

## 2004 ENGINE

### Engine Mechanical - 4.8L, 5.3L, and 6.0L - Hummer H2

## SPECIFICATIONS

### FASTENER TIGHTENING SPECIFICATIONS

#### Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Belt Tensioner Bolt	50 N.m	37 lb ft
Air Cleaner Outlet Duct Clamp Screws	7 N.m	62 lb in
Automatic Transmission Bolt/Stud	50 N.m	37 lb ft
Automatic Transmission Oil Level Indicator Tube Nut	18 N.m	13 lb ft
Battery Cable Channel Bolt	12 N.m	106 lb in
Camshaft Retainer Bolts	25 N.m	18 lb ft
Camshaft Sensor Bolt	25 N.m	18 lb ft
Camshaft Sprocket Bolts	35 N.m	26 lb ft
Connecting Rod Bolts - First Pass	20 N.m	15 lb ft
Connecting Rod Bolts - Final Pass	75 degrees	
Coolant Temperature Gauge Sensor	20 N.m	15 lb ft
Crankshaft Balancer Bolt - Installation Pass - to Ensure the Balancer is Completely Installed	330 N.m	240 lb ft
Crankshaft Balancer Bolt - First Pass - Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	50 N.m	37 lb ft
Crankshaft Balancer Bolt - Final Pass	140 degrees	
Crankshaft Bearing Cap Bolts - Inner Bolts - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap Bolts - Inner Bolts - Final Pass in Sequence	80 degrees	
Crankshaft Bearing Cap Bolts - Outer Bolts - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap Bolts - Outer Bolts - Final Pass in Sequence	51 degrees	
Crankshaft Bearing Cap Side Bolts	25 N.m	18 lb ft
Crankshaft Oil Deflector Nuts	25 N.m	18 lb ft
Crankshaft Position Sensor Bolt	25 N.m	18 lb ft
Crossbar Bolts	100 N.m	74 lb ft
Cylinder Head Bolts - First Design - First Pass all M11 Bolts in Sequence	30 N.m	22 lb ft
Cylinder Head Bolts - First Design - Second Pass all M11 Bolts in Sequence	90 degrees	
Cylinder Head Bolts - First Design - Final Pass all M11 Bolts in Sequence - Excluding the Medium Length Bolts at the Front and Rear of Each Cylinder Head	90 degrees	
Cylinder Head Bolts - First Design - Final Pass M11 Medium Length Bolts at the	50 degrees	

Front and Rear of Each Cylinder Head		
Cylinder Head Bolts - Second Design - First Pass all M11 Bolts in Sequence	30 N.m	22 lb ft
Cylinder Head Bolts - Second Design - Second Pass all M11 Bolts in Sequence	90 degrees	
Cylinder Head Bolts - Second Design - Final Pass all M11 Bolts in Sequence	70 degrees	
Cylinder Head Bolts - M8 Inner Bolts in Sequence	30 N.m	22 lb ft
Cylinder Head Coolant Plug	20 N.m	15 lb ft
Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Engine Block Coolant Drain Plugs	60 N.m	44 lb ft
Engine Block Heater	40 N.m	30 lb ft
Engine Block Oil Gallery Plugs	60 N.m	44 lb ft
Engine Block Wire Harness Rear Ground Bolt	16 N.m	12 lb ft
Engine Coolant Air Bleed Pipe and Cover Bolts	12 N.m	106 lb in
Engine Flywheel Bolts - First Pass	20 N.m	15 lb ft
Engine Flywheel Bolts - Second Pass	50 N.m	37 lb ft
Engine Flywheel Bolts - Final Pass	100 N.m	74 lb ft
Engine Front Cover Bolts	25 N.m	18 lb ft
Engine Lift Bracket Bolt - M8	25 N.m	18 lb ft
Engine Lift Bracket Bolt - M10	50 N.m	37 lb ft
Engine Mount Bracket-to-Engine Bolt	50 N.m	37 lb ft
Engine Mount Through Bolt	75 N.m	55 lb ft
Engine Mount-to-Frame Bracket Bolt	65 N.m	48 lb ft
Engine Protection Shield Bolts	30 N.m	22 lb ft
Engine Rear Cover Bolts	25 N.m	18 lb ft
Engine Service Lift Bracket M8 Bolt	25 N.m	18 lb ft
Engine Service Lift Bracket M10 Bolts	50 N.m	37 lb ft
Engine Sight Shield Bolts	10 N.m	89 lb in
Engine Sight Shield Bracket Bolts	5 N.m	45 lb in
Engine Valley Cover Bolts	25 N.m	18 lb ft
Evaporative Emission (EVAP) Purge Solenoid Bolt	10 N.m	89 lb in
Exhaust Manifold Bolts - First Pass	15 N.m	11 lb ft
Exhaust Manifold Bolts - Final Pass	25 N.m	18 lb ft
Exhaust Manifold Heat Shield Bolts	9 N.m	80 lb in
Fuel Rail Bolts	10 N.m	89 lb in
Fuel Rail Crossover Tube Bolts	3.8 N.m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N.m	37 lb ft
Generator Bolt	50 N.m	37 lb ft
Generator Bracket Bolts	50 N.m	37 lb ft
Generator Output Terminal Nut	9 N.m	80 lb in

Ground Harness Bolt	25 N.m	18 lb ft
Ignition Coil-to-Bracket Bolts	8 N.m	71 lb in
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolts	12 N.m	106 lb in
Intake Manifold Bolts - First Pass in Sequence	5 N.m	44 lb in
Intake Manifold Bolts - Final Pass in Sequence	10 N.m	89 lb in
Intake Manifold Wiring Harness Stud	10 N.m	89 lb in
Knock Sensors	20 N.m	15 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Fitting	55 N.m	40 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Level Sensor	13 N.m	115 lb in
Oil Pan Baffle Bolts	12 N.m	106 lb in
Oil Pan Closeout Cover Bolt - Left Side	9 N.m	80 lb in
Oil Pan Closeout Cover Bolt - Right Side	9 N.m	80 lb in
Oil Pan Cover Bolts	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan M8 Bolts - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pan M6 Bolts - Oil Pan-to-Rear Cover	12 N.m	106 lb in
Oil Pressure Sensor	20 N.m	15 lb ft
Oil Pump-to-Engine Block Bolts	25 N.m	18 lb ft
Oil Pump Cover Bolts	12 N.m	106 lb in
Oil Pump Relief Valve Plug	12 N.m	106 lb in
Oil Pump Screen Nuts	25 N.m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N.m	106 lb in
Positive Battery Cable Clip Bolt	9 N.m	80 lb in
Power Steering Pump Rear Bolt	50 N.m	37 lb ft
Spark Plugs - New Cylinder Heads	20 N.m	15 lb ft
Spark Plugs - All Subsequent Installations	15 N.m	11 lb ft
Throttle Body Nuts	10 N.m	89 lb in
Throttle Body Studs	6 N.m	53 lb in
Torque Converter Bolts	63 N.m	47 lb ft
Transmission Cover Bolt	12 N.m	106 lb in
		106 lb

Valve Lifter Guide Bolts	12 N.m	in
Valve Rocker Arm Bolts	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolts	12 N.m	106 lb in
Water Inlet Housing Bolts	15 N.m	11 lb ft
Water Pump Bolts - First Pass	15 N.m	11 lb ft
Water Pump Bolts - Final Pass	30 N.m	22 lb ft
Water Pump Cover Bolts	15 N.m	11 lb ft

## ENGINE MECHANICAL SPECIFICATIONS

### Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	6.0L	364 CID
• RPO	LQ4	
• VIN	U	
• Bore	101.618-101.636 mm	4.0007-4.0014 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	9.41:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Spark Plug Gap	1.524 mm	0.06 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter - First Design	59.12-59.17 mm	2.327-2.329 in
• Camshaft Bearing Bore 2 and 4 Diameter - First Design	58.87-58.92 mm	2.317-2.319 in
• Camshaft Bearing Bore 3 Diameter - First Design	58.62-58.67 mm	2.307-2.309 in
• Camshaft Bearing Bore 1 and 5 Diameter - Second Design	59.62-59.67 mm	2.347-2.349 in
• Camshaft Bearing Bore 2 and 4 Diameter - Second Design	59.12-59.17 mm	2.327-2.329 in
• Camshaft Bearing Bore 3 Diameter - Second Design	58.62-58.67 mm	2.307-2.309 in
• Crankshaft Main Bearing Bore Diameter	69.871-69.889 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	101.618-101.636 mm	4.0007-4.0017 in
• Cylinder Bore Taper - Thrust Side	0.018 mm	0.0007 in

<ul style="list-style-type: none"> <li>• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face</li> </ul>	234.57-234.82 mm	9.235-9.245 in
<ul style="list-style-type: none"> <li>• Cylinder Head Deck Surface Flatness - Measured within a 152.4 mm (6.0 in) Area</li> </ul>	0.11 mm	0.004 in
<ul style="list-style-type: none"> <li>• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck</li> </ul>	0.22 mm	0.008 in
<ul style="list-style-type: none"> <li>• Valve Lifter Bore Diameter</li> </ul>	21.417-21.443 mm	0.843-0.844 in
<b>Camshaft</b>		
<ul style="list-style-type: none"> <li>• Camshaft End Play</li> </ul>	0.025-0.305 mm	0.001-0.012 in
<ul style="list-style-type: none"> <li>• Camshaft Journal Diameter</li> </ul>	54.99-55.04 mm	2.164-2.166 in
<ul style="list-style-type: none"> <li>• Camshaft Journal Out-of-Round</li> </ul>	0.025 mm	0.001 in
<ul style="list-style-type: none"> <li>• Camshaft Lobe Lift - Exhaust</li> </ul>	7.13 mm	0.281 in
<ul style="list-style-type: none"> <li>• Camshaft Lobe Lift - Intake</li> </ul>	6.96 mm	0.274 in
<ul style="list-style-type: none"> <li>• Camshaft Runout - Measured at the Intermediate Journals</li> </ul>	0.05 mm	0.002 in
<b>Connecting Rod</b>		
<ul style="list-style-type: none"> <li>• Connecting Rod Bearing Clearance - Production</li> </ul>	0.023-0.065 mm	0.0009-0.0025 in
<ul style="list-style-type: none"> <li>• Connecting Rod Bearing Clearance - Service</li> </ul>	0.023-0.076 mm	0.0009-0.003 in
<ul style="list-style-type: none"> <li>• Connecting Rod Bore Diameter - Bearing End</li> </ul>	56.505-56.525 mm	2.224-2.225 in
<ul style="list-style-type: none"> <li>• Connecting Rod Bore Out-of-Round - Bearing End - Production</li> </ul>	0.006 mm	0.0002 in
<ul style="list-style-type: none"> <li>• Connecting Rod Bore Out-of-Round - Bearing End - Service</li> </ul>	0.006 mm	0.0002 in
<ul style="list-style-type: none"> <li>• Connecting Rod Side Clearance</li> </ul>	0.11-0.51 mm	0.00433-0.02 in
<b>Crankshaft</b>		
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Diameter - Production</li> </ul>	53.318-53.338 mm	2.0991-2.0999 in
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Diameter - Service</li> </ul>	53.308 mm	2.0987 in
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Out-of-Round - Production</li> </ul>	0.005 mm	0.0002 in
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Out-of-Round - Service</li> </ul>	0.01 mm	0.0004 in
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production</li> </ul>	0.005 mm	0.0002 in
<ul style="list-style-type: none"> <li>• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service</li> </ul>	0.02 mm	0.00078 in
<ul style="list-style-type: none"> <li>• Crankshaft End Play</li> </ul>	0.04-0.2 mm	0.0015-0.0078 in
<ul style="list-style-type: none"> <li>• Crankshaft Main Bearing Clearance - Production</li> </ul>	0.02-0.052 mm	0.0008-0.0021 in

• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in
• Crankshaft Main Journal Diameter - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.003 mm	0.000118 in
• Crankshaft Main Journal Out-of-Round - Service	0.008 mm	0.0003 in
• Crankshaft Main Journal Taper - Production	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Service	0.02 mm	0.00078 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in
• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in
• Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
<b>Cylinder Head</b>		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
• Surface Flatness - Block Deck - Measured Within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.13 mm	0.005 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.0031 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
<b>Intake Manifold</b>		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured Within a 200 mm (7.87 in) Area that Includes Two Runner Port Openings	0.3 mm	0.118 in
<b>Lubrication System</b>		
• Oil Capacity - with Filter	5.68 Liters	6.0 Quarts
• Oil Capacity - without Filter	4.73 Liters	5.0 Quarts
• Oil Pressure - Minimum - Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000

	engine RPM	engine RPM
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Rear Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.25 mm	0.0-0.01 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.31-0.52 mm	0.012-0.02 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.31-0.59 mm	0.0122-0.023 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.51-0.77 mm	0.02-0.03 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.51-0.84 mm	0.02-0.033 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.31-0.87 mm	0.0122-0.034 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.31-0.94 mm	0.0122-0.037 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.04-0.08 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.04-0.08 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.039-0.079 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.039-0.079 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.015-0.199 mm	0.0006-0.0078 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.015-0.199 mm	0.0006-0.0078 in
Pistons and Pins		
• Piston - Piston Diameter - Measured Over Skirt Coating	101.606-101.640 mm	4.0002-4.0016 in
• Piston - Piston to Bore Clearance - Production	-0.022 to +0.03 mm	-0.0009 to +0.0012 in
• Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.07 mm	0.0028 in
	0.02-0.043 mm -	0.00078-0.00169

• Pin - First Design Press Fit Pin Fit in Connecting Rod Bore	Interference	in - Interference
• Pin - First Design Press Fit Pin Clearance to Piston Pin Bore - Production	0.01-0.02 mm	0.0004-0.00078 in
• Pin - First Design Press Fit Pin Clearance to Piston Pin Bore - Service	0.01-0.022 mm	0.0004-0.00086 in
• Pin - First Design Press Fit Pin Diameter	23.997-24.0 mm	0.9447-0.9448 in
• Pin - Second Design Full Floating Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Second Design Full Floating Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Pin - Second Design Full Floating Pin Clearance to Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.0004 in
• Pin - Second Design Full Floating Pin Clearance to Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.0006 in
• Pin - Second Design Full Floating Pin Diameter	23.952-23.955 mm	0.943-0.943 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in
• Valves - Valve Lash	Net Lash - No Adjustment	
• Valves - Valve Lift - Intake	11.79 mm	0.464 in
• Valves - Valve Lift - Exhaust	12.16 mm	0.479 in
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Valve Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
• Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	



• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Valve Spring Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

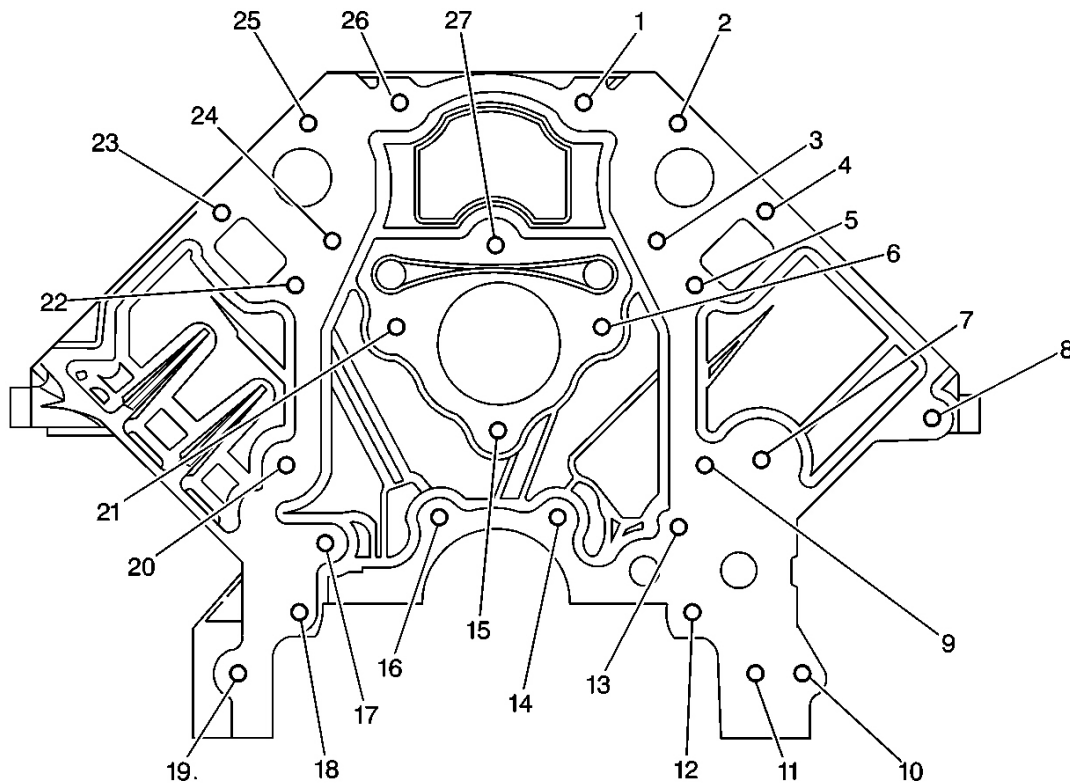
## SEALERS, ADHESIVES, AND LUBRICANTS

### Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Sensor Threads	Sealant	12346004	10953480
Cylinder Head Coolant Plugs	Threadlock	12345382	10953489
Cylinder Head Expansion Plugs - Aluminum	Threadlock	12345382	10953489
Engine Block Front Oil Gallery Plug	Threadlock	12345382	10953489
Engine Block Plug Sealing Washers	Sealant	12346004	10953480
Engine Flywheel Bolt Threads	Threadlock	12345382	10953489
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolt Threads	Threadlock	12345493	10953488
Fuel Rail Bolt Threads	Threadlock	12345382	10953489
Ignition Coil and Bracket Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket Bolts	Threadlock	12345382	10953489
Intake Manifold Bolt Threads	Threadlock	12345382	10953489
Oil Pan Surface at Front and Rear Covers	Sealant	12378190	-
Oil Pressure Sensor Threads	Sealant	12346004	10953480
Thread Repair Component Cleaner	Cleaner	12346139	10953463
Thread Repair Component Cleaner	Cleaner	12377981	10953463
Thread Repair Cutting Oil	Lubricant	1052864	992881

## THREAD REPAIR SPECIFICATIONS

### Engine Block - Front View



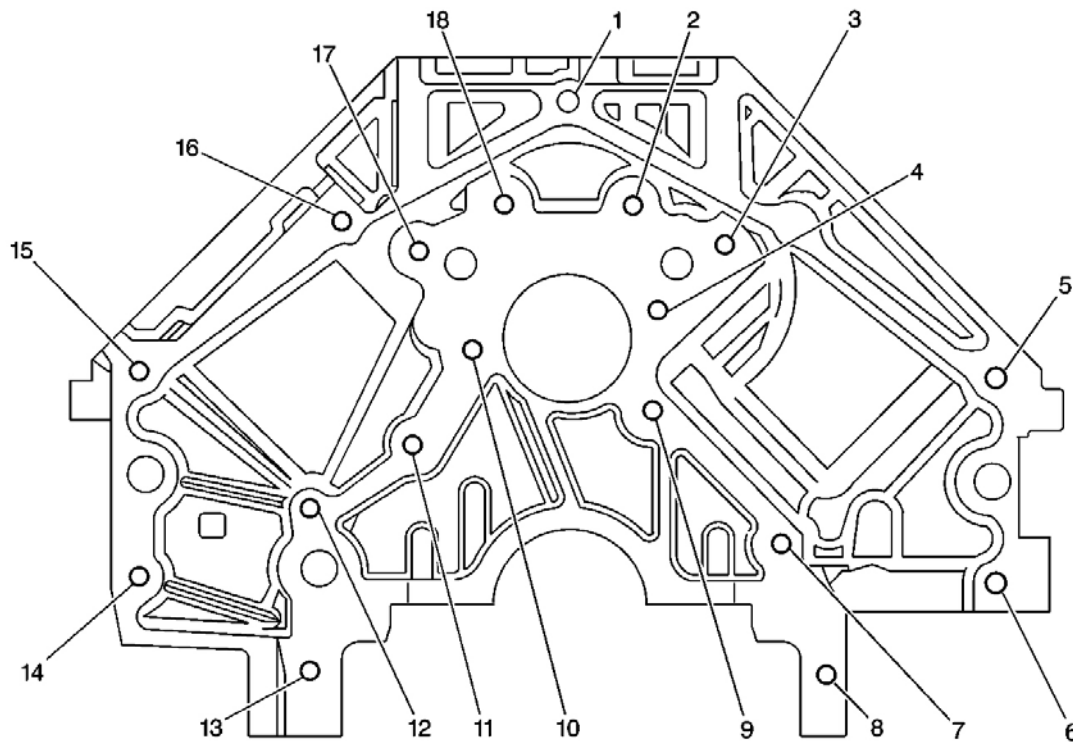
**Fig. 1: Engine Block Bolt Holes - Front View**  
 Courtesy of GENERAL MOTORS CORP.

**Engine Block - Front View**

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1-6	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
7	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	25.0 (0.984)	19.5 (0.767)
8	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	32.5 (1.28)	25.0 (0.984)
9	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
10	M10 x	J 42385-	J 42385-	J 42385-212	J 42385-	J 42385-	Thru	Thru

	1.5	215	211		213	214		
11-13	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
14	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
15	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
16	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	Thru	18.0 (0.708)
17-27	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

**Engine Block - Rear View**

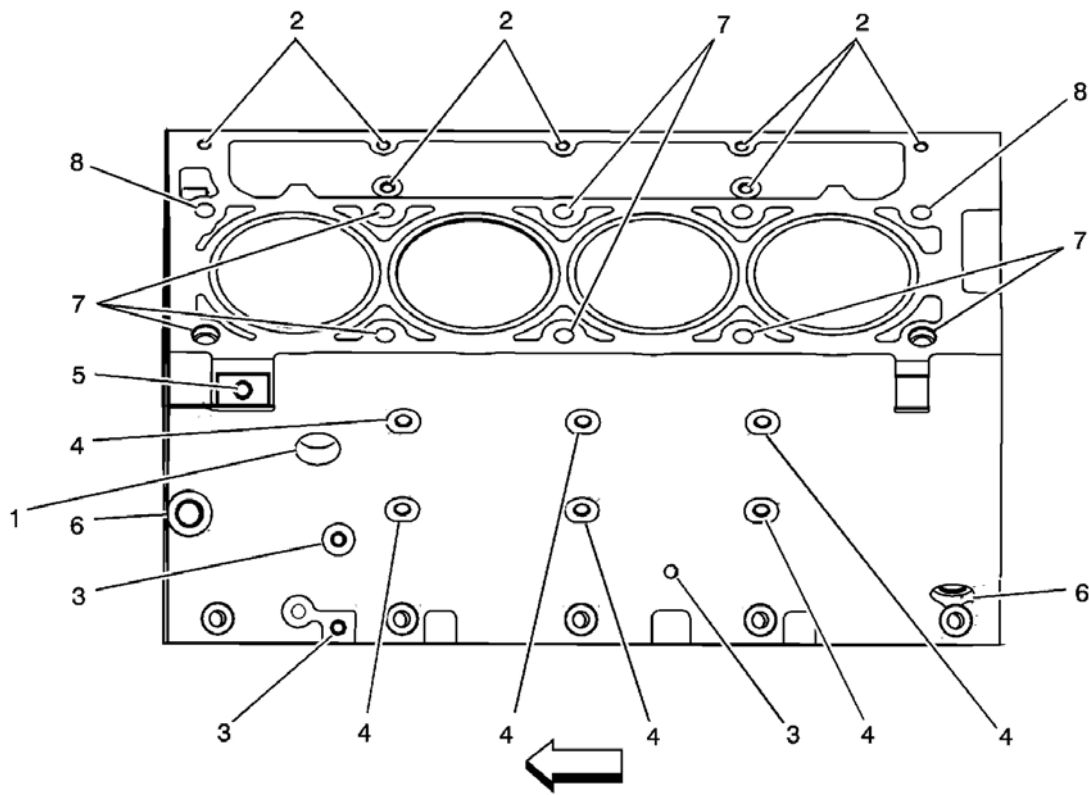


**Fig. 2: Engine Block Bolt Holes - Rear View**  
 Courtesy of GENERAL MOTORS CORP.

**Engine Block - Rear View**

<b>Hole</b>	<b>Thread Size</b>	<b>Insert</b>	<b>Drill</b>	<b>Counterbore Tool</b>	<b>Tap</b>	<b>Driver</b>	<b>Drill Depth - Maximum mm (in)</b>	<b>Tap Depth - Maximum mm (in)</b>
1	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
2-4	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
5-6	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
7-13	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
14-16	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	27.0 (1.06)	21.5 (0.846)
17-18	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)

**Engine Block - Left Side View**



**Fig. 3: Engine Block Bolt Holes - Left Side View**  
 Courtesy of GENERAL MOTORS CORP.

**Engine Block - Left Side View**

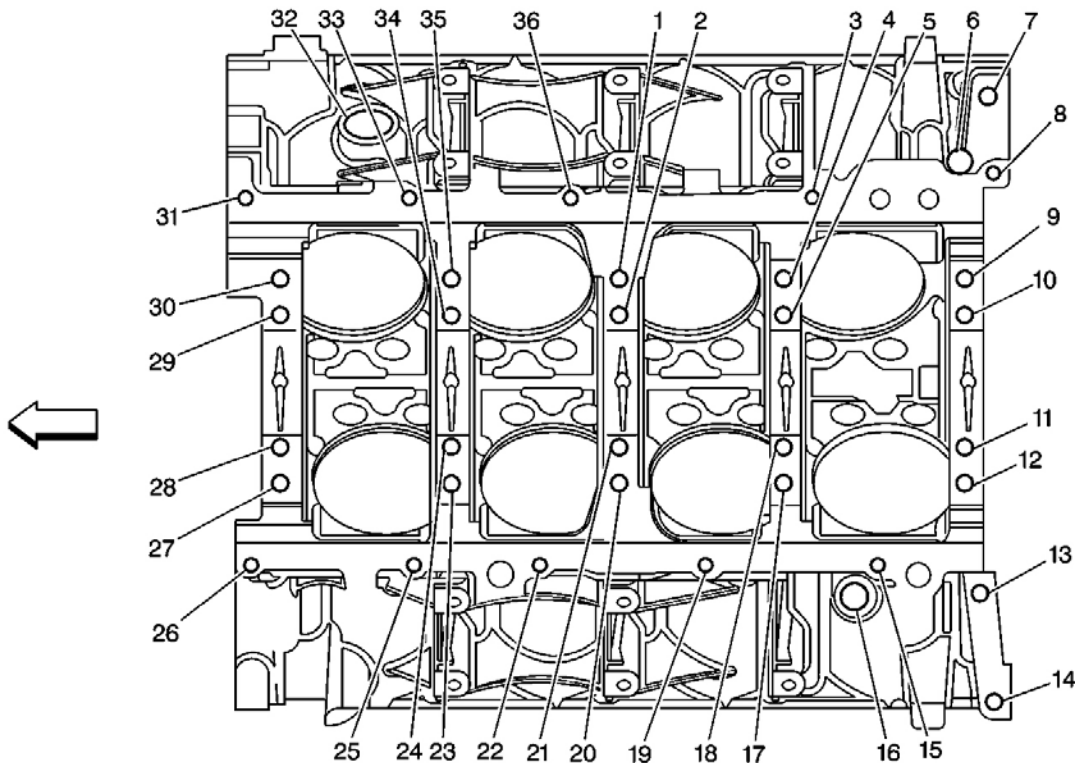
Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385								
1	M28 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	M8 x 1.25	210	206	207	208	209	28.5 (1.122)	23.0 (0.905)
3	M8 x 1.25	210	206	207	208	209	21.5 (0.846)	16.0 (0.629)
4	M10 x 1.25	215	211	212	213	214	29.0 (1.141)	23.0 (0.905)
5	M10 x 1.5	215	211	212	213	214	27.0 (1.062)	21.5 (0.846)
6	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	M11 x 2.0 First Design	108	105	N/A	106	107	124.0 (4.88)	115.0 (4.52)
7	M11 x 2.0 Second Design	108	105	N/A	106	107	69.0 (2.72)	60.0 (2.36)



5	M10 x 1.5	215	211	212	213	214	27.0 (1.062)	21.5 (0.846)
6	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	M11 x 2.0 First Design	108	105	N/A	106	107	124.0 (4.88)	115.0 (4.52)
7	M11 x 2.0 Second Design	108	105	N/A	106	107	69.0 (2.72)	60.0 (2.36)

- Bolt holes 7, second design, and 3 have a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.
- Bolt holes 7, first design, have a 85 mm (3.34 in) counterbore included in the 124.0 mm (4.88 in) drill depth.

### Engine Block - Bottom View



**Fig. 5: Engine Block Bolt Holes - Bottom View**  
 Courtesy of GENERAL MOTORS CORP.

### Engine Block - Bottom View

	Thread			Counterbore			Drill Depth - Maximum mm	Tap Depth - Maximum mm
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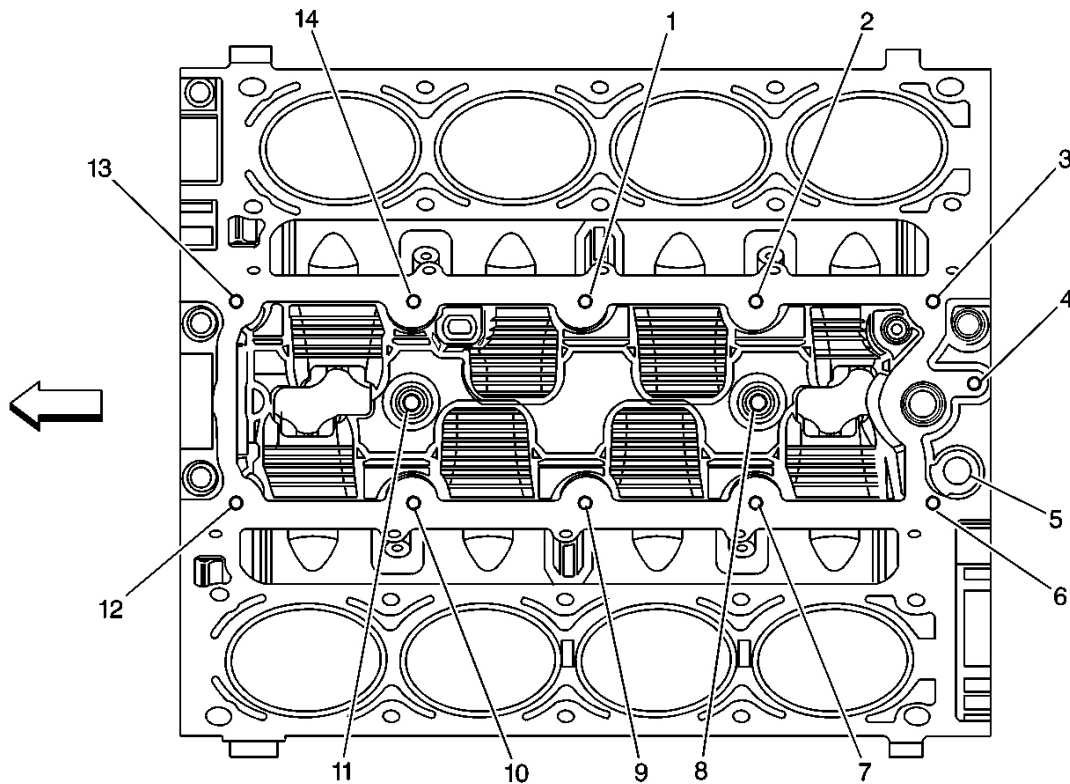
Hole	Size	Insert	Drill	Tool	Tap	Driver	(in)	(in)
1	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
2	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
3	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
4	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
5	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
6	M16 x 1.5	-	-	-	-	-	-	-
7	N/A	-	-	-	-	-	-	-
8	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
9	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
10-11	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
12	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)
13-14	M10 x 1.5	J 42385-215	J 42385-101	-	J 42385-213	J 42385-214	42.5 (1.67)	37.0 (1.45)
15	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	22.5 (0.885)	17.5 (0.688)
16	M16 x 1.5	-	-	-	-	-	-	-
17	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	53.5 (2.10)	44.0 (1.73)
18	M10 x 2.0	J 42385-104	J 42385-101	-	J 42385-102	J 42385-103	31.0 (1.22)	25.5 (1.0)



19	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	22.5 (0.885)	17.5 (0.688)
20	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	53.5 (2.10)	44.0 (1.73)
21	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	31.0 (1.22)	25.5 (1.0)
22	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	22.5 (0.885)	17.5 (0.688)
23	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	31.0 (1.22)	25.5 (1.0)
24	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	53.5 (2.10)	44.0 (1.73)
25- 26	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	22.5 (0.885)	17.5 (0.688)
27	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	31.0 (1.22)	25.5 (1.0)
28- 29	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	53.5 (2.10)	44.0 (1.73)
30	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	31.0 (1.22)	25.5 (1.0)
31	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	22.5 (0.885)	17.5 (0.688)
32	M28 x 1.25	-	-	-	-	-	-	-
33	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	22.5 (0.885)	17.5 (0.688)
34	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	53.5 (2.10)	44.0 (1.73)
35	M10 x 2.0	J 42385- 104	J 42385- 101	-	J 42385- 102	J 42385- 103	31.0 (1.22)	25.5 (1.0)
		J	J		J	J		

36	M8 x 1.25	42385- 210	42385- 206	J 42385-207	42385- 208	42385- 209	22.5 (0.885)	17.5 (0.688)
<ul style="list-style-type: none"> <li>• Bolt holes 2, 5, 10, 11, 18, 21, 24, 28, 29, and 34 have a 20.5 mm (0.807 in) counterbore included in the 53.5 mm (2.10 in) drill depth.</li> <li>• Bolt holes 1, 4, 9, 12, 17, 20, 23, 27, 30, and 35 have a 1.5 mm (0.059 in) counterbore included in the 31.0 mm (1.22 in) drill depth. Use sleeve J 42385-316 with the drill and tap.</li> <li>• Bolt holes 13 and 14 have a 11.5 mm (0.452 in) counterbore included in the 42.5 mm (1.67 in) drill depth. Use sleeve J 42385-311 with the drill and tap.</li> </ul>								

**Engine Block - Top View**



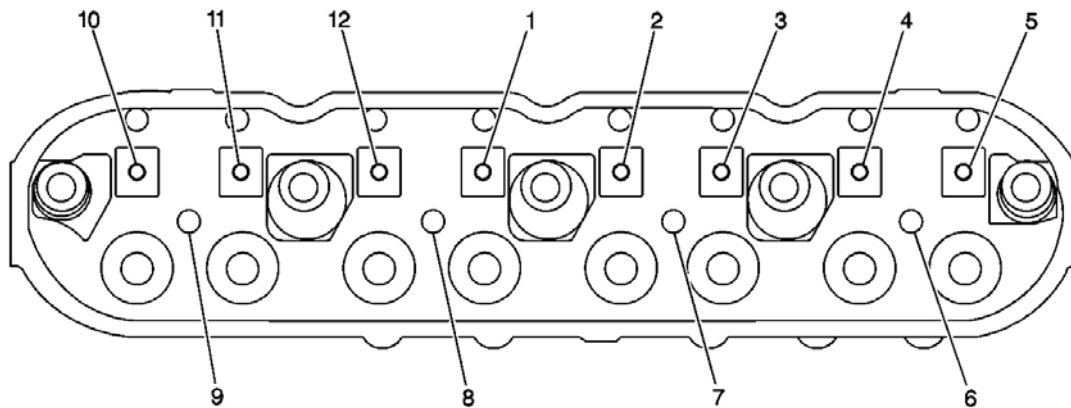
**Fig. 6: Engine Block Bolt Holes - Top View**  
 Courtesy of GENERAL MOTORS CORP.

**Engine Block - Top View**

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1-4	M8 x	J 42385-	J 42385-	J 42385-207	J 42385-	J 42385-	26.5 (1.04)	19.0 (0.784)

	1.25	210	206		208	209		
5	M16 x 1.5	-	-	-	-	-	-	-
6-7	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
8	M10 x 1.5	J 42385-216	J 42385-211	J 42385-212	J 42385-213	J 42385-214	22.5 (0.885)	17.0 (0.669)
9-10	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)
11	M10 x 1.5	J 42385-216	J 42385-211	J 42385-212	J 42385-213	J 42385-214	22.5 (0.885)	17.0 (0.669)
12-14	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)

**Cylinder Head - Top View**



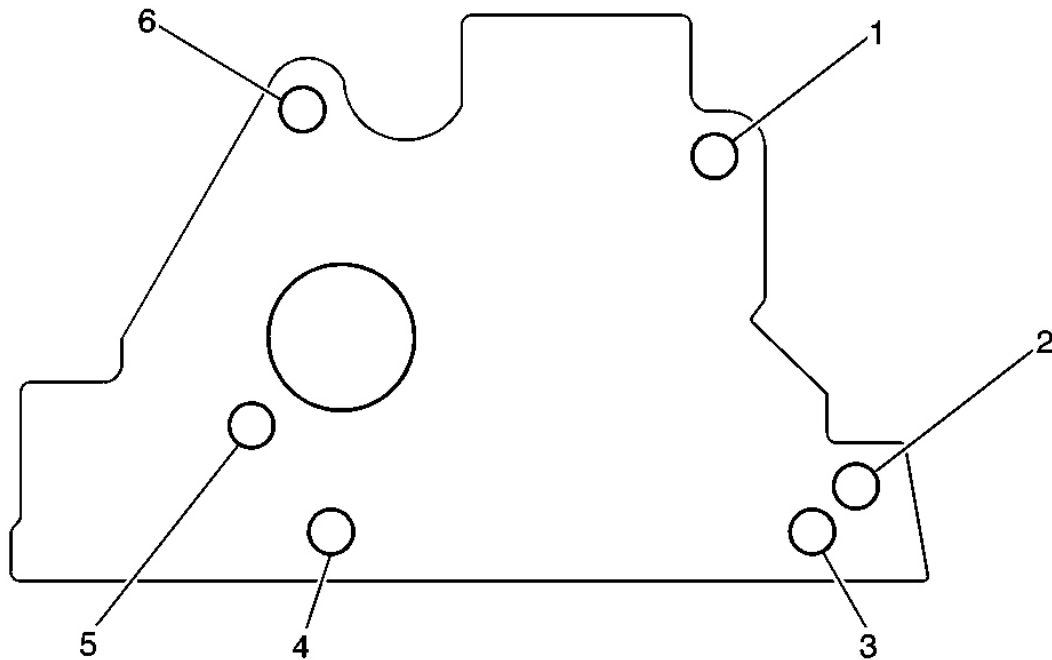
**Fig. 7: Cylinder Head Bolt Holes - Top View**  
 Courtesy of GENERAL MOTORS CORP.

**Cylinder Head - Top View**

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1-5	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	26.5 (1.04)	19.0 (0.784)

6-9	M6 x 1.0	J 42385- 205	J 42385- 201	J 42385-202	J 42385- 203	J 42385- 204	20.05 (0.789)	16.05 (0.632)
10- 12	M8 x 1.25	J 42385- 210	J 42385- 206	J 42385-207	J 42385- 208	J 42385- 209	26.5 (1.04)	19.0 (0.784)

### Cylinder Head - End View



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

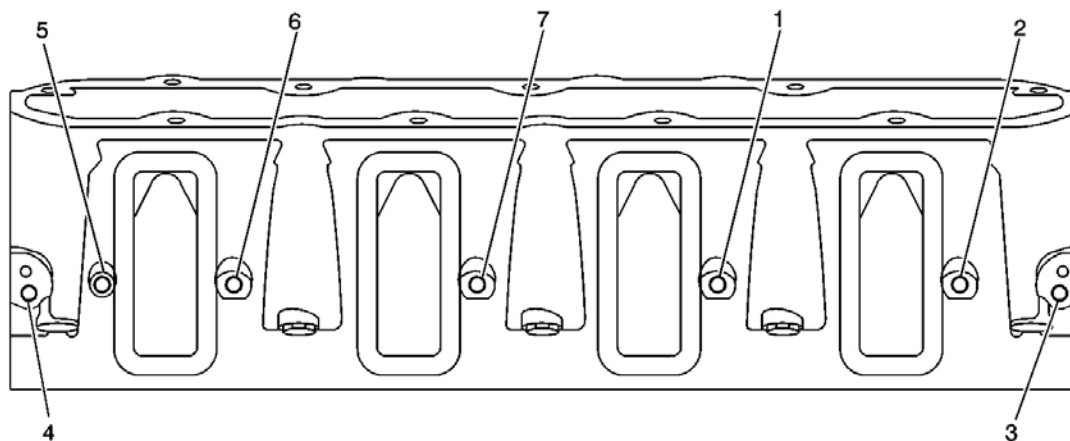
### Cylinder Head - End View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1	M10 x 1.5	J 42385- 215	J 42385- 211	J 42385-212	J 42385- 213	J 42385- 214	28.0 (1.10)	20.0 (0.787)
2	-	N/A	-	-	-	-	-	-
3	M10 x 1.5	J 42385- 215	J 42385- 211	J 42385-212	J 42385- 213	J 42385- 214	28.0 (1.10)	20.0 (0.787)



9	M14 x 1.25	-	-	-	-	-	-	-
10	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
11	M14 x 1.25	-	-	-	-	-	-	-
12	M8 x 1.25	J 42385-210	J 42385-206	J 42385-207	J 42385-208	J 42385-209	21.0 (0.826)	16.0 (0.629)
13	M12 x 1.5	-	-	-	-	-	-	-
14-15	M10 x 1.5	J 42385-215	J 42385-211	J 42385-212	J 42385-213	J 42385-214	28.0 (1.10)	20.0 (0.787)

### Cylinder Head - Intake Manifold Deck View



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

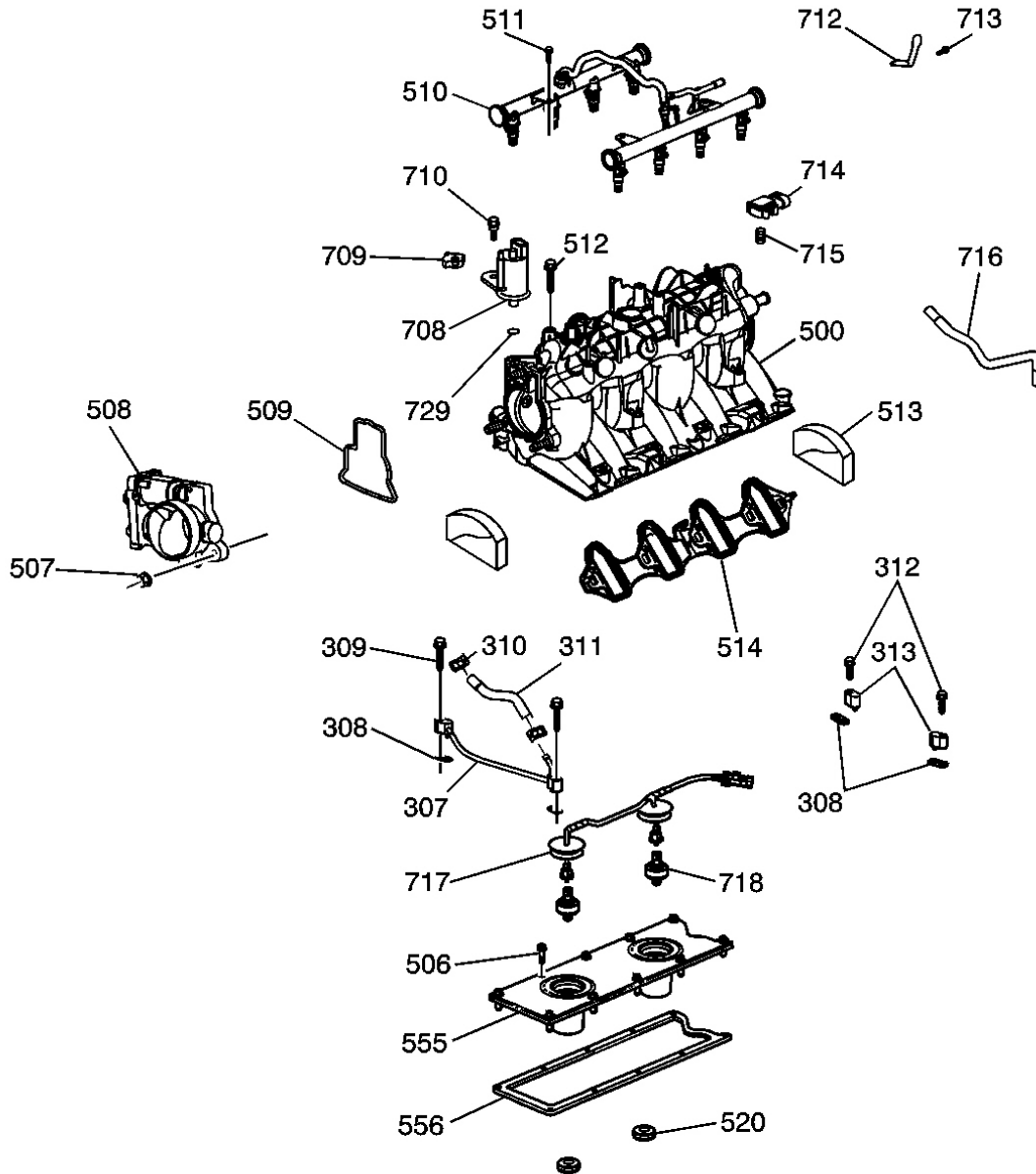
### Cylinder Head - Intake Manifold Deck View

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
1-2	M6 x 1.0	J 42385-205	J 42385-201	J 42385-202	J 42385-203	J 42385-204	Thru	Thru
3-4	M6 x 1.0	J 42385-	J 42385-	J 42385-202	J 42385-	J 42385-	22.5 (0.885)	15.0 (0.688)

		205	201		203	204		
5-7	M6 x 1.0	J 42385- 205	J 42385- 201	J 42385-202	J 42385- 203	J 42385- 204	Thru	Thru

## COMPONENT LOCATOR

### DISASSEMBLED VIEWS

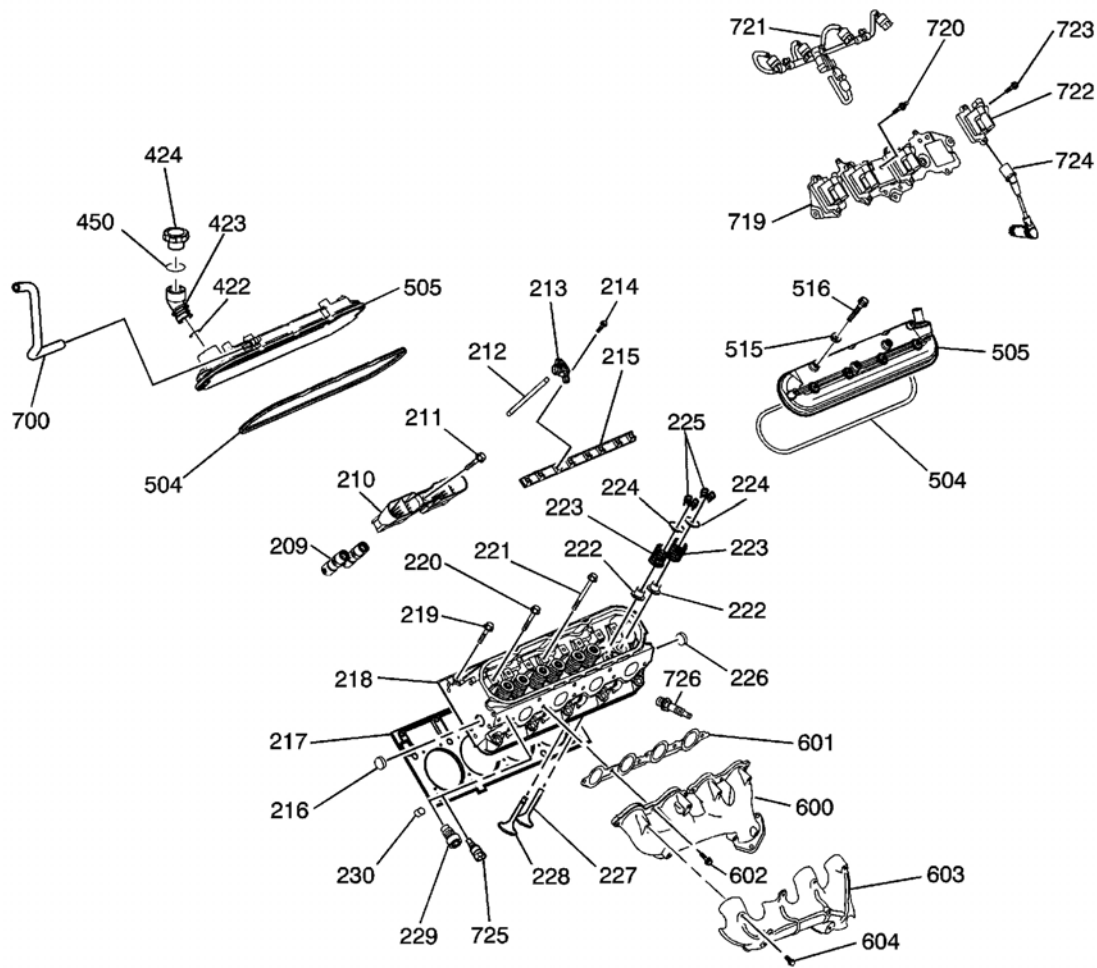


**Fig. 11: Intake Manifold/Upper Engine Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 11**

<b>Callout</b>	<b>Component Name</b>
307	Engine Coolant Air Bleed Pipe
308	Engine Coolant Air Bleed Pipe/Cover Gasket
308	Engine Coolant Air Bleed Pipe/Cover Gasket
309	Engine Coolant Air Bleed Pipe Bolt
310	Engine Coolant Air Bleed Hose Clamp
311	Engine Coolant Air Bleed Hose
312	Engine Coolant Air Bleed Cover Bolt
313	Engine Coolant Air Bleed Cover
500	Intake Manifold
506	Valley Cover Bolt
507	Throttle Body Nut
508	Throttle Body
509	Throttle Body Gasket
510	Fuel Rail with Injectors
511	Fuel Rail Bolt
512	Intake Manifold Bolt
513	Intake Manifold Insulator
514	Intake Manifold Gasket
520	Knock Sensor Oil Seals
555	Valley Cover
556	Valley Cover Gasket
708	Evaporative Emission (EVAP) Purge Valve
709	EVAP Purge Valve Isolator
710	EVAP Purge Valve Bolt
712	Fuel Rail Stop Bracket
713	Fuel Rail Stop Bracket Bolt
714	Manifold Absolute Pressure (MAP) Sensor
715	MAP Sensor Grommet
716	Positive Crankcase Ventilation (PCV) Hose
717	Knock Sensor Wire Harness
718	Knock Sensor
729	EVAP Purge Valve O-Ring



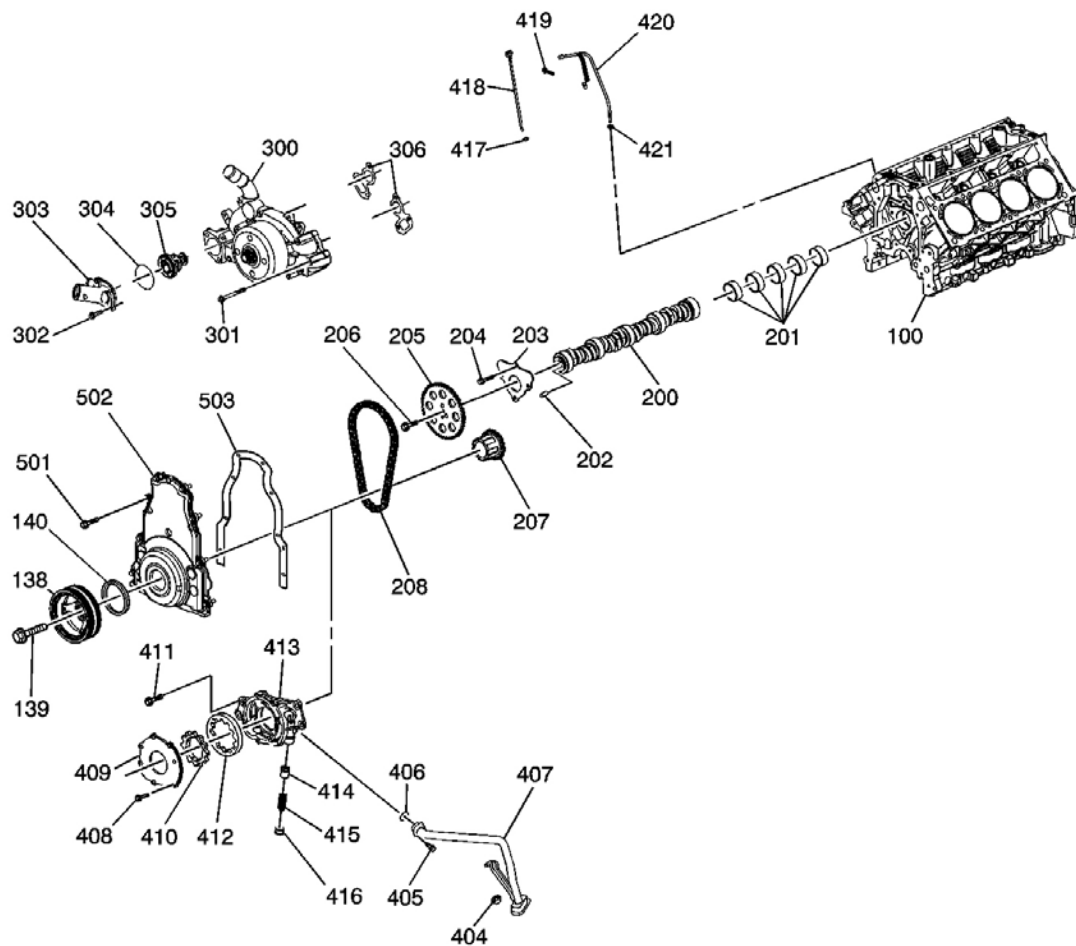


**Fig. 12: Cylinder Head/Upper Engine Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 12**

Callout	Component Name
209	Valve Lifter
210	Valve Lifter Guide
211	Valve Lifter Guide Bolt
212	Pushrod
213	Rocker Arm
214	Rocker Arm Bolt
215	Rocker Arm Pedestal
216	Expansion Plug
217	Cylinder Head Gasket
218	Cylinder Head
219	Cylinder Head Bolt - M8 Short

220	Cylinder Head Bolt - M11 Medium
221	Cylinder Head Bolt - M11 Long - First Design
222	Valve Stem Oil Seal
222	Valve Stem Oil Seal
223	Valve Spring
223	Valve Spring
224	Valve Spring Cap
224	Valve Spring Cap
225	Valve Stem Key
226	Expansion Plug
227	Intake Valve
228	Exhaust Valve
229	Cylinder Head Coolant Plug
230	Cylinder Head Locating Pin
422	Oil Fill Tube O-Ring
423	Oil Fill Tube
424	Oil Fill Cap
450	Oil Fill Cap O-Ring
504	Valve Cover Gasket
504	Valve Cover Gasket
505	Valve Cover
505	Valve Cover
515	Valve Cover Bolt Grommet
516	Valve Cover Bolt
600	Exhaust Manifold
601	Exhaust Manifold Gasket
602	Exhaust Manifold Bolt
603	Exhaust Manifold Heat Shield
604	Exhaust Manifold Heat Shield Bolt
700	Fresh Air Hose
719	Ignition Coils and Bracket Assembly
720	Ignition Coil and Bracket Assembly Bolt
721	Ignition Coil Wire Harness
722	Ignition Coil
723	Ignition Coil Bolt
724	Spark Plug Wire
725	Coolant Temperature Sensor
726	Spark Plug

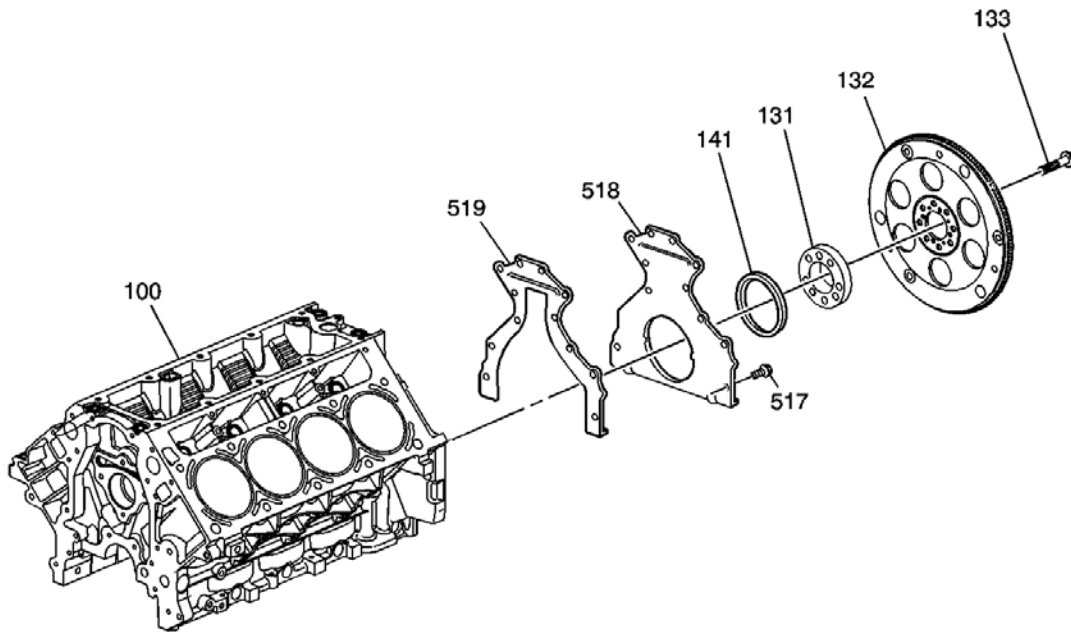


**Fig. 13: Front Of Engine Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 13**

Callout	Component Name
100	Engine Block
138	Crankshaft Balancer
139	Crankshaft Balancer Bolt
140	Crankshaft Front Oil Seal
200	Camshaft
201	Camshaft Bearings
202	Camshaft Sprocket Locating Pin
203	Camshaft Retainer Plate
204	Camshaft Retainer Plate Bolt
205	Camshaft Sprocket
206	Camshaft Sprocket Bolt

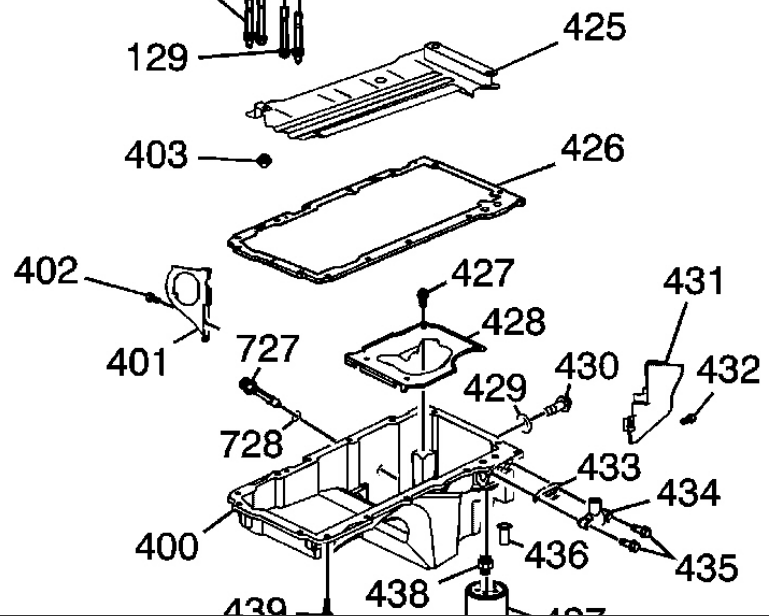
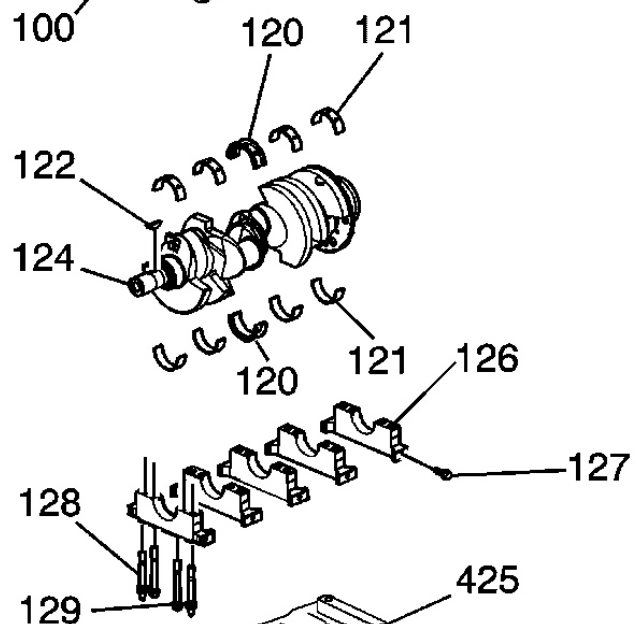
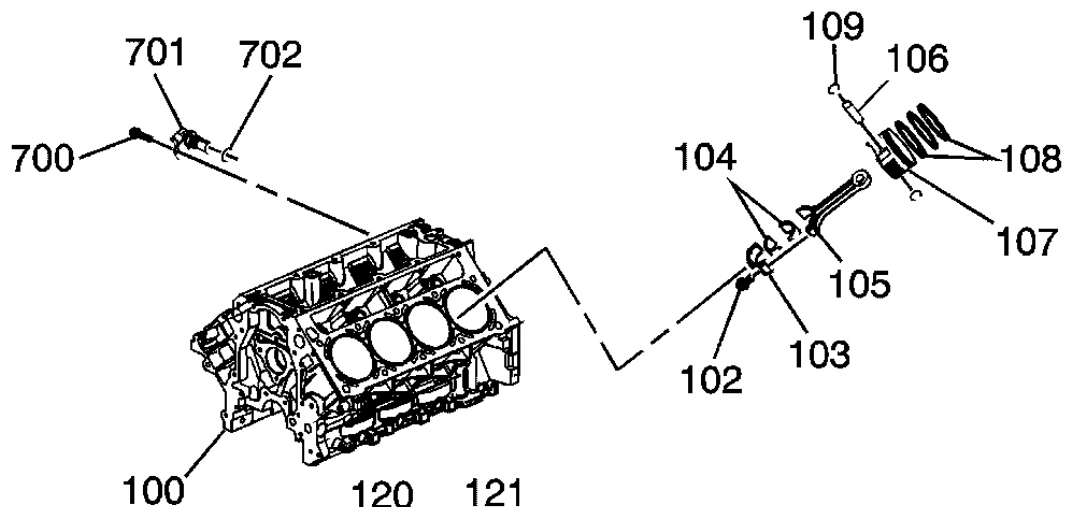
207	Crankshaft Sprocket
208	Timing Chain
300	Water Pump
301	Water Pump Bolt
302	Thermostat Housing Bolt
303	Thermostat Housing
304	O-Ring
305	Thermostat
306	Water Pump Gasket
404	Crankshaft Oil Deflector Nut
405	Oil Pump Screen Bolt
406	Oil Pump Screen O-Ring
407	Oil Pump Screen
408	Oil Pump Cover Bolt
409	Oil Pump Cover
410	Drive Gear
411	Oil Pump Bolt
412	Driven Gear
413	Oil Pump Assembly
414	Pressure Relief Valve
415	Pressure Relief Valve Spring
416	Plug
417	Oil Level Indicator O-Ring
418	Oil Level Indicator
419	Oil Level Tube Bolt
420	Oil Level Tube
421	Oil Level Tube O-Ring
501	Front Cover Bolt
502	Front Cover
503	Front Cover Gasket



**Fig. 14: Rear Of Engine Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 14**

Callout	Component Name
100	Engine Block
131	Flywheel Spacer
132	Flywheel
133	Flywheel Bolt
141	Crankshaft Rear Oil Seal
517	Rear Cover Bolt
518	Rear Cover
519	Rear Cover Gasket

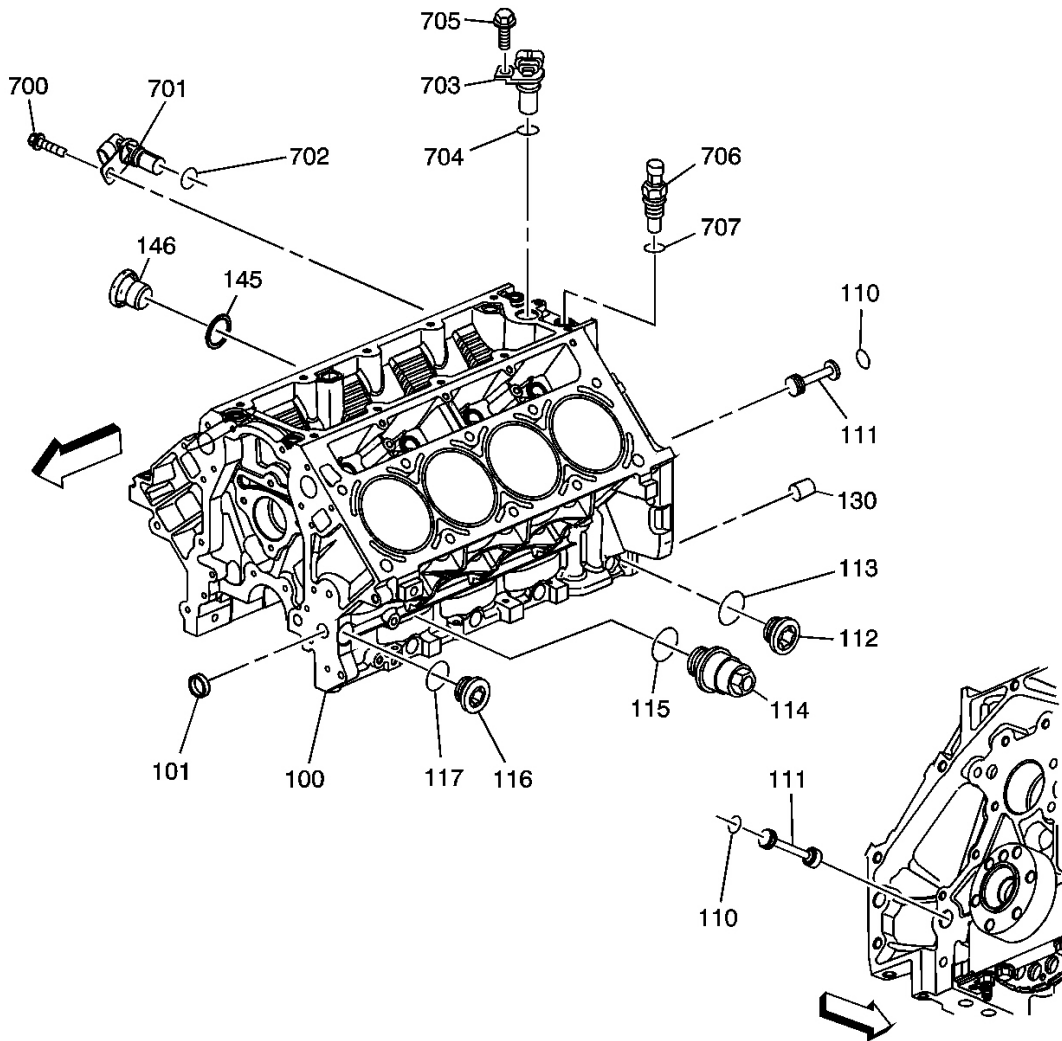


**Fig. 15: Lower Engine Assembly Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 15**

<b>Callout</b>	<b>Component Name</b>
100	Engine Block
102	Connecting Rod Bolt
103	Connecting Rod Cap
104	Connecting Rod Bearings
105	Connecting Rod
106	Piston Pin
107	Piston
108	Piston Rings
109	Piston Pin Clip - Second Design with Full-Floating Pin
120	Crankshaft Thrust Bearing
120	Crankshaft Thrust Bearing
121	Crankshaft Main Bearing
121	Crankshaft Main Bearing
122	Crankshaft Sprocket Key
124	Crankshaft
126	Bearing Cap
127	Bearing Cap Side Bolt
128	Bearing Cap Bolt/Stud
129	Bearing Cap Bolt
400	Oil Pan
401	Closeout Cover - Right
402	Closeout Cover Bolt - Right
403	Crankshaft Oil Deflector Nut
425	Crankshaft Oil Deflector
426	Oil Pan Gasket
427	Oil Pan Baffle Bolt
428	Oil Pan Baffle
429	Oil Pan Drain Plug O-Ring
430	Oil Pan Drain Plug
431	Closeout Cover - Left
432	Closeout Cover Bolt - Left
433	Oil Pan Cover Gasket
434	Oil Pan Cover
435	Oil Pan Cover Bolts
436	Oil Filter Bypass Valve
437	Oil Filter

438	Oil Filter Adapter
439	Oil Pan Bolt
700	Crankshaft Position Sensor Bolt
701	Crankshaft Position Sensor
702	Crankshaft Position Sensor O-Ring
727	Oil Level Sensor
728	O-Ring



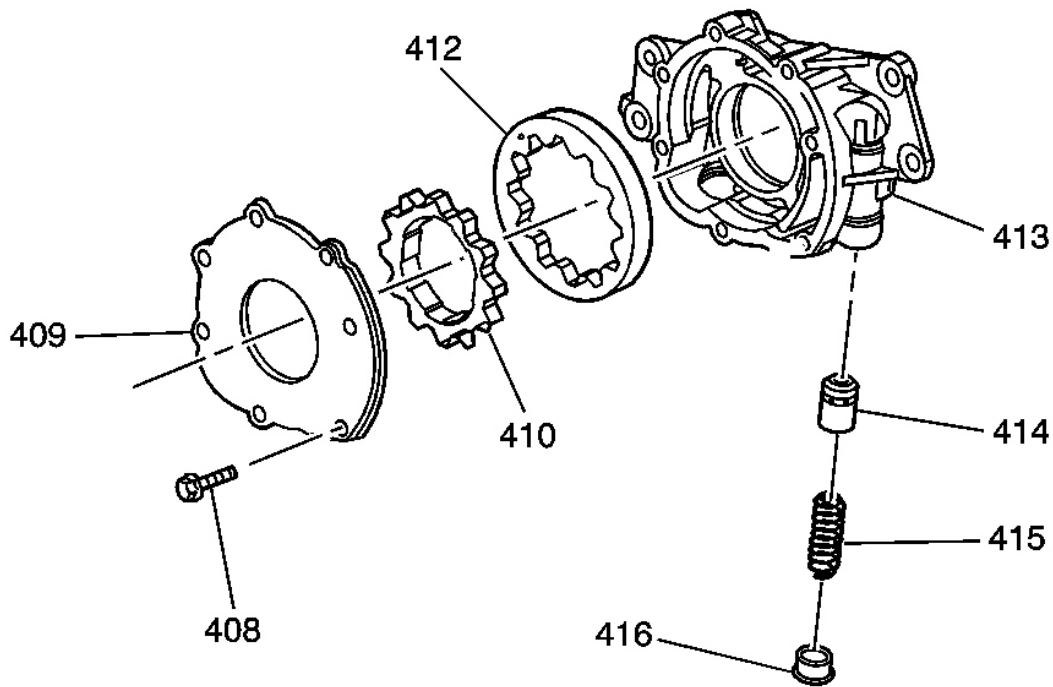
**Fig. 16: Engine Block Plugs/Sensors Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 16**

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



100	Engine Block
101	Engine Block Front Oil Gallery Plug
110	Engine Block Rear Oil Gallery Plug O-Ring
110	Engine Block Rear Oil Gallery Plug O-Ring
111	Engine Block Rear Oil Gallery Plug
111	Engine Block Rear Oil Gallery Plug
112	Oil Gallery Plug
113	Oil Gallery Plug Washer
114	Coolant Heater
115	Coolant Heater Washer
116	Oil Gallery Plug
117	Oil Gallery Plug Washer
130	Transmission Housing Locating Pin
145	Coolant Drain Plug Washer - Right
146	Coolant Drain Plug - Right
700	Crankshaft Position (CKP) Sensor Bolt
701	CKP Sensor
702	CKP Sensor O-Ring
703	Camshaft Position (CMP) Sensor
704	CMP Sensor O-Ring
705	CMP Sensor Bolt
706	Oil Pressure Sensor
707	Oil Pressure Sensor Washer

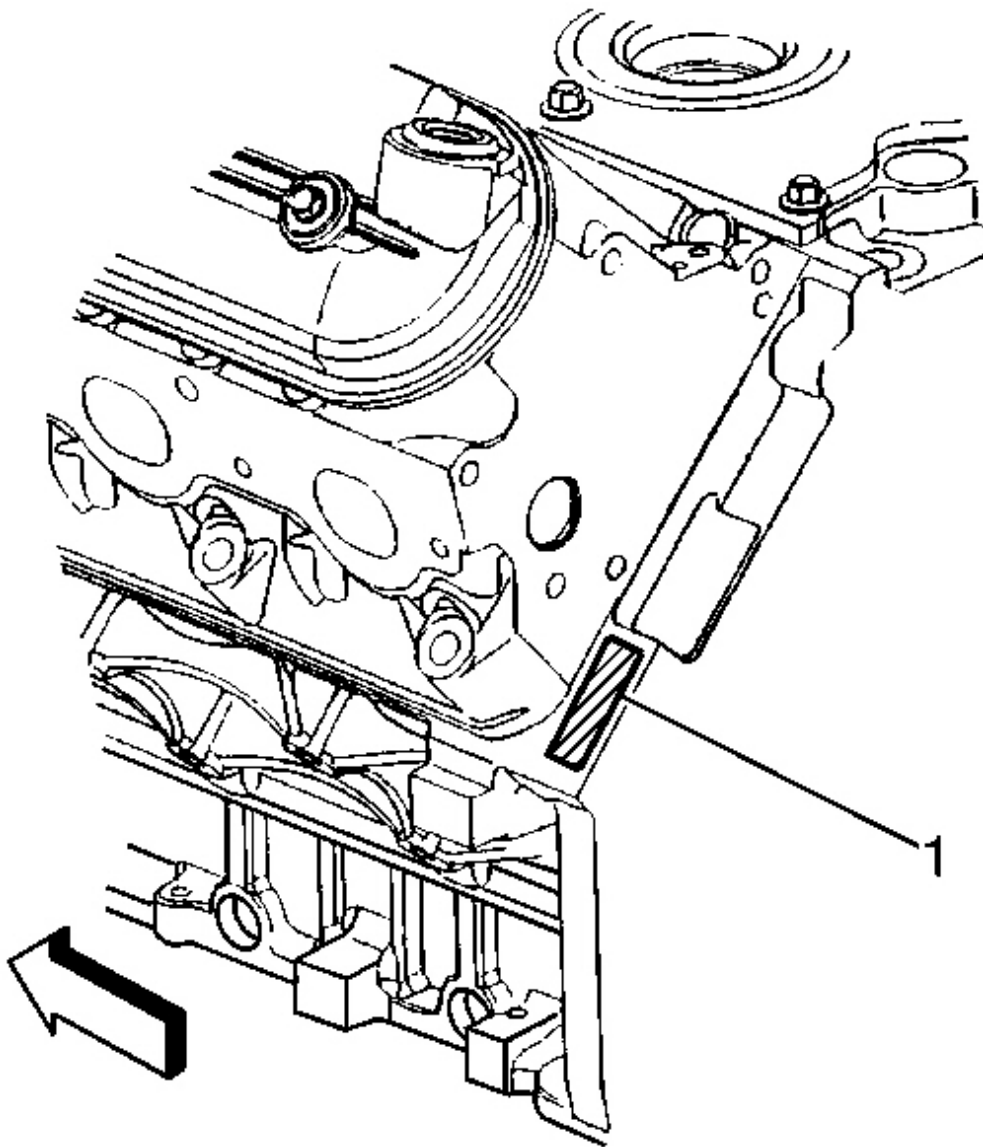


**Fig. 17: Oil Pump Assembly Component Views**  
 Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 17**

Callout	Component Name
408	Cover Bolt
409	Cover
410	Drive Gear
412	Driven Gear
413	Oil Pump
414	Pressure Relief Valve
415	Pressure Relief Valve Spring
416	Plug

**ENGINE IDENTIFICATION**



**Fig. 18: Engine Identification Location**  
Courtesy of GENERAL MOTORS CORP.

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a nine digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.

- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the VIN.

## DIAGNOSTIC INFORMATION AND PROCEDURES

### DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views** , **Engine Component Description** , **Lubrication Description** , **New Product Information** , and **Drive Belt System 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 the **Diagnostic System Check - Engine Controls** in Engine Controls - 6.0L 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** , **Lubrication Description** , **New Product Information** , and **Drive Belt System Description** .

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

#### Visual/Physical Inspection

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

#### Intermittent

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

properly.

## Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Compression Test**
- **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**
- **Coolant in Combustion Chamber**
- **Coolant in Engine Oil**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Cylinder Leakage Test**
- **Drive Belt Chirping Diagnosis**
- **Drive Belt Squeal Diagnosis**
- **Drive Belt Whine Diagnosis**
- **Drive Belt Rumbling Diagnosis**
- **Drive Belt Vibration Diagnosis**
- **Drive Belt Falls Off Diagnosis**
- **Drive Belt Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

## BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

### Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, such as 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 and lead to a	Replace the drive belt. Refer to <b><u>Drive Belt Replacement - Accessory</u></b> .

misfire DTC. A misfire code may be present without an actual misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout - May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <b><u>Engine Flywheel Replacement</u></b> or <b><u>Crankshaft Balancer Replacement</u></b> .
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Worn or bent pushrods	<ul style="list-style-type: none"> <li>• Replace the pushrods.</li> <li>• Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.</li> </ul>
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	<ul style="list-style-type: none"> <li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b> .</li> <li>• Repair or replace the oil pump as required.</li> </ul>
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages - Refer to <b><u>Diagnostic Starting Point</u></b> -	<ul style="list-style-type: none"> <li>• Inspect for spark plugs saturated by coolant. Refer to <b><u>Spark Plug Inspection</u></b> in Engine Controls -</li> </ul>

<p><b>Engine Cooling</b> in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.</p>	<p>6.0L.</p> <ul style="list-style-type: none"> <li>• Inspect the cylinder heads, engine block, and/or head gaskets. Refer to <b><u>Coolant in Combustion Chamber</u></b> .</li> <li>• Repair or replace as required.</li> </ul>
<p>Worn piston rings Oil consumption may or may not cause the engine to misfire.</p>	<ul style="list-style-type: none"> <li>• Inspect the spark plugs for oil deposits. Refer to <b><u>Spark Plug Inspection</u></b> in Engine Controls - 6.0L.</li> <li>• Inspect the cylinders for a loss of compression. Refer to <b><u>Engine Compression Test</u></b> .</li> <li>• Perform cylinder leak down and compression testing to identify the cause. Refer to <b><u>Cylinder Leakage Test</u></b> .</li> <li>• Repair or replace as required.</li> </ul>
<p>A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.</p> <ul style="list-style-type: none"> <li>• Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then sync the crankshaft position.</li> <li>• Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.</li> <li>• Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.</li> </ul>	<p>Replace the sensor and/or crankshaft as required.</p>

## BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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

Cause	Correction
<p>Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or</p>	<p>Replace the drive belt. Refer to <b><u>Drive Belt Replacement - Accessory</u></b> .</p>

components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <b>Engine Flywheel Replacement</b> or <b>Crankshaft Balancer Replacement</b> .
Worn piston rings Oil consumption may or may not cause the engine to misfire.	<ul style="list-style-type: none"> <li>• Inspect the spark plugs for oil deposits. Refer to <b>Spark Plug Inspection</b> in Engine Controls - 6.0L.</li> <li>• Inspect the cylinders for a loss of compression. Refer to <b>Engine Compression Test</b> .</li> <li>• Perform cylinder leak down and compression testing to determine the cause. Refer to <b>Cylinder Leakage Test</b> .</li> <li>• Repair or replace as required.</li> </ul>
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

## BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

### Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Worn or bent pushrods	<ul style="list-style-type: none"> <li>• Replace the pushrods.</li> <li>• Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.</li> </ul>
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.



Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

## BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

### Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages - Refer to <b><u>Diagnostic Starting Point - Engine Cooling</u></b> in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	<ul style="list-style-type: none"> <li>Inspect for spark plugs saturated by coolant. Refer to <b><u>Spark Plug Inspection</u></b> in Engine Controls - 6.0L.</li> <li>Perform a cylinder leak down test. Refer to <b><u>Cylinder Leakage Test</u></b> .</li> <li>Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to <b><u>Coolant in Combustion Chamber</u></b> .</li> <li>Repair or replace as required.</li> </ul>

## BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

### Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	<ul style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits. Refer to <b><u>Spark Plug Inspection</u></b> in Engine Controls - 6.0L.</li> <li>Repair or replace as required.</li> </ul>
Worn piston rings Oil consumption may or may not cause the engine to misfire.	<ul style="list-style-type: none"> <li>Inspect the spark plugs for oil deposits. Refer to <b><u>Spark Plug Inspection</u></b> in Engine Controls - 6.0L.</li> <li>Inspect the cylinders for a loss of compression. Refer to <b><u>Engine Compression Test</u></b> .</li> <li>Perform cylinder leak down and compression testing to determine the cause. Refer to <b><u>Cylinder Leakage Test</u></b> .</li> <li>Repair or replace as required.</li> </ul>

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil.

	2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters as required.
Worn crankshaft thrust bearing	<ol style="list-style-type: none"> <li>1. Check the crankshaft end play.</li> <li>2. Inspect the thrust bearing and crankshaft.</li> <li>3. Repair or replace as required.</li> </ol>
Damaged or faulty oil filter by-pass valve	<ul style="list-style-type: none"> <li>• Inspect the oil filter by-pass valve for proper operation.</li> <li>• Repair or replace as required.</li> </ul>

## UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

### Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	<ul style="list-style-type: none"> <li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b> .</li> <li>• Repair or replace as required.</li> </ul>
Loose and/or worn valve rocker arm attachments	<ul style="list-style-type: none"> <li>• Inspect the valve rocker arm, bolt, and pedestal.</li> <li>• Repair or replace as required.</li> </ul>
Worn or damaged valve rocker arm	<ul style="list-style-type: none"> <li>• Inspect the rocker arm for wear or missing needle bearings</li> <li>• Replace the valve rocker arms as required.</li> </ul>
Bent or damaged push rod	<p>Inspect the following components and replace as required:</p> <ul style="list-style-type: none"> <li>• The valve rocker arm</li> <li>• The valve push rod</li> <li>• The valve lifter</li> <li>• The valve lifter guide</li> <li>• The piston</li> </ul> <p>Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.</p>
Improper lubrication to the valve rocker arms	<p>Inspect the following components and repair or replace as required:</p> <ul style="list-style-type: none"> <li>• The valve rocker arm</li> <li>• The valve push rod</li> <li>• The valve lifter</li> <li>• The oil filter bypass valve</li> <li>• The oil pump and pump screen</li> </ul>

	<ul style="list-style-type: none"> <li>• The engine block oil galleries</li> </ul>
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	<ul style="list-style-type: none"> <li>• Inspect the engine camshaft lobes.</li> <li>• Replace the camshaft and valve lifters as required.</li> </ul>
Worn valve guides or valve stems	<p>Inspect the following components and repair as required:</p> <ul style="list-style-type: none"> <li>• The valves</li> <li>• The valve guides</li> </ul>
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	<p>Inspect the following components and repair as required:</p> <ul style="list-style-type: none"> <li>• The valves</li> <li>• The valve guides</li> </ul>

## LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

### Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
<p><b>IMPORTANT:</b>  A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis.  A low rumble/knocking may indicate a crankshaft or piston, lower engine, concern.</p>	
Low oil pressure	<ul style="list-style-type: none"> <li>• Perform an oil pressure test. Refer to <b>Oil Pressure Diagnosis and Testing</b> .</li> <li>• Repair or replace damaged components as required.</li> </ul>
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	<ul style="list-style-type: none"> <li>• Inspect the accessory drive system.</li> <li>• Repair or replace as required.</li> </ul>
Loose or damaged crankshaft balancer	<ul style="list-style-type: none"> <li>• Inspect the crankshaft balancer.</li> <li>• Repair or replace as required.</li> </ul>
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to <b>Detonation/Spark Knock in Engine Controls - 6.0L</b> .
Loose torque converter bolts	<ul style="list-style-type: none"> <li>• Inspect the torque converter bolts and flywheel.</li> <li>• Repair or replace as required.</li> </ul>

Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	<ul style="list-style-type: none"> <li>• Inspect the oil pump screen.</li> <li>• Repair or replace as required.</li> </ul>
Excessive piston-to-cylinder bore clearance	<ul style="list-style-type: none"> <li>• Inspect the piston and cylinder bore.</li> <li>• Repair as required.</li> </ul>
Excessive piston pin-to-bore clearance	<ul style="list-style-type: none"> <li>• Inspect the piston, pin, and connecting rod.</li> <li>• Replace the piston, pin and connecting rod as an assembly, as required.</li> </ul>
Excessive connecting rod bearing clearance	<p>Inspect the following components, and repair as required:</p> <ul style="list-style-type: none"> <li>• The connecting rod bearings</li> <li>• The connecting rods</li> <li>• The crankshaft</li> <li>• The crankshaft journals</li> </ul>
Excessive crankshaft bearing clearance	<p>Inspect the following components, and repair as required:</p> <ul style="list-style-type: none"> <li>• The crankshaft bearings</li> <li>• The crankshaft journals</li> </ul>
<p>Incorrect piston, piston pin and connecting rod installation</p> <p>Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.</p>	<ul style="list-style-type: none"> <li>• Verify the pistons, piston pins and connecting rods are installed correctly. Refer to <b><u>Piston, Connecting Rod, and Bearing Installation</u></b> .</li> <li>• Repair as required.</li> </ul>

## ENGINE NOISE UNDER LOAD

### Engine Noise Under Load

Cause	Correction
Low oil pressure	<ul style="list-style-type: none"> <li>• Perform an oil pressure test. Refer to <b><u>Oil Pressure Diagnosis and Testing</u></b> .</li> <li>• Repair or replace as required.</li> </ul>
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to <b><u>Detonation/Spark Knock</u></b> in Engine Controls - 6.0L.
Loose torque converter bolts	<ul style="list-style-type: none"> <li>• Inspect the torque converter bolts and flywheel.</li> <li>• Repair as required.</li> </ul>
Cracked flywheel - automatic transmission	<ul style="list-style-type: none"> <li>• Inspect the flywheel bolts and flywheel.</li> <li>• Repair as required.</li> </ul>

Excessive connecting rod bearing clearance	<p>Inspect the following components, and repair as required:</p> <ul style="list-style-type: none"> <li>• The connecting rod bearings</li> <li>• The connecting rods</li> <li>• The crankshaft</li> </ul>
Excessive crankshaft bearing clearance	<p>Inspect the following components, and repair as required:</p> <ul style="list-style-type: none"> <li>• The crankshaft bearings</li> <li>• The crankshaft journals</li> <li>• The cylinder block crankshaft bearing bore</li> </ul>

## ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

### Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	<ol style="list-style-type: none"> <li>1. Remove the accessory drive belts.</li> <li>2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location.</li> <li>3. Repair or replace the components as required.</li> </ol>
Seized automatic transmission torque converter	<ol style="list-style-type: none"> <li>1. Remove the torque converter-to-flywheel bolts.</li> <li>2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location.</li> <li>3. Repair or replace the components as required.</li> </ol>
Broken timing chain	<ul style="list-style-type: none"> <li>• Inspect the timing chain and gears.</li> <li>• Repair or replace the components as required.</li> </ul>
Seized timing chain or timing gears	<ul style="list-style-type: none"> <li>• Inspect the timing chain and gears for foreign material or a seized chain.</li> <li>• Repair or replace the components as required.</li> </ul>
Seized or broken camshaft	<ul style="list-style-type: none"> <li>• Inspect the camshaft and the camshaft bearings.</li> <li>• Repair or replace the components as required.</li> </ul>
Bent valve in the cylinder head	<ul style="list-style-type: none"> <li>• Inspect the valves and the cylinder heads.</li> <li>• Repair or replace the components as required.</li> </ul>
Seized oil pump	<ul style="list-style-type: none"> <li>• Inspect the oil pump assembly.</li> <li>• Repair or replace as required.</li> </ul>
Hydraulically locked cylinder <ul style="list-style-type: none"> <li>• Coolant/antifreeze in the cylinder</li> <li>• Oil in the cylinder</li> </ul>	<ol style="list-style-type: none"> <li>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. Refer to <b>Coolant in Combustion Chamber</b> .</li> <li>2. Inspect for failed/broken head gaskets.</li> </ol>

<ul style="list-style-type: none"> <li>Fuel in the cylinder</li> </ul>	<ol style="list-style-type: none"> <li>Inspect for a cracked engine block or cylinder head.</li> <li>Inspect for a sticking fuel injector.</li> <li>Repair or replace the components as required.</li> </ol>
Material in the cylinder <ul style="list-style-type: none"> <li>Broken valve</li> <li>Broken piston rings</li> <li>Piston material</li> <li>Foreign material</li> </ul>	<ul style="list-style-type: none"> <li>Inspect the cylinder for damaged components and/or foreign materials.</li> <li>Repair or replace the components as required.</li> </ul>
Seized crankshaft or connecting rod bearings	<ul style="list-style-type: none"> <li>Inspect crankshaft and connecting rod bearings.</li> <li>Repair or replace the components as required.</li> </ul>
Bent or broken connecting rod	<ul style="list-style-type: none"> <li>Inspect the connecting rods.</li> <li>Replace the piston, pin and connecting rod as an assembly, as required.</li> </ul>
Broken crankshaft	<ul style="list-style-type: none"> <li>Inspect the crankshaft.</li> <li>Repair or replace the components as required.</li> </ul>

## COOLANT IN COMBUSTION CHAMBER

### Coolant in Combustion Chamber

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

head	cylinder head gasket. Refer to <b><u>Cylinder Head Cleaning and Inspection</u></b> .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

## COOLANT IN ENGINE OIL

### Coolant in Engine Oil

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

## ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.

5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gauge at zero and crank the engine through four compression strokes, four puffs.
8. Check the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Check the compression again and record the reading.
10. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ( $1\ 035 \times 70\% = 725$ ) ( $150 \times 70\% = 105$ ).
  - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
  - Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
  - Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
  - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

## CYLINDER LEAKAGE TEST

### Tools Required

**J 35667-A** Cylinder Head Leakdown Tester or equivalent. See **Special Tools and Equipment** .

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

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



**CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.**

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 6.0L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **J 35667-A** or equivalent. See **Special Tools and Equipment** .

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

5. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturers instructions. See **Special Tools and Equipment** .
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 noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
  - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
  - Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
  - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

## **OIL CONSUMPTION DIAGNOSIS**

### **Oil Consumption Diagnosis**

<b>Checks</b>	<b>Causes</b>
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or more of engine oil within 3 200 kilometers (2,000 miles).	
Preliminary	<p>The causes of excessive oil consumption may include the following conditions:</p> <ul style="list-style-type: none"><li>• External oil leaks</li></ul> <p>Refer to <b><u>Oil Leak Diagnosis</u></b> .</p> <ul style="list-style-type: none"><li>• Incorrect oil level or improper reading of the oil level indicator</li></ul> <p>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.</p>

- 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, or not seated properly

Allow adequate time for the rings to seat.

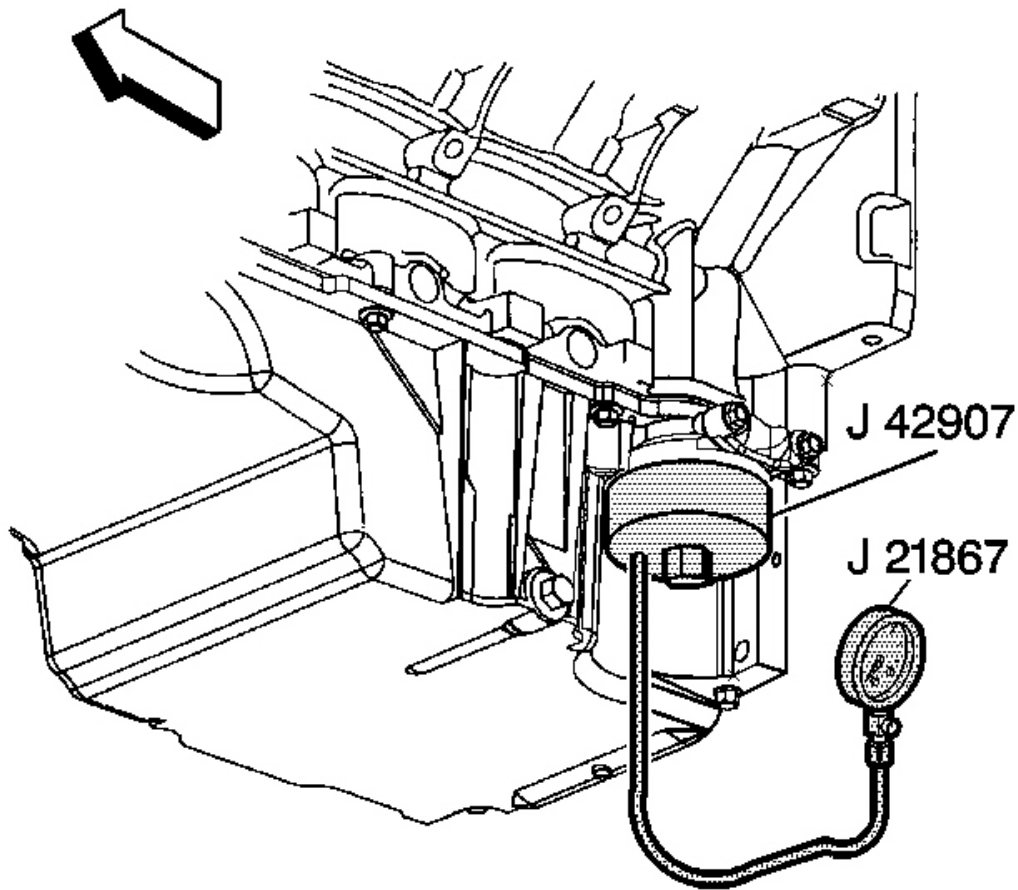
Replace worn piston rings as necessary.

- Piston and rings improperly installed or not fitted to the cylinder bore

## OIL PRESSURE DIAGNOSIS AND TESTING

### Tools Required

- **J 21867** Pressure Gauge. See **Special Tools and Equipment** .
- J 42907 Oil Pressure Testing Tool



**Fig. 19: Identifying J 21867 (Pressure Gauge) & J 42907 (Oil Pressure Testing Tool)**  
Courtesy of GENERAL MOTORS CORP.

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 the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
  - Oil diluted by water or glycol anti freeze
  - Foamy oil
6. Remove the oil filter and install the J 42907 .

7. Install **J 21867** or equivalent to the J 42907 . See **Special Tools and Equipment** .
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 conditions:

- Oil pump worn or dirty

Refer to **Oil Pump Cleaning and Inspection** .

- Oil pump-to-engine block bolts loose

Refer to **Oil Pump, Pump Screen and Deflector Installation** .

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Malfunctioning oil pump pressure relief 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 lifters

Repair as necessary.

11. If the oil pressure reading on the **J 21867** or equivalent is within specifications, inspect for the following conditions:.. See **Special Tools and Equipment** .

- Plugged or incorrect oil filter and/or malfunctioning oil bypass valve
- Malfunctioning oil pressure gauge or sensor

Repair as necessary.

## OIL LEAK DIAGNOSIS

### Oil Leak Diagnosis

Step	Action	Yes	No
<p><b>IMPORTANT:</b>            You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.</p>			
	1. Operate the vehicle until it reaches normal operating temperature.		

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

	the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to <b>Step 10</b>	Go to <b>Step 7</b>
7	<ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> Can you identify the type of fluid and the approximate location of the leak?	Go to <b>Step 10</b>	Go to <b>Step 8</b>
8	Use <b>J 28428-E</b> High Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. See <b>Special Tools and Equipment</b> . Can you identify the type of fluid and the approximate location of the leak?	Go to <b>Step 10</b>	Go to <b>Step 9</b>
9	<ol style="list-style-type: none"> <li>1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.</li> <li>2. Check for leaks at the following locations: <ul style="list-style-type: none"> <li>• Sealing surfaces</li> <li>• Fittings</li> <li>• Cracked or damaged components</li> </ul> </li> </ol> Can you identify the type of fluid and the approximate location of the leak?	Go to <b>Step 10</b>	System OK
10	<ol style="list-style-type: none"> <li>1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: <ul style="list-style-type: none"> <li>• Higher than recommended fluid levels</li> <li>• Higher than recommended fluid pressures</li> <li>• Plugged or malfunctioning fluid filters or pressure bypass valves</li> <li>• Plugged or malfunctioning engine ventilation system</li> <li>• Improperly tightened or damaged fasteners</li> <li>• Cracked or porous components</li> <li>• Improper sealants or gaskets where required</li> <li>• Improper sealant or gasket installation</li> <li>• Damaged or worn gaskets or seals</li> <li>• Damaged or worn sealing surfaces</li> </ul> </li> <li>2. Inspect the engine for customer modifications.</li> </ol> Is there mechanical damage, or customer modifications to the engine?	Go to <b>Step 11</b>	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to <b>Step 1</b>	System OK

## CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

### Crankcase Ventilation System Inspection/Diagnosis

Symptom	Correction
External oil leak	Inspect for any of the following conditions: <ul style="list-style-type: none"><li>• Restricted positive crankcase ventilation (PCV) valve</li><li>• Restricted or kinked PCV hose or engine vent hose</li><li>• Damaged, incorrect, or incorrectly installed PCV valve or hose</li><li>• Excessive crankcase pressure</li></ul>
Rough Idle	Inspect for any of the following conditions: <ul style="list-style-type: none"><li>• Restricted PCV valve</li><li>• Restricted or kinked PCV hose or engine vent hose</li><li>• Leaking (damaged) PCV valve or hose</li><li>• Vacuum hoses worn or not properly installed</li></ul>
Stalling or slow idle speed	Inspect for any of the following conditions: <ul style="list-style-type: none"><li>• Restricted PCV valve</li><li>• Restricted or kinked PCV hose or engine vent hose</li><li>• Leaking (damaged) PCV valve or hose</li></ul>
High idle speed	Inspect for a leaking (damaged) PCV valve or hose
Sludge in the engine	Inspect for any of the following conditions: <ul style="list-style-type: none"><li>• Restricted PCV valve</li><li>• Restricted or kinked PCV hose or engine vent hose</li></ul>

## DRIVE BELT CHIRPING DIAGNOSIS

### Diagnostic Aids

The chirping noise may be intermittent due to moisture on the drive belt(s) or the accessory drive pulley(s). In order to duplicate the customer's concern, it may be necessary to spray a small amount of water onto the drive belt(s). If spraying water onto the drive belt(s) duplicates the symptom, cleaning the accessory drive pulley(s) may be the most probable solution.

A loose or improper installation of a body or suspension component, or other item(s) on the vehicle may also cause the chirping noise.

### Test Description

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

**2:** The chirping 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 any further in this table.

**3:** The noise may be an internal engine noise. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the chirping noise is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.

**4:** Inspect the drive belt(s) for signs of pilling. Pilling is the small balls, pills, or strings in the drive belt grooves caused by the accumulation of rubber dust.

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

**10:** Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.

**12:** Inspection of the accessory drive pulley(s) should include inspecting for bends, dents, or other damage to the pulley(s) that would prevent the drive belt(s) from seating properly in the pulley grooves or on the smooth surface of the pulley when the back side of the drive belt is used to drive the pulley.

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

### Drive Belt Chirping Diagnosis

Step	Action	Yes	No
<p><b>NOTE:</b> Refer to <b>Belt Dressing Notice in Cautions and Notices.</b></p> <p>DEFINITION: The following items are indications of chirping:</p> <ul style="list-style-type: none"> <li>• A high pitched noise that is heard once per revolution of the drive belt(s) or a accessory drive pulley.</li> <li>• Chirping may occur on cold damp startup conditions and will subside once the vehicle reaches normal operating temperature.</li> </ul>			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to <b>Step 3</b>	Go to Diagnostic Aids
3	<ol style="list-style-type: none"> <li>1. Remove the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> .</li> <li>2. Operate the engine for no longer than 30 to 40 seconds.</li> </ol>	Go to <b>Engine Noise on Start-Up, but Only</b>	



	Does the chirping noise still exist?	<b><u>Lasting a Few Seconds</u></b>	Go to <b>Step 4</b>
<b>4</b>	Inspect for severe drive belt pilling exceeding 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to <b>Step 5</b>	Go to <b>Step 6</b>
<b>5</b>	Clean the accessory drive pulley(s) with a suitable wire brush. Were the accessory drive pulley(s) cleaned?	Go to <b>Step 15</b>	-
<b>6</b>	Inspect for a misaligned accessory drive pulley(s). Is there a misaligned accessory drive pulley(s)?	Go to <b>Step 7</b>	Go to <b>Step 8</b>
<b>7</b>	Replace and/or repair the misaligned accessory drive pulley(s). Were the misaligned accessory drive pulley(s) replaced and/or repaired?	Go to <b>Step 15</b>	-
<b>8</b>	Inspect for a bent or cracked accessory drive bracket(s). Did you find any bent or cracked accessory drive bracket(s)?	Go to <b>Step 9</b>	Go to <b>Step 10</b>
<b>9</b>	Replace the bent and/or cracked accessory drive bracket(s). Was the bent and/or cracked accessory drive bracket(s) replaced?	Go to <b>Step 15</b>	-
<b>10</b>	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose, and/or missing fasteners found?	Go to <b>Step 11</b>	Go to <b>Step 12</b>
<b>11</b>	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications</u></b> .  Were the fasteners replaced and/or tightened?	Go to <b>Step 15</b>	-
<b>12</b>	Inspect for a bent accessory drive pulley(s). Was a bent accessory drive pulley(s) found?	Go to <b>Step 13</b>	Go to <b>Step 14</b>
<b>13</b>	Replace the bent accessory drive pulley(s). Was the bent accessory drive pulley(s) replaced?	Go to <b>Step 15</b>	-
<b>14</b>	Replace the drive belt(s). Refer to <b><u>Drive Belt Replacement - Accessory</u></b> or <b><u>Drive Belt Replacement - Air Conditioning</u></b> . Was the drive belt(s) replaced?	Go to <b>Step 15</b>	-
<b>15</b>	1. Clear any codes. 2. Run the engine in order to verify the repair.  Does the chirping noise still exist?	-	System OK

## **DRIVE BELT SQUEAL DIAGNOSIS**

## Diagnostic Aids

A loose or improper installation of a body, or suspension component, or other item(s) on the vehicle may cause the squeal noise.

If the squeal is intermittent, verify that it is not the accessory drive component(s) by varying their load(s), making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

### Test Description

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

- 2:** The squeal 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 in this table
- 3:** The squeal may be an internal engine noise. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the squealing noise is related to the drive belt(s) or an accessory drive component. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.
- 4:** This test is to verify that an accessory drive component(s) does not have a seized bearing. With the belt (s) removed, test the bearings in the accessory drive component(s) for smooth operation. Also test the accessory drive component(s) with the engine operating by varying the load on the accessory drive component(s) to verify that the component(s) is operating properly.
- 5:** This test is to verify that the drive belt(s) tensioner(s) are not operating properly. If the drive belt tensioner(s) are not operating properly, proper belt tension may not be achieved to keep the drive belt(s) from slipping which could cause a squealing noise.
- 6:** This test is to verify that the drive belt(s) is not too long, which would prevent the drive belt tensioner (s) from operating properly. Also if the incorrect length drive belt(s) was installed, it may not be routed correctly and may be turning an accessory drive component in the incorrect direction.
- 7:** Misalignment of the accessory drive pulley(s) may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper removal and installation procedure for that pulley.
- 8:** Inspect the accessory drive pulley(s) to verify that they are the correct diameter or width. Using a known good vehicle, compare the accessory drive pulleys.

### Drive Belt Squeal Diagnosis

Step	Action	Yes	No
<b>NOTE:</b> Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt squeal:			

- A loud screeching noise that is caused by a slipping drive belt(s) (this is unusual for a drive belt with multiple ribs)
- The squeal occurs when a heavy load is applied to the drive belt(s), such as an A/C compressor engagement, snapping the throttle, slipping on a seized pulley, or a faulty accessory drive component.

1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Verify that there is a squealing noise. Does the engine make the squeal noise?	Go to <b>Step 3</b>	Go to Diagnostic Aids
3	<ol style="list-style-type: none"> <li>1. Remove the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> .</li> <li>2. Operate the engine for no longer than 30 to 40 seconds.</li> </ol> <p>Does the squealing noise still exist?</p>	Go to <b>Engine Noise on Start-Up, but Only Lasting a Few Seconds</b>	Go to <b>Step 4</b>
4	Inspect for a seized accessory drive component bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to <b>Step 9</b>	Go to <b>Step 5</b>
5	Inspect the drive belt tensioner for proper operation. Refer to <b>Drive Belt Tensioner Diagnosis</b> . Did you find and correct the condition?	Go to <b>Step 9</b>	Go to <b>Step 6</b>
6	Check for the correct length drive belt(s). Did you find and correct the condition?	Go to <b>Step 9</b>	Go to <b>Step 7</b>
7	Inspect for a misaligned pulley. Did you find and correct the condition?	Go to <b>Step 9</b>	Go to <b>Step 8</b>
8	Inspect for an incorrect size pulley. Did you find and correct the condition?	Go to <b>Step 9</b>	-
9	<ol style="list-style-type: none"> <li>1. Install the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> .</li> <li>2. Clear any codes.</li> <li>3. Run the engine in order to verify the repair.</li> </ol> <p>Does the squealing noise still exist?</p>	-	System OK

## DRIVE BELT WHINE DIAGNOSIS

### Diagnostic Aids

The drive belt(s) will not cause the whine.

If the whine is intermittent, verify that it is not the accessory drive component(s) by varying their loads, making

sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

### Test Description

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

**3:** This test is to verify that the whine is being caused by the accessory drive component(s). Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the whining noise is related to the accessory drive component. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.

**4:** This 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 removal and installation procedure.

### Drive Belt Whine Diagnosis

Step	Action	Yes	No
<p><b>NOTE:</b> Refer to <b>Belt Dressing Notice in Cautions and Notices.</b></p> <p>DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.</p>			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Verify that there is a whining noise. Does the engine make the whining noise?	Go to <b>Step 3</b>	Go to Diagnostic Aids
3	<ol style="list-style-type: none"> <li>1. Remove the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b>.</li> <li>2. Operate the engine for no longer than 30 to 40 seconds.</li> </ol> Does the whining noise still exist?	Go to <b>Engine Noise on Start-Up, but Only Lasting a Few Seconds</b>	Go to <b>Step 4</b>
4	<ol style="list-style-type: none"> <li>1. Inspect for a failed accessory drive component bearing.</li> <li>2. Install the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b>.</li> </ol> Did you find and correct the condition?	Go to <b>Step 5</b>	-
	<ol style="list-style-type: none"> <li>1. Clear any codes.</li> </ol>		

5	2. Run the engine in order to verify the repair.	-	System OK
	Does the whining still exist?		

## 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(s) may be the only repair for the symptom.

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

### Test Description

The number(s) below refer to the step(s) in 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. Rumbling 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. Operate the engine for a few seconds, this will verify if the rumbling noise is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.

**4:** Inspect the drive belt(s) to ensure that the drive belt(s) is not the cause of the noise. Small cracks across the ribs of the drive belt(s) will not cause the noise. Belt separation is identified by the plies of the belt separating, this may be seen at the edge of the belt or felt as a lump in the belt.

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

### Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
<p><b>NOTE:</b> Refer to Belt Dressing Notice in Cautions and Notices.</p> <p>DEFINITION:</p> <ul style="list-style-type: none"> <li>A low pitch tapping, knocking, or thumping noise heard at or just above idle.</li> </ul>			

- Heard once per revolution of the drive belt(s) or pulley(s).
- Rumbling may be caused from:
  - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt(s) pulley groove
  - The separation of the drive belt(s)
  - A damaged drive belt(s)

1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to <b>Step 3</b>	Go to Diagnostic Aids
3	<ol style="list-style-type: none"> <li>1. Remove the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b>.</li> <li>2. Operate the engine for no longer than 30 to 40 seconds.</li> </ol> Does the rumbling noise still exist?	Go to <b>Engine Noise on Start-Up, but Only Lasting a Few Seconds</b>	Go to <b>Step 4</b>
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. Were any of these conditions found?	Go to <b>Step 7</b>	Go to <b>Step 5</b>
5	Inspect for severe pilling of more than 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to <b>Step 6</b>	Go to <b>Step 7</b>
6	<ol style="list-style-type: none"> <li>1. Clean the drive belt pulleys using a suitable wire brush.</li> <li>2. Reinstall the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b>.</li> </ol> Did you complete the repair?	Go to <b>Step 8</b>	-
7	Install a new drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> . Did you complete the replacement?	Go to <b>Step 8</b>	-
8	<ol style="list-style-type: none"> <li>1. Clear any codes.</li> <li>2. Run the engine in order to verify the repair.</li> </ol> Does the rumbling noise still exist?	-	System OK

## DRIVE BELT VIBRATION DIAGNOSIS

### Diagnostic Aids

The accessory drive components may have an affect on engine vibration. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or an extra load placed on the generator are suggested items to inspect. 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(s) in the diagnostic table.

**2:** This test is to verify that the vibration 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. Remove the drive belt(s) and operate the engine for a few seconds, this will verify if the vibration is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) 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 drive belt(s).

**6:** Inspection of the fasteners can eliminate the possibility that a incorrect 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 smooth operation. Inspect for a bent fan shaft or bent mounting flange.

**9:** Inspect the water pump drive shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known, good water pump.

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

### Drive Belt Vibration Diagnosis

Step	Action	Yes	No
<p><b>NOTE:</b> Refer to Belt Dressing Notice in Cautions and Notices.</p> <p>DEFINITION: The following items are indications of drive belt vibration:</p> <ul style="list-style-type: none"> <li>• The vibration is engine-speed related.</li> <li>• The vibration may be sensitive to accessory load.</li> </ul>			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to <b>Step 3</b>	Go to Diagnostic Aids
	1. Remove the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b>		

3	<p>or <b><u>Drive Belt Replacement - Air Conditioning</u></b> .</p> <p>2. Operate the engine for no longer than 30 to 40 seconds.</p> <p>Does the engine still make the vibration?</p>	<p>Go to <b><u>Diagnostic Starting Point - Vibration Diagnosis and Correction</u></b> in Vibration Diagnosis and Correction</p>	<p>Go to <b>Step 4</b></p>
4	<p>Inspect the drive belt(s) for wear, damage, debris build-up and missing drive belt ribs. Were any of these conditions found?</p>	<p>Go to <b>Step 5</b></p>	<p>Go to <b>Step 6</b></p>
5	<p>Install a new drive belt(s). Refer to <b><u>Drive Belt Replacement - Accessory</u></b> or <b><u>Drive Belt Replacement - Air Conditioning</u></b> . Did you complete the replacement?</p>	<p>Go to <b>Step 11</b></p>	<p>-</p>
6	<p>Inspect for incorrect, loose, and/or missing fasteners. Were any of these conditions found?</p>	<p>Go to <b>Step 7</b></p>	<p>Go to <b>Step 8</b></p>
7	<p>Replace any incorrect and/or missing fastener. Tighten any loose fasteners. Refer to <b><u>Fastener Tightening Specifications</u></b> . Were the fasteners replaced and/or tightened?</p>	<p>Go to <b>Step 11</b></p>	<p>-</p>
8	<p>Inspect for damaged fan blades or a bent fan clutch shaft. Did you find and correct the condition?</p>	<p>Go to <b>Step 11</b></p>	<p>Go to <b>Step 9</b></p>
9	<p>Inspect for a bent water pump drive shaft. Did you find and correct the condition?</p>	<p>Go to <b>Step 11</b></p>	<p>Go to <b>Step 10</b></p>
10	<p>Inspect for a bent or cracked accessory drive bracket(s). Did you find and correct the condition?</p>	<p>Go to <b>Step 11</b></p>	<p>-</p>
11	<p>1. Clear any codes. 2. Run the engine in order to verify the repair.</p> <p>Does the vibration still exist?</p>	<p>-</p>	<p>System OK</p>

## DRIVE BELT FALLS OFF DIAGNOSIS

### Diagnostic Aids

If the drive belt(s) repeatedly falls off the accessory drive pulley(s), this may be caused by a pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may also cause the drive belt (s) to fall off. Verify that the accessory drive component(s) are operating properly.



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

### Test Description

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

**2:** This inspection is to verify the condition of the drive belt(s). Damage may have occurred to the drive belt(s) when the drive belt(s) fell off the pulley. Inspect the drive belt(s) for cuts, tears, sections of ribs missing, or damaged belt plys.

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

**5:** Inspection of the accessory drive pulley(s) should include inspecting for bends, dents, or other damage that would prevent the drive belt from seating properly in the pulley grooves or on the smooth surface of a pulley when the back side of the drive belt(s) is used to drive the pulley.

**6:** Accessory drive component brackets that are bent or cracked will also cause the drive belt(s) to fall off.

**7:** Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed. Missing, loose, or incorrect fasteners may cause pulley misalignment from the accessory drive bracket(s) moving under load. Over tightening the fasteners may cause misalignment of the accessory component bracket(s).

### Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
<b>NOTE:</b> Refer to <b>Belt Dressing Notice in Cautions and Notices.</b>			
DEFINITION: The drive belt(s) falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Inspect for a damaged drive belt(s). Was a damaged drive belt(s) found?	Go to <b>Step 3</b>	Go to <b>Step 4</b>
3	Install a new drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> . Does the drive belt(s) continue to fall off?	Go to <b>Step 4</b>	System OK
4	Inspect for a misaligned accessory drive pulley(s). Did you find and correct the condition?	Go to <b>Step 12</b>	Go to <b>Step 5</b>
5	Inspect for a bent or dented accessory drive pulley(s). Did you find and correct the condition?	Go to <b>Step 12</b>	Go to <b>Step 6</b>
6	Inspect for a bent or a cracked accessory drive bracket(s). Did you find and correct the condition?	Go to <b>Step 12</b>	Go to <b>Step 7</b>
7	Inspect for incorrect, loose and/or missing fasteners.	Go to	

	Were there any incorrect, loose and/or missing fasteners?	Step 8	Go to Step 9
8	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to <b>Fastener Tightening Specifications</b> . Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for correct operation. Refer to <b>Drive Belt Tensioner Diagnosis</b> . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <b>Drive Belt Tensioner Replacement - Accessory</b> or <b>Drive Belt Tensioner Replacement - Air Conditioning</b> . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for a failed drive belt idler and/or tensioner pulley bearing. Did you find and repair the condition?	Go to Step 12	-
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	-	System OK

## DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

### Diagnostic Aids

Excessive wear on a drive belt(s) is usually caused by incorrect installation or the incorrect drive belt(s) for the application.

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

Excessive misalignment of the accessory drive pulley(s) will cause excessive wear and may also make the drive belt(s) fall off.

### Test Description

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

**2:** This inspection is to verify that the drive belt(s) is correctly installed on all of the accessory drive pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one or more grooves on a pulley(s).

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

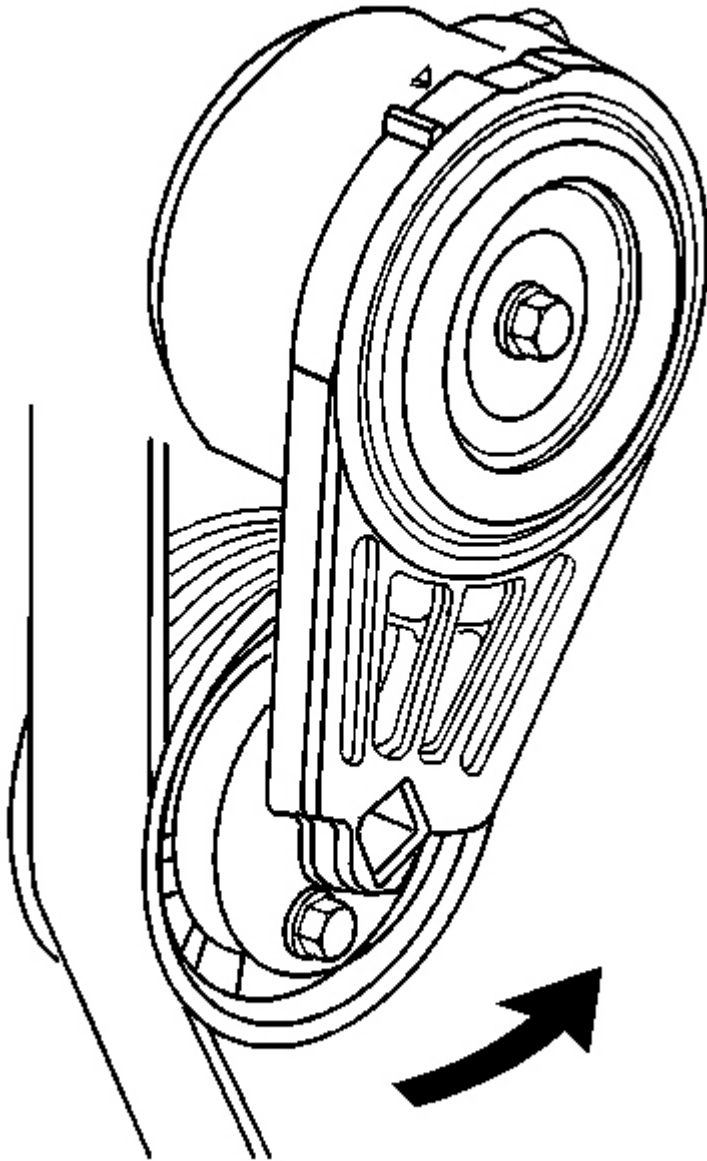
**4:** This inspection is to verify that the drive belt(s) is not contacting any part of the engine or body while the engine is operating. There should be sufficient clearance when the accessory drive components load varies. The drive belt(s) should not come in contact with an engine or a body component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

## Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
<b>NOTE:</b> Refer to <b>Belt Dressing Notice in Cautions and Notices.</b>			
DEFINITION: Wear at the outside ribs of the drive belt(s) due to incorrect installation of the drive belt (s).			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to <b>Step 2</b>	Go to <b>Symptoms - Engine Mechanical</b>
2	Inspect the drive belt(s) for proper installation. Is the drive belt(s) installed properly?	Go to <b>Step 5</b>	Go to <b>Step 3</b>
3	Inspect for the correct drive belt(s). Is the correct drive belt installed?	Go to <b>Step 5</b>	Go to <b>Step 4</b>
4	Inspect the drive belt(s) for signs of rubbing against a bracket, hose, or wiring harness. Was the drive belt(s) rubbing against anything?	Go to <b>Step 5</b>	Go to Diagnostic Aids
5	Replace the drive belt(s). Refer to <b>Drive Belt Replacement - Accessory</b> or <b>Drive Belt Replacement - Air Conditioning</b> . Did you complete the replacement?	Go to <b>Step 6</b>	-
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	-	System OK

## DRIVE BELT TENSIONER DIAGNOSIS

### Inspection Procedure



**Fig. 20: Drive Belt Movement Direction**  
Courtesy of GENERAL MOTORS CORP.

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

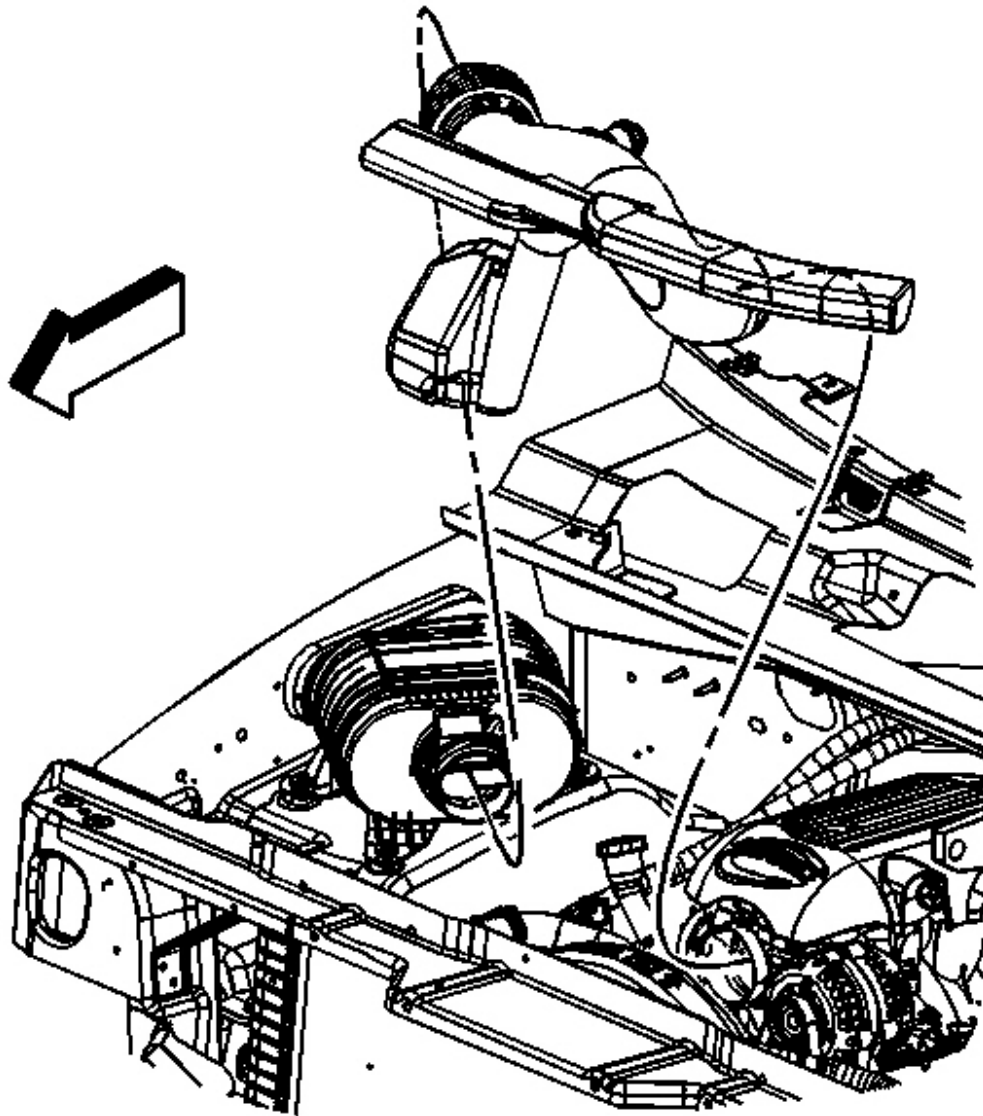
**IMPORTANT: When the engine is operating the drive belt tensioner arm will move. Do not replace the drive belt tensioner because of movement in the drive belt tensioner arm.**

1. Remove the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning** .
2. Move the drive belt tensioner through its full travel.
  - The movement should feel smooth.
  - There should be no binding.
  - The tensioner should return freely.
3. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** or **Drive Belt Tensioner Replacement - Air Conditioning** .
4. Install the drive belt. Refer to of **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning** .

## **REPAIR INSTRUCTIONS**

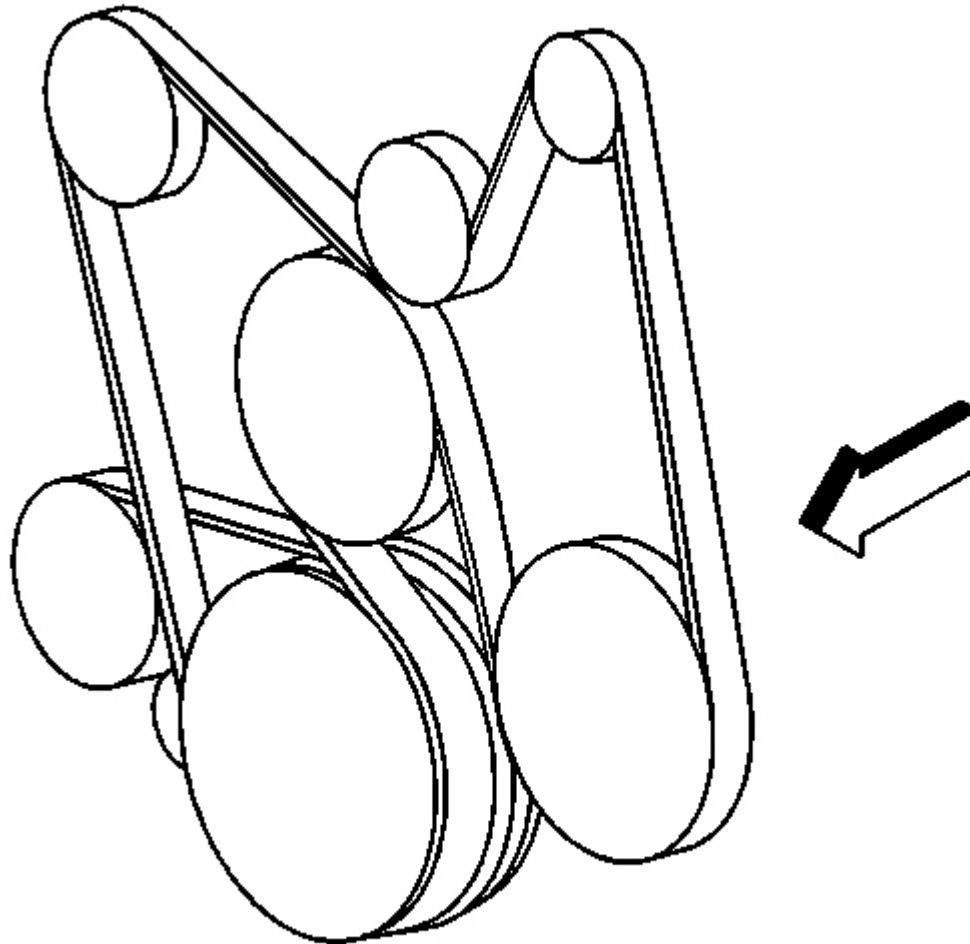
### **DRIVE BELT REPLACEMENT - ACCESSORY**

#### **Removal Procedure**



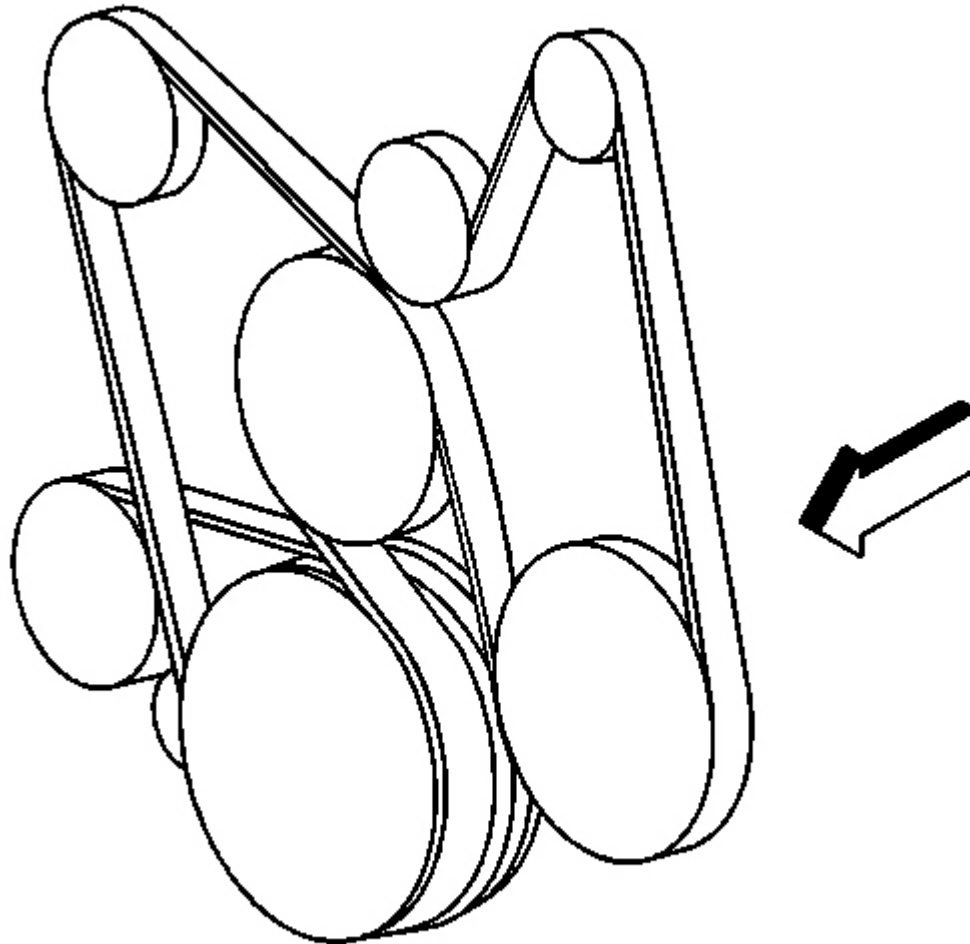
**Fig. 21: Air Cleaner Outlet Duct**  
Courtesy of GENERAL MOTORS CORP.

1. Loosen the air cleaner outlet duct clamps at the following locations:
  - Throttle body
  - Mass airflow/intake air temperature (MAF/IAT) sensor
2. Remove the air cleaner outlet duct.



**Fig. 22: Accessory Drive Belt**  
Courtesy of GENERAL MOTORS CORP.

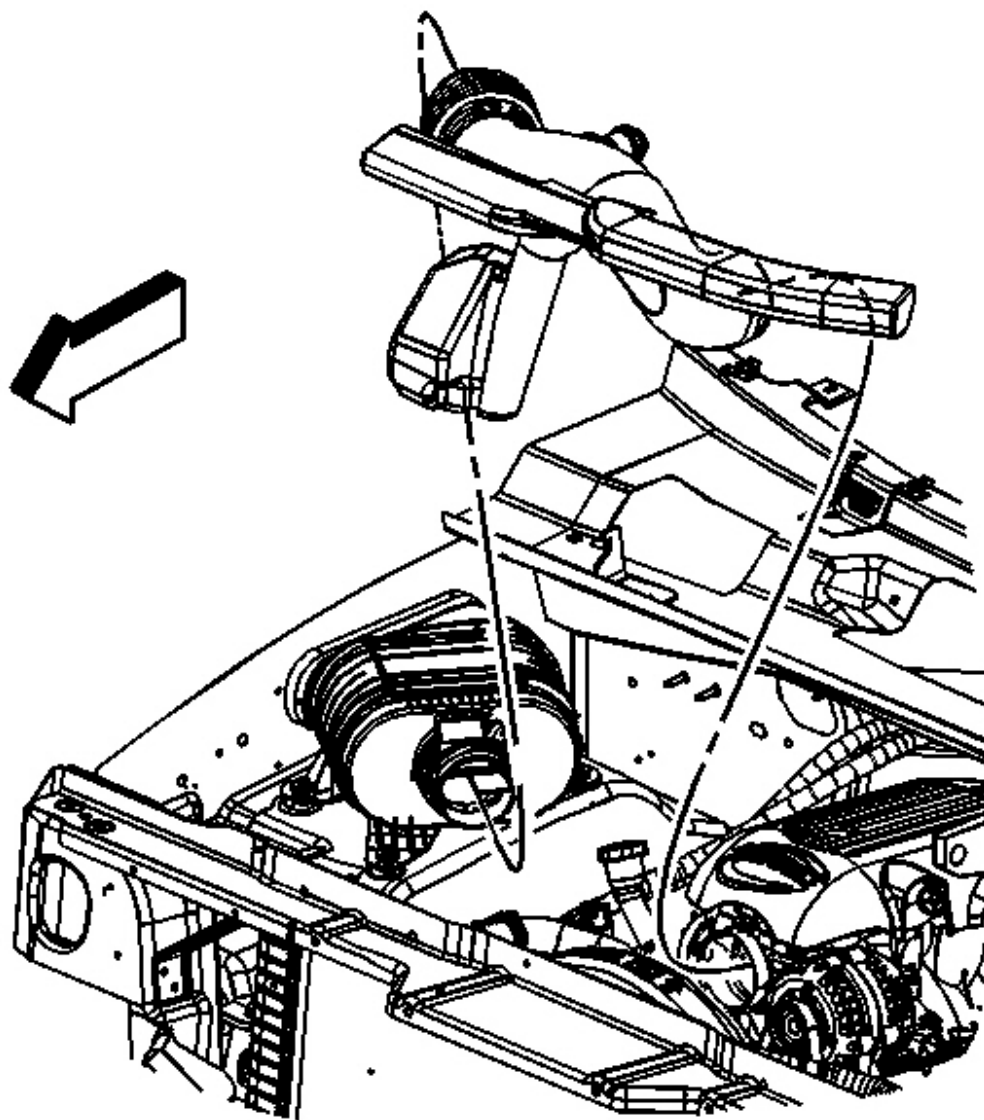
3. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.
4. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt.
5. Remove the belt from the pulleys and the drive belt tensioner.
6. Slowly release the tension on the drive belt tensioner.
7. Remove the breaker bar and socket and from the drive belt tensioner bolt.
8. Clean and inspect the belt surfaces of all the pulleys.



**Fig. 23: Accessory Drive Belt**  
**Courtesy of GENERAL MOTORS CORP.**

1. Route the drive belt around all the pulleys except the idler pulley.
2. Install the breaker bar with hex-head socket to the belt tensioner bolt.
3. Rotate the belt tensioner clockwise in order to relieve the tension on the tensioner.
4. Install the drive belt under the idler pulley.
5. Slowly release the tension on the belt tensioner.
6. Remove the breaker bar and socket from the belt tensioner bolt.
7. Inspect the drive belt for proper installation and alignment.





**Fig. 24: Air Cleaner Outlet Duct**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Align the arrow at the throttle body end of the duct with the throttle body attaching stud.

8. Install the air cleaner outlet duct.

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

9. Tighten the air cleaner outlet duct clamps at the following locations:

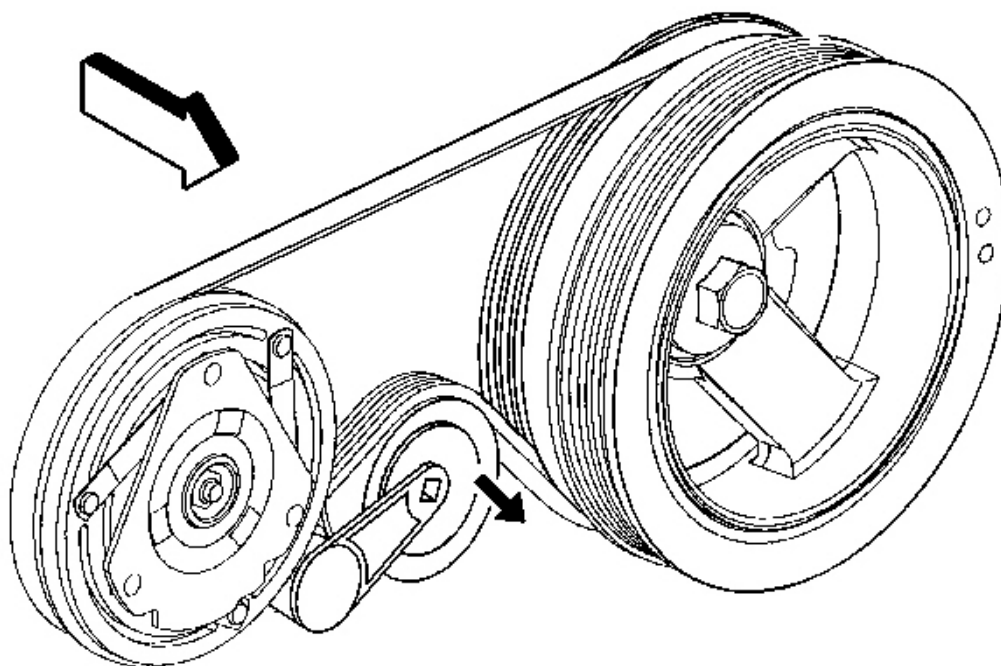
- Throttle body
- MAF/IAT sensor

**Tighten:** Tighten the air cleaner outlet duct clamp screws to 7 N.m (62 lb in).

## **DRIVE BELT REPLACEMENT - AIR CONDITIONING**

### **Removal Procedure**

1. Remove the accessory drive belt. Refer to Drive Belt Replacement - Accessory .
2. Raise and suitably support the vehicle. Refer to Lifting and Jacking the Vehicle .
3. Remove the engine protection shield. Refer to Engine Protection Shield Replacement .

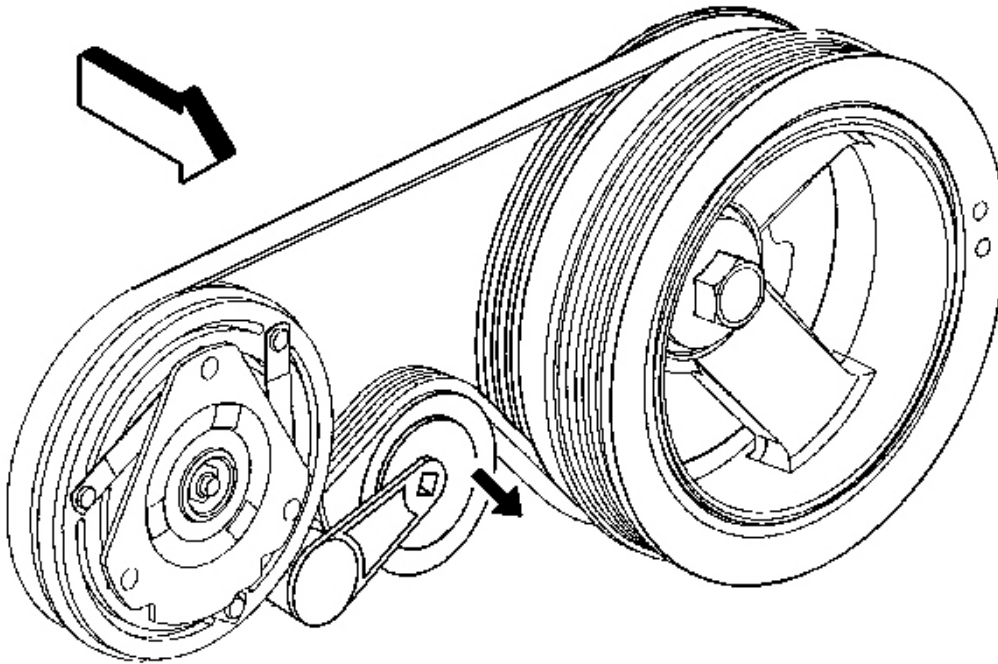


**Fig. 25: A/C Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

4. Install a ratchet into the air conditioning (A/C) belt tensioner adapter opening.

5. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
6. Remove the A/C belt from the pulleys.
7. Slowly release the tension on the A/C belt tensioner.
8. Remove the ratchet from the A/C belt tensioner.
9. Clean and inspect the belt surfaces of all the pulleys.

### **Installation Procedure**

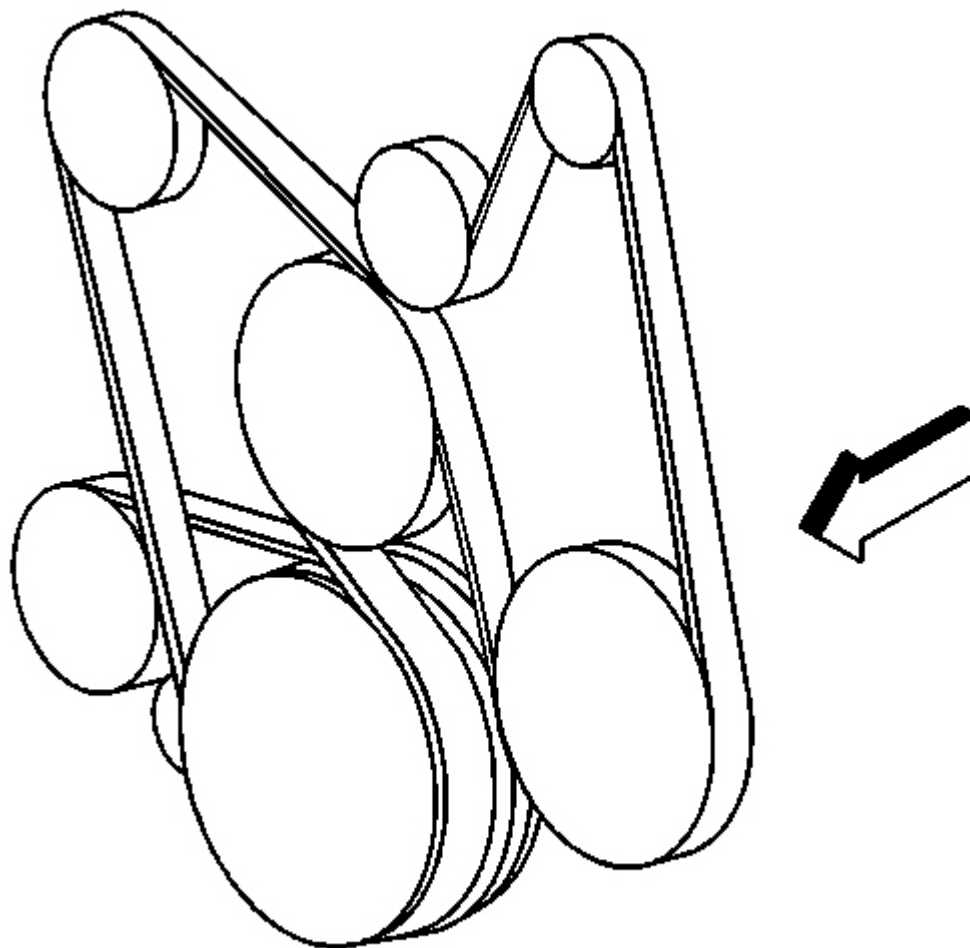


**Fig. 26: A/C Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Install the A/C belt around the crankshaft balancer.
2. Install a ratchet into the A/C drive belt tensioner adapter opening
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the tensioner.
4. Install the A/C belt over the idler pulley.
5. Install the A/C belt around the A/C compressor pulley.
6. Slowly release the tension on the A/C belt tensioner.
7. Remove the ratchet from the A/C belt tensioner.

8. Inspect the A/C belt for proper installation and alignment.
9. Install the engine protection shield. Refer to Engine Protection Shield Replacement .

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



**Fig. 27: Accessory Drive Belt**  
Courtesy of GENERAL MOTORS CORP.

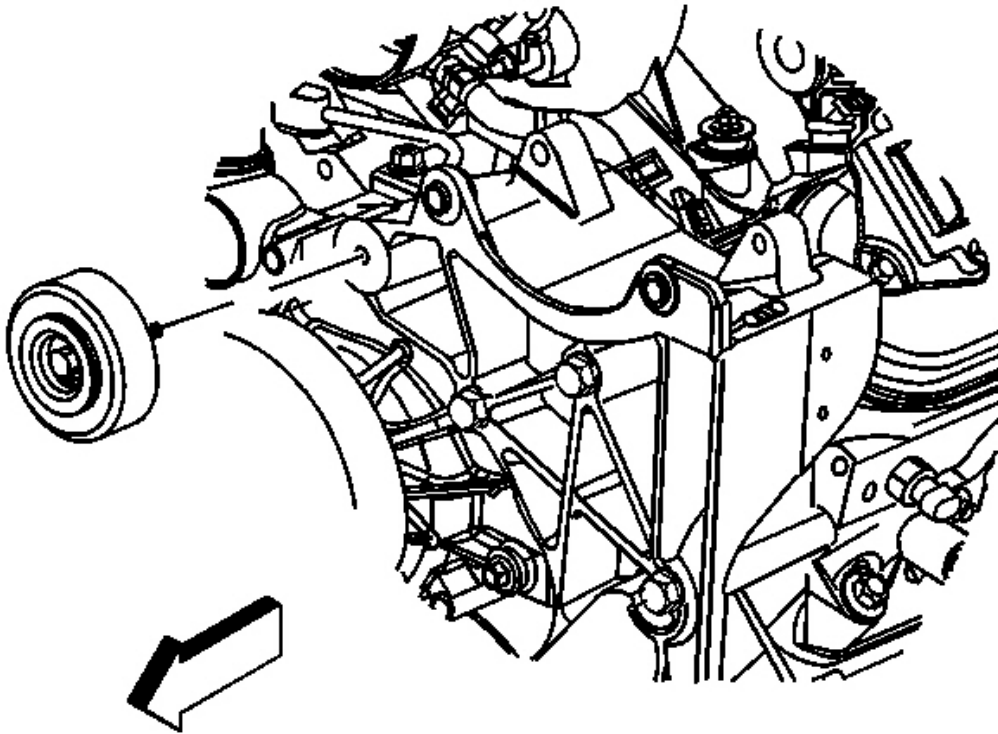
10. Install the engine shield bolts.

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

11. Lower the vehicle.
12. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory** .

## **DRIVE BELT IDLER PULLEY REPLACEMENT**

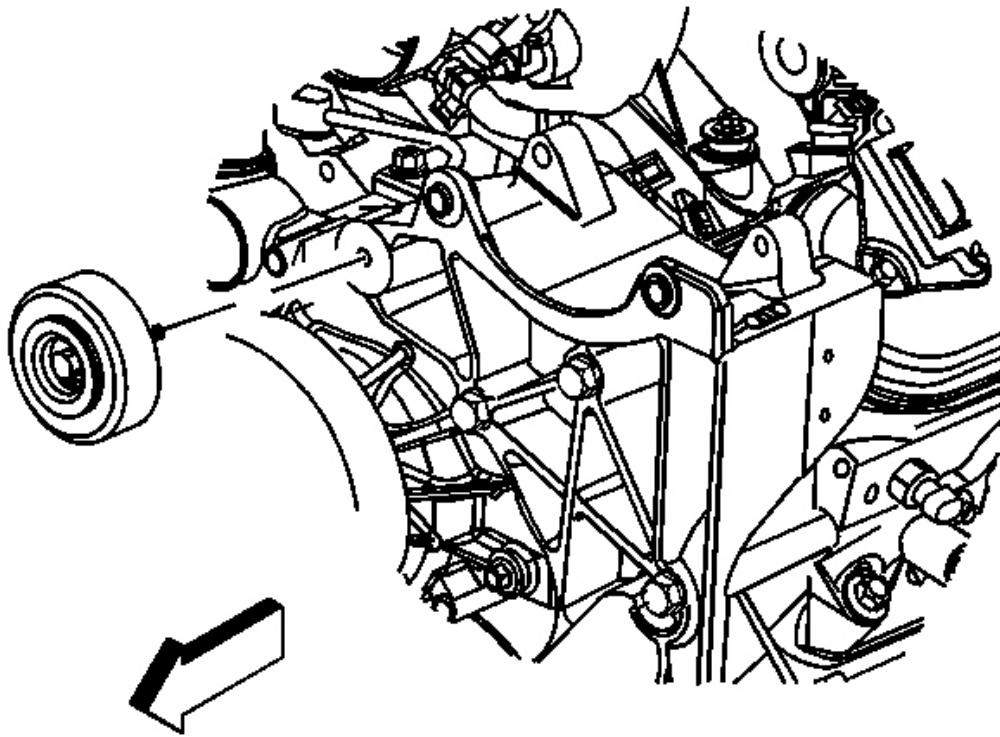
### **Removal Procedure**



**Fig. 28: Drive Belt Idler Pulley (4.8L, 5.3L & 6.0L)**  
**Courtesy of GENERAL MOTORS CORP.**

1. Loosen the drive belt idler pulley bolt.
2. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory** .
3. Remove the drive belt idler pulley and bolt.

### **Installation Procedure**



**Fig. 29: Drive Belt Idler Pulley (4.8L, 5.3L & 6.0L)**  
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley and bolt to the generator bracket.

Snug the bolt finger tight.

2. Install the drive belt. Refer to **Drive Belt Replacement - Accessory** .

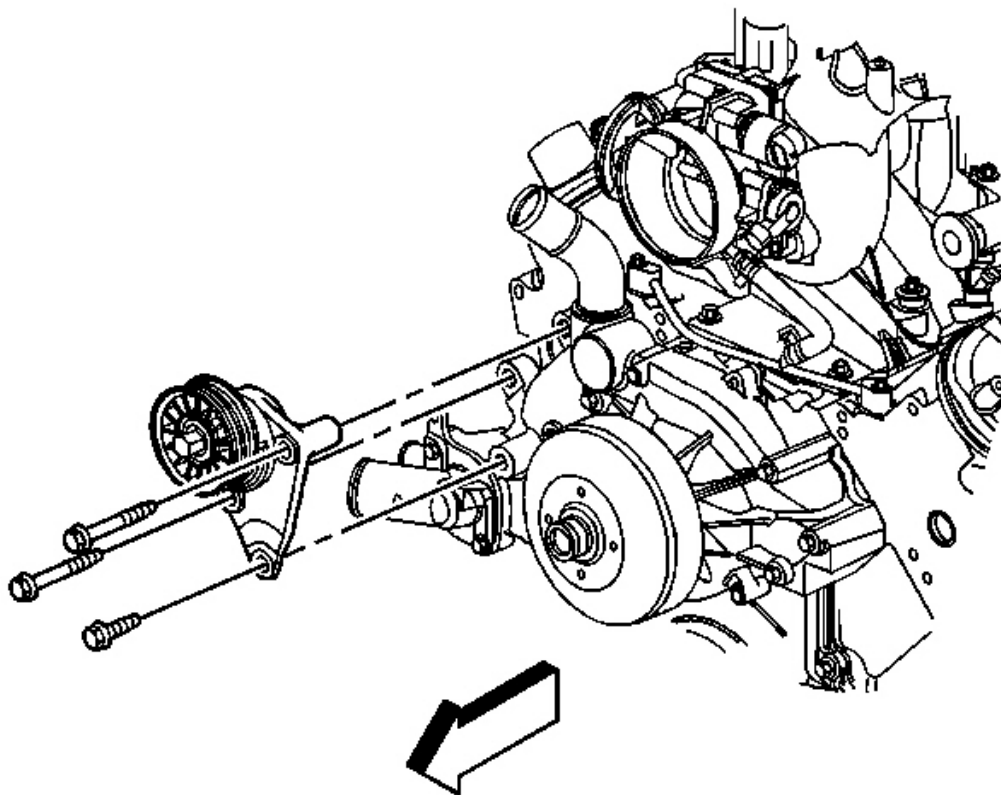
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

3. Tighten the drive belt idler pulley bolt.

**Tighten:** Tighten the drive belt idler pulley bolt to 50 N.m (37 lb ft).

## **DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY**

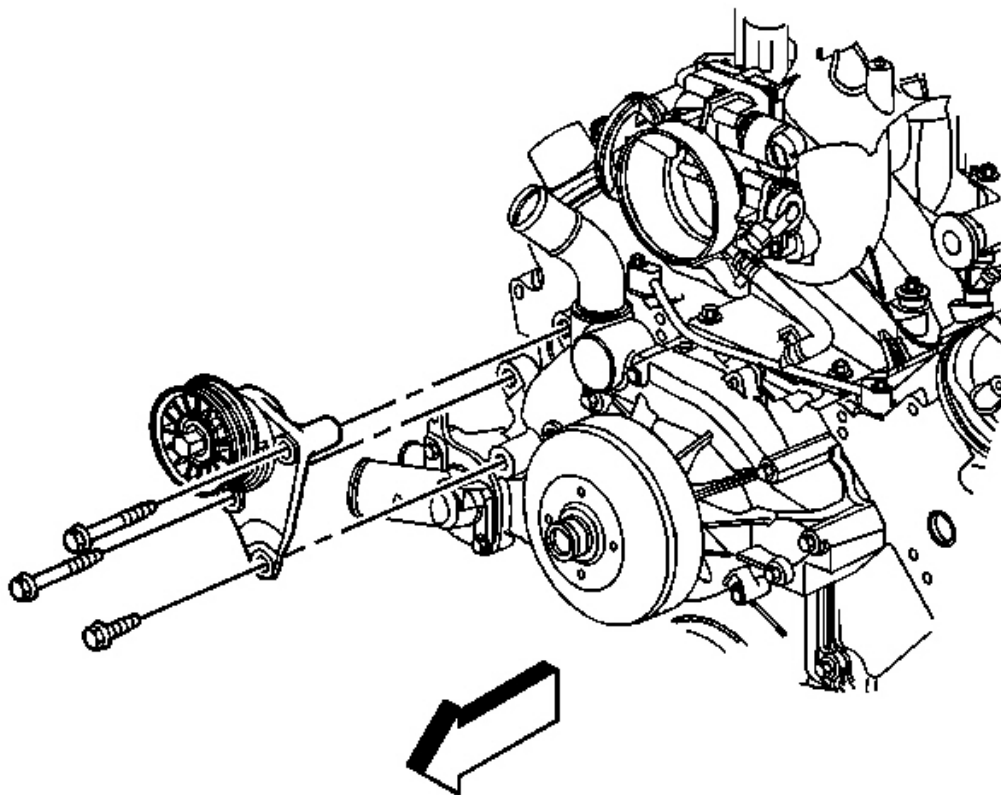
### **Removal Procedure**



**Fig. 30: Accessory Drive Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory** .
2. Remove the drive belt tensioner bolts.
3. Remove the drive belt tensioner.

#### **Installation Procedure**



**Fig. 31: Accessory Drive Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.
2. Install the drive belt tensioner bolts.

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

3. Tighten the drive belt tensioner bolts.

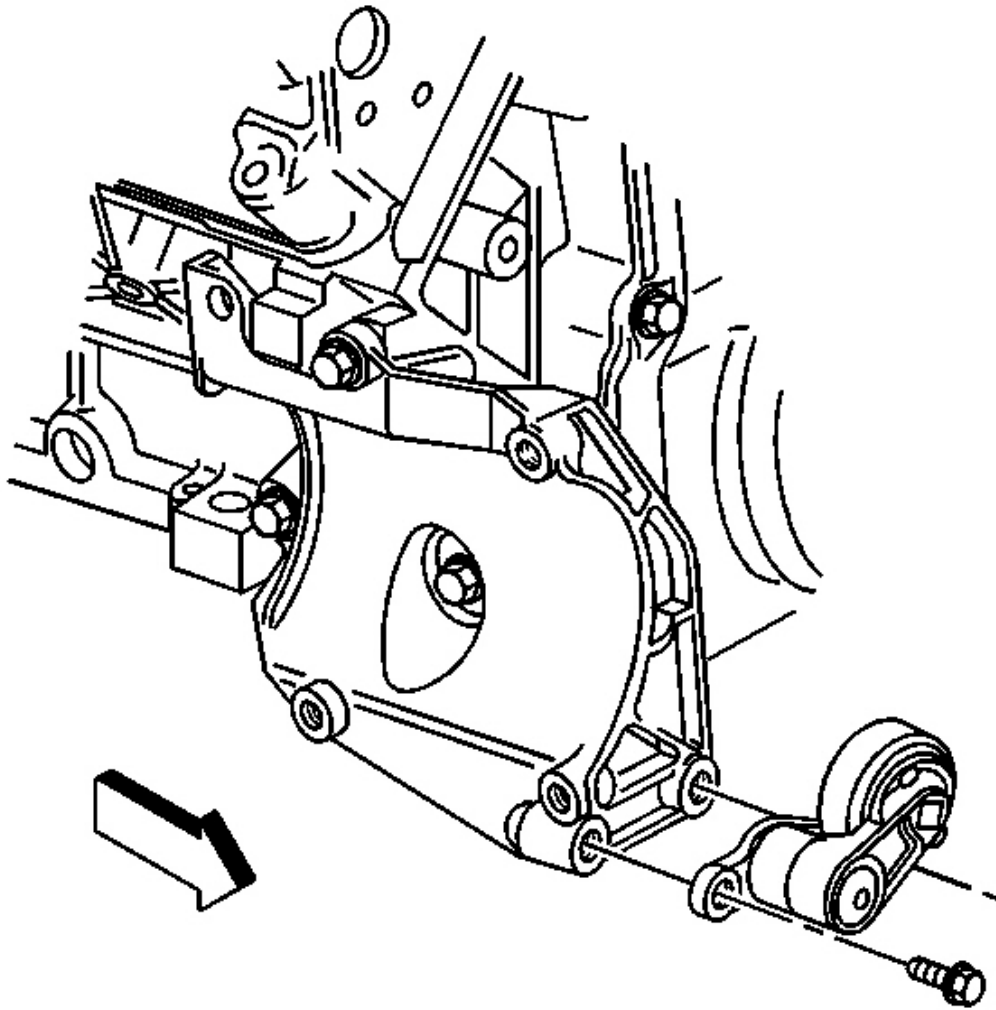
**Tighten:** Tighten the accessory drive belt tensioner bolts to 50 N.m (37 lb ft).

4. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory** .

## **DRIVE BELT TENSIONER REPLACEMENT - AIR CONDITIONING**

### **Removal Procedure**

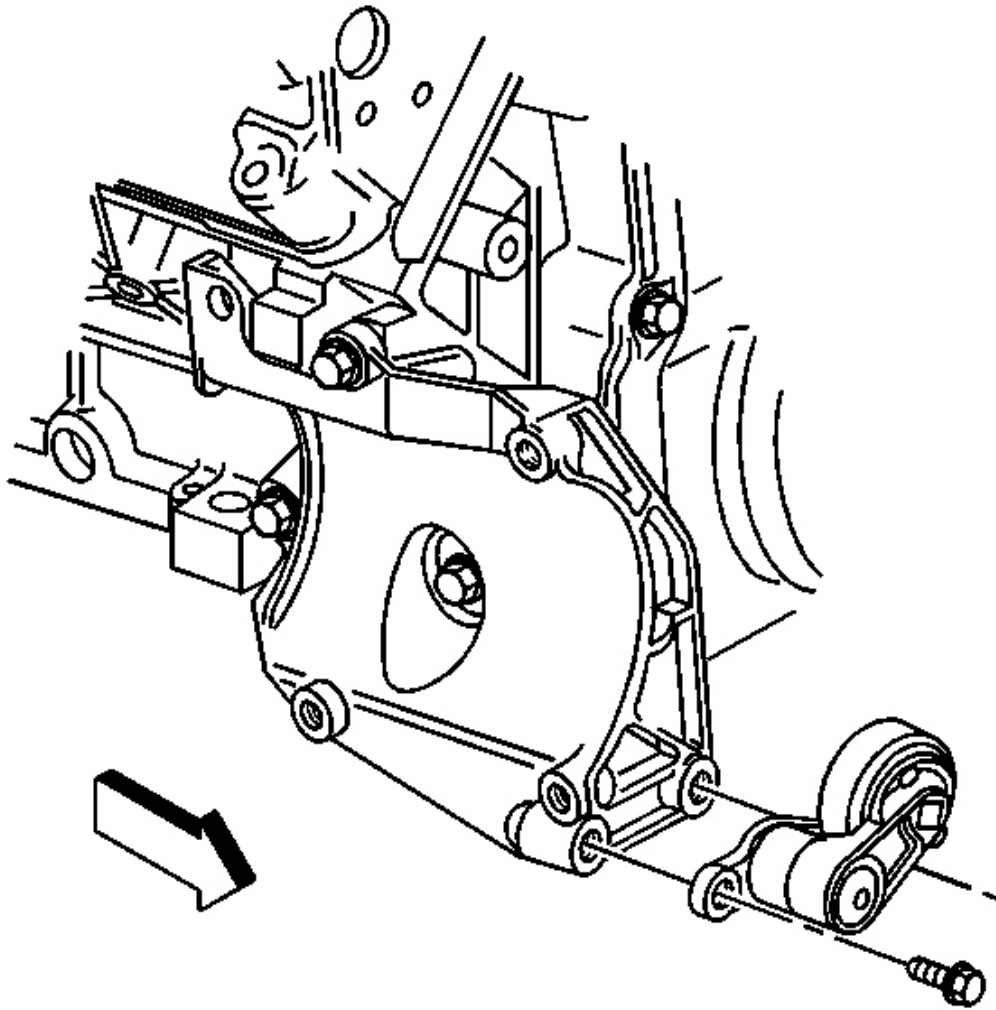




**Fig. 32: A/C Drive Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Drive Belt Replacement - Air Conditioning** .
2. Remove the A/C belt tensioner bolts.
3. Remove the A/C belt tensioner.

#### **Installation Procedure**



**Fig. 33: A/C Drive Belt Tensioner**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the A/C belt tensioner.
2. Install the A/C belt tensioner bolts.

**Tighten:** Tighten the A/C belt tensioner bolts to 50 N.m (37 lb ft).

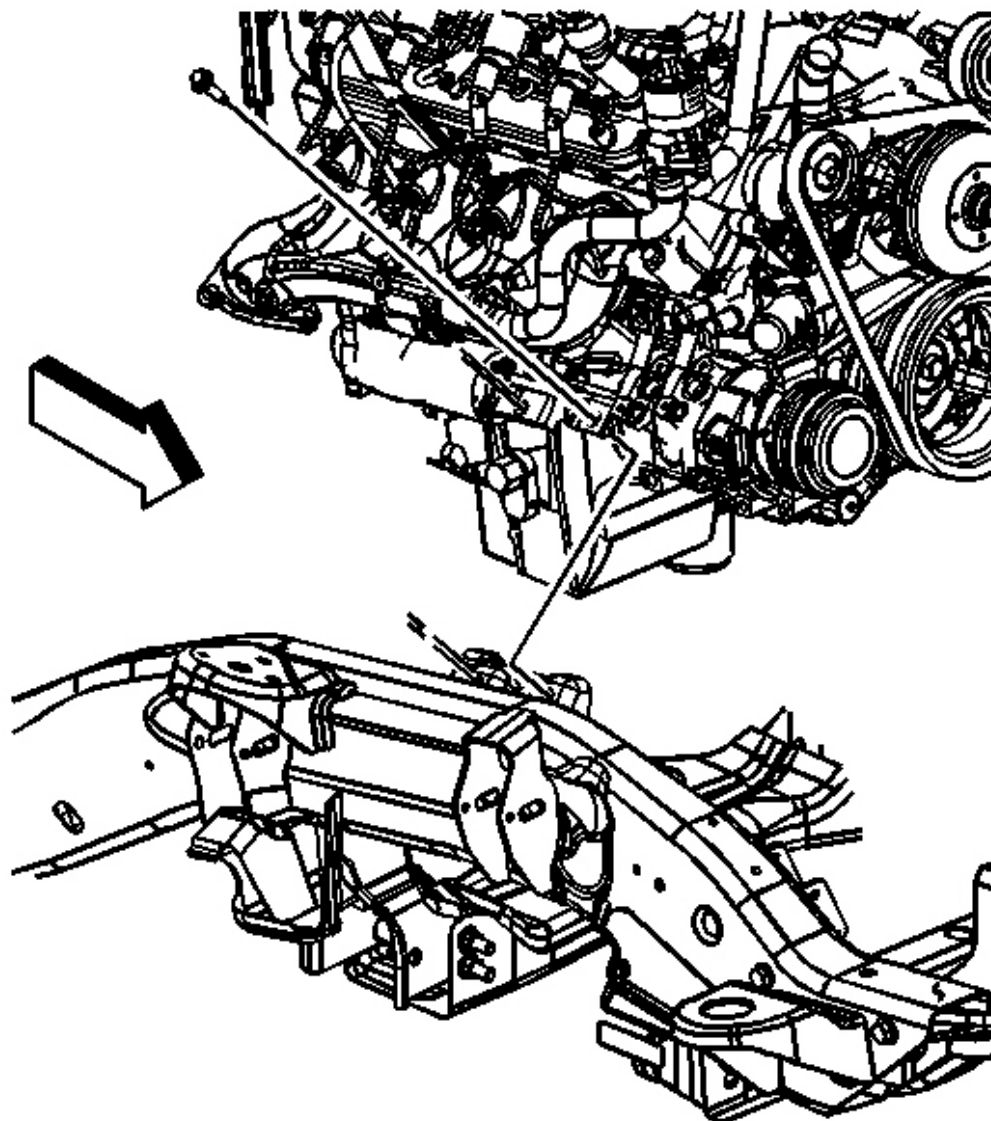
3. Install the A/C drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.

## 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 check 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, check for loose engine mount bolts.
  2. If the engine mount bolt torque is within specifications, check 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.

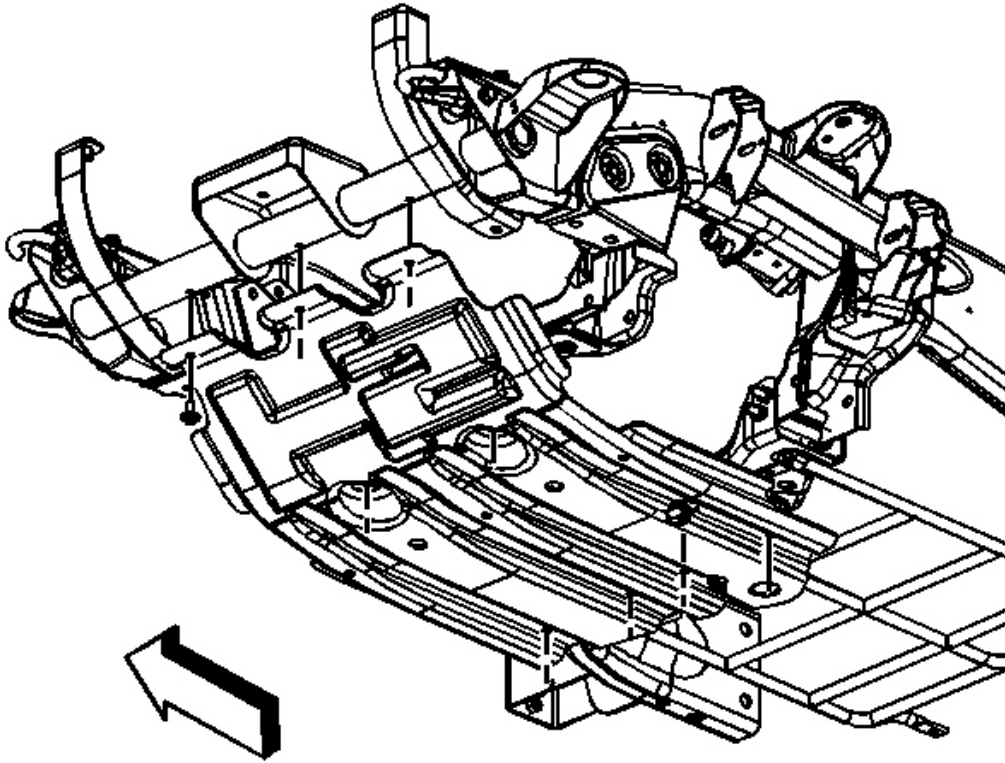
## ENGINE MOUNT REPLACEMENT - LEFT

### Removal Procedure



**Fig. 34: Engine Mount-To-Frame Bracket Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount-to-frame bracket bolts. (Right side shown, left side similar).
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

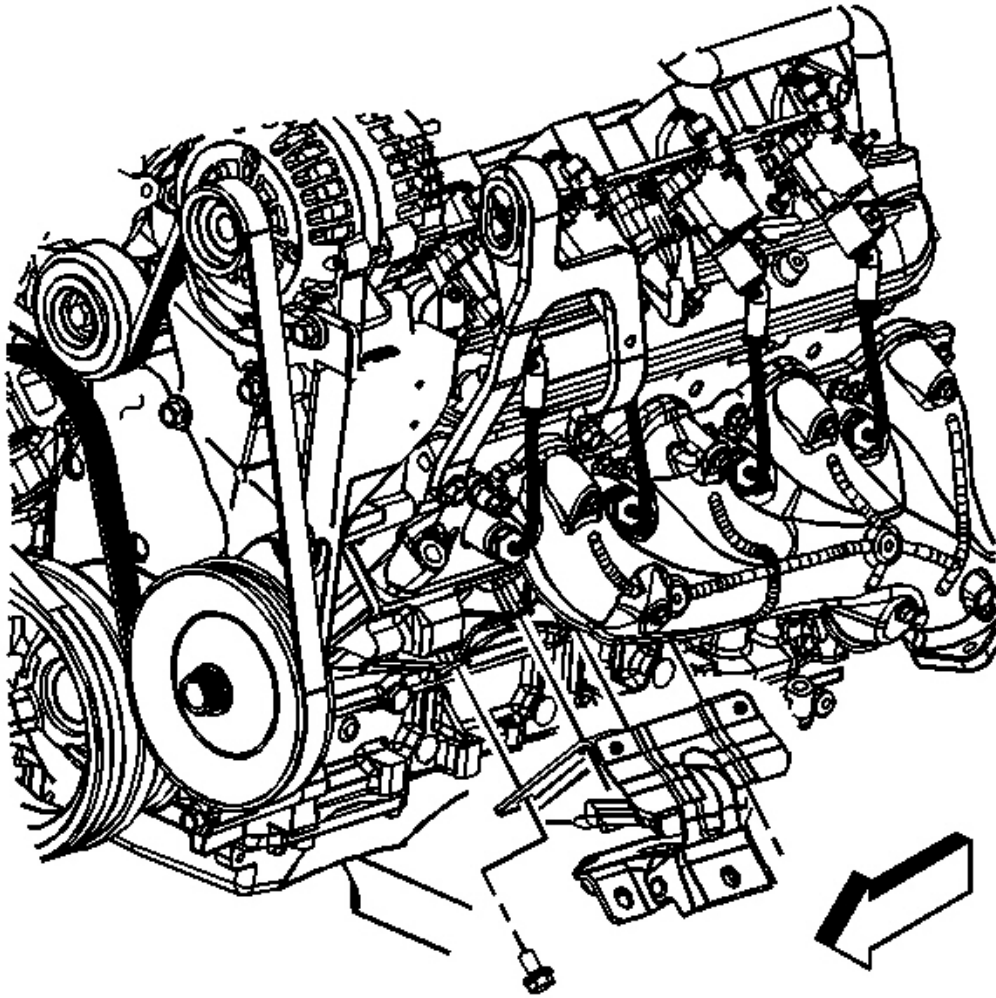


**Fig. 35: Engine Shield Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine shield bolts.
4. Remove the engine shield.

**IMPORTANT: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.**

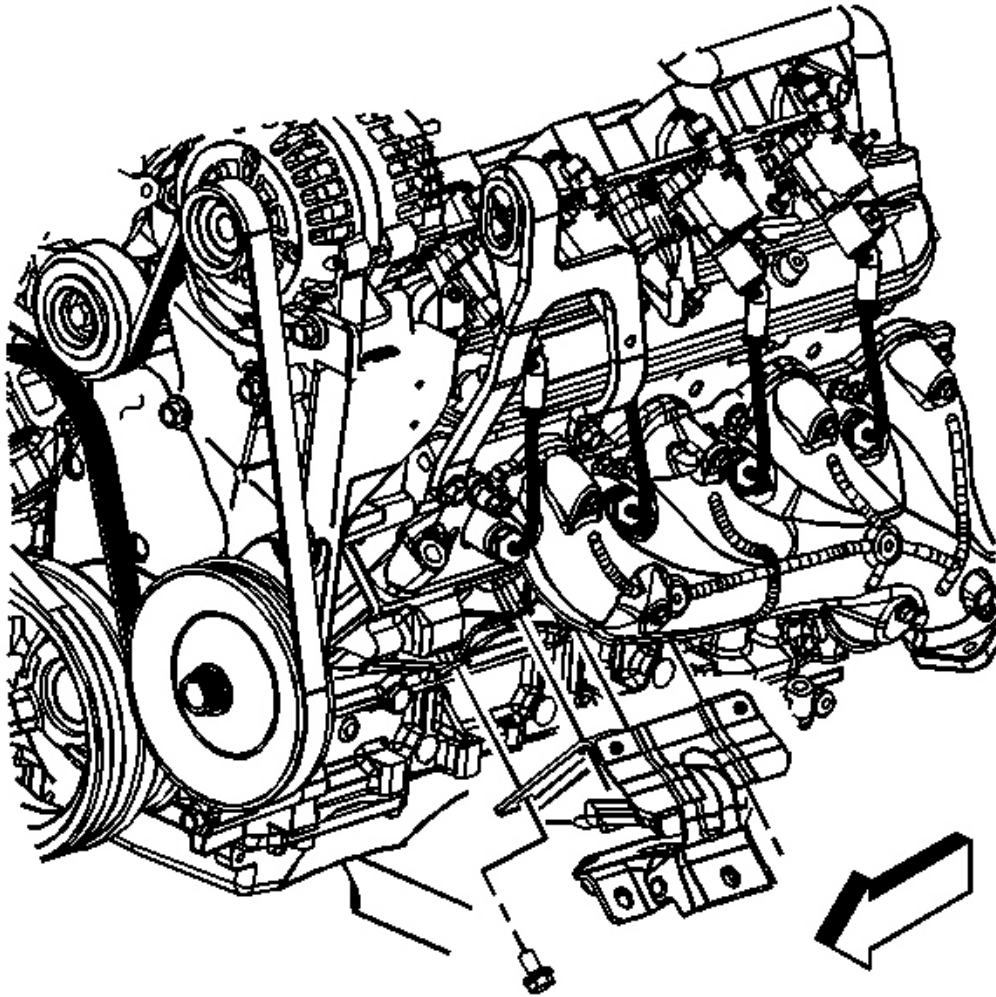
5. Raise and suitably support the engine using adjustable (screw type) jack stands.



**Fig. 36: Engine Mount (Left)**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bolts.
7. Remove the engine mount.

#### **Installation Procedure**



**Fig. 37: Engine Mount (Left)**  
Courtesy of GENERAL MOTORS CORP.

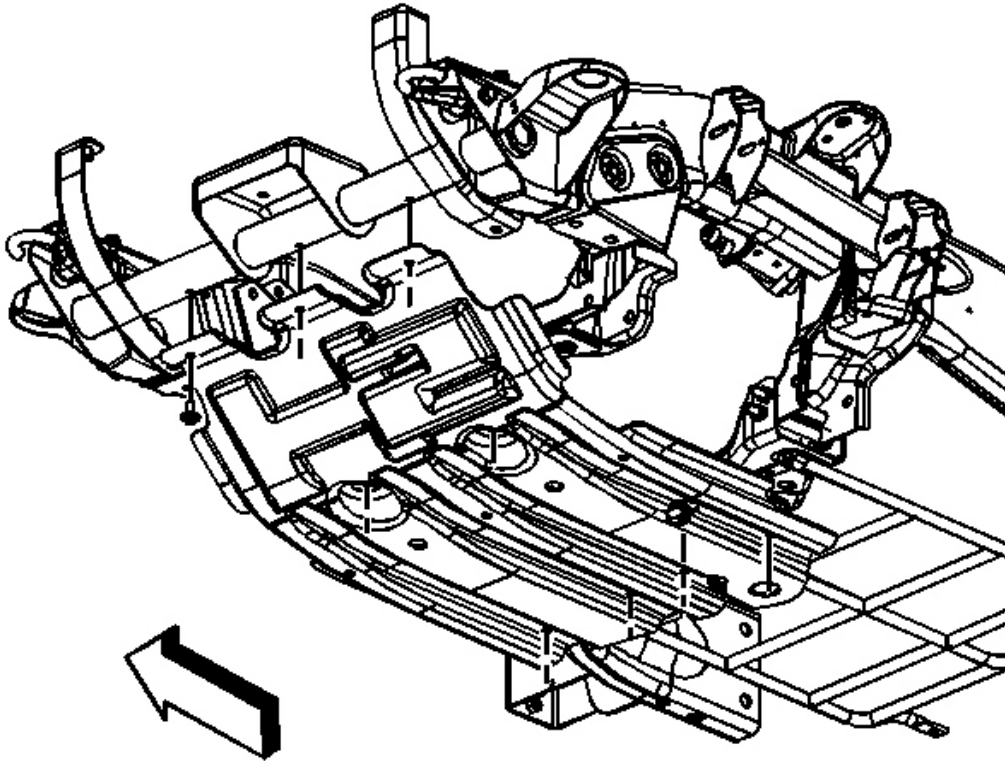
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

1. Position the engine mount to the engine.
2. Install the engine mount bolts.

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

3. Lower the engine.

4. Remove the adjustable jack stands.



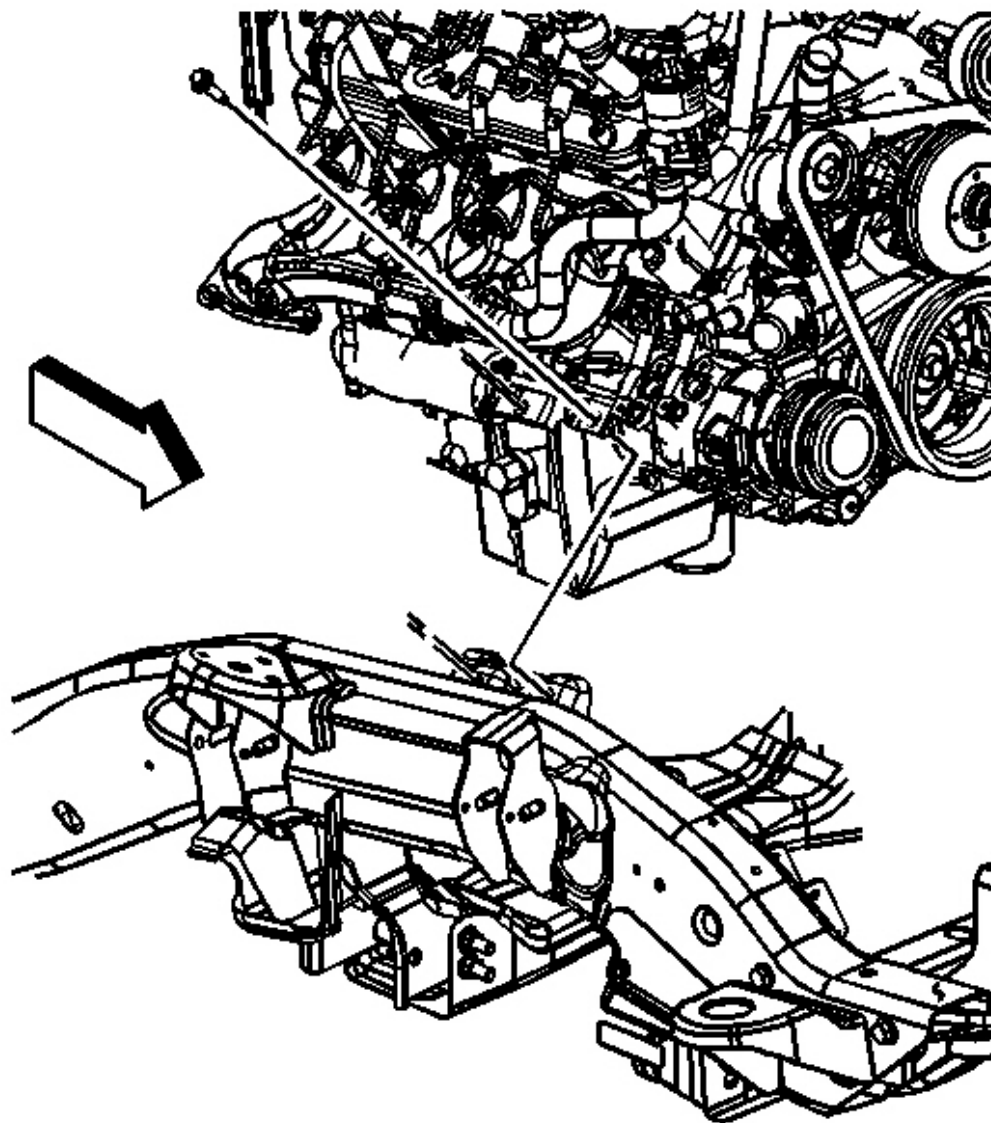
**Fig. 38: Engine Shield Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

5. Position the engine shield to the vehicle.
6. Install the engine shield bolts.

**Tighten:** Tighten the engine shield bolts to 30 N.m (22 lb ft).

7. Lower the vehicle.



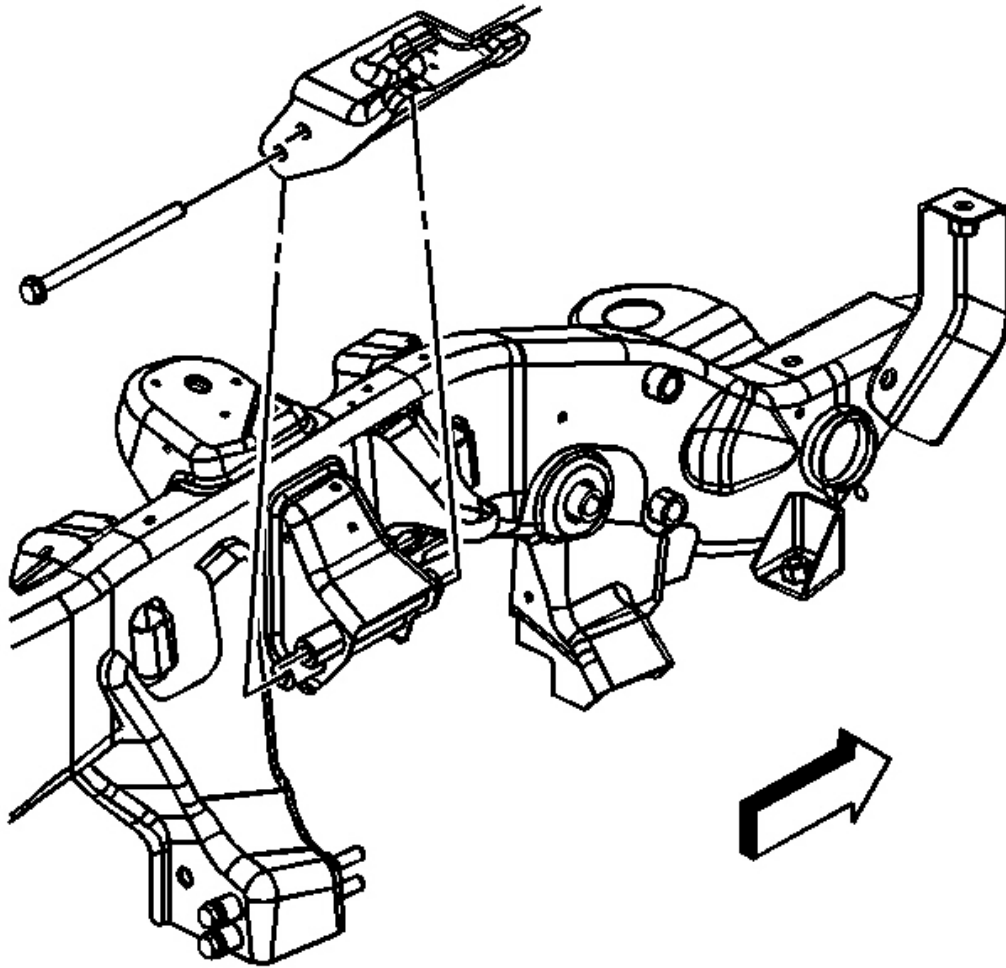


**Fig. 39: Engine Mount-To-Frame Bracket Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

8. Install the engine mount-to-frame bracket bolts. (Right side shown, left side similar).

**Tighten:** Tighten the engine mount-to-frame bracket bolts to 65 N.m (48 lb ft).

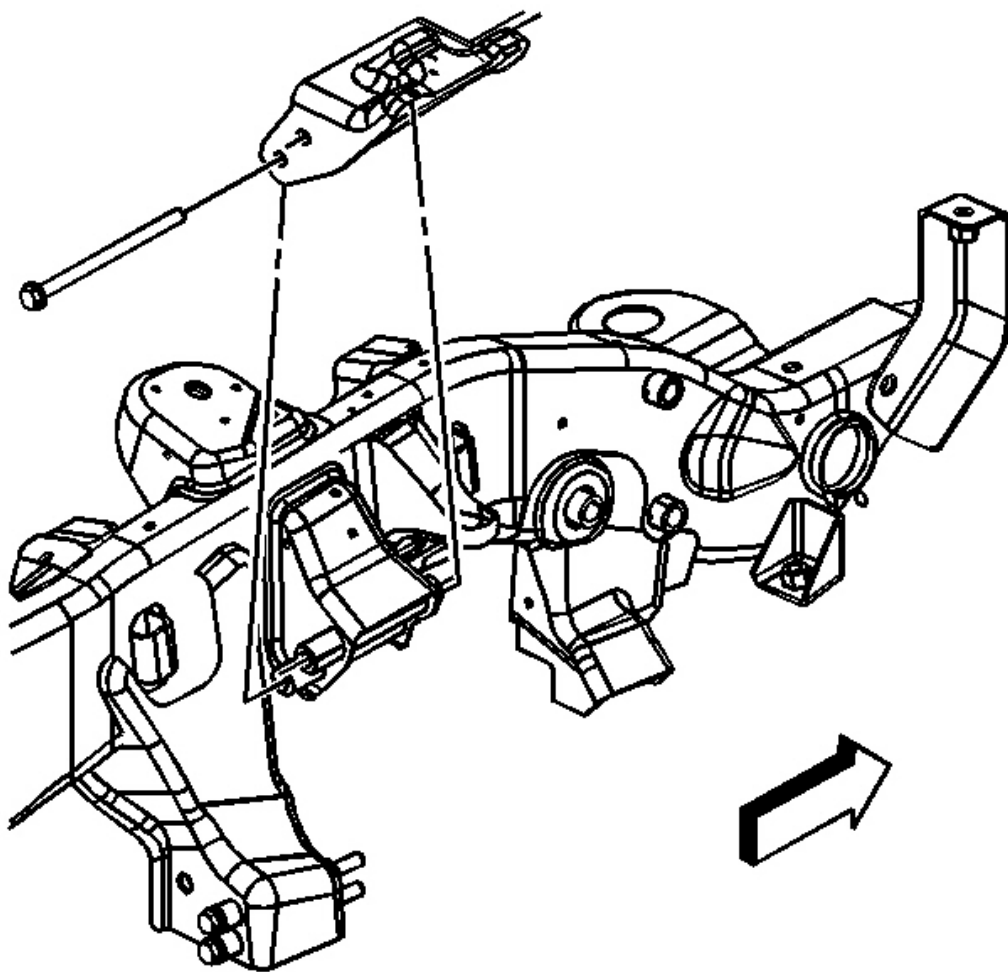
## Removal Procedure



**Fig. 40: Engine Mount Bracket (Left)**  
Courtesy of GENERAL MOTORS CORP.

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

## Installation Procedure



**Fig. 41: Engine Mount Bracket (Left)**  
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.
2. Perform the following procedure prior to installing the engine mount bracket bolts.
  - Remove all traces of the original adhesive patch.
  - Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
  - Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

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

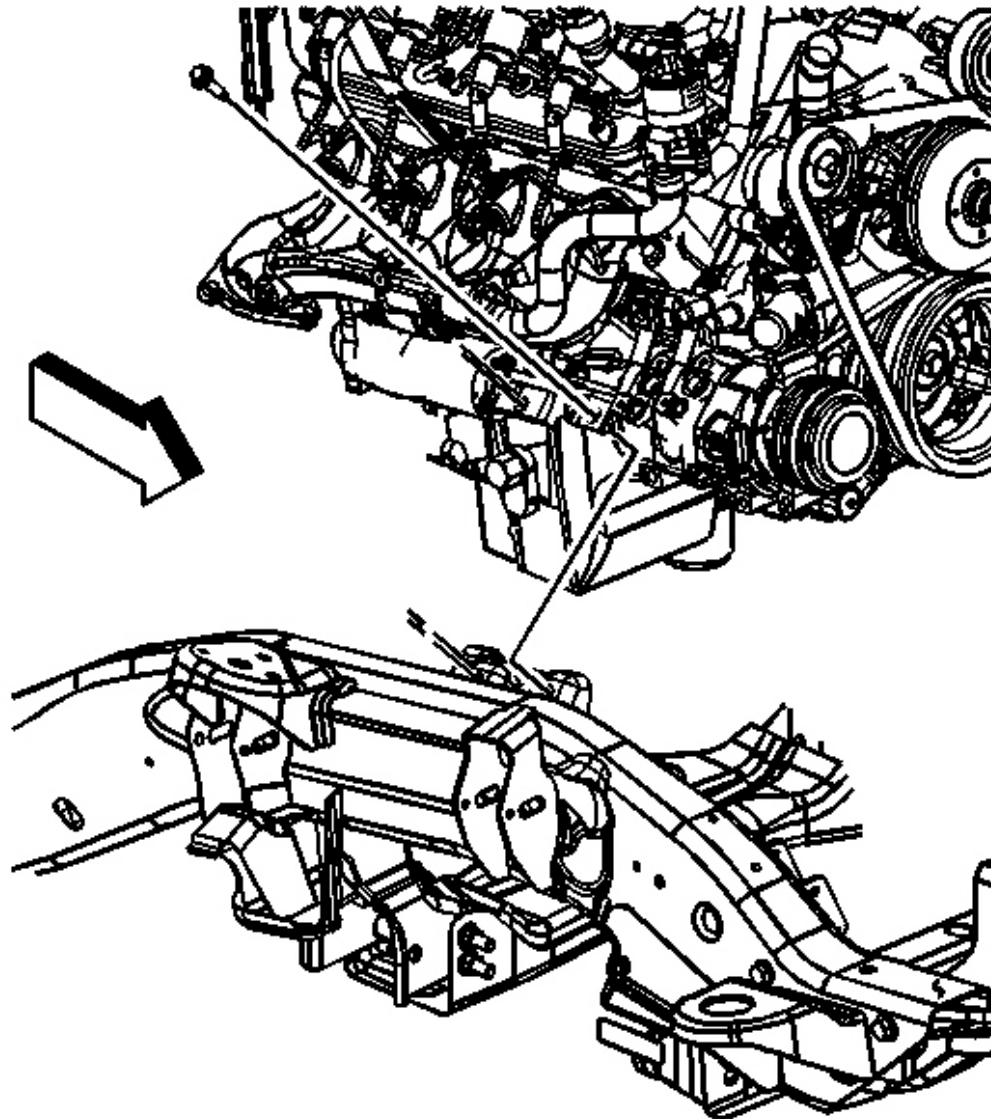
3. Install the engine mount bracket bolts.

