the primary camshaft drive chain lower guide (2) must be replaced, the oil pump (1) must be replaced.

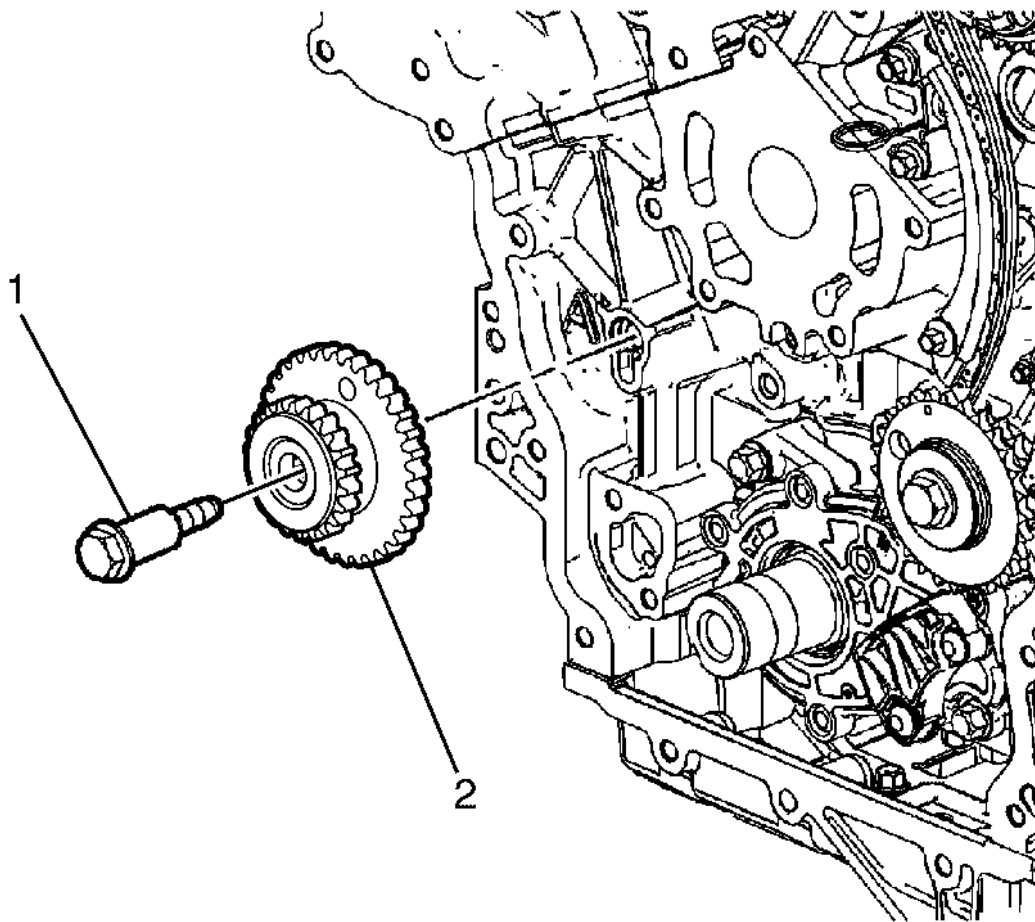
#### **PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REMOVAL**



**Fig. 197: View Of Primary Camshaft Drive Chain**  
Courtesy of GENERAL MOTORS CORP.

Remove the primary camshaft drive chain (1).

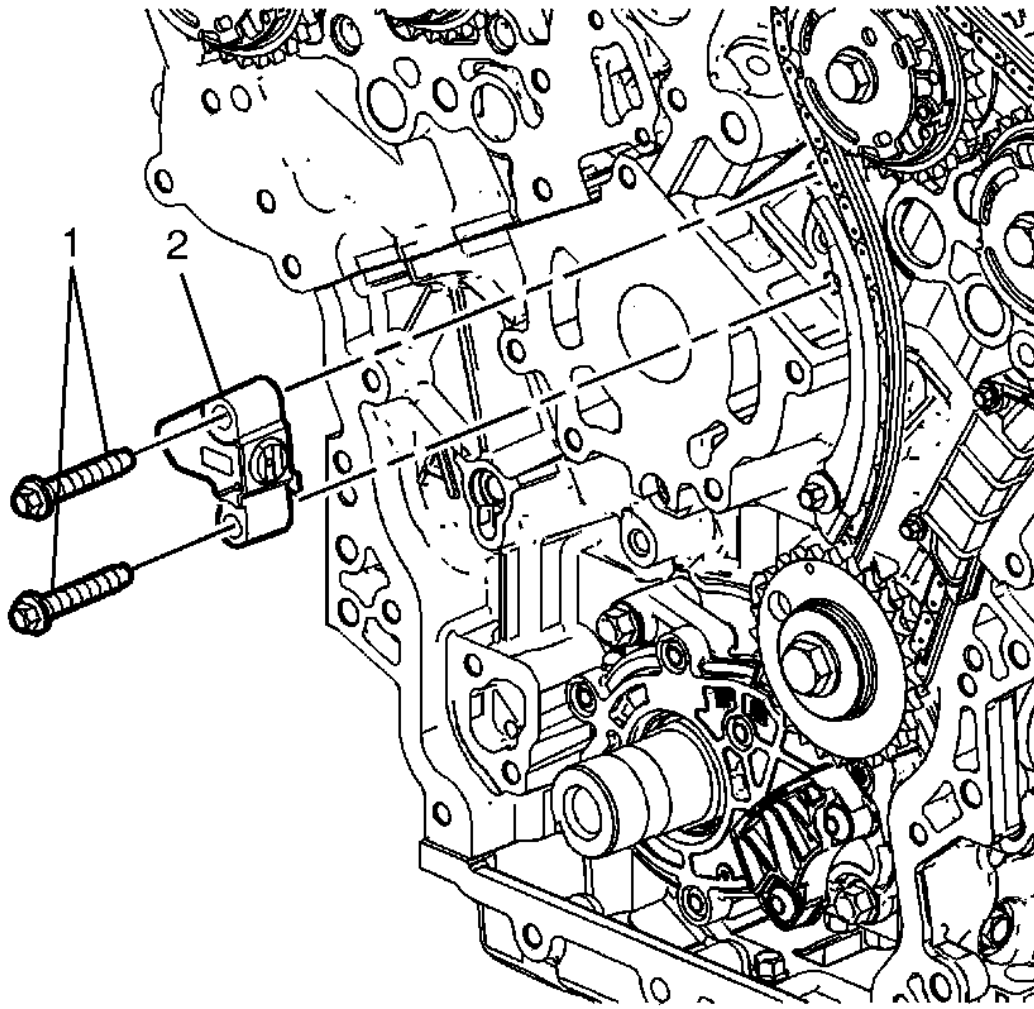
#### **CAMSHAFT INTERMEDIATE DRIVE CHAIN IDLER REMOVAL - RIGHT SIDE**



**Fig. 198: Identifying Right Camshaft Intermediate Drive Chain Idler & Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the right camshaft intermediate drive chain idler bolt (1).
2. Remove the right camshaft intermediate drive chain idler (2).

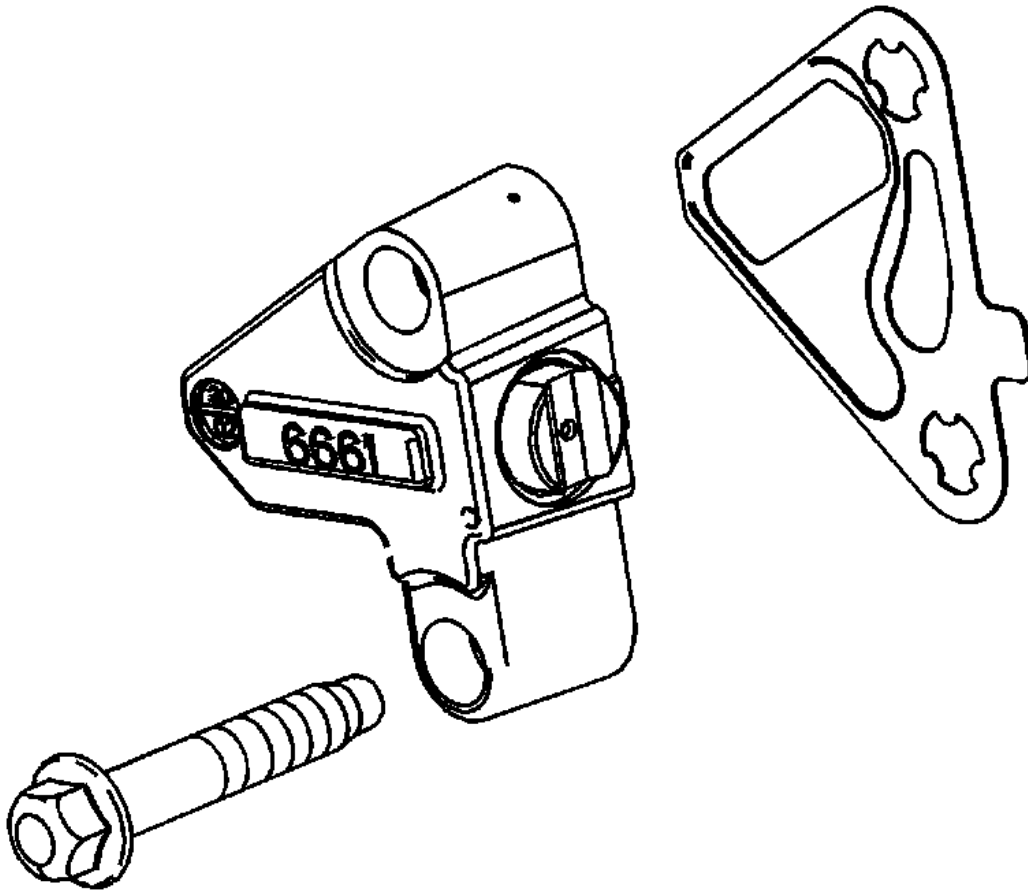
#### **SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REMOVAL - LEFT SIDE**



**Fig. 199: Identifying Left Secondary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).
2. Remove the left secondary camshaft drive chain tensioner (2).



**Fig. 200: Identifying Left Secondary Camshaft Drive Chain Tensioner & Gasket**  
Courtesy of GENERAL MOTORS CORP.

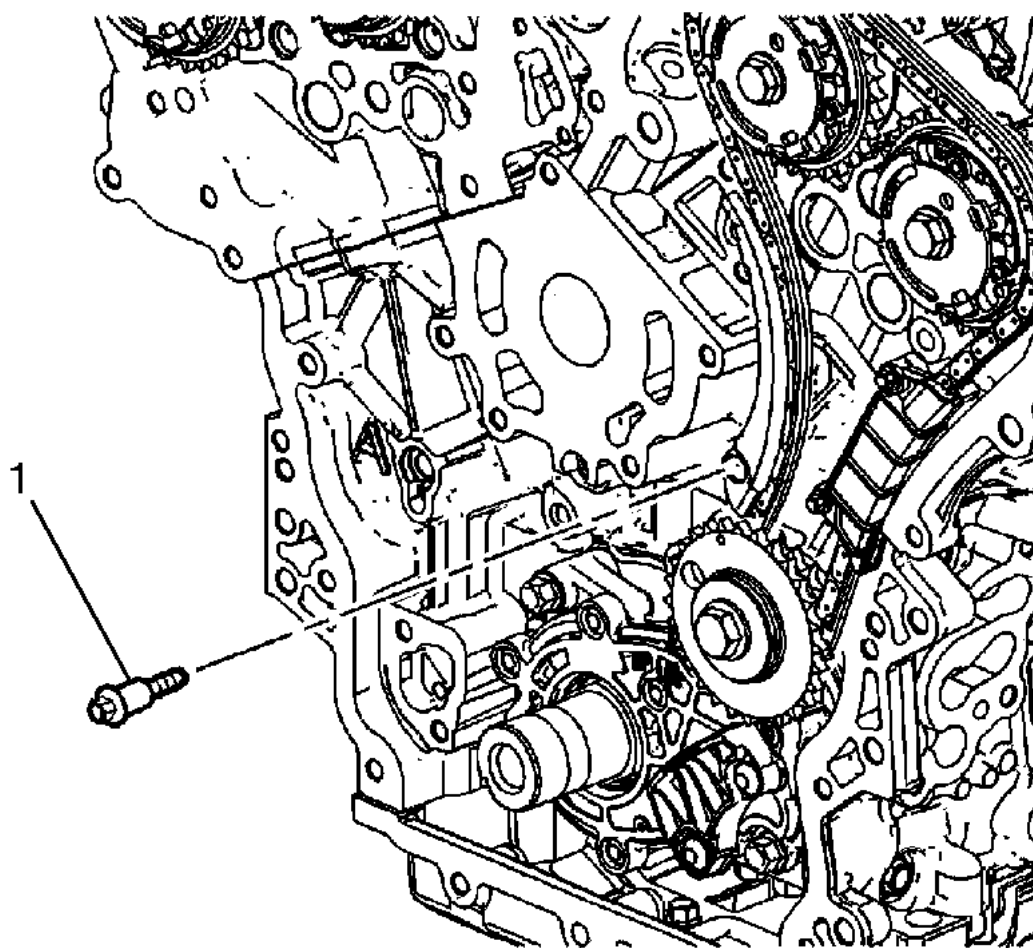
**IMPORTANT:** The left secondary camshaft drive chain tensioner gasket must be discarded whenever the left secondary camshaft drive chain tensioner has been removed from the cylinder block.

3. Remove left secondary camshaft drive chain tensioner gasket from the left secondary camshaft drive chain tensioner.

Discard the gasket.

4. Inspect the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head for burrs or any defects that may degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.

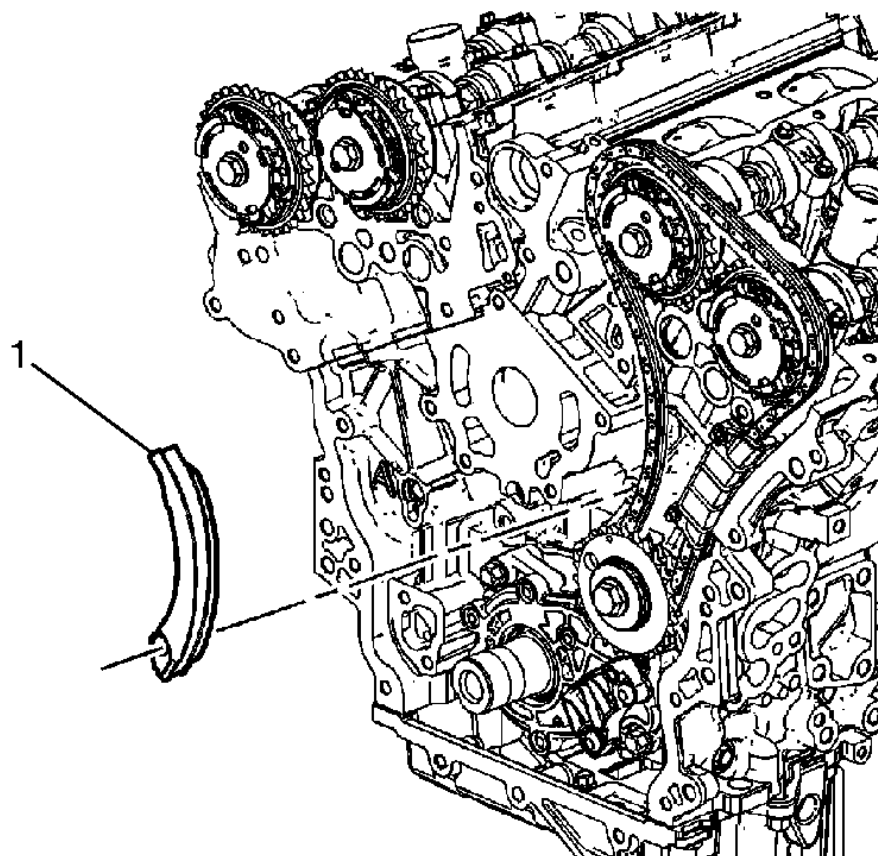
## SECONDARY CAMSHAFT DRIVE CHAIN SHOE REMOVAL - LEFT SIDE



**Fig. 201: Identifying Left Secondary Camshaft Drive Chain Shoe To Cylinder Block Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain shoe to cylinder block retaining bolt (1).

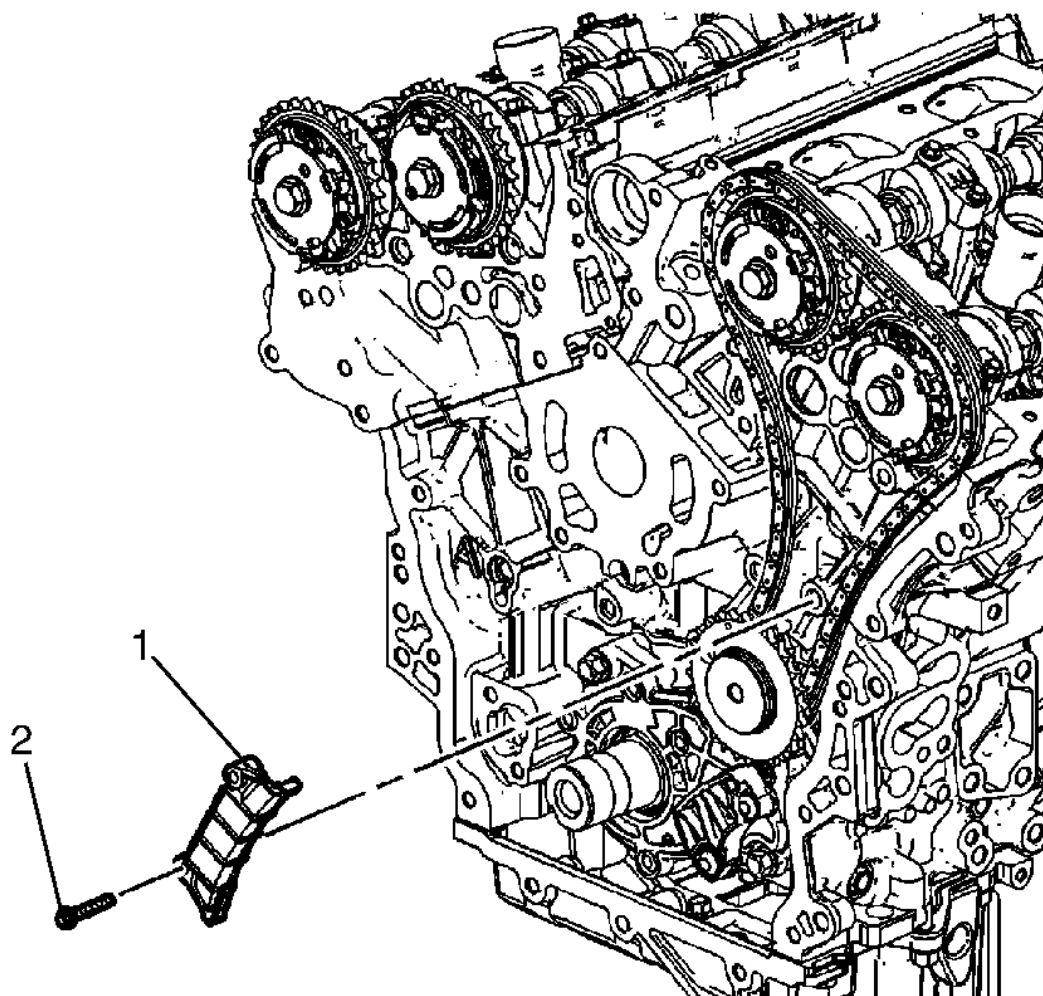




**Fig. 202: View Of Left Secondary Camshaft Drive Chain Shoe**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the left secondary camshaft drive chain shoe (1).

#### **SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REMOVAL - LEFT SIDE**

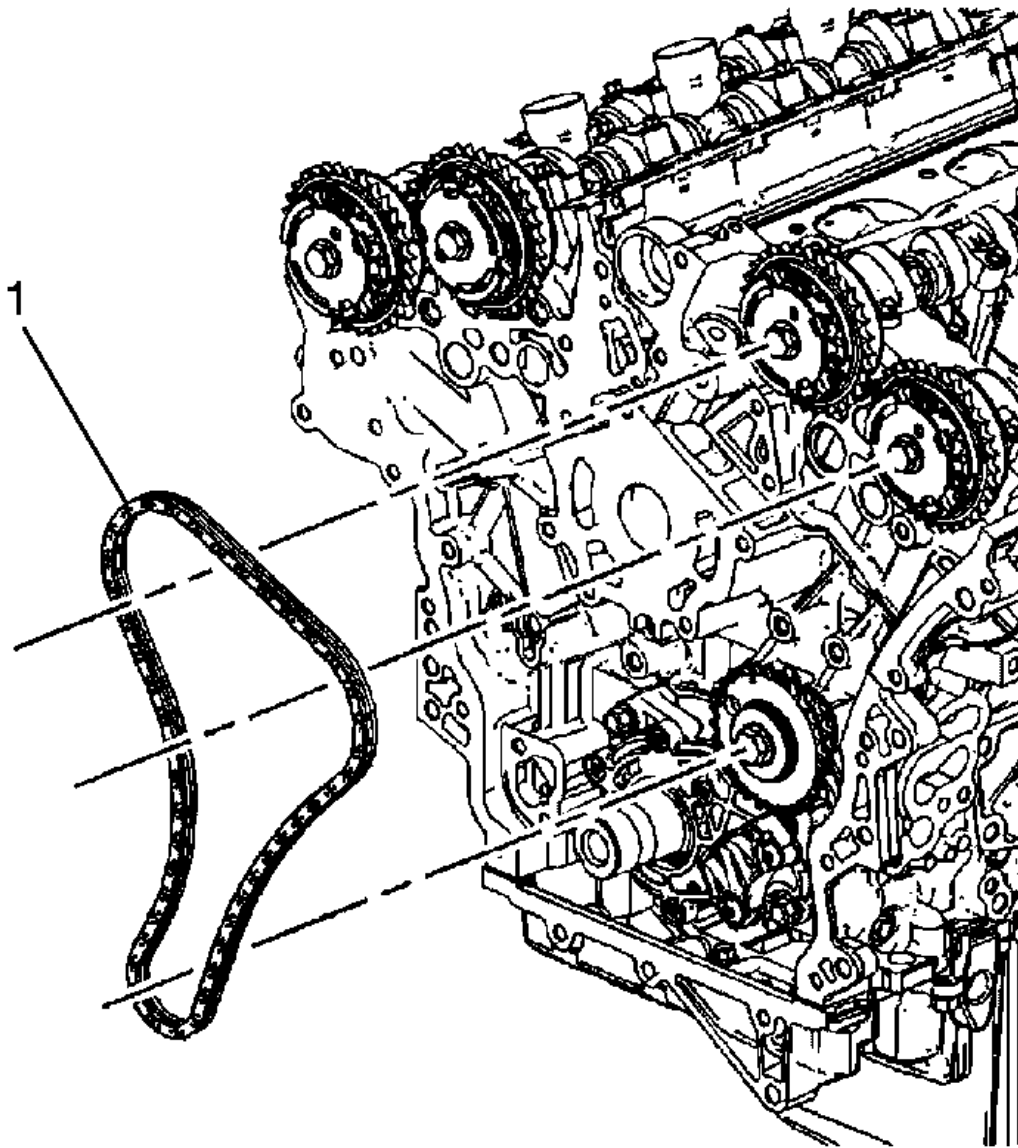


**Fig. 203: Identifying Left Secondary Camshaft Drive Chain Guide To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft drive chain guide to cylinder block retaining bolts (2).
2. Remove the left secondary camshaft drive chain guide (1).

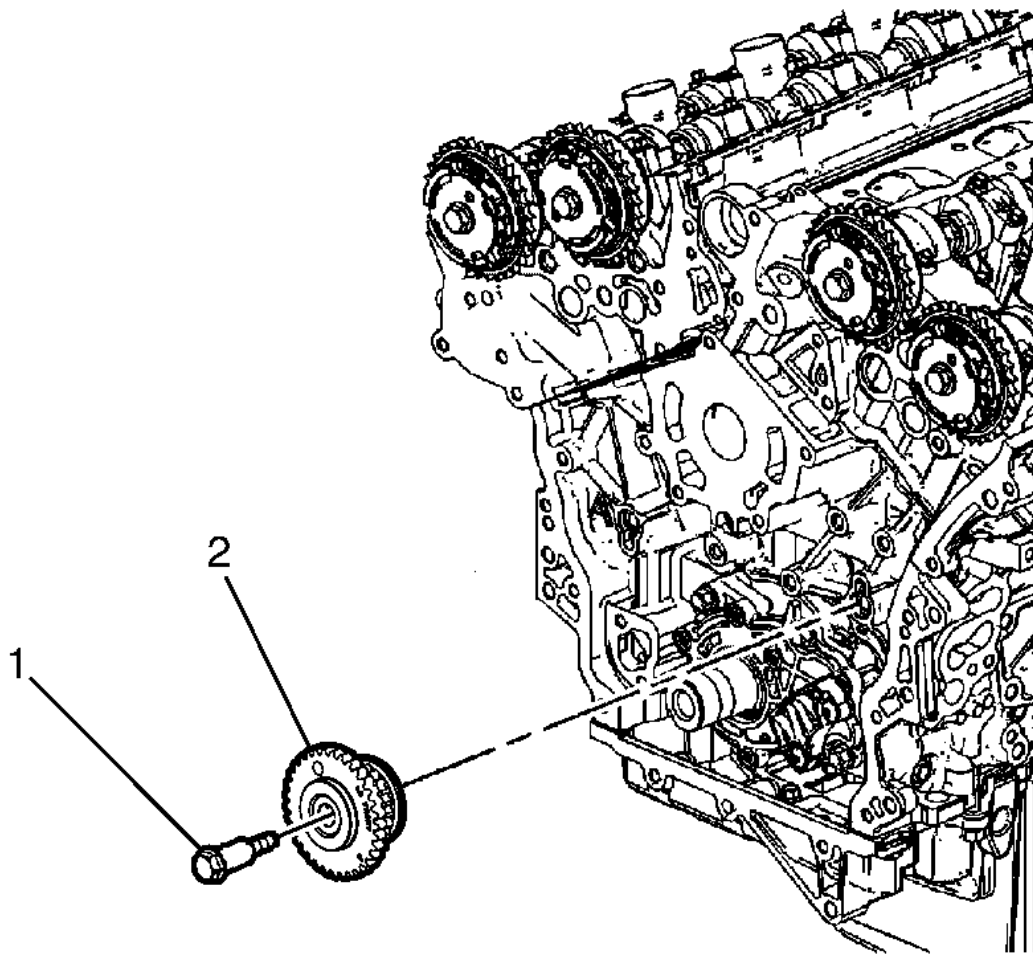
#### **SECONDARY CAMSHAFT DRIVE CHAIN REMOVAL - LEFT SIDE**



**Fig. 204: Identifying Left Secondary Camshaft Drive Chain**  
Courtesy of GENERAL MOTORS CORP.

Remove the left secondary camshaft drive chain (1).

**CAMSHAFT INTERMEDIATE DRIVE CHAIN IDLER REMOVAL - LEFT SIDE**

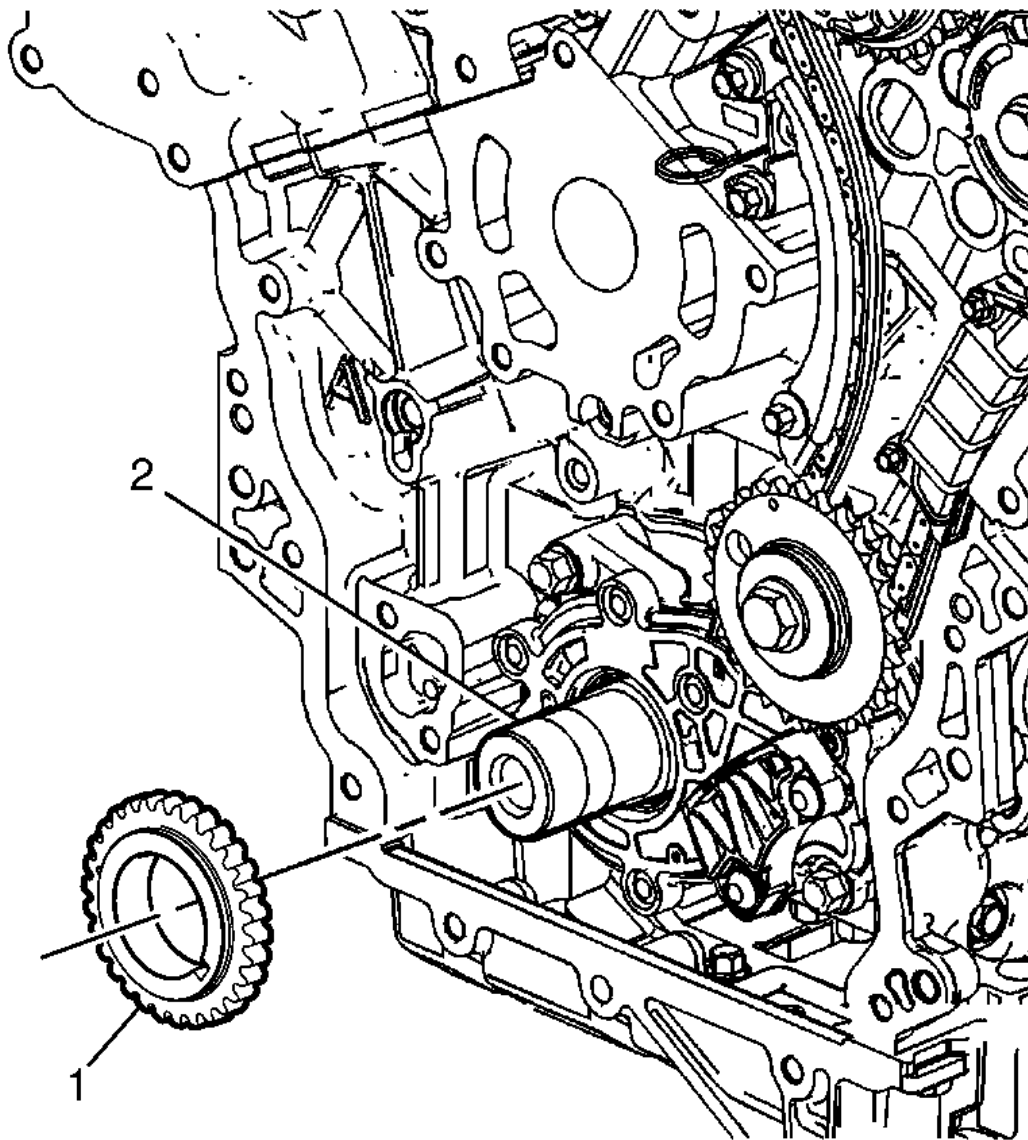


**Fig. 205: Identifying Left Camshaft Intermediate Drive Chain Idler To Cylinder Block Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

1. Remove the left camshaft intermediate drive chain idler to cylinder block retaining bolt (1).
2. Remove the left camshaft intermediate drive chain idler (2).

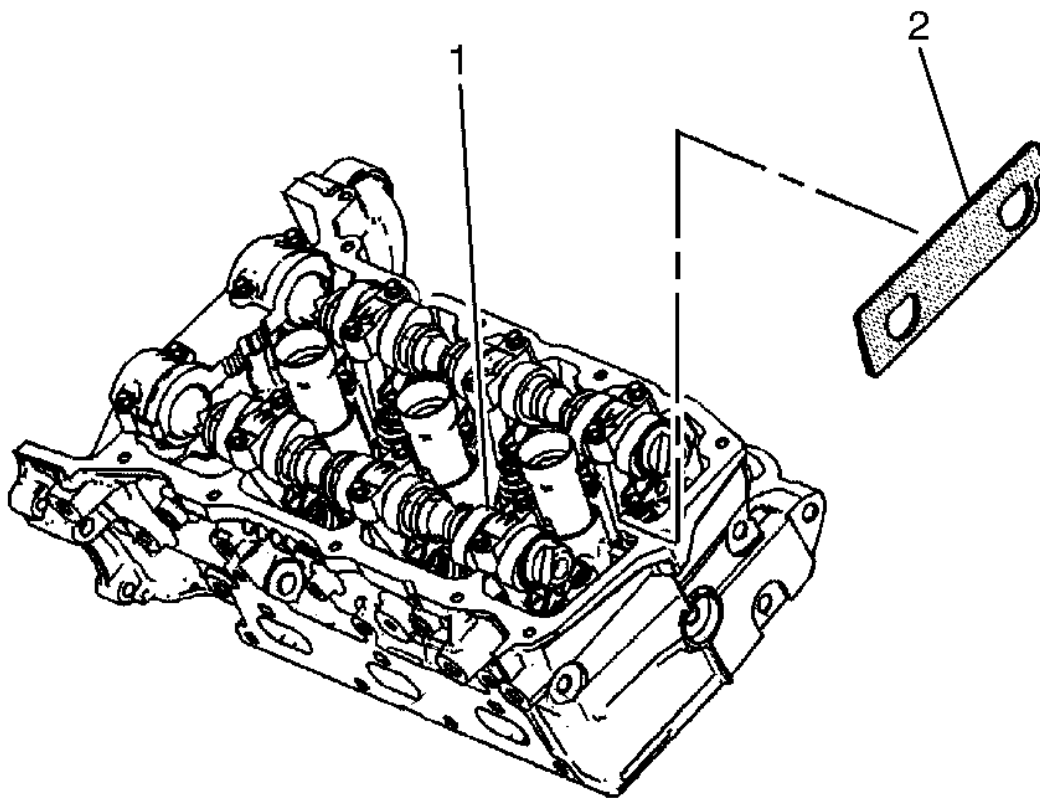
## **CRANKSHAFT SPROCKET REMOVAL**



**Fig. 206: Identifying Crankshaft & Sprocket**  
Courtesy of GENERAL MOTORS CORP.

Remove the crankshaft sprocket (1) from the nose of the crankshaft (2).

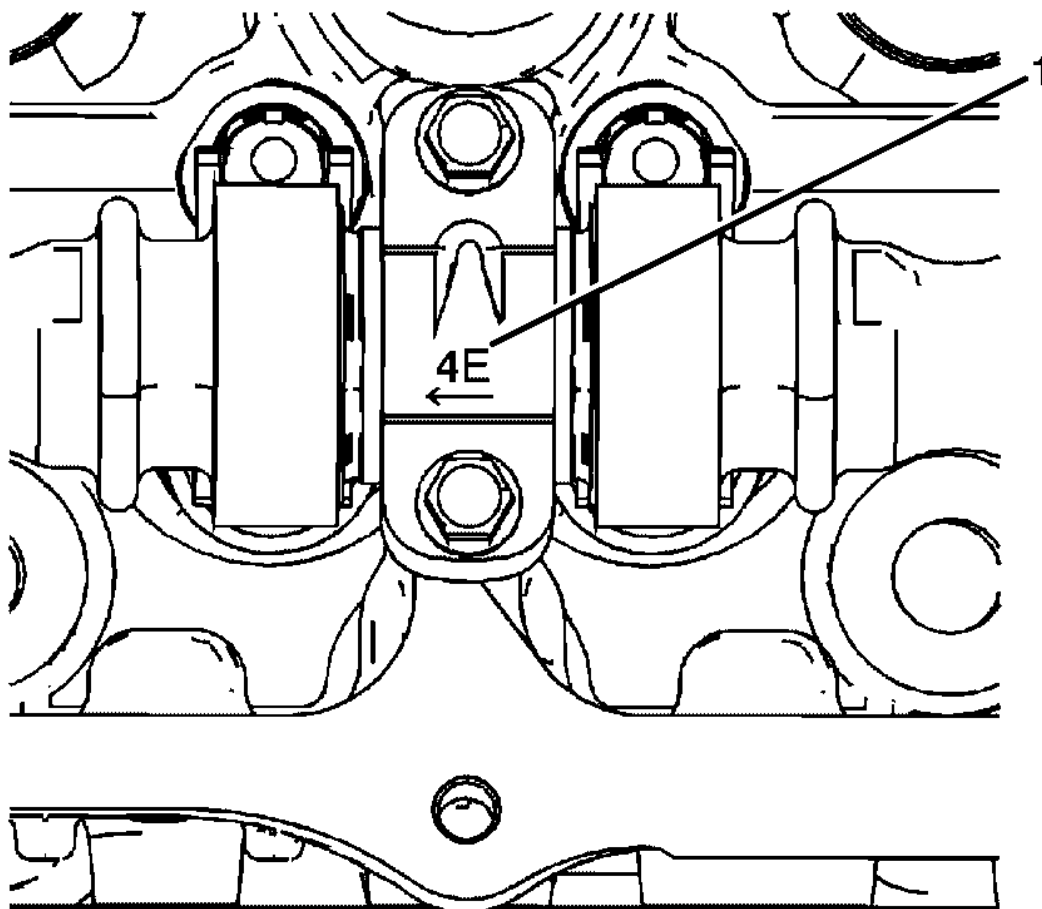
#### **CAMSHAFT REMOVAL - LEFT SIDE**



**Fig. 207: View Of EN 46105 & Left Bank Camshafts**  
Courtesy of GENERAL MOTORS CORP.

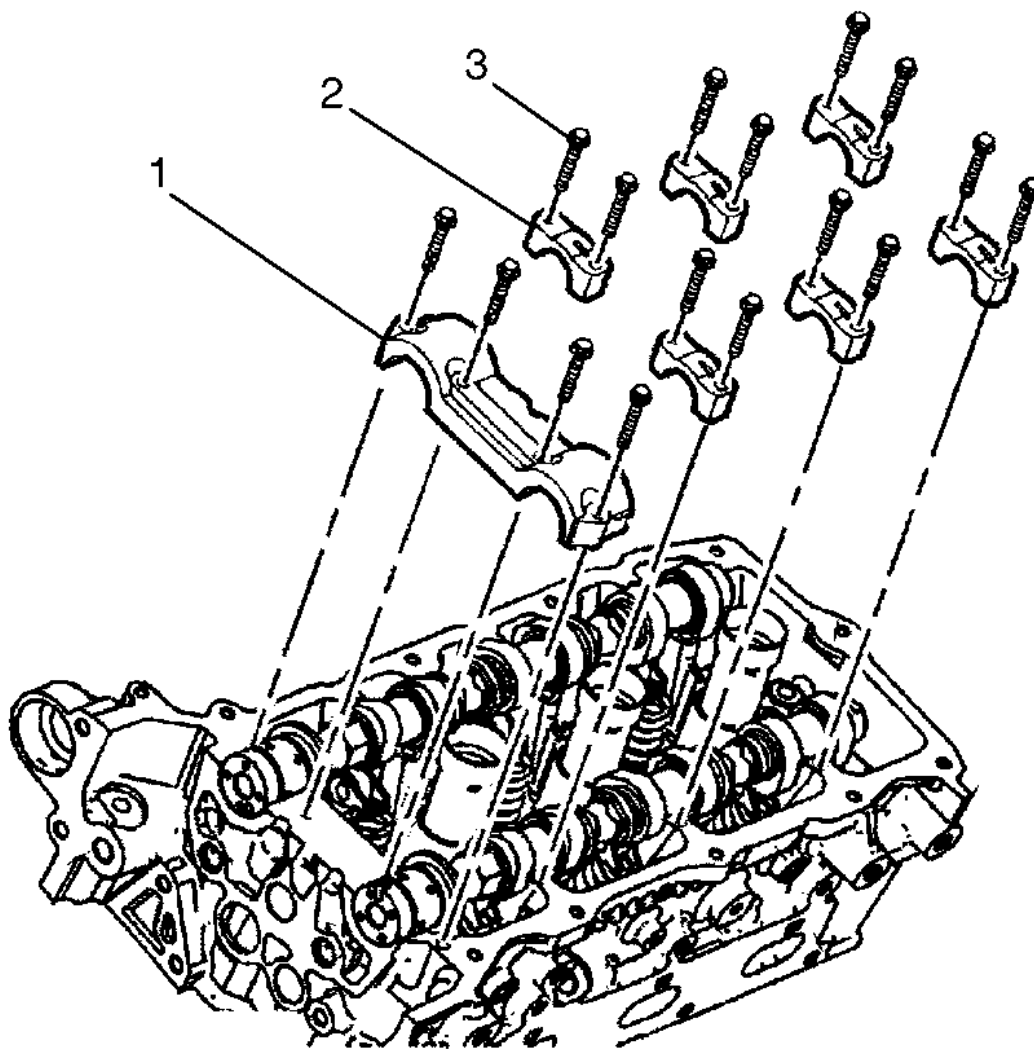
**IMPORTANT:** EN 46105 (2) was installed to the camshafts (1) as part of the left bank cylinder head camshaft position actuator removal procedure. See Special Tools .

1. Remove the **EN 46105** (2) from the left bank camshafts (1). See Special Tools .
2. Position the camshaft lobes in a neutral position.



**Fig. 208: Locating Bearing Cap Markings**  
Courtesy of GENERAL MOTORS CORP.

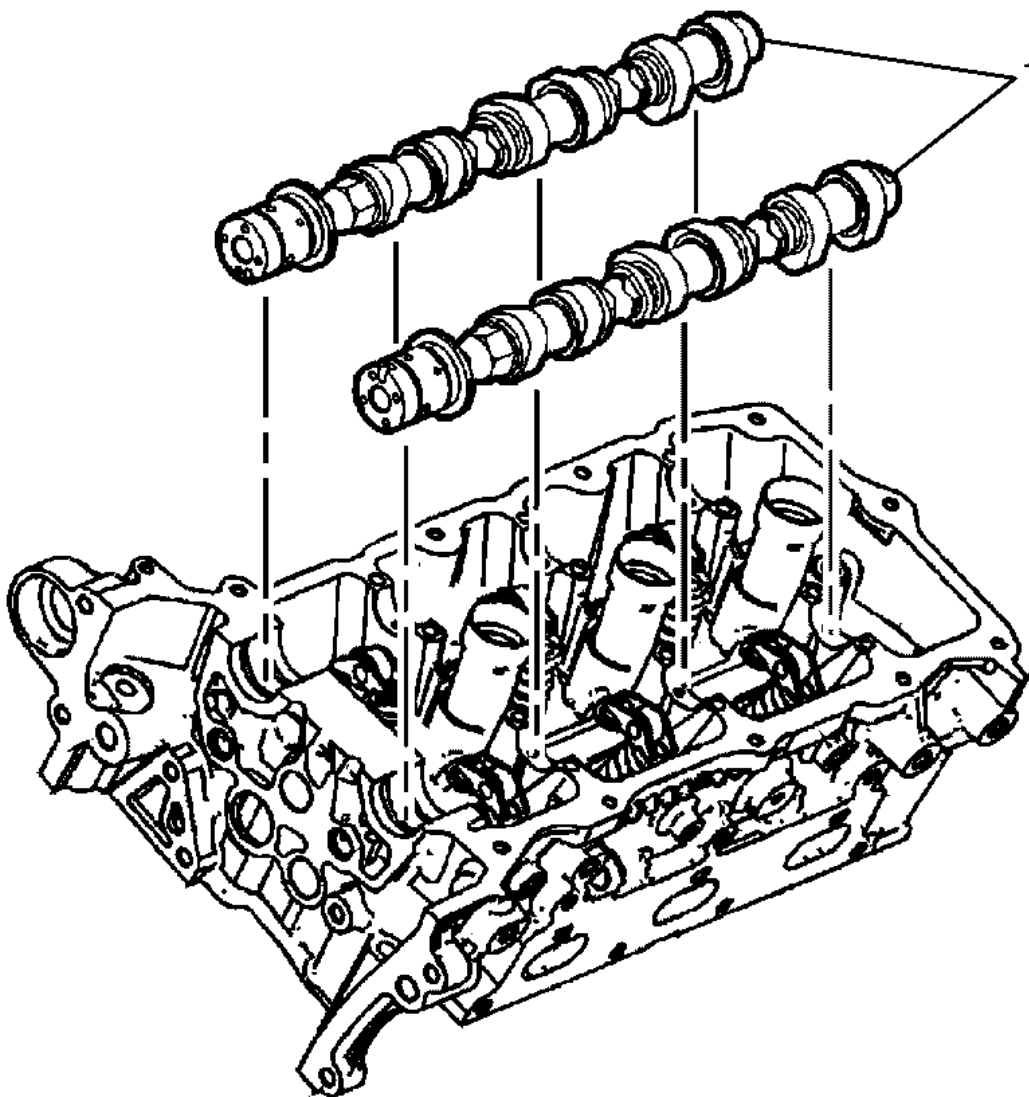
3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
  - The raised feature must always be oriented toward the center of the cylinder head.
  - The I indicates the intake camshaft.
  - The E indicates the exhaust camshaft.
  - The number indicates the journal position from the front of the cylinder block.



**Fig. 209: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft bearing cap to cylinder head retaining bolts (3).
5. Remove the camshaft bearing caps (1 and 2).



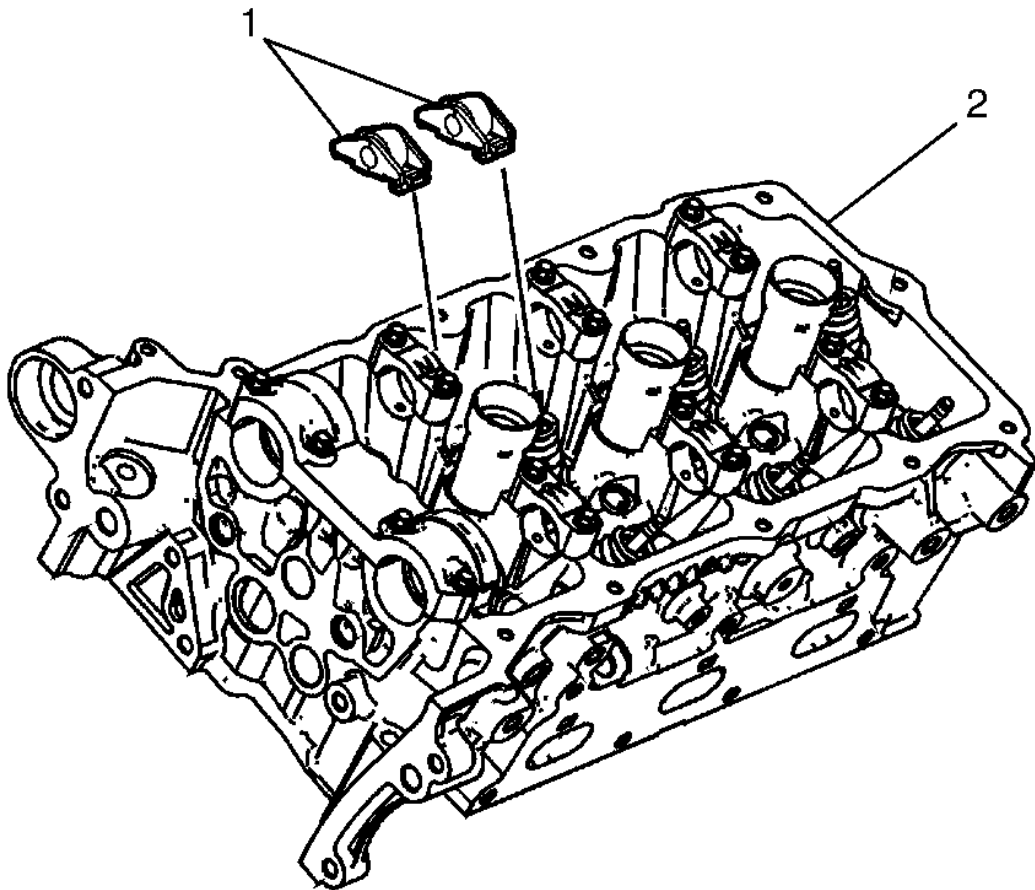


**Fig. 210: View Of Camshafts**

Courtesy of GENERAL MOTORS CORP.

6. Remove the camshafts (1).

#### VALVE ROCKER ARM REMOVAL - LEFT SIDE

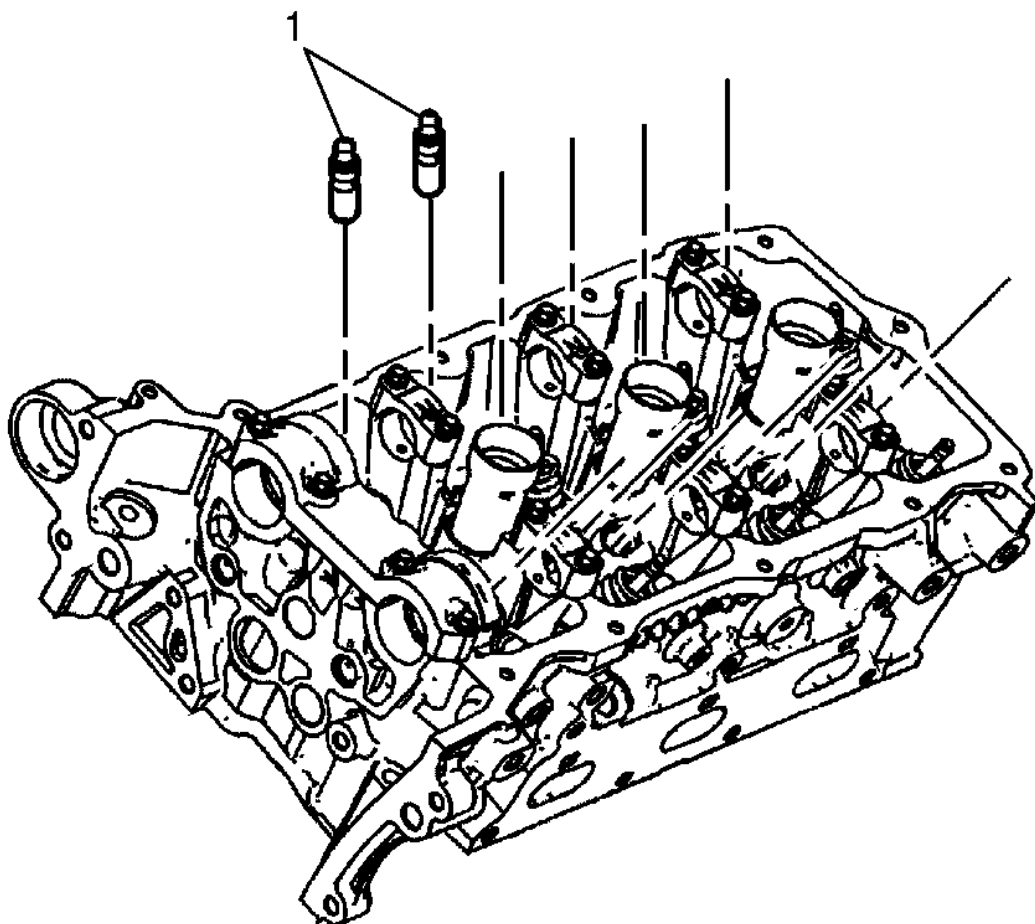


**Fig. 211: View Of Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The valve rocker arms (1) must be installed in their original locations.

1. Record the positions of the valve rocker arms (1).
2. Remove the valve rocker arms (1) from the cylinder head (2).

#### **VALVE LIFTER REMOVAL - LEFT SIDE**



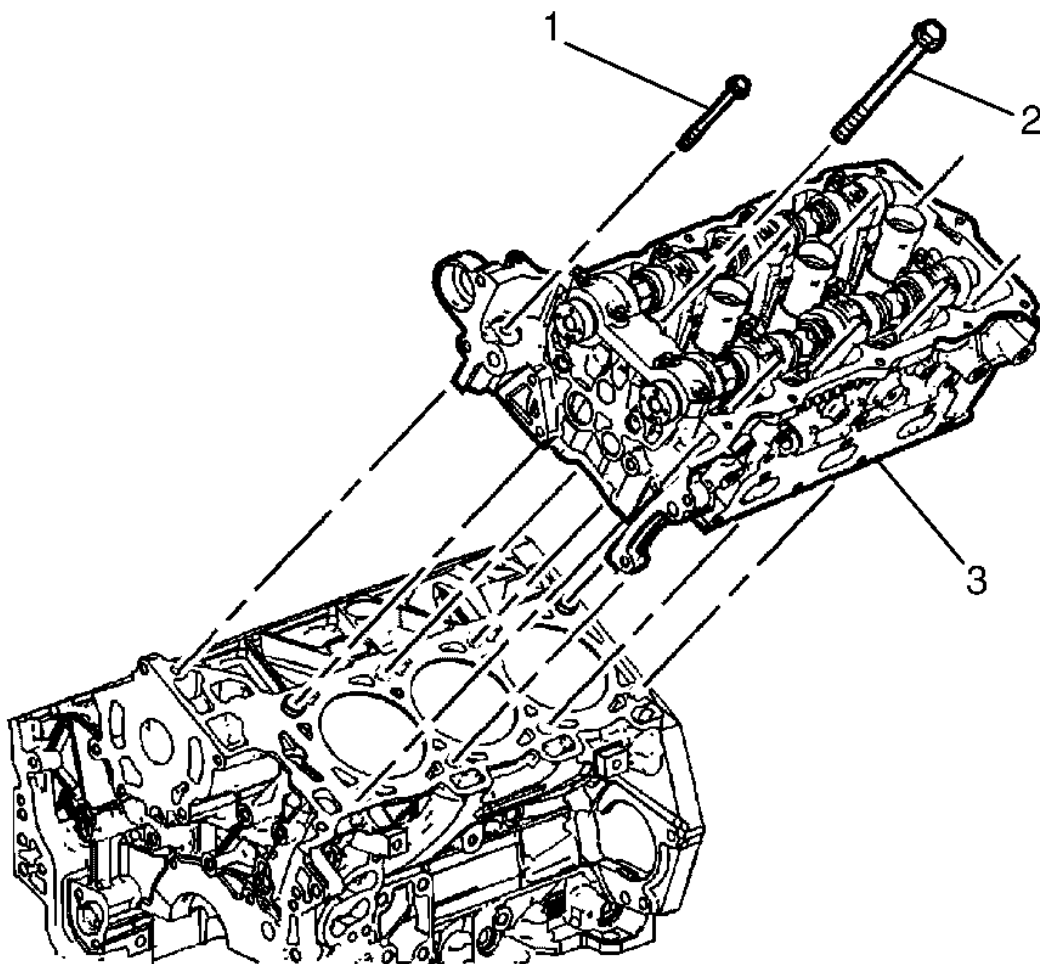
**Fig. 212: View Of Stationary Hydraulic Lash Adjusters (SHLAs)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- **DO NOT** stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- **DO NOT** allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

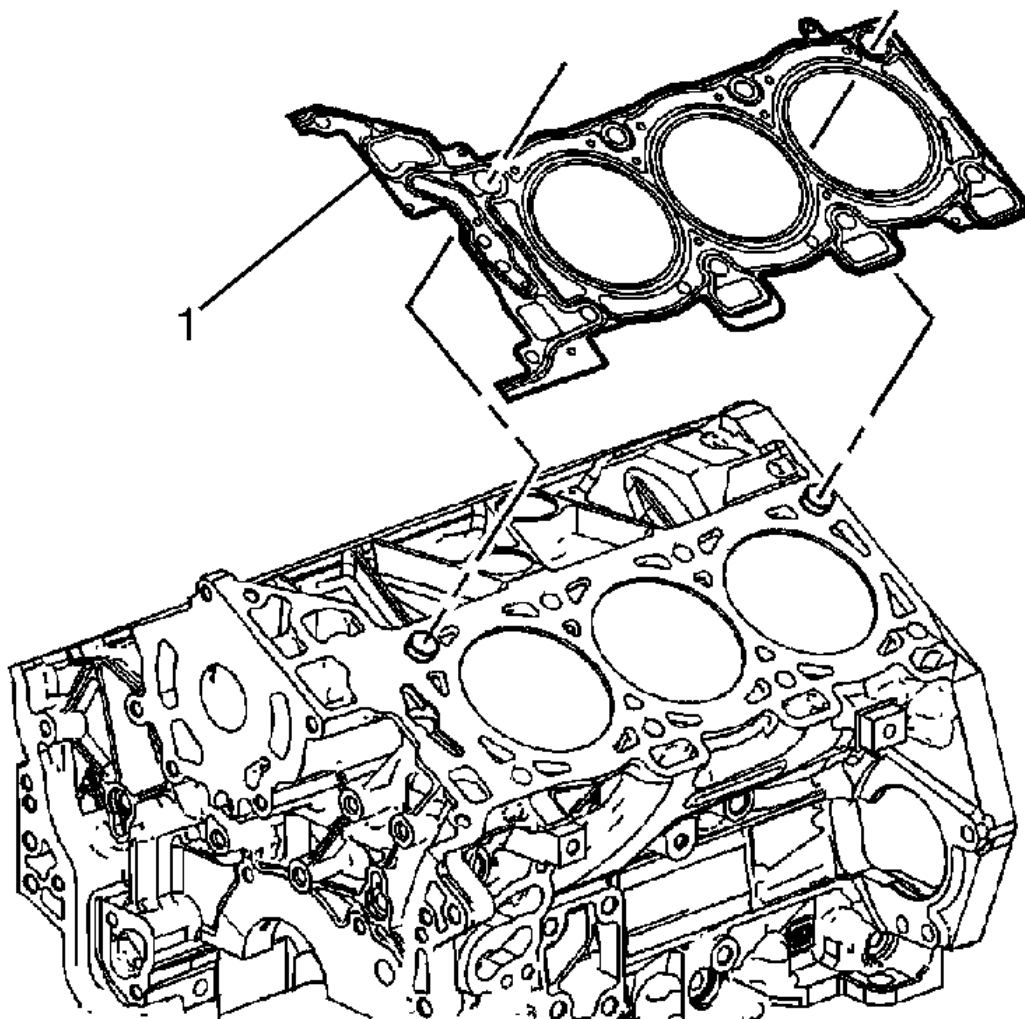
1. Remove the Stationary Hydraulic Lash Adjuster, (SHLAs) (valve lifters) (1).

**CYLINDER HEAD REMOVAL - LEFT SIDE**



**Fig. 213: Identifying M8 & M11 Cylinder Head To Cylinder Block Retaining Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

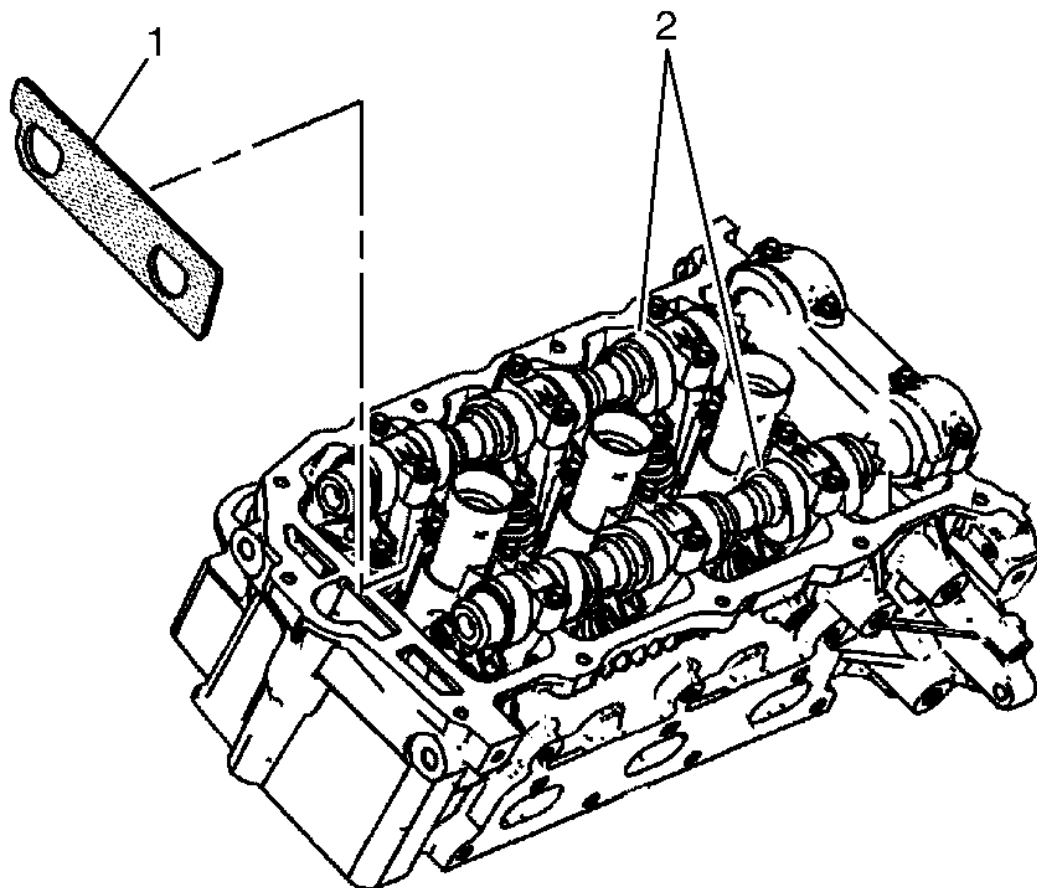
1. Remove the left bank cylinder head to cylinder block retaining bolts (1 and 2).
2. Remove the left bank cylinder head (3).



**Fig. 214: View Of Left Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the left cylinder head gasket (1).

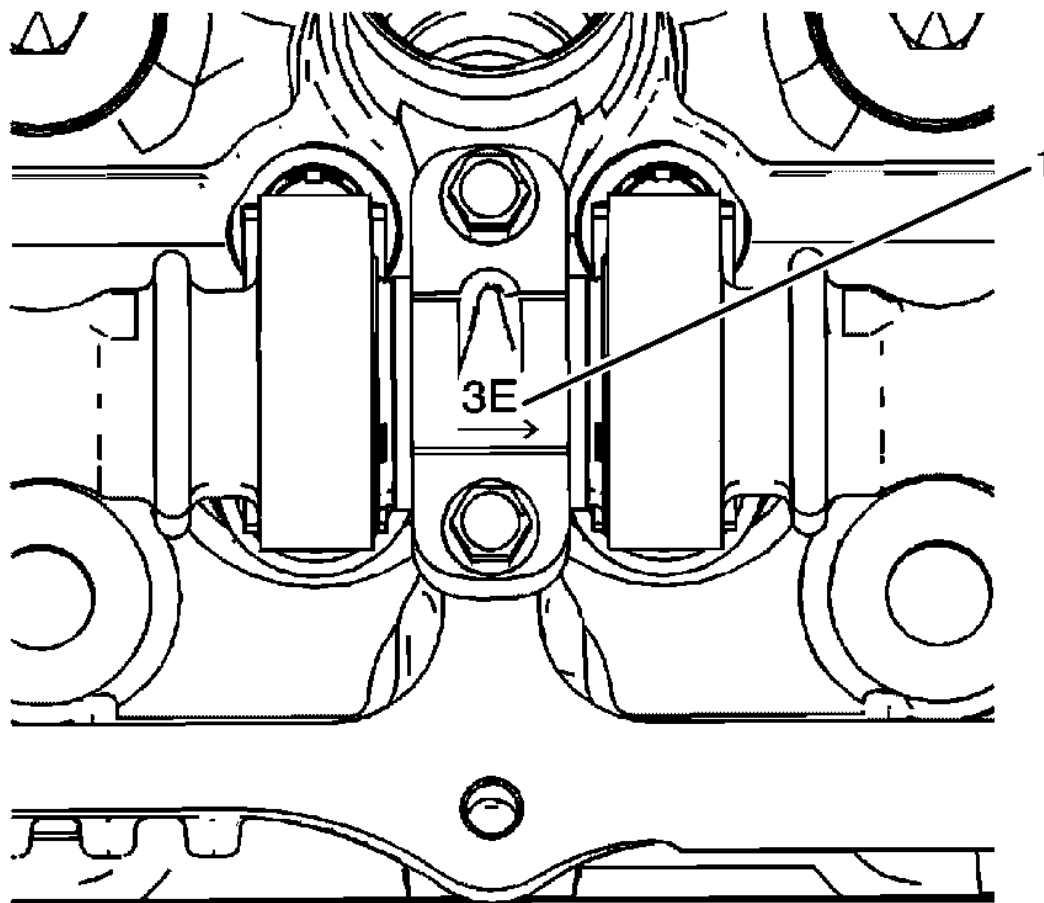
#### **CAMSHAFT REMOVAL - RIGHT SIDE**



**Fig. 215: View Of EN 46105 & Right Bank Camshafts**  
Courtesy of GENERAL MOTORS CORP.

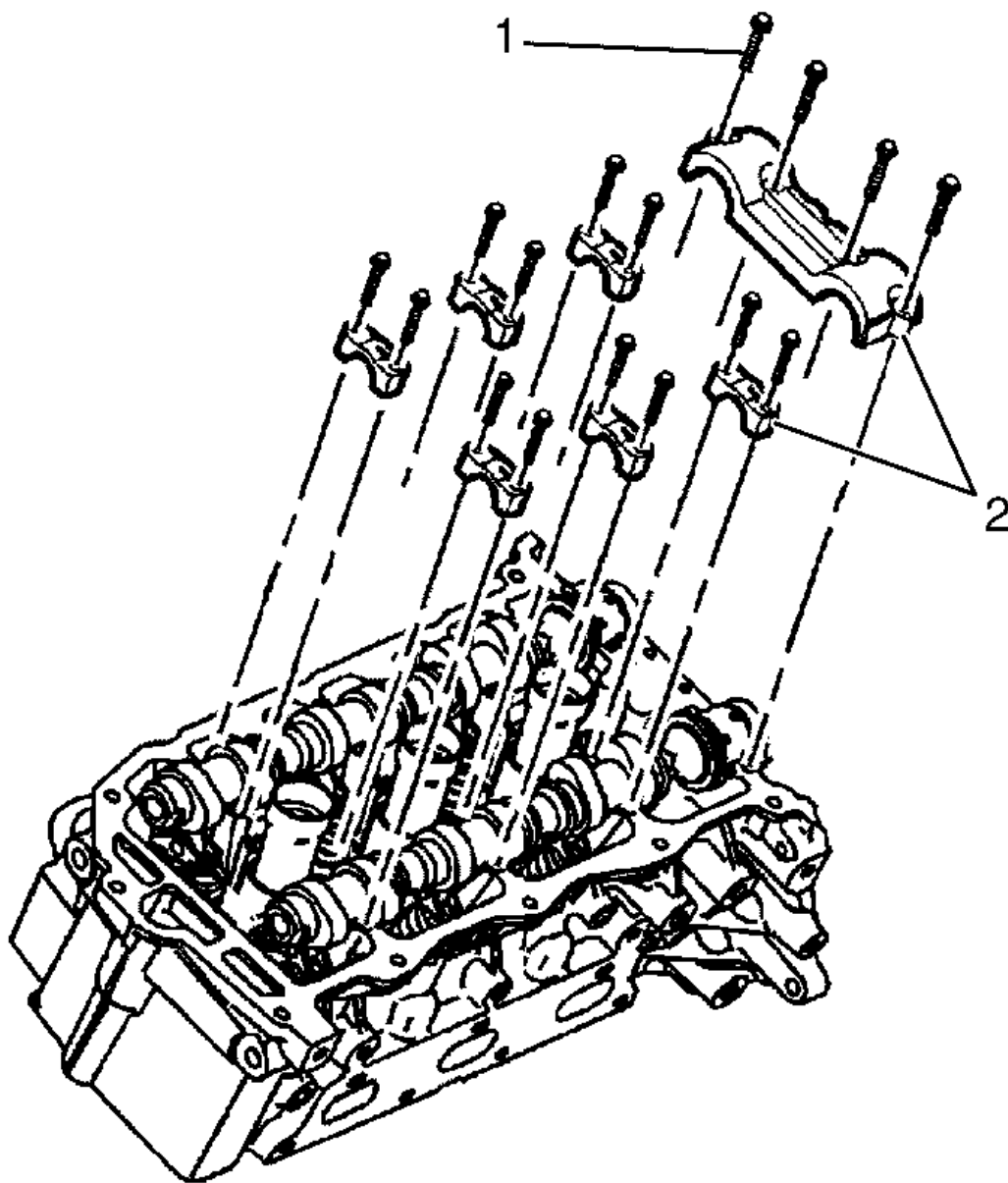
**IMPORTANT:** EN 46105 (1) was installed to the camshafts (2) as part of the right bank cylinder head camshaft position actuator removal procedure. See **Special Tools** .

1. Remove the **EN 46105** (1) from the right bank camshafts (2). See **Special Tools** .
2. Position the camshaft lobes in a neutral position.



**Fig. 216: Locating Right Cylinder Head Camshaft Bearing Cap Markings**  
Courtesy of GENERAL MOTORS CORP.

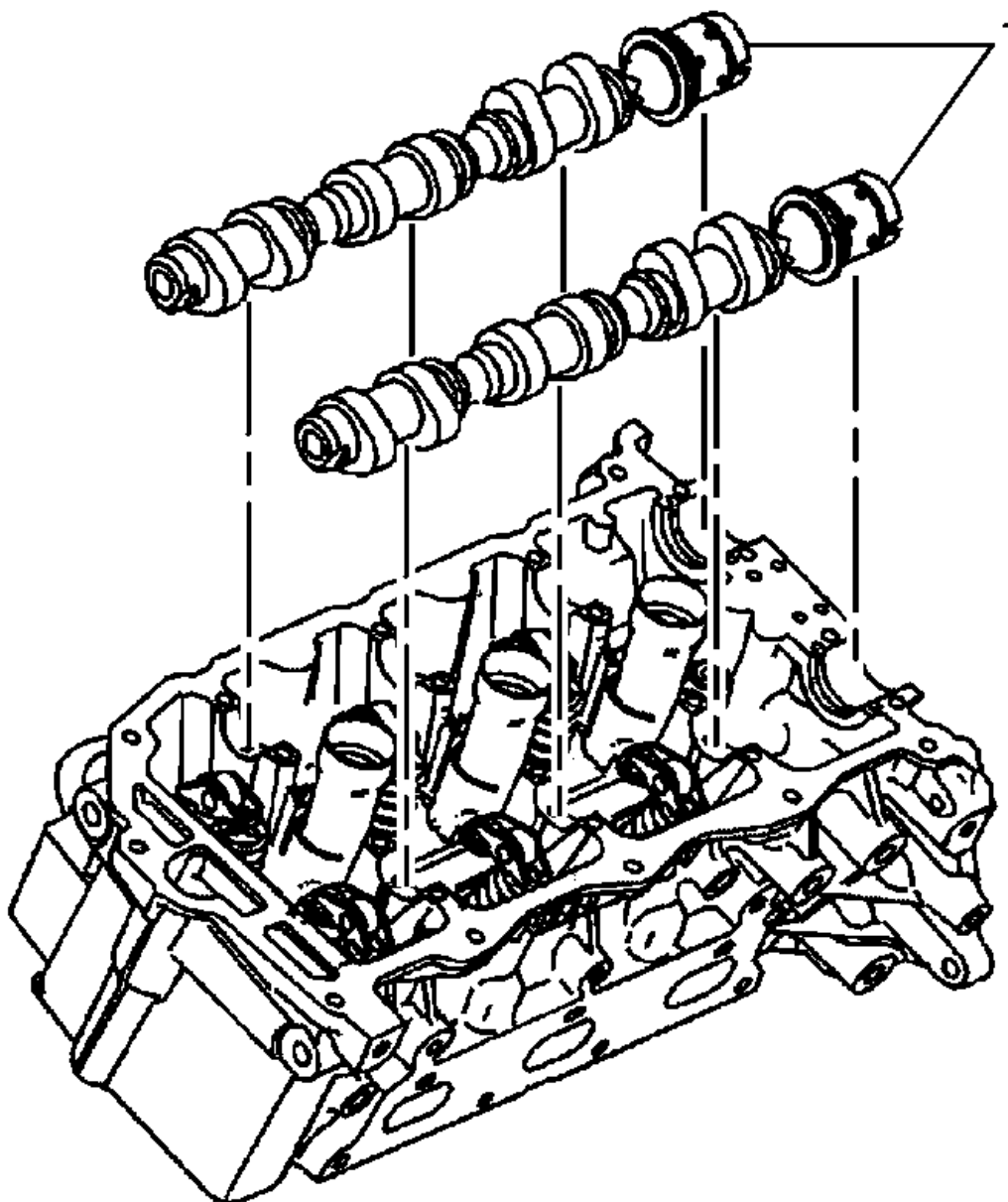
3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
  - The raised feature must always be oriented toward the center of the cylinder head.
  - The I indicates the intake camshaft.
  - The E indicates the exhaust camshaft.
  - The number indicates the journal position from the front of the cylinder block.



**Fig. 217: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft bearing cap to cylinder head retaining bolts (1).
5. Remove the camshaft bearing caps (2).

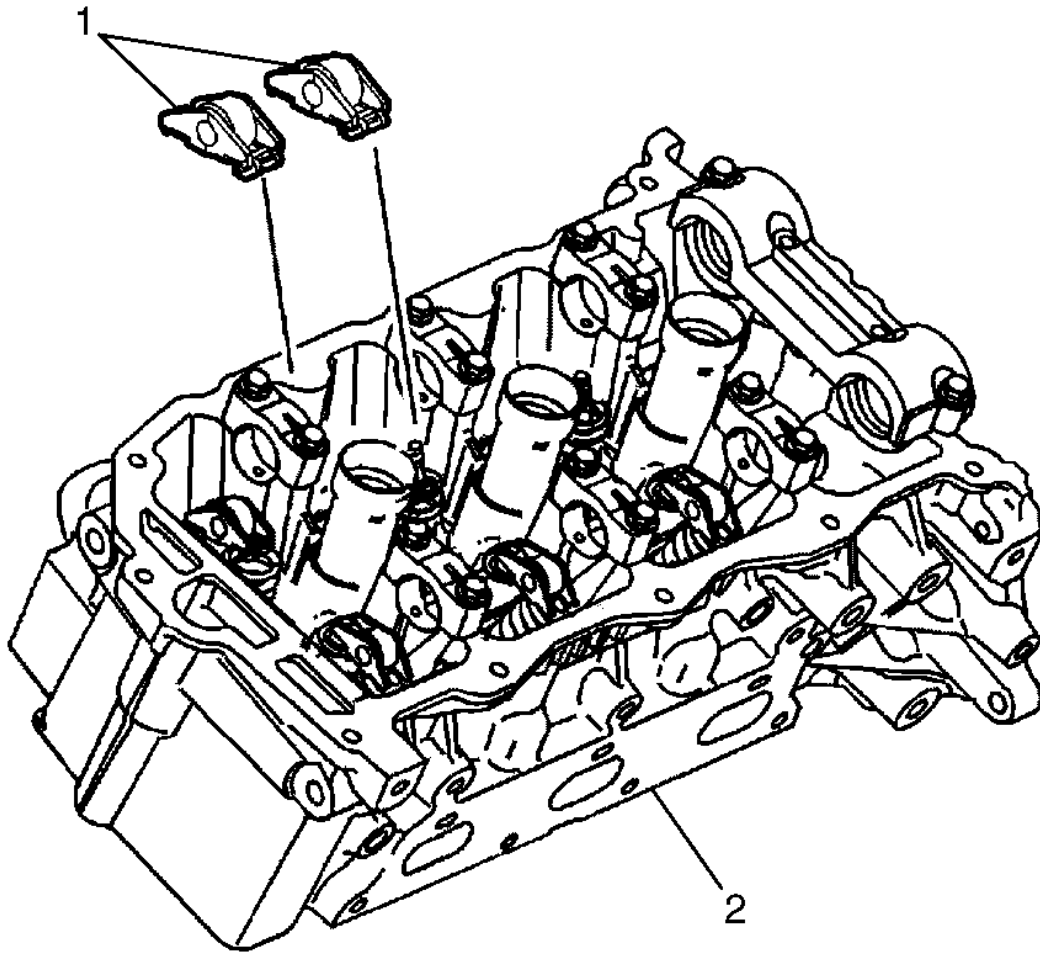




**Fig. 218: View Of Camshafts**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshafts (1).

#### VALVE ROCKER ARM REMOVAL - RIGHT SIDE

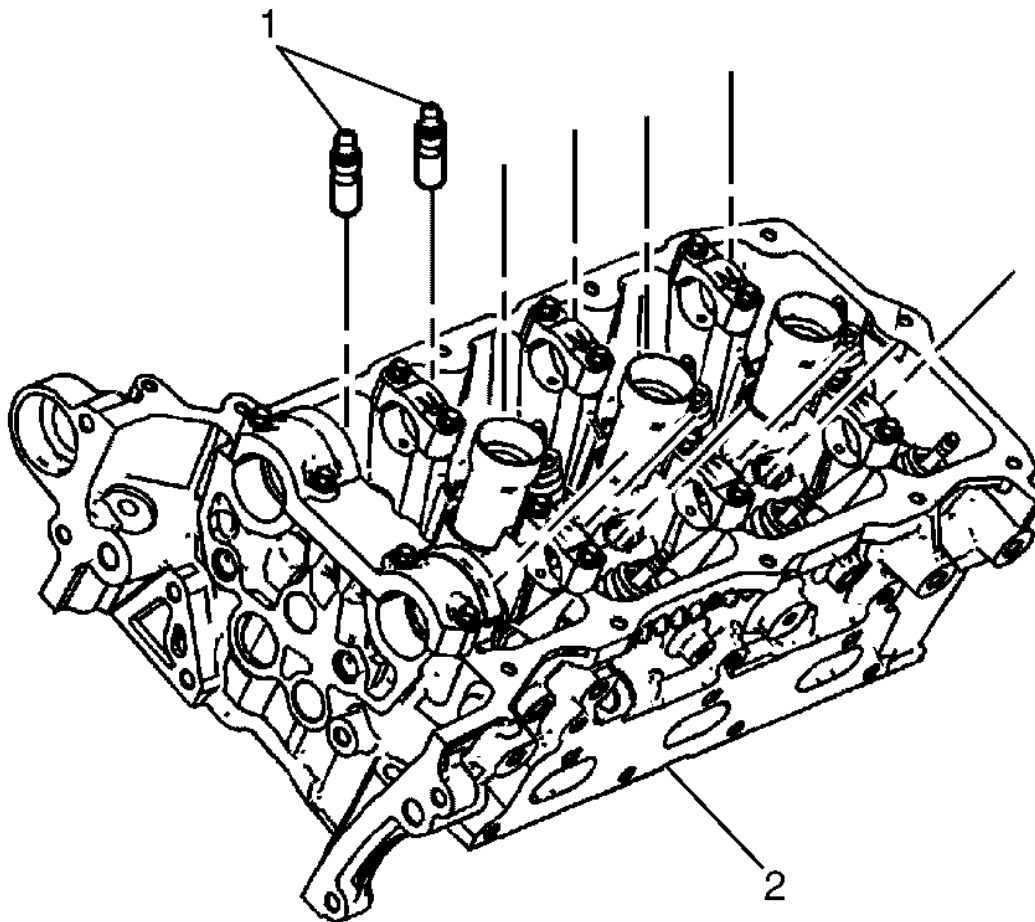


**Fig. 219: View Of Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The valve rocker arms (1) must be installed in their original locations.

1. Record the positions of the valve rocker arms (1).
2. Remove the valve rocker arms (1) from the right bank cylinder head (2).

#### VALVE LIFTER REMOVAL - RIGHT SIDE



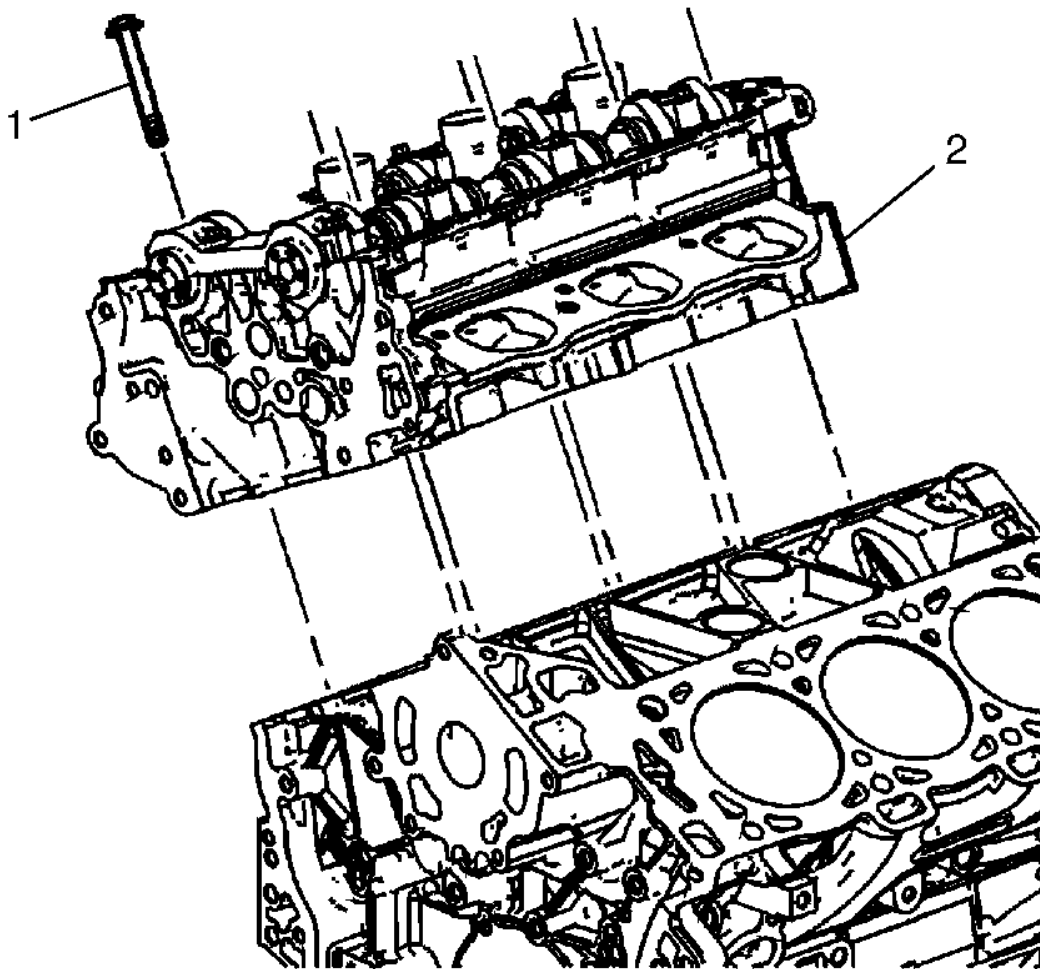
**Fig. 220: View Of SHLAs Valve Lifters**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- **DO NOT** stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- **DO NOT** allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

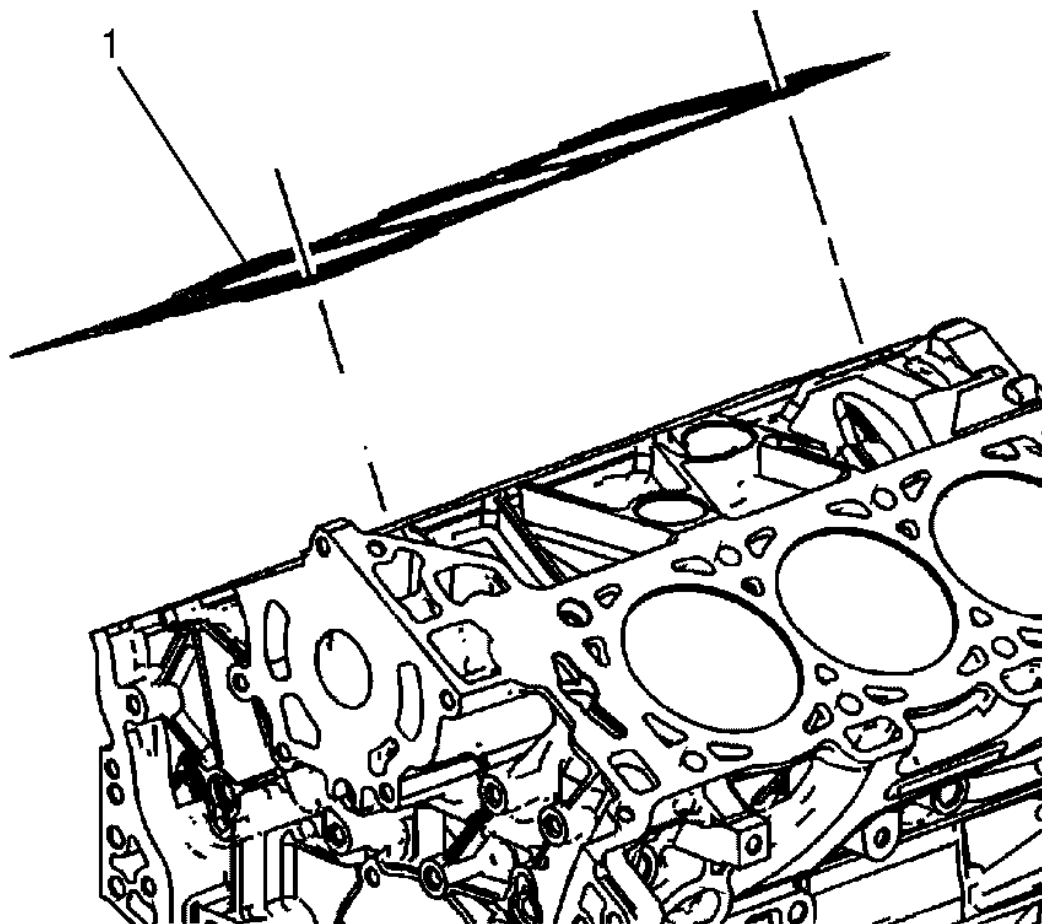
1. Remove the Stationary Hydraulic Lash Adjuster, (SHLAs) (valve lifters) (1) from the right bank cylinder head (2).

**CYLINDER HEAD REMOVAL - RIGHT SIDE**



**Fig. 221: Identifying M11 & M8 Cylinder Head To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the right bank cylinder head to cylinder block retaining bolts (1).
2. Remove the right bank cylinder head (2).



**Fig. 222: View Of Right Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

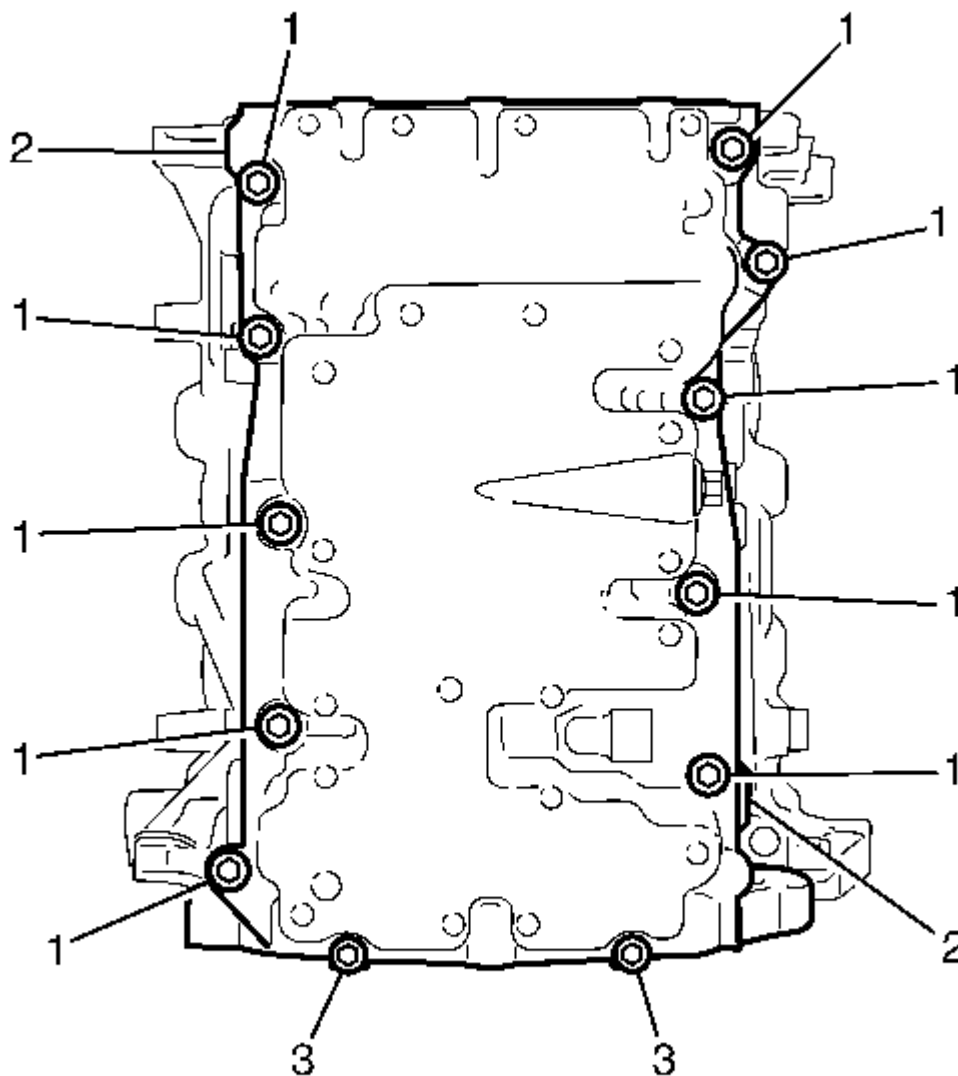
3. Remove and discard the right cylinder head gasket (1).

2009 ENGINE

Engine Mechanical - 3.6L - G8

REPAIR INSTRUCTIONS - OFF VEHICLE

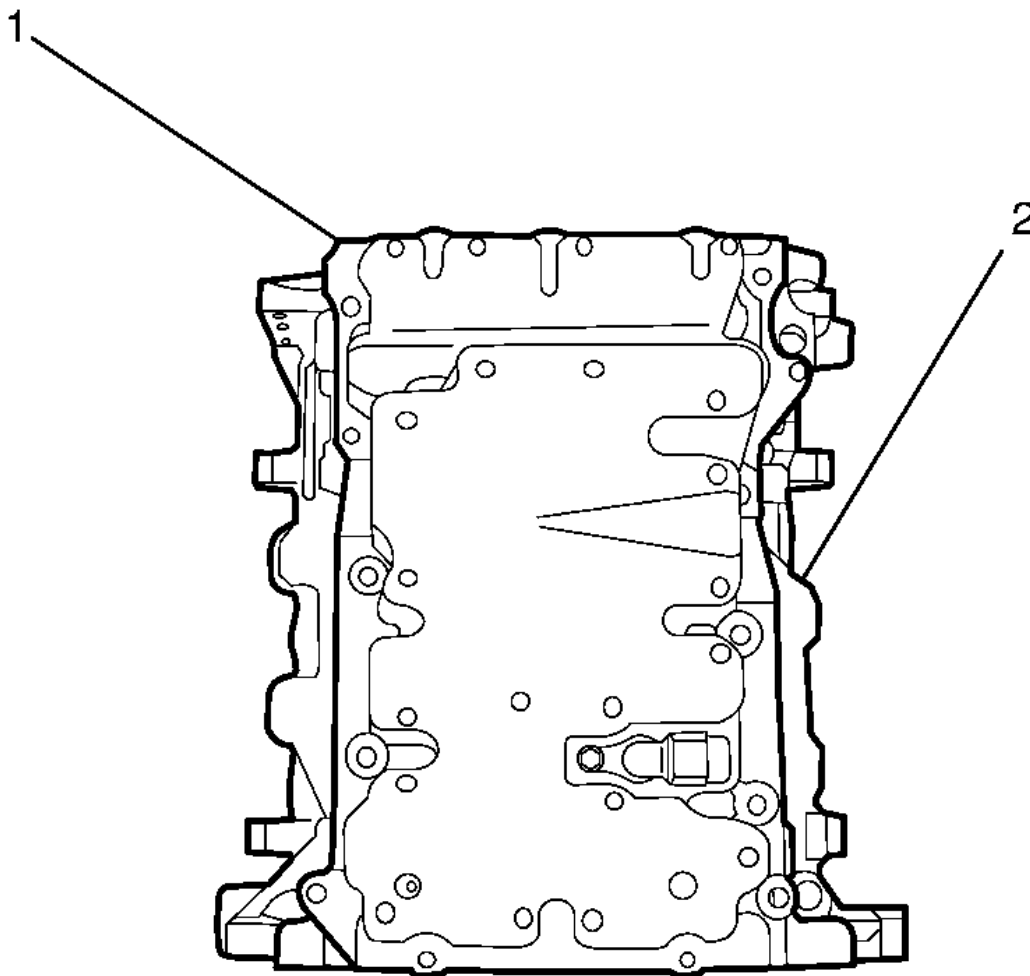
OIL PAN REMOVAL



**Fig. 1: Identifying M8 & M6 Oil Pan Retaining Bolts**

**Courtesy of GENERAL MOTORS CORP.**

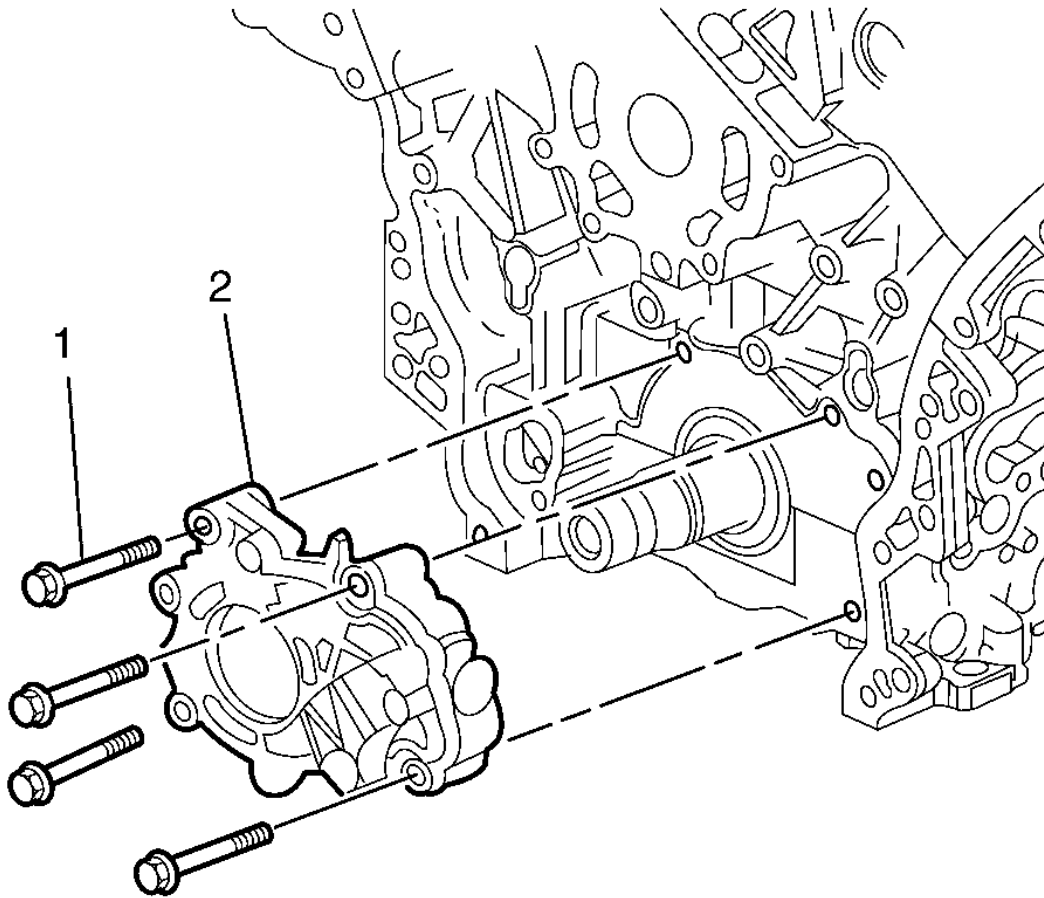
1. Remove the M8 oil pan to cylinder block retaining bolts (1).
2. Remove the M6 oil pan to crankshaft rear oil seal housing retaining bolts (3).
3. Using the pry points located at the edge of the oil pan (2) shear the RTV sealant.



**Fig. 2: View Of Oil Pan & Cylinder Block**  
**Courtesy of GENERAL MOTORS CORP.**

4. Remove the oil pan (1) from the cylinder block (2).

## **OIL PUMP REMOVAL**

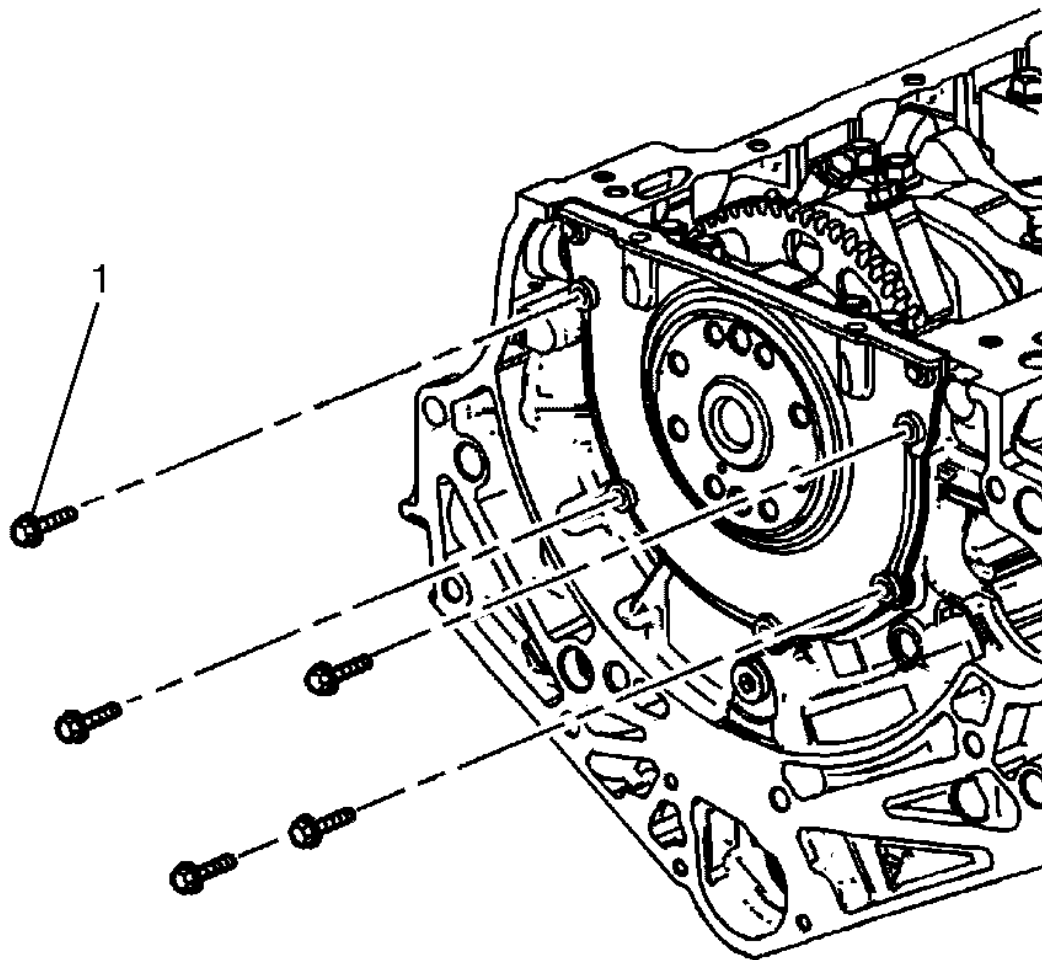


**Fig. 3: Identifying Oil Pump To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump to cylinder block retaining bolts (1).
2. Remove the oil pump (2).

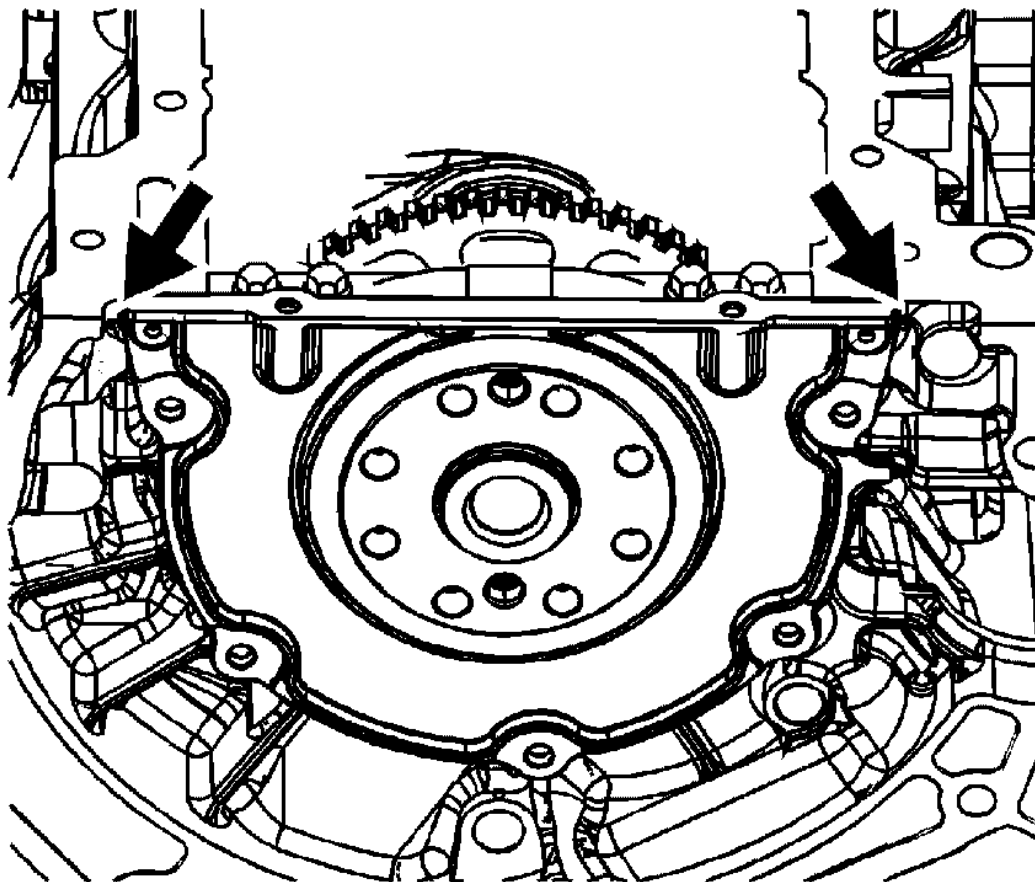
#### **CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL**





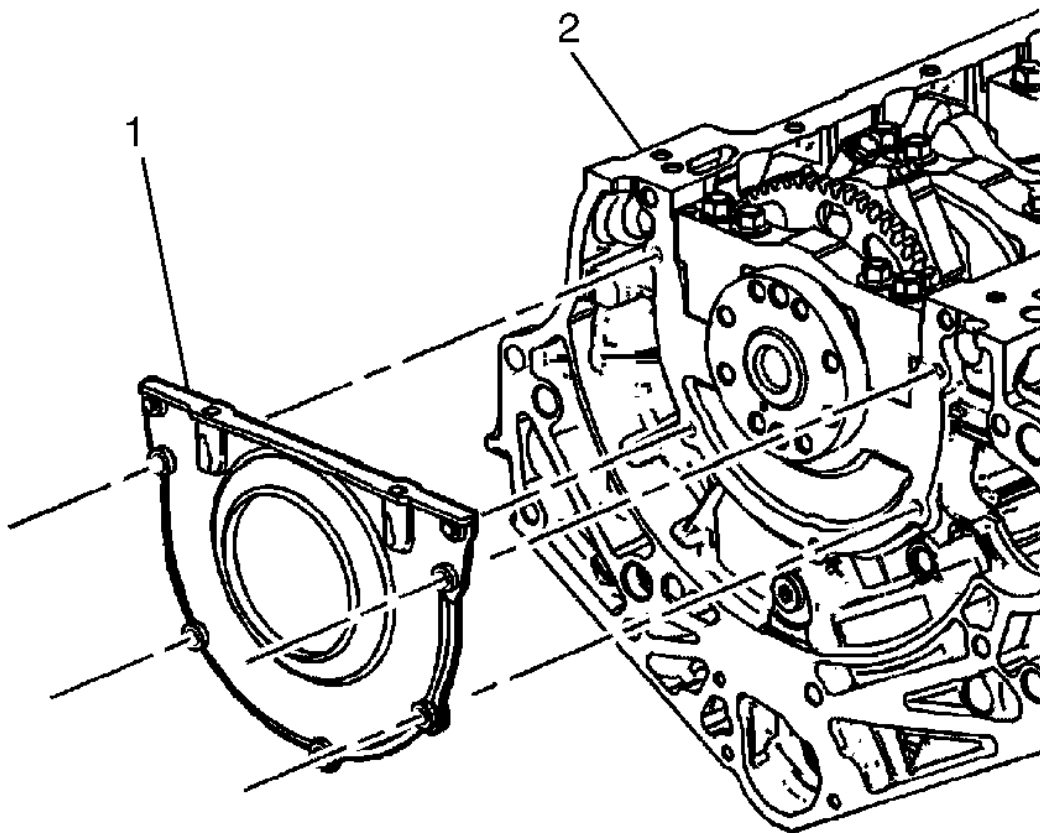
**Fig. 4: Identifying Crankshaft Rear Oil Seal Housing Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal housing bolts (1).



**Fig. 5: Identifying Crankshaft Rear Oil Seal Housing Pry Points**  
Courtesy of GENERAL MOTORS CORP.

2. Using the pry points located at the edge of the crankshaft rear oil seal housing shear the RTV sealant.



**Fig. 6: Identifying Crankshaft Rear Oil Seal Housing & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

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

## PISTON, CONNECTING ROD, AND BEARING REMOVAL

### Special Tools

**EN 46121:** Connecting Rod Guide Pin Set

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

### Removal

#### NOTE:

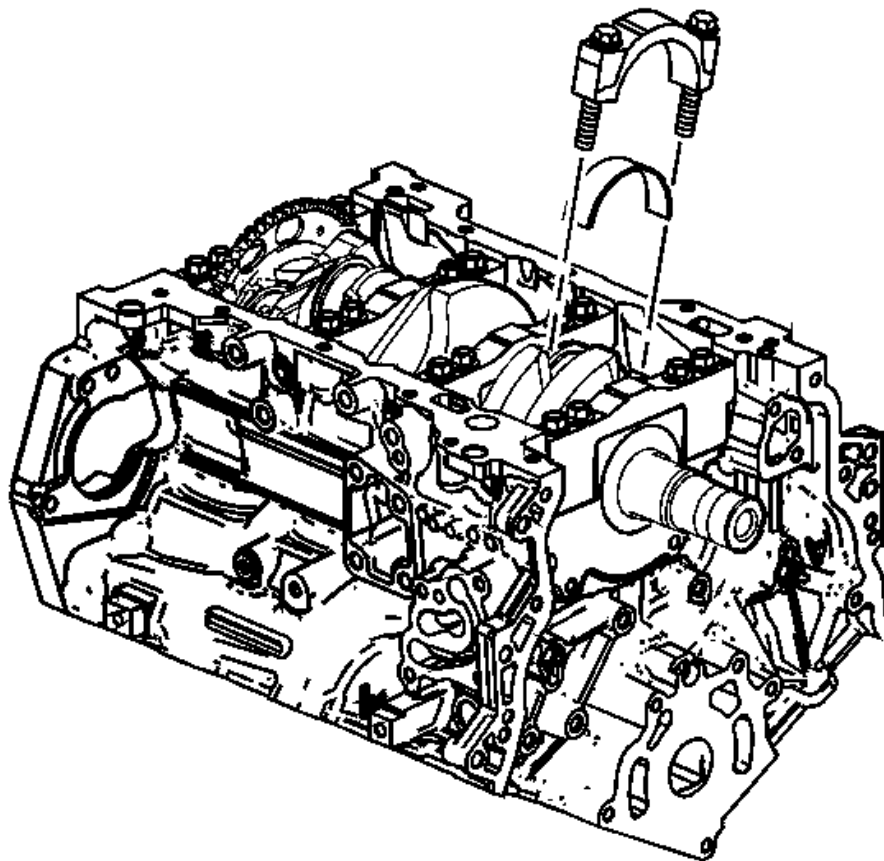
- An arrow/dot showing proper piston orientation is located on the top of the piston.
- If the connecting rod bearings have been used in a running engine,

**you must replace them with NEW connecting rod bearings for reassembly.**

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
  1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
  2. Using feeler gages, measure the clearance between the crankshaft counterweight and the connecting rod.
  3. The connecting rod side clearance should not exceed specifications. Refer to **Engine Mechanical Specifications** .
  4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection** .
  5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
  6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

**CAUTION: Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.**

3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.



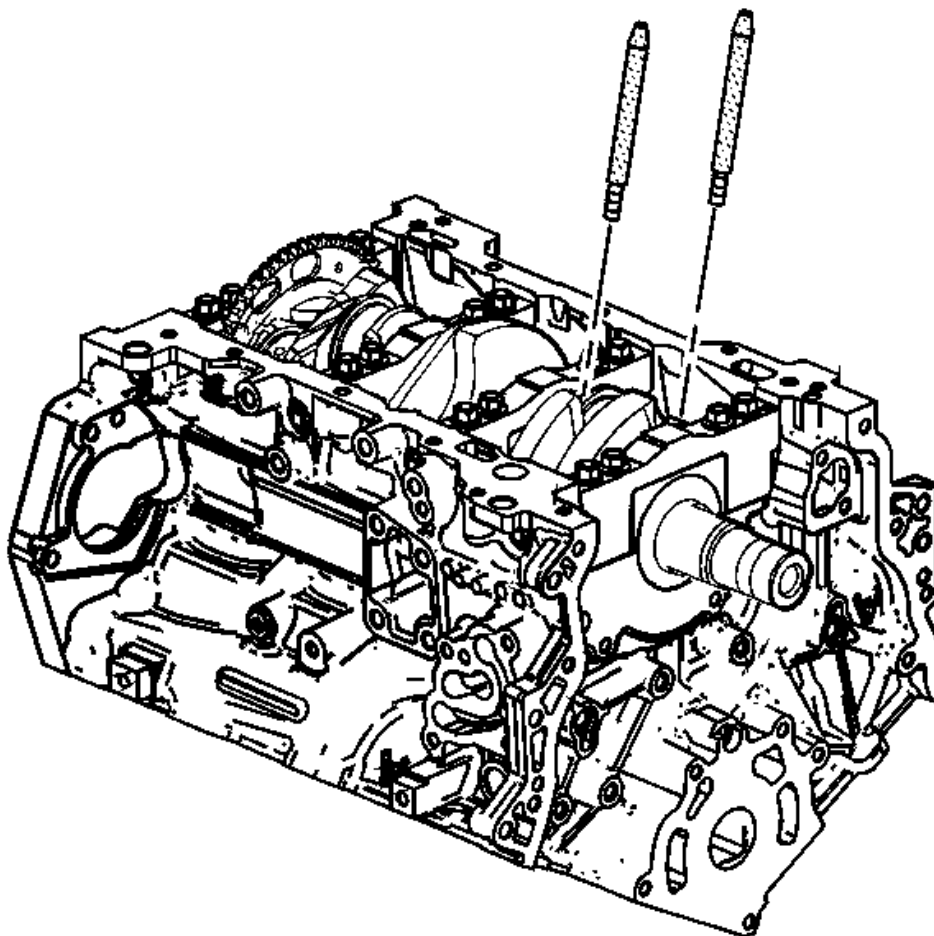
**Fig. 7: View Of Connecting Rod Bearing And Cap**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.

4. Remove the connecting rod bolts.

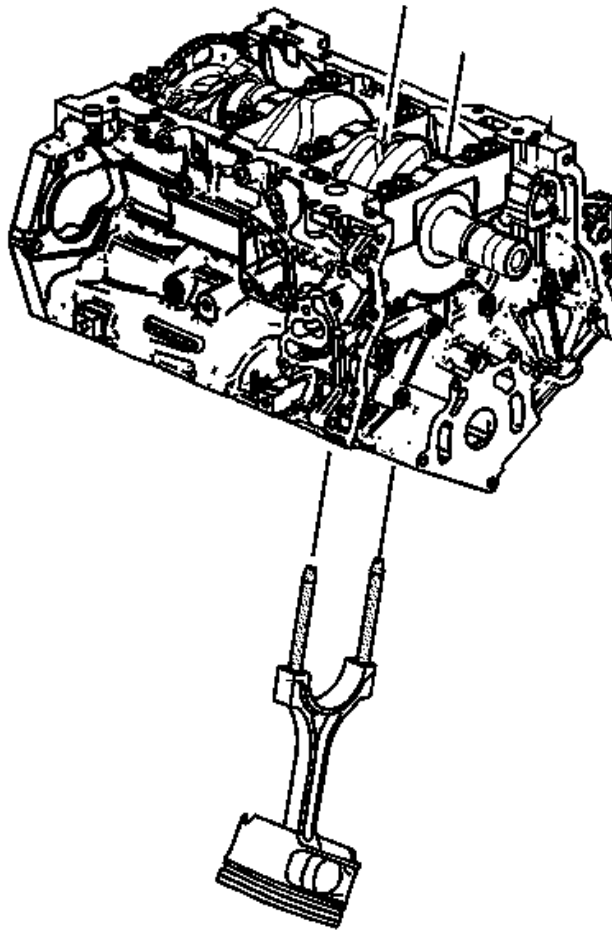
**NOTE:** The connecting rod caps must remain with the original connecting rod.

5. Remove the connecting rod cap.



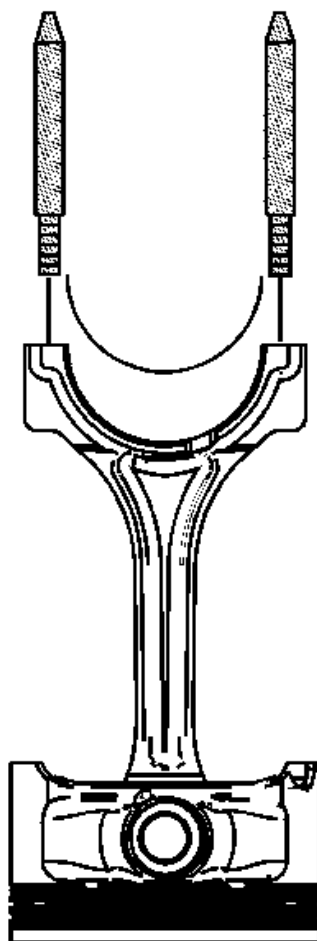
**Fig. 8: Identifying EN 46121**  
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46121**: set into the connecting rod bolt holes.



**Fig. 9: View Of Connecting Rod And Piston Assembly**  
Courtesy of GENERAL MOTORS CORP.

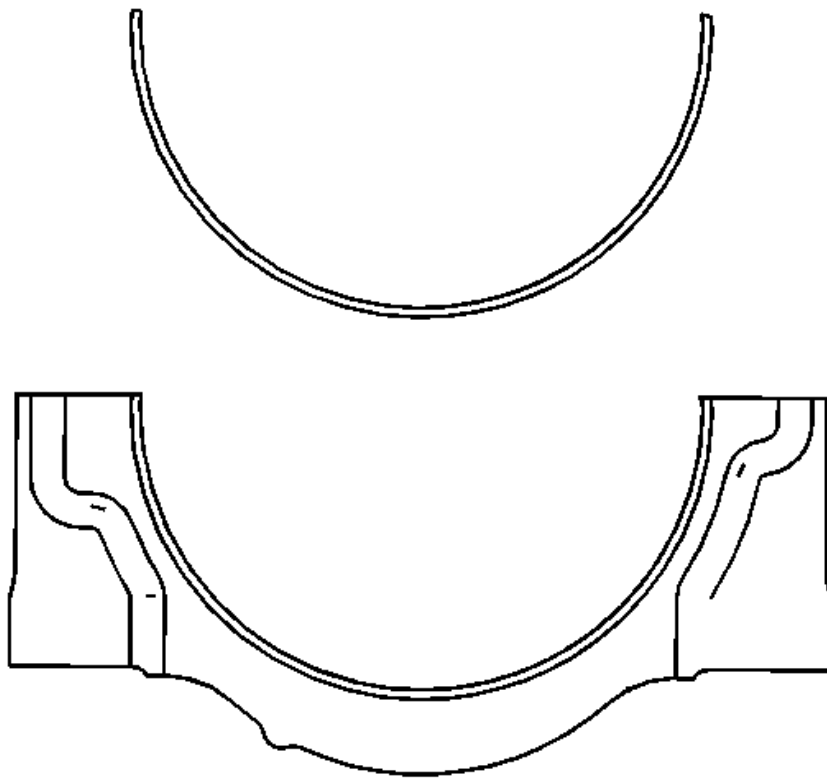
7. Using the **EN 46121** set, push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.



**Fig. 10: View Of Piston/Connecting Rod Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

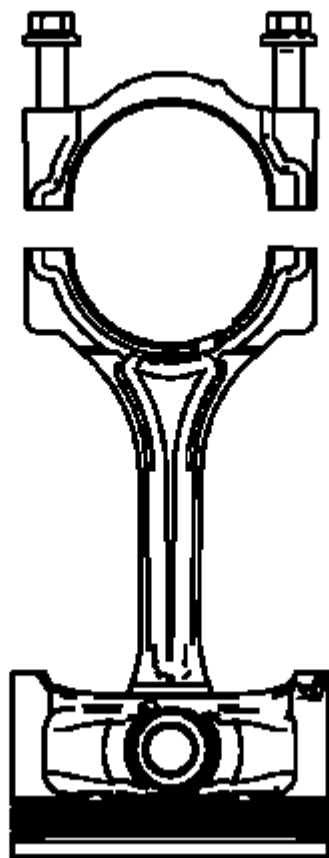
8. Remove the **EN 46121**: set from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.





**Fig. 11: View Of Lower Connecting Rod Cap And Bearing**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the lower connecting rod bearing from the connecting rod cap.



**Fig. 12: View Of Connecting Rod Cap, Connecting Rod & Piston Assembly**  
Courtesy of GENERAL MOTORS CORP.

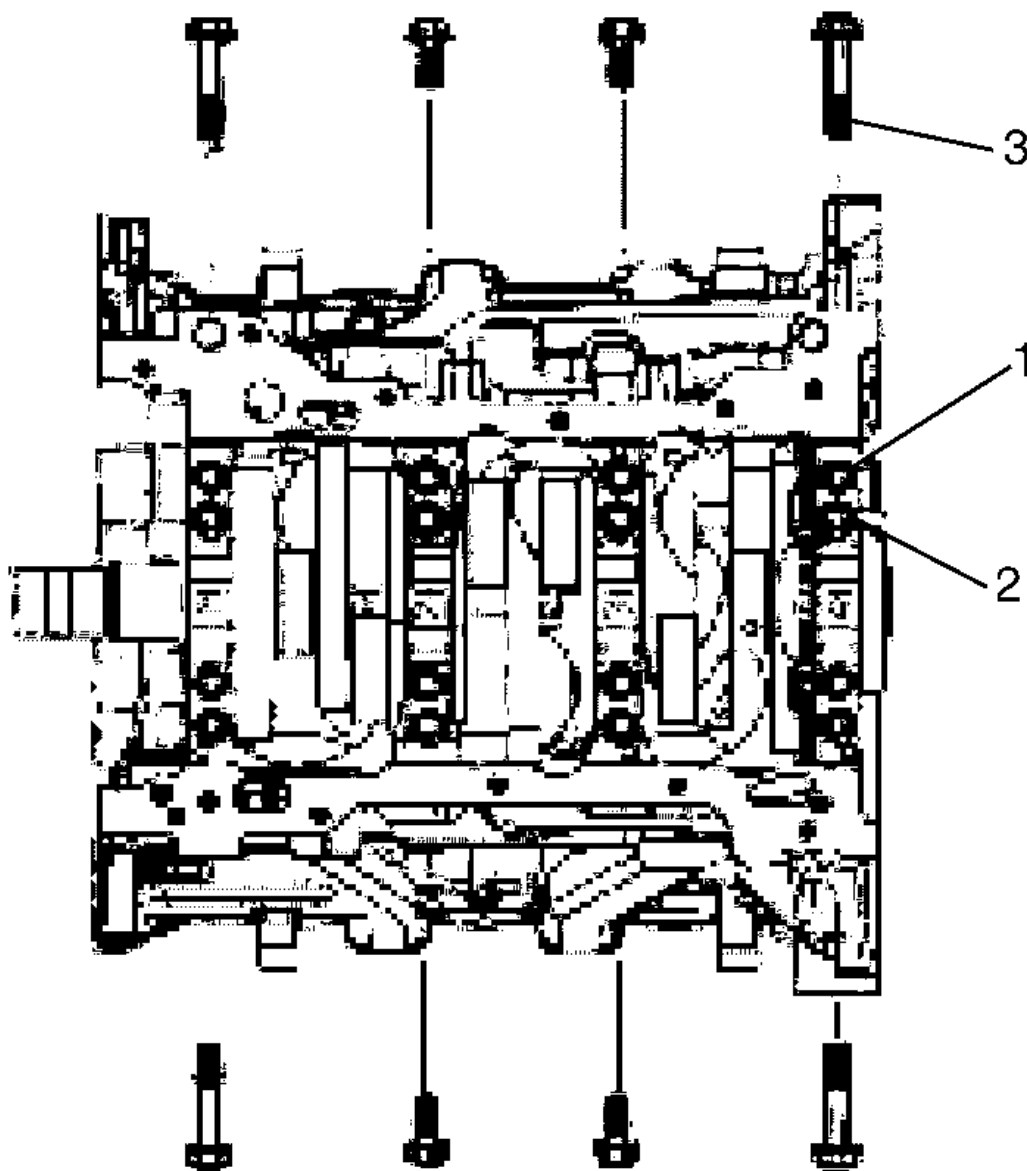
11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

## CRANKSHAFT AND BEARING REMOVAL

### Special Tools

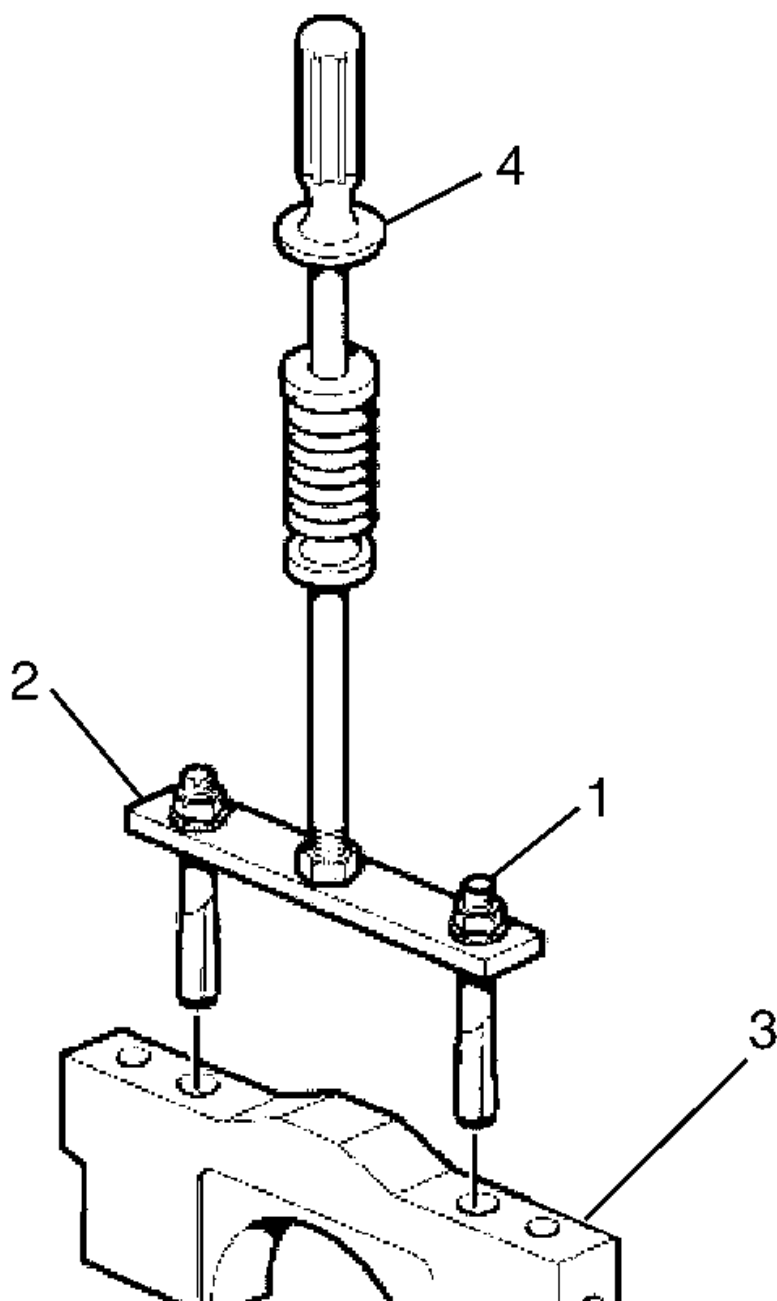
- **J 41818:** Crankshaft Bearing Cap Remover
- **J 6125-1B:** Slide Hammer with Adapter For equivalent regional tools, refer to **Special Tools** .

### Crankshaft Removal



**Fig. 13: Identifying Crankshaft Bearing Cap Inner, Outer & Side Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft bearing cap side bolts (3).
2. Remove the crankshaft bearing cap outer bolts (1).
3. Remove the crankshaft bearing cap inner bolts (2).

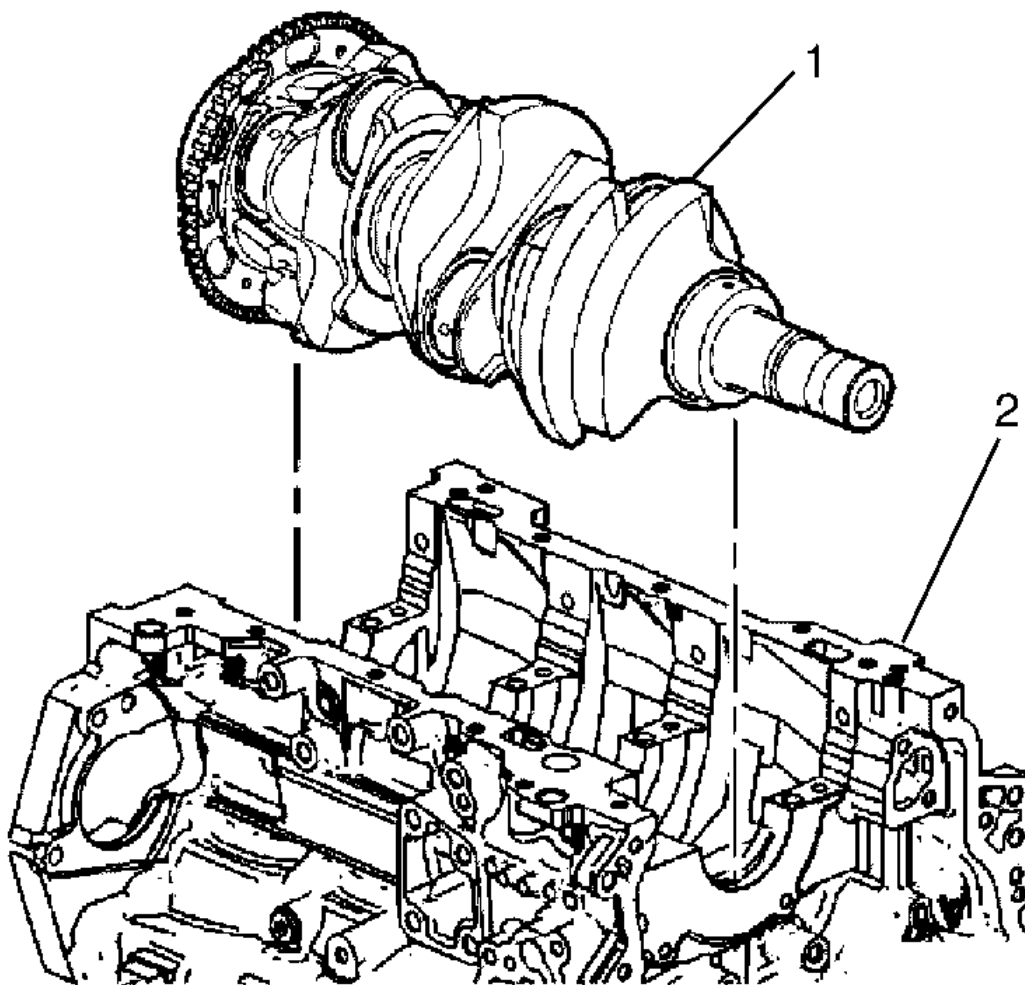


**Fig. 14: View Of J 6125-1B, Crankshaft Bearing Cap & J 41818**  
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41818**: remover (2) to the inner bolt holes of the crankshaft bearing cap (3).

**CAUTION:** Refer to Fastener Caution .

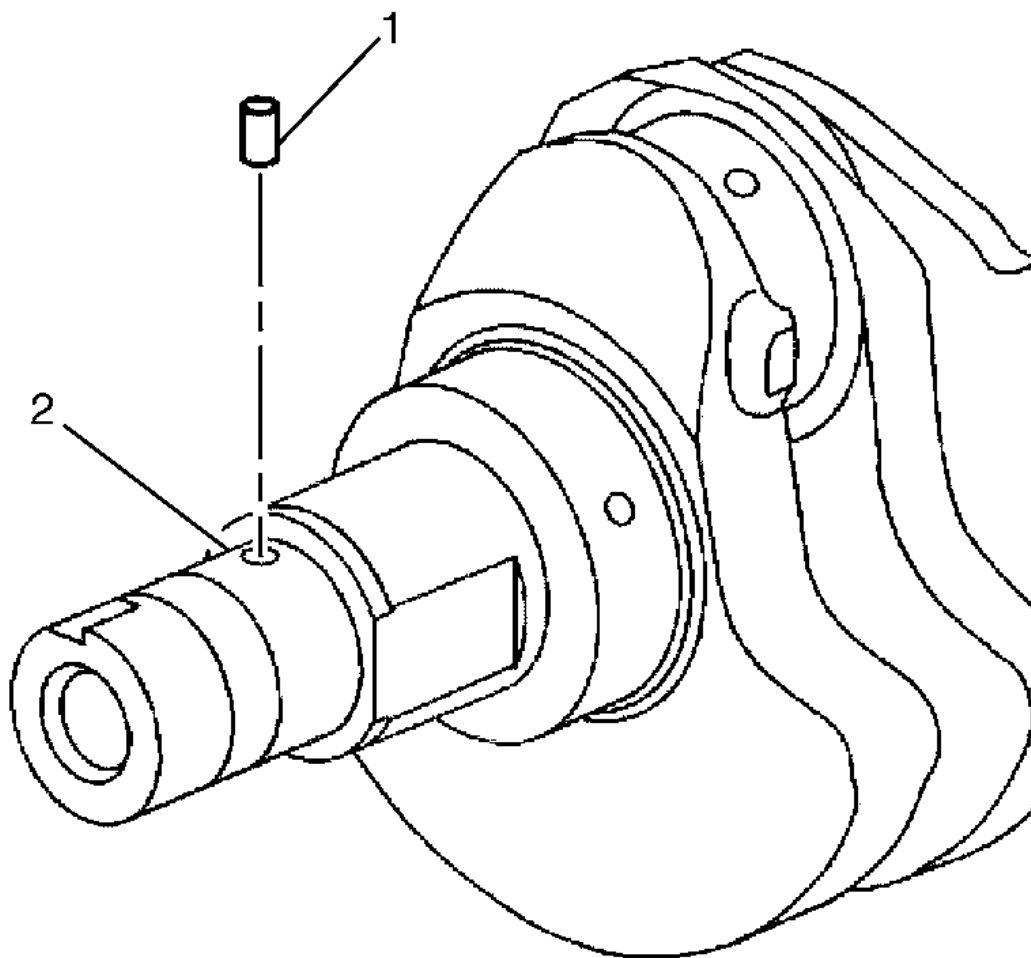
5. Tighten the **J 41818**: remover nuts (1) to 11 N.m (97 lb in).
6. Install the **J 6125-1B**: adapter (4) onto the **J 41818**: remover (2).
7. Remove the crankshaft bearing cap



**Fig. 15: View Of Crankshaft & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

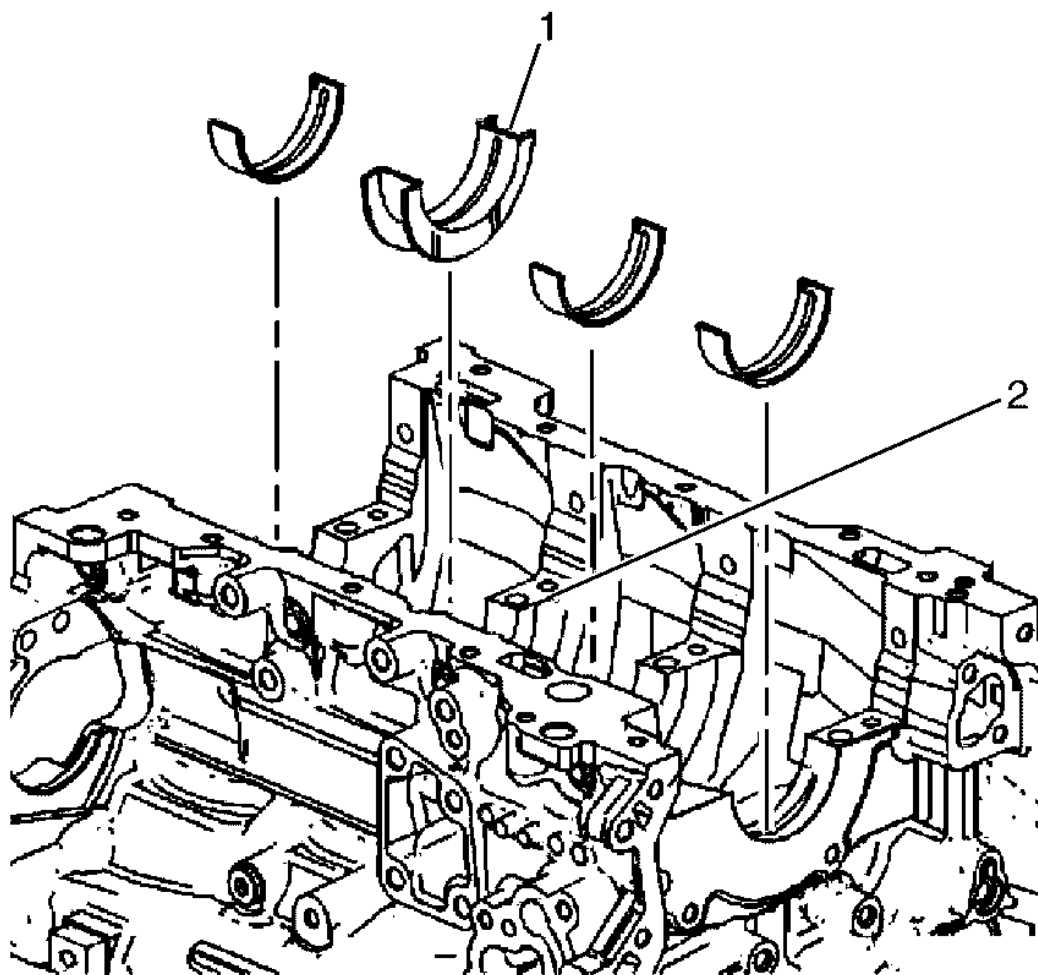
**NOTE:** Lift the crankshaft (1) straight up evenly to remove from the cylinder block (2).

8. Remove the crankshaft (1).
9. Place the crankshaft in a secure place.



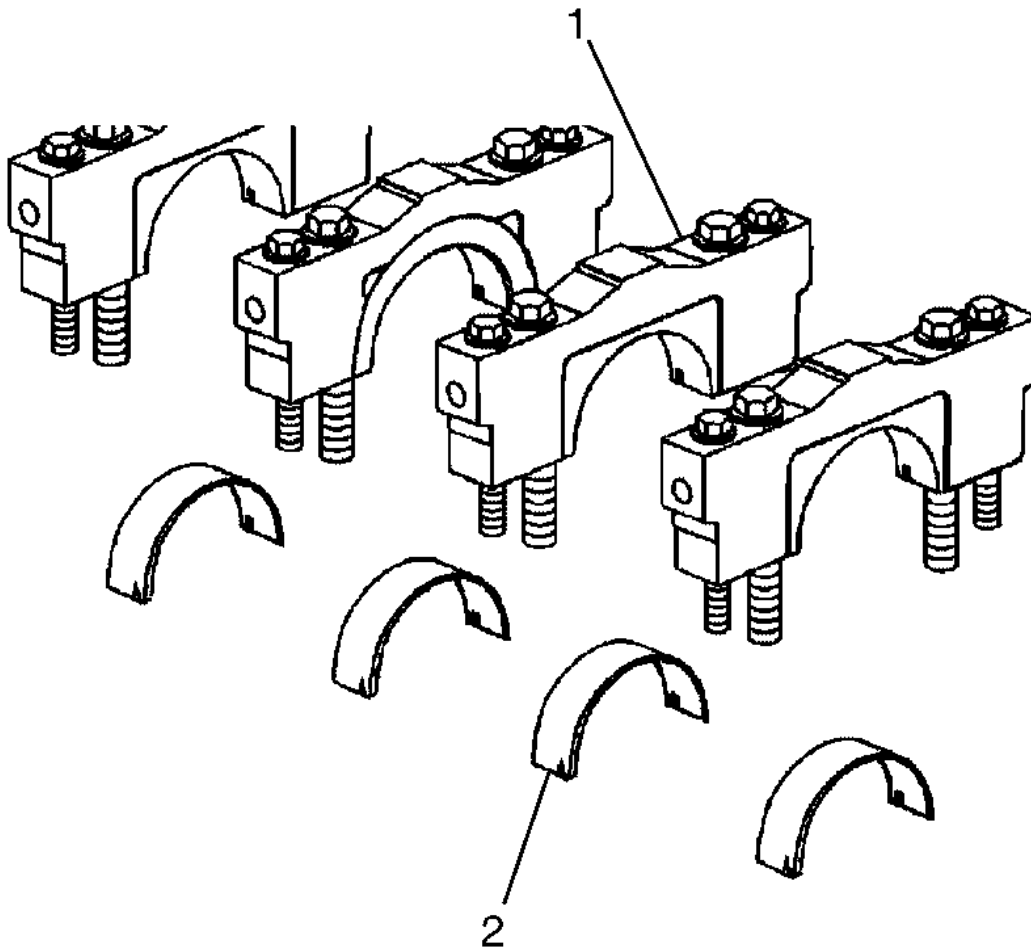
**Fig. 16: View Of Crankshaft & Sprocket Drive Pin**  
**Courtesy of GENERAL MOTORS CORP.**

10. Remove the crankshaft sprocket drive pin (1) from the nose of the crankshaft (2), if required.
11. Prepare a piece of cardboard or equivalent, numbered 1-4 for bearing identification. Main bearing journals are numbered from the front of the cylinder block.



**Fig. 17: Identifying Thrust Bearing & Number 3 Journal**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).
13. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.

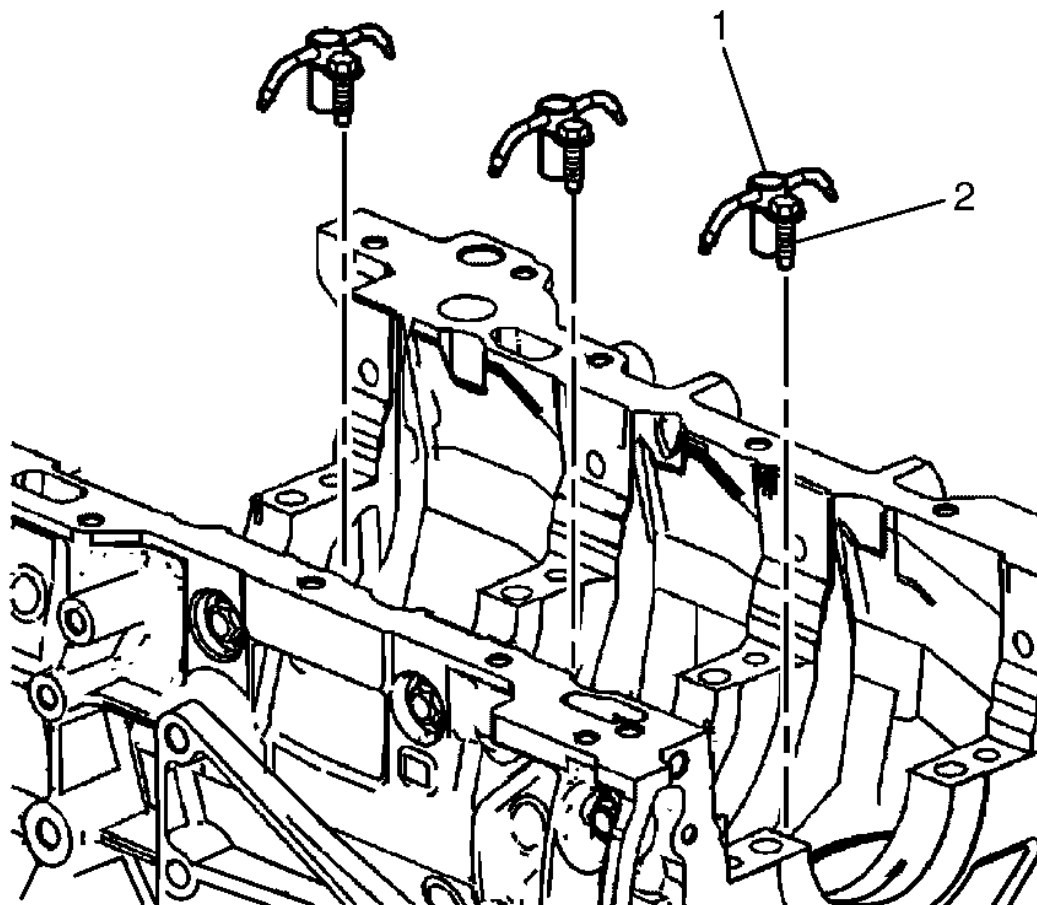


**Fig. 18: Identifying Crankshaft Lower Bearing Halves & Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

14. Remove the crankshaft lower bearing halves (2) from the crankshaft bearing caps (1).
15. Place the crankshaft lower bearing halves (2) in the correct positions on the cardboard.

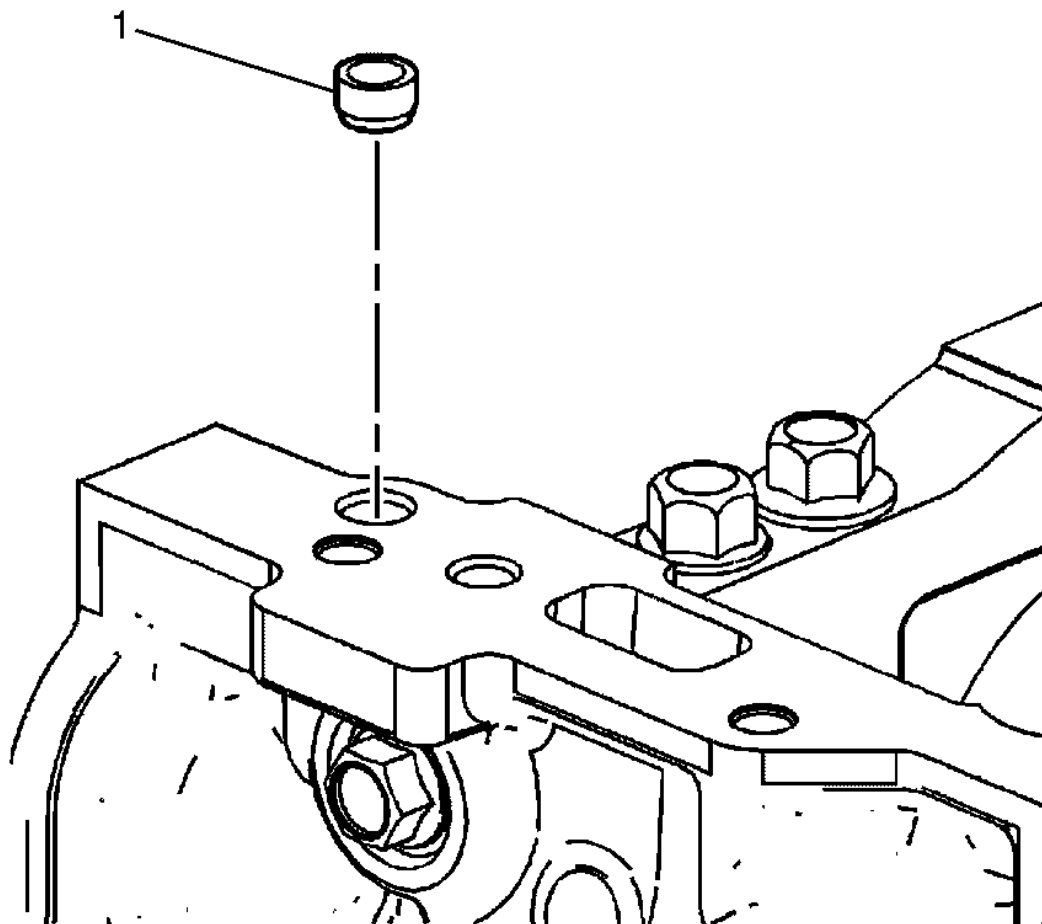
## **ENGINE BLOCK DISASSEMBLE**





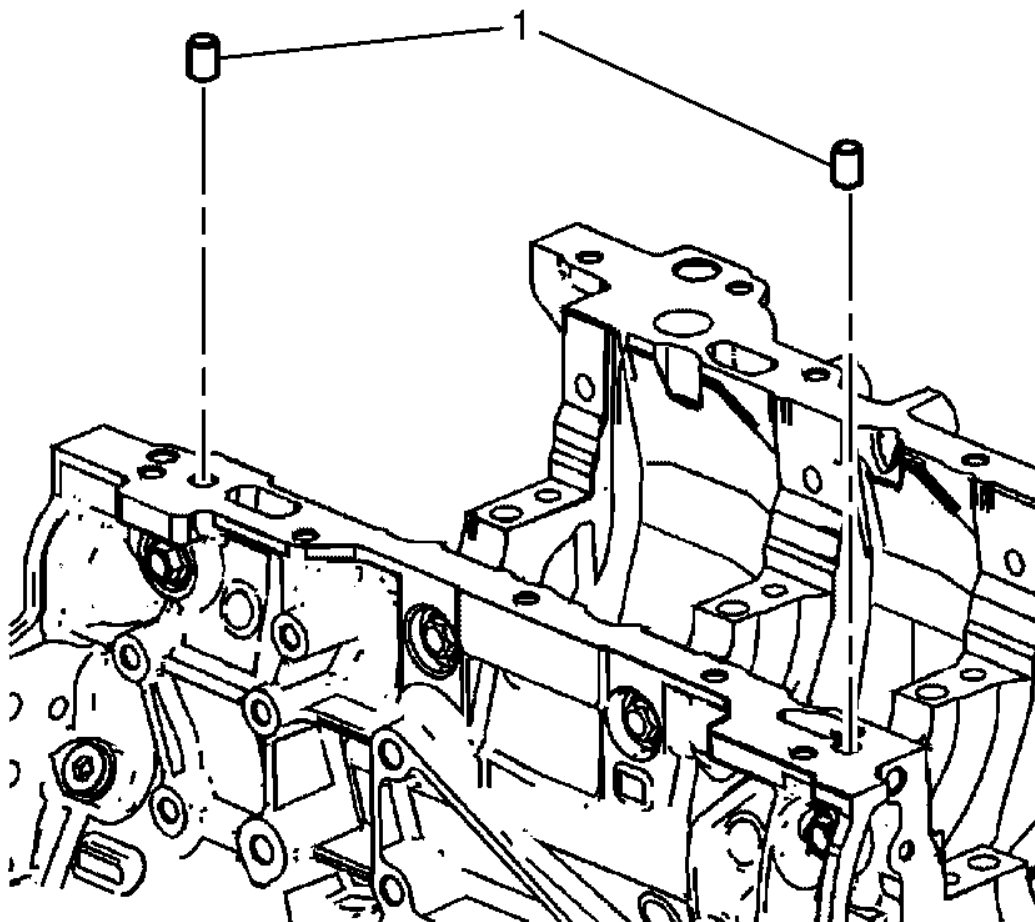
**Fig. 19: Identifying Oil Jet To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove oil jet to cylinder block retaining bolts (2).
2. Remove the oil jets (1).



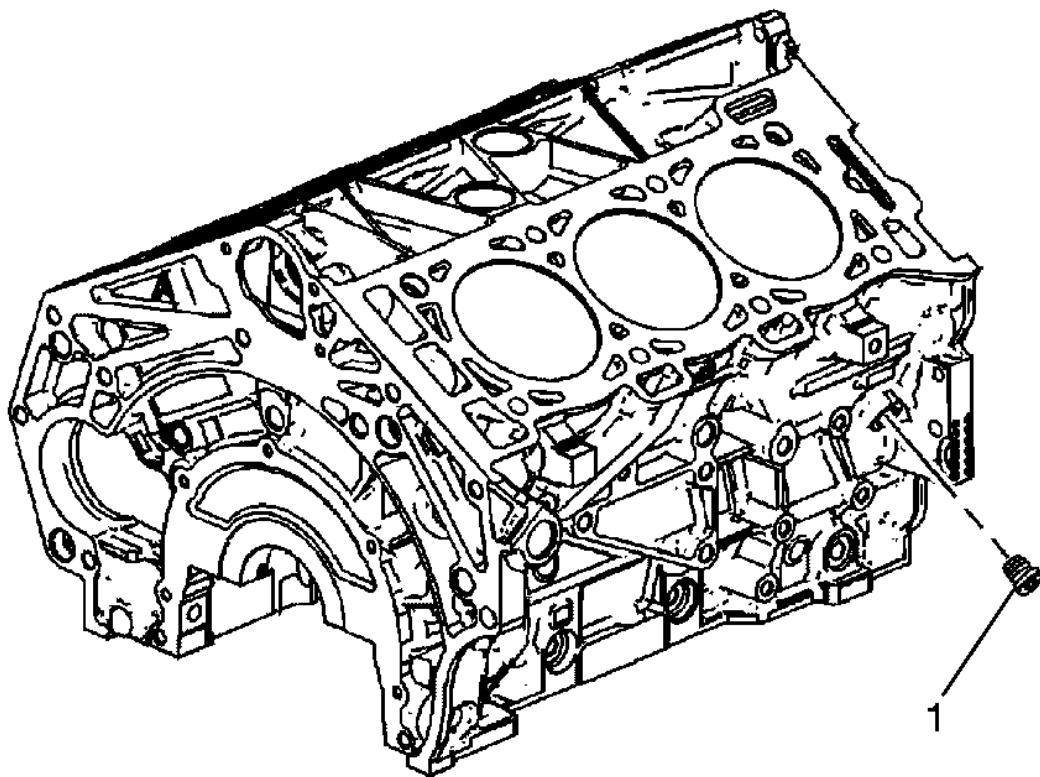
**Fig. 20: Identifying Right Front Oil Pan Rail Oil Gallery Expansion Plug**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the right front oil pan rail oil gallery expansion plug (1).



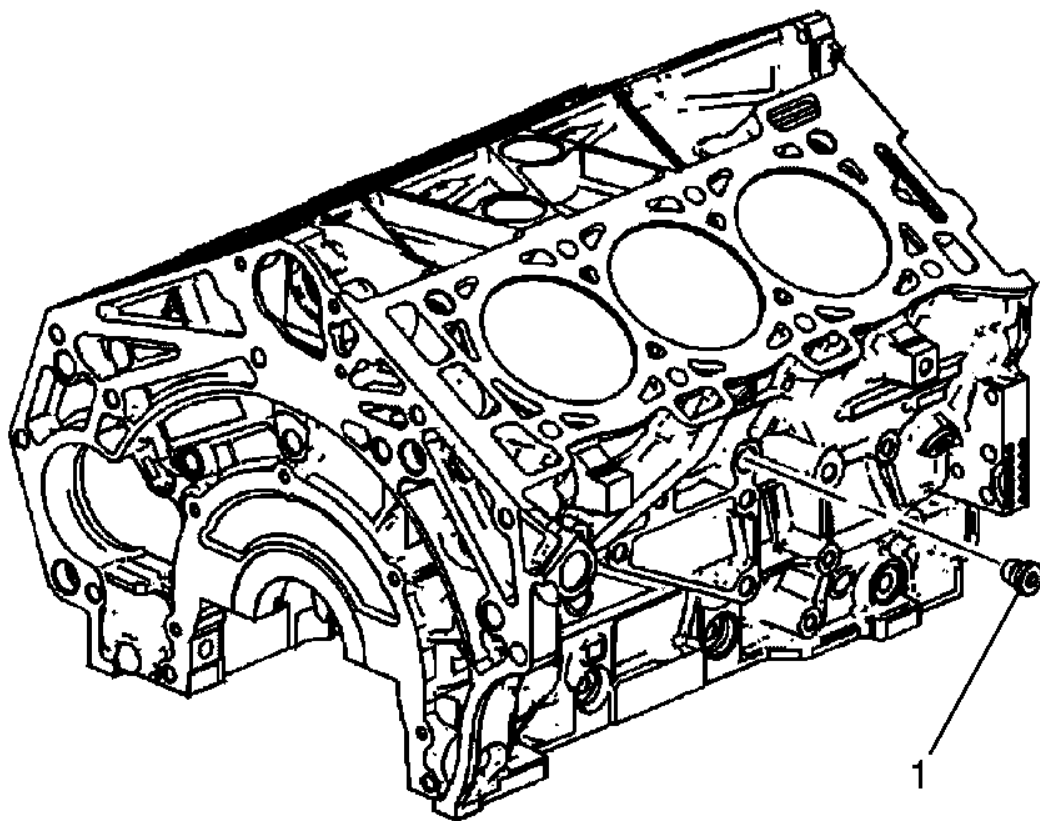
**Fig. 21: Identifying Cylinder Block-To-Oil Pan Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the cylinder block-to-oil pan alignment dowels (1).



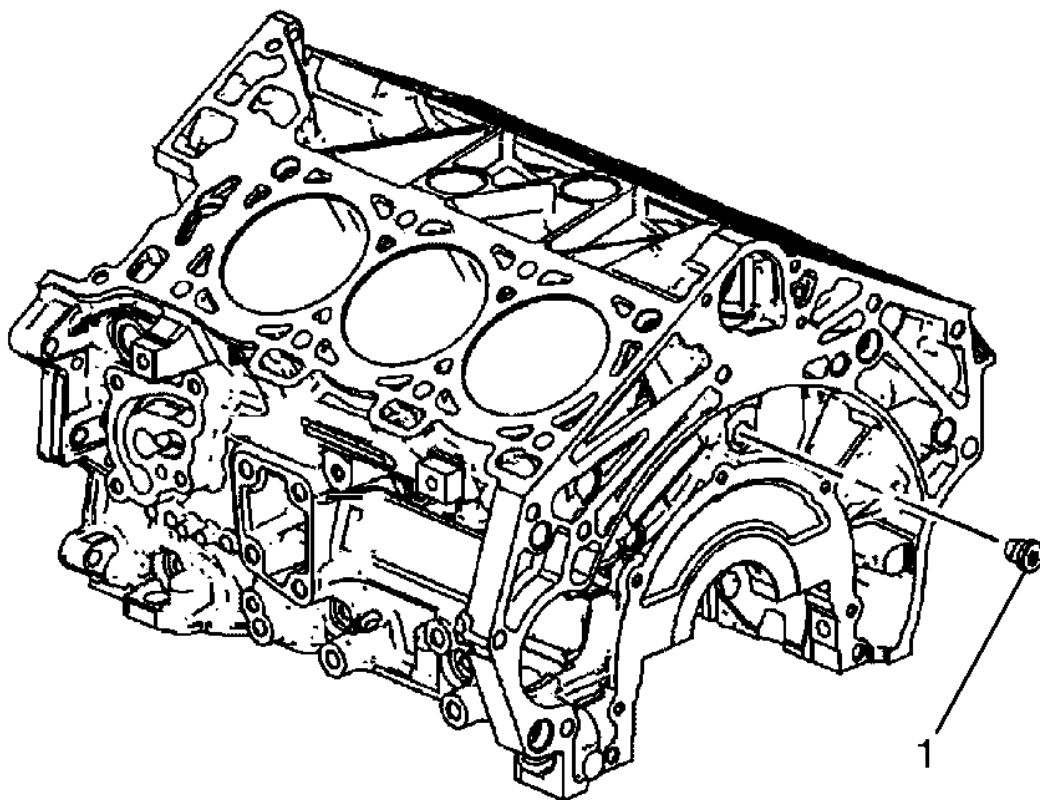
**Fig. 22: Identifying M14 Right Side Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the M14 right side oil gallery threaded plug (1).



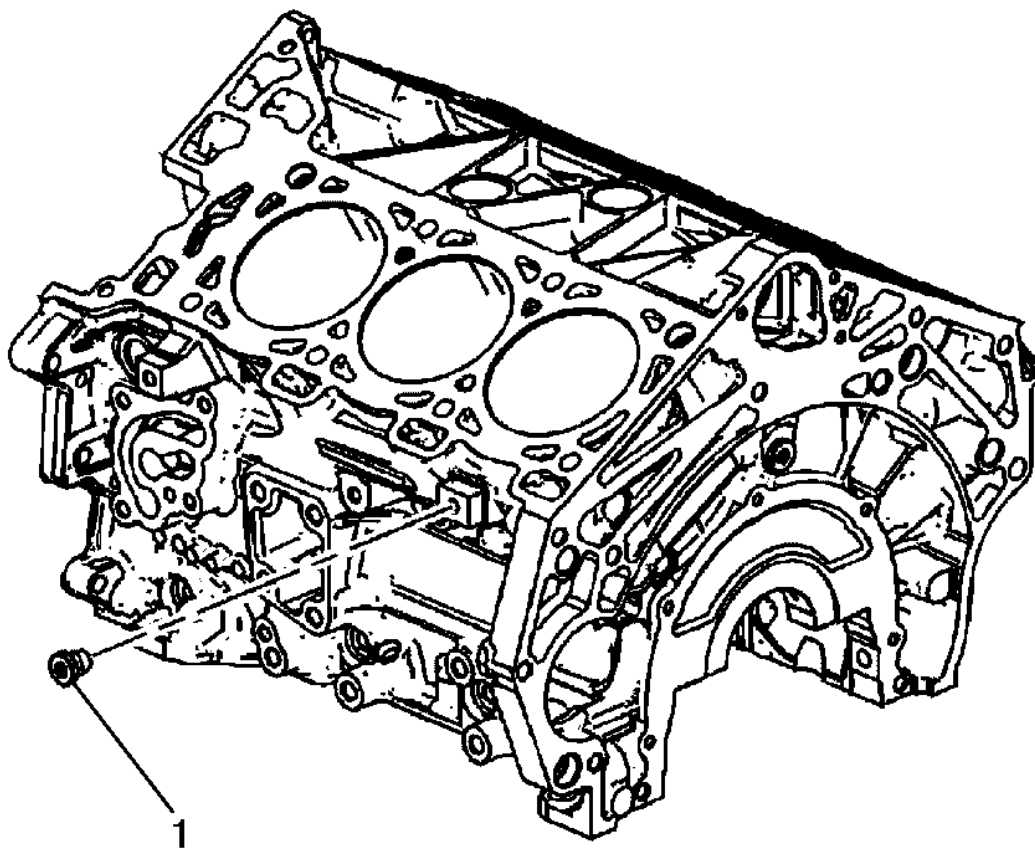
**Fig. 23: Identifying M14 Right Side Coolant Drain Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the M14 right side coolant drain threaded plug (1).



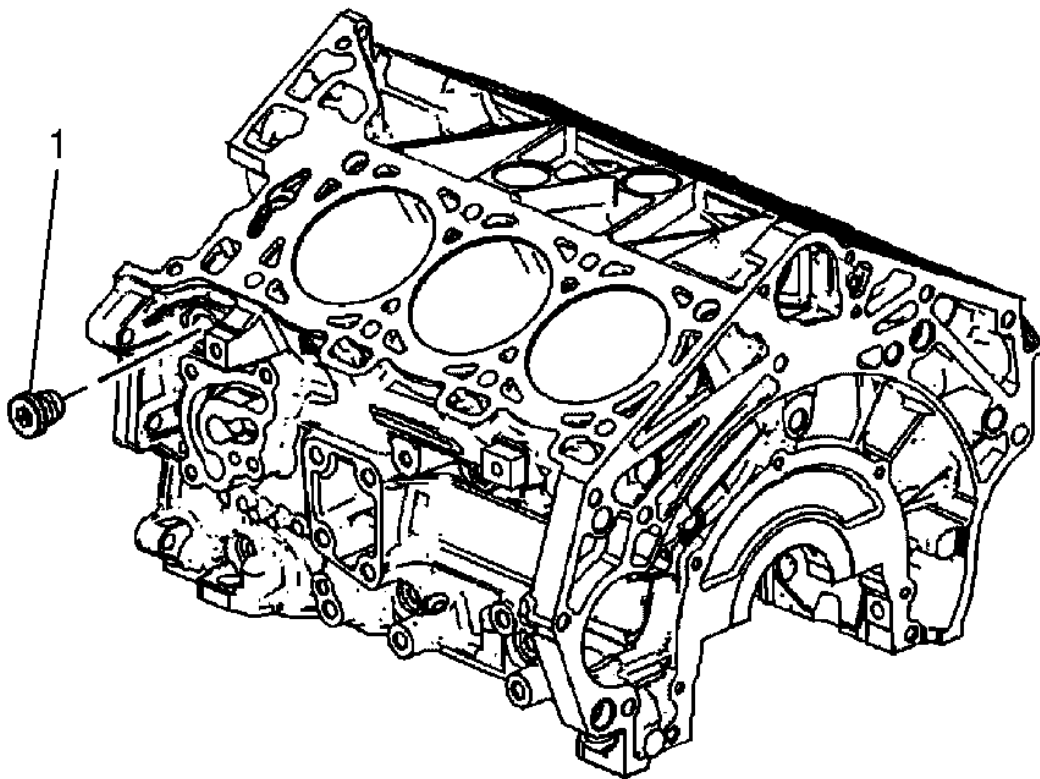
**Fig. 24: Identifying M14 Rear Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the M14 rear oil gallery threaded plug (1).



**Fig. 25: Identifying M14 Left Side Coolant Drain Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

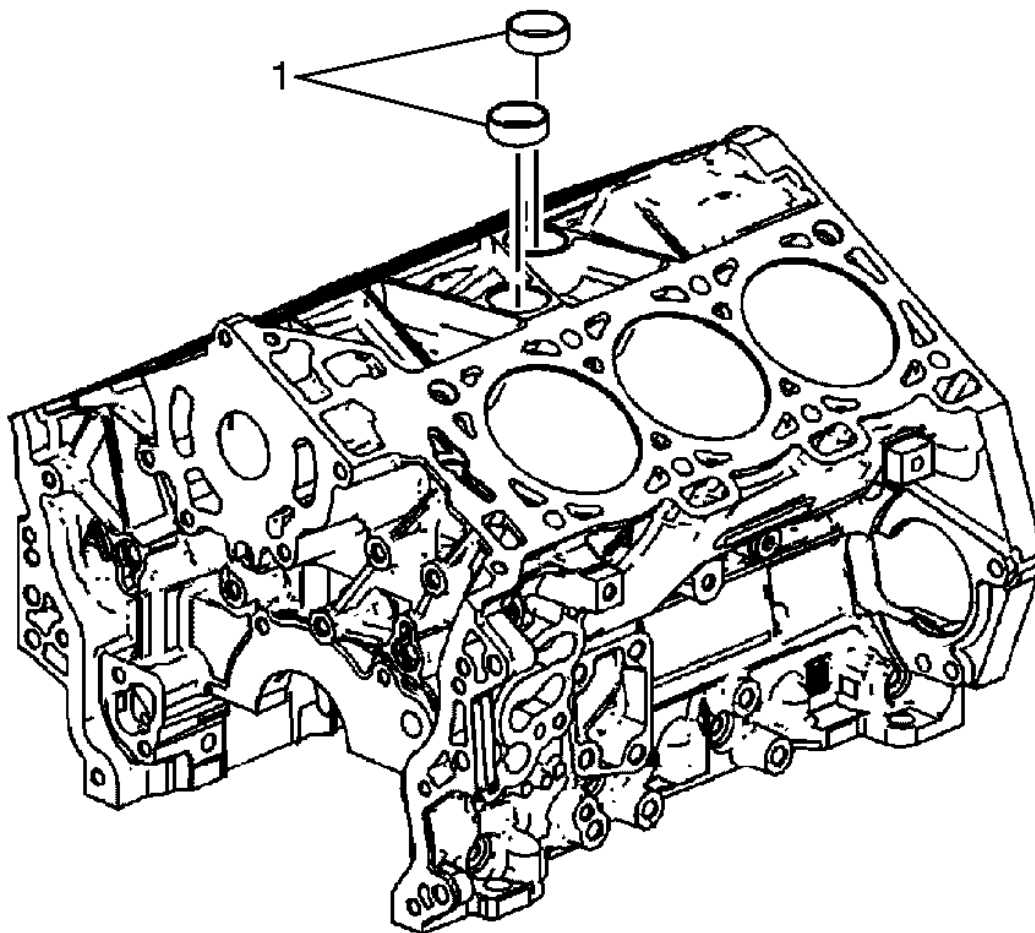
8. Remove the M14 left side coolant drain threaded plug (1).



**Fig. 26: Identifying M20 Left Side Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

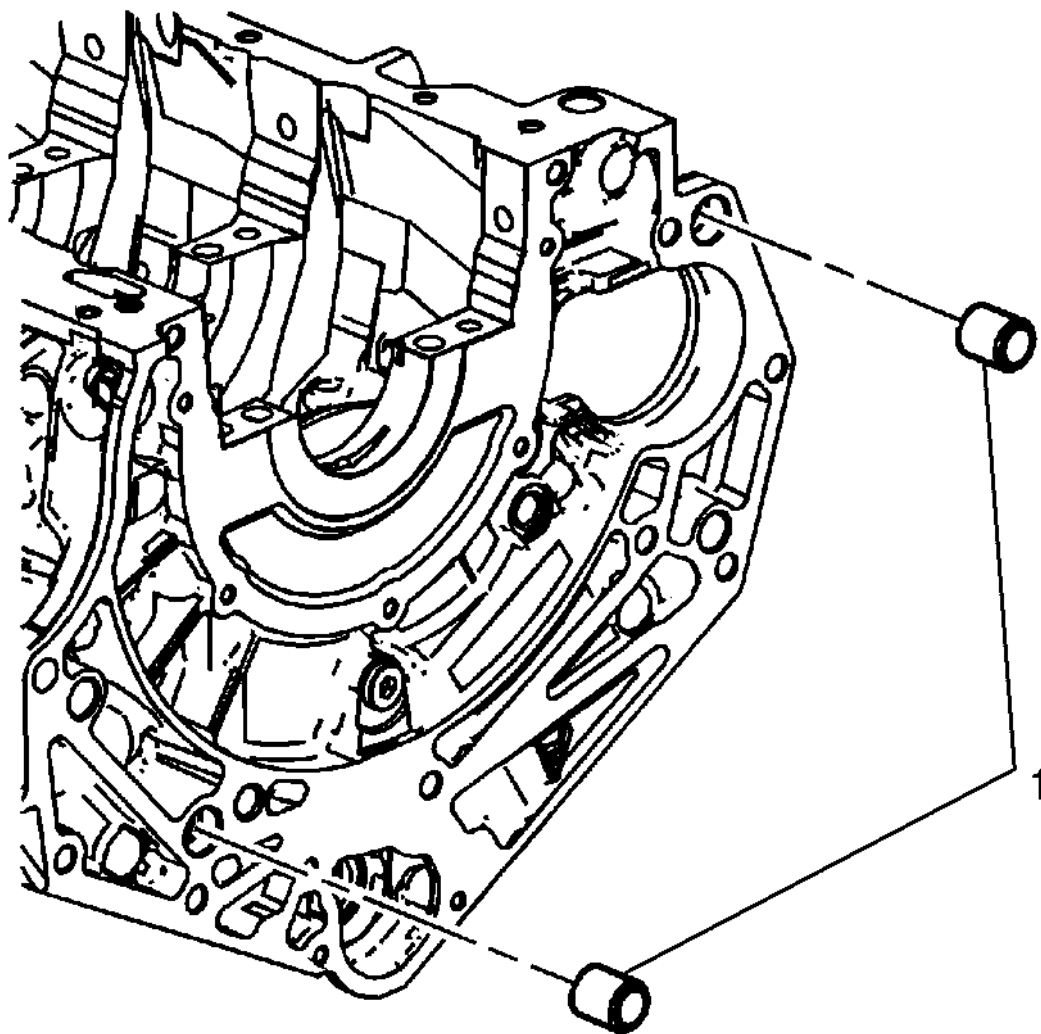
9. Remove the M20 left side oil gallery threaded plug (1).





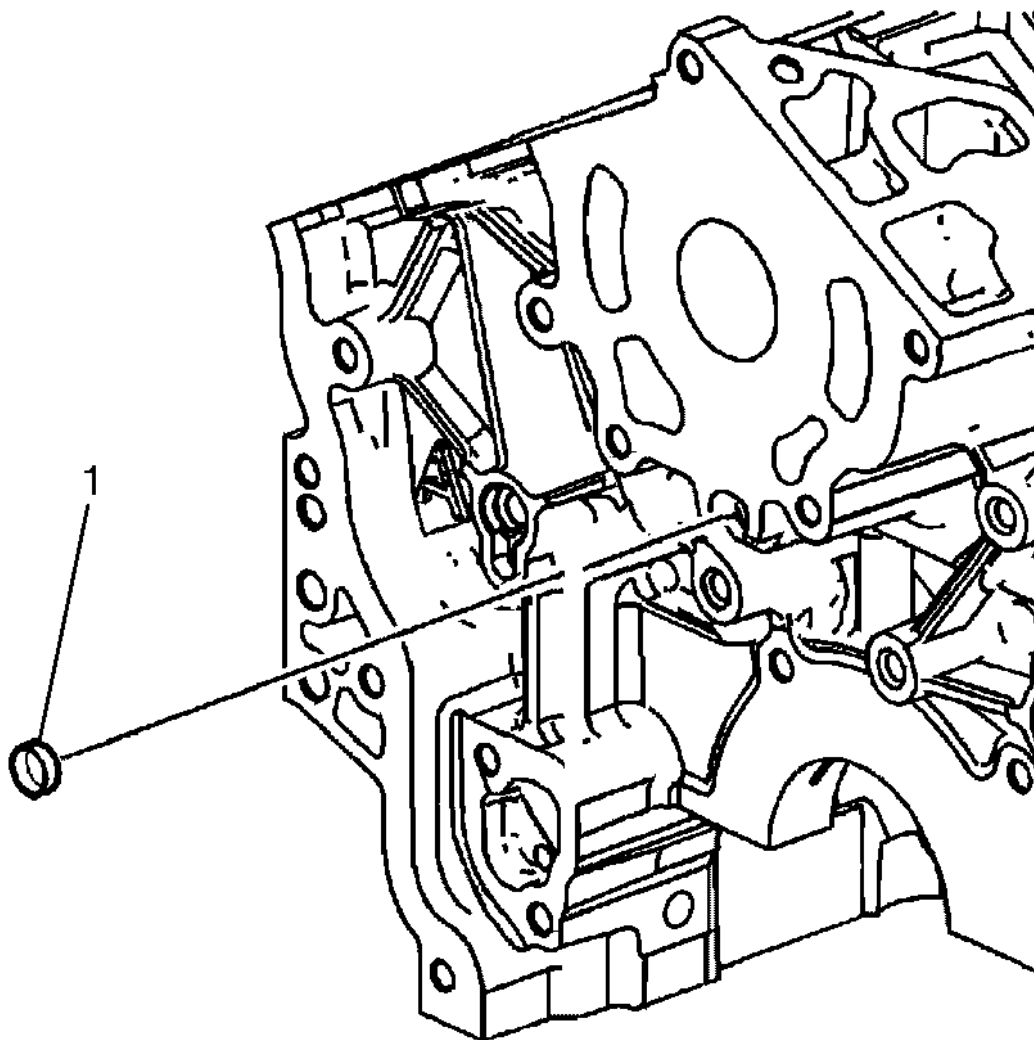
**Fig. 27: Identifying Coolant Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant expansion plugs (1).



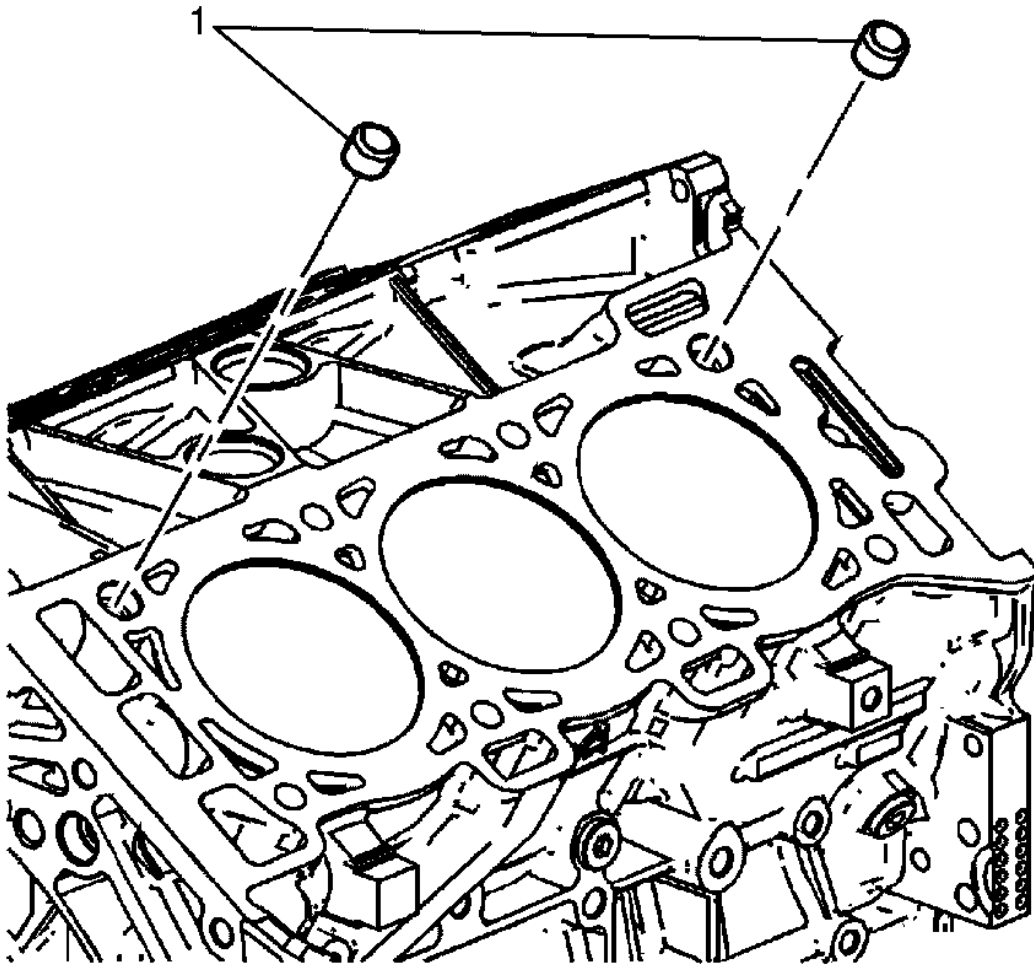
**Fig. 28: Identifying Cylinder Block-To-Transmission Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the cylinder block-to-transmission alignment dowels (1).



**Fig. 29: Identifying Front Oil Gallery Expansion Plug**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the front oil gallery expansion plug (1).



**Fig. 30: Identifying Cylinder Block-To-Cylinder Head Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

13. Remove the cylinder block-to-cylinder head alignment dowels (2).

## ENGINE BLOCK CLEANING AND INSPECTION

### Special Tools

- **J 8087:** Cylinder Bore Gage
- **J 28410:** Gasket Remover

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

### Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using **J 28410**: remover.
2. Clean all the following areas with solvent:
  - Sealing surfaces
  - Cooling passages
  - Oil passages
  - Bearing journals
3. Clean all threaded and through holes with solvent.

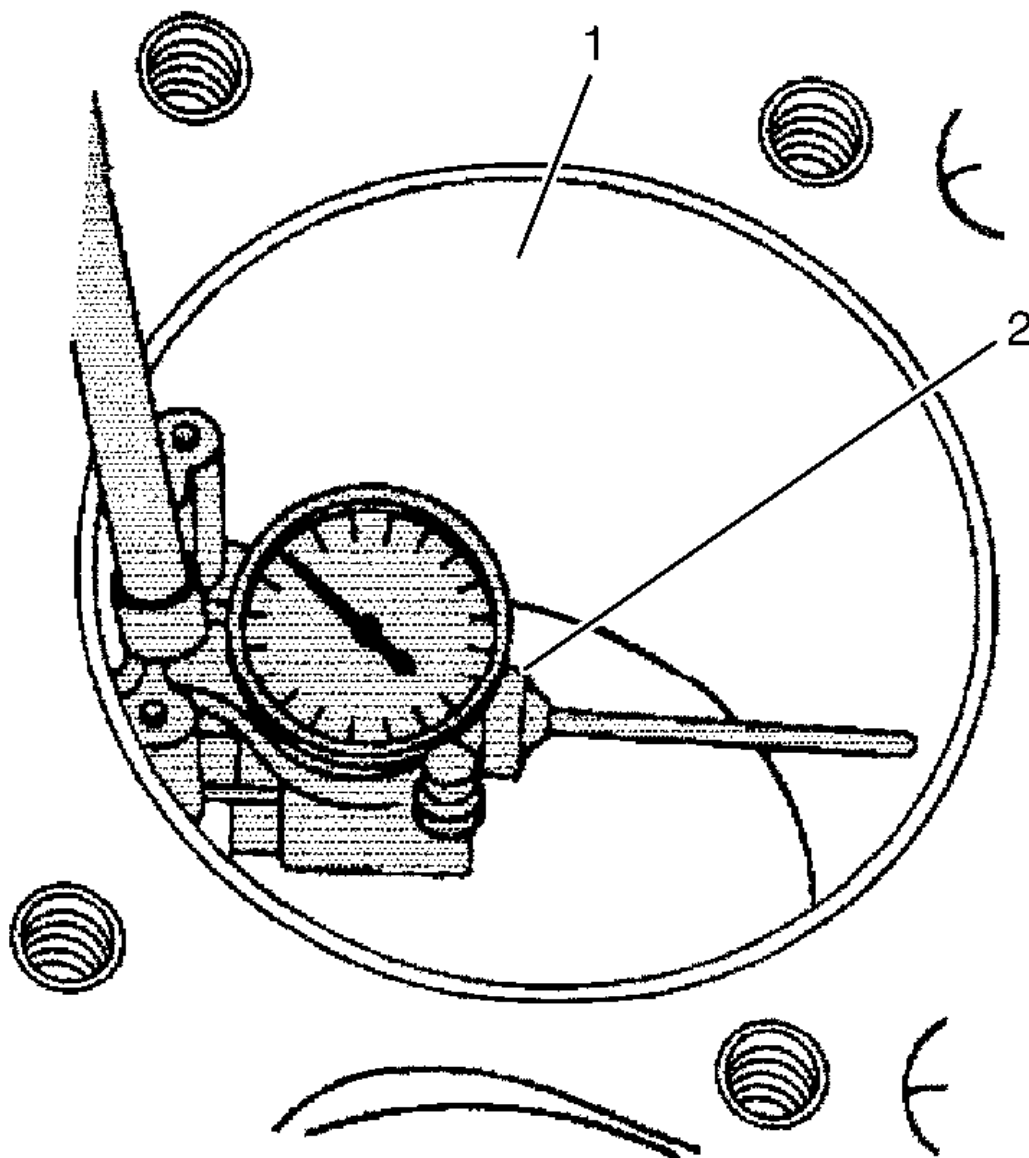
**WARNING: Refer to Safety Glasses Warning .**

4. Dry the cylinder block with compressed air.

#### **Visual Inspection**

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the primary camshaft drive chain tensioner mounting surface on the cylinder block for burrs or any defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or debris above acceptable tolerances.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the cylinder block for cracks. DO NOT repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to Thread Repair Specifications and Thread Repair.

#### **Measuring Cylinder Bore Diameter**



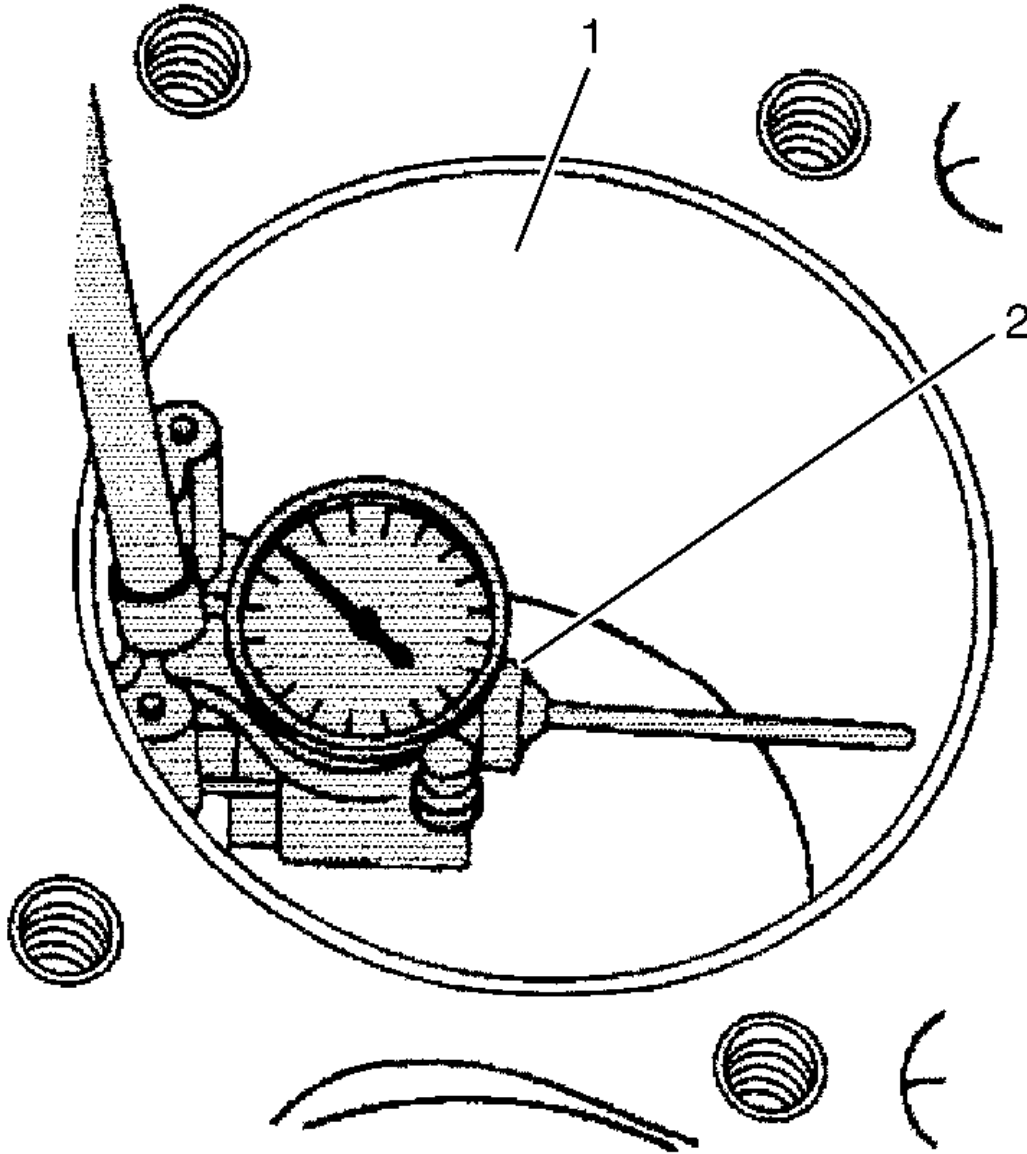
**Fig. 31: Identifying Cylinder Bore Measurement Procedure**  
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore diameter 42 mm (1.654 in) from the deck face (1) using the **J 8087**: gage (2).
2. Record and compare your results with the **Engine Mechanical Specifications** . If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be

replaced.

### Measuring Cylinder Bore Taper



**Fig. 32: Identifying Cylinder Bore Measurement Procedure**  
Courtesy of GENERAL MOTORS CORP.

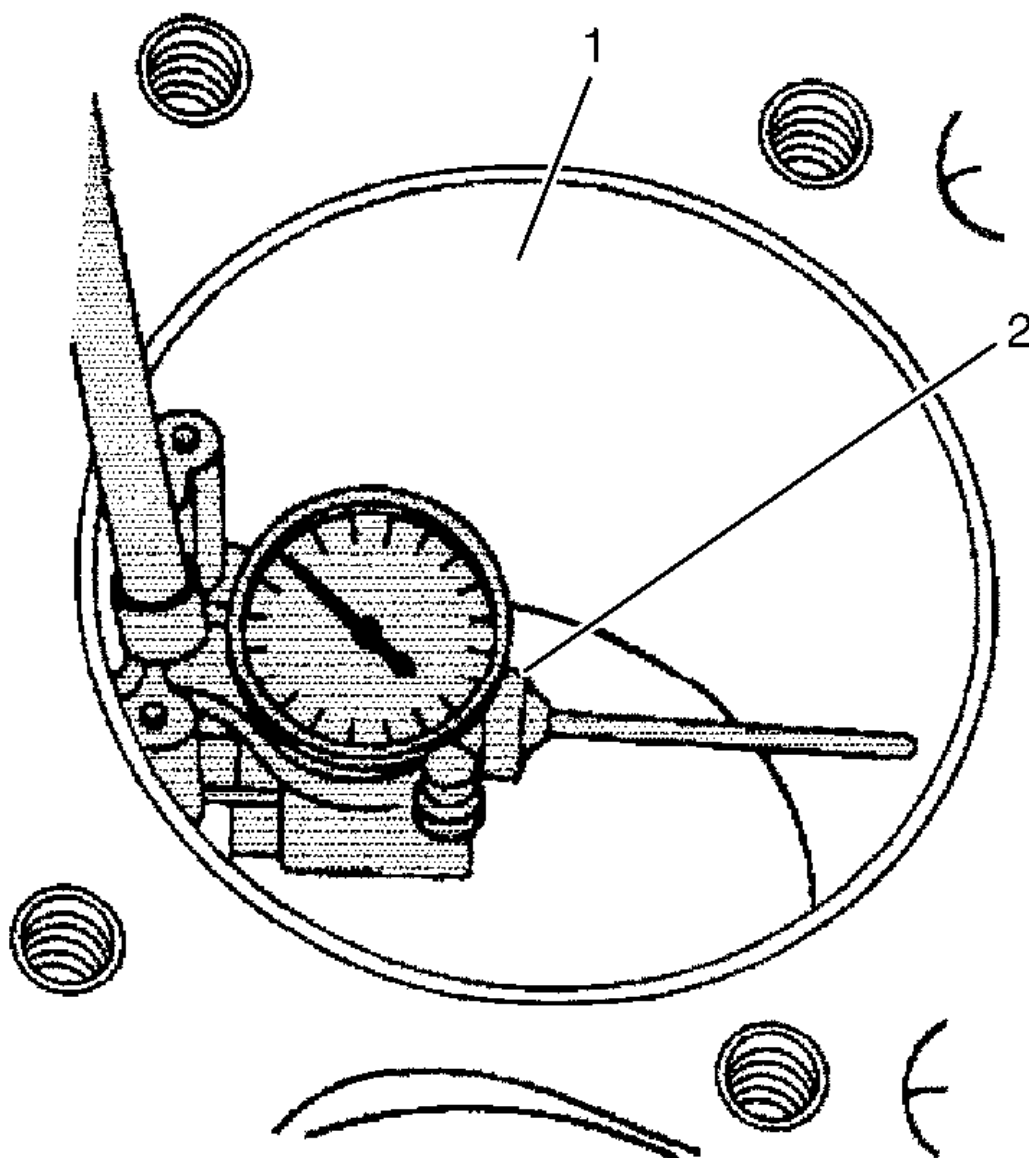
1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.

2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications** . If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

**Measuring Cylinder Bore Out-of-Round**





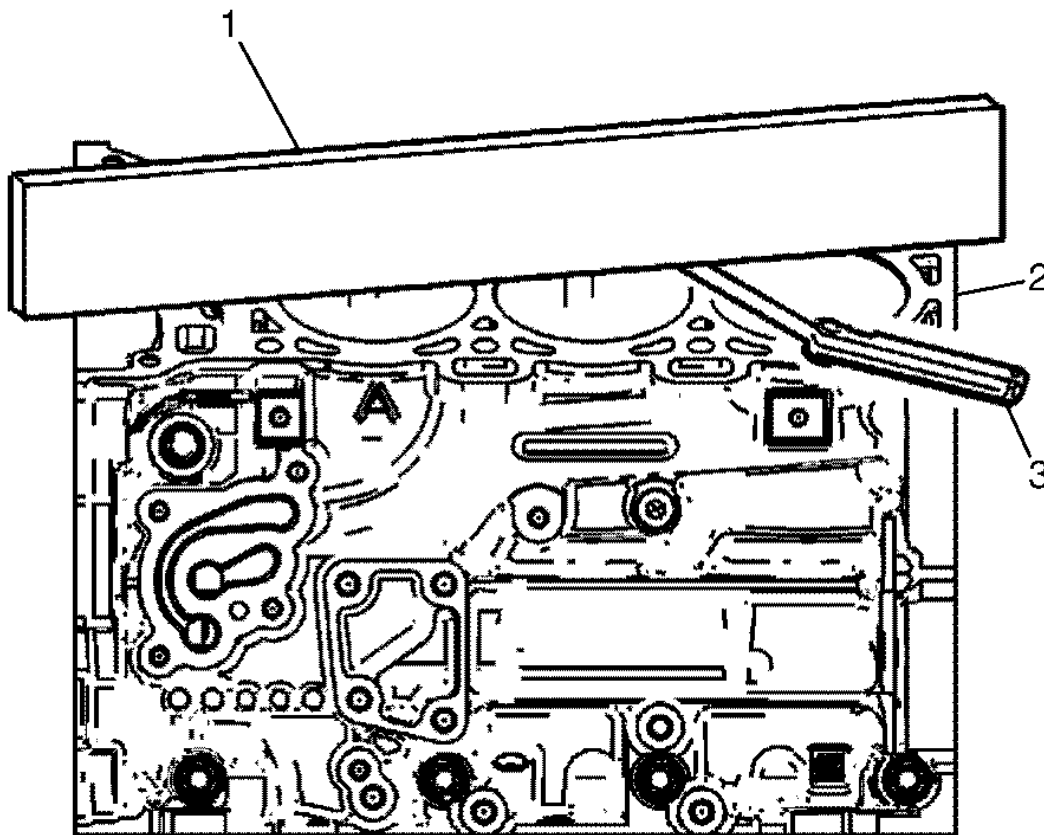
**Fig. 33: Identifying Cylinder Bore Measurement Procedure**  
Courtesy of GENERAL MOTORS CORP.

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. 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 (3.976 in) below the deck surface. Record your measurements.

4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications**. If the cylinders exceed 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.

If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

#### Deck Flatness Inspection



**Fig. 34: Identifying Straight-Edge & Cylinder Block Deck Face Measurement Procedure**  
Courtesy of GENERAL MOTORS CORP.

1. Make sure the cylinder block decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that may inhibit correct cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.

4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that may inhibit correct cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

## **CRANKSHAFT AND BEARING CLEANING AND INSPECTION**

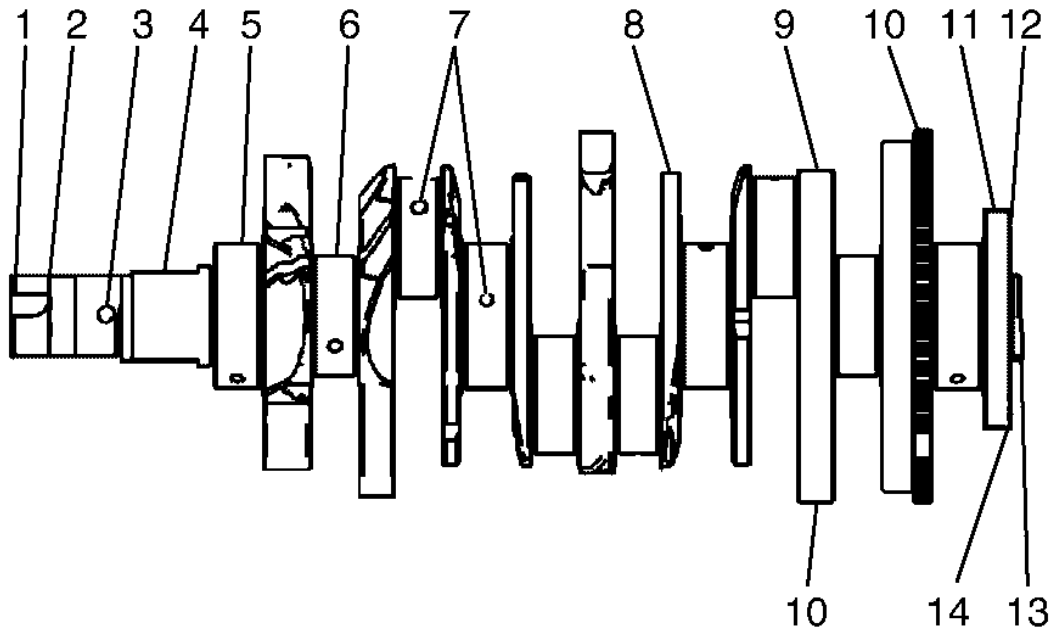
### **Cleaning Procedure**

1. Clean the following components in solvent:
  - Crankshaft bearings
  - Connecting rod bearings
  - Crankshaft journals
  - Crankpin journals
  - Crankshaft oil passages
  - Crankshaft threaded holes

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

2. Dry the following components with compressed air:
  - Crankshaft bearings
  - Connecting rod bearings
  - Crankshaft journals
  - Crankpin journals
  - Crankshaft oil passages
  - Crankshaft threaded holes

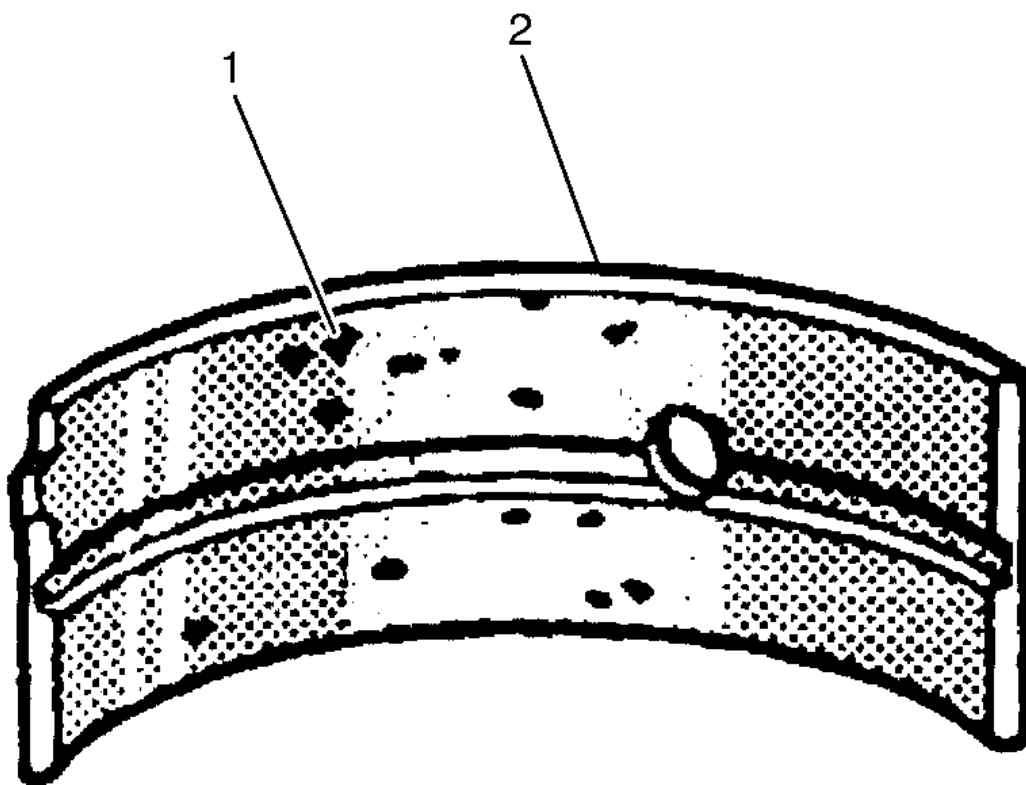
### **Visual Inspection**



**Fig. 35: Identifying Crankshaft Visual Inspections**  
 Courtesy of GENERAL MOTORS CORP.

1. Perform the following visual inspections:
  - Inspect the crankshaft balancer bolt hole (1) for thread damage.
  - Inspect the crankshaft balancer mounting area (2) for damage.
  - Inspect the crankshaft sprocket pin hole (3) for damage.
  - Inspect the oil pump drive flats (4) for damage.
  - Inspect the crankshaft main journals (5) for damage.
  - Inspect the crankshaft connecting rod journals (6) for damage.
  - Inspect the crankshaft oil passages (7) for obstructions.
  - Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
  - Inspect the crankshaft counterweights (9) for damage.
  - Inspect the crankshaft reluctor ring teeth (10) for damage.
  - Inspect the crankshaft rear main oil seal surface (11) for damage.
  - Inspect the crankshaft engine flywheel mounting surface (12) for damage.
  - Inspect the crankshaft pilot hole (13) for damage.
  - Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.
2. Repair or replace the crankshaft as necessary.

#### Crankshaft Bearing Inspection

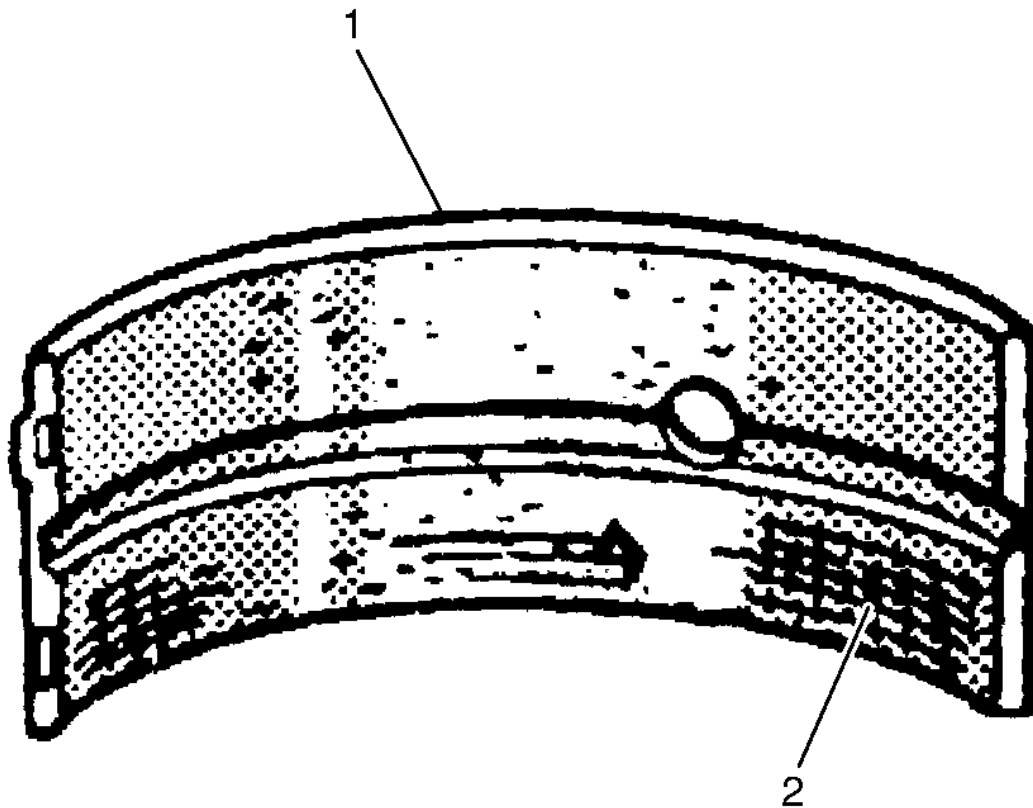


**Fig. 36: Identifying Bearing Valves & Craters/Pockets**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

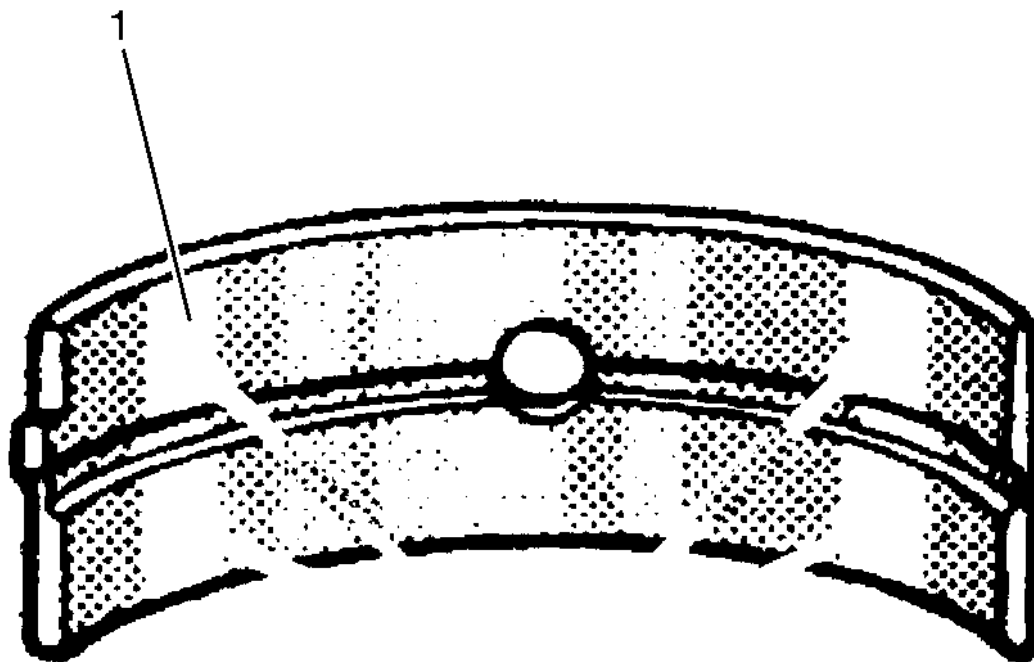
- All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.
- The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.

1. Inspect for fatigue indicated by craters or pockets (1). Flattened sections on the bearing halves (2) also indicate fatigue.



**Fig. 37: Identifying Bearing Valves & Discoloration**  
Courtesy of GENERAL MOTORS CORP.

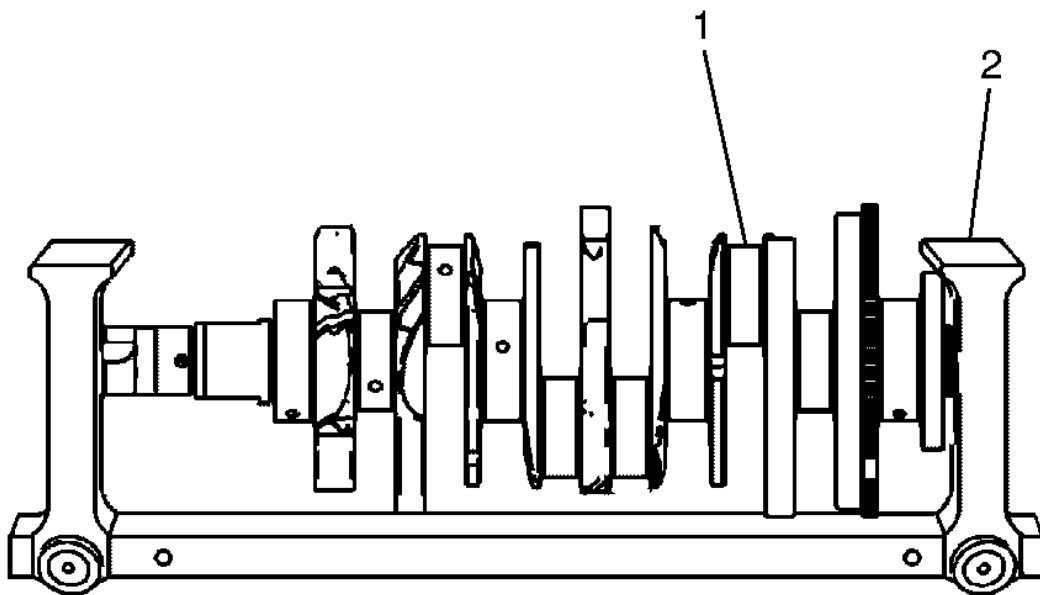
2. Inspect for scoring above acceptable tolerances or discoloration (2) on both front and back of the bearing halves (1).
3. Inspect the main bearings for dirt embedded into the bearing material.



**Fig. 38: Identifying Polished Sections**  
**Courtesy of GENERAL MOTORS CORP.**

4. Inspect for incorrect seating indicated by bright, polished sections (1).

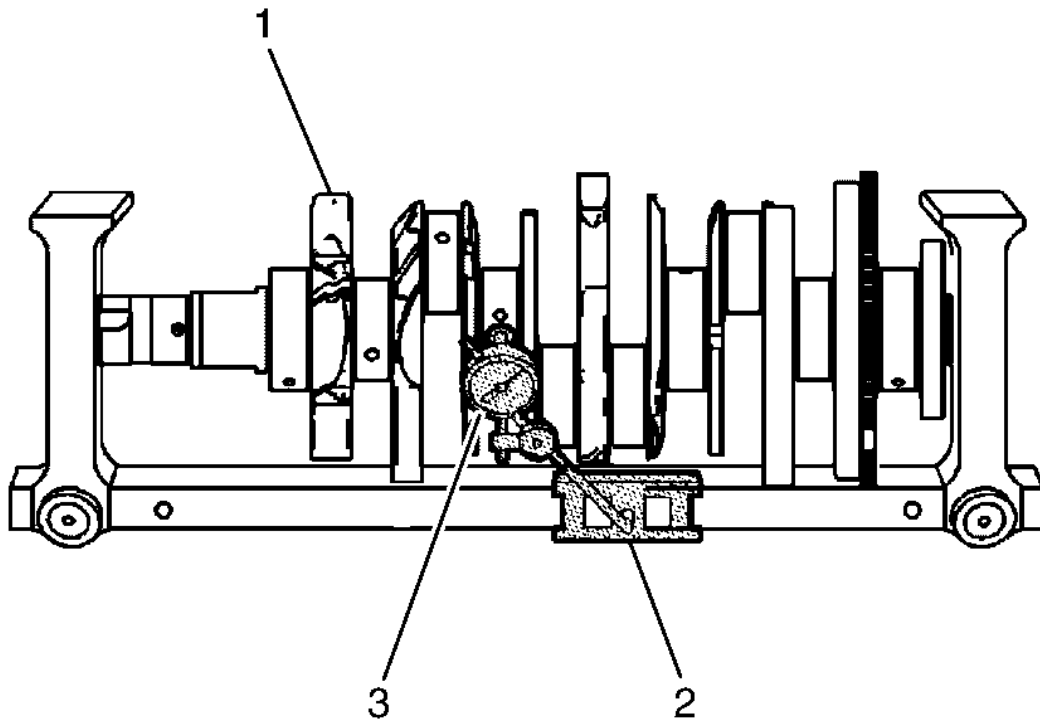
#### **Crankshaft Measurement**



**Fig. 39: Identifying Fixture & Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

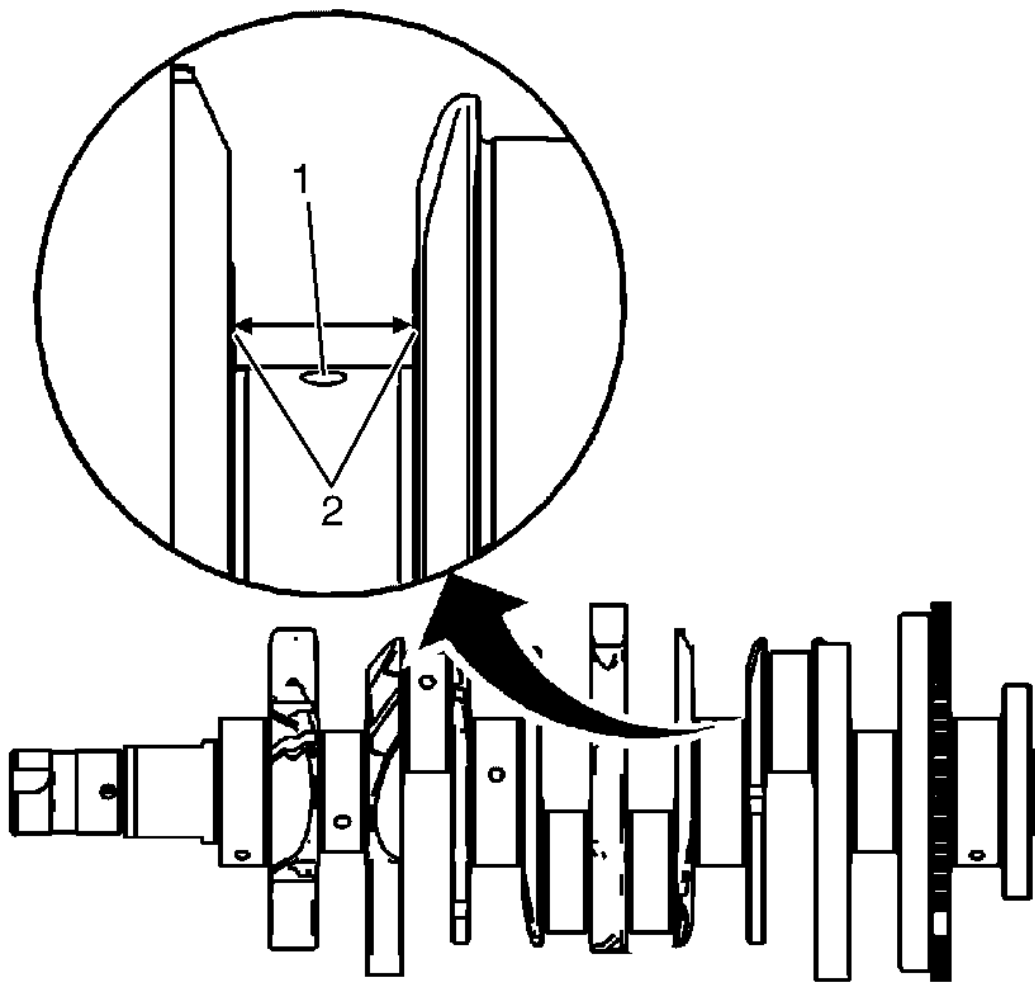
1. Using a suitable fixture (2), support the crankshaft (1).





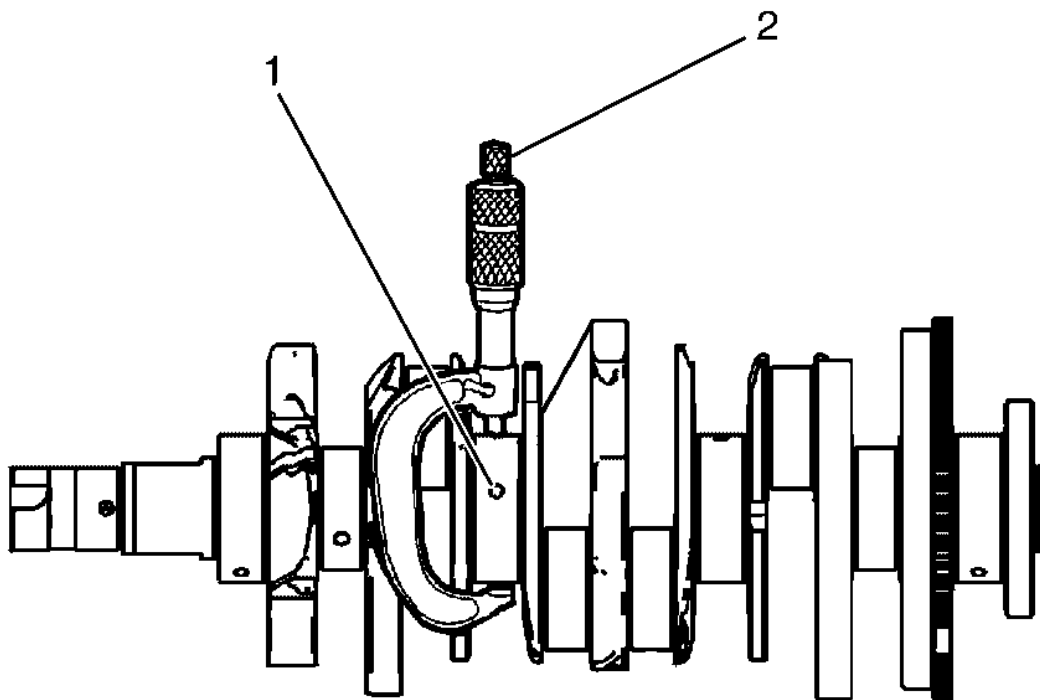
**Fig. 40: View Of Dial Indicator, Magnetic Base & Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

2. Set up a dial indicator (3) and magnetic base (2).
3. Rotate the crankshaft (1) to measure and record the crankshaft runout. Compare your results with the **Engine Mechanical Specifications** .



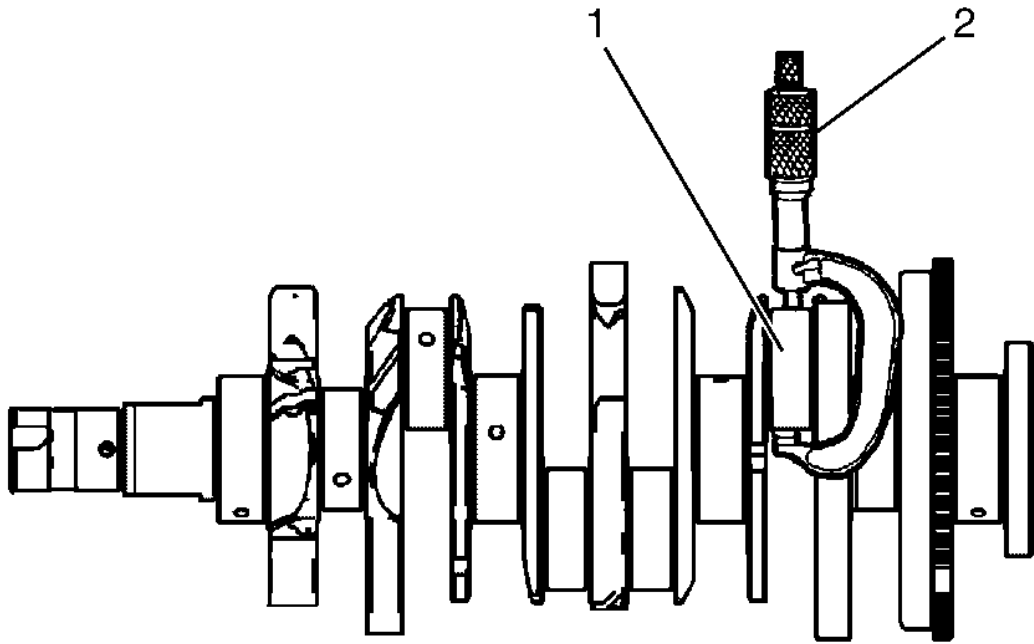
**Fig. 41: Identifying Crankshaft Thrust Wall Surface & Width**  
Courtesy of GENERAL MOTORS CORP.

4. Measure and record the crankshaft thrust wall width (2) for wear using an inside micrometer. Compare your results with the **Engine Mechanical Specifications**.
5. Measure and record the crankshaft thrust wall surface (1) for runout using the dial indicator. Compare your results with the **Engine Mechanical Specifications**.
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.



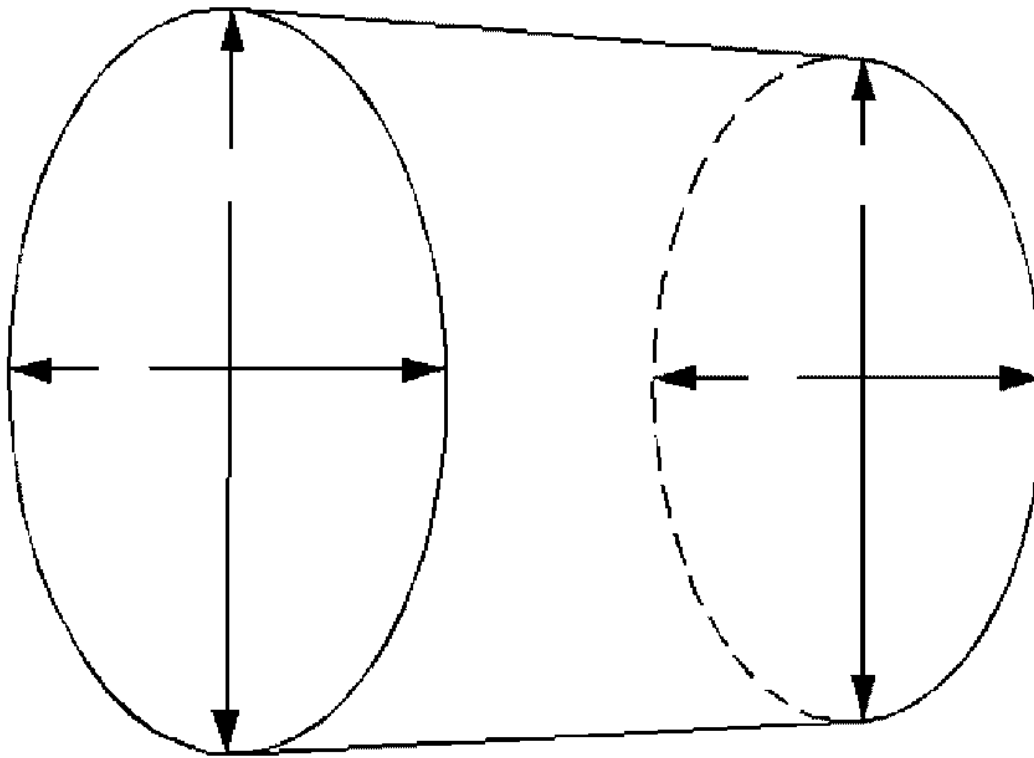
**Fig. 42: View Of Crankshaft Main Journals & Outside Micrometer**  
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft main journals (1) for undersize, using an outside micrometer (2).



**Fig. 43: View Of Crankpins & Outside Micrometer**  
**Courtesy of GENERAL MOTORS CORP.**

8. Inspect the crankpins (1) for undersize using an outside micrometer (2).
9. Compare your results with the **Engine Mechanical Specifications** . If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.



**Fig. 44: Identifying Main Bearing & Crankpin Journals**  
Courtesy of GENERAL MOTORS CORP.

10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
  1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
  2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
  3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
  4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
  5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.
11. Measure the main bearing and crankpin journals for taper using the following procedure:
  1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
  2. Subtract the smallest from the largest measurement. The result will be the journal taper.
  3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
  4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

## CRANKSHAFT BALANCER CLEANING AND INSPECTION

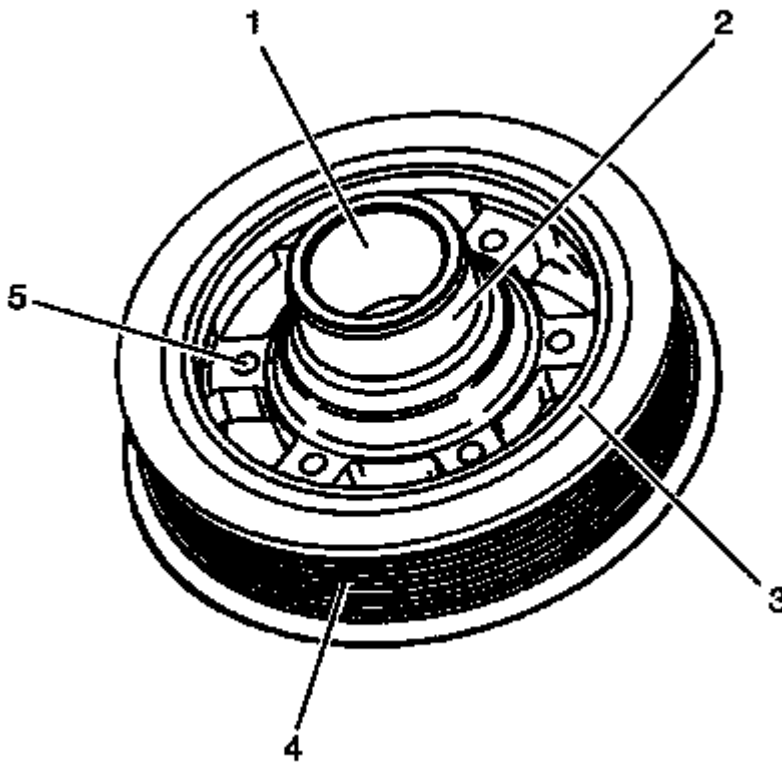
### Cleaning Procedure

1. Clean the crankshaft balancer in solvent that is compatible with the rubber.

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

2. Dry the crankshaft balancer with compressed air.

### Inspection Procedure



**Fig. 45: Identifying Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft balancer for the following:
  - Worn or damaged hub-to-crankshaft surface (1)
  - Worn, grooved or damaged hub seal surface (2).
  - Worn, chunking or deteriorated rubber between the hub and pulley (3)
  - Damaged drive belt ribs (4)

- Damaged threaded holes (5)
2. Repair or replace the crankshaft balancer as required.

## **ENGINE FLYWHEEL CLEANING AND INSPECTION**

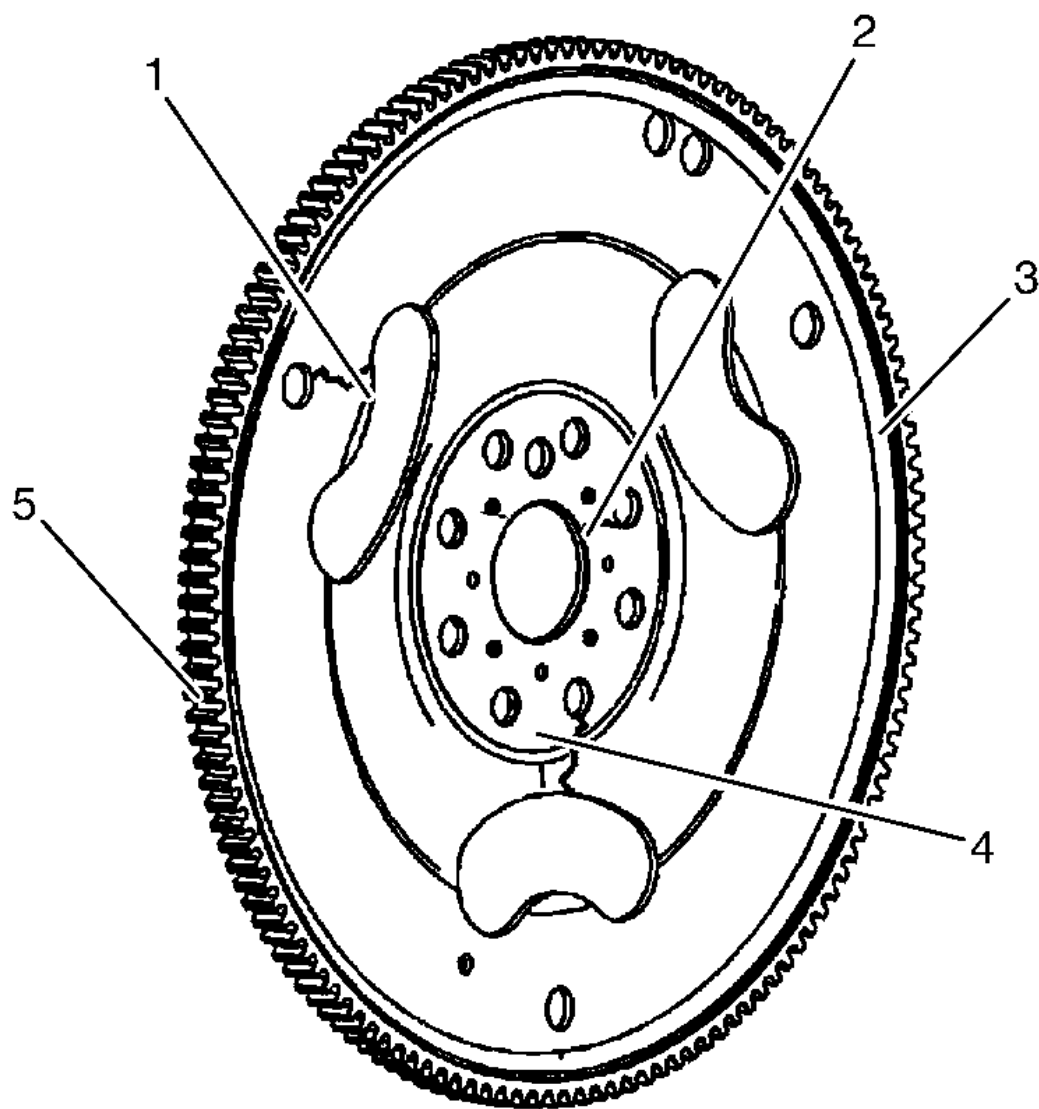
### **Cleaning Procedure**

1. Clean the engine flywheel in solvent.

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

2. Dry the engine flywheel with compressed air.

### **Inspection Procedure**



**Fig. 46: Identifying Engine Flywheel**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for the following conditions:
  - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2 and 4)

**NOTE:**      **DO NOT attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.**



- Cracks at welded areas that retain the ring gear onto the engine flywheel (3)
  - Damaged or missing ring gear teeth (5)
2. Replace the engine flywheel as necessary.

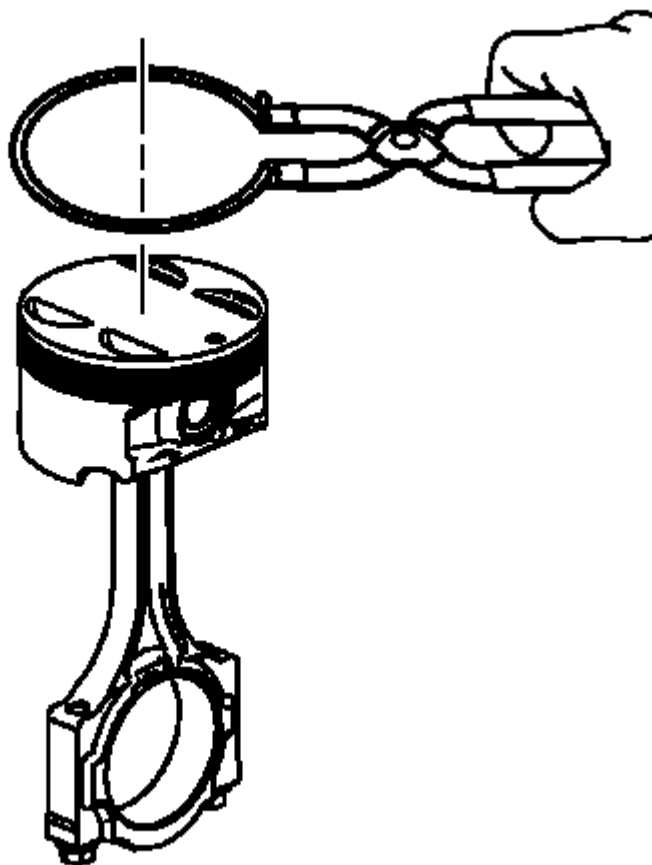
## PISTON AND CONNECTING ROD DISASSEMBLE

### Special Tools

**EN-46745:** Piston Pin Clip Remover/Installer

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

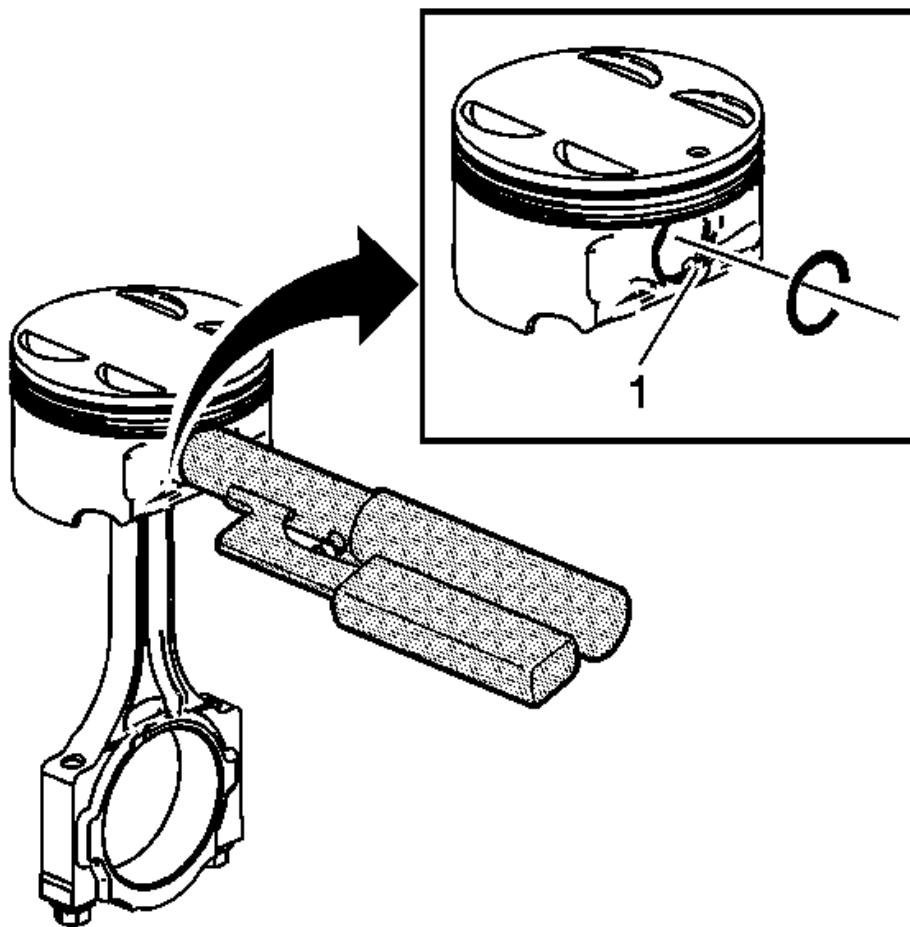
### Disassemble



**Fig. 47: View Of Piston Ring Expander**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

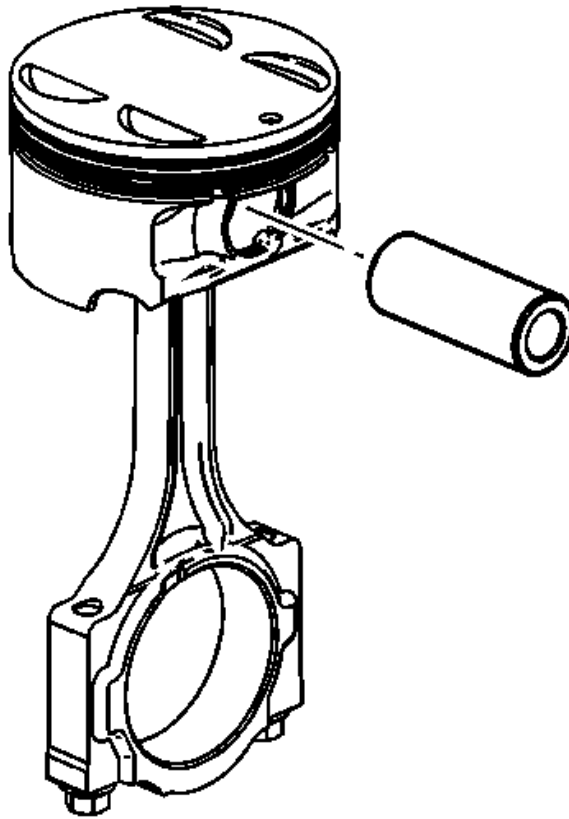


**Fig. 48: Identifying Piston Pin Retainers Removal Access Notch**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.
- **DO NOT** reuse the piston pin retainers.

2. Using the **EN-46745**: remover/installer, remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.



**Fig. 49: View Of Piston Pin**  
Courtesy of GENERAL MOTORS CORP.

3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

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

### **Cleaning Procedure**

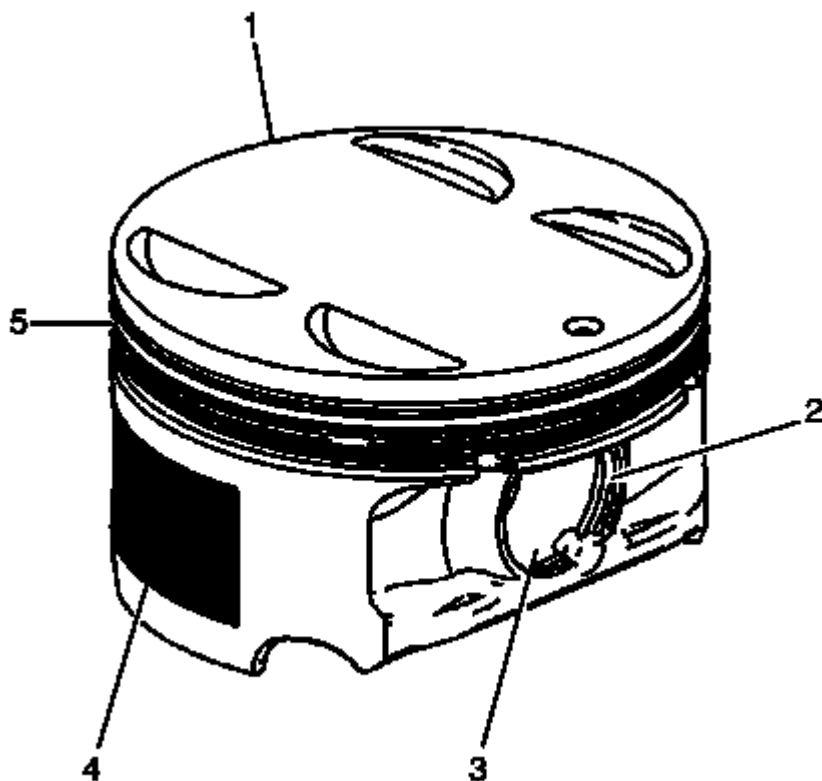
**NOTE:**        **DO NOT wire brush any part of the piston.**

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

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

3. Dry the piston with compressed air.

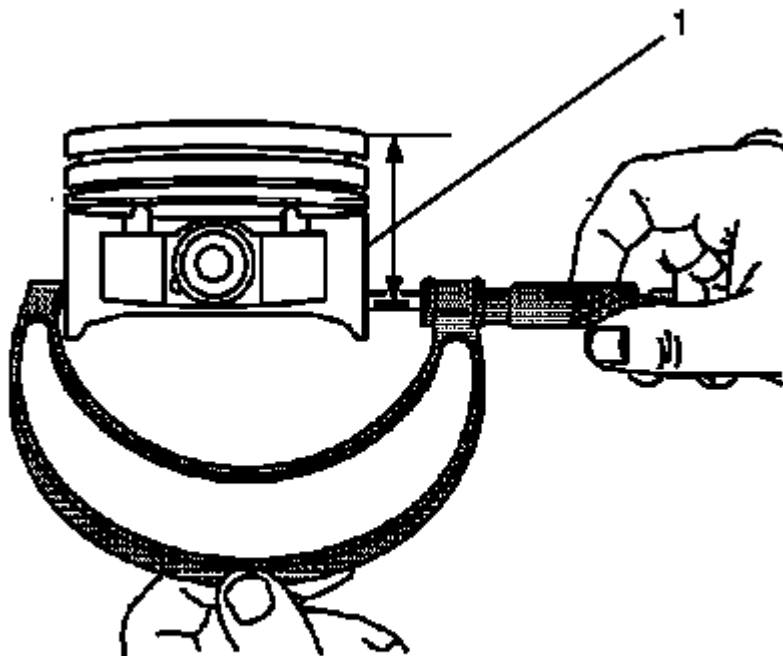
### Piston Inspection Procedure



**Fig. 50: Identifying Piston**  
Courtesy of GENERAL MOTORS CORP.

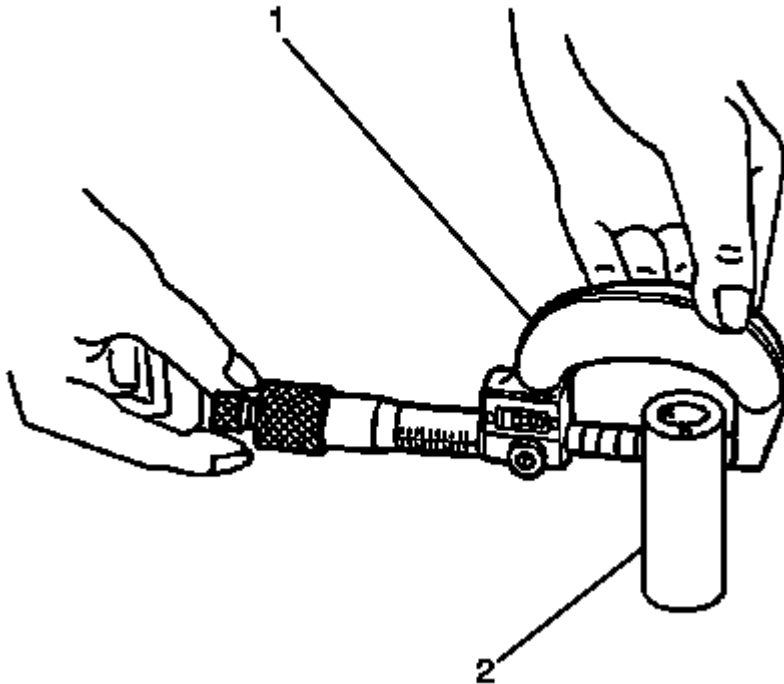
1. Inspect the pistons for the following conditions:
  - Cracked ring lands, skirts or pin bosses
  - Ring grooves for nicks, burrs that may cause binding (5)
  - Warped or worn ring lands (5)
  - Piston pin retainer grooves for burrs (2)
  - Eroded areas at the top of the piston (1)
  - Scuffed or damaged skirt coating (4)
  - Worn piston pin bores or worn piston pins (3)
2. Replace pistons that show any signs of damage or wear above acceptable tolerances.

