**SPECIFICATIONS**

**FASTENER TIGHTENING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Application</th>
<th>Specifications</th>
</tr>
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<tbody>
<tr>
<td><strong>Application</strong></td>
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</tr>
<tr>
<td>A/C Compressor Hose/Pipe Bracket Bolt</td>
<td>9 N.m</td>
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<td>A.I.R. Cover Stud</td>
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<tr>
<td>Balance Shaft Retaining Bolt</td>
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<tr>
<td>Balance Shaft Chain Guide Bolt</td>
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<tr>
<td>Balance Shaft Chain Tensioner Bolt</td>
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<tr>
<td>Battery Negative Cable to Engine Block Bolt</td>
<td>35 N.m</td>
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<tr>
<td>Battery Positive Cable to Starter Terminal Nut</td>
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<tr>
<td>Camshaft Cap Bolt</td>
<td>12 N.m</td>
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<tr>
<td>Camshaft Cover Bolt</td>
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<tr>
<td>Camshaft Position Actuator Valve Bolt</td>
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<tr>
<td>Connecting Rod Cap Bolt</td>
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<tr>
<td>• First Pass</td>
<td>25 N.m</td>
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<td>• Final Pass</td>
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<tr>
<td>Coolant Temperature Sensor</td>
<td>16 N.m</td>
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<td>Crankshaft Balancer Bolt</td>
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<td>Crankshaft Main Bearing Cap Bolt</td>
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</tr>
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<td>Crankshaft Rear Oil Seal Housing Bolt</td>
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<td>Cylinder Head Access Hole Plug - Plastic</td>
<td>5 N.m</td>
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<td>Cylinder Head Bolt - 12</td>
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**MY**

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<tr>
<th>Component</th>
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<tr>
<td>Cylinder Head End Bolts - 2 Short</td>
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<tr>
<td>Cylinder Head Oil Gallery Plug</td>
<td>7 N.m</td>
<td>120 degrees</td>
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<td>Differential Carrier Assembly Bushing to Frame Bolt</td>
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<td>Drive Belt Idler Pulley Bolt</td>
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<td>Drive Belt Tensioner Bolt</td>
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<td>50 N.m</td>
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<tr>
<td>Engine Block Coolant Plug</td>
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<td>50 N.m</td>
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<tr>
<td>Engine Block Oil Gallery Plug - Side</td>
<td>38 N.m</td>
<td>35 N.m</td>
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<tr>
<td>Engine Flywheel Bolt</td>
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<td>Engine Front Cover Bolt</td>
<td>10 N.m</td>
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<td>Engine Front Cover - Center - Small Bolt</td>
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<tr>
<td>Engine Front Cover Spacer Bolt</td>
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<td>Engine Front Lift Bracket Bolt</td>
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<td>Engine Mount Bolt</td>
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<td>Engine Mount-to-Frame Bracket Bolt</td>
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<td>Engine Wiring Ground Lead Bolt</td>
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<td>Engine Wiring Harness Bracket Bolt</td>
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<td>EVAP Purge Solenoid Valve Bolt</td>
<td>10 N.m</td>
<td>10 N.m</td>
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<tr>
<td>Exhaust Camshaft Actuator Bolt</td>
<td>25 N.m</td>
<td>25 N.m</td>
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**NOTE:**
- All torques are in N.m unless otherwise specified as lb ft.
- All angles are in degrees unless otherwise specified.
<table>
<thead>
<tr>
<th>Component</th>
<th>Torque (N.m)</th>
<th>Torque (lb in)</th>
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<tr>
<td>Exhaust Camshaft Position Sensor Bolt</td>
<td>10</td>
<td>89</td>
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<tr>
<td>Exhaust Manifold Bolt</td>
<td>20</td>
<td>15</td>
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<tr>
<td>• First Pass</td>
<td></td>
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<tr>
<td>• Second Pass</td>
<td></td>
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</tr>
<tr>
<td>• Final Pass</td>
<td></td>
<td></td>
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<tr>
<td>Exhaust Manifold Heat Shield Nut</td>
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<tr>
<td>Exhaust Manifold Heat Shield Stud</td>
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<tr>
<td>Fuel Hose/ Pipe Bracket Nut</td>
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<tr>
<td>Fuel Injector Rail Bolt</td>
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<tr>
<td>Fuel Pressure Regulator Bolt</td>
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<td>Generator Mounting Bolt</td>
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<tr>
<td>Heater Inlet Pipe Bolt</td>
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<td>89</td>
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<tr>
<td>Heater Outlet Fitting</td>
<td>45</td>
<td>33</td>
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<td>Ignition Control Module Bolt</td>
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<td>Heater Outlet Hose/ Pipe Bracket to Left Engine</td>
<td>9</td>
<td>80</td>
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<td>Oil Filter Bypass Hole Plug</td>
<td>14</td>
<td>124</td>
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<tr>
<td>Oil Level Indicator Tube Bolt</td>
<td>10</td>
<td>89</td>
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<td>Oil Pan Bolt - Ends</td>
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<td>Oil Pan Bolt - Sides</td>
<td>25</td>
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<td>Oil Pan Drain Plug</td>
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<td>19</td>
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<td>Oil Pressure Switch</td>
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<td>Oil Pump Cover Bolt</td>
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<tr>
<td>Oil Pump Pipe and Screen Assembly Bolt</td>
<td>10</td>
<td>89</td>
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<tr>
<td>Oil Pump Pressure Relief Valve Plug</td>
<td>14</td>
<td>124</td>
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<tr>
<td>Power Steering Pump Bolt</td>
<td>25</td>
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### Engine Mechanical Specifications

<table>
<thead>
<tr>
<th><strong>Application</strong></th>
<th><strong>Specifications</strong></th>
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<tbody>
<tr>
<td><strong>Metric</strong></td>
<td><strong>English</strong></td>
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<tr>
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<tr>
<td>• Engine Type</td>
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<tr>
<td>• Displacement</td>
<td>3.5L</td>
</tr>
<tr>
<td>• RPO</td>
<td>L52</td>
</tr>
<tr>
<td>• VIN</td>
<td>6</td>
</tr>
<tr>
<td>• Bore</td>
<td>93 mm</td>
</tr>
<tr>
<td>• Stroke</td>
<td>102 mm</td>
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<tr>
<td>• Compression Ratio</td>
<td>10:1</td>
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<tr>
<td>• Engine Compression Test</td>
<td>1482 kPa</td>
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<tr>
<td>• Firing Order</td>
<td>1-3-5-4-2</td>
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<tr>
<td>Measurement</td>
<td>Units</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------</td>
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<tr>
<td>Spark Plug Gap</td>
<td>1.14-1.25 mm, 0.044-0.050 in</td>
</tr>
<tr>
<td>Crankshaft Main Bearing Bore Diameter</td>
<td>78.070-78.088 mm, 3.0760-3.0766 in</td>
</tr>
<tr>
<td>Cylinder Bore Diameter</td>
<td>92.990-93.006 mm, 3.6638-3.6644 in</td>
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<tr>
<td>Cylinder Bore Out-of-Round</td>
<td>0.013 mm, 0.0005 in</td>
</tr>
<tr>
<td>Cylinder Head Deck Surface Flatness</td>
<td>0.08 mm, 0.003 in</td>
</tr>
<tr>
<td>Cylinder Liner Recession</td>
<td>0.015 mm, 0.0006 in</td>
</tr>
<tr>
<td>Camshaft End Play - Exhaust</td>
<td>0.045-0.215 mm, 0.0017-0.0084 in</td>
</tr>
<tr>
<td>Camshaft End Play - Intake</td>
<td>0.051-0.201 mm, 0.0020-0.0079 in</td>
</tr>
<tr>
<td>Camshaft Journal Diameter - All Intake and Exhaust #2-#7</td>
<td>26.936-26.960 mm, 1.0612-1.0622 in</td>
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<tr>
<td>Camshaft Journal Diameter - Exhaust #1</td>
<td>29.936-29.960 mm, 1.1794-1.1804 in</td>
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<tr>
<td>Camshaft Journal to Bore Clearance</td>
<td>0.040-0.085 mm, 0.0015-0.0033 in</td>
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<tr>
<td>Connecting Rod Bearing Clearance</td>
<td>0.021-0.065 mm, 0.0008-0.0025 in</td>
</tr>
<tr>
<td>Connecting Rod Bore Diameter - Bearing End</td>
<td>60.332-60.338 mm, 2.3749-2.3755 in</td>
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<tr>
<td>Connecting Rod Bore Out-of-Round - Bearing End</td>
<td>0.006 mm, 0.0002 in</td>
</tr>
<tr>
<td>Connecting Rod Side Clearance</td>
<td>0.05-0.35 mm, 0.0019-0.0137 in</td>
</tr>
<tr>
<td>Crankshaft End Play</td>
<td>0.112-0.388 mm, 0.0044-0.0153 in</td>
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<tr>
<td>Crankshaft Main Bearing Clearance</td>
<td>0.012-0.064 mm, 0.0004-0.0025 in</td>
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<tr>
<td>Crankshaft Main Journal Diameter</td>
<td>69.968-69.984 mm, 2.7567-2.7574 in</td>
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<tr>
<td>Crankshaft Main Journal Out-of-Round</td>
<td>0.005 mm, 0.0002 in</td>
</tr>
<tr>
<td>Crankshaft Main Journal Taper</td>
<td>0.005 mm, 0.0002 in</td>
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<tr>
<td>Surface Flatness - Block Deck</td>
<td>0.08 mm, 0.003 in</td>
</tr>
</tbody>
</table>
### Surface Flatness - Exhaust Manifold Deck
- **Exhaust Manifold**
  - **Surface Flatness**
    - 0.08 mm (0.003 in)

### Surface Flatness - Intake Manifold Deck
- **Surface Flatness**
  - 0.08 mm (0.003 in)

### Lubrication System
- **Oil Capacity - with Filter**
  - 5.6 L (6.0 qts)
- **Oil Capacity - without Filter**
  - 5.1 L (5.5 qts)
- **Oil Pressure - Minimum**
  - 85 kPa (12 psi at 1200 RPM)

### Oil Pump
- **Gear Diameter - Drive**
  - 73.415-73.370 mm (2.893-2.891 in)
- **Gear Diameter - Driven**
  - 87-86.975 mm (3.428-3.426 in)
- **Gear Pocket - Depth**
  - 15.609-15.584 mm (0.615-0.614 in)
- **Gear Pocket - Diameter**
  - 87.065-87.040 mm (3.430-3.429 in)
- **Gear Thickness - Drive**
  - 15.546-15.521 mm (0.613-0.611 in)
- **Gear Thickness - Driven**
  - 15.360-15.511 mm (0.605-0.611 in)
- **Lobe Inner Diameter - Maximum**
  - 11.9 mm (0.469 in)
- **Relief Valve-to-Bore Clearance**
  - 2.57-1.63 mm (0.101-0.064 in)

### Piston Rings
- **Piston Ring End Gap - First Compression Ring**
  - 0.2-0.4 mm (0.0079-0.0157 in)
- **Piston Ring End Gap - Second Compression Ring**
  - 0.36-0.51 mm (0.0142-0.0201 in)
- **Piston Ring End Gap - Oil Control Ring**
  - 0.250-0.760 mm (0.0098-0.0299 in)
- **Piston Ring to Groove Clearance - First Compression Ring**
  - 0.043-0.093 mm (0.0017-0.0037 in)
- **Piston Ring to Groove Clearance - Second Compression Ring**
  - 0.053-0.093 mm (0.0021-0.0037 in)
- **Piston Ring to Groove Clearance - Oil Control Ring**
  - 0.059-0.215 mm (0.0023-0.0085 in)
### Pistons and Pins

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>Piston - Piston Diameter</td>
<td>92.963 mm</td>
<td>92.977 mm</td>
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<tr>
<td>Piston - Piston Pin Bore Diameter</td>
<td>23.002 mm</td>
<td>23.008 mm</td>
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<tr>
<td>Piston - Piston to Bore Clearance</td>
<td>0.013 mm</td>
<td>0.043 mm</td>
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<tr>
<td>Pin - Piston Pin Clearance to Connecting Rod Bore</td>
<td>0.001 mm</td>
<td>0.018 mm</td>
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<tr>
<td>Pin - Piston Pin Clearance to Piston Pin Bore</td>
<td>0.003 mm</td>
<td>0.012 mm</td>
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<tr>
<td>Pin - Piston Pin Diameter</td>
<td>22.996 mm</td>
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### Valve System

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>Valves - Valve Face Runout</td>
<td>0.038 mm</td>
<td>0.0015 in</td>
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<tr>
<td>Valves - Valve Seat Runout</td>
<td>0.05 mm</td>
<td>0.002 in</td>
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<tr>
<td>Valves - Valve Stem-to-Guide Clearance - Exhaust</td>
<td>0.0375 mm</td>
<td>0.0775 mm</td>
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<tr>
<td>Valves - Valve Stem-to-Guide Clearance - Intake</td>
<td>0.030 mm</td>
<td>0.065 mm</td>
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<tr>
<td>Valve Springs - Valve Spring Load - Closed</td>
<td>211-233 N</td>
<td>47.4-52.4 lb at 1.701 in</td>
</tr>
<tr>
<td>Valve Springs - Valve Spring Load - Open</td>
<td>578-632 N</td>
<td>130-142 lb at 1.260 in</td>
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### SEALERS, ADHESIVES, AND LUBRICANTS

#### Sealers, Adhesives, and Lubricants

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<tr>
<th>Application</th>
<th>Type of Material</th>
<th>GM Part Number</th>
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<tr>
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<td>Coolant Sensor Threads</td>
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<tr>
<td>Crankshaft Position Sensor Bolt</td>
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<tr>
<td>Cylinder Block Heater Plug</td>
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<tr>
<td>Cylinder Head Core Hole Plugs</td>
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<tr>
<td>Cylinder Head Expansion Plugs</td>
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<td>Part Description</td>
<td>Part Type</td>
<td>Part Number</td>
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<tr>
<td>(Aluminum)</td>
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<td>Engine Block Oil Gallery Plugs</td>
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<td>Engine Block Plug</td>
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<tr>
<td>Engine Front Cover Surface</td>
<td>(3-Bond) Sealant</td>
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<td>Engine Oil</td>
<td>5W-30 Oil</td>
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<td>EVAP Purge Solenoid Valve Bolt</td>
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<td>Exhaust Manifold Bolt Threads</td>
<td>Threadlock</td>
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<td>Exhaust Manifold Heat Shield Nuts</td>
<td>Anti-Sieze</td>
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<td>Oil Level Indicator Tube Stud</td>
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<td>Oil Pan Surface</td>
<td>(3-Bond) Sealant</td>
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<td>Oil Pressure Sensor Threads</td>
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**THREAD REPAIR SPECIFICATIONS**

**Engine Block - Top View**
### Engine Block - Top View

<table>
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<tr>
<th>Service Hole Location</th>
<th>Thread Size</th>
<th>Drill</th>
<th>Counterbore Tool</th>
<th>Stop Collar</th>
<th>Tap</th>
<th>Driver</th>
<th>Insert</th>
<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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<td>M 11 x 2</td>
<td>402</td>
<td>n/a</td>
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J 42385-400. See Special Tools.

Fig. 1: Engine Block - Top View
Courtesy of GENERAL MOTORS CORP.

### Engine Block - Bottom View
Fig. 2: Engine Block - Bottom View
Courtesy of GENERAL MOTORS CORP.

### Engine Block - Bottom View

<table>
<thead>
<tr>
<th>Service Hole Location</th>
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J 42385-400. See Special Tools.
**Fig. 3: Engine Block - Left Side View**
_Courtesy of GENERAL MOTORS CORP._

**Engine Block - Left Side View**

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_J 42385-400. See Special Tools._
### Engine Block - Right Side View

![Diagram of Engine Block - Right Side View](image)

**Fig. 4: Engine Block - Right Side View**

Courtesy of GENERAL MOTORS CORP.

### Engine Block - Right Side View

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<th>Drill</th>
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*J 42385-400. See Special Tools.*

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*J 42385-400. See Special Tools.*
**Fig. 5: Engine Block - Front View**  
*Courtesy of GENERAL MOTORS CORP.*

### Engine Block - Front View

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J 42385-400. See Special Tools.
Fig. 6: Engine Block - Rear View
Courtesy of GENERAL MOTORS CORP.

### Engine Block - Rear View

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J 42385-400. See Special Tools.

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**Fig. 7: Cylinder Head - Top View**
*Courtesy of GENERAL MOTORS CORP.*

### Cylinder Head - Top View

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*J 42385-400. See Special Tools.*

**Cylinder Head - End - Front View**
Fig. 8: Cylinder Head - End - Front View
Courtesy of GENERAL MOTORS CORP.

### Cylinder Head - End - Front View

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J 42385-400. See Special Tools.

### Cylinder Head - End - Rear View
Fig. 9: Cylinder Head - End - Rear View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - End - Rear View

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Cylinder Head - Intake Manifold Deck View
Fig. 10: Cylinder Head - Intake Manifold Deck View  
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake Manifold Deck View

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J 42385-400 . See Special Tools.
Fig. 11: Cylinder Head - Exhaust Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Exhaust Manifold Deck View

<table>
<thead>
<tr>
<th>Service Hole Location</th>
<th>Thread Size</th>
<th>Drill</th>
<th>Counterbore Tool</th>
<th>Stop Collar</th>
<th>Tap</th>
<th>Driver</th>
<th>Insert</th>
<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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<td>201</td>
<td>202</td>
<td>n/a</td>
<td>203</td>
<td>204</td>
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<tr>
<td>3</td>
<td>M 6 x 1</td>
<td>405</td>
<td>n/a</td>
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<td>204</td>
<td>205</td>
<td>28</td>
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<td>4</td>
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<td>417</td>
<td>n/a</td>
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J 42385-400. See Special Tools.

Oil Pan - Bottom View

Fig. 12: Oil Pan - Bottom View
Courtesy of GENERAL MOTORS CORP.
Oil Pan - Bottom View

<table>
<thead>
<tr>
<th>Service Hole Location</th>
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<th>Tap</th>
<th>Driver</th>
<th>Insert</th>
<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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<tr>
<td>J 42385-400 . See Special Tools.</td>
<td>mm</td>
<td>(in)</td>
<td>mm</td>
<td>(in)</td>
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<tr>
<td>1</td>
<td>M 8 x 1.25</td>
<td>206</td>
<td>207</td>
<td>n/a</td>
<td>208</td>
<td>209</td>
<td>415</td>
<td>THRU</td>
<td>THRU</td>
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Oil Pan - Rear View

![Oil Pan - Rear View Diagram]

Fig. 13: Oil Pan - Rear View
Courtesy of GENERAL MOTORS CORP.

Oil Pan - Rear View

<table>
<thead>
<tr>
<th>Service Hole Location</th>
<th>Thread Size</th>
<th>Drill</th>
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<th>Stop Collar</th>
<th>Tap</th>
<th>Driver</th>
<th>Insert</th>
<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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<tr>
<td>J 42385-400 . See Special Tools.</td>
<td>mm</td>
<td>(in)</td>
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<td>(in)</td>
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<td>214</td>
<td>215</td>
<td>THRU</td>
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Engine Front Cover
### Engine Front Cover

**Fig. 14: Engine Front Cover**  
Courtesy of GENERAL MOTORS CORP.

#### Service Hole Location

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<tr>
<th>Service Hole Location</th>
<th>Thread Size</th>
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<th>Counterbore Tool</th>
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<th>Tap</th>
<th>Driver</th>
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<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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<tr>
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<td>n/a</td>
<td>n/a</td>
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<td>205</td>
<td>THRU</td>
<td>THRU</td>
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</table>

J 42385-400. See Special Tools.
Crankshaft Rear Oil Seal Housing

Fig. 15: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

Crankshaft Rear Oil Seal Housing

<table>
<thead>
<tr>
<th>Service Hole Location</th>
<th>Thread Size</th>
<th>Drill</th>
<th>Counterbore Tool</th>
<th>Stop Collar</th>
<th>Tap</th>
<th>Driver</th>
<th>Insert</th>
<th>Drill Depth (Max)</th>
<th>Tap Depth (Min)</th>
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</thead>
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<tr>
<td>1</td>
<td>M 6 x 1</td>
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<td>202</td>
<td>n/a</td>
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<td>204</td>
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J 42385-400. See Special Tools.

COMPONENT LOCATOR

DISASSEMBLED VIEWS
Fig. 16: Lower Engine Components
Courtesy of GENERAL MOTORS CORP.

<table>
<thead>
<tr>
<th>Callout</th>
<th>Component Name</th>
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<td>Engine Block</td>
</tr>
<tr>
<td>101</td>
<td>Transmission Locator Pin</td>
</tr>
<tr>
<td>102</td>
<td>Cylinder Head Locator Pin</td>
</tr>
<tr>
<td>102</td>
<td>Cylinder Head Locator Pin</td>
</tr>
<tr>
<td>103</td>
<td>Main Bearing Cap Locator Pin</td>
</tr>
<tr>
<td>104</td>
<td>Engine Front Cover Locator Pin</td>
</tr>
<tr>
<td>105</td>
<td>Cylinder Sleeve</td>
</tr>
<tr>
<td>106</td>
<td>Connecting Rod Bolt</td>
</tr>
<tr>
<td>107</td>
<td>Connecting Rod Cap</td>
</tr>
<tr>
<td>Part Number</td>
<td>Component</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>108</td>
<td>Connecting Rod Lower Bearing</td>
</tr>
<tr>
<td>109</td>
<td>Connecting Rod Upper Bearing</td>
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<td>110</td>
<td>Connecting Rod</td>
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<td>111</td>
<td>Connecting Rod Bushing</td>
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<tr>
<td>112</td>
<td>Piston Pin Retainer</td>
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<td>112</td>
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<tr>
<td>113</td>
<td>Piston Pin</td>
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<td>114</td>
<td>Piston</td>
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<td>Oil Control Ring Set</td>
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<td>116</td>
<td>Lower Compression Ring</td>
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<td>117</td>
<td>Upper Compression Ring</td>
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<td>118</td>
<td>Crankshaft</td>
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<td>119</td>
<td>Upper Main Bearings</td>
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<td>119</td>
<td>Upper Main Bearings</td>
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<td>Main Bearing Caps</td>
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<td>124</td>
<td>Main Bearing Cap Bolt</td>
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<td>125</td>
<td>Flywheel - Automatic Transmission</td>
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<td>126</td>
<td>Flywheel Bolt</td>
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<td>127</td>
<td>Flywheel - Manual Transmission</td>
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<td>Clutch Pilot Bearing</td>
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<td>131</td>
<td>Crankshaft Balancer</td>
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<td>132</td>
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<td>Friction Washer</td>
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Fig. 17: Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 17

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<tr>
<td>201</td>
<td>Cylinder Head Gasket</td>
</tr>
<tr>
<td>202</td>
<td>Engine Lift Bracket</td>
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<tr>
<td>203</td>
<td>Engine Lift Bracket Bolts</td>
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<td>204</td>
<td>Intake Valve</td>
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<tr>
<td>205</td>
<td>Exhaust Valve</td>
</tr>
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<td>206</td>
<td>Access Hole Plugs</td>
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<td>207</td>
<td>Cylinder Head Bolt</td>
</tr>
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<td>208</td>
<td>Valve Lash Adjusters</td>
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<td>209</td>
<td>Valve Seals</td>
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<td>210</td>
<td>Valve Springs</td>
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<td>Valve Spring Retainers</td>
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<td>Valve Keys</td>
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<td>Valve Rocker Arms</td>
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<td>Cylinder Head Bolt</td>
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<td>A.I.R. Pipe Plug</td>
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<td>Oil Gallery Plug</td>
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<td>Oil Gallery Plug</td>
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<td>Timing Chain Top Guide</td>
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<td>Timing Chain Top Guide Bolt</td>
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<td>Intake Camshaft</td>
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<td>Exhaust Camshaft</td>
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<td>Camshaft Cap</td>
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<td>Camshaft Cap</td>
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<td>226</td>
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<td>227</td>
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<td>228</td>
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<td>Intake Camshaft Sprocket Bolt</td>
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<td>Timing Chain Tensioner Shoe</td>
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<td>232</td>
<td>Timing Chain Tensioner Shoe Bolt</td>
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<td>Timing Chain Guide</td>
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<td>Timing Chain Guide Bolt</td>
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<td>Timing Chain Tensioner</td>
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<td>Right Front and Rear Balance Shaft Bearings</td>
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<td>Left Balance Shaft</td>
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<td>Left Front and Rear Balance Shaft Bearings</td>
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<td>Balance Shaft Chain Guide</td>
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<td>242</td>
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Fig. 18: Cooling Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 18

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<td>Water Pump Gasket</td>
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<td>304</td>
<td>Water Pump Bolt</td>
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<td>305</td>
<td>Thermostat Housing</td>
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<td>306</td>
<td>Thermostat Housing Seal</td>
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<td>307</td>
<td>Thermostat Housing Bolt</td>
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<td>308</td>
<td>Water Outlet</td>
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<td>310</td>
<td>Water Outlet Seal</td>
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<td>311</td>
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Fig. 19: Lubrication Components
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 19

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<td>Coolant Temperature Sensor</td>
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<td>Oil Drain Plug Gasket</td>
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<td>406</td>
<td>Oil Pump Pickup Tube</td>
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<td>407</td>
<td>Oil Pump Pickup Tube Bolt</td>
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<td>Oil Pump Seal</td>
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<td>413</td>
<td>Oil Pump Bolt</td>
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<td>414</td>
<td>Oil Pressure Relief Valve</td>
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<td>Oil Pressure Relief Valve Spring</td>
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<td>Oil Pressure Relief Valve Plug</td>
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<td>Oil Pump Outer Gear</td>
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<td>Oil Level Indicator</td>
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<td>Oil Level Indicator Tube Stud</td>
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<td>426</td>
<td>Oil Level Indicator Nut</td>
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**Fig. 20: Engine Cover and Components**
*Courtesy of GENERAL MOTORS CORP.*

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<th>Callout</th>
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<td>Positive Crankcase Vent Hose</td>
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<td>504</td>
<td>Throttle Control Module</td>
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<td>505</td>
<td>Throttle Control Module Bolt</td>
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<td>506</td>
<td>Throttle Control Module Seal</td>
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<td>507</td>
<td>Fuel Injector Rail</td>
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<td>508</td>
<td>Fuel Injector Rail Bolt</td>
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<td>509</td>
<td>Crankshaft Rear Oil Seal Housing</td>
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<td>510</td>
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<td>Engine Front Cover</td>
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<td>Engine Front Cover Bolt</td>
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<td>Component Name</td>
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<td>-------------------------------------</td>
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<td>Engine Front Cover Bolt</td>
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<td>Engine Front Cover Bolt Spacer</td>
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<td>Camshaft Cover</td>
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<tr>
<td>521</td>
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**Fig. 21: Engine Exhaust & Components**

**Courtesy of GENERAL MOTORS CORP.**

**Callouts For Fig. 21**

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<th>Callout</th>
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</tr>
<tr>
<td>601</td>
<td>Exhaust Manifold Gasket</td>
</tr>
<tr>
<td>602</td>
<td>Exhaust Manifold Bolt</td>
</tr>
<tr>
<td>603</td>
<td>Exhaust Manifold Heat Shield</td>
</tr>
<tr>
<td>Part Number</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>604</td>
<td>Exhaust Manifold Heat Shield Stud</td>
</tr>
<tr>
<td>605</td>
<td>Exhaust Manifold Heat Shield Nut</td>
</tr>
<tr>
<td>700</td>
<td>Ignition Control Module</td>
</tr>
<tr>
<td>701</td>
<td>Ignition Control Module Spring</td>
</tr>
<tr>
<td>702</td>
<td>Ignition Control Module Boot</td>
</tr>
<tr>
<td>703</td>
<td>Exhaust Camshaft Position Sensor</td>
</tr>
<tr>
<td>704</td>
<td>Exhaust Camshaft Position Sensor Bolt</td>
</tr>
<tr>
<td>705</td>
<td>EVAP Emission Canister Purge Solenoid</td>
</tr>
<tr>
<td>706</td>
<td>EVAP Emission Canister Purge Solenoid Bolt</td>
</tr>
<tr>
<td>707</td>
<td>Knock Sensor Bolt</td>
</tr>
<tr>
<td>708</td>
<td>Knock Sensor</td>
</tr>
<tr>
<td>709</td>
<td>Knock Sensor</td>
</tr>
<tr>
<td>710</td>
<td>Intake Camshaft Sensor</td>
</tr>
<tr>
<td>711</td>
<td>Intake Camshaft Sensor Bolt</td>
</tr>
<tr>
<td>712</td>
<td>Crankshaft Position Sensor</td>
</tr>
</tbody>
</table>

ENGINE IDENTIFICATION
Fig. 22: Engine Identification
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 22

<table>
<thead>
<tr>
<th>Callout</th>
<th>Component Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engine ID Location</td>
</tr>
<tr>
<td>2</td>
<td>Engine ID Location</td>
</tr>
<tr>
<td>3</td>
<td>The first digit identifies the engine build location - All first digits will be a T, this engine is only being built at Tonawanda</td>
</tr>
<tr>
<td>4</td>
<td>The second and third digits identifies the build year</td>
</tr>
<tr>
<td>5</td>
<td>The fourth, fifth and sixth digits identify the build month - Julian Date</td>
</tr>
<tr>
<td>6</td>
<td>The seventh through tenth digits identify the engine build sequence</td>
</tr>
</tbody>
</table>

SCHEMATIC AND ROUTING DIAGRAMS

TIMING CHAIN ALIGNMENT DIAGRAM
DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the Disassembled Views, Engine Component 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 in order 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 in Engine Controls before using the symptom tables (if applicable).
2. Review the system operations in order to familiarize yourself with the system functions. Refer to Disassembled Views, Engine Component Description, 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 problem. The diagnostic flow is the place to start when repairs are necessary.