**Tighten:** Tighten the engine mount bracket bolts to 75 N.m (55 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement - Left** .

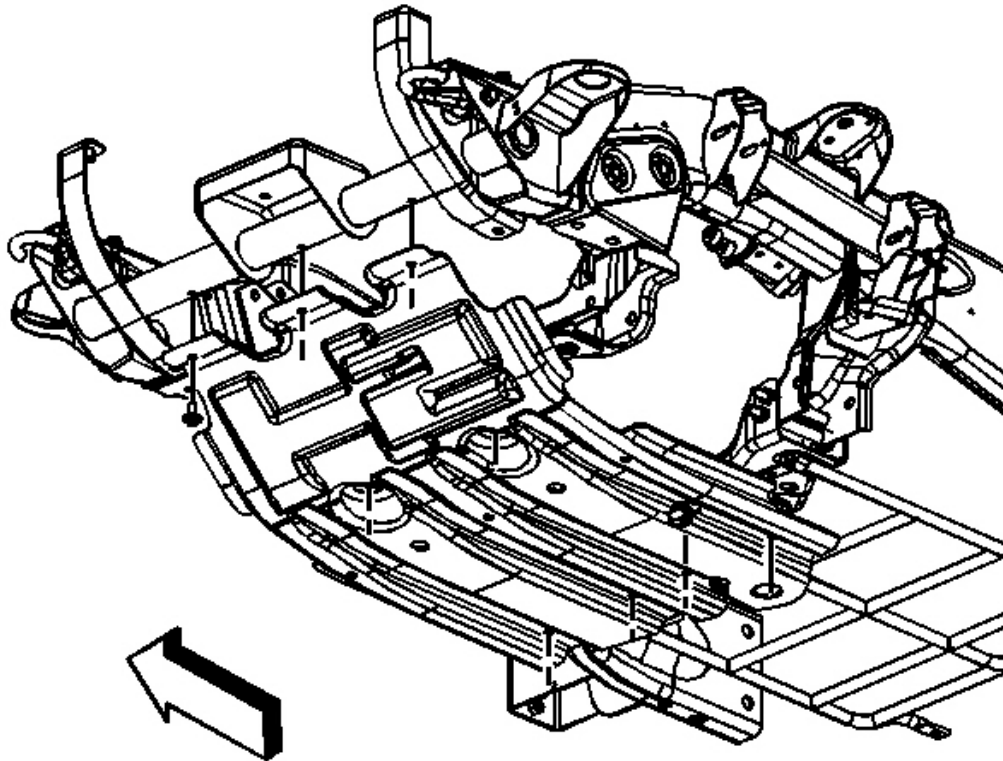
## **ENGINE MOUNT REPLACEMENT - RIGHT**

### **Removal Procedure**



**Fig. 42: Engine Mount-To-Frame Bracket Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount-to-frame bracket bolts.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

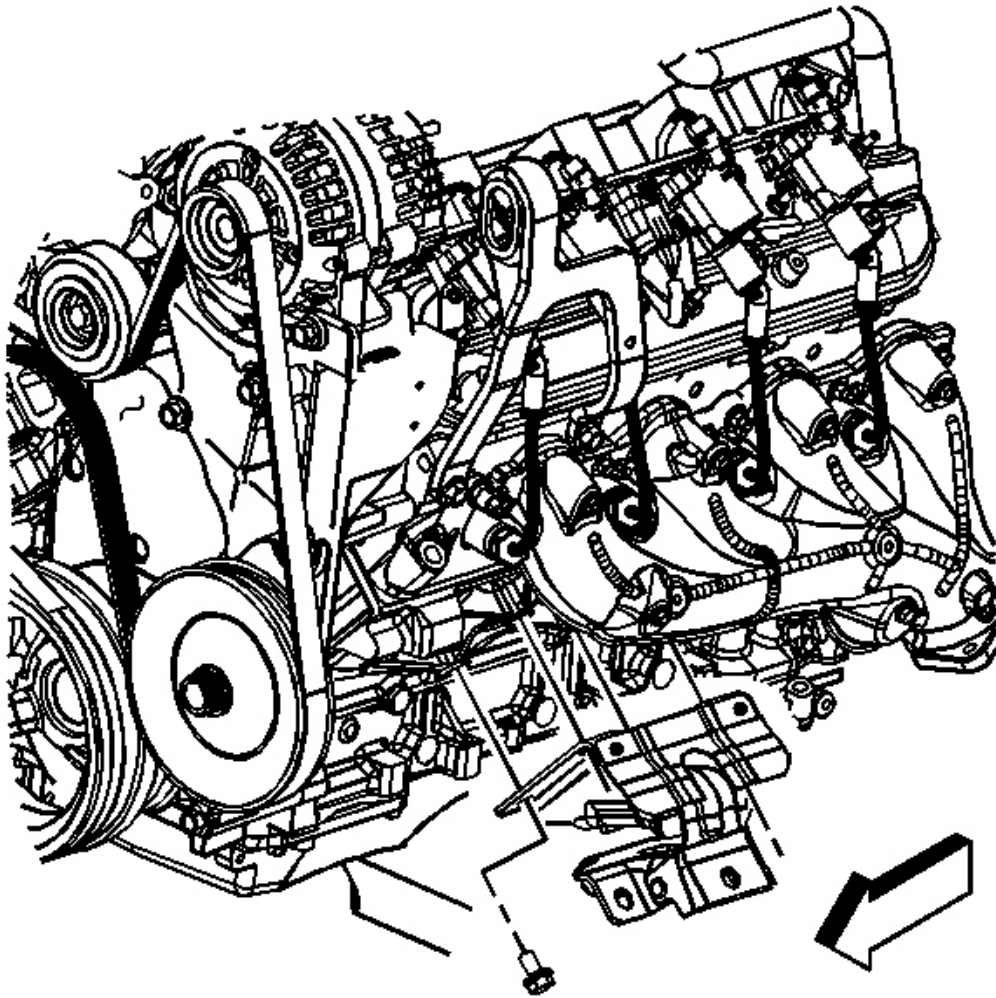


**Fig. 43: Engine Shield Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine shield bolts.
4. Remove the engine shield.
5. Remove the air conditioning (A/C) compressor. Refer to **Compressor Replacement** in Heating, Ventilation, and Air Conditioning.
6. Remove the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.

**IMPORTANT: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.**

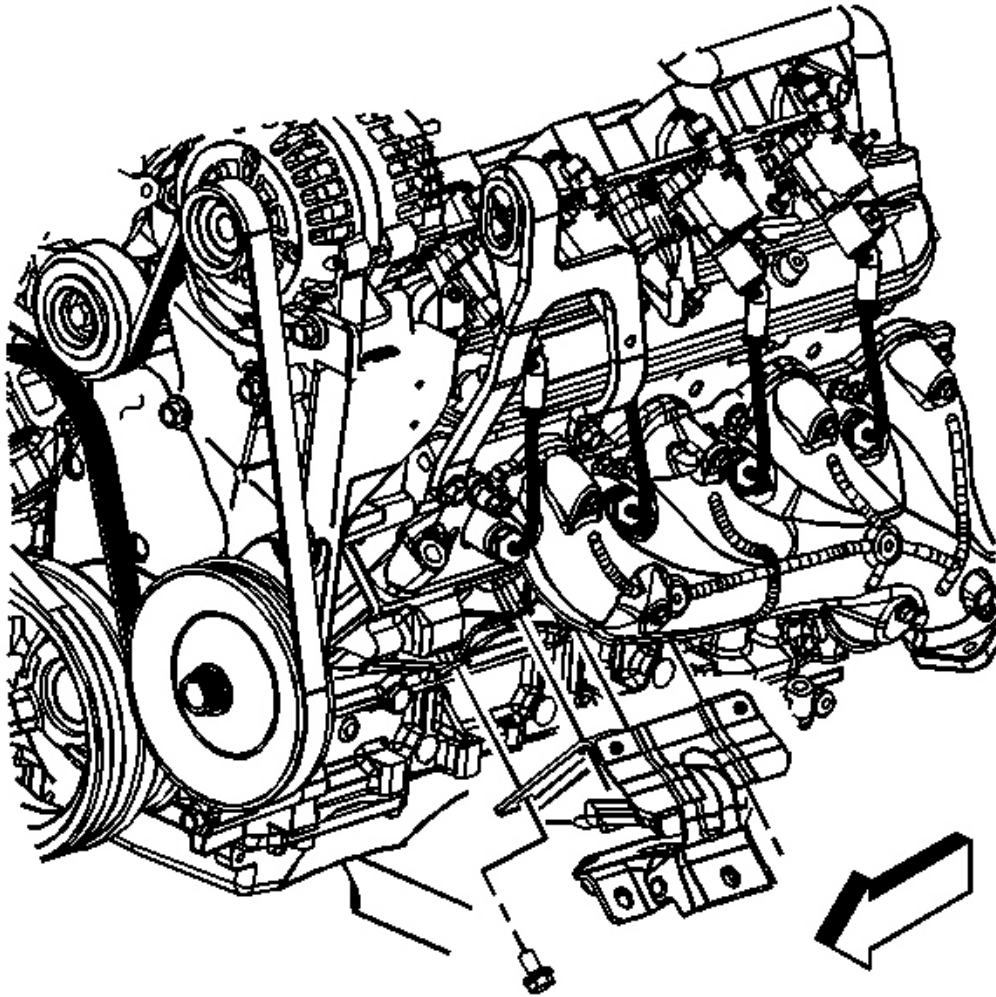
7. Raise and suitably support the engine using adjustable (screw type) jack stands.



**Fig. 44: Engine Mount (Right)**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount bolts. (Left side shown, right side similar).
9. Remove the right engine mount.

#### **Installation Procedure**



**Fig. 45: Engine Mount (Right)**  
Courtesy of GENERAL MOTORS CORP.

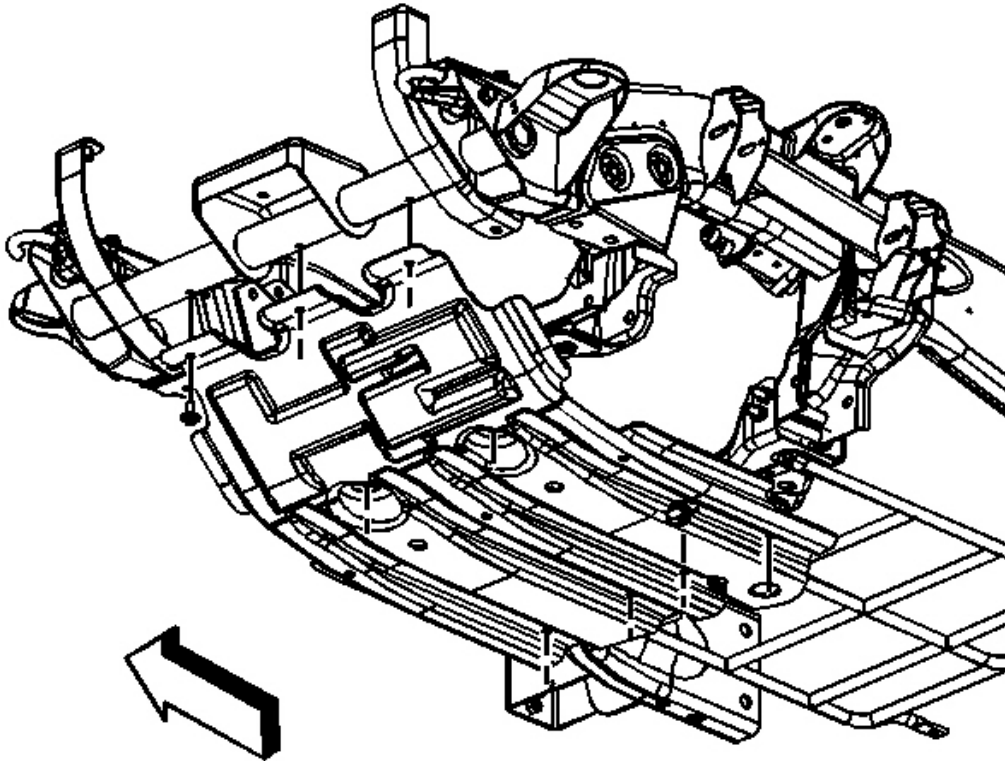
**NOTE:** Refer to **Fastener Notice** in Cautions and Notices.

1. Position the right engine mount to the engine. (Left side shown, right side similar).
2. Install the engine mount bolts.

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

3. Lower the engine.

4. Remove the adjustable jack stands.
5. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
6. Install the A/C compressor. Refer to **Compressor Replacement** in Heating, Ventilation, and Air Conditioning.



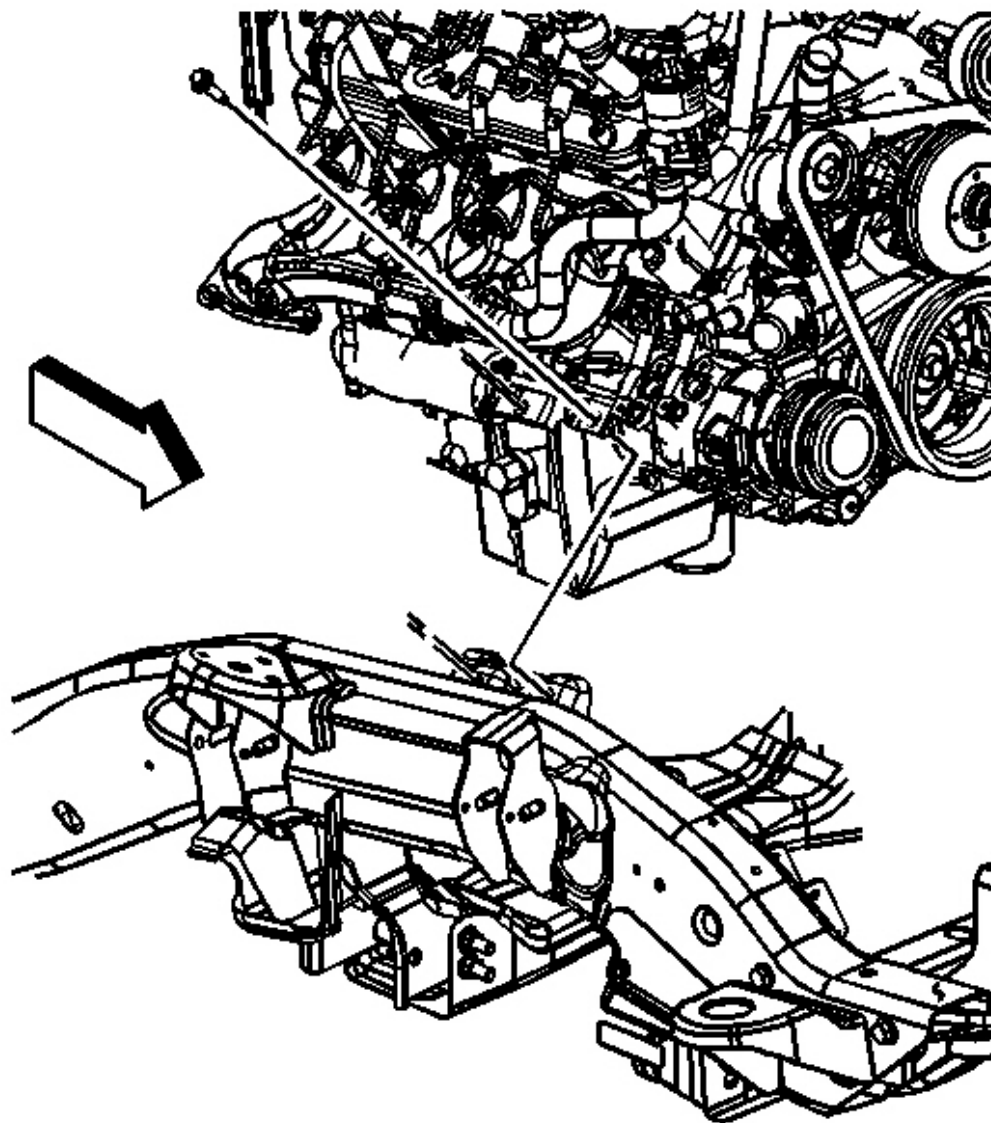
**Fig. 46: Engine Shield Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

7. Position the engine shield to the vehicle.
8. Install the engine shield bolts.

**Tighten:** Tighten the engine shield bolts to 30 N.m (22 lb ft).

9. Lower the vehicle.





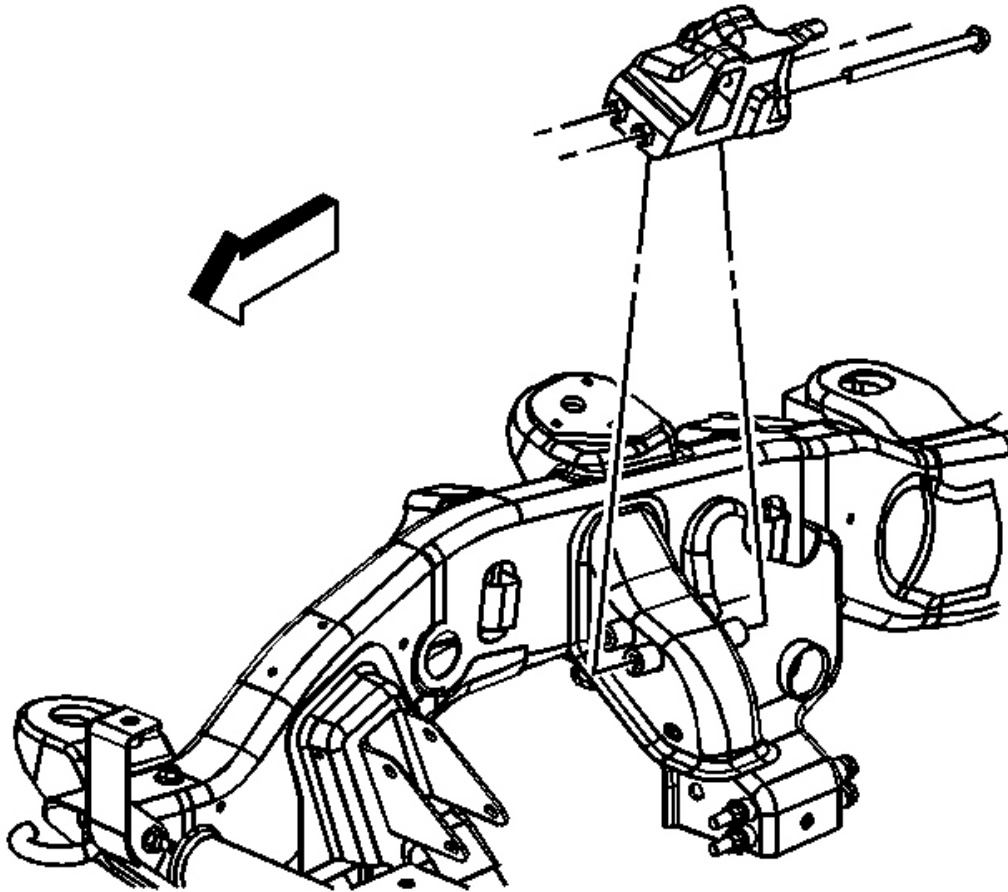
**Fig. 47: Engine Mount-To-Frame Bracket Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

10. Install the engine mount-to-frame bracket bolts.

**Tighten:** Tighten the engine mount-to-frame bracket bolts to 65 N.m (48 lb ft).

**ENGINE MOUNT BRACKET REPLACEMENT - RIGHT**

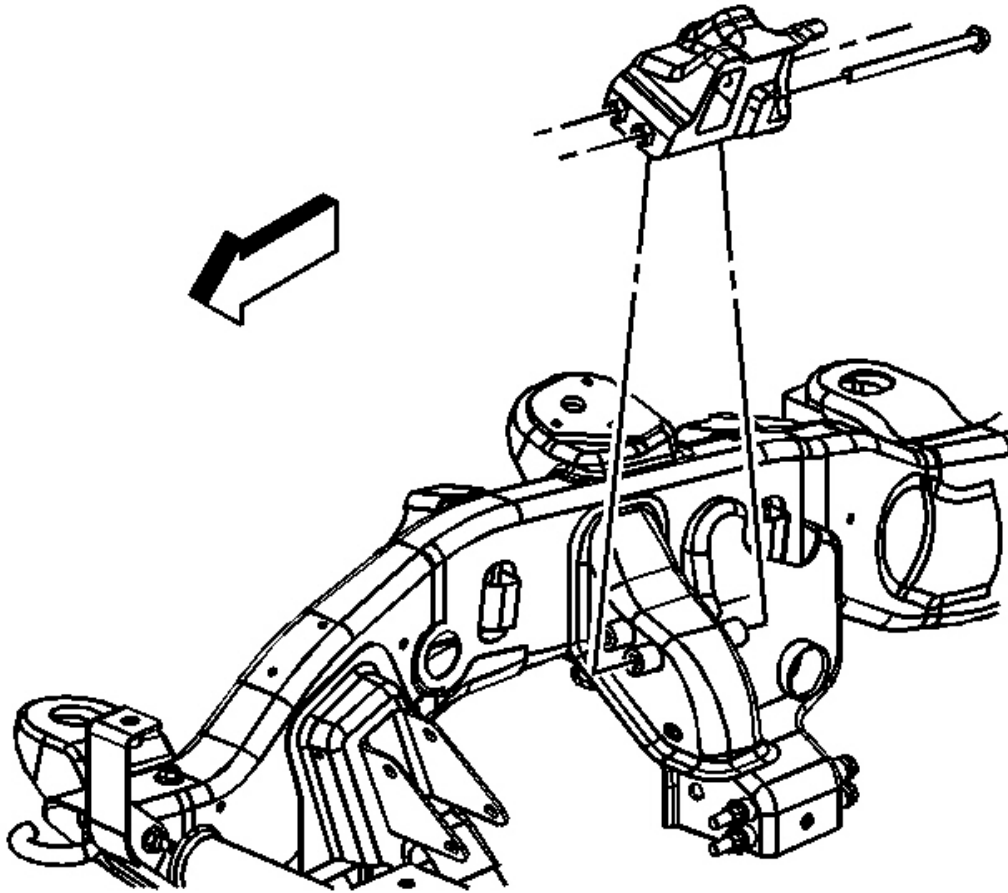
## Removal Procedure



**Fig. 48: Engine Mount Bracket (Right)**  
Courtesy of GENERAL MOTORS CORP.

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

## Installation Procedure



**Fig. 49: Engine Mount Bracket (Right)**  
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.
2. Perform the following procedure prior to installing the engine mount bracket bolts.
  - Remove all traces of the original adhesive patch.
  - Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
  - Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

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

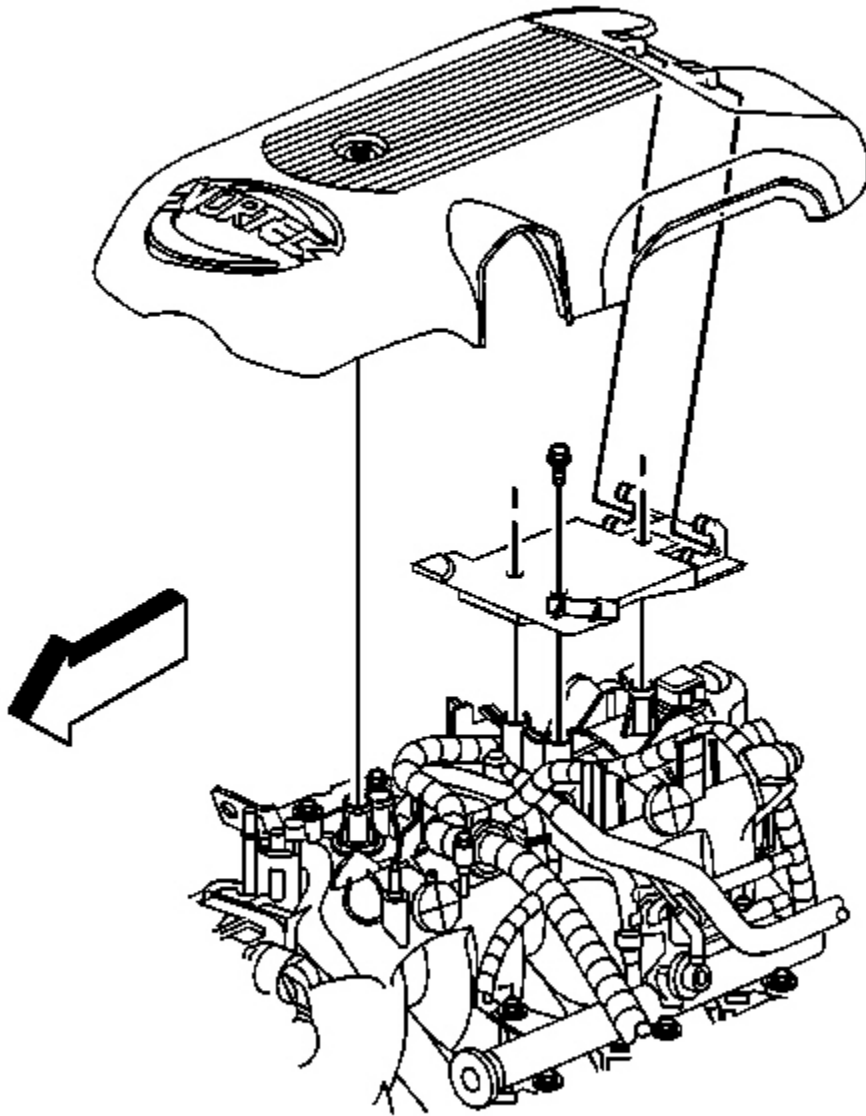
3. Install the engine mount bracket bolts.

**Tighten:** Tighten the engine mount bracket bolts to 75 N.m (55 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement - Right** .

## ENGINE SIGHT SHIELD REPLACEMENT (6.0L (LQ4))

### Removal Procedure



**Fig. 50: Top Engine Cover**

**Courtesy of GENERAL MOTORS CORP.**

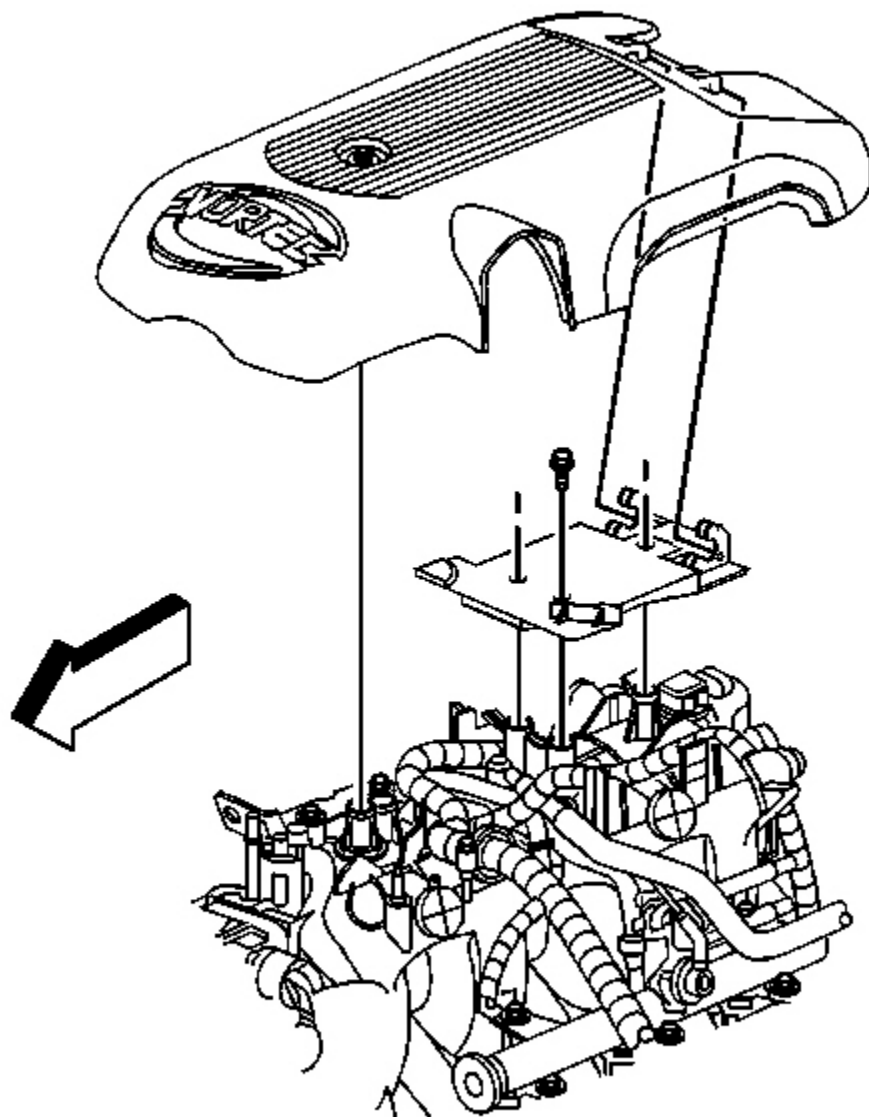
1. Loosen the intake manifold sight shield bolt.
2. Remove the sight shield from the sight shield retainer.
3. Remove the sight shield retainer bolts and the retainer, if required.

**Installation Procedure**

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

1. Install the sight shield retainer and the bolts, if required.

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



**Fig. 51: Top Engine Cover**  
Courtesy of GENERAL MOTORS CORP.

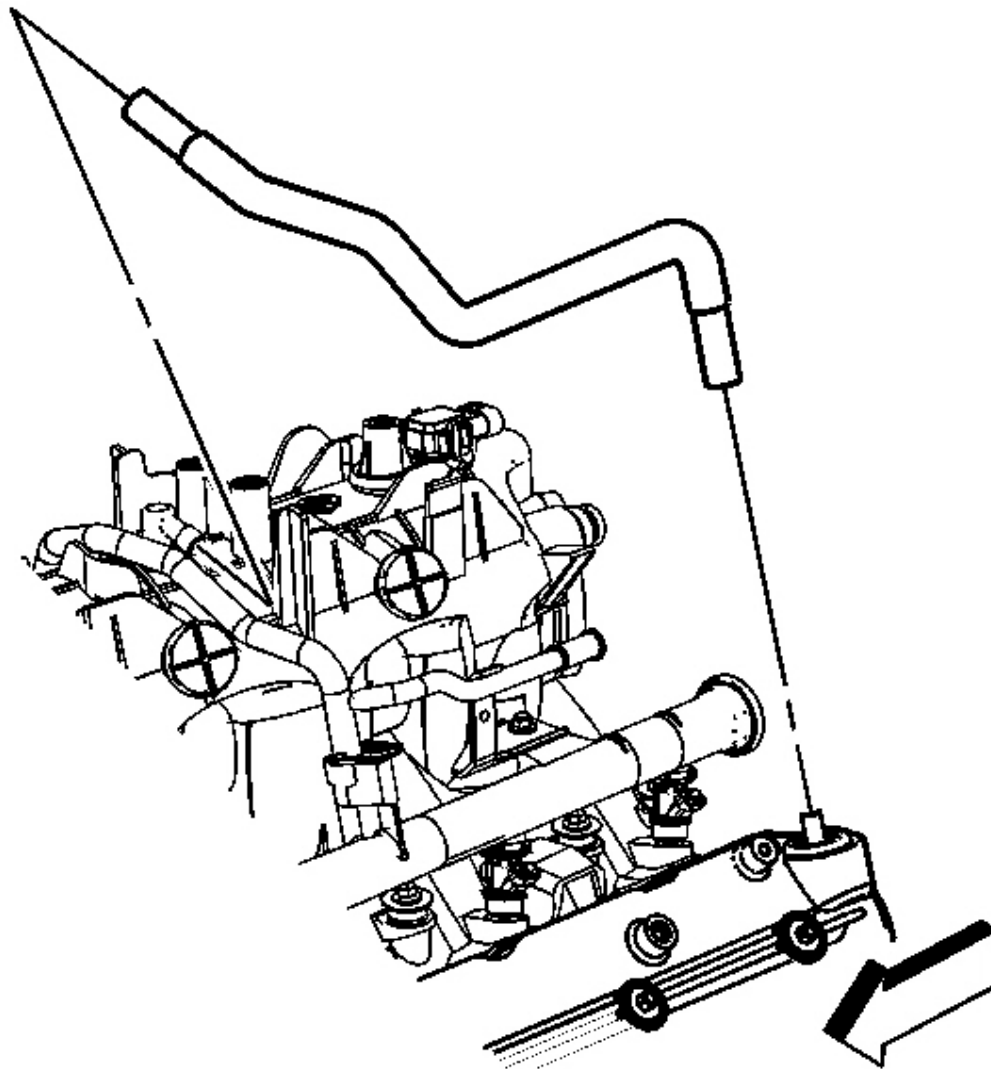
**NOTE:** Use care when installing the engine sight shield to avoid contacting the manifold absolute pressure (MAP) sensor wire harness connector. Loss of engine performance or engine damage may result.

2. Install the intake manifold sight shield to the retainer.

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

## CRANKCASE VENTILATION HOSES/PIPES REPLACEMENT

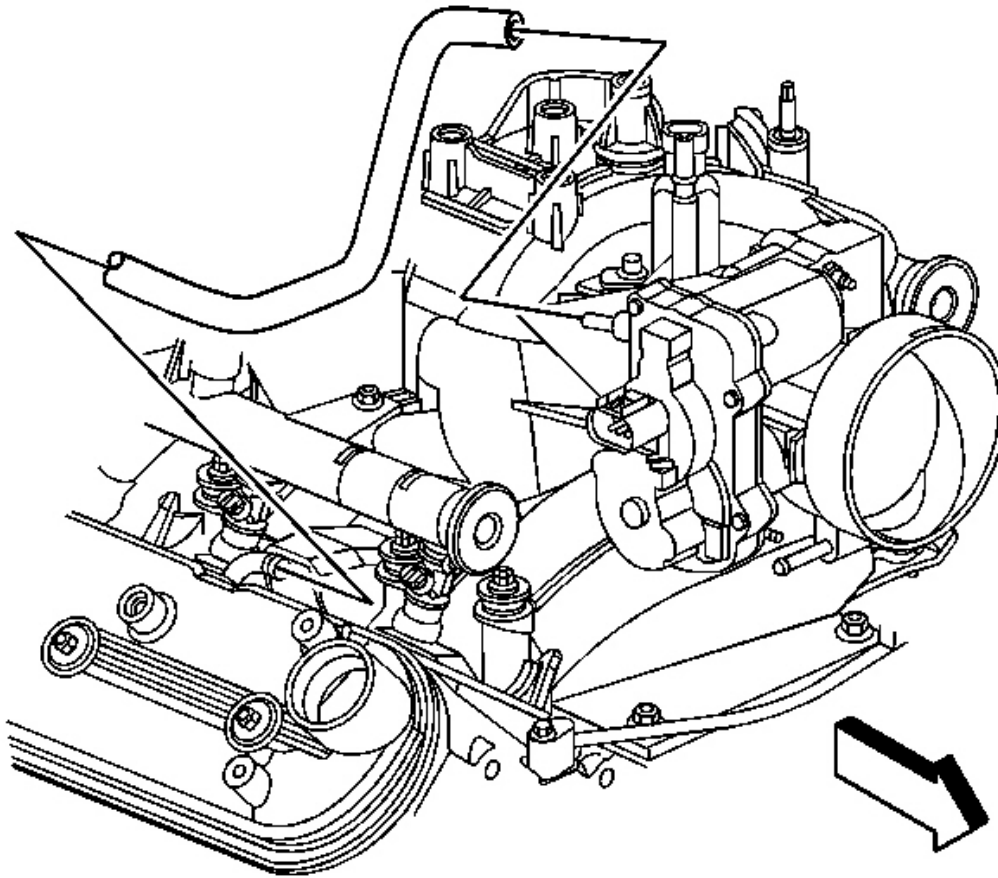
### Removal Procedure



**Fig. 52: Identifying PCV Hose**

Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .
2. Remove the positive crankcase ventilation (PCV) hose from the intake manifold and valve rocker arm cover.

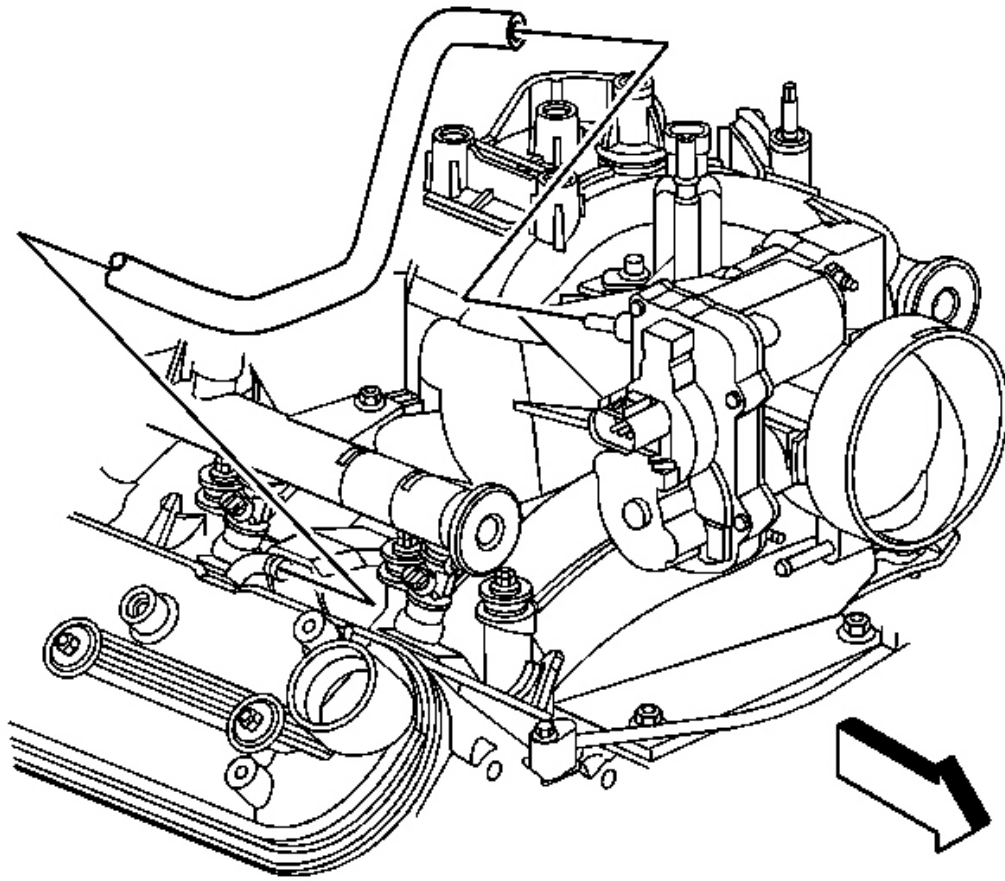


**Fig. 53: Throttle Body To Valve Rocker Arm Cover PCV Hose**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the vent hose from the throttle body and the valve rocker arm cover.
4. Replace the hose as necessary.

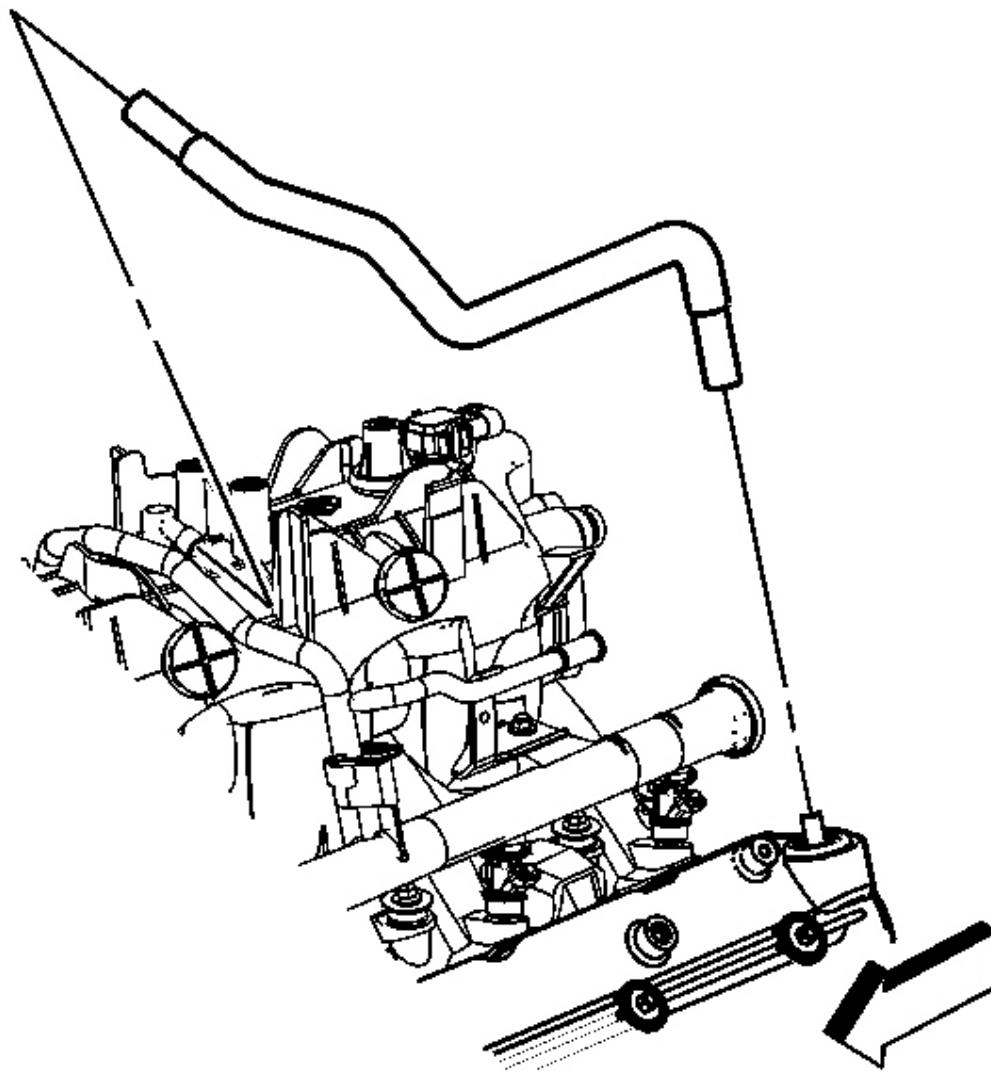
**Installation Procedure**





**Fig. 54: Throttle Body To Valve Rocker Arm Cover PCV Hose**  
Courtesy of GENERAL MOTORS CORP.

1. Install the hose as necessary.
2. Install the vent hose to the throttle body and the valve rocker arm cover.



**Fig. 55: Identifying PCV Hose**  
Courtesy of GENERAL MOTORS CORP.

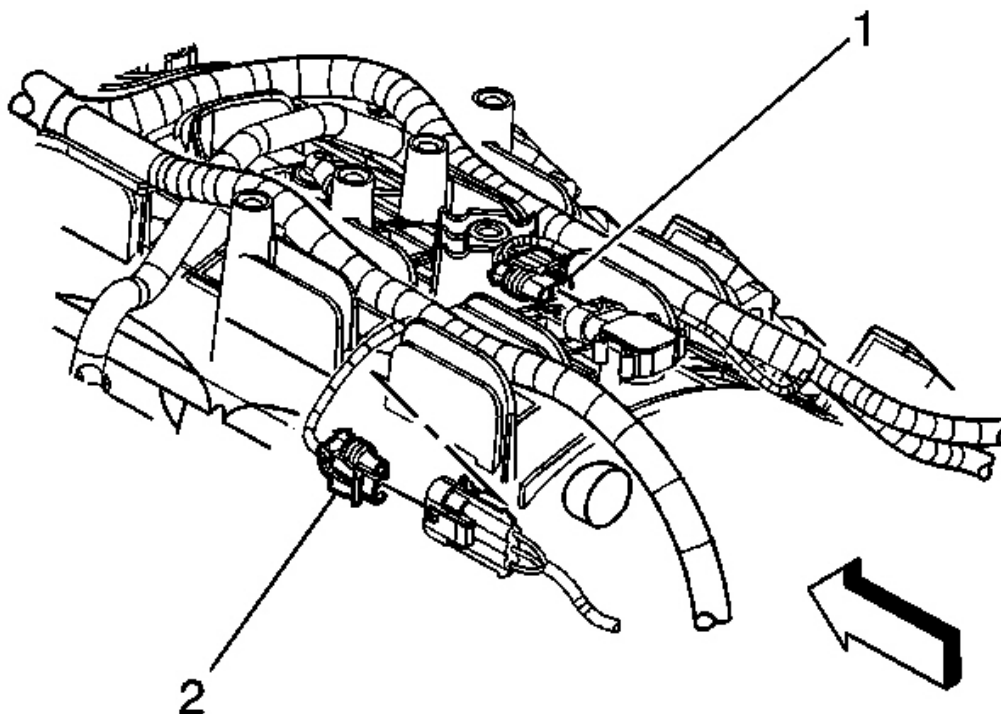
3. Install the PCV hose to the intake manifold and valve rocker arm cover.
4. Install the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .

## **INTAKE MANIFOLD REPLACEMENT**

### **Removal Procedure**

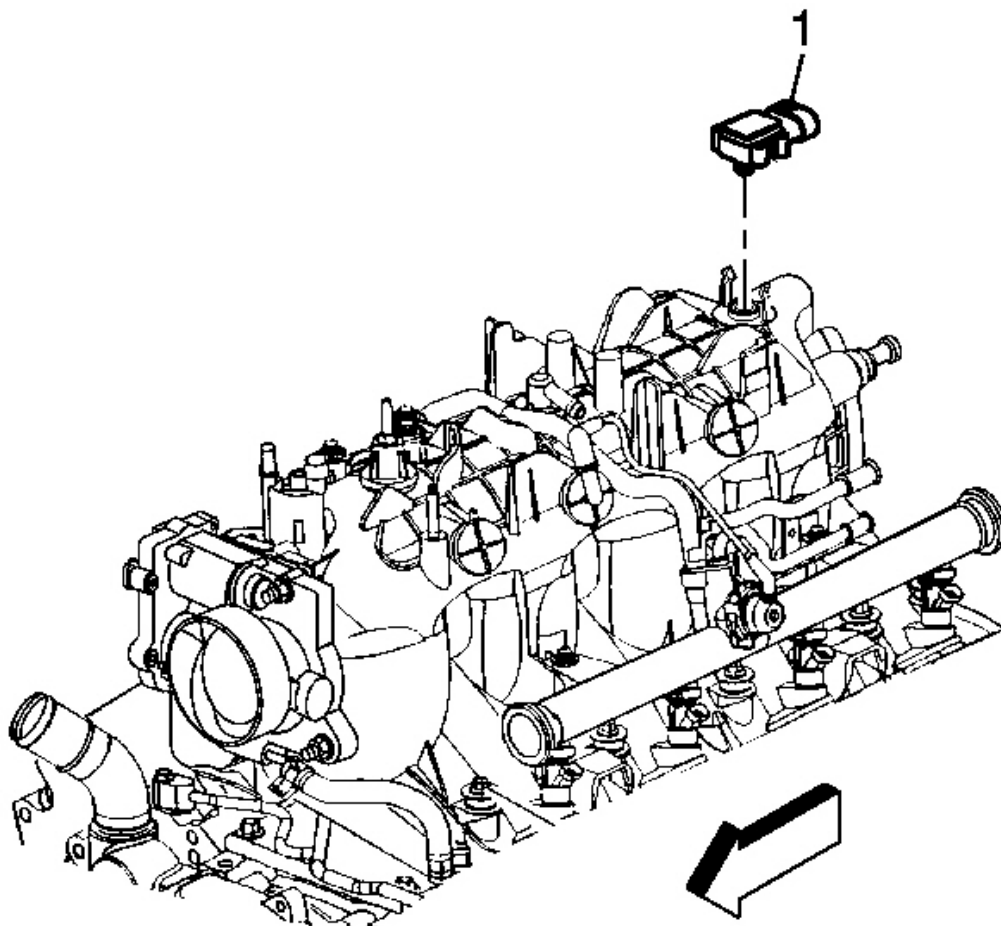
**IMPORTANT:** The intake manifold, throttle body, fuel rail, and injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
2. Remove the fuel injectors. Refer to **Fuel Injector Replacement** .



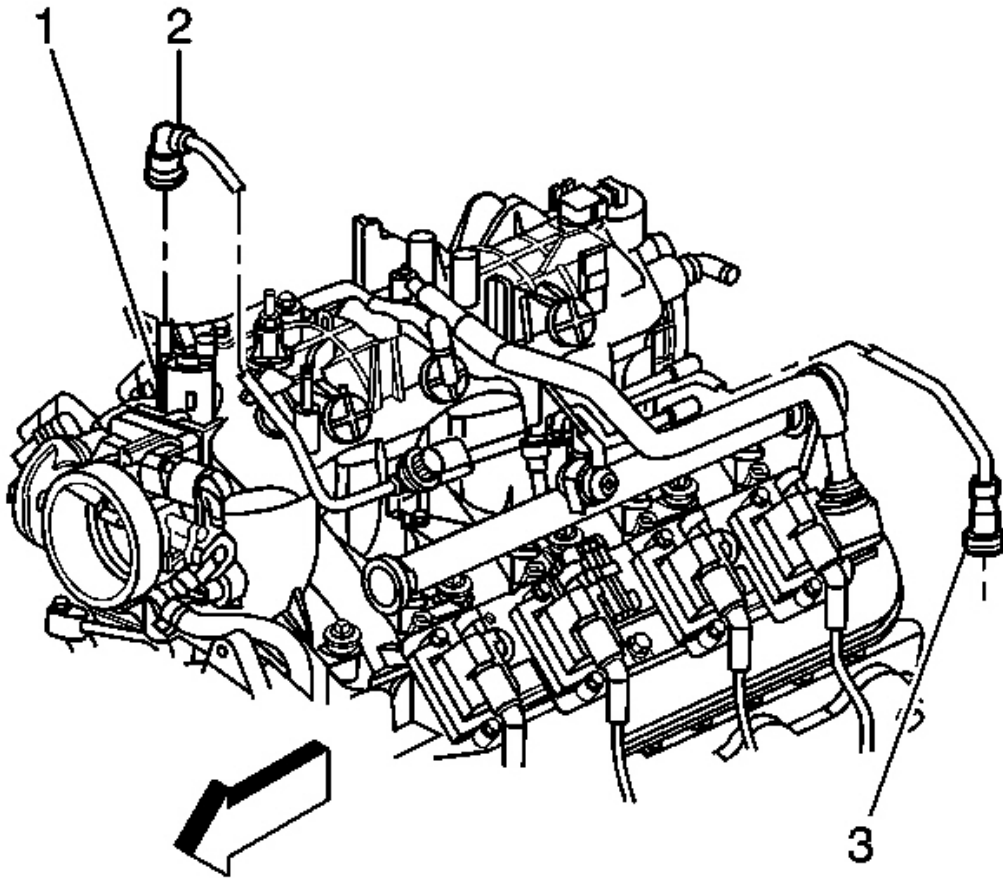
**Fig. 56: MAP Sensor & Knock Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the following electrical connectors:
  - Manifold absolute pressure (MAP) sensor (1)
  - Knock sensor (2)
4. Remove the knock sensor harness electrical connector from the intake manifold.
5. Set the electrical harness aside.



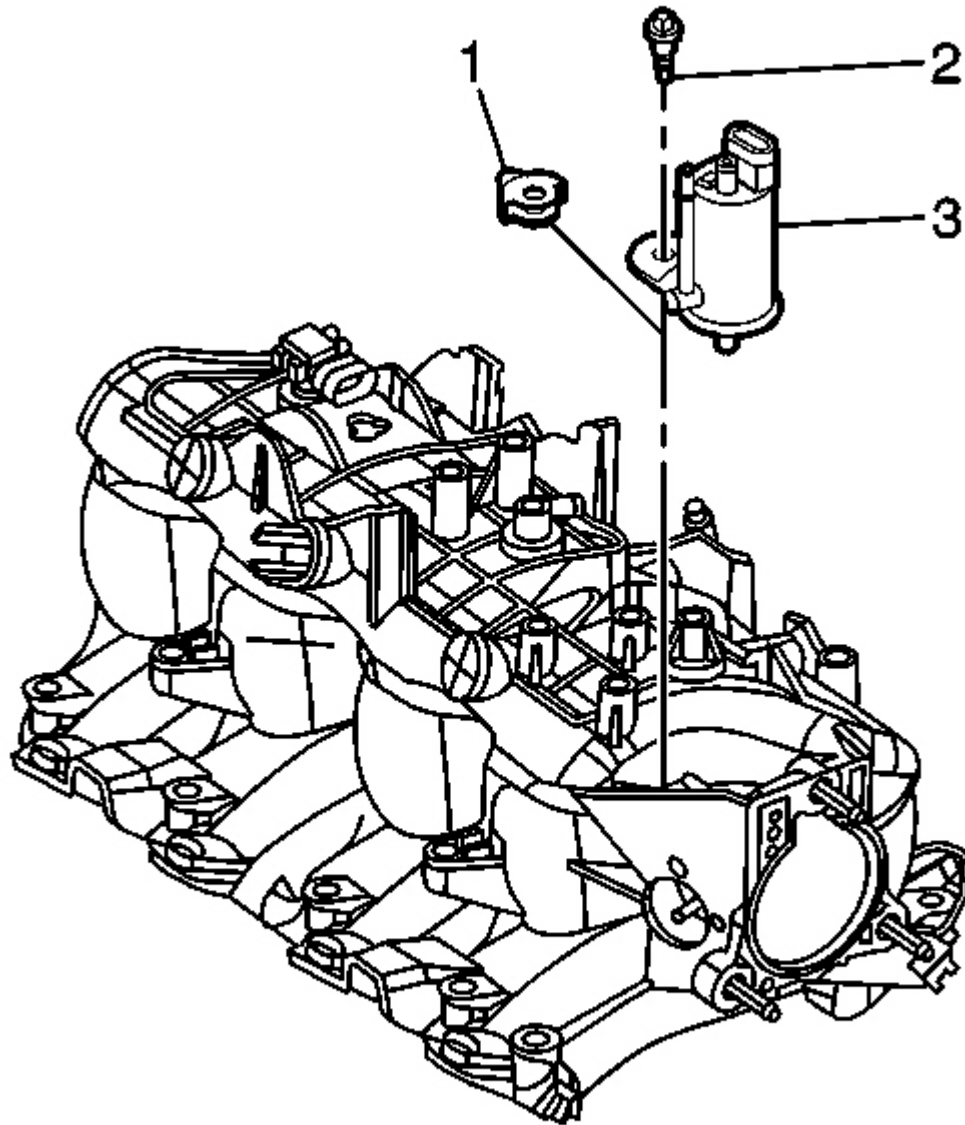
**Fig. 57: MAP Sensor & Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the MAP sensor (1) from the intake manifold.



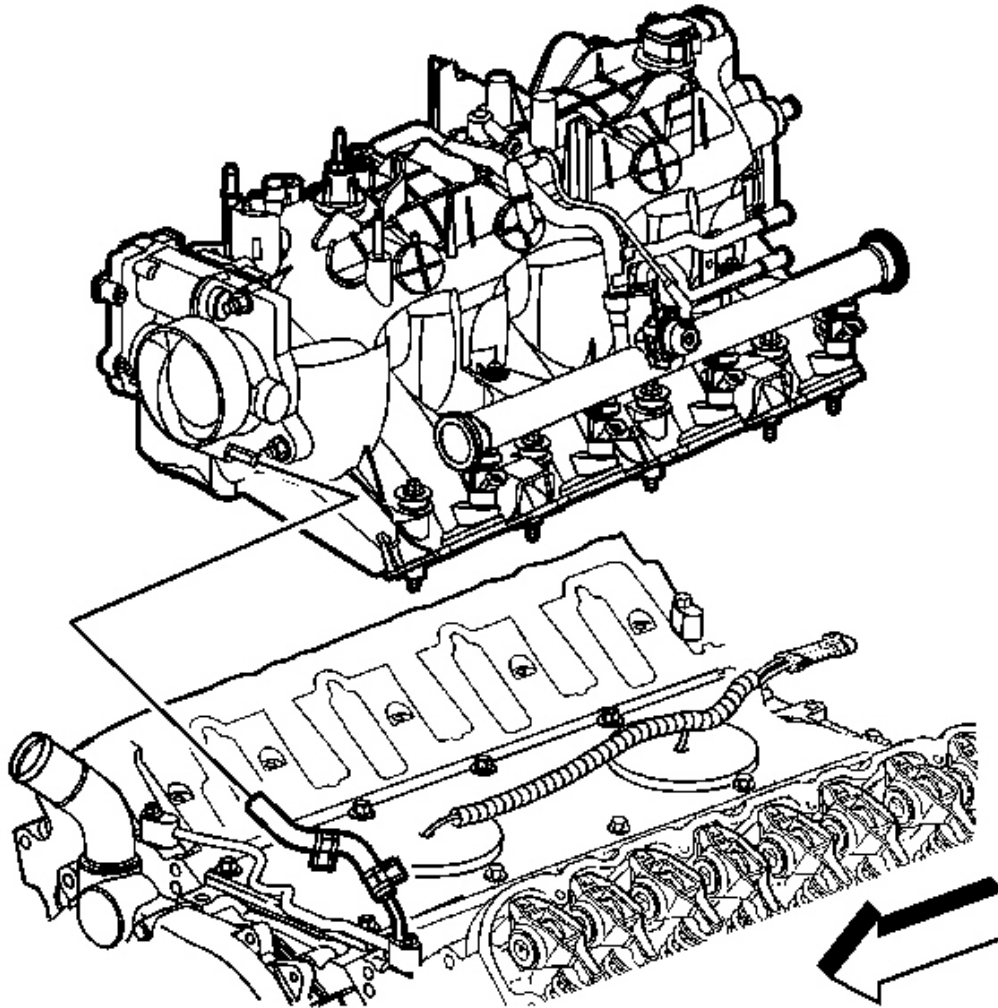
**Fig. 58: Top View Of Engine**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the evaporative emission (EVAP) purge solenoid vent tube by performing the following:
  1. Remove the EVAP tube end (2) from the solenoid (1).
  2. Squeeze the EVAP pipe quick connect fitting (3) retainer together.
  3. Remove the EVAP tube end (3) from the vapor pipe.



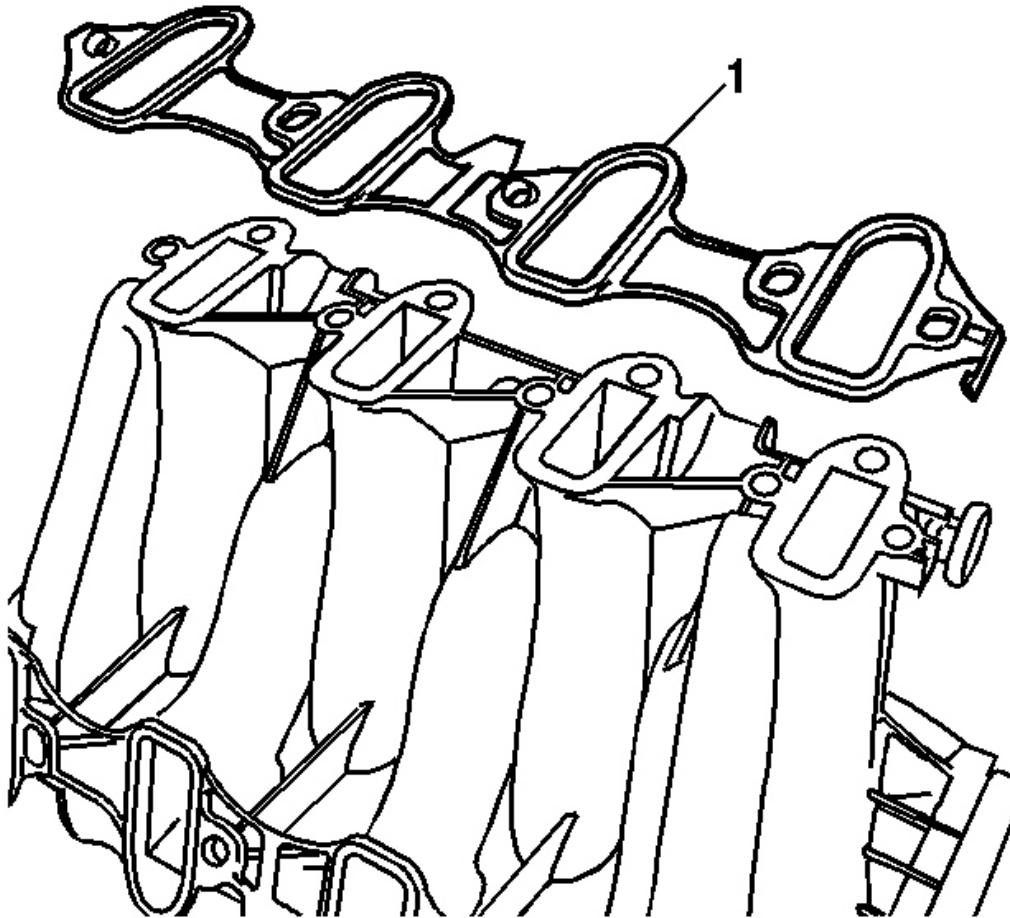
**Fig. 59: EVAP Purge Solenoid Bolt, Solenoid & Isolator**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the EVAP purge solenoid bolt (2), solenoid (3), and isolator (1) from the intake manifold.



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

9. Remove the intake manifold bolts.
10. Remove the intake manifold.

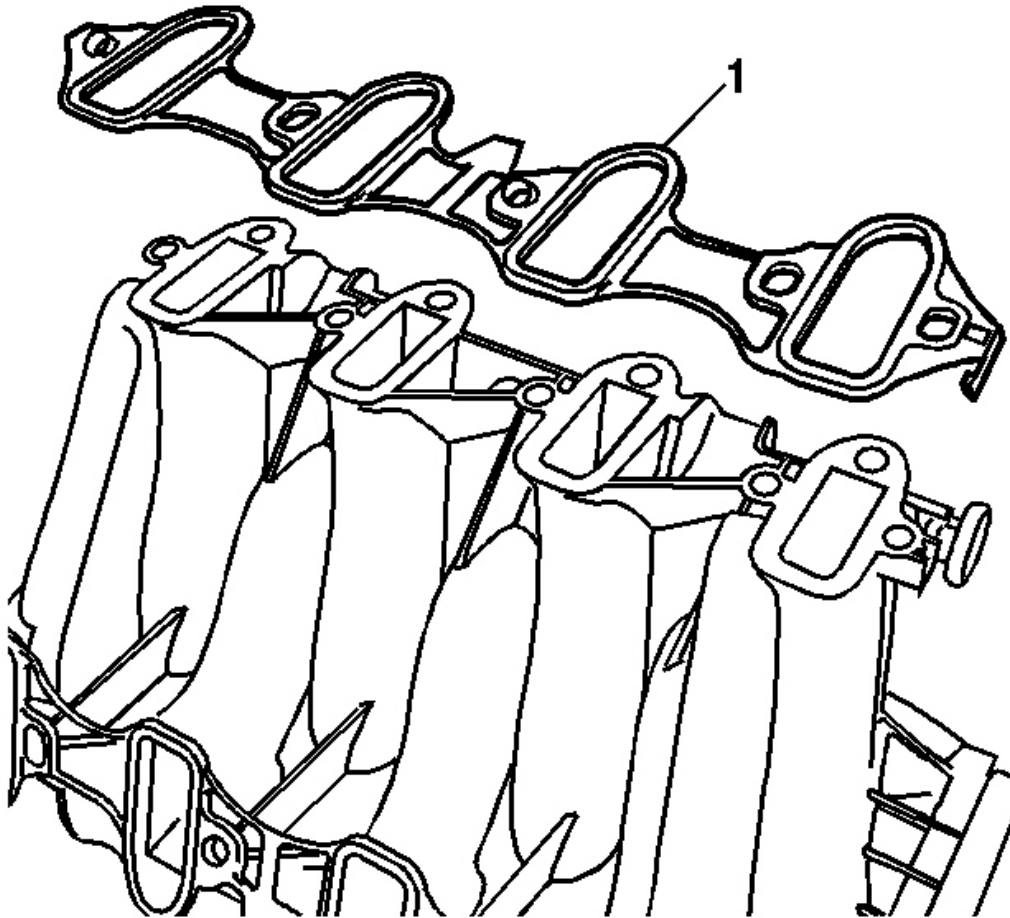


**Fig. 61: Intake Manifold Gasket**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold gaskets (1) from the intake manifold.
12. Discard the old intake manifold gaskets.
13. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection** .

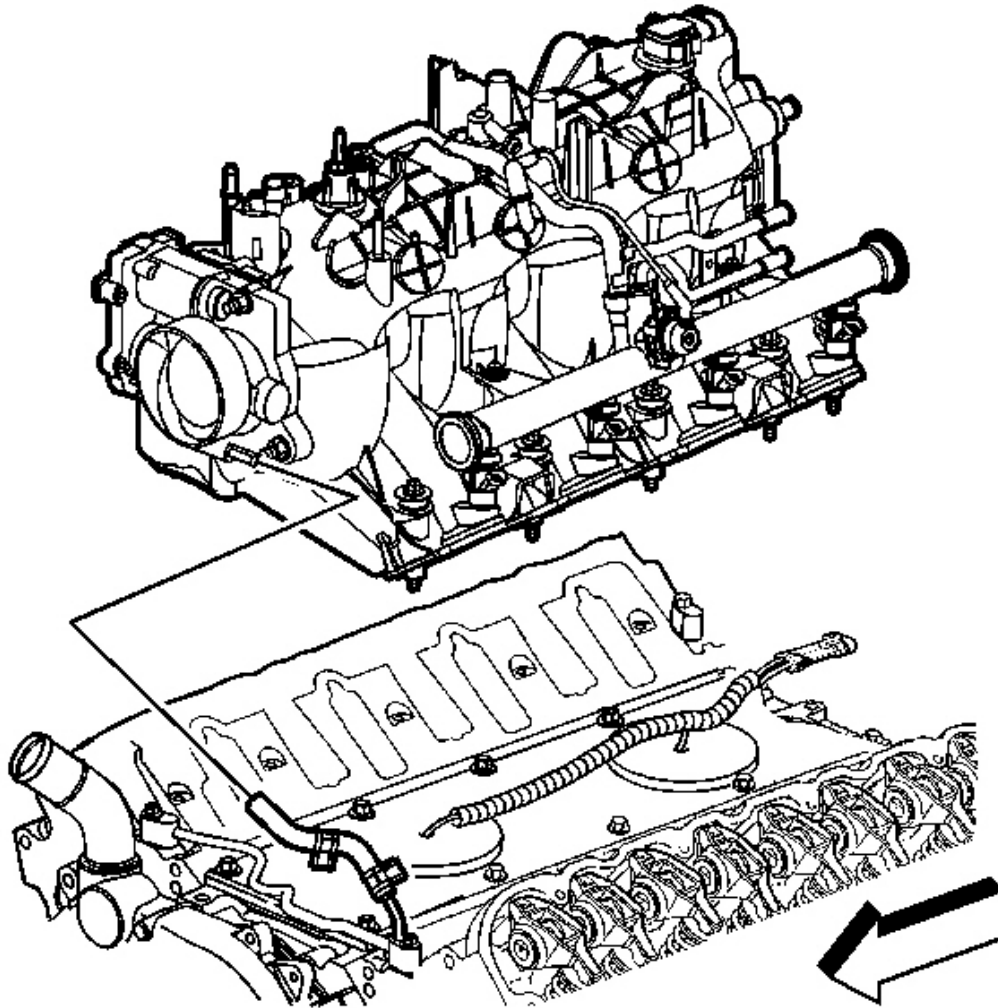
#### **Installation Procedure**





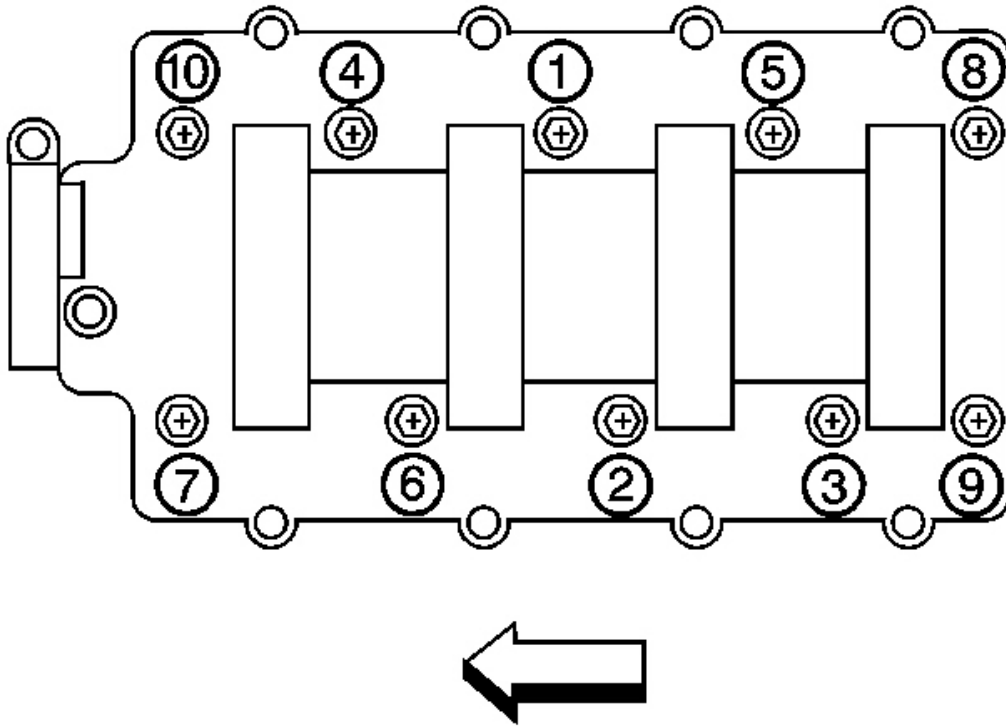
**Fig. 62: Intake Manifold Gasket**  
Courtesy of GENERAL MOTORS CORP.

1. Install new intake manifold gaskets (1) to the intake manifold.



**Fig. 63: Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM U.S. P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the intake manifold bolts.



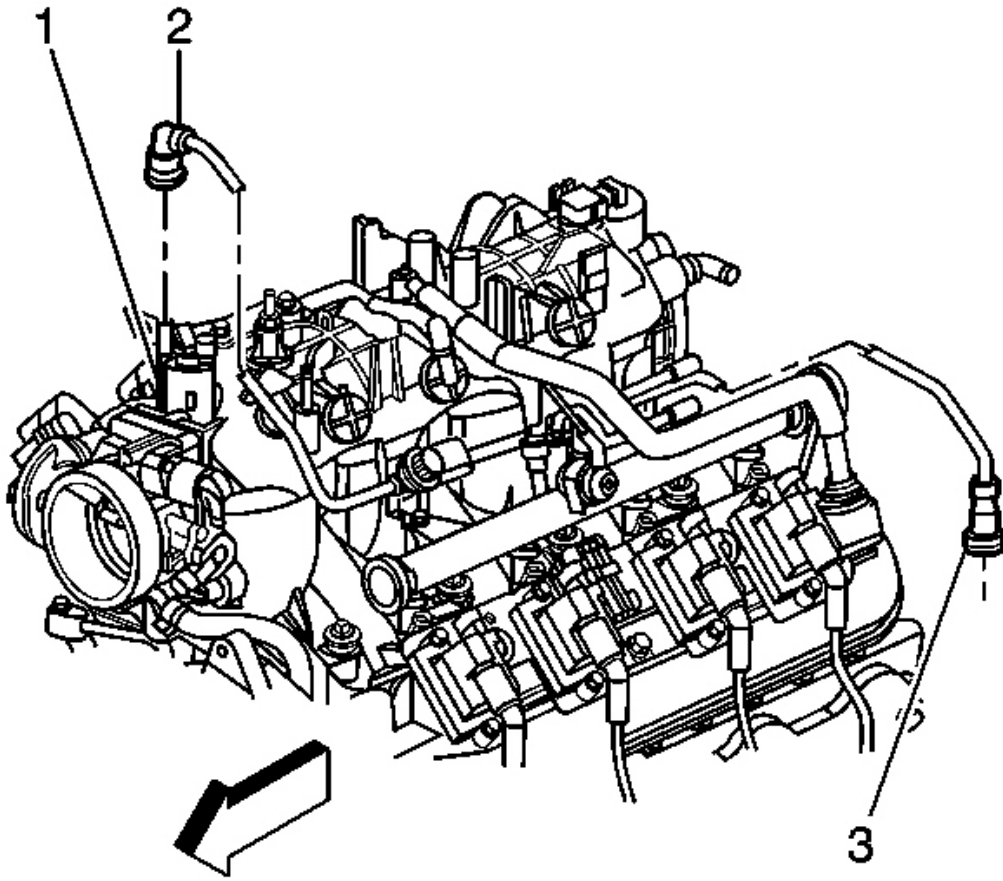
**Fig. 64: Intake Manifold Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

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

4. Install the intake manifold bolts.

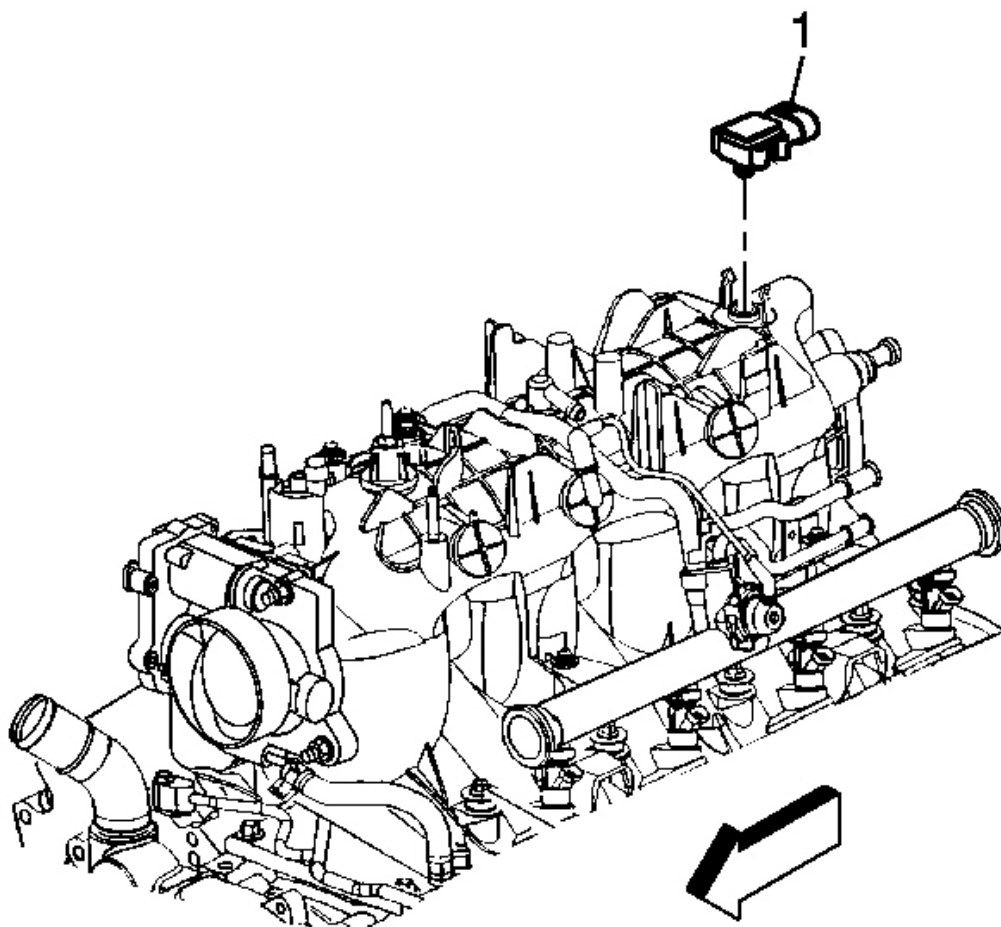
**Tighten:**

1. Tighten the intake manifold bolts a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts a final pass in sequence to 10 N.m (89 lb in).



**Fig. 65: Top View Of Engine**  
Courtesy of GENERAL MOTORS CORP.

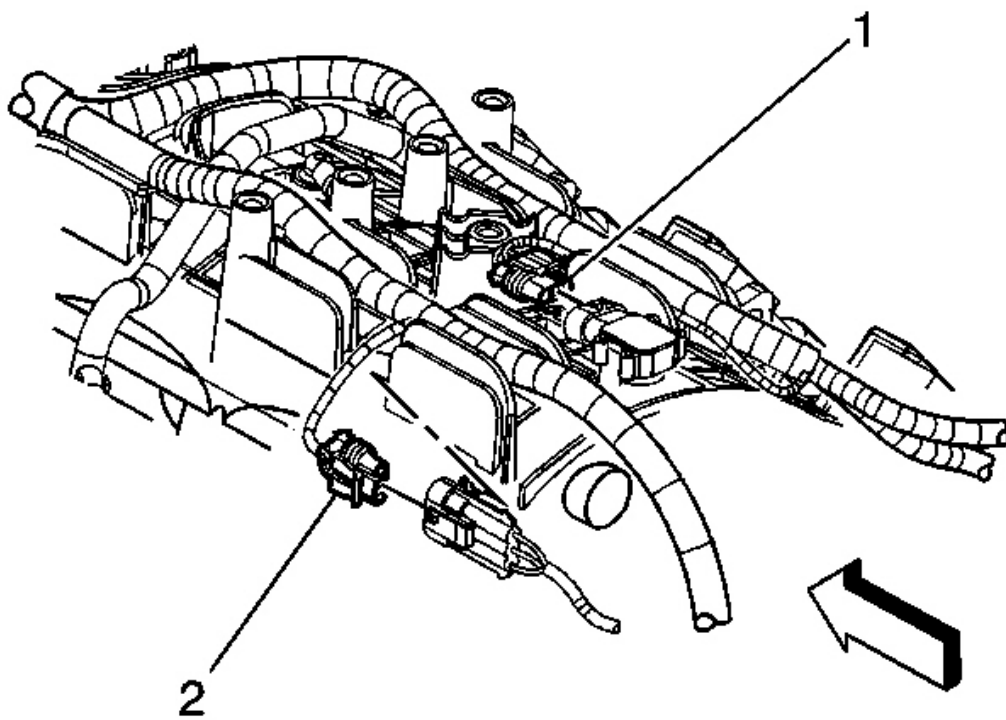
5. Install the EVAP purge solenoid vent tube to the solenoid (1) and vapor pipe.



**Fig. 66: MAP Sensor & Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Lightly coat the MAP sensor seal with clean engine oil before installing.

6. Install the MAP sensor (1) to the intake manifold.
7. Route the electrical harness into position over the engine.

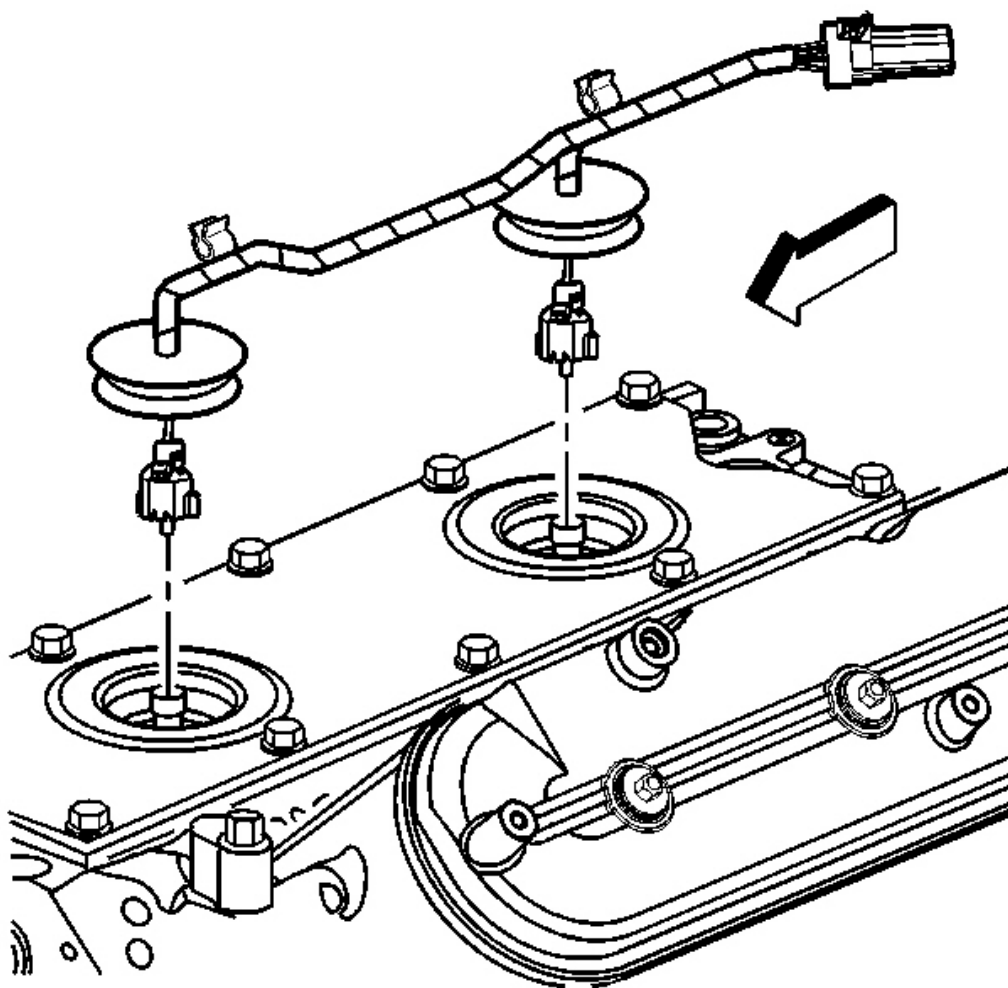


**Fig. 67: MAP Sensor & Knock Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

8. Connect the knock sensor harness electrical connector to the intake manifold.
9. Connect the following electrical connectors.
  - MAP sensor (1)
  - Knock sensor (2)
10. Install the fuel injectors. Refer to **Fuel Injector Replacement** .
11. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .

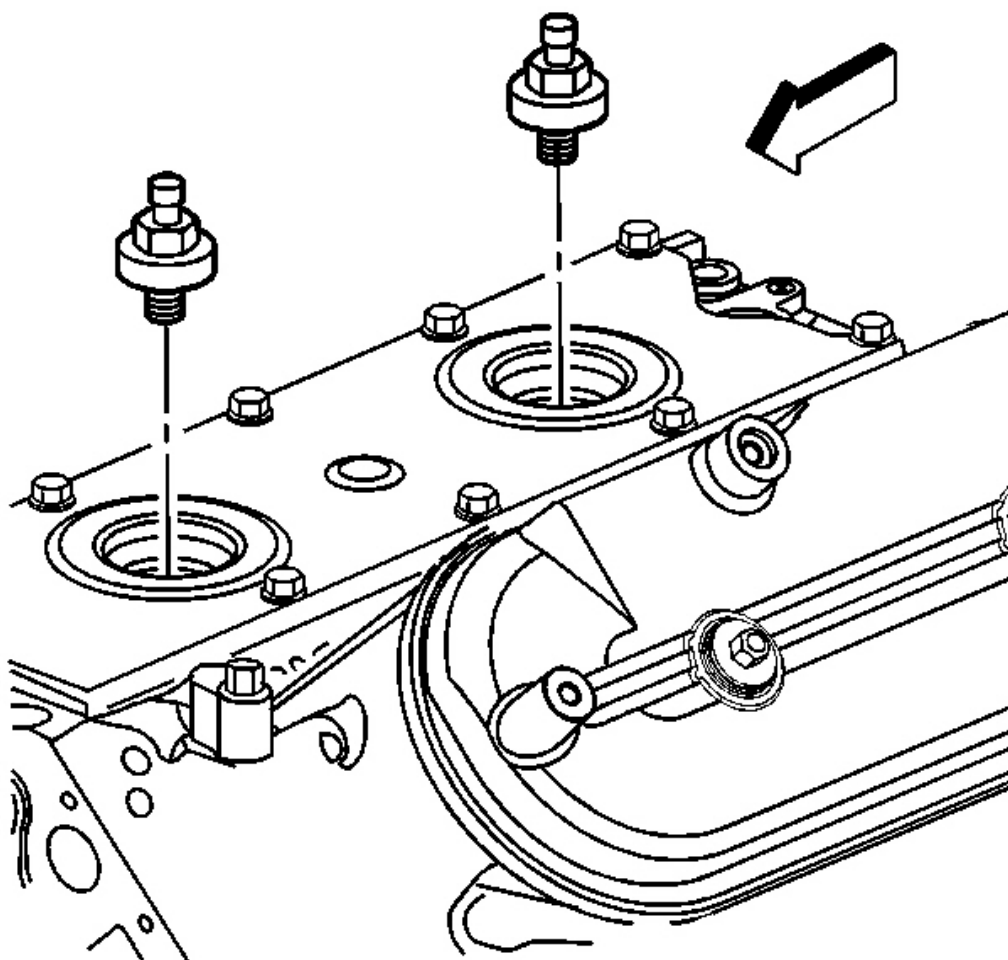
## **ENGINE VALLEY COVER REPLACEMENT**

### **Removal Procedure**



**Fig. 68: Knock Sensor Wire Harness**  
Courtesy of GENERAL MOTORS CORP.

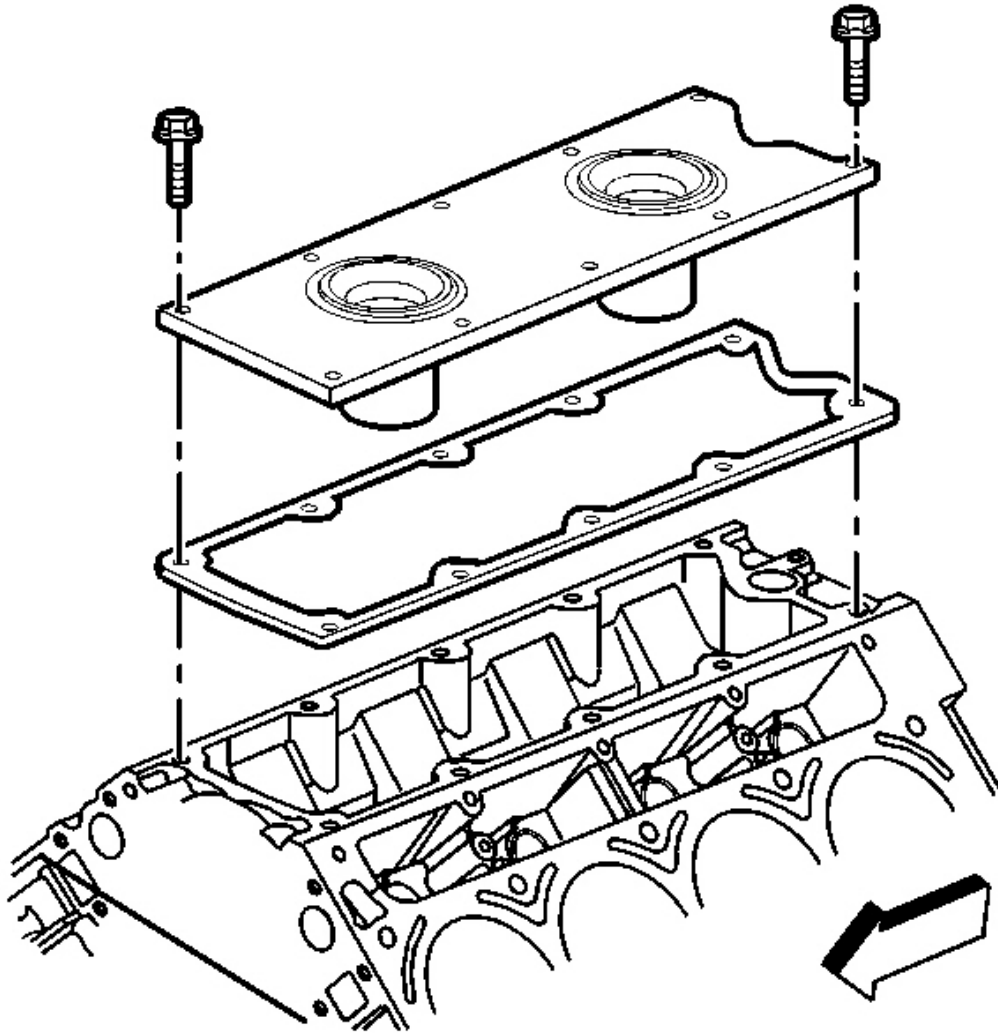
1. Remove the intake manifold. Refer to **Intake Manifold Replacement** .
2. Gently pry up the rubber covers.
3. Disconnect the knock sensor electrical connectors.



**Fig. 69: Knock Sensors**  
Courtesy of GENERAL MOTORS CORP.

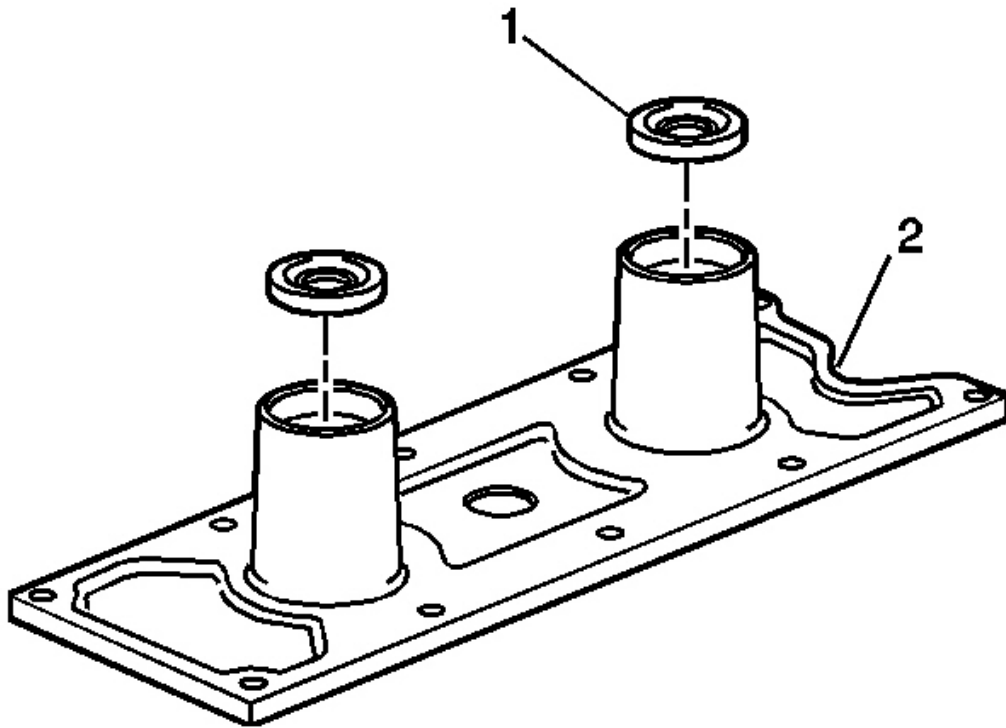
4. Remove the knock sensors.





**Fig. 70: Engine Valley Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine valley cover bolts.
6. Remove the engine valley cover and gasket.
7. Discard the old gasket.

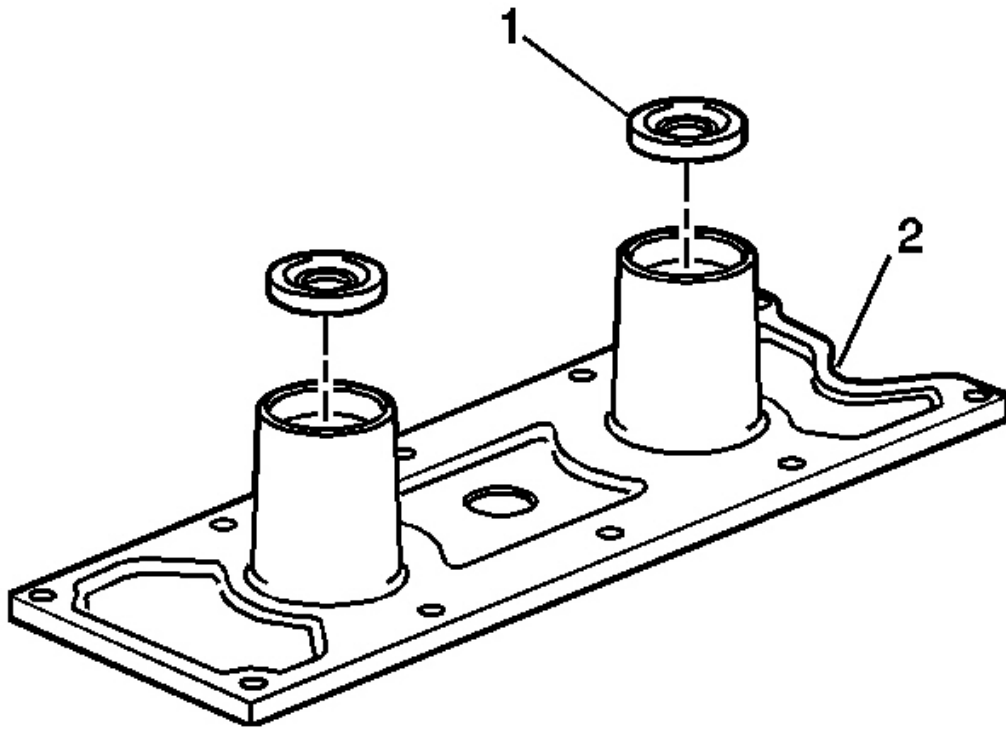


**Fig. 71: Knock Sensor Oil Seals & Cover**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the knock sensor oil seals (1) from the cover (2).
9. Clean and inspect the engine valley cover. Refer to **Engine Valley Cover Cleaning and Inspection** .

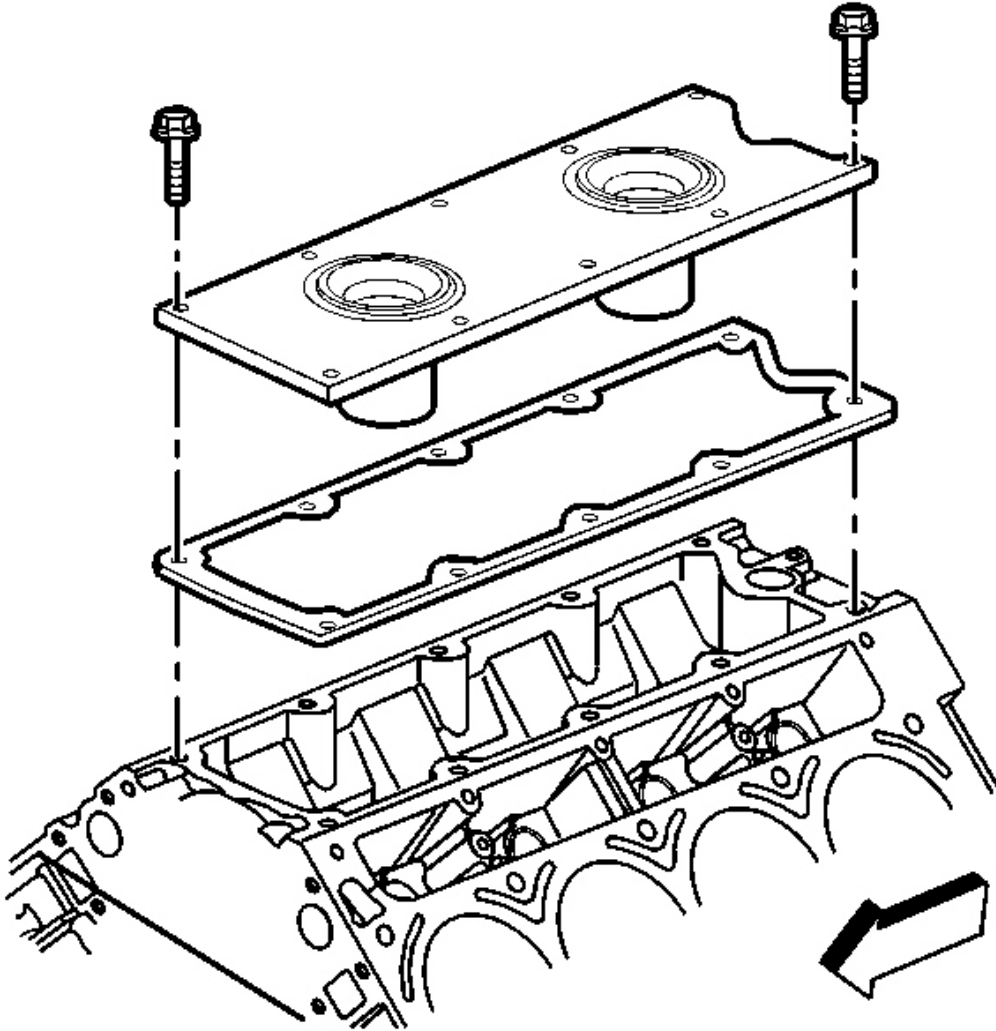
#### **Installation Procedure**

**IMPORTANT: All gasket surfaces should be free of oil or other foreign material during assembly.**



**Fig. 72: Knock Sensor Oil Seals & Cover**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the NEW knock sensor seals (1) with clean engine oil.
2. Install the knock sensor oil seals (1) into the engine valley cover (2).

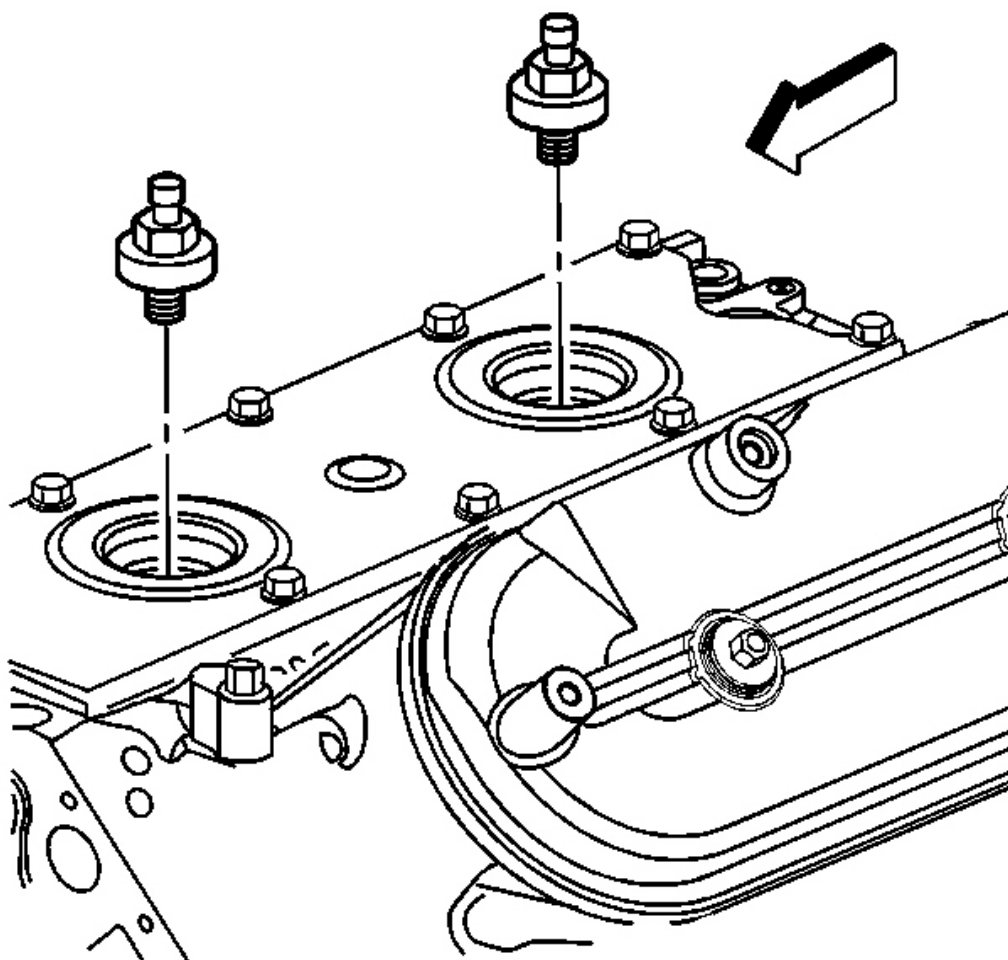


**Fig. 73: Engine Valley Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

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

3. Install the engine valley cover and a NEW gasket onto the engine block.
4. Install the engine valley cover bolts.

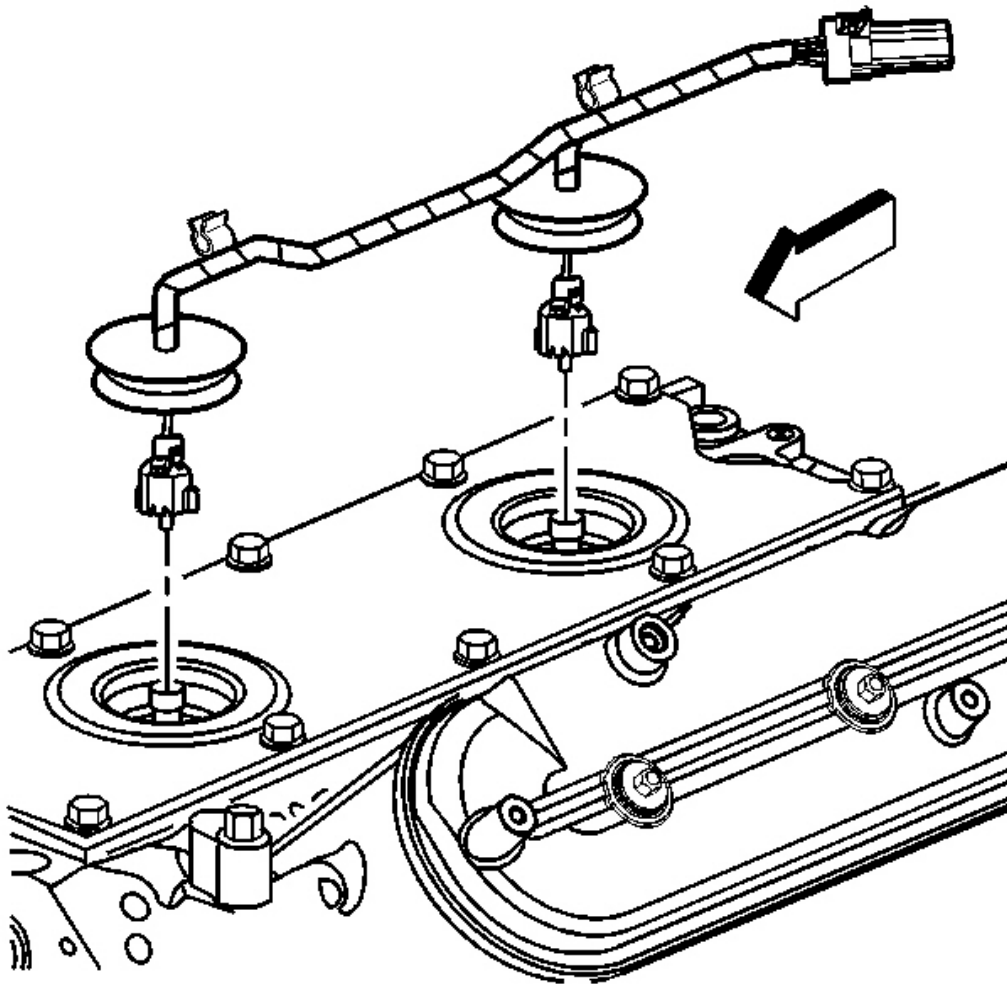
**Tighten:** Tighten the bolts to 25 N.m (18 lb ft).



**Fig. 74: Knock Sensors**  
Courtesy of GENERAL MOTORS CORP.

5. Install the knock sensors.

**Tighten:** Tighten the sensors to 20 N.m (15 lb ft).

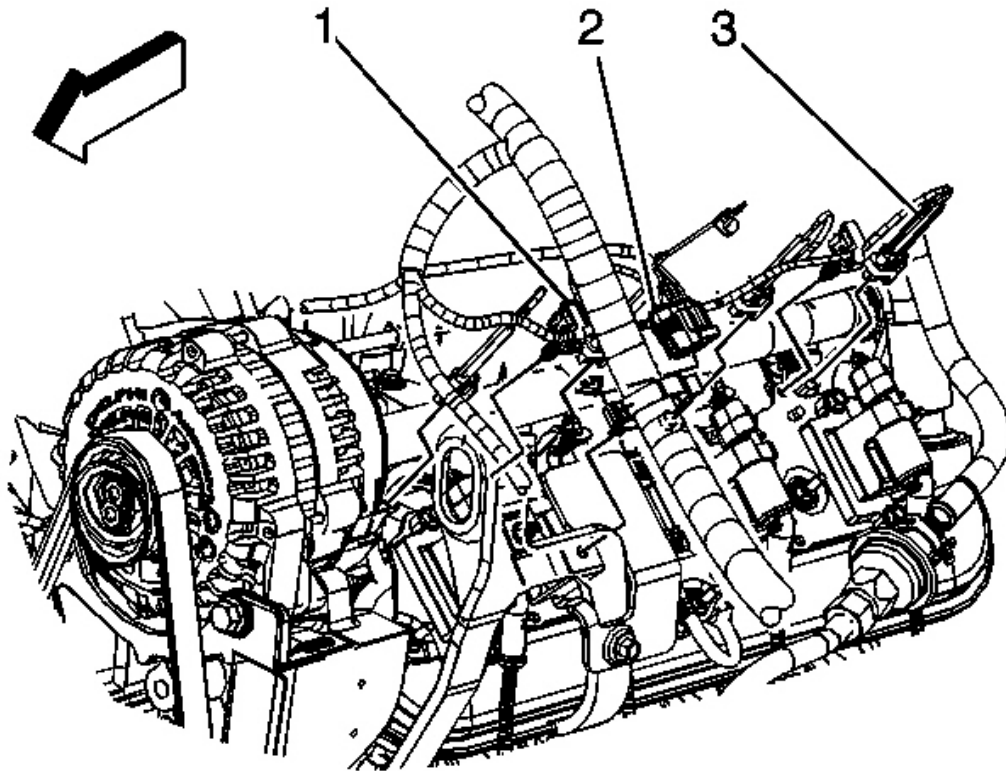


**Fig. 75: Knock Sensor Wire Harness**  
Courtesy of GENERAL MOTORS CORP.

6. Connect the knock sensor electrical connectors.
7. Push down on the rubber covers.
8. Install the intake manifold. Refer to **Intake Manifold Replacement** .

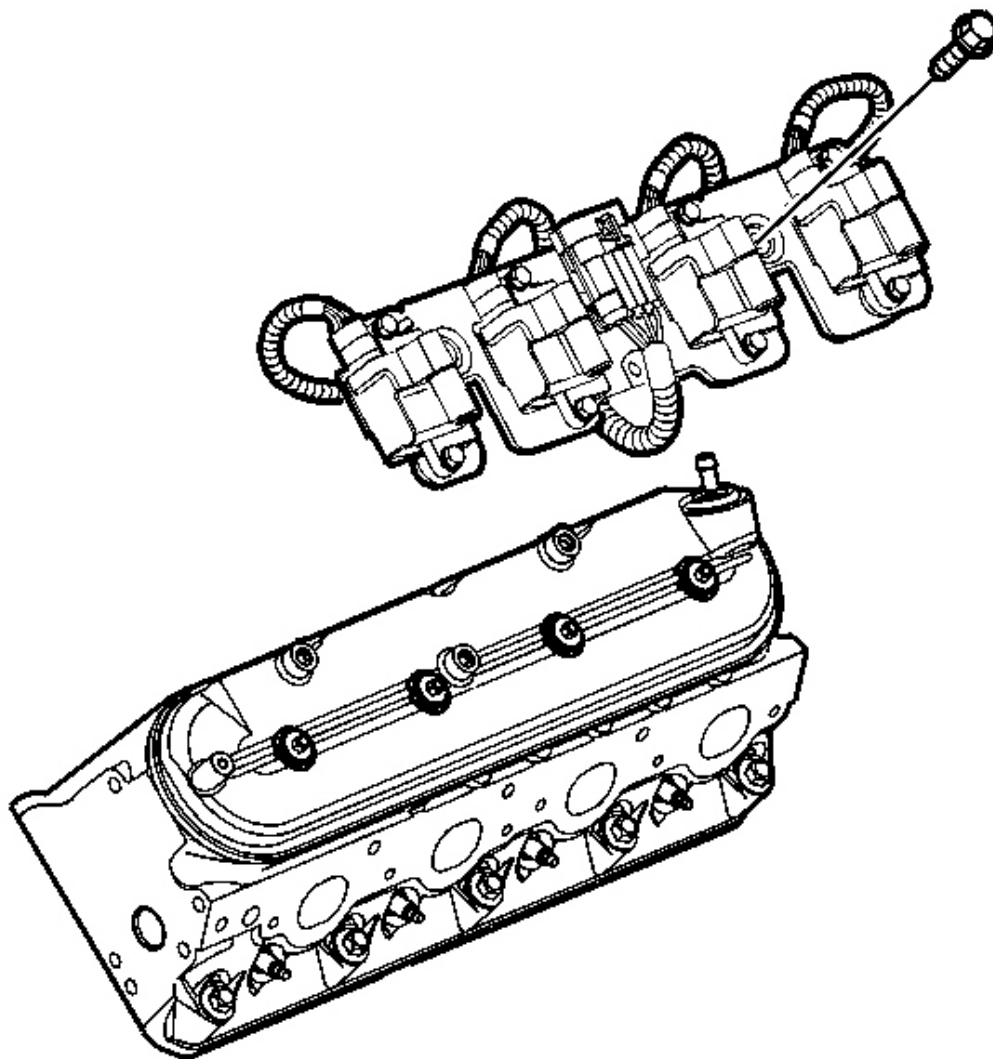
## **VALVE ROCKER ARM COVER REPLACEMENT - LEFT**

### **Removal Procedure**



**Fig. 76: Harness Clips, Main Coil Harness & Fuel Injector Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

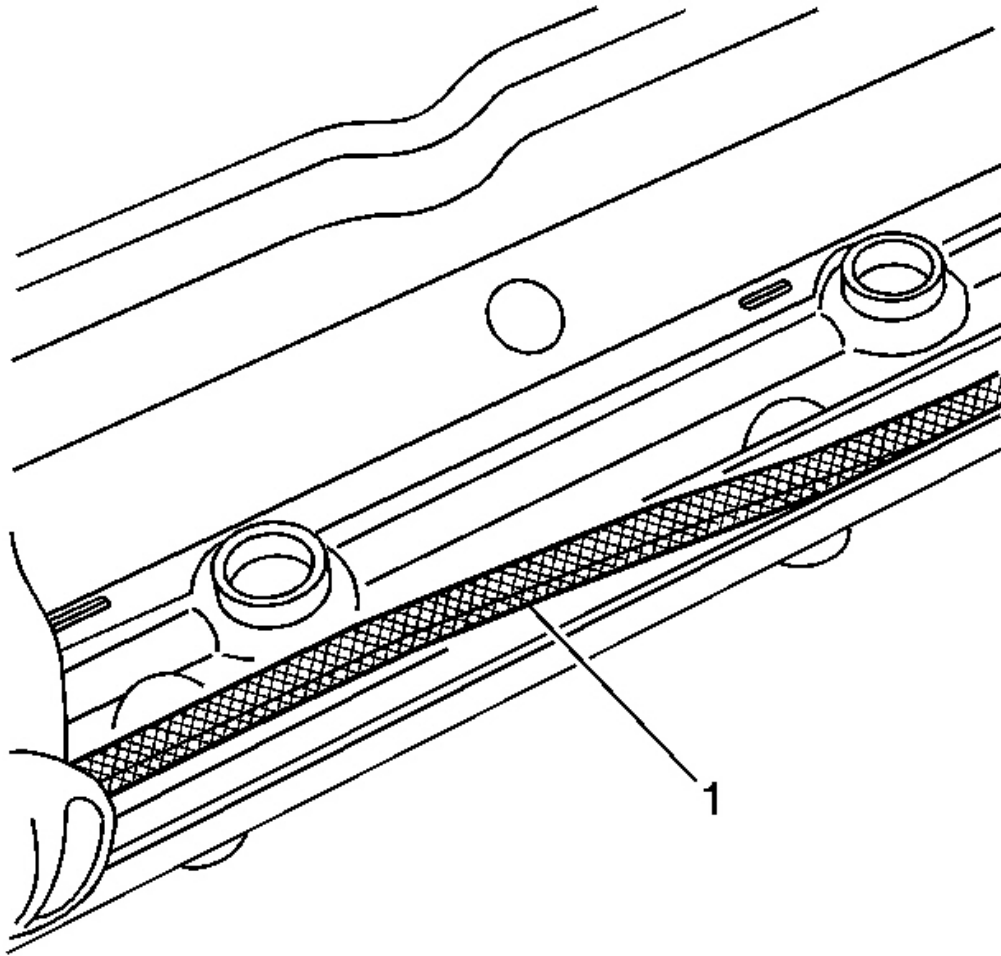
1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (2) feeding the ignition coils.
4. Remove the harness clips (1).
5. Reposition the engine harness.
6. Remove the spark plug wires from the ignition coils.
  - Twist each plug wire 1/2 turn.
  - Pull only on the boot in order to remove the wire from the ignition coil.



**Fig. 77: Ignition Coil & Bracket Assembly (Left)**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the ignition coil bracket studs from the rocker arm cover.
8. Remove the ignition coils and bracket from the rocker arm cover.
9. Remove the valve rocker arm cover bolts.
10. Remove the valve rocker arm cover.





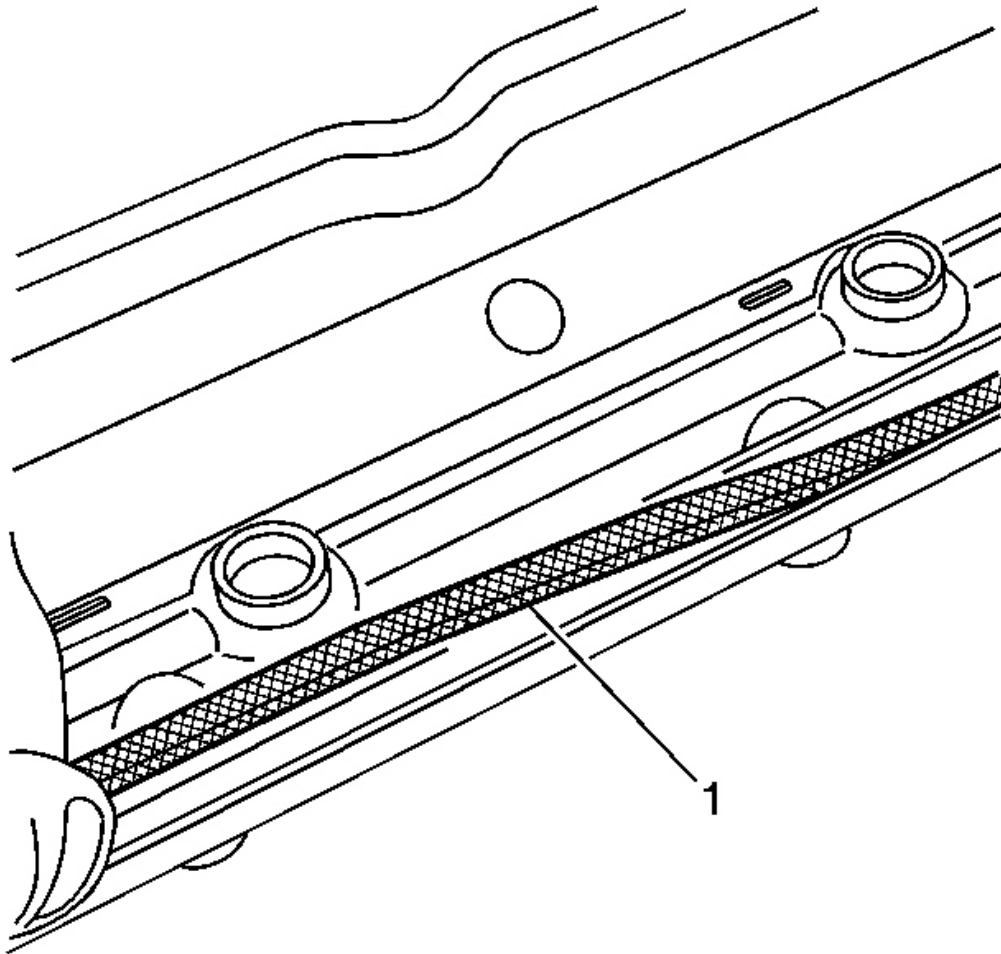
**Fig. 78: Valve Rocker Arm Cover Gasket (Left)**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the gasket (1) from the rocker cover.
12. Discard the OLD gasket.
13. Clean and inspect the rocker arm cover. Refer to Valve Rocker Arm Cover Cleaning and Inspection .

#### **Installation Procedure**

- IMPORTANT:**
- All gasket surfaces should be free of oil an/or other foreign material during assembly.
  - DO NOT reuse the valve rocker arm cover gasket.

- The valve rocker arm cover bolt grommets may be reused.
- If the PCV valve grommet has been removed from the rocker cover, install a **NEW** grommet during assembly.



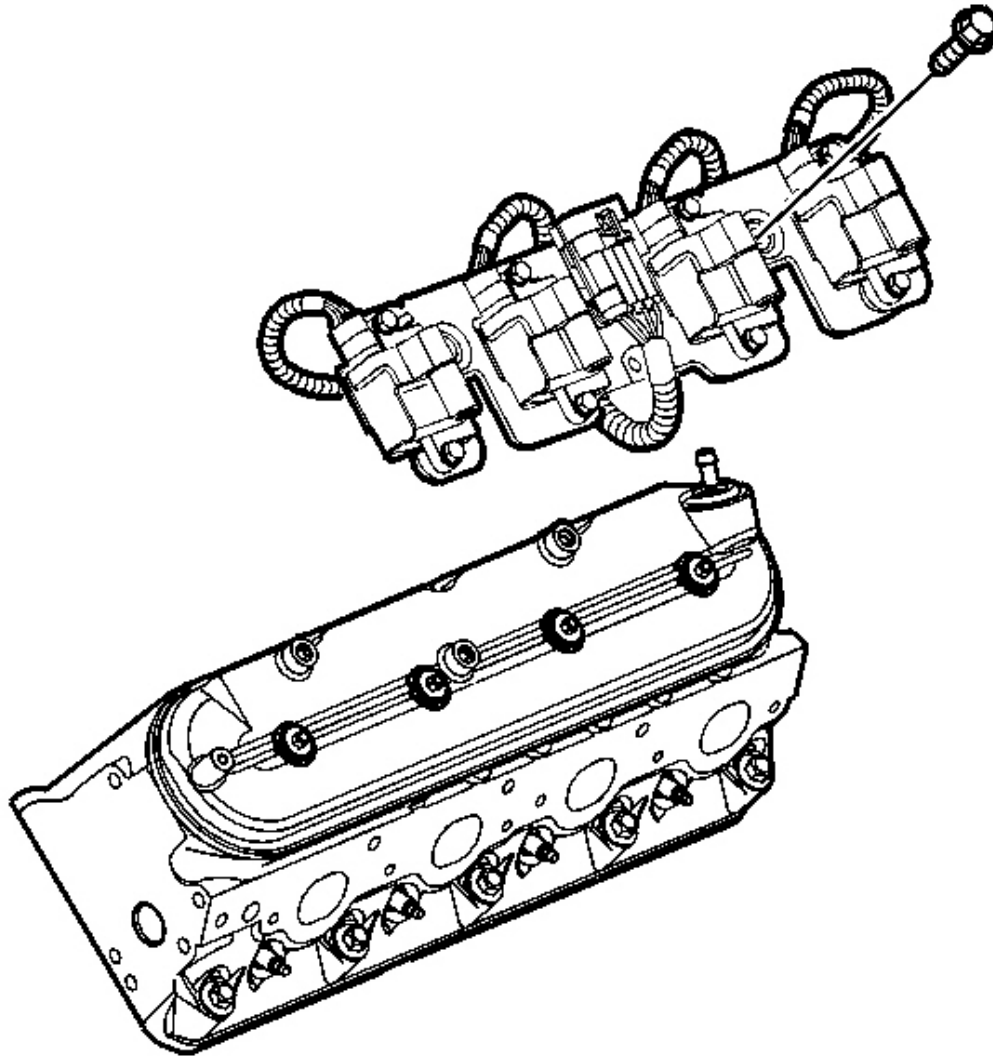
**Fig. 79: Valve Rocker Arm Cover Gasket (Left)**  
Courtesy of GENERAL MOTORS CORP.

1. Install a **NEW** rocker cover gasket (1) into the valve rocker cover lip.
2. Install the valve rocker arm cover onto the cylinder head.
3. Install new rocker arm cover grommets, if necessary.

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

4. Install the rocker arm cover bolts.

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

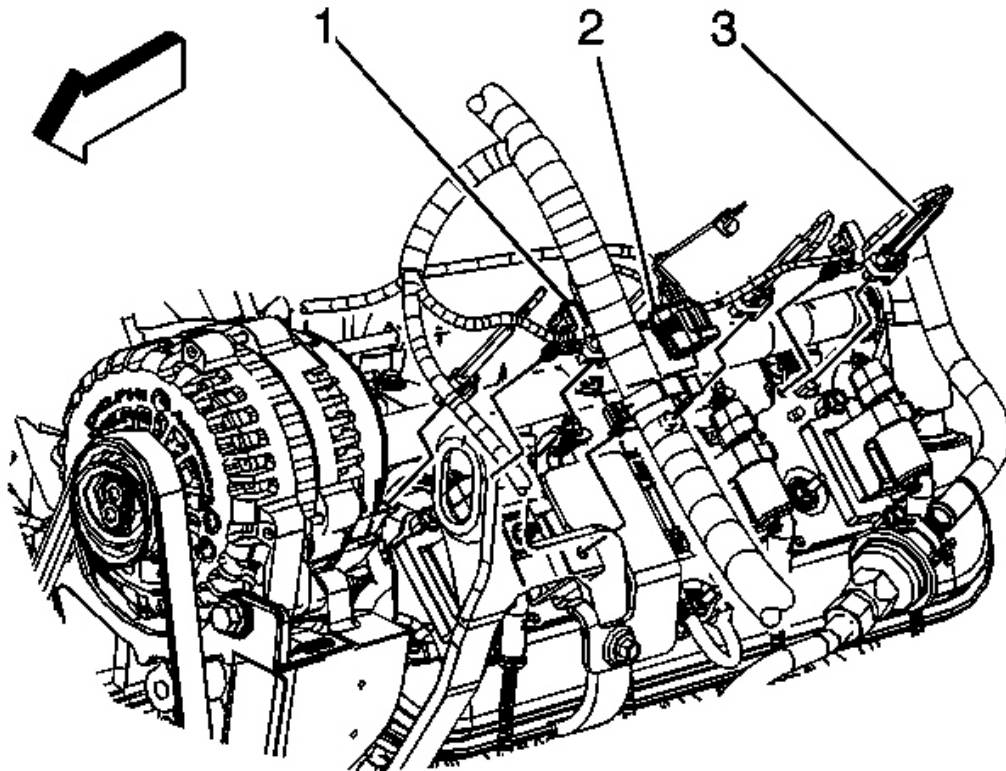


**Fig. 80: Ignition Coil & Bracket Assembly (Left)**  
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock GM U.S. P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.

6. Install the ignition coils and bracket to the rocker arm cover.
7. Install the ignition coil bracket studs to the rocker arm cover.

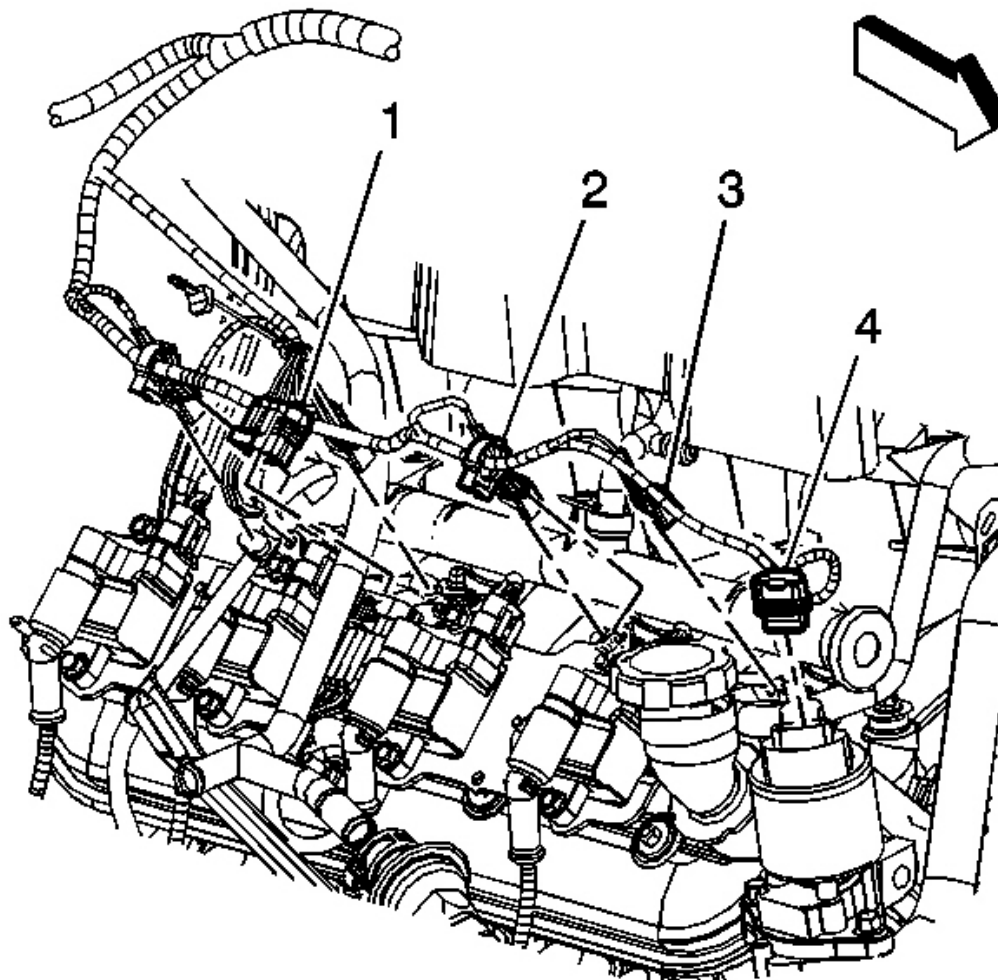
**Tighten:** Tighten the studs to 12 N.m (106 lb in).



**Fig. 81: Harness Clips, Main Coil Harness & Fuel Injector Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

8. Install the spark plug wires to the ignition coils.
9. Re-position the engine harness.
10. Install the harness clips (1).
11. Connect the main electrical connector (2) feeding the ignition coils.
12. Install the CPA lock.
13. Install the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .

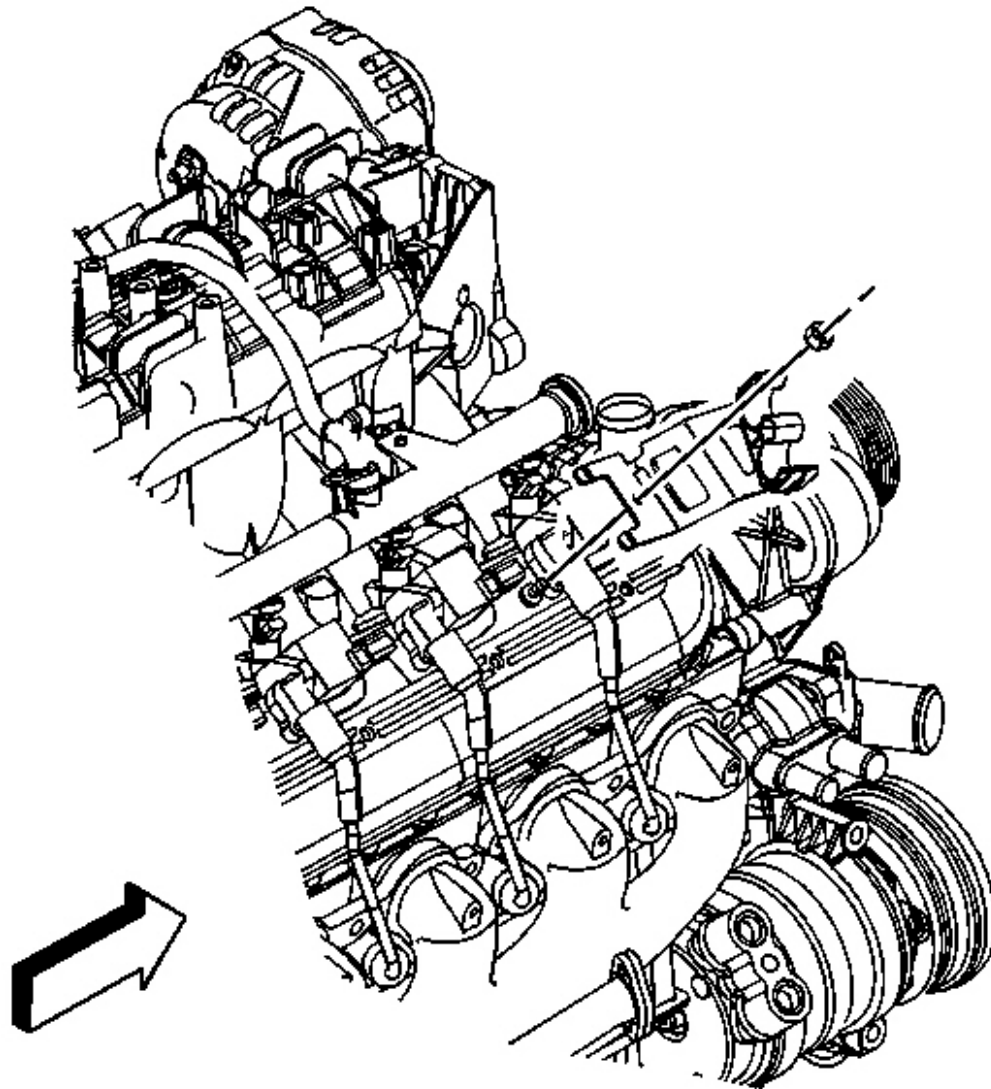
## **VALVE ROCKER ARM COVER REPLACEMENT - RIGHT**



**Fig. 82: Harness Clips, Main Coil Harness, Fuel Injectors & (EGR) Valve Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

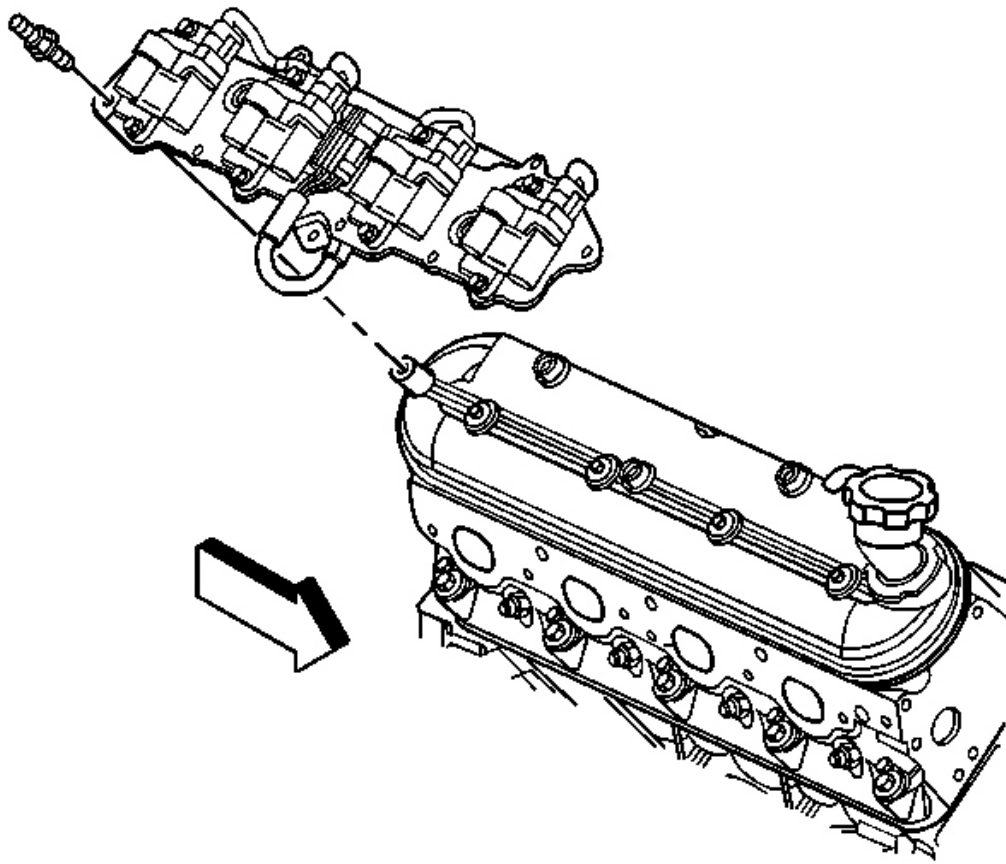
1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (1) feeding the ignition coils.
4. Remove the harness clips (2).
5. Reposition the engine harness.
6. Remove the spark plug wires from the ignition coils.

- Twist each plug wire 1/2 turn.
- Pull only on the boot in order to remove the wire from the ignition coil.



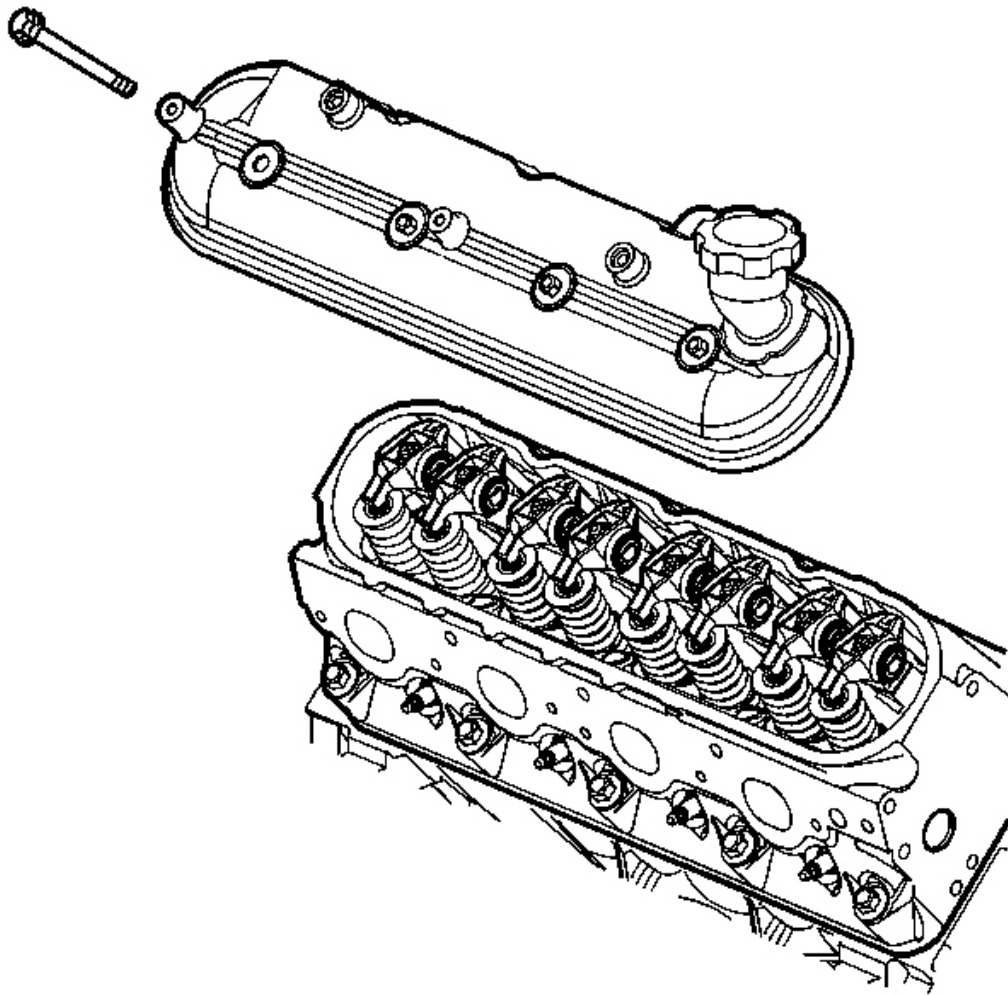
**Fig. 83: Heater Hose Bracket & Nut**  
Courtesy of GENERAL MOTORS CORP.

7. Reposition the surge tank/heater hoses from the heater hose bracket.
8. Remove the heater hose bracket nut and bracket.



**Fig. 84: Ignition Coil Bracket Studs**  
Courtesy of GENERAL MOTORS CORP.

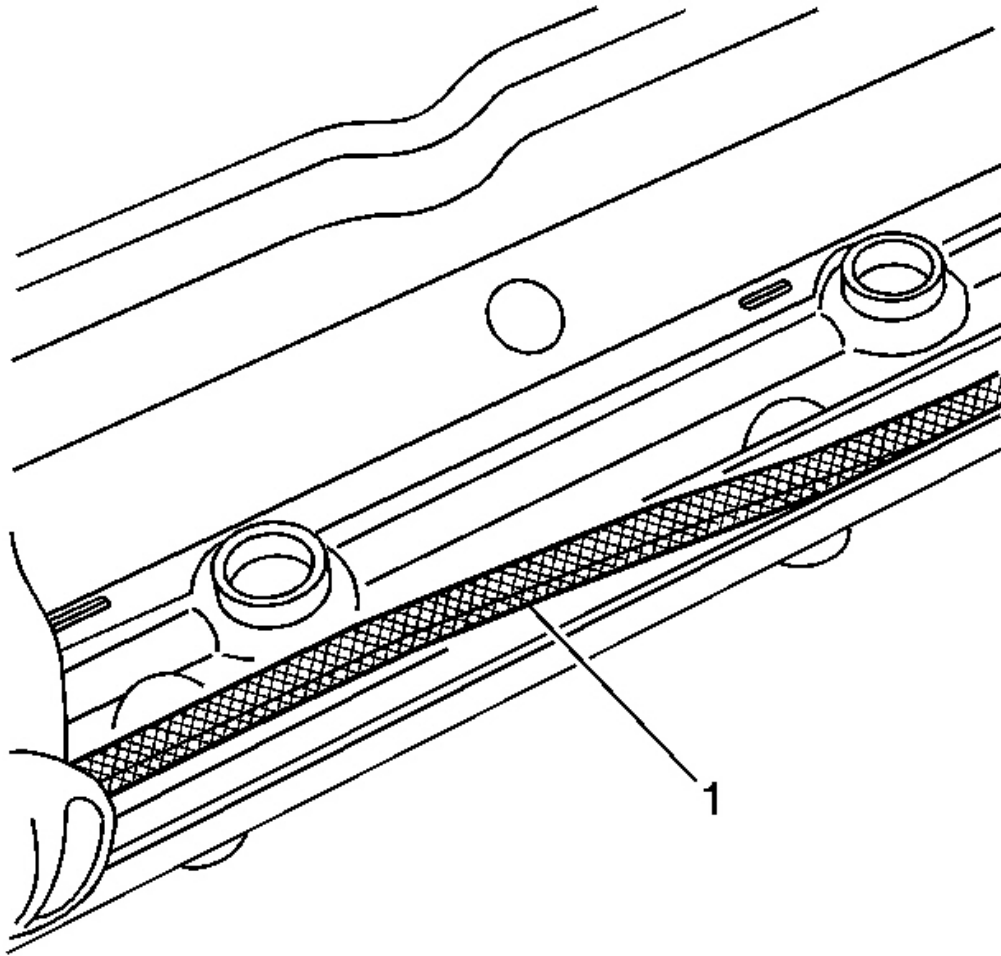
9. Remove the ignition coil bracket studs from the rocker arm cover.
10. Remove the ignition coils and bracket from the rocker cover.
11. Remove the positive crankcase ventilation (PCV) hose.



**Fig. 85: Valve Rocker Arm Cover & Bolts (Right)**  
**Courtesy of GENERAL MOTORS CORP.**

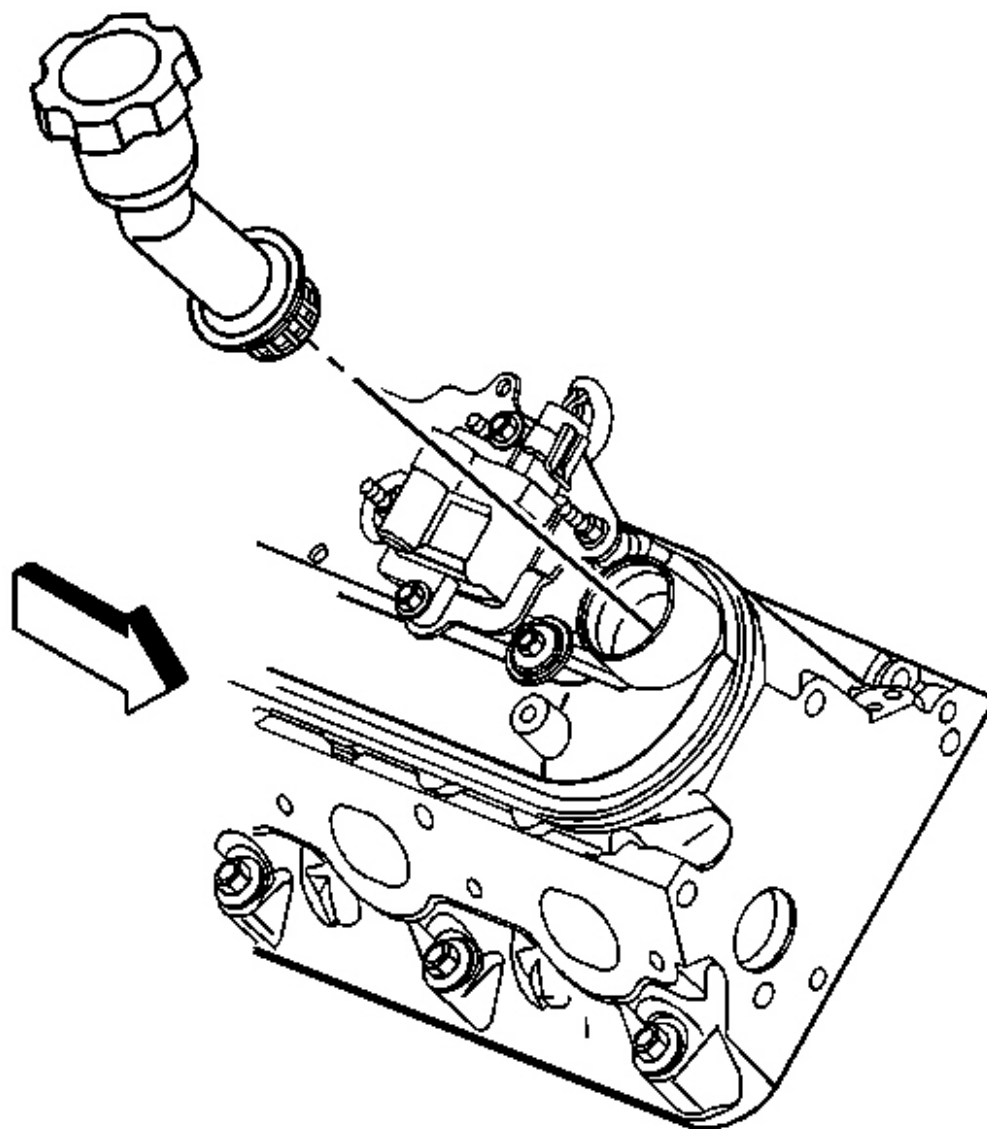
12. Remove the valve rocker arm cover bolts.
13. Remove the valve rocker arm cover.





**Fig. 86: Valve Rocker Arm Cover Gasket (Right)**  
Courtesy of GENERAL MOTORS CORP.

14. Remove the gasket (1) from the rocker cover.
15. Discard the OLD gasket.



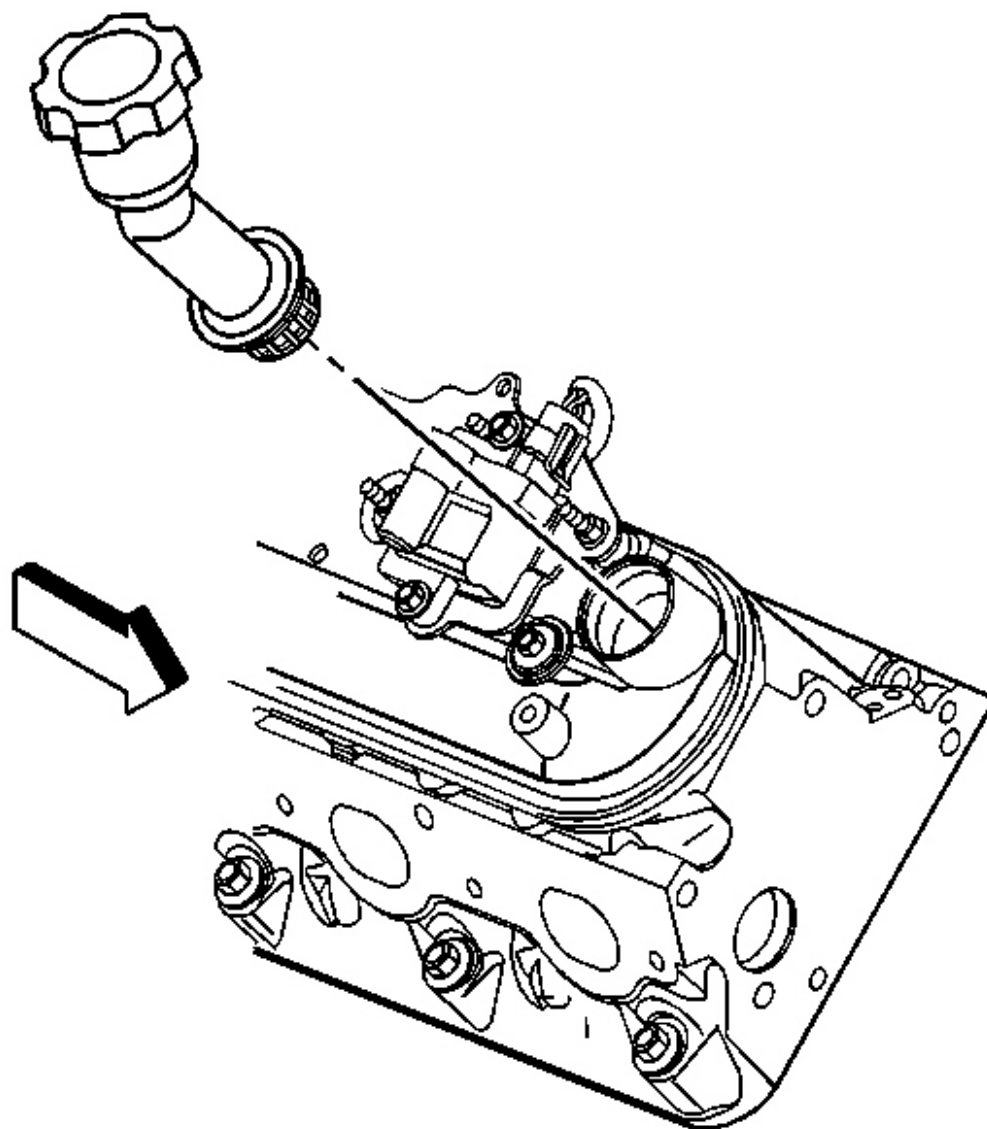
**Fig. 87: Oil Fill Tube**  
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil fill cap from the oil fill tube.
17. Remove the oil fill tube from the rocker cover, if required.
18. Discard the oil fill tube.
19. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection** .

## Installation Procedure

### **IMPORTANT:**

- All gasket surfaces should be free of oil or other foreign material during assembly.
- **DO NOT** reuse the valve rocker arm cover gasket.
- The valve rocker arm cover bolt grommets may be reused.
- If the oil fill tube has been removed from the rocker arm cover, install a **NEW** fill tube during assembly.



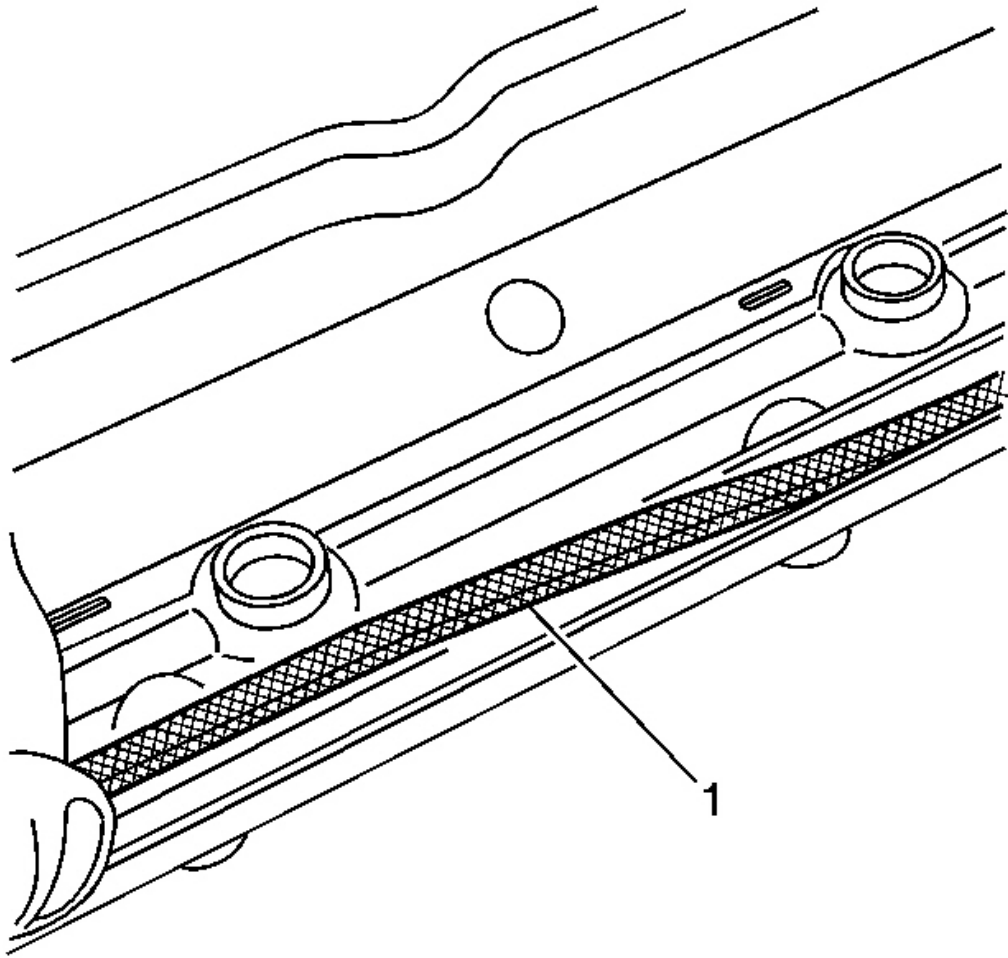
**Fig. 88: Oil Fill Tube**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.
2. Insert the NEW oil fill tube into the rocker arm cover.

Rotate the tube clockwise until locked in the proper position.

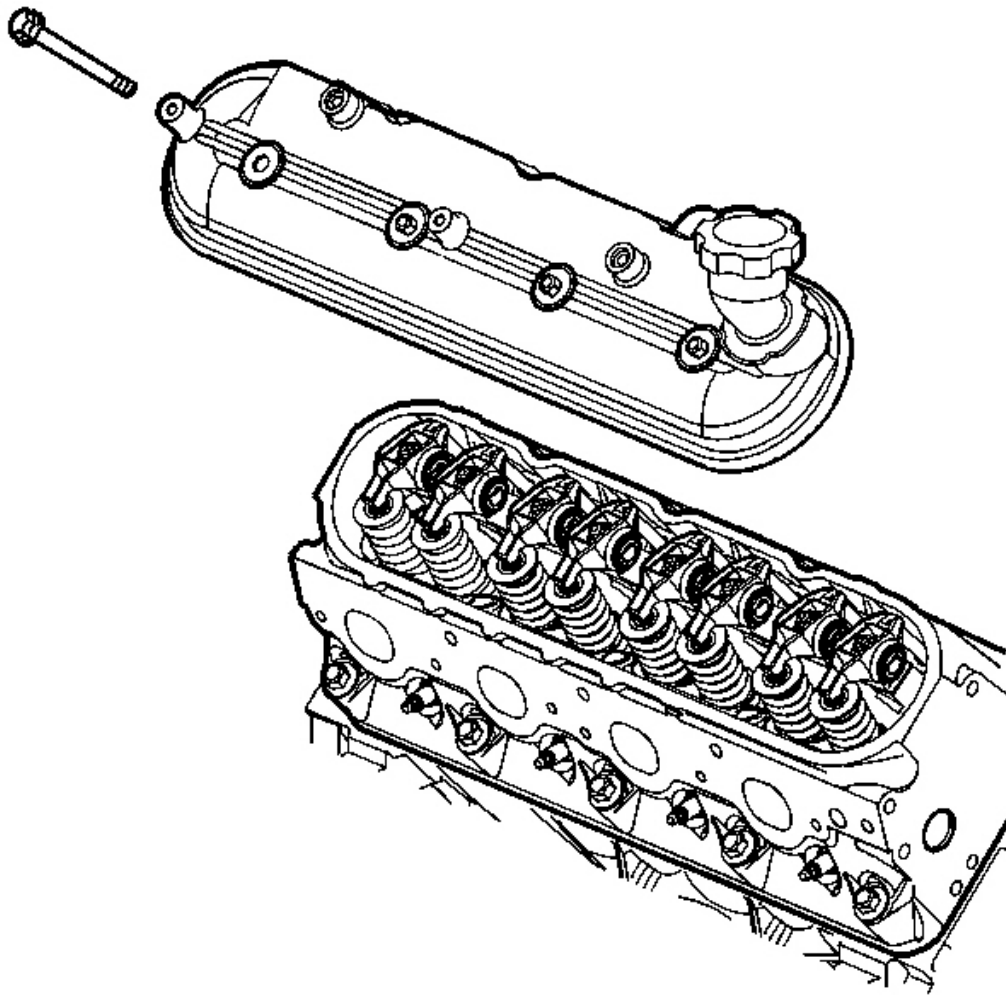
3. Install the oil fill cap into the tube.

Rotate the cap clockwise until locked in the proper position.



**Fig. 89: Valve Rocker Arm Cover Gasket (Right)**  
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW rocker cover gasket (1) into the valve rocker cover lip.



**Fig. 90: Valve Rocker Arm Cover & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

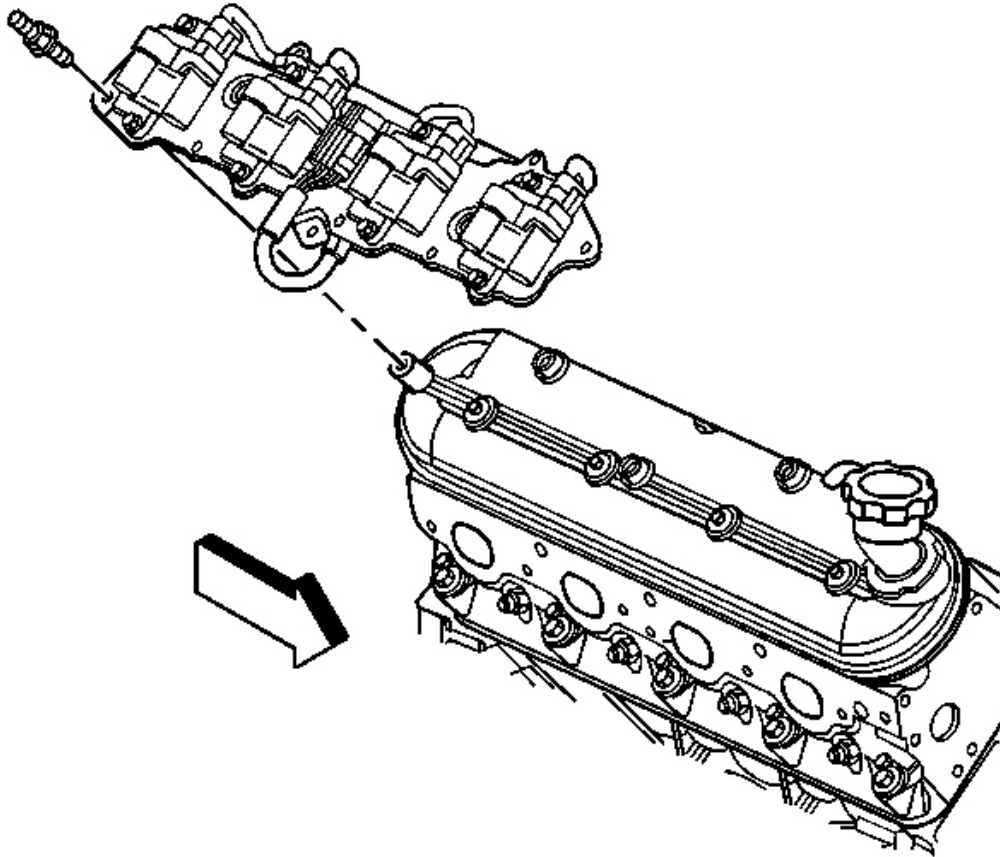
5. Install the valve rocker arm cover onto the cylinder head.
6. Install new rocker arm cover grommets, if necessary.

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

7. Install the rocker arm cover bolts and grommets.

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

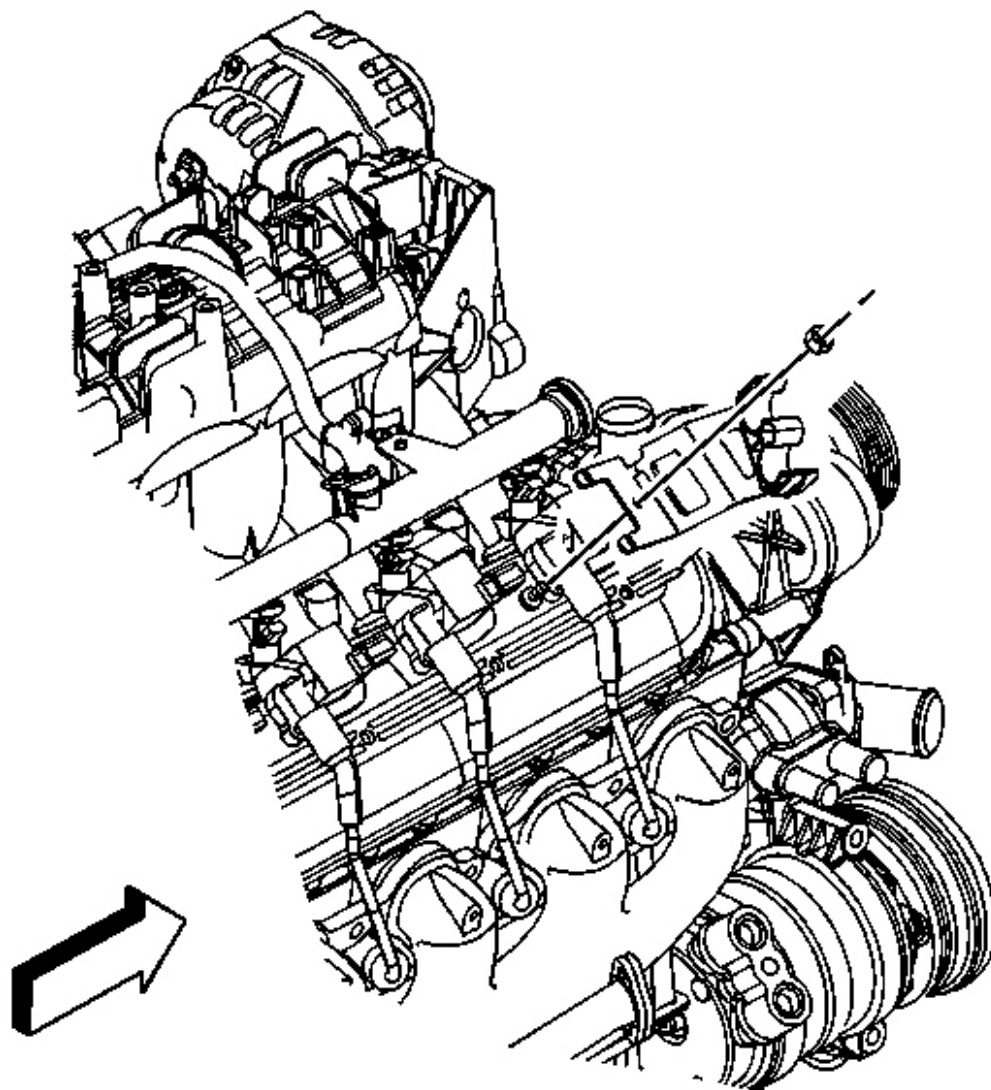
8. Install the PCV hose.



**Fig. 91: Ignition Coil Bracket Studs**  
Courtesy of GENERAL MOTORS CORP.

9. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
10. Install the ignition coils and bracket to the rocker arm cover.
11. Install the ignition coil bracket studs to the rocker cover.

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



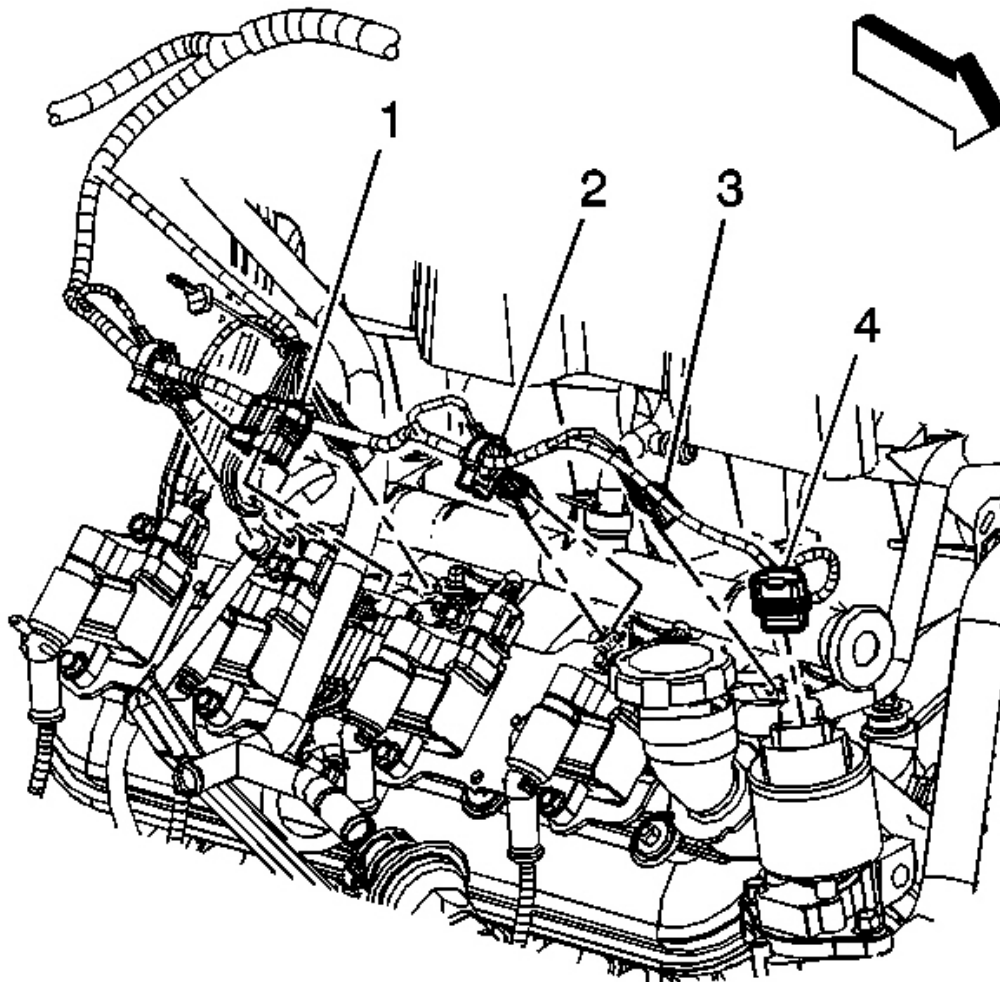
**Fig. 92: Heater Hose Bracket & Nut**  
Courtesy of GENERAL MOTORS CORP.

12. Install the heater hose bracket and nut.

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

13. Position the surge tank/heater hoses to the heater hose bracket.

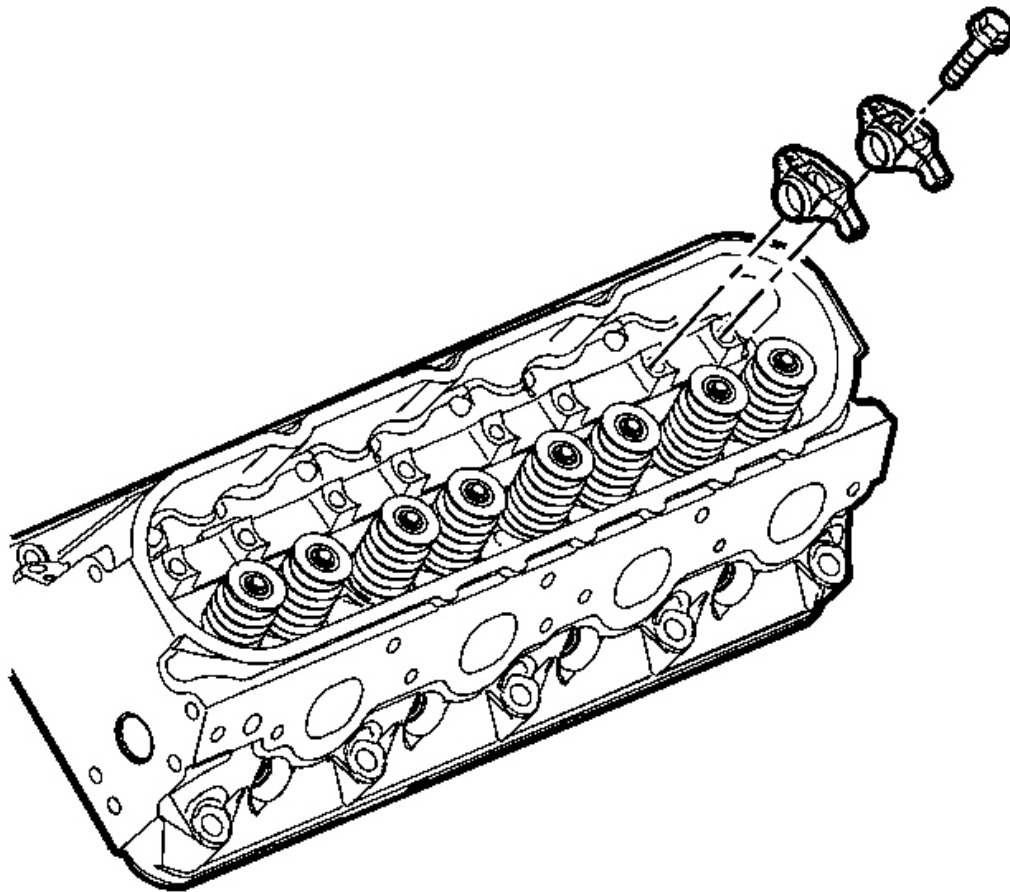




**Fig. 93: Harness Clips, Main Coil Harness, Fuel Injectors & (EGR) Valve Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

14. Install the spark plug wires to the ignition coils.
15. Re-position the engine harness.
16. Install the harness clips (2).
17. Connect the main electrical connector (1) feeding the ignition coils.
18. Install the CPA lock.
19. Install the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))** .

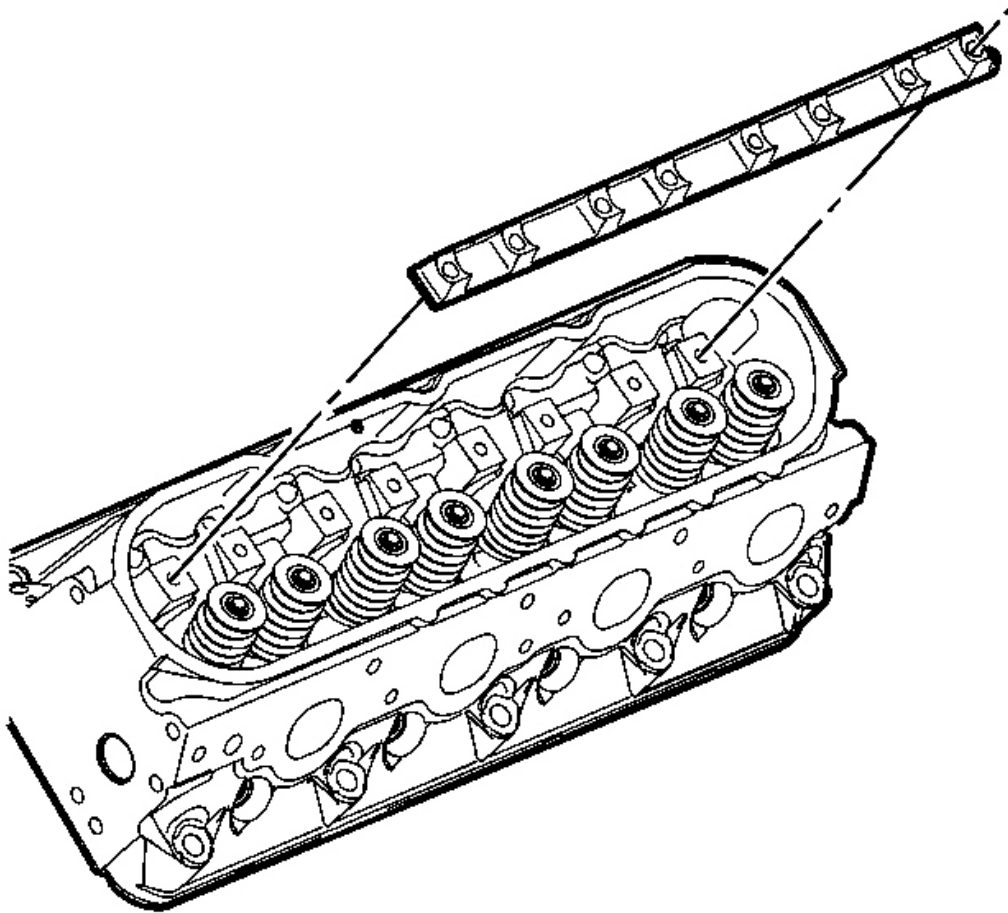
## **VALVE ROCKER ARM AND PUSH ROD REPLACEMENT**



**Fig. 94: Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

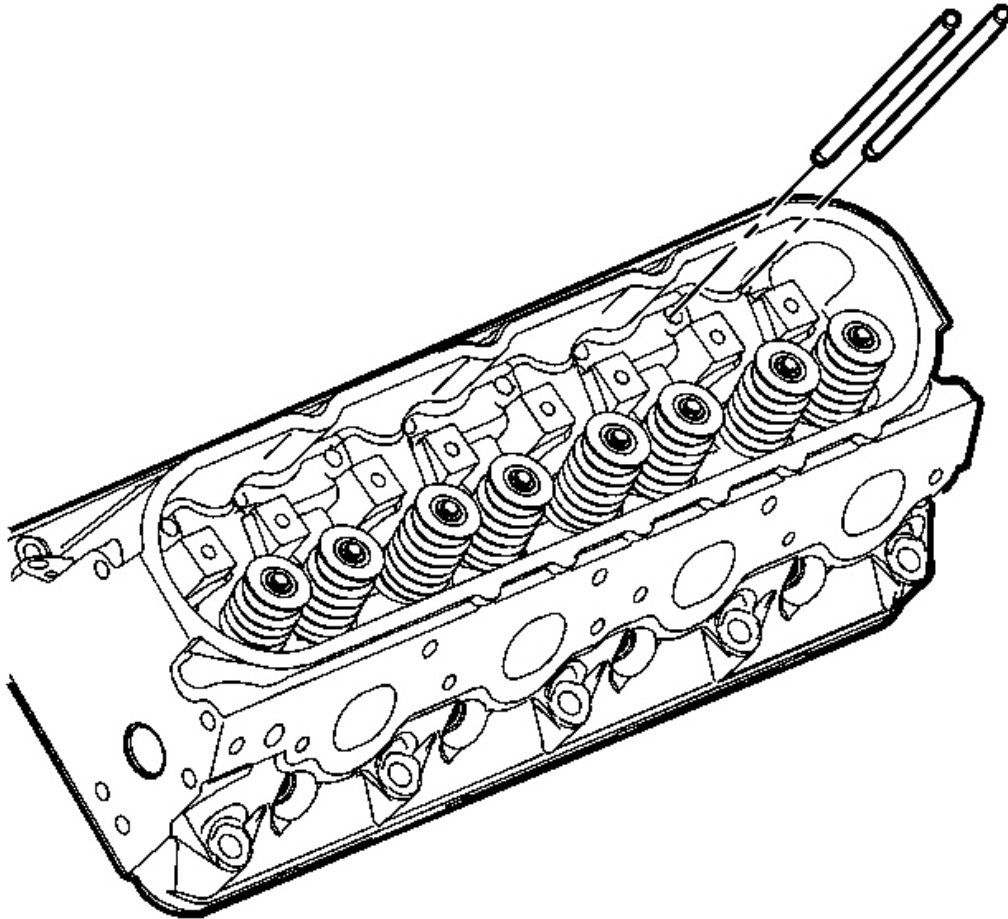
**IMPORTANT:** Place the valve rocker arms, pushrods, and pivot support, in a rack so that the can be installed in the same location from which they were removed.

1. Remove the valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Left or Valve Rocker Arm Cover Replacement - Right .
2. Remove the valve rocker arm bolts.
3. Remove the valve rocker arms.



**Fig. 95: Valve Rocker Arm Pivot Support**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm pivot support.



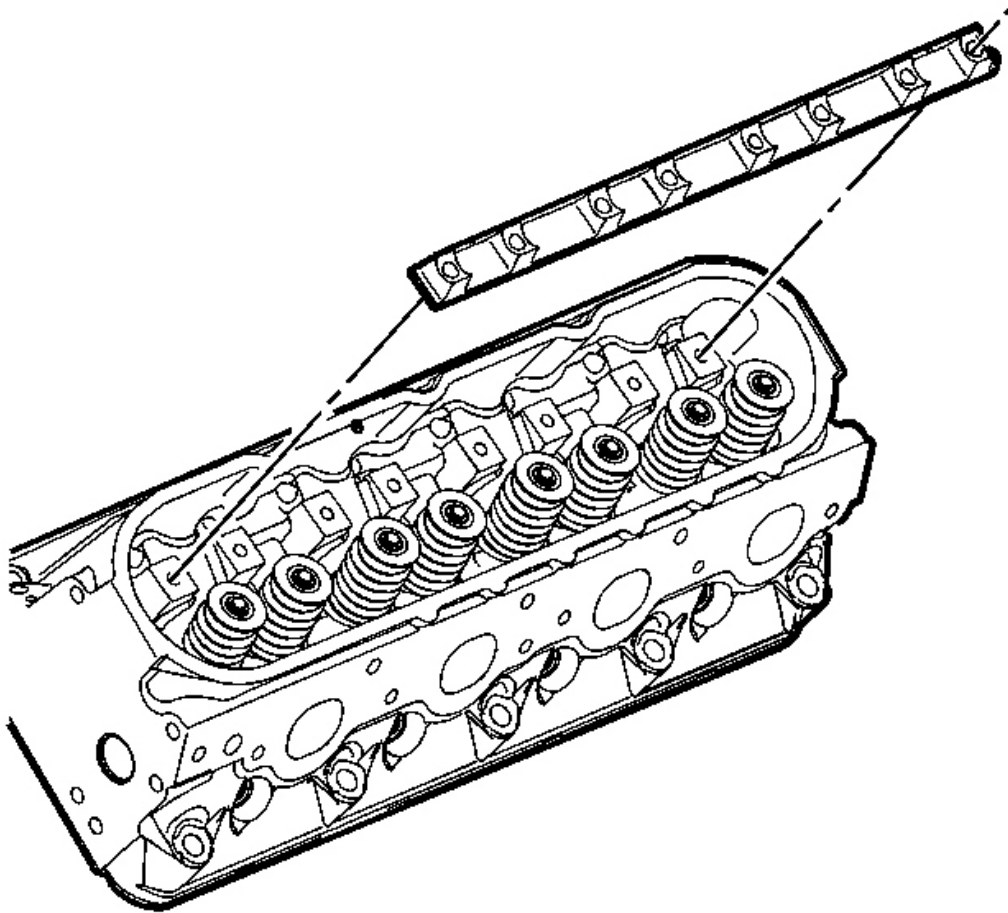
**Fig. 96: View Of Pushrods**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the pushrods.
6. Clean and inspect the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection** .

#### **Installation Procedure**

**IMPORTANT:** When reusing the valve train components, always install the components to the original location and position.

Valve lash is net build, no valve adjustment is required.

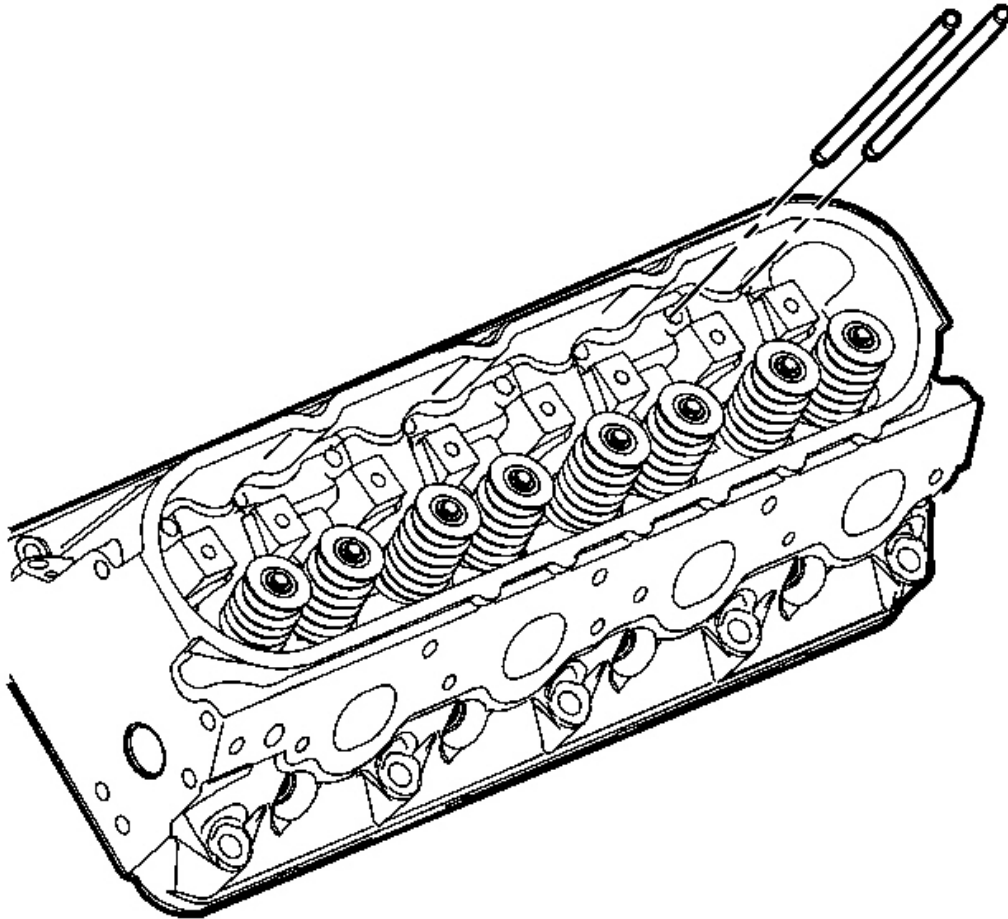


**Fig. 97: Valve Rocker Arm Pivot Support**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.

Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.

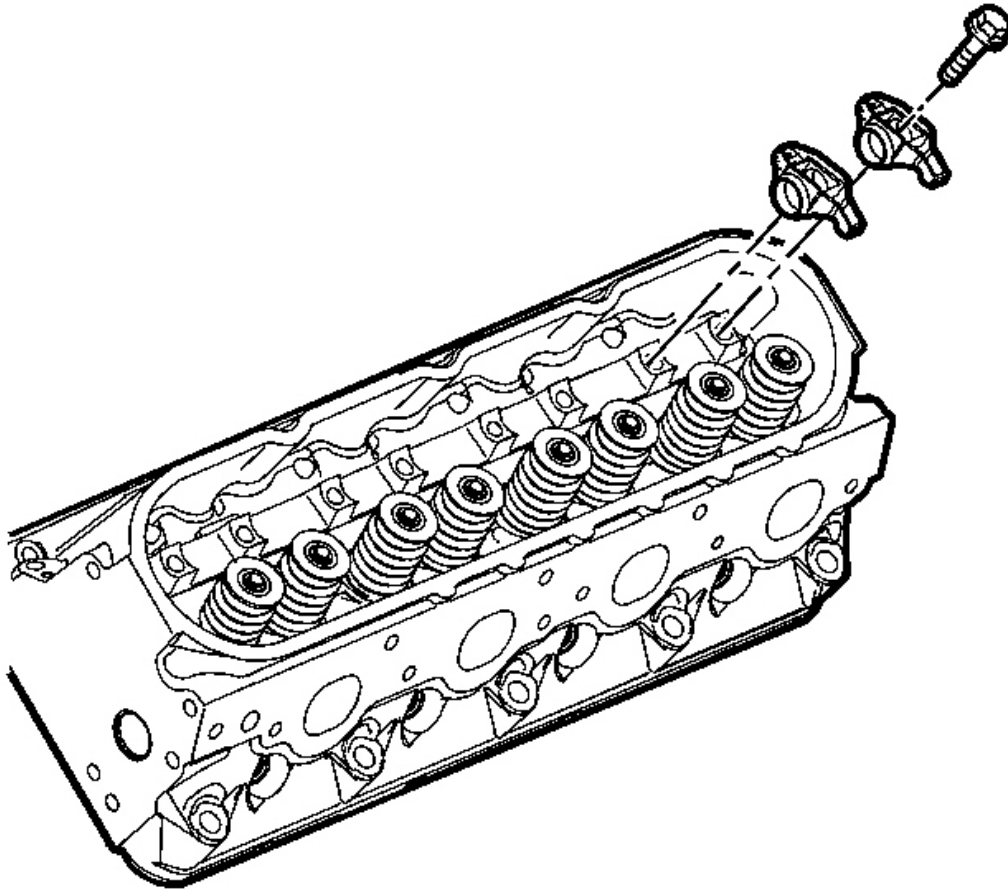
3. Install the valve rocker arm pivot support.



**Fig. 98: View Of Pushrods**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Make sure that the pushrods seat properly to the valve lifter sockets.**

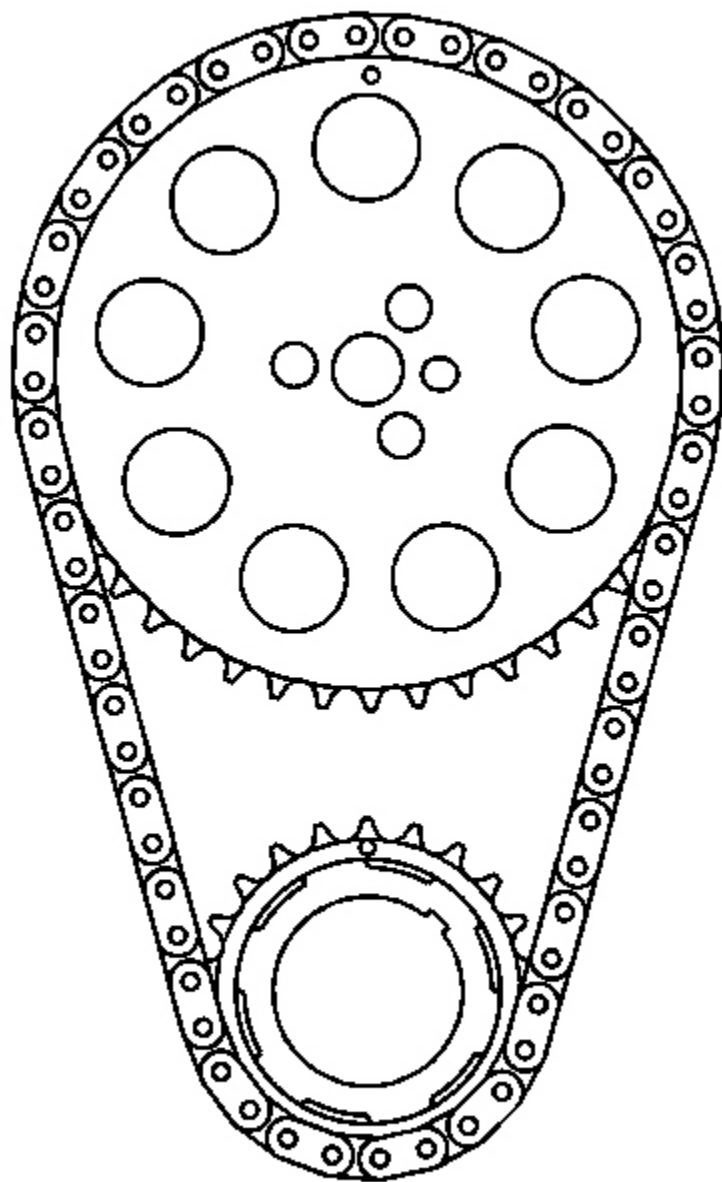
4. Install the pushrods.



**Fig. 99: Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Make sure that the pushrods seat properly to the ends of the rocker arms.  
**DO NOT** tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.



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

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



6. Rotate the crankshaft until the number one piston is at top dead center (TDC) of the compression stroke.

In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position.

The engine firing order is 1,8,7,2,6,5,4,3.

Cylinders 1,3,5 and 7 are the left bank.

Cylinder 2,4,6 and 8 are the right bank.

7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

**Tighten:**

- Tighten the cylinders 1,2,7 and 8 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
- Tighten the cylinders 1,3,4 and 5 intake valve rocker arm bolts to 30 N.m (22 lb ft).