### Piston Measurement Procedure



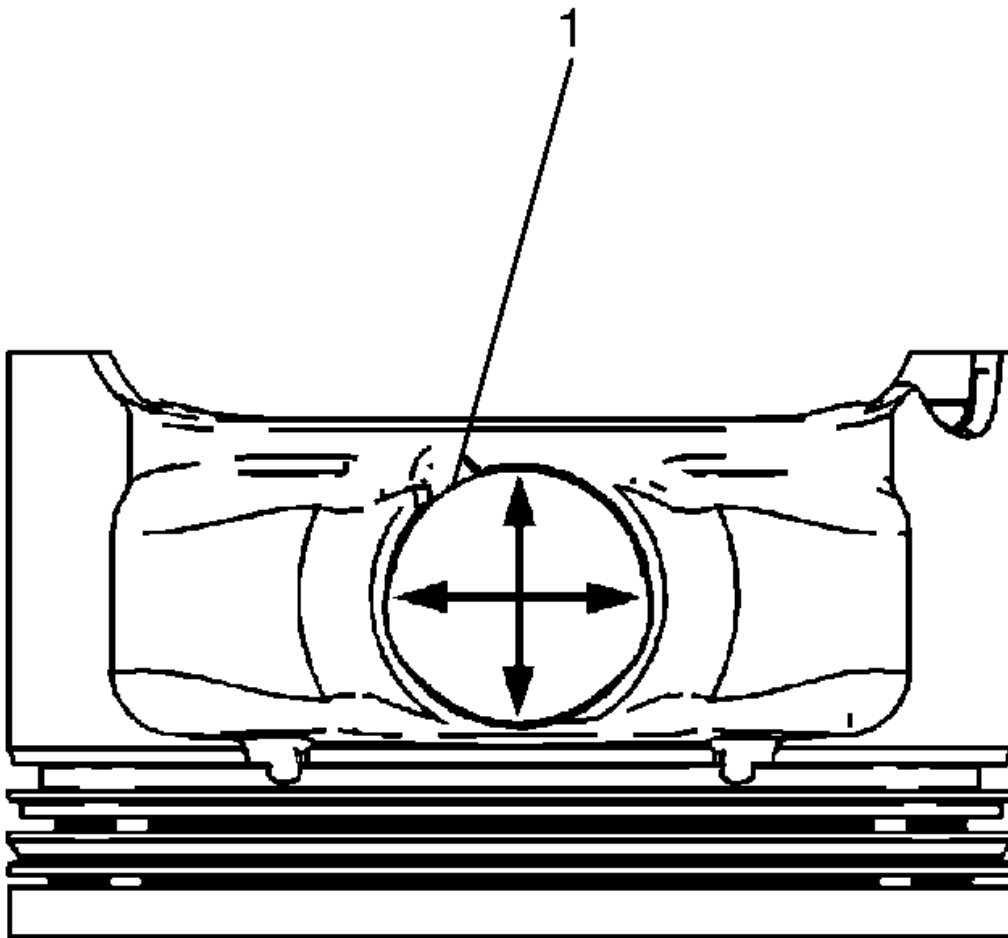
**Fig. 51: View Of Piston Measurement**  
Courtesy of GENERAL MOTORS CORP.

1. Measure piston width using the following procedure:
  1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top (1), at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
  2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
  3. Compare your results with the **Engine Mechanical Specifications** .
  4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.



**Fig. 52: Identifying Piston Pin Bore To Piston Pin Measurement From Outside Micrometer**  
Courtesy of GENERAL MOTORS CORP.

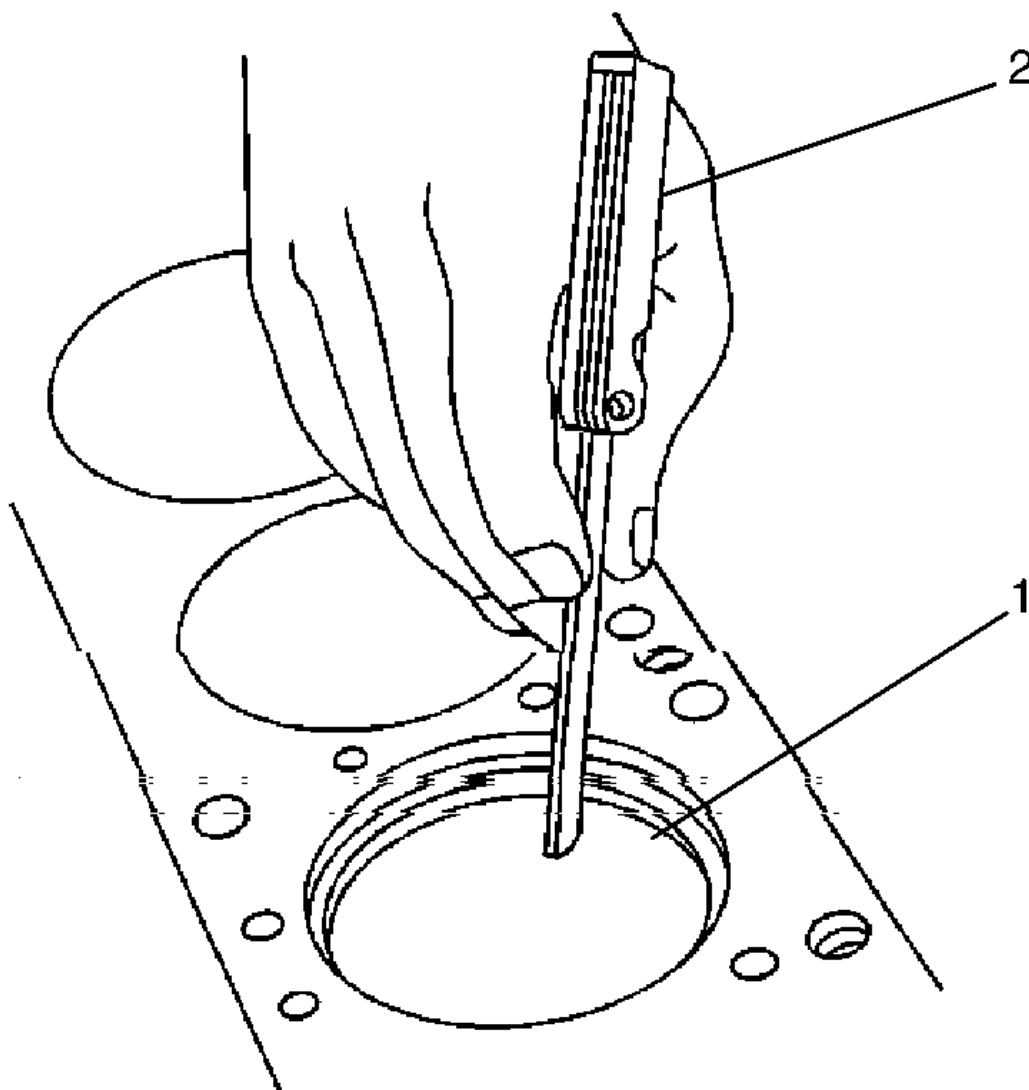
2. Measure the piston pin bore to piston pin (2) clearances using the following procedure:
  1. Piston pin bores and pins must be free of varnish or scuffing.
  2. Use an outside micrometer (1) to measure the piston pin in the piston contact areas.



**Fig. 53: Identifying Piston Pin Bore Measurement**  
Courtesy of GENERAL MOTORS CORP.

3. Using an inside micrometer, measure the piston pin bore (1). Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the **Engine Mechanical Specifications**.
4. If the clearance is above acceptable tolerances, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

#### **Piston Ring Measurement Procedure**

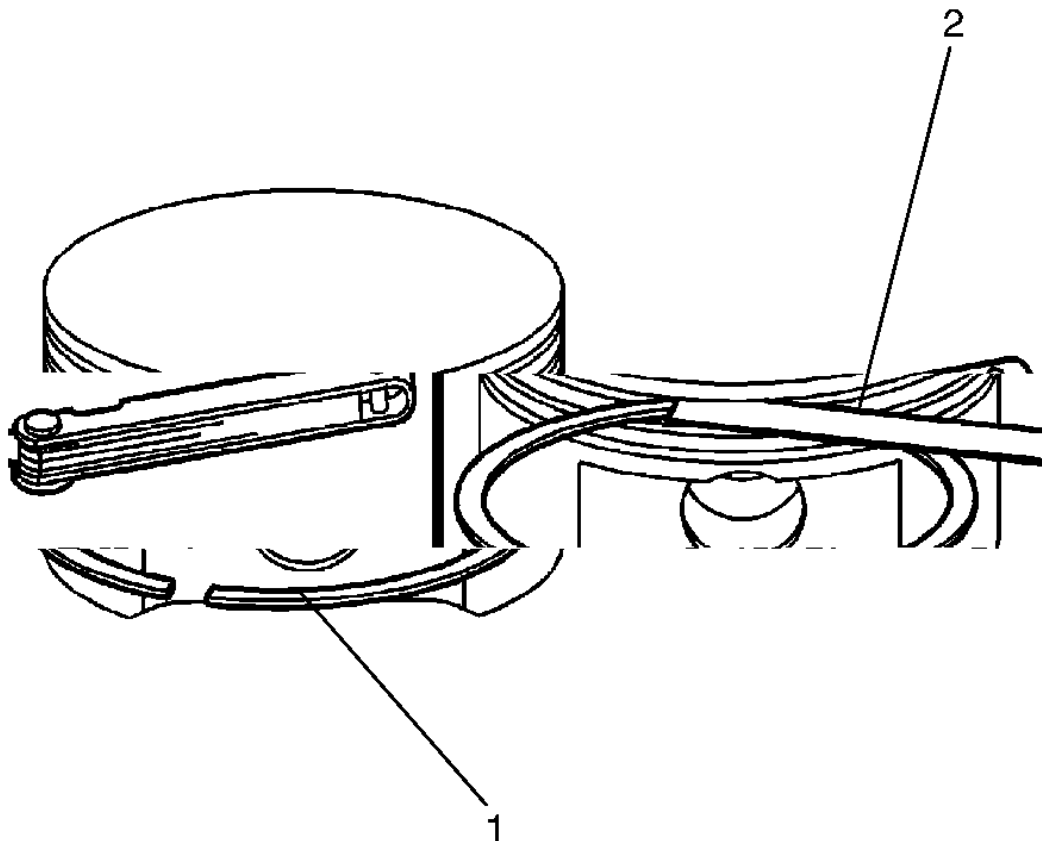


**Fig. 54: Identifying End Gap Of Piston Ring Measurement**  
Courtesy of GENERAL MOTORS CORP.

1. Measure the piston ring end gap using the following procedure:
  1. Place the piston ring (1) in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Make sure that the piston ring (1) is square with the cylinder bore by positioning the piston ring (1) with the piston head.
  2. Measure the end gap of the piston ring (1) with feeler gauges (2). Refer to **Engine Mechanical Specifications** .
  3. If the clearance exceeds the provided specifications, the piston rings (1) must be replaced.

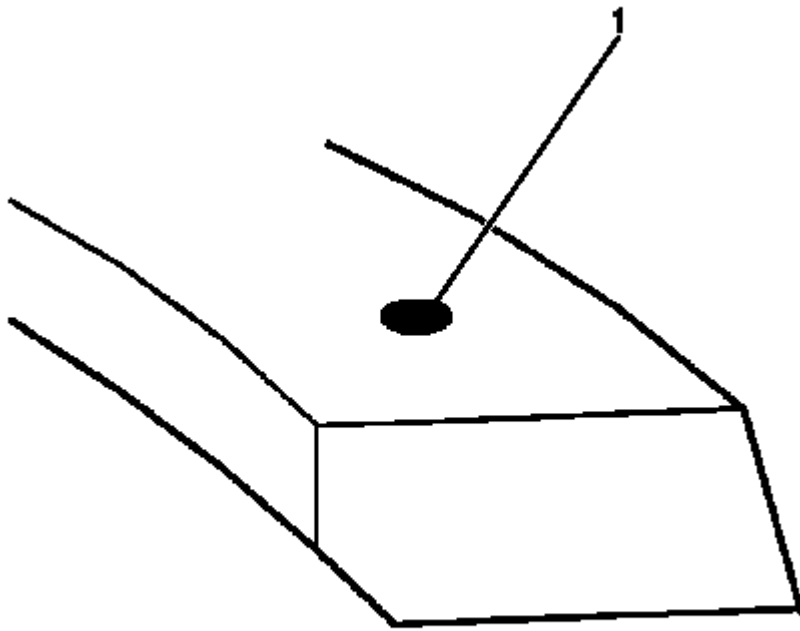


4. Repeat the procedure for all the piston rings (1).



**Fig. 55: Identifying Piston Ring Side Clearance Measurement**  
Courtesy of GENERAL MOTORS CORP.

2. Measure the piston ring (1) side clearance using the following procedure:
  1. Roll the piston ring (1) entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring (1), replace the piston ring (1).
  2. With the piston ring (1) on the piston, use feeler gauges (2) to check clearance at multiple locations.
  3. Compare the measurements with piston ring side clearance listed in the **Engine Mechanical Specifications**.
  4. If the clearance is greater than specifications, replace the piston ring (1).



**Fig. 56: Identifying Locating Dimple**  
Courtesy of GENERAL MOTORS CORP.

3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the correct specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

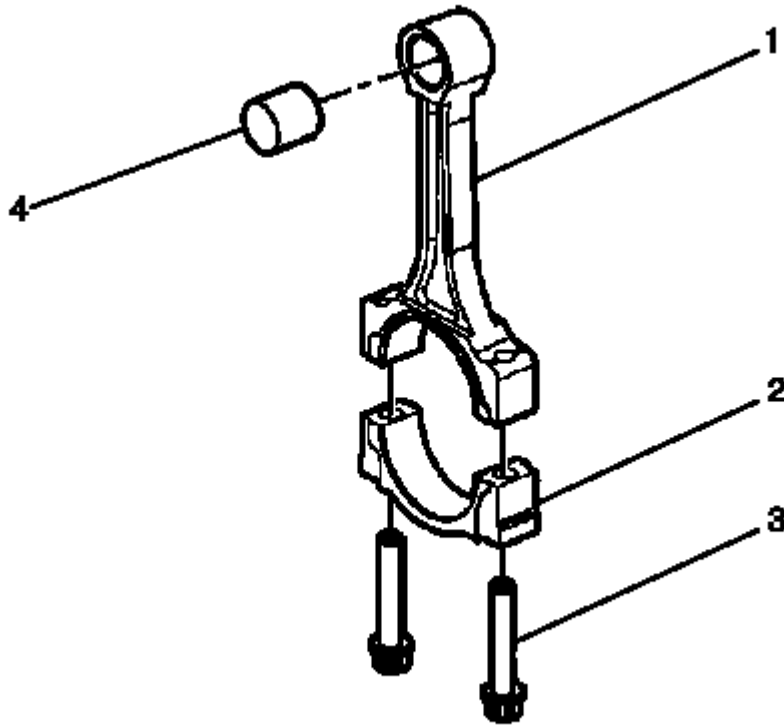
#### **Connecting Rod Cleaning Procedure**

1. Clean the connecting rods in solvent.

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

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

### Connecting Rod Visual Inspection Procedure



**Fig. 57: Identifying Piston Pin Bushing, Connecting Rod Beam, Rod Cap & Bolts**  
 Courtesy of GENERAL MOTORS CORP.

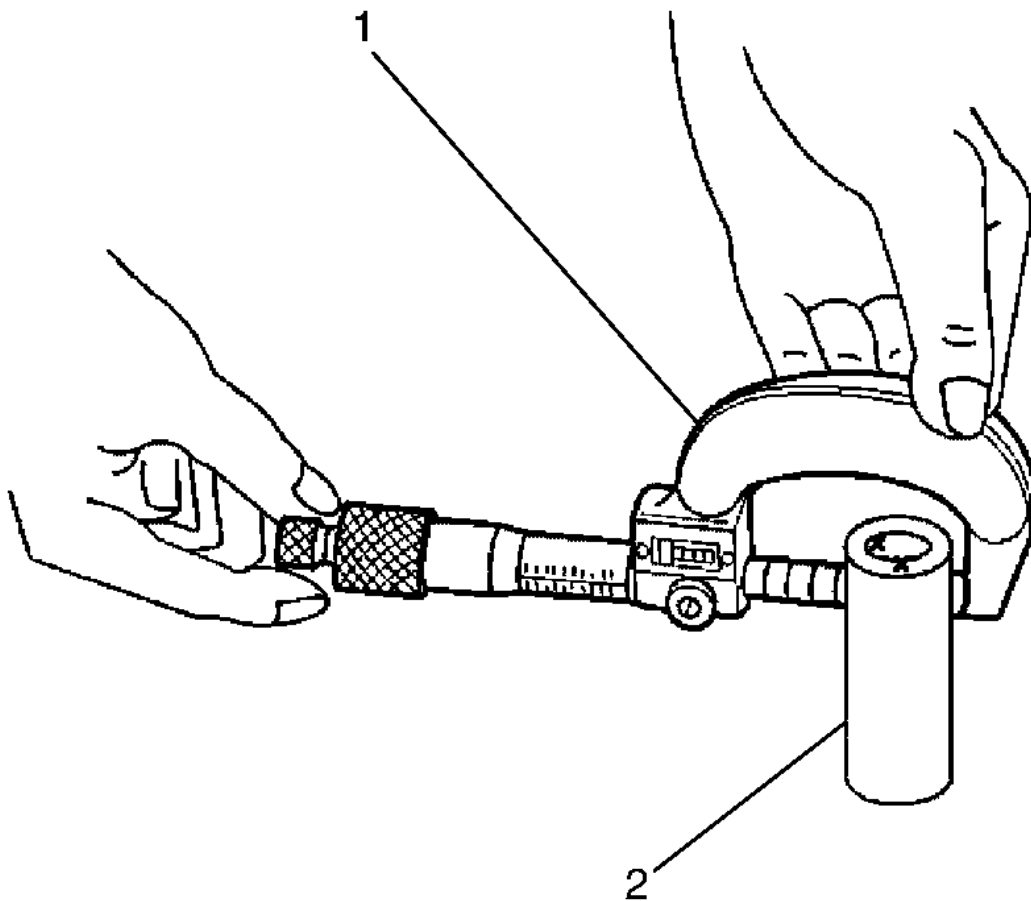
1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

**NOTE: DO NOT scrape the rod or rod cap.**

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.
6. Inspect the connecting rod bolts (3) for damage or stretching.

### Connecting Rod Measurement Procedure

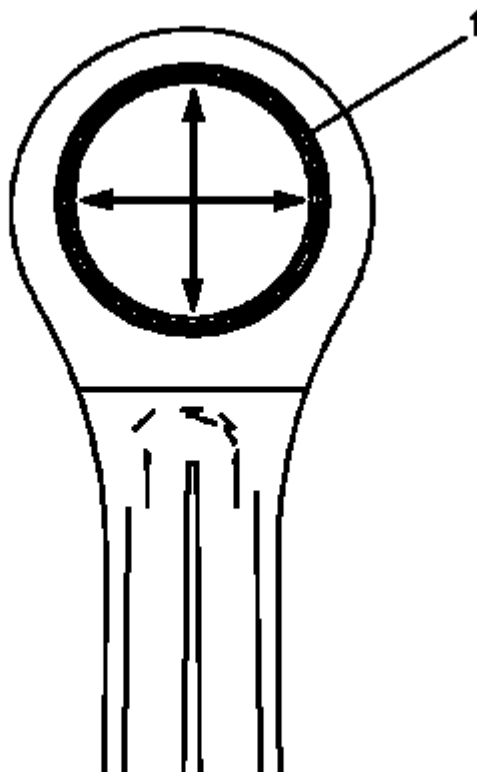
#### Piston Pin End



**Fig. 58: Identifying Measurements Of Piston Pin From Outside Micrometer**  
Courtesy of GENERAL MOTORS CORP.

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

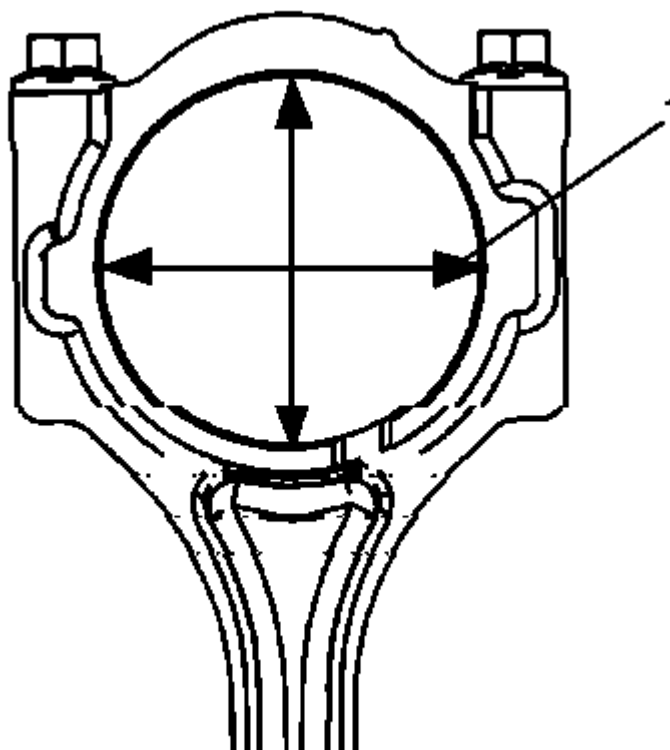
1. Using an outside micrometer (1), take 2 measurements of the piston pin (2) in the area of the connecting rod contact.



**Fig. 59: Identifying Connecting Rod Piston Pin Bore**  
Courtesy of GENERAL MOTORS CORP.

2. Using an inside micrometer, measure the connecting rod piston pin bore (1).
3. Subtract the piston pin diameter from the piston pin bore (1).
4. Compare the clearance measurements with the **Engine Mechanical Specifications** .
5. If the clearance is above acceptable tolerances, replace the piston pin. If a new pin does not resolve the clearance condition, replace the connecting rod.

### Connecting Rod Crankshaft Bearing End



**Fig. 60: Identifying Connecting Rod Crankshaft Bearing Bore Measurement From Inside Micrometer**

Courtesy of GENERAL MOTORS CORP.

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

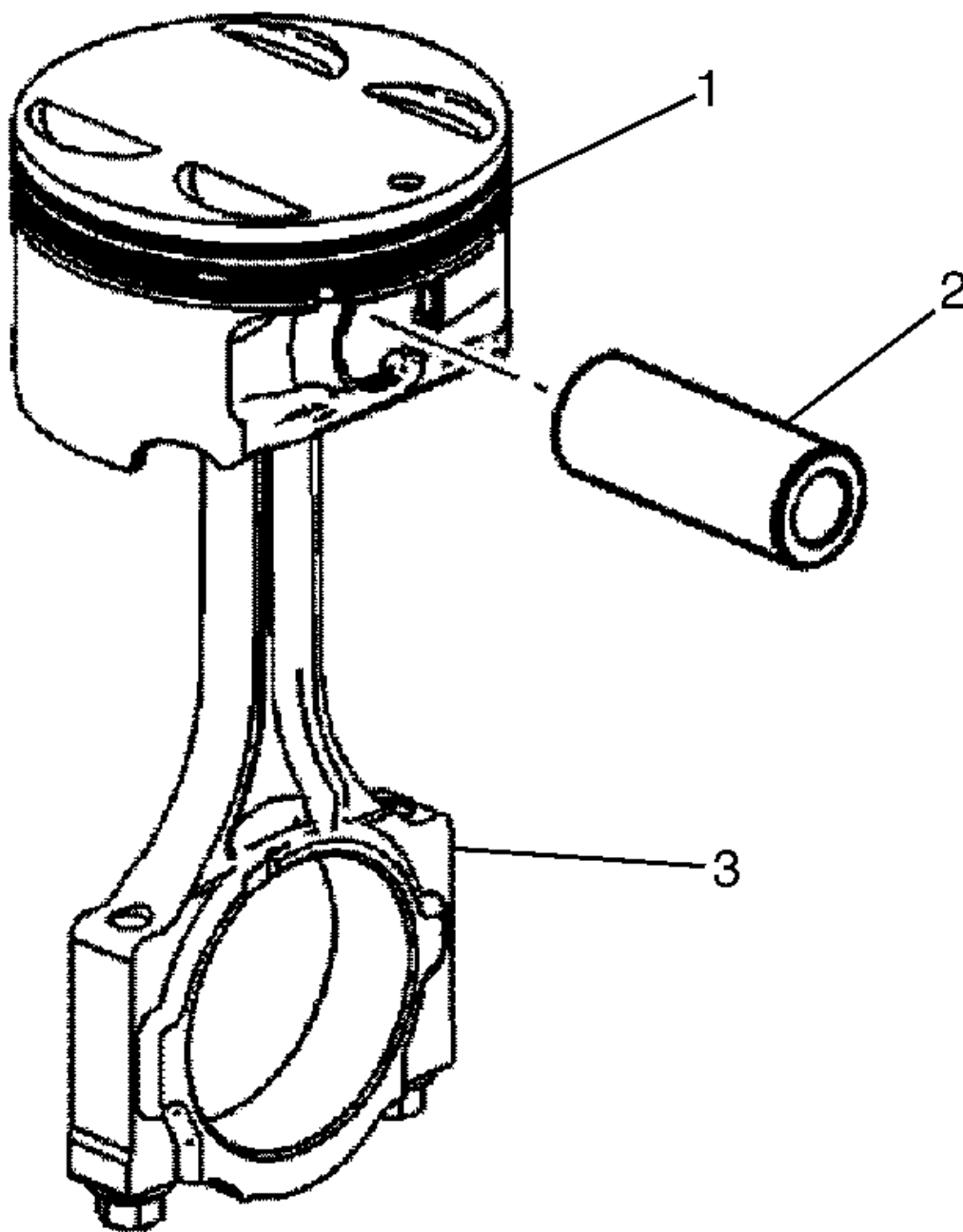
1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore (1).
2. Compare the bore measurements with the Engine Mechanical Specifications .
3. Replace the connecting rod if the connecting rod crankshaft bearing bore (1) is out of specifications. DO NOT recondition the connecting rod.

## PISTON AND CONNECTING ROD ASSEMBLE

### Tools Required

- EN 46121 Connecting Rod Guide Pin Set. See Special Tools .
- EN-46745 Piston Pin Clip Remover/Installer. See Special Tools .

### Piston and Piston Pin Installation Procedure



**Fig. 61: Identifying Connecting Rod, Piston & Pin**  
Courtesy of GENERAL MOTORS CORP.

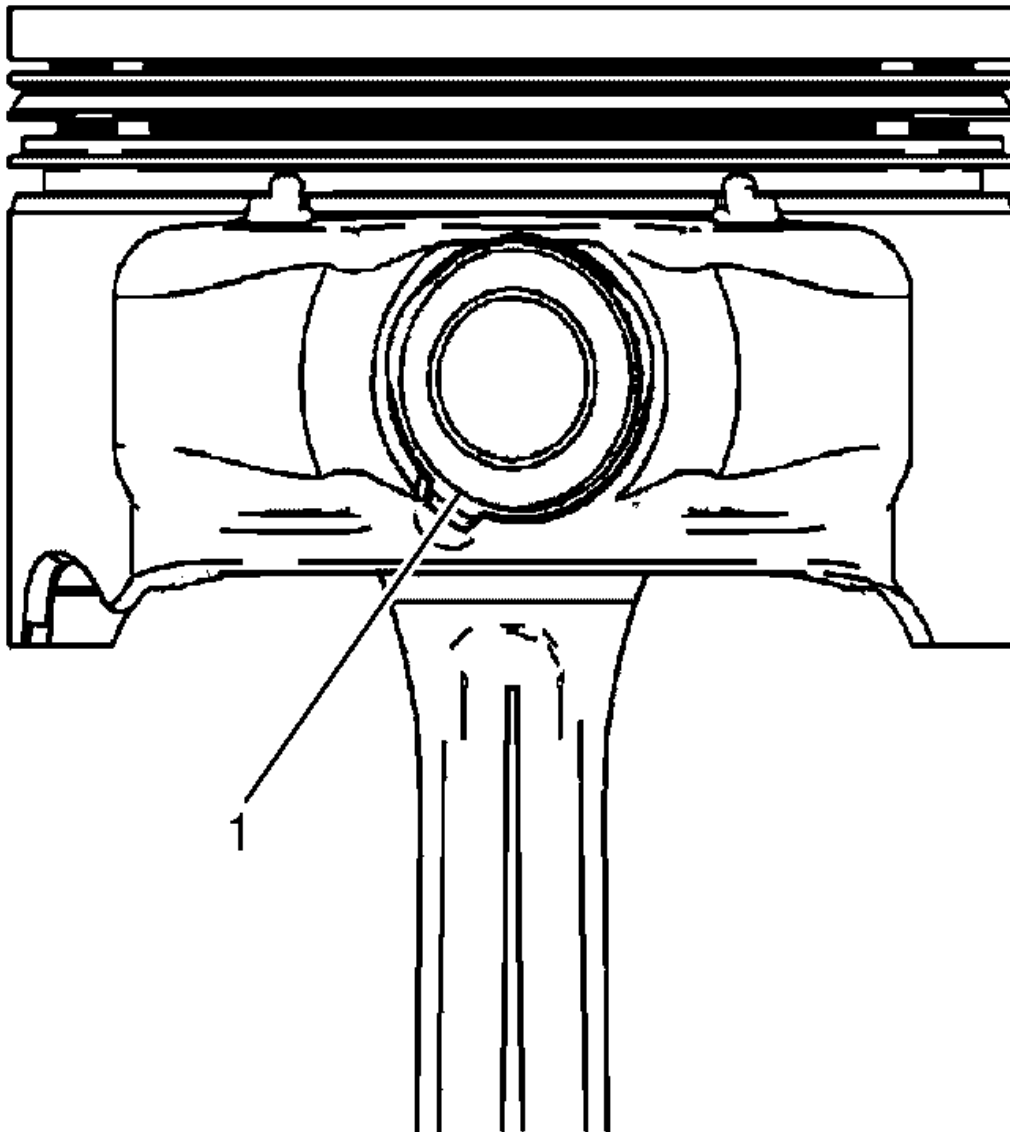
**IMPORTANT:** • The arrow located on top of the piston must point toward the front of

**the cylinder block.**

- **The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.**

1. Lubricate the piston pin (2) bores in the piston (1) and the connecting rod (3) with clean engine oil.
2. Assemble the piston (1) and piston pin (2) to the connecting rod (3). Correctly orient the piston (1) when reusing a marked connecting rod (3).
3. Align the piston pin (2) bore with the connecting rod (1) pin bore.
4. Slide the piston pin (2) into the piston (1) and the connecting rod (3).



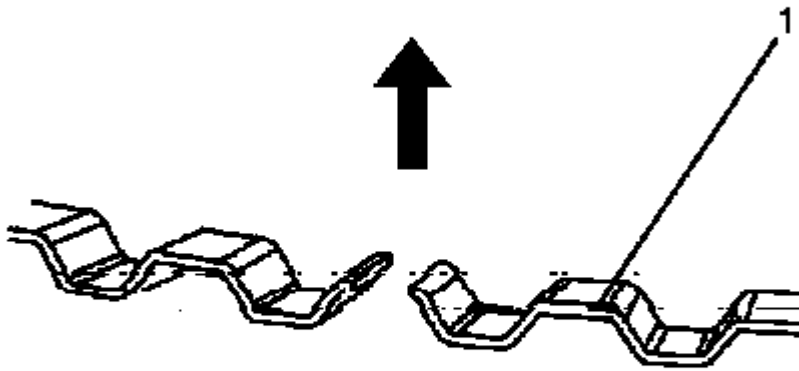


**Fig. 62: Identifying Removal Access Notch**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** New piston pin retainers must be used. Never reuse the piston pin retainers.

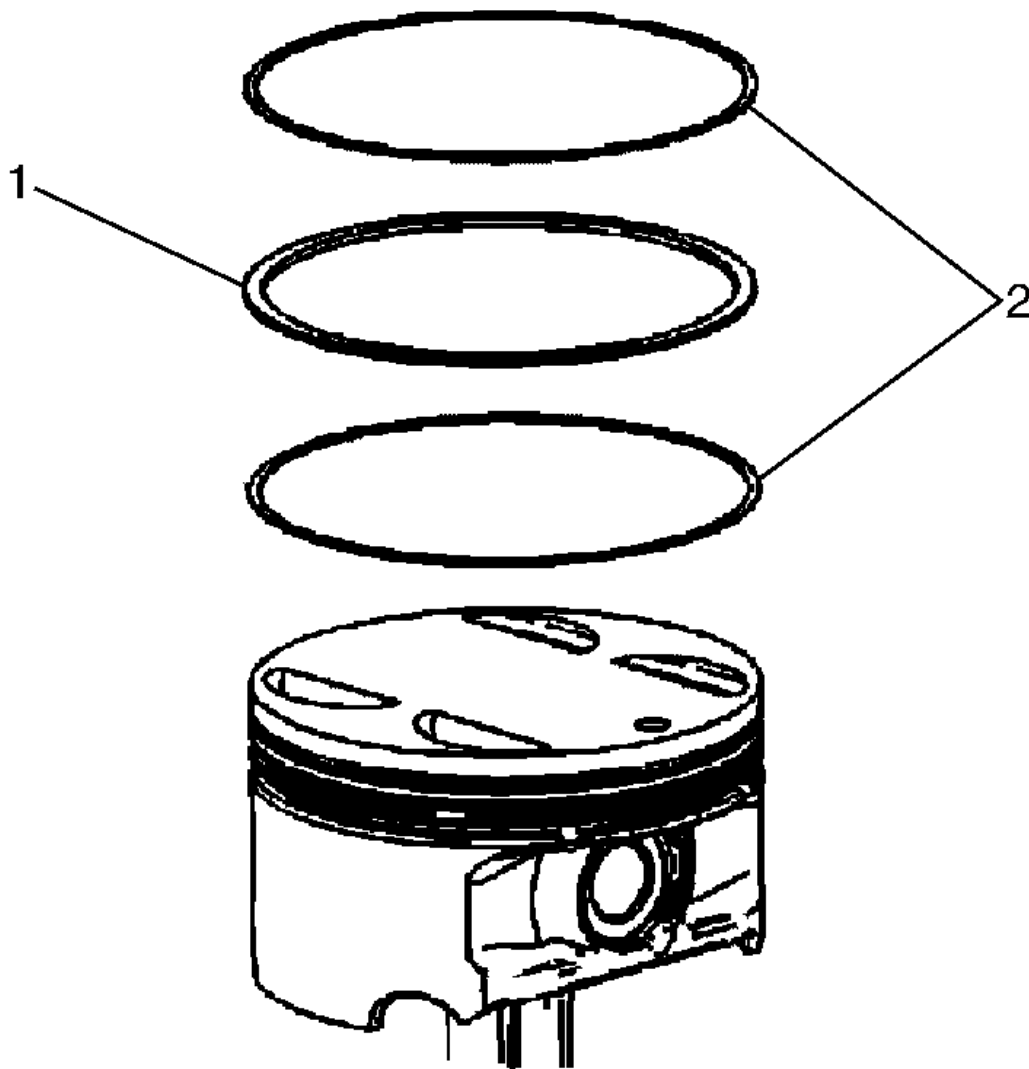
5. Install NEW piston pin retainers using the EN-46745 . See Special Tools . Align the EN-46745 to the notch (1) in the piston. See Special Tools .

6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

**Piston Ring Installation Procedure**

**Fig. 63: Identifying Oil Control Ring Expander**  
**Courtesy of GENERAL MOTORS CORP.**

1. Correctly orient the oil control ring expander (1) as shown before installation. The ends of the oil control ring expander (1) must be facing toward the top of the piston.

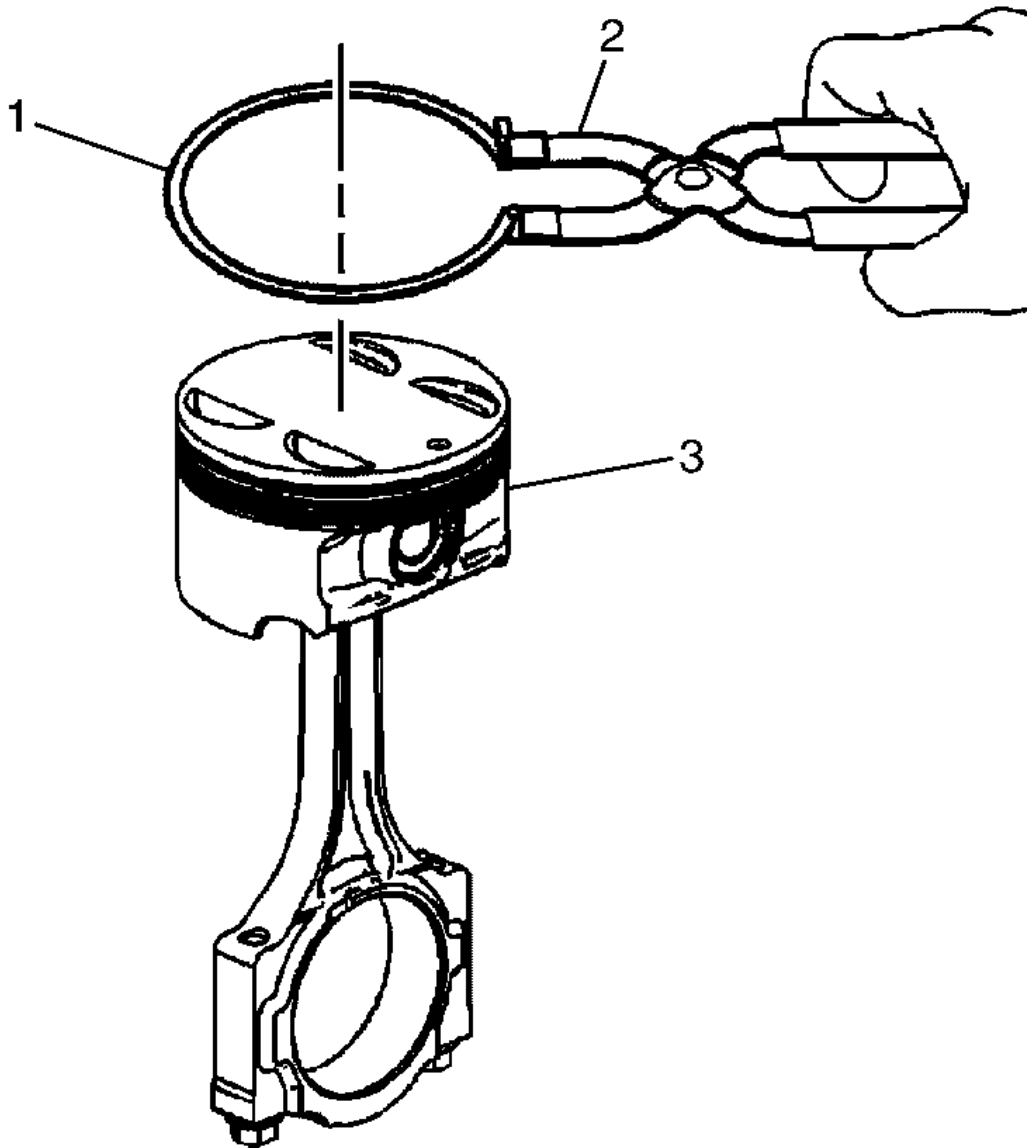


**Fig. 64: Identifying Expander & Oil Scraper Rings**  
Courtesy of GENERAL MOTORS CORP.

2. Using a piston ring expander, install the oil control ring assembly using the following procedure:
  1. Install the expander ring (1).

**IMPORTANT: Make sure that you DO NOT overexpand the piston ring.**  
**Overexpanding the piston rings will distort or crack the rings.**

2. Install the 2 oil scraper rings (2). Expand the rings only enough to clear the piston diameter.

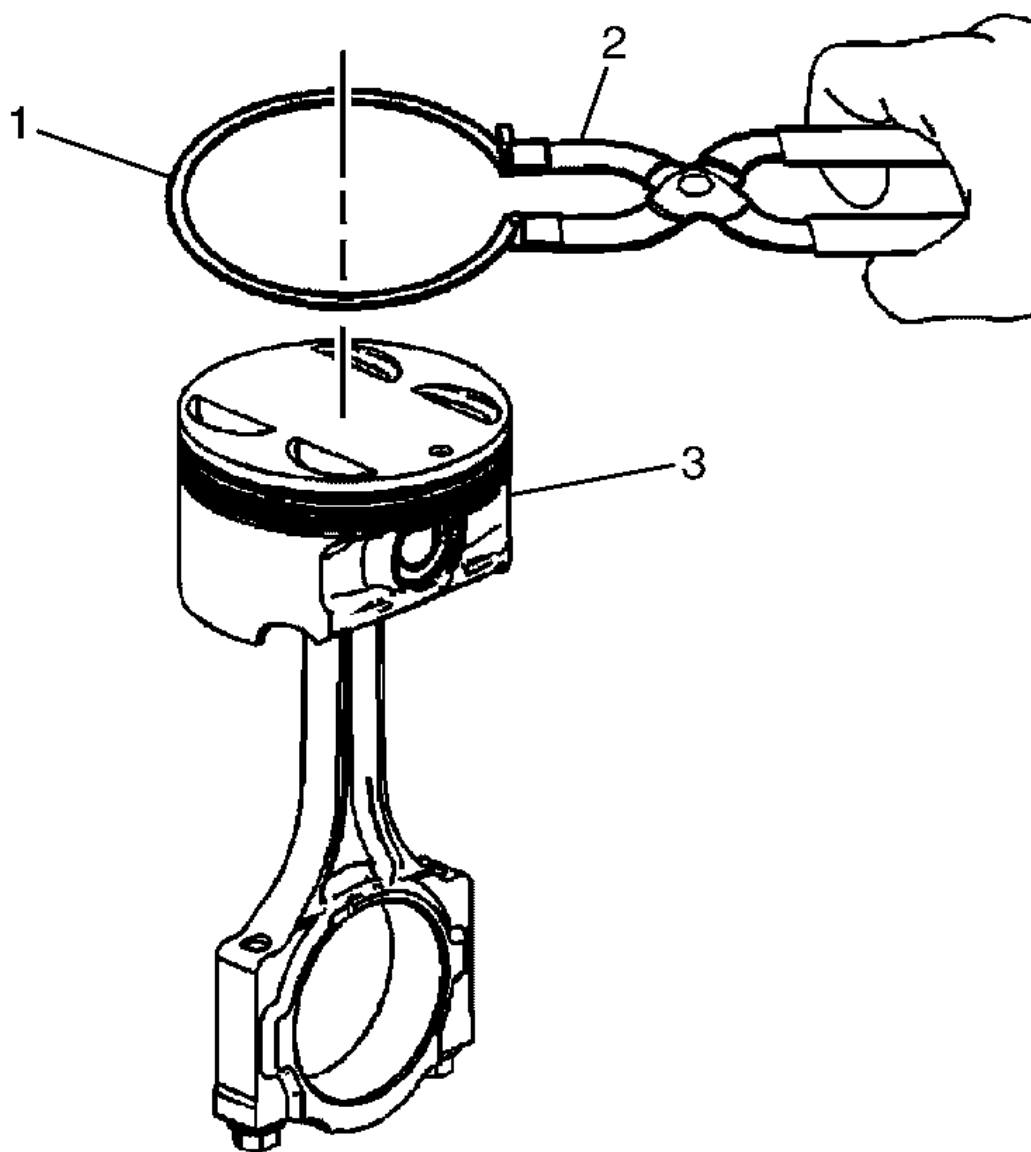


**Fig. 65: View Of Piston Ring Expander**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Make sure that you DO NOT overexpand the piston ring. Overexpanding the piston rings will distort or crack the rings.

**IMPORTANT:** Install the second piston ring (1) onto the piston (3) using the ring expander (2).

3. Install the second piston ring (1) onto the piston (3).



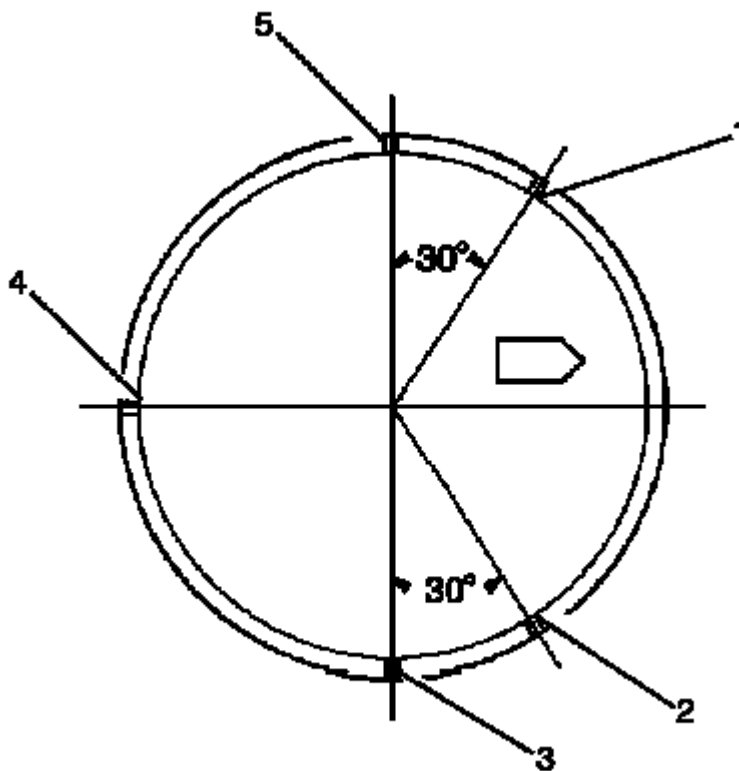
**Fig. 66: View Of Piston Ring Expander**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Make sure that you **DO NOT** overexpand the piston ring. Overexpanding the piston rings will distort or crack the rings.

**IMPORTANT:** Install the top piston ring (1) onto the piston (3) using the ring expander

(2).

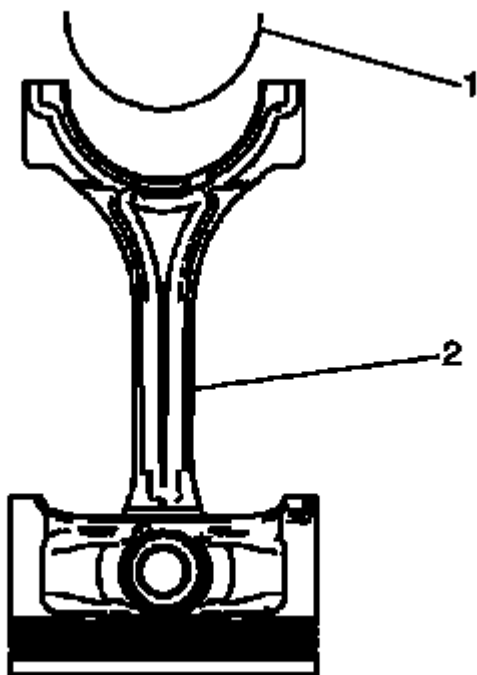
4. Install the top piston ring (1) onto the piston (3).



**Fig. 67: View Of Second Ring, Oil Control Ring Expander, Top Ring, Lower & Upper Oil Control Ring**  
Courtesy of GENERAL MOTORS CORP.

5. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.
  1. Lower oil control ring - position (1).
  2. Upper oil control ring - position (2).
  3. Top Ring - position (3).
  4. Oil control ring expander - position (4).
  5. Second ring - position (5).

#### Connecting Rod Bearing Installation Procedure

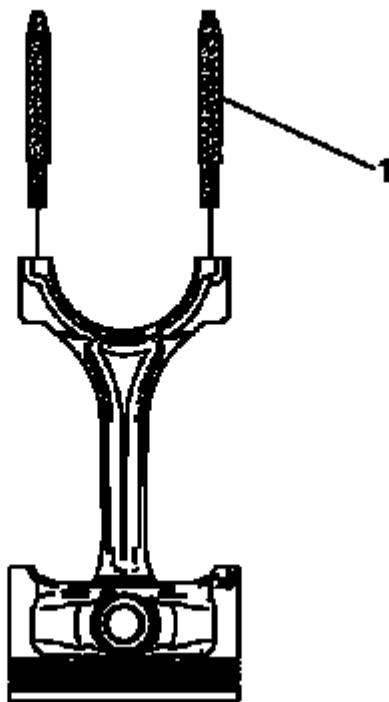


**Fig. 68: Locating Second Ring, Oil Control Ring Expander, Top Ring, Lower & Upper Oil Control Ring**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** If the connecting rod bearings (1) have been used in a running engine, you must replace them with **NEW** connecting rod bearings (1) for reassembly.

1. Clean the connecting rod (2) and the connecting rod cap bearing bore with a lint-free cloth.
2. Clean all the oil from behind the connecting rod bearing (1) halves.
3. Install new upper connecting rod bearings (1) into position. Roll the connecting rod bearings (1) into position so that the lock tang engages the alignment slot. The connecting rod bearings (1) must fit flush in the connecting rod (2).

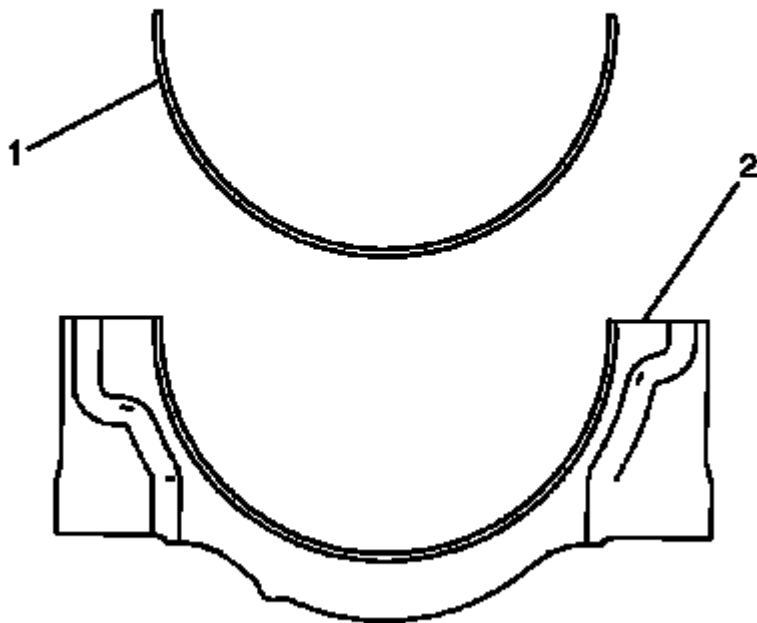


**Fig. 69: View Of EN 46121**

Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46121** (1) into the connecting rod bolt holes. See **Special Tools** .





**Fig. 70: Identifying Lower Connecting Rod Bearings & Connecting Rod Cap**  
 Courtesy of GENERAL MOTORS CORP.

5. Install new lower connecting rod bearings (1) into position in the connecting rod cap (2). Roll the connecting rod bearings (1) into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap (2).

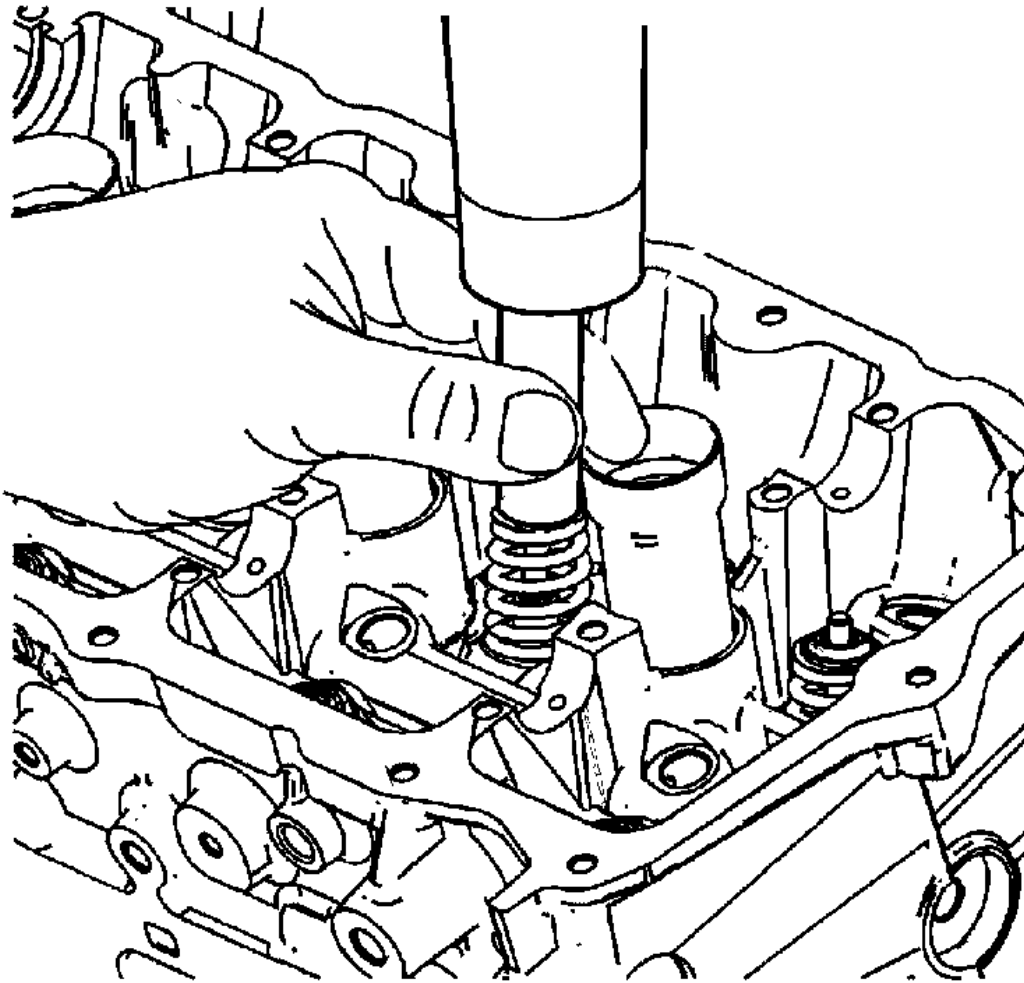
## CYLINDER HEAD DISASSEMBLE

### Special Tools

- **EN 46116:** Valve Stem Seal Remover/Installer
- **EN 46117:** Valve Stem Key Remover/Installer
- **EN 46119:** Off-Vehicle Valve Spring Compressor Adapter
- **EN-46122:** Camshaft Position Actuator Check-Ball Valve Remover/Installer
- **J 8062:** Valve Spring Compressor - Head Off

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

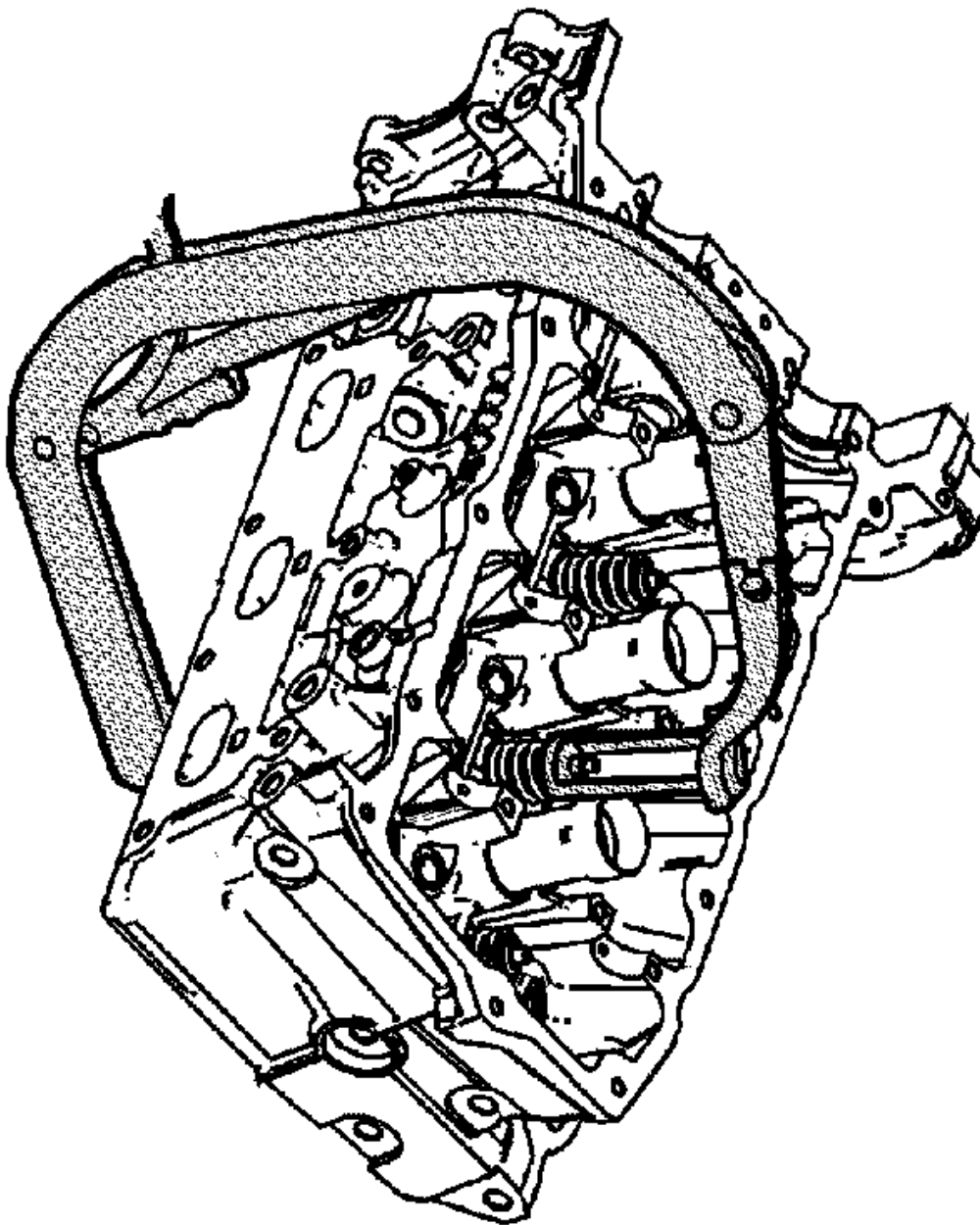
### Disassemble



**Fig. 71: Identifying Valve Collets Loosening Procedure**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **Make sure valve heads will not contact anything during the following step in order to avoid bending or damage.**

1. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve collets.



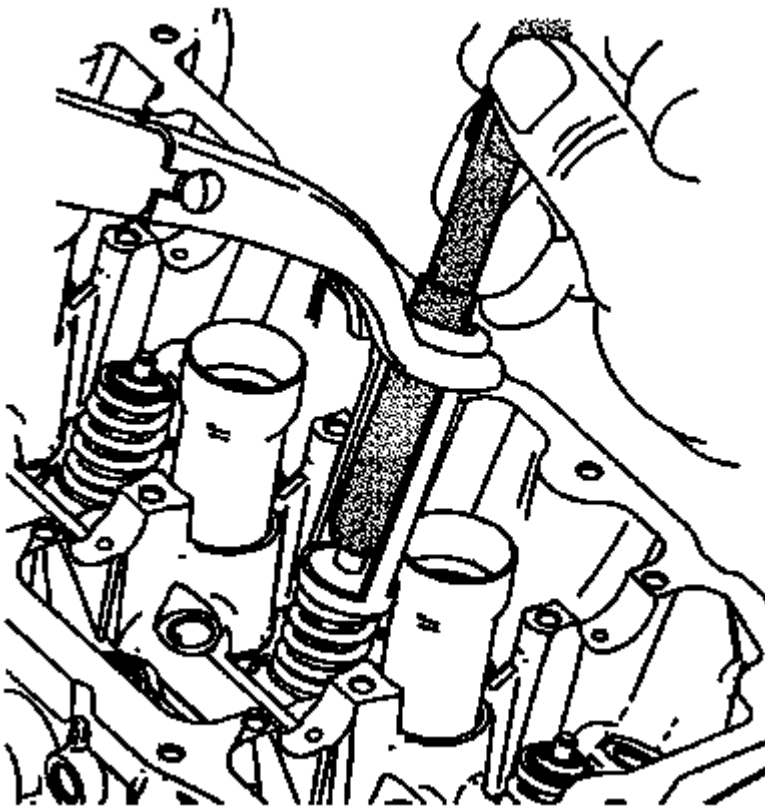
**Fig. 72: View Of J 8062 & EN 46119**  
Courtesy of GENERAL MOTORS CORP.

**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.

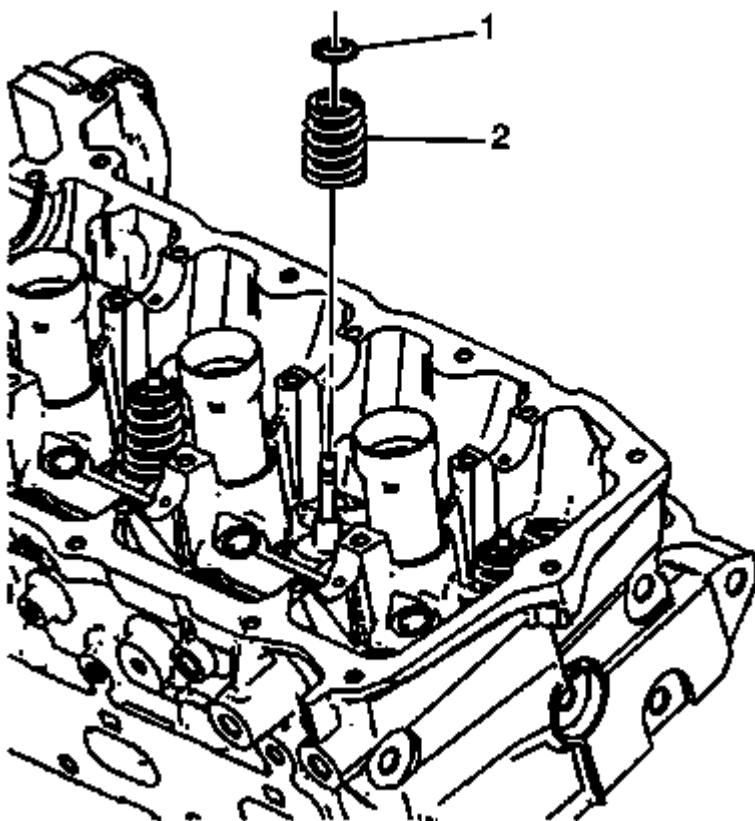
**CAUTION:** Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

2. Compress the valve spring using the **J 8062**: compressor and the **EN 46119**: adapter.



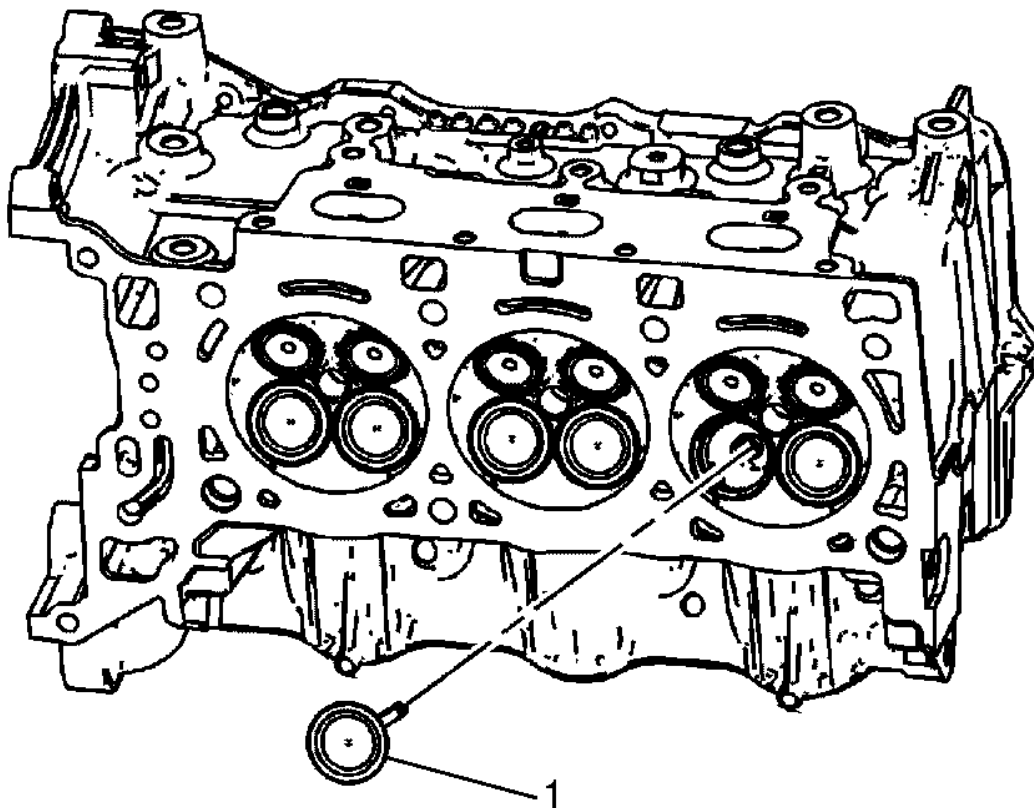
**Fig. 73: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

3. Use the magnet of the **EN 46117**: remover/installer in order to remove the valve collets.
4. Remove the valve spring compressor and the adapter.



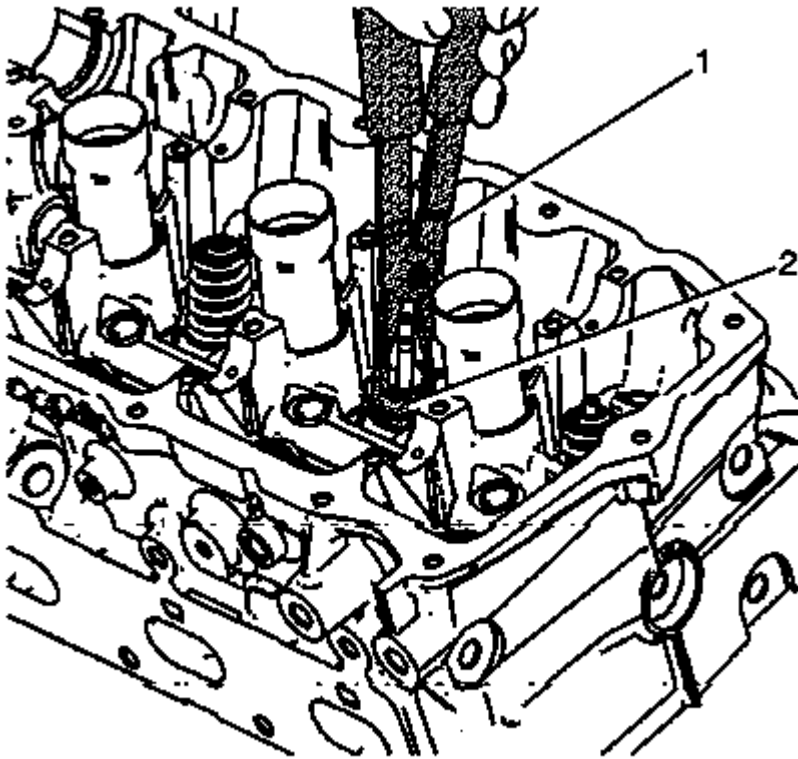
**Fig. 74: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve spring retainer (1).
6. Remove the valve spring (2).



**Fig. 75: Identifying Valve**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the valve (1).



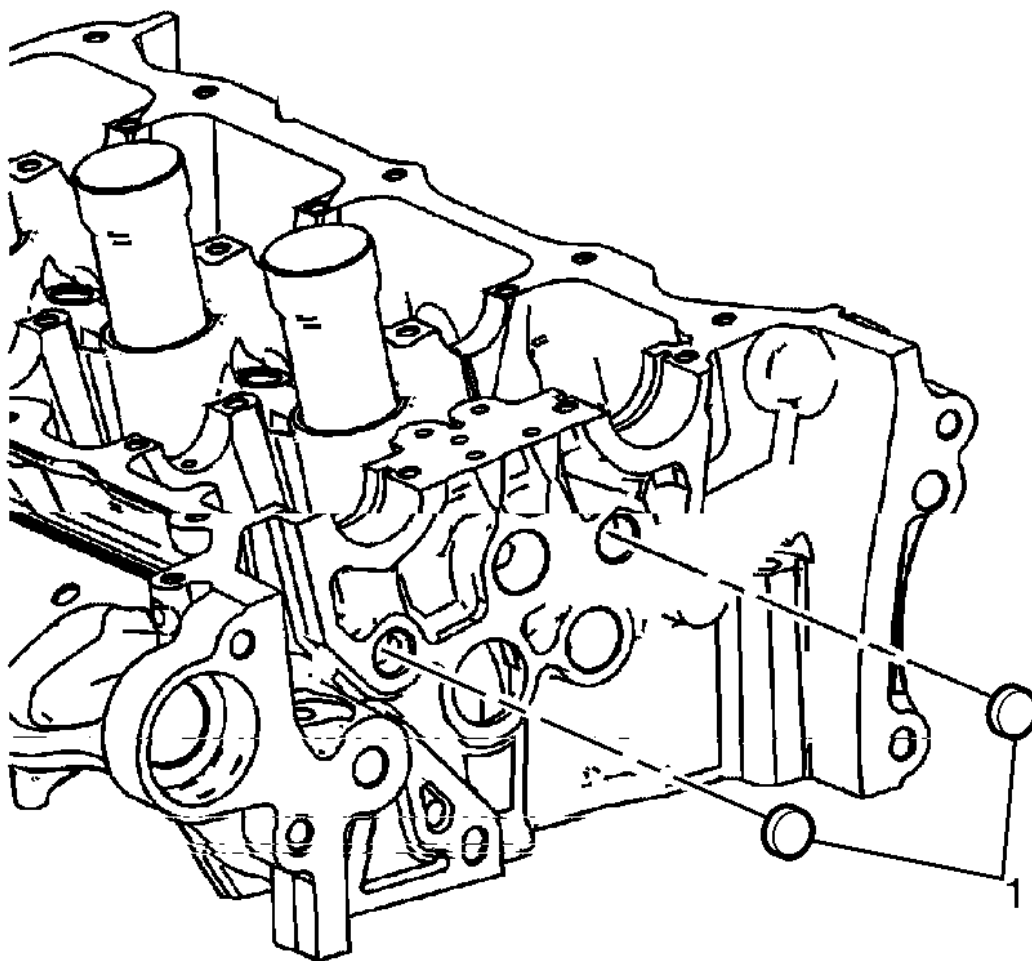
**Fig. 76: View Of EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **NEVER** reuse a valve stem oil seal.

8. Remove the valve stem oil seal (2) using the **EN 46116**: remover/installer (1).

Discard the valve stem oil seals.

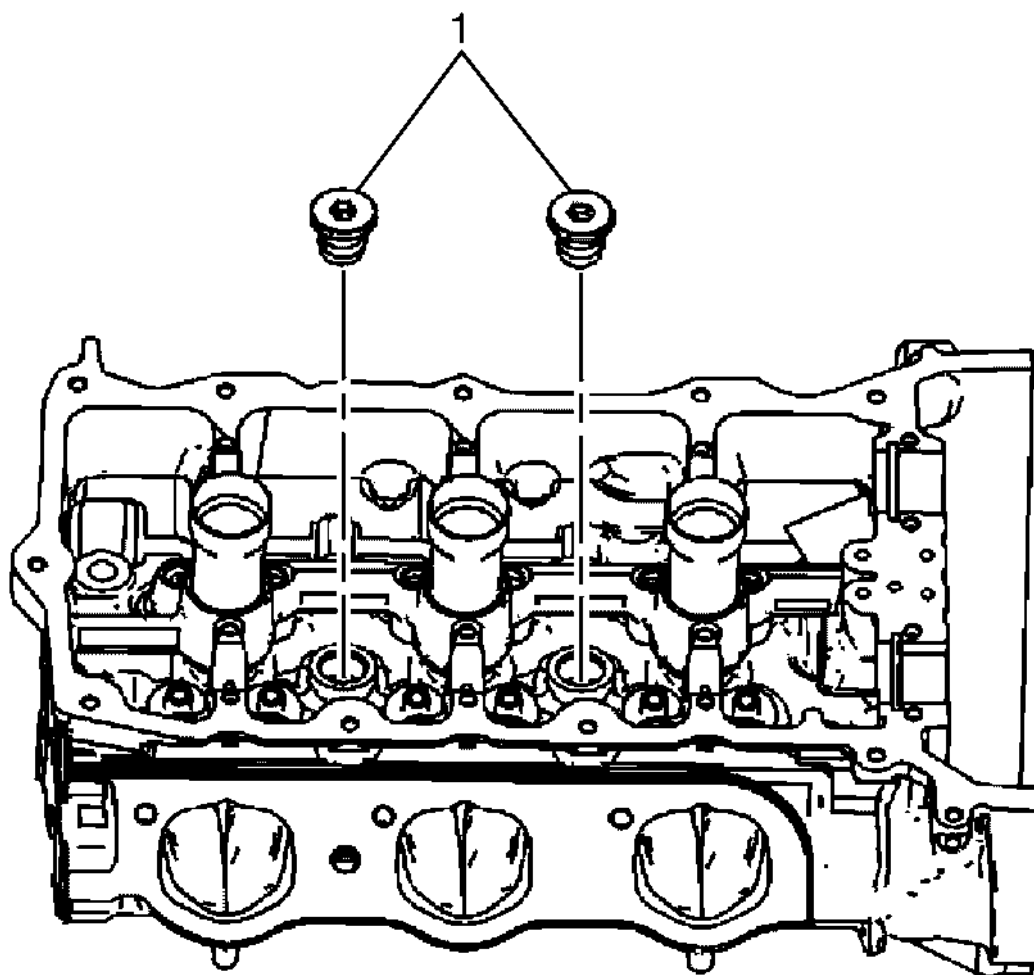
9. Repeat these procedures for the remaining valves.



**Fig. 77: Identifying Cylinder Head Oil Gallery Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

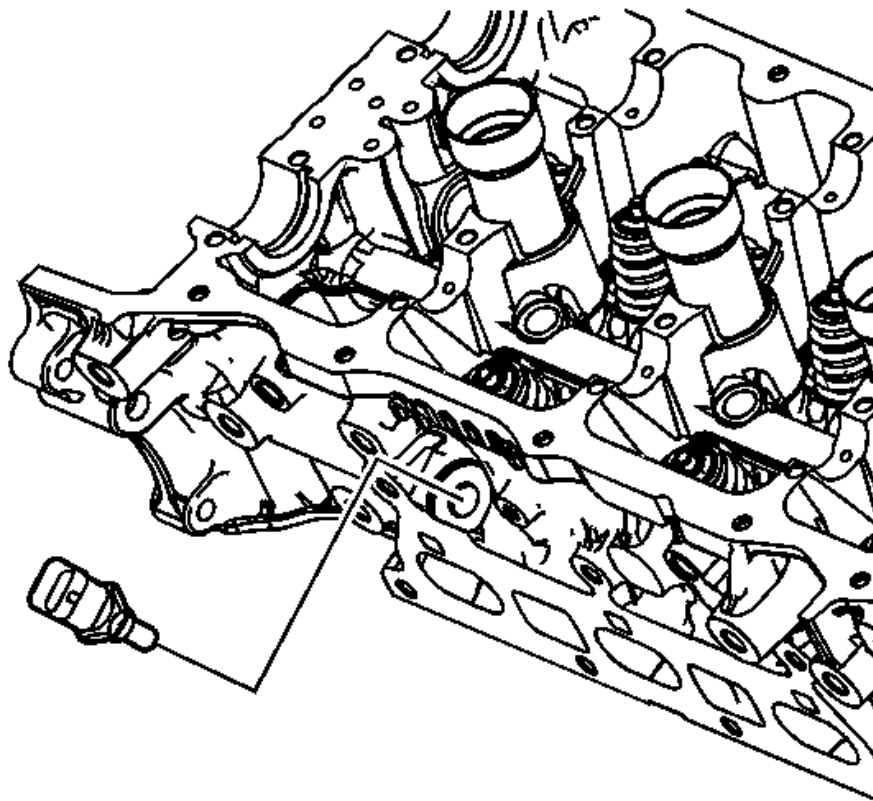
10. Remove the cylinder head oil gallery expansion plugs (1).





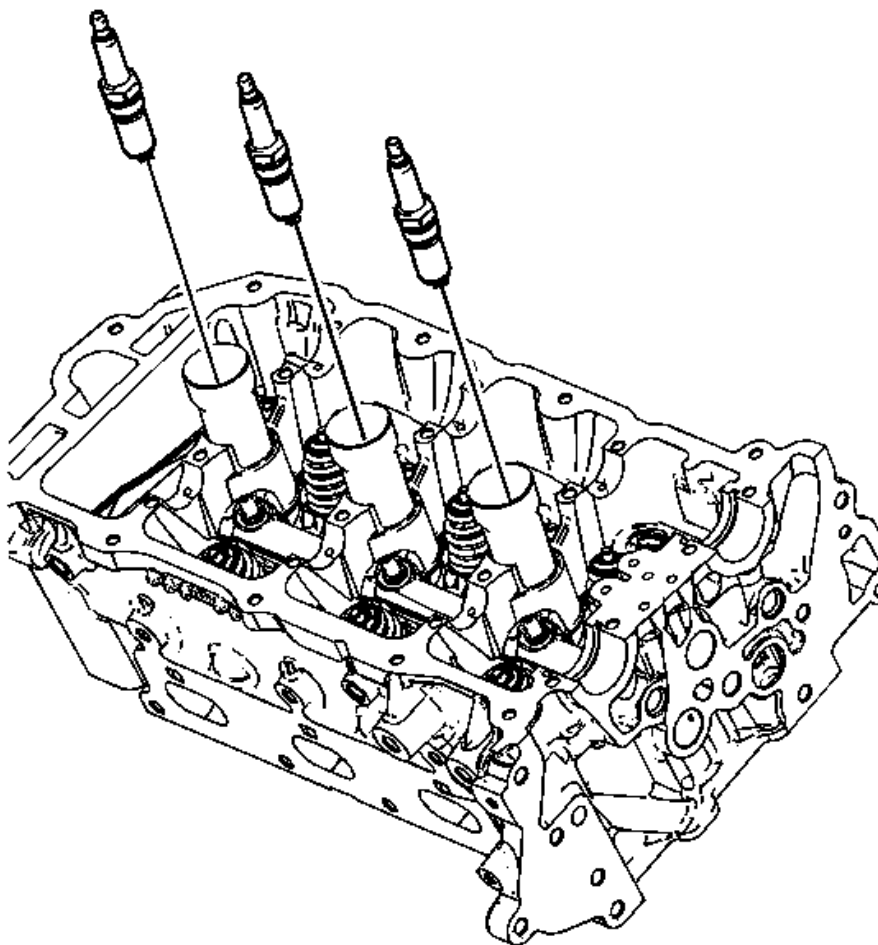
**Fig. 78: Identifying Cylinder Head Coolant Threaded Plugs**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the cylinder head coolant threaded plugs (1).



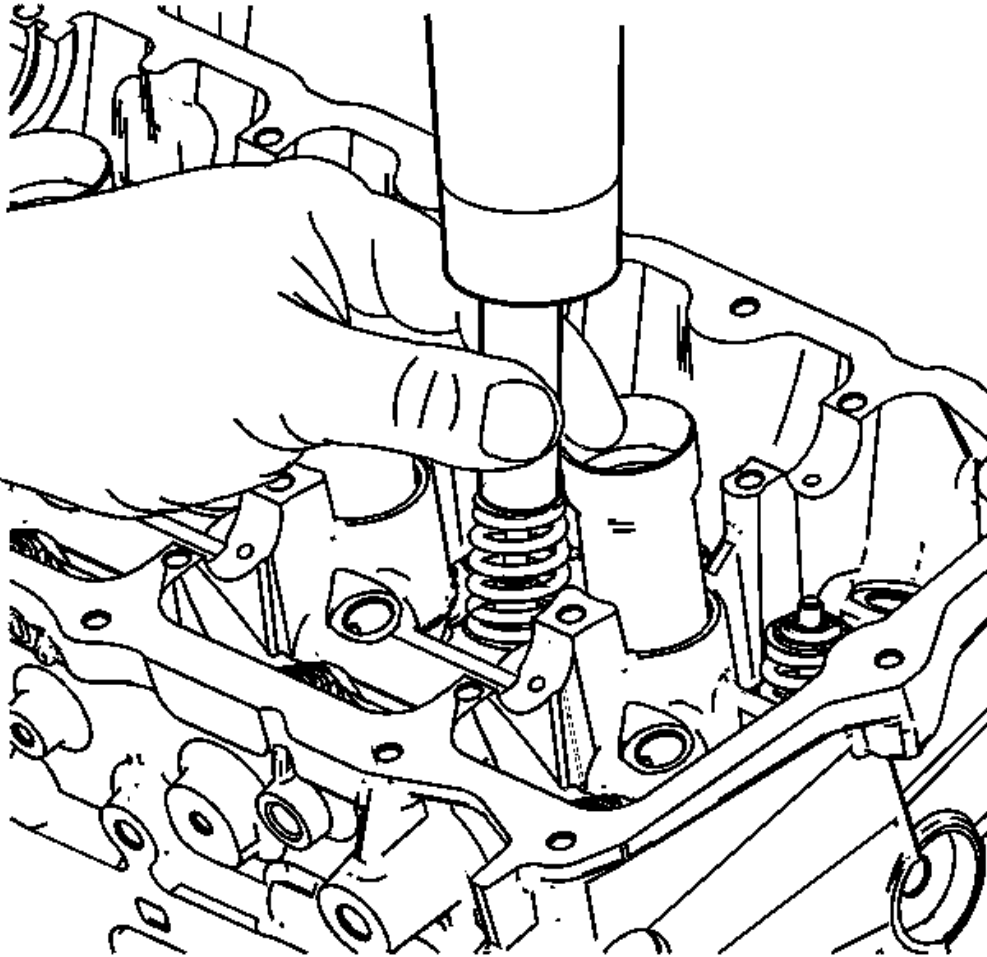
**Fig. 79: Identifying Engine Coolant Temperature (ECT) Sensor**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine coolant temperature (ECT) sensor.



**Fig. 80: Identifying Spark Plugs**  
Courtesy of GENERAL MOTORS CORP.

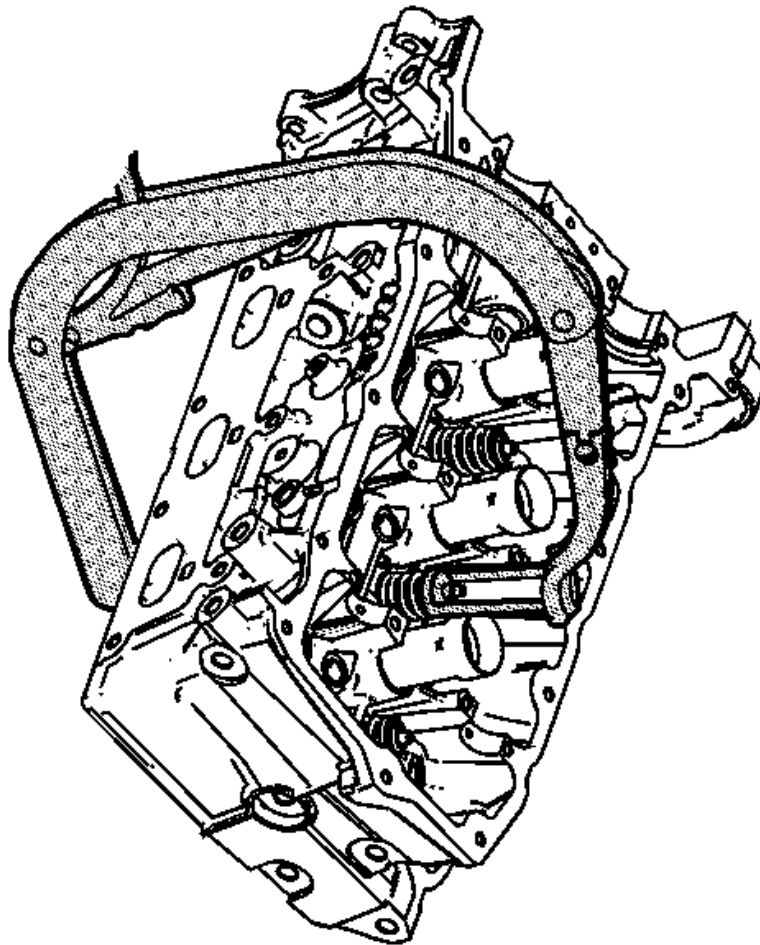
13. Remove the spark plugs.



**Fig. 81: Loosening Valve Keepers**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

14. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

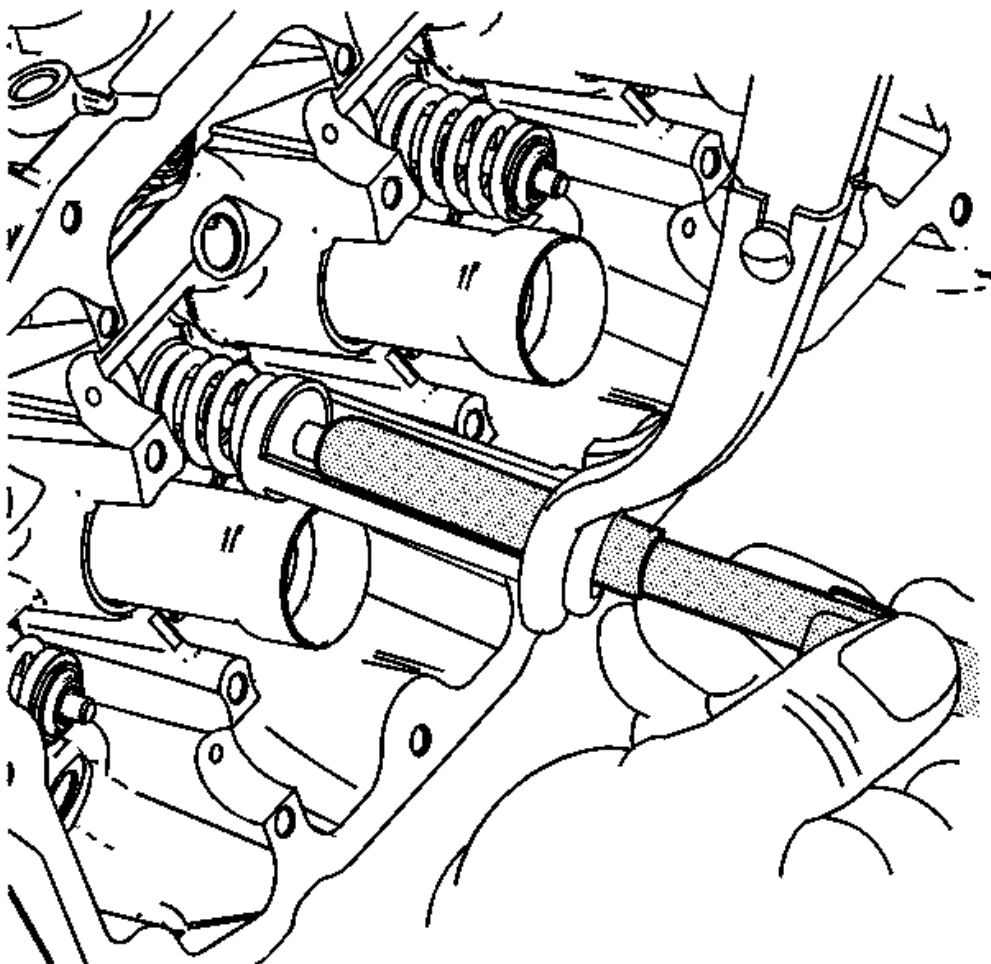


**Fig. 82: Identifying J 8062 & EN 46119**  
Courtesy of GENERAL MOTORS CORP.

**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 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.

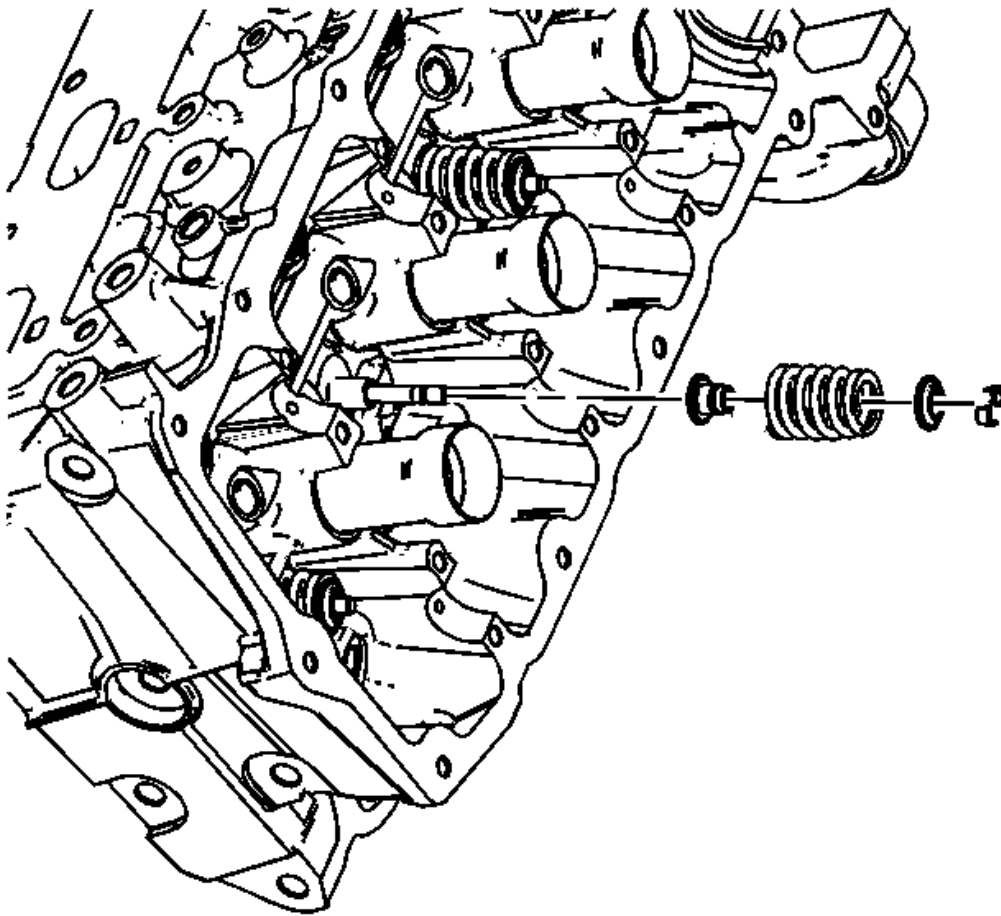
15. Compress the valve spring using the **J-8062**: compressor - head off and the **EN-46119**: adapter.



**Fig. 83: View Of EN 46117**

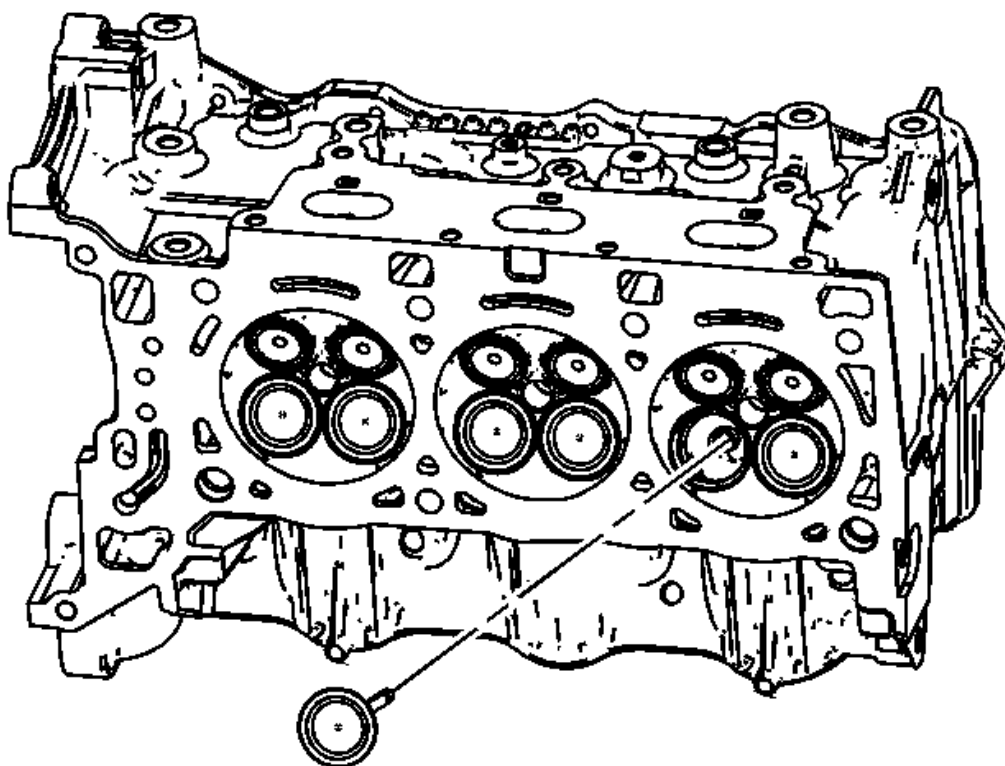
**Courtesy of GENERAL MOTORS CORP.**

16. Use the magnet of the **EN-46117**: key remover/installer in order to remove the valve keepers.
17. Remove the valve spring compressor and the adapter.



**Fig. 84: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

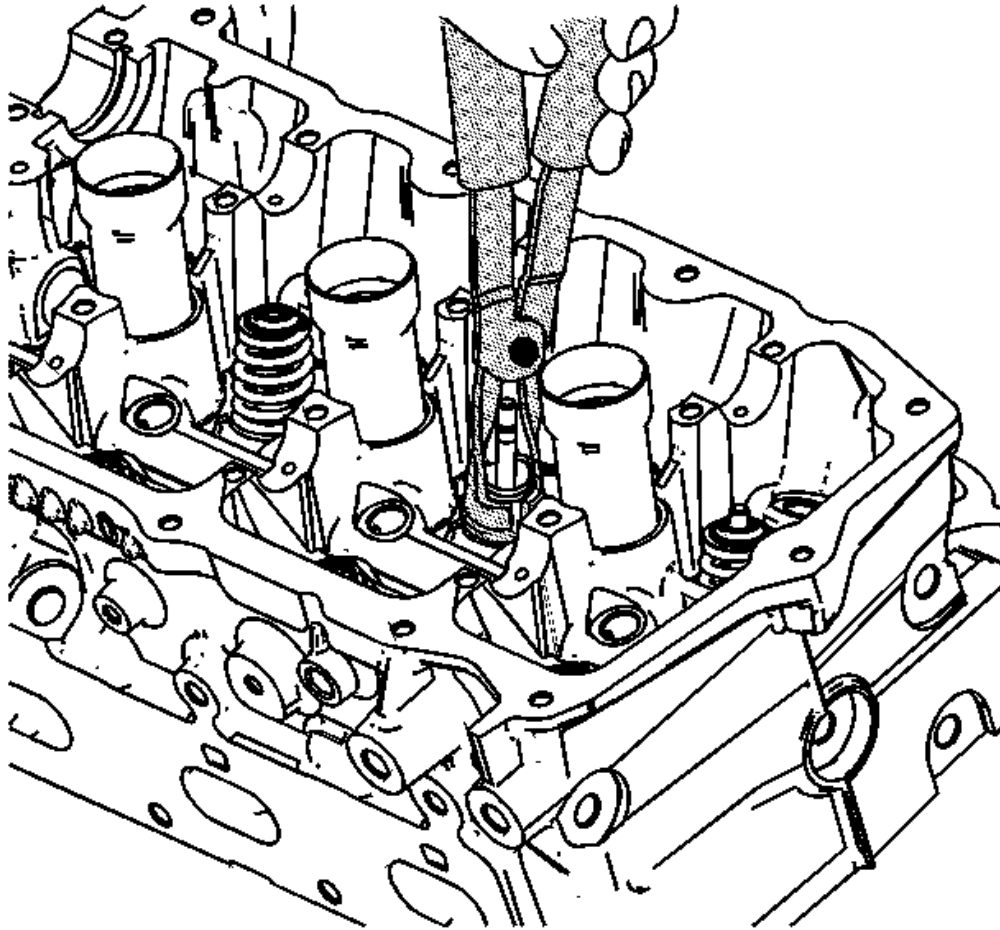
18. Remove the valve spring retainer.
19. Remove the valve spring.



**Fig. 85: View Of Valve**  
Courtesy of GENERAL MOTORS CORP.

20. Remove the valve.

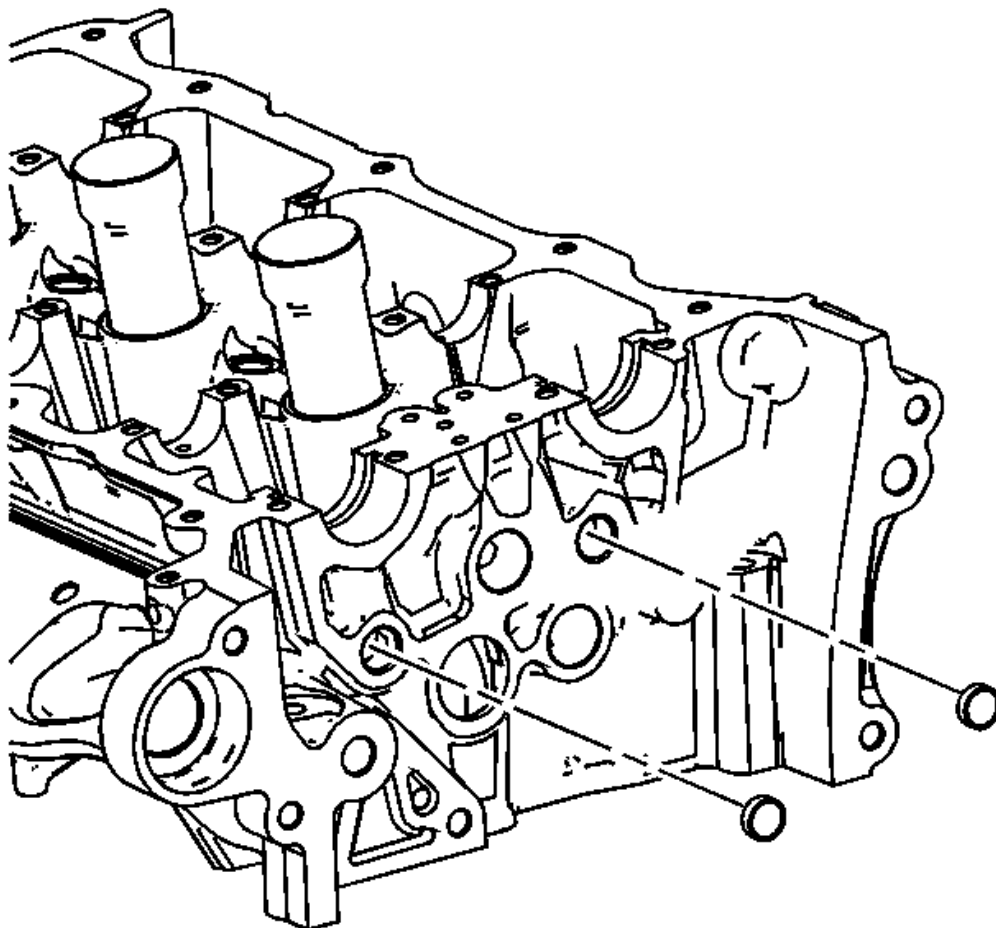




**Fig. 86: Removing/Installing Valve Stem Oil Seals With EN 46116**  
Courtesy of GENERAL MOTORS CORP.

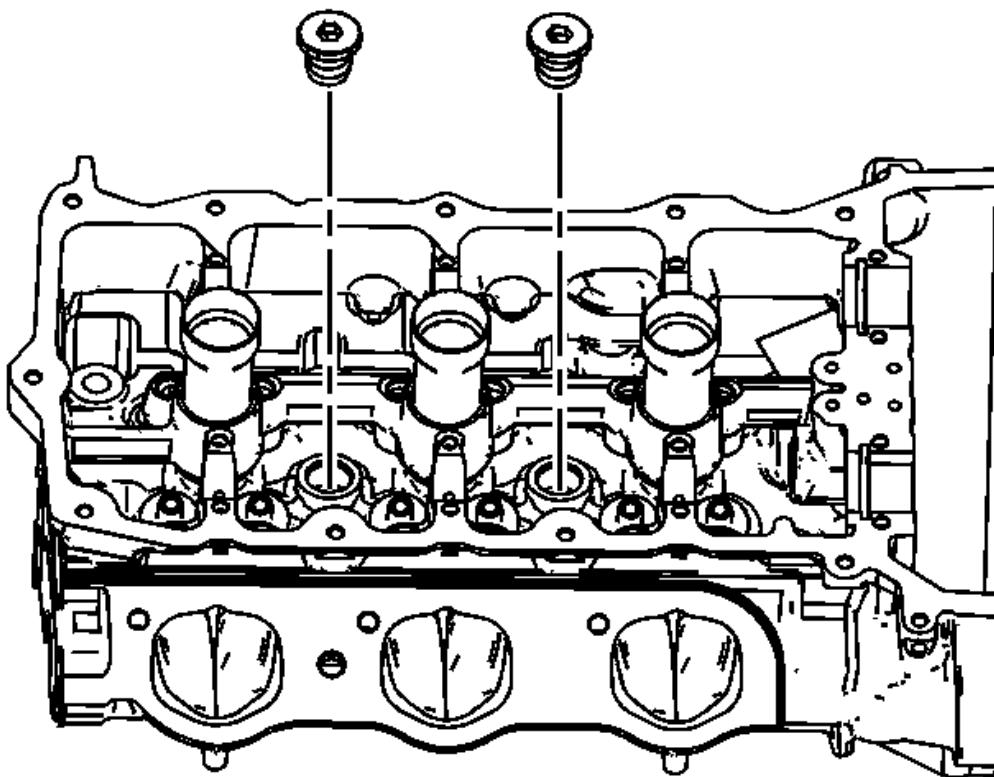
**NOTE:**        **NEVER** reuse a valve stem oil seal.

21. Remove the valve stem oil seal using the **EN-46116**: seal remover/installer and discard.
22. Repeat these procedures for the remaining valves.



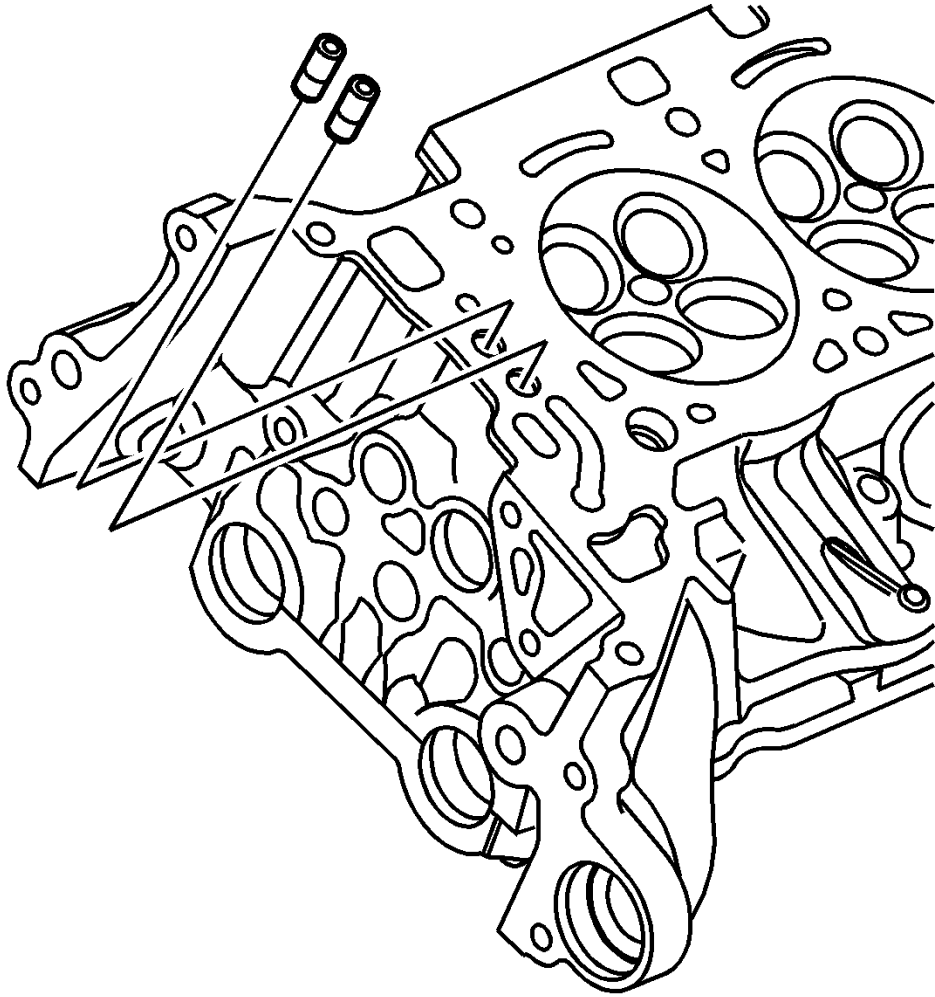
**Fig. 87: Cylinder Head Oil Gallery Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

23. Remove the cylinder head oil gallery expansion plugs.



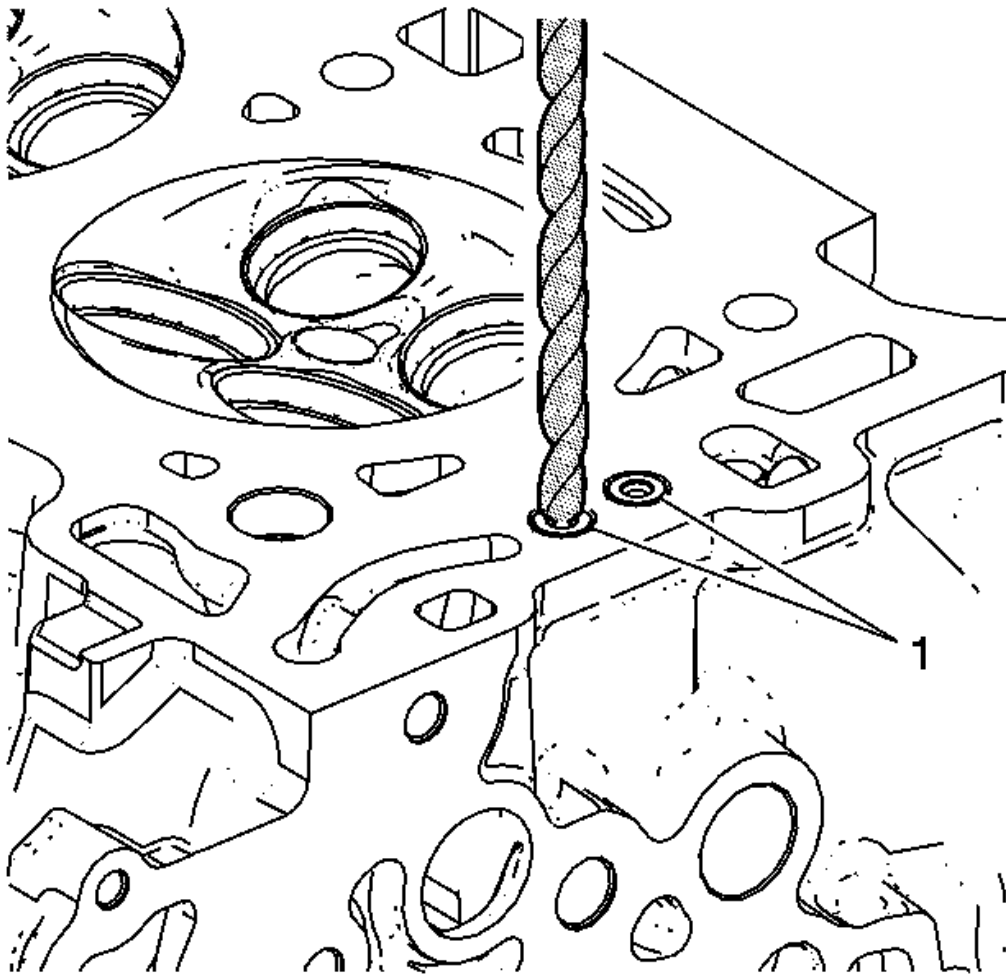
**Fig. 88: Locating Cylinder Head Coolant Threaded Plugs**  
Courtesy of GENERAL MOTORS CORP.

24. Remove the cylinder head coolant threaded plugs.



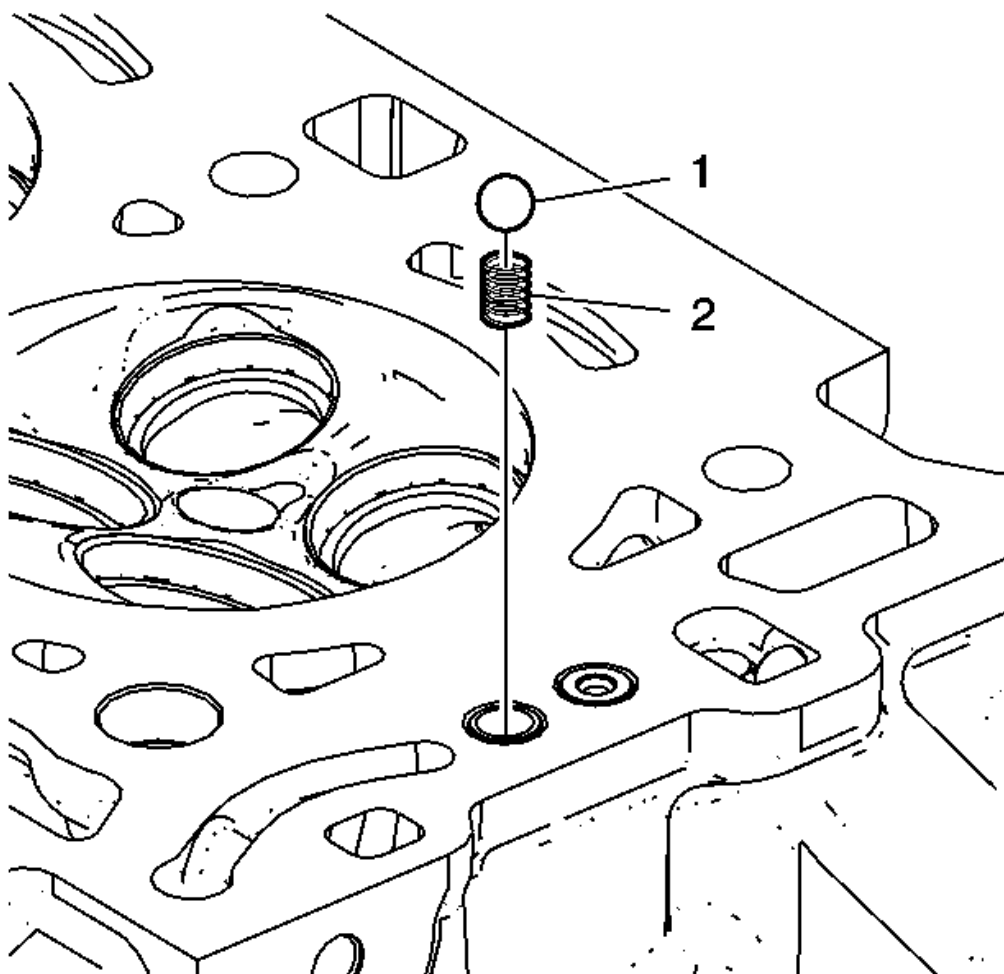
**Fig. 89: View Of Camshaft Position Actuator Oil Feed Check Valve**  
Courtesy of GENERAL MOTORS CORP.

25. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced.



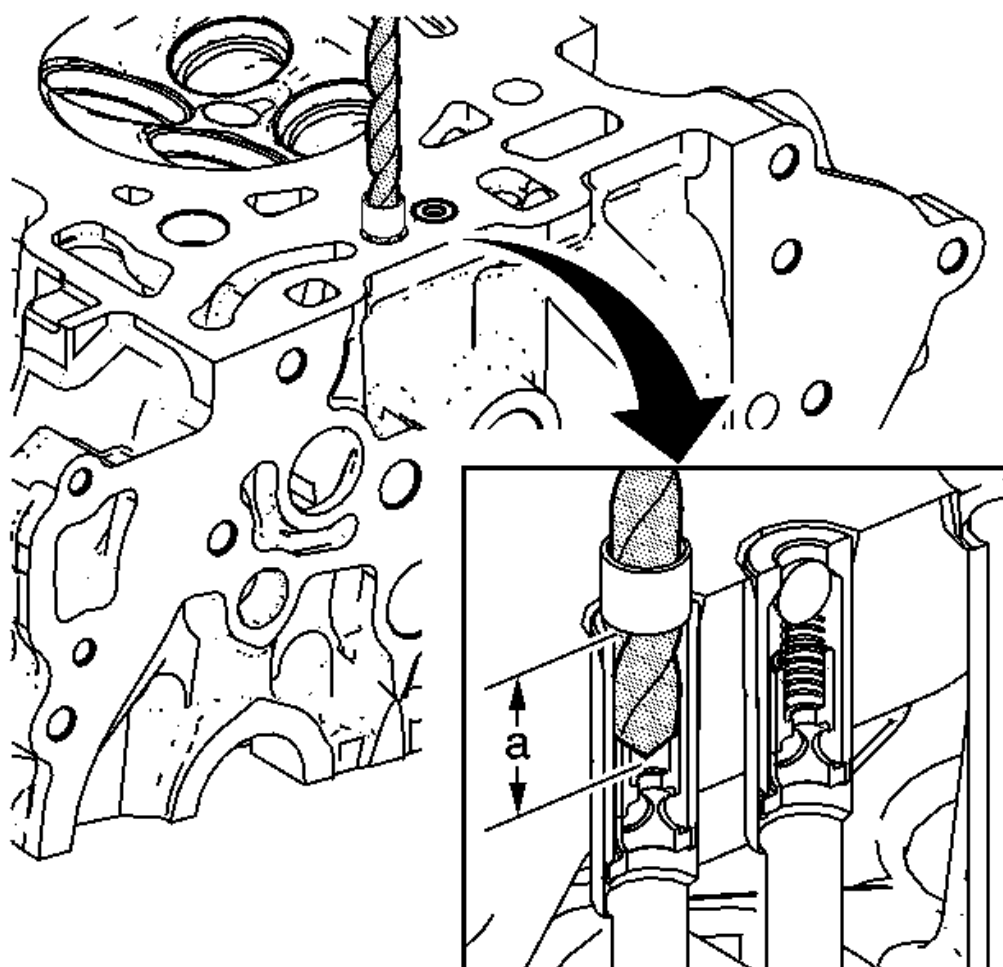
**Fig. 90: Drilling Out Top Portion Of Check Valve**  
Courtesy of GENERAL MOTORS CORP.

26. Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces.
27. Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.



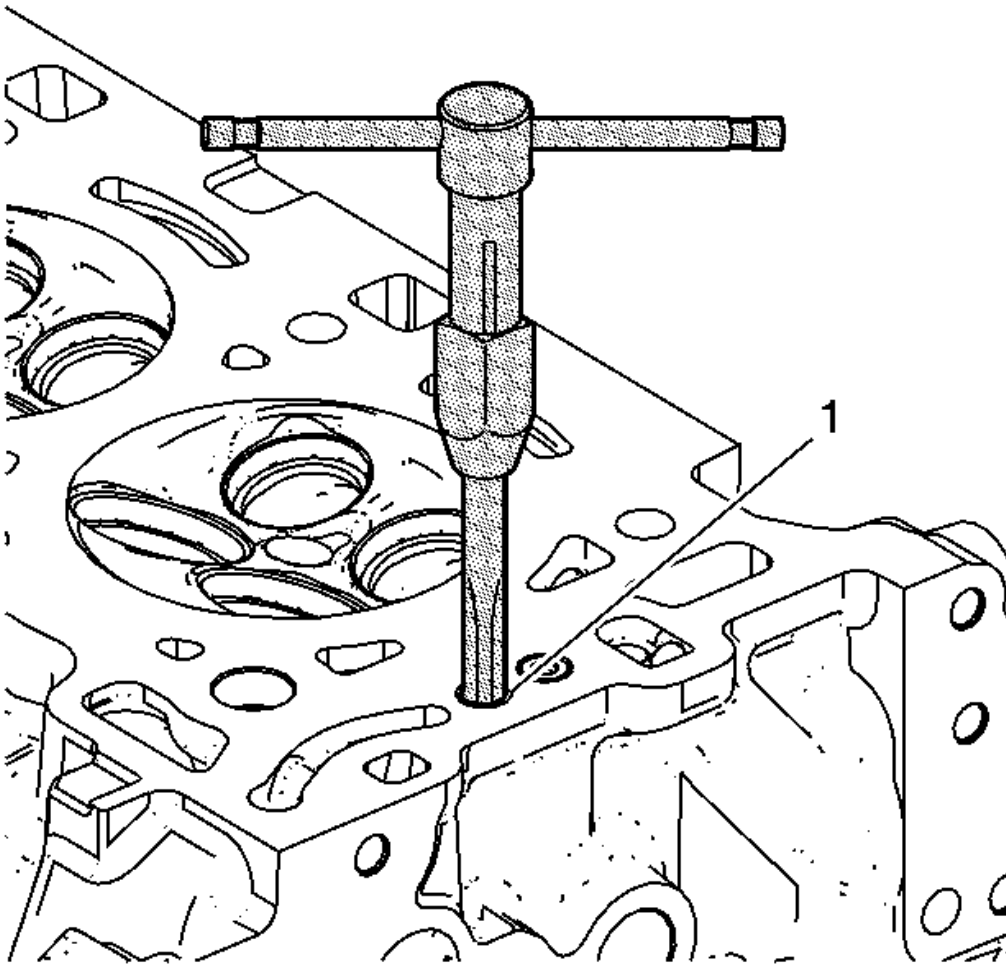
**Fig. 91: Identifying Check Ball & Check Ball Spring**  
Courtesy of GENERAL MOTORS CORP.

28. Remove check ball (1) and check ball spring (2) from inside of check valve.



**Fig. 92: Drilling Remainder Of Check Valve Sleeve**  
Courtesy of GENERAL MOTORS CORP.

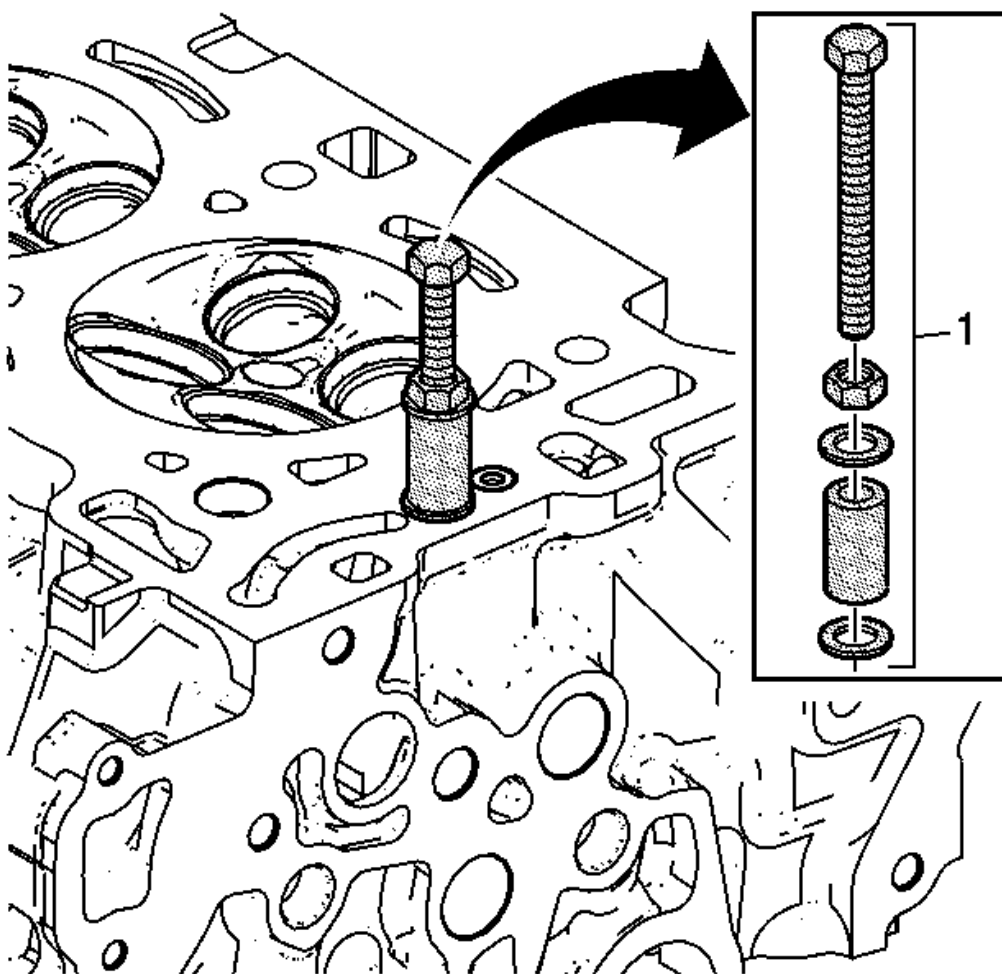
29. Continue drilling remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) (a) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve.



**Fig. 93: Tapping Drilled Out Portion Of Check Valve**  
Courtesy of GENERAL MOTORS CORP.

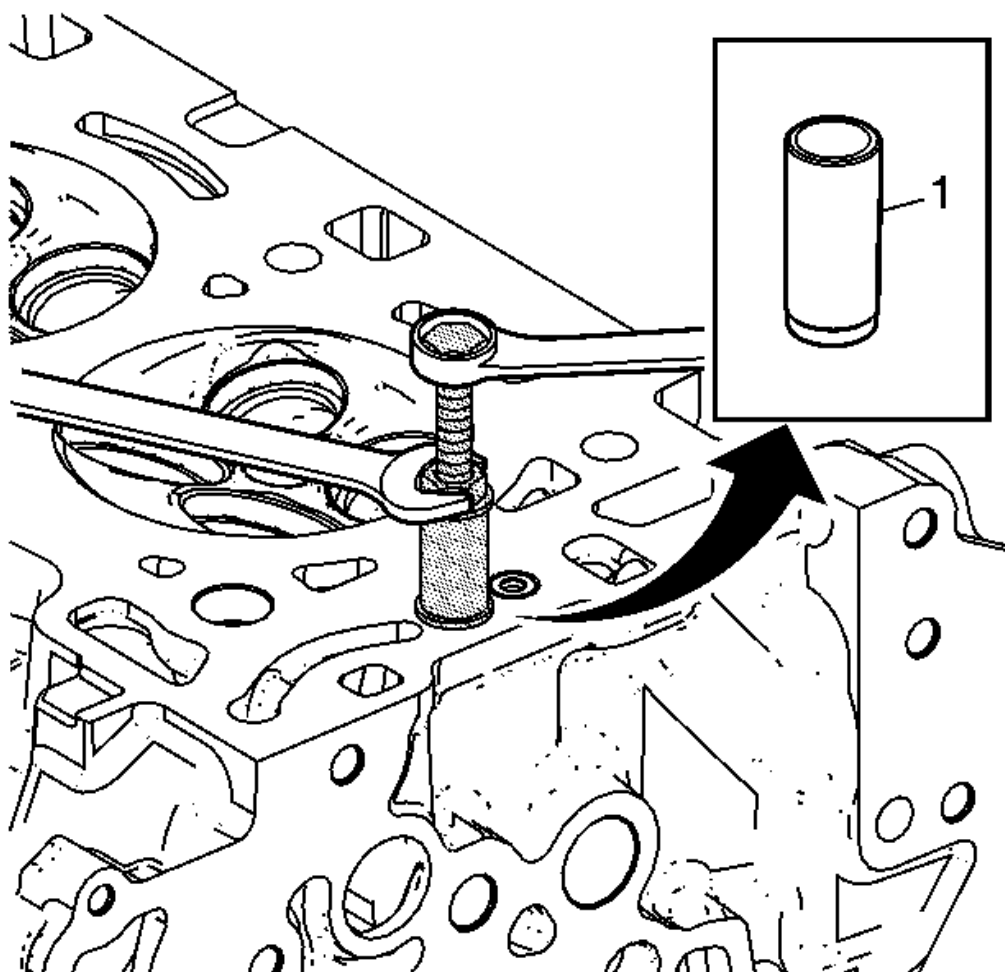
30. Lubricate tap EN-46122-4 with lubricant included in **EN-46122**: remover/installer. Tap drilled out portion of check valve (1) remaining in cylinder head. Tap to full depth possible until tap bottoms out in head.





**Fig. 94: View of Bolt, Nut, Washers and Collar EN-46122-2**  
Courtesy of GENERAL MOTORS CORP.

31. Assemble bolt, nut, washers, and collar EN-46122-2 (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head.
32. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.



**Fig. 95: Removing Check Valve Sleeve**  
 Courtesy of GENERAL MOTORS CORP.

33. Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head.
34. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

## CYLINDER HEAD CLEANING AND INSPECTION

### Special Tools

- **J 8001:** Dial Indicator Set
- **J 8358:** Carbon Removal Brush
- **J 28410:** Gasket Remover
- **J 42096:** Valve Guide Reamer

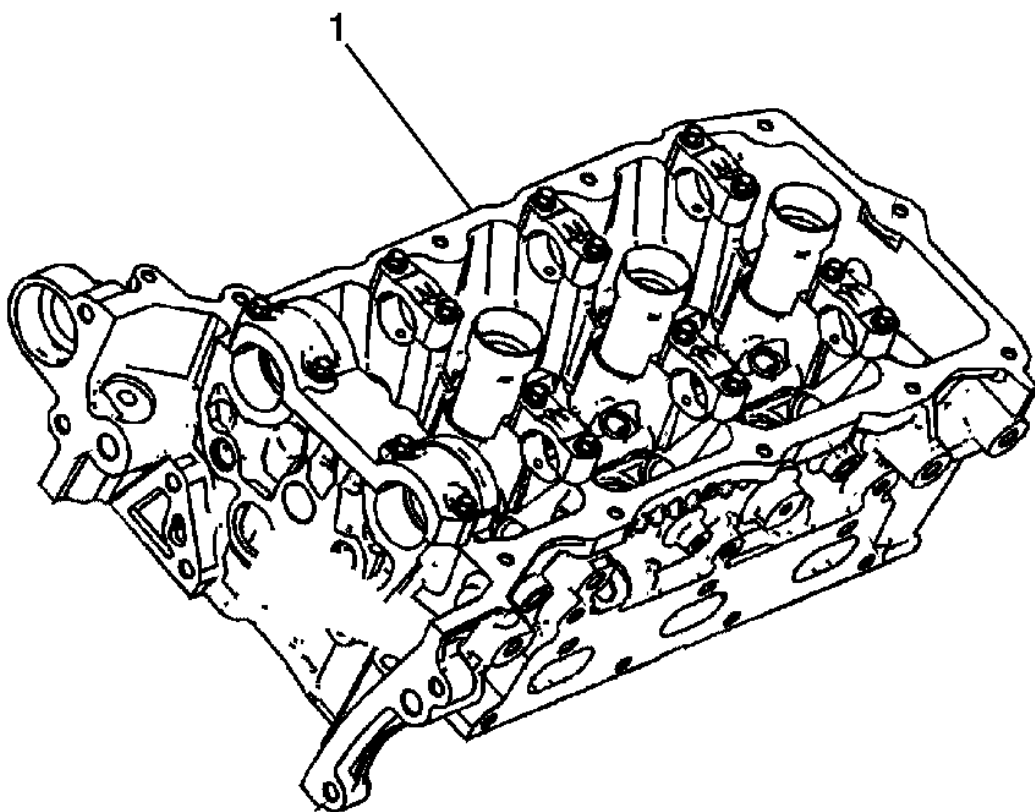
For equivalent regional tools, refer to **Special Tools** .

**Cleaning Procedure**

1. Remove any old thread sealant, gasket material or sealant using **J 28410**: remover.
2. Clean all cylinder head surfaces with non-corrosive solvent.

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

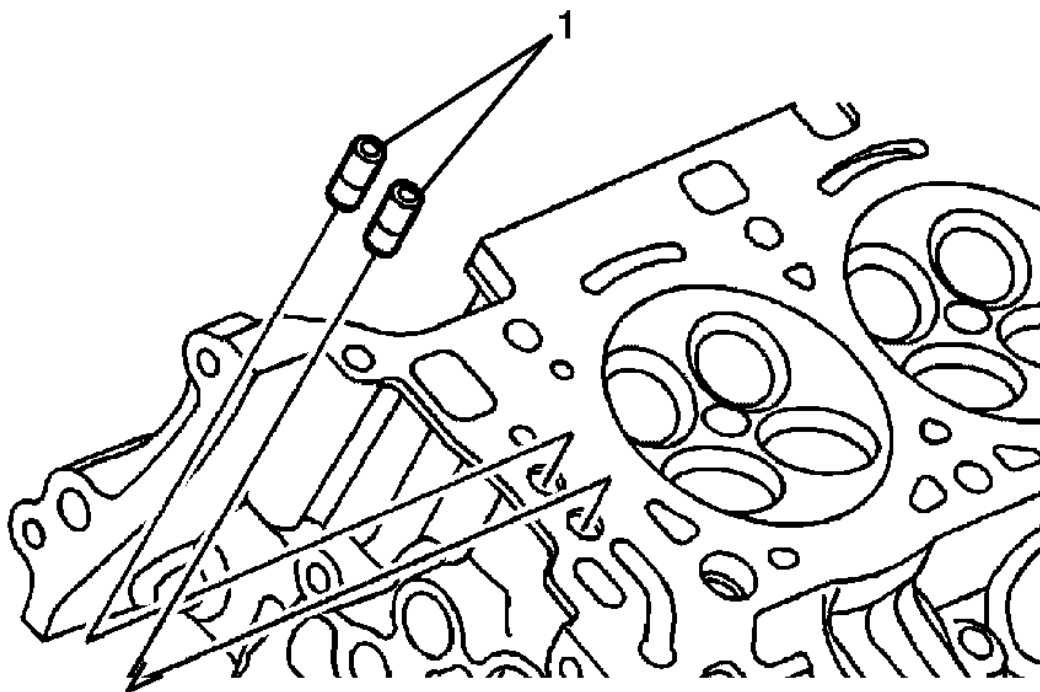
3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chambers using the **J 8358**: brush.
5. Clean any debris or build-up from the lifter pockets.

**Visual Inspection**

**Fig. 96: Identifying Cylinder Head Camshaft Bearing Surface**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head (1) camshaft bearing surfaces for the following conditions:

- Scoring or pitting above acceptable tolerances
  - Discoloration from overheating
  - Deformation from wear above acceptable tolerances
  - If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.
2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
  3. Inspect the cylinder head for the following:
    - Cracks, damage or pitting in the combustion chambers
    - Debris in the oil galleries - Continue to clean the galleries until all debris is removed.
    - Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
    - Burrs or any defects that may degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
    - Damage to any gasket surfaces
    - Damage to any threaded bolt holes
    - Burnt or eroded areas in the combustion chamber
    - Cracks in the exhaust ports and combustion chambers
    - External cracks in the water passages
    - Restrictions in the intake or exhaust passages
    - Restrictions in the cooling system passages
    - Rusted, damaged or leaking core plugs
  4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.



**Fig. 97: Identifying Check Valves**  
Courtesy of GENERAL MOTORS CORP.

5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to **Cylinder Head Disassemble**.

#### Cylinder Head Measurement

#### Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

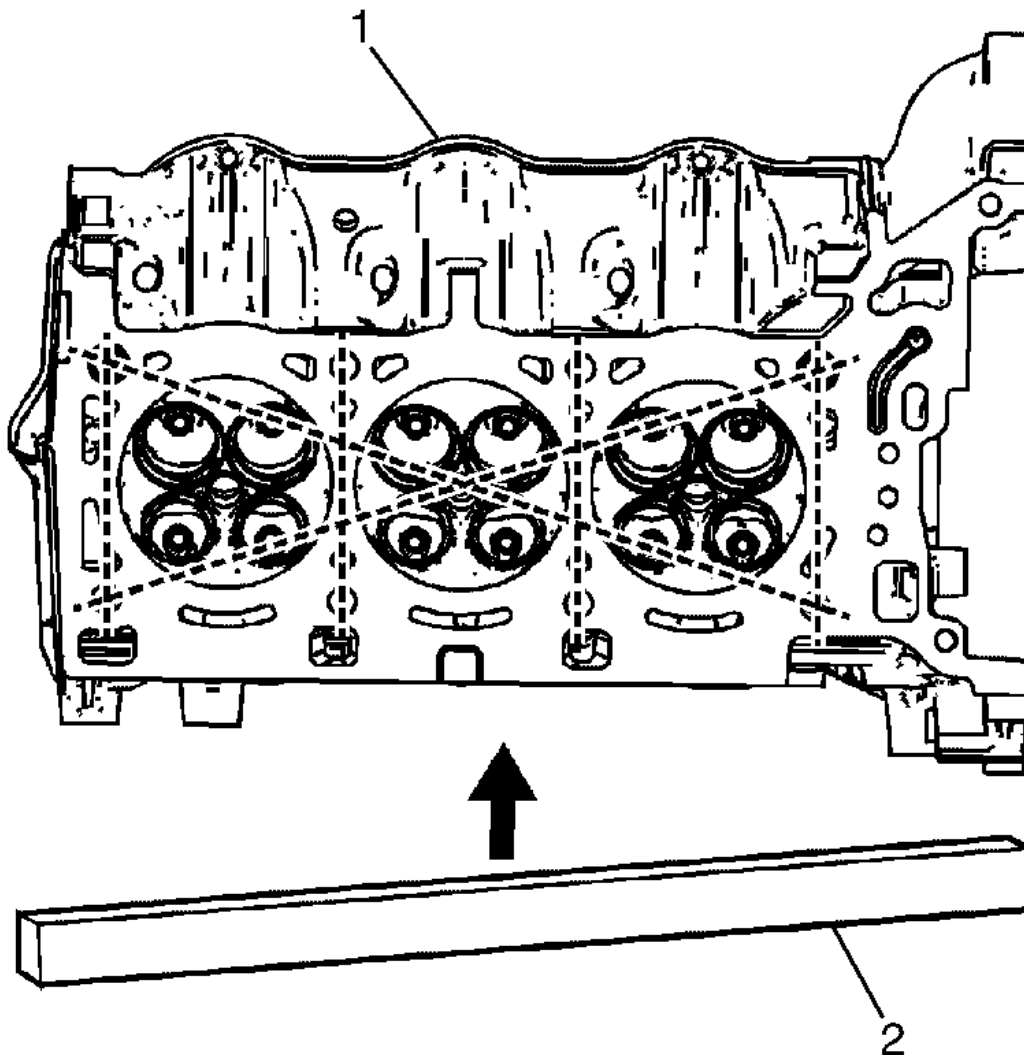
**CAUTION: Refer to Fastener Caution .**

2. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

#### Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that may inhibit correct camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

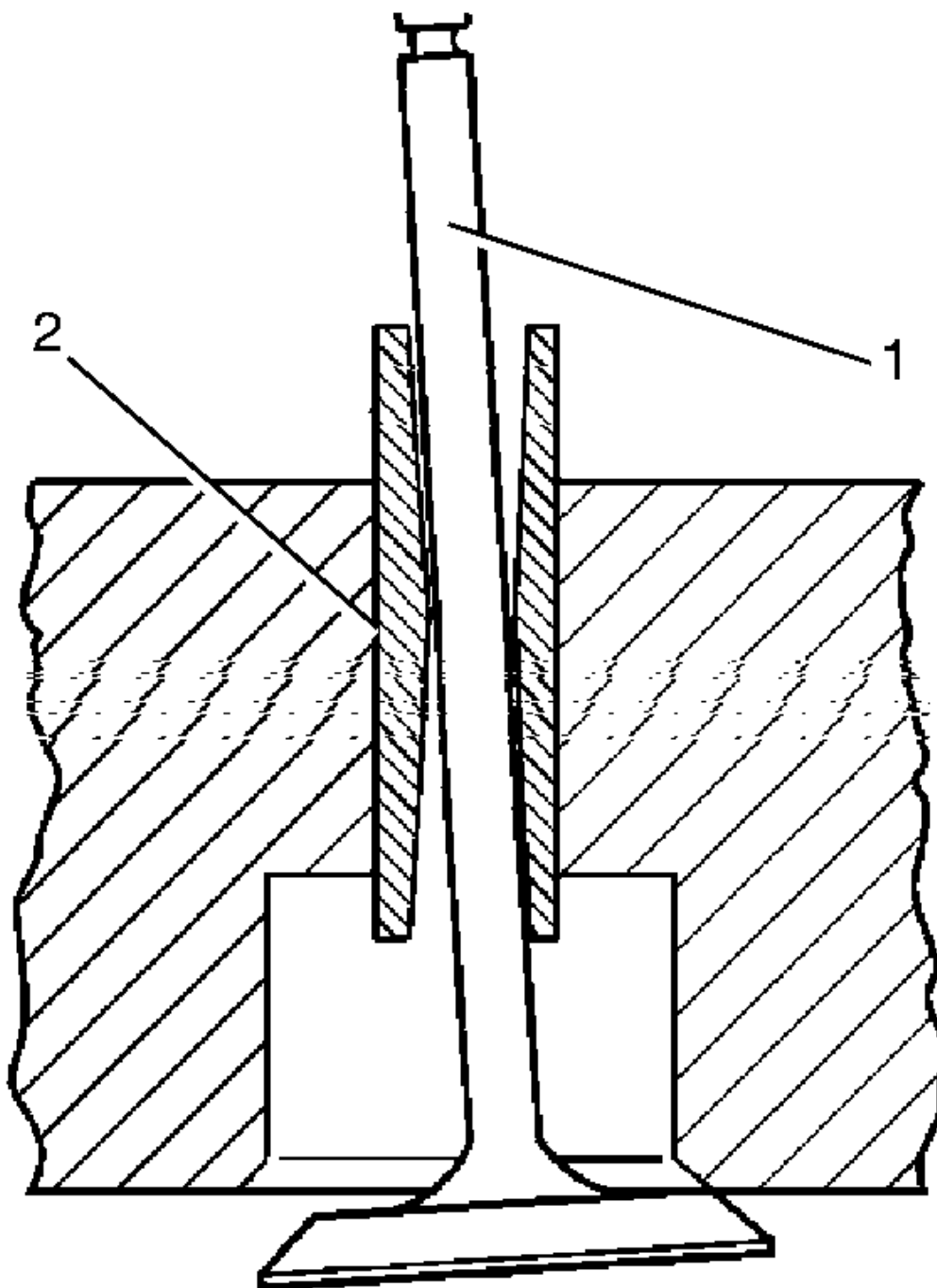
### Deck Flatness Inspection



**Fig. 98: Identifying Clearance Between Straight-Edge & Cylinder Head Deck Face Surface**  
**Courtesy of GENERAL MOTORS CORP.**

1. Ensure the cylinder head (1) decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that may inhibit correct cylinder head gasket sealing.
3. Place a straight-edge (2) diagonally across the cylinder head (1) deck face surface.
4. Measure the clearance between the straight-edge (2) and the cylinder head (1) deck face using a feeler gage at 4 points along the straight-edge (2).
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head (1) deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that may inhibit correct cylinder head gasket sealing are present, the cylinder head (1) deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head (1) deck surface requires more than 0.25 mm (0.010 in) material removal the cylinder head (1) must be replaced.

**Valve Guide Measurement**



**Fig. 99: Identifying Measurement Of Valve Stem-To-Guide Clearance**  
Courtesy of GENERAL MOTORS CORP.



1. Measure the valve stem (1)-to-guide (2) clearance. Valve stem-to-guide clearance above acceptable tolerances may cause oil consumption above acceptable tolerances 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 **J 8001:** indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem (1) 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 (1) just above the valve guide (2).
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 (1) from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications** .
  - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the **J 42096:** reamer. There is 1 size of oversized valve stem available for service.
  - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
  - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

## VALVE SPRING INSPECTION AND MEASUREMENT

### Special Tools

**J 22738-B:** Valve Spring Tester

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

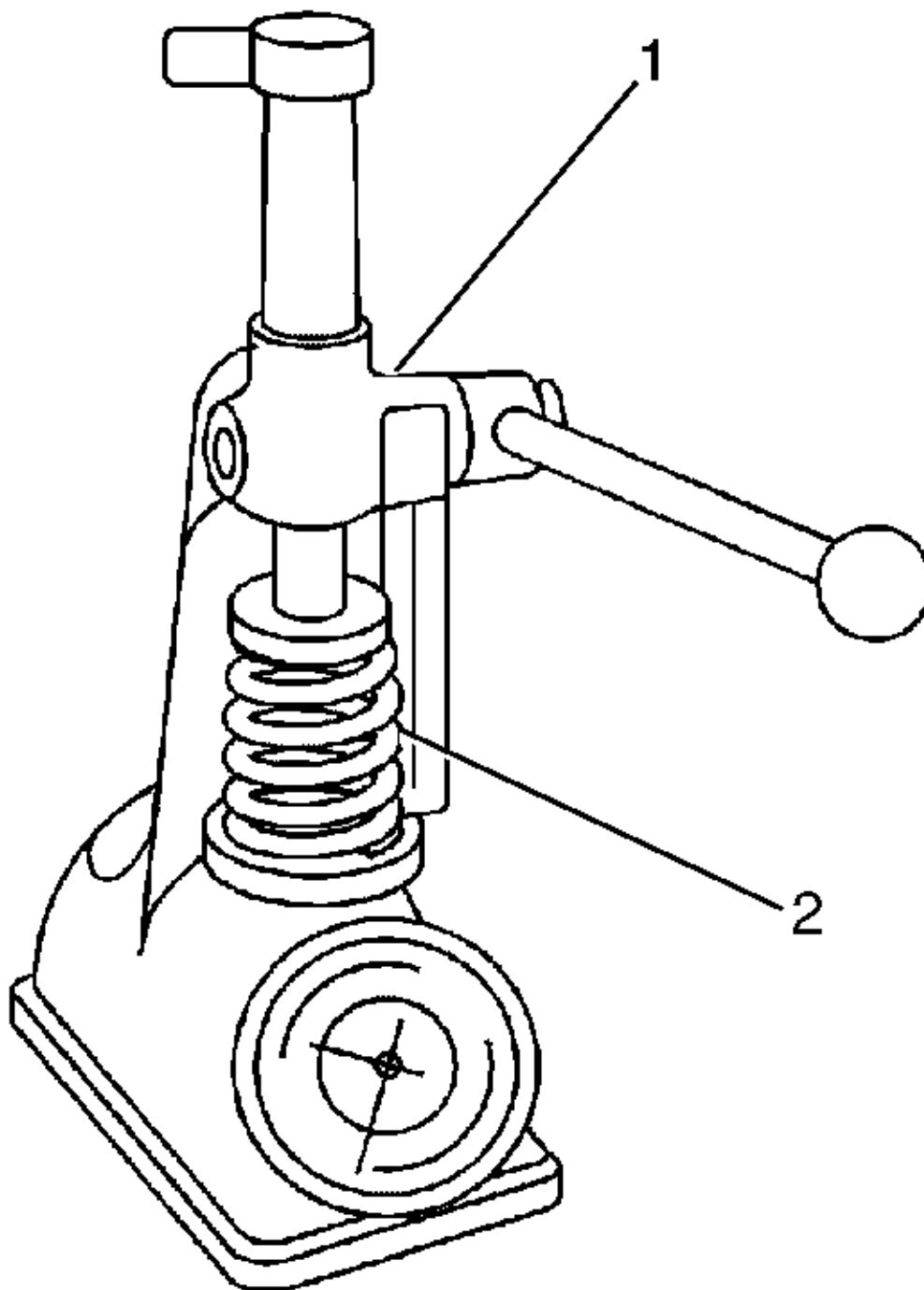
### Inspection Procedure

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.

### Measurement Procedure



**Fig. 100: Identifying Measurement Of Valve Spring Tension**

Courtesy of GENERAL MOTORS CORP.

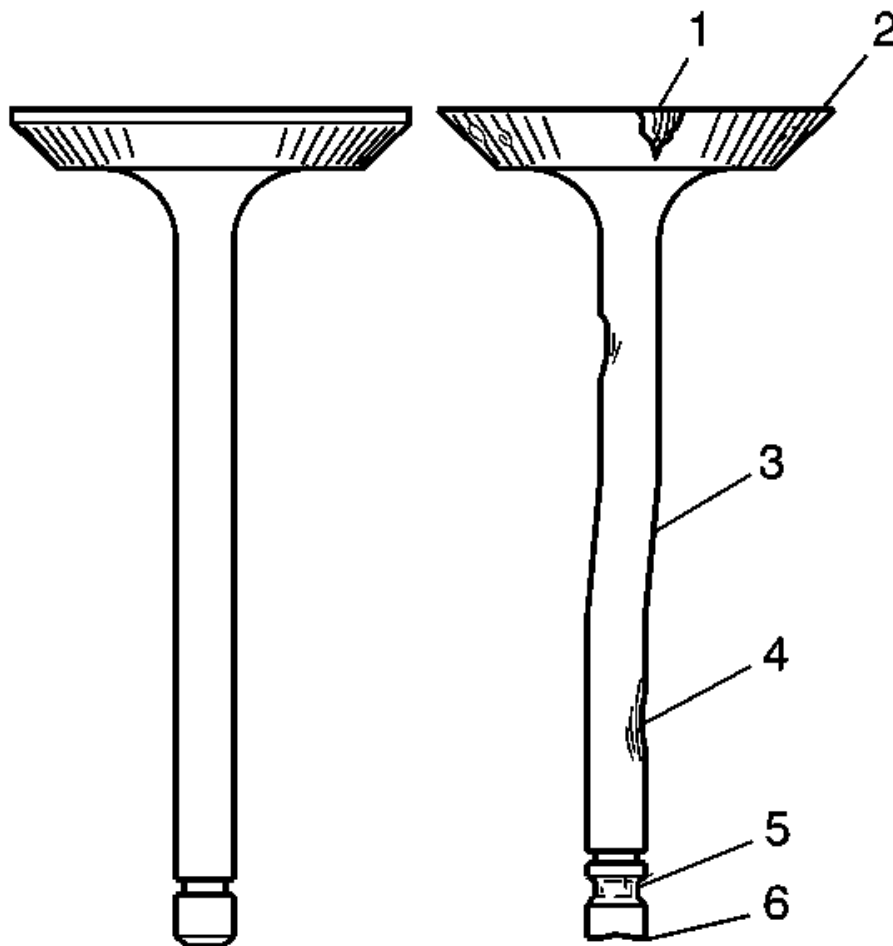
1. Measure the valve spring tension using the **J 22738-B**: tester. Refer to **Engine Mechanical Specifications** .
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

## VALVE AND SEAT GRINDING

### Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

### Valve Visual Inspection Procedure



**Fig. 101: Identifying Inspection Points For Valves Damage**  
**Courtesy of GENERAL MOTORS CORP.**

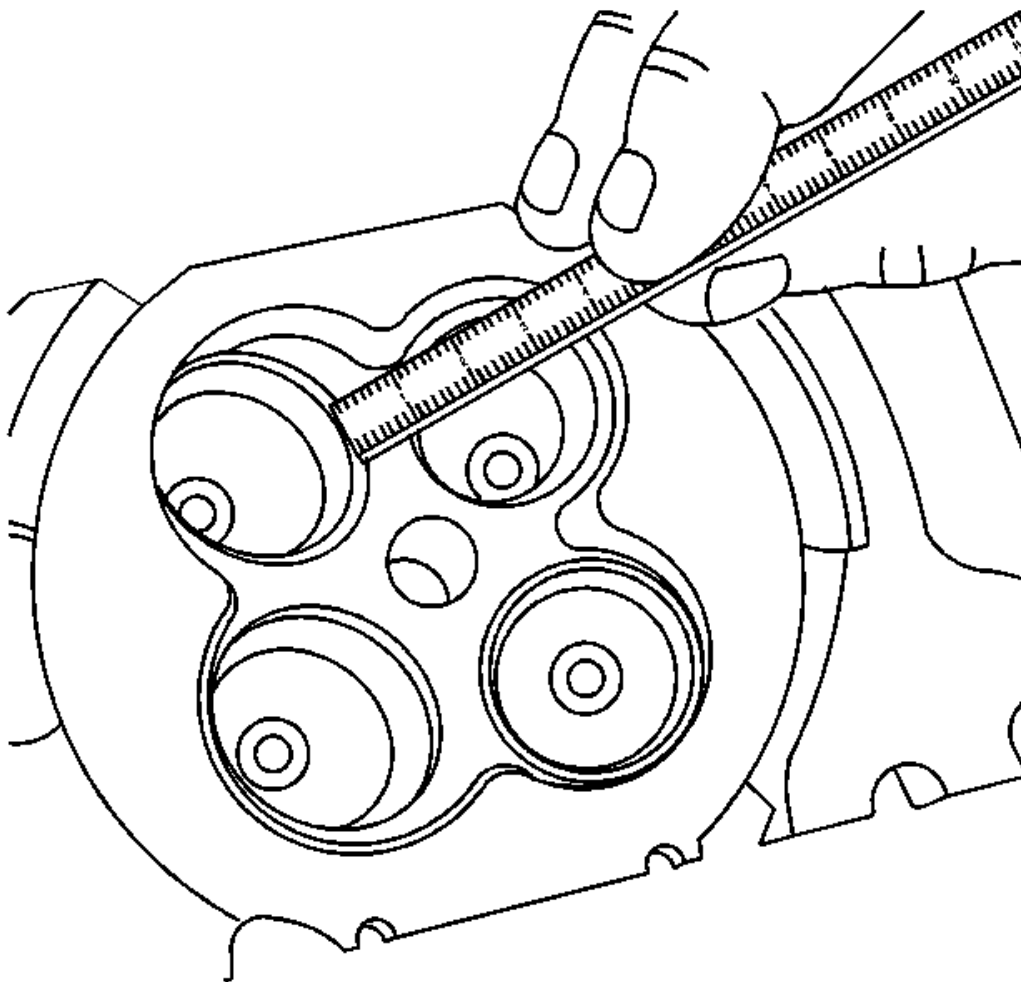
1. Inspect the valve for damage from the head to tip for the following conditions:
  - Pitting in the valve seat area (1)
  - Lack of valve margin (2)
  - Bending in the valve stem (3)
  - Pitting or excessive wear in the stem (4)
  - Worn valve key grooves (5)
  - Worn valve tip (6)
2. Replace the valve if any of these conditions exist.

**Valve Measurement and Reconditioning Overview**

**NOTE:**

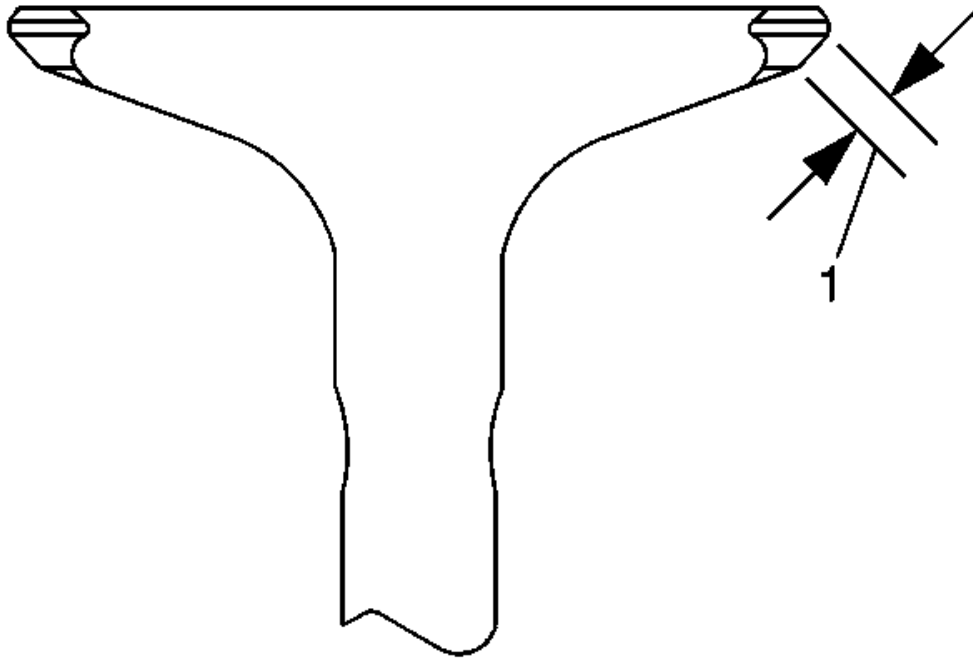
- **Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.**
- **If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the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

**Valve Seat Width Measurement Procedure**



**Fig. 102: Checking Valve Seat Width**  
**Courtesy of GENERAL MOTORS CORP.**

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



**Fig. 103: Measuring Seat Width On Valve Face**  
Courtesy of GENERAL MOTORS CORP.

2. Measure the seat width 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) of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

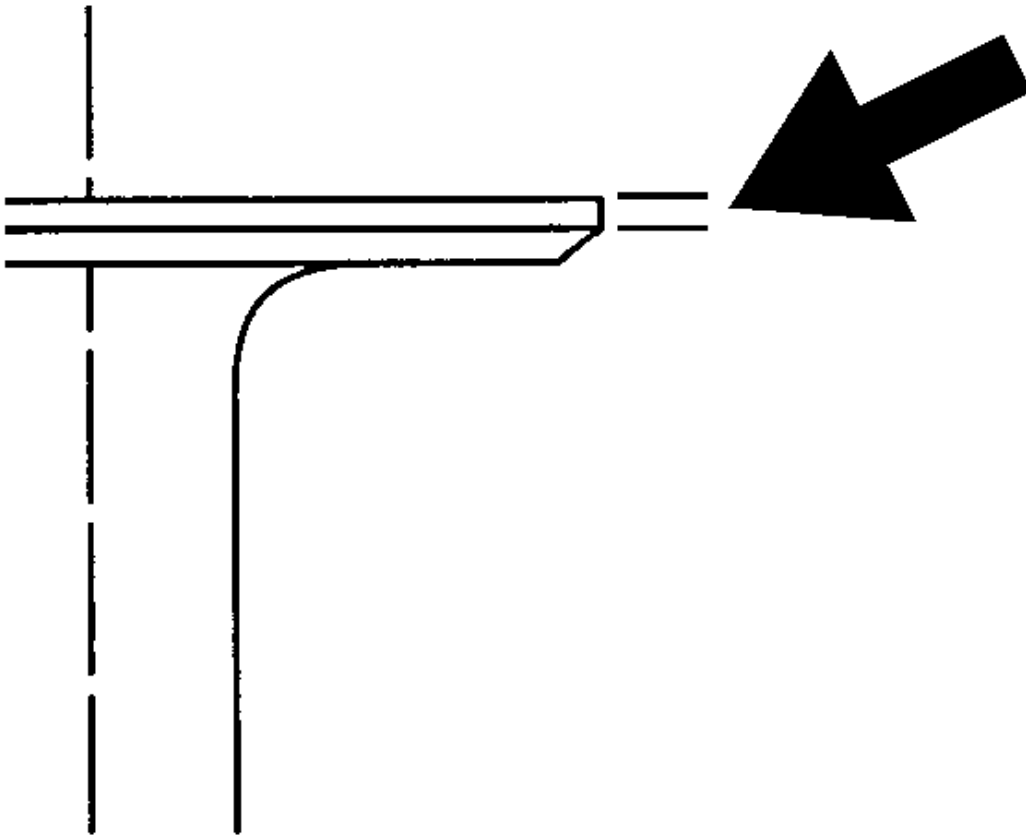
3. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

**Valve Seat Roundness Measurement Procedure**

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

**CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.**

2. Compare your measurements with the specifications listed in Engine Mechanical Specifications .
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

**Valve Margin Measurement Procedure**

**Fig. 104: View Of Valve Margin Measurement**  
**Courtesy of GENERAL MOTORS CORP.**

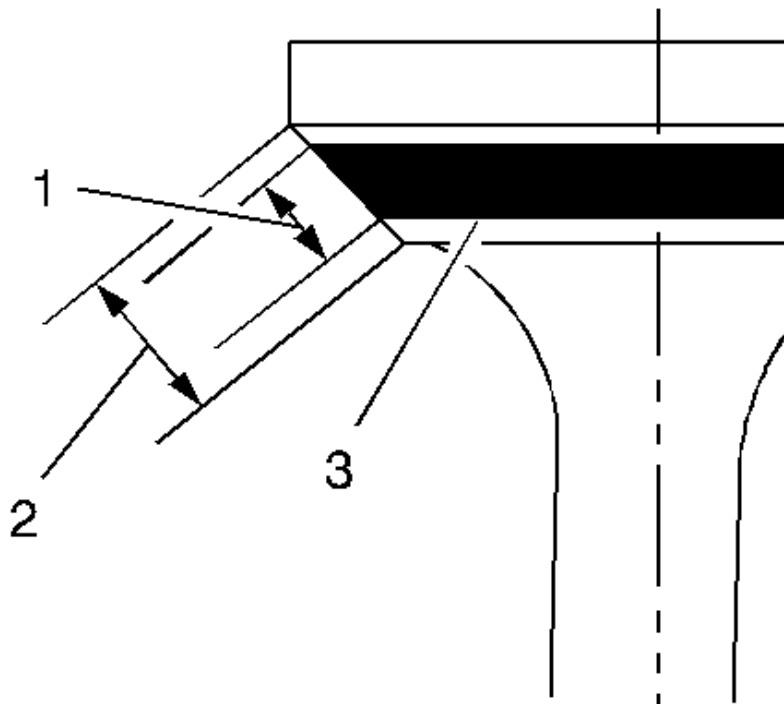
1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification and do not require refacing, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

**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. 105: View Of Valve Contact Face Measurements**  
Courtesy of GENERAL MOTORS CORP.

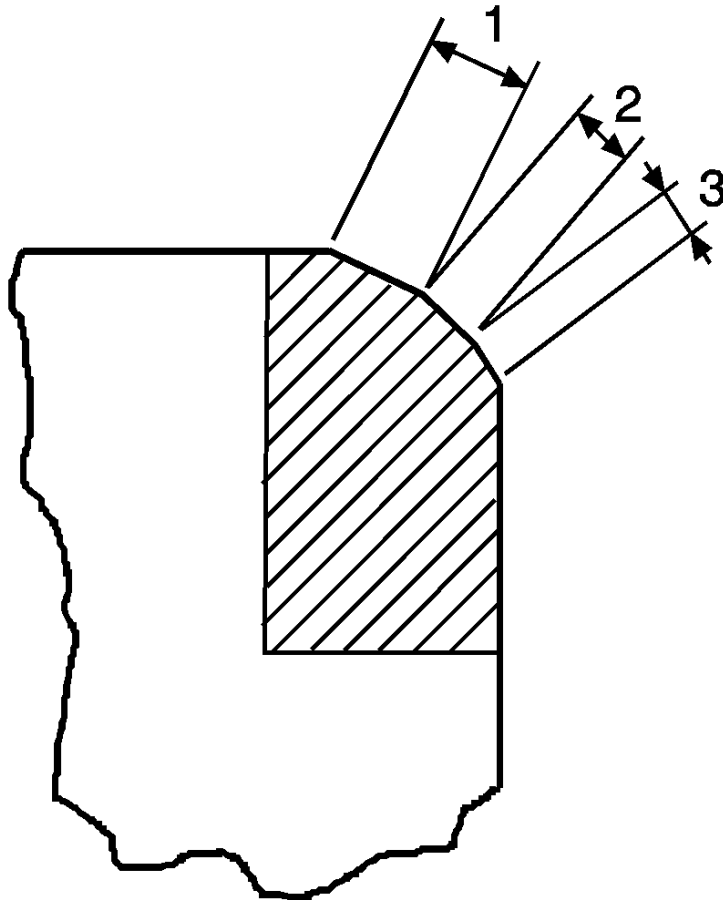
1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
  - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark will be made around the entire face (1).

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

- 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. 106: Illustrating Valve Seat Proper Angles**  
Courtesy of GENERAL MOTORS CORP.

#### NOTE:

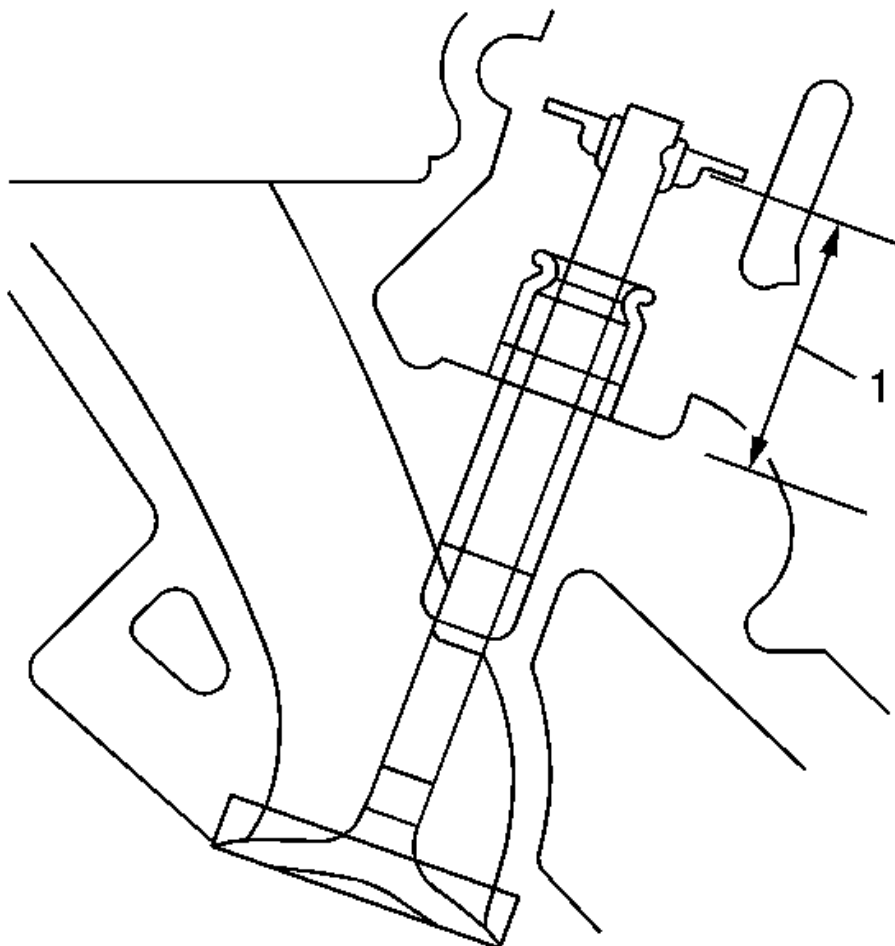
- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications** .
2. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications** .
4. If the original valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications** . Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
  - If you are using refaced 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.

**NOTE:**            **Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.**

- If you are using new valves, do not lap the valves under any condition.
7. 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.
  8. 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. 107: Measuring Valve Stem Height**  
Courtesy of GENERAL MOTORS CORP.

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

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

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

**premature wear and possible engine damage.**

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

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

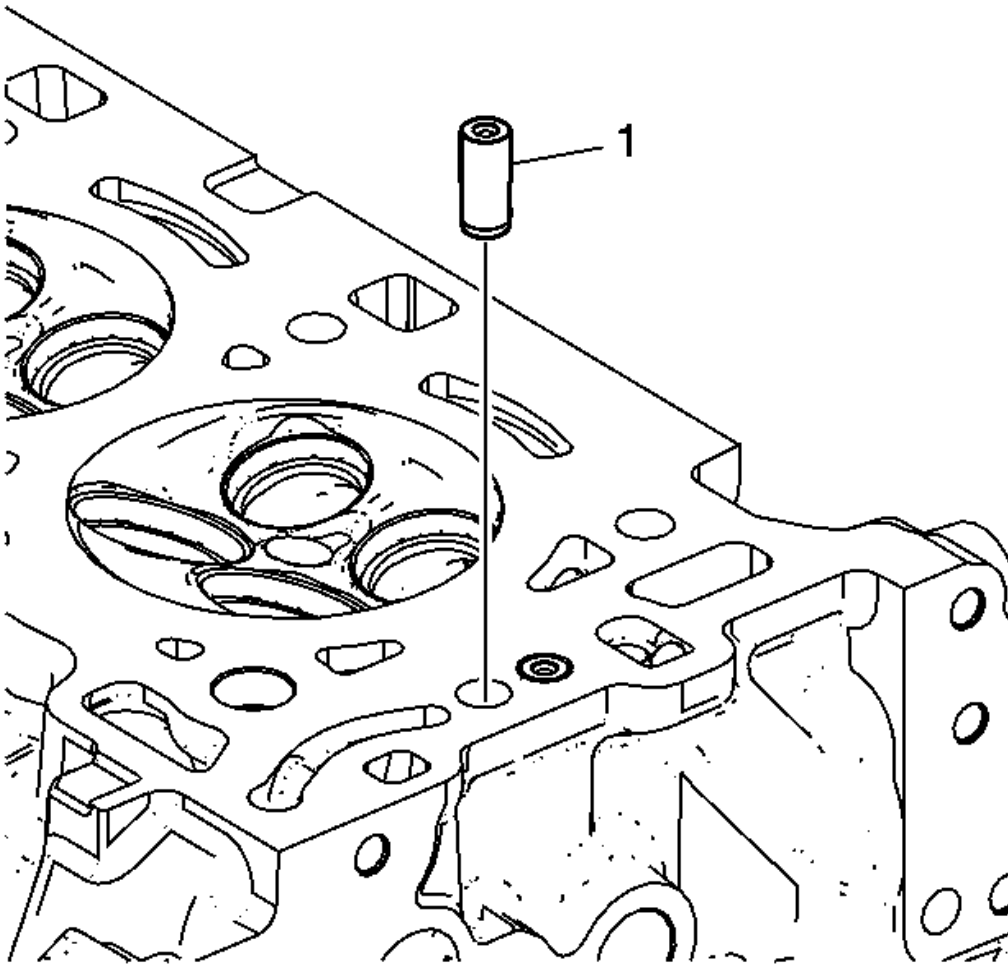
## **CYLINDER HEAD ASSEMBLE**

### **Special Tools**

- **EN 46116:** Valve Stem Seal Remover/Installer
- **EN 46117:** Valve Stem Key Remover/Installer
- **EN 46119:** Off-Vehicle Valve Spring Compressor Adapter
- **EN-46122:** Camshaft Position Actuator Check-Ball Valve Remover/Installer
- **J 8062:** Valve Spring Compressor - Head Off

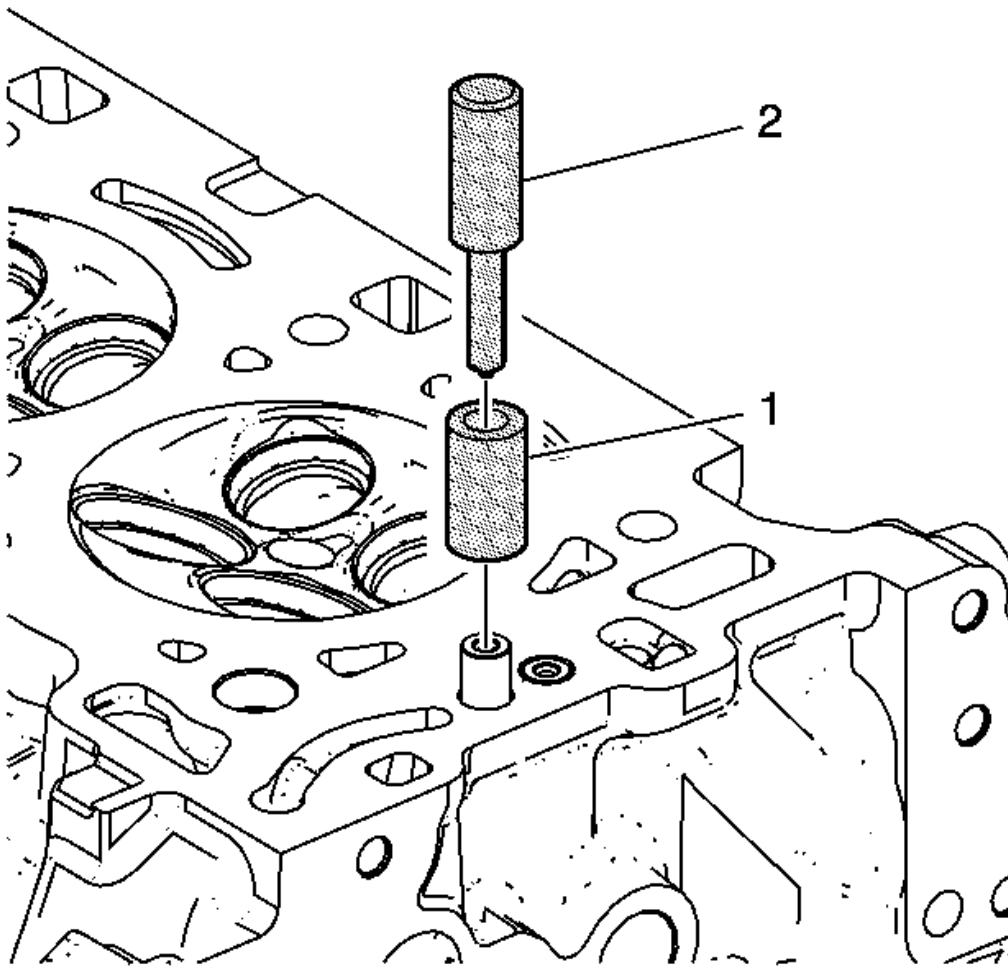
For equivalent regional tools, refer to **Special Tools** .

### **Assemble**



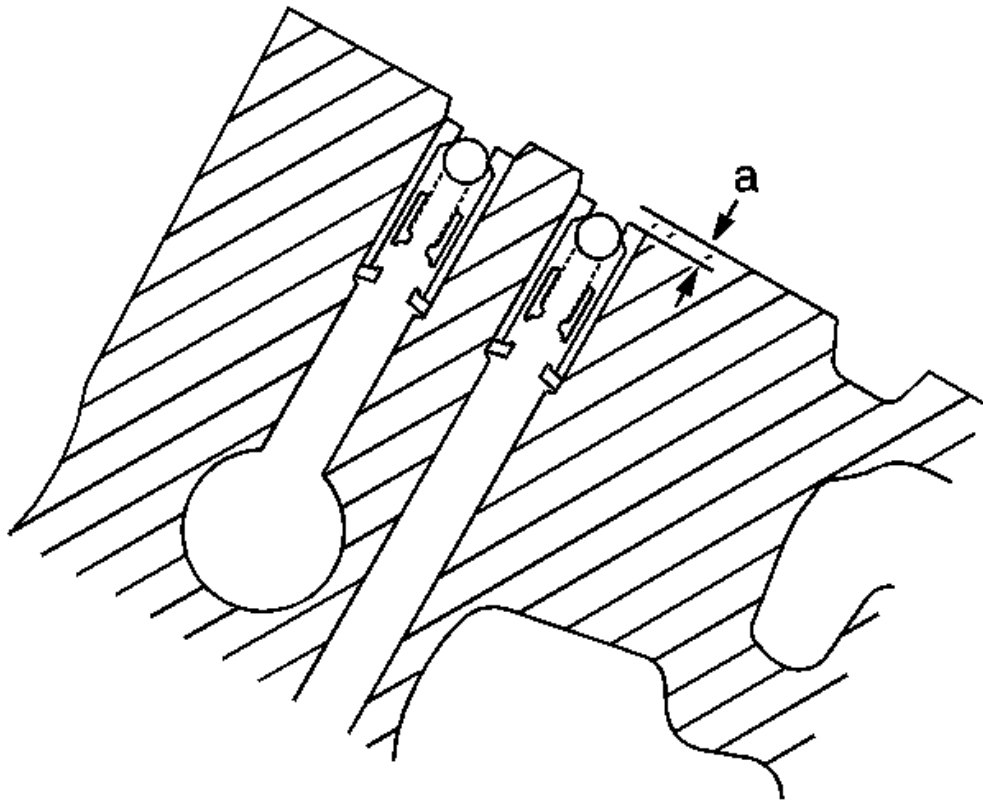
**Fig. 108: Identifying Check Valve**  
Courtesy of GENERAL MOTORS CORP.

1. Use lubricant included with **EN-46122**: remover/installer to lubricate outside of new check valve (1).
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.



**Fig. 109: Tapping Check Valve Into Place**  
Courtesy of GENERAL MOTORS CORP.

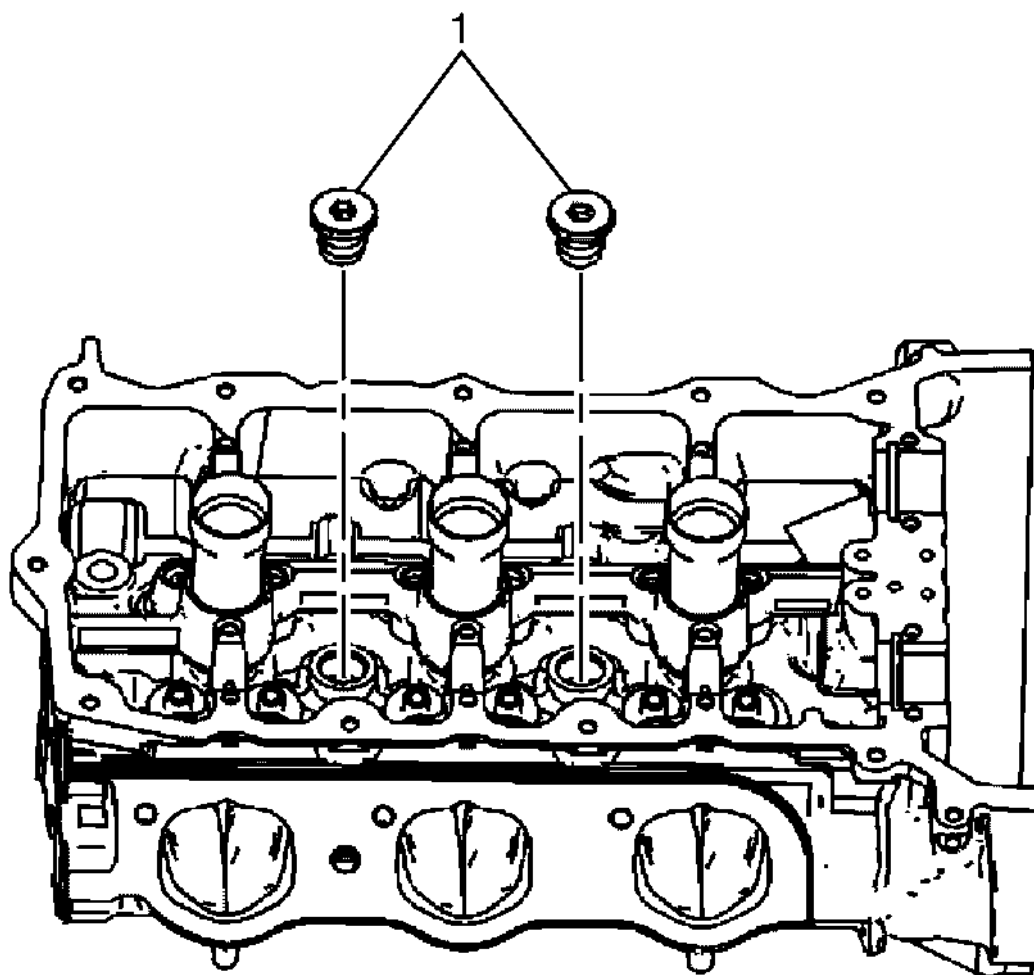
3. Place collar EN-46122-2 (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.
4. Using the driver EN-46122-1 (2), lightly tap the new check valve into place until the driver stops against the top of the collar.



**Fig. 110: Inspecting Camshaft Position Actuator Oil Feed Check Valve**  
Courtesy of GENERAL MOTORS CORP.

5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).

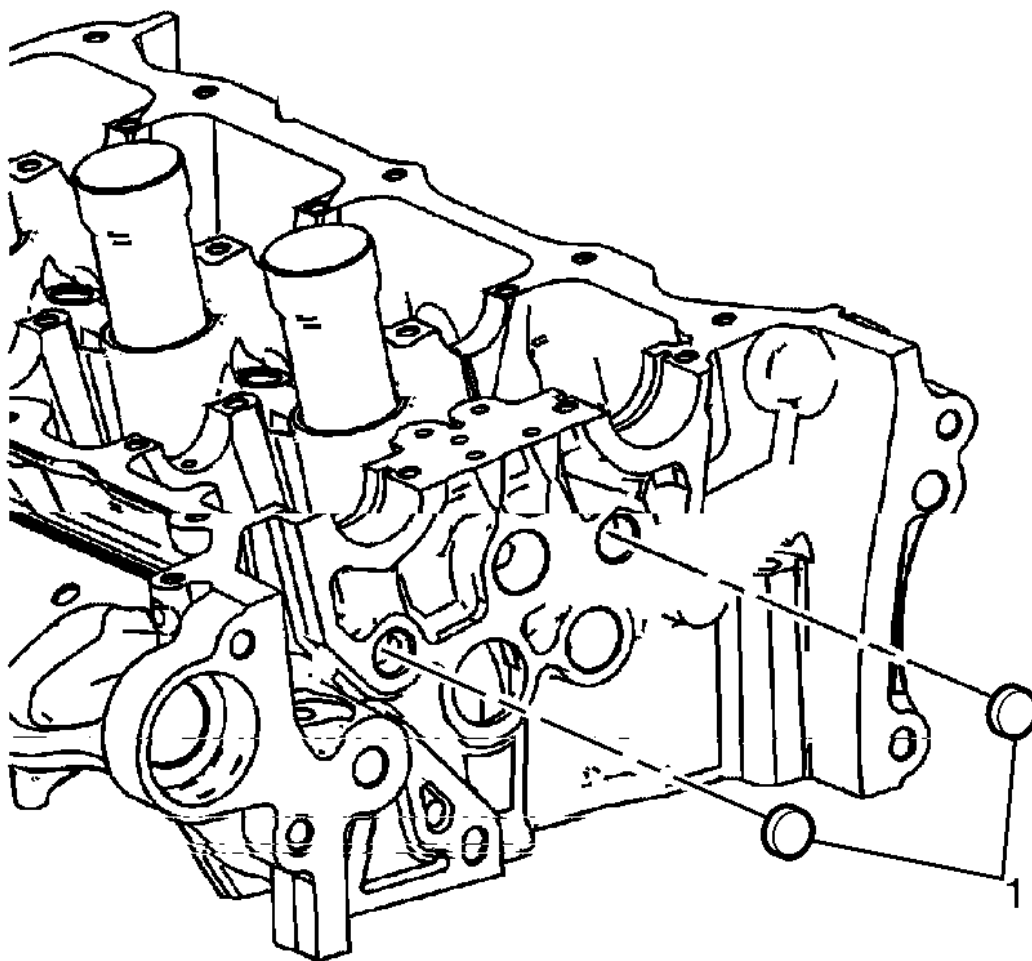




**Fig. 111: Identifying Cylinder Head Coolant Threaded Plugs**  
Courtesy of GENERAL MOTORS CORP.

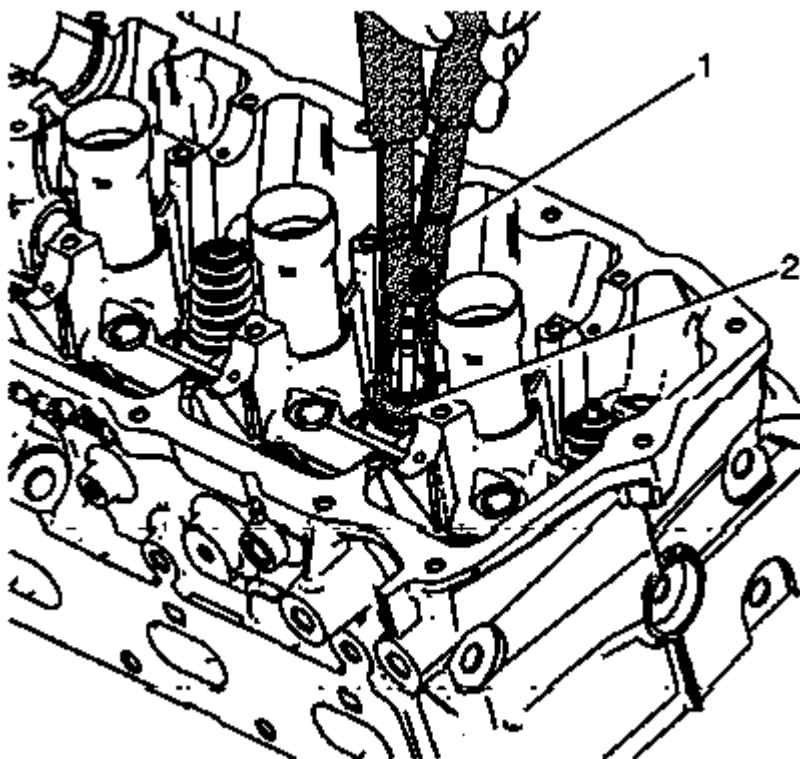
**CAUTION:** Refer to Fastener Caution .

6. Install the cylinder head coolant threaded plugs (1) and tighten to 45 N.m (33 lb ft).



**Fig. 112: Identifying Cylinder Head Oil Gallery Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head oil gallery expansion plugs (1).



**Fig. 113: View Of EN 46116 & Valve Stem Seal**  
Courtesy of GENERAL MOTORS CORP.

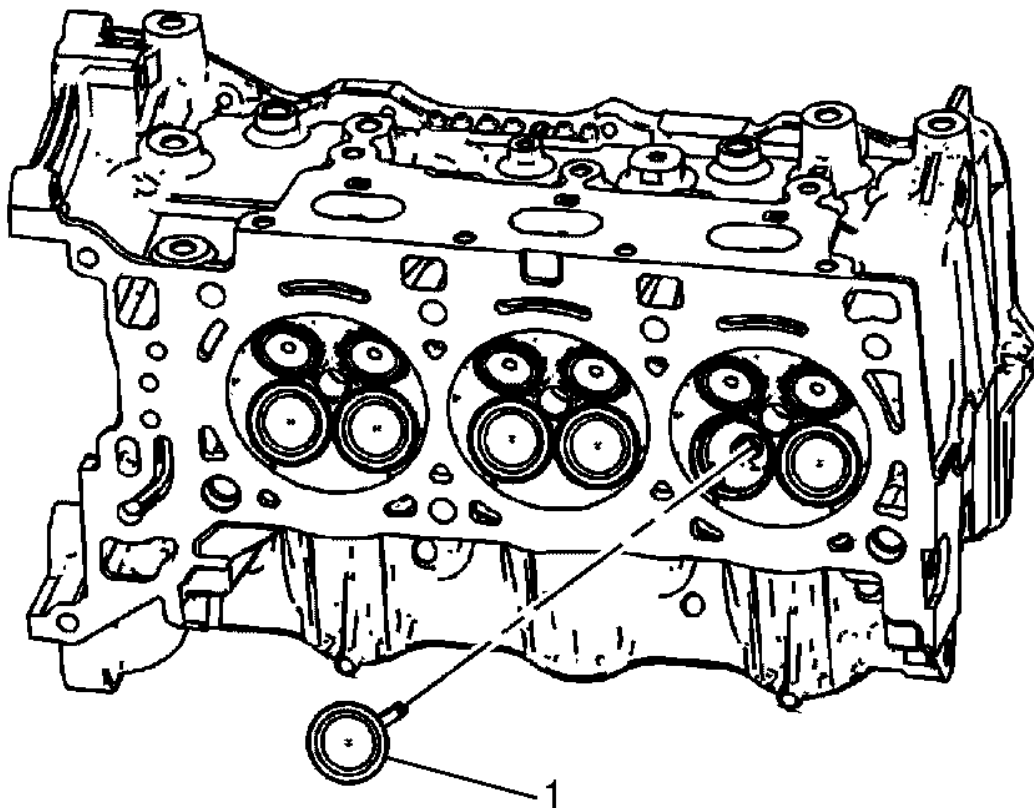
8. Place the valve stem oil seals (2) onto the guides.

**NOTE:**        **NEVER reuse a valve stem oil seal (2). Always use new seals when assembling the cylinder head.**

9. Mount a new valve stem oil seal (2) using the EN 46116: remover/installer (1).

**NOTE:**        **Force should only be applied to the valve spring contact area of the new valve stem oil seal (2) during installation.**

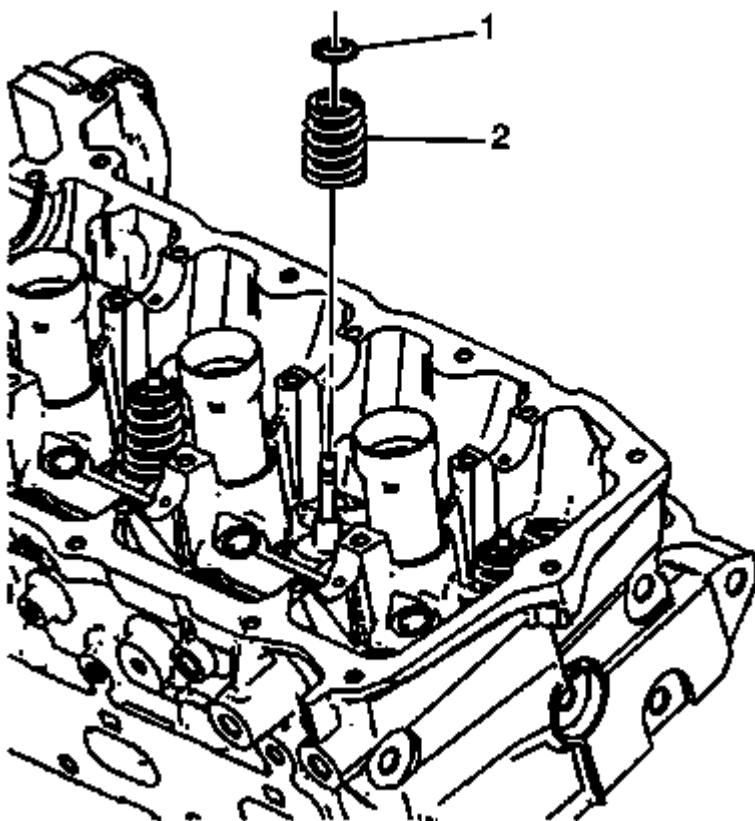
10. Push and twist the valve stem oil seal (2) into position on the valve guide until the seal positively locks on the guide using the EN 46116: remover/installer (1).
11. Lubricate the valve stem and valve guide ID with clean engine oil.



**Fig. 114: Identifying Valve**  
Courtesy of GENERAL MOTORS CORP.

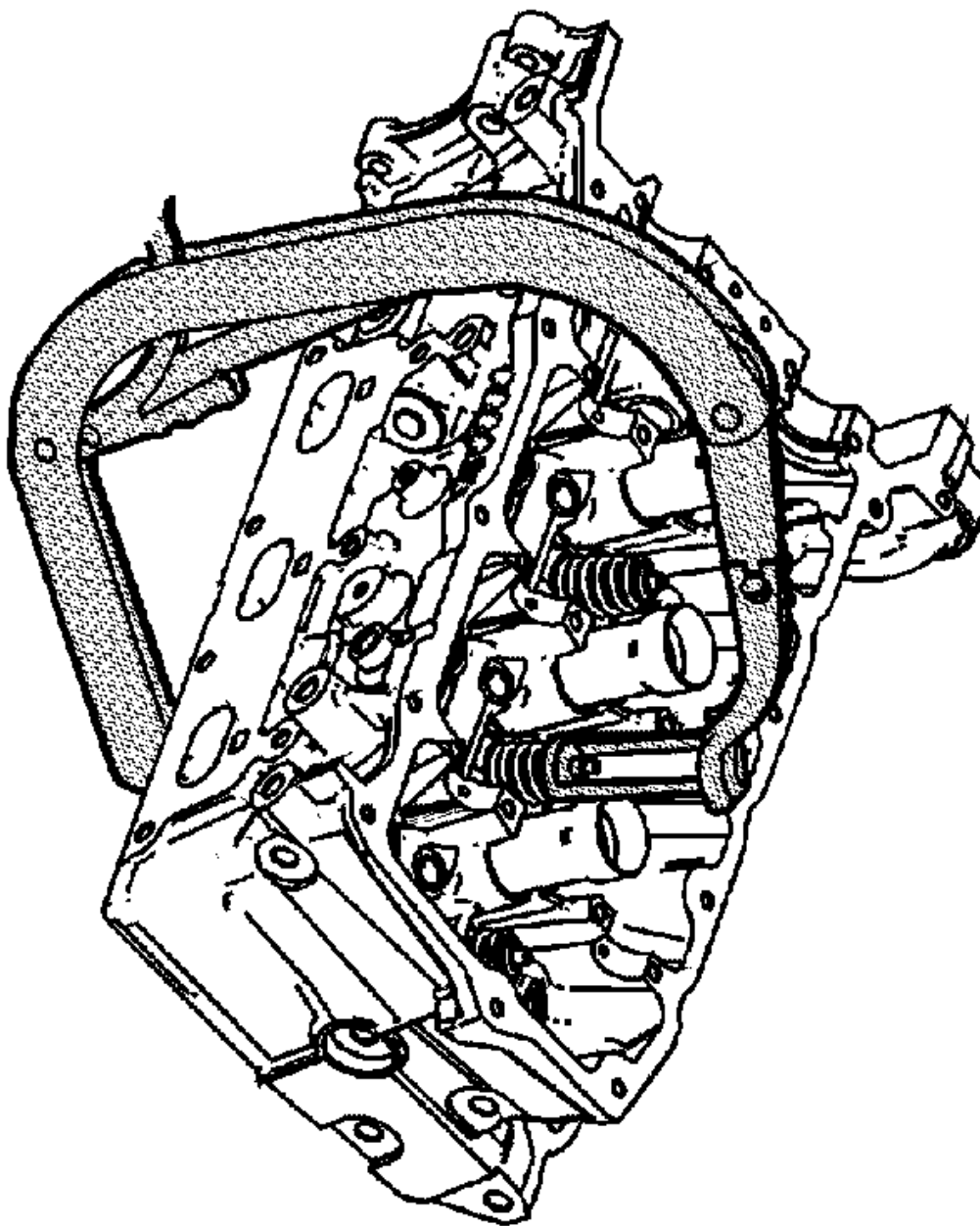
**NOTE:** The valve stem oil seal must not come loose from the valve guide when the valve is installed.

12. Insert the valve (1) into the valve guide until it bottoms on the valve seat.



**Fig. 115: Identifying Valve Spring & Retainer**  
Courtesy of GENERAL MOTORS CORP.

13. Install the valve spring (2).
14. Place the valve spring retainer (1) onto the valve spring (2).



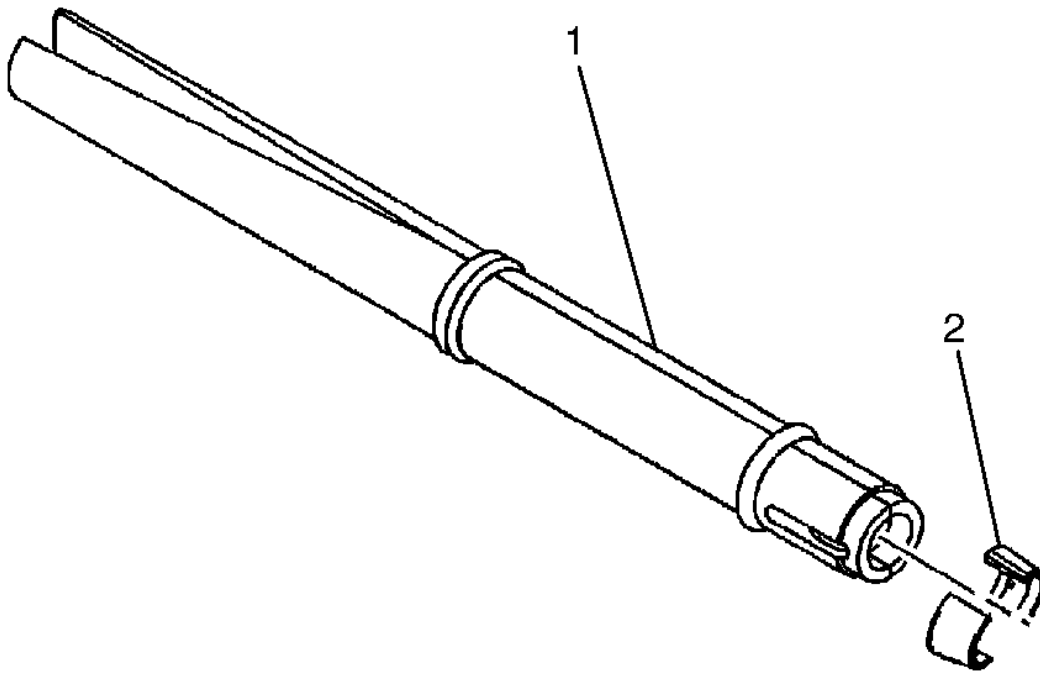
**Fig. 116: View Of J 8062 & EN 46119**  
Courtesy of GENERAL MOTORS CORP.

**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 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.

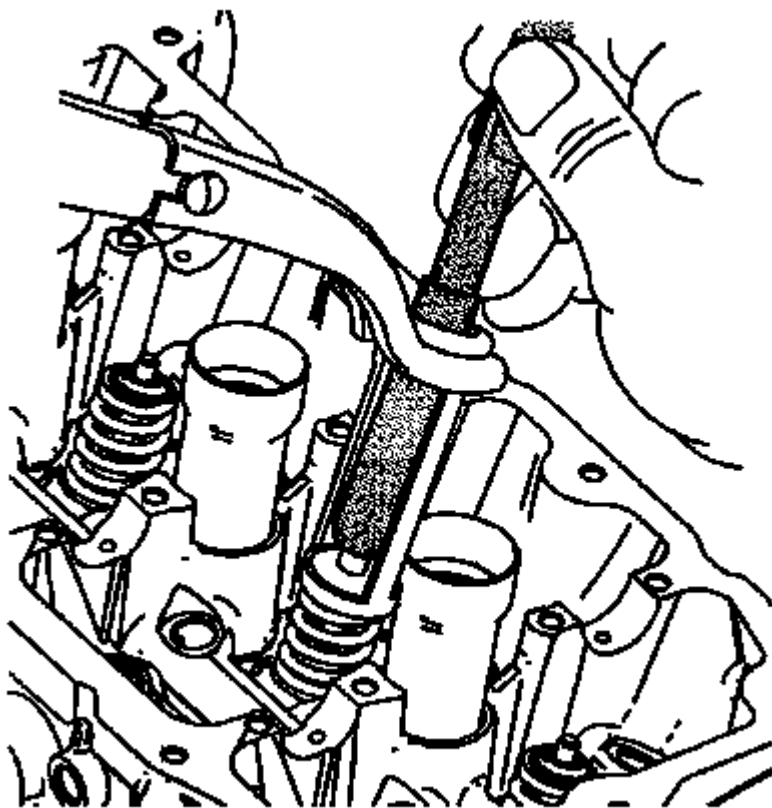
15. Compress the valve spring using the **J 8062**: compressor and the **EN 46119**: adapter.



**Fig. 117: Identifying Valve Collets & EN 46117**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Ensure correct directional placement of valve collets (2) in the **EN 46117**: remover/installer (1). The valve collets (2) must be installed with the tapered end towards the valve stem seal.

16. With the spring compressed, install the valve collets (2) into the **EN 46117**: remover/installer (1).



**Fig. 118: Identifying Magnet Of EN 46117**  
Courtesy of GENERAL MOTORS CORP.

17. Place the valve collets into position by pushing the **EN 46117**: remover/installer downward and releasing tension on the **EN 46119**: adapter and the **J 8062**: compressor.
18. Verify that the valve collets are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.

## CAMSHAFT CLEANING AND INSPECTION

### Cleaning Procedure

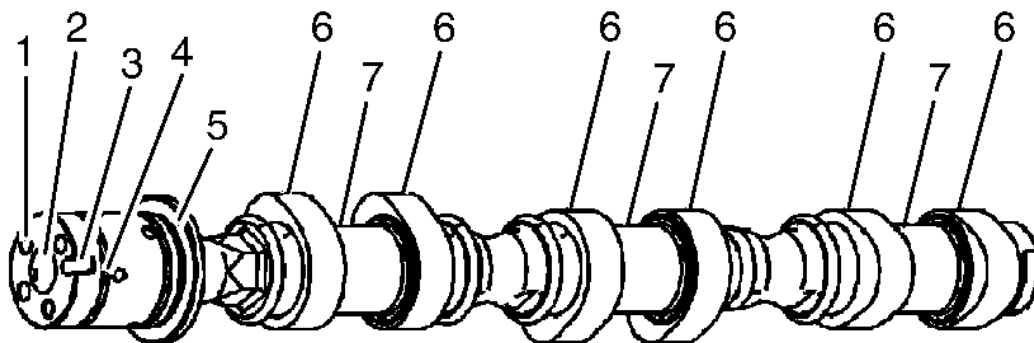
1. Clean the camshaft in solvent.

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

2. Dry the camshaft with compressed air.

### Visual Inspection



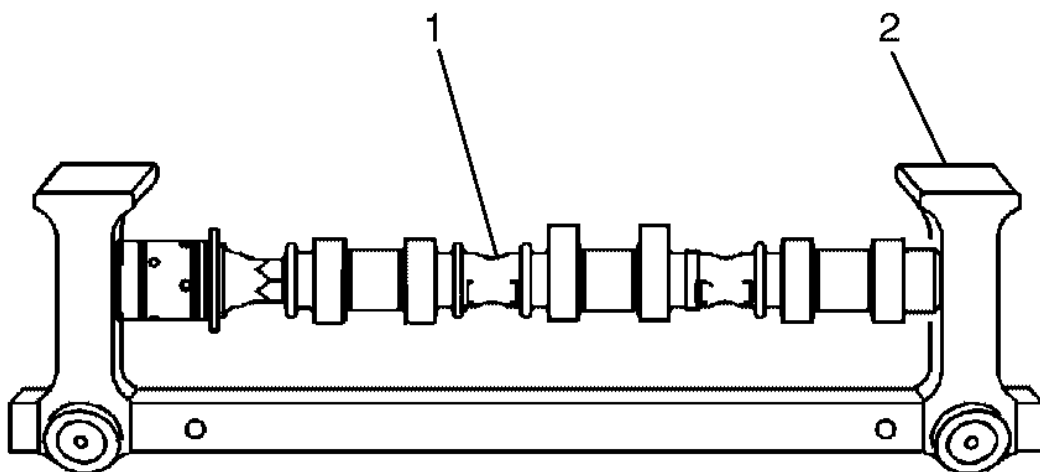


**Fig. 119: Identifying Camshaft Inspection Points**

Courtesy of GENERAL MOTORS CORP.

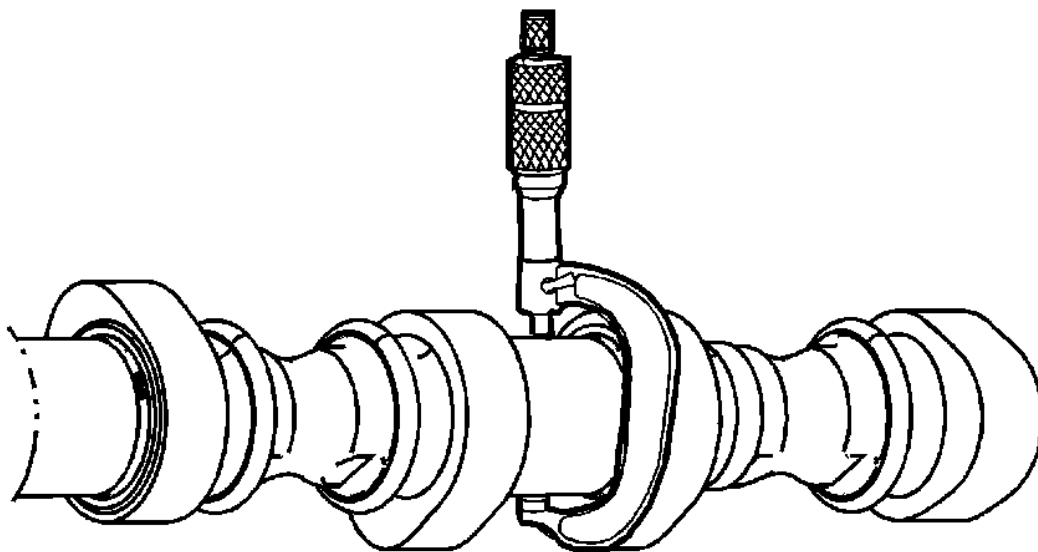
1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
  - Scoring or pitting above acceptable tolerances
  - Discoloration from overheating
  - Deformation from wear above acceptable tolerances, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

#### Camshaft Measurement



**Fig. 120: Checking Camshaft For Wear**  
Courtesy of GENERAL MOTORS CORP.

1. With the camshaft (1) in a suitable fixture (2), measure the camshaft (1) for wear.

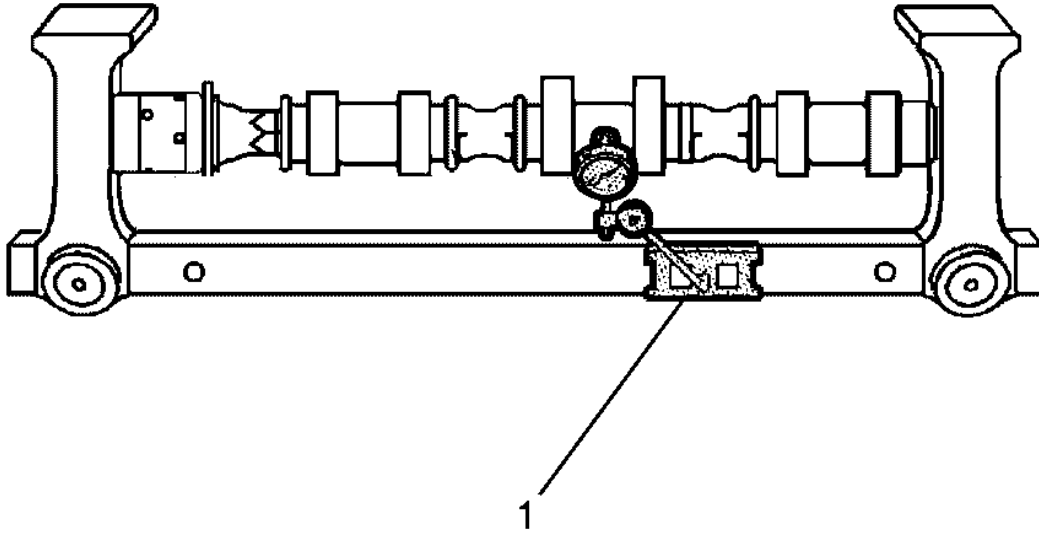


**Fig. 121: Identifying Camshaft Journal Measurement Procedure Using Outside Micrometer**  
Courtesy of GENERAL MOTORS CORP.

2. Measure and record the camshaft journals (2) for diameter and out-of-round using an outside micrometer

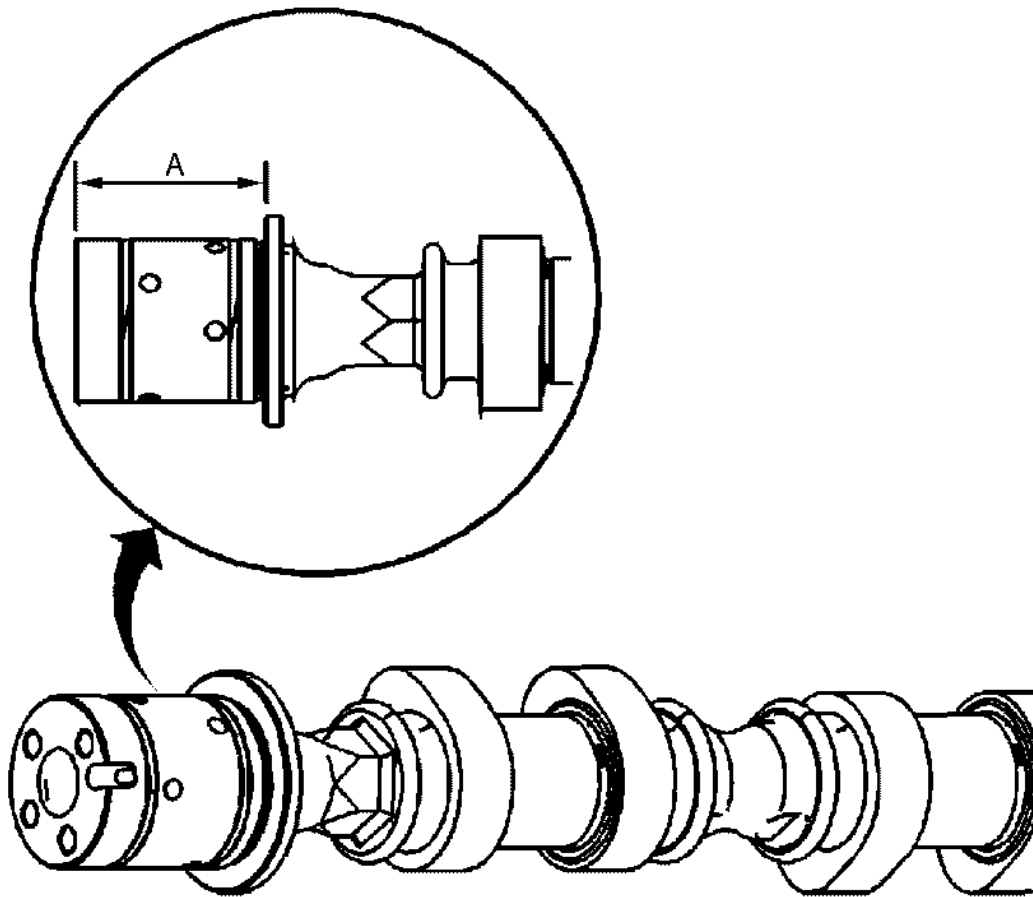
(1). Refer to **Engine Mechanical Specifications** .

- If the diameter is smaller than specifications, replace the camshaft.
- If the out-of-round exceeds specifications, replace the camshaft.



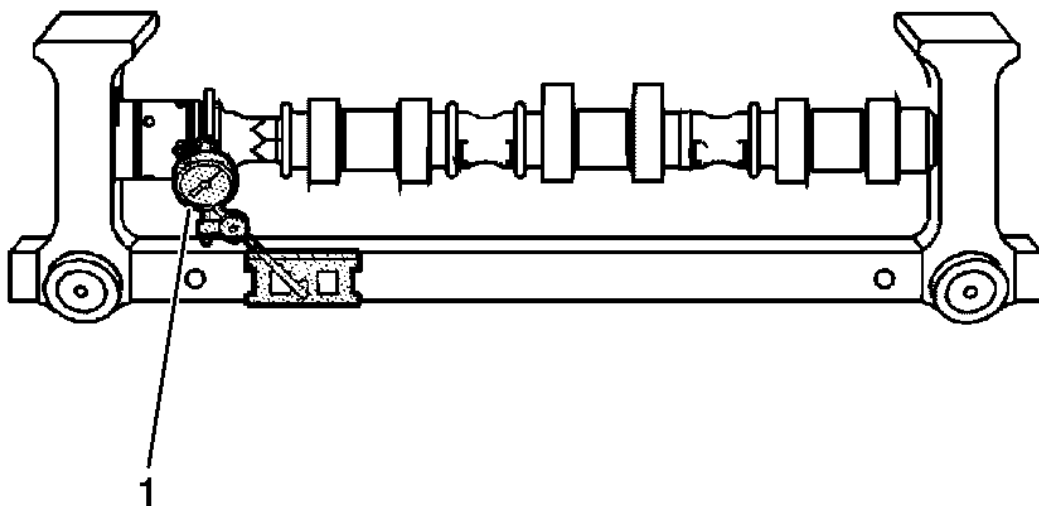
**Fig. 122: Identifying Camshaft Measurement Procedure Using Dial Indicator**  
Courtesy of GENERAL MOTORS CORP.

3. Measure and record the camshaft runout using a dial indicator (1). Refer to **Engine Mechanical Specifications** .



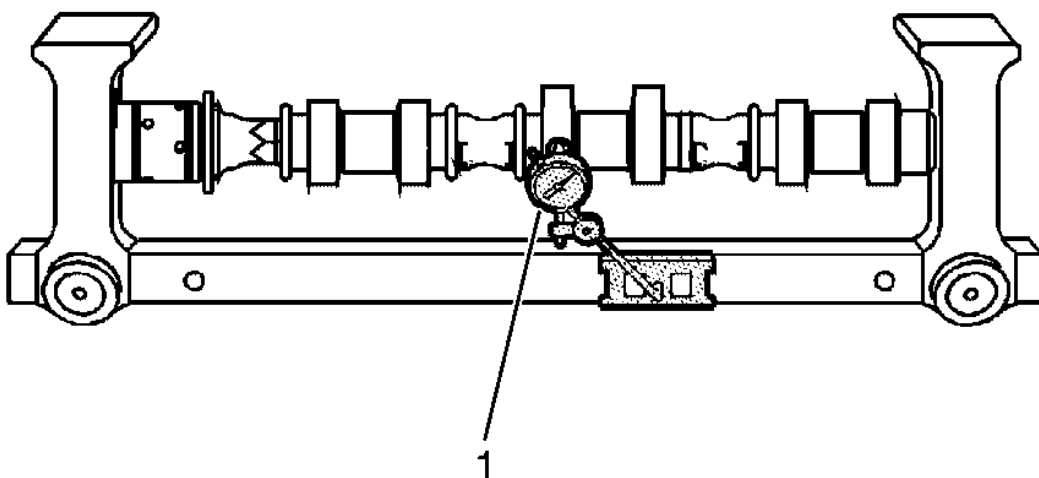
**Fig. 123: Identifying Camshaft Thrust Width Measurement Procedure Using Depth Micrometer**  
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft thrust width (A) for wear using a depth micrometer. Refer to **Engine Mechanical Specifications** .



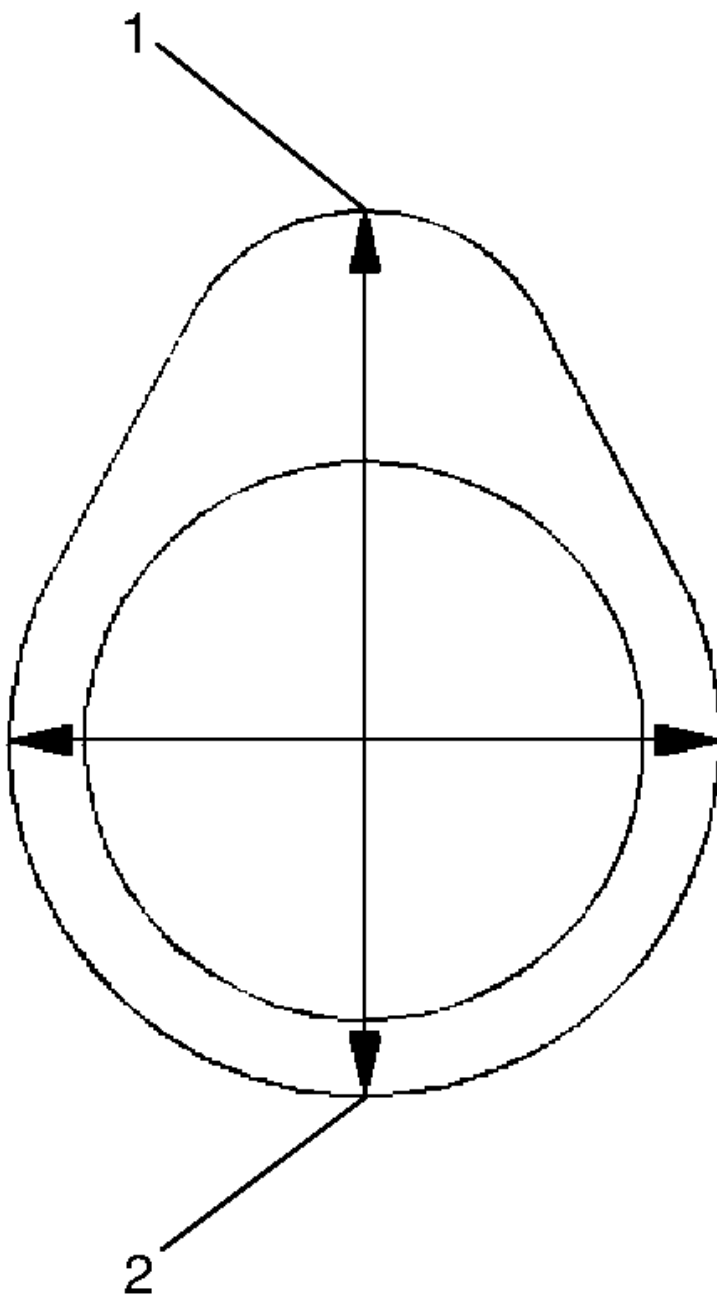
**Fig. 124: Identifying Camshaft Thrust Wall Surface Measurement Procedure Using Dial Indicator**  
Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft thrust wall surface for runout using a dial indicator (1). Refer to **Engine Mechanical Specifications** .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.



**Fig. 125: Identifying Camshaft Lobe Measurement Procedure Using Dial Indicator**  
Courtesy of GENERAL MOTORS CORP.

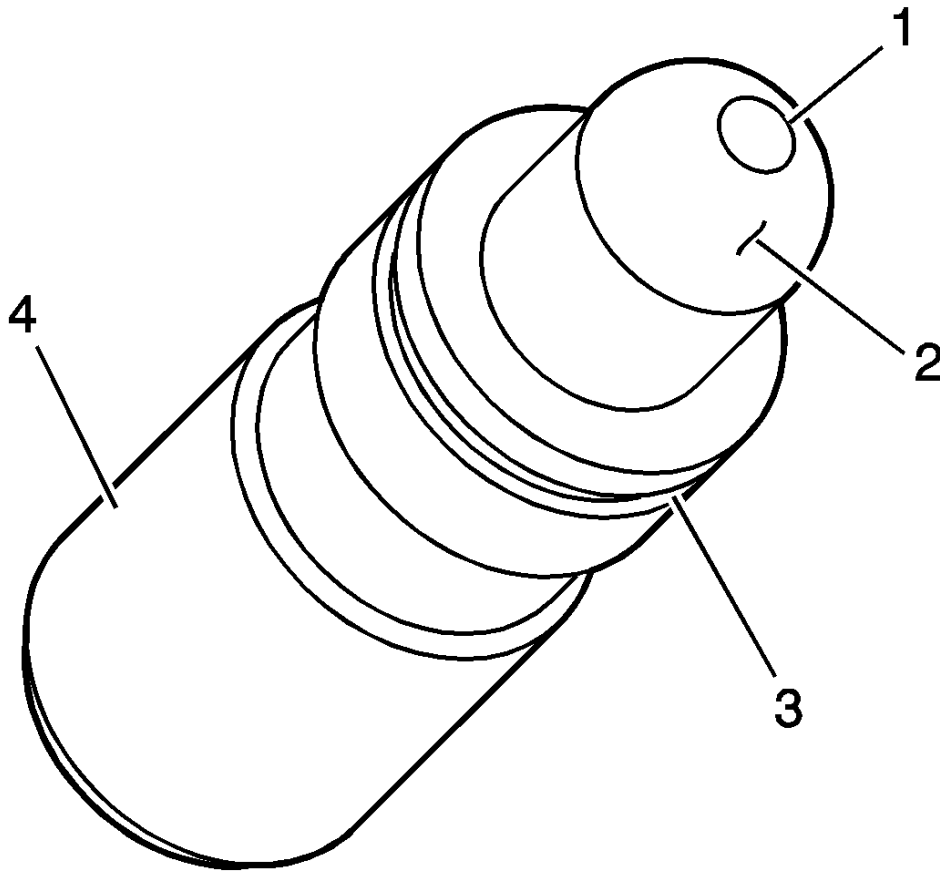
7. Measure the camshaft lobes for wear using a dial indicator (1).



**Fig. 126: Identifying Base Circle**  
**Courtesy of GENERAL MOTORS CORP.**

8. Place the dial indicator with the indicator tip on the base circle (2) of the camshaft lobe.
  1. Place the dial indicator at zero.
  2. Rotate the camshaft until the indicator tip is at the highest point (1) on the lobe. This reading is the lift of the camshaft lobe. Refer to **Engine Mechanical Specifications** .
  3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

## VALVE LIFTERS CLEANING AND INSPECTION



**Fig. 127: Valve Lifter**  
Courtesy of GENERAL MOTORS CORP.

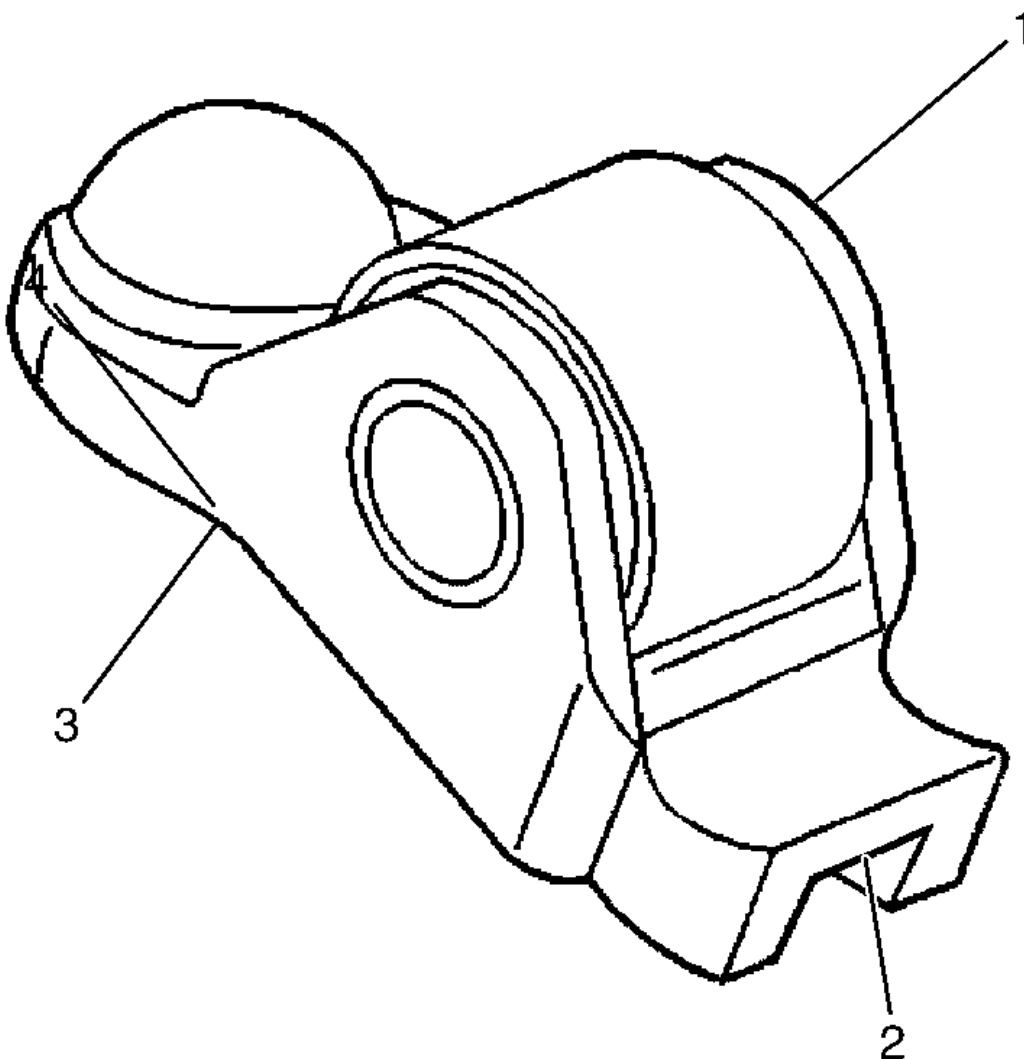
**CAUTION:** Refer to **Valve Lifter Priming Caution** .

1. Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:

- A plugged oil passage (1)
- A scored or worn camshaft follower pivot area (2)
- A damaged or broken retainer (3), some applications
- A severely scuffed or worn SHLA body (4)

2. Replace the SHLA or SHLAs as necessary.

## VALVE ROCKER ARM CLEANING AND INSPECTION



**Fig. 128: Identifying Valve Rocker Arm**  
Courtesy of GENERAL MOTORS CORP.



1. Inspect the valve rocker arm (1) for the following:
  - Flat spots.
  - Scoring and pitting above acceptable tolerances.
  - Ensure the roller spins freely.
2. Inspect the valve rocker arm valve tip area (2).
3. Inspect the valve rocker arm Stationary Hydraulic Lash Adjuster (SHLA) pivot area (3).
4. Replace the valve rocker arm or valve rocker arms as necessary.

## **CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION**

### **Cleaning Procedure**

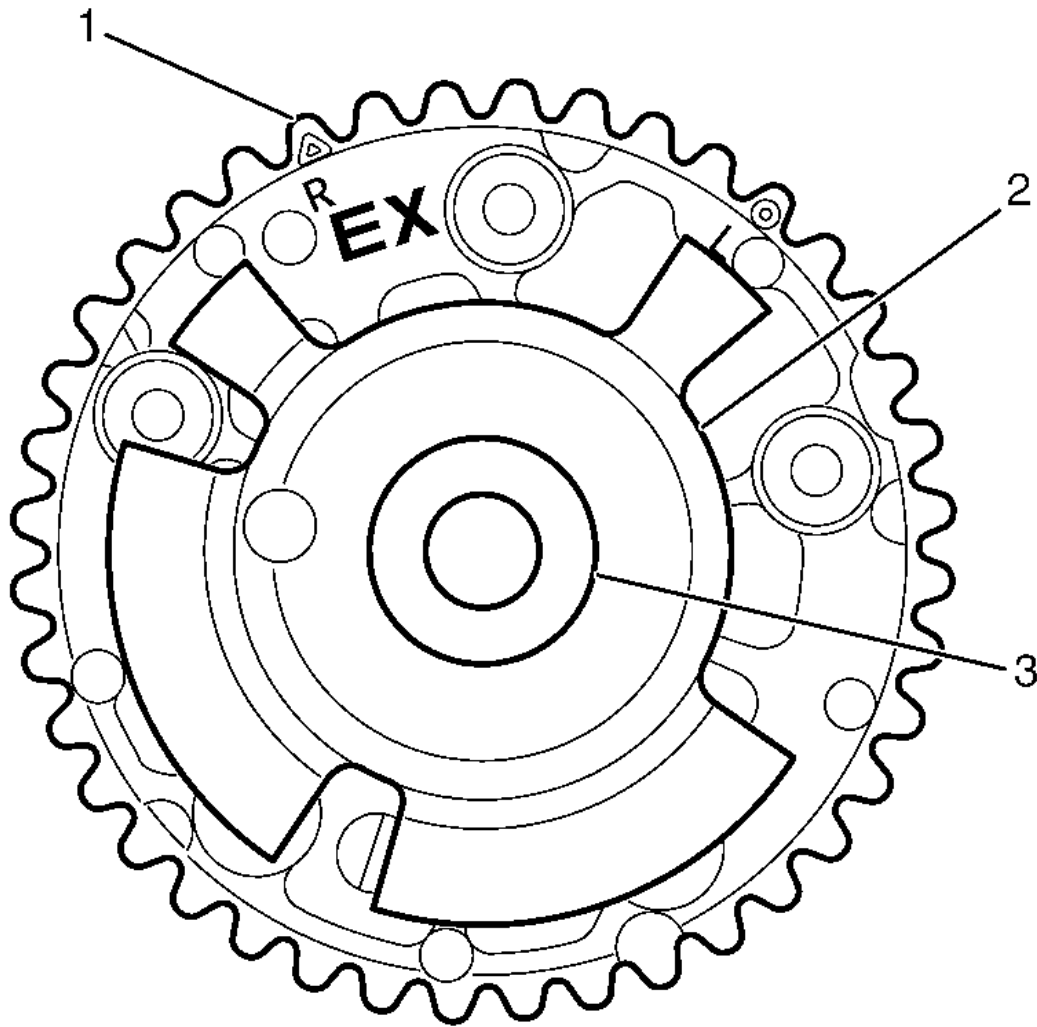
1. Clean all the following components with solvent:
  - Crankshaft sprocket.
  - Primary timing drive chain.
  - Primary timing drive chain shoe.
  - Primary timing drive chain guides.
  - Primary timing drive chain tensioner.
  - Secondary timing drive chains.
  - Secondary timing drive chain shoes.
  - Secondary timing drive chain guides.
  - Secondary timing drive chain tensioners.
  - Timing component fastening bolts.
2. Clean each camshaft position actuator's exterior with solvent.

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

3. Dry the timing components with compressed air.

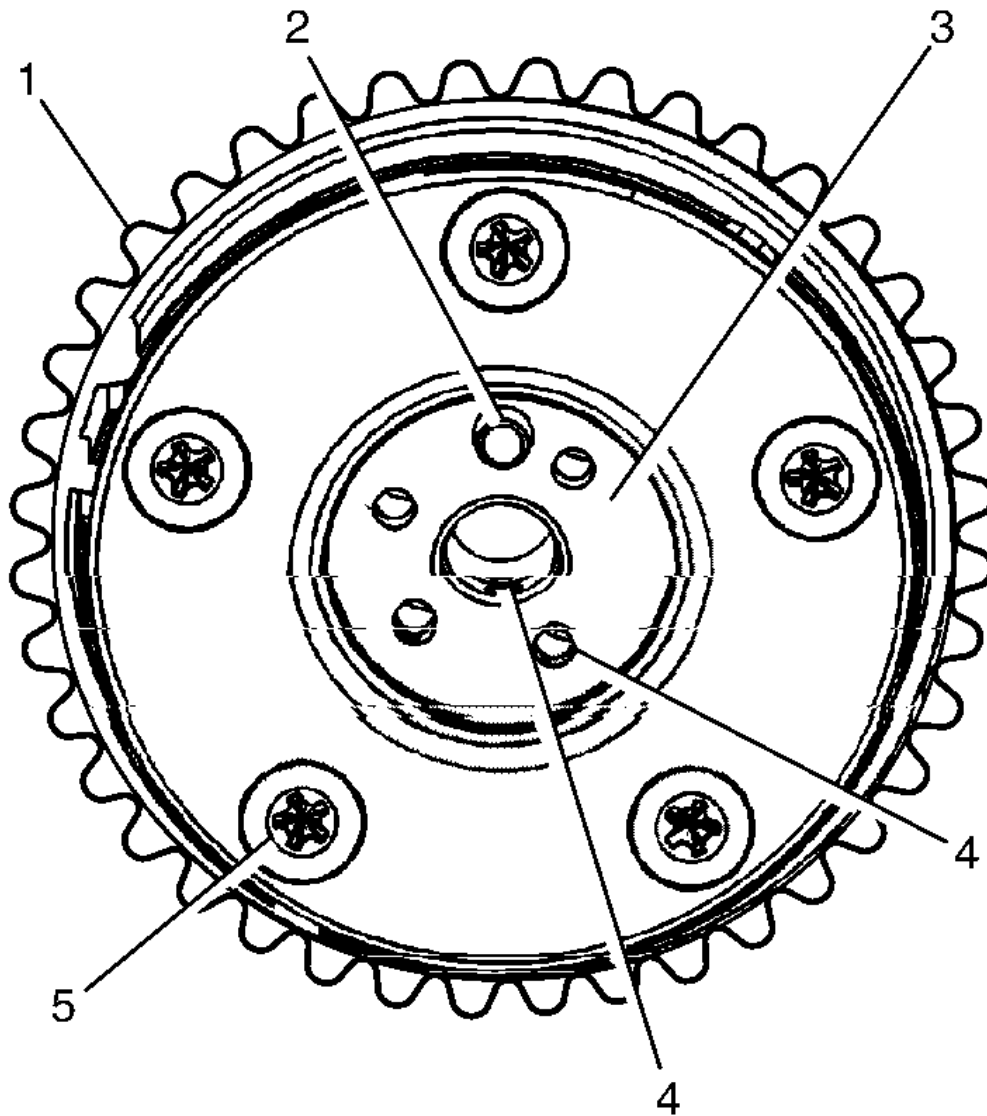
### **Visual Inspection**

#### **Camshaft Position Actuators (LY7 Engine)**



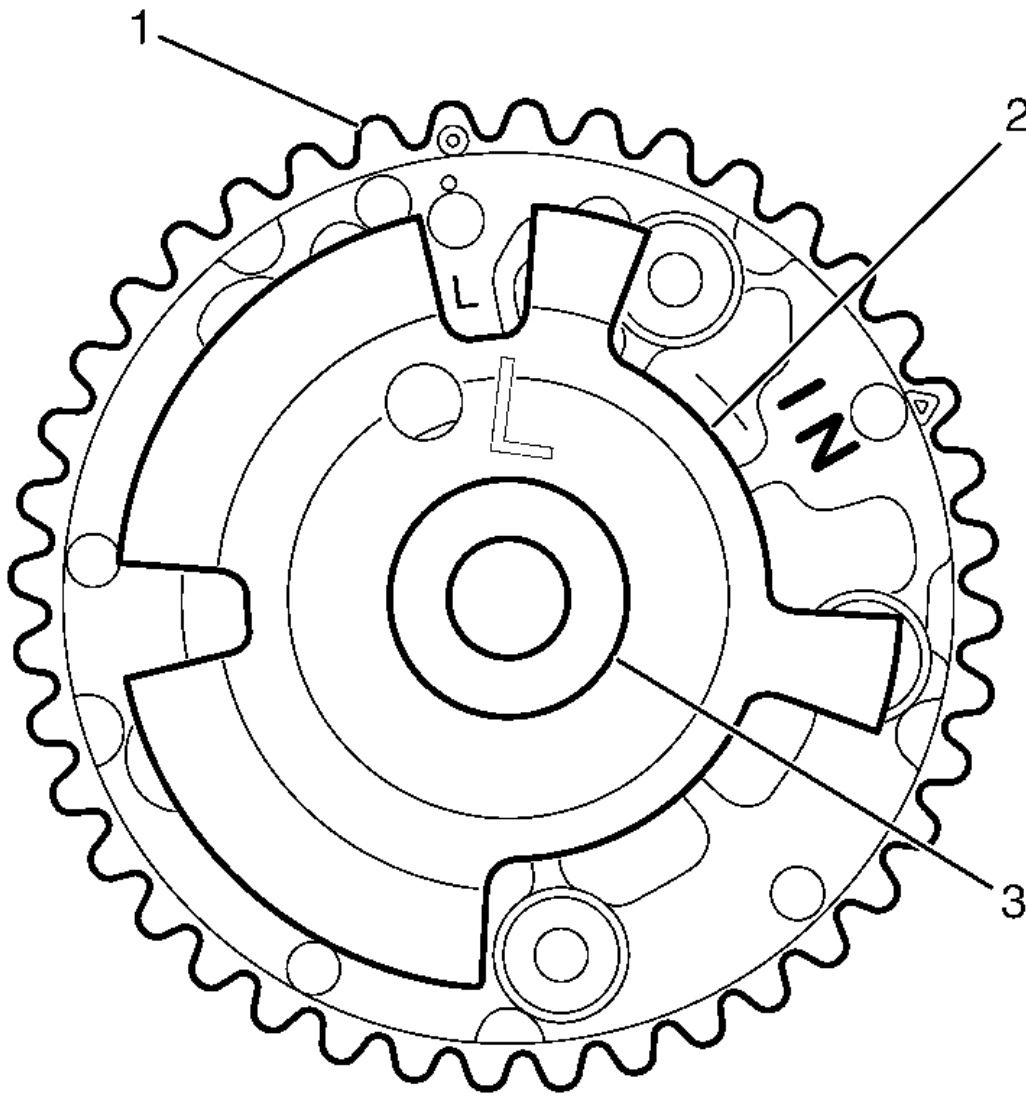
**Fig. 129: Identifying Front Of Intake/Exhaust Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the exhaust camshaft position actuators for the following:
  - Sprocket damage (1).
  - Reluctor/sensor wheel damage (2).
  - Camshaft position actuator to camshaft retaining bolt seating/sealing inner hub flange damage (3).