Visual/Physical Inspection

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

Interruption:

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

Symptom List

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

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

**BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES**

**Base Engine Misfire without Internal Engine Noises**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormalities (severe cracking, bumps, or</td>
<td>Replace the drive belt.</td>
</tr>
</tbody>
</table>

"MY"
<table>
<thead>
<tr>
<th>Condition</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing areas in the accessory drive belt</td>
<td>Inspect the components, and repair or replace as required.</td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout and may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.</td>
<td>Repair or replace the flywheel and/or balancer as required.</td>
</tr>
<tr>
<td>Loose or improperly installed engine flywheel or crankshaft balancer</td>
<td>Repair or replace as required.</td>
</tr>
<tr>
<td>A misfire code may be present without an actual misfire condition.</td>
<td></td>
</tr>
<tr>
<td>Restricted exhaust system</td>
<td>Repair or replace as required.</td>
</tr>
<tr>
<td>A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.</td>
<td></td>
</tr>
<tr>
<td>Improperly installed or damaged vacuum hoses</td>
<td>Repair or replace as required.</td>
</tr>
<tr>
<td>Improper sealing between the intake manifold and cylinder head or throttle body.</td>
<td>Replace the intake manifold, gaskets, cylinder head, and/or throttle body as required.</td>
</tr>
<tr>
<td>Improperly installed or damaged MAP sensor</td>
<td>Repair or replace the MAP sensor as required.</td>
</tr>
<tr>
<td>The sealing grommet of the MAP sensor should not be torn or damaged.</td>
<td></td>
</tr>
<tr>
<td>Damage to the MAP sensor housing and/or O-ring seal</td>
<td>Replace the intake manifold.</td>
</tr>
<tr>
<td>Worn or loose valve rocker arms</td>
<td>Replace the valve rocker arms as required.</td>
</tr>
<tr>
<td>The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.</td>
<td></td>
</tr>
<tr>
<td>Worn valve lash adjusters</td>
<td>Replace the valve lash adjusters.</td>
</tr>
<tr>
<td>Stuck valves</td>
<td>Repair or replace as required.</td>
</tr>
<tr>
<td>Condition</td>
<td>Recommended Action</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Carbon buildup on the valve stem can cause the valve not to close properly.</td>
<td>Replace the timing chain and sprockets as required.</td>
</tr>
<tr>
<td>Excessively worn or mis-aligned timing chain</td>
<td>Replace the timing chain and sprockets as required.</td>
</tr>
<tr>
<td>Worn camshaft lobes</td>
<td>Replace the camshaft and rocker arms.</td>
</tr>
</tbody>
</table>
| Excessive oil pressure | • Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**.  
• Repair or replace the oil pump as required. |
| Faulty cylinder head gasket and/or cracking or other damage to the cylinder head and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat. | • Inspect for spark plugs saturated by coolant.  
• Inspect the cylinder head, engine block, and/or head gasket.  
• Repair or replace as required. |
| Worn Piston Rings  
Oil consumption may or may not cause the engine to misfire. | • Inspect the spark plugs for oil deposits.  
• Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**.  
• Perform cylinder leak down and compression testing to identify the cause.  
• Repair or replace as required. |
| A damaged crankshaft reluctor wheel  
A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. | Replace the sensor and/or crankshaft as required. |
| • Systems with electronic communications (DIS or coil per cylinder) and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.  
• Systems with electronic communication (DIS or coil per cylinder) and slight reluctor ring damage may exhibit no loss of crankshaft position and no |
misfire may occur. However, a P0300 DTC may be set.

- Systems with mechanical communications (high voltage switch) and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.

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

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt 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.</td>
<td>Replace the drive belt.</td>
</tr>
<tr>
<td>Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.</td>
<td>Inspect the components, repair or replace as required.</td>
</tr>
<tr>
<td>Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.</td>
<td>Repair or replace the flywheel and/or balancer as required.</td>
</tr>
</tbody>
</table>
| Worn Piston Rings Oil consumption may or may not cause the engine to misfire. | - Inspect the spark plugs for oil deposits.  
- Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**.  
- Perform cylinder leak down and compression testing to determine the cause.  
- Repair or replace as required. |
| Worn Crankshaft Thrust Bearings | Replace the crankshaft and bearings as needed. |
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.

**BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE**

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

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn or loose valve rocker arms</td>
<td>Replace the valve rocker arms as required.</td>
</tr>
<tr>
<td>The rocker arm needle bearings should be intact within the rocker arm assembly.</td>
<td></td>
</tr>
<tr>
<td>Stuck valves</td>
<td>Repair or replace as required.</td>
</tr>
<tr>
<td>Carbon buildup on the valve stem can cause the valve not to close properly.</td>
<td></td>
</tr>
<tr>
<td>Excessively worn or mis-aligned timing chain</td>
<td>Replace the timing chain and sprockets as required.</td>
</tr>
<tr>
<td>Worn camshaft lobes</td>
<td>Replace the camshaft, valve lash adjusters, and rocker arms.</td>
</tr>
<tr>
<td>Sticking valve lash adjusters</td>
<td>Replace as required.</td>
</tr>
</tbody>
</table>

**BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION**

**Base Engine Misfire with Coolant Consumption**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faulty cylinder head gasket and/or cracking or other damage to the cylinder head and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.</td>
<td>• Inspect for spark plugs saturated by coolant.  &lt;br&gt;• Perform a cylinder leak down test. &lt;br&gt;• Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket. &lt;br&gt;• Repair or replace as required.</td>
</tr>
</tbody>
</table>

**BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION**

**Base Engine Misfire with Excessive Oil Consumption**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Engine Noise on Start-Up, but Only Lasting a Few Seconds

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect oil filter without anti-drainback feature</td>
<td>Install the correct oil filter.</td>
</tr>
</tbody>
</table>
| Incorrect oil viscosity              | 1. Drain the oil.  
                                          2. Install the correct viscosity oil. |
| Worn crankshaft thrust bearing       | ● Inspect the thrust bearing and crankshaft.  
                                          ● Repair or replace as required. |
| Damaged or faulty oil filter by-pass valve | ● Inspect the oil filter by-pass valve for proper operation.  
                                          ● Repair or replace as required. |

Upper Engine Noise, Regardless of Engine Speed

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
</table>
| Low oil pressure             | ● Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing.  
                                          ● Repair or replace as required. |
| Worn or damaged valve rocker arm | ● Inspect the rocker arm for wear or missing needle bearings |
Lower Engine Noise, Regardless of Engine Speed

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper lubrication to the valve rocker arms</td>
<td>Inspect the following components, and repair or replace as required:</td>
</tr>
<tr>
<td></td>
<td>- The valve rocker arm</td>
</tr>
<tr>
<td></td>
<td>- The valve lash adjusters</td>
</tr>
<tr>
<td></td>
<td>- The oil filter bypass valve</td>
</tr>
<tr>
<td></td>
<td>- The oil transfer tube</td>
</tr>
<tr>
<td></td>
<td>- The oil pump and pump screen</td>
</tr>
<tr>
<td></td>
<td>- The engine block oil galleries</td>
</tr>
<tr>
<td>Broken valve spring</td>
<td>Replace the valve spring</td>
</tr>
<tr>
<td>Worn or dirty valve lash adjusters</td>
<td>Replace the valve lash adjusters.</td>
</tr>
<tr>
<td>Stretched or broken timing chain and/or damaged sprocket teeth</td>
<td>Replace the timing chain and sprockets.</td>
</tr>
<tr>
<td>Worn engine camshaft lobes</td>
<td>- Inspect the engine camshaft lobes.</td>
</tr>
<tr>
<td></td>
<td>- Replace the camshaft, valve lash adjusters, and rocker arms as required.</td>
</tr>
<tr>
<td>Worn valve guides or valve stems</td>
<td>Inspect the following components, and repair as required:</td>
</tr>
<tr>
<td></td>
<td>- The valves</td>
</tr>
<tr>
<td></td>
<td>- The valve guides</td>
</tr>
<tr>
<td>Stuck Valves</td>
<td>Inspect the following components, and repair as required:</td>
</tr>
<tr>
<td>Carbon on the valve stem or valve seat may cause the valve to stay</td>
<td>- The valves</td>
</tr>
<tr>
<td>open.</td>
<td>- The valve guides</td>
</tr>
</tbody>
</table>

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low oil pressure</td>
<td>- Perform an oil pressure test. Refer to <strong>Oil Pressure Diagnosis and Testing</strong>.</td>
</tr>
<tr>
<td></td>
<td>- Repair or replace damaged components</td>
</tr>
</tbody>
</table>
| Issue Description                                                                 | Action and Repair
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn accessory drive components England Abnormalities such as severe cracking,</td>
<td>• Inspect the accessory drive system.</td>
</tr>
<tr>
<td>bumps or missing areas in the accessory drive belt and/or misalignment of system</td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>components.</td>
<td></td>
</tr>
<tr>
<td>Loose or damaged crankshaft balancer</td>
<td>• Inspect the crankshaft balancer.</td>
</tr>
<tr>
<td></td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>Detonation or spark knock</td>
<td>Verify the correct operation of the ignition system. Refer to <strong>Detonation/Spark Knock</strong> in Engine Controls.</td>
</tr>
<tr>
<td>Loose torque converter bolts</td>
<td>• Inspect the torque converter bolts and flywheel.</td>
</tr>
<tr>
<td></td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>Loose or damaged flywheel</td>
<td>Repair or replace the flywheel.</td>
</tr>
<tr>
<td>Oil pump screen loose, damaged or restricted</td>
<td>• Inspect the oil pump screen.</td>
</tr>
<tr>
<td></td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>Oil transfer tube loose, damaged or restricted</td>
<td>• Inspect the transfer tube.</td>
</tr>
<tr>
<td></td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>Excessive piston-to-cylinder bore clearance</td>
<td>• Inspect the piston and cylinder bore.</td>
</tr>
<tr>
<td></td>
<td>• Repair as required.</td>
</tr>
<tr>
<td>Excessive piston pin-to-bore clearance</td>
<td>• Inspect the piston, piston pin, and the connecting rod.</td>
</tr>
<tr>
<td></td>
<td>• Repair or replace as required.</td>
</tr>
<tr>
<td>Excessive connecting rod bearing clearance</td>
<td>Inspect the following components, and repair as required:</td>
</tr>
<tr>
<td></td>
<td>• The connecting rod bearings</td>
</tr>
<tr>
<td></td>
<td>• The connecting rods</td>
</tr>
<tr>
<td></td>
<td>• The crankshaft</td>
</tr>
<tr>
<td></td>
<td>• The crankshaft journals</td>
</tr>
<tr>
<td>Excessive crankshaft bearing clearance</td>
<td>Inspect the following components, and repair as required:</td>
</tr>
<tr>
<td></td>
<td>• The crankshaft bearings</td>
</tr>
</tbody>
</table>

**2006 Hummer H3**

**2006 ENGINE Engine Mechanical - 3.5L (L52) - H3**

MY

**ENGINE NOISE UNDER LOAD**

### Engine Noise Under Load

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect piston, piston pin and connecting rod installation</td>
<td>- The crankshaft journals&lt;br&gt;- Verify the pistons, piston pins and connecting rods are installed correctly.&lt;br&gt;- Repair as required.</td>
</tr>
<tr>
<td>Low oil pressure</td>
<td>- Perform an oil pressure test. Refer to <a href="#">Oil Pressure Diagnosis and Testing</a>.&lt;br&gt;- Repair or replace as required.</td>
</tr>
<tr>
<td>Detonation or spark knock</td>
<td>- Verify the correct operation of the ignition system. Refer to <a href="#">Detonation/Spark Knock</a> in Engine Controls.</td>
</tr>
<tr>
<td>Loose torque converter bolts</td>
<td>- Inspect the torque converter bolts and flywheel.&lt;br&gt;- Repair as required.</td>
</tr>
<tr>
<td>Cracked flywheel (automatic transmission)</td>
<td>- Inspect the flywheel bolts and flywheel.&lt;br&gt;- Repair as required.</td>
</tr>
<tr>
<td>Excessive connecting rod bearing clearance</td>
<td>- Inspect the following components, and repair as required:&lt;br&gt;- The connecting rod bearings&lt;br&gt;- The connecting rods&lt;br&gt;- The crankshaft</td>
</tr>
<tr>
<td>Excessive crankshaft bearing clearance</td>
<td>- Inspect the following components, and repair as required:&lt;br&gt;- The crankshaft bearings&lt;br&gt;- The crankshaft journals&lt;br&gt;- The cylinder block crankshaft bearing</td>
</tr>
</tbody>
</table>
ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
</table>
| Seized accessory drive system component         | 1. Remove the accessory drive belt.  
2. Confirm that the engine will rotate.  
  Rotate the crankshaft by hand at the  
  crankshaft balancer or flywheel location.  
  3. Repair or replace the components as  
    required.                           |
| Seized automatic transmission torque converter  | 1. Remove the torque converter-to-  
                                    flywheel bolts.  
2. Confirm that the engine will rotate.  
  Rotate the crankshaft by hand at the  
  crankshaft balancer or flywheel location.  
  3. Repair or replace the components as  
    required.                           |
| Broken timing chain                              | • Inspect the timing chain and gears.  
                                                • Repair or replace the components as  
                                                required.          |
| Seized timing chain or timing gears              | • Inspect the timing chain and gears for  
                                                foreign material or a seized chain.  
                                                • Repair or replace the components as  
                                                required.          |
| Seized or broken camshaft                        | • Inspect the camshaft.  
                                                • Repair or replace the components as  
                                                required.          |
| Bent valve in the cylinder head                  | • Inspect the valves and the cylinder  
                                                head.  
                                                • Repair or replace the components as  
                                                required.          |
Seized oil pump

- Inspect the oil pump assembly.
- Repair or replace as required.

Hydraulically locked cylinder

- Coolant/antifreeze in the cylinder
- Oil in the cylinder
- Fuel in the cylinder

1. Remove spark plugs and check for fluid in the cylinder. When rotating the engine with the spark plugs removed, the piston (on compression stroke) will push fluid from the combustion chamber.
2. Inspect for failed/broken head gasket.
3. Inspect for a cracked engine block or cylinder head.
4. Inspect for a sticking fuel injector.
5. Repair or replace the components as required.

Material in the cylinder

- Broken valve
- Broken piston ring(s)
- Piston material
- Foreign material

- Inspect the cylinder for damaged components and/or foreign materials.
- Repair or replace the components as required.

Seized crankshaft or connecting rod bearings

- Inspect crankshaft and connecting rod bearings.
- Repair or replace the components as required.

Bent or broken connecting rod

- Inspect the connecting rods.
- Repair or replace the components as required.

Broken crankshaft

- Inspect the crankshaft.
- Repair or replace the components as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage.

- A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**.
- Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore.
- Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component.
- Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.

<table>
<thead>
<tr>
<th>Faulty cylinder head gasket</th>
<th>Replace the head gasket and components as required. Refer to <strong>Cylinder Head Cleaning and Inspection</strong> and <strong>Cylinder Head Replacement</strong>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warped cylinder head</td>
<td>Replace the cylinder head and gasket. Refer to <strong>Cylinder Head Replacement</strong>.</td>
</tr>
<tr>
<td>Cracked cylinder head</td>
<td>Replace the cylinder head and gasket.</td>
</tr>
<tr>
<td>Cracked cylinder sleeve or engine block</td>
<td>Replace the components as required.</td>
</tr>
<tr>
<td>Cylinder head or engine block porosity</td>
<td>Replace the components as required.</td>
</tr>
</tbody>
</table>

**COOLANT IN ENGINE OIL**

**Coolant in Engine Oil**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFINITION: Foamy or discolored oil or an engine oil &quot;overfill&quot; condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an &quot;overtemperature&quot; condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed.</td>
<td></td>
</tr>
<tr>
<td>Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to <strong>Lower Engine Noise, Regardless of Engine Speed</strong>.</td>
<td></td>
</tr>
<tr>
<td>Inspect by performing a <strong>Cylinder Leakage Test</strong>. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged</td>
<td></td>
</tr>
</tbody>
</table>
Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.

<table>
<thead>
<tr>
<th>Component</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faulty external engine oil cooler</td>
<td>Replace the components as required.</td>
</tr>
<tr>
<td>Faulty cylinder head gasket</td>
<td>Replace the head gasket and components as required. Refer to <strong>Cylinder Head Cleaning and Inspection</strong> and <strong>Cylinder Head Replacement</strong>.</td>
</tr>
<tr>
<td>Warped cylinder head</td>
<td>Replace the cylinder head gasket. Refer to <strong>Cylinder Head Replacement</strong>.</td>
</tr>
<tr>
<td>Cracked cylinder head</td>
<td>Replace the cylinder head and gasket.</td>
</tr>
<tr>
<td>Cracked cylinder sleeve or engine block</td>
<td>Replace the components as required.</td>
</tr>
<tr>
<td>Cylinder head, block, or manifold porosity</td>
<td>Replace the components as required.</td>
</tr>
<tr>
<td>Faulty sealing on engine front cover</td>
<td>Reseal or replace front cover.</td>
</tr>
</tbody>
</table>

**ENGINE COMPRESSION TEST**

**Tools Required**

**J 38722** Compression Tester. See **Special Tools**.

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

**IMPORTANT:** The battery must be at or near full charge. Do not block the throttle open.

1. Remove the air duct from the throttle control module.
2. Remove the ignition control modules.
3. Disable the fuel system.
4. Remove the spark plugs.
5. Measure the engine compression, using the following procedure:
   1. Firmly install J 38722 to the spark plug hole. See Special Tools.
   2. Have an assistant crank the engine through at least four compression strokes in the testing cylinder.
   3. Check and record the readings on J 38722 at each stroke. See Special Tools.
   5. Repeat the compression test for each cylinder.

6. Record the compression readings from all of the cylinders. A normal reading should be approximately 1482 kPa (215 psi).
The lowest reading should not be less than 70 percent of the highest reading.

7. The following are examples of the possible measurements:
   - When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
   - When the compression is low on the first stroke and tends to build up on the following strokes, but does not reach the normal compression, or if the compression improves considerably with the addition of three squirts of oil, the piston rings may be the cause.
   - When the compression is low on the first stroke and does not build up in the following strokes, or the addition of oil does not affect the compression, the valves may be the cause.
   - When the compression is low on two adjacent cylinders, or coolant is present in the crankcase, the head gasket may be the cause.

8. Install the air duct to the throttle body.
9. Install the spark plugs.
10. Enable the fuel system.
11. Install the ignition control modules.

**CYLINDER LEAKAGE TEST**

**Tools Required**

**J 35667-A** Cylinder Head Leakdown Tester. See **Special Tools**.
Fig. 25: Checking For Cylinder Leakage
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.
**IMPORTANT:** A leakage test may be performed 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 lash adjuster
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement in Engine Control.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.

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

5. Apply shop air pressure to J 35667-A and adjust according to the manufacturers instructions. See Special Tools.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage sounds at the throttle control module or air inlet hose may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage sounds at the exhaust system tailpipe 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 engine block or a damaged cylinder head.
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged
cylinder head gasket.

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

OIL CONSUMPTION DIAGNOSIS

Oil Consumption Diagnosis

<table>
<thead>
<tr>
<th>Checks</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive oil consumption (not due to leaks) is the use of 0.95 L (1.0 qts) or more of engine oil within 2,414 kilometers (1,500 miles).</td>
<td>The causes of excessive oil consumption may include the following conditions:</td>
</tr>
<tr>
<td>Preliminary</td>
<td></td>
</tr>
</tbody>
</table>

- External oil leaks

Refer to **Oil Leak Diagnosis**.

- Incorrect oil level or improper reading of the oil level indicator

With 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.

- Improper oil viscosity

Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.

- Continuous high speed driving and/or severe usage

- Crankcase ventilation system restrictions or malfunctioning components

- Worn valve guides and/or valve stems

- Worn or improperly installed valve stem oil seals

- Piston rings broken, worn, not seated properly

Allow adequate time for the rings to seat.

Replace worn piston rings as necessary.
OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- J 21867 Pressure Gage and Hose Assembly. See Special Tools.
- J 42907 Oil Pressure Tester. See Special Tools.

Fig. 26: Measuring Oil Pressure Using J 42907

- Piston and rings improperly installed or miss-fitted to the cylinder bore
1. With 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 gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following:
   - Oil diluted by water or glycol (anti freeze)
   - Foamy oil
6. Remove the oil filter and install the J 42907 . See Special Tools.
7. Install J 21867 or equivalent to the J 42907 . See Special Tools.
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to Engine Mechanical Specifications.
10. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
    - Oil pump worn or dirty
      Refer to Oil Pump Cleaning and Inspection.
      - Oil pump screen loose, plugged, or damaged
      - Oil pump screen O-ring seal missing or damaged
      - Malfunctioning oil pump pressure regulator valve
      - Excessive bearing clearance
      - Cracked, porous, or restricted oil galleries
      - Oil gallery plugs missing or incorrectly installed
      Refer to Engine Block Plug Installation.
      - Broken valve lash adjusters
      Repair as necessary
11. If the reading on J 21867 or equivalent is within specifications, inspect for the following:
    Refer to Special Tools.
- Plugged or incorrect oil filter and/or malfunctioning oil bypass valve
- Malfunctioning vehicle oil pressure gage or sensor

Repair as necessary

**OIL LEAK DIAGNOSIS**

**Oil Leak Diagnosis**

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong></td>
<td>Operate the vehicle until it reaches normal operating temperature.</td>
<td>Go to Step 2</td>
<td>System OK</td>
</tr>
<tr>
<td></td>
<td>Park the vehicle on a level surface, over a large sheet of paper or other clean surface.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wait 15 minutes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check for drippings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are drippings present?</td>
<td>Go to Step 2</td>
<td>System OK</td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong></td>
<td>Can you identify the type of fluid and the approximate location of the leak?</td>
<td>Go to Step 10</td>
<td>Go to Step 3</td>
</tr>
<tr>
<td></td>
<td>Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check for leaks at the following locations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Sealing surfaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Fittings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cracked or damaged components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can you identify the type of fluid and the approximate location of the leak?</td>
<td>Go to Step 10</td>
<td>Go to Step 4</td>
<td></td>
</tr>
<tr>
<td><strong>3.</strong></td>
<td>Completely clean the entire engine and surrounding components.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operate the vehicle for several kilometers (miles) at normal operating temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 4    | and at varying speeds.  
3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface.  
4. Wait 15 minutes.  
5. Identify the type of fluid, and the approximate location of the leak.  
Can you identify the type of fluid and the approximate location of the leak?  
Go to Step 10  
Go to Step 5 |
| 5    | 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.  
2. Check for leaks at the following locations:  
   - Sealing surfaces  
   - Fittings  
   - Cracked or damaged components  
Can you identify the type of fluid and the approximate location of the leak?  
Go to Step 10  
Go to Step 6 |
| 6    | 1. Completely clean the entire engine and surrounding components.  
2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area.  
3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds.  
4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.  
Can you identify the type of fluid and the approximate location of the leak?  
Go to Step 10  
Go to Step 7 |
|      | 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.  |
2. Check for leaks at the following locations:
   - Sealing surfaces
   - Fittings
   - Cracked or damaged components

Can you identify the type of fluid and the approximate location of the leak?

**Go to Step 10**  **Go to Step 8**

8. Use J 28428-E High Intensity Black Light to identify the type of fluid, and the approximate location of the leak. See **Special Tools**. Refer to the manufacturer's instructions when using the tool.

Can you identify the type of fluid and the approximate location of the leak?

**Go to Step 10**  **Go to Step 9**

9. 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.

   2. Check for leaks at the following locations:
      - Sealing surfaces
      - Fittings
      - Cracked or damaged components

Can you identify the type of fluid and the approximate location of the leak?

**Go to Step 10**  **System OK**

10. 1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas:

      - Higher than recommended fluid levels
      - Higher than recommended fluid pressures
      - Plugged or malfunctioning fluid filters or pressure bypass valves
      - Plugged or malfunctioning engine ventilation system
      - Improperly tightened or damaged fasteners
## CRANKCASE VENTILATION SYSTEM INSPECTION/DESCRIPTION

### Crankcase Ventilation (CV) System Inspection

- Cracked or porous components
- Improper sealants or gaskets where required
- Improper sealant or gasket installation
- Damaged or worn gaskets or seals
- Damaged or worn sealing surfaces

2. Inspect the engine for customer modifications.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Go to</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Repair or replace all damaged or modified components. Does the engine still leak oil?</td>
<td>Step 1</td>
<td>System OK</td>
</tr>
</tbody>
</table>

CRANKCASE VENTILATION SYSTEM INSPECTION/DESCRIPTION

Crankcase Ventilation (CV) System Inspection
Test for vacuum at the positive crankcase ventilation (PCV) dirty air hose (2) where it connects to the vacuum orifice tube (5) in the camshaft cover. There should be manifold vacuum present at the hose (2). If there is no vacuum, inspect for a plugged hose, leaking hose or a plugged intake manifold passage.

If oil has accumulated in the air cleaner resonator (1), inspect for the following conditions:
o Plugged vacuum orifice tube (5) in the camshaft cover
o Plugged, restricted, or leaking PCV dirty air hose (2)
o Plugged or restricted intake manifold passage (3)
o Excessive crankcase pressure or blow-by, refer to Engine Compression Test

- Additional items to inspect:
  o Plugged or restricted vacuum tube (4) in the camshaft cover
  o Plugged or restricted PCV fresh air hose (6)
o Plugged or restricted passage in the air cleaner resonator (1)
o Inspect the cam cover, the oil pan, engine front cover, and other sealing areas for leaks

Results of Incorrect Operation

A plugged crankcase ventilation system may contribute to the following conditions:

- A rough idle
- Stalling or a slow idle speed
- Oil leaks
- Oil accumulation in the air cleaner resonator (1)
- Sludge in the engine

A leaking hose may contribute to the following conditions:

- A rough idle
- Stalling
- Unstable idle speed

The crankcase ventilation system has no serviceable components so no maintenance of the system is required.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt(s) or the pulleys. It may be necessary to spray a small amount of water on the drive belt(s) in order to duplicate the customers concern. If spraying water on the drive belt(s) duplicates the symptom, cleaning the belt pulleys may be the probable solution.
A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the chirping noise.

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

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

3: The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt(s) the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

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

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

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

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

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

Drive Belt Chirping Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFINITION: The following items are indications of chirping:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A high pitched noise that is heard once per revolution of the drive belt or a pulley.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• It usually occurs on cold damp mornings and will subside once vehicle reached normal operating temp.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Refer to Belt Dressing Notice in Cautions and Notices.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Go to</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you review the Drive Belt Symptom operation and perform the necessary inspections?</td>
<td>Step 2</td>
<td>Symptoms - Engine Mechanical</td>
</tr>
<tr>
<td>2</td>
<td>Verify that there is a chirping noise. Does the engine make the chirping noise?</td>
<td>Step 3</td>
<td>Diagnostic Aids</td>
</tr>
</tbody>
</table>
| 3    | 1. Remove the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.  
2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist? | Step 4 | Engine Noise on Start-Up, but Only Lasting a Few Seconds Go to Step 5 Go to Step 6 |
| 4    | Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling? | Step 5 | Go to Step 6 |
| 5    | Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair? | Step 15 | Go to Step 6 |
| 6    | Inspect for misalignment of the pulleys. Are any of the pulleys misaligned? | Step 7 | Go to Step 8 |
| 7    | Replace or repair any misaligned pulleys. Did you complete the repair? | Step 15 | Go to Step 8 |
| 8    | Inspect for bent or cracked brackets. Did you find any bent or cracked brackets? | Step 9 | Go to Step 10 |
| 9    | Replace any bent or cracked brackets. Did you complete the repair? | Step 15 | Go to Step 10 |
| 10   | Inspect for improper, loose or missing fasteners. Did you find the condition? | Step 11 | Go to Step 12 |
| 11   | Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to **Fastener Tightening Specifications**. Did you complete the repair? | Step 15 | Go to Step 12 |
| 12   | Inspect for a bent pulley. Did you find the condition? | Step 13 | Go to Step 14 |
| 13   | Replace the bent pulley. Did you complete the repair? | Step 15 | Go to Step 14 |
DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

A loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause the squeal noise.

If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.

Test Description

The numbers below refer to the step number(s) on the diagnostic table.

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

3: The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the squeal noise is the drive belts or an accessory drive component. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4: This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

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

6: This test is to verify that the drive belts is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

14 | Replace the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C) Did you complete the repair? | Go to Step 15 | Go to Diagnostic Aids
---|---|---|---
15 | Operate the system in order to verify the repair. Did you correct the condition? | System OK | Go to Step 3

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

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

### Drive Belt Squeal Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOTE:</strong></td>
<td>Refer to <a href="#">Belt Dressing Notice</a> in Cautions and Notices.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DEFINITION:</strong> The following items are indications of drive belt squeal:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A loud screeching noise that is caused by a slipping drive belt (this is unusual for a drive belt with multiple ribs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Did you review the Drive Belt Symptom operation and perform the necessary inspections?</td>
<td>Go to Step 2</td>
<td>Go to Symptoms - Engine Mechanical</td>
</tr>
<tr>
<td>2</td>
<td>Verify that there is a squeal noise. Does the engine make the squeal noise?</td>
<td>Go to Step 3</td>
<td>Go to Diagnostic Aids</td>
</tr>
</tbody>
</table>
| 3 | 1. Remove the drive belt(s). Refer to [Drive Belt Replacement (Without A/C)](#) or [Drive Belt Replacement (With A/C)](#).  
|   | 2. Operate the engine for no longer than 30 to 40 seconds. | Go to Engine Noise on Start-Up, but Only Lasting a Few Seconds | Go to Step 4 |
|   | Does the noise still exist? |   |    |
| 4 | Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? | Go to Step 9 | Go to Step 5 |
| 5 | Test the drive belt tensioner for proper operation. Refer to [Drive Belt Tensioner Diagnosis](#). |   |    |
### Diagnostic Aids

The drive belt(s) 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 generator failing.

### Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

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

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt(s) 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 proper inspection and replacement procedure.