8. Rotate the crankshaft 360 degrees.

9. Tighten the following valve rocker arm bolts:

**Tighten:**

- Tighten the cylinders 3, 4, 5 and 6 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
- Tighten the cylinders 2, 6, 7 and 8 intake valve rocker arm bolts to 30 N.m (22 lb ft).

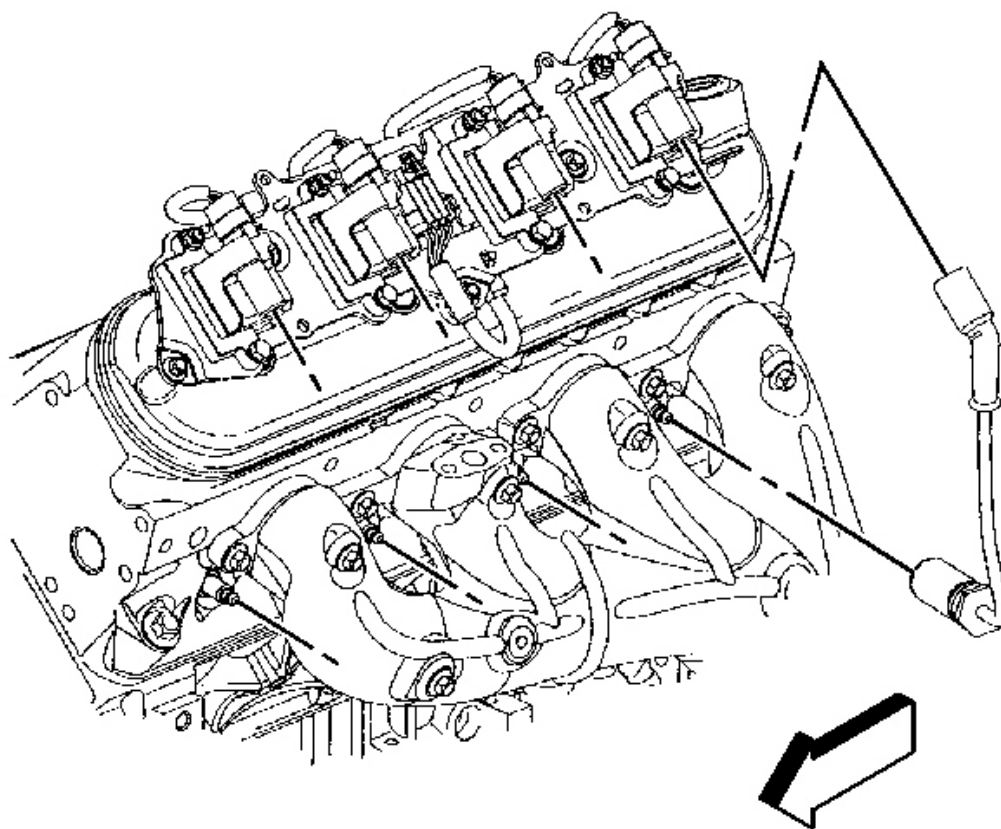
10. Install the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right** .

## **VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT**

### **Tools Required**

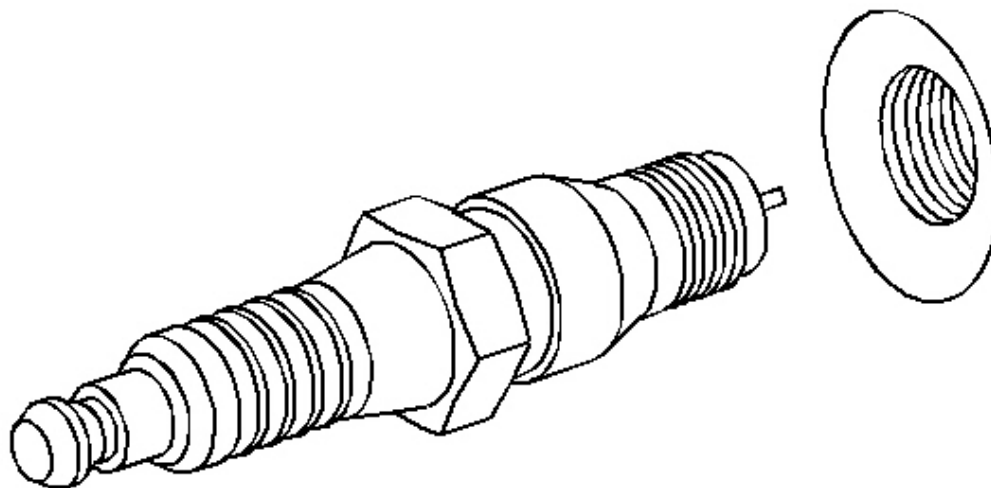
- **J 22794** Spark Plug Port Adapter. See **Special Tools and Equipment** .
- **J 38606** Valve Spring Compressor. See **Special Tools and Equipment** .

### **Removal Procedure**



**Fig. 101: Spark Plug Wire & Boot**  
Courtesy of GENERAL MOTORS CORP.

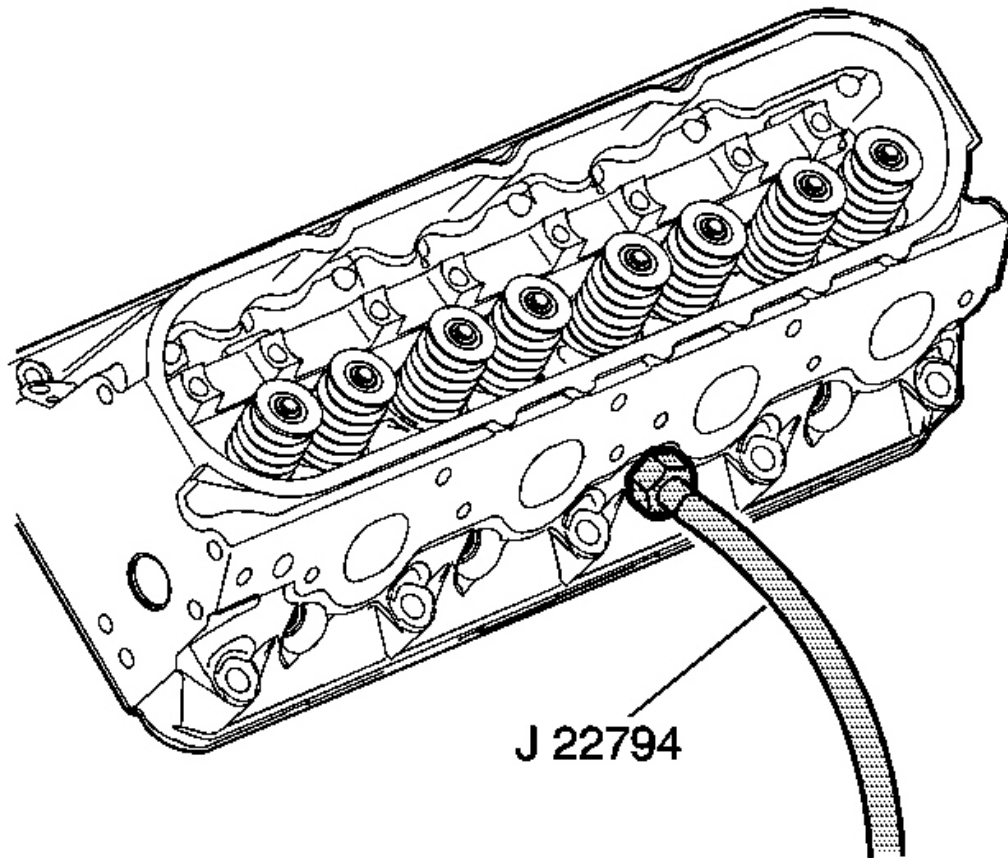
1. Remove the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement** .
2. Disconnect the spark plug wire at the spark plug.
  - Twist each plug wire boot 1/2 turn.
  - Pull only on the boot in order to remove the wire from the spark plug.



**Fig. 102: View Of Spark Plug**  
Courtesy of GENERAL MOTORS CORP.

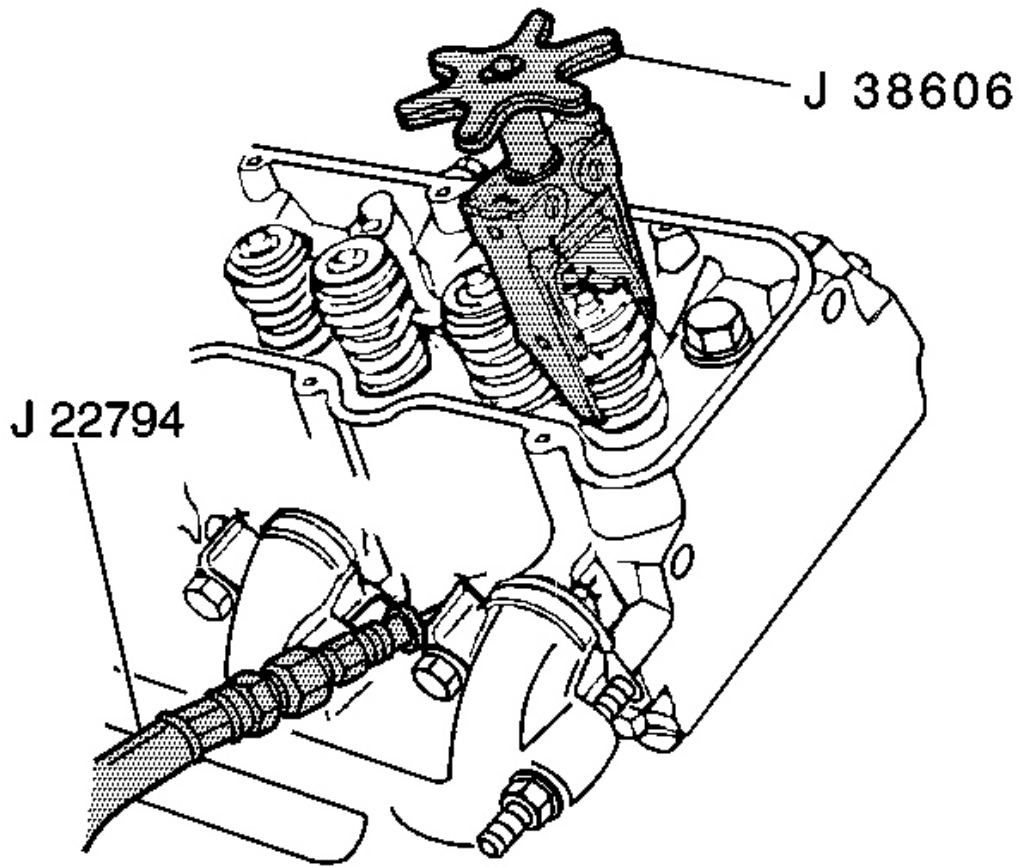
**IMPORTANT: Remove the spark plugs from the cylinder head with the engine at room temperature.**

3. Loosen the spark plug 1 or 2 turns.
4. Brush or air blast away any dirt or debris from around the spark plug.
5. Remove the spark plug.



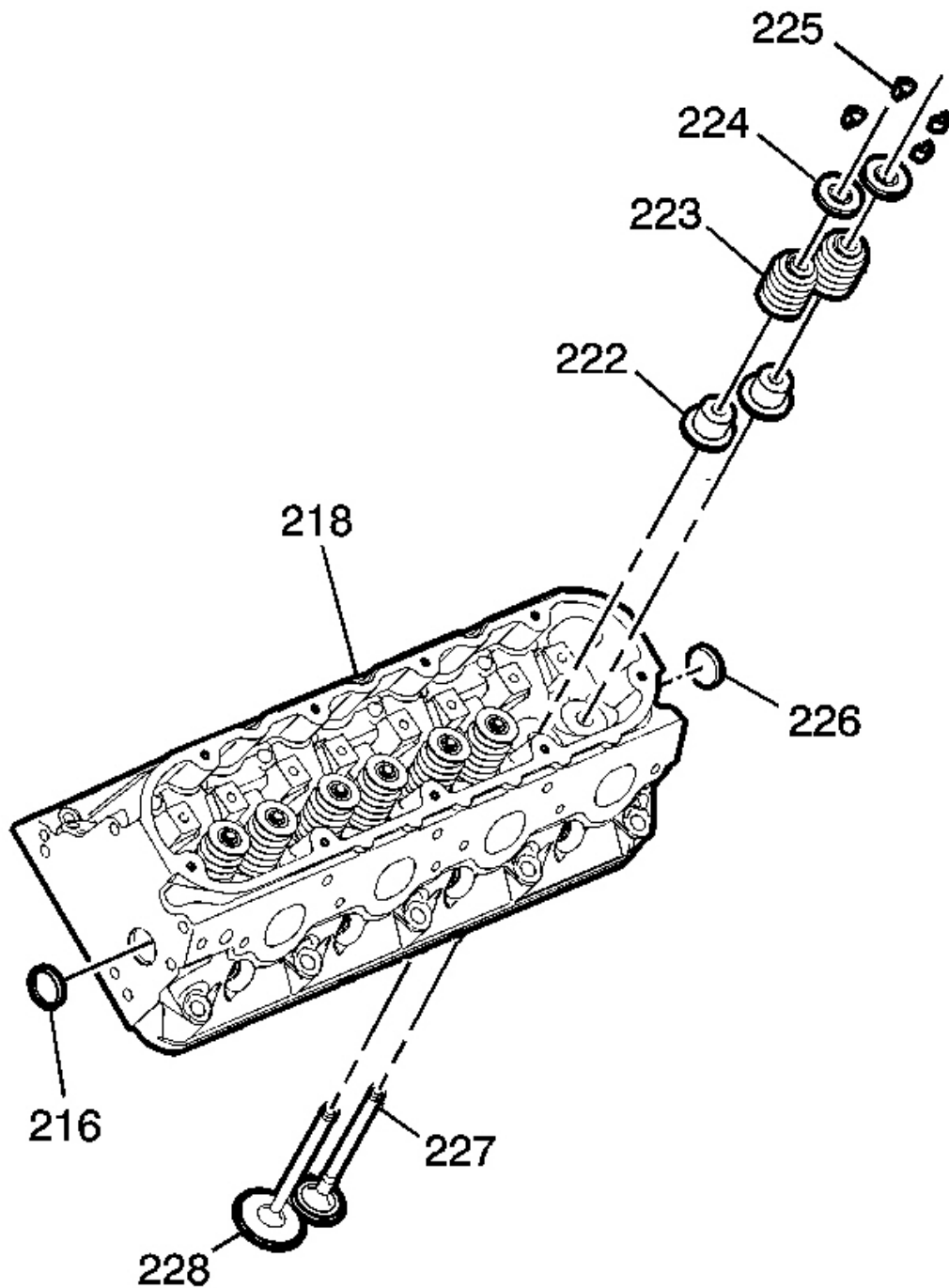
**Fig. 103: Installing J 22794 Into Spark Hole**  
Courtesy of GENERAL MOTORS CORP.

6. Install **J 22794** into the spark plug hole. See **Special Tools and Equipment** .
7. Attach an air hose to **J 22794** . See **Special Tools and Equipment** .
8. Apply compressed air to **J 22794** in order to hold the valves in place. See **Special Tools and Equipment** .



**Fig. 104: Using J 38606 & J 5892-D To Remove Valve Spring**  
Courtesy of GENERAL MOTORS CORP.

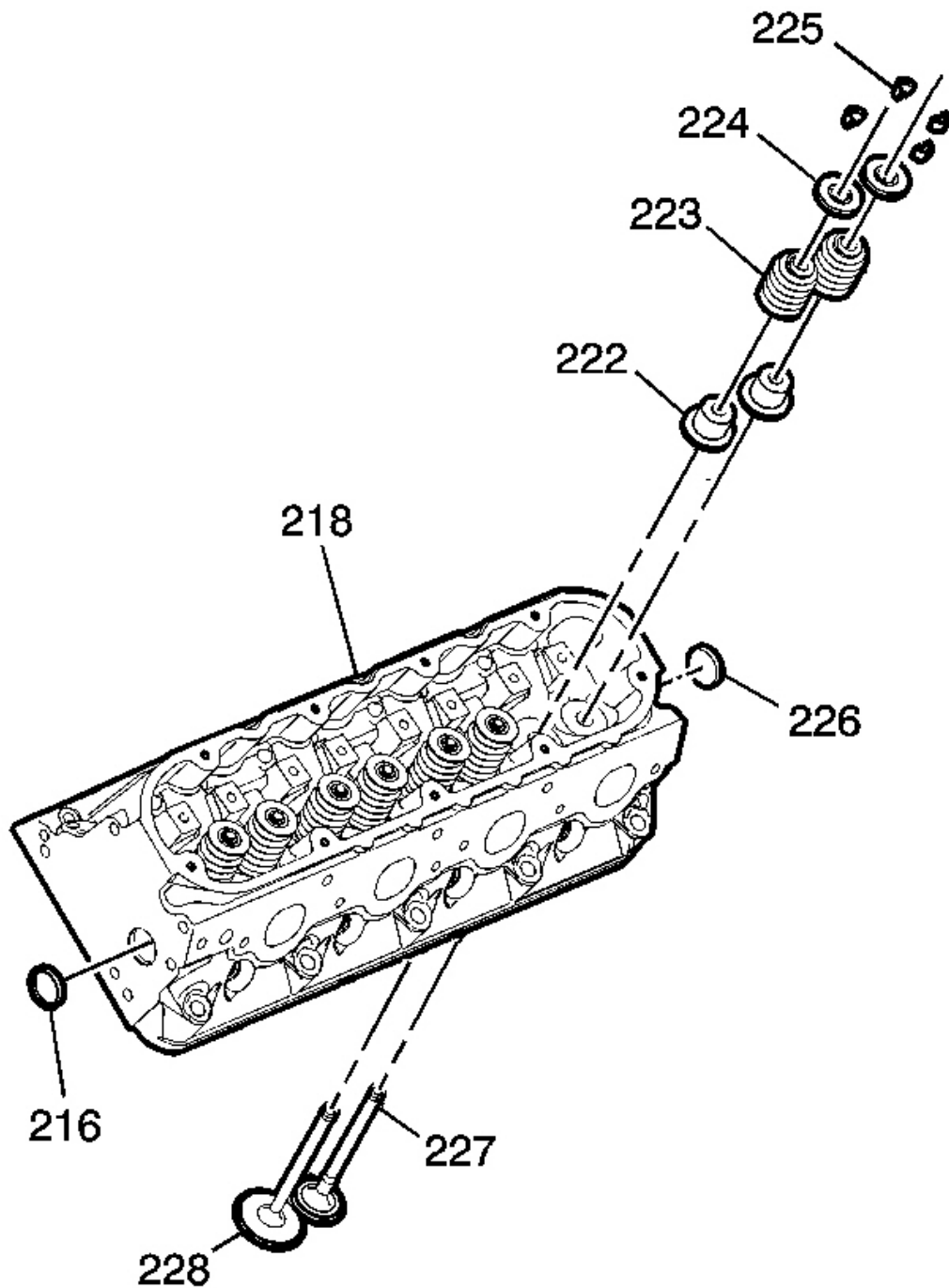
9. Use **J 38606** in order to compress the valve spring. See **Special Tools and Equipment** .



**Fig. 105: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve stem keys (225).
11. Carefully release the valve spring tension.
12. Remove the **J 38606** . See **Special Tools and Equipment** .
13. Remove the valve spring cap (224).
14. Remove the valve spring (223).
15. Remove the valve stem oil seal and shim (222) assembly.

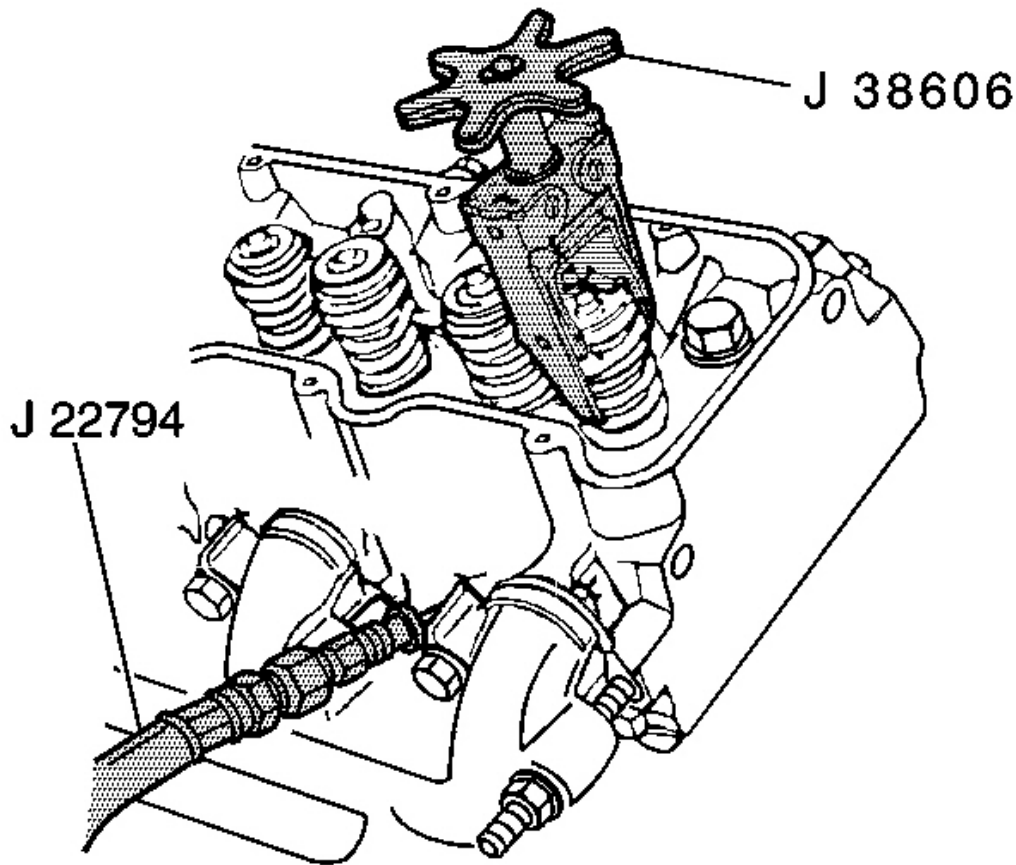
#### **Installation Procedure**



**Fig. 106: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.



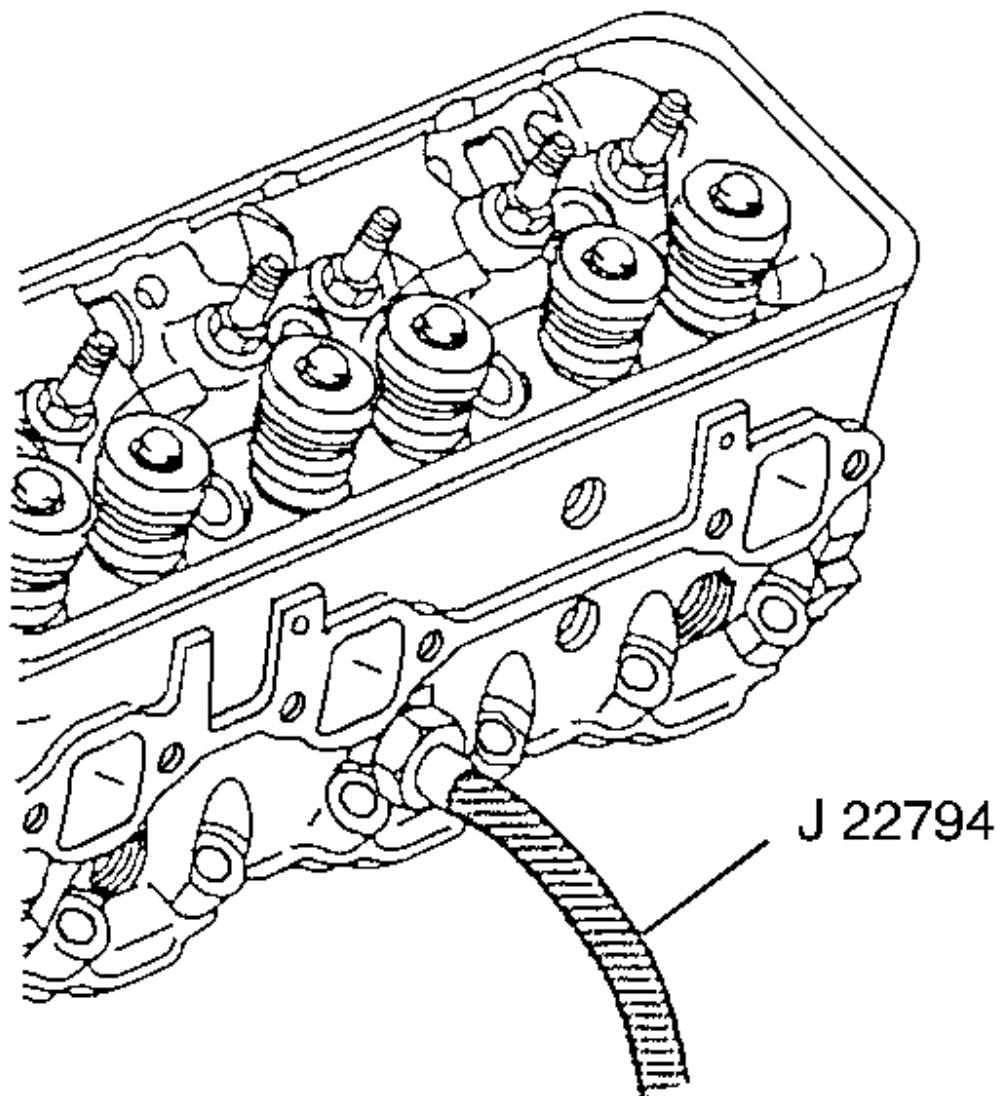
1. Clean the cylinder head valve spring seat and/or shim area.
2. Lubricate the valve guide and valve stem oil seal with clean engine oil.
3. Install the valve stem oil seal and shim (222) assembly.
4. Install the valve spring (223).
5. Install the valve spring cap (224).



**Fig. 107: Using J 38606 & J 5892-D To Remove Valve Spring**  
Courtesy of GENERAL MOTORS CORP.

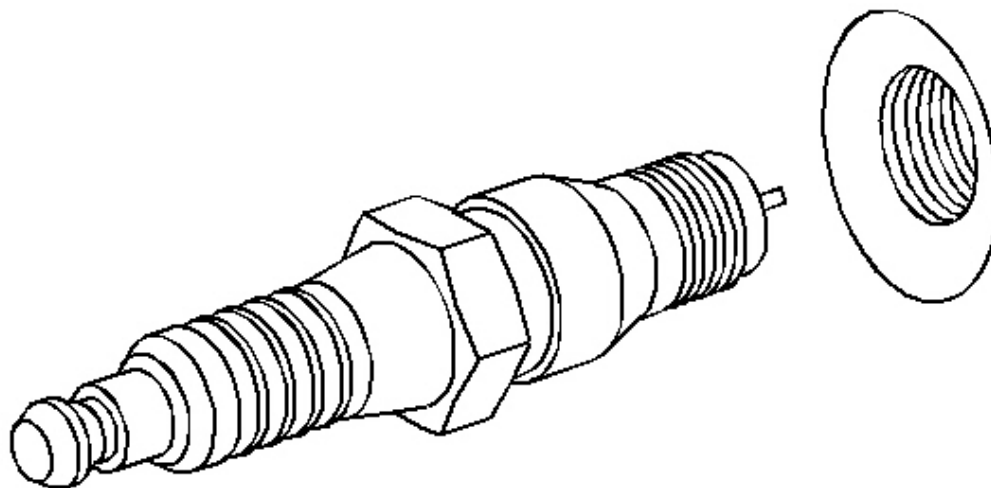
6. Compress the valve spring using the **J 38606** . See **Special Tools and Equipment** .
7. Install the valve stem keys (225).
  - Use grease in order to hold the valve keys in place.
  - Make sure the keys seat properly in the groove of the valve stem.

- Carefully release the valve spring pressure, making sure the valve keys stay in place.
- Remove the **J 38606** . See **Special Tools and Equipment** .
- Tap the end of the valve stem with a plastic faced hammer to seat the keys (if necessary).



**Fig. 108: Removing J 22794 From Spark Plug Port**  
Courtesy of GENERAL MOTORS CORP.

8. Remove **J 22794** from the spark plug port. See **Special Tools and Equipment** .



**Fig. 109: View Of Spark Plug**  
Courtesy of GENERAL MOTORS CORP.

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

9. Hand start the spark plug.

**Tighten:** Tighten the spark plug to 15 N.m (11 lb ft).

10. Install the spark plug wires at the ignition coil.

11. Install the spark plug wire to the spark plug.

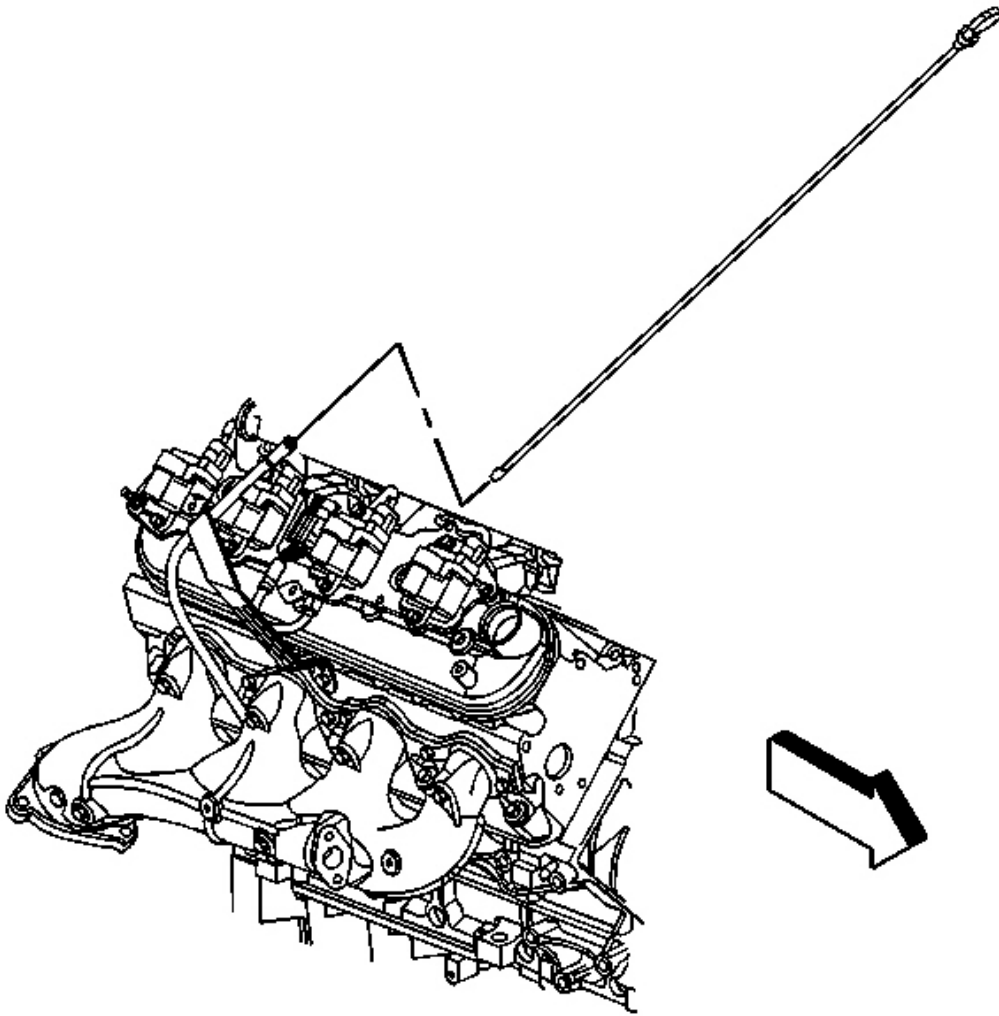
12. Inspect the wires for proper installation:

- Push sideways on each boot in order to check for proper installation.
- Reinstall any loose boot.

13. Install the valve rocker arm. Refer to Valve Rocker Arm and Push Rod Replacement .

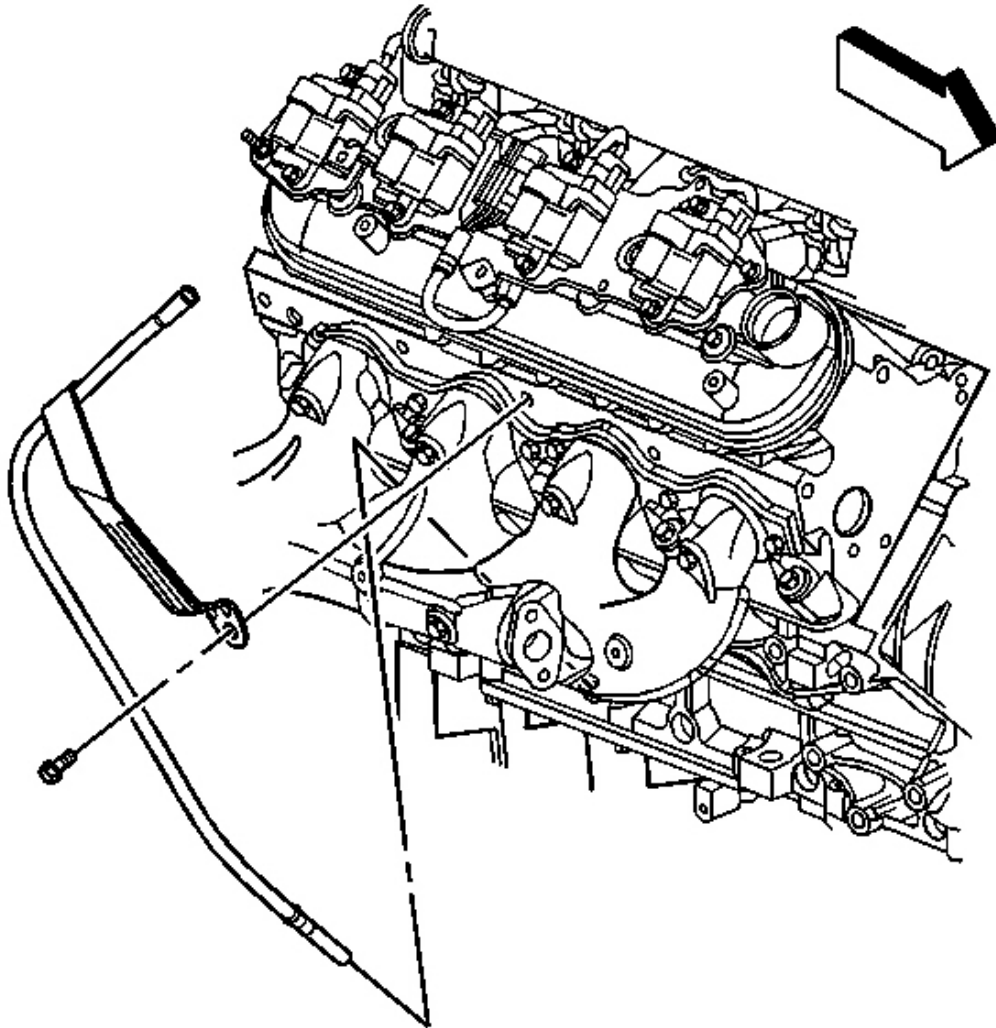
## OIL LEVEL INDICATOR AND TUBE REPLACEMENT

### Removal Procedure



**Fig. 110: Oil Level Indicator**  
**Courtesy of GENERAL MOTORS CORP.**

1. Remove the oil level indicator from the tube.

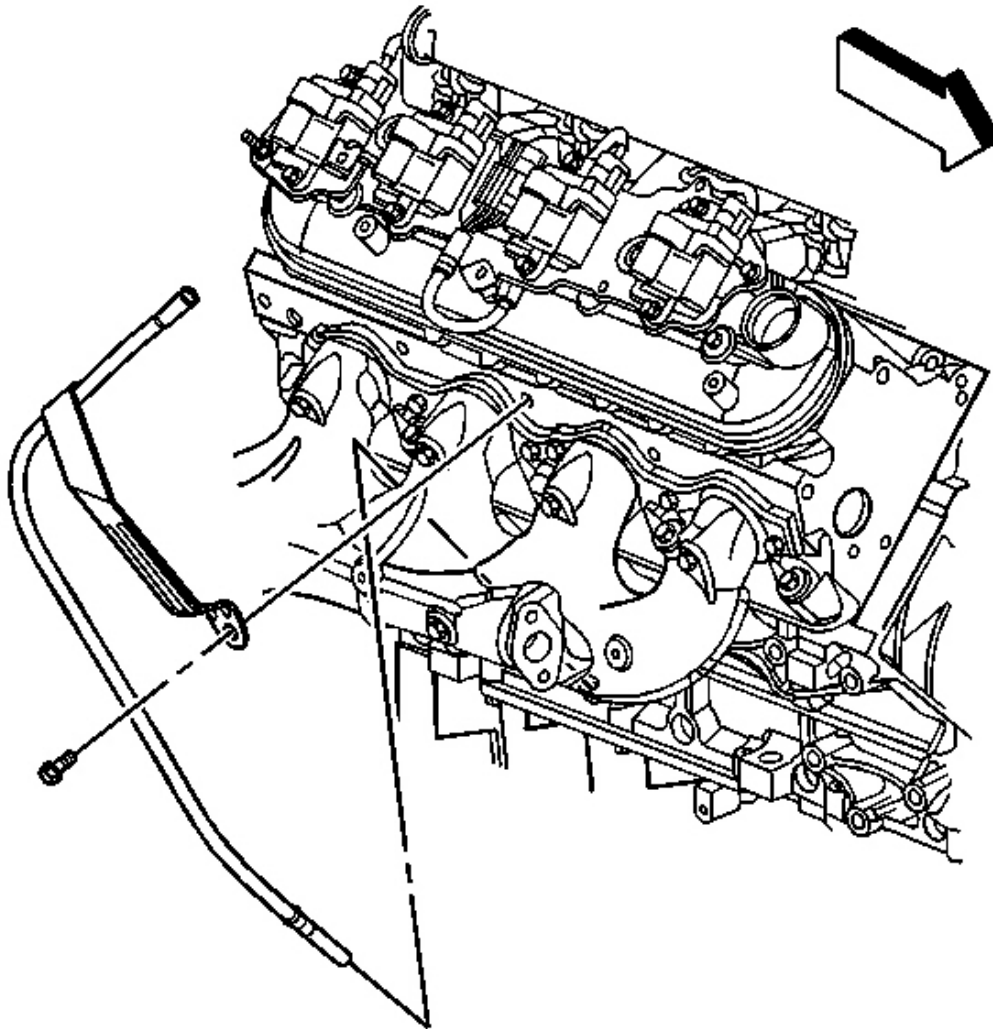


**Fig. 111: Oil Level Indicator Tube**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

**IMPORTANT: The O-ring seal may be reused if not cut or damaged.**

4. Inspect the O-ring seal for cuts or damage.
5. Remove the O-ring seal from the tube (if required).



**Fig. 112: Oil Level Indicator Tube**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the O-ring seal with clean engine oil.
2. Install the O-ring seal onto the oil level indicator tube.
3. Install the oil level indicator tube behind the exhaust manifold.
4. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
5. Install the oil level indicator tube into the block. The tube must be installed with the collar flush to the

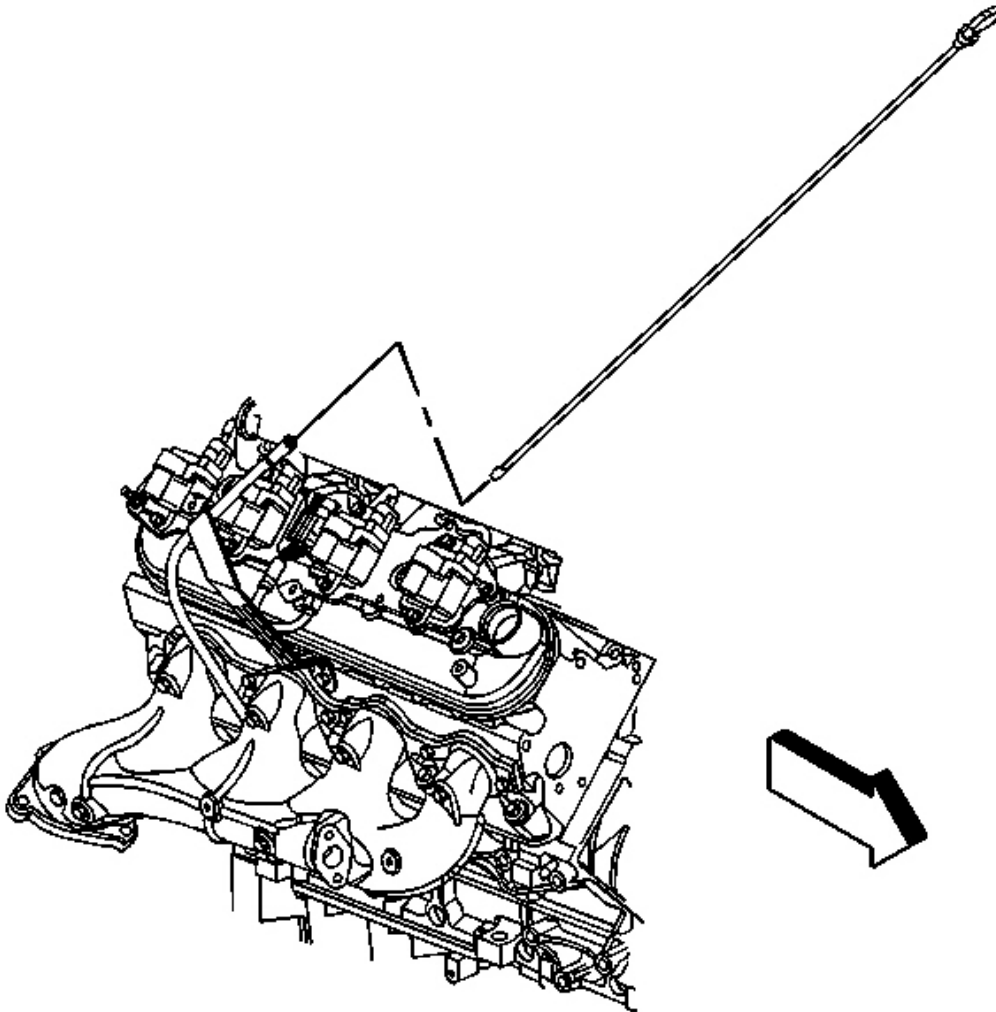
block.

6. Lower the vehicle.

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

7. Install the oil level indicator tube bolt

**Tighten:** Tighten the oil level indicator tube bolt to 25 N.m (18 lb ft).



**Fig. 113: Oil Level Indicator**  
Courtesy of GENERAL MOTORS CORP.

8. Install the oil level indicator to the tube.

## **CYLINDER HEAD REPLACEMENT - LEFT**

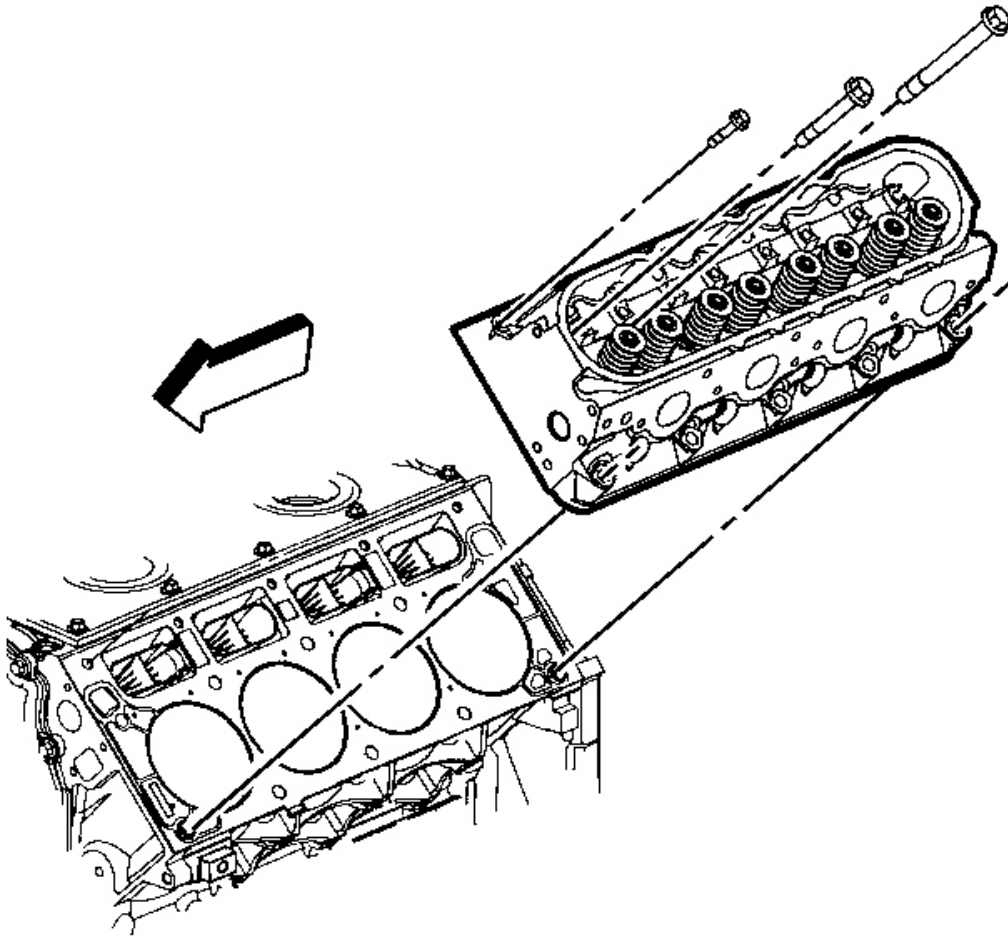
### **Tools Required**

- **J 42385-200** Thread Repair Kit. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

### **Removal Procedure**

1. Remove the generator bracket. Refer to **Generator Replacement** .
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
3. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** .
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement** .





**Fig. 114: Cylinder Head & Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

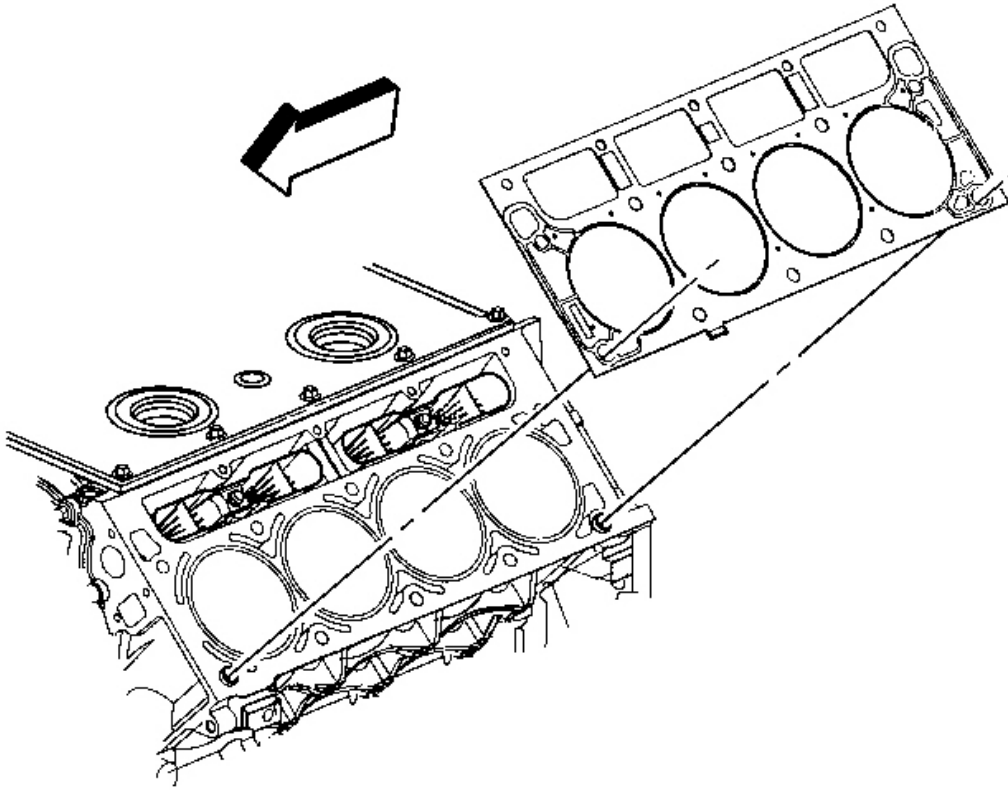
**IMPORTANT:** The cylinder head bolts are NOT reusable.

**NOTE:** After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

5. Remove the cylinder head bolts.

or

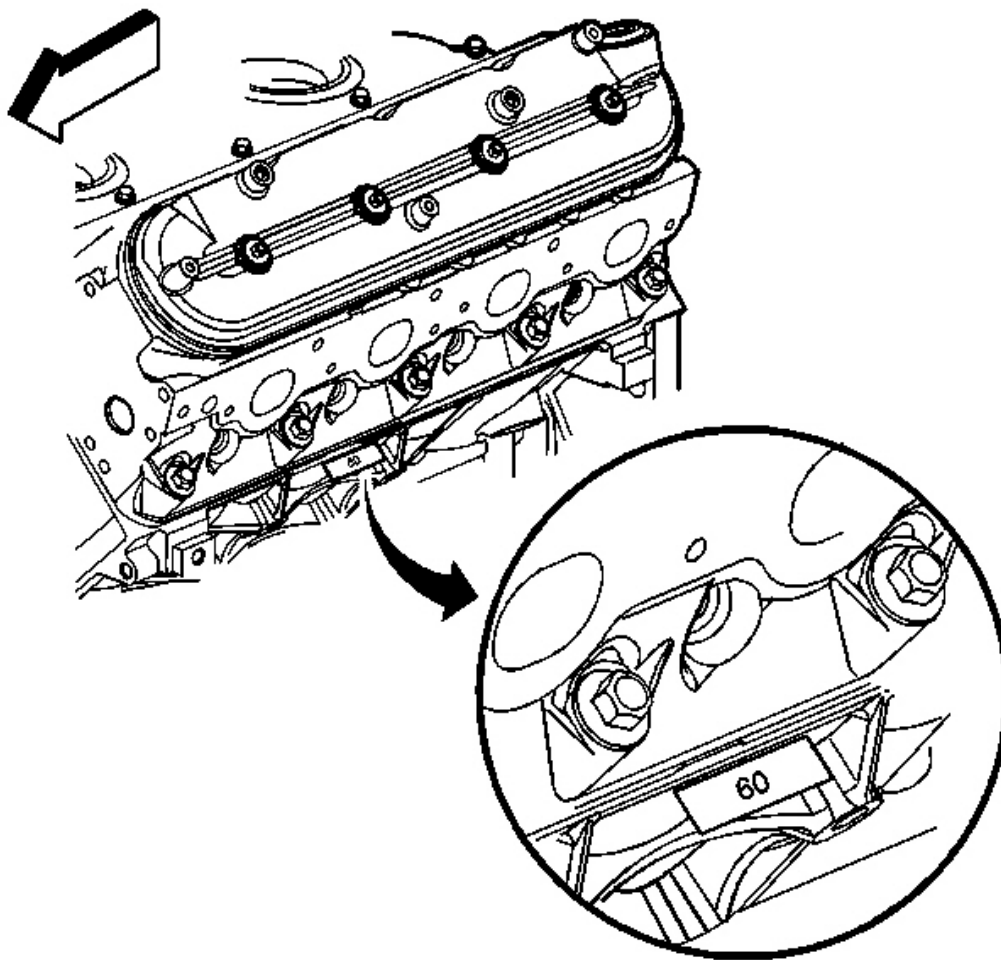
6. Remove the cylinder head.



**Fig. 115: Cylinder Head Gasket (Left)**  
**Courtesy of GENERAL MOTORS CORP.**

7. Remove the cylinder head gasket.
8. Discard the gasket.
9. Discard the cylinder head bolts.
10. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .

#### **Installation Procedure**



**Fig. 116: Cylinder Head Gaskets (6.0 L)**  
Courtesy of GENERAL MOTORS CORP.

1. The cylinder head gasket displacement can be verified by markings visible on the top side of the left gasket locating tab.
  - Some 4.8/5.3 L head gaskets may have 53 stamped onto the locating tab.
  - Some 6.0 L head gaskets may have 60 stamped onto the locating tab.
2. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement** .
3. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** .
4. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
5. Install the generator bracket. Refer to **Generator Replacement** .

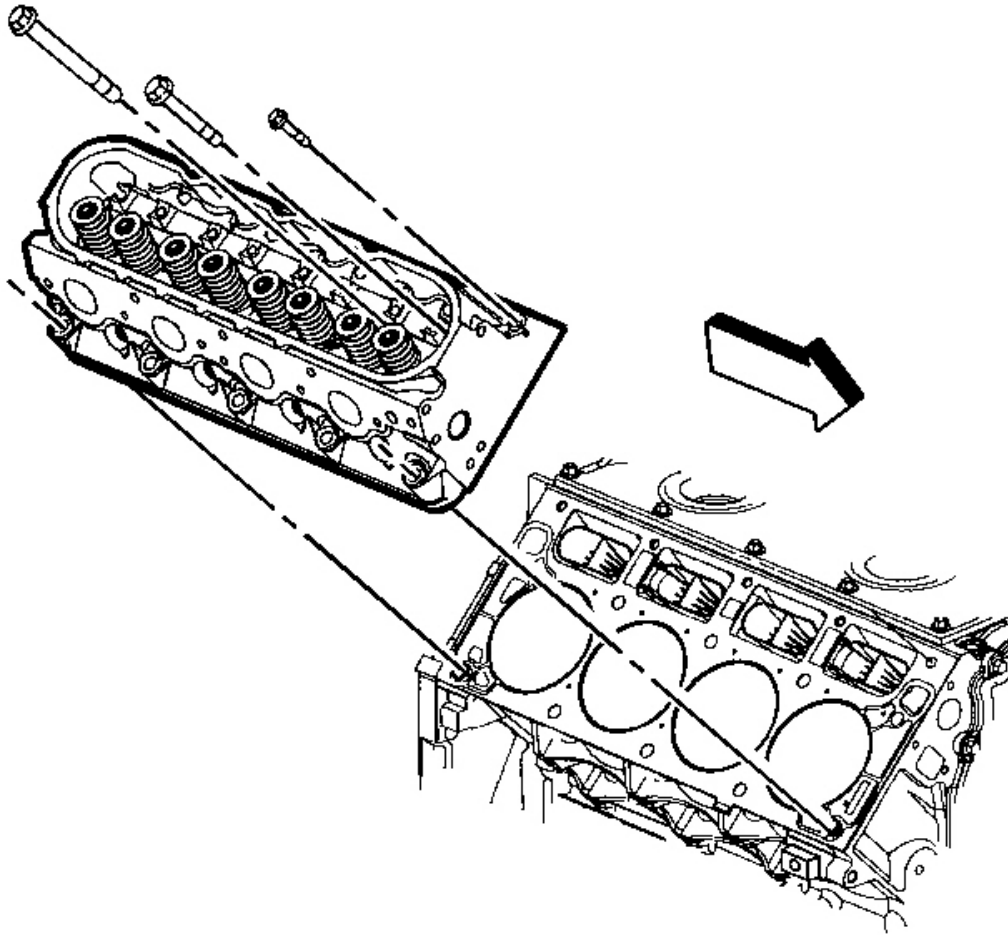
## CYLINDER HEAD REPLACEMENT - RIGHT

### Tools Required

- **J 45059** Angle Meter. See **Special Tools and Equipment** .
- **J 42385-200** Thread Repair Kit. See **Special Tools and Equipment** .

### Removal Procedure

1. Remove the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement** .
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
3. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** .
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement** .

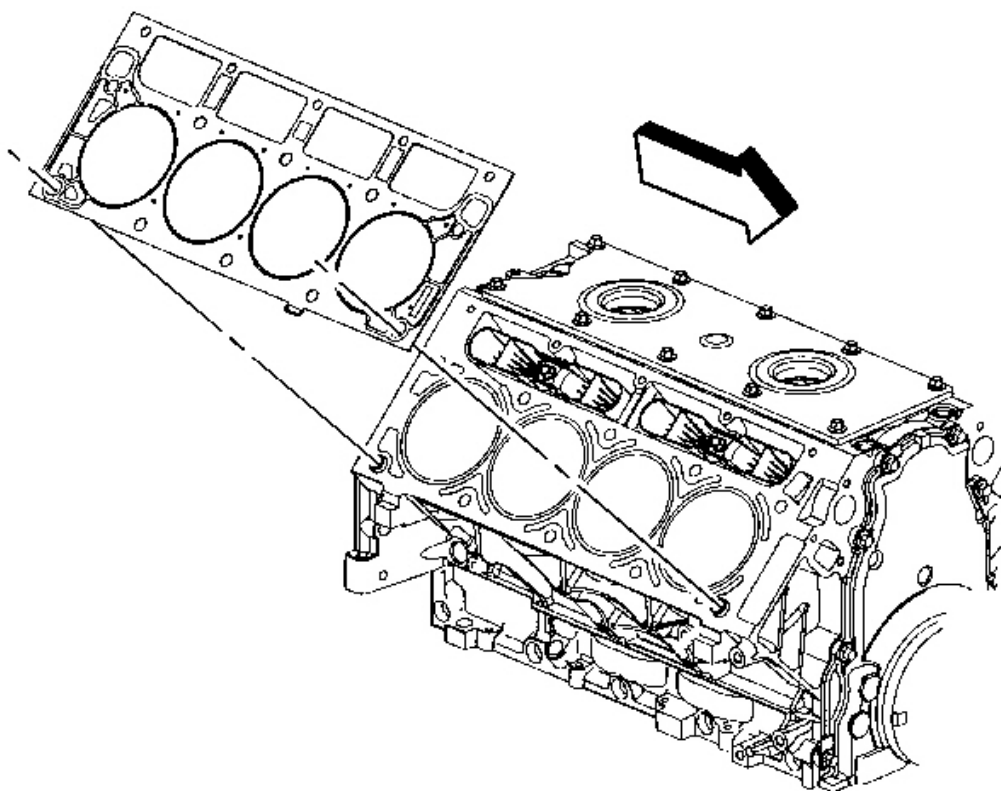


**Fig. 117: Cylinder Head & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The cylinder head bolts are NOT reusable.

**NOTE:** After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

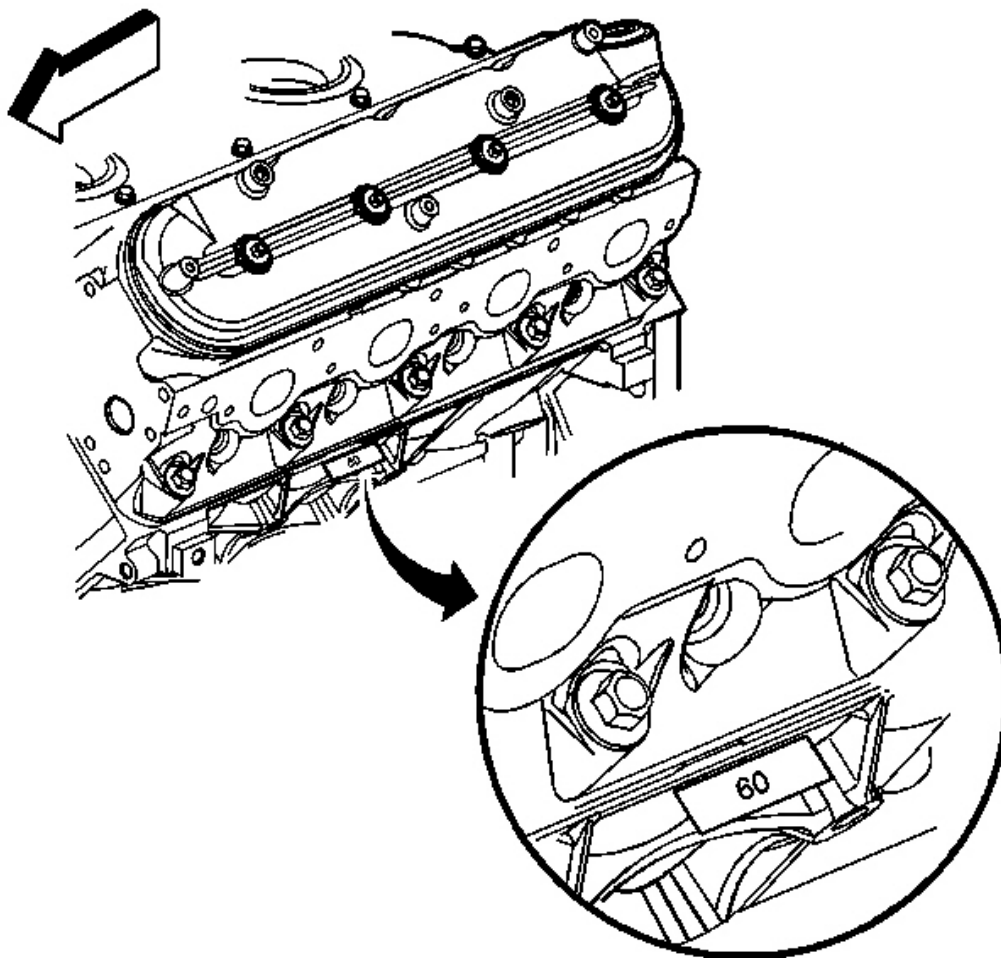
5. Remove the cylinder head bolts.
6. Remove the cylinder head.



**Fig. 118: Cylinder Head Gasket (Right)**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head gasket.
8. Discard the gasket.
9. Discard the cylinder head bolts.
10. Clean and inspect the cylinder head. Refer to Cylinder Head Cleaning and Inspection .

#### **Installation Procedure**



**Fig. 119: Cylinder Head Gaskets (6.0 L)**  
Courtesy of GENERAL MOTORS CORP.

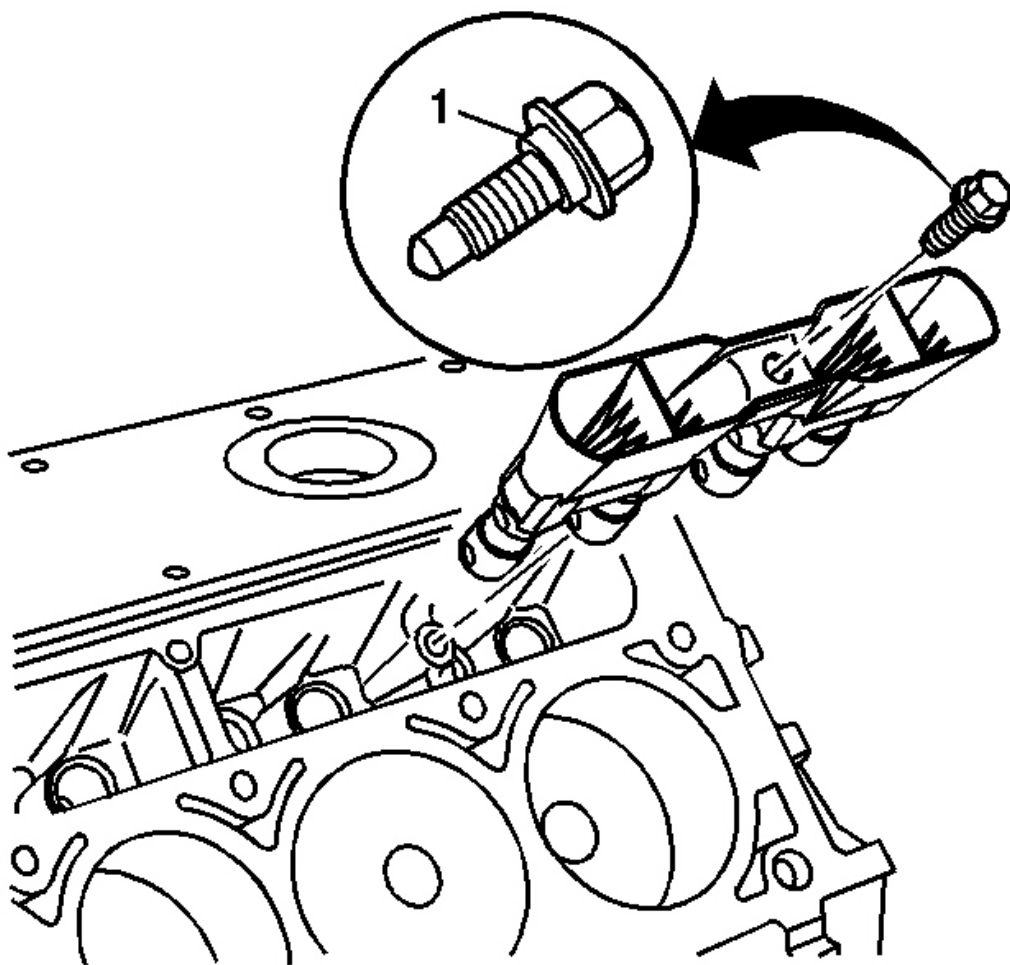
1. The cylinder head gasket displacement can be verified by markings visible on the top side of the left gasket locating tab.
  - Some 4.8/5.3 L head gaskets may have 53 stamped onto the locating tab.
  - Some 6.0 L head gaskets may have 60 stamped onto the locating tab.
2. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement** .
3. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** .
4. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
5. Install the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement** .

## VALVE LIFTER REPLACEMENT

### Tools Required

**J 3049-A** Valve Lifter Remover. See Special Tools and Equipment .

### Removal Procedure

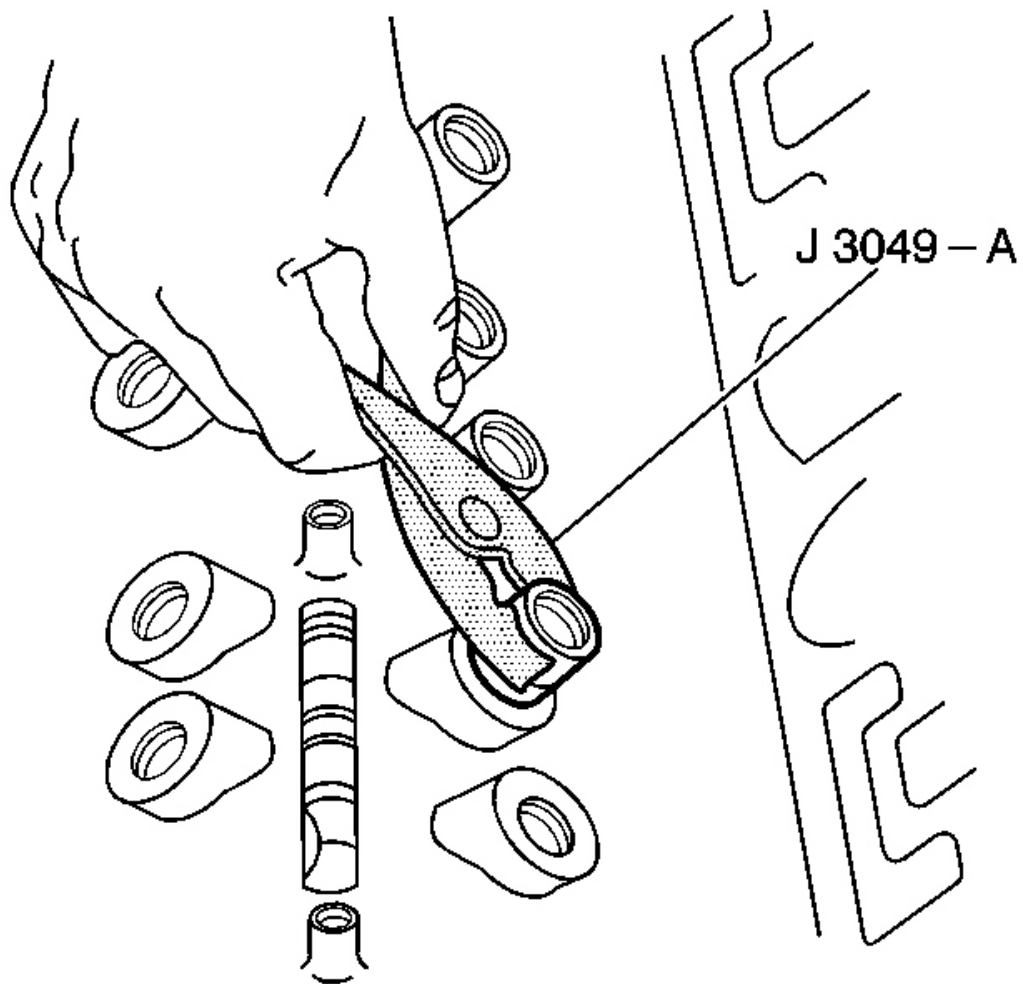


**Fig. 120: Valve Lifters & Guide**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head and gasket. Refer to Cylinder Head Replacement - Left or Cylinder Head Replacement - Right .



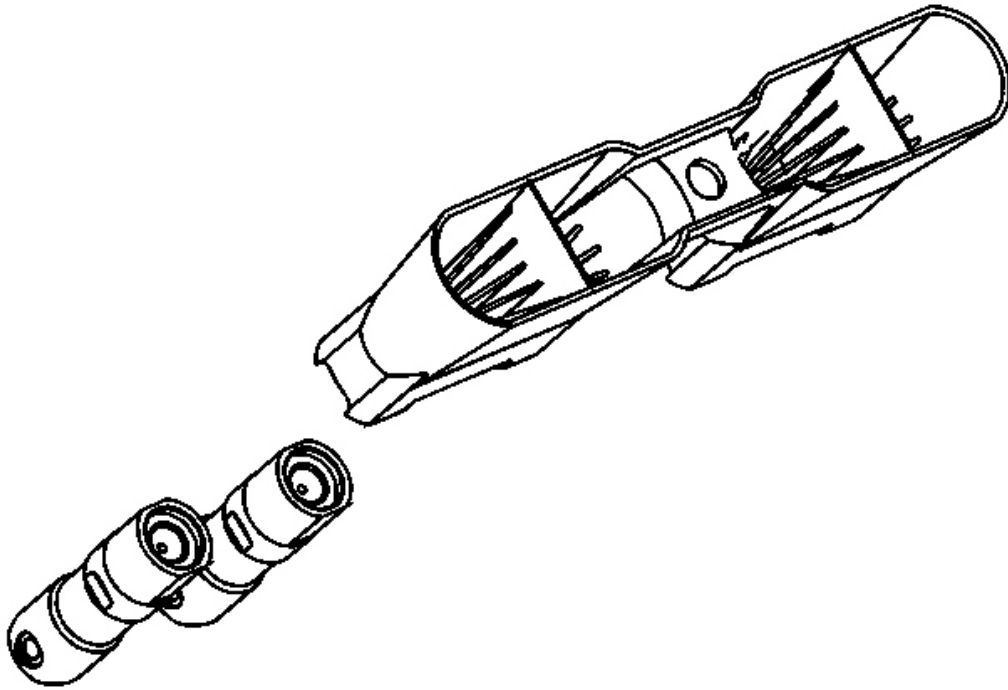
2. Remove the valve lifter guide bolts (1).
3. Remove the valve lifters and guide.



**Fig. 121: Using J 3049-A To Remove The Stuck Valve Lifters**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Some valve lifters may be stuck in their bores because of gum or varnish deposits.

4. Use **J 3049-A** or equivalent in order to remove the valve lifters (if required). See **Special Tools and Equipment** .

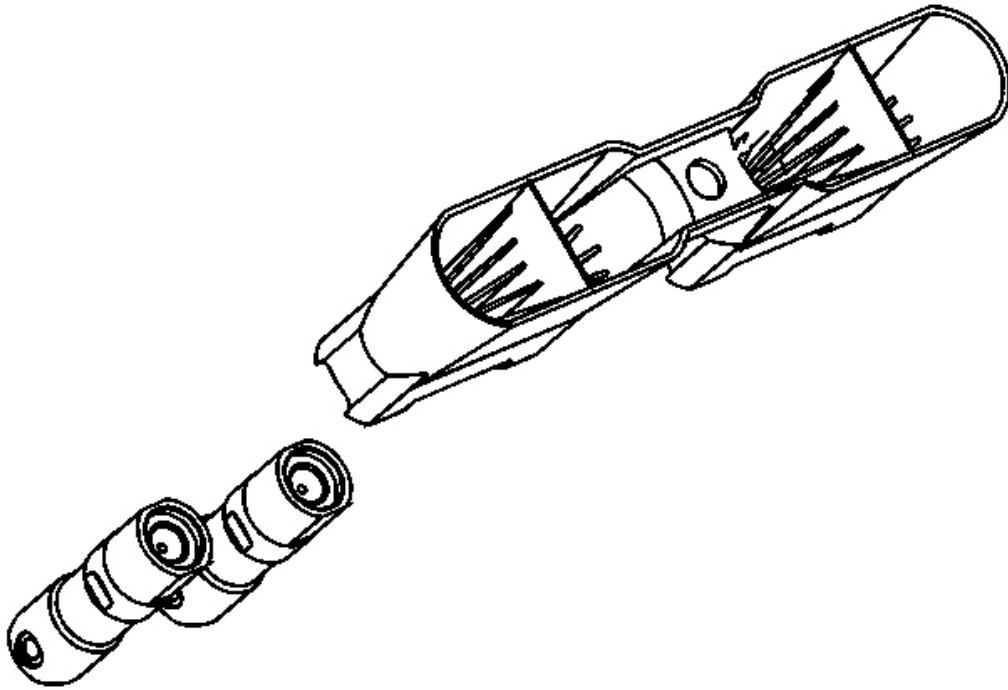


**Fig. 122: Valve Lifters & Lifter Guides**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve lifters from the guide.
6. Organize or mark the components so that they can be installed in the same location from which they were removed.
7. Clean and inspect the valve lifters. Refer to Valve Lifters and Guides Cleaning and Inspection in Engine Mechanical - 6.0L Unit Repair.

#### **Installation Procedure**

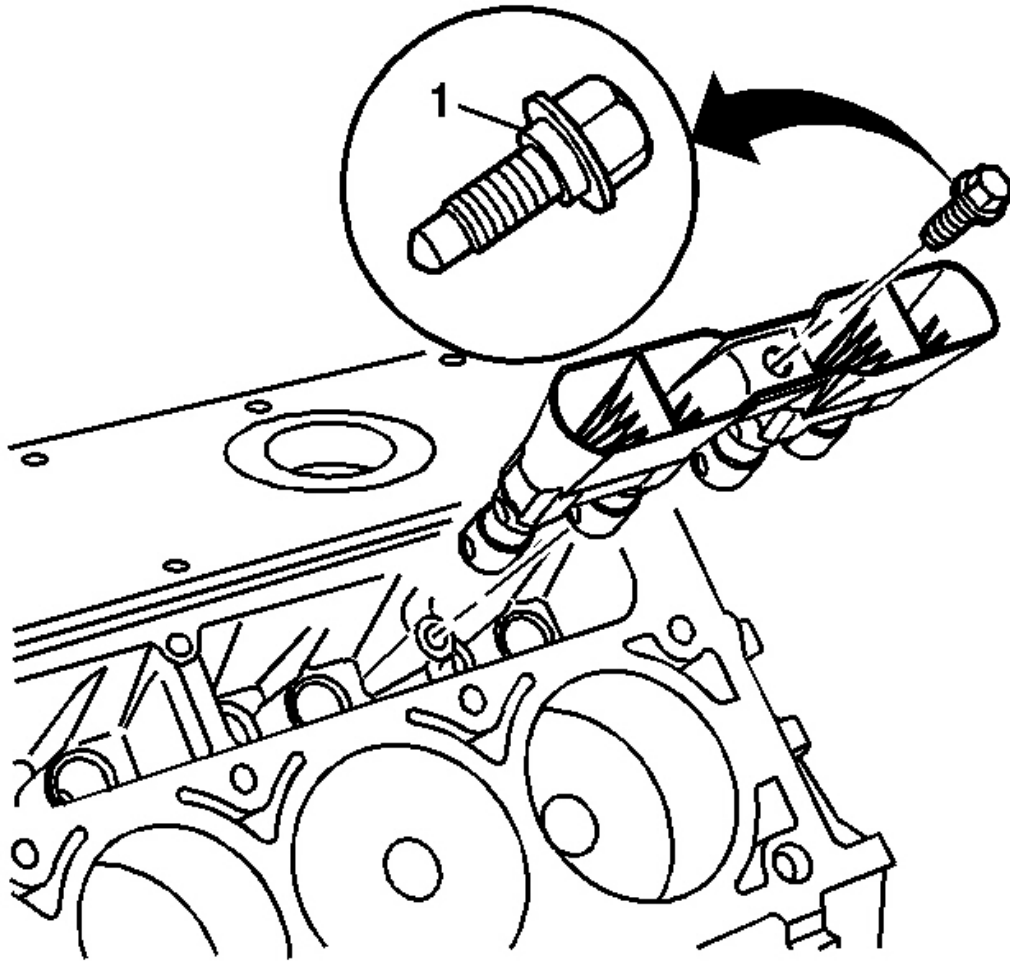
**IMPORTANT: When reusing valve lifters, install the lifters to their original locations.**



**Fig. 123: Valve Lifters & Lifter Guides**  
**Courtesy of GENERAL MOTORS CORP.**

1. Lubricate the valve lifters and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides.

Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.



**Fig. 124: Valve Lifters & Guide**  
Courtesy of GENERAL MOTORS CORP.

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

3. Install the valve lifters and guide to the engine block.
4. Install the valve lifter guide bolt (1).

**Tighten:** Tighten the valve lifter guide bolt (1) to 12 N.m (106 lb in).

5. Install the cylinder head and gasket. Refer to Cylinder Head Replacement - Left or Cylinder Head Replacement - Right.

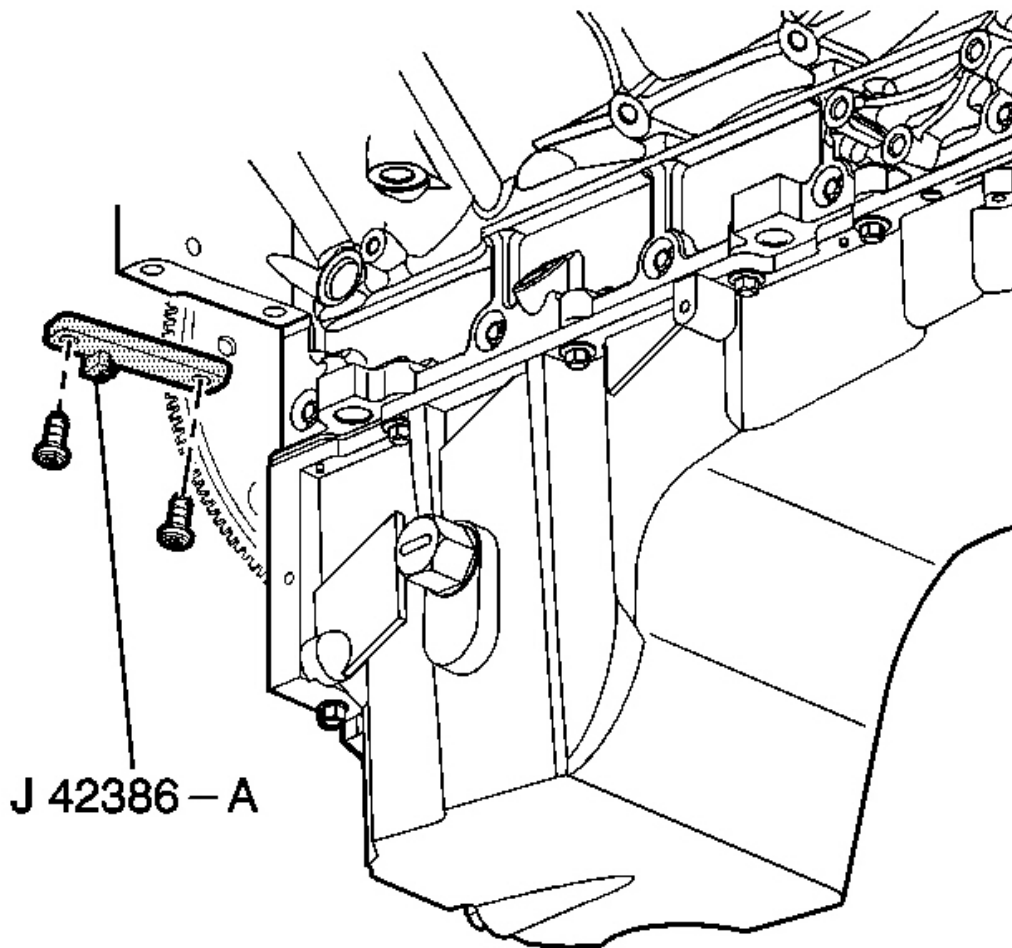
# CRANKSHAFT BALANCER REPLACEMENT

## Tools Required

- J 41816 Crankshaft Balancer Remover
- J 41816-2 Crankshaft End Protector
- J 42386-A Flywheel Holding Tool
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

## Removal Procedure

1. Remove the fan shroud. Refer to **Fan Shroud Replacement** .
2. Remove the starter motor. Refer to **Starter Motor Replacement** .



**Fig. 125: View Of J 42386-A & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Make sure that the teeth of the J 42386-A are fully engaged into the flywheel ring gear teeth.
- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.

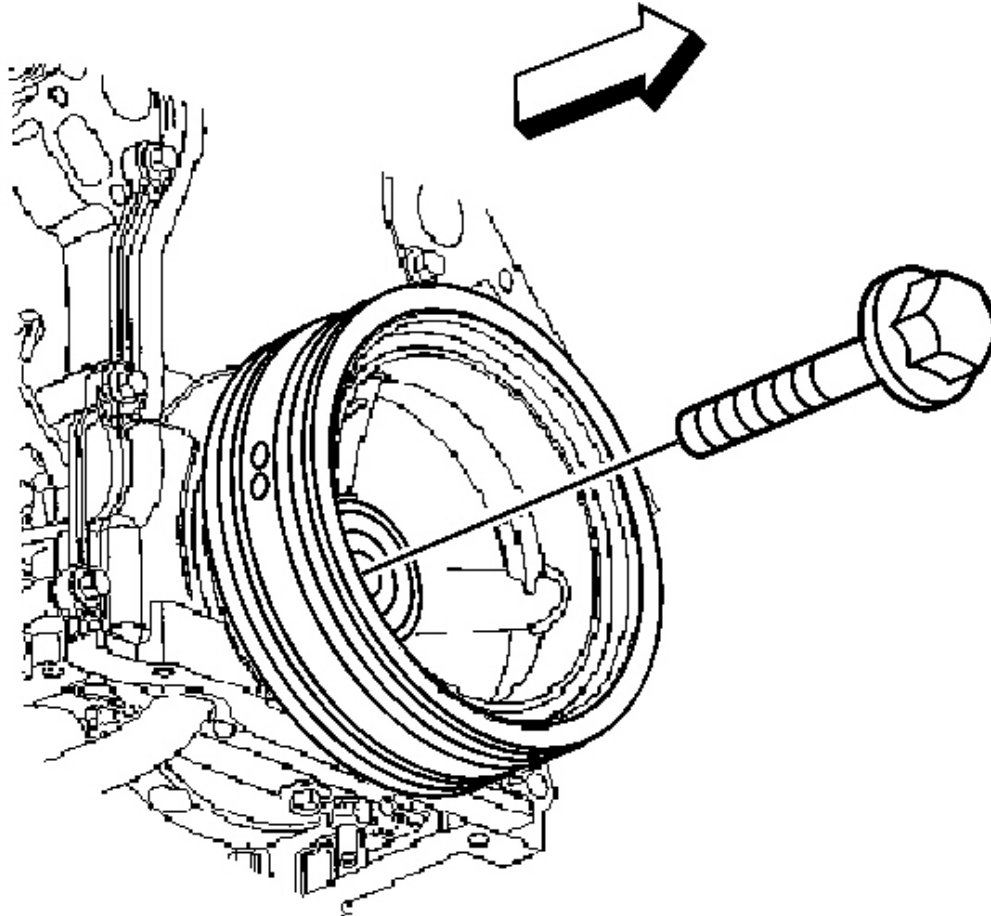
**NOTE:**

Refer to Fastener Notice in Cautions and Notices.

3. Install the J 42386-A .

Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool operation.

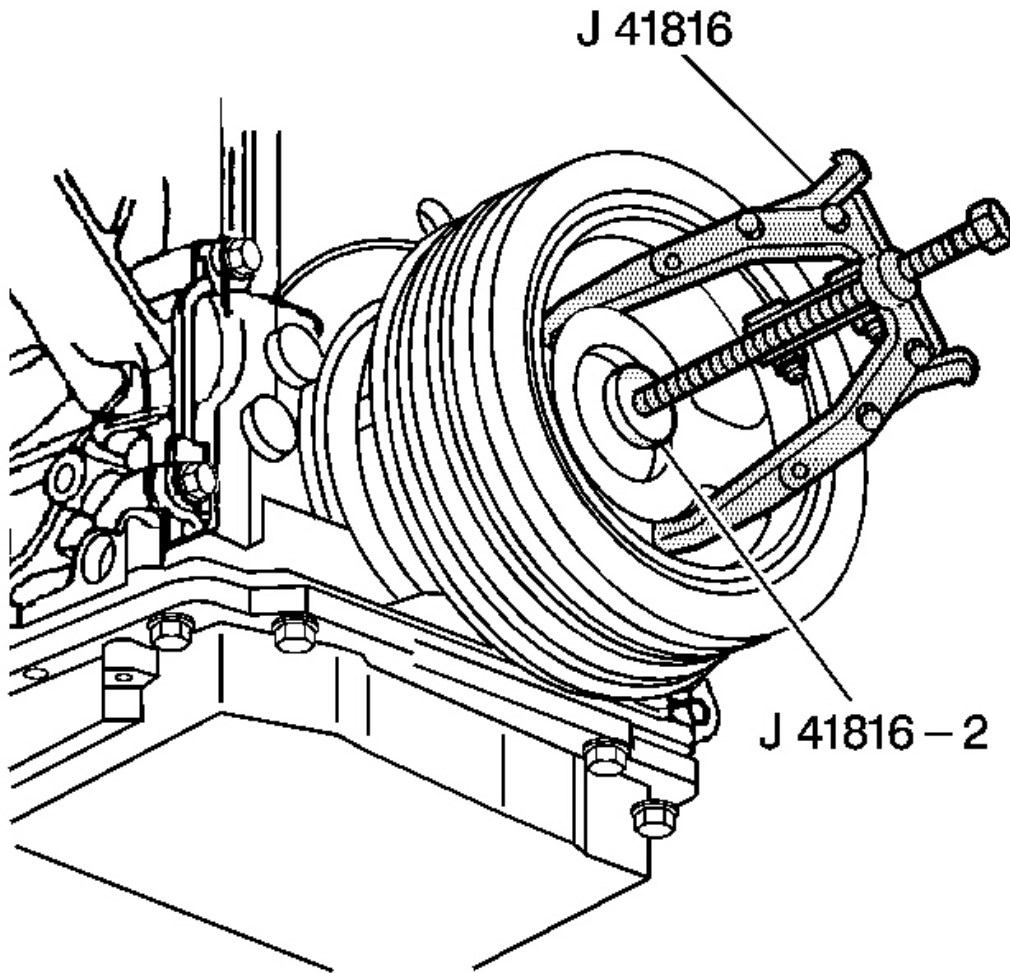
**Tighten:** Tighten the J 42386-A to 50 N.m (37 lb ft).



**Fig. 126: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer bolt.

Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.



**Fig. 127: View Of J 41816 & J 41816-2**  
Courtesy of GENERAL MOTORS CORP.

5. Use the J 41816 and J 41816-2 in order to remove the crankshaft balancer.
6. Remove the J 41816 and the J 41816-2 from the crankshaft balancer.
7. Clean and inspect the crankshaft balancer. Refer to Crankshaft Balancer Cleaning and Inspection .

#### Installation Procedure

#### IMPORTANT:

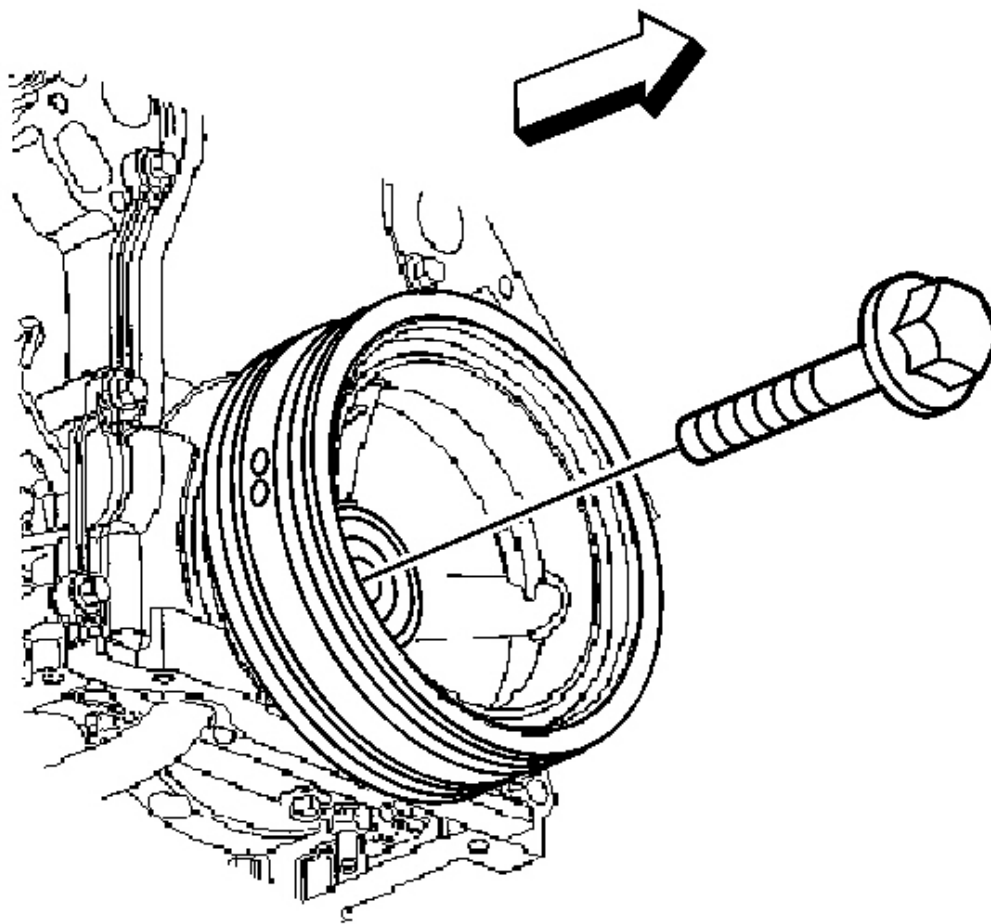
- Make sure that the teeth of J 42386-A are fully engaged into the flywheel ring gear teeth.
- The used crankshaft balancer bolt will be used only during the first pass



of the balancer installation procedure. Install a NEW bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.

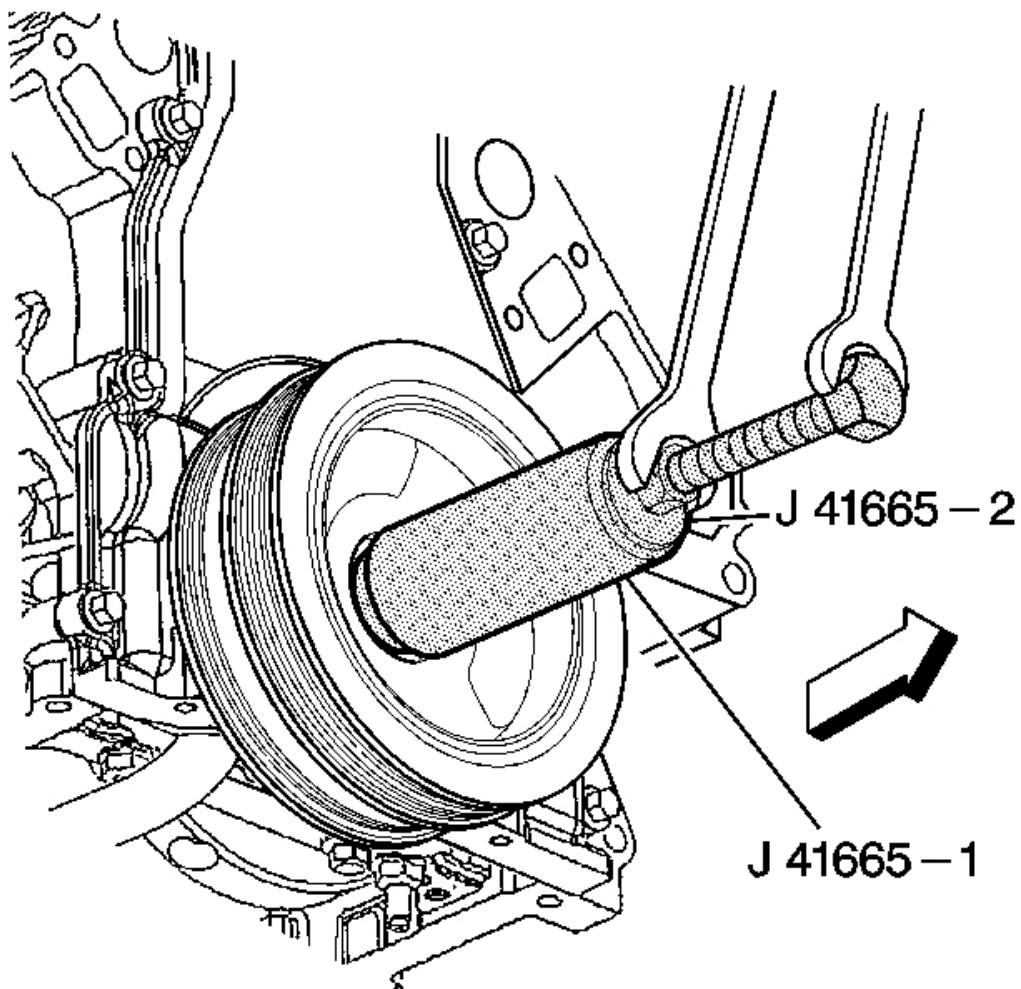
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and fourth passes tighten the new bolt to the proper torque.

**IMPORTANT:** The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.



**Fig. 128: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft balancer onto the end of the crankshaft.



**Fig. 129: View Of J 41665**  
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 41665** for the following steps. See **Special Tools and Equipment** .

1. Assemble the threaded rod, nut, washer and installer.

Insert the smaller end of the installer into the front of the balancer.

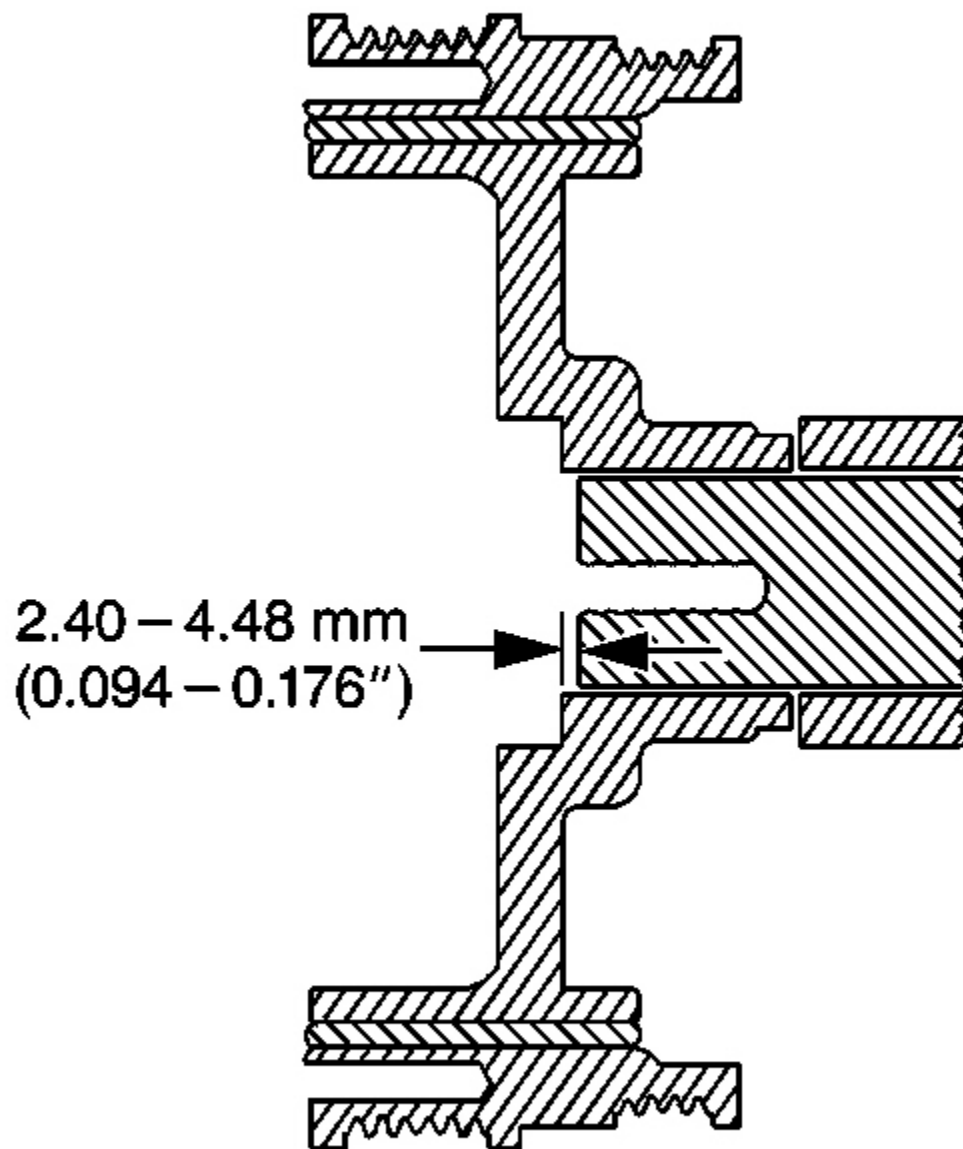
2. Use a wrench and hold the hex end of the threaded rod.
3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto

the crankshaft.

4. Remove the tool and reverse the installation tool.

Position the larger end of the installer against the front of the balancer.

5. Use a wrench and hold the hex end of the threaded rod.
6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
7. Remove the balancer installation tool.



**Fig. 130: Balancer Proper Installation Position**  
Courtesy of GENERAL MOTORS CORP.

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

3. Install the used crankshaft balancer bolt.

**Tighten:** Tighten the USED crankshaft balancer bolt to 330 N.m (240 lb ft).

4. Remove the used crankshaft balancer bolt.

**IMPORTANT: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.**

5. Measure for a correctly installed balancer.

If the balancer is not installed to the proper dimensions, install the **J 41665** . See **Special Tools and Equipment** .

6. Install a NEW crankshaft balancer bolt.

**Tighten:**

1. Tighten the crankshaft balancer bolt a first pass to 50 N.m (37 lb ft).
2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the **J 45059** . See **Special Tools and Equipment** .

7. Remove the J 42386-A .

8. Install the starter motor. Refer to **Starter Motor Replacement** .

9. Install the fan shroud. Refer to **Fan Shroud Replacement** .

10. Install the accessory drive belt (if not equipped with A/C). Refer to **Drive Belt Replacement - Accessory** .

11. Install the A/C drive belt (if equipped). Refer to **Drive Belt Replacement - Air Conditioning** .

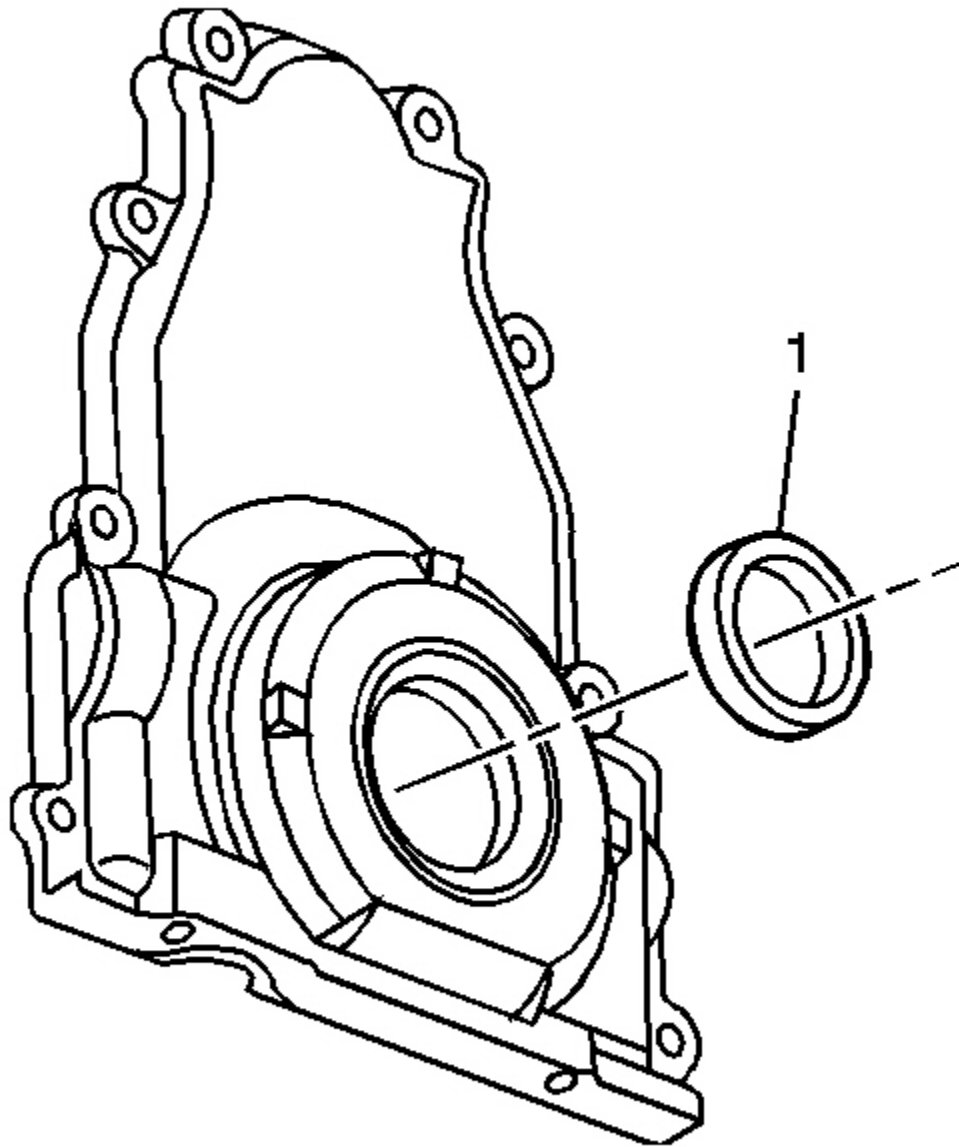
12. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **CKP System Variation Learn Procedure** .

## **CRANKSHAFT FRONT OIL SEAL REPLACEMENT**

### **Tools Required**

**J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools and Equipment** .

### **Removal Procedure**



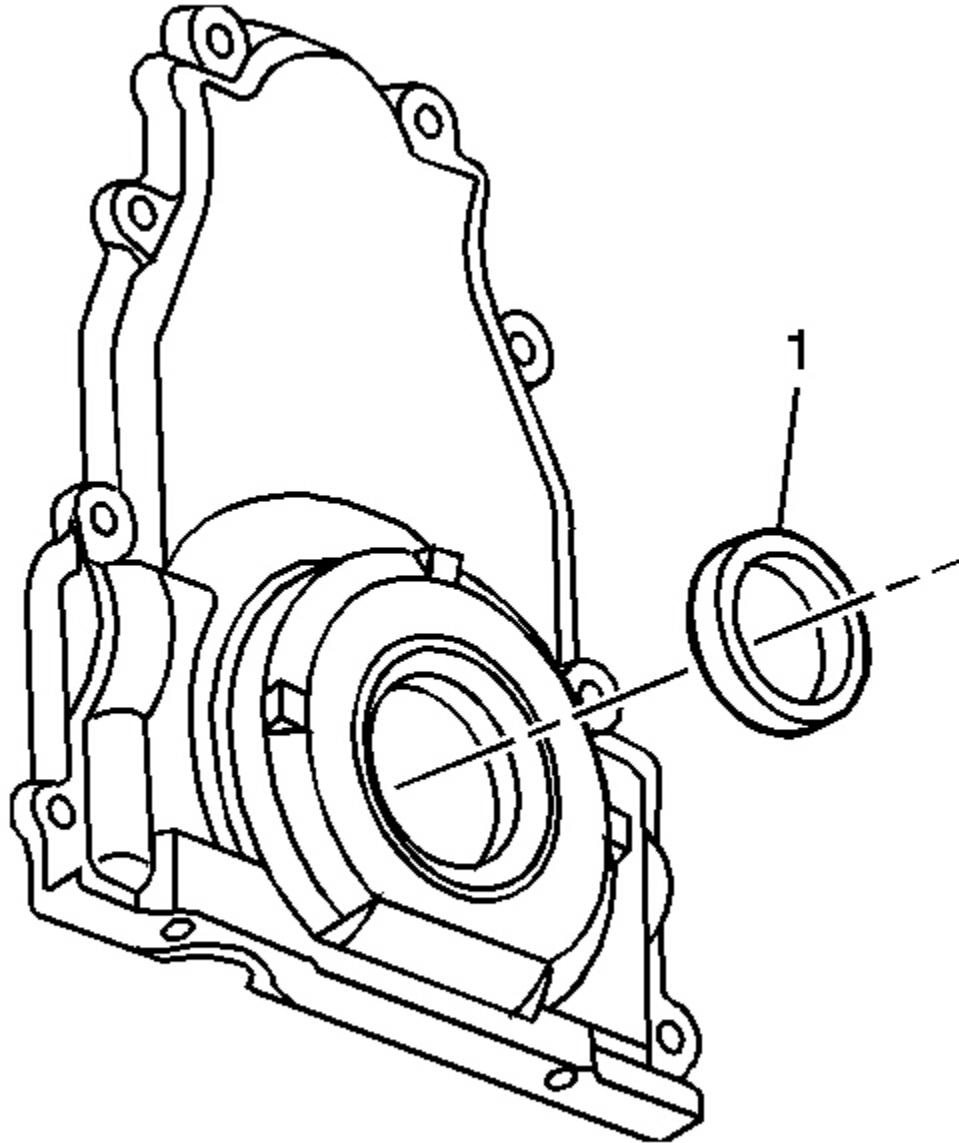
**Fig. 131: Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .
2. Remove the crankshaft oil seal (1) from the front cover.

**Installation Procedure**

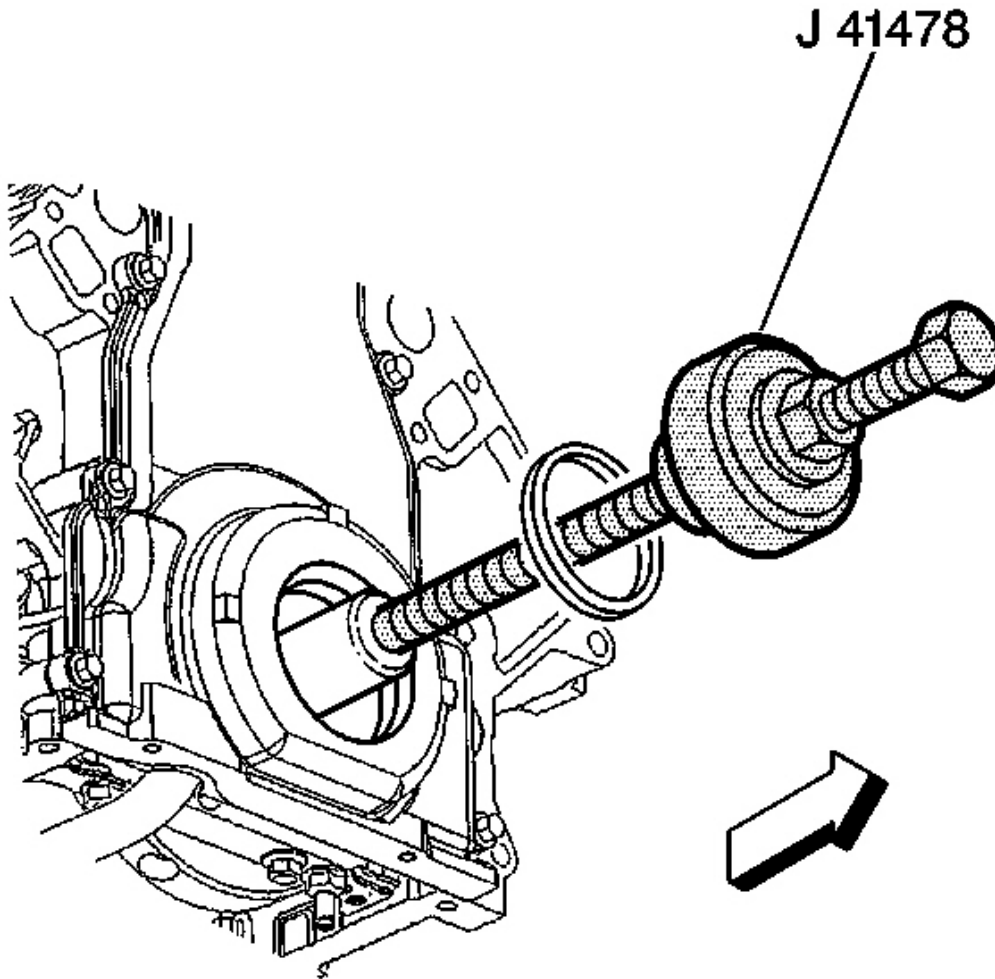
**IMPORTANT:**

- Do not lubricate the oil seal sealing surface.
- Do not reuse the crankshaft oil seal.



**Fig. 132: Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outer edge of the oil seal (1) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.



**Fig. 133: View Of J 41478**  
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal onto the **J 41478** guide. See **Special Tools and Equipment** .
4. Install the **J 41478** threaded rod (with nut, washer, guide, and oil seal) into the end of the crankshaft. See **Special Tools and Equipment** .
5. Use the **J 41478** in order to install the oil seal into the cover bore. See **Special Tools and Equipment** .
  1. Use a wrench and hold the hex on the installer bolt.



2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
3. Remove the **J 41478** . See **Special Tools and Equipment** .
4. Inspect the oil seal for proper installation.

The oil seal should be installed evenly and completely into the front cover bore.

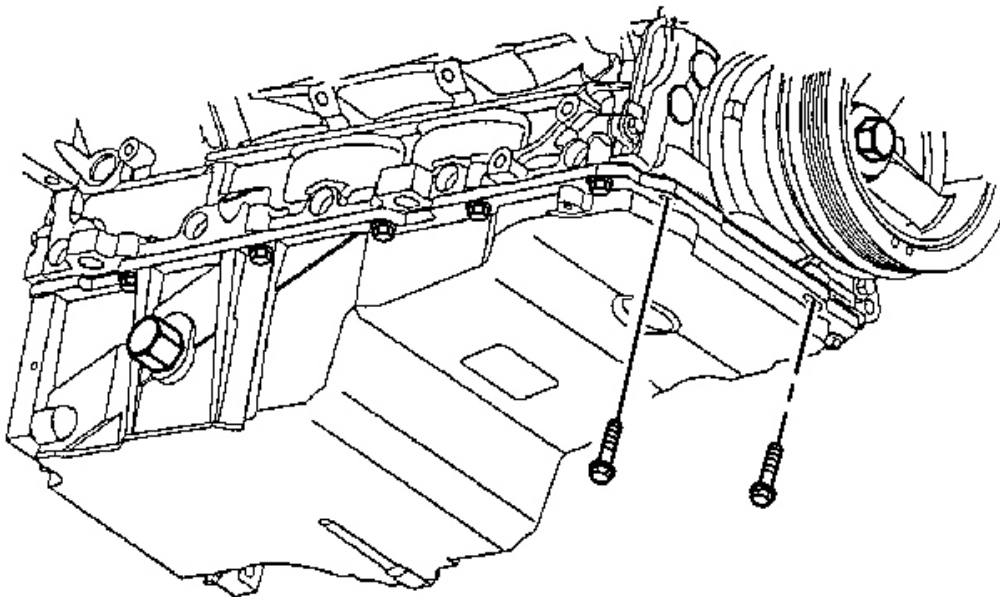
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .

## **ENGINE FRONT COVER REPLACEMENT**

### **Tools Required**

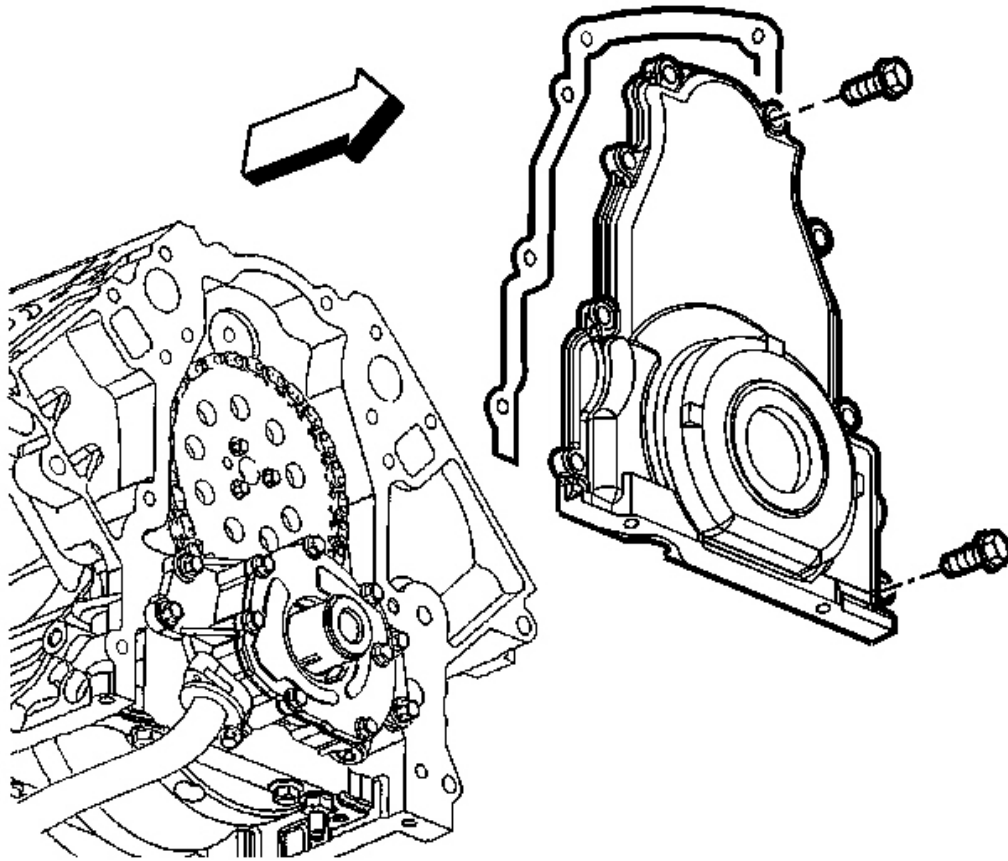
**J 41476** Front and Rear Cover Alignment (at crankshaft seal area). See **Special Tools and Equipment** .

### **Removal Procedure**



**Fig. 134: Oil Pan-To-Front Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

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 oil pan-to-front cover bolts.



**Fig. 135: Front Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the front cover bolts.
5. Remove the front cover and gasket.
6. Discard the front cover gasket.
7. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection** .

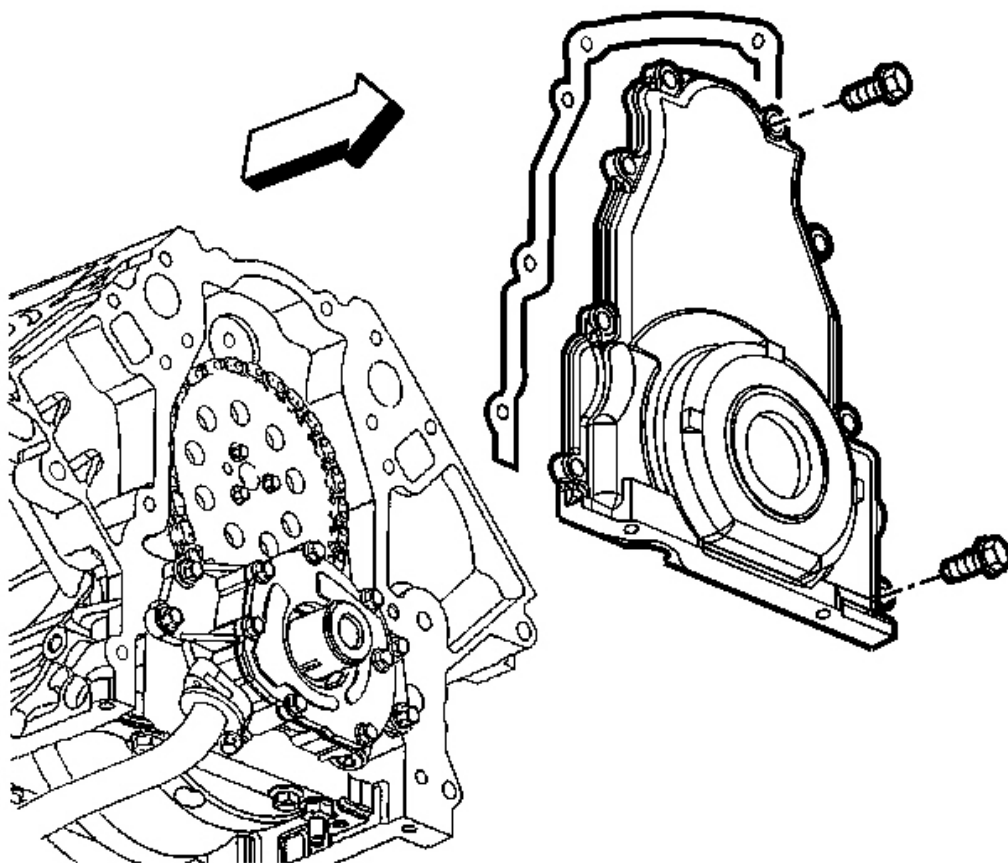
#### Installation Procedure

#### **IMPORTANT:**

- Do not reuse the crankshaft oil seal or front cover gasket.
- Do not apply any type of sealant to the front cover gasket (unless specified).
- The special tool in this procedure is used to properly center the front

### crankshaft front oil seal.

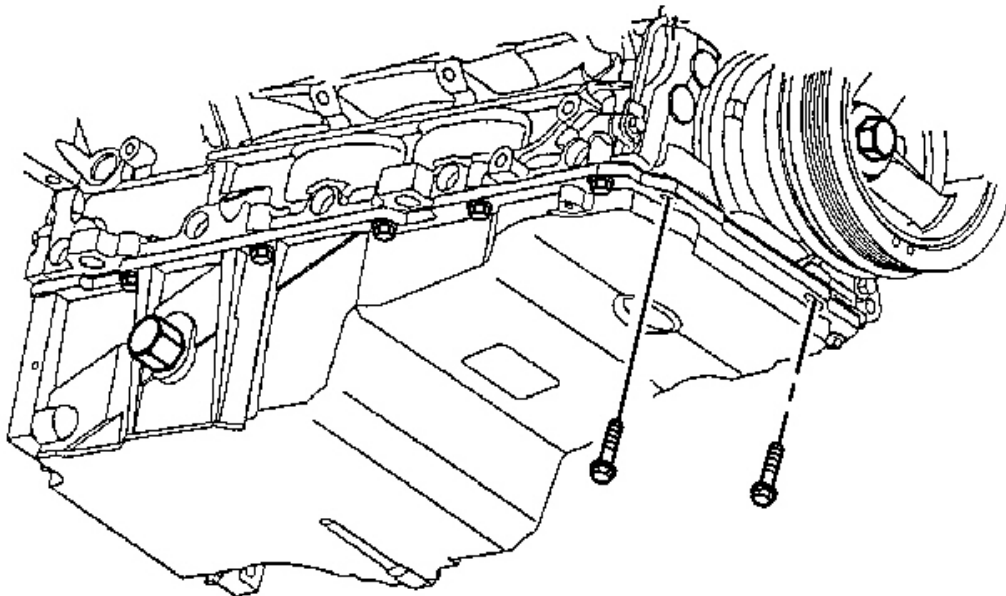
- All gasket surfaces should be free of oil or other foreign material during assembly.
- The crankshaft front oil seal **MUST** be centered in relation to the crankshaft.
- An improperly aligned front cover may cause premature front oil seal wear and/or engine oil leaks.



**Fig. 136: Front Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

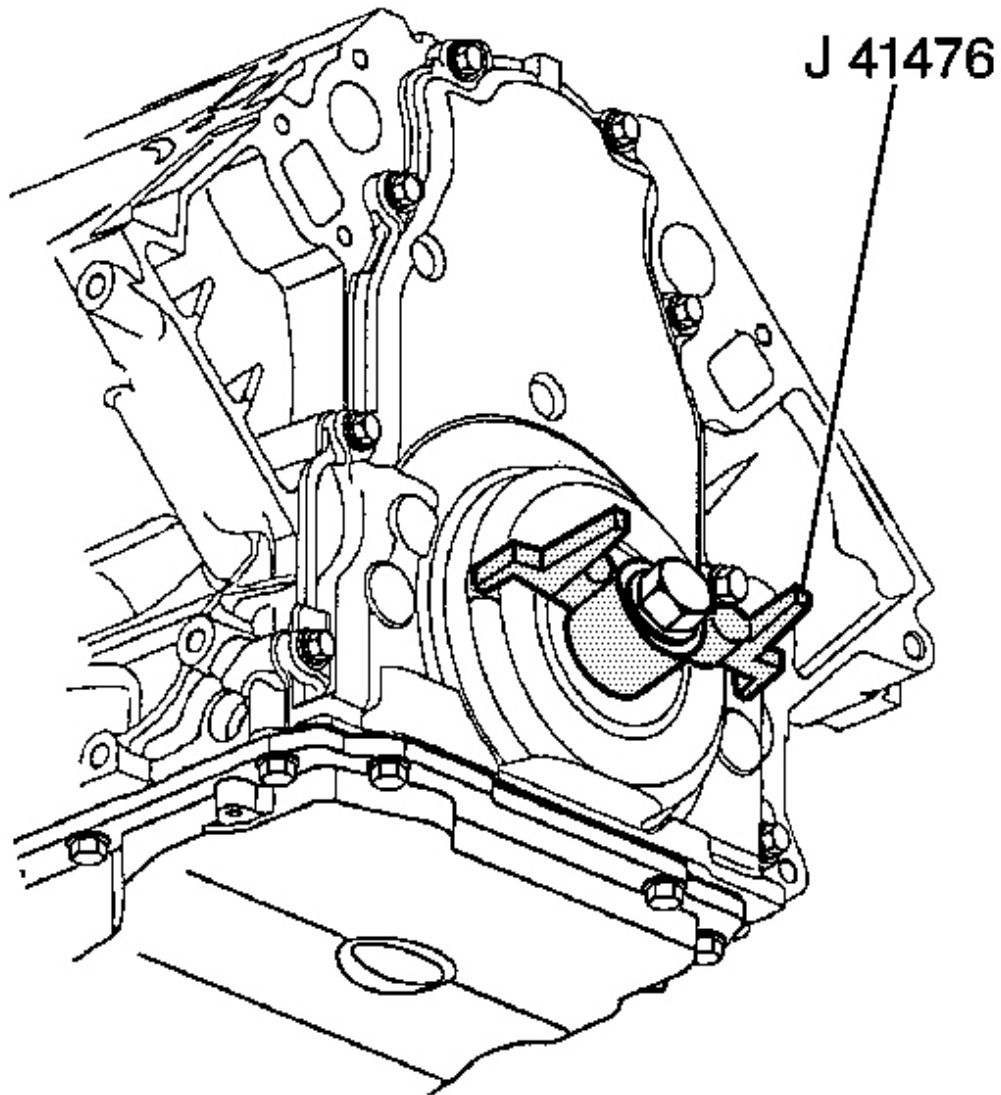
1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the oil pan to engine block junction.
2. Install the front cover gasket and cover.

3. Install the front cover bolts until snug. Do not overtighten.



**Fig. 137: Oil Pan-To-Front Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan-to-front cover bolts until snug. Do not over tighten.



**Fig. 138: View of J 41476**  
Courtesy of GENERAL MOTORS CORP.

5. Install **J 41476** to the front cover. See **Special Tools and Equipment** .
6. Align the tapered legs of the **J 41476** with the machined alignment surfaces on the front cover. See **Special Tools and Equipment** .

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

7. Install the crankshaft balancer bolt until snug. Do not overtighten.

**Tighten:**

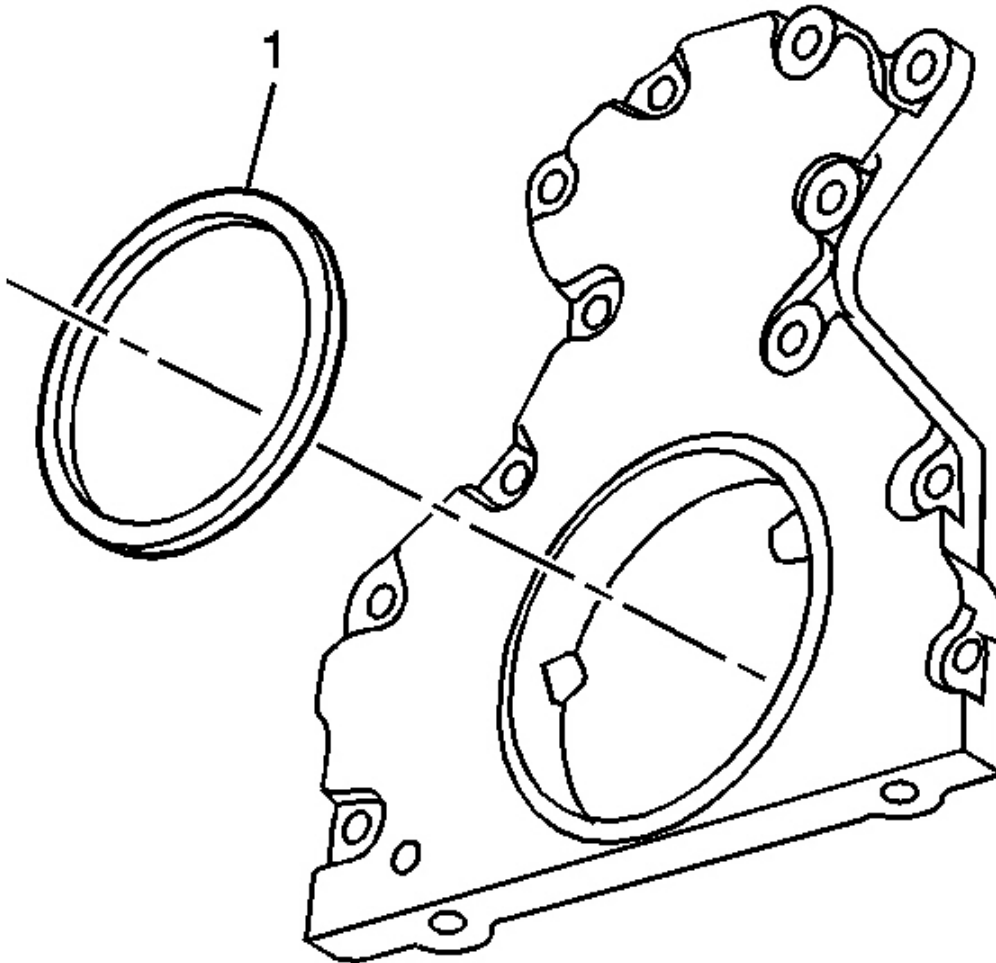
1. Tighten the oil pan to front cover bolts to 25 N.m (18 lb ft).
2. Tighten the engine front cover bolts to 25 N.m (18 lb ft).
  
8. Remove the **J 41476** . See **Special Tools and Equipment** .
9. Install a NEW crankshaft front oil seal. Refer to **Crankshaft Front Oil Seal Replacement** .
10. Install the water pump. Refer to **Water Pump Replacement** in Engine Cooling.

## **CRANKSHAFT REAR OIL SEAL REPLACEMENT**

### **Tools Required**

**J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools and Equipment** .

### **Removal Procedure**



**Fig. 139: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

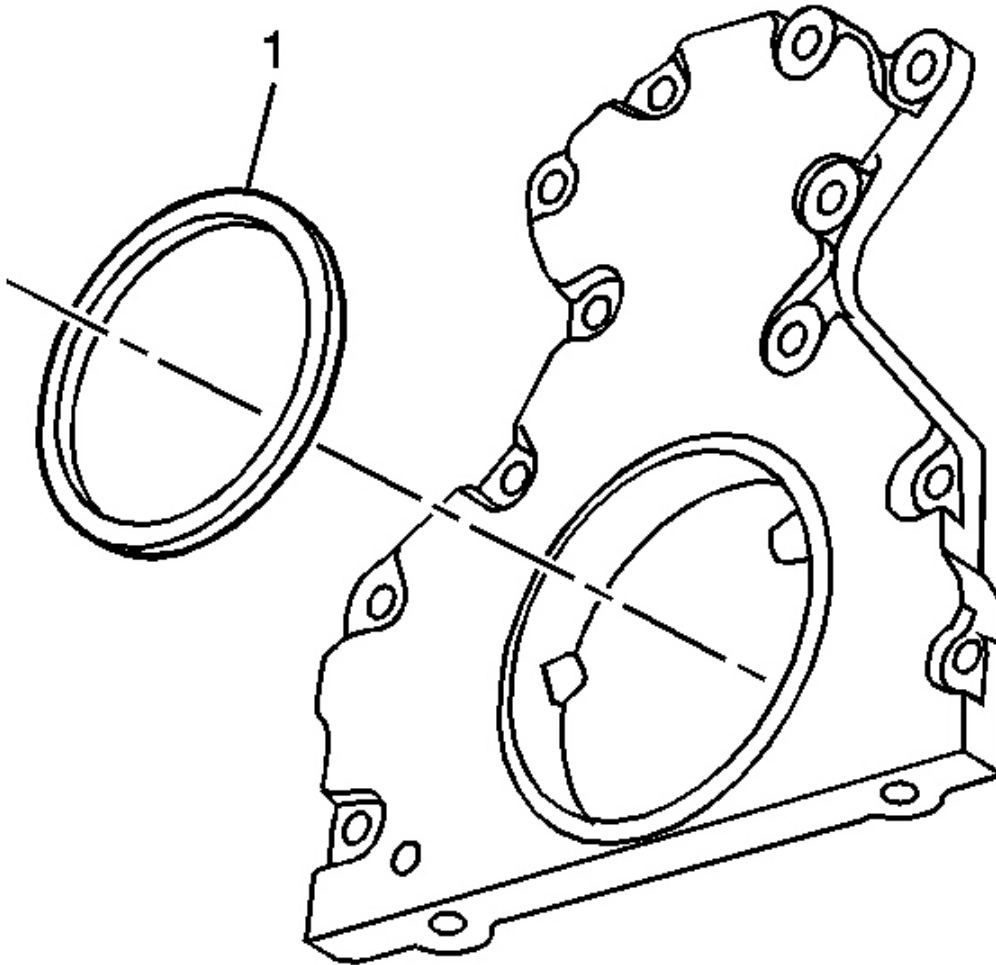
1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement** .
2. Remove the crankshaft rear oil seal (1) from the rear cover.

#### Installation Procedure

#### **IMPORTANT:**

- The flywheel spacer (if applicable) must be removed prior to oil seal installation.
- Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.

- Do not reuse the crankshaft rear oil seal.



**Fig. 140: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

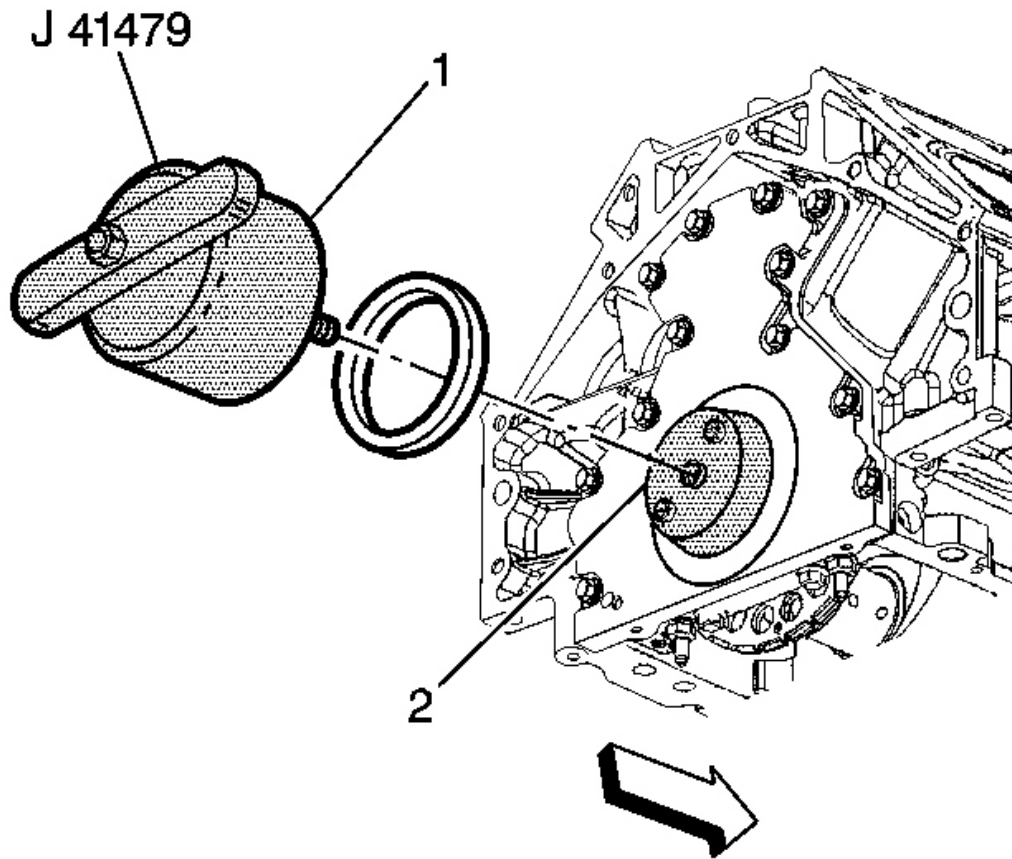
1. Lubricate the outside diameter (OD) of the oil seal (1) with clean engine oil.

DO NOT allow oil or other lubricants to contact the seal surface.

2. Lubricate the rear cover oil seal bore with clean engine oil.

DO NOT allow oil or other lubricants to contact the crankshaft surface.





**Fig. 141: View Of J 41479**  
 Courtesy of GENERAL MOTORS CORP.

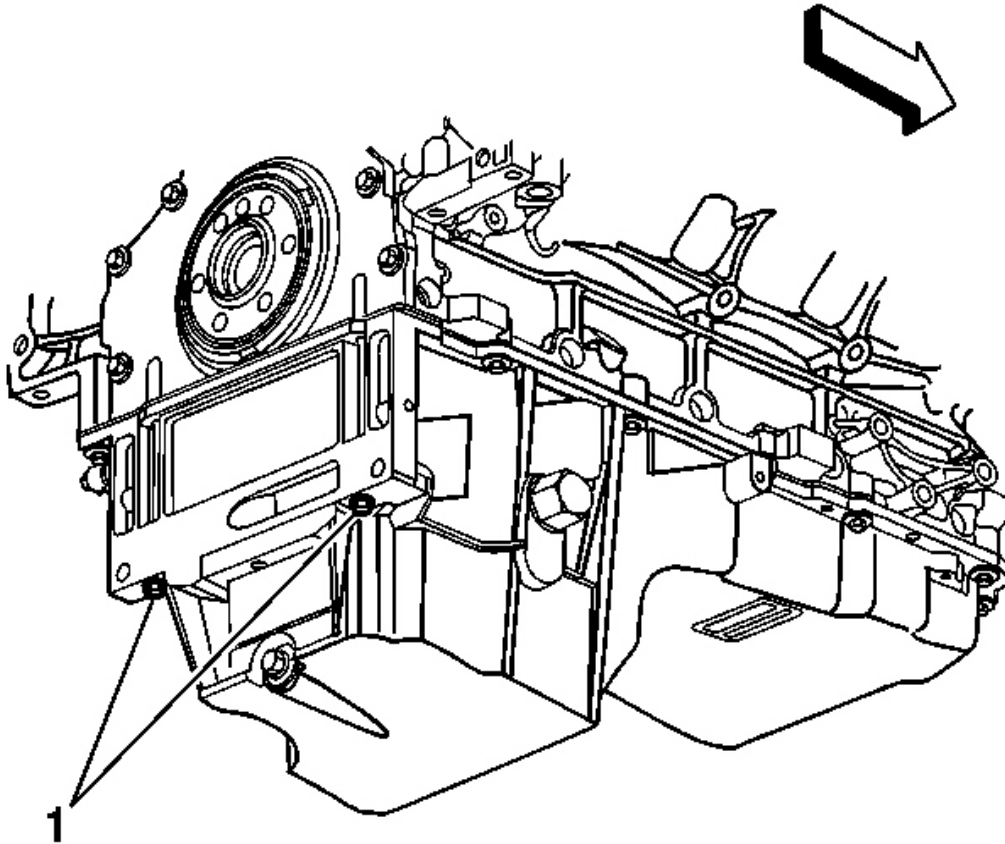
3. Install the **J 41479** tapered cone (2) and bolts onto the rear of the crankshaft. See **Special Tools and Equipment** .
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools and Equipment** .
7. Align the oil seal into the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the **J 41479** . See **Special Tools and Equipment** .
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement** .

## ENGINE REAR COVER REPLACEMENT

### Tools Required

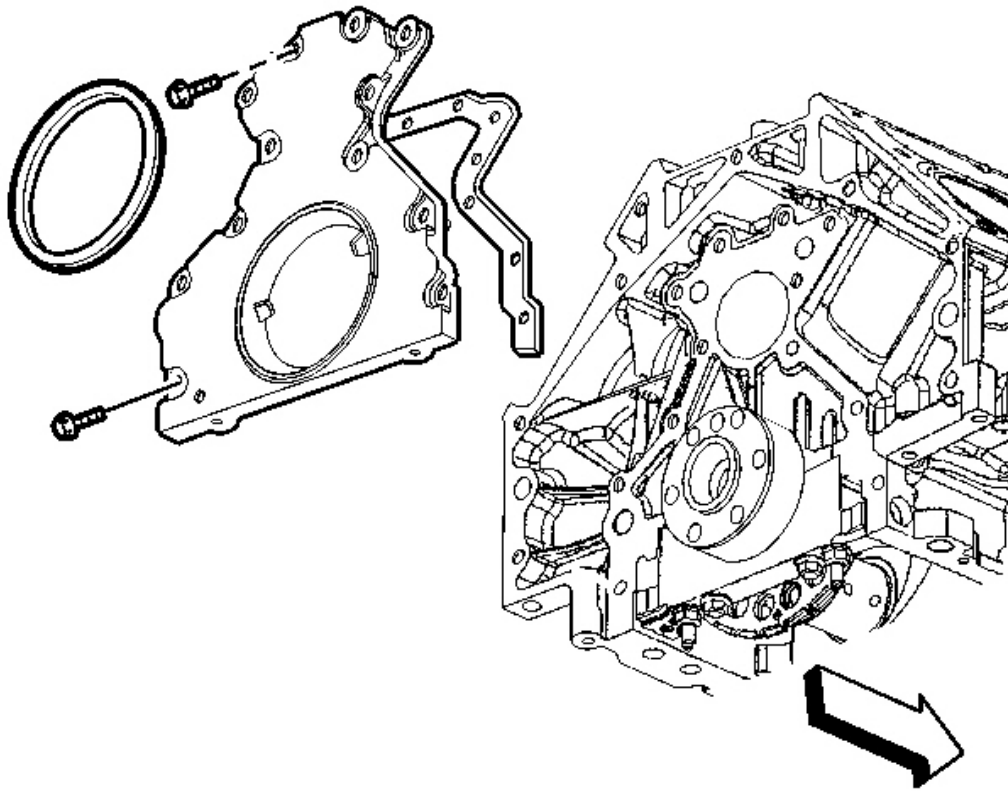
**J 41476** Front and Rear Cover Alignment (at crankshaft seal area). See **Special Tools and Equipment** .

### Removal Procedure



**Fig. 142: Oil Pan-To-Rear Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement** .
2. Remove the oil pan-to-rear cover bolts (1).



**Fig. 143: Rear Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the rear cover bolts.
4. Remove the rear cover and gasket.
5. Discard the rear cover gasket.
6. Clean and inspect the rear cover. Refer to Engine Rear Cover Cleaning and Inspection .

#### Installation Procedure

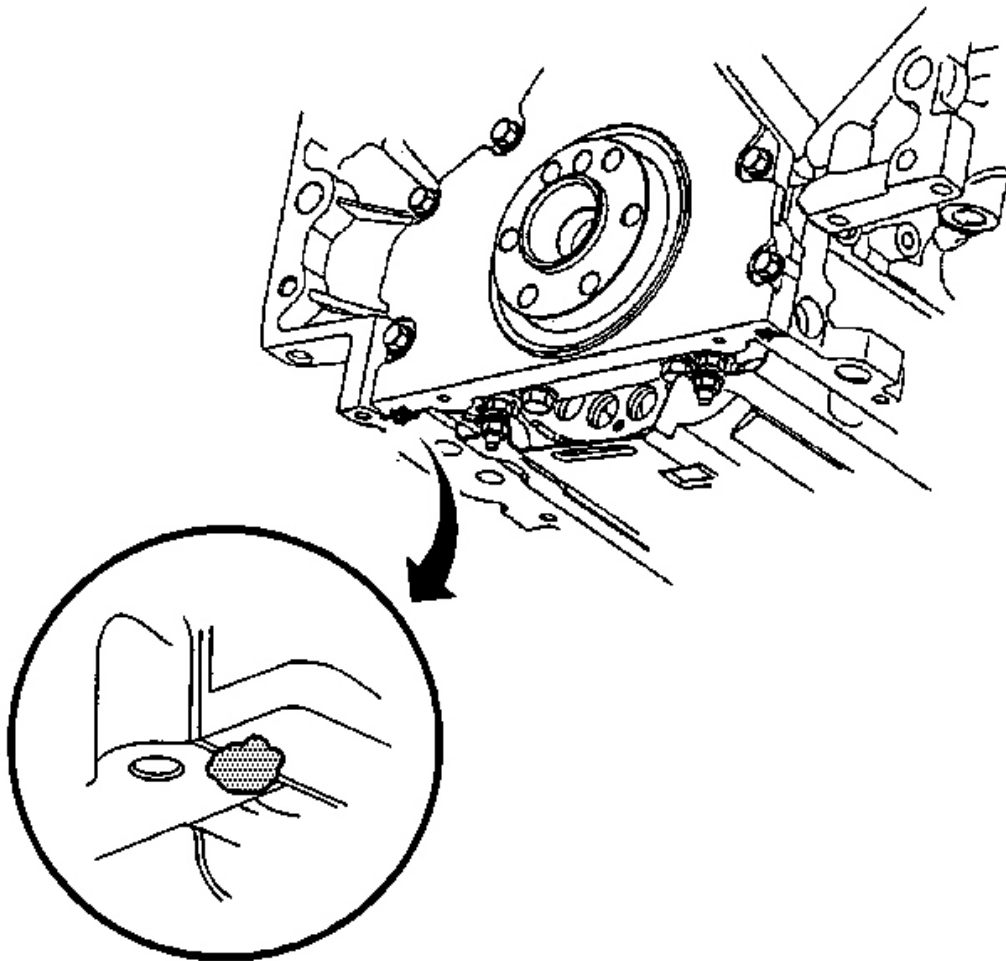
#### **IMPORTANT:**

- Do not reuse the crankshaft oil seal or rear cover gasket.
- Do not apply any type of sealant to the rear cover gasket (unless specified).
- The special tool in this procedure is used to properly center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear cover has been

installed and aligned.

Install the rear cover without the crankshaft oil seal.

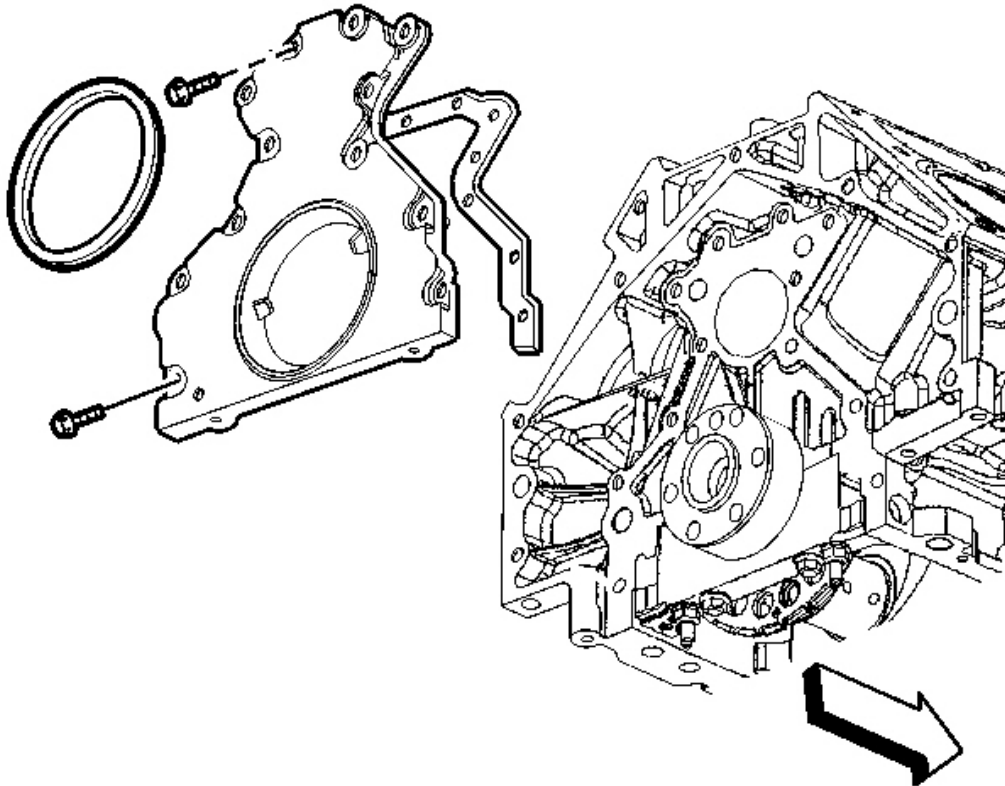
- All gasket surfaces should be free of oil or other foreign material during assembly.
- The crankshaft rear oil seal **MUST** be centered in relation to the crankshaft.
- An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.



**Fig. 144: Sealant Applied To Rear Oil Pan-To-Engine Block Junction**

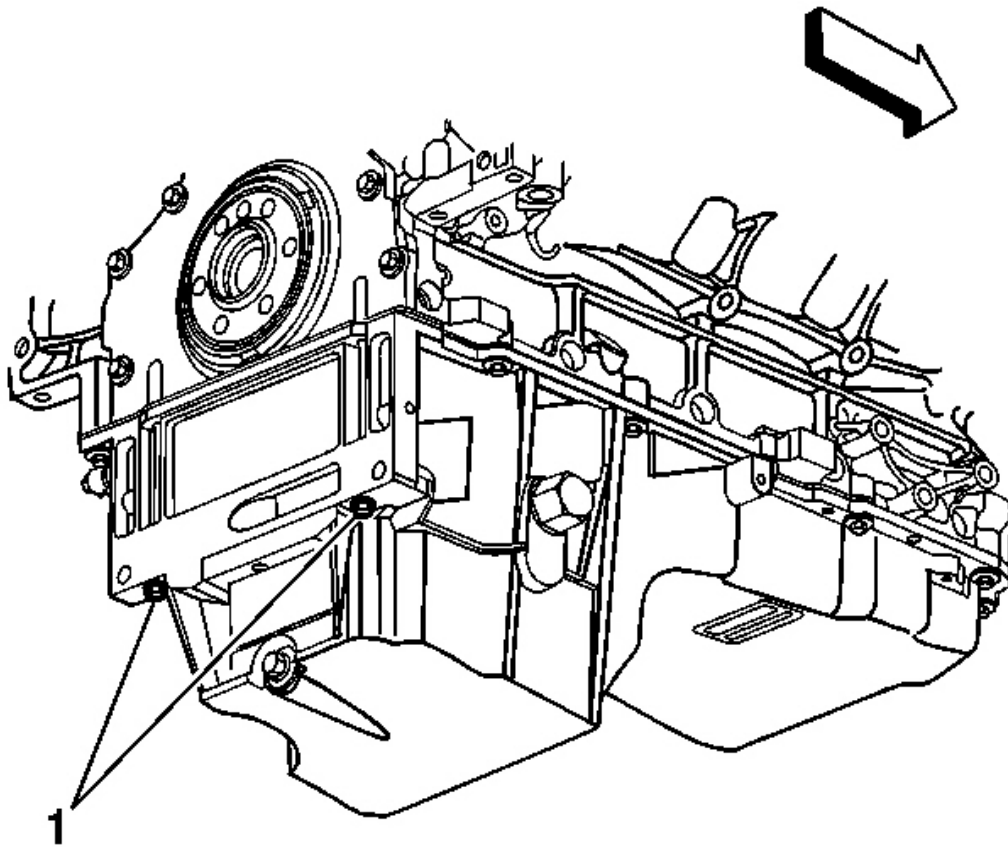
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the oil pan to engine block junction.



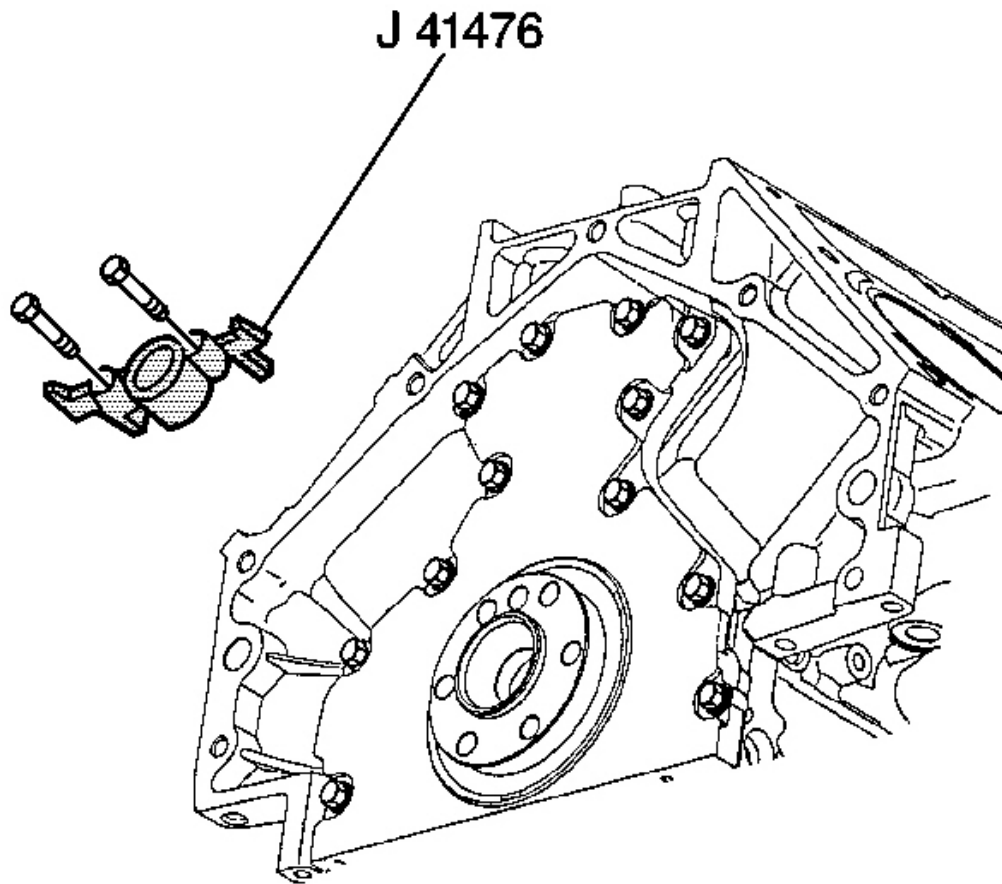
**Fig. 145: Rear Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket and cover.
3. Install the rear cover bolts until snug. Do not overtighten.



**Fig. 146: Oil Pan-To-Rear Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan-to-rear cover bolts (1) until snug. Do not overtighten.



**Fig. 147: View Of J 41476**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The tapered legs of the alignment tool must enter the rear cover oil seal bore.

5. Rotate the crankshaft until two opposing flywheel bolt holes are parallel to the oil pan surface.
6. Install the **J 41476** and bolts onto the rear of the crankshaft. See **Special Tools and Equipment** .

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

7. Tighten the **J 41476** mounting bolts until snug. See **Special Tools and Equipment** . Do not overtighten.

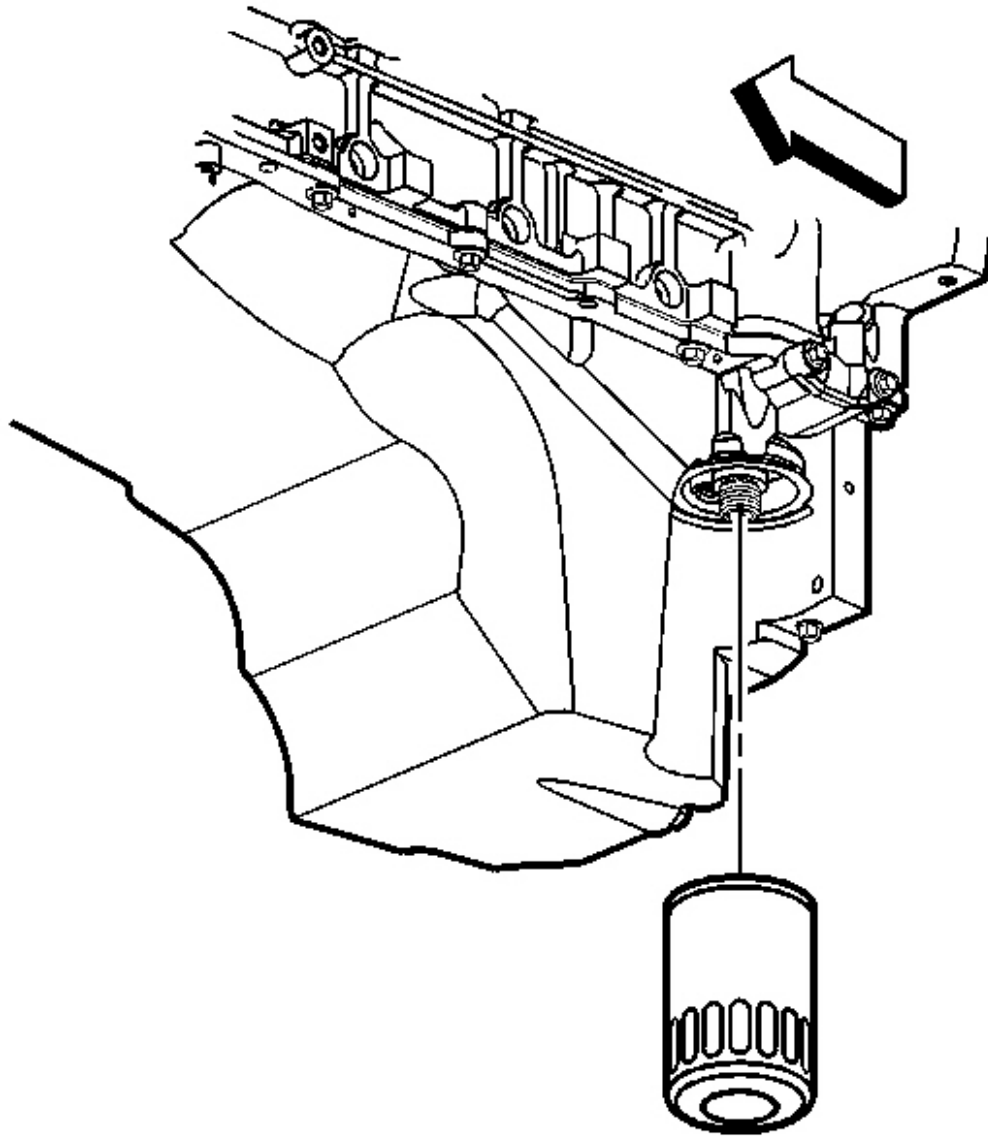
**Tighten:**

1. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
2. Tighten the engine rear cover bolts to 25 N.m (18 lb ft).
  
8. Remove the **J 41476** . See **Special Tools and Equipment** .
9. Install a NEW crankshaft rear oil seal. Refer to **Crankshaft Rear Oil Seal Replacement** .
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement** .

## **OIL FILTER ADAPTER REPLACEMENT**

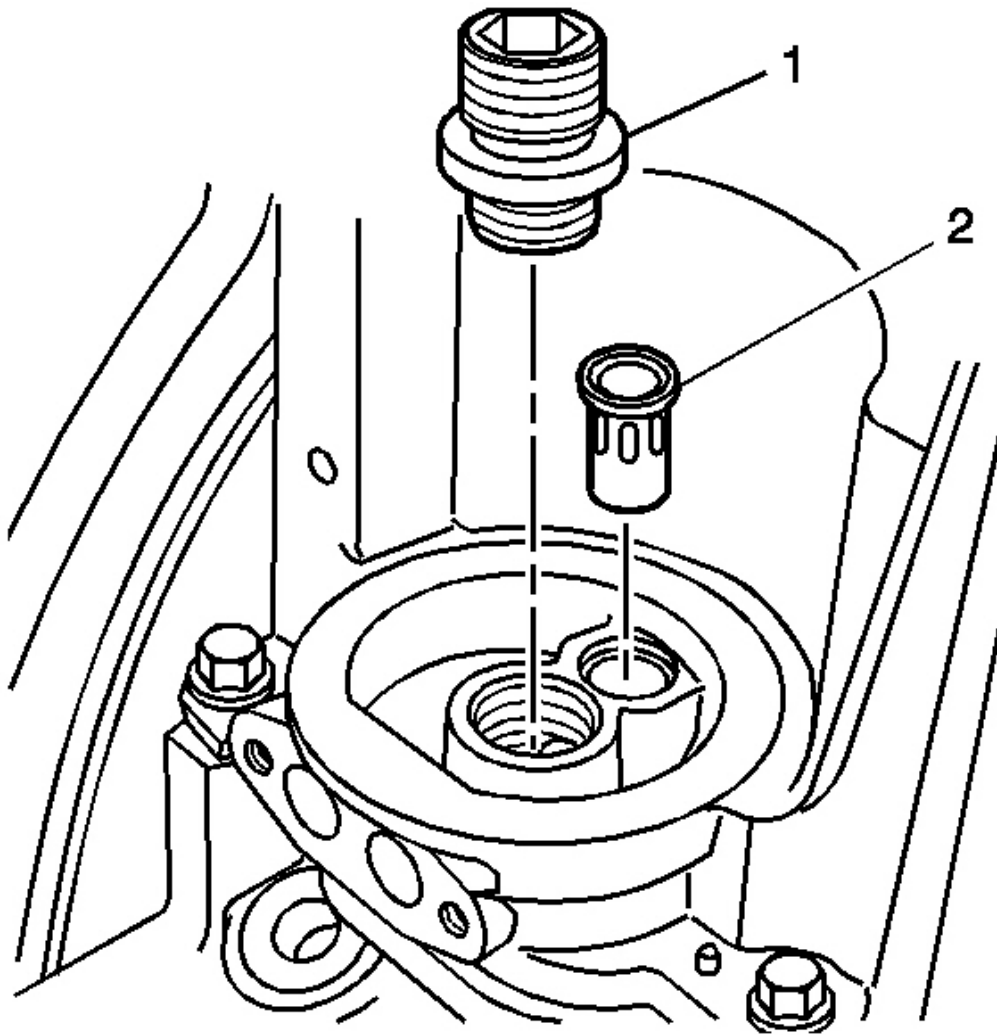
### **Removal Procedure**





**Fig. 148: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

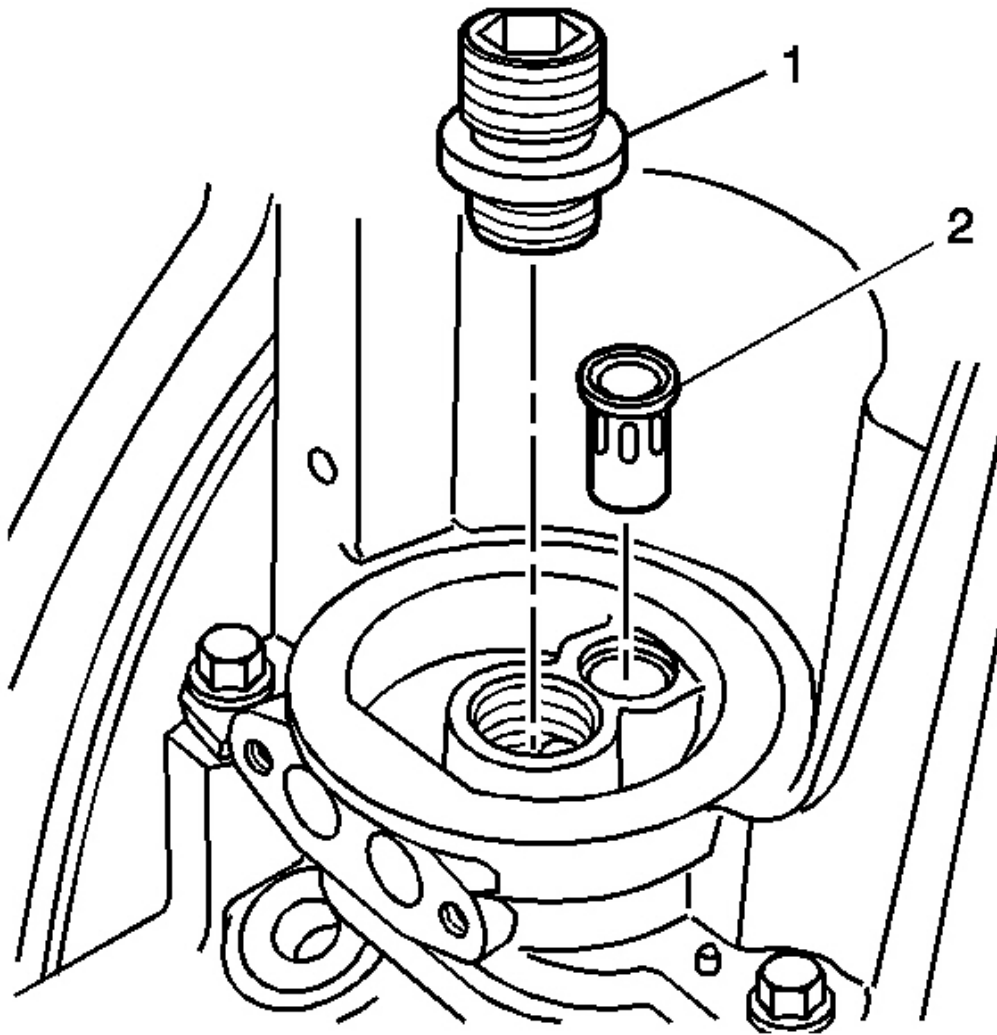
1. Drain the engine oil.
2. Remove the oil filter.



**Fig. 149: Oil Filter Adapter & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).

**Installation Procedure**

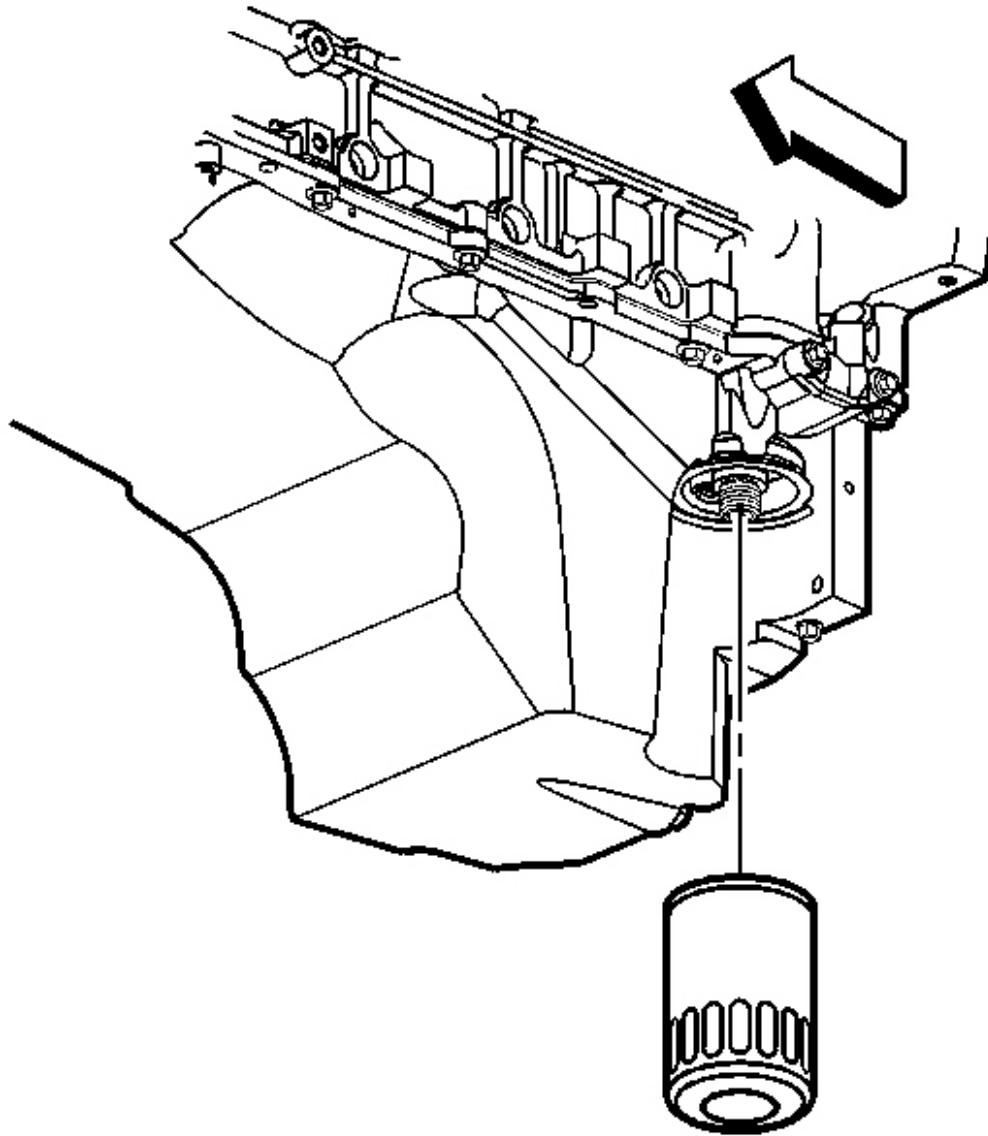


**Fig. 150: Oil Filter Adapter & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil filter adapter (1).

**Tighten:** Tighten the oil filter adapter to 55 N.m (40 lb ft).

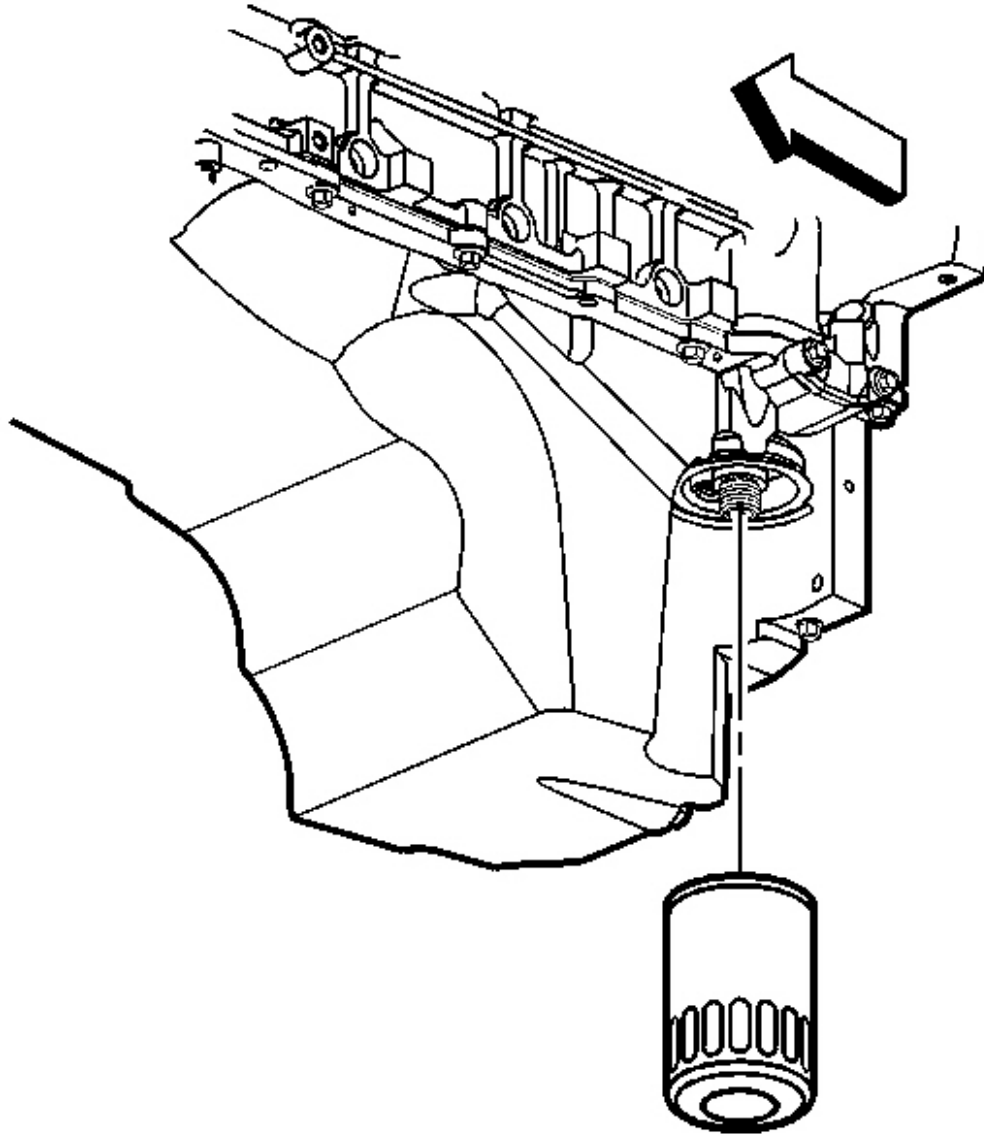


**Fig. 151: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter.
3. Refill the engine oil. Refer to **Capacities - Approximate Fluid** and/or **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.

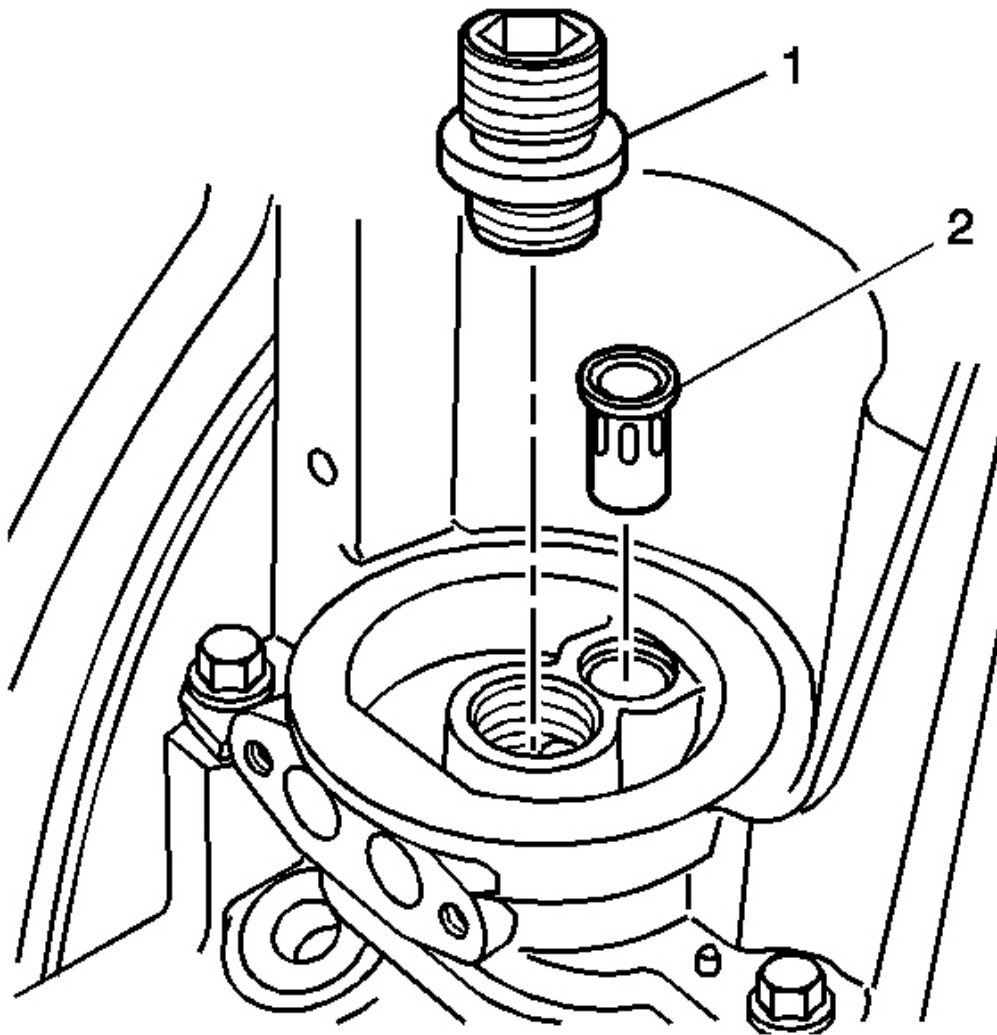
# OIL FILTER BYPASS VALVE REPLACEMENT

## Removal Procedure



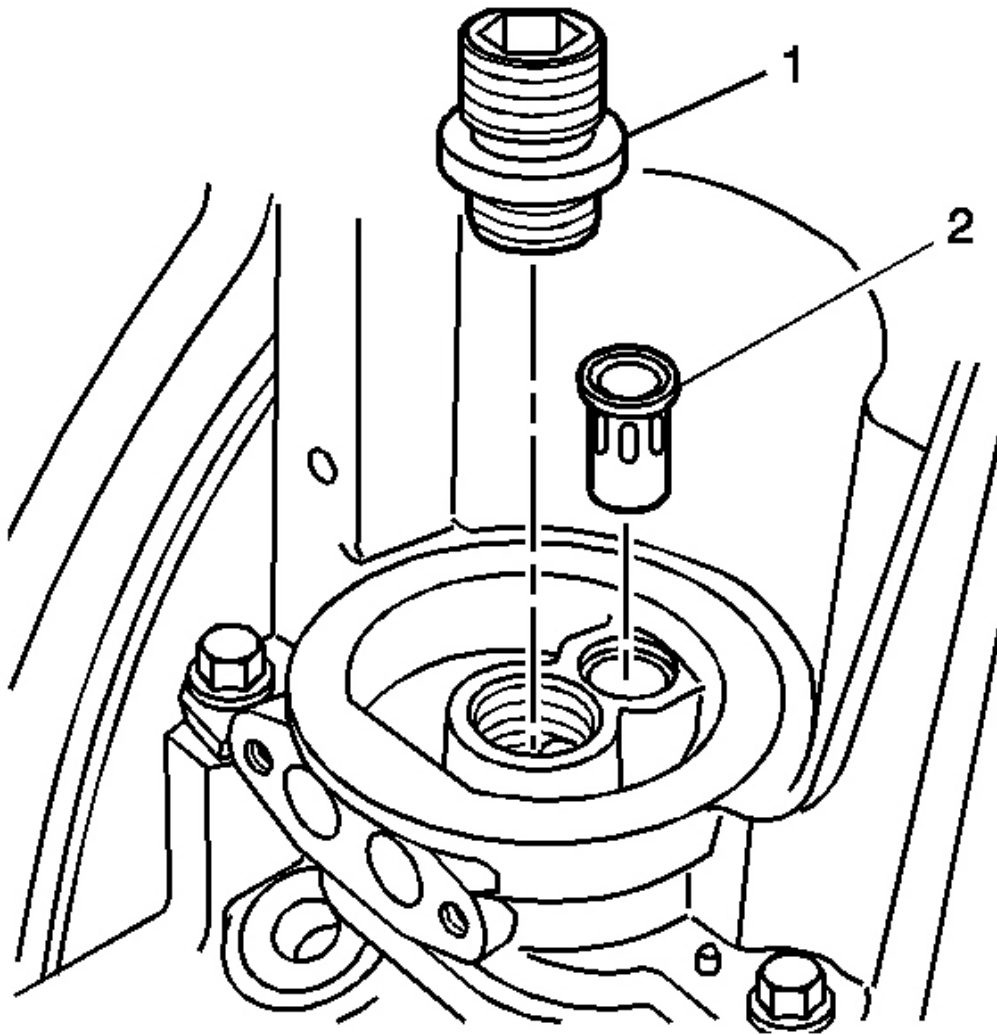
**Fig. 152: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil.
2. Remove the oil filter.



**Fig. 153: Oil Filter Adapter & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).
4. Remove the oil filter bypass valve (2).

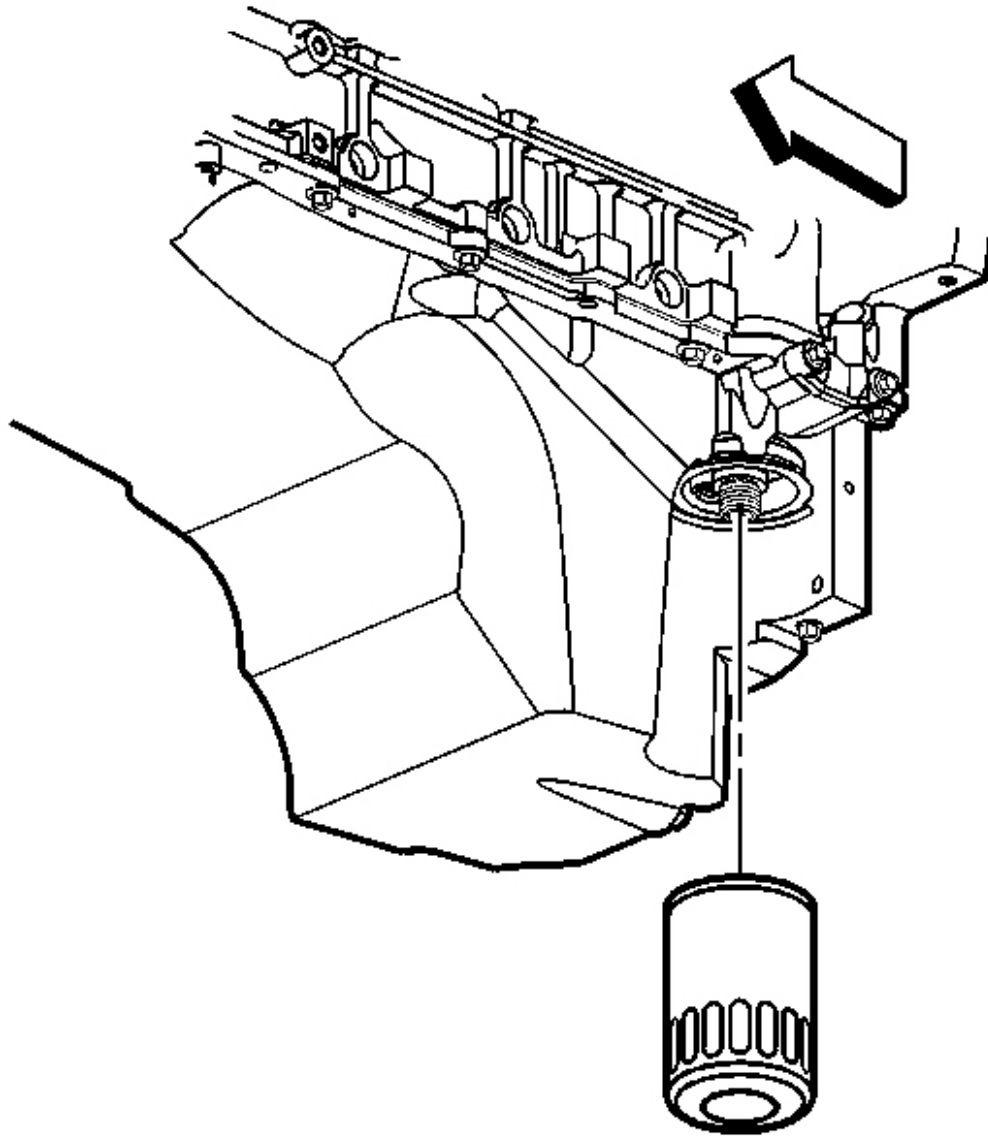


**Fig. 154: Oil Filter Adapter & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil filter bypass valve (2).
2. Install the oil filter adapter (1).

**Tighten:** Tighten the oil filter adapter to 55 N.m (40 lb ft).



**Fig. 155: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter.

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

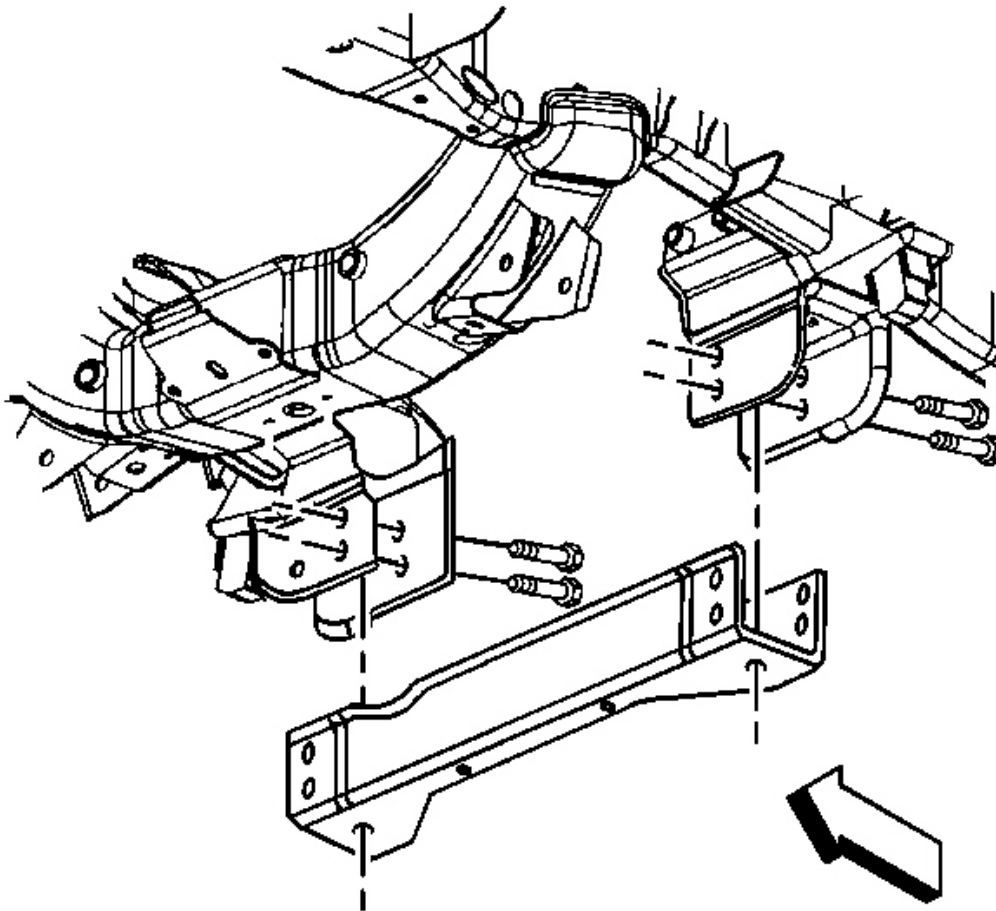


4. Refill the engine oil. Refer to **Capacities - Approximate Fluid** and/or **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.

## OIL PAN REPLACEMENT

### Removal Procedure

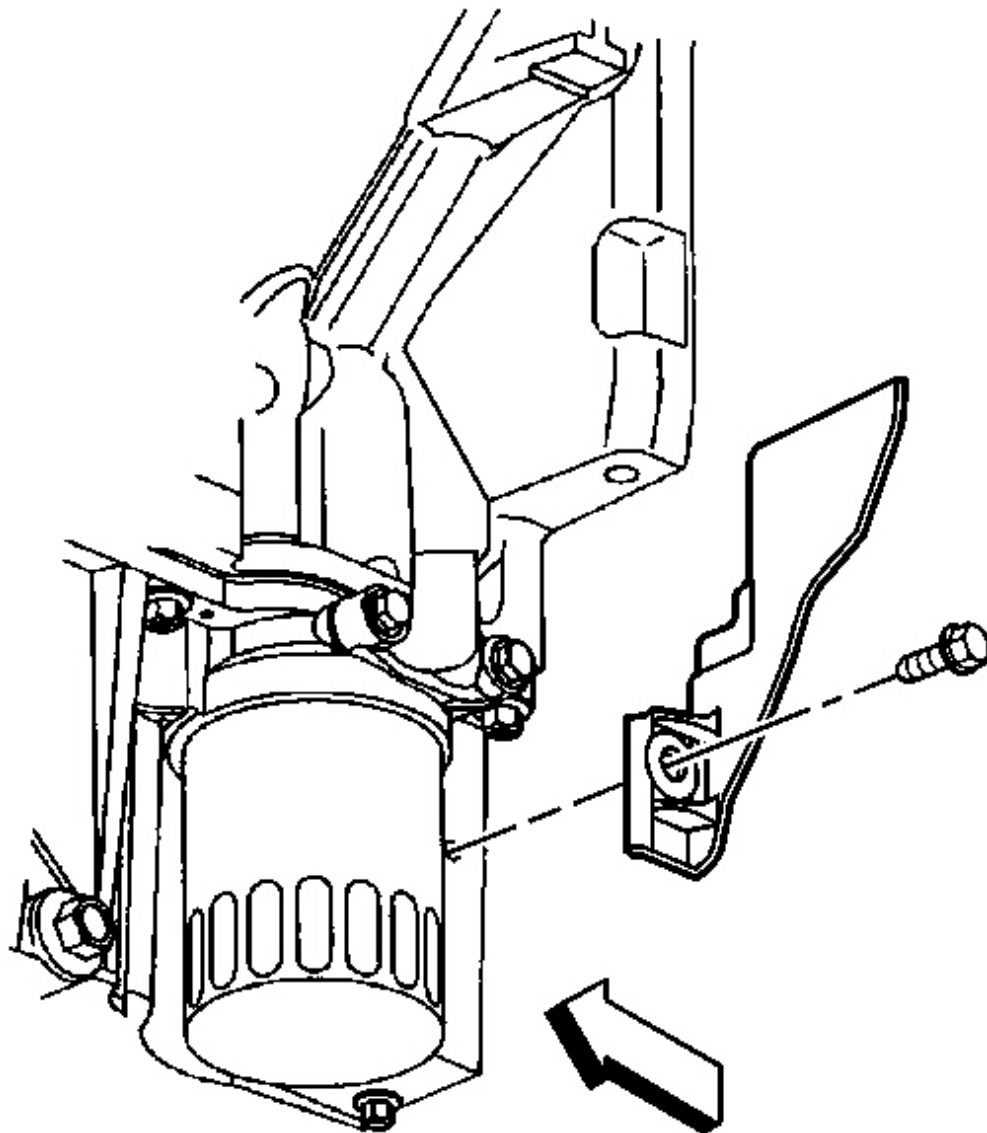
1. Remove the front differential. Refer to **Differential Carrier Assembly Replacement** in Driveline/Axle.
2. Remove the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.