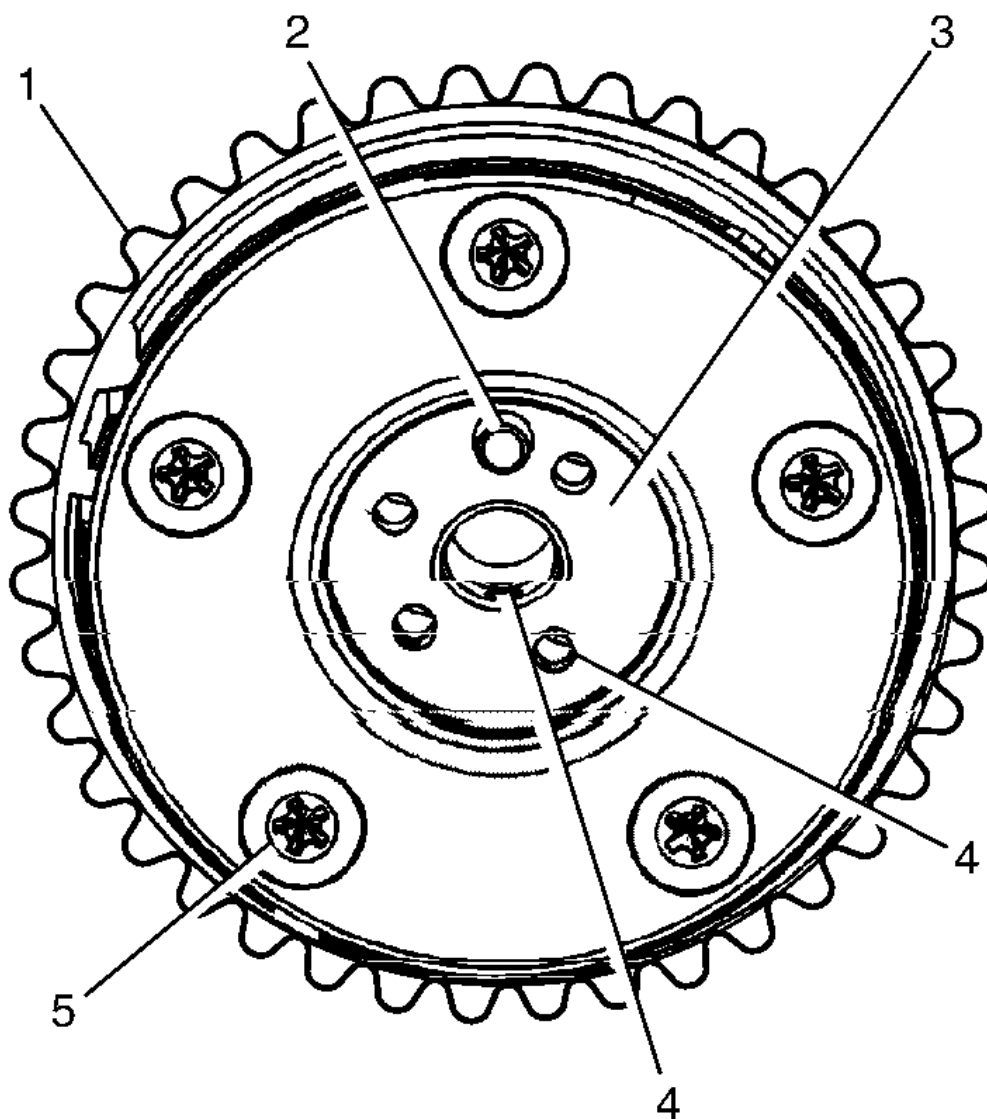
**Fig. 130: Identifying Back Of Intake/Exhaust Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the exhaust camshaft position actuators for the following:
  - Sprocket damage (1).
  - Camshaft locating pin damage (2).
  - Camshaft seating/sealing inner hub flange damage (3).
  - Blockage to the oil passages (4).
  - Loose or missing housing bolts (5).



**Fig. 131: Identifying Front Of Intake Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the intake camshaft position actuators for the following:
- Sprocket damage (1).
  - Reluctor/sensor wheel damage (2).
  - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3).

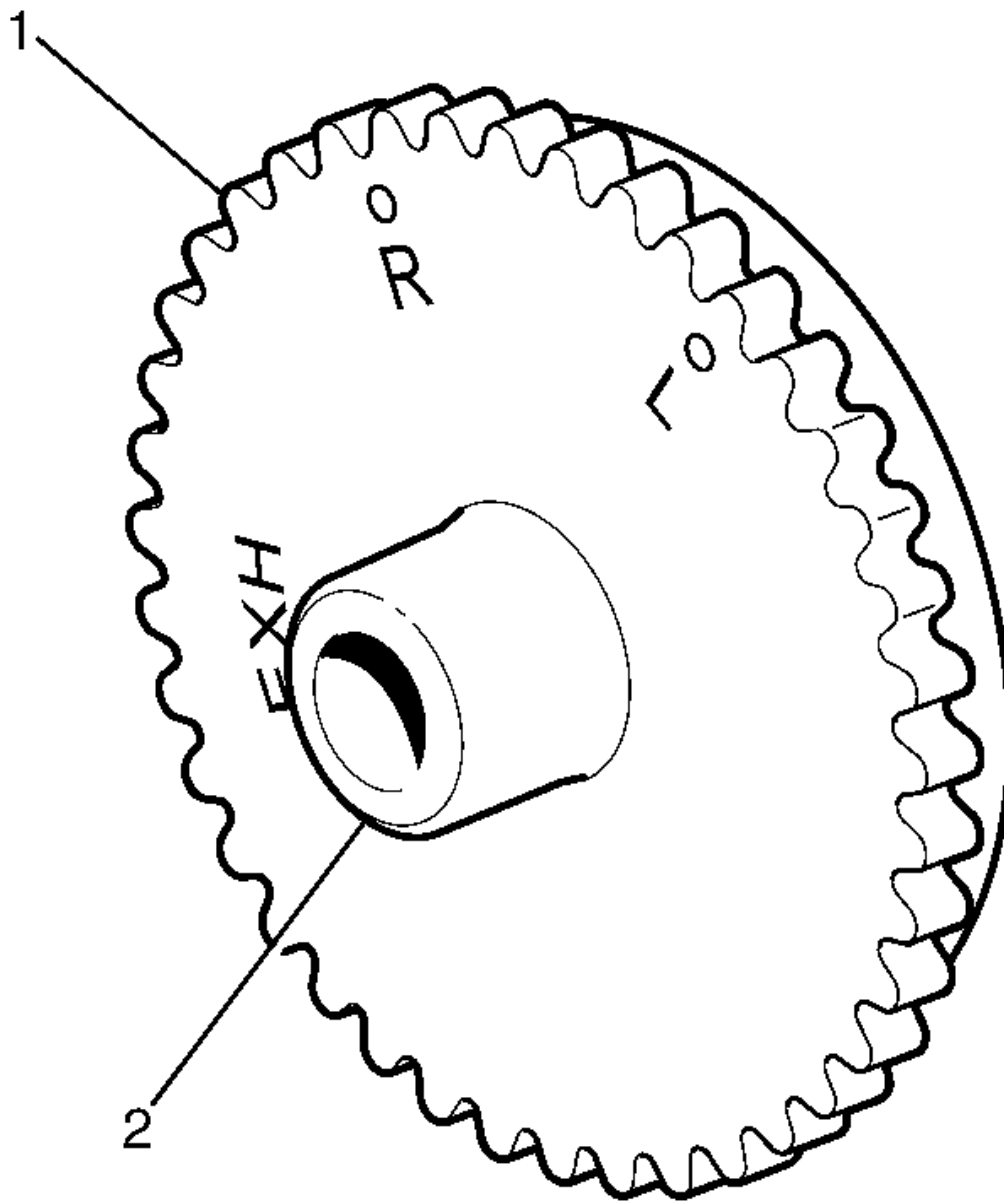


**Fig. 132: Identifying Back Of Intake/Exhaust Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the back of the intake camshaft position actuators for the following:
  - Sprocket damage (1).
  - Camshaft locating pin damage (2).
  - Camshaft seating/sealing inner hub flange damage (3).
  - Blockage to the oil passages (4).
  - Loose or missing housing bolts (5).

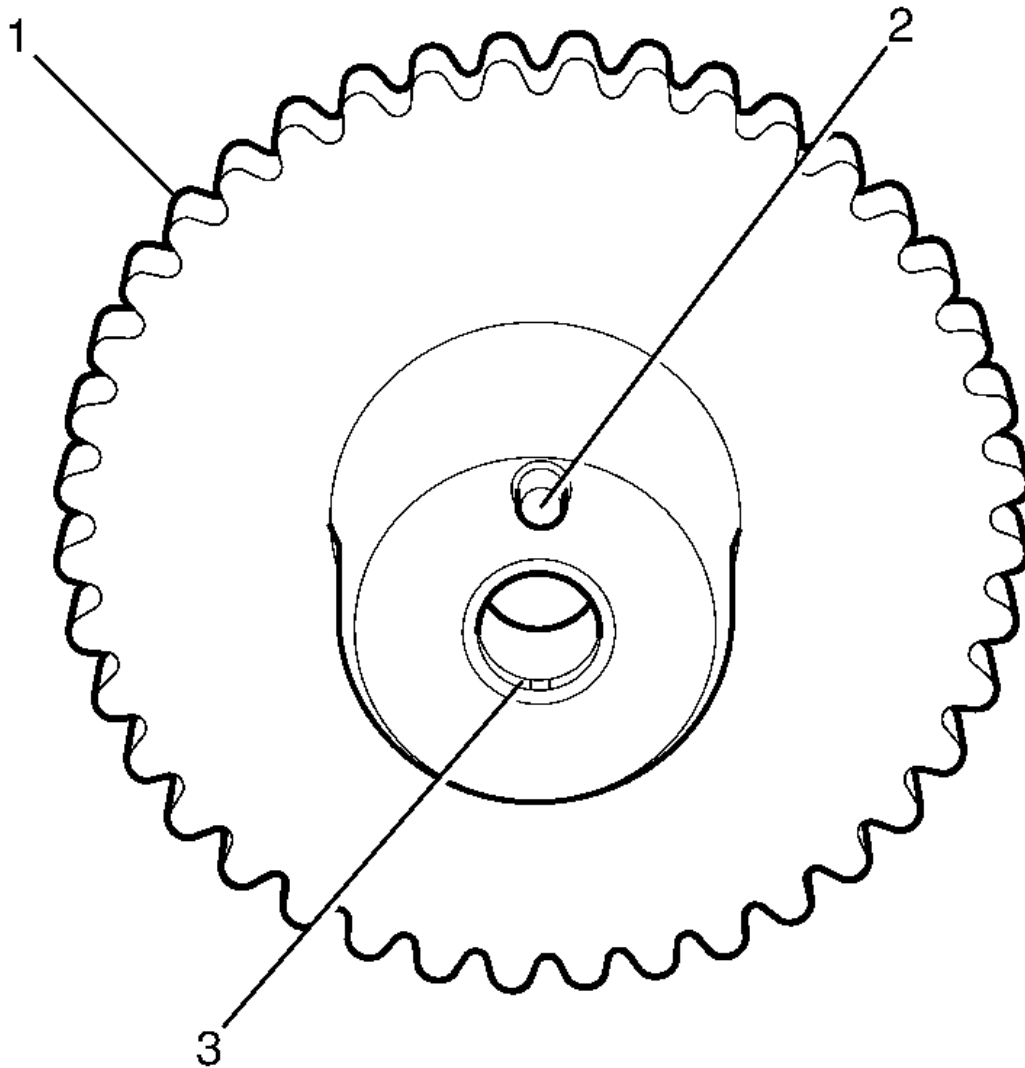
5. Replace a damaged camshaft position actuator.

### Camshaft Position Actuators and Sprockets (LE0 & LW2 Engines)



**Fig. 133: Identifying Front Of Exhaust Camshaft Sprockets**  
Courtesy of GENERAL MOTORS CORP.

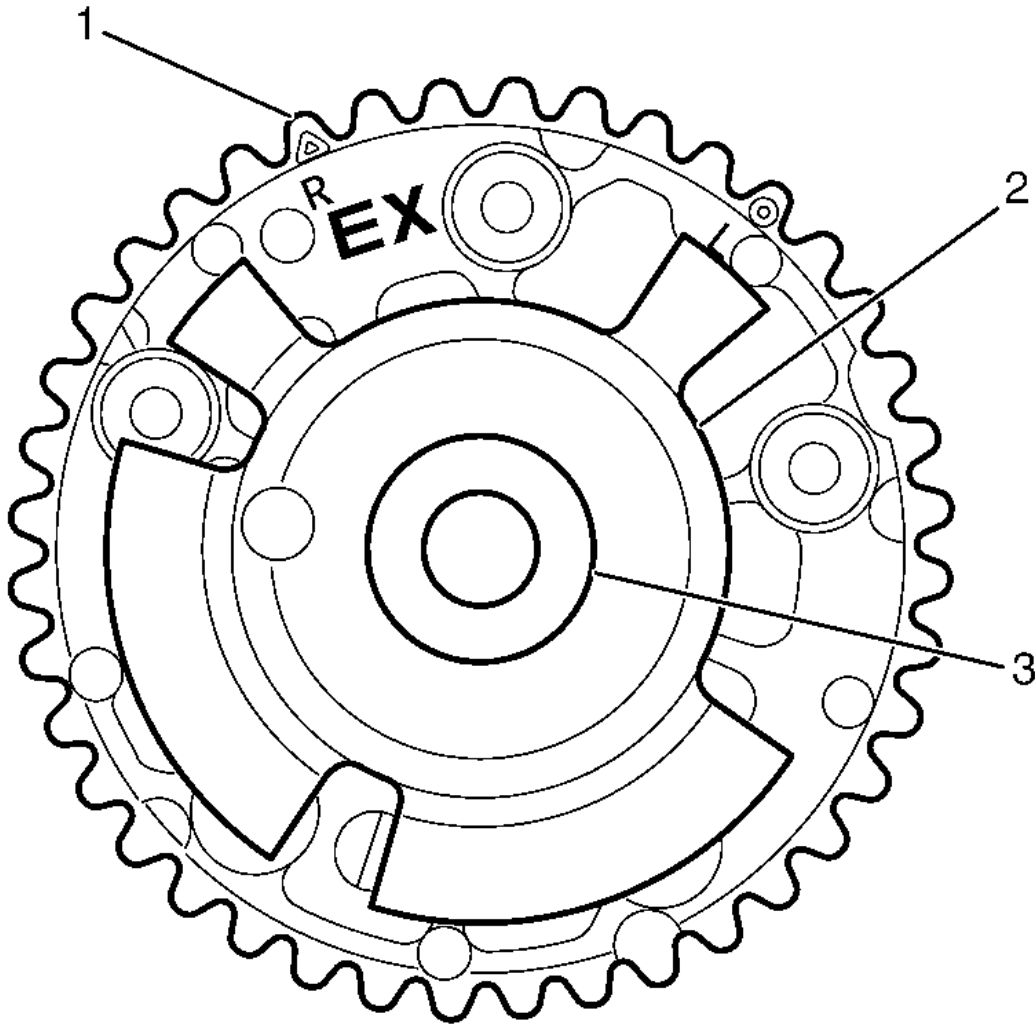
1. Inspect the front of the exhaust camshaft sprockets for the following:
  - Sprocket damage (1).
  - Exhaust camshaft sprocket bolt seating inner hub damage (2).



**Fig. 134: Identifying Back of Exhaust Camshaft Sprockets**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the exhaust camshaft sprockets for the following:
  - Sprocket damage (1).
  - Camshaft locating pin damage (2).

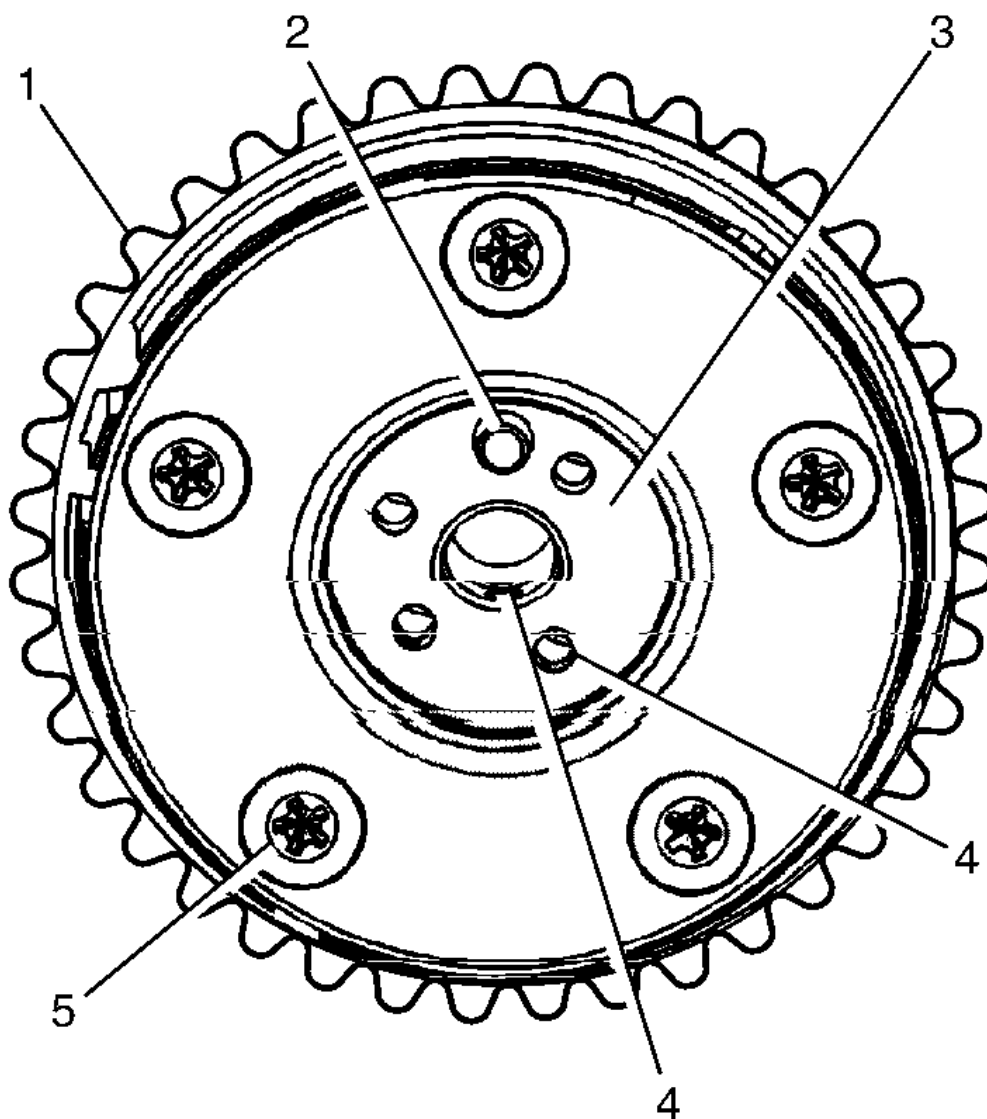
- Camshaft seating/ sealing inner hub flange damage (3).



**Fig. 135: Identifying Front Of Intake/Exhaust Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the intake camshaft position actuators for the following:
  - Sprocket damage (1).
  - Reluctor/sensor wheel damage (2).
  - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3).



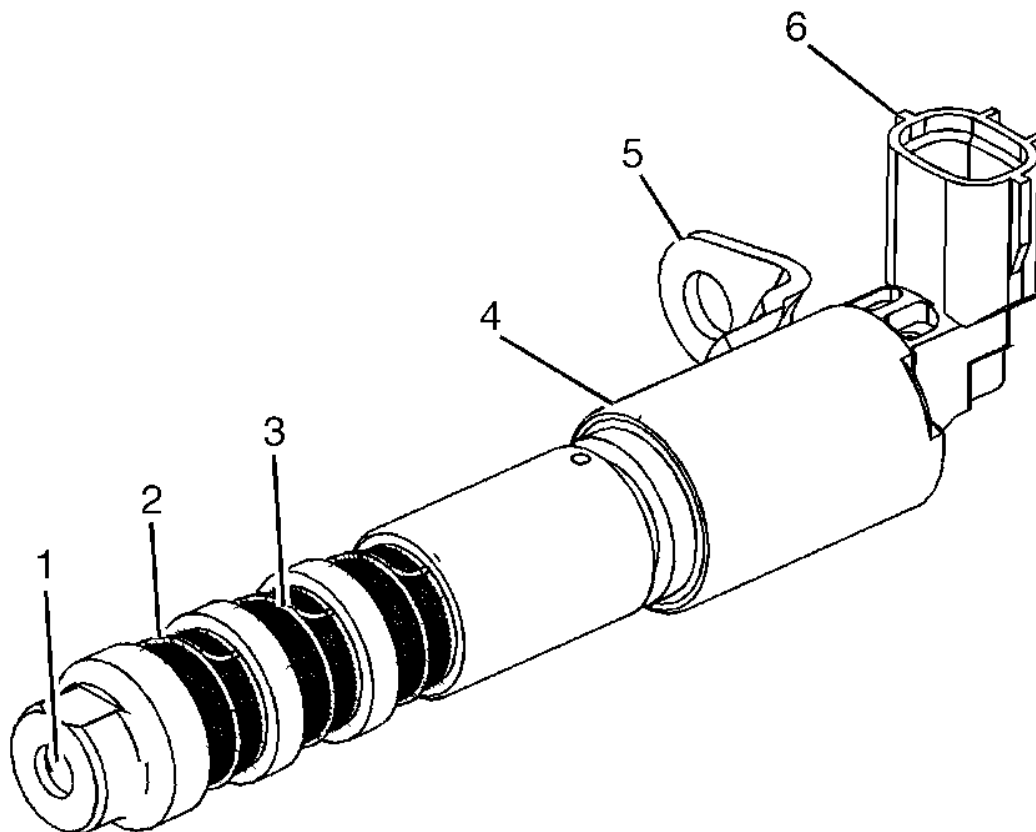


**Fig. 136: Identifying Back Of Intake/Exhaust Camshaft Position Actuators**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the back of the intake camshaft position actuators for the following:
- Sprocket damage (1).
  - Camshaft locating pin damage (2).
  - Camshaft seating/sealing inner hub flange damage (3).
  - Blockage to the oil passages (4).
  - Loose or missing housing bolts (5).

5. Replace a damaged camshaft position actuator.

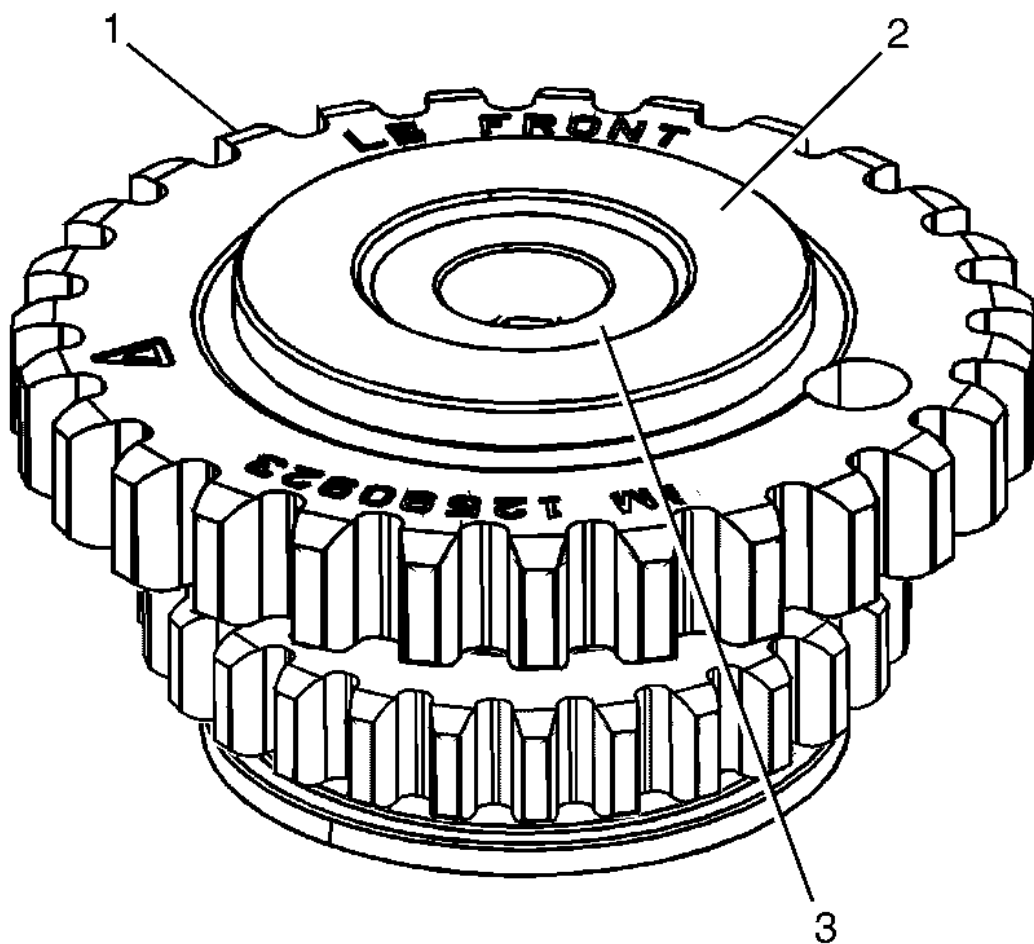
### Camshaft Position Actuator Solenoids



**Fig. 137: Identifying Camshaft Position Actuator Solenoids**  
 Courtesy of GENERAL MOTORS CORP.

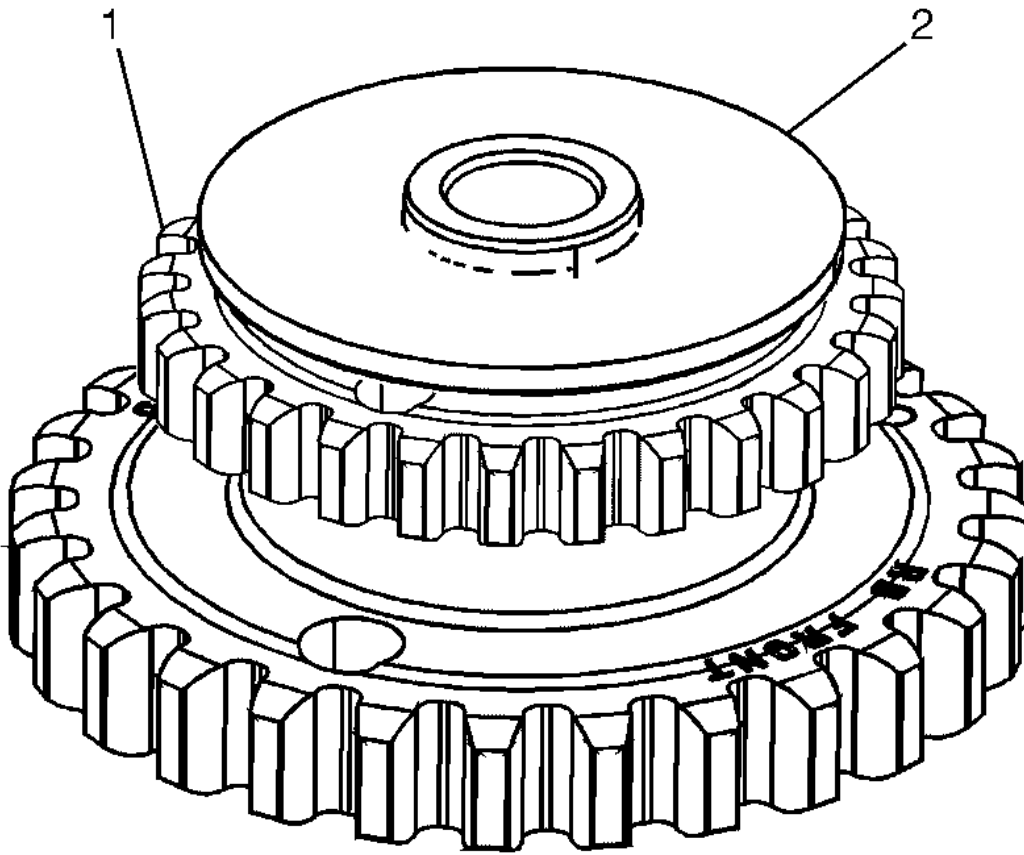
1. Inspect the camshaft position actuator solenoids for the following:
  - Blockage to the oil passage (1).
  - Missing or damaged oil screen clip (2).
  - Blockage or damage to the oil screen (3).
  - Damage to the sealing surface for the camshaft position actuator solenoid oil seal (4).
  - Damage to the bracket (5).
  - Damage to the wiring harness connection and/or terminals (6).
2. Replace a damaged camshaft position actuator solenoid.

### Left Intermediate Sprocket



**Fig. 138: Identifying Front Of Left Intermediate Sprocket**  
Courtesy of GENERAL MOTORS CORP.

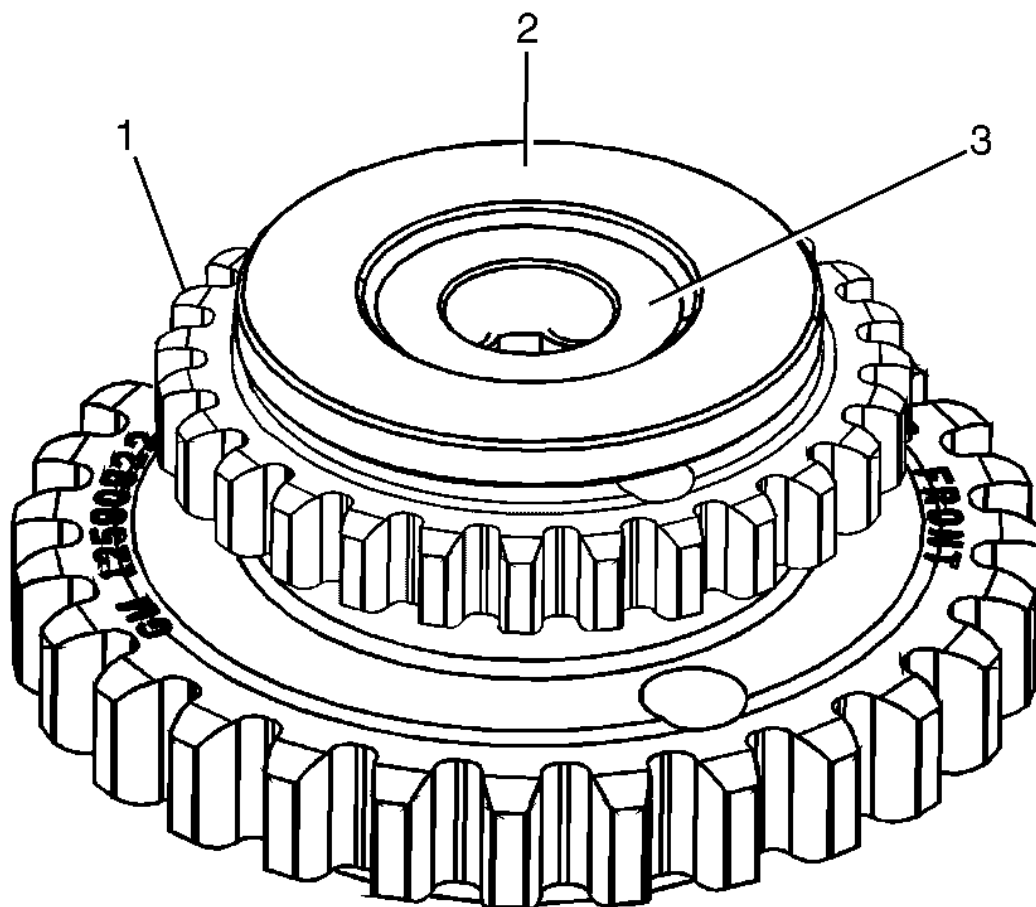
1. Inspect the front of the left intermediate sprocket for the following:
  - Damage to the primary camshaft drive chain sprocket (1).
  - Damage to the hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
  - Damage to the bolt flange seating/sealing surface (3).



**Fig. 139: Identifying Back Of Intermediate Sprocket**  
Courtesy of GENERAL MOTORS CORP.

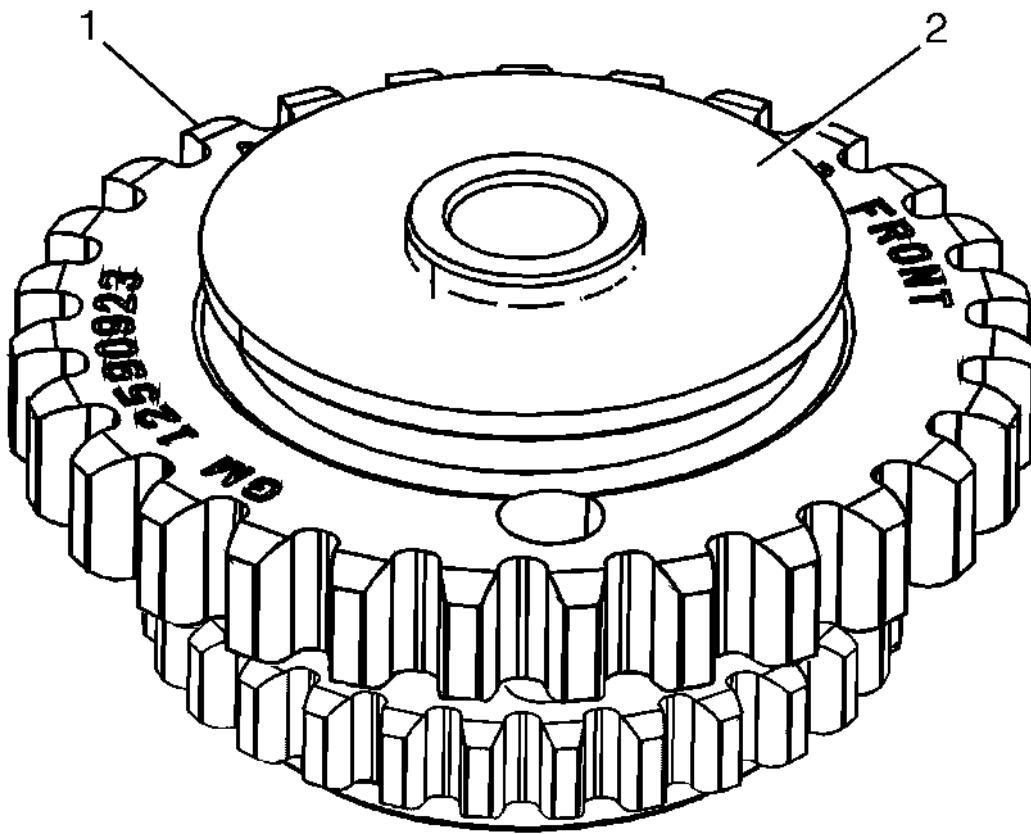
2. Inspect the back of the intermediate sprocket for the following:
  - Damage to the left secondary camshaft drive chain sprocket (1).
  - Damage to the bearing hub-to-engine block sealing surface (2).
3. Replace a damaged left intermediate sprocket.

### **Right Intermediate Sprocket**



**Fig. 140: Identifying Front Of Right Intermediate Sprocket**  
Courtesy of GENERAL MOTORS CORP.

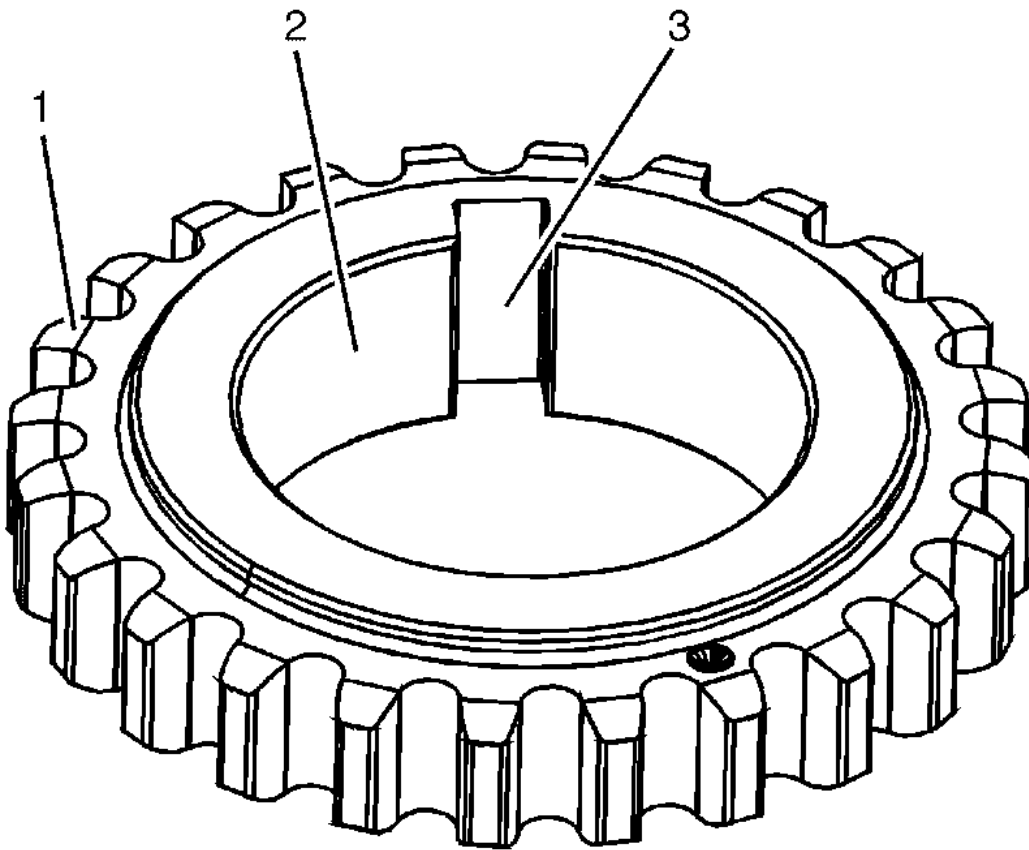
1. Inspect the front of the right intermediate sprocket for the following:
  - Damage to the right secondary camshaft drive chain sprocket (1)
  - Damage to the bearing hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
  - Damage to the bolt flange seating/sealing surface (3)



**Fig. 141: Identifying Back Of Right Intermediate Sprocket**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the right intermediate sprocket for the following:
  - Damage to the primary camshaft drive chain sprocket (1)
  - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged right intermediate sprocket.

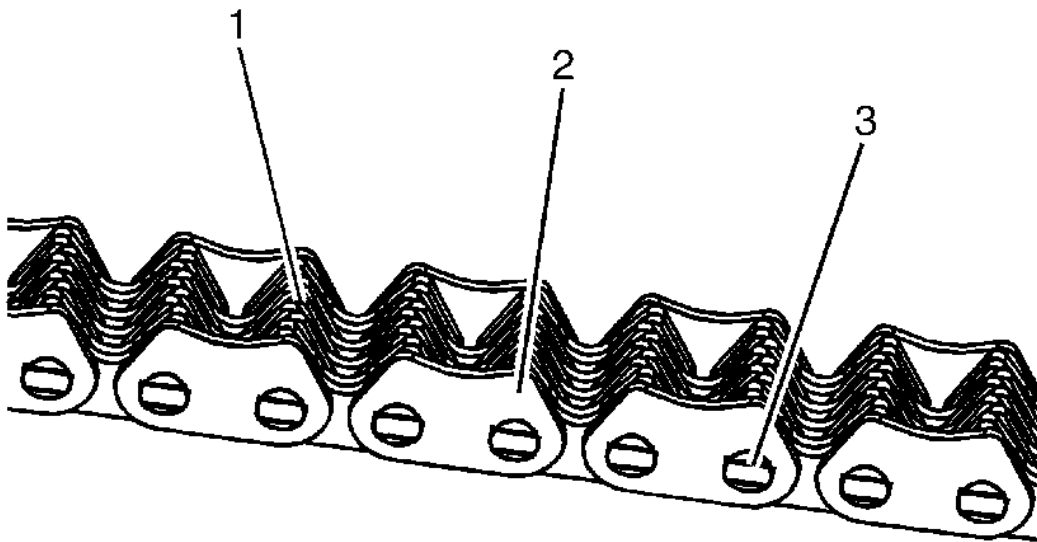
### **Crankshaft Sprocket**



**Fig. 142: Identifying Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft sprocket for the following:
  - Sprocket damage (1)
  - Bore damage (2)
  - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

### **Primary and Secondary Timing Chains**

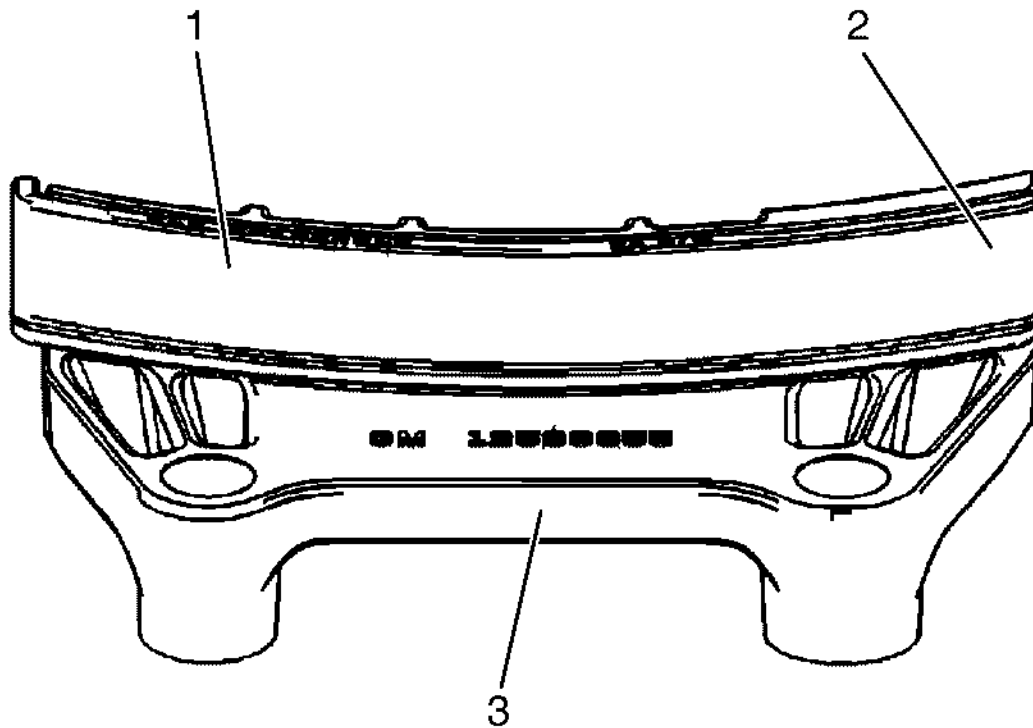


**Fig. 143: Identifying Primary & Secondary Timing Chains**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary and secondary timing chains for the following:
  - Binding or worn links (1)
  - Loose links (2)
  - Loose pins (3)
2. Replace a damaged primary timing chain.

### **Primary Timing Chain Upper Guide**

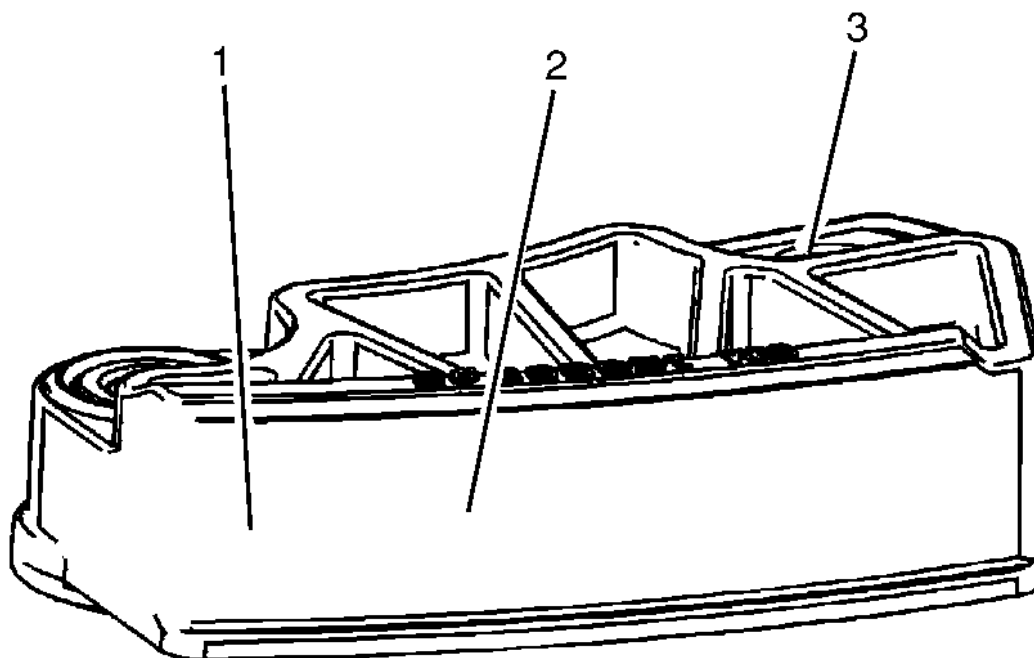




**Fig. 144: Identifying Primary Timing Chain Upper Guide**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain upper guide for the following:
  - Worn guide surface (1)
  - Cracked or broken guide surface (2)
  - Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

#### **Primary Timing Chain Lower Guide**



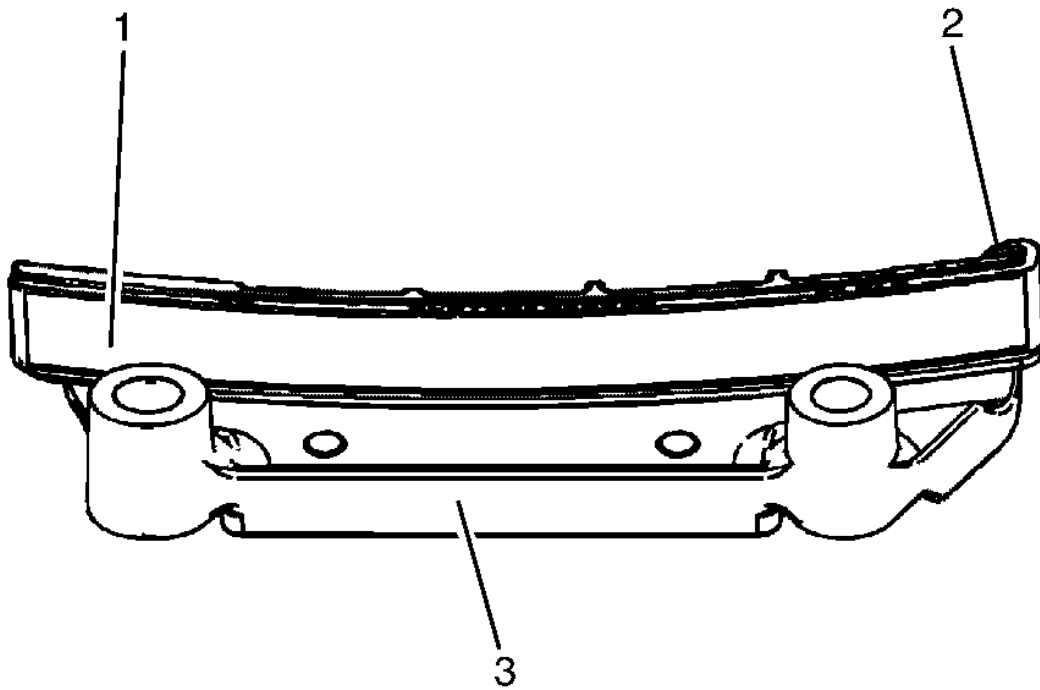
**Fig. 145: Identifying Primary Timing Chain Lower Guide**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain lower guide for the following:
  - Worn guide surface (1)
  - Cracked or broken guide surface (2)
  - Cracked or damaged guide base (3)

**NOTE:** The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

2. Replace a damaged primary timing chain lower guide by replacing the oil pump.

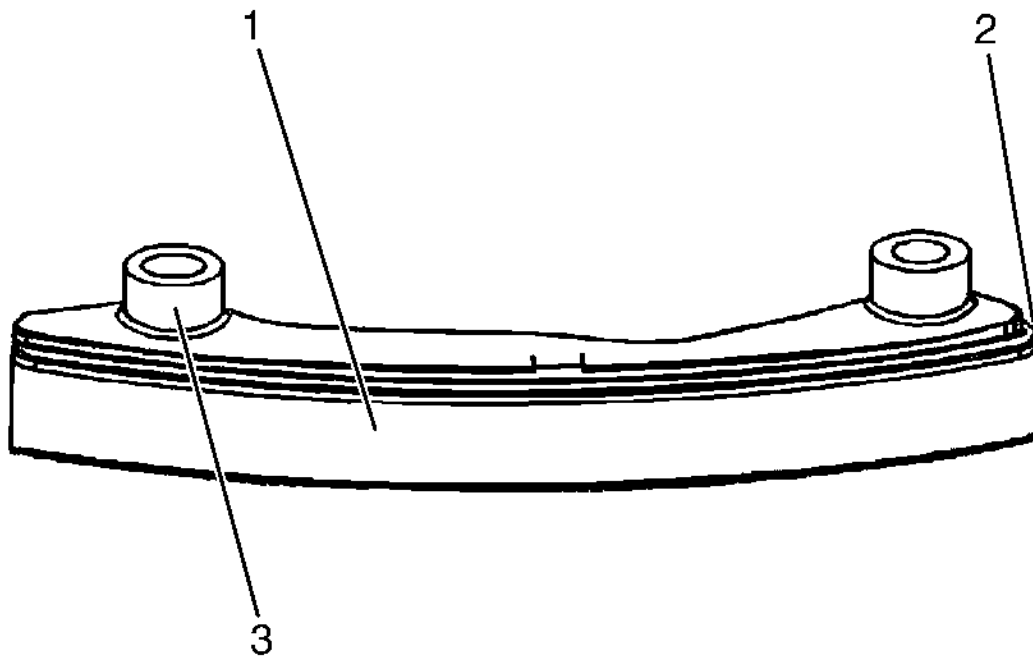
#### **Left Secondary Timing Chain Guide**



**Fig. 146: Identifying Left Secondary Timing Chain Guide**  
 Courtesy of GENERAL MOTORS CORP.

1. Inspect the left secondary timing chain guide for the following:
  - Worn guide surface (1)
  - Cracked or broken guide surface (2)
  - Cracked or damaged guide base (3)
2. Replace a damaged left secondary timing chain guide.

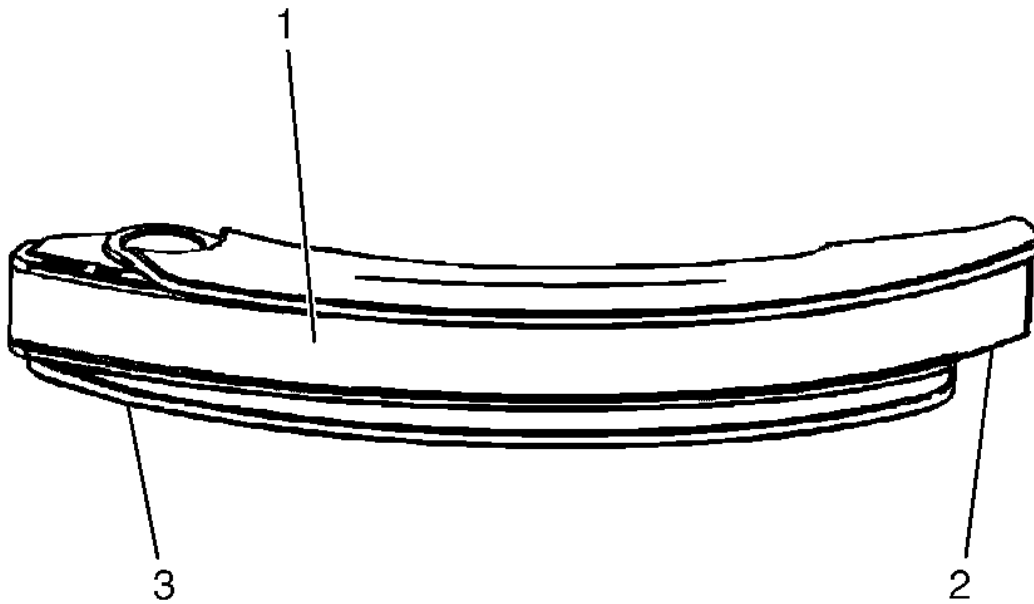
### Right Secondary Timing Chain Guide



**Fig. 147: Identifying Right Secondary Timing Chain Guide**  
Courtesy of GENERAL MOTORS CORP.

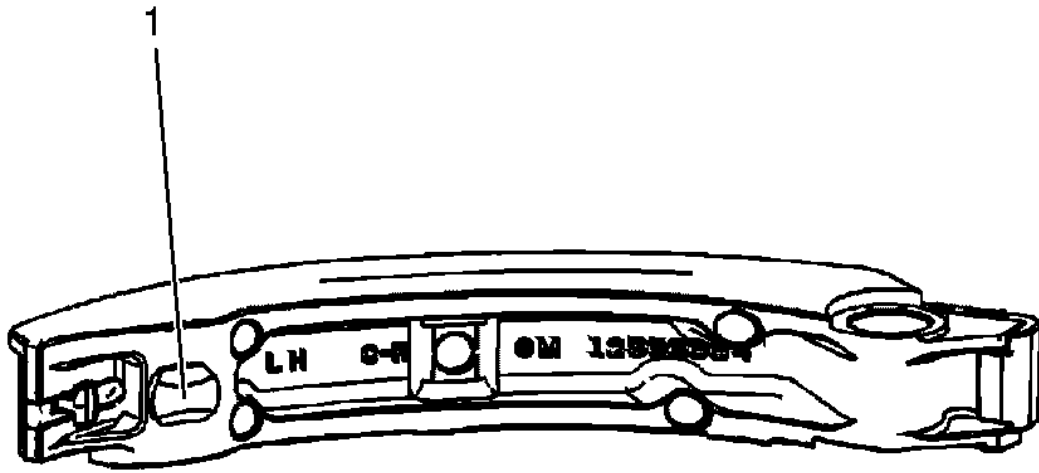
1. Inspect the right secondary timing chain guide for the following:
  - Worn guide surface (1)
  - Cracked or broken guide surface (2)
  - Cracked or damaged guide base (3)
2. Replace a damaged right secondary timing chain guide.

#### **Left Secondary Timing Chain Shoe**



**Fig. 148: Identifying Front Of Left Secondary Timing Chain Shoe**  
Courtesy of GENERAL MOTORS CORP.

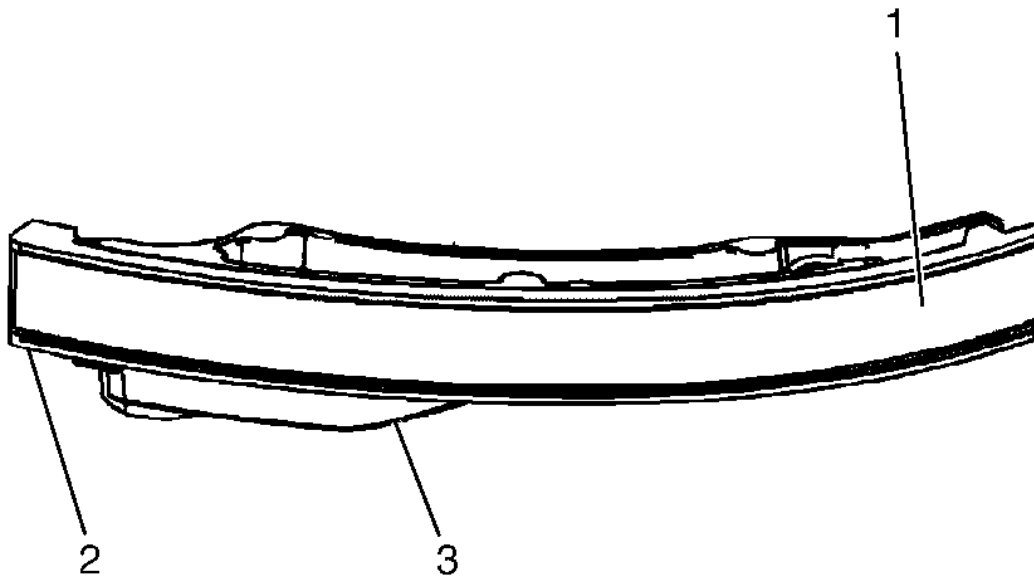
1. Inspect the front of the left secondary timing chain shoe for the following:
  - Worn shoe surface (1)
  - Cracked or broken shoe surface (2)
  - Cracked or damaged shoe (3)



**Fig. 149: Identifying Left Secondary Timing Chain Tensioner Contact Pad**  
Courtesy of GENERAL MOTORS CORP.

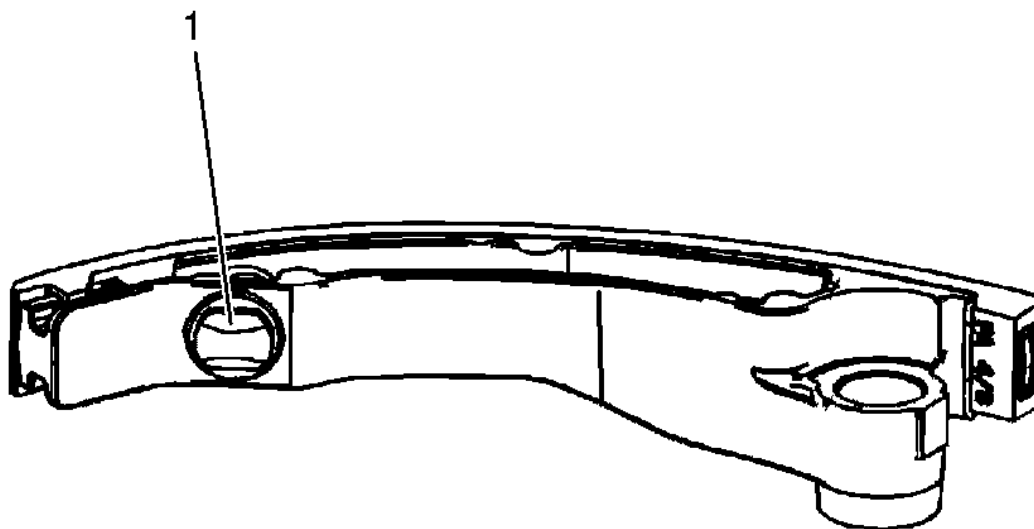
2. Inspect the back of the left secondary timing chain shoe for a damaged, worn or missing left secondary timing chain tensioner contact pad (1).
3. Replace a damaged left secondary timing chain shoe.

### **Right Secondary Timing Chain Shoe**



**Fig. 150: Identifying Front Of Right Secondary Timing Chain Shoe**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the right secondary timing chain shoe for the following:
  - Worn shoe surface (1)
  - Cracked or broken shoe surface (2)
  - Cracked or damaged shoe (3)

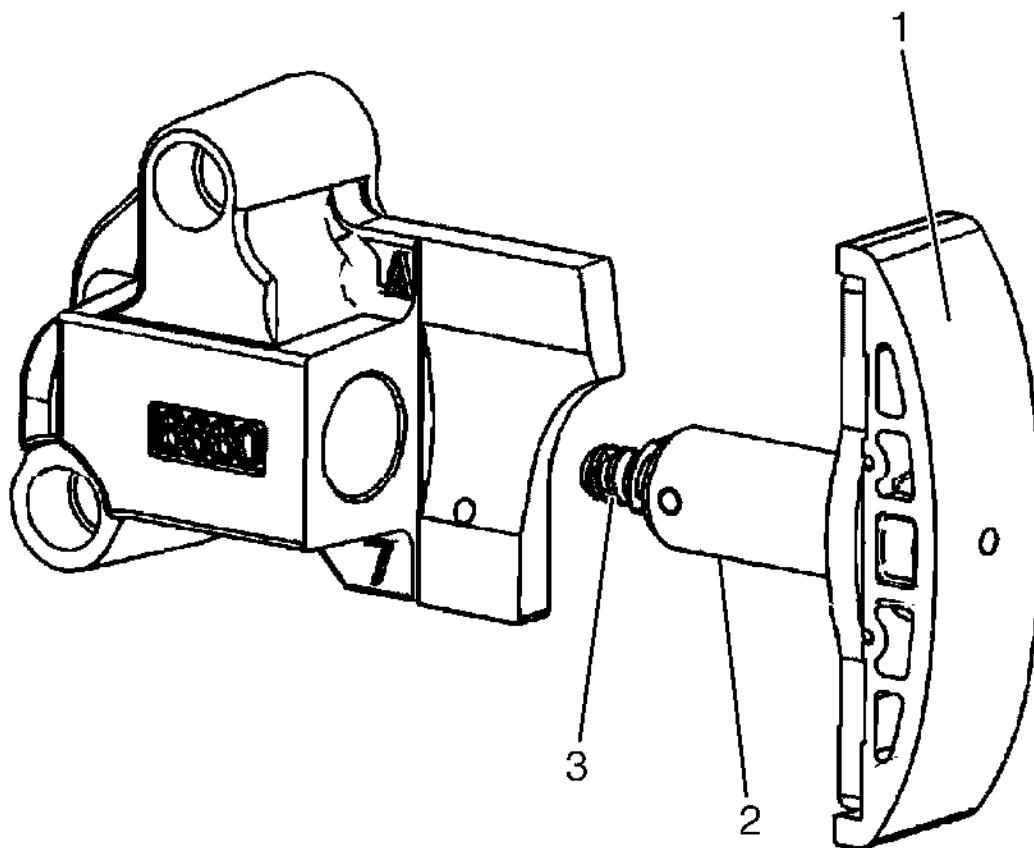


**Fig. 151: Identifying Right Secondary Timing Chain Tensioner Contact Pad**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the right secondary timing chain shoe for a damaged, worn or missing right secondary timing chain tensioner contact pad (1).
3. Replace a damaged right secondary timing chain shoe.

### **Primary Timing Chain Tensioner**

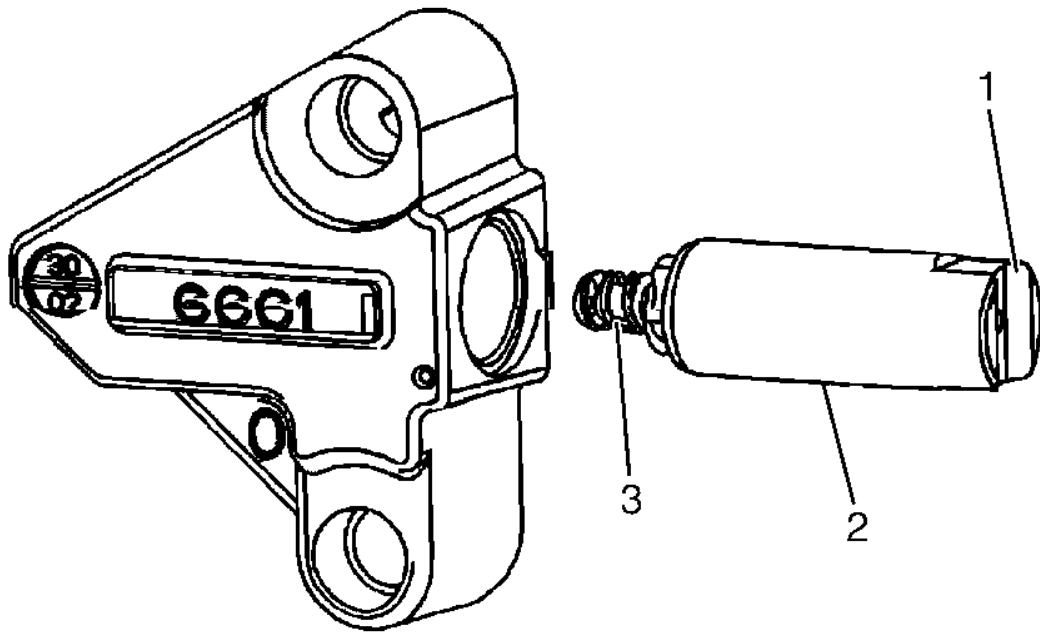




**Fig. 152: Identifying Primary Timing Chain Tensioner Shoe Surface**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Removal**.
3. Replace a damaged primary timing chain tensioner.

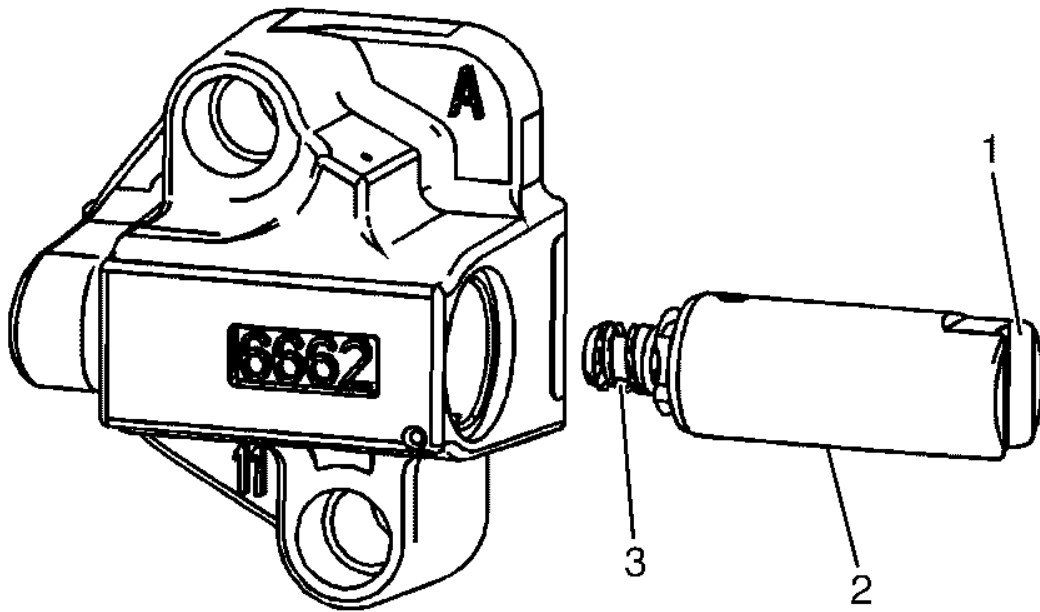
#### **Left Secondary Timing Chain Tensioner**



**Fig. 153: Identifying Left Secondary Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Left Side**.
3. Replace a damaged left secondary timing chain tensioner.

#### **Right Secondary Timing Chain Tensioner**

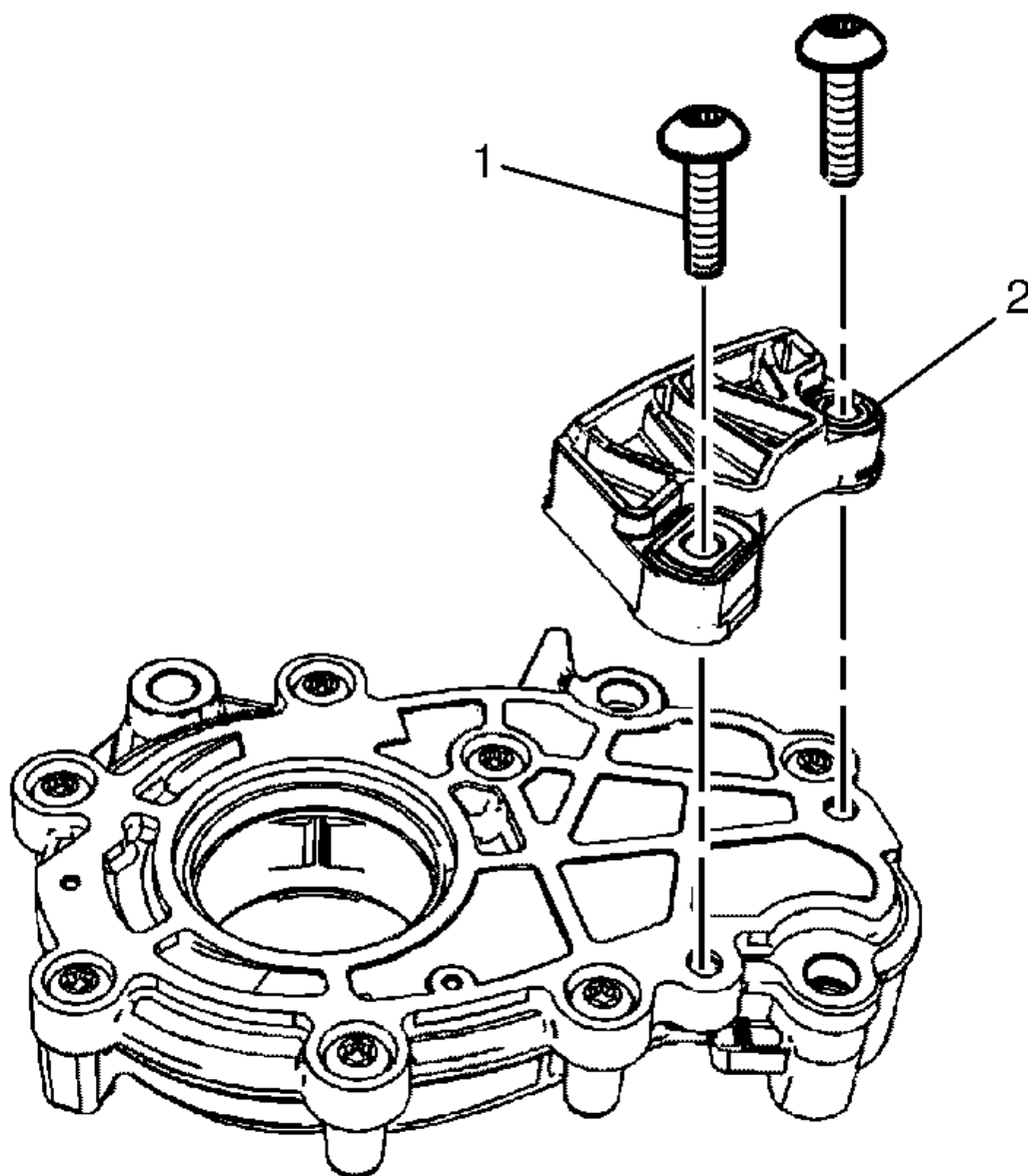


**Fig. 154: Identifying Right Secondary Timing Chain Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the right secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Right Side**.
3. Replace a damaged right secondary timing chain tensioner.

## OIL PUMP DISASSEMBLE

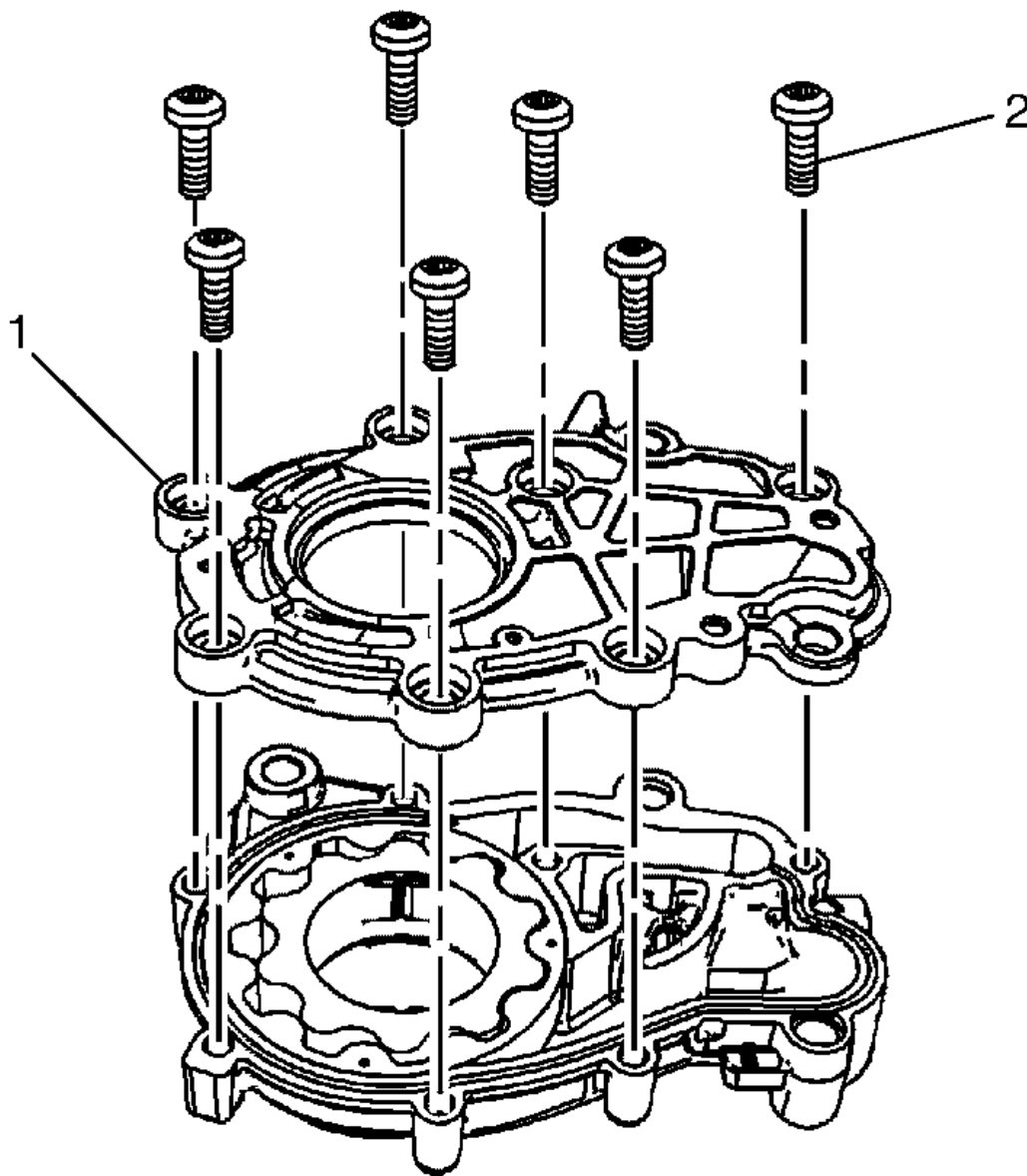
**IMPORTANT:** There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.



**Fig. 155: Identifying Primary Camshaft Drive Chain Lower Guide To Oil Pump Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

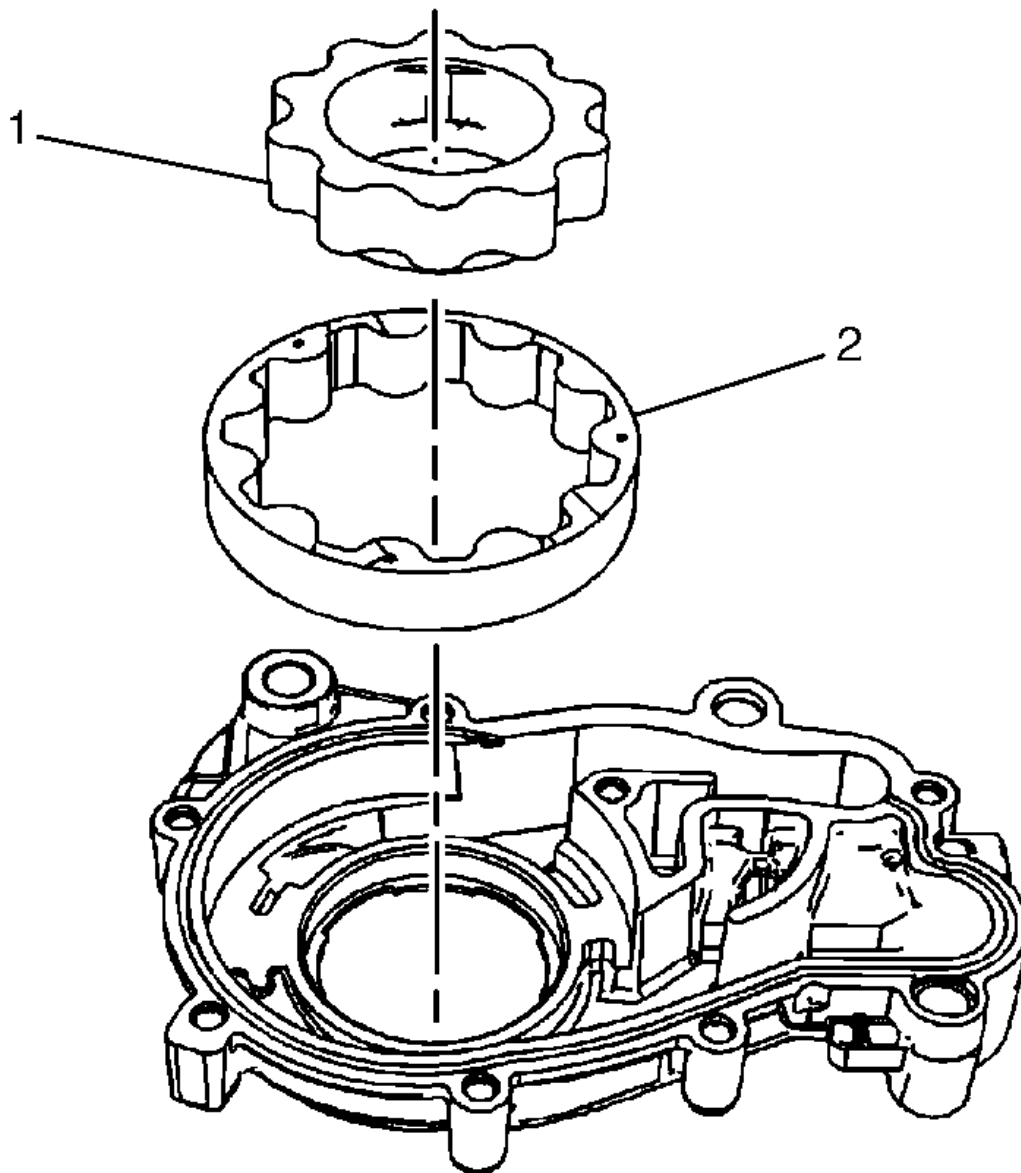
**IMPORTANT:** The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

1. Remove the primary camshaft drive chain lower guide to oil pump retaining bolts (1).
2. Remove the primary camshaft drive chain lower guide (2).



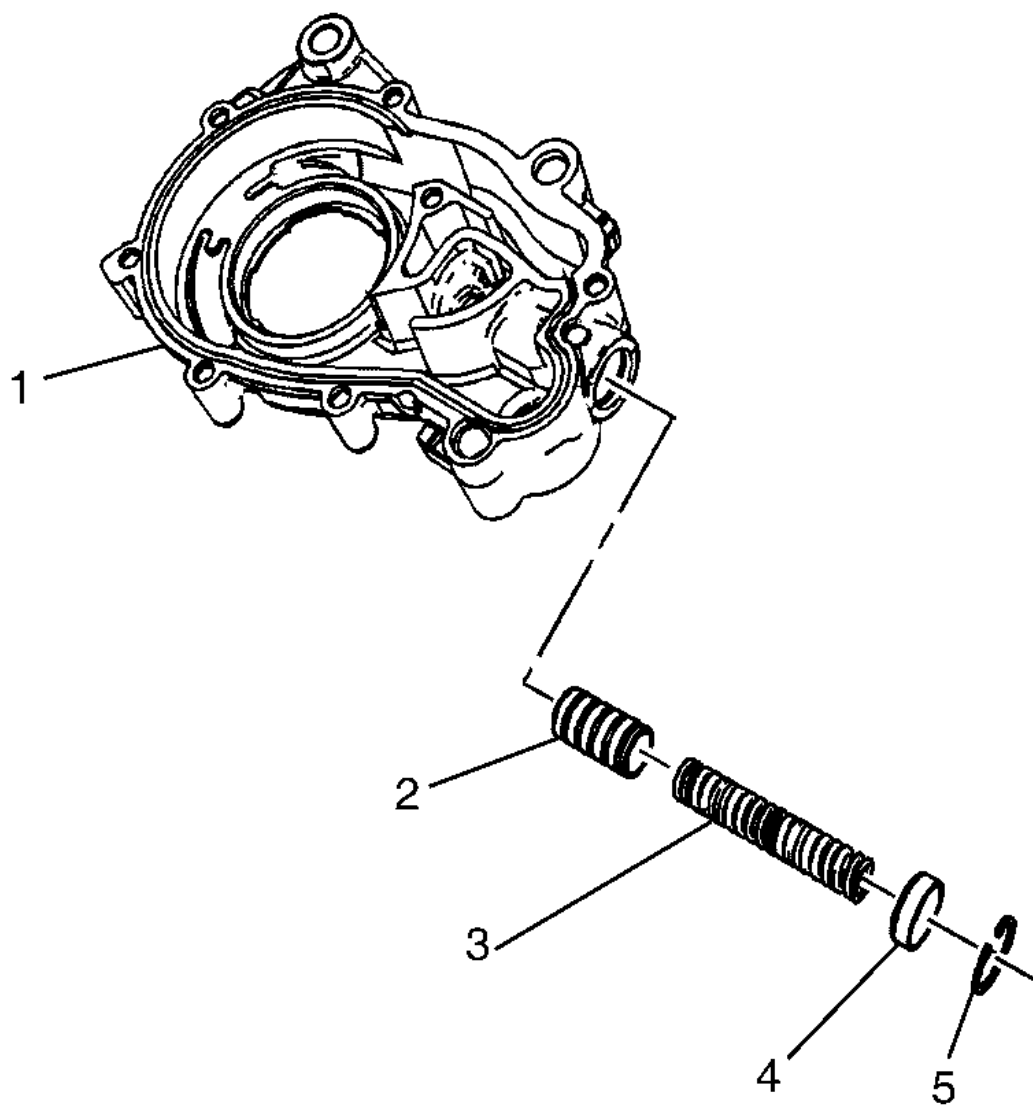
**Fig. 156: Identifying Oil Pump Cover To Oil Pump Housing Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover to the oil pump housing retaining bolts (2).
4. Remove the oil pump cover (1).



**Fig. 157: Identifying Inner & Outer Oil Pump Drive Gear**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the inner oil pump drive gear (1).
6. Remove the outer oil pump driven gear (2).



**Fig. 158: View Of Clip, Cap, Spring, Plunger & Oil Pump Housing**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the clip (5), holding the cap (4), for the oil relief valve components.
8. Remove the cap (4), spring (3) and plunger (2) from the oil pump housing (1).

## OIL PUMP CLEANING AND INSPECTION

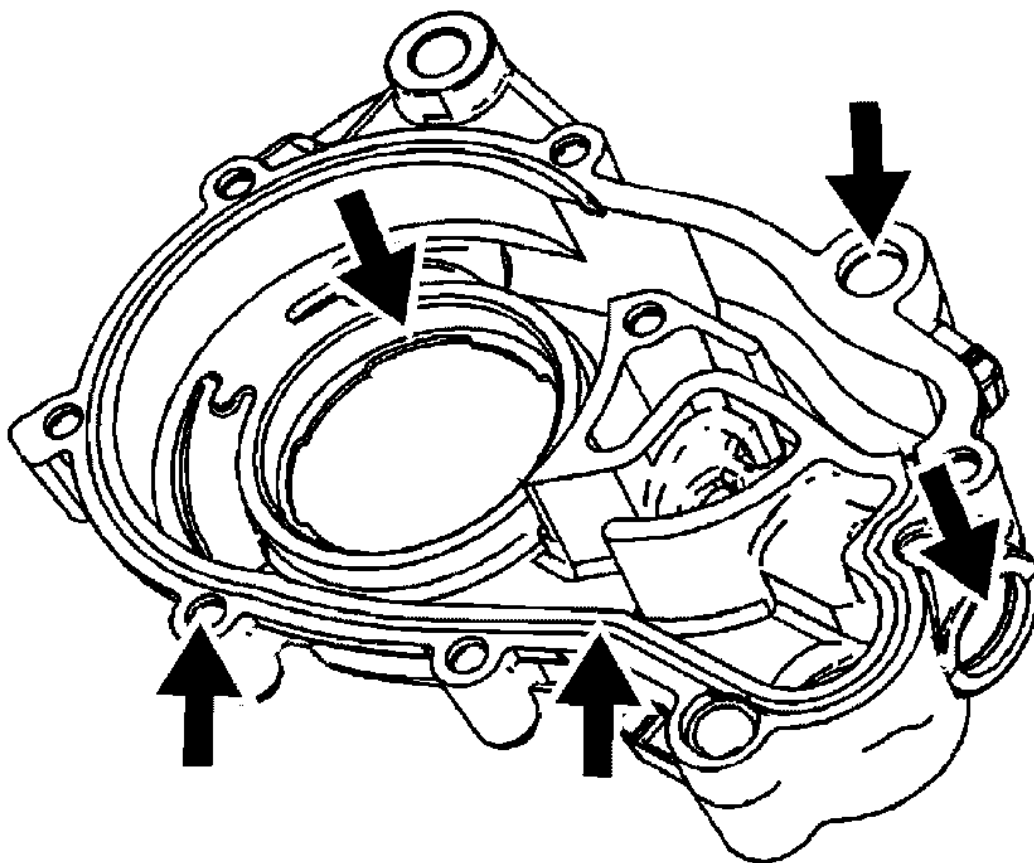
### Cleaning Procedure

1. Clean the oil pump components with non-corrosive solvent.

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

2. Dry the oil pump components with compressed air.

**Inspection Procedure**



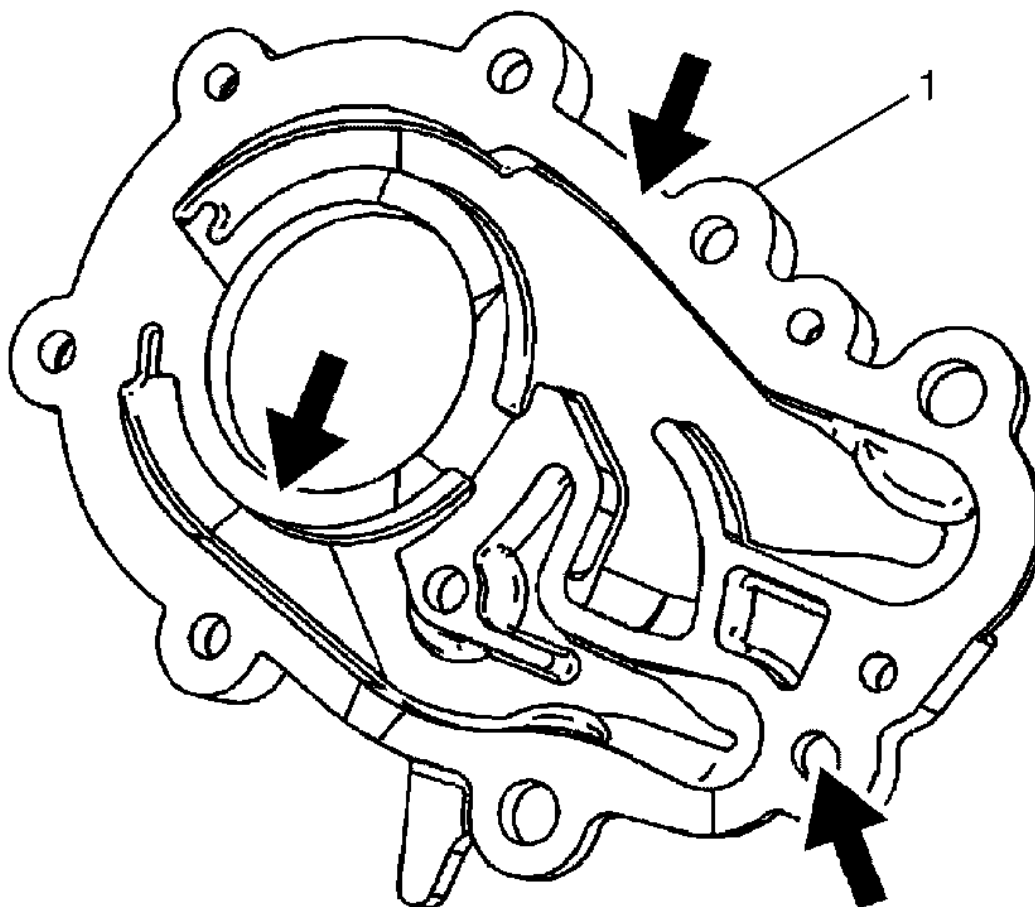
**Fig. 159: Identifying Oil Pump**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

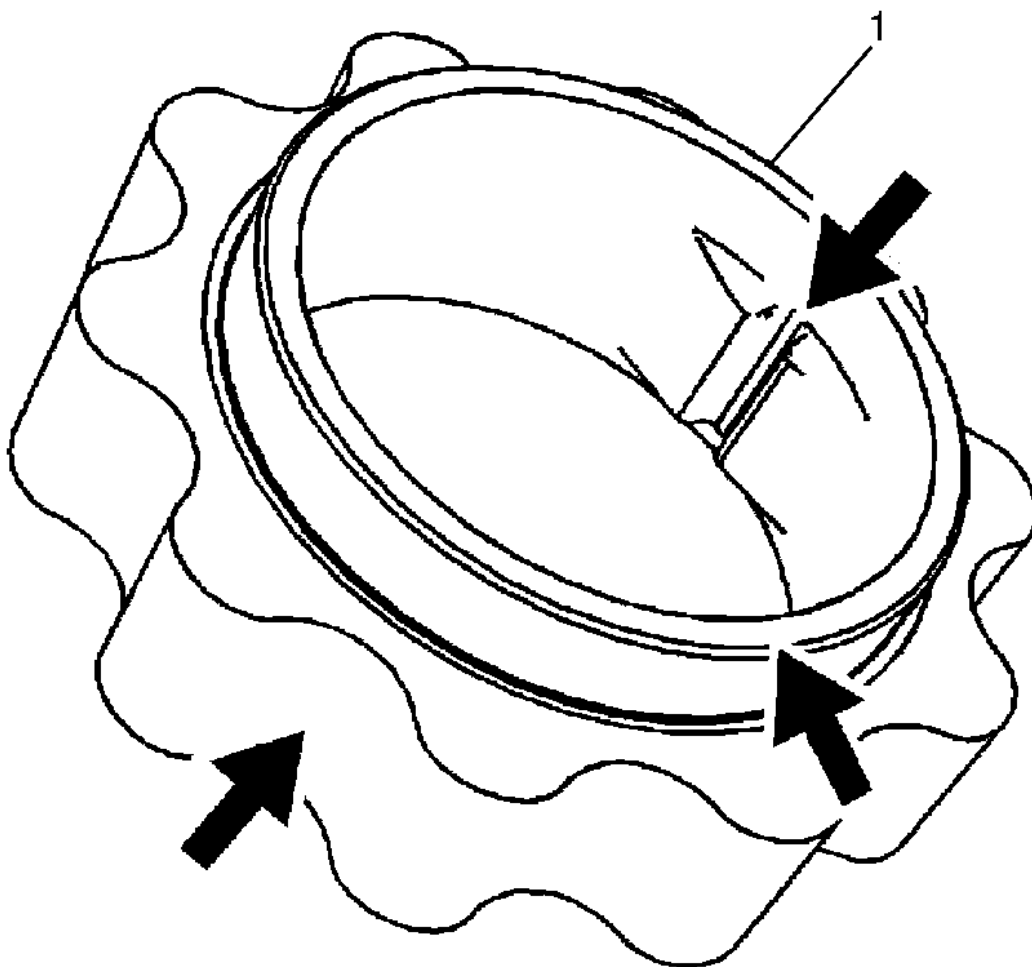
1. Inspect the oil pump housing for damage.





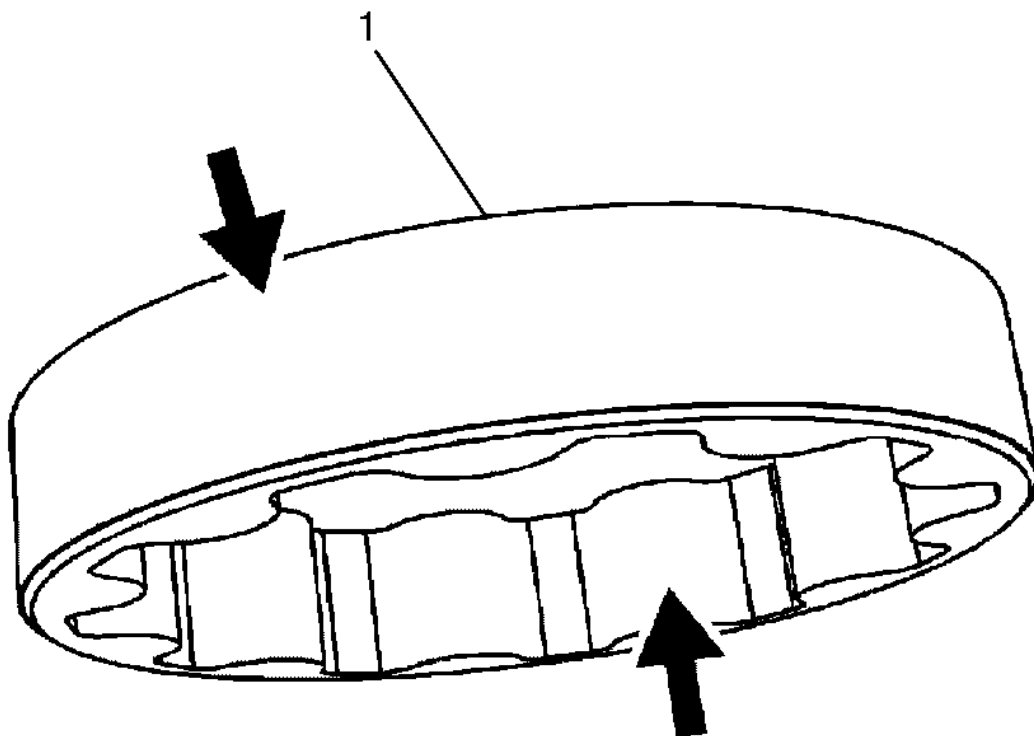
**Fig. 160: Identifying Oil Pump Cover**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil pump cover (1) for damage.



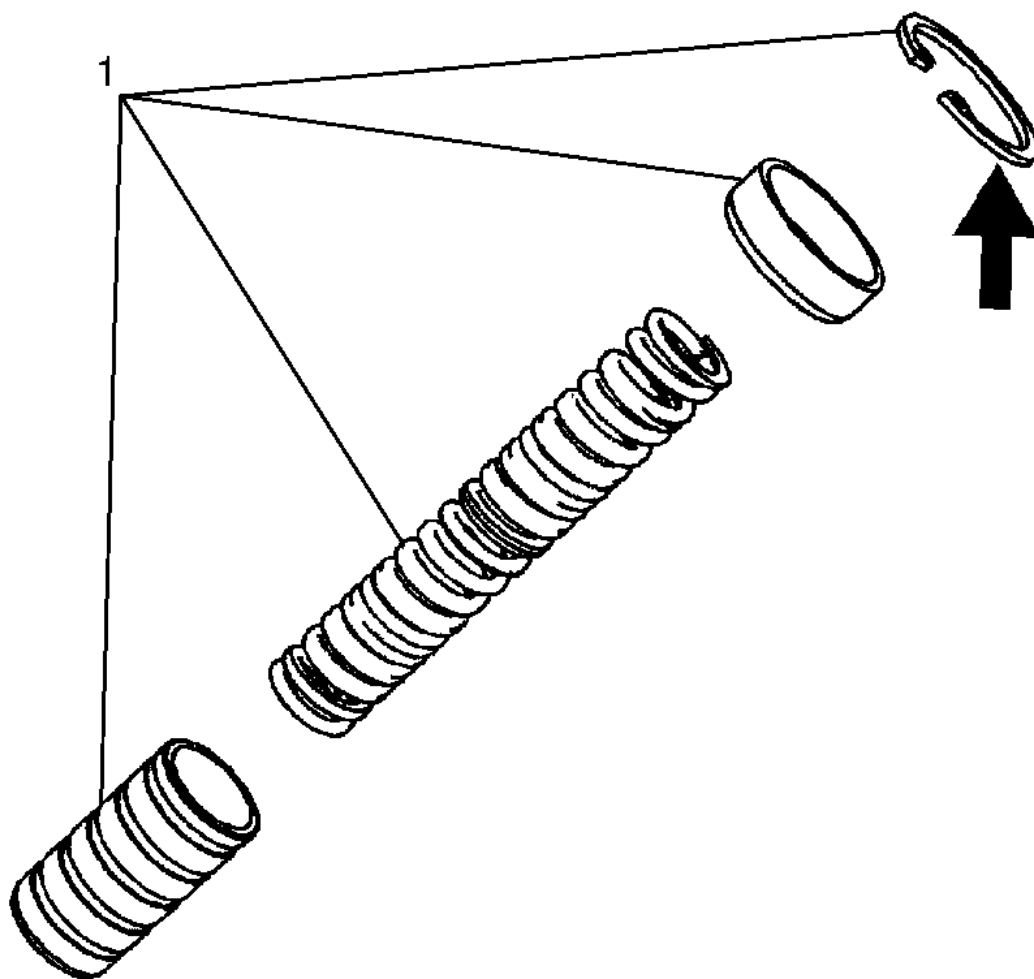
**Fig. 161: Identifying Inner Drive Gear**  
**Courtesy of GENERAL MOTORS CORP.**

3. Inspect the inner drive gear (1) for damage. If inner diameter damage is found, ensure the crankshaft is also inspected.



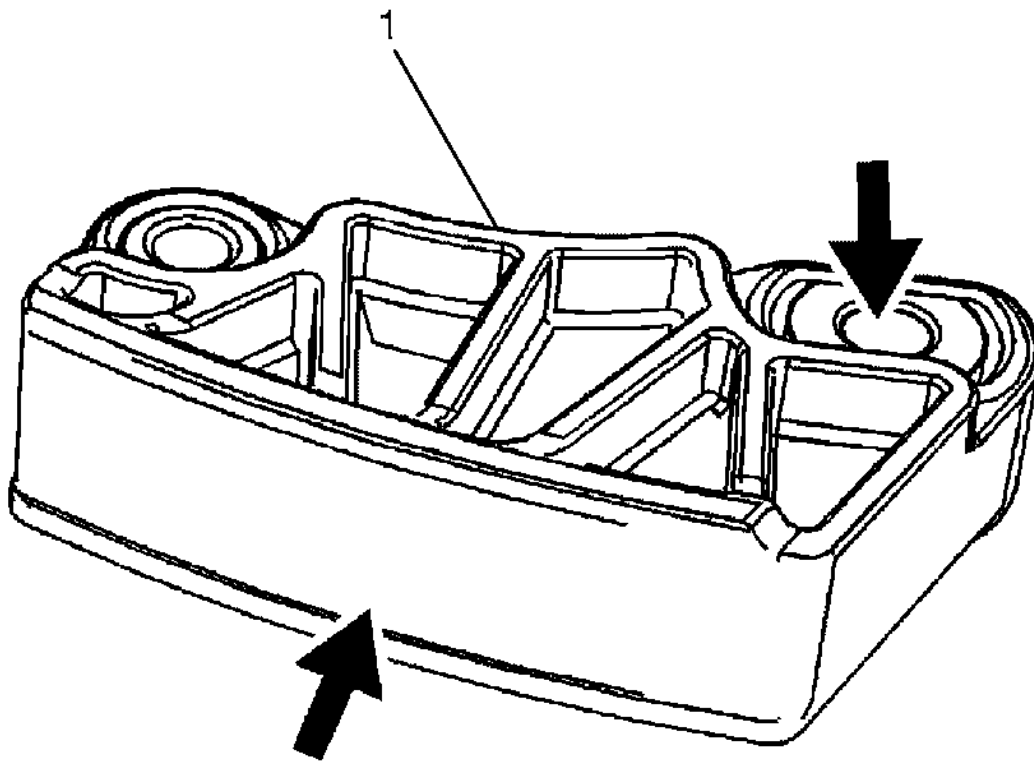
**Fig. 162: Identifying Outer Driven Gear**  
**Courtesy of GENERAL MOTORS CORP.**

4. Inspect the outer driven gear (1) for damage.



**Fig. 163: Identifying Oil Pump Relief Valve Components**  
Courtesy of GENERAL MOTORS CORP.

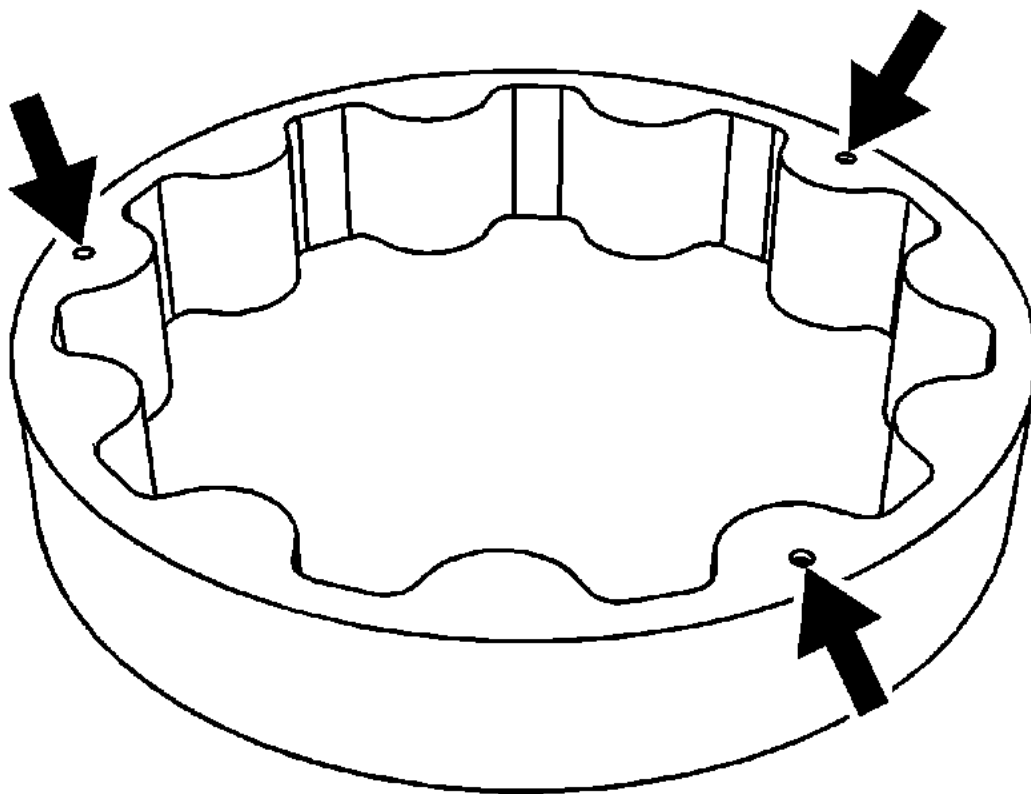
5. Inspect the oil pump relief valve components (1) for debris or damage.



**Fig. 164: Identifying Primary Camshaft Drive Chain Lower Guide**  
Courtesy of GENERAL MOTORS CORP.

6. Inspect the primary camshaft drive chain lower guide (1) for damage. If replacement of the primary camshaft drive chain lower guide (1) is necessary, replace the entire oil pump assembly. The primary camshaft drive chain lower guide (1) is not serviceable separately.
7. If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

#### **OIL PUMP ASSEMBLY**



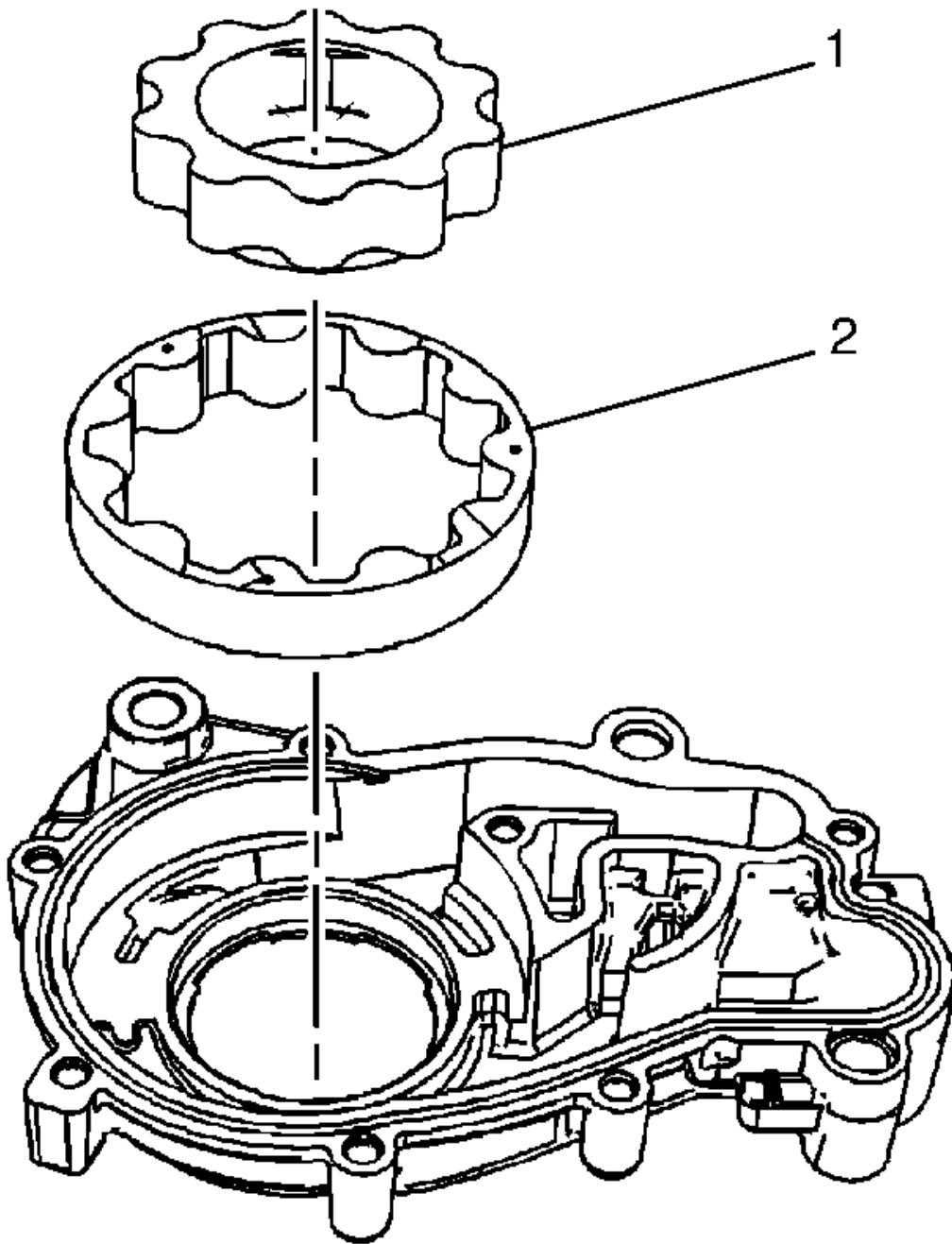
**Fig. 165: Identifying Oil Pump**

Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must be replaced. DO NOT reuse a disassembled oil pump or a serviceable oil pump with a primary camshaft drive chain lower guide that needs to be replaced.
- The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

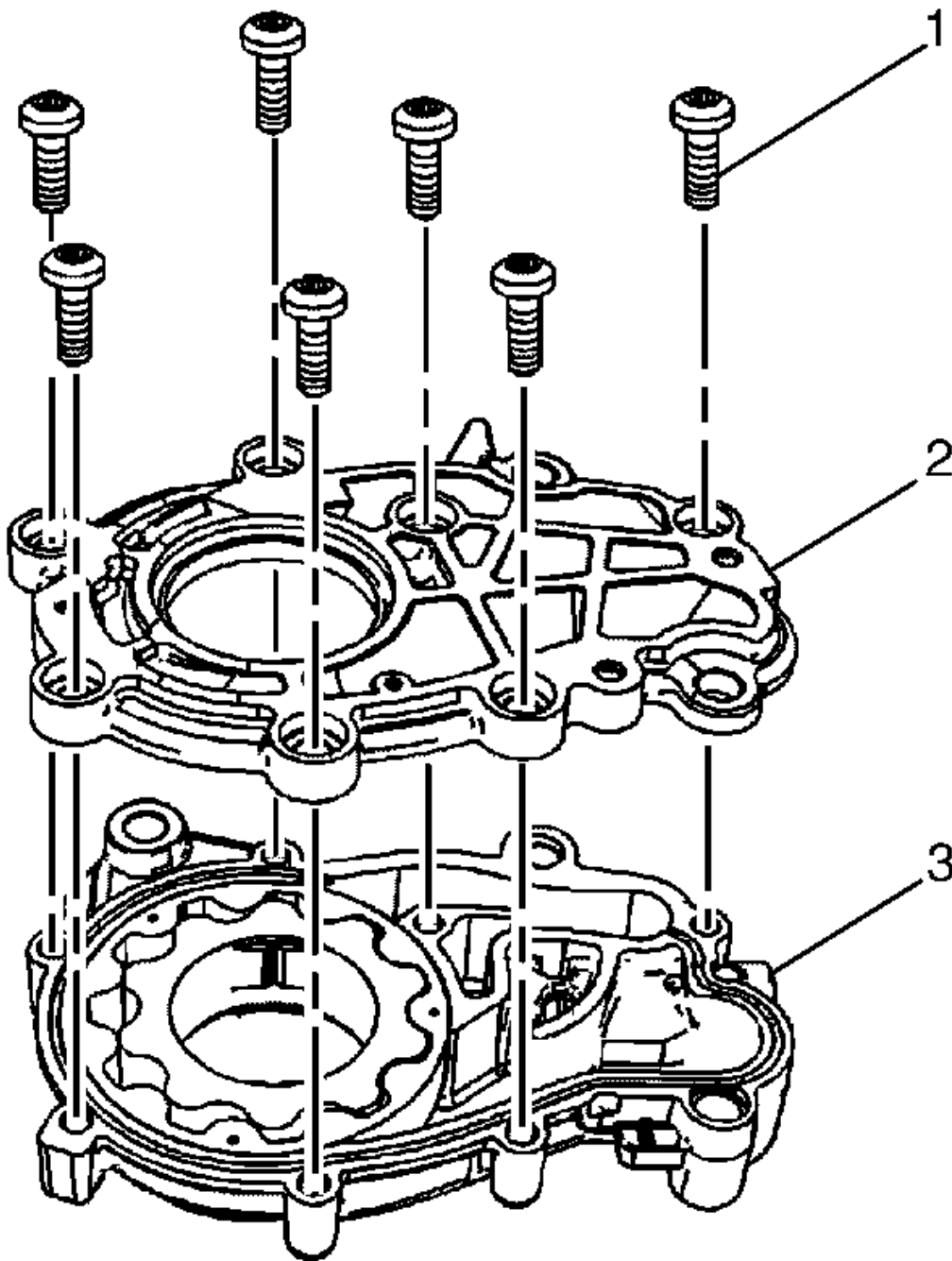
1. The dimpled surface must be face-up in the pump body.



**Fig. 166: Identifying Inner & Outer Oil Pump Drive Gear**  
Courtesy of GENERAL MOTORS CORP.

2. Install the inner oil pump drive gear (1) and the outer oil pump driven gear (2) in the pump cover in the

same orientation as removed.



**Fig. 167: Identifying Oil Pump Cover & Housing**

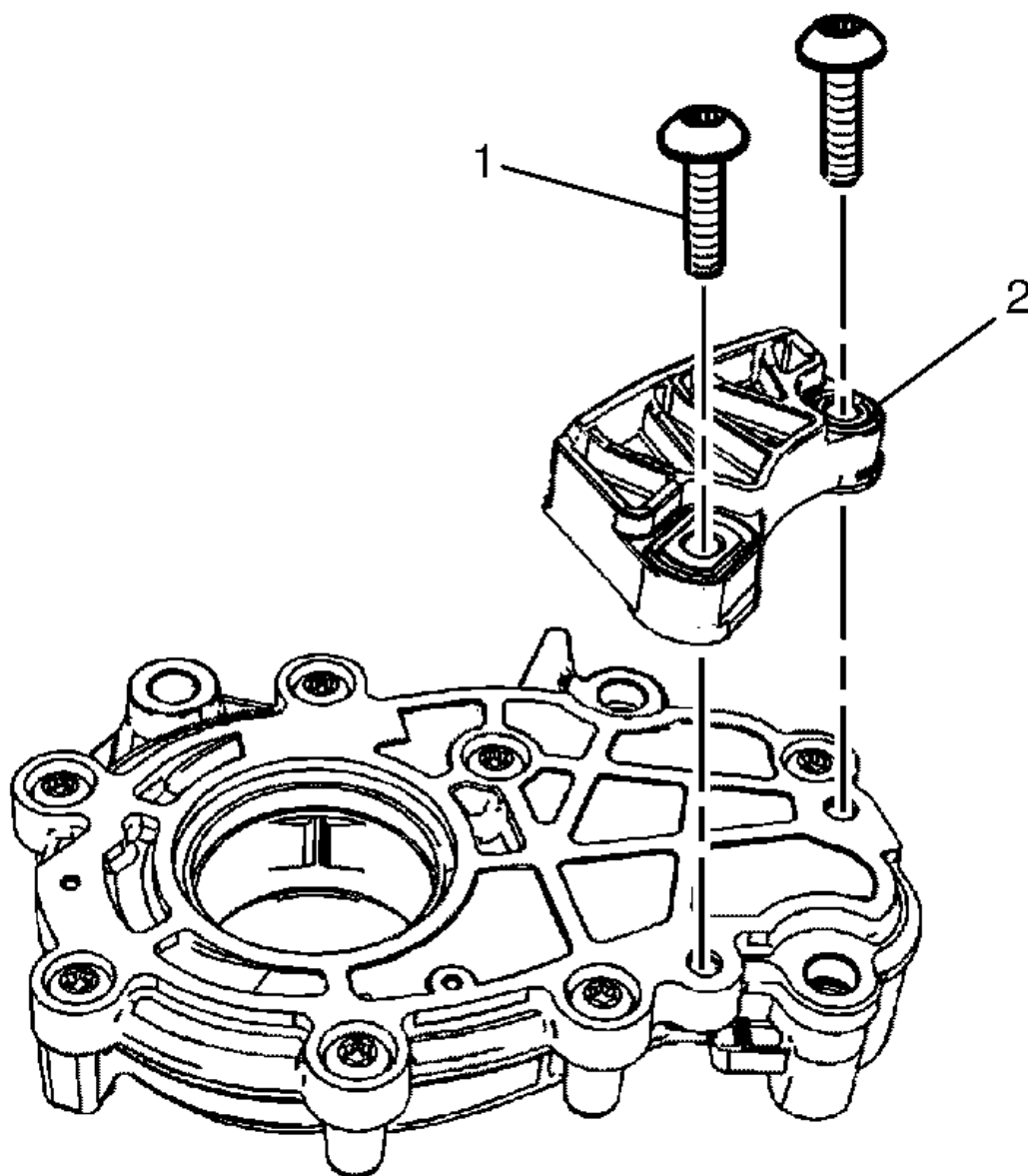


**Courtesy of GENERAL MOTORS CORP.**

3. Install the oil pump cover (2) to the oil pump housing (3).

**CAUTION: Refer to Fastener Caution .**

4. Install the oil pump cover to oil pump housing retaining bolts (1) and tighten to 10 N.m (89 lb in).

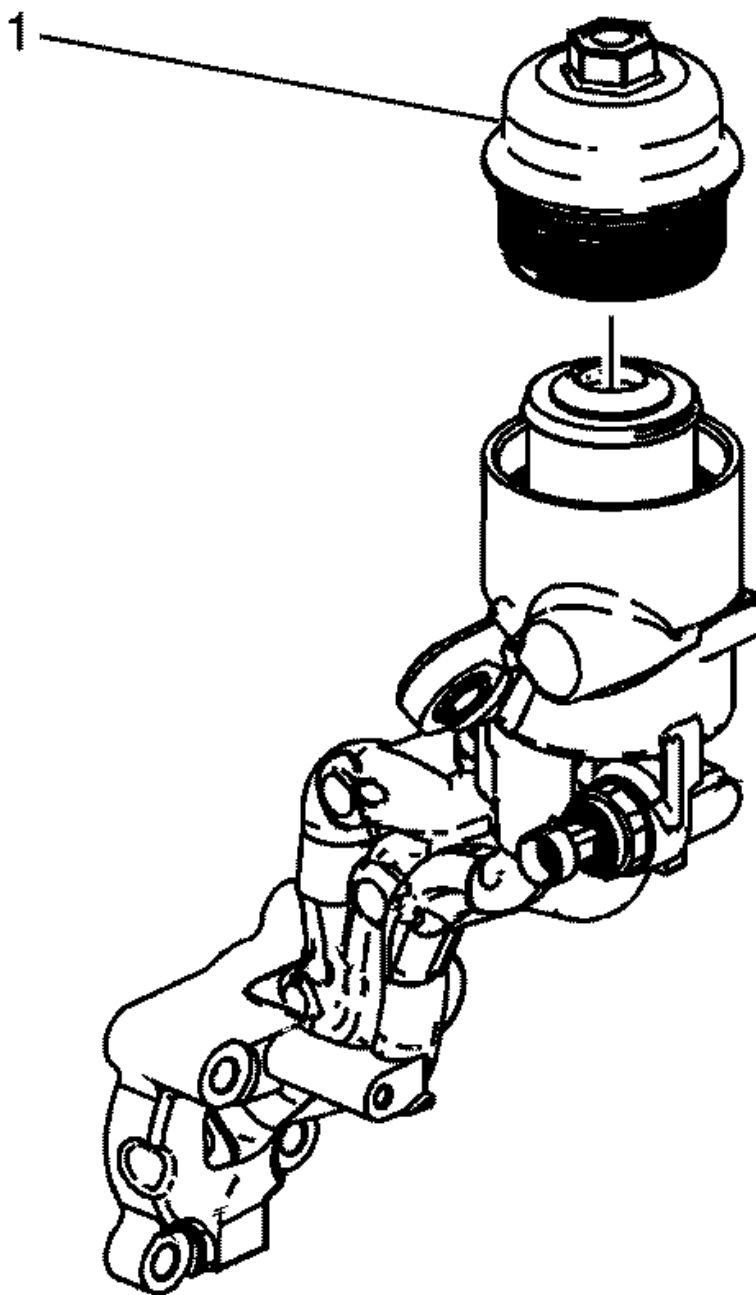


**Fig. 168: Identifying Primary Camshaft Drive Chain Lower Guide To Oil Pump Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

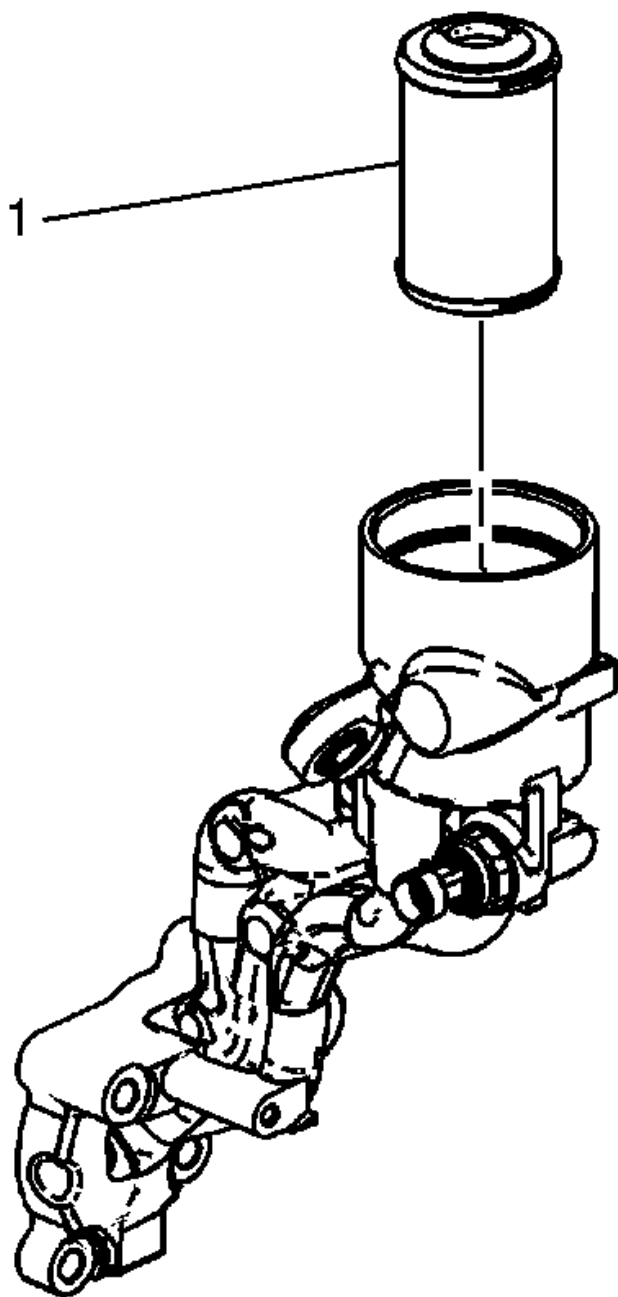
5. Install the primary camshaft drive chain lower guide (2).
6. Install the primary camshaft drive chain lower guide to oil pump retaining bolts (1) and tighten to 13 N.m (115 lb in).

**OIL FILTER ADAPTER DISASSEMBLE**



**Fig. 169: Identifying Oil Filter Cap**  
Courtesy of GENERAL MOTORS CORP.

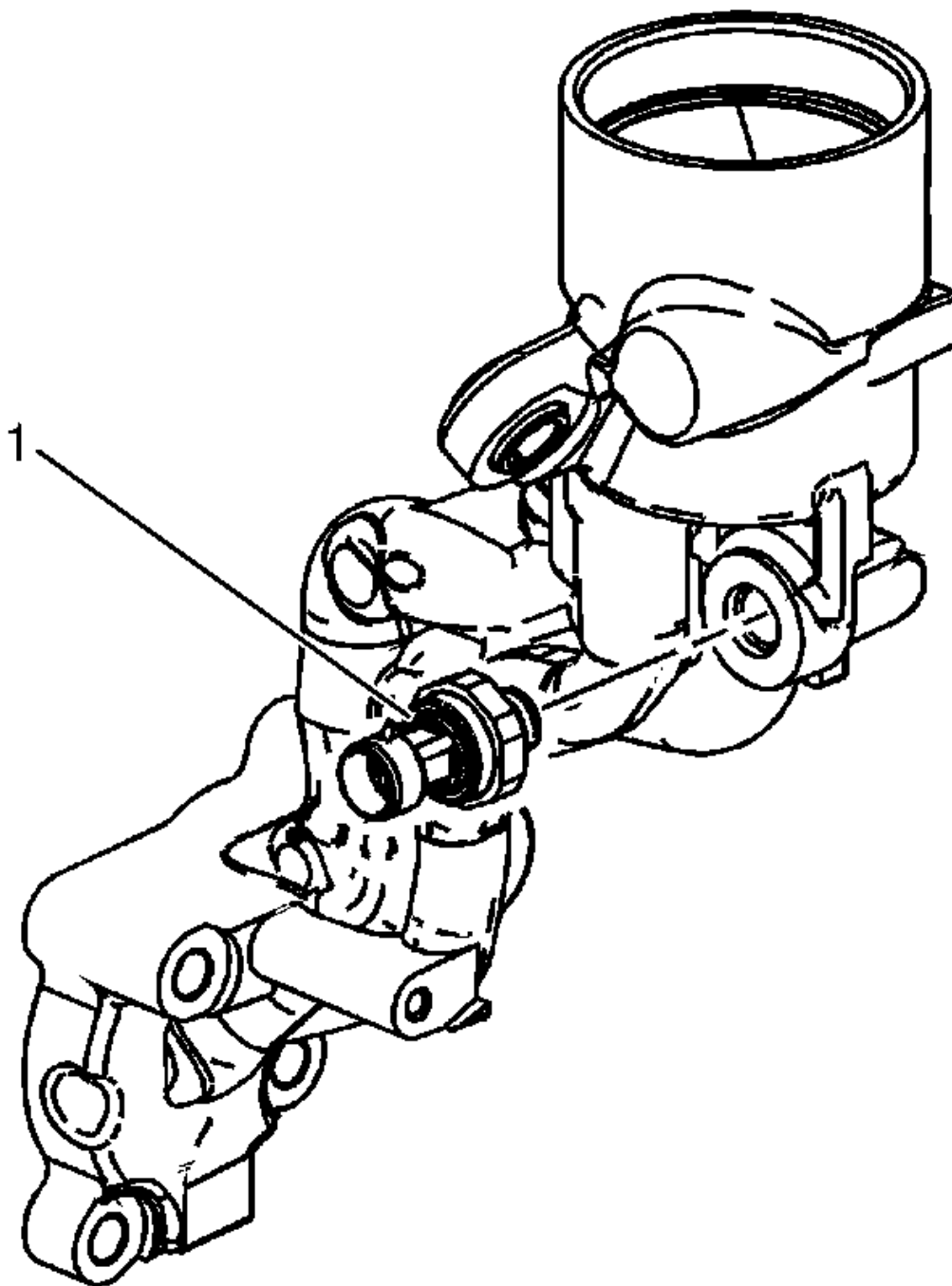
1. Remove the oil filter cap (1).



**Fig. 170: Identifying Oil Filter Cartridge**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter cartridge (1).

Discard the oil filter cartridge (1).



**Fig. 171: Identifying Oil Pressure Sender**

**Courtesy of GENERAL MOTORS CORP.**

3. Remove the oil pressure sender (1).

## **OIL FILTER ADAPTER CLEANING AND INSPECTION**

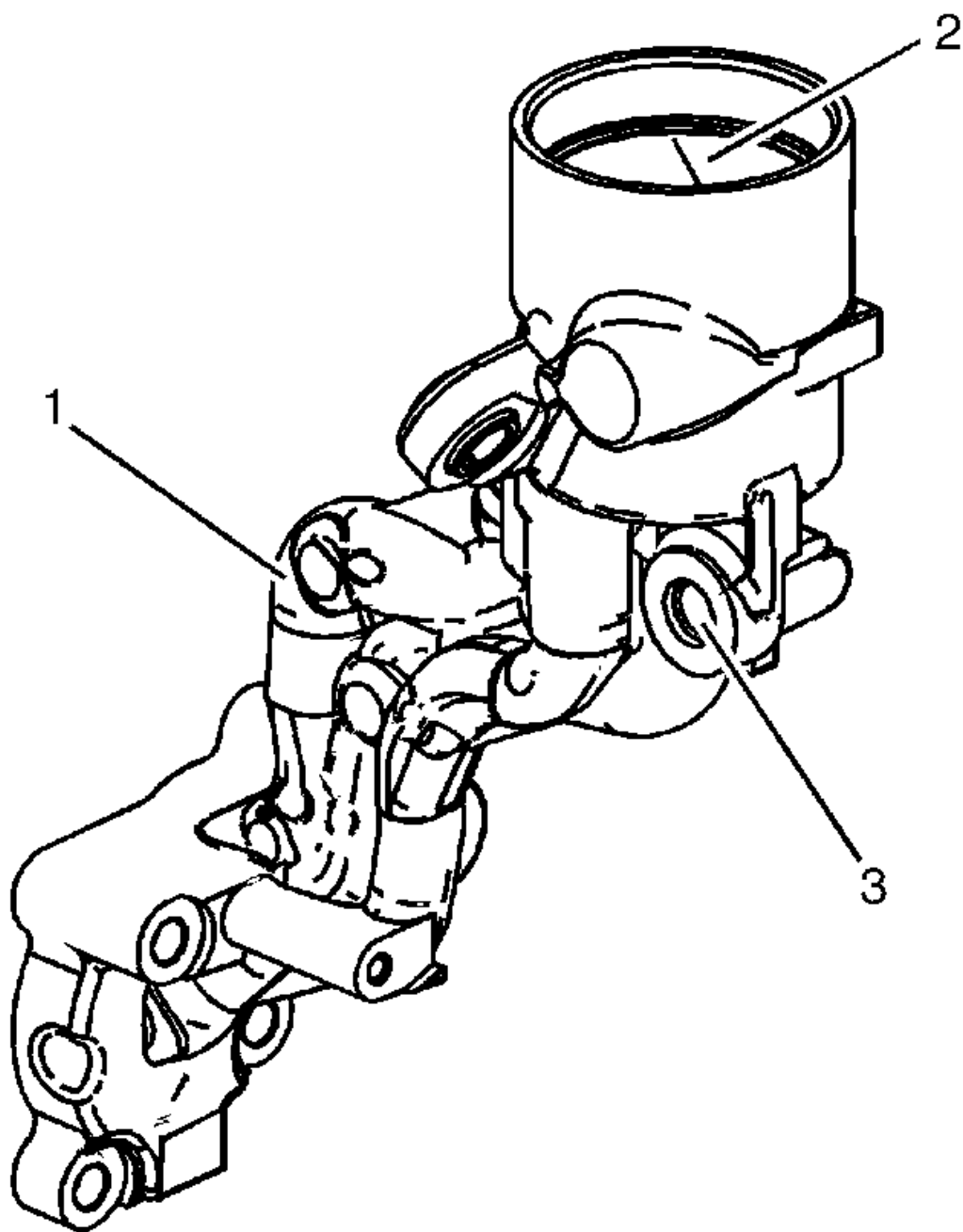
### **Cleaning Procedure**

1. Clean the oil filter adapter components with non-corrosive solvent.

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

2. Dry the oil filter adapter components with compressed air.

### **Inspection Procedure**



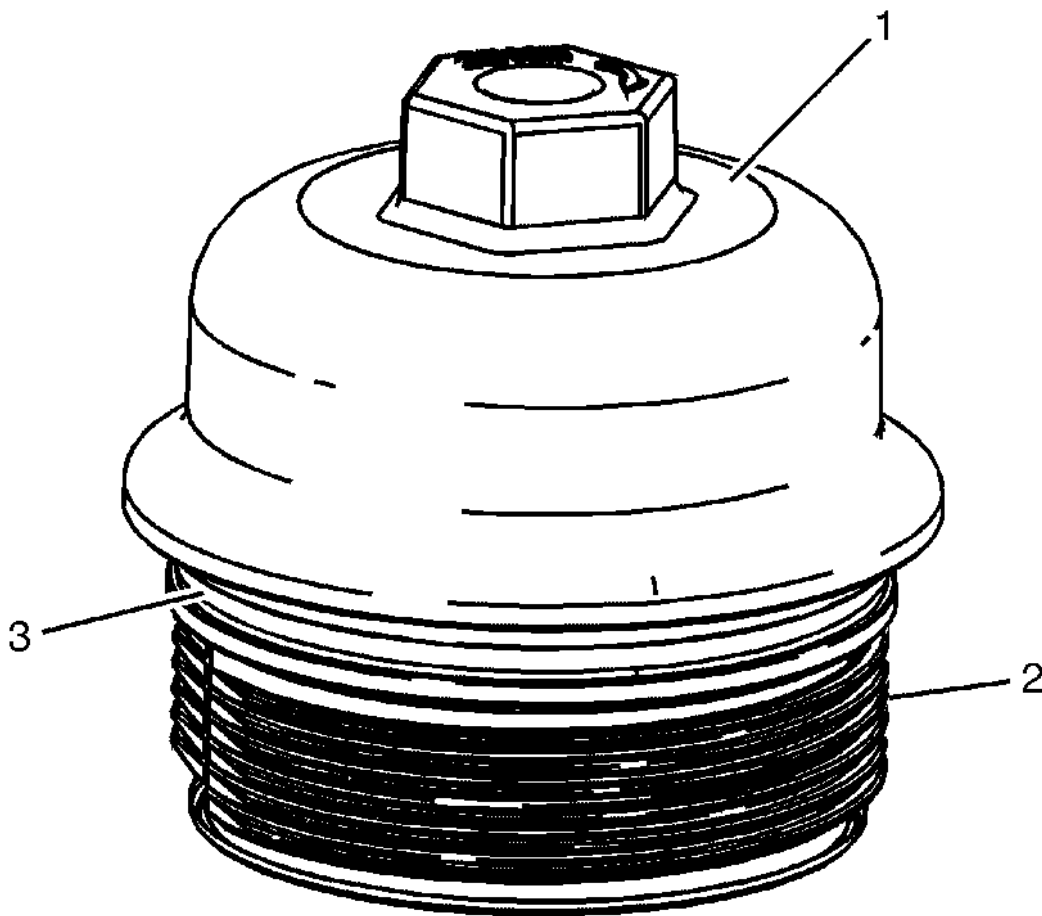
**Fig. 172: Identifying Drain Back Valve**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The internal parts of the oil filter adapter are not serviced separately. If



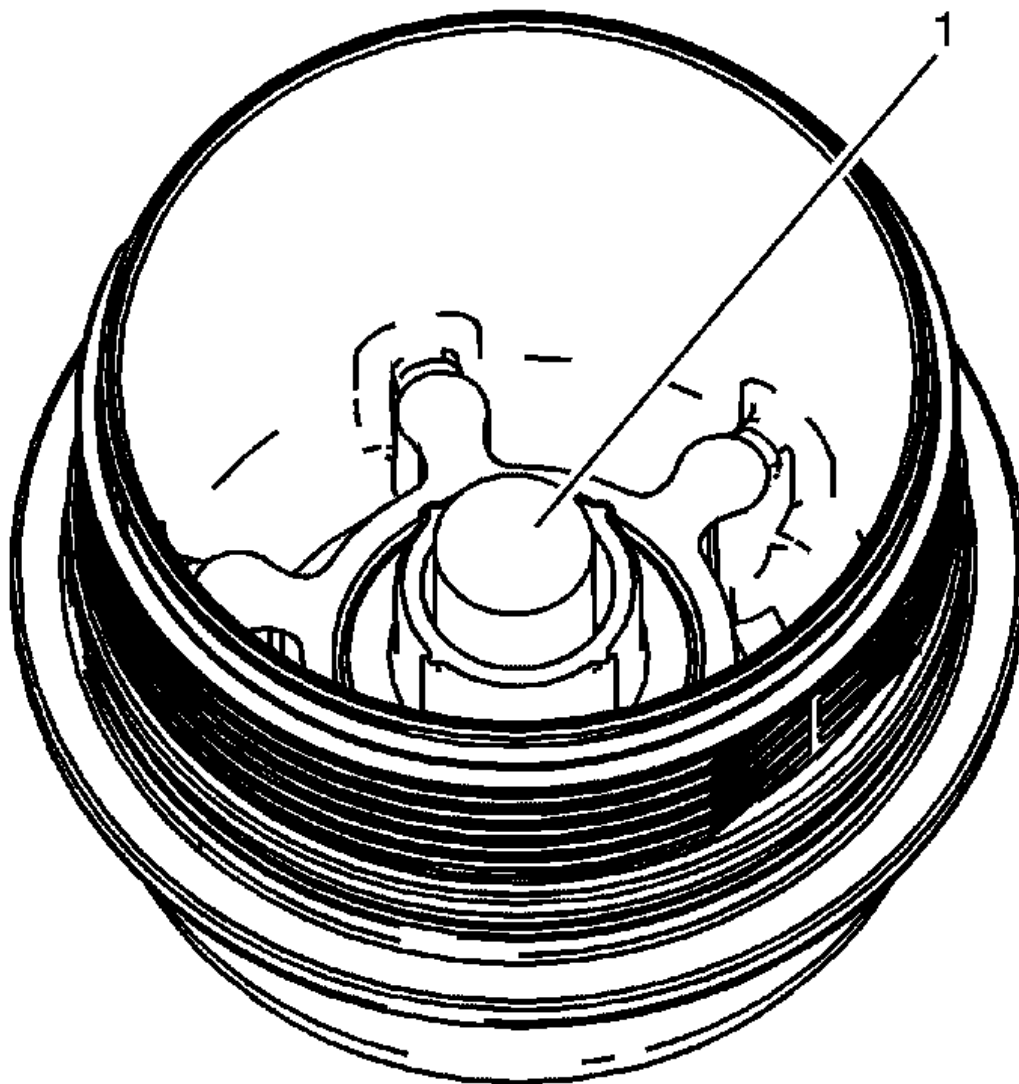
**wear or damage is noted, replace the entire oil filter adapter assembly.**

1. Inspect the oil filter housing for cracks, scoring, casting imperfections (1) and damaged threads (3).
2. Inspect the drain back valve (2) for damage or blockage.



**Fig. 173: Identifying Oil Filter Cap O-Ring**  
Courtesy of GENERAL MOTORS CORP.

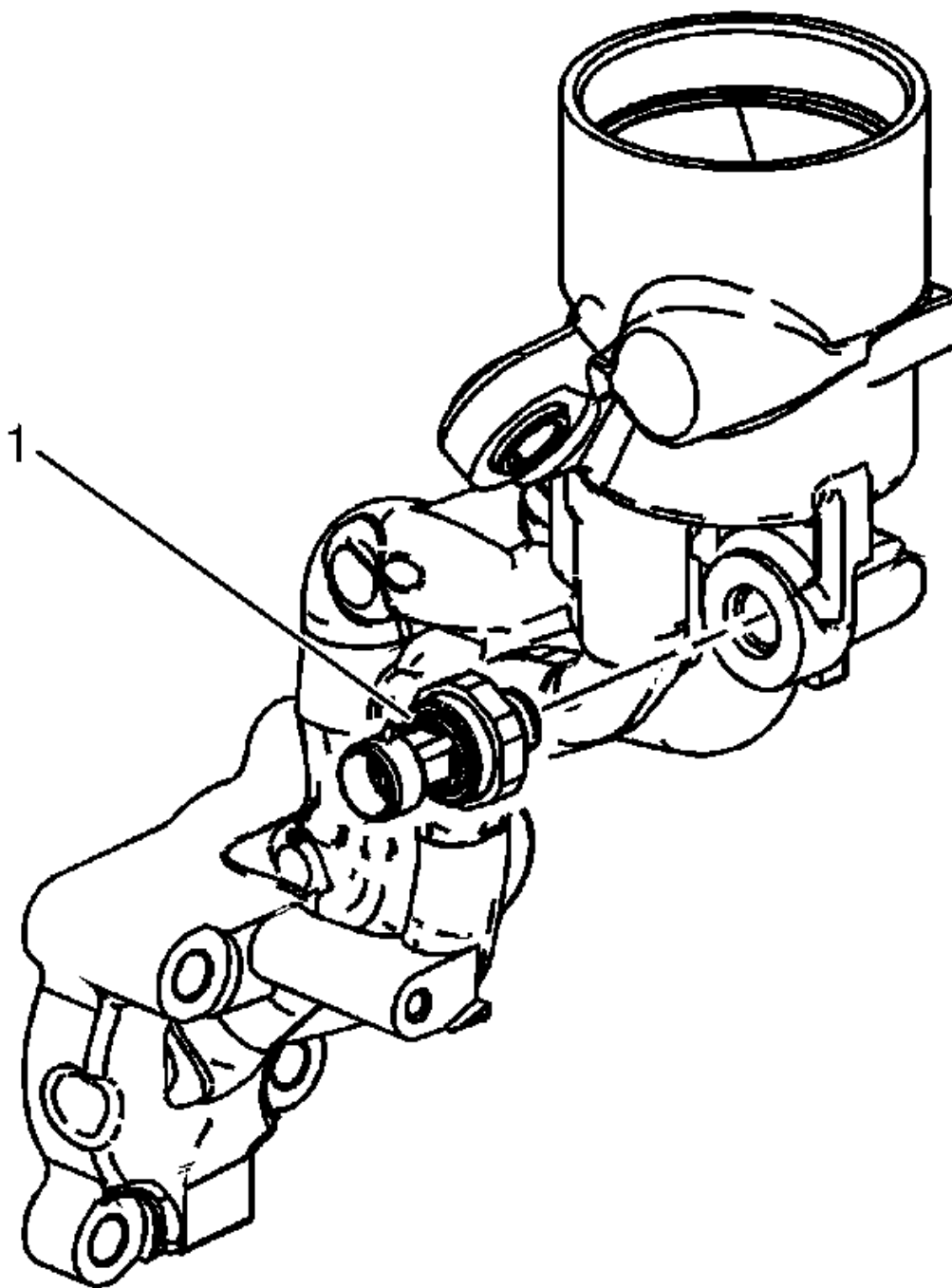
3. Inspect the oil filter cap for cracks, scoring, casting imperfections (1) and damaged threads (2). Replace as necessary.
4. Inspect the oil filter cap O-ring (3) for damage. Replace as necessary.



**Fig. 174: Identifying Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

5. Inspect the bypass valve (1) for damage or blockage.

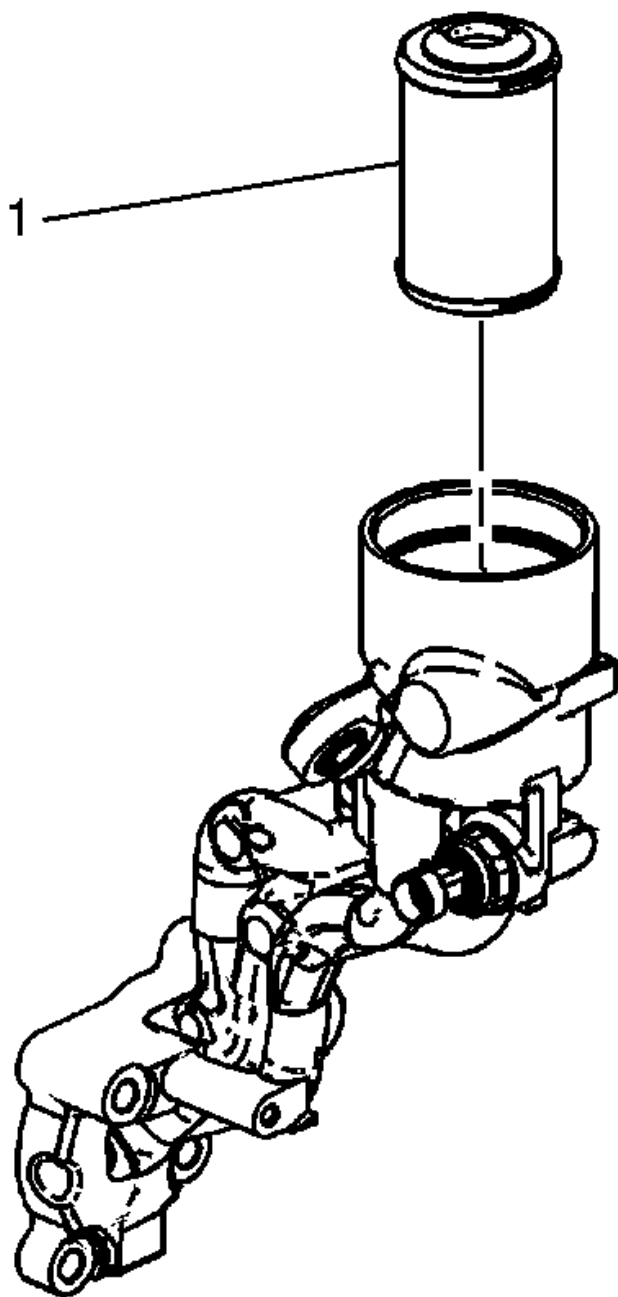
#### **OIL FILTER ADAPTER ASSEMBLY**



**Fig. 175: Identifying Oil Pressure Sender**  
**Courtesy of GENERAL MOTORS CORP.**

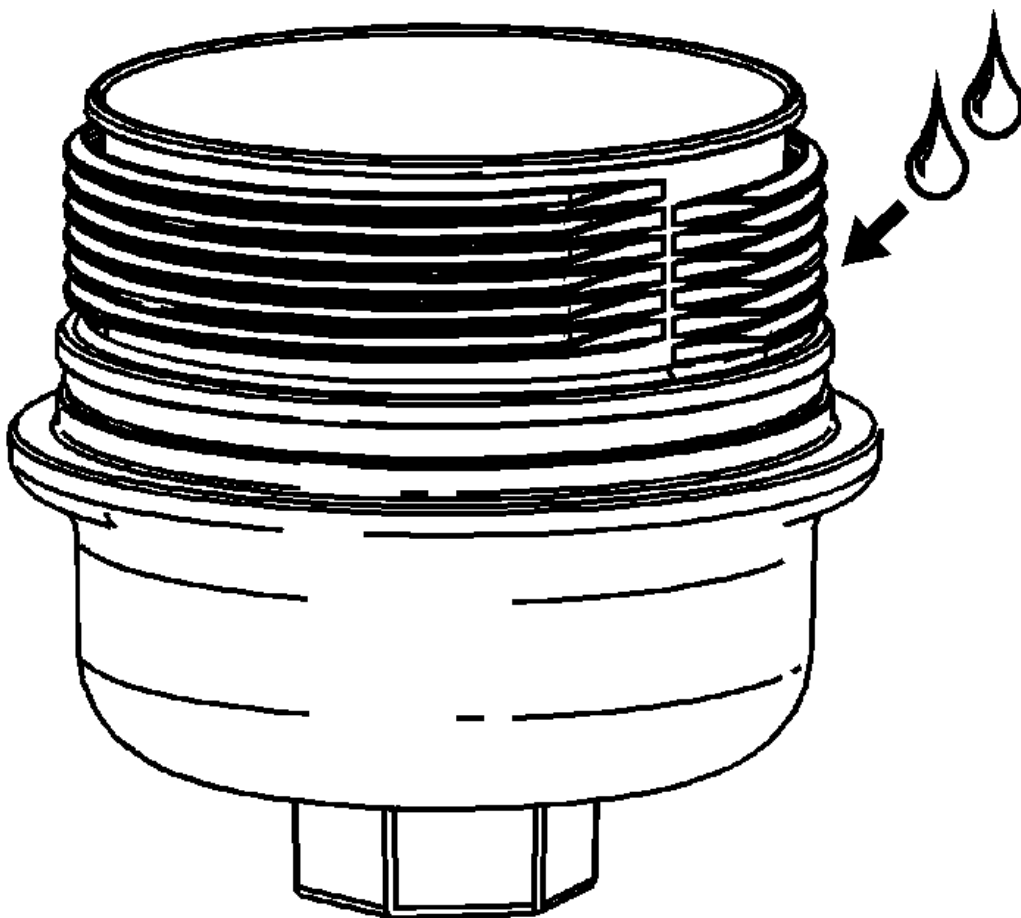
**CAUTION: Refer to Fastener Caution .**

1. Install the oil pressure sender (1) and tighten to 20 N.m (15 lb in).



**Fig. 176: Identifying Oil Filter Cartridge**  
Courtesy of GENERAL MOTORS CORP.

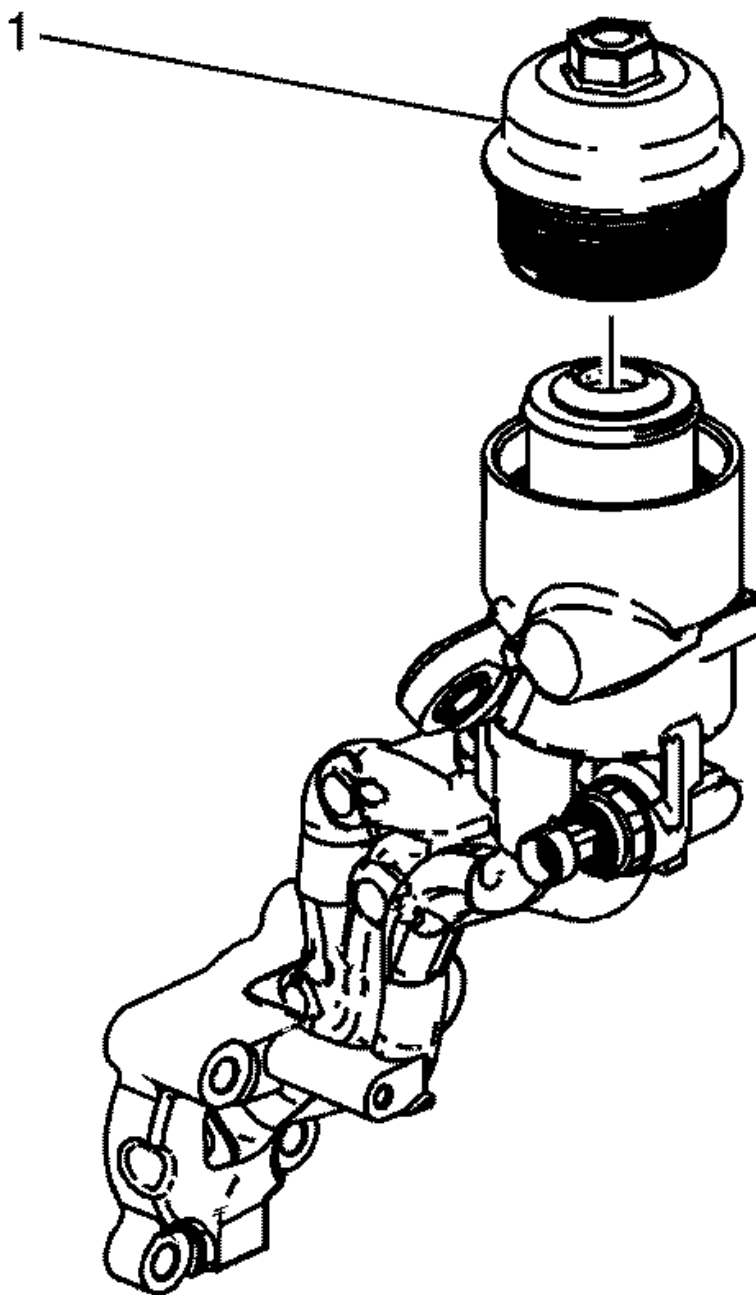
2. Install the NEW oil filter cartridge (1).



**Fig. 177: Identifying Oil Filter Cap Thread Lubrication**  
Courtesy of GENERAL MOTORS CORP.

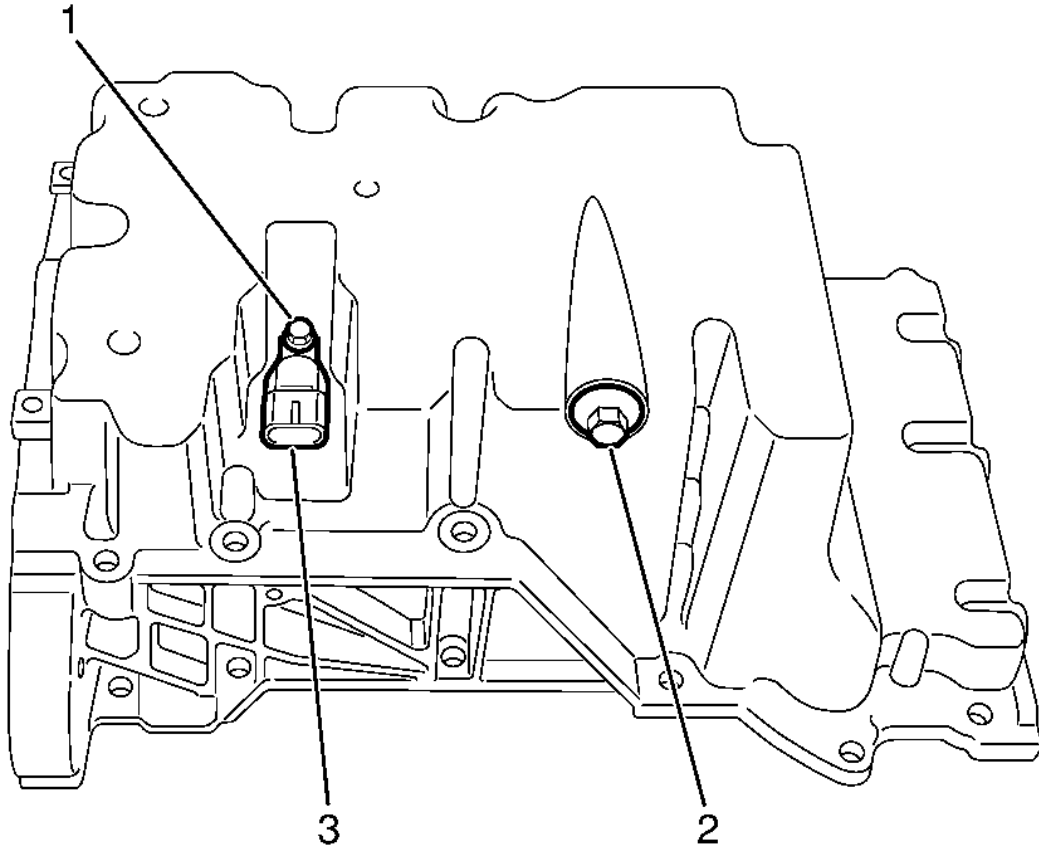
**CAUTION:** Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

3. Lubricate the oil filter cap threads with clean engine oil.



**Fig. 178: Identifying Oil Filter Cap**  
Courtesy of GENERAL MOTORS CORP.

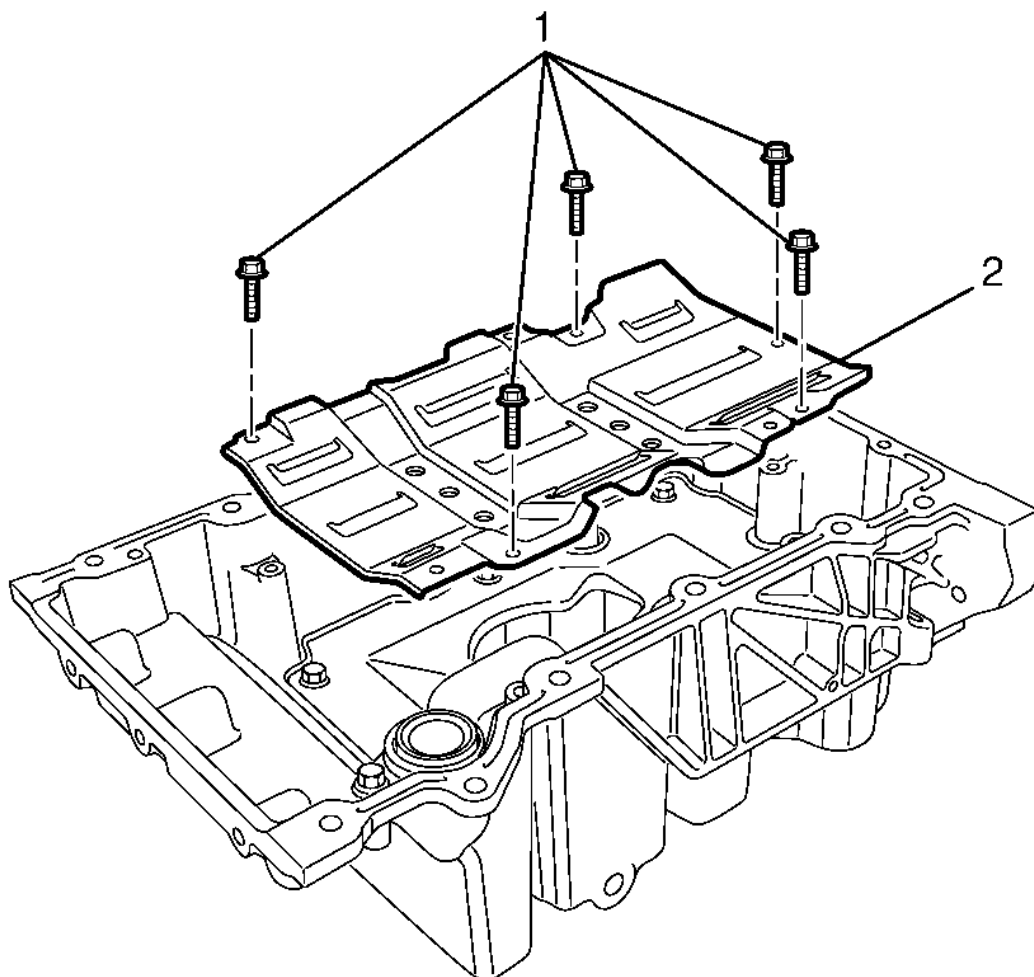
4. Install the oil filter cap (1) and tighten to 25 N.m (18 lb in).

**OIL PAN DISASSEMBLE**

**Fig. 179: Identifying Oil Level Sensor To Oil Pan Retaining Bolt**  
**Courtesy of GENERAL MOTORS CORP.**

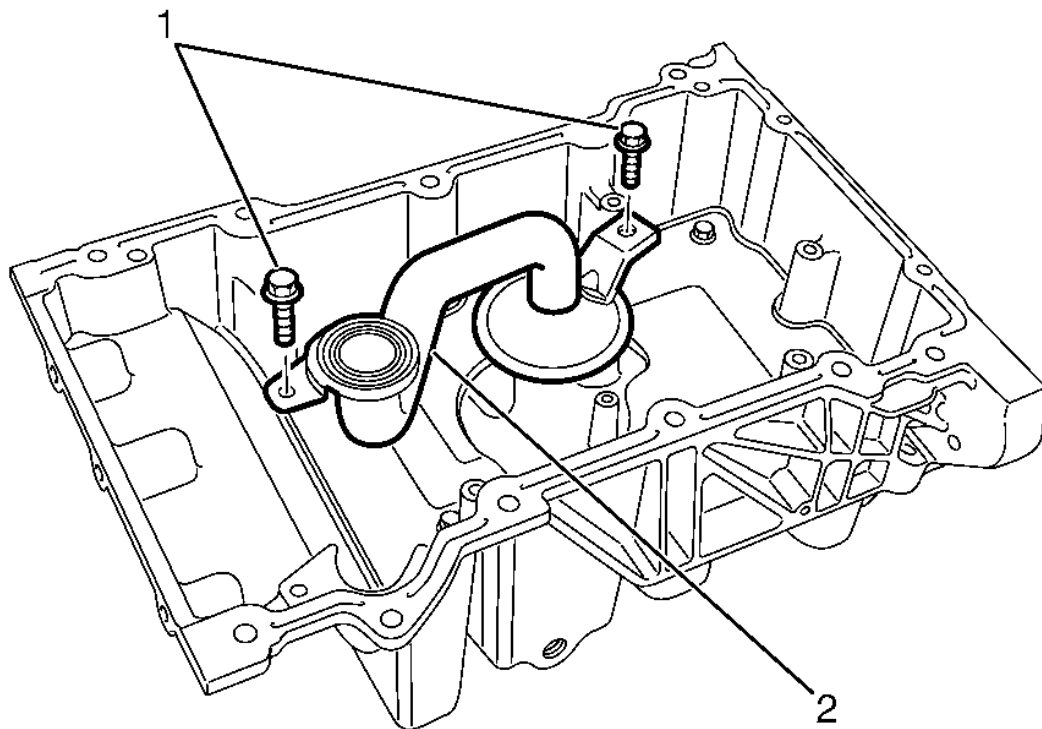
1. Remove the oil level sensor to oil pan retaining bolt (1).
2. Remove the oil level sensor (3).
3. Remove the oil pan drain plug (2).





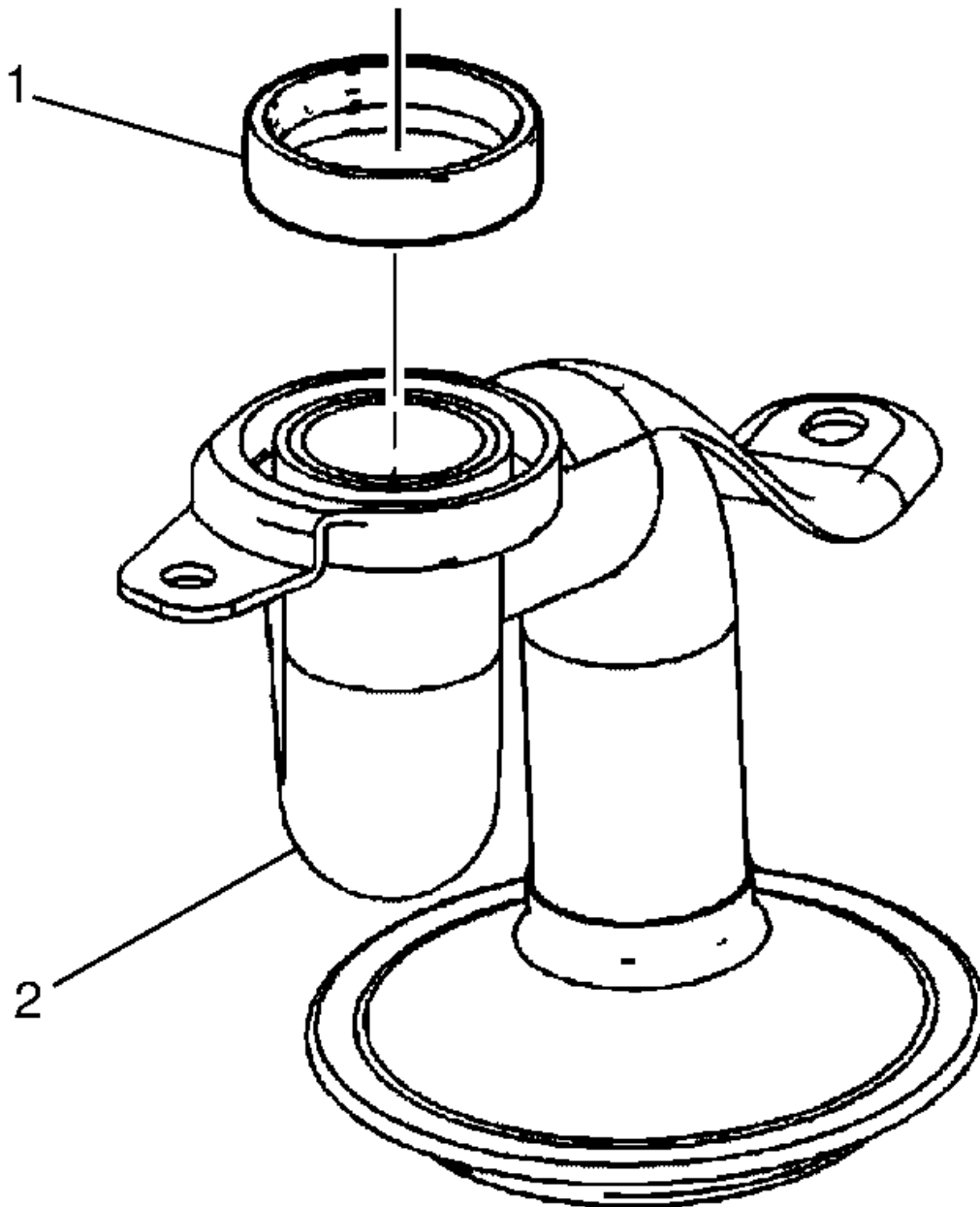
**Fig. 180: Identifying Oil Pan Scraper To Oil Pan Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan scraper to oil pan retaining bolts (1).
5. Remove the oil pan scraper (2).



**Fig. 181: Identifying Oil Suction Pipe To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil suction pipe to oil pan retaining bolts (1).
7. Remove the oil suction pipe (2).

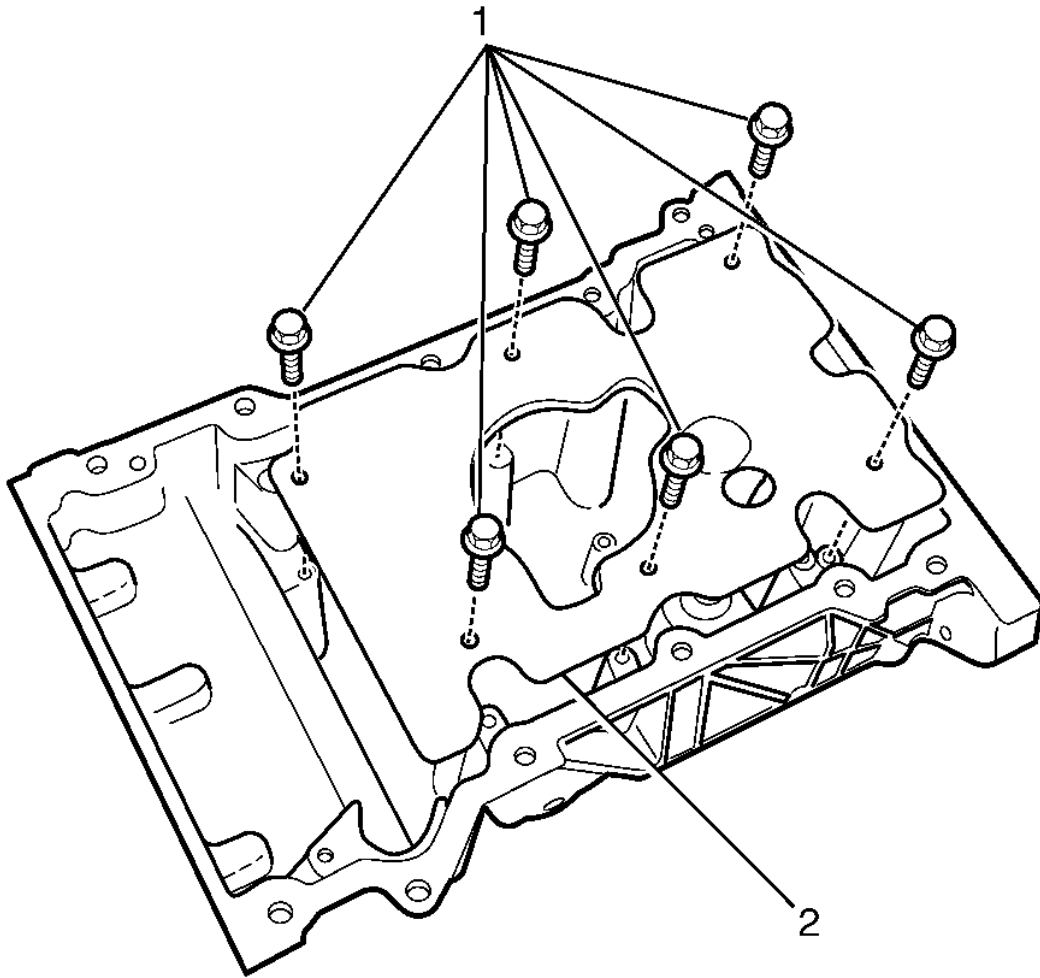


**Fig. 182: Identifying Oil Suction Pipe & Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The oil suction pipe seal (1) is a single use component and must be discarded whenever the oil suction pipe (2) is removed.

8. Remove the oil suction pipe seal (1) from the oil suction pipe (2).

Discard the oil suction pipe seal (1).



**Fig. 183: Identifying Oil Pan Baffle To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pan baffle to oil pan retaining bolts (1).
10. Remove the oil pan baffle (2).

## OIL PAN CLEANING AND INSPECTION

### Special Tools

**J 28410:** Gasket Remover

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

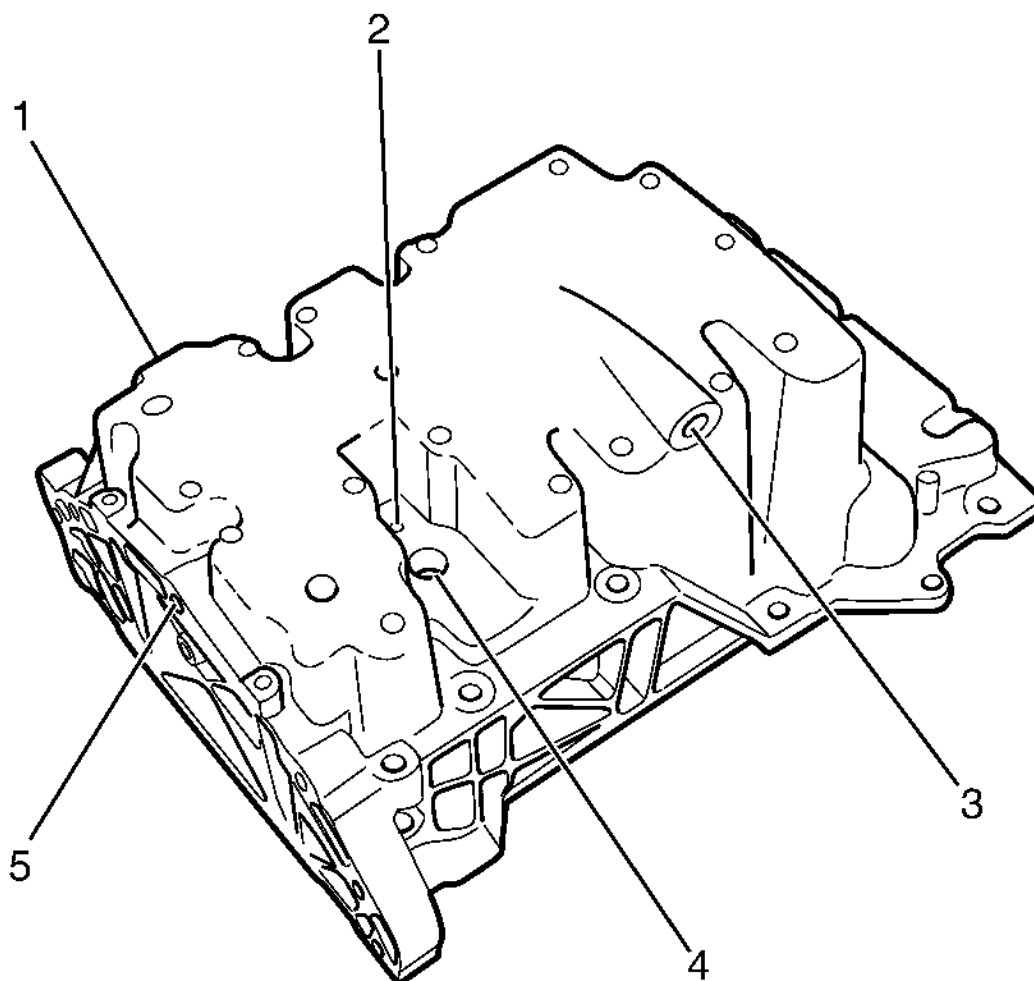
**Cleaning Procedure**

1. Remove any old thread sealant, gasket material or sealant using **J 28410**: remover
2. Clean the oil pan and oil pan components in solvent.
3. Clean out any debris from the bolt holes.

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

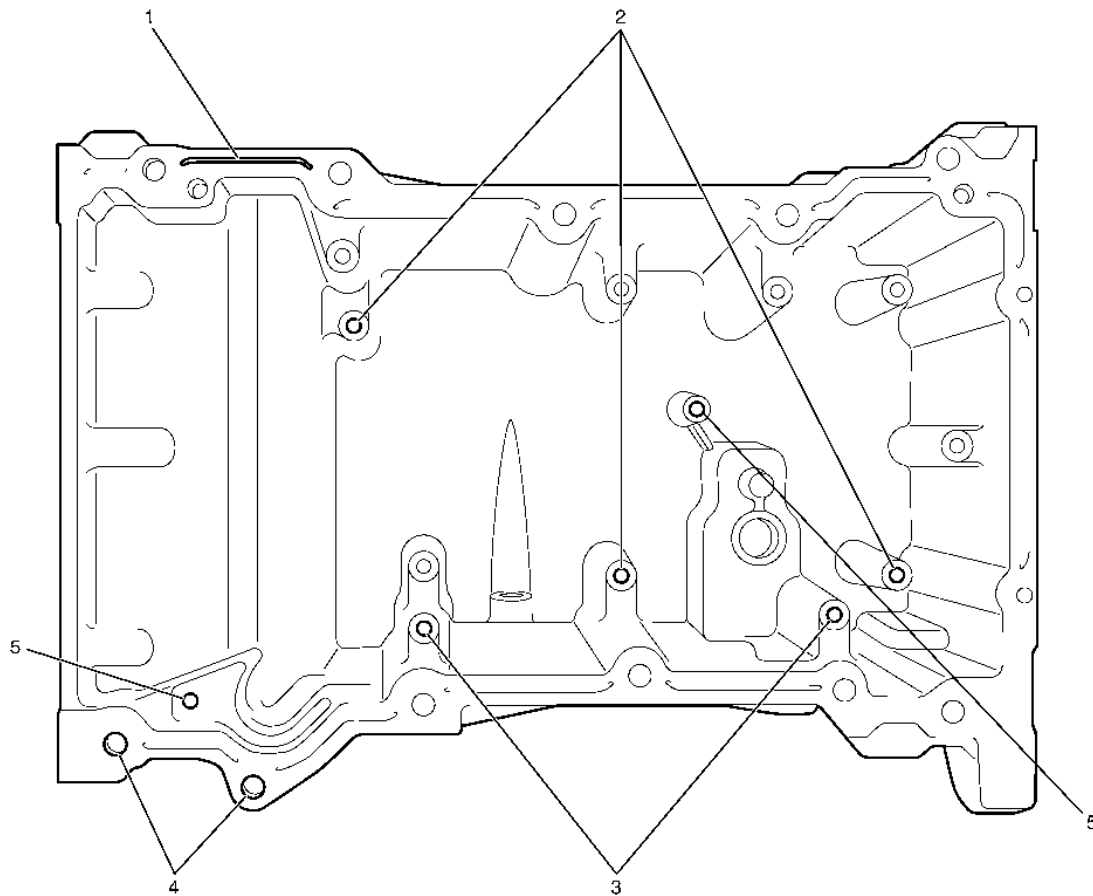
4. Dry the oil pan and oil pan components with compressed air.

**Inspection Procedure**



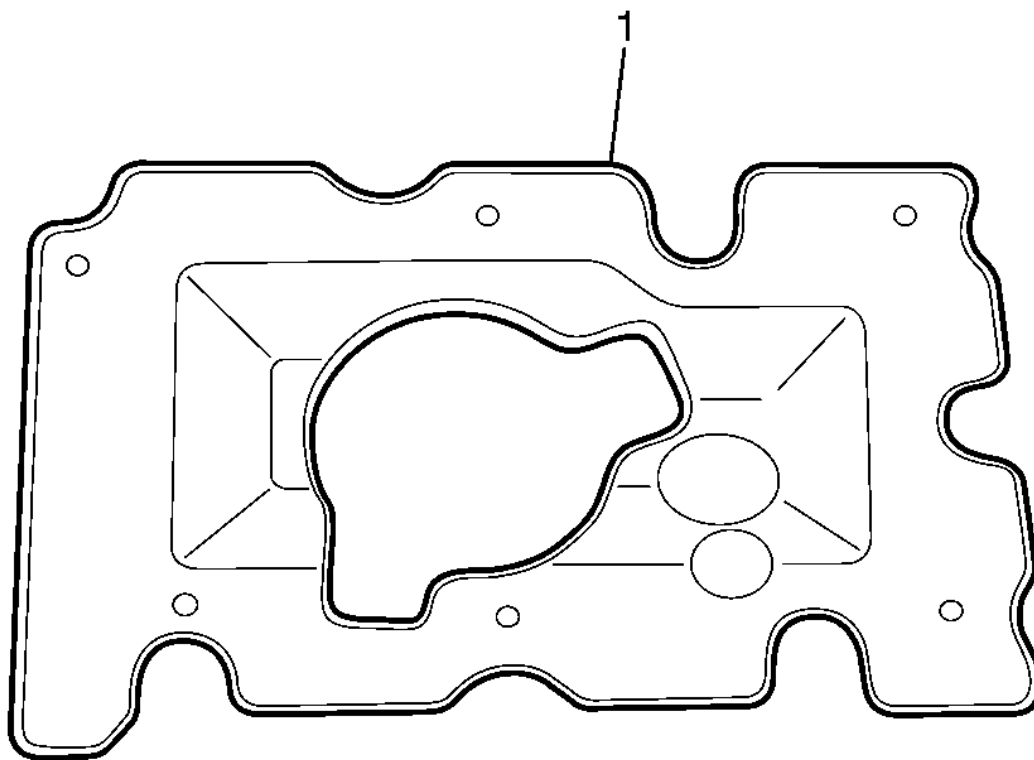
**Fig. 184: Identifying Exterior Of Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil pan for the following conditions:
  - Damage to the drain plug or drain plug hole (3).
  - Damage to the transmission mounting bosses (5).
  - Damage to the oil level/condition sensor bolt hole threads (2).
  - Damage to the oil level/condition sensor hole (4).
  - Dents or damage to the exterior (1).



**Fig. 185: Identifying Interior Of Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil pan for the following conditions:
  - Gouges or damage to the oil pan sealing surfaces (1).
  - Damage to the oil pan baffle mounting bosses (2).
  - Damage to the bolt holes (3).
  - Damage to the oil suction pipe mounting bosses (4).
  - Damage to the oil pan scraper mounting bosses (5).
3. Inspect the oil pan scraper for damage.



**Fig. 186: Identifying Oil Pan Baffle**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the oil pan baffle (1) for damage.
5. Repair or replace the oil pan and/or oil pan components as necessary.

## **OIL PUMP SUCTION PIPE AND SCREEN CLEANING AND INSPECTION**

### **Cleaning Procedure**

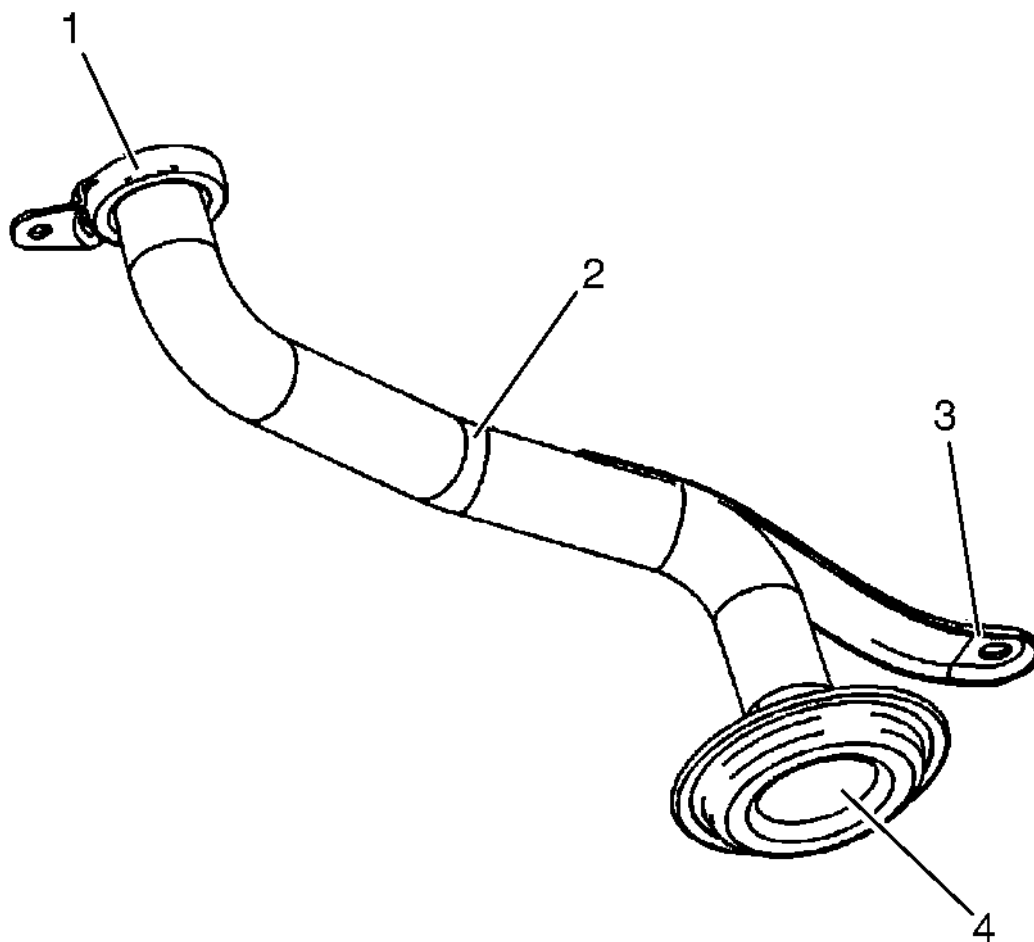
1. Clean the oil pump pipe and screen with solvent.

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

2. Dry the oil pump pipe and screen with compressed air.

### **Inspection Procedure**

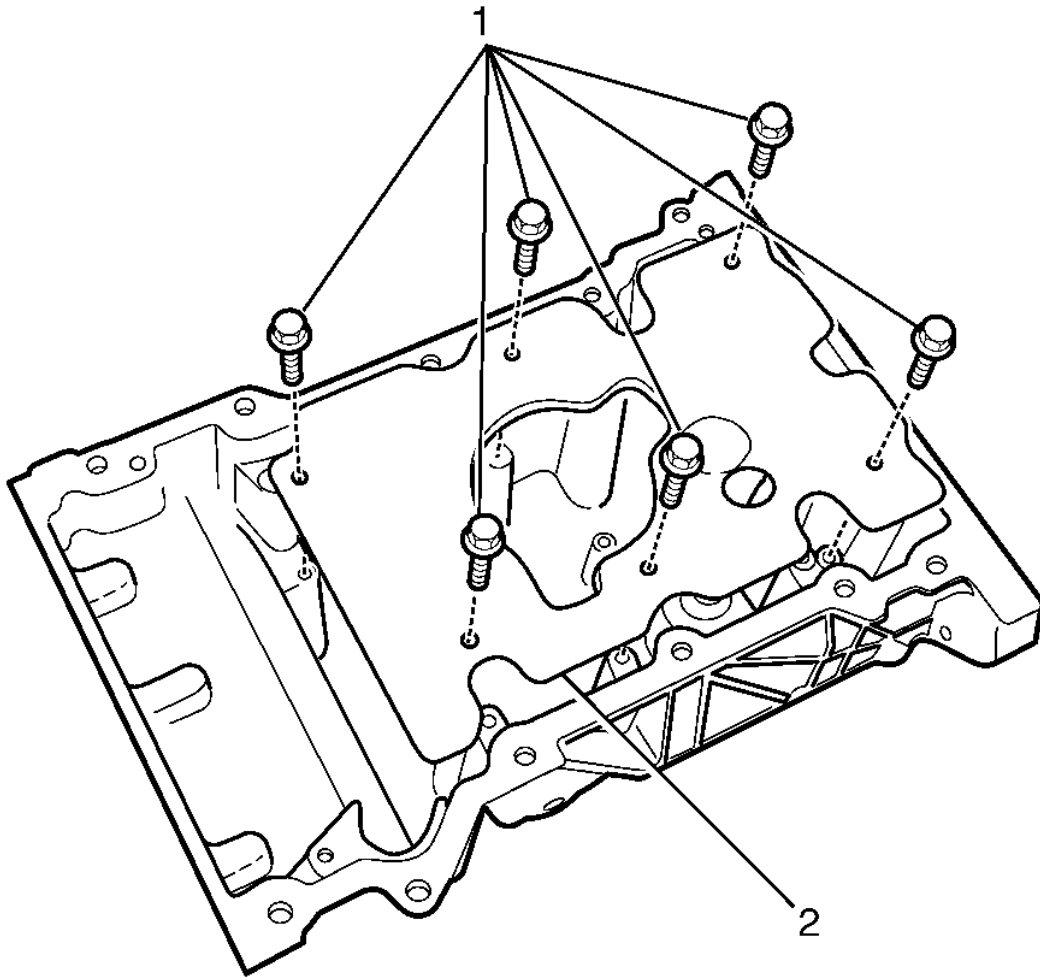




**Fig. 187: View Of Mounting Surface, Oil Pump Screen, Oil Pump Pipe Tube & Support Bracket**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

## **OIL PAN ASSEMBLE**

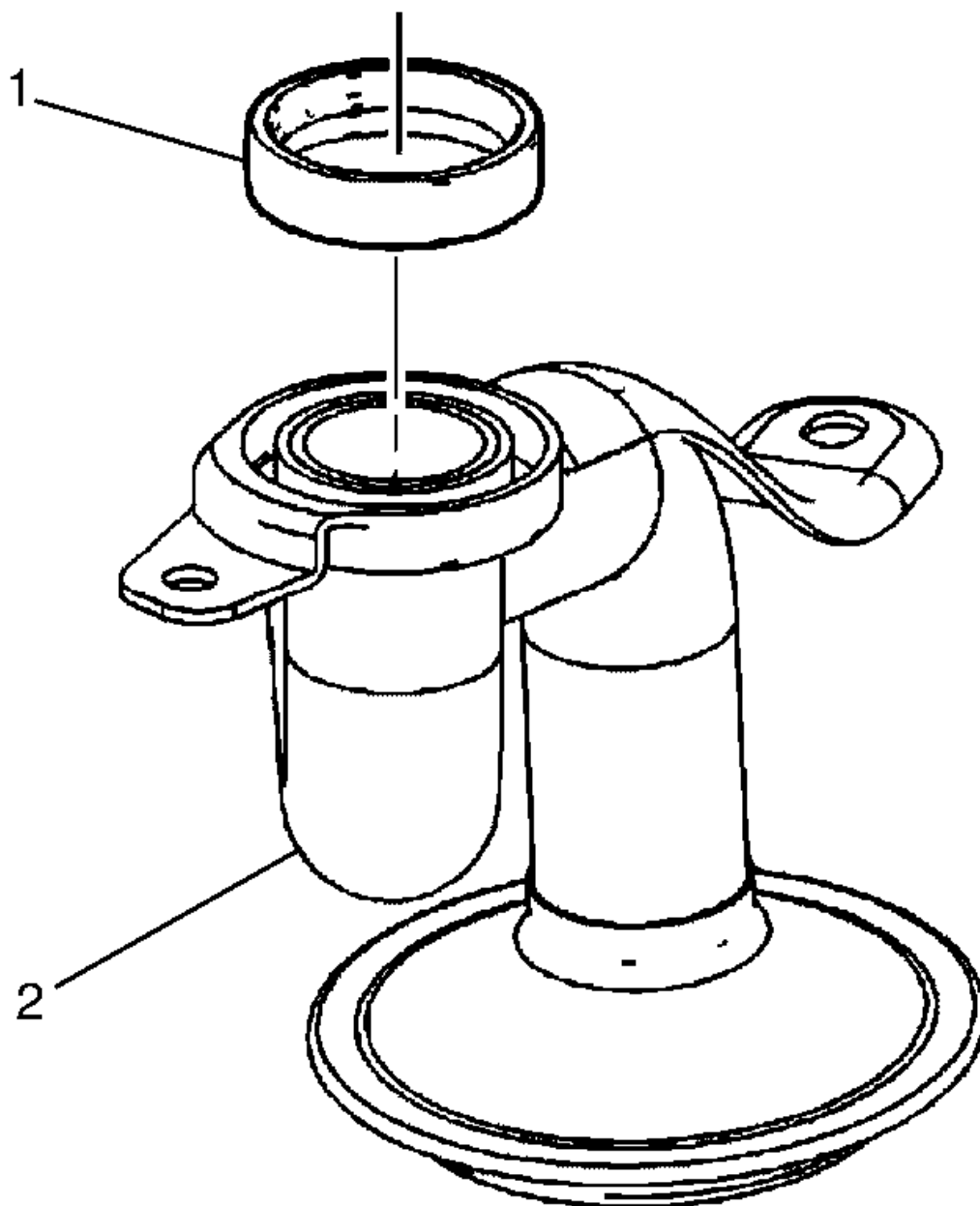


**Fig. 188: Identifying Oil Pan Baffle To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pan baffle (2).

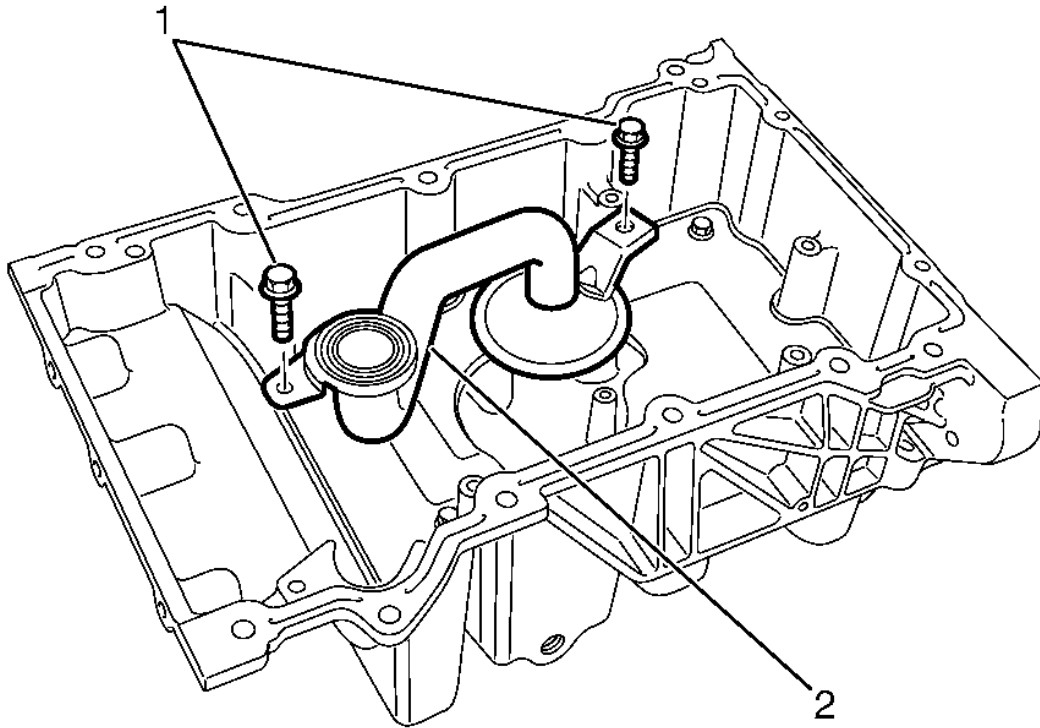
**CAUTION:** Refer to Fastener Caution .

2. Install the oil pan baffle to oil pan retaining bolts (1) and tighten to 10 N.m (89 lb in).



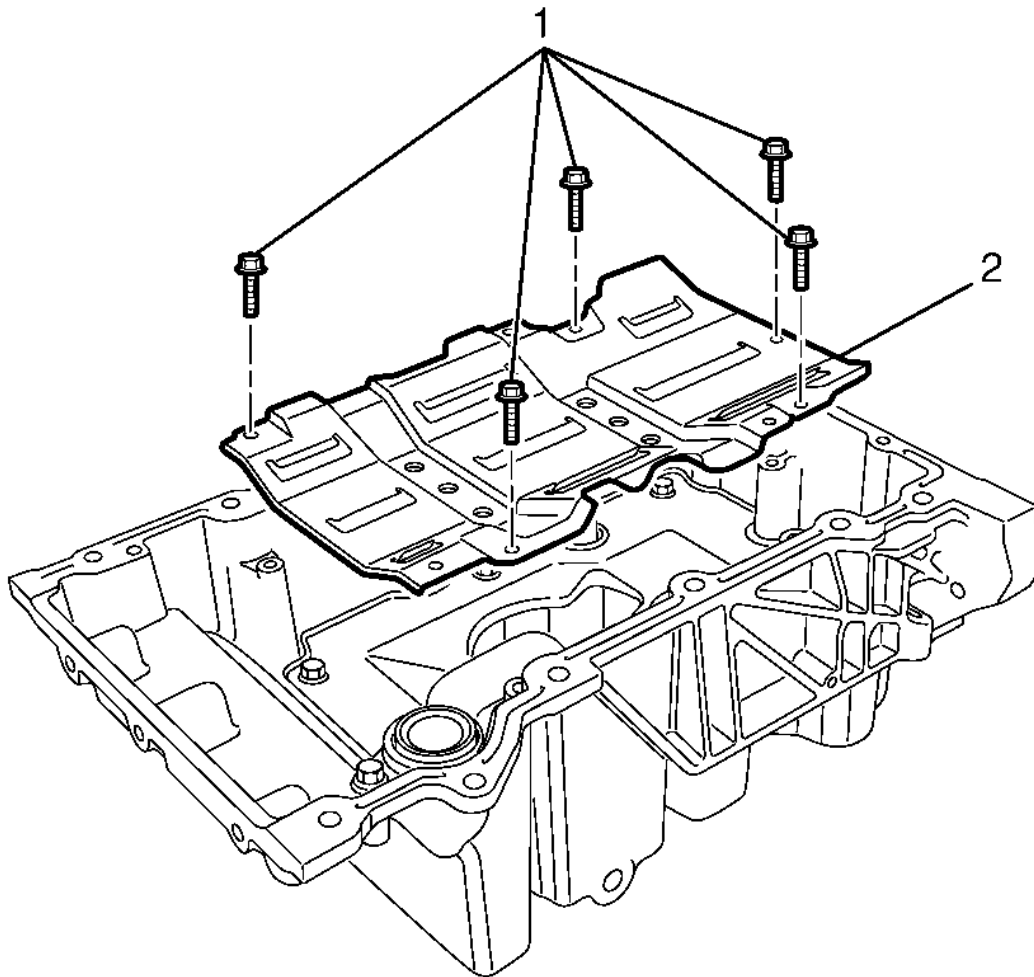
**Fig. 189: Identifying Oil Suction Pipe & Seal**  
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW oil suction pipe seal (1) onto the oil suction pipe (2).



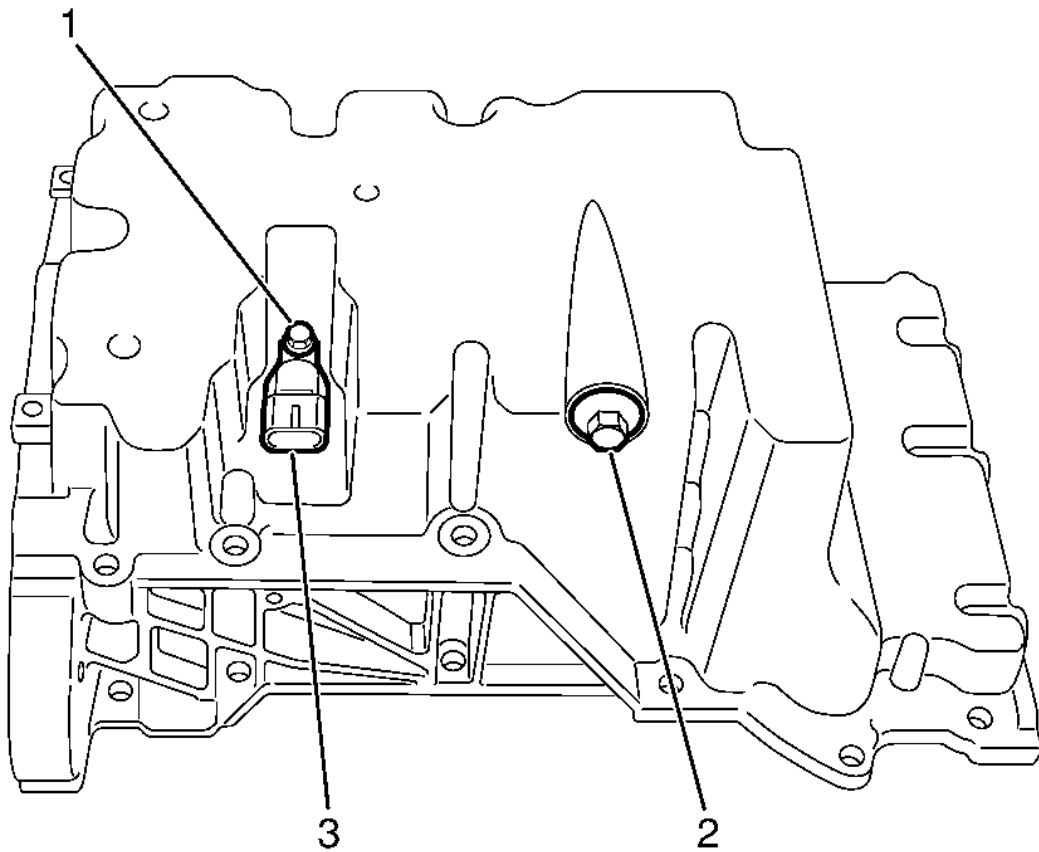
**Fig. 190: Identifying Oil Suction Pipe To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the oil suction pipe (2).
5. Install the oil suction pipe to oil pan retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 191: Identifying Oil Pan Scraper To Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan scraper (2).
7. Install the oil pan scraper to oil pan retaining bolts (1) and tighten pan scraper bolts to 10 N.m (89 lb in).



**Fig. 192: Identifying Oil Level Sensor To Oil Pan Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

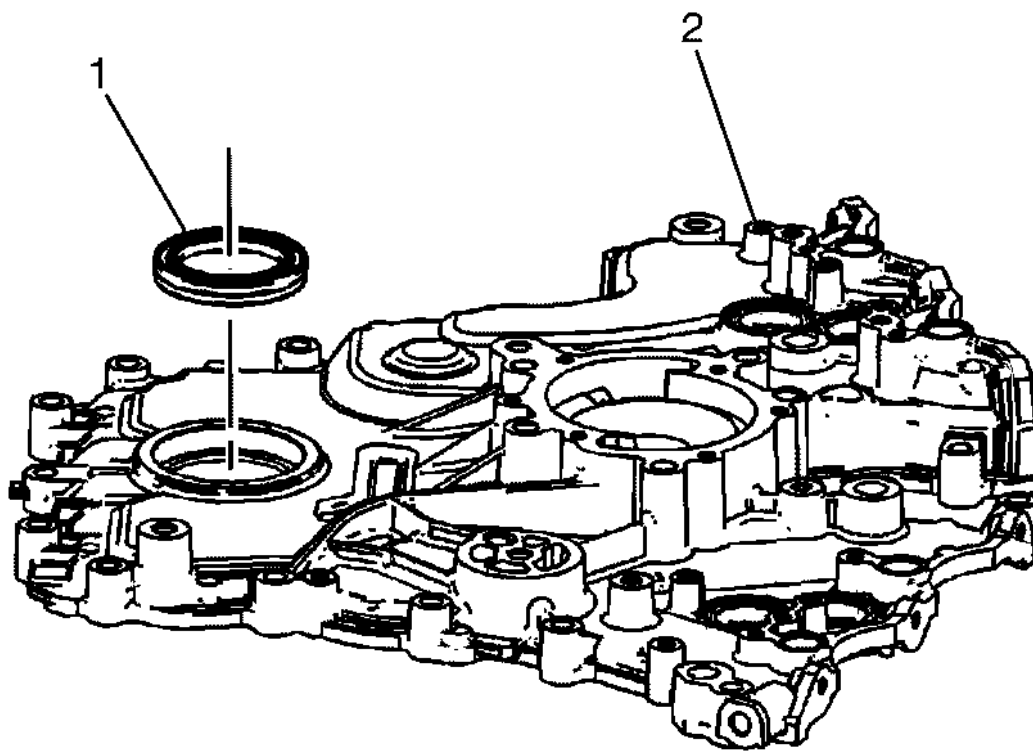
8. Install the oil pan drain plug (2) and tighten to 20 N.m (15 lb ft).
9. Install the oil level sensor (3).
10. Install the oil level sensor to oil pan retaining bolt (1) and tighten to 10 N.m (89 lb in).

## **ENGINE FRONT COVER DISASSEMBLE**

### **Tools Required**

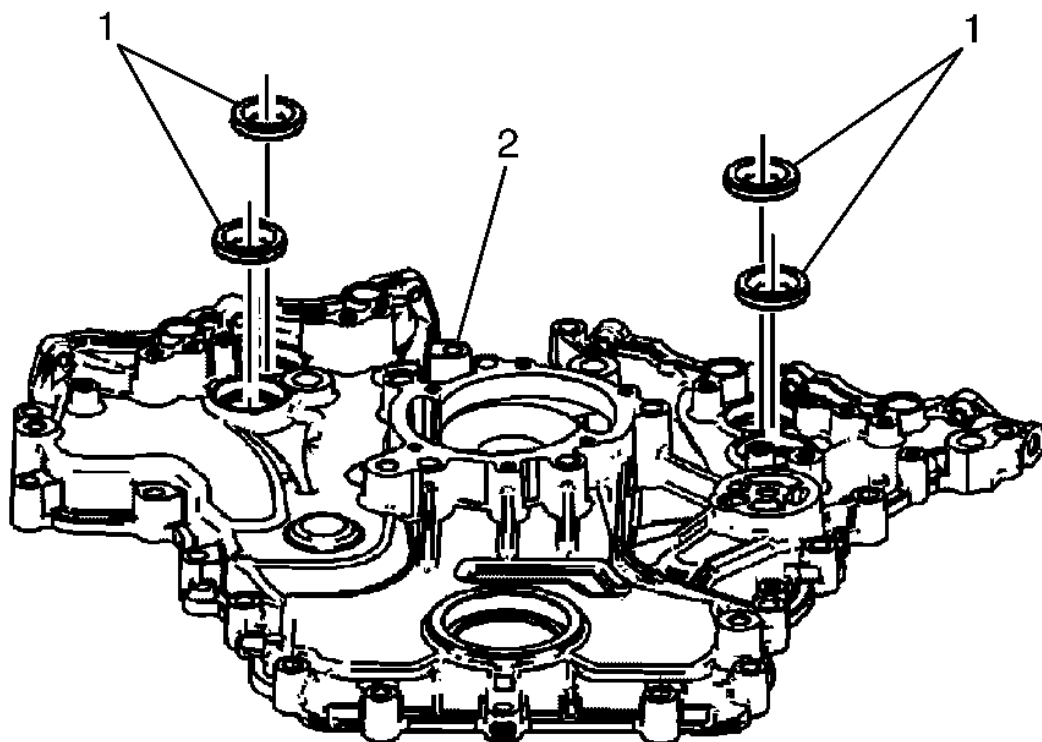
**E-308 Seal Remover**

### **Disassemble**



**Fig. 193: Identifying Crankshaft Front Oil Seal & Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft front oil (1) seal from the engine front cover (2) using the E-308 .



**Fig. 194: Identifying Camshaft Position Actuator Solenoid Valve Oil Seals & Engine Front Cover**  
 Courtesy of GENERAL MOTORS CORP.

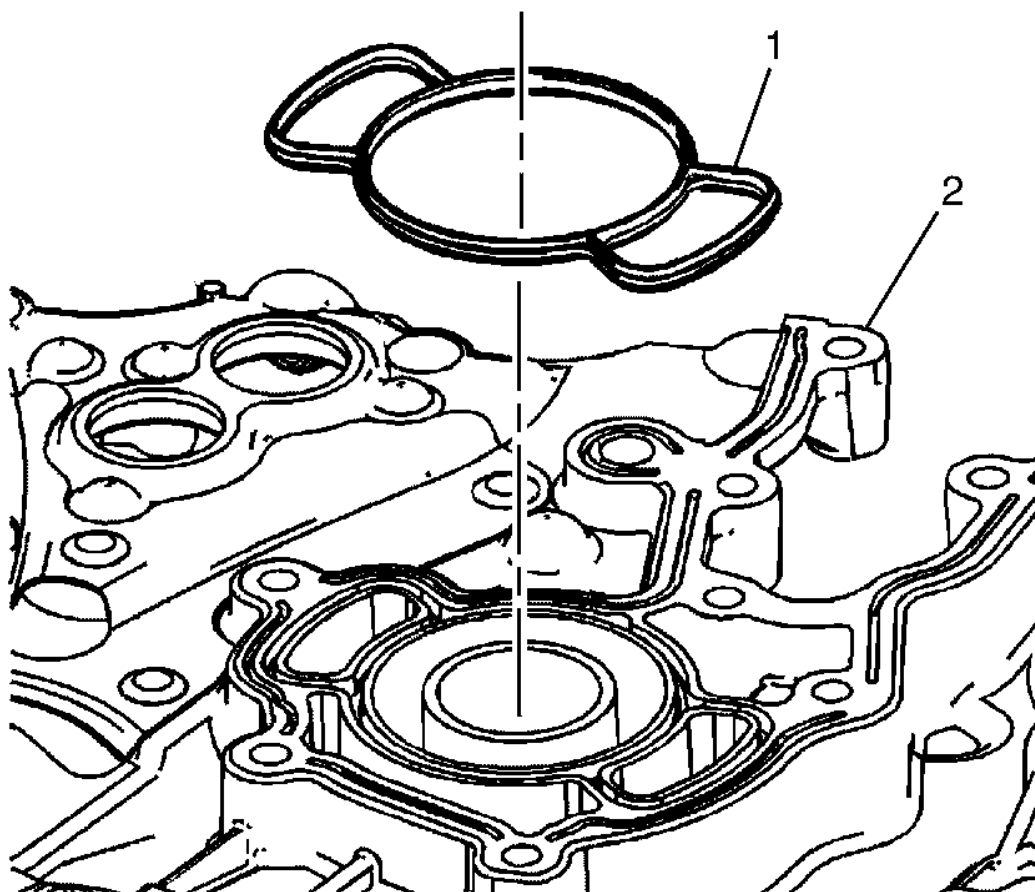
**IMPORTANT:** LE0 and LW2 engines only have an intake camshaft position actuator solenoid.

**IMPORTANT:** The camshaft position actuator solenoid valve oil seals (1) must be discarded whenever the camshaft position actuator solenoids have been removed from the front cover (2).

2. Remove the camshaft position actuator solenoid seals (1) from the engine front cover (2).

Discard the seals





**Fig. 195: Identifying Water Pump Seal & Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The water pump seal (1) must be discarded whenever the water pump has been removed from the front cover (2).

3. Remove the water pump seal (1) from the engine front cover (2).

Discard the seal

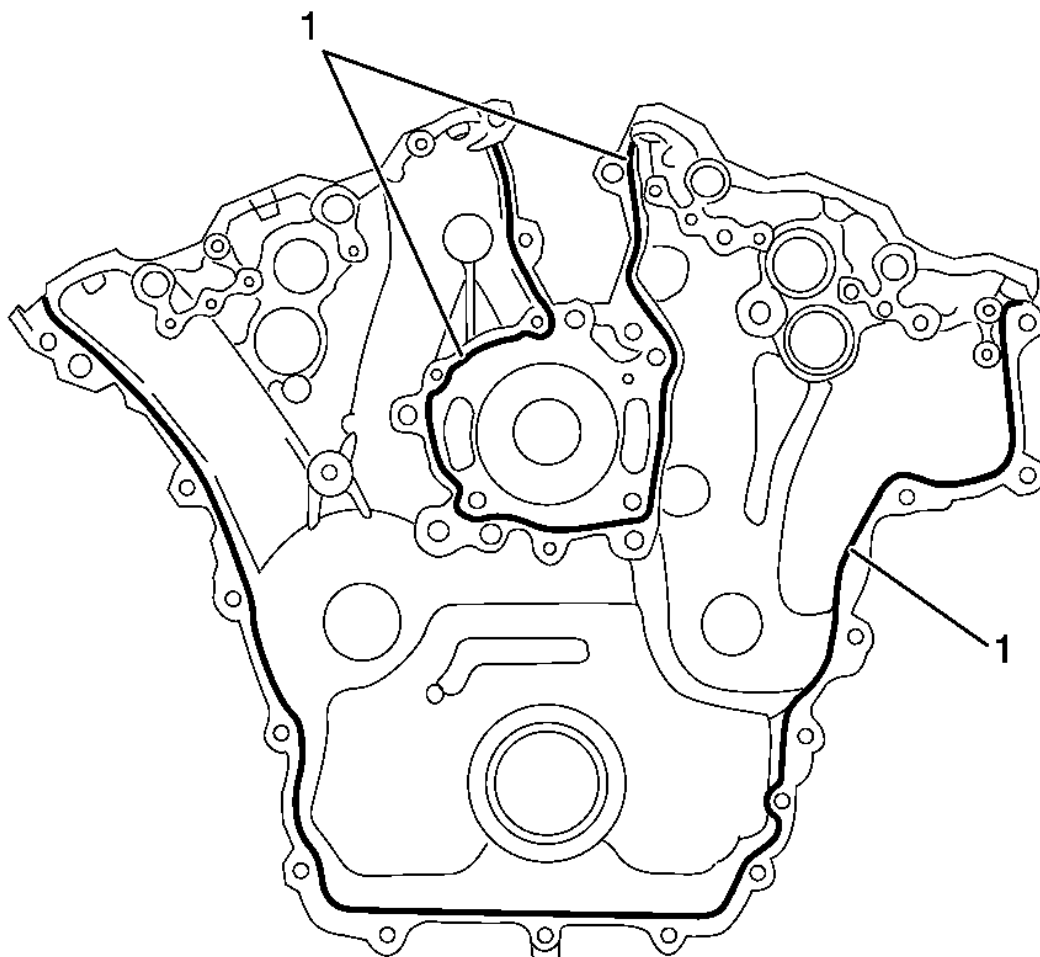
## ENGINE FRONT COVER CLEANING AND INSPECTION

### Special Tools

**J 28410:** Gasket Remover

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

### Cleaning Procedure



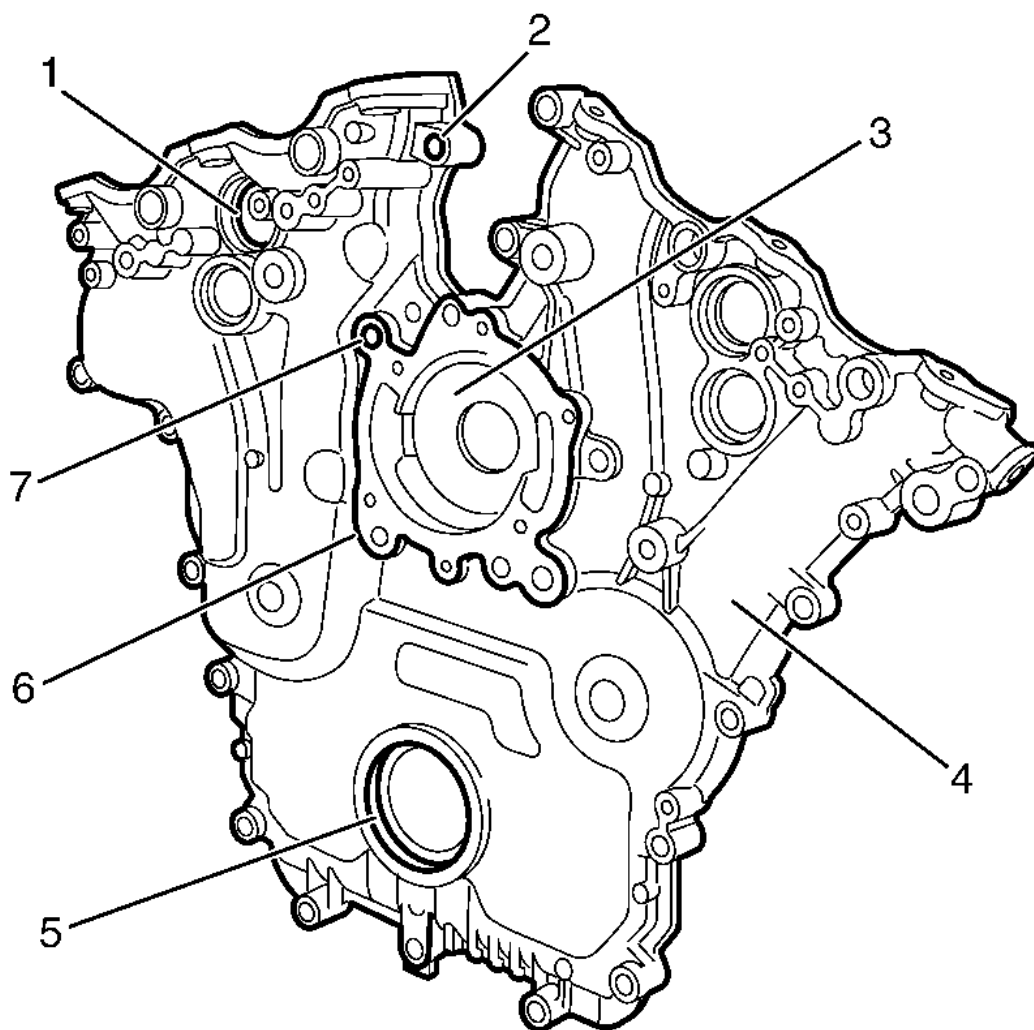
**Fig. 196: Identifying RTV Sealant Area**  
Courtesy of GENERAL MOTORS CORP.

1. Remove any RTV sealant (1) from the engine front cover using **J 28410**: remover.
2. Clean out debris from the bolt holes.
3. Clean the engine front cover (1) in solvent.

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

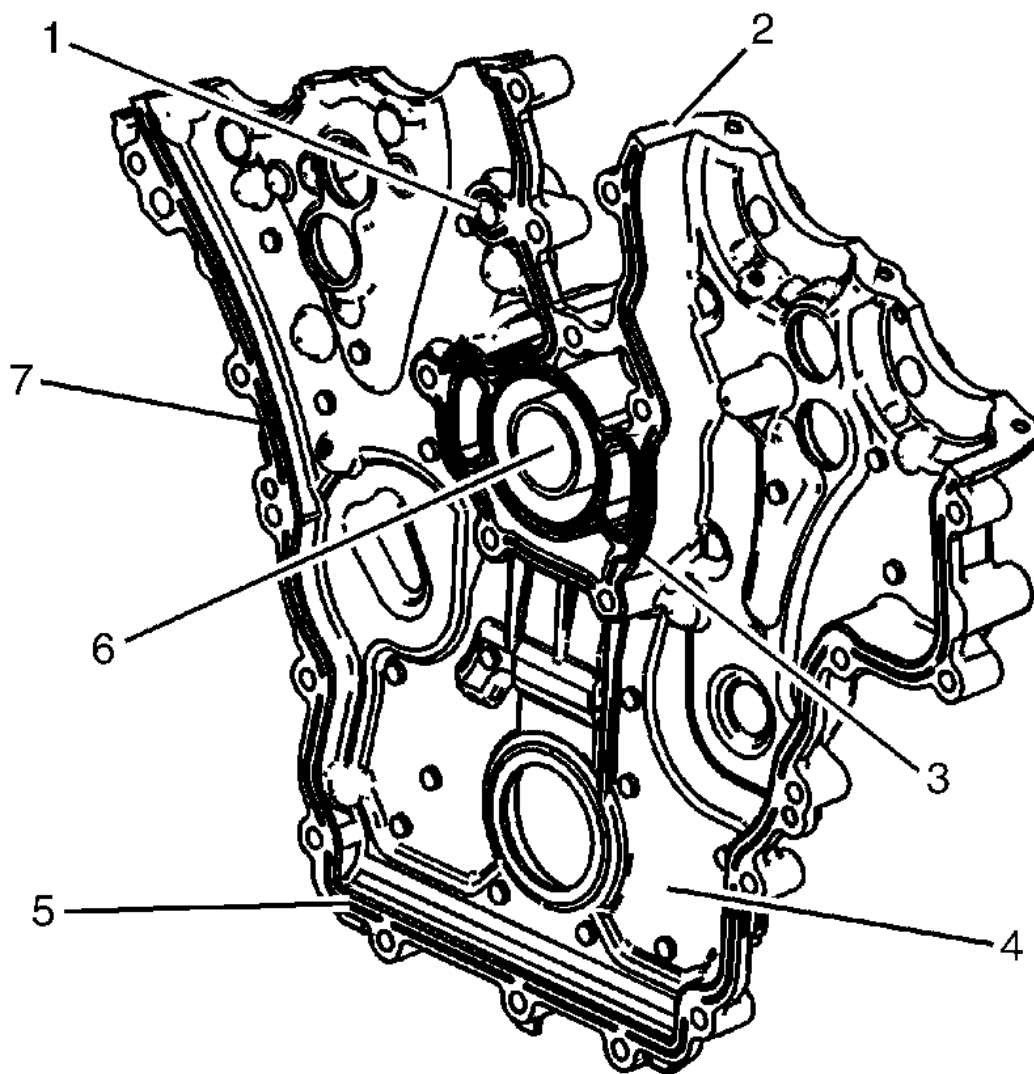
4. Dry the engine front cover (1) with compressed air.

### Inspection Procedure



**Fig. 197: Identifying Exterior Of Engine Front Cover**  
**Courtesy of GENERAL MOTORS CORP.**

1. Inspect the exterior of the engine front cover for the following conditions:
  - Damage to the water pump bolt hole threads (7).
  - Gouges or damage to the water pump sealing surfaces (6).
  - Damage to the crankshaft front oil seal bore (5).
  - Damage to the camshaft position actuator solenoid seal bores (1).
  - Damage to the engine front cover bolt holes (2).
  - Damage and/or corrosion to the engine coolant passage (3).
  - Dents or damage to the exterior (4).



**Fig. 198: Identifying Interior Of Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the engine front cover for the following conditions:
  - Gouges or damage to the engine front cover sealing surfaces to the cylinder block (7), oil pan (5), and/or camshaft covers (2).
  - Damage and/or corrosion to the engine coolant passage .(6)
  - Damage to the crankshaft front oil seal bore.
  - Gouges or damage to the O-ring sealing areas.
  - Gouges or damage to the water pump seal area (3).
  - Loose or damaged deadener plates (4).

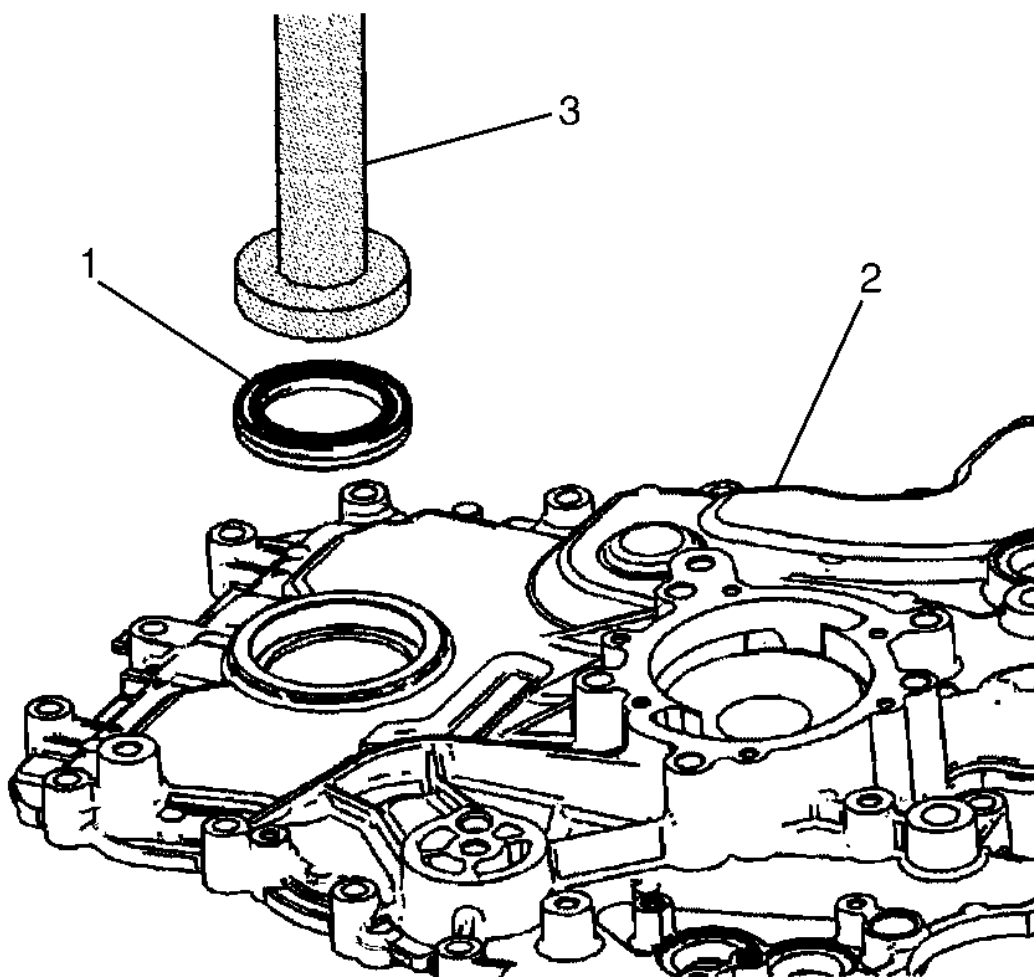
- Damage to the engine front cover bolt holes (1).
3. Repair or replace the engine front cover as necessary.

## ENGINE FRONT COVER ASSEMBLE

### Tools Required

- **EN-46103** Camshaft Actuator Valve Seal Remover/Installer. See **Special Tools** .
- **J 29184** Oil Seal Installer. See **Special Tools** .

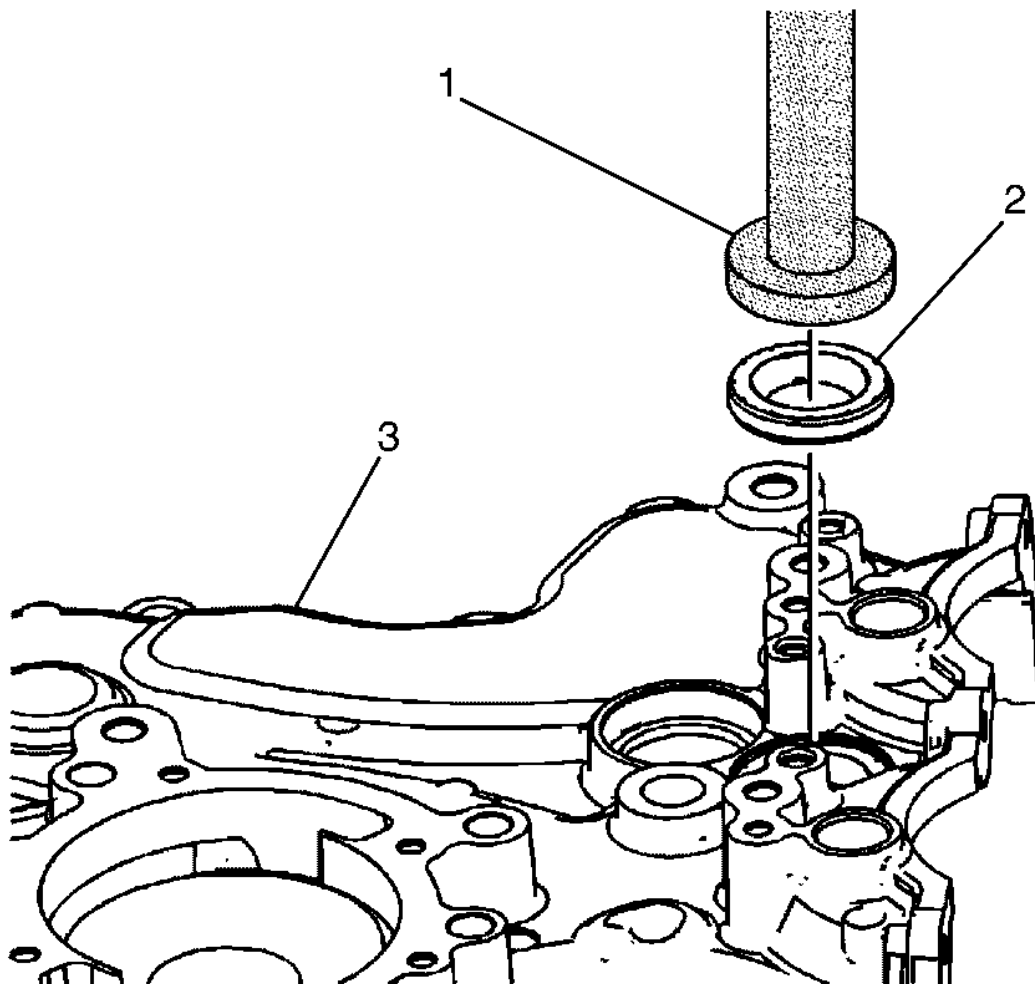
### Assemble



**Fig. 199: View Of J 29184 & Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.**

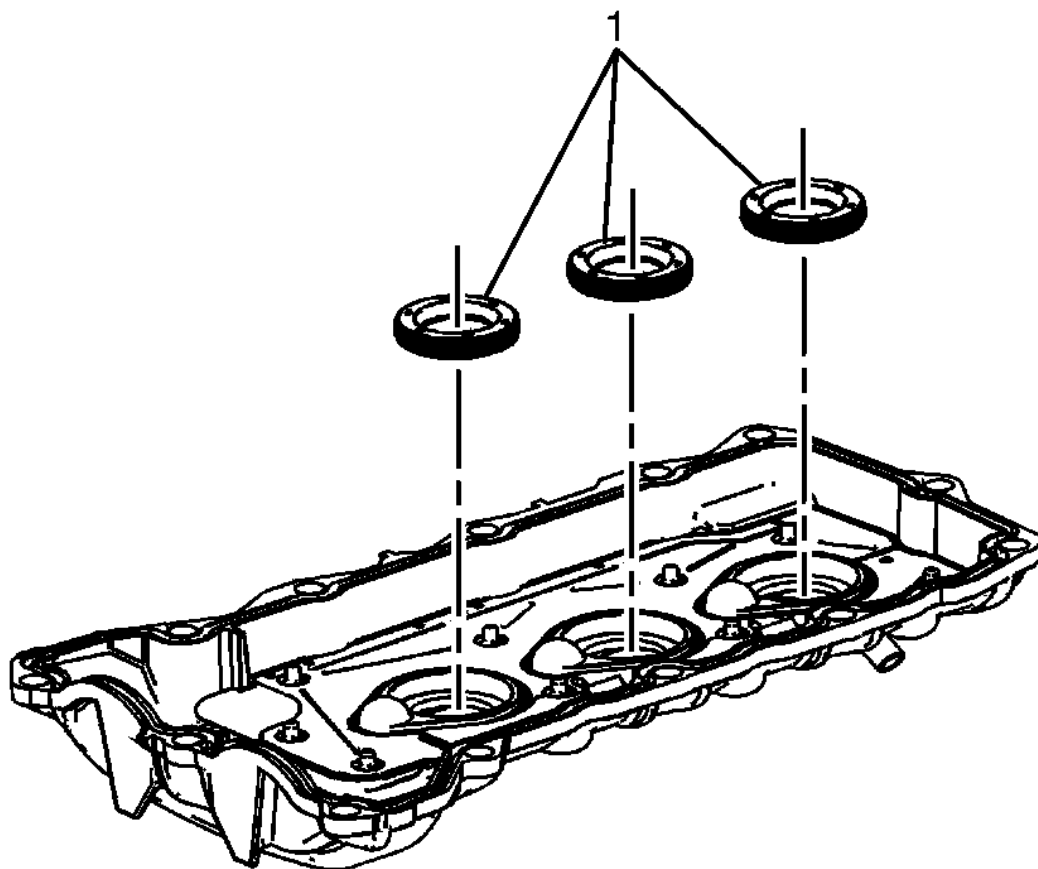
1. Install the NEW crankshaft front oil seal into the engine front cover using the **J 29184** . See Special Tools .



**Fig. 200: View Of EN-46103 & Camshaft Position Actuator Solenoid Seals**  
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW camshaft position actuator solenoid seals into the engine front cover using the **EN-46103** . See Special Tools .

## CAMSHAFT COVER DISASSEMBLE



**Fig. 201: Identifying Ignition Coil Seals**  
Courtesy of GENERAL MOTORS CORP.

Remove and discard the ignition coil seals (1).

## CAMSHAFT COVER CLEANING AND INSPECTION

### Cleaning Procedure

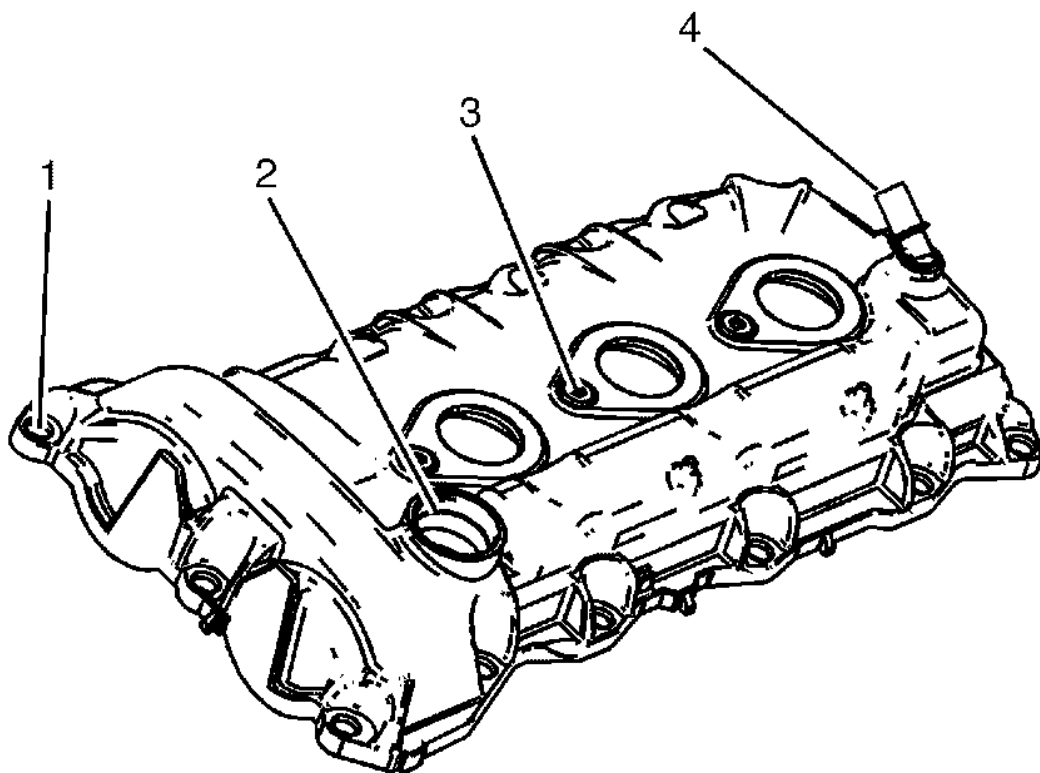
1. Clean the camshaft covers in solvent.

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

2. Dry the camshaft covers with compressed air.

### Inspection Procedure

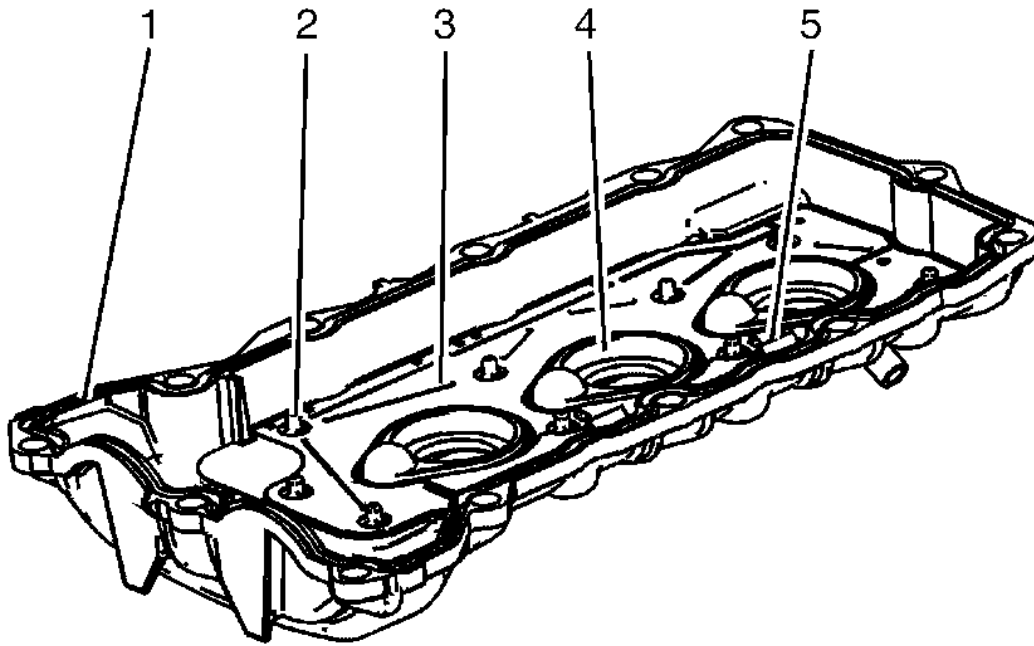
1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
  - Leak engine oil.
  - Effect crankcase ventilation.
  - Interfere with the camshafts.
  - Interfere with the ignition coil sealing.
  - Allow water or condensation to enter the engine.



**Fig. 202: Identifying Exterior Of Left Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

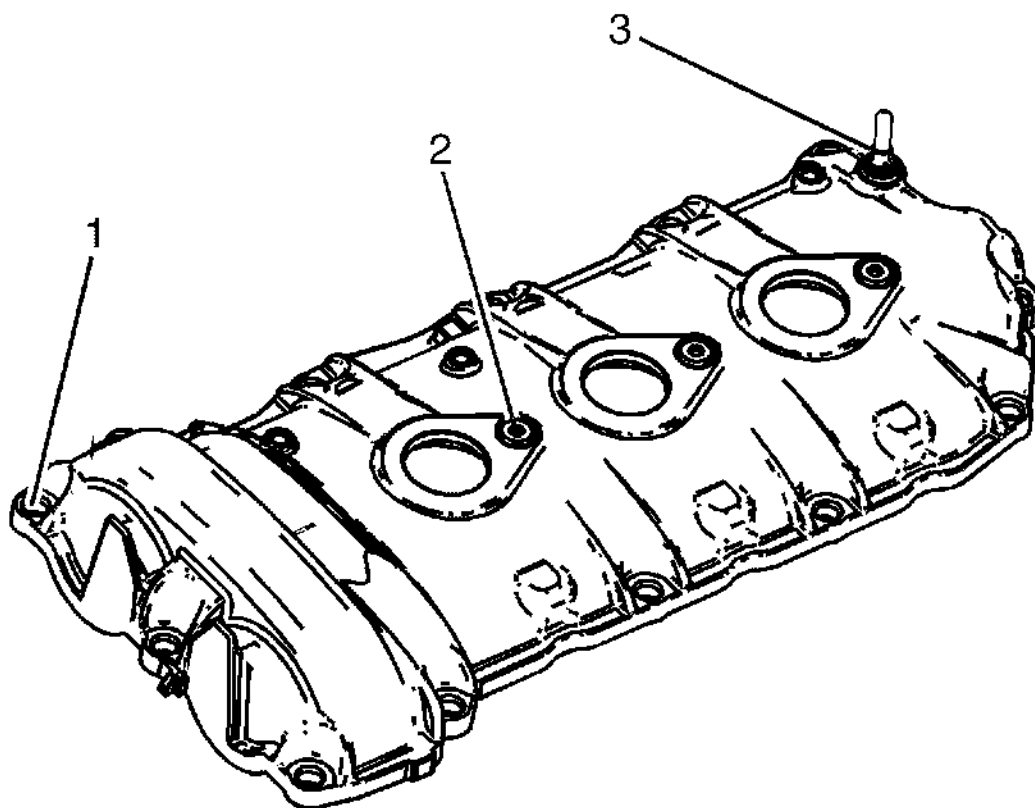
2. Inspect the exterior of the left camshaft cover for the following conditions:
  - Damage to the camshaft cover bolt holes (1).
  - Damage to the oil fill hole (2).
  - Damage to the mounting holes (3) for the ignition coil assembly.
  - Damage to the Positive Crankcase Ventilation (PCV) hose connector (4) - A damaged PCV hose connector is replaceable.





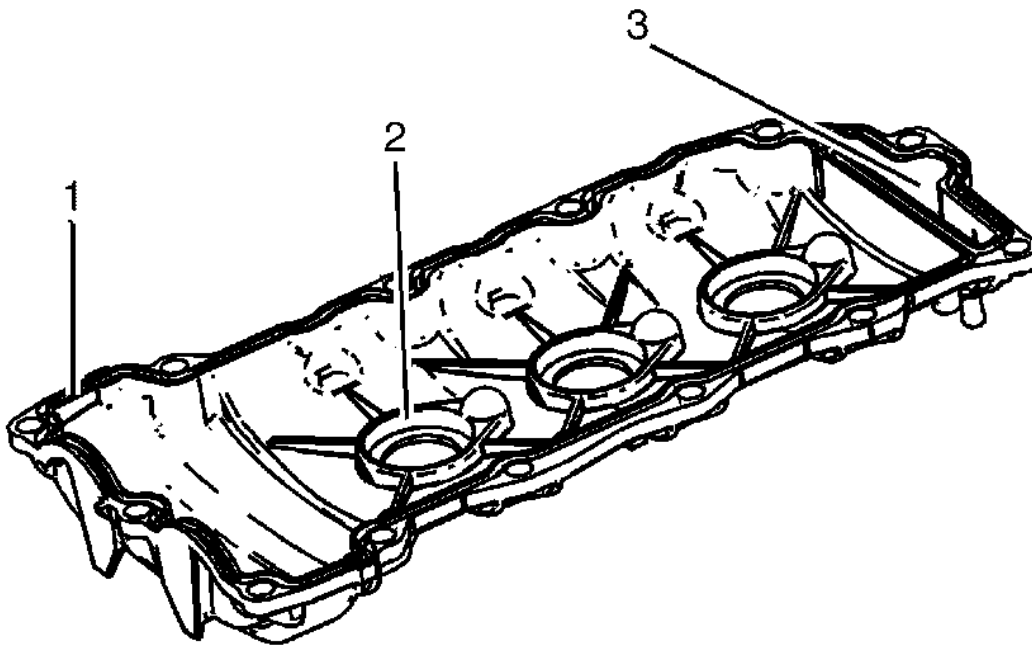
**Fig. 203: Identifying Interior Of Left Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the interior of the left camshaft cover for the following conditions:
- Gouges or damage to the camshaft cover sealing groove (1).
  - Damaged, loose or missing baffle fasteners (2).
  - Damaged, loose or missing baffle (3).
  - Gouges or damage to the ignition coil seal bore (4).
  - Restrictions to the ventilation system (5).