### Drive Belt Whine Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Corrected Condition</th>
<th>Go To Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Inspect for the correct drive belt length. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C). Did you find and correct the condition?</td>
<td>Go to Step 9</td>
<td>Go to Step 6</td>
</tr>
<tr>
<td>7</td>
<td>Inspect for misalignment of a pulley. Did you find and correct the condition?</td>
<td>Go to Step 9</td>
<td>Go to Step 7</td>
</tr>
<tr>
<td>8</td>
<td>Inspect for the correct pulley size. Did you find and correct the condition?</td>
<td>Go to Step 9</td>
<td>Go to Drive Belt Idler Pulley Replacement</td>
</tr>
<tr>
<td>9</td>
<td>Operate the system in order to verify the repair. Did you correct the condition?</td>
<td>System OK</td>
<td>Go to Step 3</td>
</tr>
</tbody>
</table>
### DRIVE BELT RUMBLING DIAGNOSIS

#### Diagnostic Aids

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

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
| **NOTE:**  
Refer to **Belt Dressing Notice** in Cautions and Notices. | | | |
| DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing. | | | |
| 1 | Did you review the Drive Belt Symptom operation and perform the necessary inspections? | Go to Step 2 | Go to Symptoms - Engine Mechanical |
| 2 | Verify that there is a whine noise. Does the engine make the whine noise? | Go to Step 3 | Go to Diagnostic Aids |
| 3 | 1. Remove the drive belt(s). Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.  
2. Operate the engine for no longer than 30 to 40 seconds.  
Does the whine noise still exist? | Go to Step 3 | Go to Engine Noise on Start-Up, but Only Lasting a Few Seconds |
| 4 | Inspect for a failed accessory drive component bearing. Did you find and repair the condition? | Go to Step 5 | Go to Diagnostic Aids |
| 5 | Operate the system in order to verify the repair. Did you correct the condition? | System OK | - |
Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

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

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

4: Inspecting the drive belt(s) is to ensure that it is not causing a the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

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

Drive Belt Rumbling Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOTE:</strong> Refer to Belt Dressing Notice in Cautions and Notices.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DEFINITION:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A low pitch tapping, knocking, or thumping noise heard at or just above idle.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Heard once per revolution of the drive belt or a pulley.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Rumbling may be caused from:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o The separation of the drive belt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o A damaged drive belt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Did you review the Drive Belt Symptom operation and perform the necessary inspections?</td>
<td>Go to Step 2</td>
<td>Go to Symptoms - Engine Mechanical</td>
</tr>
<tr>
<td>2</td>
<td>Verify that there is a rumbling noise. Does the engine make the rumbling noise?</td>
<td>Go to Step 3</td>
<td>Go to Diagnostic Aids</td>
</tr>
</tbody>
</table>
### DRIVE BELT VIBRATION DIAGNOSIS

**Diagnostic Aids**

The accessory drive components can have an affect on engine vibration. Such as but not limited to the A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

**Test Description**

The number(s) below refer to the step number(s) on the diagnostic table.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
</table>
| 3 | 1. Remove the drive belt(s). Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).  
2. Operate the engine for no longer than 30 to 40 seconds.  
Does the rumbling noise still exist? | Go to Engine Noise on Start-Up, but Only Lasting a Few Seconds  
Go to Step 4 |
| 4 | Inspect the drive belt(s) for damage, separation, or sections of missing ribs.  
Did you find any of these conditions? | Go to Step 7  
Go to Step 5 |
| 5 | Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves.  
Did you find severe pilling? | Go to Step 6  
Go to Step 7 |
| 6 | 1. Clean the drive belt pulleys using a suitable wire brush.  
2. Reinstall the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).  
Did you complete the repair? | Go to Step 8  
Go to Step 7 |
| 7 | Install a new drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).  
Did you complete the replacement? | Go to Step 8  
- |
| 8 | Operate the system in order to verify the repair.  
Did you correct the condition? | System OK  
Go to Diagnostic Aids |
2: This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.
3: This test is to verify that the drive belt(s) or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
4: The drive belt(s) may cause a vibration. While the drive belt(s) is removed this is the best time to inspect the condition of the belt.
6: Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
8: This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.
9: This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known good water pump.
10: Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOTE:</strong> Refer to Belt Dressing Notice in Cautions and Notices.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

1. Did you review the Drive Belt Symptom operation and perform the necessary inspections?  
   Go to **Step 2**

2. Verify that the vibration is engine related. Does the engine make the vibration?  
   Go to **Step 3**

1. Remove the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.  
   Go to **Diagnostic Starting Point**

Go to **Symptoms - Engine Mechanical**
Go to **Diagnostic Aids**
### DRIVING BELT FALLS OFF DIAGNOSIS

**Diagnostic Aids**

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?</td>
</tr>
<tr>
<td>4</td>
<td>Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions? Go to Step 4</td>
</tr>
<tr>
<td>5</td>
<td>Install a new drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C). Did you complete the replacement? Go to Step 5 Go to Step 6</td>
</tr>
<tr>
<td>6</td>
<td>Inspect for improper, loose or missing fasteners. Did you find any of these conditions? Go to Step 6 Go to Step 7</td>
</tr>
<tr>
<td>7</td>
<td>1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to Fastener Tightening Specifications. Did you complete the repair? Go to Step 7 Go to Step 8</td>
</tr>
<tr>
<td>8</td>
<td>Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to Fan Replacement. Did you find and correct the condition? Go to Step 8 Go to Step 9</td>
</tr>
<tr>
<td>9</td>
<td>Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to Water Pump Replacement. Did you find and correct the condition? Go to Step 9 Go to Step 10</td>
</tr>
<tr>
<td>10</td>
<td>Inspect for bent or cracked brackets. Did you find and correct the condition? Go to Step 10 Go to Diagnostic Aids</td>
</tr>
<tr>
<td>11</td>
<td>Operate the system in order to verify the repair. Did you correct the condition? System OK Go to Step 3</td>
</tr>
</tbody>
</table>
An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

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

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

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

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

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

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

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

Drive Belt Falls Off Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did you review the Drive Belt Symptom operation and perform the necessary inspections?</td>
<td>Go to Symptoms - Engine</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Refer to Belt Dressing Notice in Cautions and Notices.

DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.
DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

Excessive wear on a drive belt(s) is usually caused by an incorrect installation or the wrong drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).
belt for the application.

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

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

Test Description

The number(s) below refer to the step number(s) on the diagnostic table.

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

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

4: This inspection is to verify the drive belt(s) 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(s) should not come in contact with an engine or a body component when snapping the throttle.

### Drive Belt Excessive Wear Diagnosis

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOTE:</strong></td>
<td>Refer to Belt Dressing Notice in Cautions and Notices.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEFINITION:</td>
<td>Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Did you review the Drive Belt Symptom operation and perform the necessary inspections?</td>
<td>Go to Step 2</td>
<td>Go to Symptoms - Engine Mechanical</td>
</tr>
<tr>
<td>2</td>
<td>Inspect the drive belt(s) for the proper installation. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C). Did you find this condition?</td>
<td>Go to Step 5</td>
<td>Go to Step 3</td>
</tr>
<tr>
<td>3</td>
<td>Inspect for the proper drive belt.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### DRIVE BELT TENSIONER DIAGNOSIS

**Inspection Procedure**

**NOTE:** Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

1. Remove the drive belts. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the drive belt tensioner through it's full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
4. If any binding is observed, replace the tensioner. Refer to Drive Belt Tensioner Replacement.
5. Install the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).

### CAMSHAFT POSITION (CMP) ACTUATOR DIAGNOSIS

For overall description of the camshaft position actuator refer to Exhaust Camshaft Position Actuator Description.

The camshaft position actuator will only phase 25-cam degrees retard (counterclockwise). Full advance (clockwise) is 0 degrees.

---

<table>
<thead>
<tr>
<th>Step</th>
<th>Condition</th>
<th>Go to</th>
<th>Go to</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?</td>
<td>Step 5</td>
<td>Step 4</td>
</tr>
<tr>
<td>5</td>
<td>Replace the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C). Did you complete the replacement?</td>
<td>Step 6</td>
<td>Diagnostic Aids</td>
</tr>
<tr>
<td>6</td>
<td>Operate the system in order to verify the repair. Did you correct the condition?</td>
<td>System OK</td>
<td>-</td>
</tr>
</tbody>
</table>

---
The camshaft position actuator should always be serviced/replaced in the full advanced position (full clockwise or 0 degrees). New replacement (service) camshaft position actuators are shipped at full advance or 0 degrees. To be sure the camshaft position actuator is performing properly, perform the following to help in the diagnostics.

The camshaft position actuator must be removed from the engine to perform the proper diagnostic test.

Fig. 28: Camshaft Position (CMP) Actuator
Courtesy of GENERAL MOTORS CORP.
1. Clamp the camshaft actuator in a vice. Use care not to damage the contact area of the sprocket.

Fig. 29: Scribe or draw a line
Courtesy of GENERAL MOTORS CORP.

2. Scribe or draw a line (1) on the camshaft position actuator outer ring face, in the full advanced position. With the engine at TDC on #1 cylinder, the wording should be level.
Fig. 30: Wording Should Be Level
Courtesy of GENERAL MOTORS CORP.

3. Apply compressed air pressure to the oil port (1) on the back side of the actuator to unlock the locking pin.
4. Turn the actuator, by hand, to the full counterclockwise position.
5. Scribe or draw a line (2) on the camshaft position actuator at that position.
Fig. 31: Scribe or draw a 2nd line  
Courtesy of GENERAL MOTORS CORP.

6. Measure the distance between the two lines. The measurement (3) should be 14-15 mm (0.55-0.59 in).

**IMPORTANT:** It is normal for oil to leak out of the camshaft actuator when compressed air is applied. It is also normal for oil bubbles to form on the camshaft sprocket itself.
The camshaft position actuator must be replaced if it does not unlock when air pressure is applied, does not lock when air pressure is removed, or does not move within the 14-15 mm (0.55-0.59 in).

**REPAIR INSTRUCTIONS**

**DRIVE BELT REPLACEMENT (WITHOUT A/C)**

Removal Procedure
1. Install a 3/8 inch breaker bar into the drive belt tensioner (5).
2. Rotate the tensioner (7) clockwise, in order to relieve the tension on the drive belt (1).
3. Slide the drive belt (1) off of the water pump pulley (3).
4. Rotate the drive belt tensioner (7) counterclockwise, allowing the tensioner to return to the relaxed position.
5. Remove the drive belt (1) from the remaining pulleys.

Fig. 33: View Of Drive Belt & Pulleys (No A/C)
Courtesy of GENERAL MOTORS CORP.

Installation Procedure
Fig. 34: View Of Drive Belt & Pulleys (No A/C)
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt (1) over all the pulleys, except for the water pump pulley (3).
2. Install the 3/8 inch breaker bar into the drive belt tensioner (5).
3. Rotate the tensioner (5) clockwise.
4. Install the drive belt (1) over the top of the water pump pulley (3).
5. Slowly release the tension on the drive belt tensioner (5).

**IMPORTANT:** Ensure the drive belt is properly aligned and seated into the grooves of the drive pulleys.
6. Inspect for proper installation of the drive belt (1) on the pulleys.

DRIVE BELT REPLACEMENT (WITH A/C)

Removal Procedure

![Diagram of drive belt and pulleys with labels 1 to 8]

**Fig. 35: View Of Drive Belt & Pulleys (With A/C)**

*Courtesy of GENERAL MOTORS CORP.*

1. Install a 3/8 inch breaker bar into the drive belt tensioner (7).
2. Rotate the tensioner (7) clockwise, in order to relieve the tension on the drive belt (1).
3. Slide the drive belt (1) off of the water pump pulley (2).
4. Rotate the drive belt tensioner (7) counterclockwise, allowing the tensioner to return to the
5. Remove the drive belt (1) from the remaining pulleys.

Installation Procedure

**Fig. 36: View Of Drive Belt & Pulleys (With A/C)**
*Courtesy of GENERAL MOTORS CORP.*

1. Install the drive belt (1) over all the pulleys, except for the water pump pulley (2).
2. Install the 3/8 inch breaker bar into the drive belt tensioner (7).
3. Rotate the tensioner (7) clockwise.
4. Install the drive belt (1) over the top of the water pump pulley (2).
5. Slowly release the tension on the drive belt tensioner (7).
IMPORTANT: Ensure the drive belt is properly aligned and seated into the grooves of the drive pulleys.

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

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

Fig. 37: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.
1. Remove the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.
2. Using a wrench, loosen and remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.

**Installation Procedure**

![Diagram of drive belt tensioner]

**Fig. 38: View Of Drive Belt Tensioner**
**Courtesy of GENERAL MOTORS CORP.**

1. Position the drive belt tensioner. Ensure the alignment tab is in the proper location.
NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolt.

   **Tighten:** Tighten the bolt to 50 N.m (37 lb ft).

3. Inspect the drive belt. Replace the drive belt if necessary.

4. Install the drive belt Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).

**DRIVE BELT IDLER PULLEY REPLACEMENT**

Removal Procedure

![Diagram of drive belt system with numbered components: 1, 2, 3]
1. Remove the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).
2. Remove the drive belt idler pulley bolts.
3. Remove drive belt idler pulley.

Installation Procedure
1. Position drive belt idler pulley to the engine.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt idler pulley bolts.

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

3. Install the drive belt. Refer to Drive Belt Replacement (Without A/C) or Drive Belt Replacement (With A/C).

**ENGINE MOUNT INSPECTION**

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

1. Measure the engine movement at the engine mount in order to inspect for damage to the rubber portions of the mount.
   1. Apply the park brake.
   2. Start the engine.
   3. Firmly apply and hold the primary brakes.
   4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
   5. Slightly load the engine shifting from drive to reverse a few times.
   6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, inspect for loose engine mount bolts.

2. If the engine mount bolt torque is within specifications, inspect the condition of the engine mount.

3. Replace the engine mount if any of the following conditions exist:
- Heat check cracks cover the rubber cushion surface.
- The rubber cushion is separated from the metal plate of the mount.
- There is a split through the rubber cushion.

ENGINE MOUNT REPLACEMENT - LEFT

Removal Procedure

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the wheel and tire assembly. Refer to **Tire and Wheel Removal and Installation** in Wheels and Tires.
3. Remove the engine shield, if equipped. Refer to **Engine Shield Replacement** in Frame and Underbody
4. Remove the lower intermediate steering shaft. Refer to **Intermediate Steering Shaft Replacement - Lower** in Steering Wheel and Column.
5. Support the engine using a jack stand and a block of wood.
6. Remove the left engine mount-to-frame bracket through bolt.
Fig. 41: Left Engine Mount-To-Frame Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

7. Loosen the right side through bolt.
8. Remove the heater pipe bracket bolt from the engine mount. Refer to Heater Hose Replacement - Outlet in Heating, Ventilation, and Air Conditioning.
9. Raise the engine using the jack stand; the engine will tilt to one side.
10. Remove the engine mount bolts.

Fig. 42: Engine Mount
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine mount. You will need to articulate the mount in order to remove the mount.

Installation Procedure

1. Install the engine mount. You will need to articulate the mount in order to install the mount.
2. Install the engine mount bolts until snug, following the installation sequence.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Tighten the bolts.

   **Tighten:** Tighten the bolts to 50 N.m (37 lb ft).

   Lower the engine.
4. Install the left engine mount-to-frame bracket through bolt.

**Tighten:** Tighten both of the engine mount-to-frame bracket bolts to 85 N.m (63 lb ft).

5. Install the engine coolant pipe bracket bolt from the engine mount. Refer to **Heater Hose**
Replacement - Outlet in Heating, Ventilation, and Air Conditioning.

6. Remove the jack stand.

7. Install the lower intermediate steering shaft. Refer to Intermediate Steering Shaft Replacement - Lower in Steering Wheel and Column.

8. Install the engine shield, if equipped. Refer to Engine Shield Replacement in Frame and Underbody.

9. Install the wheel and tire assembly. Refer to Tire and Wheel Removal and Installation in Wheels and Tires.

10. Lower the vehicle.

ENGINE MOUNT REPLACEMENT - RIGHT

Removal Procedure

1. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.

2. Remove the tire and wheel assembly. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.

3. Remove the engine shield, if equipped. Refer to Engine Shield Replacement in Frame and Underbody.

4. Support the engine using a jack stand and a block of wood.
Fig. 45: Right Engine Mount-To-Frame Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the right engine mount-to-frame bracket through bolt.
6. Loosen the left side through bolt.
7. Raise the engine using the jack stand. The engine will tilt to one side.
8. Remove the engine mount bolts.
9. Remove the engine mount. You will need to articulate the mount in order to remove the mount.

Installation Procedure

1. Install the engine mount. You will need to articulate the mount in order to install the mount.
Fig. 47: Engine Mount
Courtesy of GENERAL MOTORS CORP.

2. Install the engine mount bolts until snug, following the installation sequence.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Tighten the bolts.

   **Tighten:** Tighten the bolts to 50 N.m (37 lb ft).

4. Lower the engine.
5. Install the right engine mount-to-frame bracket through bolt.

**Tighten:** Tighten both of the engine mount-to-frame bracket bolts to 85 N.m (63 lb ft).
6. Remove the jack stand.
7. Install the engine shield, if equipped. Refer to **Engine Shield Replacement** in Frame and Underbody.
8. Install the tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
9. Lower the vehicle.

ENGINE LIFT BRACKET REPLACEMENT

Removal Procedure

Fig. 49: View Of Engine Lift Bracket, A/C Compressor Hose/Pipe Bracket & Bolt, & Wiring Harness Conduit
Courtesy of GENERAL MOTORS CORP.
1. Remove the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.

2. Remove the bolt (3) securing the A/C compressor hose/pipe bracket (2) to the engine lift bracket (1).

3. Carefully disengage the engine wiring harness conduit from the engine lift bracket (1).

4. Remove the 3 generator bolts and reposition the generator.

---

**Fig. 50: View Of Generator Mounting Bolts**

*Courtesy of GENERAL MOTORS CORP.*

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Fig. 51: Removing Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine lift bracket bolts.
6. Remove the engine lift bracket.

Installation Procedure
Fig. 52: Installing Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the engine lift bracket.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the engine lift bracket bolts.

   **Tighten:**
   1. Tighten the bolts a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the bolts a final pass in sequence to 50 N.m (37 lb ft).

![Diagram of generator mounting bolts](image)

**Fig. 53: View Of Generator Mounting Bolts**
*Courtesy of GENERAL MOTORS CORP.*

3. Position the generator to the engine.
4. Install the 3 generator bolts.

**Tighten:** Tighten the bolts in sequence to 50 N.m (37 lb ft).
5. Engage the engine wiring harness conduit to the engine lift bracket (1).

6. Install the bolt (3) securing the A/C compressor hose/pipe bracket (2) to the engine lift bracket (1).

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

7. Install the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.

**CRANKCASE VENTILATION HOSES/PIPES REPLACEMENT**
Removal Procedure

1. Remove the air cleaner resonator and outlet duct. Refer to Air Cleaner Resonator and Outlet Duct Replacement in Engine Controls - 3.5L (L52).

2. Disconnect the positive crankcase ventilation (PCV) fresh air tube (6) from the air cleaner.

Fig. 55: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the positive crankcase ventilation (PCV) fresh air tube (6) from the air cleaner.
3. Disconnect the PCV dirty air tube (2) from the following:
   - The camshaft cover (5)
   - The intake manifold (3)

Installation Procedure

Fig. 56: View Of Crankcase Ventilation System
1. Connect the PCV fresh air tube (6) to the air cleaner resonator (1).
2. Connect the PCV dirty air tube (2) to the following:
   - The camshaft cover (5)
   - The intake manifold (3)
3. Install the air cleaner resonator and outlet duct. Refer to Air Cleaner Resonator and Outlet Duct Replacement in Engine Controls - 3.5L (L52).

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove the throttle body. Refer to Throttle Body Assembly Replacement in Engine Controls - 3.5L (L52).
2. Remove the battery box. Refer to Battery Box Replacement in Engine Electrical.
3. Remove the oil level indicator and tube. Refer to Oil Level Indicator and Tube Replacement.
4. Disconnect the brake booster hose (6) from the brake booster.
5. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (3).
6. Disconnect the MAP sensor wiring harness retainer (4) from the intake manifold (5).
7. Disconnect the positive crankcase ventilation (PCV) dirty air tube (2) from the camshaft cover.
8. Remove the generator. Refer to Generator Replacement in Engine Electrical.
Fig. 58: Engine Wiring Harness Retainer At Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine wiring harness retainer from the engine wiring harness bracket.
Fig. 59: View Of Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

10. Remove the 2 upper bolts securing the engine wiring harness bracket to the intake manifold.
11. Raise and support the vehicle only high enough to access the remaining components through the wheelhouse. Refer to Lifting and Jacking the Vehicle in General Information.
12. Remove the left front wheel. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
13. Remove the left front wheelhouse liner. Refer to Wheelhouse Panel Replacement in Body Front End.
14. Disconnect the following wiring harness retainers from the engine wiring harness bracket:
   - The battery cable
   - The engine (4, 6)
   - The MAP sensor (5)
15. Remove the remaining lower engine wiring harness bracket bolt. Remove the bracket from the engine compartment through the wheelhouse opening.
Fig. 62: View Of Intake Manifold  
Courtesy of GENERAL MOTORS CORP.

16. Remove the intake manifold bolts.
17. Lower the vehicle.
18. Remove the intake manifold from the cylinder head.
19. Remove and discard the seal from the intake manifold.
20. Mask off the open ports to the cylinder head, in order to prevent foreign objects from entering the engine.
21. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

1. Remove the masking from the cylinder head and ensure the sealing surface is clean and dry.
2. Install a NEW seal into the intake manifold groove.

3. Position the intake manifold to the cylinder head.

4. Raise and support the vehicle only high enough to access the following components through the wheelhouse. Refer to Lifting and Jacking the Vehicle in General Information:
   - The intake manifold bolts
   - The engine wiring harness bracket bolts
   - The wiring harnesses

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

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

6. Position the engine wiring harness bracket to the engine and harnesses.
7. Install the engine wiring harness bracket bolts.

Tighten: Tighten the bolts to 10 N.m (89 lb in).
8. Secure the following wiring harness retainers to the engine wiring harness bracket:
   - The battery cable
   - The engine (4, 6)
   - The MAP sensor (5)

9. Install the left front wheelhouse liner. Refer to **Wheelhouse Panel Replacement** in Body Front End.

10. Install the left front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires
and Wheels.

11. Lower the vehicle.

![Engine Wiring Harness Retainer At Engine Wiring Harness Bracket](image)

Fig. 66: Engine Wiring Harness Retainer At Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

12. Connect the engine wiring harness retainer to the engine wiring harness bracket.

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

Removal Procedure

Fig. 68: View Of ECT Sensor, Fuel Injector, Ignition Coil & HO2S Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to Intake Manifold Replacement.
2. Remove the ignition coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.5L (L52).

3. Disconnect the following electrical connectors from the camshaft cover:
   - The engine coolant temperature (ECT) sensor (1)
   - The fuel injector (2)
   - The heated oxygen sensor (HO2S) (5)

4. Remove the fuel pressure regulator screw, in order to gain clearance to remove the camshaft cover.

---

**Fig. 69: View Of Camshaft Cover**

*Courtesy of GENERAL MOTORS CORP.*
5. Remove the camshaft cover bolts.
6. Remove the camshaft cover from the cylinder head.
7. Remove and discard the seals from the camshaft cover.
8. Clean and inspect the cylinder head sealing surface.
9. Clean and inspect the camshaft cover. Refer to Camshaft Cover Cleaning and Inspection.

Installation Procedure

Fig. 70: View Of Camshaft Cover (Valve Cover)  
Courtesy of GENERAL MOTORS CORP.
1. Install a NEW camshaft cover seal into the camshaft cover groove.
2. Install NEW ignition control module seals into the camshaft cover grooves.
3. Position the camshaft cover to the cylinder head.

   **NOTE:** Refer to **Fastener Notice** in Cautions and Notices.

4. Install the camshaft cover bolts.
   
   **Tighten:** Tighten the bolts to 10 N.m (89 lb in).

5. Install the fuel pressure regulator screw.
   
   **Tighten:** Tighten the screw to 8 N.m (71 lb in).
6. Connect the following electrical connectors to the camshaft cover:
   - The ECT sensor (1)
   - The fuel injector (2)
   - The HO2S (5)

7. Install the ignition coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.5L (L52).
8. Install the intake manifold. Refer to Intake Manifold Replacement.

VALVE ROCKE R ARM AND VALVE LASH ADJUSTER REPLACEMENT

Removal Procedure

1. Remove the camshafts. Refer to Camshaft Replacement.

---

**Fig. 72: View Of Valve Rocker Arms**

*Courtesy of GENERAL MOTORS CORP.*

**IMPORTANT:** Once removed, place the valve rocker arms and valve lash adjusters in an organized order so the components can be installed into the original locations.

2. Remove the valve rocker arms.
3. Remove the valve lash adjusters.
4. Clean and inspect the valve rocker arms and valve lash adjusters. Refer to Valve Rocker Arm and Valve Lash Adjuster Cleaning and Inspection.

Installation Procedure
1. Lubricate and fill the valve lash adjusters with engine oil.
2. Install the valve lash adjusters in their original locations.
3. Lubricate the entire valve rocker arm.
4. Install the valve rocker arms in their original locations.
5. Install the camshafts. Refer to Camshaft Replacement.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

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

Removal Procedure

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

Fig. 76: View Of Service Slot Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the service slot plug.
3. Install the **EN 46547** (1) into the flywheel teeth. See Special Tools.
4. Lower the vehicle.
5. Remove the valve rocker arms. Refer to Valve Rocker Arm and Valve Lash Adjuster Replacement.
6. Remove the spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.5L.
(L52).

Fig. 78: View Of J 44228 Base Plate
Courtesy of GENERAL MOTORS CORP.

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

**CAUTION:** Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not
11. Tighten the swivel nut of the **J 44228** down only enough to allow access for removal of the valve locks. See [Special Tools](#).

---

**Fig. 79: View Of Valve Keys**  
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve locks. A magnet is the most suitable tool for this activity.

13. Loosen the swivel nut of the **J 44228** and swing the arm away from the valve spring retainer. See [Special Tools](#).
Fig. 80: View Of Valve Springs & Retainers
Courtesy of GENERAL MOTORS CORP.

14. Remove the valve spring retainer and valve spring.
15. Use the J 38820 in order to grip the seal. See Special Tools. Remove the seal by exerting a twisting, pulling motion.

Discard the old valve stem seal.

16. Inspect and measure the valve spring. Refer to Cylinder Head Cleaning and Inspection.

Fig. 81: Removing Valve Stem Seals
Courtesy of GENERAL MOTORS CORP.
1. Lubricate the valve stem and inner diameter of the new seal with clean engine oil.

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

2. Using a twisting, pushing motion install the NEW valve stem seal using the J 38820. See Special Tools.
3. Install the valve spring and valve spring retainer.
4. Swing the arm over the valve spring retainer and tighten the swivel nut of the J 44228 down only enough to allow access for installation of the valve locks. See Special Tools.

5. Position the valve locks to the valve stem retainer groove using the J 43059. See Special Tools.

6. Remove the swivel nut and arm of the J 44228. See Special Tools.

7. Install the arm and swivel nut of the J 44228 over the stud of any other valves being serviced for this cylinder and repeat removal steps 11 through 16 and installation steps 1 through 7. See Special Tools.

8. Relieve the air pressure to the cylinder being serviced.

9. Remove the J 39313 from the spark plug hole. See Special Tools.

10. Remove the base plate of the J 44228. See Special Tools.

11. Repeat removal steps 7 through 16 and installation steps 1 through 10 on any other cylinders.
being serviced.

12. Install the spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.5L (L52).

13. Install the valve rocker arms. Refer to Valve Rocker Arm and Valve Lash Adjuster Replacement.

14. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
15. Remove the EN 46547 (1) from the flywheel teeth. See Special Tools.

16. Install the service slot plug.

17. Lower the vehicle.

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure
Fig. 87: View Of Fuel Hoses & Retainers
Courtesy of GENERAL MOTORS CORP.

1. Disengage the fuel lines from the retainers at the oil level indicator bracket and intake manifold.
2. Remove the oil level indicator from the tube.
3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube from the engine oil pan.
Installation Procedure

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

Fig. 89: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lightly lubricate the O-ring seal with clean engine oil.
2. Install the oil level indicator tube into the engine oil pan.
NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil level indicator tube bolt.

   **Tighten:** Tighten the bolt to 10 N.m (89 lb in).

4. Install the oil level indicator into the tube.

5. Insert the fuel lines into the retainers at the oil level indicator bracket and intake manifold.
CYLINDER HEAD REPLACEMENT

NOTE: General Motors has developed a procedure for removing the cylinder head without the removal of the front cover. The new procedure can be done in vehicle with the aid of a new special service tool. See INFORMATION ON NEW IN-VEHICLE SERVICE PROCEDURE FOR REMOVAL/INSTALLATION OF LK5 OR L52 CYLINDER HEAD.

Tools Required

J 45059 Angle Meter. See Special Tools.

Removal Procedure

1. Remove the exhaust manifold. Refer to Exhaust Manifold Replacement in Engine Exhaust.
2. Remove the timing chain and sprockets. Refer to Timing Chain and Sprockets Replacement.
3. Remove and discard the cylinder head bolts.
Fig. 92: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Remove the cylinder head.
5. Place the cylinder head on a flat, clean surface with the combustion chambers face up, in order to prevent damage to the deck face.
6. Remove and discard the cylinder head gasket.
7. Remove all remaining gasket material from the engine block.
8. Inspect the cylinder head gasket mating surface on the engine block.
9. Clean and inspect the cylinder head. Refer to Cylinder Head Cleaning and Inspection.
10. Disassemble the cylinder head, if necessary. Refer to Cylinder Head Disassemble.

Installation Procedure
IMPORTANT: Ensure number 1 cylinder is at top dead center.

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

2. Install the dowel pins, cylinder head locator, if necessary.

3. Position a NEW cylinder head gasket onto the engine block.

Fig. 94: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the dowel pins, cylinder head locator, if necessary.
3. Position a NEW cylinder head gasket onto the engine block.
Fig. 95: View Of Cylinder Head  
Courtesy of GENERAL MOTORS CORP.

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

4. Install the cylinder head.
5. Install NEW cylinder head bolts.

**NOTE:** This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.
6. Tighten the NEW cylinder head bolts in the following sequence:

**Tighten:**

1. Tighten the bolts (1-12) a first pass in sequence to 30 N.m (22 lb ft). Using the J 45059 rotate the bolts (1-12) a final pass in sequence an additional 155 degrees. See Special Tools.

---

**NOTE:** Refer to Fastener Notice in Cautions and Notices.
2. Tighten the (2 Short) bolts (14-15) a first pass to 7 N.m (62 lb in). Using the \textbf{J 45059} rotate the bolts (14-15) a final pass an additional 60 degrees. See \textit{Special Tools}.

3. Tighten the (1 Long) bolt (13) a first pass to 7 N.m (62 lb in). Using the \textbf{J 45059} rotate the bolt (13) a final pass an additional 120 degrees. See \textit{Special Tools}.