**Fig. 156: Crossbar & Engine (2WD)**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the crossbar bolts.

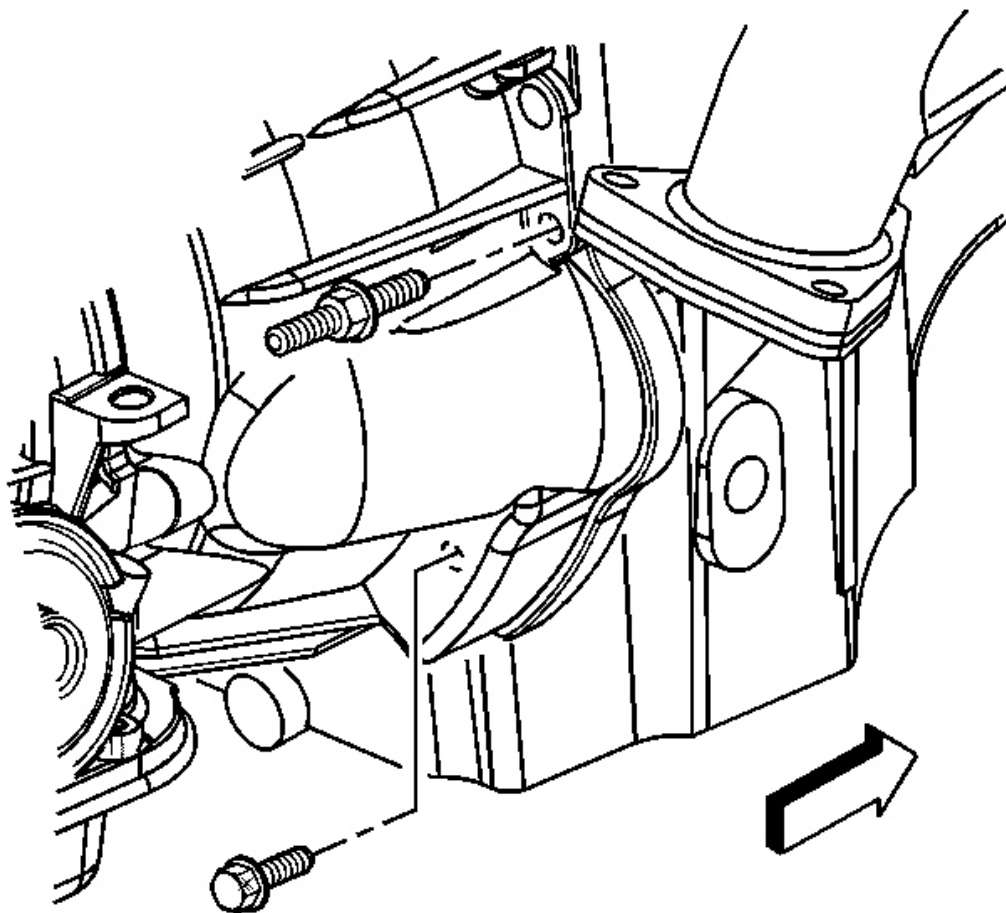
4. Remove the crossbar.



**Fig. 157: Left Closeout Cover & Bolt**  
Courtesy of GENERAL MOTORS CORP.

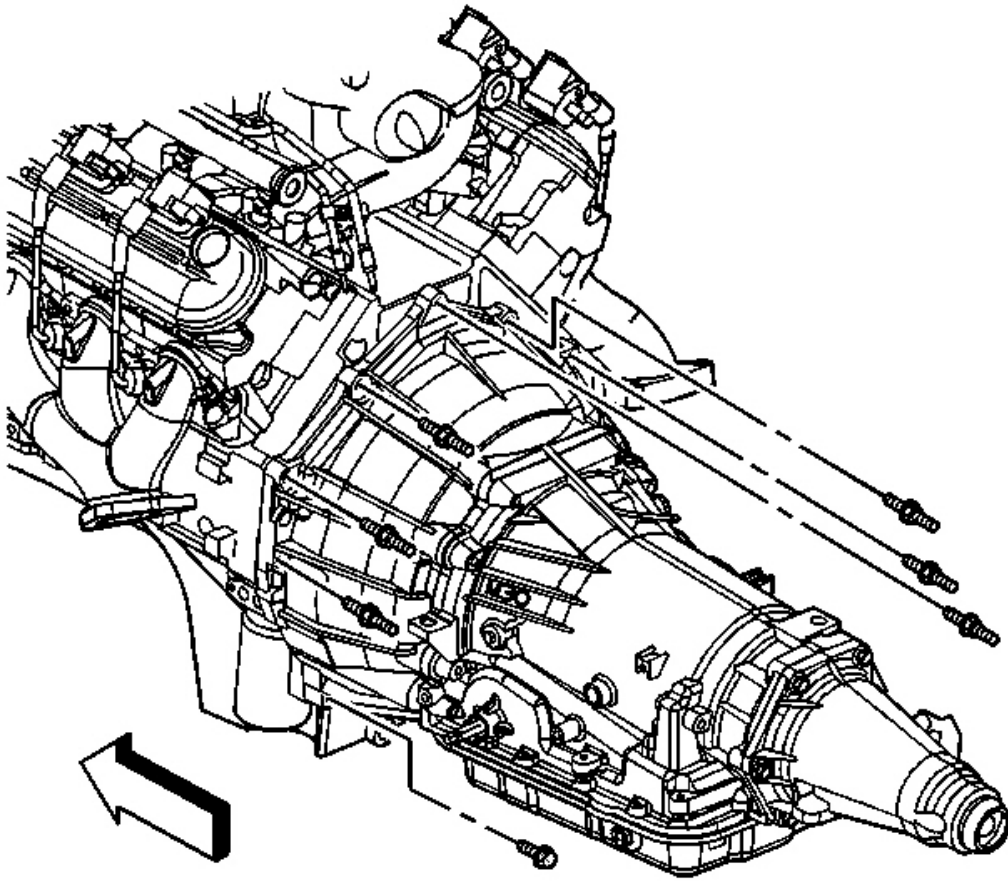
5. Remove the transmission cover bolt and cover.
6. Drain the engine oil and remove the engine oil filter.

7. Re-install the drain plug and oil filter until snug.



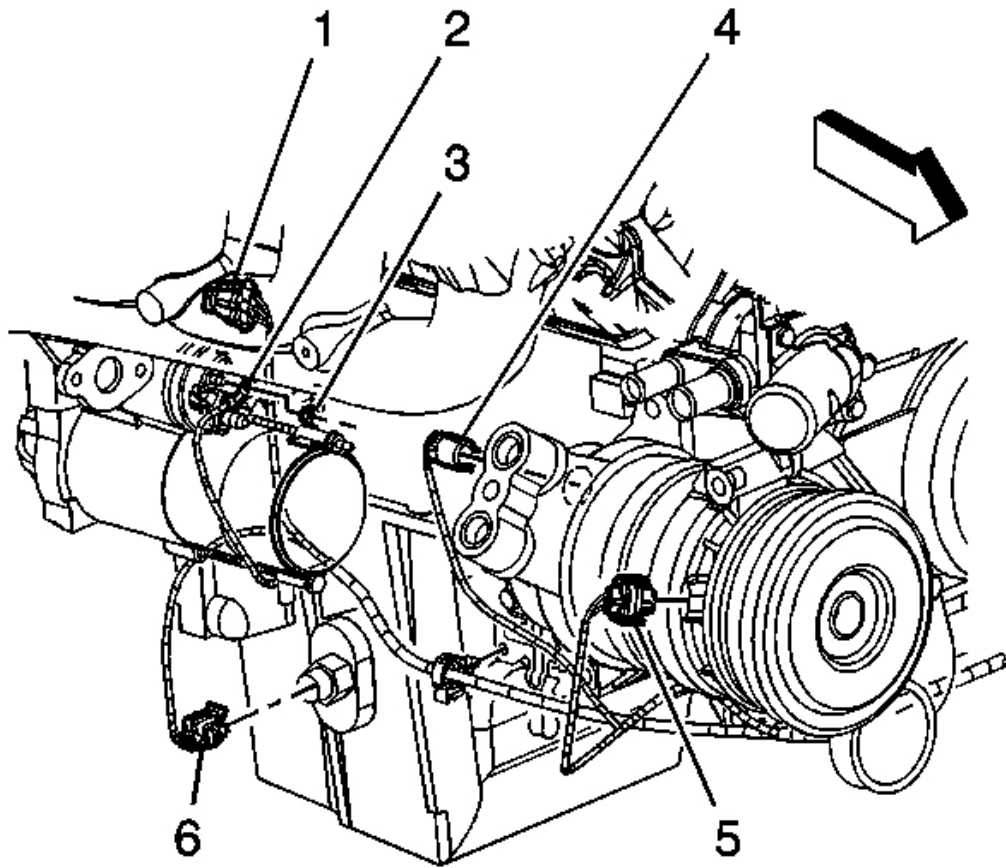
**Fig. 158: Identifying Stud & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the transmission bolt and stud on the right side.



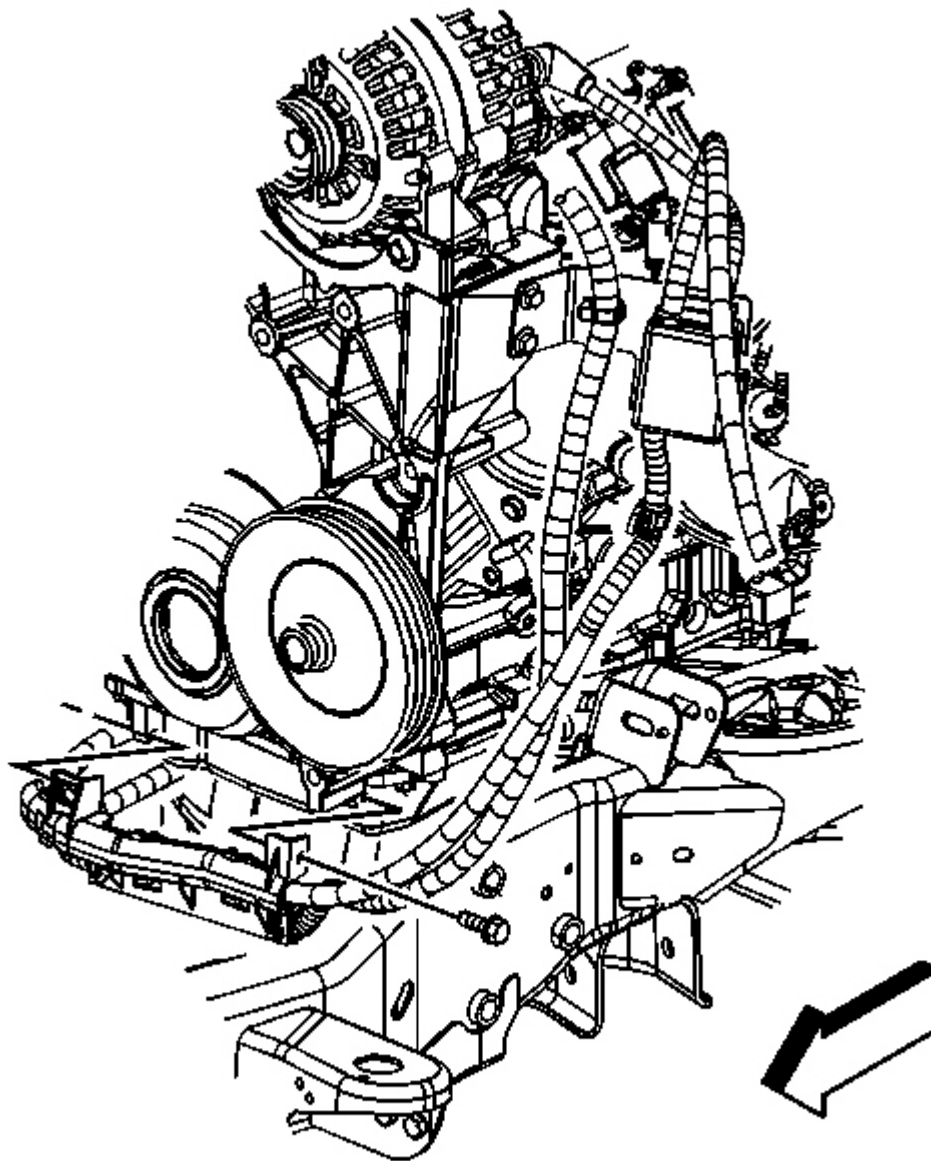
**Fig. 159: Identifying Studs & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the bottom bolt on the left side.



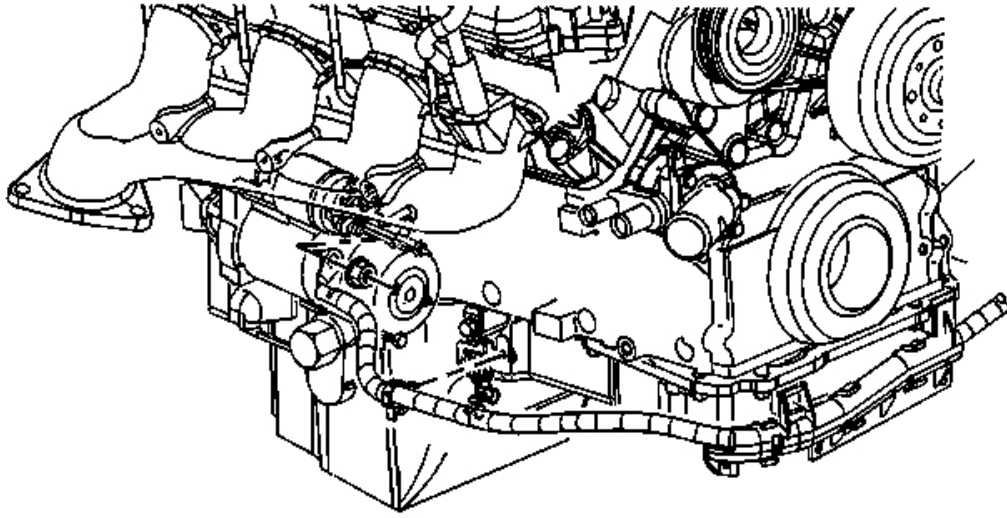
**Fig. 160: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the oil level sensor electrical connector (6).



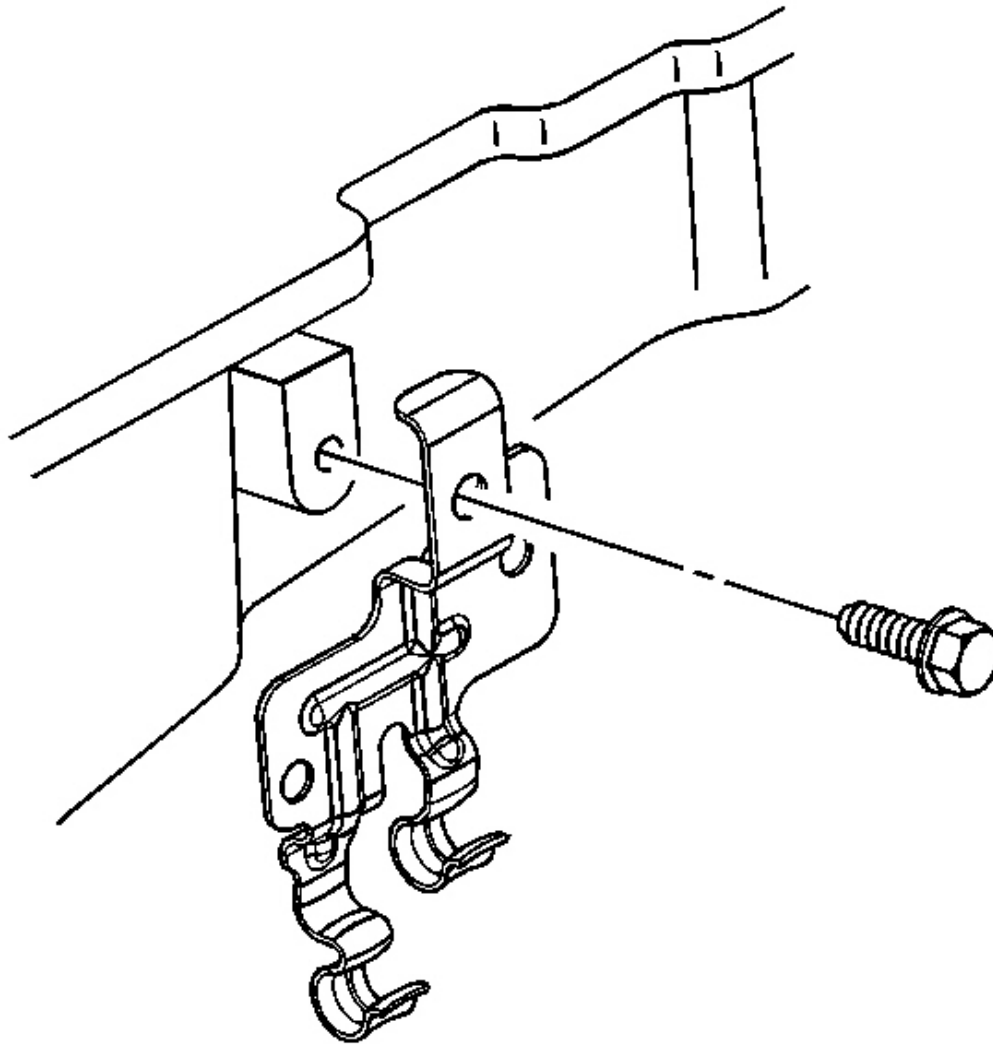
**Fig. 161: Battery Cable Channel Bolt**  
Courtesy of GENERAL MOTORS CORP.

11. Remove the battery cable channel bolt.
12. Slide the channel pin out of the oil pan tab.



**Fig. 162: Positive Battery Cable Clip**  
**Courtesy of GENERAL MOTORS CORP.**

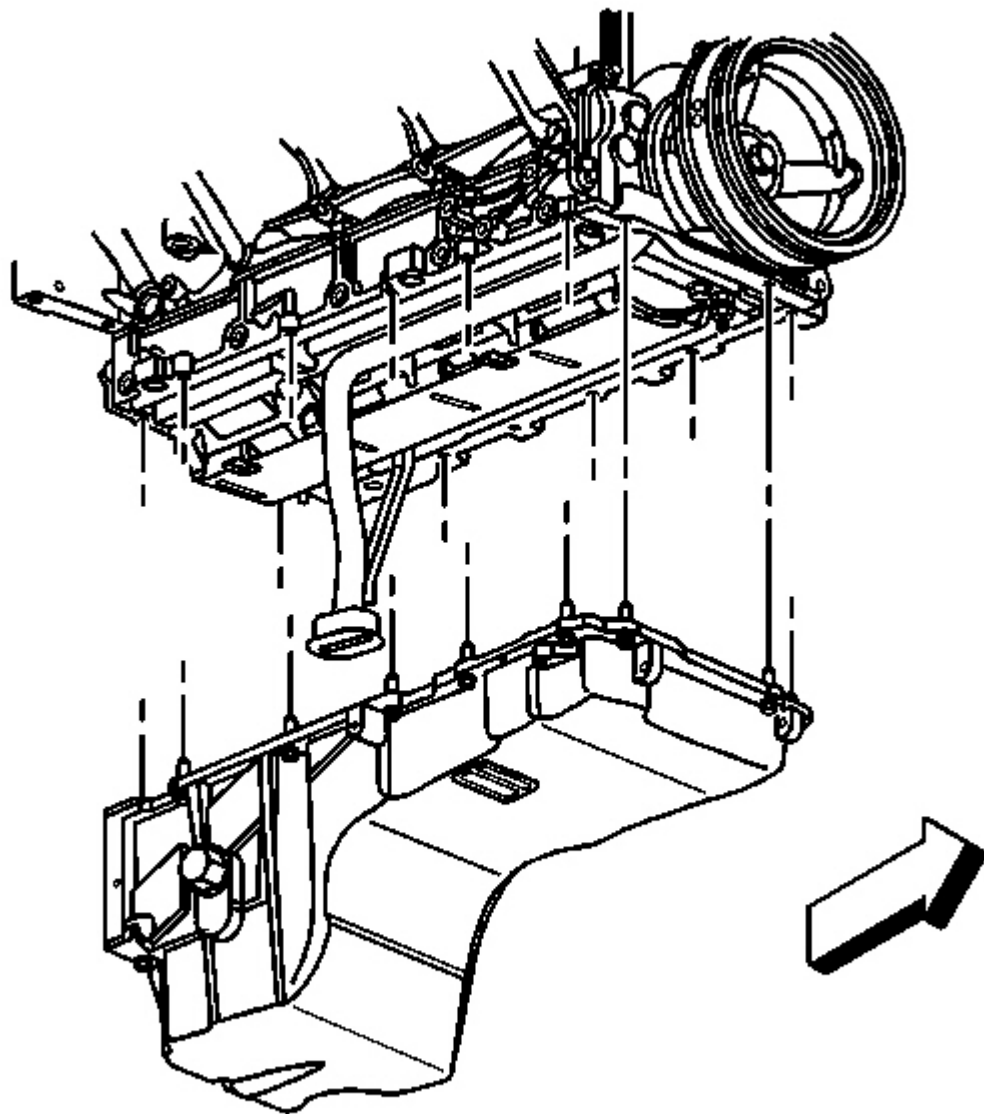
13. Remove the following from the positive battery cable clip:
  - Engine wiring harness clip
  - Positive battery cable clip



**Fig. 163: Positive Battery Cable Clip & Bolt**  
Courtesy of GENERAL MOTORS CORP.

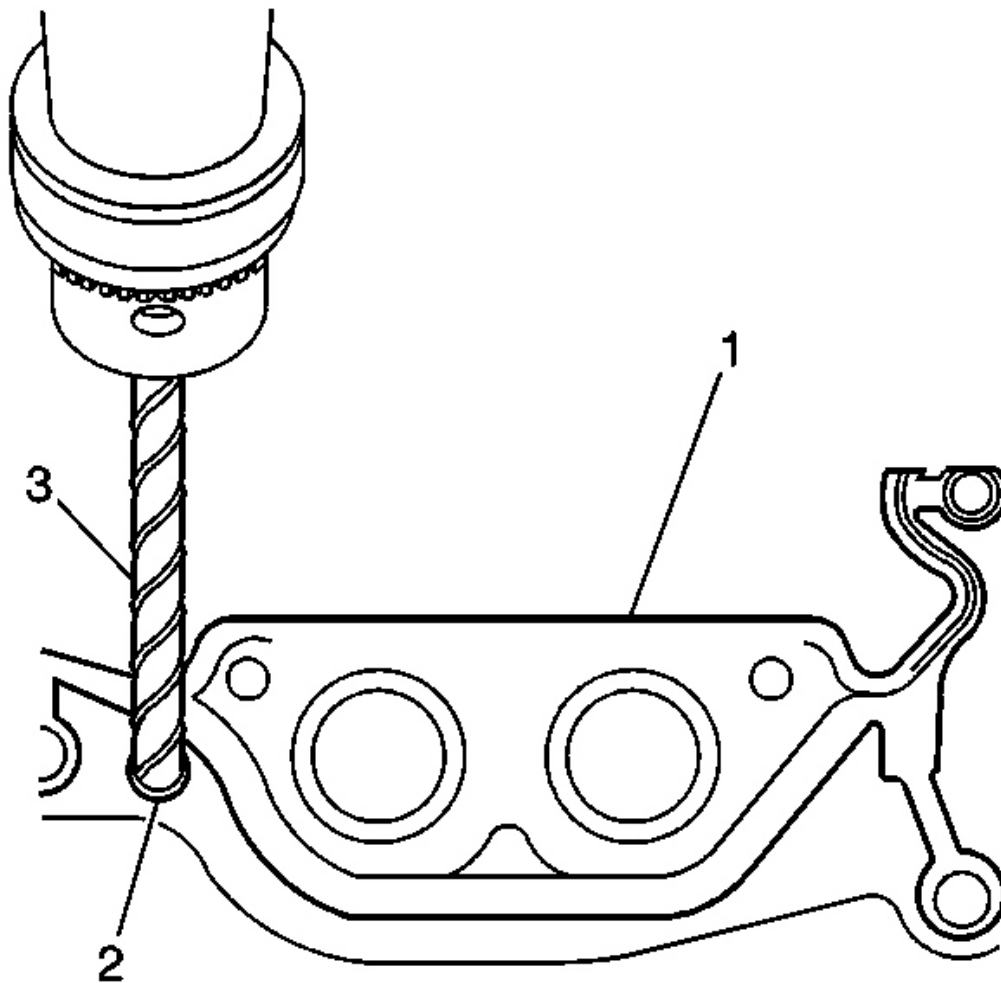
14. Remove the engine oil cooler lines from the positive battery cable clip.
15. Remove the positive battery cable clip bolt and clip.





**Fig. 164: View Of Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil pan bolts.
17. Remove the oil pan.



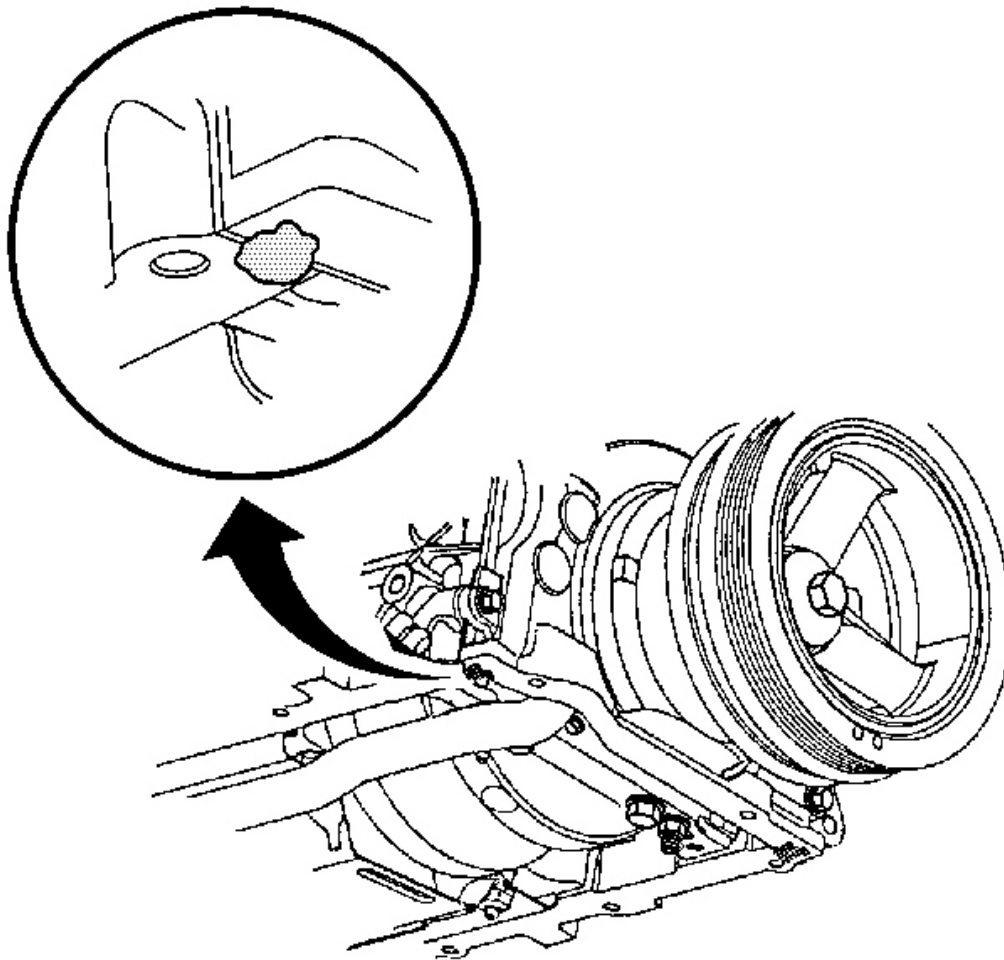
**Fig. 165: Drilling Out Oil Pan Gasket Retaining Rivets**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: DO NOT** allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.

18. Drill (3) out the oil pan gasket retaining rivets (2), if required.
19. Remove the gasket (1) from the pan.
20. Discard the gasket and rivets.
21. Clean and inspect the engine oil pan. Refer to **Oil Pan Cleaning and Inspection** .

**IMPORTANT:**

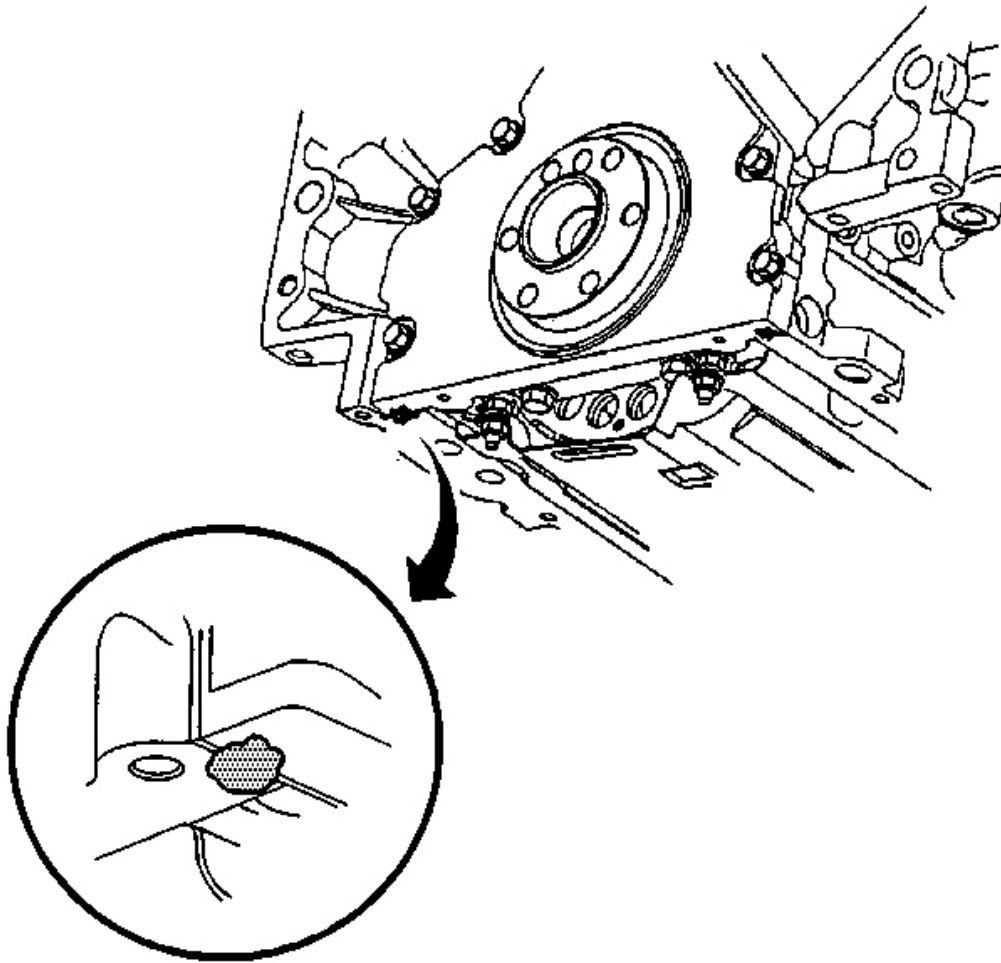
- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission bellhousing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan must **NEVER** protrude beyond the engine block and transmission bellhousing plane.
- Do not reuse the oil pan gasket.
- It is not necessary to rivet the **NEW** gasket to the oil pan.



**Fig. 166: Sealant Applied To Front Oil Pan-To-Engine Block Junction**

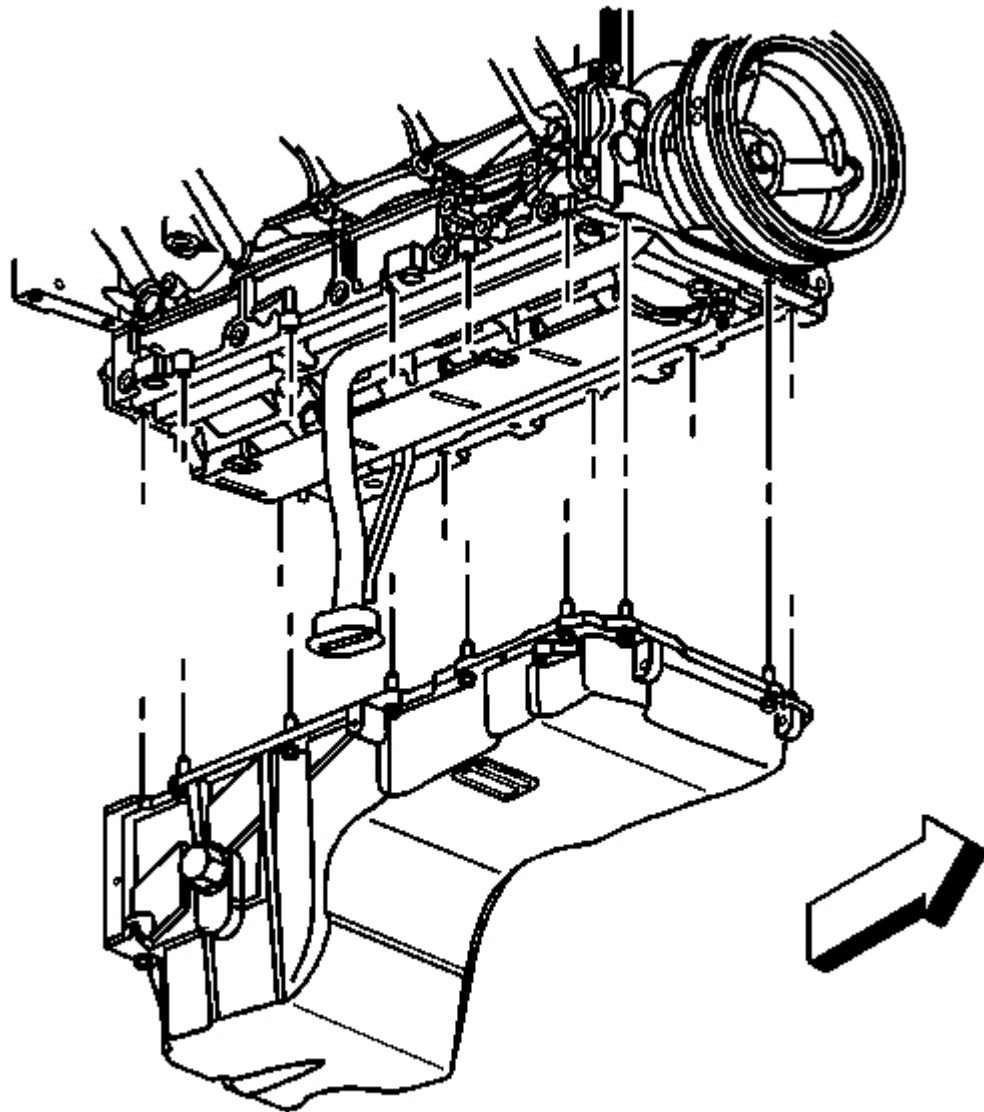
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrudes into the oil pan surface.



**Fig. 167: Sealant Applied To Rear Oil Pan-To-Engine Block Junction**  
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrudes into the oil pan surface.

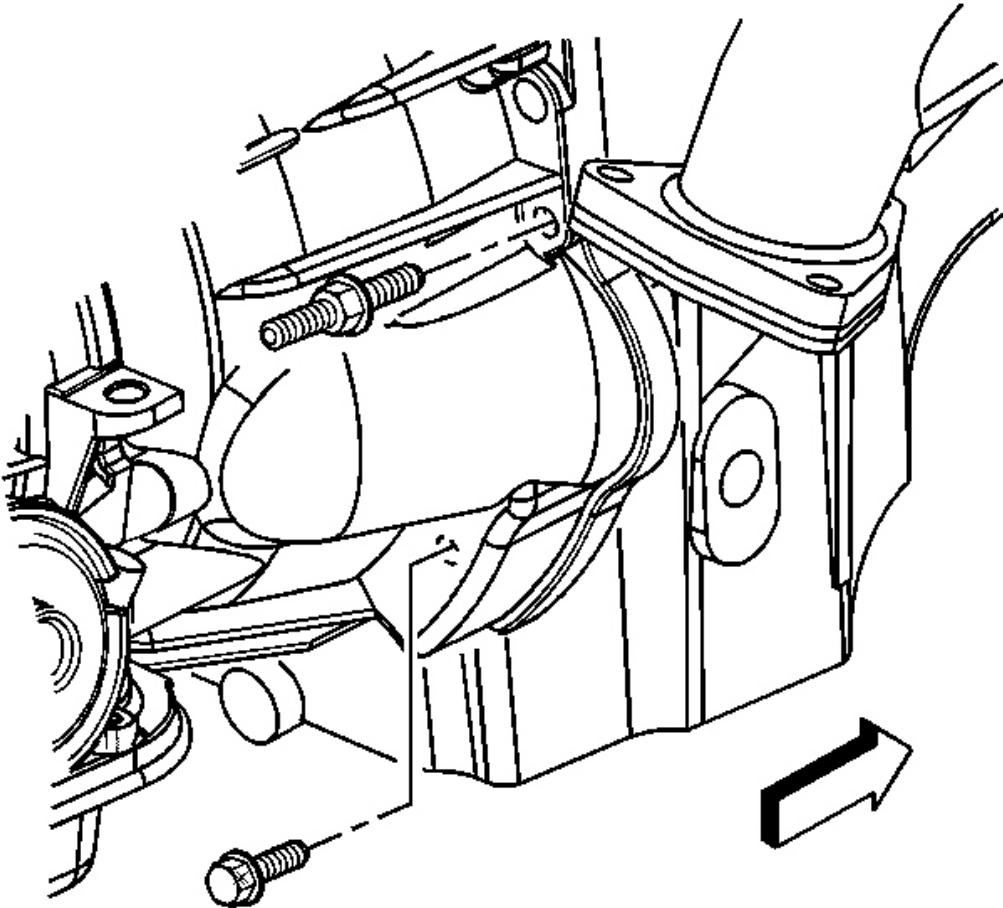


**Fig. 168: View Of Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

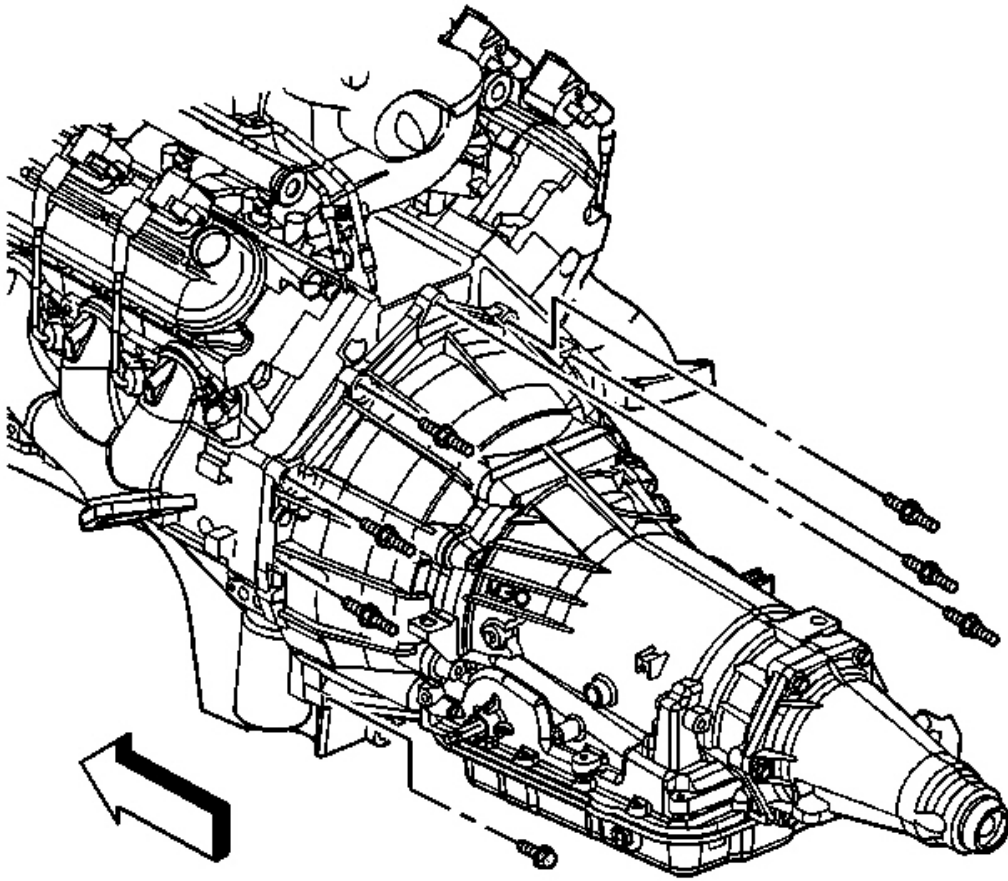
3. Pre-assemble the oil pan gasket to the pan.

- Install the gasket onto the pan.
  - Install the oil pan bolts to the pan and through the gasket.
4. Install the oil pan, gasket and bolts to the engine block.
  5. Tighten the oil pan bolts until snug. Do not overtighten.



**Fig. 169: Identifying Stud & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

6. Install the transmission bolt and stud on the right side until snug.



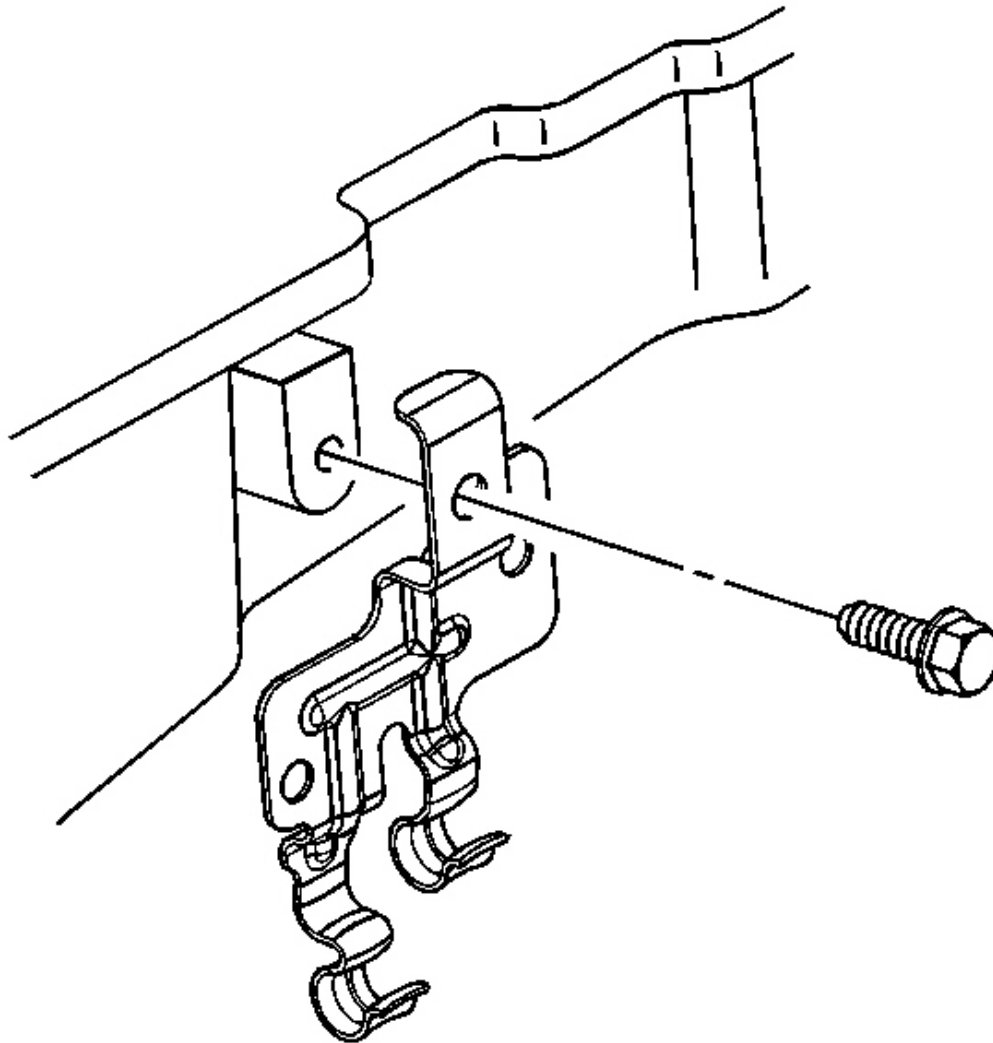
**Fig. 170: Identifying Studs & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

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

7. Install the bottom bolt on the left side until snug.

**Tighten:**

1. Tighten the oil pan and oil pan-to-oil pan front cover bolts to 25 N.m (18 lb ft).
2. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
3. Tighten the bellhousing, converter cover, and transmission bolts/stud to 50 N.m (37 lb ft).



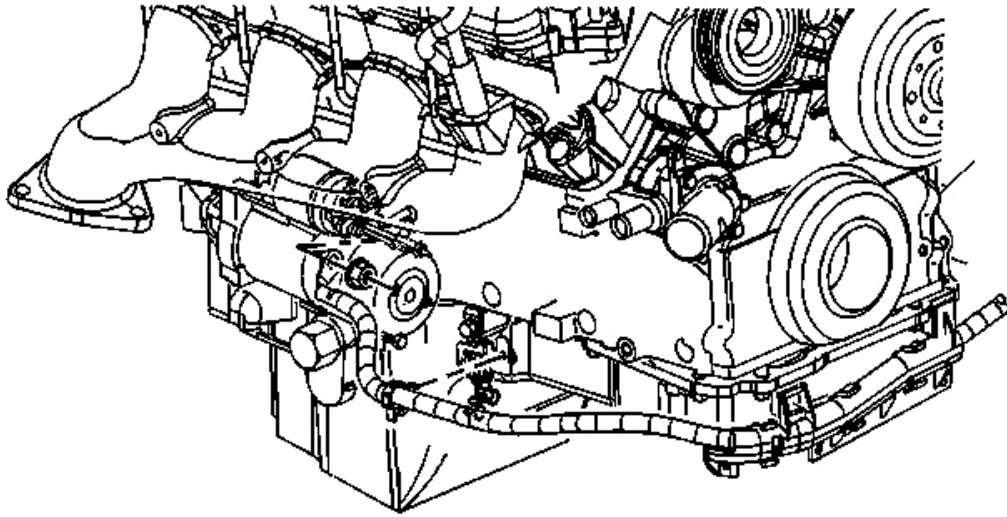
**Fig. 171: Positive Battery Cable Clip & Bolt**  
Courtesy of GENERAL MOTORS CORP.

8. Install the positive battery cable clip and bolt to the oil pan.

**Tighten:** Tighten the positive battery cable clip bolt to 9 N.m (80 lb in).

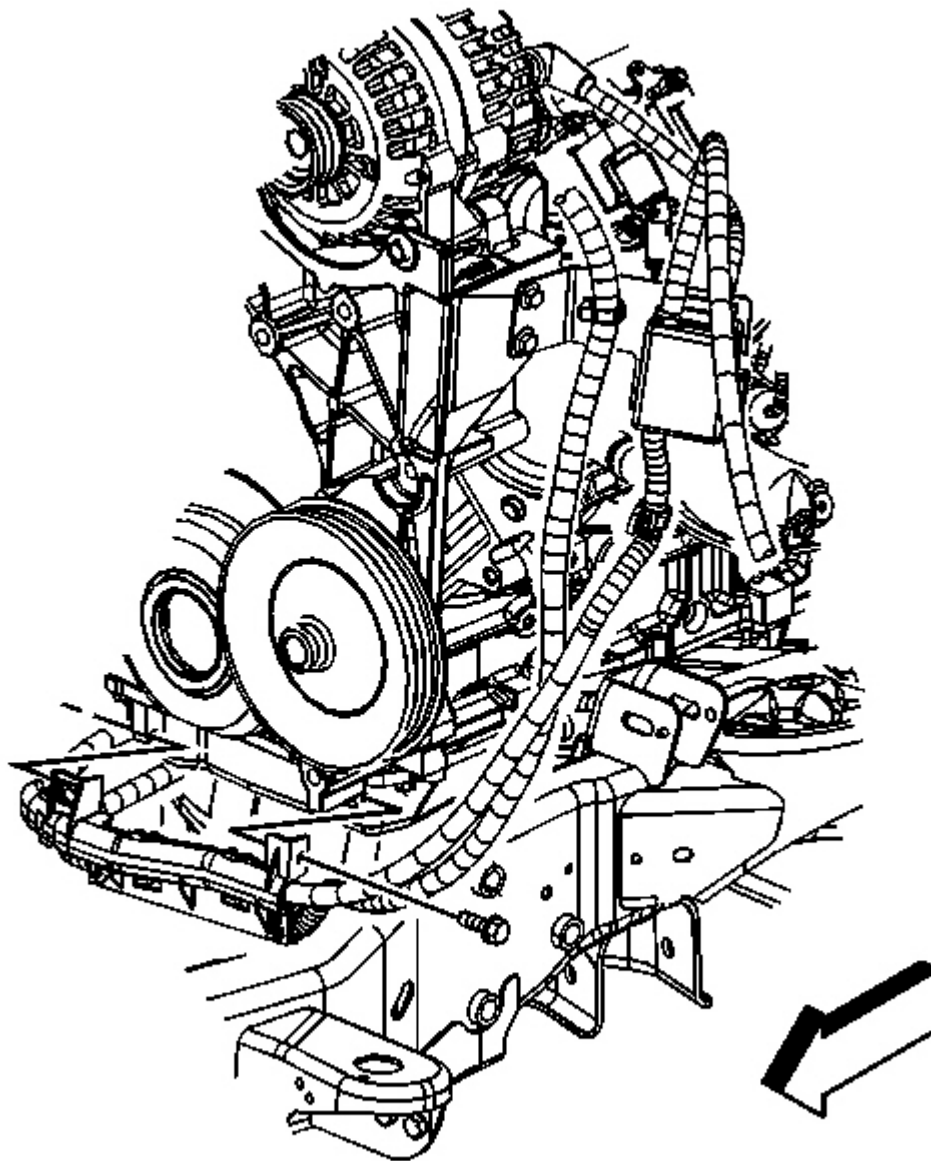
9. Install the engine oil cooler lines to the positive battery cable clip.





**Fig. 172: Positive Battery Cable Clip**  
**Courtesy of GENERAL MOTORS CORP.**

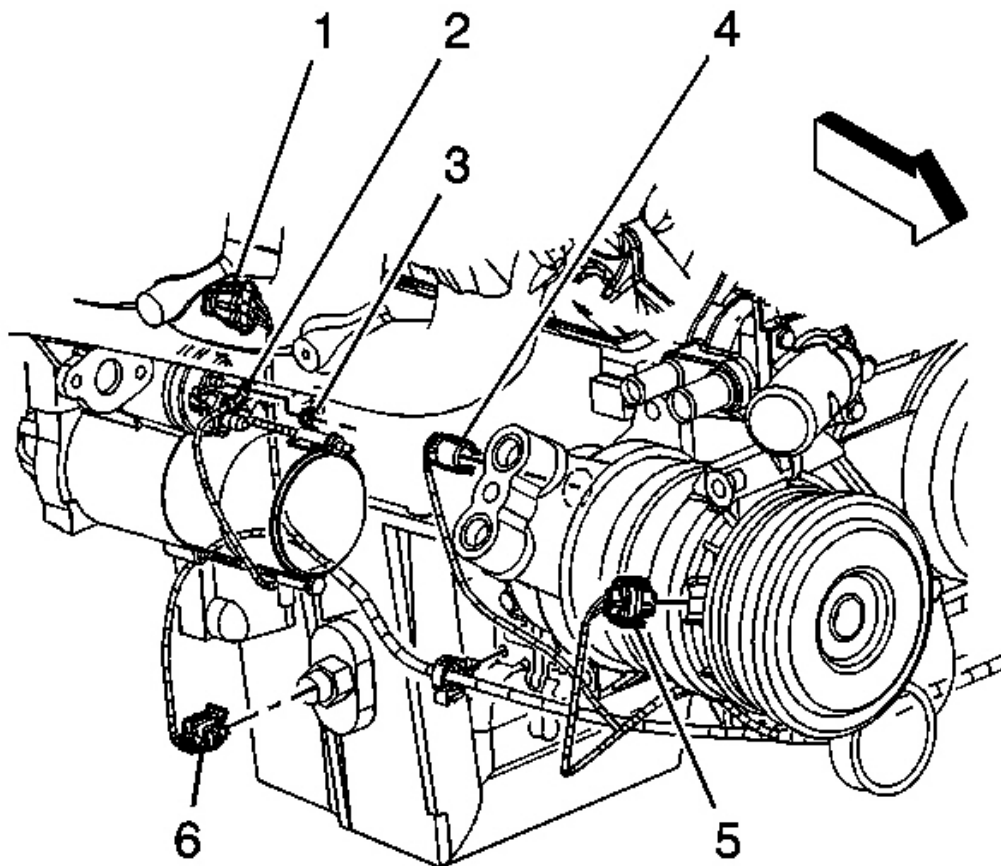
10. Install the following to the positive battery cable clip:
  - Engine wiring harness clip
  - Positive battery cable clip



**Fig. 173: Battery Cable Channel Bolt**  
Courtesy of GENERAL MOTORS CORP.

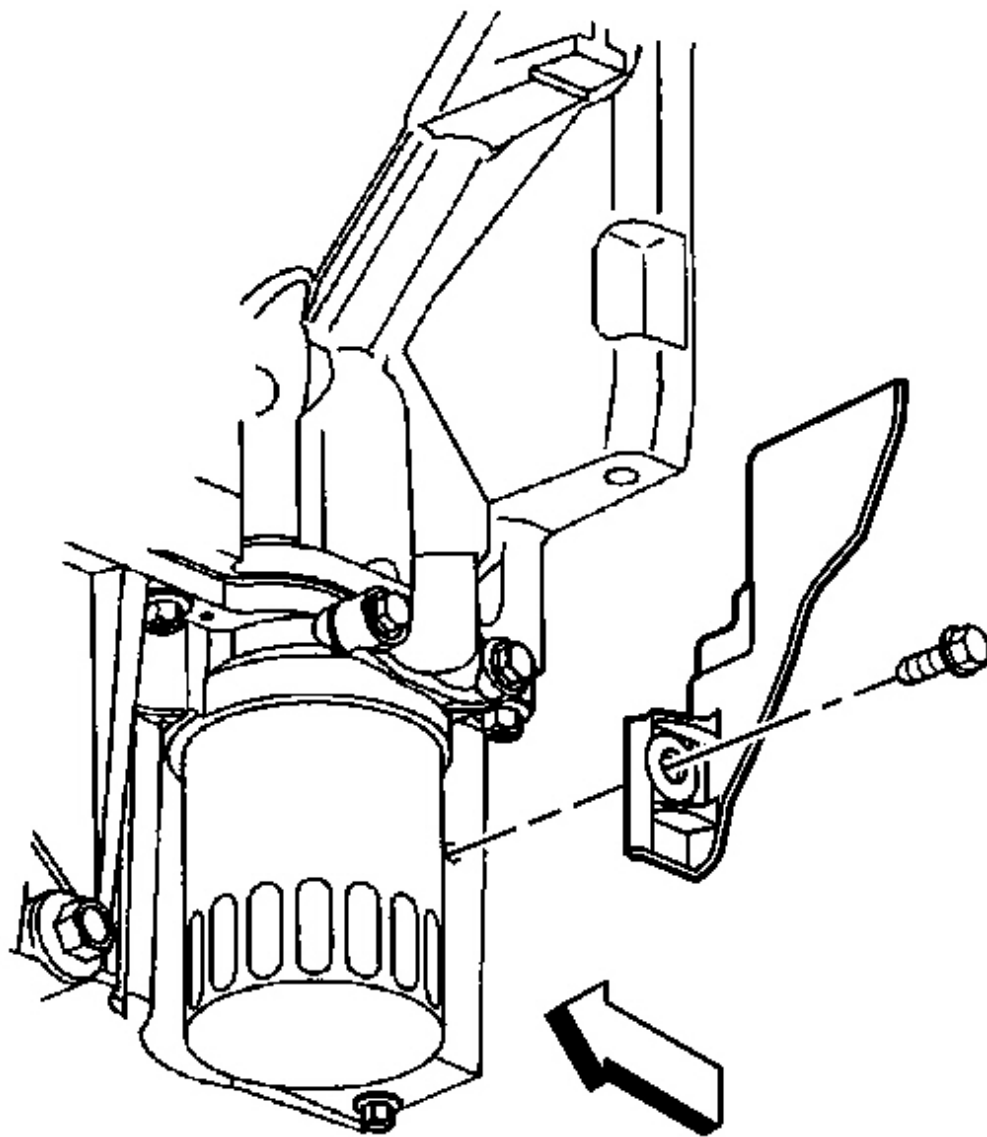
11. Slide the channel pin in to the oil pan tab.
12. Install the battery cable channel bolt.

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



**Fig. 174: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

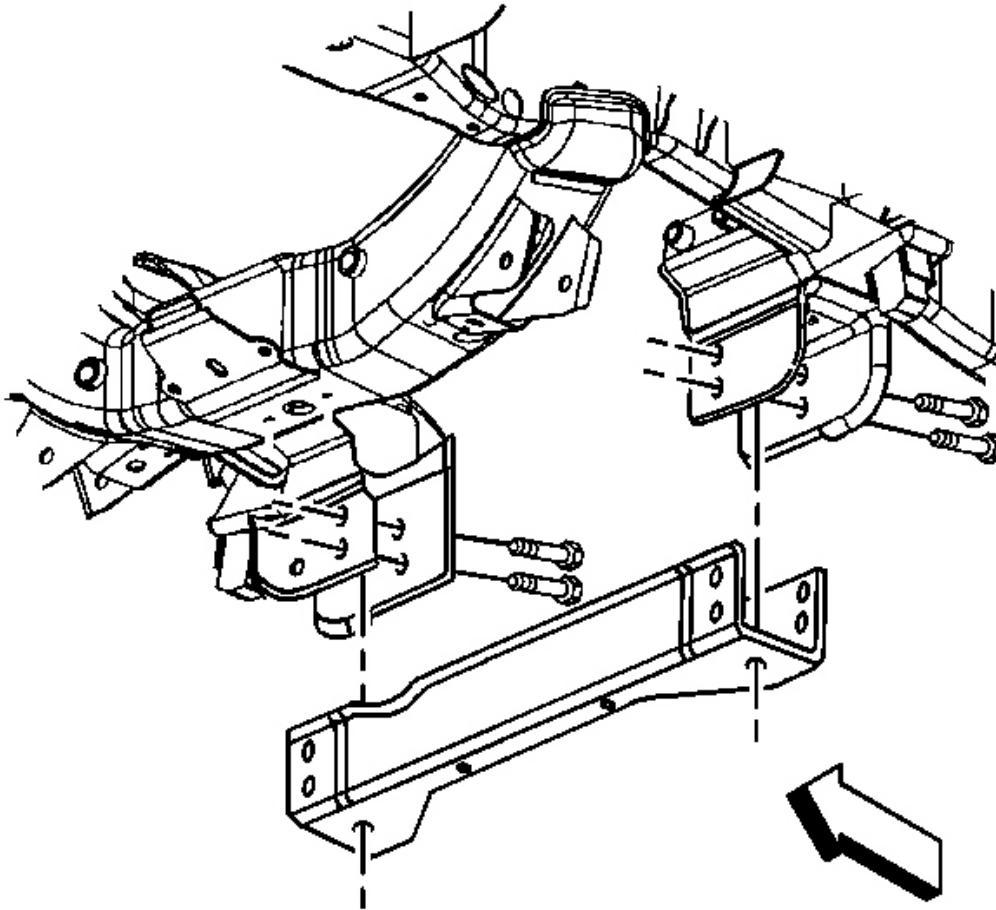
13. Connect the oil level sensor electrical connector (6).



**Fig. 175: Left Closeout Cover & Bolt**  
Courtesy of GENERAL MOTORS CORP.

14. Install the transmission cover and bolt.

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



**Fig. 176: Crossbar & Engine (2WD)**  
Courtesy of GENERAL MOTORS CORP.

15. Install the crossbar.
16. Install the crossbar bolts.

**Tighten:** Tighten the crossbar bolts to 100 N.m (74 lb ft).

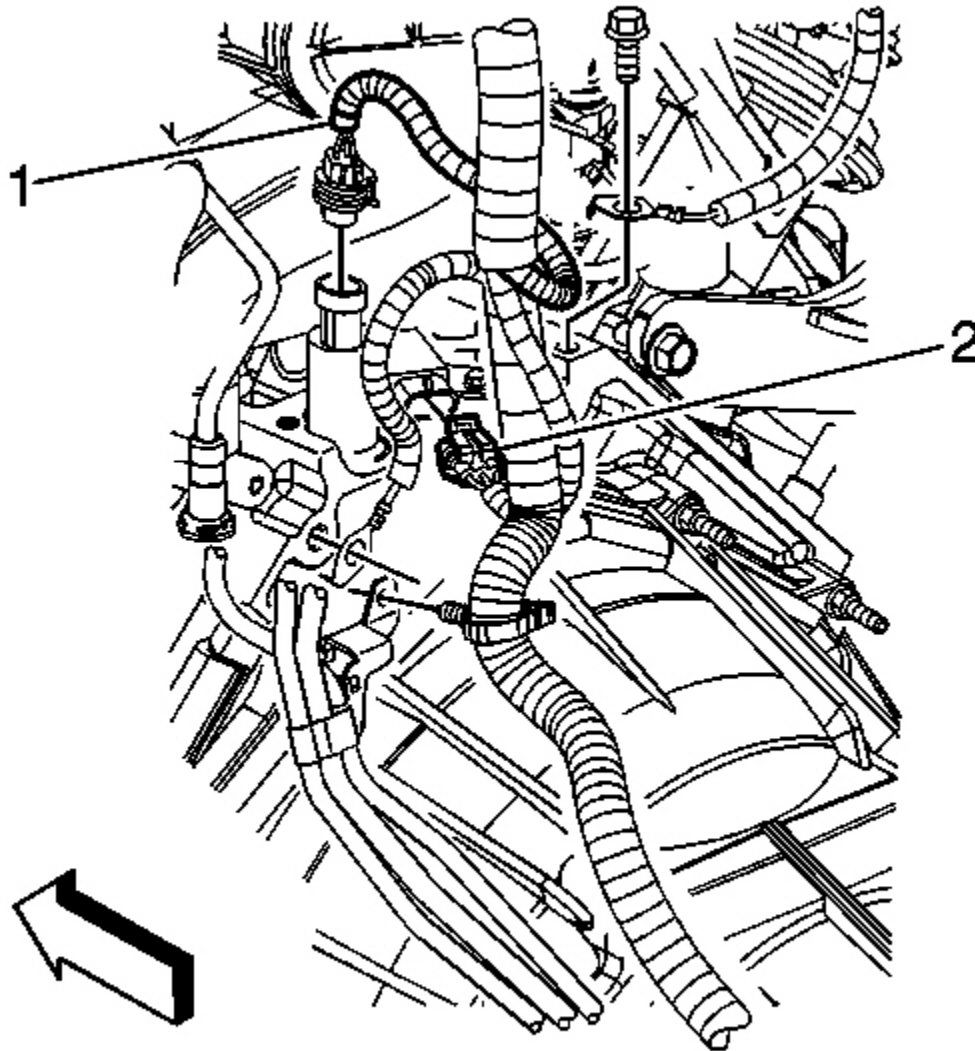
17. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
18. Install the front differential. Refer to **Differential Carrier Assembly Replacement** in Driveline Axle.
19. Install new engine oil and a new oil filter. Refer to **Engine Oil and Oil Filter Replacement** .

## ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

## Tools Required

J 41712 Oil Pressure Sensor Socket

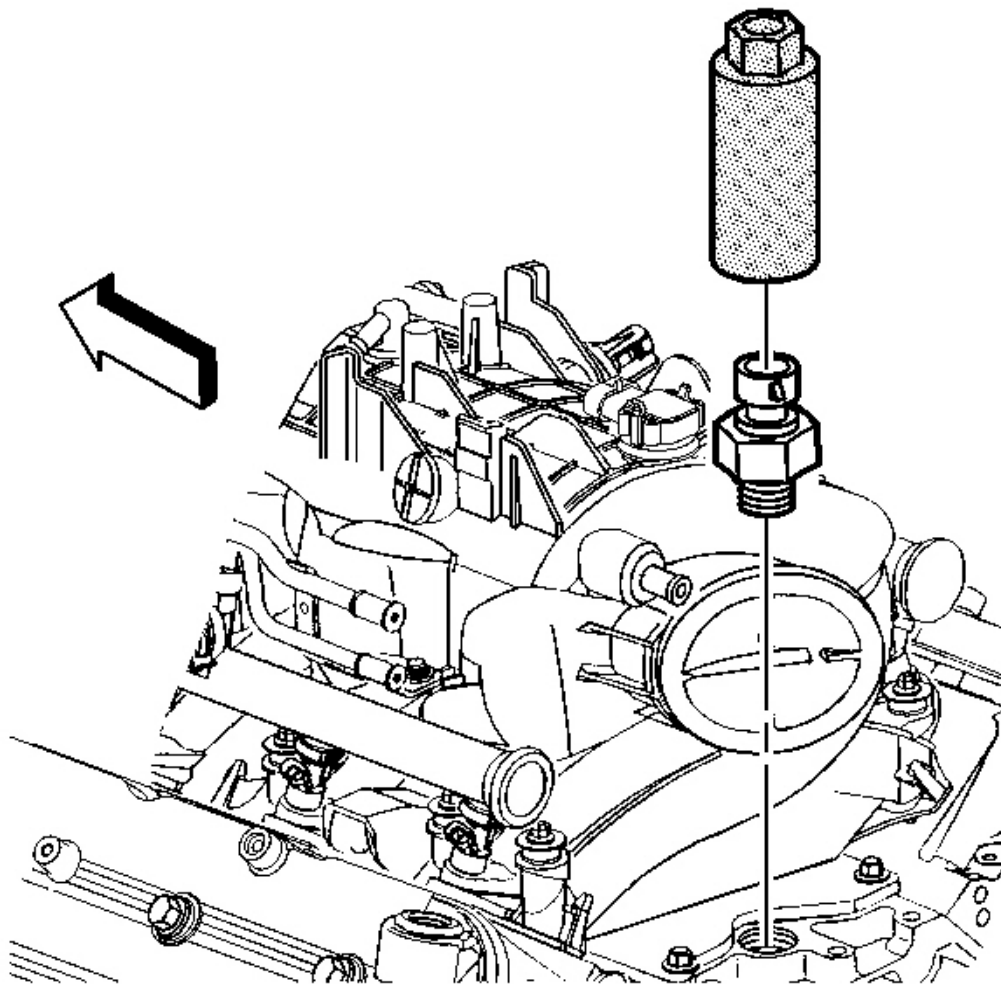
## Removal Procedure



**Fig. 177: Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

1. If necessary, remove the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LO4))**.

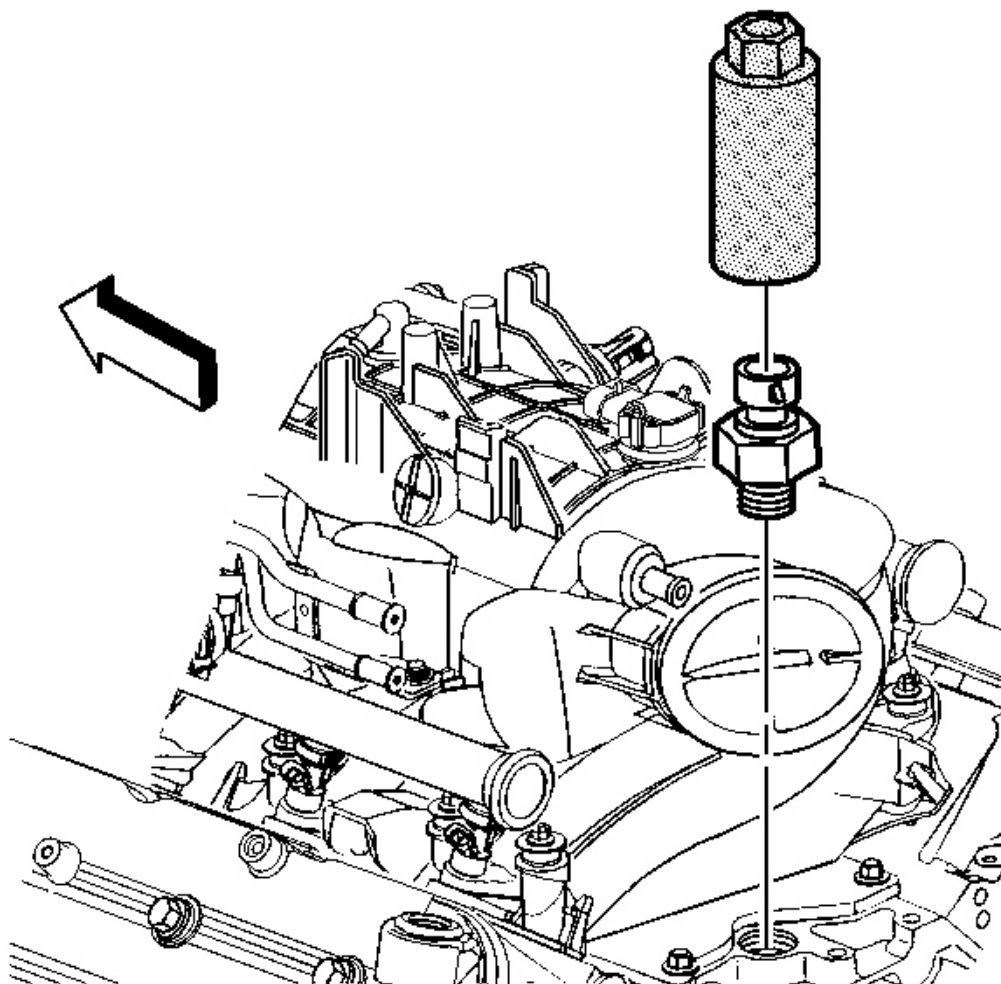
2. Disconnect the oil pressure sensor electrical connector (1).



**Fig. 178: Oil Pressure Sensor & J 41712**  
Courtesy of GENERAL MOTORS CORP.

3. Using J 41712 or equivalent, remove the oil pressure sensor.

#### **Installation Procedure**



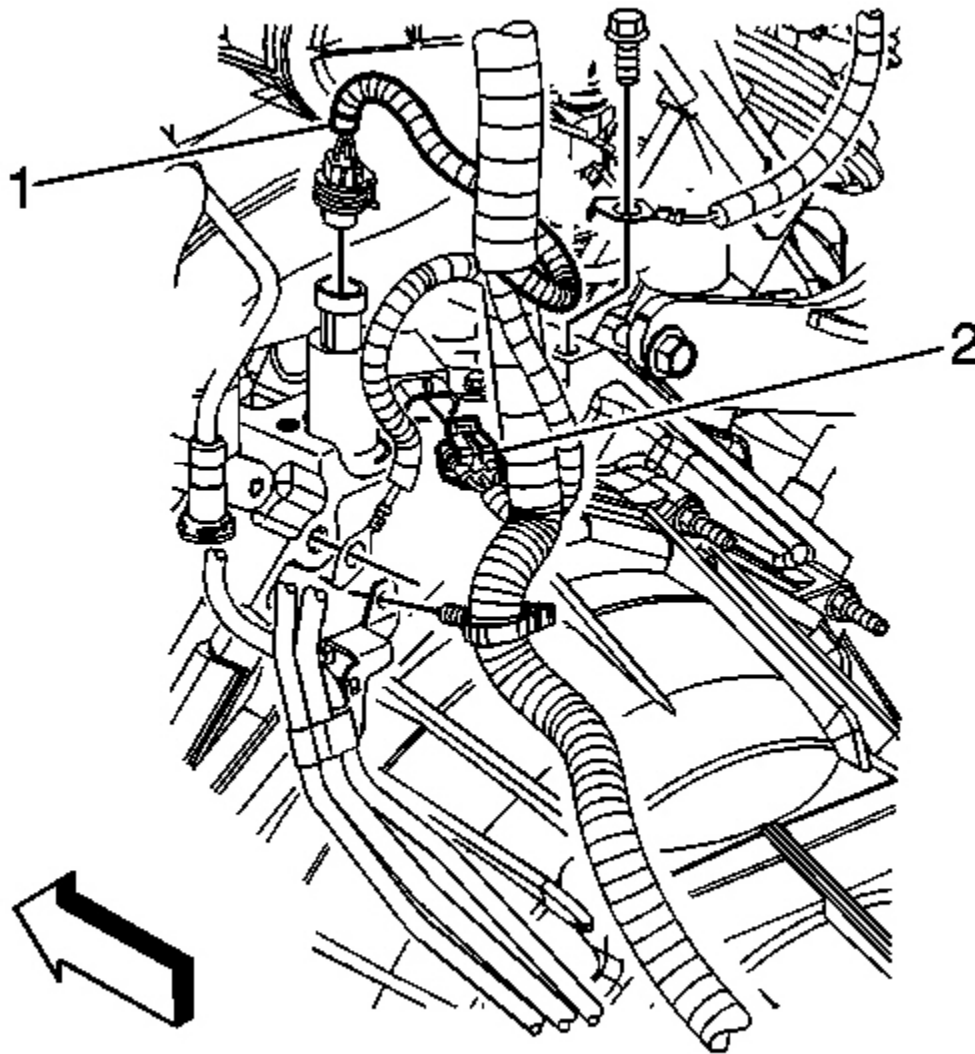
**Fig. 179: Oil Pressure Sensor & J 41712**  
Courtesy of GENERAL MOTORS CORP.

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

1. Apply sealant GM U.S. P/N 12346004, Canada P/N 10953480, or equivalent, to the threads of the oil pressure sensor.
2. Using J 41712 or equivalent, install the oil pressure sensor.

**Tighten:** Tighten the oil pressure sensor to 20 N.m (15 lb ft).



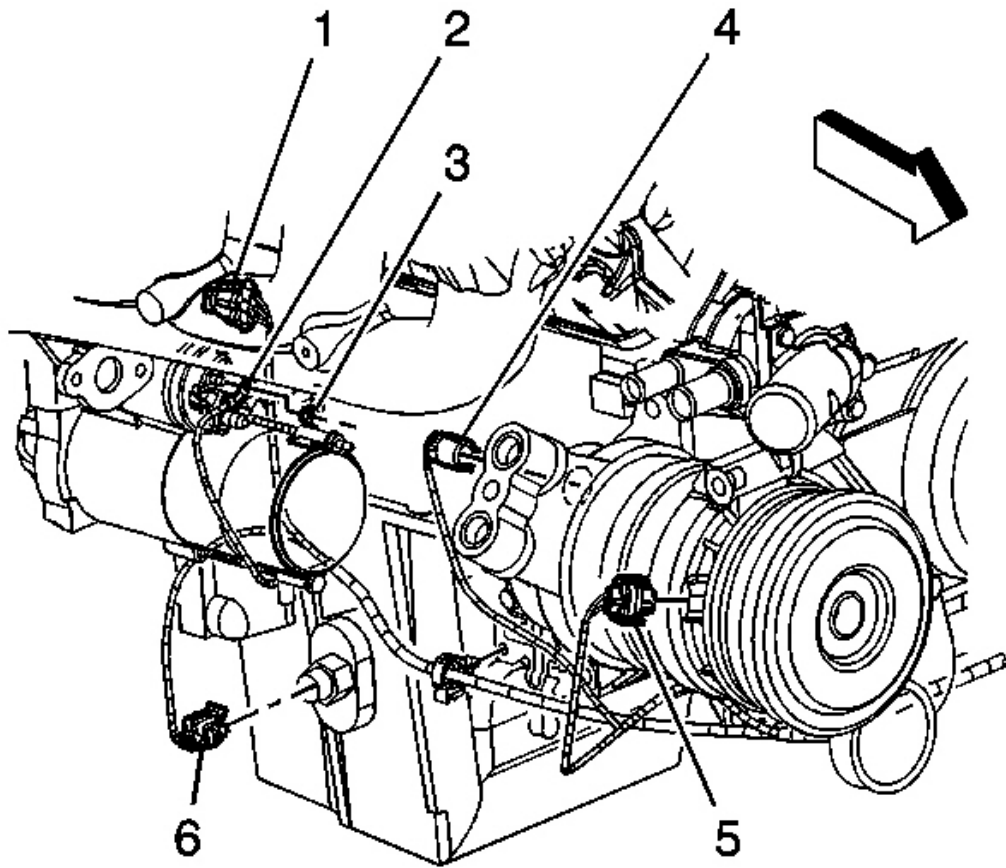


**Fig. 180: Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (1).
4. If necessary, install the engine sight shield. Refer to **Engine Sight Shield Replacement (6.0L (LQ4))**.

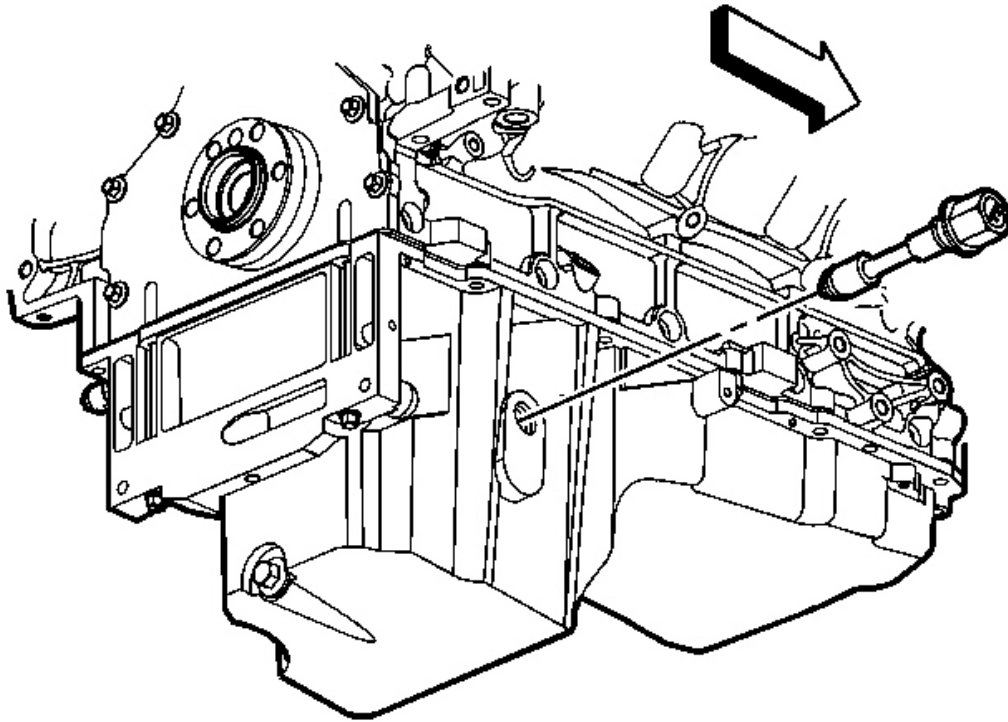
## **ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT**

### **Removal Procedure**



**Fig. 181: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

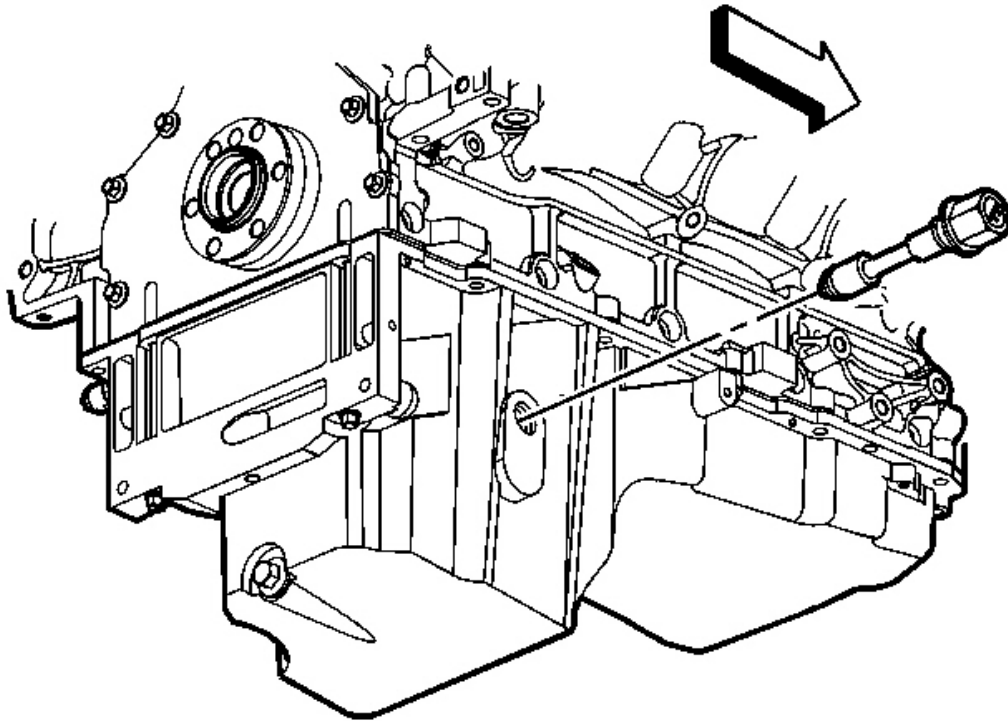
1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
2. Disconnect the oil level sensor electrical connector (6).



**Fig. 182: Oil Level Sensor**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level sensor from the oil pan.

#### **Installation Procedure**

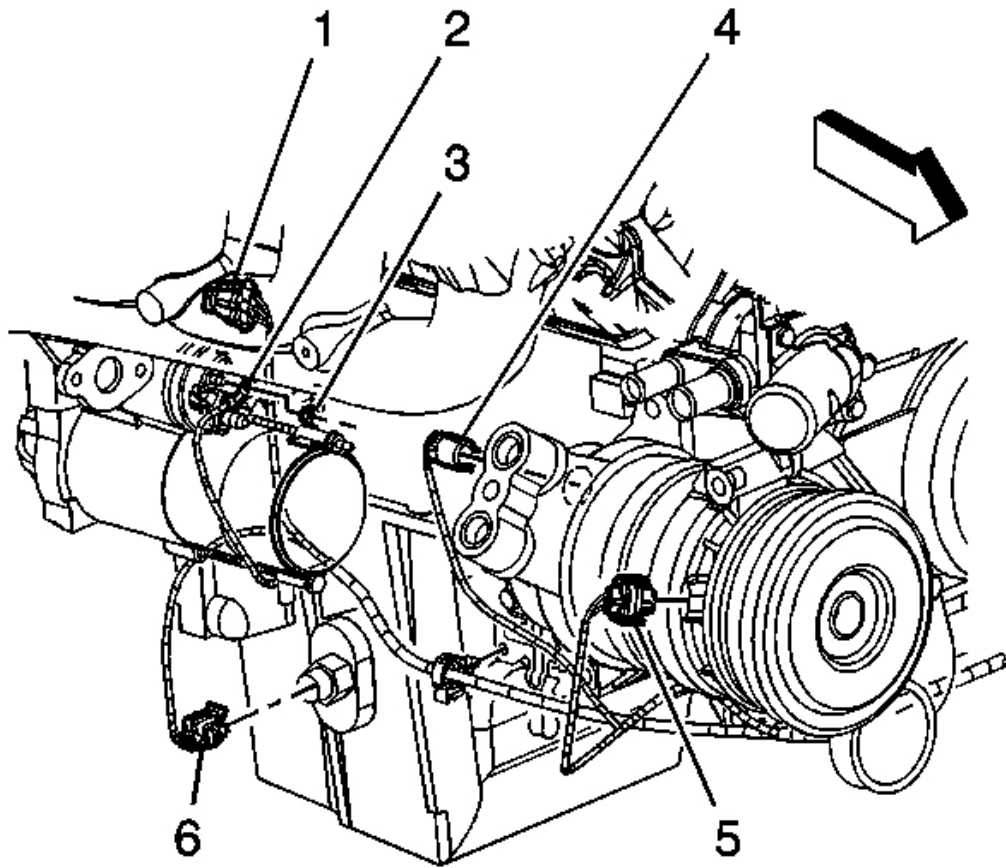


**Fig. 183: Oil Level Sensor**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil level sensor to the oil pan.

**Tighten:** Tighten the oil level sensor to 13 N.m (115 lb in).

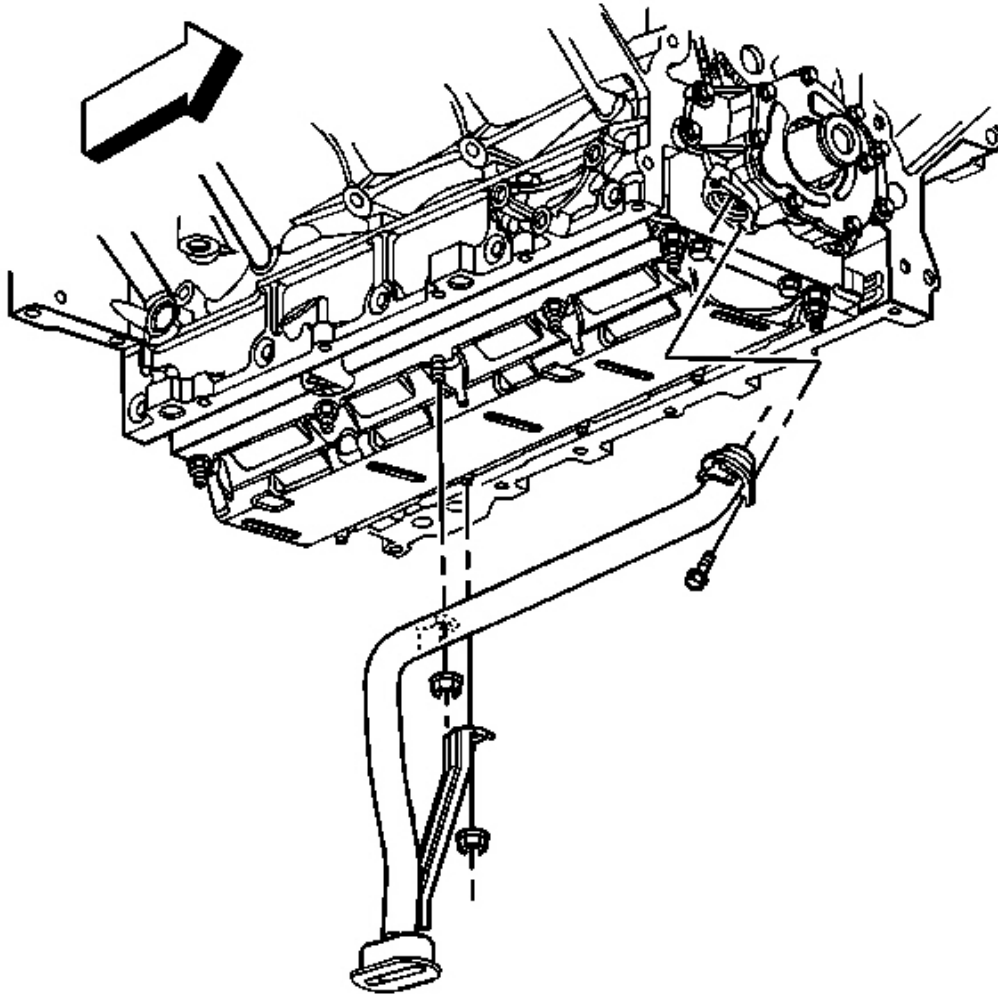


**Fig. 184: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

2. Connect the oil level sensor electrical connector (6).
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .

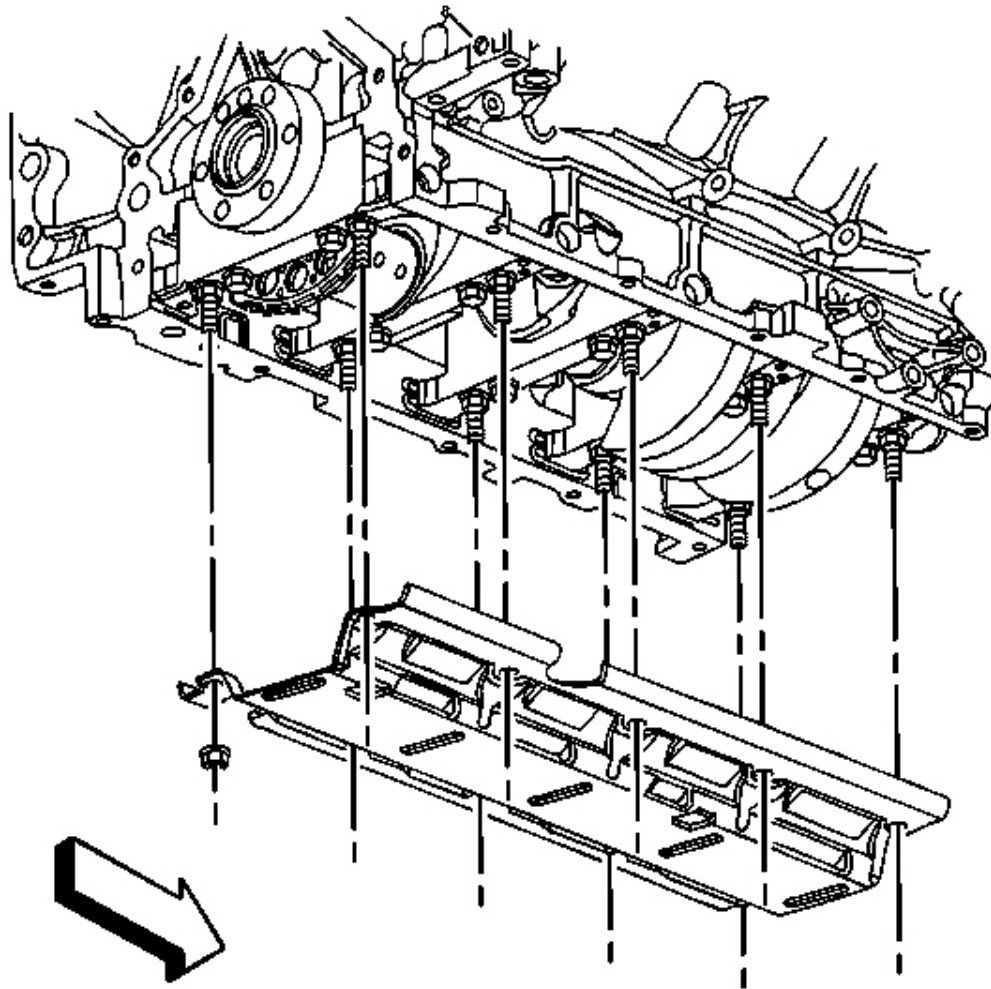
## **OIL PUMP, PUMP SCREEN AND DEFLECTOR REPLACEMENT**

### **Removal Procedure**



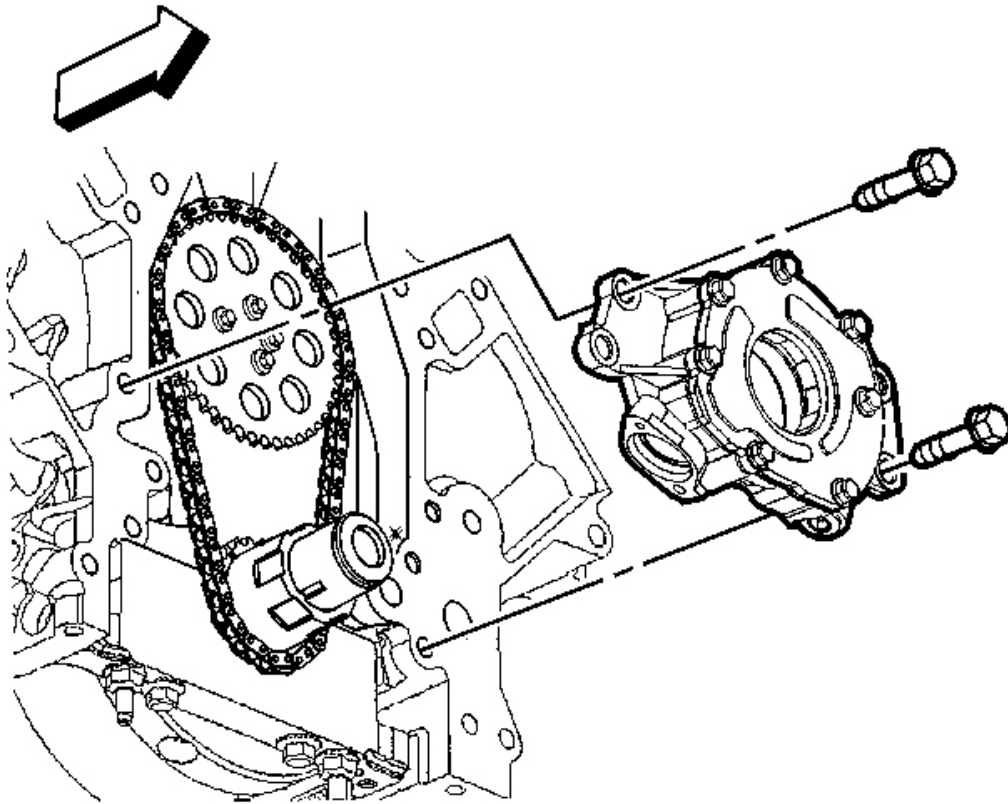
**Fig. 185: Oil Pump Screen & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement** .
2. Remove the engine front cover. Refer to **Engine Front Cover Replacement** .
3. Remove the oil pump screen bolt and nuts.
4. Remove the oil pump screen with O-ring seal.
5. Remove the O-ring seal from the pump screen.
6. Discard the O-ring seal.



**Fig. 186: Crankshaft Oil Deflector & Nuts**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the remaining crankshaft oil deflector nuts.
8. Remove the crankshaft oil deflector.



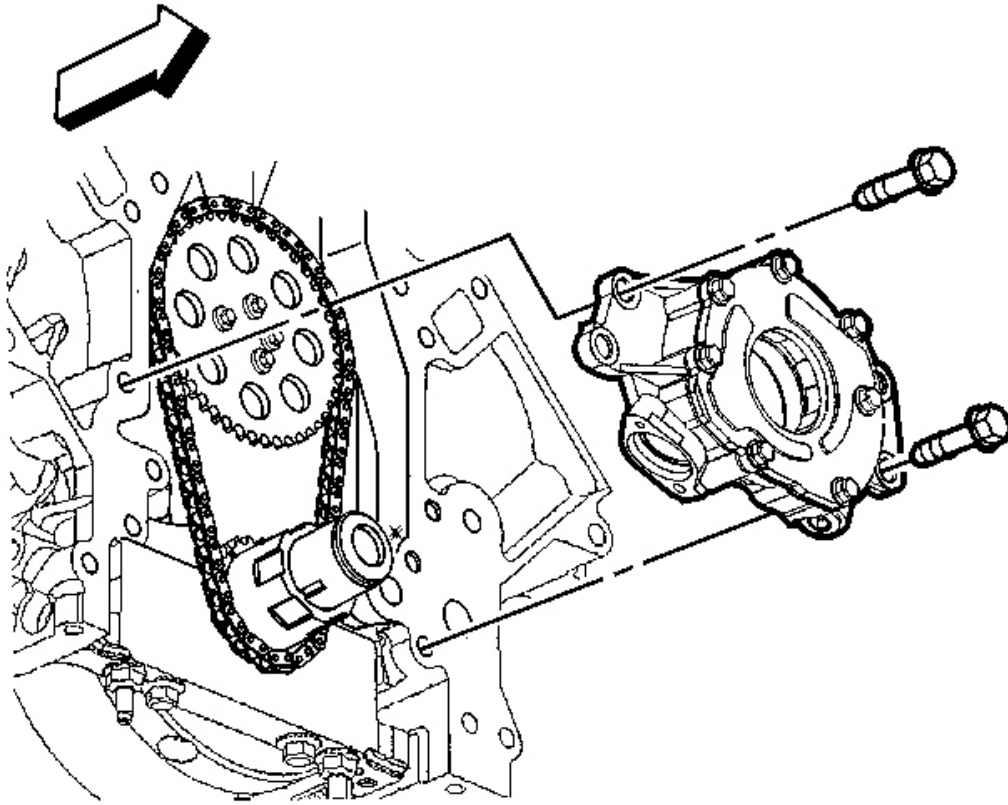
**Fig. 187: Oil Pump & Bolt**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Do not allow dirt or debris to enter the oil pump assembly, cap end as necessary.

9. Remove the oil pump bolts.
10. Remove the oil pump.
11. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection** .

#### **Installation Procedure**





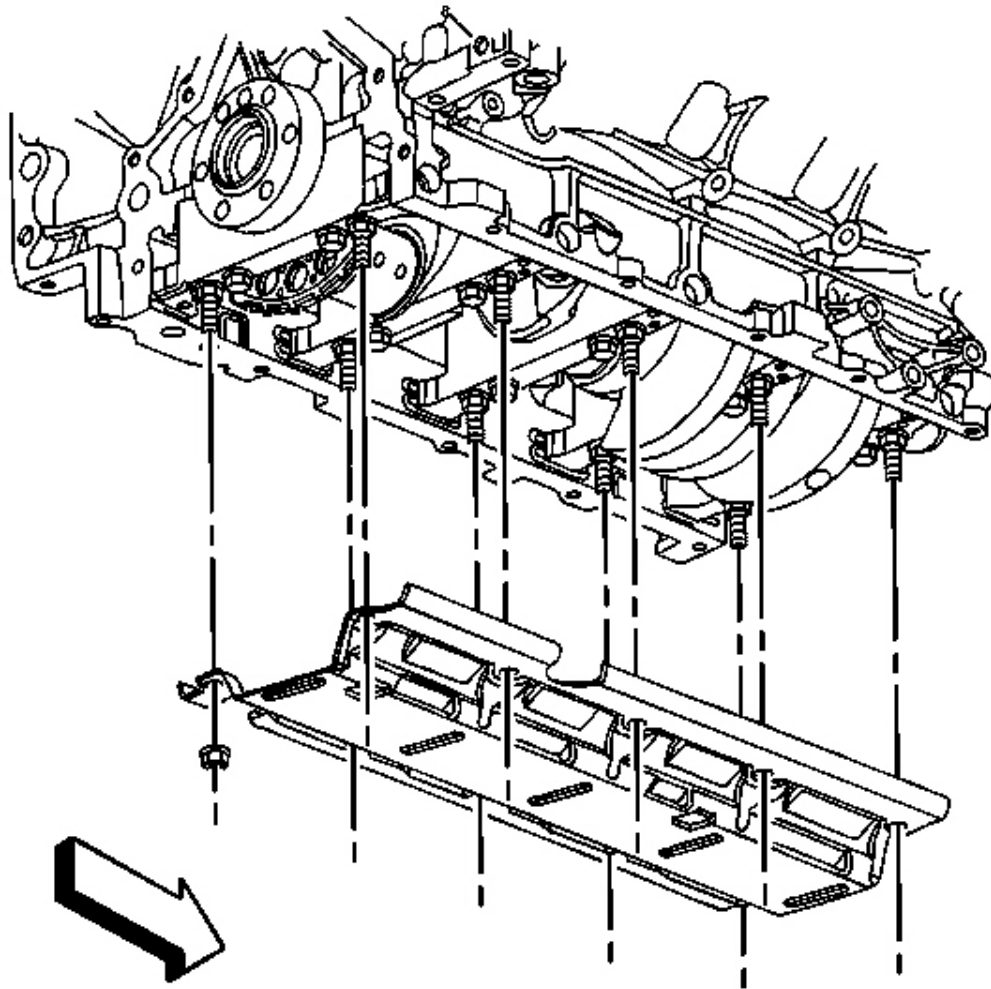
**Fig. 188: Oil Pump & Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

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

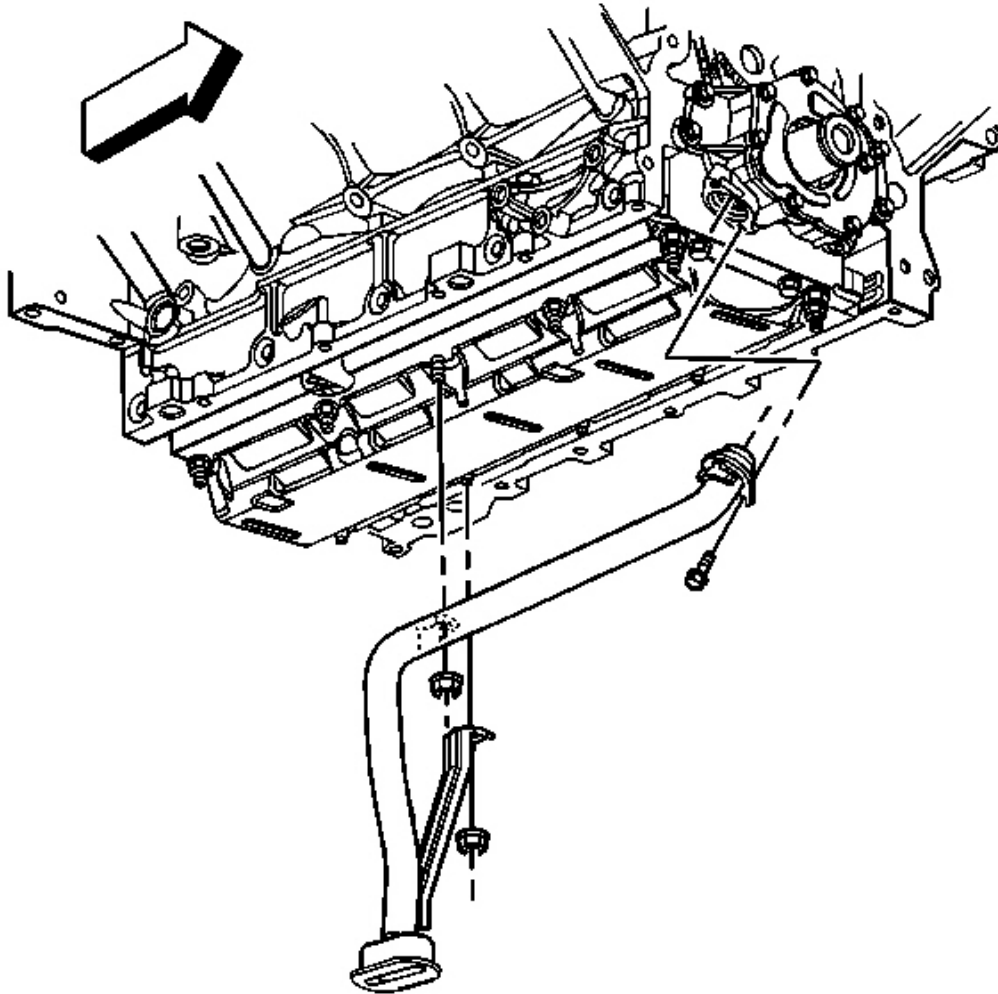
3. Install the oil pump bolts.

**Tighten:** Tighten the oil pump bolts to 25 N.m (18 lb ft).



**Fig. 189: Crankshaft Oil Deflector & Nuts**  
**Courtesy of GENERAL MOTORS CORP.**

4. Install the crankshaft oil deflector and nuts until snug.



**Fig. 190: Oil Pump Screen & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

**IMPORTANT: Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.**

Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.

7. Install the oil pump screen.
8. Install the oil pump screen bolt and nuts.

**Tighten:**

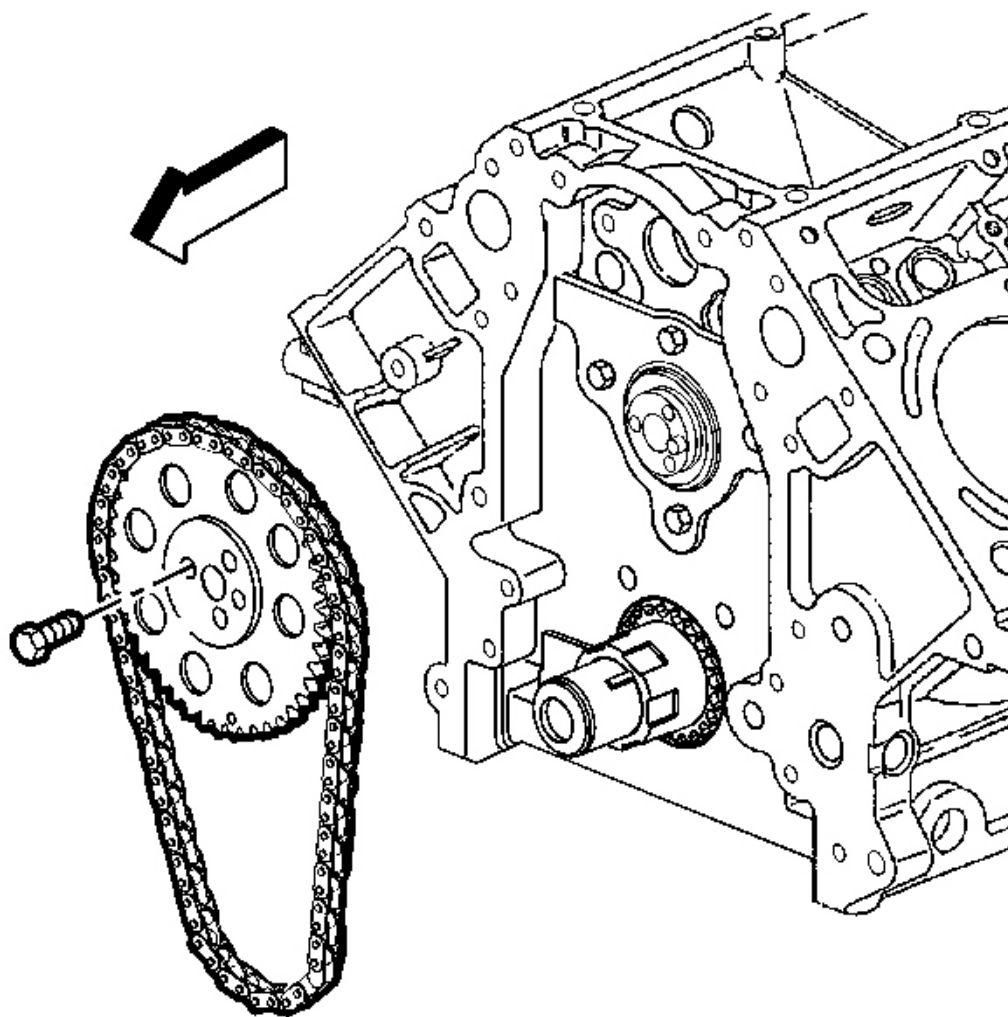
1. Tighten the oil pump screen bolt to 12 N.m (106 lb in).
  2. Tighten the crankshaft oil deflector/oil pump screen nuts to 25 N.m (18 lb ft).
9. Install the engine front cover. Refer to **Engine Front Cover Replacement** .
  10. Install the oil pan. Refer to **Oil Pan Replacement** .

## **TIMING CHAIN AND SPROCKETS REPLACEMENT**

### **Tools Required**

- J 8433 Two Jaw Puller
- J 41816-2 Crankshaft End Protector
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools and Equipment** .
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools and Equipment** .

### **Removal Procedure**



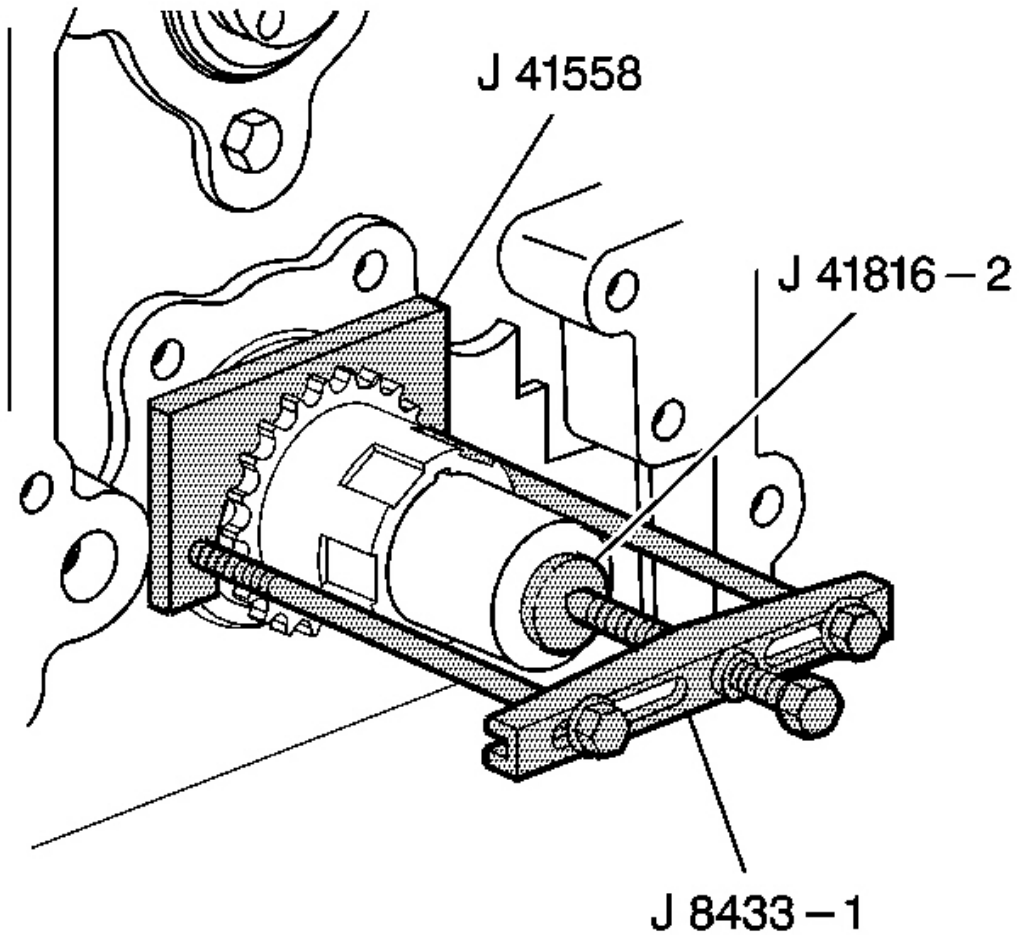
**Fig. 191: Camshaft Sprocket, Bolt & Timing Chain**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump, Pump Screen and Deflector Replacement** .
2. Rotate the crankshaft until the timing marks on the crankshaft and the camshaft sprockets are aligned.

**NOTE:** Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

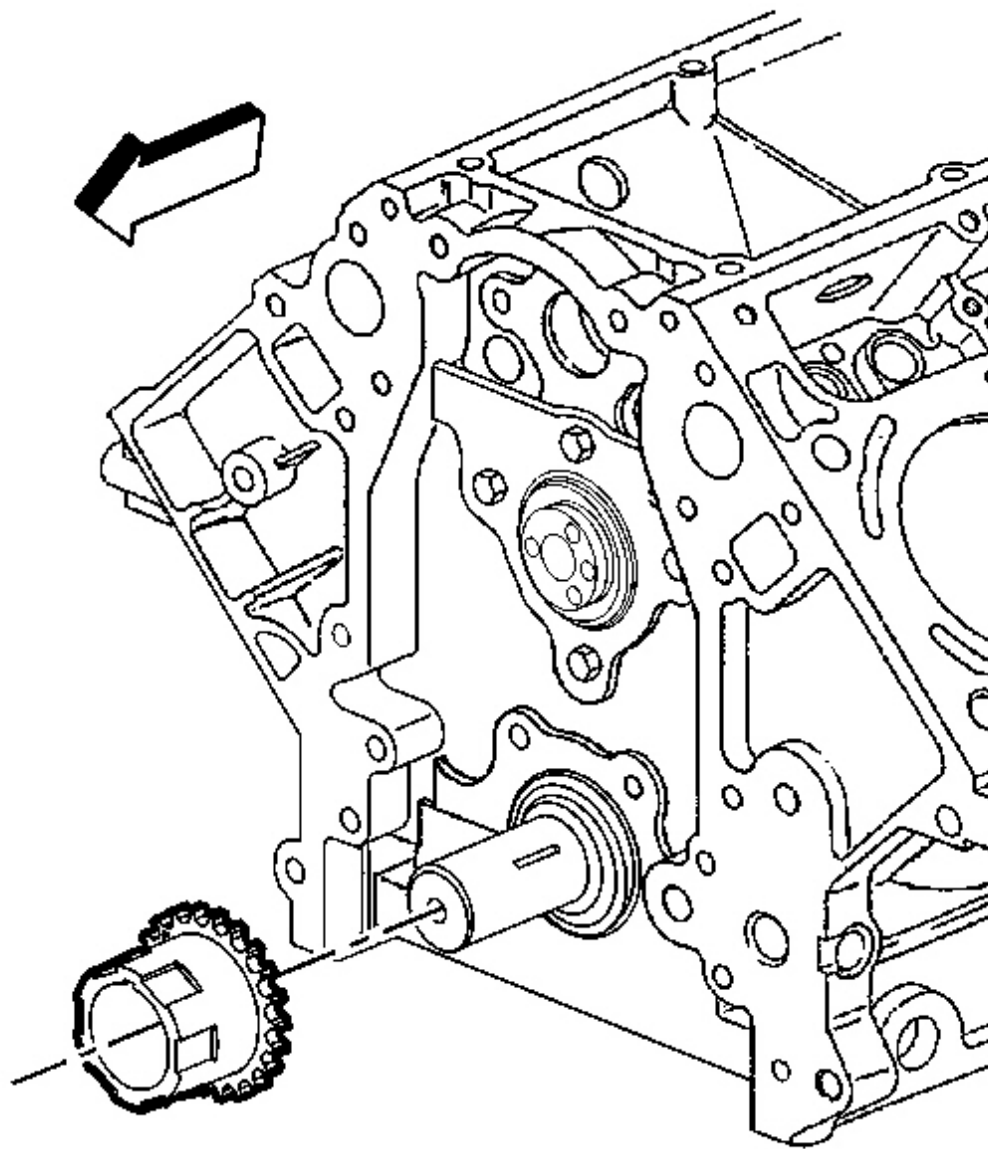
3. Remove the camshaft sprocket bolts.

4. Remove the camshaft sprocket and timing chain.



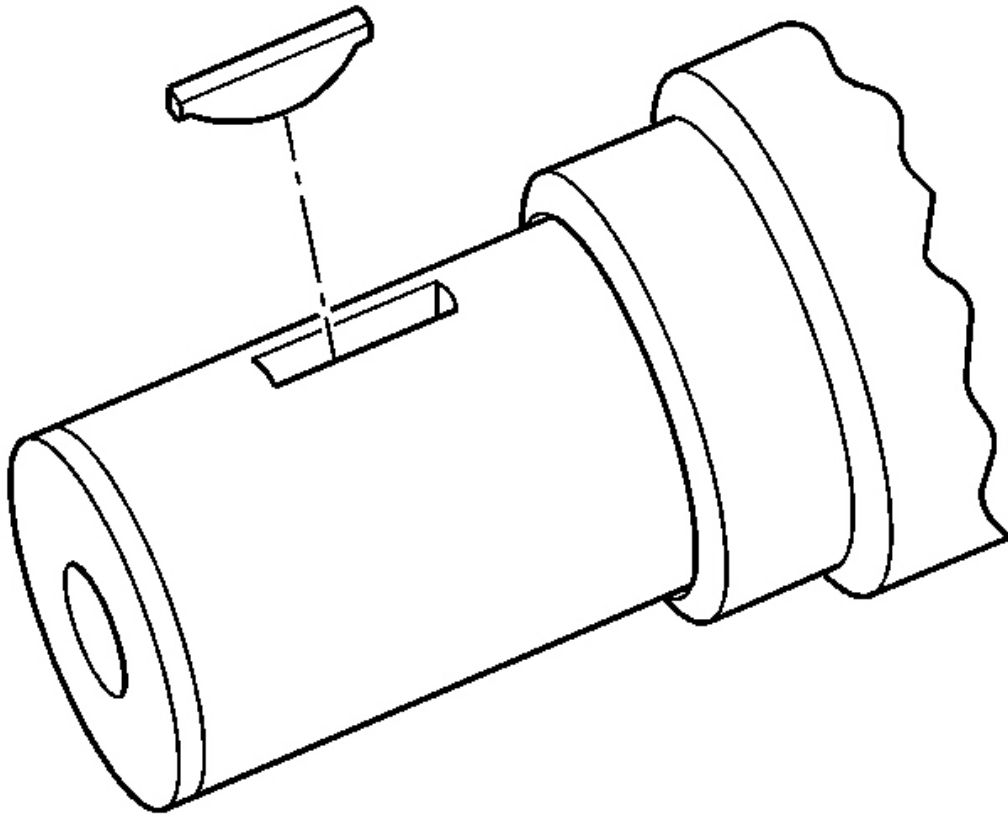
**Fig. 192: View Of J 8433-1, J 41816-2 & J 41558**  
Courtesy of GENERAL MOTORS CORP.

5. Use the J 8433 , the J 41816-2 and the **J 41558** in order to remove the crankshaft sprocket. See **Special Tools and Equipment** .



**Fig. 193: Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket.

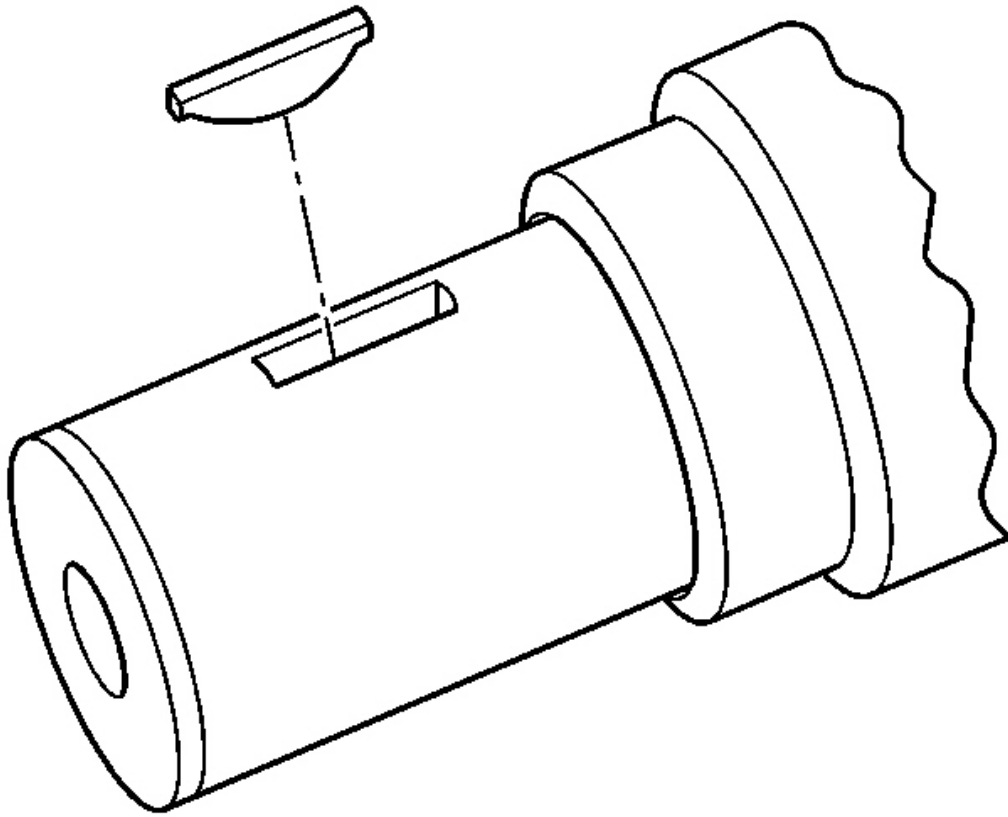


**Fig. 194: Crankshaft Sprocket Key**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket key, if required.
8. Clean and inspect the timing chain and sprockets. Refer to **Timing Chain and Sprockets Cleaning and Inspection** .

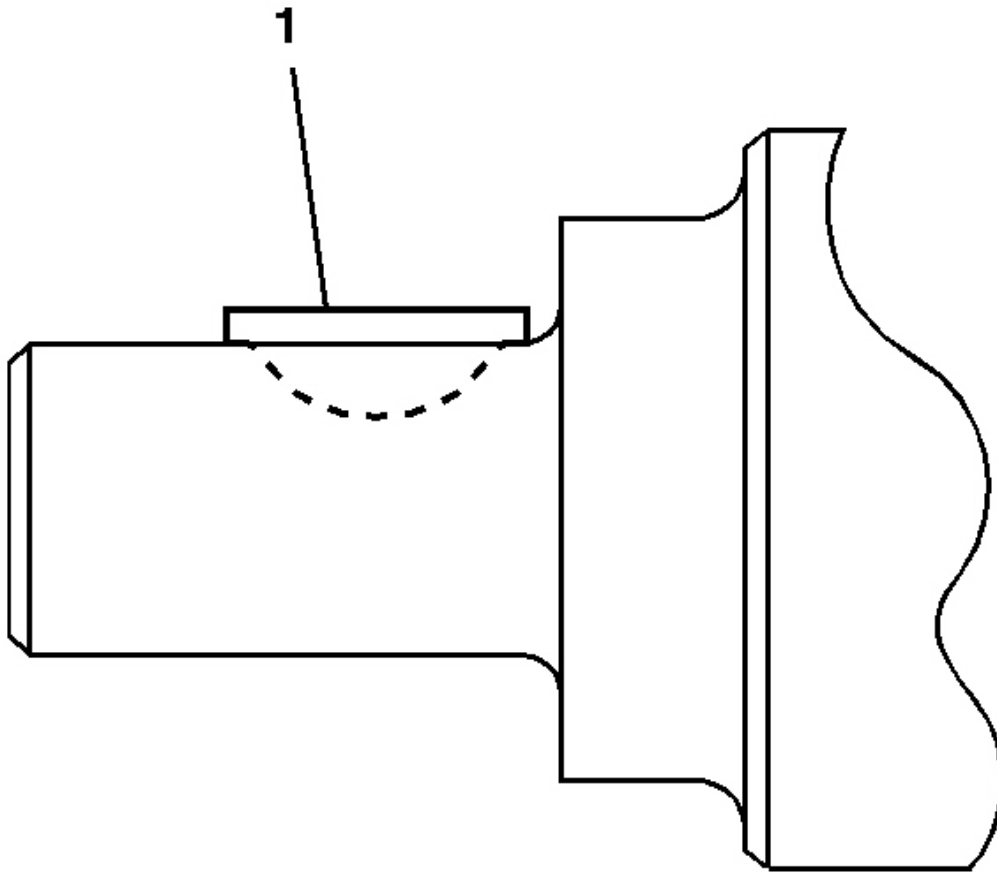
#### **Installation Procedure**





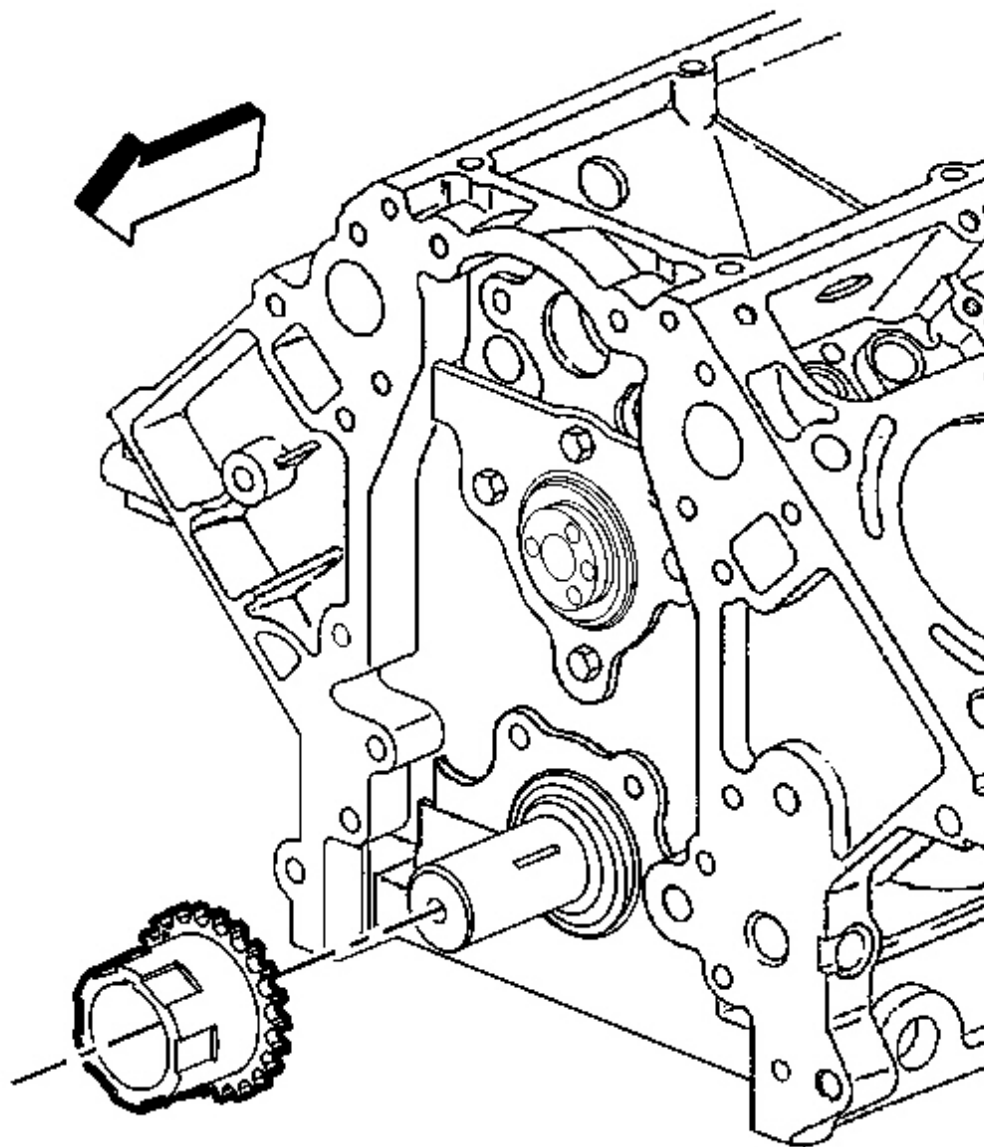
**Fig. 195: Crankshaft Sprocket Key**  
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.



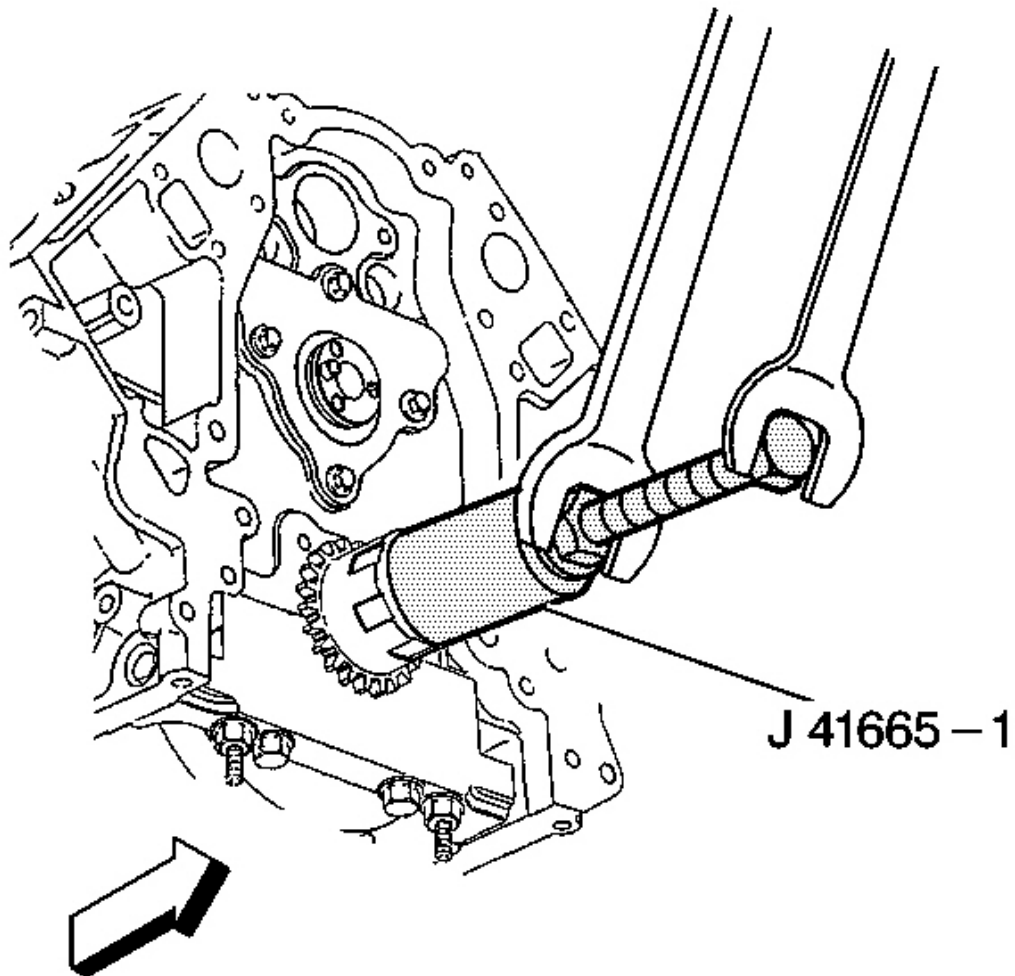
**Fig. 196: Crankshaft Sprocket Key Installation Position**  
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.



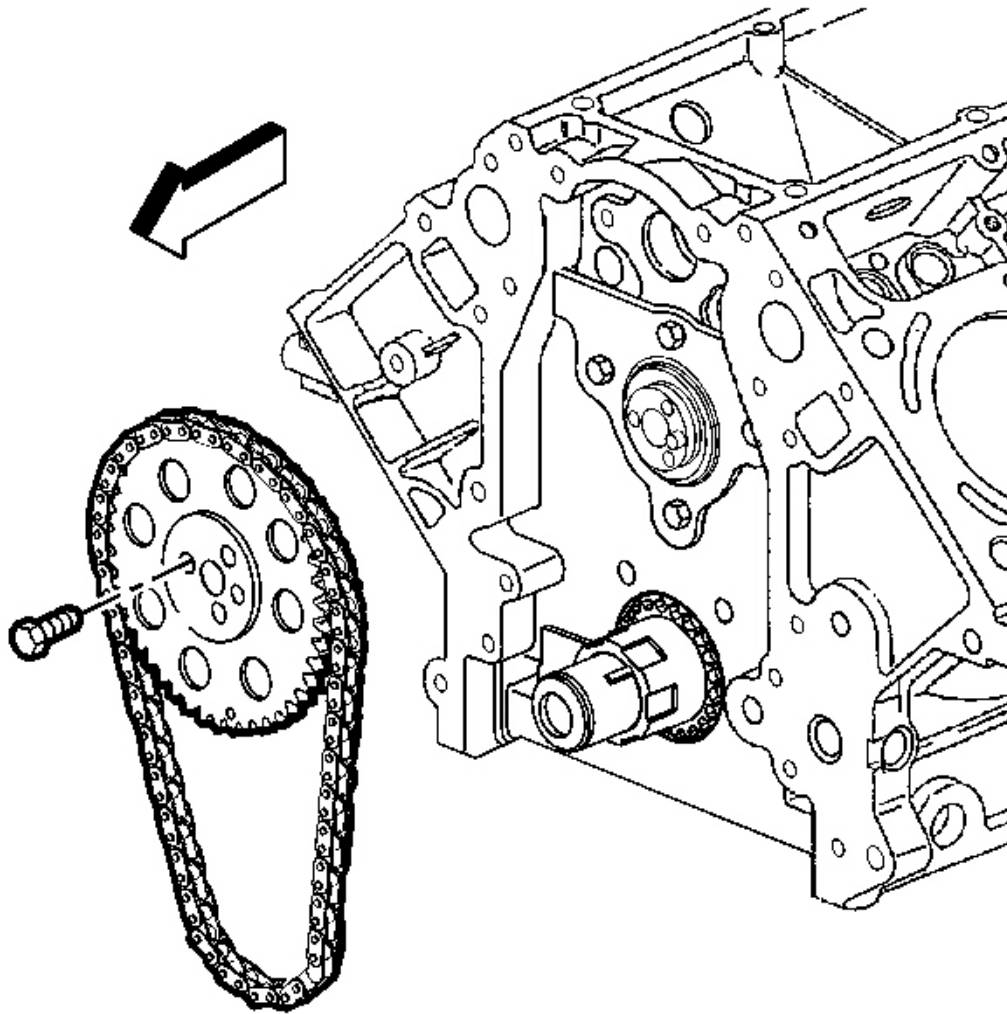
**Fig. 197: Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.



**Fig. 198: Installing Crankshaft Sprocket Using J 41665**  
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41665** in order to install the crankshaft sprocket. See **Special Tools and Equipment** .  
Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.



**Fig. 199: Camshaft Sprocket, Bolt & Timing Chain**  
Courtesy of GENERAL MOTORS CORP.

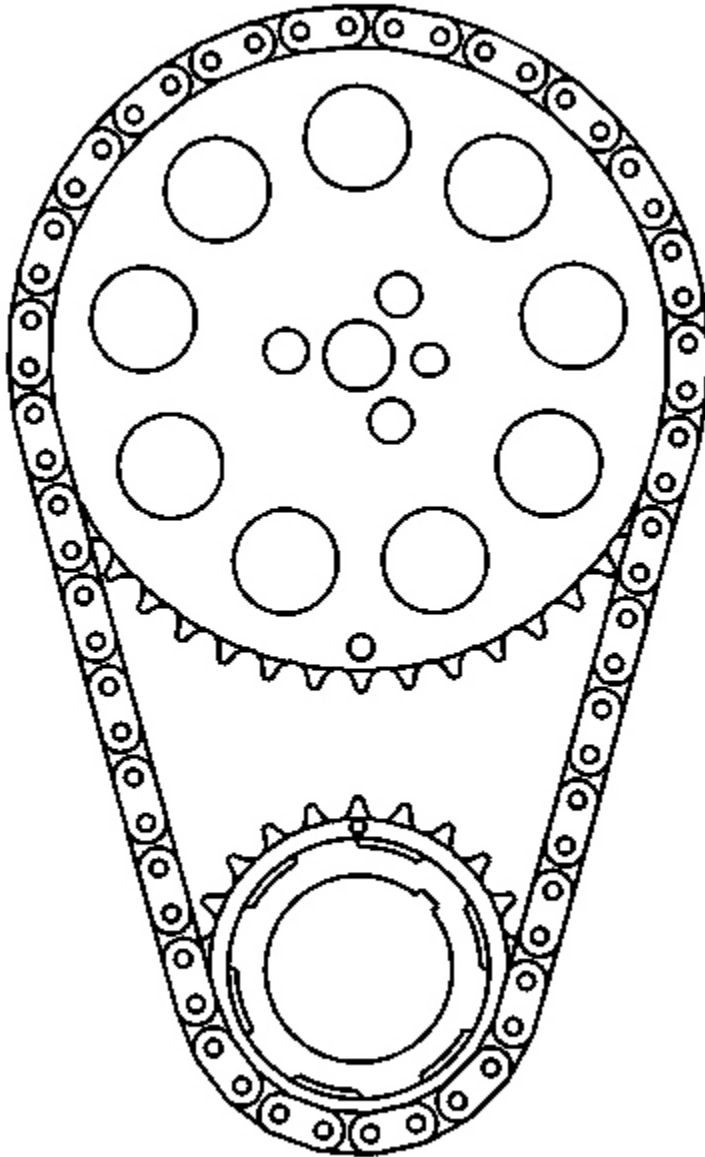
**IMPORTANT:**

- Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

Locate the camshaft sprocket alignment mark in the 6 o'clock

position.

6. Install the camshaft sprocket and timing chain.



**Fig. 200: Camshaft & Crankshaft Sprockets Aligned**  
Courtesy of GENERAL MOTORS CORP.

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

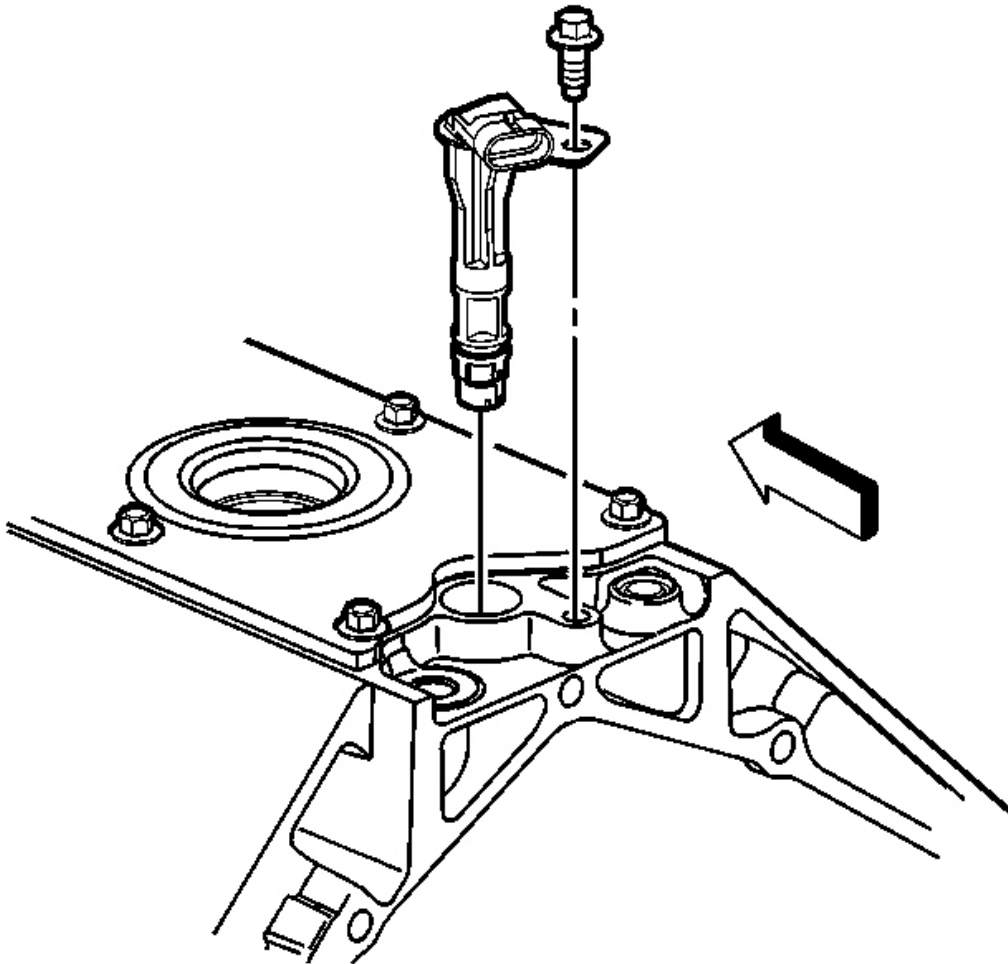
7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.
8. Install the camshaft sprocket bolts.

**Tighten:** Tighten the camshaft sprocket bolts to 35 N.m (26 lb ft).

9. Install the oil pump. Refer to Oil Pump, Pump Screen and Deflector Replacement .

## CAMSHAFT REPLACEMENT

### Removal Procedure



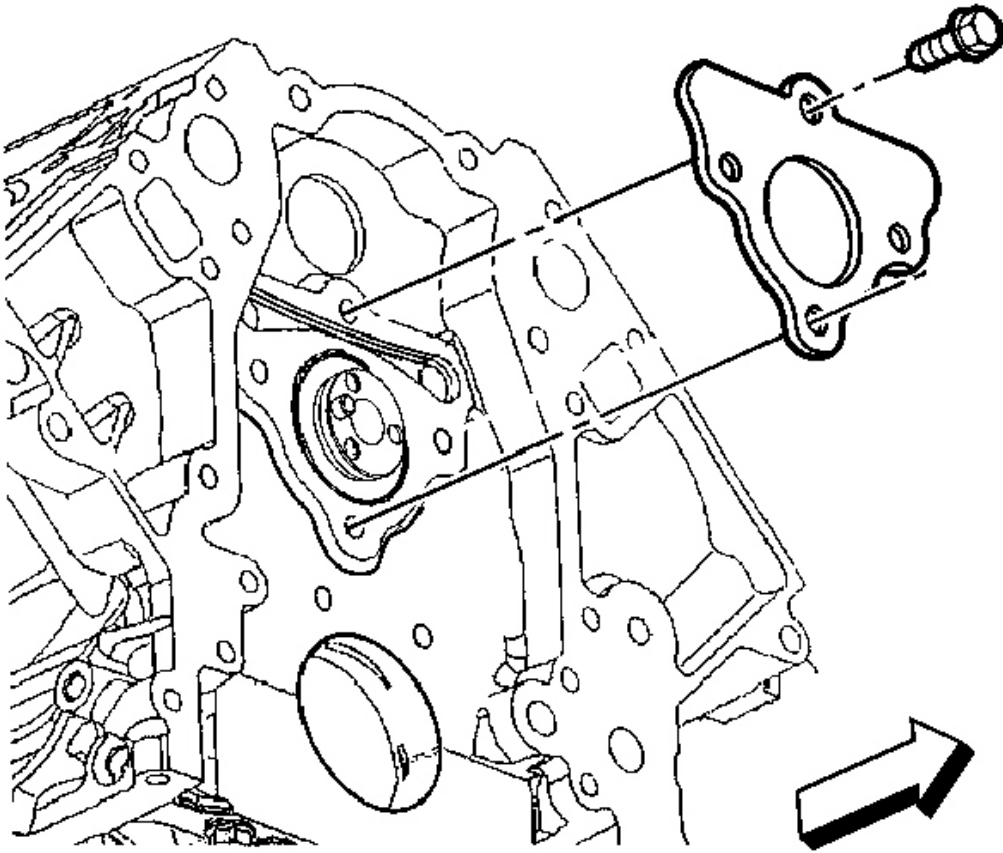
**Fig. 201: Camshaft Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the hood. Refer to **Hood Replacement** in Body Front End.
2. Remove the radiator support. Refer to **Radiator Support Replacement** in Body Front End.
3. Remove the valve lifters from both cylinder heads. Refer to **Valve Lifter Replacement** .
4. Remove the camshaft sensor bolt and sensor.
5. Remove the engine front cover. Refer to **Engine Front Cover Removal** .
6. Rotate the engine until the timing marks are aligned.

**NOTE:**        **Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.**

7. Remove the camshaft sprocket bolts.
8. Remove the camshaft sprocket and reposition the timing chain.

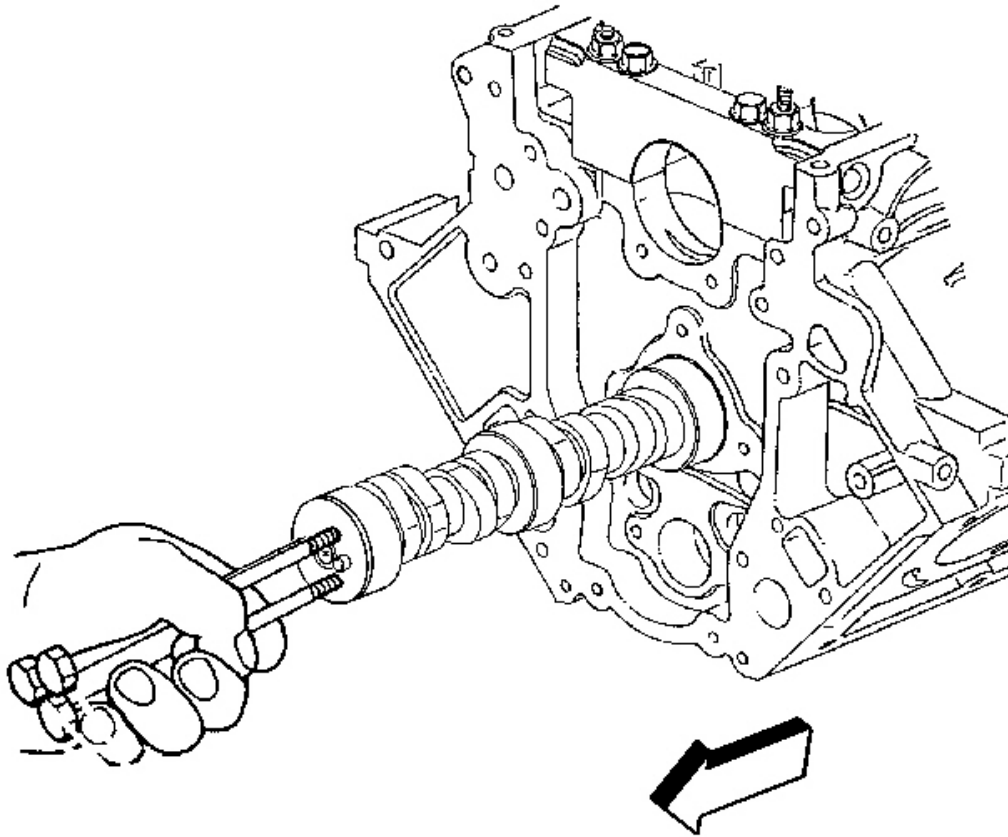




**Fig. 202: Camshaft Retainer & Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft retainer bolts and retainer.

**NOTE:** All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

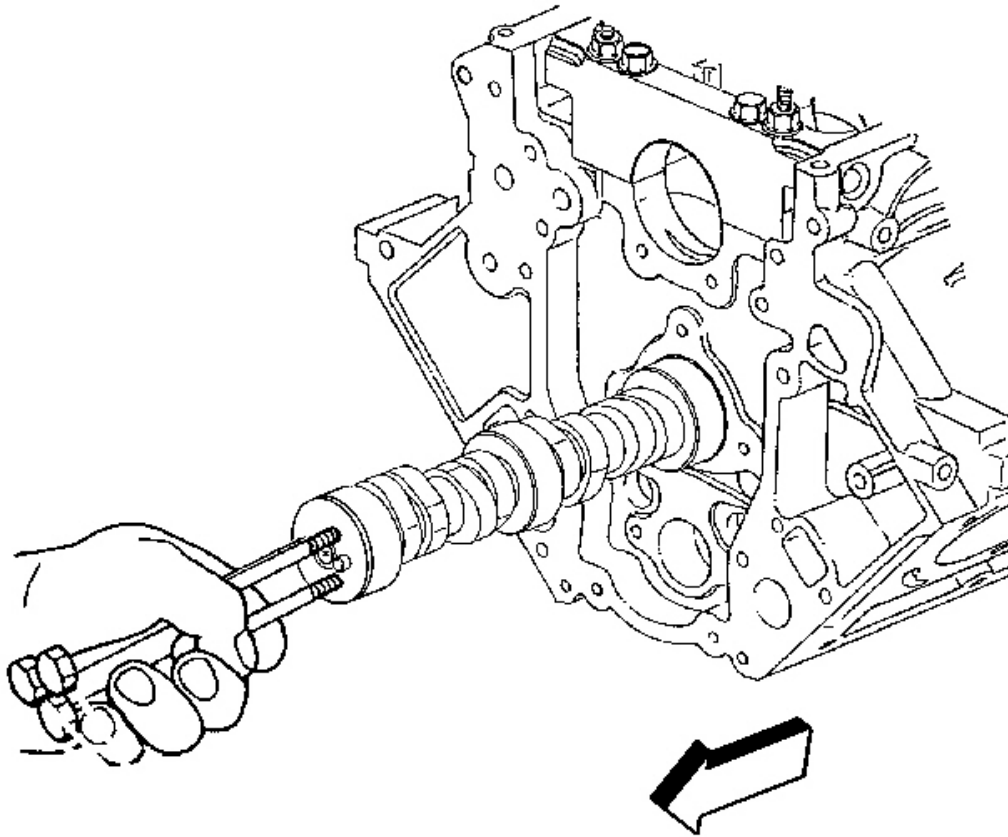


**Fig. 203: Camshaft Front Bolt Holes**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft.
  1. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.
  2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
  3. Remove the three bolts from the camshaft.
11. Clean and inspect the camshaft and bearings. Refer to **Camshaft and Bearings Cleaning and Inspection** .

#### **Installation Procedure**

**IMPORTANT:** If camshaft replacement is required, the valve lifters must also be replaced.

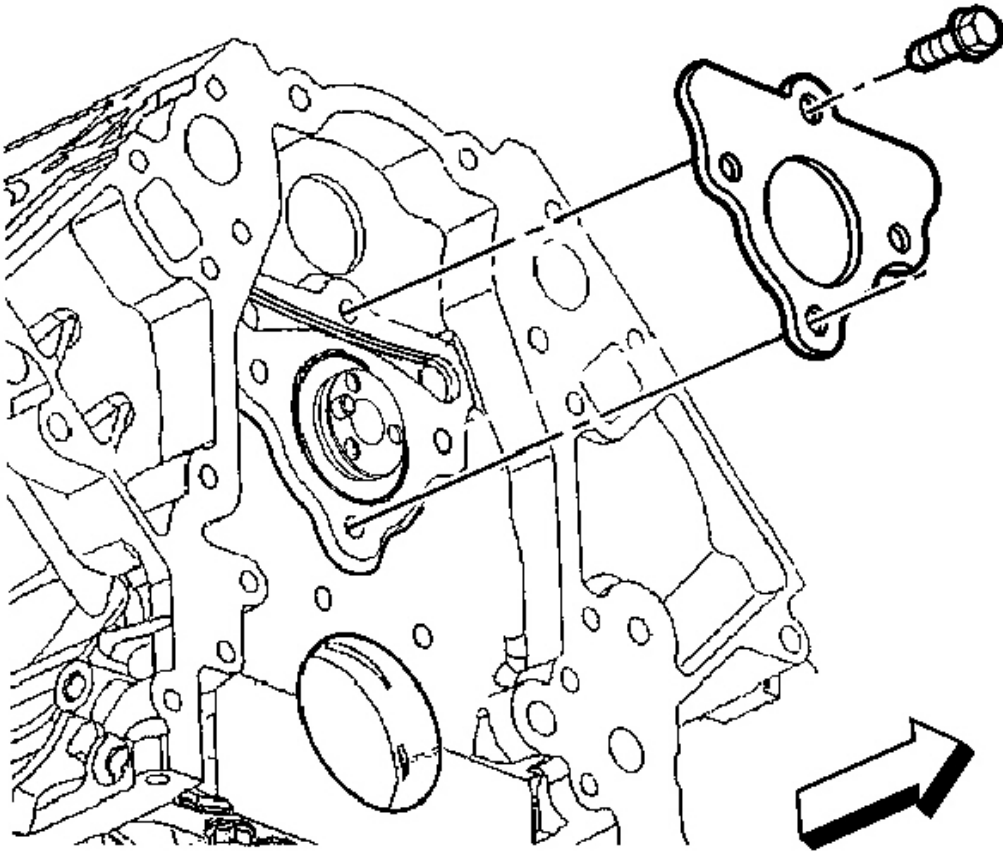


**Fig. 204: Camshaft Front Bolt Holes**  
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.

**NOTE:** All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the three bolts from the front of the camshaft.



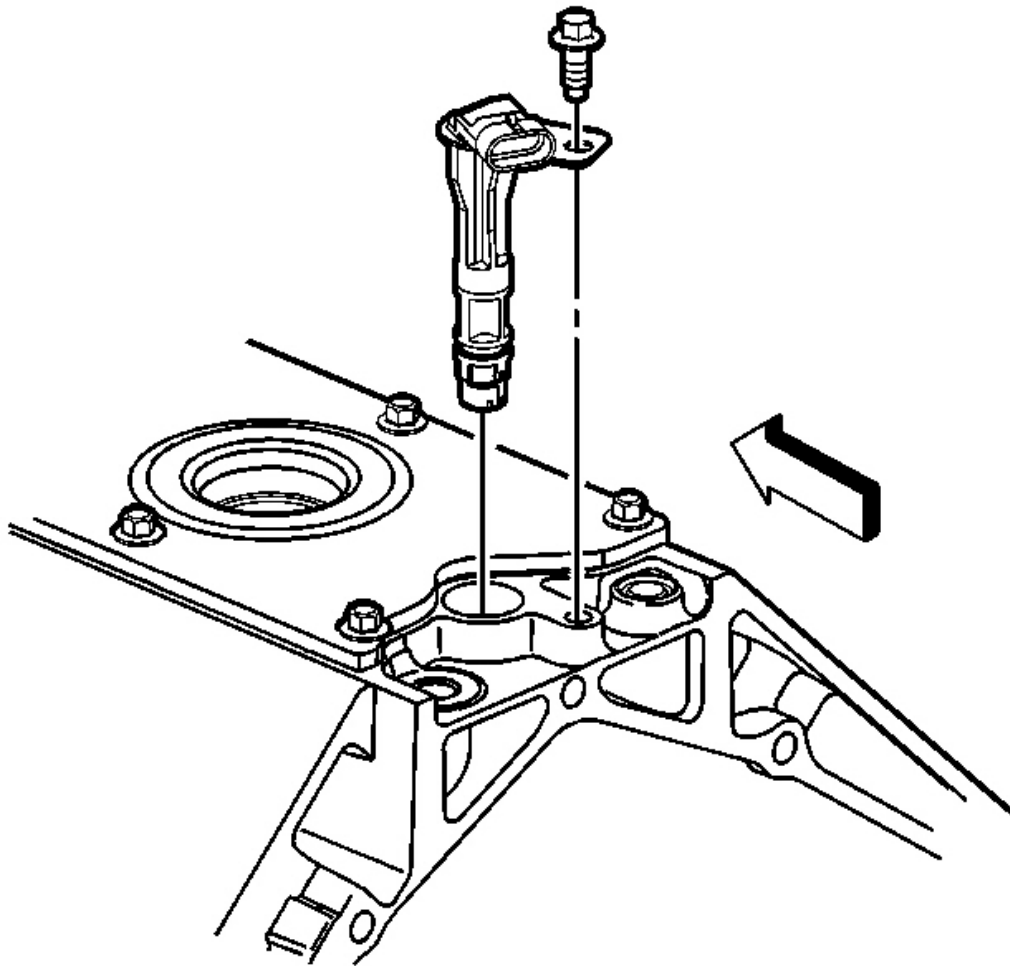
**Fig. 205: Camshaft Retainer & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Install the retainer plate with the sealing gasket facing the engine block. The gasket surface on the engine block should be clean and free of dirt and/or debris.

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

5. Install the camshaft retainer and bolts.

**Tighten:** Tighten the camshaft retainer bolts to 25 N.m (18 lb ft).



**Fig. 206: Camshaft Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.

6. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be reused.
7. Lubricate the O-ring seal with clean engine oil.
8. Install the camshaft sensor and bolt.

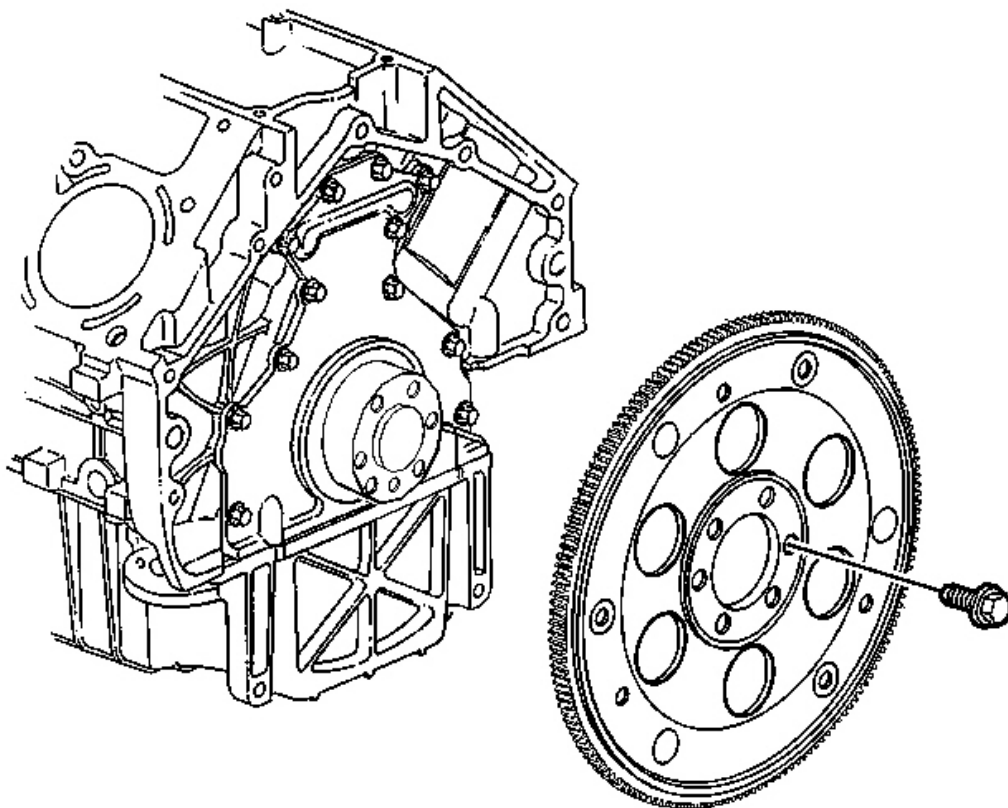
**Tighten:** Tighten the camshaft sensor bolt to 25 N.m (18 lb ft).

9. Install the camshaft sprocket and timing chain. Refer to **Timing Chain and Sprockets Replacement** .
10. Install the engine front cover. Refer to **Engine Front Cover Removal** .
11. Install the valve lifters. Refer to **Valve Lifter Replacement** .

12. Install the radiator support. Refer to **Radiator Support Replacement** in Body Front End.
13. Install the hood. Refer to **Hood Replacement** in Body Front End.
14. Lower the hood to the normal position.

## ENGINE FLYWHEEL REPLACEMENT

### Removal Procedure

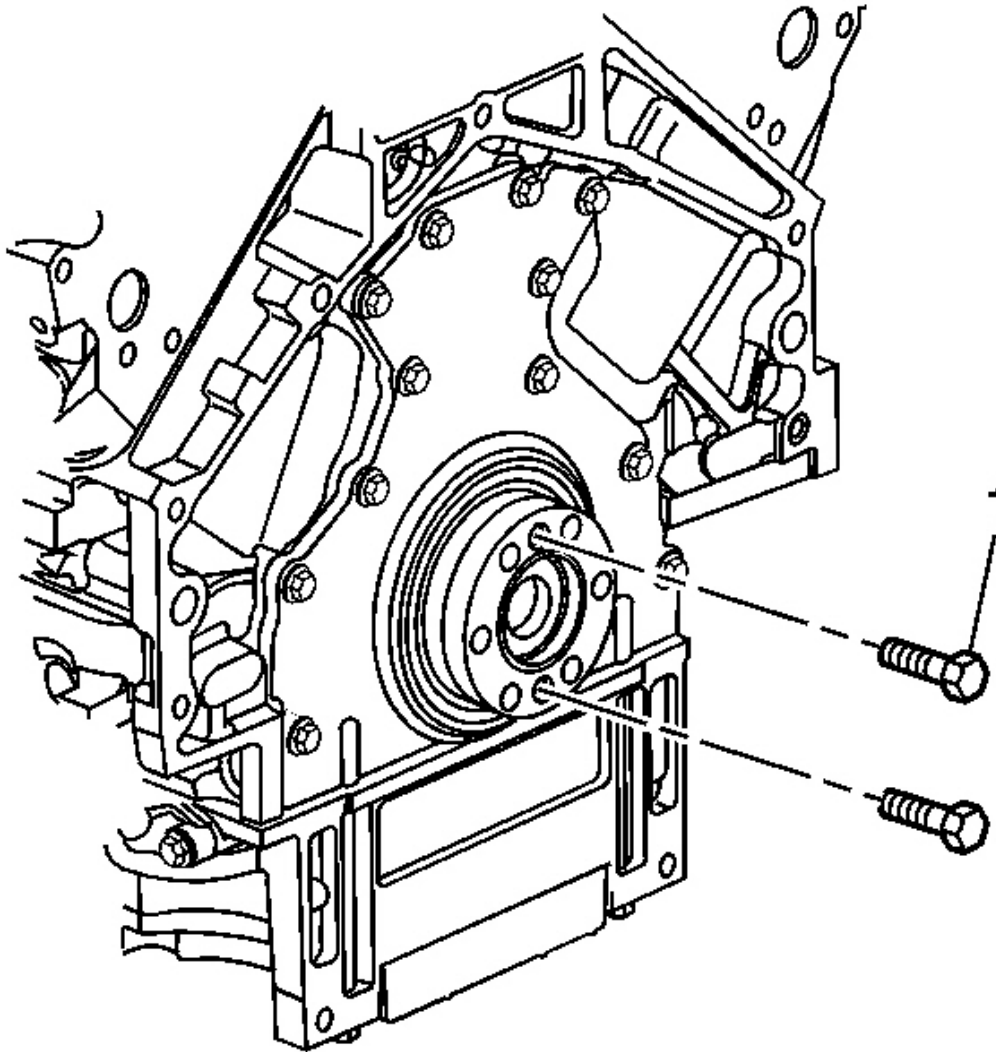


**Fig. 207: Engine Flywheel & Bolts (Automatic Transmission)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Note the position and direction of the engine flywheel before removal.

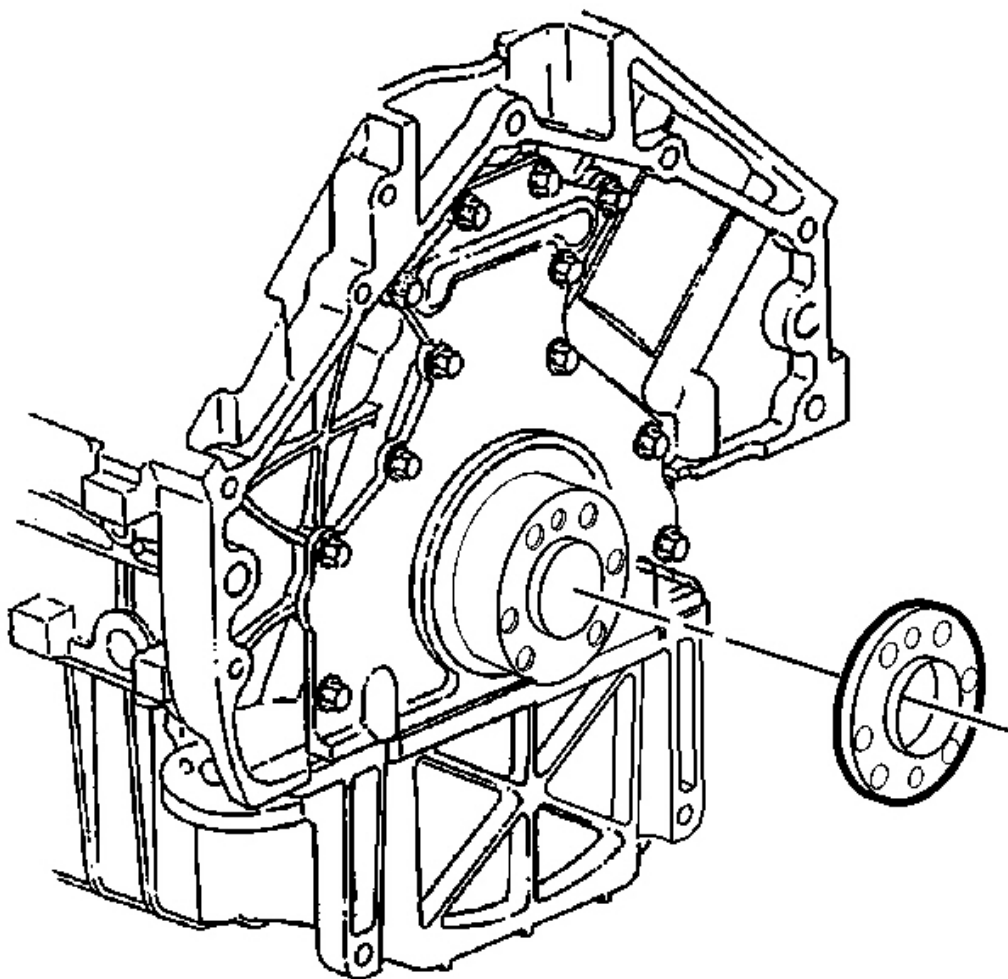
1. Remove the automatic transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4L60-E.
2. Remove the engine flywheel bolts.

3. Remove the automatic transmission engine flywheel.



**Fig. 208: Bolts & Spacer Threaded Holes**  
Courtesy of GENERAL MOTORS CORP.

4. Install two M11x1.5 mm bolts (1) to the threaded holes of the spacer, if applicable.
5. Rotate the bolts clockwise to remove the spacer.



**Fig. 209: Spacer & Crankshaft Rear**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the spacer from the rear of the crankshaft, if applicable.

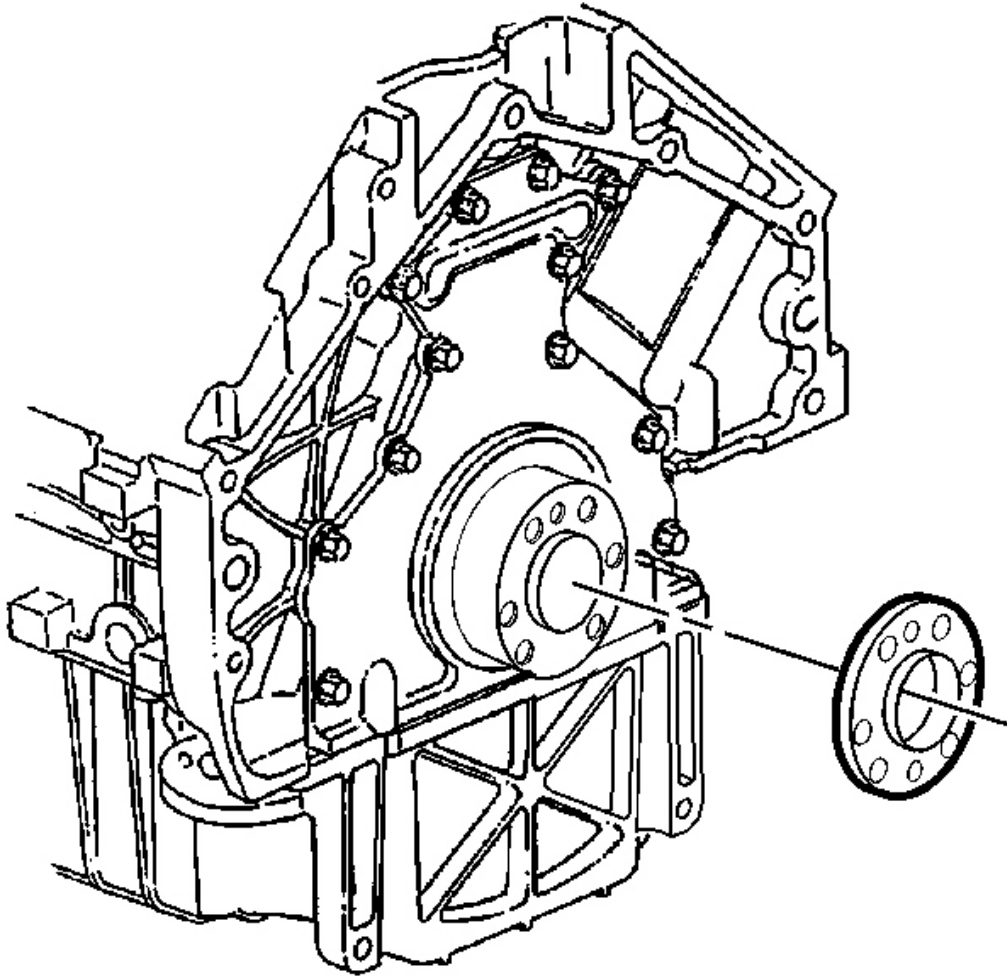
#### Installation Procedure

#### **IMPORTANT:**

- The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer (if applicable), but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.
- Certain applications (6.0L) require a spacer and longer bolts for proper

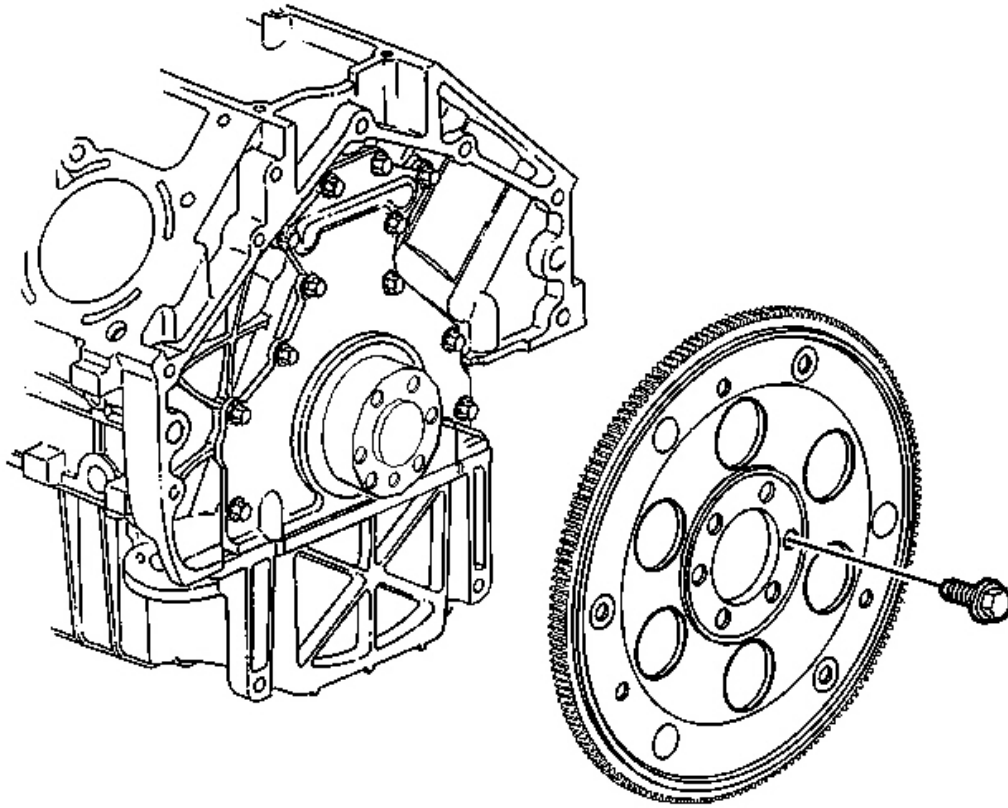


flywheel position.



**Fig. 210: Spacer & Crankshaft Rear**  
Courtesy of GENERAL MOTORS CORP.

1. Install the spacer (if applicable) onto the rear of the crankshaft.

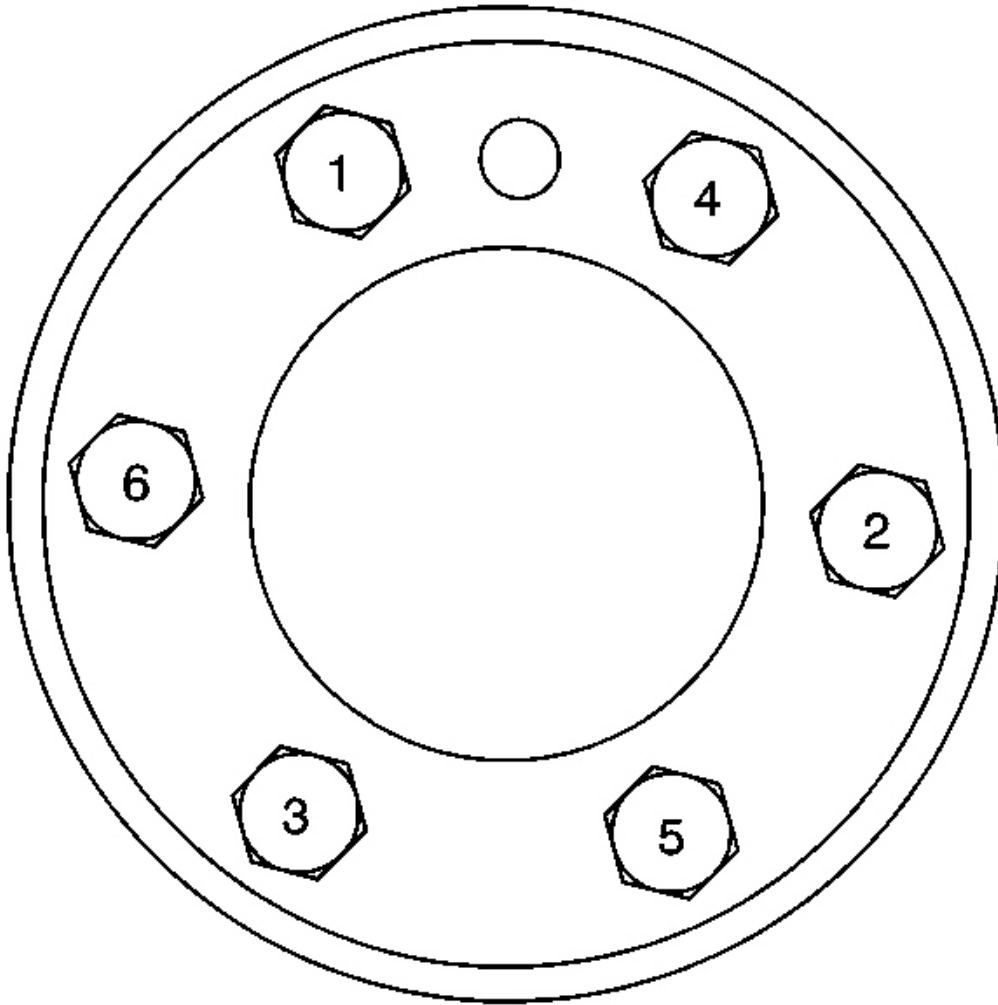


**Fig. 211: Engine Flywheel & Bolts (Automatic Transmission)**

**Courtesy of GENERAL MOTORS CORP.**

**IMPORTANT: Longer flywheel bolts must be used on applications using a flywheel spacer.**

2. Install the automatic transmission engine flywheel to the crankshaft.
3. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.



**Fig. 212: Flywheel Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

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

4. Install the engine flywheel bolts.

**Tighten:**

1. Tighten the engine flywheel bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine flywheel bolts a second pass in sequence to 50 N.m (37 lb ft).

3. Tighten the engine flywheel bolts a final pass in sequence to 100 N.m (74 lb ft).
5. Install the automatic transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4L60-E.

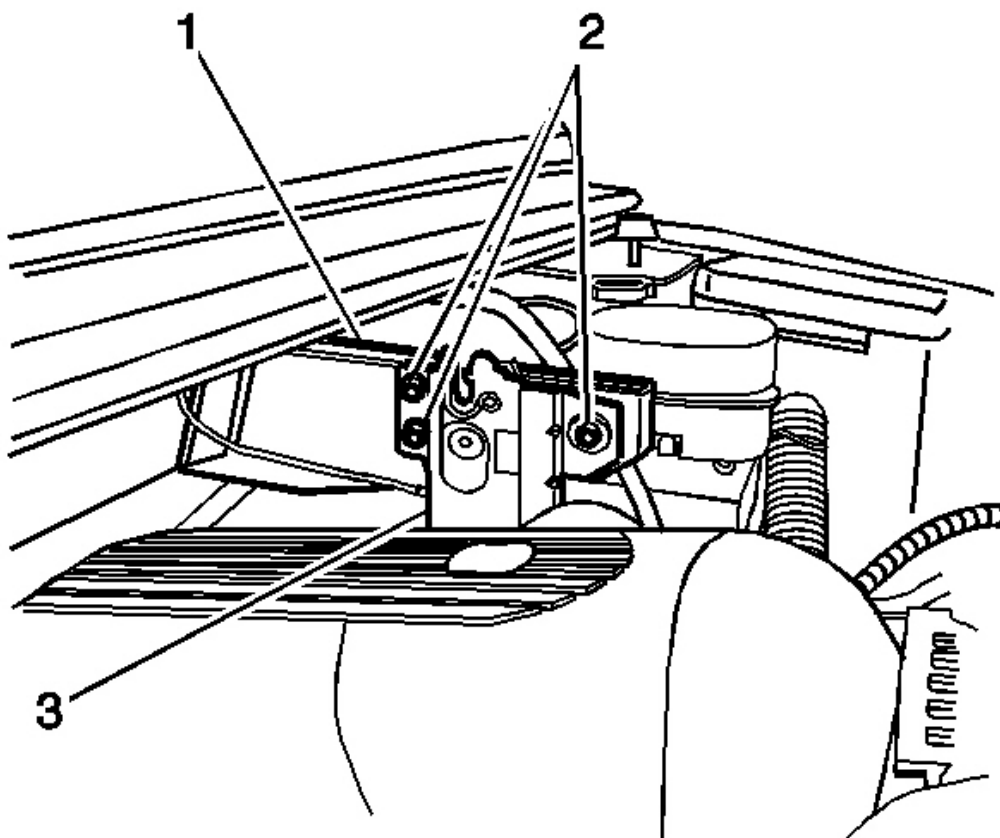
## ENGINE REPLACEMENT

### Tools Required

- **J 41798** Engine Lift Bracket. See **Special Tools and Equipment** .
- **J 21366** Convert Holding Strap. See **Special Tools and Equipment** .

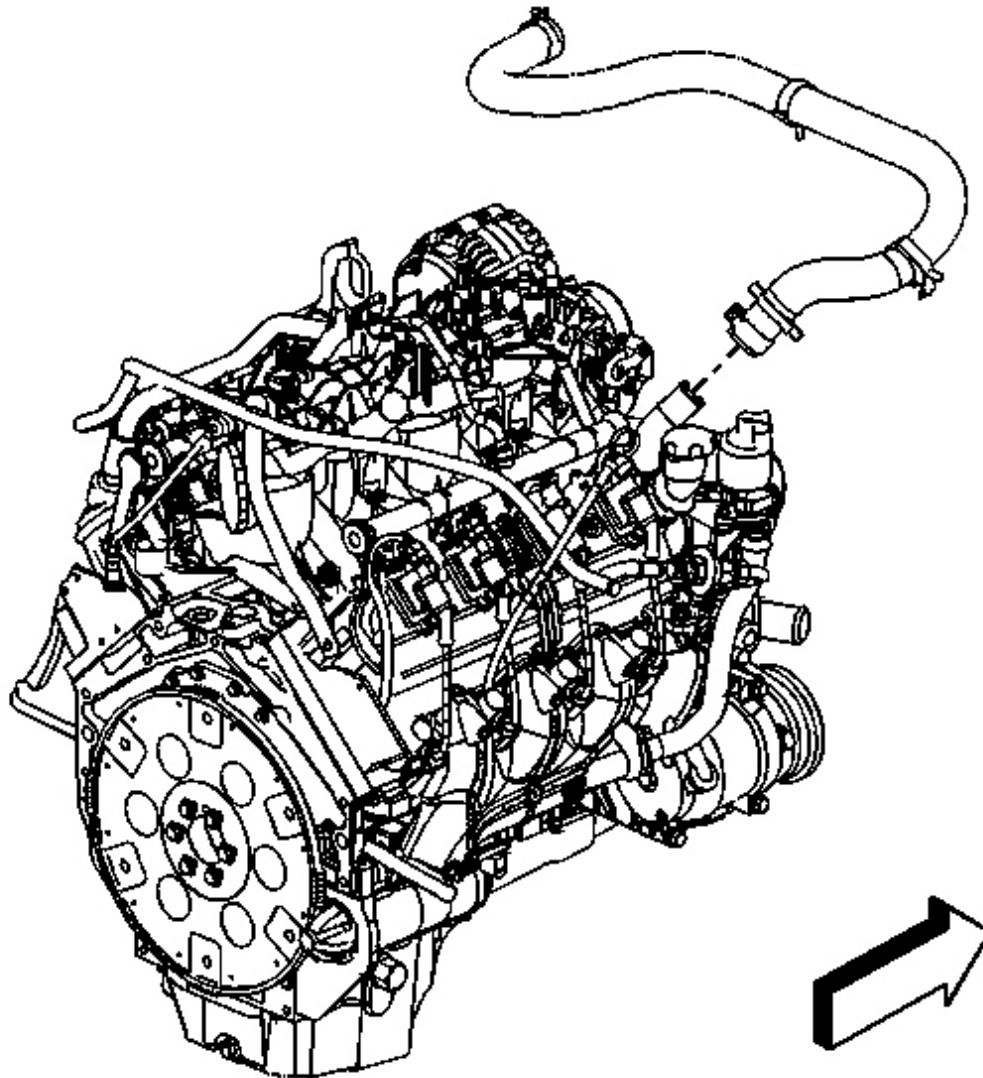
### Removal Procedure

1. Remove the hood. Refer to **Hood Replacement** in Body Front End.



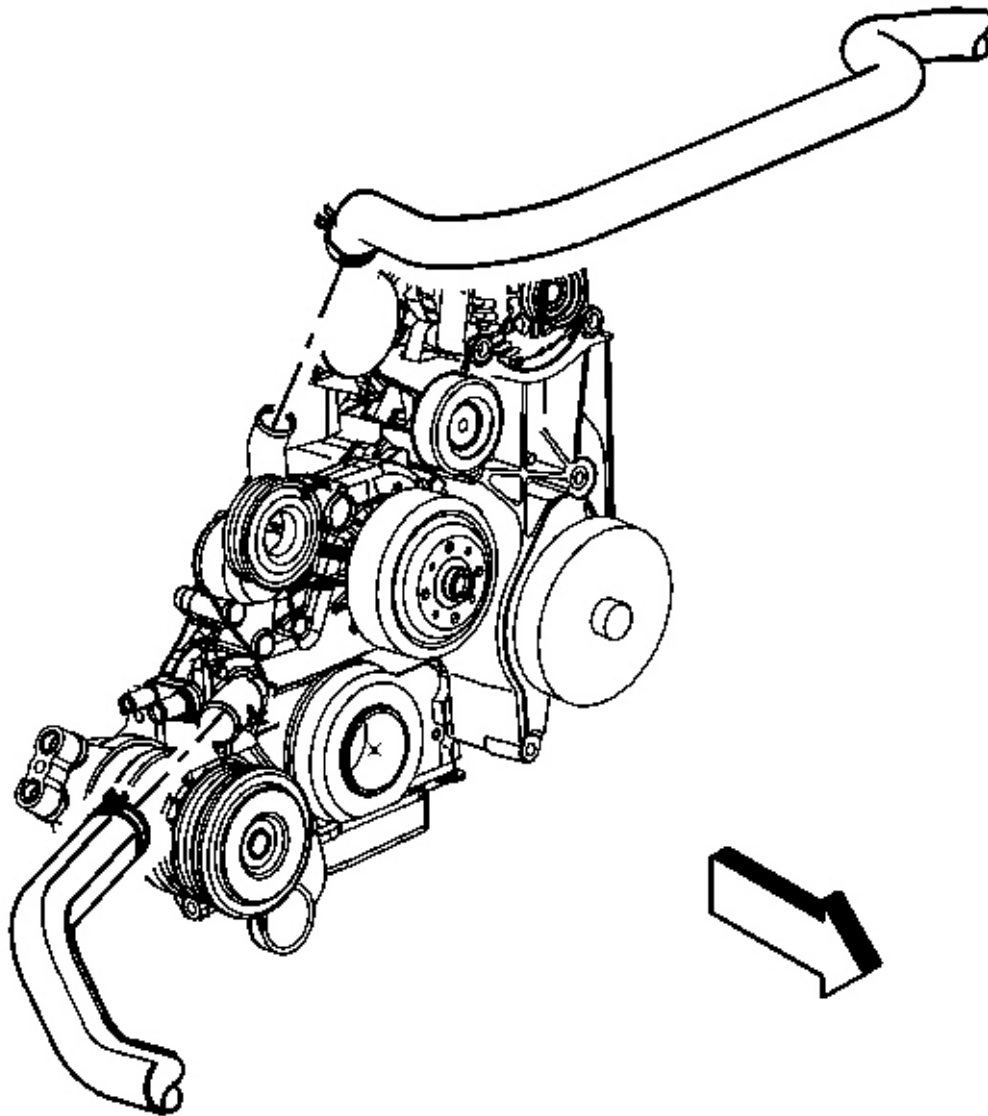
**Fig. 213: Hood Latch & Cowl**  
Courtesy of GENERAL MOTORS CORP.

2. Remove hood latch (1) from cowl.
3. Leaving the A/C compressor lines connected remove the condenser mounting bolts and secure to frame rail.
4. Remove the upper radiator support. Refer to **Radiator Support Replacement** in Body Front End.



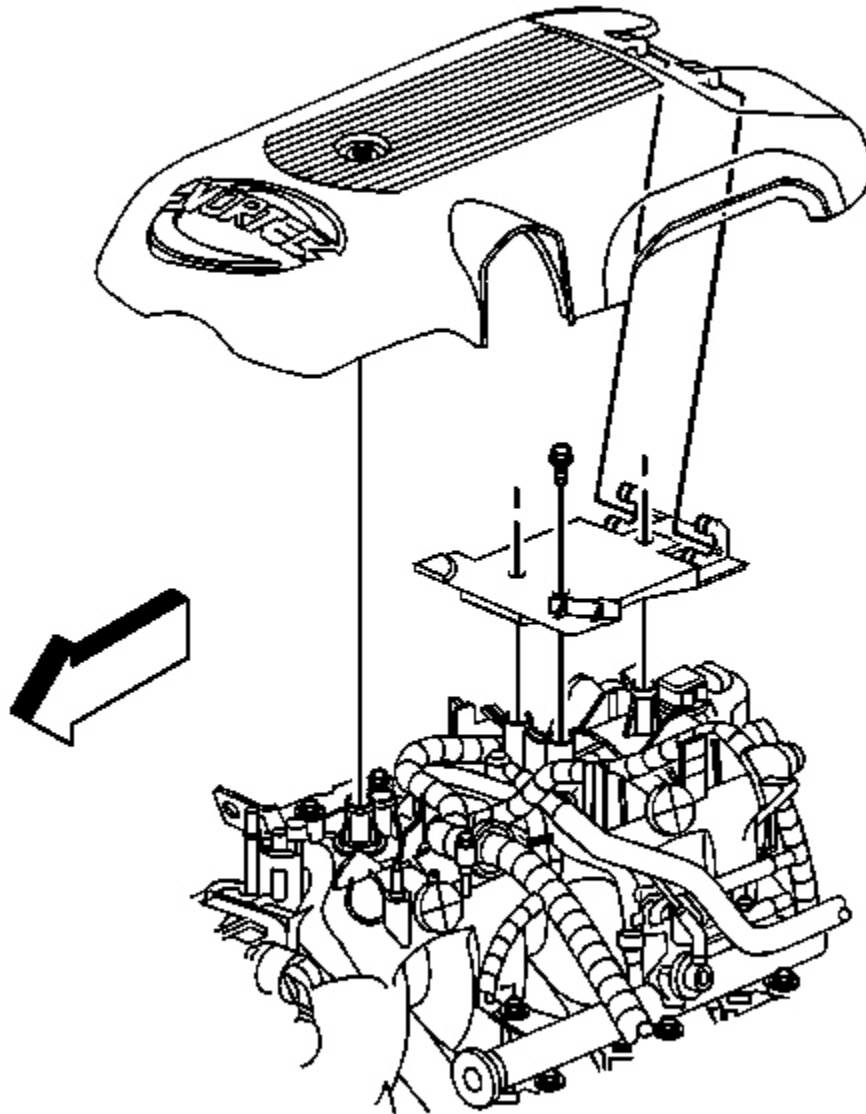
**Fig. 214: Radiator Inlet Hose & Water Pump (4.8, 5.3, & 6.0L)**  
Courtesy of GENERAL MOTORS CORP.