**Fig. 204: Identifying Exterior Of Right Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

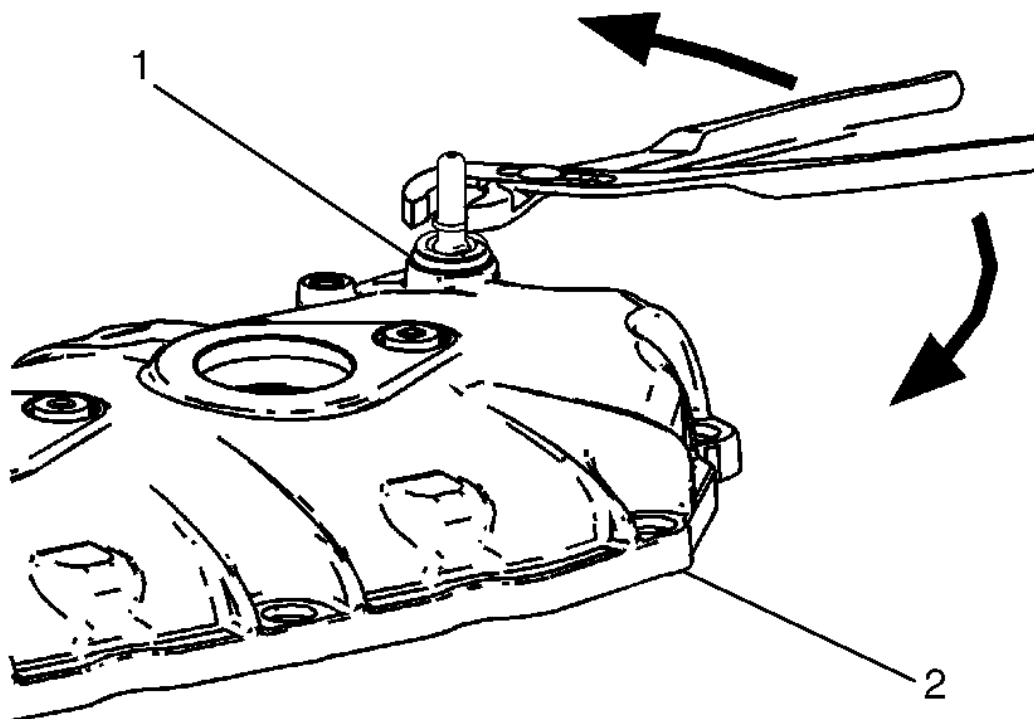
4. Inspect the exterior of the right camshaft cover for the following conditions:
- Damage to the camshaft cover bolt holes (1).
  - Damage to the mounting holes (2) for the ignition coil assembly.
  - Damage to the PCV orifice (3) - A damaged PCV orifice can be replaced. Refer to PCV Orifice Replacement below.



**Fig. 205: Identifying Interior Of Right Camshaft Cover**  
 Courtesy of GENERAL MOTORS CORP.

5. Inspect the interior of the right camshaft cover for the following conditions:
  - Gouges or damage to the camshaft cover sealing groove (1).
  - Gouges or damage to the ignition coil seal bore (2).
  - Restrictions to the ventilation system (3).
6. Repair or replace the camshaft cover or covers as necessary.

#### PCV Orifice Replacement

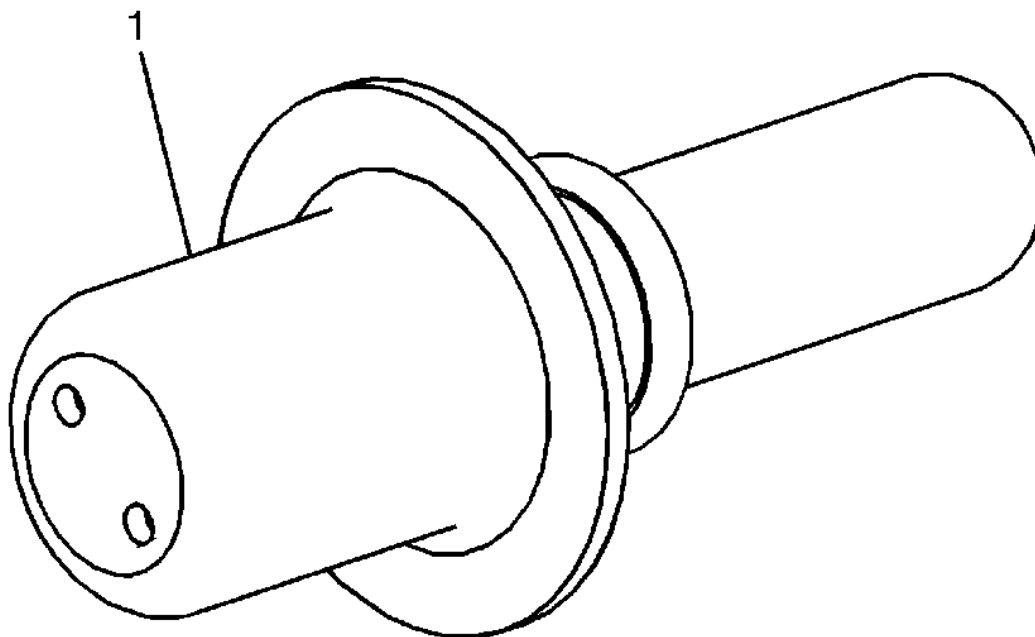


**Fig. 206: Identifying PCV Orifice & Right Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** If the PCV orifice is damaged or plugged and cannot be cleaned out, the PCV orifice can be replaced.

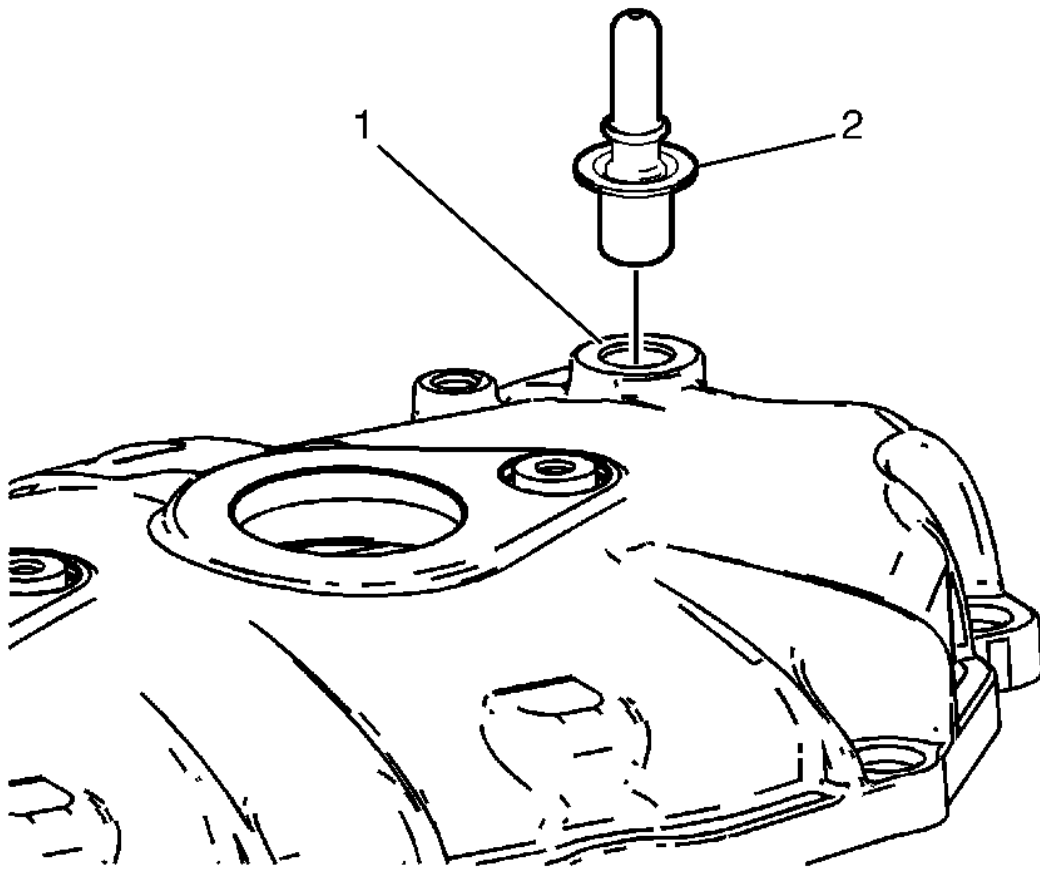
**NOTE:** Remove the PCV orifice (1) by gripping the neck of the PCV orifice (1) with pliers and twisting and pulling out of the right camshaft cover (2).

1. Remove the PCV orifice (1) from the right camshaft cover (2).



**Fig. 207: Identifying PCV Orifice**  
Courtesy of GENERAL MOTORS CORP.

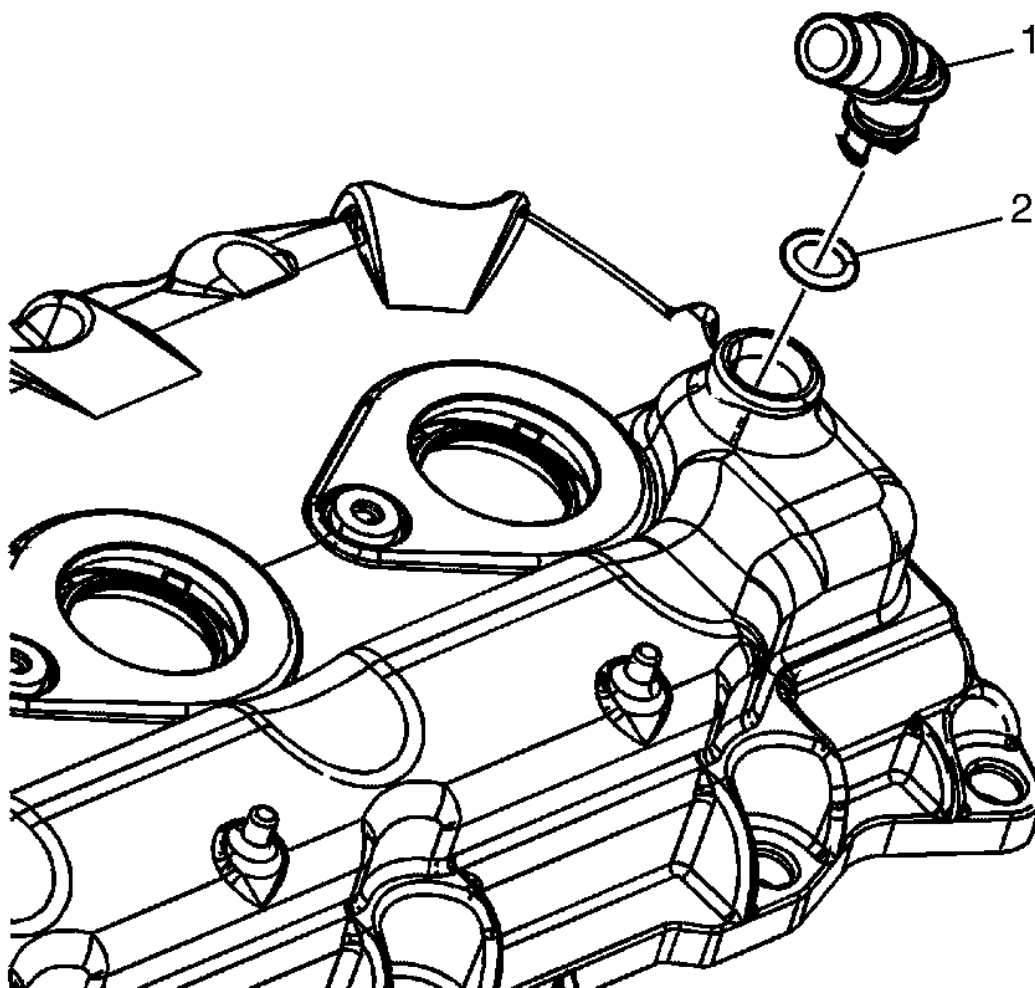
2. Apply a GM approved sealant to the NEW PCV orifice (1).



**Fig. 208: Identifying PCV Orifice & Right Camshaft Cover**  
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW PCV orifice (2) into the right camshaft cover (1). After insertion, twist the PCV orifice (2) in order to address any vertical leak paths in the sealant.

#### **PCV Fitting Replacement**



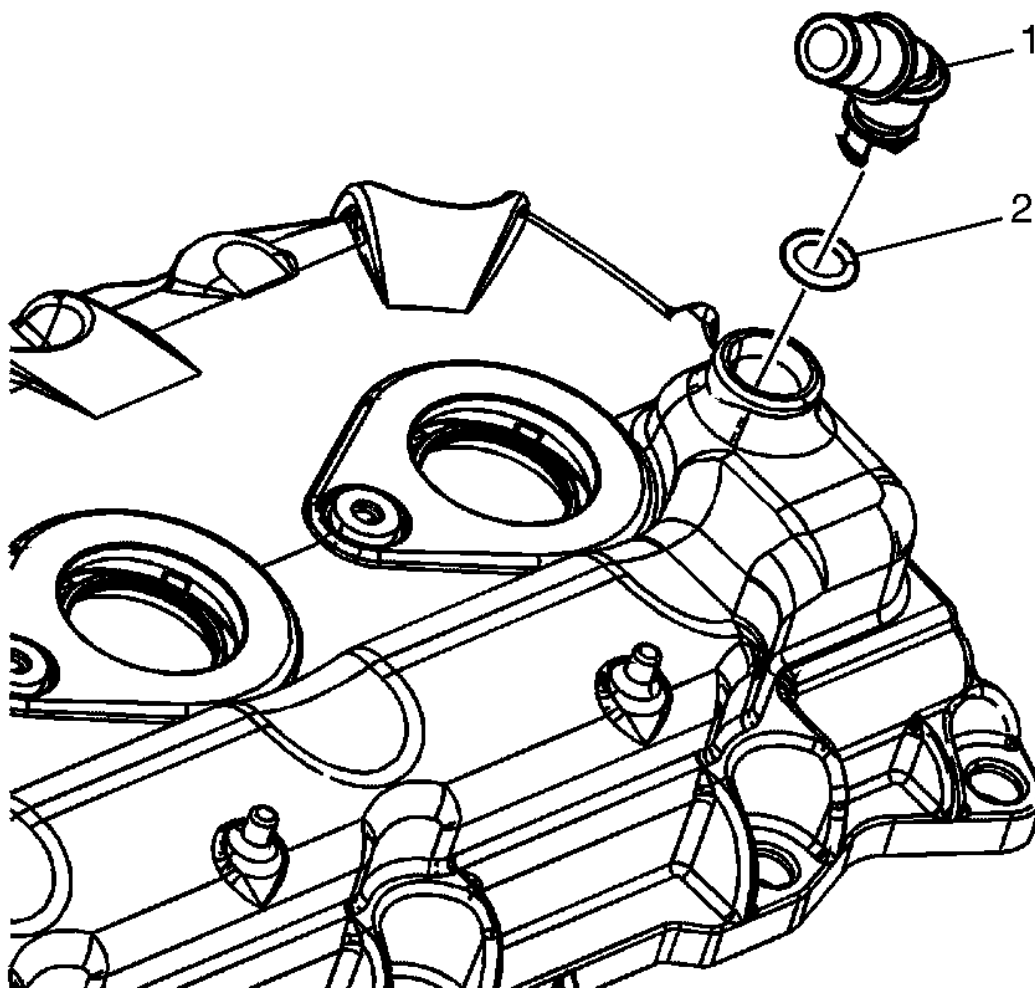
**Fig. 209: Identifying PCV Fitting & O-Ring**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** If the PCV fitting (1) is damaged or plugged and cannot be cleaned out, the PCV fitting (1) can be replaced.

**NOTE:** The PCV fitting O-ring (2) is a single use component and must be discarded whenever the PCV fitting (1) is removed.

1. Remove the PCV fitting (1).

Discard the PCV fitting O-ring (2).



**Fig. 210: Identifying PCV Fitting & O-Ring**  
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW PCV fitting (1) with a NEW PCV fitting O-ring (2).

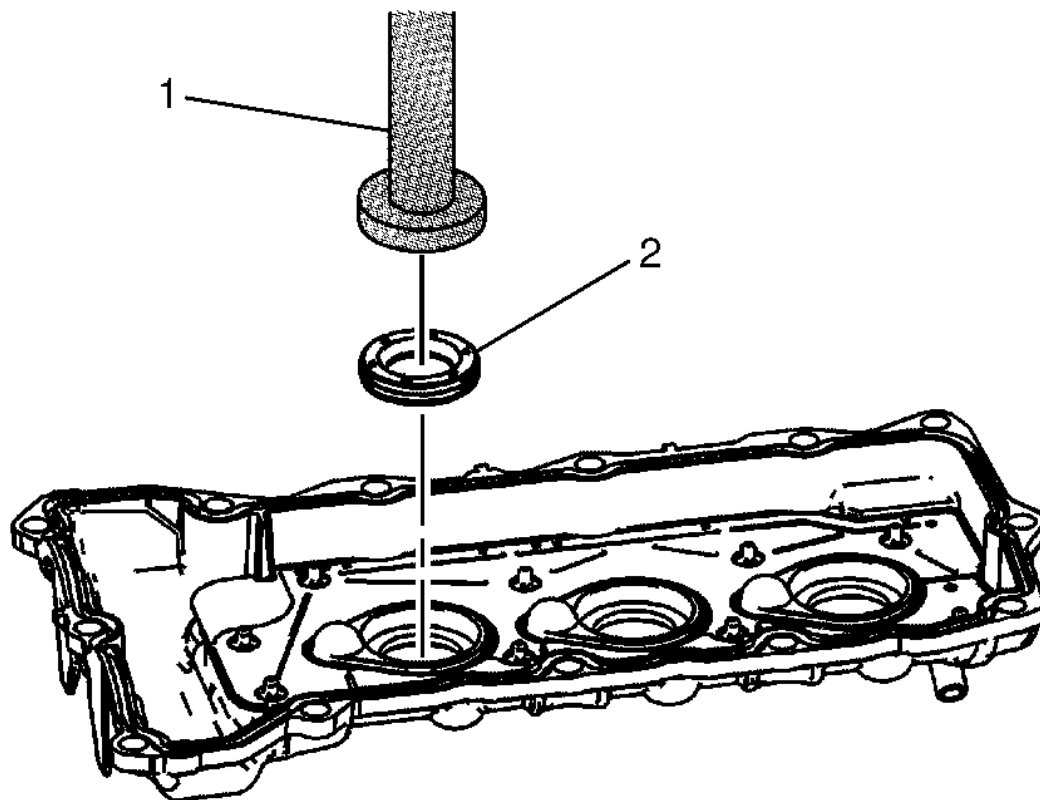
## CAMSHAFT COVER ASSEMBLE

### Tools Required

**J 24254** Oil Seal Installer. See **Special Tools** .

### Assemble



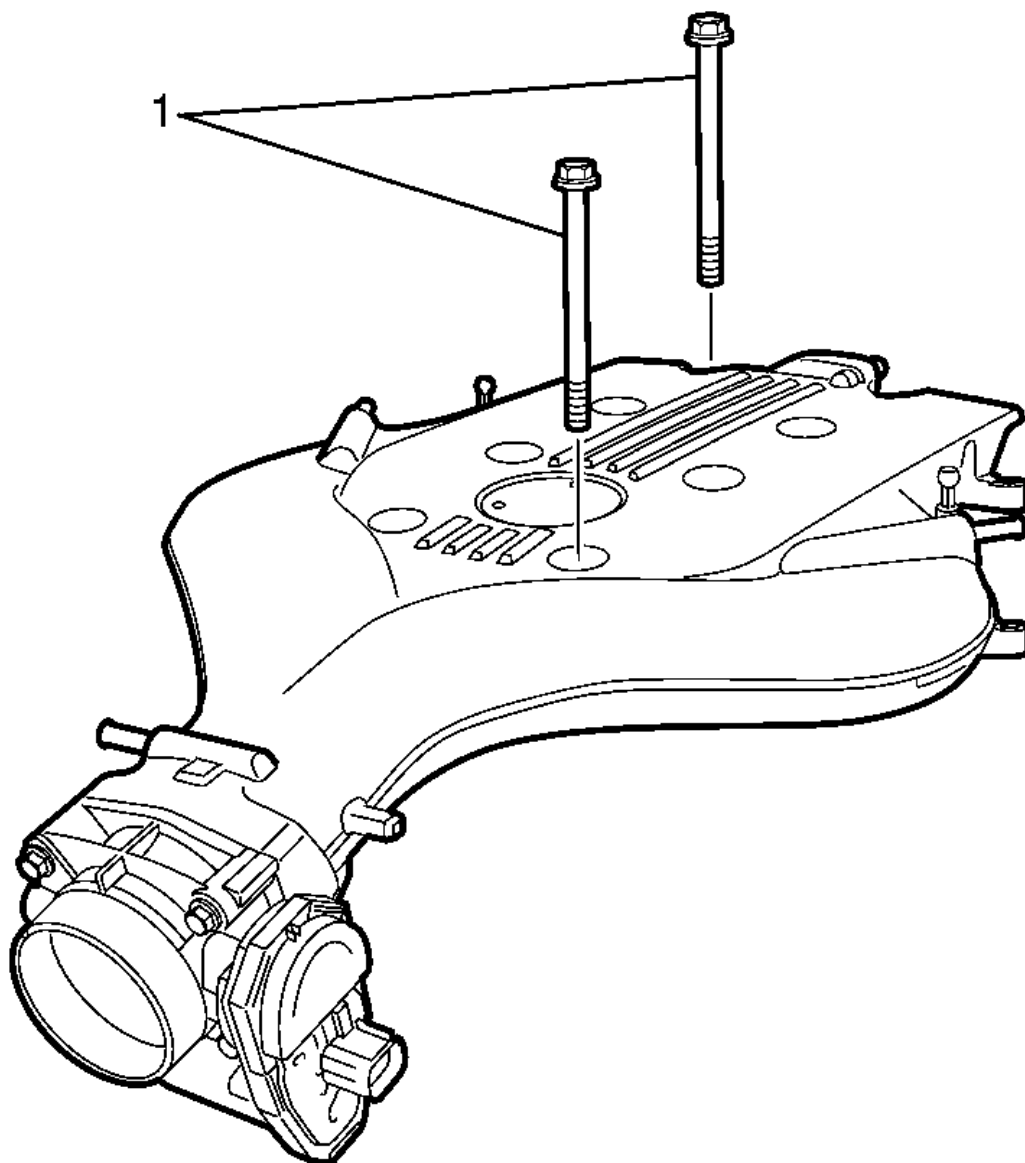


**Fig. 211: Identifying Ignition Coil Seals & J 24254**  
Courtesy of GENERAL MOTORS CORP.

Install the NEW ignition coil seals (2) using the J 24254 (1). See **Special Tools** .

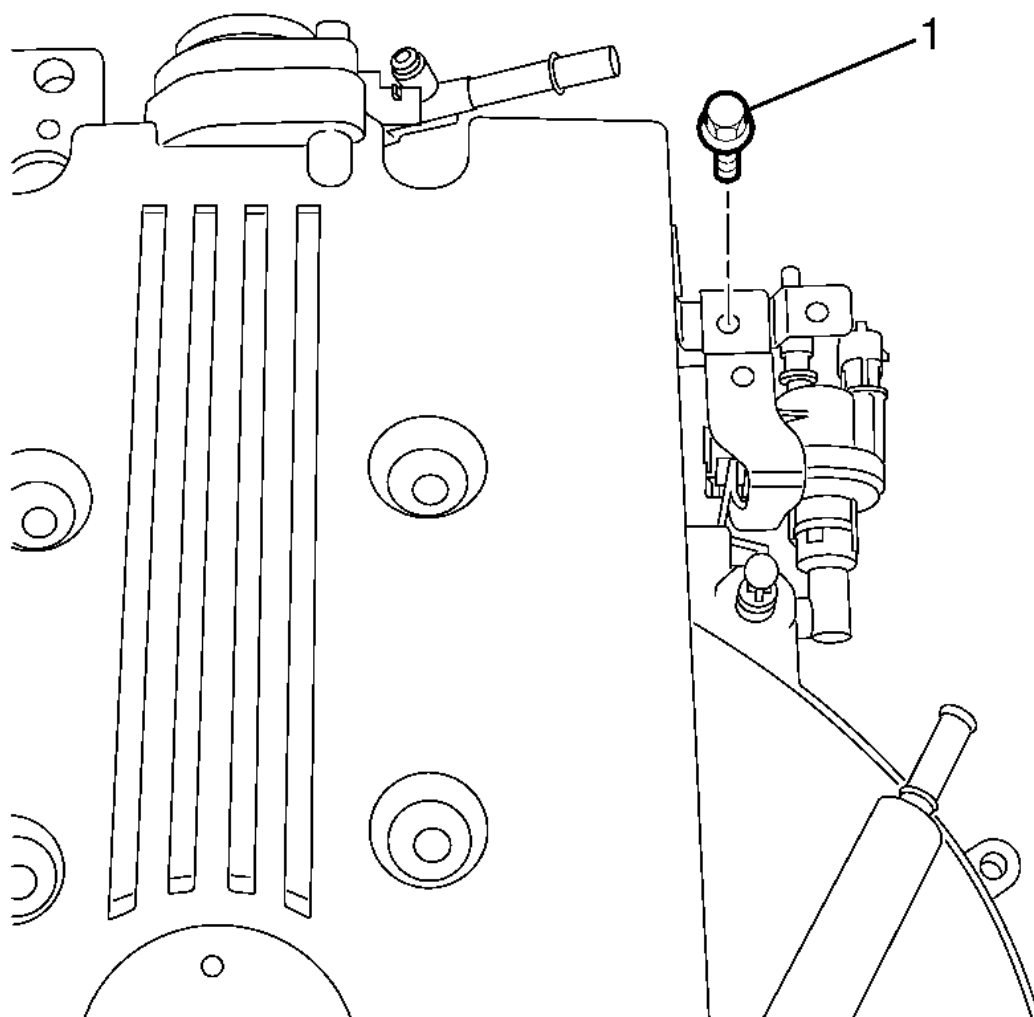
## INTAKE MANIFOLD DISASSEMBLE

### Upper to Lower Intake Manifold Disassemble Procedure



**Fig. 212: Identifying Upper-To-Lower Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

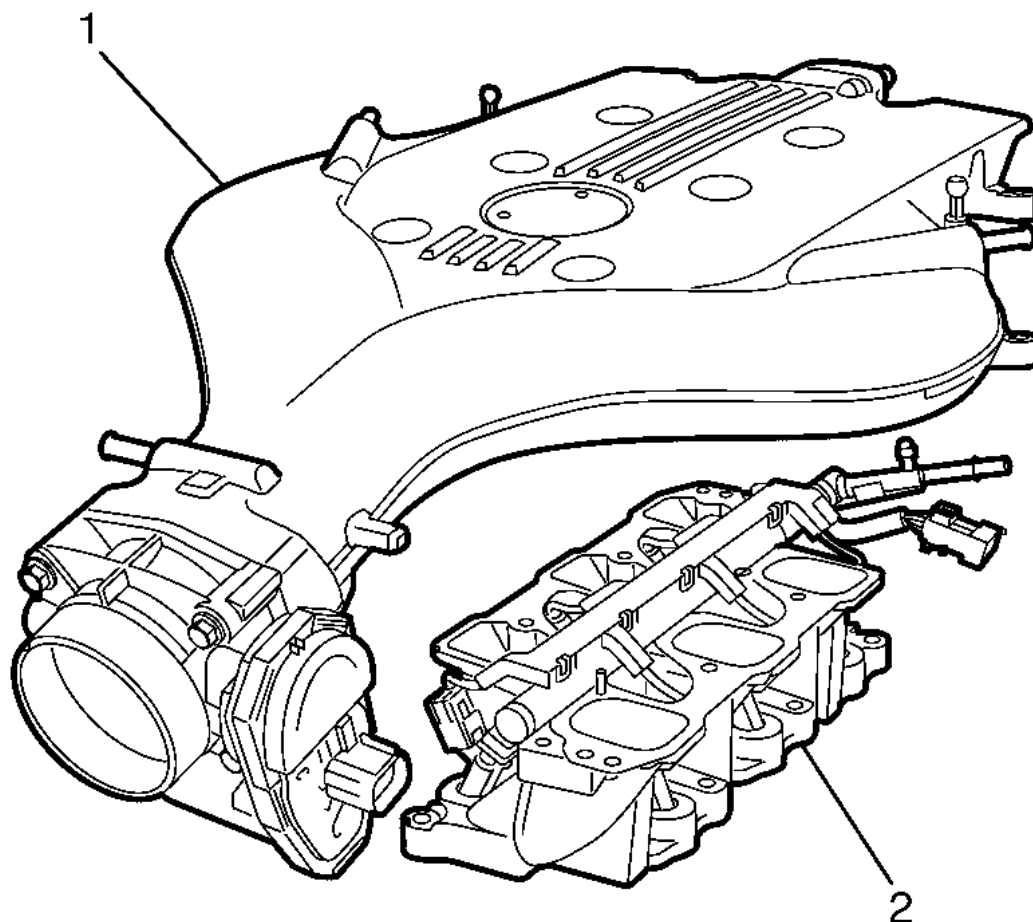
1. Remove the upper-to-lower intake manifold retaining bolts (1).



**Fig. 213: Identifying Fuel Injector Wiring Harness Bracket To Upper Intake Manifold Retaining Bolt**

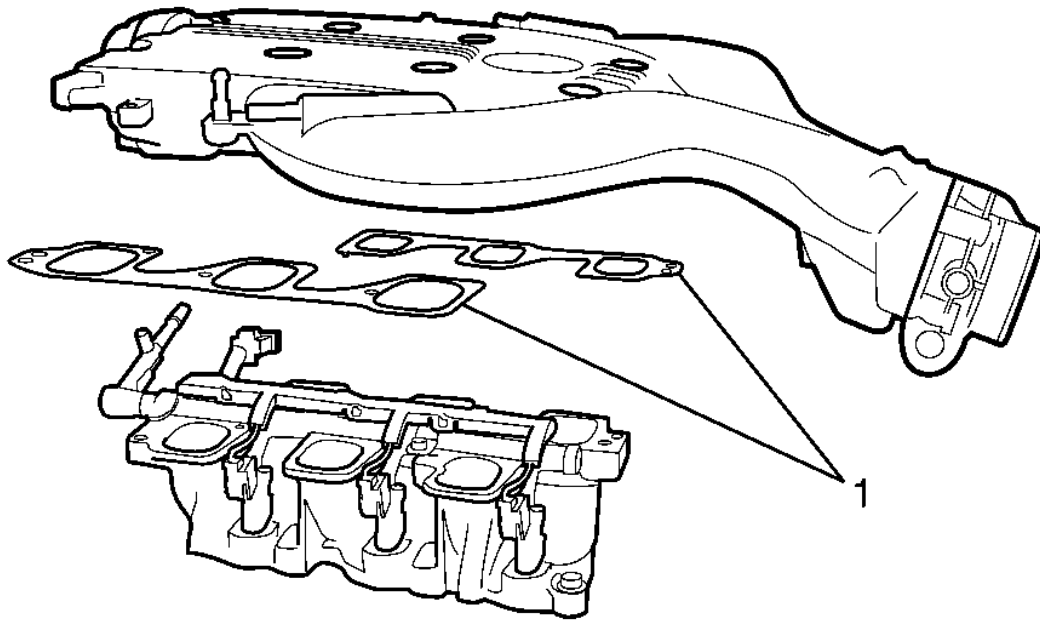
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector wiring harness bracket to upper intake manifold retaining bolt (1).



**Fig. 214: Identifying Upper & Lower Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the upper intake manifold (1) from the lower intake manifold (2).



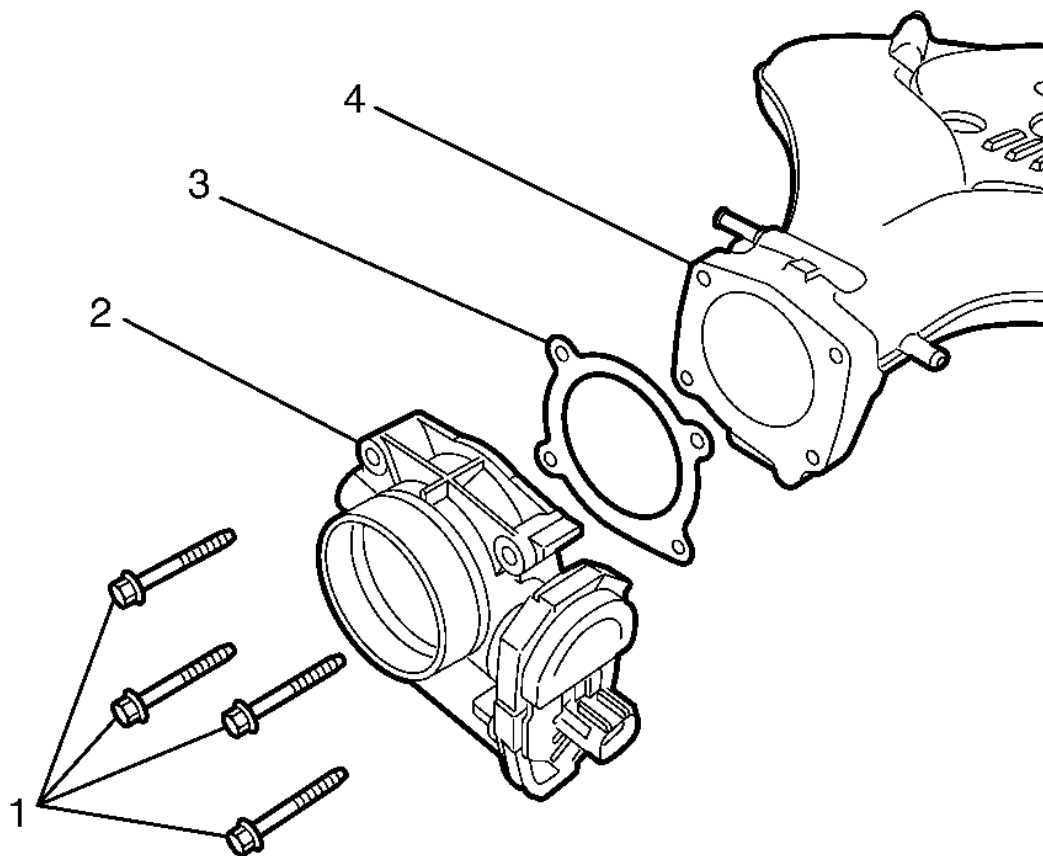
**Fig. 215: Identifying Upper-To-Lower Intake Manifold Gaskets**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.**

4. Remove the upper-to-lower intake manifold gaskets (1).

Discard the upper-to-lower intake manifold gaskets (1).

#### Upper Intake Manifold Disassemble Procedure



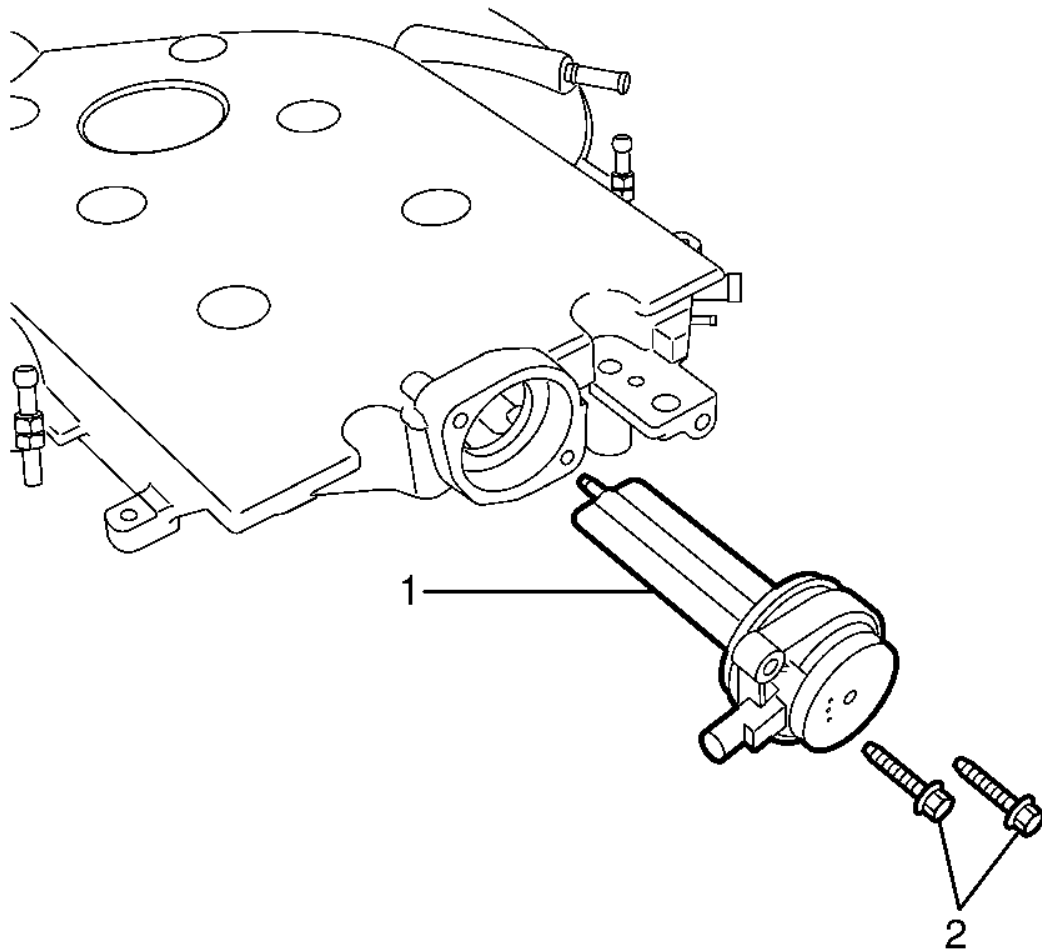
**Fig. 216: Identifying Throttle Body Bolts To Upper Intake Manifold Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body bolts to upper intake manifold retaining bolts (1).
2. Remove the throttle body (2).

**IMPORTANT:** The throttle body gasket (3) must be discarded whenever the throttle body (2) has been removed from the upper intake manifold (4).

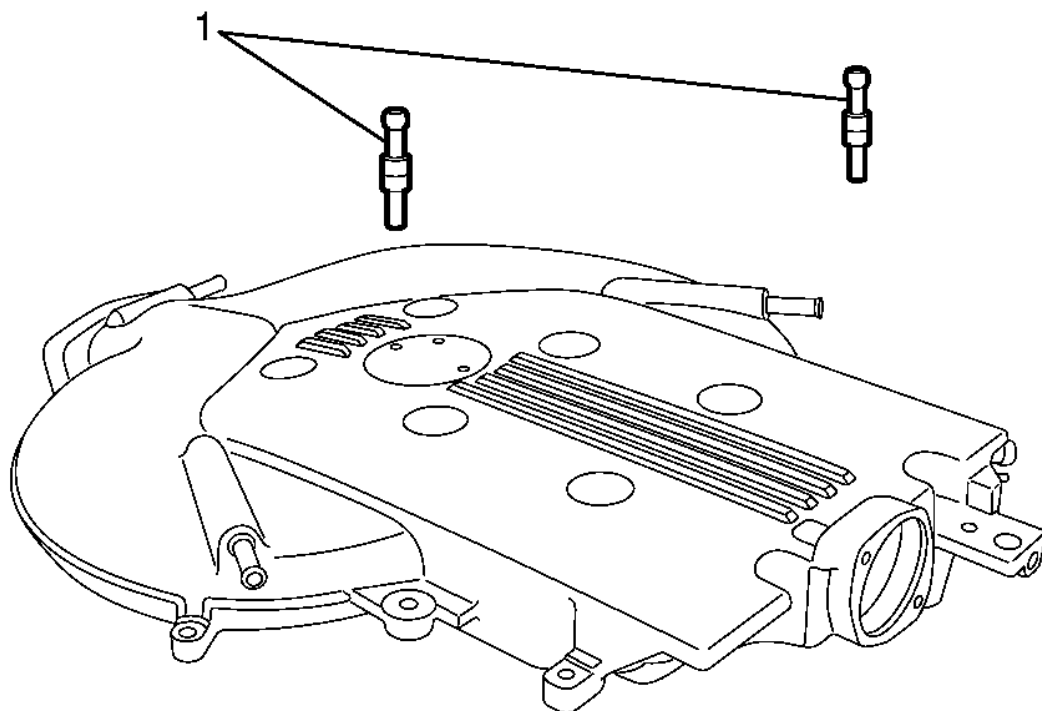
3. Remove the throttle body gasket (3).

Discard the gasket



**Fig. 217: Identifying IMRC Flap To Upper Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the Intake Manifold Runner Control (IMRC) flap to upper intake manifold retaining bolts (2).
5. Remove the IMRC flap (1).

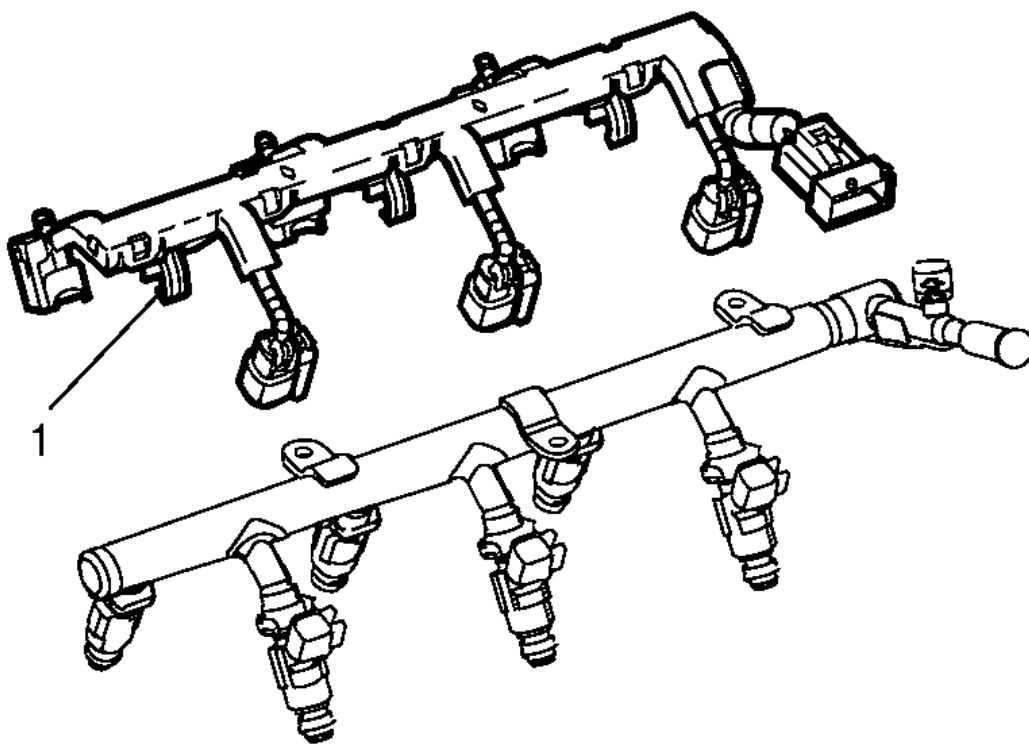


**Fig. 218: Identifying Sight Shield Ball Studs**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the sight shield ball studs (1).

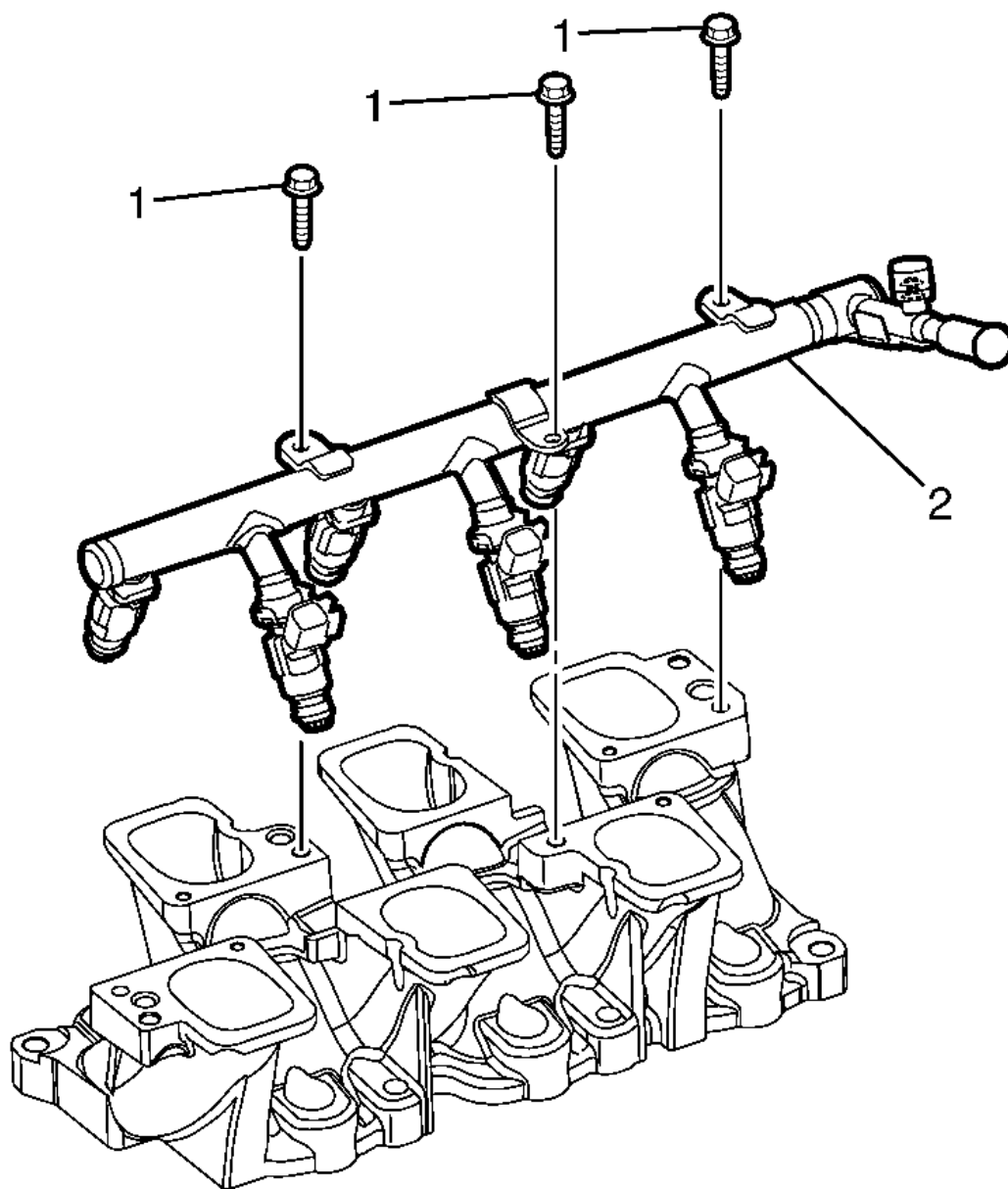
#### **Lower Intake Manifold Disassemble Procedure**





**Fig. 219: Identifying Fuel Injector Wiring Harness**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector wiring harness (1).



**Fig. 220: Identifying Fuel Injector Rail To Lower Intake Manifold Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector rail to lower intake manifold retaining bolts (1).
3. Remove the fuel injector rail (2).

## INTAKE MANIFOLD CLEANING AND INSPECTION

**Upper Intake Manifold Cleaning Procedure**

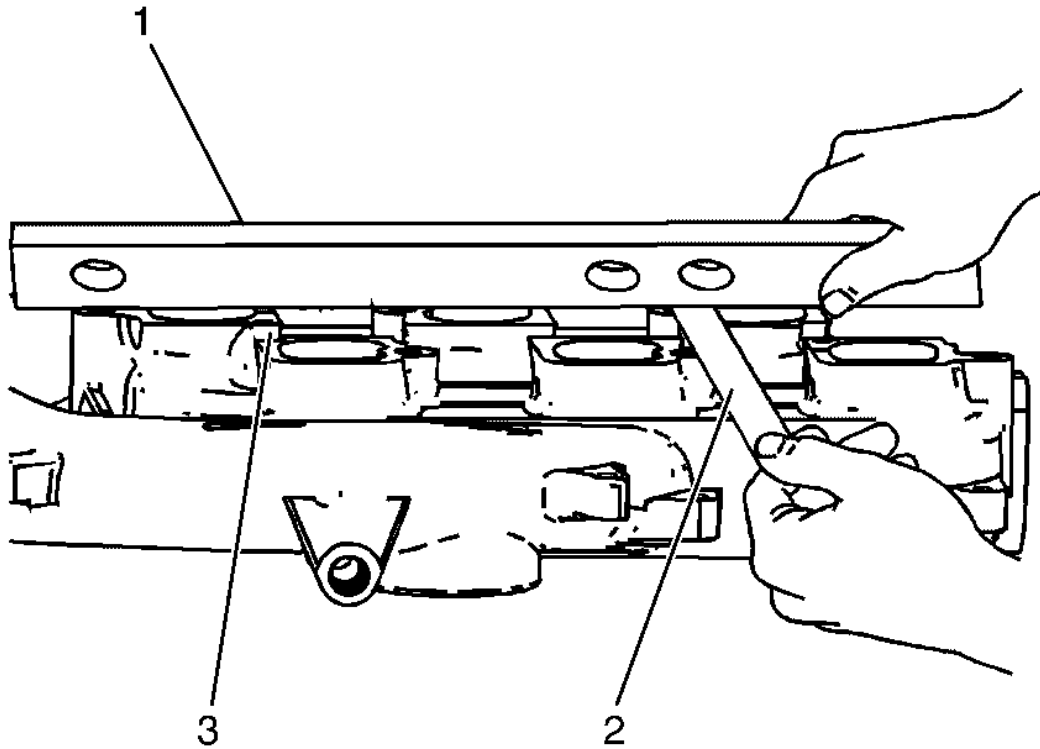
1. Remove any remaining gasket and/or gasket material from the following:
  - Throttle body.
  - Intake manifold.
2. Clean the following intake manifold areas in solvent.
  - Intake manifold gasket sealing areas.
  - Intake manifold passages.
  - Brake booster hose passage.
  - Evaporative emission (EVAP) solenoid passage.
  - Positive Crankcase Ventilation (PCV) vacuum hose passages.

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

3. Dry the upper intake manifold and throttle body with compressed air.

**Inspection Procedure**

1. Inspect the upper intake manifold for the following conditions:
  - Damage, debris or restrictions to the brake vacuum booster hose port.
  - Damage to the throttle body bolt holes.
  - Damage, debris or restrictions to the PCV system hose ports.
  - Damage to the intake manifold bolt bosses.
  - Damage to the EVAP purge solenoid mounting boss.
  - Damage, debris or restrictions to the EVAP purge solenoid port.
  - Damage, debris or restrictions in the vacuum passage.
  - Damage to the intake manifold runner control flap mounting bosses.
  - Damage, debris or restrictions to the intake manifold runner control flap port.
  - Damage to the intake manifold runner control flap components.
  - Gouges or damage to the upper intake manifold sealing surfaces.
  - Damage to the gasket sealing surface for the throttle body.



**Fig. 221: Identifying Upper Intake Manifold Sealing Surface Inspection Of Warpage**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the upper intake manifold sealing surface for warpage.
  1. Locate a straight edge (1) across the upper-to-lower intake manifold sealing surface (3).
  2. Insert a feeler gauge (2) between the upper-to-lower intake manifold sealing surface (3) and the straight edge (1). An upper intake manifold with warpage in excess of 0.05 mm (0.020 in) must be replaced.
3. Repair or replace the upper intake manifold as necessary.

#### **Lower Intake Manifold Cleaning Procedure**

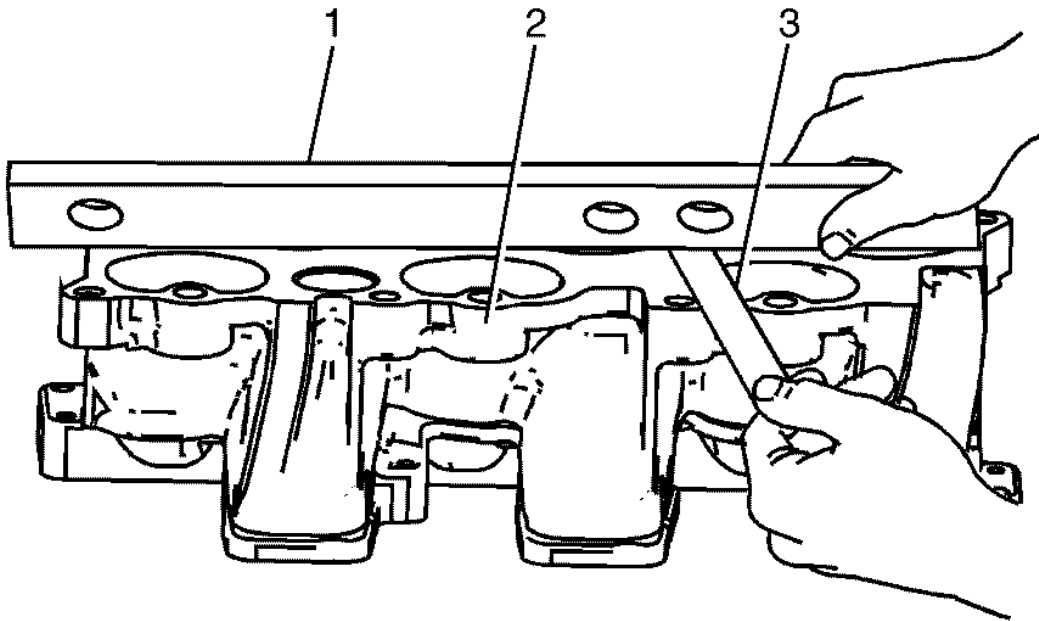
1. Remove any remaining gasket and/or gasket material from the following:
  - Upper-to-lower intake manifold sealing surface.
  - Cylinder head-to-lower intake manifold sealing surface.
2. Clean the following intake manifold areas in solvent.
  - Intake manifold gasket sealing surfaces.
  - Intake manifold passages.

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

3. Dry the intake manifold with compressed air.

#### Inspection Procedure

1. Inspect the lower intake manifold for the following conditions:
  - Damage, debris or restrictions to the lower intake manifold ports
  - Damage to the fuel rail mounting bolt holes
  - Damage to the fuel rail
  - Gouges or damage to the intake manifold sealing surfaces
  - Damage to the lower intake manifold bolt bosses
  - Damage to the fuel injector ports

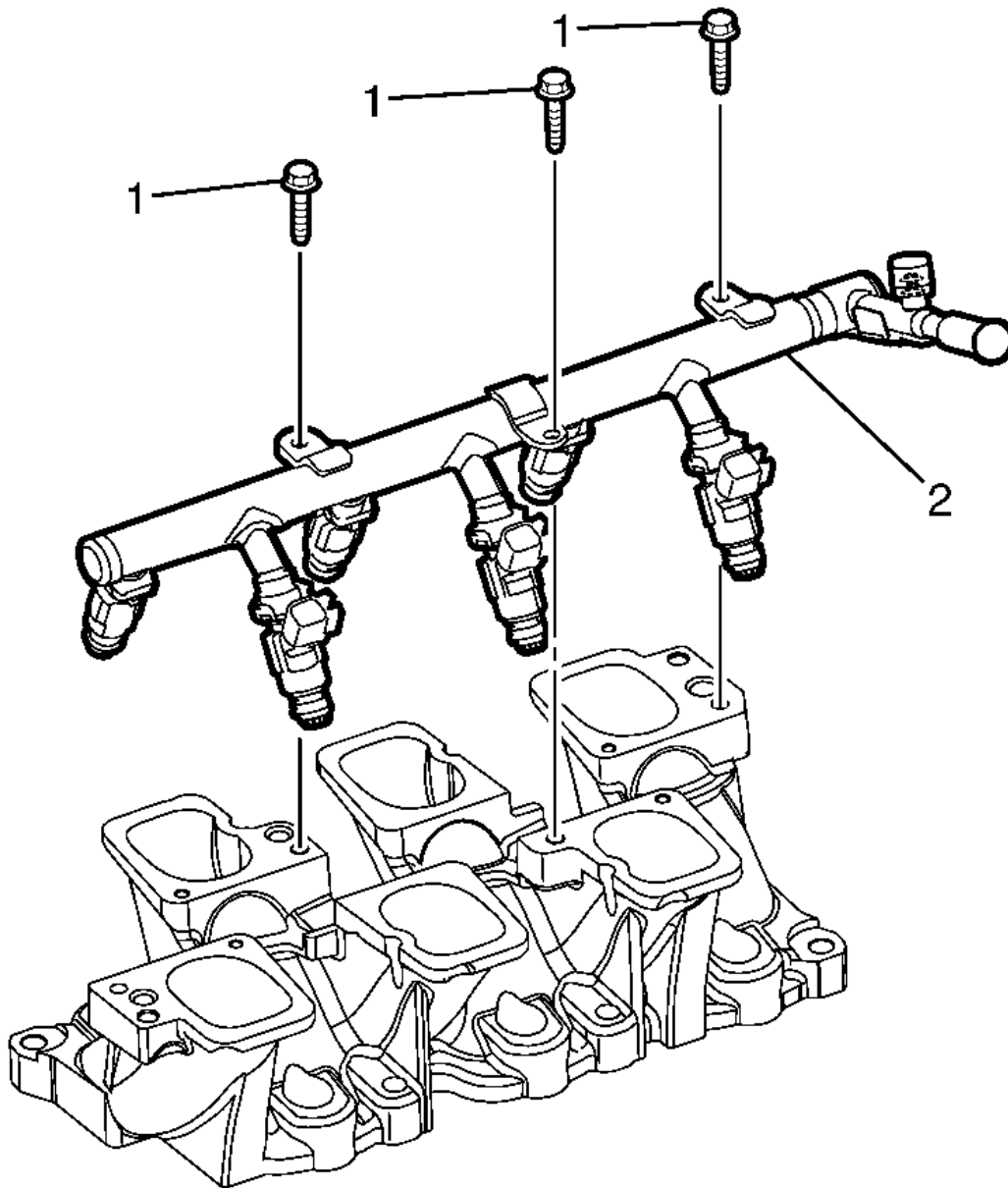


**Fig. 222: Identifying Lower Intake Manifold Sealing Surface Inspection Of Warpage**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the lower intake manifold sealing surfaces for warpage.
  1. Locate a straight edge (1) across the lower intake manifold sealing surfaces (2).
  2. Insert a feeler gauge (3) between the lower intake manifold sealing surfaces (2) and the straight edge (1). A lower intake manifold with warpage in excess of 0.5 mm (0.020 in) must be replaced.
3. Repair or replace the lower intake manifold as necessary.

## INTAKE MANIFOLD ASSEMBLE

### Lower Intake Manifold Assemble Procedure

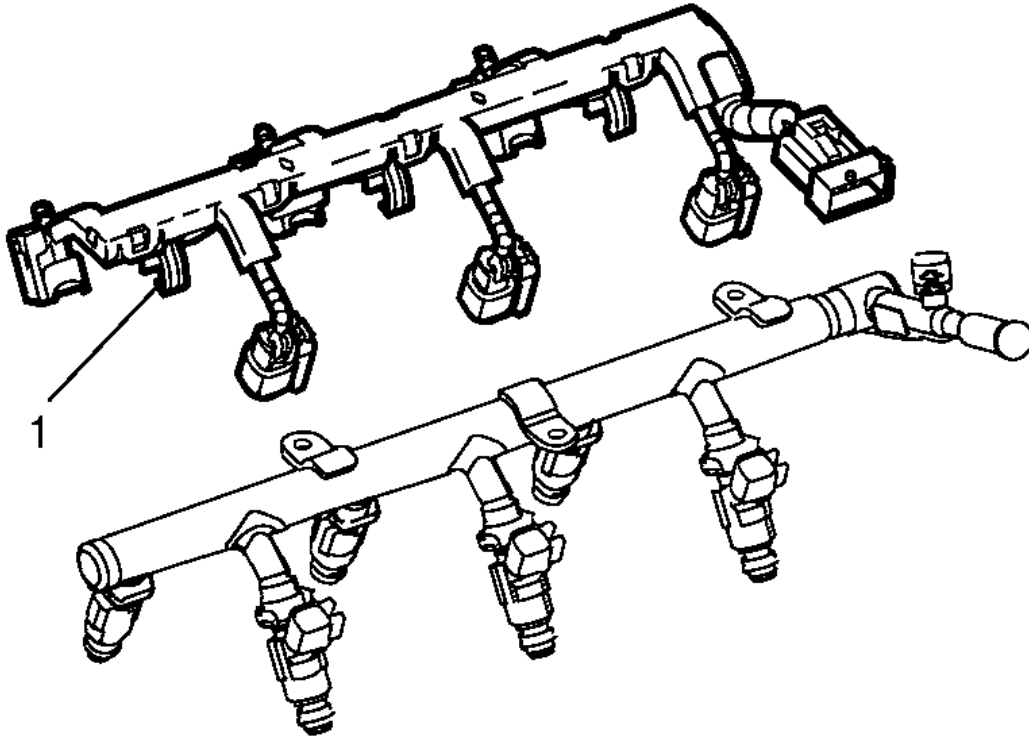


**Fig. 223: Identifying Fuel Injector Rail To Lower Intake Manifold Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

1. Install the fuel injector rail (2).

**CAUTION:** Refer to Fastener Caution .

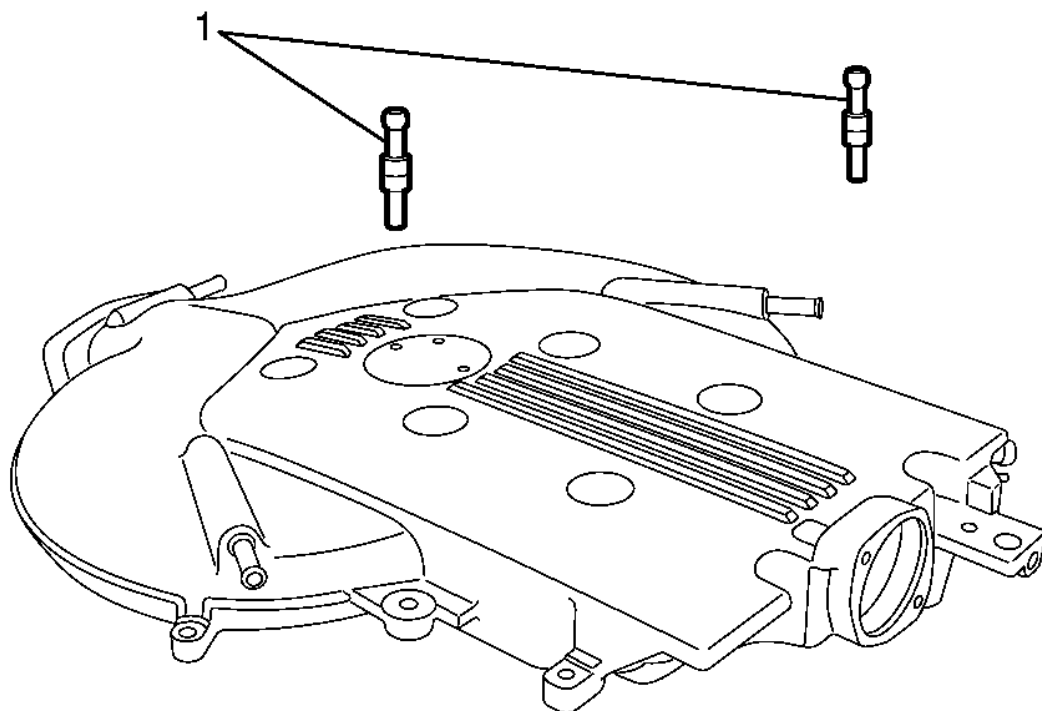
2. Install the fuel injector rail to lower intake manifold retaining bolts (1) and tighten fuel injector rail bolts to 10 N.m (89 lb in).



**Fig. 224: Identifying Fuel Injector Wiring Harness**  
 Courtesy of GENERAL MOTORS CORP.

3. Install the fuel injector wiring harness (1).

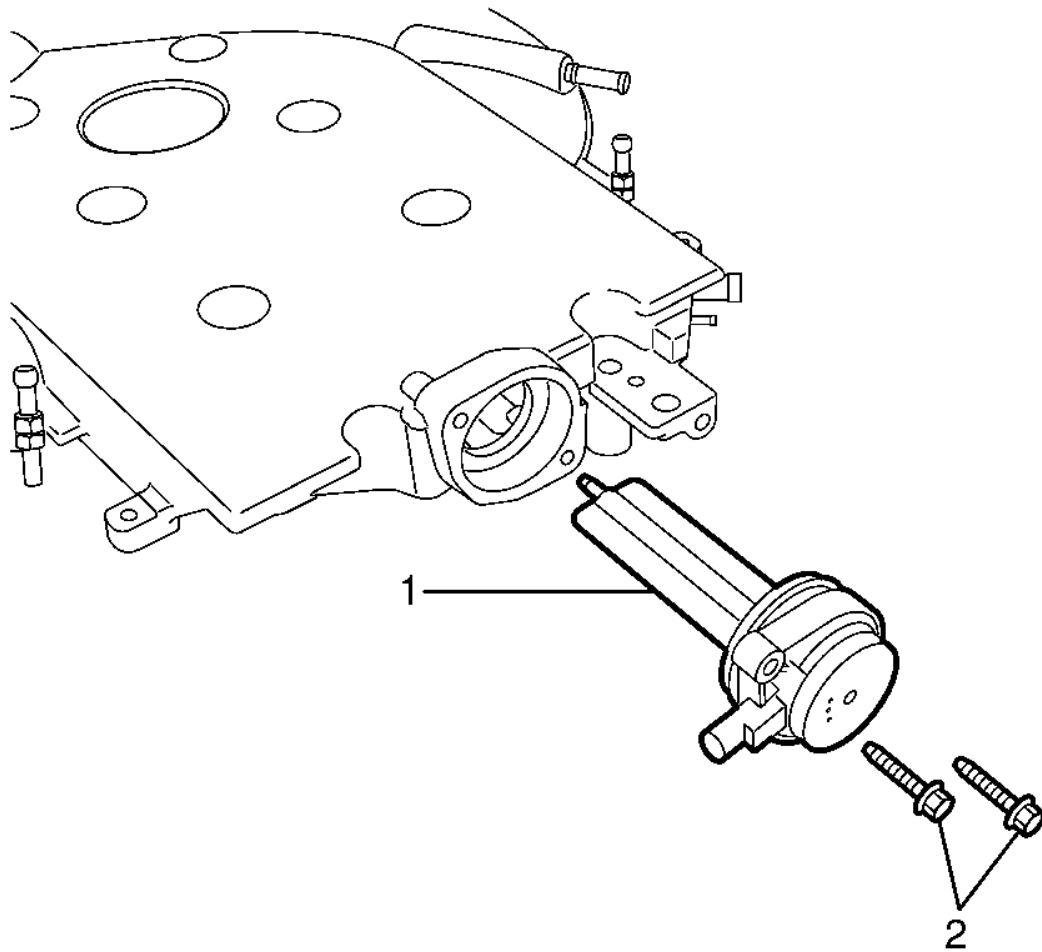
#### Upper Intake Manifold Assemble Procedure



**Fig. 225: Identifying Sight Shield Ball Studs**  
Courtesy of GENERAL MOTORS CORP.

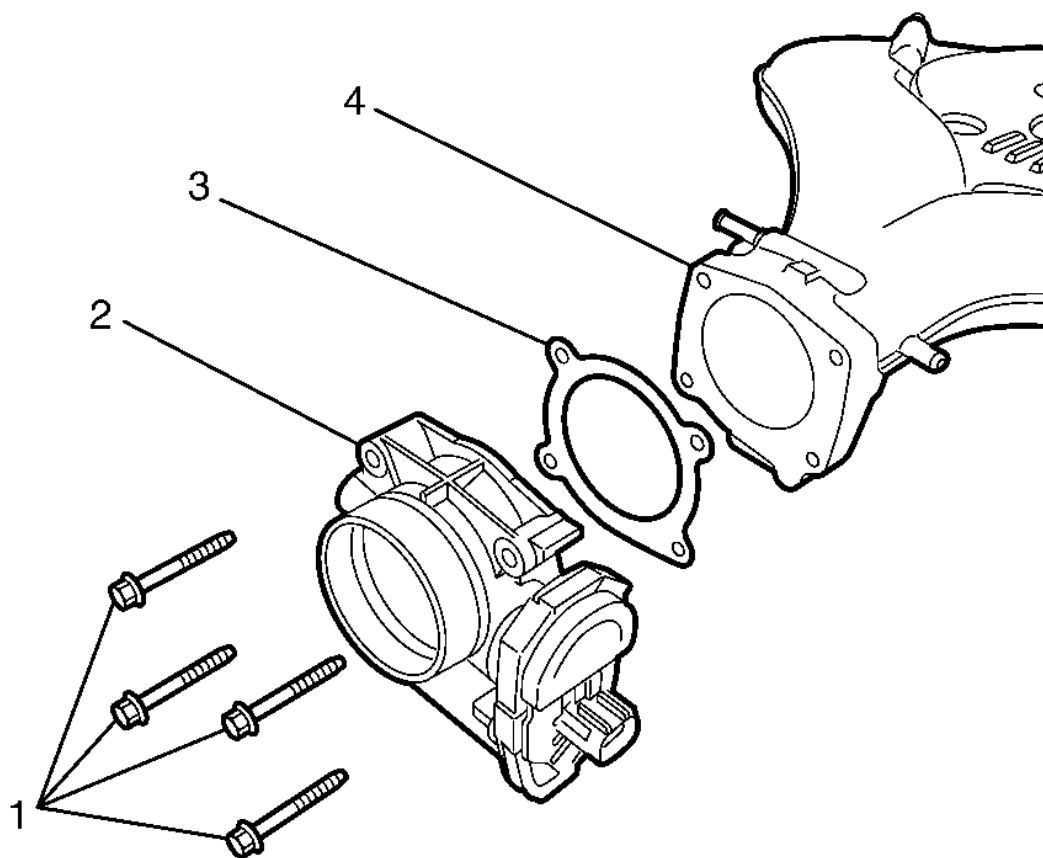
1. Install the engine cover ball studs (1) and tighten to 7 N.m (62 lb in).





**Fig. 226: Identifying IMRC Flap To Upper Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

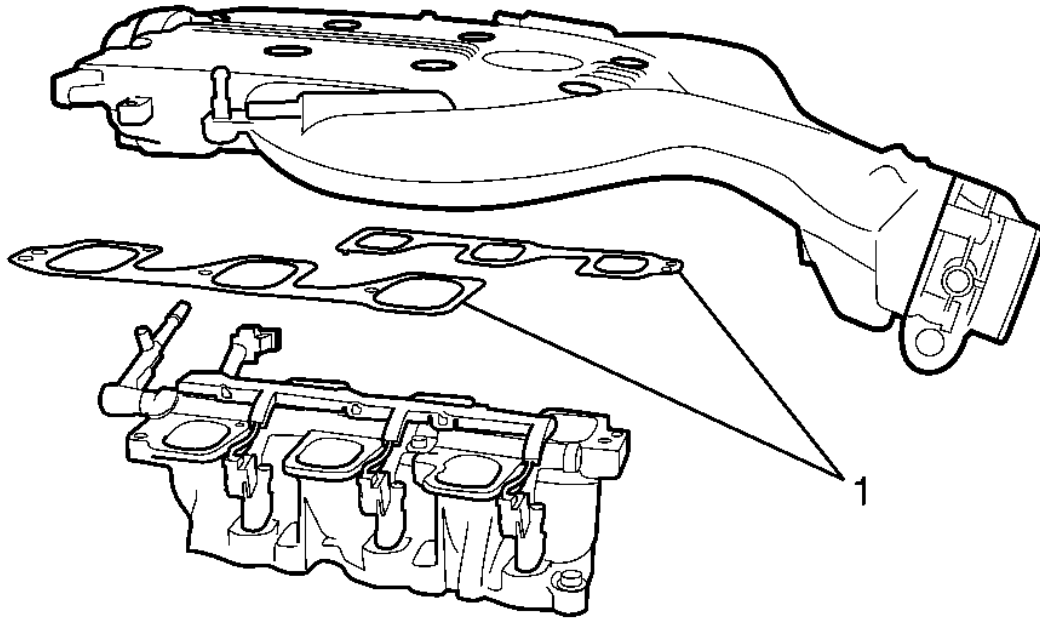
2. Install the Intake Manifold Runner Control (IMRC) flap (1).
3. Install the IMRC flap to upper intake manifold retaining bolts (2) and tighten to 10 N.m (89 lb in).



**Fig. 227: Identifying Throttle Body Bolts To Upper Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW throttle body gasket (3) to the intake manifold (4).
5. Install the throttle body (2).
6. Install the throttle body bolts to upper intake manifold retaining bolts (1) and tighten to 10 N.m (89 lb in).

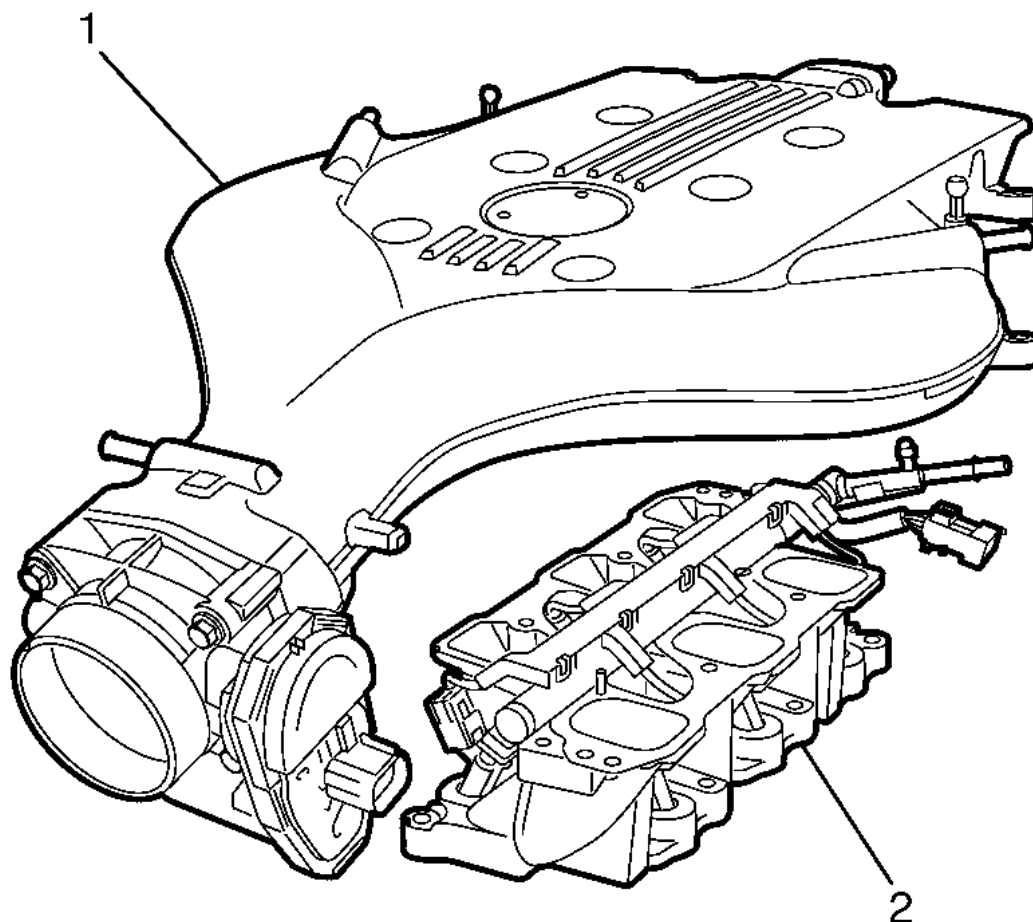
#### Upper to Lower Intake Manifold Assemble Procedure



**Fig. 228: Identifying Upper-To-Lower Intake Manifold Gaskets**  
Courtesy of GENERAL MOTORS CORP.

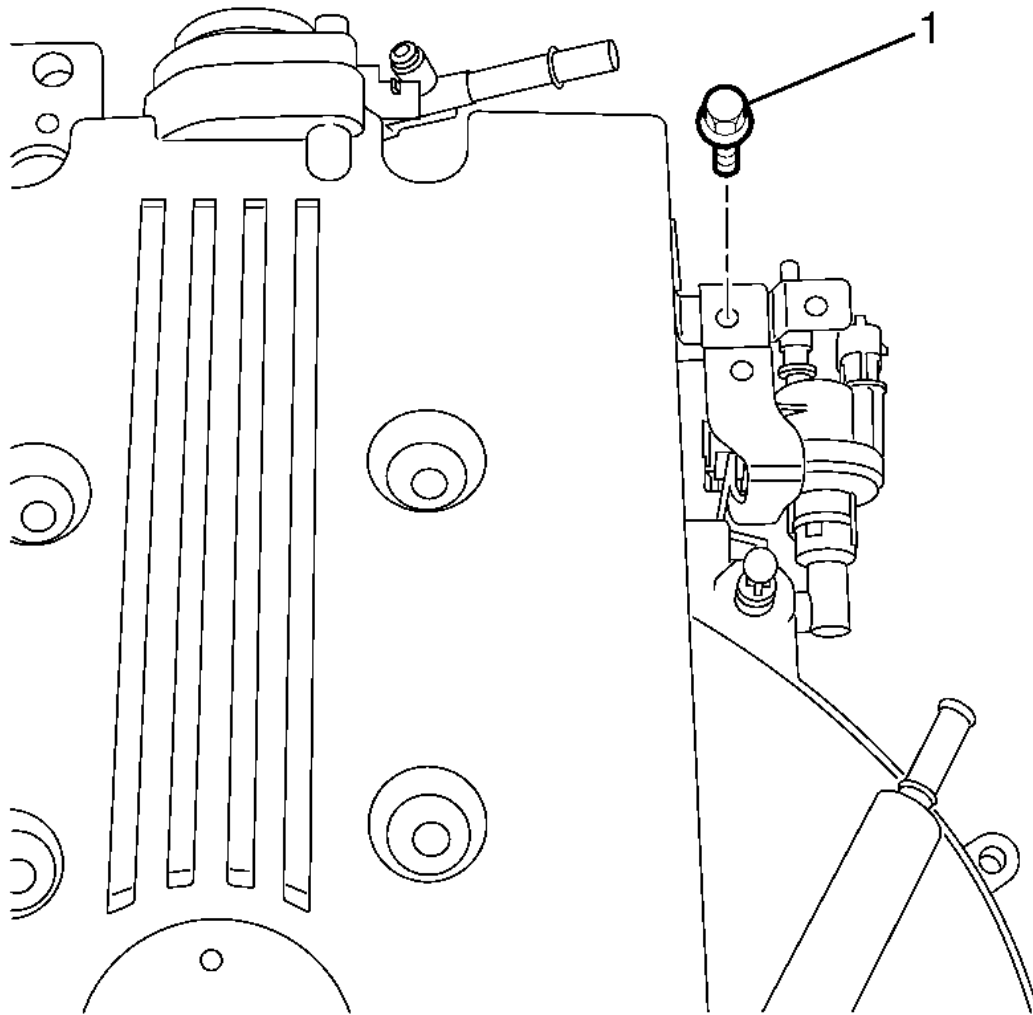
**NOTE:**        **DO NOT** reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

1. Install the NEW upper-to-lower intake manifold gaskets (1).



**Fig. 229: Identifying Upper & Lower Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

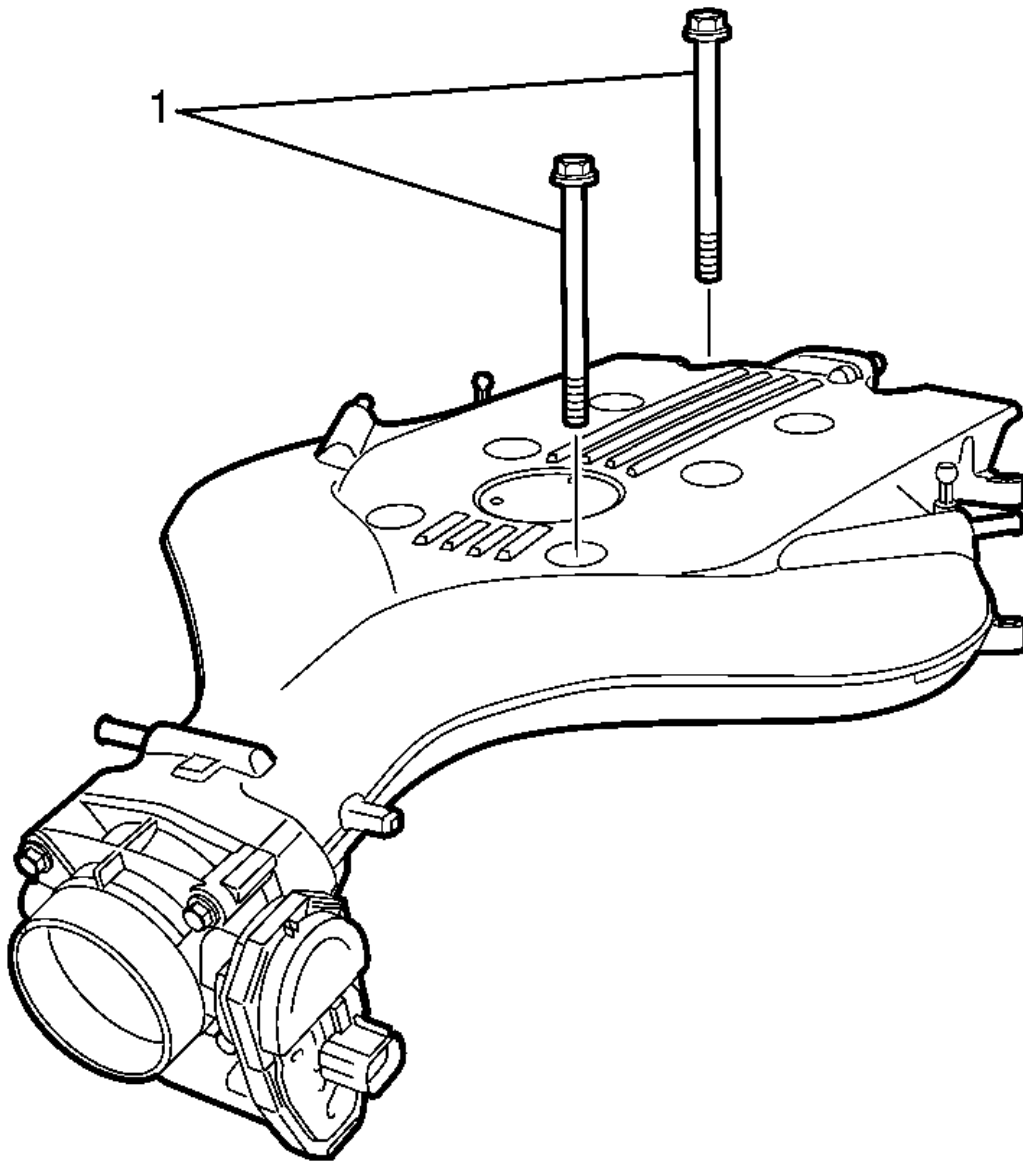
2. Install the upper intake manifold (1) to the lower intake manifold (2).



**Fig. 230: Identifying Fuel Injector Wiring Harness Bracket To Upper Intake Manifold Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

3. Install the fuel injector wiring harness bracket to upper intake manifold retaining bolt (1) and tighten to 10 N.m (89 lb in).



**Fig. 231: Identifying Upper-To-Lower Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the upper-to-lower intake manifold retaining bolts (1) and tighten to 23 N.m (17 lb ft).

## **EXHAUST MANIFOLD CLEANING AND INSPECTION - LEFT SIDE**

### **Cleaning Procedure**

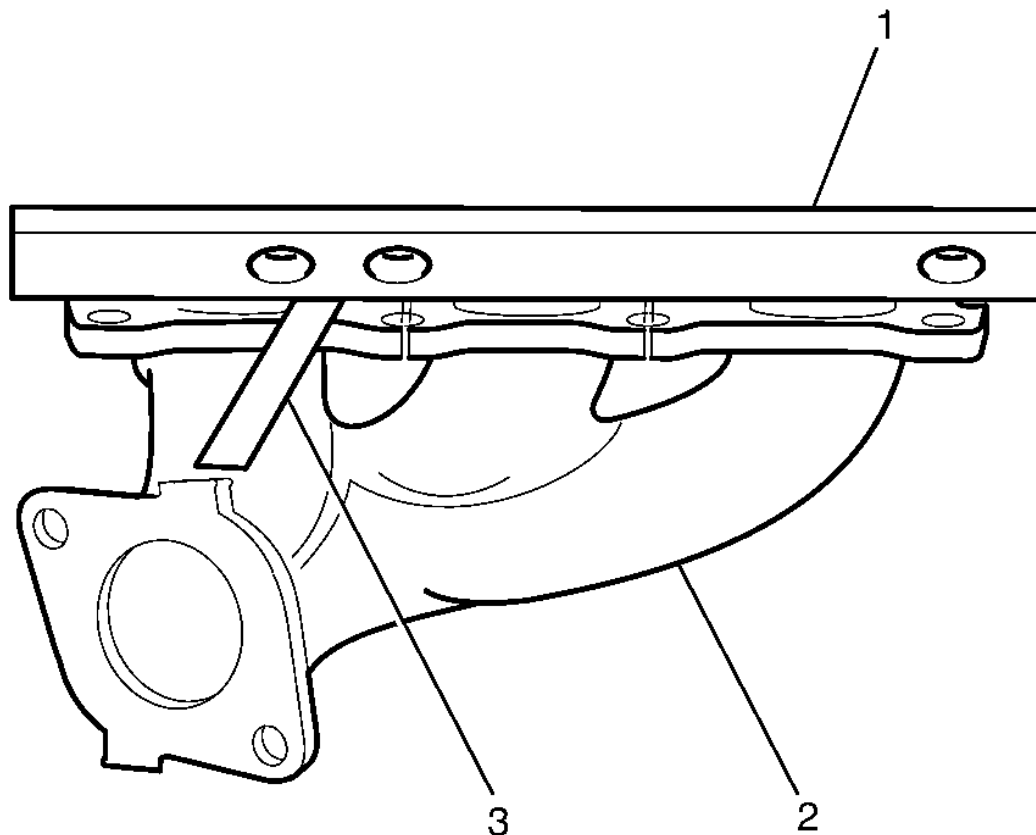
1. Clean the exhaust manifold in solvent.

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

2. Dry the exhaust manifold with compressed air.

#### **Inspection Procedure**

1. Inspect the left exhaust manifold for the following:
  - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
  - Damage to the exhaust manifold mounting holes.
  - Damage to the threaded holes for the heat shield.
  - Damage to the exhaust manifold flange bolt holes.
  - Damage to the gasket sealing surfaces.
  - Damage or restrictions within the exhaust passages.
2. Repair or replace the left exhaust manifold and/or components as necessary.



**Fig. 232: Identifying Measurement Of Alignment Or Surface Flatness Of Exhaust Manifold Flanges**

Courtesy of GENERAL MOTORS CORP.

3. Measure the alignment or surface flatness of the exhaust manifold (2) flanges, using a straight edge (1) and a feeler gauge (3). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the surface flatness is not within specifications, the exhaust manifold (2) is warped and must be replaced.

## EXHAUST MANIFOLD CLEANING AND INSPECTION - RIGHT SIDE

### Cleaning Procedure

1. Clean the exhaust manifold in solvent.

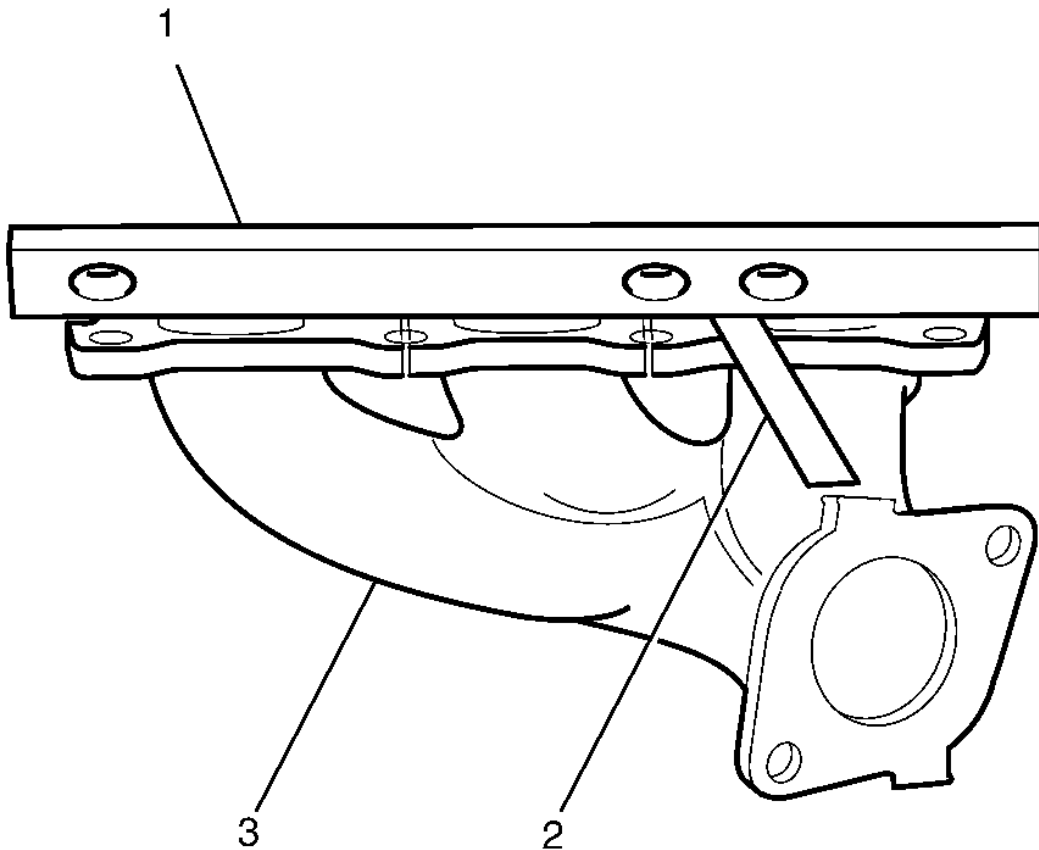
**WARNING:** Refer to Safety Glasses Warning .



2. Dry the exhaust manifold with compressed air.

**Inspection Procedure**

1. Inspect the left exhaust manifold for the following:
  - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
  - Damage to the exhaust manifold mounting holes.
  - Damage to the threaded holes for the heat shield.
  - Damage to the exhaust manifold flange bolt holes.
  - Damage to the gasket sealing surfaces.
  - Damage or restrictions within the exhaust passages.
2. Repair or replace the left exhaust manifold and/or components as necessary.



**Fig. 233: Identifying Measurement Of Alignment Or Surface Flatness Of Exhaust Manifold Flanges**

Courtesy of GENERAL MOTORS CORP.

3. Measure the alignment or surface flatness of the exhaust manifold (3) flanges, using a straight edge (1) and a feeler gauge (2). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the surface flatness is not within specifications, the exhaust manifold (3) is warped and must be replaced.

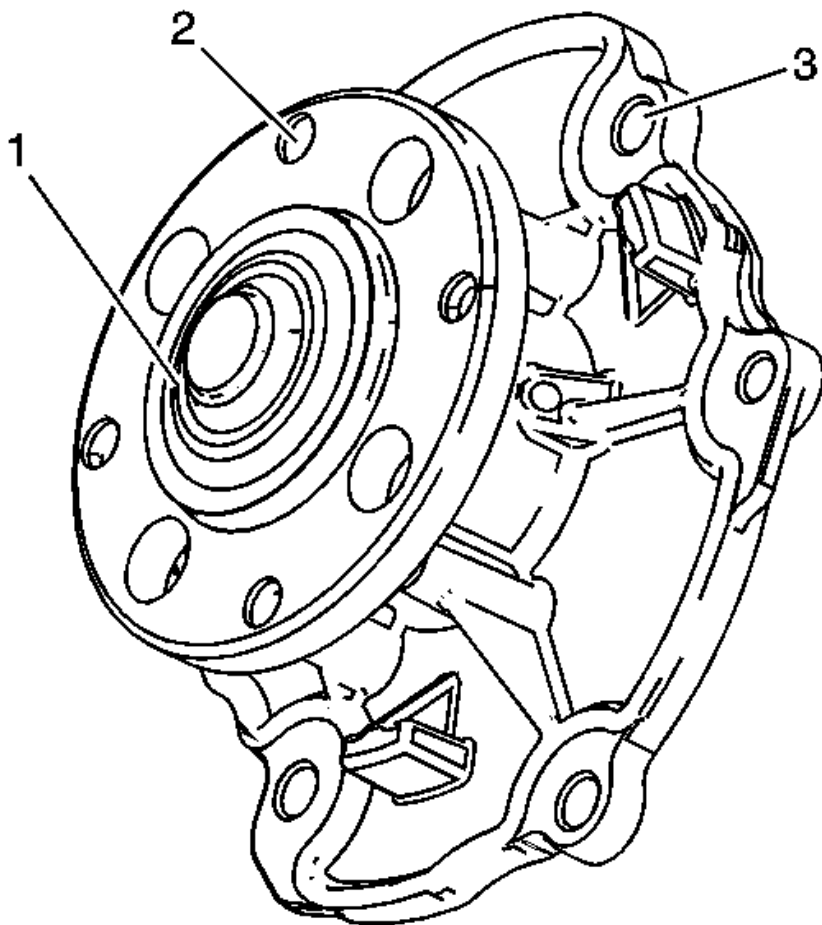
## **WATER PUMP CLEANING AND INSPECTION**

### **Cleaning Procedure**

**CAUTION:** Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

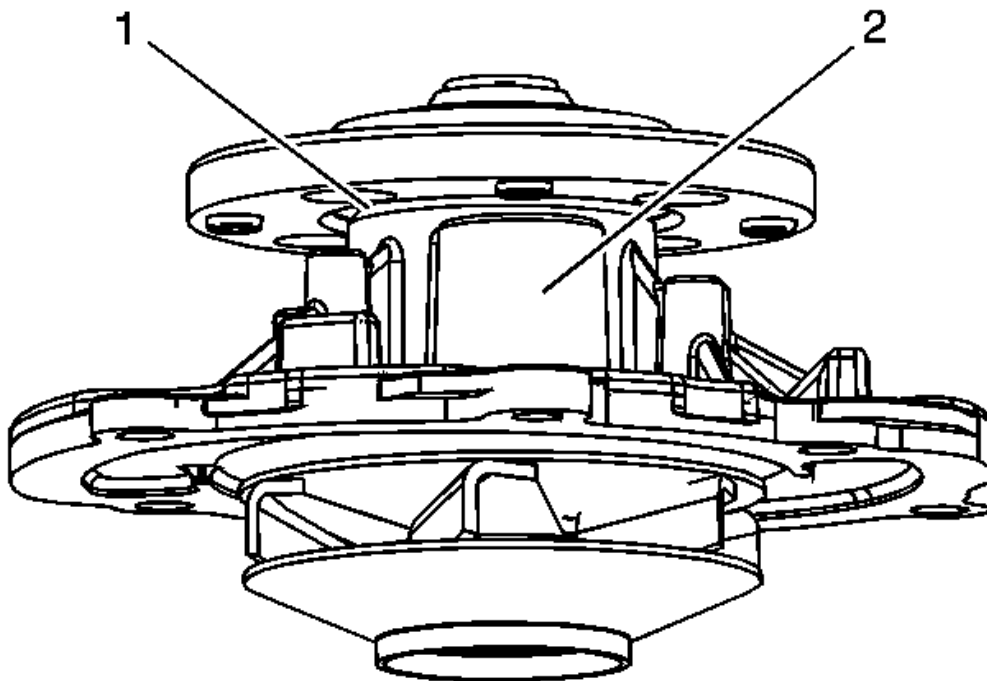
1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.

### **Inspection Procedure**



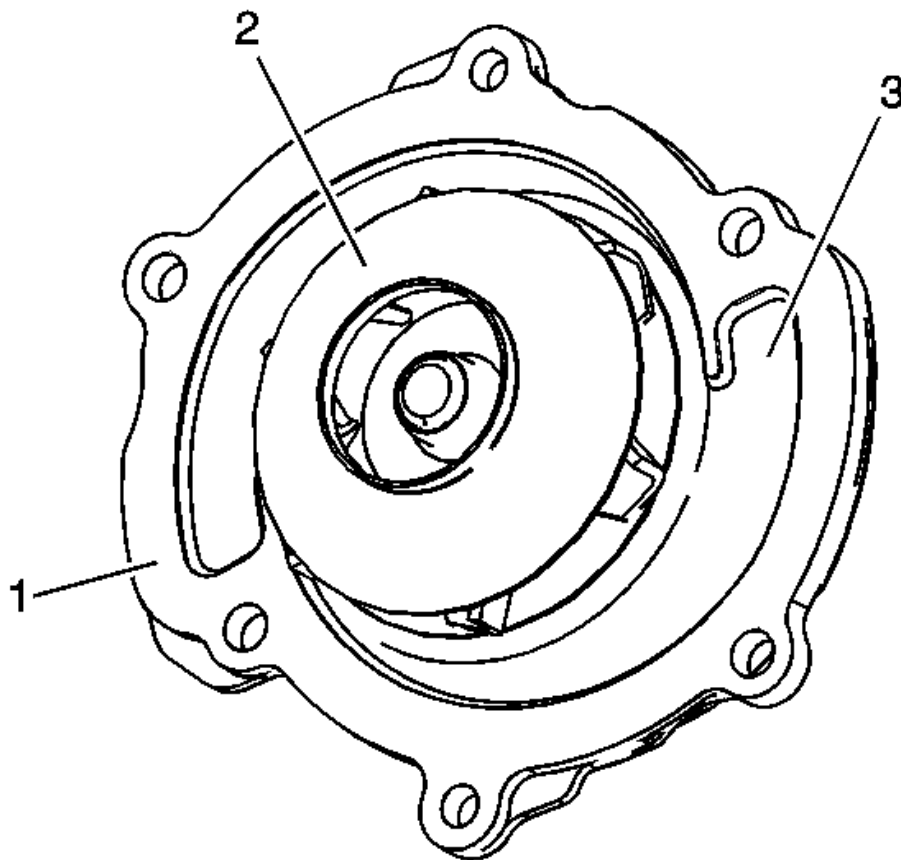
**Fig. 234: Inspecting Water Pump & Hub**  
Courtesy of GENERAL MOTORS CORP.

1. Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
2. Inspect the exterior of the water pump for the following:
  - Damage to the water pump hub bolt threads (2) for the water pump pulley
  - Damage to the water pump bolt holes (3)



**Fig. 235: Checking Water Pump Shaft & Weep Hole For Leakage**  
Courtesy of GENERAL MOTORS CORP.

3. Examine the water pump shaft (1) and the weep hole reservoir (2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.



**Fig. 236: Inspecting Interior Of Water Pump For Damage**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the interior of the water pump for the following:
  - Damage to the water pump gasket sealing surface (1)
  - Damage, corrosion or restrictions to the water pump impeller (2)
  - Damage, corrosion or restrictions to the coolant passages (3)
5. Repair or replace the water pump as necessary.

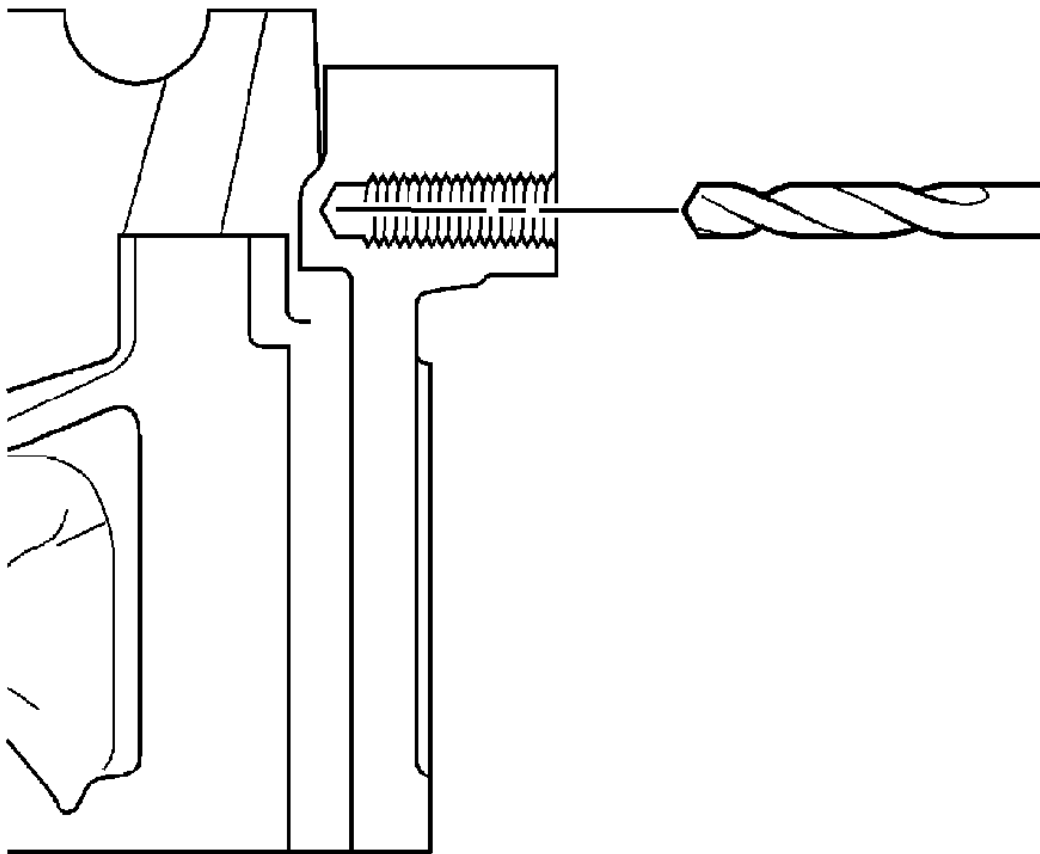
## THREAD REPAIR

### Special Tools

- **J 42385-700:** High Feature Thread Repair Kit High Feature Thread Repair Kit
- **J 42385-2000:** Thread Insert Kit
- **J 43965:** Thread Repair Extension Kit

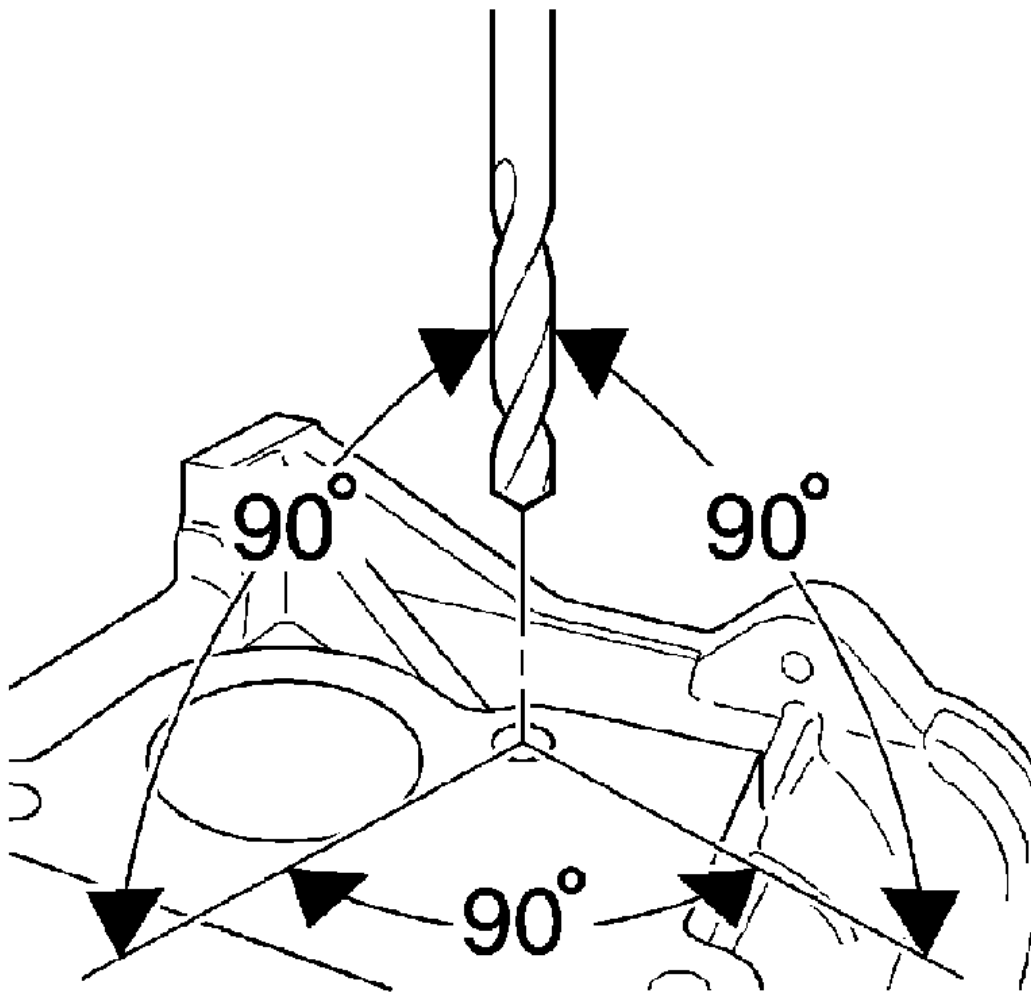
For equivalent regional tools, refer to **Special Tools** .

- The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.
- The drill bit and counter bore tool from the tool kit **J 42385-700**: kit and **J 42385-2000**: thread insert kit is designed for use with either a suitable tap wrench or drill motor. Limited access and larger hole repair may process better using a tap wrench. An extension from kit **J 43965**: extension kit may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. Use only a tap wrench when tapping the hole and during installation of the insert.



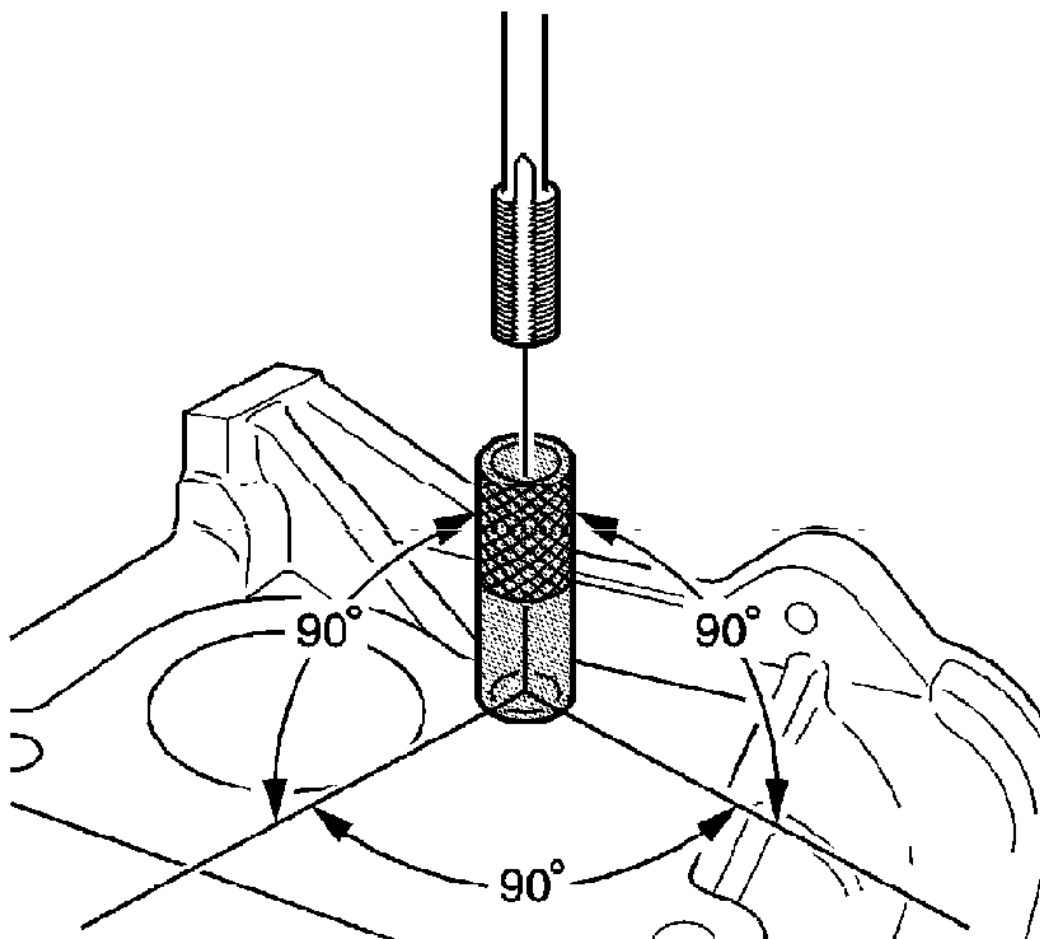
**Fig. 237: Identifying Drilling, Counterboring & Tapping Of Hole**  
Courtesy of GENERAL MOTORS CORP.

1. It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.



**Fig. 238: Identifying Drilling & Tapping Of Hole**  
Courtesy of GENERAL MOTORS CORP.

2. During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

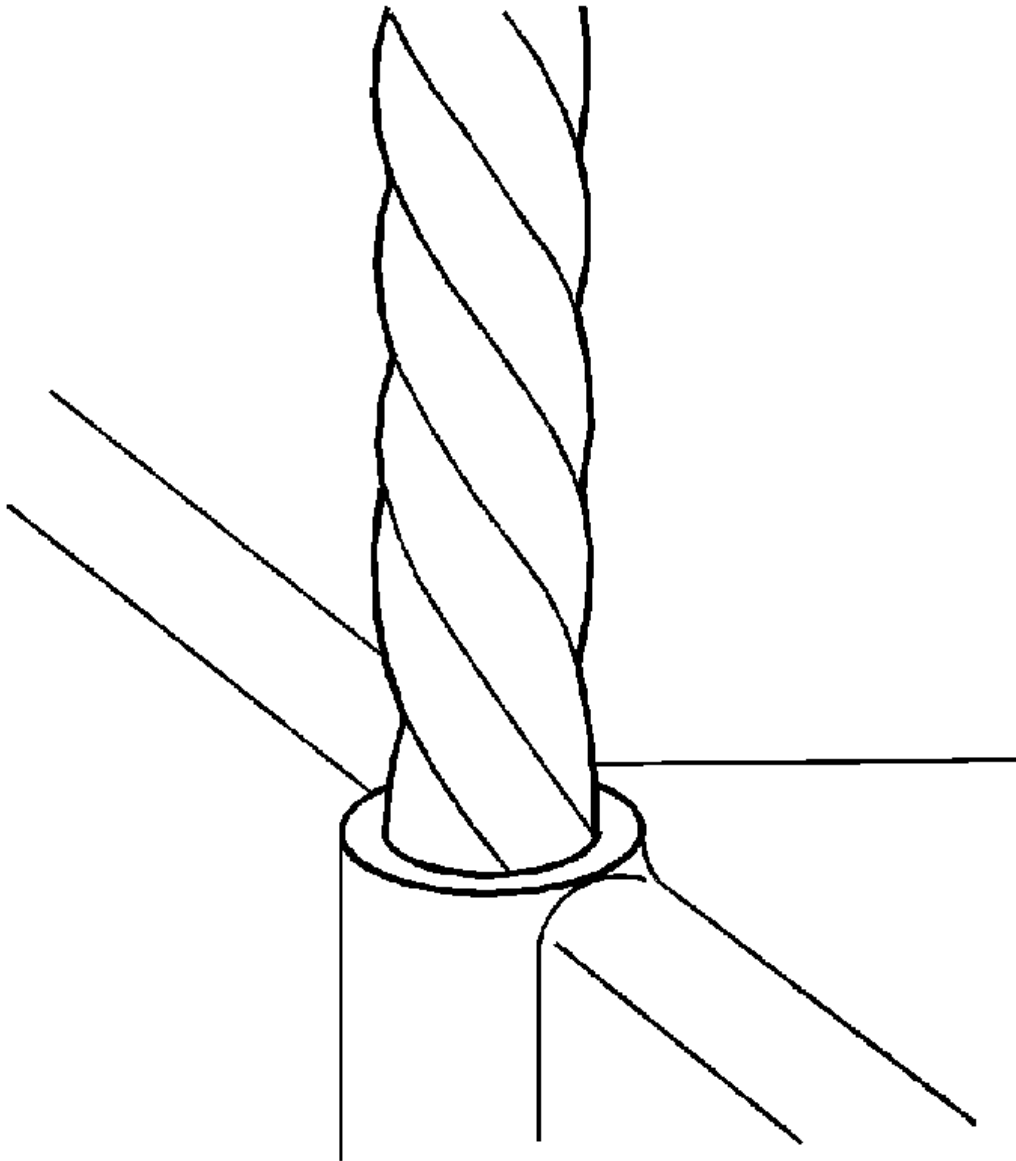


**Fig. 239: Identifying Tapping Guides**  
 Courtesy of GENERAL MOTORS CORP.

3. If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

| Tap Size | Tap Guide | Tape Size | Tape Guide | Tap Size | Tape Guide |
|----------|-----------|-----------|------------|----------|------------|
| -        | J 42385-  | -         | J 42385-   | -        | J 42385-   |
| 6 x 1.0  | 729       | 10 x 1.5  | 731        | 14 x 1.5 | 736        |
| 8 x 1.25 | 730       | 12 x 1.5  | 732        | 20 x 1.5 | 737        |

#### Standard Thread Repair - Flush Hole



**Fig. 240: Identifying Drilling Out Threads Of Damaged Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

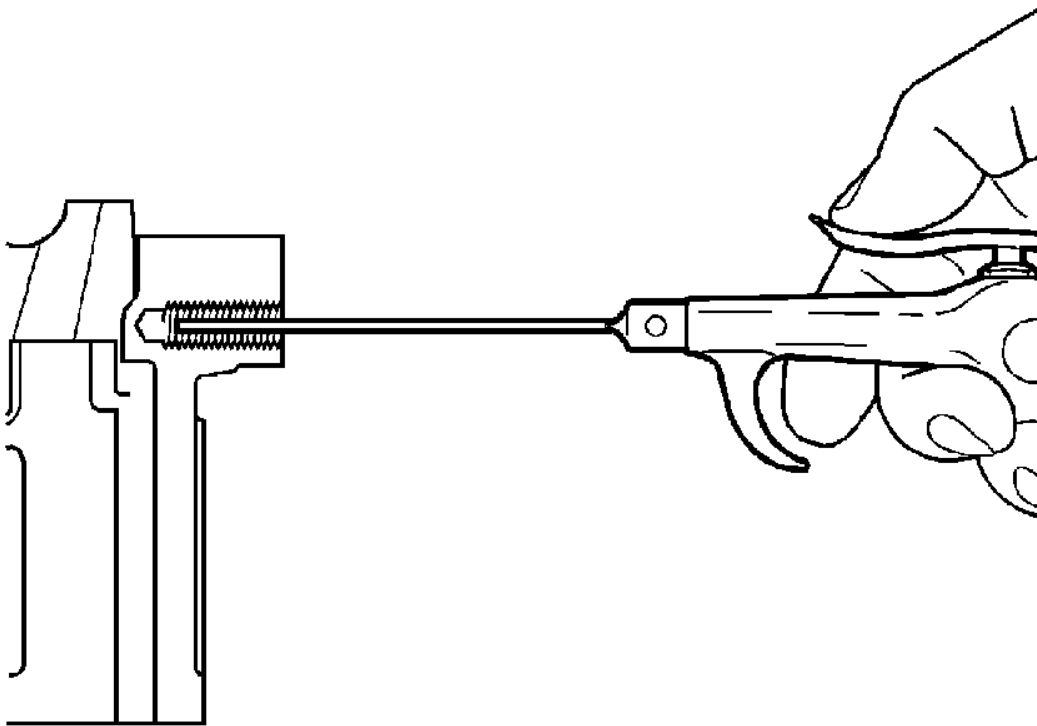
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- **DO NOT** drill any further than the original hole depth.

1. Drill out the threads of the damaged hole.



**Specifications:**

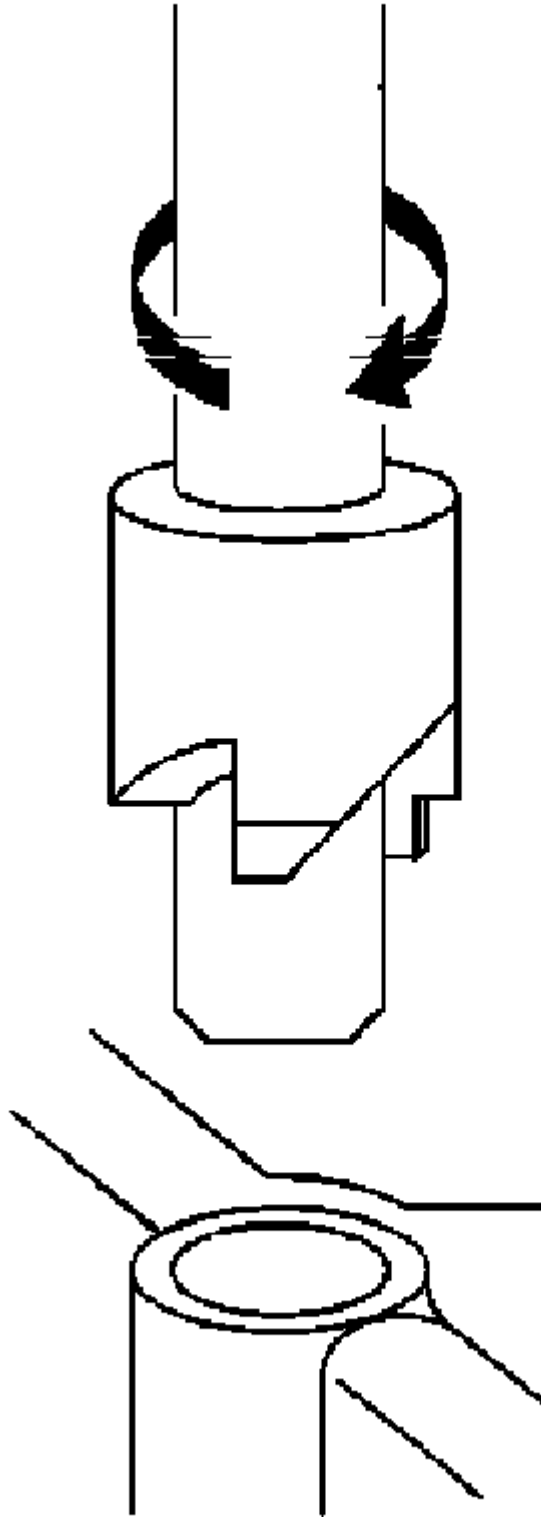
- M6 inserts require a minimum drill depth of 15 mm (0.59 in).
- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
- M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).



**Fig. 241: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

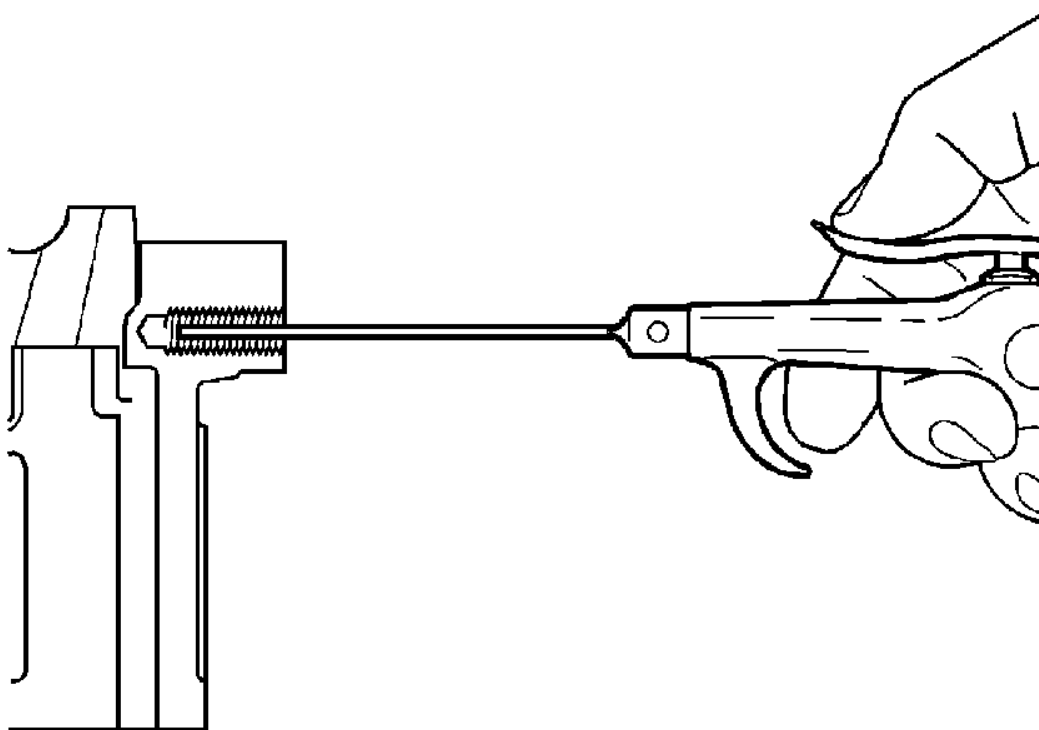
2. Using compressed air, clean out any chips.



**Fig. 242: Identifying Counterbore Procedure**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** A correctly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

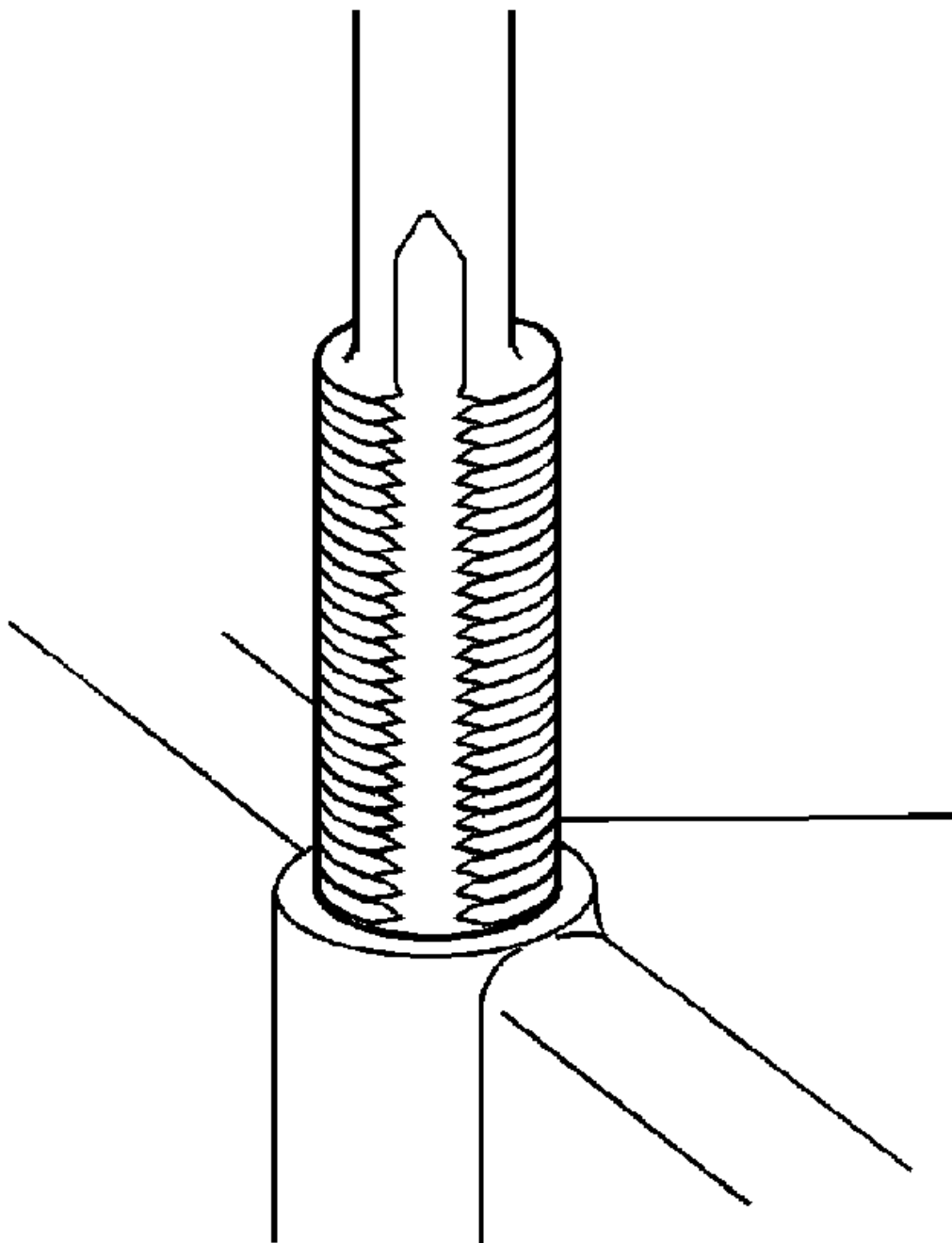
3. Counterbore the drilled hole to the full depth permitted by the tool (1).



**Fig. 243: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

4. Using compressed air, clean out any chips.



**Fig. 244: Identifying Drilled Hole Tapping Procedure**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the tapping process, it is necessary to repeatedly remove the

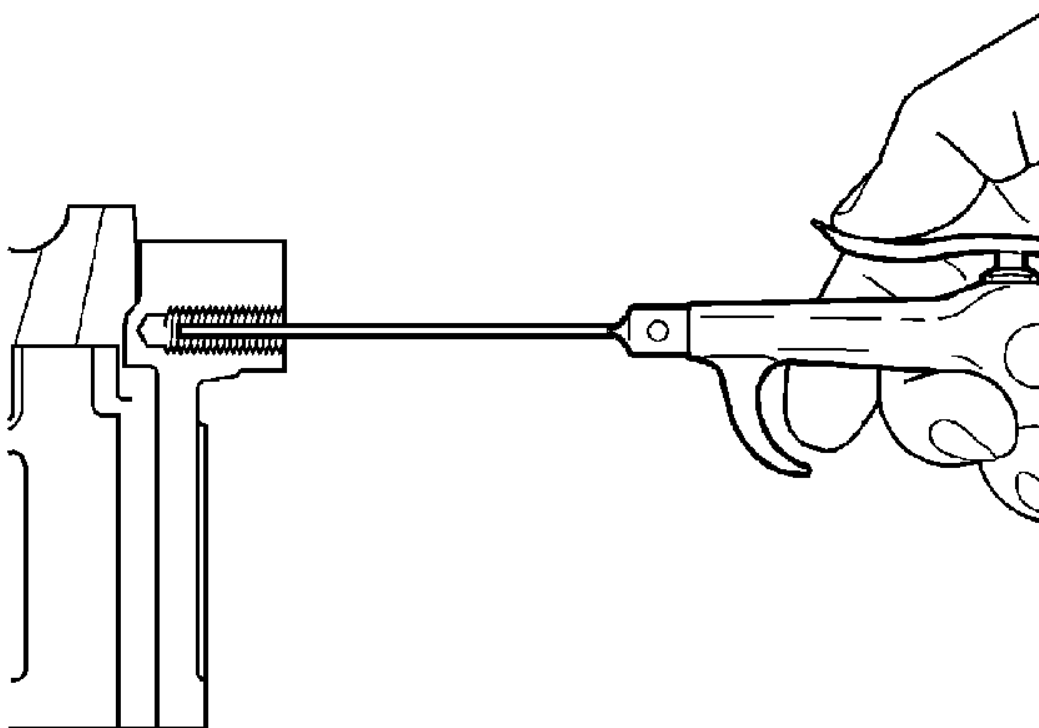
tap and clean chips from the hole and the flutes of the tap.

- Make sure the tap has created full threads at least to the depth equal to the insert length.

5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

**Specifications:**

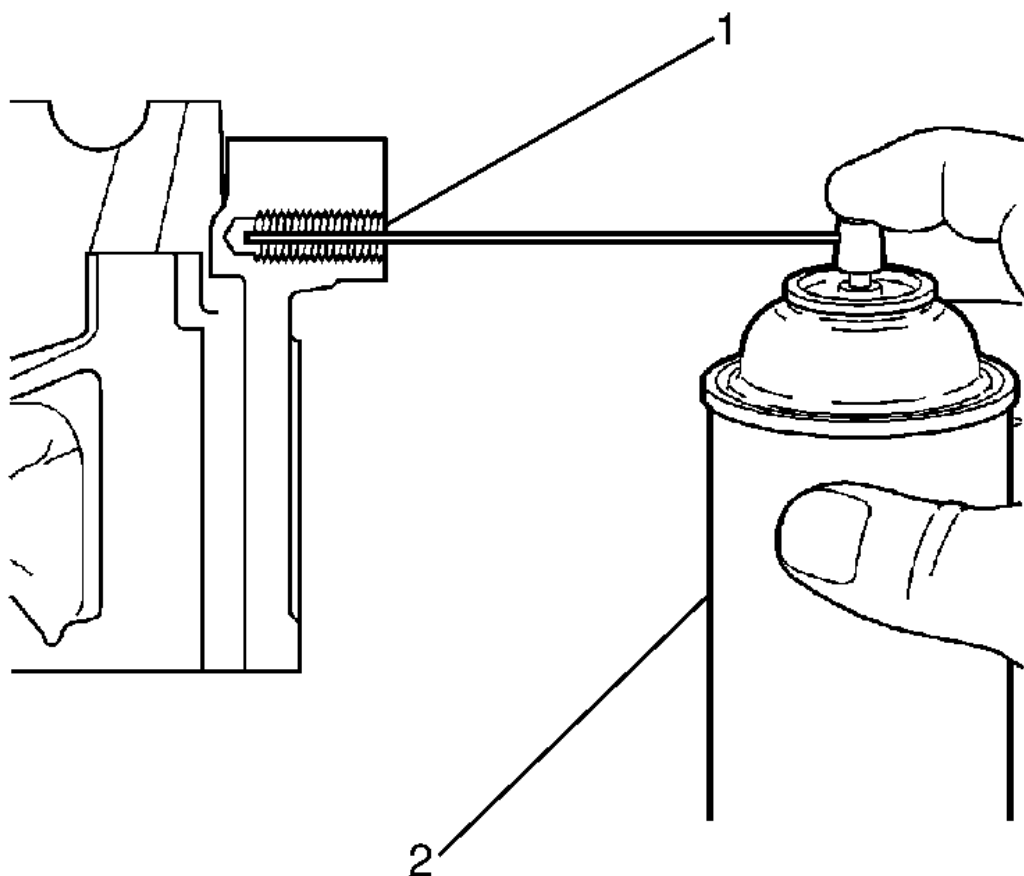
- M6 inserts require a minimum tap depth of 15 mm (0.59 in).
- M8 inserts require a minimum tap depth of 20 mm (0.79 in).
- M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).



**Fig. 245: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

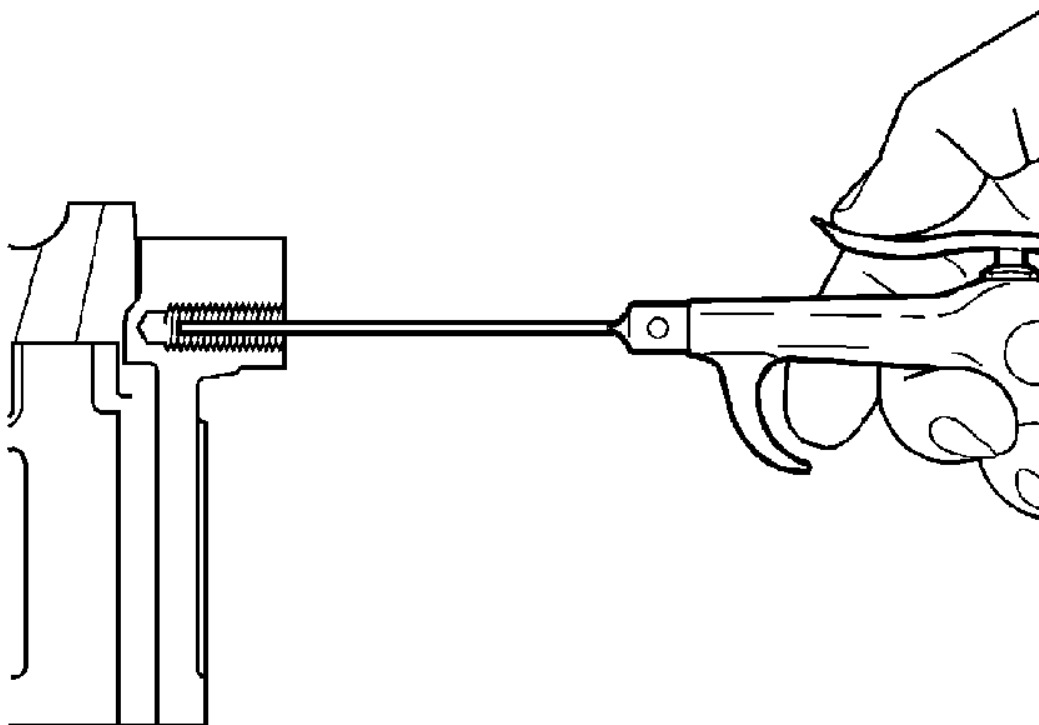
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.



**Fig. 246: View Of Thread Cleaner & Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

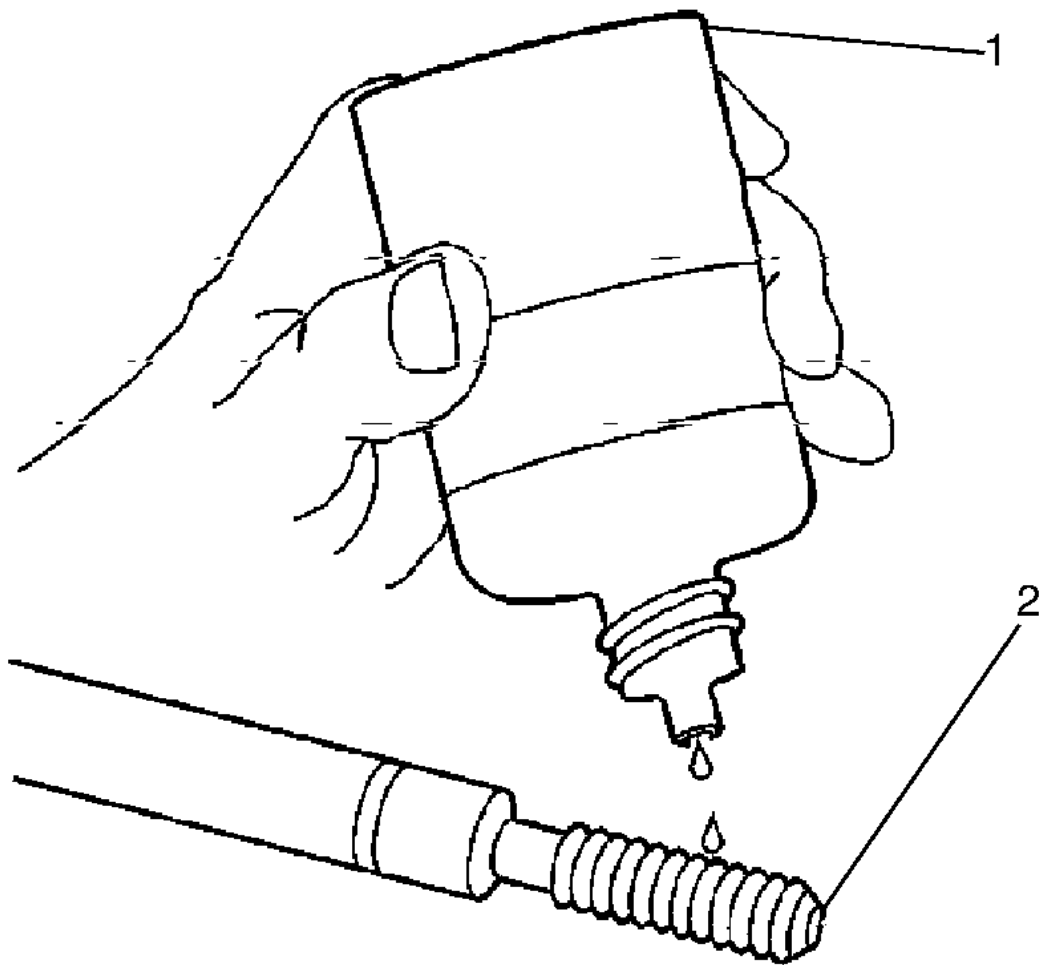
7. Spray a commercially available thread cleaner (2) into the tapped hole (1).



**Fig. 247: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.

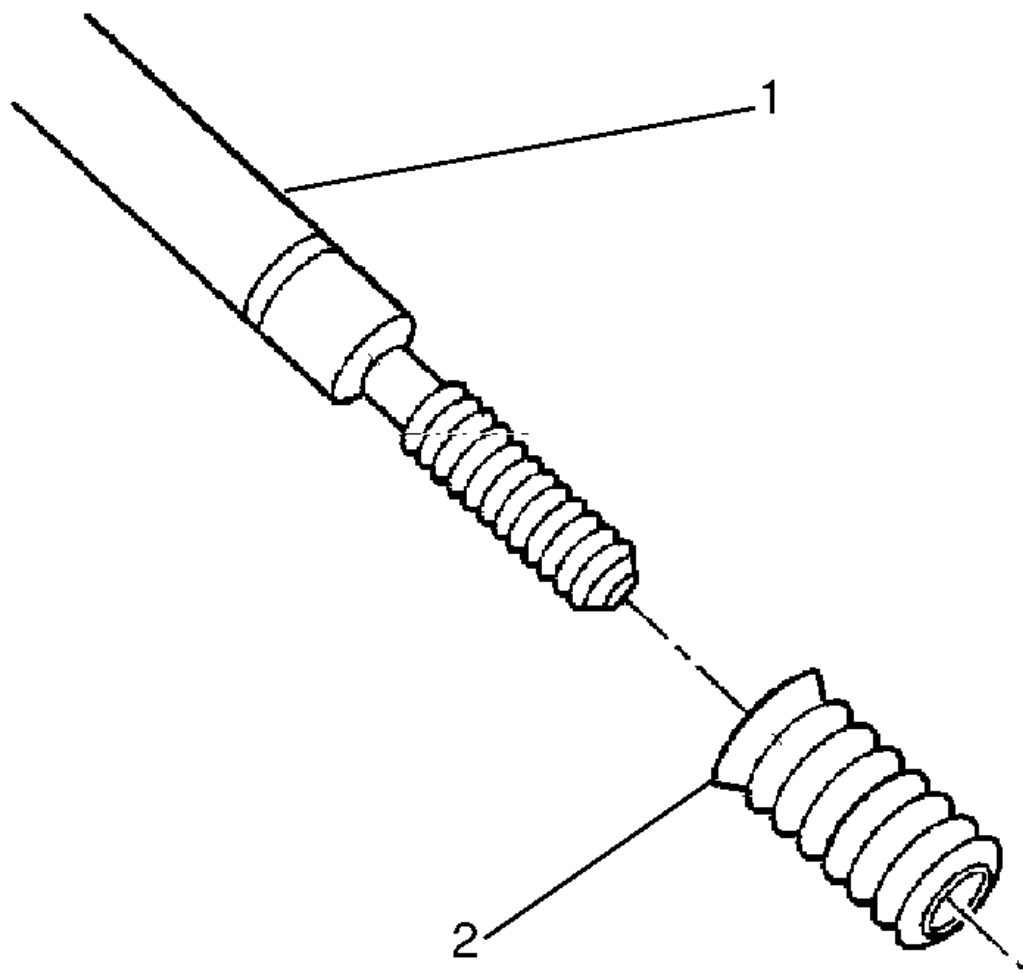


**Fig. 248: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**      **DO NOT** allow oil or other foreign material to contact the **Outside Diameter (OD)** of the insert.

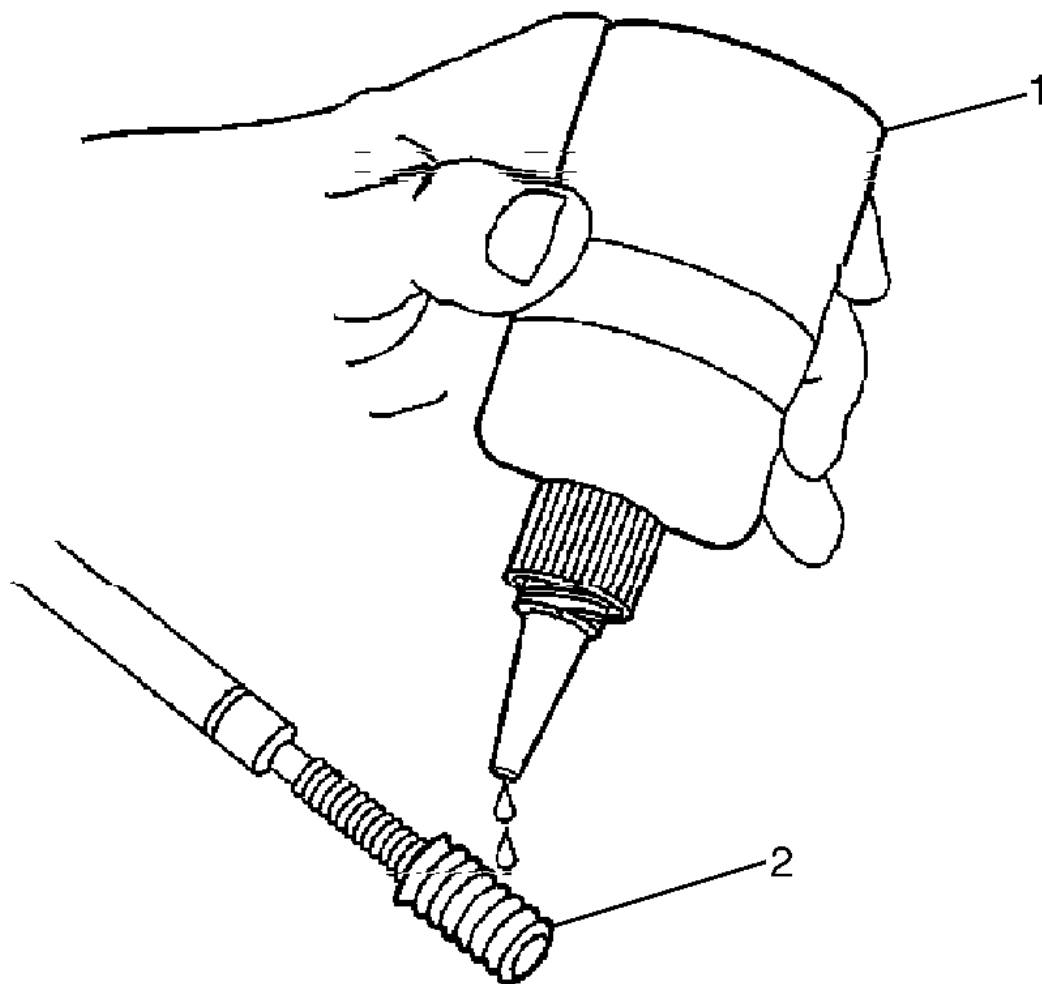
9. Lubricate the threads of the driver installation tool (2) with the driver oil (1).





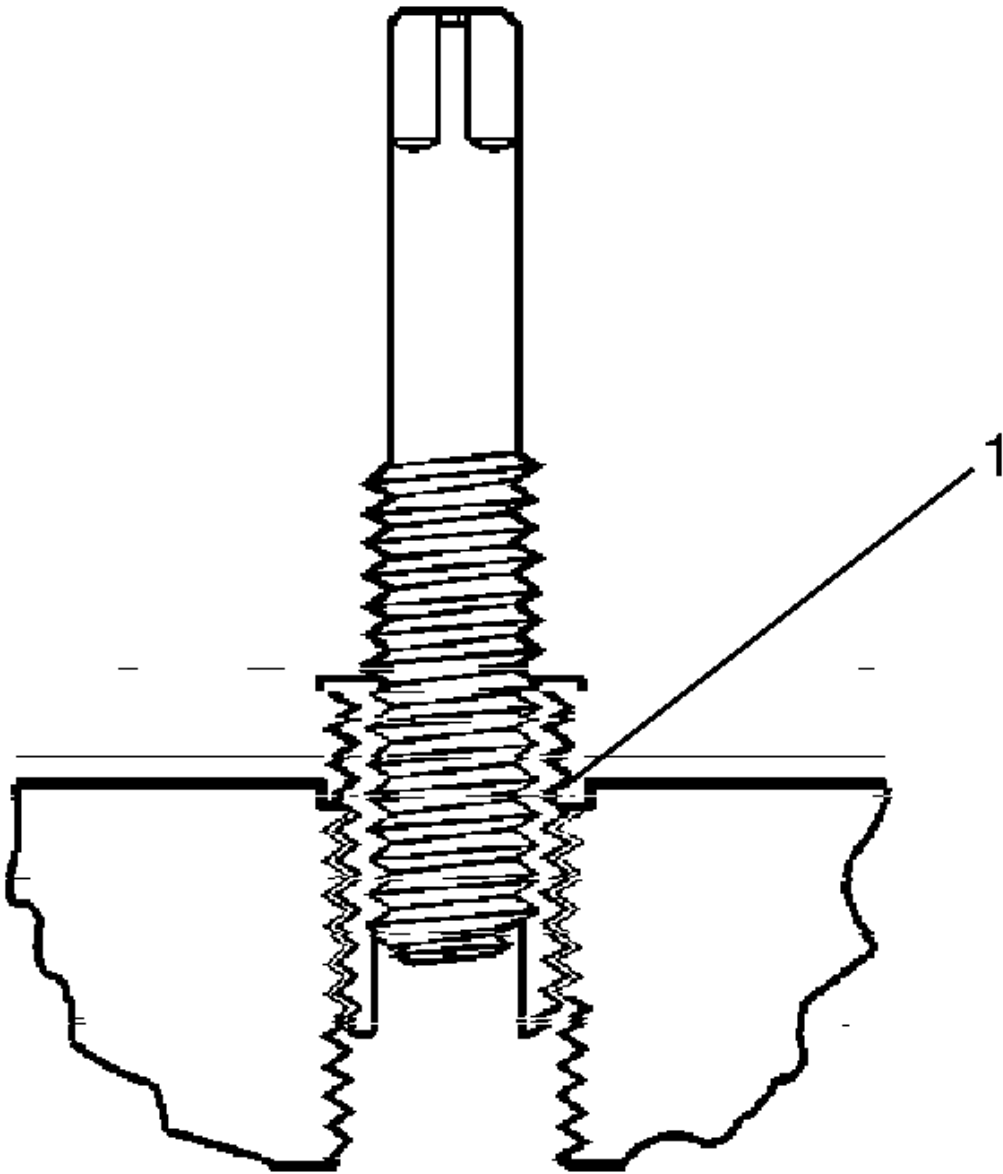
**Fig. 249: Identifying Insert & Driver Installation Tool**  
**Courtesy of GENERAL MOTORS CORP.**

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



**Fig. 250: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).

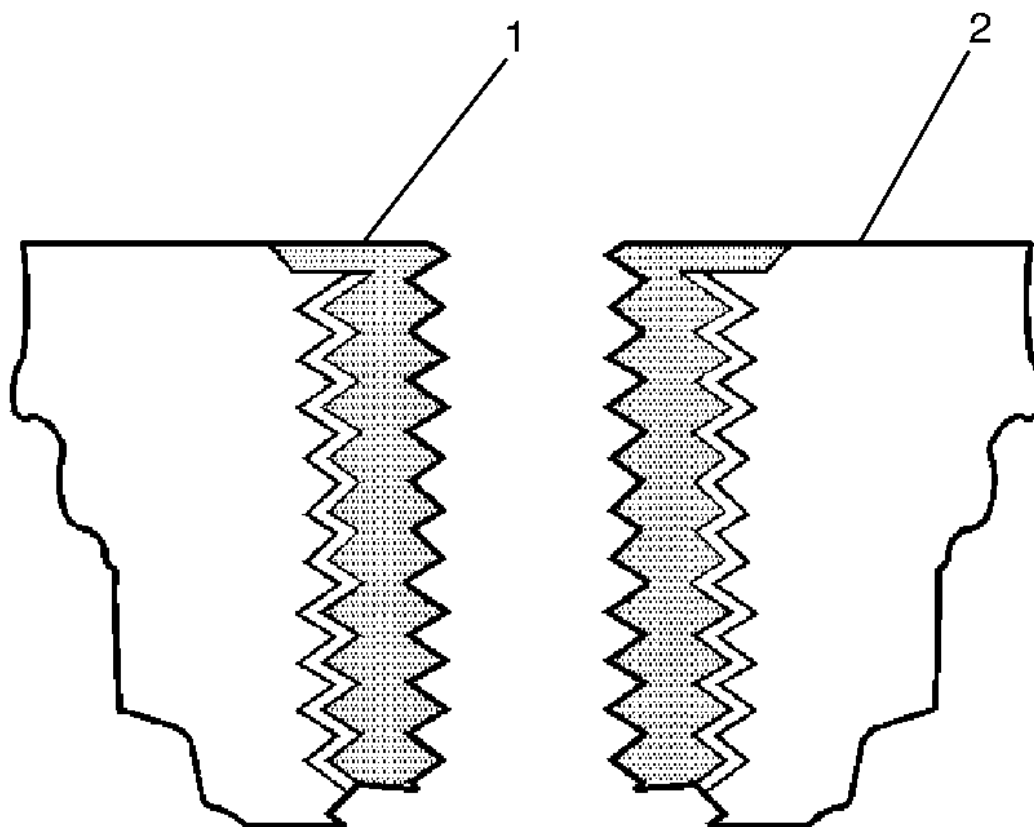


**Fig. 251: Identifying Insert**  
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (1) into the tapped hole by hand only.

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

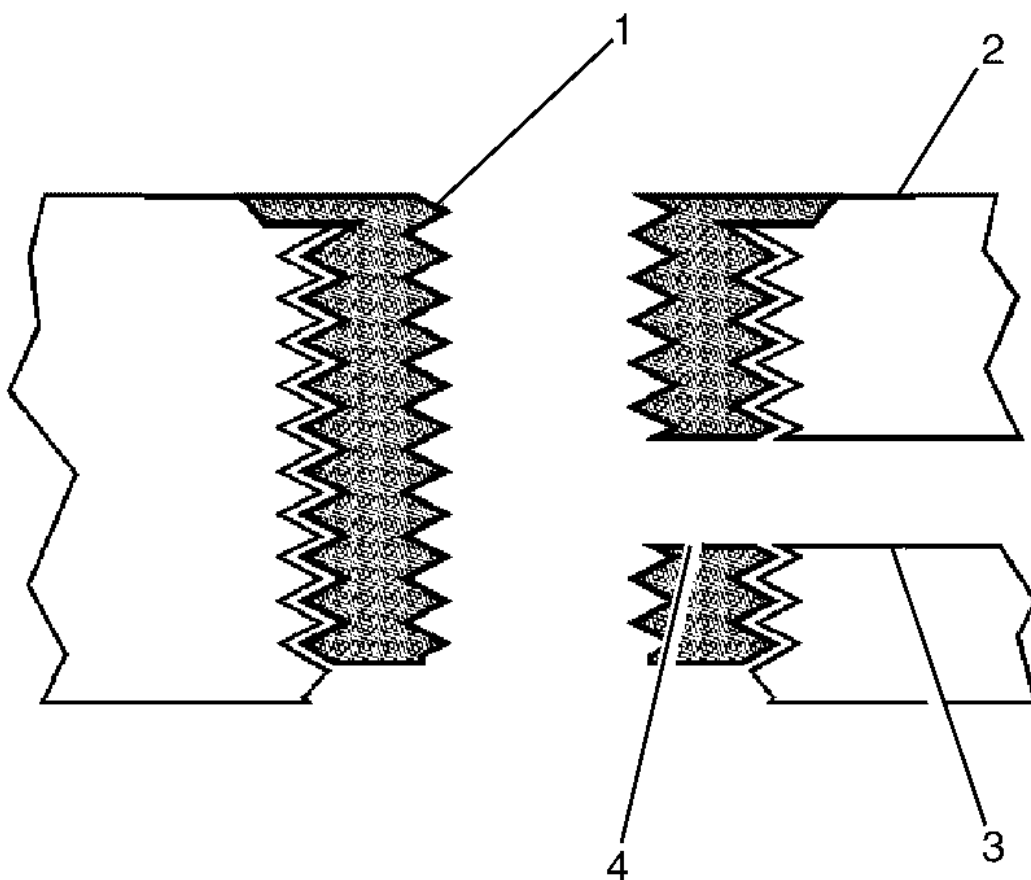
The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.



**Fig. 252: Identifying Installed Insert & Surface Of Base Material**  
Courtesy of GENERAL MOTORS CORP.

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

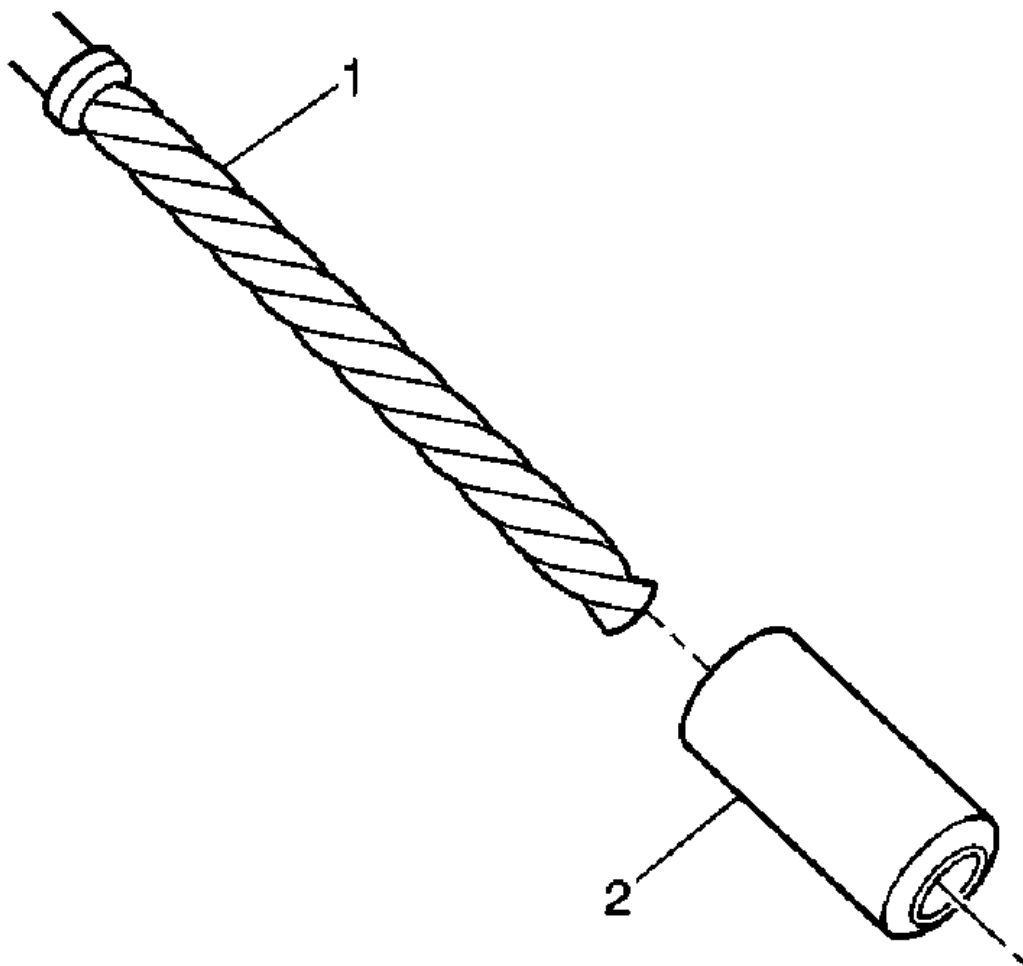
A correctly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).



**Fig. 253: Identifying Oil Or Engine Coolant Passage**  
Courtesy of GENERAL MOTORS CORP.

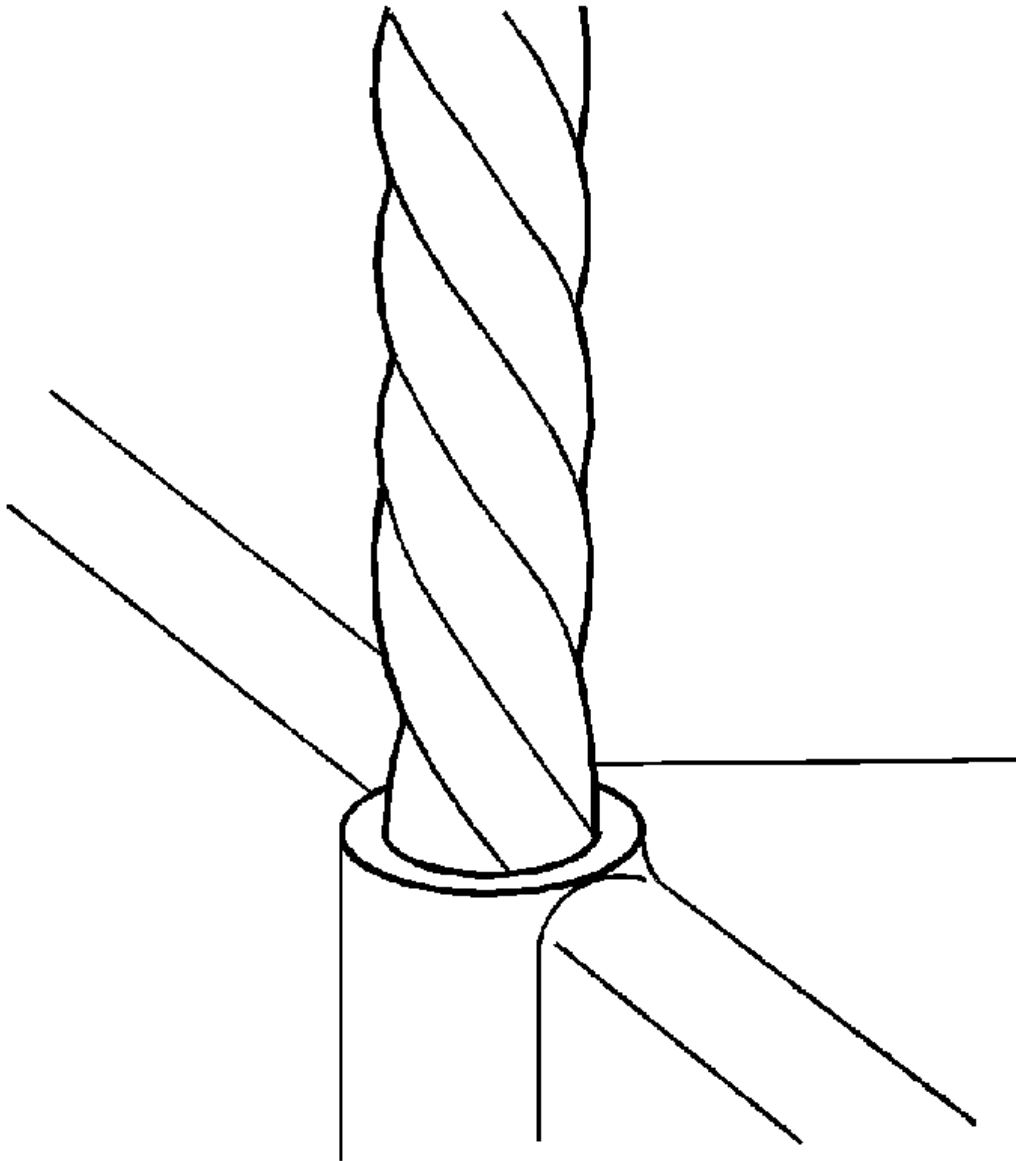
14. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

#### Recessed Thread Repair



**Fig. 254: Identifying Stop Collar & Counterbore Drill**  
Courtesy of GENERAL MOTORS CORP.

1. Install a stop collar (2) on the counterbore drill (1), if required.

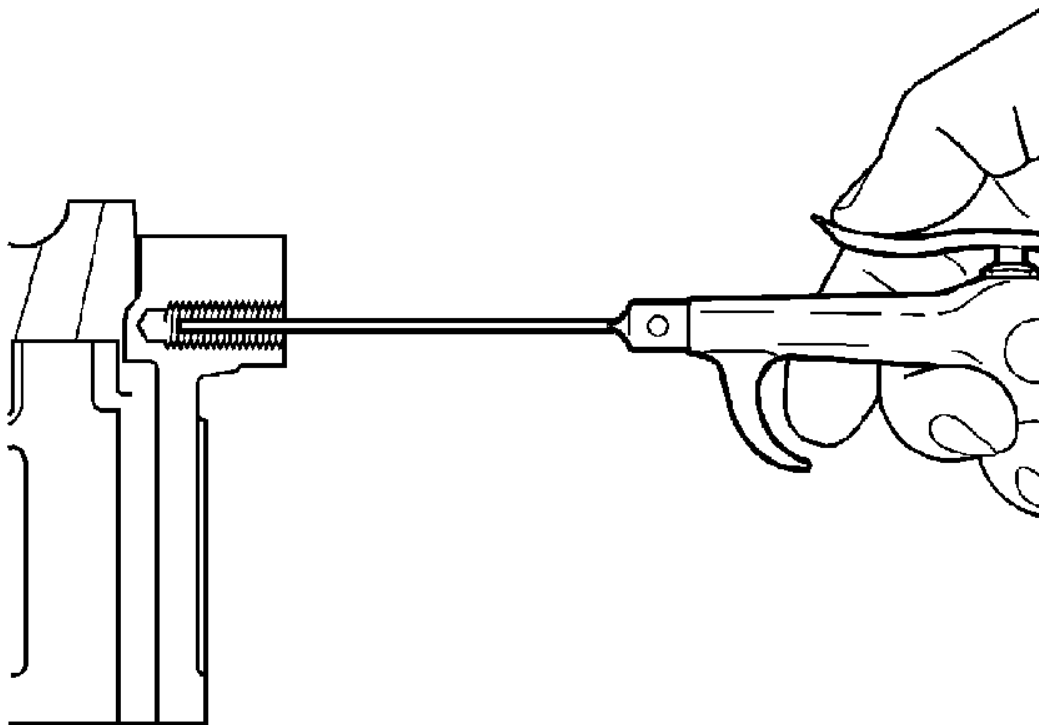


**Fig. 255: Identifying Drilling Out Threads Of Damaged Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

2. Drill out the threads of the damaged hole.

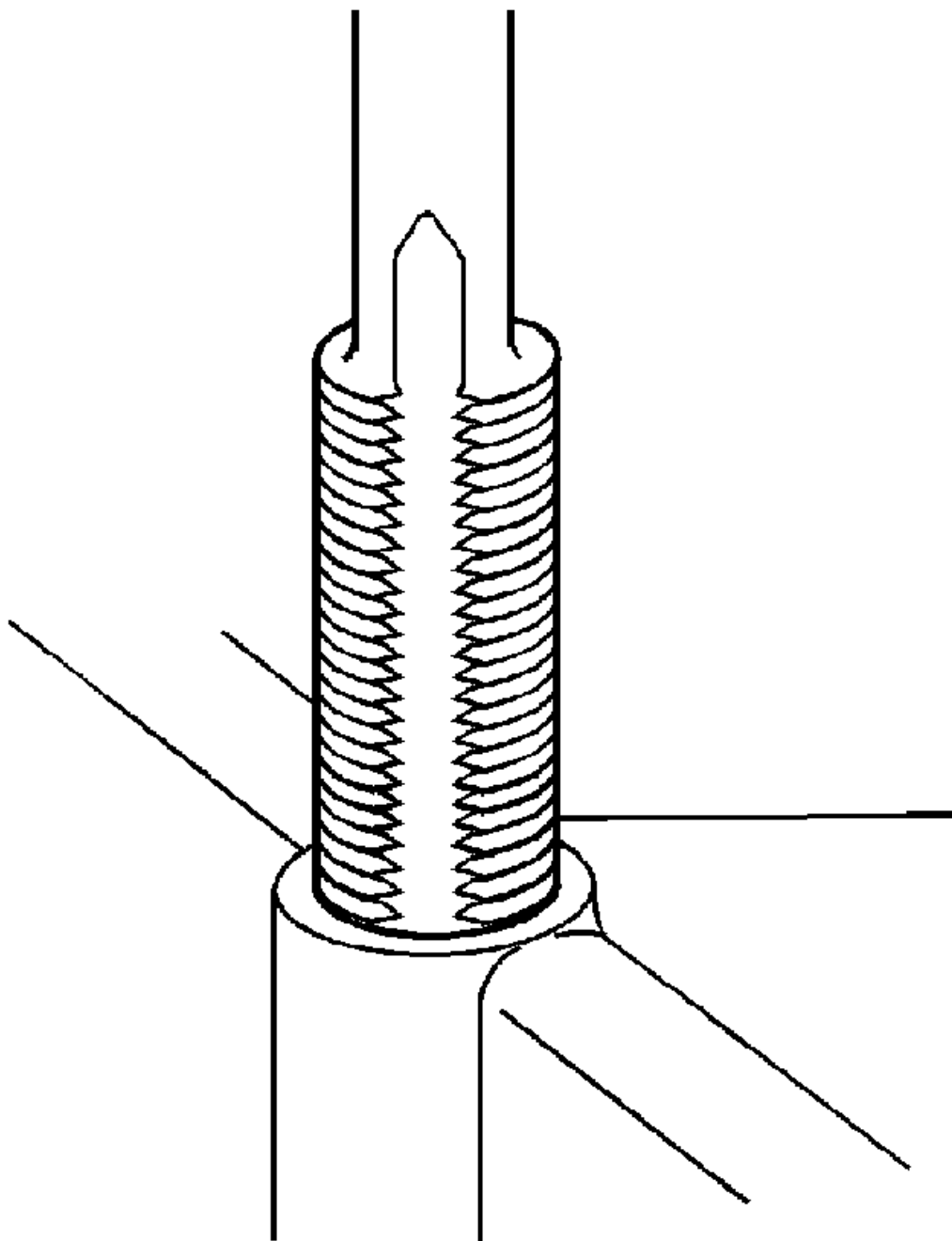


**Fig. 256: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.





**Fig. 257: Identifying Drilled Hole Tapping Procedure**  
Courtesy of GENERAL MOTORS CORP.

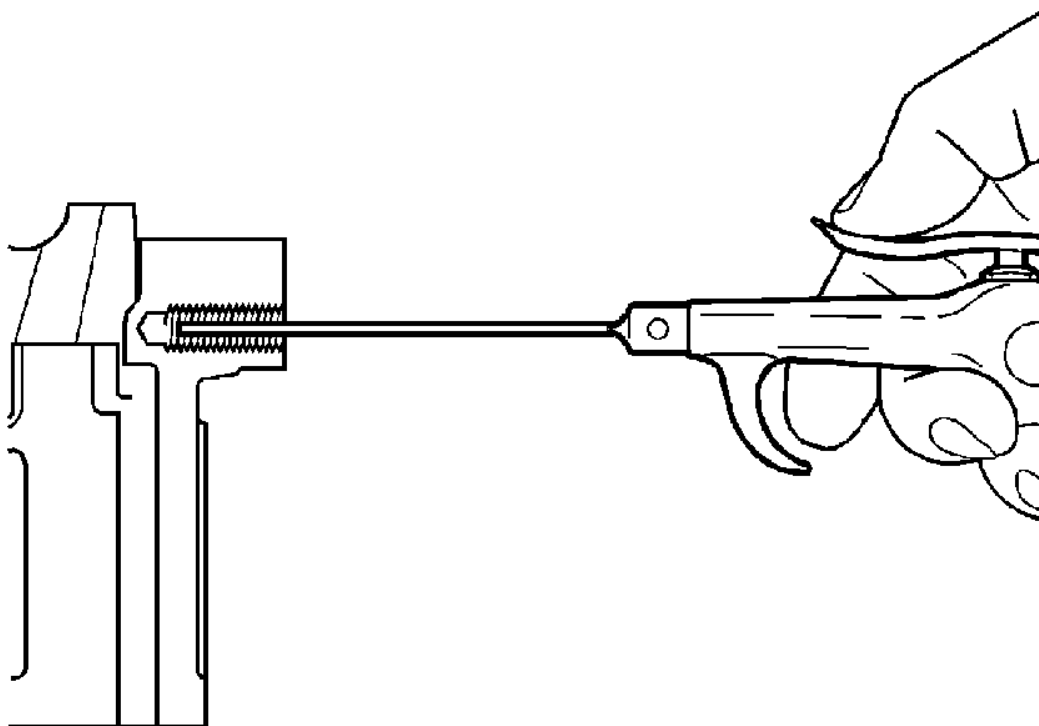
**NOTE:**

- During the tapping process, it is necessary to repeatedly remove the

tap and clean chips from the hole and the flutes of the tap.

- Make sure the tap has created full threads at least to the depth equal to the insert length.

4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

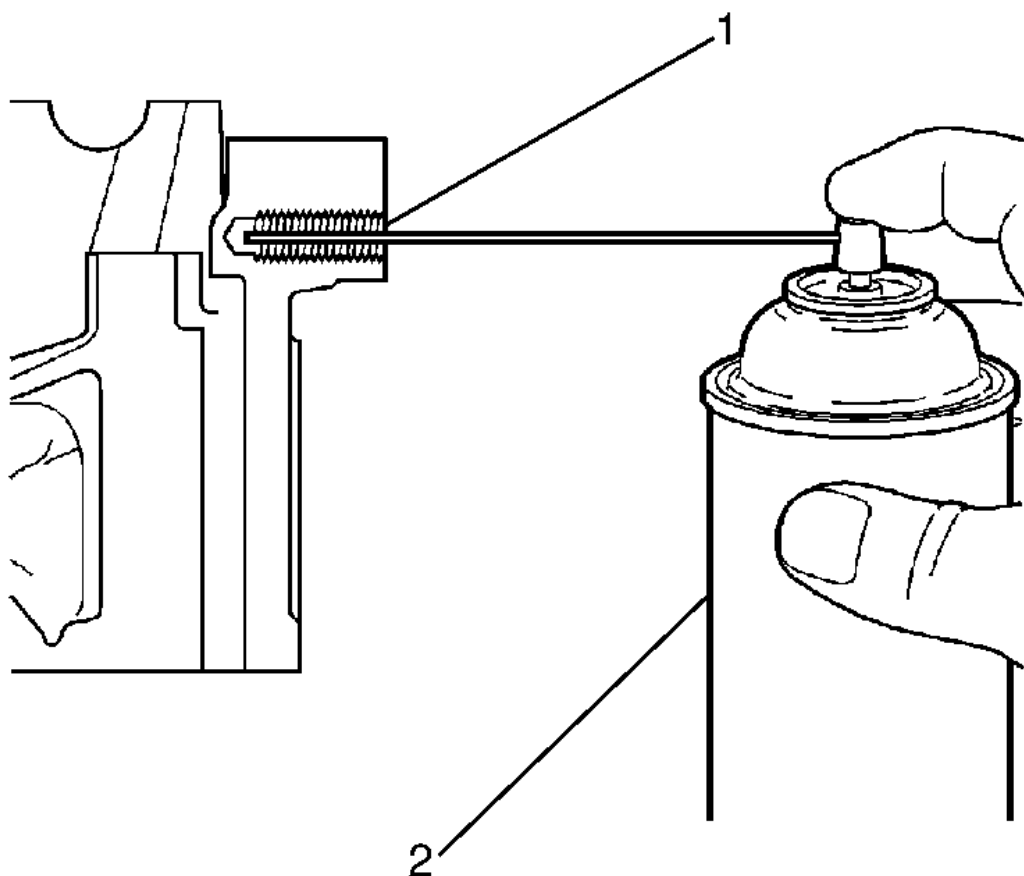


**Fig. 258: Locating Tapped Hole**

Courtesy of GENERAL MOTORS CORP.

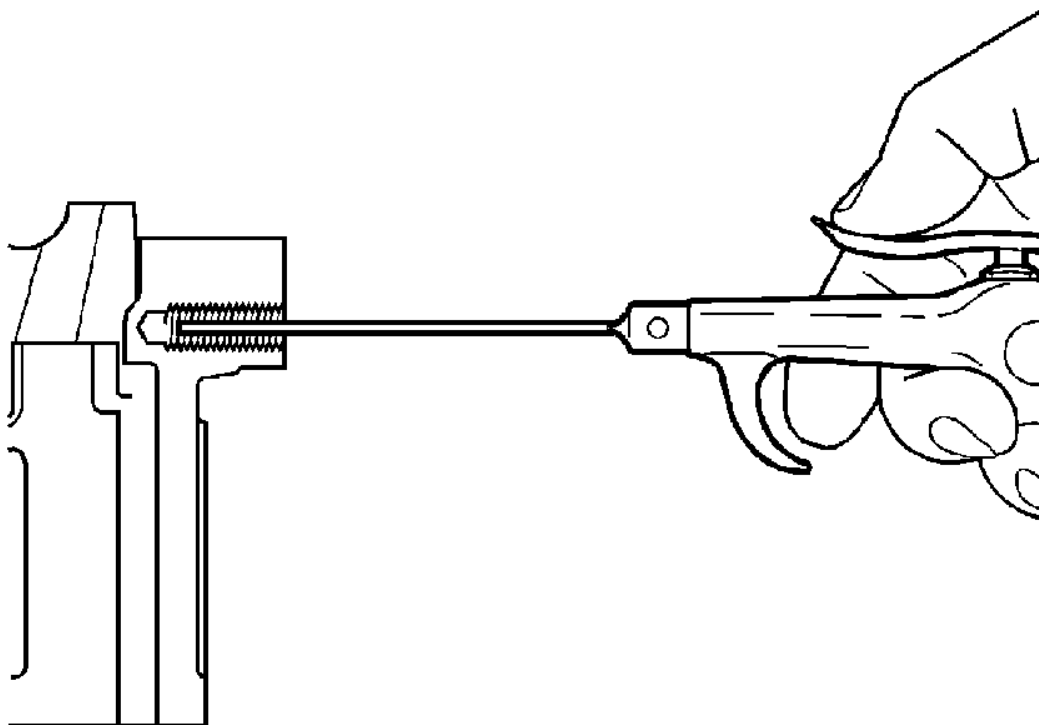
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.



**Fig. 259: View Of Thread Cleaner & Tapped Hole**  
**Courtesy of GENERAL MOTORS CORP.**

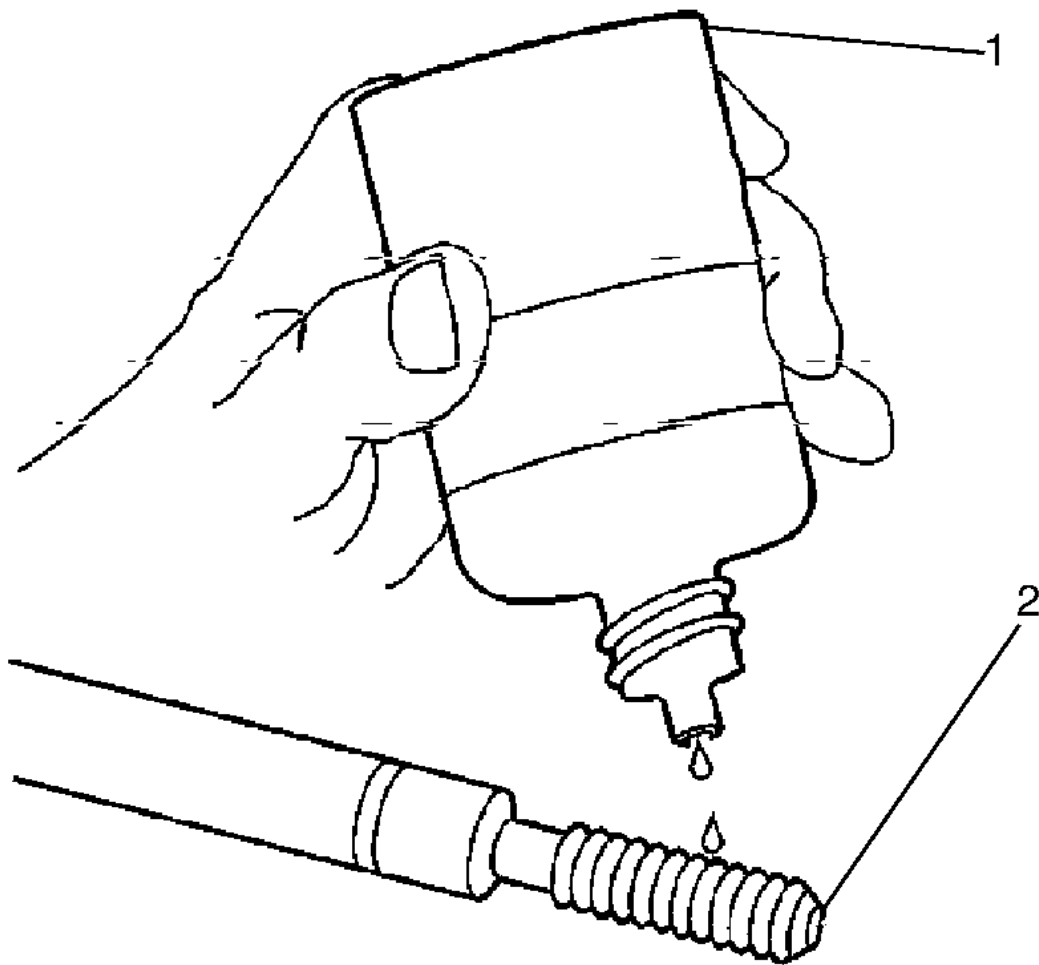
6. Spray a commercially available thread cleaner (2) into the tapped hole (1).



**Fig. 260: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

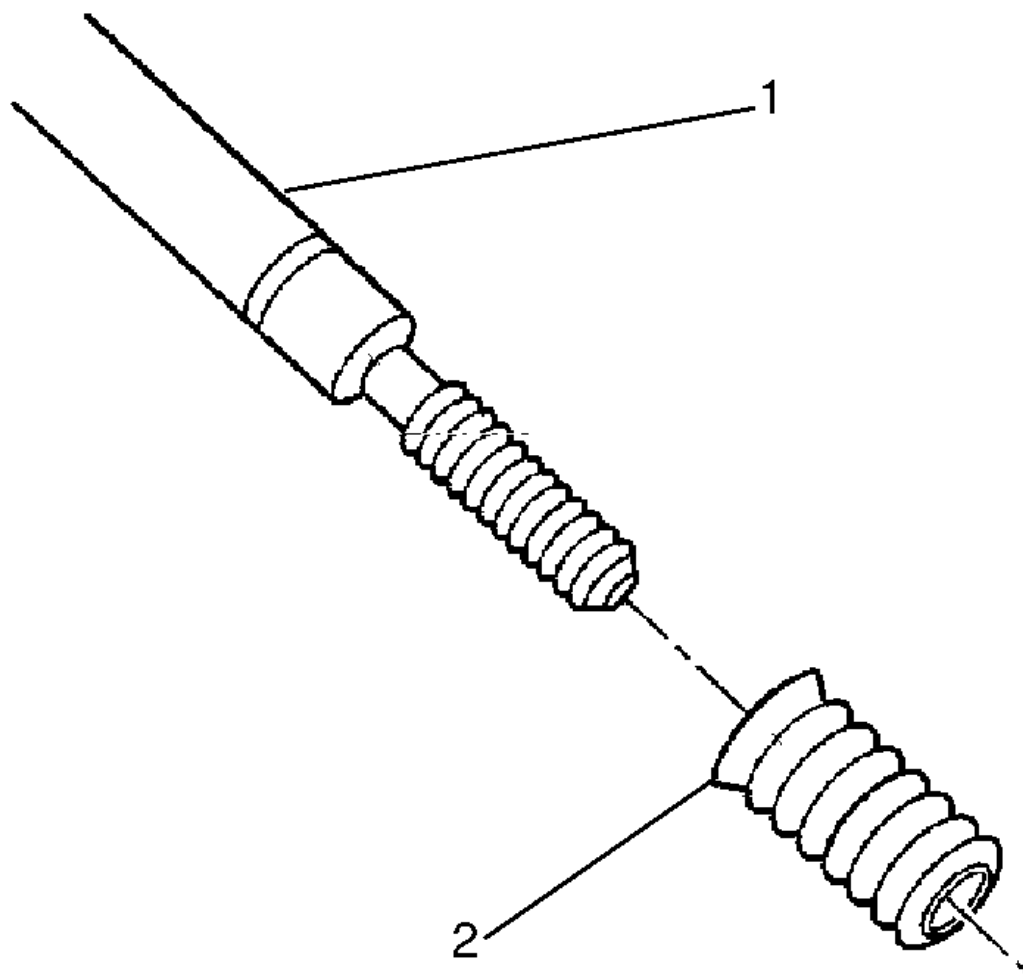
7. Using compressed air, clean out any chips.



**Fig. 261: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

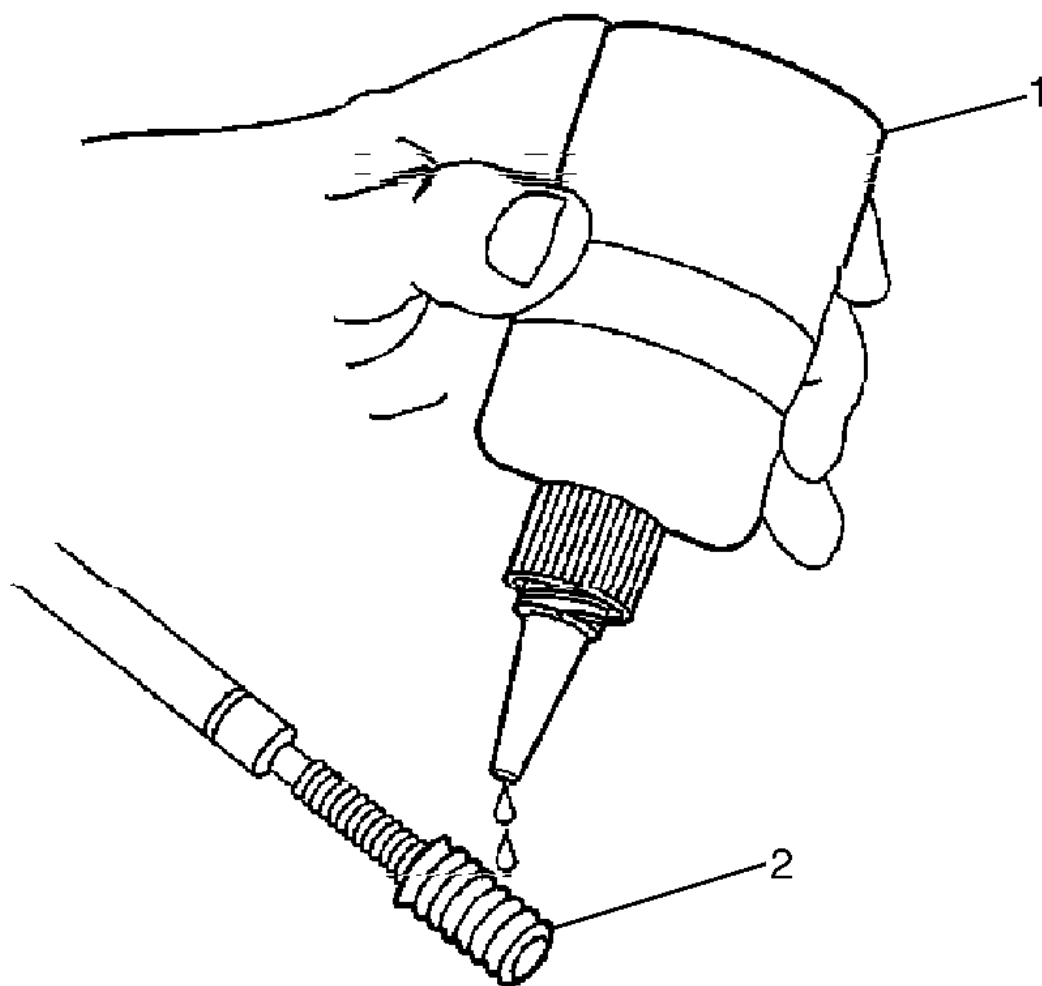
**NOTE:**      **DO NOT** allow oil or other foreign material to contact the **Outside Diameter (OD)** of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1).



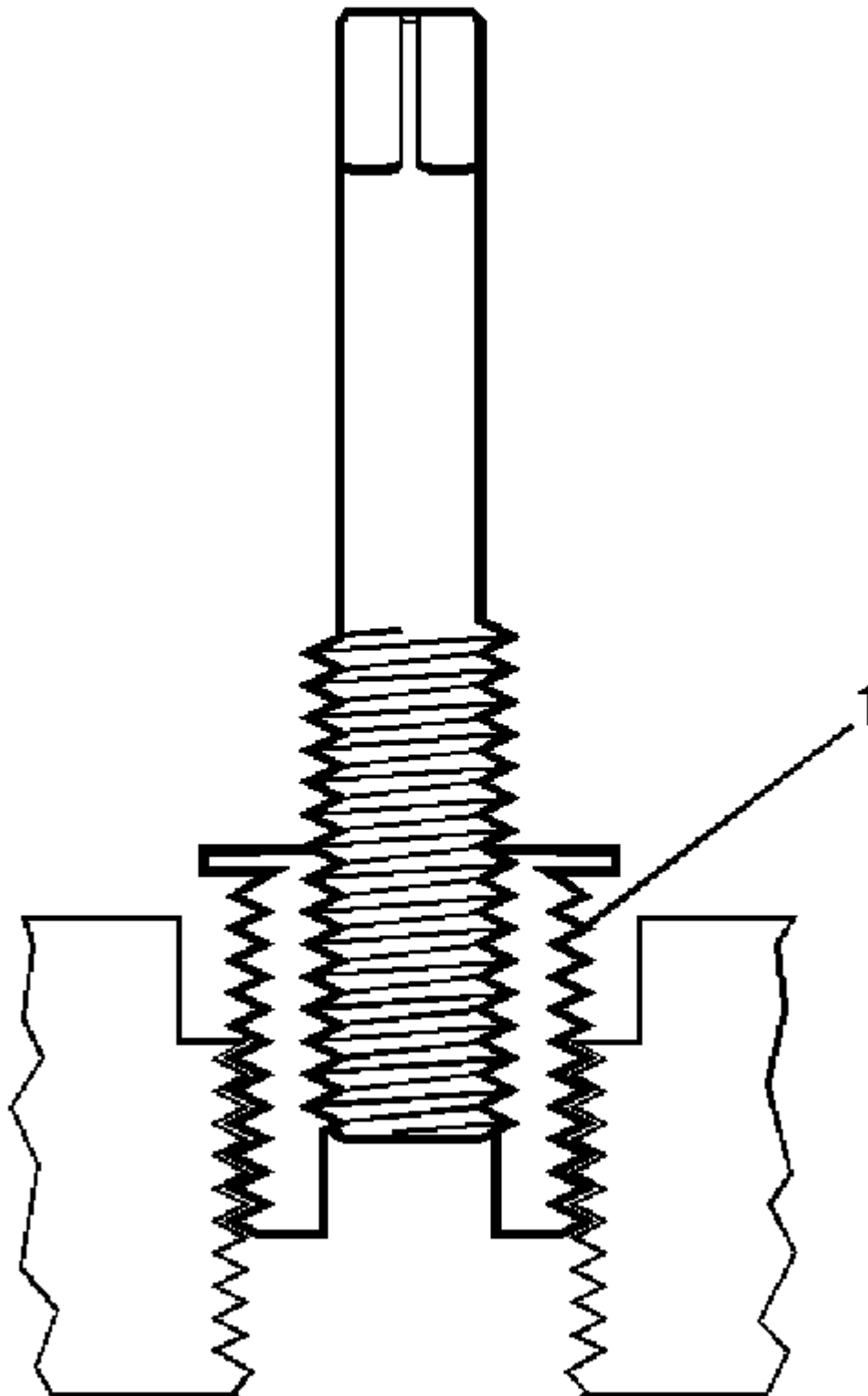
**Fig. 262: Identifying Insert & Driver Installation Tool**  
**Courtesy of GENERAL MOTORS CORP.**

9. Install the insert (2) onto the driver installation tool (1).



**Fig. 263: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

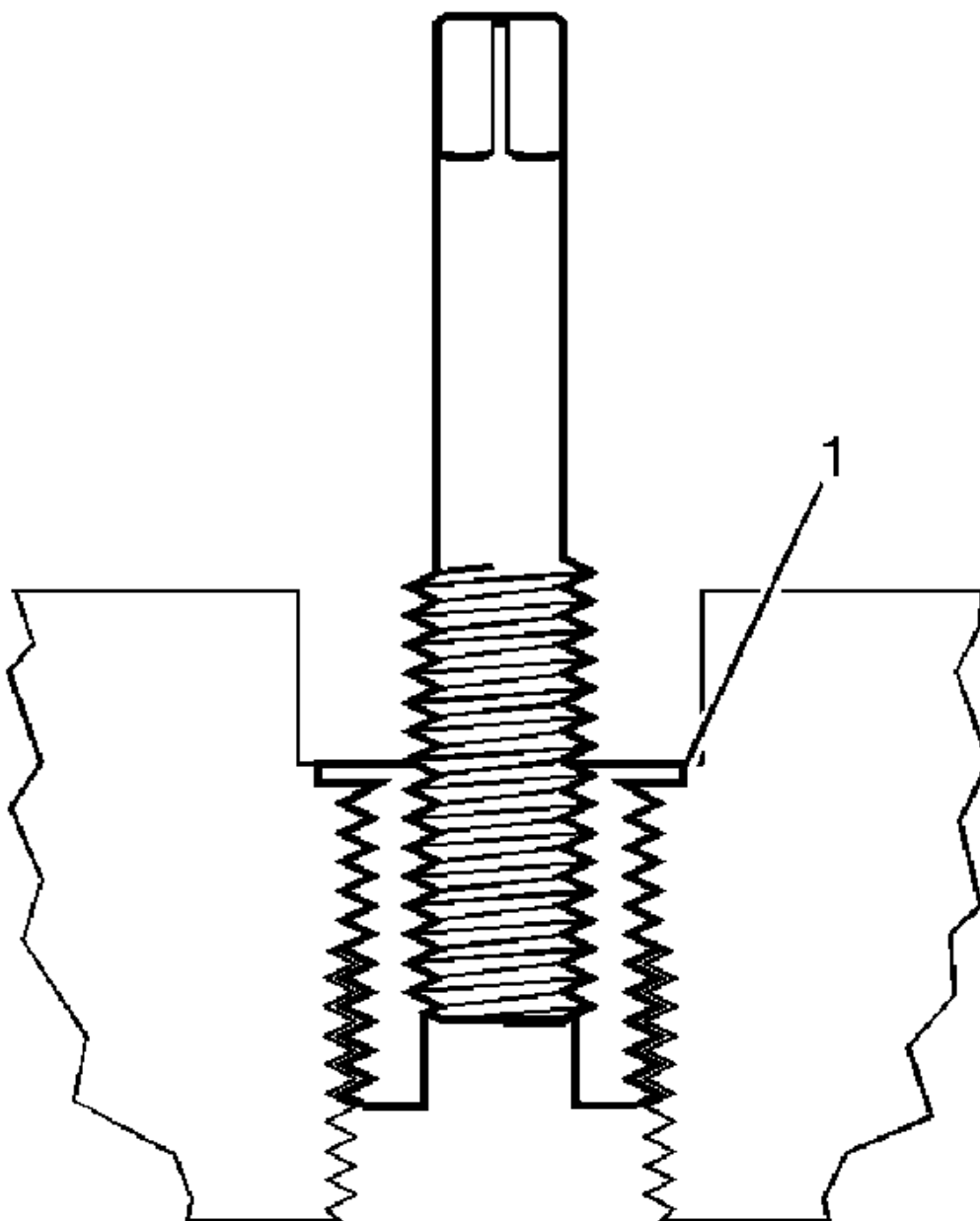
10. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).





**Fig. 264: Identifying Insert****Courtesy of GENERAL MOTORS CORP.**

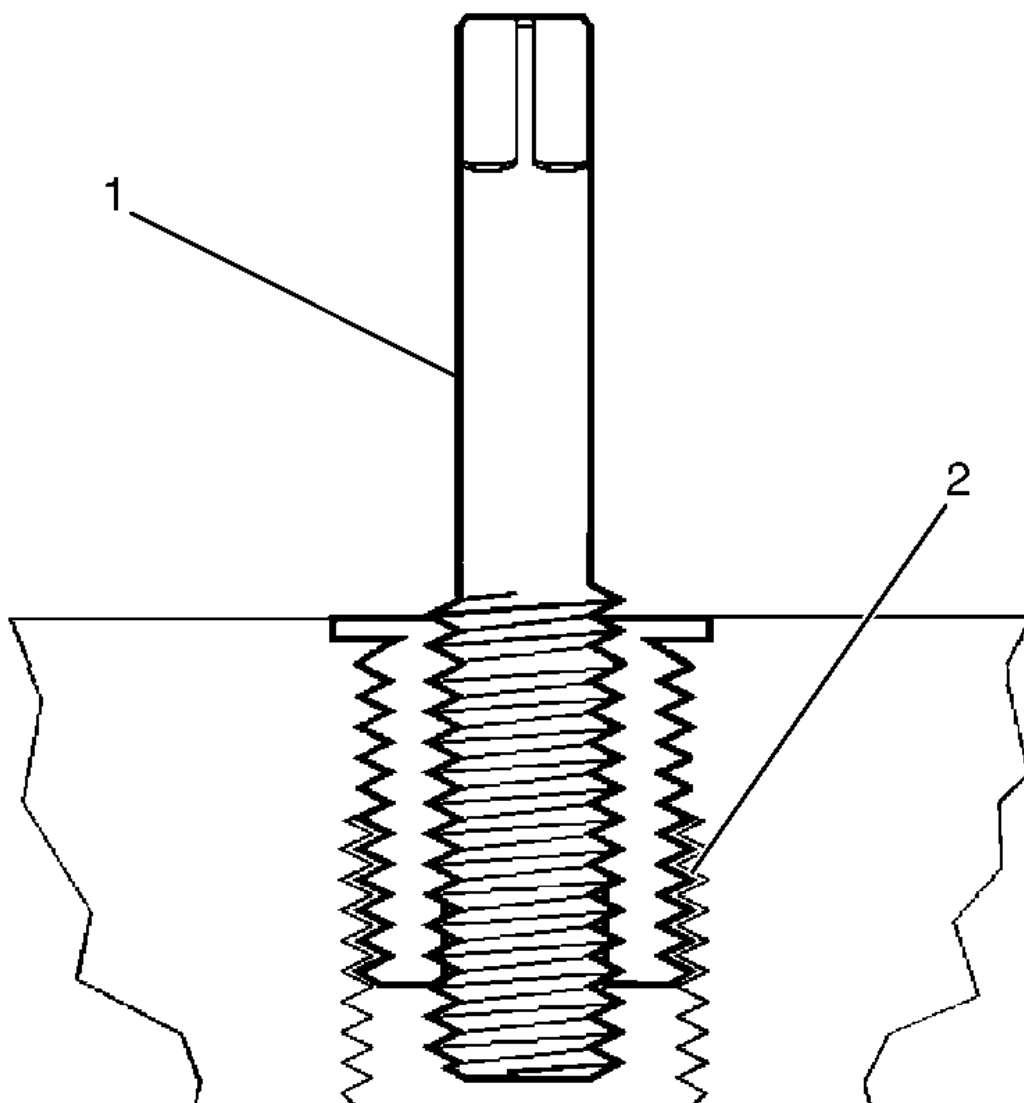
11. Install the insert (1) into the tapped hole by hand only.

**Fig. 265: Identifying Flange Of Insert**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

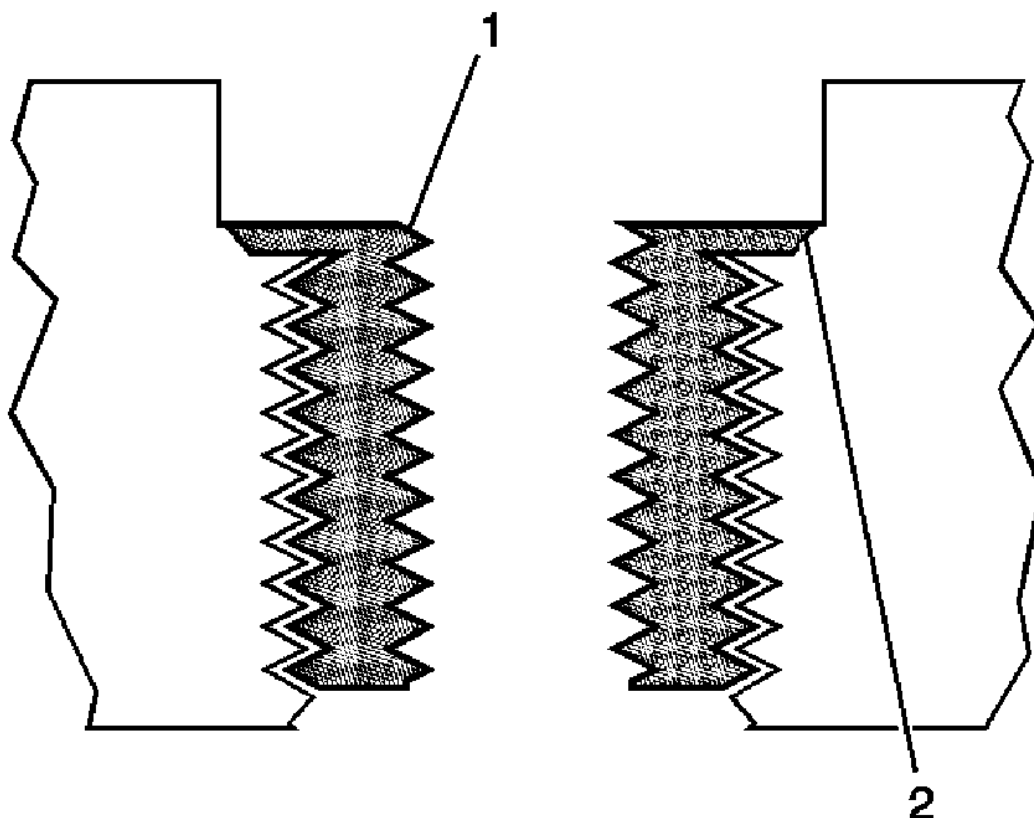
12. Install the insert until the flange (1) of the insert contacts the counterbored surface.



**Fig. 266: Identifying Driver Installation Tool & Insert**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

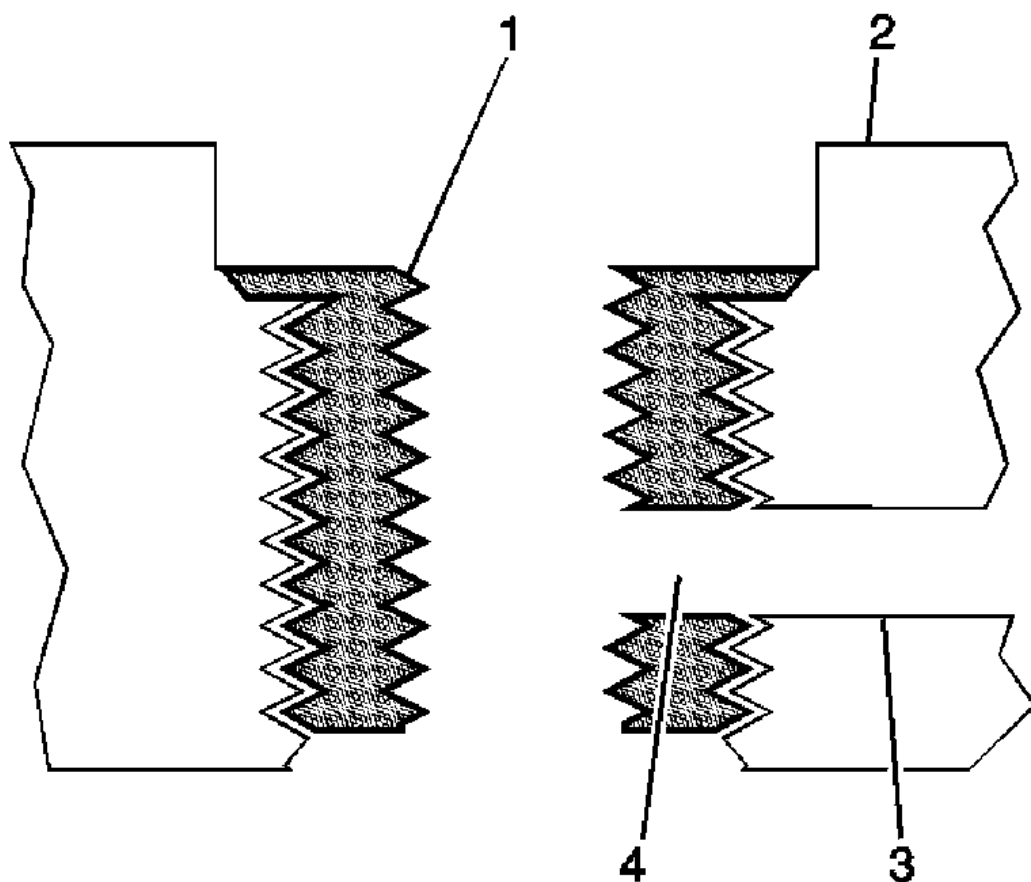
13. Continue to rotate the driver installation tool (1) through the insert (2).



**Fig. 267: Identifying Insert**

Courtesy of GENERAL MOTORS CORP.

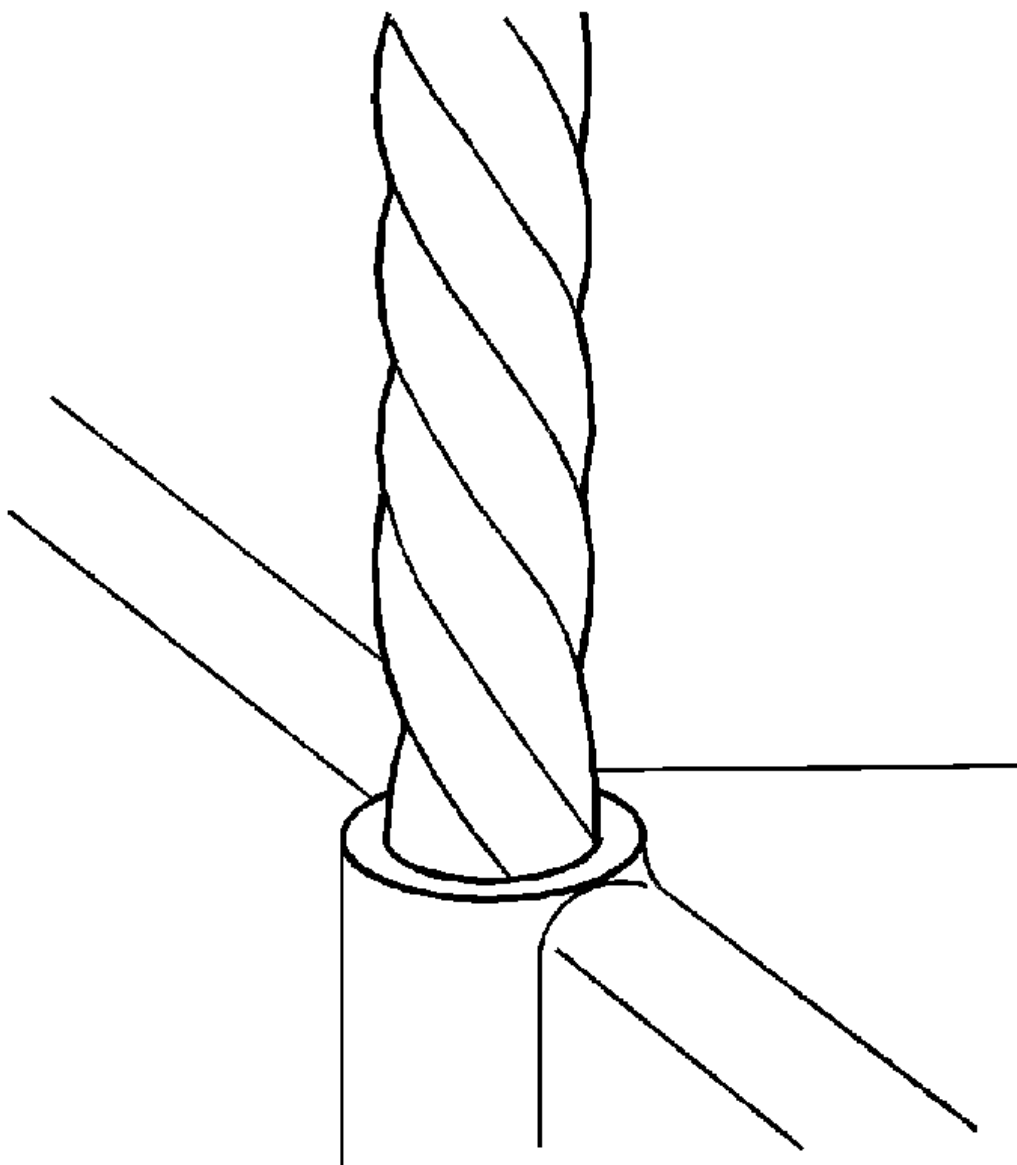
14. Inspect the insert (1) for correct installation (2) into the tapped hole.



**Fig. 268: Identifying Oil Or Engine Coolant Passage**  
Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

#### **Tapered Pipe Thread Repair**



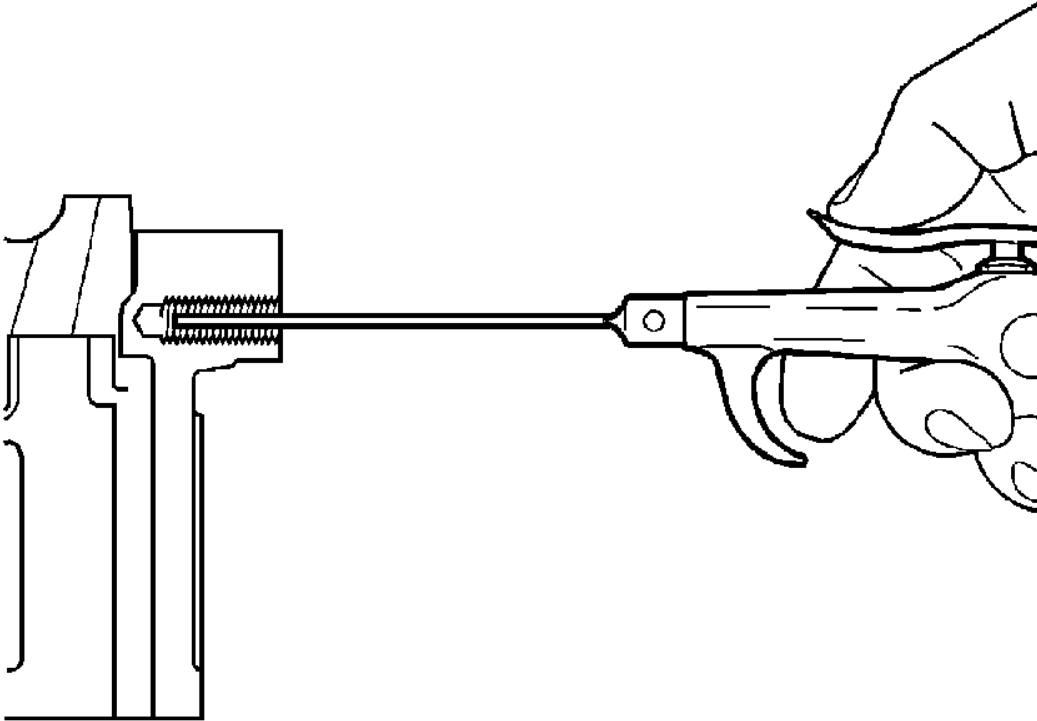
**Fig. 269: Identifying Drilling Out Threads Of Damaged Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base

**material.**

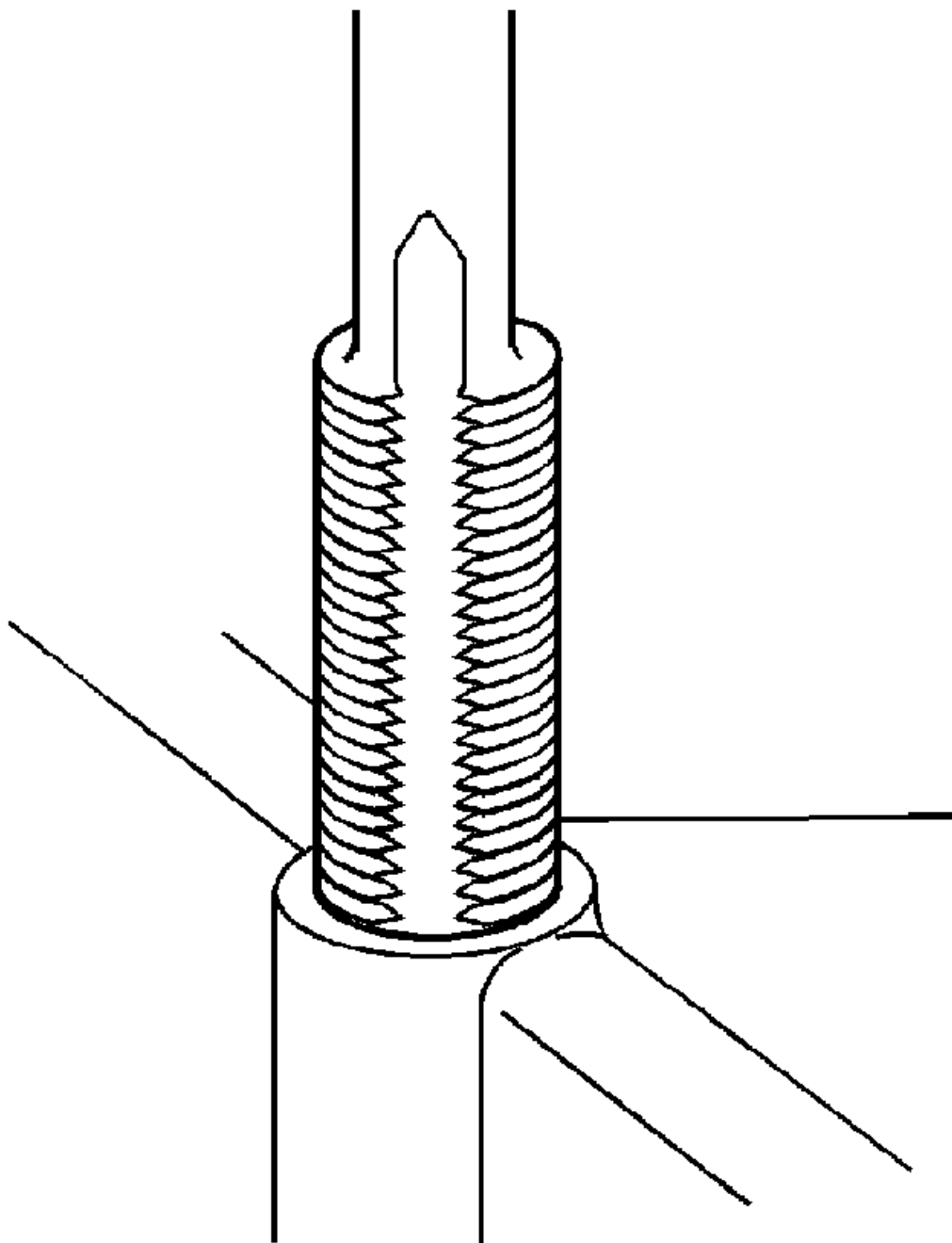
1. Drill out the threads of the damaged hole.



**Fig. 270: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.



**Fig. 271: Identifying Drilled Hole Tapping Procedure**  
Courtesy of GENERAL MOTORS CORP.

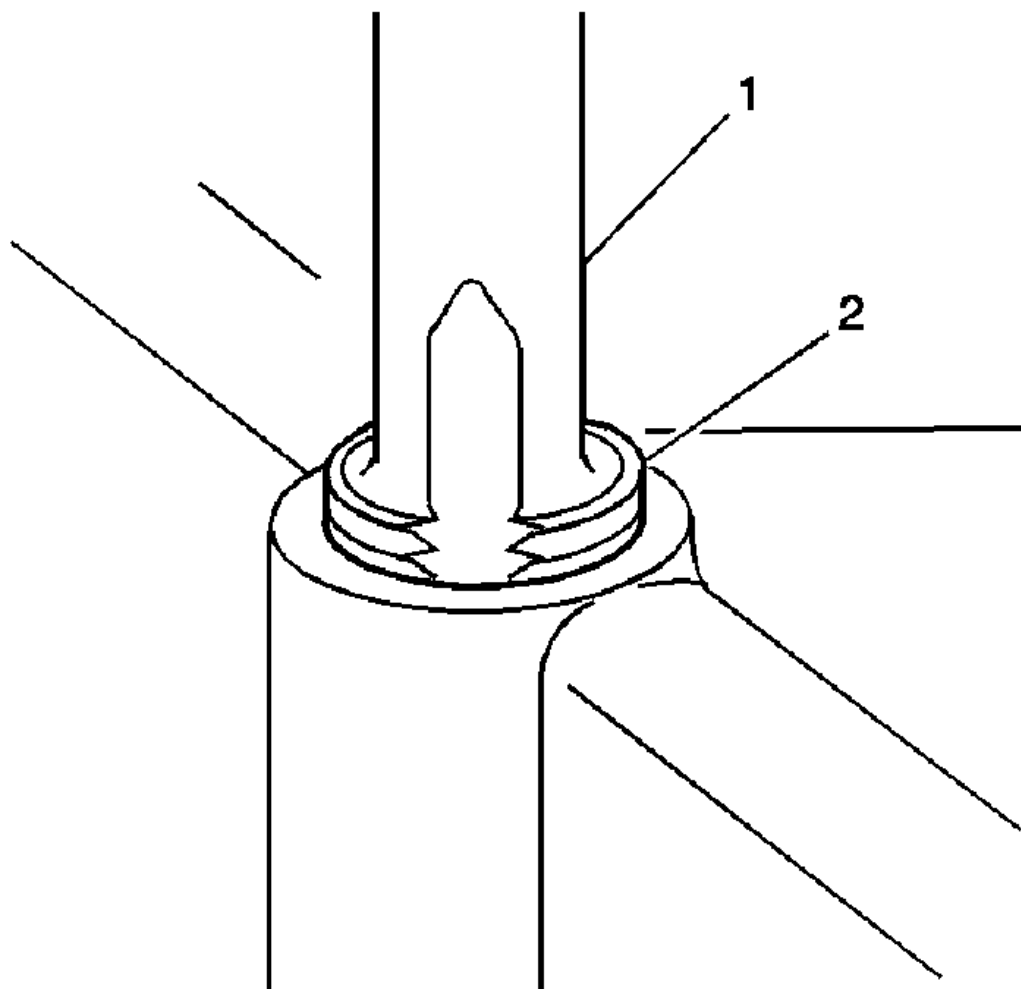
**NOTE:**

- During the tapping process, it is necessary to repeatedly remove the

tap and clean chips from the hole and the flutes of the tap.

- Make sure the tap has created full threads at least to the depth equal to the insert length.

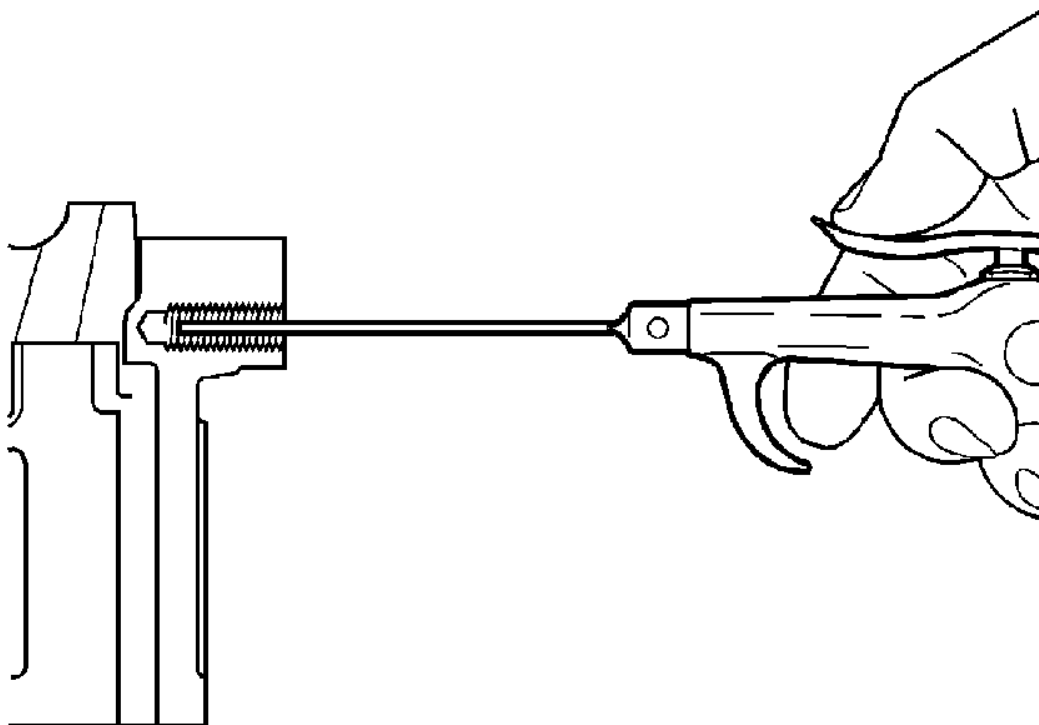
3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.



**Fig. 272: Identifying Surface Of Base Material**  
Courtesy of GENERAL MOTORS CORP.

4. Tap the drilled hole until the threads at the top of the tap (1) are down to the surface of the base material (2).

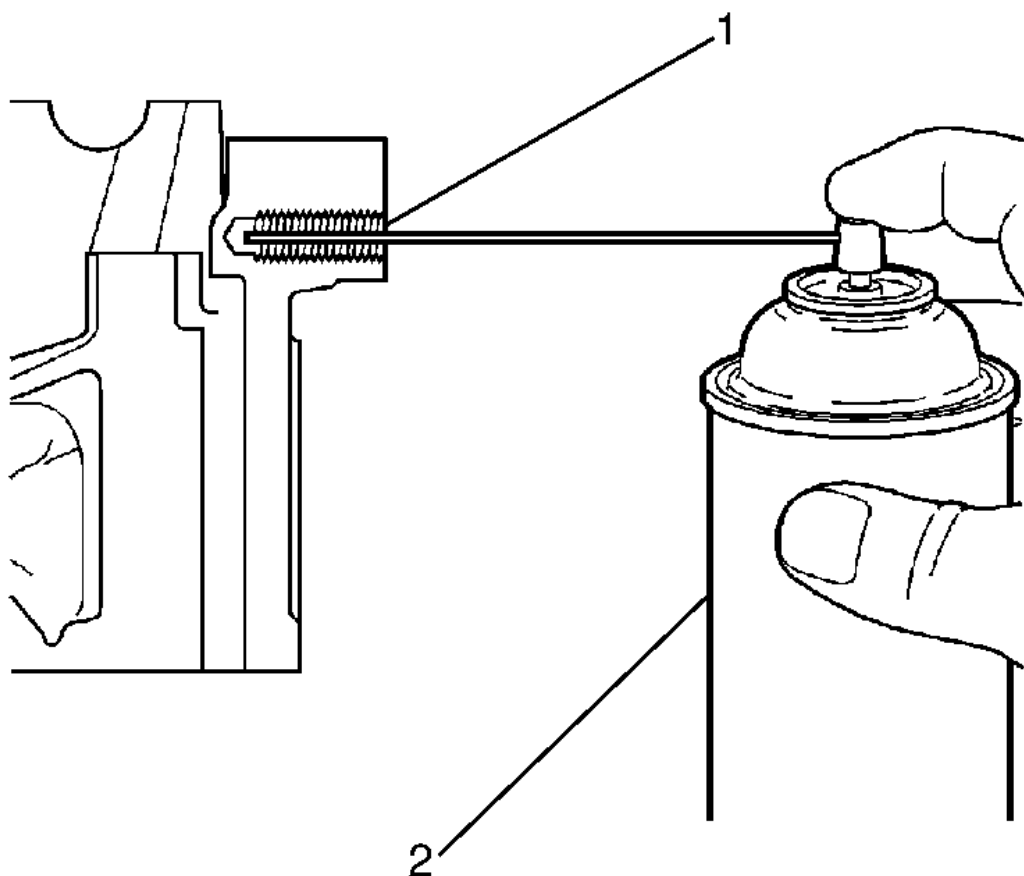




**Fig. 273: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

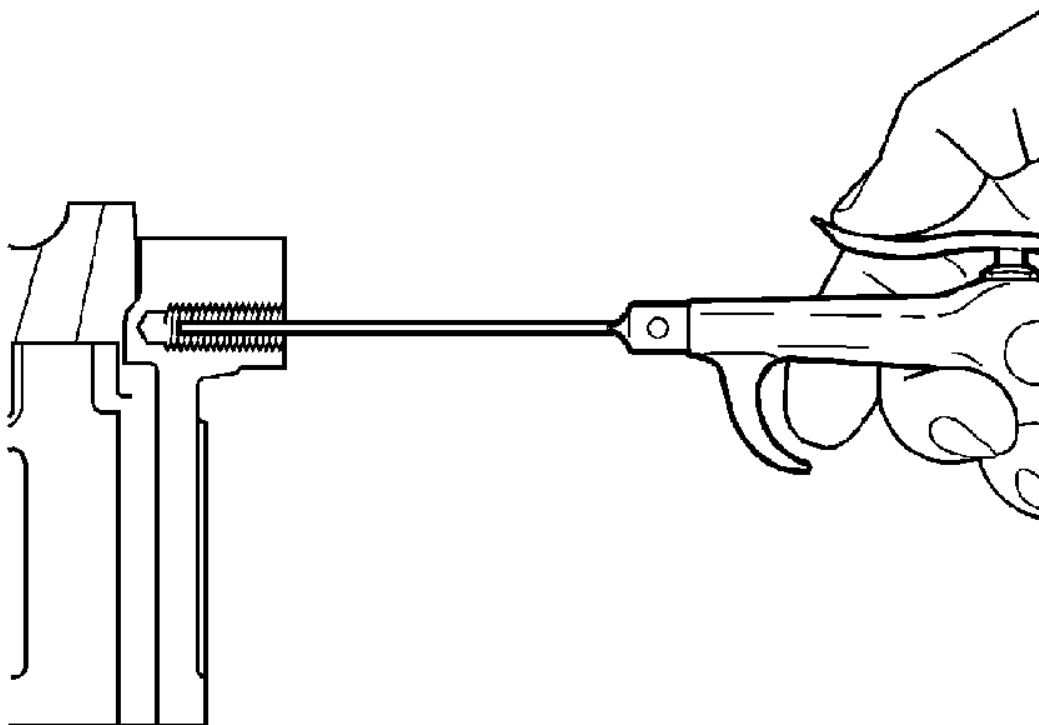
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.



**Fig. 274: View Of Thread Cleaner & Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

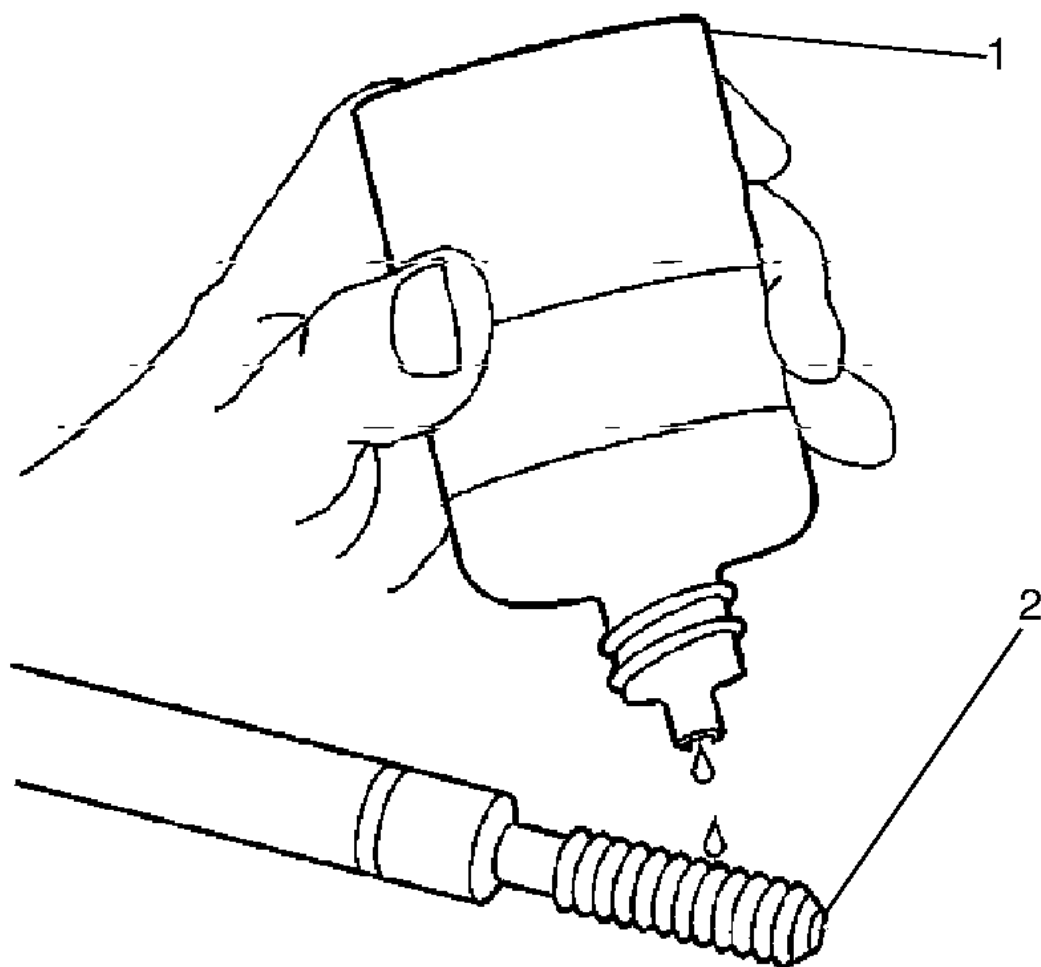
6. Spray a commercially available thread cleaner (2) into the tapped hole (1).



**Fig. 275: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

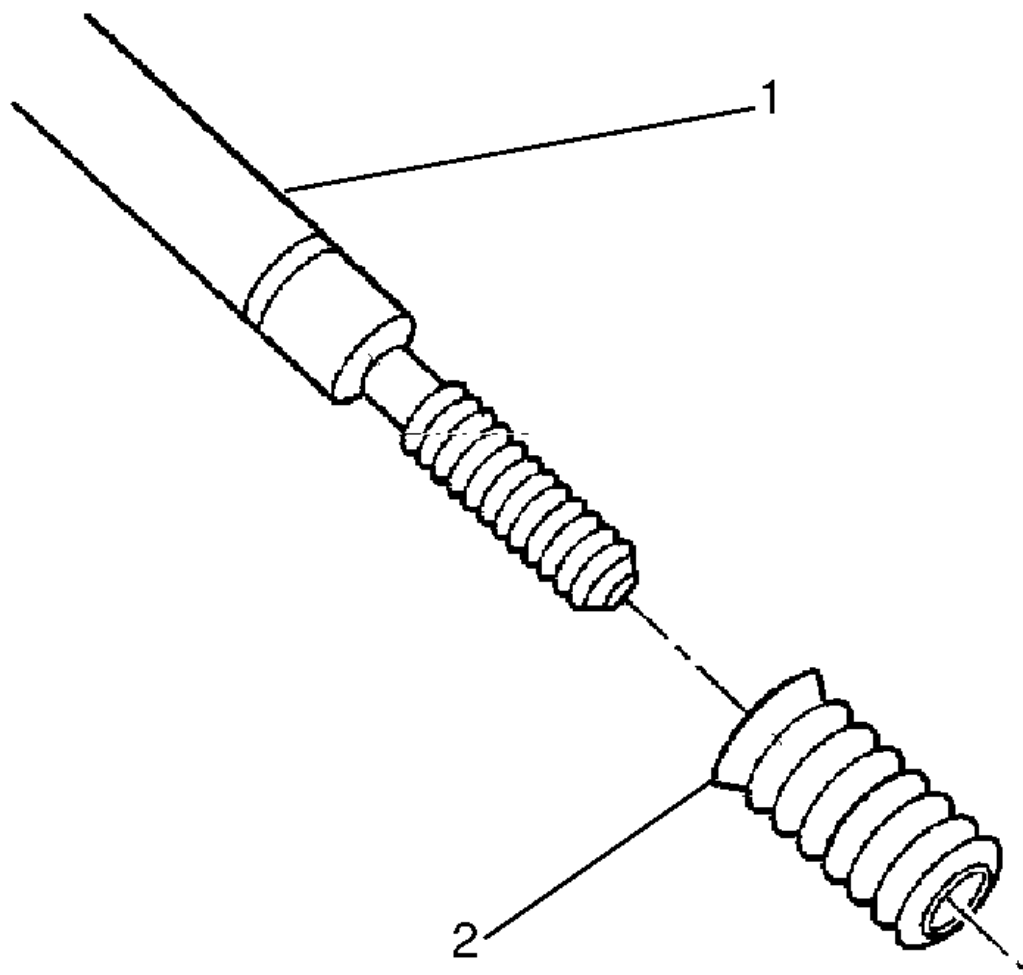
7. Using compressed air, clean out any chips.



**Fig. 276: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

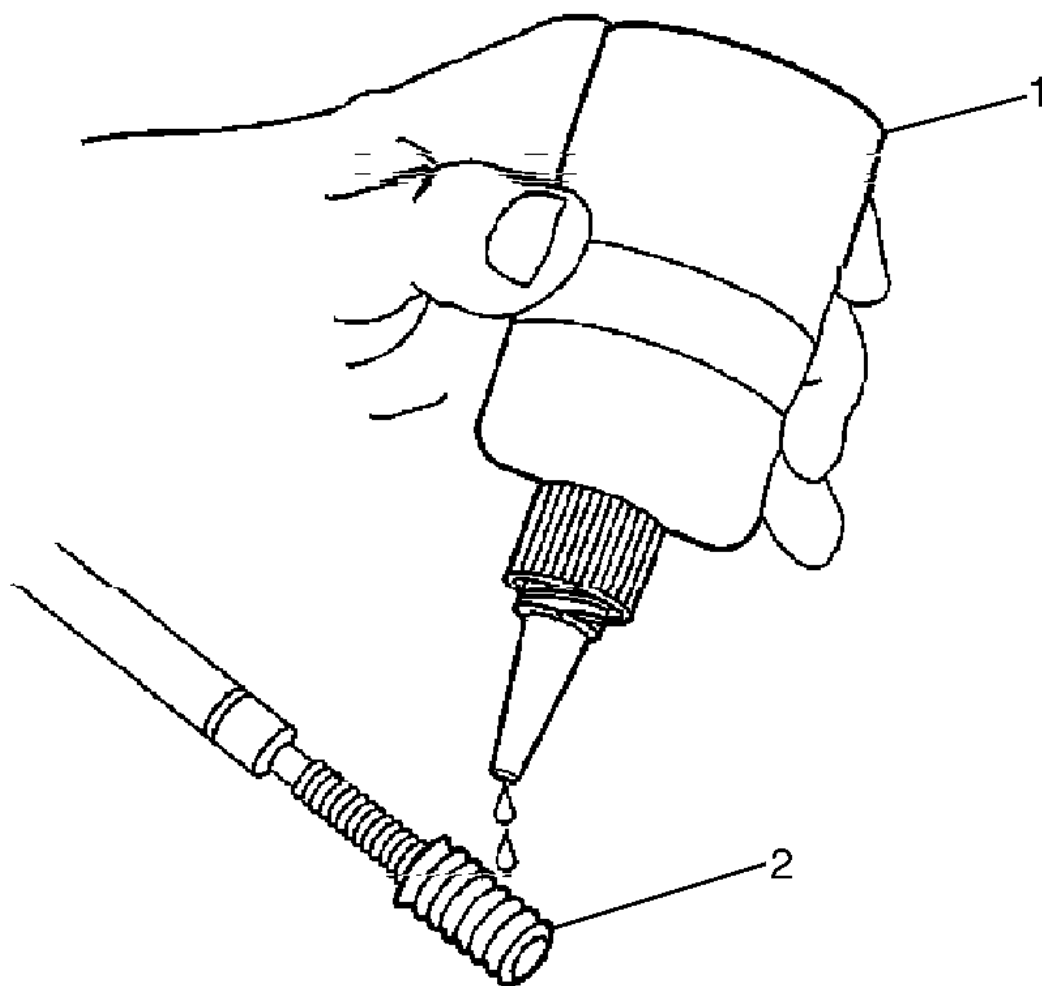
**NOTE:**      **DO NOT** allow oil or other foreign material to contact the **Outside Diameter (OD)** of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1).