7. Install the timing chain and sprockets. Refer to \textit{Timing Chain and Sprockets Replacement}.

8. Install the exhaust manifold. Refer to \textit{Exhaust Manifold Replacement} in Engine Exhaust.

\section*{CRANKSHAFT BALANCER REPLACEMENT}

\subsection*{Tools Required}

- \textbf{EN 46547} Flywheel Holding Tool. See \textit{Special Tools}.
- \textbf{J 41478} Crankshaft Balancer Installer. See \textit{Special Tools}.
- \textbf{J 41816-2} Crankshaft End Protector. See \textit{Special Tools}.
- \textbf{J 45059} Angle Meter. See \textit{Special Tools}.

\subsection*{Removal Procedure}

1. Remove the drive belt. Refer to \textit{Drive Belt Replacement (Without A/C)} or \textit{Drive Belt Replacement (With A/C)}.

2. Raise and support the vehicle. Refer to \textit{Lifting and Jacking the Vehicle} in General Information.
Fig. 98: View Of Service Slot Plug  
Courtesy of GENERAL MOTORS CORP.

3. Remove the service slot plug.
Fig. 99: Identifying EN 46547
Courtesy of GENERAL MOTORS CORP.

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

4. Install the EN 46547 (1) into the flywheel teeth. See Special Tools.
5. Lower the vehicle.

Fig. 100: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the crankshaft balancer bolt.
7. Install the J 41816-2 into the end of the crankshaft. See Special Tools.

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

8. Using a 3 jaw puller, remove the crankshaft balancer.
10. Remove the crankshaft balancer friction washer.

   This will be located at the end of the crankshaft balancer or on the crankshaft.

11. Clean and inspect the crankshaft balancer. Refer to Crankshaft Balancer Cleaning and Inspection.
Installation Procedure

1. Install the crankshaft balancer friction washer to the end of the crankshaft balancer.

2. Install the crankshaft balancer using the J 41478. See Special Tools.

3. Remove the J 41478. See Special Tools.
4. Install the crankshaft balancer washer and a NEW bolt.

**Tighten:** Tighten the bolt a first pass to 150 N.m (111 lb ft). Using the J 45059 rotate the bolt a final pass an additional 180 degrees. See Special Tools.

5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

---

**Fig. 103:** View Of Crankshaft Balancer Bolt  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.
6. Remove the **EN 46547 (1)** from the flywheel teeth. See **Special Tools**.
7. Install the service slot plug.
8. Lower the vehicle.
9. Install the drive belt. Refer to **Drive Belt Replacement (Without A/C)** or **Drive Belt Replacement (With A/C)**.

**CRANKSHAFT FRONT OIL SEAL REPLACEMENT**

**Tools Required**

**J 45951** Front Seal Installer. See **Special Tools**.
Removal Procedure

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

Fig. 106: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

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

Discard the seal.
Installation Procedure

Fig. 107: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Apply the engine oil to the outside diameter of the crankshaft front oil seal.
2. Use the J 45951 to install the NEW crankshaft front oil seal. See Special Tools.
3. Remove the J 45951. See Special Tools.
4. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.

ENGINE FRONT COVER REPLACEMENT
Tools Required

**J 44219** Cover Alignment Pins. See **Special Tools**.

Removal Procedure

1. Remove the water pump. Refer to **Water Pump Replacement** in Engine Cooling.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
4. Remove the power steering pump. Refer to **Power Steering Pump Replacement** in Power Steering.
5. Remove the oil pump pipe and screen assembly. Refer to **Oil Pump Pipe and Screen Assembly Replacement**.
6. Lower the vehicle.
Fig. 109: View Of 7 mm Center Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the 7 mm center bolt (1).
8. Remove the remaining engine front cover bolts.
9. Install 2 bolts into the threaded holes to act as jack screws and tighten evenly in order to separate the engine front cover from the engine block.
10. Remove the engine front cover.
11. Remove the 2 bolts from the jack screw holes.
12. Remove the oil pump if necessary. Refer to **Oil Pump Replacement**.
13. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

14. Clean and inspect the engine block sealing surface.

**Installation Procedure**

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

![Diagram of Installing J 44219 Into Engine Block](image)

**Fig. 110: Installing J 44219 Into Engine Block**

Courtesy of GENERAL MOTORS CORP.

2. To aid in alignment of the front cover, thread the J 44219 into the engine block. See **Special Tools**.
Fig. 111: Applying Sealant To Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

3. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the engine front cover (1).
4. Align the oil pump to the crankshaft sprocket splines.
5. Install the engine front cover over the J 44219, and to the engine block. See Special Tools.
6. Install the engine front cover bolts.
7. Remove the J 44219 from the engine block. See Special Tools.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

8. Install the 2 remaining engine front cover bolts.
Tighten:
1. Tighten the bolts to 10 N.m (89 lb in).
2. Tighten the small center bolt (1) last to 8 N.m (71 lb in).

9. Install the oil pump pipe and screen assembly. Refer to **Oil Pump Pipe and Screen Assembly Replacement**.

10. Install the power steering pump. Refer to **Power Steering Pump Replacement** in Power Steering System.

11. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.

12. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

13. Install the water pump. Refer to **Water Pump Replacement** in Engine Cooling.

**CAMSHAFT POSITION ACTUATOR REPLACEMENT - EXHAUST**

**Tools Required**

- **EN-44217-45** Chain Holding Tool. See Special Tools.
- **J 44217** Timing Chain Retention Tool. See Special Tools.
- **J 44221** Camshaft Holding Tool. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.

**Removal Procedure**

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

2. Ensure the exhaust camshaft position (CMP) actuator is functioning properly. Refer to **Camshaft Position (CMP) Actuator Diagnosis**.

3. Remove the exhaust CMP sensor. Refer to **Camshaft Position (CMP) Sensor Replacement-Exhaust** in Engine Controls - 3.5L (L52).

4. Remove the intake CMP sensor. Refer to **Camshaft Position (CMP) Sensor Replacement-Intake** in Engine Controls - 3.5L (L52).
5. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.

6. Using the timing mark on the exhaust camshaft position actuator sprocket as a reference,
make a mark on the timing chain link adjacent to it.

Fig. 114: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

7. Install the J 44221 to the rear of the camshafts. See Special Tools.
Fig. 115: Installing 44217 & EN-44217-45 To Timing Chains  
Courtesy of GENERAL MOTORS CORP.

8. Complete the following in order to install the J **44217** (1) and the EN-**44217-45** (1). See Special Tools.

   1. Install the hook portion of the timing chain retention tools into one of the timing chain links near the timing chain shoe on both sides of the engine.
   2. Tighten the wingnuts.
   3. Ensure the hooks are still in one of the links and the gage blocks of the tool are firmly
in place on the edge of the head.

Fig. 116: View Of Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the exhaust camshaft position actuator bolt.
10. Remove the exhaust camshaft position actuator.
11. Clean and inspect the sprocket. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.
1. Ensure the camshaft actuator is fully advanced prior to installation.

Fig. 117: Aligning Exhaust Camshaft Position Actuator  
Courtesy of GENERAL MOTORS CORP.

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

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

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

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

3. Install the exhaust camshaft actuator onto the exhaust camshaft.
4. Install a NEW exhaust camshaft actuator bolt.

**Tighten:** Tighten the bolt a first pass to 25 N.m (18 lb ft). Using the J 45059 rotate the bolt a final pass an additional 135 degrees. See **Special Tools**.
5. Remove the J 44217 (1) and the EN-44217-45 (1). See Special Tools.
6. Remove the J 44221 from the camshafts. See Special Tools.

7. Install the CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Intake in Engine Controls - 3.5L (L52).

8. Install the exhaust CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Exhaust in Engine Controls - 3.5L (L52).

9. Install the camshaft cover. Refer to Camshaft Cover Replacement.

INTAKE CAMSHAFT SPROCKET REPLACEMENT

Tools Required
• **EN-44217-45** Chain Holding Tool. See **Special Tools**.
• **J 44217** Timing Chain Retention Tool. See **Special Tools**.
• **J 44221** Camshaft Holding Tool. See **Special Tools**.
• **J 45059** Angle Meter. See **Special Tools**.

**Removal Procedure**

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the intake camshaft position (CMP) sensor. Refer to **Camshaft Position (CMP) Sensor Replacement-Intake** in Engine Controls - 3.5L (L52).
Fig. 121: View Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.

4. Using the timing mark on the intake camshaft sprocket as a reference, make a mark on the
timing chain link adjacent to it.

Fig. 122: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

5. Install the J 44221 to the rear of the camshafts. See Special Tools.
Fig. 123: Installing 44217 & EN-44217-45 To Timing Chains
Courtesy of GENERAL MOTORS CORP.

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

Fig. 124: View Of Intake Camshaft Sprocket Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the intake camshaft sprocket bolt.
8. Remove the intake camshaft sprocket.
9. Clean and inspect the sprocket. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.
Installation Procedure

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

Fig. 125: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.

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

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

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

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Install a NEW intake camshaft sprocket bolt.

**Tighten:** Tighten the bolt a first pass to 20 N.m (15 lb ft). Using the J 45059 rotate the bolt a final pass an additional 100 degrees. See Special Tools.
Fig. 126: Installing 44217 & EN-44217-45 To Timing Chains
Courtesy of GENERAL MOTORS CORP.

4. Remove the J 44217 (1) and the EN-44217-45 (1). See Special Tools.
5. Remove the **J 44221** from the camshafts. See **Special Tools**.

6. Install the intake CMP sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Intake** in Engine Controls - 3.5L (L52).

7. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

**TIMING CHAIN AND SPROCKETS REPLACEMENT**

**Tools Required**

- **J 44221** Camshaft Holding Tool. See **Special Tools**.
• J 45059 Angle Meter. See Special Tools.

Removal Procedure

1. Remove #1 cylinder spark plug. Refer to Spark Plug Replacement in Engine Controls - 3.5L (L52).
2. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
3. Remove the exhaust camshaft position (CMP) sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Exhaust in Engine Controls - 3.5L (L52).
4. Remove the intake CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Intake in Engine Controls - 3.5L (L52).
5. Remove the engine front cover. Refer to Engine Front Cover Replacement.
Fig. 128: View Of CMP Actuator  
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.
Fig. 129: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

7. Install the J 44221 to the rear of the camshafts. See Special Tools.
8. Release the tension on the timing chain by moving the tensioner shoe in.

Fig. 130: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS CORP.
Fig. 131: View Of Tee At Timing Chain Tensioner  
Courtesy of GENERAL MOTORS CORP.

9. Place the tee into the tensioner to hold the shoe in place.
10. Remove and discard the exhaust camshaft position actuator bolt.

11. Remove the exhaust camshaft position actuator.
12. Remove and discard the intake camshaft sprocket bolt.
13. Remove the intake camshaft sprocket.
14. Remove the timing chain.
15. Remove the crankshaft sprocket.
16. Clean and inspect the timing chain and sprockets. Refer to Timing Chain and Sprockets Cleaning and Inspection.

Installation Procedure
Fig. 134: Installing Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

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

1. Install the crankshaft sprocket to the crankshaft snout.

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

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

3. Feed the timing chain down through the opening in the cylinder head.
4. Install the timing chain on the crankshaft sprocket.

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

**IMPORTANT: Ensure the alignment pin is properly engaged with the camshaft**

5. Install the intake camshaft sprocket onto the intake camshaft.
Fig. 135: View Of Intake Camshaft Sprocket Washer & Bolt  
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install a NEW intake camshaft sprocket bolt.

**Tighten:** Tighten the bolt a first pass to 20 N.m (15 lb ft). Using the J 45059 rotate the bolt a final pass an additional 100 degrees. See Special Tools.
7. Ensure the camshaft actuator is fully advanced prior to installation.

Fig. 136: Aligning Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

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

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

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

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

9. Install the exhaust camshaft actuator onto the exhaust camshaft.
Fig. 137: View Of CMP Actuator  
Courtesy of GENERAL MOTORS CORP.

10. Install a NEW exhaust camshaft actuator bolt.

**Tighten:** Tighten the bolt a first pass to 25 N.m (18 lb ft). Using the J 45059 rotate the bolt a final pass an additional 135 degrees. See **Special Tools**.
Fig. 138: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

11. Remove the tee in the timing chain tensioner in order to regain tension on the timing chain.
12. Remove the J 44221 from the camshafts. See Special Tools.
Fig. 140: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.

13. The dark links (1) on the timing chain should be aligned with the marks on the sprockets as shown.
14. Install the engine front cover. Refer to Engine Front Cover Replacement.
15. Install the intake CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Intake in Engine Controls - 3.5L (L52).
16. Install the exhaust CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Exhaust in Engine Controls - 3.5L (L52).
17. Install the camshaft cover. Refer to Camshaft Cover Replacement.
18. Install #1 cylinder spark plug. Refer to Spark Plug Replacement in Engine Controls - 3.5L (L52).

TIMING CHAIN TENSIONER REPLACEMENT

Tools Required

J 44221 Camshaft Holding Tool. See Special Tools.

Removal Procedure

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

   The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.
4. Install the **J 44221** to the rear of the camshafts. See **Special Tools**.
Fig. 143: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.

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

Fig. 144: Releasing Tension On Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Release the tension on the timing chain by moving the tensioner shoe in.
7. Place the tee into the tensioner to hold the shoe in place.

Fig. 145: View Of Tee At Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.
8. Remove the timing chain tensioner bolts.
9. Remove the timing chain tensioner from the engine.

Installation Procedure
Fig. 147: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the timing chain tensioner to the engine.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the timing chain tensioner bolts.

   **Tighten:** Tighten the bolts to 25 N.m (18 lb ft).
Fig. 148: View Of Tee At Timing Chain Tensioner
      Courtesy of GENERAL MOTORS CORP.

3. Remove the tee in the timing chain tensioner in order to regain tension on the timing chain.
Fig. 149: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

4. Remove the J 44221 from the camshafts. See Special Tools.
Fig. 150: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Every 7th link of the timing chain is darkened to aid in aligning the timing marks.
5. Align the marked links (1) on the timing chain with the timing marks on the following:
   - The exhaust camshaft position actuator sprocket
   - The Intake camshaft sprocket
   - The crankshaft sprocket
6. Install the engine front cover. Refer to Engine Front Cover Replacement.
7. Install the camshaft cover. Refer to Camshaft Cover Replacement.

TIMING CHAIN TENSIONER SHOE REPLACEMENT

Tools Required

J 44221 Camshaft Holding Tool. See Special Tools.

Removal Procedure

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

The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.
Fig. 152: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the J 44221 to the rear of the camshafts. See Special Tools.
5. Using the timing marks on the following as a reference, make a mark on the timing chain links (1) adjacent to them:

Fig. 153: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.
6. Release the tension on the timing chain by moving the tensioner shoe in.
7. Place the tee into the tensioner to hold the shoe in place.
8. Remove the cylinder head access hole plug.

Fig. 156: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.
9. Remove the timing chain tensioner shoe bolt.
10. Remove the timing chain tensioner shoe from the engine.

Installation Procedure
Fig. 158: View Of Timing Chain Tensioner Shoe & Bolt
Courtesy of GENERAL MOTORS CORP.

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

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the timing chain tensioner shoe bolt.

   **Tighten:** Tighten the bolt to 25 N.m (18 lb ft).
3. Install the cylinder head access hole plug.

**Tighten:** Tighten the plug to 5 N.m (44 lb in).
4. Remove the tee in the timing chain tensioner in order to regain tension on the timing chain.
Fig. 161: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Remove the J 44221 from the camshafts. See Special Tools.
Fig. 162: View Of Timing Chain Marked Links
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Every 7th link of the timing chain is darkened to aid in aligning the timing marks.
6. Align the marked links (1) of the timing chain with the timing marks on the following:
   - The exhaust camshaft position actuator sprocket
   - The Intake camshaft sprocket
   - The crankshaft sprocket
7. Install the engine front cover. Refer to Engine Front Cover Replacement.
8. Install the camshaft cover. Refer to Camshaft Cover Replacement.

TIMING CHAIN GUIDE REPLACEMENT-UPPER

Removal Procedure

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
Fig. 163: View Of Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper timing chain guide bolts.
3. Remove the upper timing chain guide from the cylinder head.

Installation Procedure
1. Position the upper timing chain guide to the cylinder head.
2. Apply threadlock GM P/N 12345498 (Canadian P/N 10953488) to the upper timing chain guide bolt threads.

**NOTE:** Refer to *Fastener Notice* in Cautions and Notices.

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

4. Install the camshaft cover. Refer to Camshaft Cover Replacement.

TIMING CHAIN GUIDE REPLACEMENT-LOWER

Removal Procedure

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

Fig. 165: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.
Fig. 166: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the lower timing chain guide bolts.

   **Tighten:** Tighten the bolts to 18 N.m (13 lb ft).
3. Install the cylinder head access hole plug.

**Tighten:** Tighten the plug to 5 N.m (44 lb in).

4. Install the crankshaft sprocket to the crankshaft sprocket snout.

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

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

CAMSHAFT REPLACEMENT

Tools Required

- **J 44221** Camshaft Holding Tool. See Special Tools.
- **J 44222** Camshaft Sprocket Holding Tool. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.

Removal Procedure

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement.
2. Remove the exhaust camshaft position (CMP) sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Exhaust in Engine Controls - 3.5L (L52).
3. Remove the intake CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Intake in Engine Controls - 3.5L (L52).
4. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the compression stroke.

The word Delphi on the exhaust camshaft position actuator will be parallel with the cylinder head to cam cover mating surface.

Fig. 169: View Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.
5. Install the J 44221 to the rear of the camshafts. See Special Tools.
6. Remove and discard the intake and the exhaust camshaft sprocket bolts.
7. Install the **J 44222** onto the cylinder head and adjust the horizontal bolts into the camshaft sprockets in order to maintain chain tension and keep from disturbing the timing chain components. See *Special Tools*.

8. Carefully slide the sprockets with the timing chain from the camshafts to the **J 44222**. See *Special Tools*.
9. Alternately loosen the camshaft cap bolts a few turns at a time until all valve spring pressure has been released.

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

10. Remove the camshaft caps.
11. Remove the J 44221 from the camshafts. See Special Tools.
12. Remove the camshafts from the cylinder head.
13. Clean and inspect the camshafts. Refer to **Camshafts Cleaning and Inspection**.

**Installation Procedure**

1. Coat the camshaft journals, camshaft journal thrust face, and camshaft lobes with clean engine oil.
Fig. 174: Installing J 44221 To Camshafts
Courtesy of GENERAL MOTORS CORP.

2. Install the J 44221 with the camshaft flats up and the #1 piston at TDC. See Special Tools.
3. Install the intake and exhaust camshafts to their original positions.
4. Observe the markings on the camshaft caps. Each camshaft cap is marked in order to identify its location. The markings have the following meanings:

- The arrow should point to the front of the engine
- The number indicates the position from the front of the engine
- The "E" indicates the exhaust camshaft.
- The "I" indicates the intake camshaft.
5. Install the camshaft caps according to the identification marks.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

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

**Tighten:** Tighten the bolts to 12 N.m (106 lb in).
Fig. 177: View Of J 44222 Installed Onto Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

7. Carefully slide the sprockets with the timing chain from the J 44222 to the camshafts. See Special Tools.
8. Remove the J 44222 from the cylinder head. See Special Tools.
9. Install the new intake camshaft sprocket bolt.
10. Install the new exhaust camshaft actuator bolt.

**Tighten:**

1. Tighten the intake camshaft sprocket bolt a first pass to 20 N.m (15 lb ft). Using the J45059 rotate the bolt a final pass an additional 100 degrees. See Special Tools.
2. Tighten the exhaust camshaft sprocket bolt a first pass to 25 N.m (18 lb ft). Using the J45059 rotate the bolt a final pass an additional 135 degrees. See Special Tools.

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**Fig. 178: View Of J 44221 Installed On Camshafts**

Courtesy of GENERAL MOTORS CORP.

11. Remove the J 44221 from the camshafts. See Special Tools.
12. Install the intake CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Intake in Engine Controls - 3.5L (L52).
13. Install the exhaust CMP sensor. Refer to Camshaft Position (CMP) Sensor Replacement-Exhaust in Engine Controls - 3.5L (L52).
14. Install the camshaft cover. Refer to Camshaft Cover Replacement.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

1. Remove the oil filter. Refer to Engine Oil and Oil Filter Replacement.
2. Remove the oil filter adapter from the engine block.
Fig. 179: Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

Installation Procedure
Fig. 180: Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.
1. Install the oil filter adapter into the engine block.

   **Tighten:** Tighten the adapter to 50 N.m (37 lb ft).

2. Install the oil filter. Refer to [Engine Oil and Oil Filter Replacement](#).

**OIL FILTER BYPASS VALVE REPLACEMENT**

**Removal Procedure**
1. Remove the oil filter. Refer to Engine Oil and Oil Filter Replacement.
2. Using a suitable tool, pry the oil filter bypass valve from the engine block. Discard the oil filter bypass valve.

Installation Procedure
Fig. 182: Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Press the NEW oil filter bypass valve into the engine block.
2. Install the oil filter. Refer to Engine Oil and Oil Filter Replacement.

OIL PAN REPLACEMENT

Removal Procedure
1. Remove the oil level indicator and tube. Refer to **Oil Level Indicator and Tube Replacement**.

2. Remove the oil pan skid plate. Refer to **Oil Pan Skid Plate Replacement** in Frame and Underbody.

3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

4. Remove the crossmember. Refer to **Crossmember Replacement** in Frame and Underbody.

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**Fig. 183: View Of Mounting Bracket To Frame Bolts**

Courtesy of GENERAL MOTORS CORP.
5. Remove the differential carrier assembly bushing to frame bolts ONLY.
6. Pull the differential carrier assembly downward.
7. Secure the pinion yoke, in order to prevent the differential carrier from rotating.

Fig. 184: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the service slot plug.
9. Remove the nuts securing the fuel hose/pipe bracket to the transmission, and position aside.
10. Remove 4 lower transmission mounting bolts that are attached to the oil pan.
11. Remove the power steering gear. Refer to **Power Steering Gear Replacement** in Power Steering System.

12. Pull the power steering gear downward in order to gain access to the oil pan.

13. Disconnect the engine wiring harness retainers from the oil pan.

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**Fig. 185: Oil Pan Mounting**

*Courtesy of GENERAL MOTORS CORP.*
14. Remove the oil pan bolts.
15. Install 2 bolts in the threaded holes at the rear of the oil pan to act as jack screws and tighten evenly to release the oil pan from the engine block.
16. Remove the oil pan.
17. Remove the 2 bolts from the jack screw holes.
18. Clean and inspect the oil pan. Refer to **Oil Pan Cleaning and Inspection**.
19. Clean and inspect the engine block sealing surface.

**Installation Procedure**

**Fig. 186: View Of Oil Pan Sealant Application**
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The oil pan must be installed within 10 minutes from when
1. Apply a 5.5 mm (0.22 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the oil pan in the areas marked (1).

2. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the oil pan in the area marked (2).
IMPORTANT: Use care not to allow the sealer to contact the oil pump pipe and screen assembly.

3. Position the oil pan to the engine block.
4. Ensure the oil pan is positioned fully rearward against the transmission mounting surface.
5. Install the oil pan bolts.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

Tighten the oil pan bolts.

**Tighten:**
- Tighten the (side) bolts to 25 N.m (18 lb ft).
- Tighten the (end) bolts to 10 N.m (89 lb in).

6. Connect the engine wiring harness retainers to the oil pan.
7. Position the power steering gear upward to the frame assembly.
8. Install the power steering gear. Refer to **Power Steering Gear Replacement** in Power Steering System.
Fig. 188: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the 4 lower transmission mounting bolts.

**Tighten:** Tighten the bolts to 50 N.m (37 lb ft).

10. Install the nuts securing the fuel hose/pipe bracket to the transmission.

**Tighten:** Tighten the nuts to 20 N.m (15 lb ft).
11. Install the service slot plug.

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

12. Position the differential carrier assembly to the frame.
13. Install the differential carrier assembly bushing to frame bolts.

**Tighten:** Tighten the bolts to 152 N.m (112 lb ft).
14. Install the crossmember. Refer to Crossmember Replacement in Frame and Underbody.
15. Install the oil pan skid plate. Refer to Oil Pan Skid Plate Replacement in Frame and Underbody.
16. Install the oil level indicator and tube. Refer to Oil Level Indicator and Tube Replacement.
17. Fill the engine oil. Refer to Engine Oil and Oil Filter Replacement.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Disconnect the oil pressure switch electrical connector (1).
3. Remove the engine oil pressure switch.

Installation Procedure
Fig. 192: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Refer to Component Fastener Tightening Notice in Cautions and Notices.

1. Install the engine oil pressure switch.

   **Tighten:** Tighten the switch to 20 N.m (15 lb ft).
Fig. 193: View Of Oil Pressure Switch Engine Wiring Harness Electrical Connector Courtesy of GENERAL MOTORS CORP.

2. Connect the oil pressure switch electrical connector (1).
3. Lower the vehicle.

OIL PUMP PIPE AND SCREEN ASSEMBLY REPLACEMENT

Removal Procedure
1. Remove the oil pan. Refer to Oil Pan Replacement.
2. Remove the oil pump pipe screen brace bolts.
3. Remove the oil pump pipe screen bolt.
4. Remove the oil pump pipe screen from the engine.
5. Remove and discard the oil pump pipe seal.
6. Clean and inspect the oil pump pipe screen.
Fig. 195: Oil Pump Pipe and Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil pump pipe seal onto the oil pump pipe screen assembly.
2. Install the oil pump pipe screen to the engine.
3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the oil pump pipe bolt threads.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump pipe screen assembly bolts.

   **Tighten:** Tighten the bolts to 10 N.m (89 lb in).

5. Install the oil pan. Refer to **Oil Pan Replacement**.

**OIL PUMP REPLACEMENT**
Removal Procedure

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

![Exploded View Of Oil Pump](image)

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

2. Remove the oil pump cover bolts.
3. Remove the oil pump cover.
4. Mark the inner and the outer gears in relation to the oil pump housing.
5. Remove the inner and the outer oil pump gears.
6. Remove the oil pump pressure relief valve plug.
7. Remove the oil pump pressure relief valve and the spring.
8. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

**Installation Procedure**

![Exploded View Of Oil Pump](https://example.com/fig197)

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

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

**NOTE:** Refer to **Component Fastener Tightening Notice** in Cautions and Notices.
2. Install the oil pump pressure relief valve plug.

   **Tighten:** Tighten the plug to 14 N.m (124 lb in).

3. Install the oil pump outer and inner gears as removed.
4. Install the oil pump cover.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pump cover bolts.

   **Tighten:** Tighten the bolts to 10 N.m (89 lb in).

6. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

CRANKSHAFT REAR OIL SEAL AND HOUSING REPLACEMENT

**Tools Required**

- J 8092 Driver Handle
- J 44215 Rear Seal Installer. See **Special Tools**.

**Removal Procedure**
1. Remove the flywheel. Refer to Engine Flywheel Replacement (w/Automatic Transmission) or Engine Flywheel Replacement (w/Manual Transmission).

2. Remove the 2 bolts securing the oil pan to the crankshaft rear oil seal housing.

3. Remove the crankshaft rear oil seal housing bolts.

4. Install 2 bolts into the threaded holes to act as jack screws and tighten evenly to separate the crankshaft rear oil seal housing from the engine block and oil pan.

5. Remove the crankshaft rear oil seal housing.

6. Remove the 2 bolts from the jack screw holes.
7. Using a hammer and a punch, remove and discard the crankshaft rear oil seal.
8. Clean and inspect the crankshaft rear oil seal housing.
9. Clean and inspect the engine block and oil pan sealing surface.

**IMPORTANT**: Do not damage the seal bore.
Fig. 200: View Of Crankshaft Rear Oil Seal Housing Sealant Application
Courtesy of GENERAL MOTORS CORP.

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

1. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) (1) or equivalent, to the following:
   - The crankshaft rear oil seal housing, were the housing meets the engine block
   - The surface of the crankshaft rear oil seal housing, were the housing meets the oil pan
   - The surface of the oil pan, were the oil pan meets the housing
2. Complete the following to install the crankshaft rear oil seal housing:
   1. Align the housing with the right alignment dowel, tilting the left side up slightly.
   2. Align the housing with the left alignment dowel.
   3. Press the housing against the engine block into place.
3. Install the crankshaft rear oil seal housing bolts.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

4. Install the 2 oil pan bolts.
Tighten:

- Tighten the crankshaft rear oil seal housing bolts to 10 N.m (89 lb in).
- Tighten the (end) oil pan bolts to 10 N.m (89 lb in).

5. Lightly lubricate the crankshaft rear oil seal lip with clean engine oil.

6. Position the plastic installation sleeve supplied with the new seal to the crankshaft.

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

7. Using the J 44215 with the J 8092 and a hammer, install the crankshaft rear oil seal into the crankshaft rear oil seal housing.
The spring side of the seal goes toward the engine.

- Ensure the seal is installed square.
- The seal will bottom out in the housing when fully installed.

8. Install the flywheel. Refer to Engine Flywheel Replacement (w/Automatic Transmission) or Engine Flywheel Replacement (w/Manual Transmission).

BALANCE SHAFT CHAIN TENSIONER REPLACEMENT

Removal Procedure

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

IMPORTANT: Every 11 crankshaft rotations, 3 of the 5 dark links on the timing chain will line up with the timing marks.
3. Remove the balance shaft chain tensioner bolts.
4. Remove the balance shaft chain tensioner.

Installation Procedure

1. Collapse the balance shaft chain tensioner using the following procedure:
   1. Rotate the ratchet release lever (2) clockwise and hold.
   2. Collapse the tensioner shoe (1) and hold.
   3. Release the ratchet lever.

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

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

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

3. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.
Fig. 207: View Of Balance Shaft Chain Tensioner  
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure the tensioner release lever is facing outward.

4. Install the balance shaft chain tensioner and bolts.

Tighten: Tighten the bolts to 10 N.m (89 lb in).

5. Remove the pin holding the tensioner to tighten any slack in the balance shaft drive chain.
6. Verify the correct timing chain and timing mark alignments:
   - The left hand balance shaft sprocket timing mark (1) is at the 12:00 position.
   - The right hand balance shaft sprocket timing mark (2) is at the 2:30 position.
   - The crankshaft sprocket timing mark (3) is at the 4:30 position.
   - The 3 timing marks (1-3) on the sprockets line up with a dark link on the chain.

7. Install the crankshaft rear oil seal housing. Refer to **Crankshaft Rear Oil Seal and Housing Replacement**.

**Fig. 208: View Of Sprocket Timing Marks**
*Courtesy of GENERAL MOTORS CORP.*
1. Remove the balance shaft chain tensioner. Refer to **Balance Shaft Chain Tensioner Replacement**.