5. Reposition the radiator inlet hose clamp at the water pump.
6. Remove the radiator inlet hose from the water pump.



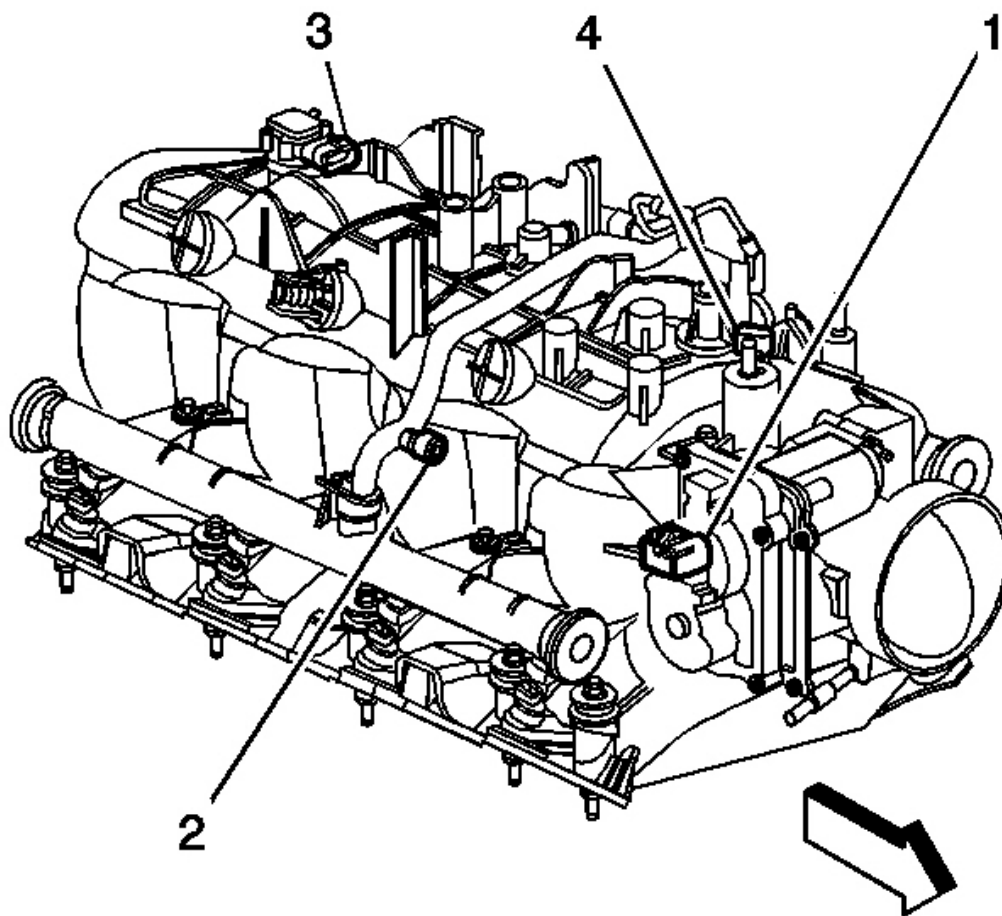
**Fig. 215: Radiator Outlet Hose & Water Pump**  
Courtesy of GENERAL MOTORS CORP.

7. Reposition the radiator outlet hose clamp at the water pump.
8. Remove the radiator outlet hose from the water pump.
9. Remove the heater hoses. Refer to **Heater Hose Replacement - Inlet** and **Heater Hose Replacement - Outlet** in Heating, Ventilation, and Air Conditioning.



**Fig. 216: View Of Top Engine Cover**  
Courtesy of GENERAL MOTORS CORP.

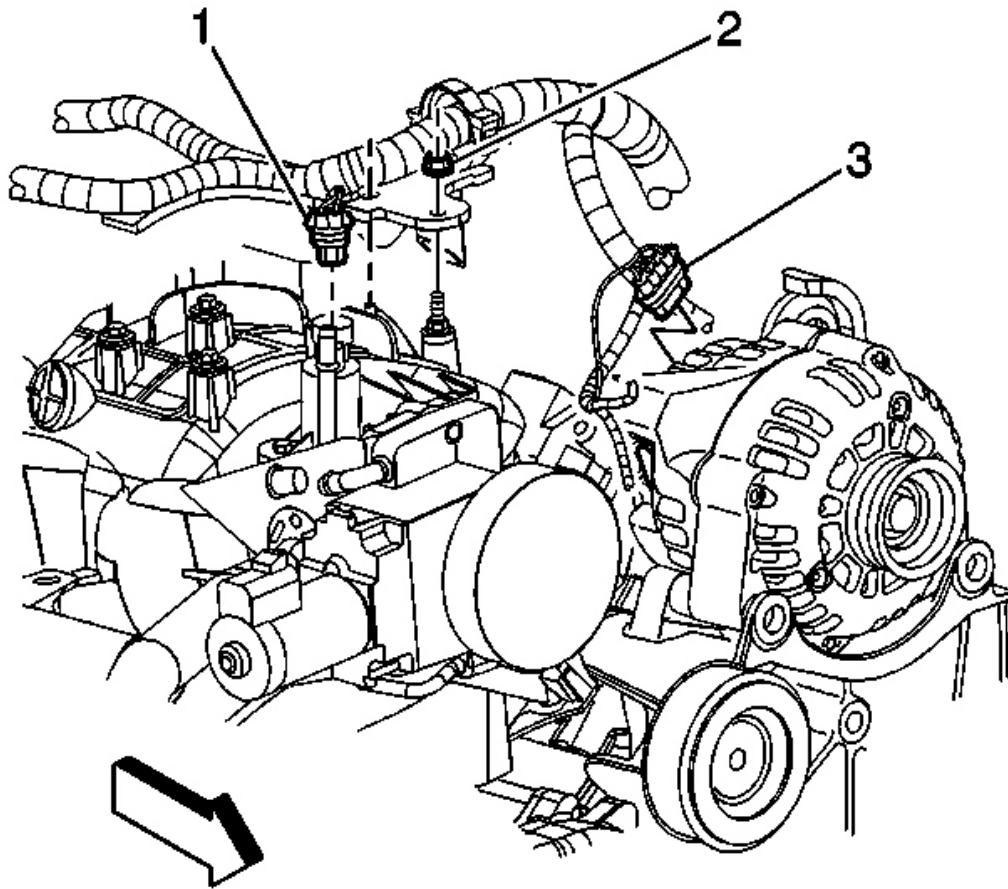
10. Loosen the intake manifold sight shield bolt.
11. Remove the sight shield from the retainer.



**Fig. 217: Throttle Body Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

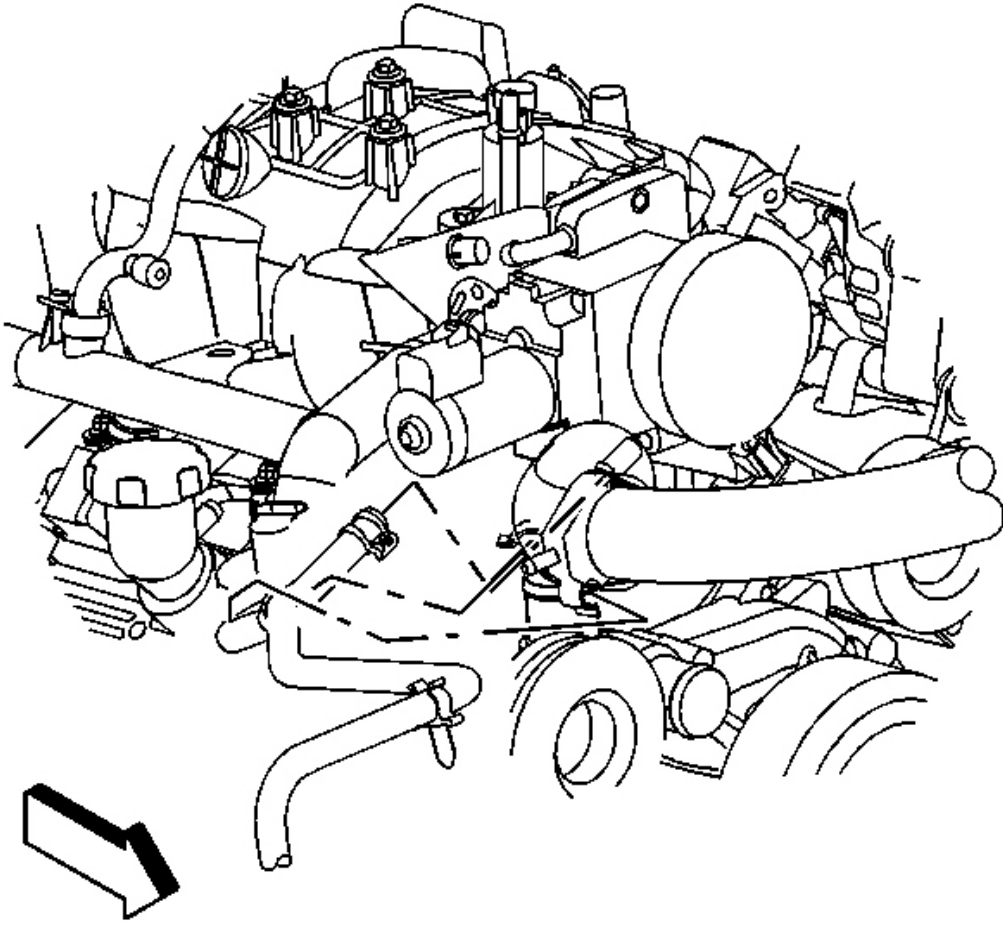
12. Disconnect the throttle body electrical connector (1).





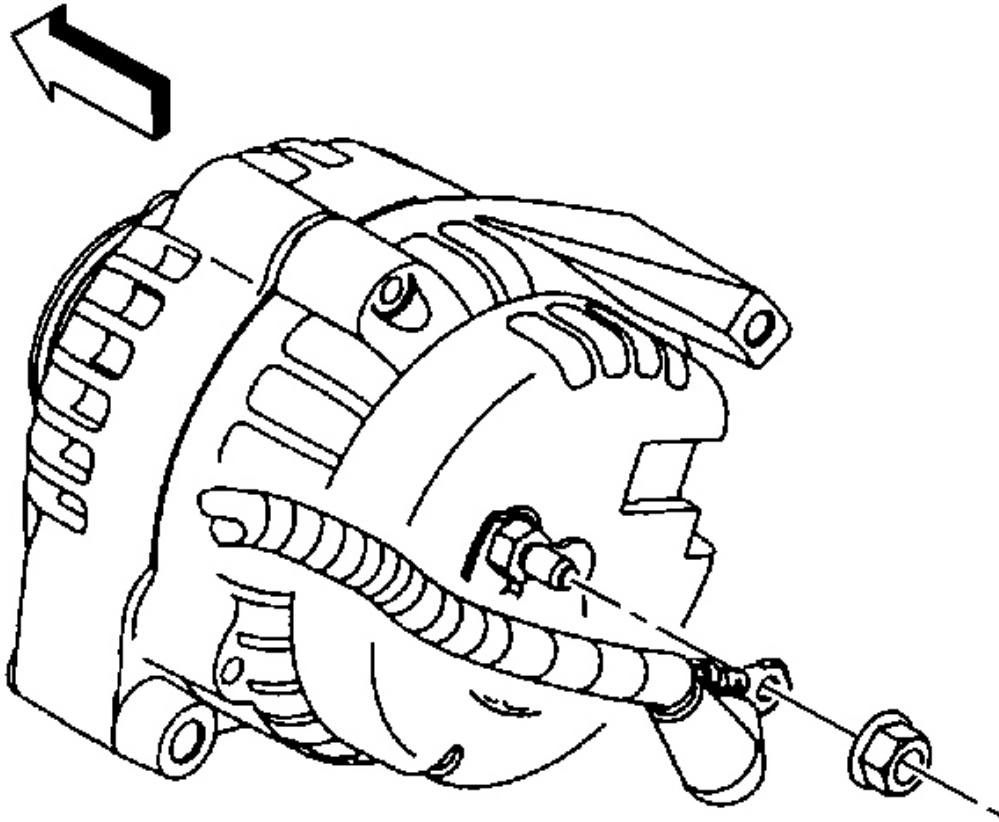
**Fig. 218: EVAP Canister Purge Solenoid & Generator Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the following electrical connectors:
  - Evaporative emissions (EVAP) canister purge solenoid (1)
  - Generator (3)
14. Remove the harness bracket nut (2) in order to remove the engine harness from the intake manifold.



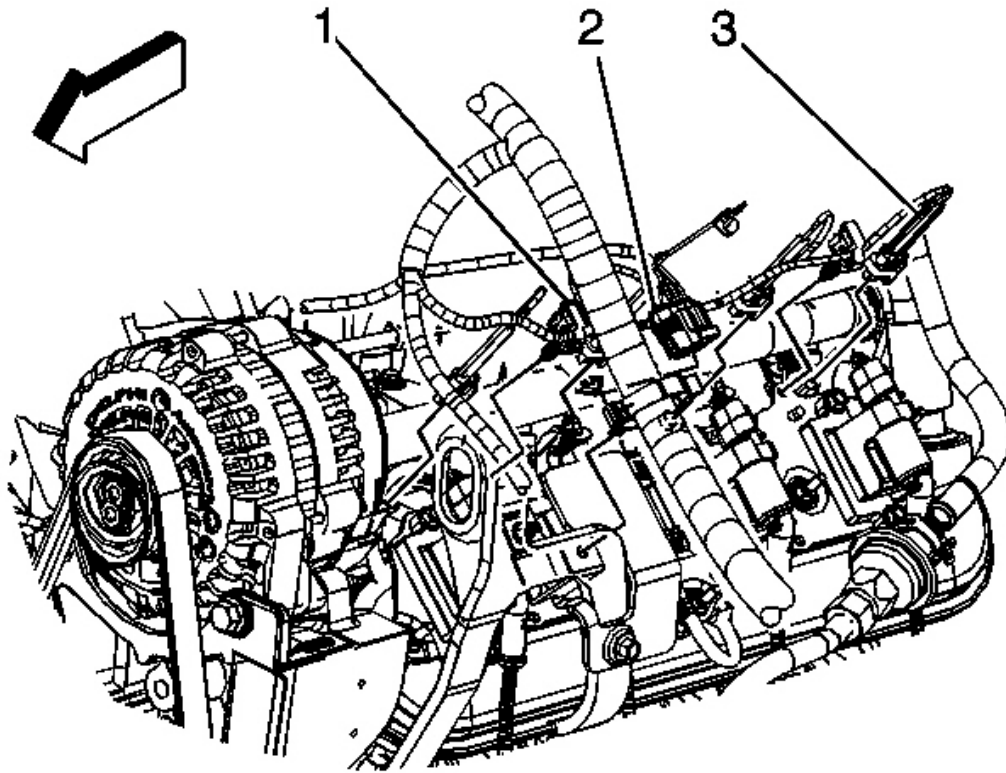
**Fig. 219: Vent Inlet Hose & Throttle Body**  
Courtesy of GENERAL MOTORS CORP.

15. Remove the radiator vent inlet hose from the throttle body.



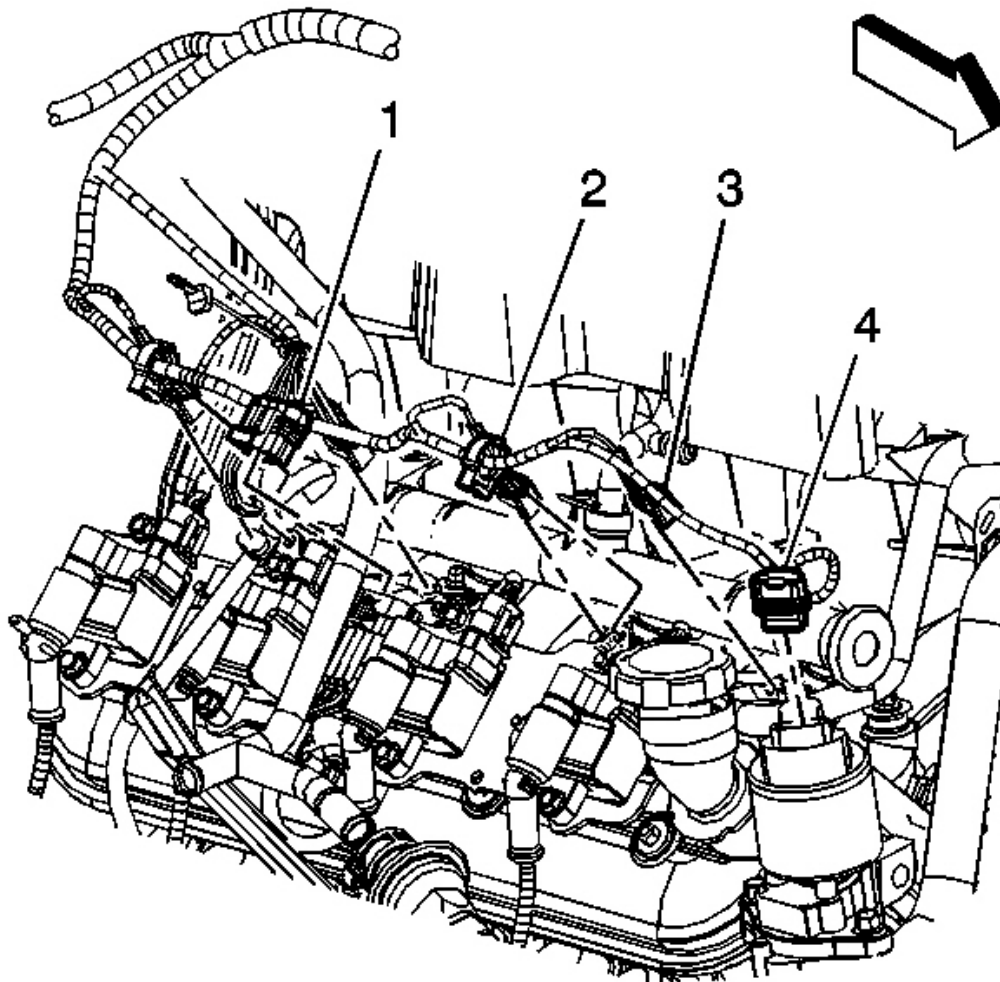
**Fig. 220: View Of Generator Cable & Nut**  
**Courtesy of GENERAL MOTORS CORP.**

16. Remove the generator cable from the generator, perform the following:
  1. Slide the boot down revealing the terminal stud.
  2. Remove the generator cable nut from the terminal stud.
  3. Remove the generator cable.



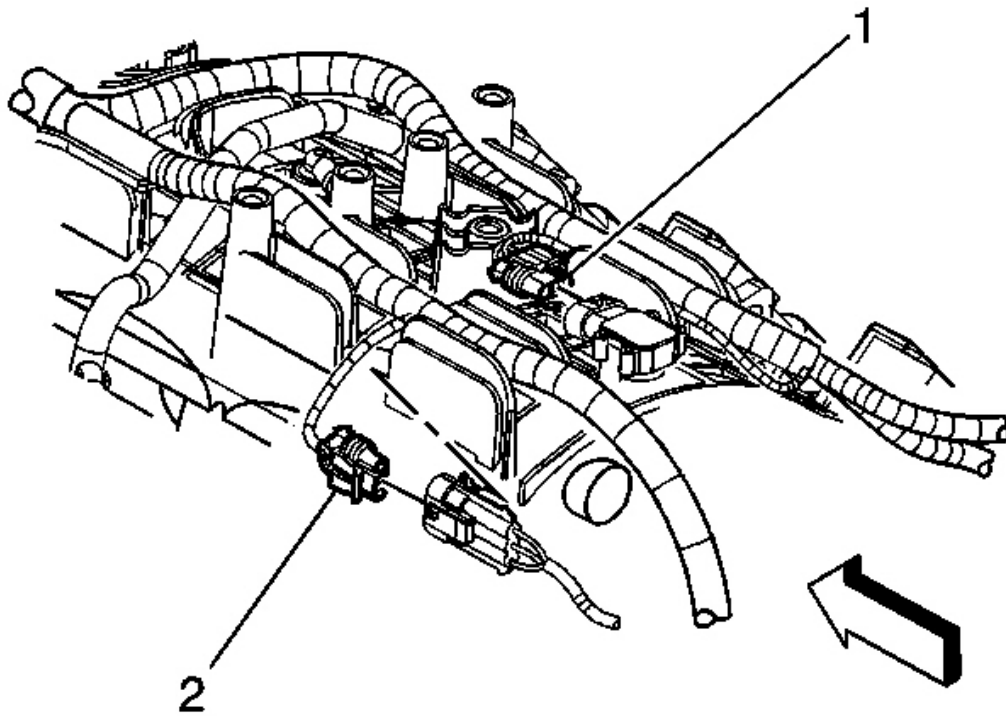
**Fig. 221: Harness Clips, Main Coil Harness & Fuel Injector Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.



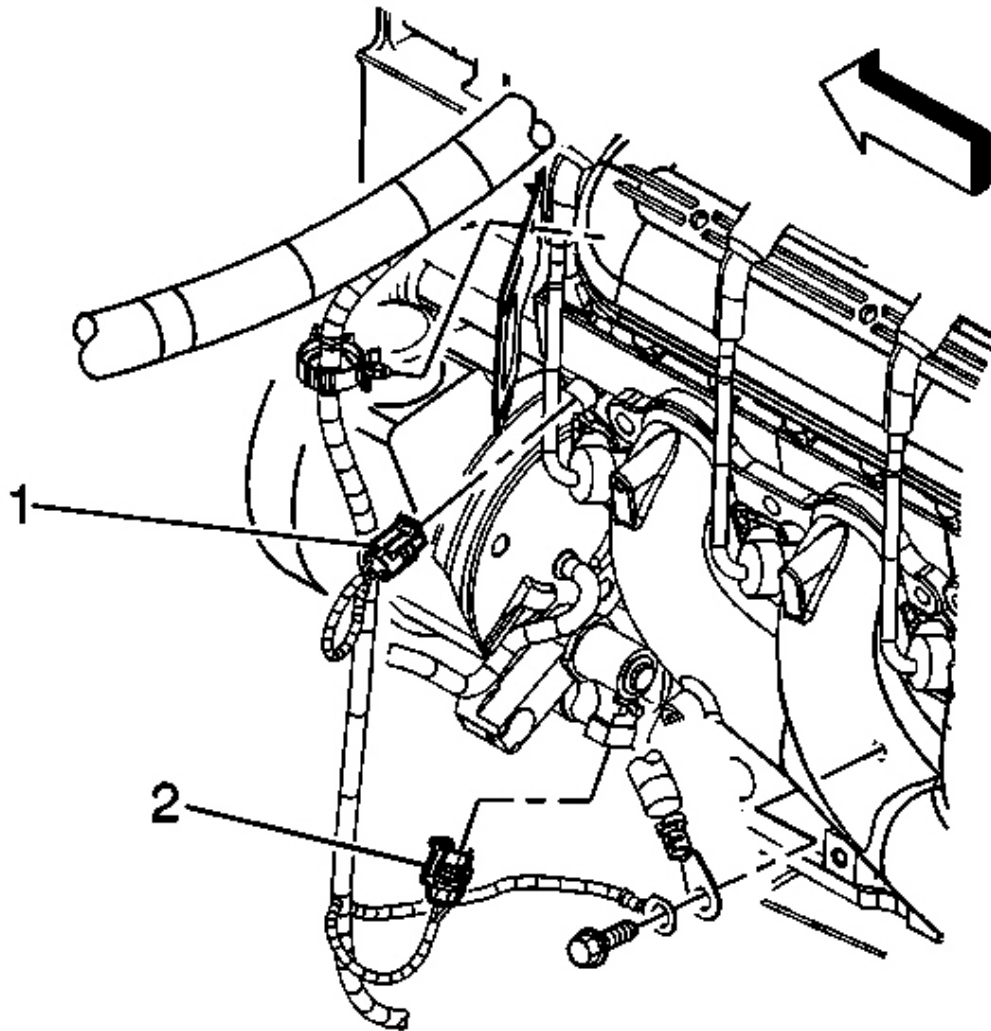
**Fig. 222: Harness Clips, Main Coil Harness, Fuel injectors & (EGR) Valve Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the following electrical connectors:
- Main coil harness (1)
  - Fuel injectors (3)
  - Exhaust gas recirculation (EGR) valve (4)



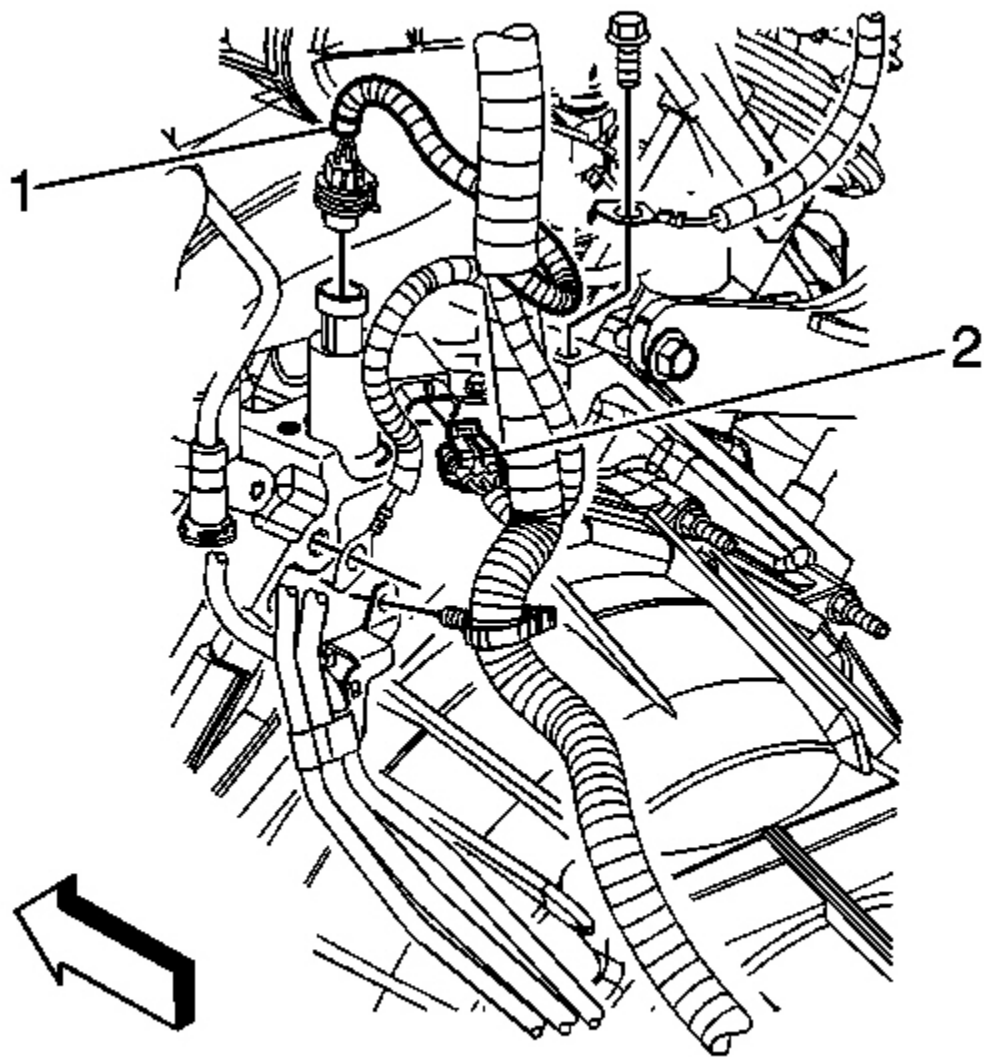
**Fig. 223: MAP Sensor & Knock Sensor Electrical Connectors**  
**Courtesy of GENERAL MOTORS CORP.**

19. Disconnect the manifold absolute pressure (MAP) sensor (1) and knock sensor (2) electrical connectors.



**Fig. 224: Coolant Temperature Sensor & Electronic Variable Orifice Switch Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

20. Remove the harness ground bolt.
21. Reposition the harness ground and negative battery cable from the block.
22. Disconnect the following electrical connectors:
  - Coolant temperature sensor (1)
  - Electronic variable orifice switch (2)

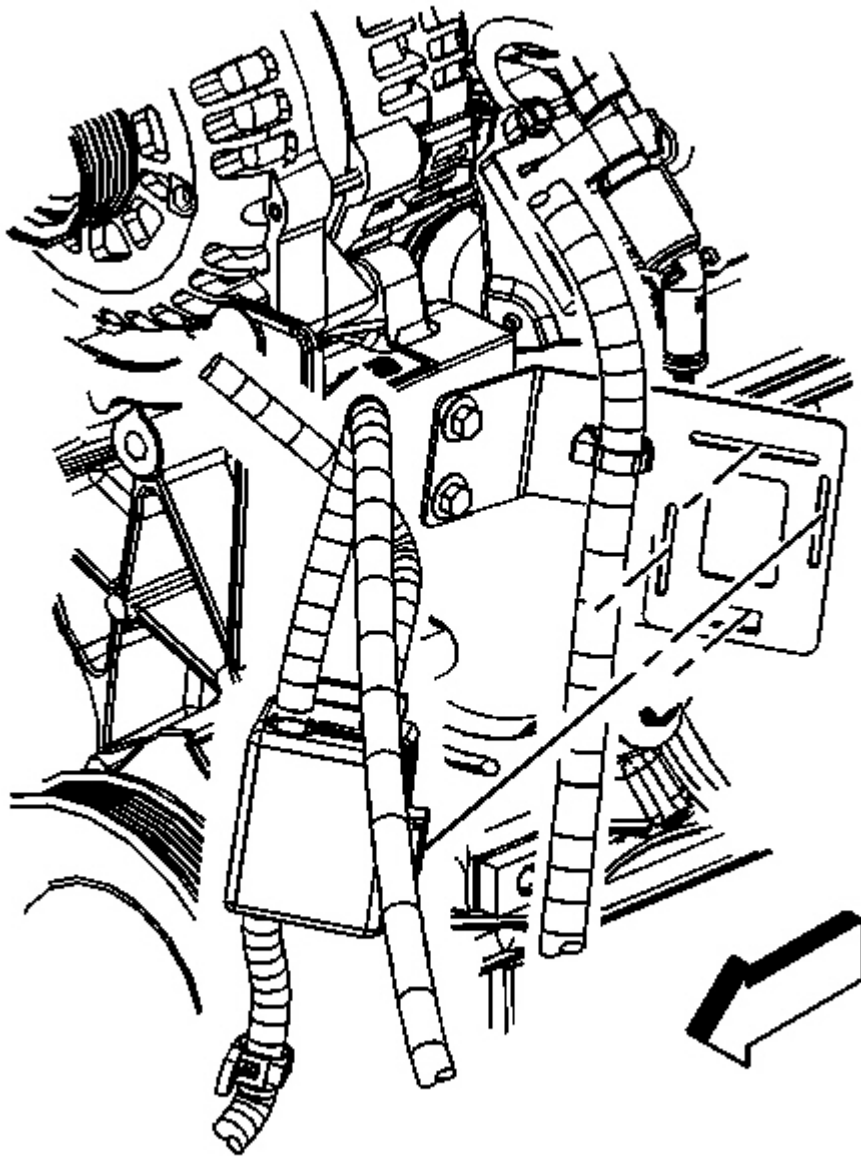


**Fig. 225: Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

23. Remove the harness ground bolt at the right rear of the engine block.
24. Reposition the harness ground from the block.
25. Remove the harness ground bolt at the left rear of the engine block
26. Reposition the harness ground, and engine ground strap from the block.
27. Disconnect the following electrical connectors:

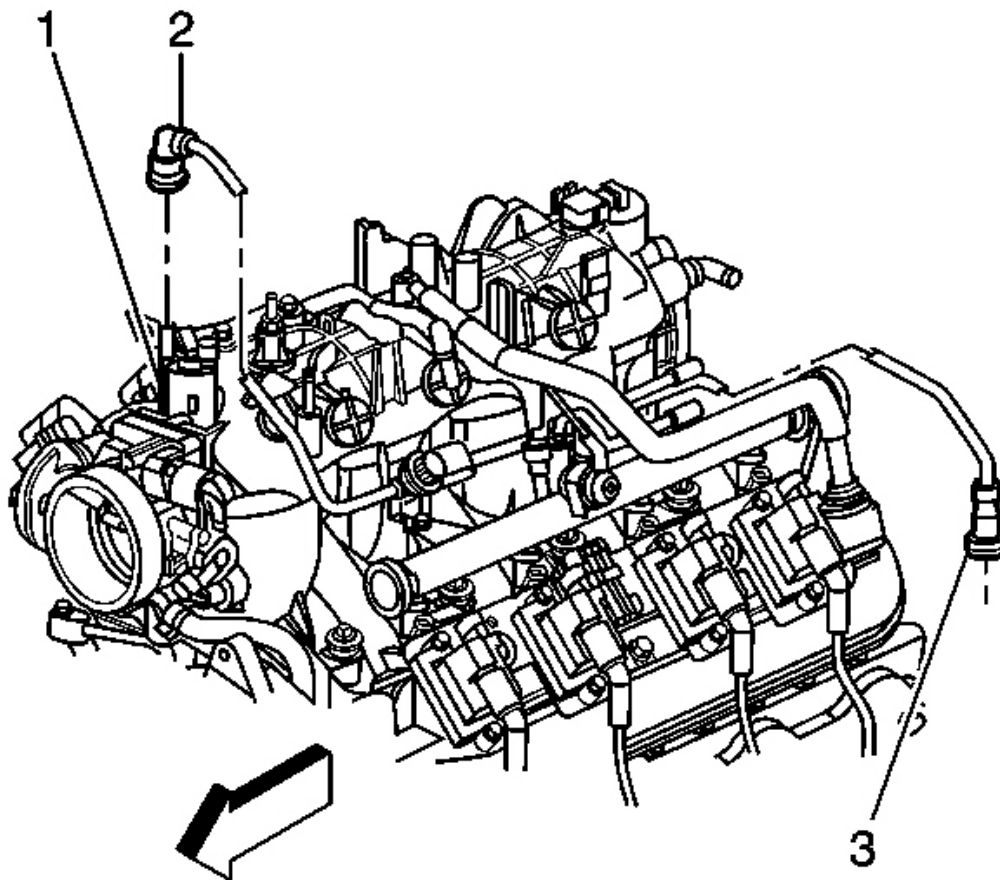


- Oil pressure sensor (1)
  - Camshaft position (CMP) sensor (2)
28. Unclip all of the engine harness clips from the engine.



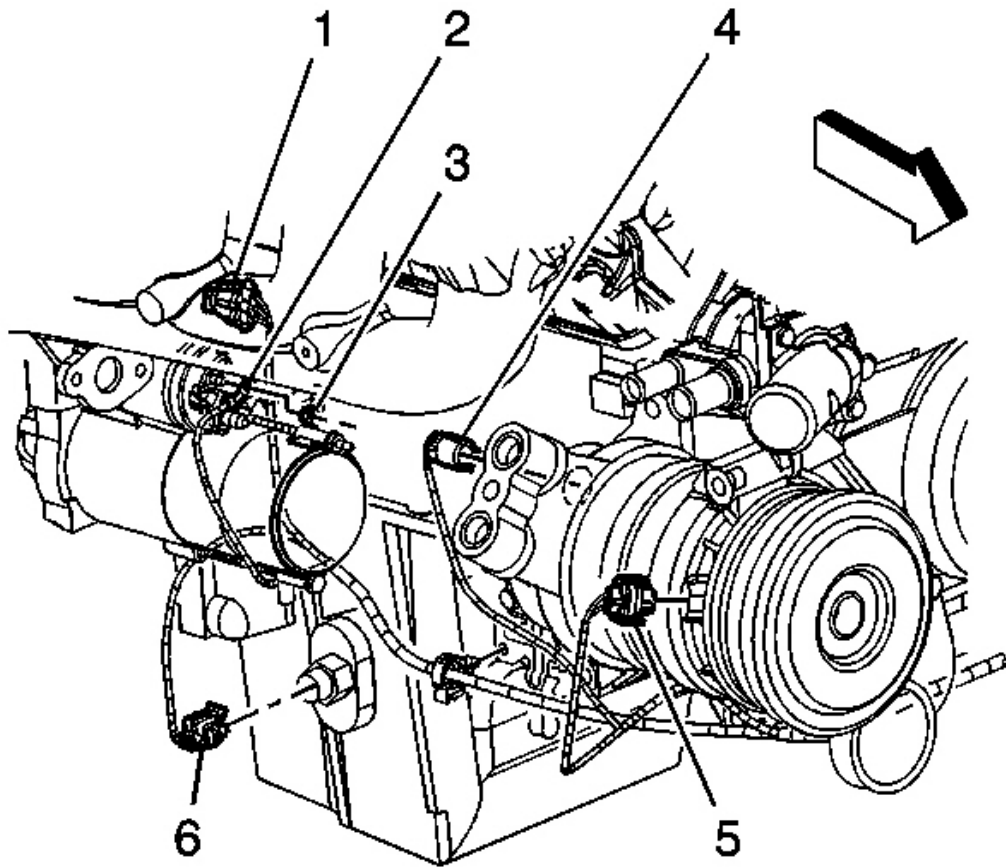
**Fig. 226: Battery Cable Junction Block & Junction Block Bracket**  
Courtesy of GENERAL MOTORS CORP.

29. Remove the battery cable junction block from the junction block bracket.



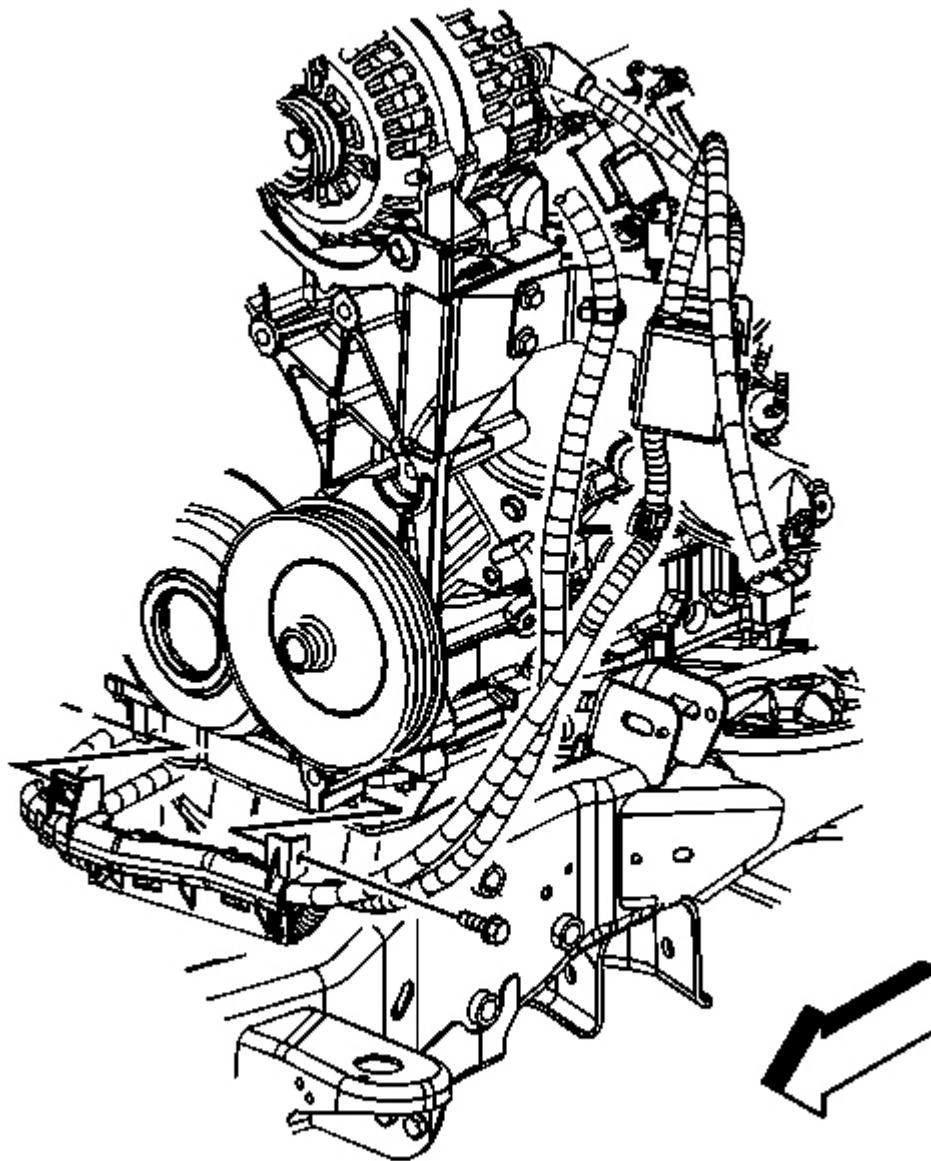
**Fig. 227: Top View Of Engine**  
Courtesy of GENERAL MOTORS CORP.

30. Remove the EVAP purge solenoid vent tube, perform the following:
- Remove the EVAP tube end (2) from the solenoid (1).
  - Remove the EVAP tube end (3) from the vapor pipe.
31. Disconnect the fuel pipes. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls - 6.0L.
32. Raise the vehicle.



**Fig. 228: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

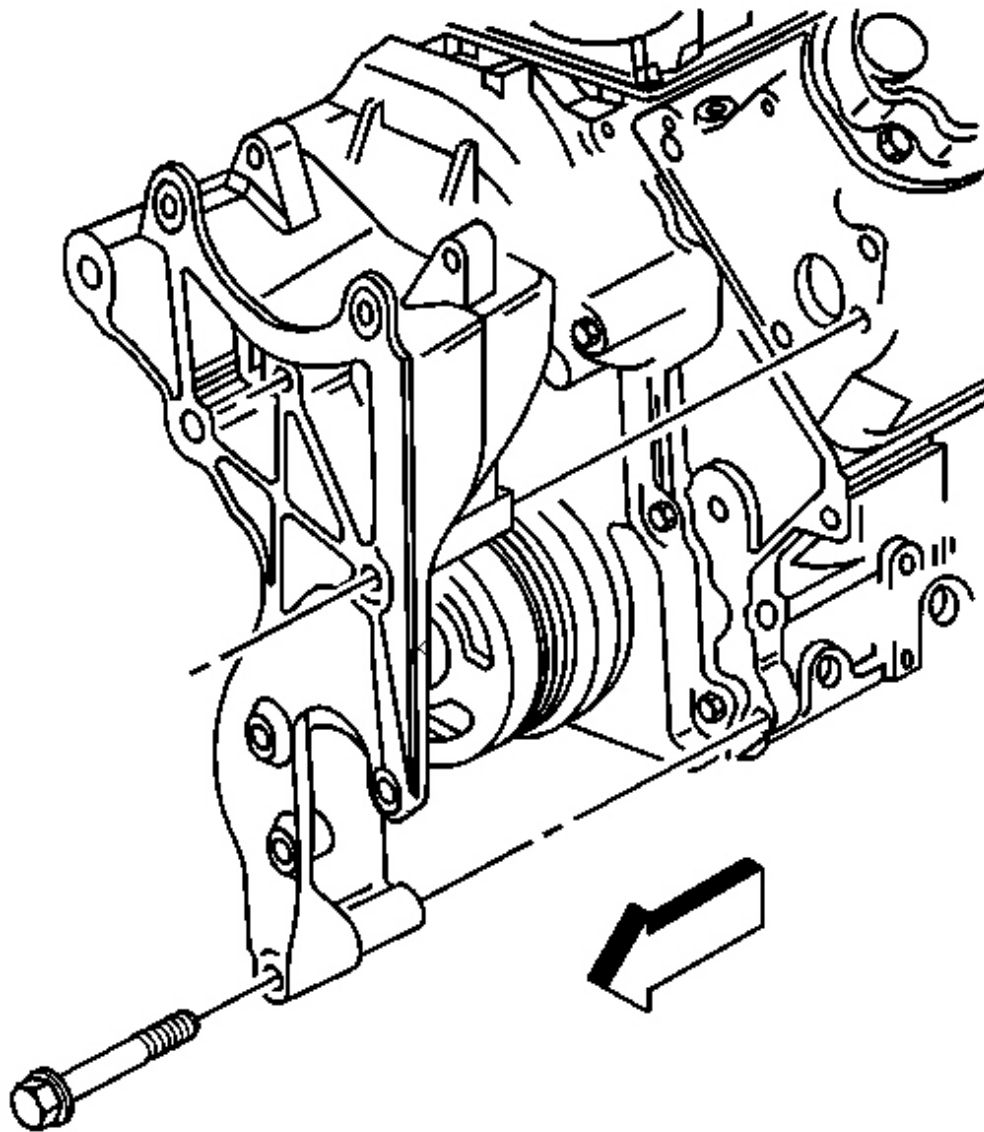
33. Disconnect the following electrical connectors:
- The crankshaft position (CKP) sensor (1)
  - The engine oil level sensor (6)
  - The coolant heater, if equipped



**Fig. 229: Battery Cable Channel Bolt**  
Courtesy of GENERAL MOTORS CORP.

34. Remove the battery cable channel bolt.
35. Slide the channel pin out of the oil pan tab.
36. Gather all branches of the engine wiring harness and reposition off to the side.

37. Lower the vehicle.

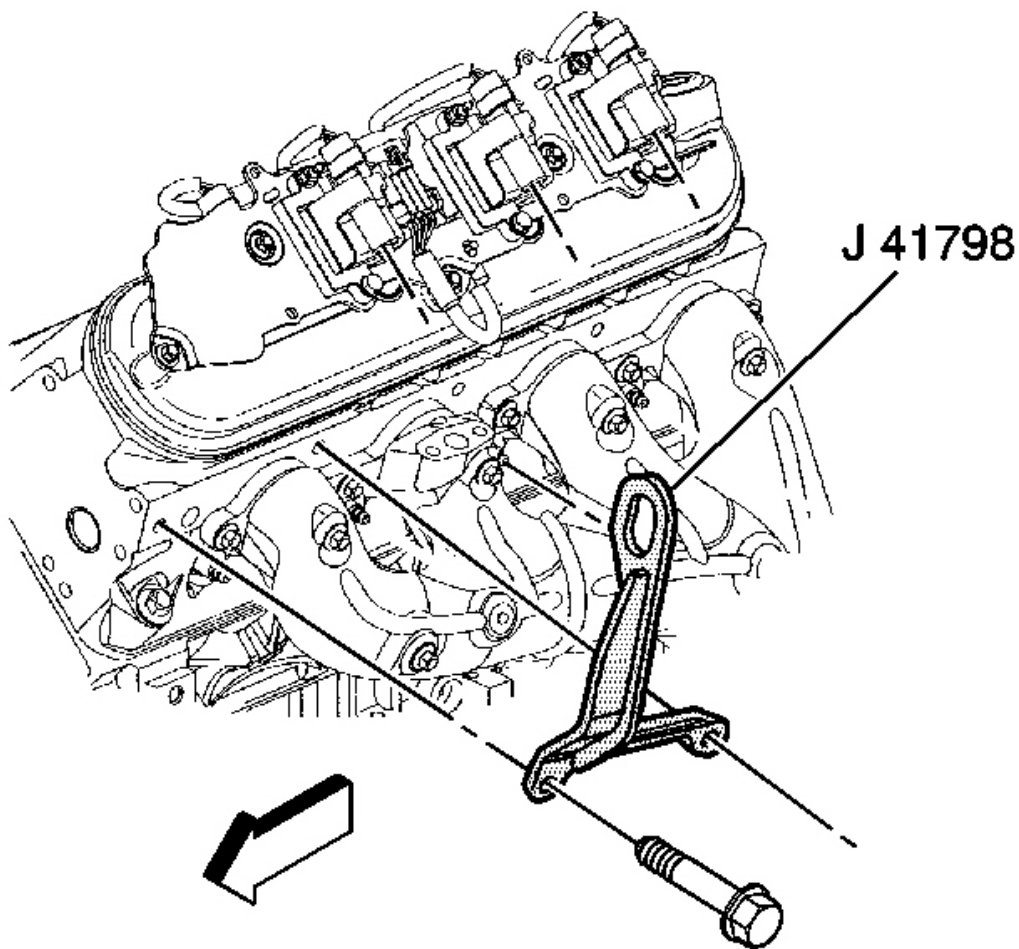


**Fig. 230: View Of Generator Bracket & Bolts**  
Courtesy of GENERAL MOTORS CORP.

38. Remove the rear power steering pump-to-engine block bolt.

39. Remove the generator bracket mounting bolts.

40. Position the bracket aside.
41. Remove the ignition coil, as required for the proper fit of the **J 41798** before lifting the engine. See **Special Tools and Equipment** . Refer to **Ignition Coil(s) Replacement** in Engine Controls - 6.0L.



**Fig. 231: View Of J 41798**

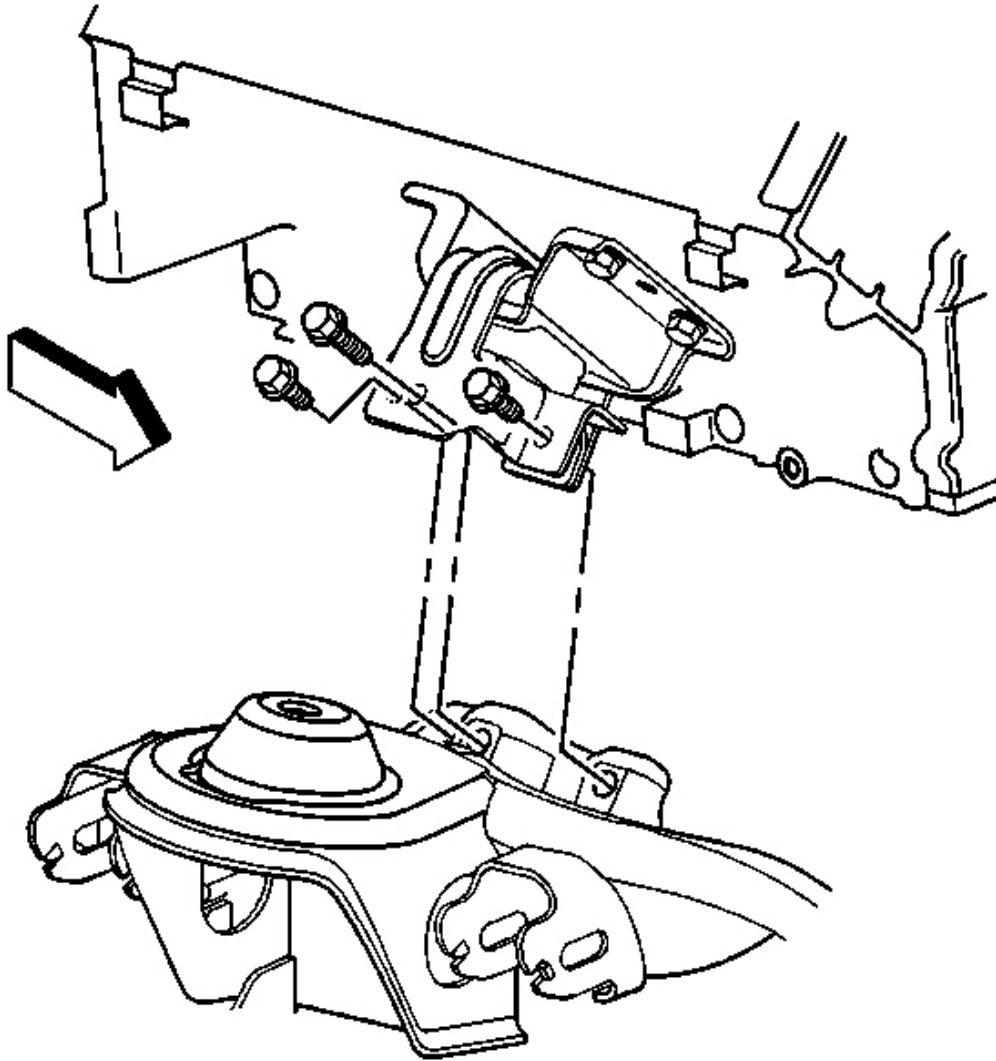
Courtesy of GENERAL MOTORS CORP.

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

42. Install the **J 41798** to the cylinder heads. See **Special Tools and Equipment** .

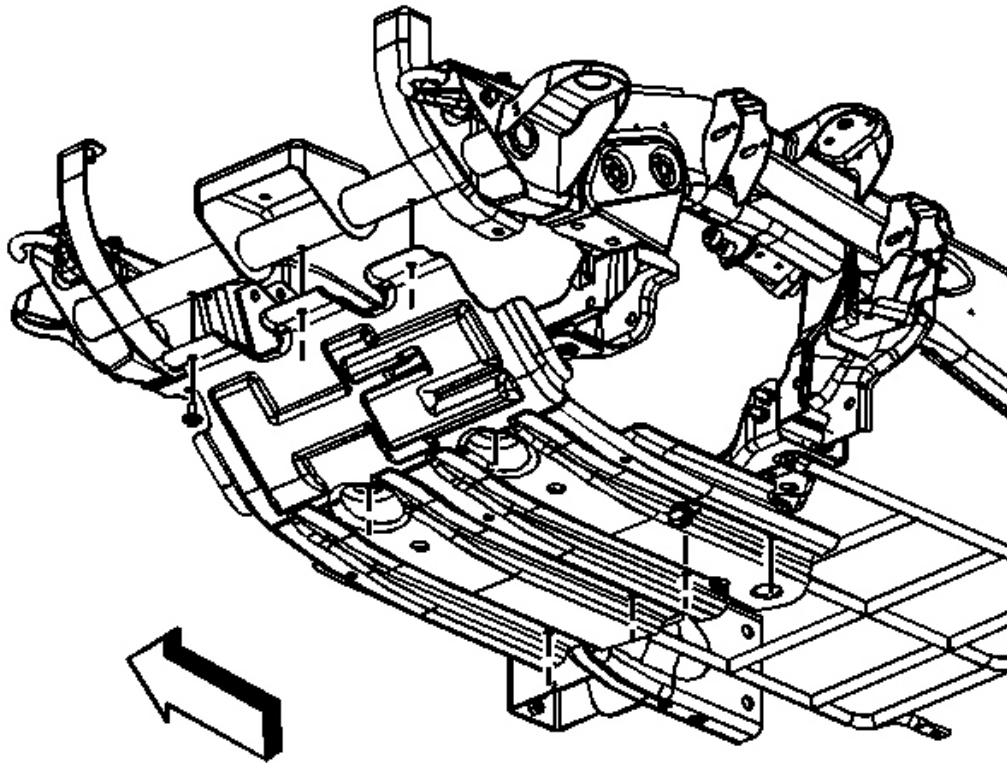
**Tighten:**

- Tighten the M8 engine lift bracket bolts to 25 N.m (18 lb ft).
- Tighten the M10 engine lift bracket bolts to 50 N.m (37 lb ft).



**Fig. 232: Engine Mount-To-Engine Mount Bracket**  
Courtesy of GENERAL MOTORS CORP.

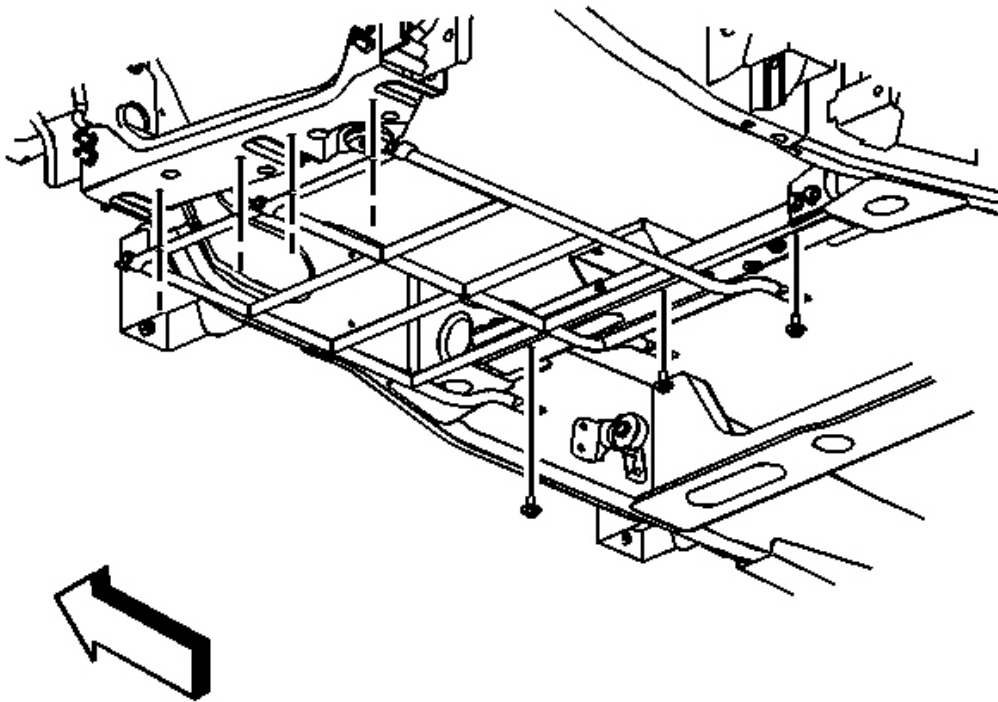
43. Remove the left and right engine mount-to-engine mount bracket bolts.
44. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.



**Fig. 233: Engine Shield Bolts**  
Courtesy of GENERAL MOTORS CORP.

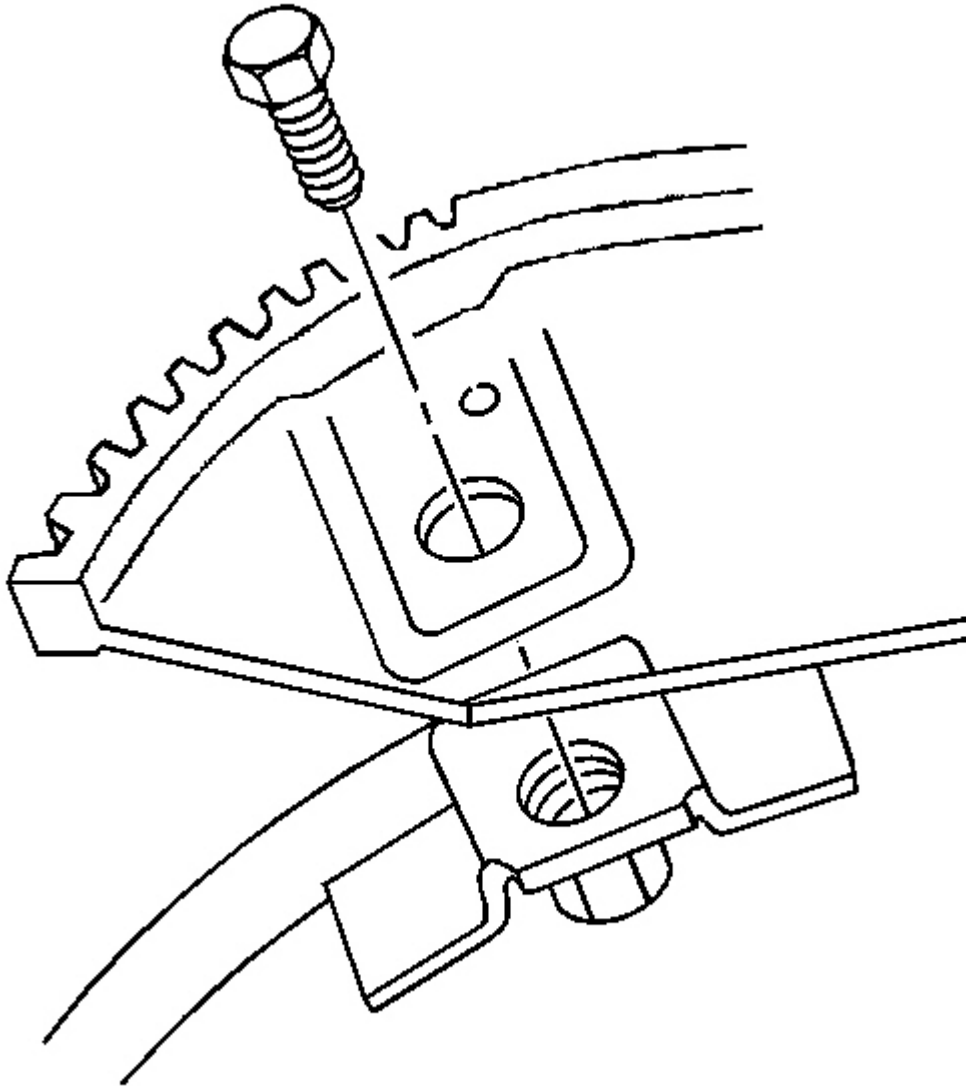
45. Remove the engine shield bolts and shield.





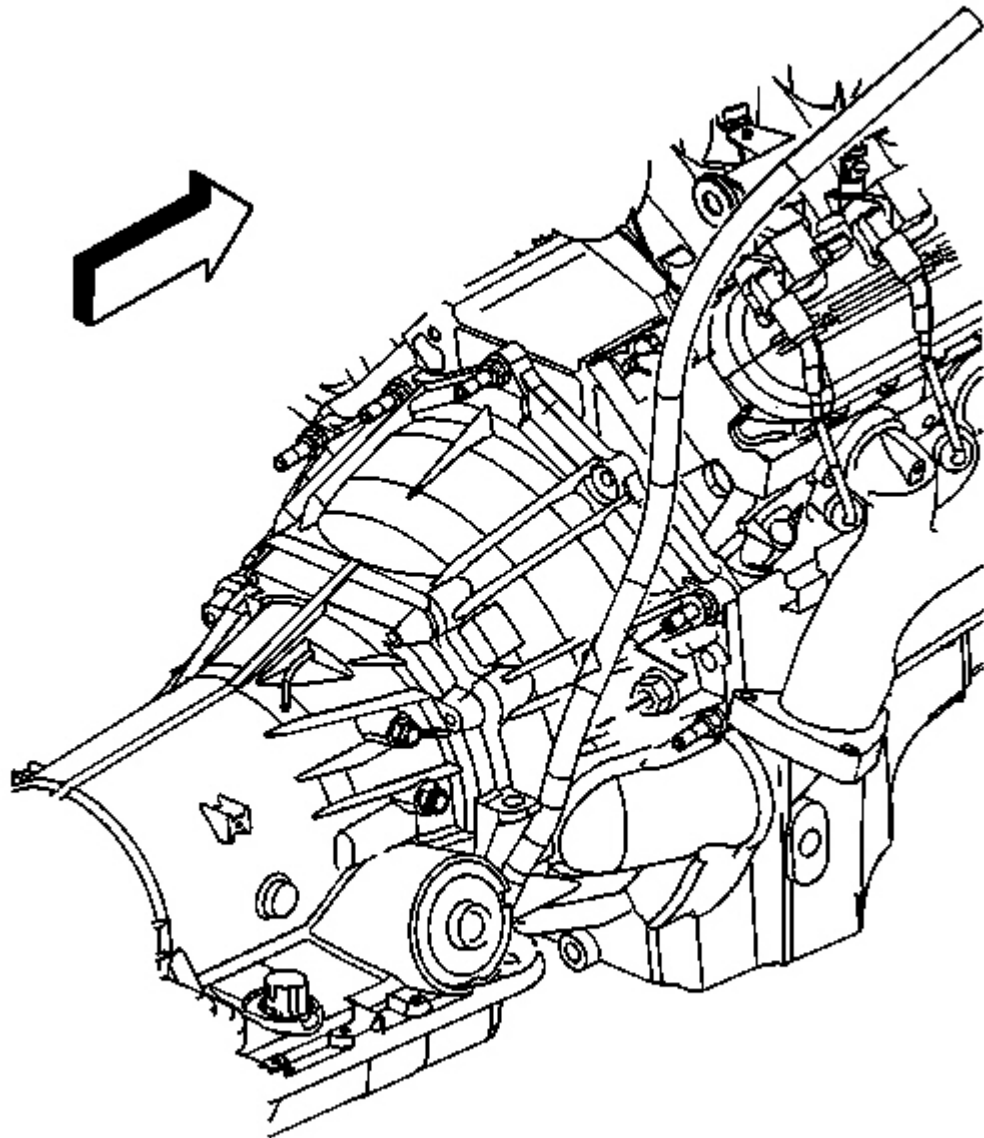
**Fig. 234: Ladder Shield, Bolts & Plate**  
**Courtesy of GENERAL MOTORS CORP.**

46. Remove the ladder shields bolts and plate.
47. Drain the engine oil.



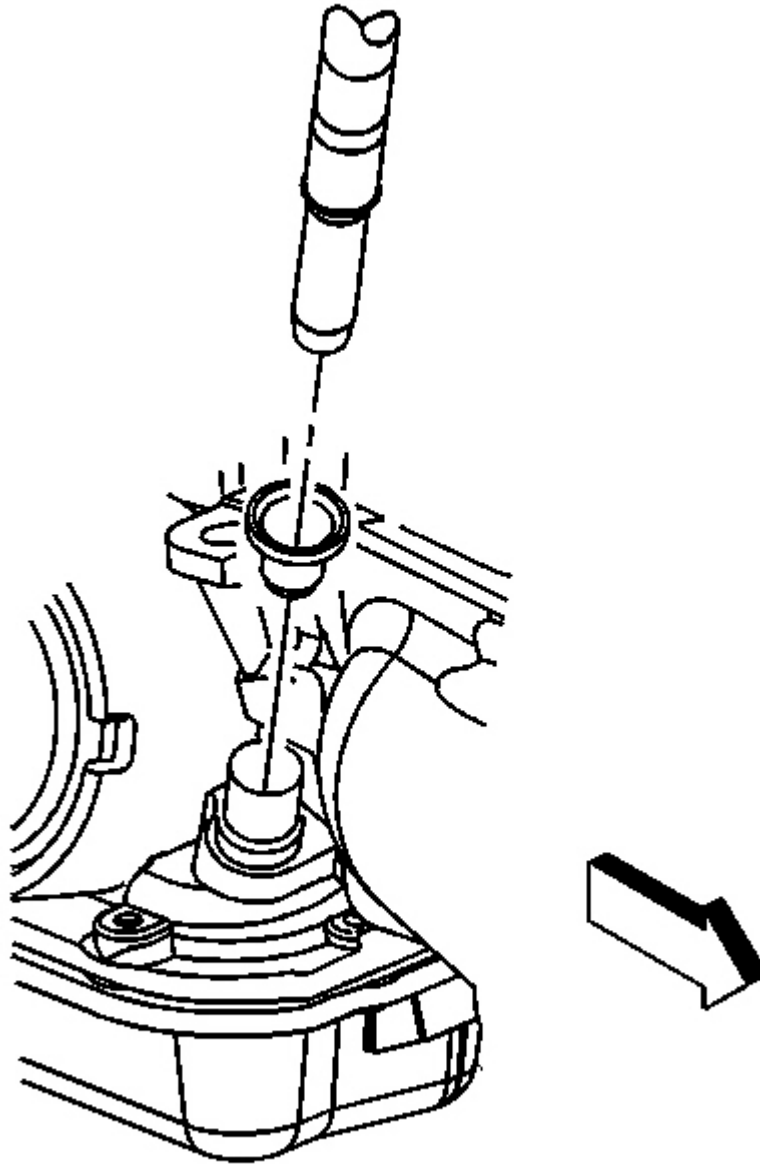
**Fig. 235: Flywheel-To-Torque Converter Bolts**  
Courtesy of GENERAL MOTORS CORP.

48. Remove the flywheel to torque converter bolts.



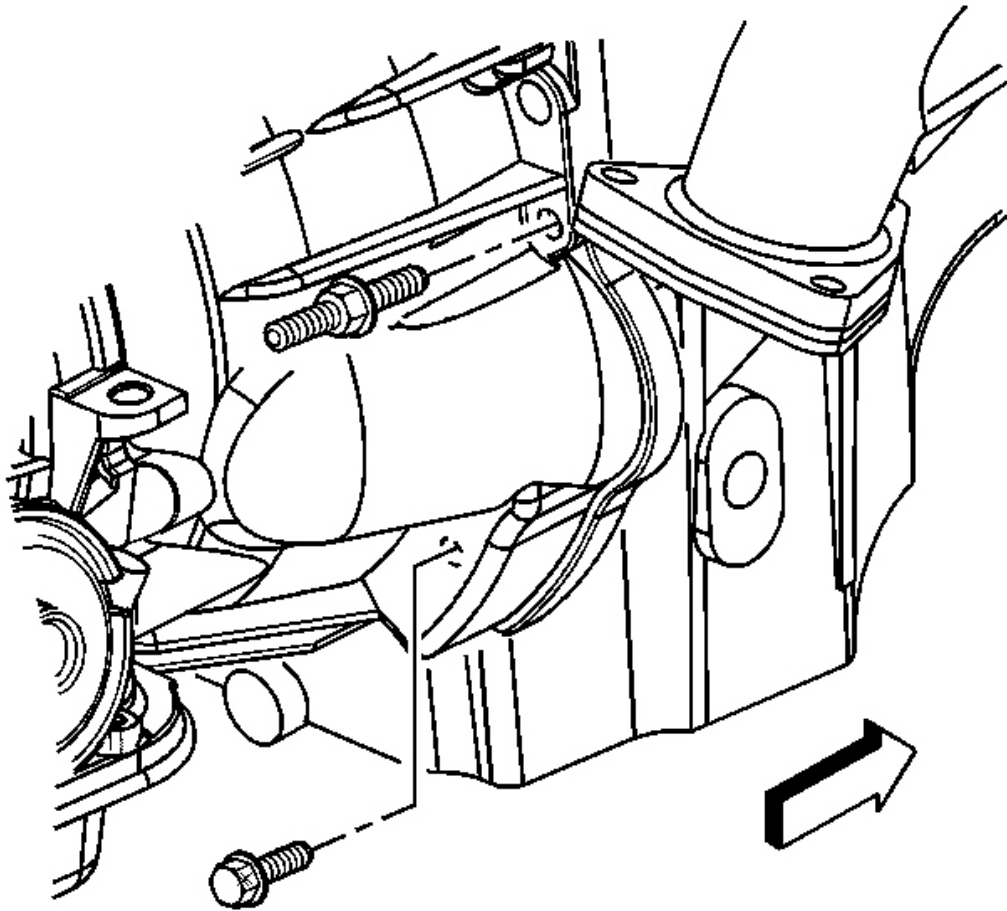
**Fig. 236: Automatic Transmission Oil Indicator Tube Nut**  
Courtesy of GENERAL MOTORS CORP.

49. Remove the transmission oil level indicator tube nut.



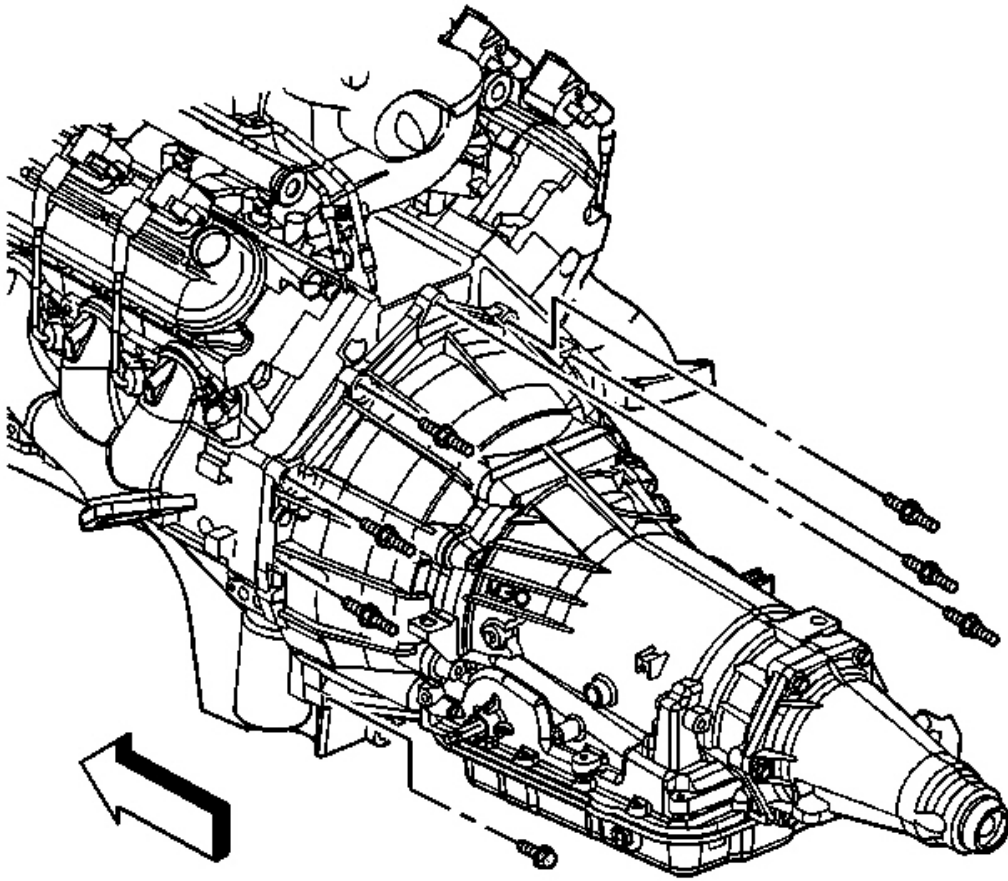
**Fig. 237: Automatic Transmission Oil Level Indicator Tube (Without RPO HP2)**  
Courtesy of GENERAL MOTORS CORP.

50. Remove the transmission oil level indicator tube.



**Fig. 238: Identifying Stud & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

51. If equipped with the 4L60-E automatic transmission, remove the transmission bolt and stud on the right side.



**Fig. 239: Identifying Studs & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

52. Remove the automatic transmission bolt/studs.
53. Separate the engine from the automatic transmission.

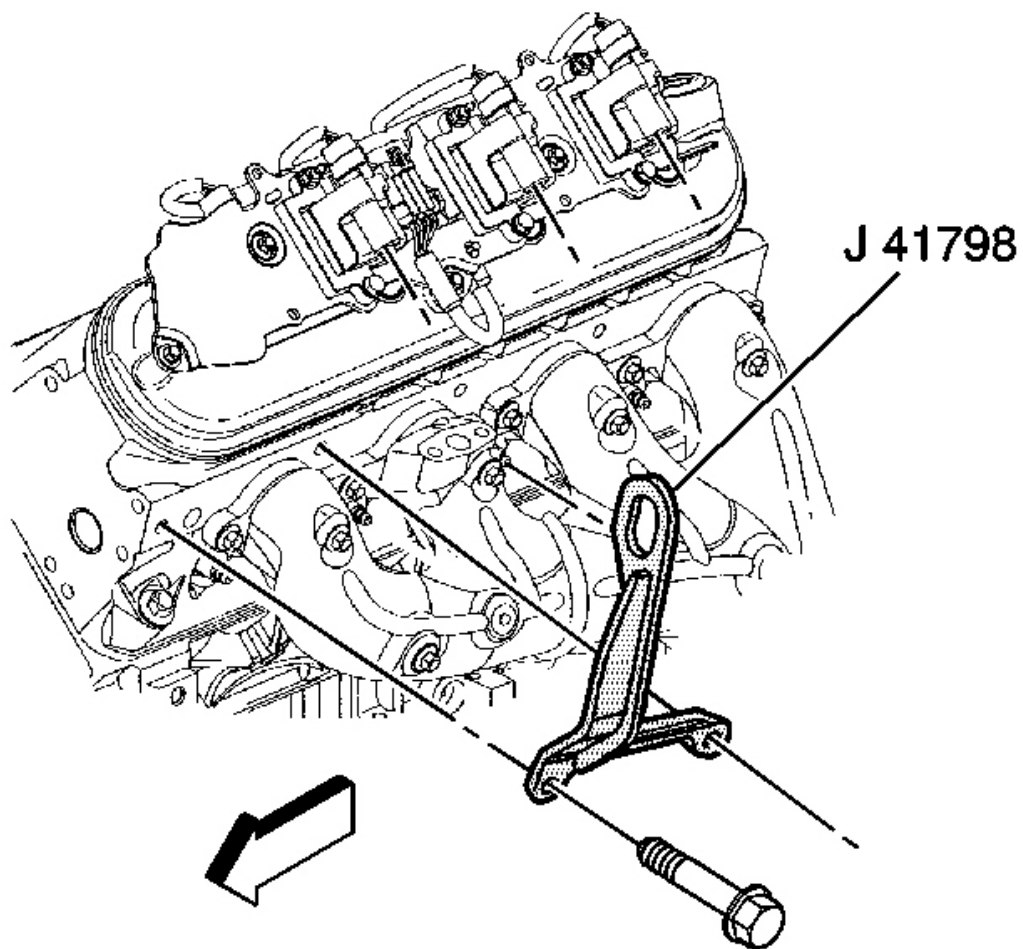
Install the **J 21366** . See **Special Tools and Equipment** .

54. Lower the vehicle.
55. Install an engine hoist to the **J 41798** . See **Special Tools and Equipment** .
56. Install a floor jack under the transmission for support.

**NOTE:** Use care while moving the engine assembly in order to avoid breaking the MAP sensor locating tabs. Broken MAP sensor tabs may result in

decreased engine performance.

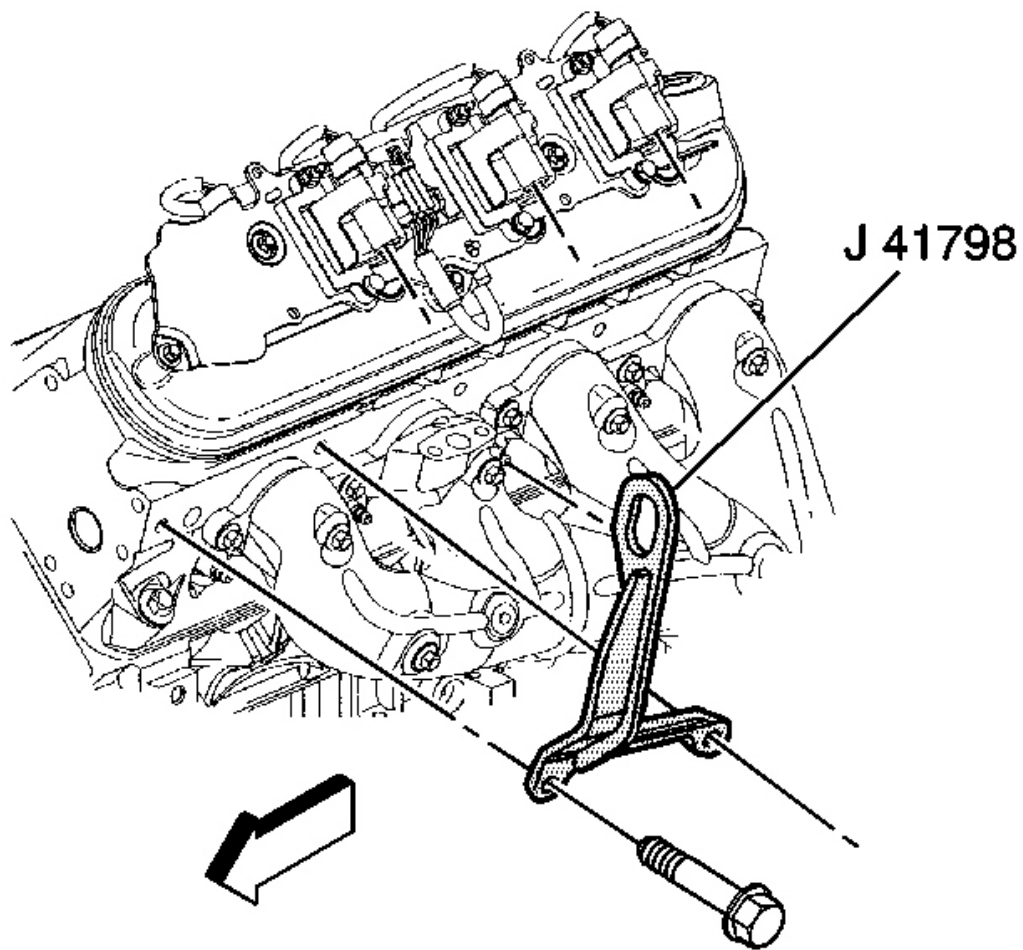
57. Remove the engine.
58. Install the engine to an engine stand.
59. Remove the engine hoist.



**Fig. 240: View Of J 41798**  
Courtesy of GENERAL MOTORS CORP.

60. Remove the **J 41798** . See Special Tools and Equipment .

**Installation Procedure**



**Fig. 241: View Of J 41798**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the **J 41798** to the engine. See Special Tools and Equipment .

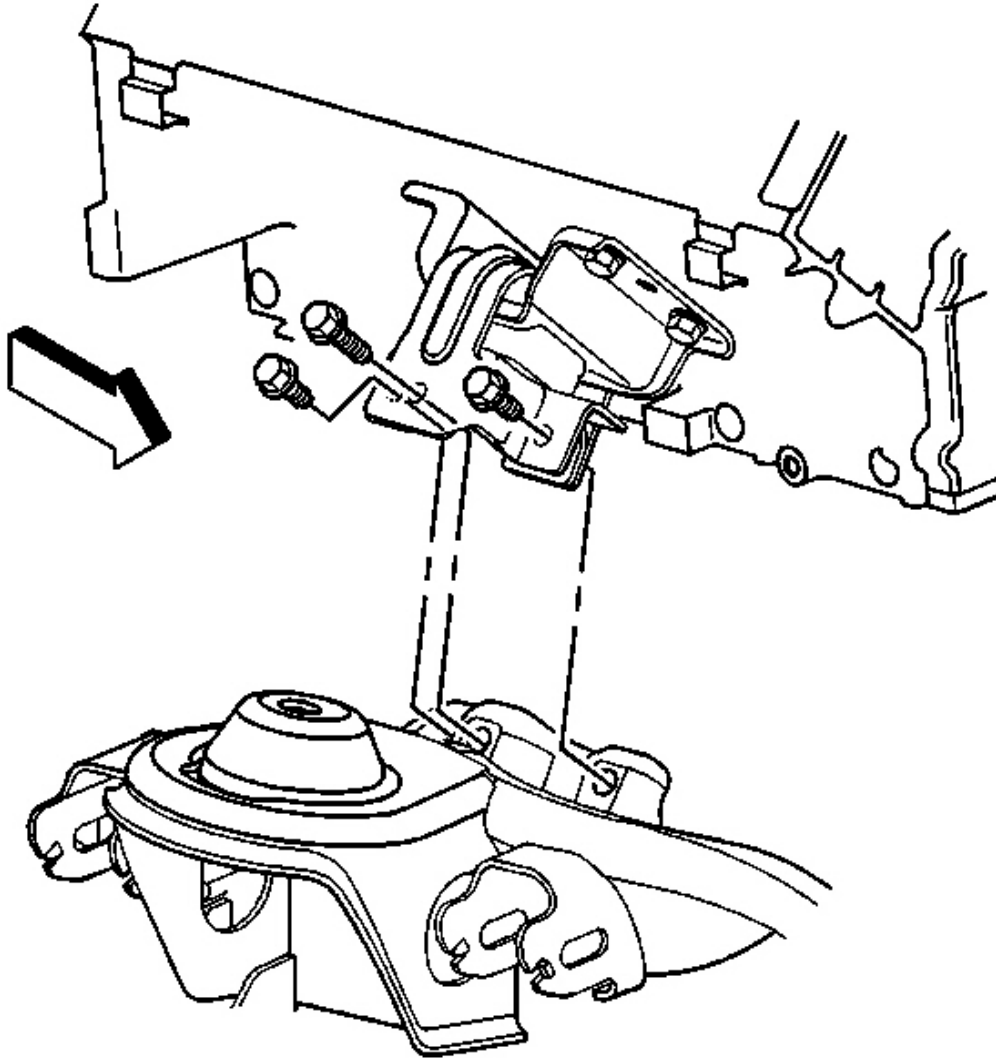
**Tighten:**

- Tighten the M8 engine lift bracket bolts to 25 N.m (18 lb ft).
- Tighten the M10 engine lift bracket bolts to 50 N.m (37 lb ft).

2. Install an engine hoist to the **J 41798** . See Special Tools and Equipment .



3. Remove the engine from the engine stand.
4. Install the engine to the vehicle.
5. Align the engine and transmission.

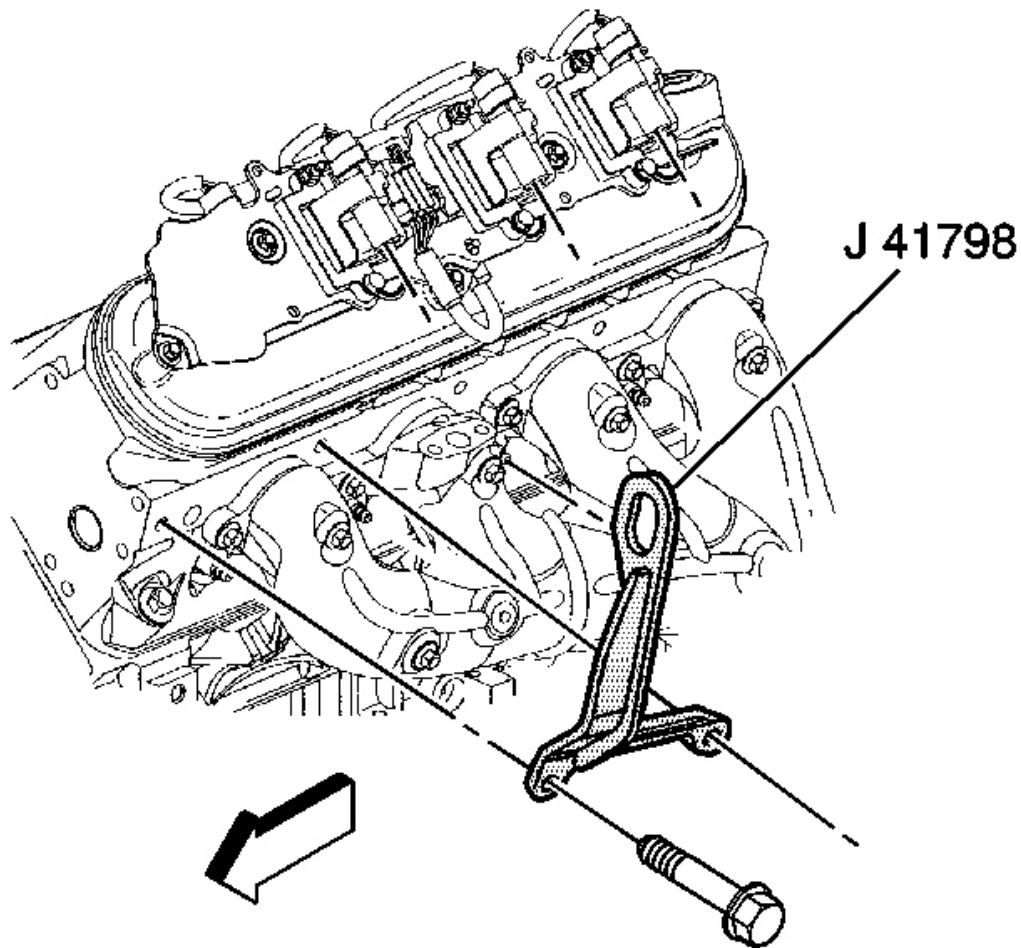


**Fig. 242: Engine Mount-To-Engine Mount Bracket**  
Courtesy of GENERAL MOTORS CORP.

6. Install the left and right engine mount-to-engine mount bracket bolts.

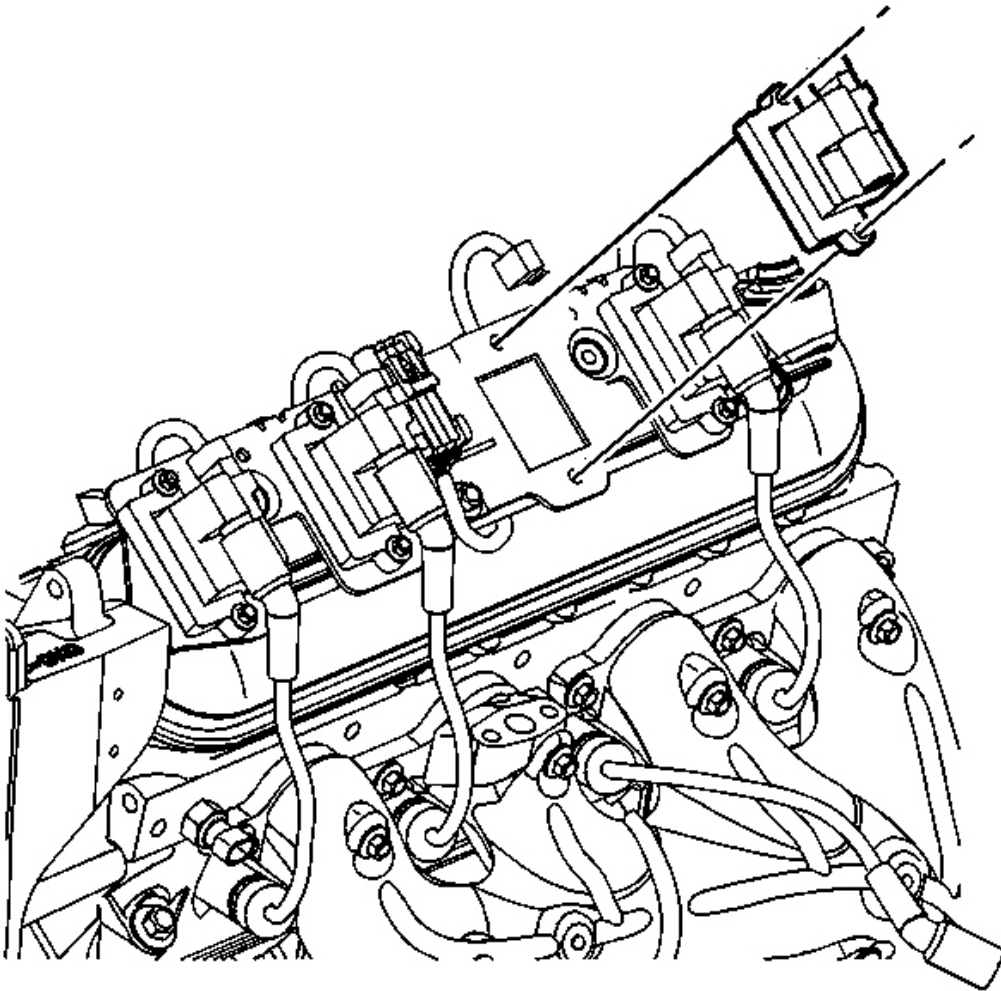
**Tighten:** Tighten the engine mount-to-engine mount bracket bolts to 65 N.m (48 lb ft).

7. Install the upper transmission bolts until snug.
8. Remove the floor jack from under the transmission.
9. Remove the engine hoist.



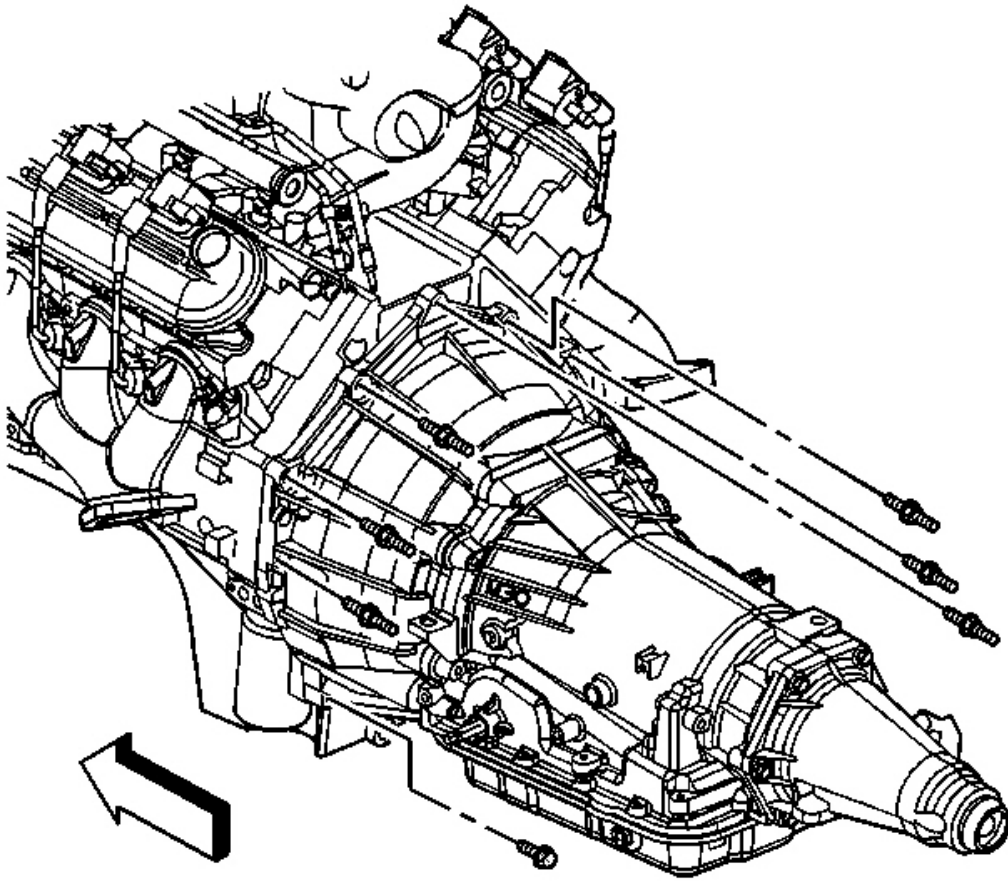
**Fig. 243: View Of J 41798**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the **J 41798** . See **Special Tools and Equipment** .



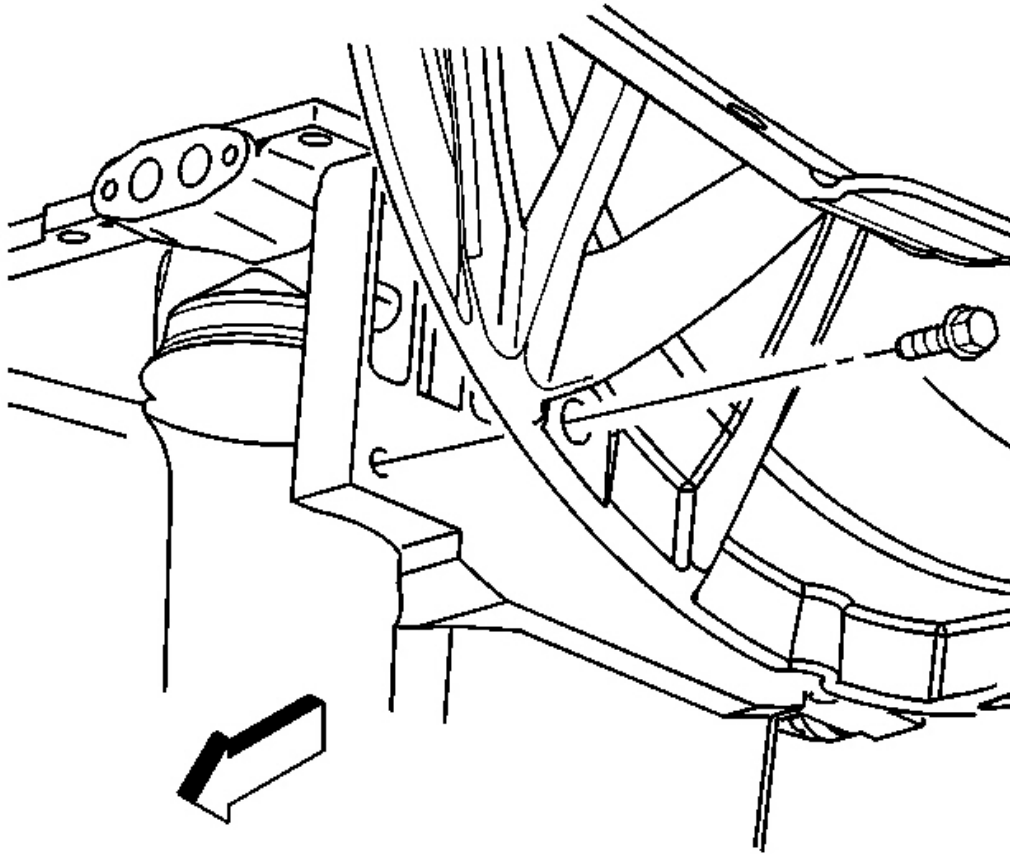
**Fig. 244: Installing Ignition Coils & Spark Plug Wires**  
Courtesy of GENERAL MOTORS CORP.

11. Install the ignition coils and the spark plug wires. Refer to **Ignition Coil(s) Replacement** in Engine Controls-6.0L.
12. Raise the vehicle.



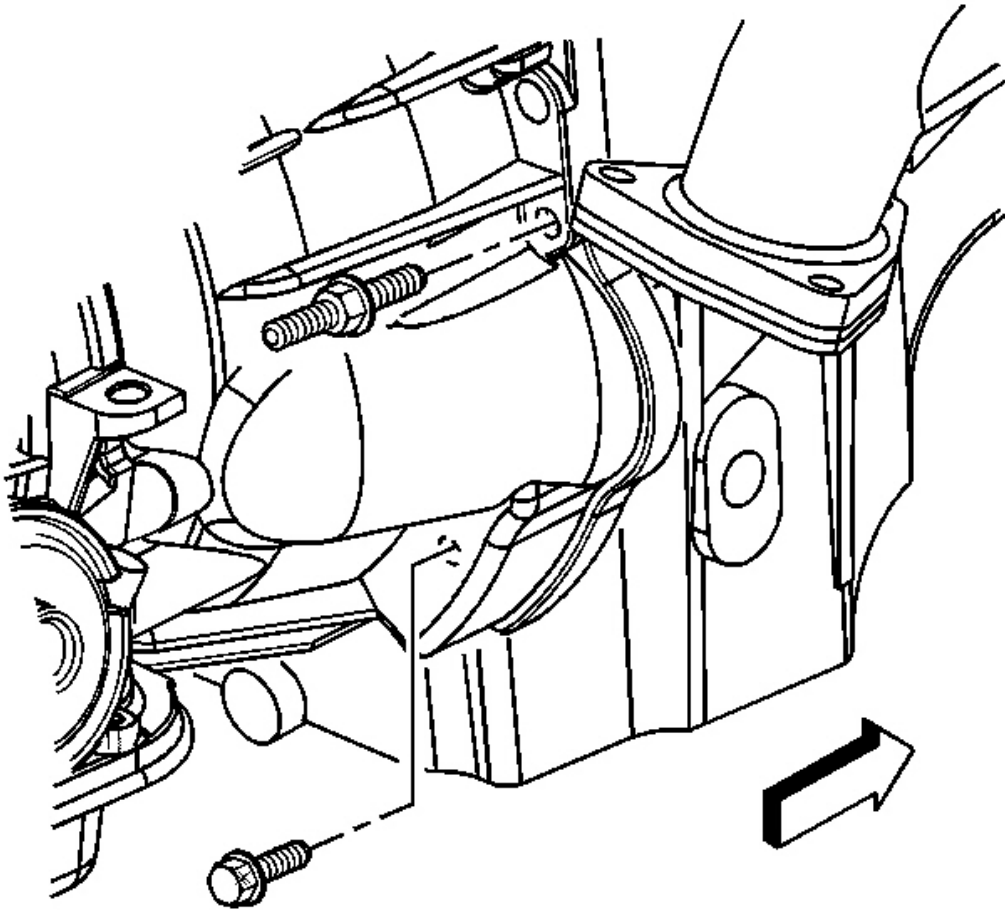
**Fig. 245: Identifying Studs & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

13. Remove the **J 21366** . See **Special Tools and Equipment** .
14. Install the automatic transmission bolt/studs.



**Fig. 246: Transmission Converter Cover Bolt (4L80-E)**  
Courtesy of GENERAL MOTORS CORP.

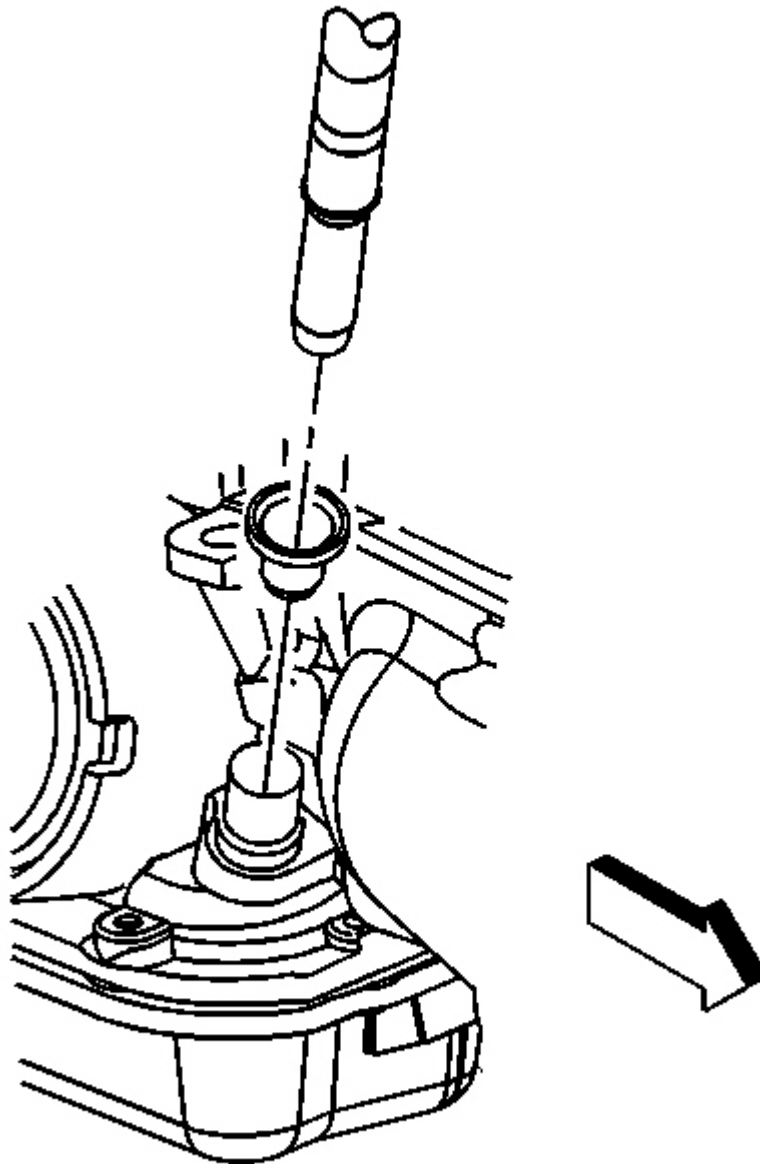
15. Install the transmission converter cover bolts.



**Fig. 247: Identifying Stud & Bolt Securing Transmission To Engine**  
Courtesy of GENERAL MOTORS CORP.

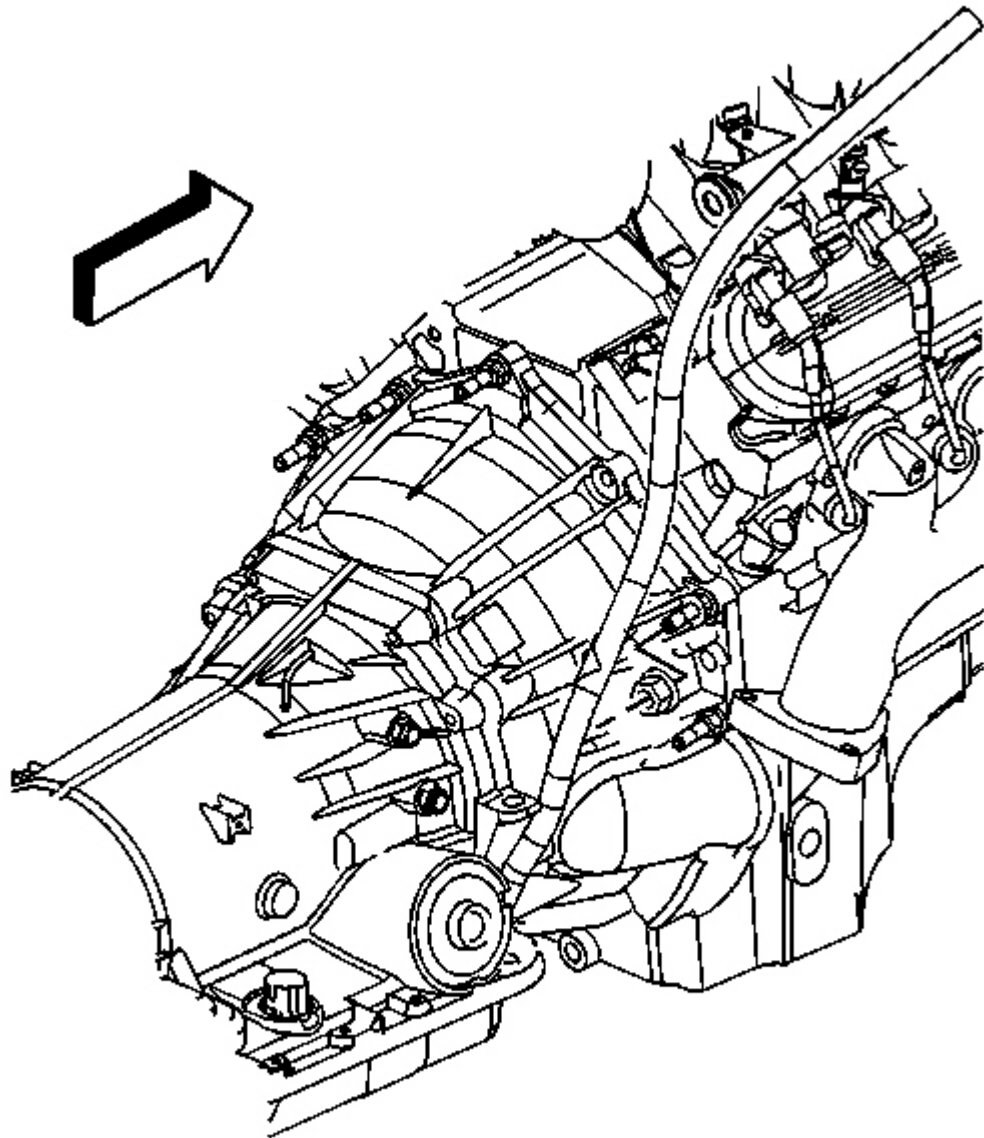
16. Install the transmission bolt and stud on the right side.

**Tighten:** Tighten the automatic transmission bolts/studs to 50 N.m (37 lb ft).



**Fig. 248: Automatic Transmission Oil Level Indicator Tube (Without RPO HP2)**  
Courtesy of GENERAL MOTORS CORP.

17. Install the automatic transmission oil level indicator tube.

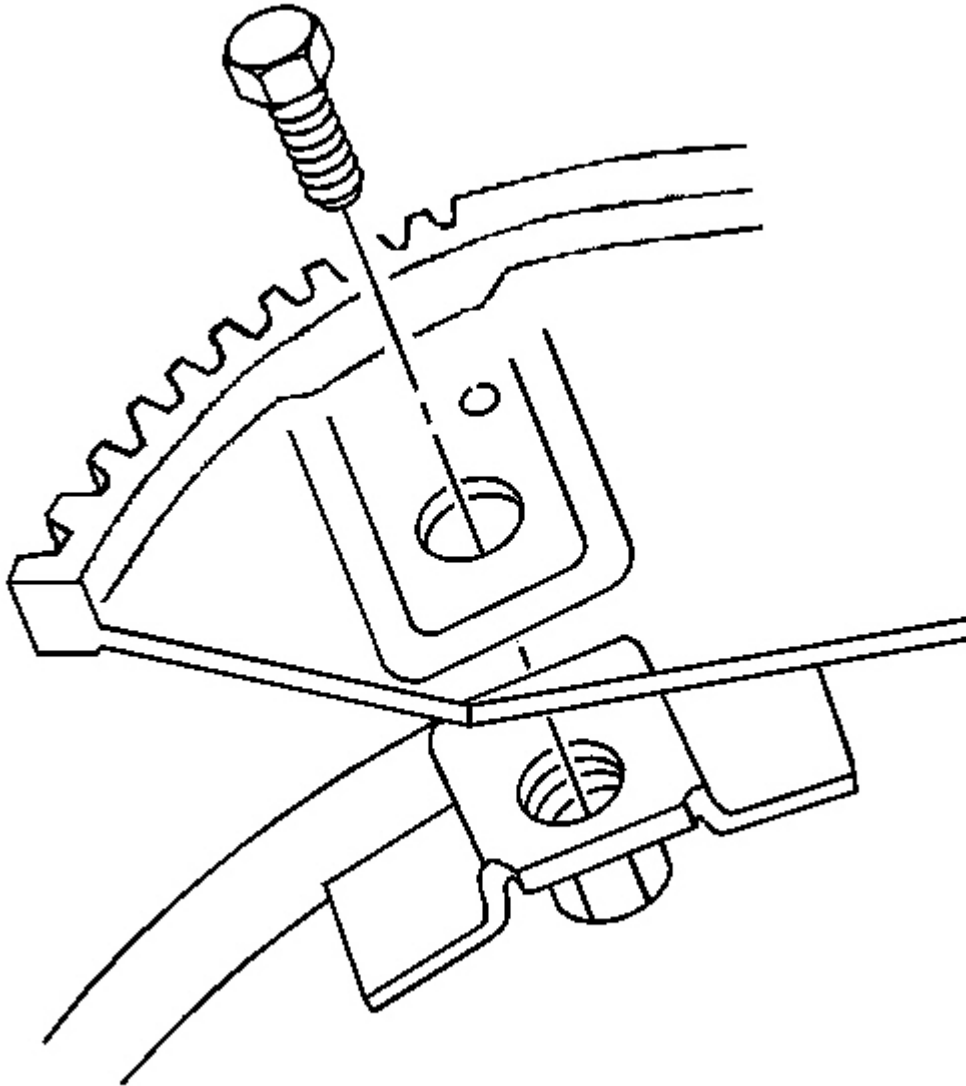


**Fig. 249: Automatic Transmission Oil Indicator Tube Nut**  
Courtesy of GENERAL MOTORS CORP.

18. Install the automatic transmission oil level indicator tube nut.

**Tighten:** Tighten the automatic transmission oil level indicator tube nut to 18 N.m (13 lb ft).



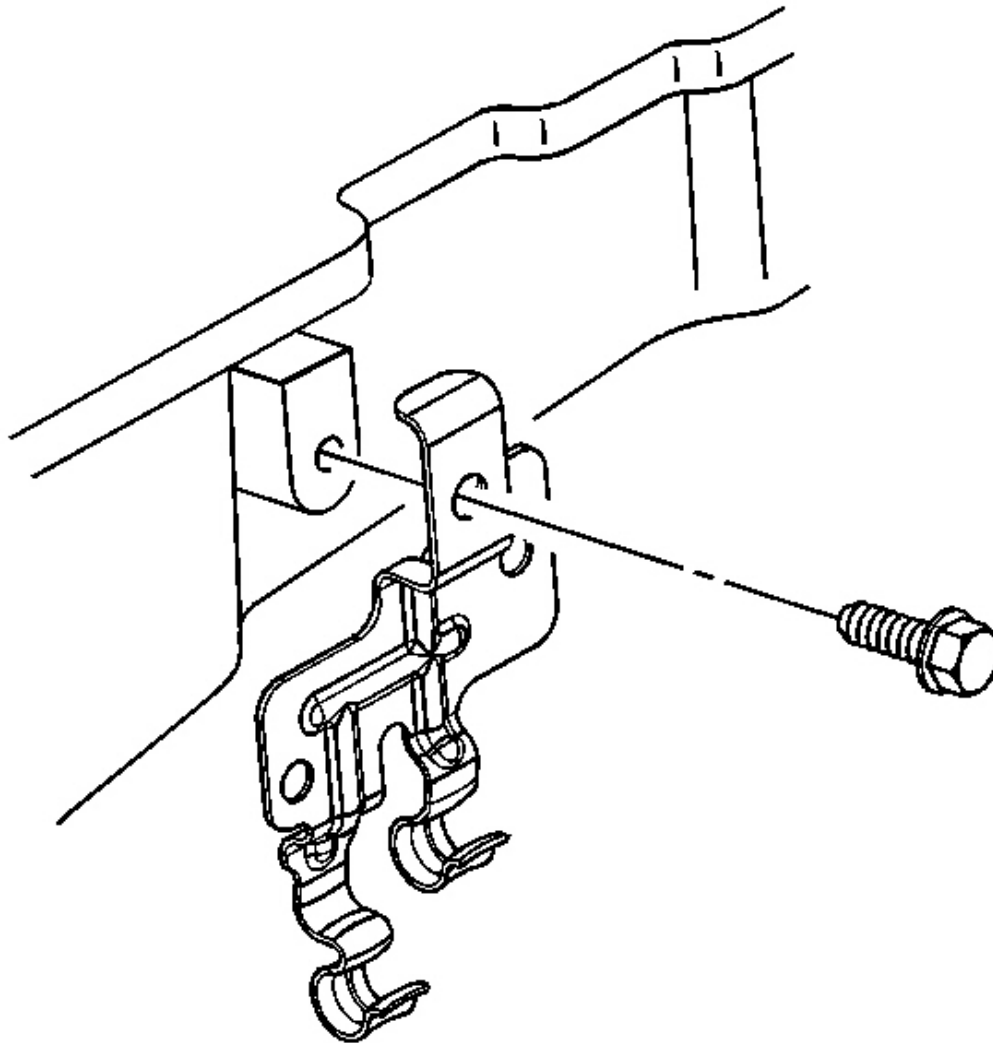


**Fig. 250: Flywheel-To-Torque Converter Bolts**  
Courtesy of GENERAL MOTORS CORP.

19. Install the flywheel to torque converter bolts.

**Tighten:** If equipped with a 4L60E transmission, tighten the bolts to 63 N.m (47 lb ft).

20. Install exhaust pipes to the exhaust manifolds.



**Fig. 251: Positive Battery Cable Clip & Bolt**  
Courtesy of GENERAL MOTORS CORP.

21. Install the positive battery cable clip and bolt.

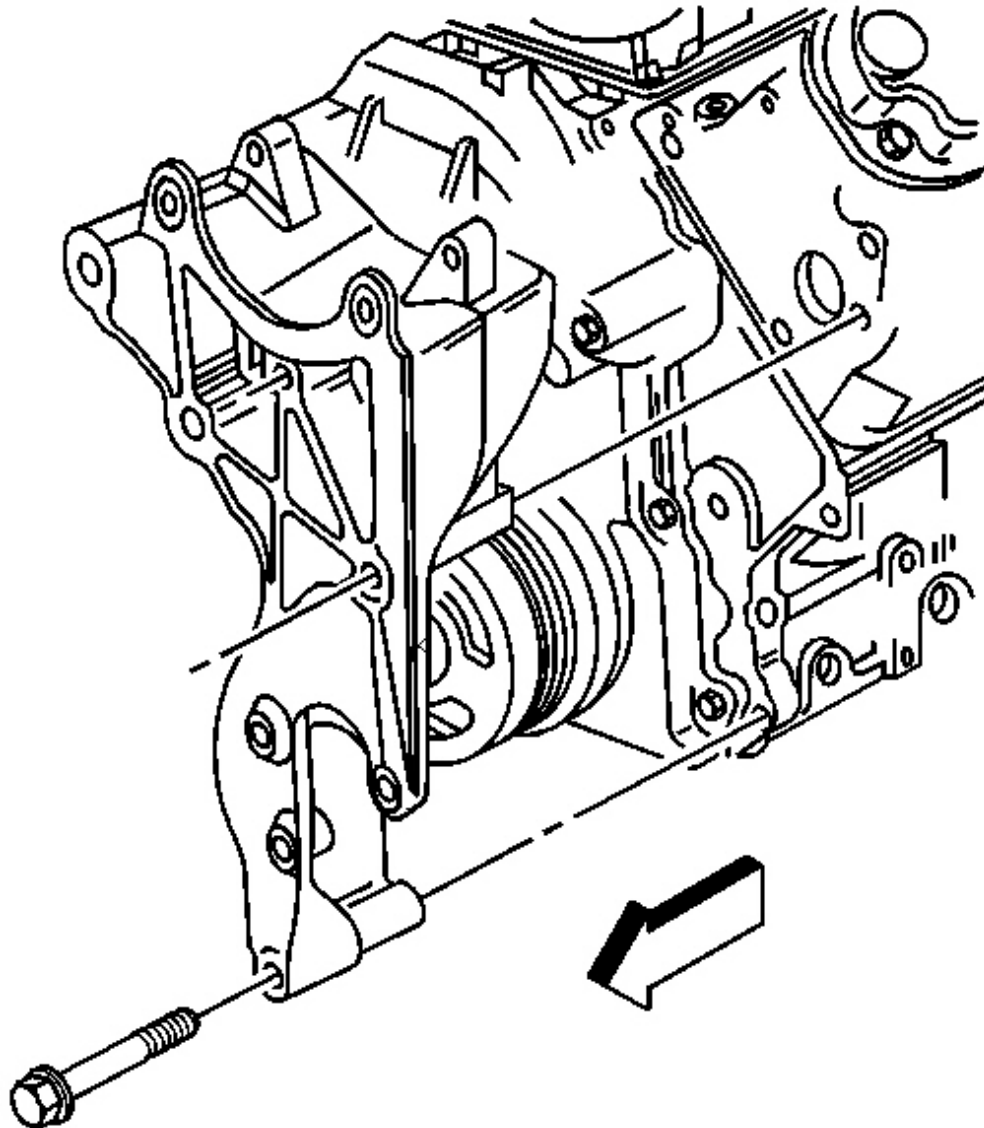
**Tighten:** Tighten the positive battery cable clip bolt to 9 N.m (80 lb in).

22. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
23. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.

**Tighten:** Tighten the oil pan skid plate bolts to 20 N.m (15 lb ft).

24. Lower the vehicle.
25. Install the ground cable to the engine block.

**Tighten:** Tighten the ground cable bolt to 25 N.m (18 lb ft).

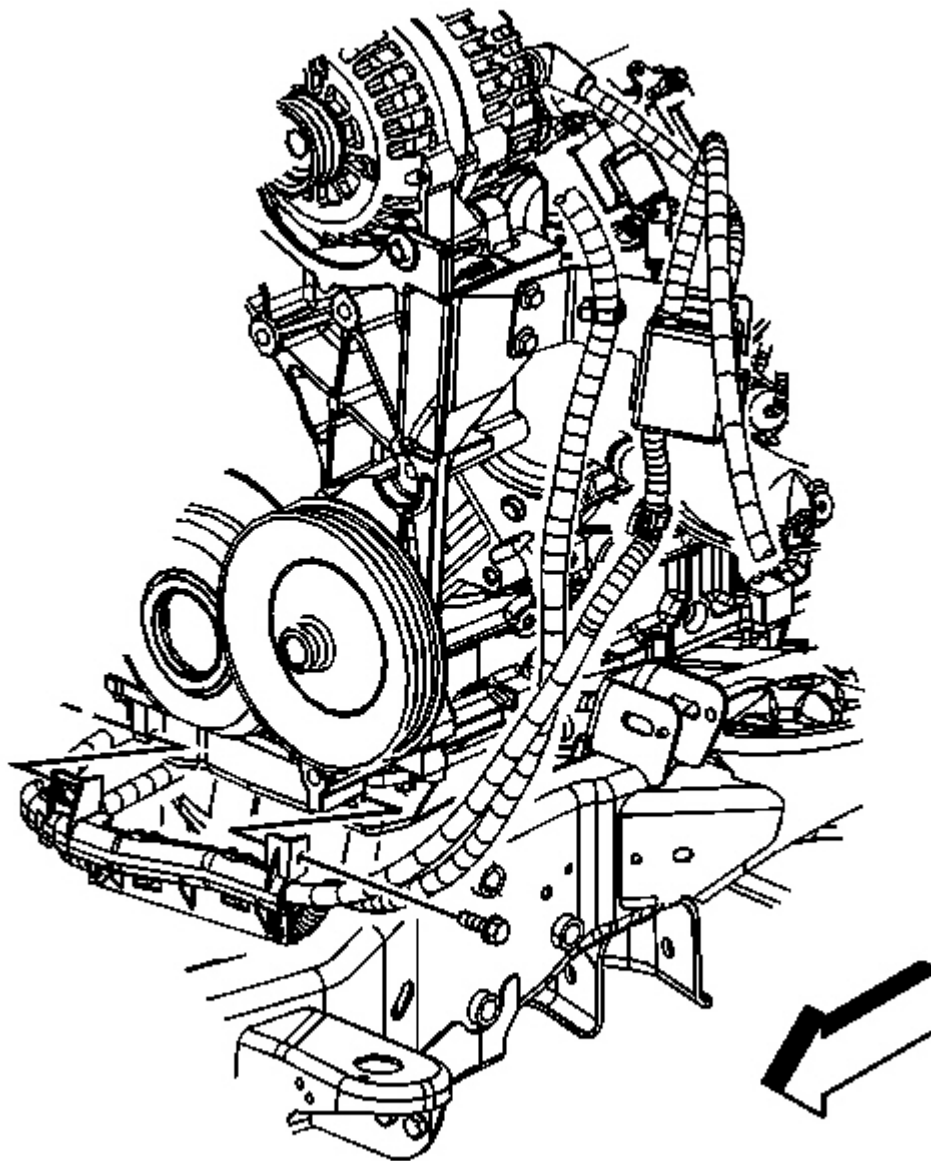


**Fig. 252: View Of Generator Bracket & Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

26. Position the generator bracket to the front of the engine.
27. Install the generator bracket bolts until snug.
28. Install the rear power steering pump-to-engine block bolt until snug.

**Tighten:**

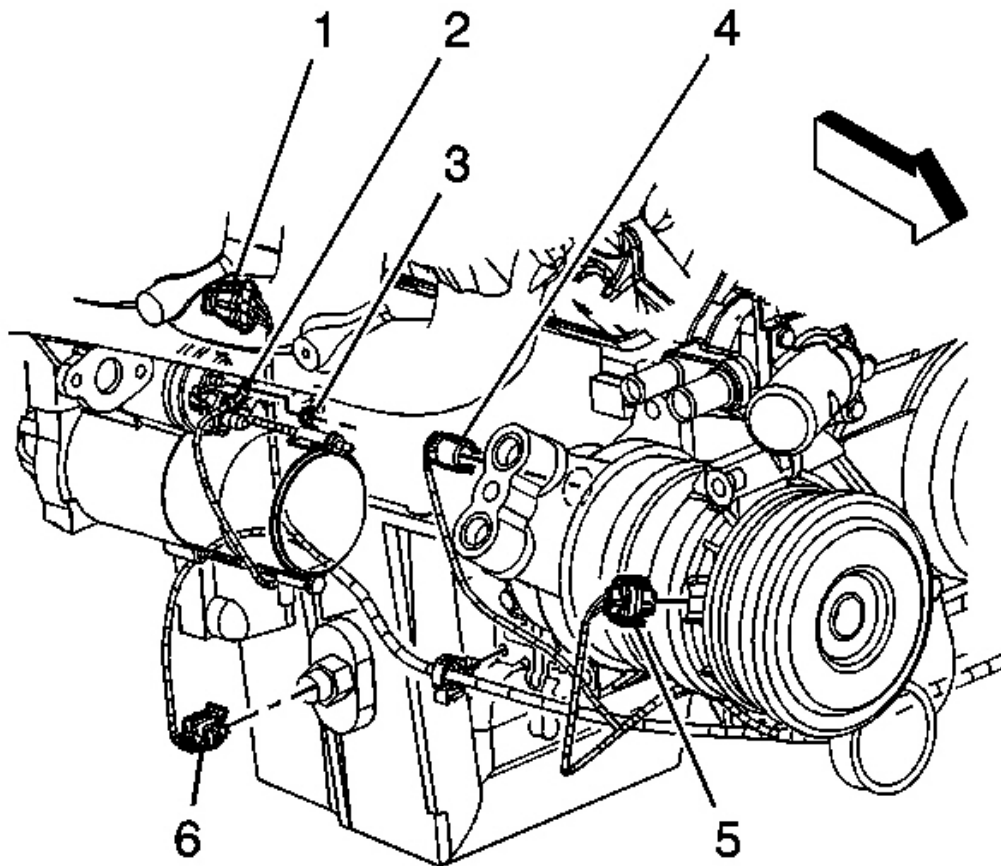
- Tighten the rear power steering pump bolt to 50 N.m (37 lb ft).
  - Tighten the generator bracket bolts to 50 N.m (37 lb ft).
29. Route the engine wiring harness to the lower engine area.
  30. Raise the vehicle.



**Fig. 253: Battery Cable Channel Bolt**  
Courtesy of GENERAL MOTORS CORP.

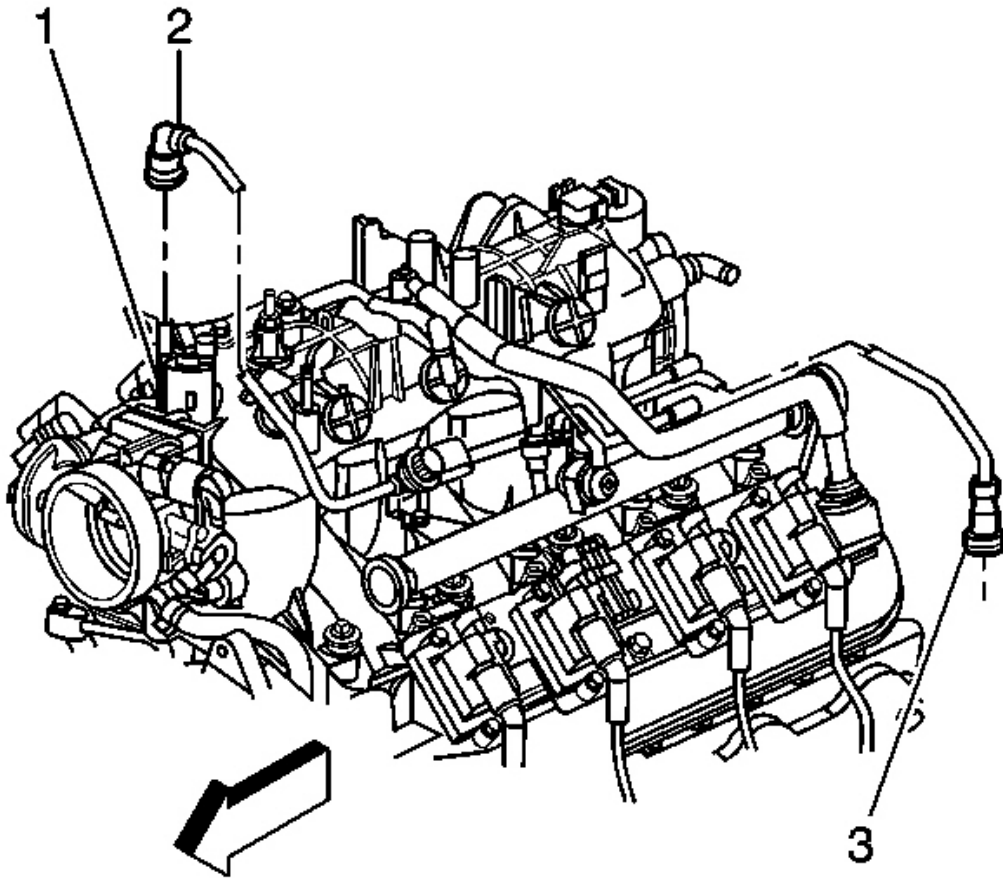
31. Slide the channel pin into the oil pan tab.
32. Install the battery cable channel bolt.

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



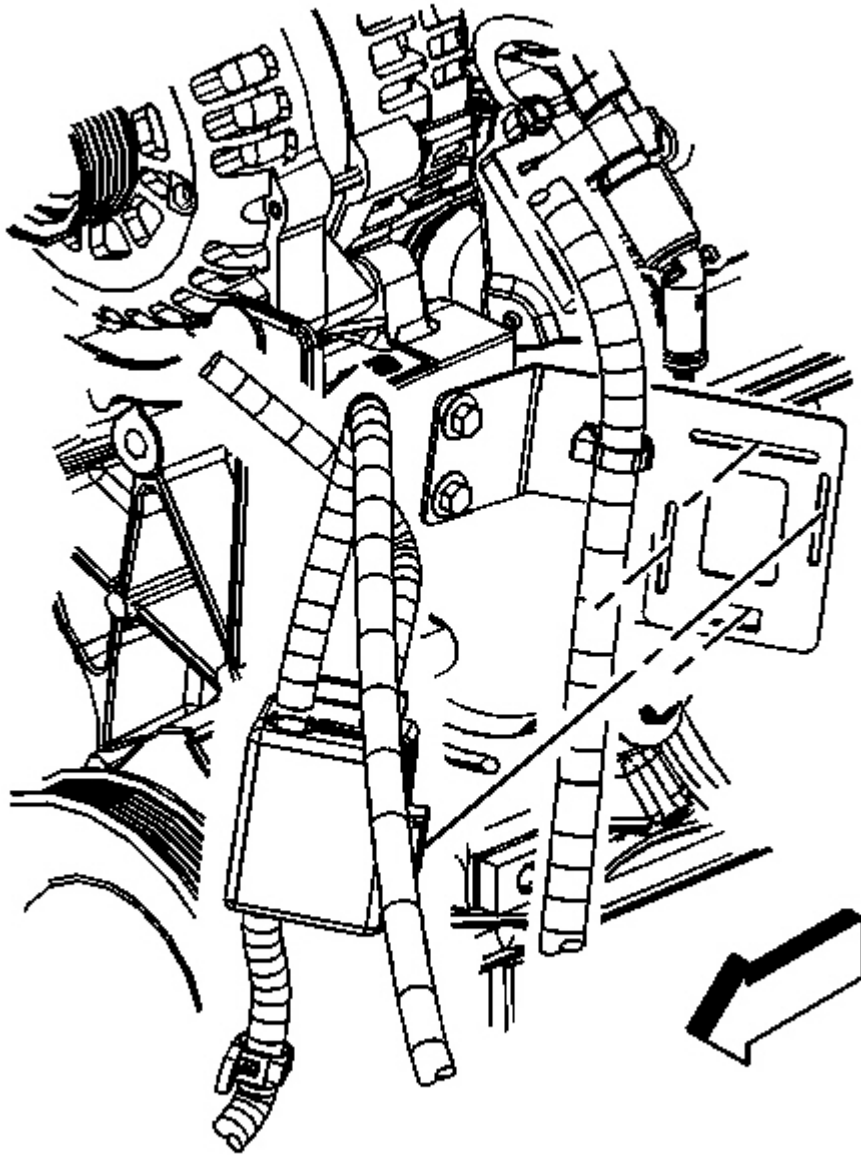
**Fig. 254: Oil Level Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

33. Connect the following electrical connectors:
  - The CKP sensor (1)
  - The engine oil level sensor (6)
  - The coolant heater, if equipped
34. Lower the vehicle.
35. Connect the fuel pipes.



**Fig. 255: Top View Of Engine**  
Courtesy of GENERAL MOTORS CORP.

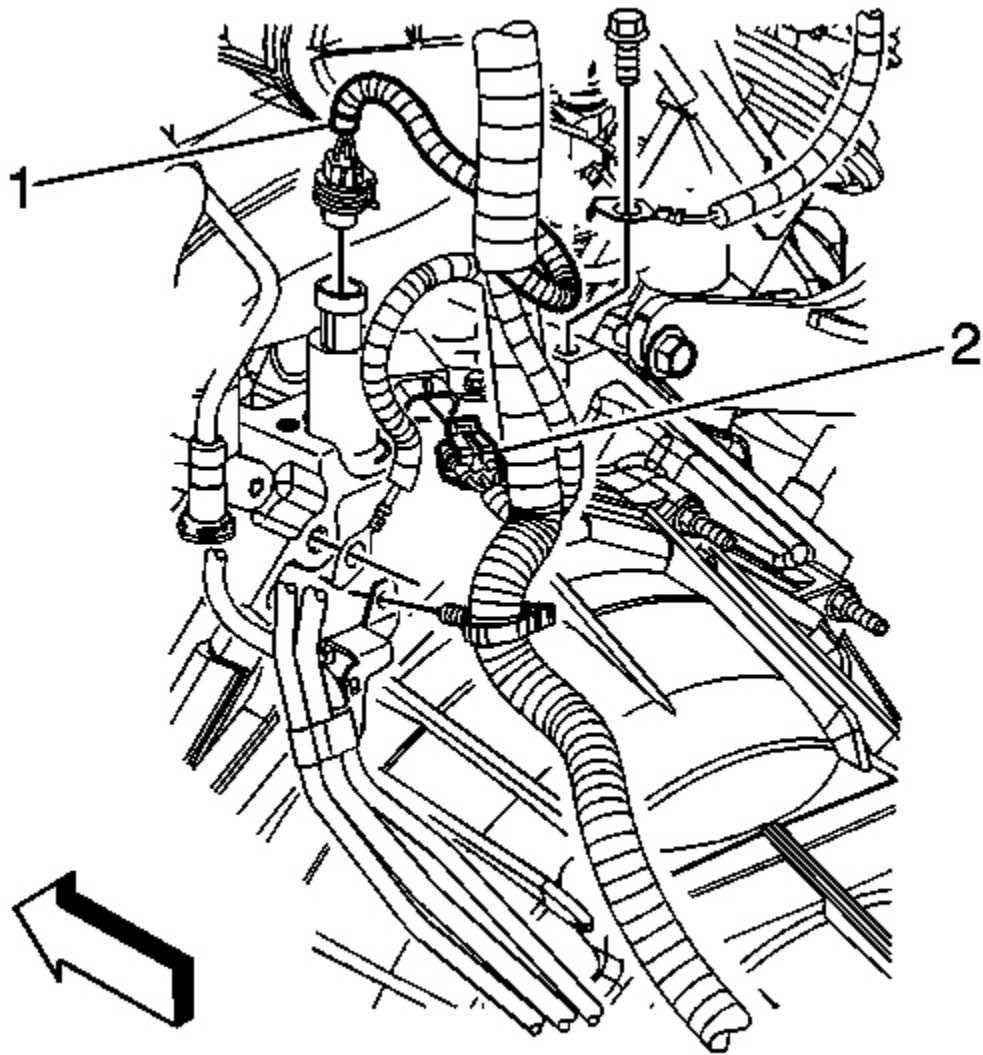
36. Install the EVAP purge solenoid vent tube to the solenoid (1).
37. Install the EVAP tube end (3) to the vapor pipe.



**Fig. 256: Battery Cable Junction Block & Junction Block Bracket**  
Courtesy of GENERAL MOTORS CORP.

38. Install the battery cable junction block to the junction block bracket.
39. Clip all of the engine wiring harness clips to their correct location.



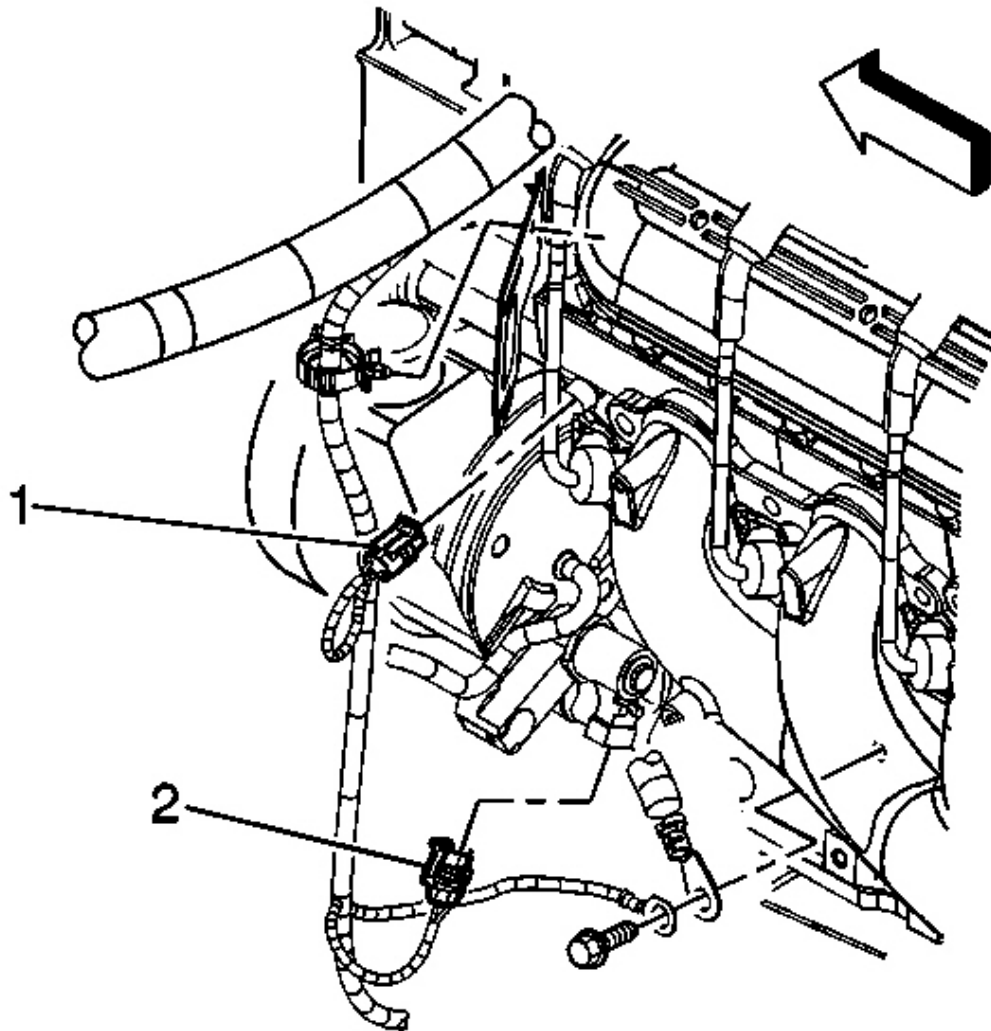


**Fig. 257: Oil Pressure Sensor Electrical Connector**  
Courtesy of GENERAL MOTORS CORP.

40. Connect the following electrical connectors:
  - Oil pressure sensor (1)
  - CMP sensor (2)
41. Position the harness ground and the engine ground strap to the block.
42. Install the harness ground bolt at the left rear of the engine block.

43. Position the harness ground to the block.
44. Install the harness ground bolt at the right rear of the engine block.

**Tighten:** Tighten the harness ground bolts at the rear of the block to 16 N.m (12 lb ft).



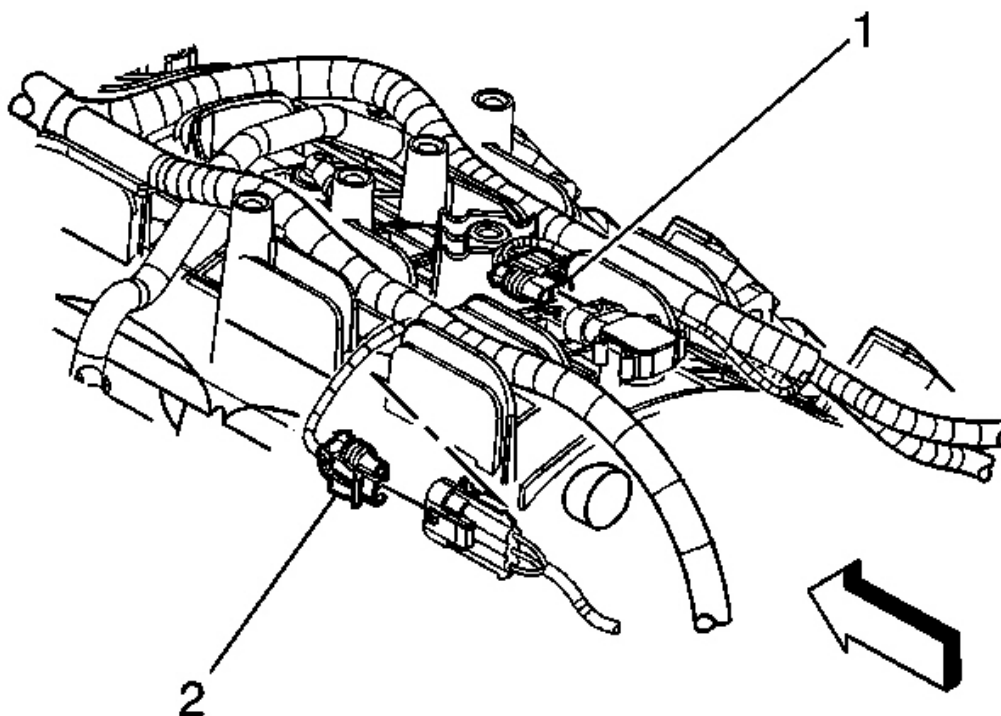
**Fig. 258: Coolant Temperature Sensor & Electronic Variable Orifice Switch Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

45. Connect the following electrical connectors:

- Coolant temperature sensor (1)

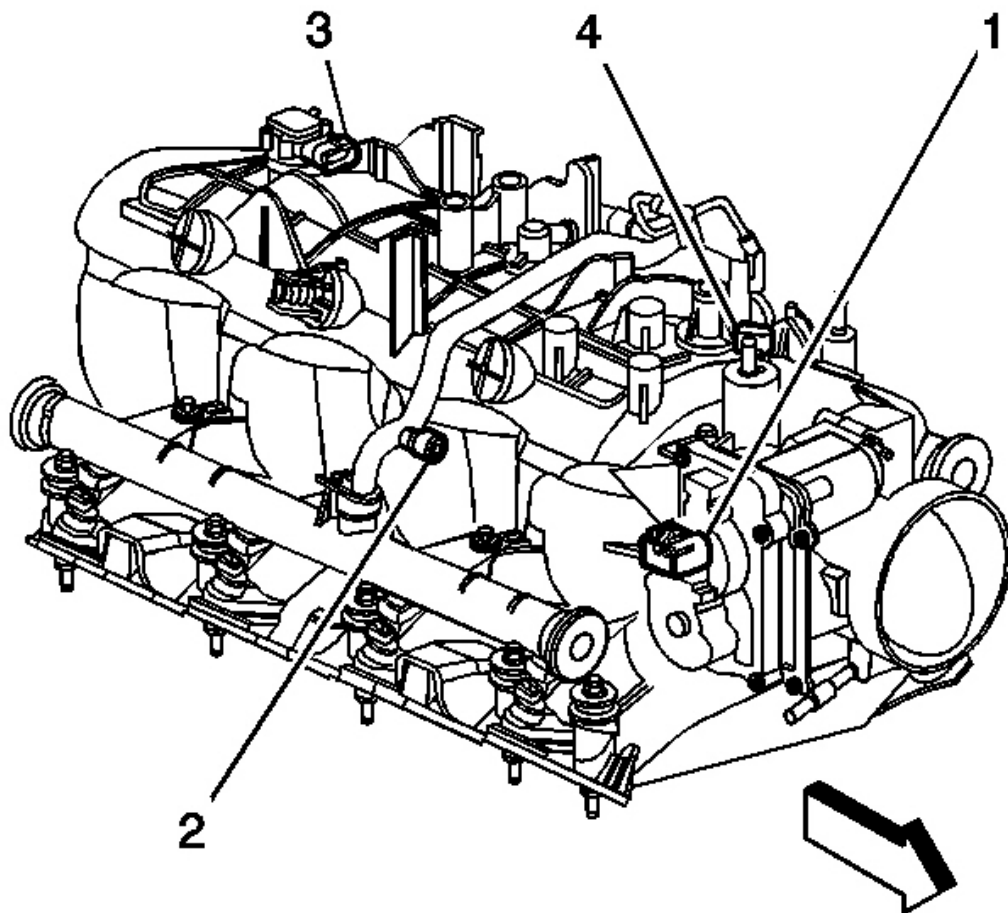
- Electronic variable orifice switch (2)
46. Position the harness ground and negative battery cable to the block.
  47. Install the harness ground bolt.

**Tighten:** Tighten the harness ground bolt to 25 N.m (18 lb ft).



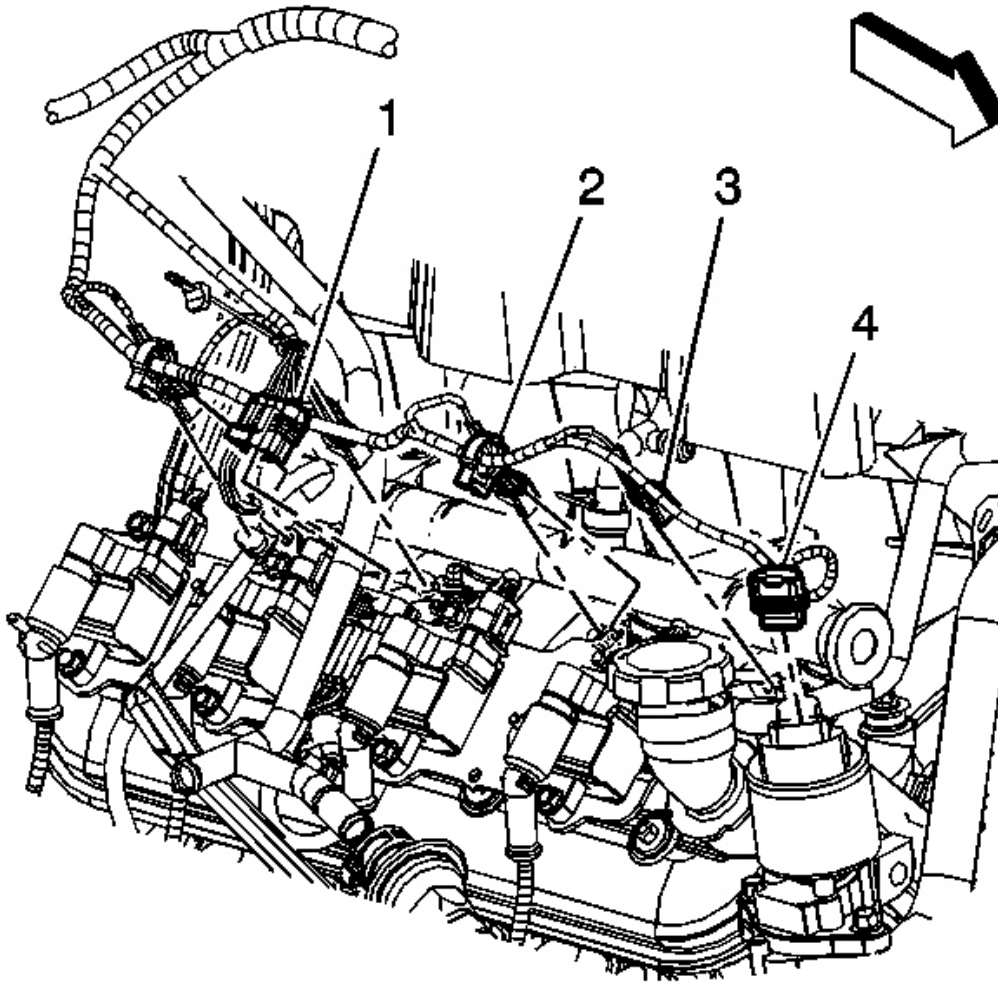
**Fig. 259: MAP Sensor & Knock Sensor Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

48. Connect the MAP sensor (1) and knock sensor (2) electrical connectors.



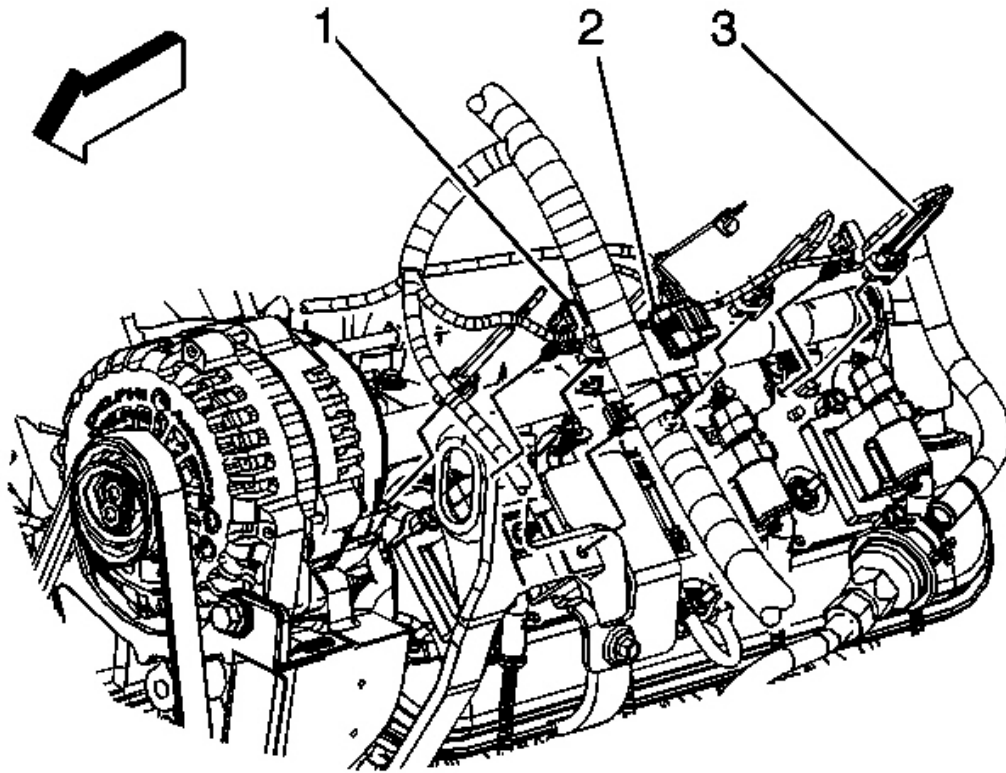
**Fig. 260: Throttle Body Electrical Connector**  
**Courtesy of GENERAL MOTORS CORP.**

49. Connect the ETC connector (1).



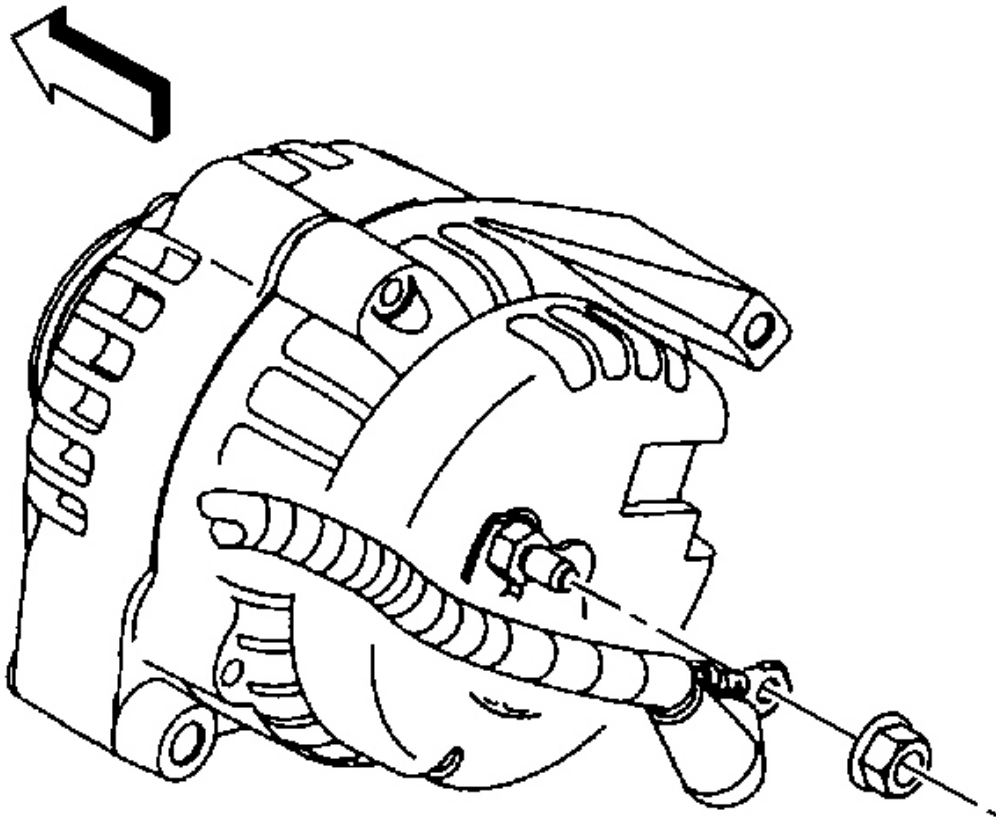
**Fig. 261: Harness Clips, Main Coil Harness, Fuel injectors & (EGR) Valve Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

50. Connect the following electrical connectors:
- Main coil harness (1)
  - Fuel injectors (3)
  - EGR valve (4)



**Fig. 262: Harness Clips, Main Coil Harness & Fuel Injector Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

51. Connect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.



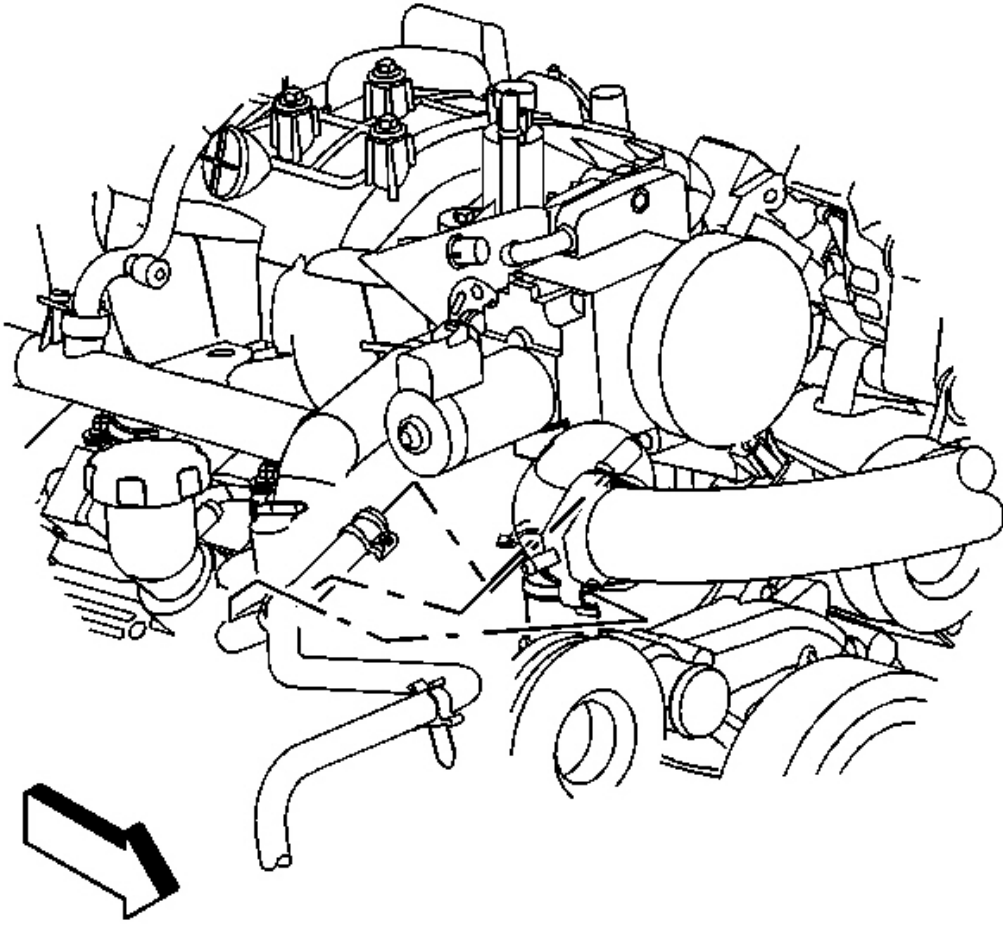
**Fig. 263: View Of Generator Cable & Nut**  
Courtesy of GENERAL MOTORS CORP.

52. Install the generator cable to the generator, perform the following:

1. Install the generator cable.
2. Install the generator cable nut to the terminal stud.

**Tighten:** Tighten the generator output terminal nut to 9 N.m (80 lb in).

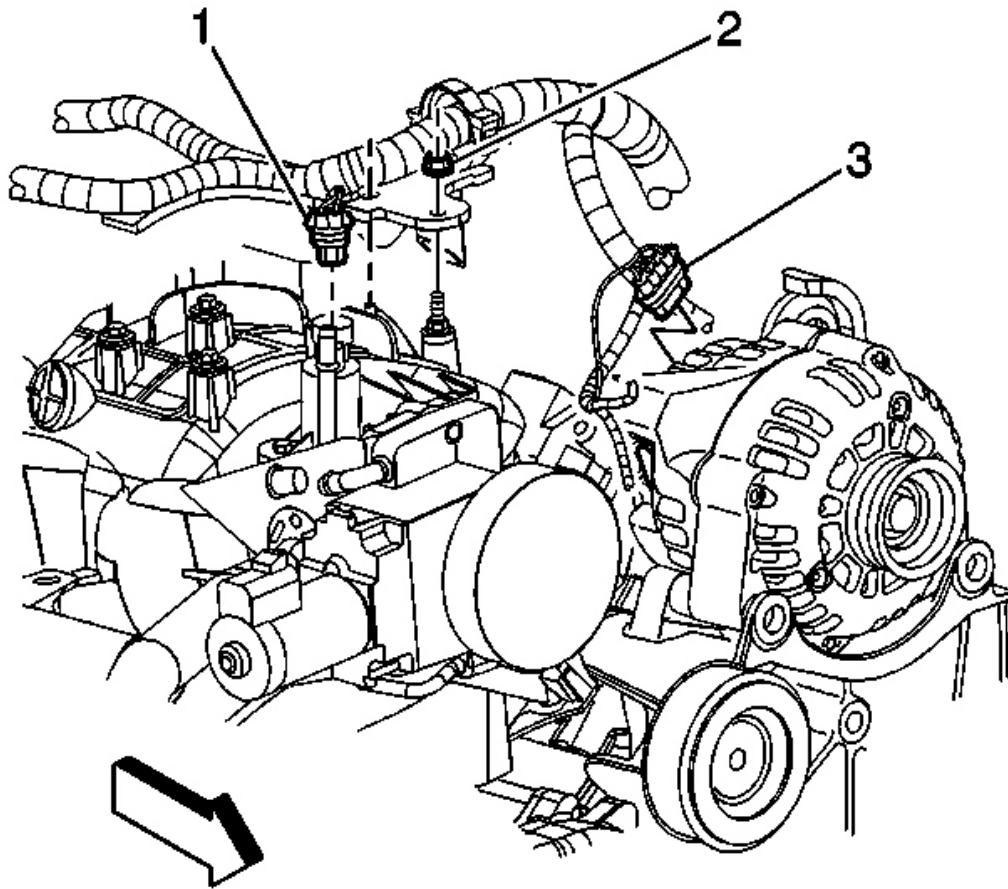
3. Slide the boot over the terminal stud.



**Fig. 264: Vent Inlet Hose & Throttle Body**  
**Courtesy of GENERAL MOTORS CORP.**

53. Install the radiator vent inlet hose to the throttle body.
54. Position the vent inlet hose clamp at the throttle body.





**Fig. 265: EVAP Canister Purge Solenoid & Generator Electrical Connectors**  
Courtesy of GENERAL MOTORS CORP.

55. Install the engine wiring harness bracket and nut (2).

**Tighten:** Tighten the engine wiring harness bracket nut to 5 N.m (44 lb in).

56. Connect the following electrical connectors:

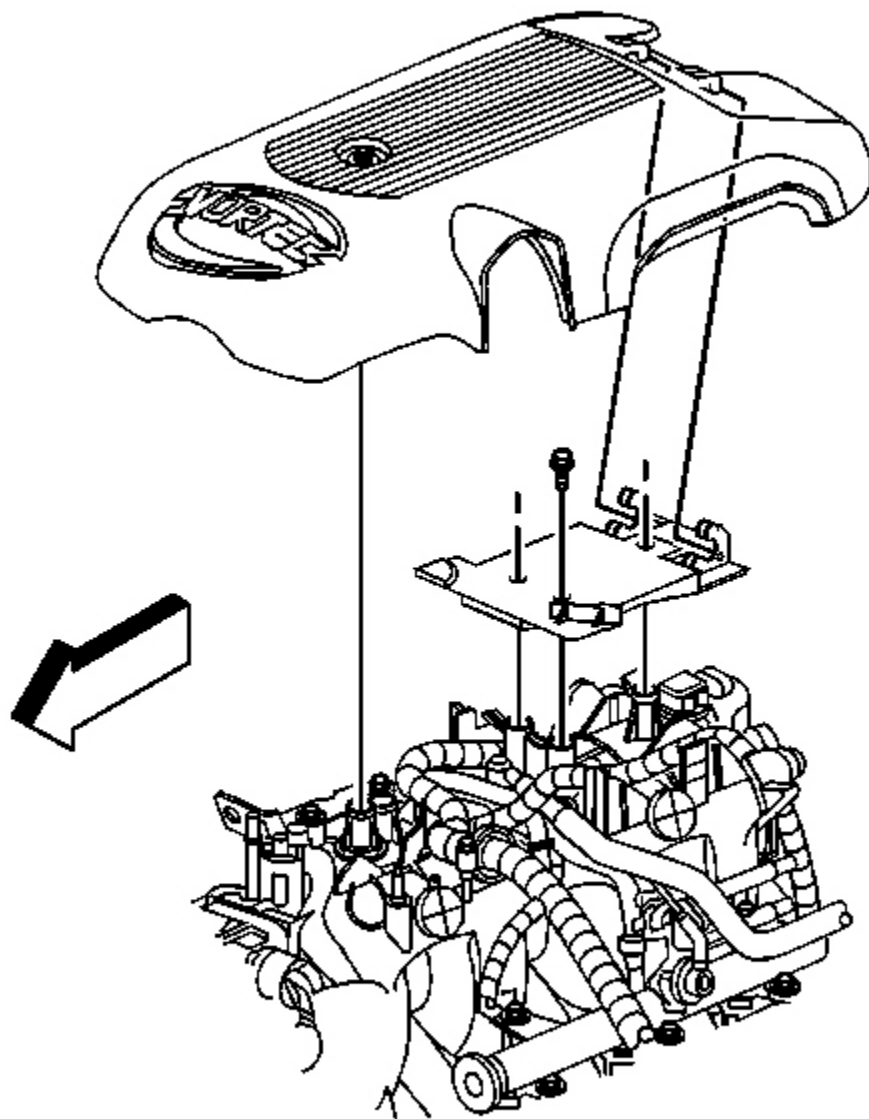
- EVAP canister purge solenoid (1)
- Generator (3)

57. Install the engine sight shield retainer and bolts.

**Tighten:** Tighten the engine sight shield retainer bolts to 5 N.m (44 lb in).

58. Install the left fuel rail cover.
59. If equipped with the 6.0L with RPO LQ4, install the engine sight shield to the retainer.
60. Tighten the engine sight shield bolt.

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



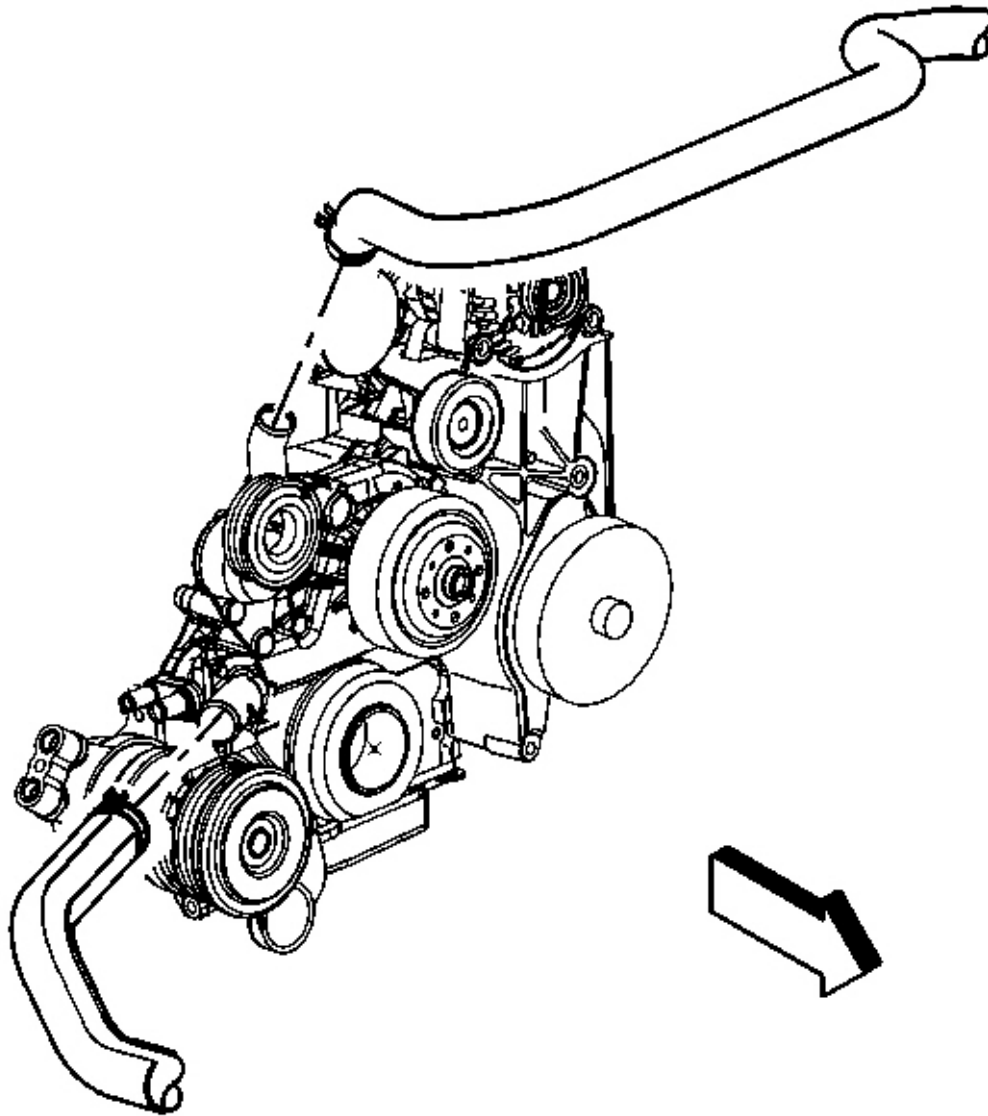
**Fig. 266: View Of Top Engine Cover**

**Courtesy of GENERAL MOTORS CORP.**

61. If equipped with the 4.8L, 5.3L, or 6.0L with RPO LQ4, install the engine sight shield to the retainer.
62. Tighten the engine sight shield bolt.

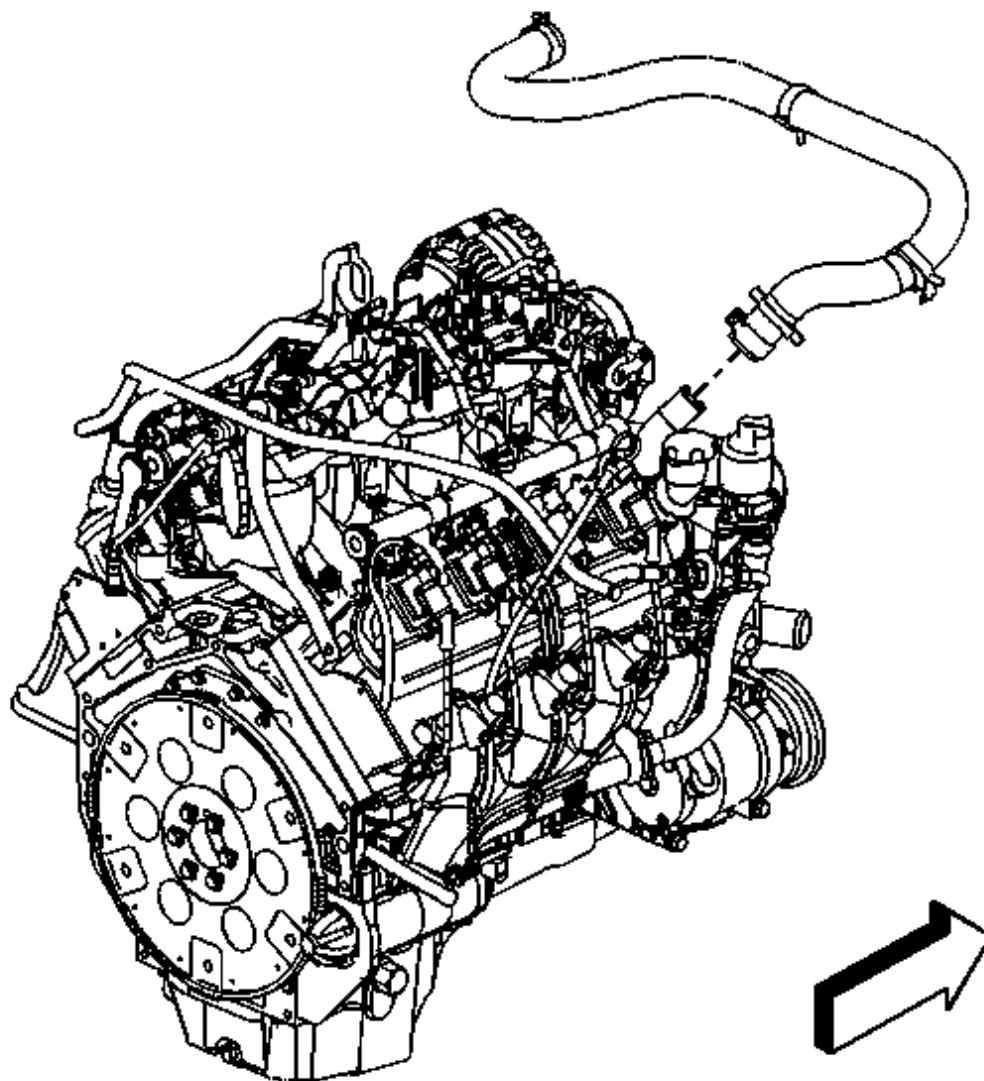
**Tighten:** Tighten the bolt to 10 N.m (89 lb in).

63. Install the heater hoses. Refer to **Heater Hose Replacement - Inlet** and **Heater Hose Replacement - Outlet** in Heating, Ventilation and Air Conditioning.



**Fig. 267: Radiator Outlet Hose & Water Pump**  
Courtesy of GENERAL MOTORS CORP.

64. Install the radiator outlet hose to the water pump.
65. Position the radiator outlet hose clamp at the water pump.



**Fig. 268: Radiator Inlet Hose & Water Pump (4.8, 5.3, & 6.0L)**  
Courtesy of GENERAL MOTORS CORP.

66. Install the radiator inlet hose to the water pump.
67. Position the radiator inlet hose clamp at the water pump.
68. Install the radiator supports. Refer to **Radiator Support Replacement** in Body Front End.
69. Install the A/C compressor. Refer to **Compressor Replacement** in Heating, Ventilation and Air Conditioning.

70. Install the hood. Refer to **Hood Replacement** in Body Front End.
71. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** or **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.
72. Perform the CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls-6.0L.

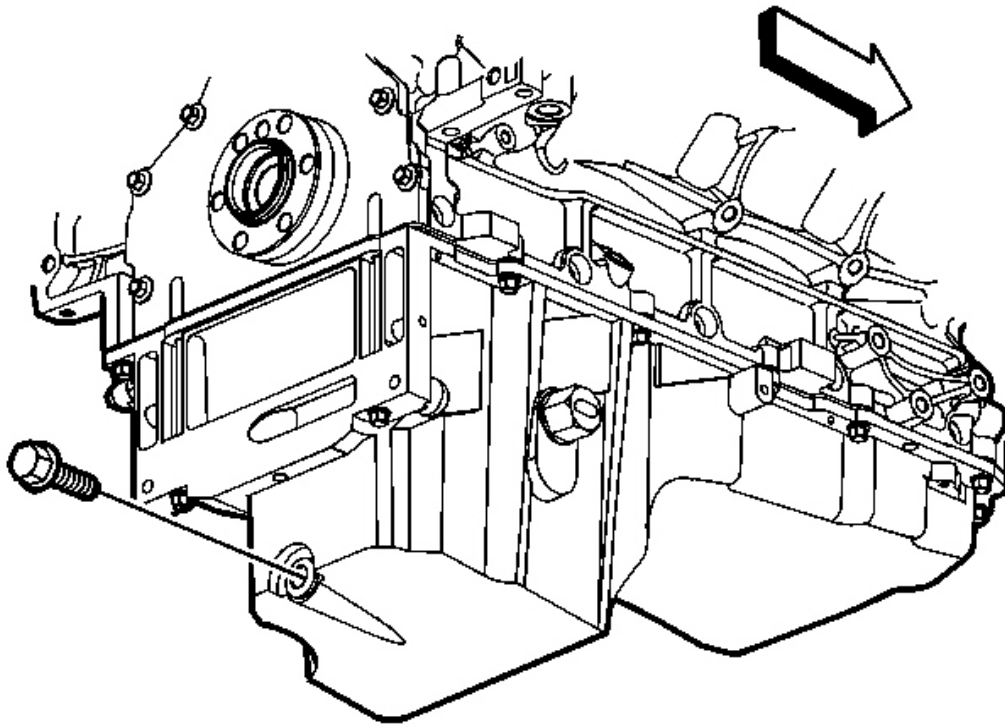
**IMPORTANT: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.**

1. Disable the ignition system.
  2. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
  3. Enable the ignition system.
  4. Start the engine and listen for unusual noises.
  5. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
  6. Run the engine speed at about 1000 RPM until the engine has reached normal operating temperature.
  7. Listen for sticking lifter and other unusual noises.
  8. Inspect for fuel, oil and/or coolant leaks while the engine is running.
  9. Perform a final inspection for the proper engine oil and coolant levels.
73. Close the hood.

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

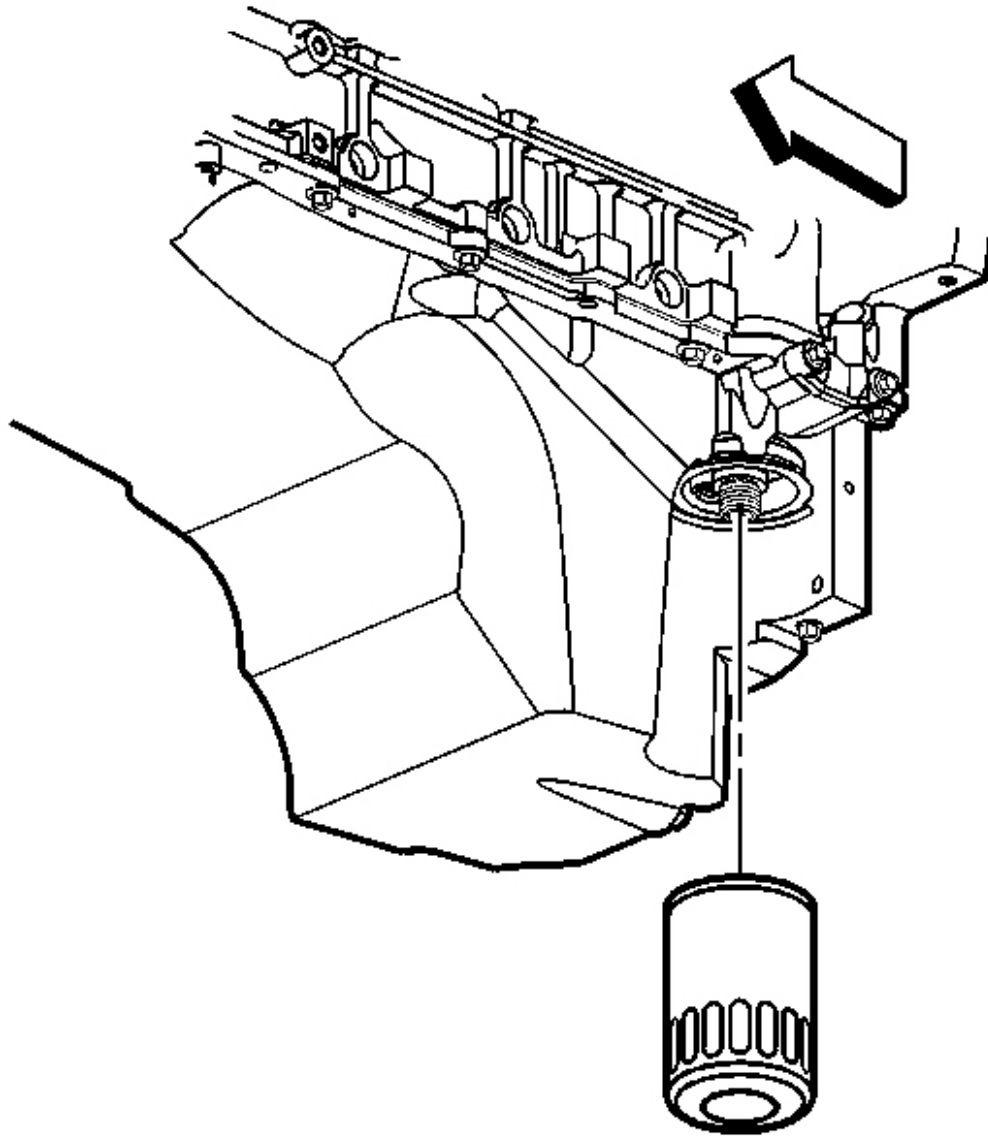
### **Removal Procedure**

**IMPORTANT: In order to completely drain the oil from the oil pan internal baffling, the bottom of the oil pan must be level during the oil drain procedure.**



**Fig. 269: Oil Pan Drain Plug & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Place a oil drain pan under the oil pan drain plug.
5. Remove the oil pan drain plug.
6. Drain the engine oil.
7. Wipe the excess oil from the drain plug hole and plug.



**Fig. 270: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

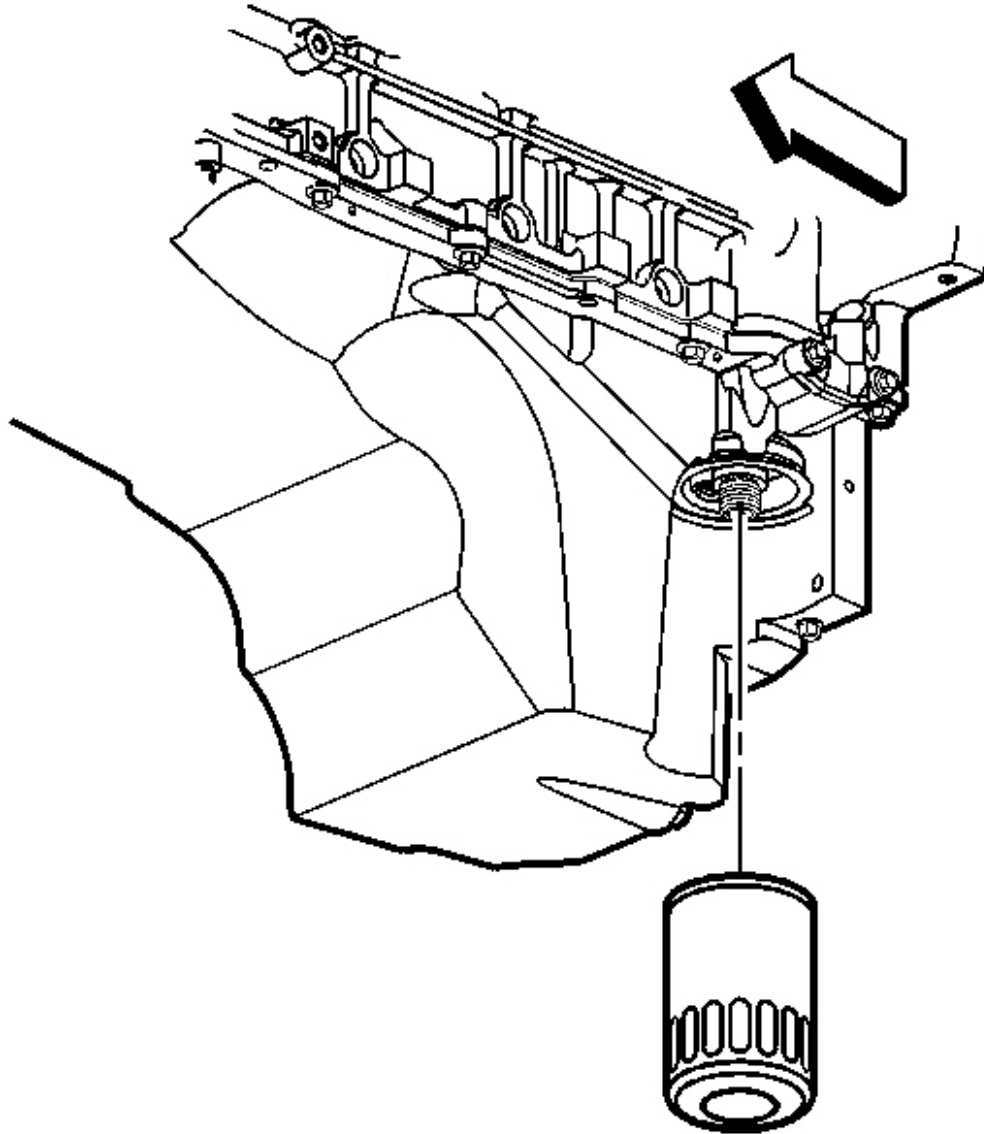
**IMPORTANT:** Check the old oil filter to ensure that the filter seal is not left on the engine block.

8. Remove the oil filter from the engine block.



9. Wipe the excess oil from the oil filter mounting.

### Installation Procedure

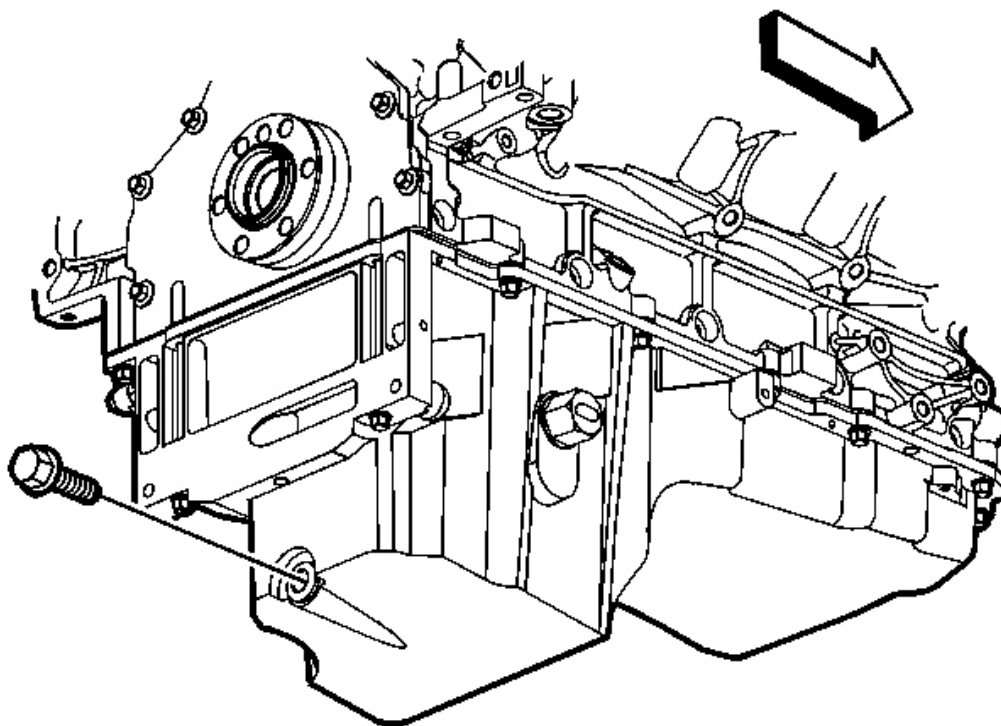


**Fig. 271: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

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

1. Lubricate the oil filter seal with clean engine oil.
2. Install the oil filter to the engine block.

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



**Fig. 272: Oil Pan Drain Plug & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

3. Install the oil drain plug to the engine block.

**Tighten:** Tighten the oil pan drain plug to 25 N.m (18 lb ft).

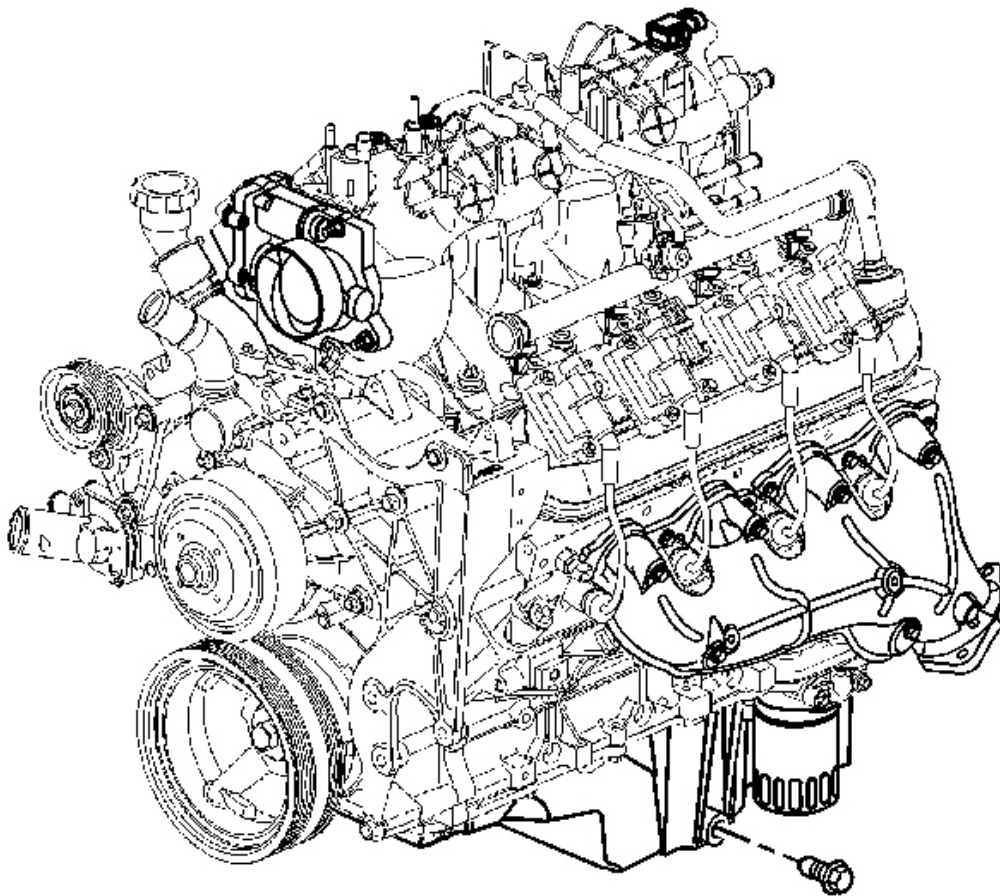
4. Lower the vehicle.
5. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.
6. Remove the oil level indicator.

7. Wipe the indicator with a clean cloth.
8. Install the oil level indicator.
9. Remove the oil level indicator in order to check the level.
10. Add oil if necessary.
11. Close the hood.