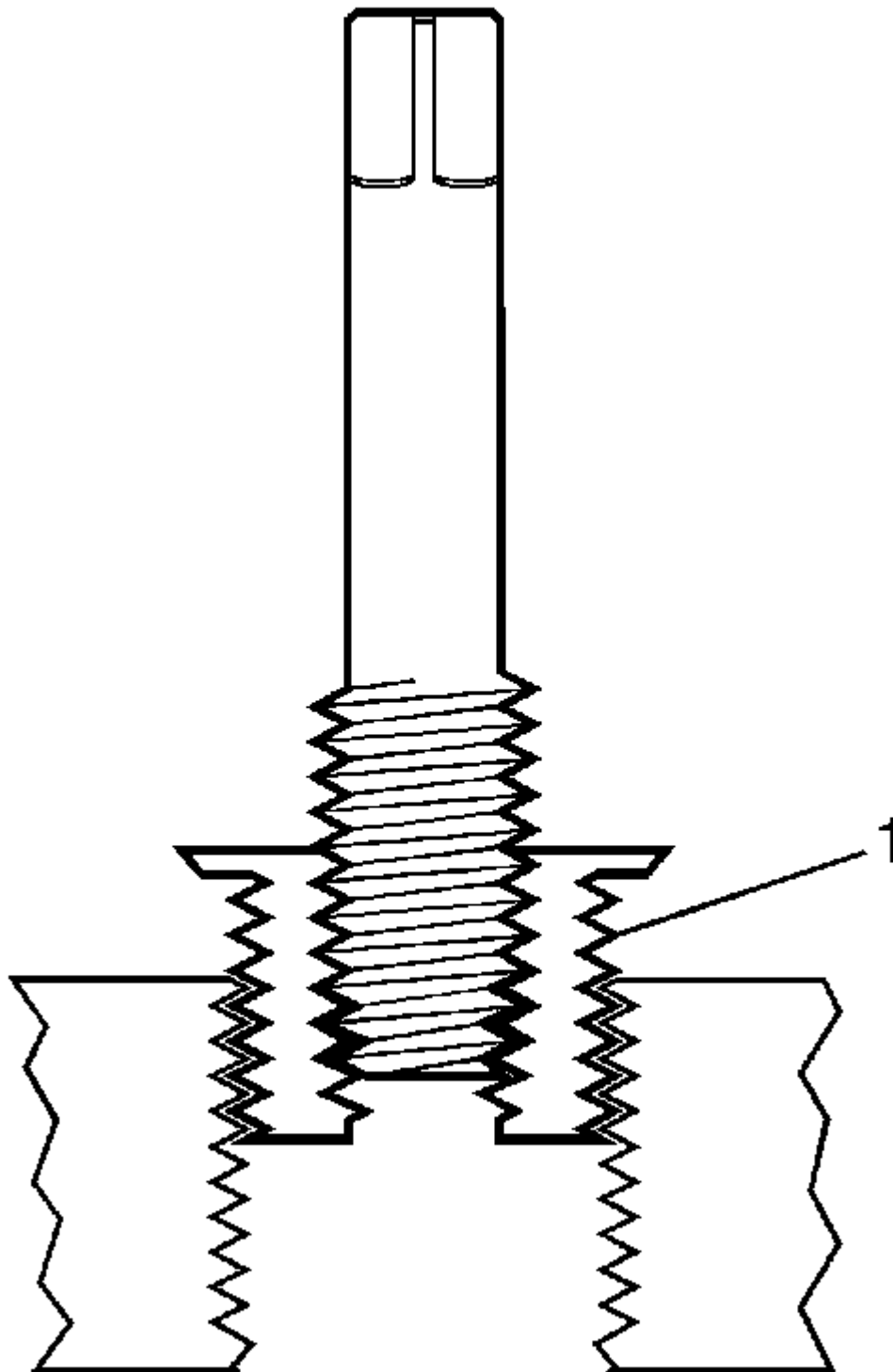
**Fig. 277: Identifying Insert & Driver Installation Tool**  
**Courtesy of GENERAL MOTORS CORP.**

9. Install the insert (2) onto the driver installation tool (1).



**Fig. 278: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

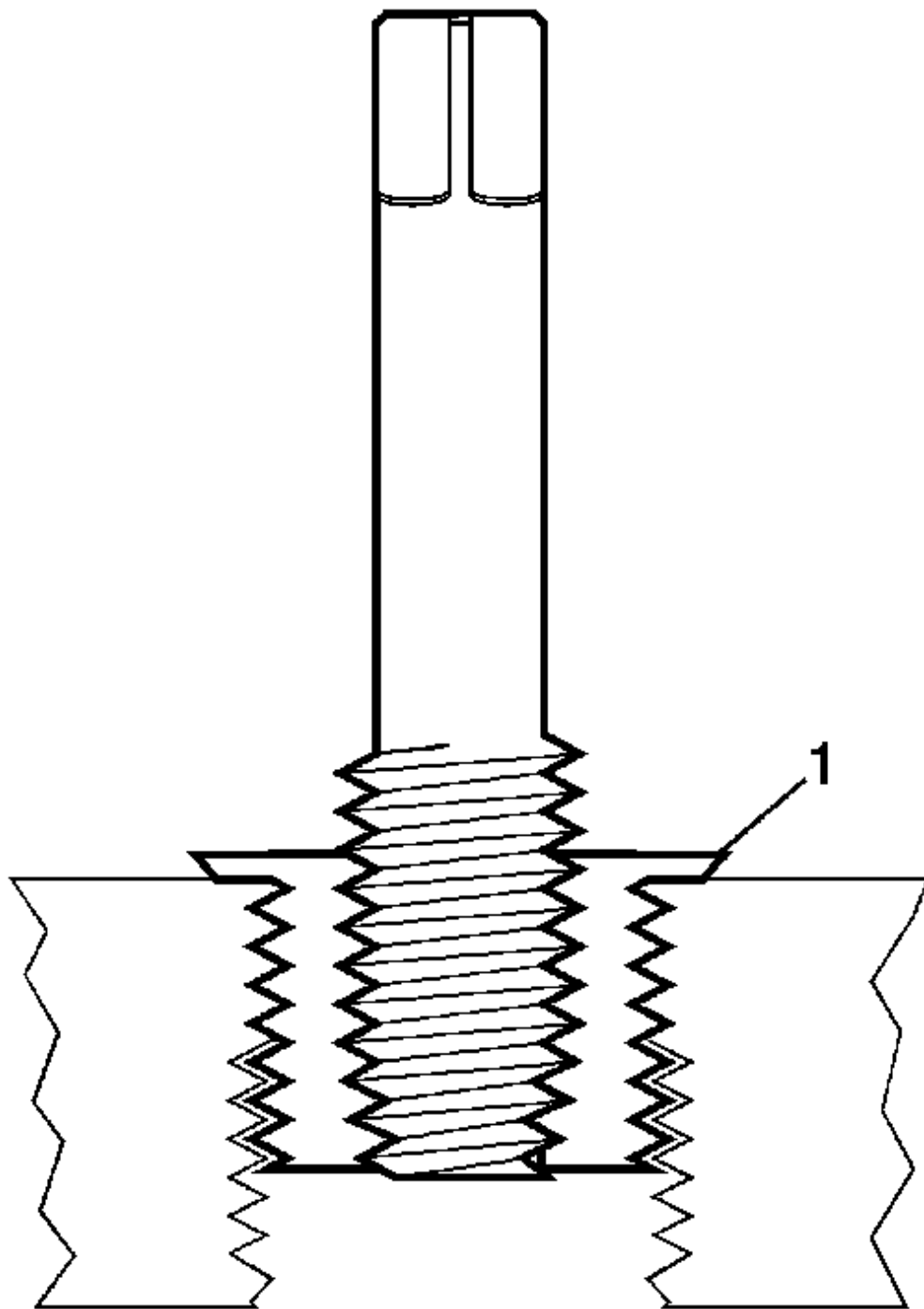
10. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).



**Fig. 279: Identifying Insert****Courtesy of GENERAL MOTORS CORP.**

11. Install the insert (1) into the tapped hole by hand only.



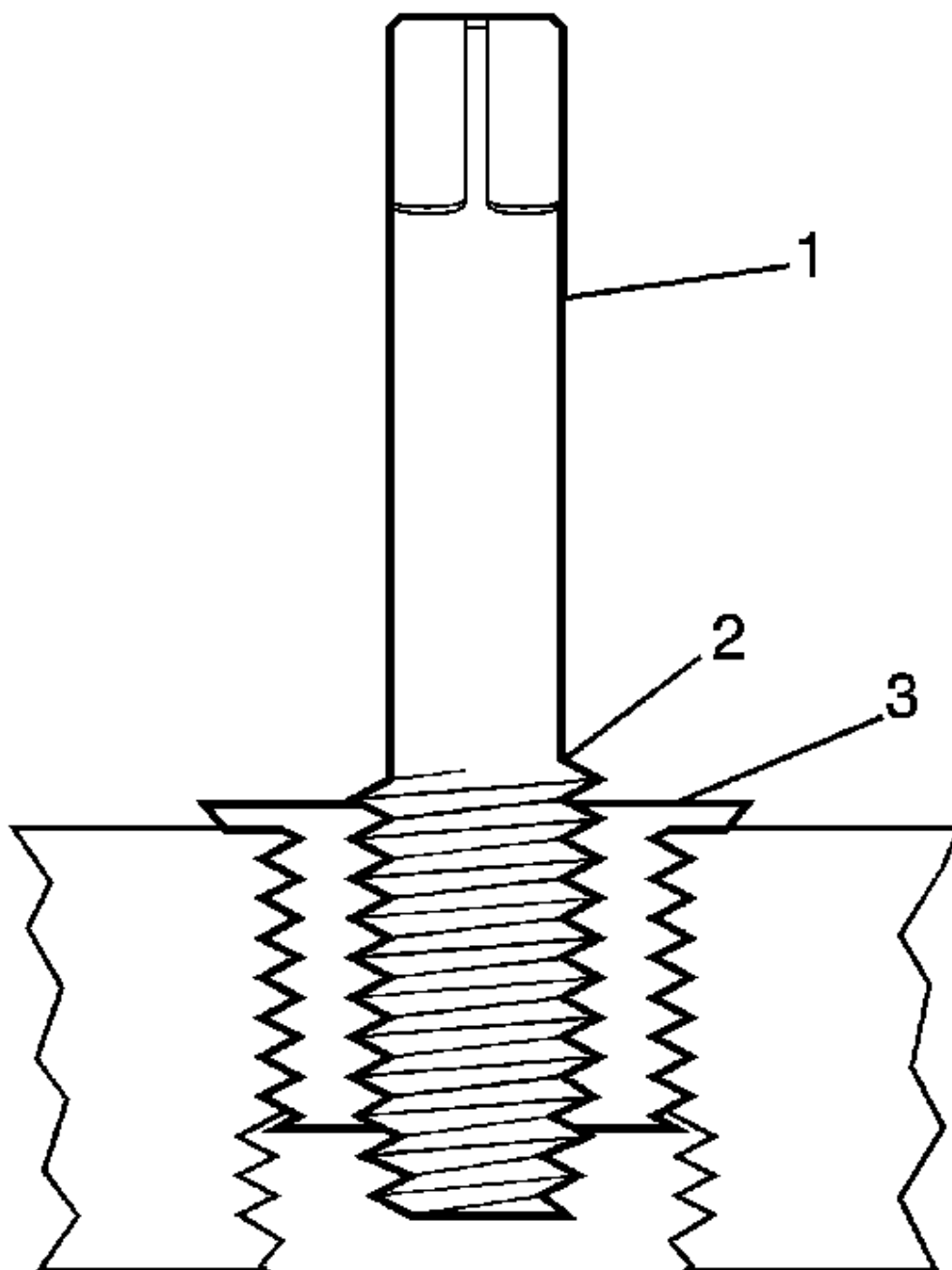


**Fig. 280: Identifying Flange Of Insert**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

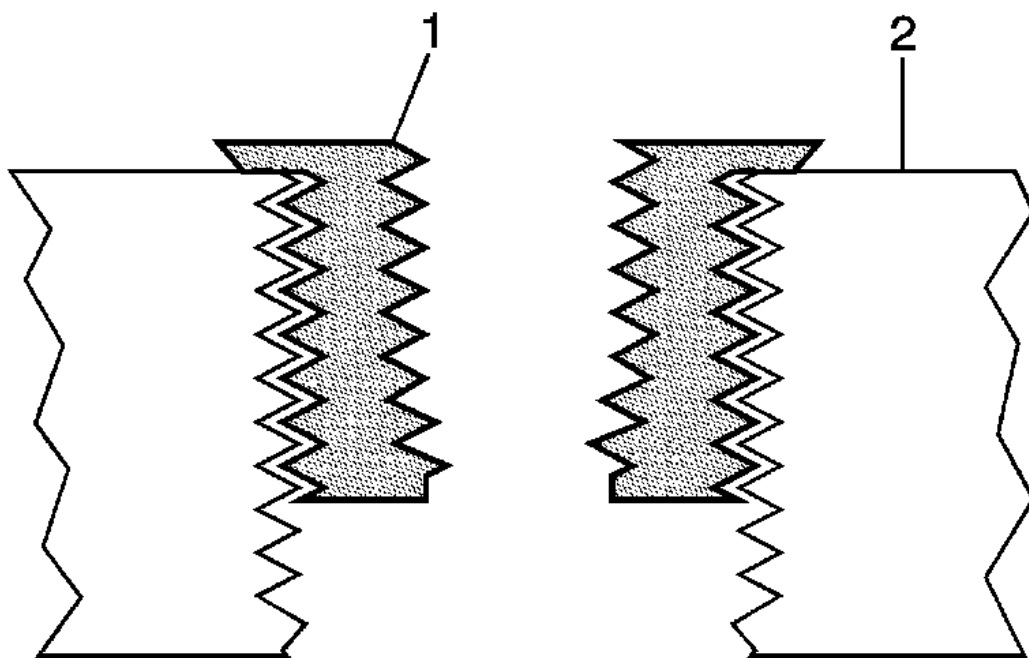
12. Install the insert until the flange (1) of the insert contacts the surface of the base material.



**Fig. 281: Identifying Driver Installation Tool, Top Of Threaded Section & Insert**  
Courtesy of GENERAL MOTORS CORP.

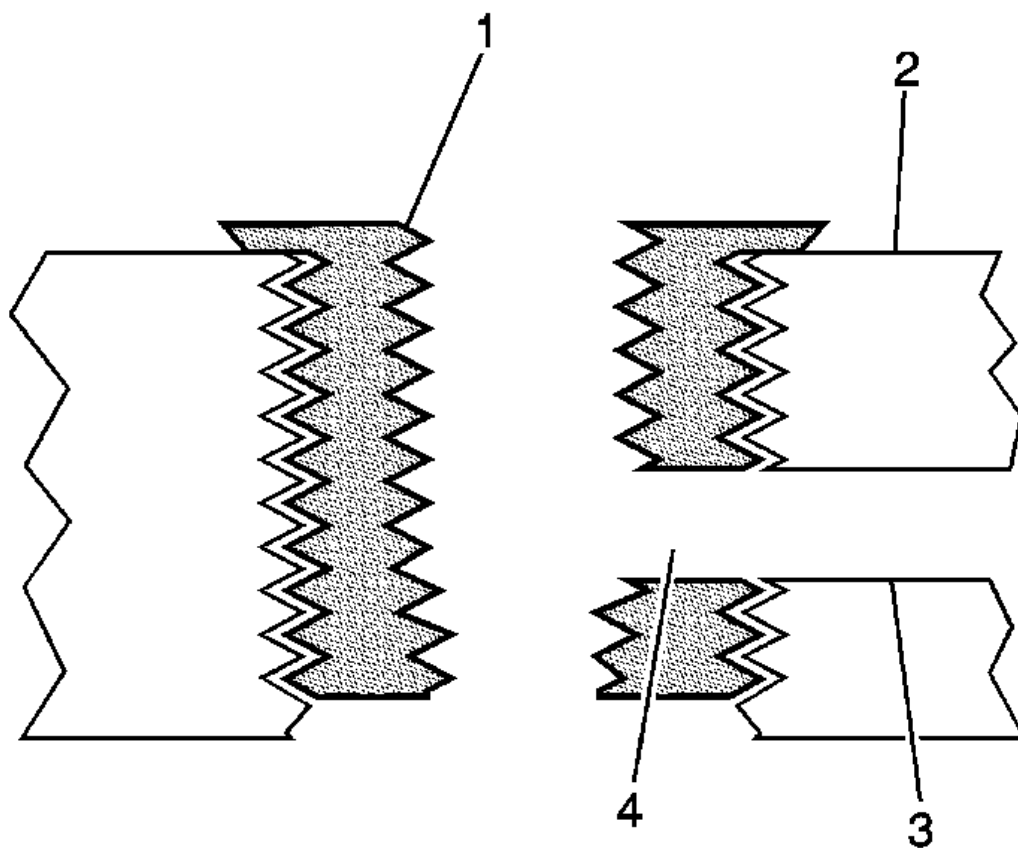
**NOTE:** The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).



**Fig. 282: Identifying Insert**  
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for correct installation (2) into the tapped hole.



**Fig. 283: Identifying Oil Or Engine Coolant Passage**  
Courtesy of GENERAL MOTORS CORP.

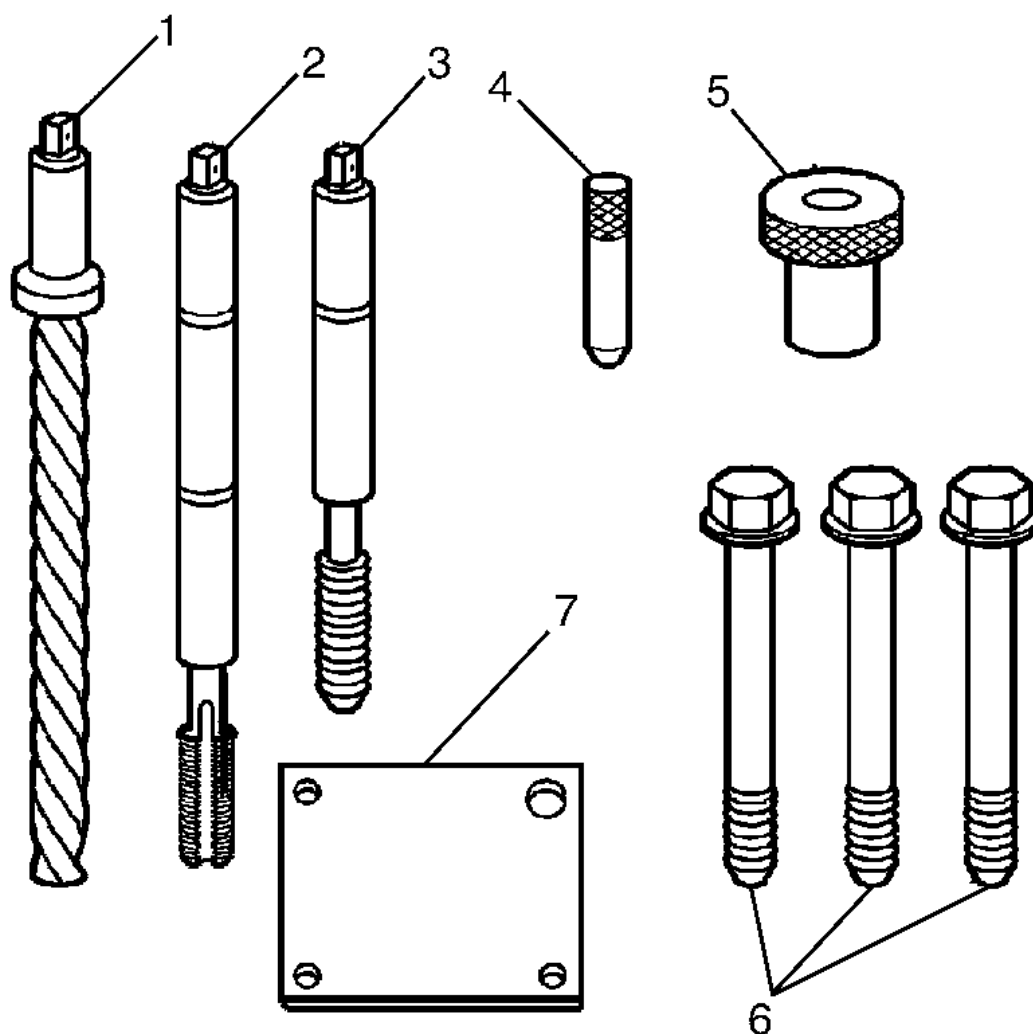
15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

#### Cylinder Head Bolt Hole Thread Repair

##### Special Tools

- **J 42385-700:** High Feature Thread Repair Kit
- **J 42385-2000:** Thread Insert Kit

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



**Fig. 284: View Of Cylinder Head Bolt Hole Thread Repair Components**

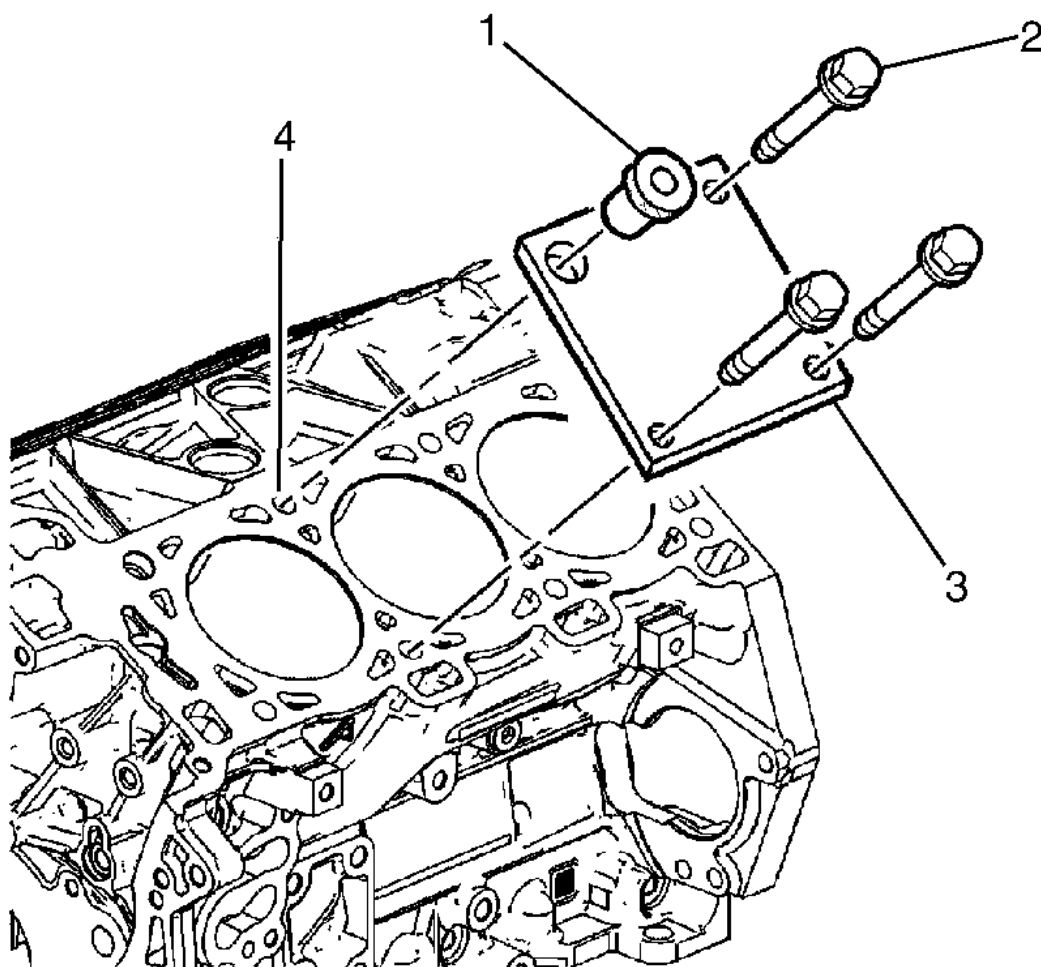
Courtesy of GENERAL MOTORS CORP.

- The cylinder head bolt hole thread repair tooling are in the kits **J 42385-2000:** thread insert kit and **J 42385-700:** kit. The cylinder head bolt hole thread repair components consist of the following:
- J 42385-723 Drill (1)
- J 42385-724 Tap (2)
- J 42385-725 Installation driver (3)
- J 42385-303 Alignment pin (4)
- J 42385-302 Bushing (5)
- J 42385-733 Bolts (6)
- J 42385-401 Fixture plate (7)

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

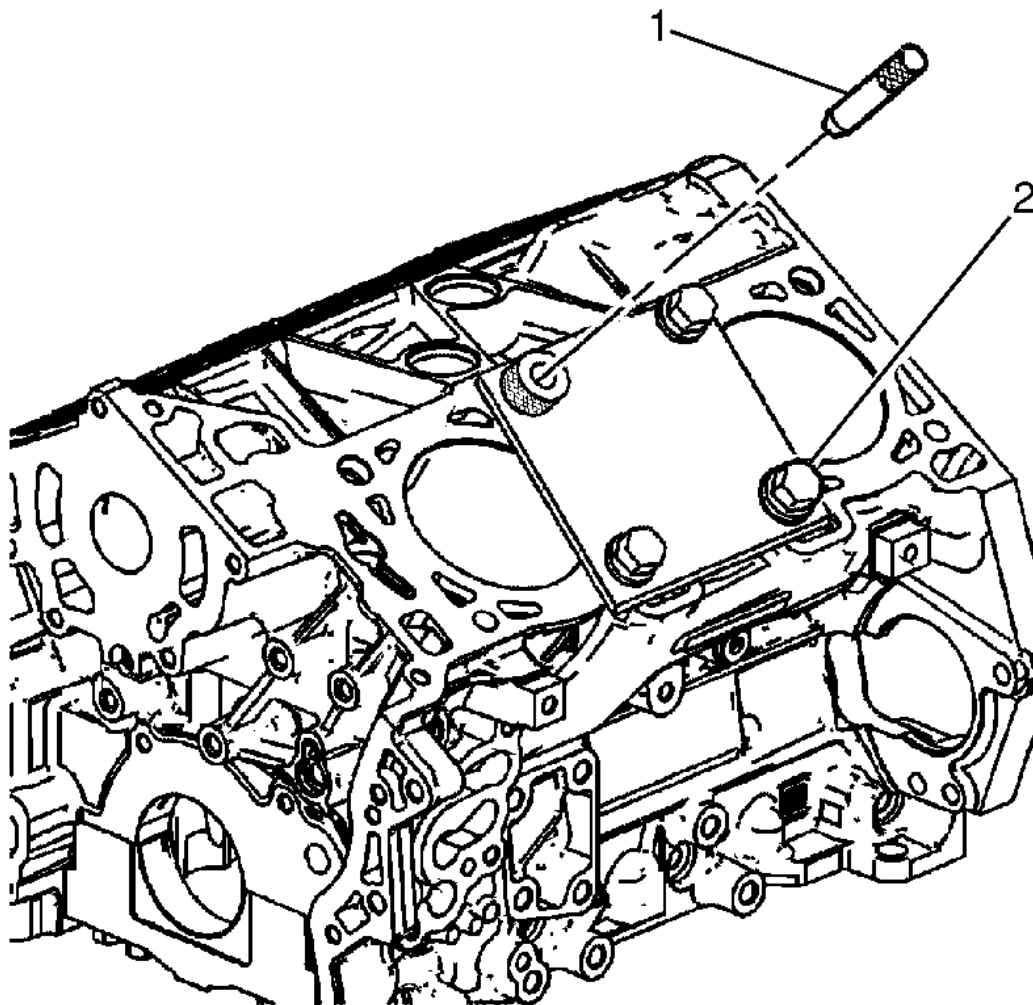
**NOTE:**

- Remove the fixture plate prior to installing the insert with the installer tool.
  - The use of a cutting type fluid such as WD 40®; or equivalent is recommended when performing the drilling, counterboring and tapping procedures.
- 
- When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



**Fig. 285: View Of Bushing & Fixture Plate With Bolts**  
Courtesy of GENERAL MOTORS CORP.

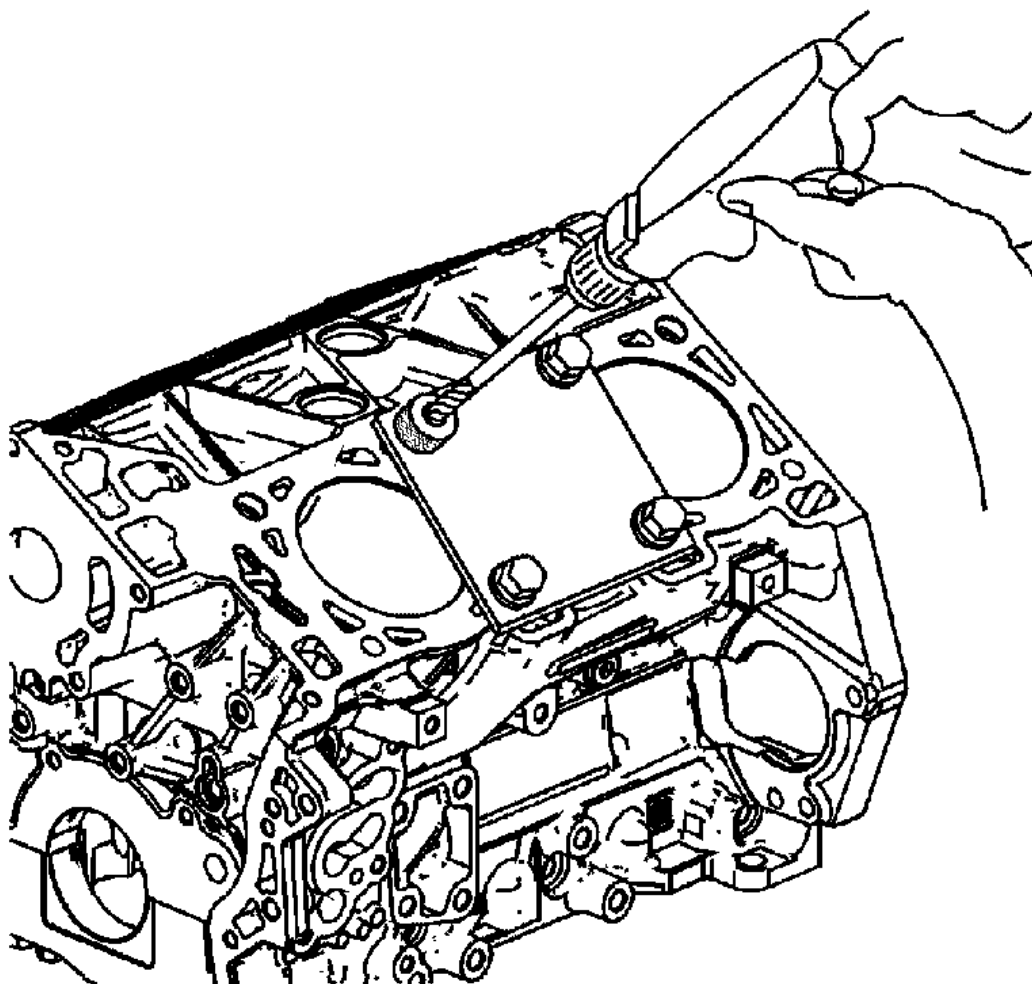
1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.



**Fig. 286: Identifying Alignment Pin & Fixture Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

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





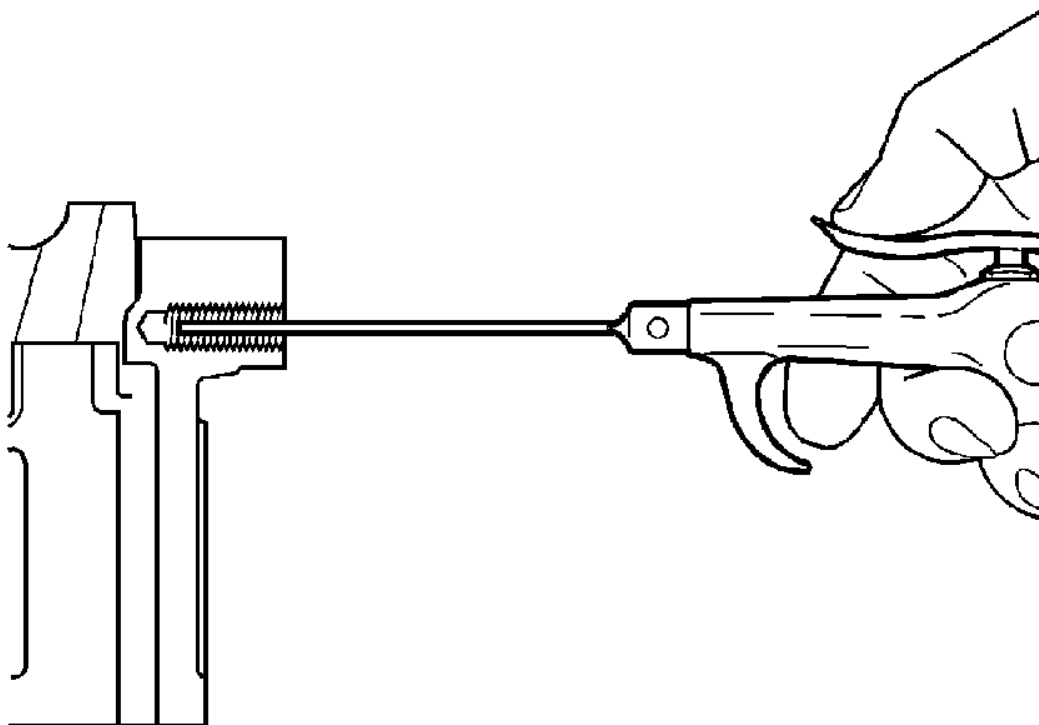
**Fig. 287: Identifying Drilling Out Threads Of Damaged Hole**

Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the top of the drill bushing.

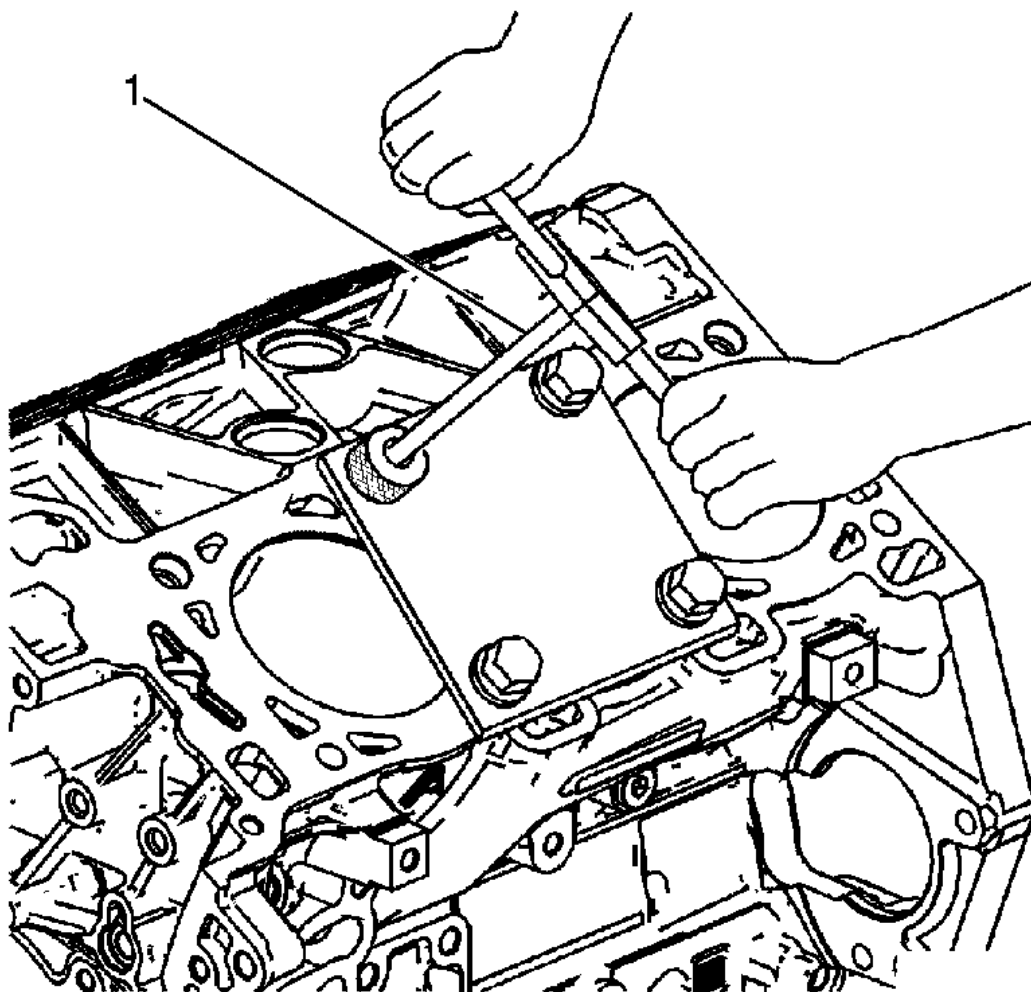
6. Drill out the threads of the damaged hole.



**Fig. 288: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

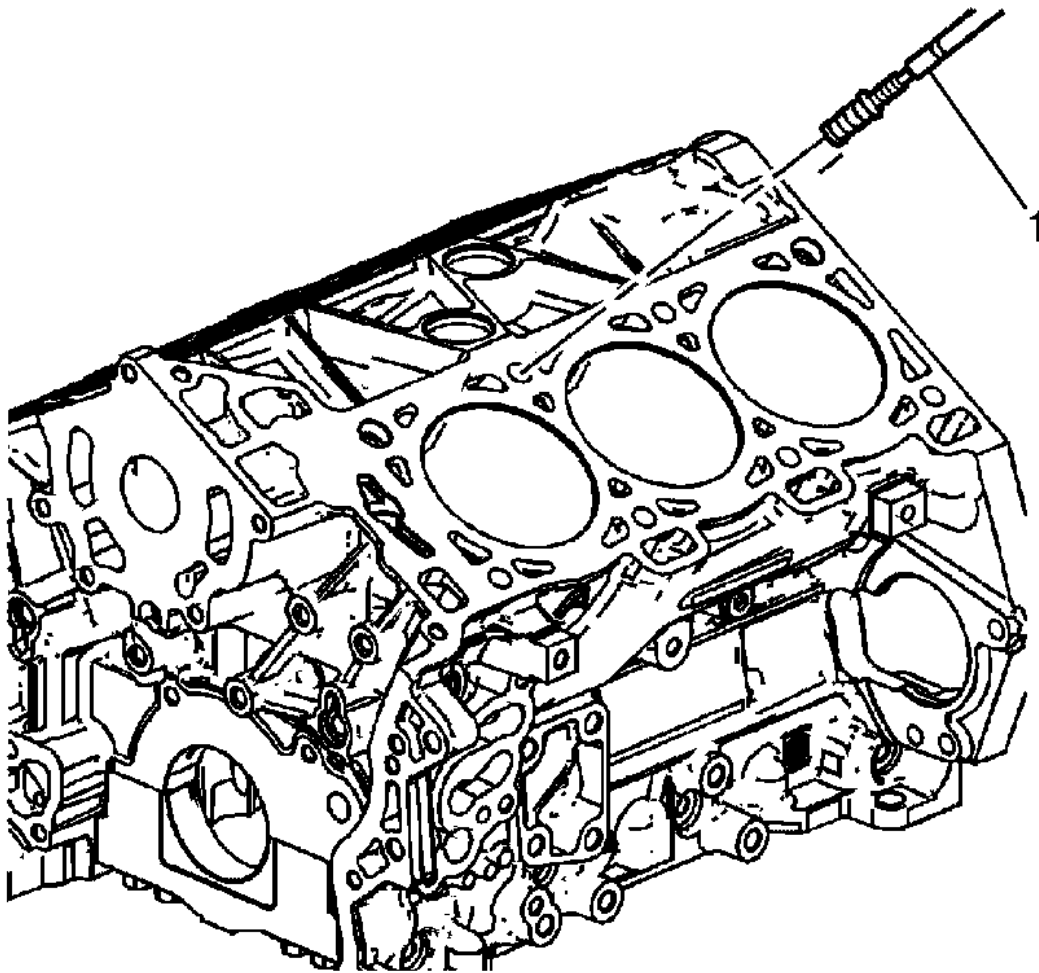


**Fig. 289: View Of Tapping Wrench**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

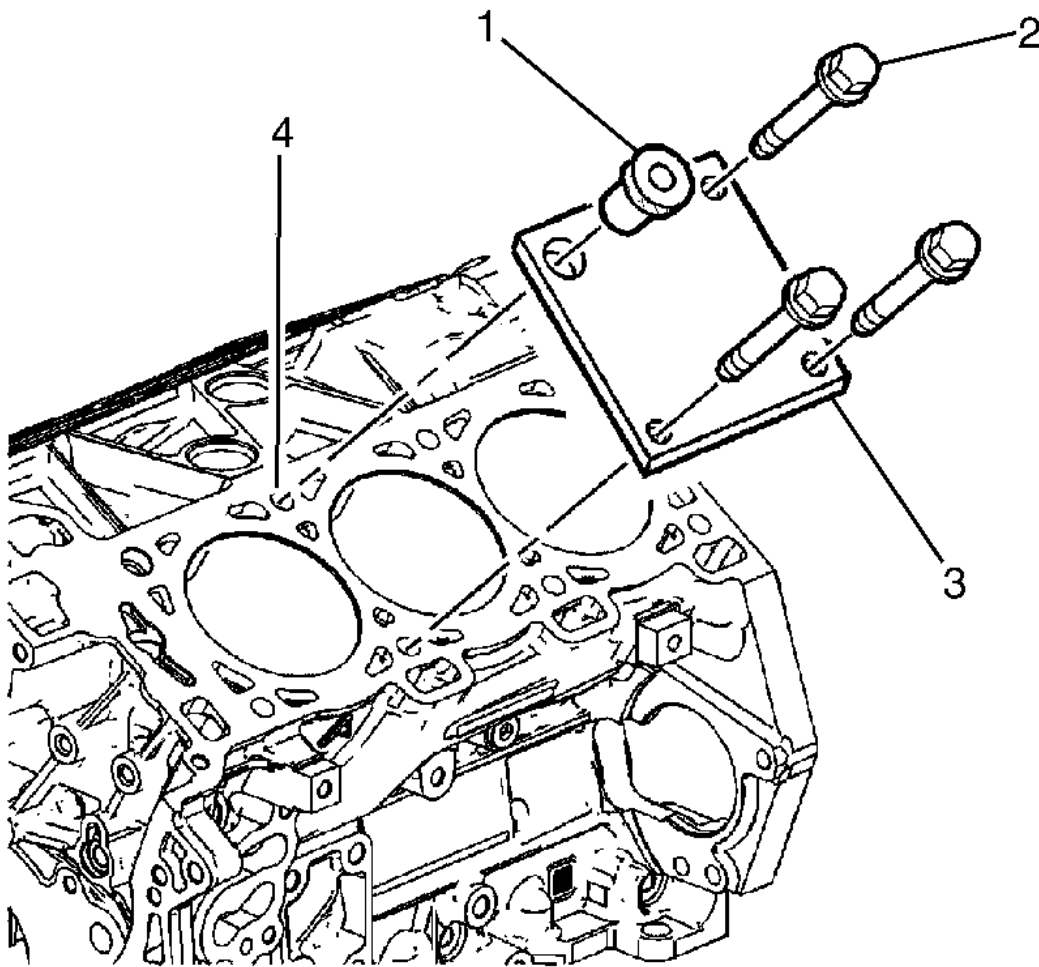
8. Using a suitable tapping wrench (1), tap the threads of the drilled hole by hand only.



**Fig. 290: Identifying Cylinder Head Bolt Hole**

Courtesy of GENERAL MOTORS CORP.

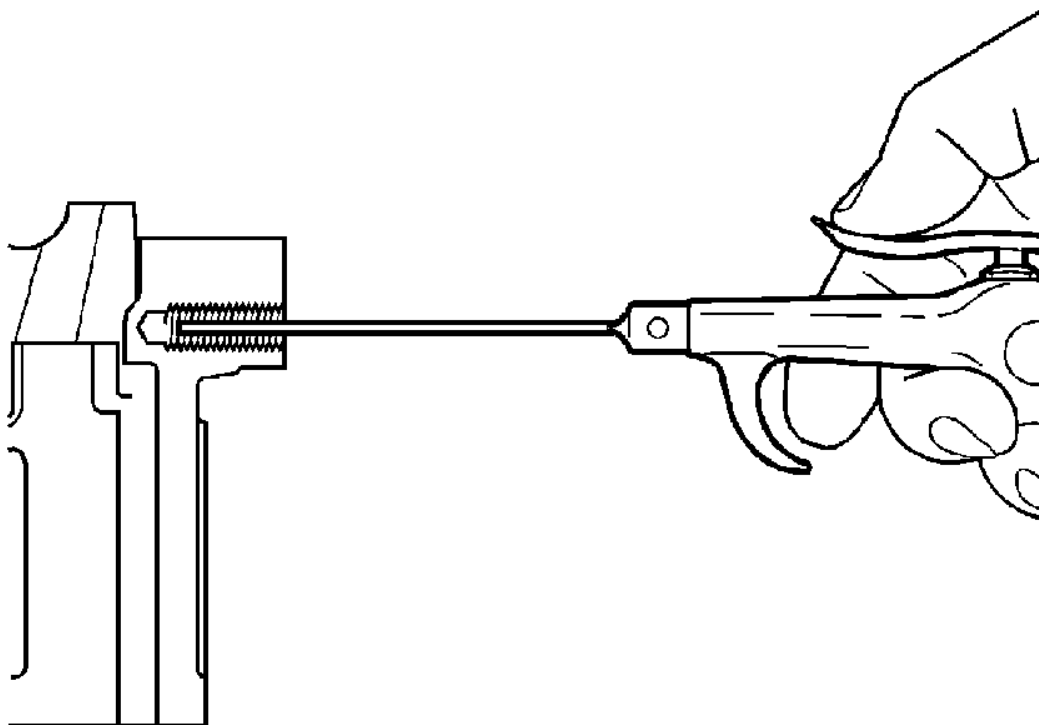
9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the cylinder head bolt hole until the mark (1) on the tap aligns with the top of the drill bushing.



**Fig. 291: View Of Bushing & Fixture Plate With Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Remove the fixture plate prior to installing the insert with the installer tool.

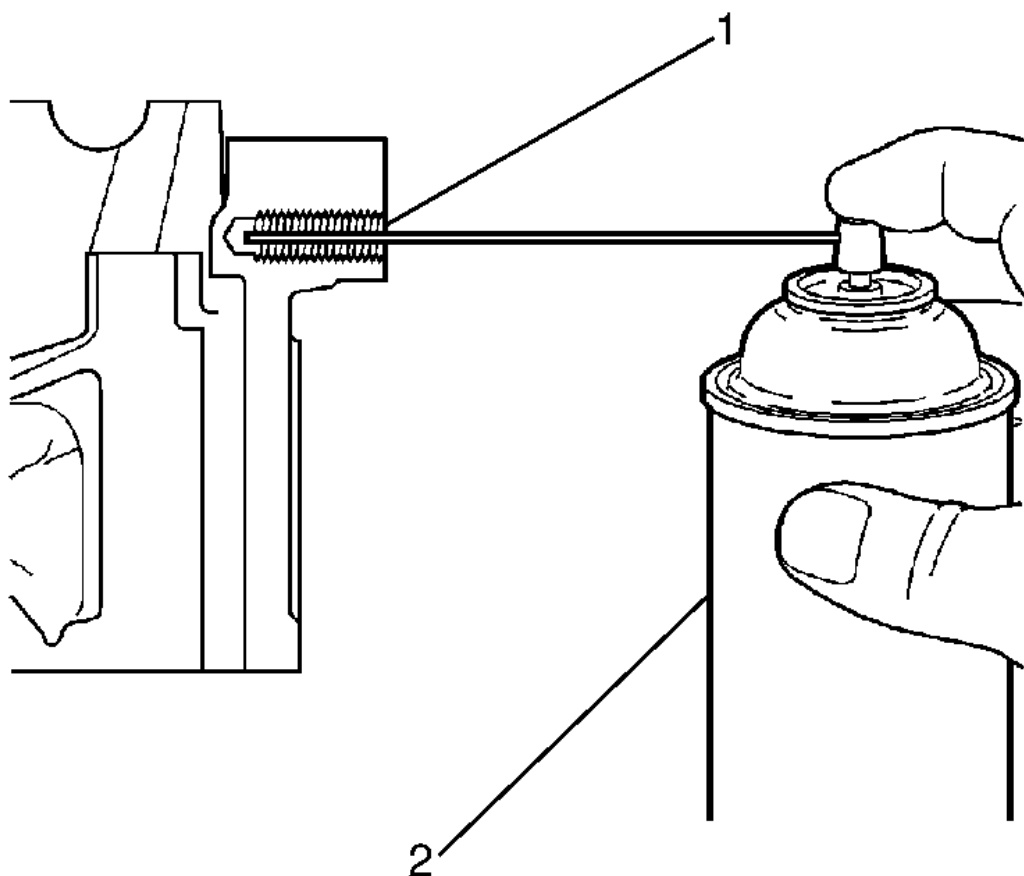
10. Remove the fixture plate bolts (2).
11. Remove the fixture plate (3) and bushing (1).



**Fig. 292: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

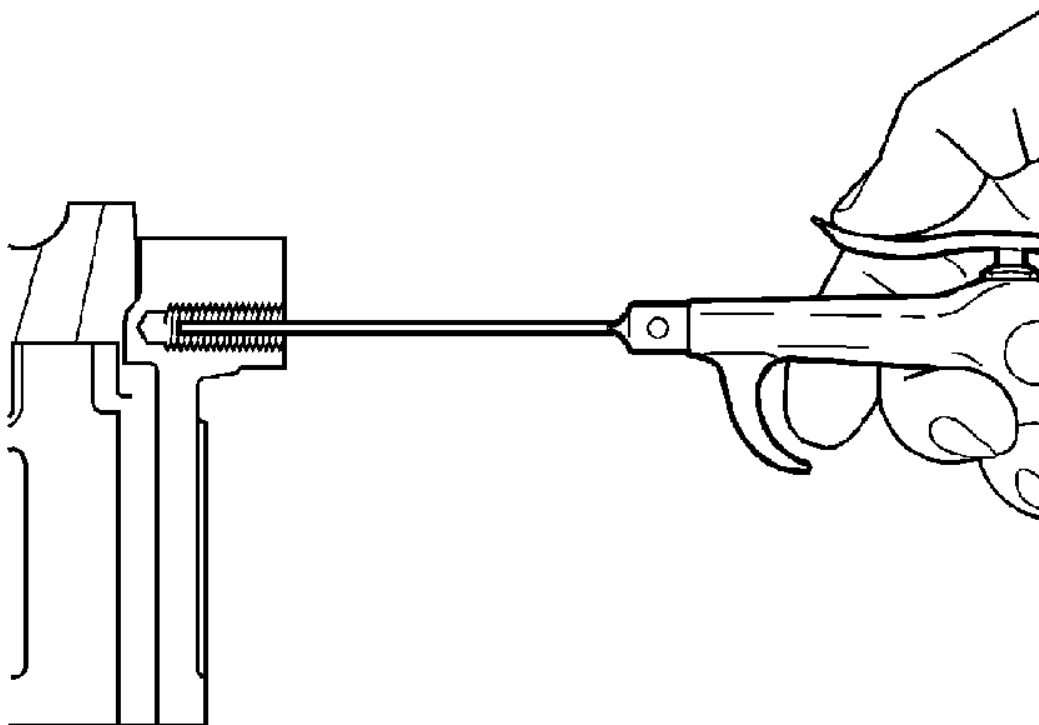
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.



**Fig. 293: View Of Thread Cleaner & Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

13. Spray a commercially available thread cleaner (2) into the tapped hole (1).

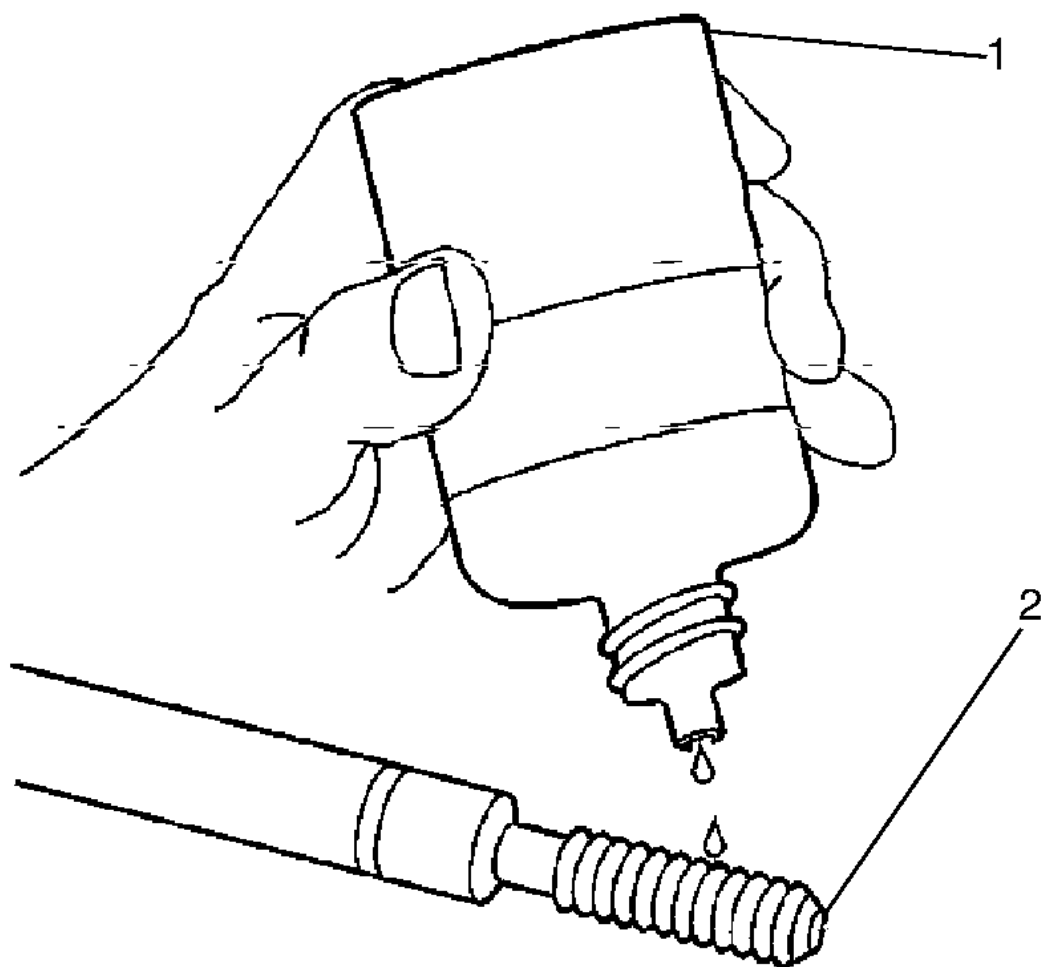


**Fig. 294: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

14. Using compressed air, clean out any chips.

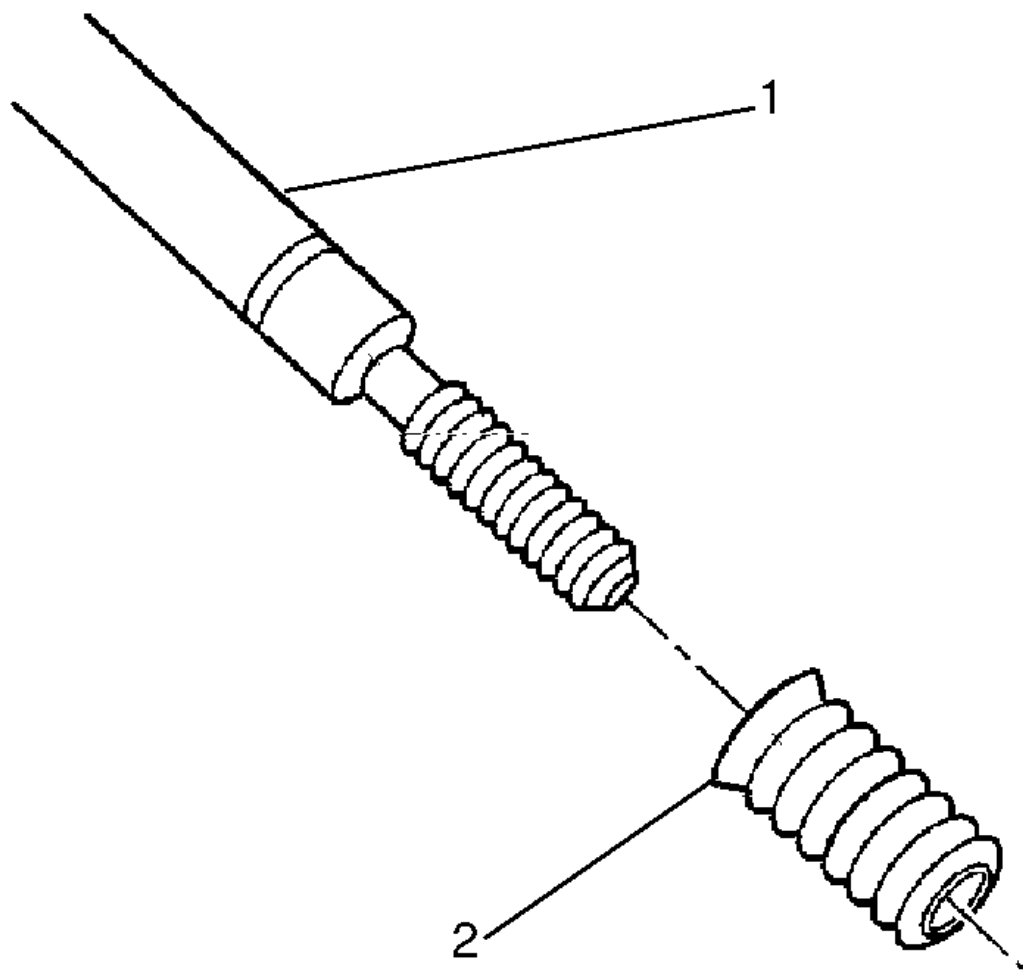




**Fig. 295: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

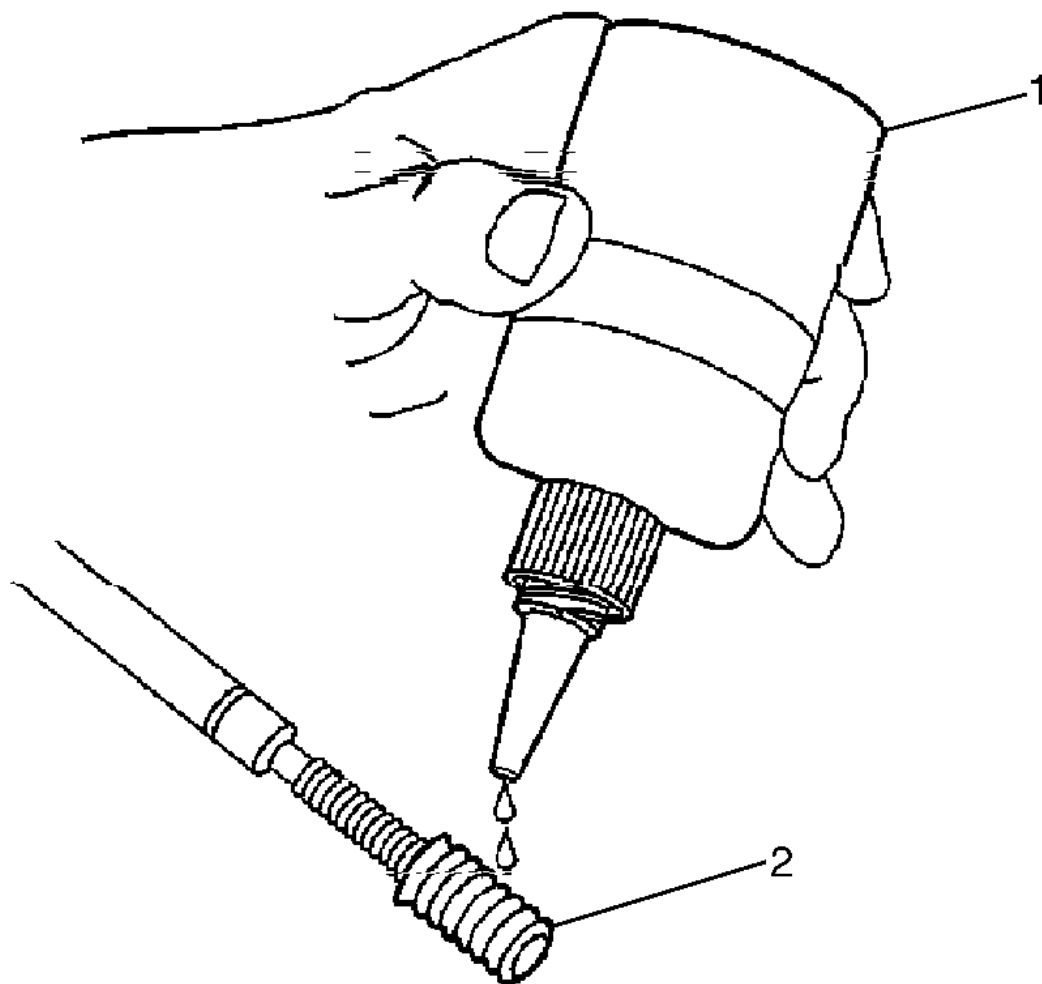
**NOTE:** DO NOT allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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



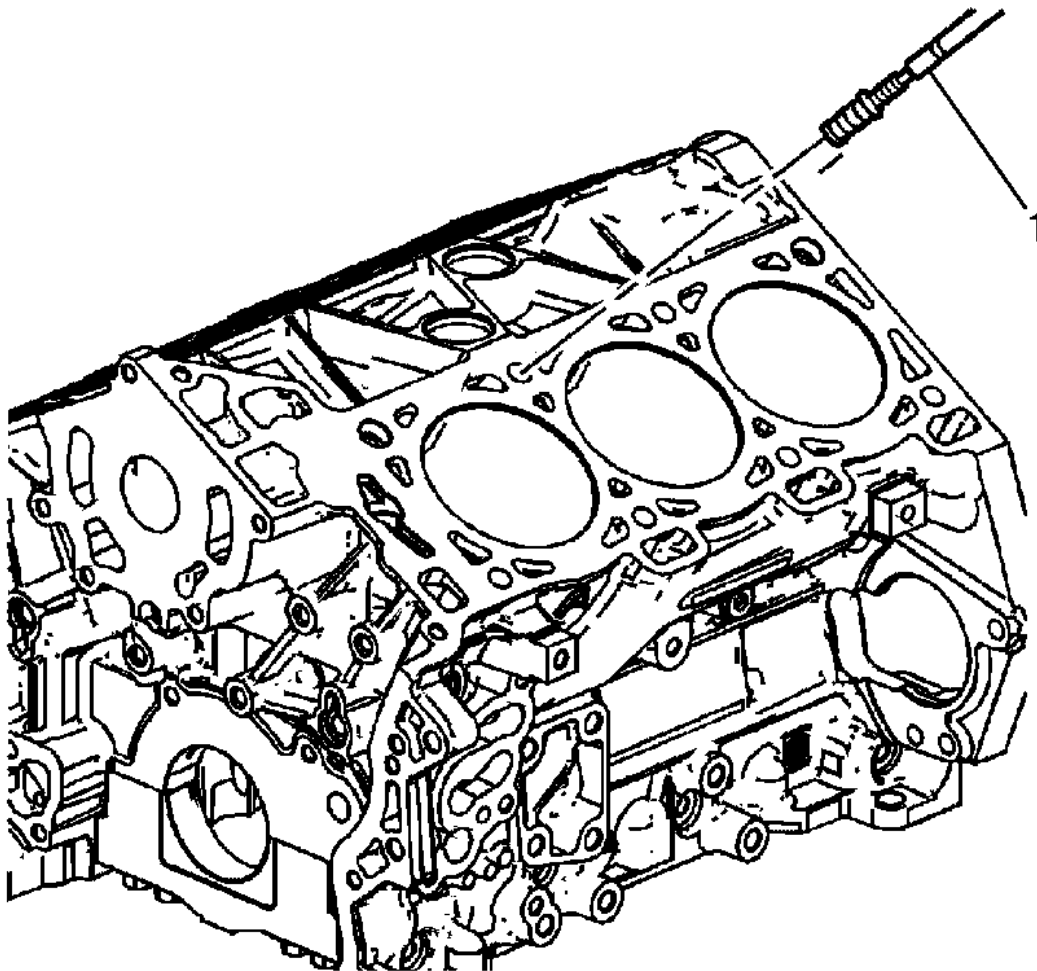
**Fig. 296: Identifying Insert & Driver Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

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



**Fig. 297: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock sealant such as LOCTITE 277®; or equivalent (1) to the insert OD threads (2).



**Fig. 298: Identifying Cylinder Head Bolt Hole**  
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and installation driver (1) into the tapped hole by hand only.
19. Start the insert into the threaded hole.

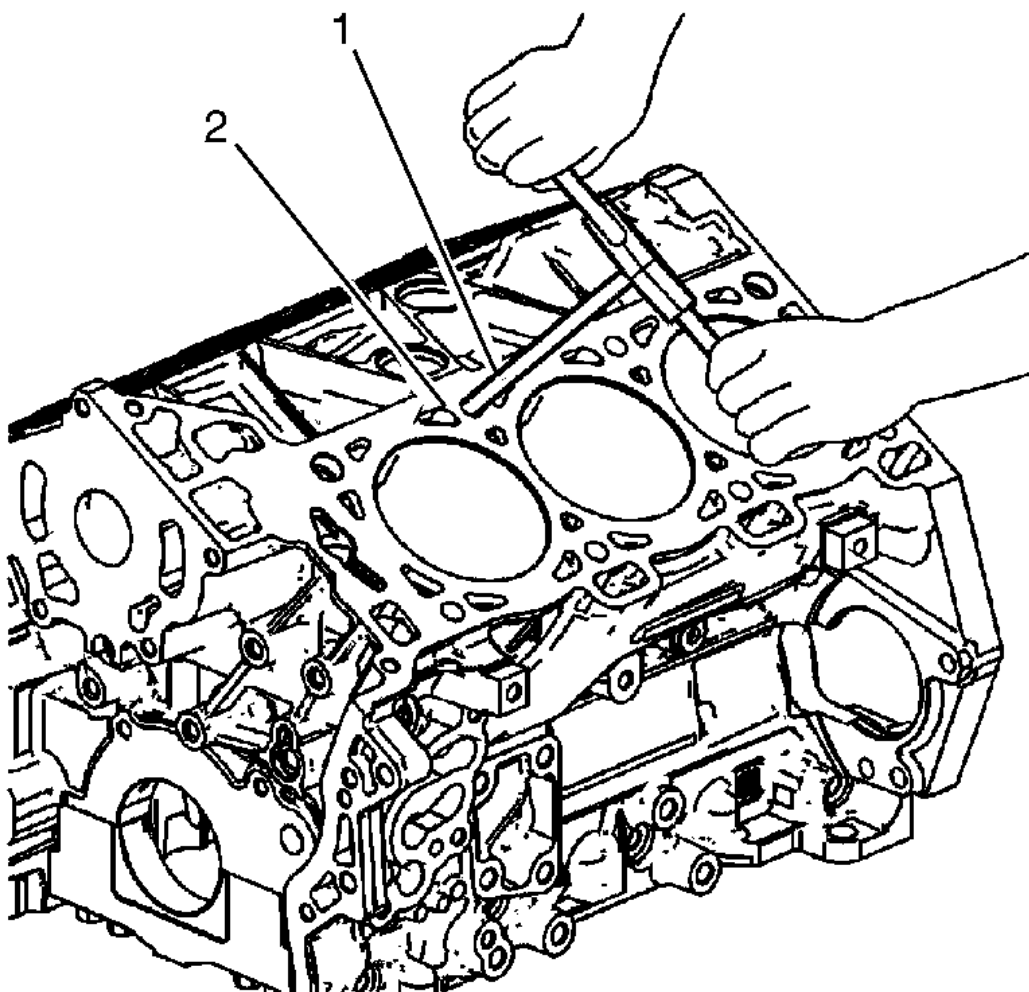
**NOTE:** If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

**NOTE:** The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

insert are being formed and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.



**Fig. 299: Identifying Driver Installation Tool & Surface Of Cylinder Block Deck**  
Courtesy of GENERAL MOTORS CORP.

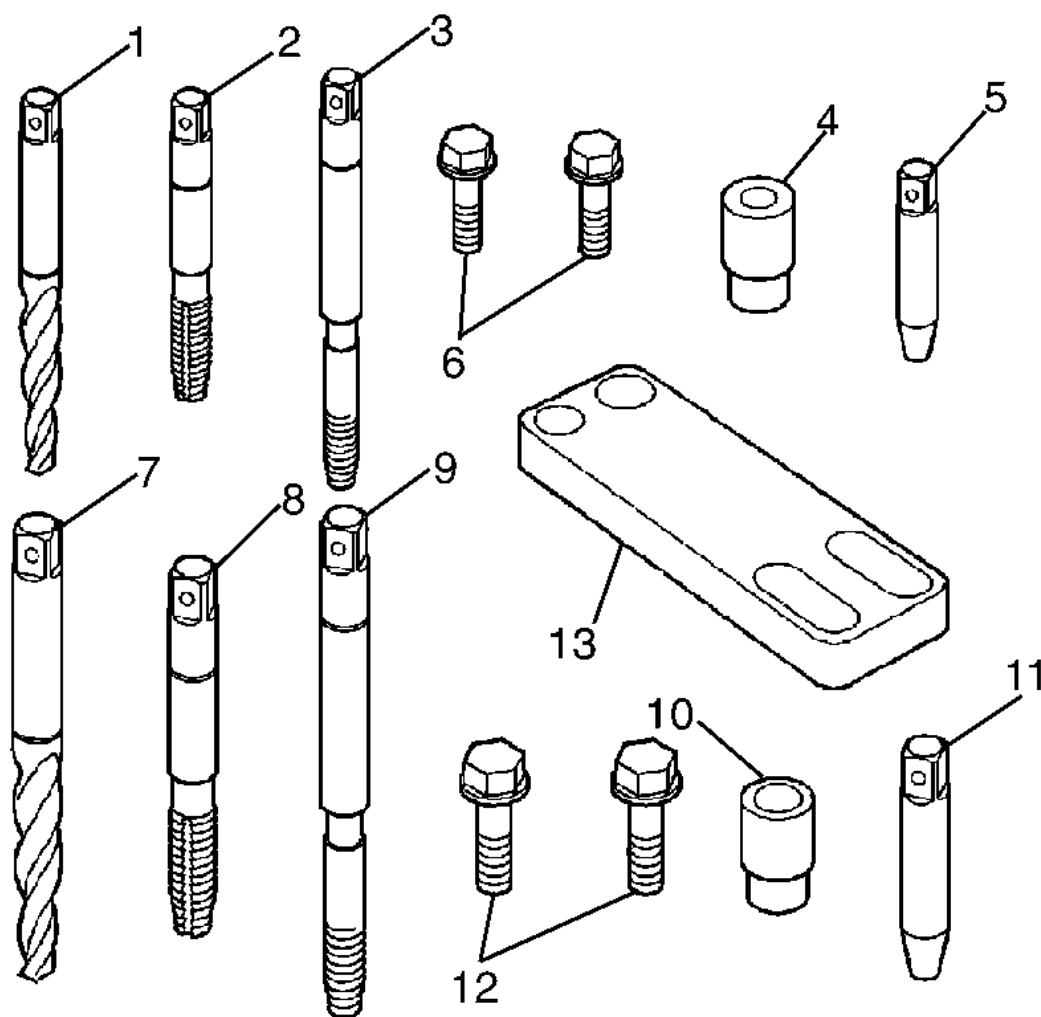
22. In order to completely form the new threads in the insert, rotate the driver installation tool through the insert until the mark (1) on the driver installation tool aligns with the surface of the cylinder block deck (2).
23. Inspect the insert for correct installation into the tapped hole.

#### Crankshaft Main Bolt Hole Thread Repair

## Special Tools

- **J 42385-700:** High Feature Thread Repair Kit
- **J 42385-2000:** Thread Insert Kit

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



**Fig. 300: View Of Crankshaft Main Bearing Bolt Hole Thread Repair Components**  
Courtesy of GENERAL MOTORS CORP.

### NOTE:

- In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.
- **DO NOT** remove the fixture plate prior to installing the insert with the

**installation driver. The fixture plate remains in position throughout the thread repair process.**

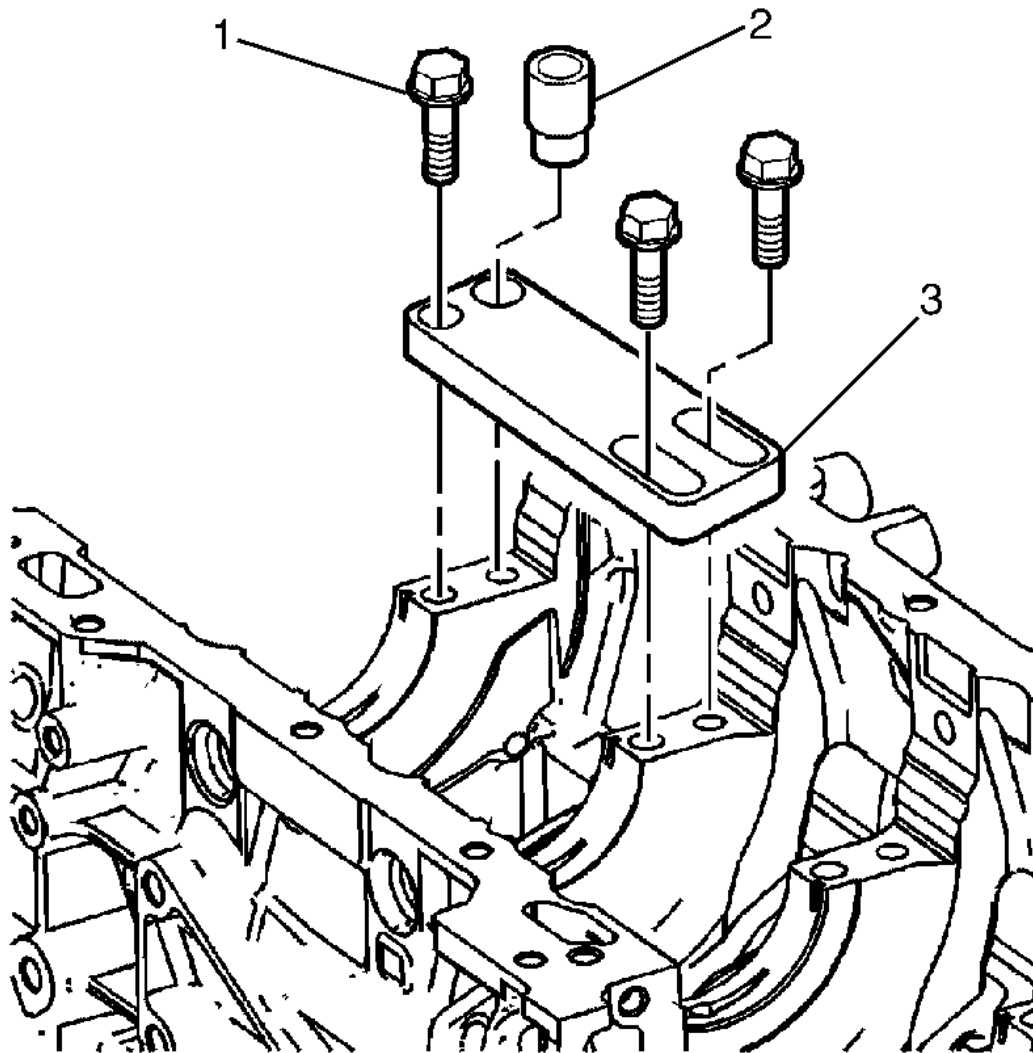
- The crankshaft main bearing bolt hole thread repair tooling are in the kits **J 42385-2000:** thread insert kit and **J 42385-700:** kit. The crankshaft main bearing bolt hole thread repair components consist of the following:
  - J 42385-702 Drill (1) for outboard holes
  - J 42385-703 Tap (2) for outboard holes
  - J 42385-704 Installation driver (3) for outboard holes
  - J 42385-726 Bushing (4) for outboard holes
  - J 42385-727 Alignment pin (5) for outboard holes
  - J 42385-728 Bolts (6) for outboard holes
  - J 42385-720 Drill (7) for inboard holes
  - J 42385-721 Tap (8) for inboard holes
  - J 42385-722 Installation driver (9) for inboard holes
  - J 42385-713 Bushing (10)
  - J 42385-308 Alignment pin (11)
  - J 42385-734 Bolts (12)
  - J 42385-712 Fixture plate (13)

#### **Outboard Bolt Holes**

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

#### **NOTE:**

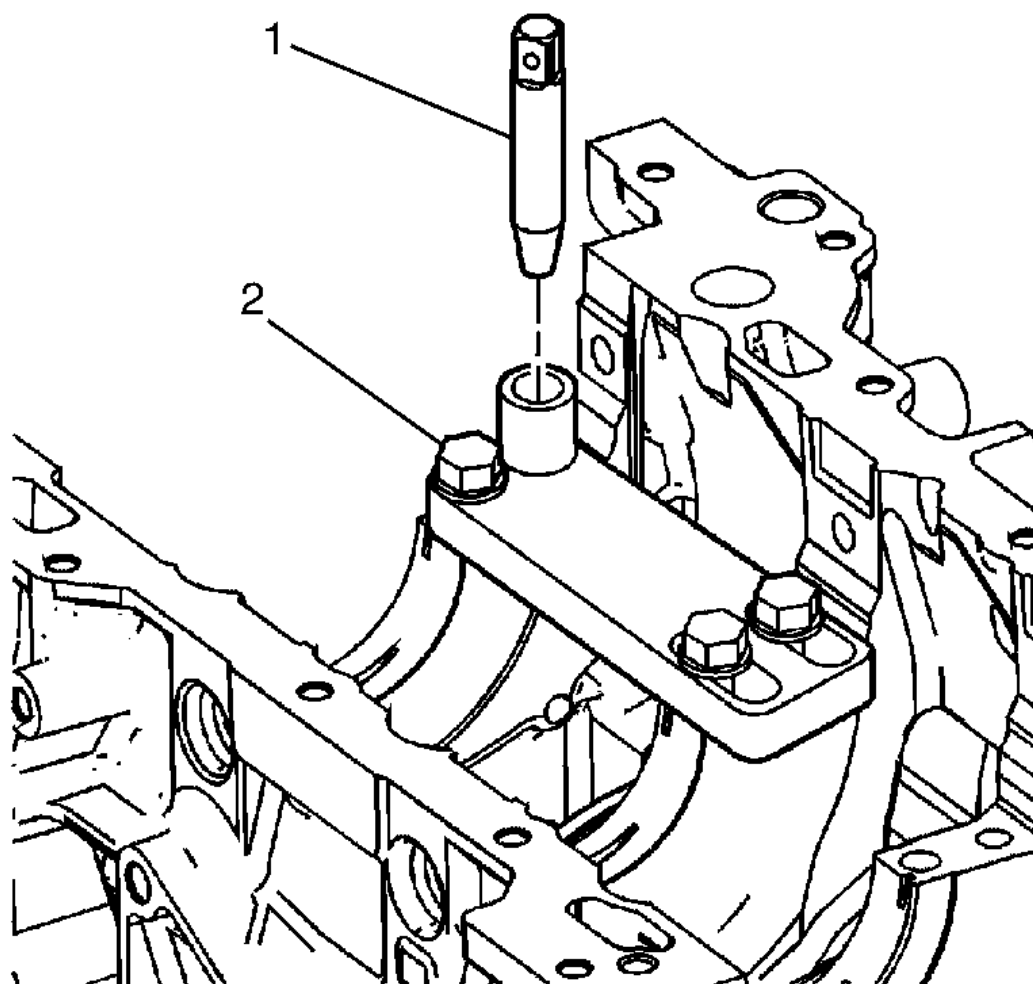
- **Ensure the fixture plate is installed during the machining and installation processes of the insert.**
- **The use of a cutting type fluid such as WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.**
- When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



**Fig. 301: View Of Bushing, Fixture Plate & Bolts**  
Courtesy of GENERAL MOTORS CORP.

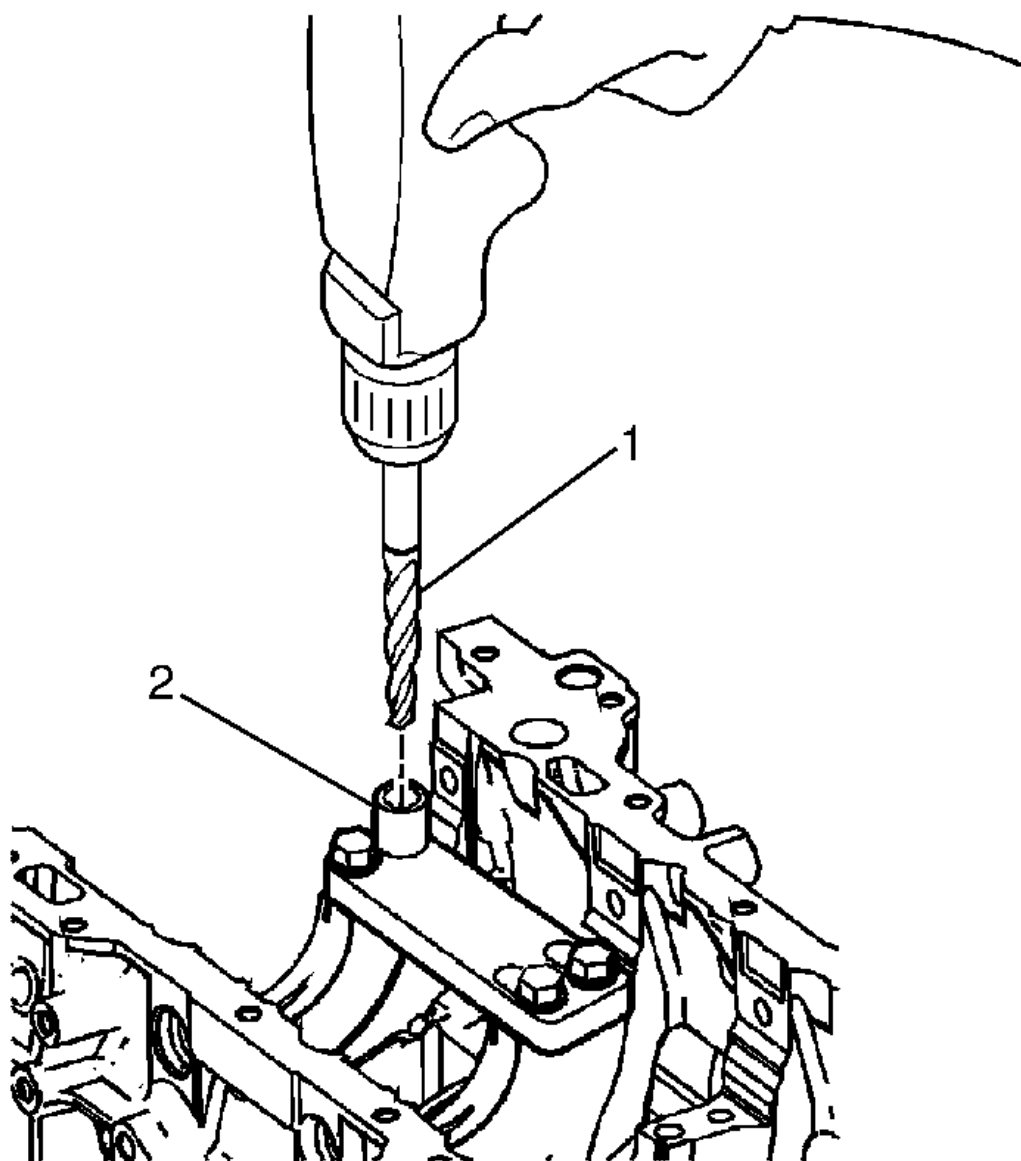
1. Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.





**Fig. 302: Identifying Fixture Retaining Bolts & Alignment Pin**  
Courtesy of GENERAL MOTORS CORP.

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

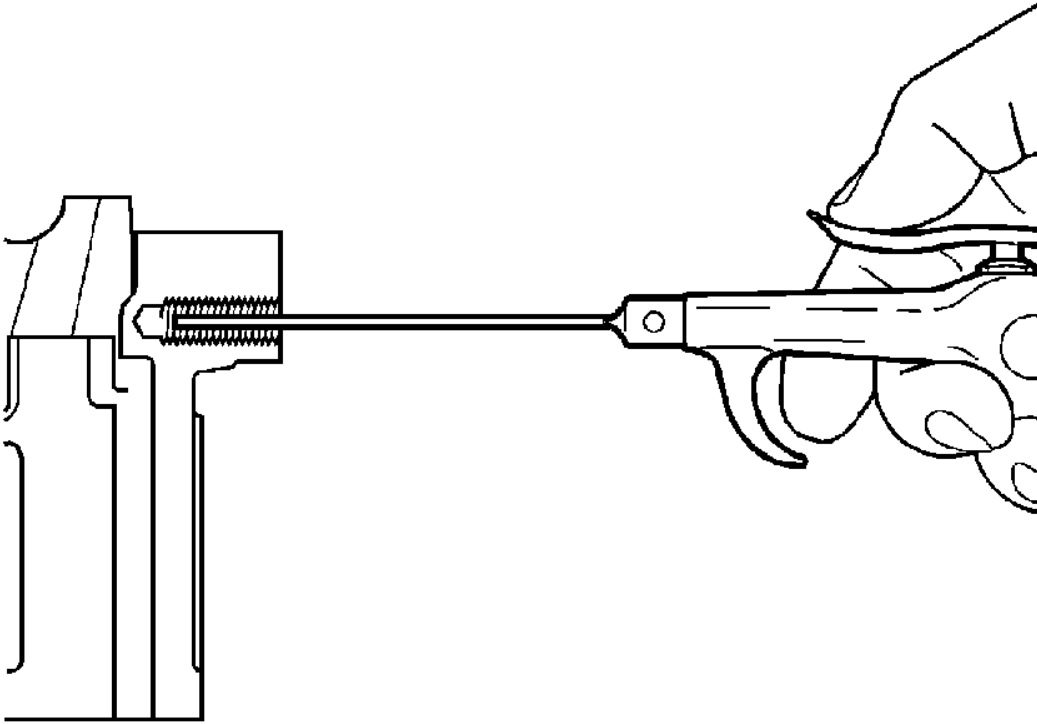


**Fig. 303: View Of Drill Bushing & Mark**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

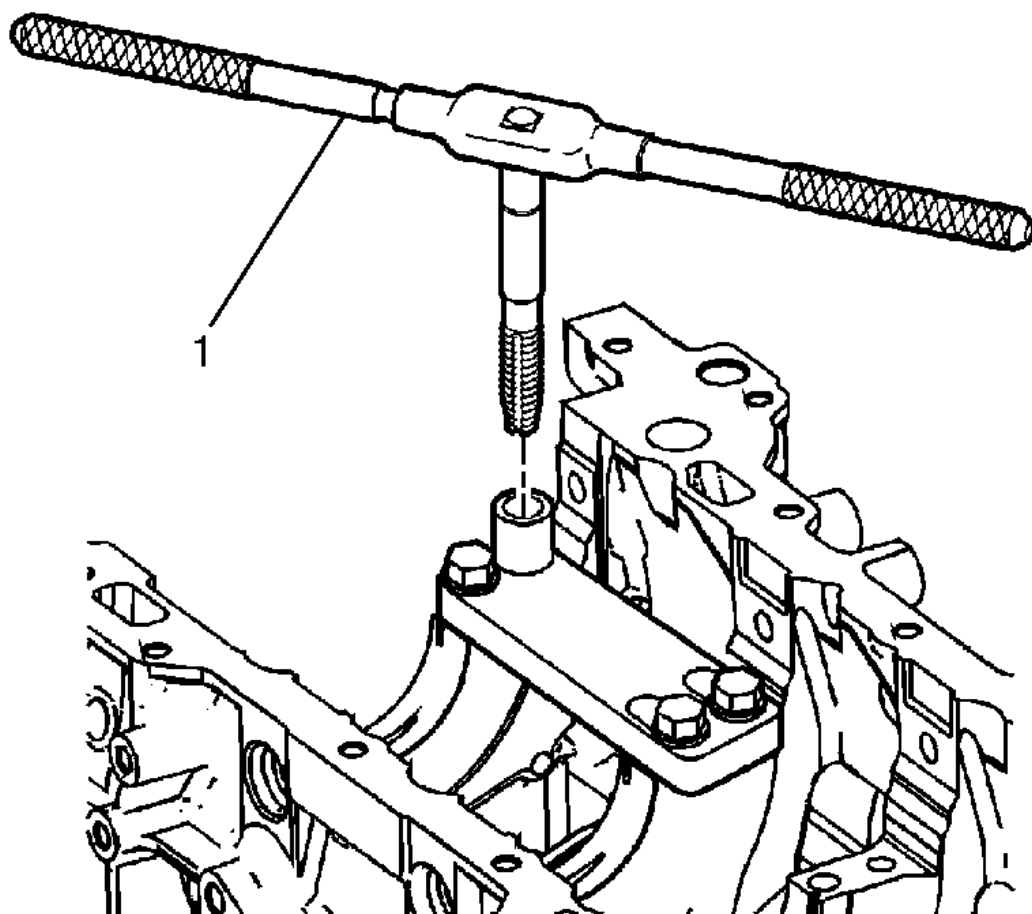
6. Drill out the threads of the damaged hole.



**Fig. 304: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.



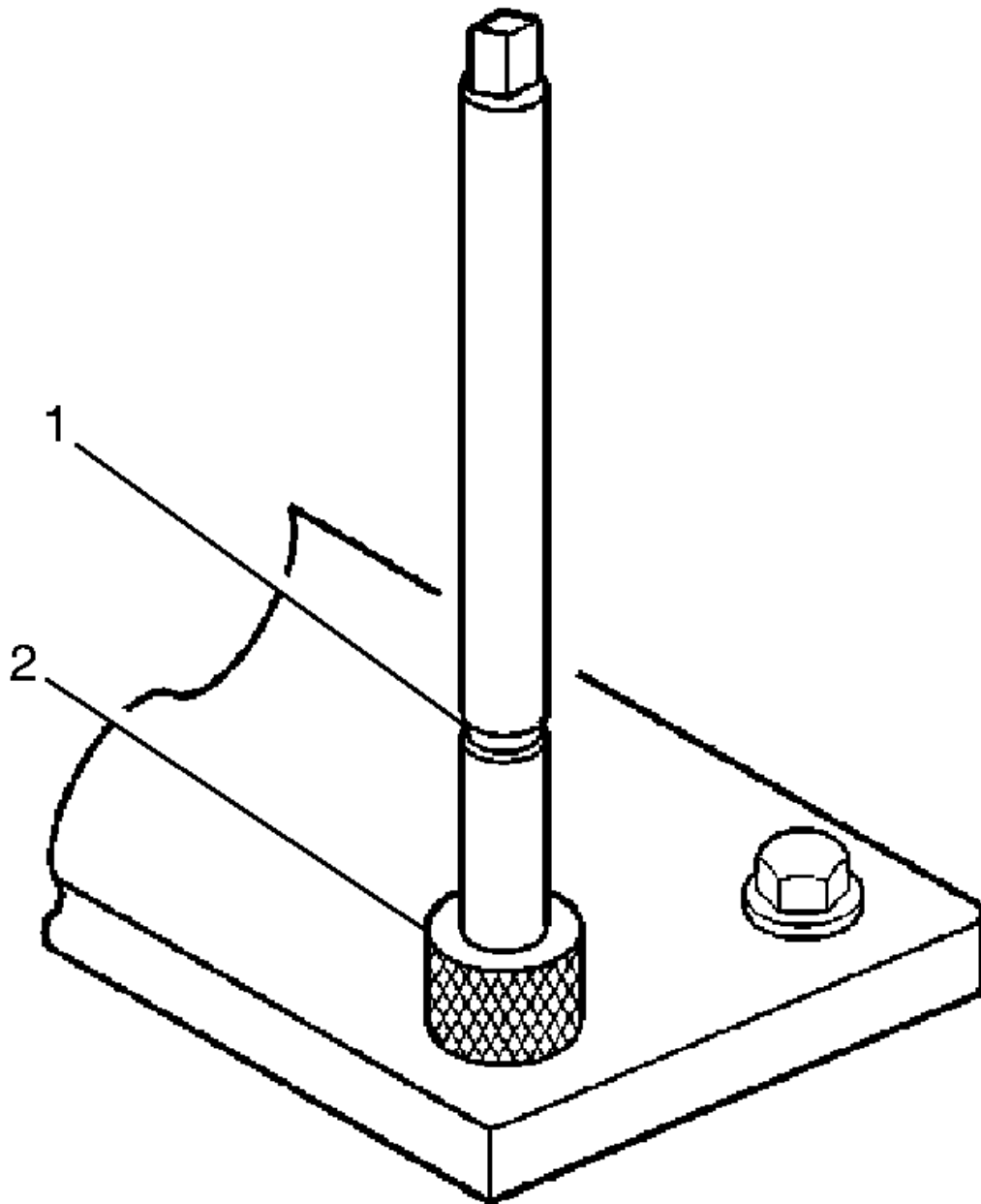
**Fig. 305: View Of Tapping Wrench**

Courtesy of GENERAL MOTORS CORP.

**NOTE:**

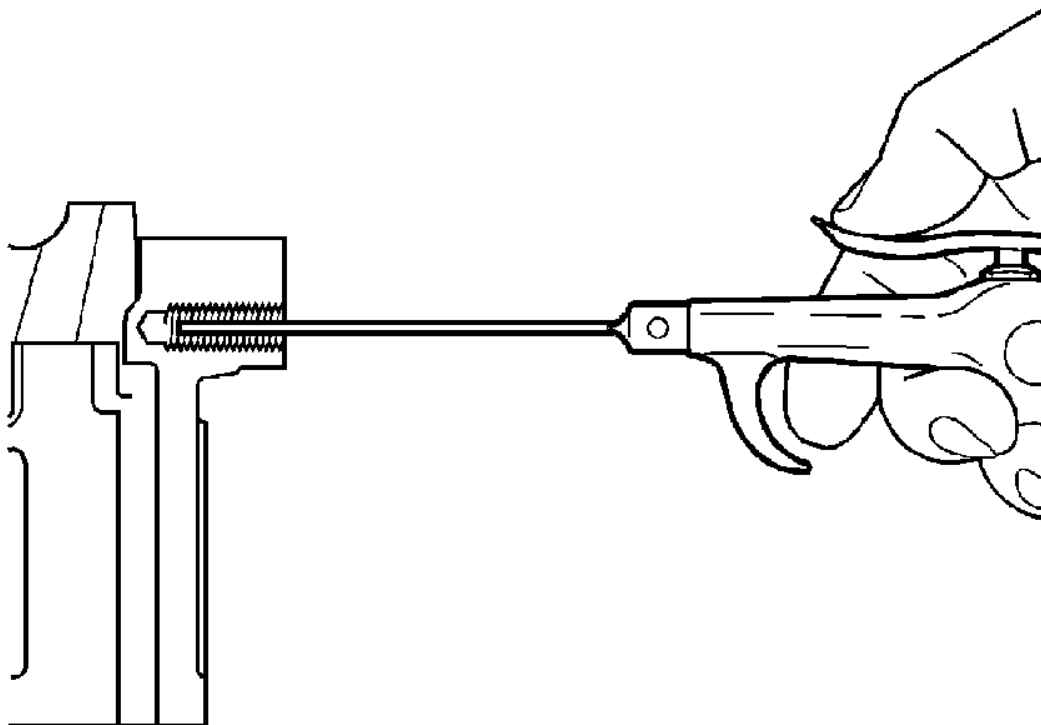
- **DO NOT** remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench (1), tap the threads of the drilled hole by hand only.



**Fig. 306: Locating Drill Bushing & Mark**  
Courtesy of GENERAL MOTORS CORP.

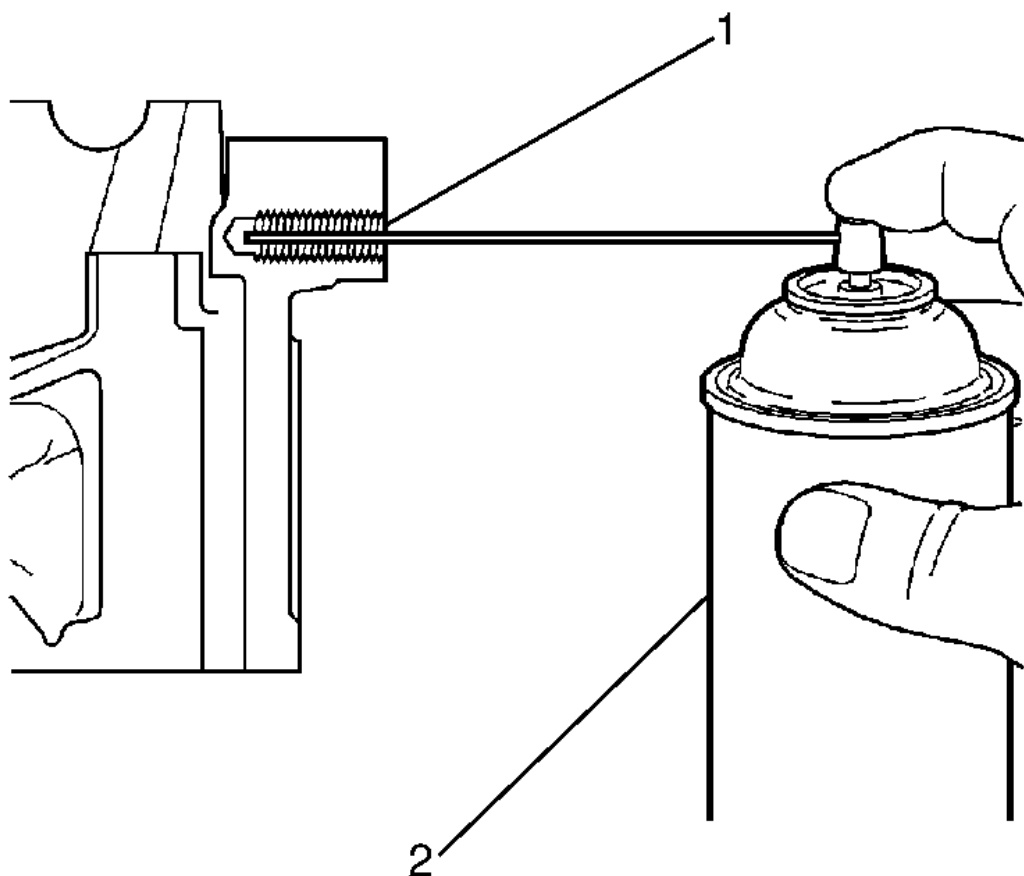
9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the crankshaft main cap bolt hole until the mark (1) on the tap aligns with the top of the drill bushing (2).



**Fig. 307: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

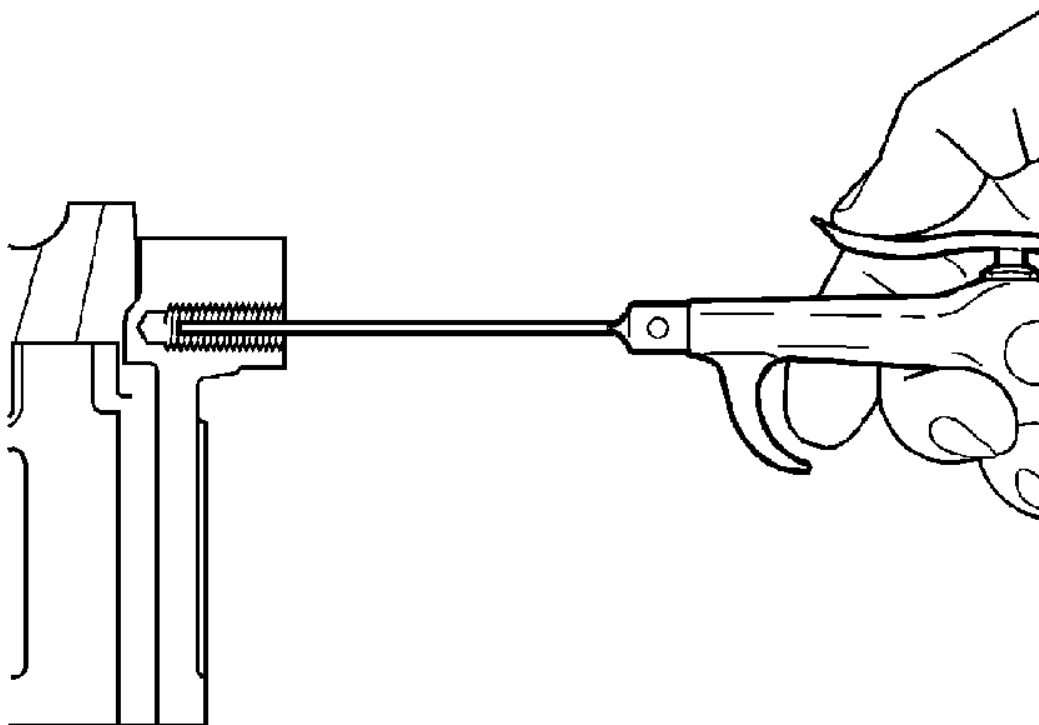
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.



**Fig. 308: View Of Thread Cleaner & Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

11. Spray a commercially available thread cleaner (2) into the tapped hole (1).

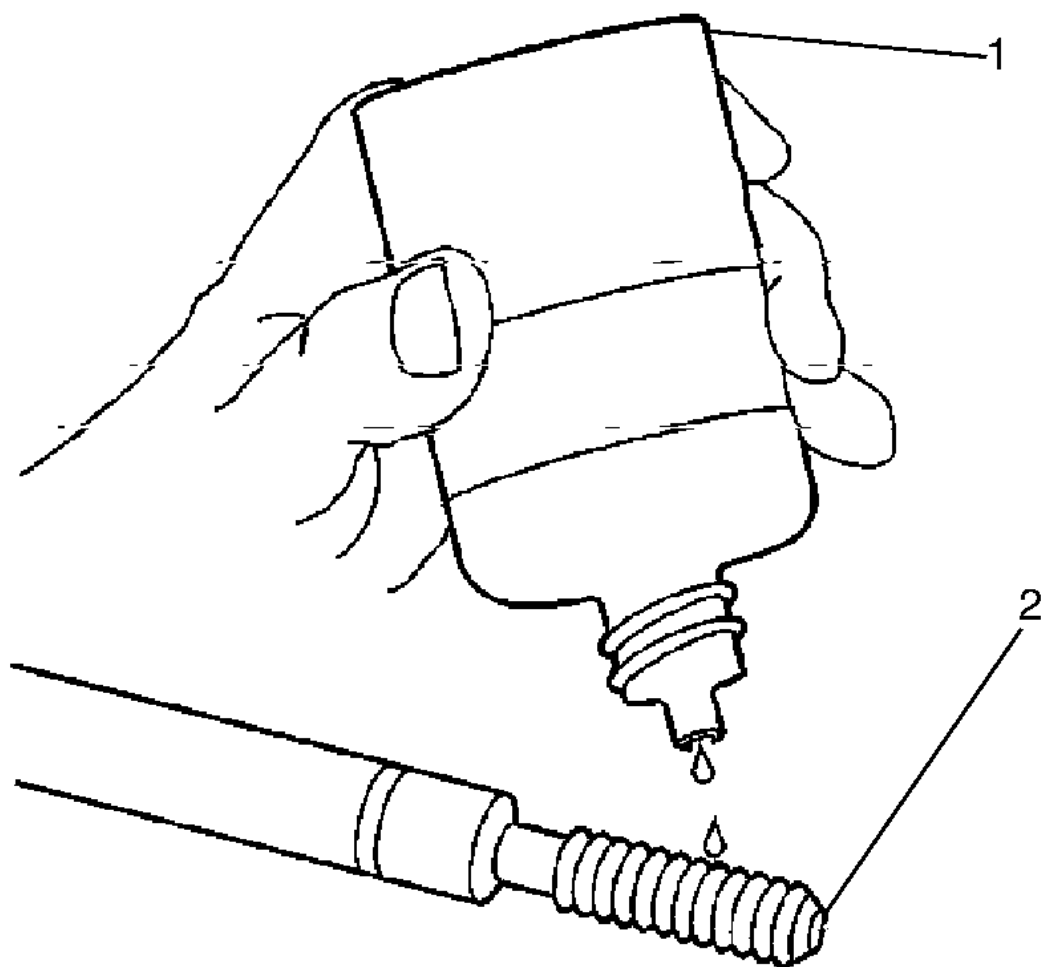


**Fig. 309: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.



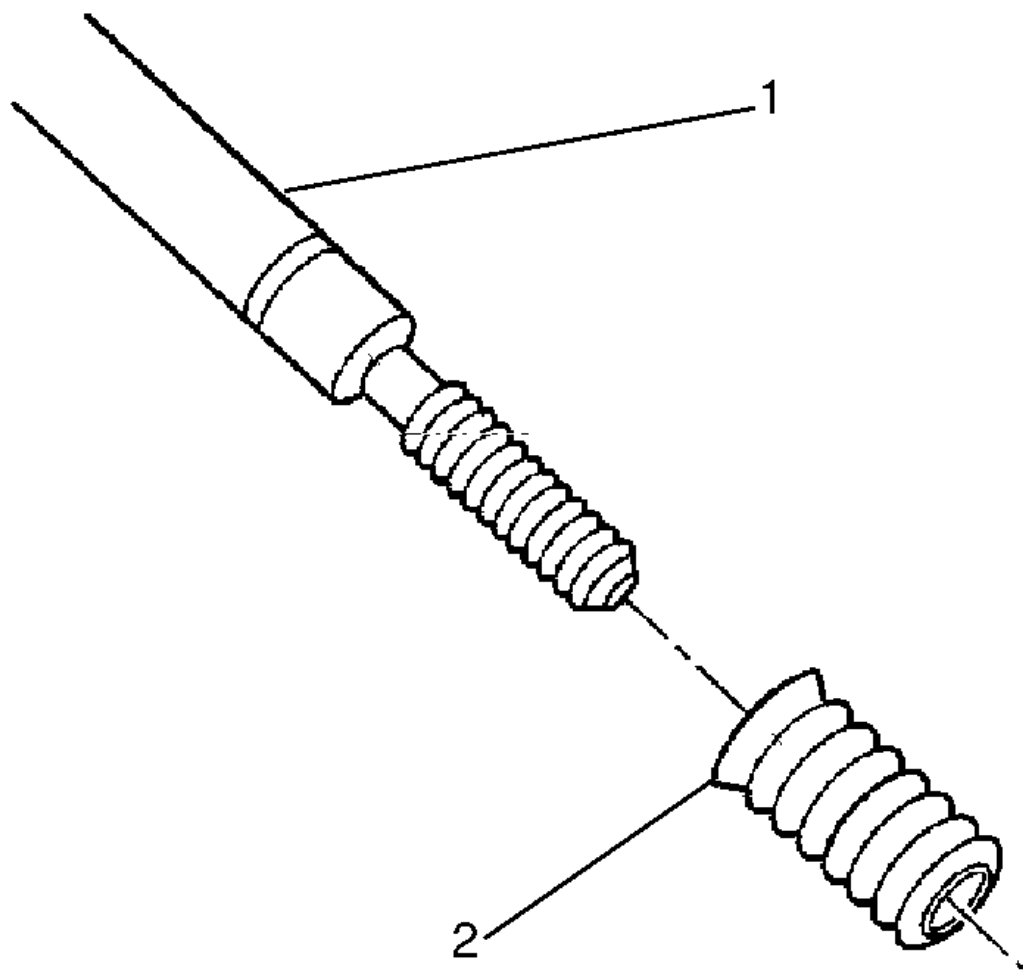


**Fig. 310: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

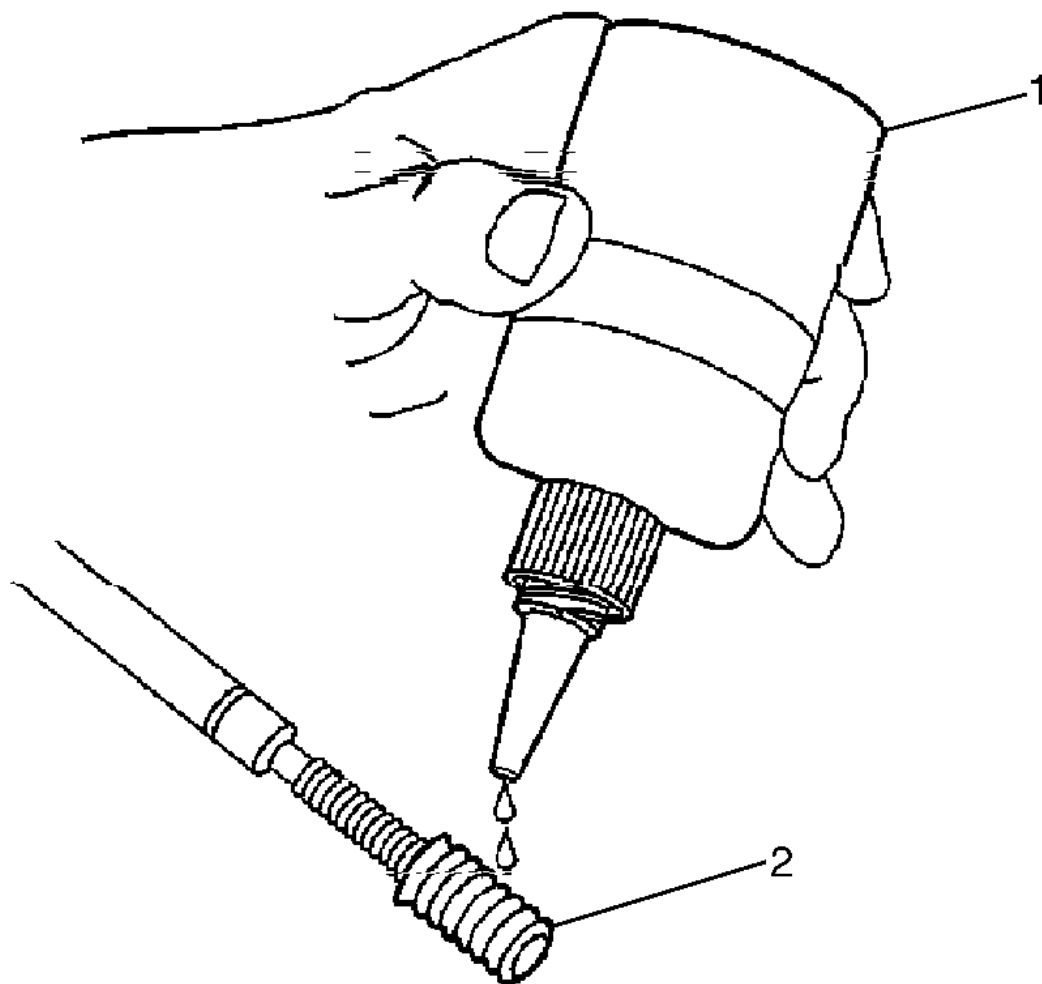
- **DO NOT** remove the fixture plate, make sure the fixture plate is installed during the installation process of the insert.
- **DO NOT** allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

13. Lubricate the threads of the driver installation tool (2) with the driver oil (1).



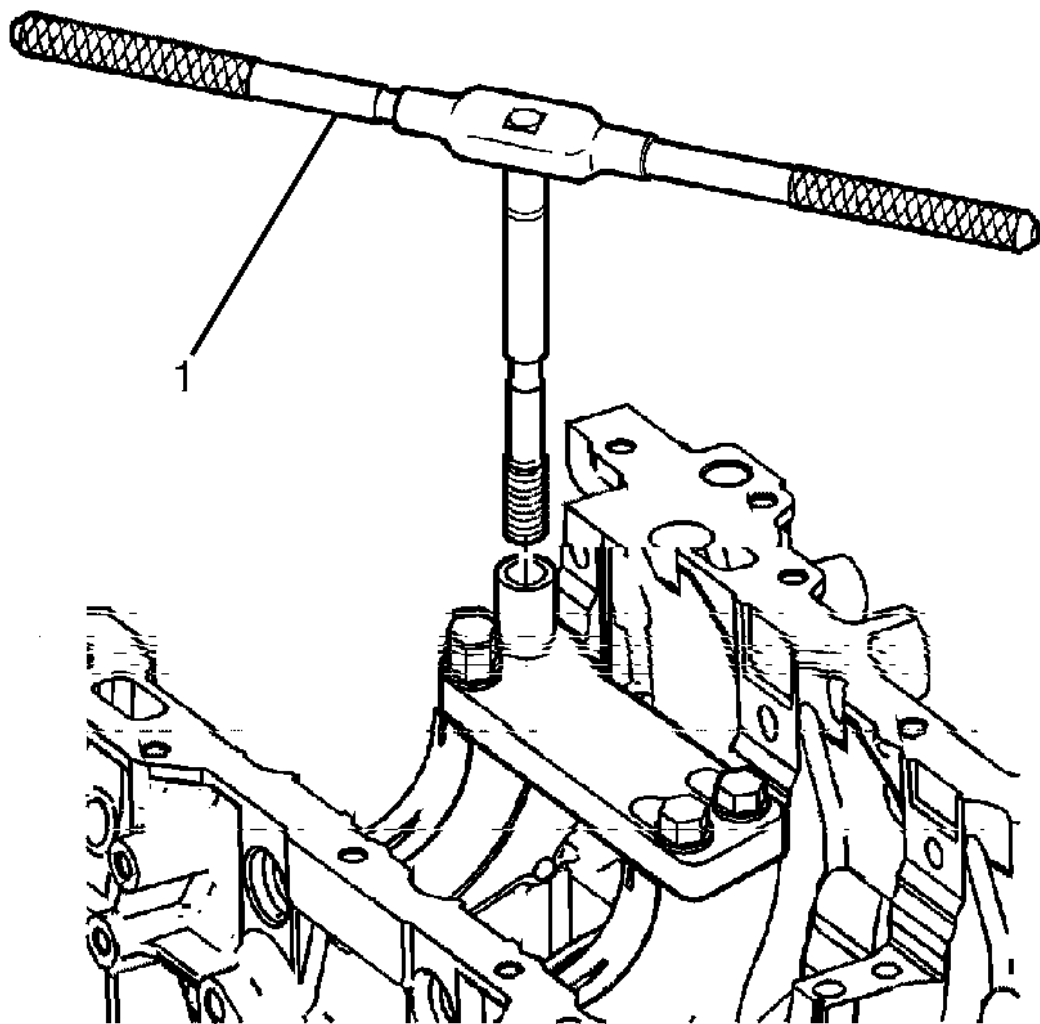
**Fig. 311: Identifying Insert & Driver Installation Tool**  
**Courtesy of GENERAL MOTORS CORP.**

14. Install the insert (2) onto the driver installation tool (1).



**Fig. 312: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

15. Apply threadlock sealant such as LOCTITE 277®, or equivalent (1) to the insert OD threads (2).



**Fig. 313: Identifying Insert & Installation Driver**  
Courtesy of GENERAL MOTORS CORP.

16. Install the insert and installation driver (1) into the tapped hole by hand only.
17. Start the insert into the threaded hole.

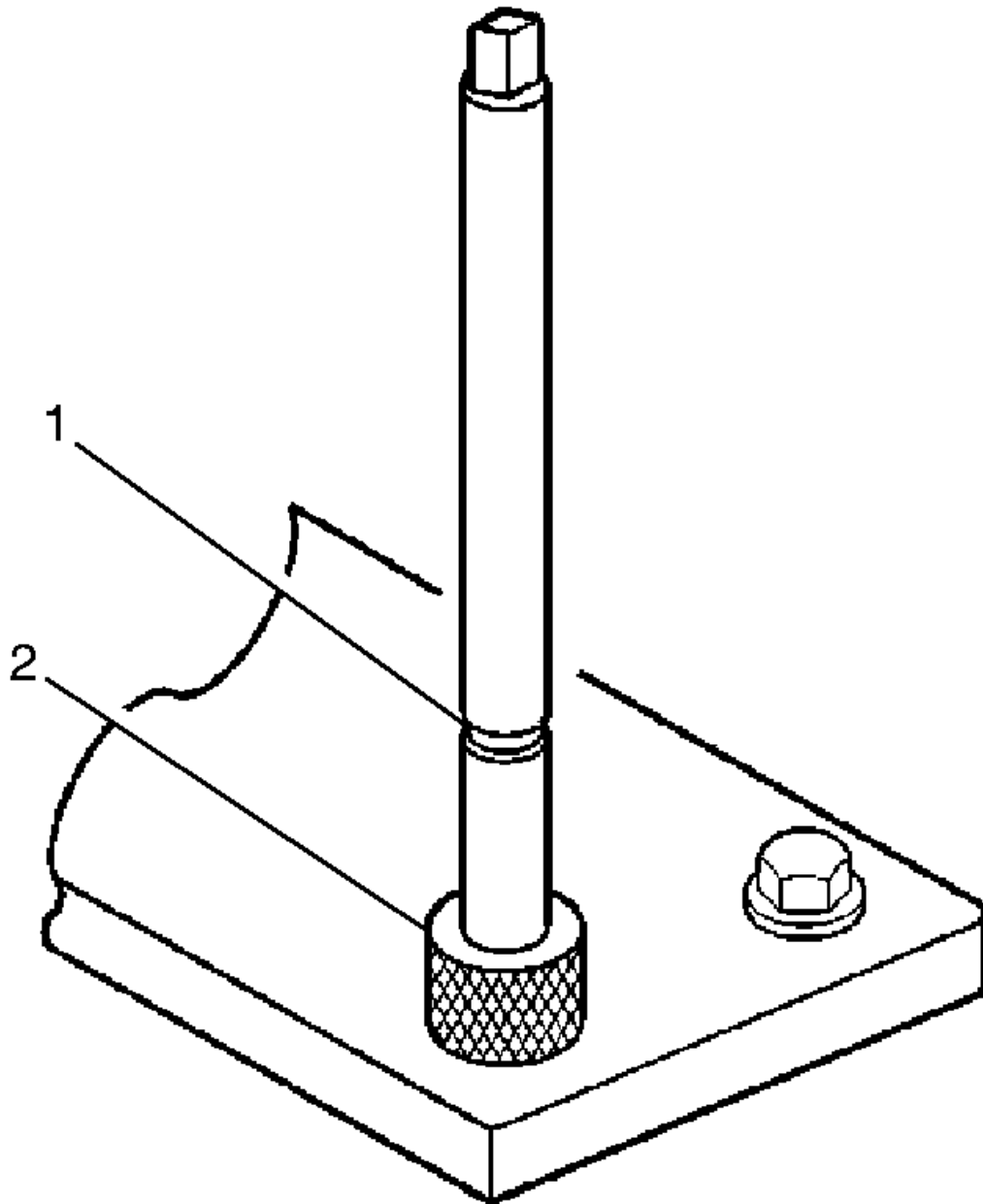
**NOTE:** If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

**NOTE:** The driver installation tool (1) will tighten up before screwing completely

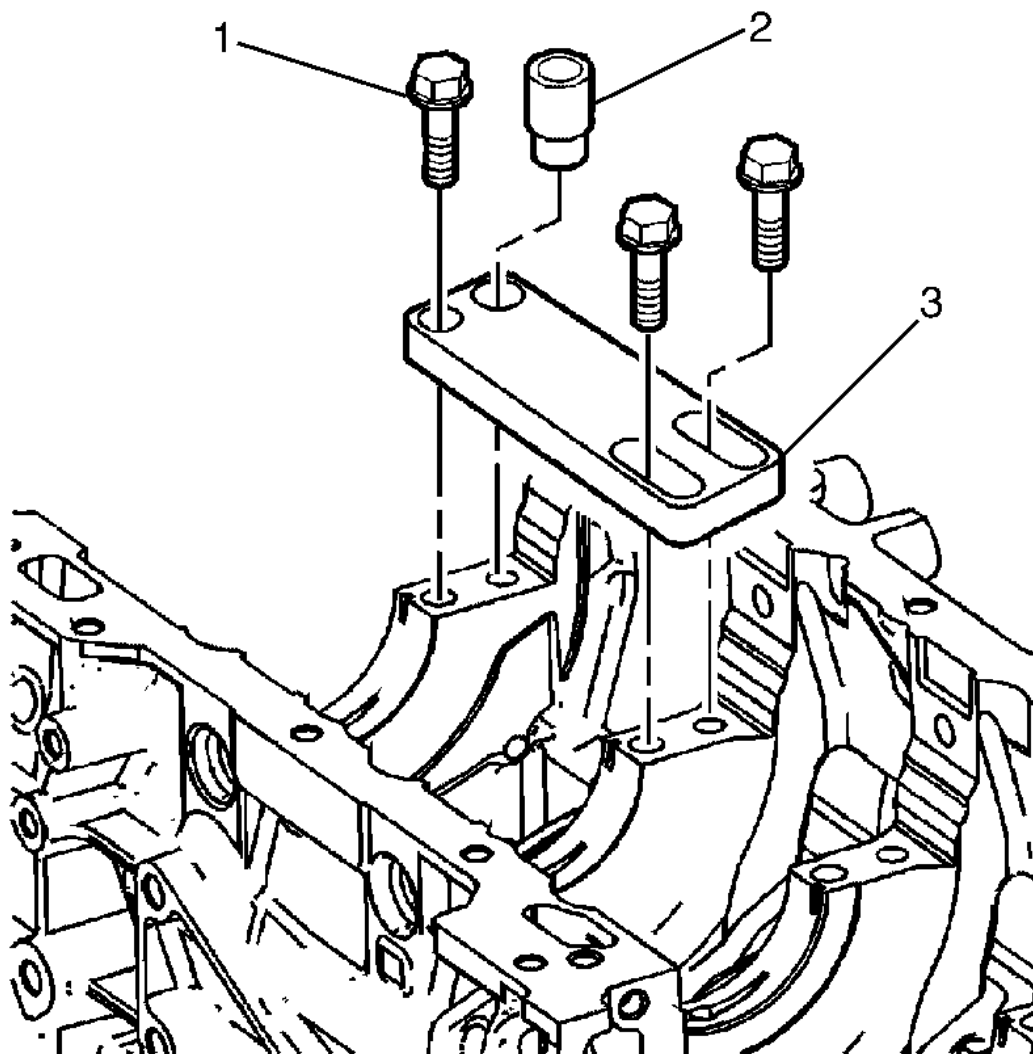
through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool (1) through the insert.



**Fig. 314: Locating Drill Bushing & Mark**  
Courtesy of GENERAL MOTORS CORP.

20. Rotate the driver installation tool until the mark (1) on the driver installation tool aligns with the top of the drill bushing (2).
21. Inspect the insert for correct installation into the tapped hole.



**Fig. 315: Identifying Bushing, Fixture Plate & Bolts**  
Courtesy of GENERAL MOTORS CORP.

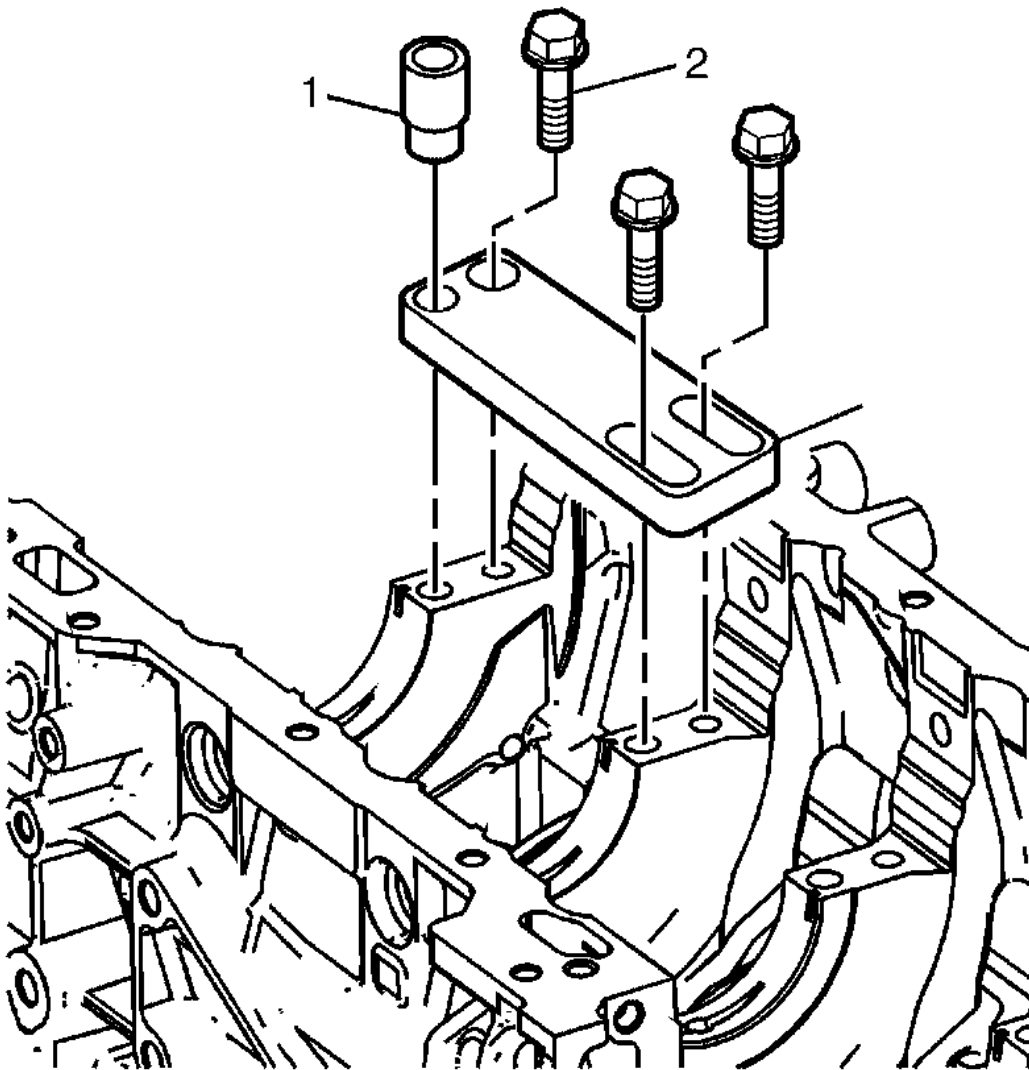
22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

**Inboard Bolt Holes**

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

**NOTE:**

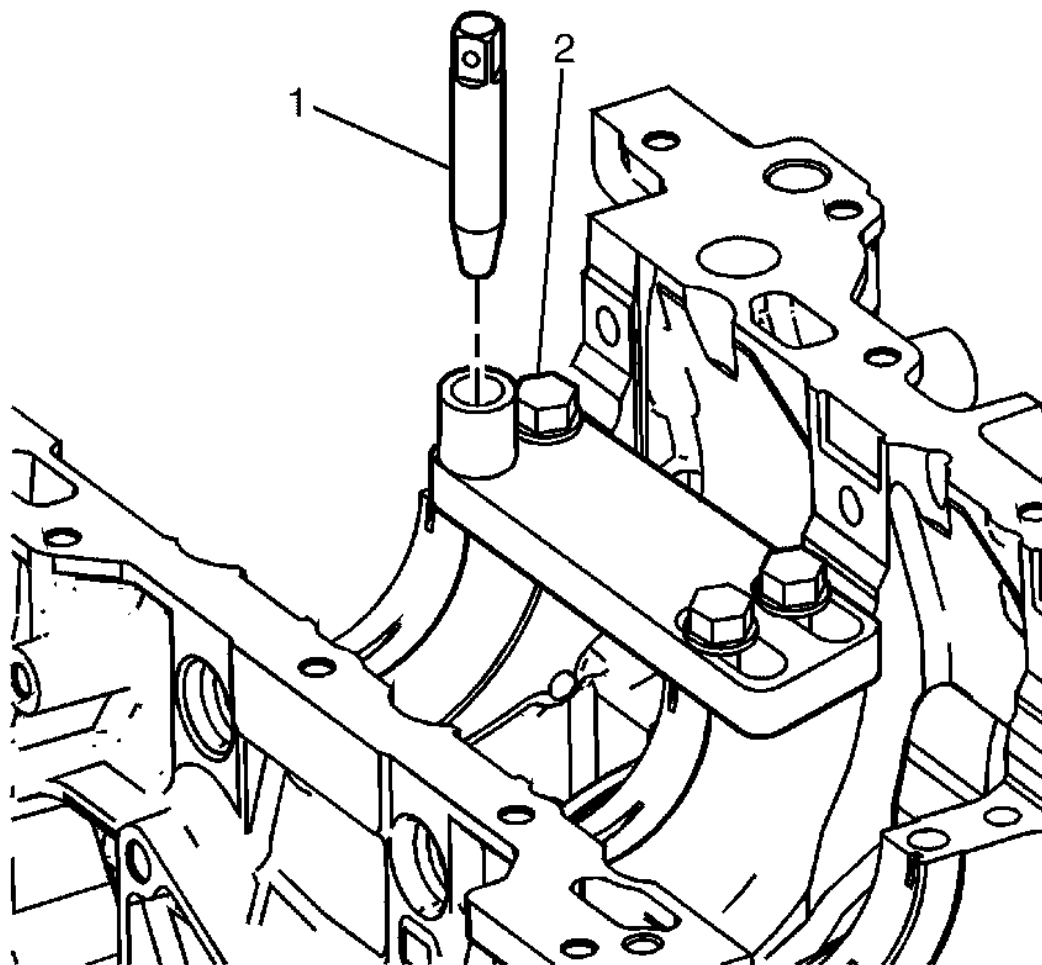
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
  - The use of a cutting type fluid such as WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.
- 
- When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



**Fig. 316: View Of Bushing & Fixture Plate Bolts**  
Courtesy of GENERAL MOTORS CORP.

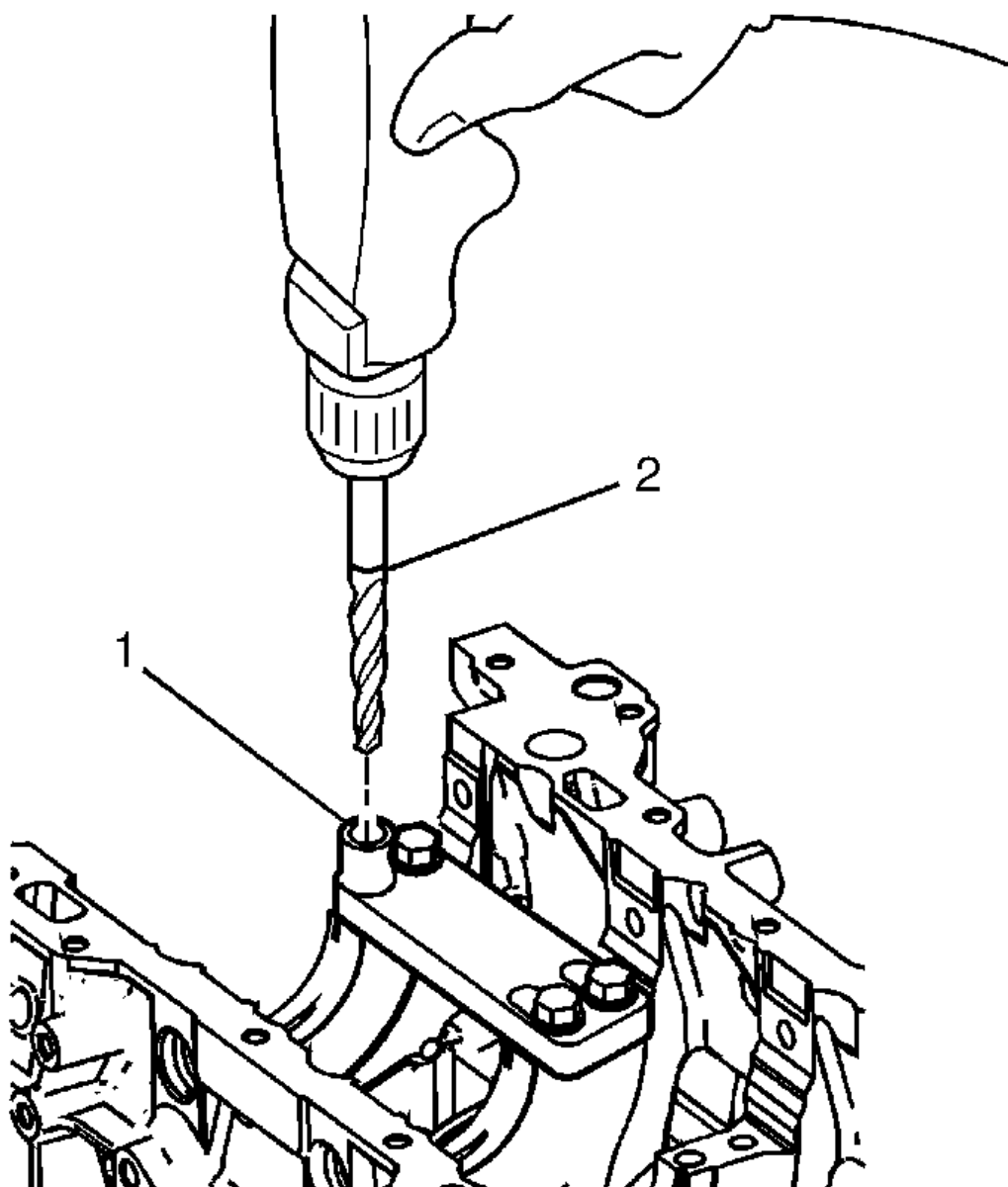
1. Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.





**Fig. 317: View Of Alignment Pin & Fixture Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

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

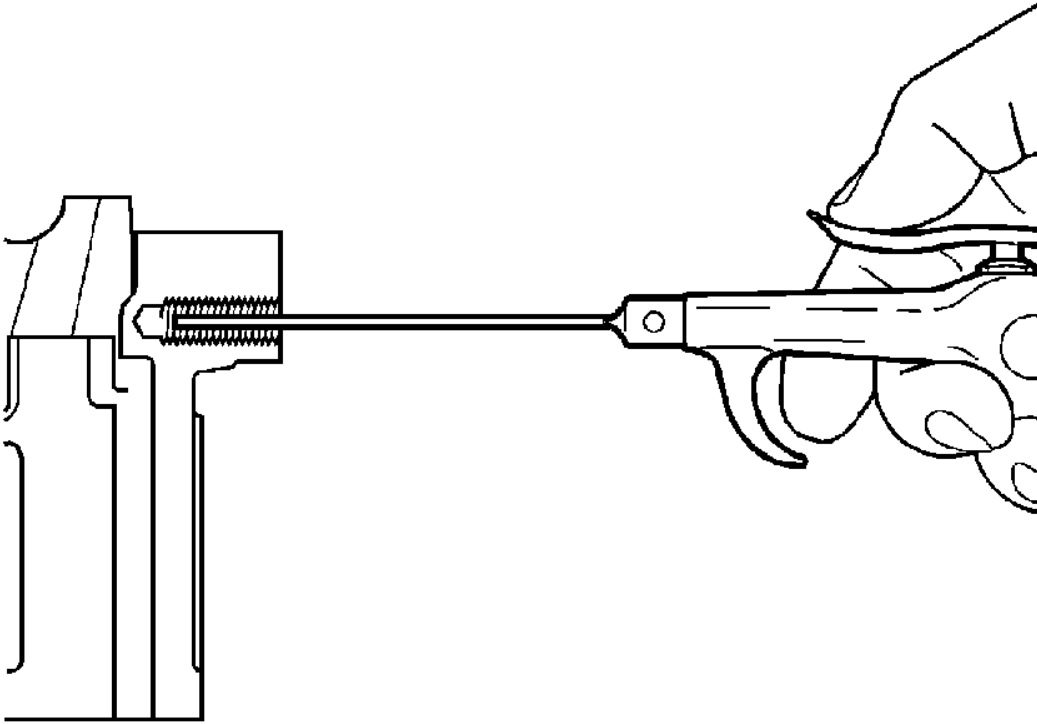


**Fig. 318: View Of Drill Bushing & Mark**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

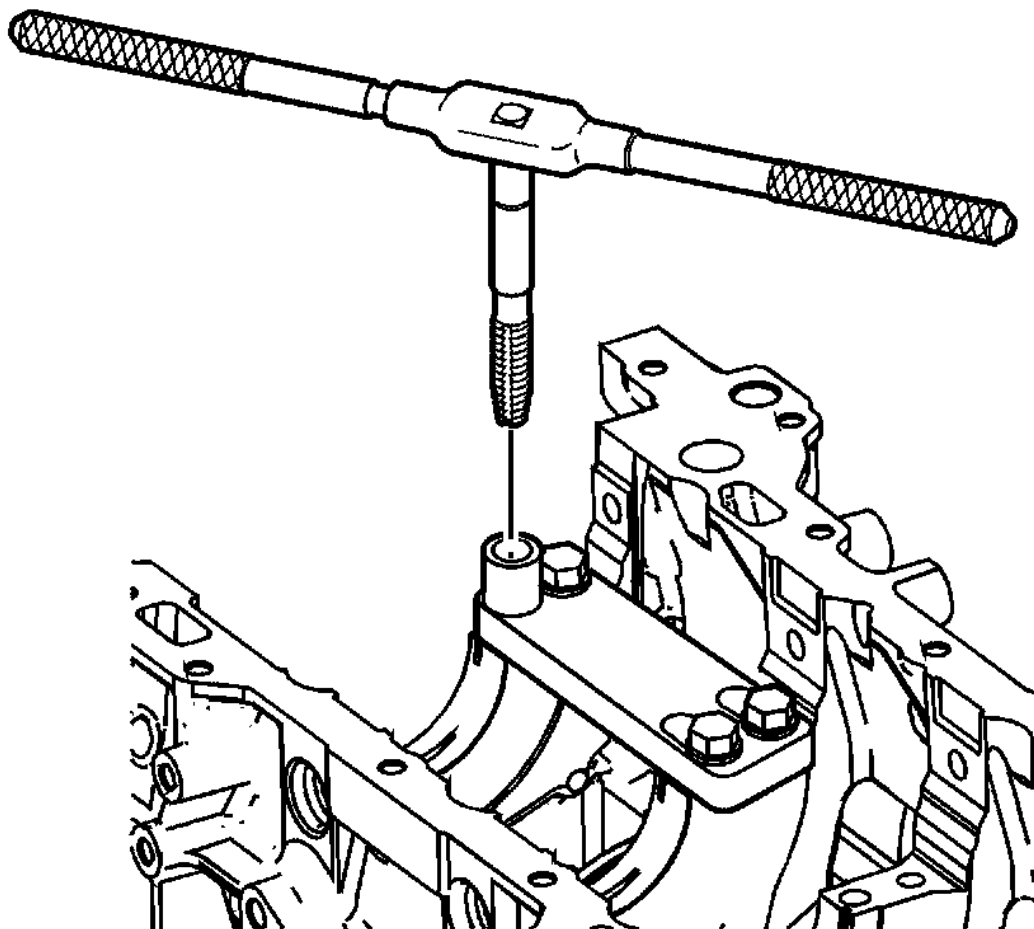
6. Drill out the threads of the damaged hole.



**Fig. 319: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

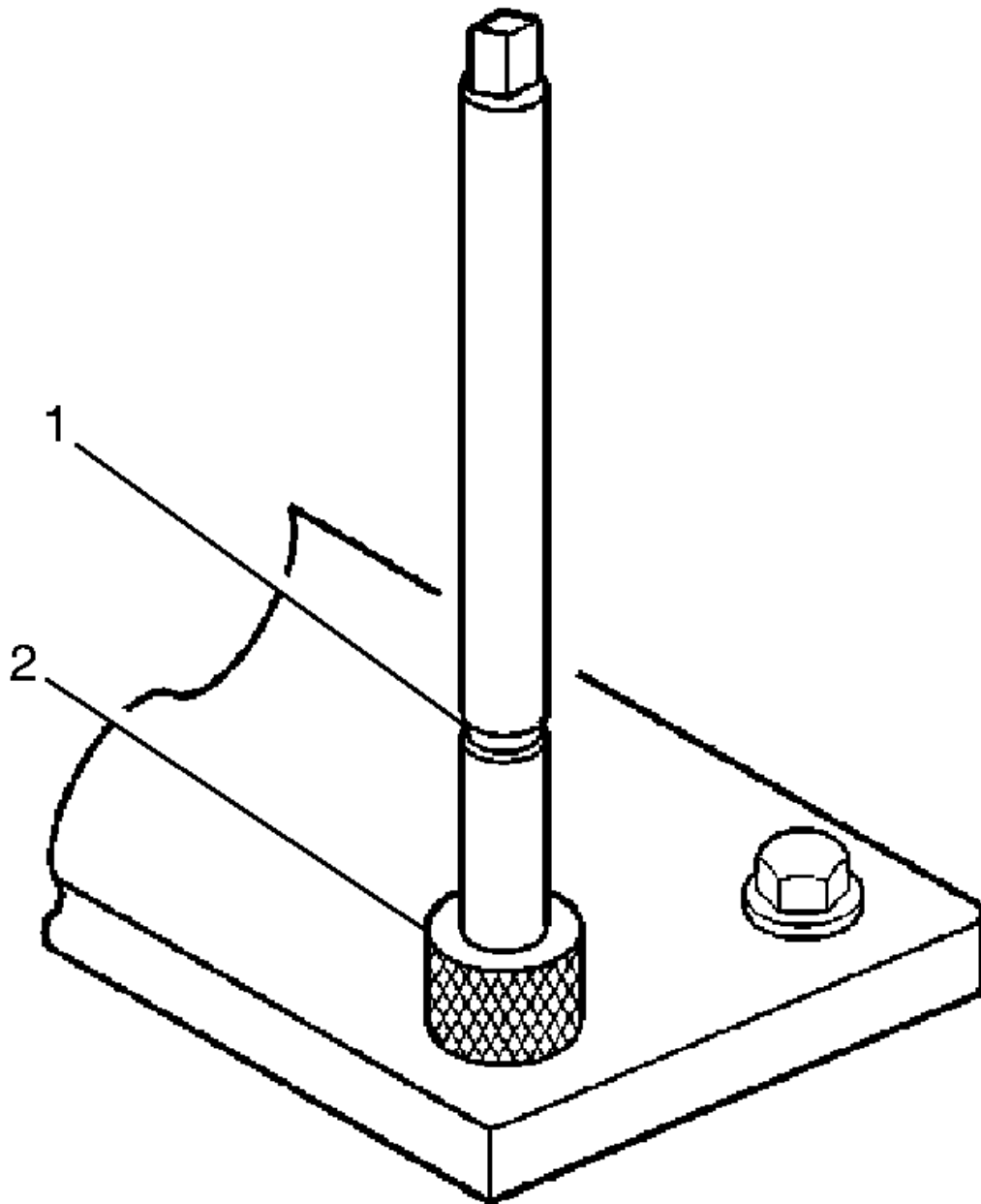


**Fig. 320: Locating Tapping Wrench**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

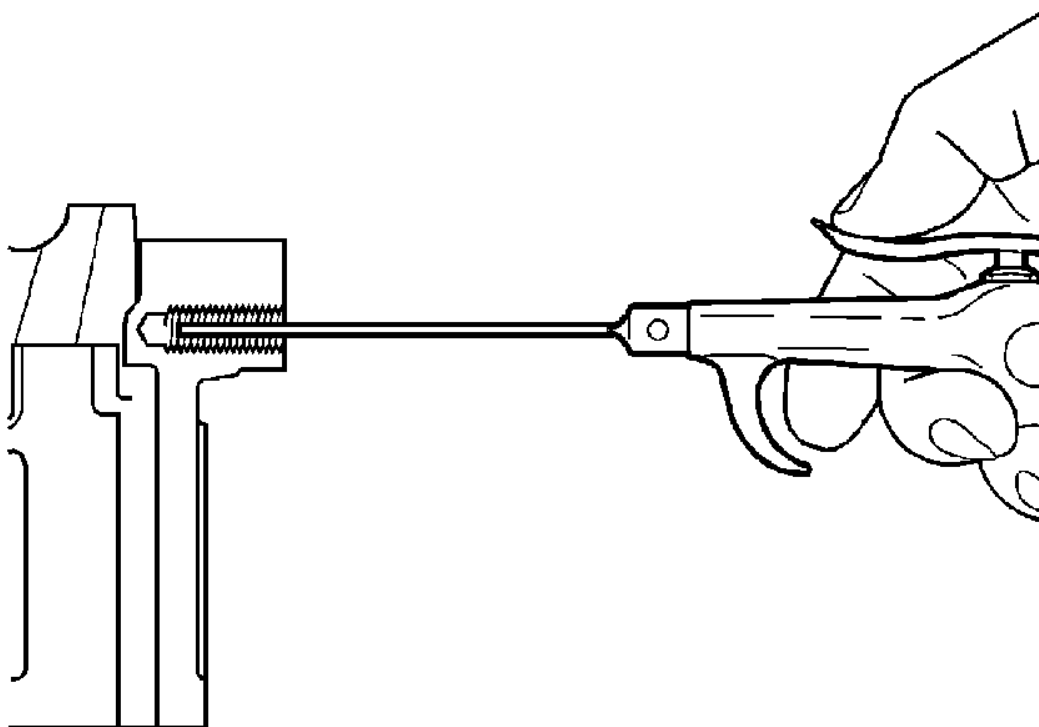
- **DO NOT** remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.



**Fig. 321: Locating Drill Bushing & Mark**  
Courtesy of GENERAL MOTORS CORP.

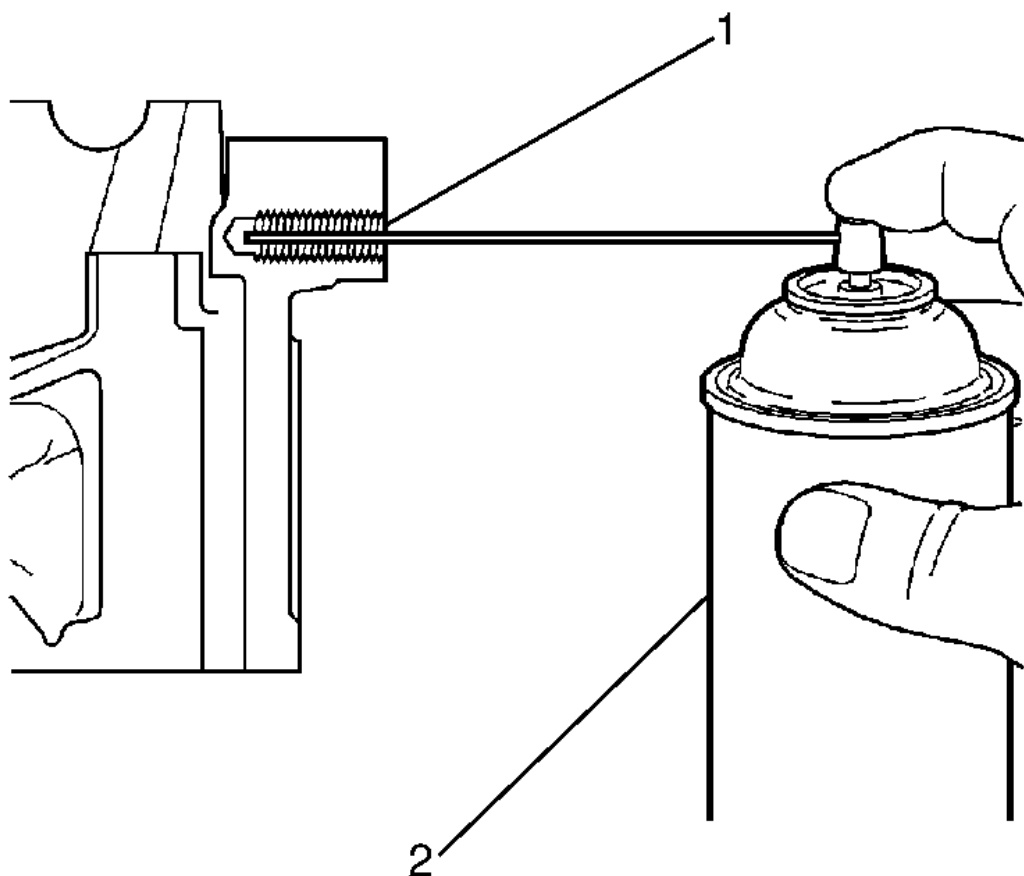
9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the crankshaft main cap bolt hole until the mark (1) on the tap aligns with the top of the drill bushing (2).



**Fig. 322: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

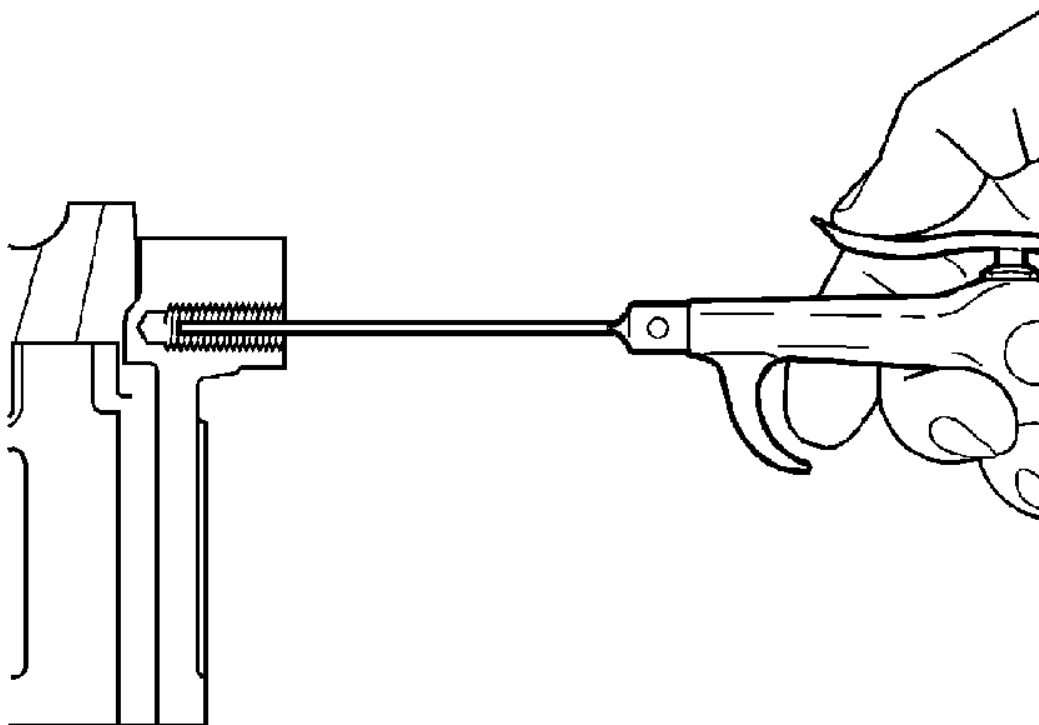
**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.



**Fig. 323: View Of Thread Cleaner & Tapped Hole**  
**Courtesy of GENERAL MOTORS CORP.**

11. Spray a commercially available thread cleaner (2) into the tapped hole (1).

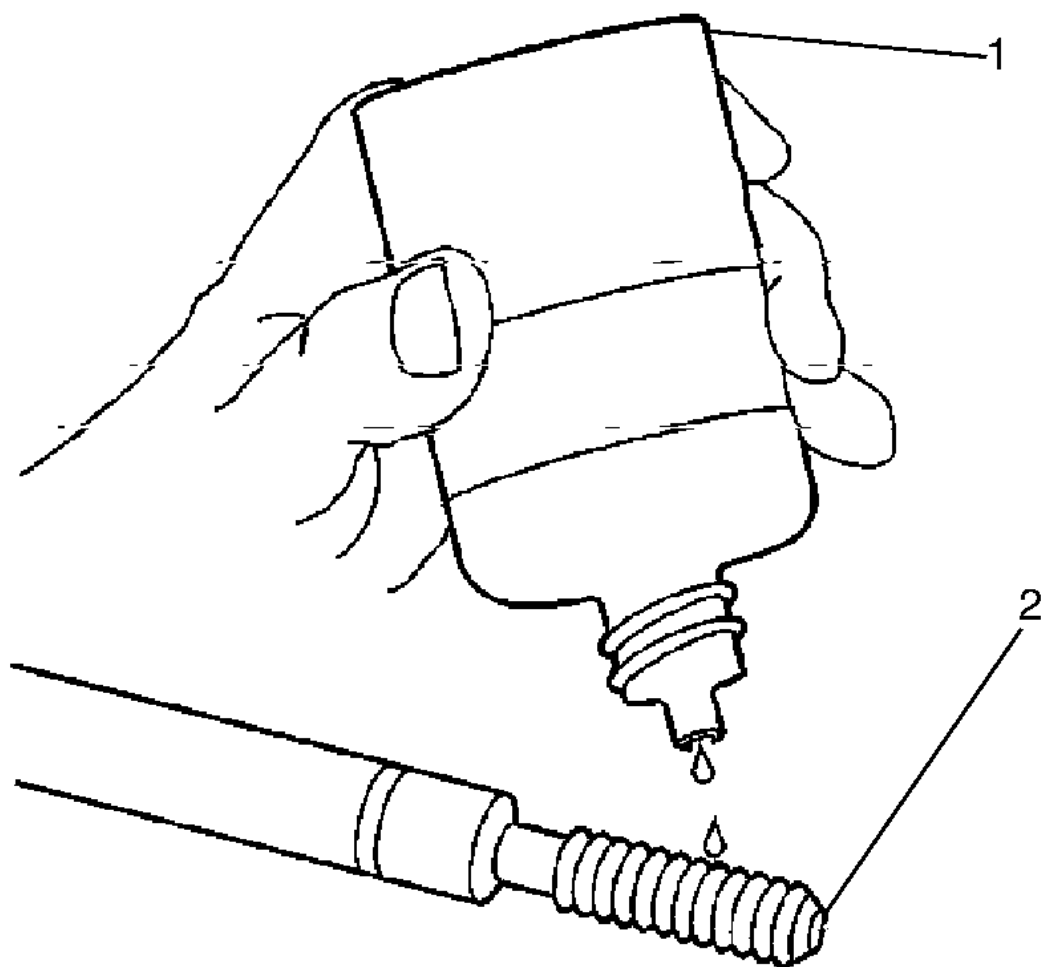


**Fig. 324: Locating Tapped Hole**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.



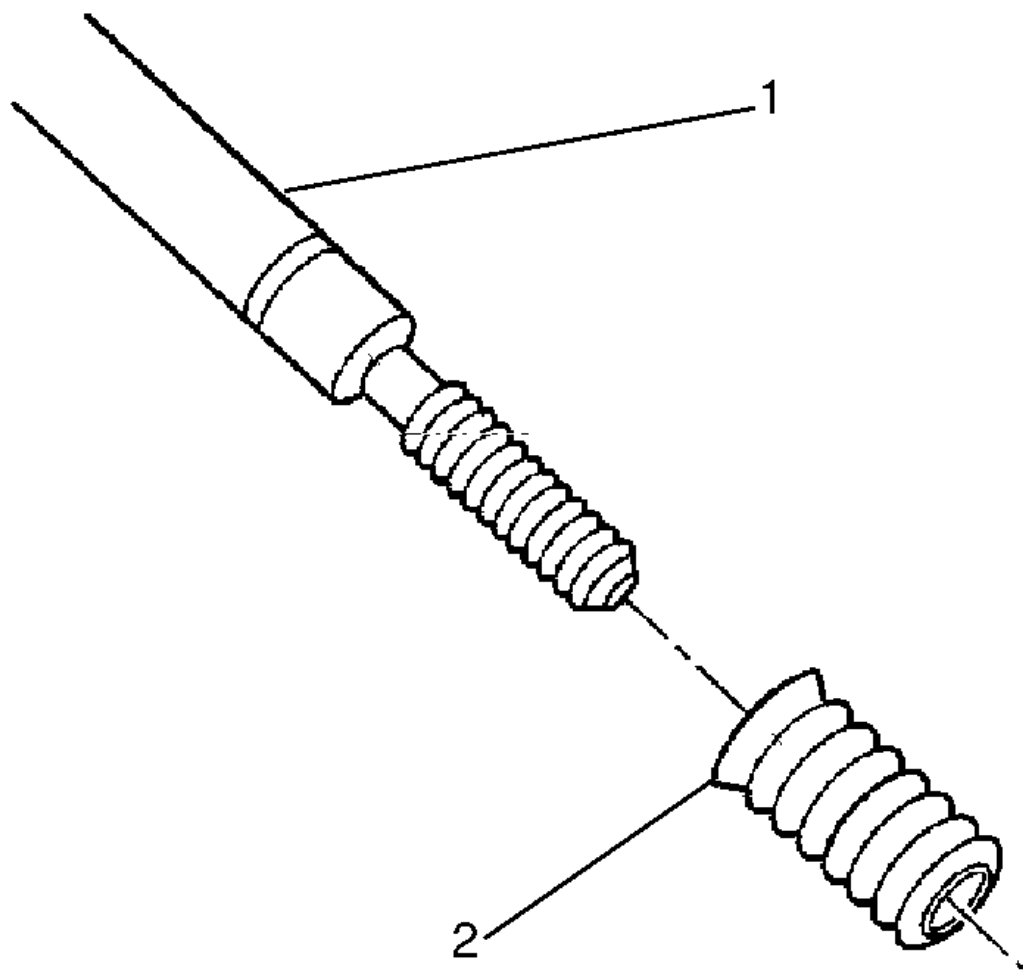


**Fig. 325: View Of Driver Oil & Installation Tool**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**

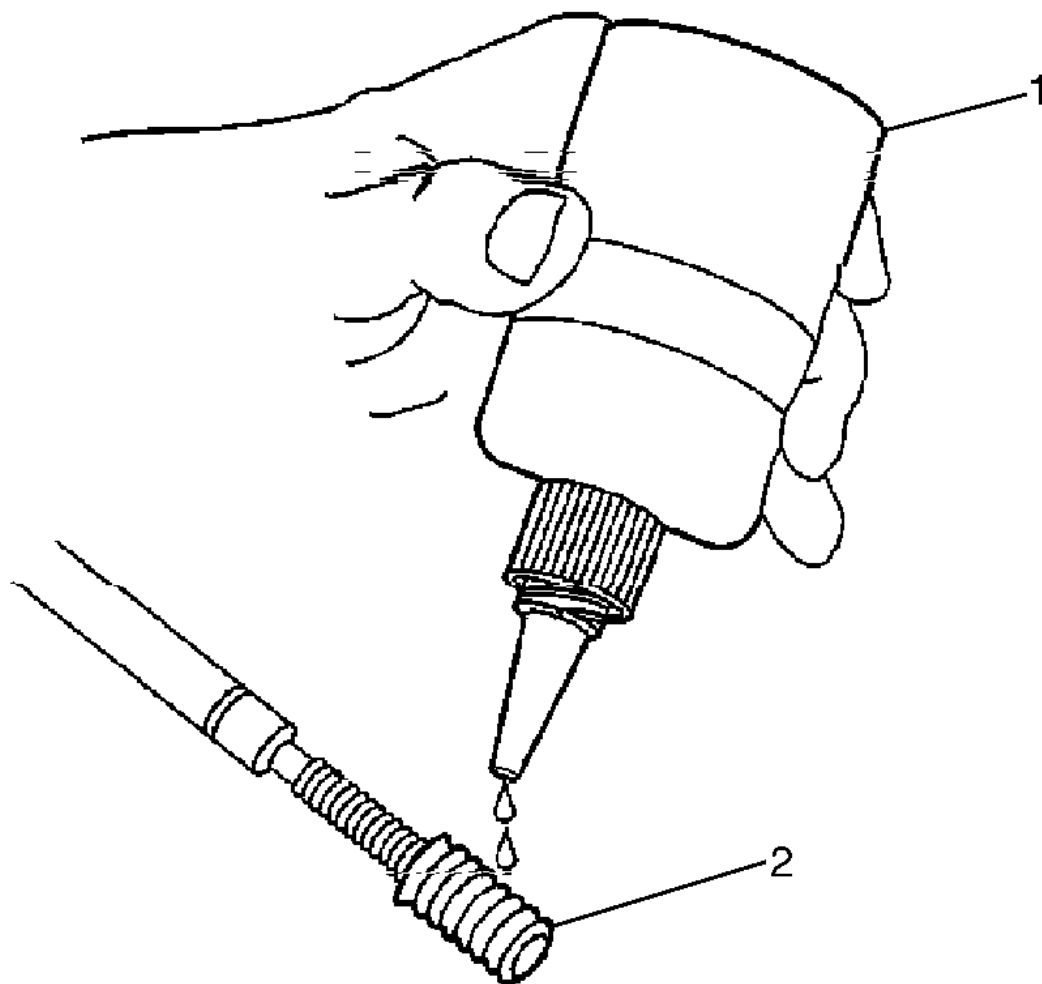
- **DO NOT** remove the fixture plate, make sure the fixture plate is installed during the installation process of the insert.
- **DO NOT** allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

13. Lubricate the threads of the driver installation tool (2) with the driver oil (1).



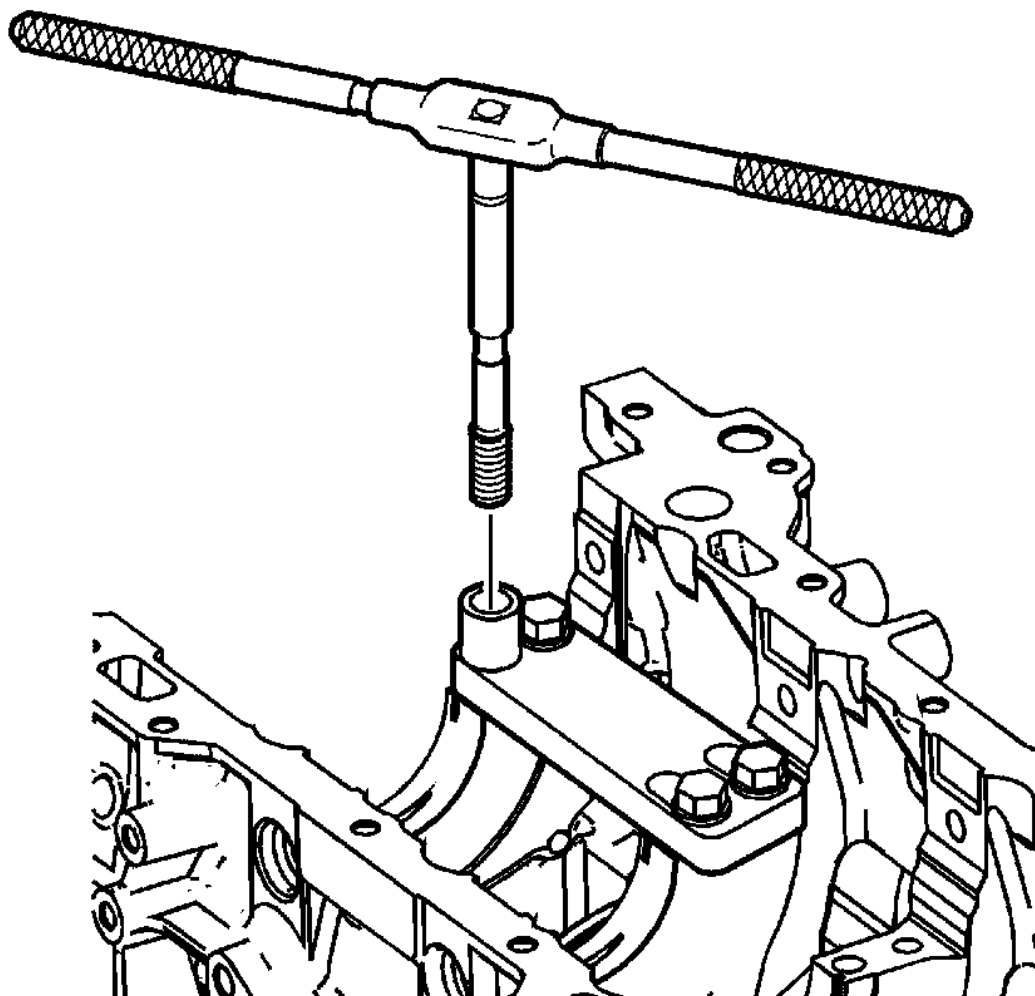
**Fig. 326: Identifying Insert & Driver Installation Tool**  
**Courtesy of GENERAL MOTORS CORP.**

14. Install the insert (2) onto the driver installation tool (1).



**Fig. 327: Locating Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

15. Apply threadlock sealant such as LOCTITE 277®, or equivalent (1) to the insert OD threads (2).



**Fig. 328: View Of Insert & Installation Driver**  
Courtesy of GENERAL MOTORS CORP.

16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

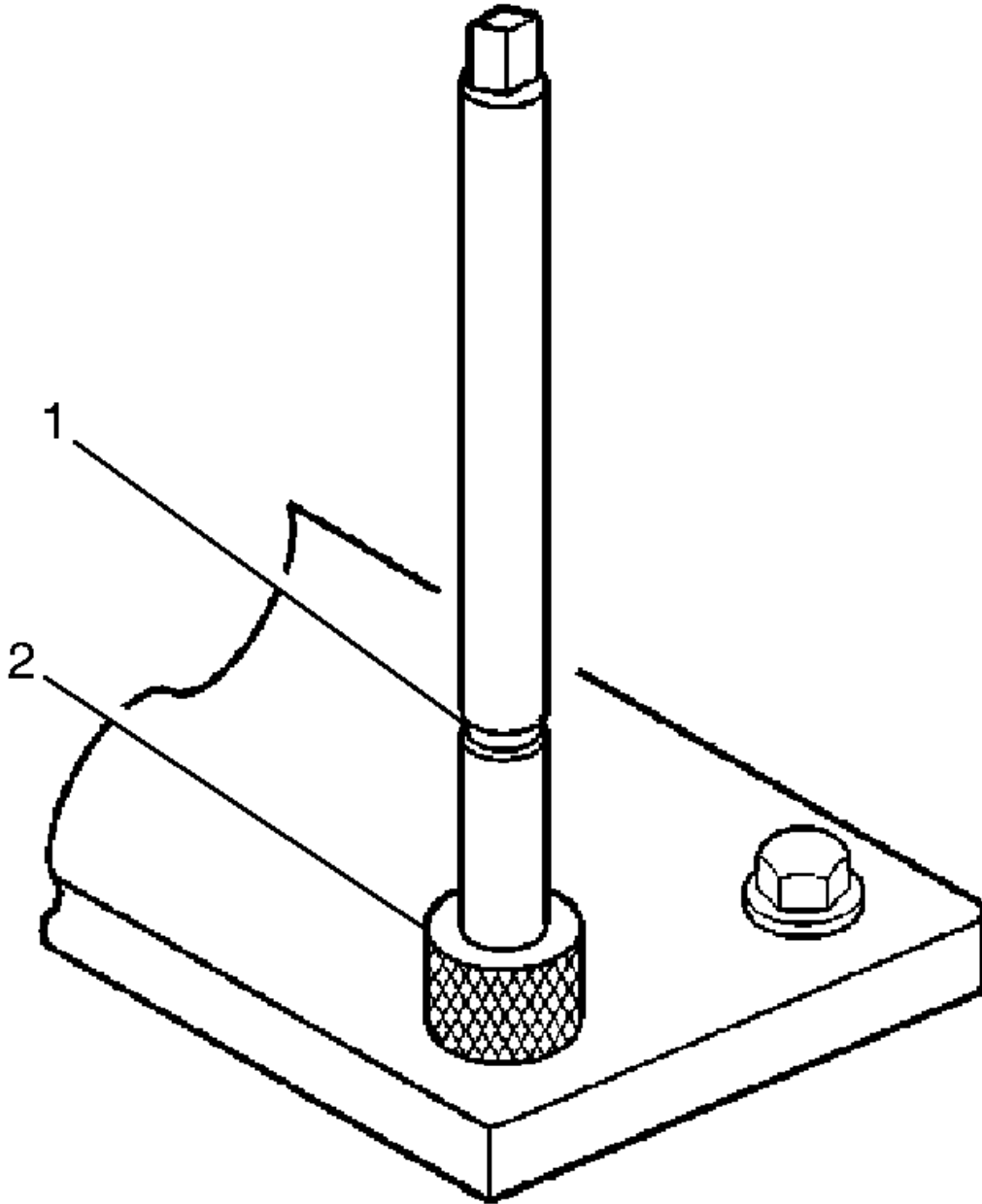
**NOTE:** If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

**NOTE:** The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the

insert are being formed and the insert is mechanically locking the insert into the base material threads.

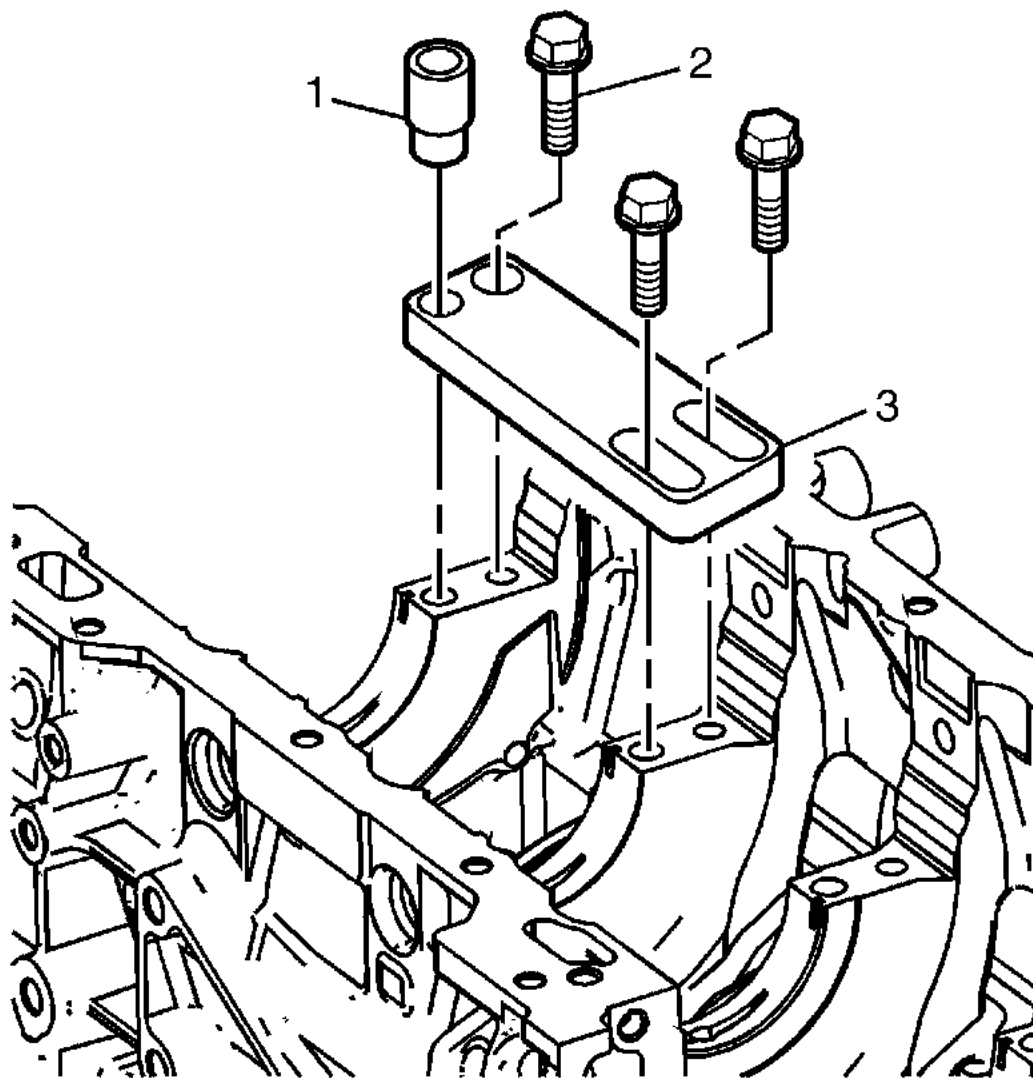
19. Continue to rotate the driver installation tool through the insert.



**Fig. 329: Locating Drill Bushing & Mark**

Courtesy of GENERAL MOTORS CORP.

20. Rotate the driver installation tool until the mark (1) on the driver installation tool aligns with the top of the drill bushing (2).
21. Inspect the insert for correct installation into the tapped hole.

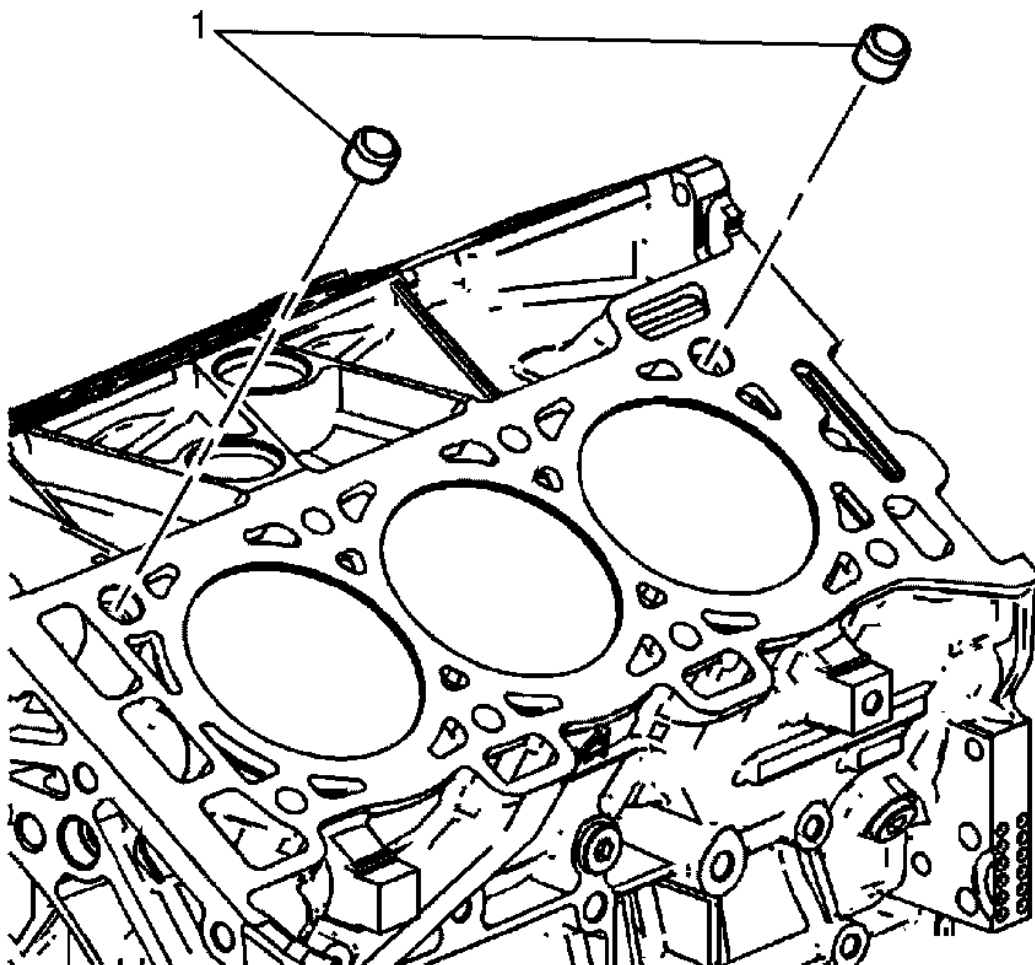


**Fig. 330: View Of Bushing, Fixture Plate & Bolts**  
Courtesy of GENERAL MOTORS CORP.

22. Remove the fixture plate bolts (2).
23. Remove the fixture plate (3) and bushing (1).

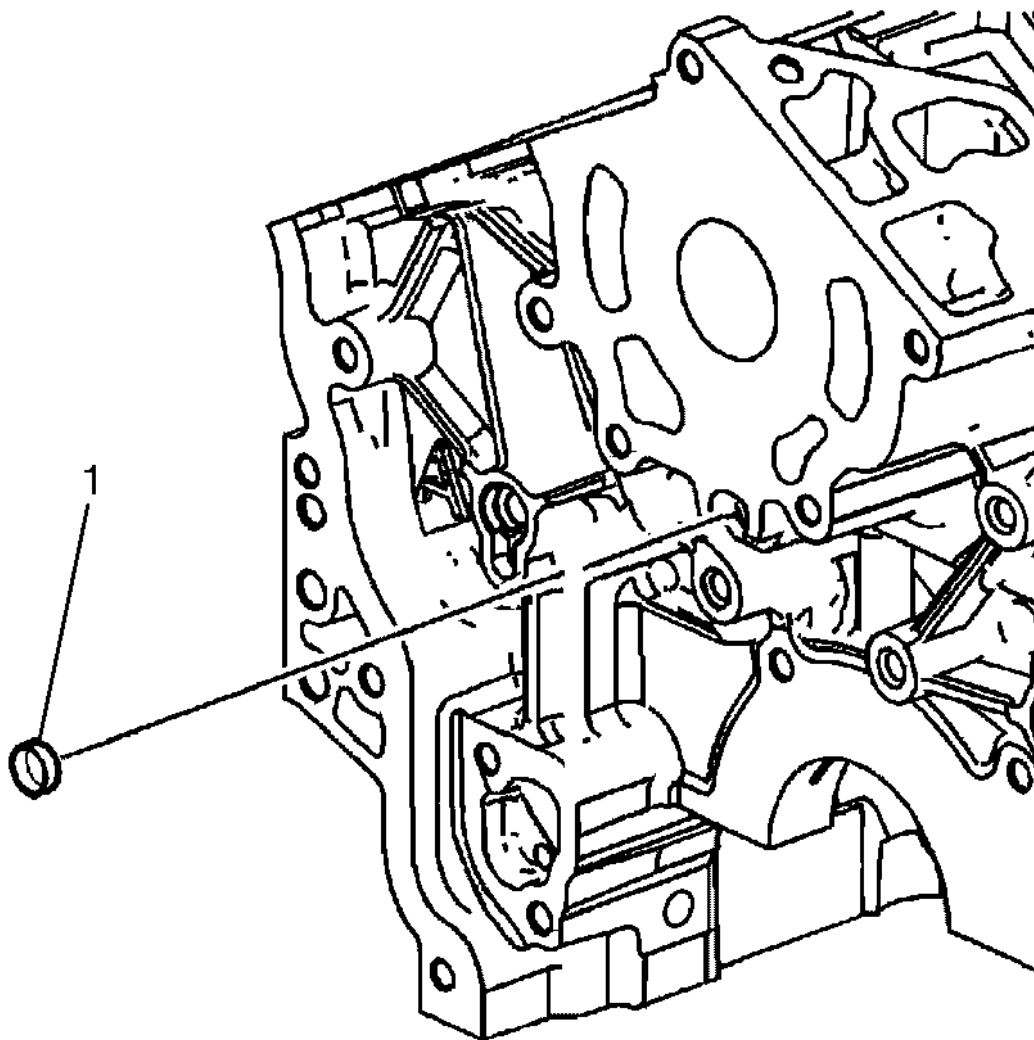
**SERVICE PRIOR TO ASSEMBLY**

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the correct tools to measure the components when checking for wear above acceptable tolerances. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

**ENGINE BLOCK ASSEMBLE**

**Fig. 331: Identifying Cylinder Block-To-Cylinder Head Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

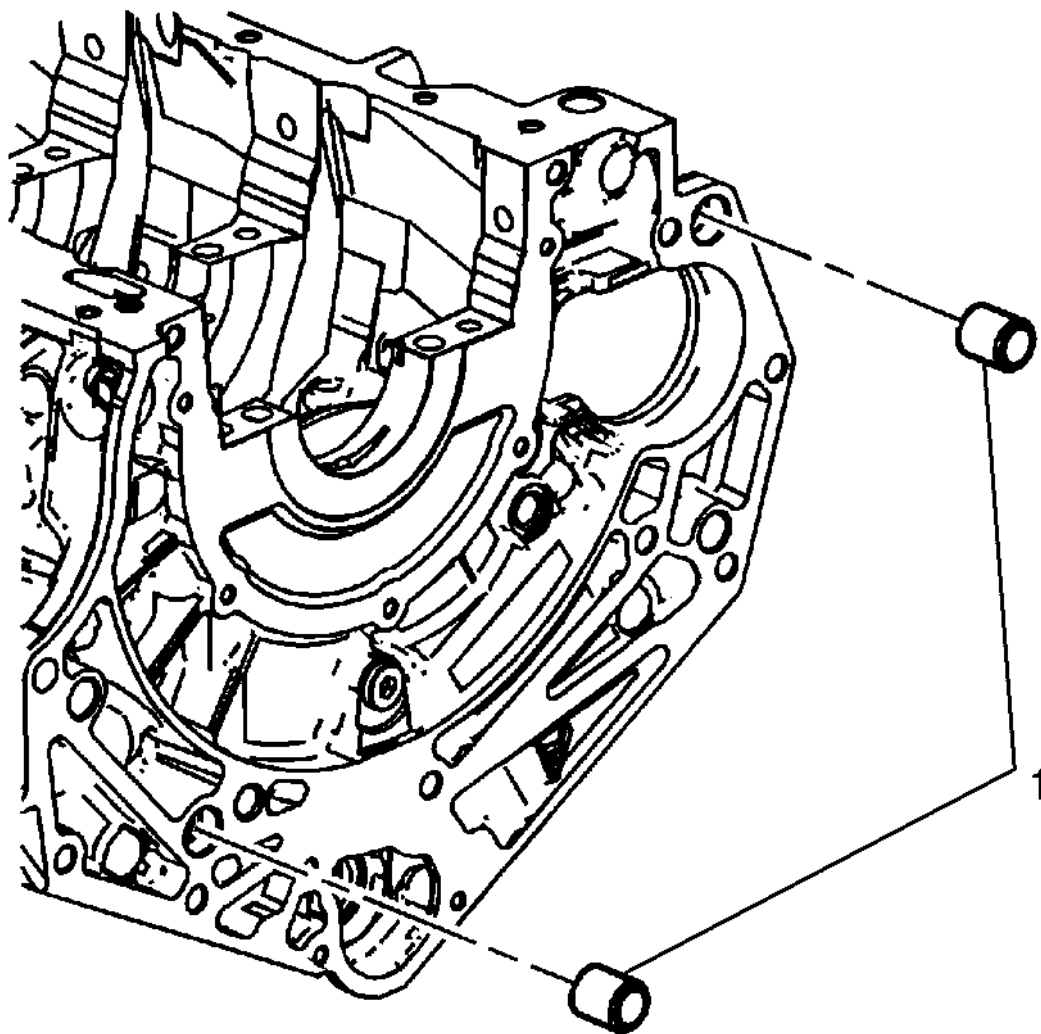
1. Install the cylinder block-to-cylinder head alignment dowels (1).



**Fig. 332: Identifying Front Oil Gallery Expansion Plug**  
Courtesy of GENERAL MOTORS CORP.

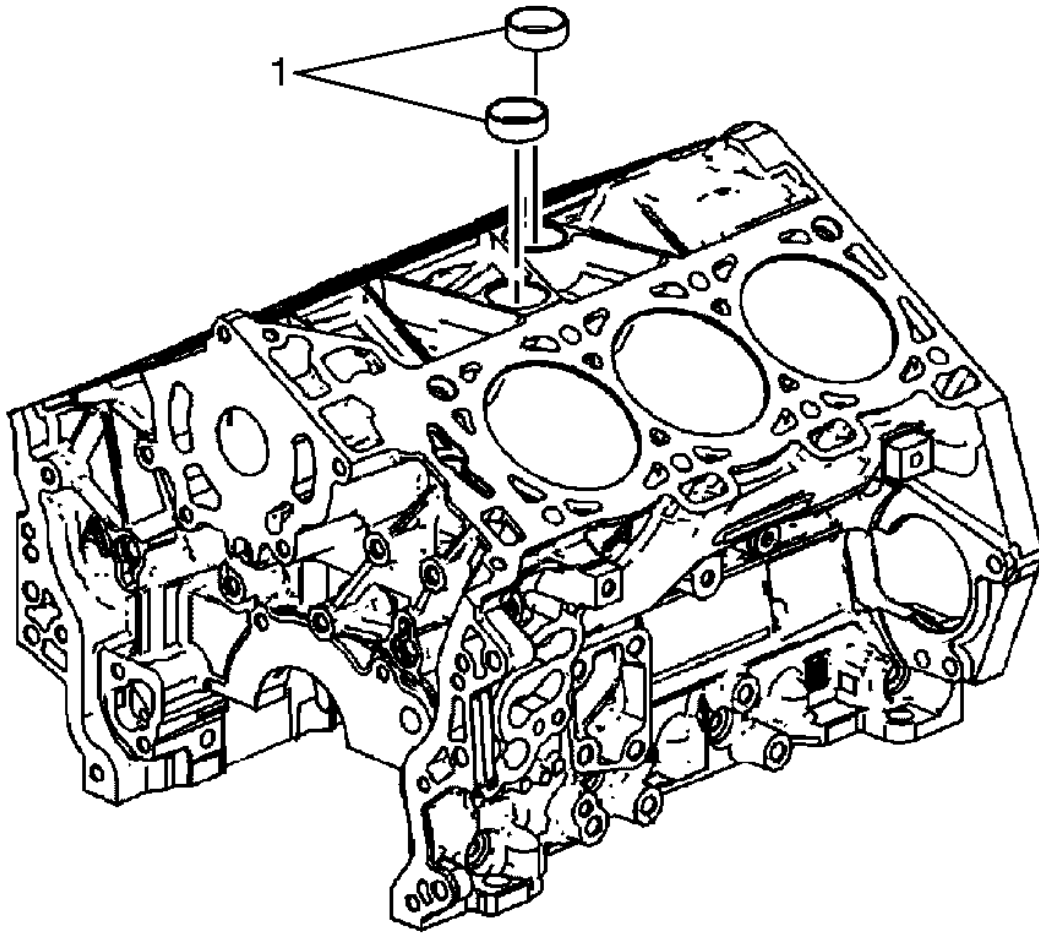
2. Install the NEW front oil gallery expansion plug (1).
3. Make sure the NEW front oil gallery expansion plug (1) is installed to the correct depth.





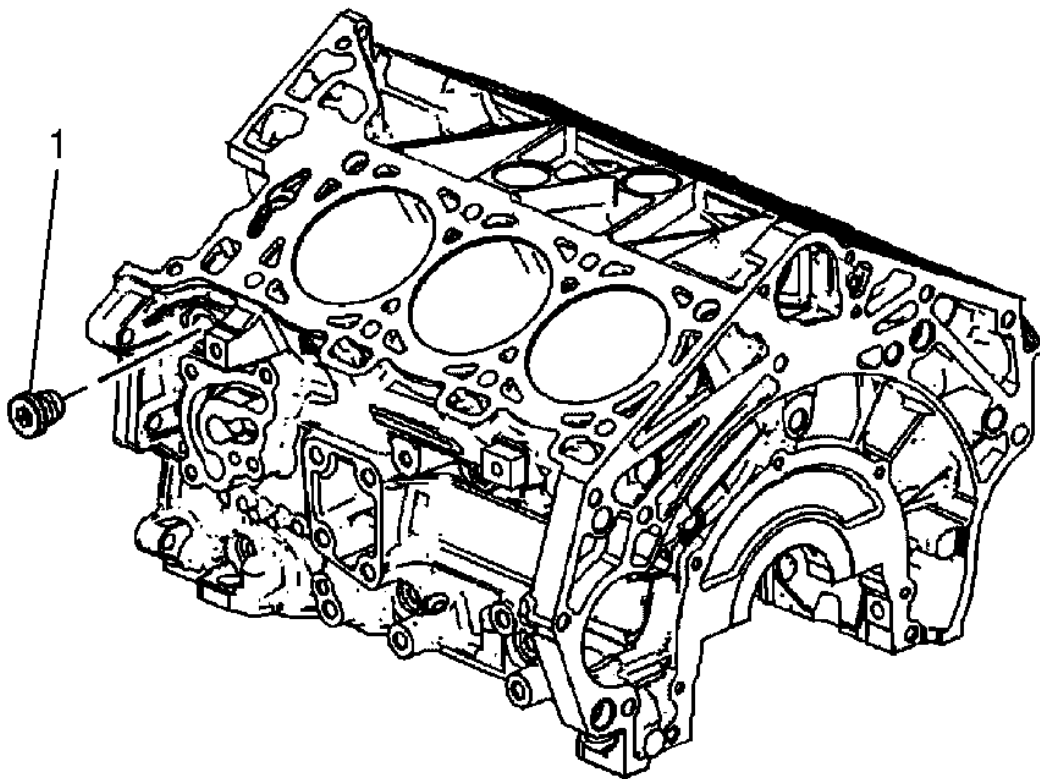
**Fig. 333: Identifying Cylinder Block-To-Transmission Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder block-to-transmission alignment dowels (1).



**Fig. 334: Identifying Coolant Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

5. Apply RTV sealant on the NEW coolant expansion plugs (1).
6. Install the NEW coolant expansion plugs (1).
7. Make sure the NEW coolant expansion plugs (1) are installed to the correct depth.

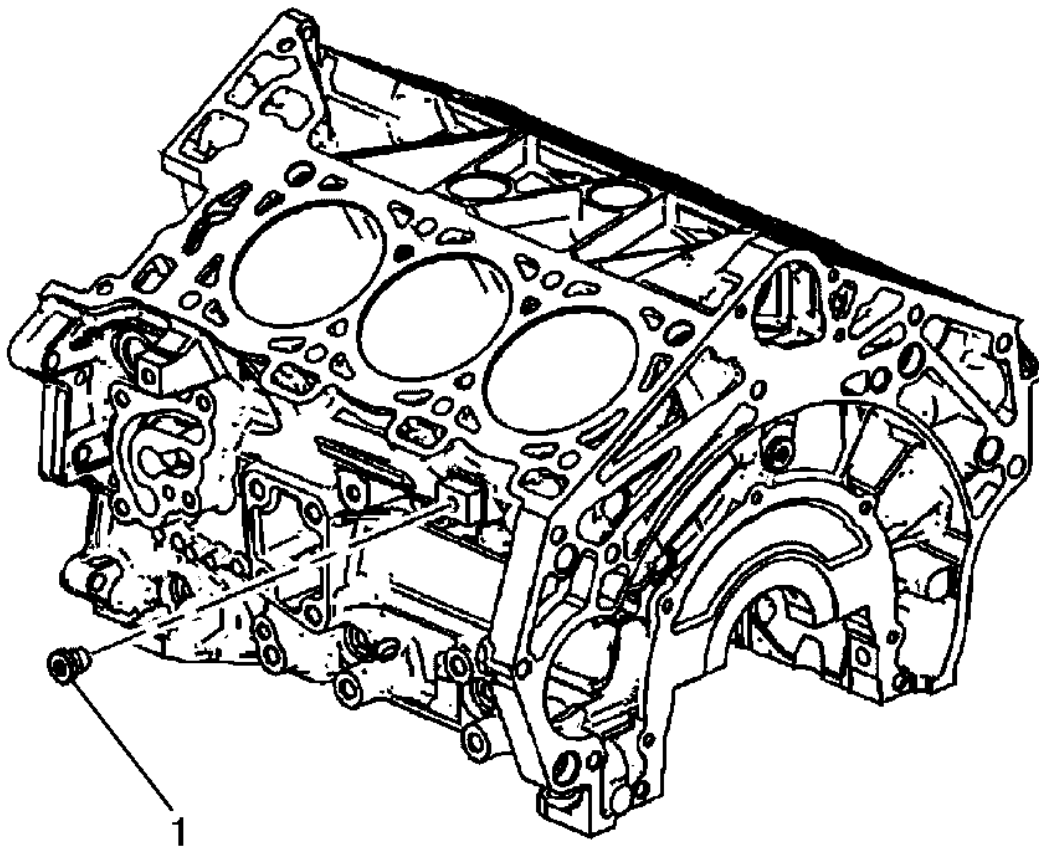


**Fig. 335: Identifying M20 Left Side Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

8. Apply thread sealant on the threads of the M20 left side oil gallery threaded plug (1).

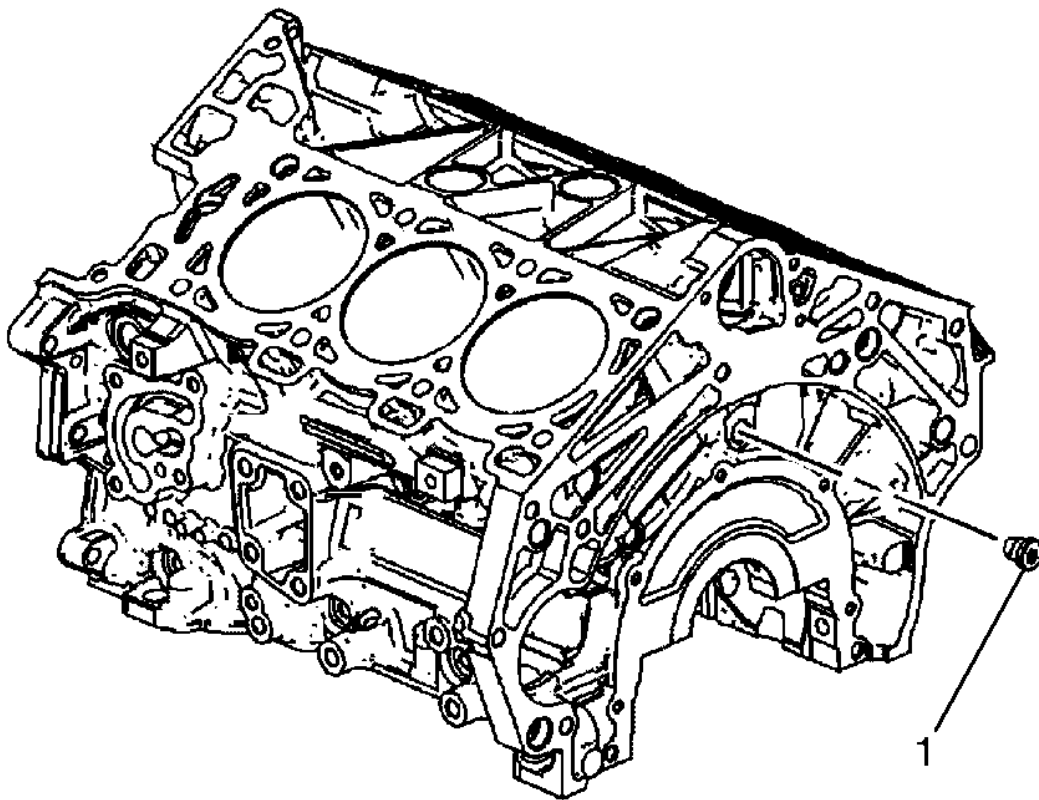
**CAUTION:** Refer to Fastener Caution .

9. Install the M20 left side oil gallery threaded plug (1) and tighten to 31 N.m (23 lb ft).



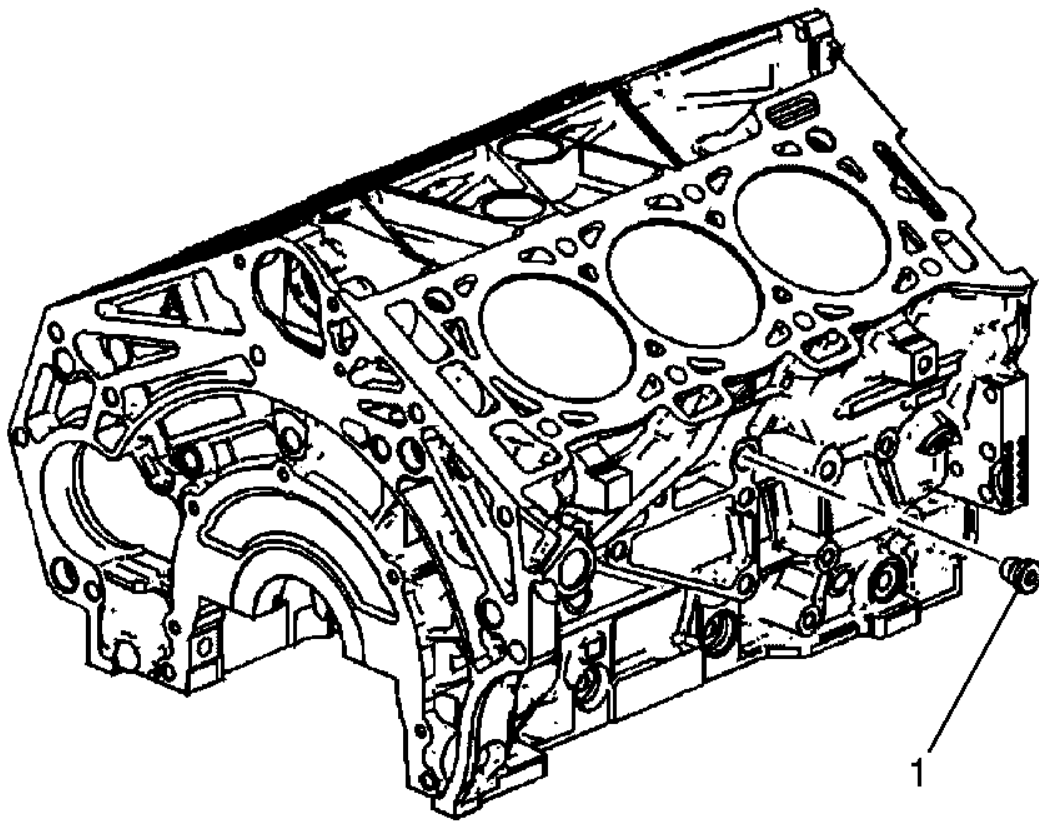
**Fig. 336: Identifying M14 Left Side Coolant Drain Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

10. Apply thread sealant on the threads of the M14 left side coolant drain threaded plug (1).
11. Install the M14 left side coolant drain threaded plug (1) and tighten to 31 N.m (23 lb ft).



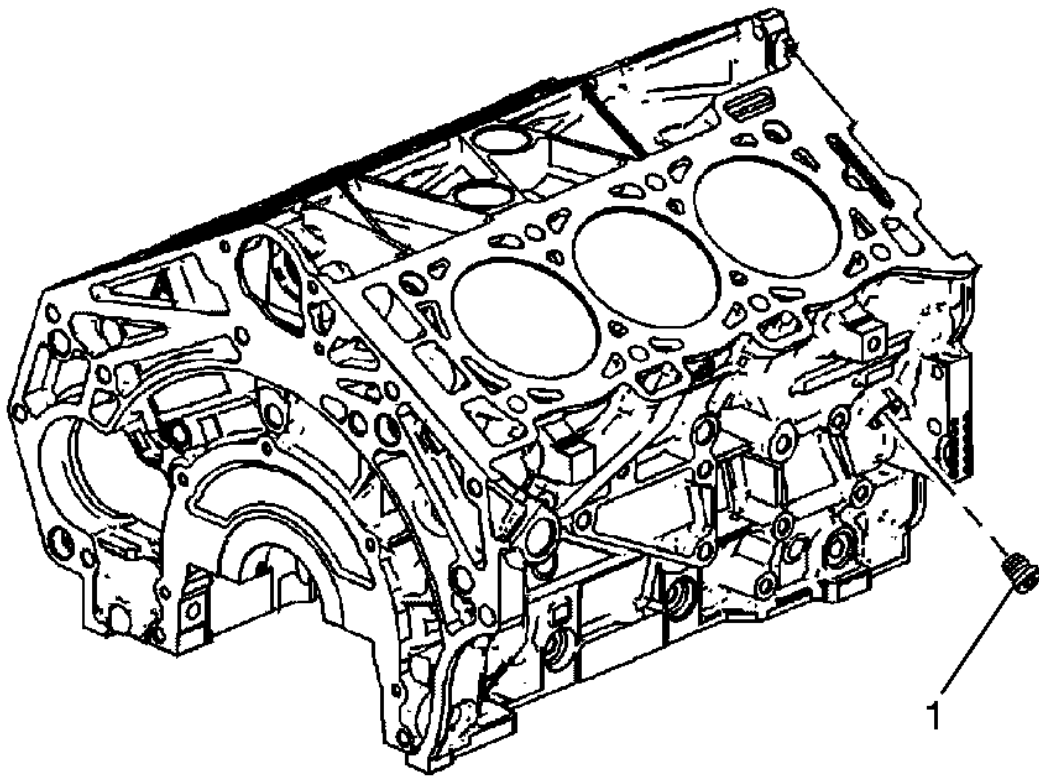
**Fig. 337: Identifying M14 Rear Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

12. Apply thread sealant on the threads of the M14 rear oil gallery threaded plug (1).
13. Install the M14 rear oil gallery threaded plug (1) and tighten to 31 N.m (23 lb ft).



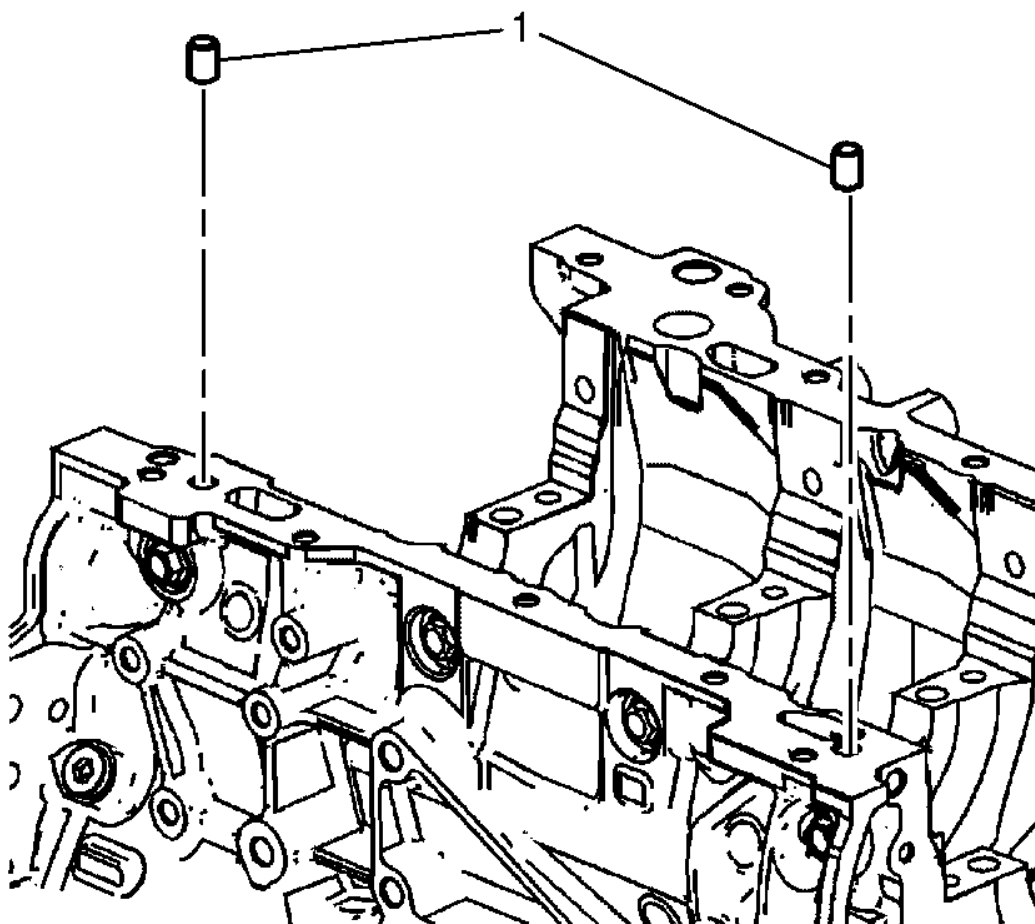
**Fig. 338: Identifying M14 Right Side Coolant Drain Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

14. Apply thread sealant on the threads of the M14 right side coolant drain threaded plug (1).
15. Install the M14 right side coolant drain threaded plug (1) and tighten to 31 N.m (23 lb ft).



**Fig. 339: Identifying M14 Right Side Oil Gallery Threaded Plug**  
Courtesy of GENERAL MOTORS CORP.

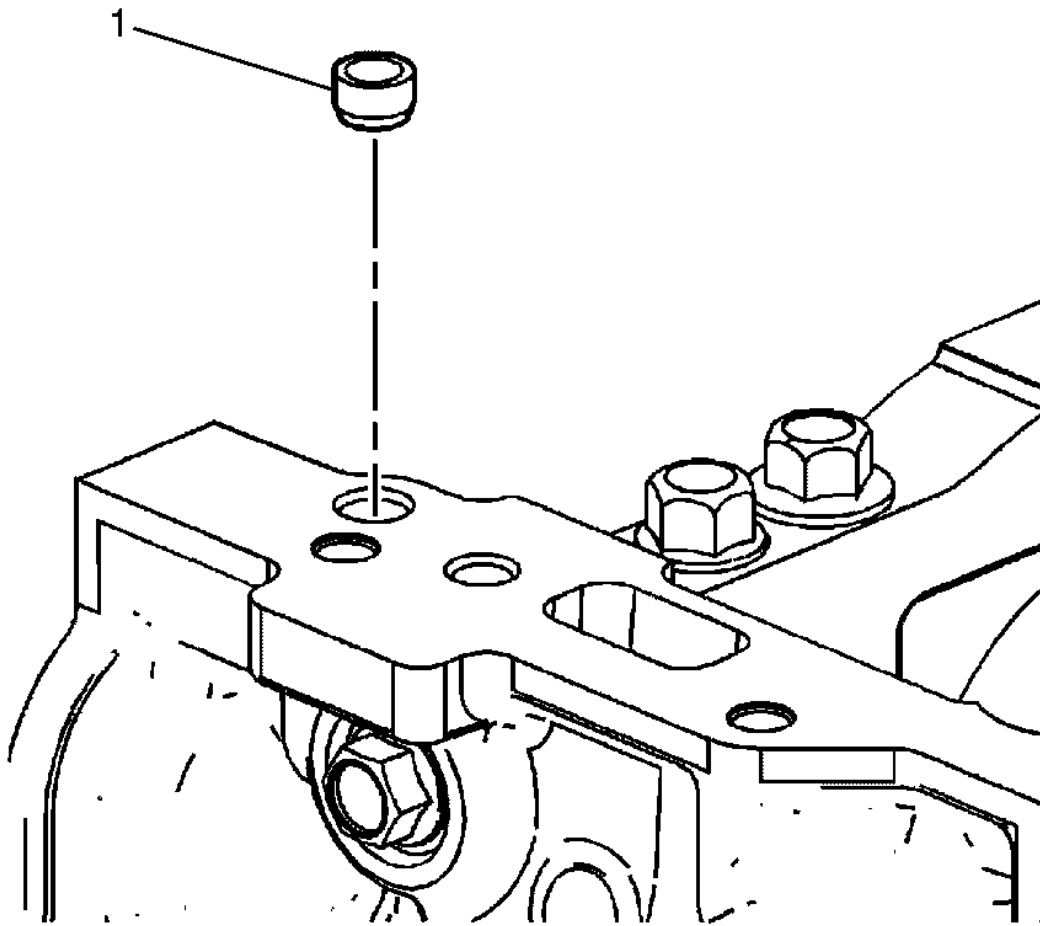
16. Apply thread sealant on the threads of the M14 right side oil gallery threaded plug (1).
17. Install the M14 right side oil gallery threaded plug (1) and tighten to 31 N.m (23 lb ft).



**Fig. 340: Identifying Cylinder Block-To-Oil Pan Alignment Dowels**  
Courtesy of GENERAL MOTORS CORP.

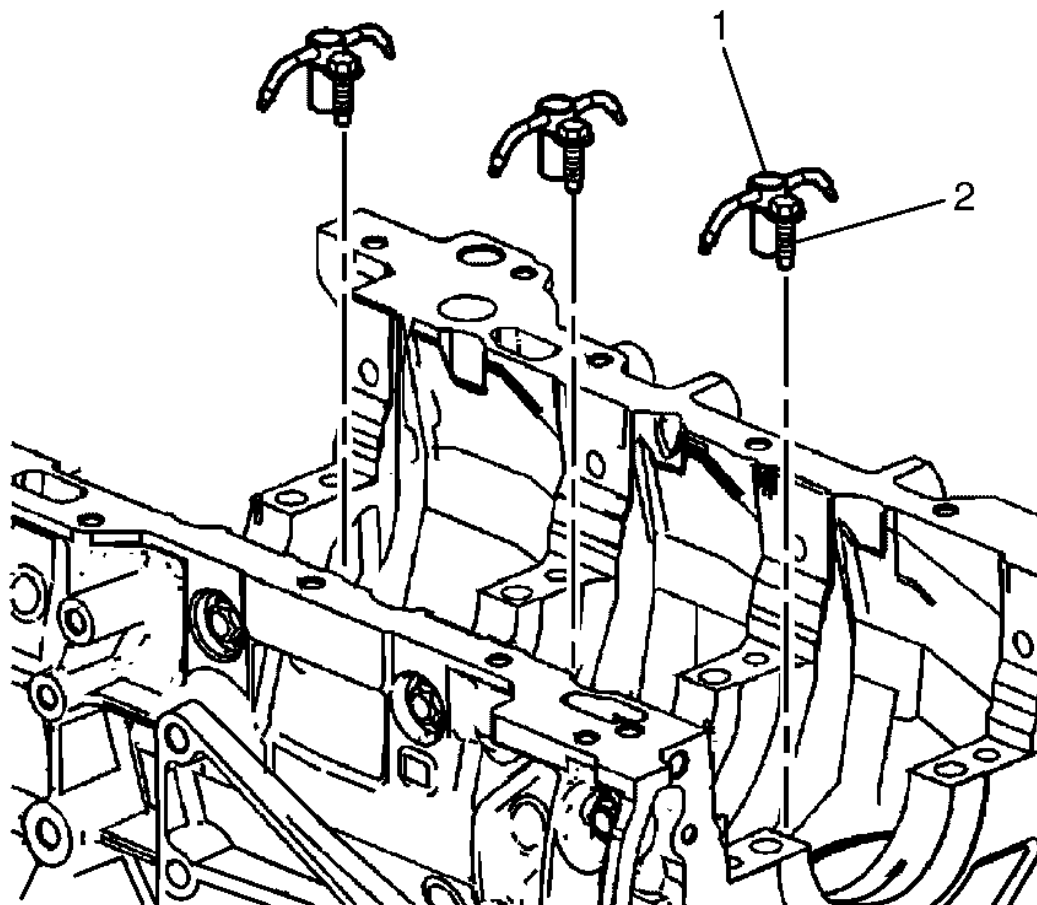
18. Install the cylinder block-to-oil pan alignment dowels (1).





**Fig. 341: Identifying Right Front Oil Pan Rail Oil Gallery Expansion Plug**  
Courtesy of GENERAL MOTORS CORP.

19. Install the NEW right front oil pan rail oil gallery expansion plug (1).
20. Make sure the NEW right front oil pan rail oil gallery expansion plug (1) is installed to the correct depth.



**Fig. 342: Identifying Oil Jet To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

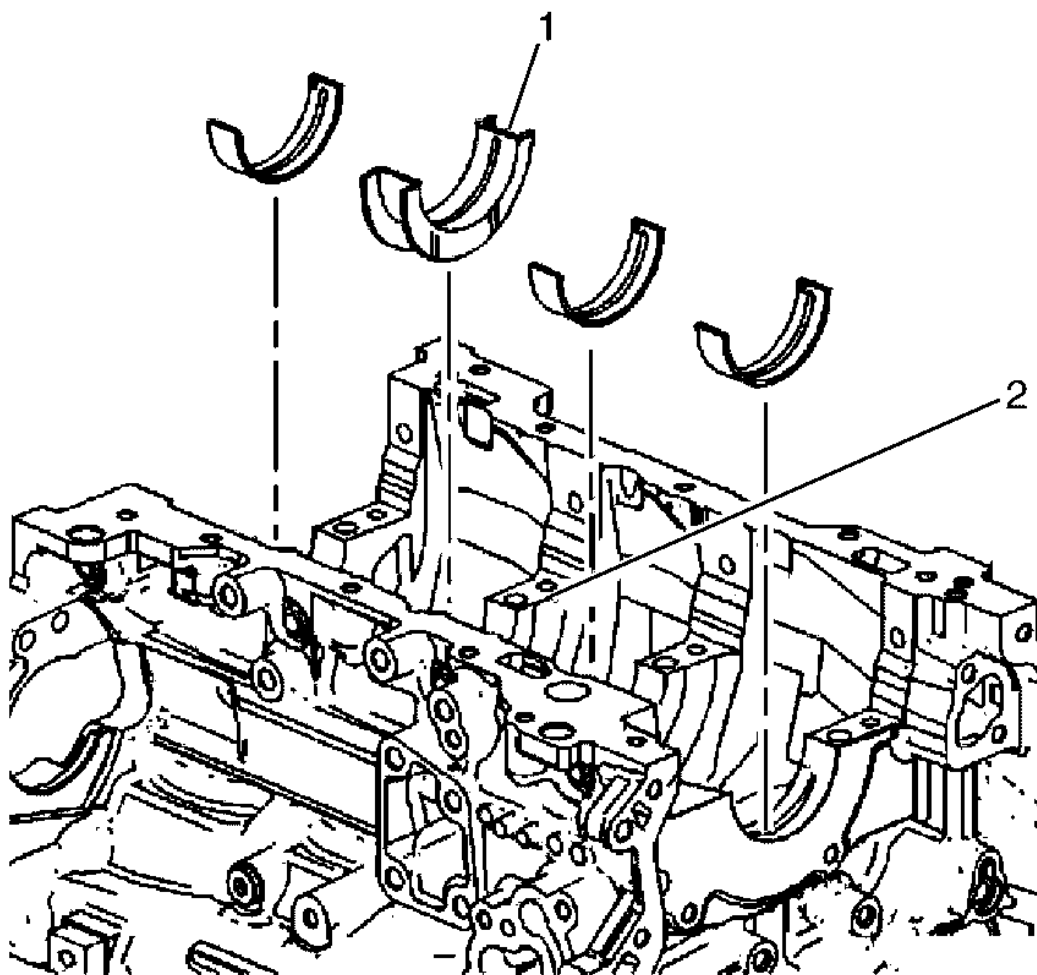
21. Install the oil jets (1).
22. Install the oil jet to cylinder block retaining bolts (2) and tighten to 10 N.m (89 lb in).

## CRANKSHAFT AND BEARING INSTALLATION

### Crankshaft Bearing Installation Procedure

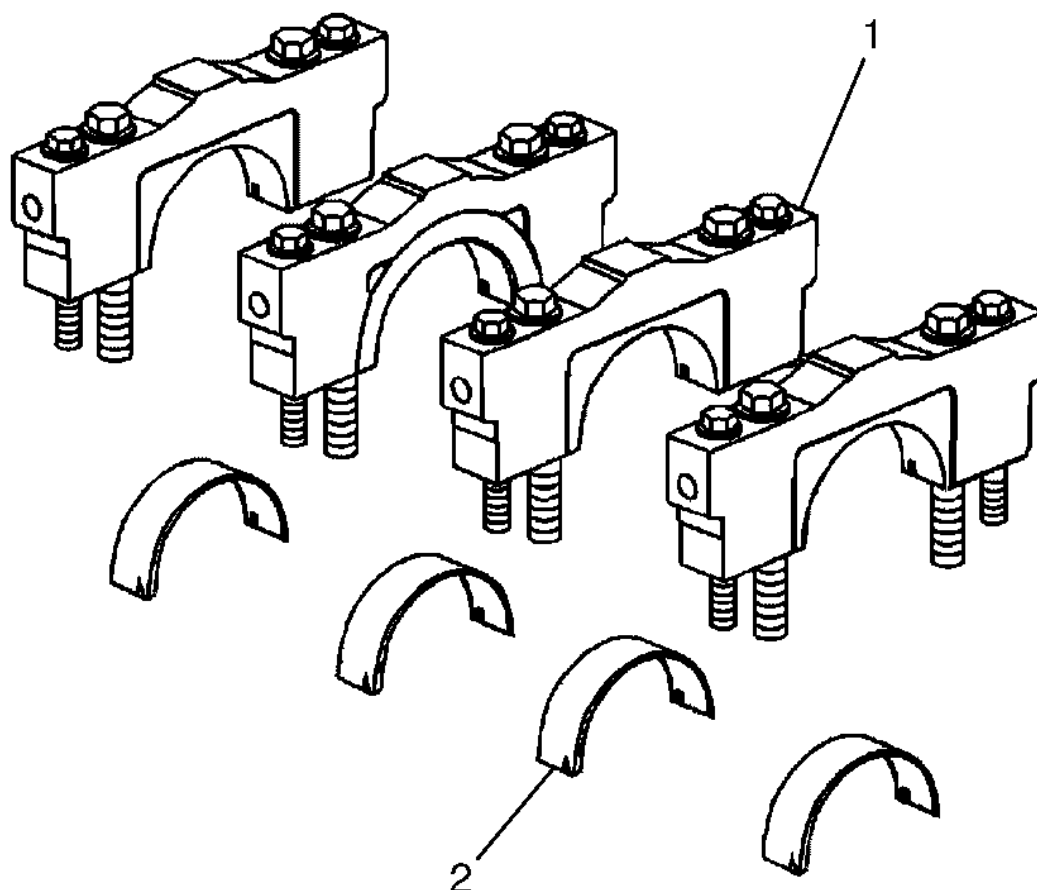
**NOTE:** If the crankshaft bearings have been used in a running engine, you must replace them with **NEW** crankshaft bearings for reassembly.

1. Clean the crankcase crank bore with a lint-free cloth.
2. Clean all the oil from the backside of new bearing halves.



**Fig. 343: Identifying Thrust Bearing & Number 3 Journal**  
Courtesy of GENERAL MOTORS CORP.

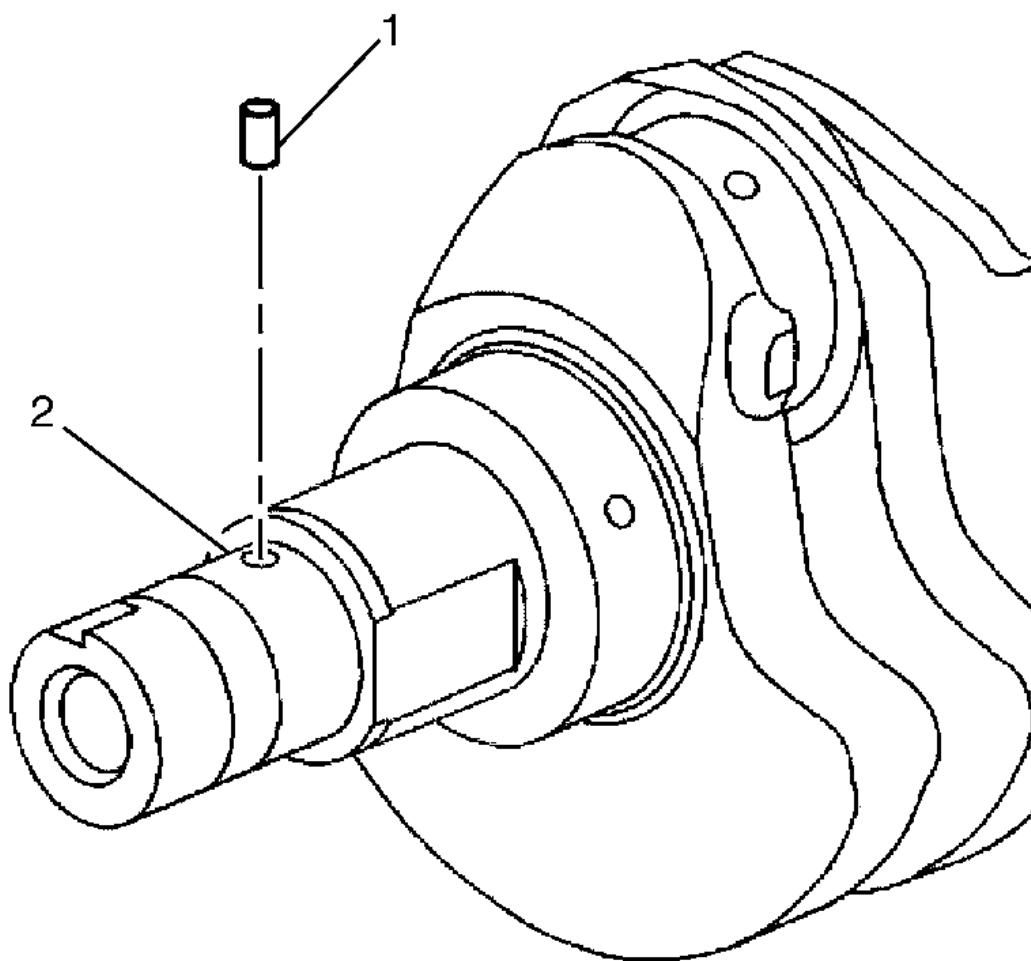
3. Install the new upper crankshaft bearings into position. The thrust bearing (1) belongs in the number 3 journal (2). Make sure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.



**Fig. 344: View Of Crankshaft Bearings & Caps**  
Courtesy of GENERAL MOTORS CORP.

4. Install the new lower crankshaft bearings (2) into position in the crankshaft bearing caps (1). The lower crankshaft bearings (2) are identified by NO grooves or holes. The lower crankshaft bearings (2) must fit flush with the crankshaft bearing caps (1).

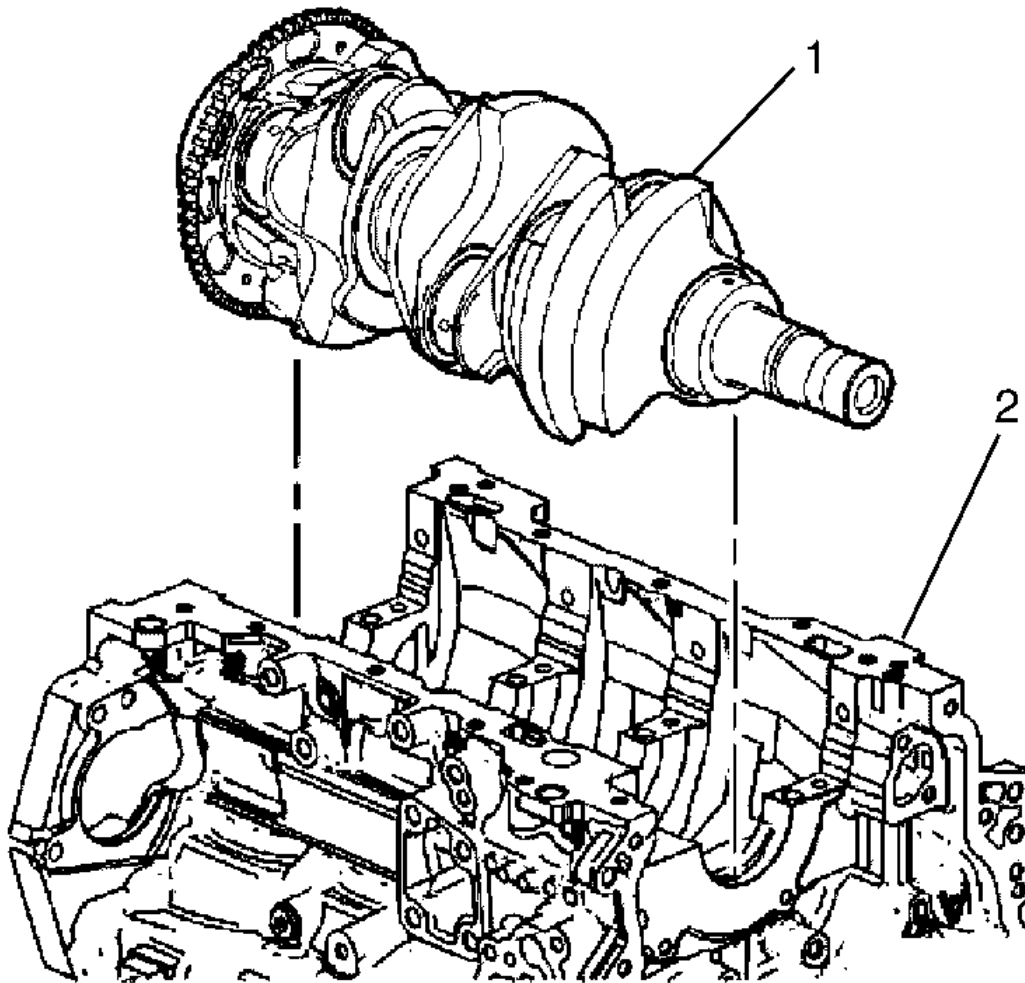
#### Crankshaft Installation Procedure



**Fig. 345: View Of Crankshaft & Sprocket Drive Pin**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The crankshaft sprocket drive pin must be set to the proper depth. Installing the crankshaft sprocket drive pin too deep can lead to damage to the crankshaft sprocket and extensive engine damage.

1. If removed, install the crankshaft sprocket drive pin (1). Lightly tap the crankshaft sprocket drive pin (1) in place with a small soft face, bronze/plastic, hammer until it bottoms in the hole of the crankshaft (2).



**Fig. 346: View Of Crankshaft & Cylinder Block**  
 Courtesy of GENERAL MOTORS CORP.

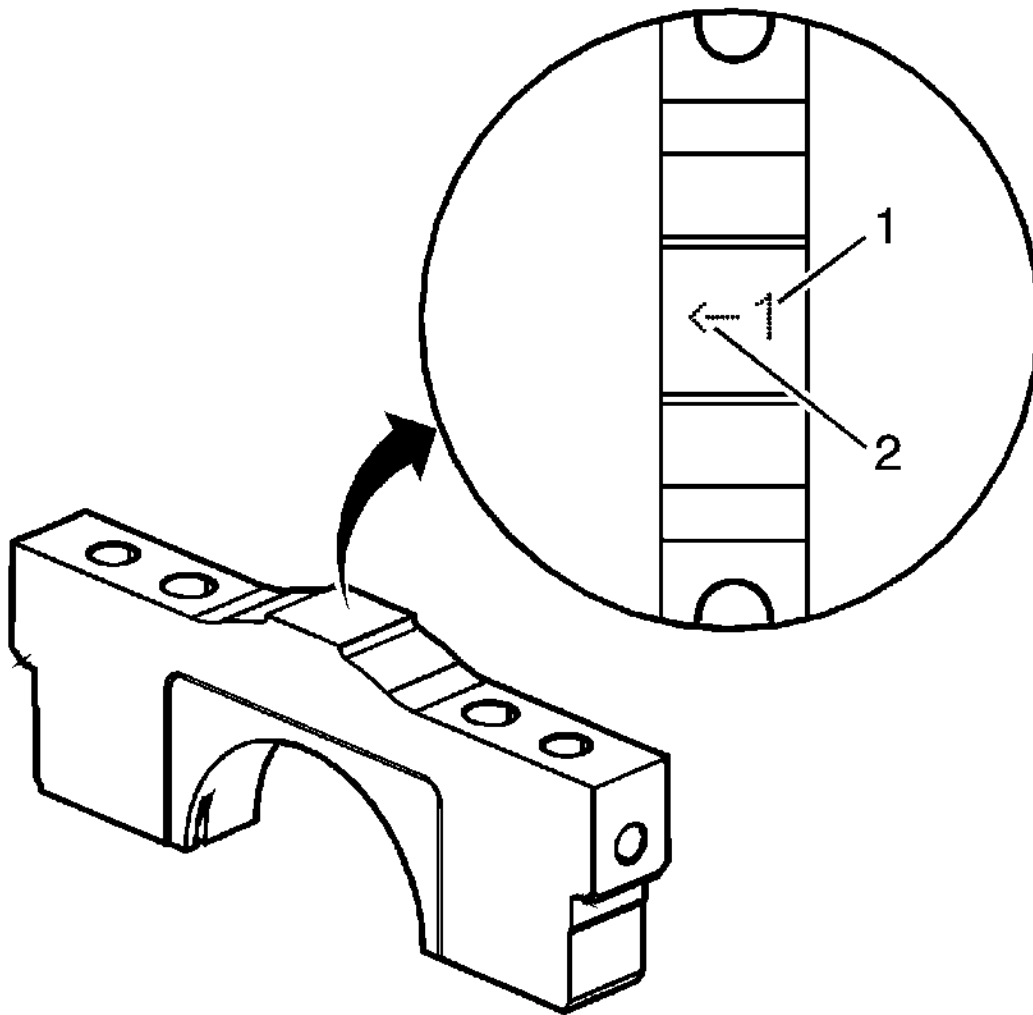
2. Gently lower the crankshaft (1) into position in the cylinder block (2).

#### Crankshaft Bearing Clearance Measurement Procedure

#### Special Tools

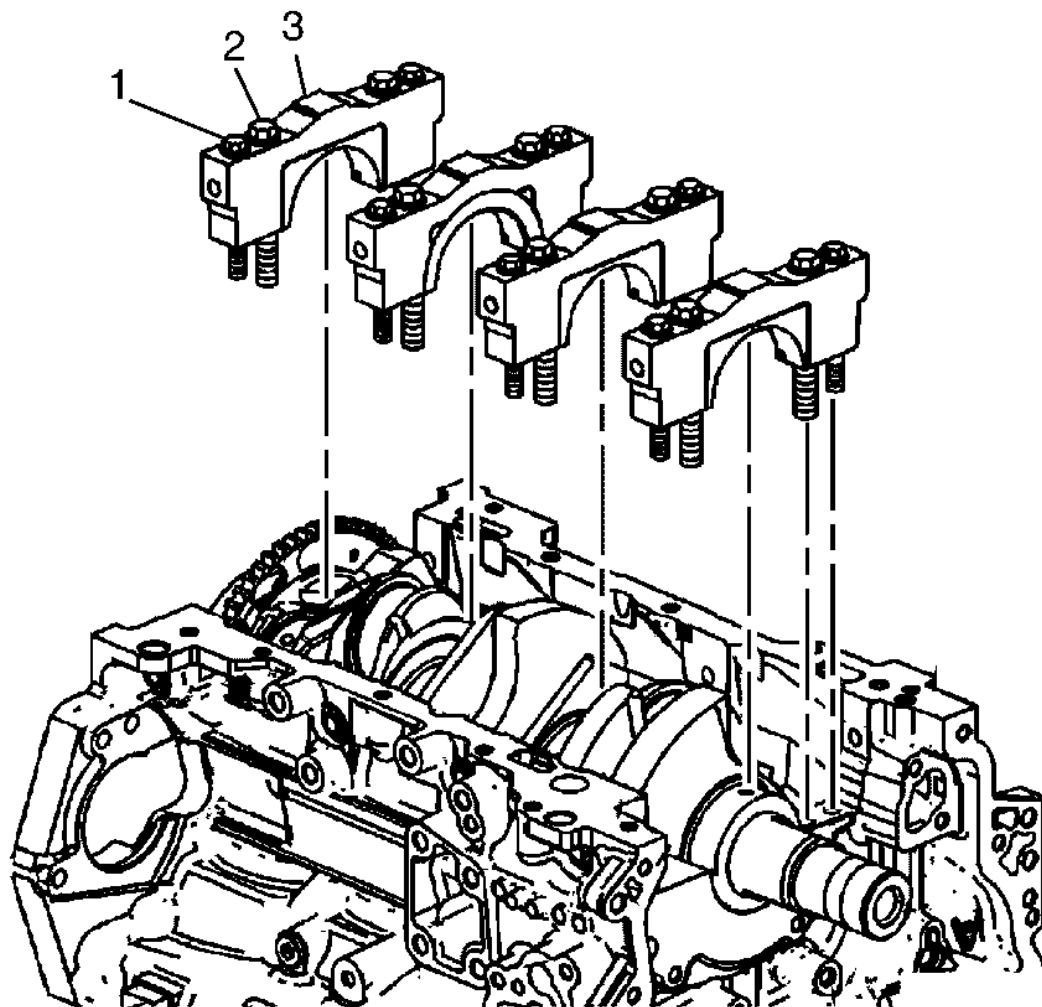
- **J 6125-1B:** Slide Hammer Adapter
- **J 41818:** Crankshaft Bearing Cap Remover
- **J 45059:** Angle Meter

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



**Fig. 347: Locating Crankshaft Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

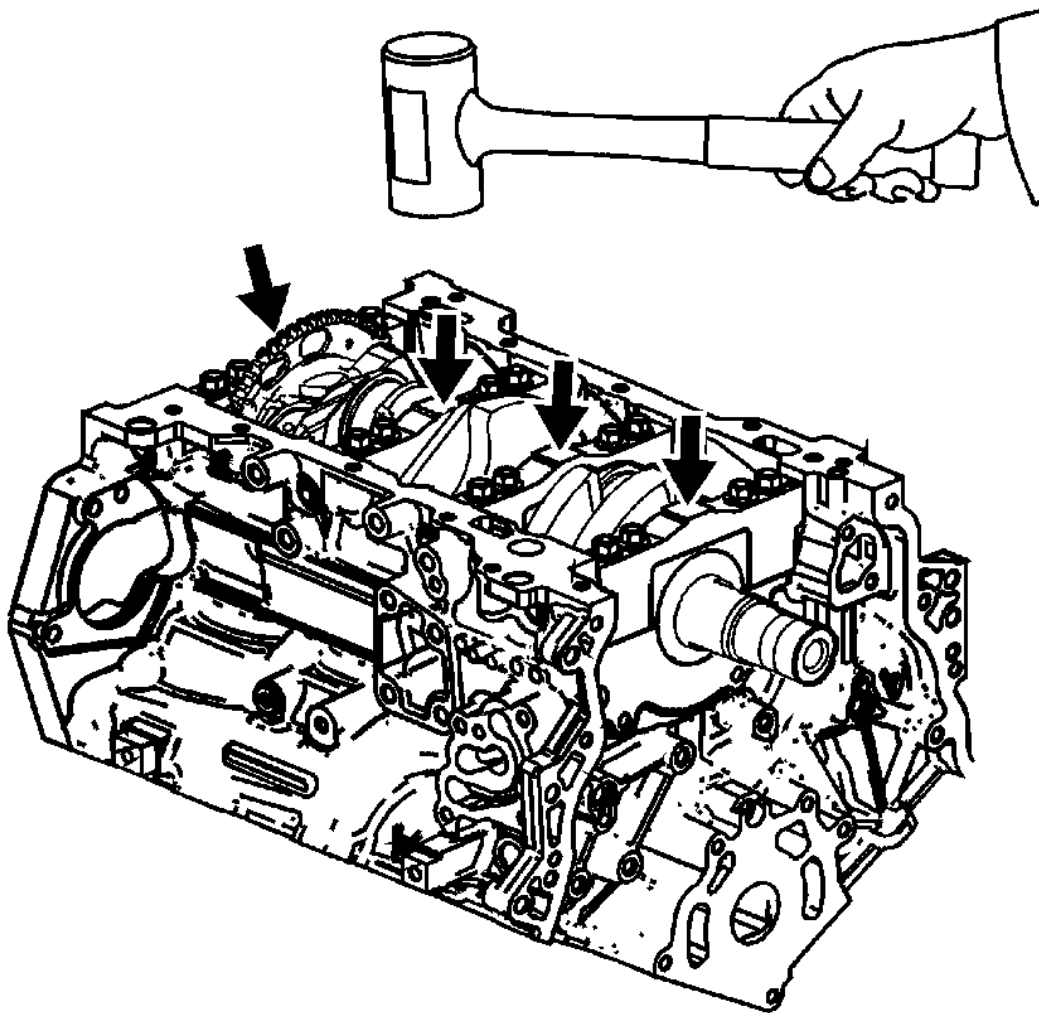
1. Place a length of fresh, room temperature plastic gauging material all the way across all the crankshaft bearing journals.
2. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.