![Fig. 209: View Of Balance Shaft Drive Chain](Clipart_General_Motors_Corp.png)

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

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

**Installation Procedure**
Fig. 210: View Of Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Ensure the darkened links are facing outward.

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

3. Install the balance shaft chain tensioner. Refer to **Balance Shaft Chain Tensioner Replacement**.

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

**BALANCE SHAFT REPLACEMENT-LEFT**

**Removal Procedure**

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

![Fig. 212: View Of Balance Shafts](image)

*Fig. 212: View Of Balance Shafts*
*Courtesy of GENERAL MOTORS CORP.*

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

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

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

**NOTE:** Refer to **Fastener Notice** in Cautions and Notices.

3. Install a NEW balance shaft bolt.

   **Tighten:** Tighten the bolt to 12 N.m (106 lb in).

4. Install the balance shaft drive chain. Refer to **Balance Shaft Drive Chain Replacement**.

**BALANCE SHAFT REPLACEMENT-RIGHT**
Removal Procedure

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

![Fig. 214: View Of Balance Shafts](https://example.com/fig214.jpg)

**Fig. 214: View Of Balance Shafts**

*Courtesy of GENERAL MOTORS CORP.*

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

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

Installation Procedure
Fig. 215: View Of Balance Shafts  
Courtesy of GENERAL MOTORS CORP.

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

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Install the NEW balance shaft bolts.

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

4. Install the balance shaft drive chain. Refer to Balance Shaft Drive Chain Replacement.

**BALANCE SHAFT CHAIN GUIDE REPLACEMENT**
Removal Procedure

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

![Fig. 216: View Of Balance Shaft Chain Guide](image)

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

2. Remove the balance shaft chain guide bolts.
3. Remove the balance shaft chain guide.

Installation Procedure
1. Install the balance shaft chain guide.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the balance shaft chain guide bolts.

   **Tighten:** Tighten the bolts to 10 N.m (89 lb in).

3. Install the balance shaft drive chain. Refer to Balance Shaft Drive Chain Replacement.
CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

- J 8092 Driver Handle
- J 44215 Rear Seal Installer. See Special Tools.

Removal Procedure

1. Remove the flywheel. Refer to Engine Flywheel Replacement (w/Automatic Transmission) or Engine Flywheel Replacement (w/Manual Transmission).

Fig. 218: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the crankshaft or seal bore.
2. Using a suitable tool, pry the crankshaft rear oil seal out from the crankshaft rear oil seal housing. Discard the seal.

**Installation Procedure**

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

![Fig. 219: Installing Crankshaft Rear Oil Seal](image)

**Fig. 219: Installing Crankshaft Rear Oil Seal**

*Courtesy of GENERAL MOTORS CORP.*

3. Using the **J 44215** with the **J 8092** and a hammer, install the crankshaft rear oil seal into the crankshaft rear oil seal housing.
The spring side of the seal goes toward the engine.
- Ensure the seal is installed square.
- The seal will bottom out in the housing when fully installed.

4. Install the flywheel. Refer to Engine Flywheel Replacement (w/Automatic Transmission) or Engine Flywheel Replacement (w/Manual Transmission).

ENGINE FLYWHEEL REPLACEMENT (W/AUTOMATIC TRANSMISSION)

Tools Required

J 45059 Angle Meter. See Special Tools.

Removal Procedure

1. Remove the transmission. Refer to Transmission Replacement in Automatic Transmission - 4L60-E/4L65-E.
Fig. 220: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

2. Remove and discard the flywheel bolts.
3. Remove the flywheel.
4. Clean and inspect the flywheel. Refer to Engine Flywheel Cleaning and Inspection (Automatic Transmission) or Engine Flywheel Cleaning and Inspection (Manual Transmission).

Installation Procedure
1. Position the flywheel to the crankshaft

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the NEW flywheel bolts.

**Tighten:** Tighten the bolts a first pass to 25 N.m (18 lb ft). Using the J 45059 rotate the bolts a final pass an additional 50 degrees. See Special Tools.
3. Install the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4L60-E/4L65-E.

**ENGINE FLYWHEEL REPLACEMENT (W/MANUAL TRANSMISSION)**

**Tools Required**

**J 45059** Angle Meter. See **Special Tools**.

**Removal Procedure**

1. Remove the clutch assembly. Refer to **Clutch Assembly Replacement** in Clutch.
Fig. 222: View Of Engine Flywheel - Manual Transmission
Courtesy of GENERAL MOTORS CORP.

2. Remove and discard the flywheel bolts.
3. Remove the flywheel.
4. Clean and inspect the flywheel. Refer to Engine Flywheel Cleaning and Inspection (Automatic Transmission) or Engine Flywheel Cleaning and Inspection (Manual Transmission).

Installation Procedure
1. Position the flywheel to the crankshaft.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the NEW flywheel bolts.

   **Tighten:** Tighten the bolts a first pass to 25 N.m (18 lb ft). Using the J 45059 rotate the bolts a final pass an additional 50 degrees. See Special Tools.

3. Install the clutch assembly. Refer to Clutch Assembly Replacement in Clutch.

**ENGINE REPLACEMENT**

**Tools Required**

- J 38185 Hose Clamp Pliers. See Special Tools.

**Removal Procedure**

1. Remove the hood. Refer to Hood Replacement.
2. Remove the battery box. Refer to Battery Box Replacement.
3. Drain the engine coolant. Refer to Draining and Filling Cooling System.
4. Remove the outlet radiator hose. Radiator Hose Replacement - Outlet.
5. Remove the cooling fan. Refer to Fan Replacement.
6. Remove the air cleaner assembly. Refer to Air Cleaner Assembly Replacement in Engine Controls - 3.5L (L52).
7. Remove the air cleaner resonator and outlet duct. Refer to Air Cleaner Resonator and Outlet Duct Replacement in Engine Controls - 3.5L (L52).
8. Remove the generator. Refer to Generator Replacement.
9. Reinstall the engine lift bracket. Refer to Engine Lift Bracket Replacement.
Fig. 224: View Of Radiator Inlet Hose  
Courtesy of GENERAL MOTORS CORP.

10. Position the J 38185 to the clamp (3) in order to remove the radiator inlet hose (2) from the water outlet housing (4). See Special Tools.

11. Remove the washer solvent container/coolant recovery reservoir mounting bolts ONLY, in order to gain clearance to remove the engine wiring harness. Refer to Washer Solvent Container Replacement.
Fig. 225: 2 Engine Wiring Harness Connectors At Powertrain Control Module (PCM)
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the 2 engine wiring harness connectors from the powertrain control module (PCM).
13. Remove the engine wiring harness clips from the wheelhouse.
14. Disconnect the engine wiring harness retainers (1) from the power steering pump (2).

15. Disconnect the engine wiring harness connectors from the following components:
   - The electric motor actuator connector
   - The oil pressure switch
16. Disconnect the engine wiring harness retainer (2) from the camshaft cover (3).

17. Disconnect the engine wiring harness connectors from the following components:
   - The exhaust camshaft position (CMP) sensor (5)
   - The exhaust camshaft actuator (6)
Fig. 228: View Of ECT Sensor, Fuel Injector, Ignition Coil & HO2S Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the engine wiring harness connectors from the following components:
   - The engine coolant temperature (ECT) sensor (1)
   - The fuel injector harness (2)
   - The ignition coils (4)
   - The heated oxygen sensor (HO2S) (5)
19. Disconnect the engine wiring harness retainer (3) from the camshaft cover (4).
20. Disconnect the engine wiring harness connector (2) from the throttle body (1).
Fig. 230: View Of Intake CMP Sensor Engine Wiring Harness Connector
Courtesy of GENERAL MOTORS CORP.

21. Disconnect the engine wiring harness connector from the intake CMP sensor.
22. Carefully disengage the engine wiring harness conduit from the camshaft cover.
23. Remove the transmission filler tube. Refer to **Filler Tube and Seal Replacement** in Automatic Transmission - 4L60-E/4L65-E.
24. Drain the engine oil, if necessary. Refer to **Engine Oil and Oil Filter Replacement**.
25. Remove the studs securing the secondary air injection (AIR) pipe cover to the cylinder head.

Remove the AIR pipe cover and gasket.

Discard the gasket.
26. Install the J 44220 in place of the AIR adapter. See **Special Tools**.
27. Disconnect the inlet heater hose quick connect (1) from the heater core (2), and secure to the engine.
Fig. 235: View Of Power Steering Pump & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

28. Remove the power steering pump mounting bolts ONLY, and position aside.
Fig. 236: Right Engine Mount-To-Frame Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

29. Remove the right engine mount-to-frame bracket bolt.
30. Disconnect the engine wiring harness retainer from the engine wiring harness bracket.
31. Position the engine wiring harness aside.
32. Disconnect the fuel feed pipe from the fuel rail. Refer to Quick Connect Fitting(s) Service (Metal Collar) in Engine Controls - 3.5L (L52).
33. Disconnect the evaporative emission (EVAP) pipe at the purge solenoid. Refer to Quick Connect Fitting(s) Service (Plastic Collar) in Engine Controls - 3.5L (L52).
34. Remove the oil level indicator and tube. Refer to Oil Level Indicator and Tube Replacement.
Fig. 238: Identifying Intake Manifold External Components
Courtesy of GENERAL MOTORS CORP.

35. Disconnect the brake booster hose (6) from the brake booster.

36. Remove the manifold absolute pressure (MAP) sensor. Refer to Manifold Absolute Pressure (MAP) Sensor Replacement in Engine Controls - 3.5L (L52).

37. Disconnect the MAP sensor wiring harness retainer (4) from the intake manifold (5).

38. Raise and support the vehicle only high enough to access the wiring harnesses through the wheelhouse. Refer to Lifting and Jacking the Vehicle.
Fig. 239: View Of Wiring Harness Retainers
Courtesy of GENERAL MOTORS CORP.

39. Disconnect the following wiring harness retainers from the engine wiring harness bracket:
   - The battery cable
   - The engine (4, 6)
   - The MAP sensor (5)
40. Remove the starter solenoid "S" terminal nut (3) and disconnect the lead (4) from the starter.

41. Remove the starter terminal nut (1) and disconnect the battery positive cable (2) from the starter.
42. Remove the bolt (5) securing the battery negative cable ground terminal (4) to the engine block.
Fig. 242: View Of EVAP Canister Purge Solenoid Valve Engine Wiring Harness Connector
Courtesy of GENERAL MOTORS CORP.

43. Disconnect the engine wiring harness connector from the EVAP canister purge solenoid valve.
44. Disconnect the engine wiring harness connector (3) from the # 2 knock sensor (KS) (1).
45. Disconnect the coolant heater cord from the coolant heater, if equipped.
46. Disconnect the engine wiring harness connector from the # 1 KS (2).
47. Disconnect the engine wiring harness retainer (4) from the engine oil pan rail.
48. Remove the bolt (5) securing the heater outlet hose/pipe to the left engine mount (4).
49. Position the J 38185 (2) to the clamp (1) in order to remove the heater outlet hose from the heater outlet hose fitting (3). See Special Tools.
50. Disconnect the engine wiring harness connector (3) from the crankshaft position (CKP) sensor (1).

51. Raise the vehicle completely. Refer to Lifting and Jacking the Vehicle.

52. Remove the 3 bolts securing the engine wiring ground leads (2) to the engine block.

53. Disconnect the engine wiring harness retainer (5) from the engine oil pan rail.

54. Position the engine wiring harness aside.
Fig. 247: Left Engine Mount-To-Frame Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

55. Remove the left engine mount-to-frame bracket bolt.
56. Disconnect the fuel line clips from the brackets on the transmission (manual only).
57. Disconnect the fuel line clips from the brackets on the transmission (automatic only).
58. Remove the crossmember. Refer to Crossmember Replacement.
59. Remove the front propeller shaft. Refer to Propeller Shaft Replacement - Front.
60. Remove the differential carrier assembly bushing to frame bolts ONLY.
61. Position the differential carrier assembly forward.
62. Secure the pinion yoke, in order to prevent the differential carrier from rotating.
63. Remove the exhaust seal. Refer to **Exhaust Seal Replacement**.
Fig. 251: View Of Transmission Oil Cooler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

64. Remove the bolt (2) securing the transmission oil cooler pipe bracket to the right side of the engine oil pan rail (automatic only).
65. Remove the inspection plug (3) from the transmission (1) (M30 only).

66. Mark the torque converter to flexplate/flywheel orientation to ensure proper realignment (M30 only).
67. Remove the service slot plug.

68. Repeat the following steps for all 3 torque converter bolts (automatic only):
   1. Rotate the harmonic balancer center bolt clockwise ONLY, in order to access the torque converter bolt through the service slot.
   2. Remove the torque converter bolt using one of the following:
      - 18 mm crowfoot wrench
      - Short T50 TORX bit
Fig. 254: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

69. Remove the 9 transmission mounting bolts.
70. Remove the remaining transmission mounting bolts (2).
71. Lower the vehicle.
72. Place a jack under the transmission for support.
73. Install an engine lift chain to the engine lift brackets and attach to an engine lift device.
74. Using the engine lift device, raise the engine only enough to remove the engine mounts.
75. Remove the bolts securing the following to the engine block:
   - The left engine mount
   - The right engine mount
76. Position the engine mounts away from the engine.

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

- The A/C compressor
77. Carefully raise the engine from the engine compartment, ensuring the transmission stays supported.

78. Install the engine to an engine stand.

79. Remove the engine lift chain from the engine lift brackets.

Installation Procedure

1. Install an engine lift chain to the engine lift brackets and attach to an engine lift device.
2. Remove the engine from the engine stand.
3. Ensure the torque converter is fully engaged with the transmission oil pump (M30 only).

- The A/C hoses
- The engine mounts
- The engine wiring harness
- The fuel hose/pipes
- The heater outlet hose/pipe
- The power steering pump
- The radiator
- The transmission input shaft (manual only)
- The transmission oil cooler pipes (automatic only)
Fig. 257: View Of Engine Lift Chain
Courtesy of GENERAL MOTORS CORP.

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

- The A/C compressor
- The A/C hoses
- The engine mounts
- The engine wiring harness
- The fuel hose/pipes
- The heater outlet hose/pipe
- The power steering pump
- The radiator
4. Carefully lower the engine into the engine compartment, aligning the engine dowels with the transmission.

- The transmission input shaft (manual only)
- The transmission oil cooler pipes (automatic only)

**Fig. 258: View Of Transmission Mounting Bolts & Engine Dowels**
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Ensure the torque converter turns freely while tightening the transmission mounting bolts (automatic only).

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

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

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

Fig. 259: Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Install the engine mount bolts until snug, following the installation sequence.

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

NOTE: Refer to Fastener Notice.
10. Tighten the bolts using the installation sequence.

**Tighten:** Tighten the engine mount bolts to 50 N.m (37 lb ft).

![Fig. 260: Engine Mount](image)

**Fig. 260: Engine Mount**  
*Courtesy of GENERAL MOTORS CORP.*

11. Install the engine mount bolts until snug, following the installation sequence.

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

12. Tighten the bolts using the installation sequence.

**Tighten:** Tighten the engine mount bolts to 50 N.m (37 lb ft).

13. Lower the engine fully on to the engine mounts.

14. Remove the engine lift chain from the engine lift brackets.
15. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**.

![Figure 261: View Of Transmission Mounting Bolts & Engine Dowels](image)

**Fig. 261: View Of Transmission Mounting Bolts & Engine Dowels**  
*Courtesy of GENERAL MOTORS CORP.*

16. Tighten the 2 transmission mounting bolts (2) previously installed.

**Tighten:** Tighten the transmission mounting bolts to 50 N.m (37 lb ft).
Fig. 262: View Of Transmission Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

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

17. Install the remaining transmission mounting bolts.

**Tighten:** Tighten the transmission mounting bolts to 50 N.m (37 lb ft).
18. Align the torque converter to flexplate/flywheel orientation marks made during the removal procedure (automatic only).

19. Repeat the following steps for all 3 torque converter bolts (automatic only):
   1. Rotate the harmonic balancer center bolt clockwise ONLY, in order to access the torque converter bolt holes in the flexplate/flywheel through the service slot.
   2. To aid in alignment of the torque converter to the flexplate/flywheel. Install all 3 torque converter bolts before fully tightening using one of the following:

      **Tighten:** Tighten the torque converter bolts to 60 N.m (44 lb ft).

         ■ 18 mm crowfoot wrench
         ■ Short T50 TORX bit
20. Install the inspection plug (3) to the transmission (1) (automatic only).
Fig. 264: View Of Transmission Oil Cooler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

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

Tighten: Tighten the transmission oil cooler pipe bracket bolt to 20 N.m (15 lb ft).

22. Install the exhaust seal. Refer to Exhaust Seal Replacement in Engine Exhaust.
23. Install the service slot plug.
24. Install the crossmember. Refer to Crossmember Replacement.
25. Position the differential carrier assembly to the frame.

26. Install the differential carrier assembly bushing to frame bolts.

**Tighten:** Tighten the differential carrier assembly bushing to frame bolts to 152 N.m (112 lb ft).

27. Install the front propeller shaft. Refer to Propeller Shaft Replacement - Front.
Fig. 267: Clips Attaching Fuel Feed Lines To Transmission (A/T)
Courtesy of GENERAL MOTORS CORP.

28. Install the fuel line clips to the brackets on the transmission (automatic only).

**Tighten:** Tighten the fuel hose/pipe bracket nuts to 20 N.m (15 lb ft).
Fig. 268: Clips Attaching Fuel Feed Lines To Transmission (M/T)  
Courtesy of GENERAL MOTORS CORP.

29. Install the fuel line clips to the brackets on the transmission (manual only).

**Tighten:** Tighten the fuel hose/pipe bracket nuts to 20 N.m (15 lb ft).

30. Install the left engine mount-to-frame bracket bolt.

**Tighten:** Tighten the engine mount-to-frame bracket bolt to 85 N.m (63 lb ft).
Fig. 269: Left Engine Mount-To-Frame Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.
31. Connect the engine wiring harness retainer (5) to the engine oil pan rail.
32. Install the 3 bolts securing the engine wiring ground leads (2) to the engine block.

**Tighten:** Tighten the engine wiring ground lead bolts to 20 N.m (15 lb ft).

33. Lower the vehicle to chest level in order to access the components through the wheelhouse.
34. Connect the engine wiring harness connector (3) to the CKP sensor (1).

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**Fig. 270: View Of Engine Wiring Harness**
*Courtesy of GENERAL MOTORS CORP.*
35. Position the J 38185 (2) to the clamp (1) in order to connect the heater outlet hose to the heater outlet hose fitting (3). See Special Tools.

36. Install the bolt (5) securing the heater outlet hose/pipe to the left engine mount (4).

Tighten: Tighten the heater outlet hose/pipe bracket to the left engine mount bolt to 9 N.m (80 lb in).
37. Connect the engine wiring harness retainer (4) to the engine oil pan rail.
38. Connect the engine wiring harness connector to the #1 KS (2).
39. Connect the engine wiring harness connector (3) to the # 2 KS (1).
40. Connect the coolant heater cord to the coolant heater, if equipped.
41. Connect the engine wiring harness connector to the EVAP canister purge solenoid valve.
42. Install the bolt (5) securing the battery negative cable ground terminal (4) to the engine block.

**Tighten:** Tighten the battery negative cable to engine block bolt to 35 N.m (26 lb ft).
43. Connect the battery positive cable (2) to the starter and install the starter terminal nut (1).

**Tighten:** Tighten the battery positive cable to starter terminal nut to 9 N.m (80 lb in).

44. Connect the lead (4) to the starter solenoid and install the starter solenoid "S" terminal nut (3).

**Tighten:** Tighten the starter solenoid "S" terminal nut to 3.5 N.m (31 lb in).
45. Secure the following wiring harness retainers to the engine wiring harness bracket:
   - The battery cable
   - The engine (4, 6)
   - The MAP sensor (5)

46. Lower the vehicle.
Fig. 278: Identifying Intake Manifold External Components
Courtesy of GENERAL MOTORS CORP.

47. Connect the MAP sensor wiring harness retainer (4) to the intake manifold (5).
48. Install the MAP sensor. Refer to Manifold Absolute Pressure (MAP) Sensor Replacement in Engine Controls - 3.5L (L52).
49. Connect the brake booster hose (6) to the brake booster.
50. Install the oil level indicator and tube. Refer to Oil Level Indicator and Tube Replacement.
51. Connect the EVAP pipe at the purge solenoid. Refer to Quick Connect Fitting(s) Service (Plastic Collar) in Engine Controls - 3.5L (L52).
52. Connect the fuel feed pipe to the fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** in Engine Controls - 3.5L (L52).

53. Connect the engine wiring harness retainer to the engine wiring harness bracket.

**Fig. 279: Engine Wiring Harness Retainer At Engine Wiring Harness Bracket**

*Courtesy of GENERAL MOTORS CORP.*
54. Install the right engine mount-to-frame bracket bolt.

**Tighten:** Tighten the engine mount-to-frame bracket bolt to 85 N.m (63 lb ft).
55. Position the power steering pump to the power steering pump bracket.
56. Install the power steering pump mounting bolts.

**Tighten:** Tighten the power steering pump mounting bolts to 25 N.m (18 lb ft).
57. Connect the inlet heater hose quick connect (1) to the heater core (2).
Fig. 283: Identifying J 44220
Courtesy of GENERAL MOTORS CORP.

58. Remove the J 44220 from the cylinder head. See Special Tools.
59. Position the AIR pipe cover and NEW gasket to the cylinder head.

60. Install the AIR pipe cover studs.

**Tighten:** Tighten the AIR cover studs to 25 N.m (18 lb ft).

61. Install the transmission filler tube. Refer to **Filler Tube and Seal Replacement** in Automatic Transmission - 4L60-E/4L65-E.
62. Engage the engine wiring harness conduit to the camshaft cover.
63. Connect the engine wiring harness connector to the Intake CMP sensor.
Fig. 287: View Of Engine Wiring Harness Connections To Camshaft Cover & Throttle Body
Courtesy of GENERAL MOTORS CORP.

64. Connect the engine wiring harness retainer (3) to the camshaft cover (4).
65. Connect the engine wiring harness connector (2) to the throttle body (1).
66. Connect the engine wiring harness connectors to the following components:
   - The ECT sensor (1)
   - The fuel injector harness (2)
   - The ignition coils (4)
   - The HO2S (5)
67. Connect the engine wiring harness retainer (2) to the camshaft cover (3).
68. Connect the engine wiring harness connectors to the following components:
   - The exhaust CMP sensor (5)
   - The exhaust camshaft actuator (6)
69. Connect the engine wiring harness retainers (1) to the power steering pump (2).

70. Connect the engine wiring harness connectors to the following components:
   - The electric motor actuator connector (4WD only)
   - The oil pressure switch

71. Connect the engine wiring harness retainers to the wheelhouse.

72. Connect the 2 engine wiring harness connectors to the PCM.
Fig. 291: 2 Engine Wiring Harness Connectors At Powertrain Control Module (PCM)
Courtesy of GENERAL MOTORS CORP.

73. Install the washer solvent container/coolant recovery reservoir mounting bolts. Refer to Washer Solvent Container Replacement.
74. Position the J 38185 to the clamp (3) in order to connect the radiator inlet hose (2) to the water outlet housing (4). See Special Tools.

75. Install the generator. Refer to Generator Replacement.

76. Install the air cleaner resonator and outlet duct. Refer to Air Cleaner Resonator and Outlet Duct Replacement in Engine Controls - 3.5L (L52).

77. Install the air cleaner assembly. Refer to Air Cleaner Assembly Replacement in Engine Controls - 3.5L (L52).

78. Install the cooling fan. Refer to Fan Replacement.
79. Install the outlet radiator hose. Refer to Radiator Hose Replacement - Outlet.
80. Fill the cooling system. Refer to Draining and Filling Cooling System.
81. Install the battery box. Refer to Battery Box Replacement.
82. Install the hood. Refer to Hood Replacement.
83. Fill the engine oil, if previously drained. Refer to Engine Oil and Oil Filter Replacement.

Engine Final Test and Inspection

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

1. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any parts are binding.
2. Start the engine and listen for abnormal conditions.
3. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
4. Run the engine at approximately 1,000 RPM until the engine reaches normal operating temperature.
5. While the engine continues to idle raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
6. Inspect for oil, coolant, transmission fluid, and exhaust leaks while the engine is idling.
7. Lower the vehicle.
8. Perform the CKP variation learn procedure. Refer to CKP System Variation Learn Procedure in Engine Controls - 3.5L (L52).
9. Perform a final inspection for the proper engine oil, transmission fluid and coolant levels.
10. Road test the vehicle.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Remove the oil fill cap.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
3. Clean away all dirt and debris from the engine oil pan drain plug area.
4. Position an appropriate container under the engine oil pan.
5. Remove the oil pan drain plug.

   Allow the engine oil to drain into the container.

6. Position the container under the engine oil filter drain deflector.
Fig. 294: Oil Filter
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Ensure the old oil filter seal is not left on the engine block.

7. Remove the oil filter using a suitable wrench.
Allow the engine oil to drain to the oil filter drain deflector and into the container.

Installation Procedure

1. Lubricate the oil filter seal with clean engine oil.
NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

2. Install a NEW oil filter.

   **Tighten:** Tighten the filter to 30 N.m (22 lb ft).

3. Wipe the excess oil from the oil filter drain deflector.

4. Install the oil pan drain plug.

   **Tighten:** Tighten the oil pan drain plug to 26 N.m (19 lb ft).
5. Lower the vehicle.

6. Fill the crankcase with the proper type and amount of engine oil. Refer to **Fluid and Lubricant Recommendations** and **Capacities - Approximate Fluid** in Maintenance and Lubrication.

7. Install the oil fill cap.

8. Start the engine and check the oil pressure gage for the appropriate pressure to build up.

9. Shut the engine off.

10. Inspect under the vehicle in the oil filter and oil pan drain plug areas for leaks.

11. Remove the oil level indicator and check for the correct oil level. Add oil if necessary.

**ENGINE FLYWHEEL REMOVAL (AUTOMATIC TRANSMISSION)**
Fig. 297: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the flywheel bolts.
2. Remove the flywheel.

ENGINE FLYWHEEL REMOVAL (MANUAL TRANSMISSION)
Fig. 298: View Of Engine Flywheel - Manual Transmission
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the flywheel bolts.
2. Remove the flywheel.

DRAINING FLUIDS AND OIL FILTER REMOVAL
Fig. 299: Removing Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug.
2. Drain the engine oil.
Fig. 300: View Of Oil Filter  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

DRIVE BELT TENSIONER REMOVAL
Fig. 301: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner bolt.
2. Remove the drive belt tensioner.

POWER STEERING PUMP BRACKET REMOVAL
1. Remove the power steering pump bracket bolts.
2. Remove the power steering pump bracket.

DRIVE BELT IDLER PULLEY REMOVAL
Fig. 303: Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt idler pulley bolts.
2. Remove the drive belt idler pulley.

OIL LEVEL INDICATOR AND TUBE REMOVAL
1. Remove the oil level indicator.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube.

Fig. 304: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.
EXHAUST MANIFOLD REMOVAL

Fig. 305: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust manifold heat shield nuts.
2. Remove the exhaust manifold heat shield.
3. Remove the exhaust manifold studs (if needed).
4. Remove the exhaust manifold bolts.
5. Remove the exhaust manifold.
6. Remove and discard the exhaust manifold gasket.

OIL FILTER ADAPTER REMOVAL
Fig. 309: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter.
2. Remove the oil filter bypass valve.

**HEATER INLET PIPE REMOVAL**
Fig. 311: View Of Heater Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater inlet pipe bolt.
2. Remove the heater inlet pipe.

HEATER OUTLET HOSE FITTING REMOVAL
Fig. 312: View Of Heater Outlet Hose Fitting
Courtesy of GENERAL MOTORS CORP.

Remove the heater outlet hose fitting.

WATER OUTLET REMOVAL
Fig. 313: View Of Water Outlet
Courtesy of GENERAL MOTORS CORP.

1. Remove the water outlet bolts.
2. Remove the water outlet.

WATER PUMP REMOVAL
Tool Required

**J 41240 Pulley Holding Tool. See Special Tools.**

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**Fig. 314: View Of Water Pump Pulley, Bolts & J 41240**  
Courtesy of GENERAL MOTORS CORP.

1. Install **J 41240** to hold the pulley. See Special Tools.
2. Remove the water pump pulley bolts.
4. Remove the water pump pulley
5. Remove the water pump bolts.
6. Remove the water pump.
7. Remove and discard the water pump gasket.

THERMOSTAT HOUSING REMOVAL
Fig. 316: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the thermostat housing bolts.
2. Remove the thermostat housing.

INTAKE MANIFOLD REMOVAL
Fig. 317: View Of Throttle Control Module
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle control module bolts.
2. Remove the throttle control module.
3. Remove and discard the throttle control module gasket.
Fig. 318: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold and bolts.
5. Remove and discard the intake manifold gasket.

FUEL RAIL AND INJECTORS REMOVAL
Fig. 319: Fuel Injector Rail  
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector rail bolts.
2. Remove the fuel injector rail.

CAMSHAFT POSITION ACTUATOR VALVE REMOVAL
1. Remove the camshaft position actuator valve bolt.
2. Remove the camshaft position actuator valve.

CAMSHAFT COVER REMOVAL
Fig. 321: View Of Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition control modules and bolts.
Fig. 322: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft cover and bolts.
3. Remove the discard the camshaft cover seal.

OIL PAN REMOVAL
Fig. 323: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts.
2. Install 2 of the oil pan bolts into the threaded holes (jack bolts) to break the seal of oil pan.
3. Remove the oil pan.

OIL PUMP PIPE AND SCREEN ASSEMBLY REMOVAL
Fig. 324: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump pipe bolts.
2. Remove the oil pump pipe.
3. Remove and discard the oil pump pipe gasket.

CRANKSHAFT BALANCER REMOVAL

Tools Required:

**J 41816-2** Crankshaft End Protector. See **Special Tools.**
1. Remove and discard the crankshaft balancer bolt.
2. Install J 41816-2 into the end of the crankshaft. See Special Tools.

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

   IMPORTANT: The friction washer may come off with the crankshaft balancer.

3. Use a three jaw puller to remove the crankshaft balancer.


CRANKSHAFT FRONT OIL SEAL REMOVAL
Fig. 327: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

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

ENGINE FRONT COVER REMOVAL
Fig. 328: View Of 7 mm Center Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the 7 mm center bolt (1) first.
2. Loosen the engine front cover bolts.
3. Remove the engine front cover and bolts.
4. Remove the spacer bolt.