## **DRAINING FLUIDS AND OIL FILTER REMOVAL**

### **Tools Required**

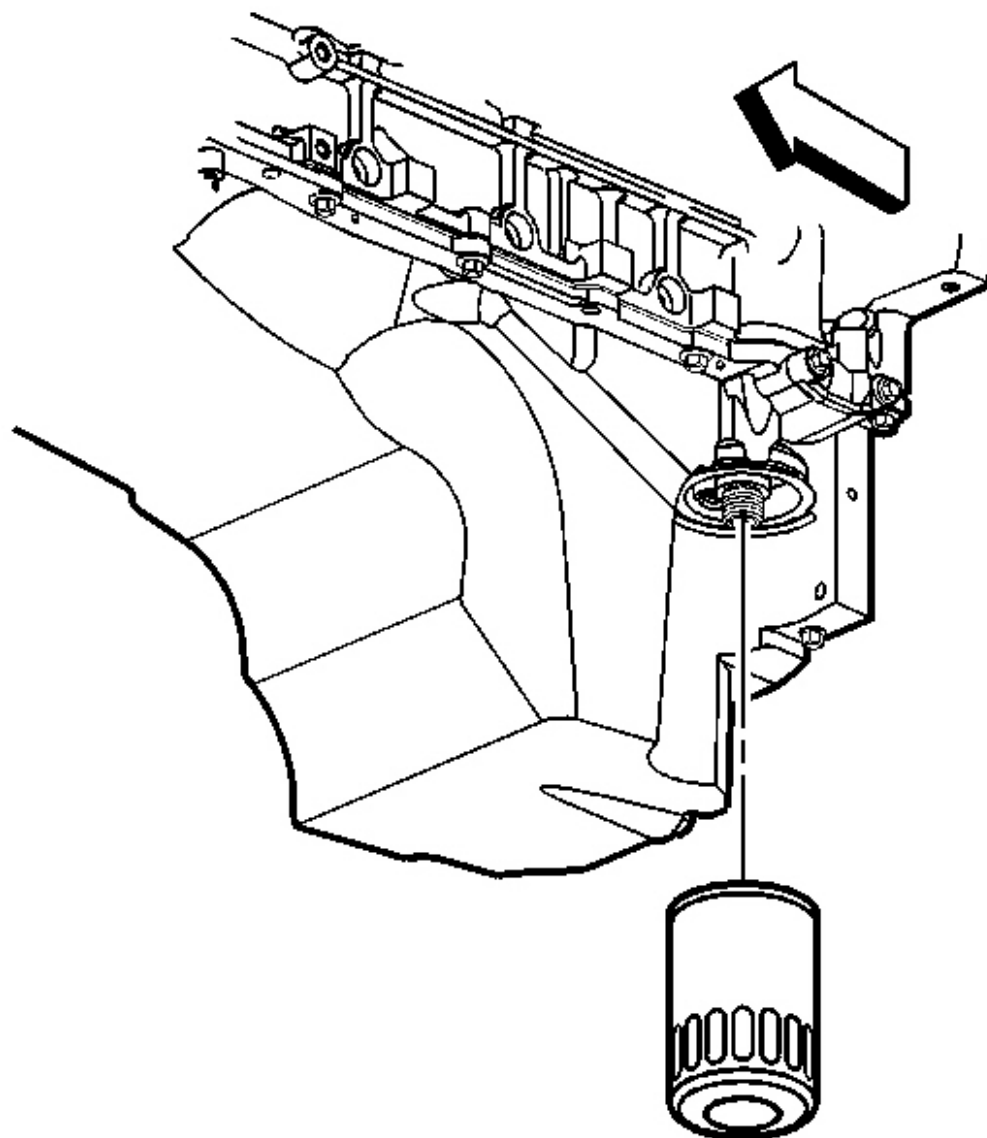
J 41712 Oil Pressure Switch Socket



**Fig. 273: Removing Oil Pan Drain Plug**  
Courtesy of GENERAL MOTORS CORP.

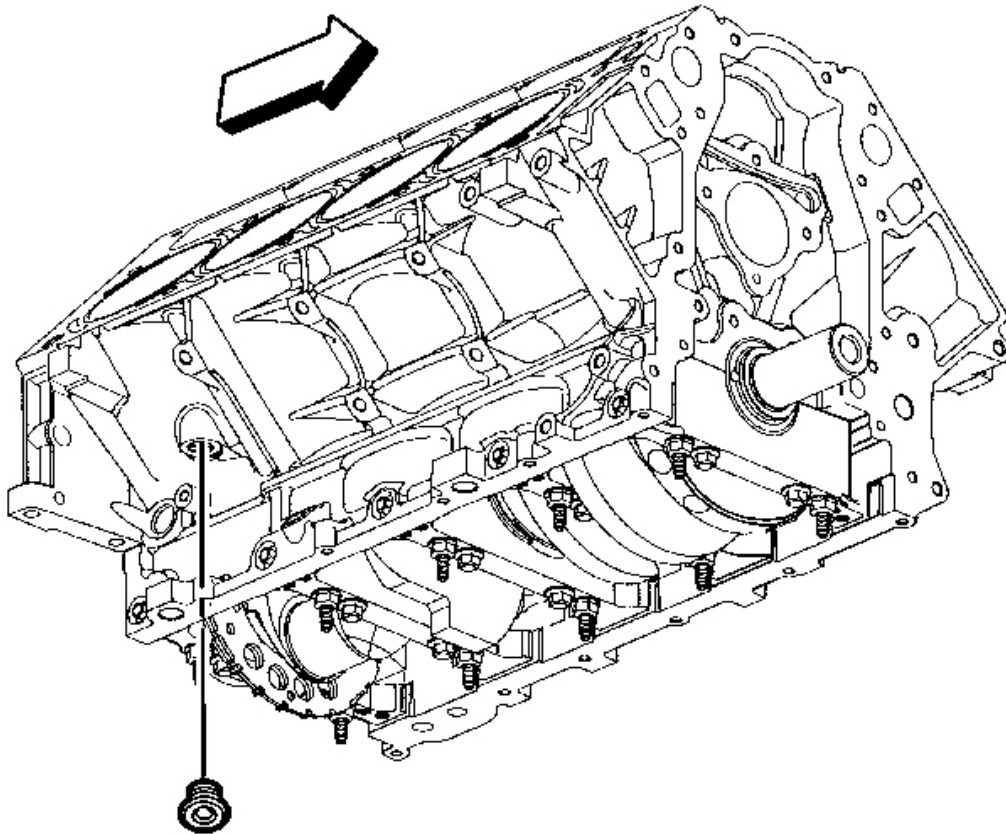
**IMPORTANT:** In order to completely drain the oil, the bottom of the oil pan must be level during the oil drain procedure.

1. Remove the oil pan drain plug and allow the oil to drain.



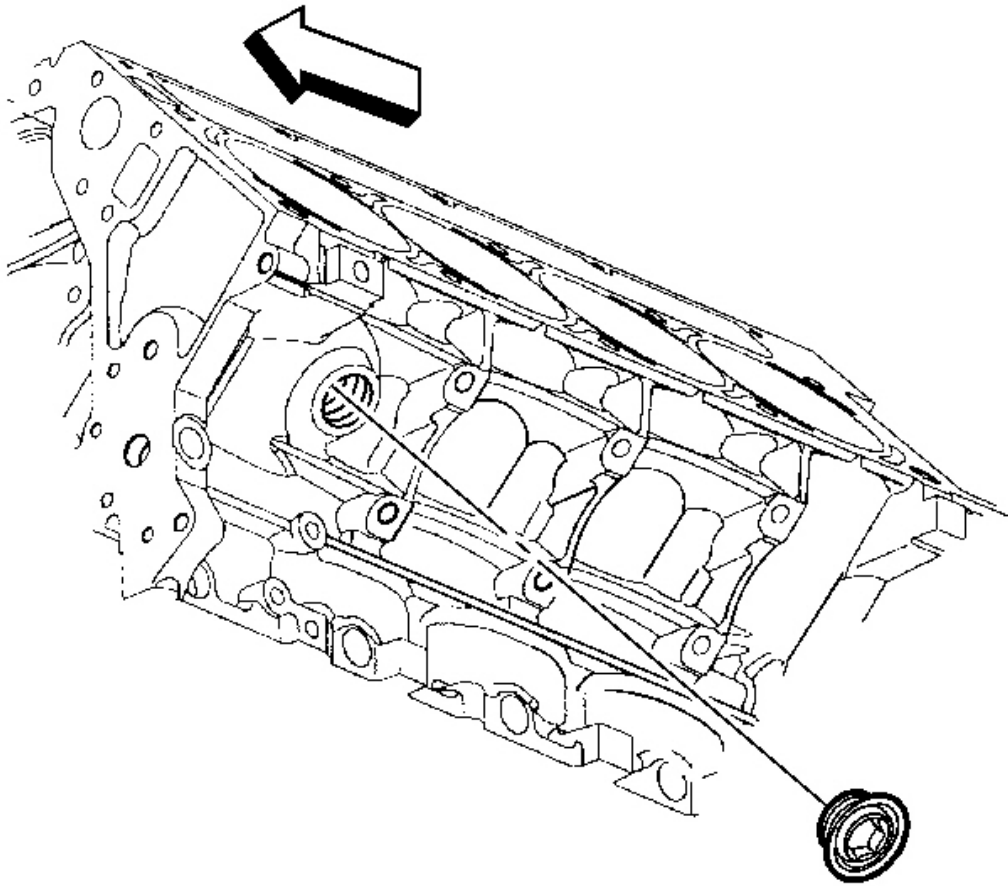
**Fig. 274: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter.



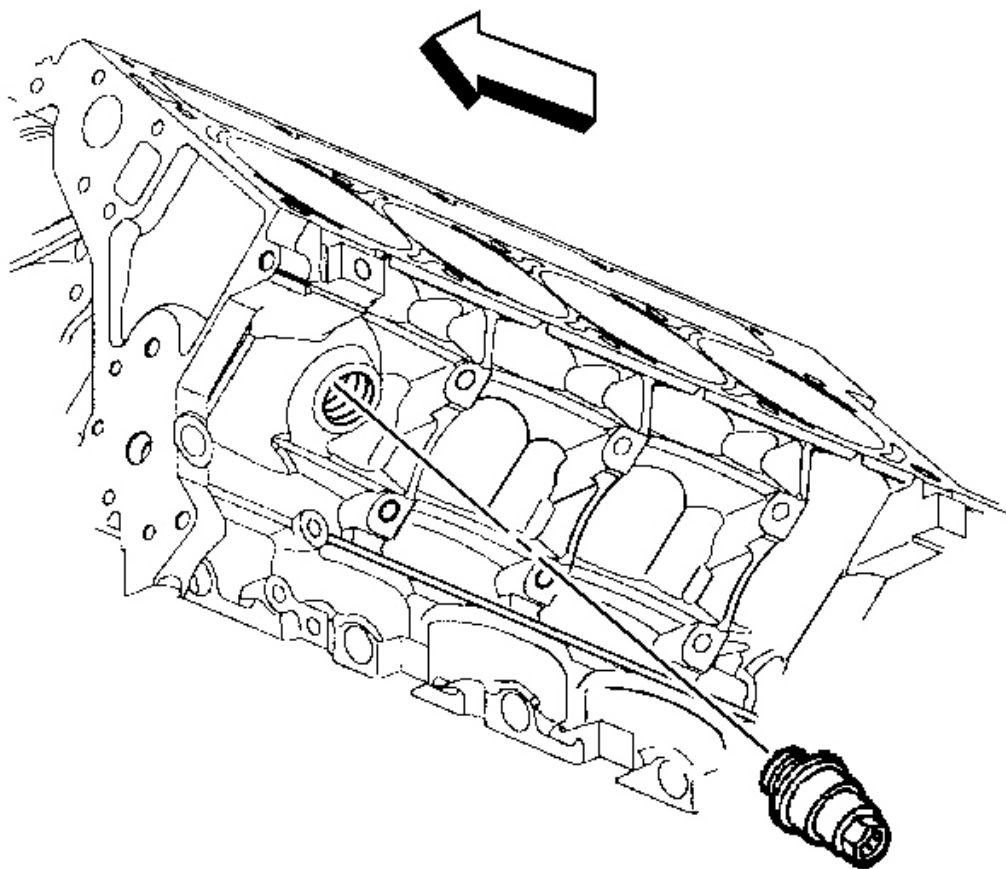
**Fig. 275: Identifying Plug Location On Underside Of Block**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the right rear engine block coolant drain hole plug and allow the coolant to drain.



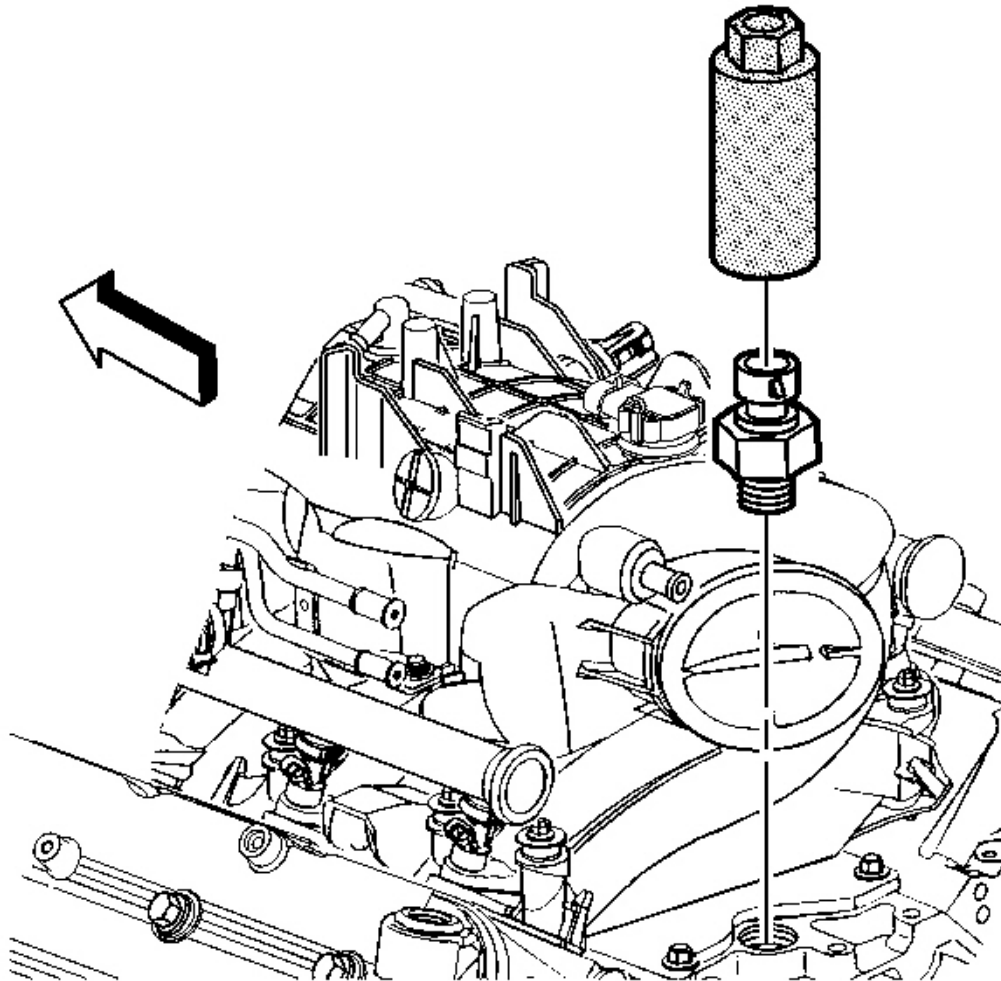
**Fig. 276: Engine Block Left Rear Coolant Drain Hole Plug**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the left front engine block coolant drain hole plug, if applicable, and allow the coolant to drain.



**Fig. 277: Engine Block Coolant Heater**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block coolant heater, if applicable, and allow the coolant to drain.



**Fig. 278: Oil Pressure Sensor & J 41712**  
Courtesy of GENERAL MOTORS CORP.

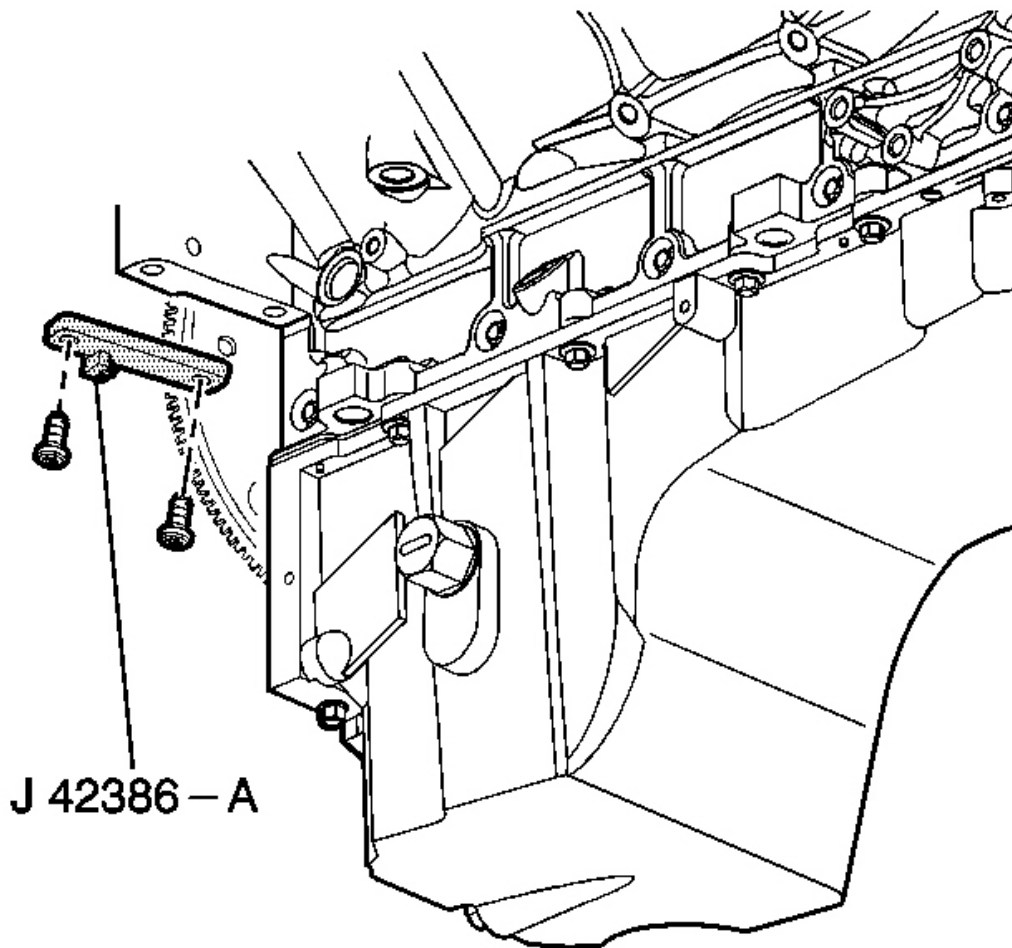
6. Use the J 41712 or equivalent in order to remove the oil pressure sensor, if required.

## **CRANKSHAFT BALANCER REMOVAL**

### **Tools Required**

- J 41816 Crankshaft Balancer Remover
- J 41816-2 Crankshaft End Protector
- J 42386-A Flywheel Holding Tool





**Fig. 279: View Of J 42386-A & Bolts**  
Courtesy of GENERAL MOTORS CORP.

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

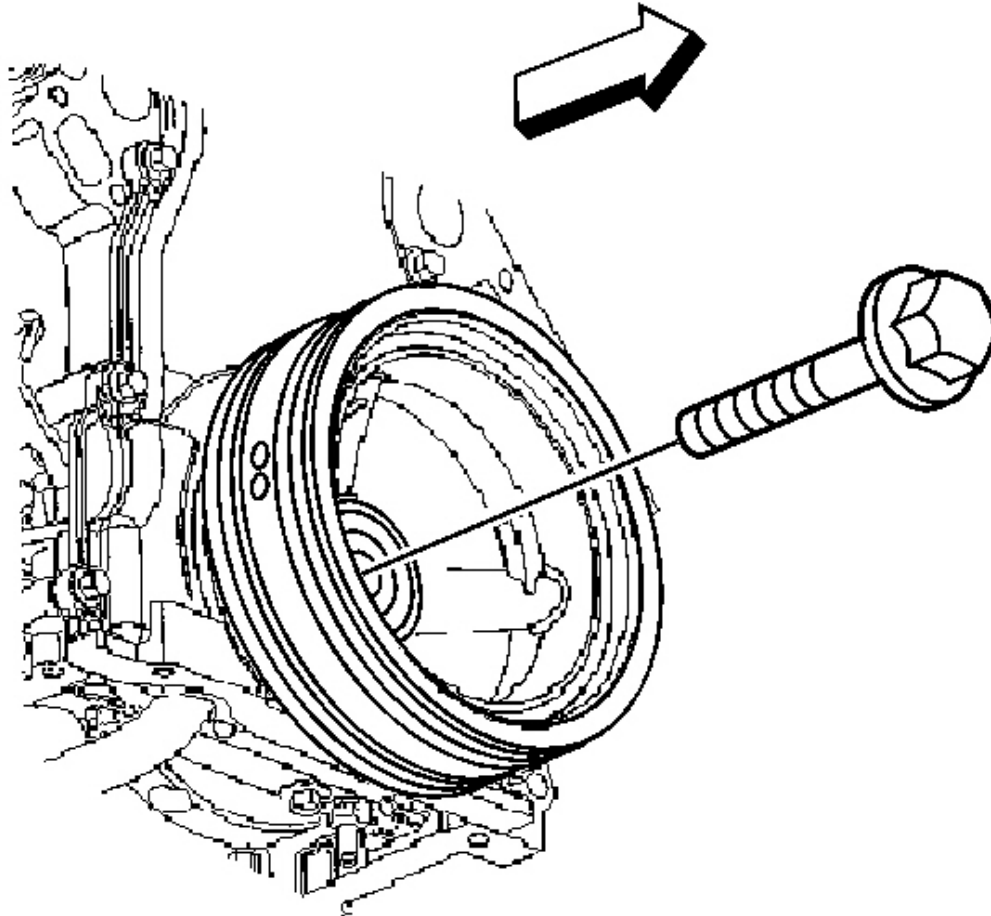
**IMPORTANT:**

- Do not use the crankshaft balancer bolt again. Install a **NEW** crankshaft balancer bolt during final assembly.
- Ensure the teeth of the flywheel holding tool mesh with the teeth of the engine flywheel.

1. Install the J 42386-A and bolts.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

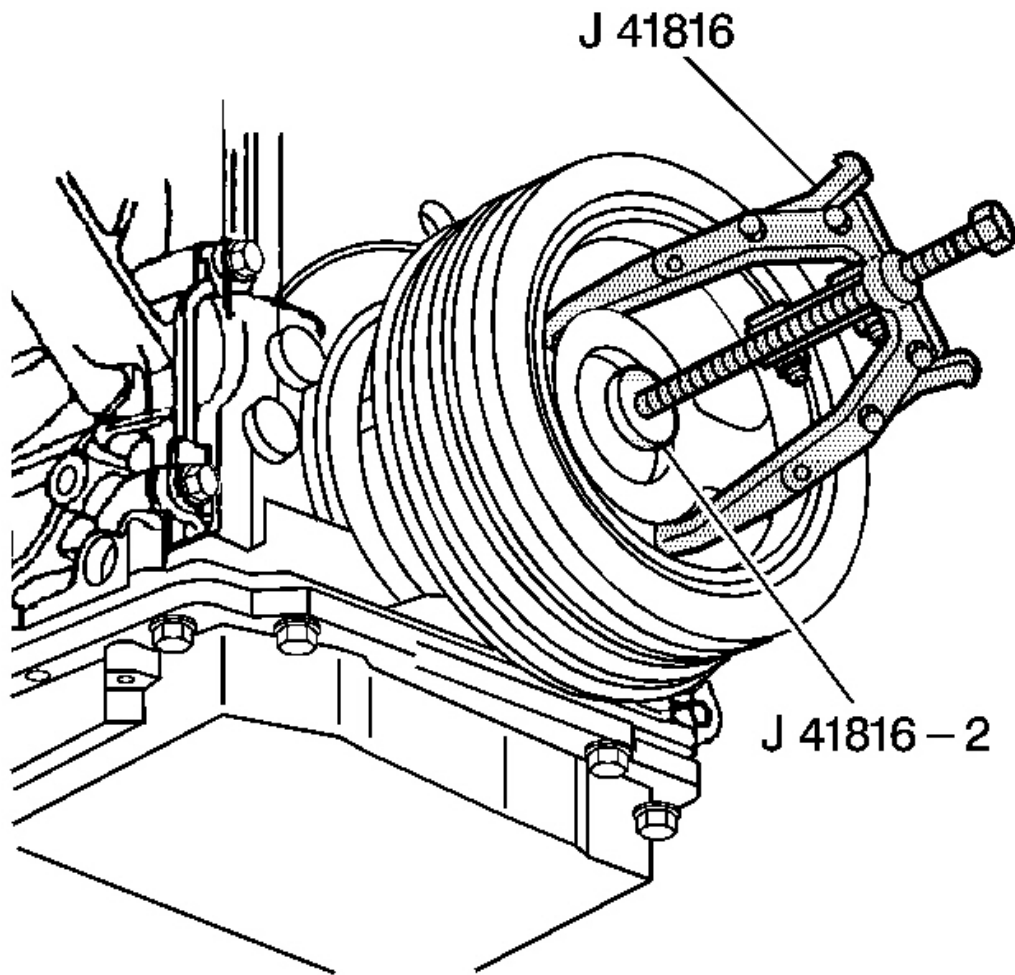
**Tighten:** Tighten the J 42386-A bolts to 50 N.m (37 lb ft).



**Fig. 280: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt.

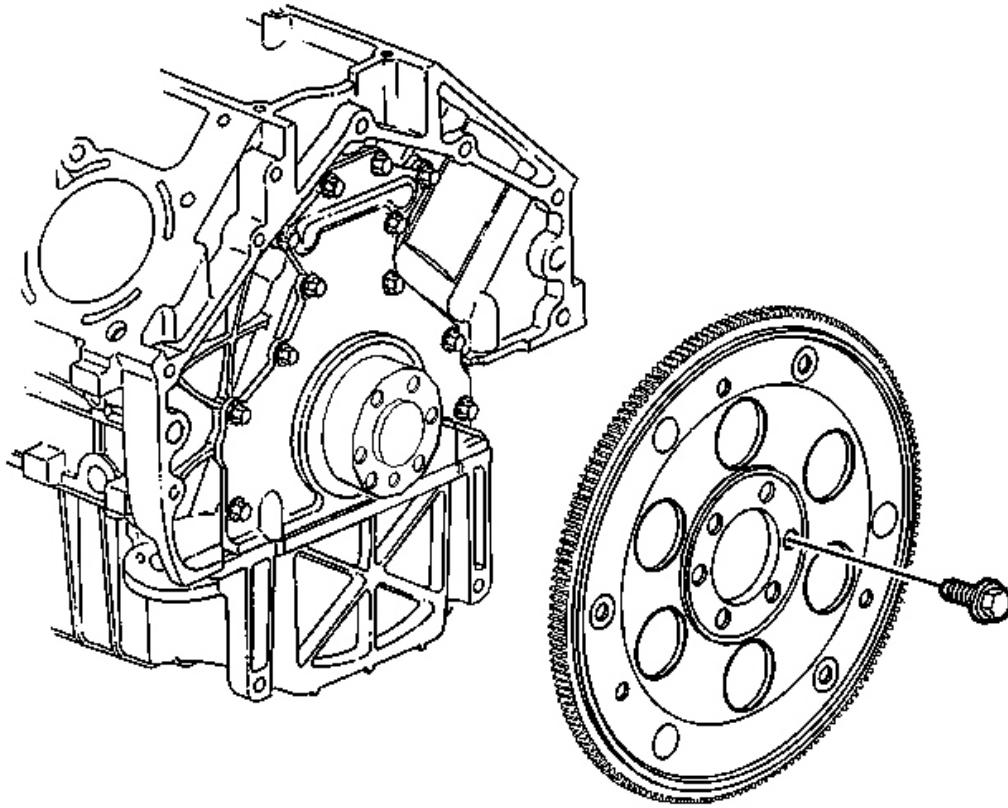
Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.



**Fig. 281: View Of J 41816 & J 41816-2**  
Courtesy of GENERAL MOTORS CORP.

3. Use the J 41816 and the J 41816-2 in order to remove the crankshaft balancer.
4. Remove the J 42386-A and bolts.

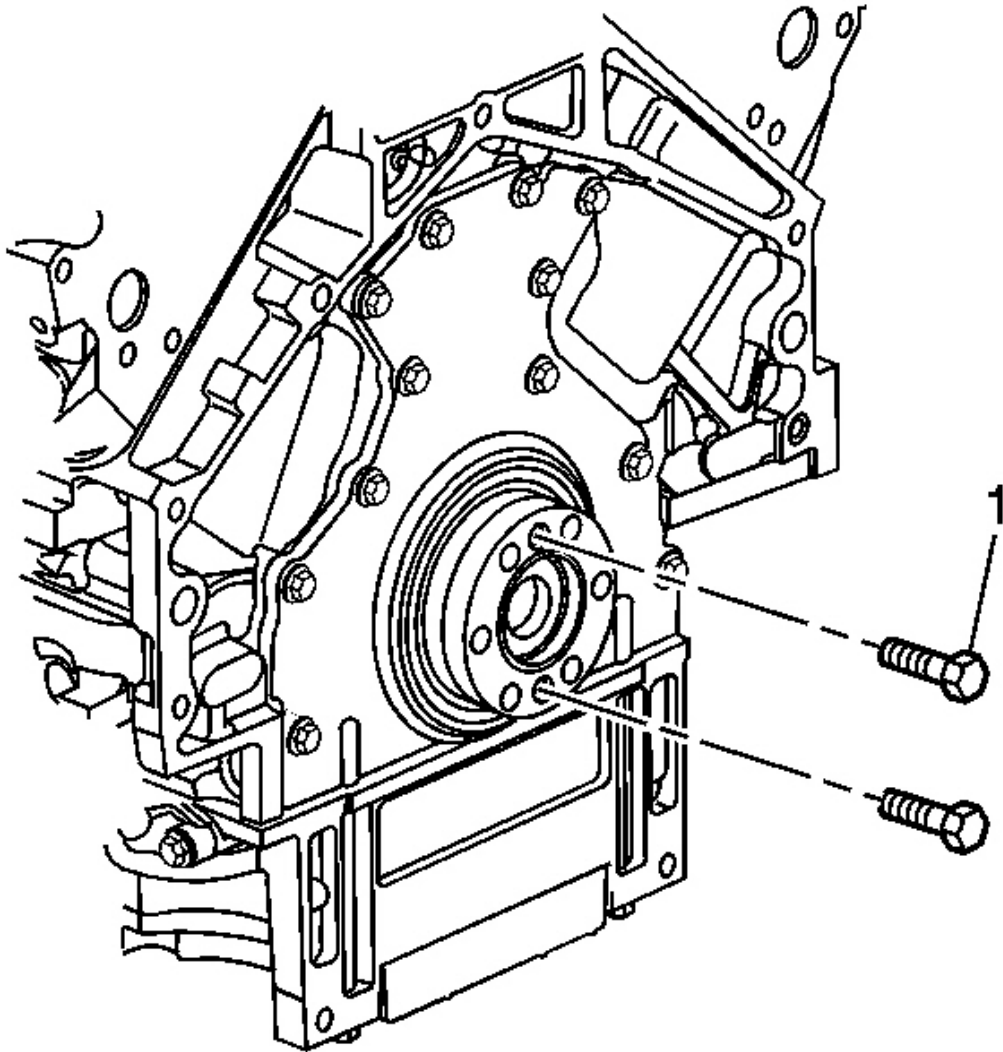
## **ENGINE FLYWHEEL REMOVAL**



**Fig. 282: Engine Flywheel & Bolts (Automatic Transmission)**  
Courtesy of GENERAL MOTORS CORP.

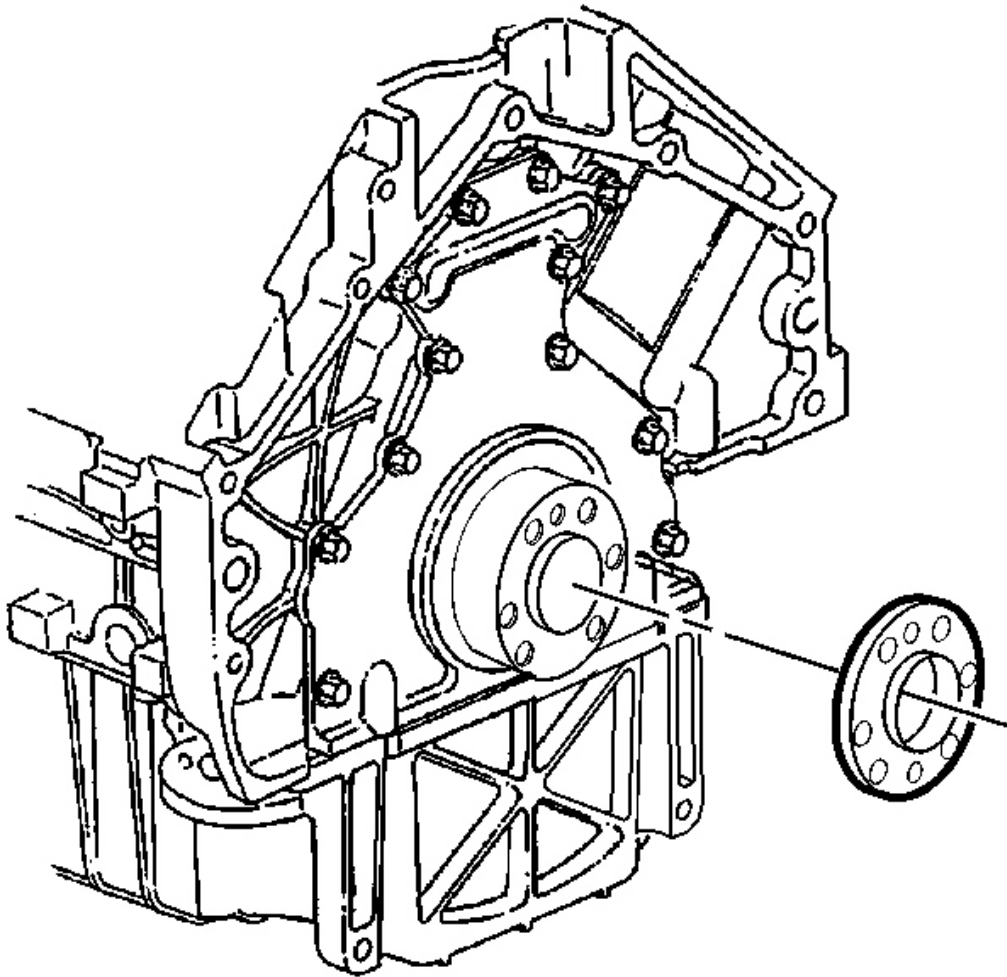
**IMPORTANT:** The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a 3 stage tightening process.

1. Remove the engine flywheel bolts.
2. Remove the automatic transmission engine flywheel.



**Fig. 283: Bolts & Spacer Threaded Holes**  
Courtesy of GENERAL MOTORS CORP.

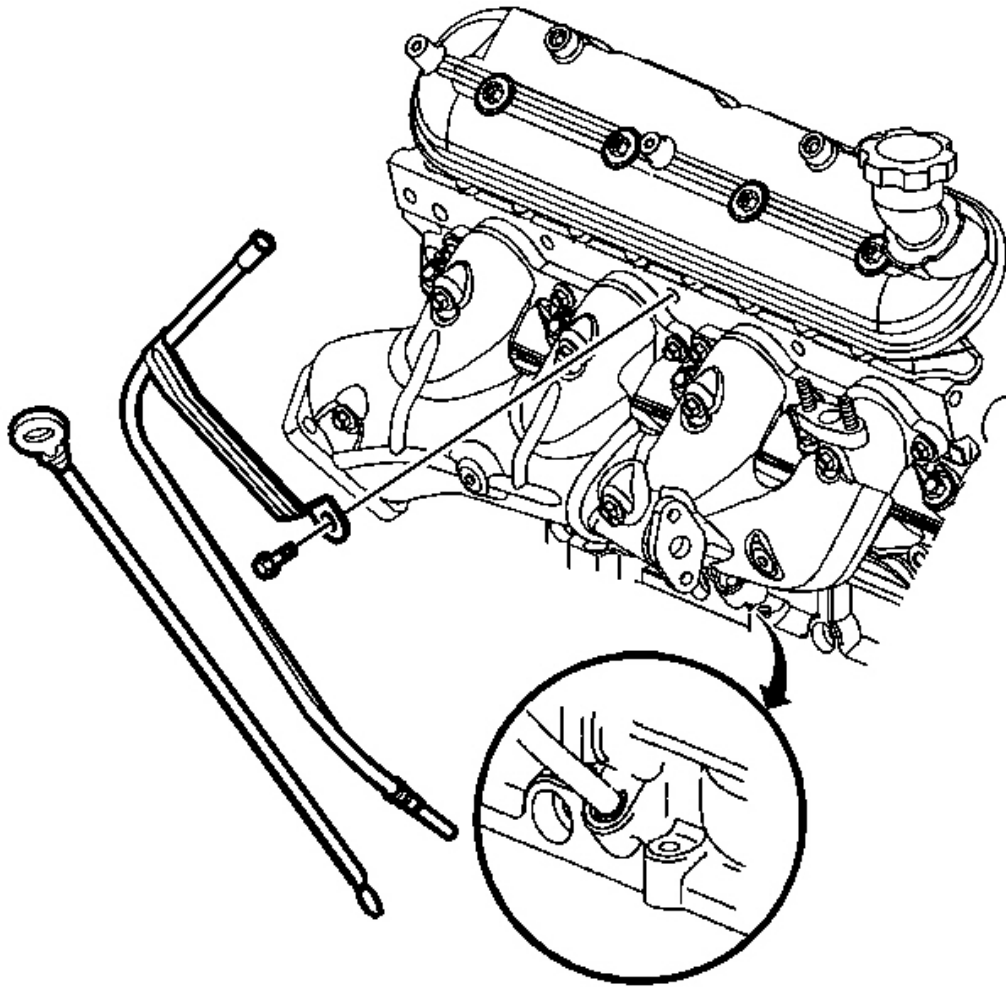
3. Install 2 M11x1.5 mm bolts (1) into the threaded holes of the spacer, if applicable.
4. Rotate the bolts clockwise to remove the spacer.



**Fig. 284: View Of Spacer & Crankshaft Rear**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the spacer from the rear of the crankshaft, if applicable.

## **OIL LEVEL INDICATOR AND TUBE REMOVAL**



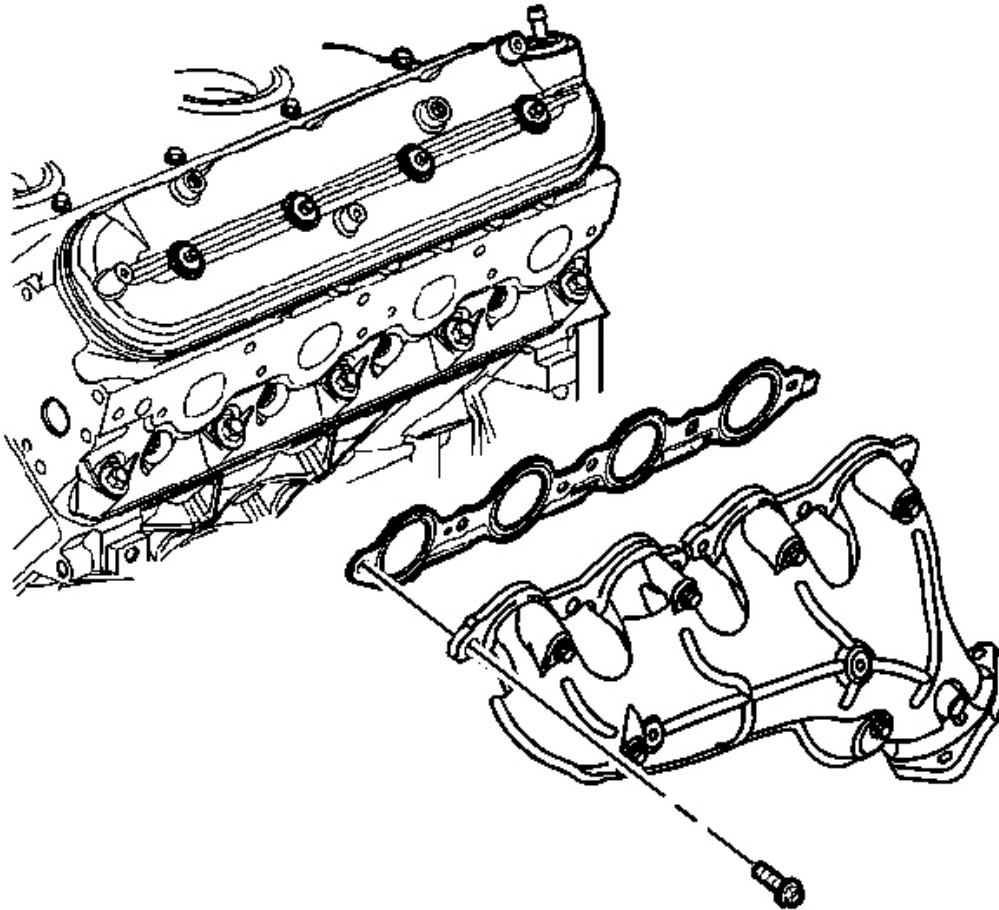
**Fig. 285: Oil Level Indicator & Tube**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the tube.
2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

**IMPORTANT: Inspect the O-ring seal for cuts or damage. The O-ring seal may be used again if it is not cut or damaged.**

4. Remove the O-ring seal from the tube, if required.

## EXHAUST MANIFOLD REMOVAL - LEFT



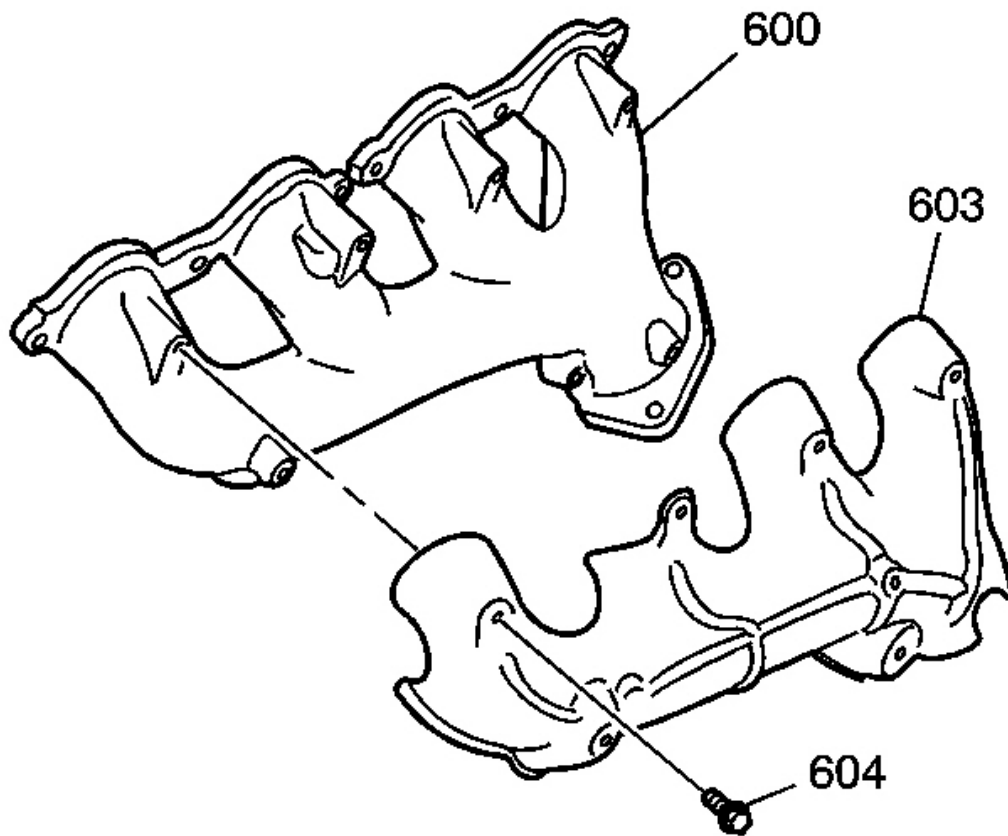
**Fig. 286: Exhaust Manifold, Gasket & Bolt (Left)**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.

Do not remove the spark plug wires from the ignition coils unless required.

2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

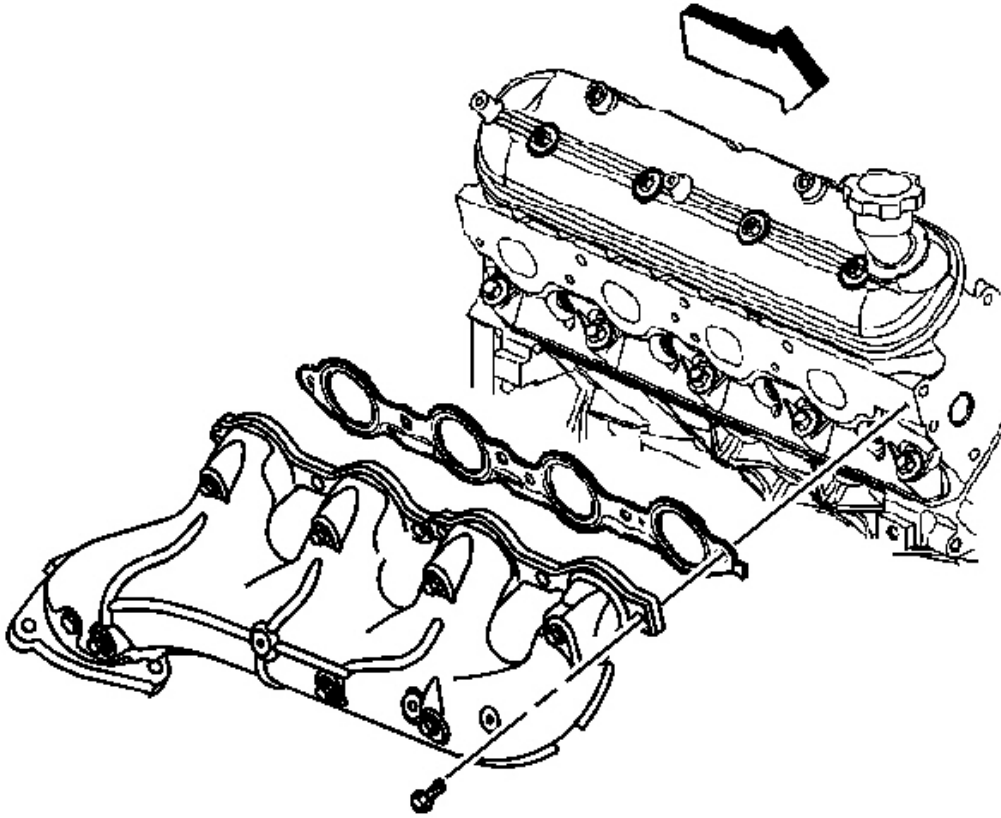




**Fig. 287: Exhaust Manifold & Heat Shield**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600), if required.

#### **EXHAUST MANIFOLD REMOVAL - RIGHT**

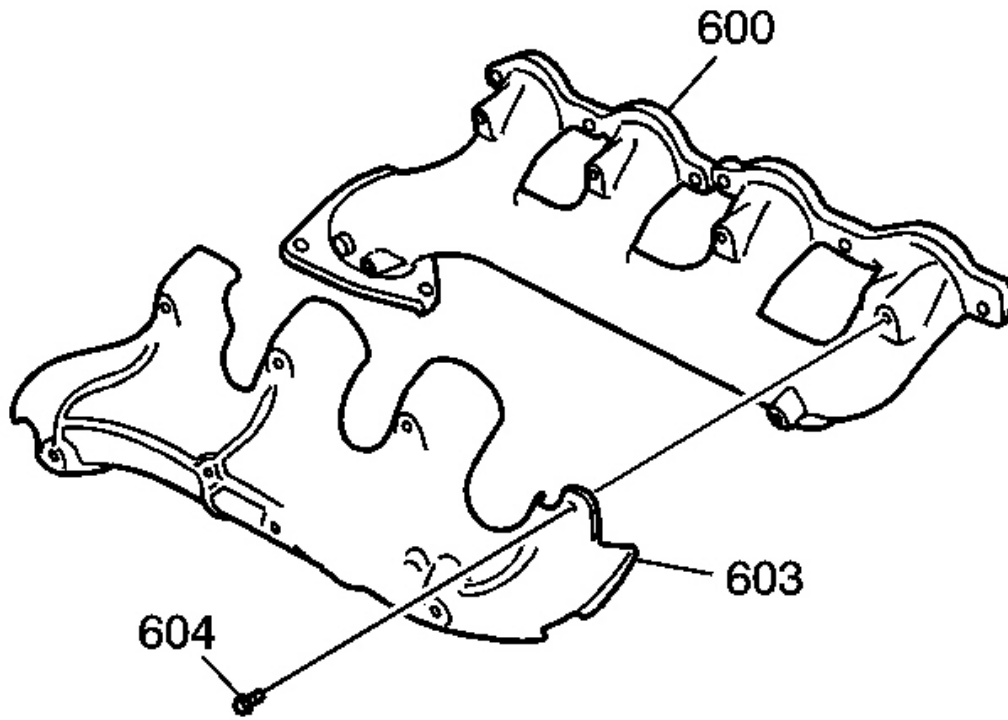


**Fig. 288: Exhaust Manifold, Gasket & Bolt (Right)**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.

Do not remove the spark plug wires from the ignition coils unless required.

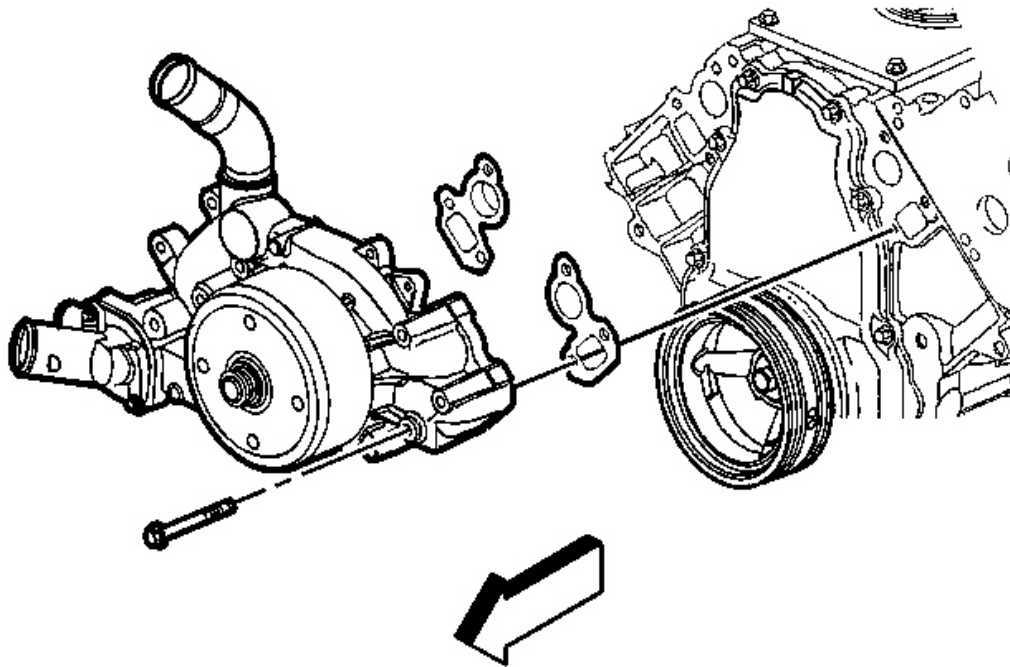
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.



**Fig. 289: Manifold, Heat Shield & Bolts (Right)**  
**Courtesy of GENERAL MOTORS CORP.**

4. Remove the heat shield (603) and bolts (604) from the manifold (600), if required.

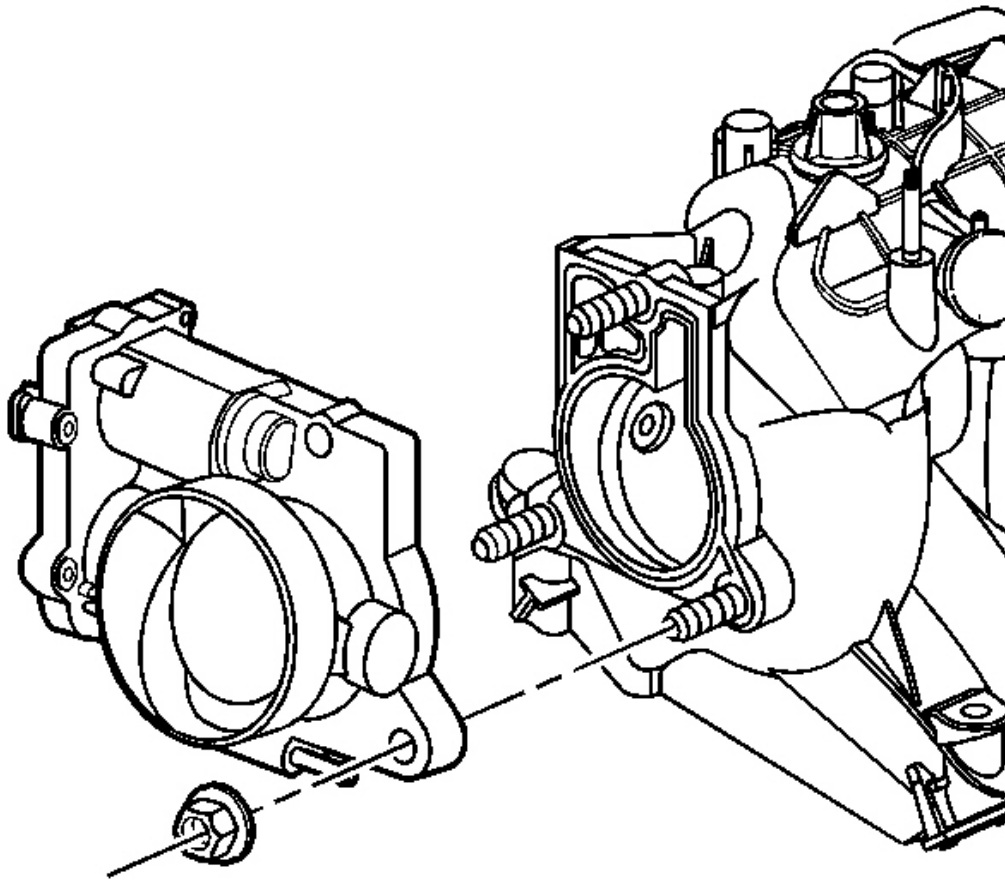
## **WATER PUMP REMOVAL**



**Fig. 290: Water Pump, Bolts & Gaskets**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump bolts.
2. Remove the water pump and gaskets.
3. Discard the water pump gaskets.

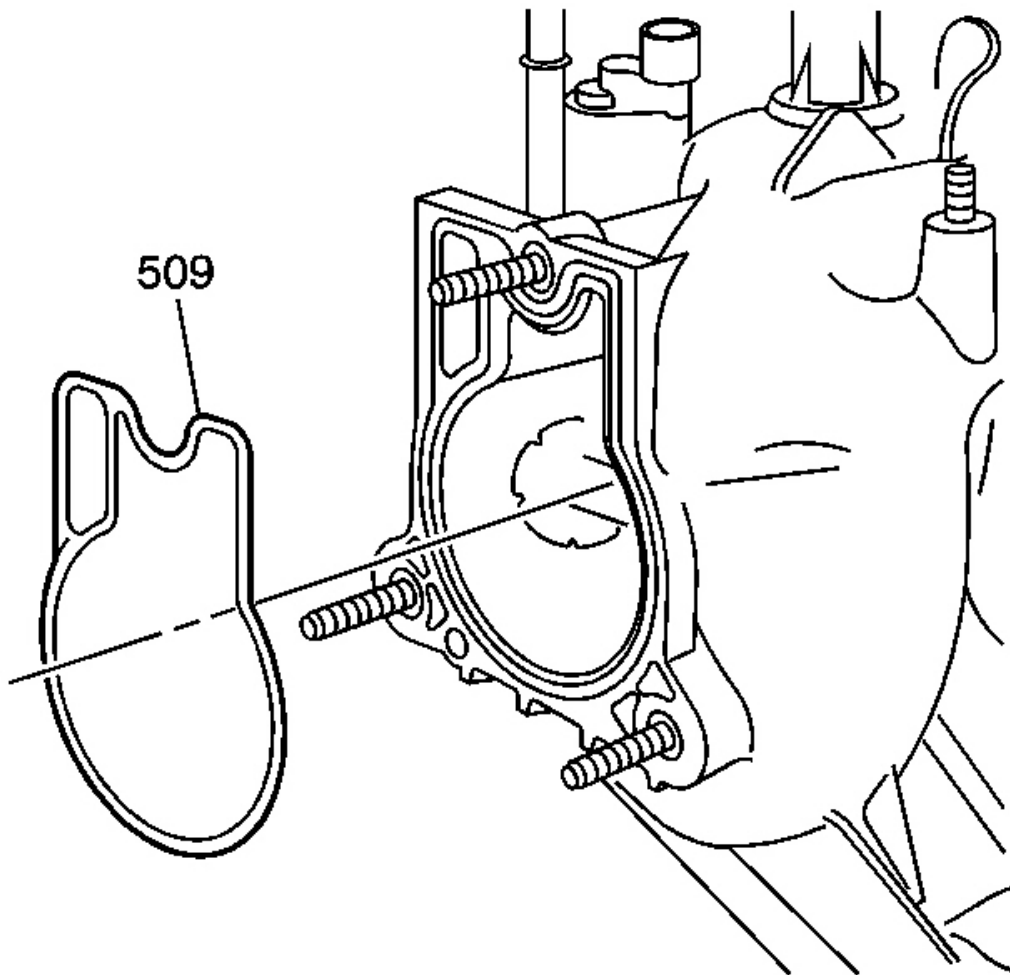
### **THROTTLE BODY REMOVAL**



**Fig. 291: Throttle Body & Nuts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

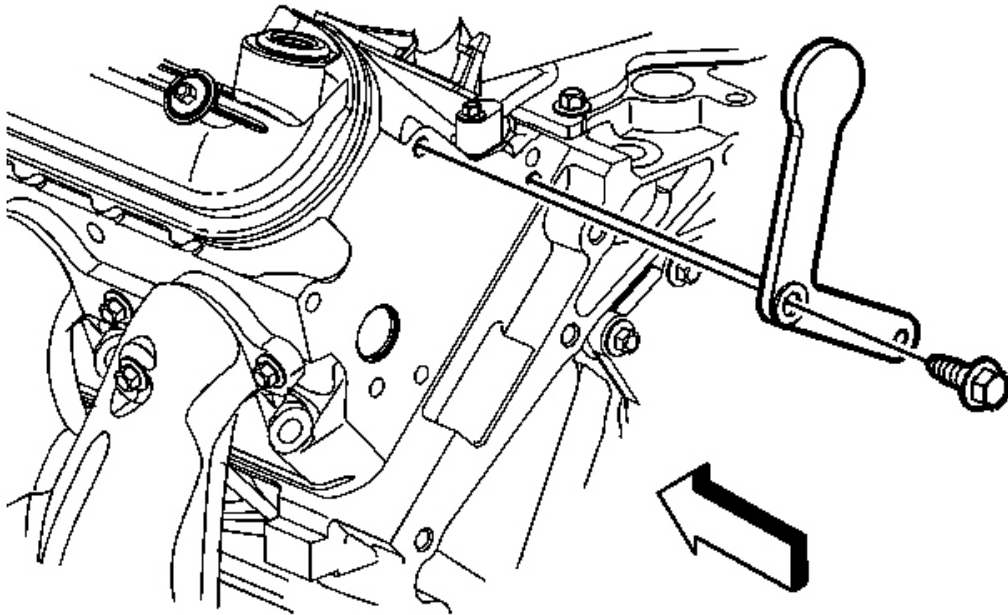
1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the engine coolant air bleed hose and clamp.
3. Remove the throttle body nuts.
4. Remove the throttle body.



**Fig. 292: Throttle Body Gasket**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the throttle body gasket (509).
6. Discard the gasket.
7. Remove the throttle body studs, if required.

## **FUEL RAIL AND INJECTORS REMOVAL**



**Fig. 293: Fuel Rail Stop Bracket & Bolt**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

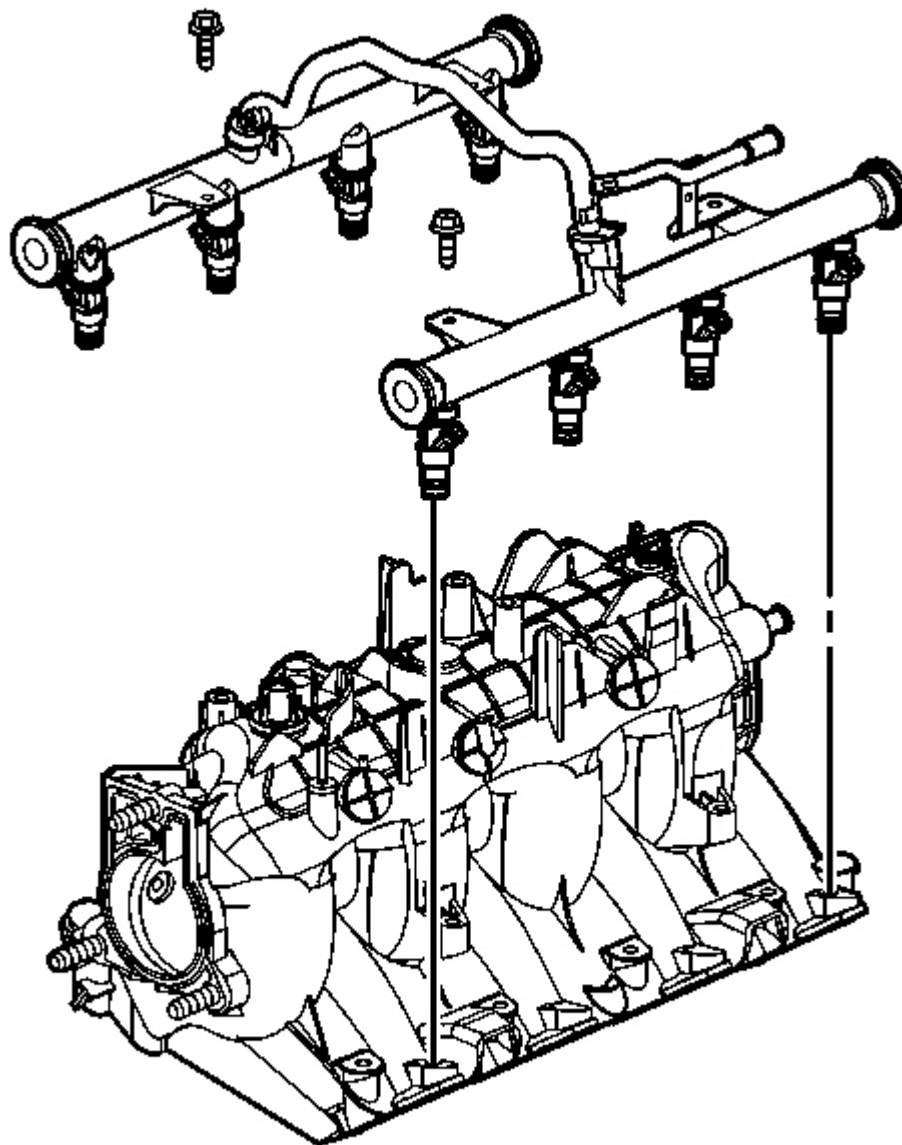
**NOTE:**

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

**IMPORTANT:** The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the intake manifold as a complete assembly.

1. Remove the fuel rail stop bracket and bolt, if required.
2. Loosen the crossover tube-to-right fuel rail retaining bolt.

3. Remove the fuel rail bolts.



**Fig. 294: Removing Fuel Rail With Injectors**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** • Do not separate the fuel injectors from the fuel rail unless

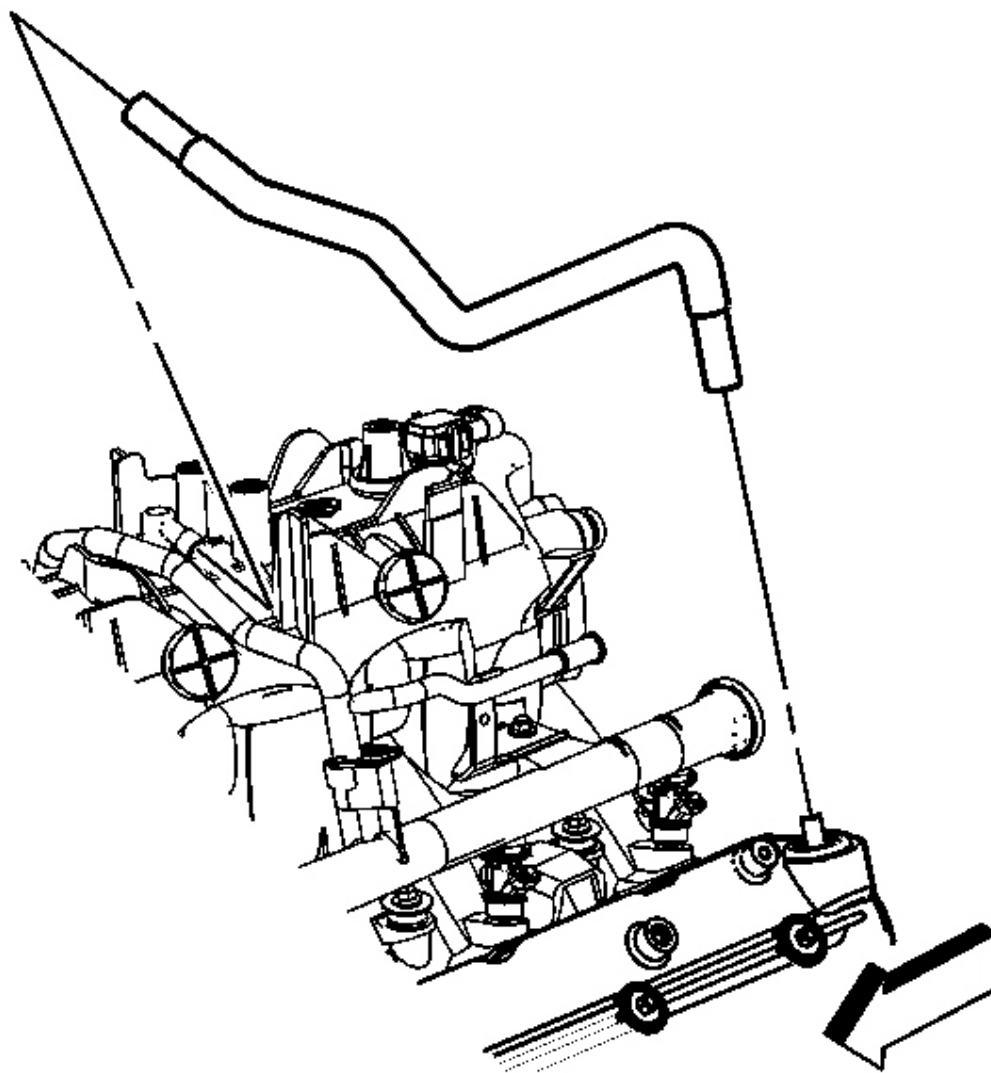


**component service is required.**

- **Use cleanliness and care when handling the fuel system components.**
- **Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends as necessary.**

4. Remove the fuel rail, with injectors, lifting evenly from both sides of the fuel rail until all the injectors have left their bores.

## **INTAKE MANIFOLD REMOVAL**

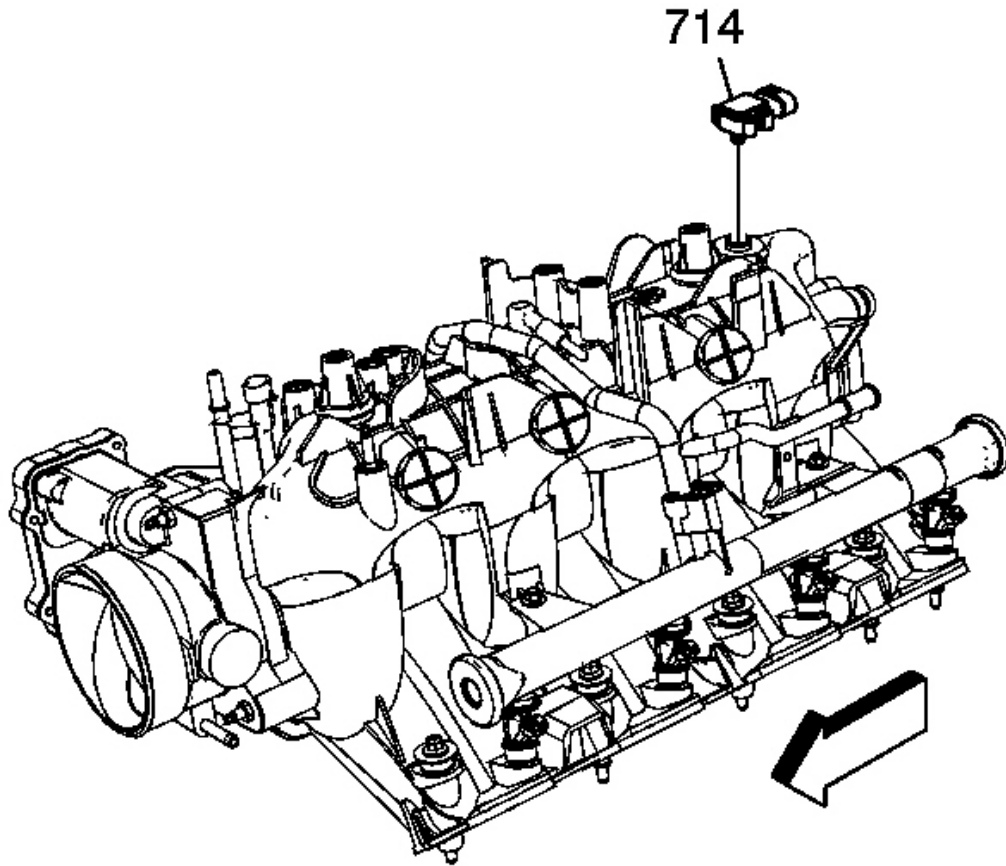


**Fig. 295: Identifying PCV Hose**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

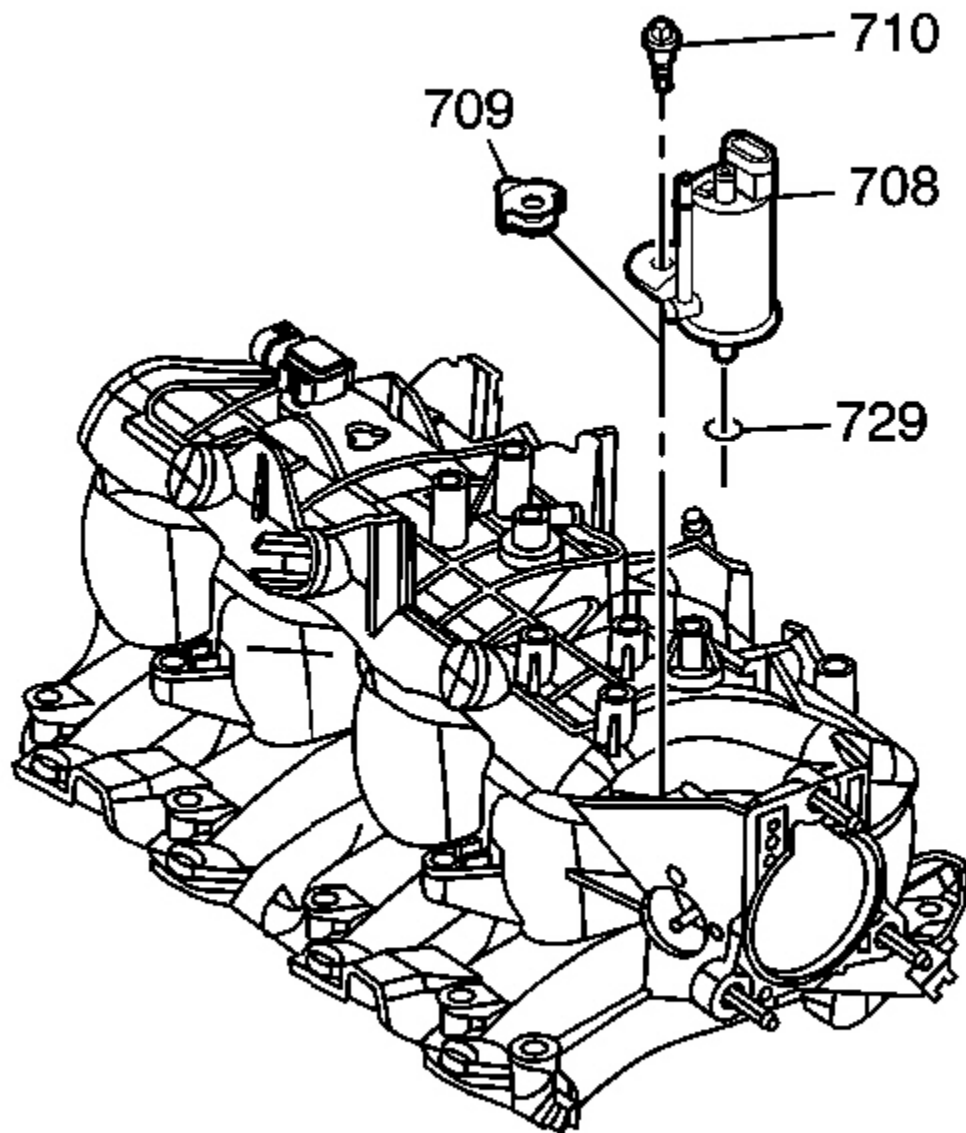
- The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.
- DO NOT use the intake manifold-to-cylinder head gaskets again.

1. Remove the positive crankcase ventilation (PCV) hose - dirty air.



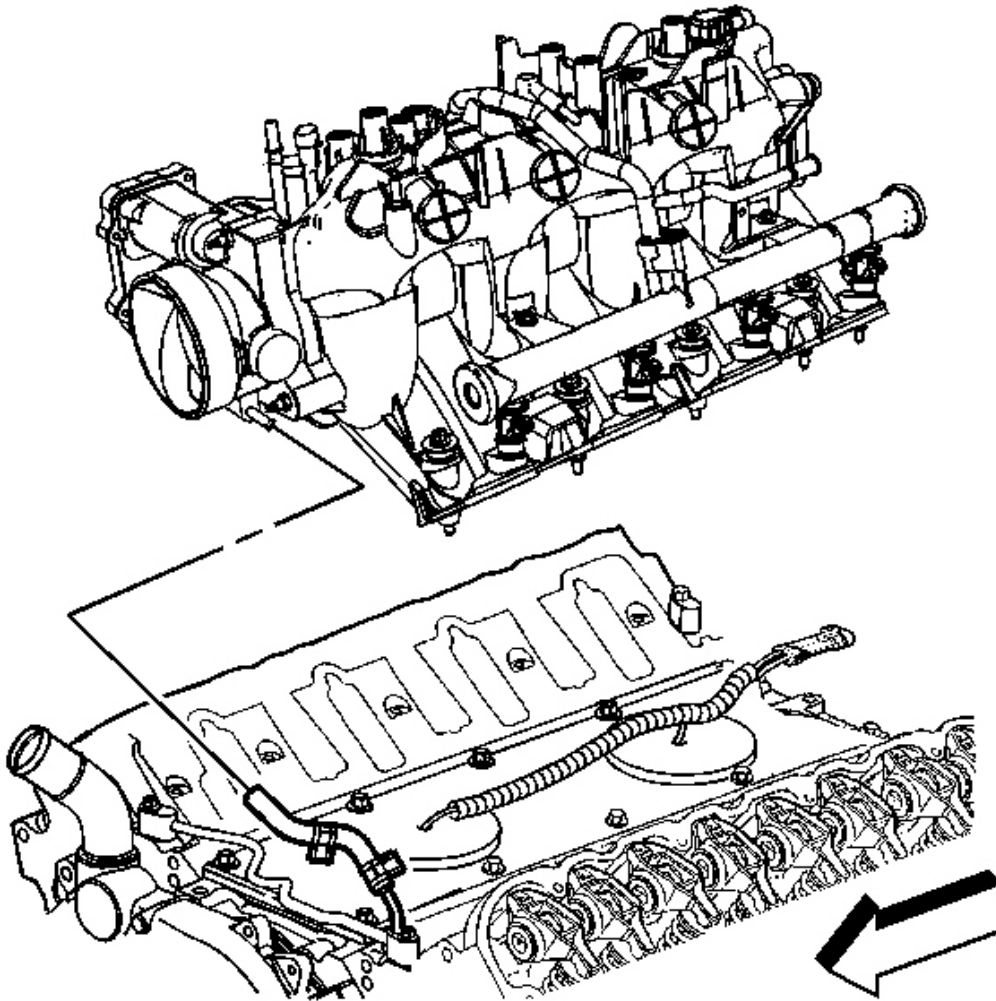
**Fig. 296: View Of MAP Sensor**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714), if required.
3. Remove the engine coolant air bleed clamp and hose from the throttle body.



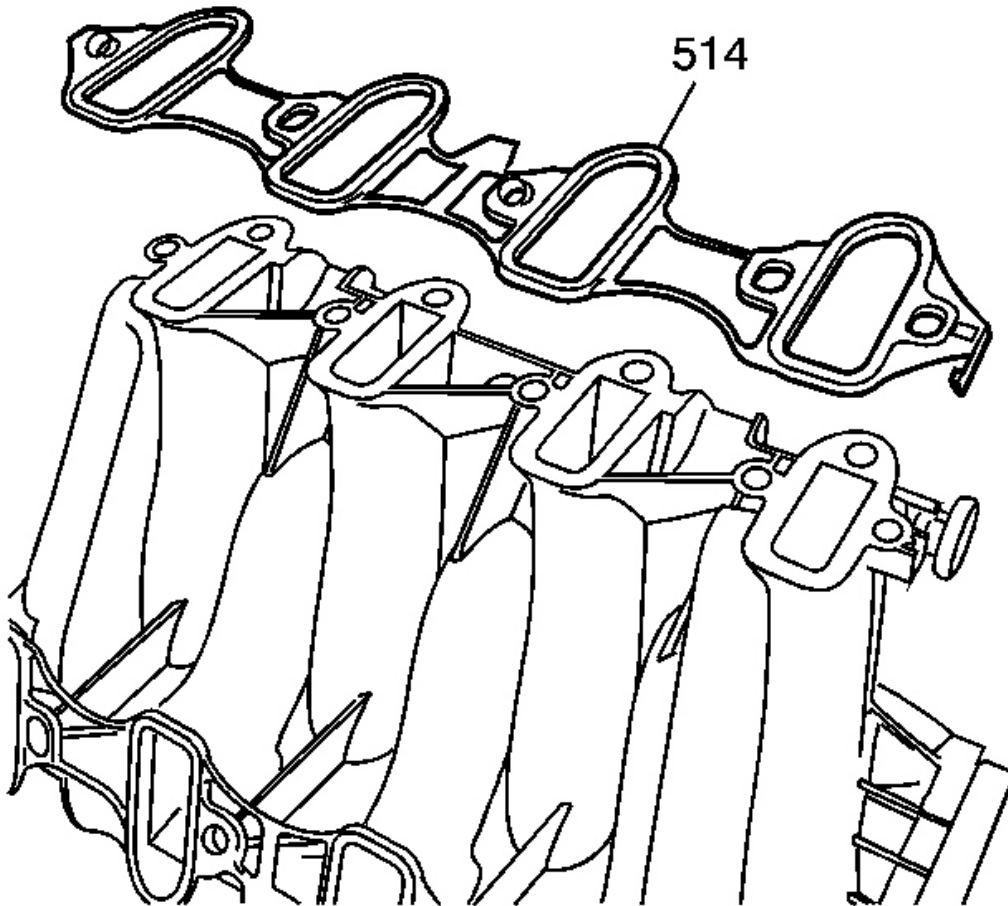
**Fig. 297: EVAP Purge Solenoid, Bolt & Isolator**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the evaporative emission (EVAP) solenoid (708), bolt (710), and isolator (709).



**Fig. 298: View Of Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

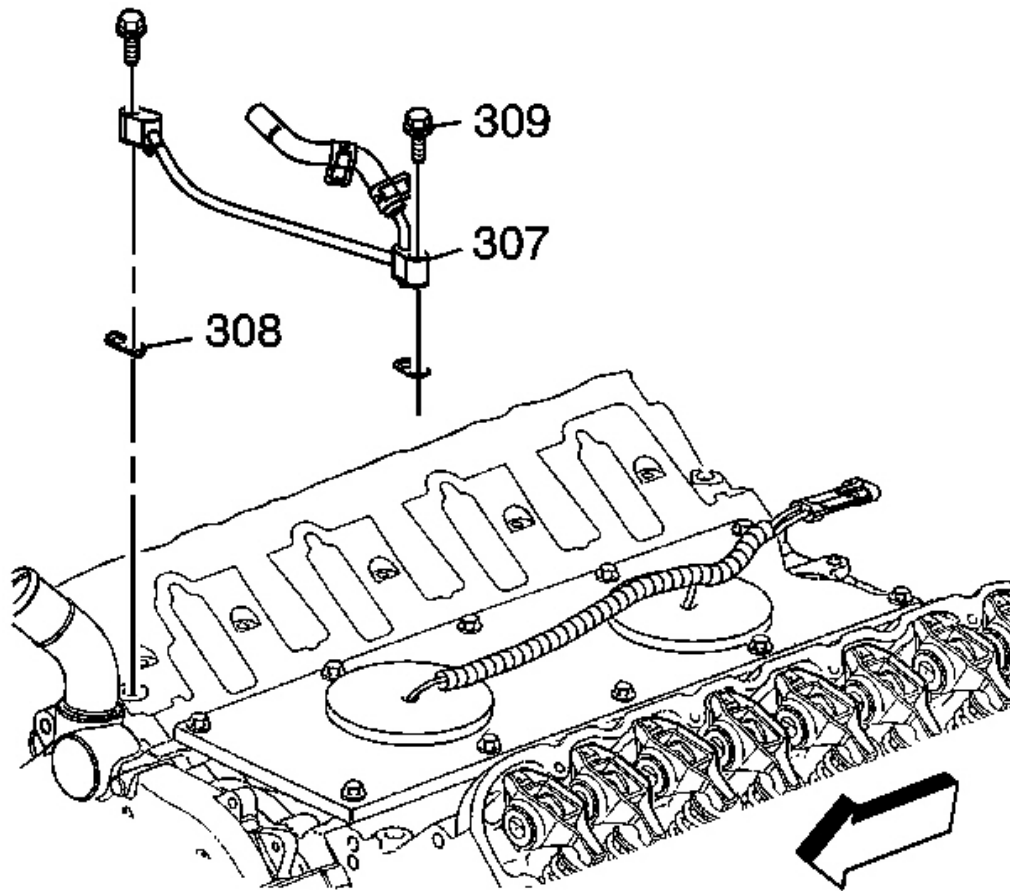
5. Remove the intake manifold bolts.
6. Remove the intake manifold with gaskets.



**Fig. 299: Intake Manifold-To-Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

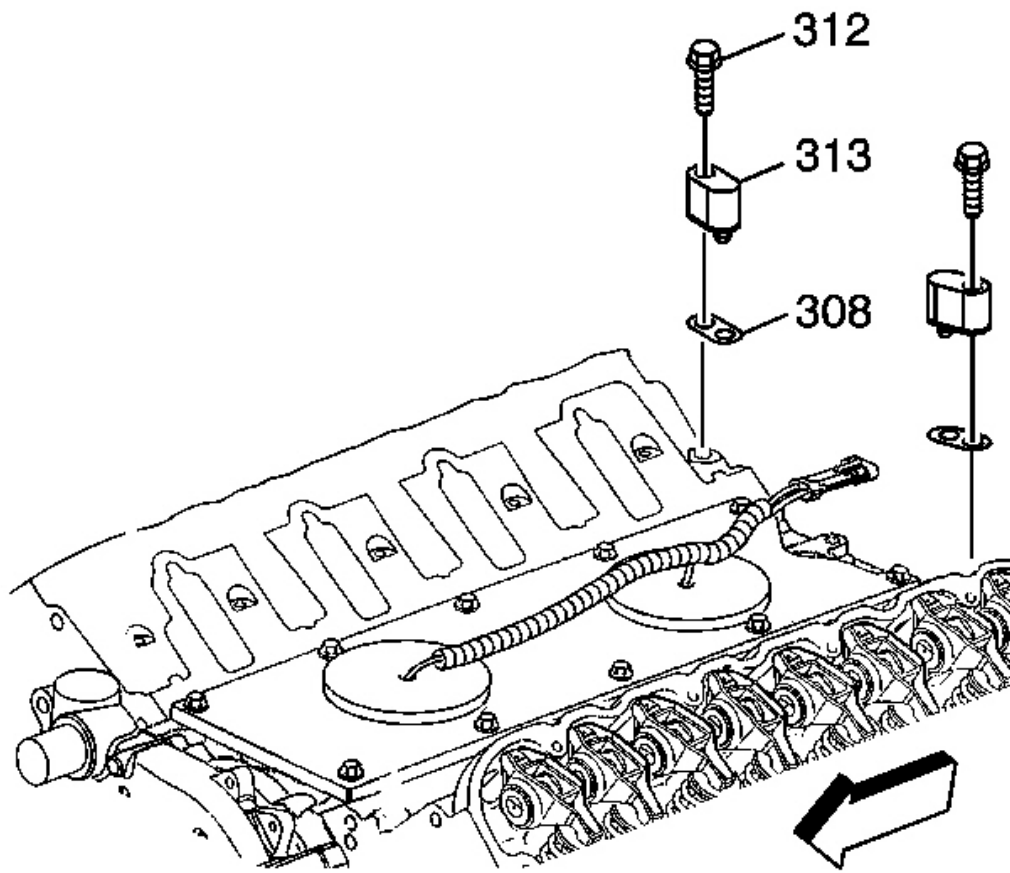
7. Separate the intake manifold-to-cylinder head gaskets (514) from the manifold.
8. Discard the intake manifold gaskets.

#### **COOLANT AIR BLEED PIPE REMOVAL**



**Fig. 300: Removing Engine Coolant Air Bleed Pipe, Bolt & Gasket**  
Courtesy of GENERAL MOTORS CORP.

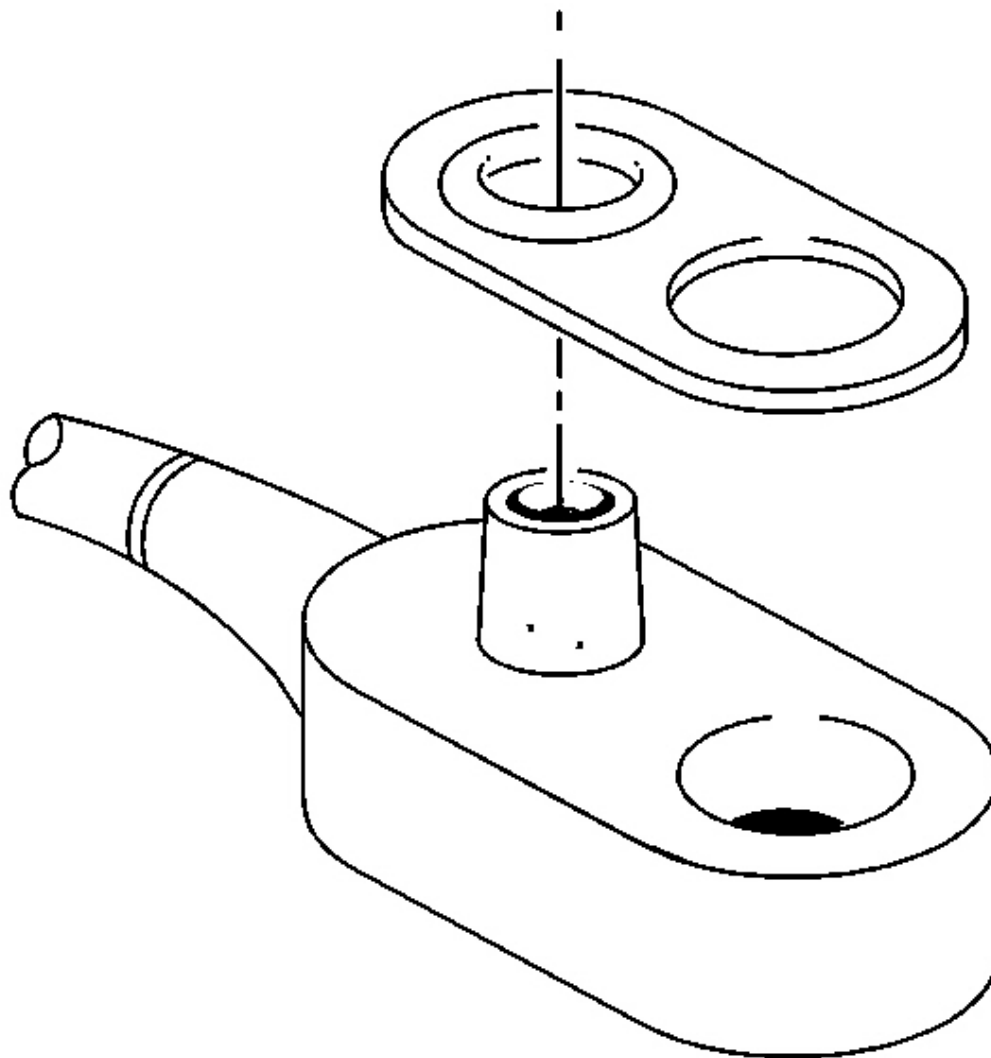
1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with hose and gaskets (308).



**Fig. 301: Engine Coolant Air Bleed Cover, Gasket & Bolts**  
Courtesy of GENERAL MOTORS CORP.

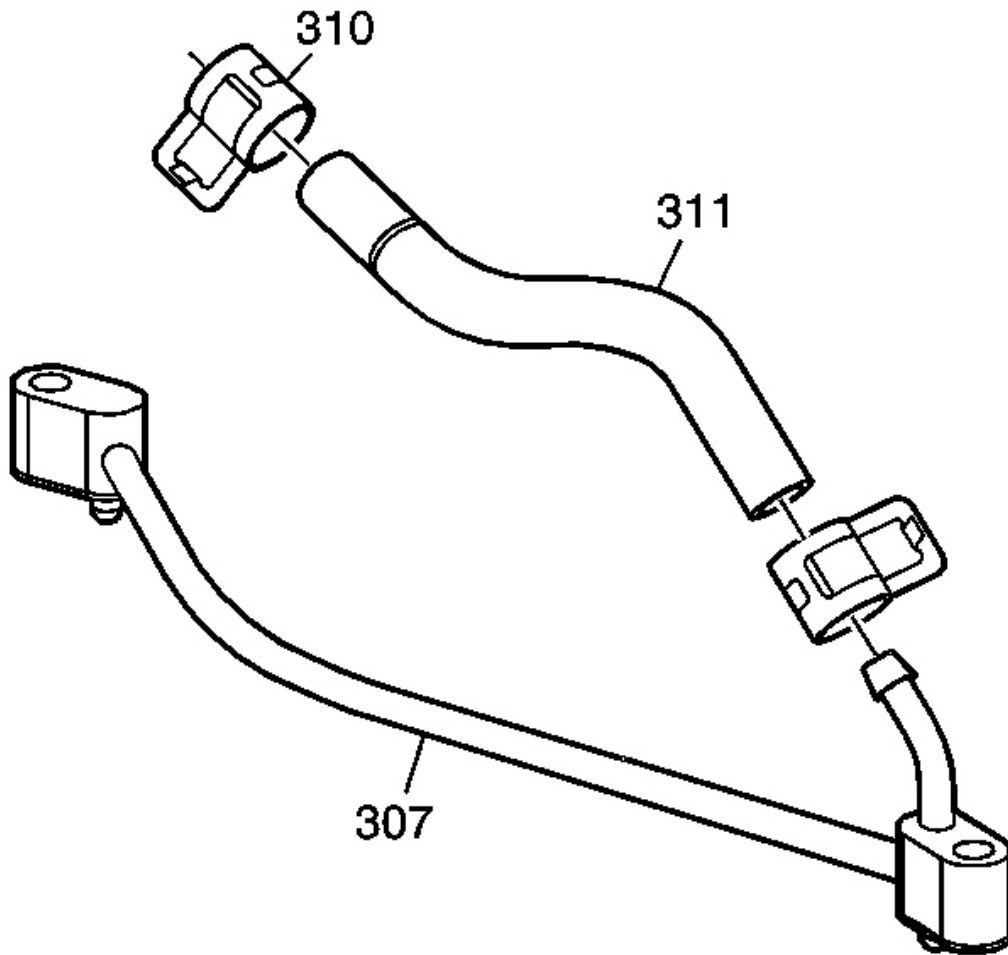
3. Remove the engine coolant air bleed cover bolts (312), covers (313), and gaskets (308).





**Fig. 302: View Of Pipe & Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

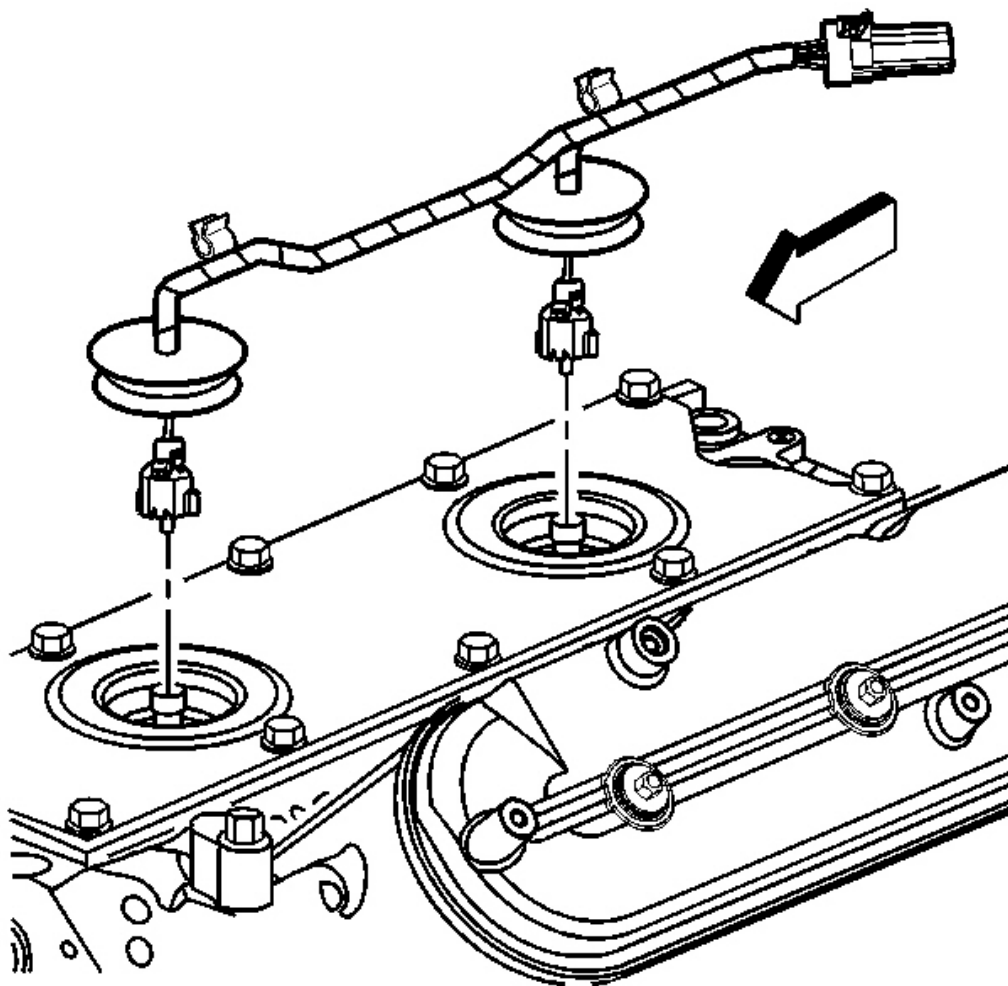
4. Remove the gaskets from the pipe and covers.
5. Discard the gaskets.



**Fig. 303: Air Bleed Pipe, Hose & Clamp**  
Courtesy of GENERAL MOTORS CORP.

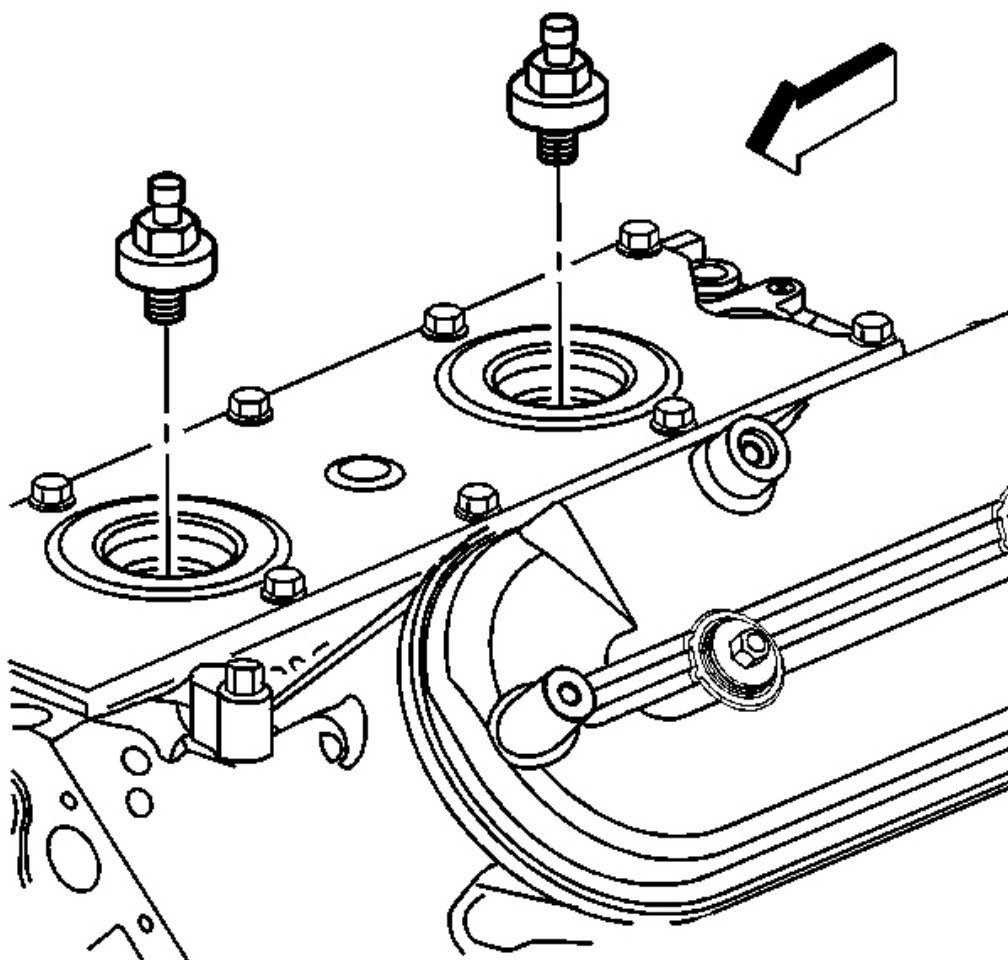
6. Remove the hose (311) and clamps (310) from the pipe (307).

## **ENGINE VALLEY COVER REMOVAL**



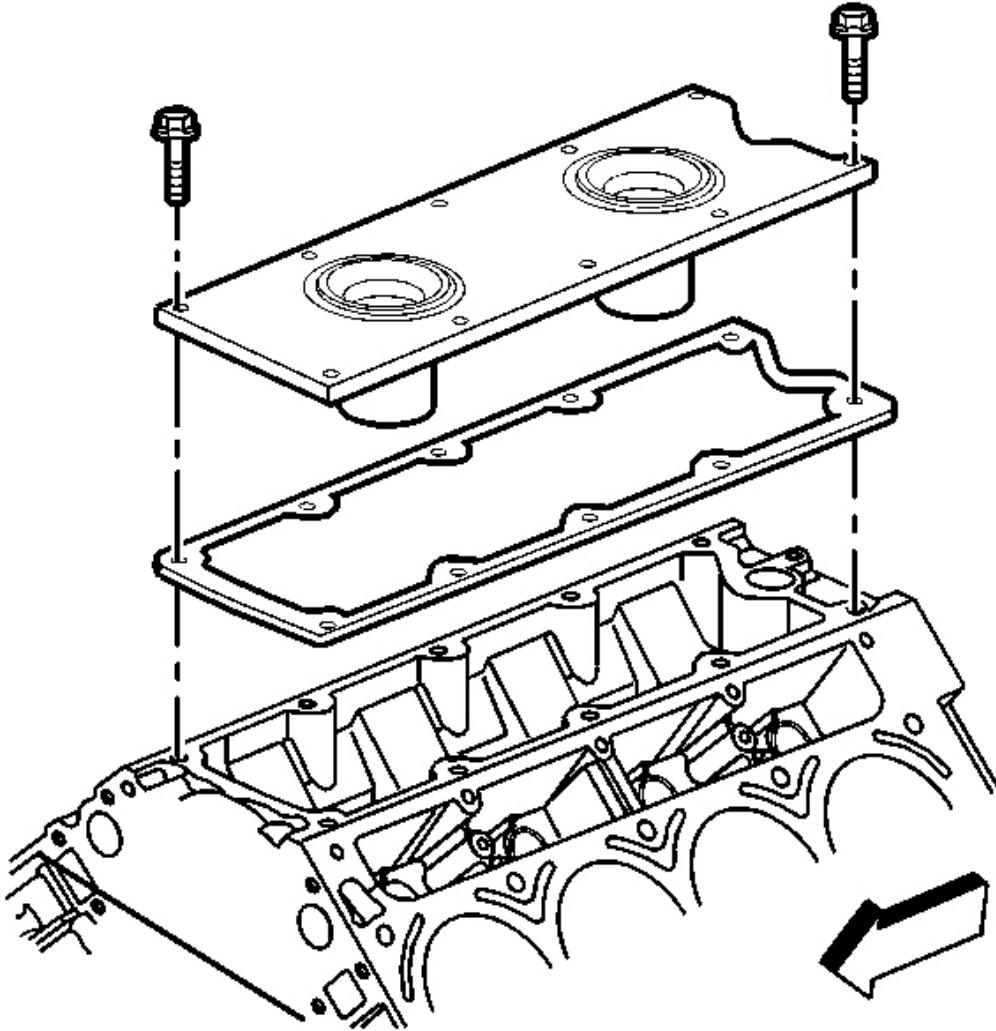
**Fig. 304: Knock Sensor Wire Harness**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the knock sensor wire harness.



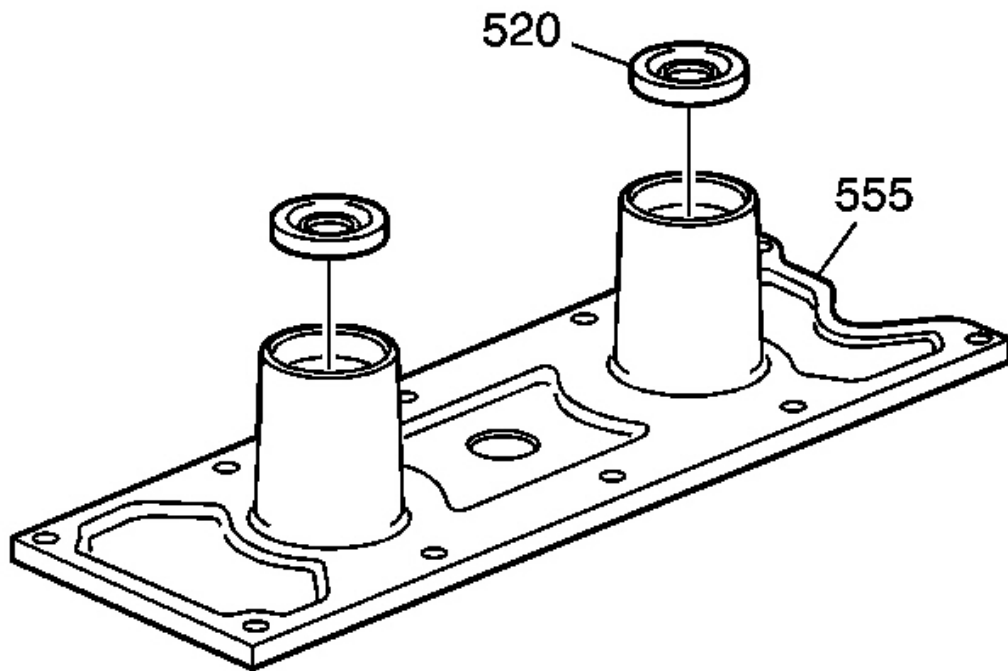
**Fig. 305: Knock Sensors**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the knock sensors.



**Fig. 306: Engine Valley Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

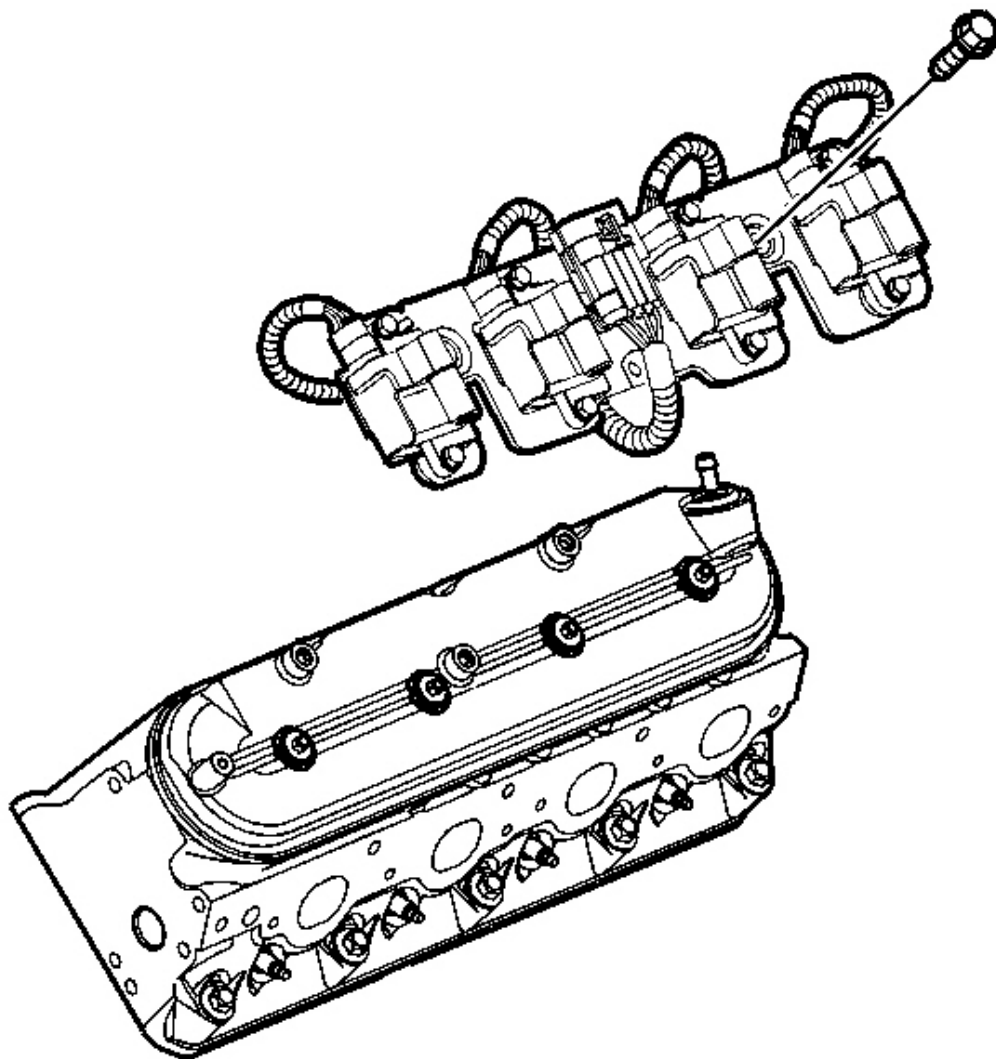
3. Remove the valley cover bolts.
4. Remove the valley cover and gasket.
5. Discard the valley cover gasket.



**Fig. 307: Knock Sensor Oil Seals & Valley Cover**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the knock sensor oil seals (520) from the cover (555).

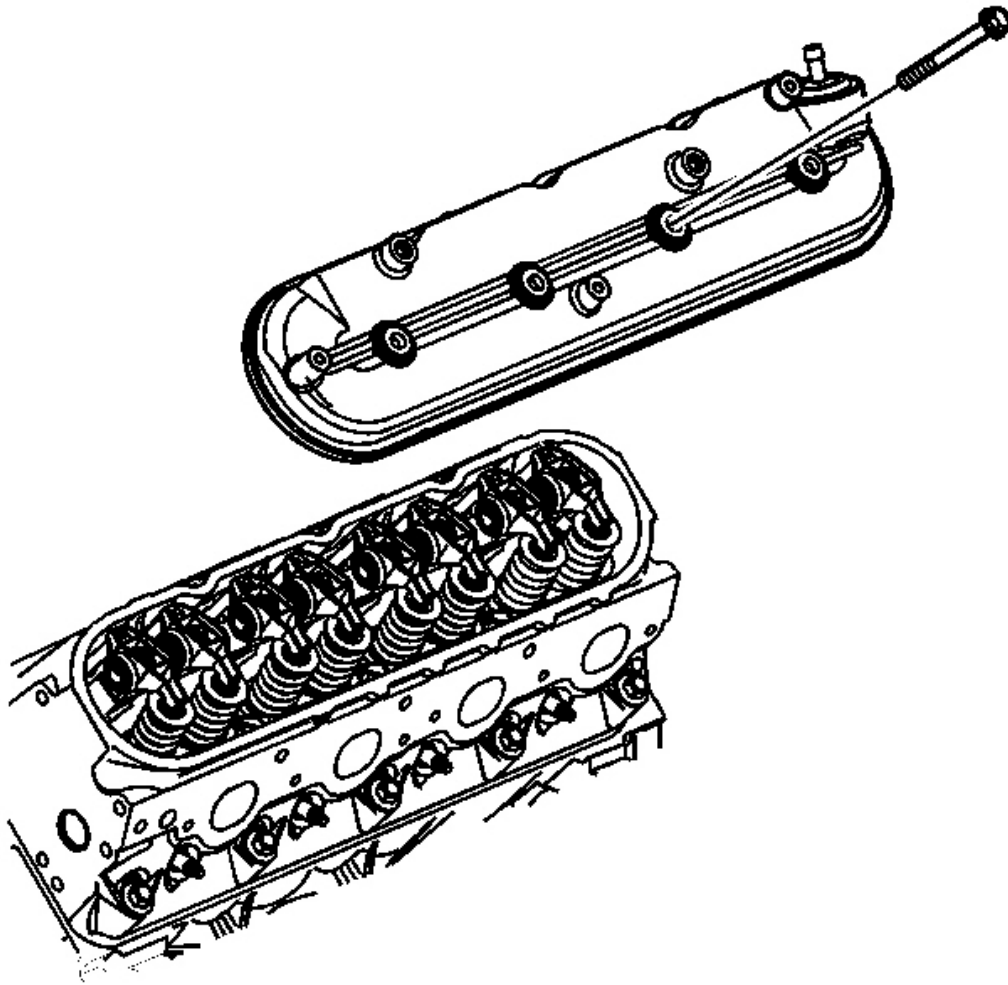
#### **VALVE ROCKER ARM COVER REMOVAL - LEFT**



**Fig. 308: Ignition Coil & Bracket Assembly (Left)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.**

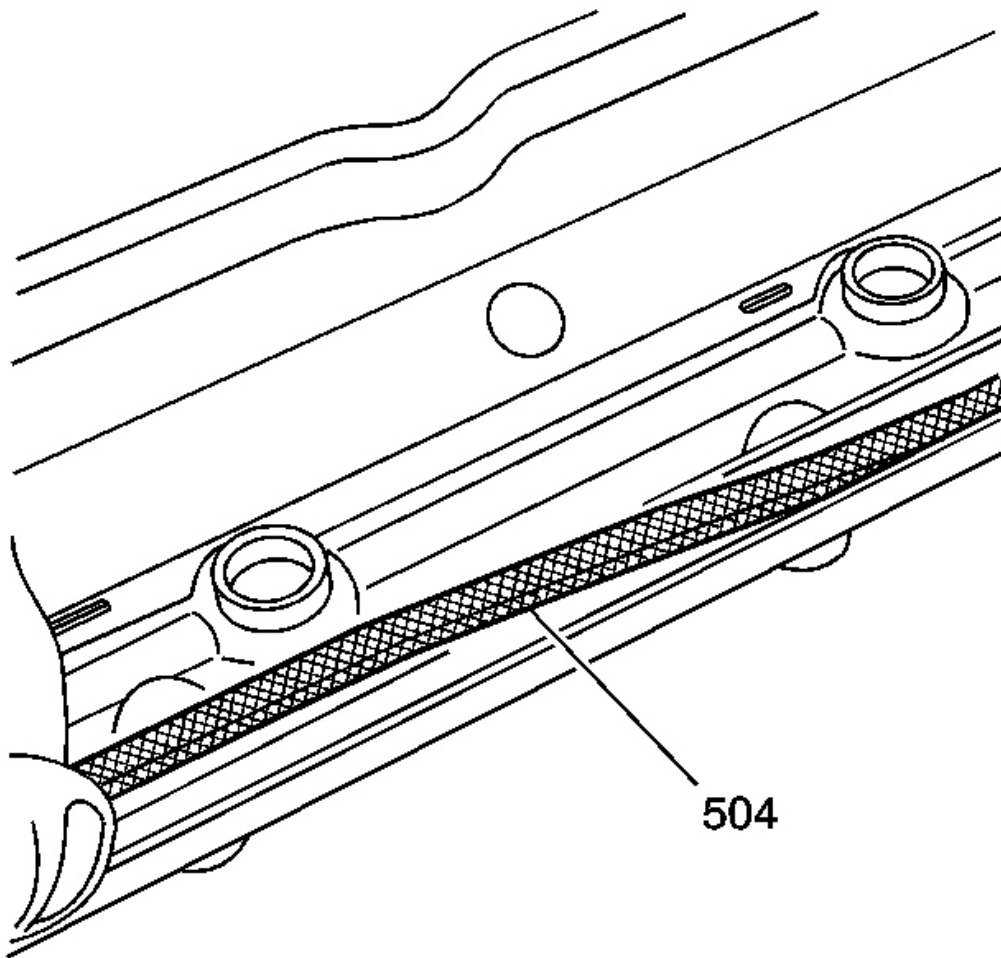
1. Remove the ignition coil bracket bolts from the rocker arm cover, if required.
2. Remove the ignition coil and bracket assembly from the cover.



**Fig. 309: Valve Rocker Arm Cover (Left)**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm cover bolts.
4. Remove the valve rocker arm cover.



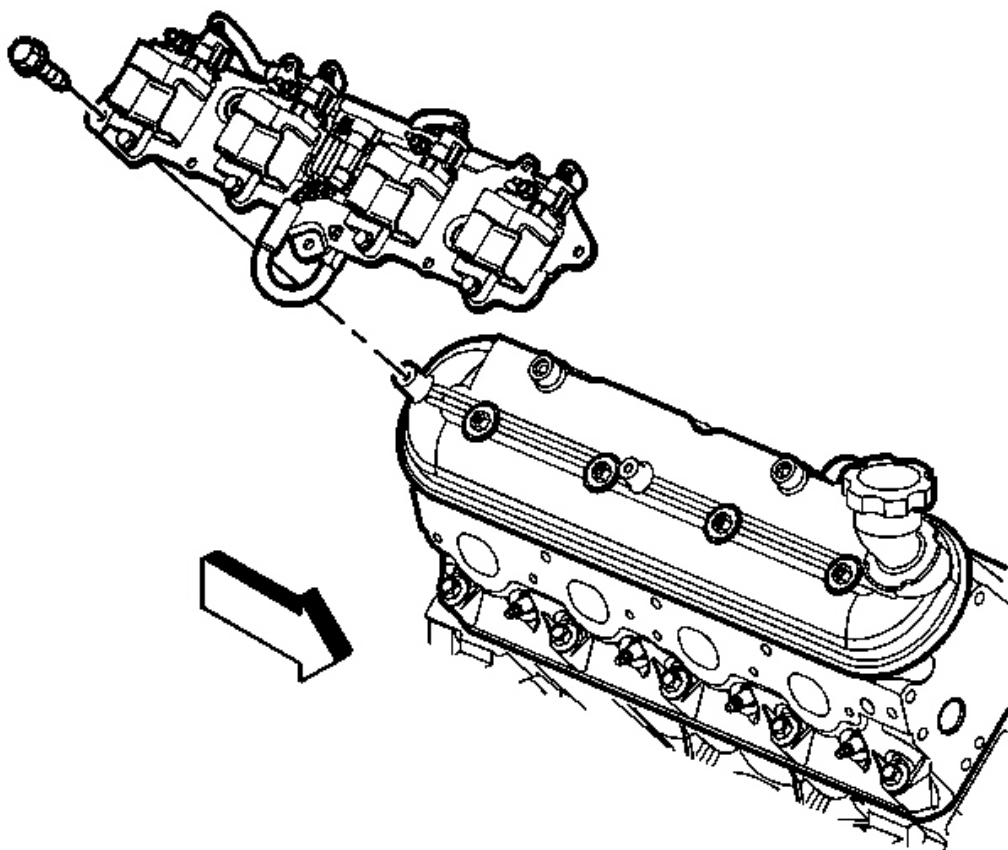


**Fig. 310: Valve Rocker Arm Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the gasket (504) from the left cover.
6. Discard the gasket.

The bolt grommets may be used again if they are not damaged.

#### **VALVE ROCKER ARM COVER REMOVAL - RIGHT**

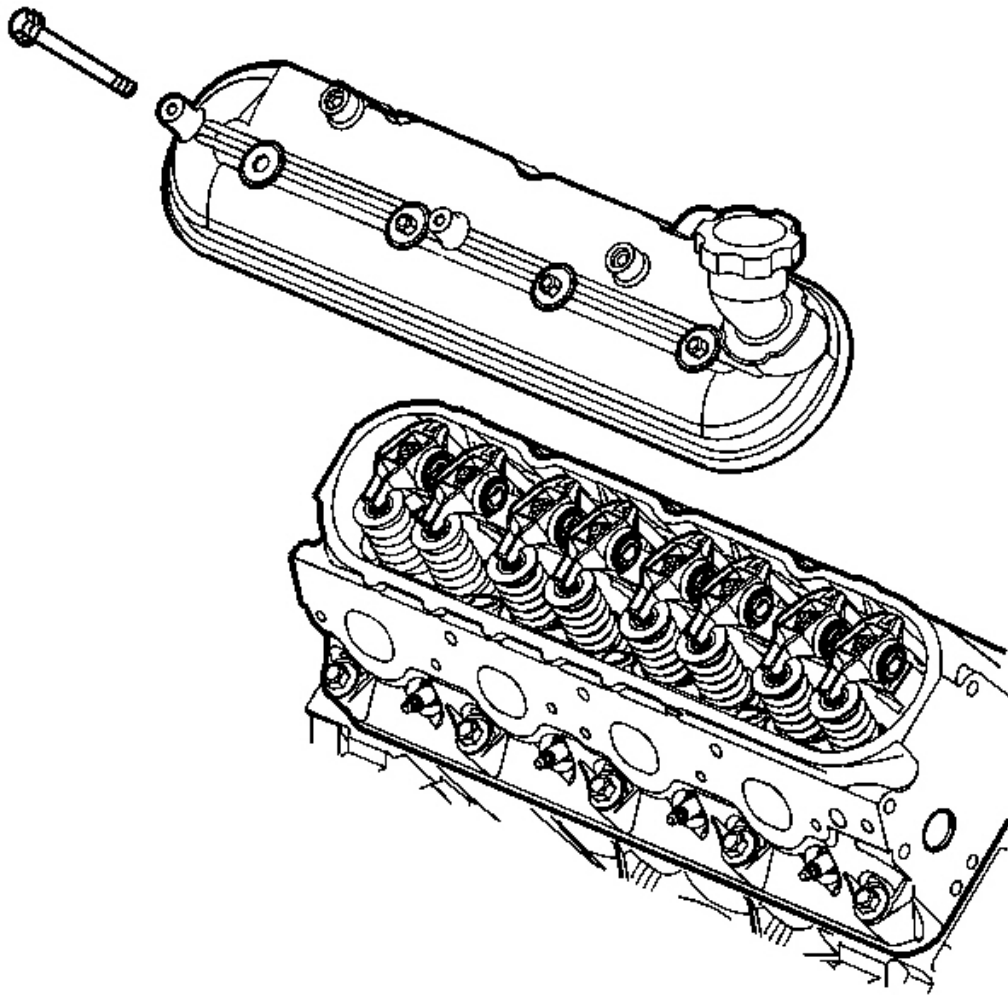


**Fig. 311: Ignition Coil & Bracket Assembly (Right)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

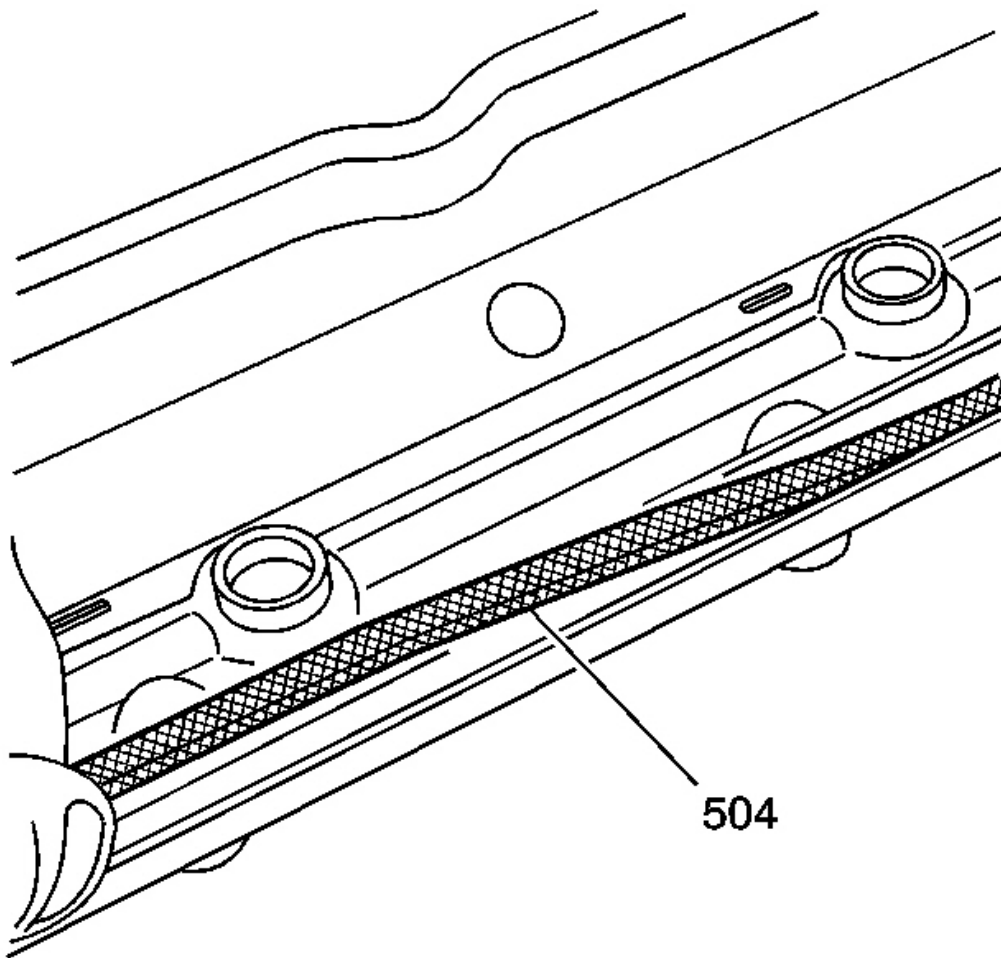
- Do not remove the ignition coils from the valve rocker arm cover unless required.
- Do not remove the oil fill tube from the cover unless service is required.
- If the oil fill tube has been removed from the cover, install a **NEW** tube during assembly.

1. Remove the ignition coil bracket bolts from the rocker arm cover, if required.
2. Remove the ignition coil and bracket assembly from the cover.



**Fig. 312: Valve Rocker Arm Cover & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

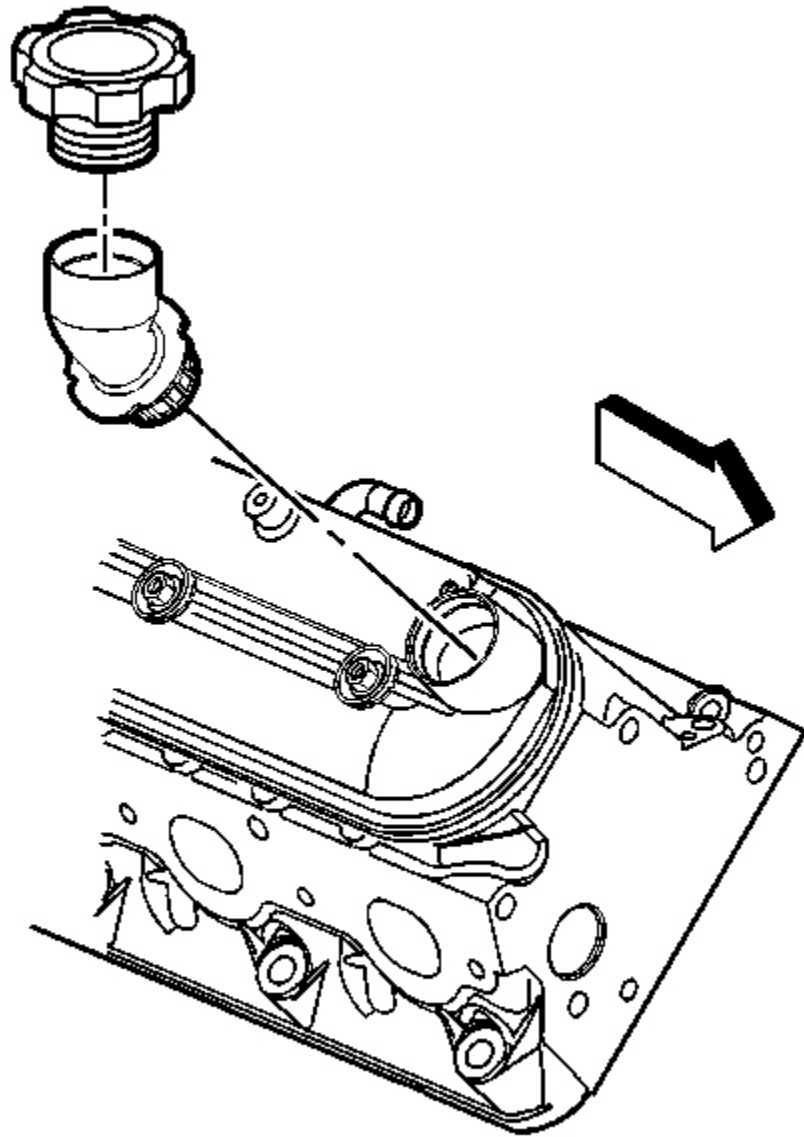
3. Remove the valve rocker arm cover bolts.
4. Remove the valve rocker arm cover.



**Fig. 313: Valve Rocker Arm Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the gasket (504) from the right cover.
6. Discard the gasket.

The bolt grommets may be used again if they are not damaged.

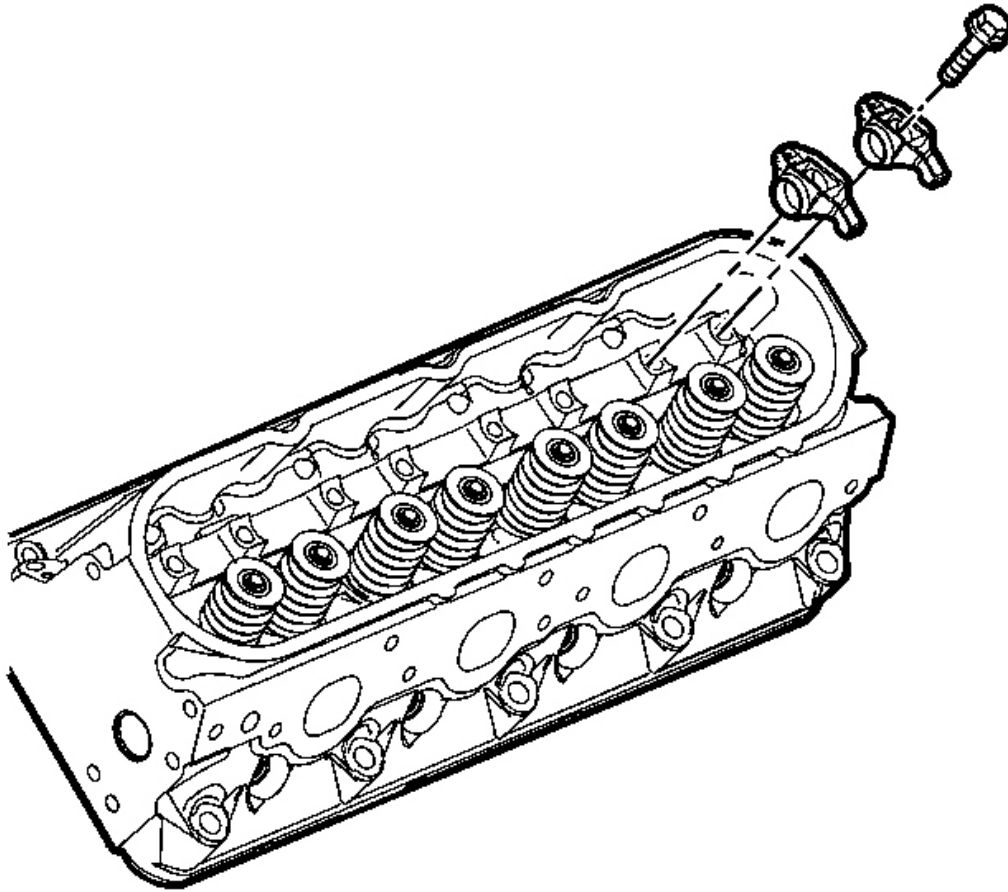


**Fig. 314: View Of Oil Fill Tube**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil fill cap from the oil fill tube.
8. Remove the oil fill tube, if required.
9. Discard the oil fill tube.

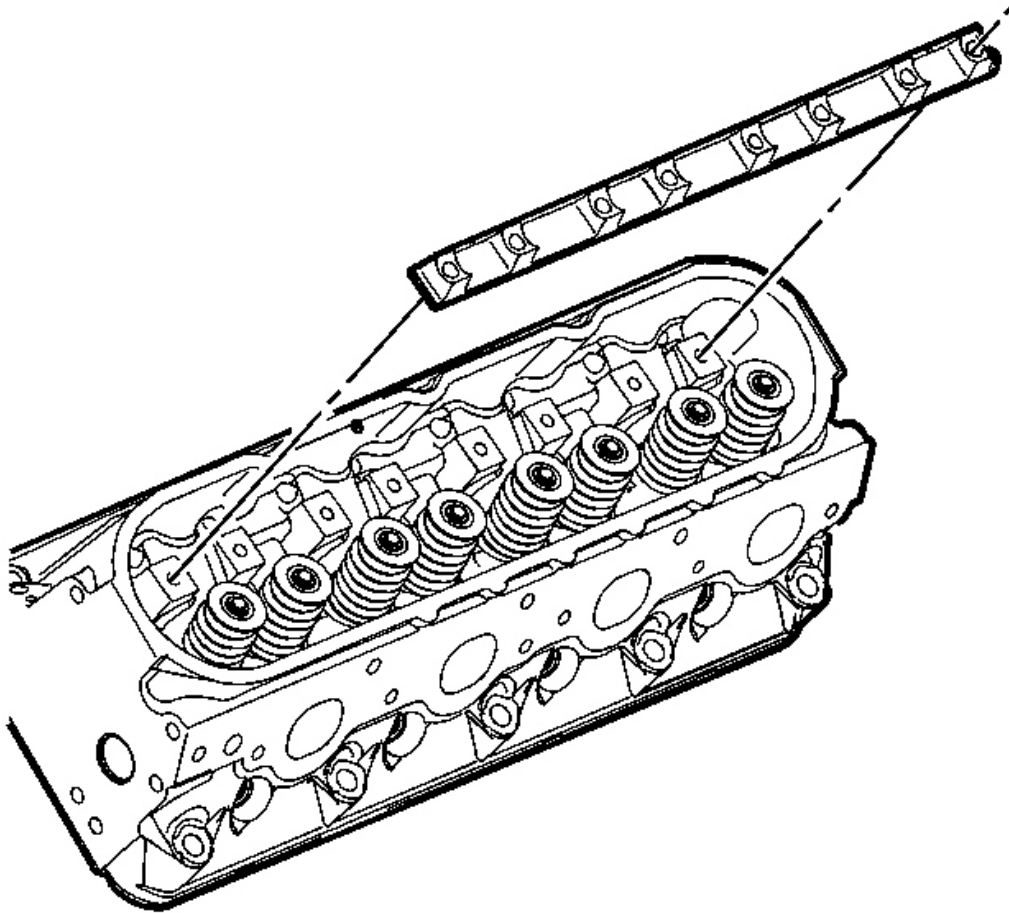
## VALVE ROCKER ARM AND PUSH ROD REMOVAL

**IMPORTANT:** Place valve rocker arms, valve pushrods, and pivot support, in a rack so that they can be installed in the same location from which they were removed.



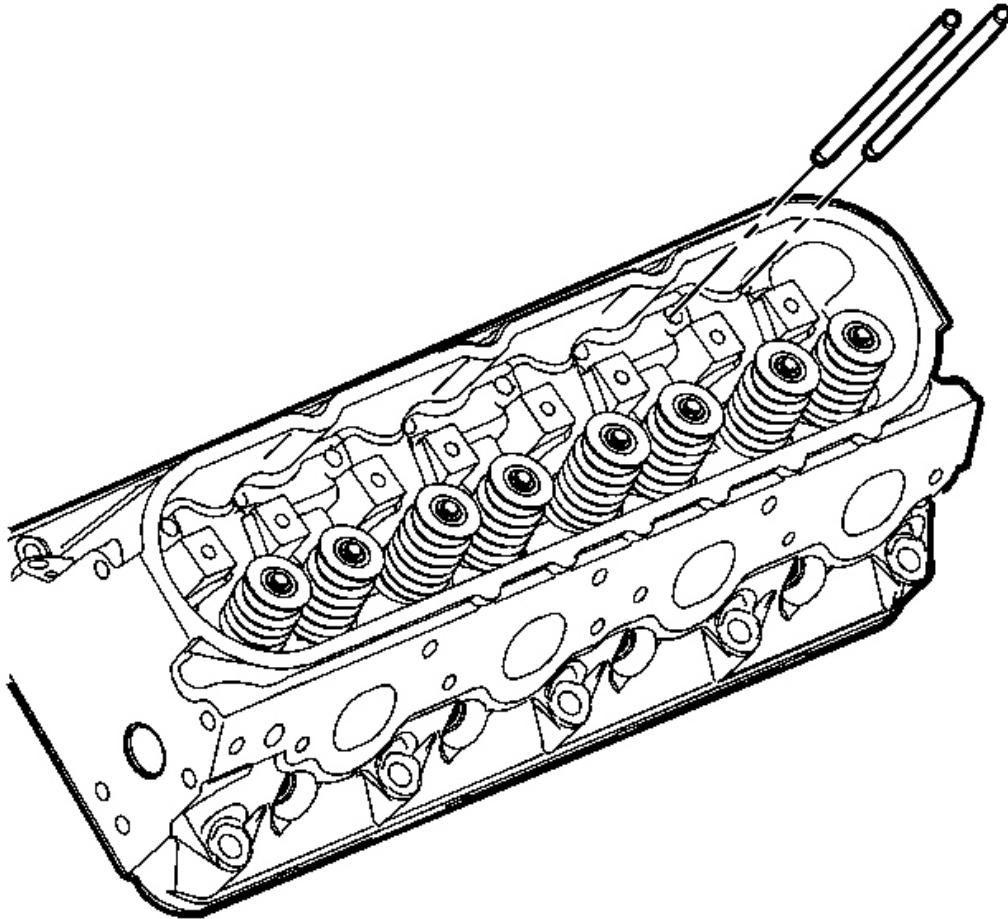
**Fig. 315: Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm bolts.
2. Remove the valve rocker arms.



**Fig. 316: Valve Rocker Arm Pivot Support**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

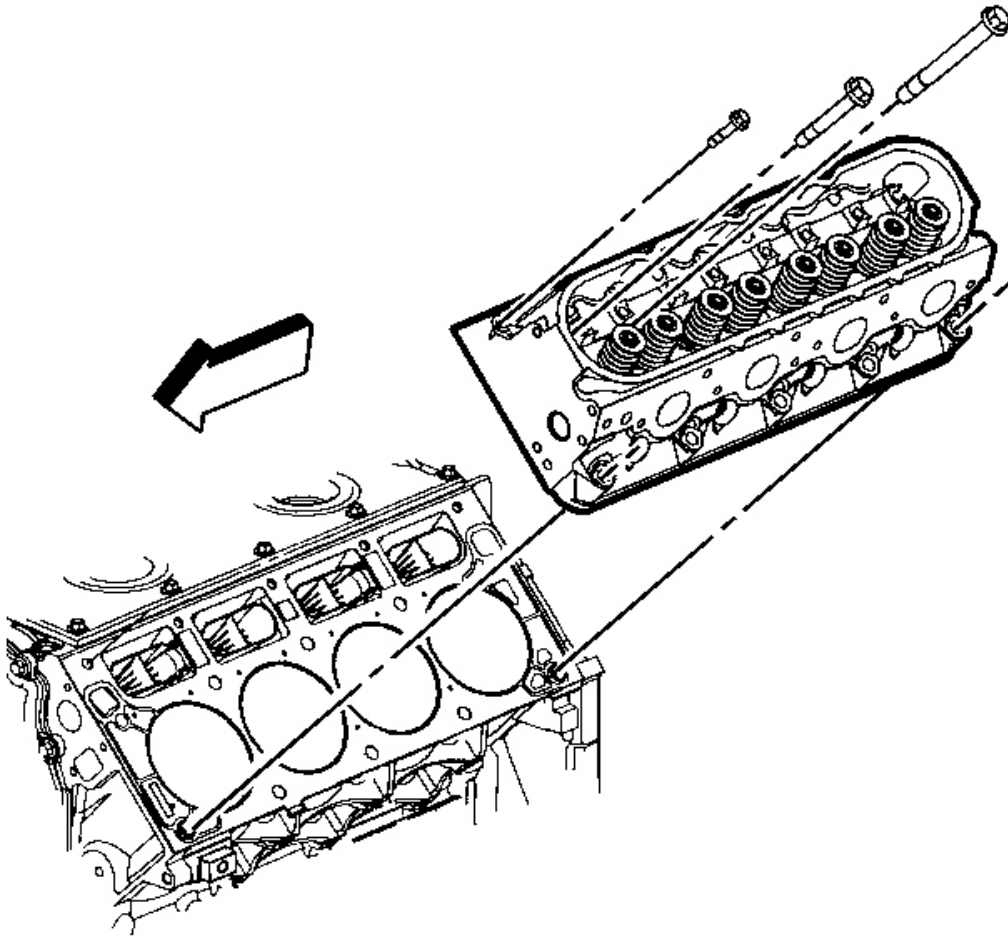


**Fig. 317: View Of Pushrods**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

**CYLINDER HEAD REMOVAL - LEFT**





**Fig. 318: Cylinder Head & Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

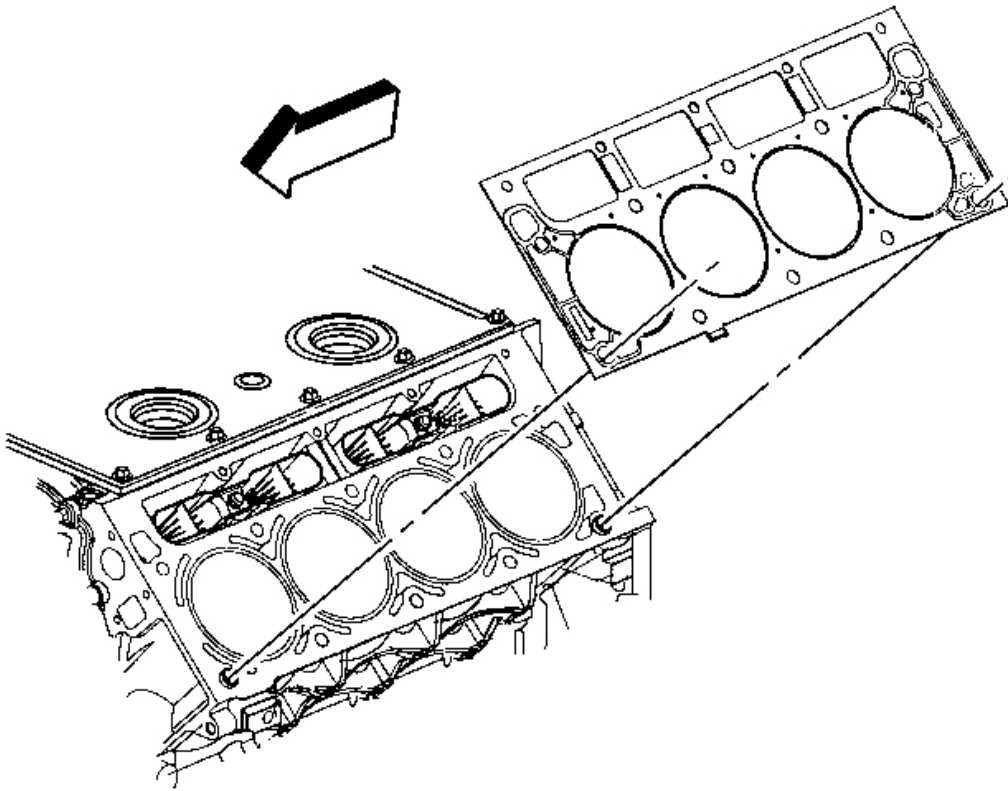
1. Remove the spark plugs from the cylinder head.

**IMPORTANT:** The cylinder head bolts can NOT be used again. Install NEW cylinder head bolts during assembly.

2. Remove the cylinder head bolts.

**NOTE:** After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

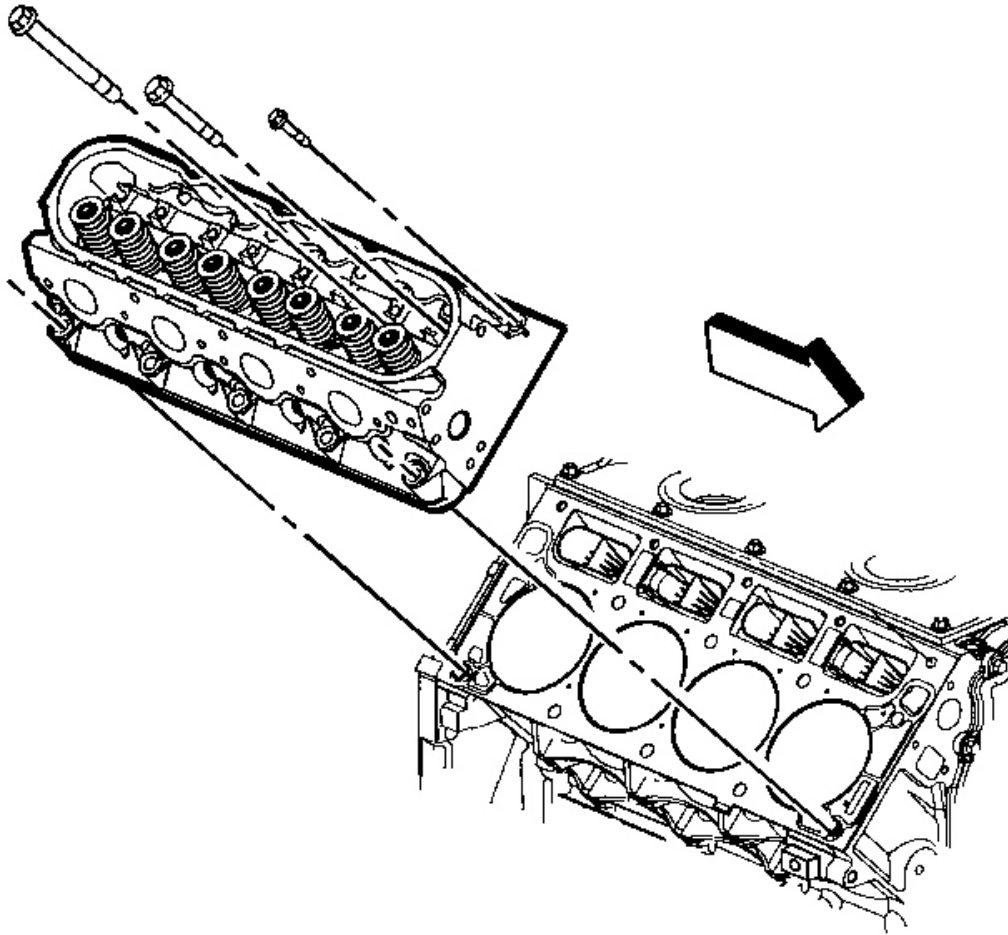
3. Remove the cylinder head.



**Fig. 319: Cylinder Head Gasket (Left)**  
**Courtesy of GENERAL MOTORS CORP.**

4. Remove the gasket.
5. Discard the gasket.
6. Discard the cylinder head bolts.

### **CYLINDER HEAD REMOVAL - RIGHT**



**Fig. 320: Cylinder Head & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

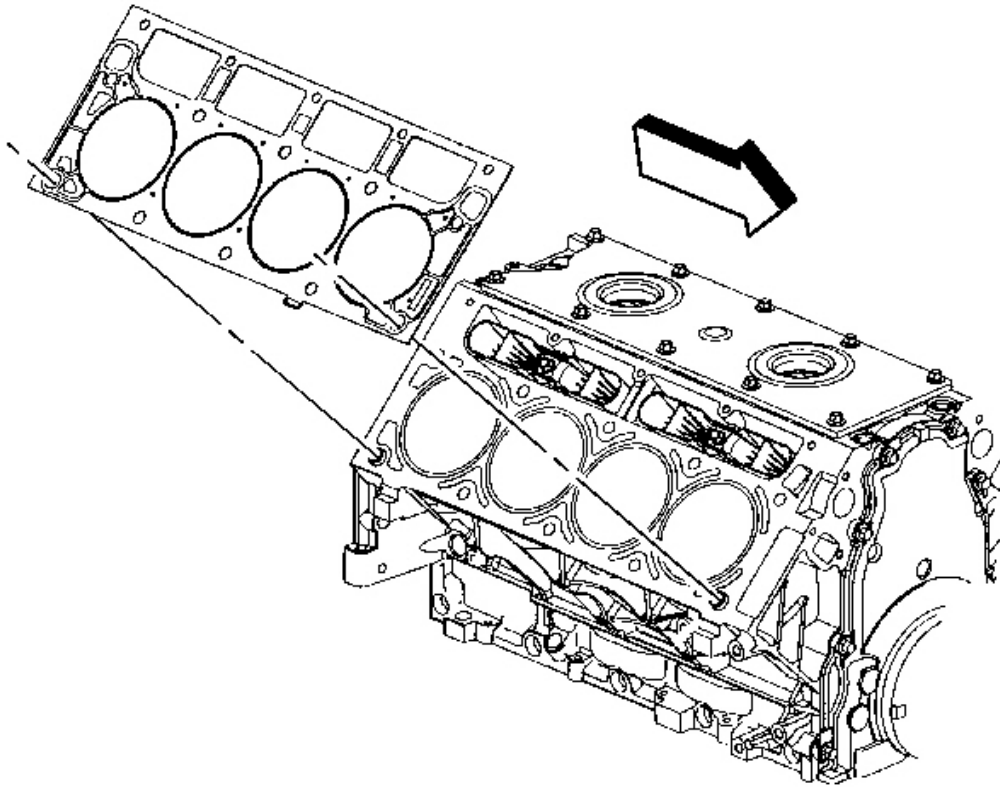
1. Remove the spark plugs from the cylinder head.

**IMPORTANT:** The cylinder head bolts can NOT be used again. Install NEW cylinder head bolts during assembly.

2. Remove the cylinder head bolts.

**NOTE:** After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

3. Remove the cylinder head.

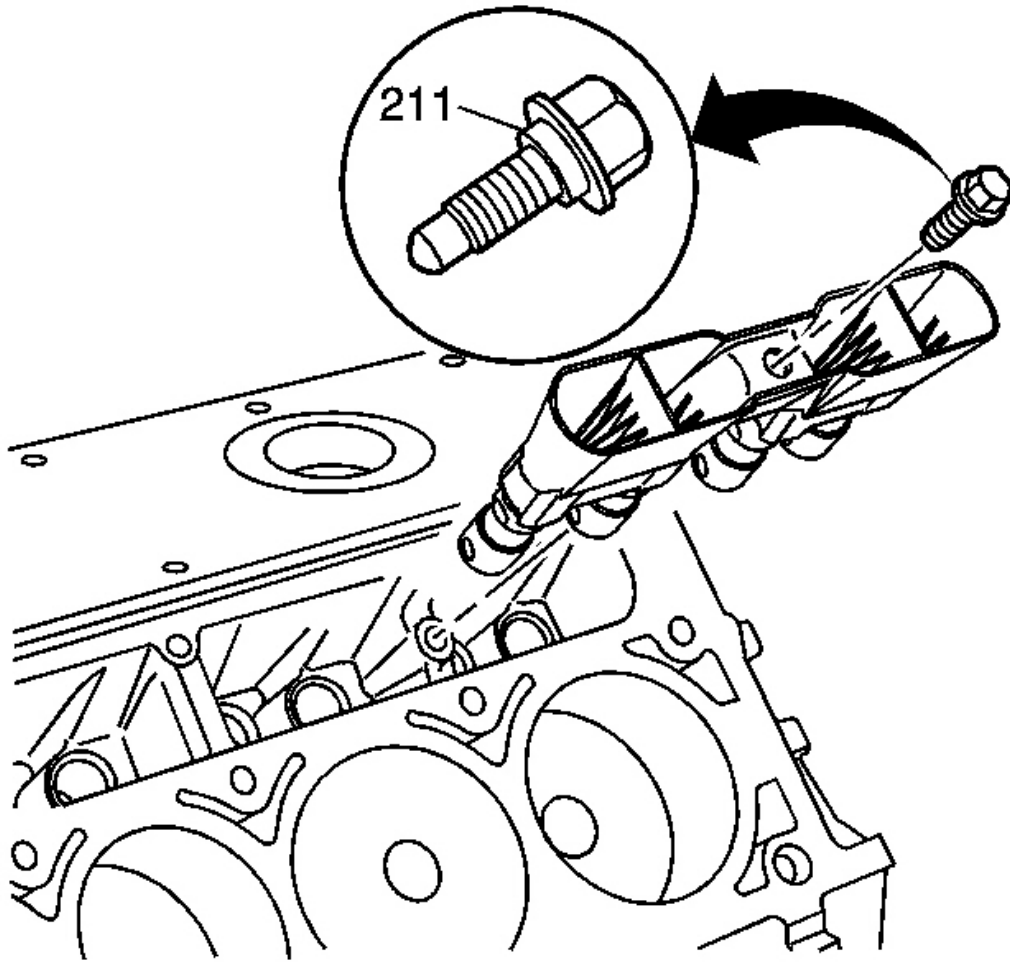


**Fig. 321: Cylinder Head Gasket (Right)**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the gasket.
5. Discard the gasket.
6. Discard the cylinder head bolts.

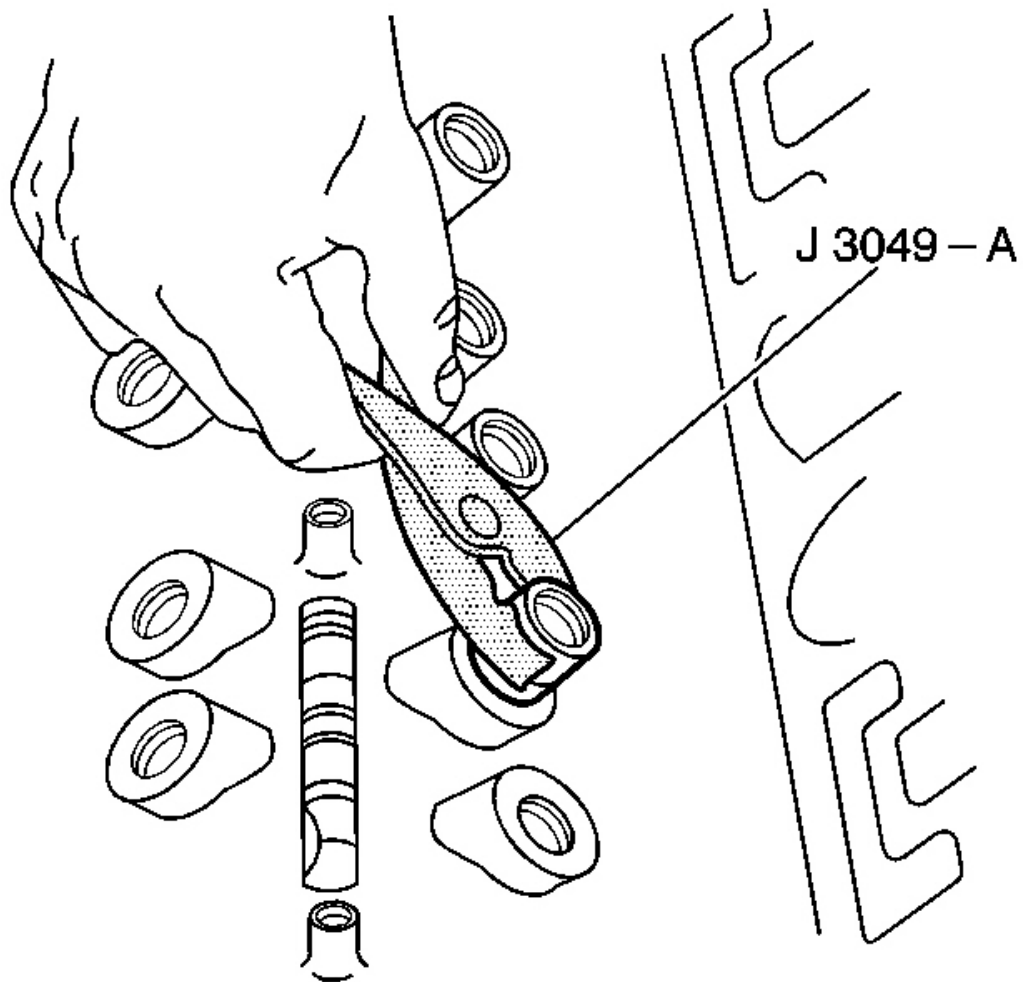
## **VALVE LIFTER REMOVAL**

**J 3049-A** Valve Lifter Remover. See **Special Tools and Equipment** .



**Fig. 322: Valve Lifters, Guide & Guide Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

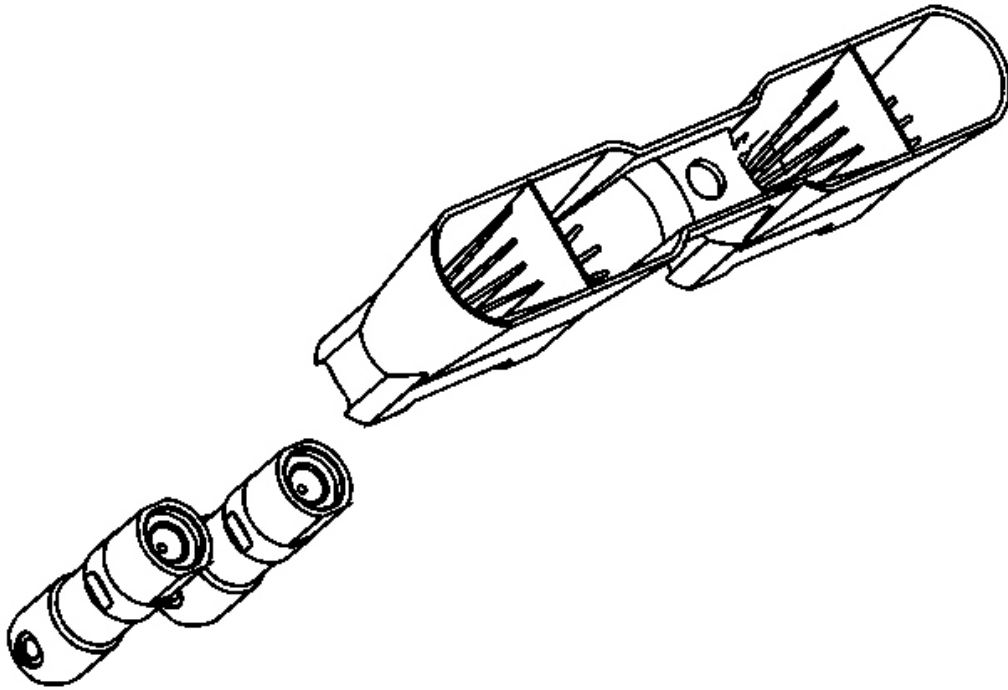
1. Remove the valve lifter guide bolts (211).
2. Remove the valve lifters and guide.



**Fig. 323: Using J 3049-A To Remove The Stuck Valve Lifters**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Some valve lifters may be stuck in their bores because of gum or varnish deposits.

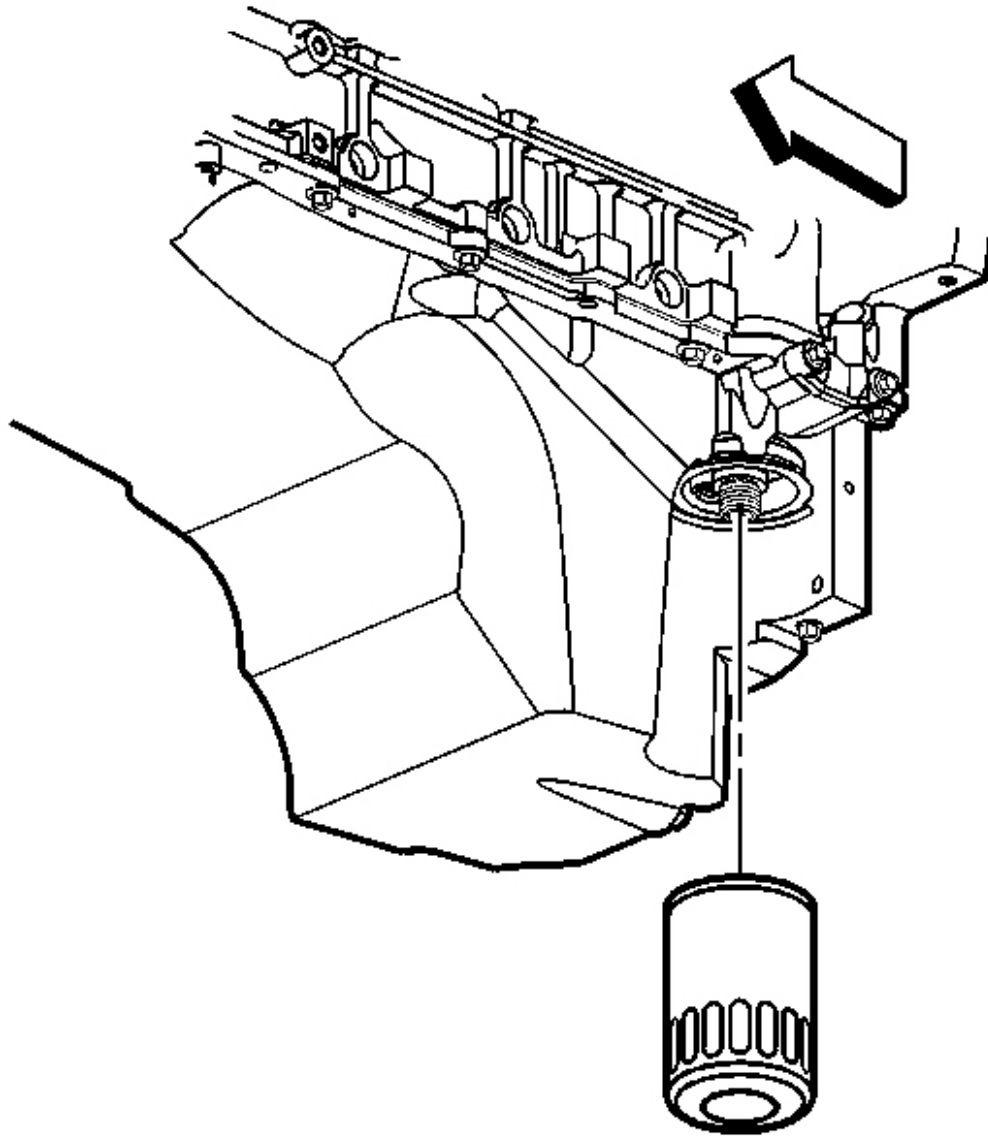
3. Use the **J 3049-A** or equivalent in order to remove the valve lifters, if required. See **Special Tools and Equipment** .



**Fig. 324: Valve Lifters & Lifter Guides**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve lifters from the guide.
5. Organize or mark the components so that they can be installed in the same location from which they were removed. Refer to **Separating Parts** .

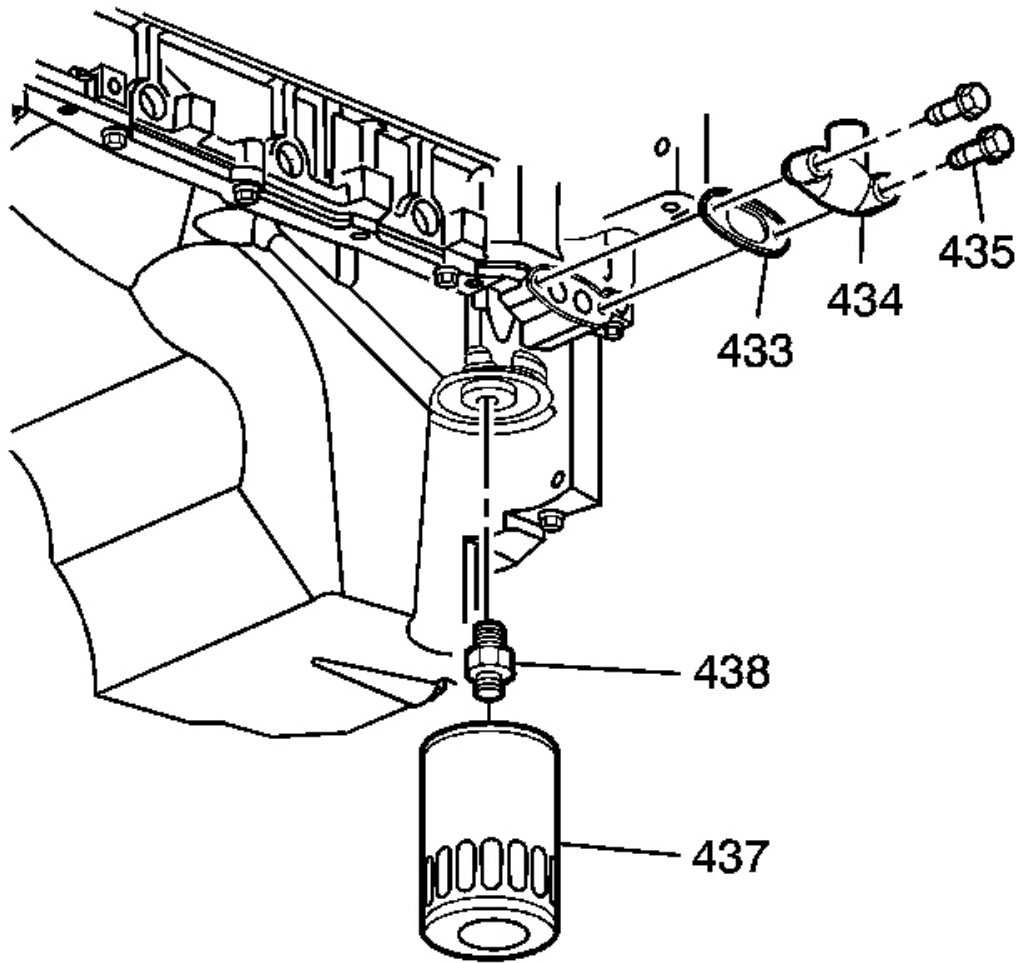
#### **OIL FILTER, ADAPTER AND PAN COVER REMOVAL**



**Fig. 325: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

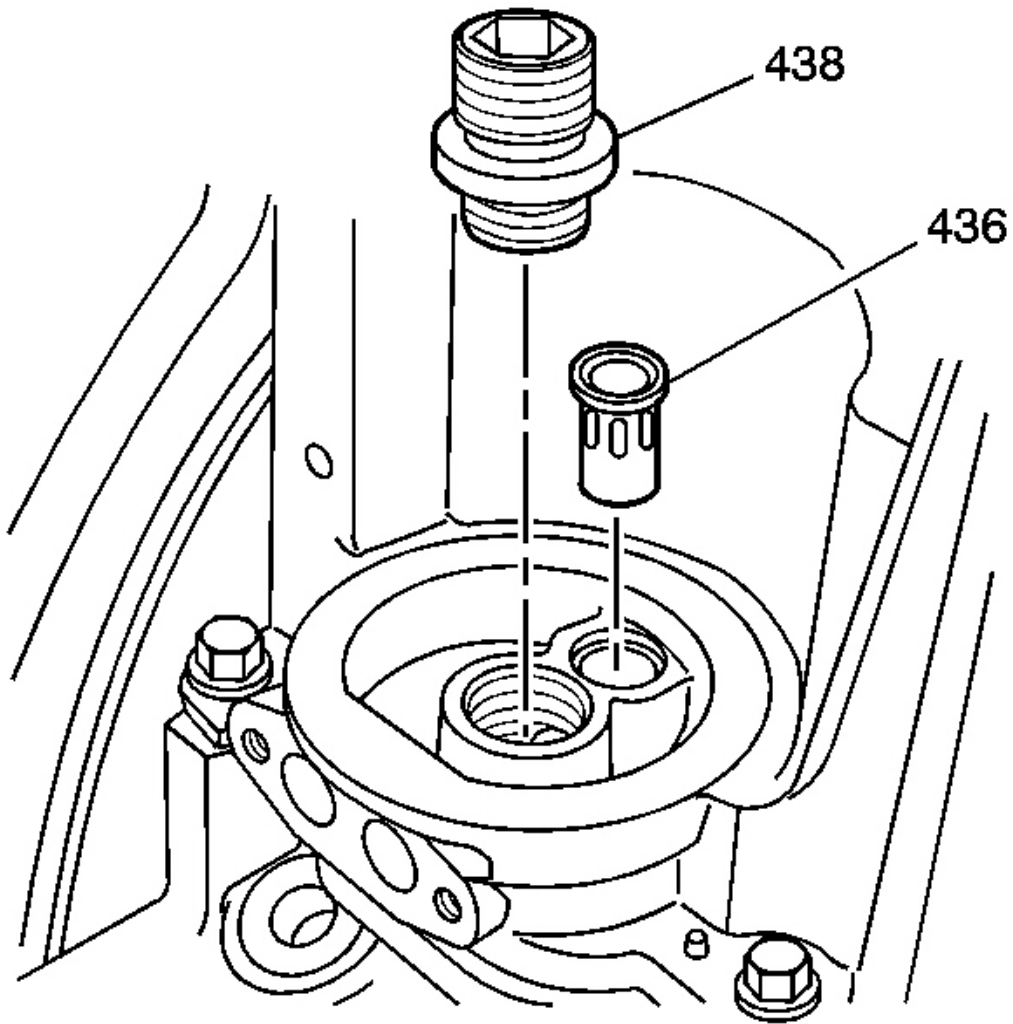
1. Remove the oil filter.





**Fig. 326: Oil Pan Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

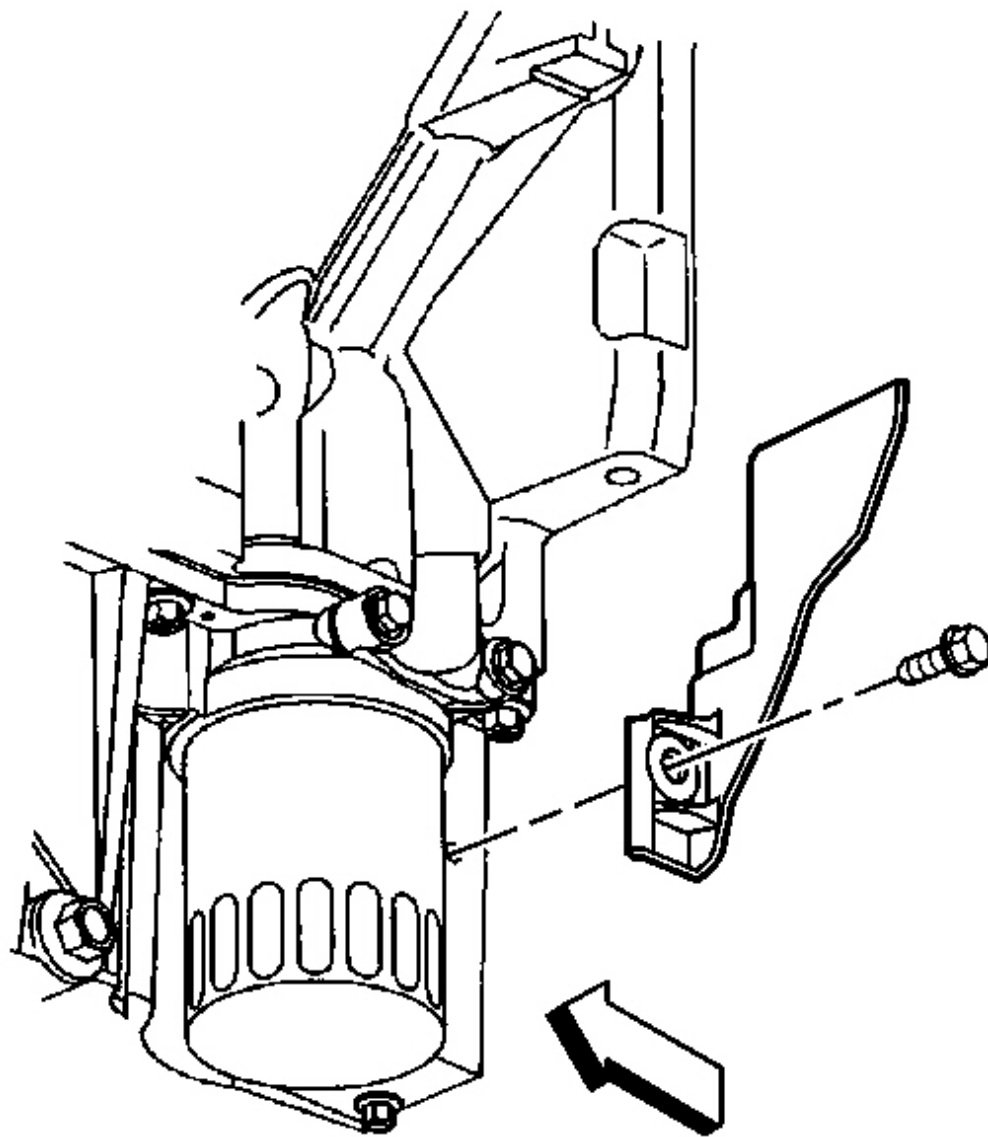
2. Remove the oil pan cover (434), bolts (435), and gasket (433).
3. Discard the gasket.



**Fig. 327: Oil Filter Fitting & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter fitting (438) and bypass valve (436), if required.

## **OIL PAN REMOVAL**



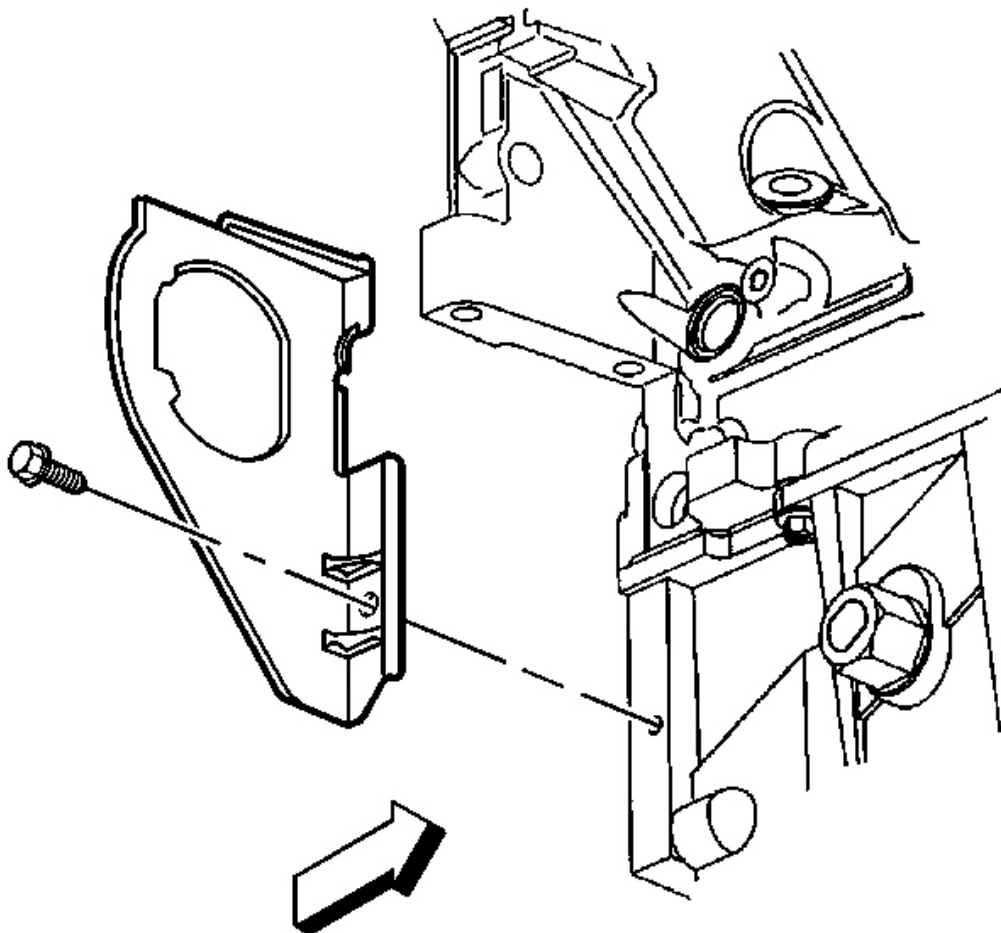
**Fig. 328: Left Closeout Cover & Bolt**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing a new gasket, it is not necessary to install new oil pan gasket rivets.

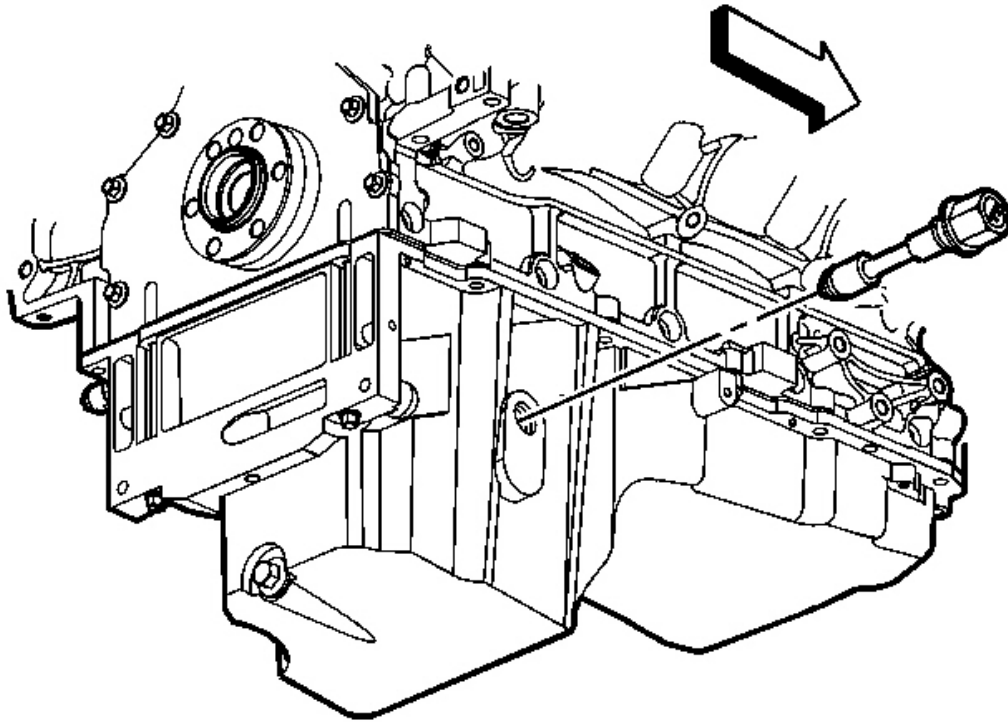
- **DO NOT** use the oil pan gasket again. When installing the oil pan, install a **NEW** oil pan gasket.
- It is not necessary to remove the oil level sensor prior to oil pan removal. Remove the oil level sensor if service is required.

1. Remove the left closeout cover and bolt.



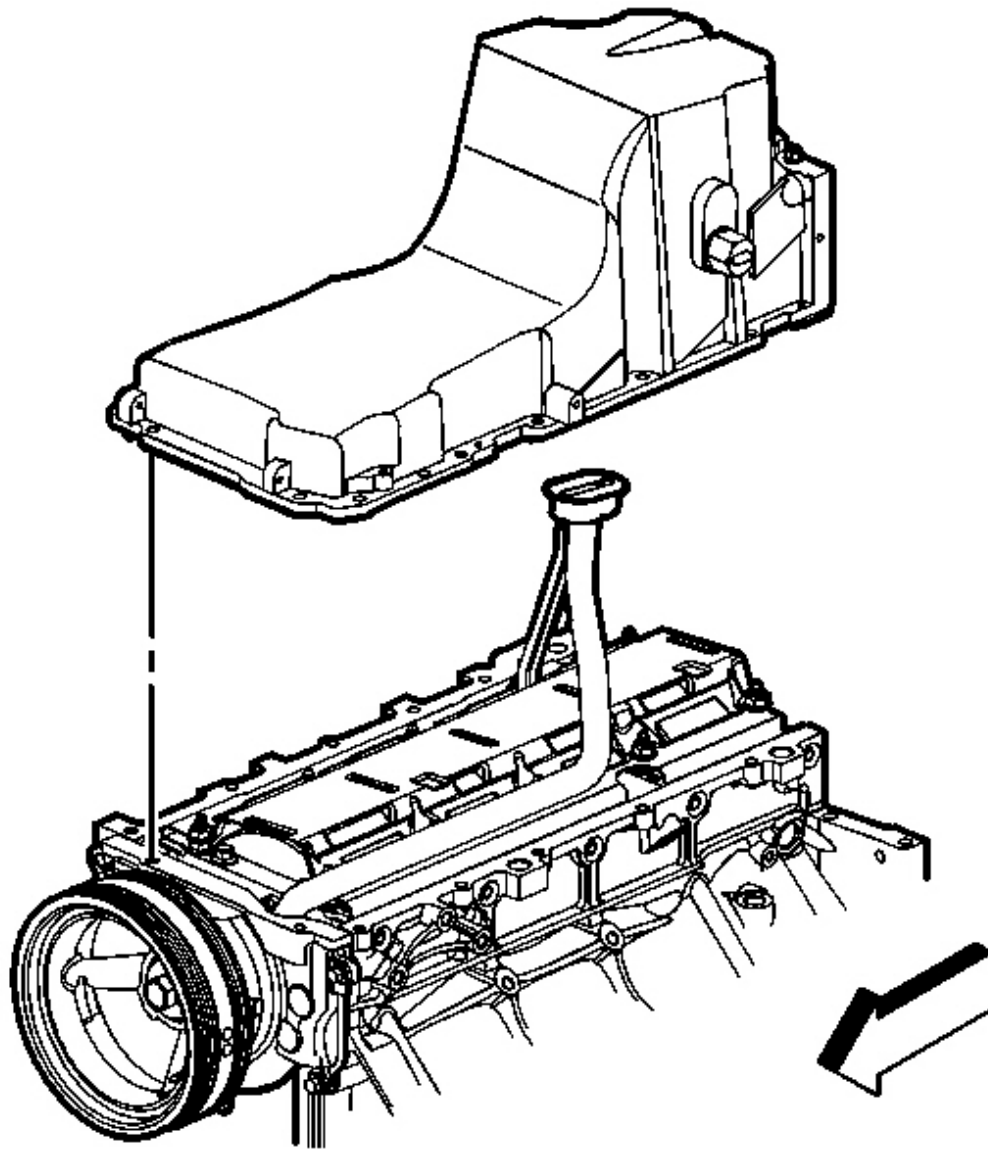
**Fig. 329: Right Closeout Cover & Bolt**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the right closeout cover and bolt.



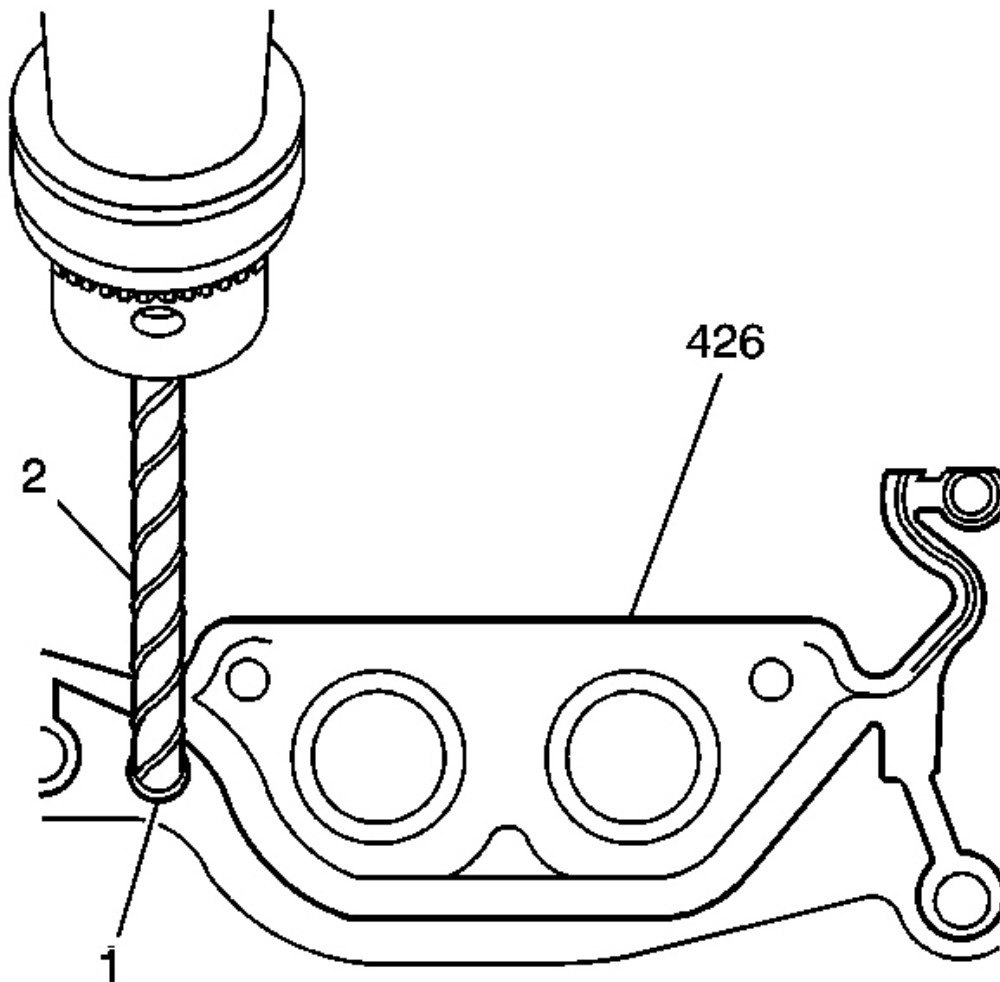
**Fig. 330: Oil Level Sensor**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level sensor from the oil pan, if required.



**Fig. 331: View Of Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan bolts.
5. Remove the oil pan.

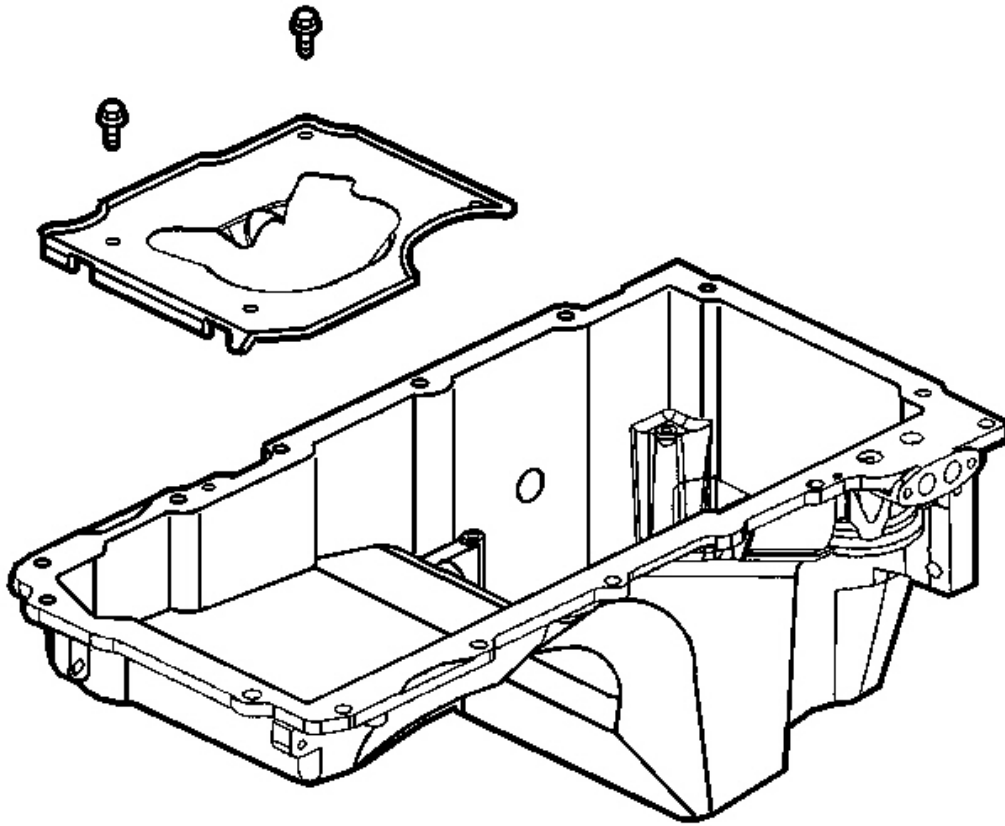


**Fig. 332: Drilling Out Oil Pan Gasket Retaining Rivets**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- **DO NOT** allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.
- Use care not to gouge, score, or damage the oil pan sealing surface.

6. Drill (2) out the oil pan gasket retaining rivets (1), if required.
7. Remove the gasket (426) from the pan.
8. Discard the gasket and rivets.

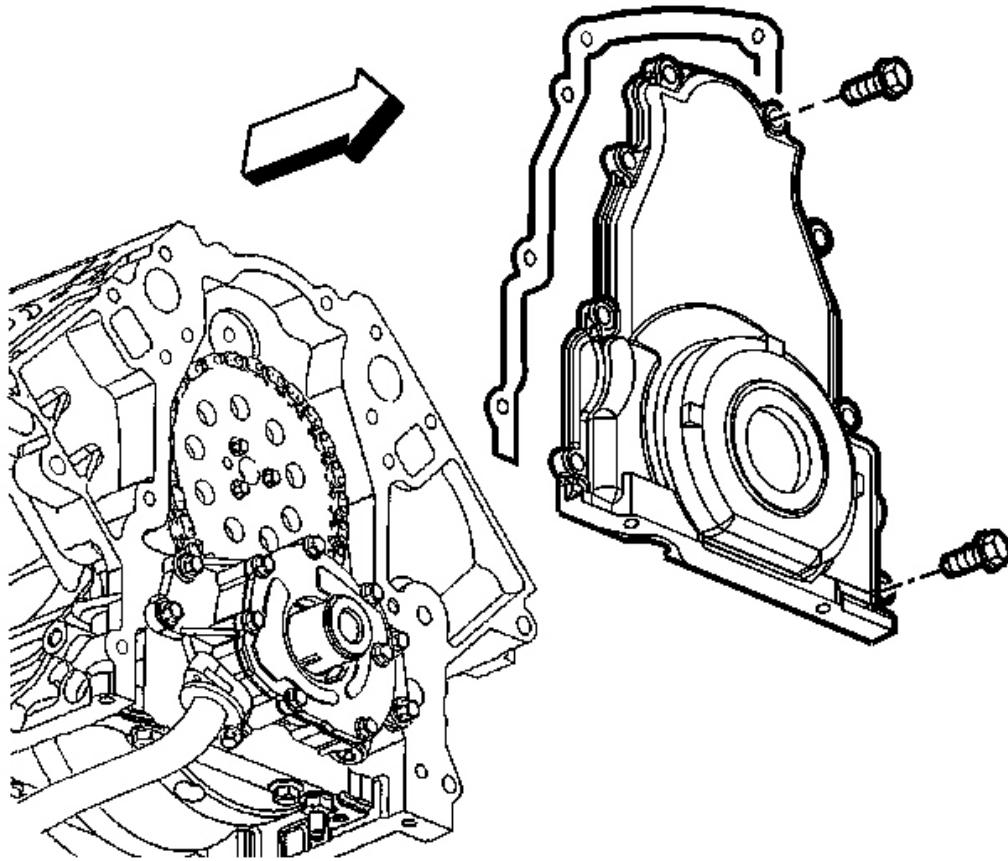


**Fig. 333: Oil Pan Baffle & Bolts**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pan baffle bolts and baffle, if required.