**Fig. 348: Identifying Inner/Outer Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

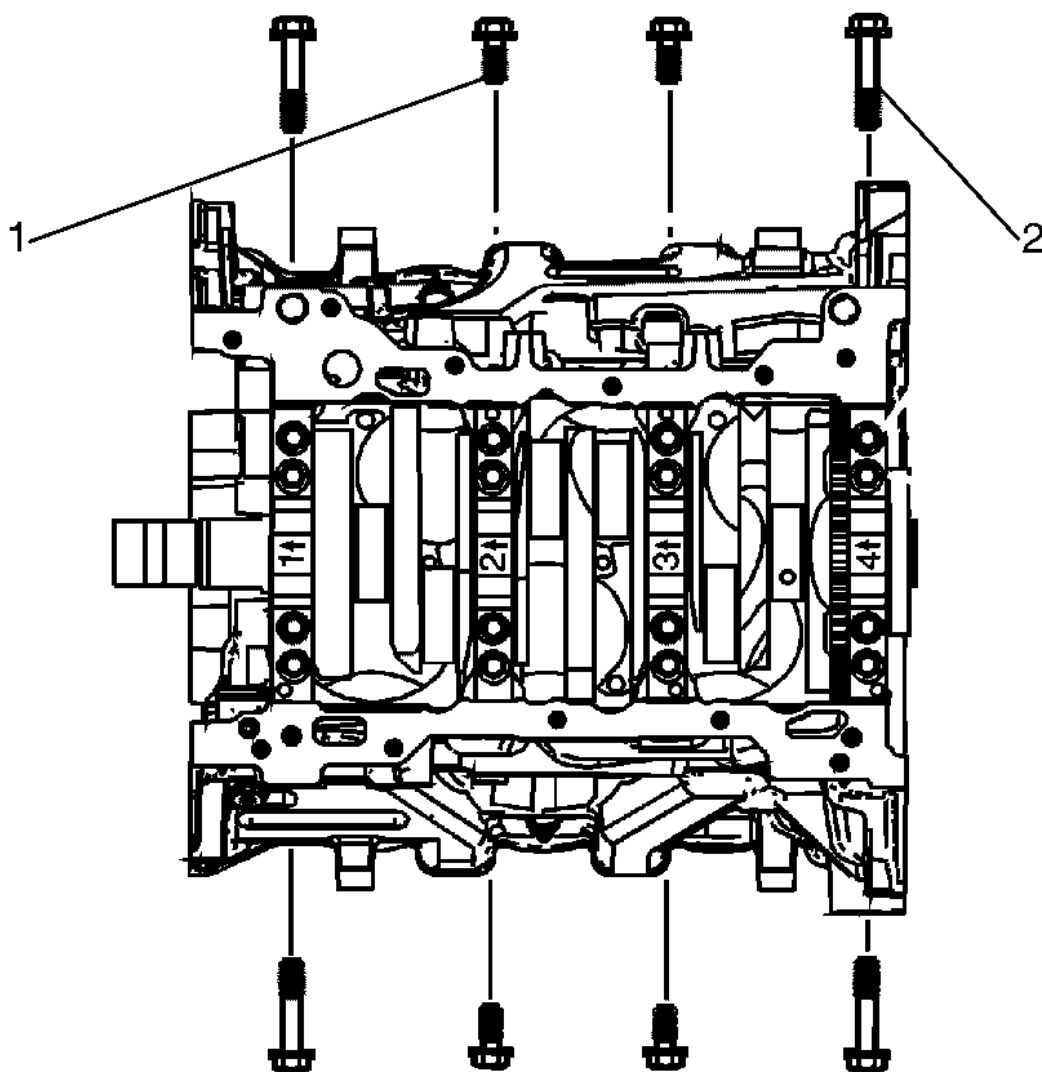
3. Install the crankshaft bearing caps (3).
4. Loosely install the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
5. Loosely install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).





**Fig. 349: View Of Crankshaft Bearing Cap Tapping Sequence**  
Courtesy of GENERAL MOTORS CORP.

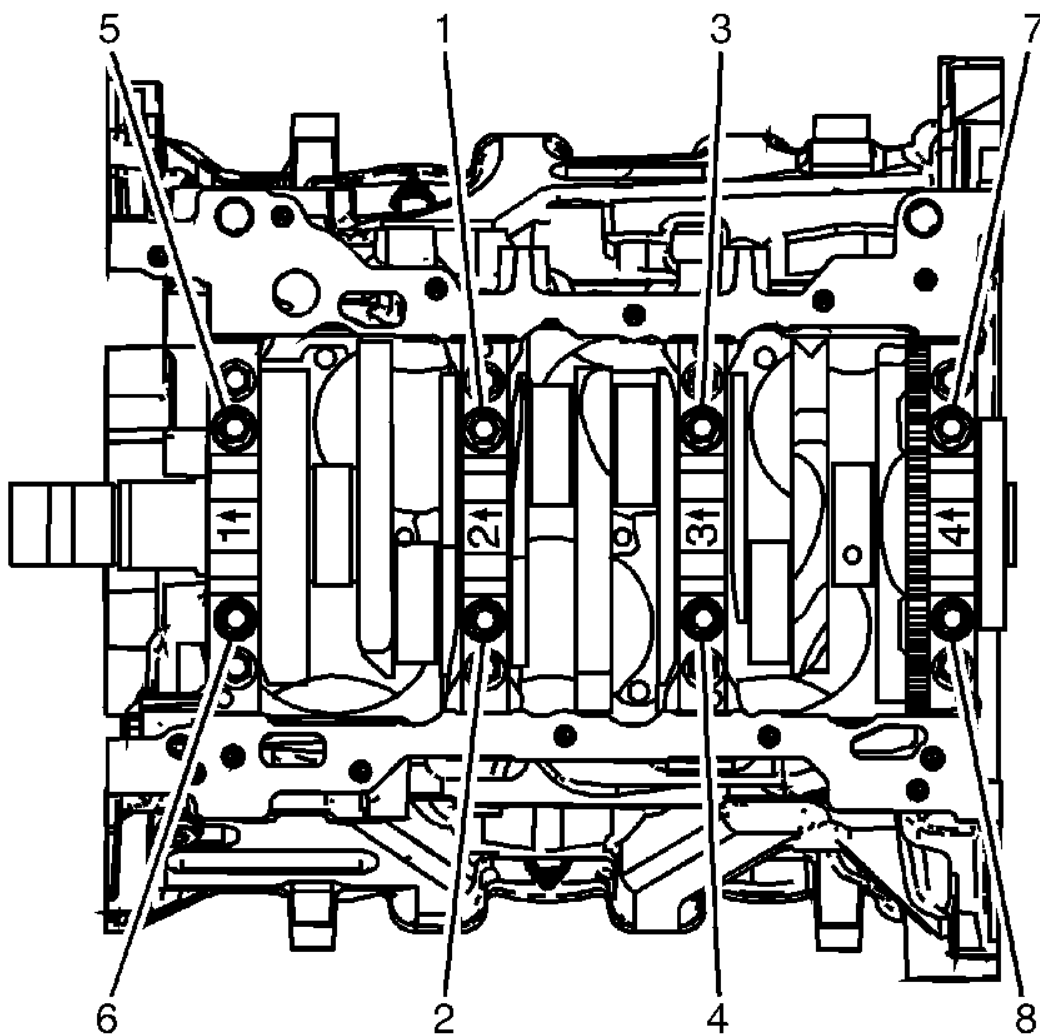
6. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.



**Fig. 350: Identifying Short/Inner & Long/Outer Side Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

7. Loosely install the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
8. Loosely install the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).
9. Tighten the crankshaft bearing cap to cylinder block retaining bolts using the **J 45059** meter in the following sequence:

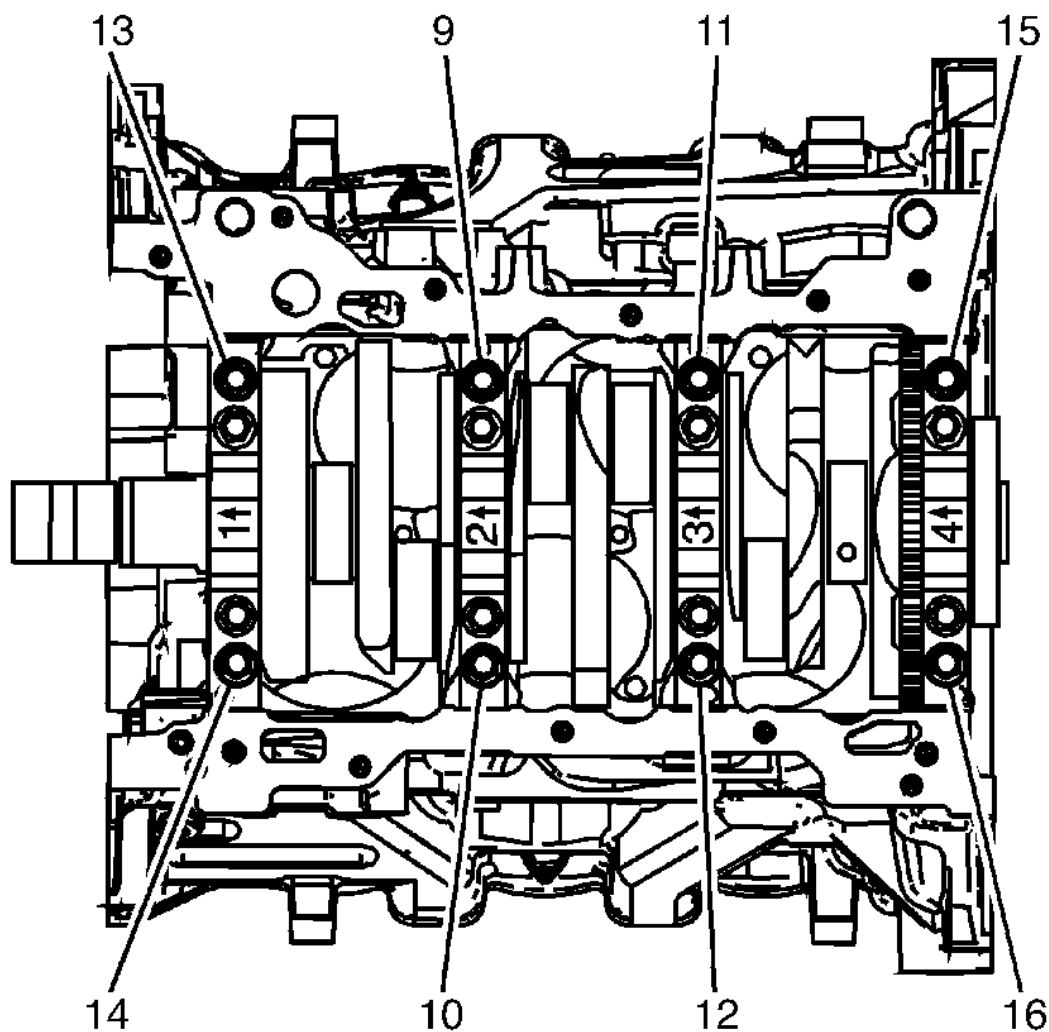


**Fig. 351: Identifying Inboard Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

**CAUTION: Refer to Fastener Caution .**

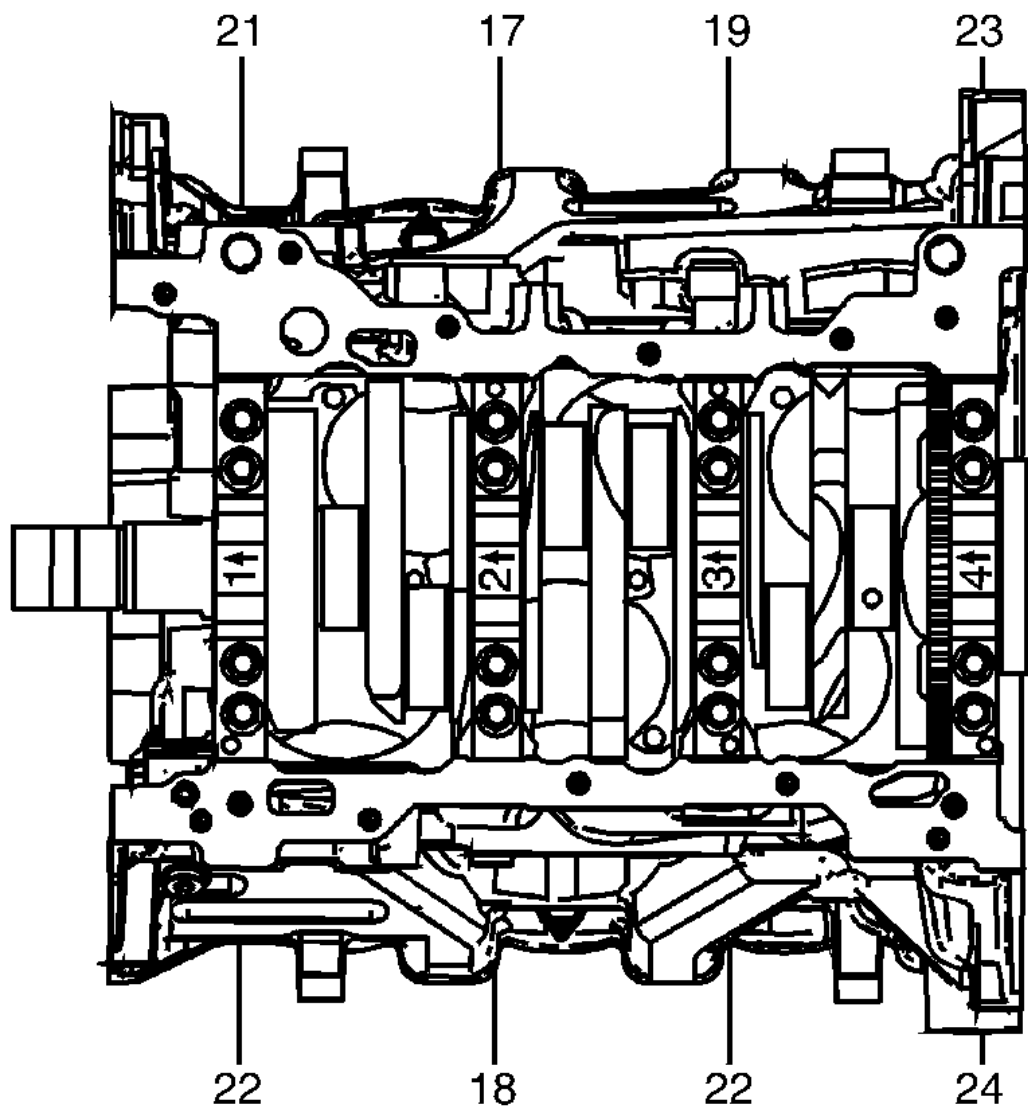
10. Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1-8) and tighten to 20 N.m (15 lb ft) plus 80 degrees.



**Fig. 352: Identifying Outboard Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

11. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9-16) and tighten to 15 N.m (11 lb ft) plus 110 degrees.



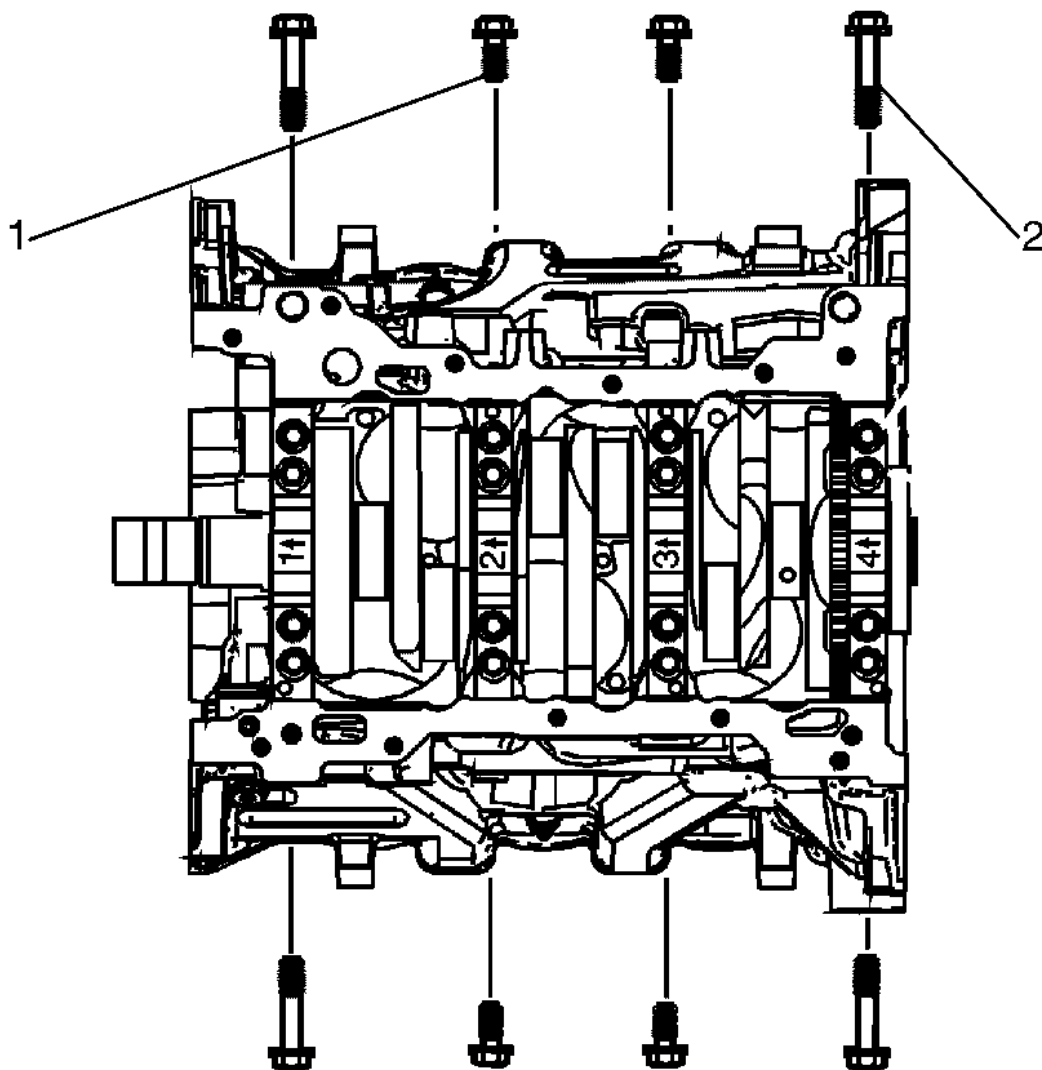
**Fig. 353: View Of Short/Inner & Long/Outer Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

12. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17-20) and tighten to 30 N.m (22 lb ft) plus 60 degrees.
13. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21-24) and tighten to 30 N.m (22 lb ft) plus 60 degrees.

**NOTE:** DO NOT rotate the crankshaft.

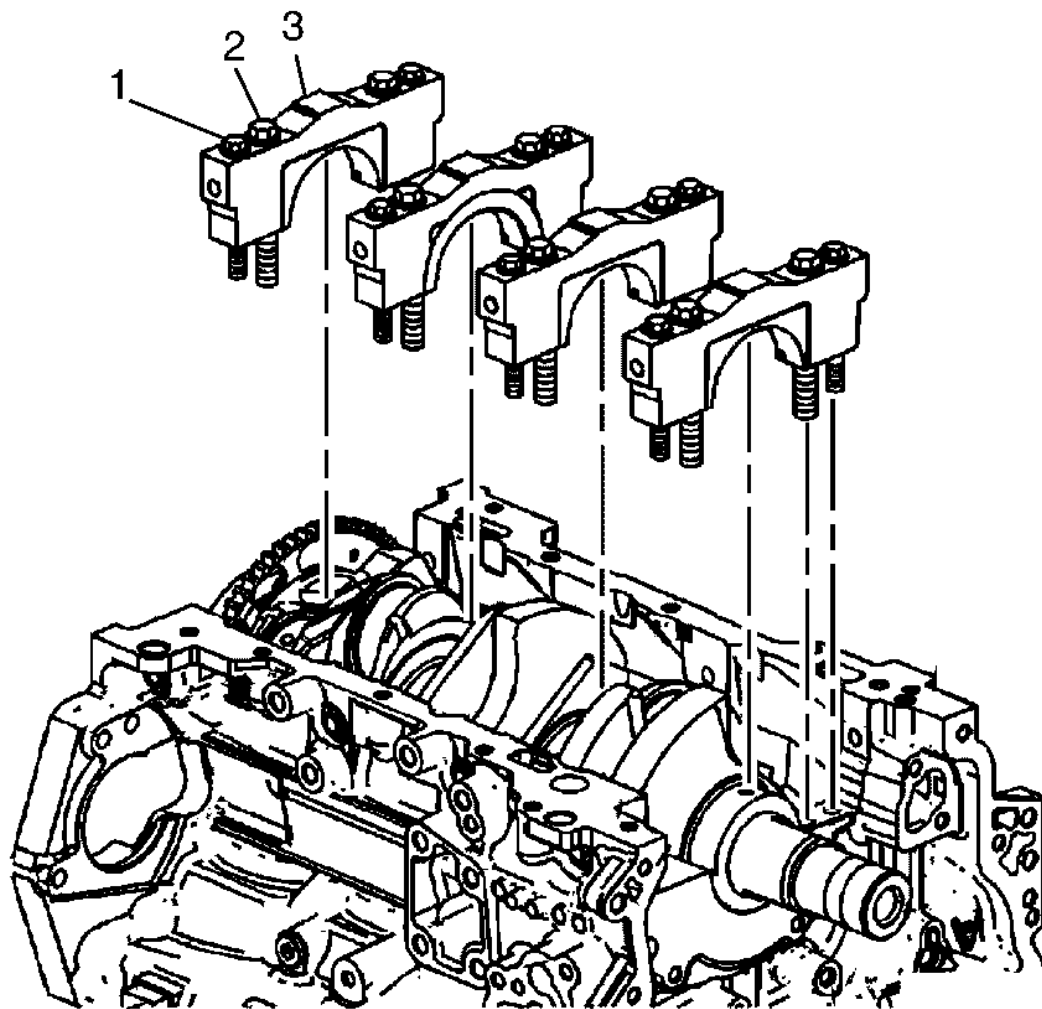
14. After reaching final torque, allow the assembly to sit for 2 minutes.



**Fig. 354: Identifying Short/Inner & Long/Outer Side Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**

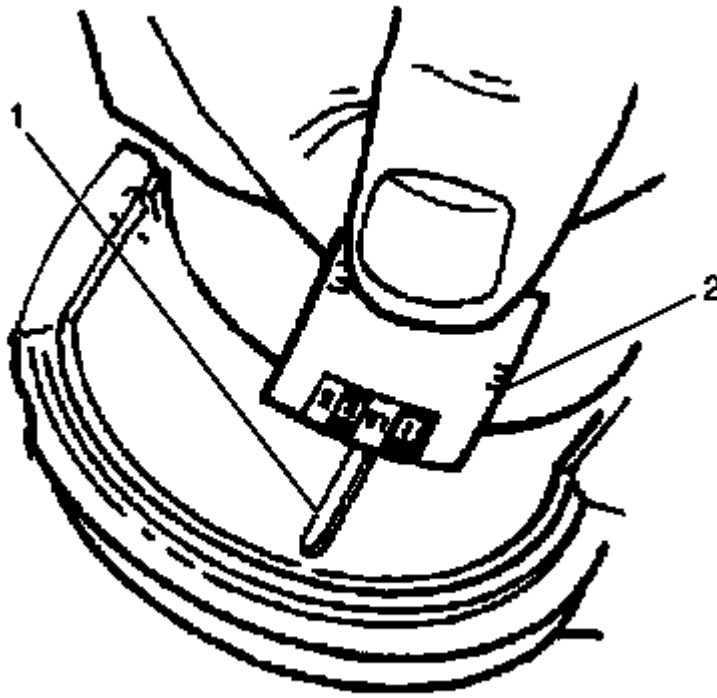
Courtesy of GENERAL MOTORS CORP.

15. Remove the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).  
16. Remove the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).



**Fig. 355: Identifying Inner/Outer Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

17. Remove the install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).
18. Remove the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
19. Remove the crankshaft bearing caps (3) using the **J 6125-1B**: adapter and **J 41818**: remover



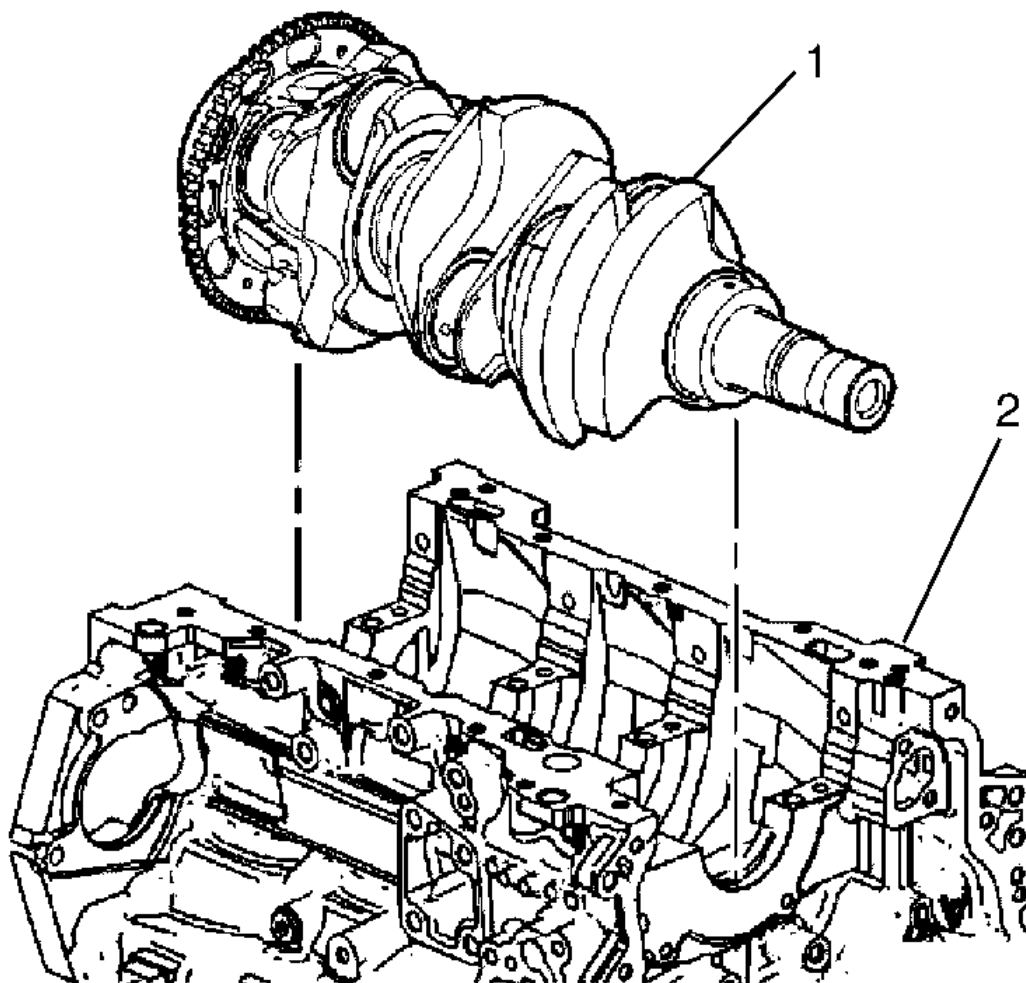
**Fig. 356: View Of Crankshaft Bearing Clearance**  
Courtesy of GENERAL MOTORS CORP.

20. Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).

**NOTE:**        **The crankshaft bearings CAN be reused after checking the clearance if the bearings have never been used in a running engine.**

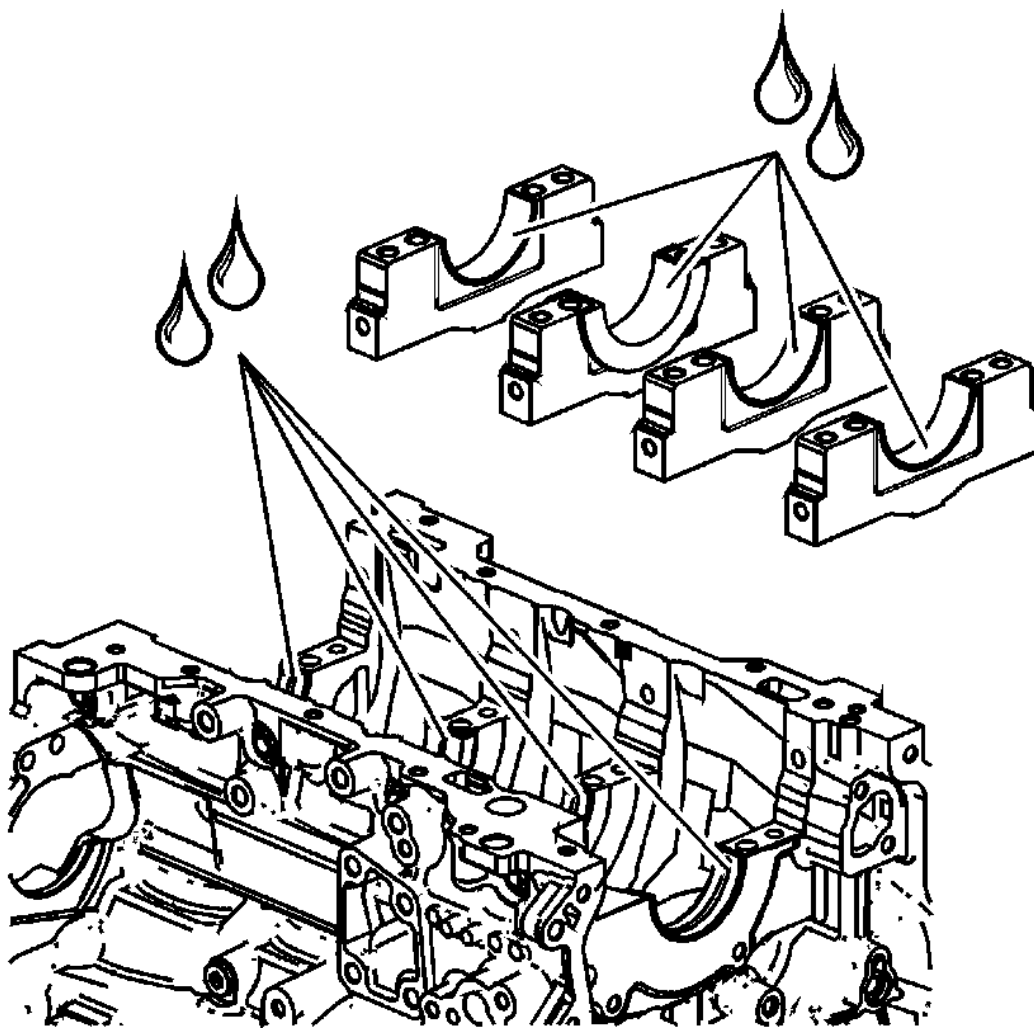
21. Compare your measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** . If the new bearings DO NOT provide the proper crankshaft to bearing clearance, inspect the following:
  1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
  2. Re-measure the cylinder block crankshaft bearing bore diameter to ensure proper size. The cylinder block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.
22. Clean the plastic gauging material from the crankshaft bearing journals with a soft, lint-free cloth.





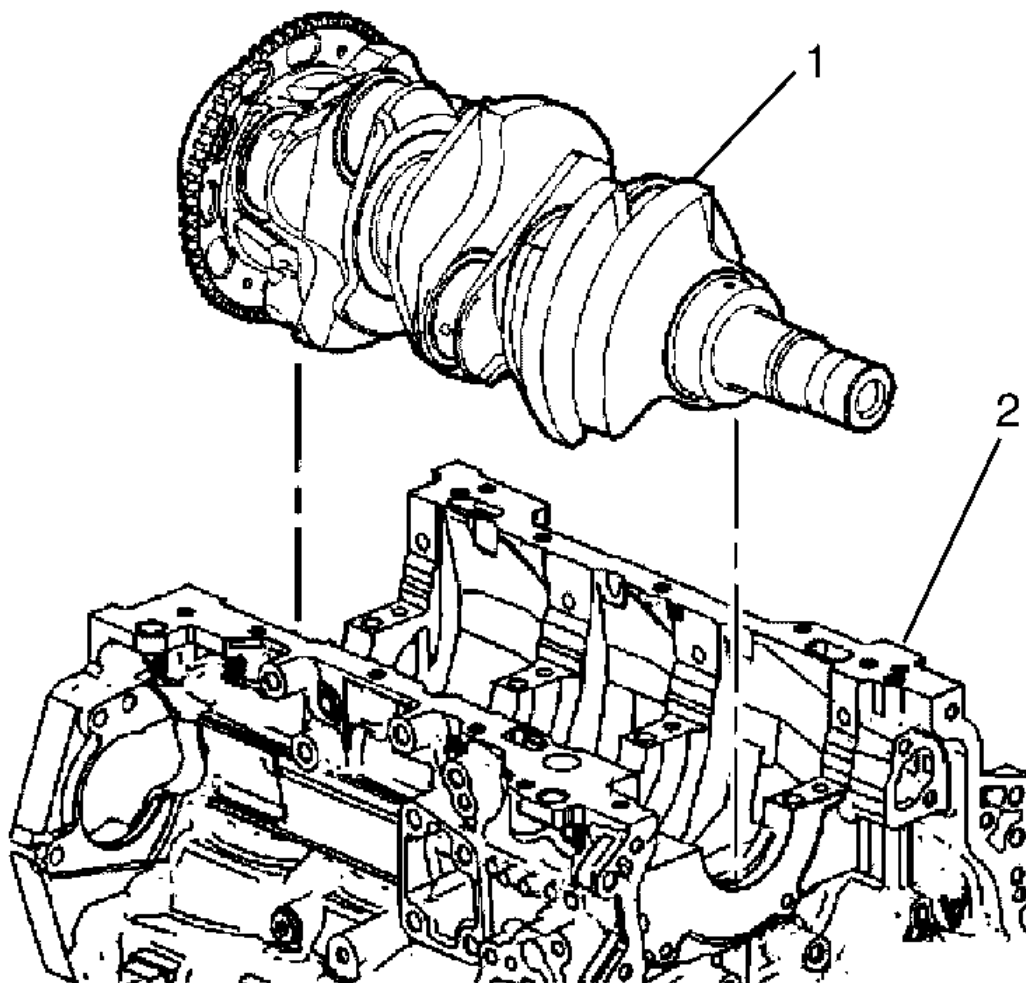
**Fig. 357: View Of Crankshaft & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

23. Lift the crankshaft (1) out of the cylinder block (2).



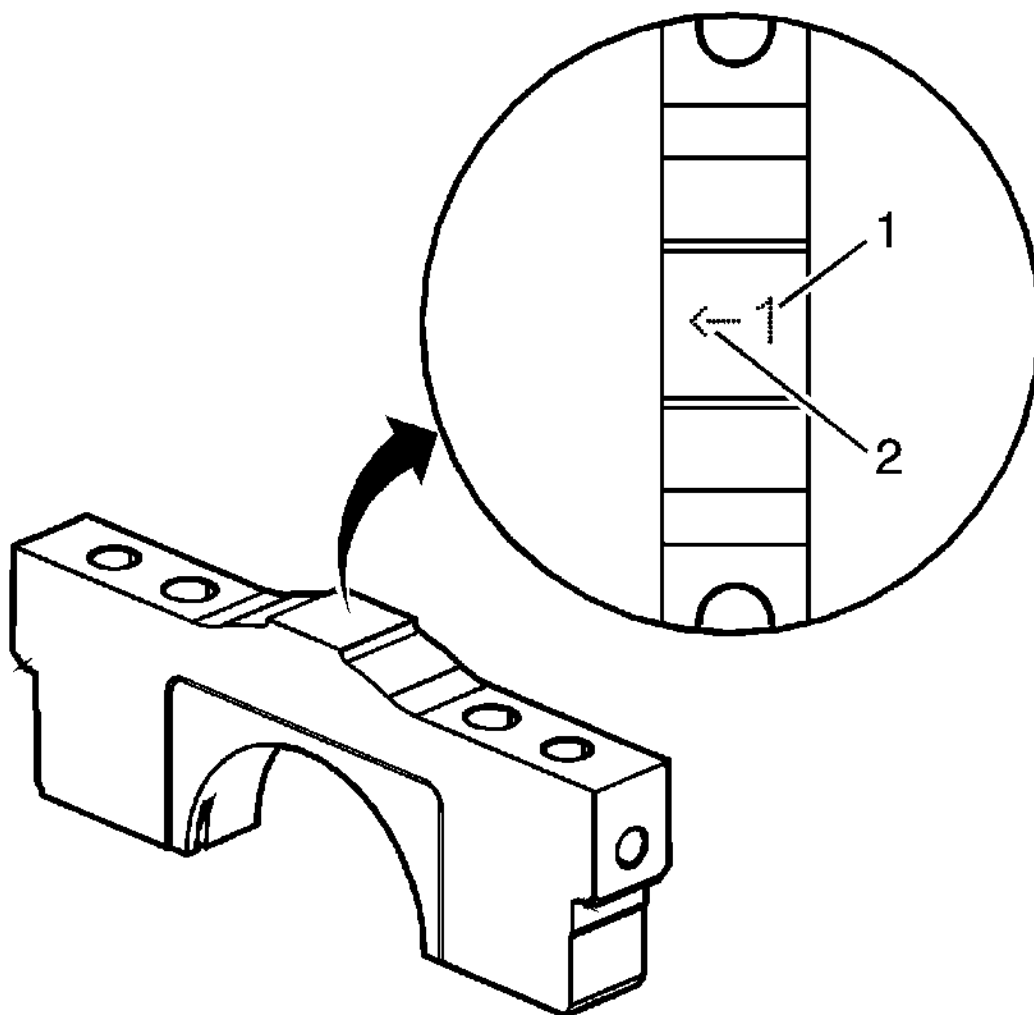
**Fig. 358: View Of Upper & Lower Bearing Surfaces**  
Courtesy of GENERAL MOTORS CORP.

24. Apply a liberal amount of clean engine oil to the upper and lower bearing surfaces.



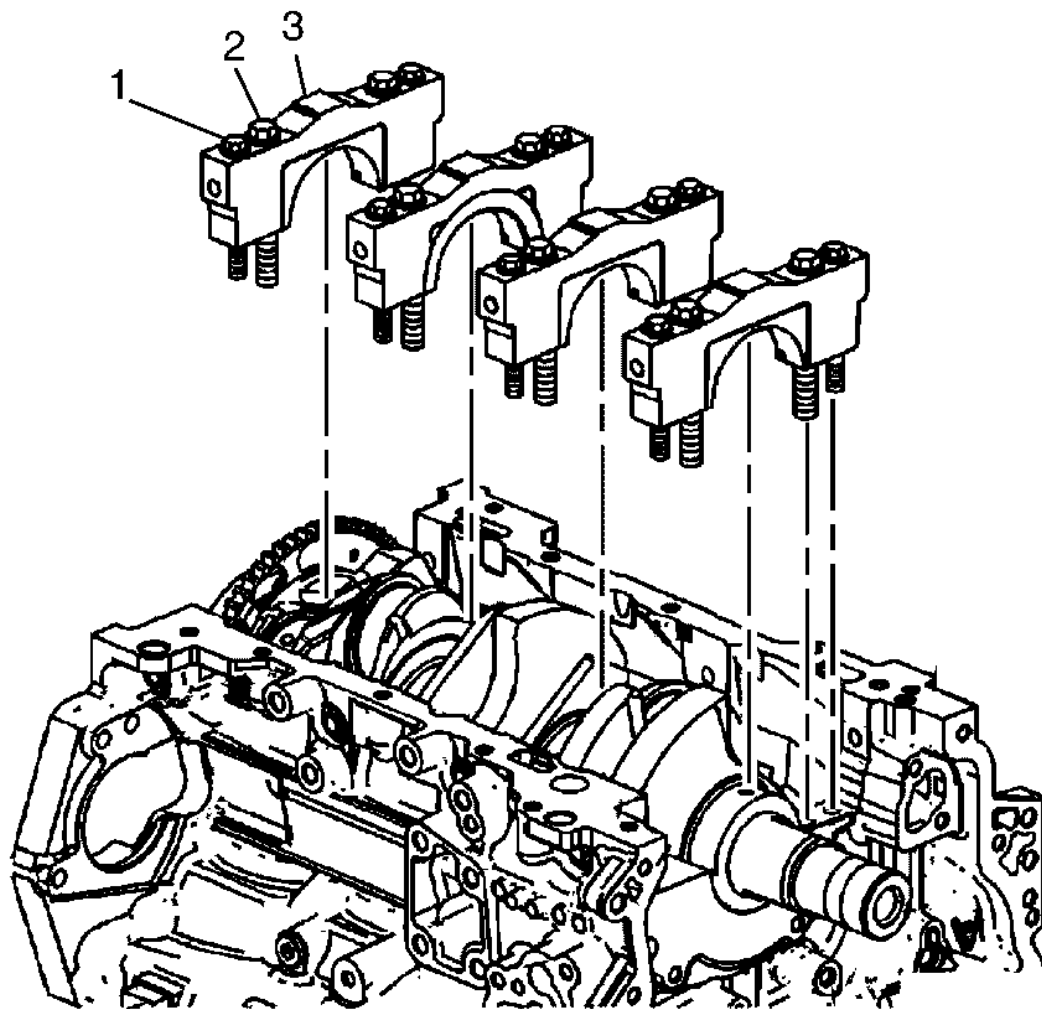
**Fig. 359: View Of Crankshaft & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

25. Gently lower the crankshaft (1) into position in the cylinder block (2).



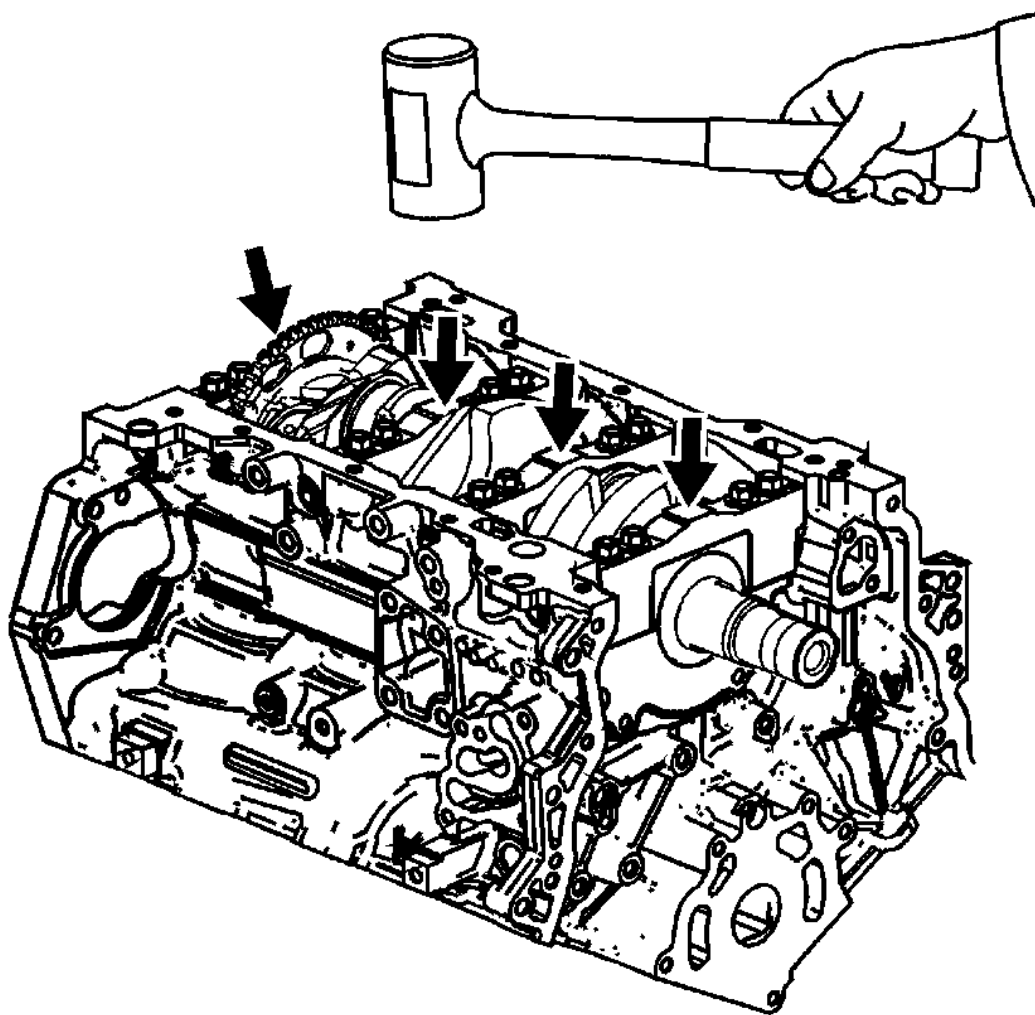
**Fig. 360: Locating Crankshaft Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

26. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.



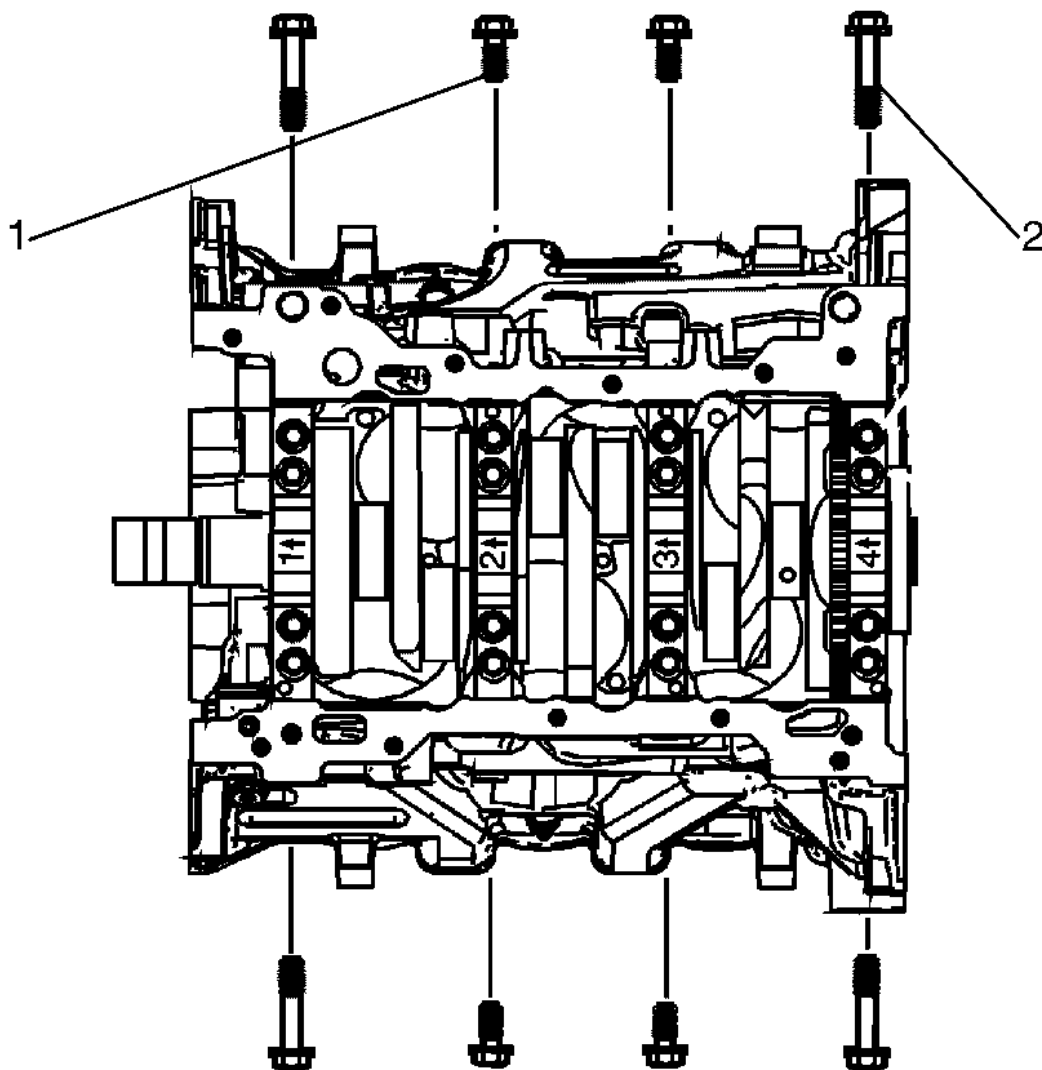
**Fig. 361: Identifying Inner/Outer Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

27. Install the crankshaft bearing caps (3).
28. Loosely install the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
29. Loosely install the NEW outer crankshaft bearing cap to cylinder block retaining bolts (2).



**Fig. 362: View Of Crankshaft Bearing Cap Tapping Sequence**  
Courtesy of GENERAL MOTORS CORP.

30. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.

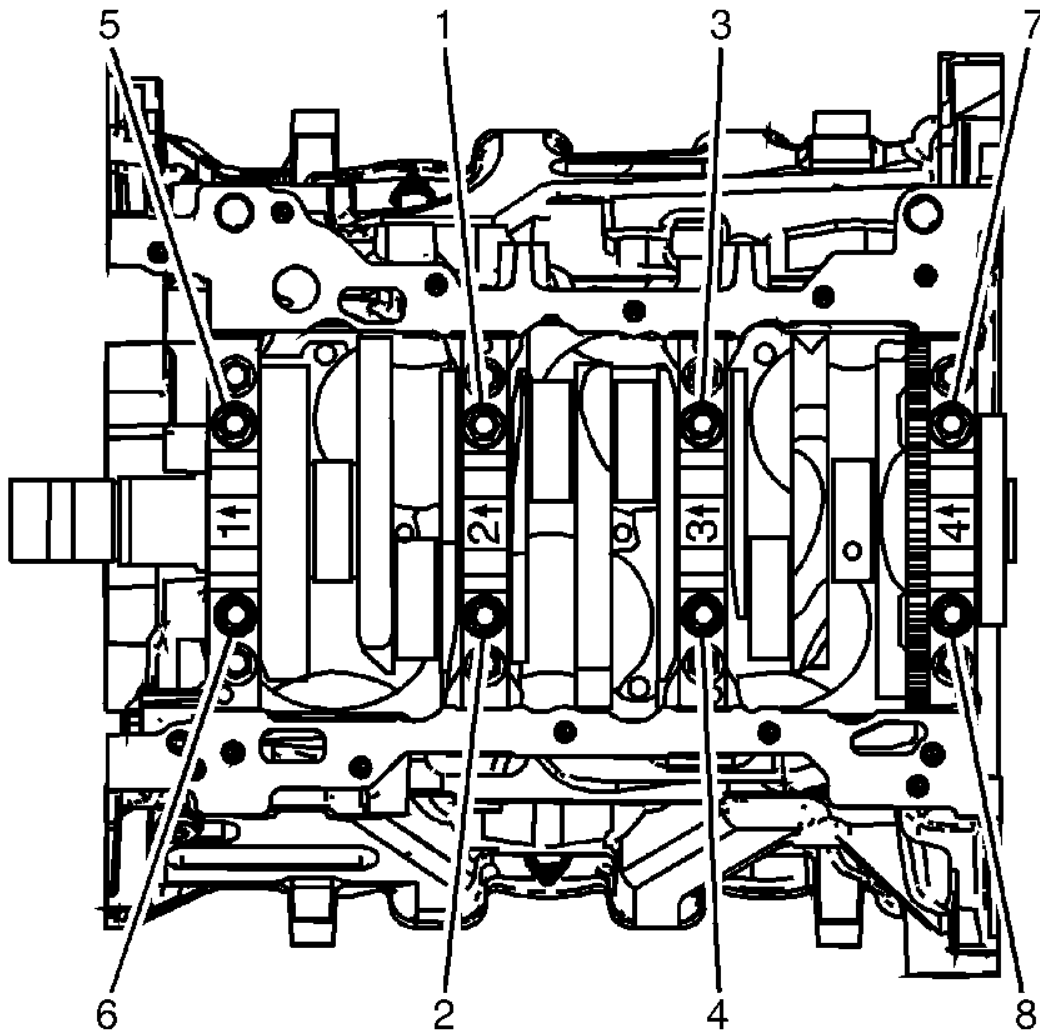


**Fig. 363: Identifying Short/Inner & Long/Outer Side Crankshaft Bearing Cap To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

**NOTE:** The side main cap bolts originally have a sealant on the flange of the bolt head. **NEW** bolts must be used. If **NEW** bolts are not used, oil can leak from the crankcase past the bolts.

31. Loosely install the NEW short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
32. Loosely install the NEW long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).
33. Tighten the crankshaft bearing cap to cylinder block retaining bolts using the **J 45059**: meter in the following sequence:

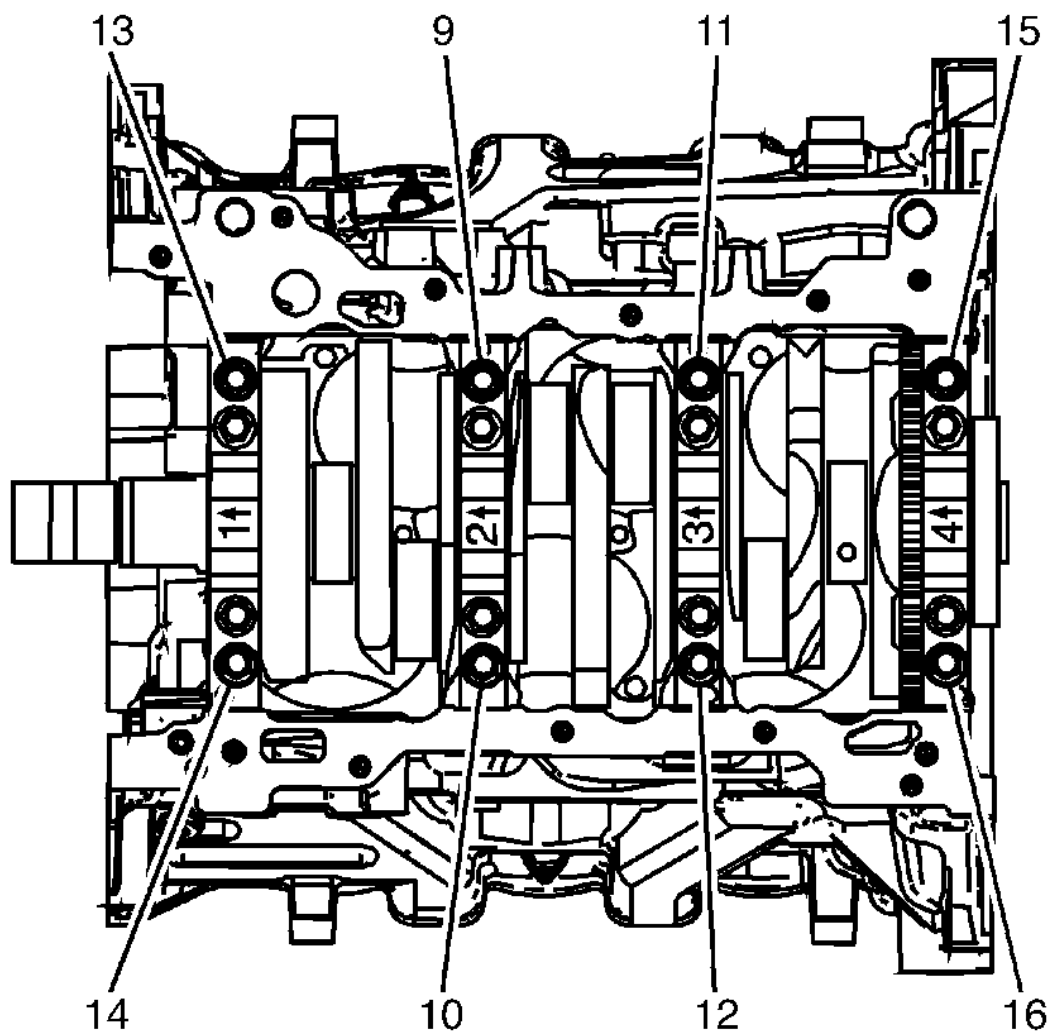


**Fig. 364: Identifying Inboard Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1-8) and tighten to 20 N.m (15 lb ft) plus 80 degrees.

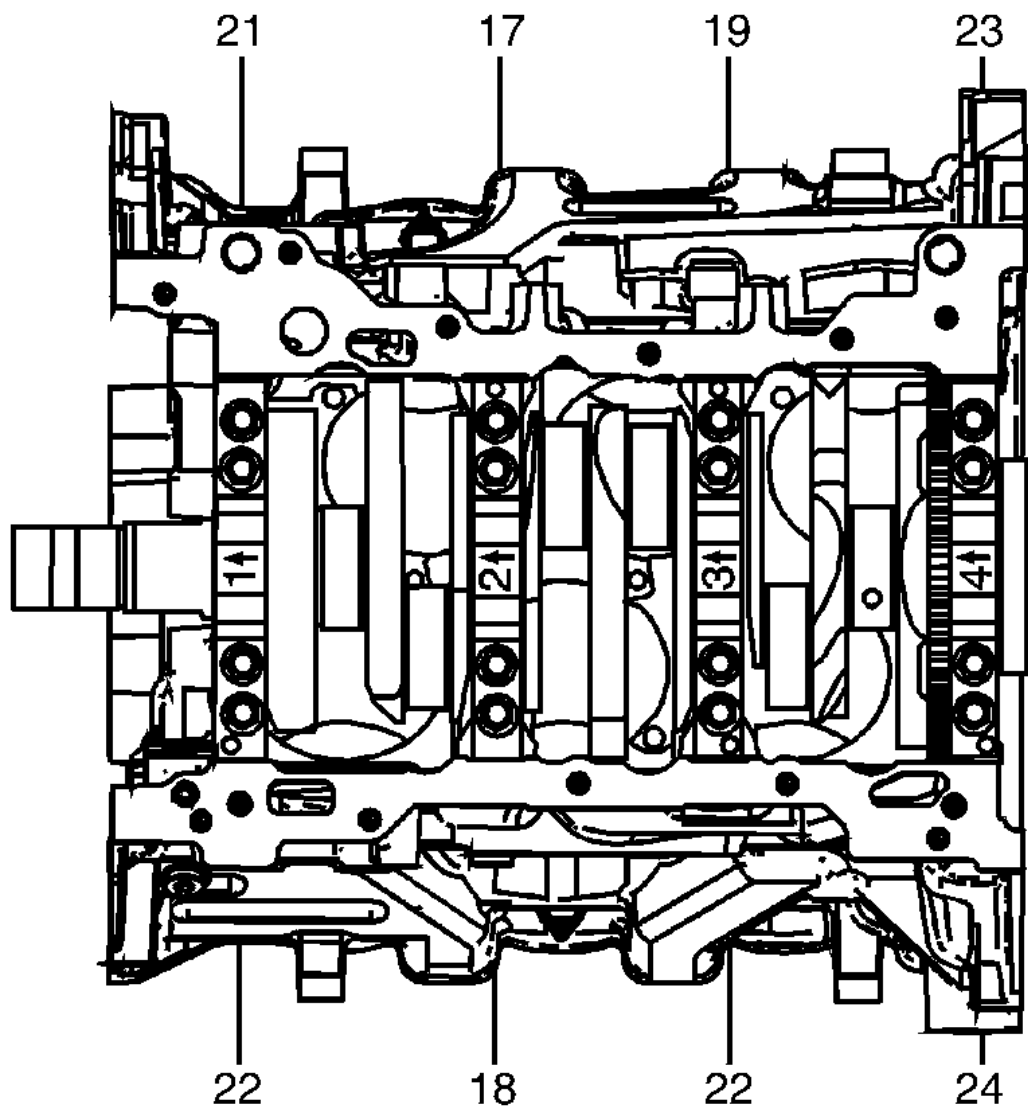




**Fig. 365: Identifying Outboard Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

34. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9-16) and tighten to 15 N.m (11 lb ft) plus 110 degrees.



**Fig. 366: View Of Short/Inner & Long/Outer Crankshaft Bearing Cap To Cylinder Block Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

35. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17-20) and tighten to 30 N.m (22 lb ft) plus 60 degrees.
36. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21-24) and tighten to 30 N.m (22 lb ft) plus 60 degrees.
37. Make sure that the crankshaft turns without binding or noise.

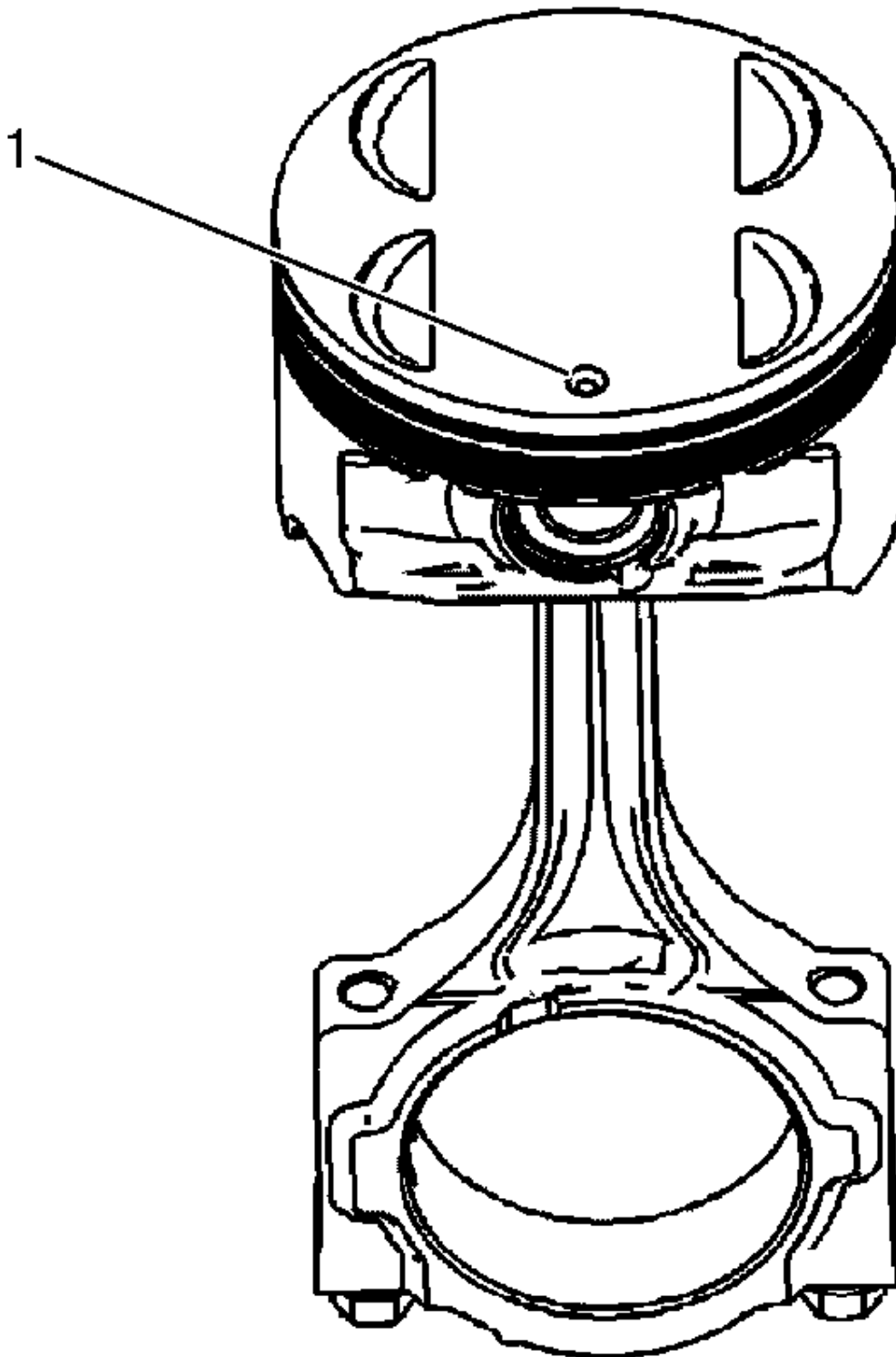
#### **PISTON, CONNECTING ROD, AND BEARING INSTALLATION**

**Special Tools**

- **EN 46111:** Crankshaft Rotation Socket
- **EN 46121:** Connecting Rod Guide Pin Set
- **J 45059:** Angle Meter

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

**Piston and Connecting Rod Assembly Procedure**

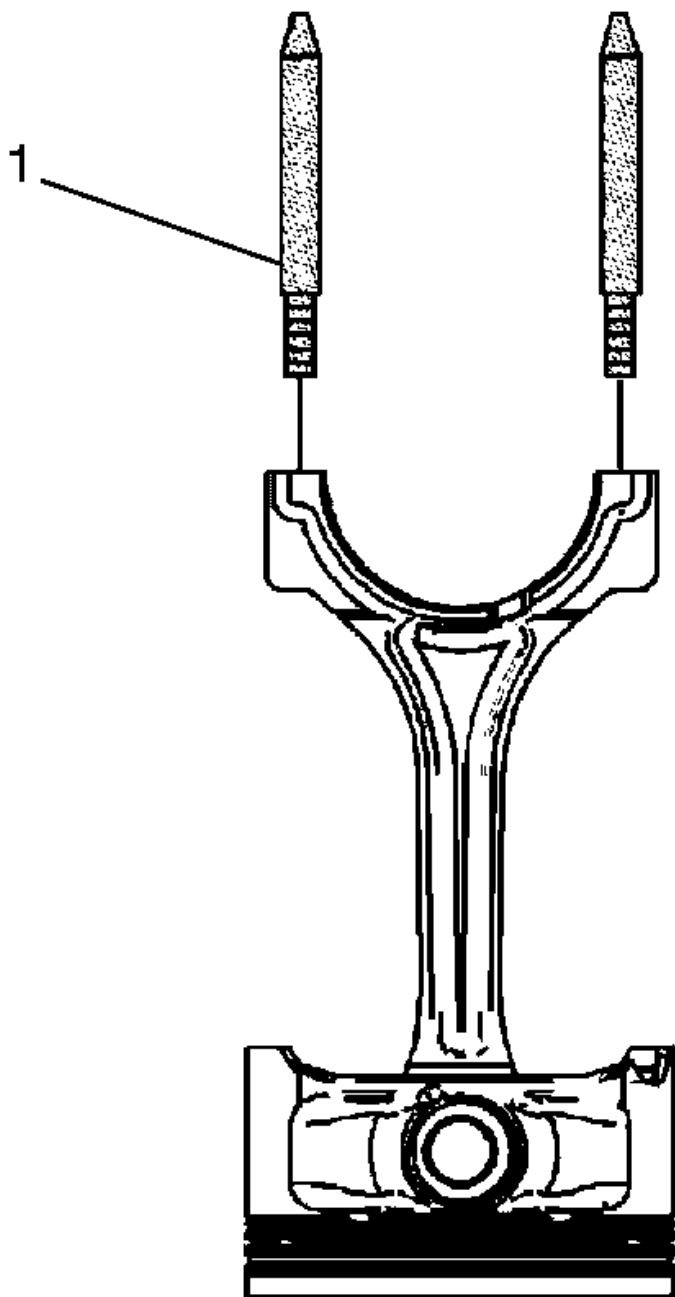


**Fig. 367: Locating Showing Proper Piston Orientation Dot**  
**Courtesy of GENERAL MOTORS CORP.**

1. Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

**NOTE:**        **The piston is directional and must be installed in the cylinder block in the correct direction.**

2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston.

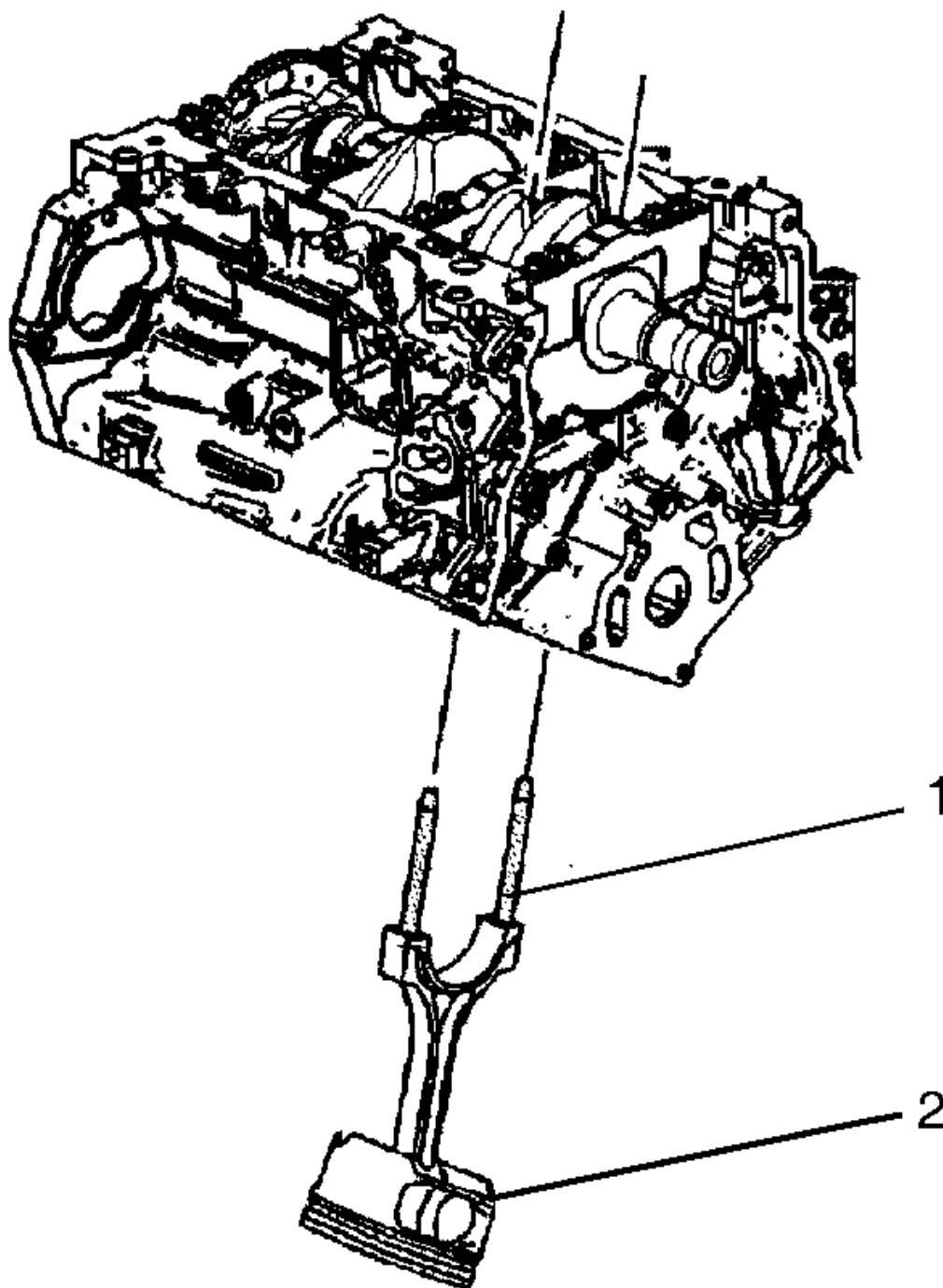


**Fig. 368: Guide Pin Set**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** If the connecting rod bearings have been used in a running engine, you

**must replace them with NEW connecting rod bearings for reassembly.**

3. Install the connecting rod bearing into the connecting rod.
4. Install the **EN 46121:** guide pin set (1) into the connecting rod bolt holes.
5. Compress the piston rings using a commercially available ring compressor.

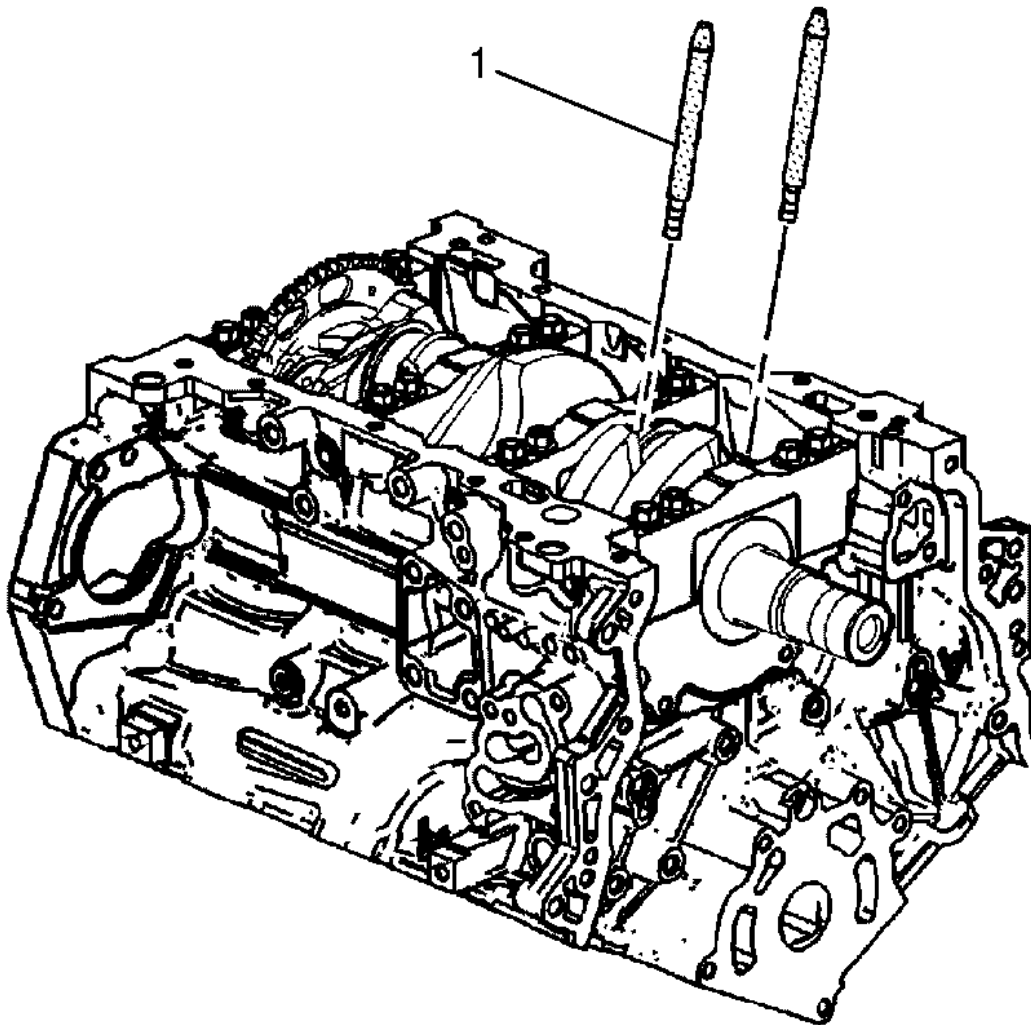


**Fig. 369: View Of EN 46121 & Piston**  
**Courtesy of GENERAL MOTORS CORP.**



**NOTE:** Extreme care must be used when installing the piston (2) and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets, or the crankshaft surfaces.

6. Using both hands, slowly guide the piston (2) and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.
7. When the ring compressor contacts the deck surface, gently tap the piston (2) into the cylinder using the handle end of a dead-blow hammer. Guide the connecting rod onto the crankshaft bearing journal using the **EN 46121**: guide pin set (1) while gently tapping the piston (2) into the cylinder with a soft-blow hammer.



**Fig. 370: View Of EN 46121**  
Courtesy of GENERAL MOTORS CORP.

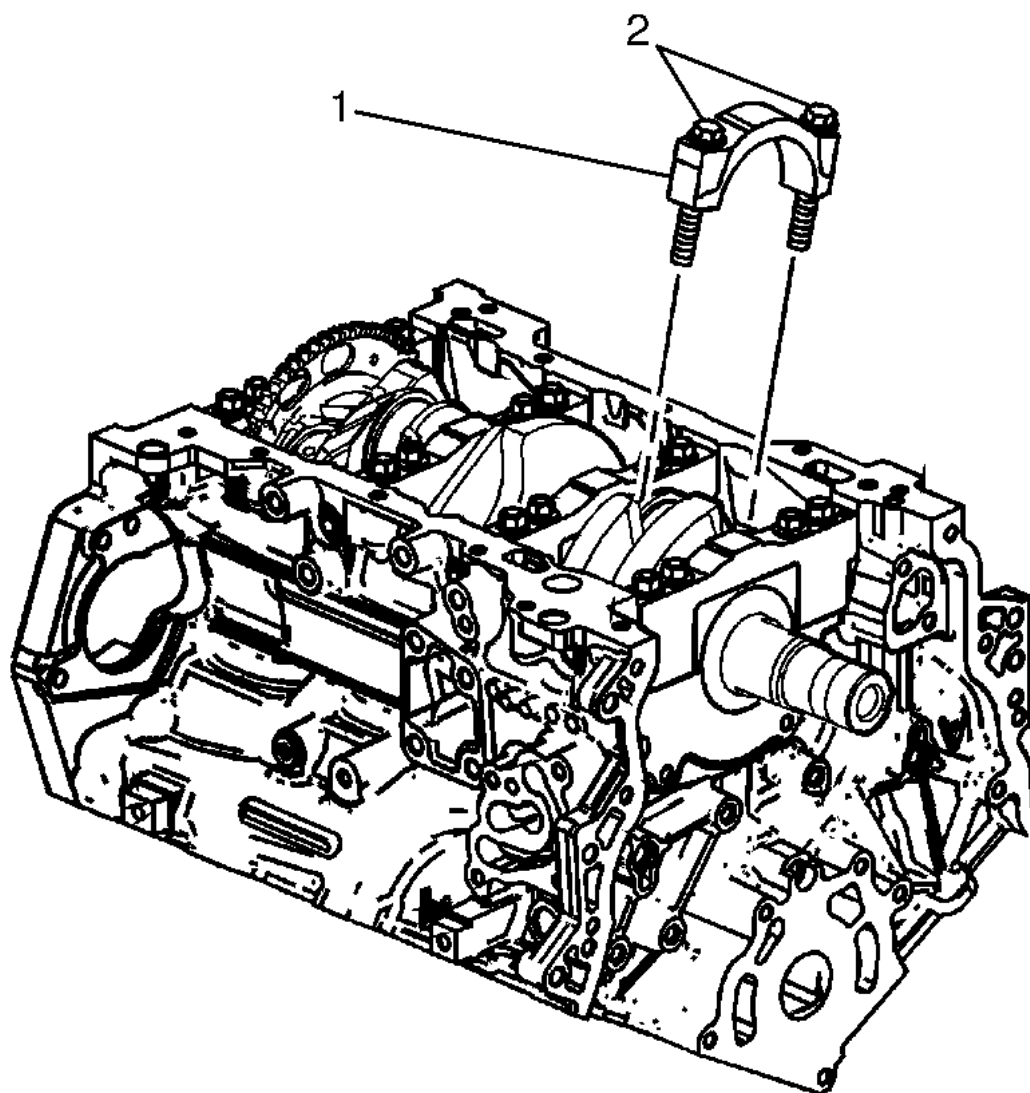
8. Remove the **EN 46121**: guide pin set (1) from the connecting rod bolt holes.

**Connecting Rod Bearing Clearance Measurement Procedure - Using Plastic Gaging**

**NOTE:**        **Connecting rod bearings that have been run in an engine should NEVER be reused.**

**NOTE:**        **Prior to final assembly it is the clearance of the new connecting rod bearings must be checked.**

1. Place a length of fresh, room temperature plastic gauging material all the way across the connecting rod bearing journal.
2. Install the connecting rod bearing into the connecting rod cap.



**Fig. 371: Identifying Connecting Rod End Cap & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.

3. Install the connecting rod end cap (1) on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the connecting rod.

**CAUTION:** Refer to Fastener Caution .

**CAUTION:** Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

**NOTE:** Reuse the old connecting rod bolts (2) ONLY for measuring the connecting rod bearing clearance.

4. Install the connecting rod bolts (2) into the connecting rod cap (1) and tighten bolts to 30 N.m (22 lb ft).
5. Loosen the connecting rod bolts (2) until the torque reading is zero.
6. Re-tighten the connecting rod bolts (2).

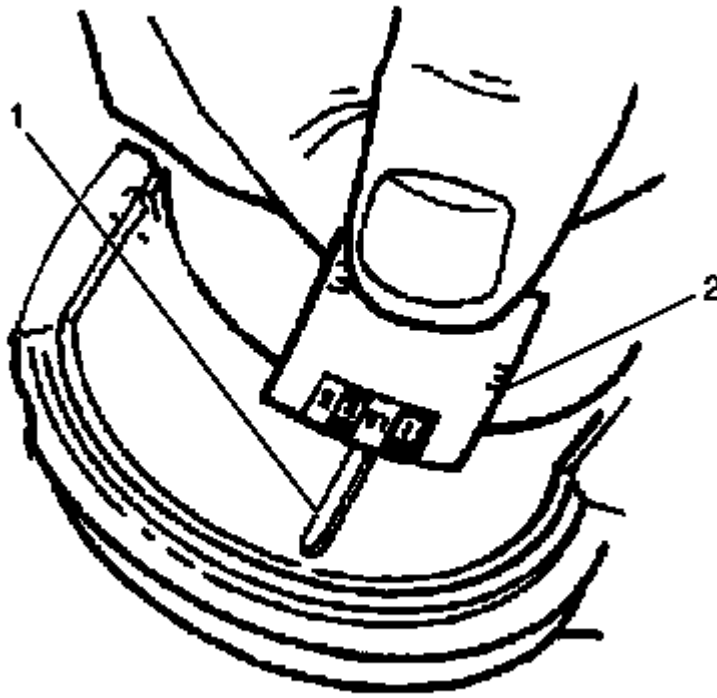
1. First Pass

Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **J 45059:** meter.

7. Allow the assembly to sit for at least 2 minutes.
8. Remove the connecting rod cap bolts (2).
9. Remove the connecting rod cap (1).



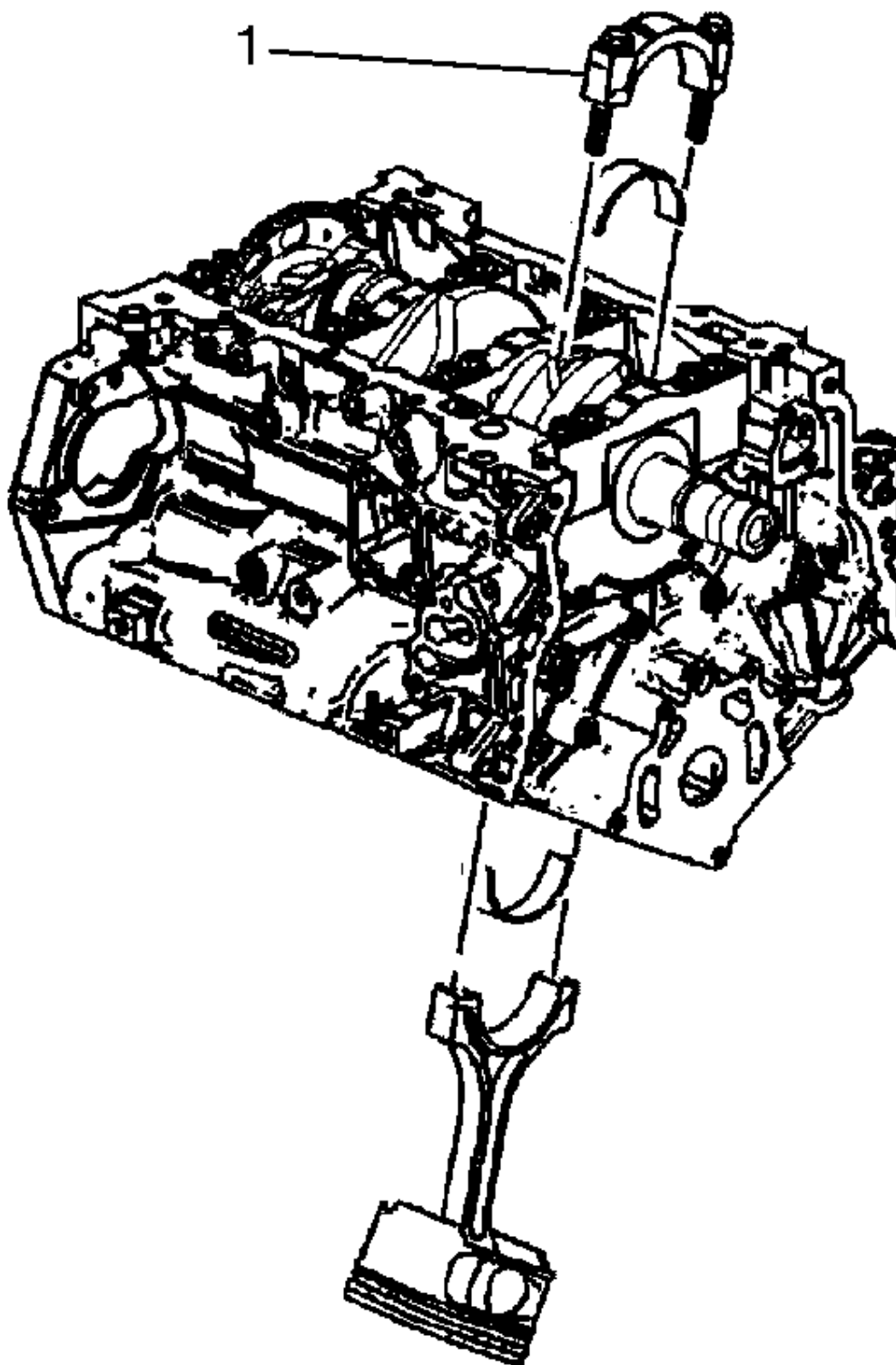
**Fig. 372: View Of Crankshaft Bearing Clearance**  
Courtesy of GENERAL MOTORS CORP.

10. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).
11. Compare your measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** . If the new bearings DO NOT provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
  1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
  2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.
12. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

#### Connecting Rod Final Assembly Procedure

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of clean engine oil to the crankshaft connecting rod bearing journal.
3. Guide the connecting rod to the crankshaft connecting rod journal.

4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.



**Fig. 373: Identifying Connecting Rod Cap**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

**NOTE:** DO NOT reuse the old connecting rod bolts.

5. Install the NEW connecting rod bolts into the connecting rod cap (1) and tighten the NEW bolts to 30 N.m (22 lb ft).
6. Loosen the connecting rod bolts until the torque reading is zero.
7. Re-tighten the connecting rod bolts.

1. First Pass

Tighten the connecting rod bolts to 25 N.m (18 lb ft)..

2. Final Pass

Tighten the connecting rod bolts an additional 110 degrees using the **J 45059:** meter.

8. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the cylinder block.
9. Repeat these procedures for the remaining piston/connecting rod assemblies using the **EN 46111:** socket in order to rotate the crankshaft.

## CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

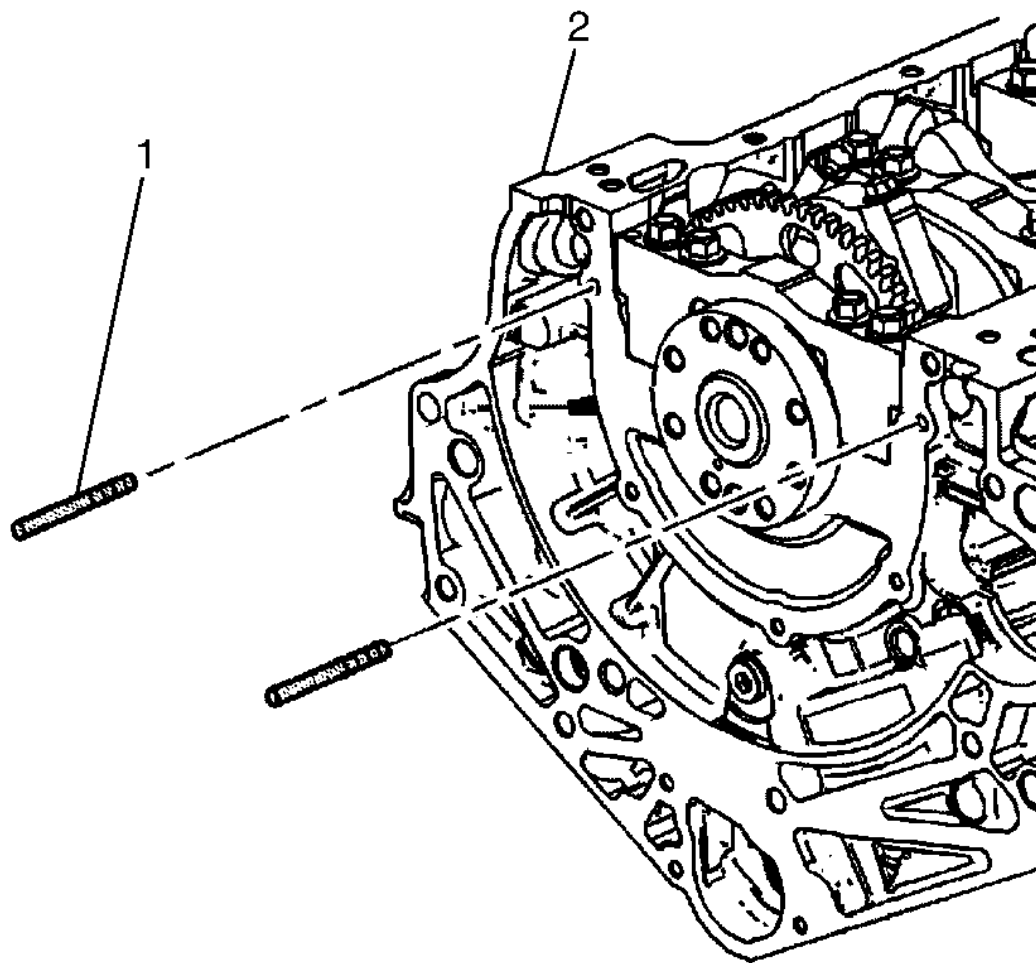
### Special Tools

- **EN 46109:** Guide Pin Set
- **EN 47839:** Crankshaft Rear Oil Seal Installation Tool
- **J 42183:** Handle

For equivalent regional tools, refer to Special Tools .

### Installation

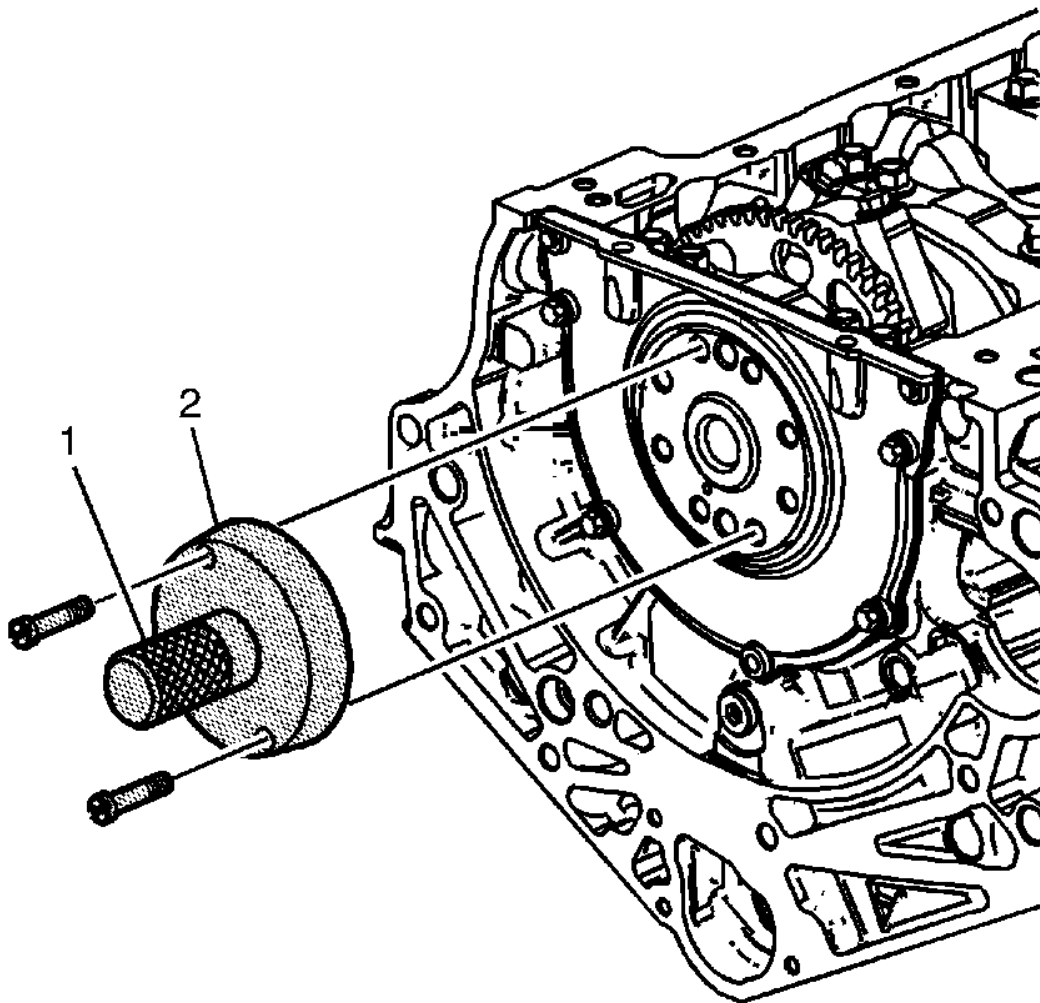




**Fig. 374: Guide Pins**

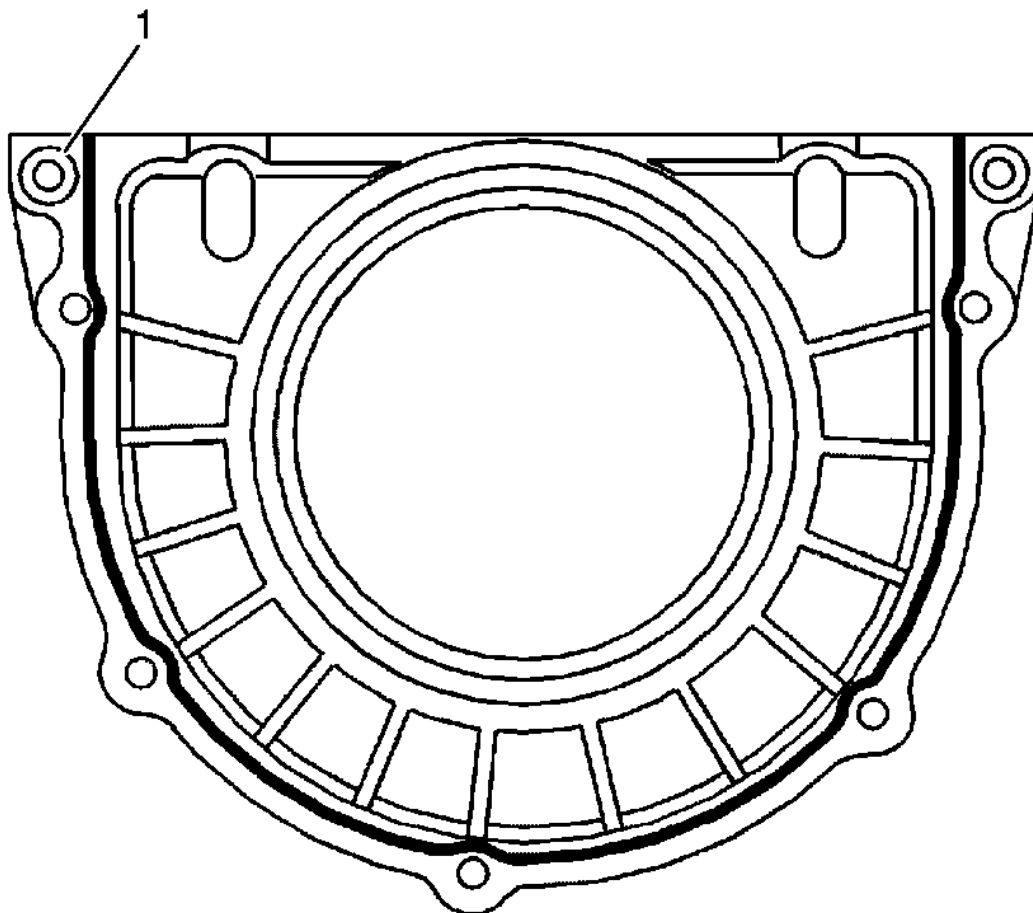
Courtesy of GENERAL MOTORS CORP.

1. Install the 6 mm (0.236 in) guides from the **EN 46109**: guide pin set (1) into the 2 crankshaft rear oil seal housing corner bolt holes of the cylinder block (2).



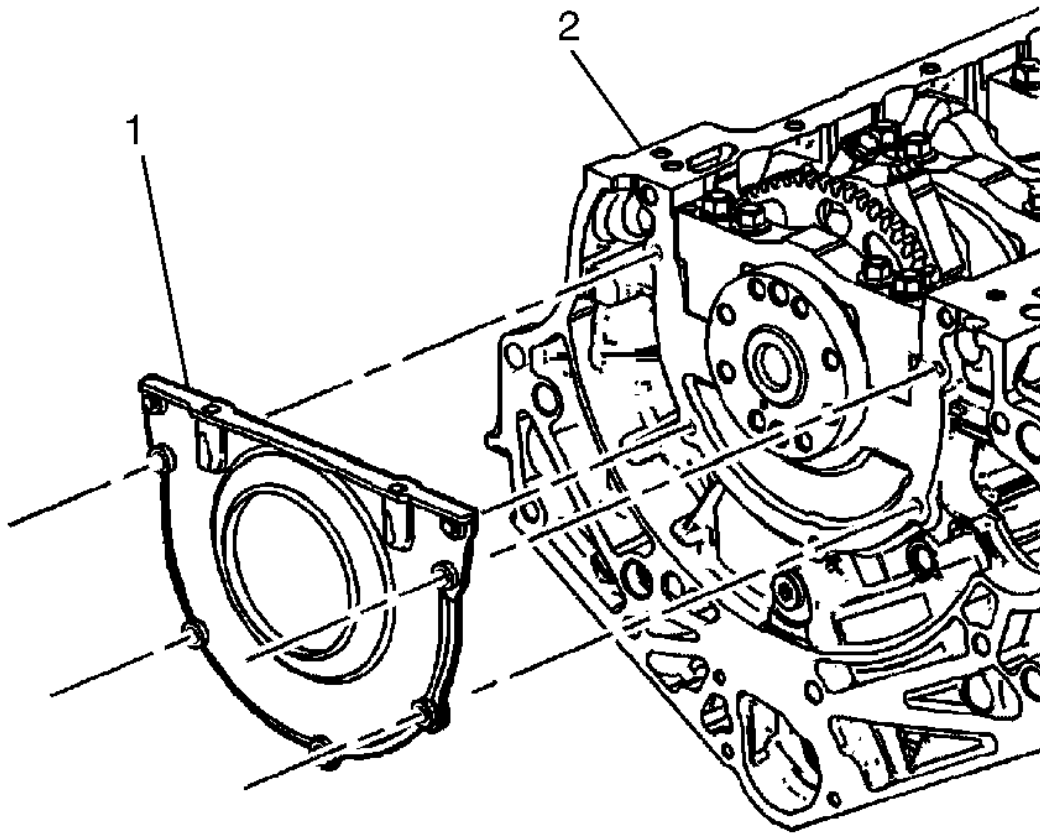
**Fig. 375: View Of J 42183 & EN-47839**  
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 42183**: handle (1) with the **EN 47839**: installation tool (2) onto the rear of the crankshaft flange.



**Fig. 376: View Of RTV Sealant Application Areas**  
Courtesy of GENERAL MOTORS CORP.

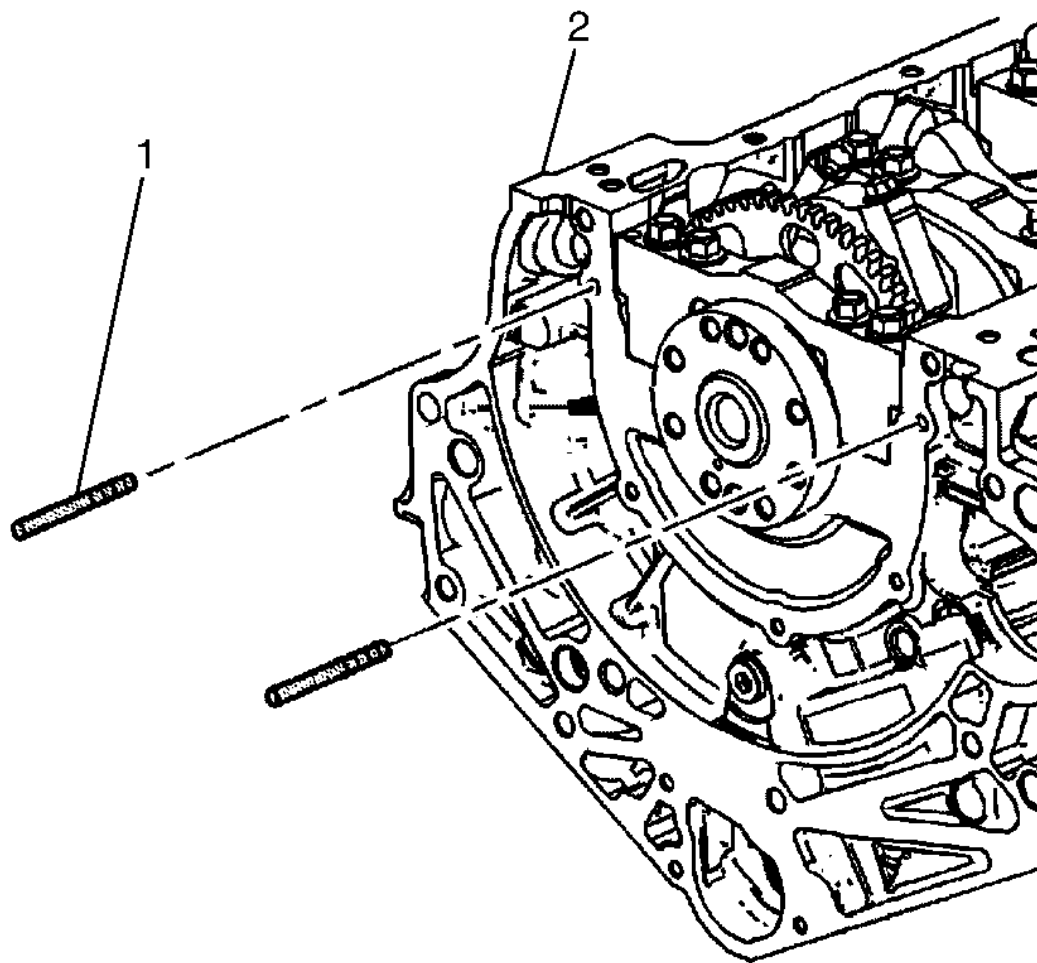
3. Place a 3 mm (0.118 in) bead of RTV sealant (1) to the NEW crankshaft rear oil seal housing as shown.



**Fig. 377: Identifying Crankshaft Rear Oil Seal Housing & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

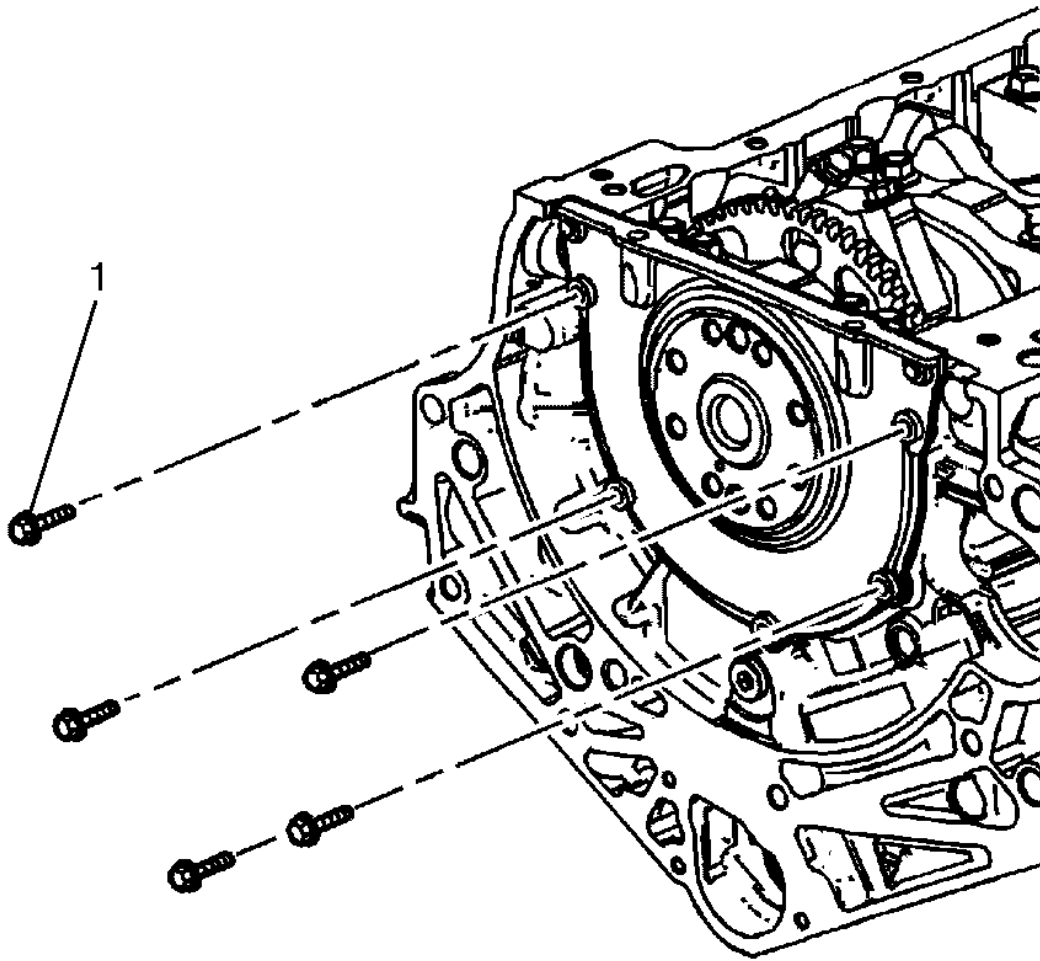
4. Install the crankshaft rear oil seal housing (1) to the cylinder block (2).



**Fig. 378: Guide Pins**

Courtesy of GENERAL MOTORS CORP.

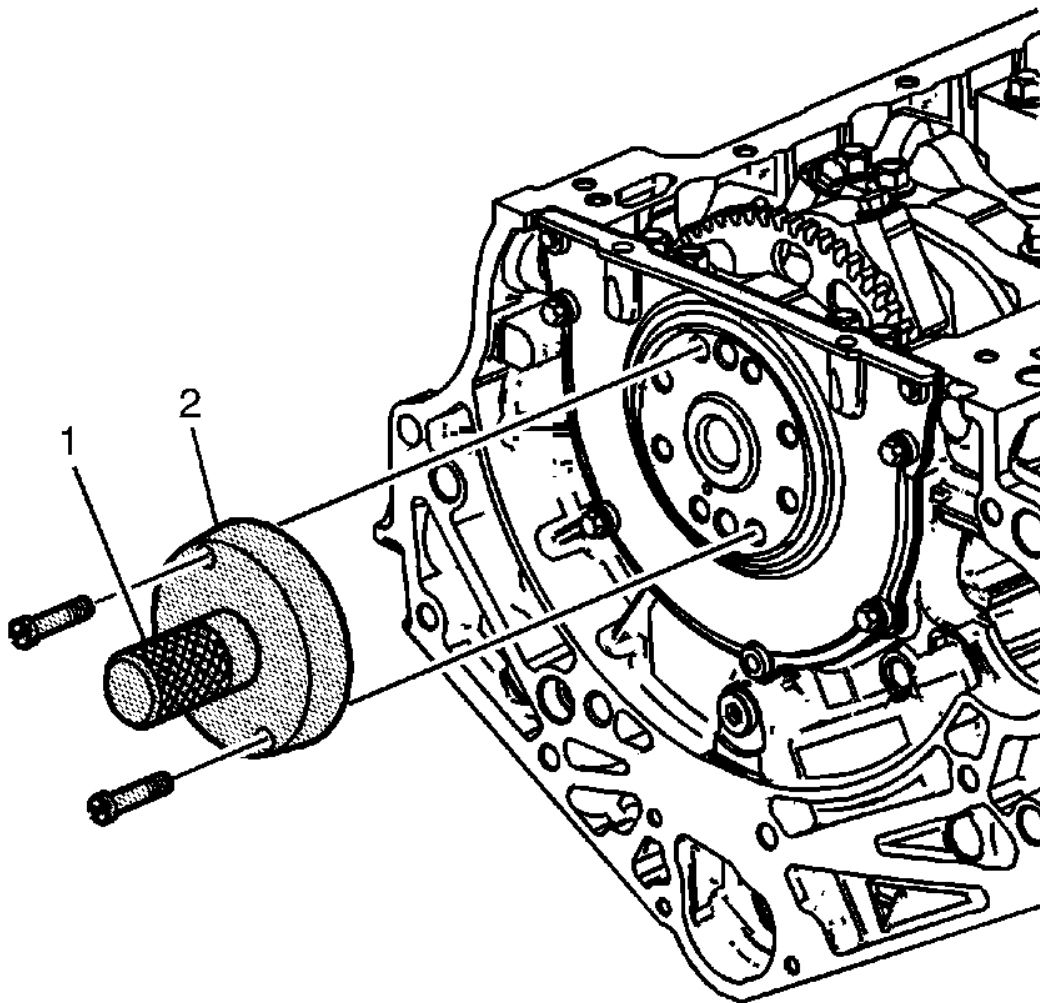
5. Remove the **EN 46109:** guide pin set mm (0.236 in) guides (1) from the cylinder block (2).



**Fig. 379: Identifying Crankshaft Rear Oil Seal Housing Bolts**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

6. Install the crankshaft rear oil seal housing to cylinder block retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 380: View Of J 42183 & EN-47839**  
Courtesy of GENERAL MOTORS CORP.

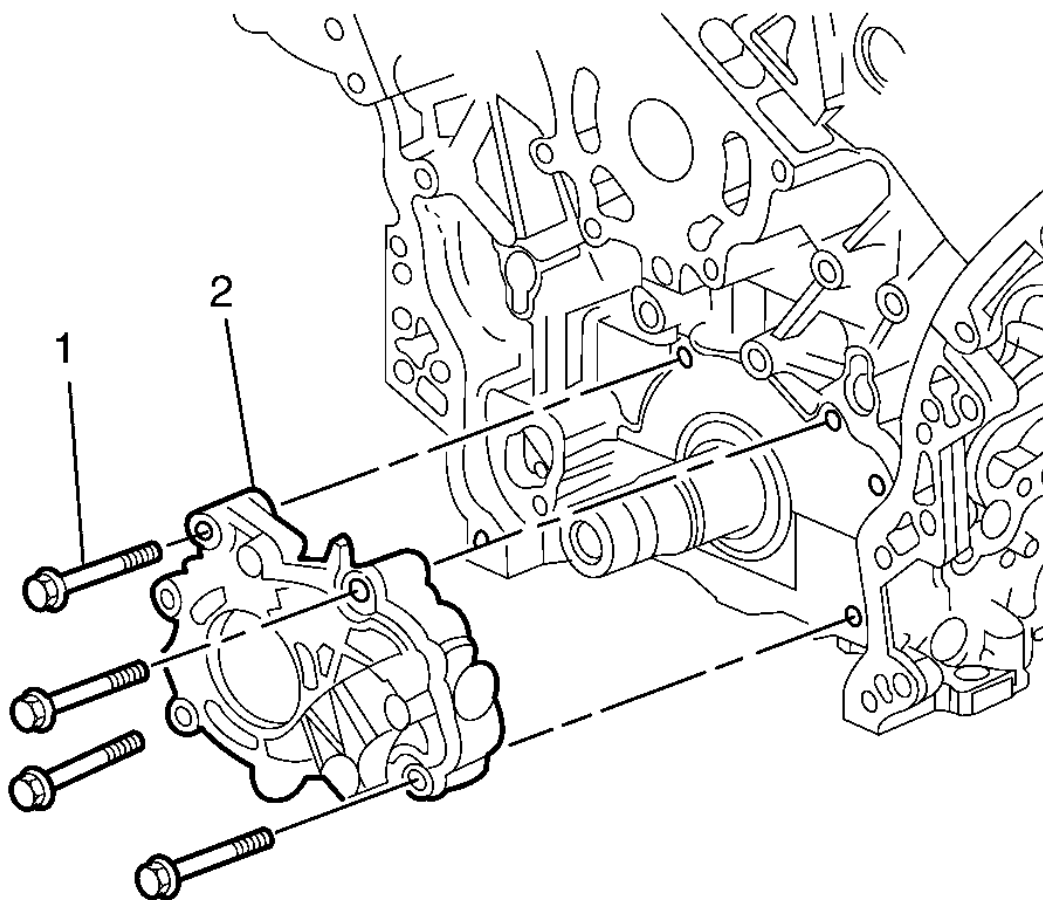
7. Remove the **J 42183**: handle (1) and **EN 47839**: installation tool (2) from the crankshaft flange.

## 2009 ENGINE

### Engine Mechanical - 3.6L

## REPAIR INSTRUCTIONS - OFF VEHICLE

### OIL PUMP INSTALLATION



**Fig. 1: Identifying Oil Pump To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Align the oil pump gerotor with the crankshaft flats and install the oil pump (2).
2. Align the oil pump (2) body mounting holes.

**CAUTION: Refer to Fastener Caution .**



3. Install the oil pump to cylinder block retaining bolts (1) and tighten to 23 N.m (17 lb ft).

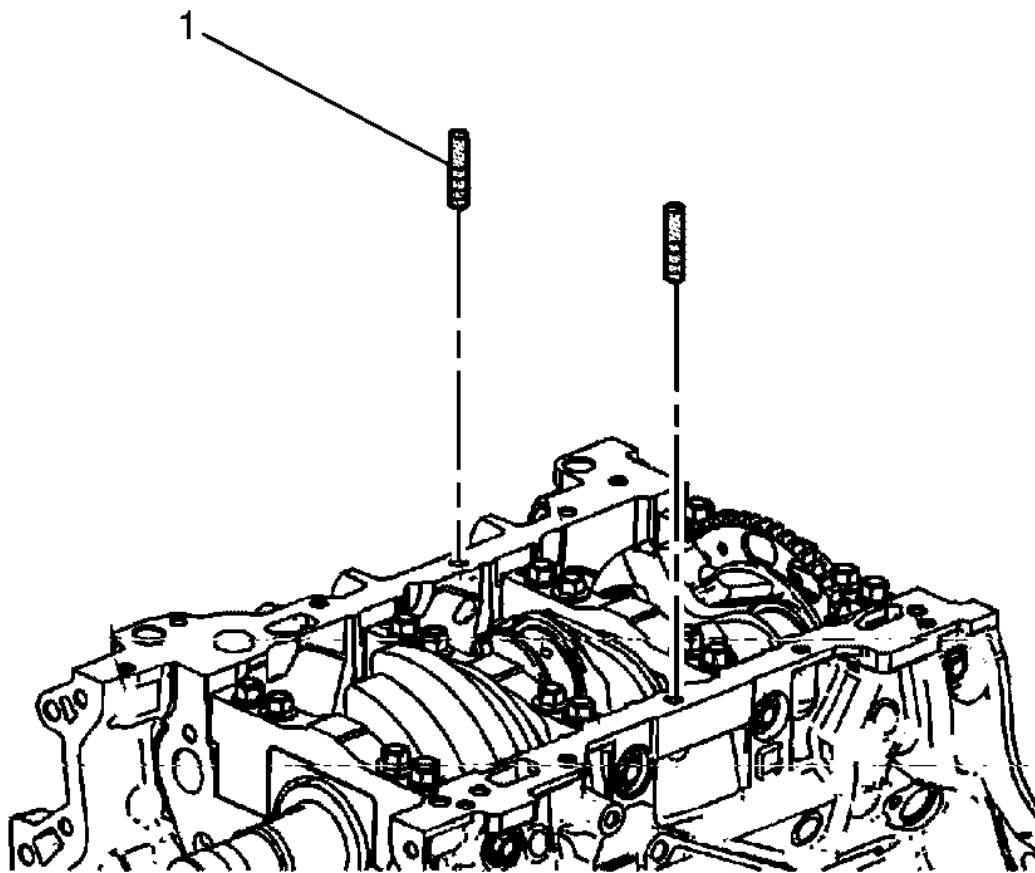
## OIL PAN INSTALLATION

### Special Tools

**EN 46109:** Guide Pin Set

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

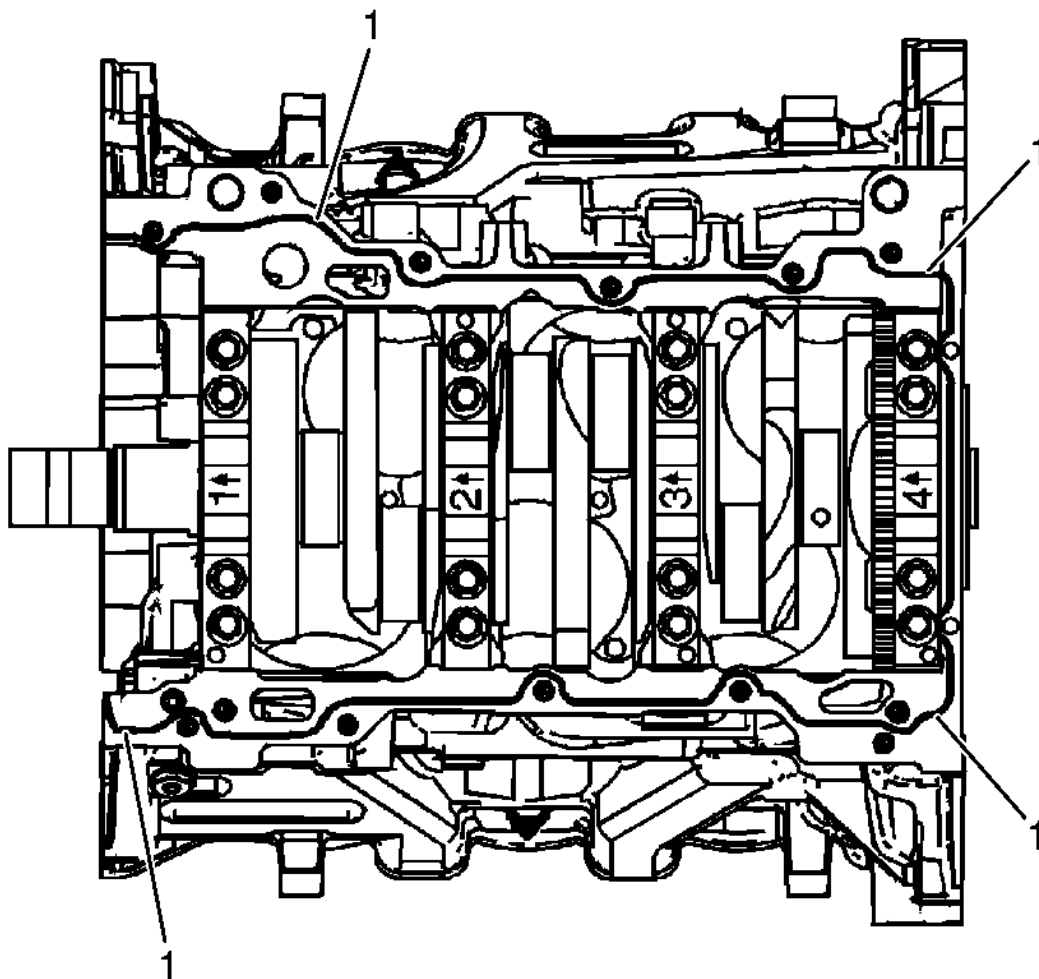
### Installation



**Fig. 2: View Of EN 46109**

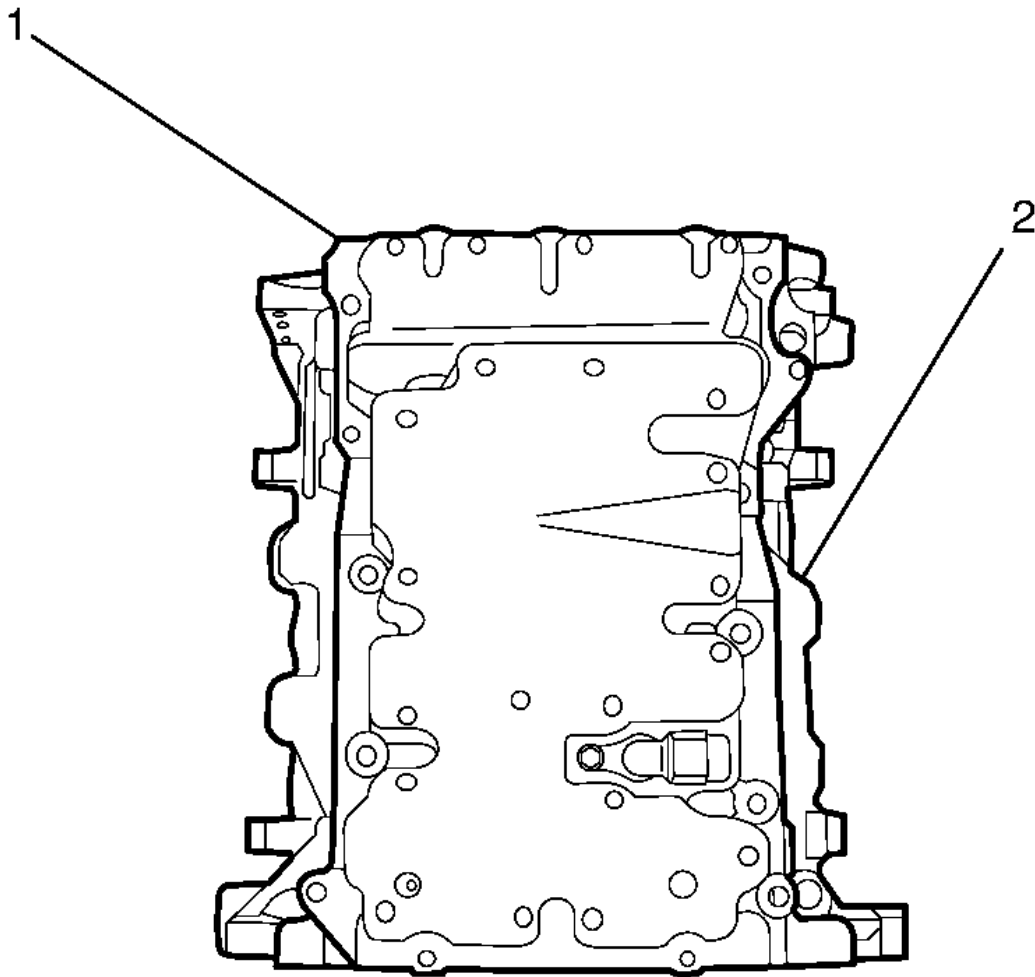
Courtesy of GENERAL MOTORS CORP.

1. Install the 8 mm (0.315 in) guides from the **EN 46109:** guide pin set (1) into the center oil pan rail bolt hole on each side of the cylinder block.



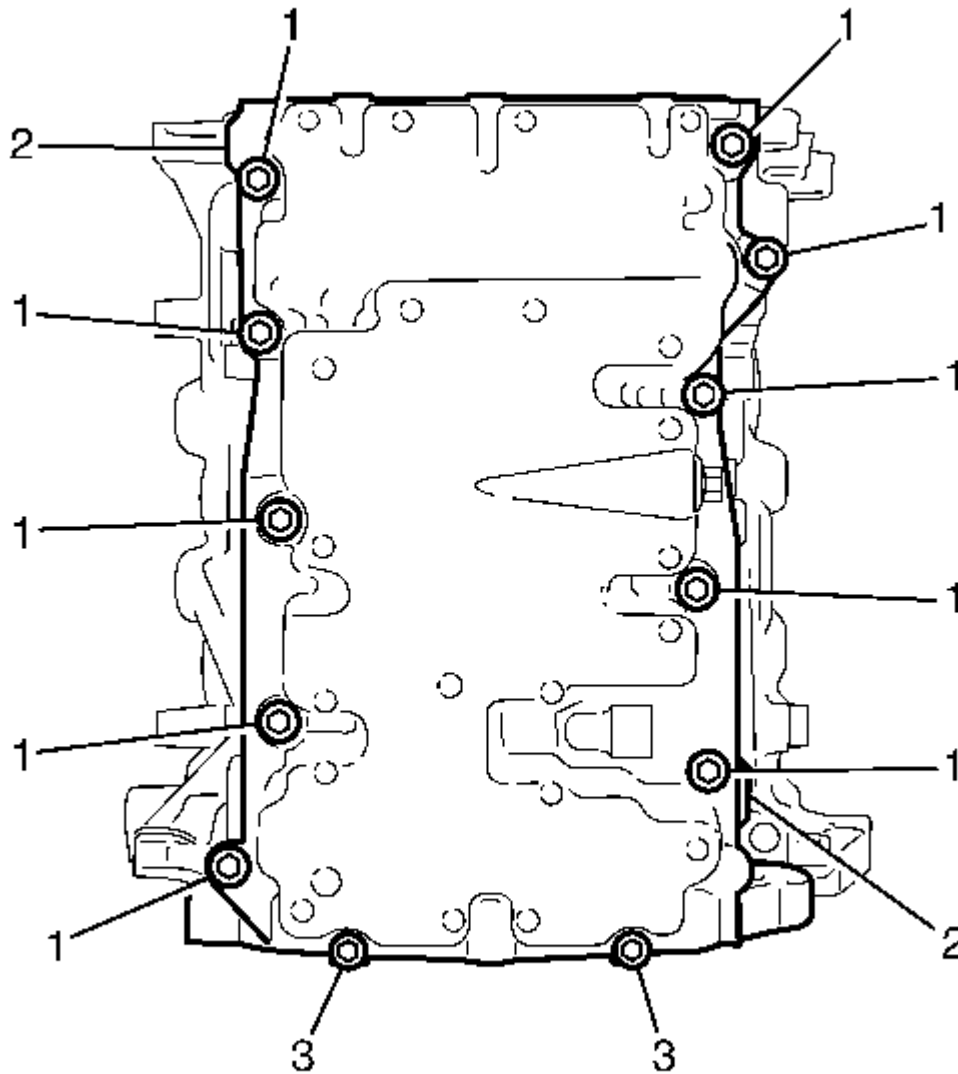
**Fig. 3: View Of RTV Sealant Application Areas**  
Courtesy of GENERAL MOTORS CORP.

2. Place a 3 mm (0.118 in) bead of RTV sealant (1) on the block pan rail and the crankshaft rear oil seal housing.



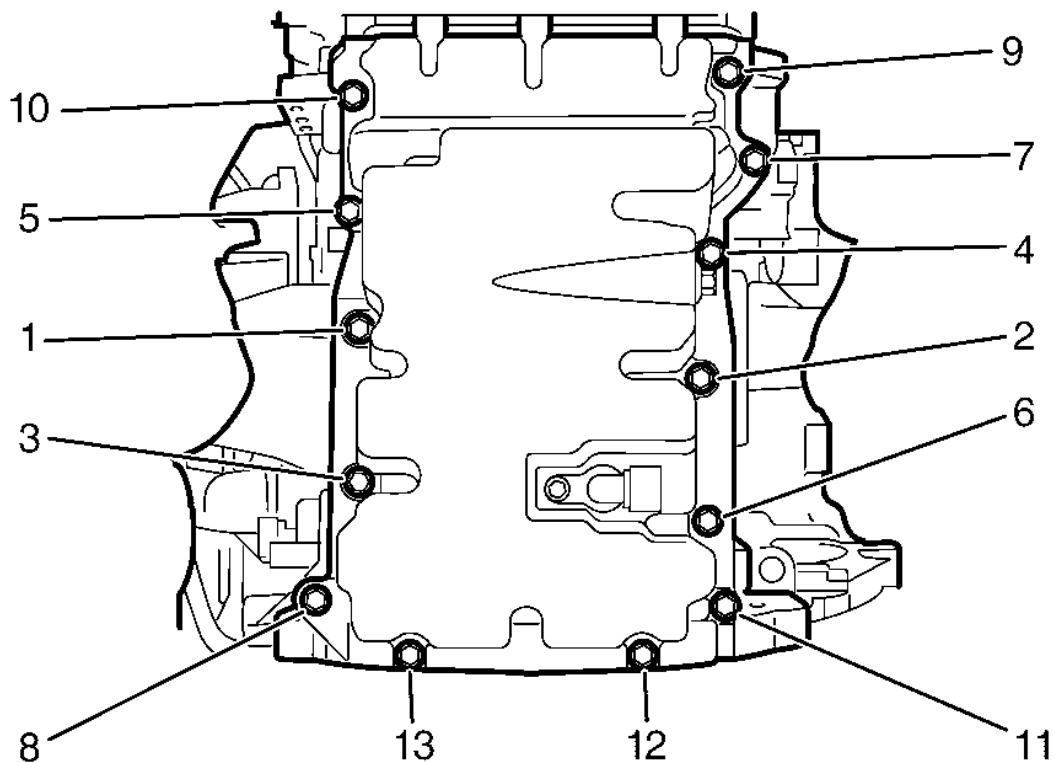
**Fig. 4: View Of Oil Pan & Cylinder Block**  
Courtesy of GENERAL MOTORS CORP.

3. Position the oil pan (1) onto the block (2).
4. Remove the **EN 46109:** guide pin set mm (0.315 in) guides from the cylinder block.



**Fig. 5: Identifying M8 & M6 Oil Pan Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

5. Loosely install the M8 oil pan to cylinder block retaining bolts (1).
6. Loosely install the M6 oil pan to crankshaft rear oil seal housing retaining bolts (3).



**Fig. 6: Identifying Cylinder Block & Crankshaft Rear Oil Seal Housing Retaining Bolt Tightening Sequence**

Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

7. Install and tighten the M8 oil pan to cylinder block retaining bolts (1-11) and the M6 oil pan to crankshaft rear oil seal housing retaining bolts (12, 13) in the sequence shown.
  - Tighten the M8 bolts (1-11) to 23 N.m (17 lb ft) .
  - Tighten the M6 bolts (12, 13) to 10 N.m (89 lb in) .

## CYLINDER HEAD INSTALLATION - RIGHT SIDE

### Special Tools

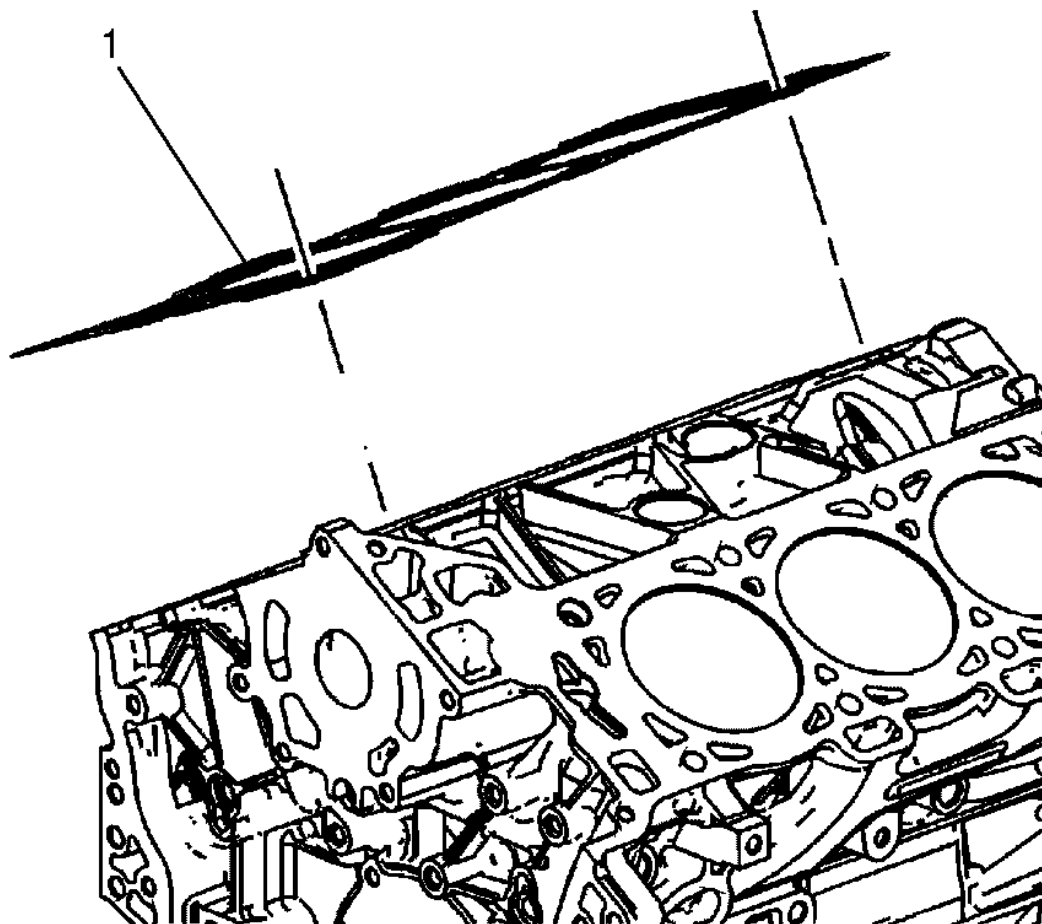
- **EN 46111:** Crankshaft Rotation Socket
- **J 45059:** Angle Meter

For equivalent regional tools, refer to Special Tools .

**Installation**

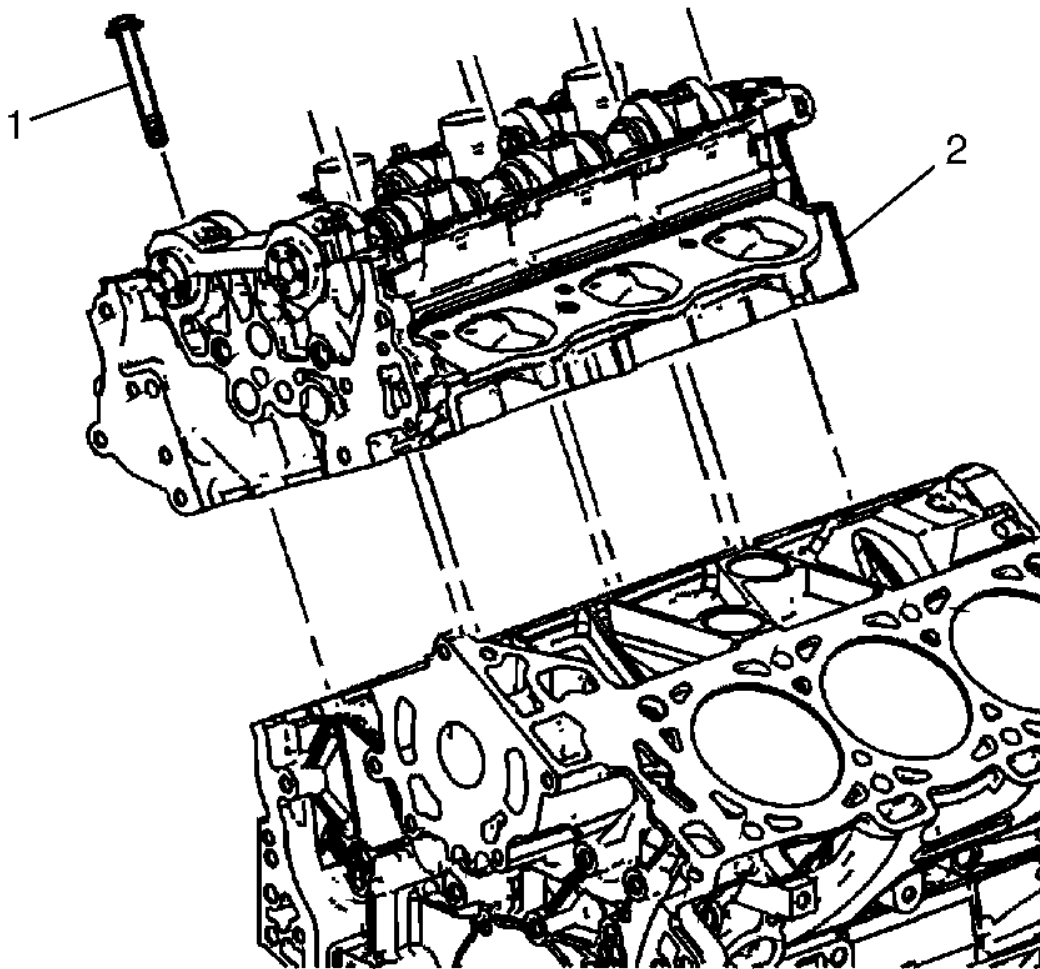
**NOTE:** Make sure that the crankshaft is in the timing drive assembly position using the EN 46111: socket.

1. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.



**Fig. 7: View Of Right Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW right cylinder head gasket (1) using the deck face locating pins for retention.



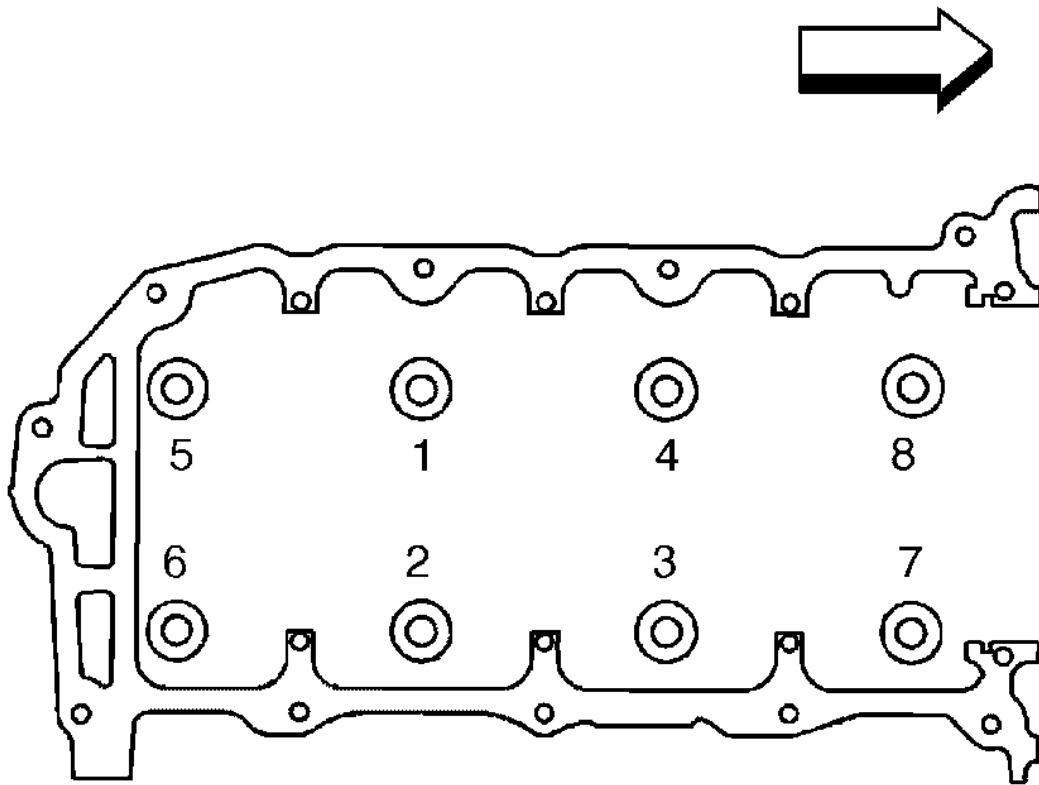
**Fig. 8: Identifying M11 & M8 Cylinder Head To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Align the right cylinder head (2) with the deck face locating pins.
4. Place the right cylinder head (2) in position on the deck face.

**NOTE:** DO NOT allow oil on the cylinder head bolt bosses.

**NOTE:** DO NOT reuse the old M11 cylinder head bolts.

5. Loosely install the NEW M11 and M8 cylinder head to cylinder block retaining bolts (1).



**Fig. 9: Identifying Cylinder Head To Cylinder Block Retaining Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

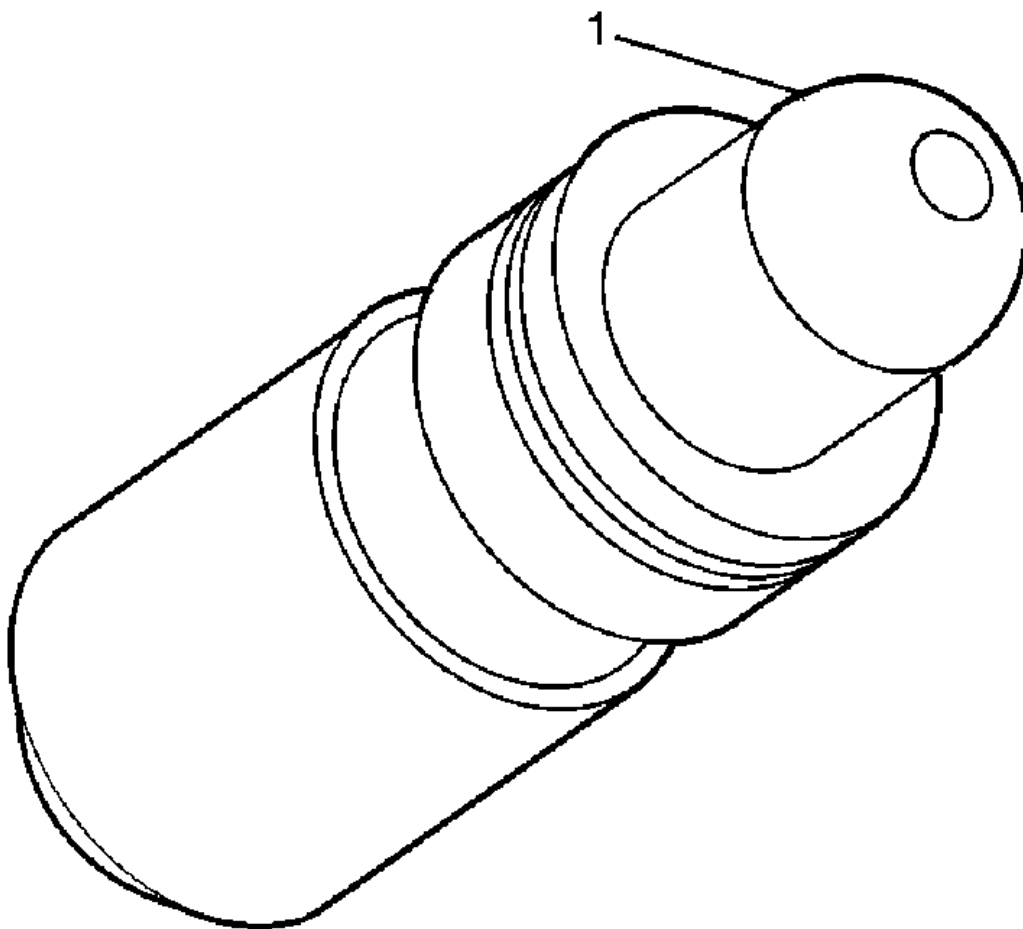
6. Tighten the cylinder head to cylinder block retaining bolts in the sequence shown.
7. Tighten the M11 cylinder head to cylinder block retaining bolts a first pass in sequence to 45 N.m (33 lb ft).
  1. Back off the M11 cylinder head to cylinder block retaining bolts 120 degrees using the **J 45059:** meter .
  2. Tighten the M11 cylinder head to cylinder block retaining bolts a second pass in sequence to 30 N.m (22 lb ft) .
  3. Tighten the M11 cylinder head to cylinder block retaining bolts a third pass in sequence an additional 150 degrees using the **J 45059:** meter .
8. Install the 2 front M8 left cylinder head to cylinder block retaining bolts (9, 10).

Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a first pass to 15 N.m (11 lb ft).



Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a second pass in sequence an additional 60 degrees using the **J 45059** meter.

#### VALVE LIFTER INSTALLATION - RIGHT SIDE



**Fig. 10: Identifying Pivot Sphere Area Of SHLA**  
Courtesy of GENERAL MOTORS CORP.

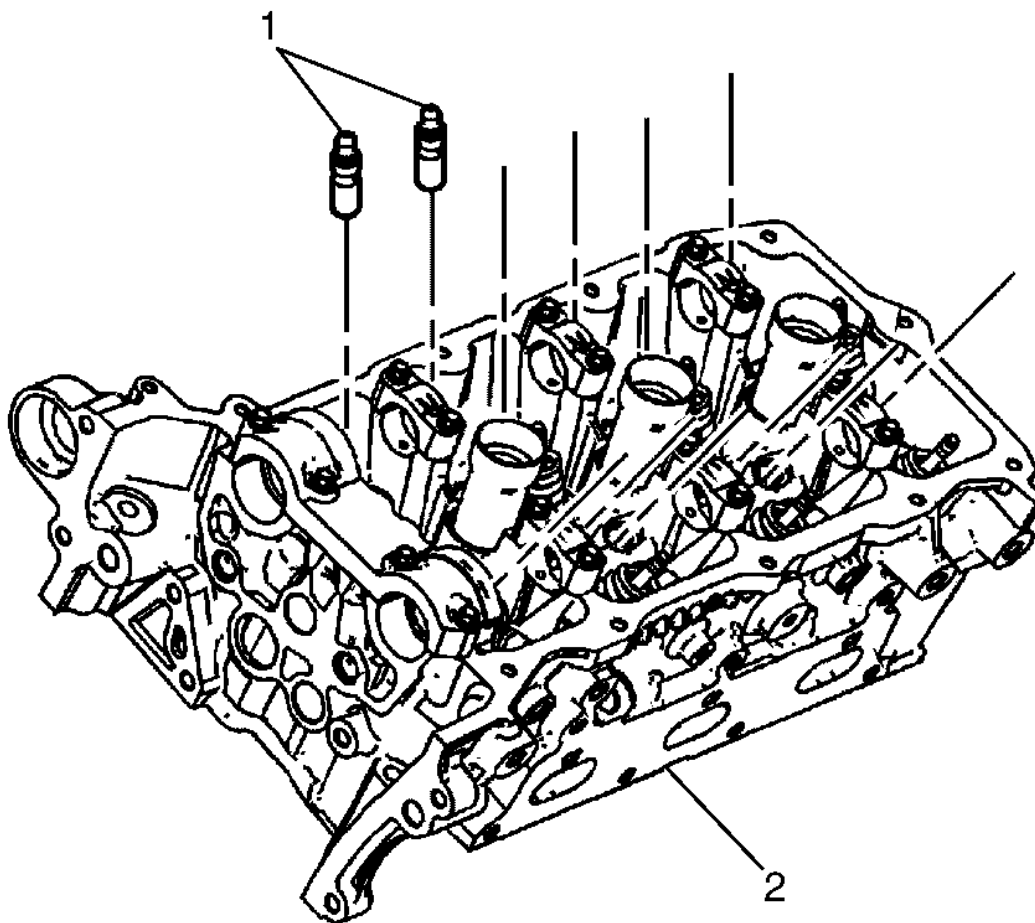
**IMPORTANT: DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.**

**IMPORTANT: DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.**

1. Fill the Stationary Hydraulic Lash Adjuster (SHLA) with clean engine oil. Take precautions to prevent

scratching the pivot sphere area (1) of the SHLA.

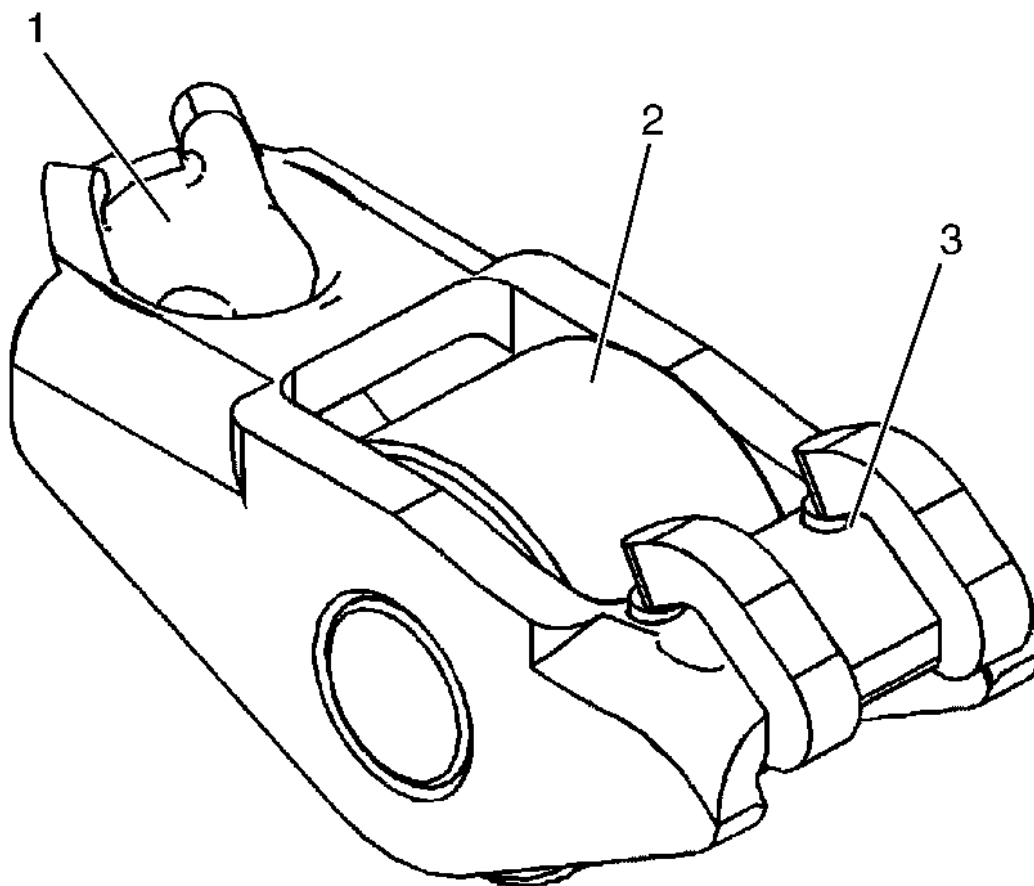
2. Lubricate the SHLA bores in the cylinder head with clean engine oil.



**Fig. 11: View Of SHLAs Valve Lifters**  
Courtesy of GENERAL MOTORS CORP.

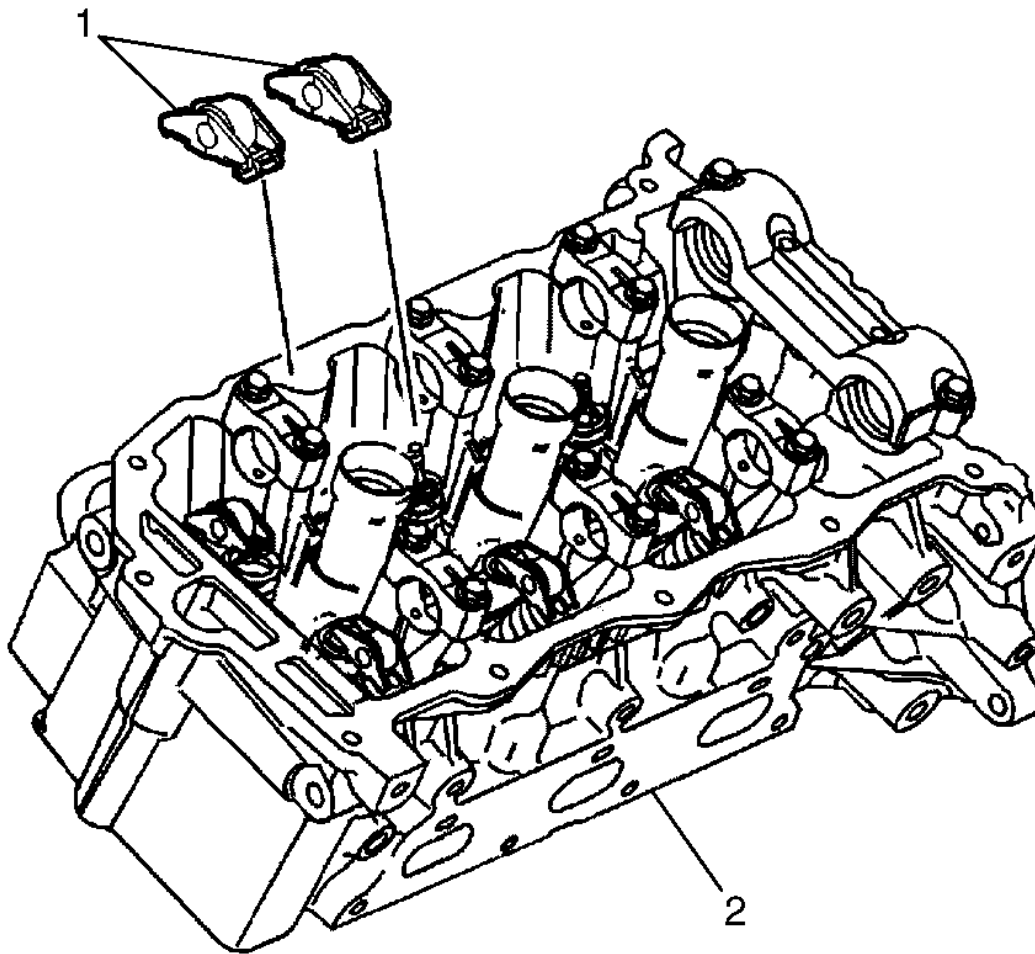
3. Install the SHLAs (1) in the cylinder head (2).
4. Apply a liberal amount of commercially available camshaft/lifter prelube to the SHLA pivot spheres.

#### VALVE ROCKER ARM INSTALLATION - RIGHT SIDE



**Fig. 12: View Of Pivot Pocket, Roller & Valve Slot Prelube Areas**  
**Courtesy of GENERAL MOTORS CORP.**

1. Apply a liberal amount of commercially available camshaft/lifter prelube to the pivot pocket (1), roller (2) and valve slot (3) areas of the valve rocker arms.



**Fig. 13: View Of Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The valve rocker arms (1) must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the valve rocker arms (1) are being reused you must put them back in their original location.

2. Place the valve rocker arms (1) in position on the valve tip and Stationary Hydraulic Lash Adjuster (SHLA).
3. The rounded head end of the valve rocker arms (1) go on the SHLA while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

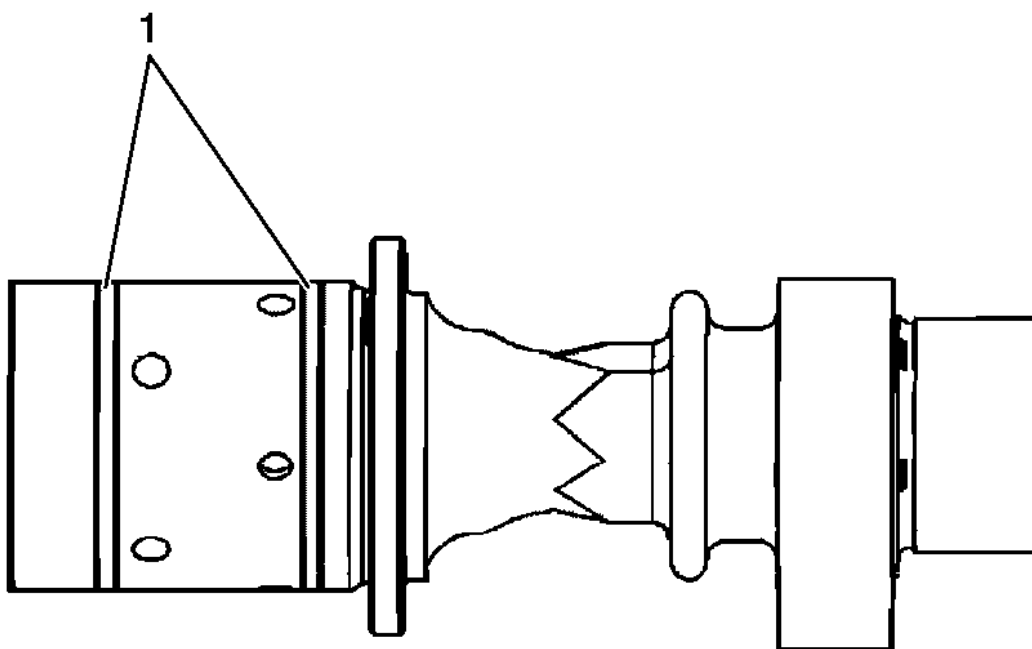
#### CAMSHAFT INSTALLATION - RIGHT SIDE

**Special Tools****EN 46111:** Crankshaft Rotation Socket

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

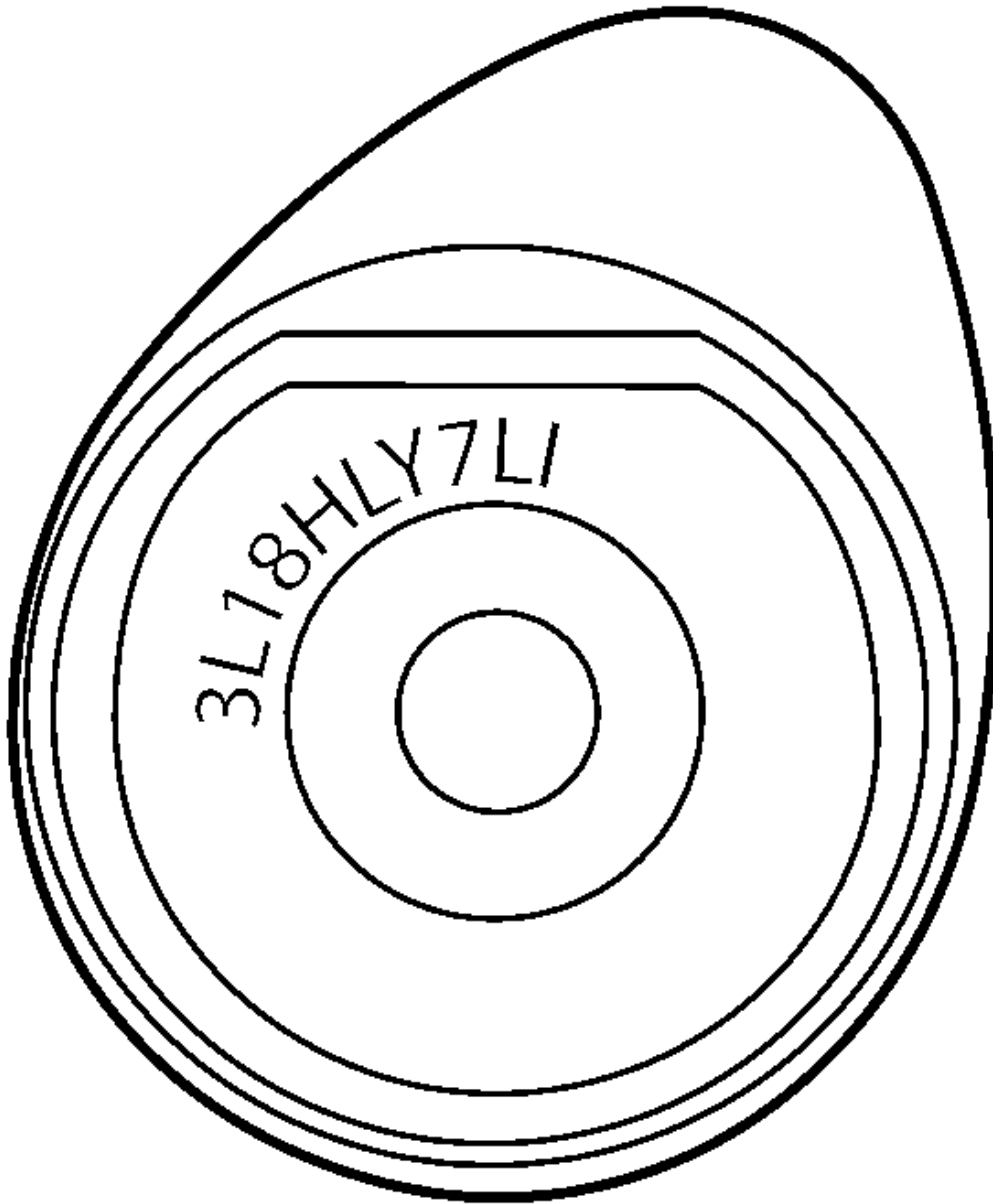
**Installation**

1. Ensure that the crankshaft is in the stage one timing drive assembly position using the **EN 46111:** socket. Refer to **Camshaft Timing Drive Chain Alignment Diagram** .



**Fig. 14: Identifying Camshaft Sealing Rings**  
Courtesy of GENERAL MOTORS CORP.

2. Make sure that the camshaft sealing rings (1) are in place in the camshaft grooves.



**Fig. 15: Locating ID Markings On Rear End Of Camshaft**  
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft for the particular installation location. ID markings are on the rear end of each camshaft. The ID markings are defined as follows:
  1. The first five digits refer to the date and time of production.

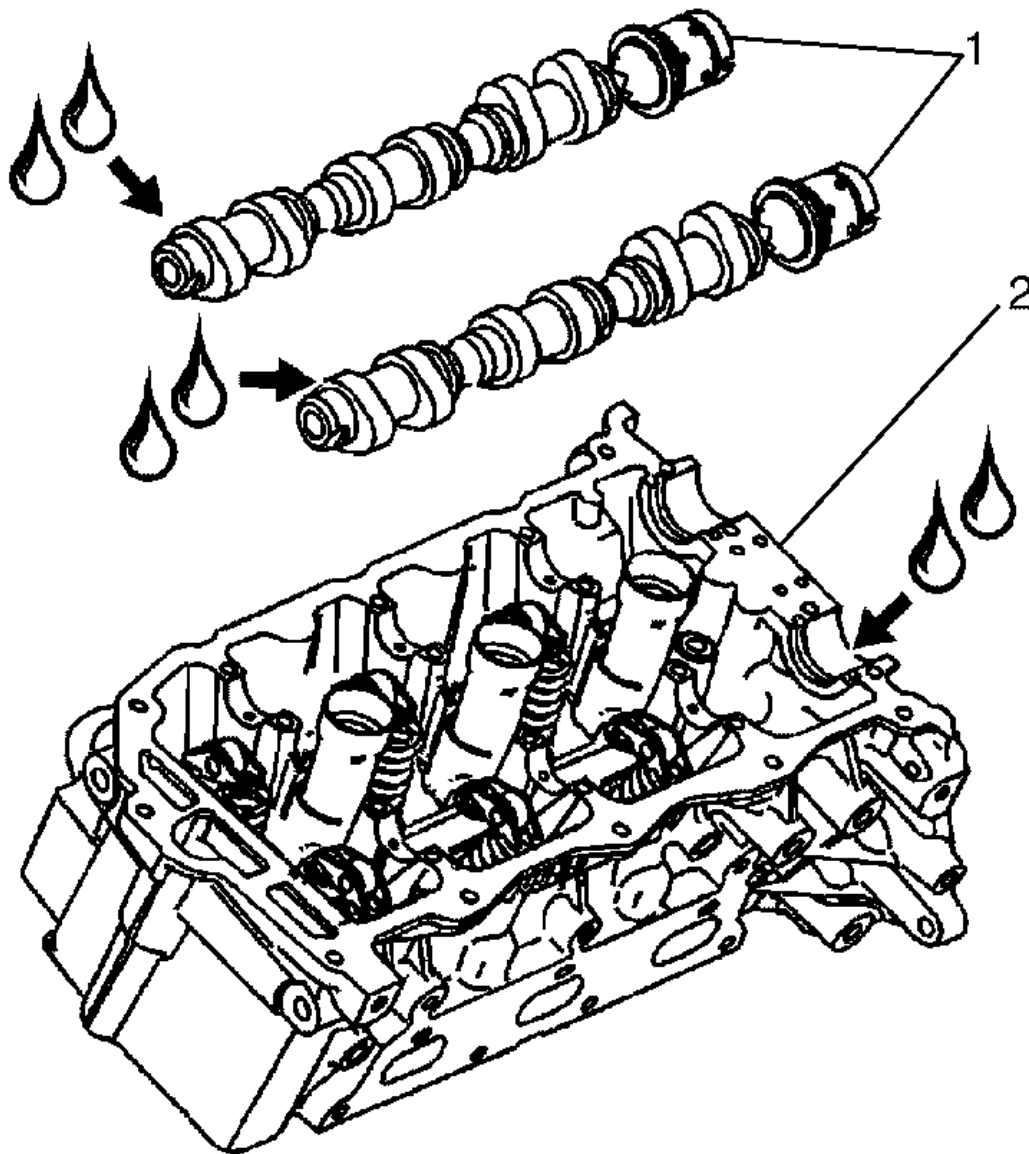
Example: 3L18H.

2. Digits 6-9 refer to the production code.

LY7 - High Feature V6

3. The last two digits refer to the camshaft position.

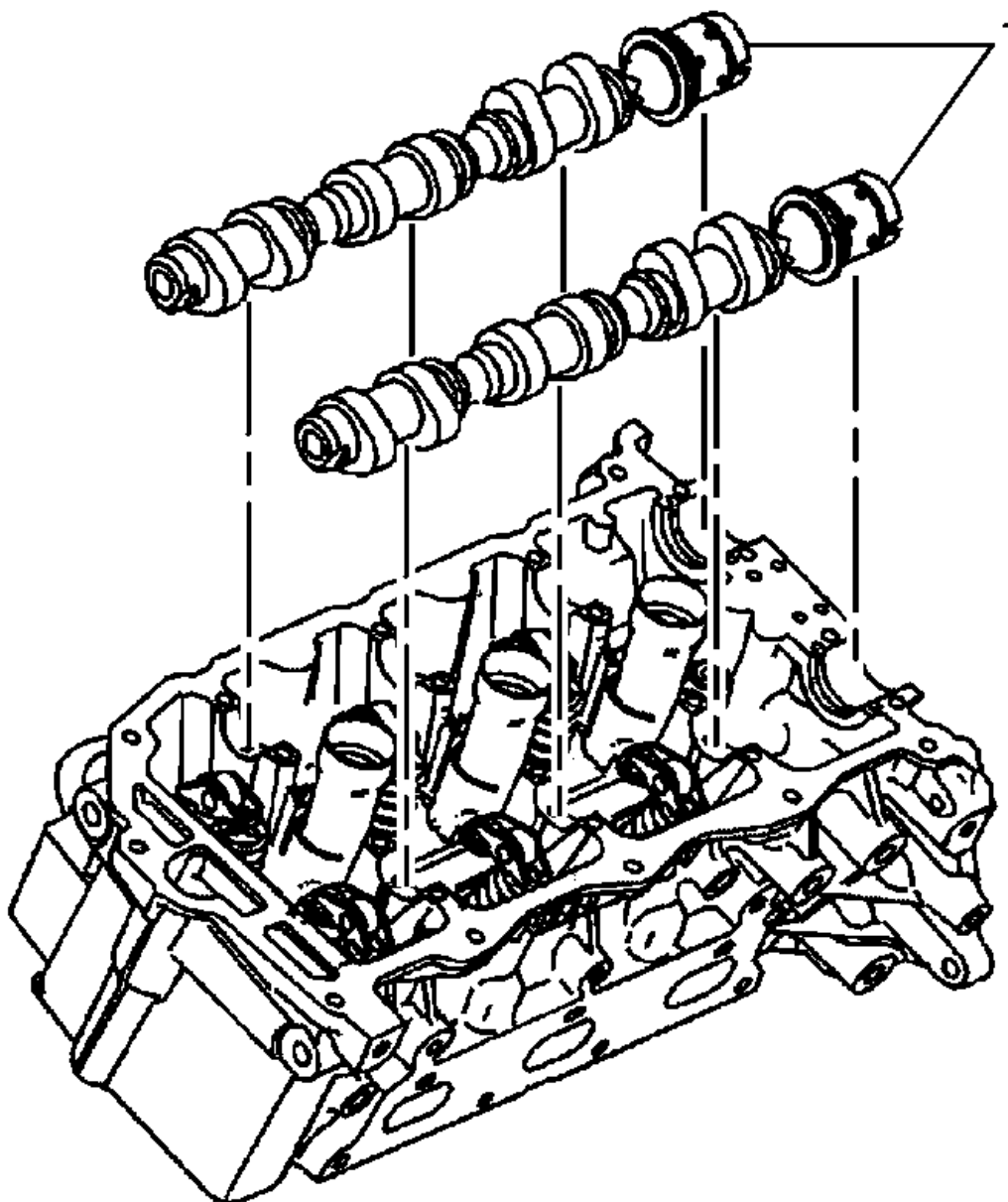
- Example:
- LI - Left Bank Intake
- LE - Left Bank Exhaust
- RI - Right Bank Intake
- RE - Right Bank Exhaust



**Fig. 16: Locating Right Cylinder Head Camshaft & Carriers**  
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of engine oil to the camshaft (1) journals and the right cylinder head (2) camshaft carriers.

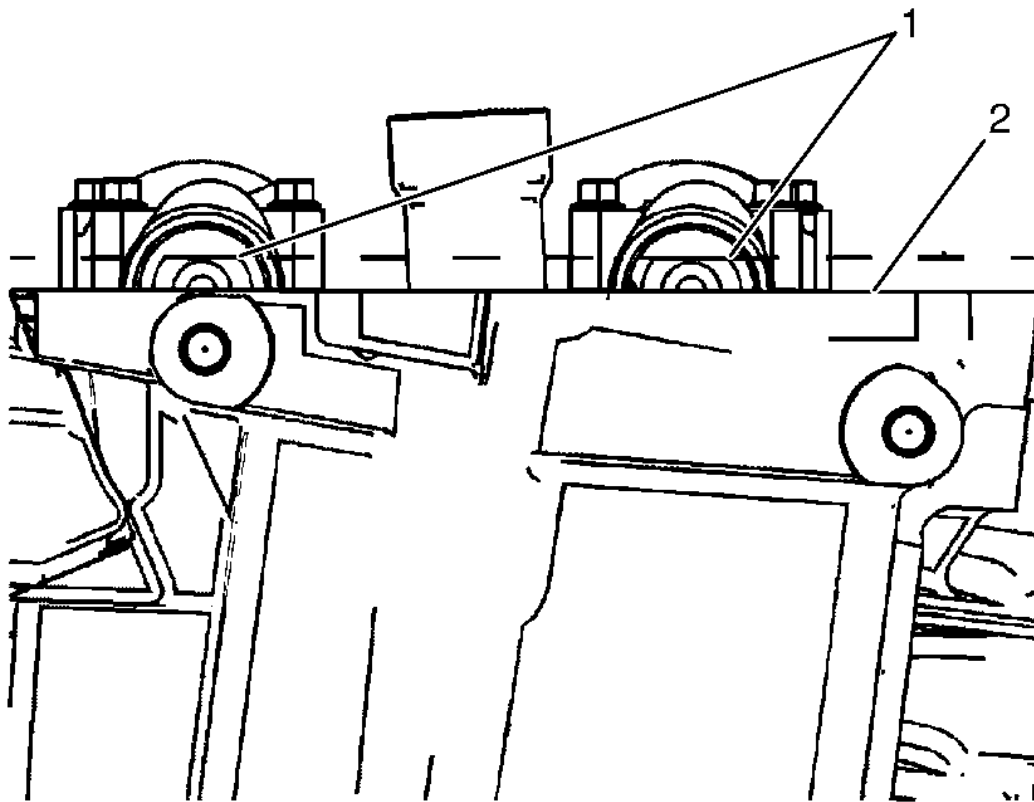




**Fig. 17: View Of Camshafts**

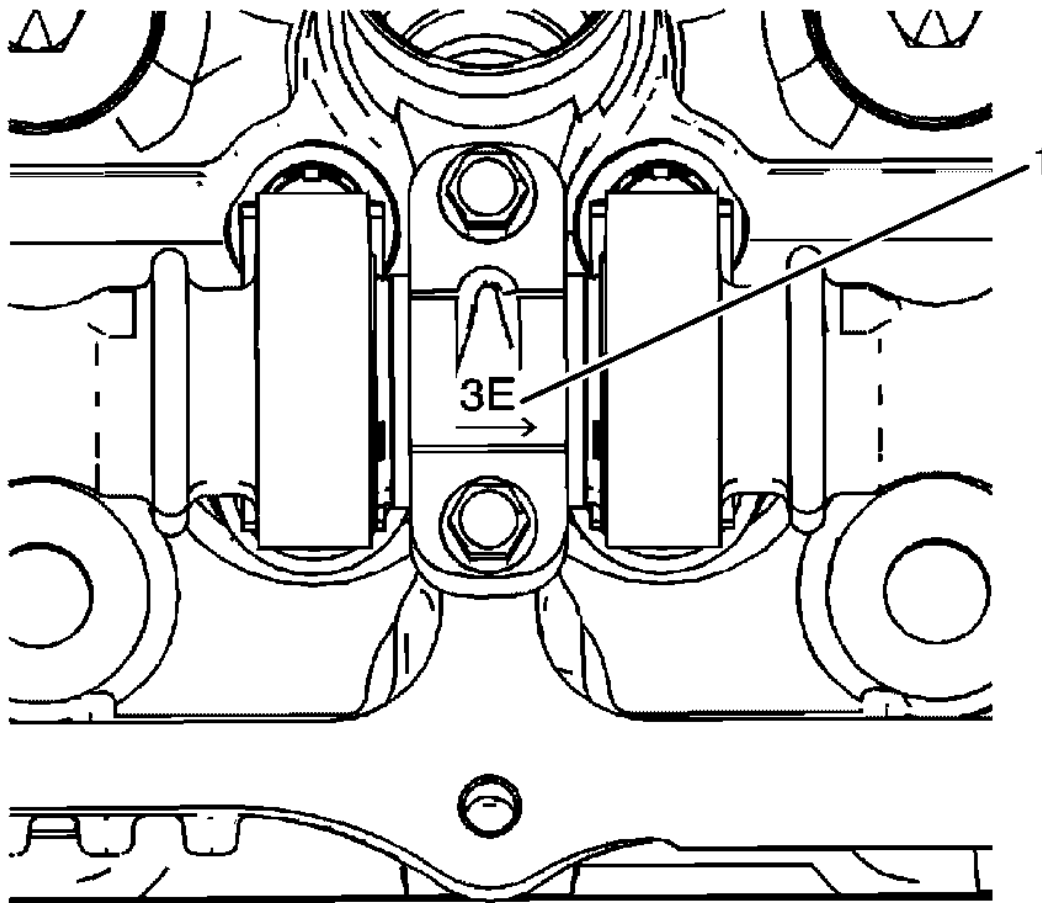
Courtesy of GENERAL MOTORS CORP.

5. Place the camshafts (1) in position in the right cylinder head (2).



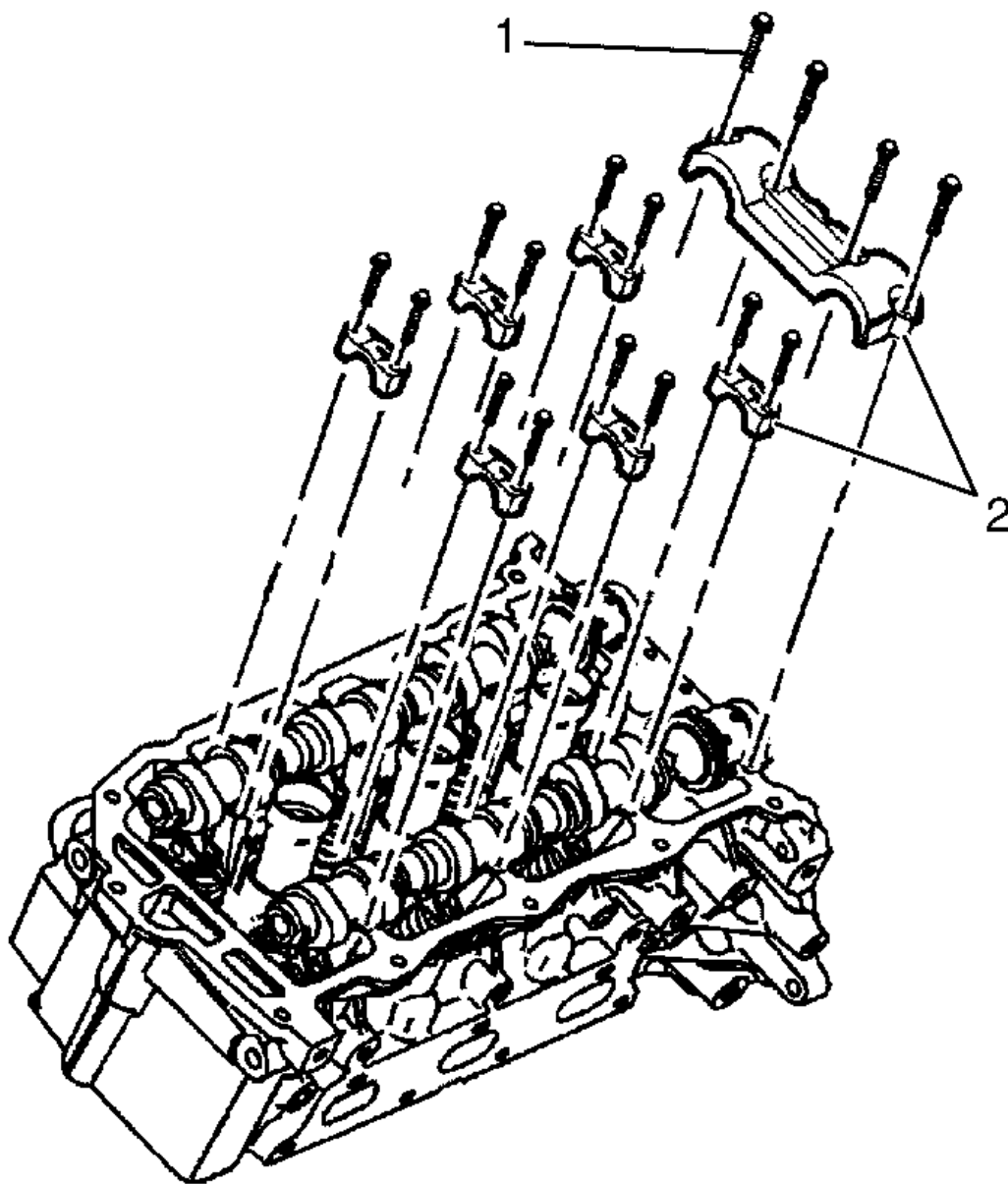
**Fig. 18: View Of Right Cylinder Head Camshaft Cover Rail**  
**Courtesy of GENERAL MOTORS CORP.**

6. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the right cylinder head camshaft cover rail.



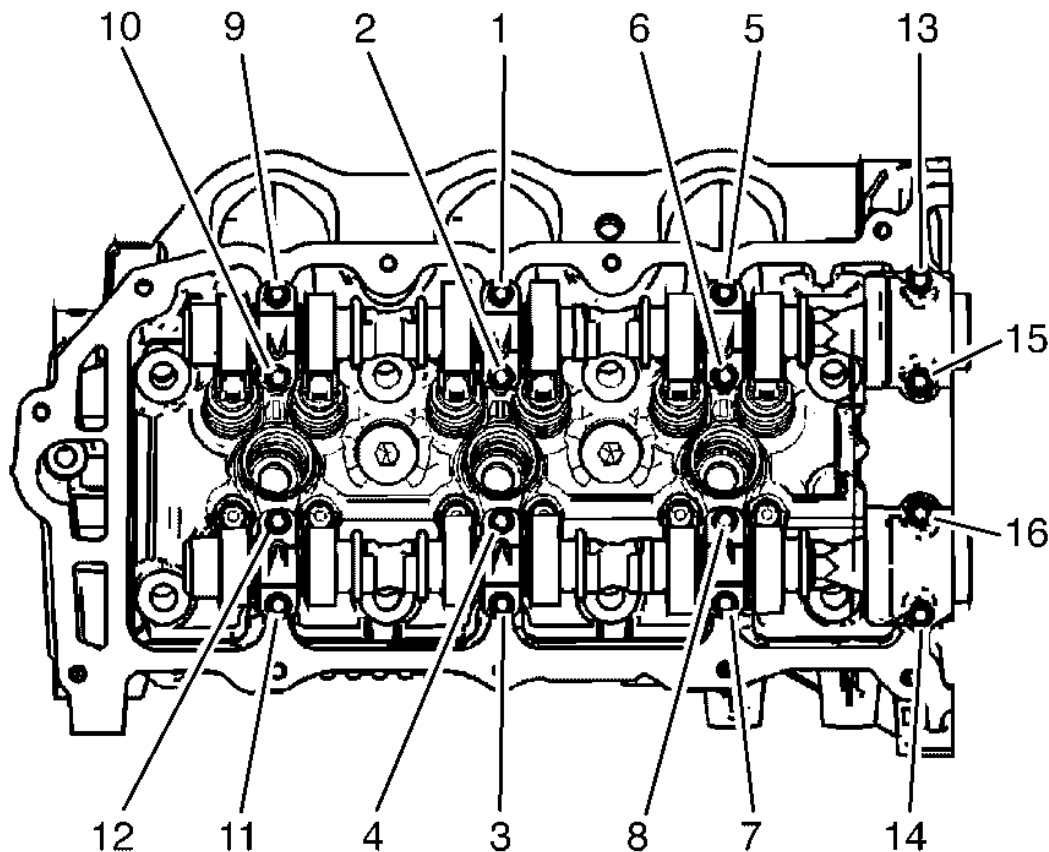
**Fig. 19: Locating Right Cylinder Head Camshaft Bearing Cap Markings**  
Courtesy of GENERAL MOTORS CORP.

7. Observe the markings on the right cylinder head camshaft bearing caps. Each bearing cap is marked (1) in order to identify its location. The markings have the following meanings:
  - The raised feature must always be oriented toward the center of the cylinder head.
  - The I indicates the intake camshaft.
  - The E indicates the exhaust camshaft.
  - The number 1, 3, 5 indicates the cylinder position from the front of the cylinder block.
8. Apply a liberal amount of engine oil to the camshaft bearing caps.



**Fig. 20: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Install the camshaft bearing thrust cap (2) in the first journal of the right cylinder head.
10. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
11. Hand start all the camshaft bearing cap to cylinder head retaining bolts (1).



**Fig. 21: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolt Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

12. Tighten the camshaft bearing cap to cylinder head retaining bolts in the sequence shown and tighten to 10 N.m (89 lb in).
13. Loosen the center intake camshaft bearing cap to cylinder head retaining bolts (1, 2) and the center exhaust camshaft bearing cap to cylinder head retaining bolts (3, 4).
14. Retighten the center camshaft bearing cap to cylinder head retaining bolts (1, 2, 3, 4) to 10 N.m (89 lb in).

## CYLINDER HEAD INSTALLATION - LEFT SIDE

### Special Tools

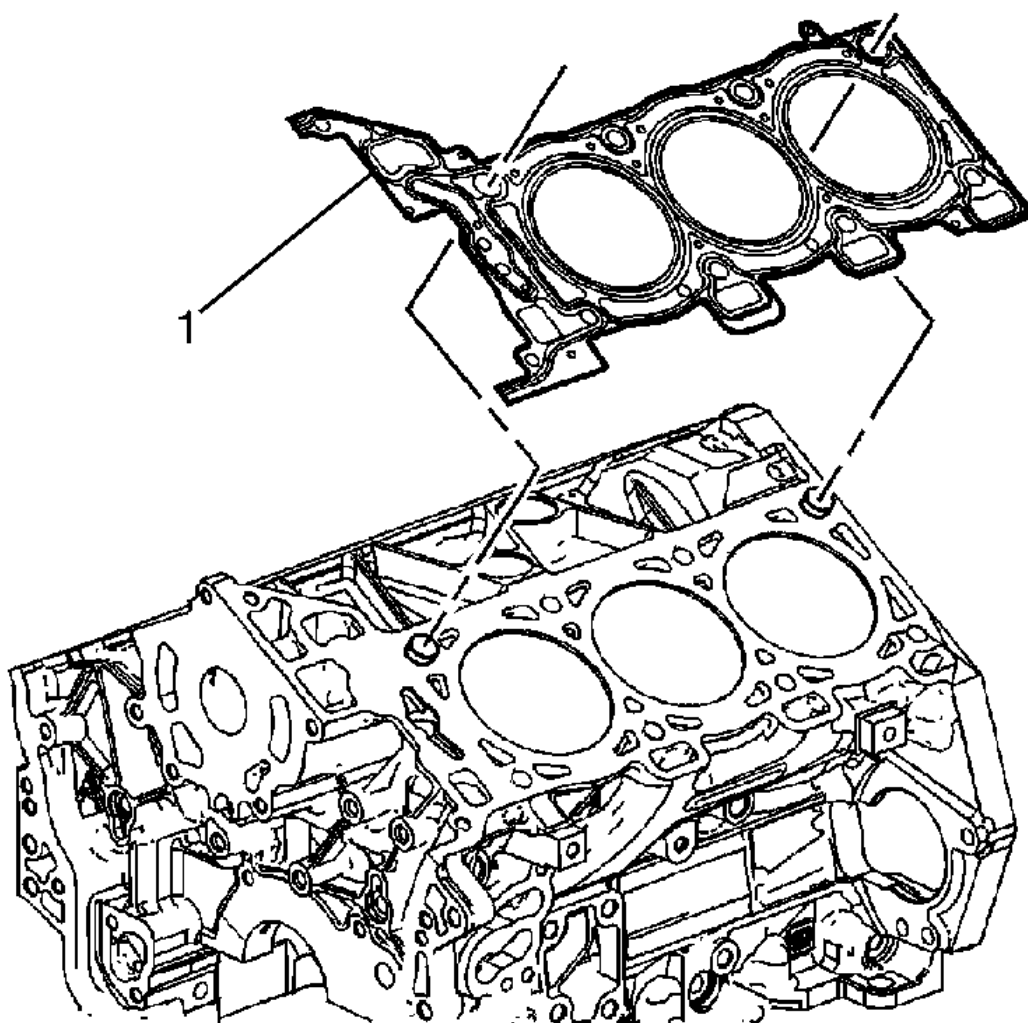
- **EN 46111:** Crankshaft Rotation Socket

- **J 45059:** Angle Meter

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

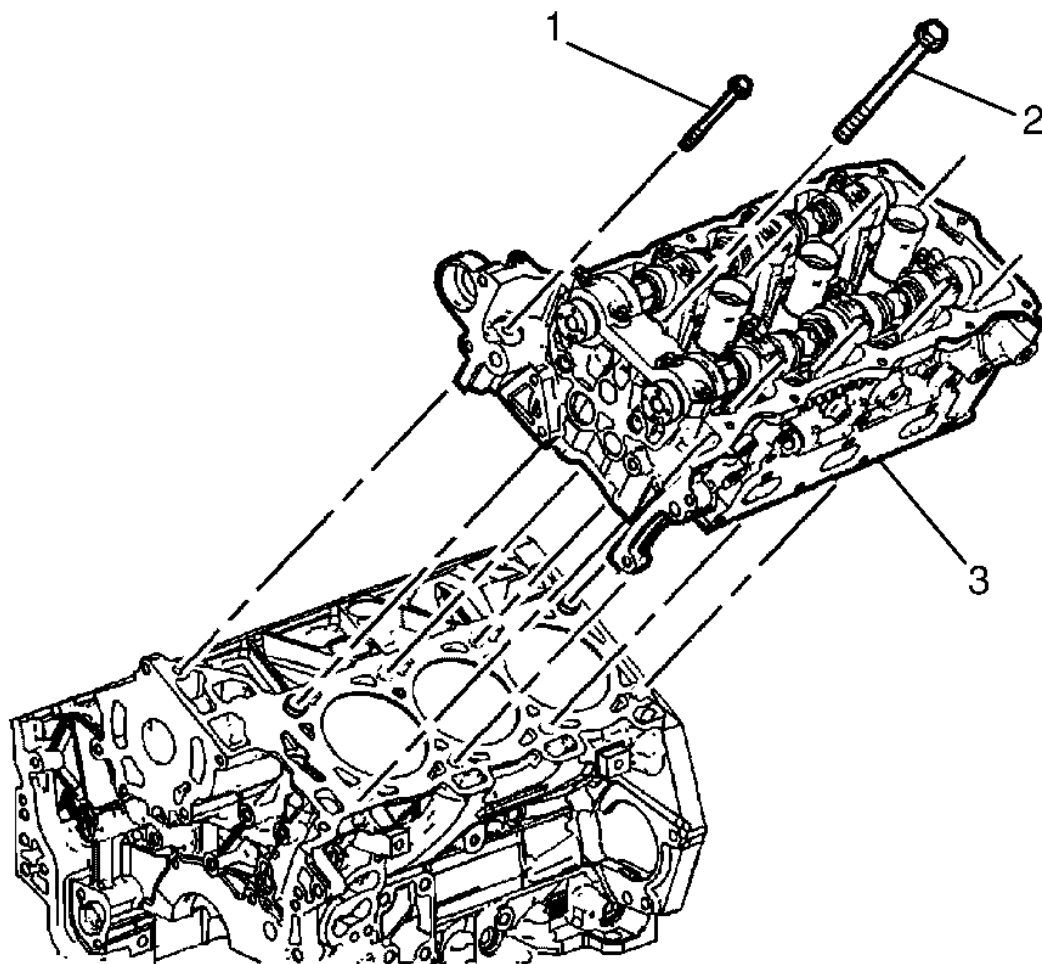
**NOTE:** Make sure that the crankshaft is in the timing drive assembly position using the EN 46111: socket.

1. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.



**Fig. 22: View Of Left Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW left cylinder head gasket (1) using the deck face locating pins for retention.



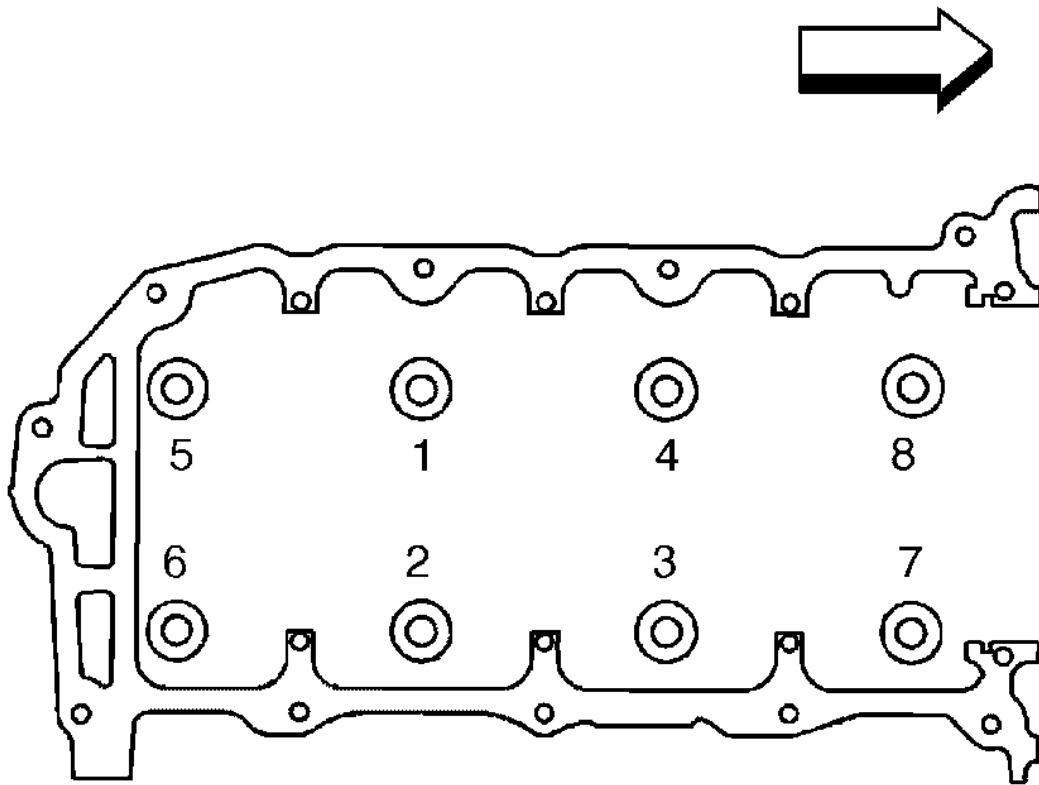
**Fig. 23: Identifying M8 & M11 Cylinder Head To Cylinder Block Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

3. Align the left cylinder head (3) with the deck face locating pins.
4. Place the left cylinder head (3) in position on the deck face.

**NOTE:**        **DO NOT** allow oil on the cylinder head bolt bosses.

**NOTE:**        **DO NOT** reuse the old M11 cylinder head bolts.

5. Loosely install the NEW M11 cylinder head to cylinder block retaining bolts (2).
6. Loosely install the NEW M8 front cylinder head to cylinder block retaining bolts (1).



**Fig. 24: Identifying Cylinder Head To Cylinder Block Retaining Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

7. Tighten the cylinder head to cylinder block retaining bolts in the sequence shown.

Tighten the M11 cylinder head to cylinder block retaining bolts a first pass in sequence to 45 N.m (33 lb ft).

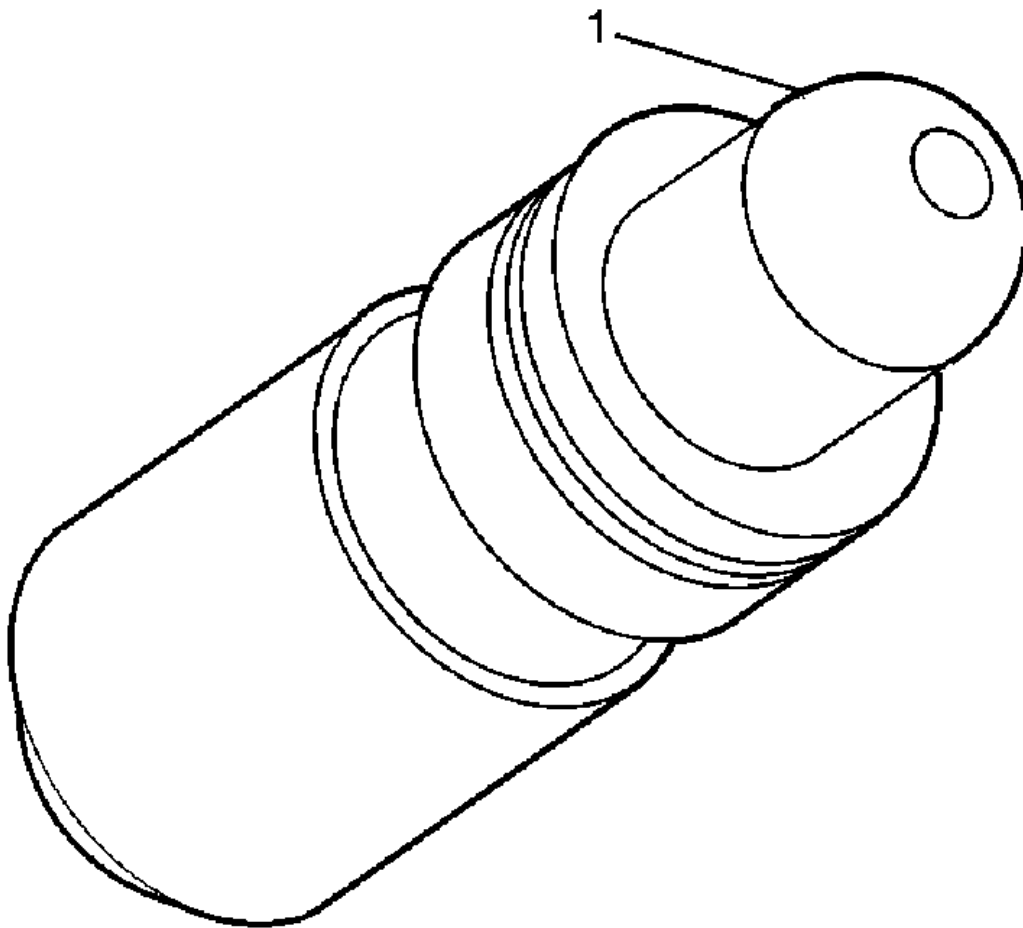
1. Back off the M11 cylinder head to cylinder block retaining bolts 120 degrees using the **J 45059:** meter .
  2. Tighten the M11 cylinder head to cylinder block retaining bolts a second pass in sequence to 30 N.m (22 lb ft) .
  3. Tighten the M11 cylinder head to cylinder block retaining bolts a third pass in sequence an additional 150 degrees using the **J 45059:** meter J 45059.
8. Install the 2 front M8 left cylinder head to cylinder block retaining bolts (9, 10).



Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a first pass to 15 N.m (11 lb ft).

Tighten the M8 cylinder head to cylinder block retaining bolts (9, 10) a second pass in sequence an additional 60 degrees using the **J 45059** meter.

#### **VALVE LIFTER INSTALLATION - LEFT SIDE**

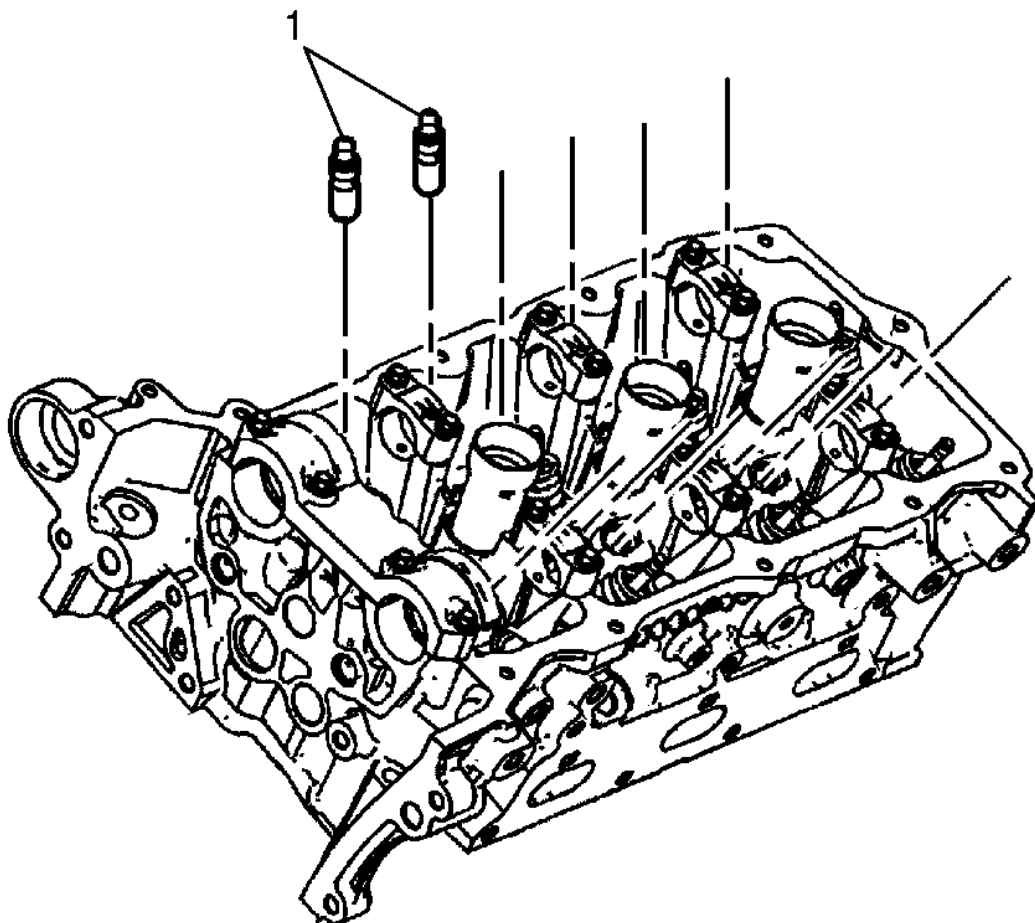


**Fig. 25: Identifying Pivot Sphere Area Of SHLA**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.**

**IMPORTANT: DO NOT allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.**

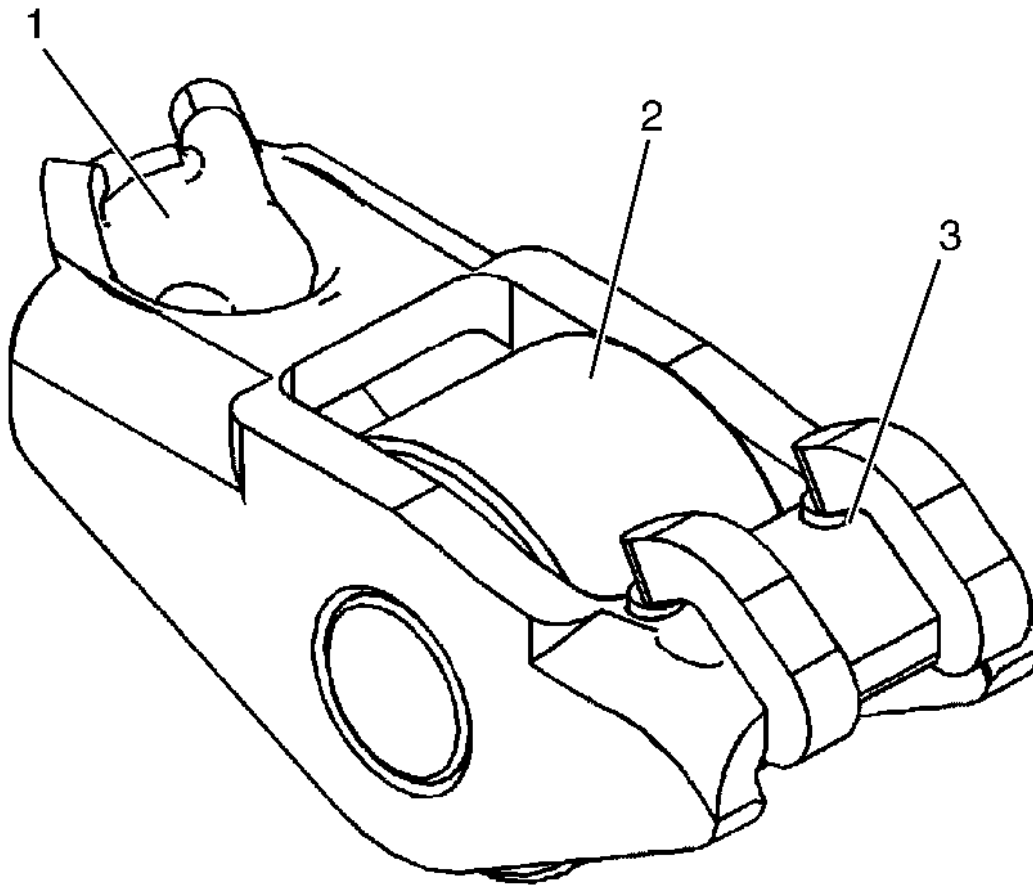
1. Fill the Stationary Hydraulic Lash Adjuster (SHLA) with clean engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil.



**Fig. 26: View Of Stationary Hydraulic Lash Adjusters (SHLAs)**  
Courtesy of GENERAL MOTORS CORP.

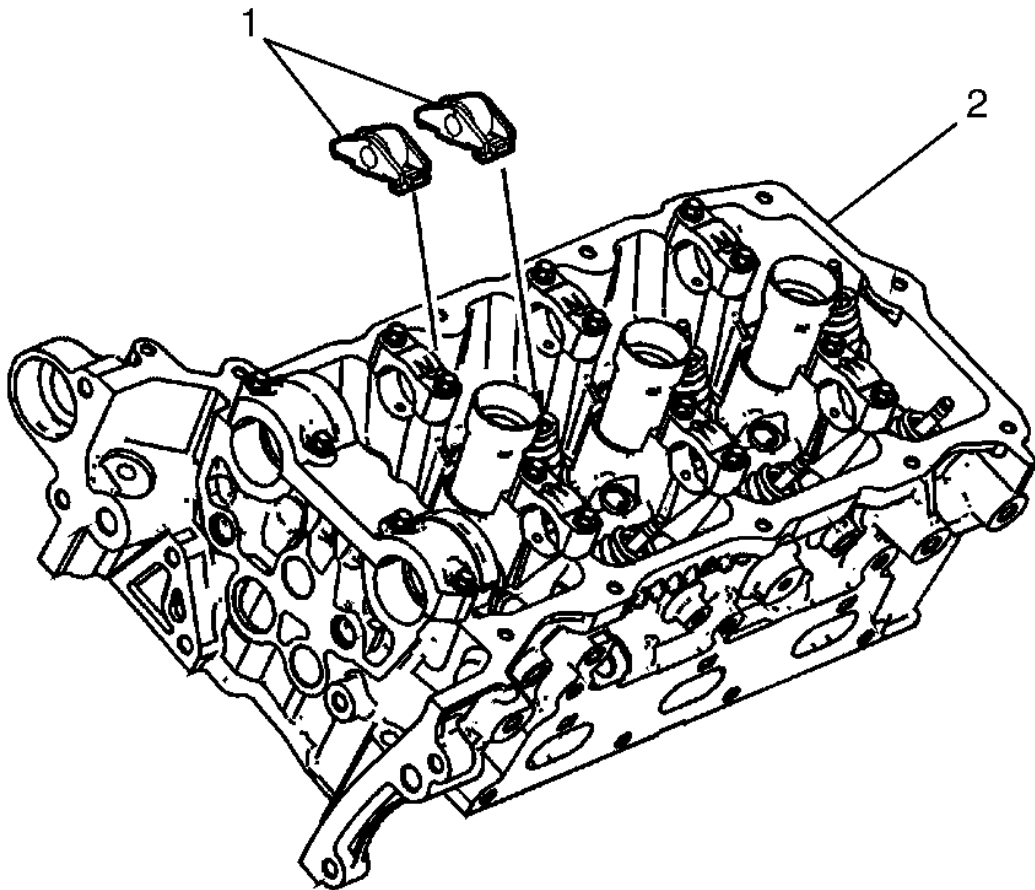
3. Install the SHLAs (1).
4. Apply a liberal amount of commercially available camshaft/lifter prelude to the SHLA (1) pivot spheres.

#### **VALVE ROCKER ARM INSTALLATION - LEFT SIDE**



**Fig. 27: View Of Pivot Pocket, Roller & Valve Slot Prelube Areas**  
**Courtesy of GENERAL MOTORS CORP.**

1. Apply a liberal amount of commercially available camshaft/lifter prelube to the pivot pocket (1), roller (2) and valve slot (3) areas of the valve rocker arms.



**Fig. 28: View Of Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The valve rocker arms (1) must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the valve rocker arms (1) are being reused you must put them back in their original location.

2. Place the valve rocker arms (1) in position on the valve tip and Stationary Hydraulic Lash Adjuster (SHLA).
3. The rounded head end of the valve rocker arms (1) go on the SHLA while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

## CAMSHAFT INSTALLATION - LEFT SIDE

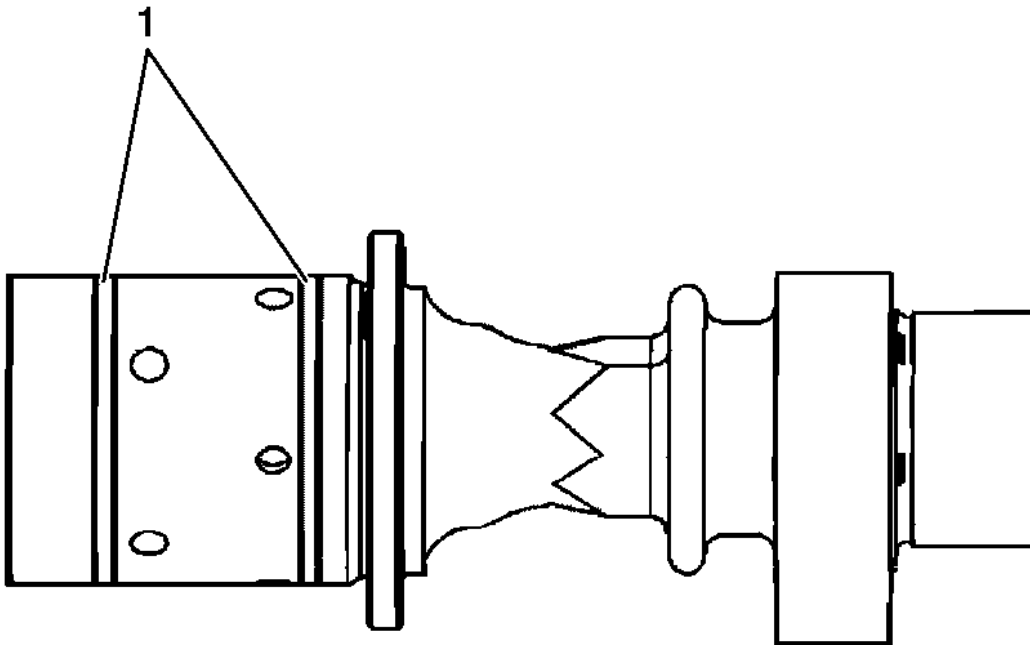
### Special Tools

**EN 46111: Crankshaft Rotation Socket**

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

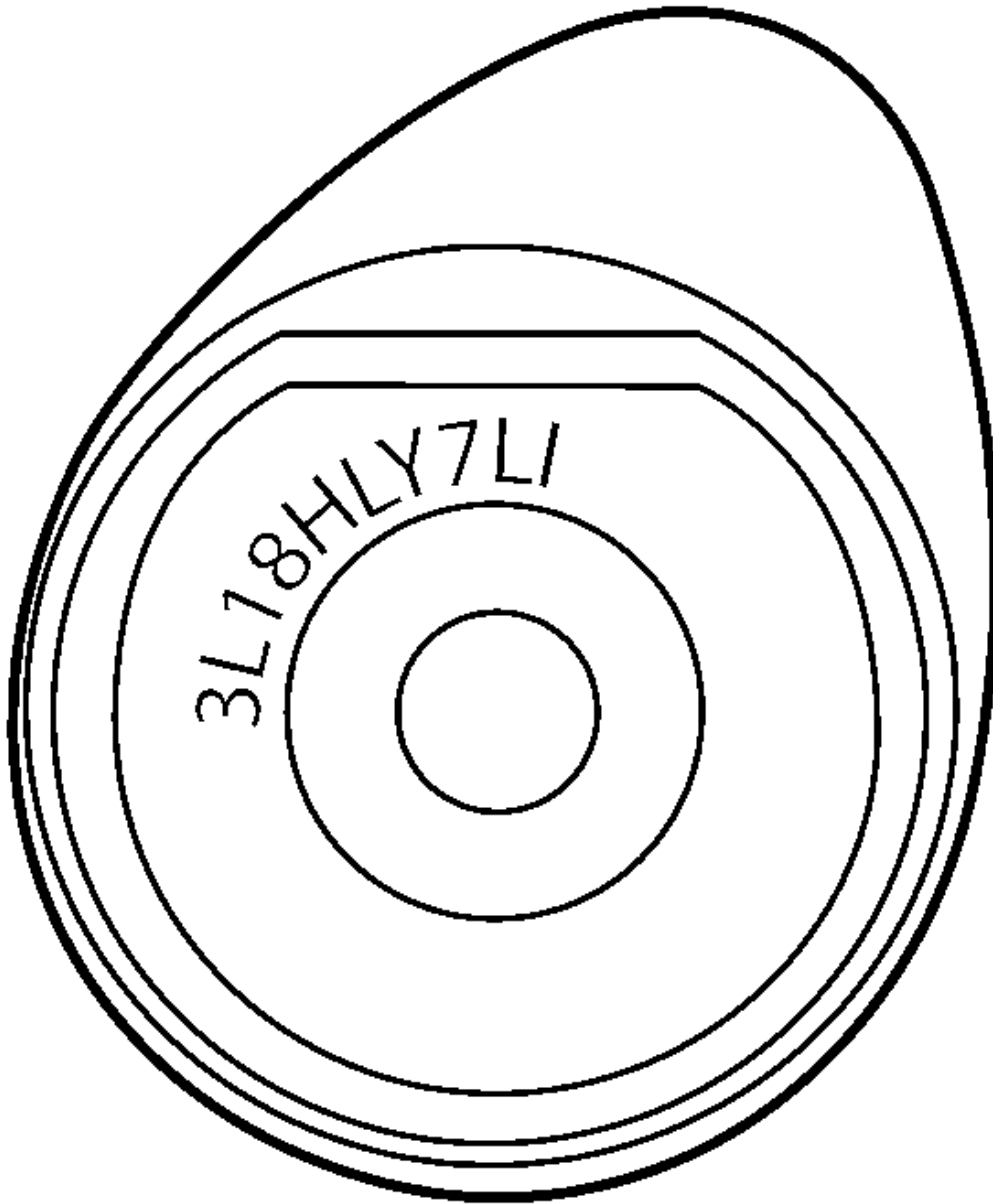
**Installation**

1. Ensure that the crankshaft is in the stage one timing drive assembly position using the **EN 46111: socket**. Refer to **Camshaft Timing Drive Chain Alignment Diagram** .



**Fig. 29: Identifying Camshaft Sealing Rings**  
Courtesy of GENERAL MOTORS CORP.

2. Make sure that the camshaft sealing rings (1) are in place in the camshaft grooves.



**Fig. 30: Locating ID Markings On Rear End Of Camshaft**  
Courtesy of GENERAL MOTORS CORP.

3. Select the proper camshaft for the particular installation location. ID markings are on the rear end of each camshaft. The ID markings are defined as follows:
  1. The first five digits refer to the date and time of production.

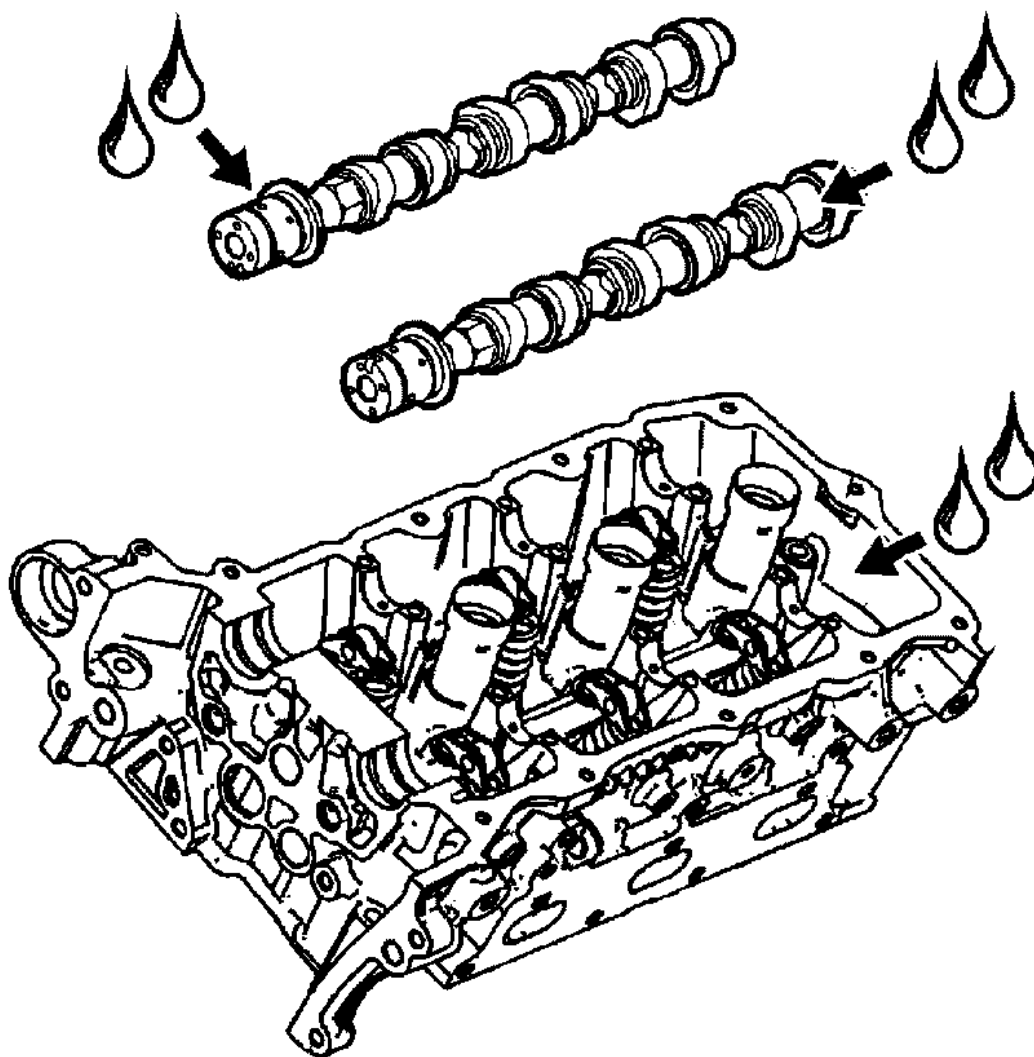
Example: 3L18H.

2. Digits 6-9 refer to the production code.

LY7 - High Feature V6

3. The last two digits refer to the camshaft position.

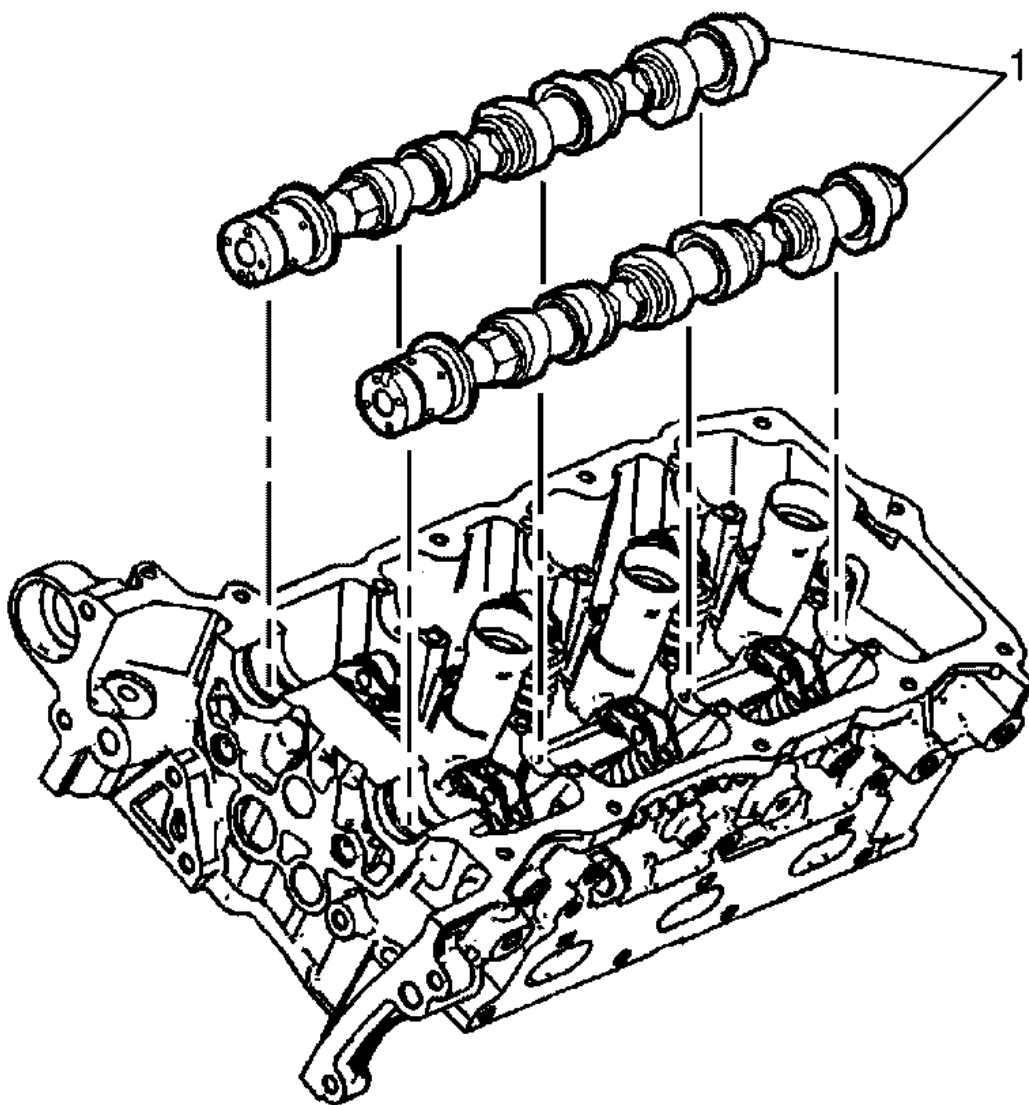
- Example:
- LI - Left Bank Intake
- LE - Left Bank Exhaust
- RI - Right Bank Intake
- RE - Right Bank Exhaust



**Fig. 31: Identifying Camshaft Journals & Left Cylinder Head Camshaft Carriers**  
Courtesy of GENERAL MOTORS CORP.

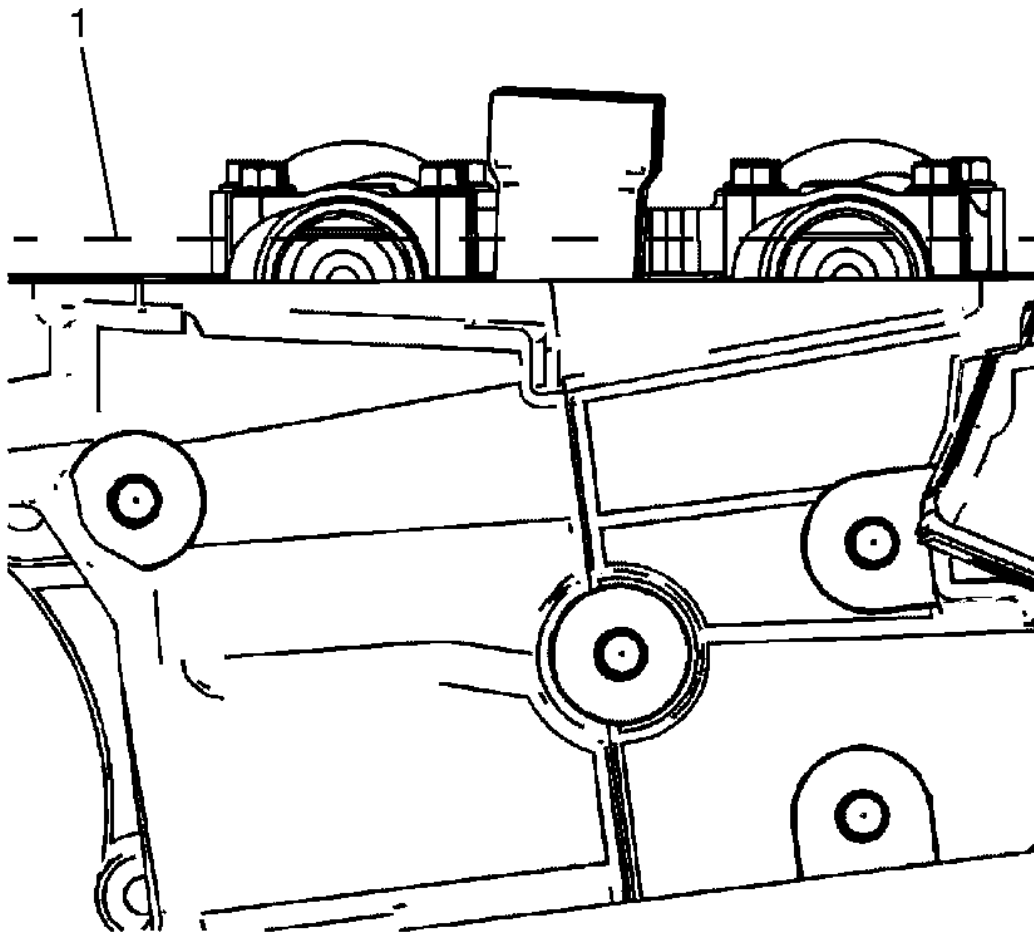
4. Apply a liberal amount of engine oil to the camshaft (1) journals and the left cylinder head (2) camshaft carriers.





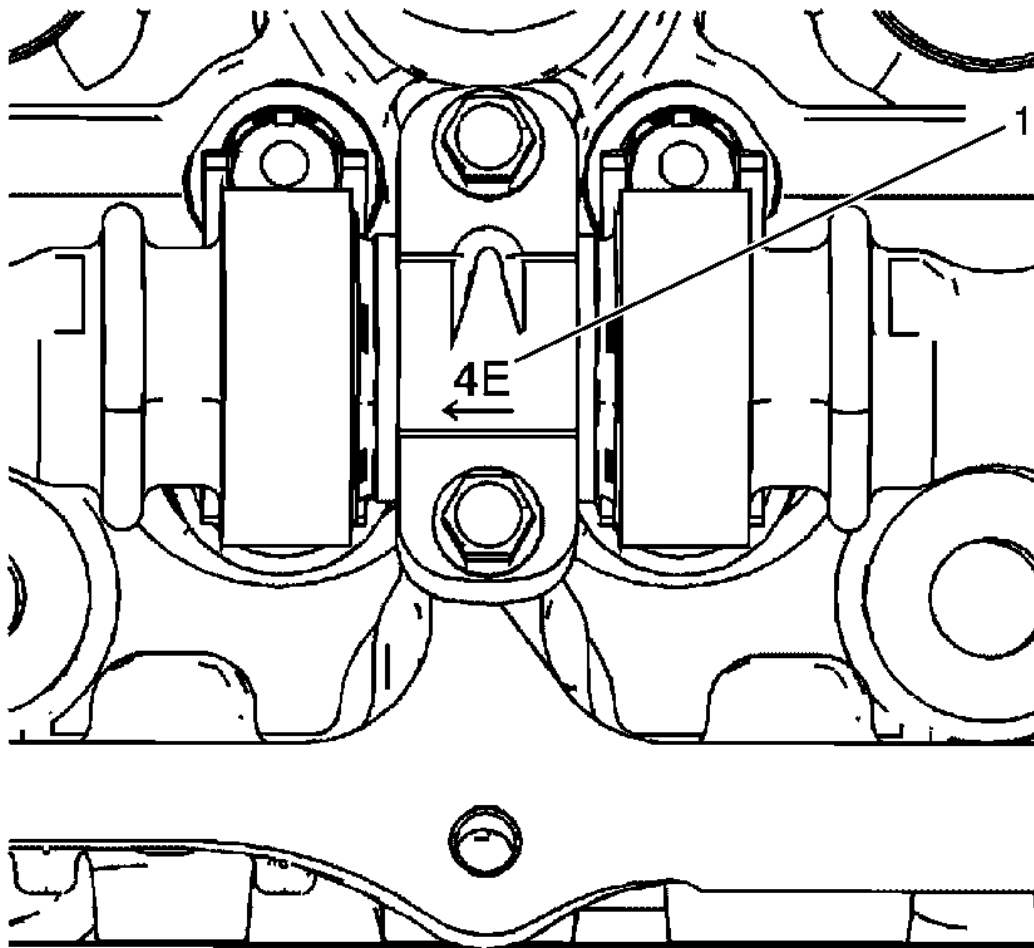
**Fig. 32: Identifying Left Cylinder Head & Camshafts**  
Courtesy of GENERAL MOTORS CORP.

5. Place the camshafts (1) in position in the left cylinder head (2).



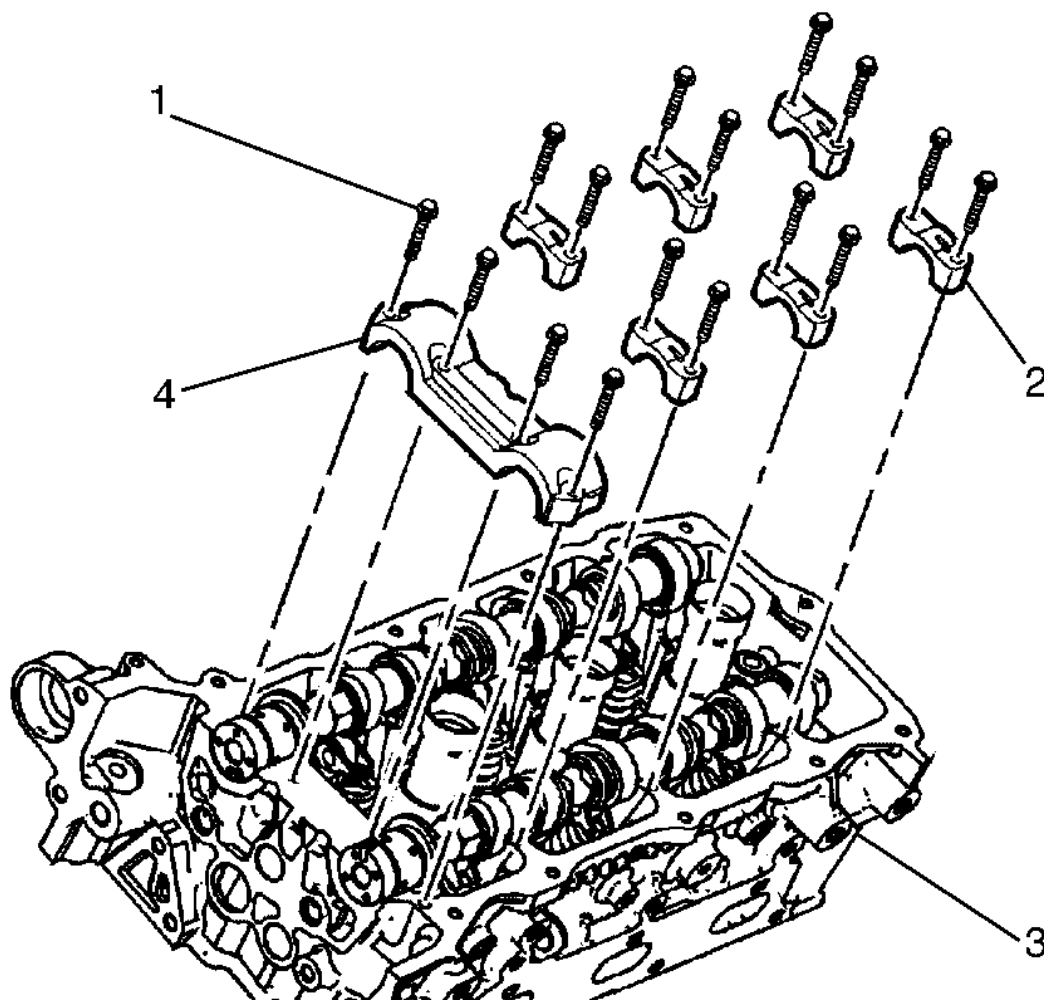
**Fig. 33: View Of Left Cylinder Head Camshaft Cover Rail**  
Courtesy of GENERAL MOTORS CORP.

6. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the left cylinder head camshaft cover rail.



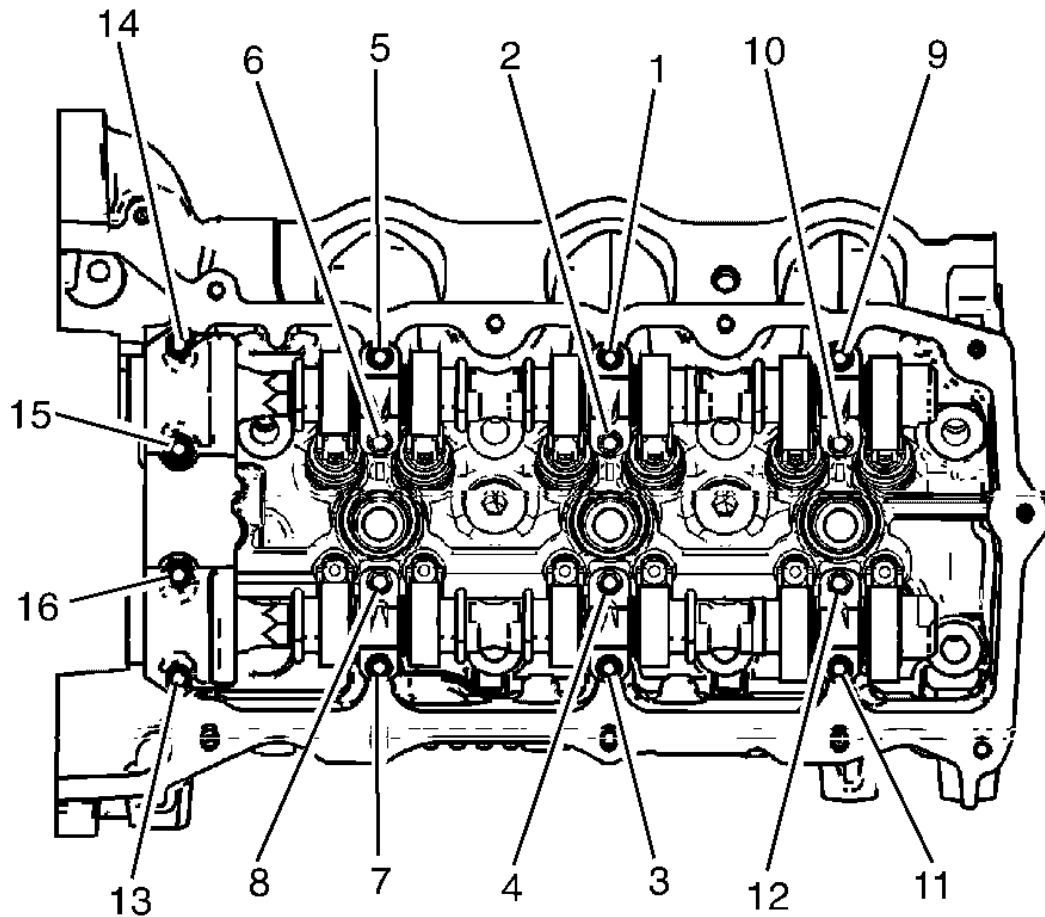
**Fig. 34: Identifying Left Cylinder Head Camshaft Bearing Cap Mark**  
Courtesy of GENERAL MOTORS CORP.

7. Observe the markings on the left cylinder head camshaft bearing caps. Each bearing cap is marked (1) in order to identify its location. The markings have the following meanings:
  - The raised feature must always be oriented toward the center of the cylinder head.
  - The I indicates the intake camshaft.
  - The E indicates the exhaust camshaft.
  - The number 1, 3, 5 indicates the cylinder position from the front of the cylinder block.
8. Apply a liberal amount of engine oil to the camshaft bearing caps.



**Fig. 35: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Install the camshaft bearing thrust cap (4) in the first journal of the right cylinder head (3).
10. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head (3).
11. Hand start all the camshaft bearing cap to cylinder head retaining bolts (1).



**Fig. 36: Identifying Camshaft Bearing Cap To Cylinder Head Retaining Bolt Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

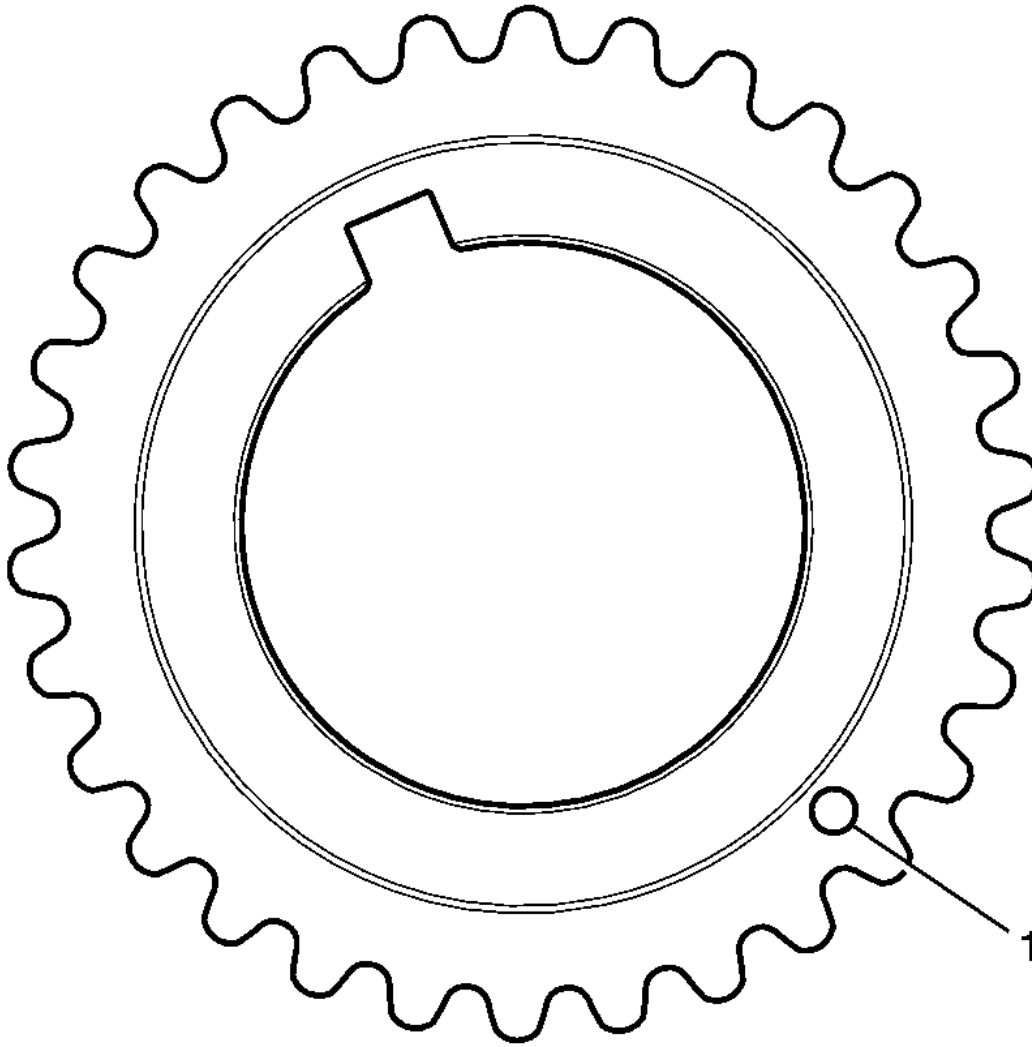
12. Tighten the camshaft bearing cap to cylinder head retaining bolts in the sequence shown to 10 N.m (89 lb in).
13. Loosen the center intake camshaft bearing cap to cylinder head retaining bolts (1, 2) and the center exhaust camshaft bearing cap to cylinder head retaining bolts (3, 4).
14. Retighten the center camshaft bearing cap to cylinder head retaining bolts (1, 2, 3, 4) to 10 N.m (89 lb in).