**IMPORTANT:** The friction washer may have come off with the crankshaft balancer.

5. Remove the crankshaft balancer friction washer from the crankshaft snout.

**OIL PUMP REMOVAL**
Fig. 330: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump cover bolts.
2. Remove the oil pump cover.
3. Mark the inner and outer gears in relation to the oil pump housing.
4. Remove the inner and outer oil pump gears.
5. Remove the oil pump pressure relief valve plug.
6. Remove the oil pump pressure relief valve and spring.

TIMING CHAIN AND SPROCKETS REMOVAL
Fig. 331: View Of Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft sensor bolt.
2. Remove the exhaust camshaft sensor.
3. Remove the intake camshaft sensor bolt.
4. Remove the intake camshaft sensor.
5. Remove the top chain guide bolts.
6. Remove the top chain guide.
7. Remove and discard the exhaust camshaft position actuator bolt.
8. Remove the exhaust camshaft position actuator.
Fig. 334: Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.
9. Remove the intake camshaft sprocket bolt.
10. Remove the intake camshaft sprocket.
11. Remove the timing chain.
12. Remove the crankshaft sprocket.

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL
1. Remove the crankshaft rear oil seal housing and bolts.
2. Install 2 bolts (Jack Screws) into the threaded holes to break the seal of the housing.
3. Remove the crankshaft rear oil seal housing.

CRANKSHAFT REAR OIL SEAL REMOVAL
Fig. 337: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the crankshaft or seal bore. Pry out the crankshaft rear oil seal out using a suitable tool.

Remove the crankshaft rear oil seal and discard.

BALANCE SHAFT REMOVAL
Fig. 338: Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not disassemble the balance shaft assemblies. Remove and install the balance shafts as complete assemblies.

1. Rotate the crankshaft until the left hand balance shaft sprocket timing mark is at 12:00. The right hand balance shaft sprocket timing mark should be at 2:30. The crankshaft sprocket timing mark should be at 4:30. Make sure the 3 timing marks on the sprockets line up with a dark link on the chain (1). Every 11-crankshaft rotations, 3 of the 5 dark links on the timing chain will line up with the timing marks.
Fig. 339: View Of Balance Shaft Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to retract the tensioner plunger by rotating the link plate clockwise. Insert a small tool into the link plate hole in order to prevent the tensioner from ratcheting to full extension.

2. Remove the balance shaft chain tensioner and bolts.
3. Remove the chain from the crankshaft sprocket.

**IMPORTANT:** It may be necessary to remove the right balance shaft bolts and rotate the retainer plate counter-clockwise in order to gain chain slack.

4. Remove the chain from the balancer sprockets.
5. Remove the balance shaft chain guide bolts.
6. Remove the balance shaft chain guide.

**IMPORTANT:** Rotate the balance shafts to check for free rotation. If the balance shafts do not turn free, inspect the balance shaft bearings and bearing surface for damage.
7. Remove the balance shaft assembly retaining bolts.
8. Remove the balance shaft assemblies.

**TIMING CHAIN TENSIONER REMOVAL**
Fig. 343: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head access hole plugs.
2. Remove the timing chain tensioner shoe bolt.
3. Remove the timing chain tensioner shoe.
Fig. 345: View Of Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the timing chain tensioner guide bolts.
5. Remove the timing chain tensioner guide.
Fig. 346: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing chain tensioner bolts.
7. Remove the timing chain tensioner.

ENGINE LIFT BRACKET REMOVAL
Fig. 347: Removing Engine Lift Bracket  
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine lift bracket bolts.
2. Remove the engine lift bracket.

CAMSHAFT REMOVAL
1. Remove the camshaft cap bolts.

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

2. Remove the camshaft caps.
3. Remove the camshafts.

VALVE ROCKER ARM AND VALVE LASH ADJUSTER REMOVAL
Fig. 350: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Once removed, place the valve rocker arms and valve lash adjusters in an organized order so the components can be installed into the original locations.

1. Remove the valve rocker arms.
2. Remove the valve lash adjusters.

**Fig. 351: View Of Valve Lash Adjusters**
*Courtesy of GENERAL MOTORS CORP.*

**CYLINDER HEAD REMOVAL**
Fig. 352: View Of Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the cylinder head bolts.
2. Remove the cylinder head.

Fig. 353: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.
3. Remove the cylinder head gasket.

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

**Tools Required**

**J 41556** Connecting Rod Guides. See **Special Tools**.
Fig. 355: View Of Connecting Rod, Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Mark the piston with the number of the cylinder from which the piston is being removed. Also mark the orientation.

2. Mark the connecting rod and the connecting rod cap with the cylinder position. Also mark the orientation. This will ensure the caps and connecting rods are re-assembled properly.

3. Remove the connecting rod bolts.
4. Remove the connecting rod cap and bearing half.

5. Install J 41556 on the connecting rod. See Special Tools.
Fig. 357: View Of Connecting Rod, Piston Assembly & J 41556
Courtesy of GENERAL MOTORS CORP.

6. Remove the connecting rod and piston assembly. Push out the assembly.

CRANKSHAFT AND BEARINGS REMOVAL

Fig. 358: View Of Crankshaft Main Bearing Cap Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the crankshaft main bearing cap bolts.
Fig. 359: View Of Crankshaft Main Bearing Cap Stiffener
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft main bearing cap stiffener.
Fig. 360: View Of Crankshaft Main Bearing Caps & Lower Bearings
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft main bearing caps and lower bearings.
4. Remove the crankshaft.

Fig. 361: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.
5. Remove the upper crankshaft main bearing halves.

**CLUTCH PILOT BEARING REMOVAL**

Tools Required

Fig. 363: View Of Clutch Pilot Bearing  
Courtesy of GENERAL MOTORS CORP.

1. Install J 43276 into the pilot bearing. See Special Tools.
2. Remove the pilot bearing from the crankshaft.

AUTOMATIC TRANSMISSION FLYWHEEL LOCATOR REMOVAL

Tools Required

J 45849-1 Flywheel Locator Removal Tool. See Special Tools.
Fig. 364: View Of Flywheel Locator
Courtesy of GENERAL MOTORS CORP.

1. Install J 45849-1 into the flywheel locator. See Special Tools.
2. Remove the flywheel locator from the crankshaft.

BALANCE SHAFT BEARING REMOVAL

Tools Required

J 44225 Balance Shaft Bearing Remover/Installer
Fig. 365: View Of Balance Shaft Journals
Courtesy of GENERAL MOTORS CORP.

1. Position the cylinder block so the cylinder head deck face is down and identify the following:
   - The left balance shaft bearings are in the shorter length balance shaft journal (3) and (4).
   - The right balance shaft - outer diameter is grooved, bearings are in the longer length balance shaft journal (1) and (2).
2. Identify the following:

- Bearings (2) and (3) are the front bearings and bearings (1) and (4) are the rear bearings.

- The rear bearings (1) and (4) have a slightly larger diameter than the front bearings (2) and (3). This allows for easier removal and installation of the front bearings. The rear bearings also have notches on them.
3. Install **J 44225** into the right balance shaft bearing bore.
4. Position the swivel end inside lip of **J 44225** against the frontside of the rear bearing.
5. Turn the nut clockwise to remove the bearing.
Fig. 368: View Of Right Bearing  
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the right rear bearing (1).
7. Install **J 44225** into the right balance shaft bearing bore.
8. Position the swivel end inside lip of **J 44225** against the frontside of the front bearing.
9. Turn the nut clockwise to remove the bearing.
10. Remove and discard the right front bearing (1).

Fig. 370: View Of Right Bearing  
Courtesy of GENERAL MOTORS CORP.
11. Install **J 44225** into the left balance shaft bearing bore.
12. Position the swivel end inside lip of **J 44225** against the frontside of the rear bearing.
13. Turn the nut clockwise to remove the bearing.

Fig. 372: View Of Left Bearing  
Courtesy of GENERAL MOTORS CORP.

14. Remove and discard the left rear bearing (1).
Fig. 373: Installing J 4425 Into Left Balance Shaft Bearing Bore
Courtesy of GENERAL MOTORS CORP.

15. Install J 44225 into the left balance shaft bearing bore.
16. Position the swivel end inside lip of J 44225 against the frontside of the front bearing.
17. Turn the nut clockwise to remove the bearing.

**Fig. 374: View Of Left Bearing**  
*Courtesy of GENERAL MOTORS CORP.*

18. Remove and discard the left front bearing (1).

**ENGINE BLOCK PLUG REMOVAL**
Fig. 375: View Of Engine Block Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block oil gallery plugs.
2. Remove the engine block coolant plug.
3. Remove the crankshaft position sensor.
Fig. 378: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

4. Remove the knock sensors.
Fig. 379: View Of EVAP Solenoid  
 Courtesy of GENERAL MOTORS CORP.

5. Remove the EVAP solenoid.
Fig. 380: View Of Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the coolant temperature sensor.
Fig. 381: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pressure switch.

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

- J 8001 Dial Indicator Set
- J 8087 Cylinder Bore Gage. See Special Tools.
- J 45059 Angle Meter. See Special Tools.
1. Clean the sealing material from all gasket mating surfaces.
2. Clean the engine block with a cleaning solution.
3. Flush the engine block with clean water.
4. Clean the oil passages.
5. Coat the cylinder bores and the machined surfaces with engine oil.
6. Inspect the threaded holes. Clean the holes with a tap, if needed.
7. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully...
remove any minor irregularities. Replace the block if there is more than 0.08 mm (0.003 in) gap.

Fig. 383: Measuring Cylinder Bores With J 8087
Courtesy of GENERAL MOTORS CORP.
8. Inspect the cylinder bores. Use J 8087 to measure the cylinder bore. See Special Tools. Inspect the bores for the following conditions:

- Wear
- Taper
- Runout
- Ridging

9. Replace the cylinder sleeve if the bore is out of specification.

Fig. 384: Measuring Engine Block Flange Runout
Courtesy of GENERAL MOTORS CORP.
10. Inspect the oil pan rail for nicks. Use a flat file to remove any nicks.
11. Inspect the front cover attaching area for nicks. Use a flat file to remove any nicks.
12. Inspect the mating surfaces of the transmission case.
13. Use the following procedure to measure the engine block flange runout at the mounting bolt hole bosses:
   1. Temporarily install the crankshaft. Measure the crankshaft flange runout.
   2. Hold a gage plate flat against the crankshaft flange.
   3. Place J 8001 (dial indicator stem) on the transmission mounting bolt hole boss. Set the indicator to zero.
   4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.25 mm (0.010 in).
   5. Recheck the crankshaft flange runout if the readings vary more than 0.25 mm (0.010 in). If the crankshaft flange runout is within the specification, replace the engine block.
14. Remove the crankshaft.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

15. Re-install the crankshaft bearing caps, stiffener, and bolts.

**Tighten:**

1. Tighten the crankshaft bearing cap bolts to 25 N.m (18 lb ft).
2. Use J 45059 to tighten the crankshaft bearing cap bolts an additional 180 degrees. See Special Tools.

IMPORTANT: Perform the following inspections, and reconditioning (if necessary), with the crankshaft main bearing caps installed and tightened to specification.

16. Inspect the crankshaft main bearing bores. Use J 8087 to measure the bearing bore concentricity and alignment. See Special Tools.

17. Remove the crankshaft main bearing cap stiffener and main bearing caps with bearings.

CYLINDER HONING

Fig. 386: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.
CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

1. When honing the cylinder bores, follow the manufacturer’s recommendations for equipment use, cleaning, and lubrication.
   - Use only clean sharp stones of the proper grade for the amount of material to be removed.
   - Dull, dirty stones cut unevenly and generate excessive heat.
   - DO NOT hone to a final grade with a coarse or medium-grade stone.
   - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
   - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45-65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
   - Repeatedly check the cylinder bore fit with the selected piston.
   - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.
   Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.
   - The finish marks should be clean but not sharp.
   - The finish marks should be free from imbedded particles or torn or folded metal.
4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
5. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
   1. Scrub the cylinder bores with a stiff bristle brush.
   2. Rinse the cylinder bores thoroughly with clean hot water.
   3. Dry the cylinder bores with a clean rag.
   4. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear
of the bearings.
6. Perform final measurements of the piston and the cylinder bore.
7. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

- J 8087 Cylinder Bore Gauge. See Special Tools.
- J 45059 Angle Meter. See Special Tools.

Fig. 387: Inspecting Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the
reluctor wheel and crankshaft bearing surfaces.

1. Clean the crankshaft of all elements.
2. Inspect the crankshaft oil passages for obstructions.
3. Inspect the crankshaft for the following conditions:
   - Damaged threads (1)
   - Damaged mounting faces
   - Worn crankshaft pin (2)
   - Wear without any grooves or scratches (3)
   - Grooves or scoring (3)
   - Scratches (3)
   - Pitting or embedded bearing material (3)
   - Overheating - discoloration (3)
   - Damaged teeth (4)
Fig. 388: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

4. Inspect the corresponding crankshaft bearing inserts for embedded material and determine the source of the material.

**IMPORTANT:** If cracks, severe gouges or burned spots are found, replace the crankshaft. Remove slight roughness using a fine polishing cloth soaked in clean engine oil. Remove any burrs using a fine oil stone.
5. Inspect the outer surfaces of the crankshaft bearings for the following conditions:
   - Wear - surface wear indicates either movement of the insert or high spots in the surrounding material (spot wear)
   - Overheating or discoloration
   - Looseness or rotation indicated by flattened tangs and wear grooves

**IMPORTANT:** Note the location of the crankshaft main bearing high spots. If the spots are not in line, the crankshaft is bent. Replace the crankshaft.

6. Inspect the crankshaft main bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.
7. Inspect the thrust surfaces of the main thrust bearing for the following conditions:
   - Wear
   - Grooving - Grooves are caused by irregularities of the crankshaft thrust surface.
8. Inspect the crankshaft bearings for excessive scoring or discoloration.
9. Inspect the crankshaft bearings for dirt or imbedded debris.
10. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections.
11. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

**IMPORTANT:** If crankshaft bearing failure is due to conditions other than normal wear, investigate the cause of the condition. Inspect the crankshaft or connecting rod bearing bores.

12. Inspect the connecting rod bearing bores using the following procedure:
   1. Tighten the connecting rod bearing cap to specification.
   2. Use **J 8087** to measure the bearing bore for taper and out-of-round. See Special Tools. Record the readings.
   3. No taper or out-of-round should exist.
13. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
14. Measure the crankshaft bearing journal taper and runout.
15. Install the crankshaft bearing caps.
16. Install the crankshaft main bearing cap stiffener.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

17. Install the crankshaft bearing cap bolts.
Tighten:
1. Tighten the crankshaft bearing cap bolts to 25 N.m (18 lb ft).
2. Use J 45059 to tighten the crankshaft bearing cap bolts an additional 180 degrees. See Special Tools.

18. Measure the crankshaft main bearing inside diameter with an inside micrometer.
19. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
20. If the specified clearances cannot be met, the crankshaft, connecting rods, or block may need to be replaced.

CRANKSHAFT BALANCER CLEANING AND INSPECTION
1. Inspect the crankshaft balancer sealing area for grooves, nicks, or burs (1).
2. Inspect the crankshaft balancer belt ribs for dents or damage (2).
3. Replace the crankshaft balancer if damage is present.

ENGINE FLYWHEEL CLEANING AND INSPECTION (AUTOMATIC TRANSMISSION)
Fig. 392: Inspecting Engine Flywheel For Damage - Automatic Transmission  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for cracks (1).
2. Inspect the engine flywheel teeth for damage (2).
3. Replace the engine flywheel if damage is present.
ENGINE FLYWHEEL CLEANING AND INSPECTION (MANUAL TRANSMISSION)

1. Inspect the engine flywheel for damaged teeth (1).
2. Inspect the engine flywheel for cracks, hot spots, or any surface damage (2).
3. Replace the engine flywheel if damage is present.

Fig. 393: Inspecting Engine Flywheel For Damage - Manual Transmission
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for damaged teeth (1).
2. Inspect the engine flywheel for cracks, hot spots, or any surface damage (2).
3. Replace the engine flywheel if damage is present.
PISTON AND CONNECTING ROD DISASSEMBLE

Tools Required

**J 43654** Piston Pin Retainer Remover/Installer. See Special Tools.

*Fig. 394: View Of Piston Rings & Piston Expander*
Courtesy of GENERAL MOTORS CORP.

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

**IMPORTANT:** Do not reuse the piston rings.

1. Remove the piston rings using a piston ring expander.
IMPORTANT: Two retainers hold the piston pins in place. Reuse the retainers if they are not damaged during removal.

2. Remove the piston pin retainers.
3. Remove the piston pin.

PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION

Tools Required

J 8087 Cylinder Bore Gage. See Special Tools.
Fig. 397: View Of Piston Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean and soak the following components in a carburetor cleaning solution to remove carbon, sludge, and varnish:
   - Piston
   - Piston pin
   - Connecting rod
Fig. 398: Identifying Twisted Connecting Rod  
Courtesy of GENERAL MOTORS CORP.

2. Install the connecting rod cap.
3. Place the connecting rod assembly on a checking fixture.
4. Inspect the connecting rod assembly for bending or twisting.
5. Replace any bent or twisted connecting rods.

6. If the connecting rod large bore contains minor scratches or abrasions, clean the bore in a circular direction with light emery paper. DO NOT scrape the connecting rod or cap.

7. Measure the piston pin to connecting rod bore using the following procedure:
   - Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
   - Using an inside micrometer, measure the connecting rod piston pin bore.
   - Subtract the piston pin diameter from the piston pin bore diameter.
   - The clearance should not be more than 0.018 mm (0.0007 in).

8. If there is excessive clearance, replace the piston pin.

9. If there is still excessive clearance, replace the connecting rod.

10. If there is evidence of pin bore or pin scoring, replace the rod and pin assembly.

11. Inspect the connecting rod bearings for the following conditions:
   - Craters or pockets
- Flattened sections
- Excessive scoring or discoloration.
- Imbedded debris
  - bright, polished sections

12. Inspect the inside of the connecting rod bearing and outside diameter of the connecting rod bearing journal for wear. This indicates high spots.

13. Inspect the connecting rod bearing bore for taper and out-of-round.

14. Inspect the connecting rod bolts for stretching (compare to new or known good bolt). (1) is a stretched bolt, (2) is a new or good bolt.

15. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.

16. Clean the piston ring grooves. Ensure that the oil ring holes and slots are clean.

17. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts, or pin bosses
   - Ring grooves for nicks, burrs that may cause binding
   - Warped or worn ring lands
   - Eroded areas at the top of the piston
   - Scuffed or damaged skirts
   - Worn piston pin bores

18. Replace pistons that show any signs or damage or excessive wear.
Fig. 400: Measuring Piston Diameter  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** When fitting pistons, consider both the piston and the cylinder bore conditions together. Production and service pistons have the same nominal weight and may be intermixed without affecting engine balance. If necessary, used pistons may be fitted selectively to any cylinder of the engine, providing the pistons are in good condition and the same weight. Do not cut oversize pistons down or the engine balance may be affected. Finish hone when selecting the piston.

19. Measure the piston diameter for size with a micrometer or caliper at a right angle to the pin center line, across the skirts, 38 mm (1.50 in) from the top of the piston.
Fig. 401: Measuring Cylinder Bores With J 8087
Courtesy of GENERAL MOTORS CORP.

20. Replace the piston if worn beyond specifications or if damaged.
21. Use J 8087 to measure the cylinder bore. See Special Tools.
22. Hone to size if necessary. Use the following procedure to hone the cylinder bore to the correct size.
   1. Select a piston.
   2. Hone the cylinder bore to obtain the recommended clearance.
3. Clean the piston and cylinder bore with soap and water. Dry the cylinder bore and piston. Lubricate the cylinder bore with clean engine oil.

23. Use the following procedure to measure the piston-to-cylinder bore clearance.
   1. Subtract the piston diameter from the cylinder bore diameter to determine the piston-to-bore clearance.
   2. Compare the piston-to-bore clearance using the specifications to determine if the clearance is in the acceptable range.
   3. If the used piston is not acceptable, a new service piston may be selected.

24. When a piston has been selected, mark the piston to identify the cylinder for which the piston was fitted.

25. Select a set of new piston rings.

26. Install each ring, one at a time, into the corresponding cylinder.

27. Install the piston for that cylinder, upside down (top of piston pushing on the ring) and push the ring to approximately 25 mm (1 in) down from the deck surface.

28. Remove the piston.

29. Measure the ring end gap with a feeler gage.
30. If the ring gap is not within the specification range, replace the rings.

31. Measure the piston ring side clearance - compression rings.

**NOTE:** The piston ring groove must only be cleaned with a ring groove cleaning tool. Proper engine performance and durability depends on the straightness and smoothness of the ring groove. Cleaning the piston ring groove with an improper tool can damage the piston ring groove and effect the performance and durability of the engine.
32. Use the following procedure to measure the compression ring side clearance.
   1. Roll the piston ring around the groove.
   2. Measure the side clearance with a feeler gage.
   3. If the ring is too tight, inspect the piston ring groove for nicks, burrs, or damage. Use emery cloth to remove any minor burrs.
   4. If the ring side clearance is greater than the specification, replace the piston.

**CYLINDER SLEEVE REMOVAL**

**Tools Required**

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See Special Tools.

**NOTE:** Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

**NOTE:** Do not damage the crankshaft connecting rod journals or reluctor ring or engine damage will occur.
1. If the crankshaft is still installed, rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.

2. Install the cylinder bore sleeve puller EN 45680-402 (1) which is part of EN-45680-400, through the cylinder bore. See Special Tools.

**NOTE:** Ensure that the shoe is flat against the bottom of the cylinder bore sleeve or damage to the cylinder bore sleeve puller will occur.
3. Align the shoe (1) of the cylinder bore sleeve puller EN 45680-402 to the bottom of the cylinder bore sleeve (117).

Fig. 405: Threaded Shaft
Courtesy of GENERAL MOTORS CORP.
4. Hold the threaded shaft of the cylinder bore sleeve puller EN 45680-402 upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.

5. Install the fixture EN 456850-401 (4) onto the threaded shaft of the cylinder bore sleeve puller EN 456850-402 and the engine block.

6. Install the bearing (3) and the nut (1).

7. Tighten the nut (1) to the bearing (3).

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

**IMPORTANT:** Use four old cylinder head bolts for the attaching bolts.

8. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block.

**Tighten:** Tighten the bolts to 15 N.m (11 lb ft).
9. Rotate the nut clockwise in order to remove the cylinder bore sleeve.
Fig. 407: Removing Cylinder Bore Sleeve  
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the cylinder block surface. Damage to the cylinder block surface can cause engine failure.

10. Remove fixture EN 45680-401, cylinder bore sleeve puller EN 45680-402, and the cylinder bore sleeve (117) from the engine block.

11. Loosen the nut (1) in order to remove the cylinder bore sleeve (117).

12. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.

13. Inspect the piston, piston rings, and connecting rod for damage. Refer to Piston, Connecting Rod, and Bearings Cleaning and Inspection.

CYLINDER SLEEVE INSTALLATION

Tools Required

EN-45680-400 Cylinder Sleeve Removal and Installation Kit. See Special Tools.

NOTE: Do not use assembly aids or lubricants on the cylinder bore.
sleeve or the cylinder bore block when installing a new cylinder bore sleeve, or engine damage will occur. These items will not aid in the installation of the new cylinder bore sleeve.

**NOTE:** Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.
1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) which is part of **EN-45680-400**, over the cylinder bore sleeve (117) and onto the cylinder block. See **Special Tools**. Do not apply downward pressure to the cylinder bore sleeve (117).
Fig. 409: Installing Cylinder Bore Sleeve Puller Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Use 4 old cylinder head bolts for the attaching bolts.

3. Insert the 4 attachment bolts into the legs of the fixture EN 45680-401 (1).

**NOTE:** Refer to **Fastener Notice** in Cautions and Notices.

4. Tighten the 4 attachment bolts. Do not apply downward pressure to the cylinder bore sleeve.
(117).

**Tighten:** Tighten the 4 attachment bolts to 15 N.m (11 lb ft).

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**Fig. 410: View Of Proper Liner Alignment**

*Courtesy of GENERAL MOTORS CORP.*

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).
6. Align the installation arbor (1) onto the top of the cylinder bore sleeve (117).
7. Align the pusher block (2) of cylinder bore sleeve installer EN 45680-403 into the groove of fixture EN 45680-401 (1).

**Fig. 412: View Of Pusher Block**

*Courtesy of GENERAL MOTORS CORP.*
8. Using a ratchet, rotate the threaded shaft of fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) in order to install the cylinder bore sleeve (117) into the engine block (100).
9. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

**Fig. 414: Seating Cylinder Bore Sleeve Completely Using Tool**

Courtesy of GENERAL MOTORS CORP.

10. Using a torque wrench, torque the threaded shaft of the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly to 102 N.m (75 lb ft) in order to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore sleeve flange will protrude above the block deck surface.
Fig. 415: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly (1) from the cylinder block (100).

Cylinder Sleeve Trimming
Fig. 416: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- EN 45680-865 Debris Collector (3)
- EN 45680-411 Trim Tool Assembly (2)
- Air Control Valve (1 - Part of EN 45680-411)
- Drill Motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction
Fig. 417: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- Trim Tool Preloader (1)
- EN 45680-412 Set Gage Ring (2)
- EN 45680-413 Metal Shavings Catch Plug (3)
- EN 45680-866 Drive Adapter (4)
- EN 45680-414 Bolts (5)

NOTE: Do not bore or hone the cylinder bore sleeve. The cylinder bore sleeve inside diameter (I.D) is fully machined and honed to size and is optimally finished as shipped. Any attempt to modify this factory-produced sizing and finish with additional boring and honing will lead to engine damage, excessive noise or abnormal oil consumption.
1. After installing the NEW cylinder bore sleeve(s) into the engine block, trim the excess material from the cylinder bore sleeve flange.

**NOTE:** Ensure that all the metal particles are collected in order to prevent internal damage to the transaxle or bearings.

2. Place metal shaving catch plug EN 45680-413 into the cylinder bore sleeve to be trimmed. Position the top of the EN 45680-413 approximately 3.0 mm (0.12 in) below the top
surface of the cylinder bore sleeve.

3. Place additional metal shaving catch plugs EN 45680-413 into all remaining cylinder bore sleeves.

Fig. 419: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Installing the metal shaving catch plug deeper than the recommended depth will create a decrease in vacuum system performance. A decrease in vacuum system performance will cause metal shavings to enter the engine and cause engine
failure.

**NOTE:** Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.

4. Ensure that the metal shaving catch plug EN 45680-413 is 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.

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**Fig. 420: Identifying Set Gauge Ring Groove**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Before using trim tool assembly EN 45680-411, the height of the cutting blades must be set to the proper specification. The proper specification is that the cylinder bore sleeve flange must be flush to +0.02 mm (0.0008 in) above the block.
5. The groove side of the set gage ring EN 45680-412 (1) should be positioned upward on a flat surface.

**Fig. 421: View Of Trim Tool Assembly Components And Positioning**

*Courtesy of GENERAL MOTORS CORP.*

**IMPORTANT:** Ensure that the set gage ring EN 45680-412 surfaces are clean.
7. Loosen the shaft collar screw (2).
8. Push the shaft collar (2) downward using the trim tool preloader (1) until the shaft collar is positioned against the top of the flange bearing (3).

**IMPORTANT:** Once this procedure is done, it is not necessary to reset the trim tool assembly EN 45680-411 height until the blades are worn or damaged.

9. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw.

**Tighten:** Tighten the shaft collar screw to 19 N.m (14 lb ft).
10. Place trim tool assembly EN 45680-411 onto the cylinder to be trimmed with the directional arrow (1) pointing in line with the crankshaft centerline and the front of the block.

11. Install the 4 bolts EN 45680-414 (2) into the cylinder head bolt holes in the block.

**Tighten:** Tighten the bolts to 20 N.m (15 lb ft).
12. Fasten drive adapter EN 45680-866 (1) into the drill chuck.

**NOTE:** For proper tool operation, a drill motor with a 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction must be used. If the proper drill motor is not used, damage to the cylinder bore sleeve will occur.
NOTE: Ensure that there are no crimps in the air feed hose or the vacuum hose. Crimps in the hose may cause metal shavings to exit the cutting tool in any direction, causing engine damage.

13. Connect a compressed air supply (75-125 psi) to the male quick connect (3) located on trim tool assembly EN 45680-411. Turn the compressed air valve (2) to the open position. This starts the venturi vacuum system that will catch the metal shavings.

14. Place drive adapter EN 45680-866 and drill assembly (1) vertically onto the drive adapter end of trim tool assembly EN 45680-411. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, gradually apply downward force until the cutting action is complete in approximately 5 seconds.

15. Remove drive adapter EN 45680-866 (1) and drill assembly from the trim tool assembly EN 45680-411.

16. Turn off the compressed air valve (2).

17. Remove trim tool assembly EN 45680-411 from the engine block.

18. Remove any material shavings that may be found on the metal shaving catch plug EN 45680-413.

19. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug EN 45680-413.
20. Install a straight edge on the cylinder block perpendicular to the crankshaft center line.

21. Using a light, illuminate the backside of the straight edge.
22. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder bore sleeve flange. If light is present of either side or both sides of the cylinder bore sleeve, the cylinder bore sleeve is cut incorrectly and a new cylinder bore sleeve needs to be installed.
23. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.

24. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

PISTON AND CONNECTING ROD ASSEMBLE

Tools Required

**J 43654** Piston Pin Retainer Remover/Installer. See *Special Tools*. 
Fig. 427: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the piston pin with clean engine oil.
2. Install one of the piston pin retainers into the retainer groove.
Fig. 428: View Of Piston Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Install the connecting rod and piston pin. Push the piston pin in until it bottoms against the installed piston pin retainer.
Fig. 429: View Of Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

4. Install the second piston pin retainer.
Fig. 430: Installing Piston Rings  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The piston ring end gaps must be staggered 90 degrees apart.

**NOTE:** Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

5. Install the following components of the bottom ring assembly (oil control ring).
1. The expander
2. The lower oil control ring
3. The upper oil control ring

Fig. 431: Installing Middle Ring (Compression Ring)
6. Install the middle ring (compression ring) with the napier groove facing down.
7. Install the top ring.