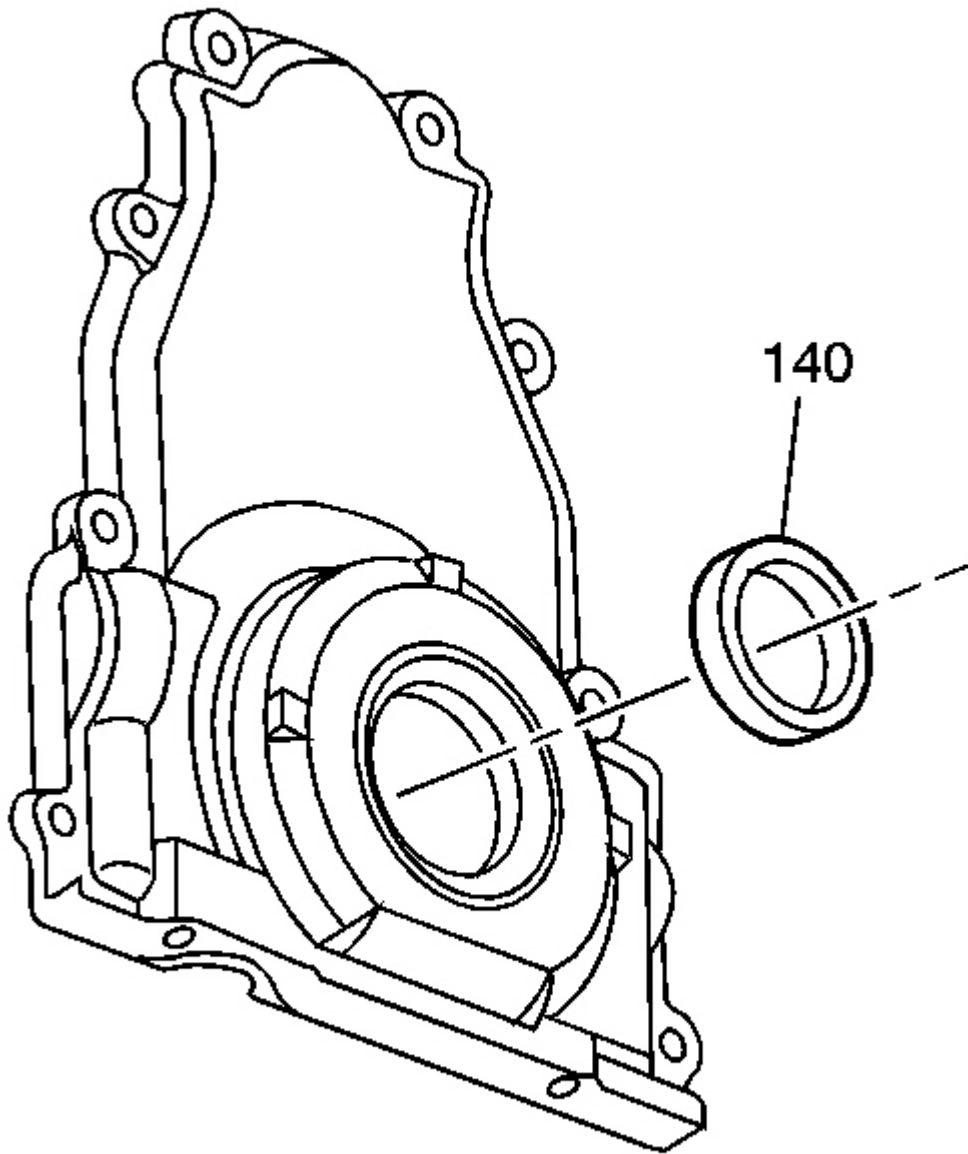
#### **ENGINE FRONT COVER REMOVAL**





**Fig. 334: Front Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

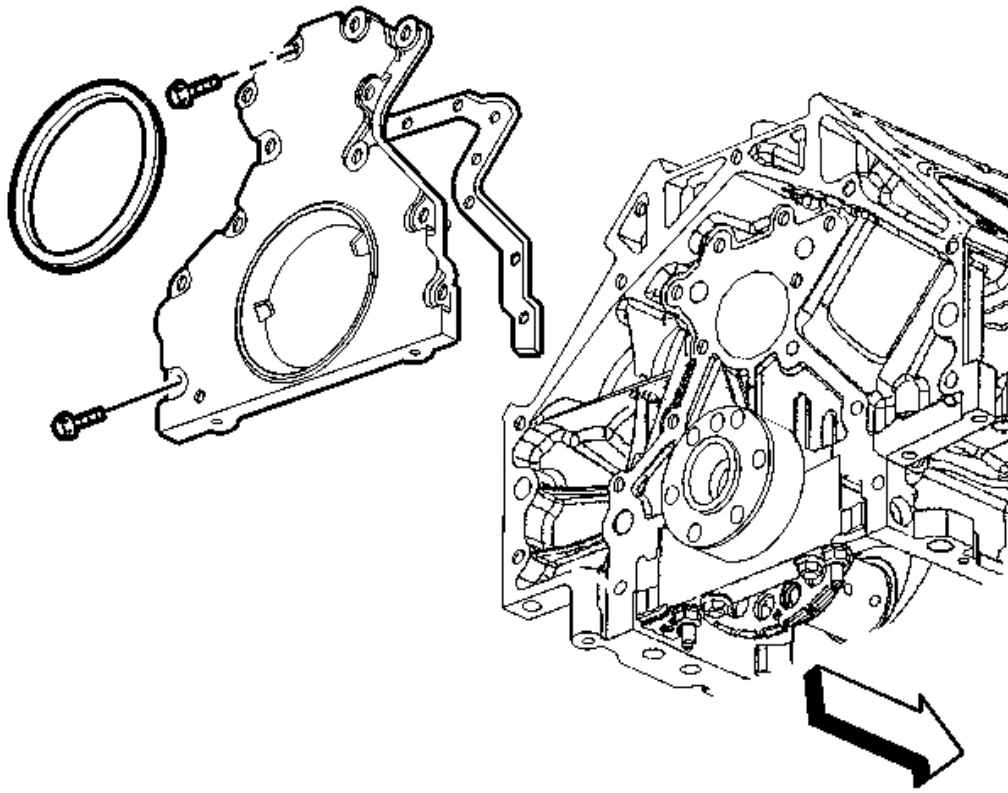
1. Remove the front cover bolts.
2. Remove the front cover and gasket.
3. Discard the front cover gasket.



**Fig. 335: Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

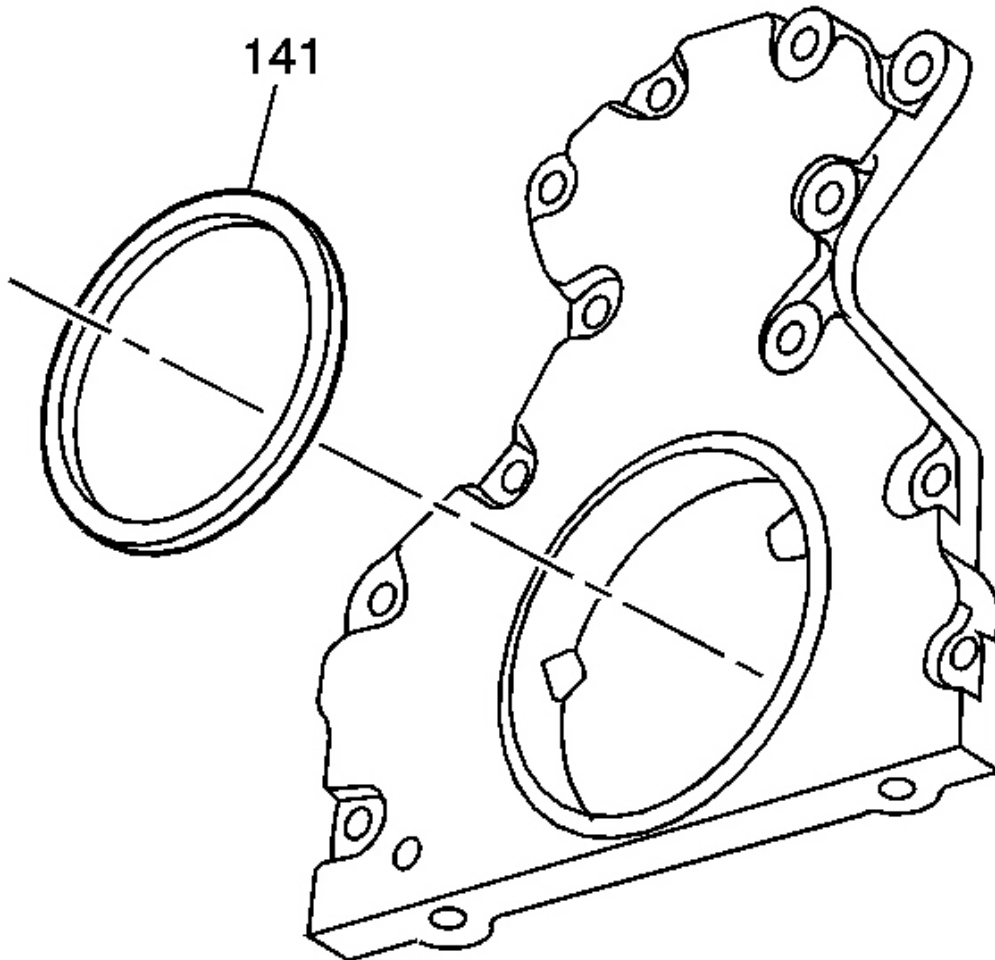
4. Remove the crankshaft front oil seal (140) from the cover.

#### **ENGINE REAR COVER REMOVAL**



**Fig. 336: Rear Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

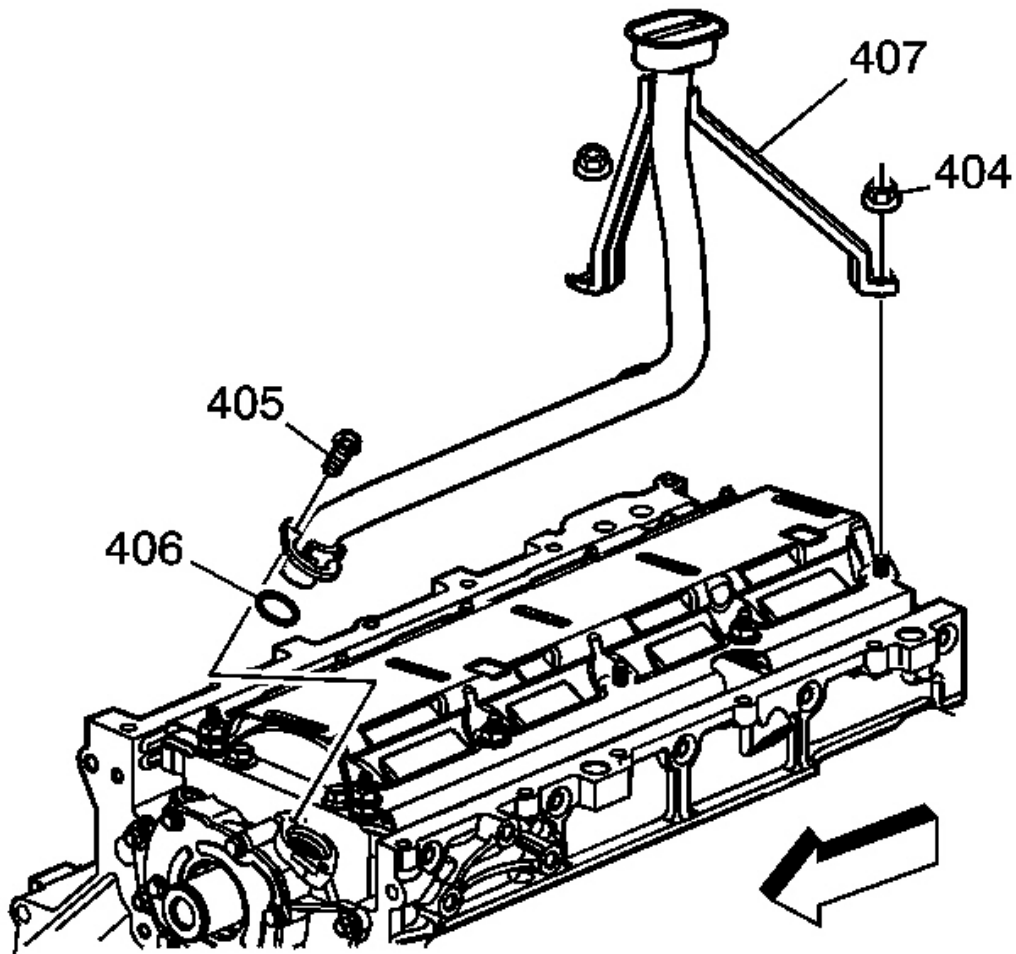
1. Remove the rear cover bolts.
2. Remove the rear cover and gasket.
3. Discard the rear cover gasket.



**Fig. 337: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

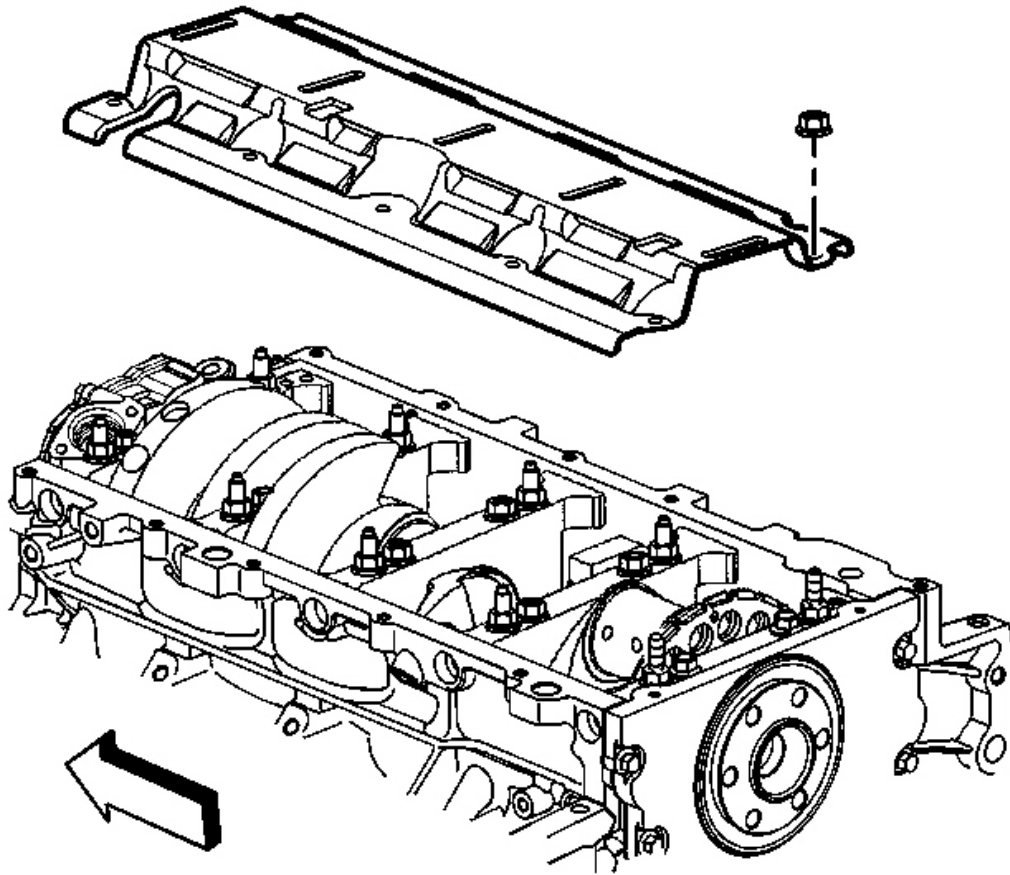
4. Remove the crankshaft rear oil seal (141) from the cover.

#### **OIL PUMP, PUMP SCREEN AND DEFLECTOR REMOVAL**



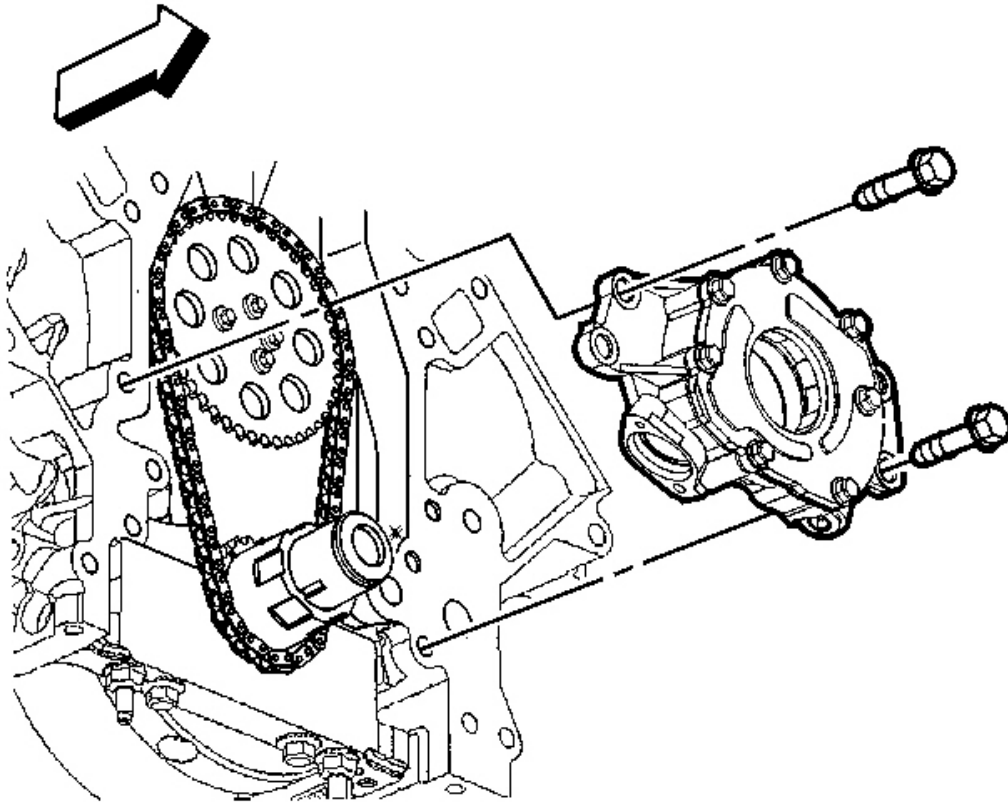
**Fig. 338: Oil Pump Screen, Bolt, Nuts & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump screen bolt (405) and nuts (404).
2. Remove the oil pump screen (407) with O-ring seal (406).
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.



**Fig. 339: Crankshaft Oil Deflector**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the remaining crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.



**Fig. 340: Oil Pump & Bolt**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pump bolts.

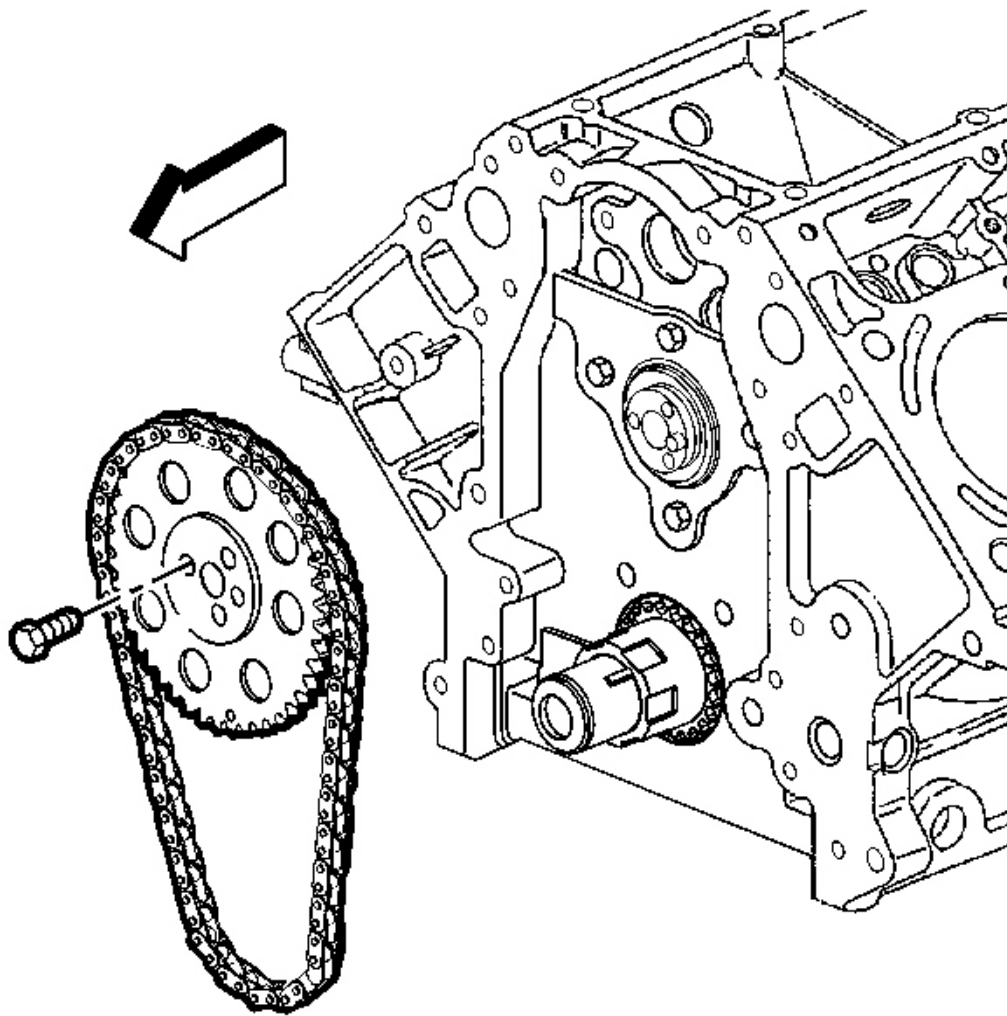
**IMPORTANT: Do not allow dirt or debris to enter the oil pump assembly, cap ends as necessary.**

8. Remove the oil pump.

## **TIMING CHAIN AND SPROCKETS REMOVAL**

### **Tools Required**

- **J 8433-1** Puller Bar. See **Special Tools and Equipment** .
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools and Equipment** .
- **J 41816-2** Crankshaft End Protector

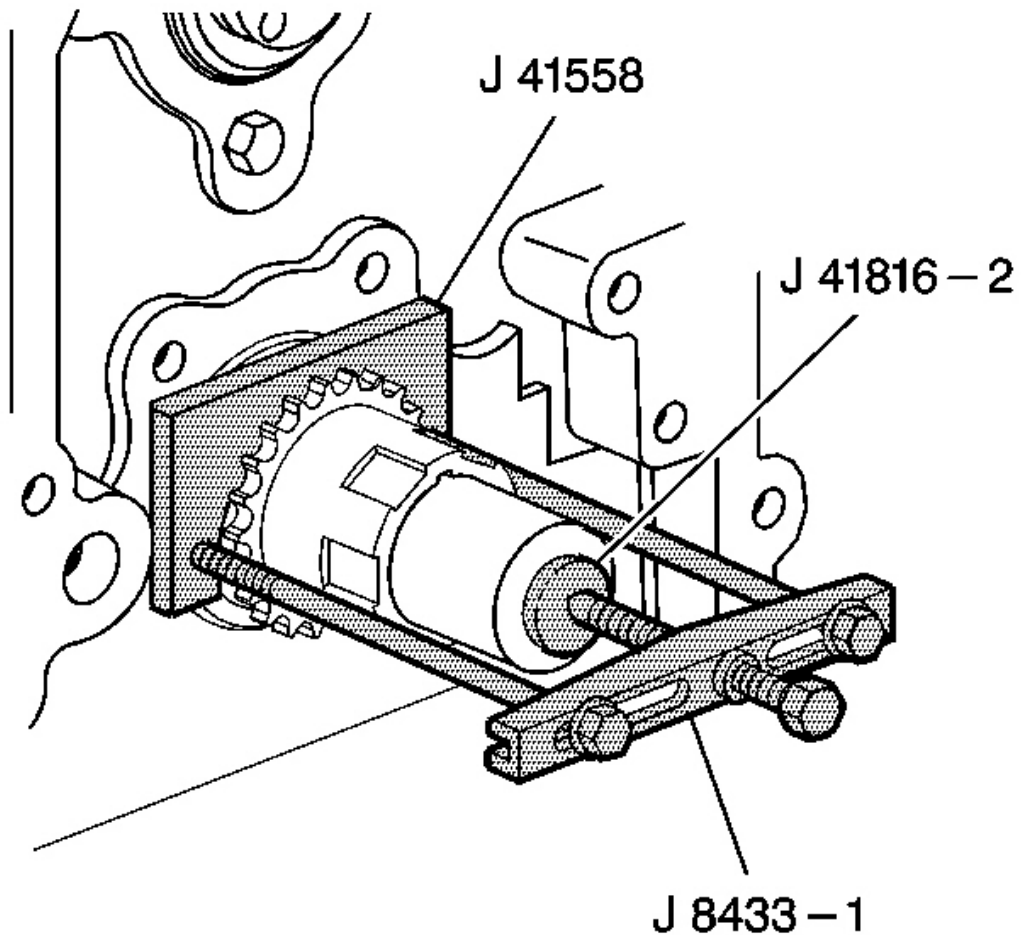


**Fig. 341: Camshaft Sprocket, Bolt & Timing Chain**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

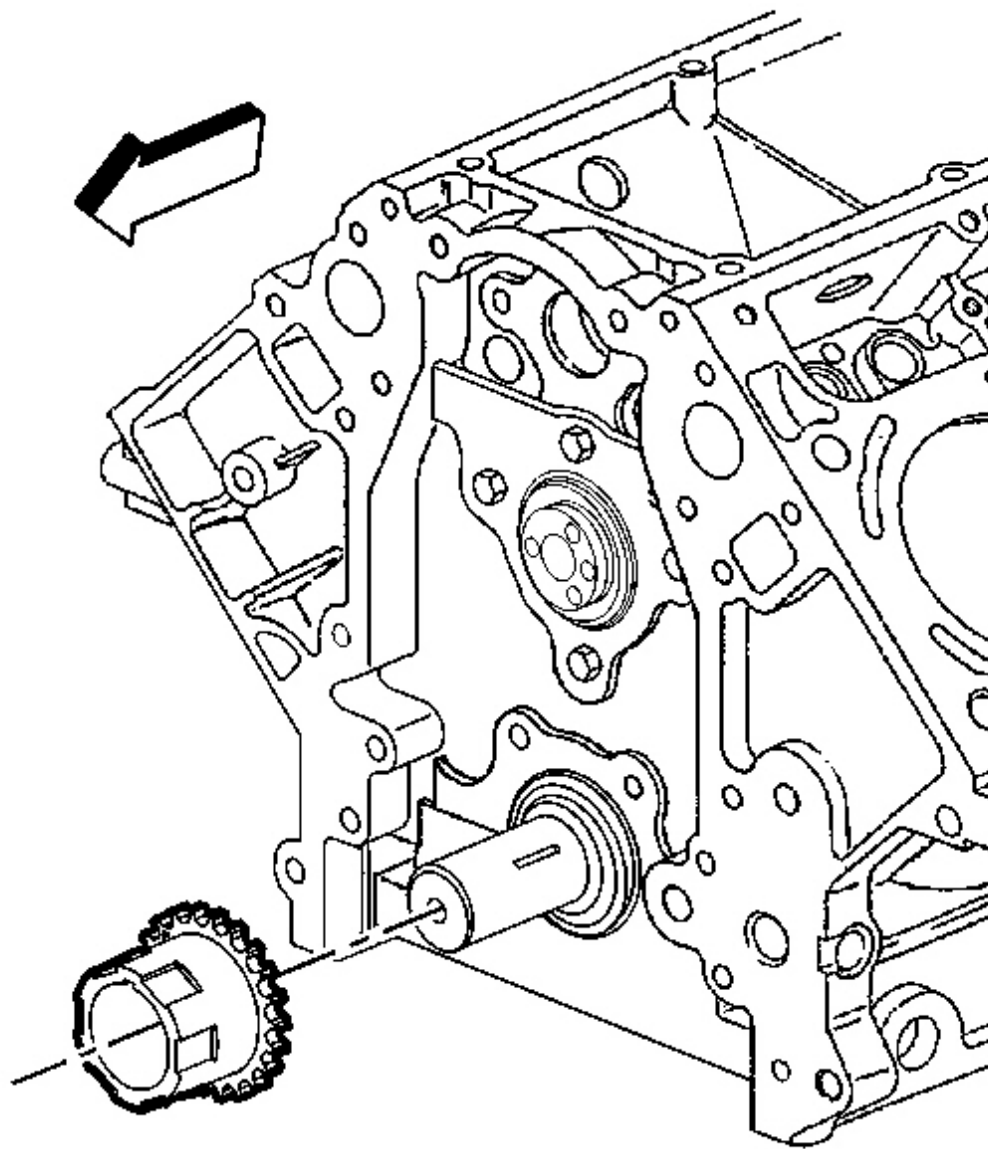
1. Remove the camshaft sprocket bolts.
2. Remove the camshaft sprocket and timing chain.





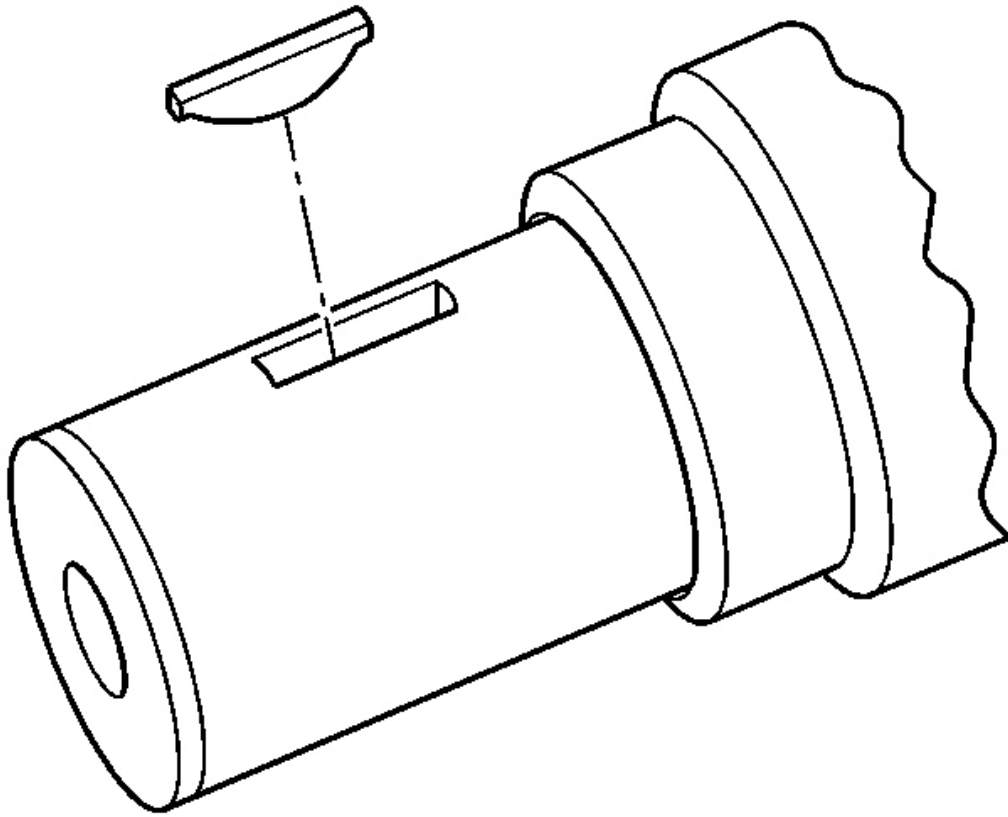
**Fig. 342: View Of J 8433-1, J 41816-2 & J 41558**  
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 8433-1** , the **J 41816-2** , and the **J 41558** in order to remove the crankshaft sprocket. See **Special Tools and Equipment** .



**Fig. 343: Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

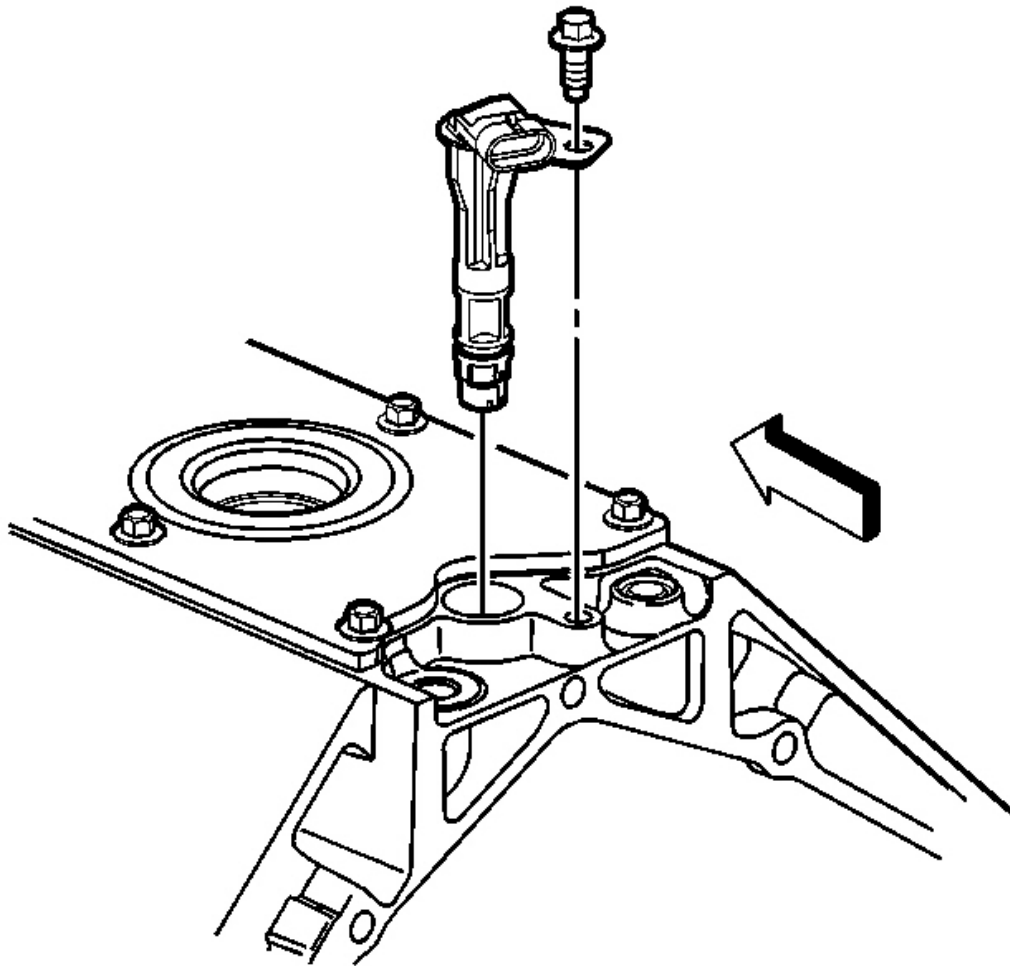
4. Remove the crankshaft sprocket.



**Fig. 344: Crankshaft Sprocket Key**  
Courtesy of GENERAL MOTORS CORP.

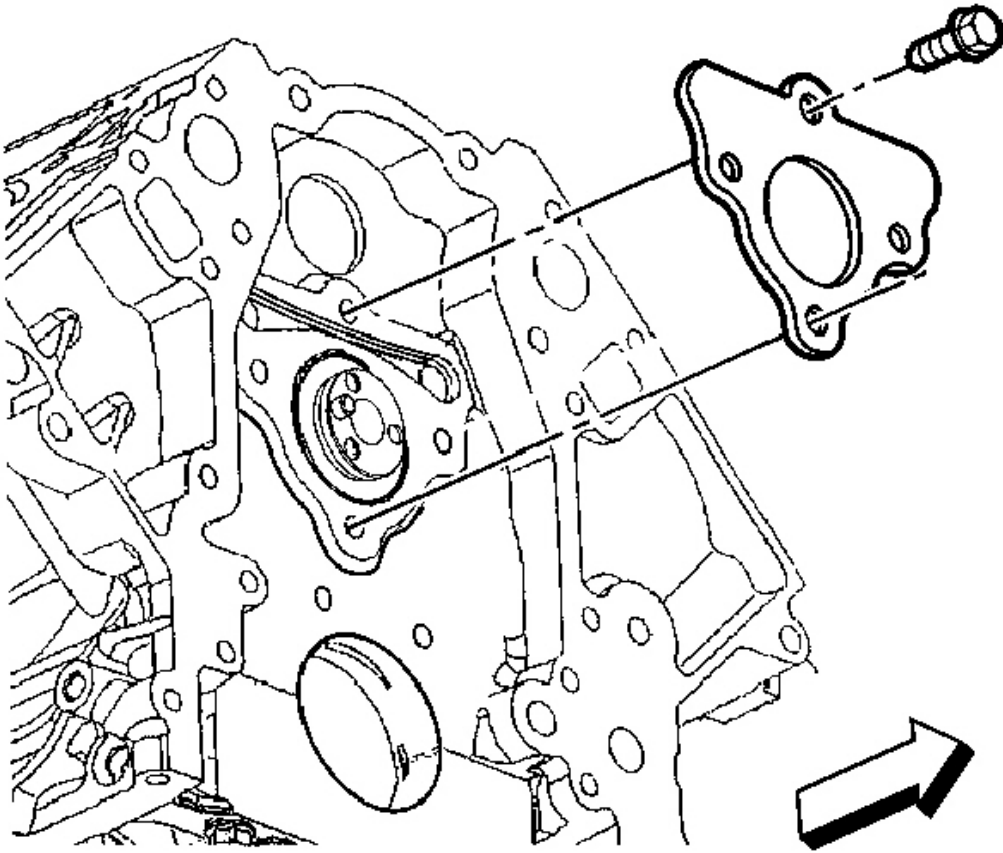
5. Remove the crankshaft sprocket key, if required.

## **CAMSHAFT REMOVAL**



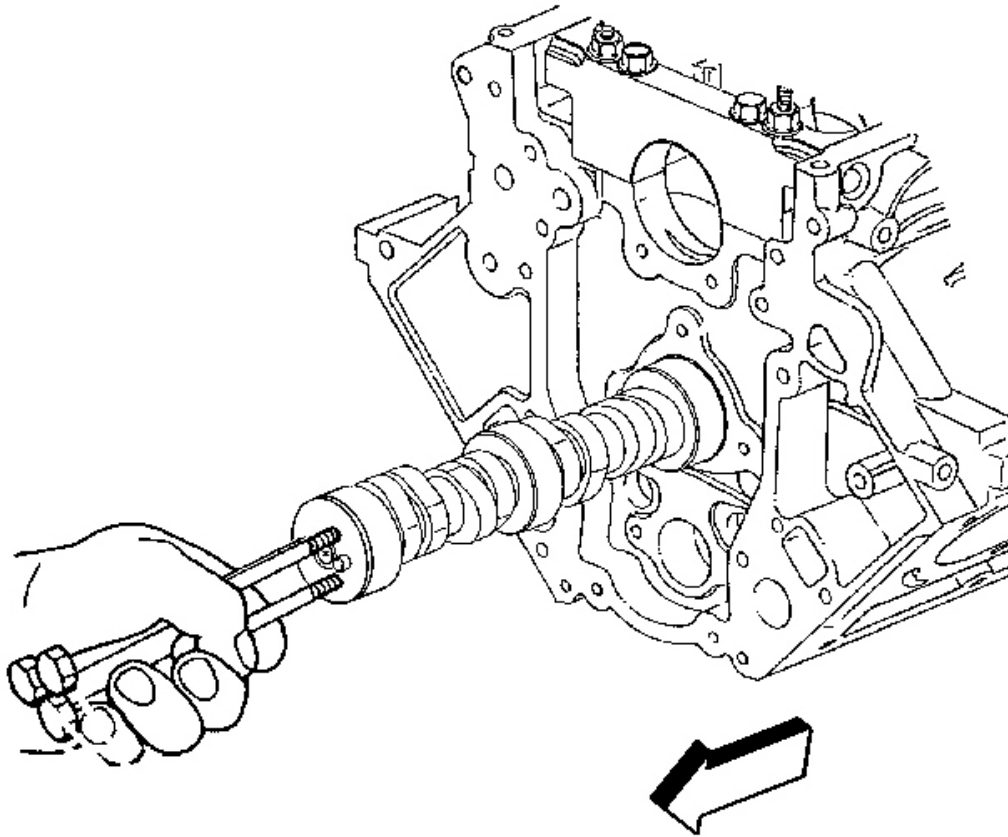
**Fig. 345: Camshaft Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position (CMP) sensor bolt and the sensor.



**Fig. 346: Camshaft Retainer & Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

2. Remove the camshaft retainer bolts and the retainer.



**Fig. 347: Camshaft Front Bolt Holes**  
Courtesy of GENERAL MOTORS CORP.

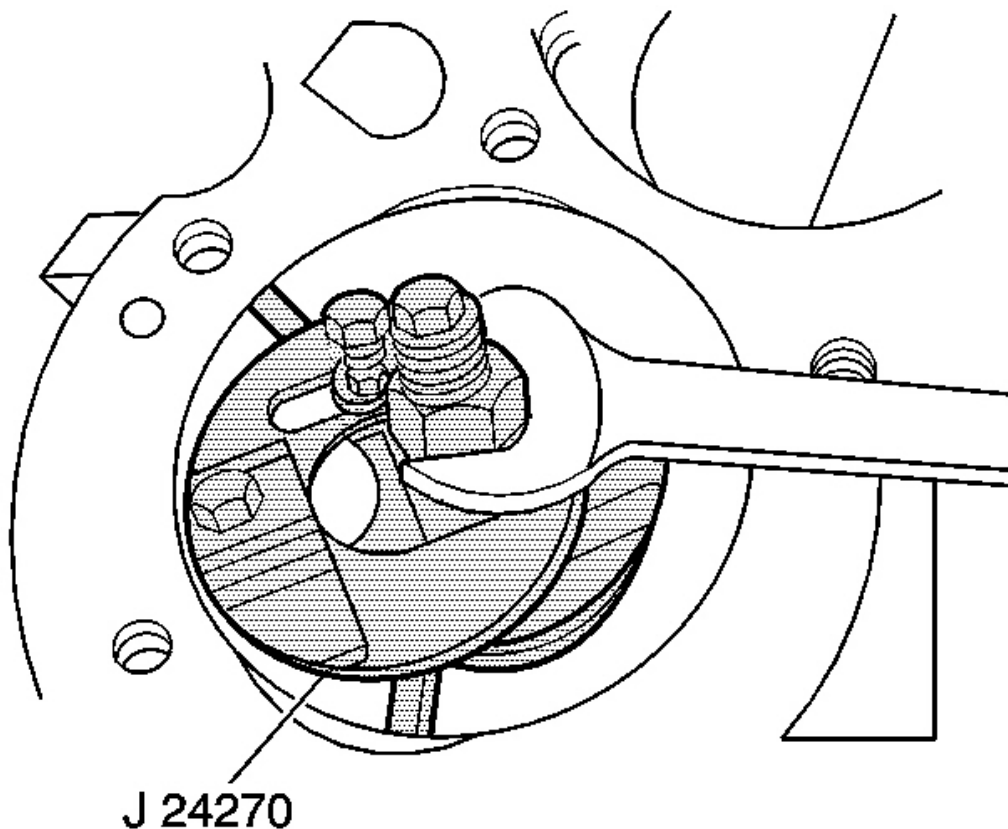
**NOTE:** All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Remove the camshaft.
  1. Install the 3 M8 - 1.25 x 100 mm bolts in the camshaft front bolt holes.
  2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
  3. Remove the bolts from the front of the camshaft.

## **PISTON, CONNECTING ROD, AND BEARING REMOVAL**

### **Tools Required**

- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools and Equipment** .
- **J 41556** Connecting Rod Guide. See **Special Tools and Equipment** .

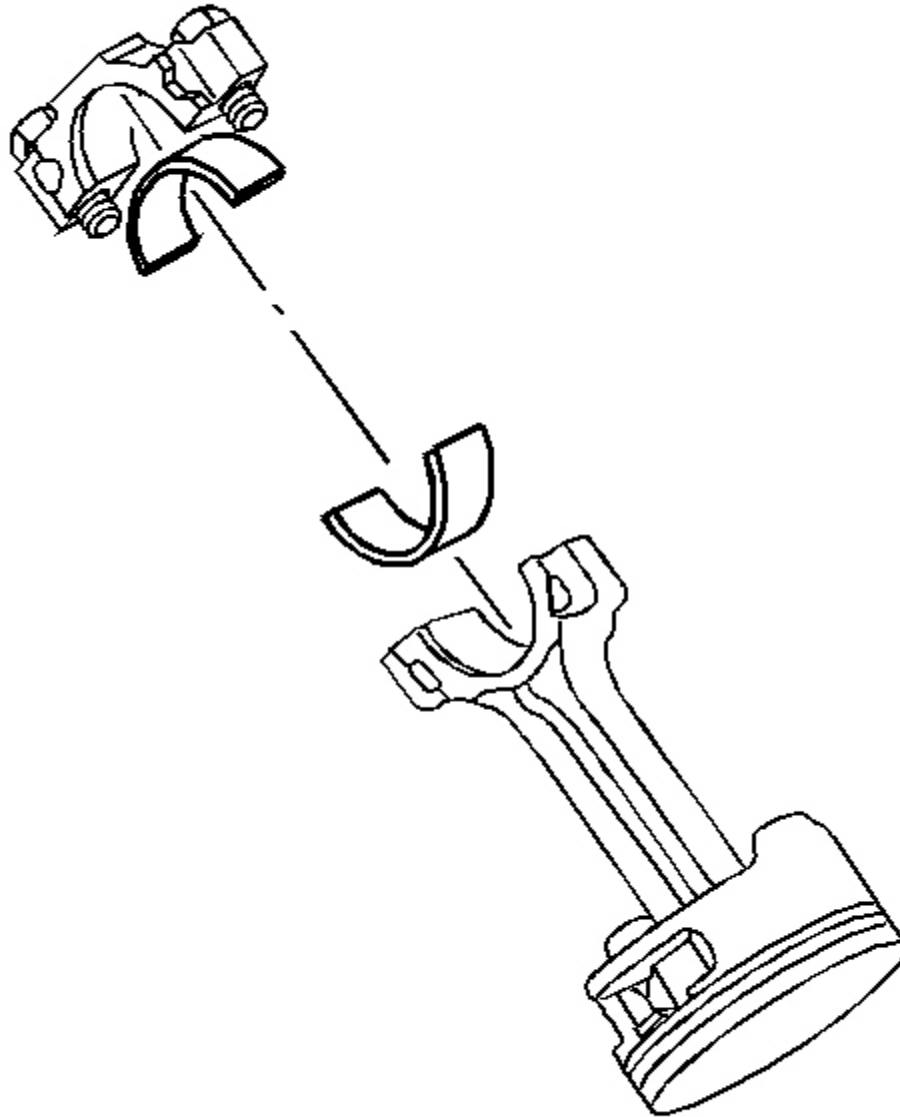


**Fig. 348: Removing Cylinder Ridge Using J 24270**  
 Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: The connecting rods and the bearing caps are NOT interchangeable.**

1. Use the **J 24270** in order to remove the cylinder bore ring ridge, if required. See **Special Tools and Equipment** .
  1. Turn the crankshaft until the piston is at the bottom of the stroke.
  2. Place a cloth on top of the piston.
  3. Use the **J 24270** or equivalent in order to remove a cylinder ring ridge. See **Special Tools and Equipment** .
  4. Turn the crankshaft so the piston is at the top of the stroke.

5. Remove the cloth.
6. Remove the cutting debris from the cylinder and piston.



**Fig. 349: Connecting Rod & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

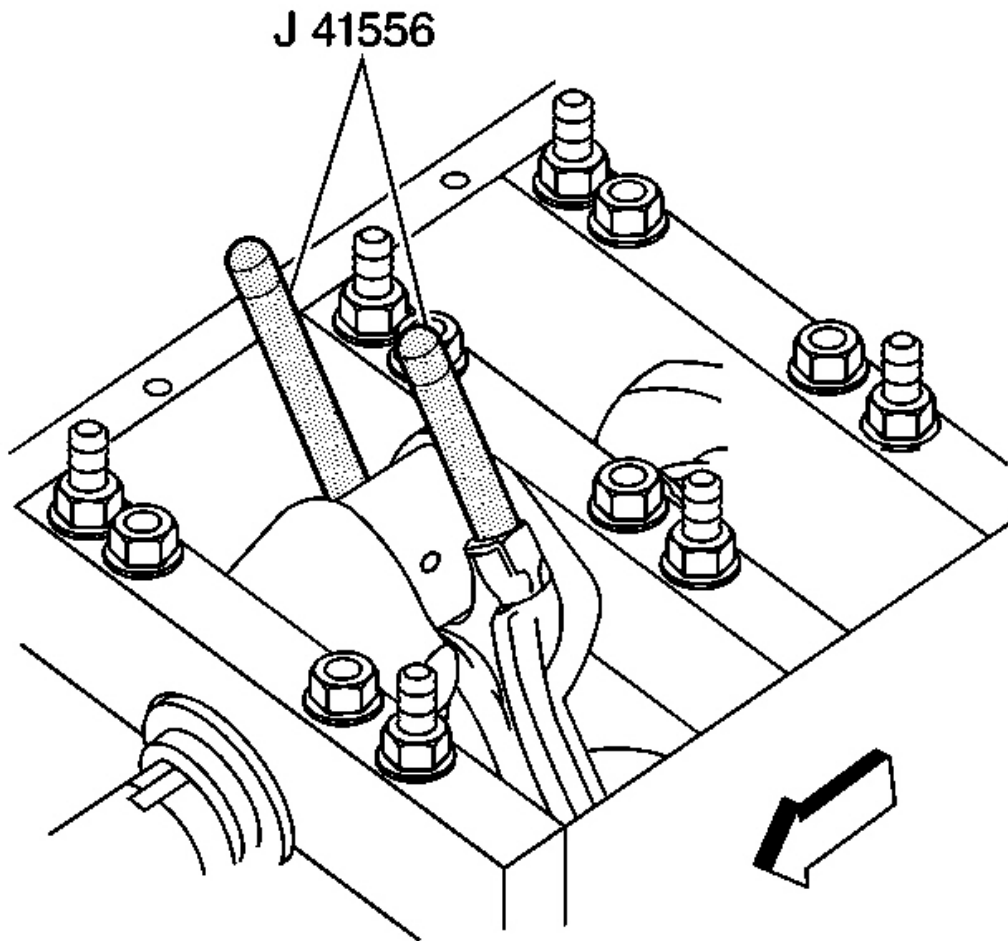


- Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps **MUST** be assembled to their original position and direction.
- A stamping mark on the side of the connecting rod, at the crank journal, may affect component geometry.
- Mark the top of the piston to the specific cylinder bore.

2. Remove the connecting rod bolts.

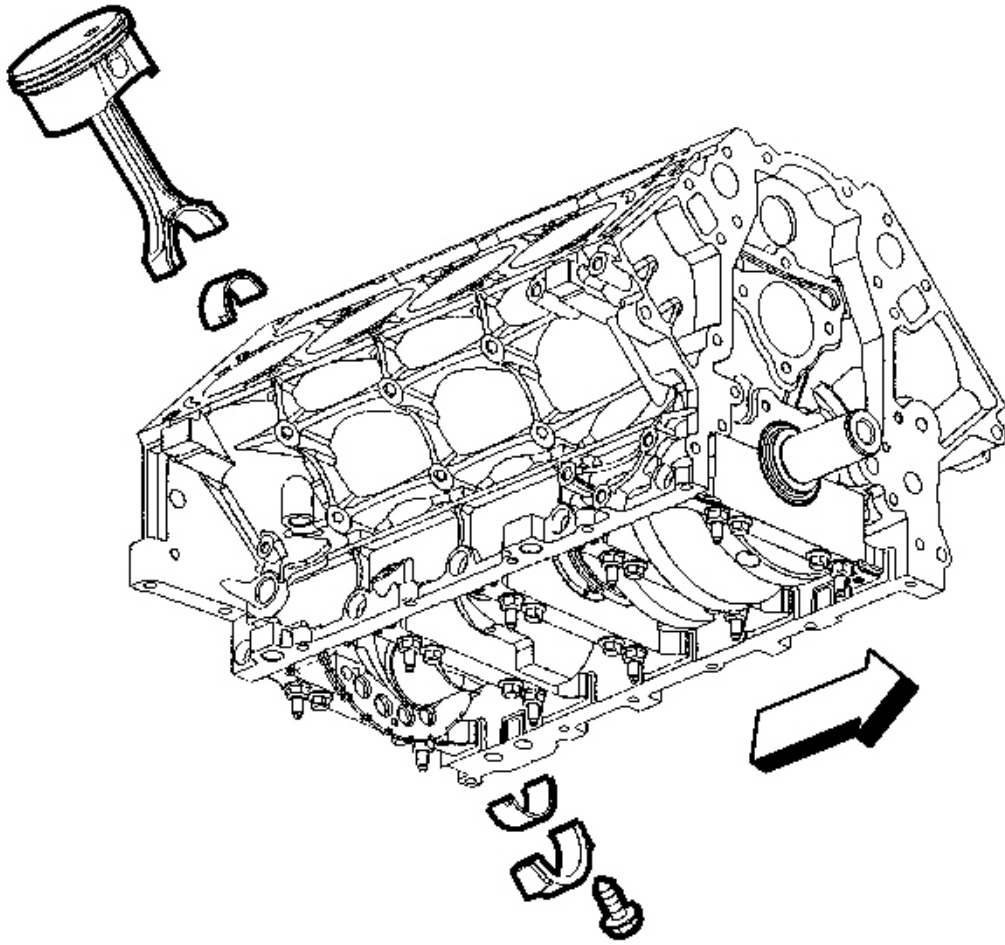
**IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location.**

3. Remove the connecting rod cap. Refer to Separating Parts .



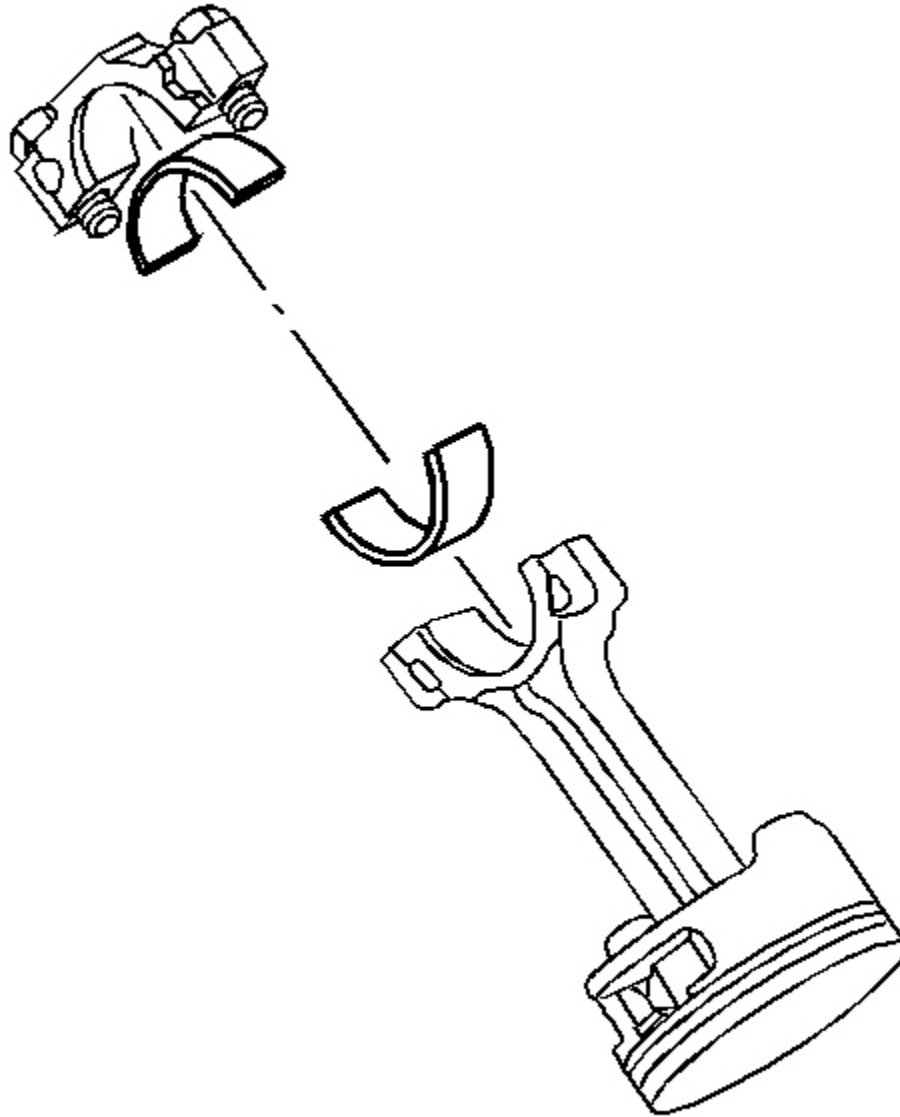
**Fig. 350: View Of J 41556**  
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod. See **Special Tools and Equipment** .



**Fig. 351: Piston & Connecting Rod Assembly**  
Courtesy of GENERAL MOTORS CORP.

5. Use a hammer and tap lightly on the end of the **J 41556** in order to remove the piston and connecting rod assembly from the cylinder bore. See **Special Tools and Equipment** .



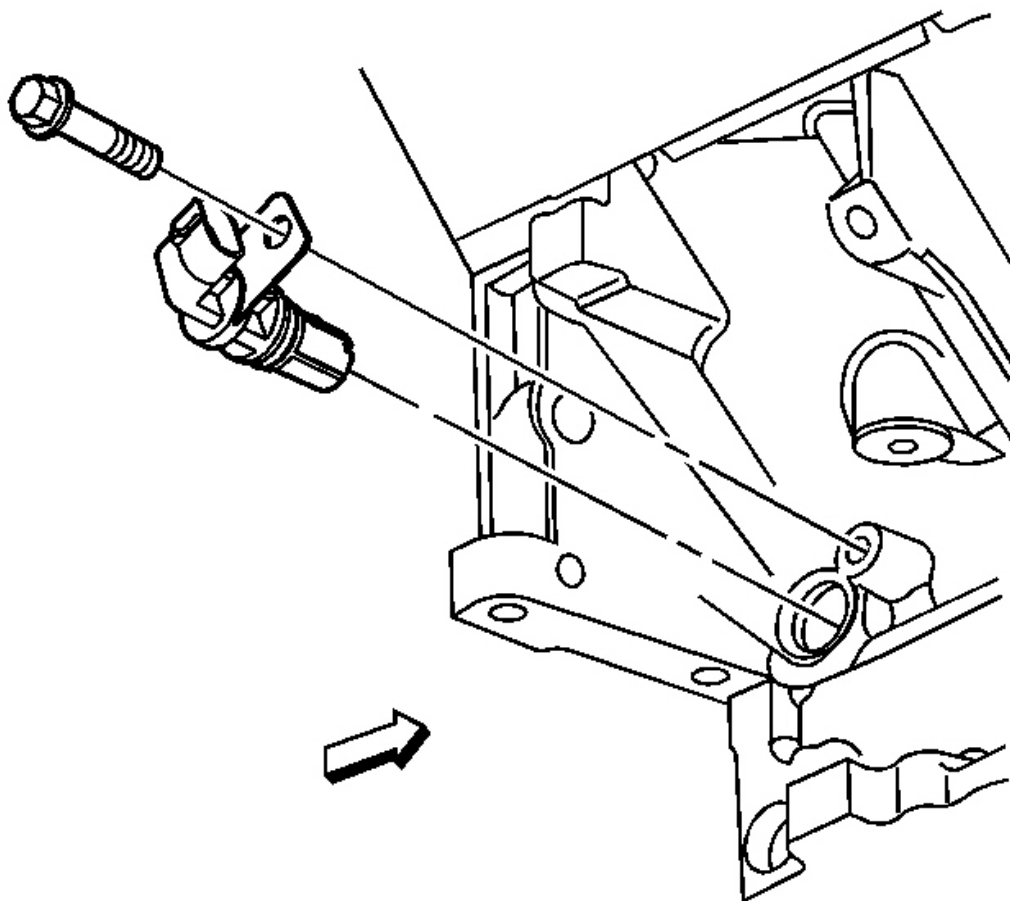
**Fig. 352: Connecting Rod & Bolts**  
Courtesy of GENERAL MOTORS CORP.

6. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

## **CRANKSHAFT AND BEARINGS REMOVAL**

## Tools Required

- **J 6125-1B** Slide Hammer. See **Special Tools and Equipment** .
- **J 41818** Crankshaft Bearing Cap Remover

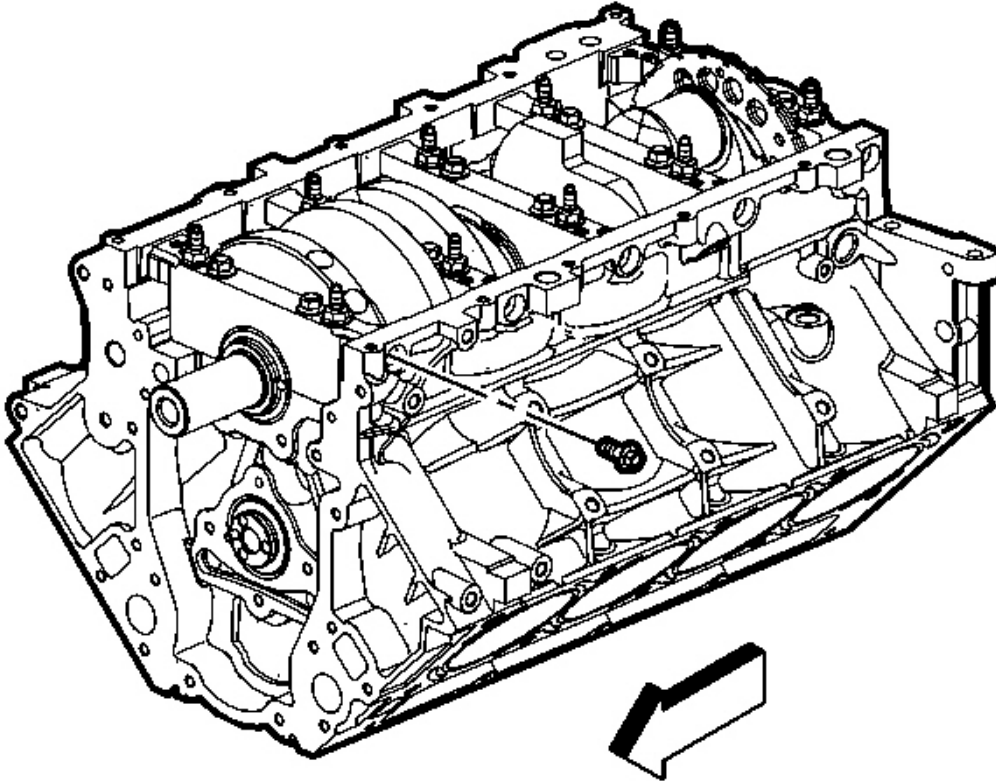


**Fig. 353: CKP Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.

### **IMPORTANT:**

- The crankshaft bearing caps are machined with the engine block, for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps **MUST** be installed to their original position and direction.
- Do not use the bearing cap M8 side bolts again.
- Remove the bearing cap M8 side bolts prior to cap removal.

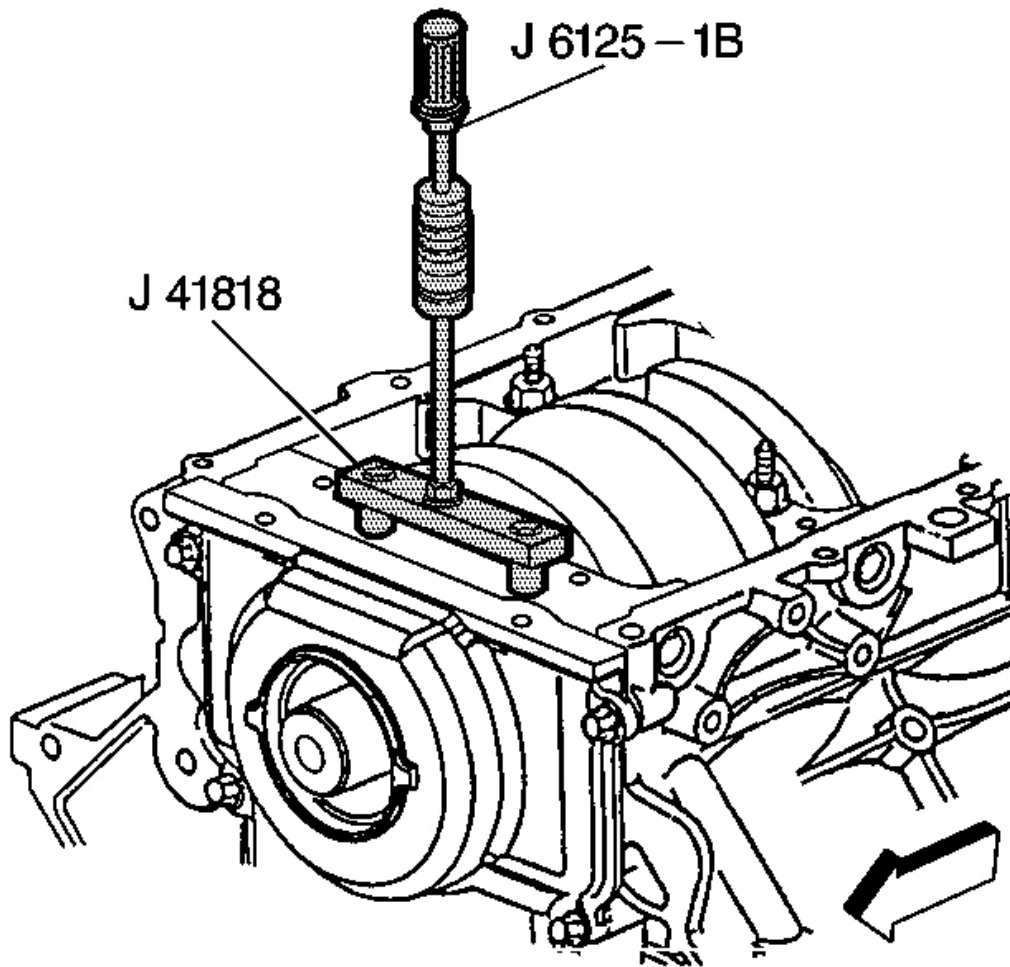
1. Remove the crankshaft position (CKP) sensor bolt.
2. Remove the CKP sensor.



**Fig. 354: Bearing Cap Bolts & Studs**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing cap M8 bolts.
4. Remove the bearing cap M10 bolts and studs.

Note the M10 bolt/stud locations.



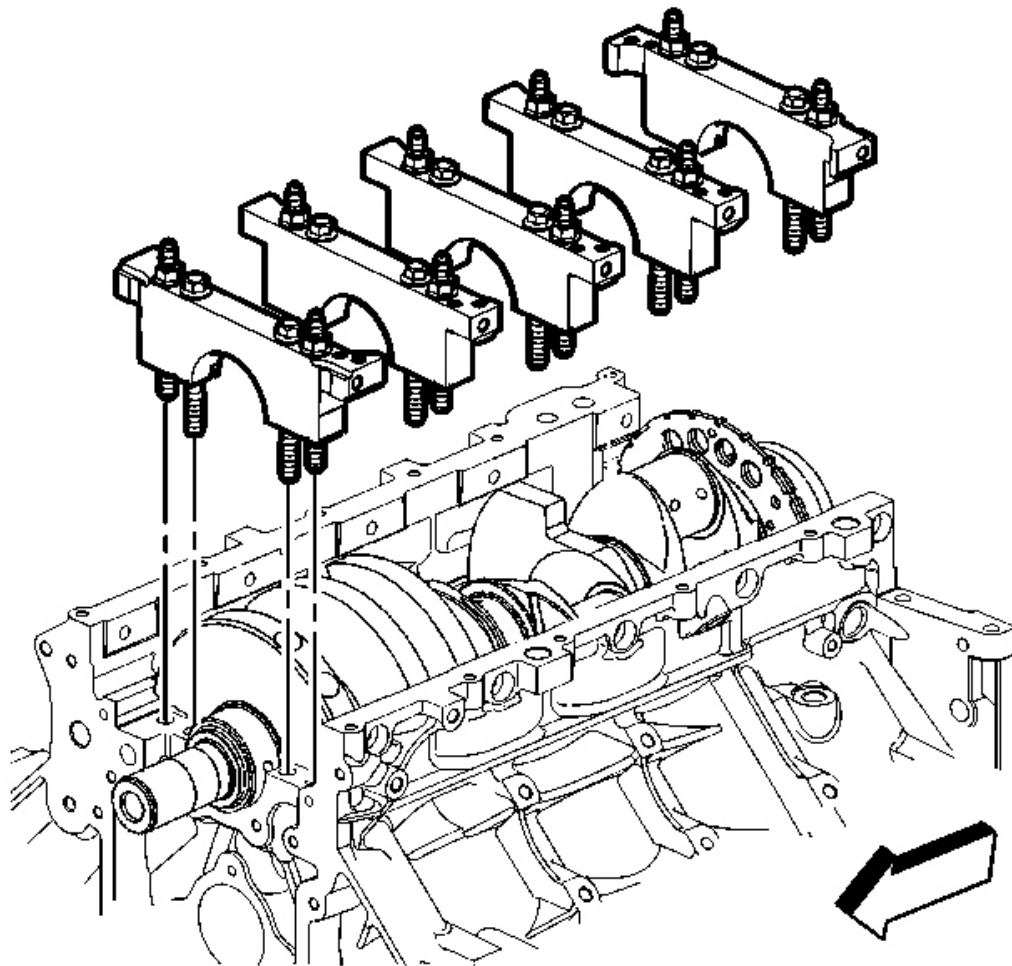
**Fig. 355: View Of J 6125-1B & J 41818**  
Courtesy of GENERAL MOTORS CORP.

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

5. Install the J 41818 .

**Tighten:** Tighten the J 41818 bolts to 11 N.m (100 lb in).

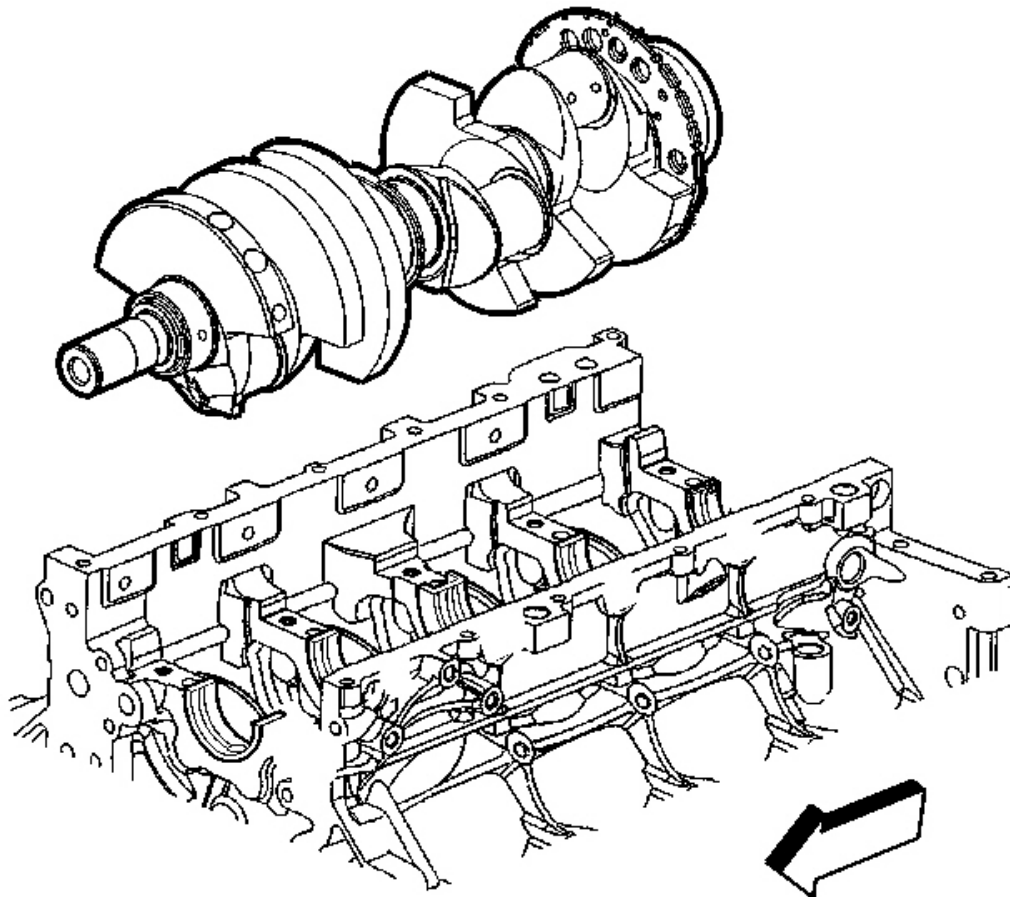
6. Install the **J 6125-1B** to the J 41818 in order to remove the crankshaft bearing caps.



**Fig. 356: View Of Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

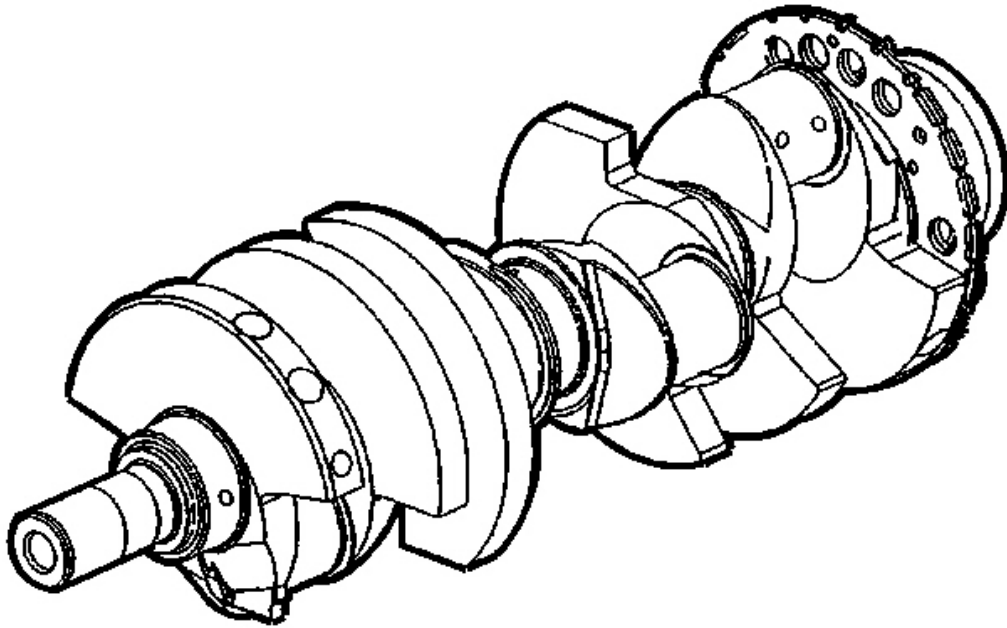
7. Remove the bearing caps.





**Fig. 357: Crankshaft & Engine Block**  
Courtesy of GENERAL MOTORS CORP.

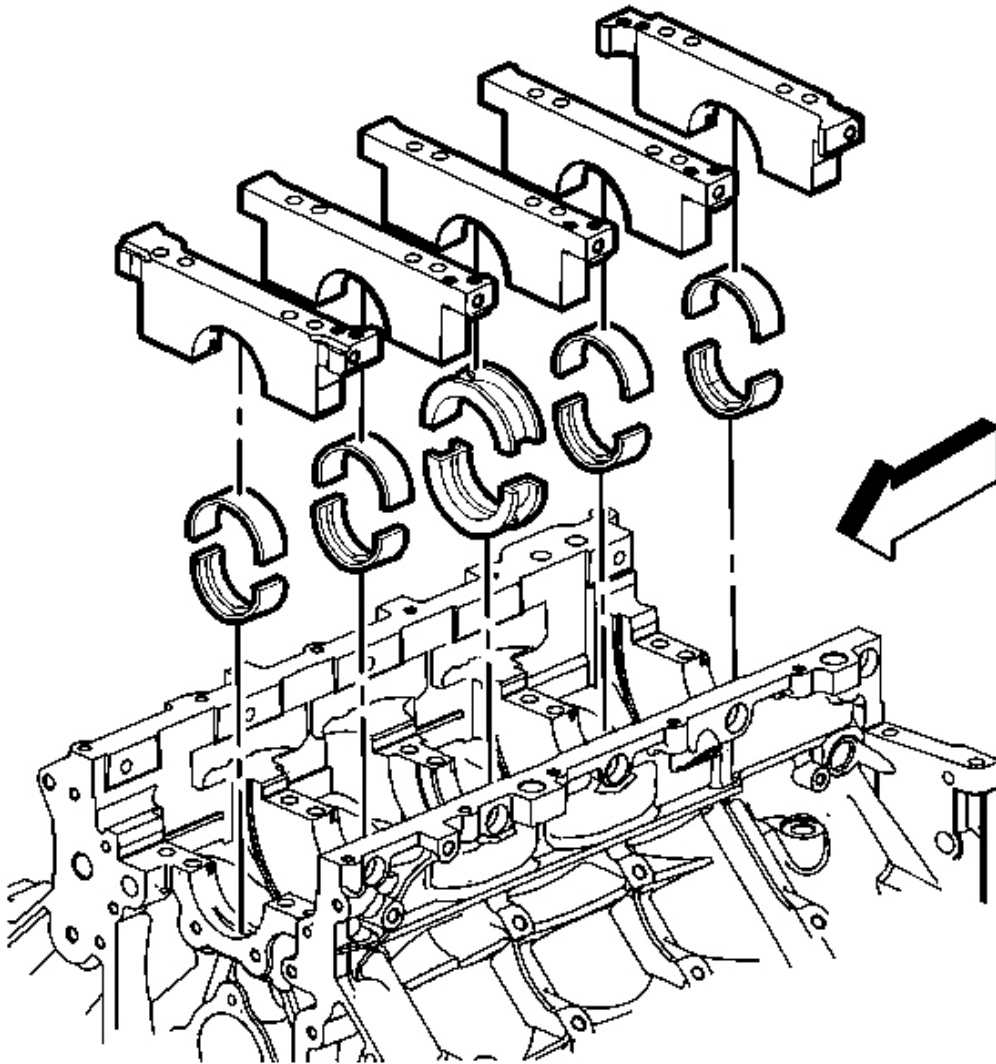
8. Remove the crankshaft.



**Fig. 358: View Of Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may effect On-Board Diagnostics (OBD) II system performance.

9. Lay the crankshaft onto 2 wooden V blocks or other protective surface.



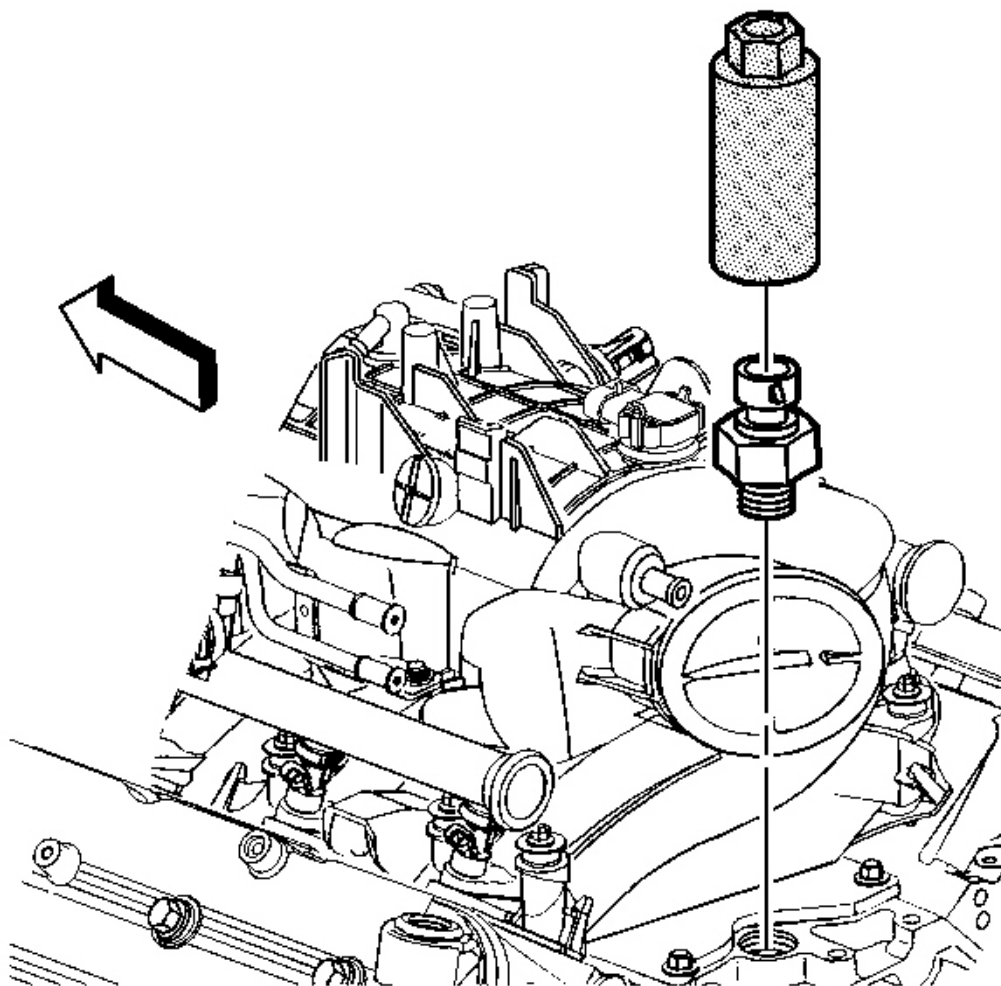
**Fig. 359: Crankshaft Bearings & Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft bearings from the bearing caps and the engine block.
11. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to **Separating Parts** .

## **ENGINE BLOCK PLUG REMOVAL**

## Tools Required

J 41712 Oil Pressure Switch Socket

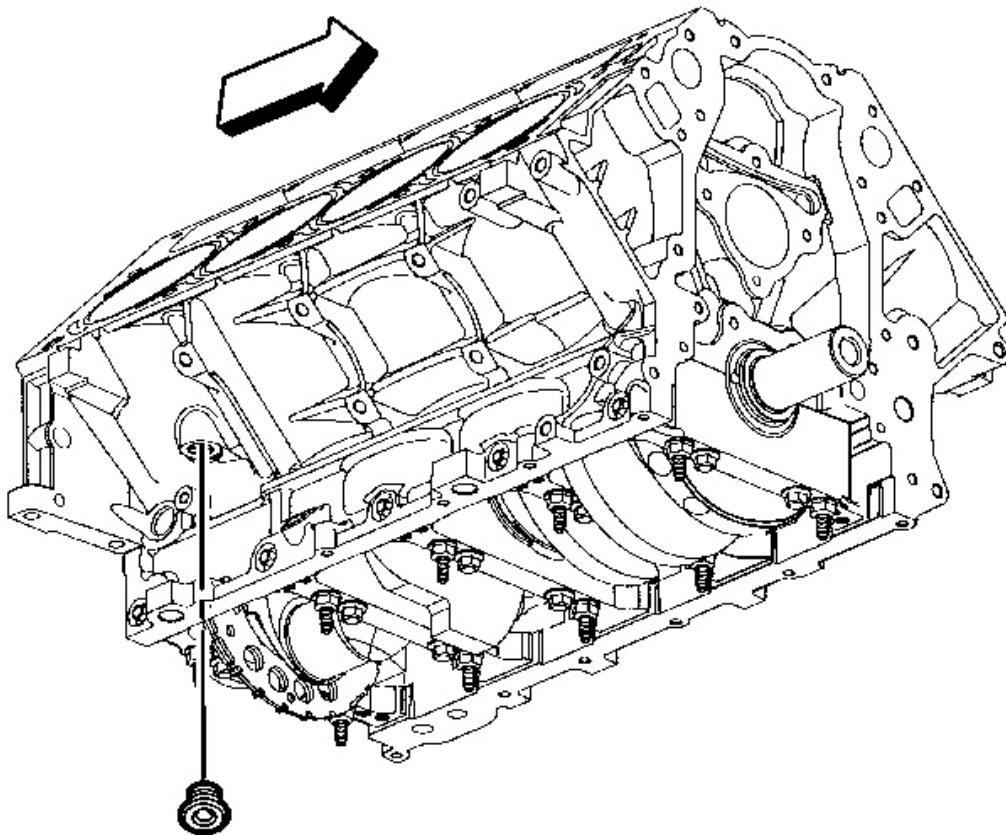


**Fig. 360: Oil Pressure Sensor & J 41712**  
Courtesy of GENERAL MOTORS CORP.

### **IMPORTANT:**

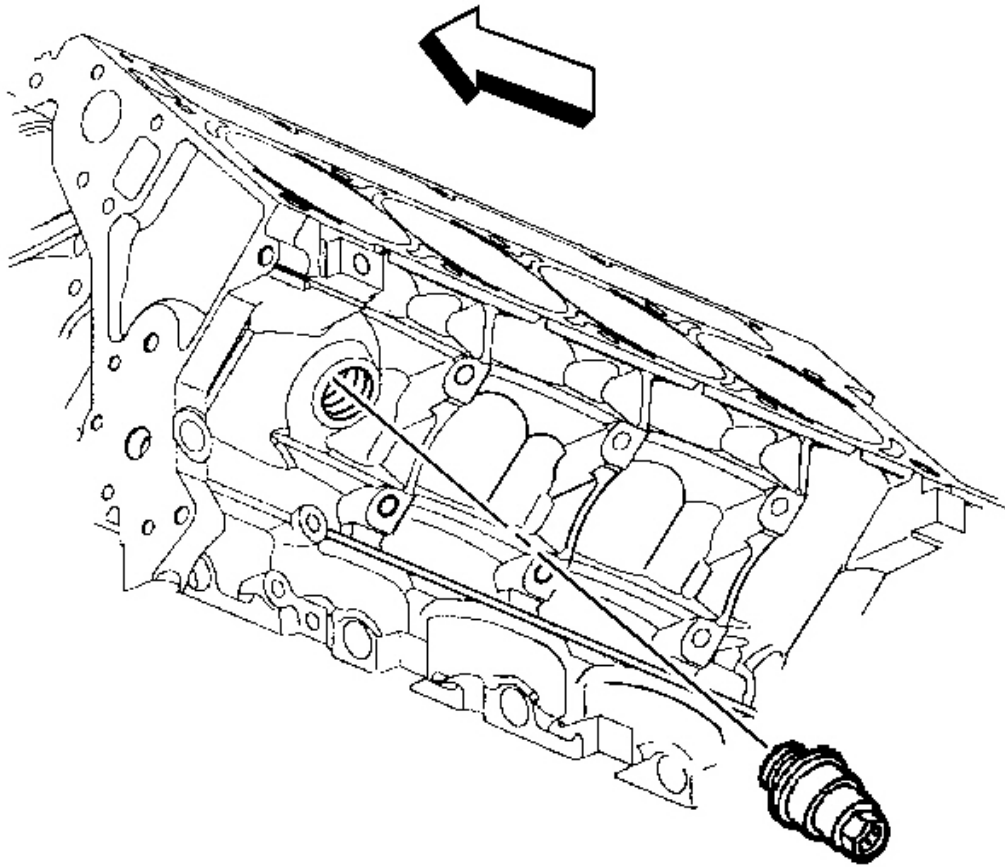
- Do not remove the engine block front oil gallery plug unless service is required.
- If the front oil gallery plug is removed for service, a **NEW** oil gallery plug must be installed.

1. Remove the oil pressure sensor, if not previously removed, using the J 41712 or equivalent.



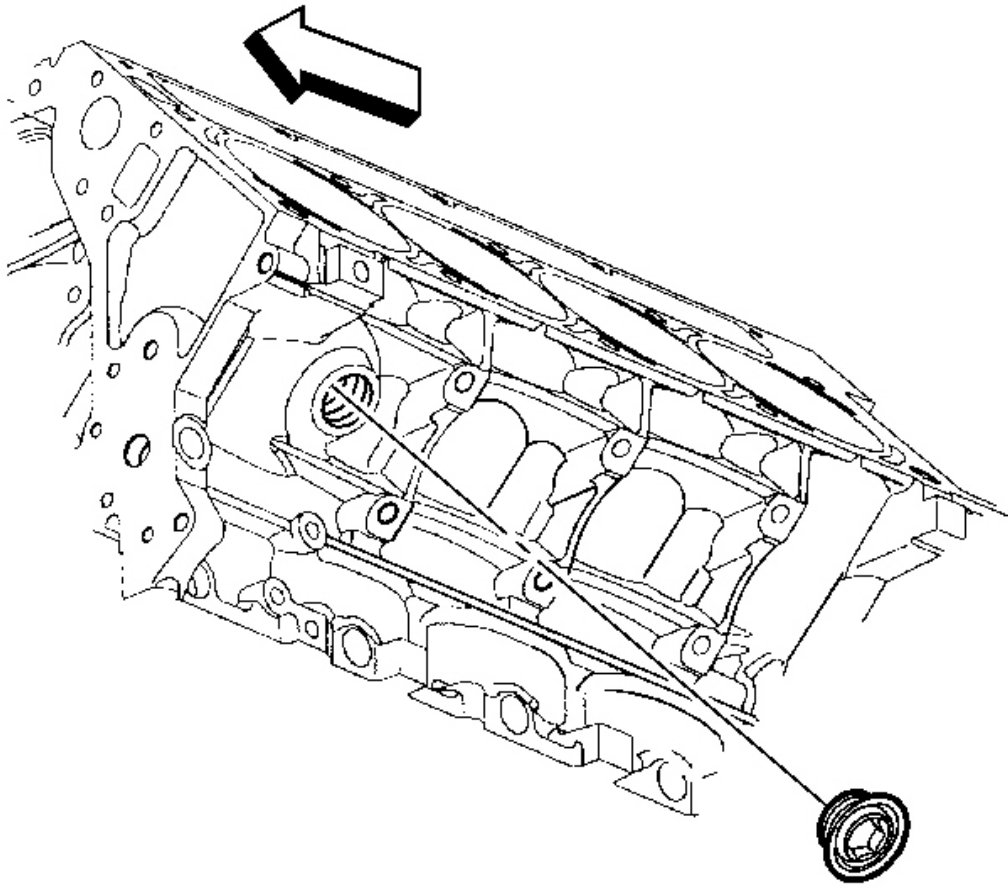
**Fig. 361: Identifying Plug Location On Underside Of Block**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block right rear coolant drain hole plug.



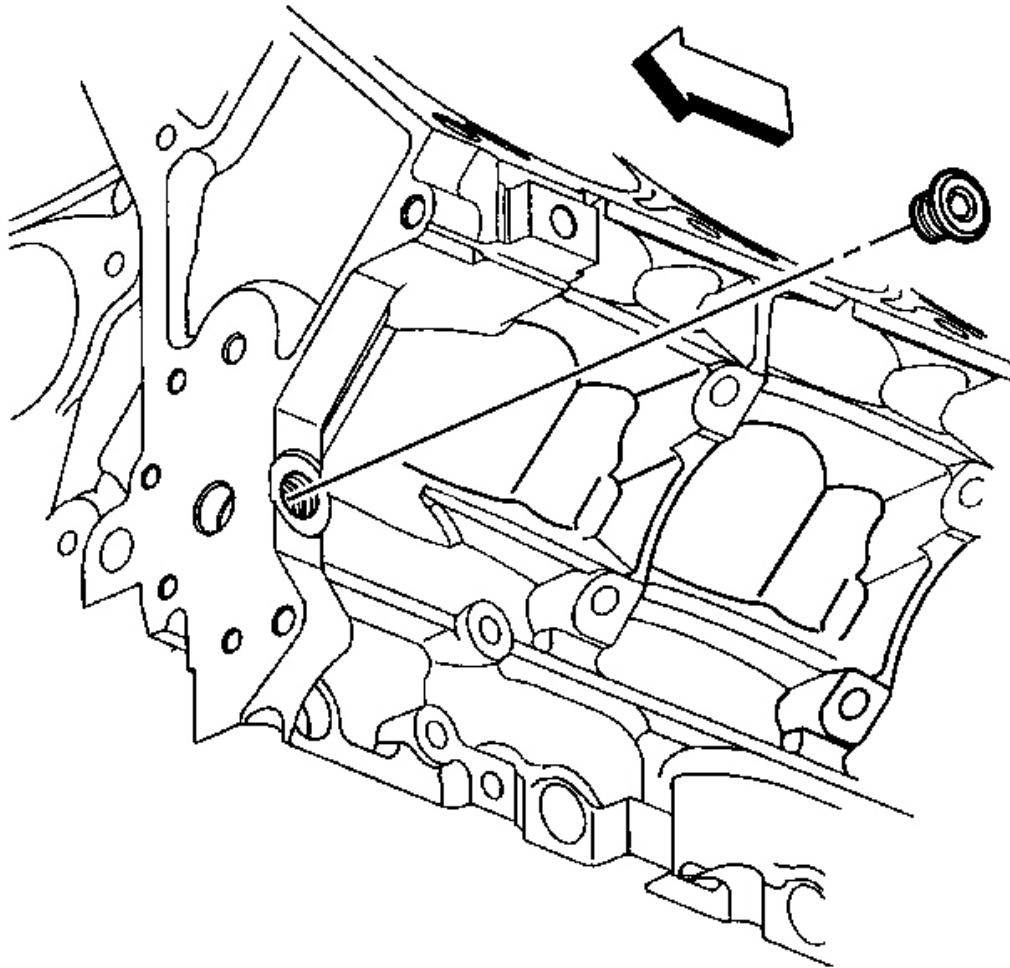
**Fig. 362: Engine Block Coolant Heater**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block coolant heater, if applicable.



**Fig. 363: Engine Block Left Rear Coolant Drain Hole Plug**  
Courtesy of GENERAL MOTORS CORP.

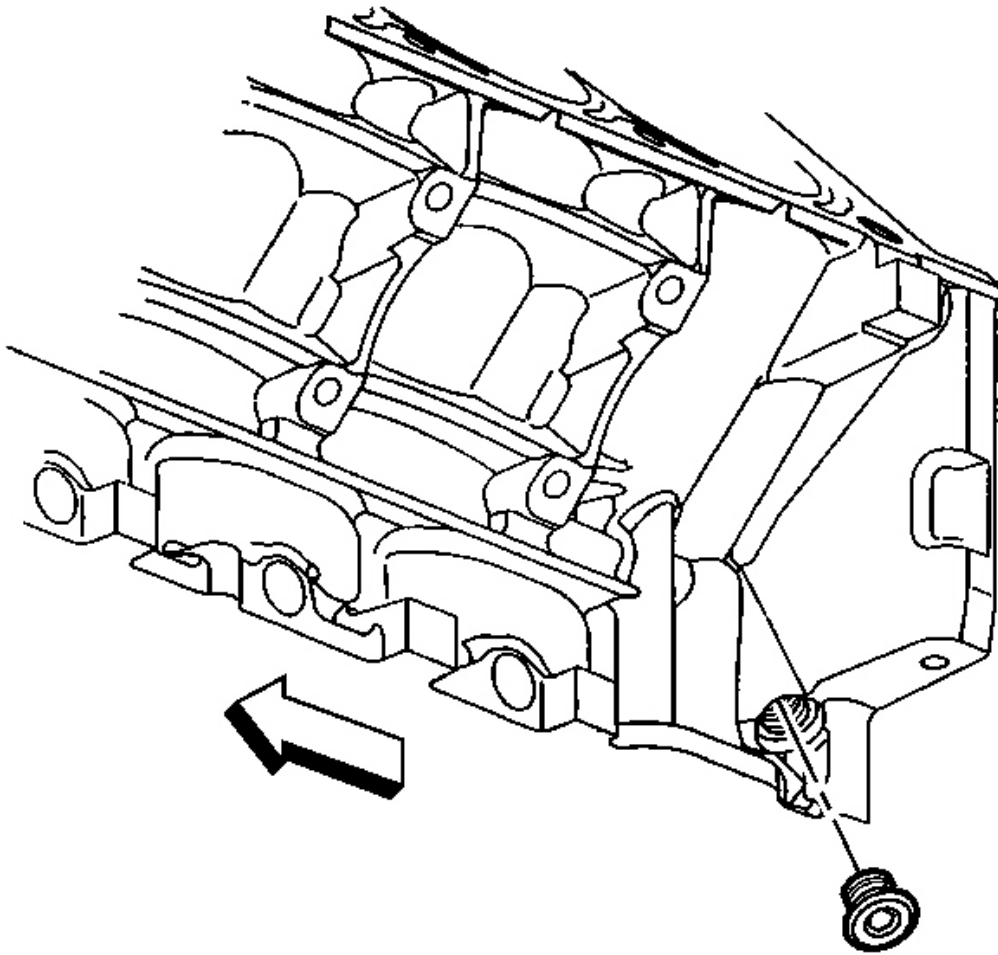
4. Remove the engine block left front coolant drain hole plug, if applicable.



**Fig. 364: Engine Block Left Front Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block left front oil gallery plug.

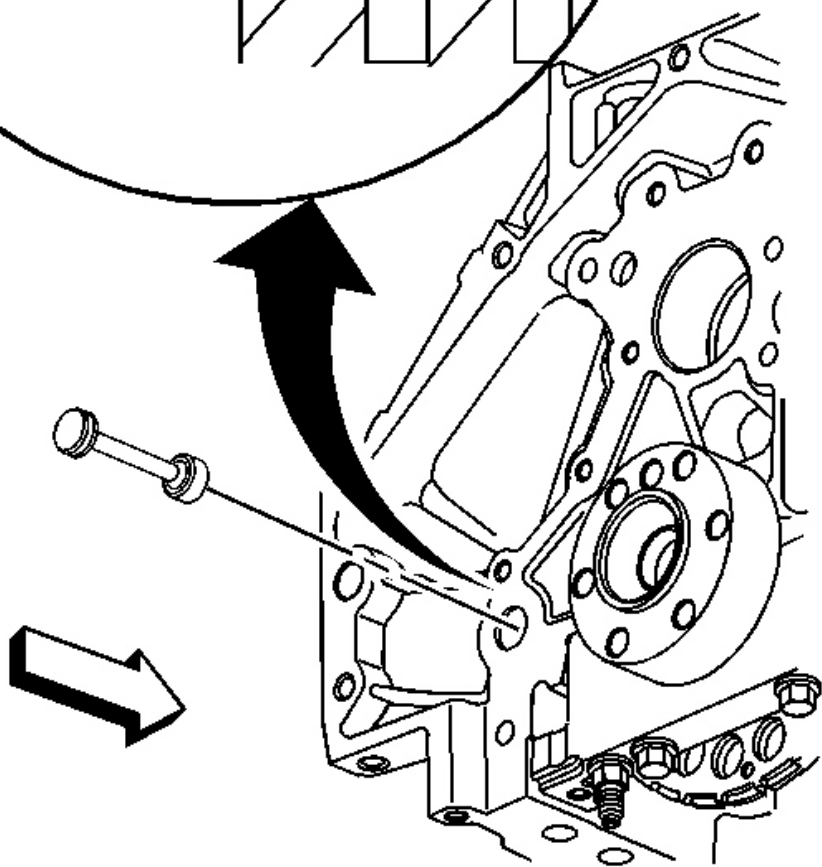
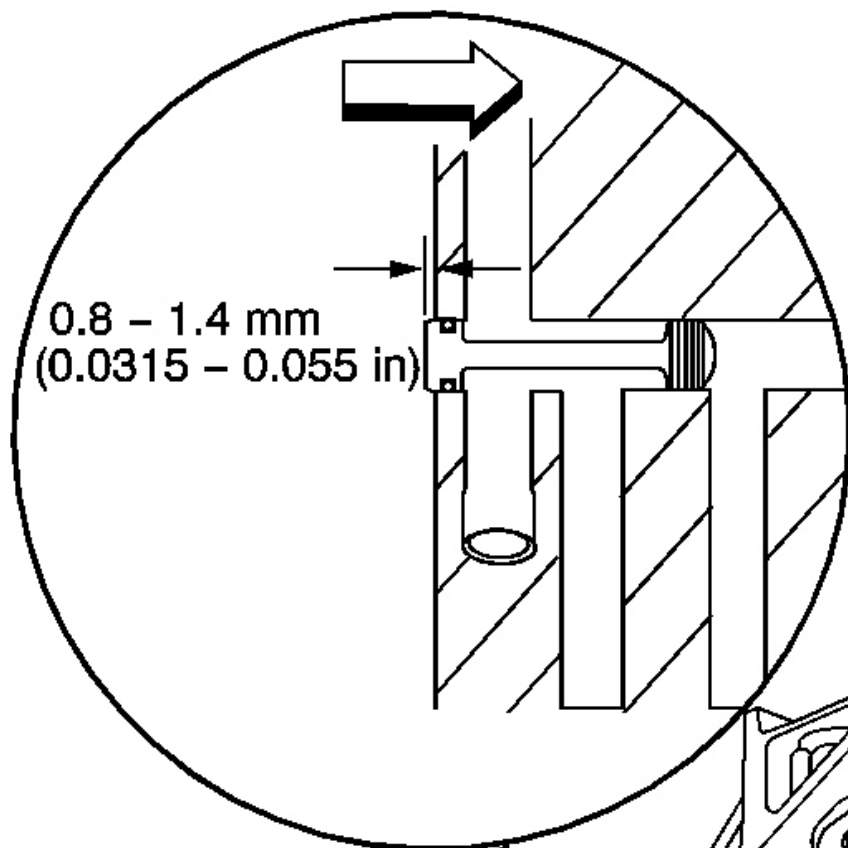




**Fig. 365: Engine Block Left Rear Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine block left rear oil gallery plug.
7. Inspect the block plug sealing washers.

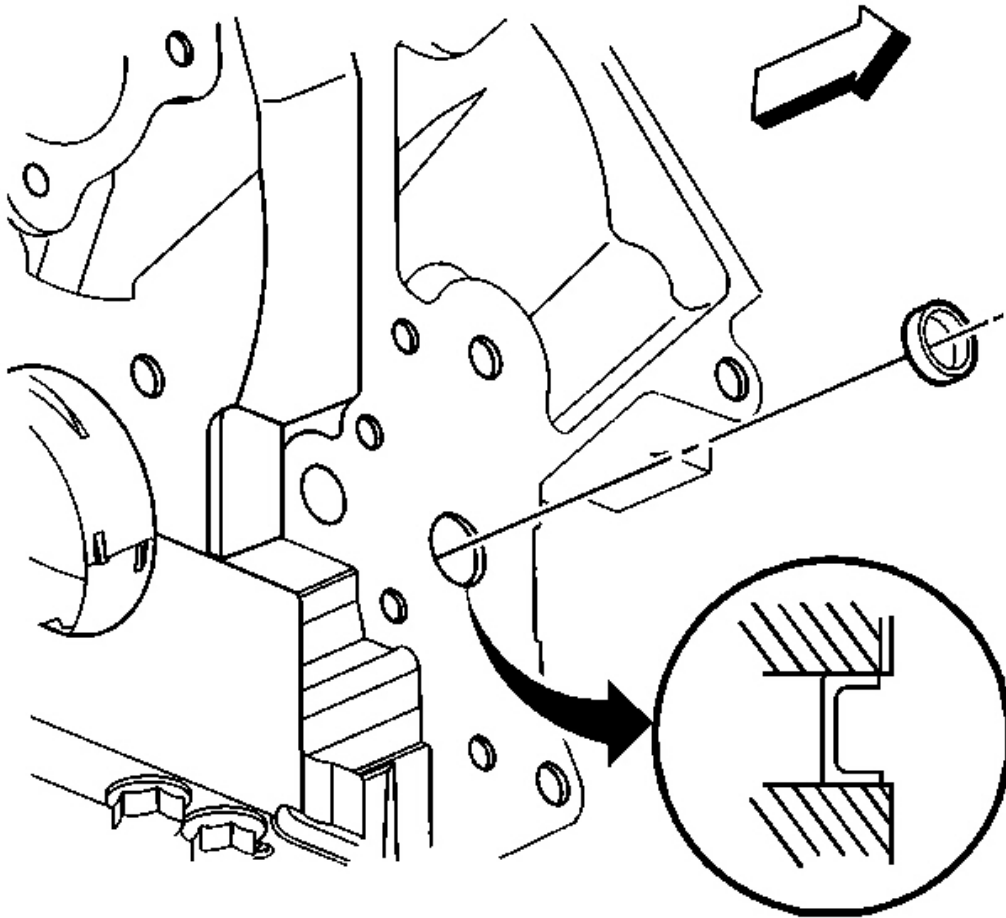
If the block plug and heater sealing washers are not damaged, they may be used during assembly.



**Fig. 366: Engine Block Rear Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine block rear oil gallery plug.
9. Inspect the O-ring seal of the rear oil gallery plug.

If the O-ring seal is not cut or damaged, the plug and O-ring seal may be used during assembly.



**Fig. 367: Engine Block Front Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Remove the front oil gallery plug only if service is required.
- If the front oil gallery plug is removed, a NEW oil gallery plug must

**be installed.**

10. Remove the engine block front oil gallery plug.

## **ENGINE BLOCK CLEANING AND INSPECTION**

### **Tools Required**

- **J 8087** Cylinder Bore Gauge. See **Special Tools and Equipment** .
- **J 42385-100** Thread Repair Kit. See **Special Tools and Equipment** .

1. Clean the following areas:

**NOTE:** Do not use a caustic solution to clean the aluminum engine block.

**IMPORTANT:** When cleaning the engine block in a thermal type oven, do not exceed 450°F (232°C).

- The engine block in the solvent, to remove all sludge, dirt, or debris

Refer to **Cleanliness and Care** .

**CAUTION:** Refer to **Safety Glasses Caution** in Cautions and Notices.

- Dry the block with compressed air.
- The gasket surfaces

Refer to **Replacing Engine Gaskets** .

- The coolant passages
- The oil galleries
- The main bearing caps
- The engine block cylinder head bolt holes for threadlocking material

Thread repair driver tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Inspect the following areas:

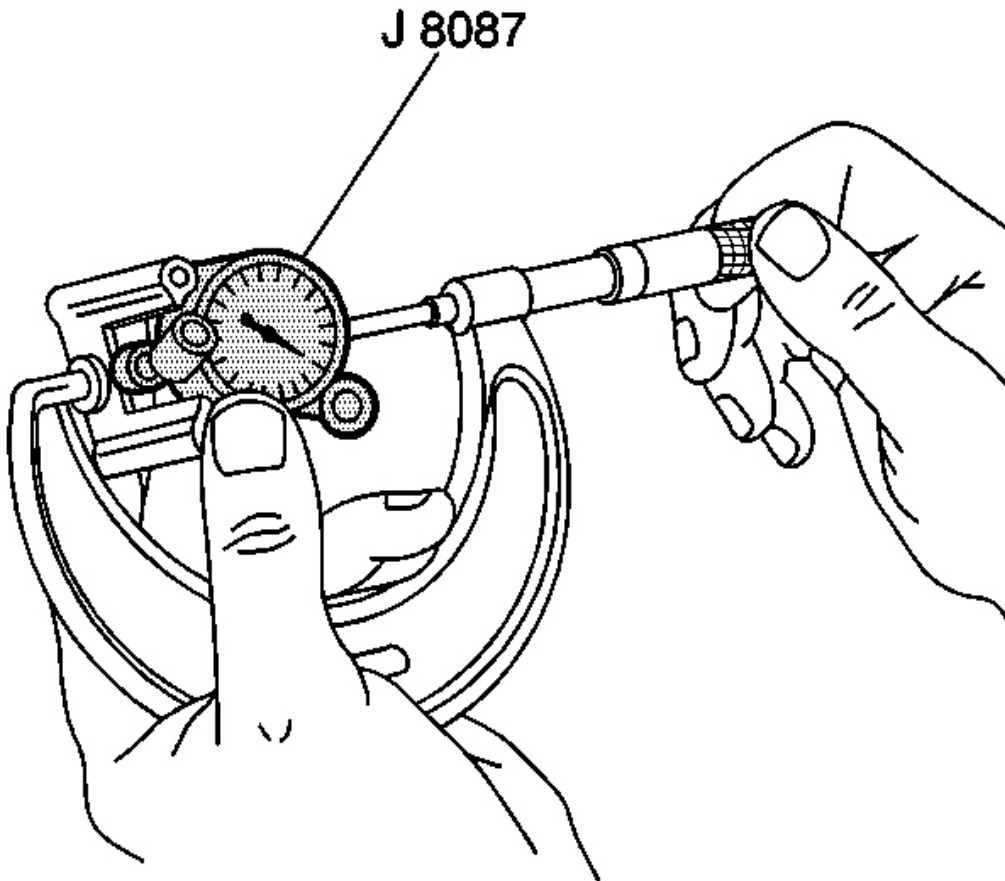
- The cylinder walls for excessive scratches, gouging, or ring ridge
- The cylinder bores for excessive ring ridge at the top of the cylinder
- The coolant jacket for cracks

- The valve lifter bores for excessive scoring or wear
- The crankshaft bearing webs for cracks
- The gasket sealing surfaces for excessive scratches or gouging

Refer to **Replacing Engine Gaskets** .

- The oil galleries for restrictions
  - All threaded bolt holes for damage
3. Measure the following areas:
- The cylinder bores for taper
  - The cylinder bores for excessive ring ridge at the top of the cylinder

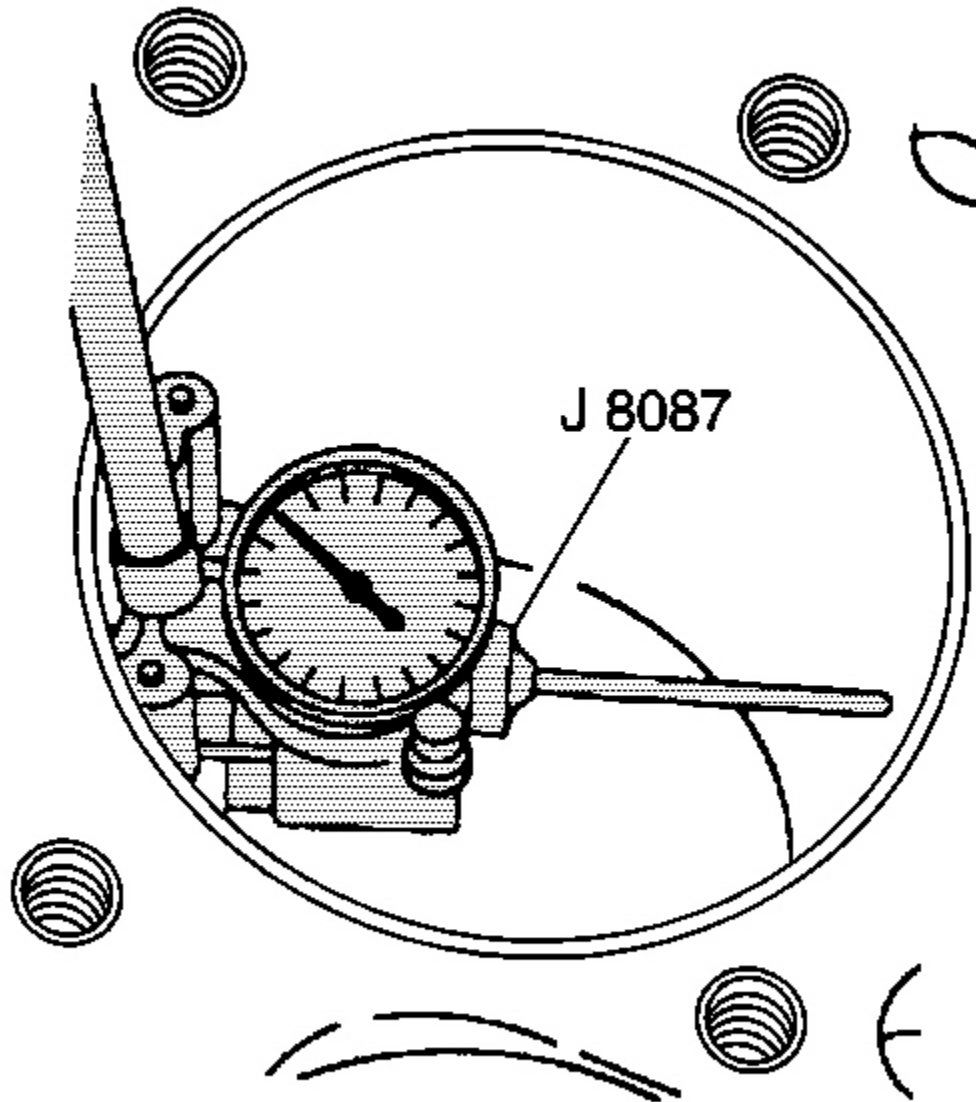
### Measuring the Cylinder for Taper, Out-of-Round, and Oversize



**Fig. 368: Measuring J 8087 Dimension**  
Courtesy of GENERAL MOTORS CORP.

1. Adjust the micrometer to a dimension slightly smaller than the bore size.

Adjust the micrometer to 101.62 mm (4.0 in) for 6.0 liter engines.



**Fig. 369: Determining Cylinder Bore Out-Of-Round Using J 8087**

## Courtesy of GENERAL MOTORS CORP.

2. Insert the bore gauge into the micrometer and zero the bore gauge dial.
3. Use the **J 8087** or equivalent and measure the cylinder bore for taper, out-of-round, and oversize. See **Special Tools and Equipment** .

Slide the bore gauge up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center, and bottom of the bore.

A 6.0L cylinder bore that measures 101.618-101.636 mm (4.0007-4.0014 in) may be honed and serviced with a standard size piston.

A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston.

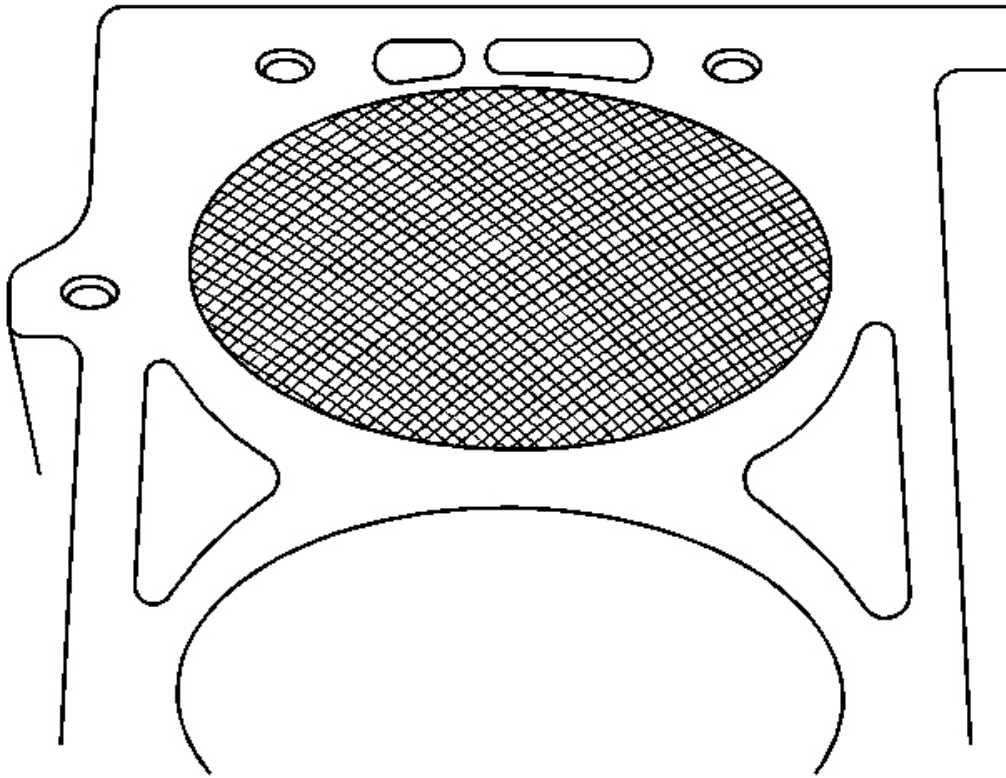
## CYLINDER BORING AND HONING

### Boring Procedure

**IMPORTANT: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available for the 6.0 liter engine.**

1. Measure all pistons with a micrometer to determine the cylinder bore diameter.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned, tilted, and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, make sure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

### Honing Procedure



**Fig. 370: Cylinder Bore Cross Hatch Pattern**  
Courtesy of GENERAL MOTORS CORP.

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly check the cylinder bore for fit with the selected piston.

All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100 grit stone.
4. Perform final cylinder honing with a 240 grit stone and obtain a 45 degree cross hatch pattern.



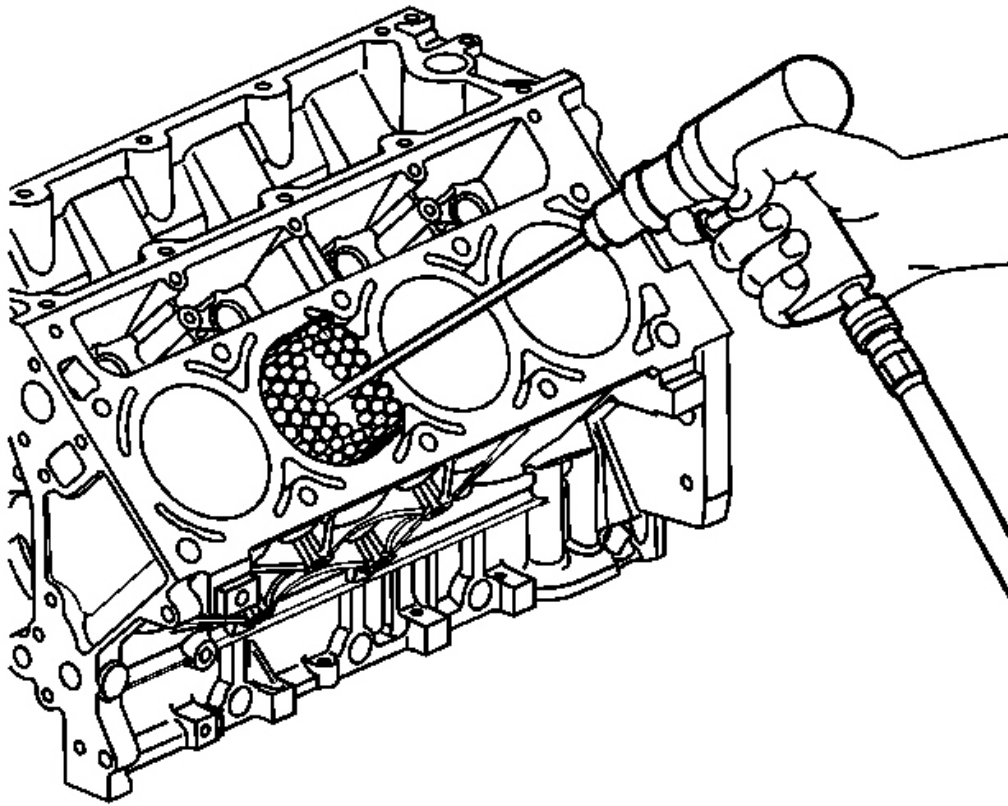
A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.

5. When honing to eliminate taper in the cylinder, make full strokes the complete length of the bore.

Repeatedly check the measurement at the top, the middle, and the bottom of the bore.

6. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
7. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
8. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
9. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.
10. Perform final measurements of the piston and the cylinder bore.
11. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
12. Apply clean engine oil to each cylinder bore in order to prevent rusting.

### **Deglazing Procedure**



**Fig. 371: Deglazing Cylinder Bore**  
Courtesy of GENERAL MOTORS CORP.

Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240 grit stone of silicone carbide or equivalent material when performing the deglazing procedure.

A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.

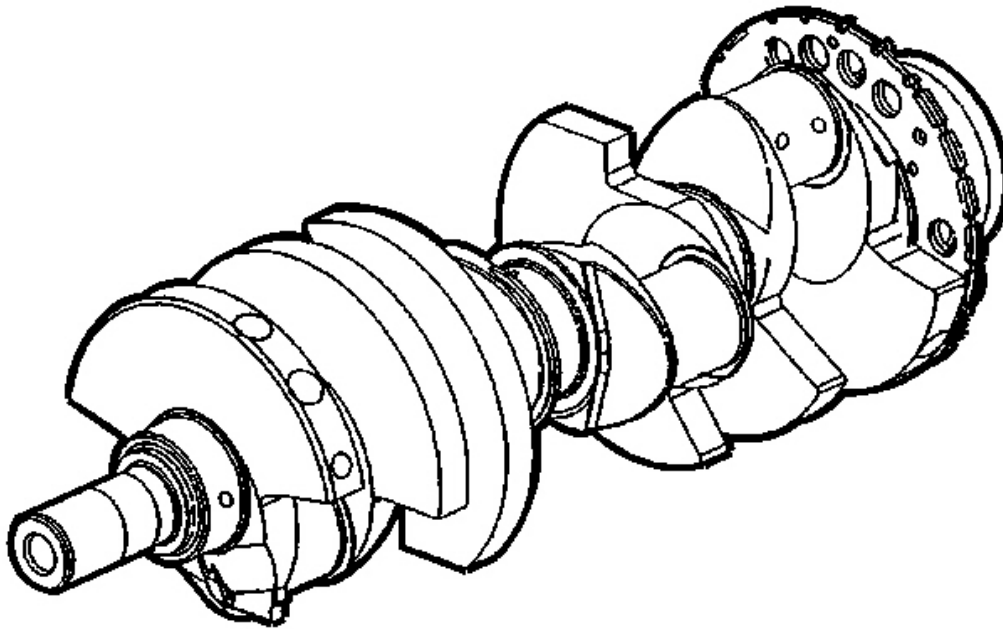
## **CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION**

### **Tools Required**

- **J 6125-1B** Slide Hammer. See **Special Tools and Equipment** .
- **J 7872** Magnetic Base Dial Indicator Set
- **J 41818** Crankshaft Bearing Cap Remover

- **J 43690** Rod Bearing Checking Tool. See **Special Tools and Equipment** .
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit. See **Special Tools and Equipment** .
- **J 45059** Angle Meter. See **Special Tools and Equipment** .

#### Cleaning Procedure



**Fig. 372: View Of Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

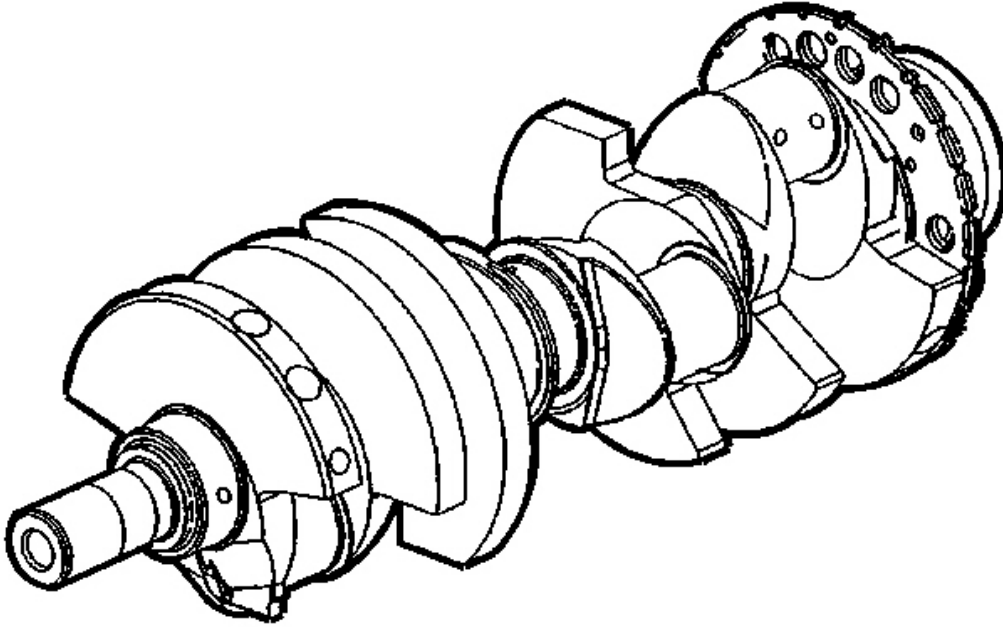
**IMPORTANT:** Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may effect On-Board Diagnostics (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

**CAUTION:** Refer to **Safety Glasses Caution** in Cautions and Notices.

3. Dry the crankshaft with compressed air.

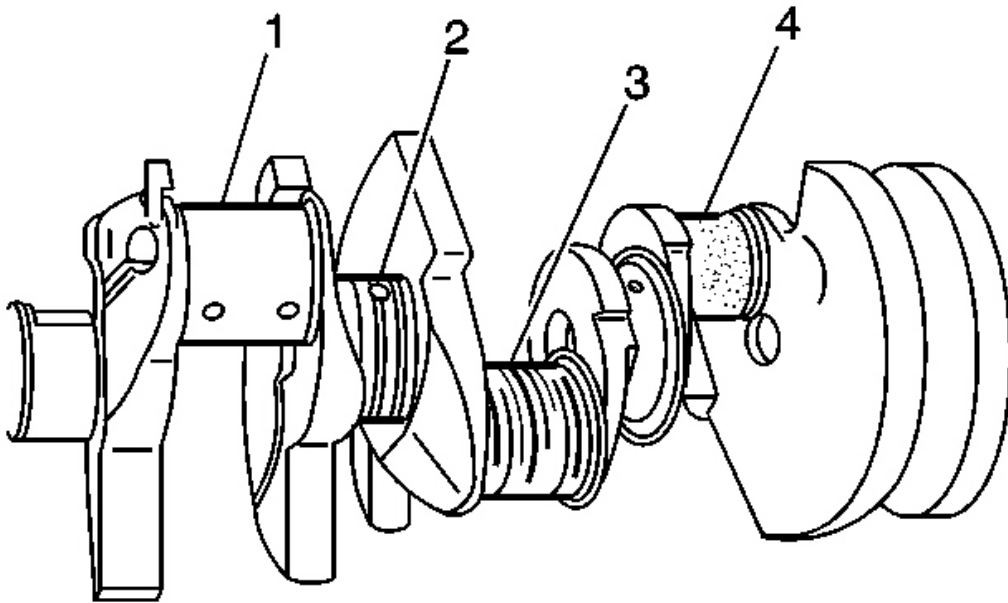
### Inspection Procedure



**Fig. 373: View Of Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The reluctor ring teeth should not have imperfections on the rising or falling edges.  
Imperfections of the reluctor ring teeth may effect OBD II system performance.

1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the crankshaft position (CKP) reluctor ring lobes for damage.

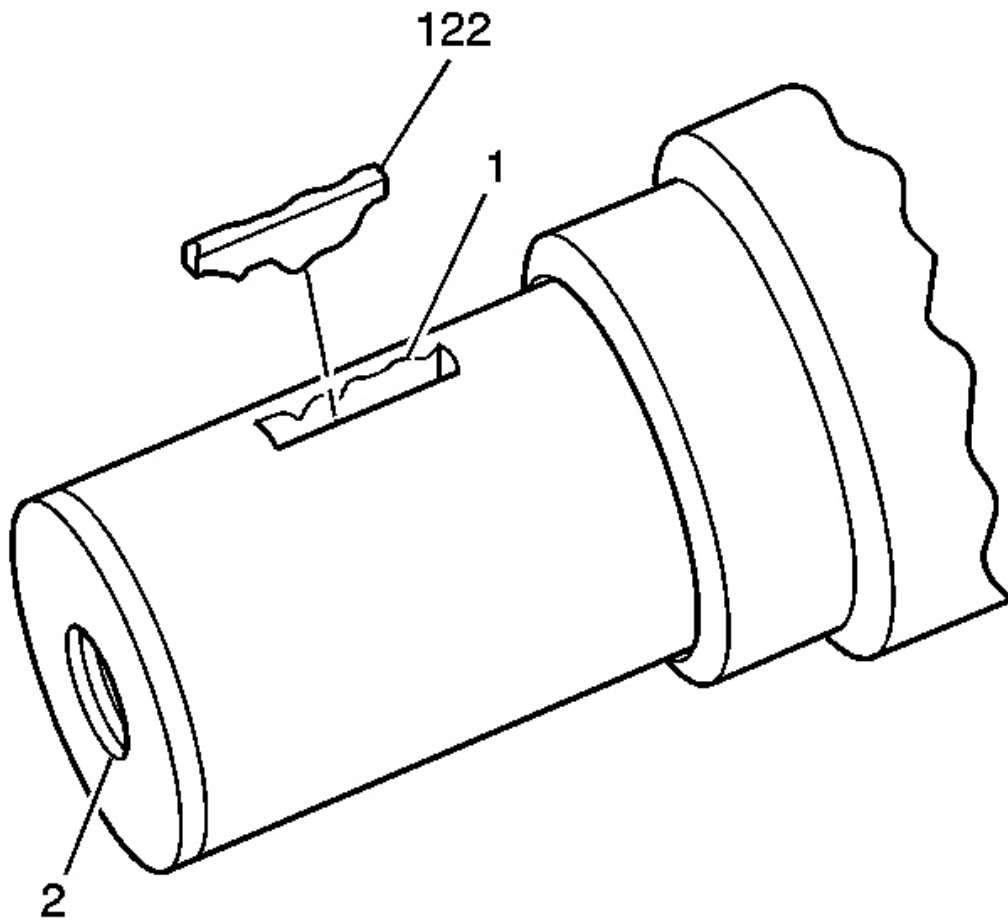


**Fig. 374: Crankshaft Inspection Areas**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft journals for wear (1).

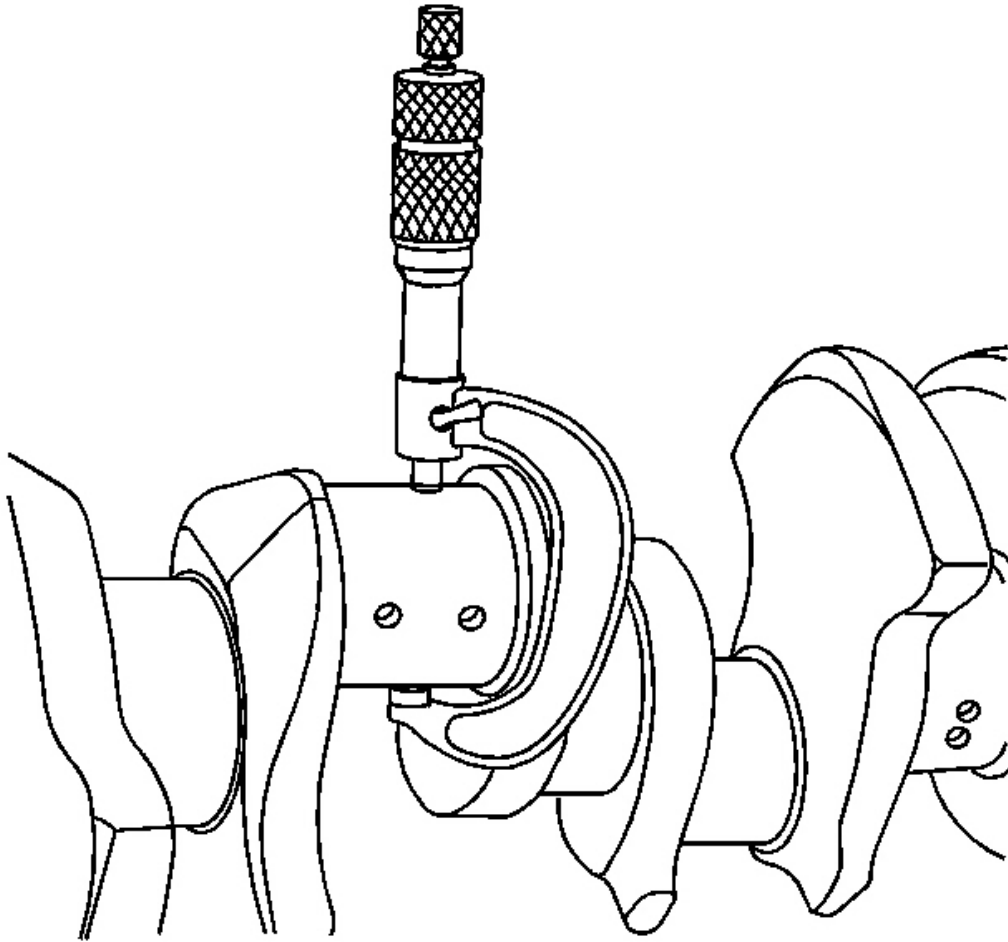
Journals should be smooth with no signs of scoring, wear, or damage.

4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded bearing material (4).



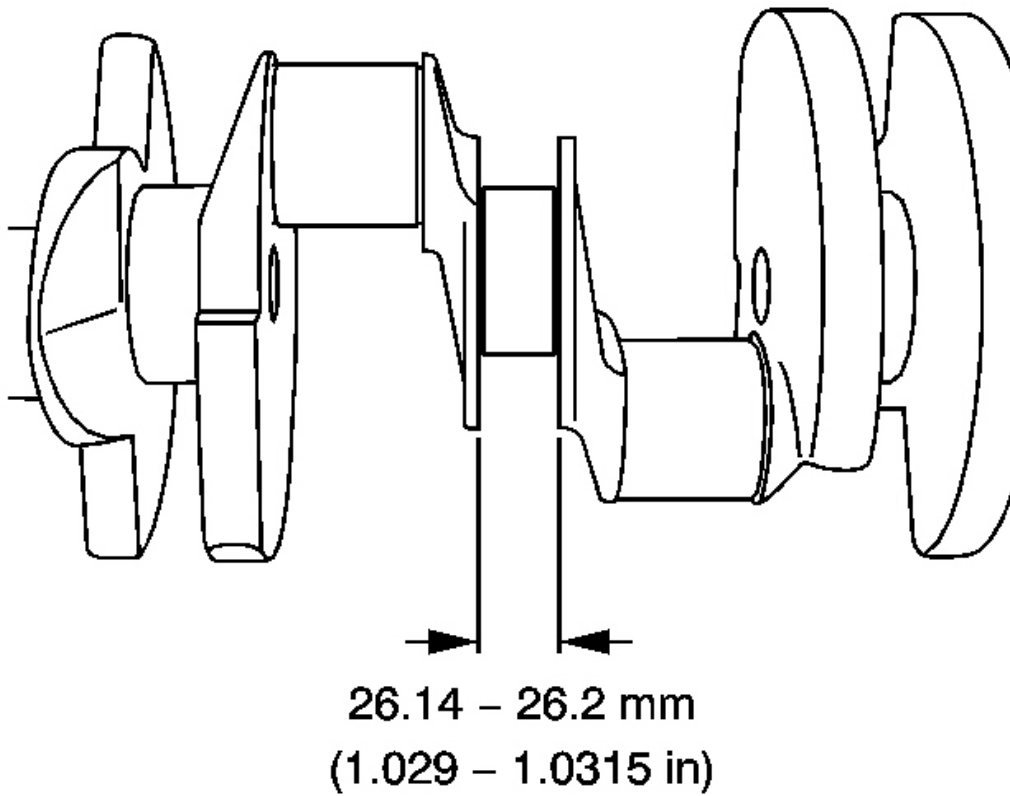
**Fig. 375: Crankshaft Key, Keyway & Threaded Hole**  
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.



**Fig. 376: Measuring Crankshaft Journals**  
**Courtesy of GENERAL MOTORS CORP.**

8. Measure the crankpins for the out-of-round.
9. Measure the crankpins for taper.

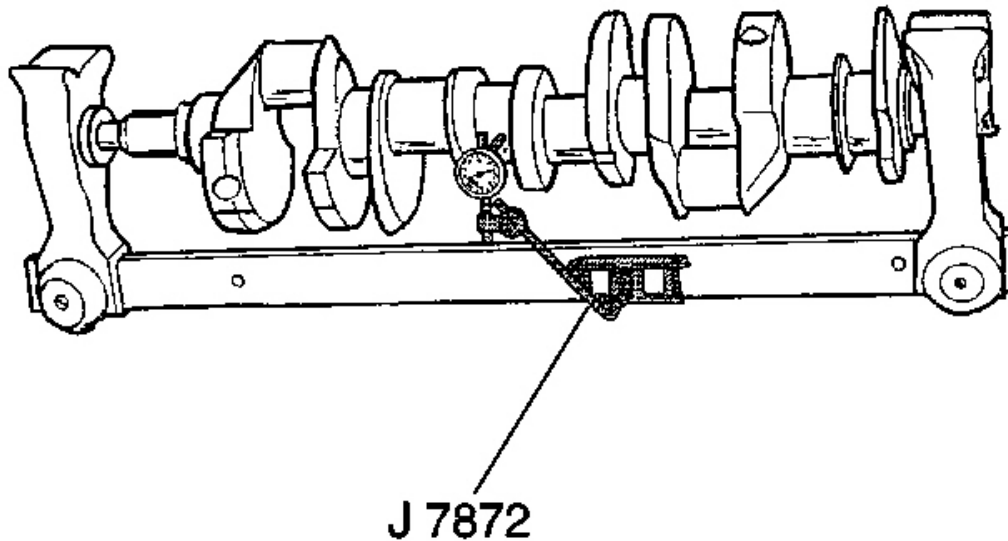


**Fig. 377: Measuring Crankshaft Thrust Wall Width**  
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft thrust wall width.

A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.





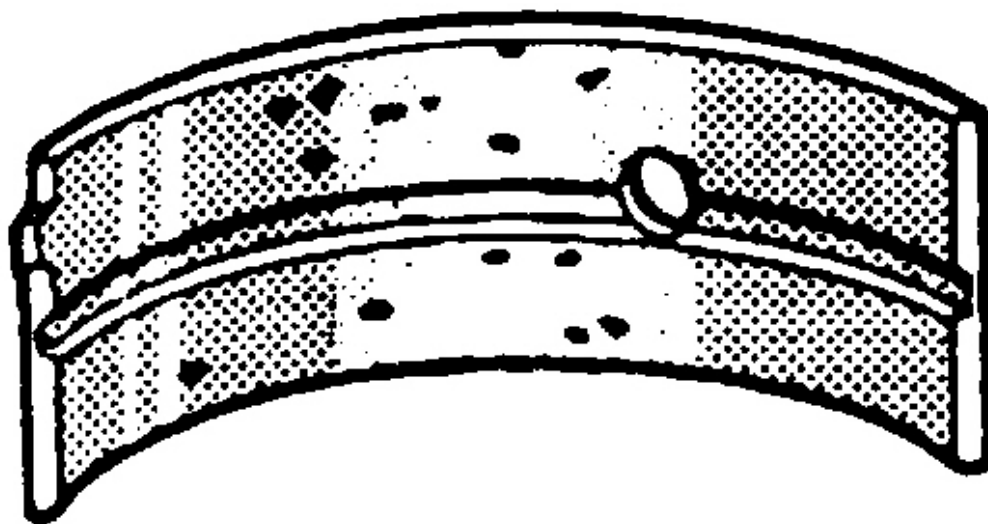
**Fig. 378: Measuring Crankshaft Journal Runout**  
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft runout.

Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.

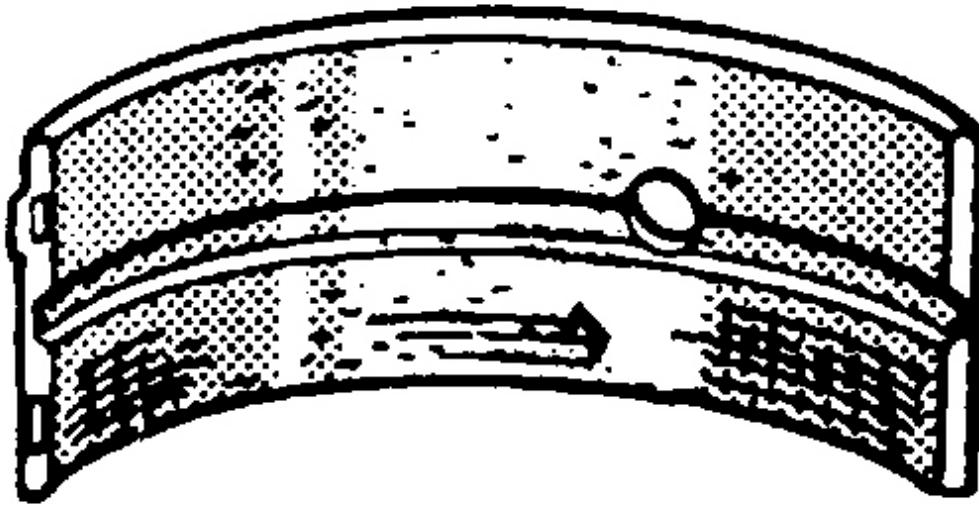
12. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals.
13. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
14. Use the **J 7872** in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.



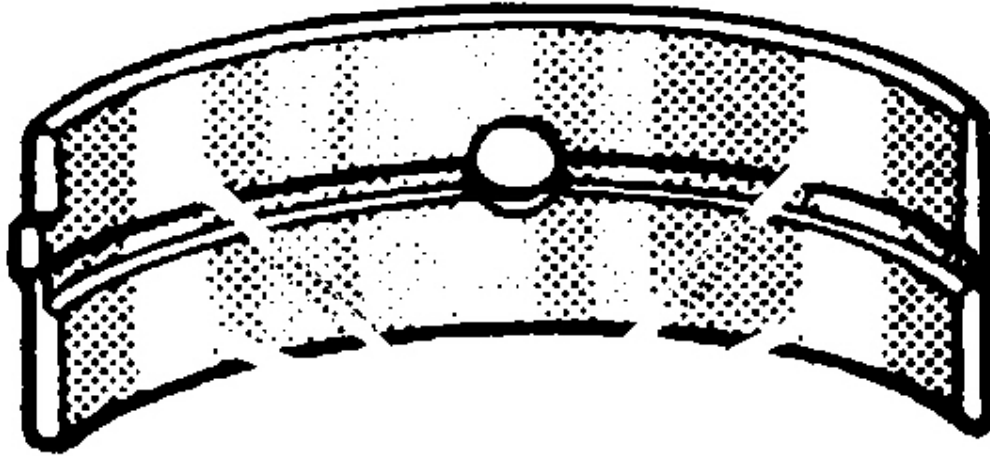
**Fig. 379: Inspecting Bearings For Damage**  
Courtesy of GENERAL MOTORS CORP.

15. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.



**Fig. 380: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration**  
Courtesy of GENERAL MOTORS CORP.

16. Inspect the crankshaft bearings for excessive scoring or discoloration.
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



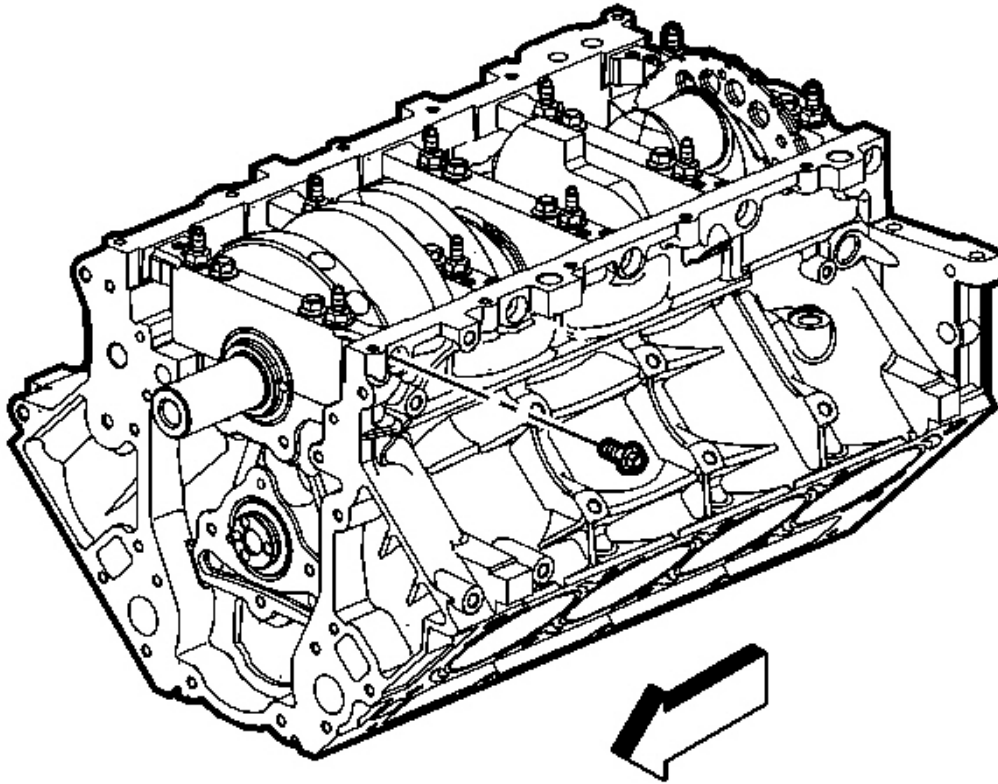
**Fig. 381: Inspecting Bearings For Improper Seating**  
Courtesy of GENERAL MOTORS CORP.

18. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

#### **Measuring Main Bearing Clearance - Gaging Plastic Method**

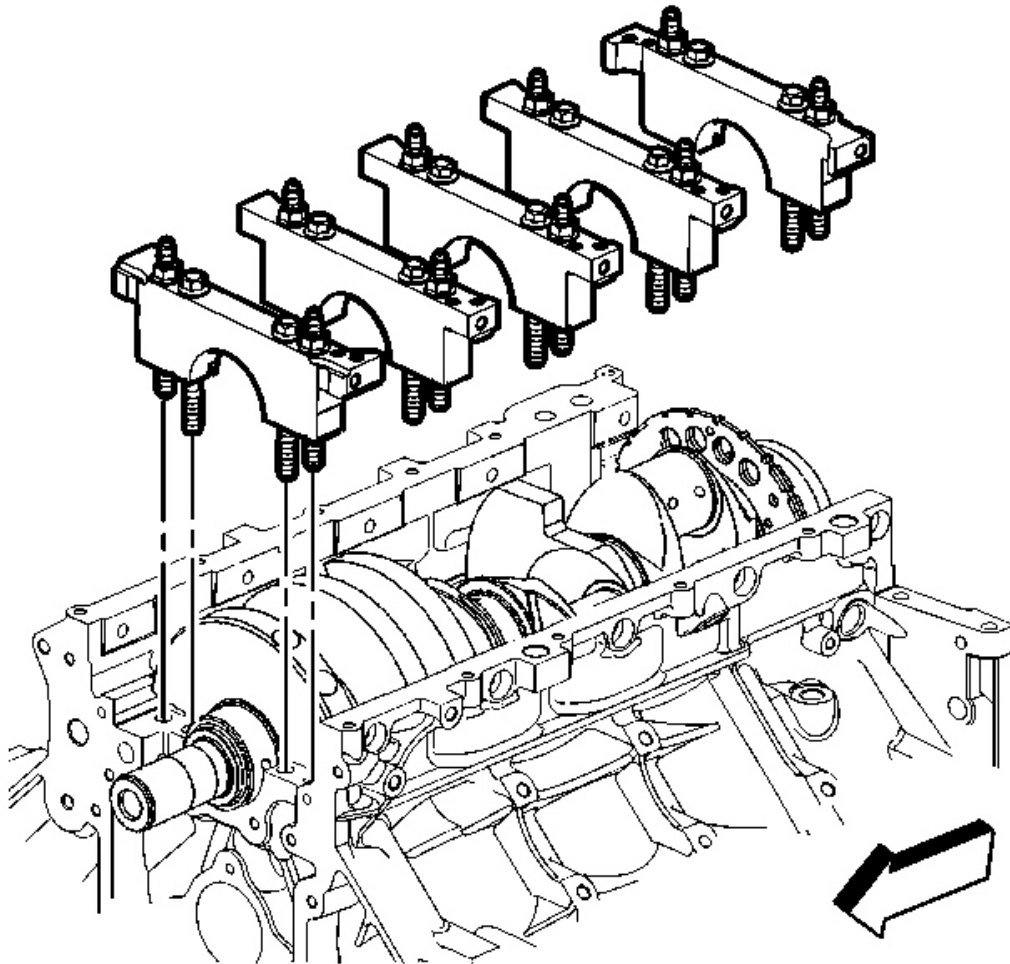


**Fig. 382: Bearing Cap Bolts & Studs**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

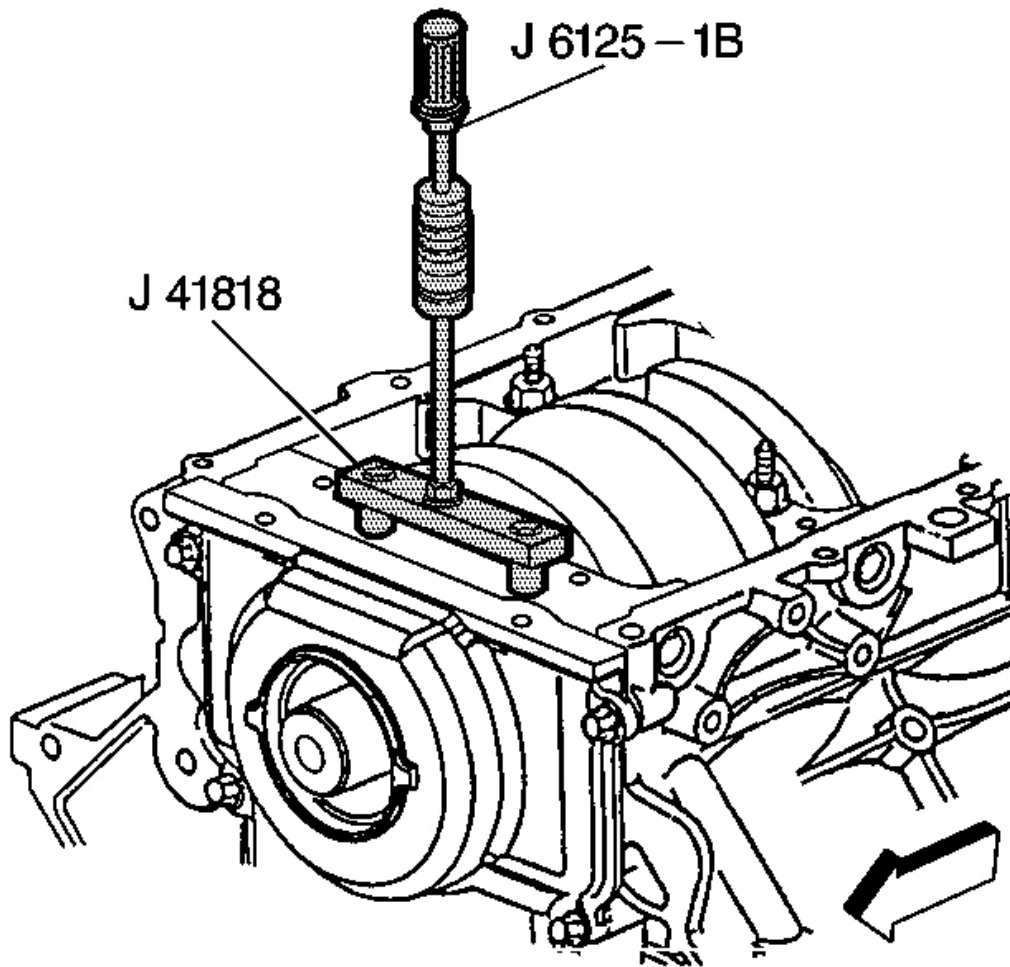
- The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.
- Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.
- The crankshaft bearing clearances are critical. Excessive bearing clearance may effect crankshaft position sensor signals and may effect On-Board Diagnostics (OBD) II system operation.
- Remove the bearing cap side bolts prior to cap removal.

1. Remove the bearing cap M8 side bolts.



**Fig. 383: View Of Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the bearing cap M10 bolts and studs.



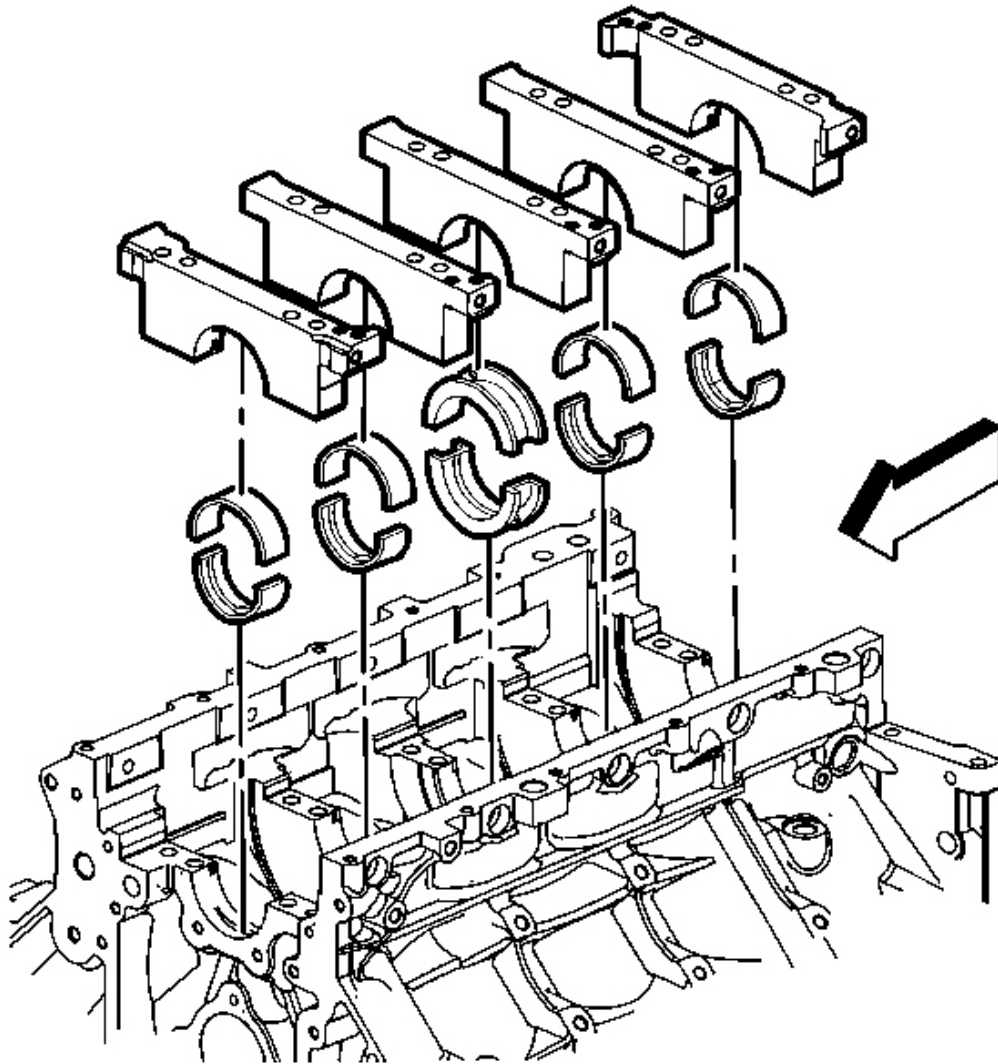
**Fig. 384: View Of J 6125-1B & J 41818**  
Courtesy of GENERAL MOTORS CORP.

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

3. Install the J 41818 to the bearing cap.

**Tighten:** Tighten the J 41818 bolts to 11 N.m (100 lb in).

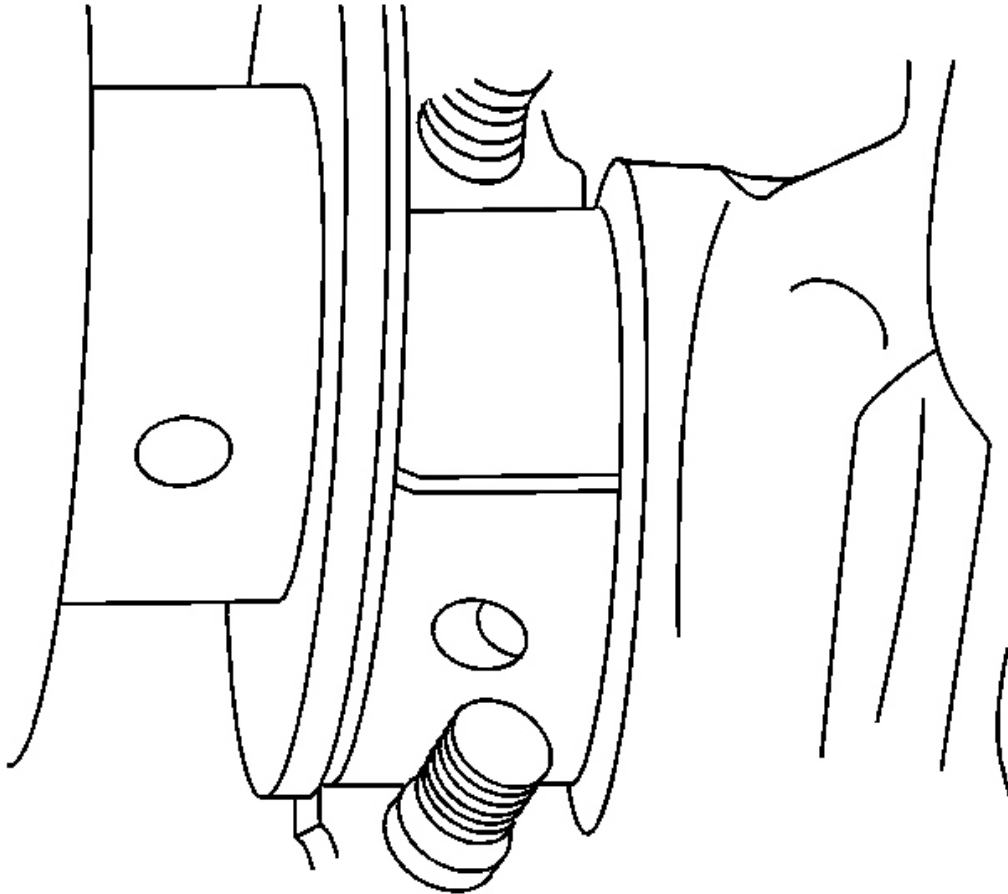
4. Install the **J 6125-1B** to the. See Special Tools and Equipment . J 41818 in order to remove the bearing cap.



**Fig. 385: Crankshaft Bearings & Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

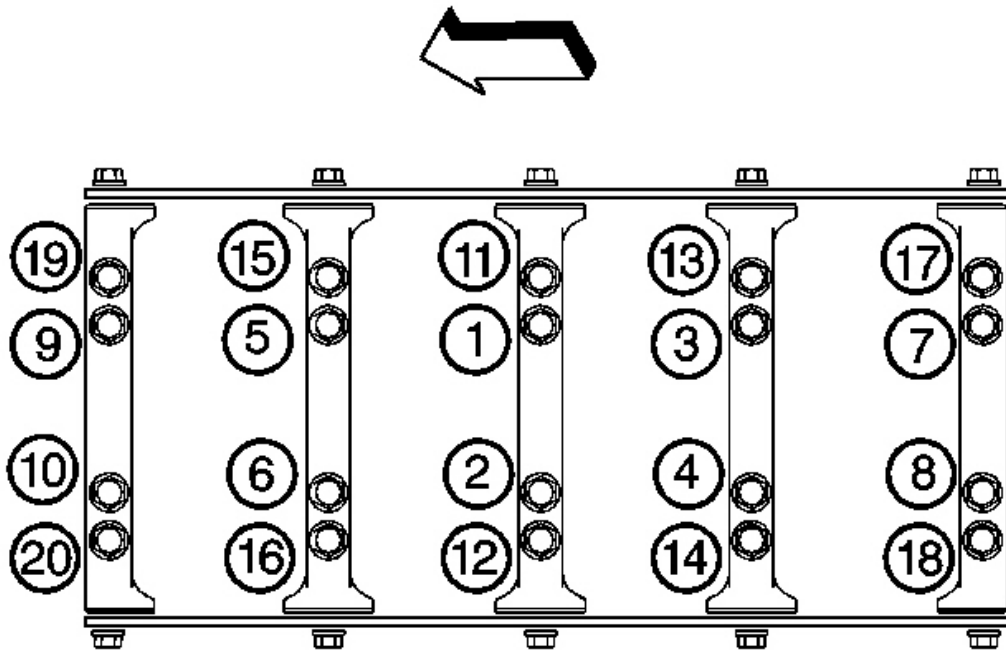
5. Remove the bearing cap and lower bearing.





**Fig. 386: Gaging Plastic Installed On Crankshaft Journal**  
Courtesy of GENERAL MOTORS CORP.

6. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of crankshaft bearing journal.



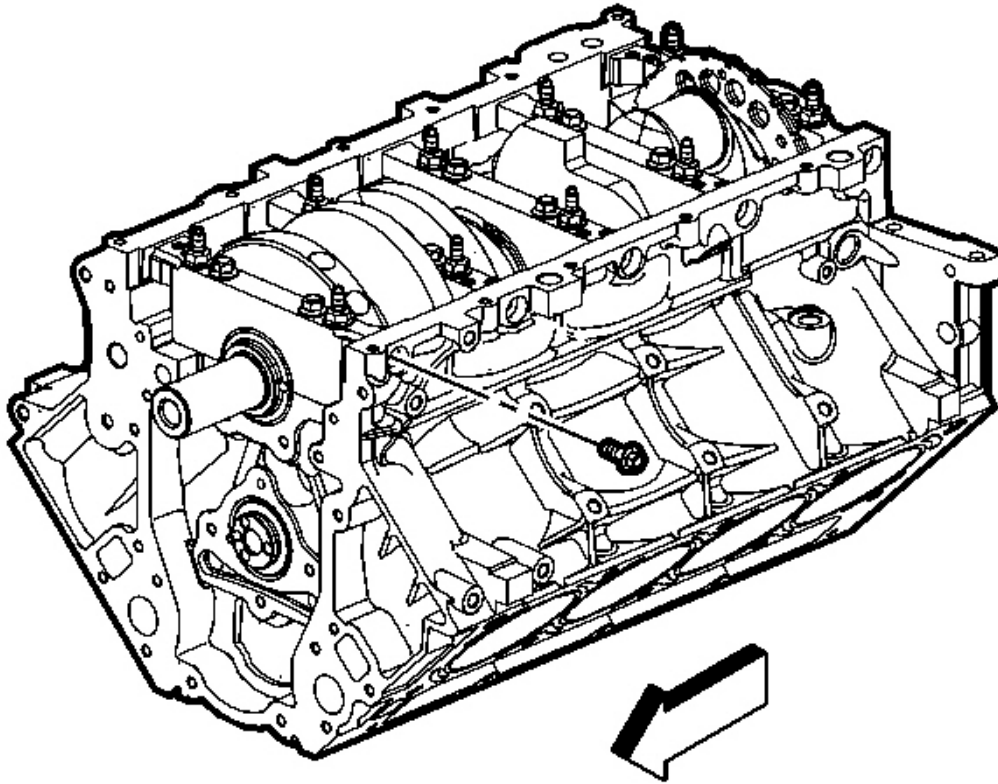
**Fig. 387: Main Cap Bolt Hole Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

7. Install the bearing, bearing cap, bolts and bolt/studs.

**Tighten:**

1. Tighten the M10 bolts (1-10) a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the M10 bolts (1-10) a final pass in sequence to 80 degrees using the **J 45059** . See **Special Tools and Equipment** .
3. Tighten the M10 studs (11-20) a first pass in sequence to 20 N.m (15 lb ft).
4. Tighten the M10 studs (11-20) a final pass in sequence to 53 degrees using the **J 45059** . See **Special Tools and Equipment** .
5. Tighten the M8 bolts to 25 N.m (18 lb ft).

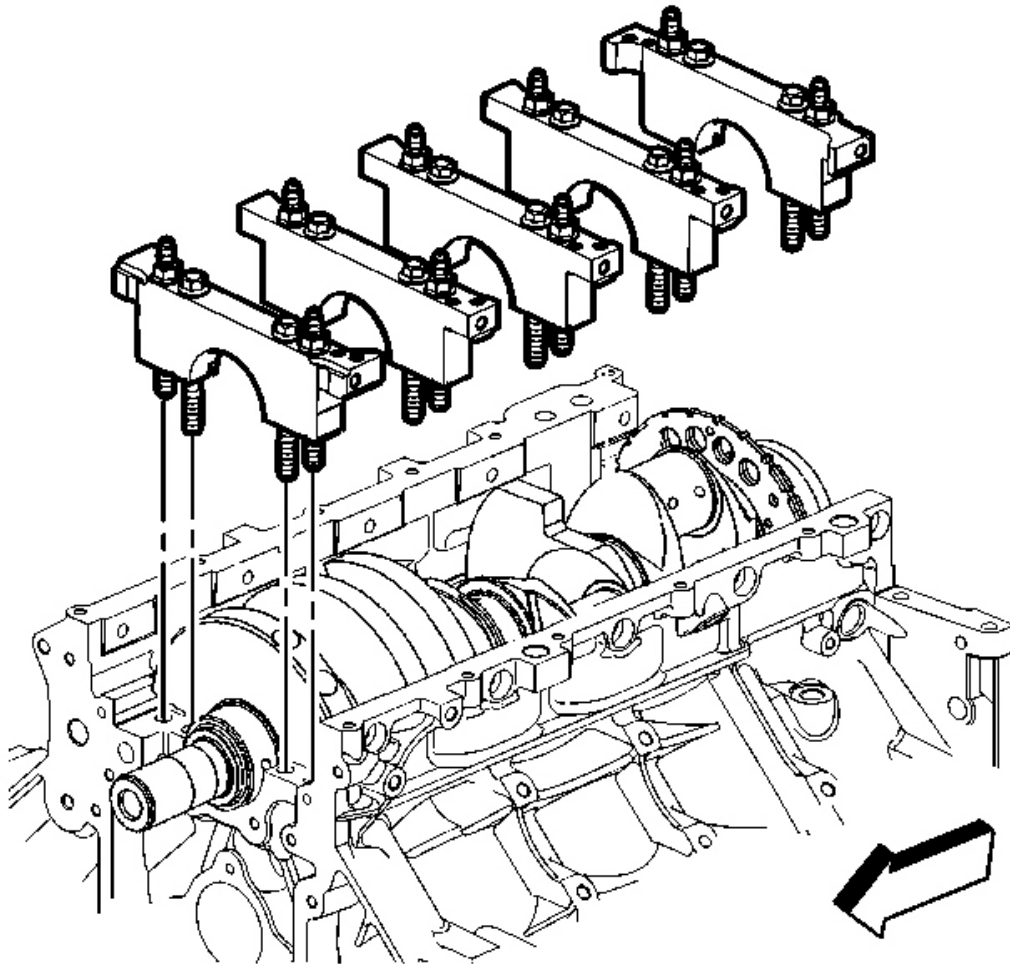
Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.



**Fig. 388: Bearing Cap Bolts & Studs**  
Courtesy of GENERAL MOTORS CORP.

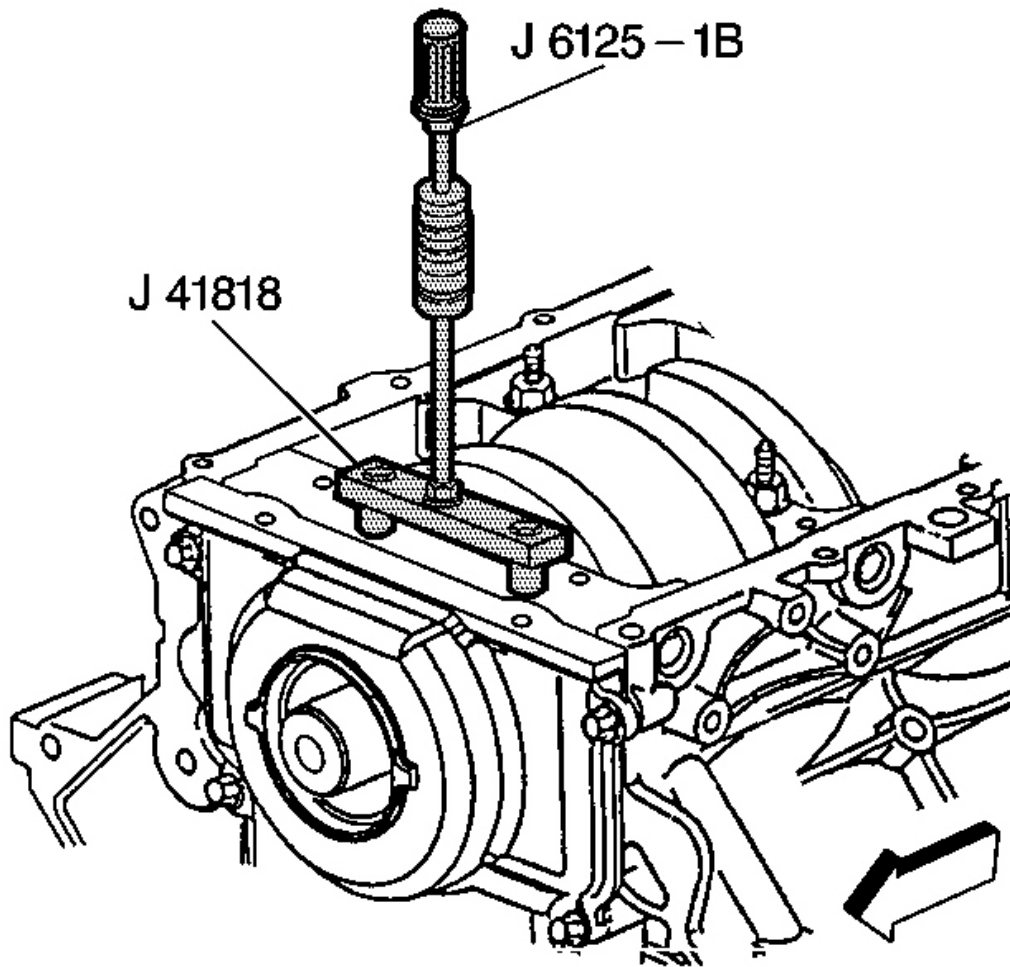
**IMPORTANT: Remove the bearing cap side bolts prior to cap removal.**

8. Remove the bearing cap M8 bolts.



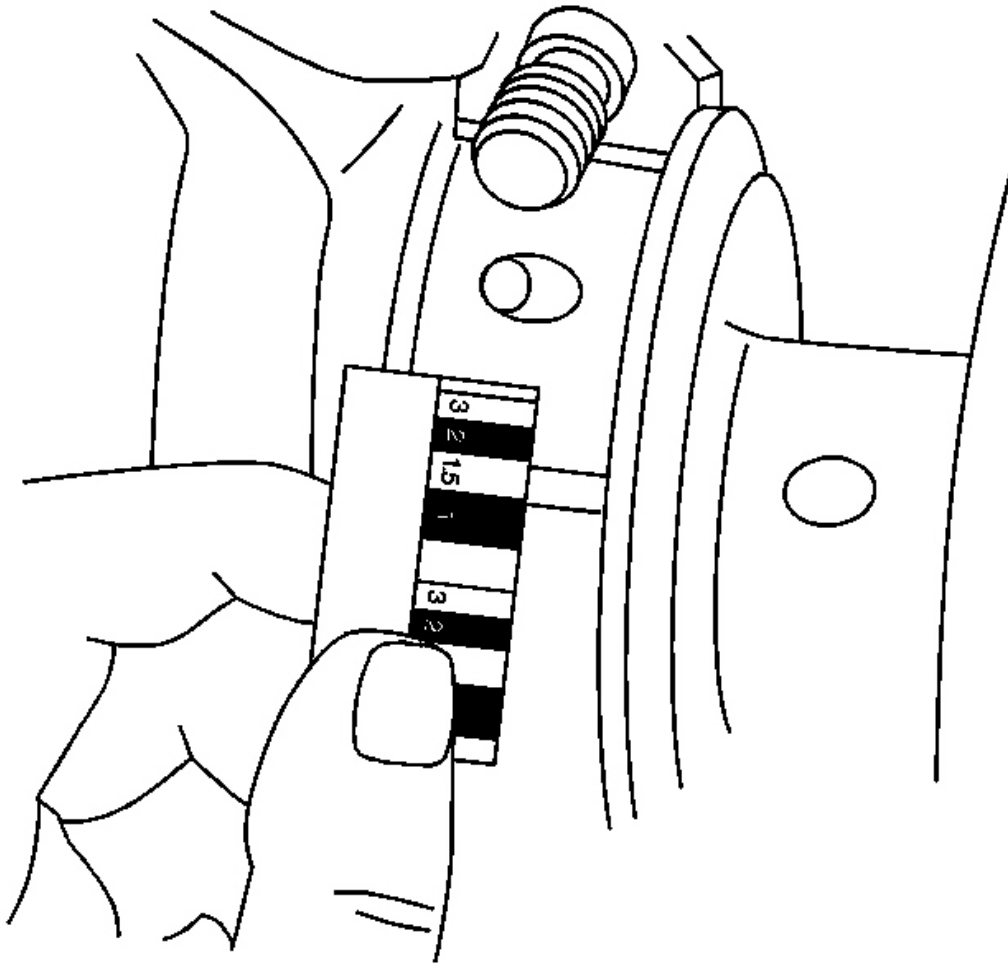
**Fig. 389: View Of Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the bearing cap M10 bolts and studs.



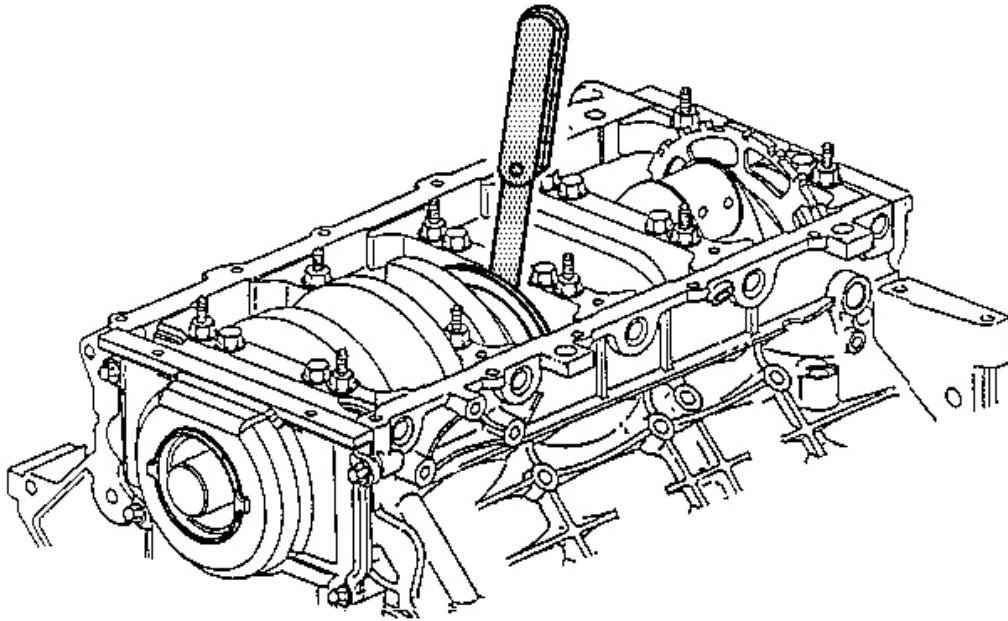
**Fig. 390: View Of J 6125-1B & J 41818**  
Courtesy of GENERAL MOTORS CORP.

10. Use the J 41818 and the J 6125-1B in order to remove the bearing cap. See **Special Tools and Equipment** .



**Fig. 391: Measuring Gaging Plastic On Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

11. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.
  - If the gaging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
  - If the bearing clearance is greater than 0.065 mm (0.0025 in), select and install an undersized bearing set, and measure the clearance with gaging plastic.
  - If clearance cannot be brought to specifications, replace the crankshaft or grind the crankshaft for use with the next undersized bearing.



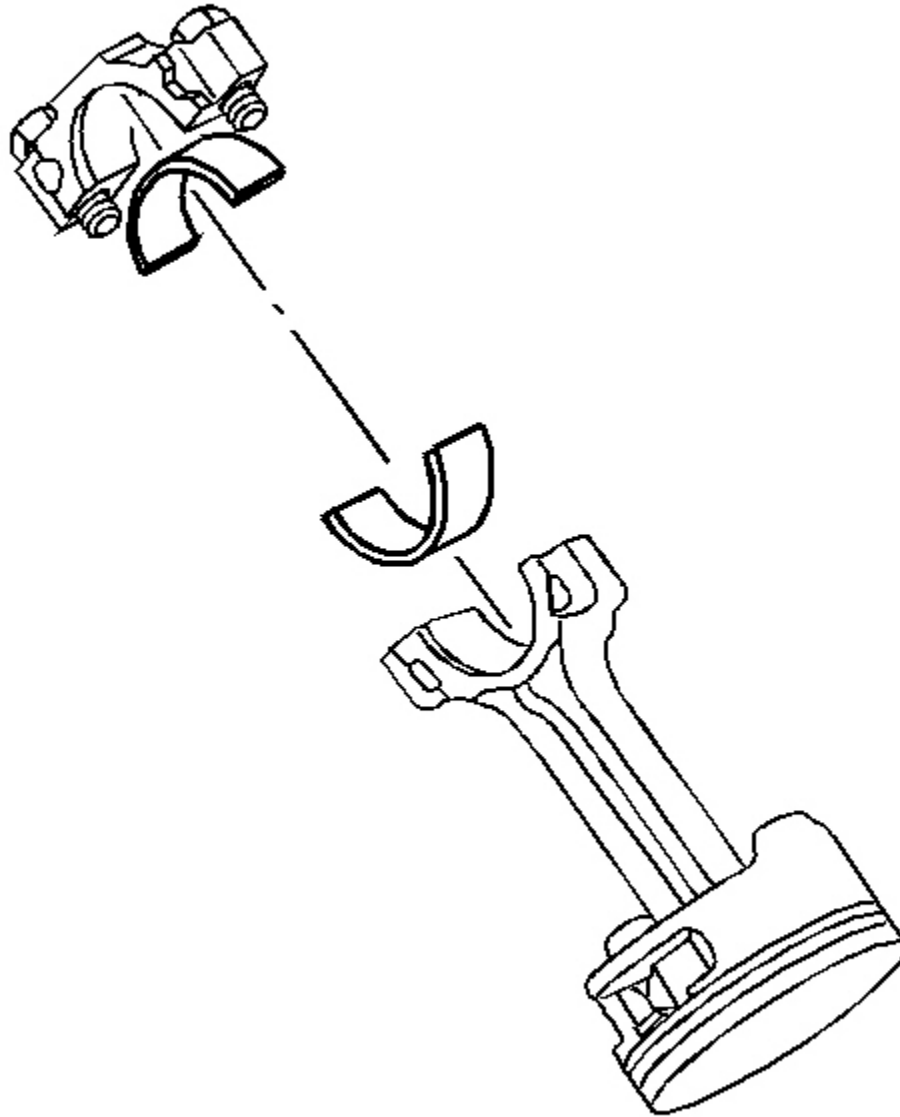
**Fig. 392: Measuring Crankshaft End Play**  
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft end play.
  1. Thrust the crankshaft forward or rearward.
  2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

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.
  - Replace the thrust bearings and measure the end play.
  - If the correct measurements cannot be obtained, repair the crankshaft thrust surfaces or replace the crankshaft.

**Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method**



**Fig. 393: Connecting Rod & Bolts**  
Courtesy of GENERAL MOTORS CORP.

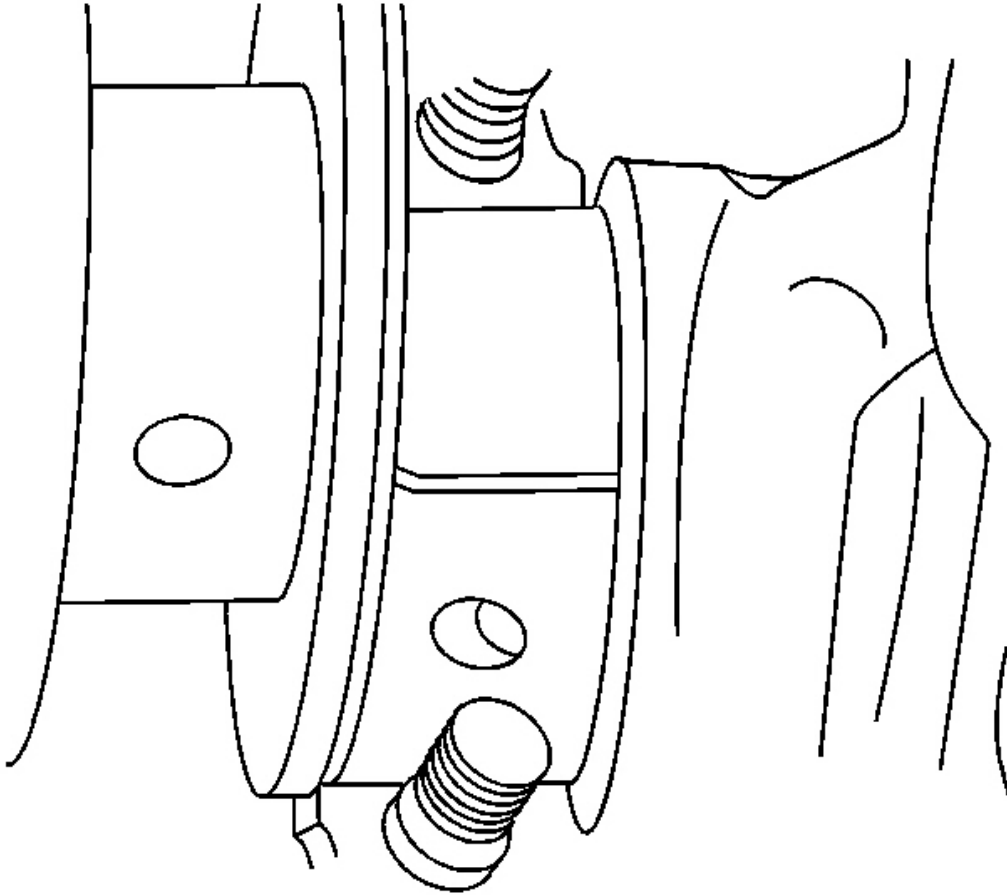
**IMPORTANT:**

- Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required.



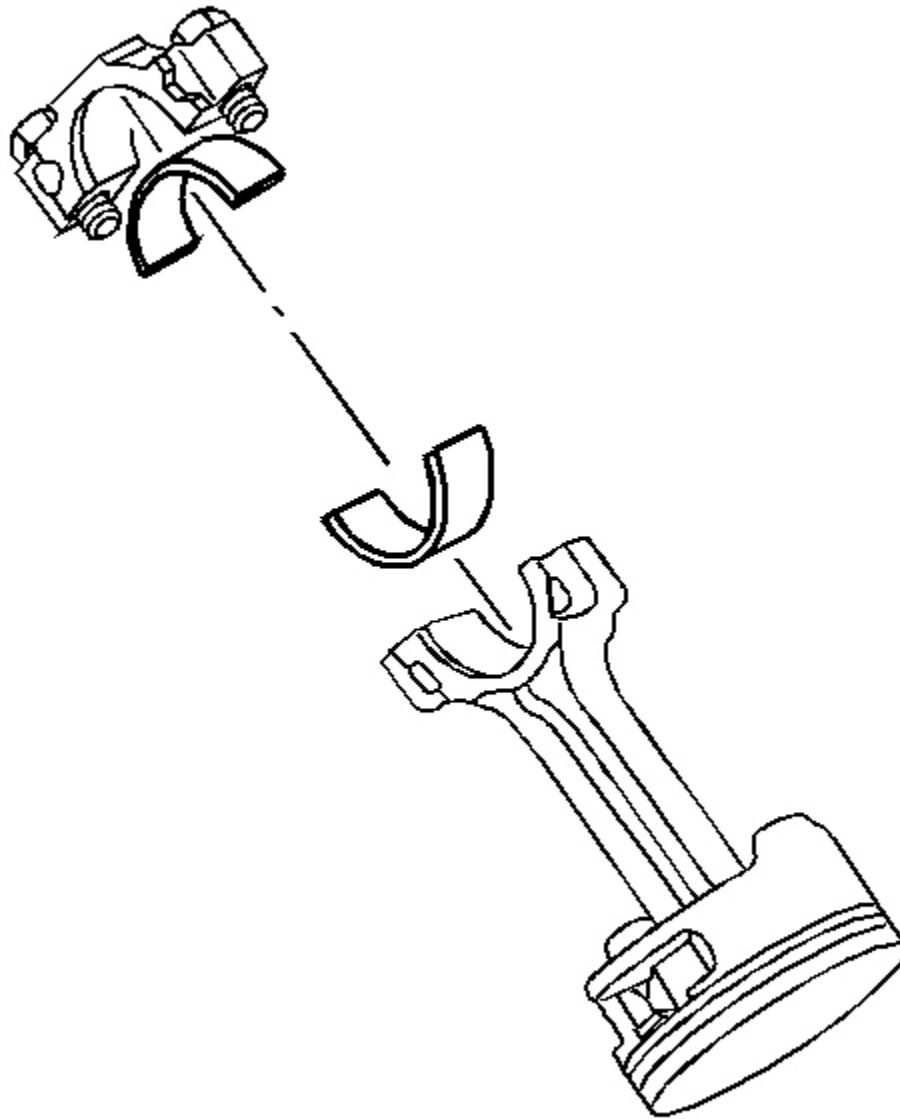
- Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.

1. Remove the bearing cap, bearing half and bolts.



**Fig. 394: Gaging Plastic Installed On Crankshaft Journal**  
Courtesy of GENERAL MOTORS CORP.

2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.



**Fig. 395: Connecting Rod & Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Install the bearing cap, bearing, and bolts.

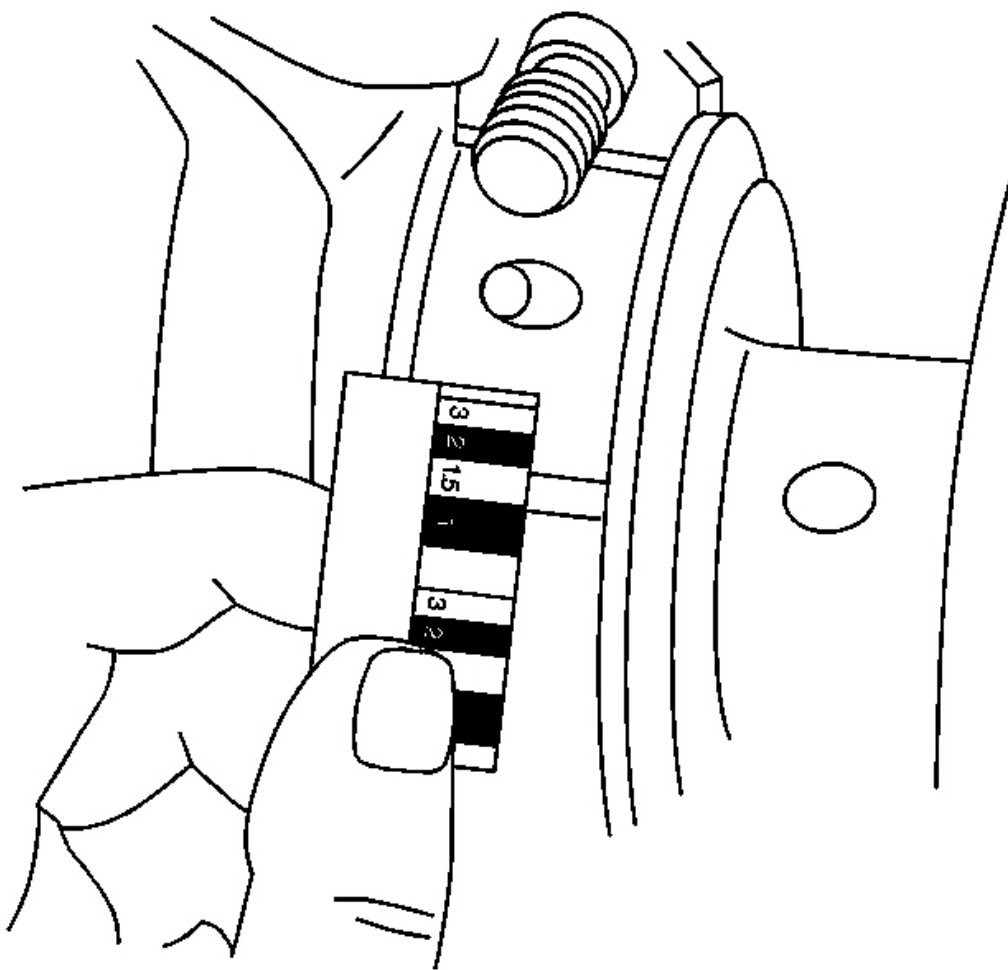
**Tighten:**

1. Tighten the connecting rod bolts first pass to 20 N.m (15 lb ft).

2. Tighten the connecting rod bolts a final pass to 75 degrees using the **J 45059** . See **Special Tools and Equipment** .