## CRANKSHAFT SPROCKET INSTALLATION

### Tools Required

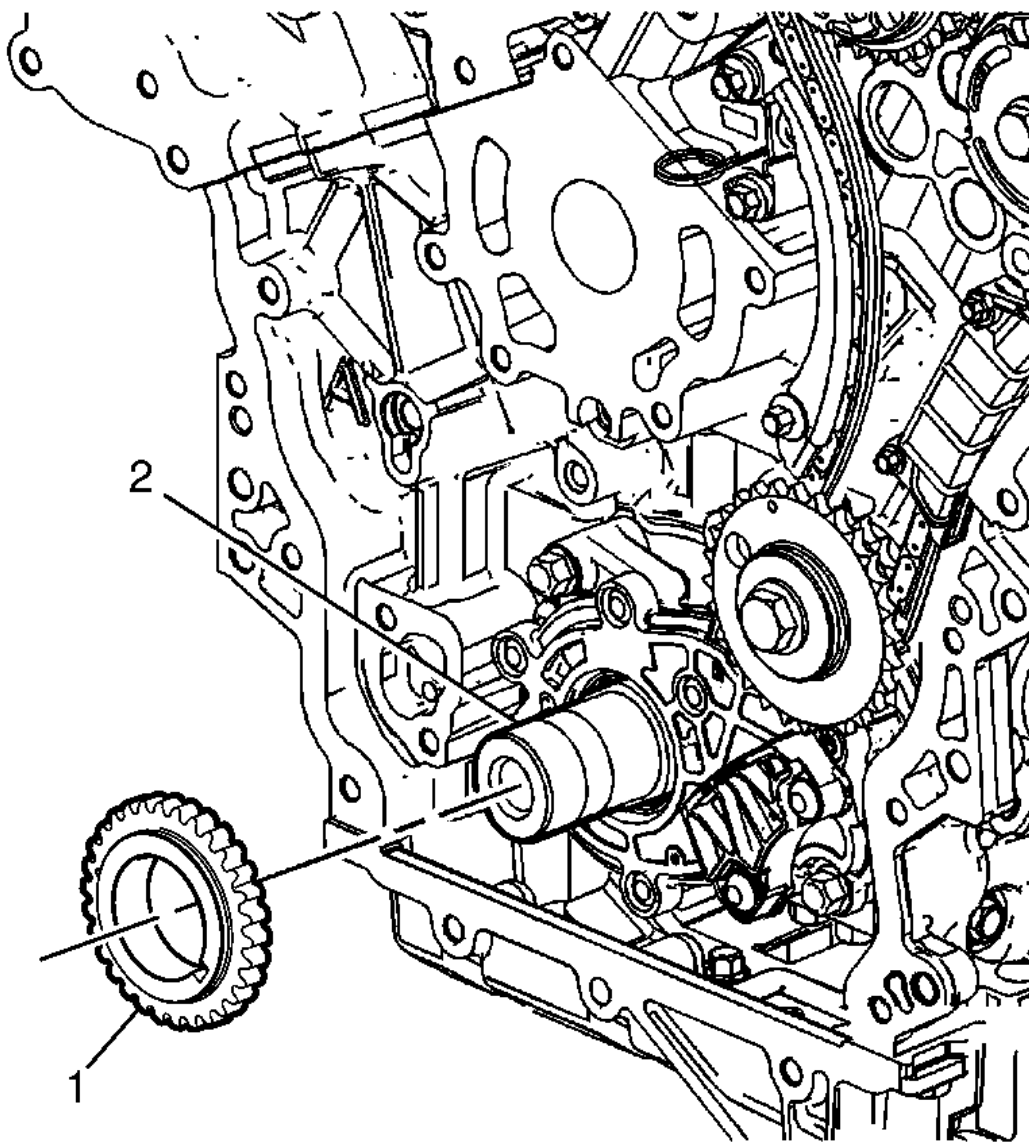
**EN 46111** Crankshaft Rotation Socket. See **Special Tools** .

**Installation**



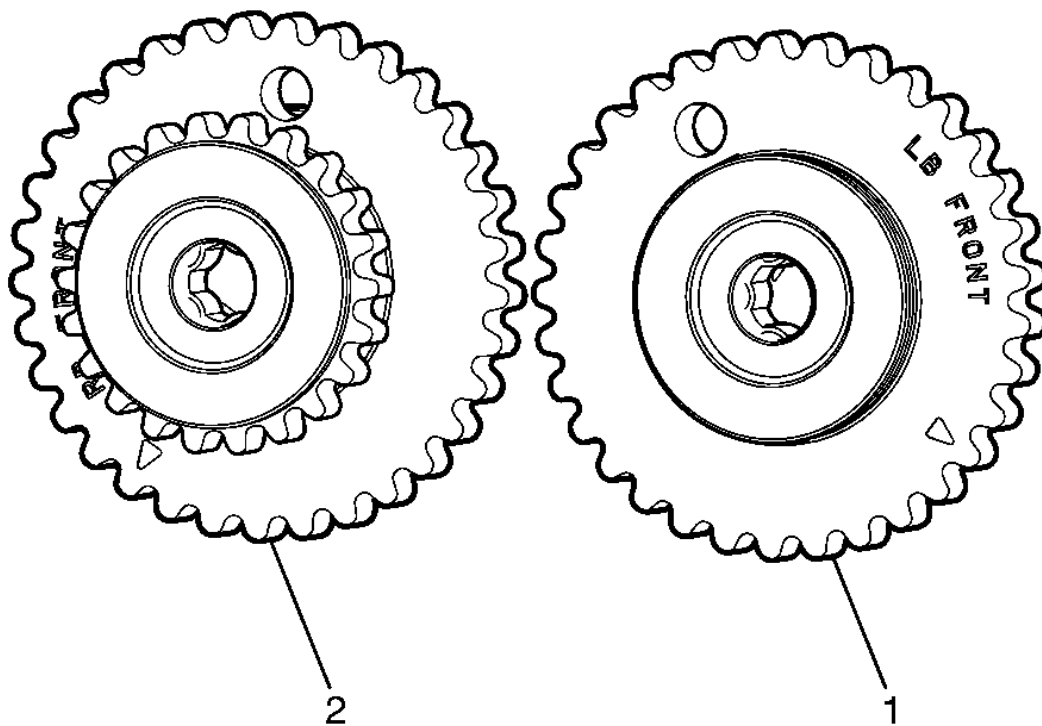
**Fig. 37: View Of Timing Mark**  
**Courtesy of GENERAL MOTORS CORP.**

1. Make sure the crankshaft sprocket is installed with the timing mark (1) visible.



**Fig. 38: Identifying Crankshaft & Sprocket**  
Courtesy of GENERAL MOTORS CORP.

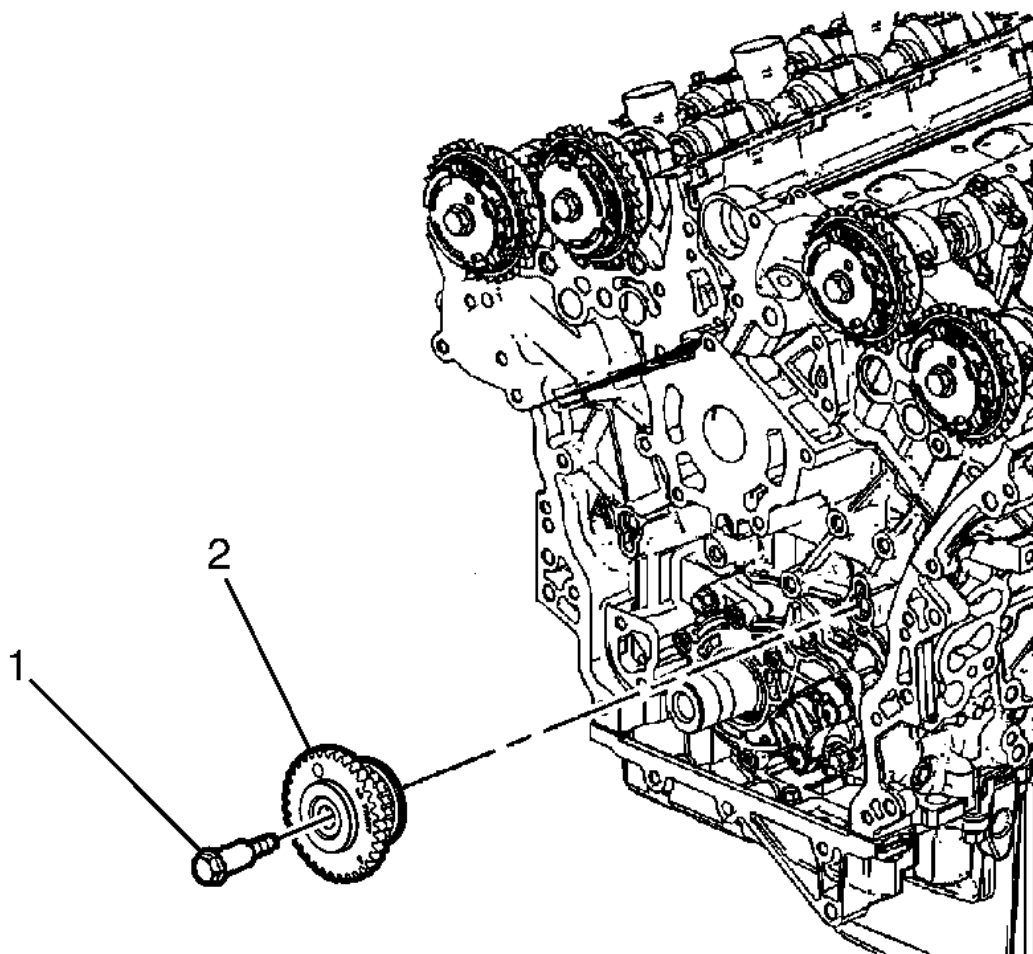
2. Install the crankshaft sprocket (1) on to the nose of the crankshaft (2).
3. Align the keyway in the crankshaft sprocket (1) with the key in the crankshaft (2).
4. Slide the crankshaft sprocket on the crankshaft (2) nose until the crankshaft sprocket (1) contacts the step in the crankshaft (2).
5. If necessary, align the crankshaft sprocket to the stage one timing drive assembly position using the **EN 46111** . See **Special Tools** . Refer to **Camshaft Timing Drive Chain Alignment Diagram** .

**CAMSHAFT INTERMEDIATE DRIVE CHAIN IDLER INSTALLATION - LEFT SIDE**

**Fig. 39: View Of Left Camshaft Intermediate Drive Chain Idler & Recessed Hub**  
Courtesy of GENERAL MOTORS CORP.

1. Make sure that the left camshaft intermediate drive chain idler (1) is being installed. The recessed hub (2) and the larger sprocket of the left camshaft intermediate drive chain idler is installed outward. The raised hub and the smaller sprocket of the left camshaft intermediate drive chain idler is installed towards the cylinder block.





**Fig. 40: Identifying Left Camshaft Intermediate Drive Chain Idler To Cylinder Block Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

2. Install the left camshaft intermediate drive chain idler (2).

**CAUTION: Refer to Fastener Caution .**

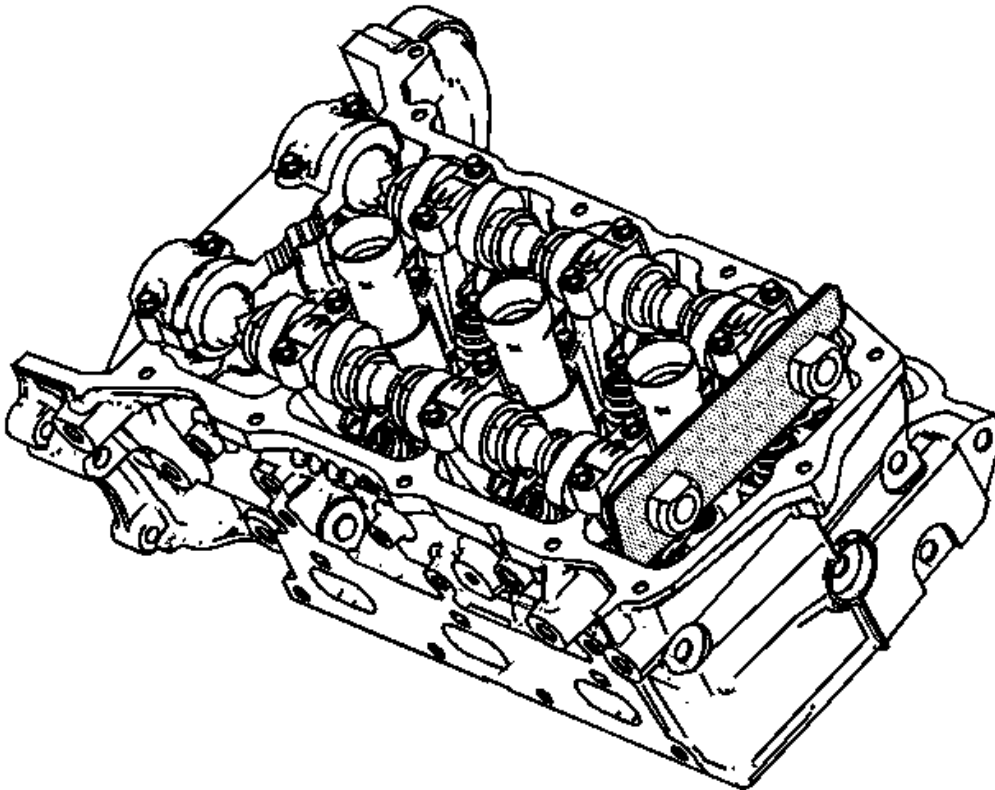
3. Install the camshaft intermediate drive chain idler to cylinder block retaining bolt (1) and tighten to 58 N.m (43 lb ft).

## SECONDARY CAMSHAFT DRIVE CHAIN INSTALLATION - LEFT SIDE (LY7 OR LP1)

### Special Tools

- **EN-48383** Camshaft Retaining Tools
- **EN-48589** Crankshaft Rotation Socket

#### Installation



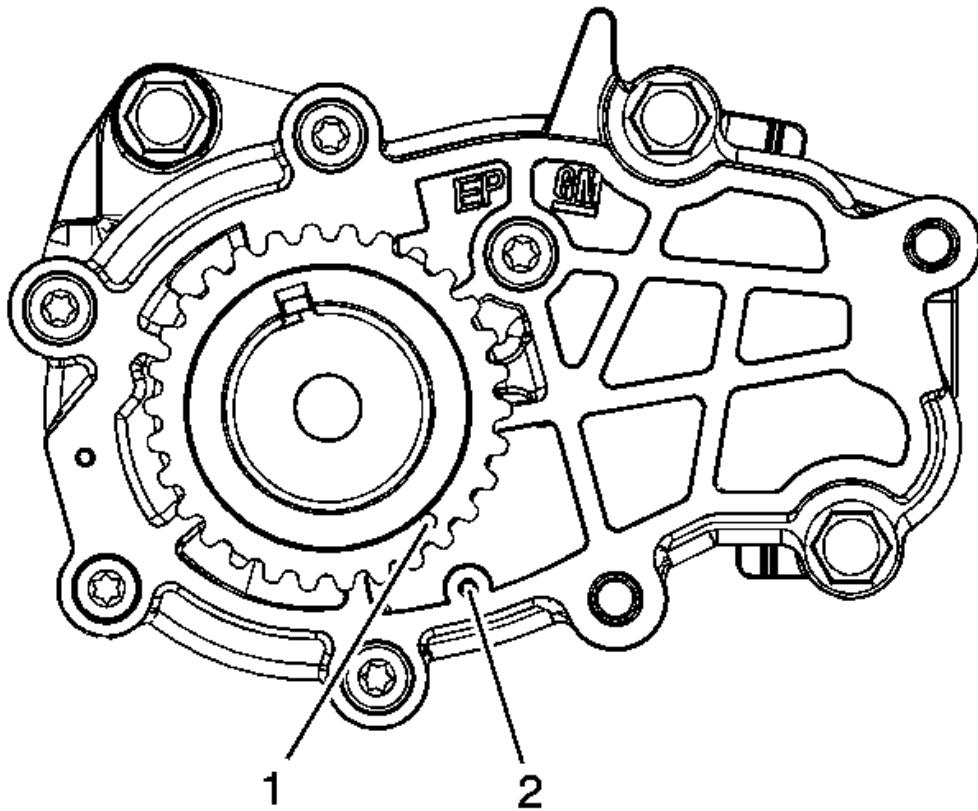
**Fig. 41: Installing EN 46105-1**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** There should be no need to rotate the camshaft more than 10 degrees.  
Using the hex cast into the camshaft rotate the camshaft in order to install the EN-48383 .

1. Install the EN 48383-1 onto the rear of the left camshafts.

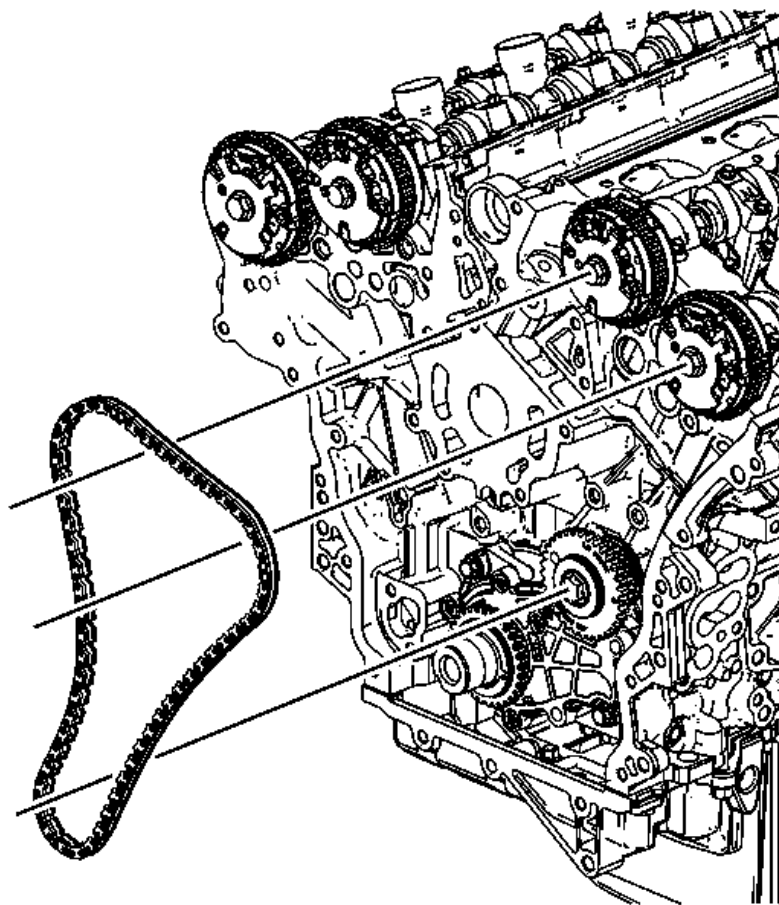
**IMPORTANT:** All camshafts must be locked in place before installation of any camshaft drive chains.

2. Ensure that the EN 48383-1 is fully seated onto the camshafts.



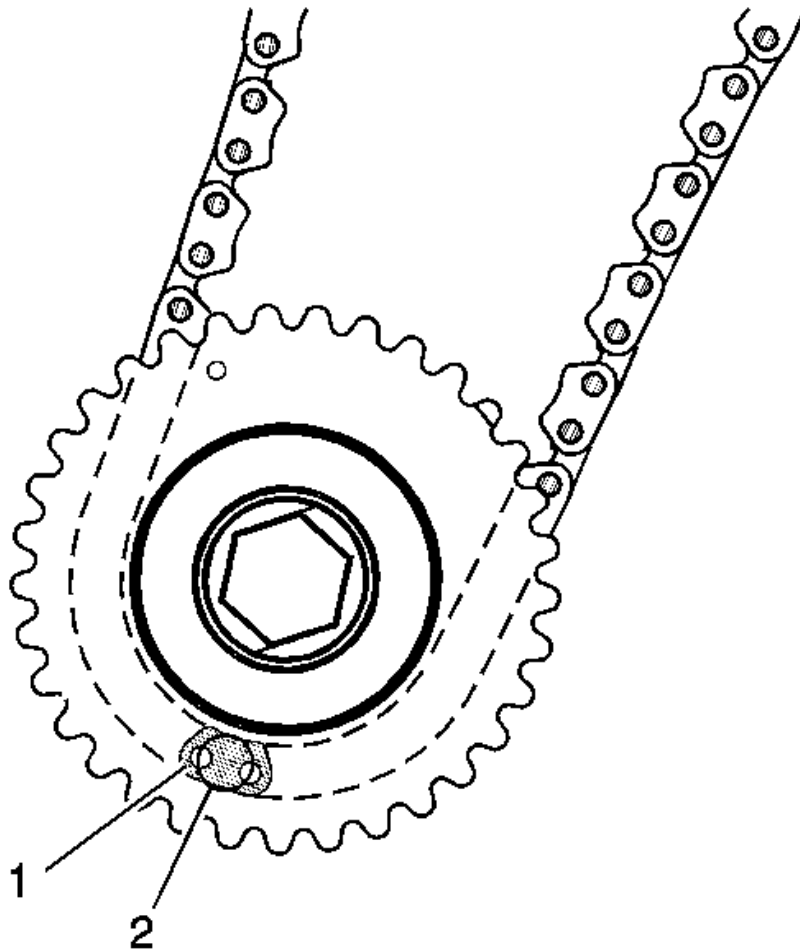
**Fig. 42: View Of Crankshaft Sprocket Timing Mark & Oil Pump Cover**  
Courtesy of GENERAL MOTORS CORP.

3. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (1) aligned to the stage one timing mark on the oil pump cover (2) using the **EN-48589** . Refer to **Camshaft Timing Drive Chain Alignment Diagram** .



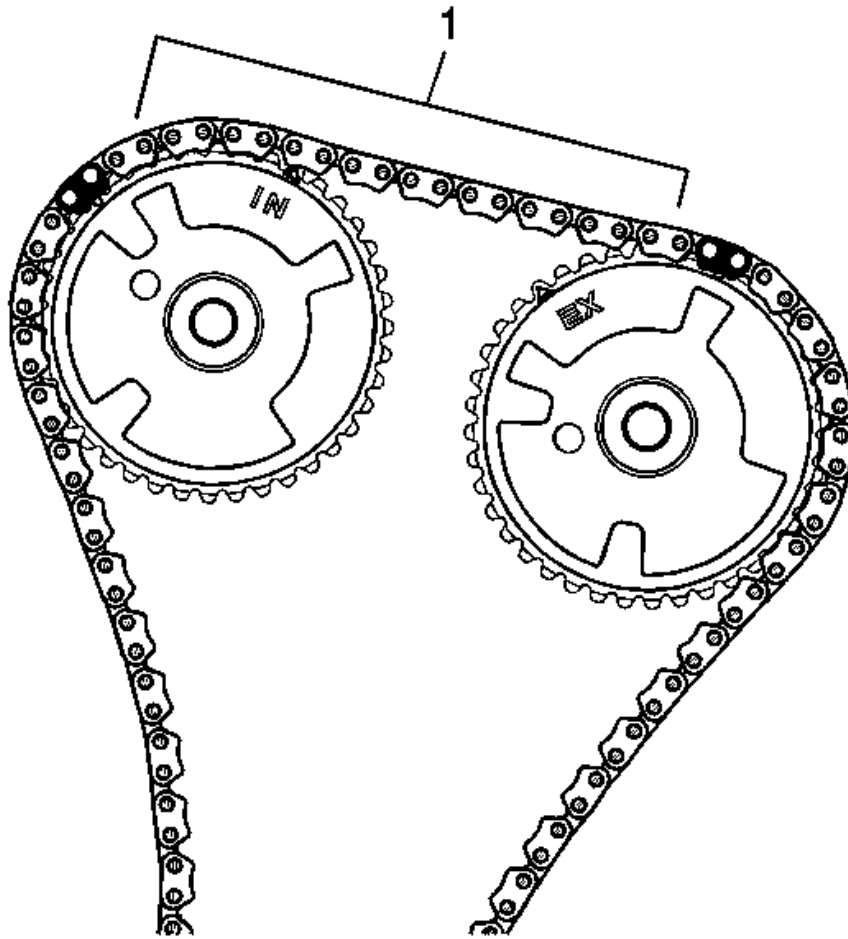
**Fig. 43: Identifying Secondary Camshaft Drive Chain**  
Courtesy of GENERAL MOTORS CORP.

4. Install the left secondary camshaft drive chain.



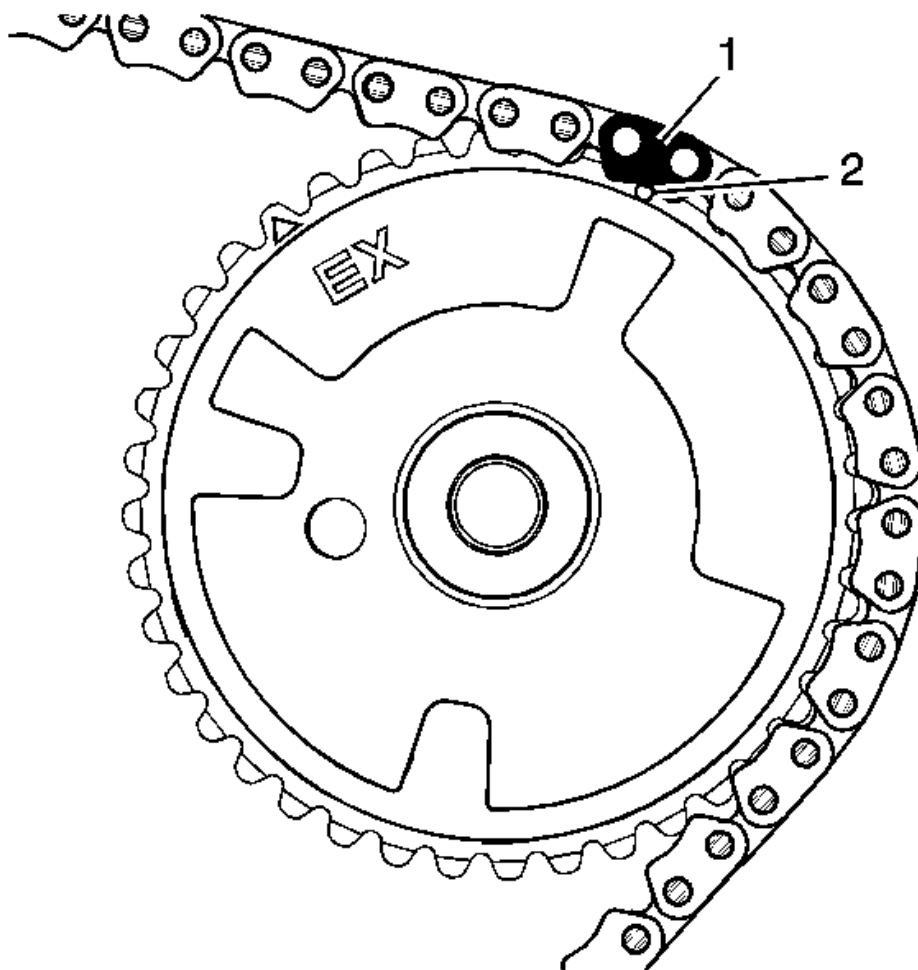
**Fig. 44: View Of Timing Camshaft Drive Chain Link And Alignment Access Hole**  
Courtesy of GENERAL MOTORS CORP.

5. Place the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler with the timing camshaft drive chain link (1) aligned to the alignment access hole (2) made in the left camshaft intermediate drive chain idler outer sprocket.



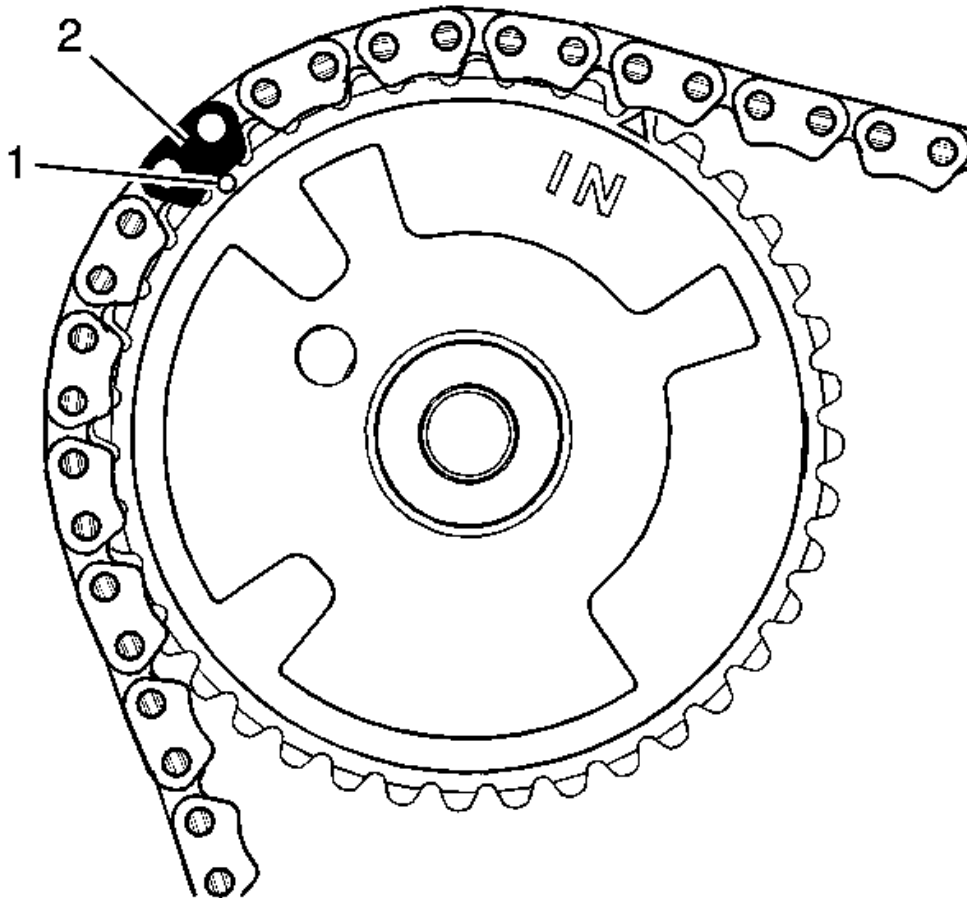
**Fig. 45: View Of Camshaft Drive Chain Links**  
Courtesy of GENERAL MOTORS CORP.

6. Wrap the secondary camshaft drive chain around both left actuator drive sprockets.
7. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.



**Fig. 46: View Of Camshaft Marks**  
Courtesy of GENERAL MOTORS CORP.

8. Align the left exhaust camshaft position actuator sprocket alignment circle mark (2) with the timing camshaft drive chain link (1).

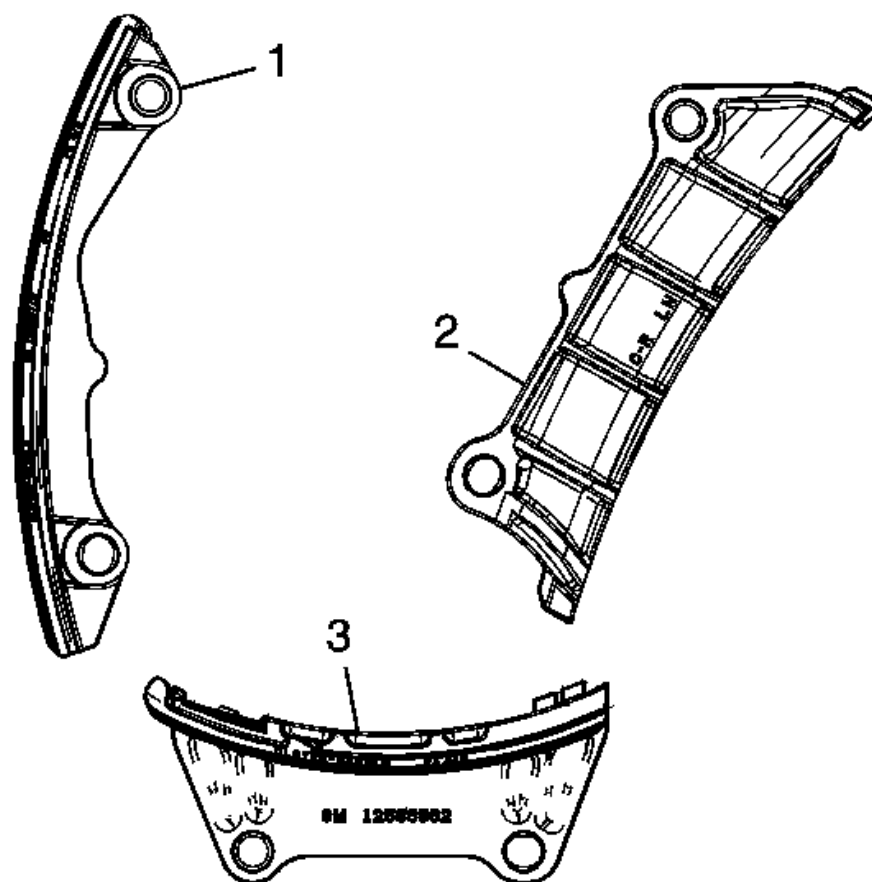


**Fig. 47: View Of Camshaft Marks**  
 Courtesy of GENERAL MOTORS CORP.

9. Align the left intake camshaft position actuator sprocket alignment circle mark (1) with the timing camshaft drive chain link (2).

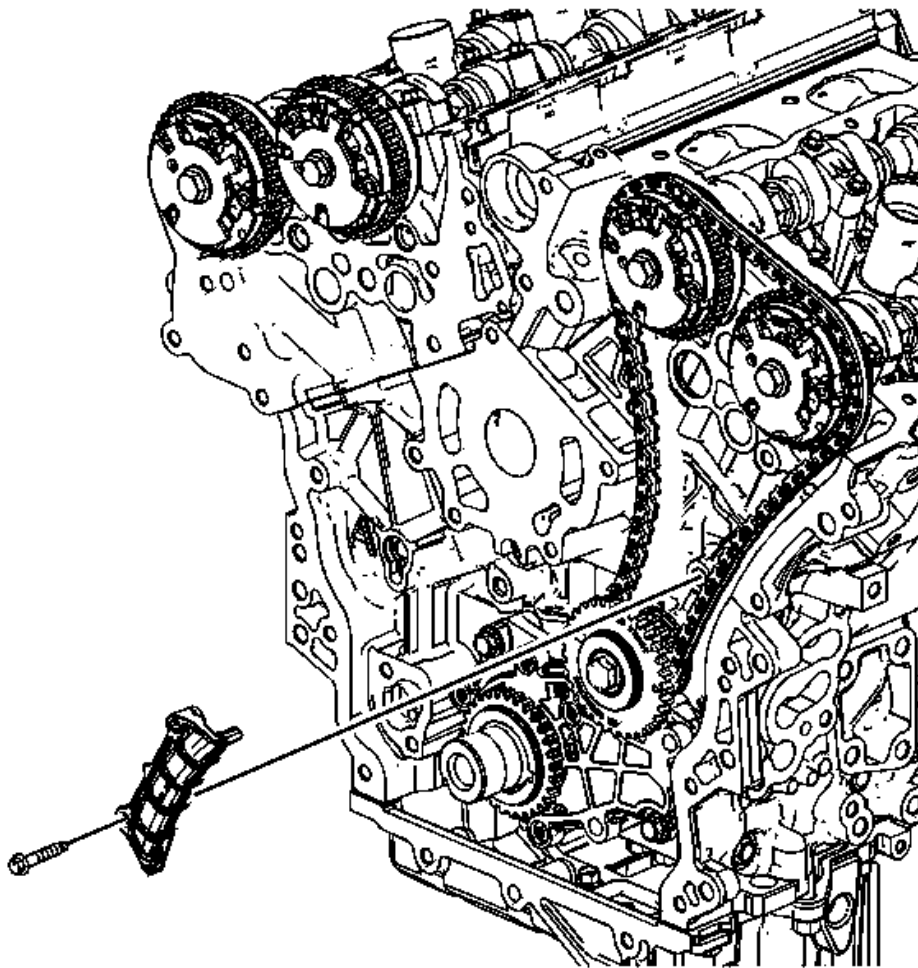
#### SECONDARY CAMSHAFT DRIVE CHAIN GUIDE INSTALLATION - LEFT SIDE





**Fig. 48: View Of Camshaft Drive Chain Guide**  
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left secondary camshaft drive chain guide (2) is being installed.



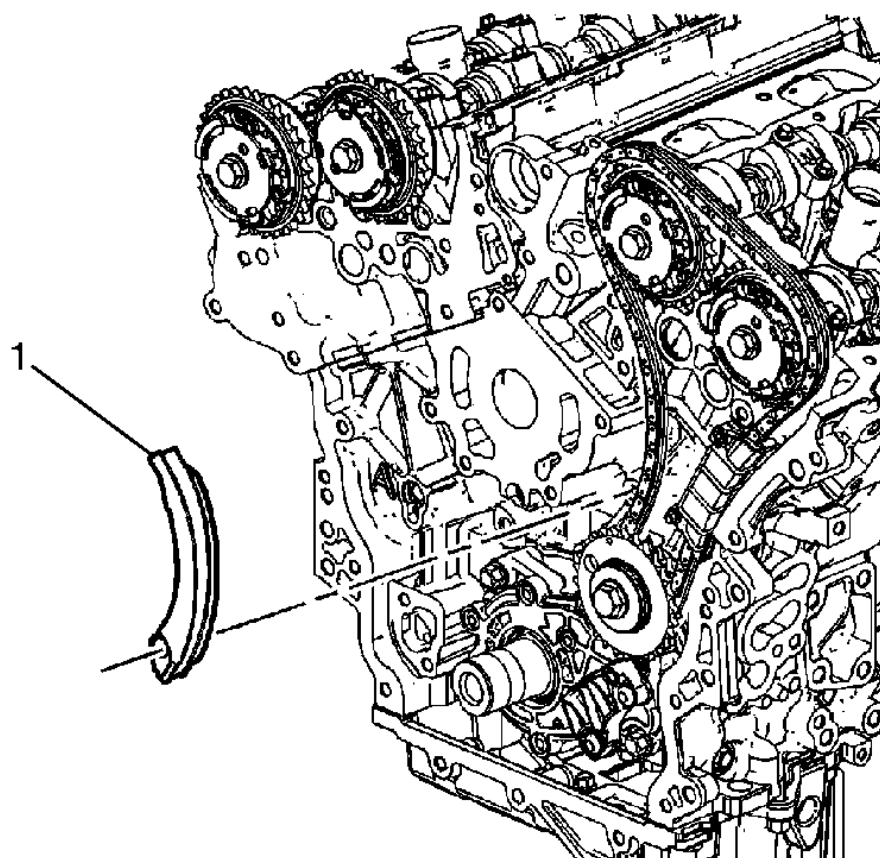
**Fig. 49: View Of Secondary Camshaft Drive Chain Guide Bolts**  
Courtesy of GENERAL MOTORS CORP.

2. Position the left secondary camshaft drive chain guide.

**CAUTION: Refer to Fastener Caution .**

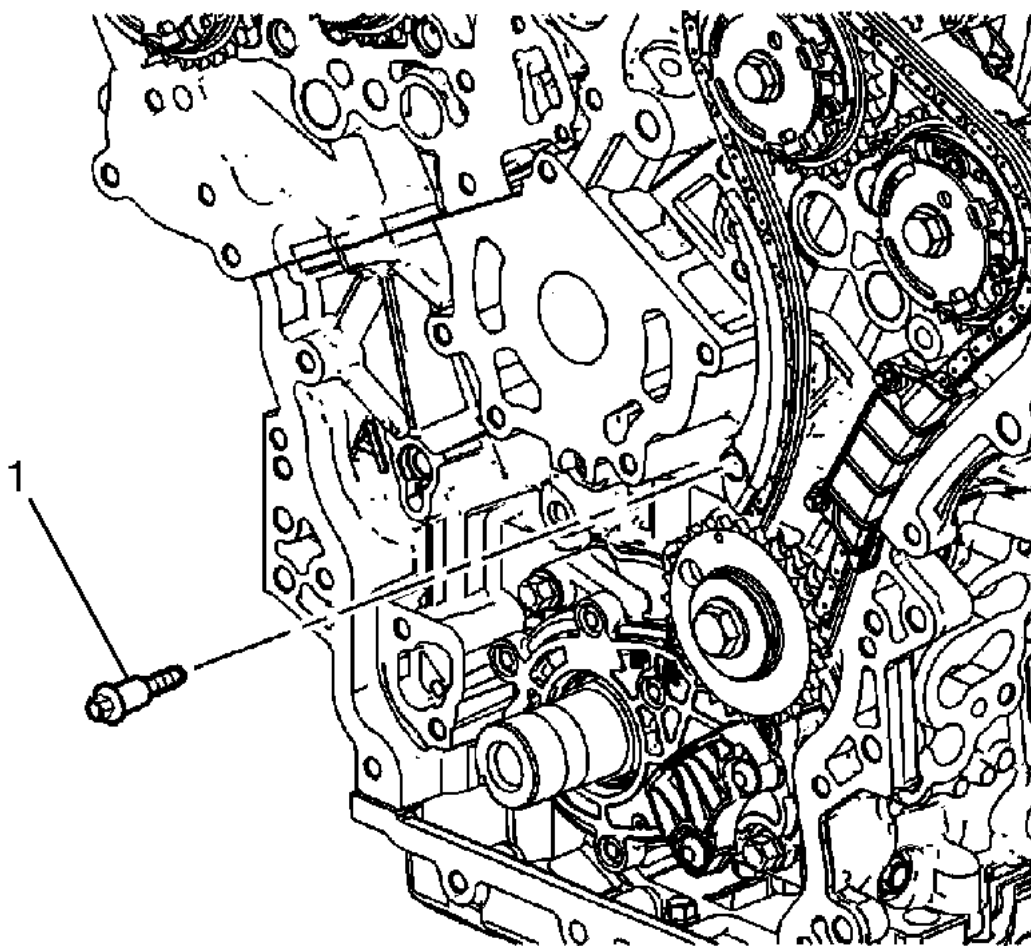
3. Install the secondary camshaft drive chain guide bolts and tighten to 23 N.m (17 lb ft).

#### **SECONDARY CAMSHAFT DRIVE CHAIN SHOE INSTALLATION - LEFT SIDE**



**Fig. 50: View Of Left Secondary Camshaft Drive Chain Shoe**  
**Courtesy of GENERAL MOTORS CORP.**

1. Install the left secondary camshaft drive chain shoe (1).



**Fig. 51: Identifying Left Secondary Camshaft Drive Chain Shoe To Cylinder Block Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

2. Install the secondary camshaft drive chain shoe to cylinder block retaining bolt (1) and tighten to 23 N.m (17 lb ft).

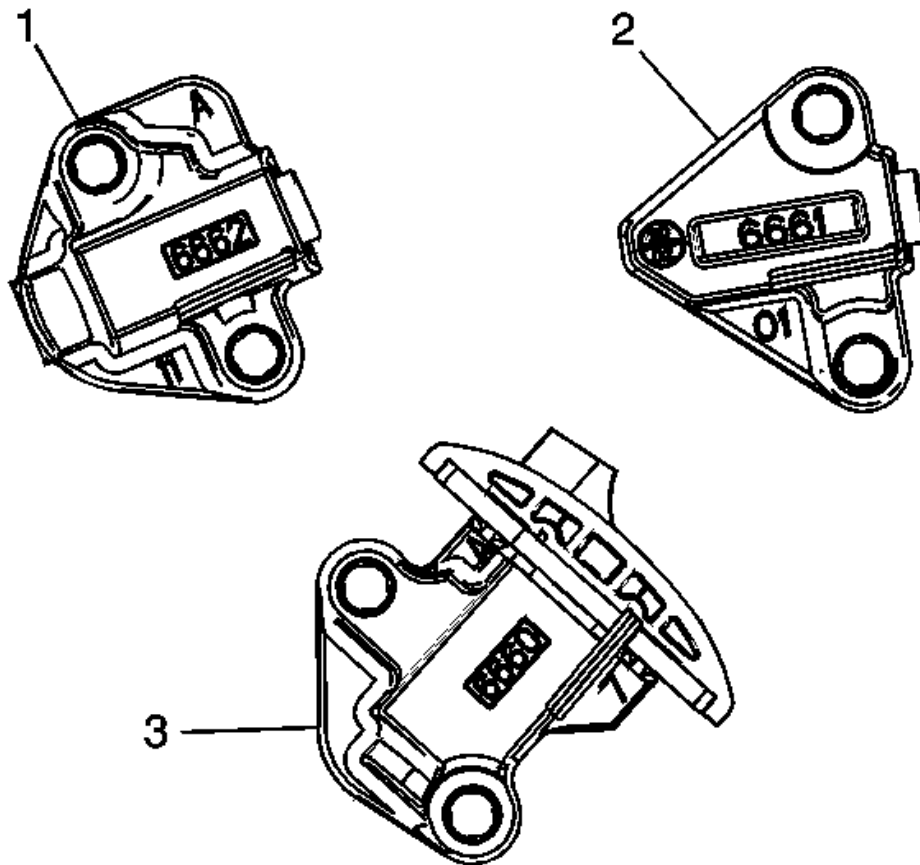
## SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER INSTALLATION - LEFT SIDE

### Special Tools

- **EN-46112:** Tensioner Retraction Pins
- **J-45027:** Tensioner Tool

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

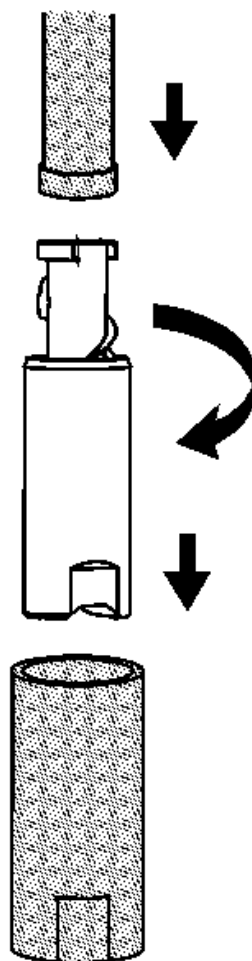
### Installation



**Fig. 52: Identifying Left & Right Secondary Camshaft Drive Chain Tensioner & Primary Camshaft Drive Chain Tensioner**

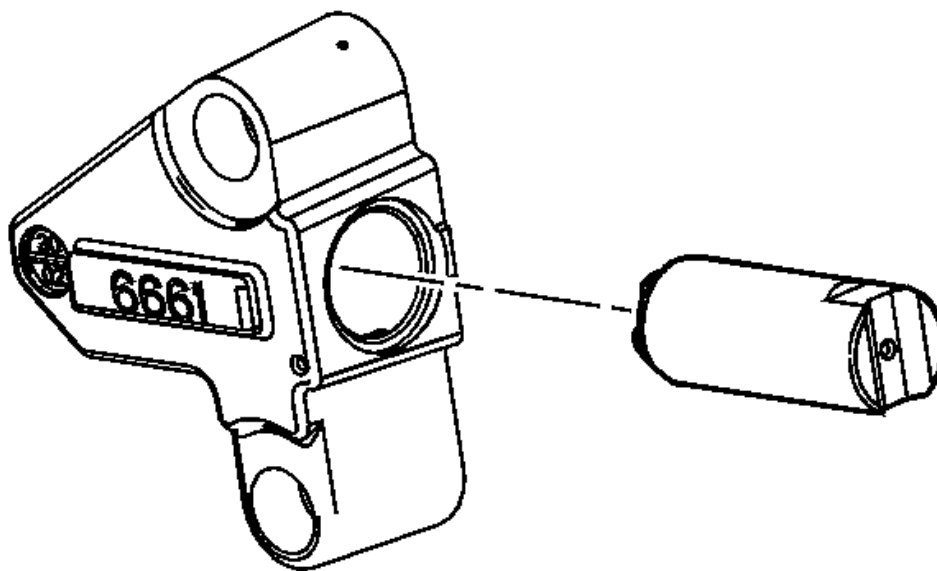
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the left secondary camshaft drive chain tensioner (2) is being installed.



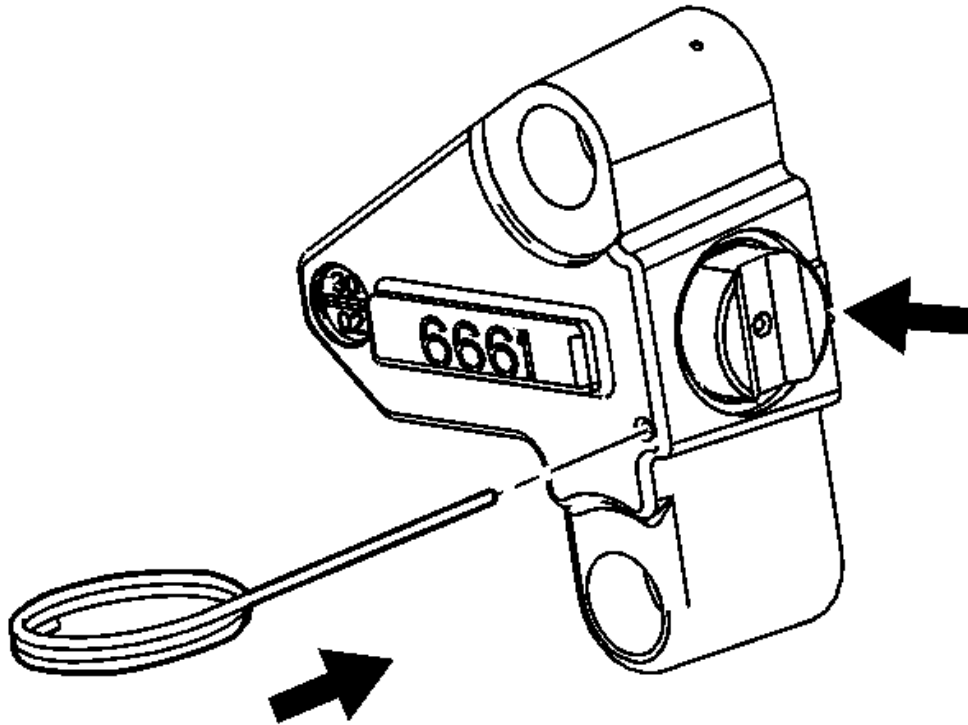
**Fig. 53: Resetting Left Secondary Camshaft Drive Chain Tensioner Plunger With J 45027**  
Courtesy of GENERAL MOTORS CORP.

2. Using the **J-45027**: tool, reset the left secondary camshaft drive chain tensioner plunger.



**Fig. 54: Installing Plunger Into Left Secondary Camshaft Drive Chain Tensioner Body**  
Courtesy of GENERAL MOTORS CORP.

3. Install the plunger into the left secondary camshaft drive chain tensioner body.

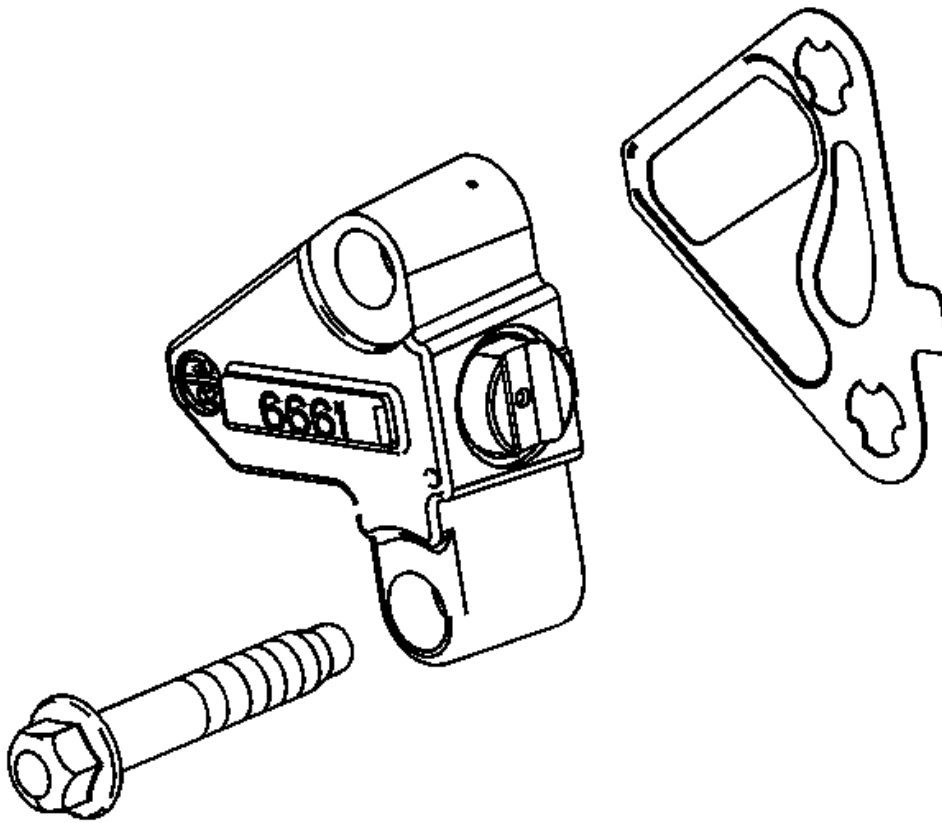


**Fig. 55: Inserting EN 46112 Into Access Hole In Side Of Left Secondary Camshaft Drive Chain Tensioner Body**

Courtesy of GENERAL MOTORS CORP.

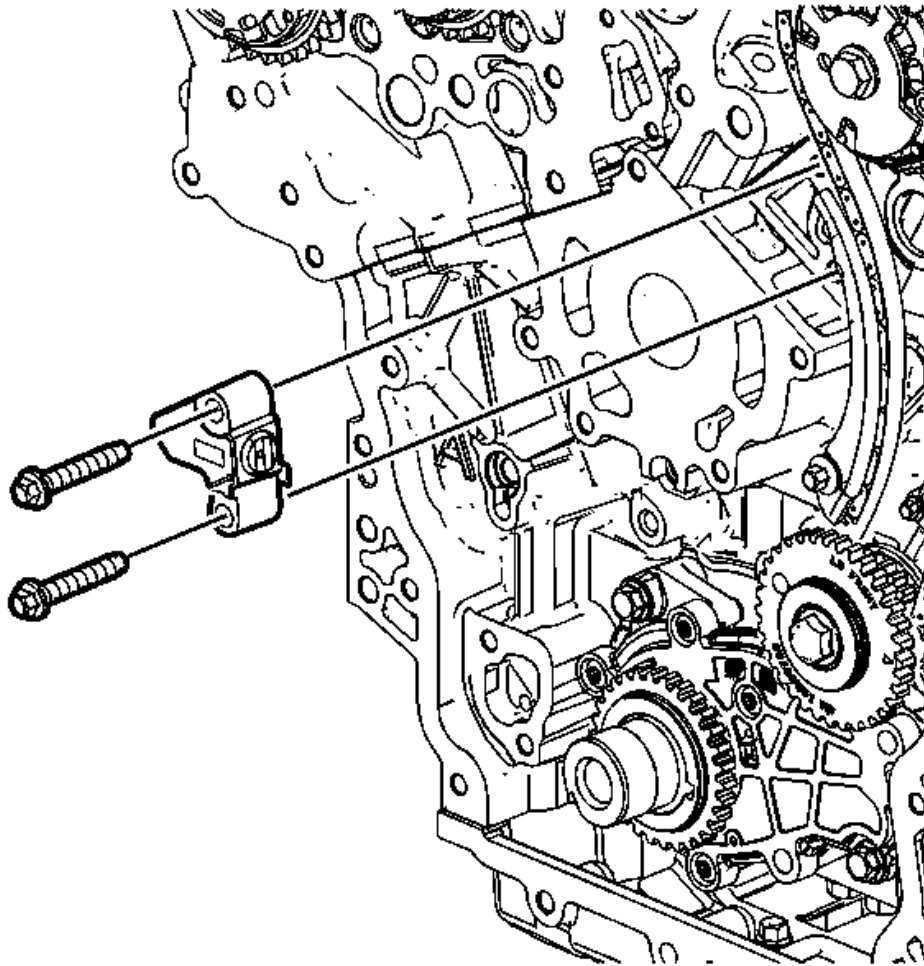
4. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the **EN-46112**: pins into the access hole in the side of the left secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.





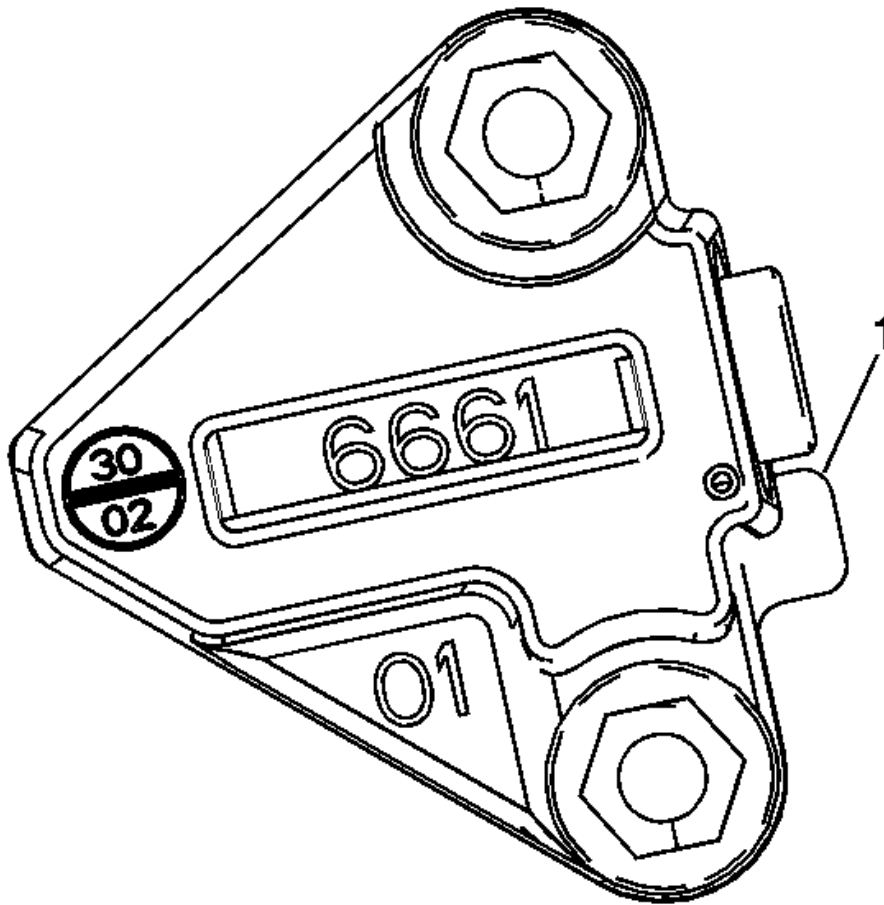
**Fig. 56: Identifying Left Secondary Camshaft Drive Chain Tensioner Gasket**  
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW left secondary camshaft drive chain tensioner gasket to the left secondary camshaft drive chain tensioner.
7. Install the left secondary camshaft drive chain tensioner bolts through the left secondary camshaft drive chain tensioner and gasket.
8. Ensure the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.



**Fig. 57: View Of Secondary Camshaft Drive Chain Tensioner And Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Place the left secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.



**Fig. 58: Locating Left Secondary Camshaft Drive Chain Tensioner Gasket Tab**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION: Refer to Fastener Caution .**

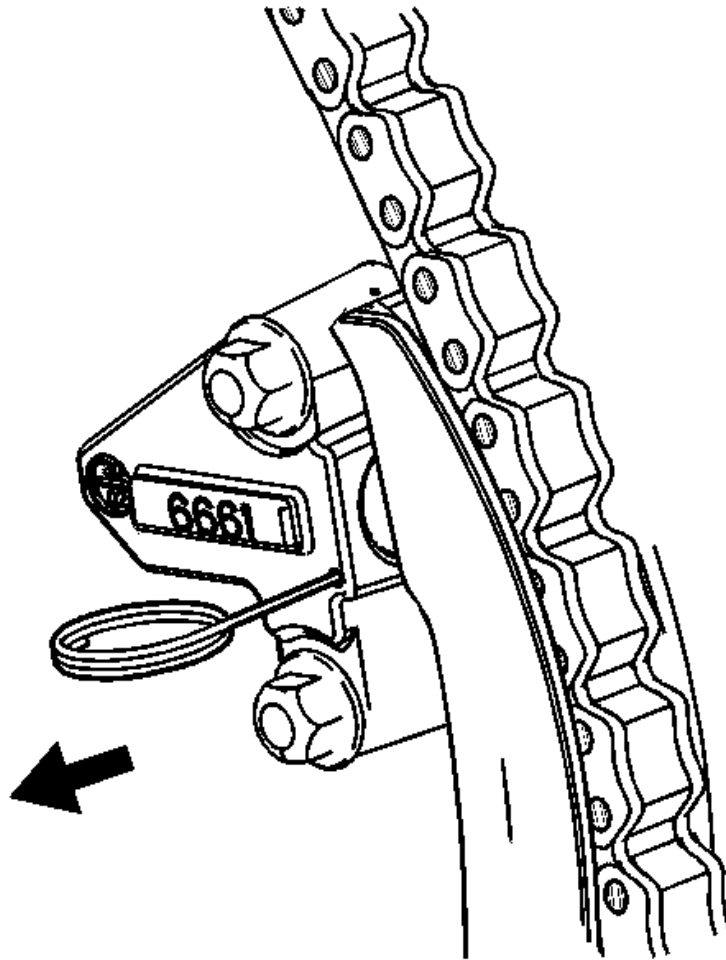
10. Verify the proper placement of the left secondary camshaft drive chain tensioner gasket tab (1).

1. First Pass

Tighten the left secondary camshaft drive chain tensioner bolts to 5 N.m (44 lb in) .

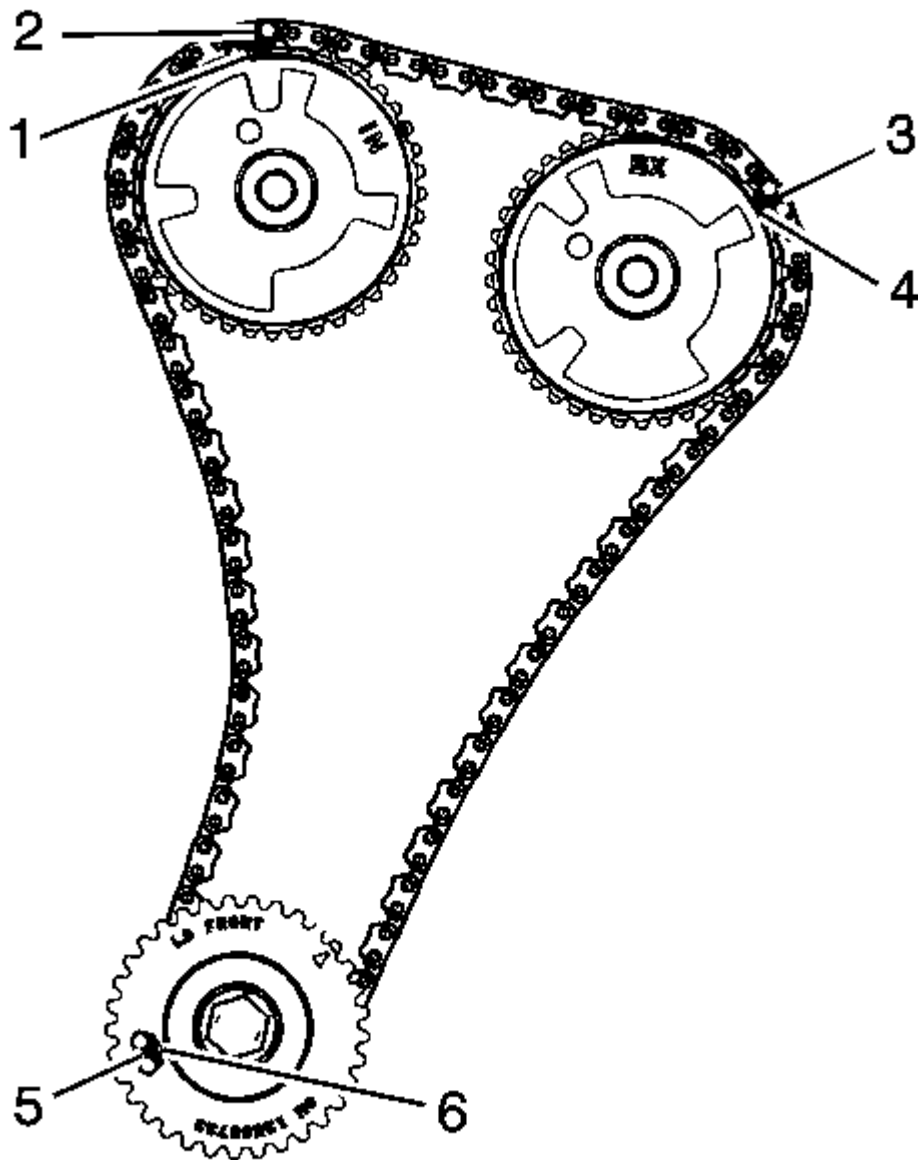
2. Final Pass

Tighten the left secondary camshaft drive chain tensioner bolts to 23 N.m (17 lb ft) .



**Fig. 59: View Of Left Secondary Camshaft Drive Chain Tensioner**  
Courtesy of GENERAL MOTORS CORP.

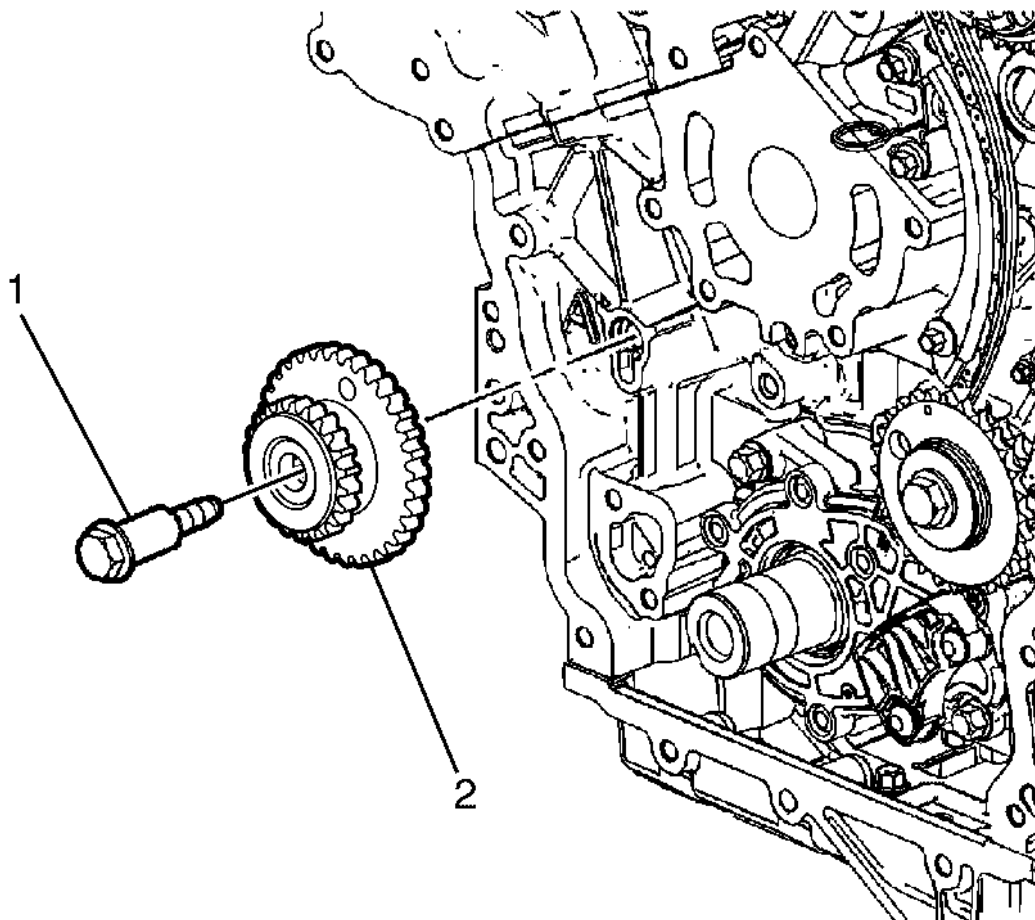
11. Release the left secondary camshaft drive chain tensioner by pulling out the **EN-46112:** pins and unlocking the tensioner plunger.



**Fig. 60: View Of Left Secondary Camshaft Drive Chain Timing Mark**  
 Courtesy of GENERAL MOTORS CORP.

12. Verify the left secondary camshaft drive chain timing mark alignments (1-6). Also refer to **Camshaft Timing Drive Chain Alignment Diagram** - Stage One.

#### **CAMSHAFT INTERMEDIATE DRIVE CHAIN IDLER INSTALLATION - RIGHT SIDE**



**Fig. 61: Identifying Right Camshaft Intermediate Drive Chain Idler & Bolt**  
Courtesy of GENERAL MOTORS CORP.

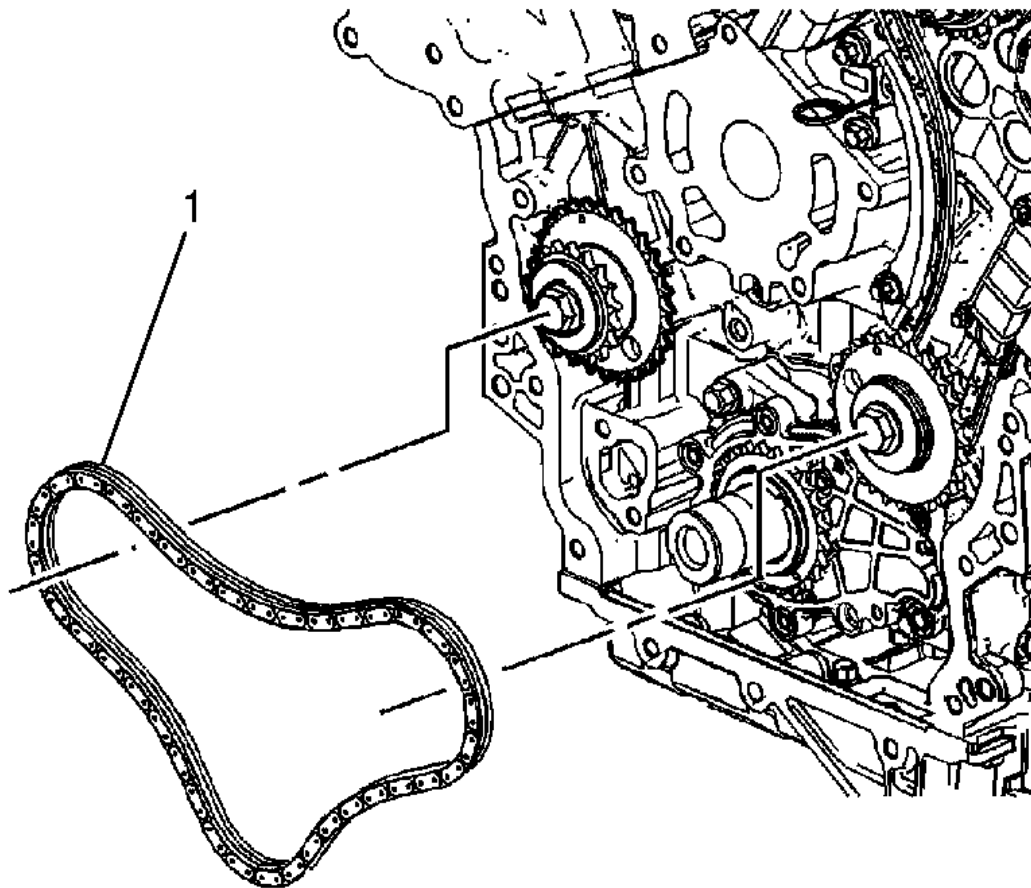
**NOTE:** The recessed hub and the smaller sprocket of the right camshaft intermediate drive chain idler (2) is installed outward. The raised hub and the larger sprocket of the right camshaft intermediate drive chain idler (2) is installed towards the block.

1. Install the right camshaft intermediate drive chain idler (2).

**CAUTION:** Refer to Fastener Caution .

2. Install the camshaft intermediate drive chain idler bolt (1) and tighten to 58 N.m (43 lb ft).

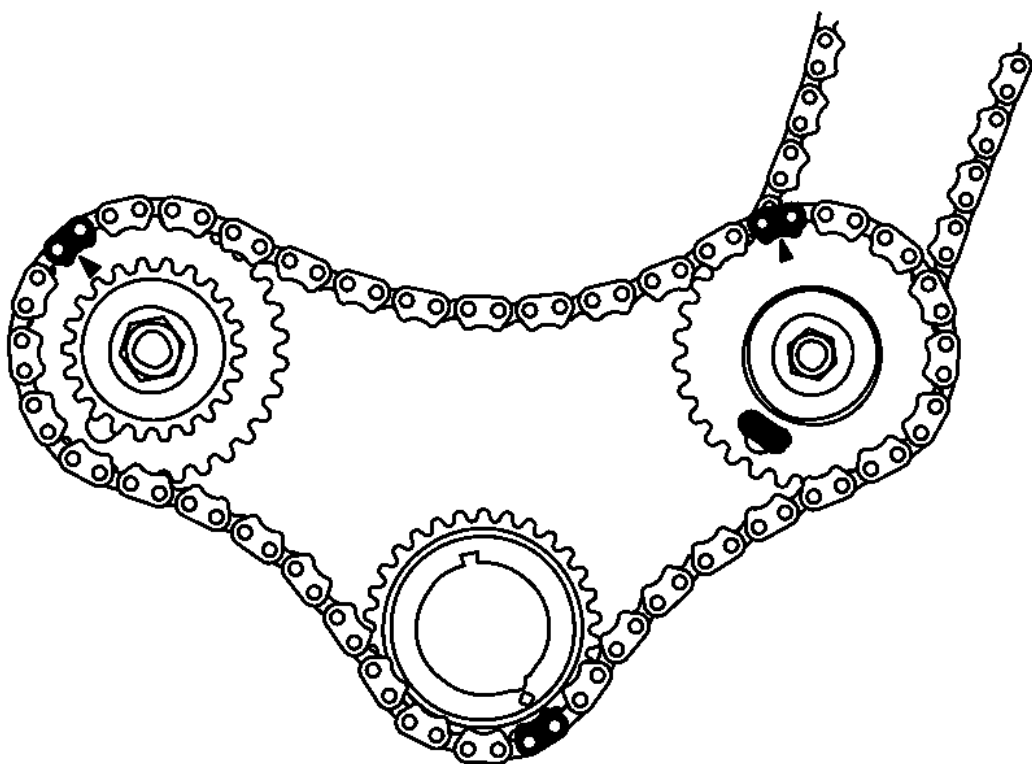
#### PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN INSTALLATION



**Fig. 62: View Of Primary Camshaft Drive Chain**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Ensure that the crankshaft is in the stage one timing drive assembly position.

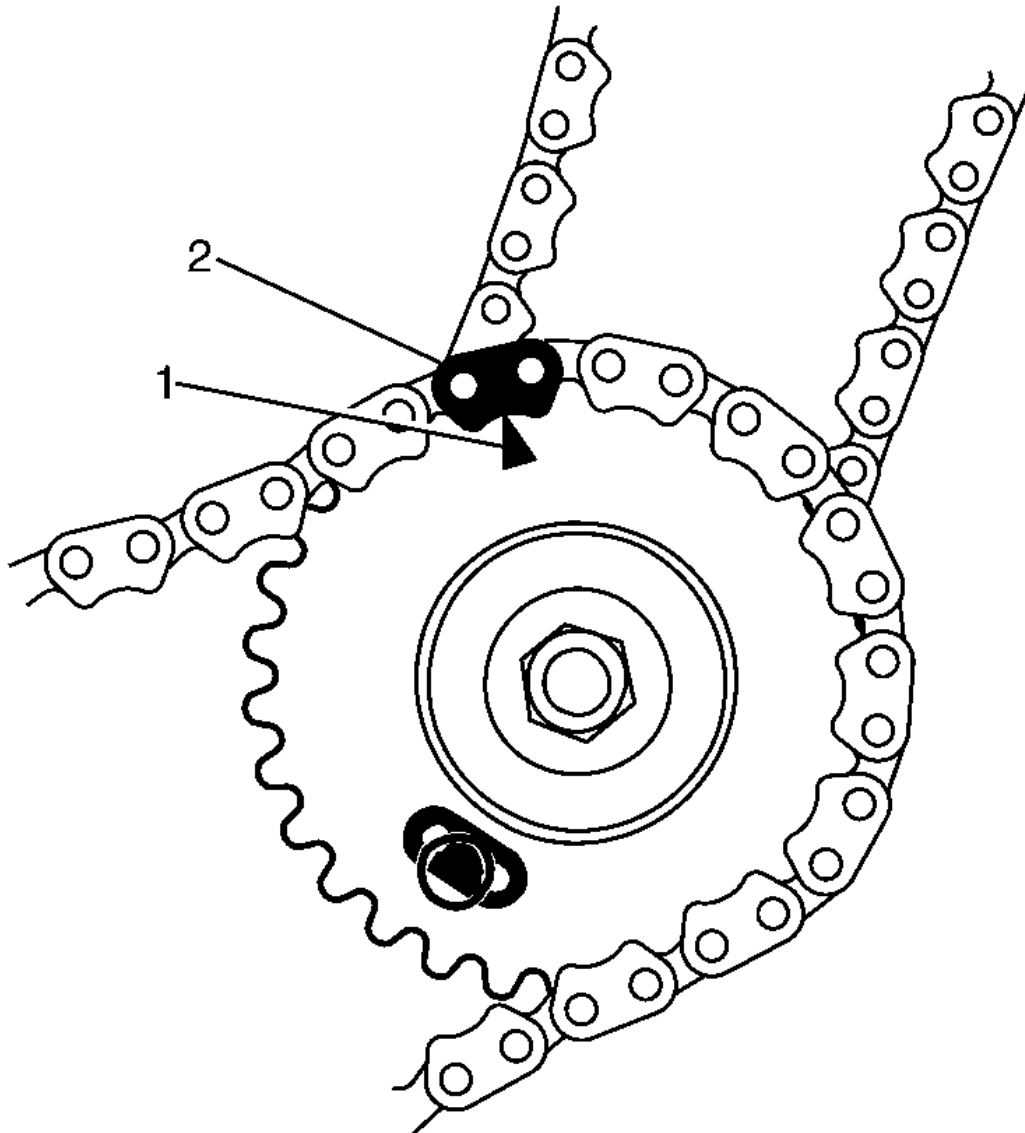
1. Install the primary camshaft drive chain (1).



**Fig. 63: View Of Primary Camshaft Drive Chain**  
**Courtesy of GENERAL MOTORS CORP.**

2. Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket.

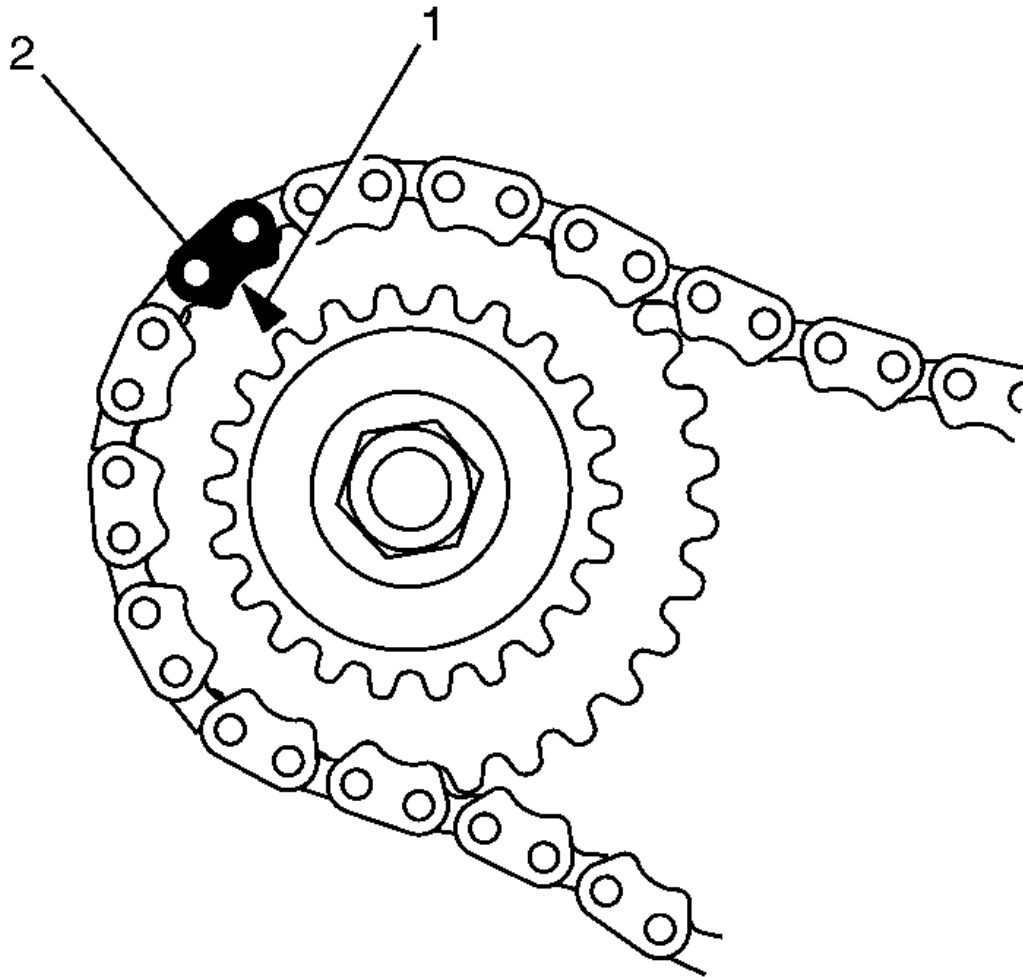




**Fig. 64: View Of Left Camshaft Intermediate Drive Chain Idler Timing Mark & Timing Camshaft Drive Chain Link**

**Courtesy of GENERAL MOTORS CORP.**

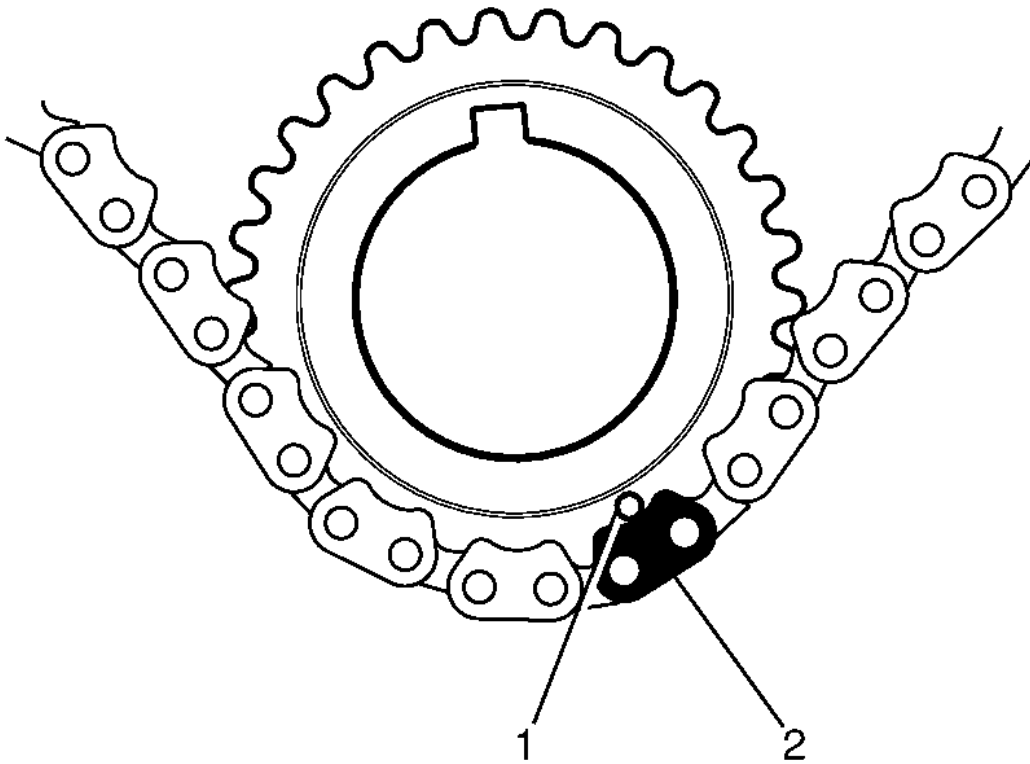
3. The left camshaft intermediate drive chain idler timing mark (1) will align with a timing camshaft drive chain link (2).



**Fig. 65: View Of Right Camshaft Intermediate Drive Chain Idler Timing Mark & Timing Camshaft Drive Chain Link**

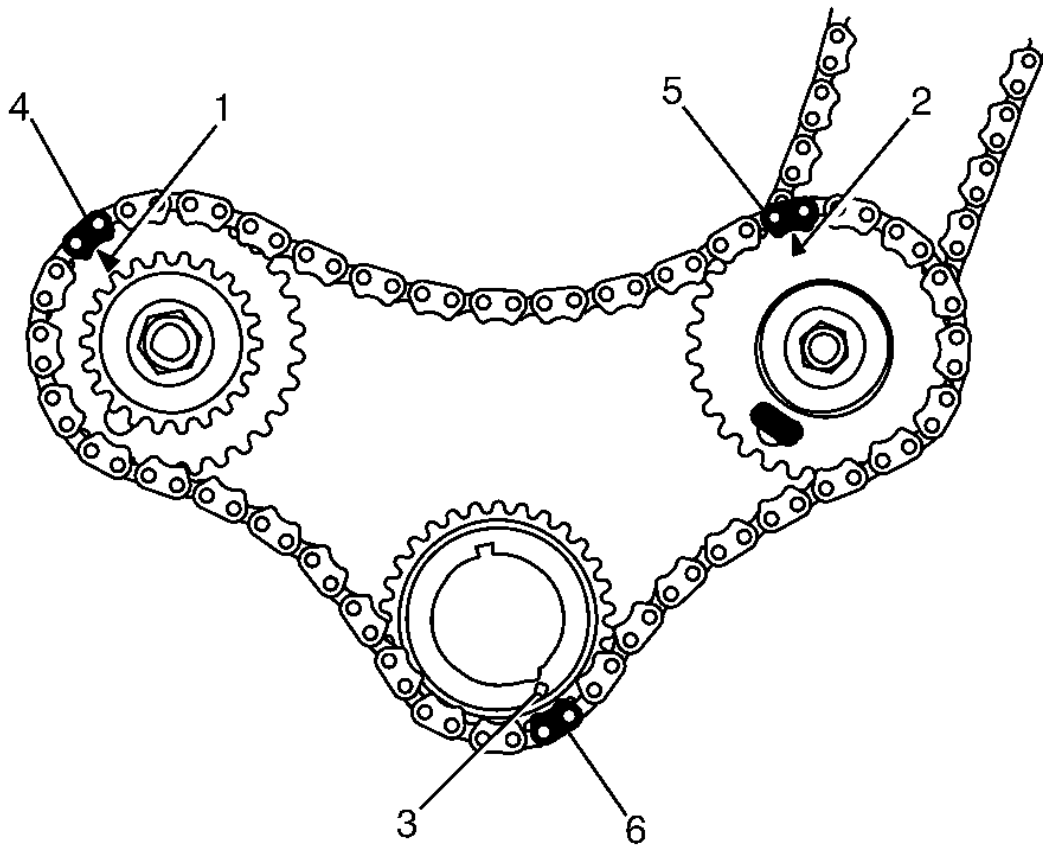
**Courtesy of GENERAL MOTORS CORP.**

4. The right camshaft intermediate drive chain idler timing mark (2) will align with a timing camshaft drive chain link (1).



**Fig. 66: Identifying Crankshaft Sprocket Timing Mark & Timing Camshaft Drive Chain Link**  
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft sprocket timing mark (2) will align with a timing camshaft drive chain link (1).



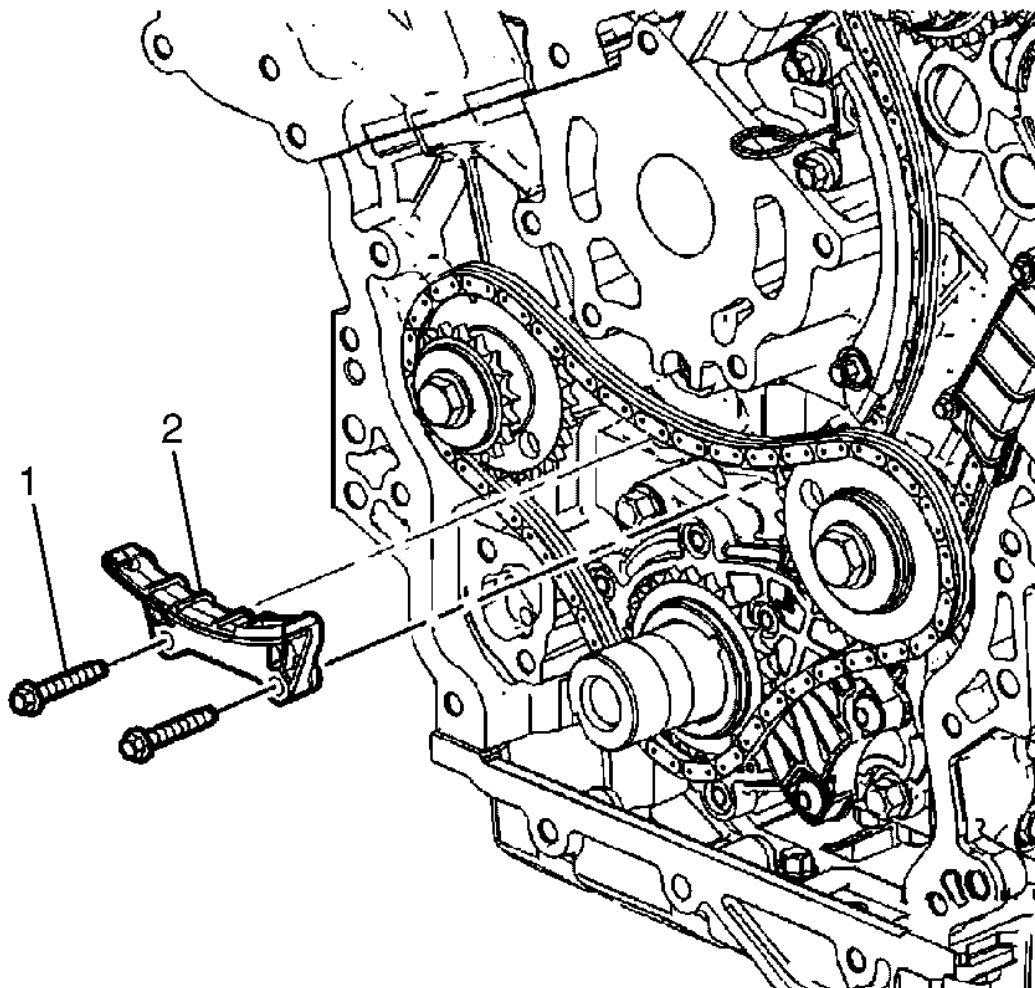
**Fig. 67: View Of Timing Marks & Timing Camshaft Drive Chain Links**  
Courtesy of GENERAL MOTORS CORP.

6. Ensure all the timing marks (2, 3, 6) are properly aligned with the timing camshaft drive chain links (1, 4, 5).

#### **PRIMARY TIMING CHAIN GUIDE INSTALLATION - LOWER**

DO NOT remove the primary camshaft drive chain lower guide. The primary camshaft drive chain lower guide is not serviceable separately. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

#### **PRIMARY TIMING CHAIN GUIDE INSTALLATION - UPPER**



**Fig. 68: Identifying Primary Camshaft Drive Chain Upper Guide To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

1. Install the primary camshaft drive chain upper guide (2).

**CAUTION: Refer to Fastener Caution .**

2. Install the primary camshaft drive chain upper guide to cylinder block retaining bolts (1) and tighten to 23 N.m (17 lb ft).

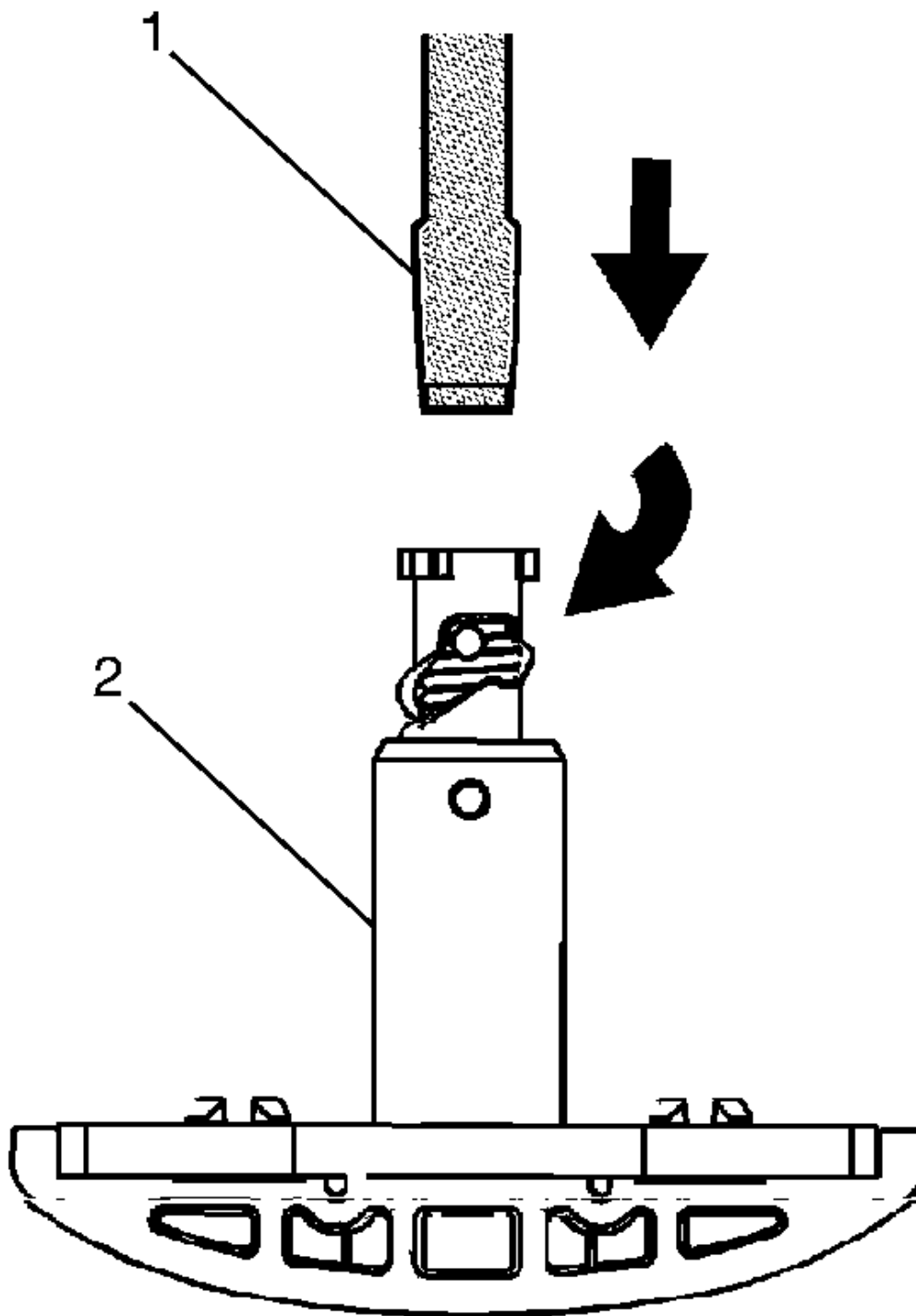
#### **PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER INSTALLATION**

**Special Tools**

- **EN 46105:** Camshaft Locking Tools
- **EN 46111:** Crankshaft Rotation Socket
- **EN 46112:** Tensioner Retraction Pins
- **J 45027:** Tensioner Tool

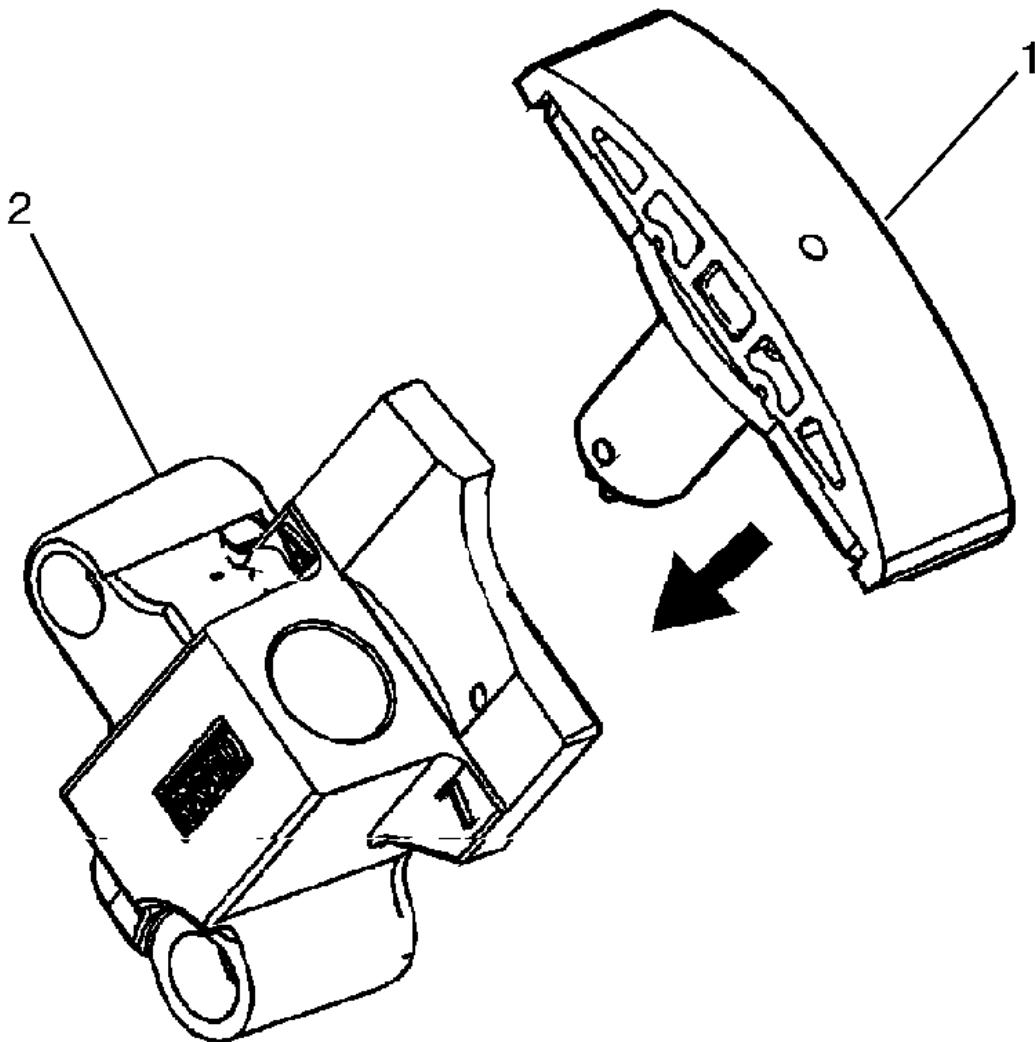
For equivalent regional tools, refer to **Special Tools** .

**Installation**



**Fig. 69: View Of J 45027 & Primary Camshaft Drive Chain Tensioner Plunger**  
Courtesy of GENERAL MOTORS CORP.

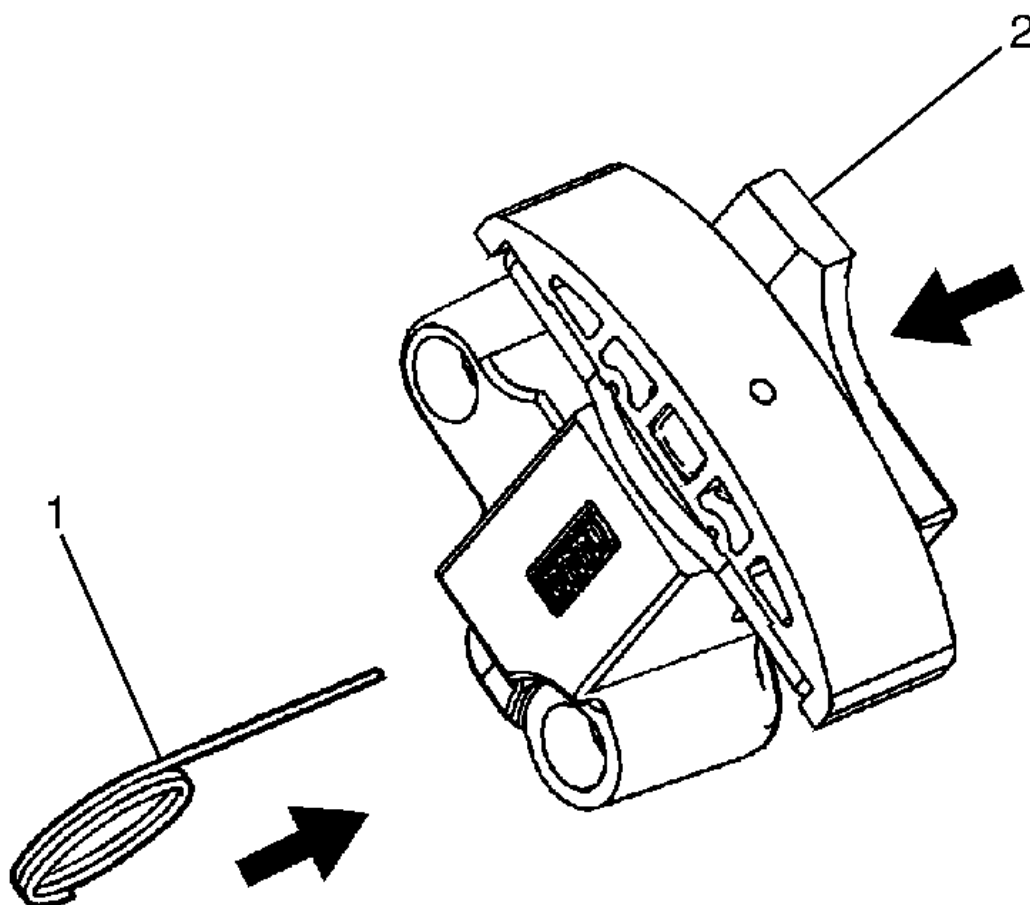
1. Using the **J 45027**: tool (1) reset the primary camshaft drive chain tensioner plunger (2).



**Fig. 70: Identifying Primary Camshaft Drive Chain Tensioner Body & Plunger**  
Courtesy of GENERAL MOTORS CORP.

2. Install the plunger (1) into the primary camshaft drive chain tensioner body (2).

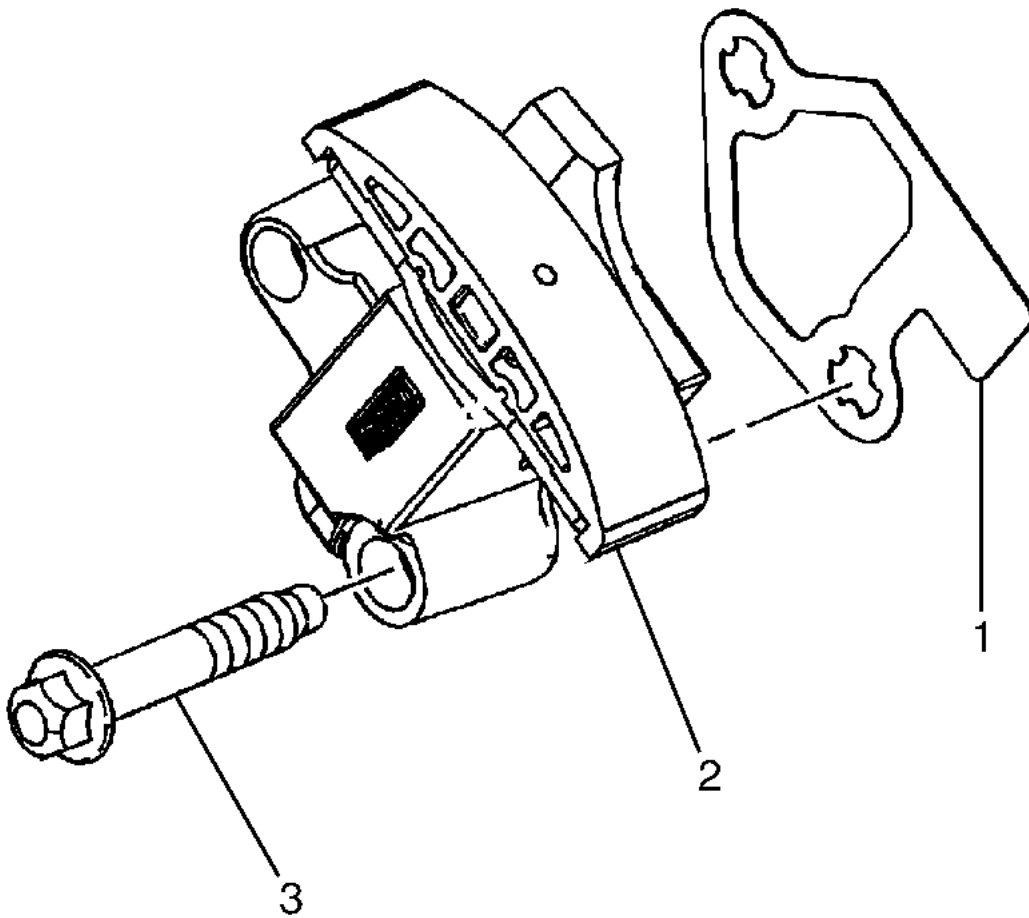




**Fig. 71: View Of EN 46112**

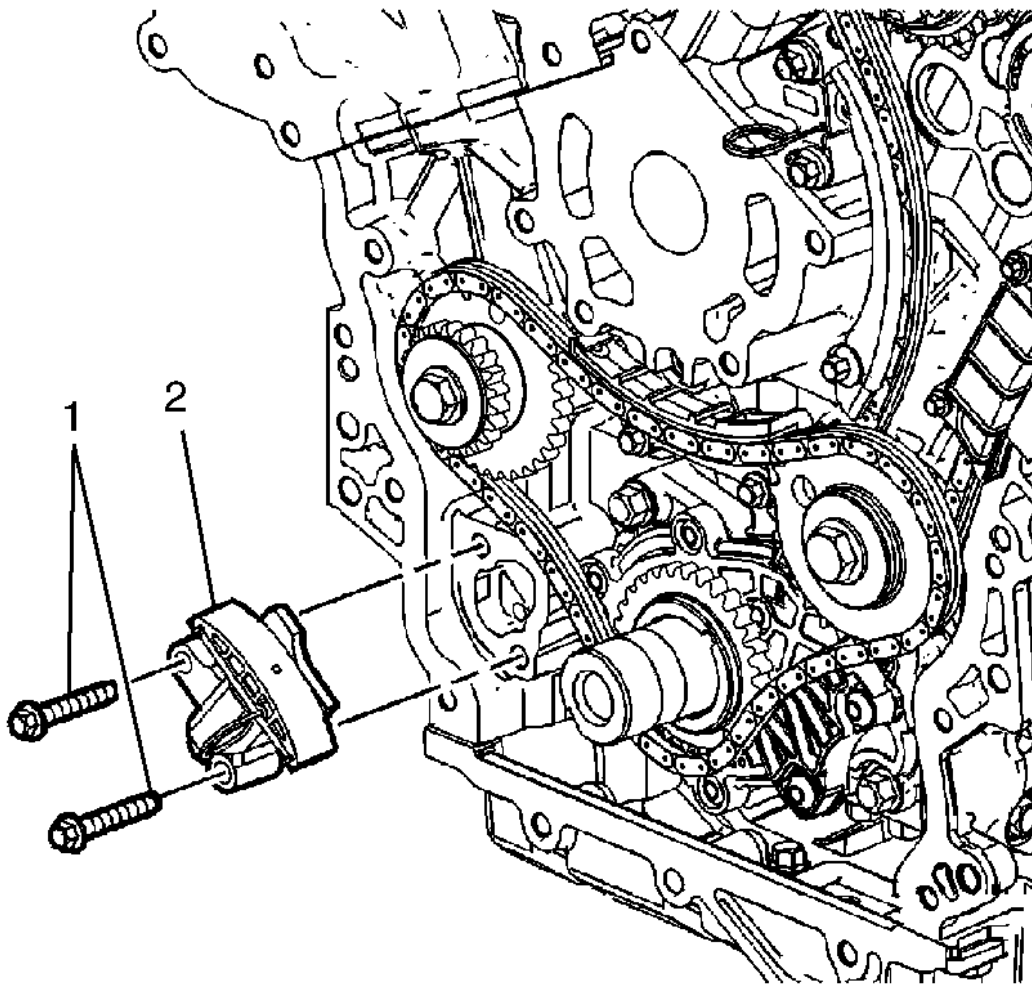
Courtesy of GENERAL MOTORS CORP.

3. Compress the plunger into the body and lock the primary camshaft drive chain tensioner (2) by inserting the EN 46112: pins (1) into the access hole in the side of the primary camshaft drive chain tensioner (2).
4. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.



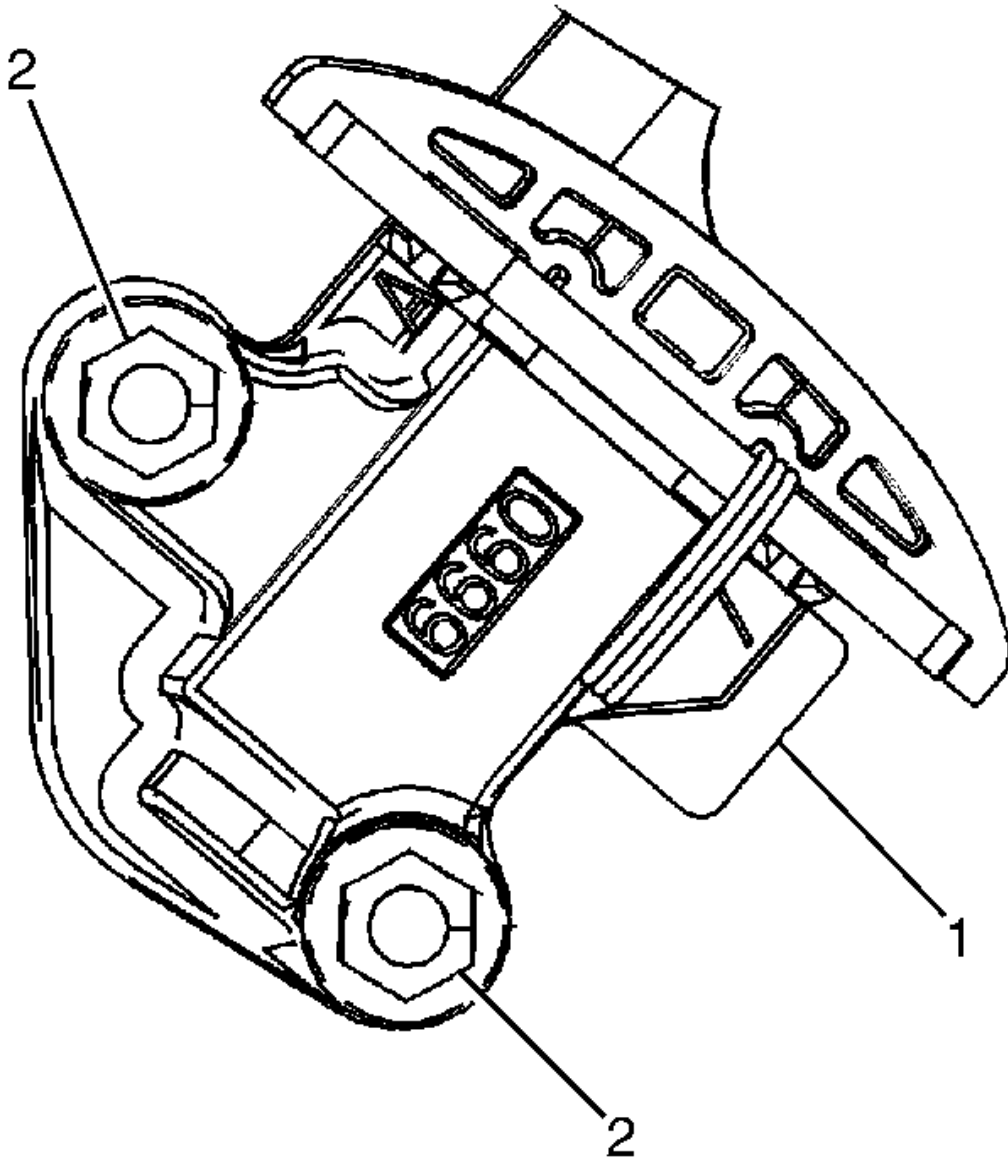
**Fig. 72: View Of Primary Camshaft Drive Chain Tensioner, Gasket & Bolts**  
Courtesy of GENERAL MOTORS CORP.

5. Install a NEW primary camshaft drive chain tensioner gasket (1) to the primary camshaft drive chain tensioner (2).
6. Install the primary camshaft drive chain tensioner bolts (3) through the primary camshaft drive chain tensioner (2) and gasket (1).
7. Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket (1).



**Fig. 73: Identifying Primary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

8. Place the primary camshaft drive chain tensioner (2) into position and loosely install the primary camshaft drive chain tensioner to cylinder block retaining bolts (1).



**Fig. 74: Identifying Primary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

9. Verify the proper placement of the primary camshaft drive chain tensioner gasket tab (1).

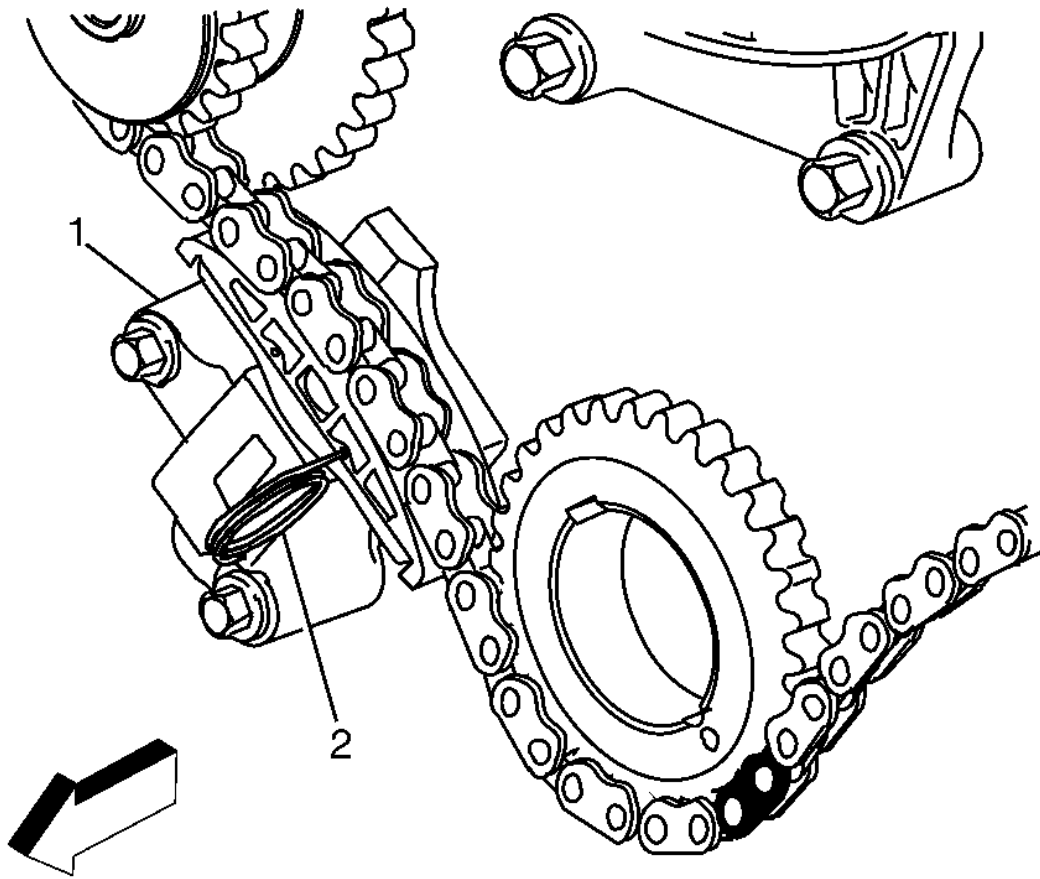
10. Tighten the primary camshaft drive chain tensioner to cylinder block retaining bolts (2)

1. First Pass

Tighten the bolts to 5 N.m (44 lb in) .

2. Final Pass

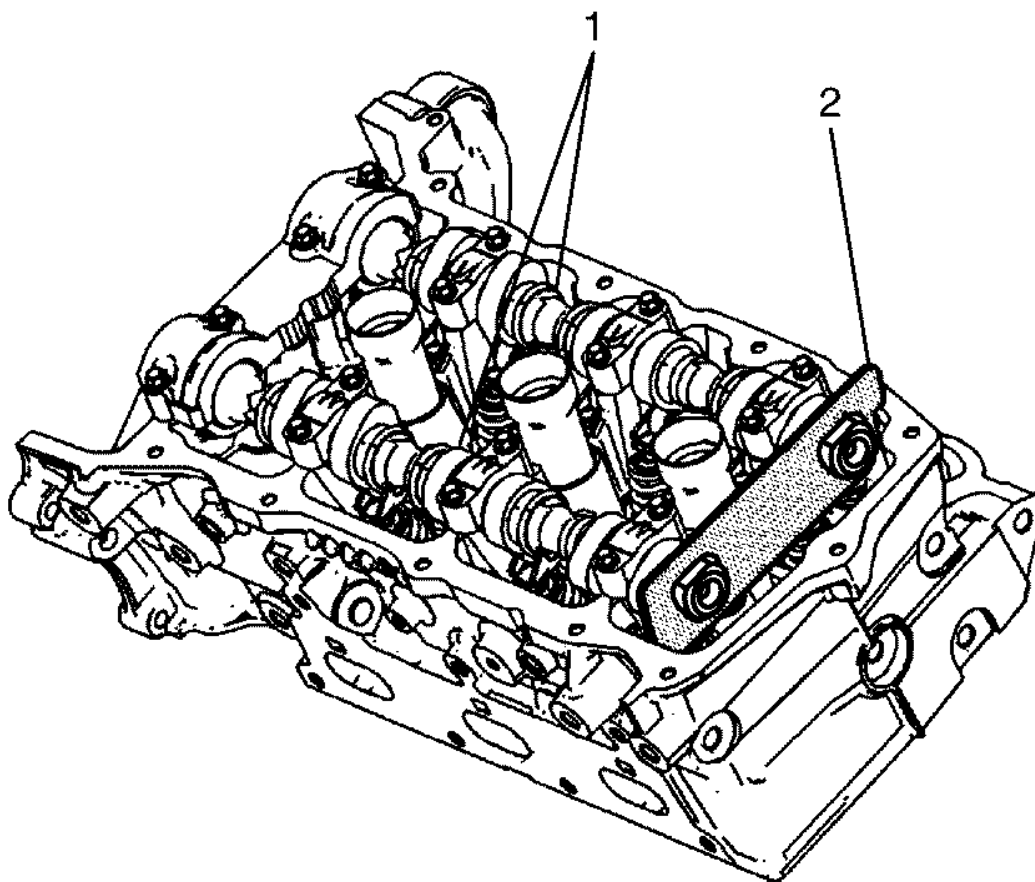
Tighten the bolts to 23 N.m (17 lb ft) .



**Fig. 75: View Of EN 46112 & Primary Camshaft Drive Chain Tensioner**  
Courtesy of GENERAL MOTORS CORP.

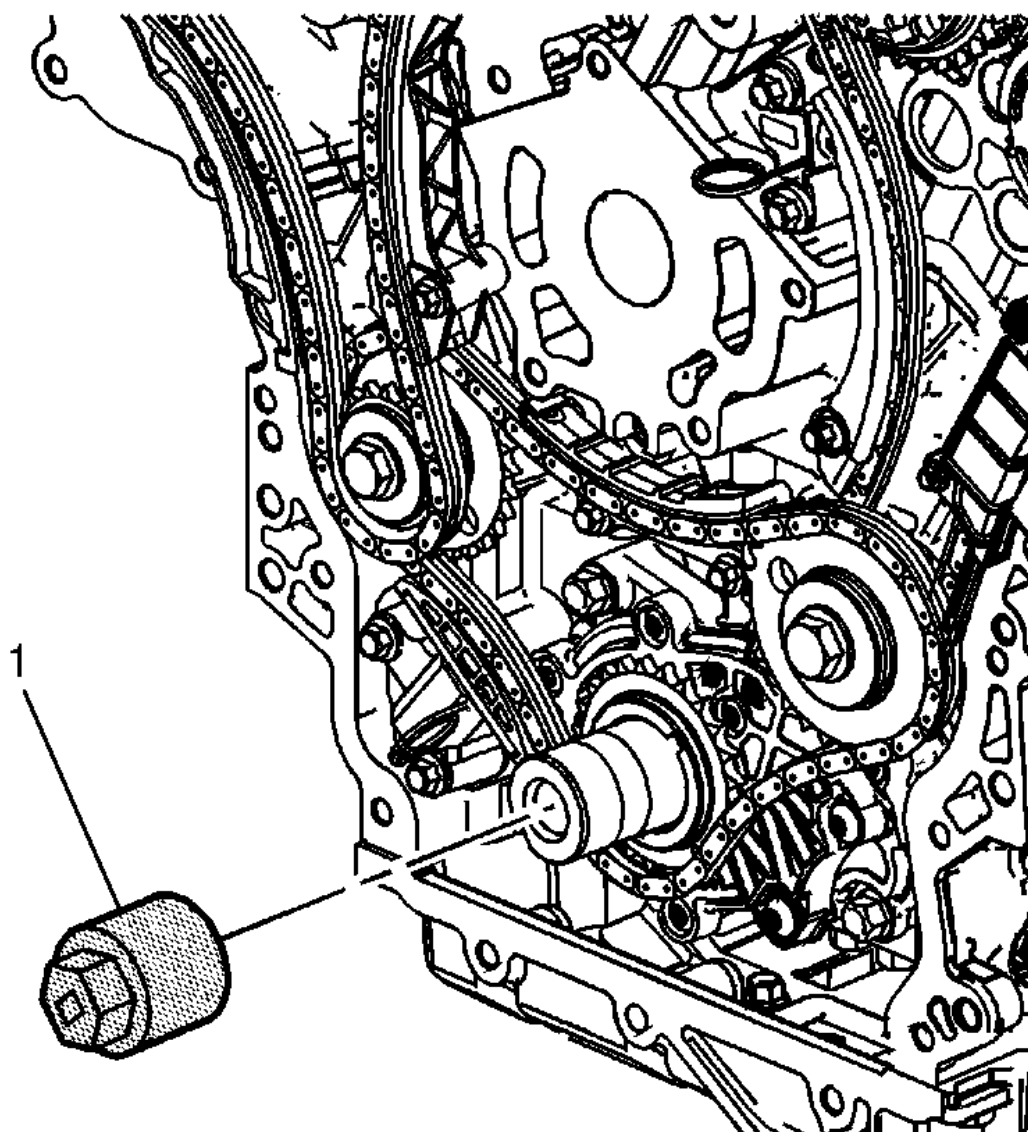
11. Release the primary camshaft drive chain tensioner (1) by pulling out the EN 46112: pins (2).

12. Verify the primary and left secondary camshaft drive chain timing mark alignments (1-12). Refer to **Camshaft Timing Drive Chain Alignment Diagram** .



**Fig. 76: View Of EN 46105 & Left Side Camshafts**  
**Courtesy of GENERAL MOTORS CORP.**

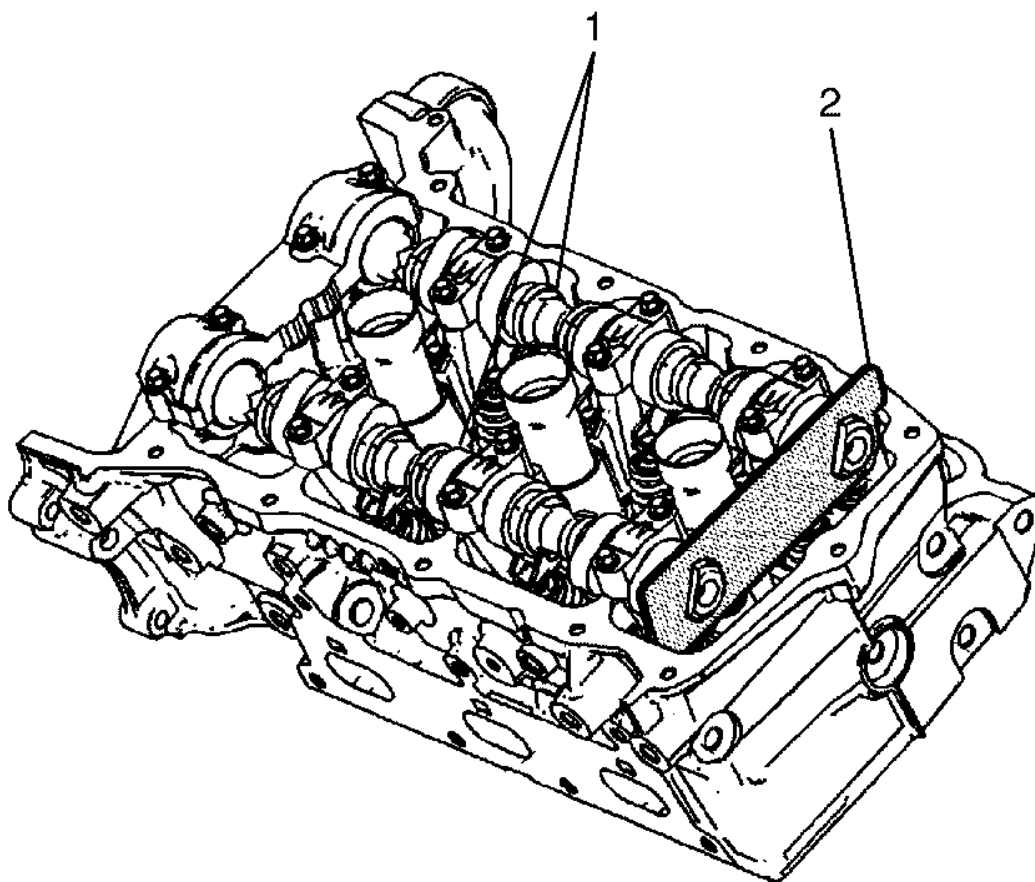
13. Remove the **EN 46105**: tools (2) from the rear of the left hand camshafts (1).



**Fig. 77: View Of EN 46111**

Courtesy of GENERAL MOTORS CORP.

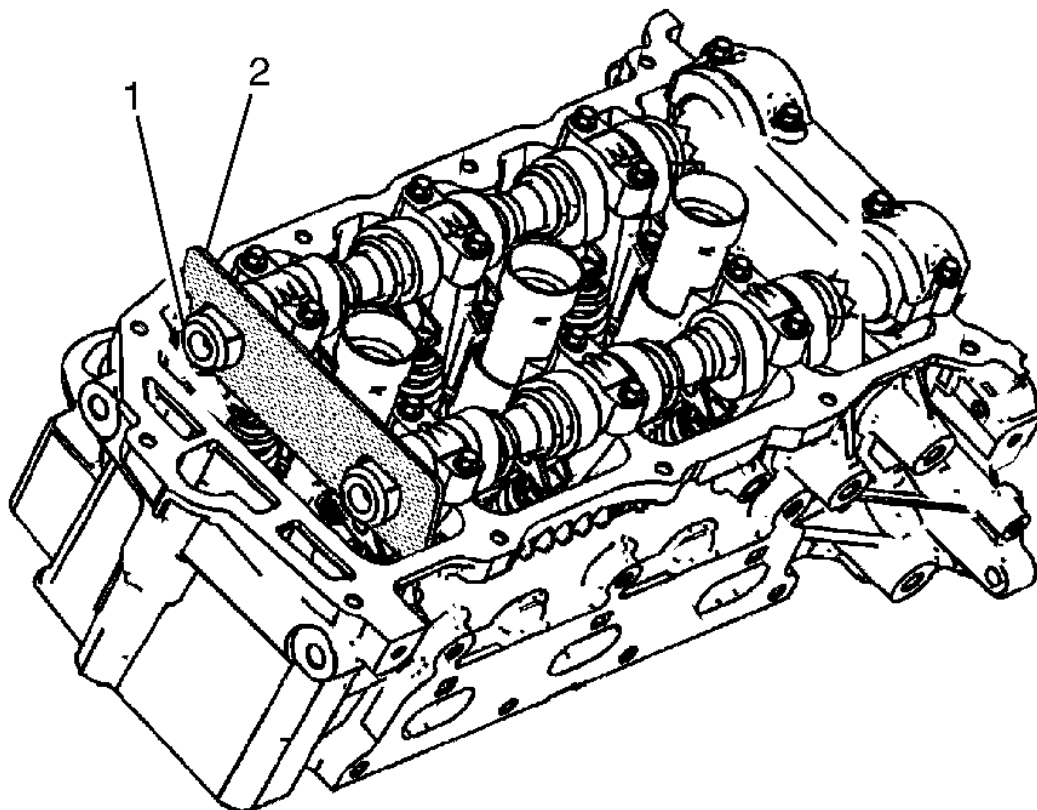
14. Using the **EN 46111**: socket (1) rotate the crankshaft and crankshaft sprocket from the stage one alignment position (1) to the stage two alignment position, 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components.



**Fig. 78: View Of EN 46105 & Left Hand Camshafts**  
Courtesy of GENERAL MOTORS CORP.

15. Install the **EN 46105**: tools (2) onto the rear of the left hand camshafts (1).

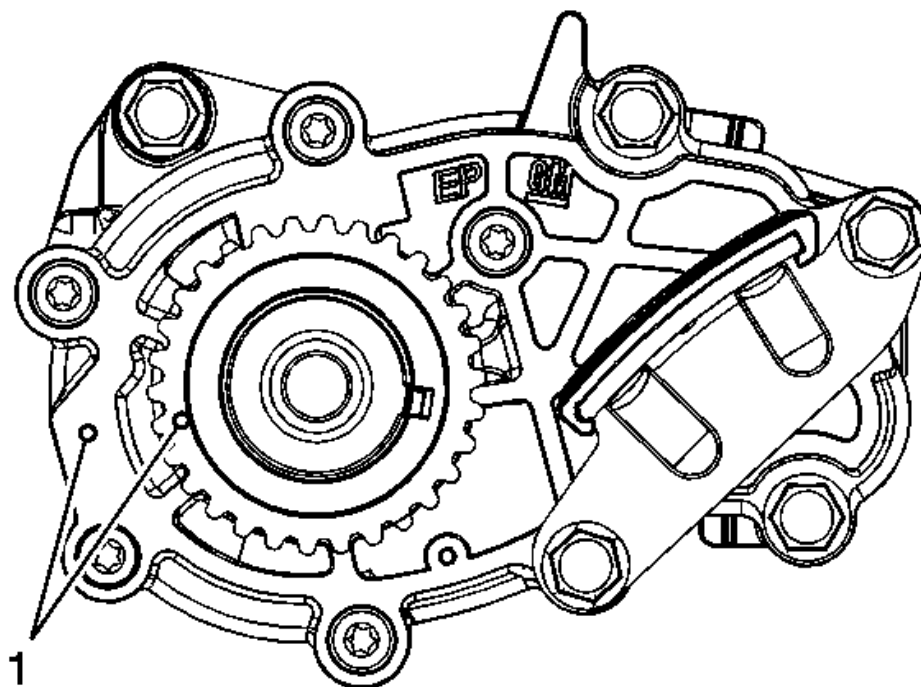




**Fig. 79: View Of EN 46105 & Right Side Camshafts**  
Courtesy of GENERAL MOTORS CORP.

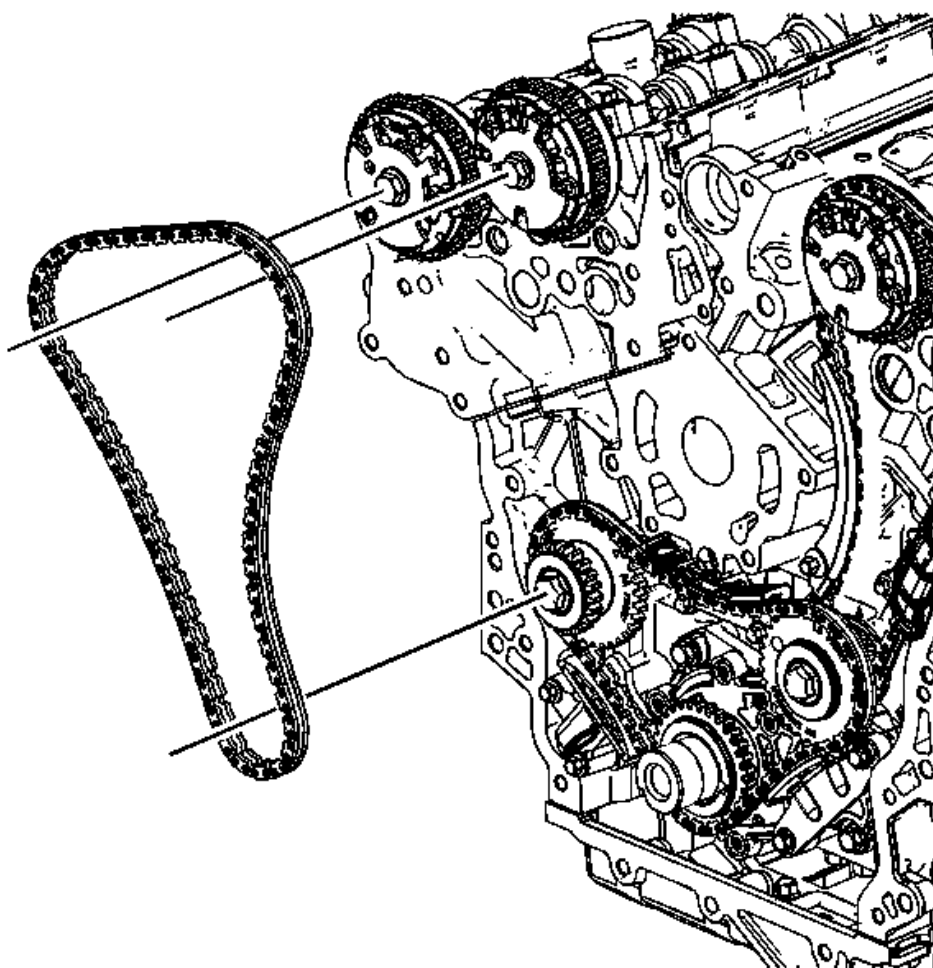
16. Install the **EN 46105**: tools (2) onto the rear of the right hand camshafts (1).

#### **SECONDARY CAMSHAFT DRIVE CHAIN INSTALLATION - RIGHT SIDE**



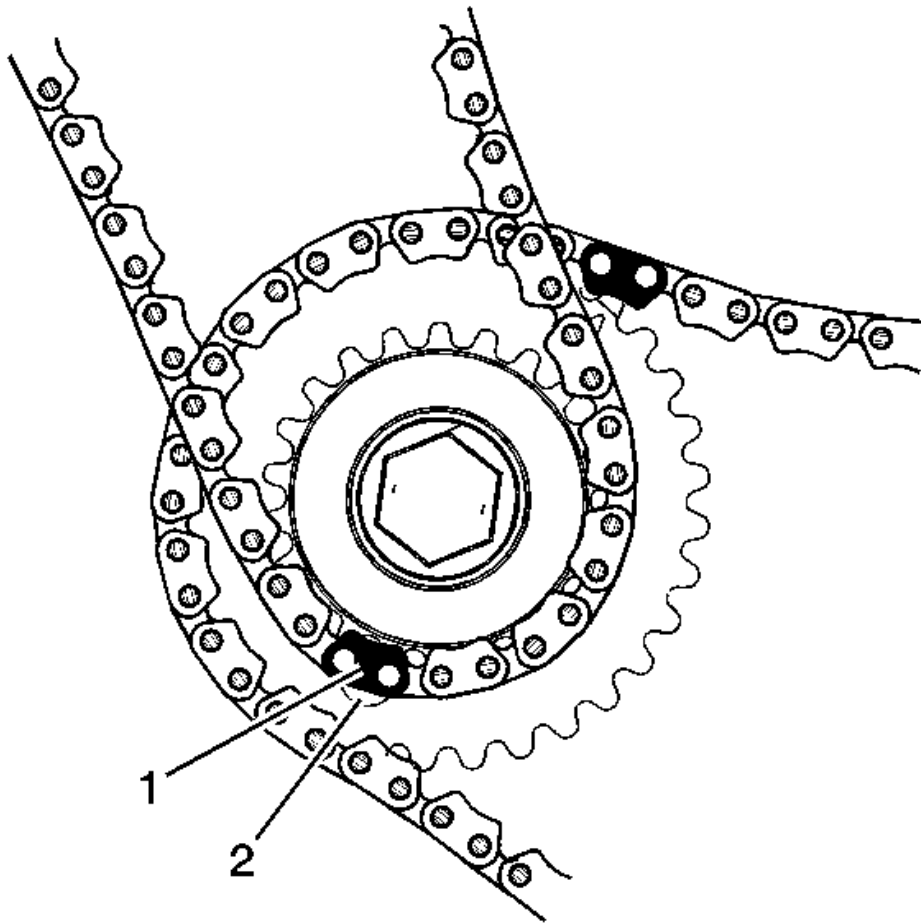
**Fig. 80: View Of Crankshaft In Stage 2 Timing Drive Assembly Position**  
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the crankshaft is in the stage 2 timing drive assembly position (1).



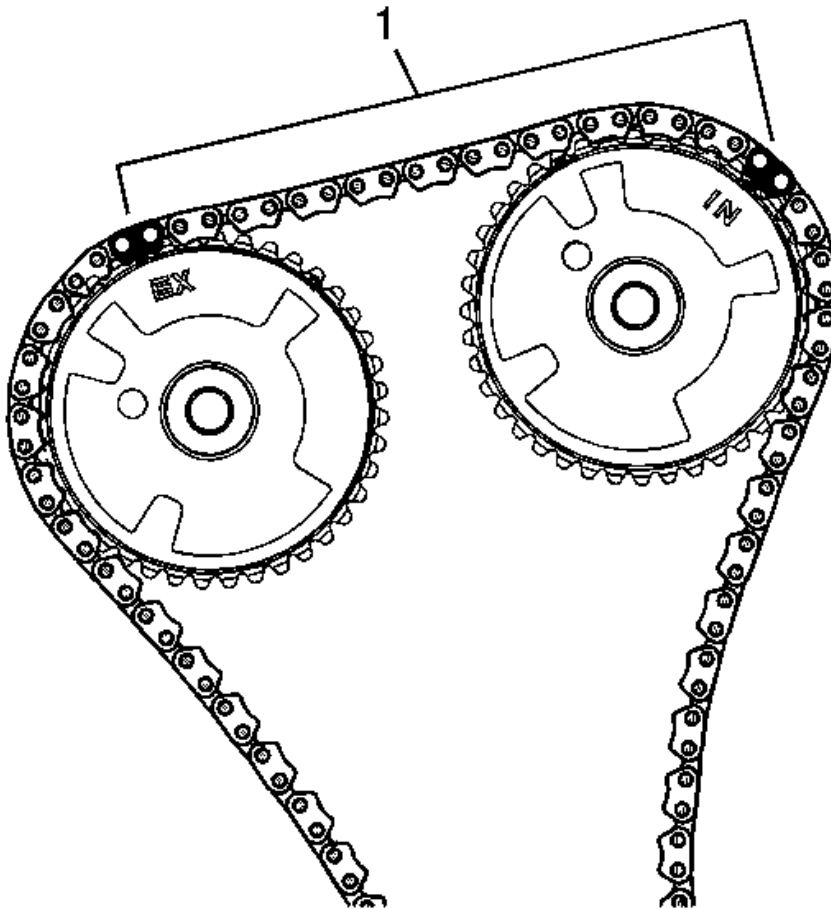
**Fig. 81: View Of Secondary Camshaft Drive Chain**  
Courtesy of GENERAL MOTORS CORP.

2. Install the right secondary camshaft drive chain.



**Fig. 82: View Of Timing Camshaft Drive Chain Link And Alignment Access Hole**  
Courtesy of GENERAL MOTORS CORP.

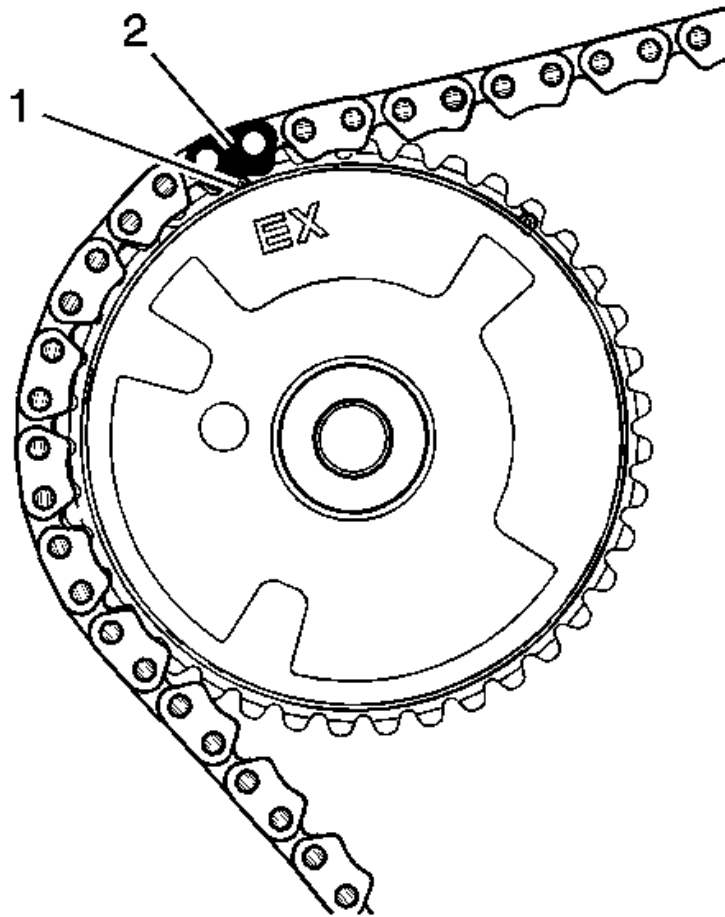
3. Place the secondary camshaft drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the timing camshaft drive chain link (1) with the alignment access hole (2) made in the right camshaft intermediate drive chain idler inner sprocket.



**Fig. 83: View Of Links**

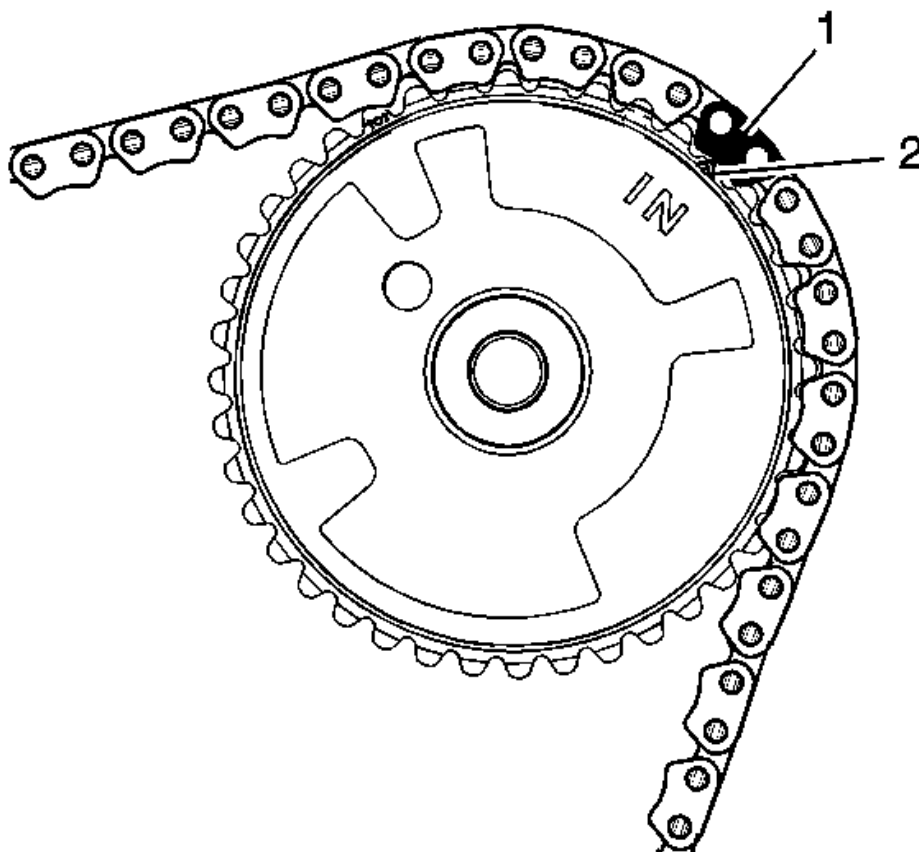
Courtesy of GENERAL MOTORS CORP.

4. Wrap the secondary camshaft drive chain around both right actuator drive sprockets.
5. Ensure there are 10 links (1) between the timing camshaft drive chain links for the camshaft position actuator sprockets.



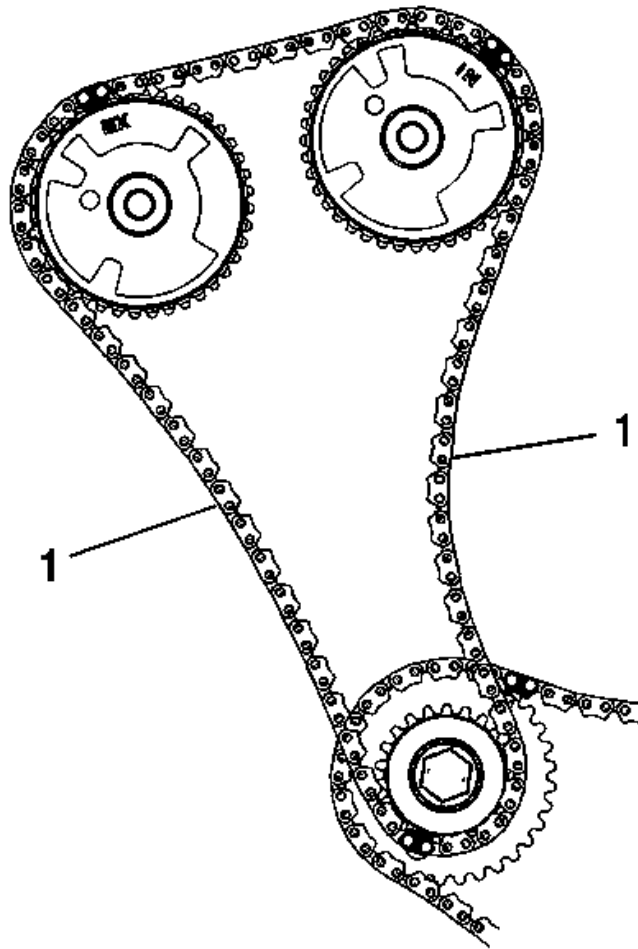
**Fig. 84: View Of Camshaft Marks**  
Courtesy of GENERAL MOTORS CORP.

6. Align the right exhaust camshaft position actuator sprocket alignment triangle mark (1) with the timing camshaft drive chain link (2).



**Fig. 85: View Of Right Intake Camshaft Position Actuator Sprocket Alignment Triangle Mark**  
Courtesy of GENERAL MOTORS CORP.

7. Align the right intake camshaft position actuator sprocket alignment triangle mark (2) with the timing camshaft drive chain link (1).



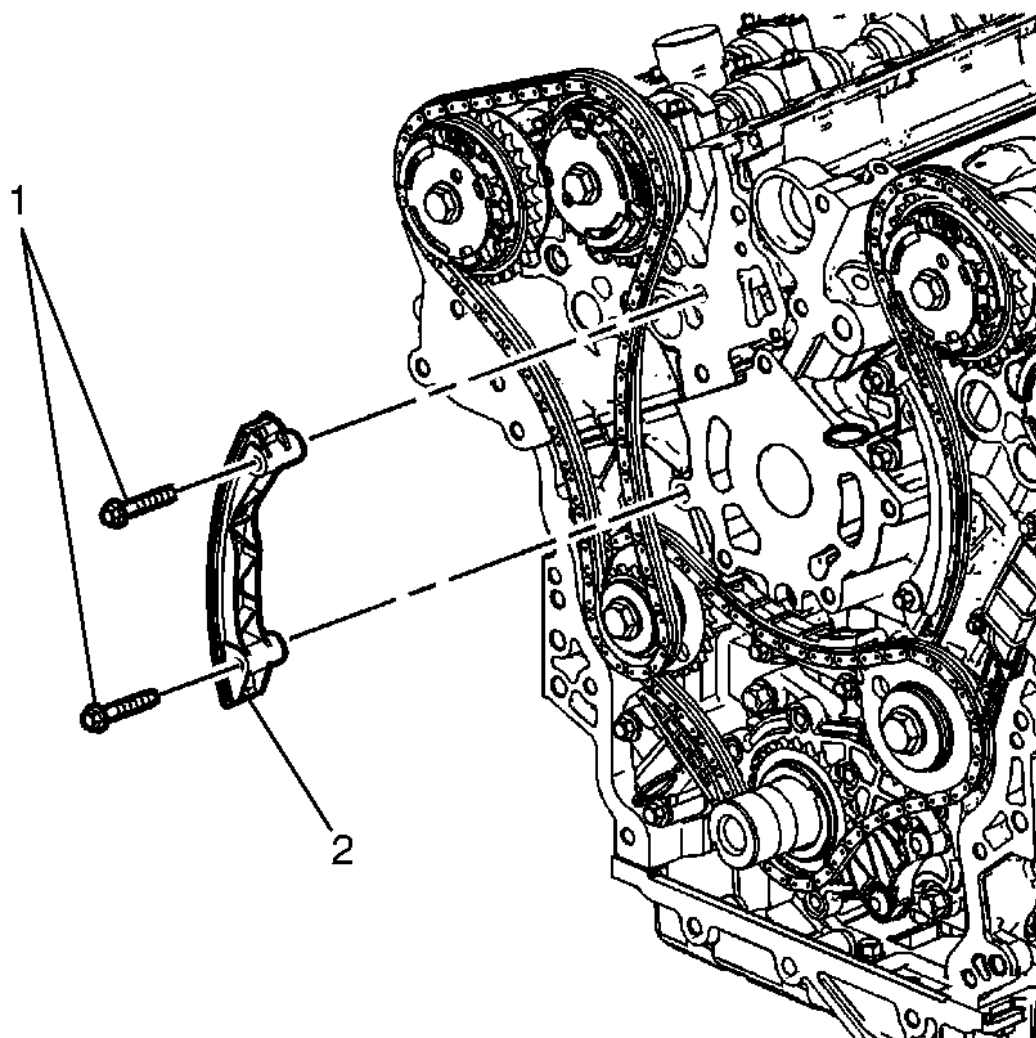
**Fig. 86: View Of Links**

Courtesy of GENERAL MOTORS CORP.

8. There will be 22 links (1) between the right camshaft intermediate drive chain idler timing camshaft drive chain link and each right camshaft position actuator sprocket timing camshaft drive chain link.

## **SECONDARY CAMSHAFT DRIVE CHAIN GUIDE INSTALLATION - RIGHT SIDE**





**Fig. 87: Identifying Right Secondary Camshaft Drive Chain Guide To Cylinder Block Retaining Bolts**

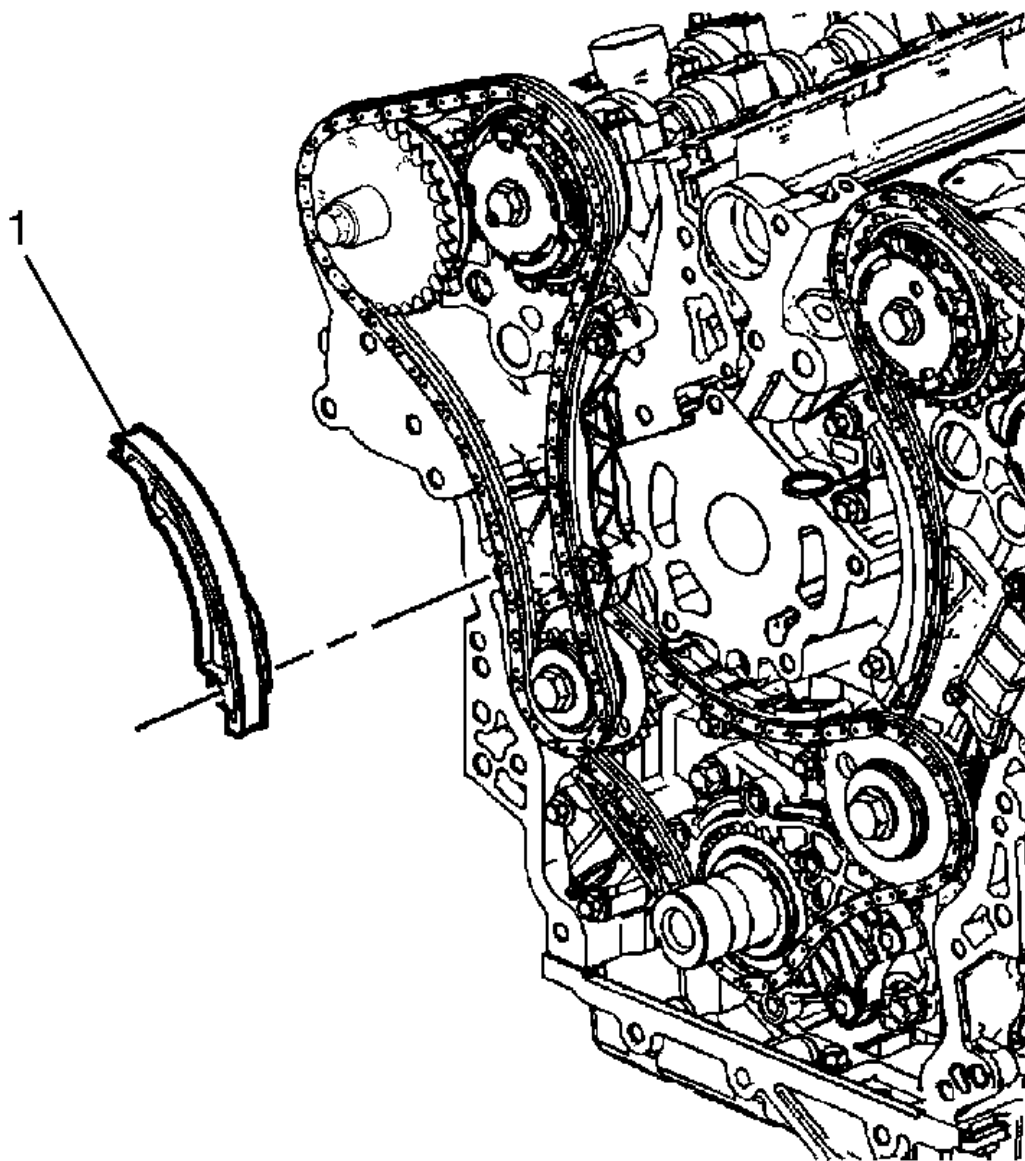
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain guide (2).

**CAUTION: Refer to Fastener Caution .**

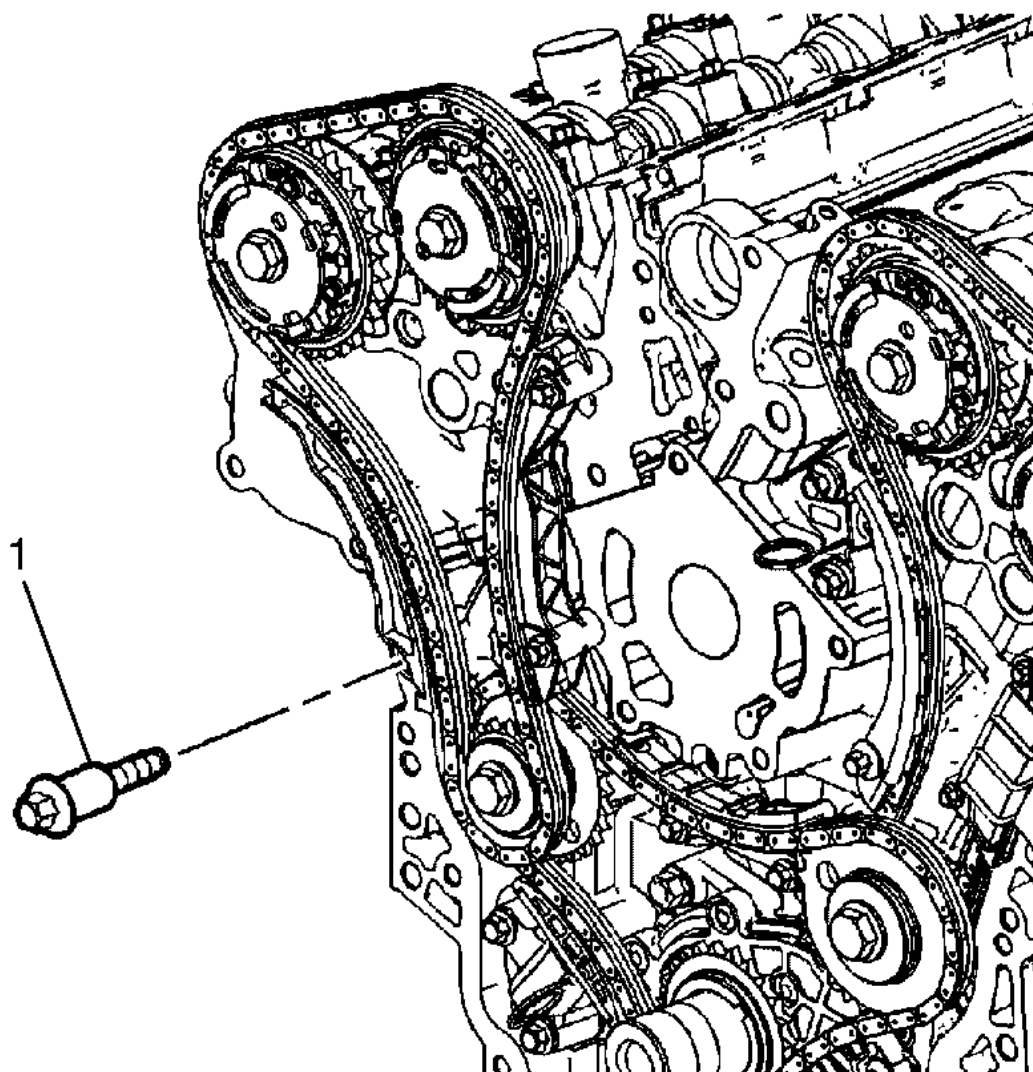
2. Install the secondary camshaft drive chain guide to cylinder block retaining bolts (1) and tighten to 23 N.m (17 lb ft).

## SECONDARY CAMSHAFT DRIVE CHAIN SHOE INSTALLATION - RIGHT SIDE



**Fig. 88: View Of Right Secondary Camshaft Drive Chain Shoe**  
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain shoe (1).



**Fig. 89: Identifying Right Secondary Camshaft Drive Chain Shoe To Cylinder Block Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

2. Install the right secondary camshaft drive chain shoe to cylinder block retaining bolt (1) and tighten to 23 N.m (17 lb ft).

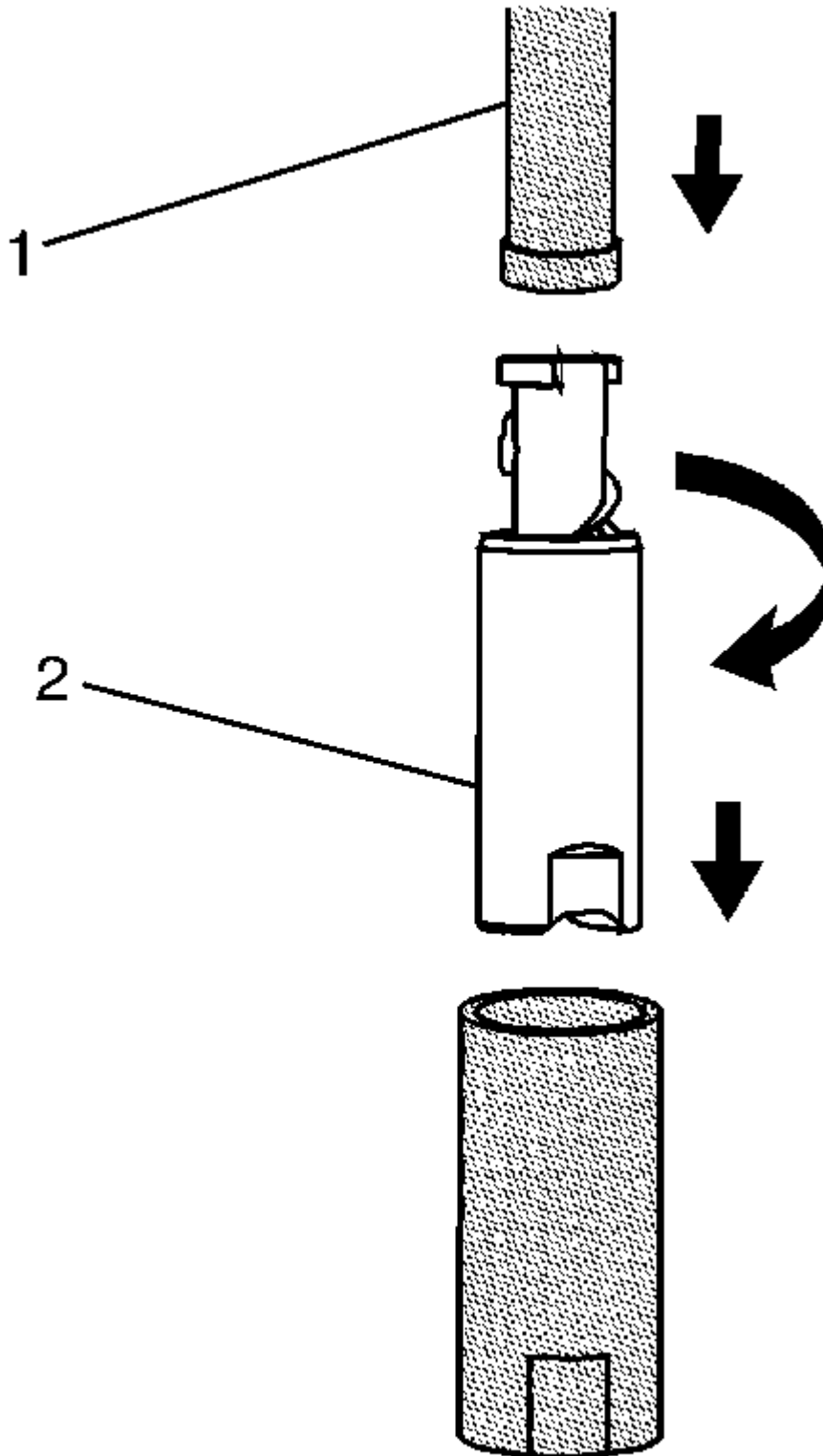
#### **SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER INSTALLATION - RIGHT SIDE**

**Special Tools**

- **EN 46112:** Tensioner Retraction Pins
- **J 45027:** Tensioner Tool

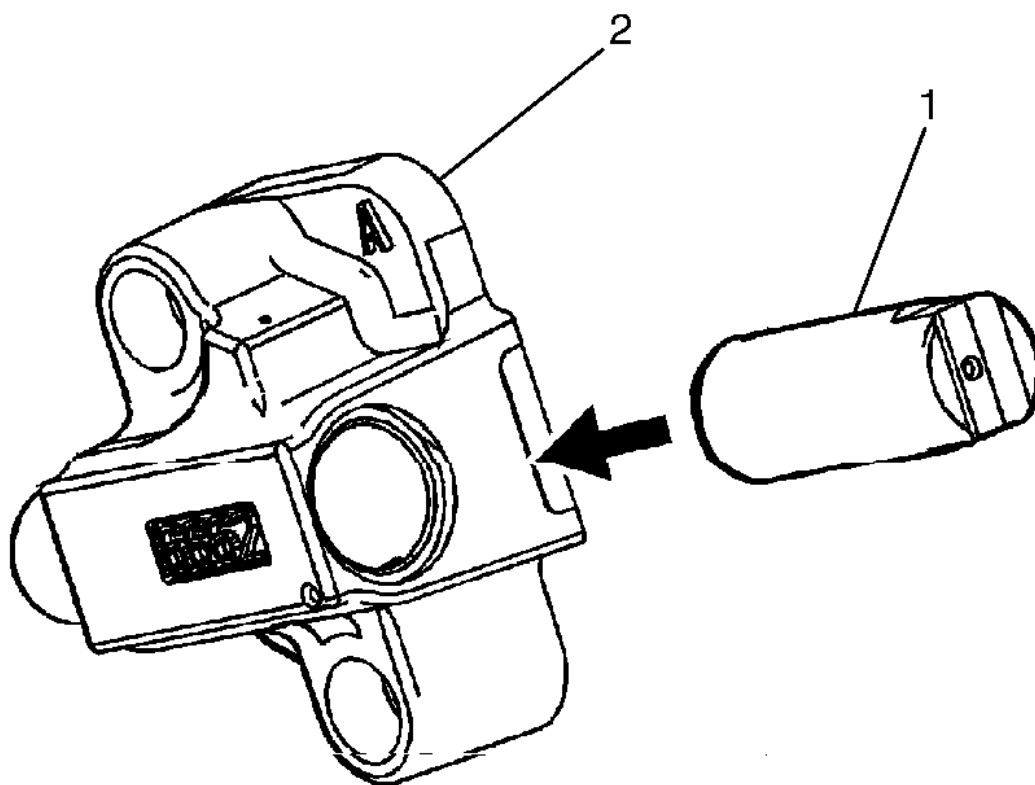
For equivalent regional tools, refer to **Special Tools** .

**Installation**



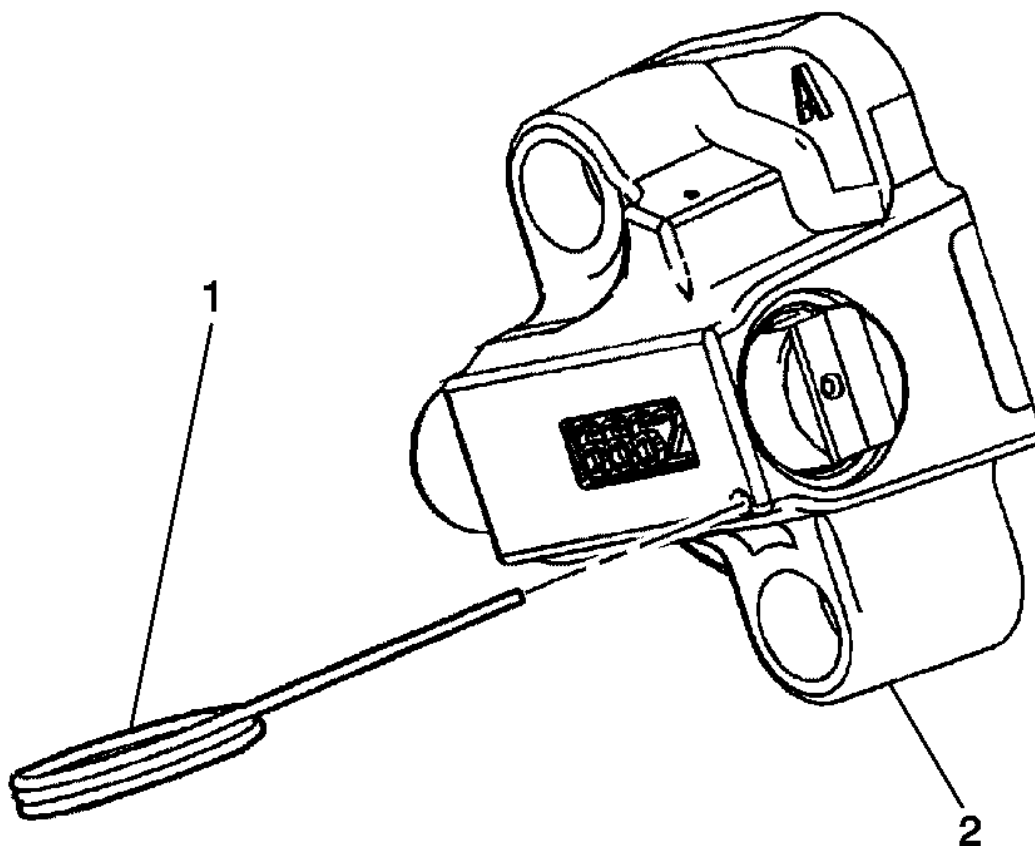
**Fig. 90: View Of J 45027 & Left Secondary Camshaft Drive Chain Tensioner Plunger**  
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 45027**: tool reset the right secondary camshaft drive chain tensioner plunger.



**Fig. 91: Identifying Right Secondary Camshaft Drive Chain Tensioner Body With Plunger**  
Courtesy of GENERAL MOTORS CORP.

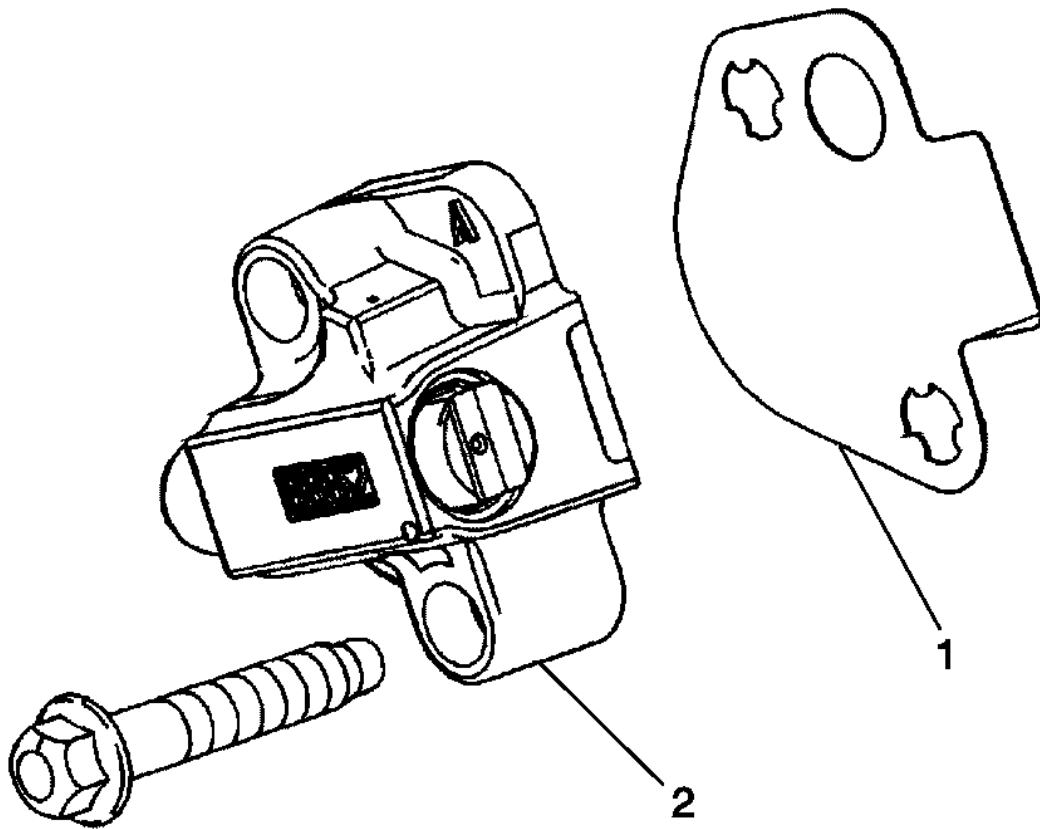
2. Install the plunger (1) into the right secondary camshaft drive chain tensioner body (2).



**Fig. 92: View Of EN 46112**

**Courtesy of GENERAL MOTORS CORP.**

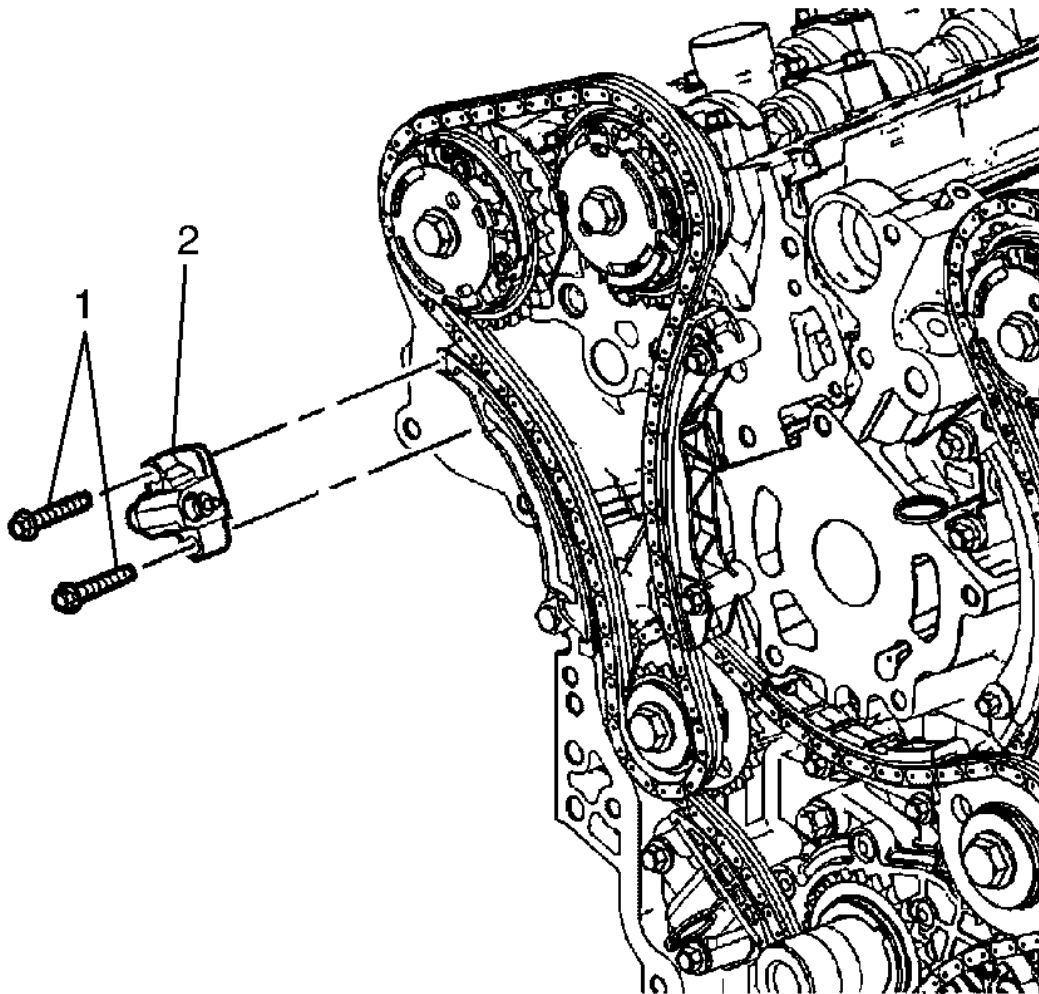
3. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner (2) by inserting the **EN 46112**: pins (1) into the access hole in the side of the right secondary camshaft drive chain tensioner (2).
4. Slowly release pressure on the right secondary camshaft drive chain tensioner (2). The right secondary camshaft drive chain tensioner (2) should remain compressed.



**Fig. 93: Identifying Right Secondary Camshaft Drive Chain Tensioner & Gasket**  
 Courtesy of GENERAL MOTORS CORP.

5. Install a NEW right secondary camshaft drive chain tensioner gasket (1) to the right secondary camshaft drive chain tensioner (2).
6. Install the right secondary camshaft drive chain tensioner bolts through the right secondary camshaft drive chain tensioner (2) and gasket (1).
7. Ensure the right secondary camshaft drive chain tensioner (2) mounting surface on the right cylinder head does not have any burrs or defects that may degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket (1).

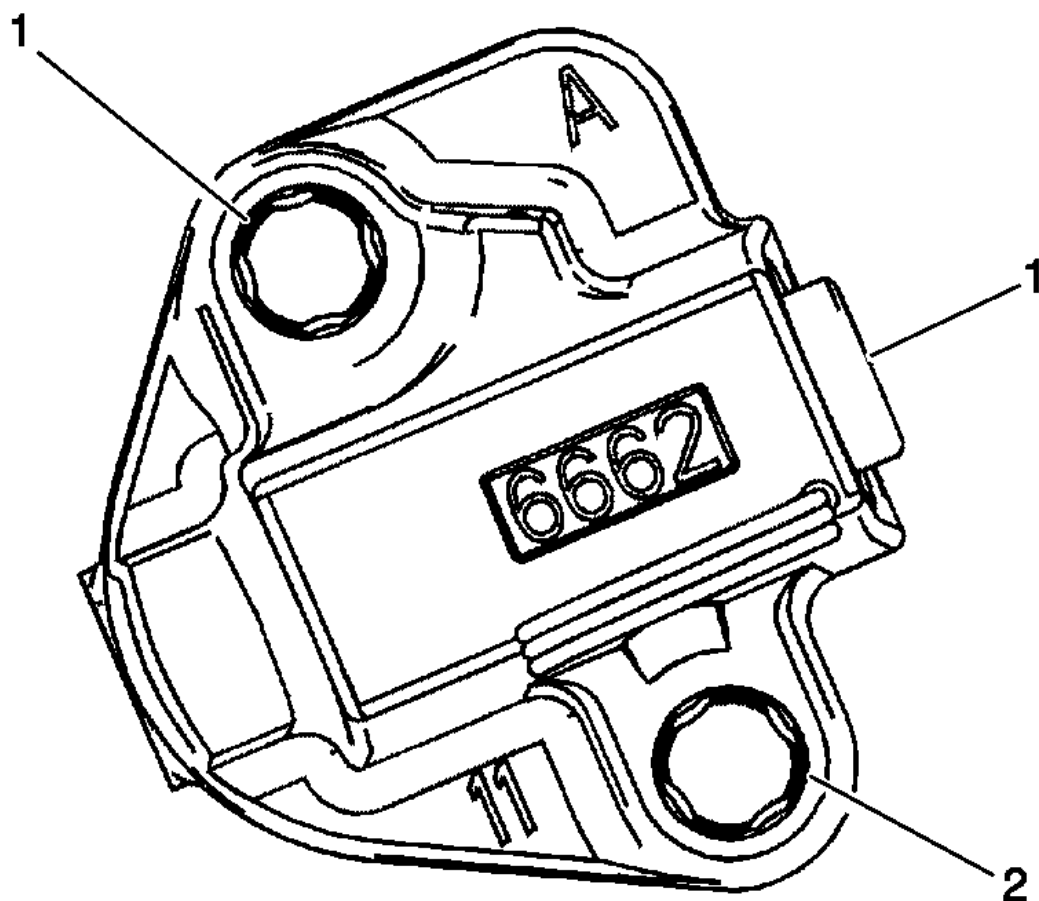




**Fig. 94: Identifying Right Secondary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

8. Place the right secondary camshaft drive chain tensioner (2) into position and loosely install right secondary camshaft drive chain tensioner to cylinder block retaining bolts (1).



**Fig. 95: Identifying Right Secondary Camshaft Drive Chain Tensioner To Cylinder Block Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

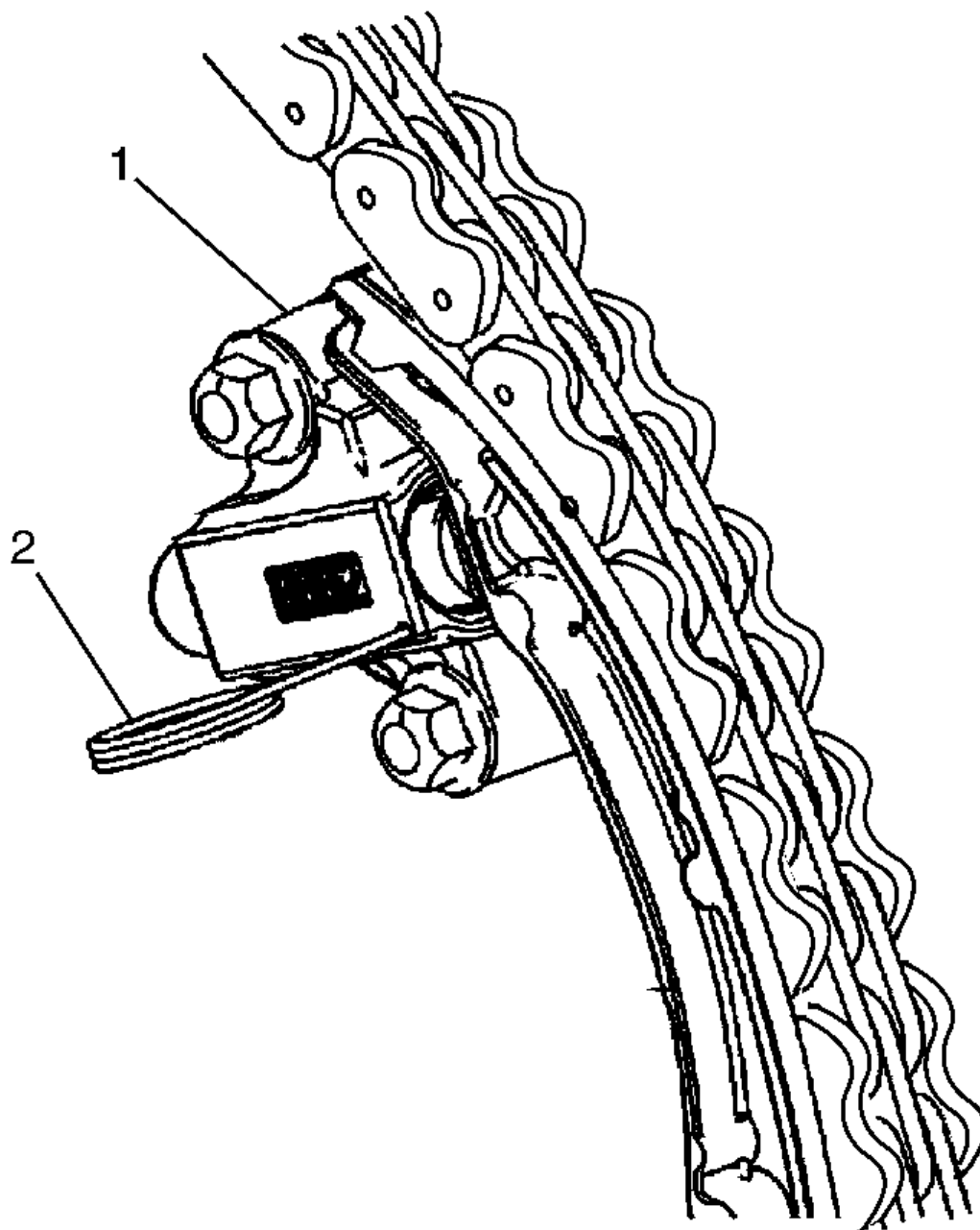
**CAUTION: Refer to Fastener Caution .**

9. Verify the proper placement of the right secondary camshaft drive chain tensioner gasket tab (1).
10. Tighten the right secondary camshaft drive chain tensioner to cylinder block retaining bolts (2).
  1. First Pass

Tighten the bolts to 5 N.m (44 lb in) .

2. Final Pass

Tighten the bolts to 23 N.m (17 lb ft) .



**Fig. 96: View Of EN 46112**

Courtesy of GENERAL MOTORS CORP.

11. Release the right camshaft drive chain tensioner by pulling out the **EN 46112**: pins and unlocking the tensioner plunger.

**CAUTION:** Ensure that all timing chain tensioners are completely released. A timing chain tensioner that is not properly released can lead to serious engine damage.

12. Verify all primary and secondary camshaft drive chain timing mark alignments. Refer to **Camshaft Timing Drive Chain Alignment Diagram** .

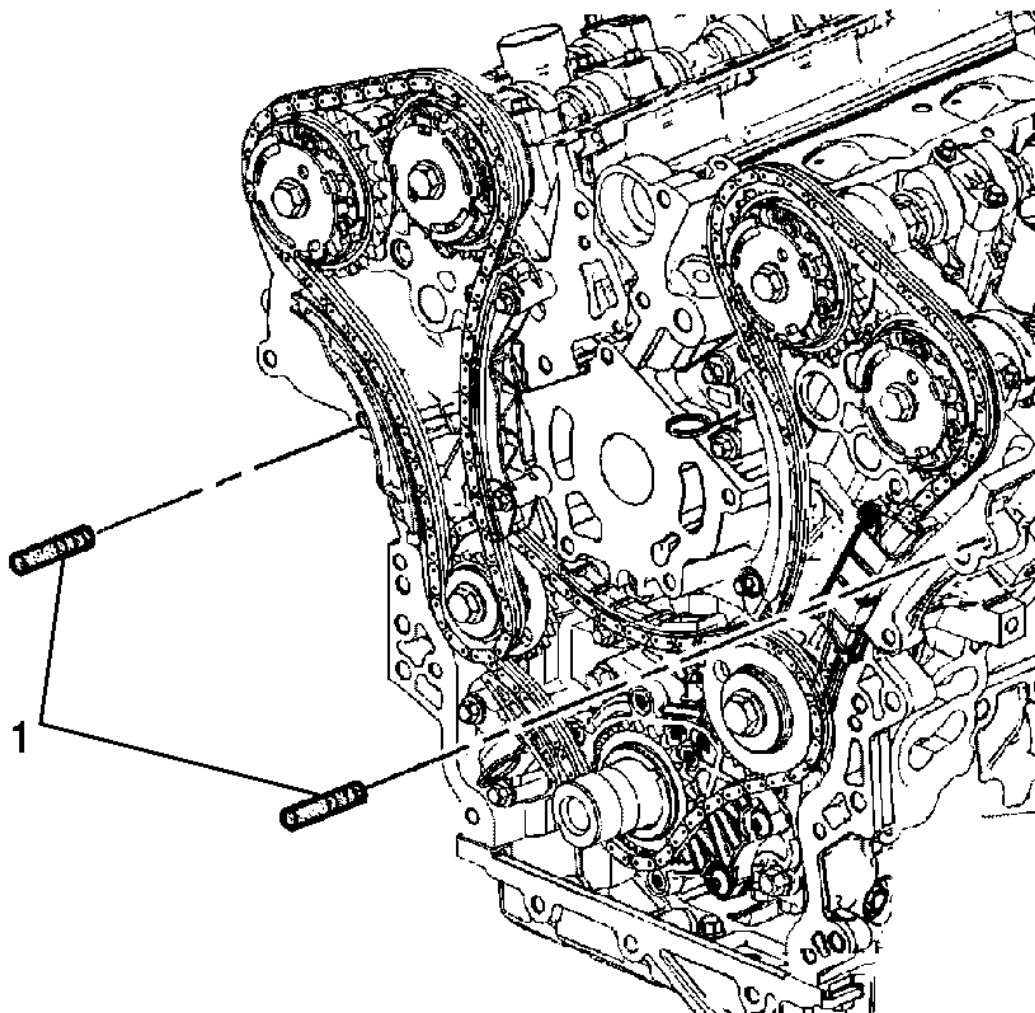
## **ENGINE FRONT COVER INSTALLATION**

### **Special Tools**

- **EN 46109:** Guide Pin Set
- **J 45059:** Angle Meter

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

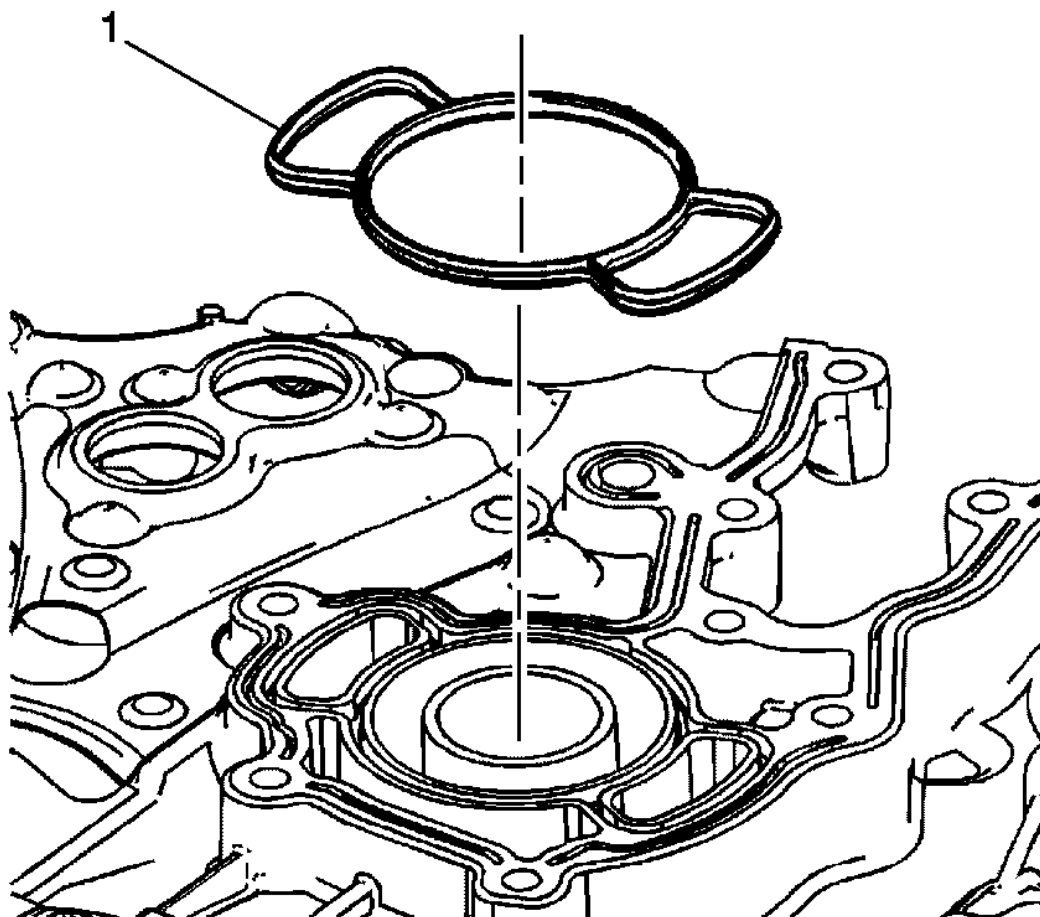
### **Installation**



**Fig. 97: View Of EN 46109**

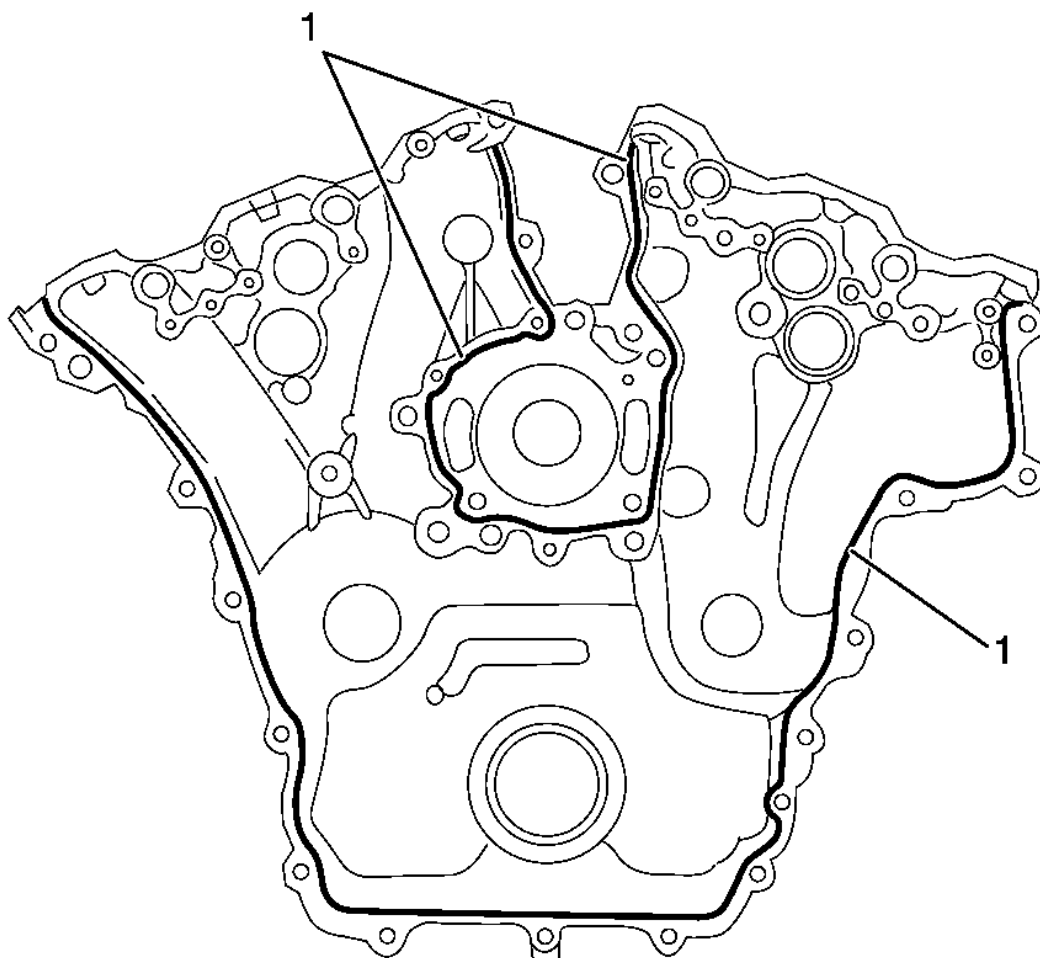
Courtesy of GENERAL MOTORS CORP.

1. Install the 8 mm (0.315 in) guide from the **EN 46109**: set (1) into the cylinder block positions as shown.



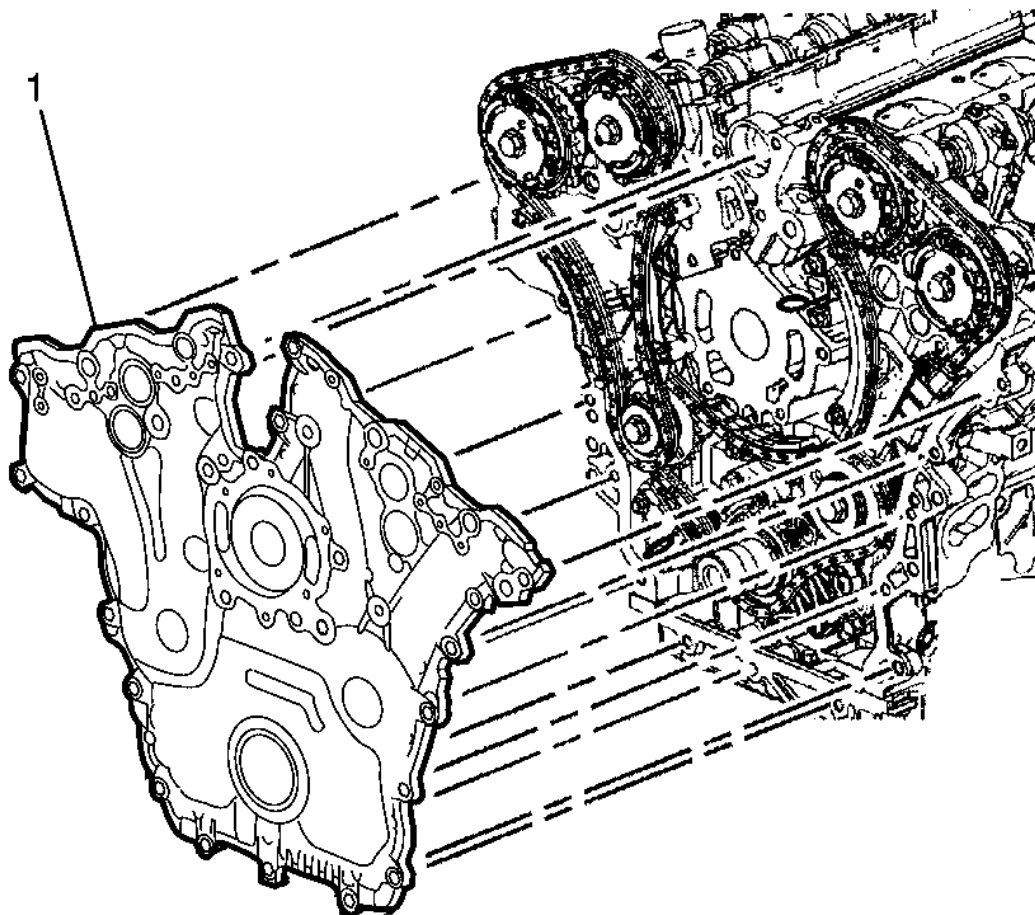
**Fig. 98: Identifying Engine Front Cover To Cylinder Block Seal**  
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW engine front cover to cylinder block seal (1).



**Fig. 99: Identifying RTV Sealant Area**  
**Courtesy of GENERAL MOTORS CORP.**

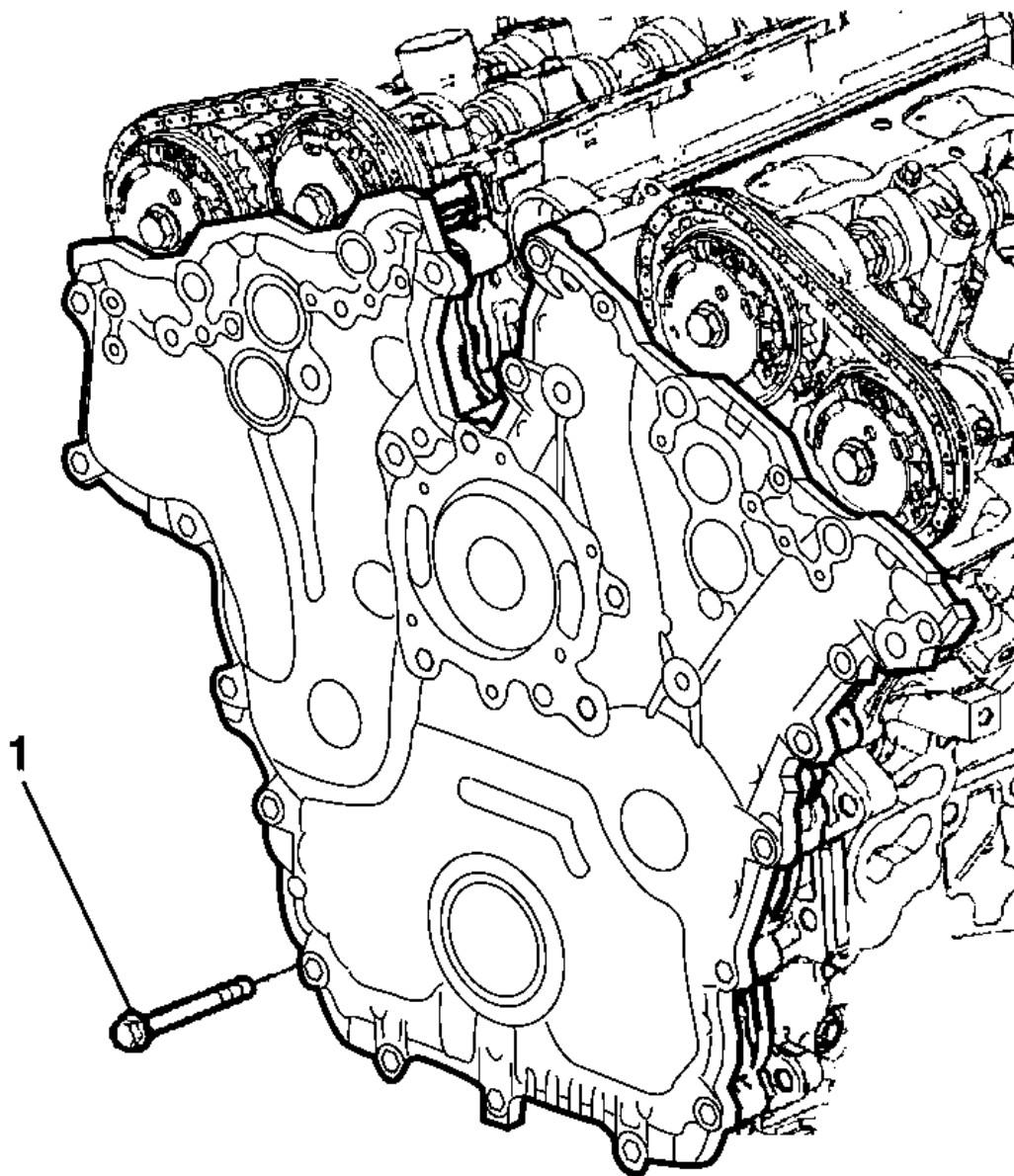
3. Place a 3 mm (0.118 in) bead of RTV sealant (1), on the engine front cover as shown.



**Fig. 100: Identifying Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

4. Place the engine front cover (1) onto the **EN 46109**: set and slide into position.
5. Remove the **EN 46109**: set from the cylinder block.

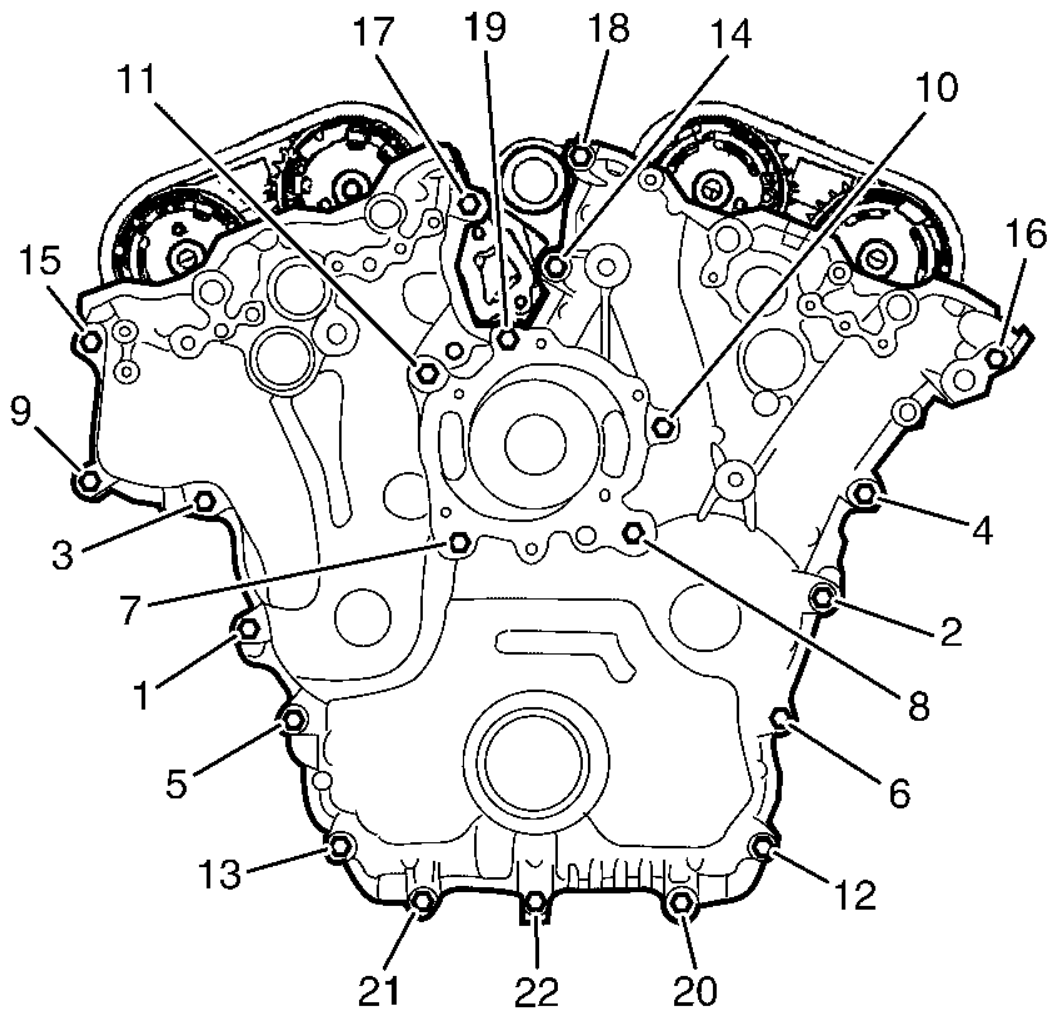




**Fig. 101: Identifying Engine Front Cover To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

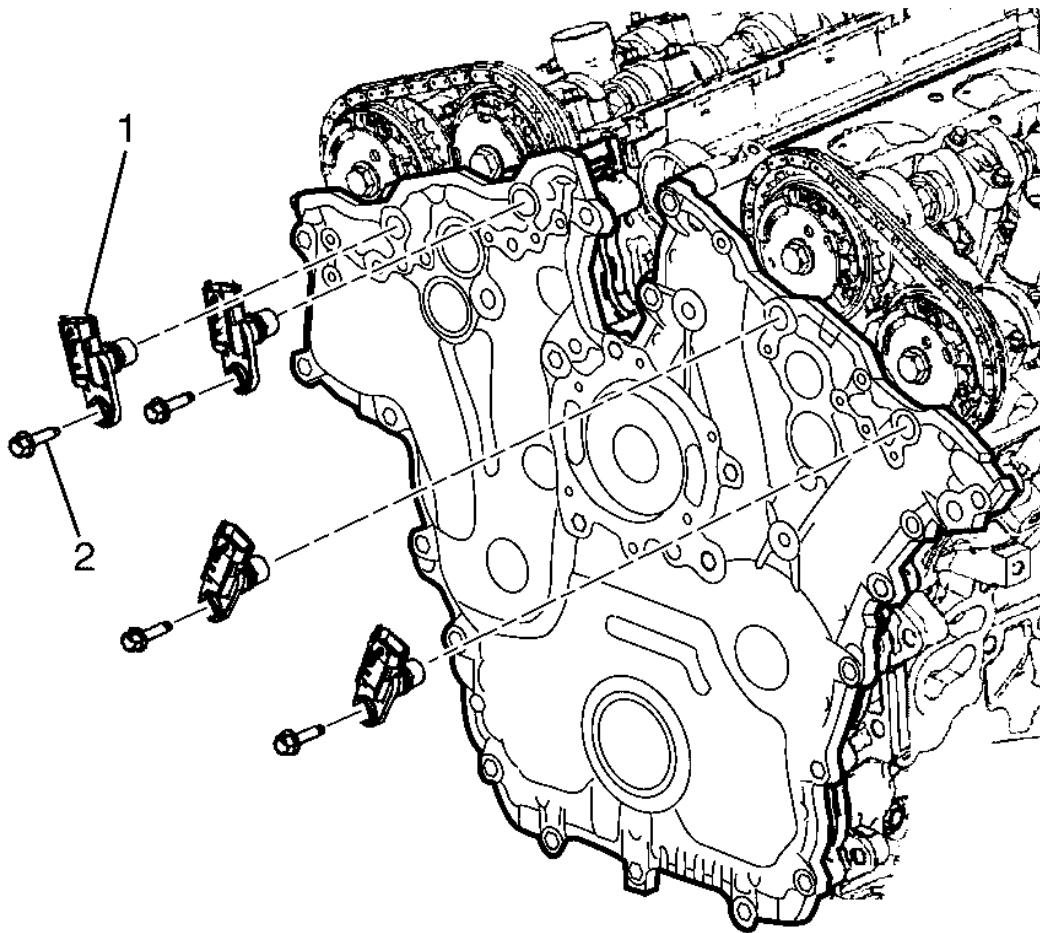
**CAUTION:** Refer to Fastener Caution .

6. Hand start all the engine front cover to cylinder block retaining bolts (1).



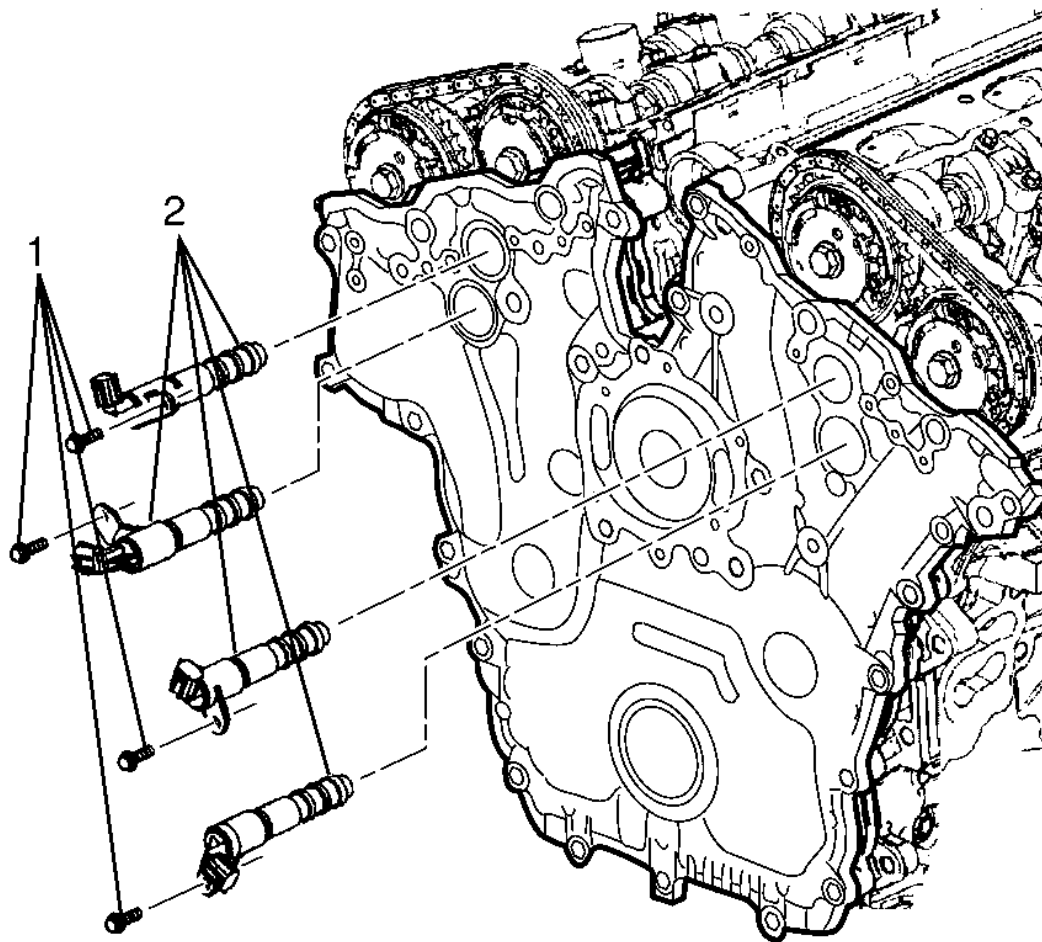
**Fig. 102: Identifying Engine Front Cover To Cylinder Block Retaining Bolt Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

7. Tighten the engine front cover to cylinder block retaining bolts in the sequence shown.
  1. Tighten the bolts a first pass in sequence to 20 N.m (17 lb ft) .
  2. Tighten the bolts a second pass in sequence an additional 60 degrees using the **J 45059**: meter .
8. Install NEW O-rings on the camshaft position sensors.



**Fig. 103: Identifying Camshaft Position Sensor To Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Install the camshaft position sensors (2).
10. Install the camshaft position sensor to front cover retaining bolts (1) and tighten to 10 N.m (89 lb in).



**Fig. 104: Identifying Camshaft Position Actuator Solenoid To Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

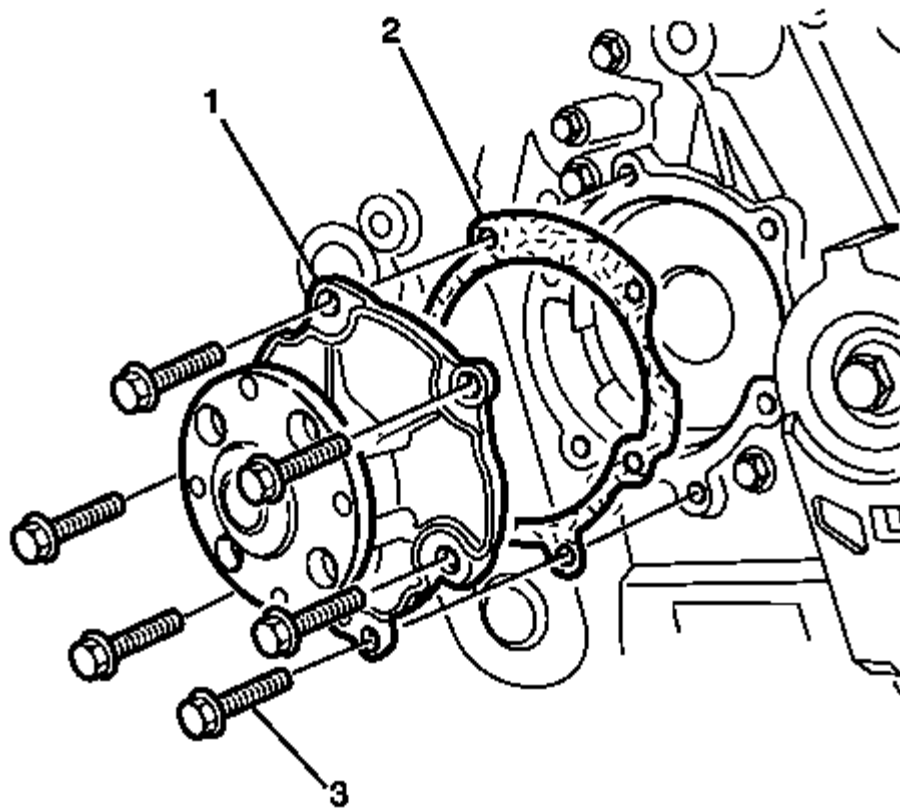
**NOTE:** LE0 and LW2 engines only have intake camshaft position actuator solenoids.

11. Install the camshaft position actuator solenoids (2).
12. Install the camshaft position actuator solenoid to front cover retaining bolts (1).
  1. Tighten the bolts to 10 N.m (89 lb in) .
  2. Tighten the bolts a second pass in sequence an additional 60 degrees using the **J 45059**: meter .

## WATER PUMP INSTALLATION

**NOTE:** Make sure all mating surfaces are clean and free of grease.

1. Using a water sealant install the water pump and gasket to front engine cover.
2. Make sure all retaining bolts are clean and free of debris.

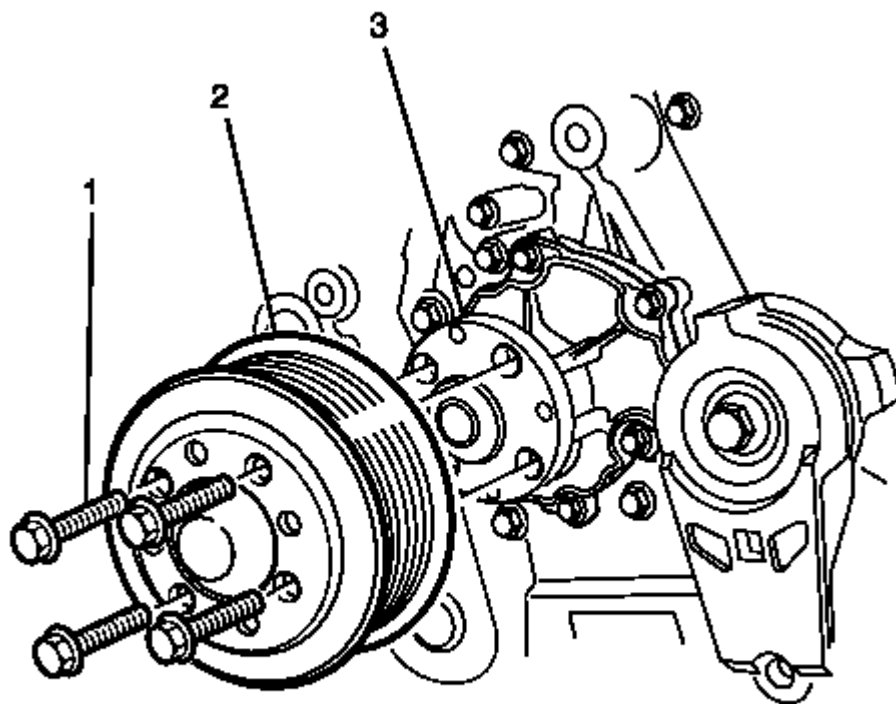


**Fig. 105: Identifying Water Pump To Engine Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Install the water pump (1) and NEW gasket (2).

**CAUTION: Refer to Fastener Caution .**

4. Install the water pump to engine front cover retaining bolts (3) and tighten to 10 N.m (89 lb in).



**Fig. 106: Identifying Water Pump Pulley To Water Pump Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

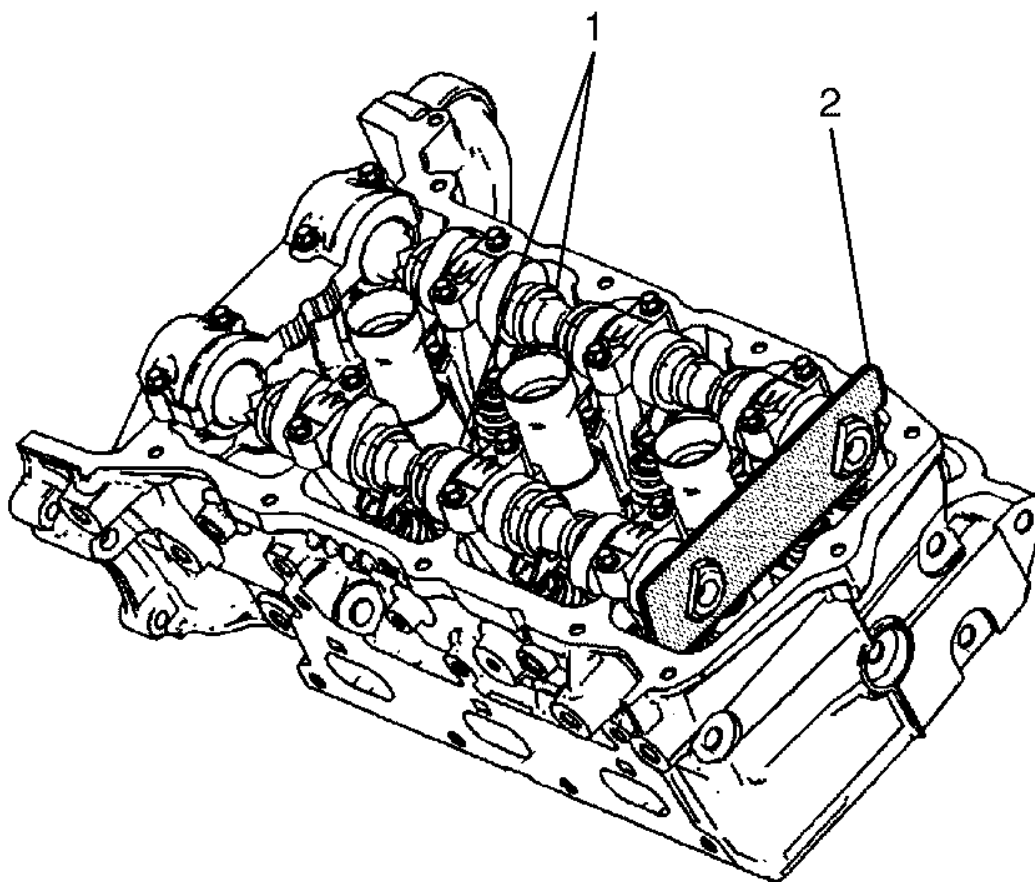
5. Install the water pump pulley (2) to the water pump (3)
6. Install the water pump pulley to water pump retaining bolts (1) and tighten to 10 N.m (89 lb in).

## **CAMSHAFT COVER INSTALLATION - LEFT SIDE**

### **Special Tools**

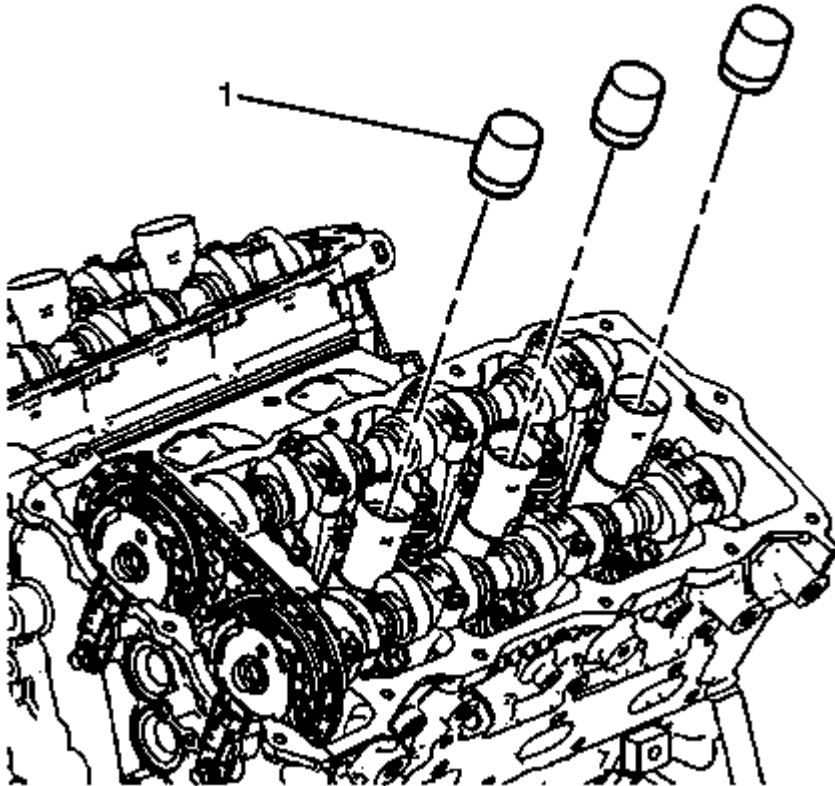
- **EN 46101:** Spark Plug Tube Seal Guide
- **EN 46105:** Camshaft Locking Tools For equivalent regional tools, refer to **Special Tools** .

### **Installation**



**Fig. 107: View Of EN 46105 & Left Hand Camshafts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the **EN 46105**: tools (2) from the rear of the left hand camshafts (1).

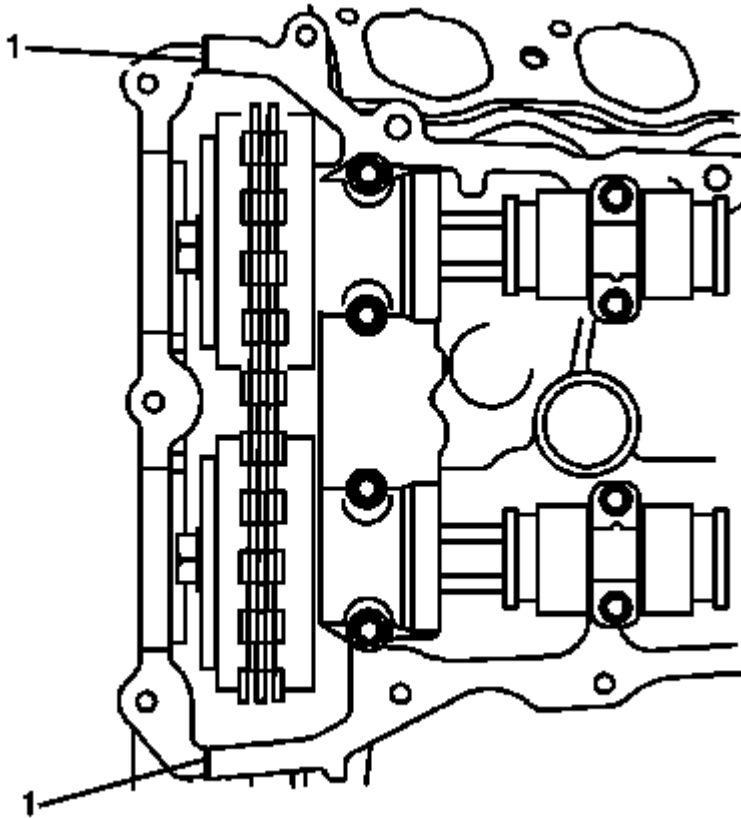


**Fig. 108: View Of EN-46101**

Courtesy of GENERAL MOTORS CORP.

2. Install the **EN 46101**: guide (1) onto the spark plug tubes of the left cylinder head.
3. Install the camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.

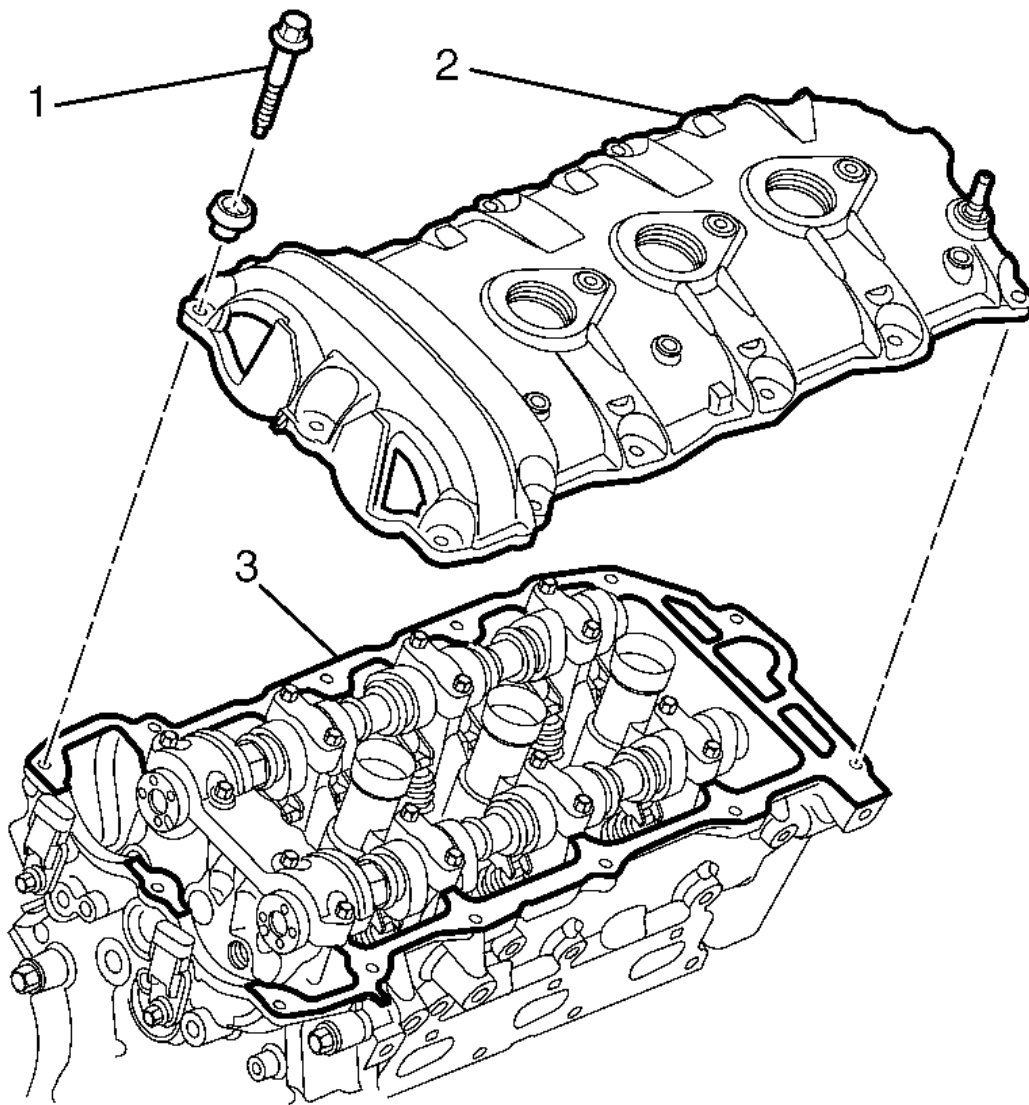




**Fig. 109: View Of Engine Front Cover Split Lines**  
Courtesy of GENERAL MOTORS CORP.

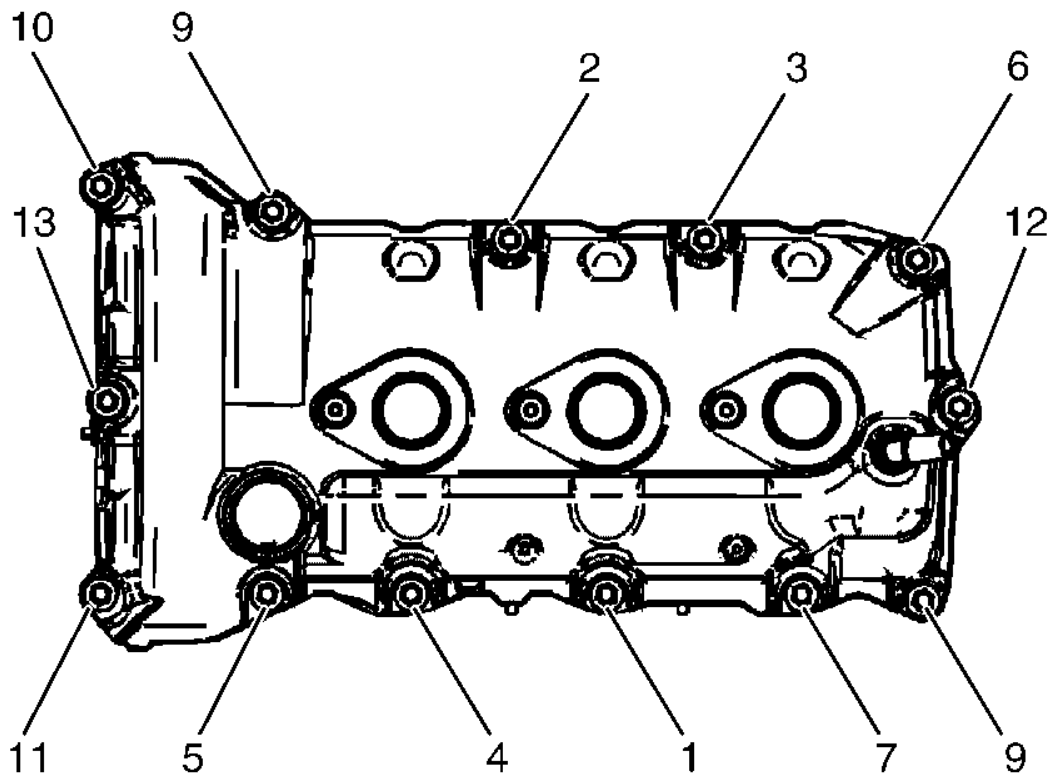
**NOTE:** Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.

5. Place a 3 mm bead of RTV sealant (1) on the join line between the engine front cover and the cylinder head.
6. Install a NEW camshaft cover seal and NEW grommets.



**Fig. 110: Identifying Left Camshaft Cover To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

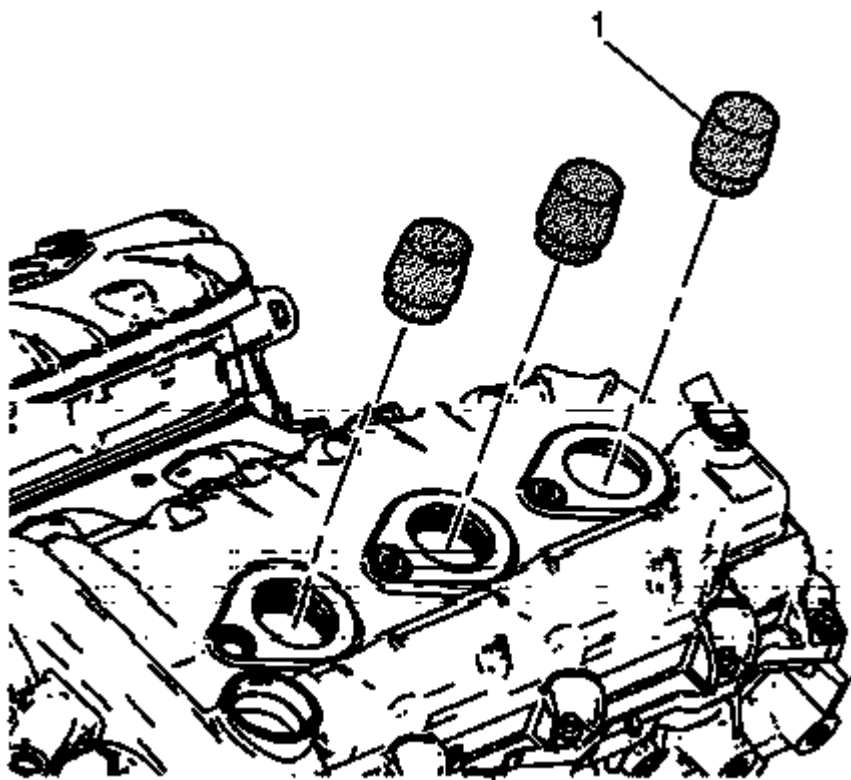
7. Install the camshaft cover (2) from the cylinder head (3).
8. Loosely install the left camshaft cover to cylinder head retaining bolts (1).