CAMSHAFTS CLEANING AND INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator Set

1. Clean the camshafts with cleaning solvent.
2. Inspect the camshafts for the following conditions:
   - Scored camshaft journals

Fig. 432: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.
- Damaged camshaft lobes
- Damaged camshaft sprocket locator slots
- Damaged threads

3. Measure the camshaft lobes using a micrometer. The intake camshaft lobes should be a minimum of 41.5 mm (1.635 in). The exhaust camshaft lobes should be a minimum of 41 mm (1.615 in).

![Fig. 433: Measuring Camshaft Runout & Lobe Lift](courtesy of GENERAL MOTORS CORP.)

4. Use J 7872 to measure the camshaft runout.
   1. Set the camshaft in V-blocks between the centers.
   2. Measure the intermediate camshaft journal.

5. Use J 7872 to measure the camshaft lobe lift.
   1. Lubricate the camshaft to V-block contact areas with engine oil.
   2. Set the camshaft on V-blocks.
   3. Measure the camshaft lobe lift.

6. If the runout or camshaft lobe lift is not within specifications, replace the camshaft.
TIMING CHAIN AND SPROCKETS CLEANING AND INSPECTION

1. Inspect the timing chain sprockets for cracks or teeth that are worn, broken, or chipped.
2. Inspect the dowel pin for wear or damage.
3. Inspect the timing chain for binding or stretching.
4. Inspect the crankshaft sprocket keyway and locating dowel pin in the crankshaft for damage.

Fig. 434: Timing Chain and Sprockets
Courtesy of GENERAL MOTORS CORP.
5. Inspect the timing chain shoe and guide for excessive wear or cracks.
6. Inspect the timing chain tensioner for damage.
7. Replace the timing chain and sprockets if damaged.

VALVE ROCKER ARM AND VALVE LASH ADJUSTER CLEANING AND INSPECTION

Fig. 435: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

1. Clean the valve rocker arms and valve lash adjusters in cleaning solvent.
2. Dry the valve rocker arms and valve lash adjusters with compressed air.
3. Inspect the valve rocker arms for the following conditions:
   - Excessive wear at the valve contact or valve lash adjuster socket area
   - A loose or damaged pin
   - A worn or damaged roller. The roller should rotate freely with no binding or
Fig. 436: View Of Valve Lash Adjuster
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep the valve rocker arms and valve lash adjusters in the order from where they were removed.
4. Inspect the valve lash adjusters for the following conditions:
   - Excessive wear
   - Clogging of the oil passage
   - Damage
   - Collapsed or spongy

CYLINDER HEAD DISASSEMBLE

Tools Required

- J 8062 Valve Spring Compressor. See Special Tools.
- J 42037 Valve Spring Compressor Adapter. See Special Tools.
- J 38820 Valve Stem Seal Remover/Installer. See Special Tools.
Fig. 437: Installing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.
2. Remove the A.I.R. injection pipe cover studs.
3. Remove the A.I.R. injection pipe cover and gasket.
Fig. 439: Using J 8062 & J 42037 To Compress Valve Spring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Organize the valve train components when disassembling so they can be reassembled in the same location and matched up with the same components as previously installed.

4. Use **J 8062** (2) and **J 42037** (1) to compress the valve spring. See *Special Tools*. 
Fig. 440: View Of Valve Keys
Courtesey of GENERAL MOTORS CORP.

5. Remove the valve keys.

7. Remove the valve spring retainer and valve spring.
8. Remove the valves.
Fig. 443: Removing Valve Stem Seals  
Courtesy of GENERAL MOTORS CORP.

9. Use J 38820 to remove the valve seals. See Special Tools.
Fig. 444: View Of Water Jacket Plug
Courtesy of GENERAL MOTORS CORP.

10. Inspect the water jacket plug, for leakage. Replace if necessary.
11. Inspect the (inner) oil gallery plug, for leakage. Replace if necessary.
12. Inspect the (end) oil gallery plugs, for leakage. Replace if necessary.

CYLINDER HEAD CLEANING AND INSPECTION

Tools Required

J 9666 Valve Spring Tester
Fig. 447: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surface. Inspect for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. The following conditions may cause gasket failure:
   - Improper installation
   - Warped cylinder head
   - Missing or not fully seated dowel pins
   - Low torque on the cylinder head bolts
   - Incorrect length cylinder head bolts
   - A warped engine block surface
   - Scratched surfaces
   - Foreign material
3. Clean the following components:
   - The gasket surfaces
   - Valve stems and valve heads
   - The bolt hole threads

   Remove all dirt, debris, or threadlocking material from the bolt holes.

4. Inspect the cylinder head mating surfaces for flatness. Use a feeler gauge and a straight edge.
5. Replace the cylinder head if warped more than 0.08 mm (0.003 in).
6. Inspect the cylinder head for cracks.

   **IMPORTANT:** Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head. Minor nicks may be repaired with a fine flat file or emery cloth.

7. Inspect the cylinder head deck for corrosion.
8. Inspect the valve springs for squareness.
9. Use J 9666 to measure the valve spring tension. Replace the valve spring if the tension is not within specification.
10. Inspect the valve guides for wear. The valve guides may be reamed oversized 0.075 mm (0.003 in) and oversized stemmed valves may be installed. The same size valve seal should be used.

11. Inspect the valve seats for excessive wear, damage, or hot spots.

12. Use the following procedure to measure the valve seat concentricity:
1. Lift the valve off the valve seat.
2. Apply a dab of blue dye to the valve face.
3. Seat and rotate the valve. The blue dye traces transferred to the valve seat are an indication of concentricity of the valve seat.

13. Use the following procedure to measure the valve runout:
   1. Clean off the blue dye.
   2. Apply blue dye to the valve seat.
   3. Seat and rotate the valve.
   4. The traces of blue dye transferred to the valve indicates valve runout.

14. Replace the head if the valve seats are damaged.
15. Inspect the valves for the following damage:
   - Grooving (1, 2)
   - Bent valve stem (3). Replace any bent valve.
   - Burrs or scratches (4). Minor burrs or scratches may be removed with a fine oil stone.
   - Chipped or worn key grooves (5). Replace if damaged.
   - Valve tip wear (6). Replace if worn.

CYLINDER HEAD ASSEMBLY

Tools Required

- J 8062 Valve Spring Compressor. See Special Tools.
- J 42037 Valve Spring Compressor Adapter. See Special Tools.
- J 38820 Valve Stem Seal Remover/Installer. See Special Tools.

1. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the threads.

   NOTE: Refer to Fastener Notice in Cautions and Notices.
Fig. 451: Oil Gallery Plugs  
Courtesy of GENERAL MOTORS CORP.

2. Install the (end) oil gallery plugs.

Tighten: Tighten the oil gallery plugs to 38 N.m (28 lb ft).
3. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the plugs.
4. Install the (inner) oil gallery plugs.
5. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the plug.
6. Install the water jacket plug.
Fig. 454: Removing Valve Stem Seals
Courtesy of GENERAL MOTORS CORP.

7. Use J 38820 to install the valve seals. See Special Tools. There is only one size valve seal.
Fig. 455: View Of Valves
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Lubricate the valve stems with clean engine oil before installing.

8. Install the valves. 0.075 mm (0.003 in) oversized valves are available if the valve guides needed to be reamed. Use the same (original size) valve seal.
9. Install the valve spring and the valve spring retainer.
Fig. 457: Using J 8062 & J 42037 To Compress Valve Spring
Courtesy of GENERAL MOTORS CORP.

10. Use **J 8062** (2) and **J 42037** (1) to compress the valve spring. See **Special Tools**.
11. Install the valve keys.
13. Measure the valve installed height using a ruler. Measure from the base of the valve spring to the top of the valve. Refer to **Engine Mechanical Specifications**.
14. Install the remaining valves, springs, and other components.
15. Install the spark plugs.

**Tighten:** Tighten the spark plugs to 18 N.m (13 lb ft).

**IMPORTANT:** Do not try to centralize the electrode on the spark plug. The electrode is offset by design.
17. Install the A.I.R. injection pipe cover.
18. Install the A.I.R. injection pipe studs.

**Tighten:** Tighten the studs to 25 N.m (18 lb ft).

**CAMSHAFT COVER CLEANING AND INSPECTION**
1. Remove and discard the rubber ignition coil seals, and the camshaft cover seal.
2. Clean the camshaft cover with a suitable cleaning solvent.
3. Inspect the camshaft cover for cracks or damage.
4. Inspect the bolt threads for damage.
5. Replace the camshaft cover if necessary.

**OIL PUMP CLEANING AND INSPECTION**
Fig. 463: Measuring Inner Oil Pump Gear Tip Clearance
Courtesy of GENERAL MOTORS CORP.

1. Clean all parts of sludge, oil, and varnish by soaking in carburetor cleaner or cleaning solvent.
2. Inspect for foreign material and determine the source of the foreign material.
3. Inspect the oil pump housing and engine front cover for the following conditions:
   - Cracks or casting imperfections
   - Scoring
4. Do not attempt to repair the oil pump housing. Replace the oil pump housing if damage is found.
5. Inspect the oil pump gears for damage.
6. Measure the inner oil pump gear tip clearance in several places.

Fig. 464: Measuring Outer Oil Pump Gear Diameter Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the outer oil pump gear tip clearance in several places.
8. Measure the oil pump gear side clearance.
9. Inspect the pressure regulator valve for the following conditions:
   - Scoring
   - Sticking
   - Burrs - Burrs may be removed using a fine oil stone.

**IMPORTANT:** When deciding oil pump serviceability based on end clearance, consider depth of the wear pattern in the pump cover.
10. Inspect the pressure regulator valve spring for loss of tension or bending. Replace the pressure regulator spring if damaged.

11. Inspect the oil pump pipe pickup tube and screen assembly for the following conditions:
   - Looseness - If the oil pump pipe pickup tube is loose or bent, replace the oil pump pipe pickup tube.
   - Broken wire mesh or screen
   - Inspect the O-ring seal at the base of the oil pump pickup tube for damage.

OIL PAN CLEANING AND INSPECTION

![Fig. 466: Inspecting Oil Pan](https://example.com/fig466.png)

1. Clean the oil pan in solvent. Remove all sludge and debris from the oil pan.

   **IMPORTANT:** Do not use a motorized tool or bristle disc to clean this component.
2. Remove all sealing material from the oil pan rails.
3. Inspect the oil pan sealing surfaces for nicks or damage. Remove any minor nicks with a fine flat file.
4. Inspect the threads in the oil drain plug hole.
5. Replace the oil pan if necessary.

ENGINE FRONT COVER CLEANING AND INSPECTION
1. Clean the engine front cover with cleaning solvent.

**IMPORTANT**: Do not use a motorized tool or bristle disc to clean this
2. Remove all sealing material.
3. Inspect the engine front cover sealing surfaces for nicks or damage. Use a fine flat file to remove any minor nicks.
4. Inspect the engine front cover threaded holes for damage.
5. Repair or replace the engine front cover as necessary.

INTAKE MANIFOLD CLEANING AND INSPECTION

1. Clean the intake manifold gasket mating surface.

Fig. 468: Inspecting Intake Manifold
Courtesy of GENERAL MOTORS CORP.
2. Inspect the threads on the retaining bolts.
3. Inspect the intake manifold for cracks.
4. Clean the internal ports of all debris.
5. Replace the intake manifold if necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

1. Clean the exhaust manifold.
2. Inspect the exhaust manifold for cracks or damage.
3. Inspect the exhaust manifold threads and studs (if necessary).
Fig. 470: Checking Exhaust Manifold Mating Surface For Flatness Courtesy of GENERAL MOTORS CORP.

4. Check the exhaust manifold mating surface for flatness. Use a straight edge and a feeler gage.
5. Replace the exhaust manifold if necessary.

WATER PUMP CLEANING AND INSPECTION
Fig. 471: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove all sealing material from the sealing surface.
2. Inspect the water pump impeller for damage.
3. Inspect the water pump shaft for looseness.
4. Inspect the threads for damage.
5. Replace the water pump if necessary.

THREAD REPAIR

Tools Required
- **J 42385-400** Thread Repair Kit. See **Special Tools**.
- **J 43965** Extension Kit. See **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.

*Fig. 472: View Of J 42385-400 Tool Kit*  
*Courtesy of GENERAL MOTORS CORP.*

The tool kit **J 42385-400** is designed for use with either a suitable tap wrench or drill motor. See **Special Tools**.
**Special Tools.** Limited access and larger hole repair may process better using a tap wrench. An extension **J 43965** may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. See **Special Tools.**

![Fig. 473: Drilled Hole Centerline](image)

**Fig. 473: Drilled Hole Centerline**
Courtesy of GENERAL MOTORS CORP.

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.
During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.
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.

### Thread Repair

<table>
<thead>
<tr>
<th>Tap Size</th>
<th>Tap Guide</th>
<th>Tape Size</th>
<th>Tape Guide</th>
<th>Tap Size</th>
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<td>-</td>
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<td>12 x 1.5</td>
<td>732</td>
<td>20 x 1.5</td>
<td>737</td>
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</tbody>
</table>
CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.
When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

Fig. 477: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.
1. Drill out the threads of the damaged hole.
   - 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).

   IMPORTANT:
   - 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.

   IMPORTANT: All chips must be removed from the drilled hole prior to tapping.
2. Using compressed air, clean out any chips.
3. Counterbore the drilled hole to the full depth permitted by the tool (1).

**IMPORTANT:** A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

4. Using compressed air, clean out any chips.

**IMPORTANT:** All chips must be removed from the drilled hole prior to tapping.

**Fig. 480: Cleaning Out Metal Chips**
Courtesy of GENERAL MOTORS CORP.

4. Using compressed air, clean out any chips.
Fig. 481: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: • During the tapping process, it is necessary to repeatedly
remove the tap and clean chips from the hole and the flutes of the tap.

- Ensure 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.
   - 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. 482: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.
6. Using compressed air, clean out any chips.

7. Spray cleaner GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

Fig. 483: Spraying Cleaner Into Tapped Hole  
Courtesy of GENERAL MOTORS CORP.
Fig. 484: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.
9. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

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

Fig. 485: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.
10. Install the insert (2) onto the driver installation tool (1).
Fig. 487: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock sealant GM P/N 12345493 (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).
12. Install the insert (2) into the tapped hole.
Fig. 489: Installing Insert - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 improper tapping.

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.
14. Continue to rotate the driver installation tool (1) through the insert (2).

**Fig. 491: View Of Bushing Type Insert & Base Material**

Courtesy of GENERAL MOTORS CORP.

15. Inspect the insert for proper installation into the tapped hole. A properly installed insert (1)
will be either flush or slightly below flush with the surface of the base material (2).

![Diagram](image)

**Fig. 492: View Of Restricted Engine Coolant Passages - Standard Thread Repair**

**Courtesy of GENERAL MOTORS CORP.**

16. 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. 493: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT:

- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.
- Do NOT remove the original stop collar from a counterbore drill.

When installed to the proper depth, the flange of the insert (1) will be seated against the
counterbore (2) of the drilled/tapped hole.

Fig. 494: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

1. Install a stop collar (2) on the counterbore drill (1), if required.
Fig. 495: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
2. Drill out the threads of the damaged hole.

Fig. 496: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.
Fig. 497: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:  • During the tapping process, it is necessary to repeatedly
4. Using a suitable tapping wrench, tap the threads of the drilled hole.

* Ensure the tap has created full threads at least to the depth equal to the insert length.

5. Using compressed air, clean out any chips.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.
6. Spray cleaner GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.
Fig. 500: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.
Fig. 501: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT**: 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) J 42385-110.
9. Install the insert (2) onto the driver installation tool (1).
10. Apply threadlock sealant GM P/N 12345493 (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).
Fig. 504: Installing Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole.
Fig. 505: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 improper tapping.

12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

Fig. 506: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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).

14. Inspect the insert (1) for proper installation (2) into the tapped hole.
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

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.
CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.
Fig. 510: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
1. Drill out the threads of the damaged hole.

2. Using compressed air, clean out any chips.

**Fig. 511: Cleaning Out Metal Chips**
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: All chips must be removed from the drilled hole prior to tapping.**

2. Using compressed air, clean out any chips.
Fig. 512: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: • During the tapping process, it is necessary to repeatedly
3. Using a suitable tapping wrench, tap the threads of the drilled hole.

- Ensure the tap has created full threads at least to the depth equal to the insert length.

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the flutes of the tap.

Fig. 513: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS CORP.
base material.

Fig. 514: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.
6. Spray cleaner GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.
Fig. 516: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.
8. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

**Fig. 517: Lubricating Installer Tool Using Driver Oil**

**Courtesy of GENERAL MOTORS CORP.**

**IMPORTANT:** Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.
Fig. 518: View of Bushing Type Insert  
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).
Fig. 519: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493 (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).
11. Install the insert (2) into the tapped hole.
Fig. 521: Installing Insert - Tapered Pipe Thread Repair  
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately.
12. Install the insert until the flange (2) of the insert contacts the surface of the base material.
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. 523: Inspecting Insert For Proper Installation - Tapered Thread**

14. Inspect the insert (1) for proper installation (2) into the tapped hole.
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

**Fig. 524: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair**

*Courtesy of GENERAL MOTORS CORP.*
Fig. 525: View Of Cylinder Head Bolt Hole Required Tools
Courtesy of GENERAL MOTORS CORP.

The cylinder head bolt hole required tools consist of the following:

- Drill (1) J 42385-402
• Tap (2) J 42385-403
• Installation driver (3) J 42385-404
• Alignment pin (4) J 42385-303
• Bushing (5) J 42385-302
• Bolts (6) J 42385-421
• Fixture plate (7) J 42385-401

**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

**IMPORTANT:**
• Remove the fixture plate prior to installing the insert with the installer tool.
• The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.
Fig. 526: View Of Bushing, Fixture Plate, Bolts & Bolt Hole
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.
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. 528: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.

6. Drill out the threads of the damaged hole.
Fig. 529: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.
8. Using a suitable tapping wrench, tap the threads of the drilled hole.

**IMPORTANT:**
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.
Fig. 531: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the first mark (1) on the tap aligns with the top of the drill bushing (3).
Fig. 532: View Of Bushing, Fixture Plate, Bolts & Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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. 533: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.
14. Using compressed air, clean out any chips.
15. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

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

Fig. 536: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.
16. Install the insert (2) onto the driver installation tool (1).
17. Apply threadlock sealant GM P/N 12345493 (Canadian P/N 10953488), J 42385-109, LOCTITE 277®, or equivalent (1) to the insert OD threads (2).
18. Install the insert and installation driver (1) into the tapped hole.
19. Start the insert into the threaded hole.

**IMPORTANT:** 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 improper tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

**IMPORTANT:** 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.
22. Inspect the insert for proper installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair
IMPORTANT:

- 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 required tools consist of the following:
CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT:

- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid GM P/N United States 1052864, GM P/N Canada 992881, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.
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.
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. 543: Drilling Out Threads Of Damaged Hole - Crankshaft Main Bolt Hole Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- 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. 544: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.
Fig. 545: Tapping Threads Using Tapping Wrench - Crankshaft Main Bolt Hole Thread Repair
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**
- 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.
- Ensure 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.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

Fig. 546: View Of Fixture Plate, Drill Bushing & Tool Marking Courtesy of GENERAL MOTORS CORP.
Fig. 547: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.
11. Spray cleaner GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.
Fig. 549: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.
13. Lubricate the threads of the driver installation tool (2) with the driver oil (1) J 42385-110.

**IMPORTANT:**
- Do not remove the fixture plate, ensure 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.

Fig. 550: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.
14. Install the insert (2) onto the driver installation tool (1).

Fig. 551: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.
15. Apply threadlock sealant GM P/N 12345493 (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).
16. Install the insert and installation driver (1) into the tapped hole.
17. Start the insert into the threaded hole.

**IMPORTANT:** 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 improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.
IMPORTANT: 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.
20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

21. Inspect the insert for proper installation into the tapped hole.
22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

SERVICE PRIOR TO ASSEMBLY

Dirt will cause premature wear of the rebuilt engine. Clean all of the components. Use the proper tools in order to measure components when inspecting for excessive wear. Repair or replace the components that are not within the manufacturers specification. When components are reinstalled into an engine, return the components to their original location, position, and direction. During assembly, lubricate all of the moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started.

BALANCE SHAFT BEARING INSTALLATION

Tools Required

J 44225 Balance Shaft Bearing Remover/Installer
Position the cylinder block so the cylinder head deck face is down and identify the following:

- The left balance shaft bearings are in the shorter length balance shaft journal (3) and (4).
- The right balance shaft - grooved bearings are in the longer length balance shaft journal (1) and (2).
Identify the following:

- Bearings (2) and (3) are the front bearings and bearings (1) and (4) are the rear bearings.
- The rear bearings (1) and (4) have a slightly larger diameter than the front bearings (2) and (3). This allows for easier removal and installation of the front bearings. The rear bearings also have notches on them for identification purposes.
Fig. 558: Installing Right Balance Shaft Bearing
Courtesy of GENERAL MOTORS CORP.

1. Install the new right front balance shaft bearing onto J 44225 (2).
2. Install J 44225 into the balance shaft bearing bore and align the front bearing.
3. Turn the threaded rod clockwise until the guide (1) is seated into the rear journal.
4. Install and tighten the balance shaft mounting bolt (1) to hold J 44225.
5. Turn the threaded rod clockwise until it bottoms to install the right front balance shaft.
bearing to the proper depth.

6. Remove the balance shaft mounting bolt and J 44225.

7. Install the new right rear balance shaft bearing onto J 44225 (2).

8. Install J 44225 into the balance shaft bearing bore and align the rear bearing.

9. Turn the threaded rod clockwise until the guide (1) is seated into the rear journal.
10. Install and tighten the balance shaft mounting bolt (1) to hold **J 44225**.
11. Install J44225 - spacer (2) between the guide (3) and the washer (1).
12. Turn the threaded rod clockwise until it bottoms to install the right rear balance shaft bearing to the proper depth.
Fig. 563: Removing Right Balance Shaft Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

13. Remove the balance shaft mounting bolt (1) and J44225.
14. Install the new left front balance shaft bearing onto **J 44225** (2).

15. Install **J 44225** into the balance shaft bearing bore and align the front bearing.

16. Turn the threaded rod clockwise until the guide (1) is seated into the rear journal.

---

**Fig. 564: Installing Left Balance Shaft Bearing**

Courtesy of GENERAL MOTORS CORP.
17. Install and tighten the balance shaft mounting bolt (1) to hold J 44225.
18. Turn the threaded rod clockwise until it bottoms to install the left front balance shaft bearing to the proper depth.
19. Remove the balance shaft mounting bolt (1) and J 44225.
20. Install the new left rear balance shaft bearing onto J 44225 (2).
21. Install J 44225 into the balance shaft bearing bore and align the rear bearing.
22. Turn the threaded rod clockwise until the guide (1) is seated into the rear journal.
Fig. 567: Installing Left Balance Shaft Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

23. Install and tighten the balance shaft mounting bolt (1) to hold J 44225.
24. Install **J 44225** - spacer (2) between the guide (3) and the washer (1).

25. Turn the threaded rod clockwise until it bottoms to install the left rear balance shaft bearing to the proper depth.

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**Fig. 568: Installing J 44225-Spacer Between Guide & Washer - Left**

*Courtesy of GENERAL MOTORS CORP.*
Fig. 569: Removing Left Balance Shaft Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

26. Remove the balance shaft mounting bolt (1) and J 44225.

ENGINE BLOCK PLUG INSTALLATION
1. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the plug threads.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the engine block coolant plug.

**Tighten:** Tighten the engine block coolant plug to 50 N.m (37 lb ft).
3. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the plug threads.
4. Install the engine block oil gallery plugs to front and left of block.

**Tighten:**
- Tighten the side engine block oil gallery plugs to 35 N.m (26 lb ft).
- Tighten the front (1) engine block oil gallery plug to 80 N.m (40 lb ft).
5. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the coolant temperature sensor threads.

6. Install the coolant temperature sensor.

**Tighten:** Tighten the coolant temperature sensor to 16 N.m (12 lb ft).
7. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the EVAP solenoid bolt threads.

**Tighten:** Tighten the EVAP solenoid bolt to 10 N.m (89 lb in).
Fig. 574: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

8. Install the knock sensors.

**Tighten:** Tighten the knock sensors to 25 N.m (18 lb ft).
9. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the crankshaft position sensor bolt.

10. Install the crankshaft position sensor and bolt.

**Tighten:** Tighten the crankshaft position sensor bolt to 10 N.m (89 lb in).
11. Install the oil pressure switch.

**Tighten:** Tighten the oil pressure switch to 20 N.m (15 lb ft).

**CLUTCH PILOT BEARING INSTALLATION**

**Tools Required**

**J 45949** Pilot Bearing and Flywheel Locator Installer. See [Special Tools](#).
Install J 45949 into the pilot bearing. See Special Tools.
2. Install the pilot bearing into the crankshaft.

AUTOMATIC TRANSMISSION FLYWHEEL LOCATOR INSTALLATION

Tools Required

J 45949 Pilot Bearing and Flywheel Locator Installer. See Special Tools.
Fig. 578: View Of Flywheel Locator
Courtesy of GENERAL MOTORS CORP.

1. Install J 45949 into the flywheel locator. See Special Tools.
2. Install the flywheel locator into the crankshaft.

CRANKSHAFT AND BEARINGS INSTALLATION

Tools Required

J 45059 Angle Meter. See Special Tools.
Fig. 579: View Of Upper Crankshaft Main Bearing Halves
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft main bearings into the block.
Fig. 580: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the upper crankshaft main bearing surface with clean engine oil.
3. Install the crankshaft.
4. Install the lower crankshaft main bearings into the main bearing caps.
5. Lubricate the lower crankshaft main bearing surface with clean engine oil.
6. Install the crankshaft main bearing caps.

**IMPORTANT:** Refer to the pin stamp on the crankshaft main bearing caps for sequence and direction of installation.
Fig. 582: View Of Crankshaft Main Bearing Cap Stiffener
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The crankshaft main bearing cap stiffener is directional. The end marked front goes to the front.

7. Install the crankshaft main bearing cap stiffener.
8. Install new crankshaft main bearing bolts. Start the crankshaft main bearing cap bolts by hand. Ensure the bottom of the crankshaft main bearing cap is parallel to the block surface.
Fig. 584: Installing Crankshaft Main Bearing Cap Bolts
Courtesey of GENERAL MOTORS CORP.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

9. Tighten the crankshaft main bearing cap bolts in equal increments.

**Tighten:**
1. Tighten the crankshaft main bearing cap bolts to 25 N.m (18 lb ft) in sequence.
2. Use **J 45059** to tighten the crankshaft main bearing cap bolts an additional 180 degrees. See **Special Tools**.
Fig. 585: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft end play.
   1. Thrust the crankshaft forward or rearward.
   2. Insert a feeler gage between the thrust crankshaft bearing and the bearing surface of
      the crankshaft and measure the bearing clearance. Refer to Engine Mechanical
      Specifications for the proper clearance.
   3. If the bearing clearance is not within specifications, inspect the thrust surfaces for
      nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION
Tools Required

- **J 41556** Connecting Rod Guide. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.
- **EN-47701** Piston Ring Compressor. See Special Tools.

Fig. 586: View Of Connecting Rods & Caps
Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft so the connecting rod journal for the piston being installed is at Bottom Dead Center.
2. Lubricate the cylinder wall with engine oil.
3. Lubricate the piston and rings with engine oil.
4. Stagger the ring end gaps 90 degrees apart.
5. Use EN-47701 to compress the rings. See Special Tools.
6. Install the connecting rod bearings into the connecting rods and caps (1).
7. Lubricate the connecting rod bearing contact surfaces with engine oil.
8. Install the J 41556 into the connecting rod. See Special Tools.
Fig. 588: View Of Piston Alignment Mark & Flat Casting Boss
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore. The piston alignment mark MUST face the front of the engine block (1) or the flat casting boss (2).
9. Install the connecting rod and piston into the proper cylinder bore.

![Fig. 589: Installing Piston](image)

Fig. 589: Installing Piston  
Courtesy of GENERAL MOTORS CORP.

10. Hold EN-47701 firmly against the engine block. See Special Tools. Using a wooden hammer handle, lightly tap the top of the piston until all of the piston rings enter the cylinder bore.
11. Guide the connecting rod end onto the crankshaft journal.

   Use J 41556 to pull the connecting rod into place. See Special Tools.

12. Install the connecting rod bearing, cap, and bolts.

Fig. 590: View Of Connecting Rod, Cap & Bolts
Courtesy of GENERAL MOTORS CORP.
Tighten:
1. Tighten the connecting rod bearing cap bolts on the first pass to 25 N.m (18 lb ft).
2. Use J 45059 to tighten the connecting rod bearing cap bolts on the second pass an additional 110 degrees. See Special Tools.

Fig. 591: Tapping Connecting Rod Assembly Parallel To Crankshaft
Courtesy of GENERAL MOTORS CORP.

13. With the pistons and connecting rods installed, use a soft faced mallet and lightly tap each connecting rod assembly parallel to the crankshaft.
14. Measure the connecting rod side clearance using a feeler gauge. Connecting rod side clearance should be between 0.05-0.35 mm (0.0019-0.0137 in).

BALANCE SHAFT INSTALLATION

Fig. 592: View Of Balance Shafts
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Do not disassemble the balance shaft assemblies. Remove and install the balance shafts as complete assemblies.

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

**NOTE:** Refer to Fastener Notice in Cautions and Notices.
3. Install NEW left balance shaft assembly retaining bolts.

**Tighten:** Tighten the NEW left balance shaft assembly retaining bolts to 10 N.m (89 lb in).

![View Of Balance Shaft Chain Guide](Courtesy of GENERAL MOTORS CORP.)

4. Install the balance shaft chain guide.
5. Install the balance shaft chain guide bolts.

**Tighten:** Tighten the balance shaft chain guide bolts to 10 N.m (89 lb in).
Fig. 594: View Of Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Rotate the right balance shaft retainer plate counterclockwise to allow chain installation over all 3 sprockets.

6. Install the balance shaft chain onto the balancer sprockets and crankshaft sprocket.
7. Rotate the crankshaft until the left hand balance shaft sprocket timing mark is at 12:00. The right hand balance shaft sprocket timing mark should be at 2:30. The crankshaft sprocket mark should be at 4:30. Make sure the 3 timing marks on the sprockets (1) line up with a dark link on the chain. Every 11 crankshaft rotations, 3 of the 5 dark links on the chain will line up with the timing marks.

8. Rotate the retainer plate clockwise while holding the chain onto the crankshaft sprocket.
9. Install NEW right balance shaft assembly retaining bolts.