**Fig. 111: Identifying Left Camshaft Cover To Cylinder Head Retaining Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

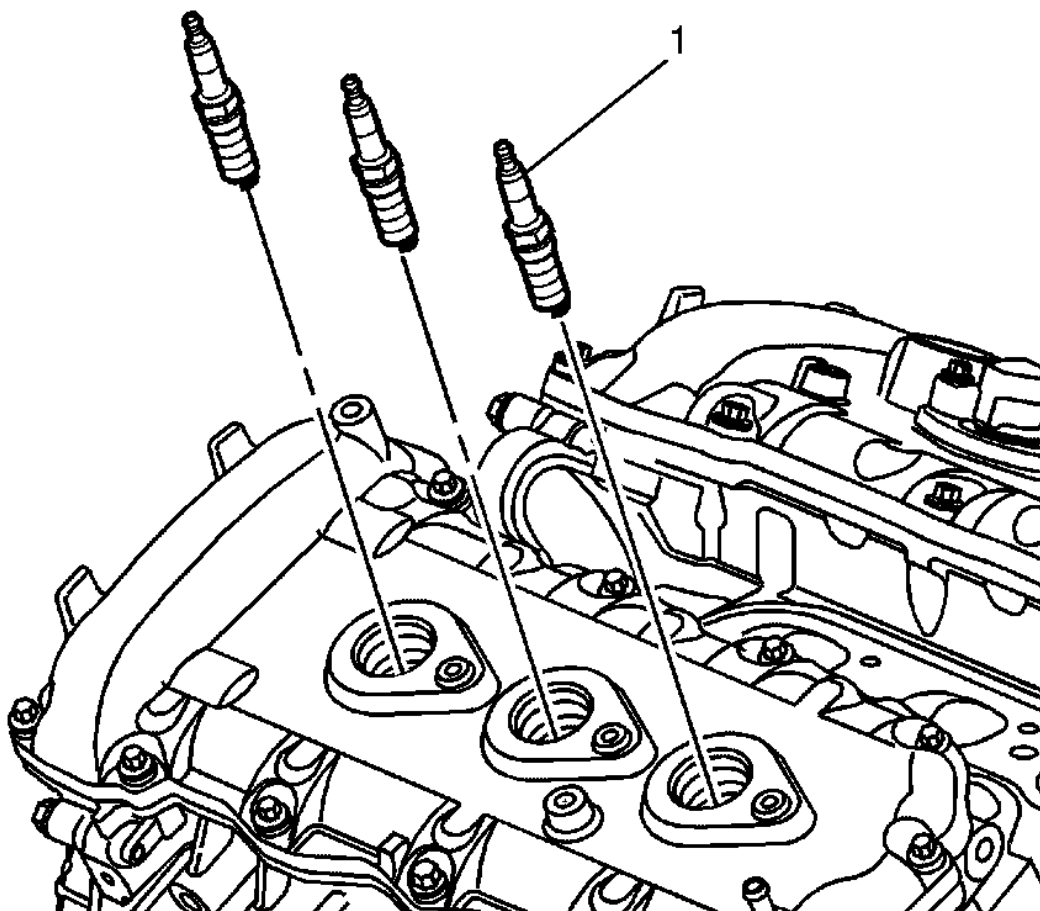
9. Tighten the left camshaft cover to cylinder head retaining bolts in the sequence shown and tighten in sequence to 10 N.m (89 lb in).



**Fig. 112: View Of EN 46101**

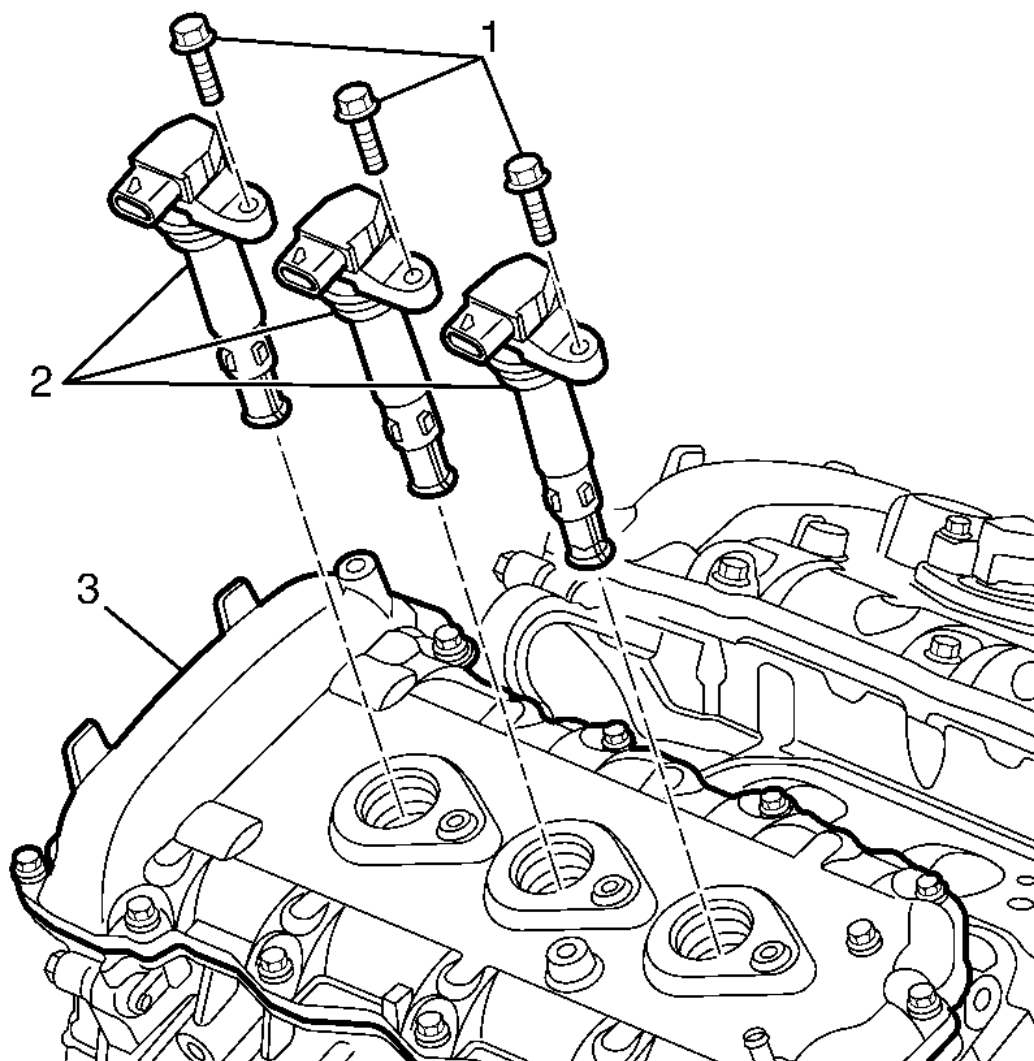
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN 46101**: guide (1) from the spark plug tubes of the left cylinder head.



**Fig. 113: View Of Spark Plugs**  
Courtesy of GENERAL MOTORS CORP.

11. Install the spark plugs (1).



**Fig. 114: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

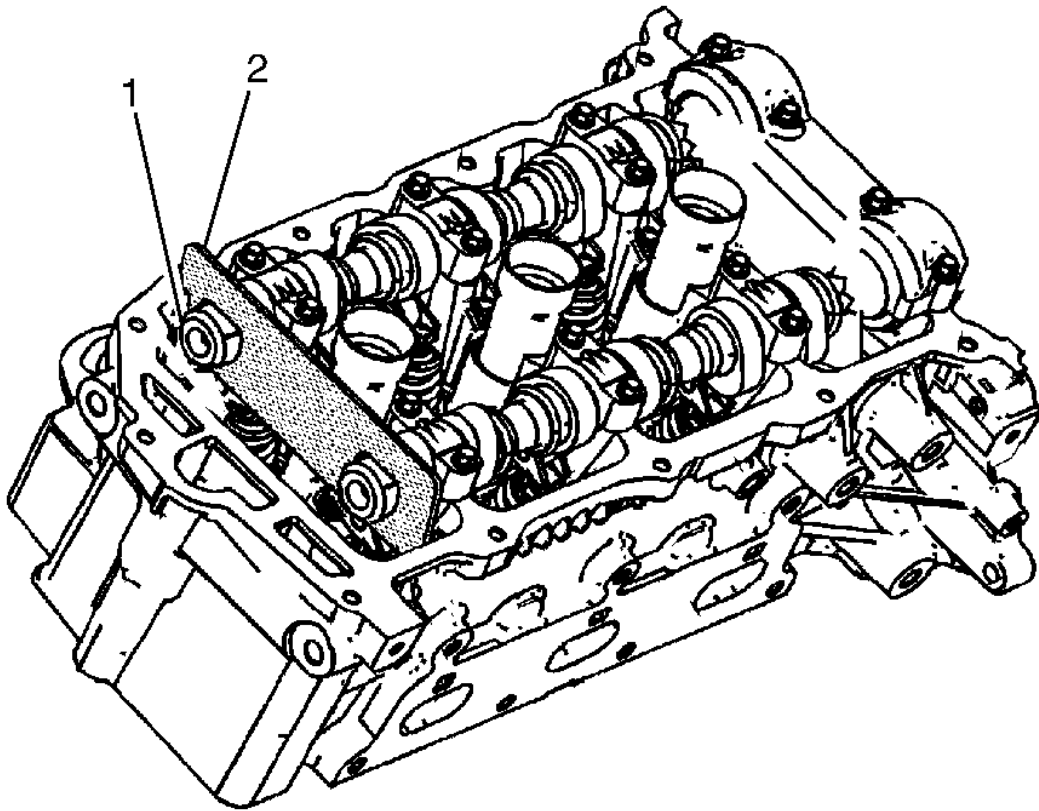
**NOTE:** DO NOT damage the spark plug and/or the seal in the left camshaft cover or an engine misfire condition may result.

12. Install the ignition coils (2) to the camshaft cover (3).
13. Install each ignition coil to camshaft cover retaining bolt (1) and tighten to 10 N.m (89 lb in).

#### CAMSHAFT COVER INSTALLATION - RIGHT SIDE

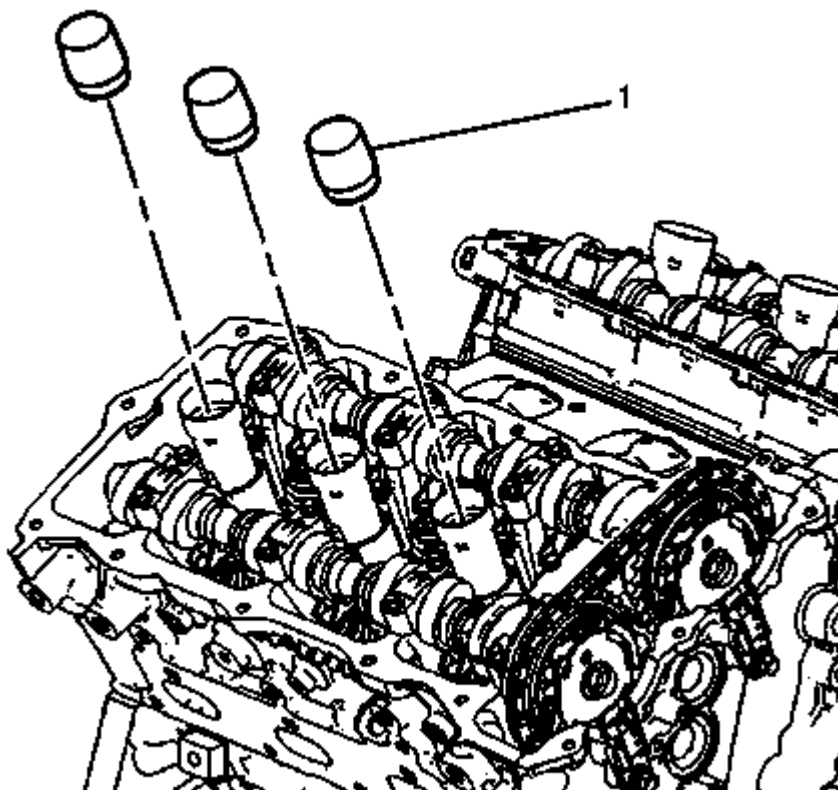
##### Special Tools

- **EN 46101:** Spark Plug Tube Seal Guide
- **EN 46105:** Camshaft Locking Tools For equivalent regional tools, refer to **Special Tools** .

**Installation**

**Fig. 115: View Of EN 46105 & Right Side Camshafts**  
**Courtesy of GENERAL MOTORS CORP.**

1. Remove the **EN 46105:** tools (2) from the rear of the right camshafts (1).

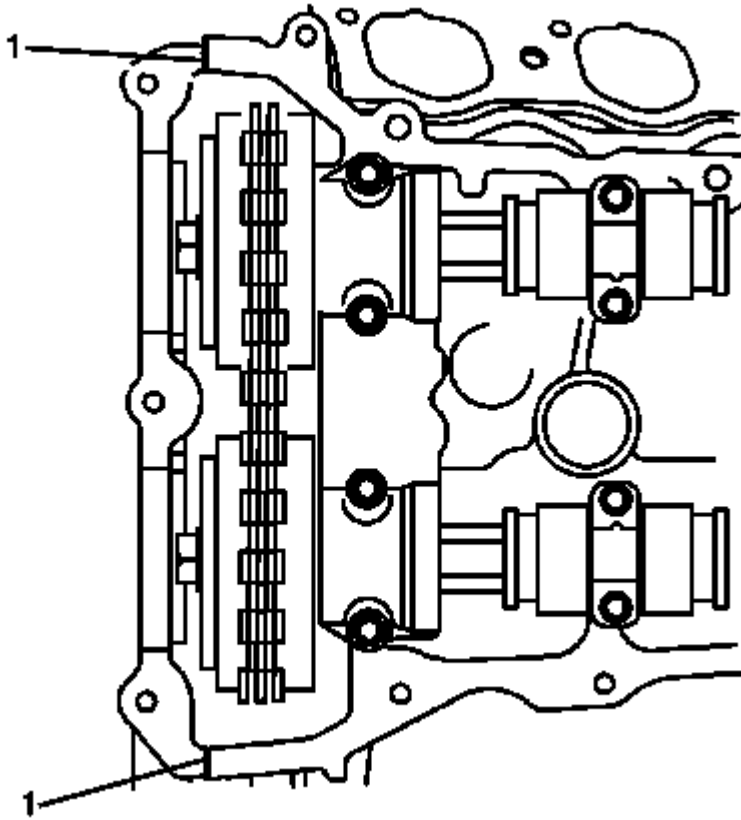


**Fig. 116: View Of EN-46101**

Courtesy of GENERAL MOTORS CORP.

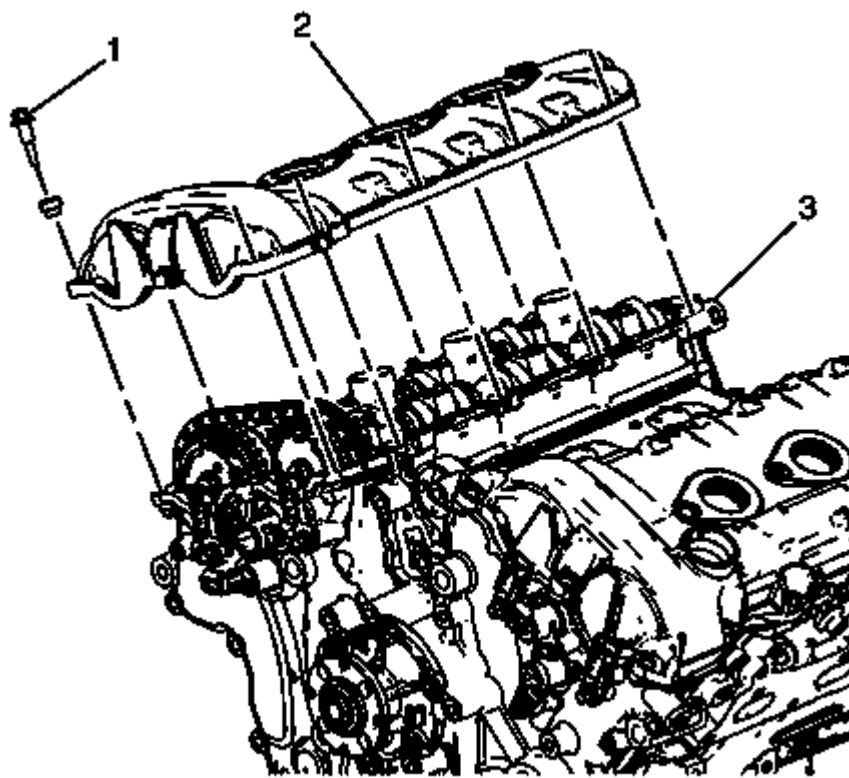
2. Install the **EN 46101**: guide (1) onto the spark plug tubes of the right cylinder head.
3. Install the camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the right cylinder head with a clean, lint-free cloth.





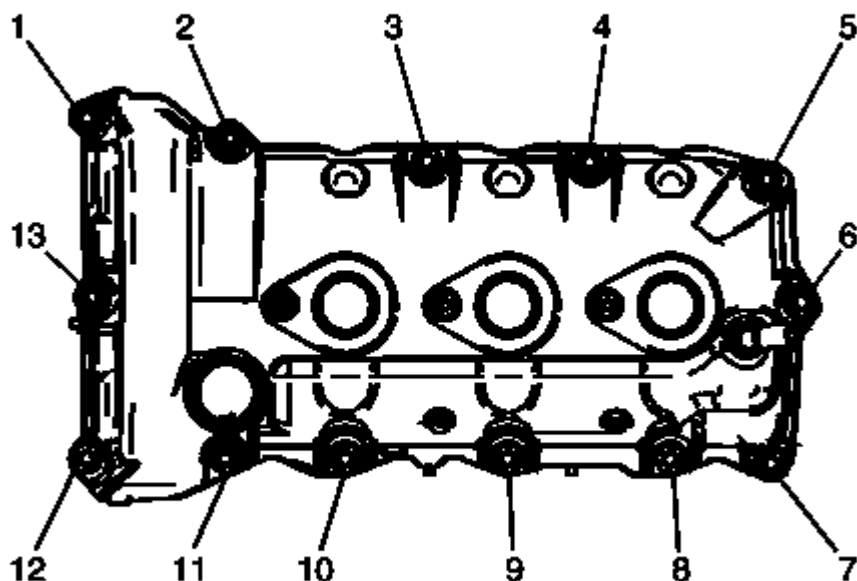
**Fig. 117: View Of Engine Front Cover Split Lines**  
Courtesy of GENERAL MOTORS CORP.

5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines (1).



**Fig. 118: Identifying Right Camshaft Cover With Bolts**  
Courtesy of GENERAL MOTORS CORP.

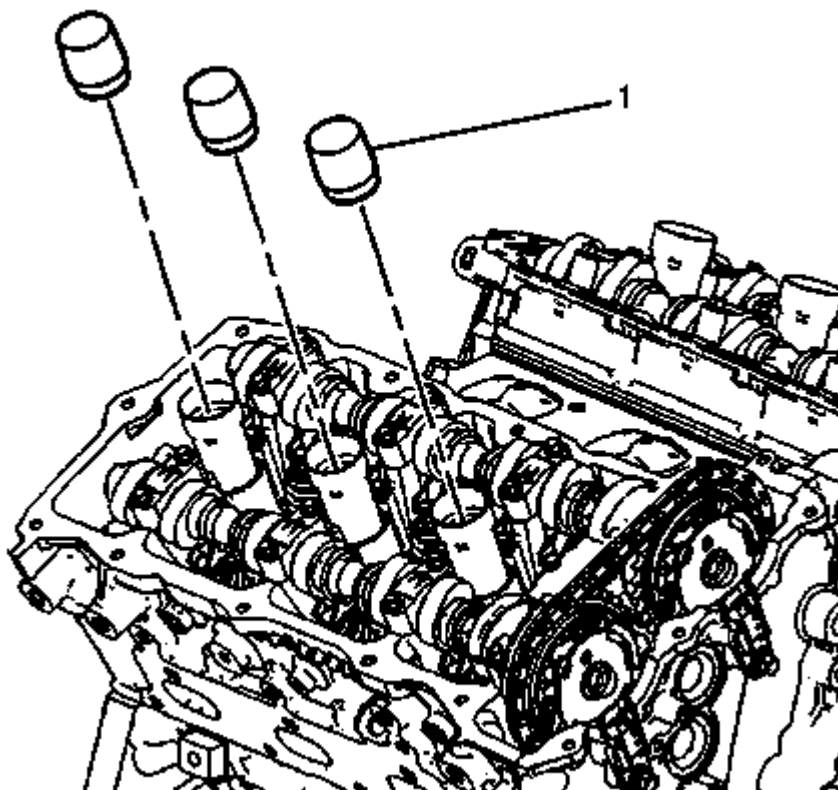
6. Place the right camshaft cover (2) into position onto the right cylinder head (3).
7. Loosely install the right camshaft cover bolts (1).



**Fig. 119: Identifying Left Camshaft Cover To Cylinder Head Retaining Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

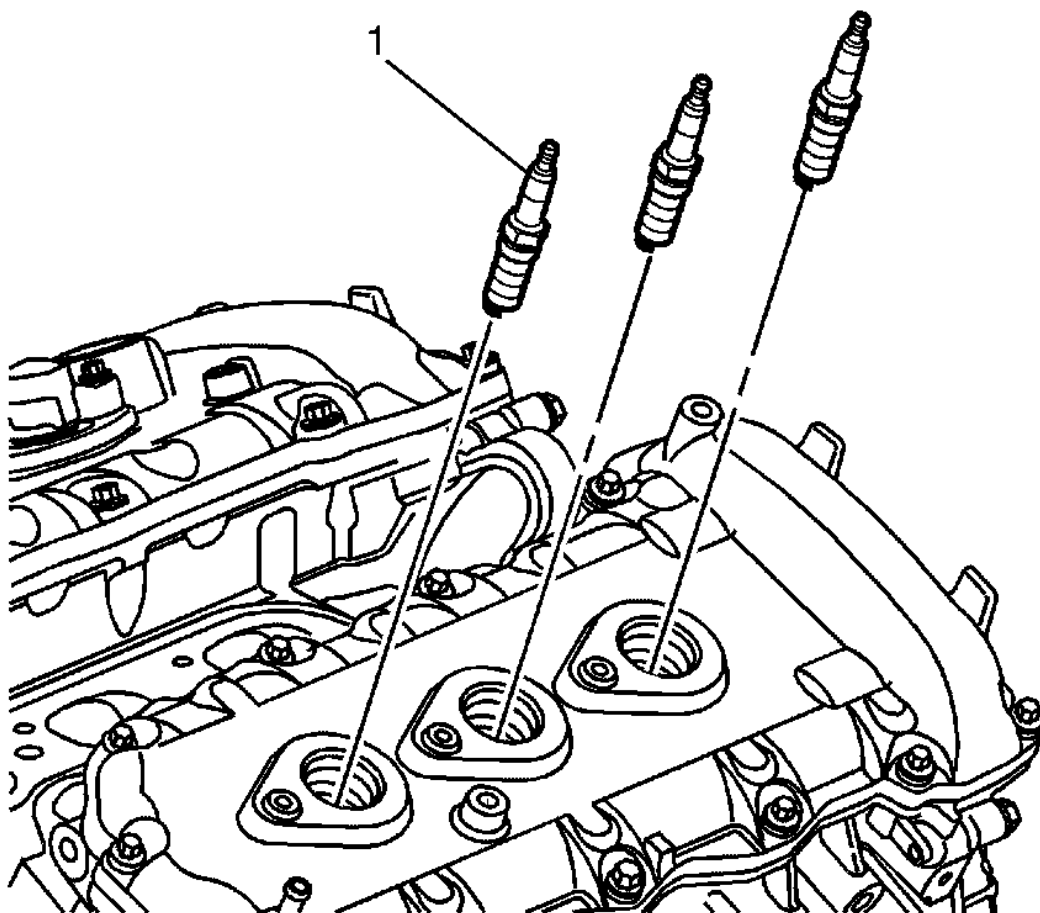
8. Tighten the left camshaft cover to cylinder head retaining bolts in the sequence shown and tighten in sequence to 10 N.m (89 lb in).



**Fig. 120: View Of EN-46101**

Courtesy of GENERAL MOTORS CORP.

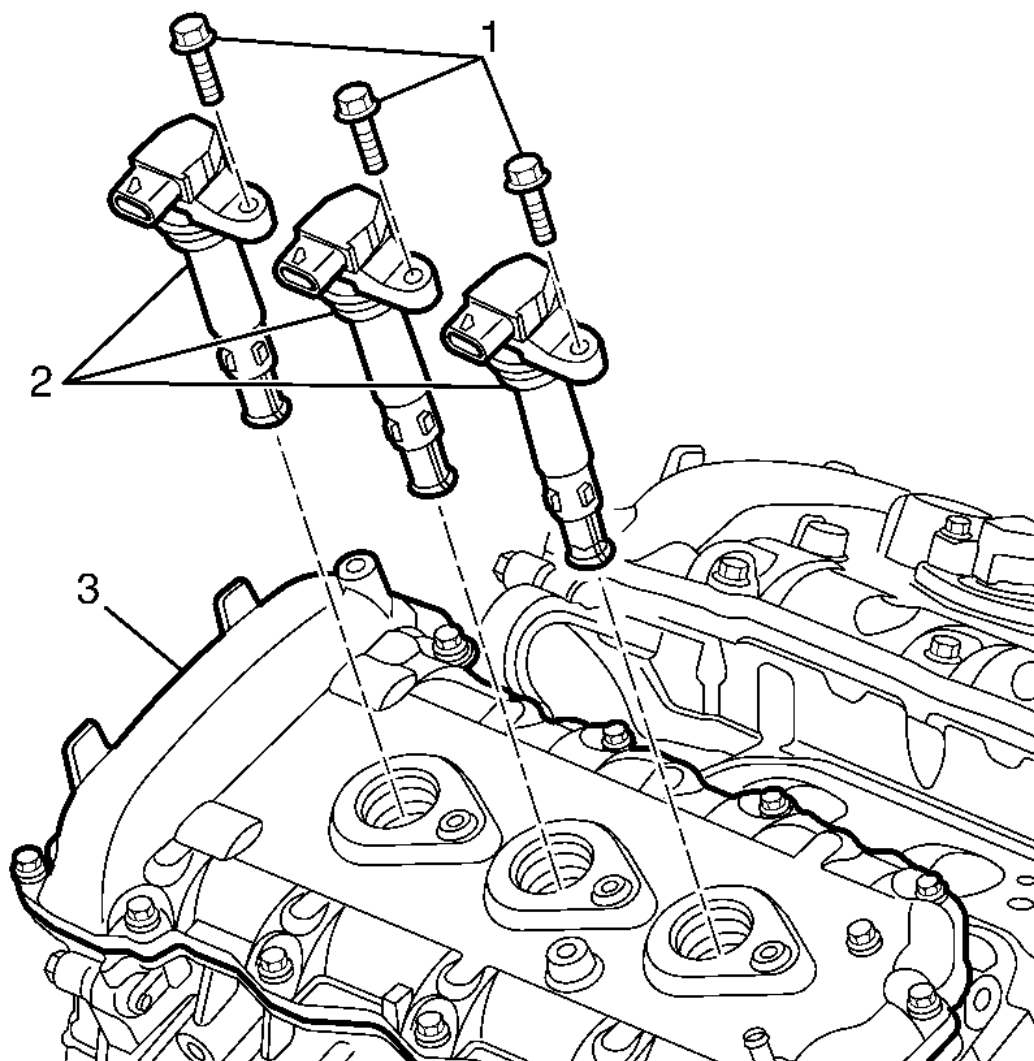
9. Remove the **EN 46101**: guide (1) from the spark plug tubes of the right cylinder head.



**Fig. 121: View Of Spark Plugs**

Courtesy of GENERAL MOTORS CORP.

10. Install the NEW spark plugs (1) and tighten to 20 N.m (15 lb ft).

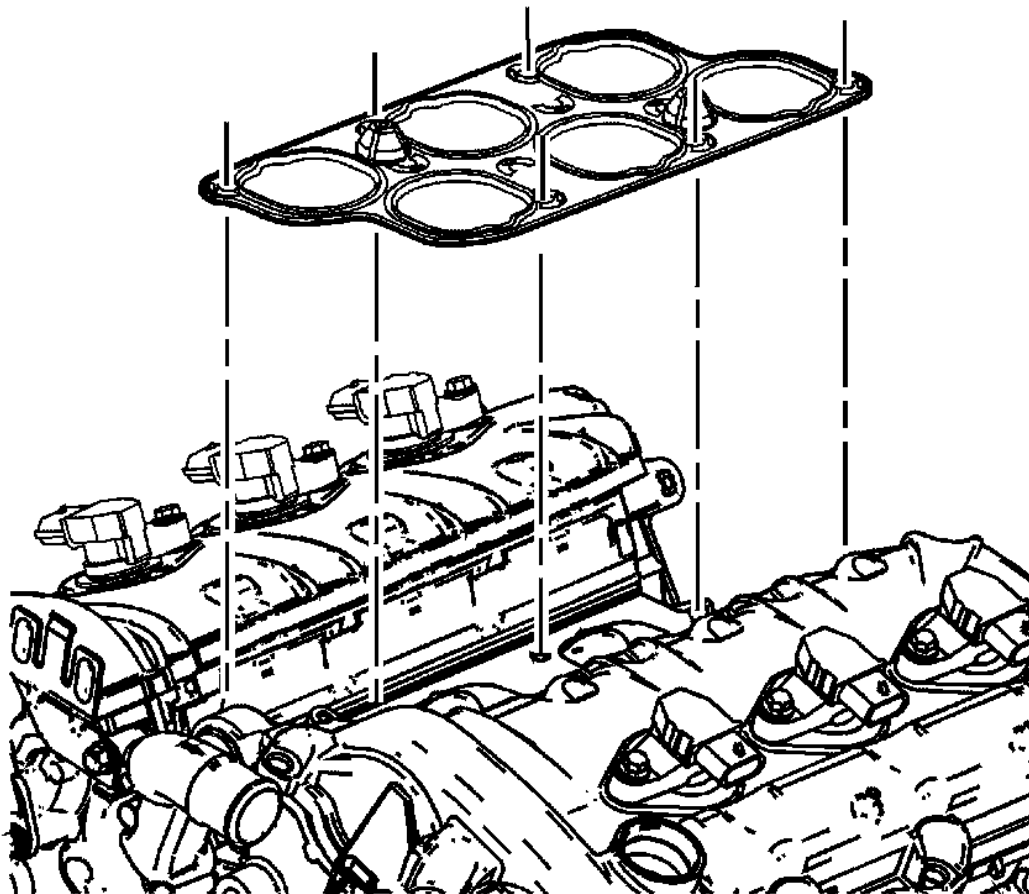


**Fig. 122: Identifying Ignition Coil To Camshaft Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT damage the spark plug and/or the seal in the left camshaft cover or an engine misfire condition may result.

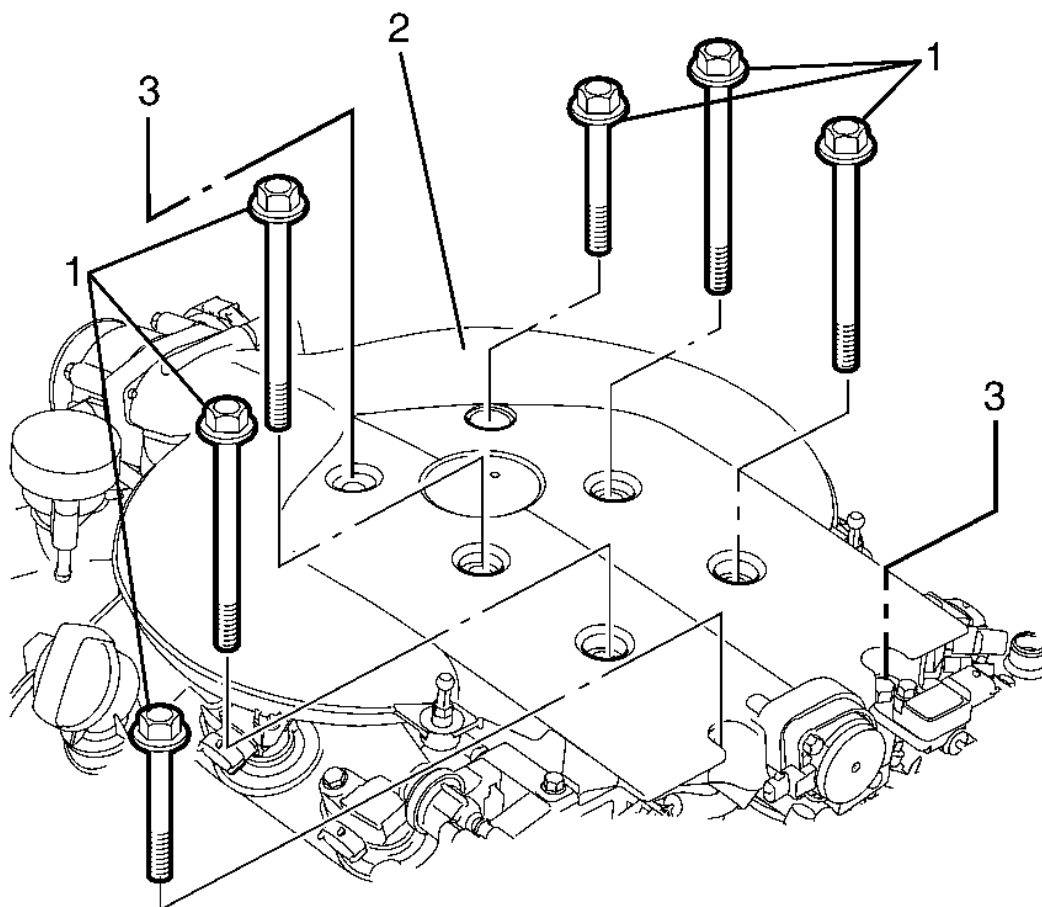
11. Install the ignition coils (2).
12. Install each ignition coil to camshaft cover retaining bolt (1) and tighten to 10 N.m (89 lb in).

#### INTAKE MANIFOLD INSTALLATION



**Fig. 123: View Of Lower Intake Manifold Gasket**  
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW intake manifold gasket.



**Fig. 124: Identifying Throttle Body, Intake Manifold & Bolts**  
Courtesy of GENERAL MOTORS CORP.

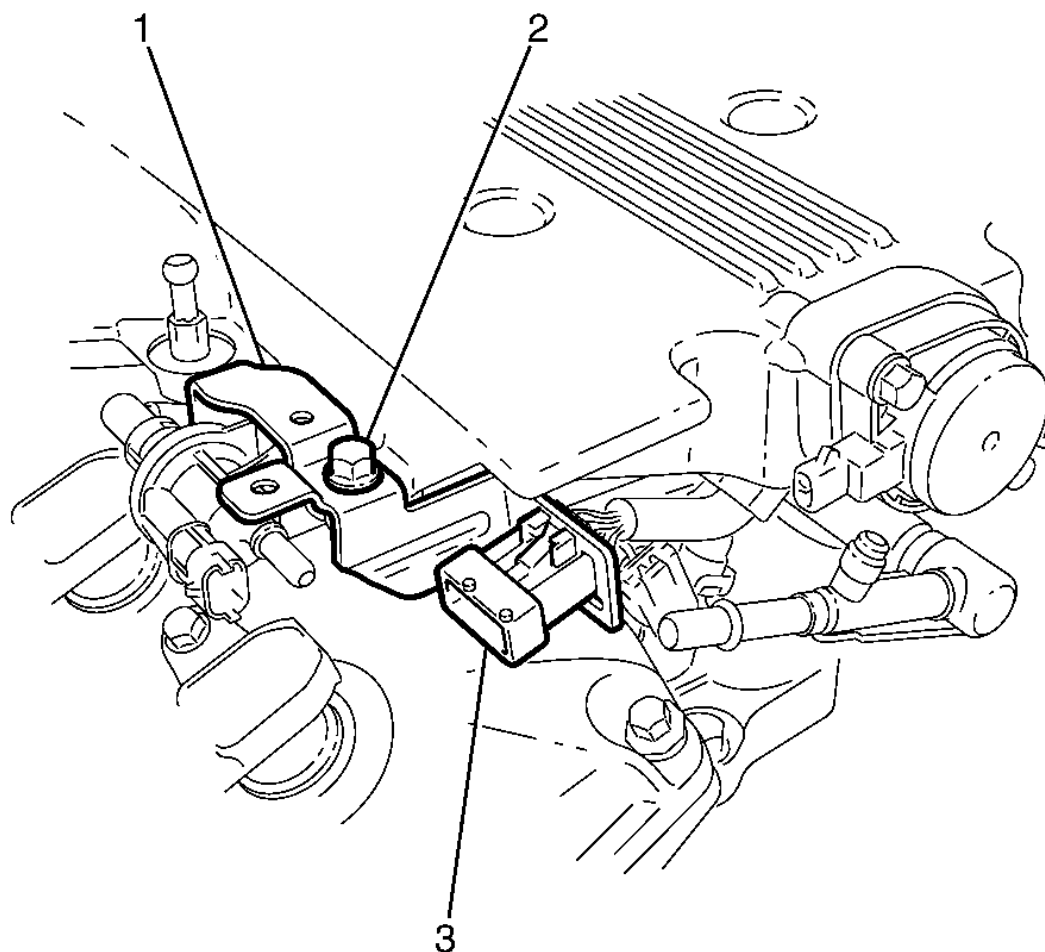
2. Install the intake manifold (2) and the throttle body (3) as an assembly as an assembly.

**CAUTION:** Refer to Fastener Caution .

**NOTE:** Tighten the intake manifold bolts (1) in a circular pattern starting at the center (long bolts) and moving outward.

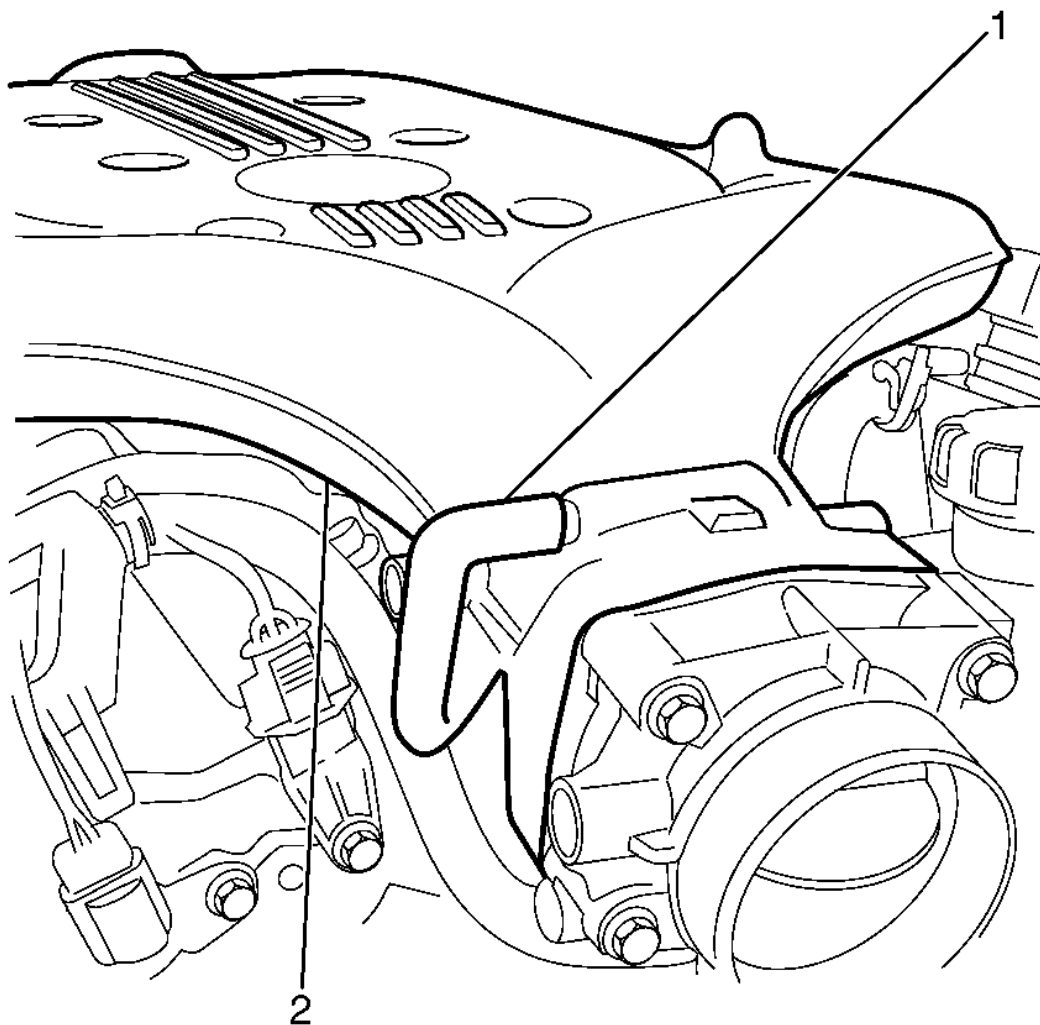
3. Install the intake manifold bolts (1) and tighten to 23 N.m (17 lb ft).





**Fig. 125: Identifying Fuel Injector Harness Electrical Connector & EVAP Valve Mounting Bracket**  
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel injector harness electrical connector/EVAP valve mounting bracket (1).
5. Install the fuel injector harness electrical connector/EVAP valve mounting bracket to intake manifold retaining bolt (2) and tighten to 10 N.m (89 lb in).
6. Attach the fuel injector harness electrical connector (3) to the fuel injector harness electrical connector/EVAP valve mounting bracket (1).



**Fig. 126: View Of EVAP Hose & Upper Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

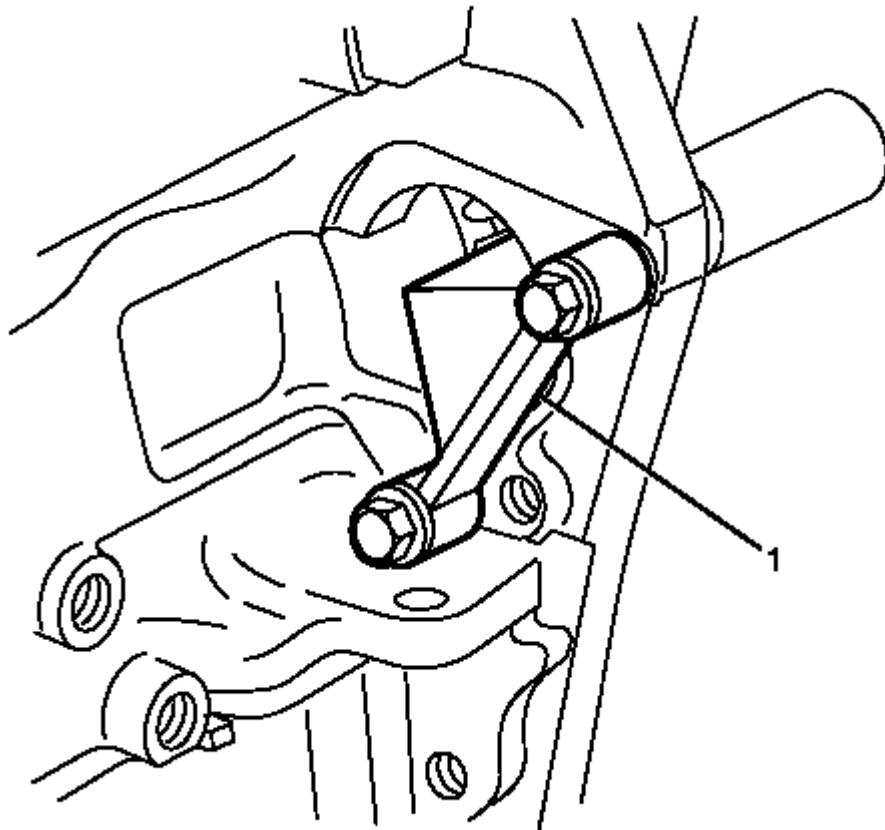
7. Connect the EVAP hose (1) to the upper intake manifold (2).
8. Install the PCV tube and PCV fresh air tubes. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement** .

## ENGINE FLYWHEEL INSTALLATION

### Special Tools

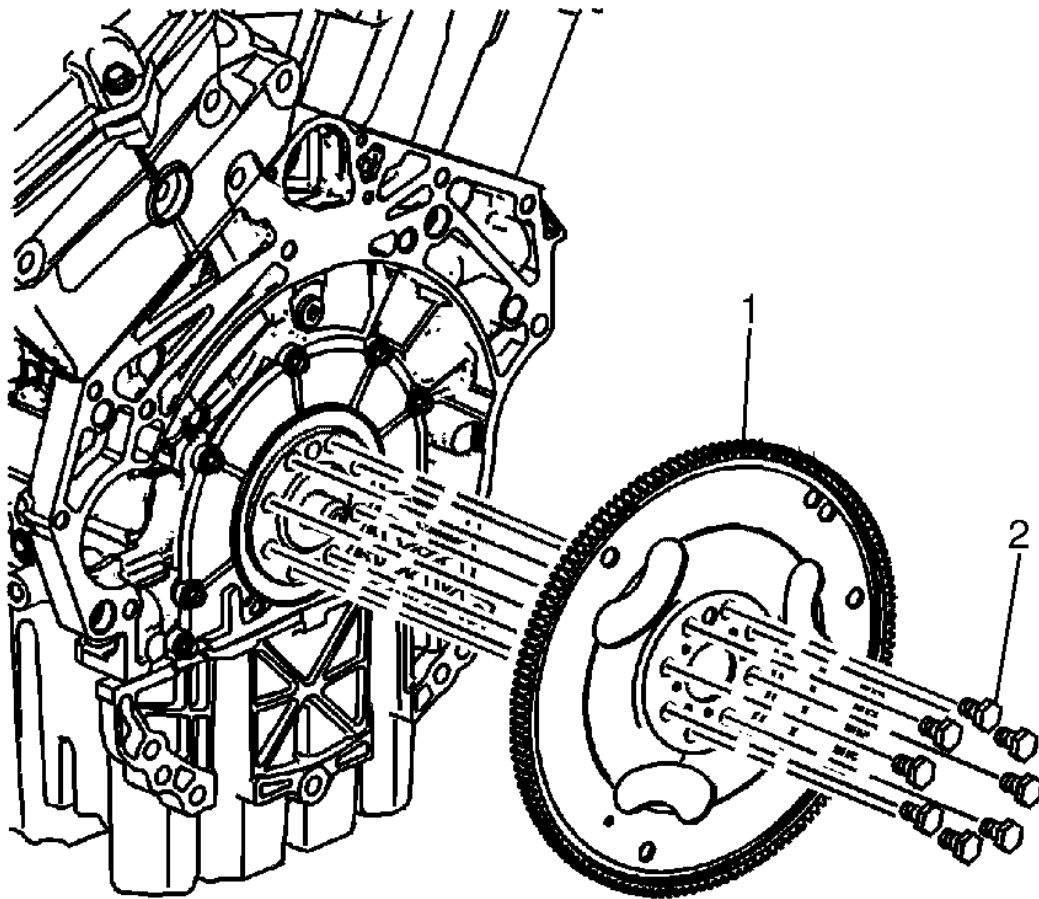
- **EN 46106:** Engine Flywheel Holding Tool
- **J 45059:** Angle Meter

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

**Installation**

**Fig. 127: View Of EN 46106**  
Courtesy of GENERAL MOTORS CORP.

1. Install the **EN 46106**: tool (1).



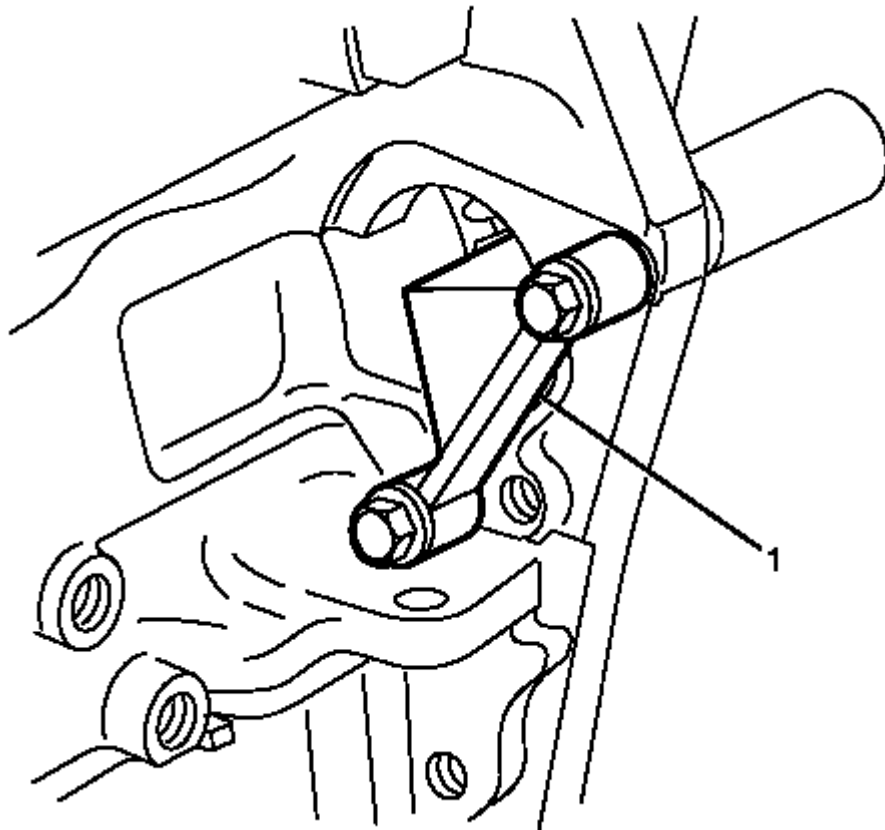
**Fig. 128: Identifying Automatic Transmission Flex Plate To Crankshaft Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

2. Place the automatic transmission flex plate (2) in position.
3. Install 2 NEW automatic transmission flex plate to crankshaft retaining bolts (1) in location at the top and bottom of the automatic transmission flex plate (2) bolt pattern allowing the automatic transmission flex plate (2) to hang in position.

**CAUTION: Refer to Fastener Caution .**

4. Install the remaining NEW automatic transmission flex plate to crankshaft retaining bolts (1) and tighten to 30 N.m (22 lb ft).

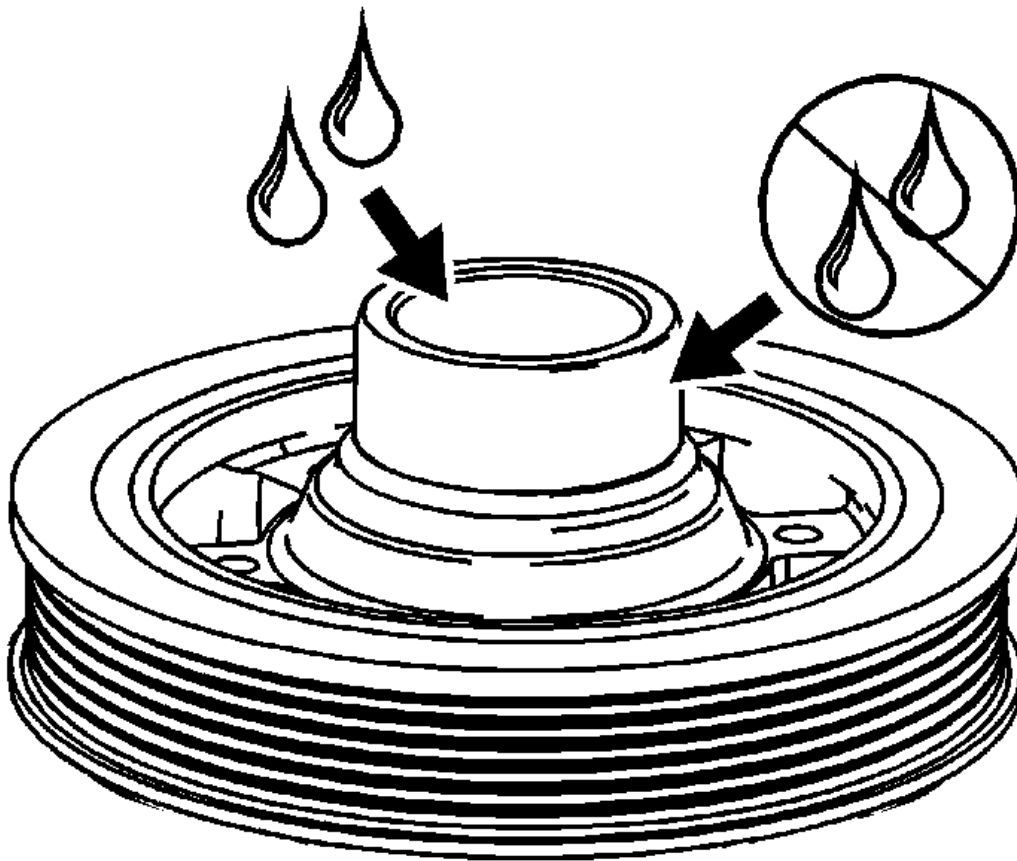
Tighten the bolts an additional 45 degrees using the **J 45059**: meter.

**CRANKSHAFT BALANCER INSTALLATION****Installation**

**Fig. 129: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

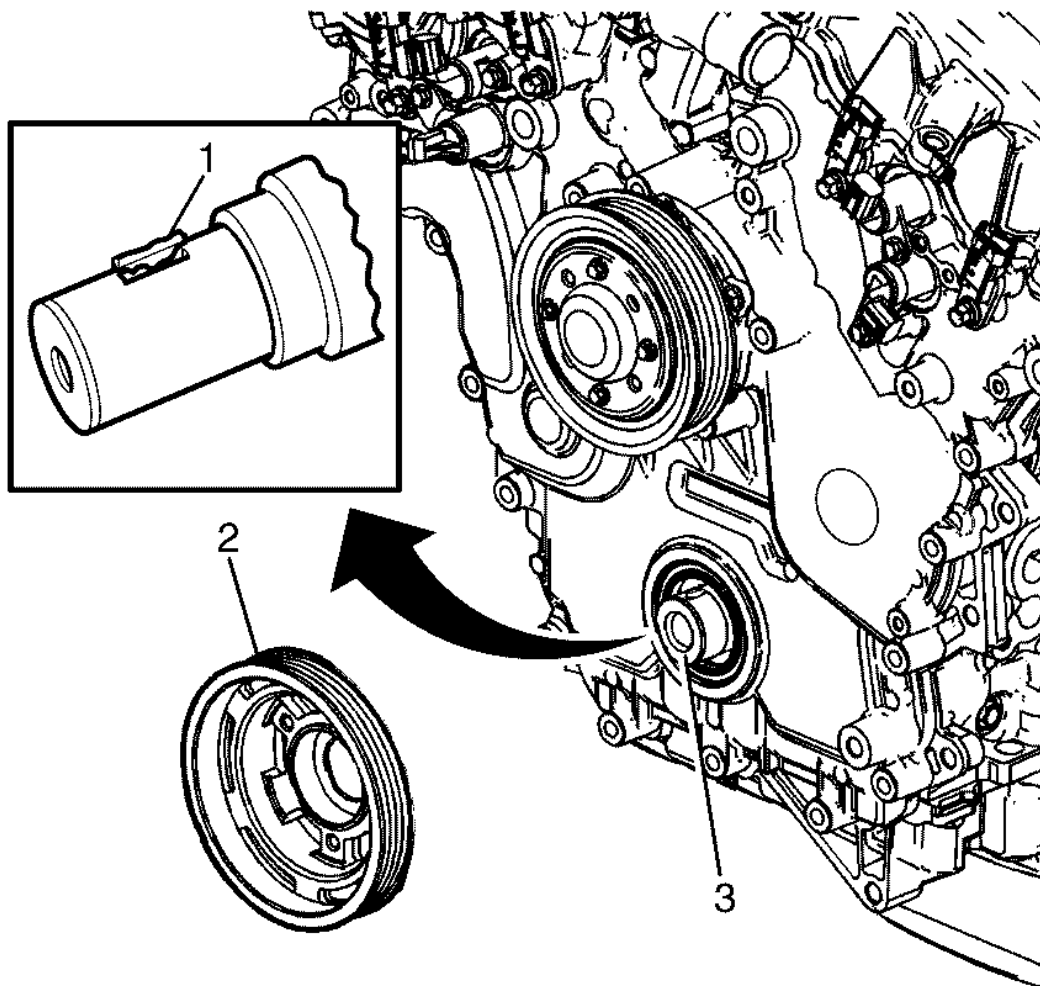
1. The **EN 46106**: tool (1) must be installed.



**Fig. 130: View Of Crankshaft Balancer Hub Bore Lubrication**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**      **DO NOT** lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

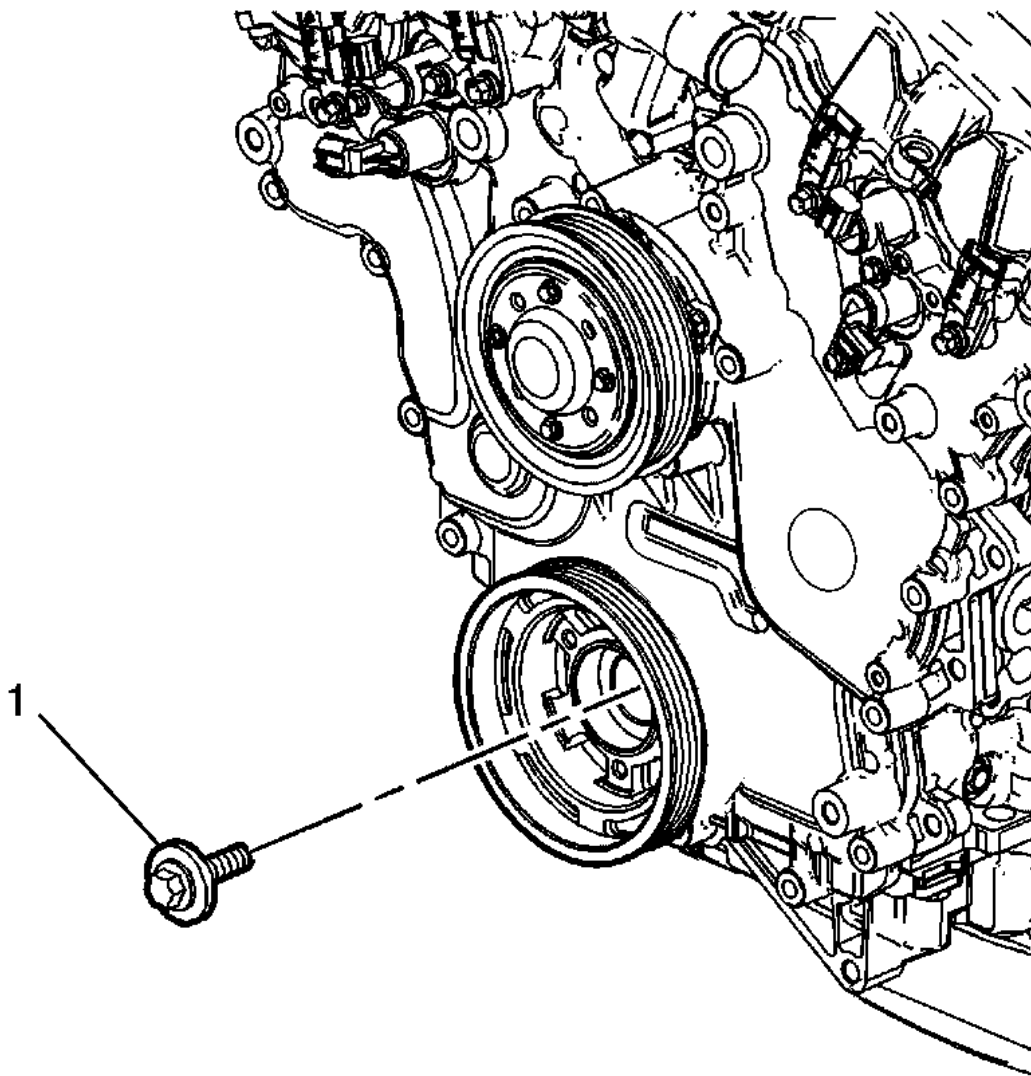
2. Apply lubricant to the inside of the crankshaft balancer hub bore.



**Fig. 131: View Of Crankshaft & Balancer**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the key (1) located on the top of the crankshaft is correctly installed in the crankshaft. Failure to adhere to this may cause engine damage.

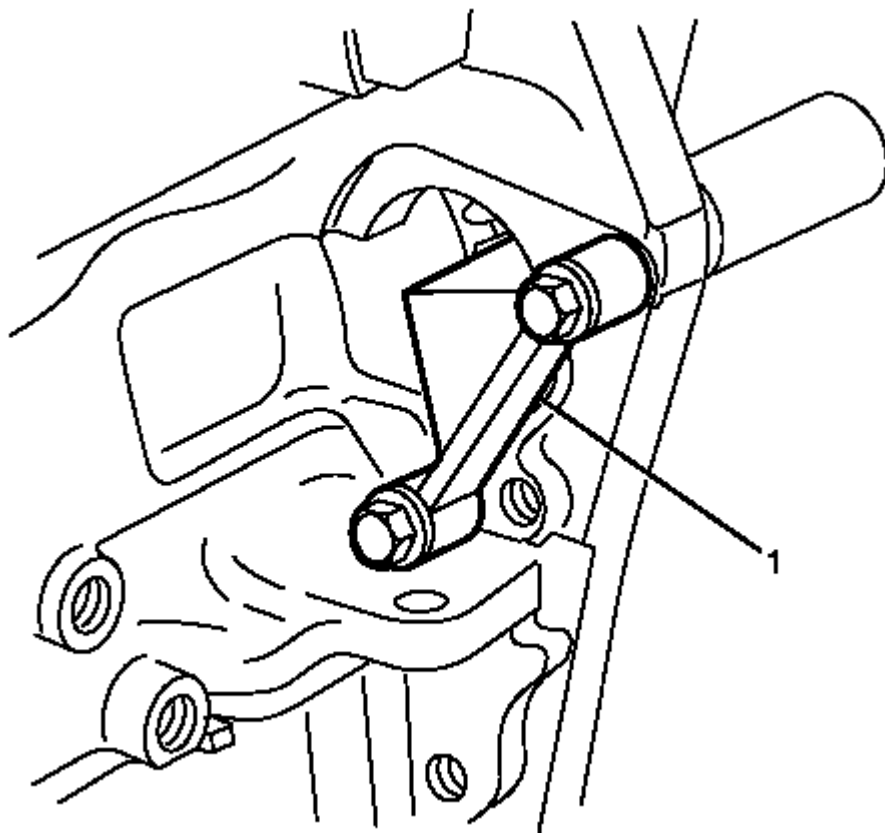
3. Install the crankshaft balancer (2) on to the crankshaft (3).



**Fig. 132: Identifying Crankshaft Balancer To Crankshaft Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft balancer to crankshaft retaining bolt (1).
  - Tighten the bolt to 100 N.m (74 lb ft).
  - Tighten the crankshaft balancer to crankshaft retaining bolt an additional 150 degrees using the **J 45059** meter.



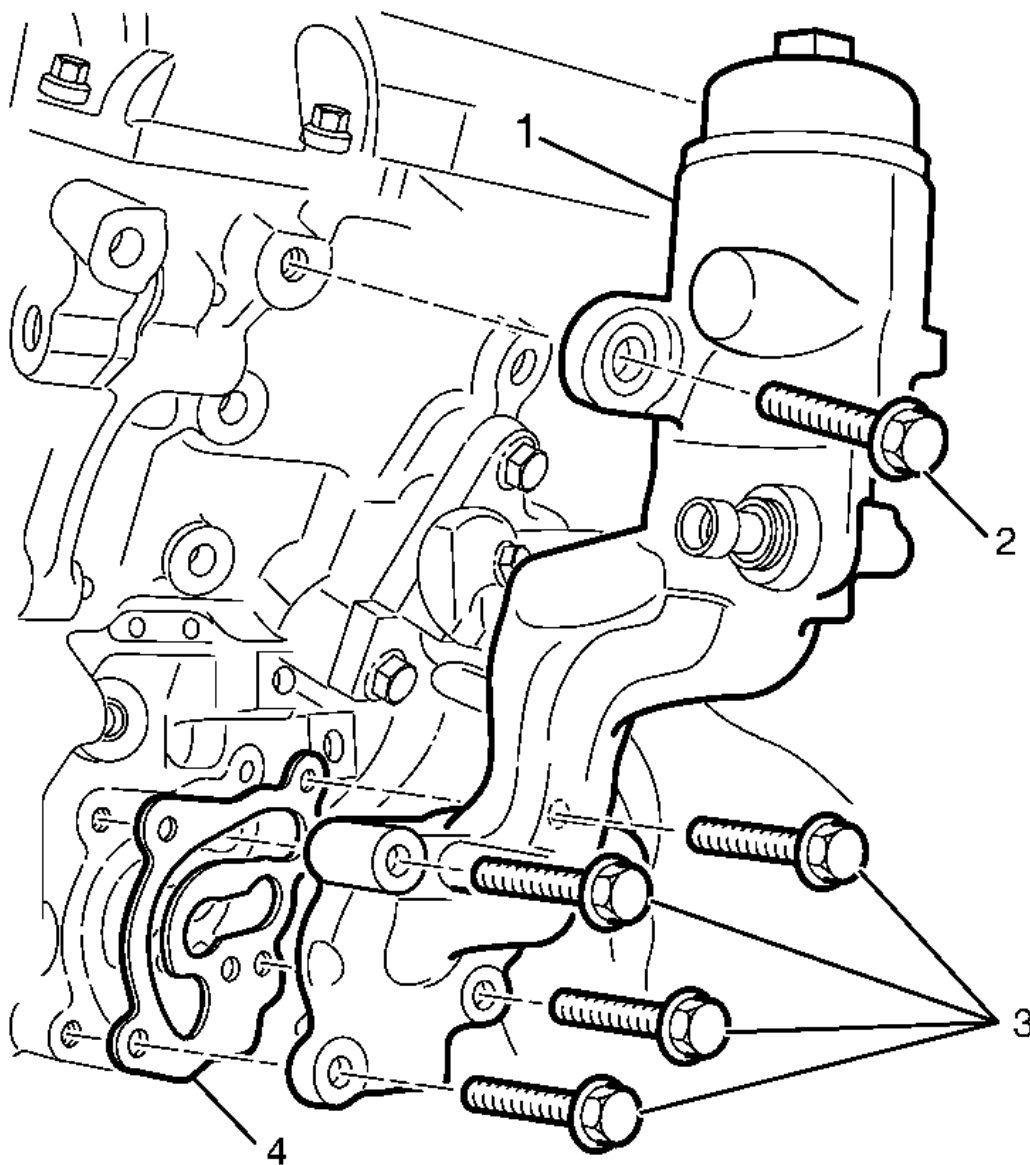


**Fig. 133: View Of EN 46106**

Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46106**: tool (1).

## **OIL FILTER ADAPTER INSTALLATION**

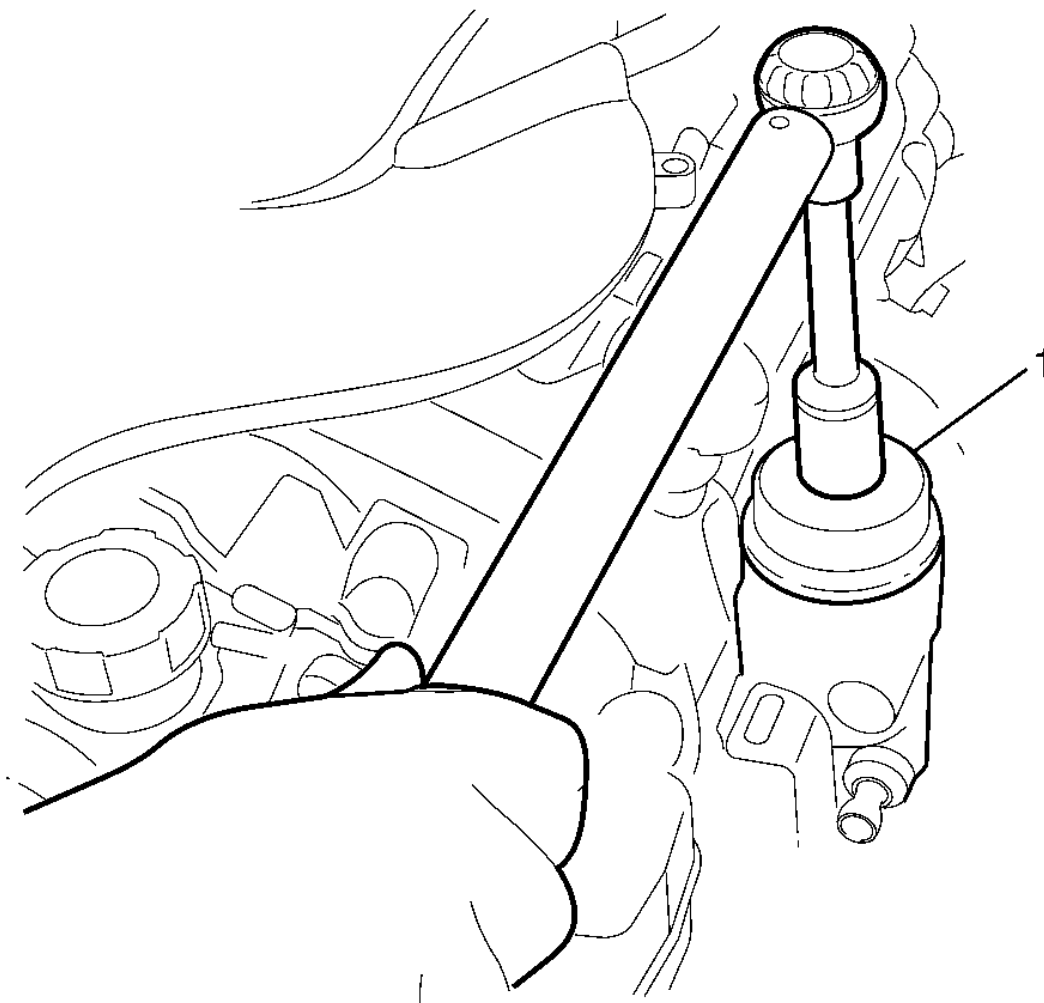


**Fig. 134: Identifying M8 & M10 Oil Filter Adapter Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Position a NEW oil filter adapter gasket (4) onto the oil filter adapter (1).
2. Install the M8 lower oil filter adapter to cylinder block retaining bolts (3).
3. Loosely tighten the M8 lower oil filter adapter to cylinder block retaining bolts (3).
4. Install the M10 upper oil filter adapter to cylinder head retaining bolt (2).
5. Loosely tighten the M10 upper oil filter adapter to cylinder head retaining bolt (2).

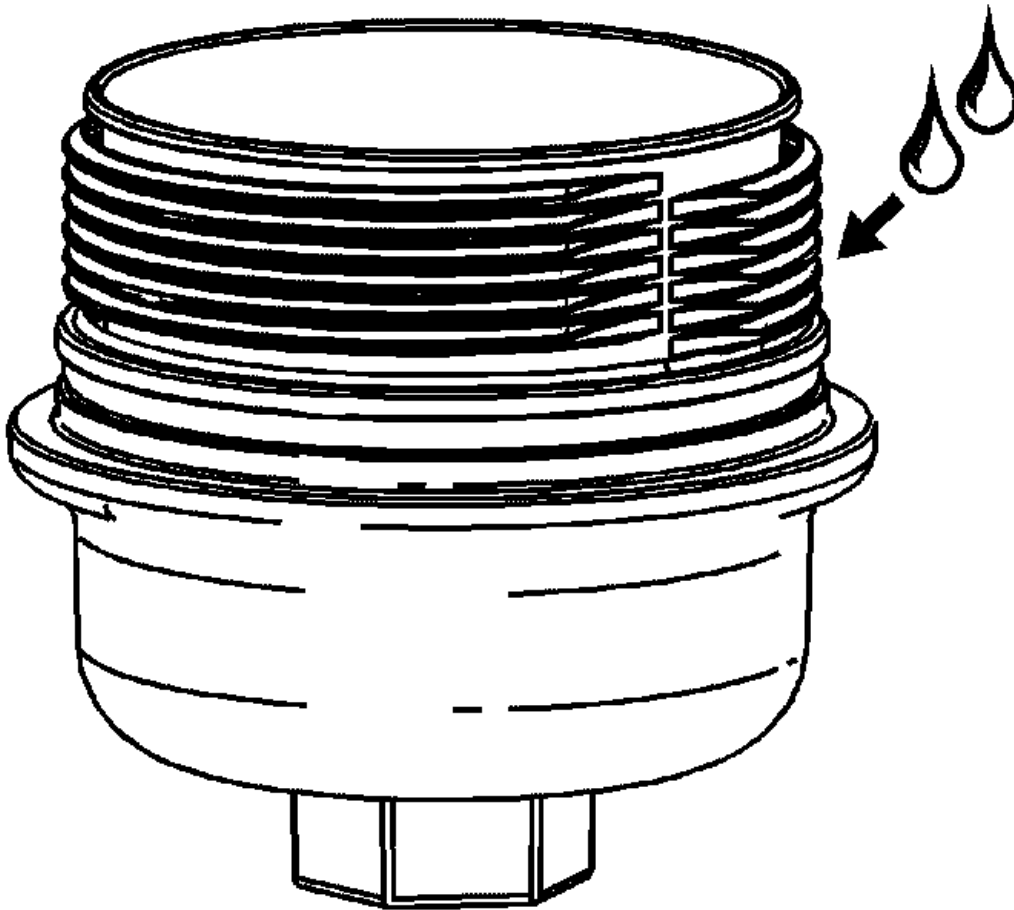
**CAUTION:** Refer to Fastener Caution .

6. Tighten the M8 lower oil filter adapter to cylinder block retaining bolts (3) and tighten to 23 N.m (17 lb ft).
7. Tighten the M10 upper oil filter adapter to cylinder head retaining bolt (2) and tighten to 58 N.m (42 lb ft).



**Fig. 135: Identifying Oil Filter Cap**  
Courtesy of GENERAL MOTORS CORP.

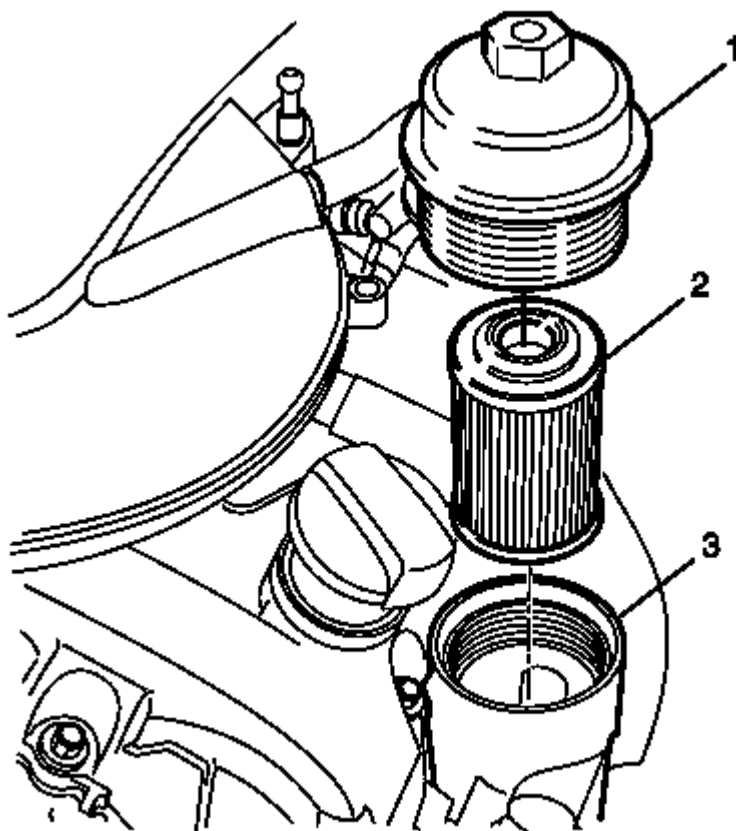
8. Remove the oil filter cap (1).



**Fig. 136: View Of Oil Filter Cap Thread Lubrication**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

9. Lubricate the oil filter cap threads with clean engine oil.



**Fig. 137: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

10. Install the NEW oil filter cartridge (2).

**CAUTION:** Proper oil filter cap tightening is mandatory. Failure to tighten the oil filter cap to the proper specification can hinder later removal and cause possible oil filter cap damage.

**NOTE:** Use a six-point socket to install the oil filter cap.

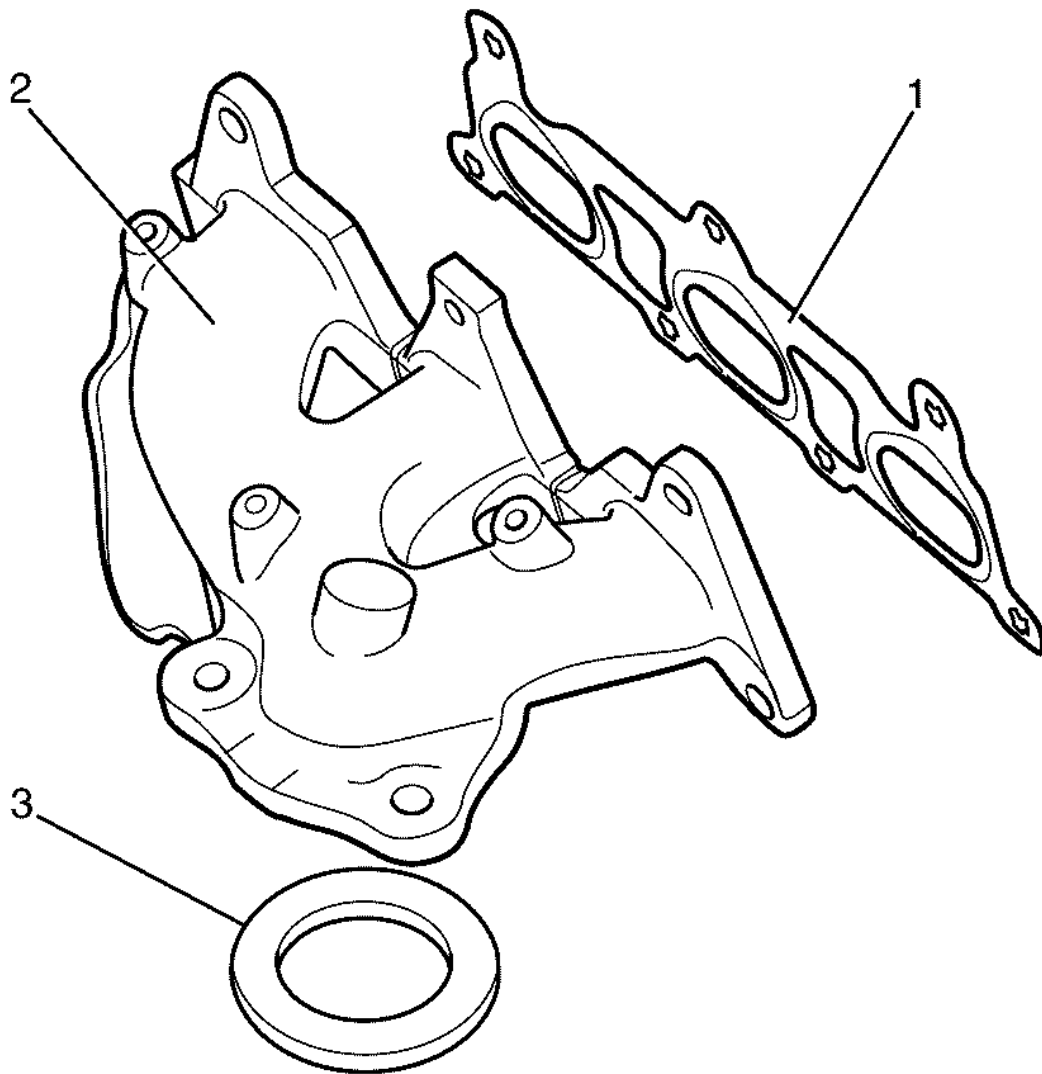
11. Install the oil filter adapter cap (1) to the engine oil filter adapter (3) and tighten to 25 N.m (18 lb ft).

## EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

### Installation Procedure

**CAUTION:** Refer to Exhaust System Inspection Caution .

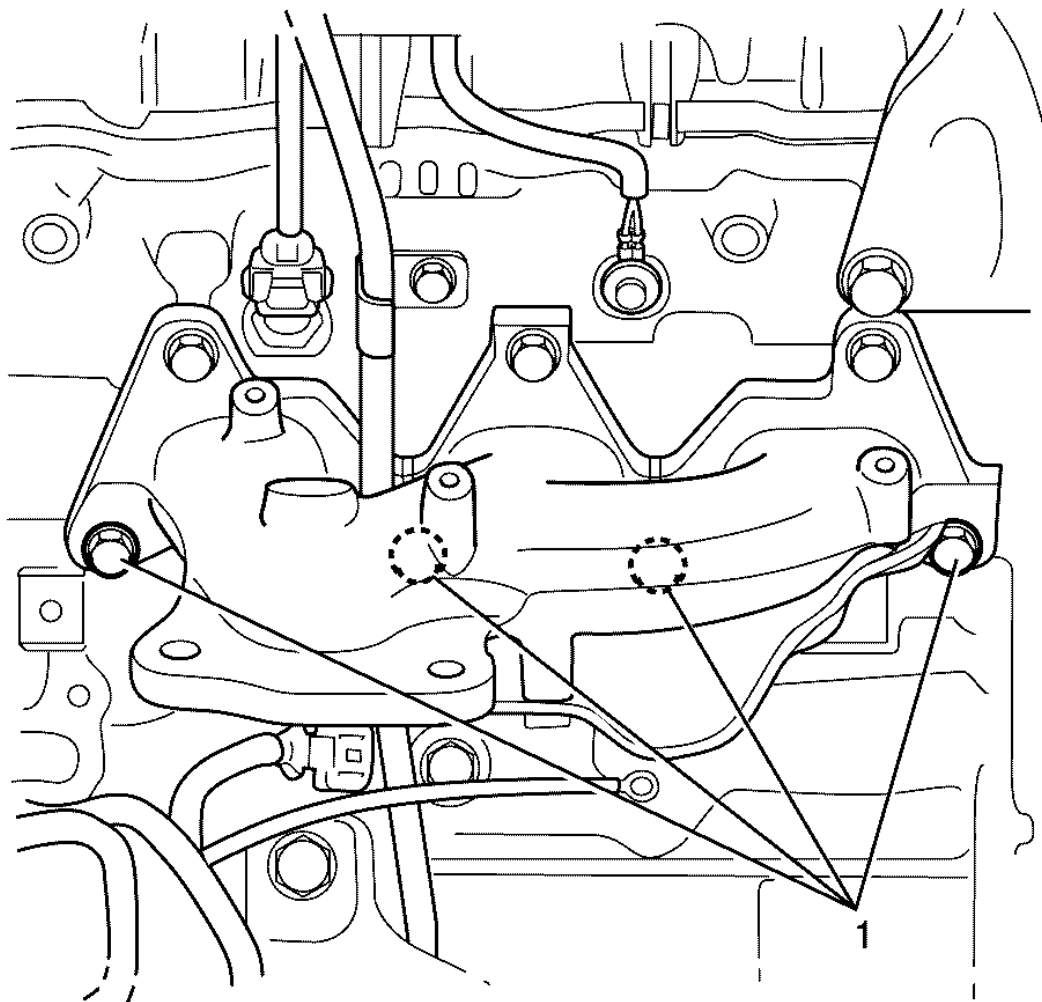
1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Left Side .



**Fig. 138: Identifying Sealing Ring & Exhaust Manifold With Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:**        **Make sure the sealing ring is seated correctly.**

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.



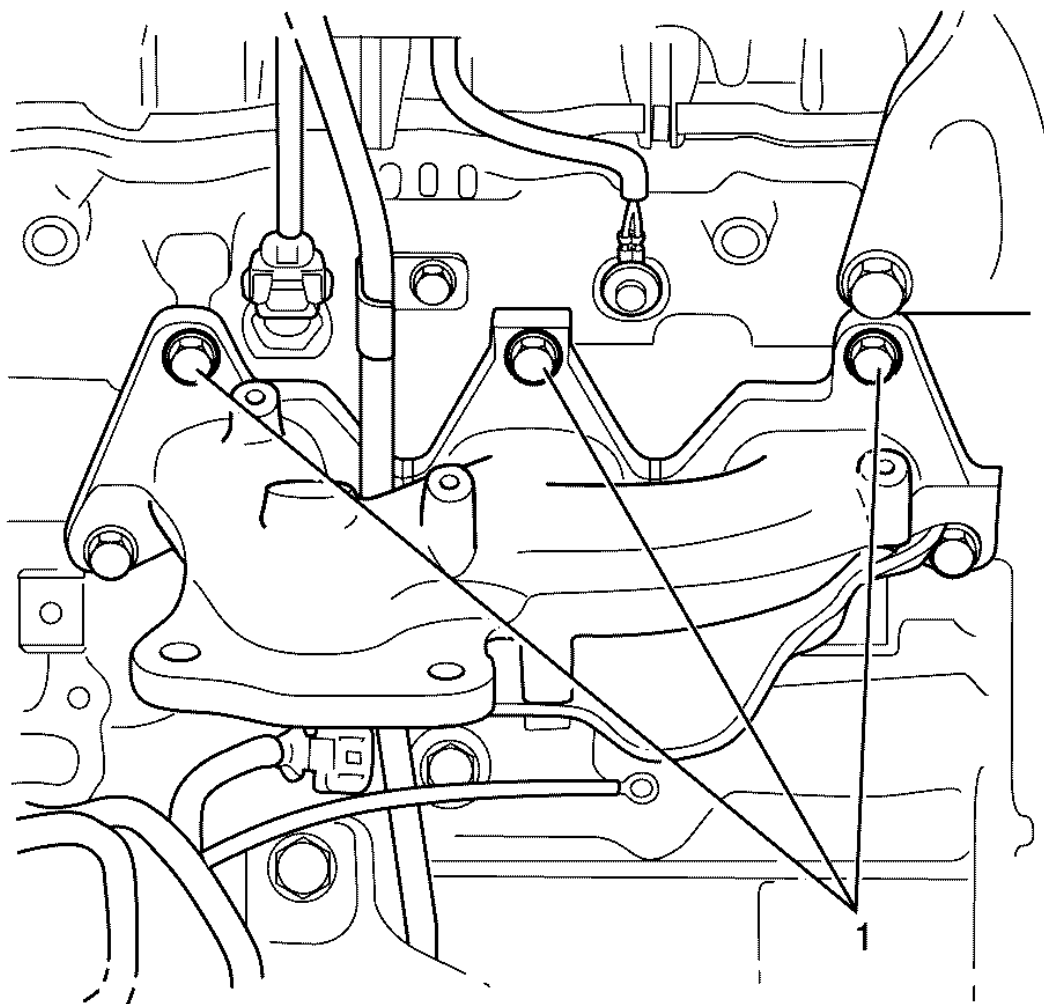
**Fig. 139: Lower Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

**CAUTION:** Refer to Fastener Caution .

5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to 20 N.m (15 lb ft).



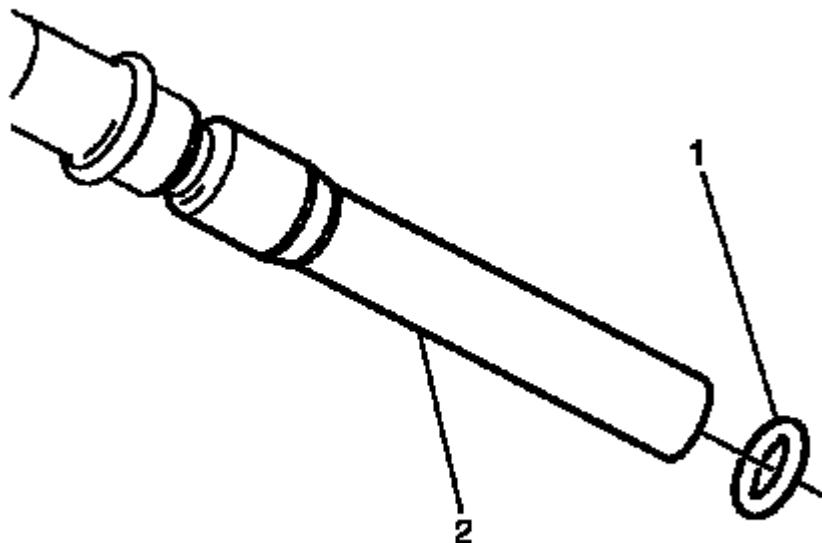
**Fig. 140: Upper Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to 20 N.m (15 lb ft).

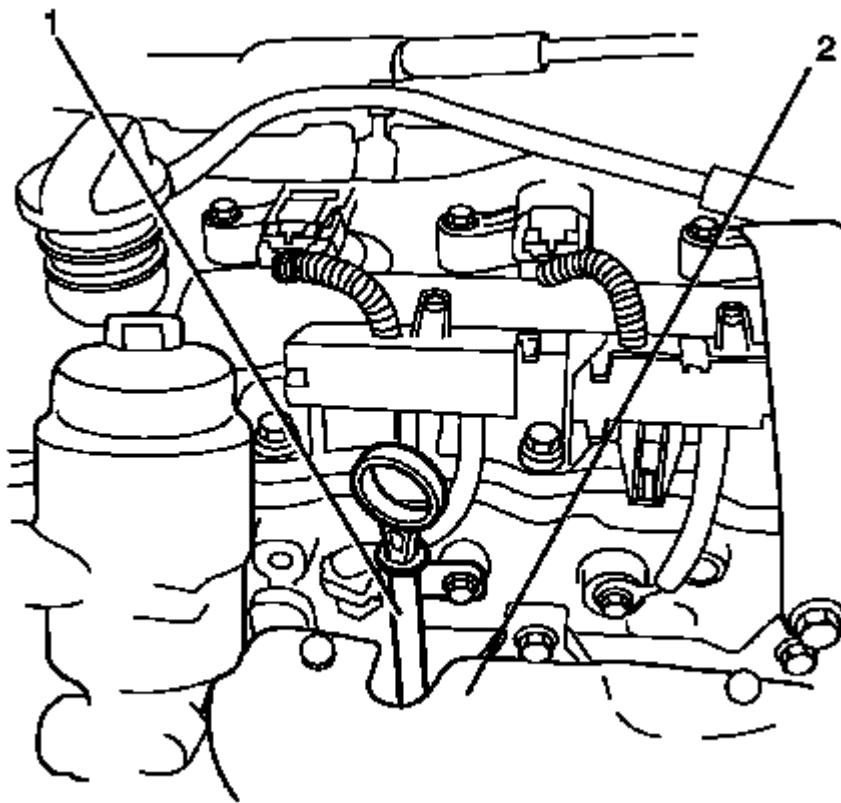
#### OIL LEVEL INDICATOR AND TUBE INSTALLATION





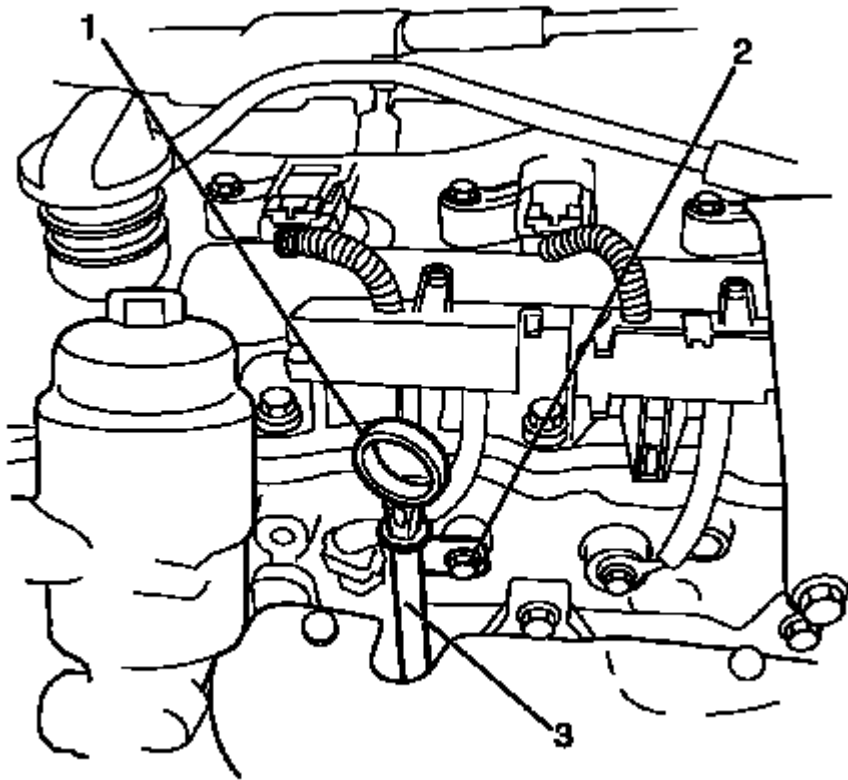
**Fig. 141: Identifying Oil Level Indicator Tube & O-Ring**  
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring (2) on the oil level indicator tube (1).



**Fig. 142: Identifying Oil Level Indicator Tube & Exhaust Manifold**  
Courtesy of GENERAL MOTORS CORP.

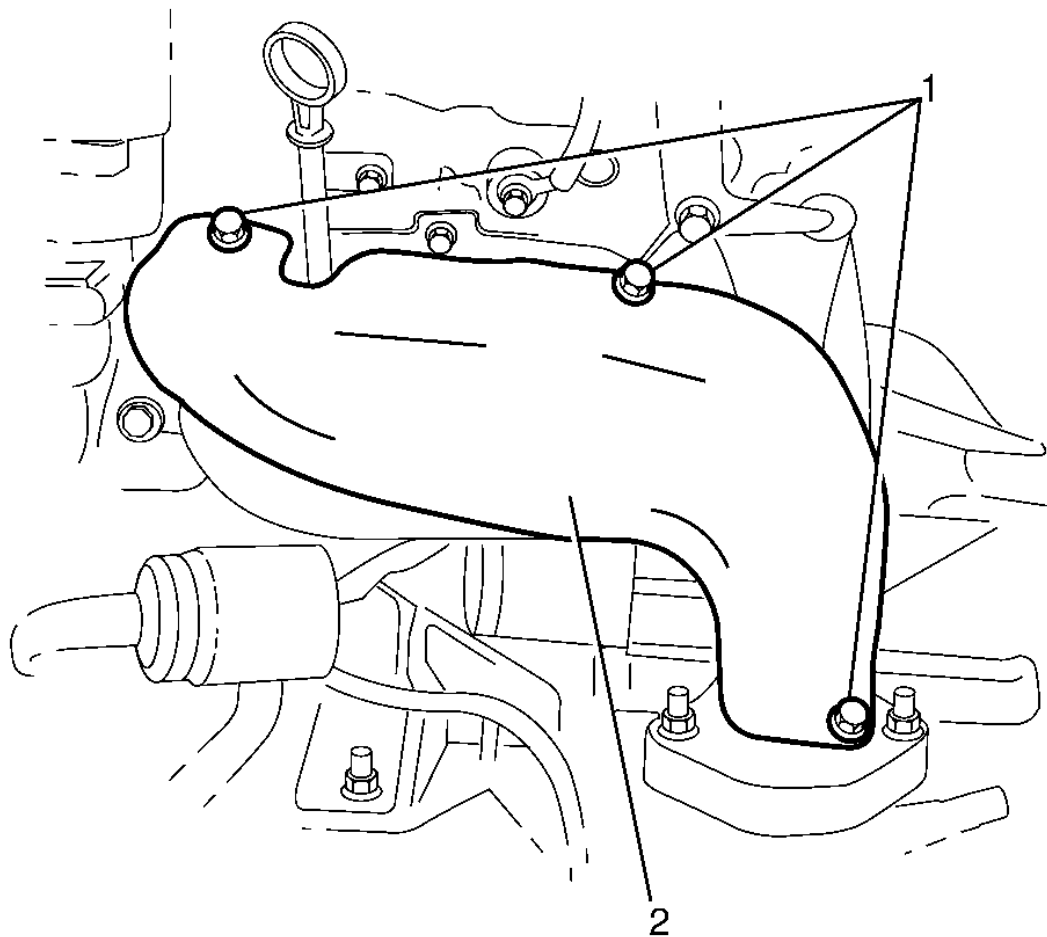
2. Install the oil level indicator and tube (1) by sliding the oil level indicator and tube (1) down through the exhaust manifold (2).



**Fig. 143: Identifying Oil Level Indicator Tube Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

3. Install the oil level indicator tube bracket to cylinder head retaining bolt (2) and tighten to 10 N.m (89 lb in).



**Fig. 144: Identifying Exhaust Manifold Heat Shield To Exhaust Manifold Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

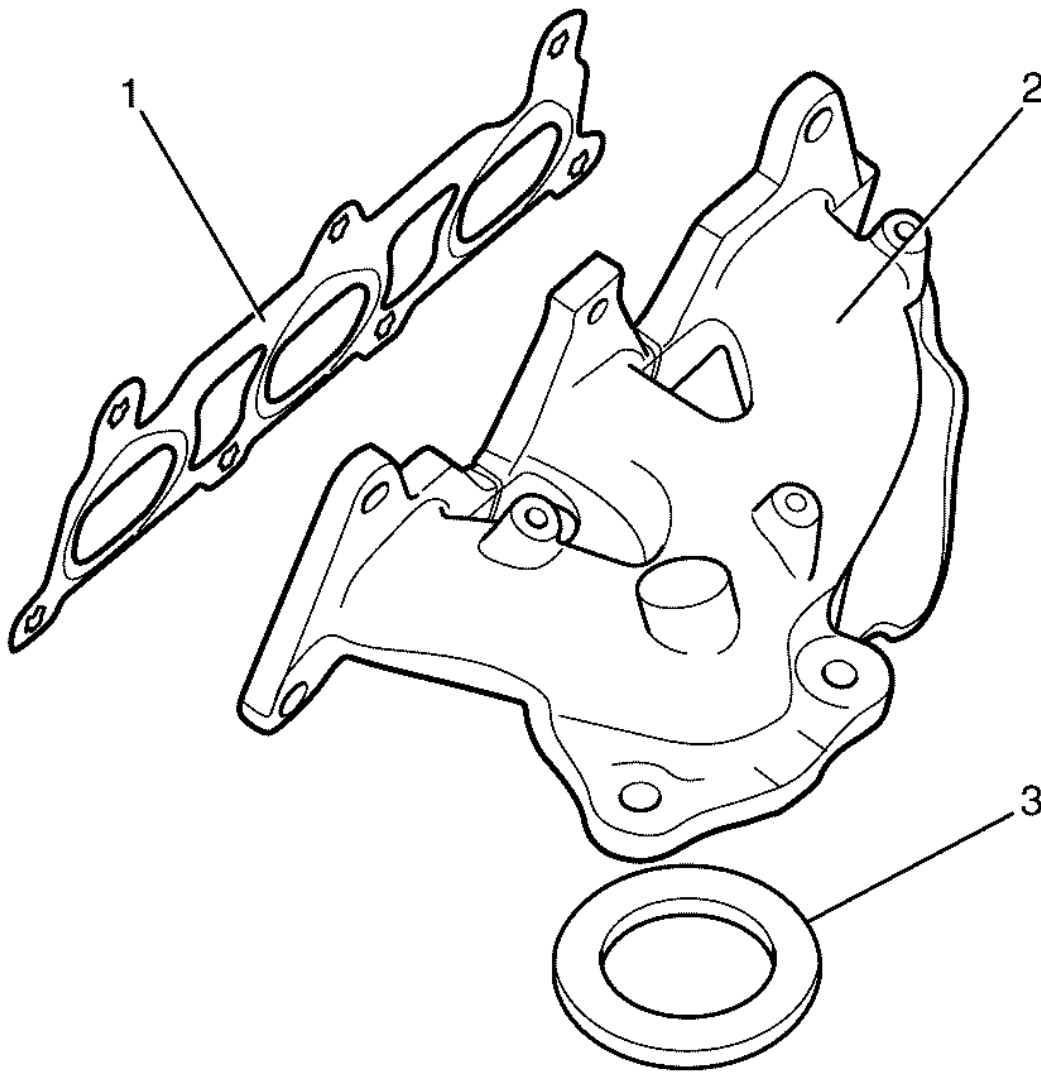
4. Install the exhaust manifold heat shield (2).
5. Install the exhaust manifold heat shield to exhaust manifold retaining bolts (1) and tighten to 10 N.m (89 lb in).

## EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

### Installation Procedure

**CAUTION:** Refer to Exhaust System Inspection Caution .

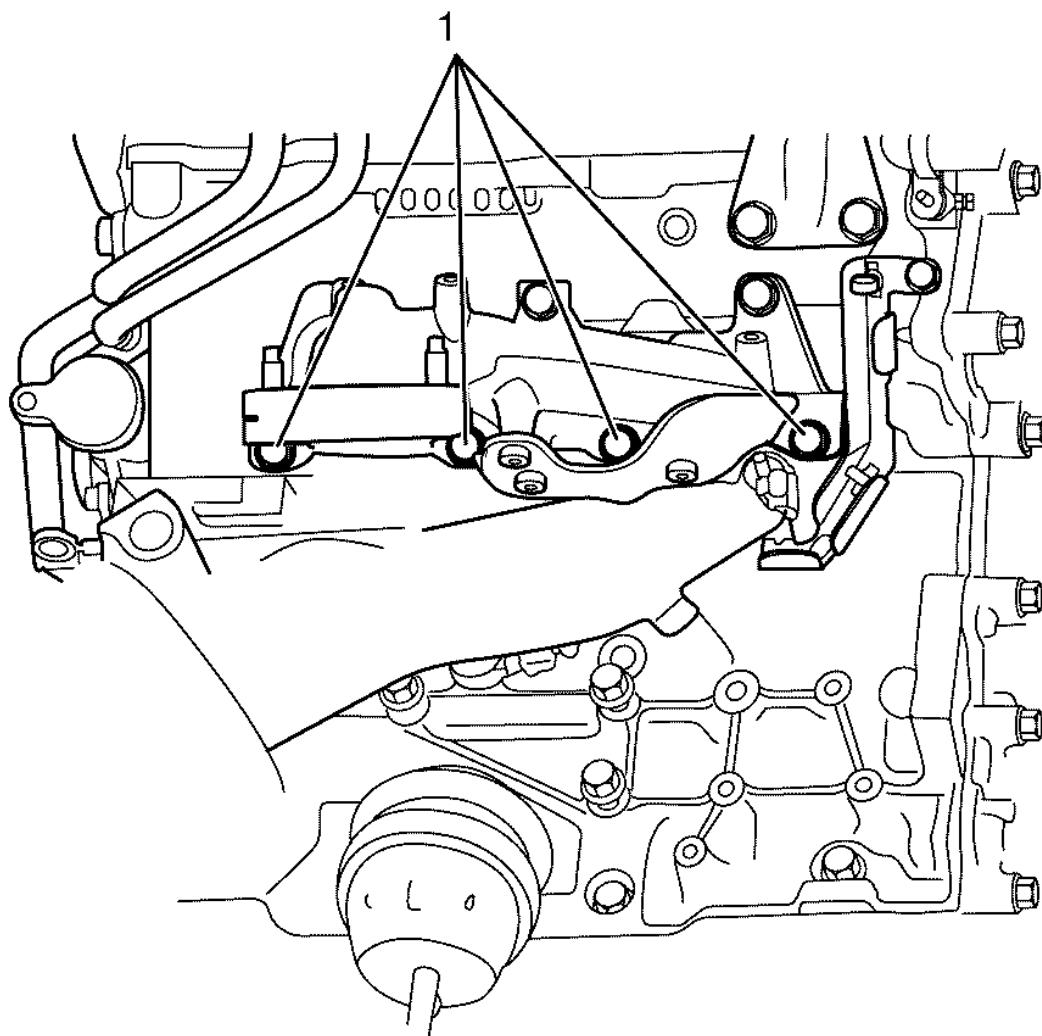
1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Right Side .



**Fig. 145: Identifying Sealing Ring, Exhaust Manifold & Gasket**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Make sure the sealing ring is seated correctly.

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.



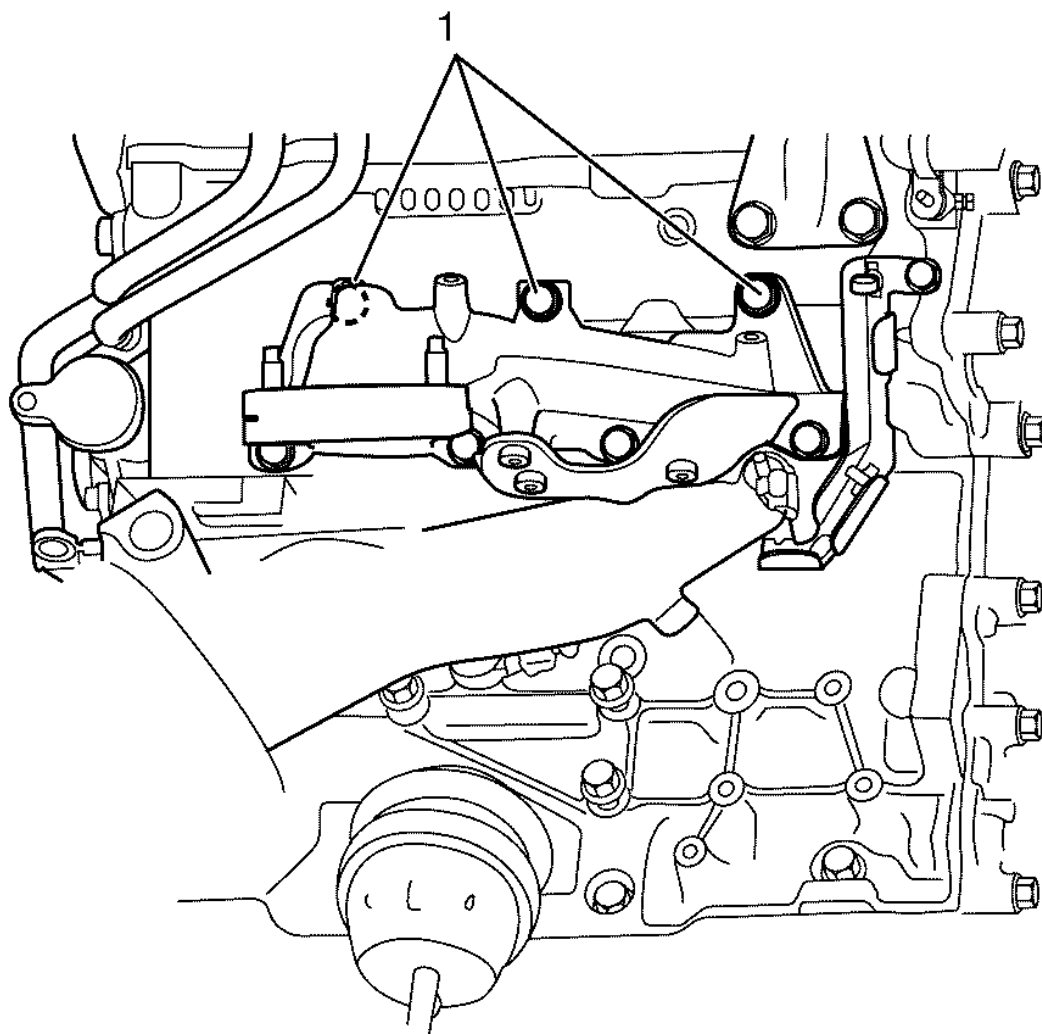
**Fig. 146: Lower Exhaust Manifold Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

**CAUTION:** Refer to Fastener Caution .

5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to 20 N.m (15 lb ft).

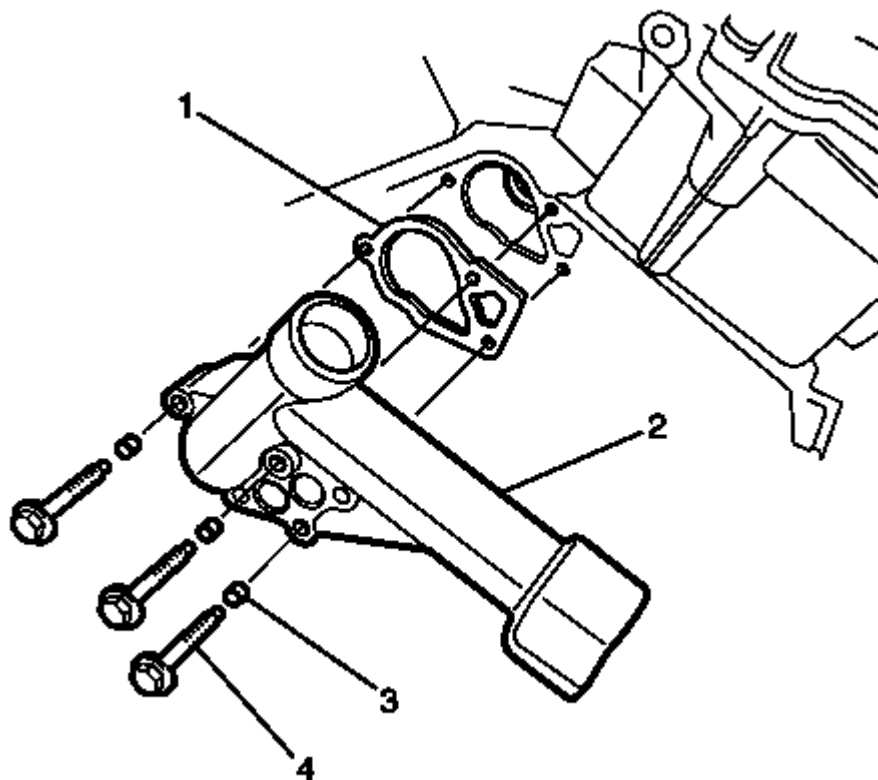


**Fig. 147: Upper Exhaust Manifold Bolts**  
 Courtesy of GENERAL MOTORS CORP.

**NOTE:** Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to 20 N.m (15 lb ft).

#### ENGINE COOLANT THERMOSTAT HOUSING INSTALLATION

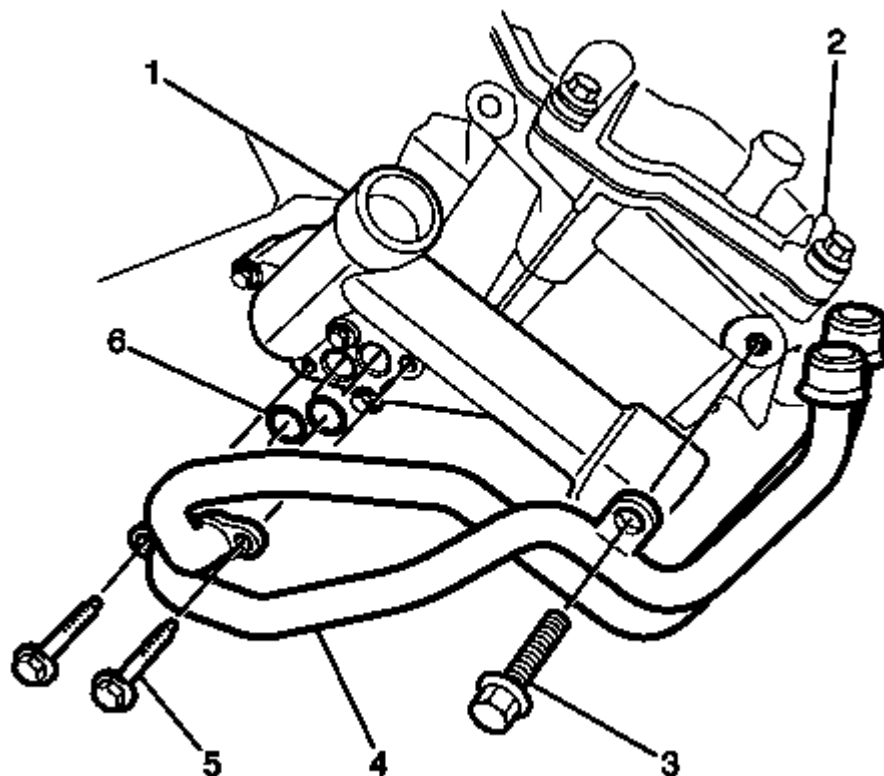


**Fig. 148: Identifying Thermostat Housing To Cylinder Block Retaining Bolts & Rubber Grommets**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fastener Caution .

1. Install thermostat housing to cylinder block retaining bolts (4) ensuring a new block gasket (1) and rubber grommets (3) has been fitted and tighten bolts to 10 N.m (89 lb in).

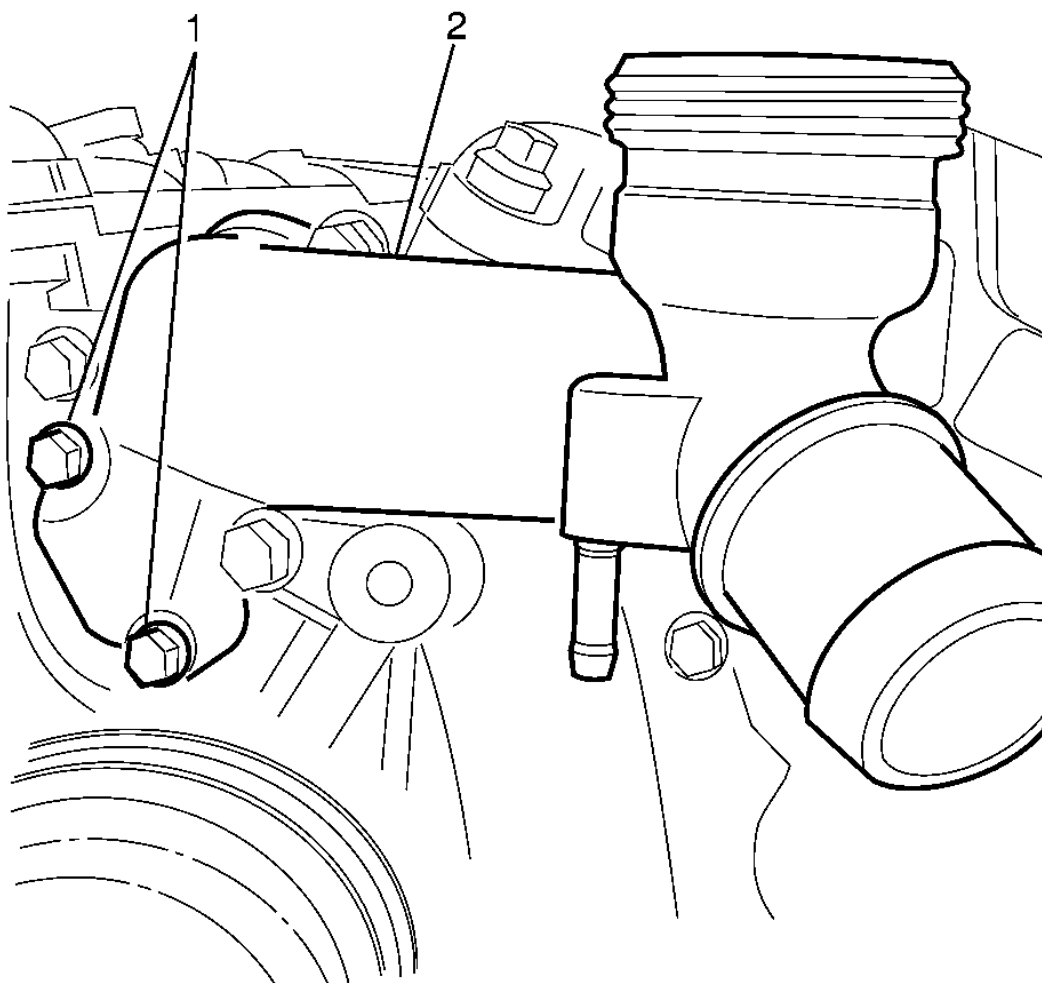




**Fig. 149: Identifying Heater Hose Assembly To Right Bank Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

2. Install the heater pipe assembly to thermostat housing retaining bolts (5) ensuring new O-ring seals (6) have been fitted and tighten bolts to 10 N.m (89 lb in).
3. Install the heater pipe assembly (4) to cylinder head (2) retaining bolt (3) and tighten to 35 N.m (26 lb ft).

## WATER OUTLET INSTALLATION



**Fig. 150: Identifying Coolant Outlet Housing To Intake Manifold Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

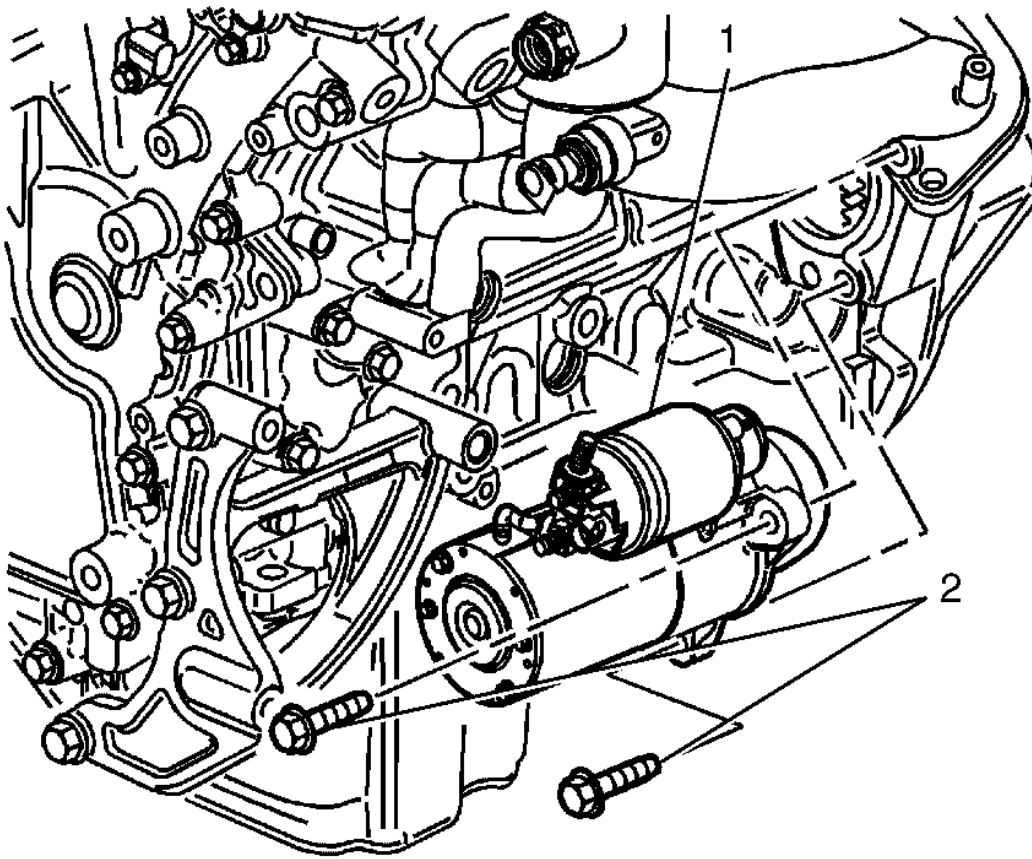
**NOTE:** Ensure a new rubber O-ring and seal is used when installing the water outlet housing.

1. Install the coolant outlet housing (2) to the intake manifold.

**CAUTION:** Refer to Fastener Caution .

2. Install the coolant outlet housing to intake manifold retaining bolts (1) and tighten to 10 N.m (89 lb in).

## STARTER INSTALLATION



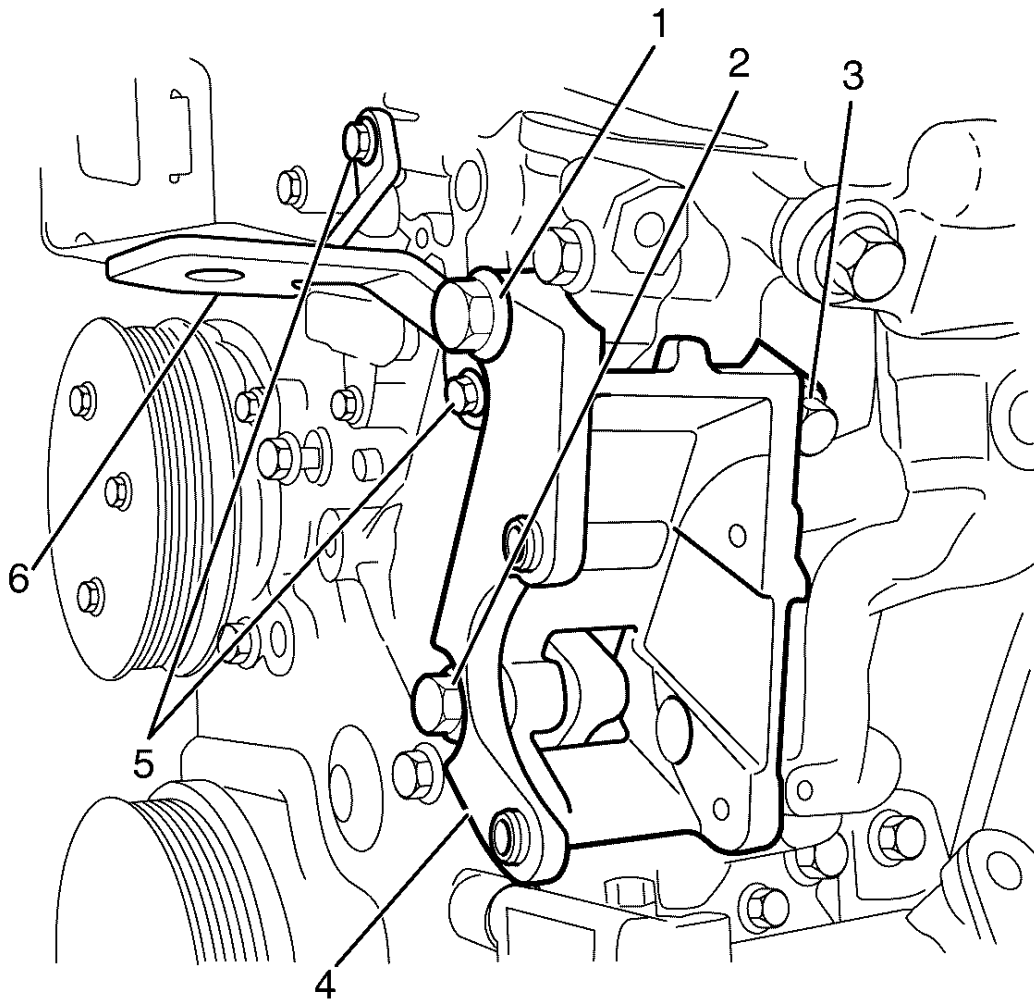
**Fig. 151: Identifying Starter Motor To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Install the starter motor (1).

**CAUTION:** Refer to Fastener Caution .

2. Install the starter motor to cylinder block retaining bolts (2) and tighten to 58 N.m (42 lb ft).

## POWER STEERING PUMP INSTALLATION



**Fig. 152: Identifying Power Steering Fluid Reservoir Bracket To Engine Front Cover Retaining Bolts**

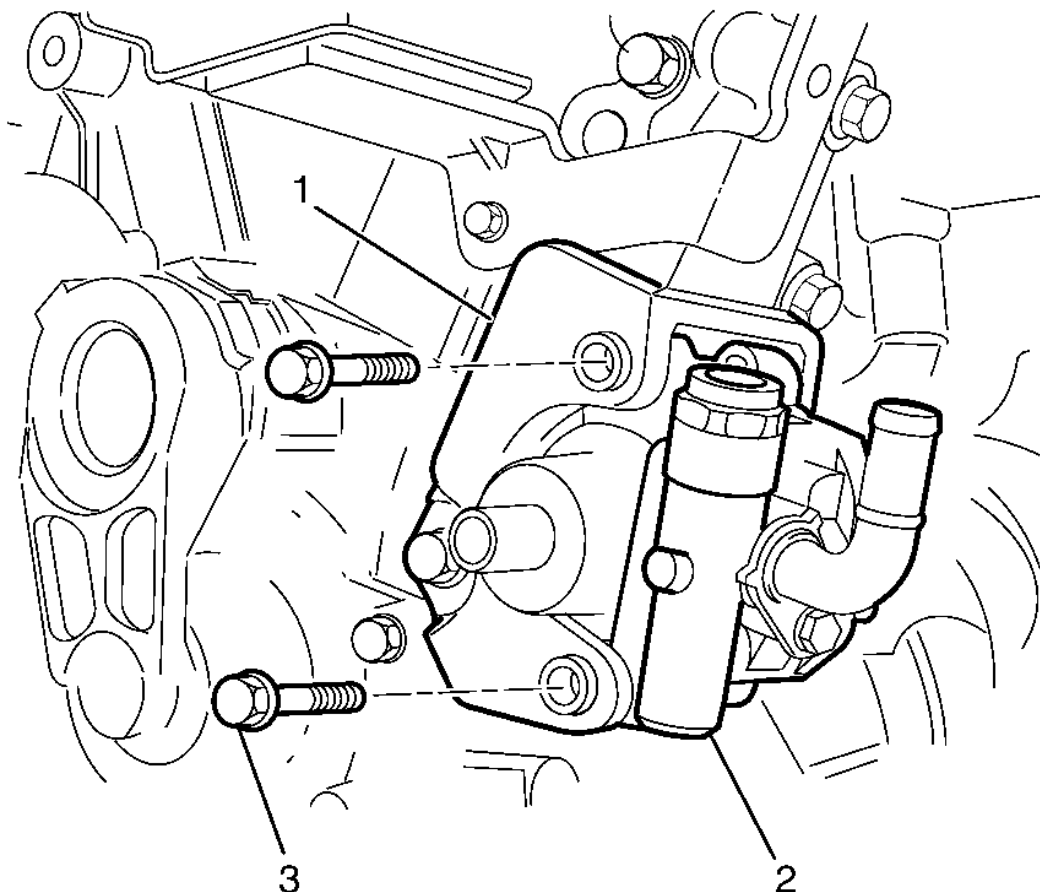
Courtesy of GENERAL MOTORS CORP.

1. Install the power steering pump bracket (2).
2. Install the NEW power steering bracket to cylinder head retaining bolts (1).

**Tighten:** Tighten the bolts to 58 N.m (43 lb ft).

3. Install the power steering fluid reservoir bracket (4).
4. Install the NEW power steering fluid reservoir bracket to engine front cover retaining bolts (3).

**Tighten:** Tighten the bolts to 9 N.m (80 lb ft).

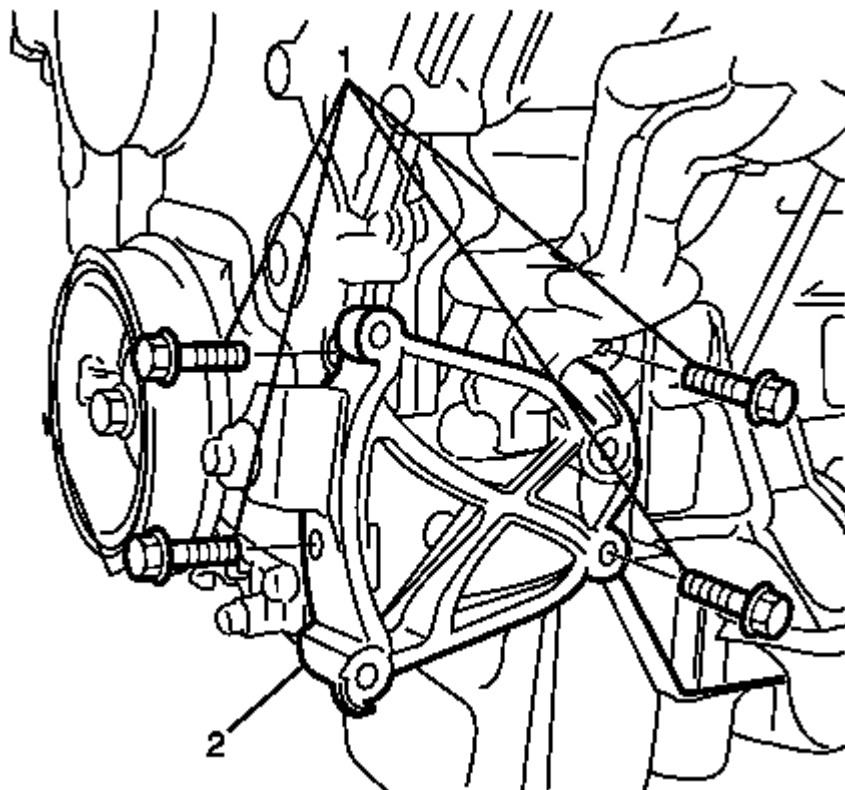


**Fig. 153: Identifying Power Steering Pump To Mounting Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

5. Install the power steering pump (2) to the power steering pump mounting bracket (3).
6. Install the power steering pump to mounting bracket retaining bolts (1).

#### AIR CONDITIONING (A/C) COMPRESSOR INSTALLATION

**NOTE:** Follow the procedure sequence in order to prevent drive belt misalignment and/or possible damage/distortion to the components.

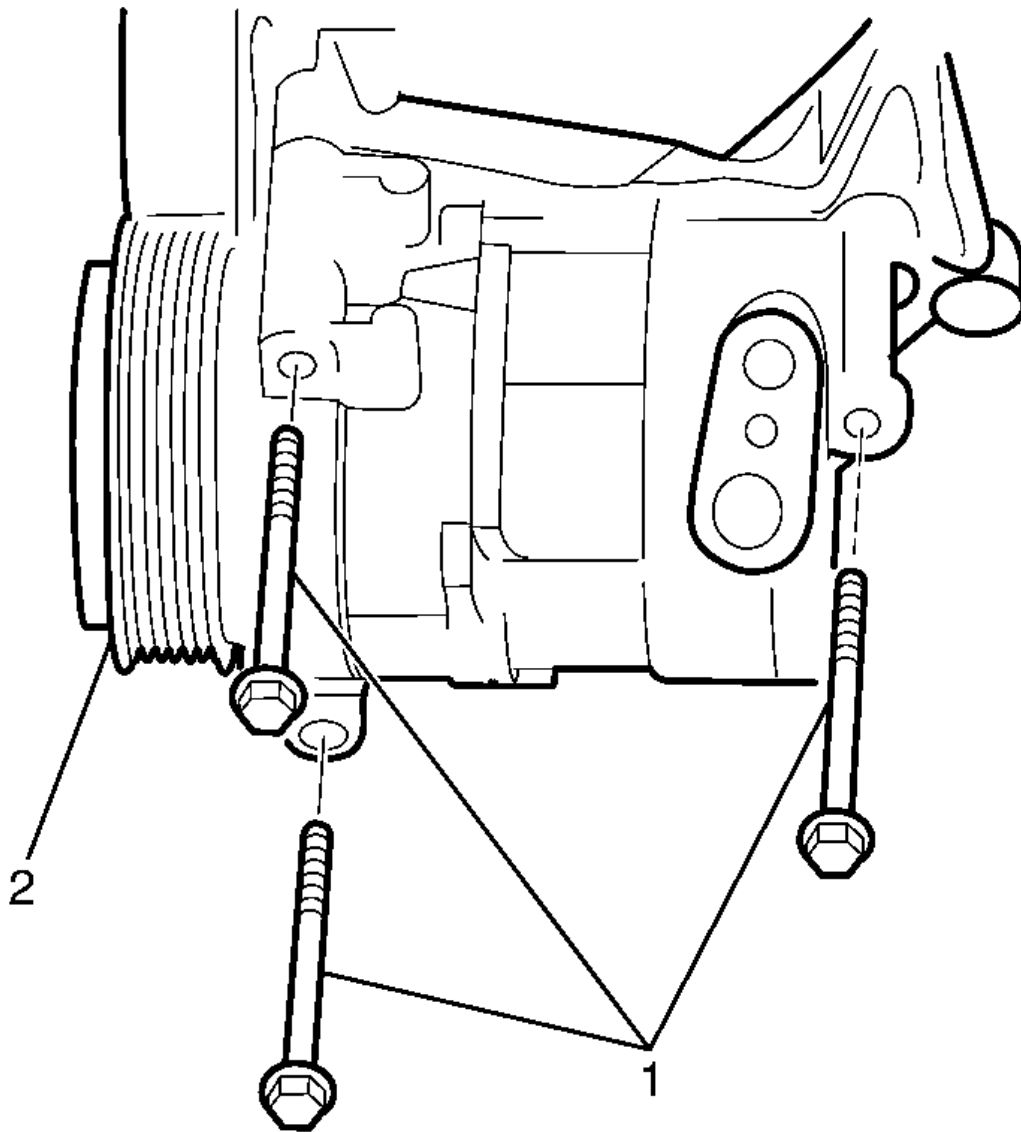


**Fig. 154: Identifying A/C Compressor Bracket To Cylinder Block Retaining Bolts**  
 Courtesy of GENERAL MOTORS CORP.

1. Install the A/C compressor bracket (2).

**CAUTION:** Refer to Fastener Caution .

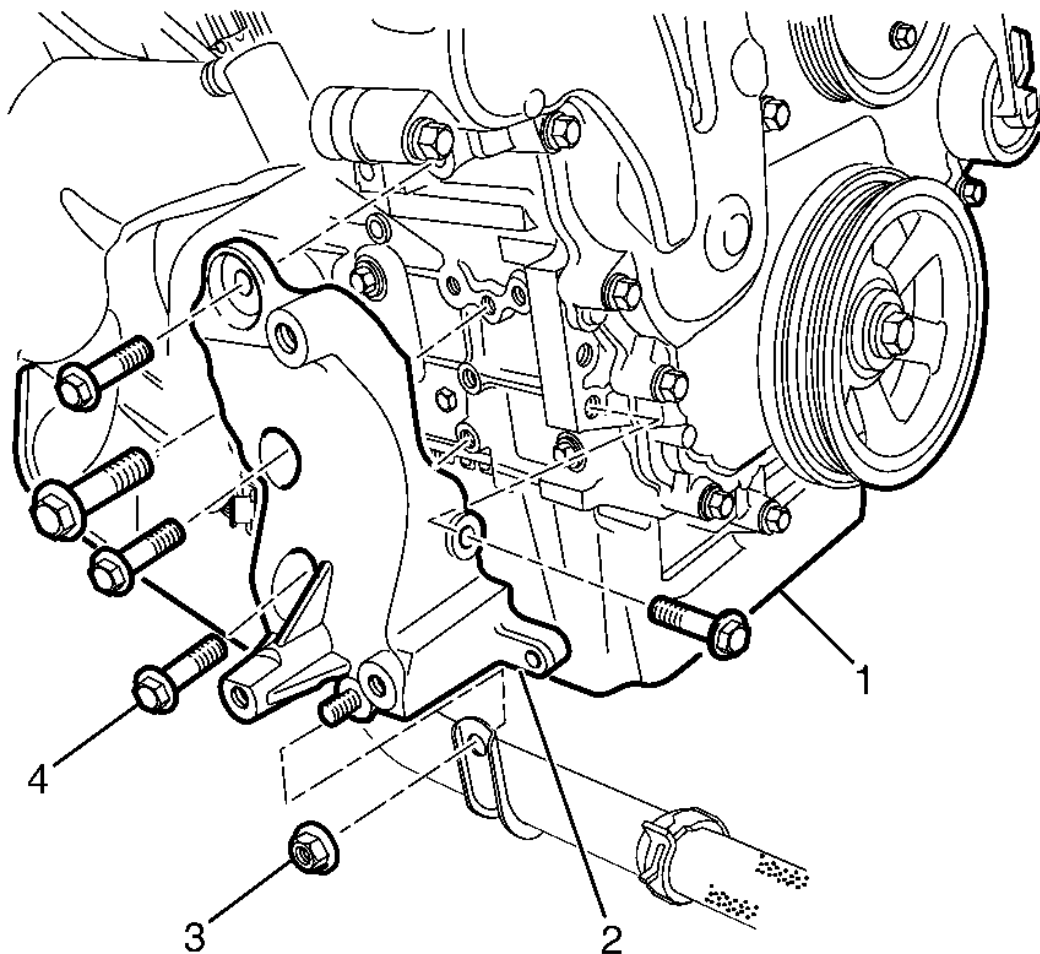
2. Install the A/C compressor bracket to cylinder block retaining bolts (1) and tighten to 58 N.m (42 lb ft).
3. If you are replacing the compressor, balance the compressor oil. Refer to Air Conditioning Compressor Oil Balancing .



**Fig. 155: Identifying A/C Compressor To A/C Compressor Bracket Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the A/C compressor (2).
5. Install the A/C compressor to A/C compressor bracket retaining bolts (1) and tighten to 22 N.m (16 lb ft).

## GENERATOR INSTALLATION



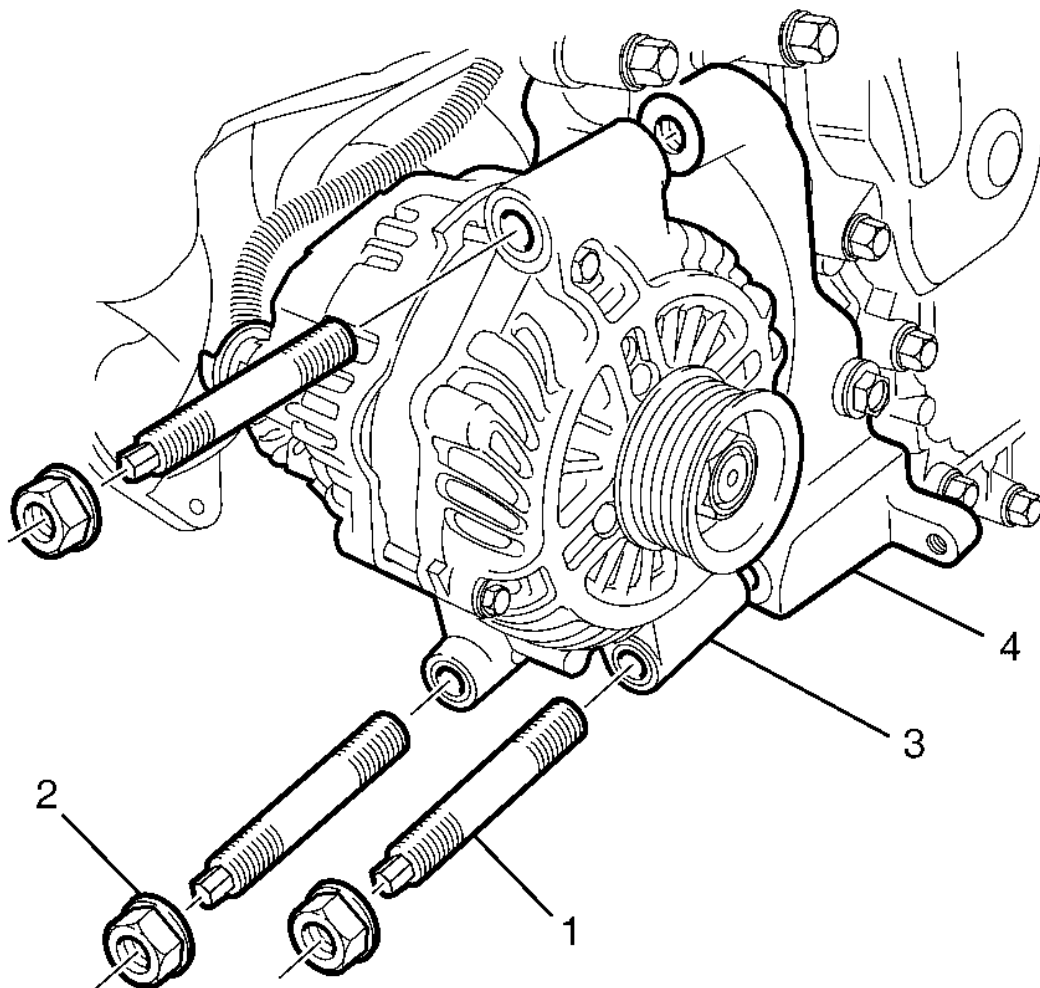
**Fig. 156: Identifying Alternator Mounting Bracket To Cylinder Block Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Install the alternator bracket (2) to the engine block.

**CAUTION:** Refer to Fastener Caution .

2. Install the alternator bracket to engine block retaining bolts and tighten to 50 N.m (37 lb ft).
3. Install the coolant inlet pipe to alternator mounting bracket retaining nut (3) and tighten to 22 N.m (16 lb ft).





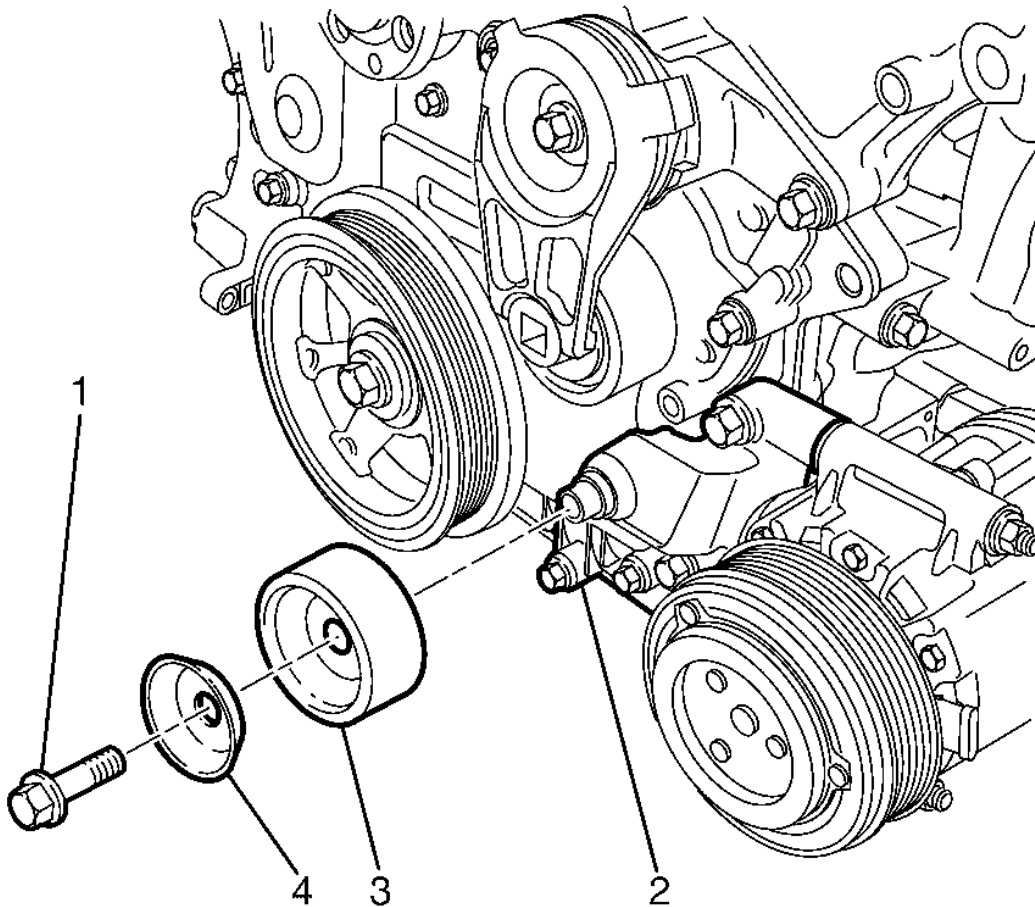
**Fig. 157: Identifying Alternator Bracket Retaining Nuts & Studs**  
 Courtesy of GENERAL MOTORS CORP.

4. Position the alternator (3) on the alternator mounting bracket (4).

**NOTE:** The alternator mounting studs (4) have hexagonal outer ends to assist with removal and installation.

5. Install the alternator to alternator bracket retaining studs (1) if required and tighten to 18 N.m (13 lb ft).
6. Install the alternator to alternator bracket stud retaining nuts (2) and tighten to 18 N.m (13 lb ft).

## DRIVE BELT IDLER PULLEY INSTALLATION



**Fig. 158: View Of Dished Washer, Drive Belt Idler Pulley, Accessory Drive Mounting Bracket & Retaining Bolt**

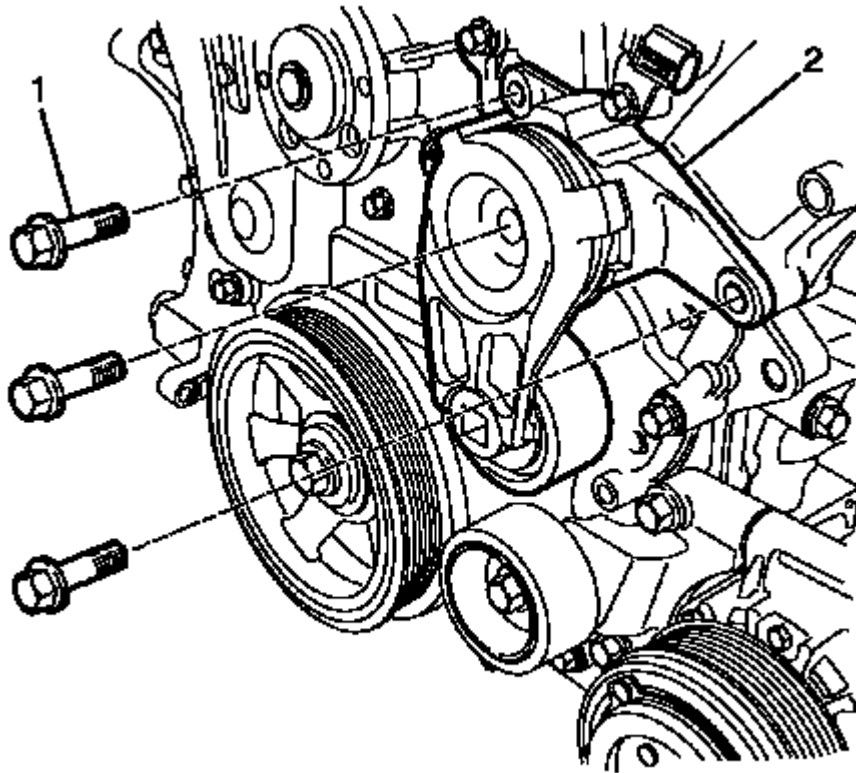
Courtesy of GENERAL MOTORS CORP.

1. Install the dished washer (4) and drive belt idler pulley (3) to the accessory drive mounting bracket (2).
2. Hand tighten the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1).

**CAUTION:** Refer to Fastener Caution .

3. Tighten the drive belt idler pulley to accessory drive mounting bracket retaining bolt (1) and tighten to 22 N.m (16 lb ft).

## DRIVE BELT TENSIONER INSTALLATION



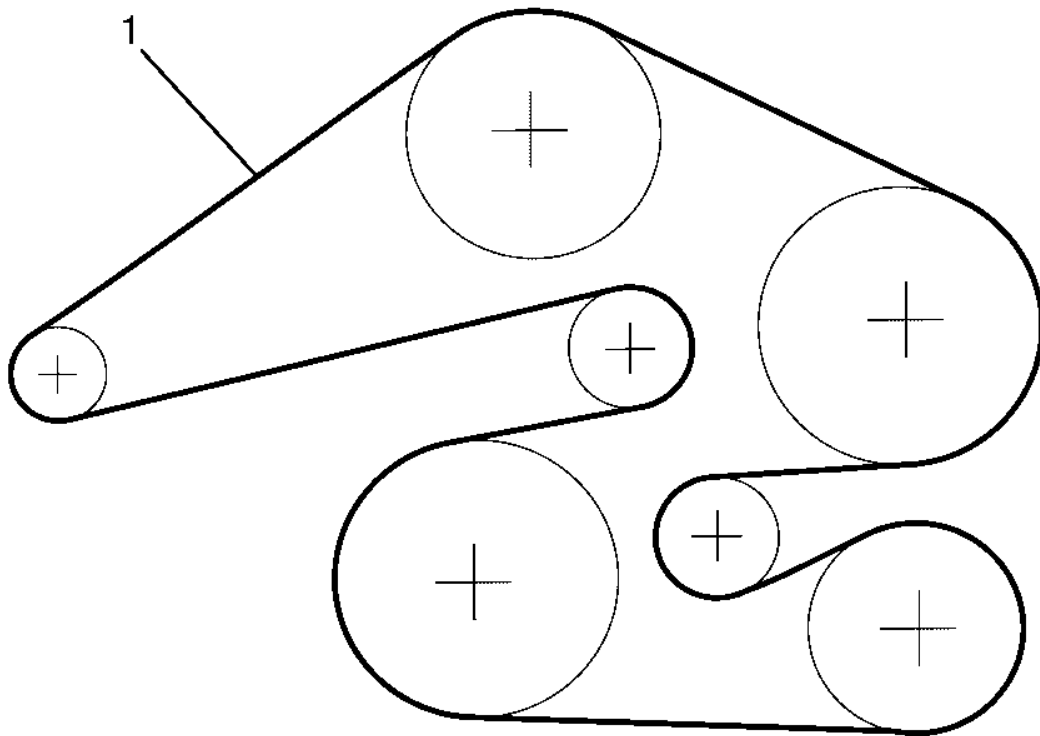
**Fig. 159: Identifying Drive Belt Tensioner To Engine Front Cover Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner (2) to the engine front cover.

**CAUTION:** Refer to Fastener Caution .

2. Install the drive belt tensioner to engine front cover retaining bolts (1) and tighten to 22 N.m (16 lb ft).

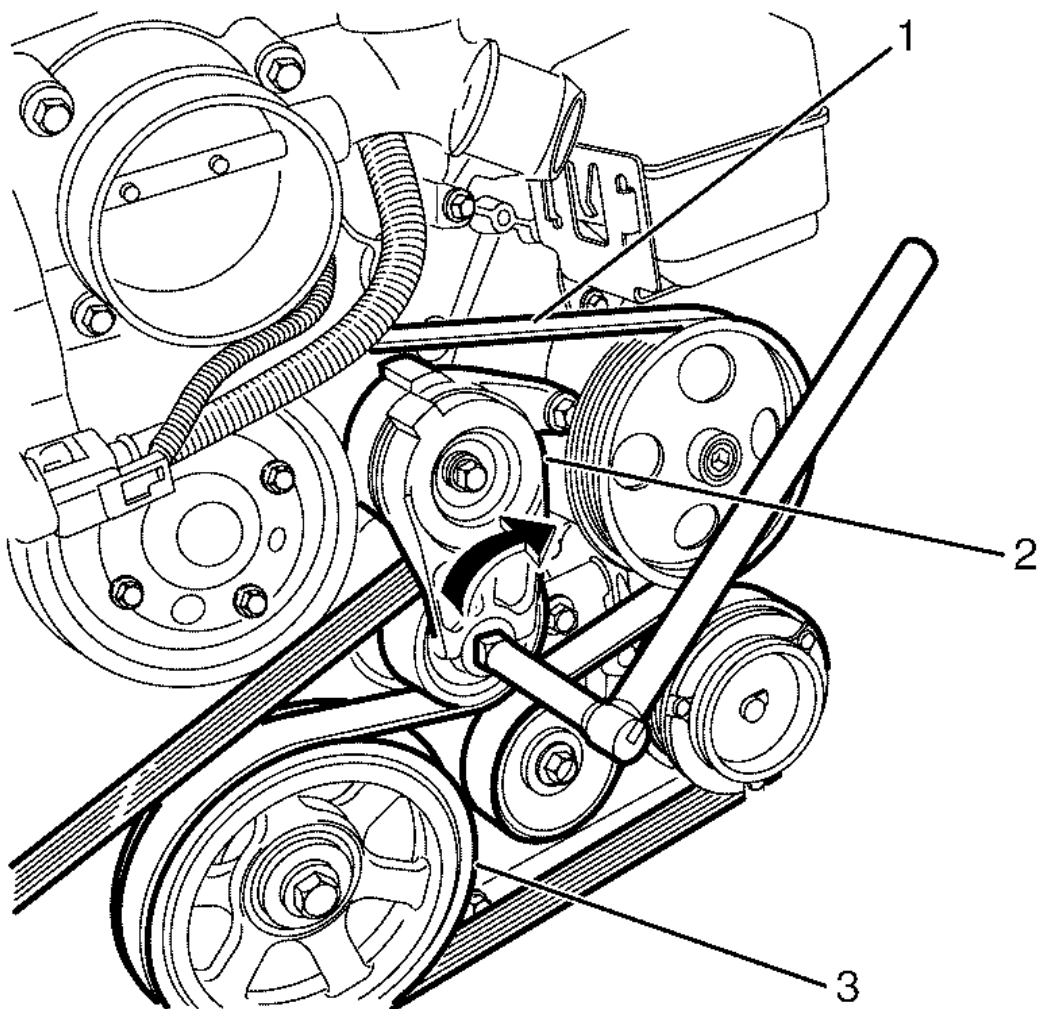
## **DRIVE BELT INSTALLATION**



**Fig. 160: Drive Belt Routing**

Courtesy of GENERAL MOTORS CORP.

1. Install and correctly route the drive belt (1) around the following:
  - Water pump pulley
  - Generator
  - Drive belt tensioner
  - Crankshaft balancer
  - Air conditioning compressor
  - Idler pulley
  - Power steering pump



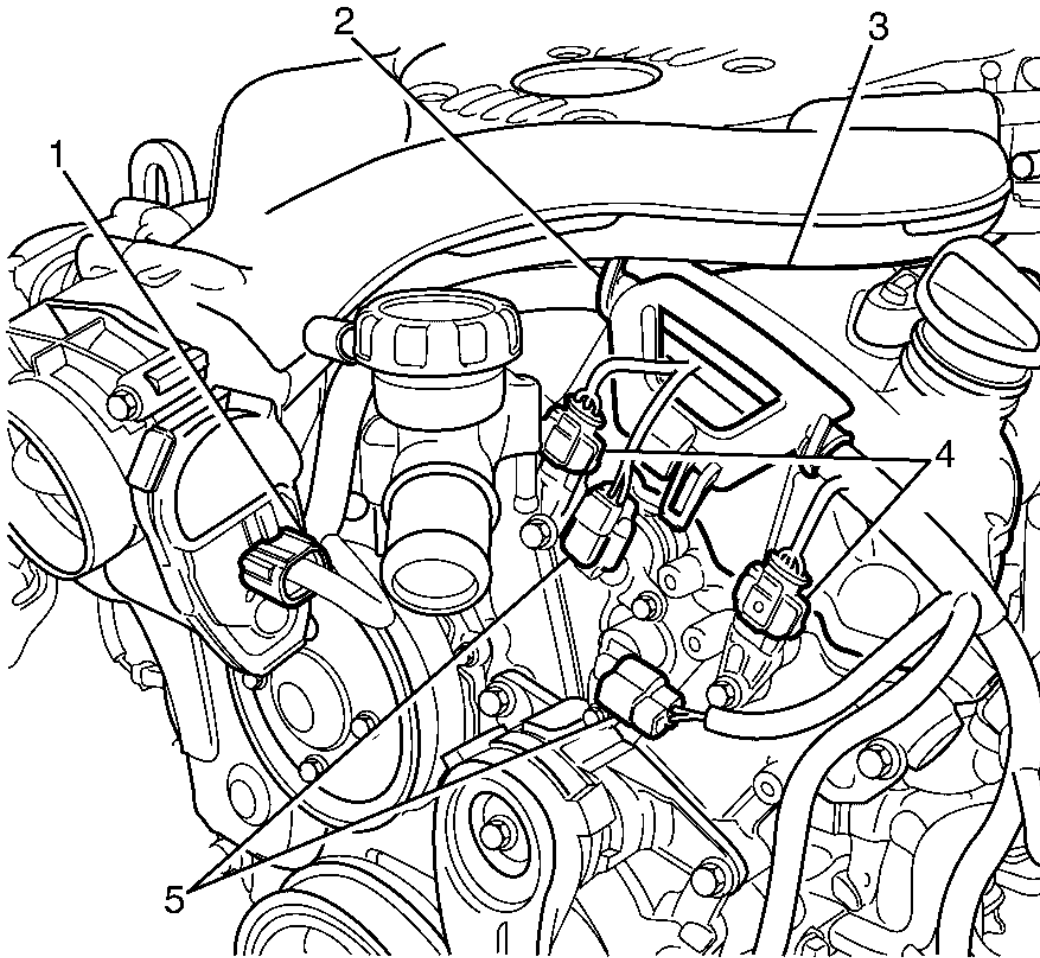
**Fig. 161: Identifying Drive Belt Tensioner Rotation (Clockwise)**  
Courtesy of GENERAL MOTORS CORP.

2. Using a suitable tool rotate the drive belt tensioner (2) clockwise.
3. Install the drive belt (1) to the crankshaft pulley (3).

**IMPORTANT: Make sure the drive belt (1) is correctly aligned and seated into the grooves of the accessory drive pulleys.**

4. Slowly release the drive belt tensioner (2).
5. Remove the suitable tool from the drive belt tensioner (2).

#### ENGINE WIRING HARNESS ASSEMBLY INSTALLATION



**Fig. 162: View Of Throttle Position Sensor Electrical Connector, Engine Wiring Harness Bracket & Left Bank Camshaft Cover**

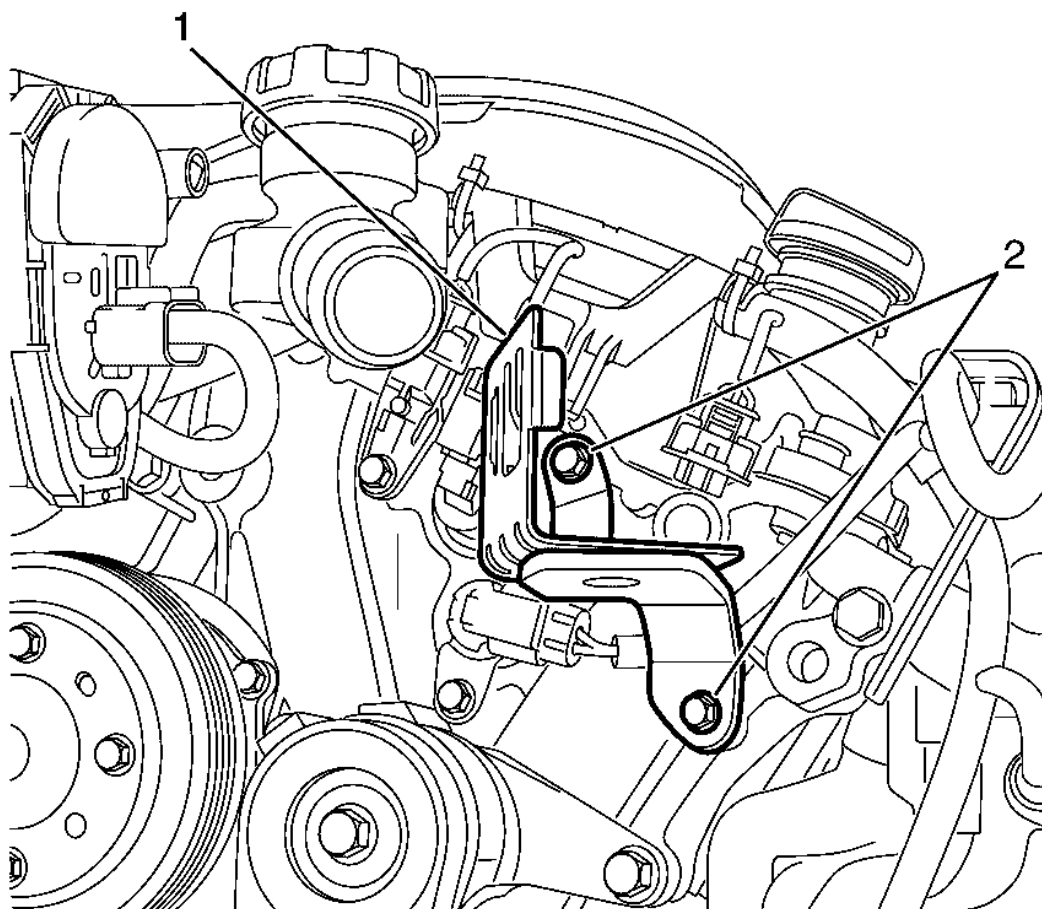
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Attach the engine wiring harness bracket (2) to the locating clip lug on the left bank camshaft cover (3) to avoid an induced rattle condition.

1. Attach the engine wiring harness bracket (2) to the left bank camshaft cover (3).
2. Connect the throttle position sensor electrical connector (1).

**IMPORTANT:** LE0 and LW2 engines only have intake camshaft position actuator solenoids.

3. Connect the left bank intake and exhaust camshaft position actuator solenoid electrical connectors (5).
4. Connect the left camshaft position sensors electrical connectors (4).

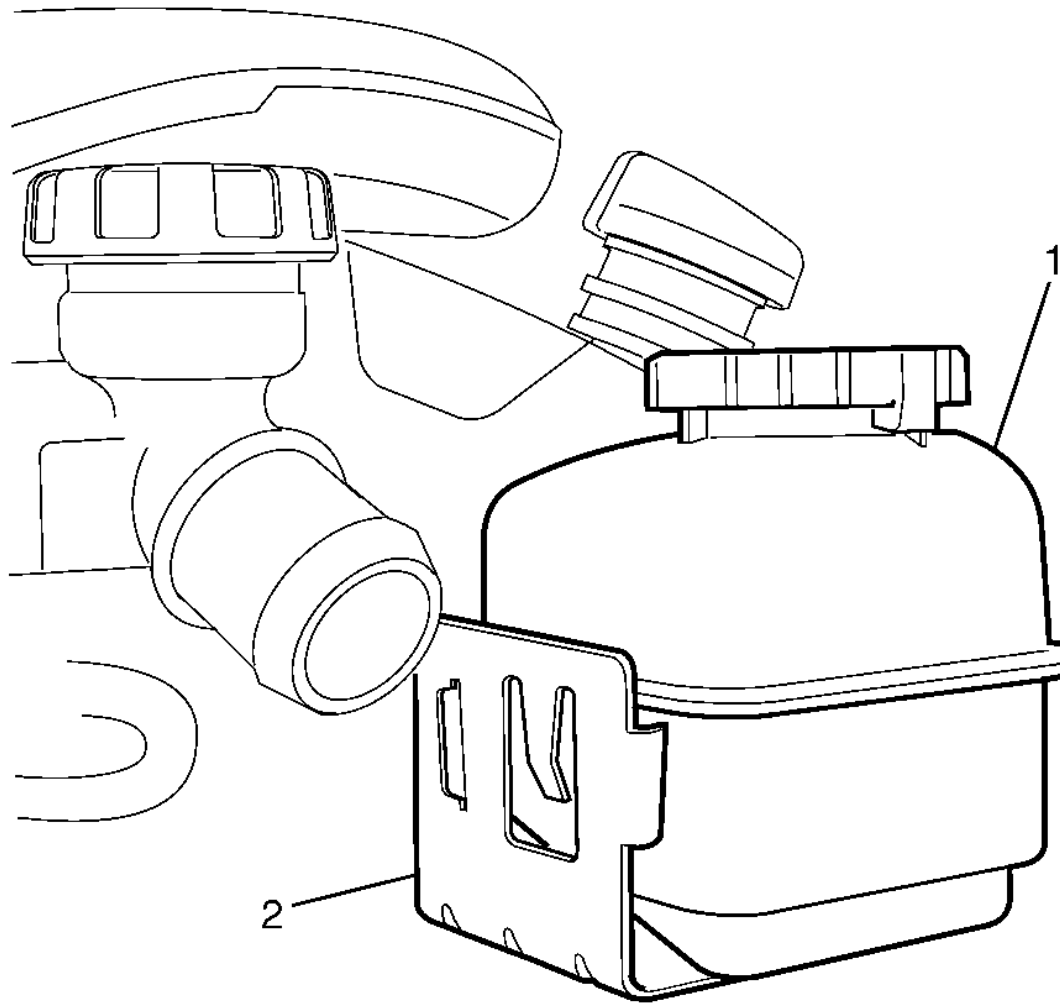


**Fig. 163: Identifying Power Steering Fluid Reservoir Bracket To Engine Front Cover Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

5. Install the power steering fluid reservoir bracket (1).
6. Install the power steering fluid reservoir bracket to engine front cover retaining bolts (2).

**Tighten:** Tighten the bolts to 9 N.m (80 lb in).

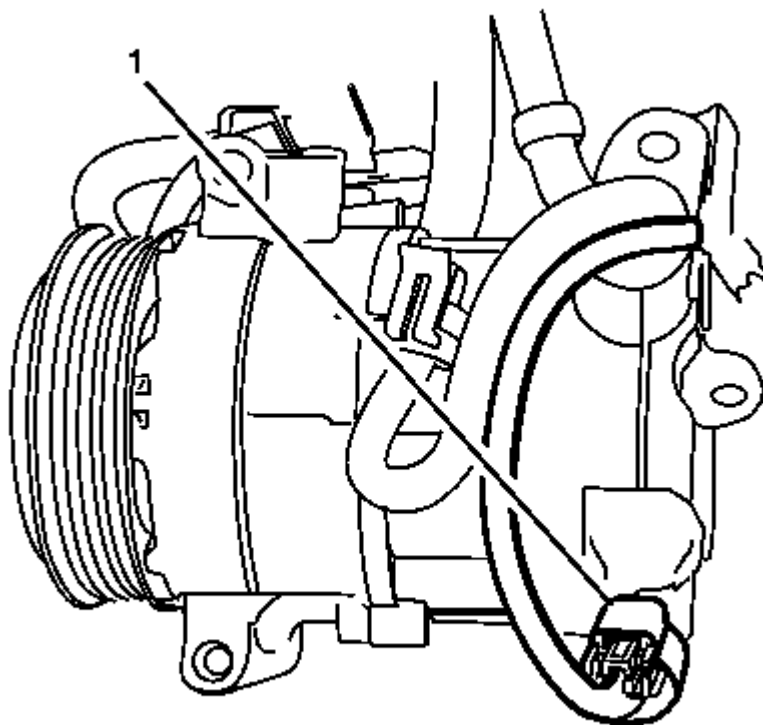


**Fig. 164: View Of Power Steering Reservoir & Bracket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Make sure the power steering reservoir (1) and the the locking tang on the power steering reservoir bracket (2) are engaged to avoid an induced rattle condition.

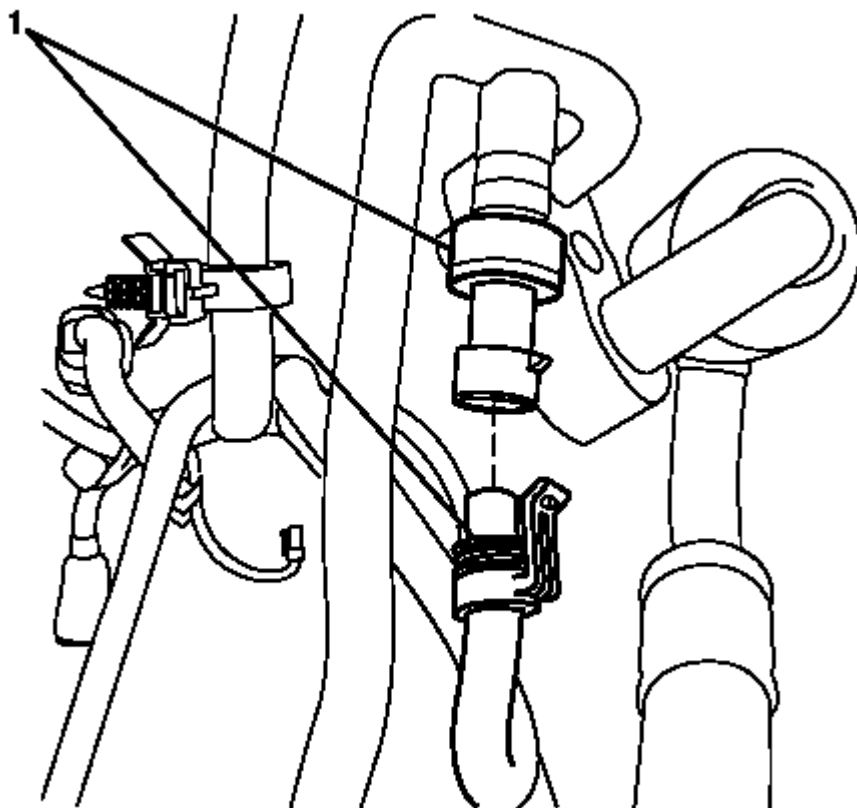
7. Install the power steering fluid reservoir to the power steering fluid reservoir bracket.





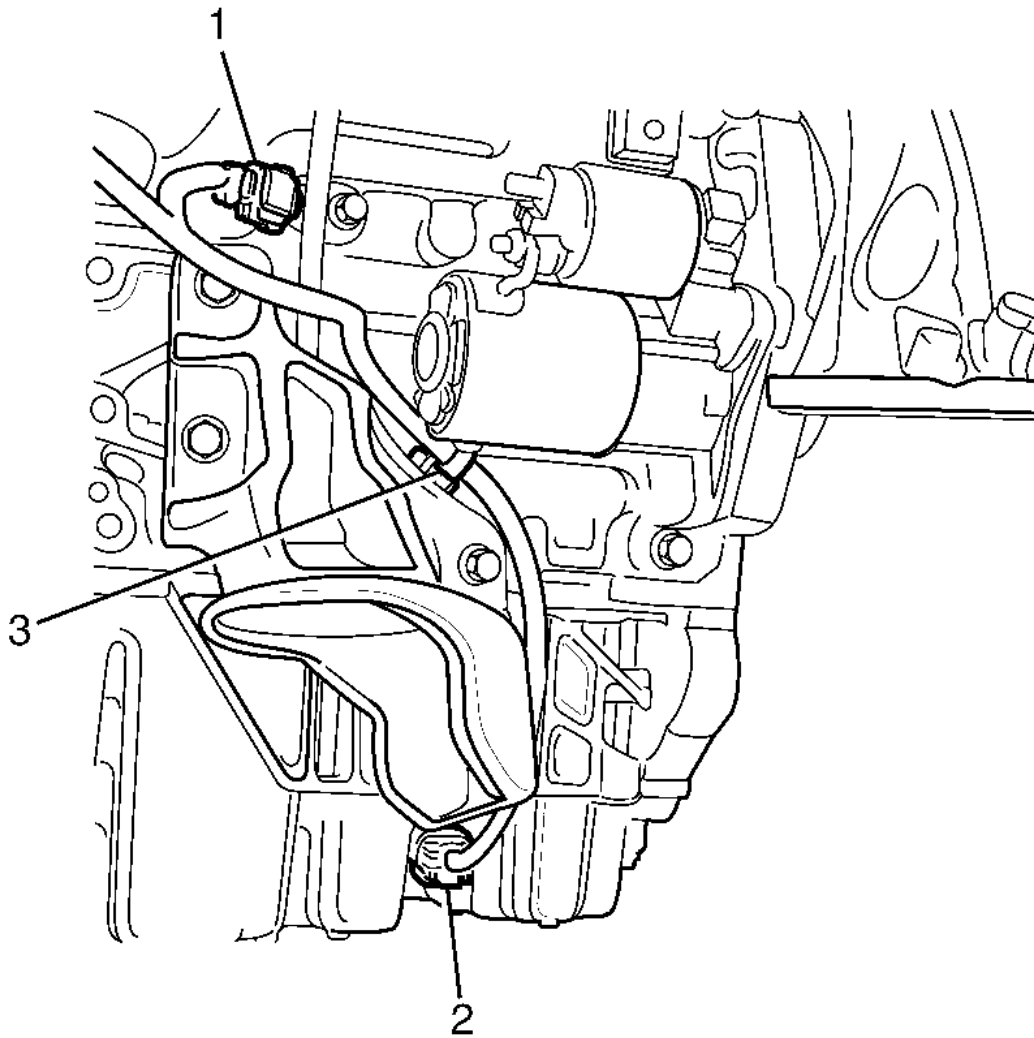
**Fig. 165: Identifying A/C Compressor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

8. Connect the A/C compressor electrical connector (1).



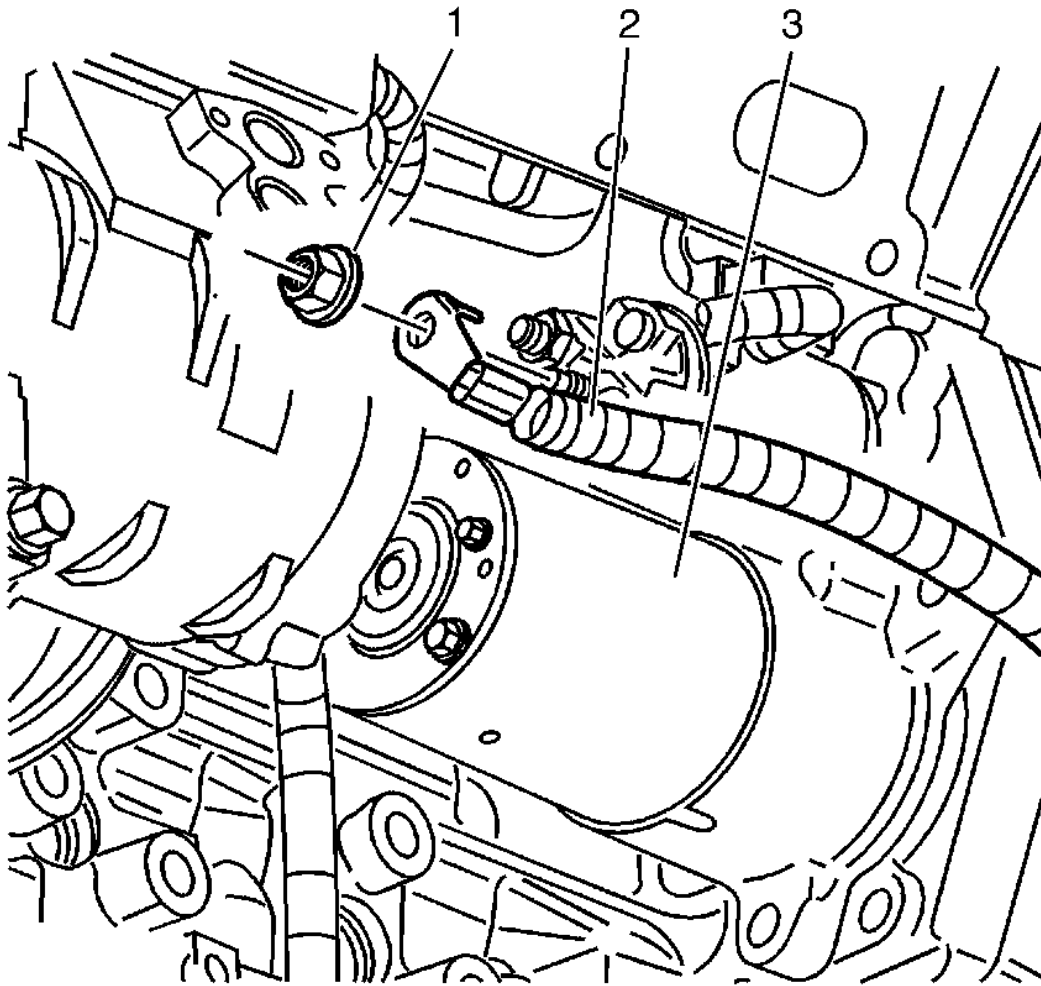
**Fig. 166: Identifying A/C Refrigerant Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

9. Connect the A/C pressure transducer electrical connector (1).



**Fig. 167: Identifying Left Bank Knock Sensor & Oil Level Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

10. Attach the engine wiring harness to cylinder block retaining lug (3).
11. Connect the oil level sensor electrical connector (2).
12. Connect the left bank knock sensor electrical connector (1).

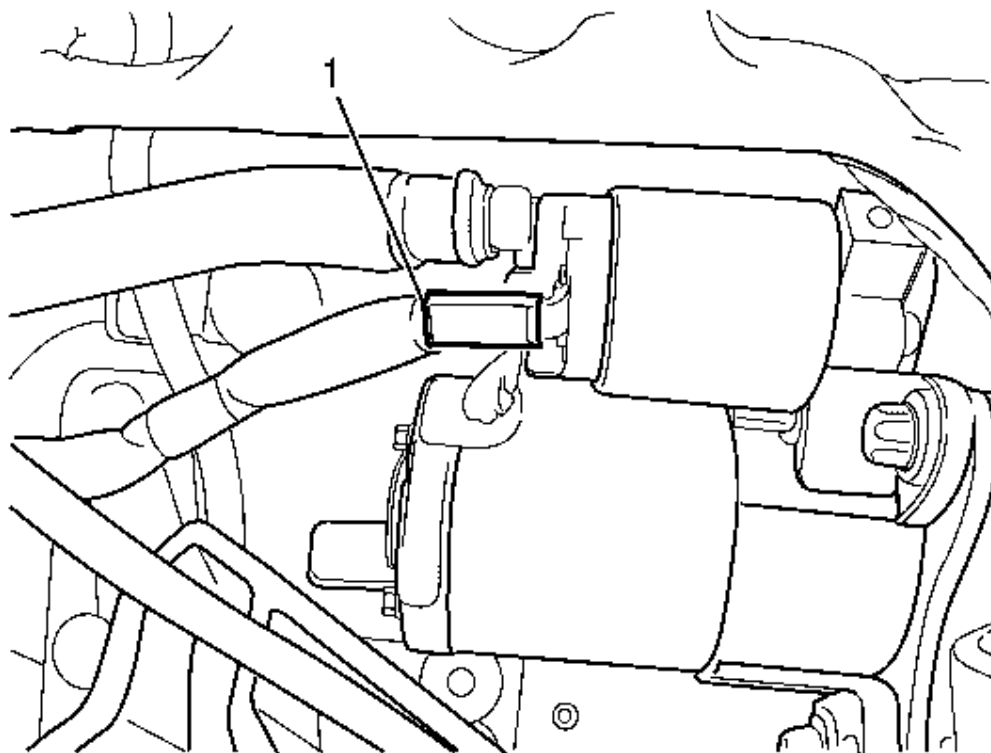


**Fig. 168: Identifying Battery Cable Harness To Starter Motor Retaining Nut**  
Courtesy of GENERAL MOTORS CORP.

13. Install the battery positive cable to starter motor terminal retaining nut (1).

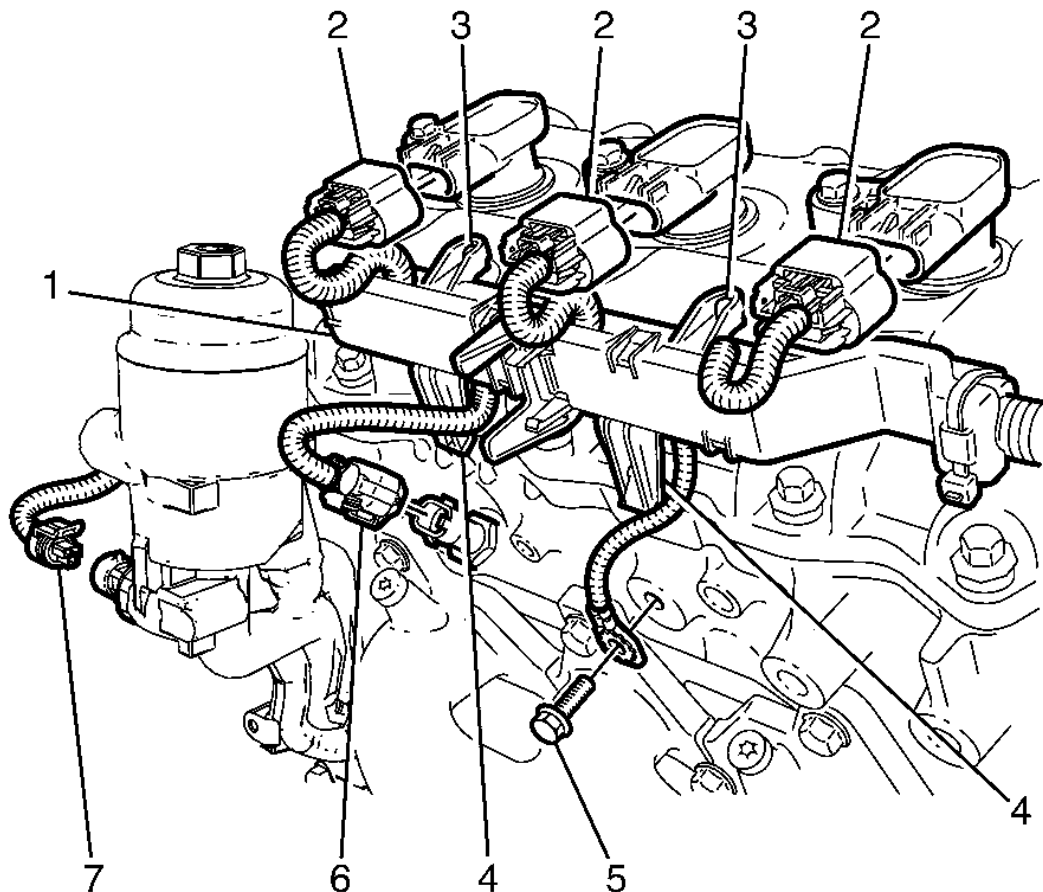
**Tighten:** Tighten the nut to 20 N.m (14 lb ft).

14. Connect the battery positive cable (2) to the starter motor (3).



**Fig. 169: View Of Starter Motor Electrical Connector**  
**Courtesy of GENERAL MOTORS CORP.**

15. Connect the starter motor electrical connector (1).



**Fig. 170: View Of Left Bank Ignition Coil Electrical Connectors & Right Bank Camshaft Cover Lugs**

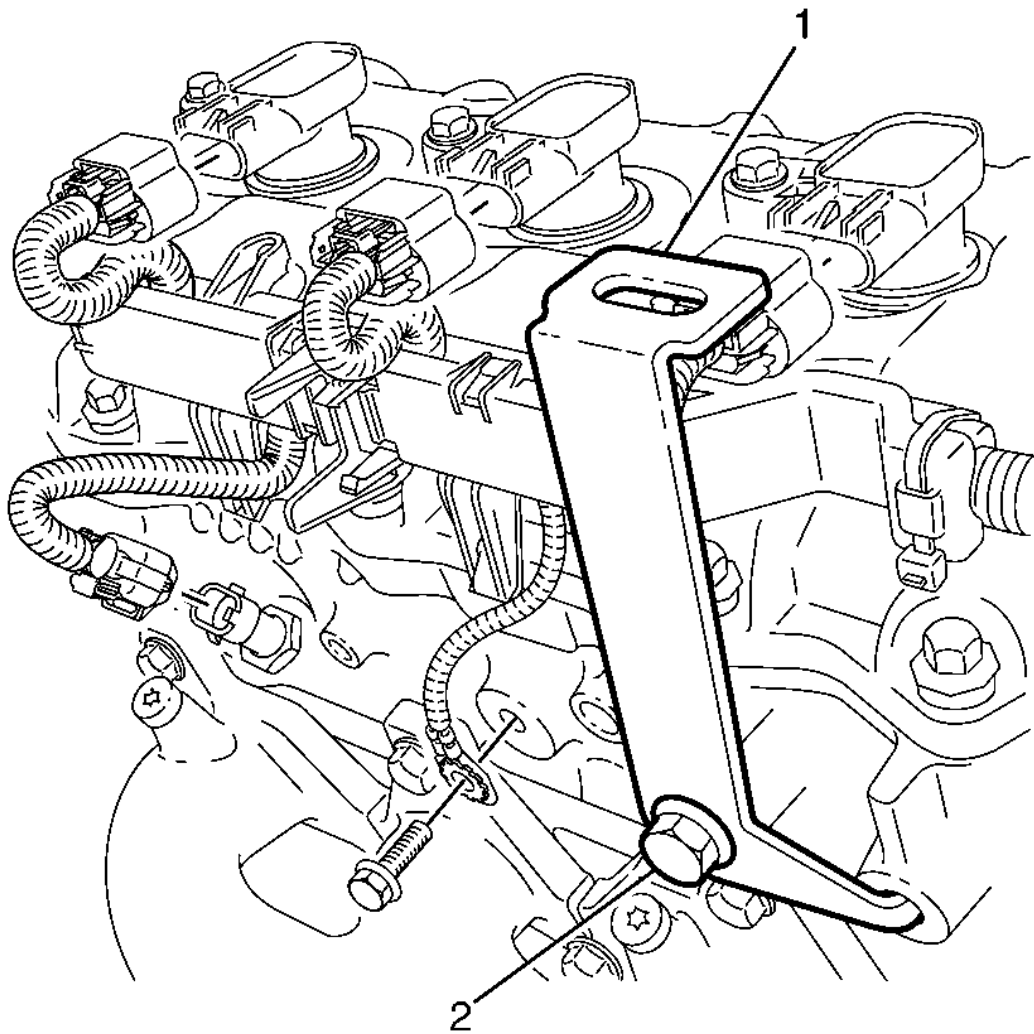
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Attach the engine wiring harness (1) clips to the right bank camshaft cover clips (4) and lugs (3) to avoid an induced rattle condition.

16. Attach the engine wiring harness bracket (1) to the right bank camshaft cover lugs (3).
17. Connect the oil pressure sensor electrical connector (7).
18. Connect the coolant temperature sensor electrical connector (6).
19. Install the engine wiring harness ground and engine wiring harness ground to left bank cylinder head retaining bolt (5).

**Tighten:** Tighten the bolt to 10 N.m (89 lb in).

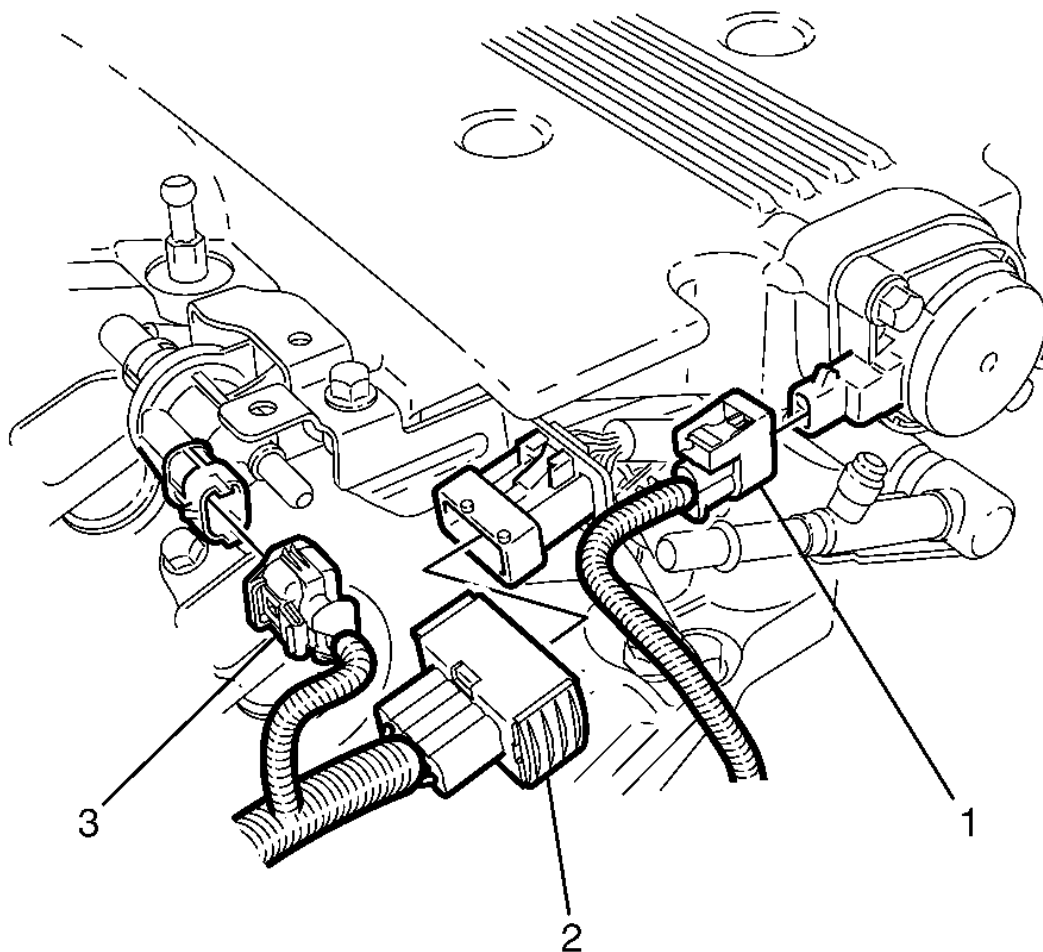
20. Connect the left bank ignition coil electrical connectors (2).



**Fig. 171: Identifying Engine Cover Bracket To Cylinder Head Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

21. Install the engine cover bracket (1).
22. Install the engine cover bracket to cylinder head retaining bolt (2).

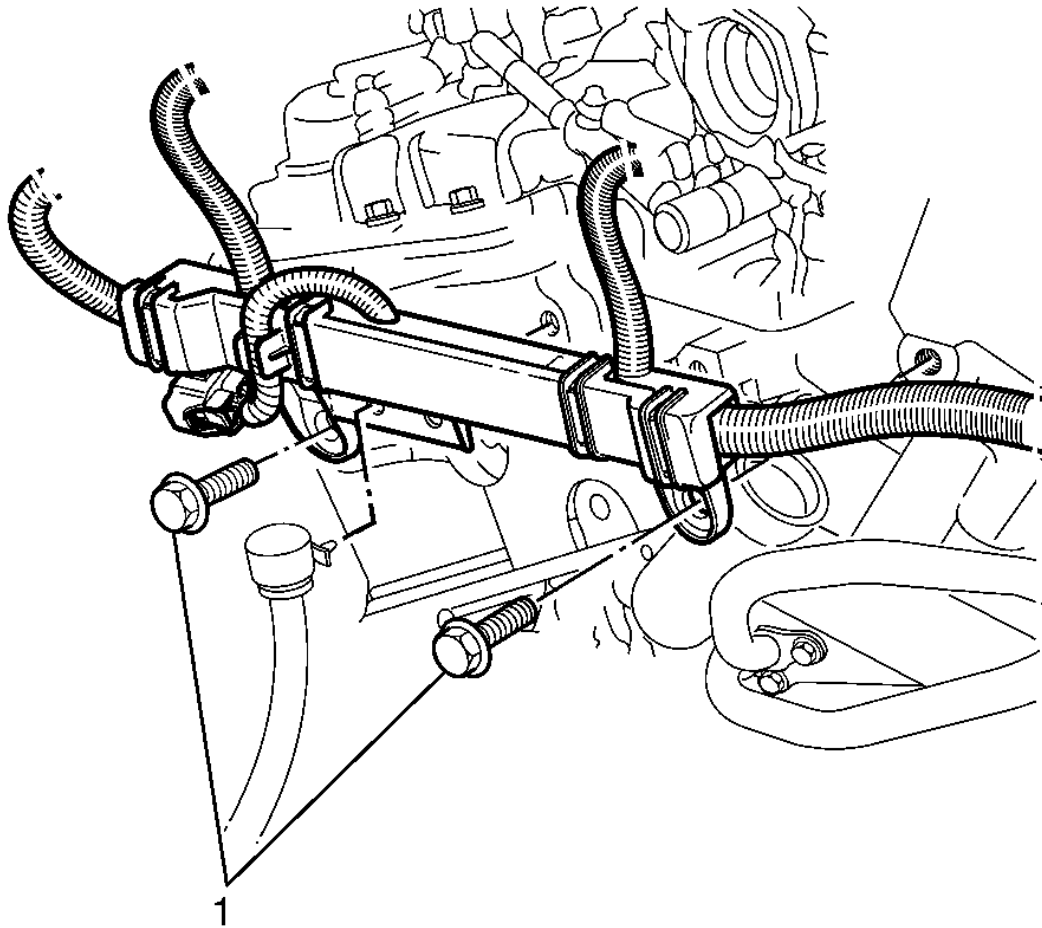
**Tighten:** Tighten the bolt to 35 N.m (26 lb ft).



**Fig. 172: View Of IMRC, Injector Harness & Purge Solenoid Electrical Connectors**  
**Courtesy of GENERAL MOTORS CORP.**

23. Connect the purge solenoid electrical connector (3).
24. Connect the injector harness electrical connector (2).
25. Connect the Intake Manifold Runner Control (IMRC) electrical connector (1).

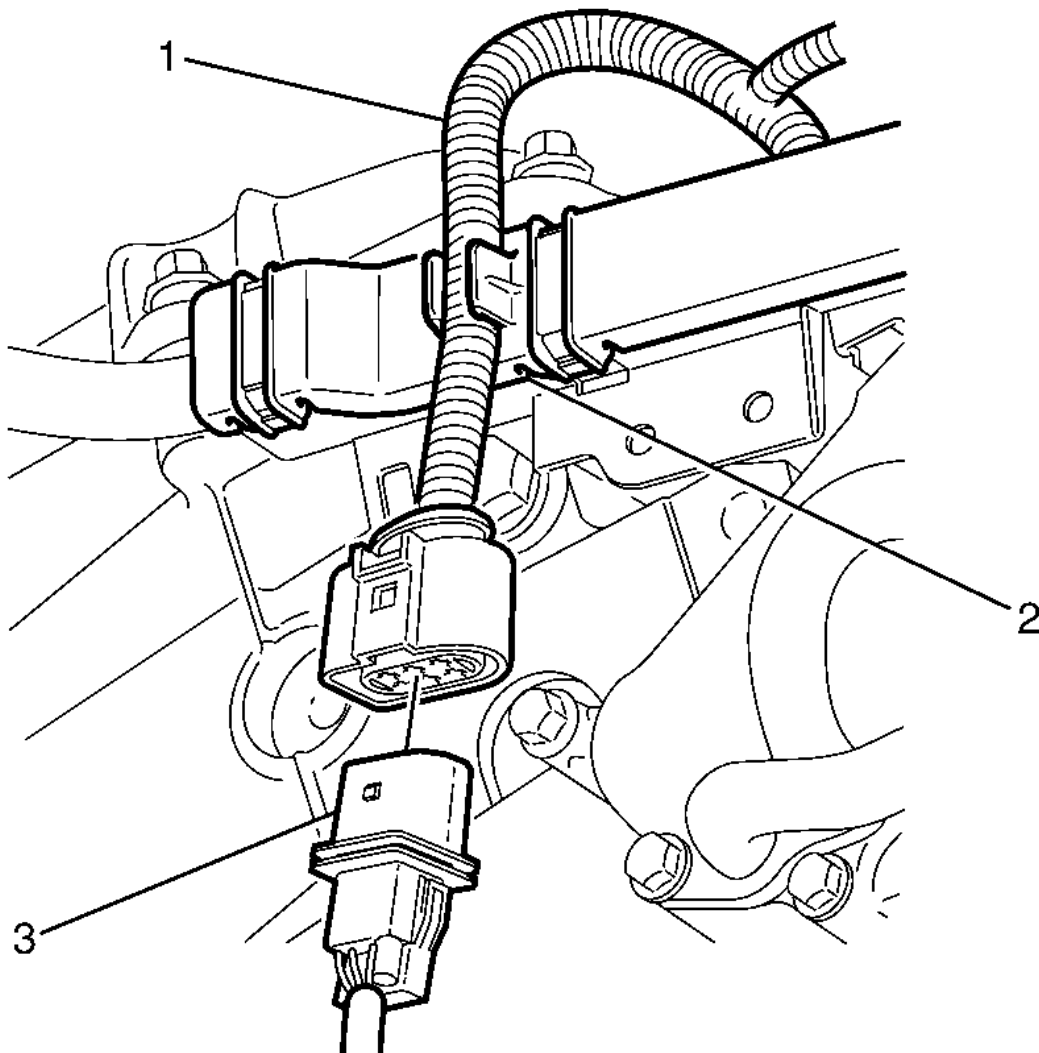




**Fig. 173: Identifying Engine Wiring Harness Bracket To Cylinder Head Retaining Bolts**  
Courtesy of GENERAL MOTORS CORP.

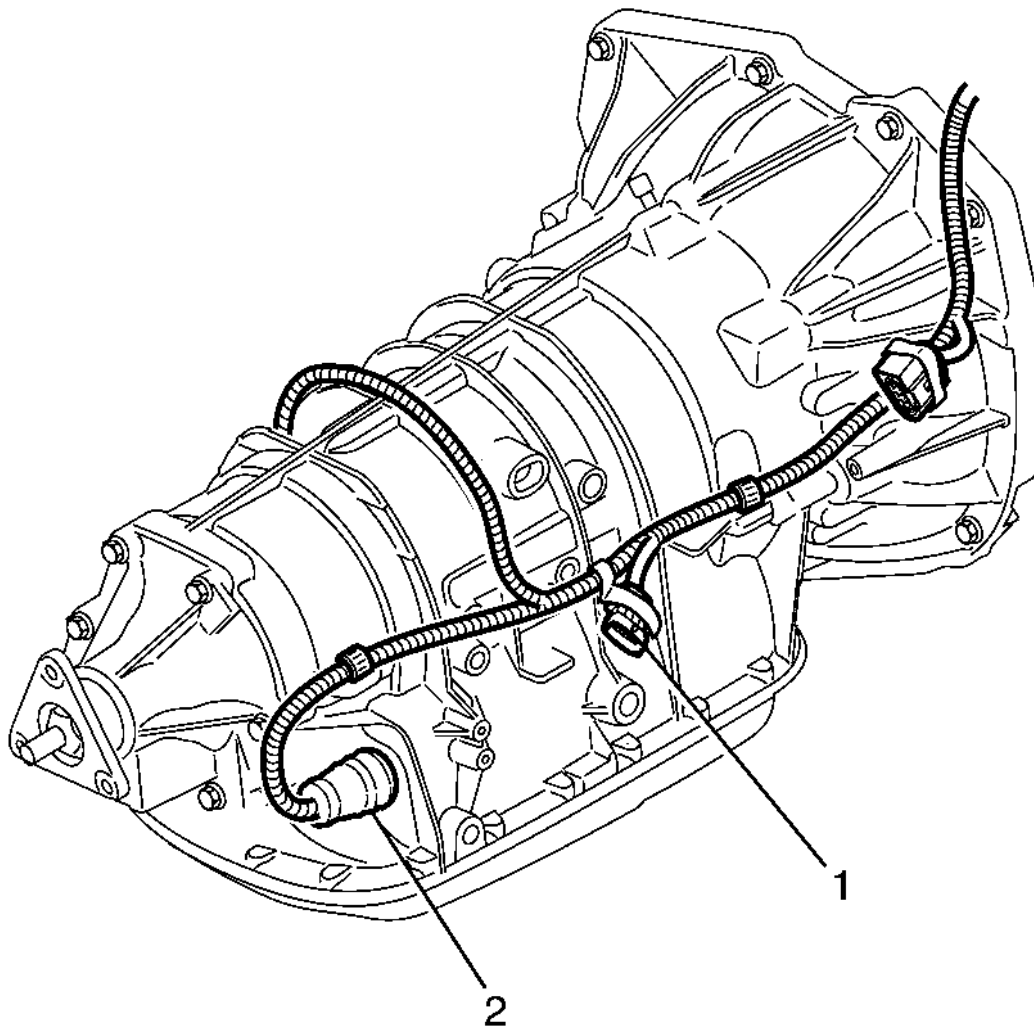
26. Install the engine wiring harness bracket to cylinder head retaining bolts (1).

**Tighten:** Tighten the nut to 40 N.m (30 lb ft).



**Fig. 174: View Of Left Hand Heated Oxygen Sensor 1 Electrical Harness & Connector**  
Courtesy of GENERAL MOTORS CORP.

27. Attach the left hand Heated Oxygen Sensor 1 electrical harness (1) to the engine wiring harness bracket (2).
28. Connect the left hand Heated Oxygen Sensor 1 electrical connector (3).

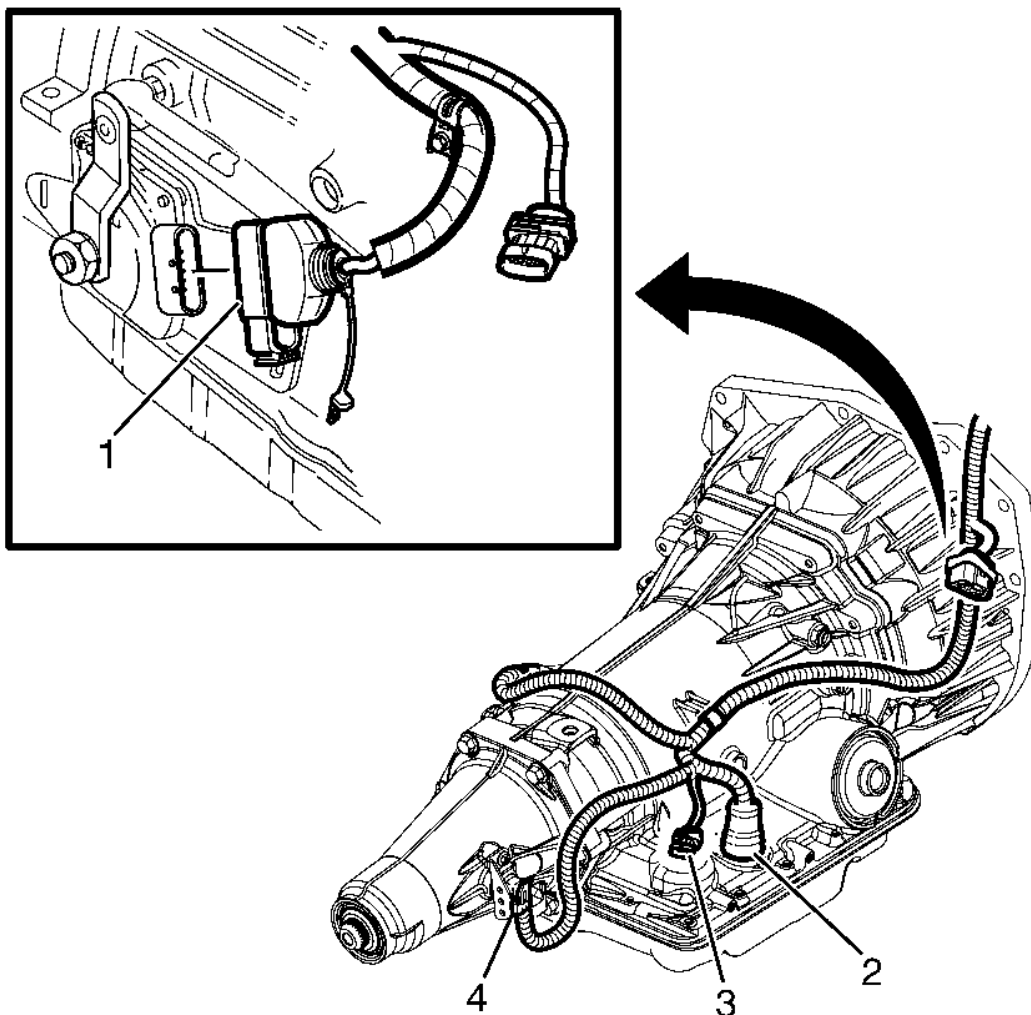


**Fig. 175: View Of Right Hand Heated Oxygen Sensor 1 & Main Transmission Electrical Connectors**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Steps 30 and 31 refer to the 5L40E 5 speed automatic transmission only.**

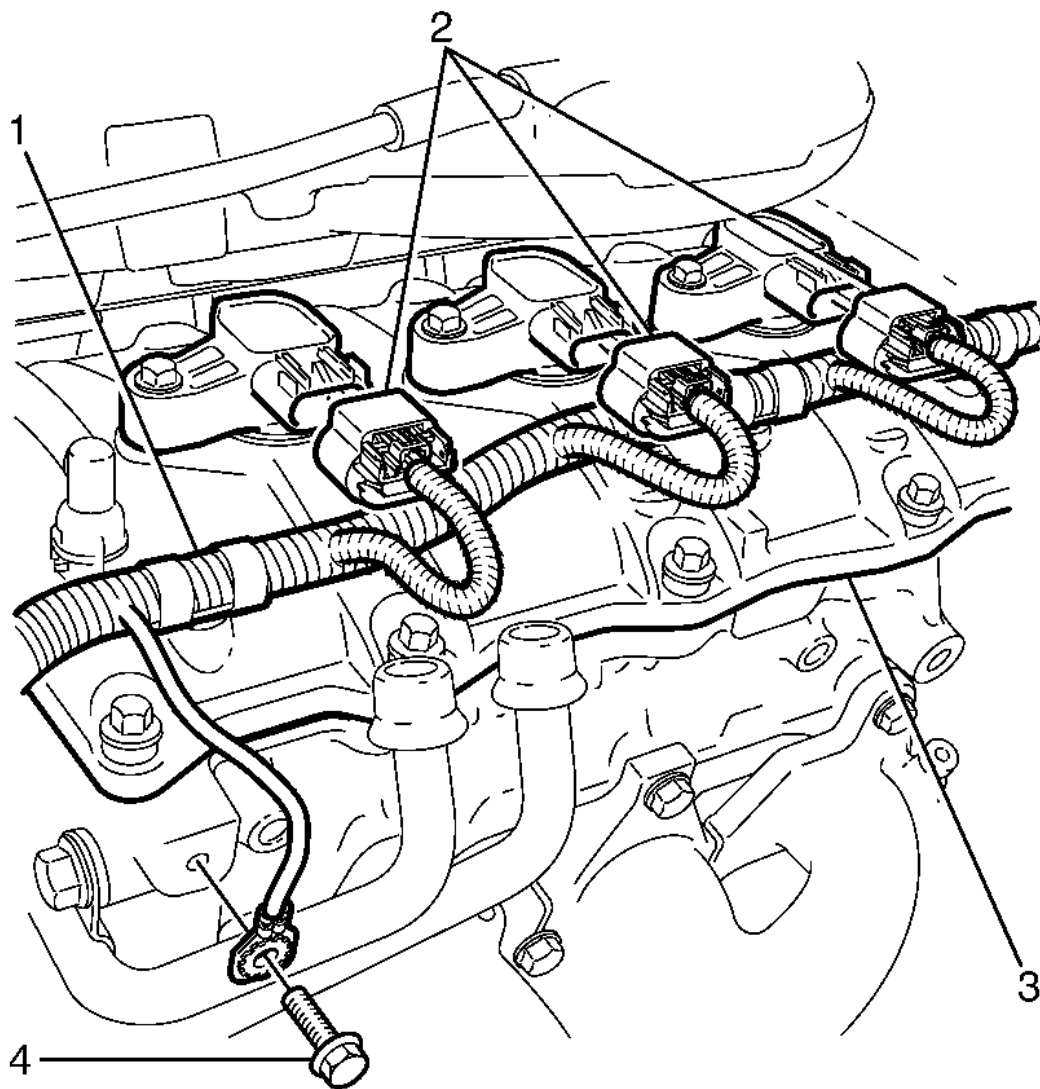
29. Connect the right hand Heated Oxygen Sensor 1 electrical connector (1).
30. Connect the main transmission electrical connector (2).



**Fig. 176: Identifying Park/Neutral Switch Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Steps 33-36 refer to the 4L60E 4 speed automatic transmission only.**

31. Connect the right hand Heated Oxygen Sensor 1 electrical connector (2).
32. Connect the main transmission electrical connector (3).
33. Connect the vehicle speed sensor electrical connector (4)
34. Connect the park/neutral switch electrical connector (1).



**Fig. 177: View Of Engine Wiring Harness, Right Bank Camshaft Cover & Right Bank Ignition Coil Electrical Connectors**

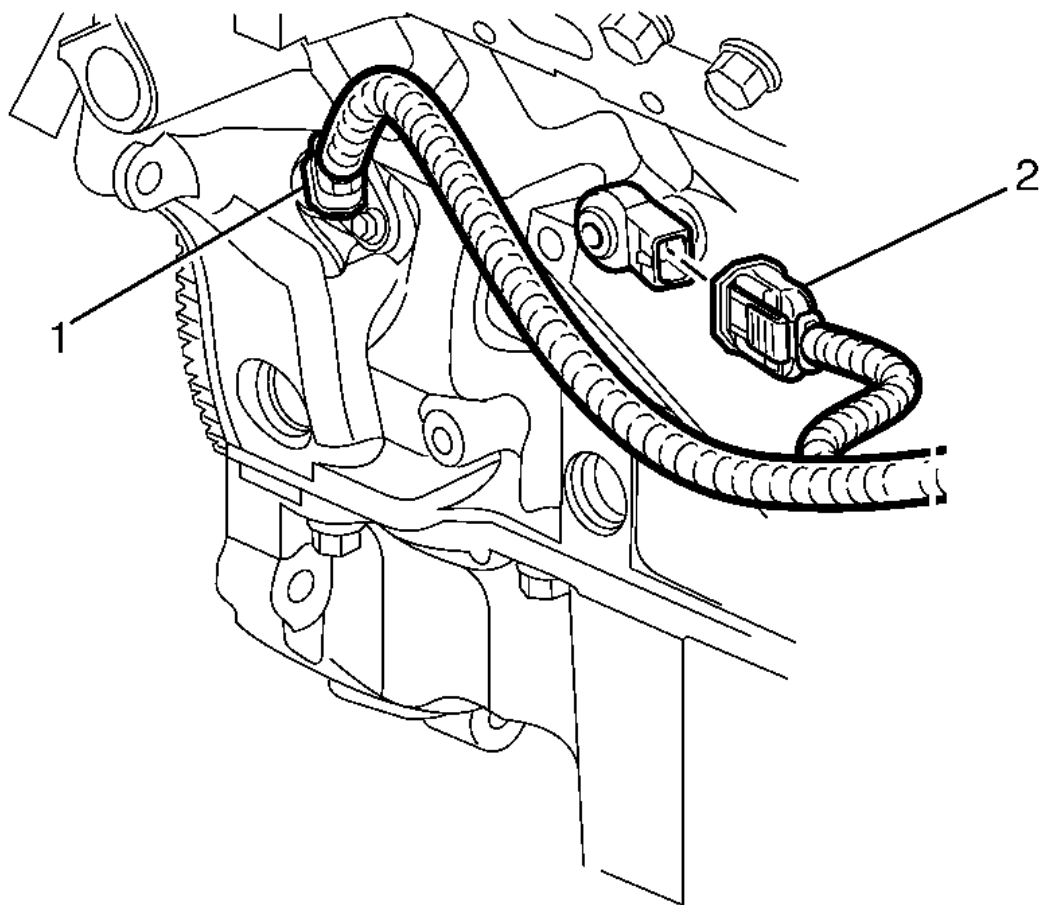
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Attach the engine wiring harness (1) clips to the right bank camshaft cover (3) to avoid an induced rattle condition.

35. Attach the engine wiring harness (1) to the right bank camshaft cover (3).
36. Install the engine wiring harness ground and engine wiring harness ground to right bank cylinder head retaining bolt (4).

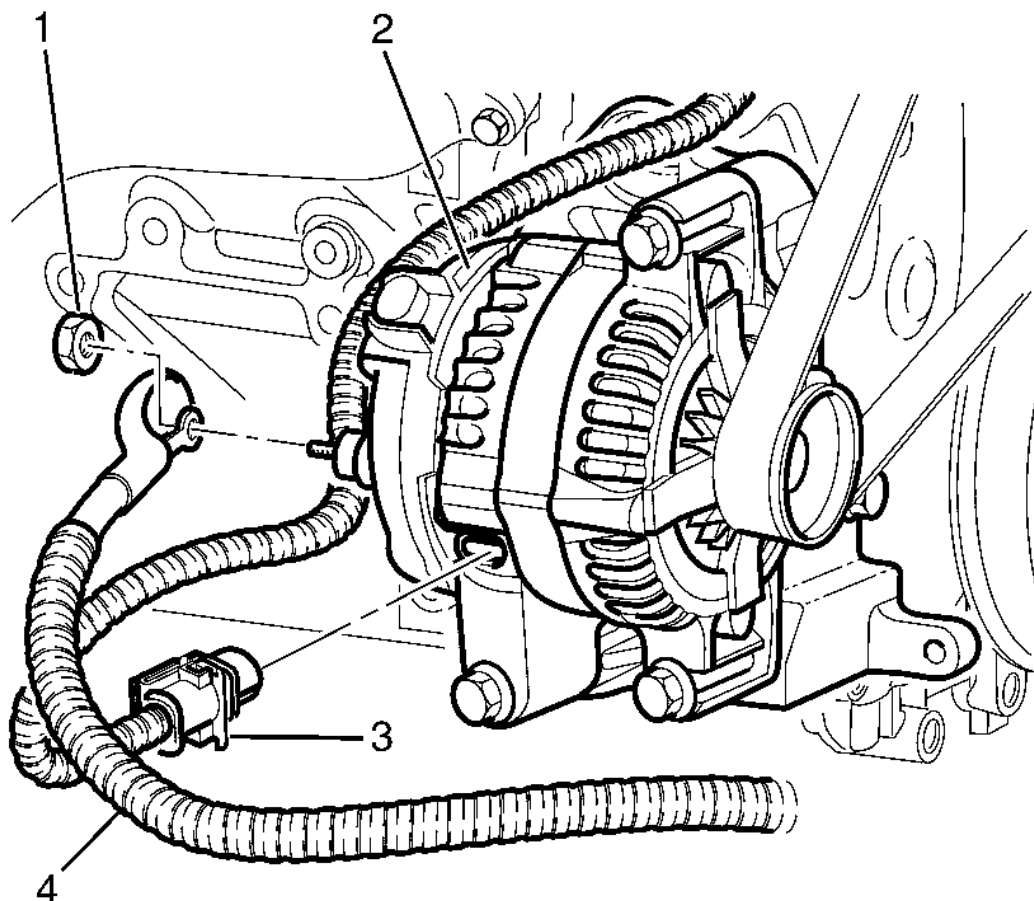
**Tighten:** Tighten the bolt to 10 N.m (89 lb in).

37. Connect the right bank ignition coil electrical connectors (2).



**Fig. 178: Identifying Crankshaft Position & Right Bank Knock Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

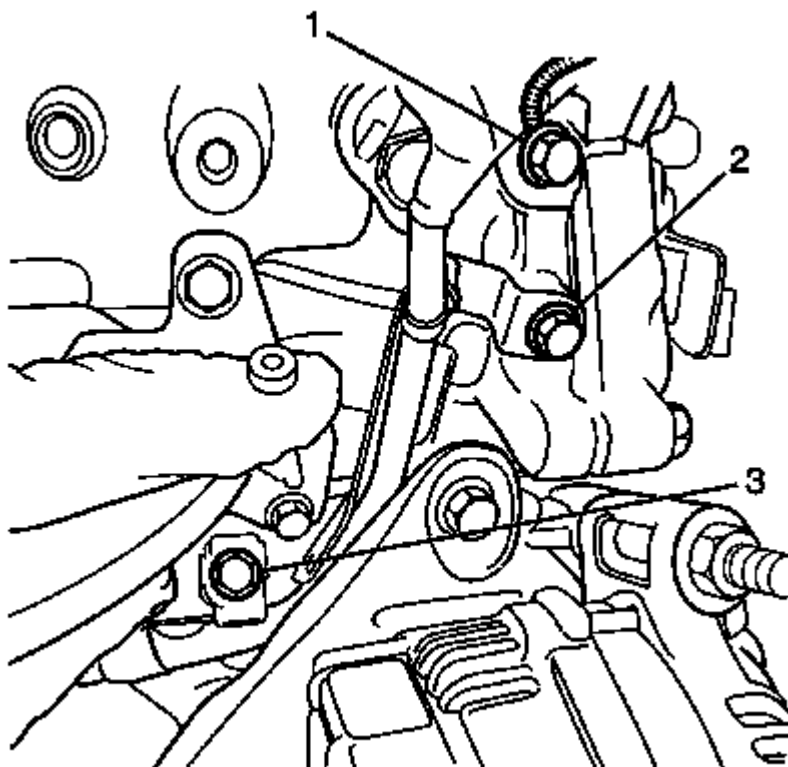
38. Connect the crankshaft position sensor electrical connector (1).  
39. Connect the right bank knock sensor electrical connector (2).  
40. Install the alternator and mounting bracket. Refer to **Generator Installation**.



**Fig. 179: Identifying Alternator, Battery Positive Cable & Alternator Battery Harness Connector**  
Courtesy of GENERAL MOTORS CORP.

41. Connect the alternator battery harness connector (3).
42. Connect the battery positive cable (4) from the alternator (2).
43. Install the battery positive cable to alternator retaining nut (1).

**Tighten:** Tighten the nut to 13 N.m (115 lb in).



**Fig. 180: Identifying Engine Wiring Harness Bracket To Right Bank Cylinder Head Retaining Bolts**

Courtesy of GENERAL MOTORS CORP.

44. Install the engine wiring harness bracket to cylinder block retaining bolt (3).

**Tighten:** Tighten the nut to 10 N.m (89 lb in).

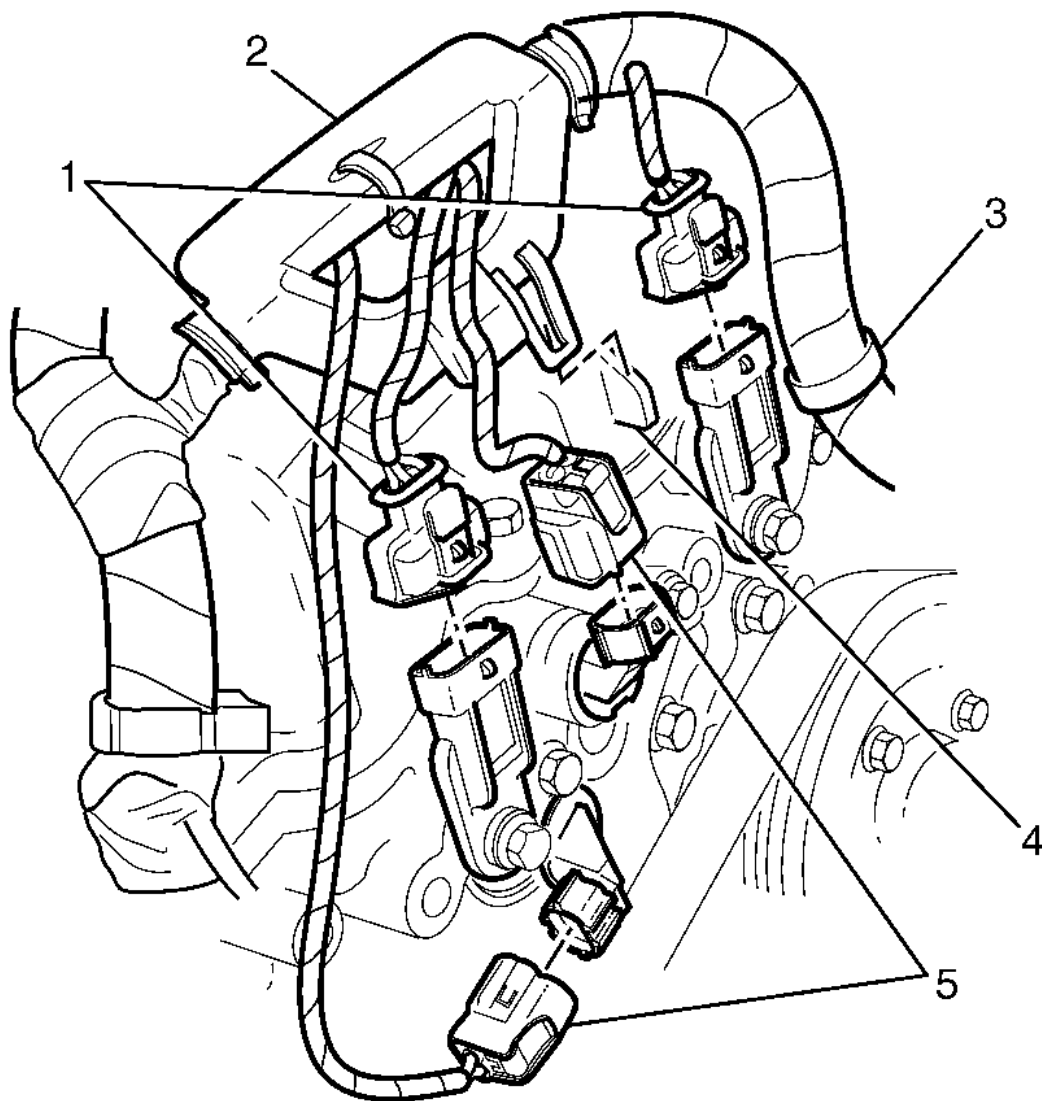
45. Install the engine wiring harness bracket to right bank cylinder head retaining bolt (2).

**Tighten:** Tighten the nut to 10 N.m (89 lb in).

46. Install the engine wiring harness ground to right bank cylinder head retaining bolt (1).

**Tighten:** Tighten the nut to 10 N.m (89 lb in).





**Fig. 181: Identifying Right Camshaft Position Sensors Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Attach the engine wiring harness bracket (2) to the locating clip lug on the right bank camshaft cover (4) to avoid an induced rattle condition.

47. Attach the engine wiring harness bracket (2) from the right bank camshaft cover (4).
48. Attach the engine wiring harness to cylinder head retaining lug (3).

**IMPORTANT:** LE0 and LW2 engines only have intake camshaft position actuator solenoids.

49. Connect the right bank intake and exhaust camshaft position actuator solenoid electrical connectors (5).
50. Connect the right camshaft position sensors electrical connectors (1).
51. Install the engine covers. Refer to **Engine Cover Replacement** .

## ENGINE PRELUBING

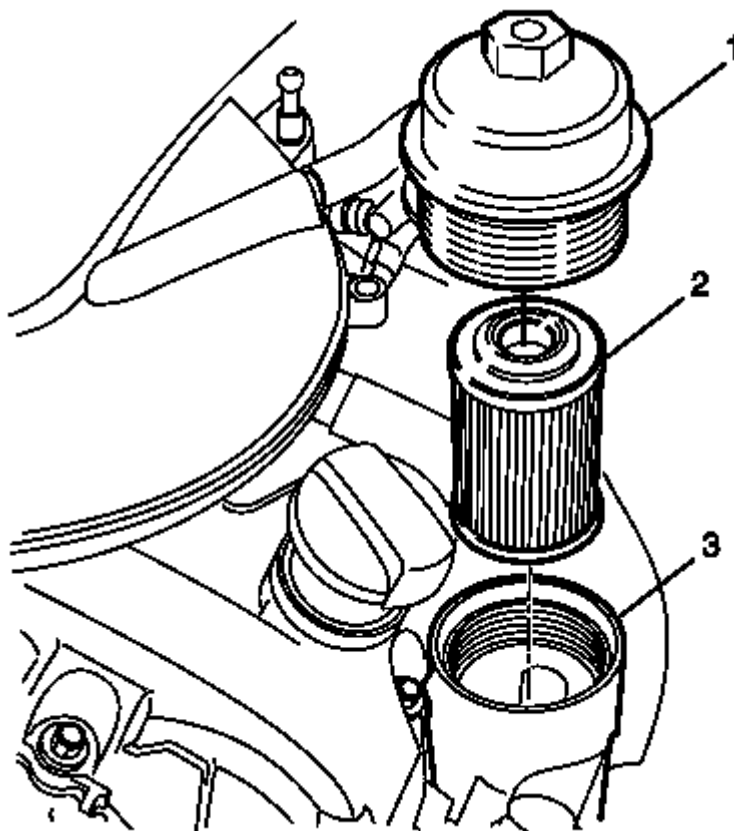
### Special Tools

**J 45299:** Engine Preluber

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

### Prelube

**NOTE:** A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

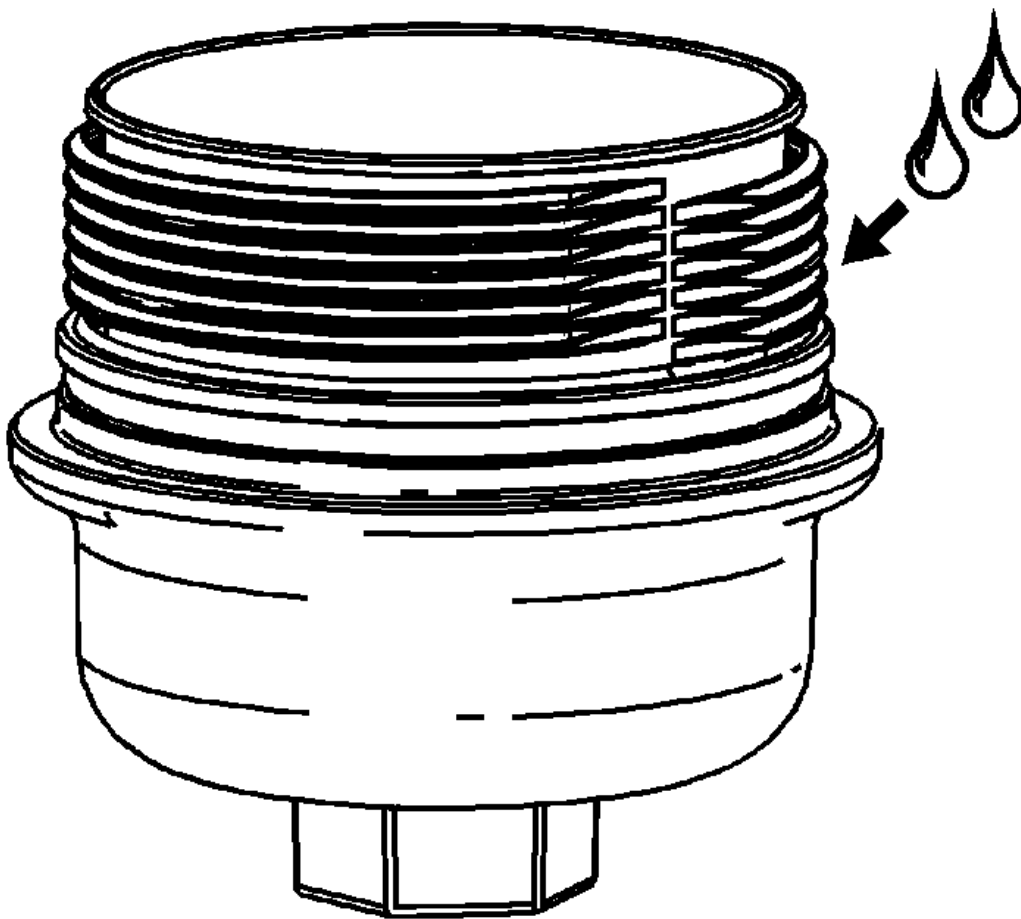


**Fig. 182: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Use a six-point socket to remove the oil filter cap (1).

1. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).
2. Remove the oil filter cartridge (2).

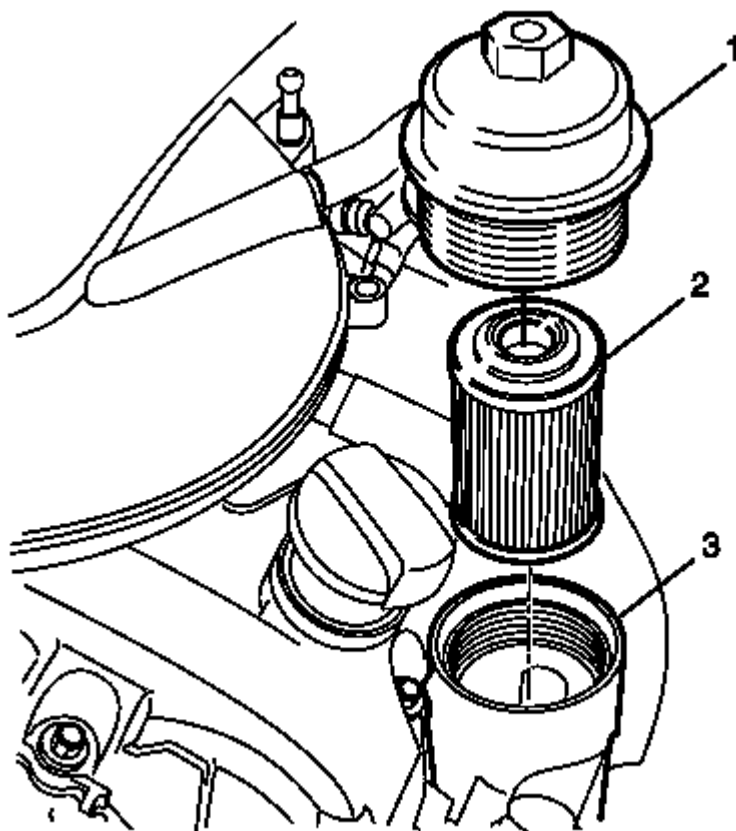
Discard the oil filter cartridge (2).



**Fig. 183: Identifying Oil Filter Cap Thread Lubrication**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

3. Lubricate the oil filter cap threads with clean engine oil.



**Fig. 184: Identifying Engine Oil Filter Adapter With Oil Filter Cartridge & Cap**  
Courtesy of GENERAL MOTORS CORP.

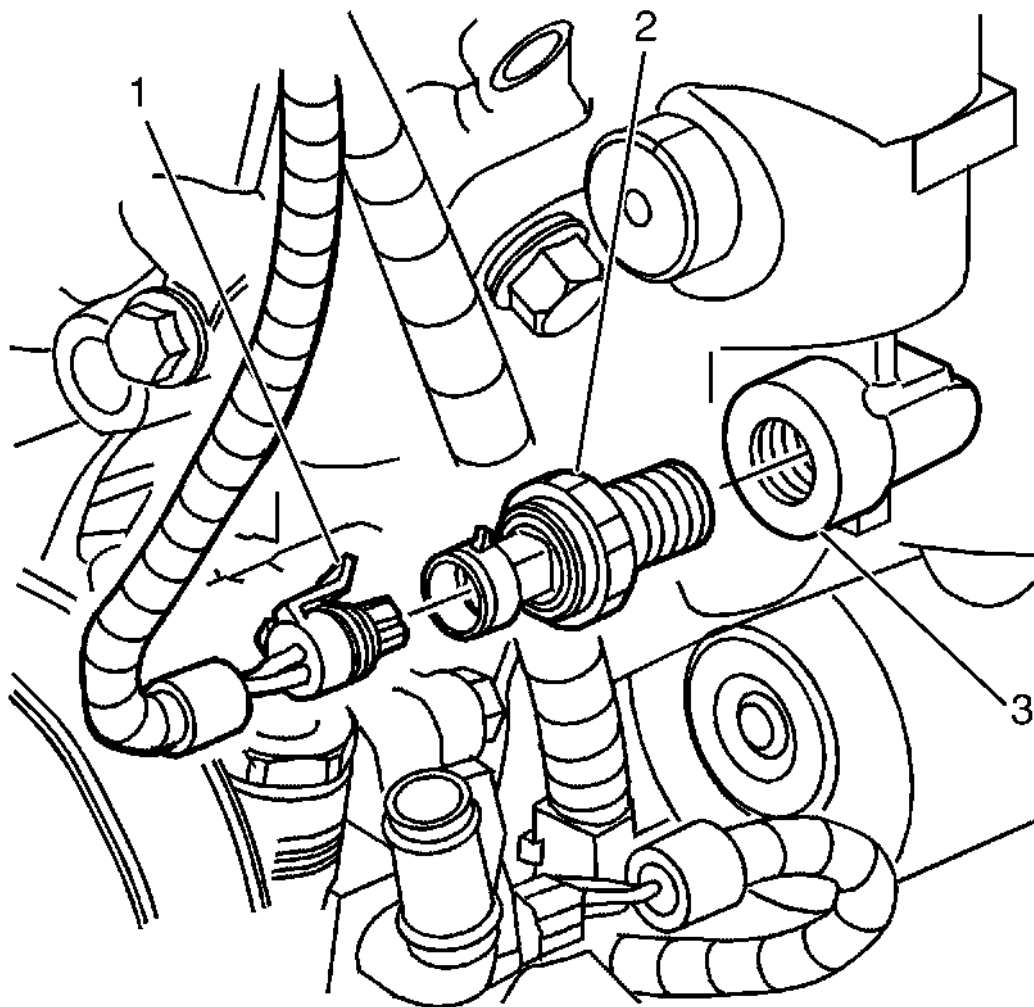
4. Install the NEW oil filter cartridge (2).

**CAUTION:** Refer to Fastener Caution .

**CAUTION:** Proper oil filter cap tightening is mandatory. Failure to tighten the oil filter cap to the proper specification can hinder later removal and cause possible oil filter cap damage.

**NOTE:** Use a six-point socket to install the oil filter cap.

5. Install the oil filter adapter cap (1) to the engine oil filter adapter (3) and tighten the oil filter cap to 25 N.m (18 lb ft).

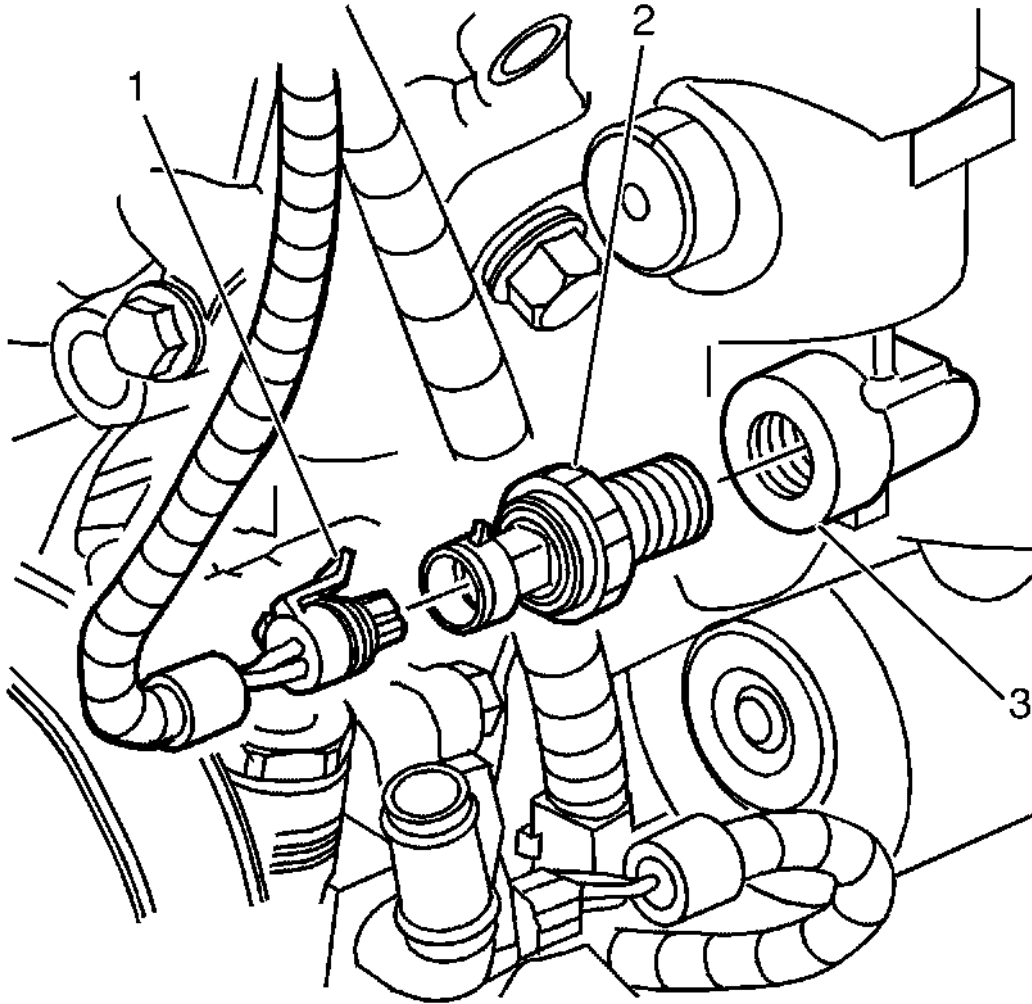


**Fig. 185: Identifying Oil Pressure Sending Unit With Electrical Connector & Oil Filter Adapter**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

6. Remove the oil pressure sending unit (2) from the oil filter adapter (3).
7. Disconnect the oil pressure sending unit electrical connector (1).
8. Install a 14 x 1.5 mm adapter to the oil filter adapter (3).
9. Install the flexible hose to the adapter and open the valve.
10. Pump the handle on the **J 45299**: preluber 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.

11. Close the valve and remove the flexible hose and adapter from the oil filter adapter.



**Fig. 186: Identifying Oil Pressure Sending Unit With Electrical Connector & Oil Filter Adapter**  
 Courtesy of GENERAL MOTORS CORP.

12. Install the oil pressure sending unit (2) to the oil filter adapter (3) and tighten the oil pressure sending unit to 20 N.m (15 lb ft).
13. Connect the oil pressure sending unit electrical connector (1).
14. Top-off the engine oil to the correct level.