**Tighten**: Tighten the NEW right balance shaft assembly retaining bolts to 12 N.m (106 lb in).

10. Install the balance shaft chain tensioner and bolts.

**Tighten**: Tighten the balance shaft chain tensioner bolts to 10 N.m (89 lb in).
**IMPORTANT:** Do not force the tensioner to the next notch by pushing up on the tensioner shoe. This will over-tension the chain and may result in a whine noise.

11. Remove the small tool from the link plate hole in order to regain chain tension.

**CYLINDER HEAD INSTALLATION**

**Tools Required**

**J 45059** Angle Meter. See **Special Tools**.

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**Fig. 597: View Of Cylinder Head Gasket**
1. Install the dowel pins - cylinder head locator, if necessary.
2. Install a new cylinder head gasket.

3. Install the cylinder head.

Fig. 598: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.
4. Install new cylinder head bolts.
5. Tighten the new cylinder head bolts in the following sequence:

**Tighten:**
1. Tighten the (12) long cylinder head bolts in sequence to 30 N.m (22 lb ft).
2. Use J 45059 to tighten the cylinder head bolts in sequence an additional 155 degrees. See Special Tools.
3. Tighten the (2 Short) end bolts to 7 N.m (62 lb in).

   Use **J 45059** to tighten the short cylinder head end bolts an additional 60 degrees. See Special Tools.

4. Tighten the (1 Long) end bolt to 7 N.m (62 lb in).

   Use **J 45059** to tighten the long cylinder head end bolt an additional 120 degrees. See Special Tools.

**VALVE ROCKER ARM AND VALVE LASH ADJUSTER INSTALLATION**

![Fig. 601: View Of Valve Lash Adjusters](image)

_Courtesy of GENERAL MOTORS CORP._

1. Lubricate and fill the valve lash adjusters with engine oil.
2. Install the valve lash adjusters in their original locations.

Fig. 602: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve rocker arm.
4. Install the valve rocker arms in their original locations.

CAMSHAFT INSTALLATION

Tools Required

J 44221 Camshaft Holding Tool. See Special Tools.
Fig. 603: View Of Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Coat the camshaft journals, camshaft journal thrust face, and camshaft lobes with clean engine oil.
2. Install the exhaust camshaft.
3. Install the intake camshaft.
Fig. 604: Installing J 44221 To Camshafts
Courtesy of GENERAL MOTORS CORP.

4. Install J 44221 with the camshaft flats up and the number 1 cylinder at top dead center. See Special Tools.
5. Install the exhaust camshaft caps.
6. Install the intake camshaft caps.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.
7. Install the camshaft cap bolts. Tighten the bolts evenly in order to compress the valve springs before final torque.

**Tighten:** Tighten the camshaft cap bolts to 12 N.m (106 lb in).

8. Remove J 44221. See **Special Tools**.

**ENGINE LIFT BRACKET INSTALLATION**

![Fig. 606: Installing Engine Lift Bracket](image)

*Courtesy of GENERAL MOTORS CORP.*
1. Install the engine lift bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine lift bracket bolts in sequence.

Tighten:
- Tighten the engine lift bracket bolts a first pass in sequence to 5 N.m (44 lb in)
- Tighten the engine lift bracket bolts a final pass in sequence to 50 N.m (37 lb ft)

TIMING CHAIN TENSIONER INSTALLATION

Fig. 607: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.
1. Install the timing chain tensioner.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the timing chain tensioner bolts.

   **Tighten:** Tighten the timing chain tensioner bolts to 25 N.m (18 lb ft).

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**Fig. 608: View Of Timing Chain Guide & Bolts**  
Courtesy of GENERAL MOTORS CORP.
3. Install the timing chain tensioner guide.
4. Install the timing chain tensioner guide bolts.

**Tighten:** Tighten the timing chain tensioner guide bolts to 18 N.m (13 lb ft).

5. Install the timing chain tensioner shoe.
6. Install the timing chain tensioner shoe bolt.

**Fig. 609: View Of Timing Chain Tensioner Shoe & Bolt**
*Courtesy of GENERAL MOTORS CORP.*
Tighten: Tighten the timing chain tension shoe bolt to 25 N.m (18 lb ft).

Fig. 610: View Of Cylinder Head Access Hole Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the cylinder head access hole plugs.

Tighten: Tighten the cylinder head access hole plugs to 5 N.m (44 lb in).

TIMING CHAIN AND SPROCKETS INSTALLATION
Tools Required

- J 44221 Camshaft Holding Tool. See Special Tools.
- J 45059 Angle Meter. See Special Tools.

Fig. 611: View Of J 44221 Installed On Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Install J 44221 with the camshaft flats up and the number 1 cylinder at top dead center. See Special Tools. The crankshaft pin should be at 12 o'clock when the number 1 piston is at top dead center.
Fig. 612: Installing Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

2. Compress the tensioner and lock in place.
3. Install the crankshaft sprocket.
4. Install the intake camshaft sprocket into the timing chain.
5. Align the (dark) link of the timing chain with the timing mark on the intake camshaft sprocket (1).
6. Feed the timing chain down through the opening in the head.
7. Install the timing chain onto the crankshaft sprocket. Align the (dark) link of the timing chain with the timing mark on the crankshaft sprocket (2).
8. Install the intake camshaft sprocket onto the intake camshaft.

**IMPORTANT:** It may be necessary to remove J 44221 to rotate and hold the camshaft (hex) to align the pin to the camshaft sprocket. See Special Tools.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

Fig. 613: View Of Intake Camshaft Sprocket Washer & Bolt
Courtesy of GENERAL MOTORS CORP.
9. Install the intake camshaft sprocket washer and new bolt.

   **Tighten:**
   
   - Tighten the new intake camshaft sprocket bolt the first pass to 20 N.m (15 lb ft).
   - Use J 45059 to tighten the intake camshaft sprocket bolt the final pass an additional 100 degrees. See **Special Tools**.

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

11. Align the (dark) link of the timing chain with the timing mark on the exhaust camshaft actuator (1).

   **IMPORTANT:** It may be necessary to remove J 44221 to rotate and hold the camshaft (hex) to align the pin to the camshaft sprocket. See **Special Tools**.

12. Install the exhaust camshaft actuator onto the exhaust camshaft.
Fig. 614: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.
Fig. 615: Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Rotate the camshaft actuator clockwise relative to the camshaft prior to tightening the bolt.
13. Install the new exhaust camshaft actuator bolt.

**Tighten:**
- Tighten the new exhaust camshaft actuator bolt the first pass to 25 N.m (18 lb ft).
- Use J 45059 to tighten the exhaust camshaft actuator bolt the final pass an additional 135 degrees. See Special Tools.

14. Unlock the tensioner.
16. The dark links (1) on the chain should be aligned with marks on sprockets as shown.
17. Install the top chain guide.
18. Add threadlock GM P/N United States 89021297, GM P/N Canada 10953488 to the top chain guide bolt threads.
19. Install the top chain guide bolts.

**Tighten:** Tighten the top chain guide bolts to 10 N.m (89 lb in).
20. Lube the exhaust camshaft position sensor bore with clean engine oil.
21. Install and seat the exhaust camshaft position sensor.
22. Install the exhaust camshaft position sensor bolt.

**Tighten:** Tighten the exhaust camshaft position sensor bolt to 10 N.m (89 lb in).
23. Lube the intake camshaft position sensor bore with clean engine oil.
24. Install and seat the intake camshaft position sensor.
25. Install the intake camshaft position sensor bolt.

**Tighten:** Tighten the intake camshaft position sensor bolt to 10 N.m (89 lb in).

**CAMSHAFT COVER INSTALLATION**
1. Install a new camshaft cover seal.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft cover and bolts.

**Tighten:** Tighten the camshaft cover bolts to 10 N.m (89 lb in).
3. Install new ignition control module seals.
4. Install the ignition control modules and bolts.

**Tighten:** Tighten the ignition control module bolts to 10 N.m (89 lb in).

**CAMSHAFT POSITION ACTUATOR VALVE INSTALLATION**
1. Apply clean engine oil to the camshaft position actuator valve hole.
2. Install the camshaft position actuator valve.
3. Add sealant GM P/N 12378521 (Canadian P/N 88901148) to the camshaft position actuator valve bolt threads.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft position actuator valve bolt.
Tighten: Tighten the camshaft position actuator valve bolt to 10 N.m (89 lb in).

OIL PUMP INSTALLATION

Fig. 623: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pump pressure relief valve plug.
Tighten: Tighten the oil pump pressure relief valve plug to 14 N.m (124 lb in).

3. Install the oil pump outer and inner gears as removed.
4. Install the oil pump cover.
5. Install the oil pump cover bolts.

Tighten: Tighten the oil pump cover bolts to 10 N.m (89 lb in).

ENGINE FRONT COVER INSTALLATION

Tools Required

J 44219 Engine Cover Alignment Pins. See Special Tools.
1. Install the engine front cover spacer bolt.

**Tighten:** Tighten the engine front cover spacer bolt to 10 N.m (89 lb in).
2. Install J 44219. See Special Tools.
3. Remove 2 bolts from the engine front cover in the location of the alignment pins.

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

4. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the block sealing surface (1).
5. Align the oil pump to the crankshaft sprocket splines.
6. Install the engine front cover and bolts.
8. Install the 2 remaining engine front cover bolts.

**Tighten:**

1. Tighten the engine front cover bolts to 10 N.m (89 lb in).
2. Tighten the small center bolt (1) last to 8 N.m (71 lb in).

**Fig. 627: Engine Front Cover**
*Courtesy of GENERAL MOTORS CORP.*

**CRANKSHAFT FRONT OIL SEAL INSTALLATION**
Tools Required

**J 45951** Front Seal Installer. See Special Tools.

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**Fig. 628: Installing Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Apply engine oil to the outside diameter of the crankshaft front oil seal.
2. Use **J 45951** to install a new crankshaft front oil seal. See Special Tools.

WATER PUMP INSTALLATION

Tool Required

J 41240 Fan Clutch Remover and Installer. See Special Tools.

Fig. 629: View Of Water Pump, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW water pump gasket.
2. Install the water pump.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Install the water pump bolts.
**Tighten:** Tighten the water pump bolts to 10 N.m (89 lb in).

4. Install the water pump pulley.
5. Install the water pump pulley bolts.
6. Install J 41240 to hold pulley. See **Special Tools**.
7. Tighten the water pump pulley bolts.

**Tighten:** Tighten the water pump pulley bolts to 25 N.m (18 lb ft).

8. Remove J 41240. See **Special Tools**.

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**Fig. 630: View Of Water Pump Pulley, Bolts & J 41240**

*Courtesy of GENERAL MOTORS CORP.*

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**CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION**
Tools Required

**J 44219** Cover Alignment Pins. See **Special Tools**.

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**Fig. 631: Locating Rear Block Sealing Surface Adhesive**

Courtesy of GENERAL MOTORS CORP.

1. Apply a 3 mm (0.12 in) bead of GM P/N 12378521 (Canadian P/N 88901148) to the rear sealing surface of the block (1).
2. Install J 44219 into the block. See Special Tools.

IMPORTANT: With the help of the plastic installation aid (supplied with the new seal), be sure the lip of the seal faces inward.

3. Slide the crankshaft rear oil seal housing and bolts over the J 44219 and crankshaft, except
the 2 in place of the guide pins. See Special Tools.


5. Snug the crankshaft rear oil seal housing bolts.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

6. Install the remaining two crankshaft rear oil seal housing bolts.

**Tighten:** Tighten the crankshaft rear oil seal housing bolts to 10 N.m (89 lb in).
7. Wipe off any excess material from the bottom of the oil pan sealing area (1).

**Fig. 633: View Of Bottom Of Oil Pan Sealing Area**

*Courtesy of GENERAL MOTORS CORP.*
1. Install a new oil pump pipe gasket.
2. Install the oil pump pipe and screen assembly.
3. Add sealant GM P/N 12378521 (Canadian P/N 88901148) to the oil pump pipe bolt threads.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump pipe and screen assembly bolts.
**Tighten:** Tighten the oil pump pipe and screen assembly bolts to 10 N.m (89 lb in).

**OIL PAN INSTALLATION**

![Fig. 635: View Of Oil Pan Sealant Application](image)

 Courtesy of GENERAL MOTORS CORP.

1. Apply a 5.5 mm (0.22 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent, to the oil pan in areas marked (1).

2. Apply a 3 mm (0.12 in) bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the oil pan area marked (2).
3. Install the oil pan.
4. Install the oil pan bolts.

**IMPORTANT:** The oil pan must be installed within 10 minutes from when the sealer was applied.
5. Check the oil pan alignment. Use a straight edge on the back of the block and oil pan (transmission mounting surface).

**IMPORTANT:** When installing the oil pan, it could be shifted front or back a little which could cause a transmission alignment problem. The back of the oil pan needs to be flush with the block.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

6. Tighten the oil pan bolts.

**Tighten:**
- Tighten the (side) oil pan bolts to 25 N.m (18 lb ft).
- Tighten the (end) oil pan bolts to 10 N.m (89 lb in).

CRANKSHAFT BALANCER INSTALLATION

Tools Required

- J 45059 Angle Meter. See Special Tools.
- J 41478 Crankshaft Balancer Installer. See Special Tools.

Fig. 638: Installing Crankshaft Balancer Using The J 41478
Courtesy of GENERAL MOTORS CORP.

1. Install the friction washer on the back side of the crankshaft balancer.
2. Install the crankshaft balancer using J 41478. See Special Tools.
4. Hold the flywheel or back of the crankshaft. The crankshaft balancer does not have a keyway so the crankshaft could turn when tightening, causing an improper torque.

Fig. 639: View Of Crankshaft Balancer Bolt
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the crankshaft balancer washer and new bolt.

Tighten:

1. Tighten the new crankshaft balancer bolt while holding the back to 150 N.m (110 lb
2. Use J 45059 to tighten the crankshaft balancer bolt an additional 180 degrees. See Special Tools.

FUEL RAIL AND INJECTORS INSTALLATION

Fig. 640: Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the lower injector O-rings with mineral oil GM P/N 9981704.
2. Install the fuel injector rail.
3. Install the fuel injector rail bolts.

**Tighten:** Tighten the fuel injector rail bolts to 10 N.m (89 lb in).

**INTAKE MANIFOLD INSTALLATION**

![Intake Manifold Image]

**Fig. 641: Intake Manifold**
*Courtesy of GENERAL MOTORS CORP.*

1. Install a new intake manifold gasket.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the intake manifold and bolts.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.
**Tighten**: Tighten the intake manifold bolts from the inside out to 10 N.m (89 lb in).

**Fig. 642: View Of Throttle Control Module**
*Courtesy of GENERAL MOTORS CORP.*

3. Install a new throttle control module gasket.
4. Install the throttle control module.
5. Add sealer GM P/N 12378521 (Canadian P/N 88901148) to the throttle control module bolt threads.
6. Install the throttle control module bolts.

**Tighten**: Tighten the throttle control module bolts to 10 N.m (89 lb in).
THERMOSTAT HOUSING INSTALLATION

Fig. 643: View Of Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat housing.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the thermostat housing bolts.

   **Tighten:** Tighten the thermostat housing bolts to 10 N.m (89 lb in).
HEATER INLET PIPE INSTALLATION

Fig. 644: View Of Heater Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the heater inlet pipe.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the heater inlet pipe bolt.
**Tighten:** Tighten the heater inlet pipe bolt to 10 N.m (89 lb in).

**HEATER OUTLET HOSE FITTING INSTALLATION**

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**Fig. 645:** View Of Heater Outlet Hose Fitting  
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the heater outlet hose fitting threads.
NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the heater outlet hose fitting.

Tighten: Tighten the heater outlet hose fitting to 45 N.m (33 lb ft).

WATER OUTLET INSTALLATION
Fig. 646: View Of Water Outlet
Courtesy of GENERAL MOTORS CORP.

1. Install the water outlet.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the water outlet bolts.

   **Tighten:** Tighten the water outlet bolts to 10 N.m (89 lb in).

OIL FILTER ADAPTER INSTALLATION
1. Install the oil filter bypass valve.
Fig. 648: View Of Oil Filter Adapter  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter adapter.

**Tighten:** Tighten the oil filter adapter to 30 N.m (22 lb ft).

EXHAUST MANIFOLD INSTALLATION
Fig. 649: View Of Exhaust Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW exhaust manifold gasket.
2. Install the exhaust manifold.
3. Add threadlock GM P/N 89021297 (Canadian P/N 10953488) to the exhaust manifold bolt threads.
4. Install the exhaust manifold bolts.
Fig. 651: Installing Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the exhaust manifold bolts.

Tighten:
1. Tighten the exhaust manifold bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the exhaust manifold bolts a second pass in sequence to 20 N.m (15 lb ft).
3. Tighten the exhaust manifold bolts a final pass in sequence to 20 N.m (15 lb ft).

Fig. 652: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

6. Install the exhaust manifold heat shield studs (if required).

**Tighten:** Tighten the exhaust manifold heat shield studs to 10 N.m (89 lb in).
Fig. 653: Exhaust Manifold Heat Shield  
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust manifold heat shield.
8. Add anti-seize GM P/N 12371386 (Canadian P/N 993128) to the exhaust manifold heat shield nuts.
9. Install the exhaust manifold heat shield nuts.

**Tighten:** Tighten the exhaust manifold heat shield nuts to 10 N.m (89 lb in).

**OIL LEVEL INDICATOR AND TUBE INSTALLATION**
Fig. 654: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube.
2. Add sealant GM P/N 12378521 (Canadian P/N 88901148) to the oil level indicator tube stud threads.
NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil level indicator tube stud.

   **Tighten:** Tighten the oil level indicator tube stud to 10 N.m (89 lb in).

4. Install the oil level indicator.

POWER STEERING PUMP BRACKET INSTALLATION

![Fig. 655: View Of Power Steering Pump Bracket](Image)

Courtesy of GENERAL MOTORS CORP.
1. Install the power steering pump bracket.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the power steering pump bracket bolts.

   **Tighten:** Tighten the power steering pump bracket bolts to 50 N.m (37 lb ft).

**DRIVE BELT TENSIONER INSTALLATION**

![Fig. 656: View Of Drive Belt Tensioner](image)

*Courtesy of GENERAL MOTORS CORP.*
1. Install the drive belt tensioner.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolt.

**Tighten:** Tighten the drive belt tensioner bolt to 50 N.m (37 lb ft).

**DRIVE BELT IDLER PULLEY INSTALLATION**
1. Install the drive belt idler pulley.

   **NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt idler pulley bolts.

   **Tighten:** Tighten the drive belt idler pulley bolts to 50 N.m (37 lb ft).

**CRANKSHAFT REAR OIL SEAL INSTALLATION**

**Tools Required**

**J 44215** Rear Seal Installer. See **Special Tools**.
1. Use the plastic installation sleeve supplied with the new seal when installing a new seal.

   Use **J 44215** to install the crankshaft rear oil seal. See **Special Tools**.

2. Remove **J 44215**. See **Special Tools**.

ENGINE FLYWHEEL INSTALLATION (AUTOMATIC TRANSMISSION)

**Tools Required**

**J 45059** Angle Meter. See **Special Tools**.
Fig. 659: Installing Flywheel - Automatic Transmission  
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install new flywheel bolts.

**Tighten:**

1. Tighten the new flywheel bolts to 40 N.m (30 lb ft).
2. Use J 45059 to tighten the flywheel bolts an additional 45 degrees. See Special Tools.

ENGINE FLYWHEEL INSTALLATION (MANUAL TRANSMISSION)

Tools Required

J 45059 Angle Meter. See Special Tools.

Fig. 660: Installing Flywheel - Manual Transmission

Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.
NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install new flywheel bolts.

   Tighten:
   1. Tighten the new flywheel bolts to 40 N.m (30 lb ft).
   2. Use J 45059 to tighten the flywheel bolts an additional 45 degrees. See Special Tools.

ENGINE PRELUBING

Tools Required

J 45299 Engine Preluber. See Special Tools.
Fig. 661: View Of Engine Block Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** A constant/continuous flow of clean engine oil is required to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

**NOTE:** Refer to Fastener Notice in Cautions and Notices.

1. Remove the engine oil filter, fill with clean engine oil, and reinstall.

**Tighten:** Tighten the oil filter to 30 N.m (22 lb ft).
2. Remove the engine block oil gallery plug (1).
3. Install the M16 x 1.5 adapter P/N 509375.
4. Install the flexible hose to the adapter and open the valve.

5. Pump the handle on J 45299 to flow a minimum of 1-2 quarts of engine oil. See Special Tools. Observe the flow of engine oil through the flexible hose and into the engine assembly.

6. Close the valve and remove the flexible hose and adapter from the engine.

7. Install the oil pressure sensor.

   **Tighten:** Tighten the oil pressure sensor to 35 N.m (26 lb ft).

8. Top-off the engine oil to the proper level.

**DESCRIPTION AND OPERATION**

**CRANKCASE VENTILATION SYSTEM DESCRIPTION**
A crankcase ventilation system is used to consume crankcase vapors 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 (5) into the intake manifold (3).
The PCV orificed tube (5) restricts the flow rate of the blow-by gases using a 2.5 mm (0.098 in) orifice located in the camshaft cover tube (5). If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase ventilation fresh air tube (6) into the air cleaner resonator (1) 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, if belt driven
  - The generator
  - The A/C compressor, if equipped
  - The engine cooling fan, if belt driven
  - The water pump, if belt driven
  - The vacuum pump, if equipped
  - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. 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 plys containing either fiber 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.
Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Block

The lost foam all aluminum engine block utilizes a deep skirt design for increased rigidity. The cylinders are positioned in a straight in-line orientation. The crankshaft bearing caps have a bearing beam or "ladder" for enhanced structural rigidity and vibration reduction.

Oil Pan

A single piece cast aluminum oil pan contributes to crankshaft and block rigidity while reducing overall weight. The oil pan bolts to the bell housing as well as the block. This eliminates points of vibration and makes the complete powertrain act as a single casting. Jack screws are used to remove the oil pan.

Crankshaft

The crankshaft is a nodular iron design.

Connecting Rods

The connecting rods are forged powdered metal. The connecting rods and caps are of a fractured split design to improve durability and reduce internal friction. Care must be taken to ensure the mating surfaces are not damaged during service procedures.

Pistons

The pistons are a full-floating design. The piston pins are a slip fit in the bronze bushed connecting rod and are retained in the piston by round wire retainers. There are 2 compression rings and 1 oil control ring.

Cylinder Head

The cylinder head is also made of the lost foam aluminum for lighter weight and rapid heat dissipation. There are 4 valves per cylinder and the ports are of a high swirl design for improved combustion. The cylinder head gasket consists of a steel laminated construction.

Valve Train

The engine utilizes dual overhead camshafts and roller followers for reduced friction, which results in improved gas mileage.
Fuel System

A new electronic throttle control system is used on the engine. A throttle actuator control or TAC system eliminates cable linkage from the pedal to the throttle control module. All throttle movements are controlled by the powertrain control module (PCM).

Oil Pump

The oil pump is gear driven directly from the crankshaft. The oil pump drive gear is a slip fit to the crankshaft.

Engine Covers

There is a front engine cover and a rear engine cover, both are made of aluminum. The front engine cover and rear engine cover have "T" sealing joints and need to be removed after the oil pan. The front and rear covers need to be installed before the oil pan. Jack screws are used to remove the covers. Guide pins are used to aid in the installation of both covers.

EXHAUST CAMSHAFT POSITION ACTUATOR DESCRIPTION

The camshaft position actuator is bolted to the front of the exhaust camshaft and is integral with the sprocket. The actuator and sprocket can only be replaced as one unit. The total range of actuator rotation is 0 to 25 camshaft degrees. At idle, the exhaust camshaft position actuator is at full advance or 0 degrees.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important new features for the service community.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- Special tools required

New Sealants and/or Adhesives
- U.S. and Canadian SPO part numbers
- 3-Bond sealant P/N 12378521

**Engine Features**

- Powder metal connecting rods
- Full floating piston pins
- Lost foam casted aluminum block and head
- Composite plastic camshaft cover
- Electronic Throttle Control - ETC
- Composite intake manifold
- Bridge/bearing beam - stiffener ladder
- Stainless steel fuel rail
- Coil-on-plug ignition system
- Inlet side thermostat
- No EGR
- No AIR

**LUBRICATION DESCRIPTION**
Fig. 664: View Of Engine Lubrication System
The engine lubrication system is of the force-feed type. The oil is supplied under full pressure to the crankshaft, connecting rods, valve lash adjusters, and cam phasing system. A controlled volume of oil is supplied to the camshaft and valve rocker arms. Gravity flow or splash lubricates all other parts. The engine oil is stored in the oil pan, which is filled through a fill cap in the camshaft cover. A removable oil level indicator, on the right side of the engine block, is provided to check the oil level. The oil pump is located in the engine front cover and is driven by the crankshaft. It is a gerotor-style pump, which is a combination of a gear, and a rotor pump. It is connected by a passage in the cylinder block to an oil screen and pipe assembly. The screen is submerged in the oil supply and has ample volume for all operating conditions. Oil is drawn into the pump through the screen and pipe assembly, and a passage in the crankcase, connecting to the passages in the engine front cover. Oil is discharged from the oil pump to the oil filter. The oil pressure relief valve limits the oil pressure. The oil filter bypass valve opens when the oil filter is restricted to approximately 68.95 kPa (10 psi) of pressure difference between the oil filter inlet and discharge. The oil will then bypass the oil filter and channel unfiltered oil directly to the main oil galleries of the engine. A full-flow oil filter is mounted to the oil filter adapter on the lower right front side of the engine. The main oil galleries run the full length of the engine block and cut into the valve lash adjuster holes to supply oil at full pressure to the valve lash adjusters. Holes are drilled from the crankshaft bearings to the main oil gallery. Oil is transferred from the crankshaft bearings to the connecting rod bearings through holes drilled in the crankshaft. Pistons, piston pins, and cylinder walls are lubricated by oil splash from the crankshaft and connecting rods. The camshafts and valve rocker arms are supplied with oil from the oil passages drilled into the camshaft mounting areas.

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 proper cleaning and protection procedures to the machined surfaces and to the friction areas.
NOTE: 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.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

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 Engine Electrical.

SEPARATING PARTS

The components of an internal combustion engine develop wear patterns with their mating components. During disassembly of the engine, parts should be separated and kept in order so they may be reinstalled in the same location from which they were removed.

REPLACING ENGINE GASKETS

1. Do not reuse any gasket unless otherwise specified. Reusable gaskets will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service procedure.
2. Use jack screws to separate components.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a component. Do not use the following items in order to clean the gasket surfaces:

- Abrasive pads
- Sand paper
- Power tools

These methods of cleaning may damage the component. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may
cause internal engine damage.

3. Remove all of the gasket and the sealing material from the component using a plastic or a wood scraper. Do not gouge or scrape the sealing surfaces.

**IMPORTANT:** Do not allow the sealant to enter any blind threaded holes. The sealant may cause the following conditions:

- Prevent you from properly seating the bolt
- Cause damage when you tighten the bolt

4. When assembling components, use only the sealant specified in the service procedure. Ensure that the sealing surfaces are clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure.

5. Tighten the bolts to the specifications.

**USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER**

Sealant Types

**IMPORTANT:** 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:

- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

**Aerobic Type Room Temperature Vulcanizing (RTV) Sealant**

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to 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.

**IMPORTANT:** Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- 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.
- Assemble the components while the RTV sealant is still wet to the touch. Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

**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.

**IMPORTANT:** Fasteners that are partially torqued and then the threadlock
Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

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.

**IMPORTANT:** Do not allow the pipe sealant to enter any of the blind threaded holes, as the pipe sealant may prevent the fastener from clamping properly, or cause component damage when the fastener is tightened.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

TOOLS AND EQUIPMENT

Work in a clean and well-lit area. Have the following components available before you begin to work:

- A suitable parts cleaning tank
• A compressed air supply
• Trays, in order to keep the parts and the fasteners organized
• An adequate set of hand tools

An approved engine repair stand will prevent personal injury or damage to the engine components. The special tools are designed in order to quickly and safely accomplish the operations for which the tools are intended. Using the tools will minimize possible damage to the engine components. Precision measuring tools are required for the inspection of certain critical components. Torque wrenches are needed for the correct assembly of various parts.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Special Tools

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J 9666
Valve Spring Tester
Pressure Gage and Hose

High Intensity Black Light

Cylinder Leakdown Tester

J 21867

J 28428-E

J 35667-A

J 38185
<table>
<thead>
<tr>
<th>Tool Name</th>
<th>Model Number</th>
<th>Description</th>
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<tr>
<td>Hose Clamp Pliers</td>
<td>J 38722</td>
<td>Compression Tester</td>
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<td>J 38820 Valve Stem Seal Remover &amp; Installer</td>
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<td>J 39313 Spark Plug Port Adapter</td>
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<tr>
<td>Part Number</td>
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<td>J 41240</td>
<td>Fan Clutch Wrench</td>
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<td>J 41478</td>
<td>Crankshaft Balancer Installer</td>
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<td>J 41556</td>
<td>Connecting Rod Guides</td>
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<td>J 41816-2</td>
<td>Crankshaft End Protector</td>
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<td>J 42037</td>
<td>Valve Spring Compressor Adapter</td>
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| J 42385-400  
Thread Repair Kit |
|-------------------|
| J 42907  
Oil Pressure Tester Adapter |
| J 43059  
Valve Retainer Remover/Installer |
J 43276
Clutch Pilot Bearing Remover

J 43654
Piston Pin Retaining Clip Remover/Installer

J 43965
Thread Repair Extension Kit
<table>
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<tr>
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<td>J 44215</td>
<td>Rear Seal Installer</td>
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<td>J 44217</td>
<td>Timing Chain Retention Tool</td>
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<td>J 44219</td>
<td>Cover Alignment Pins</td>
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<td>J 44220</td>
<td>Engine Lift Bracket</td>
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<td>J 44221</td>
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<td>Camshaft Holding Tool</td>
<td>J 44222</td>
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<td>Camshaft Sprocket Holding Tool</td>
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<td>Balance Shaft Bearing Remover/Installer</td>
<td>J 44228</td>
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<td>Valve Spring Compressor</td>
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J 45059
Angle Meter

J 45299
Engine Pre-Luber

J 45849-1
Flywheel Locator Remover
J 45949
Pilot Bearing and Flywheel Locator Installer

J 45951
Front Seal Installer

J 46525
Storage Case