Refer to **Piston, Connecting Rod, and Bearing Installation** .

4. Remove the bearing cap, bearing, and bolts.



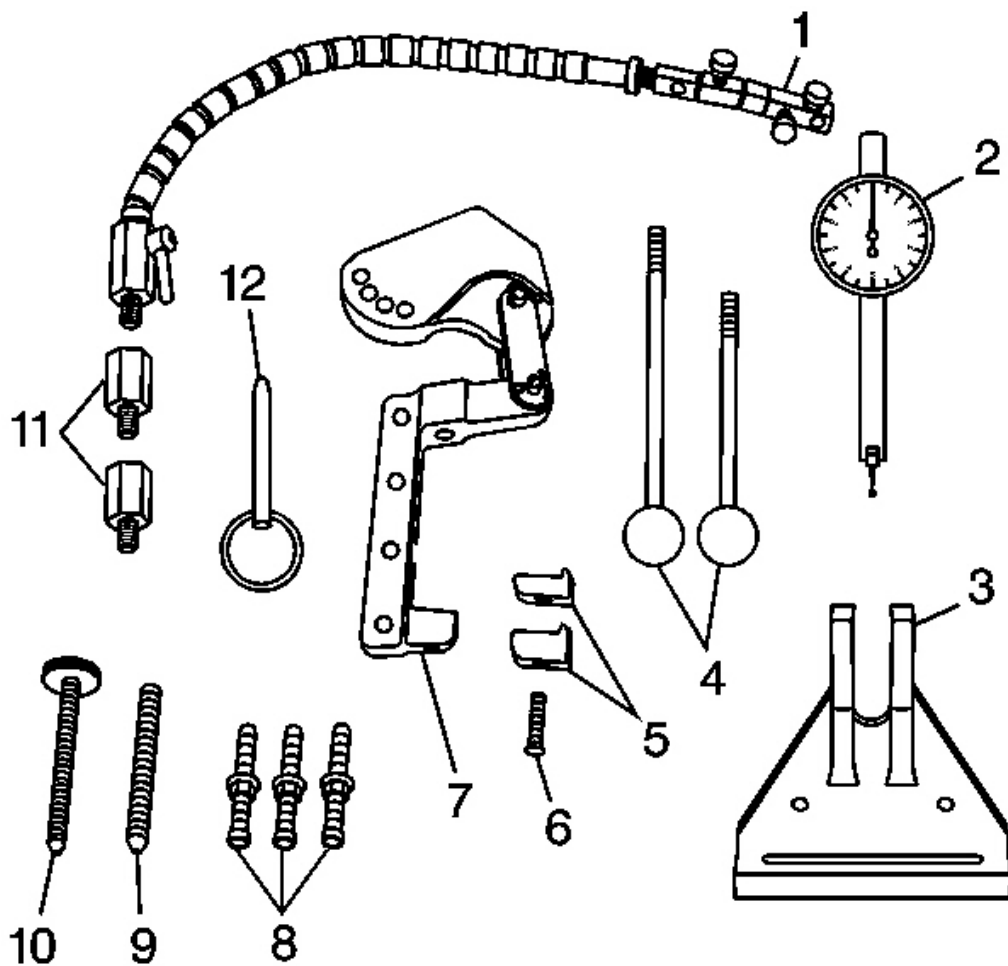
**Fig. 396: Measuring Gaging Plastic On Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.

The connecting rod bearing clearance should be 0.023-0.076 mm (0.0009-0.003 in).

## Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

**J 43690** and **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer. See **Special Tools and Equipment** .



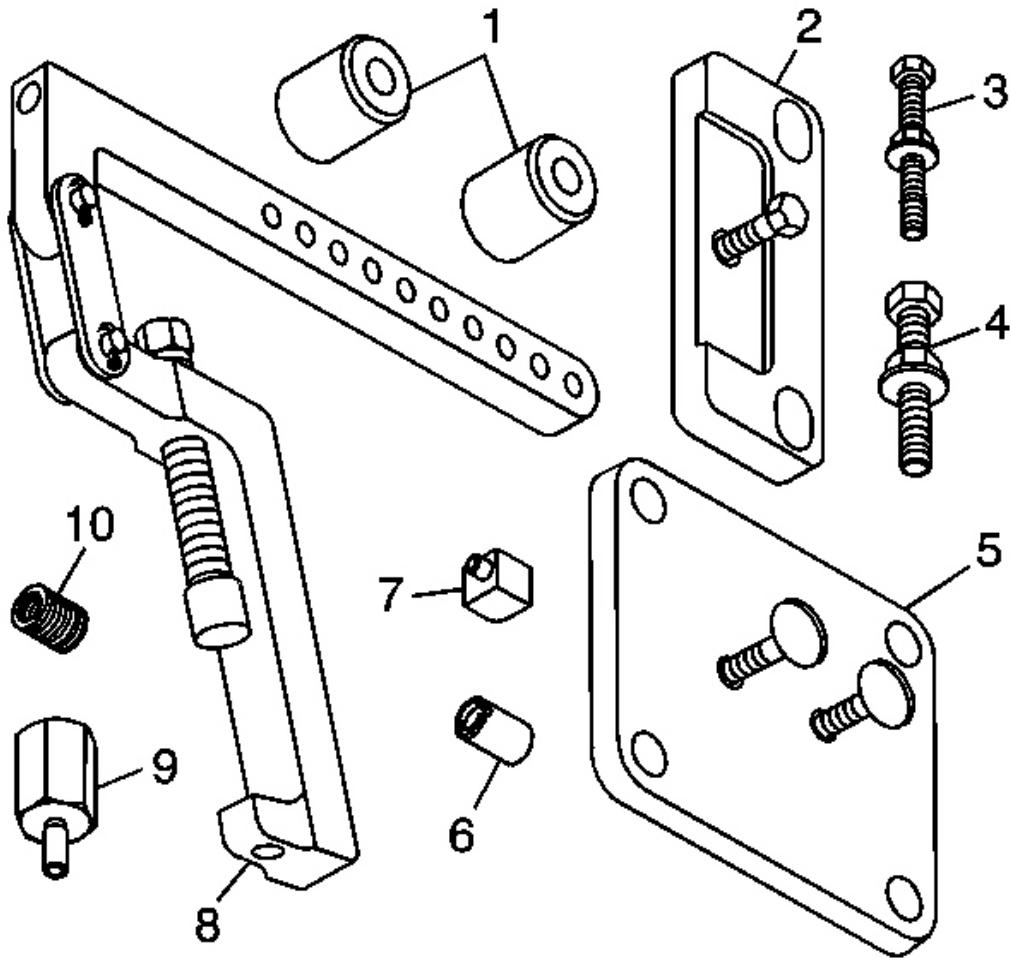
**Fig. 397: View Of J 43690**

Courtesy of GENERAL MOTORS CORP.

### Rod Bearing Checking Tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)

- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

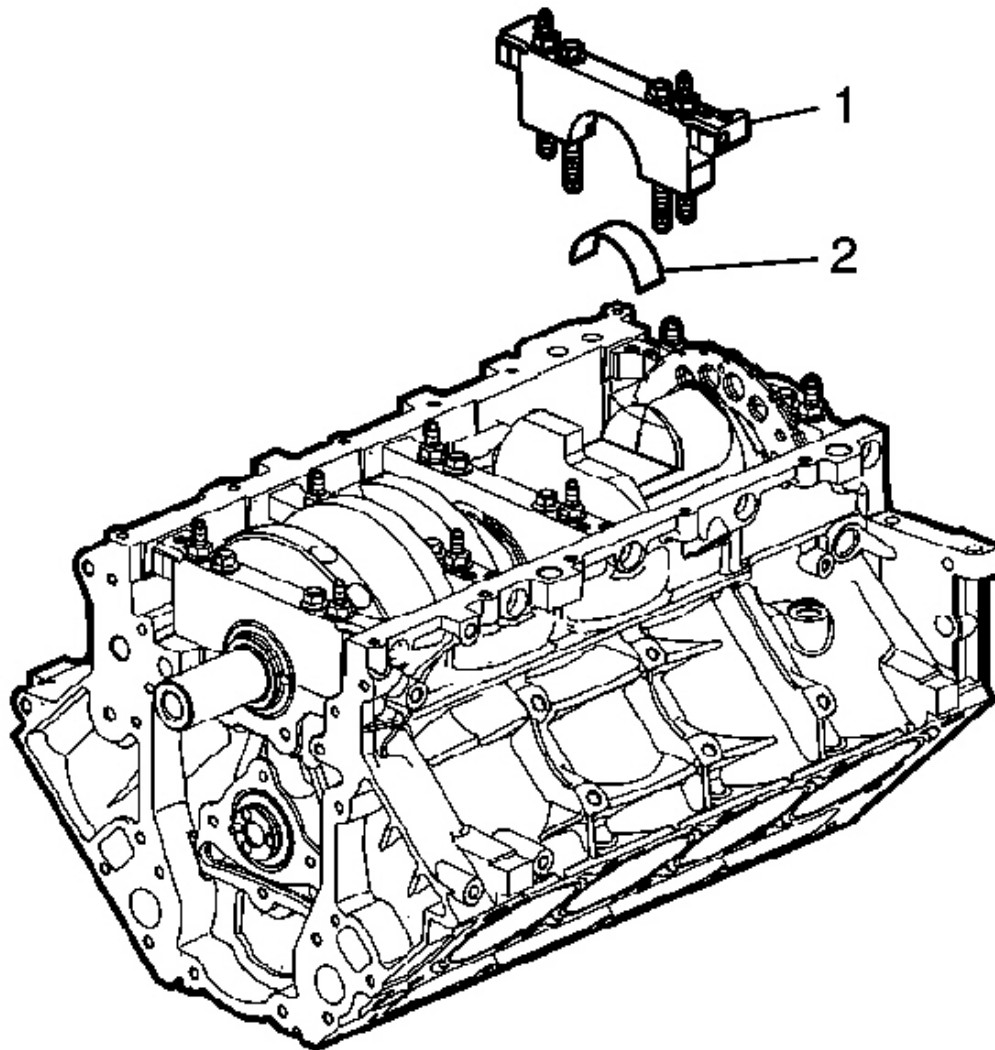


**Fig. 398: View Of J 43690-100**

**Courtesy of GENERAL MOTORS CORP.**

**Rod Bearing Checking Tool - Adapter Kit**

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

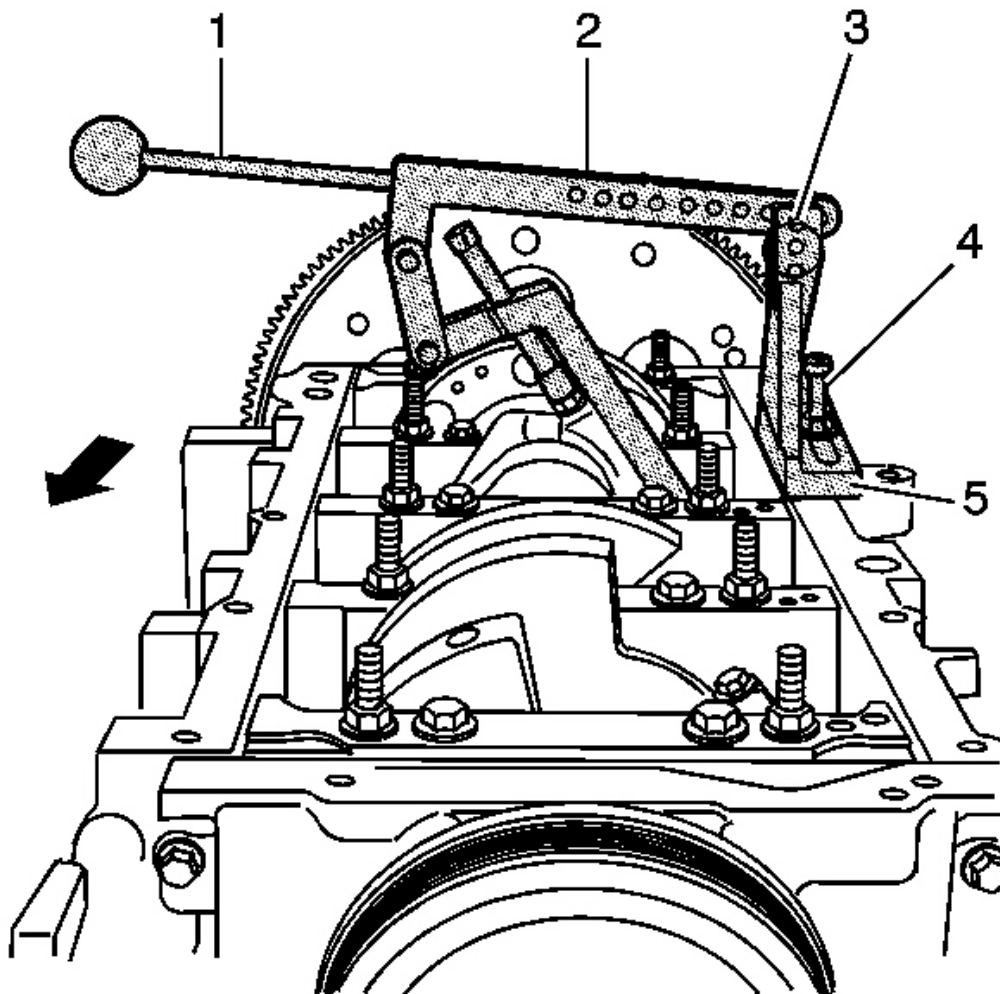


**Fig. 399: Bearing Cap Bolt & Bearing Half**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).

4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to **Fastener Tightening Specifications** .

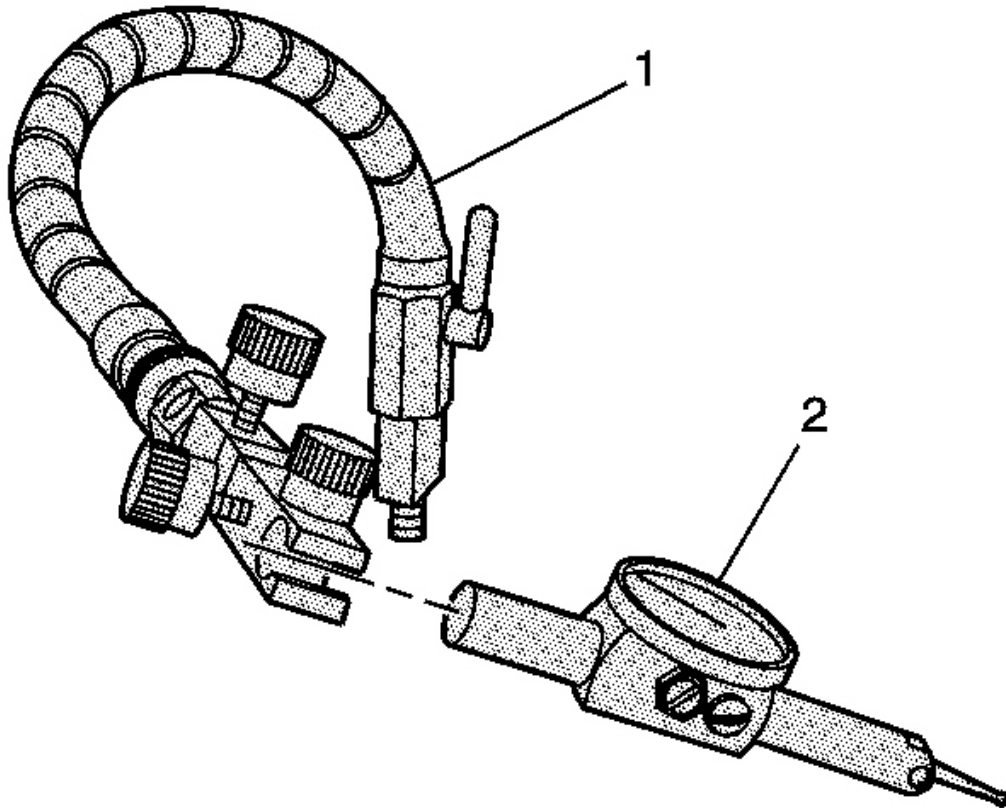


**Fig. 400: J 43690-2, J 43690-3, J 43690-101, 280310 & J 43690-5**  
**Courtesy of GENERAL MOTORS CORP.**

6. Install the following:
  1. J 43690-2 (5)
  2. J 43690-3 (4)
  3. J 43690-101 (2)



4. 280310 (3)
5. J 43690-5 (1)

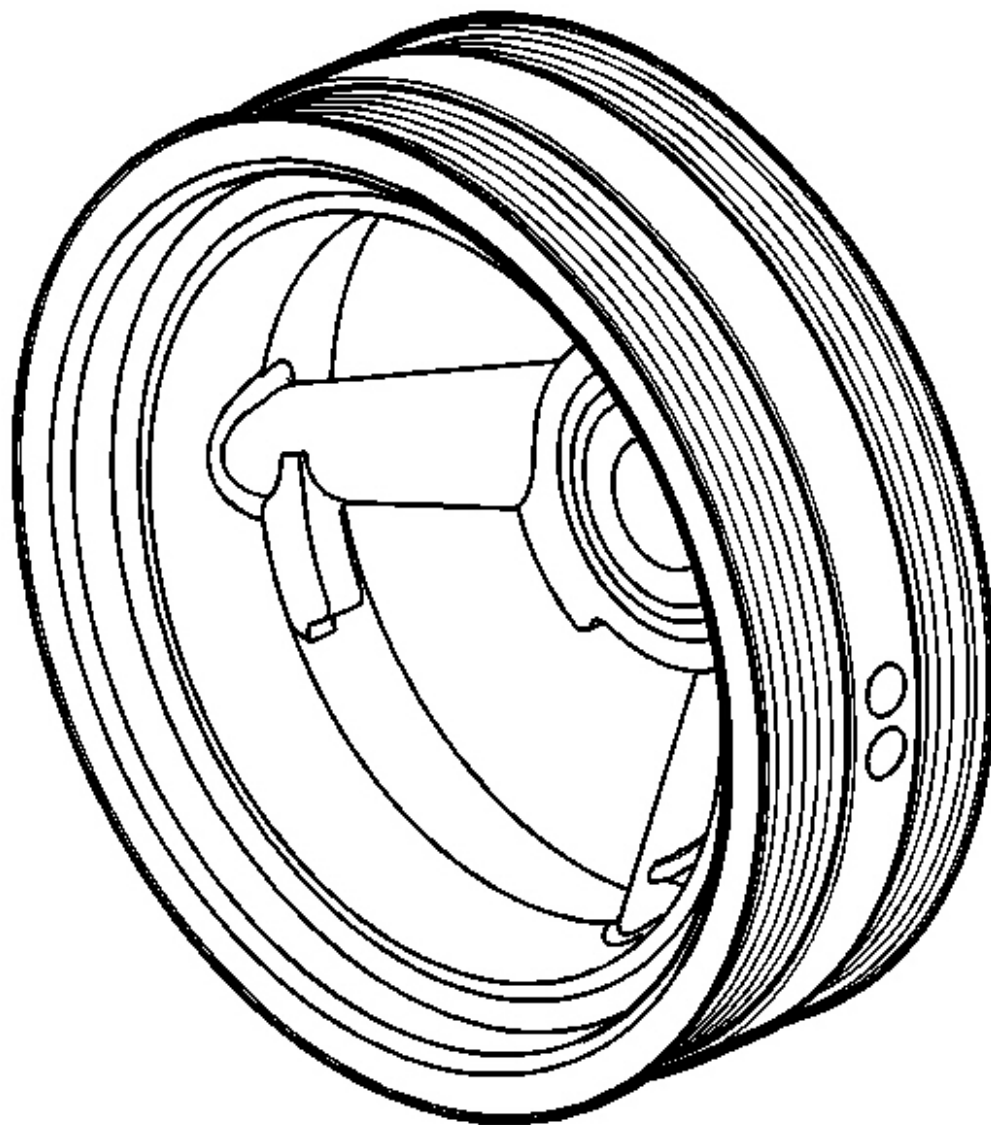


**Fig. 401: Identifying Swivel Base & Indicator**  
Courtesy of GENERAL MOTORS CORP.

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components as required.

## **CRANKSHAFT BALANCER CLEANING AND INSPECTION**



**Fig. 402: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:

- Worn, grooved, or damaged hub seal surface

A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

**IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.**

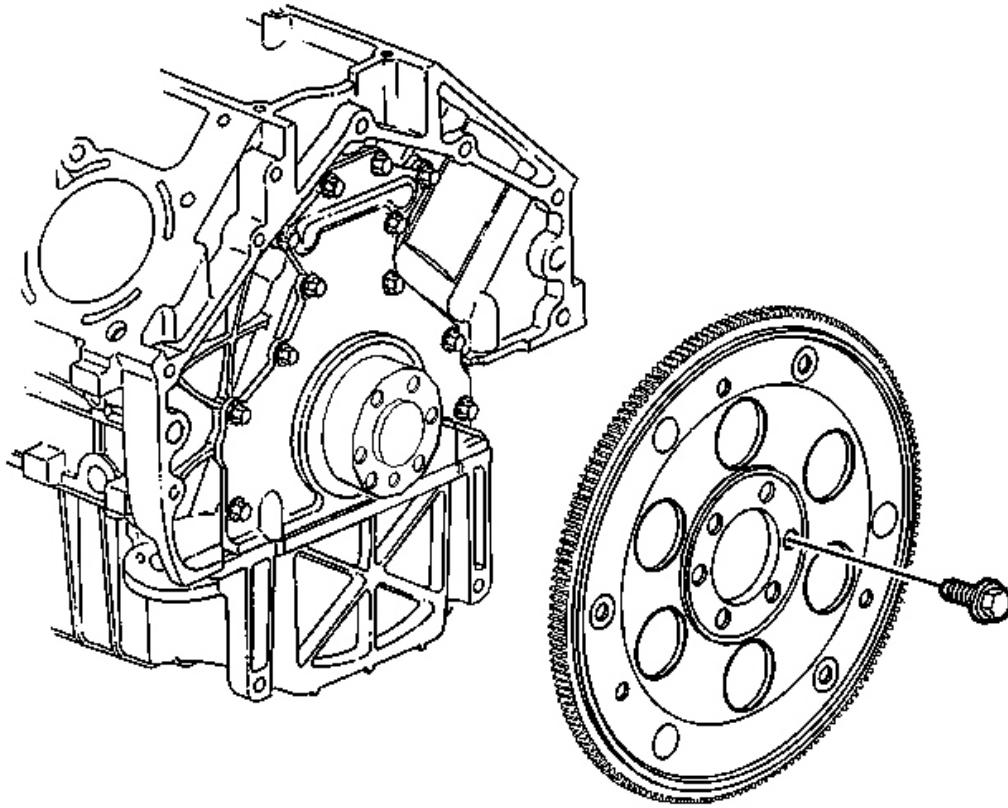
- Dirty or damaged belt grooves

The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

Minor imperfections may be removed with a fine file.

- Worn, chunking or deteriorated rubber between the hub and pulley

## **ENGINE FLYWHEEL CLEANING AND INSPECTION**



**Fig. 403: Engine Flywheel & Bolts (Automatic Transmission)**  
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.
2. Dry the flywheel with compressed air.
3. Inspect the automatic transmission flywheel for the following conditions:
  - Damaged ring gear teeth
  - Stress cracks around the flywheel-to-crankshaft bolt hole locations

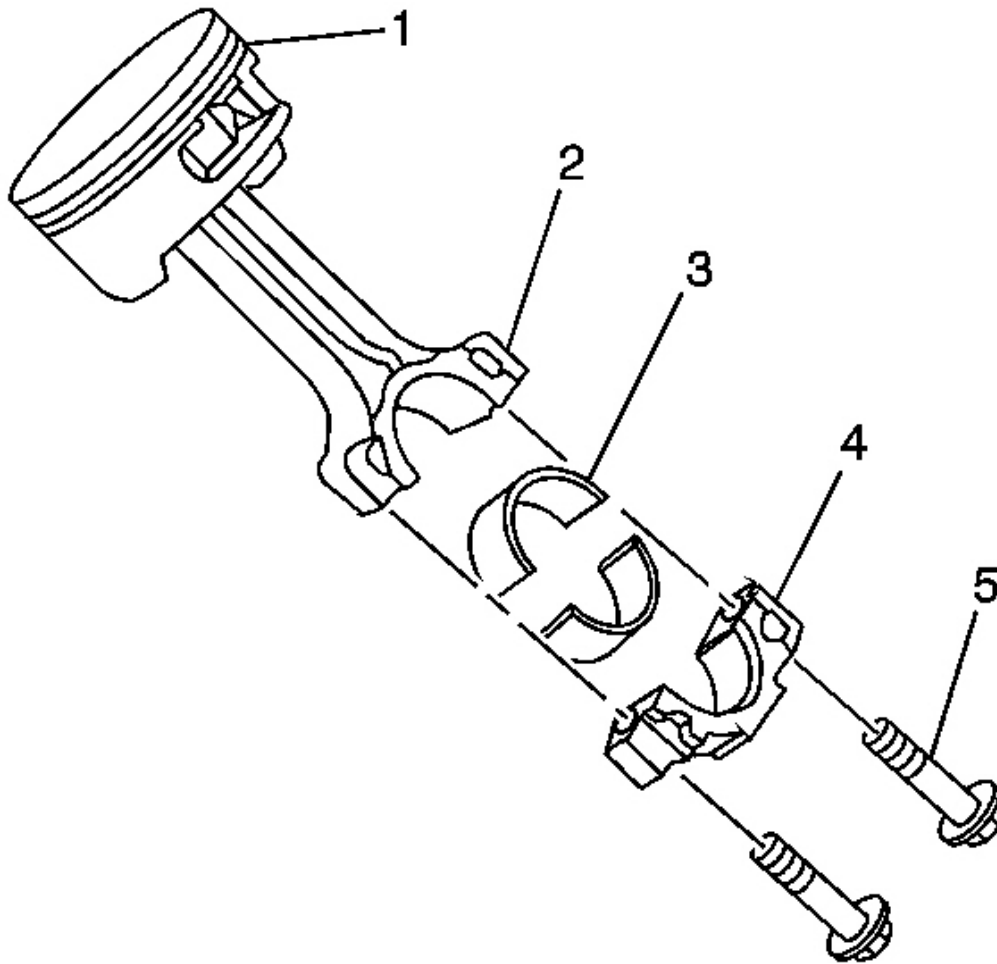
**IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.**

- Welded areas that retain the ring gear onto the flywheel for cracking

## Press-Fit Piston Pin

### Tools Required

**J 24086-C** Piston Pin Remover/Installer Set. See Special Tools and Equipment .



**Fig. 404: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

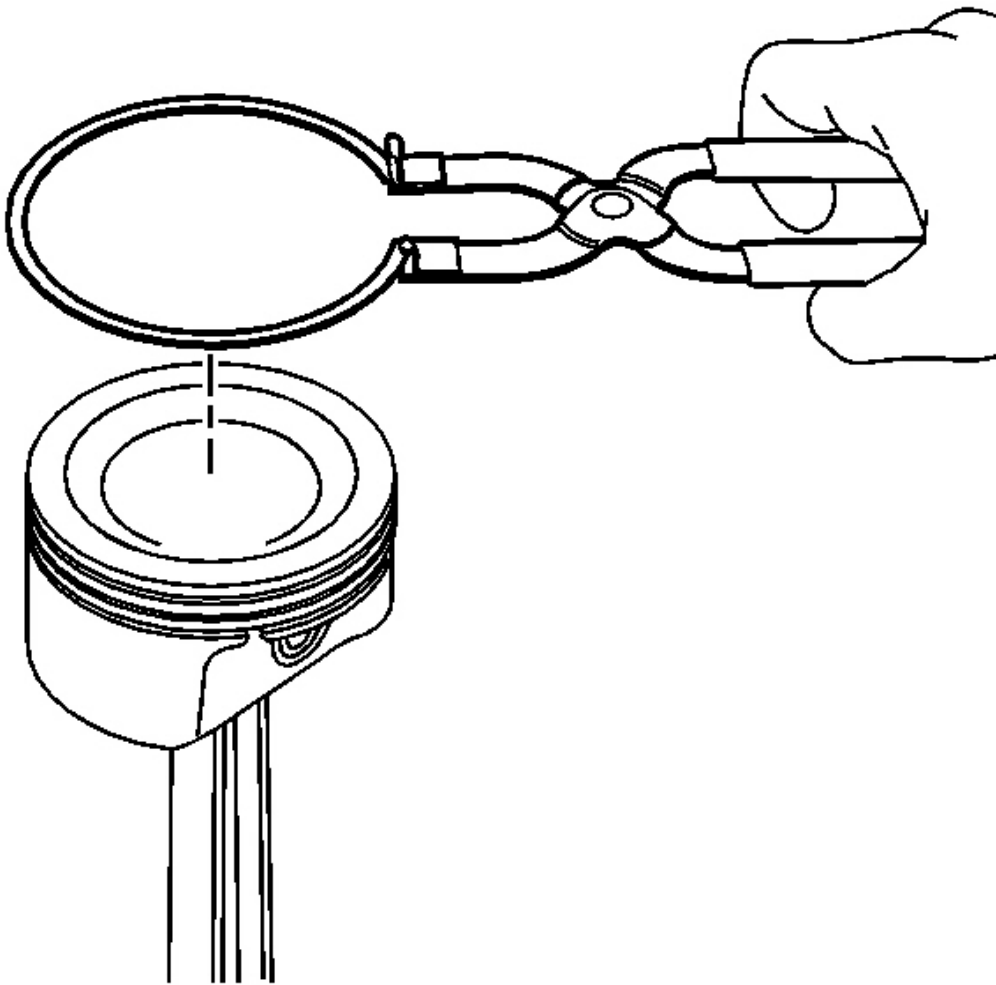
#### **IMPORTANT:**

- Disassembly of the piston, press-fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been

disassembled, replace the components as an assembly.

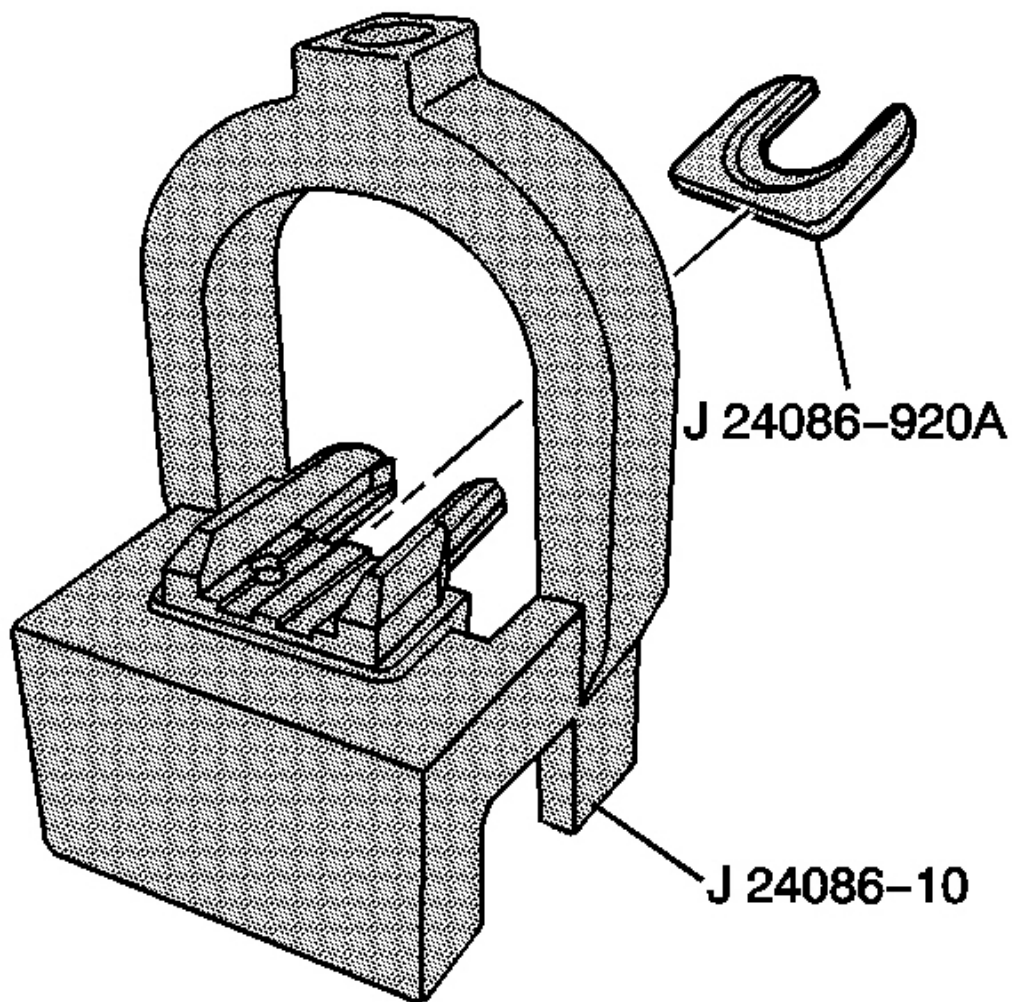
- The disassembly procedure, as shown, is to be used for diagnostic purposes only.

1. Remove the connecting rod bearings (3) from the rod (2) and cap (4).



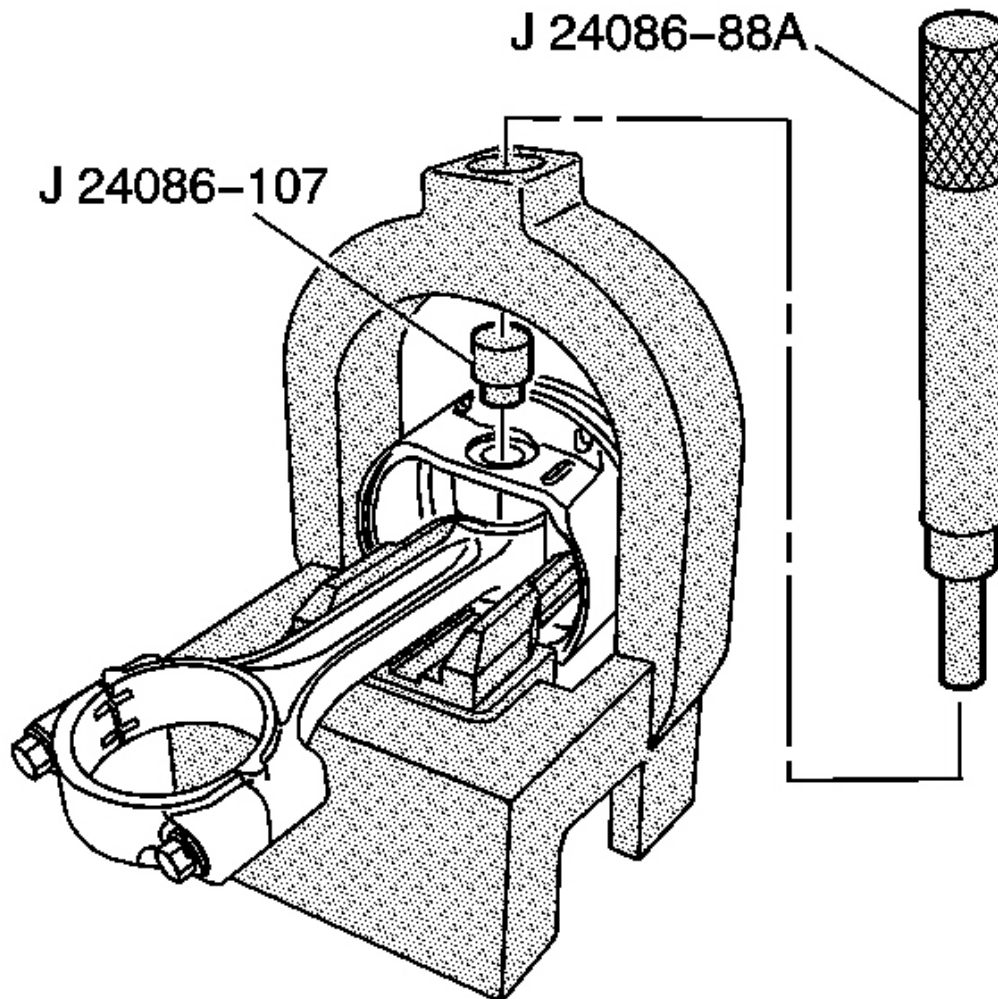
**Fig. 405: Piston Rings & Piston**  
Courtesy of GENERAL MOTORS CORP.

2. Using piston ring pliers, remove the piston rings from the piston.



**Fig. 406: View Of J 24086-920A & J 24086-10**  
Courtesy of GENERAL MOTORS CORP.

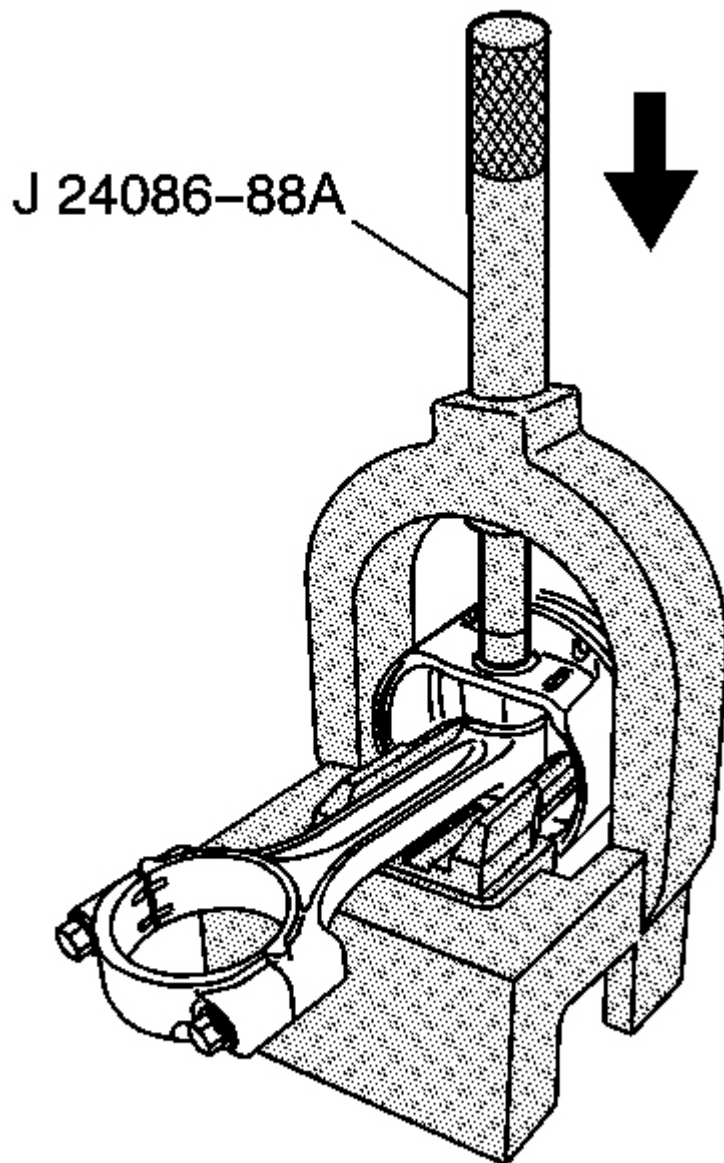
3. Install fork insert J 24086-920A into J 24086-10 . See Special Tools and Equipment .



**Fig. 407: Installing Piston & Connecting Rod Assembly Onto J 24086-10**  
Courtesy of GENERAL MOTORS CORP.

4. Install the piston and connecting rod assembly onto **J 24086-10** . See **Special Tools and Equipment** .
5. Install J 24086-107 to the piston pin.
6. Install J 24086-88A through the fixture and to the J 24086-107.



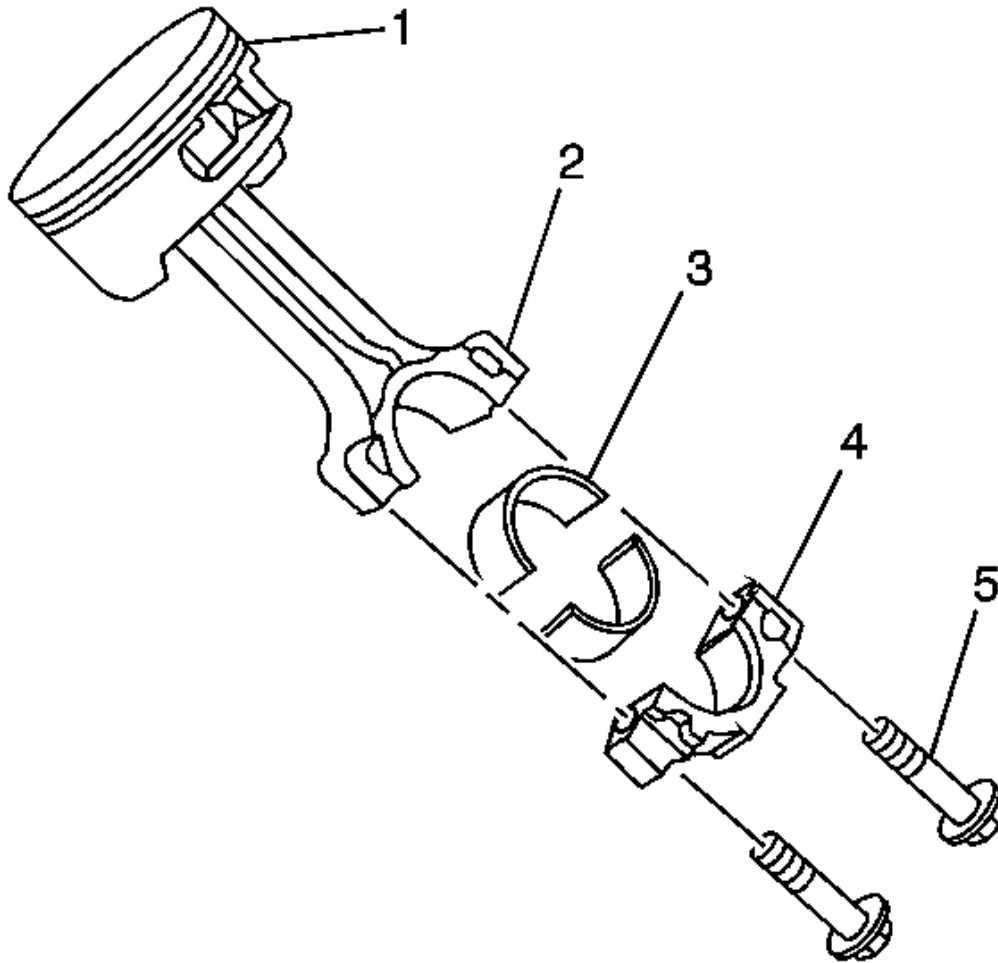


**Fig. 408: Pressing Piston Pin From Piston & Connecting Rod Assembly**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** After the installer hub bottoms on the support assembly, do not exceed 35 000 kPa (5,000 psi) pressure, this could cause damage to the tool.

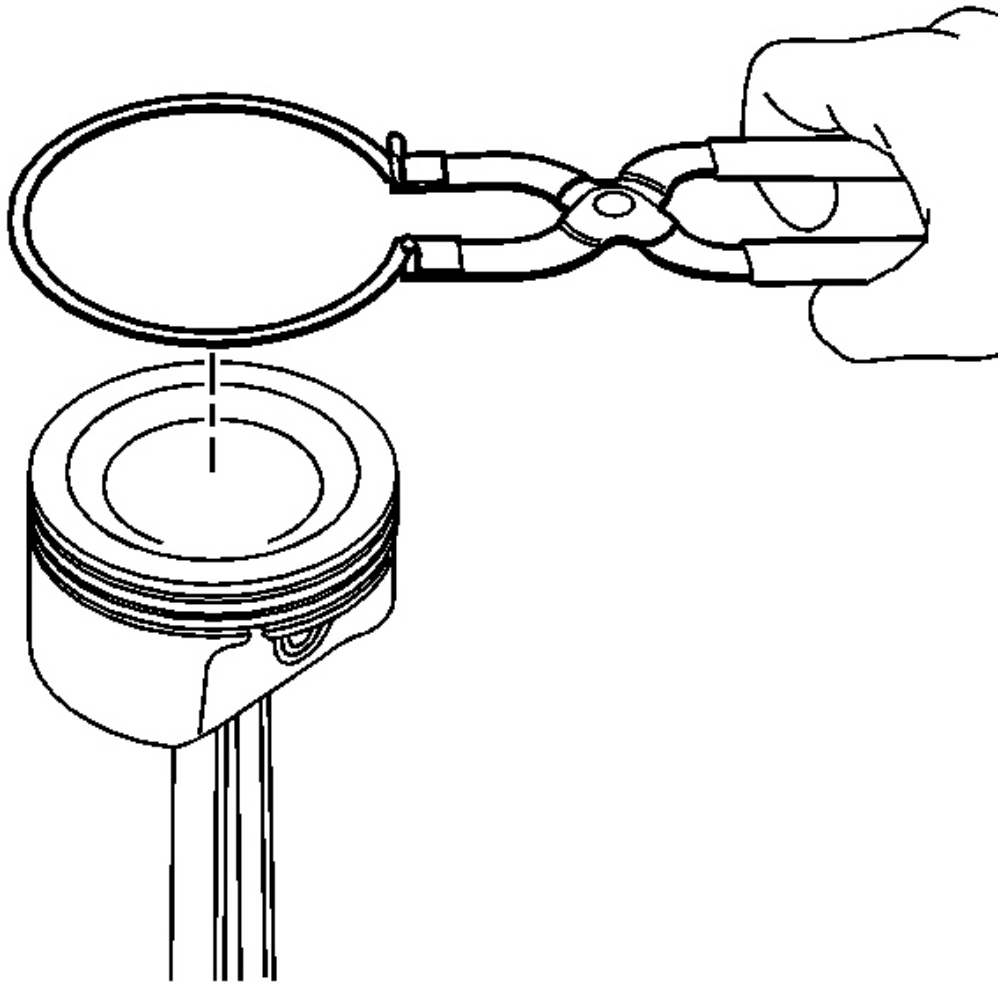
7. Press the piston pin from the piston and connecting rod assembly.

### Full-Floating Piston Pin



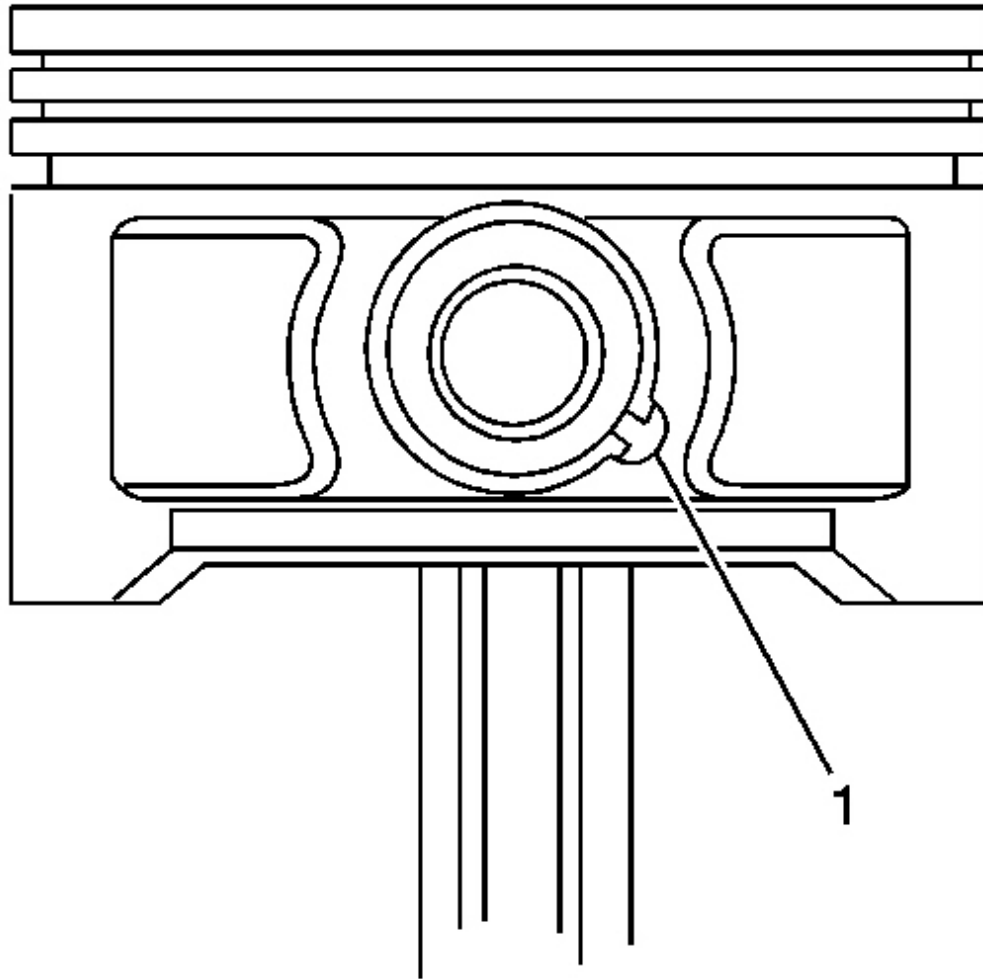
**Fig. 409: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings (3) from the rod (2) and cap (4).



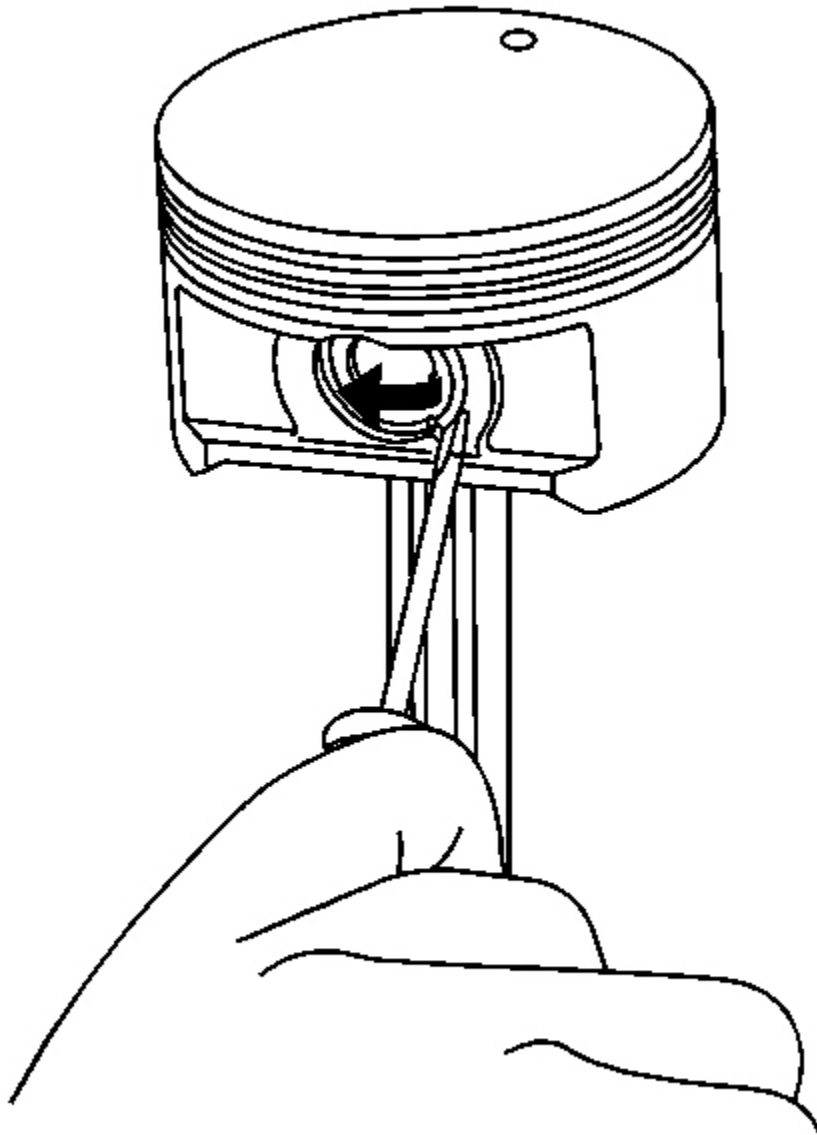
**Fig. 410: Piston Rings & Piston**  
Courtesy of GENERAL MOTORS CORP.

2. Using piston ring pliers, remove the piston rings from the piston.



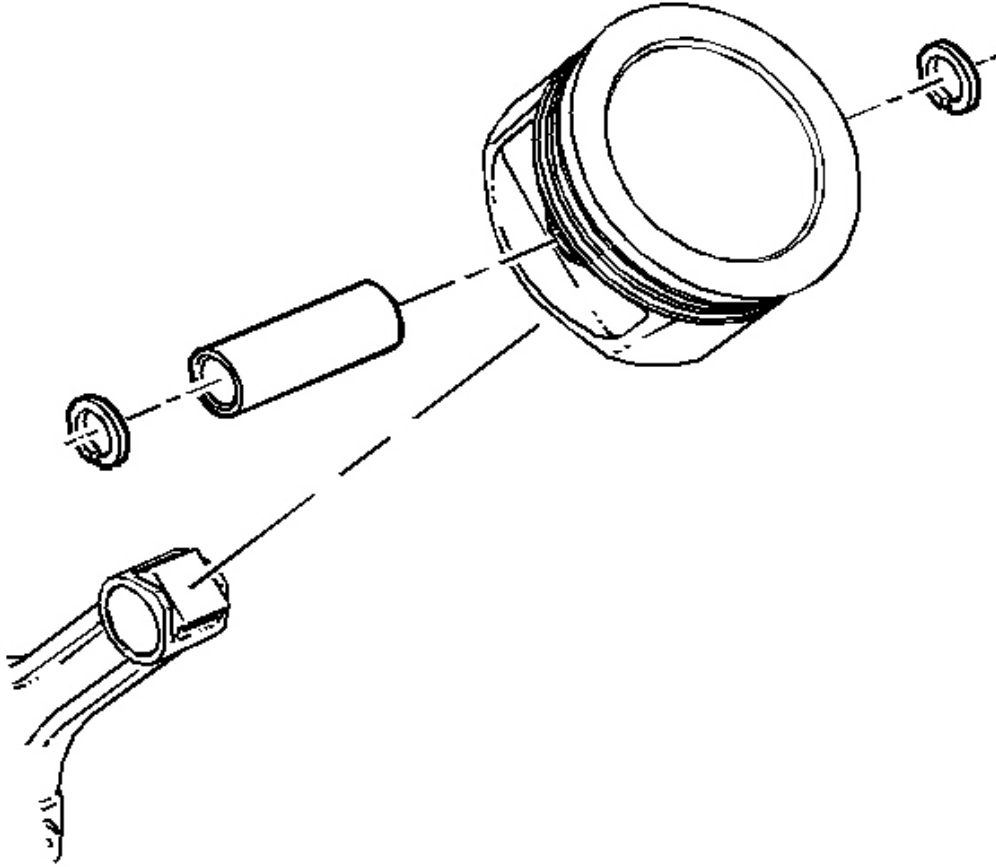
**Fig. 411: Piston Pin Retaining Clip Ring Gap & Cutout Area Of Pin Bore**  
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retaining clips until the ring end gap is positioned in the cutout area (1) of the pin bore.



**Fig. 412: Piston Pin Retaining Clips**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the clips starting in the cutout area of the pin bore.



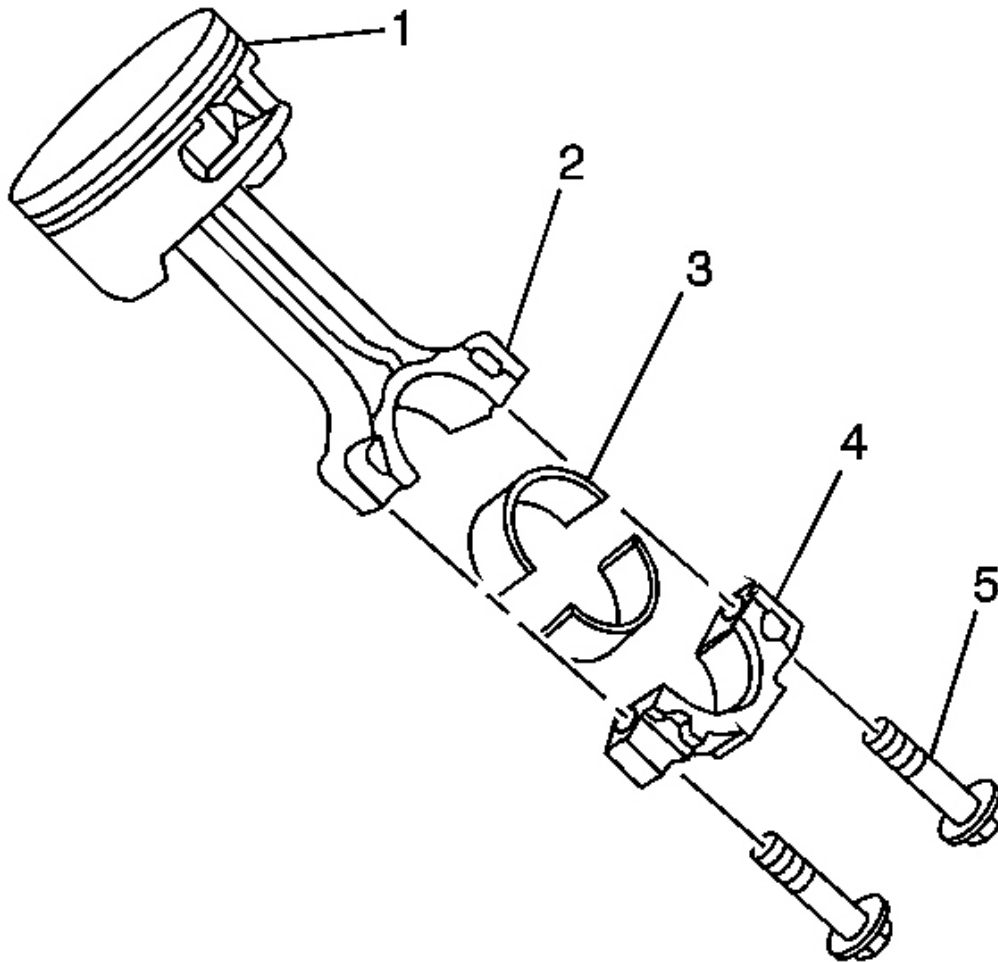
**Fig. 413: Identifying Piston & Components**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

Mark, sort, or organize the piston and the matching piston pin.

## **PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION**

### **Piston, Pin, and Piston Rings**



**Fig. 414: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

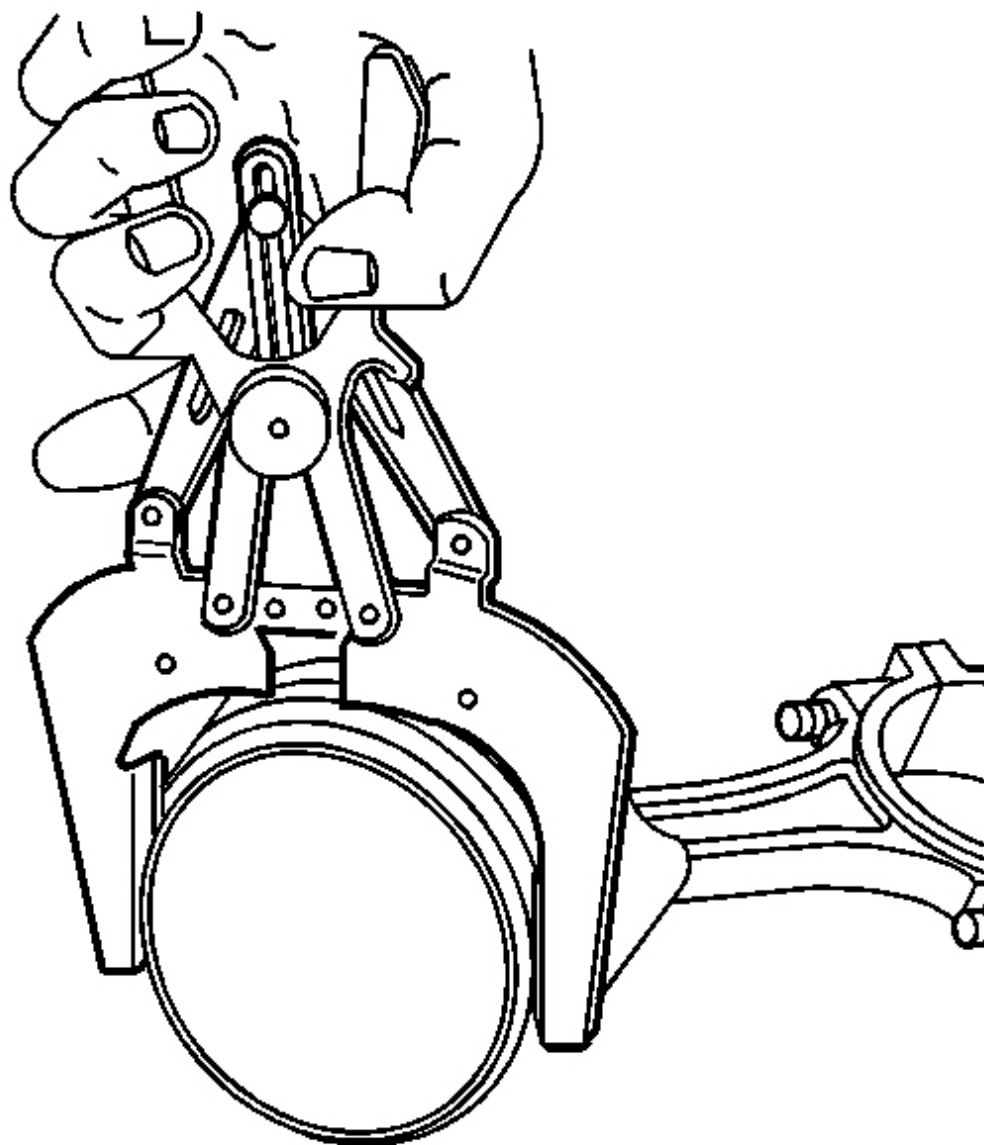
- Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.
- The first design press-fit piston, pin, and connecting rod are to be serviced as an assembly.
- Do not wire brush any part of the piston.
- Measurement of the components should be taken with the components at normal room temperature.

1. Clean the varnish and carbon from the piston (1) using cleaning solvent.

**CAUTION: Wear safety glasses in order to avoid eye damage.**

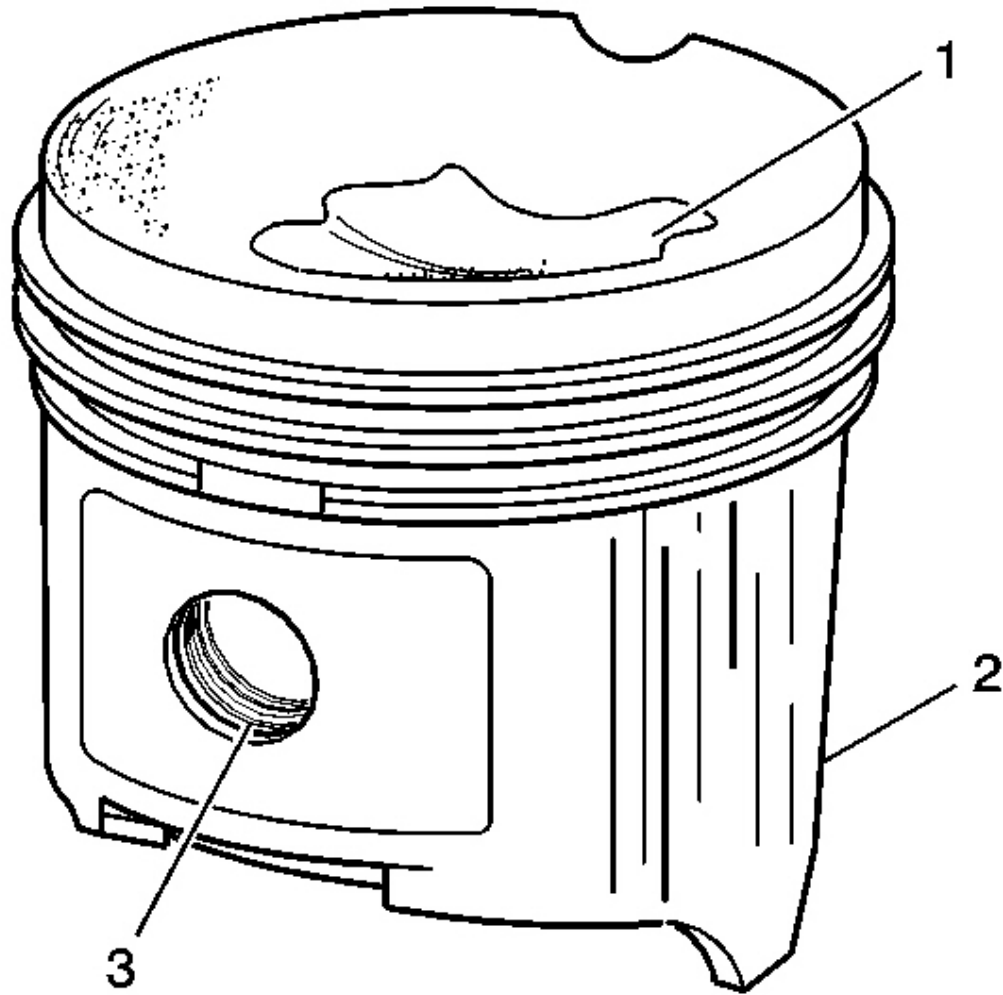
2. Dry the components with compressed air.





**Fig. 415: Cleaning Piston Ring Grooves**  
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.



**Fig. 416: Inspecting Piston For Damage**  
Courtesy of GENERAL MOTORS CORP.

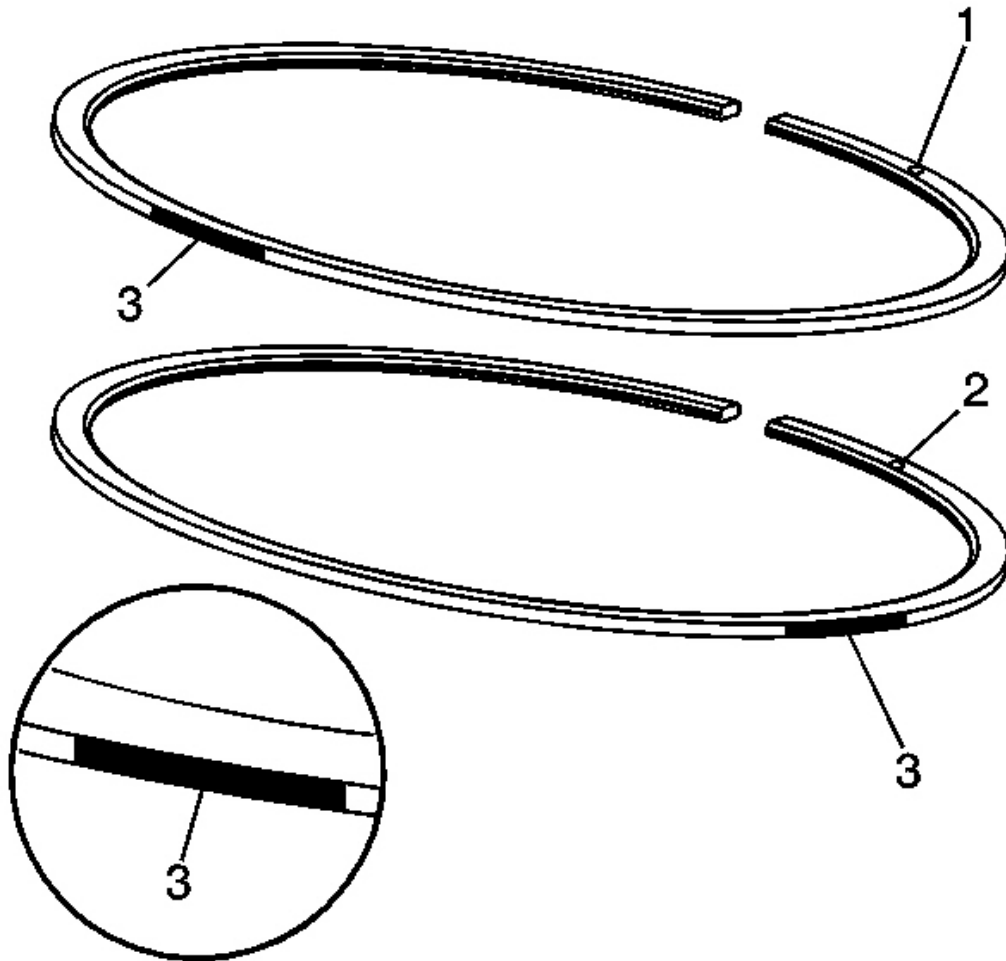
5. Inspect the piston for the following conditions:

- Cracks in the piston ring lands, the piston skirt, or pin bosses
- Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind

MINOR imperfections may be removed from the piston with a fine file.

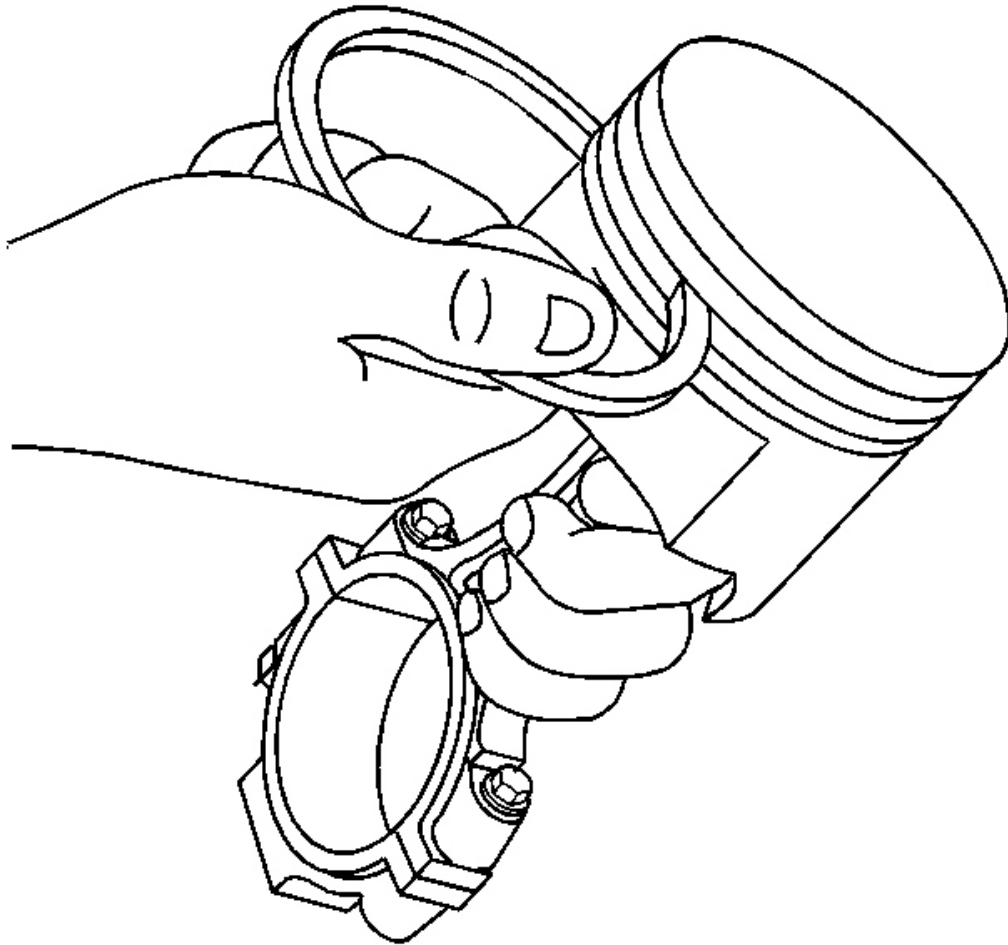
- Scuffed or damaged skirts (2)
- Eroded areas at the top of the piston (1)

- Scoring to the full-floating design piston pin bore (3) or piston pin



**Fig. 417: Upper & Lower Compression Rings & Marks**  
Courtesy of GENERAL MOTORS CORP.

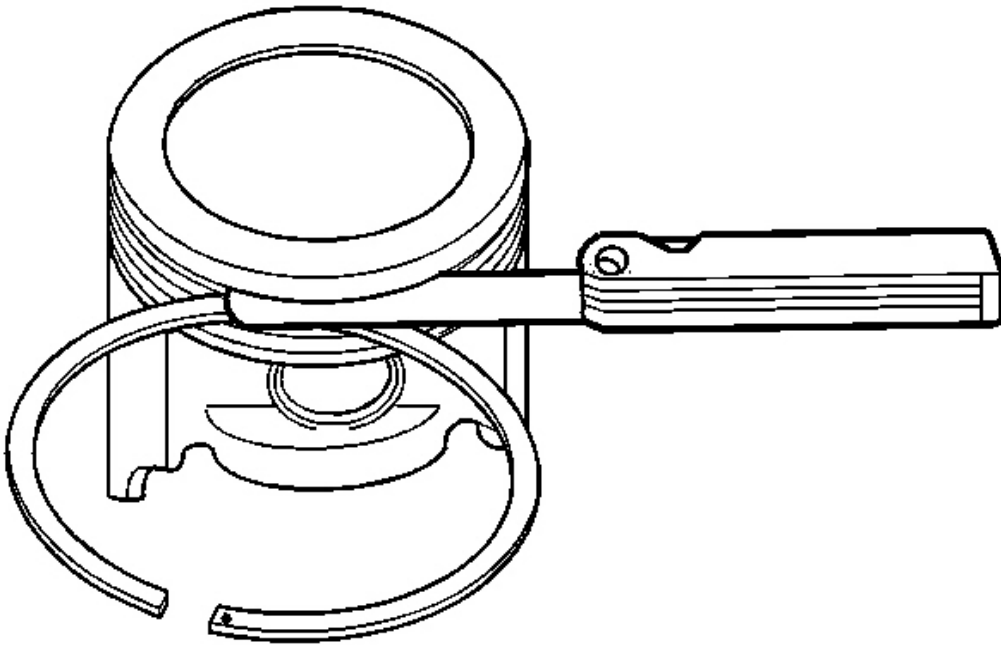
6. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



**Fig. 418: Measuring Piston Ring-To-Piston Ring Groove Side Clearance**  
Courtesy of GENERAL MOTORS CORP.

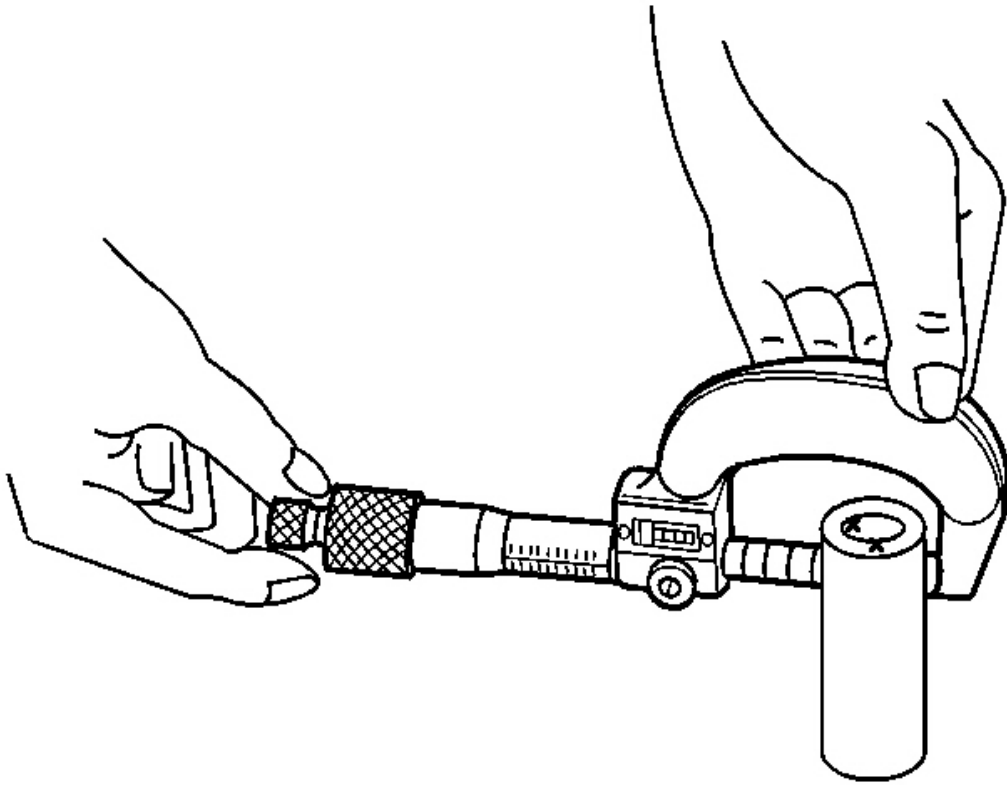
7. Insert the edge of the piston ring into the piston ring groove.

Roll the piston ring completely around the piston. If binding is caused by distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings as required.



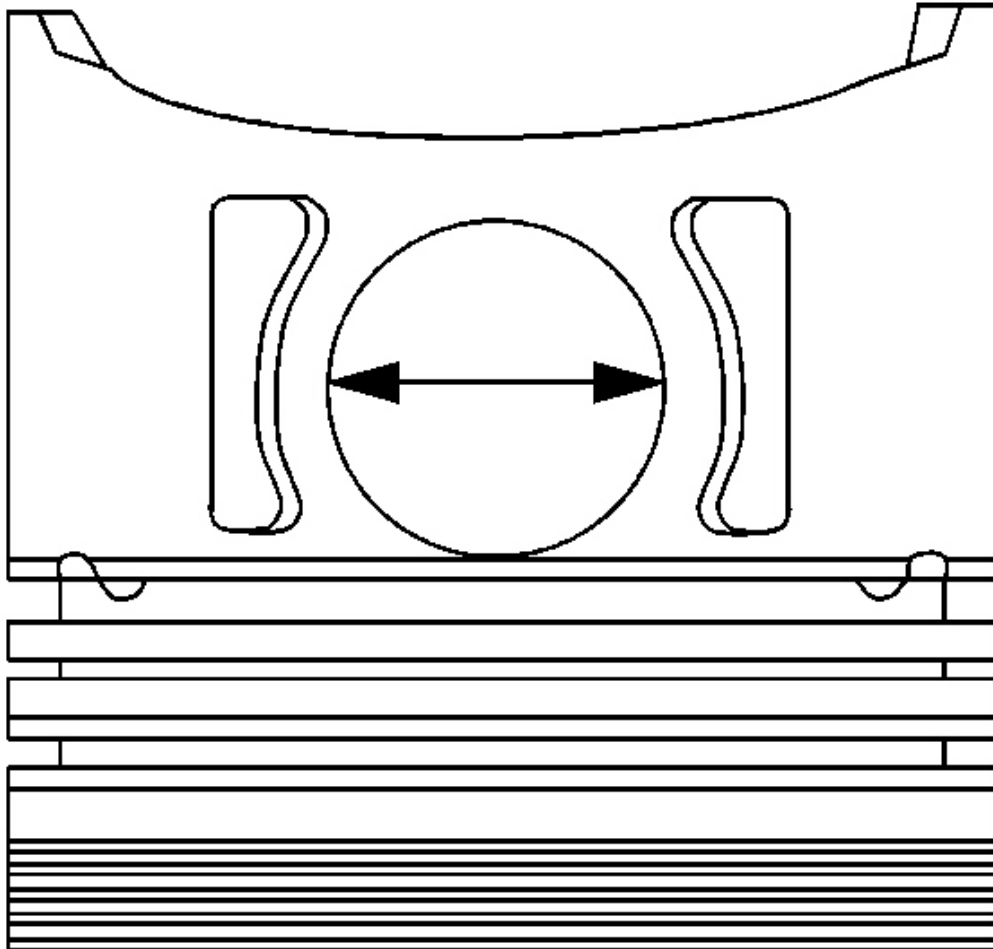
**Fig. 419: Measuring Piston Ring Side Clearance With Feeler Gauge**  
**Courtesy of GENERAL MOTORS CORP.**

8. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the first design press-fit piston, pin, and connecting rod assembly. Refer to **Engine Mechanical Specifications** .



**Fig. 420: Measuring Piston Pin Diameter**  
Courtesy of GENERAL MOTORS CORP.

9. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

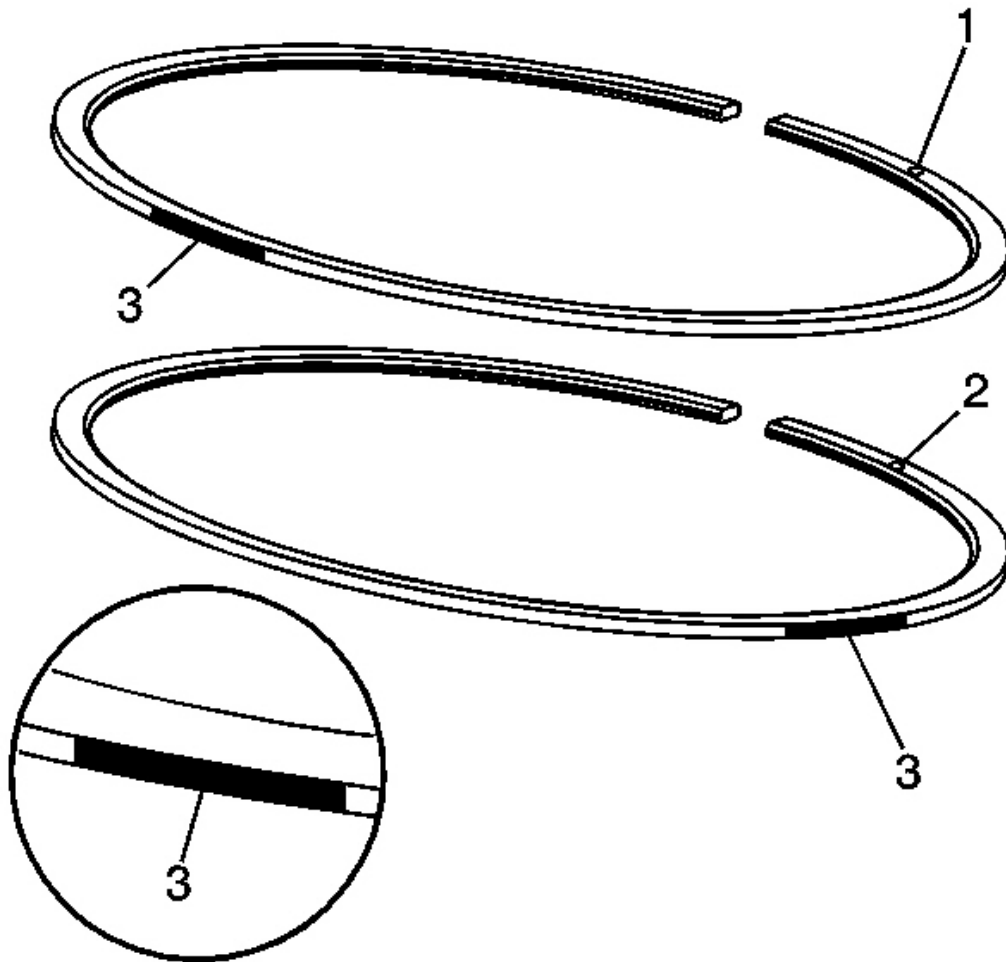


**Fig. 421: Measuring Piston Pin Bore**  
Courtesy of GENERAL MOTORS CORP.

10. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
11. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance.

Refer to Engine Mechanical Specifications .

**Measuring Piston Ring End Gap**



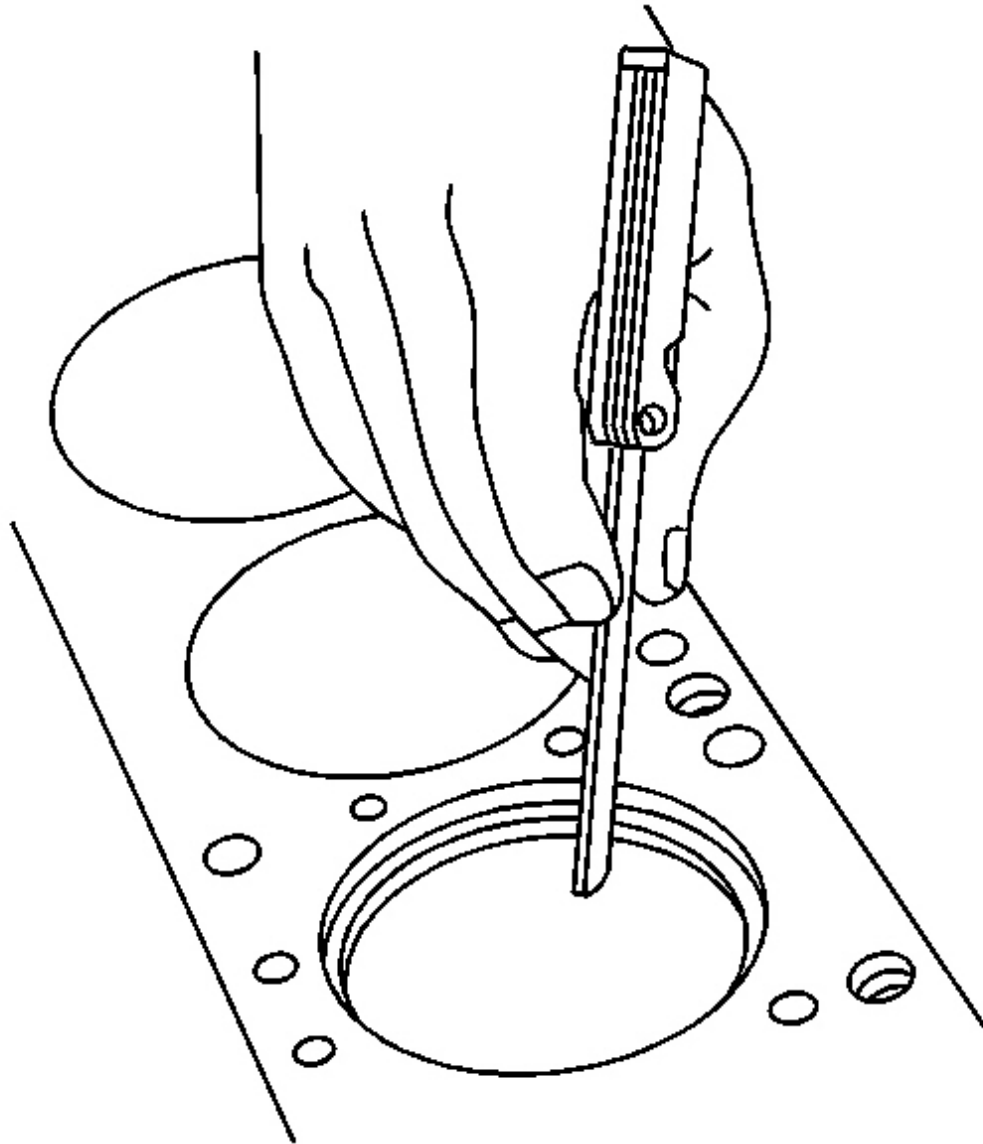
**Fig. 422: Upper & Lower Compression Rings & Marks**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.
- Measure the piston ring in the cylinder in which it will be used.

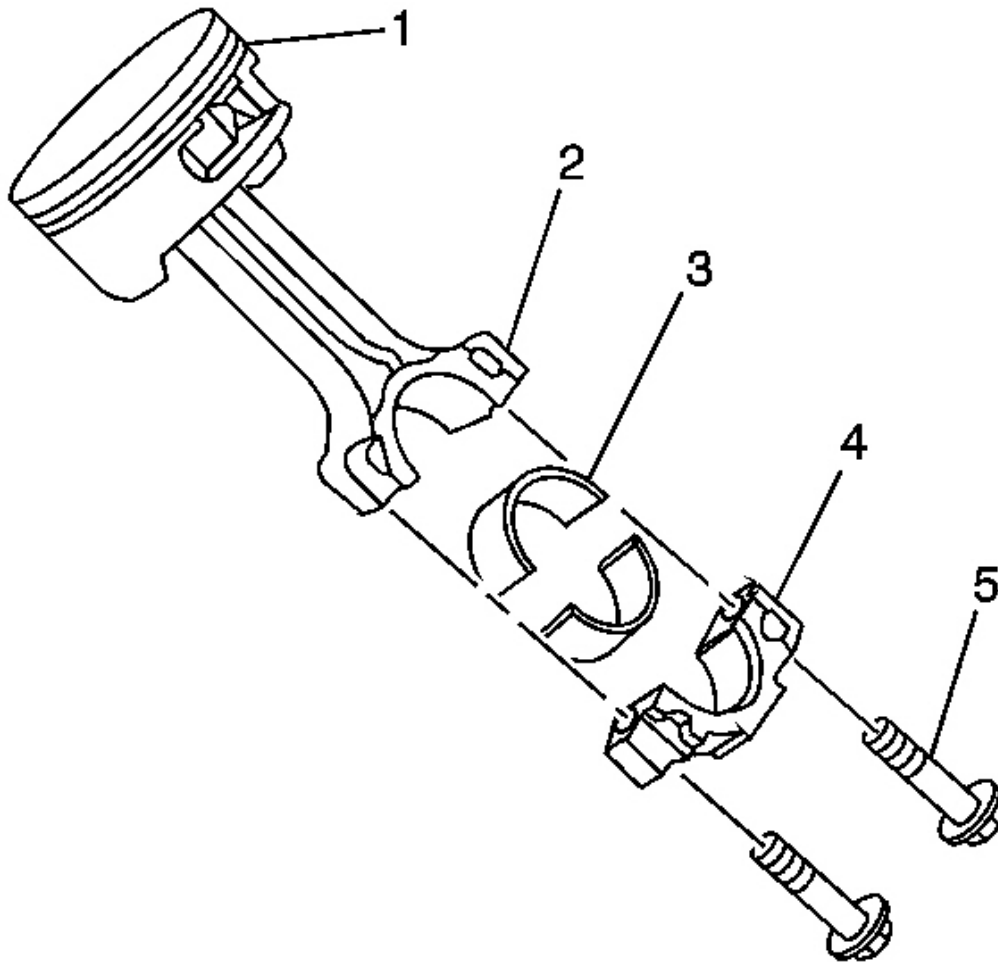
1. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.





**Fig. 423: Measuring Piston Compression Ring End Gap**  
Courtesy of GENERAL MOTORS CORP.

2. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area.
3. Insert a feeler gauge and measure the piston ring end gap. Refer to **Engine Mechanical Specifications** .



**Fig. 424: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

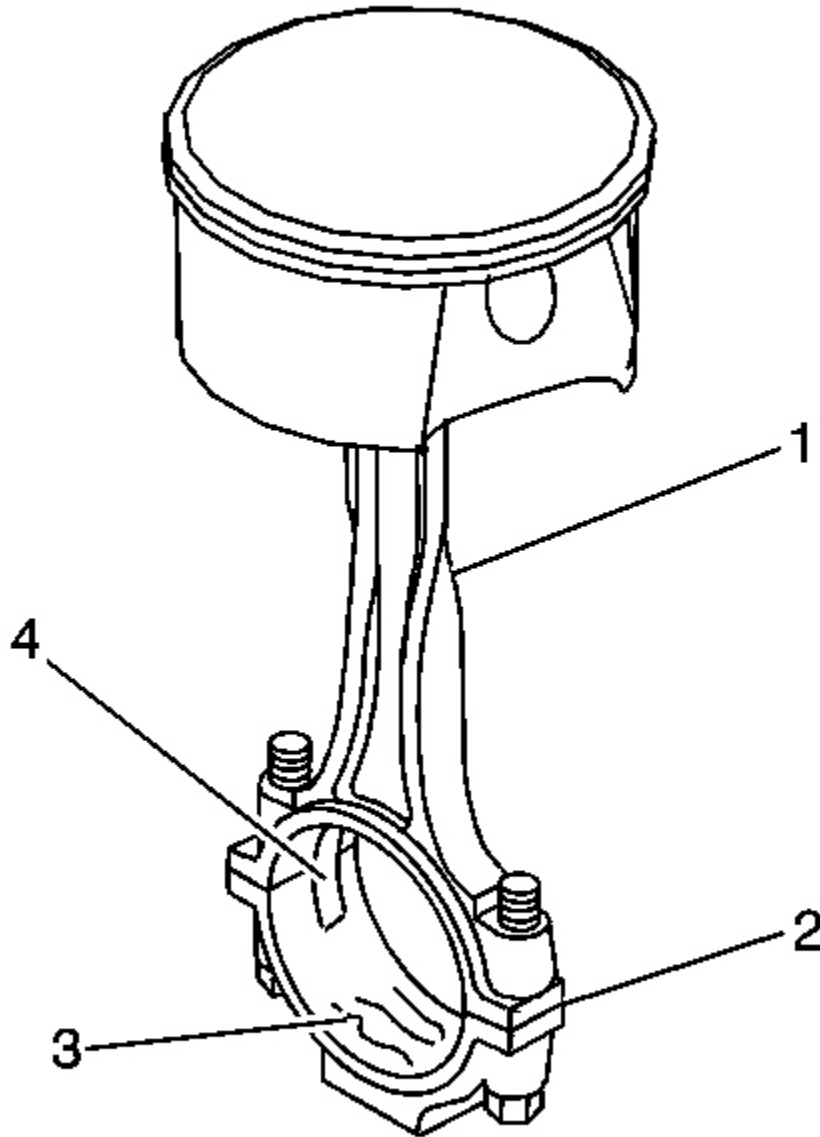
**IMPORTANT:**

- The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the first design press-fit piston, pin, and connecting rod as an assembly.
- Do not attempt to repair the bolt hole threads of the connecting rod.

1. Clean the connecting rod (2) and cap (4) in solvent.

**CAUTION: Wear safety glasses in order to avoid eye damage.**

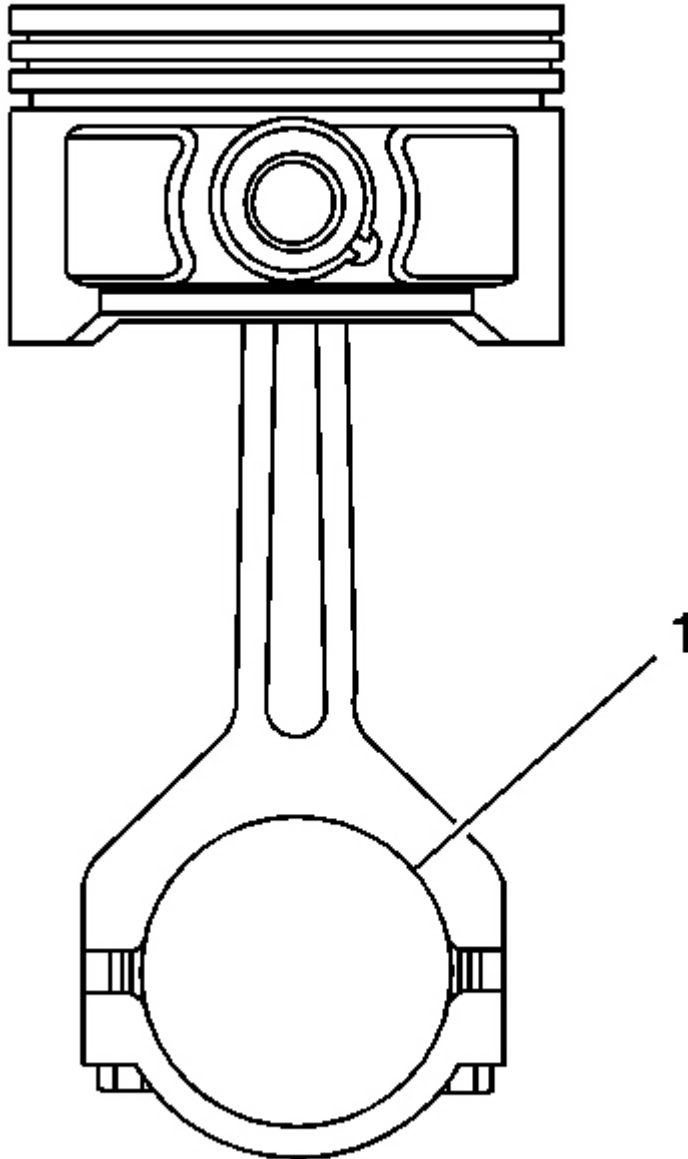
2. Dry the components with compressed air.



**Fig. 425: Inspecting Connecting Rod For Damage**

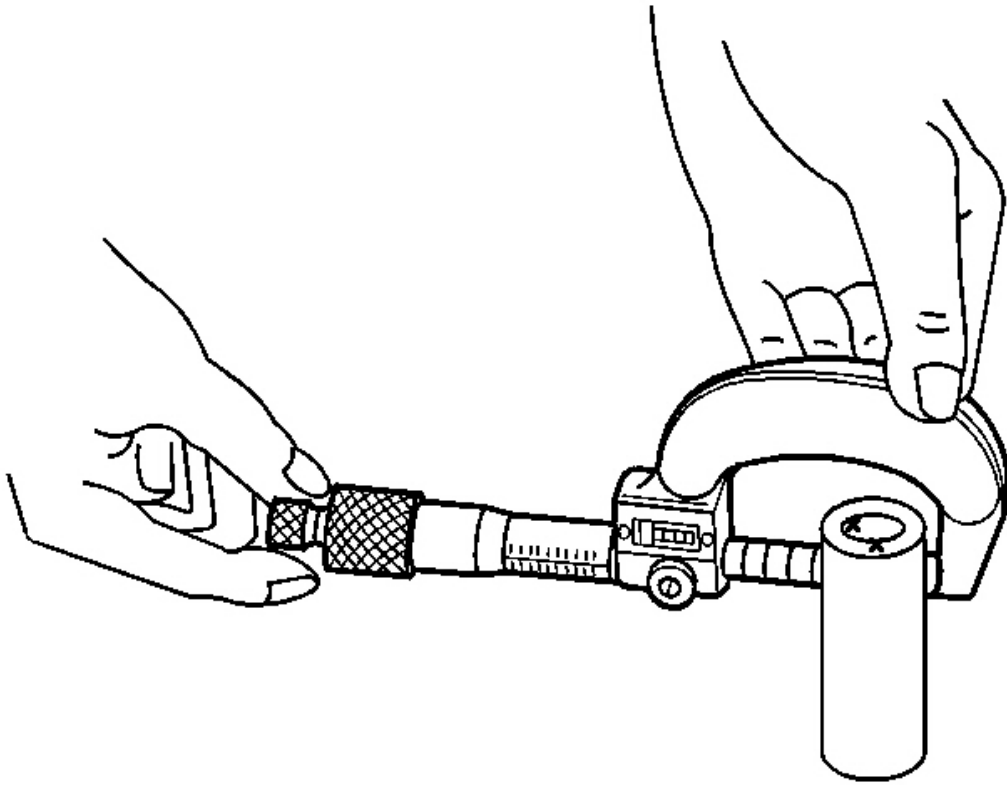
**Courtesy of GENERAL MOTORS CORP.**

3. Inspect the connecting rod for the following conditions:
  - Twisting (1)
  - Proper fit of the connecting rod and cap mating surfaces (2)
  - Nicks or gouges in the bearing bore (3)
  - Damage to the bearing locating slots (4)



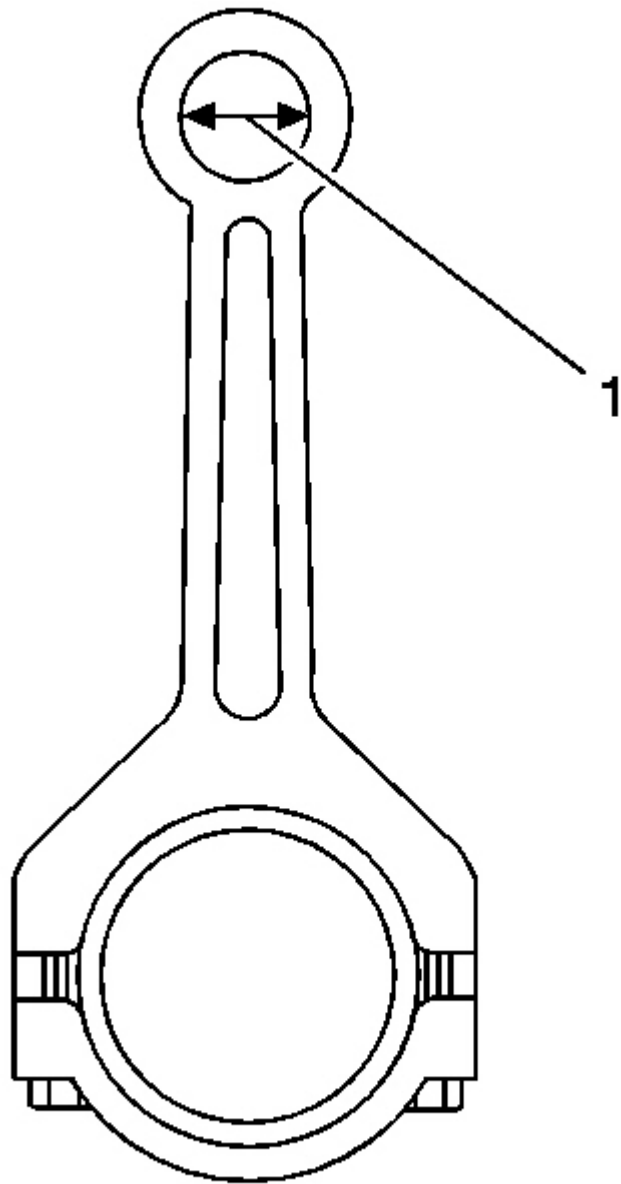
**Fig. 426: Connecting Rod Bearing Bore**  
Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore (1) for an out-of-round condition. Refer to Engine Mechanical Specifications .



**Fig. 427: Measuring Piston Pin Diameter**  
Courtesy of GENERAL MOTORS CORP.

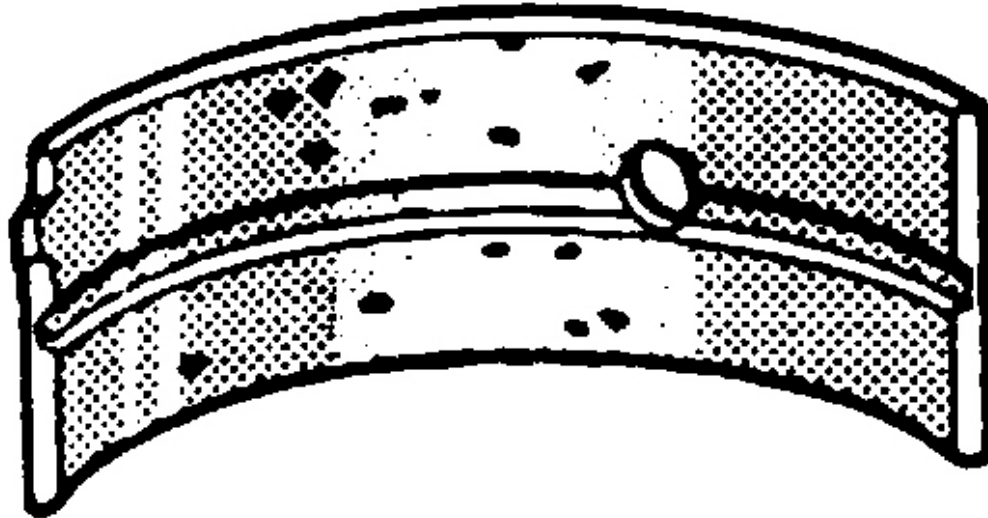
5. To determine full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin outside diameter (OD).



**Fig. 428: Connecting Rod Pin Bore**  
Courtesy of GENERAL MOTORS CORP.

6. To determine the full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) inside diameter (ID).
7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine

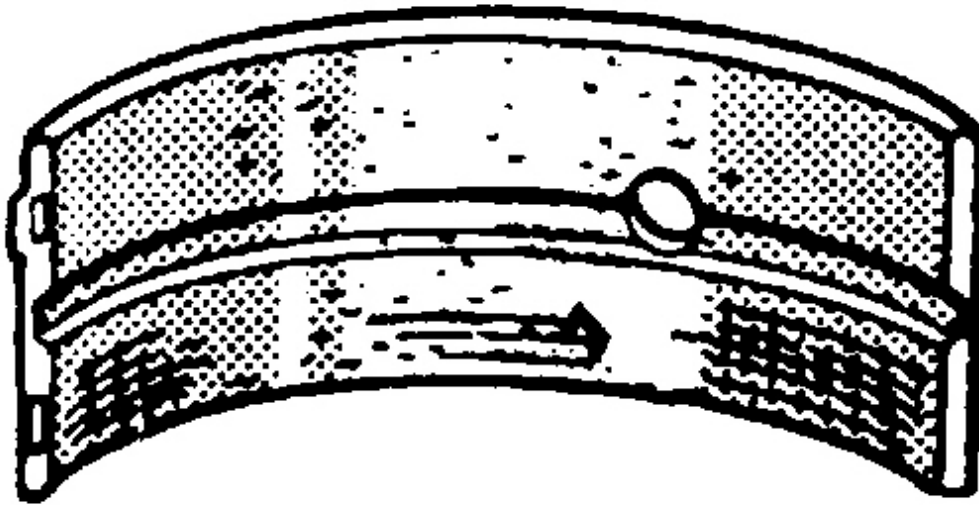
pin-to-bore clearance. Refer to **Engine Mechanical Specifications** .



**Fig. 429: Inspecting Bearings For Damage**  
Courtesy of GENERAL MOTORS CORP.

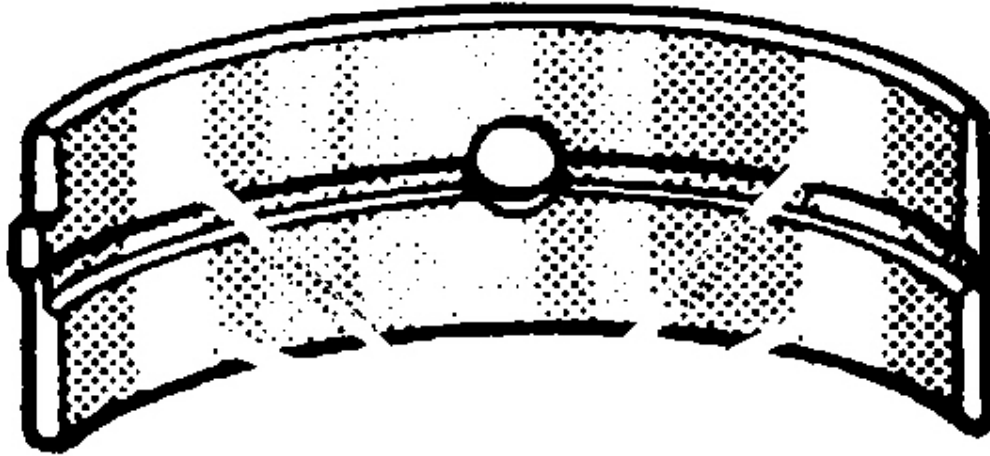
8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.





**Fig. 430: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration**  
Courtesy of GENERAL MOTORS CORP.

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.



**Fig. 431: Inspecting Bearings For Improper Seating**  
Courtesy of GENERAL MOTORS CORP.

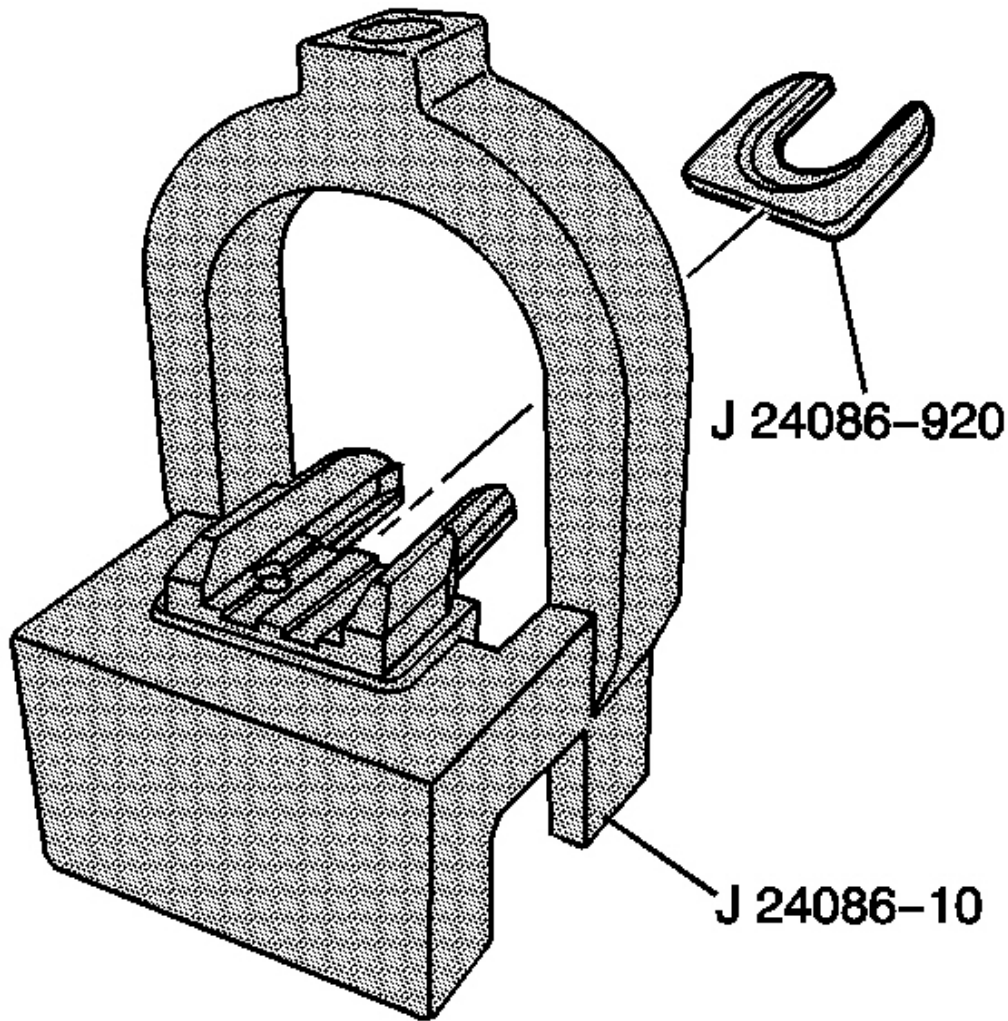
11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.

## **PISTON AND CONNECTING ROD ASSEMBLE**

**Press-Fit Piston Pin**

### **Tools Required**

**J 24086-C** Piston Pin Remover/Installer Set. See **Special Tools and Equipment** .



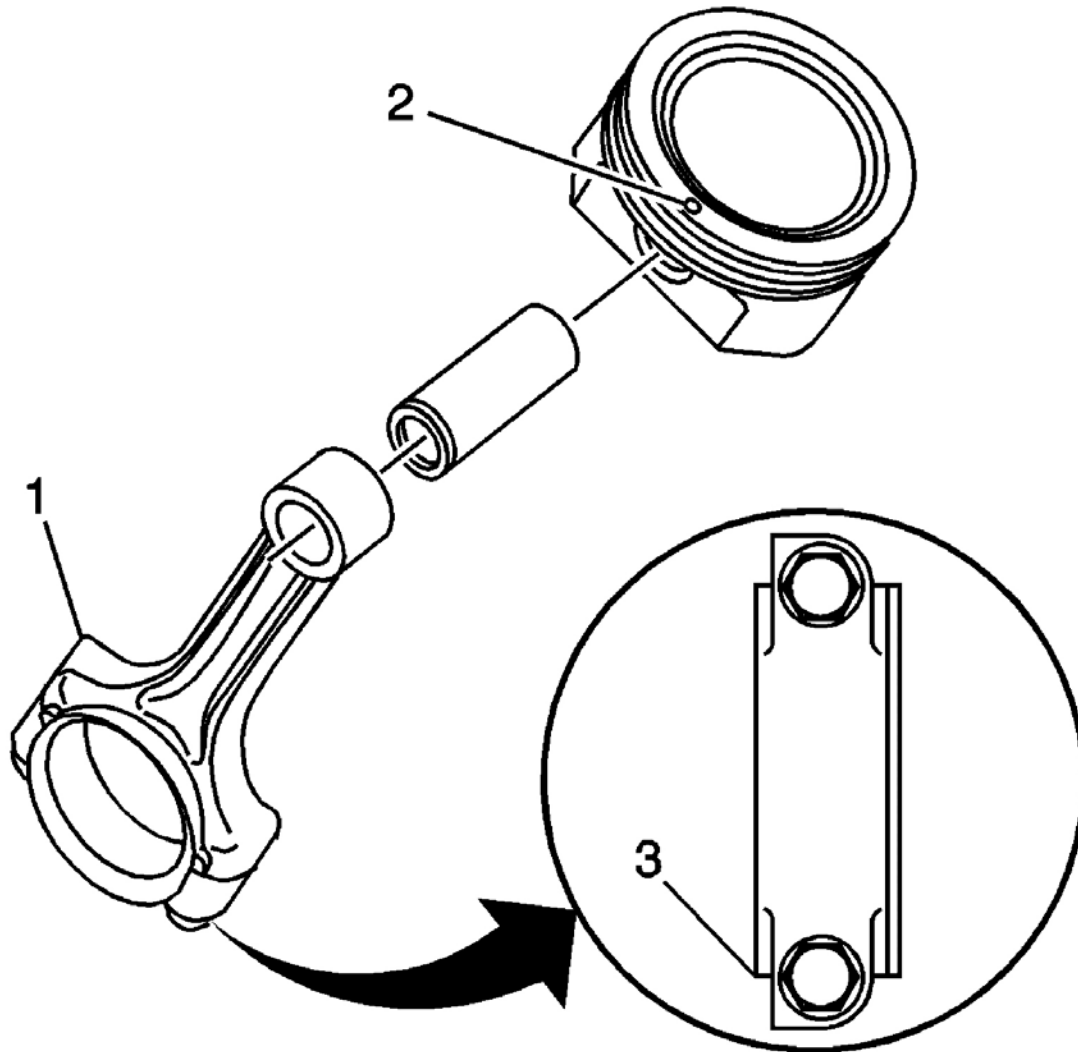
**Fig. 432: View Of J 24086-920 & J 24086-10**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Disassembly of the piston, press-fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.
- If reusing the piston and connecting rod assembly, install the assembly to the original cylinder and corresponding crankshaft journal.

- The assembly procedure, as shown, is to be used for diagnostic purposes only.

1. Install fork insert J 24086-920 into J 24086-10 . See Special Tools and Equipment .



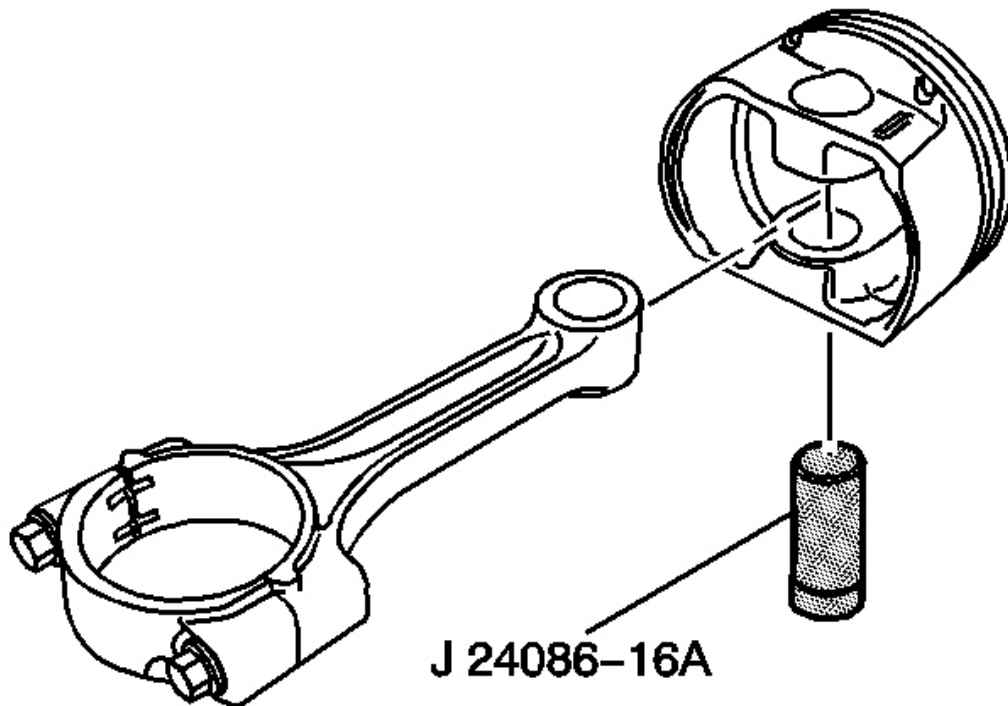
**Fig. 433: Connecting Rod Positioning Tab, Flat Flange & Mark On Top Of Piston**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Avoid contact with HOT components. Wear safety glasses and protective gloves to avoid personal injury.

**NOTE:** Applying excessive heat to the connecting rod may damage or distort the rod. Rod temperature SHOULD NOT exceed 315°C (600°F). At this

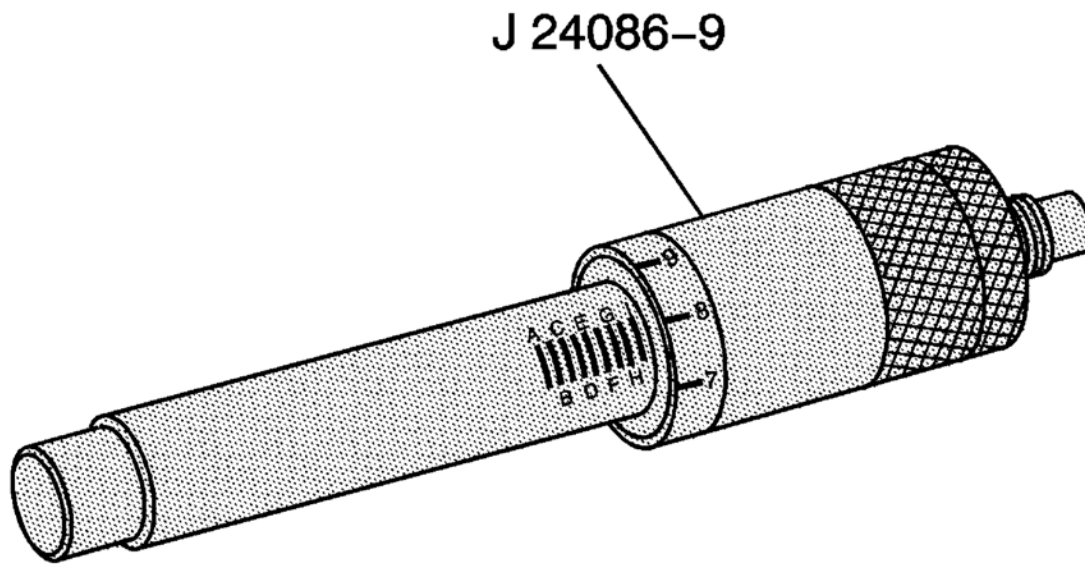
**temperature the end of the connecting rod will turn a straw color upon visual inspection.**

2. Use a torch and apply MILD heat to the pin end of the connecting rod. Mild heating of the connecting rod will ease in piston and pin assembly.
3. Identify the positioning tab (1) or flat flange (3) of the connecting rod. When properly assembled, the positioning tab or flat flange of the rod and the mark (2) on the top of the piston should both be facing the front of the engine.



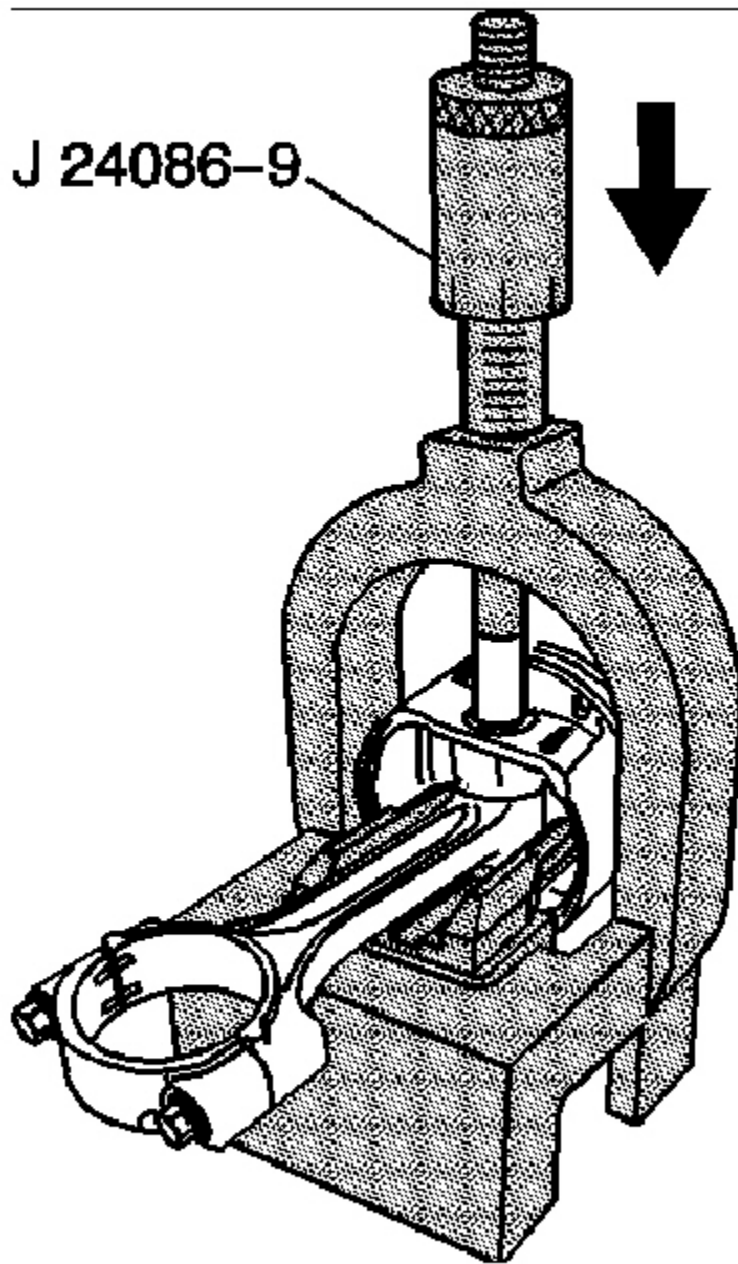
**Fig. 434: Piston, Connecting Rod & J 24086-16A**  
Courtesy of GENERAL MOTORS CORP.

4. Assemble the piston, the connecting rod, and the J 24086-16A.



**Fig. 435: Adjusting J 24086-9 To G-4**  
Courtesy of GENERAL MOTORS CORP.

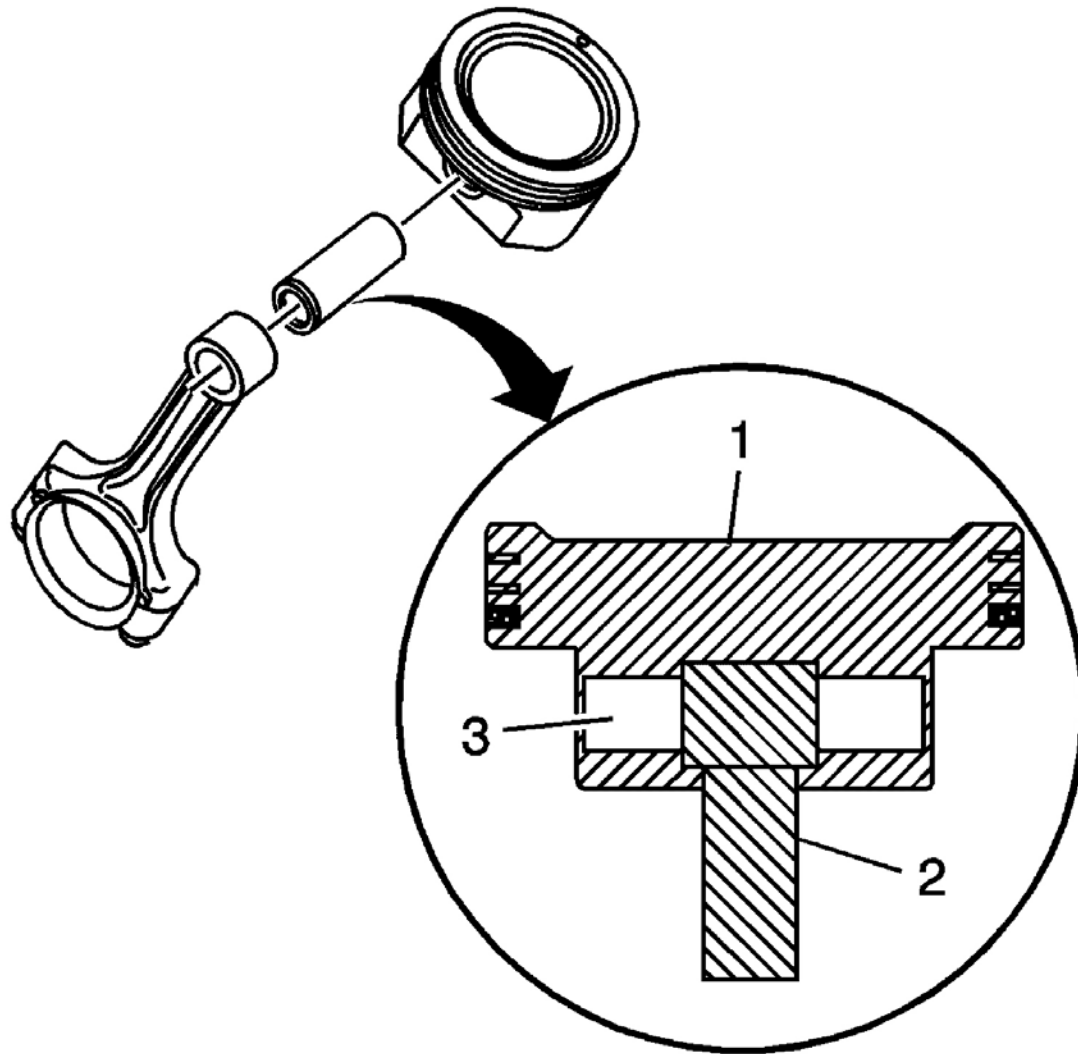
5. Adjust the J 24086-9 to I 8.



**Fig. 436: Inserting J 24086-9**  
Courtesy of GENERAL MOTORS CORP.

6. Install the piston, connecting rod, piston pin, and J 24086-16A to the J 24086-10. See **Special Tools and**

## Equipment .



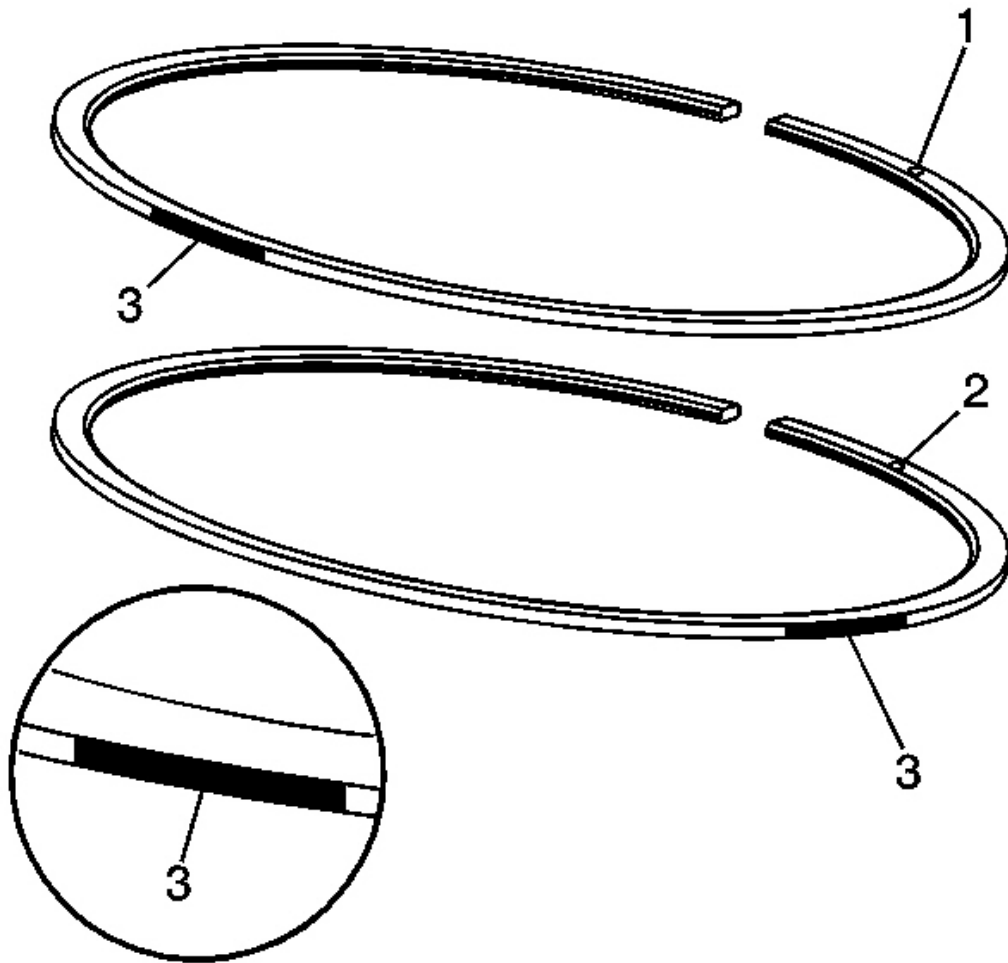
**Fig. 437: Piston, Pin & Connecting Rod Proper Assembly**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** After the installer hub bottoms on the support assembly, do not exceed 35 000 kPa (5,000 psi) pressure, this could cause damage to the tool.

7. Insert J 24086-9 through J 24086-10 and to the piston pin. See Special Tools and Equipment .
8. Press J 24086-9 until the installer bottoms on the J 24086-10 . See Special Tools and Equipment .
9. Inspect the piston (1), pin (3), and connecting rod (2) for proper assembly.

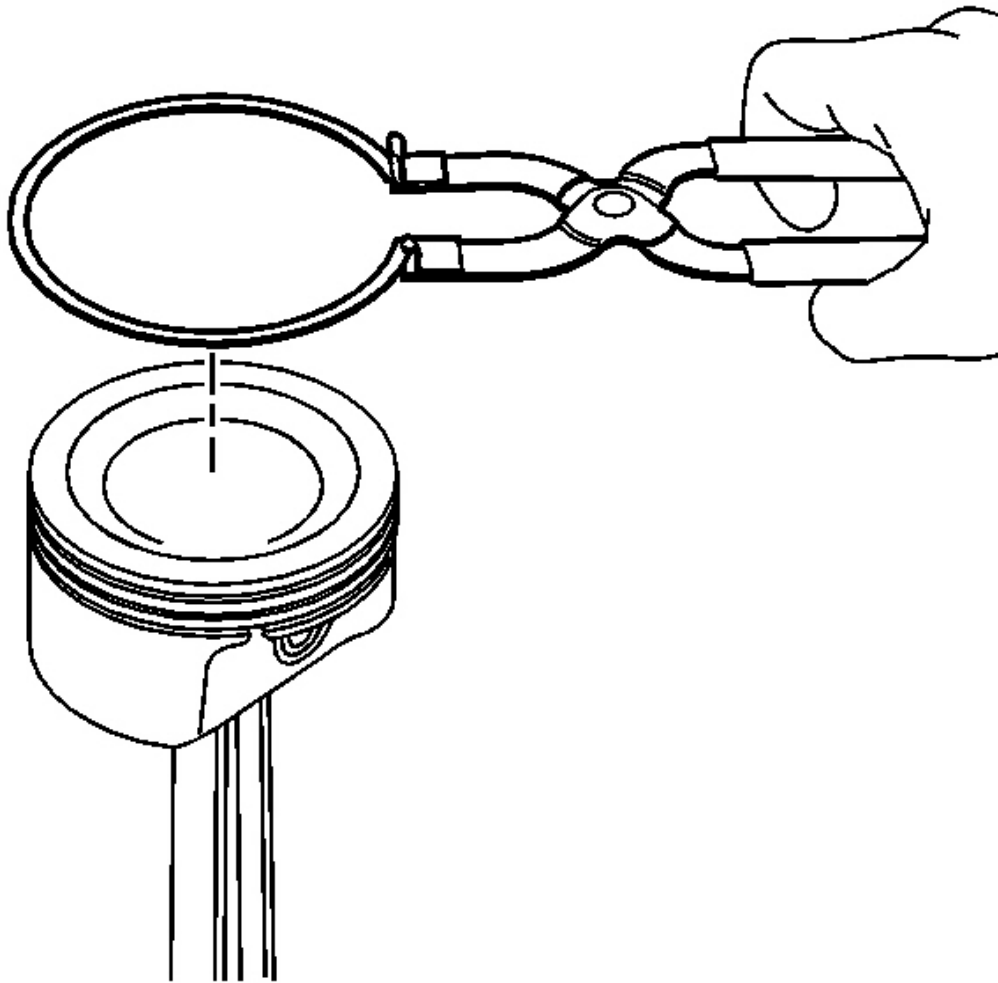
When properly installed, the piston pin (3) should be centered in the connecting rod (2).





**Fig. 438: Upper & Lower Compression Rings & Marks**  
Courtesy of GENERAL MOTORS CORP.

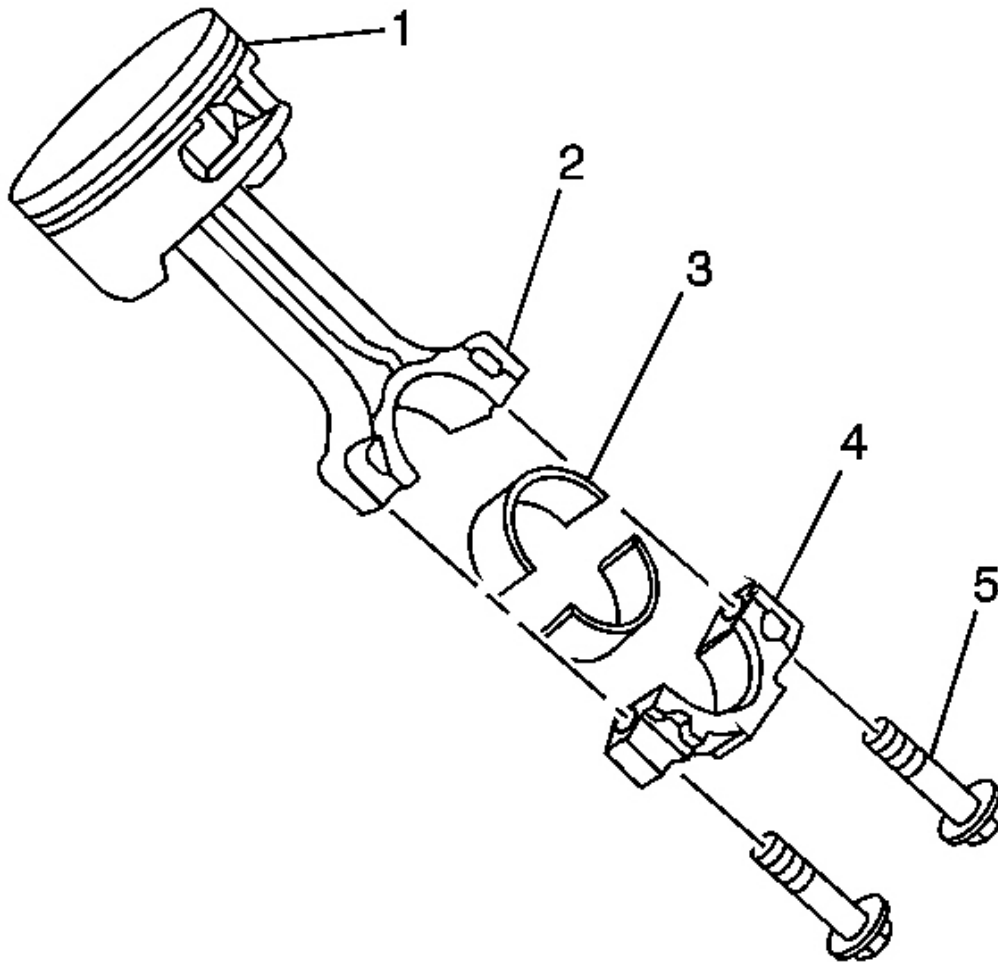
10. Identify the compression and oil control rings for proper installation. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



**Fig. 439: Piston Rings & Piston**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

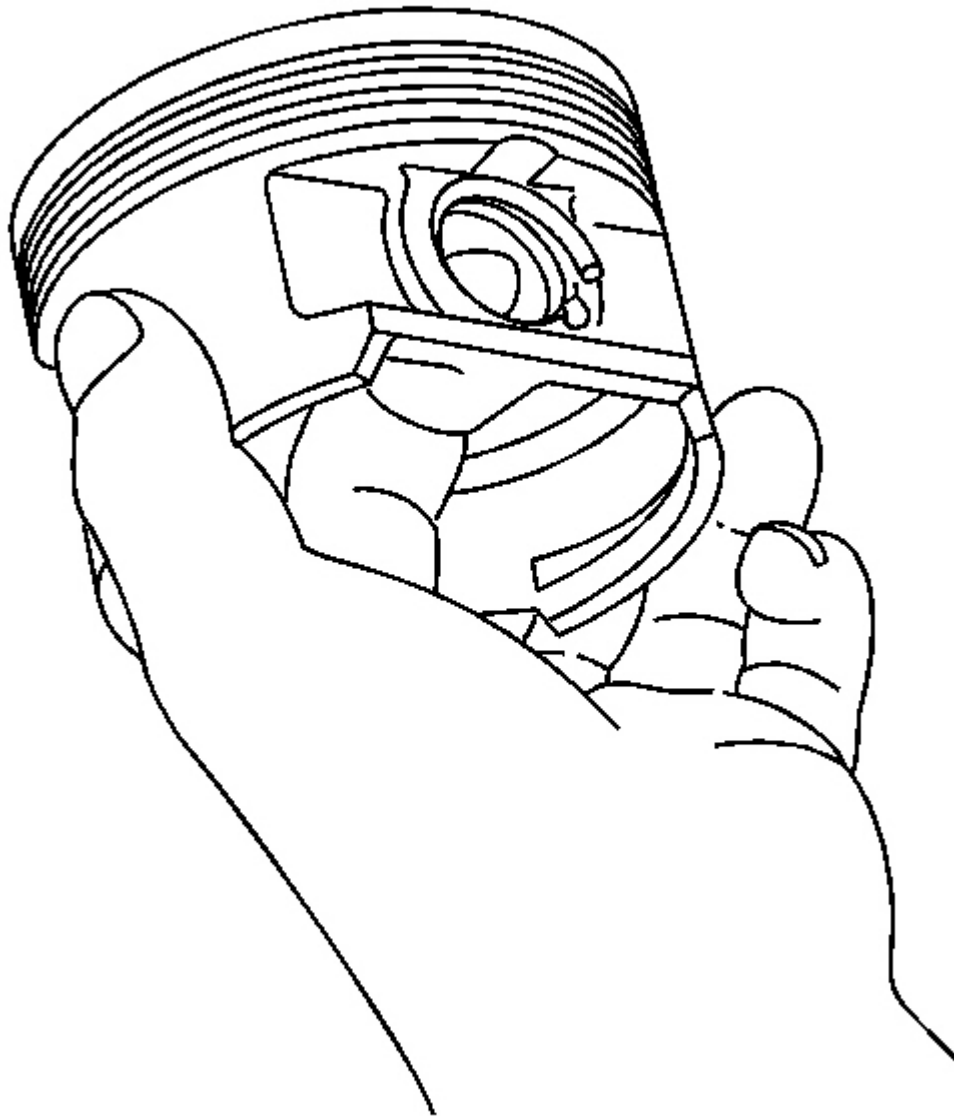
11. Using piston ring pliers, install the piston rings onto the piston.
12. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
13. Position the compression ring end gaps 180 degrees opposite each other.



**Fig. 440: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

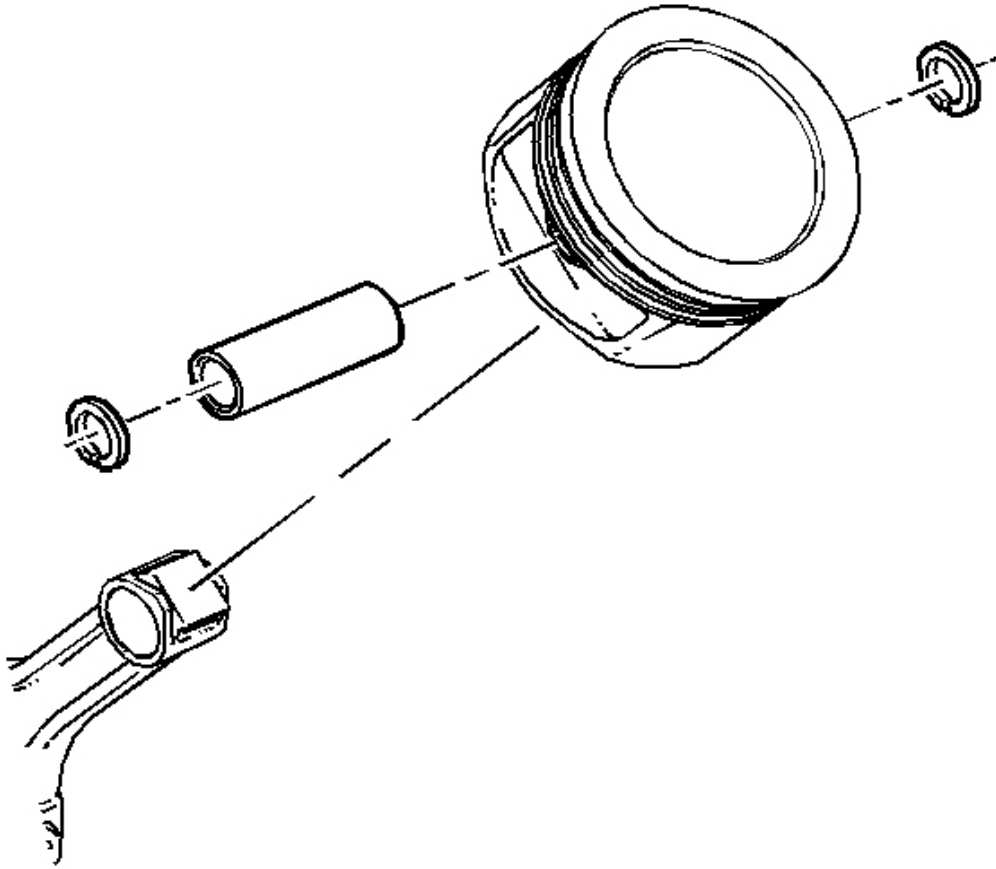
14. Install the connecting rod bearings (3) to the rod (2) and cap (4).

#### **Full-Floating Piston Pin**



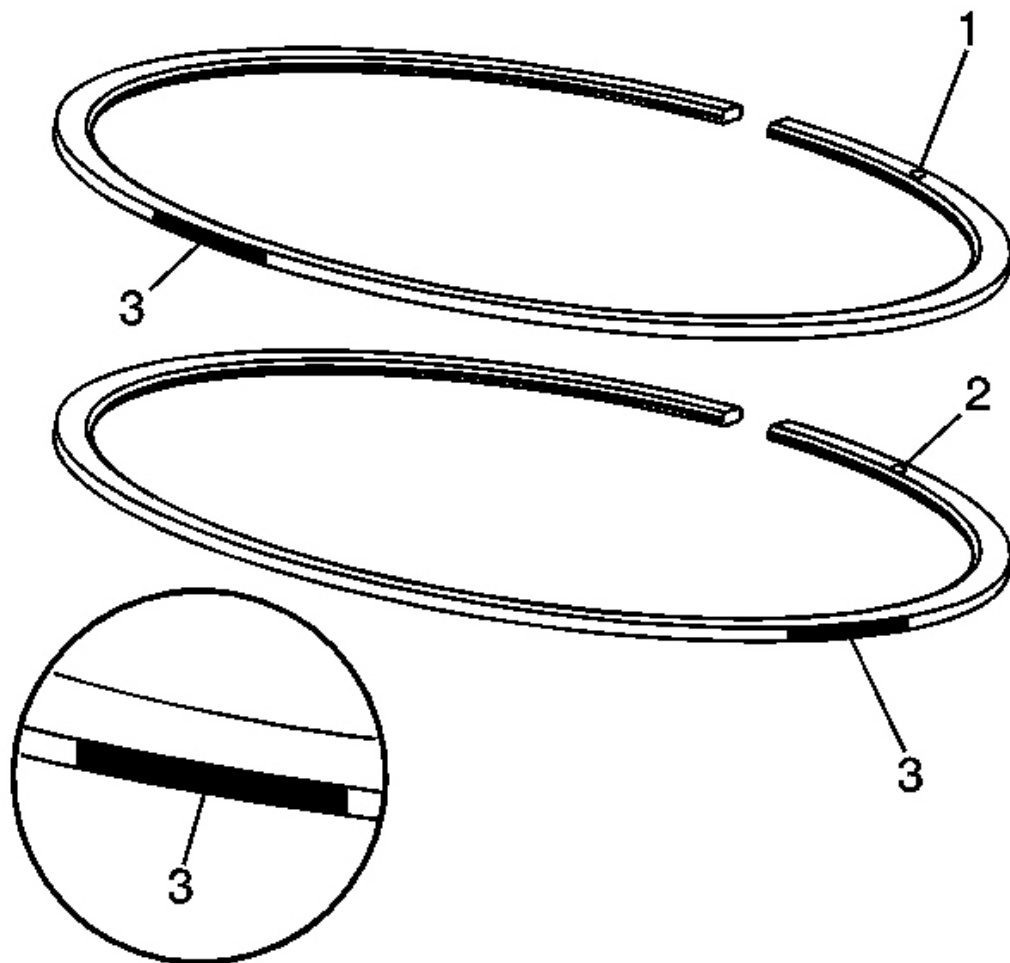
**Fig. 441: Retaining Clip In Pin Bore Groove**  
**Courtesy of GENERAL MOTORS CORP.**

1. Install the retaining clip. The clip should be seated in the groove of the pin bore.



**Fig. 442: Identifying Piston & Components**  
Courtesy of GENERAL MOTORS CORP.

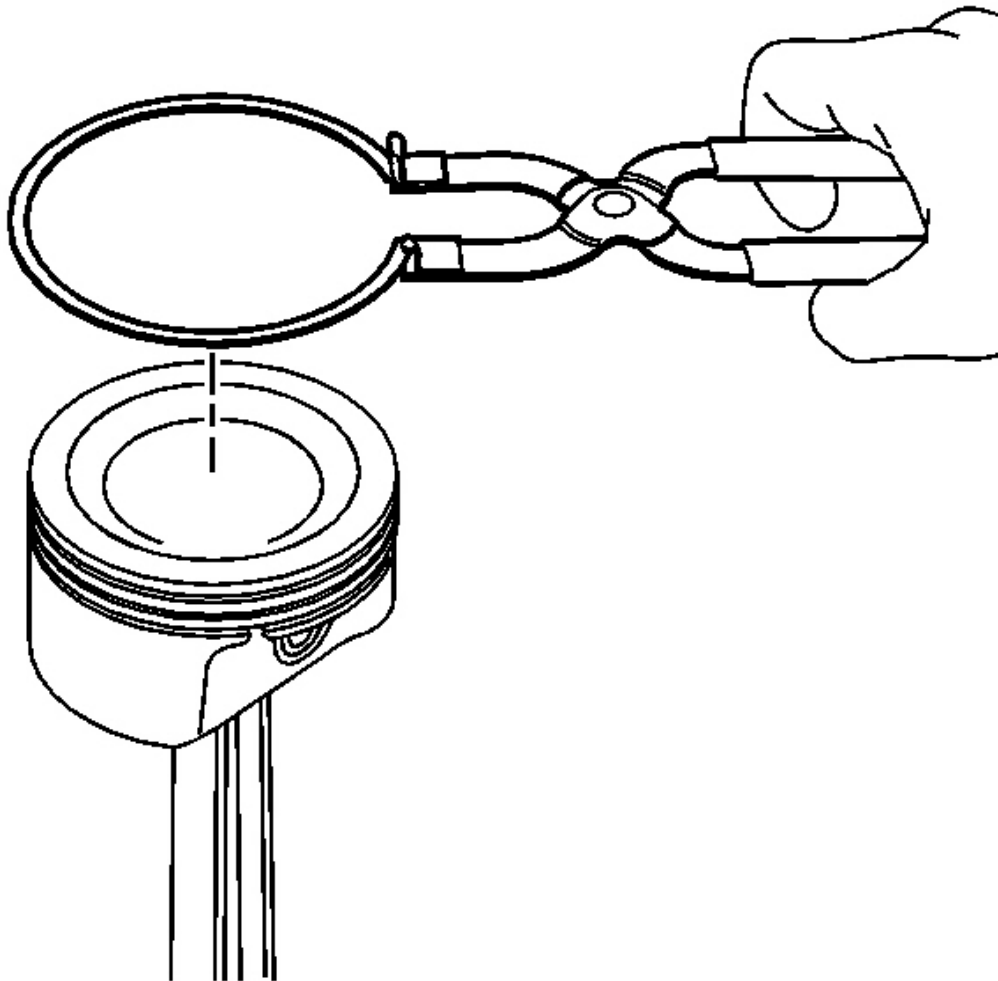
2. Install the piston pin to the piston and connecting rod.
3. Install the retaining clip. The clip should be seated in the groove of the pin bore.



**Fig. 443: Upper & Lower Compression Rings & Marks**  
Courtesy of GENERAL MOTORS CORP.

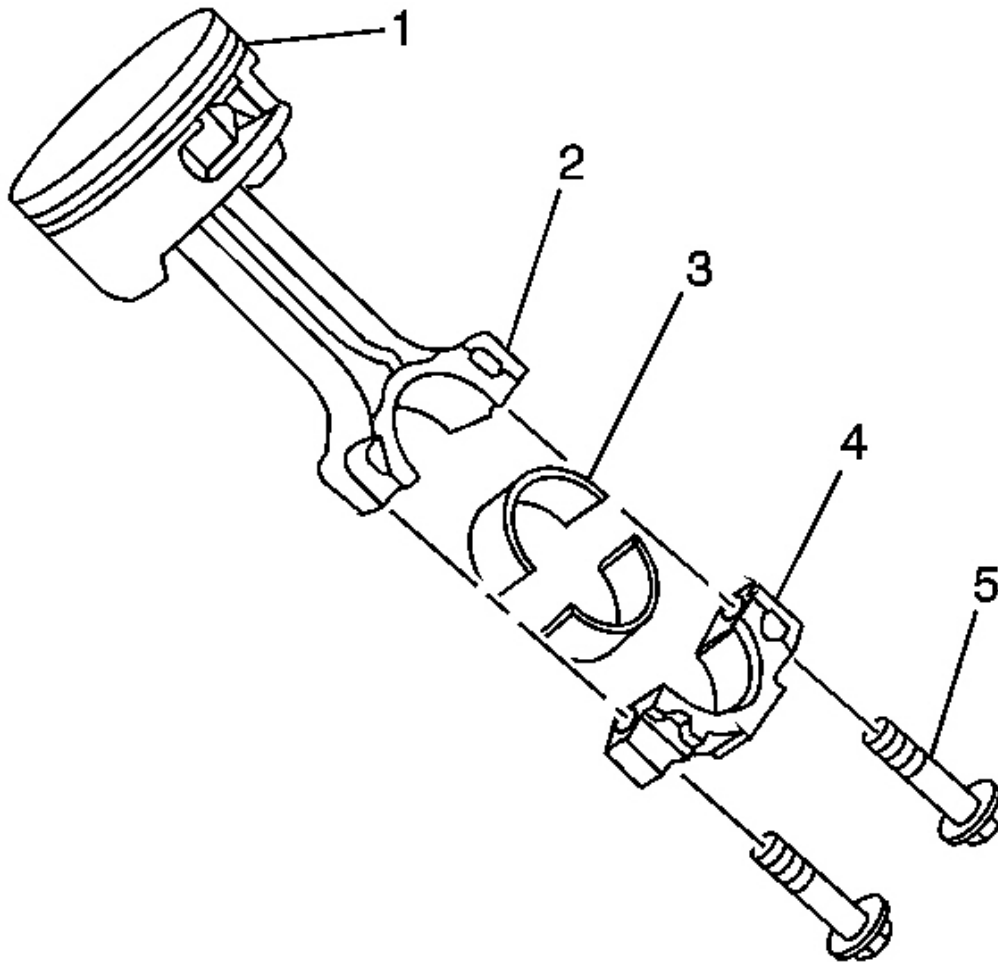
**IMPORTANT:** When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

4. Identify the compression and oil control rings for proper installation. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.



**Fig. 444: Piston Rings & Piston**  
Courtesy of GENERAL MOTORS CORP.

5. Using piston ring pliers, install the piston rings onto the piston.
6. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
7. Position the compression ring end gaps 180 degrees opposite each other.



**Fig. 445: Piston & Connecting Rod Components**  
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod bearings (3) to the rod (2) and cap (4).

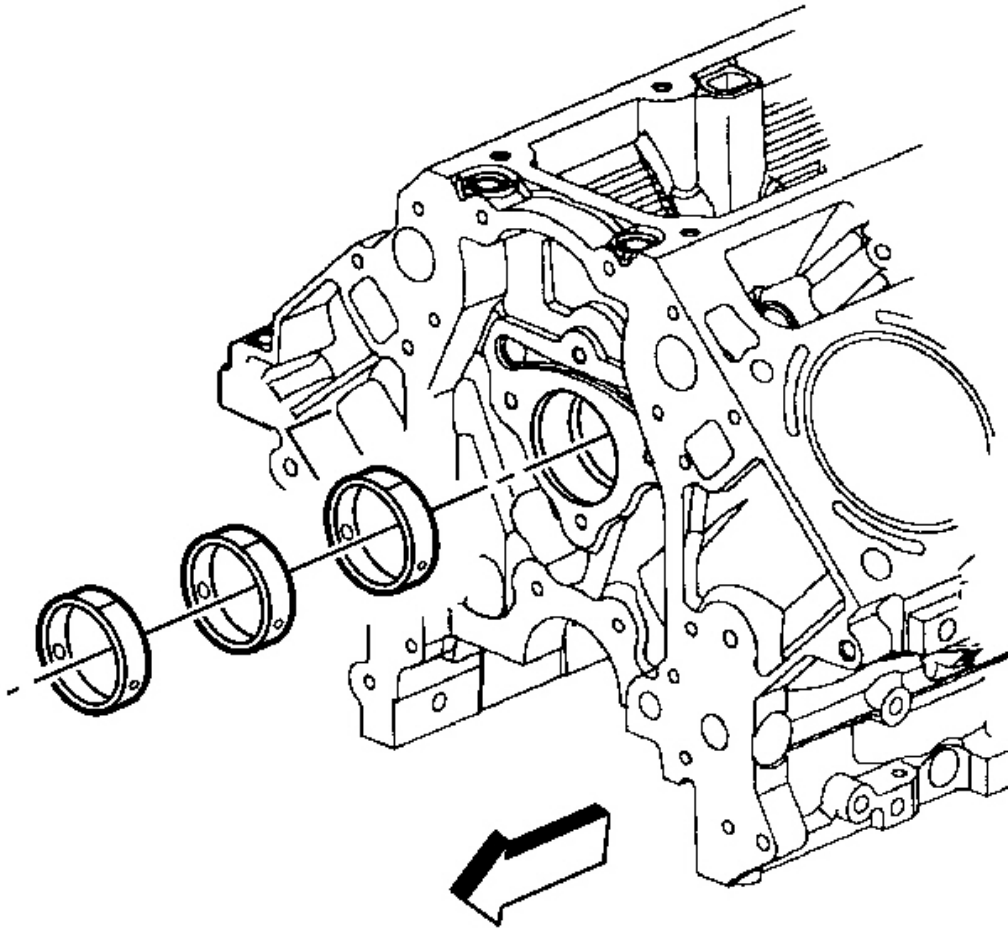
## **CAMSHAFT BEARING REMOVAL**

### **Tools Required**

**J 33049** Camshaft Bearing Service Set. See **Special Tools and Equipment** .

### **Removal Procedure**





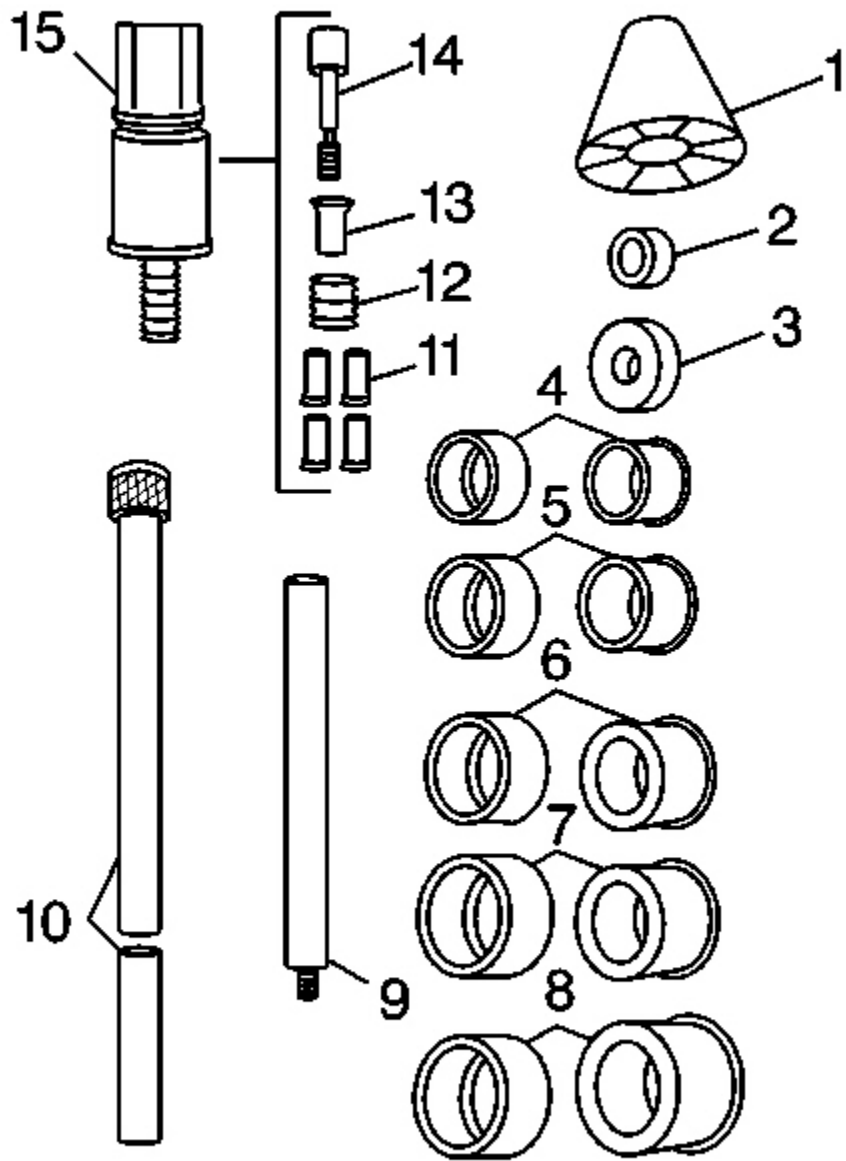
**Fig. 446: Camshaft Bearings**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.**

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores.

Refer to **Camshaft and Bearings Cleaning and Inspection** .

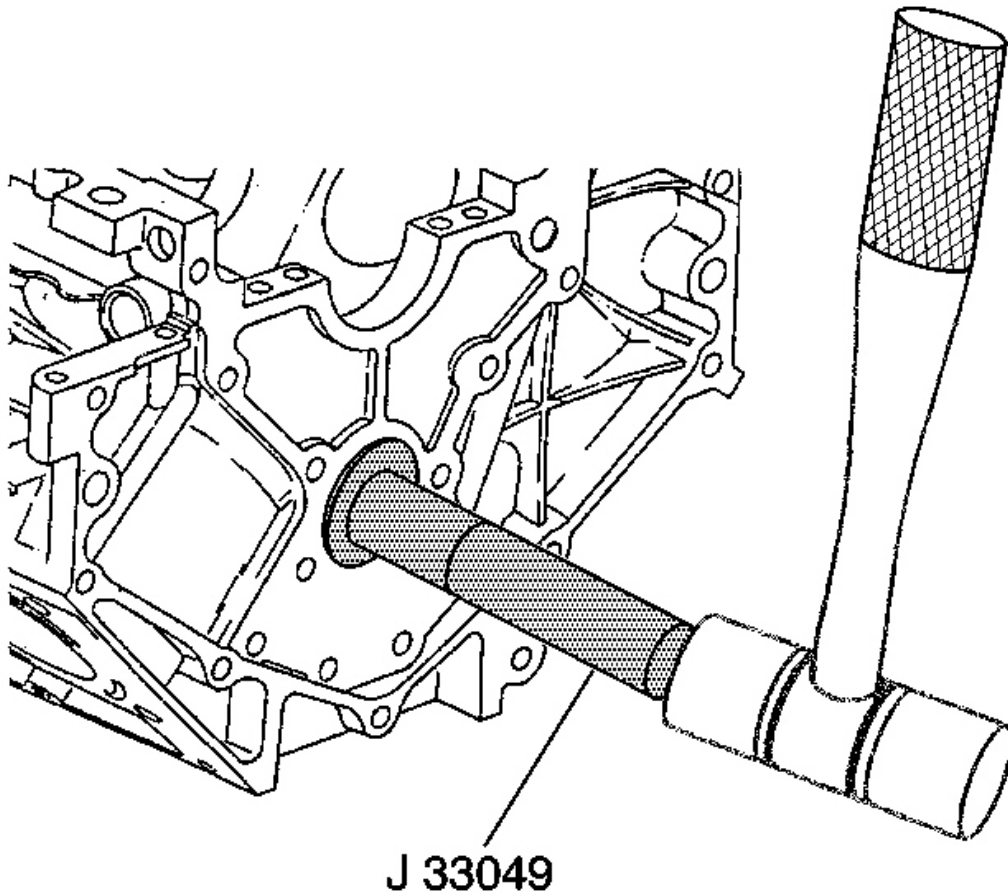
2. Repair or replace the components as required.



**Fig. 447: J 33049 Camshaft Bearing Service Kit Components**  
 Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . See **Special Tools and Equipment** .
4. Assemble the tool.

5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing to align the tool.



**Fig. 448: Driving Bearing From Block Bore**  
Courtesy of GENERAL MOTORS CORP.

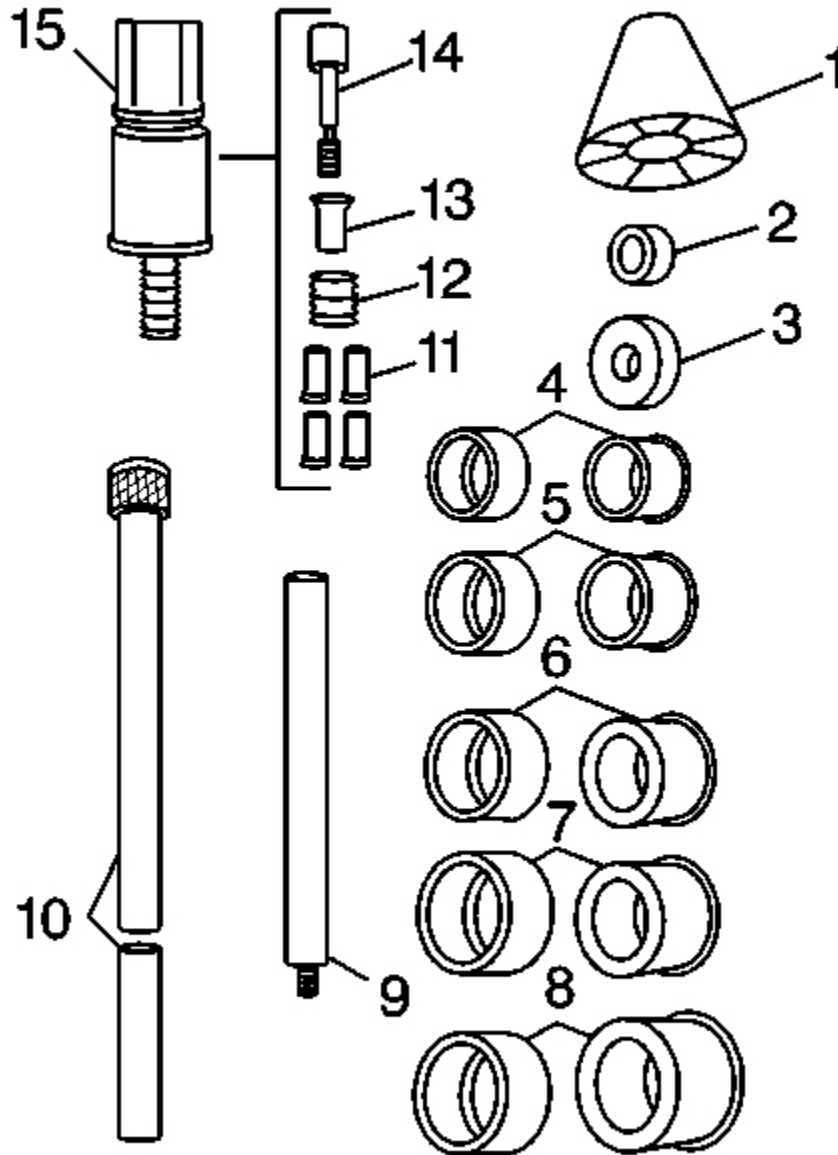
8. Drive the bearing from the block bore.

**IMPORTANT:** To remove the front camshaft bearing, operate the tool from the rear of the block using the guide cone in the rear camshaft bearing bore.

9. Repeat the above procedures to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information



**Fig. 449: J 33049 Camshaft Bearing Service Kit Components**  
Courtesy of GENERAL MOTORS CORP.

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).
- Expander bearing driver number one inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the expander assembly and the small washer.
- Expander bearing driver number two inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number one expanding driver and the small washer.
- Expander bearing driver number three inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number two expanding driver and the large washer.
- Expander bearing driver number four inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number three expanding driver and the large washer.
- Expander bearing driver number five inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with number four expanding driver and the large washer.
- Expander bearing driver number six inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number five expanding driver and the large washer.

### **Tool Assembly and Operation**

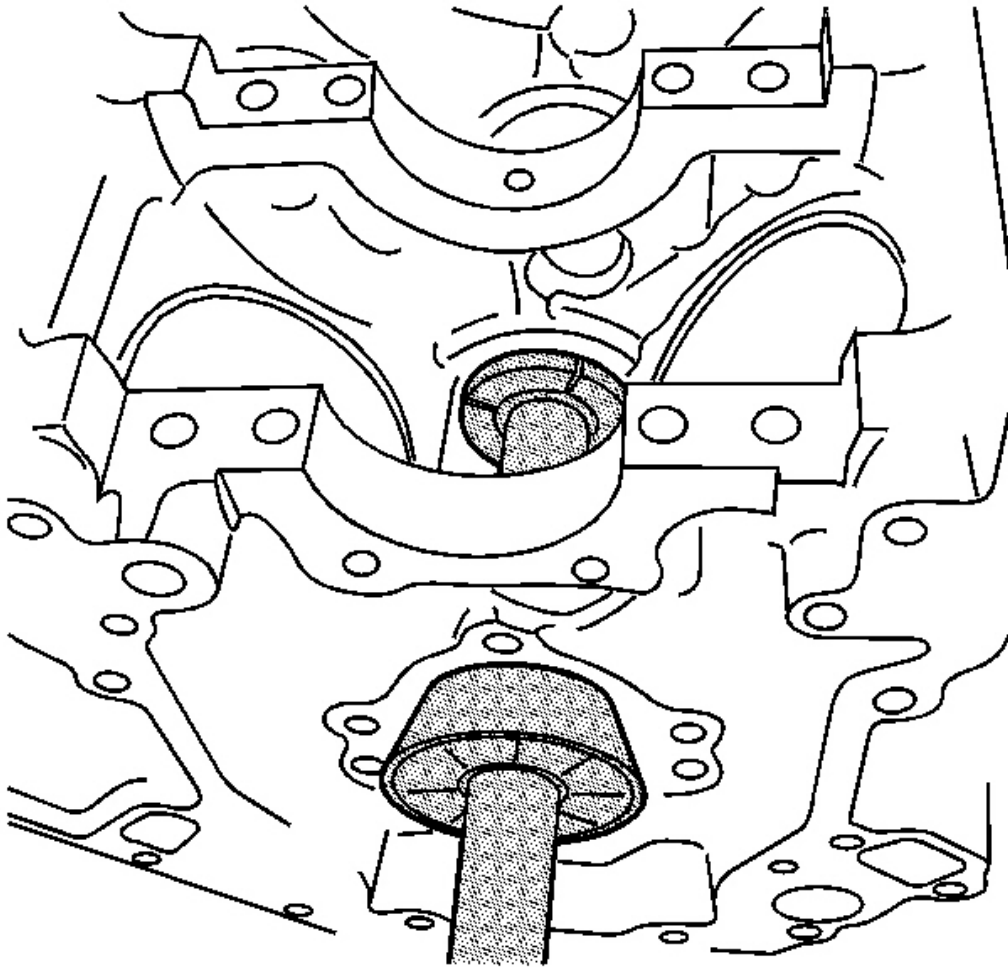
1. Select the proper expanding driver and washer from the expanding driver and washer information.

**IMPORTANT: To install or remove the expanding driver, always push on or pull from the ends.**

**Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.**

2. Place the expanding driver onto the expander assembly.
3. Check to insure that the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. Place the guide cone over the driving bar, with the small end of the cone facing the driver assembly.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

It may be necessary to install the driver bar extension for removal of the inner bearings.



**Fig. 450: Inserting J 33049 Tool & Nylon Cone**  
**Courtesy of GENERAL MOTORS CORP.**

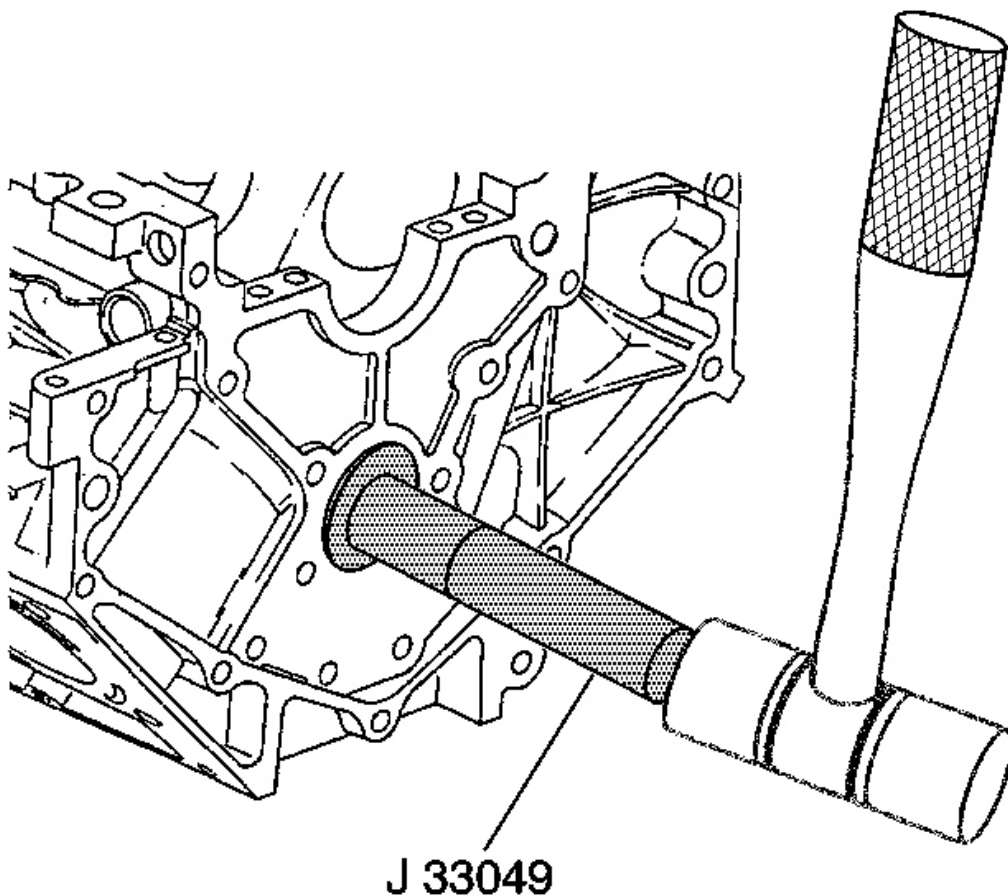
7. Insert the tool into a inner camshaft bearing and tighten until snug.

Operate the tool from the front or rear of the engine block.

On some engine blocks the nut on the expander assembly is inaccessible except from either end. In this case you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.

10. Repeat the procedure for the additional inner bearings.



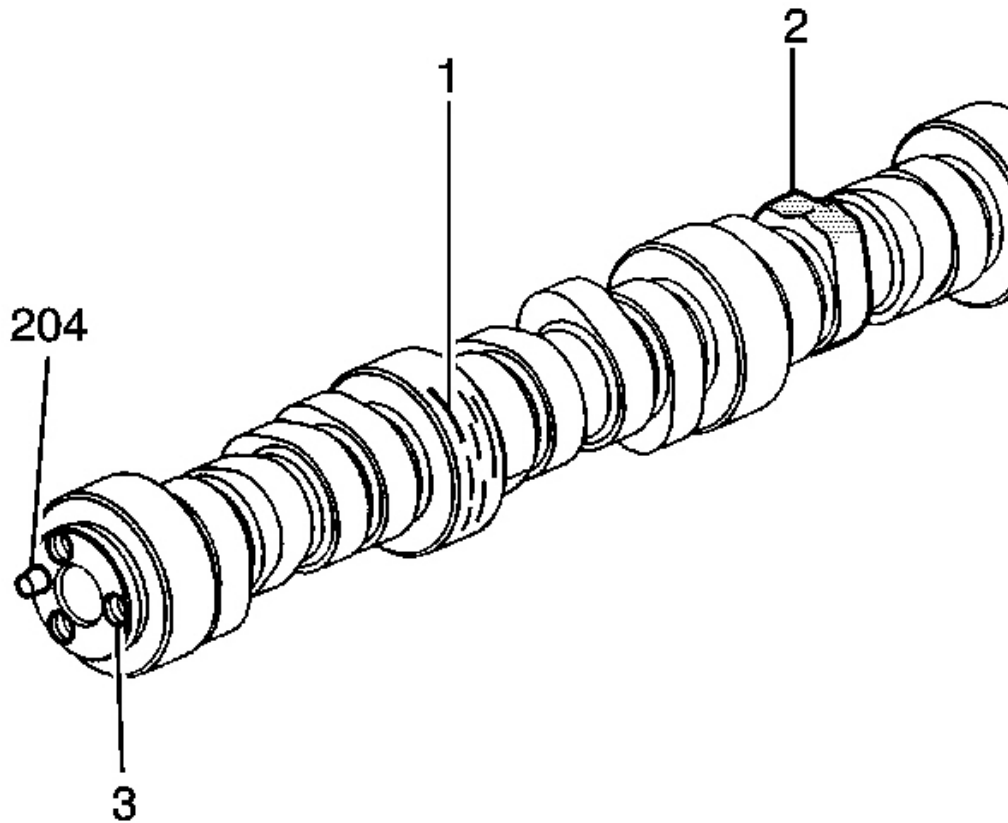
**Fig. 451: Driving Bearing From Block Bore**  
Courtesy of GENERAL MOTORS CORP.

11. For the two end bearings, front and rear, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

## **CAMSHAFT AND BEARINGS CLEANING AND INSPECTION**

### **Tools Required**

- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Cam Lobe Lift Indicator. See **Special Tools and Equipment** .



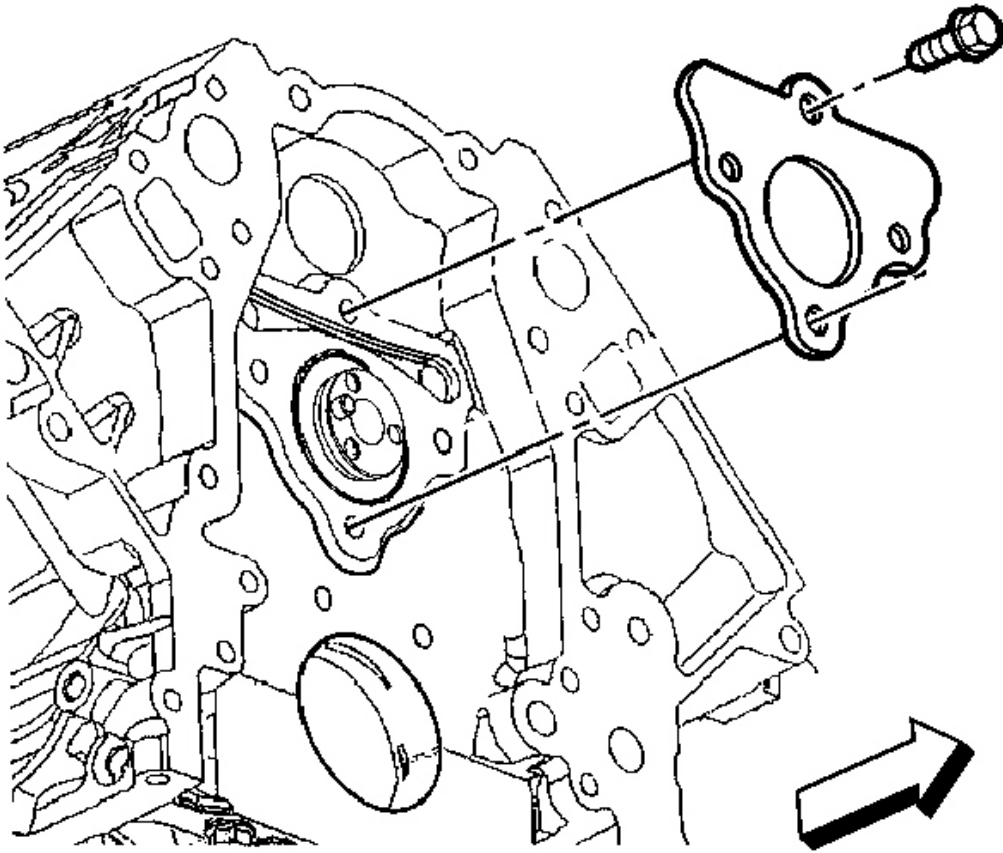
**Fig. 452: Camshaft & Bearing Inspection Areas**  
Courtesy of GENERAL MOTORS CORP.

1. Clean the components in solvent.

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the threaded bolt holes (3) in the front of the camshaft for damaged threads or debris.
6. Inspect the camshaft sprocket pin (204) for damage.
7. Inspect the camshaft position reluctor ring for nicks or damage.

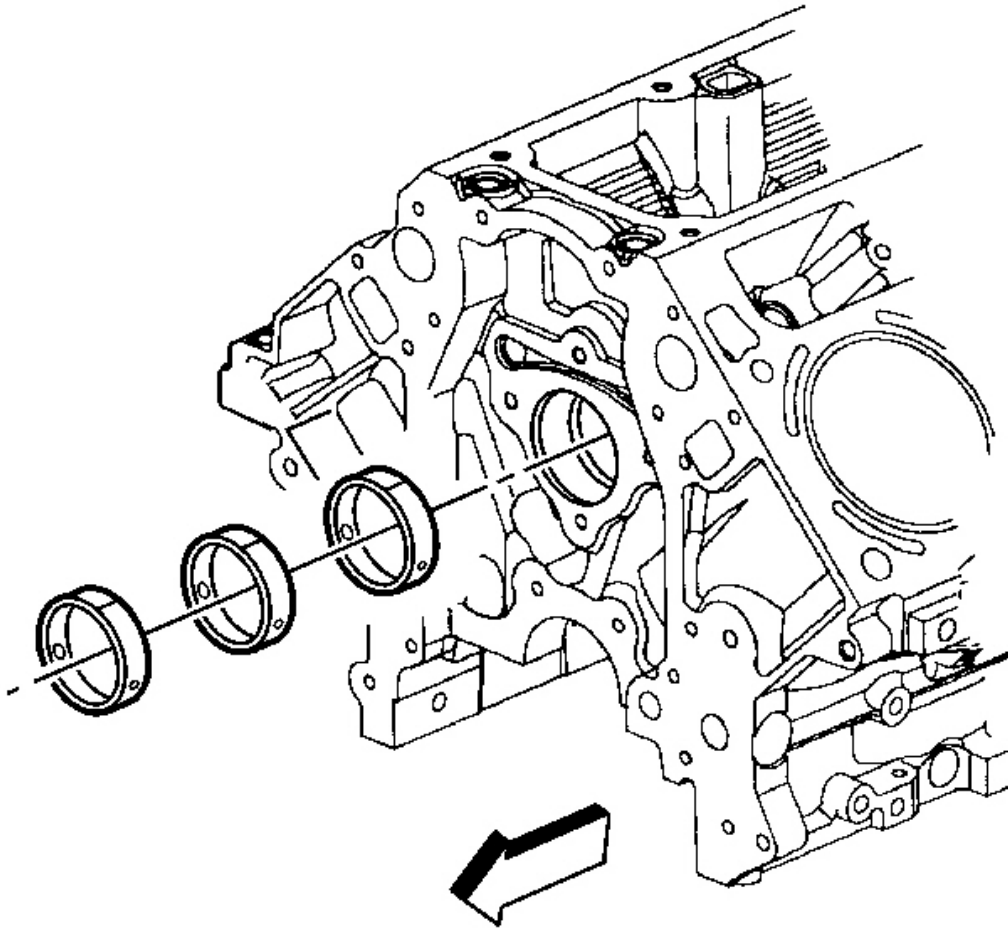




**Fig. 453: Camshaft Retainer & Bolts**  
**Courtesy of GENERAL MOTORS CORP.**

8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

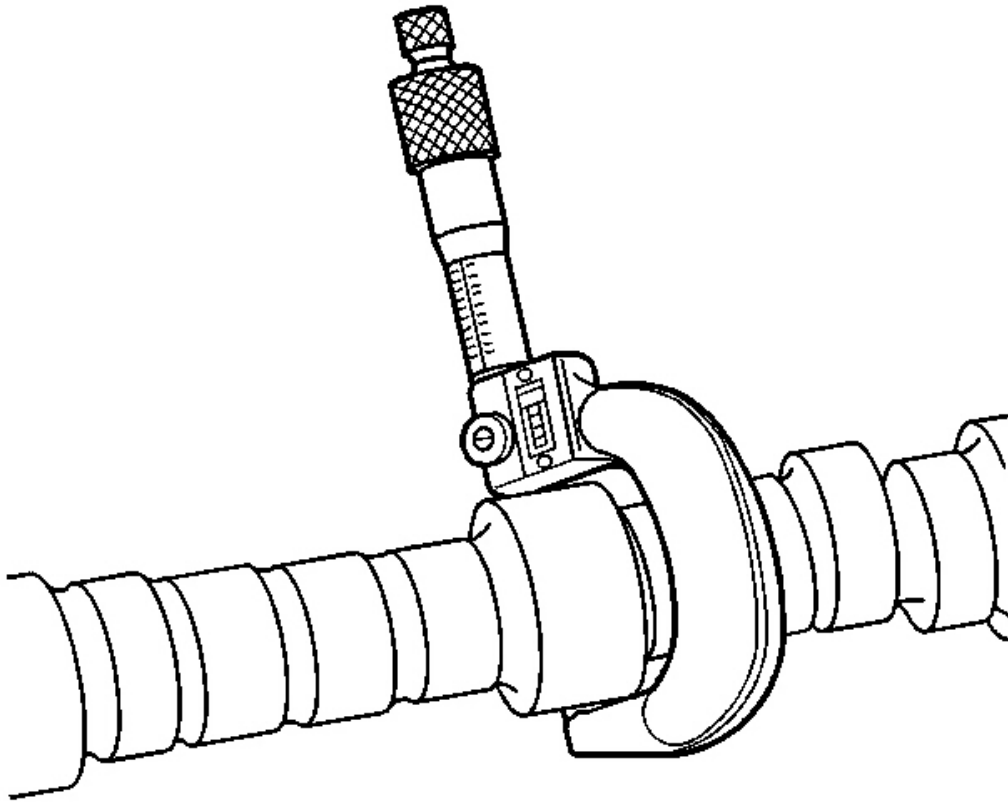
If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.



**Fig. 454: Camshaft Bearings**  
Courtesy of GENERAL MOTORS CORP.

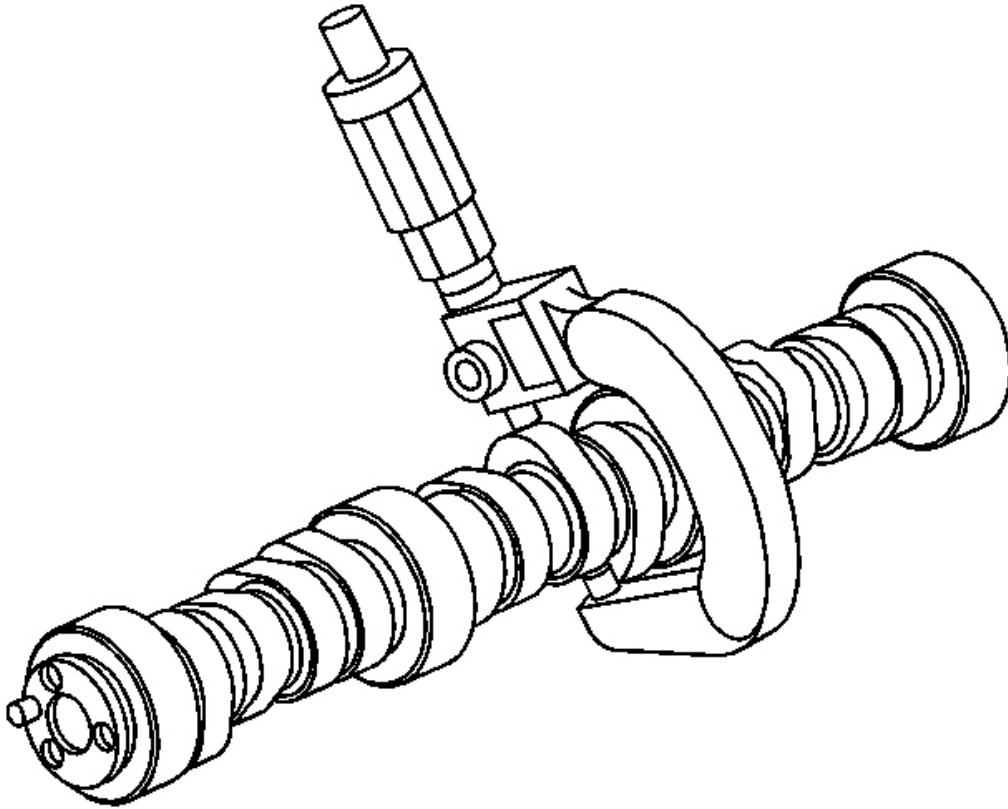
9. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
10. Inspect the camshaft bearings for excessive wear or scoring.

Bearings with excessive scoring or wear must be replaced.



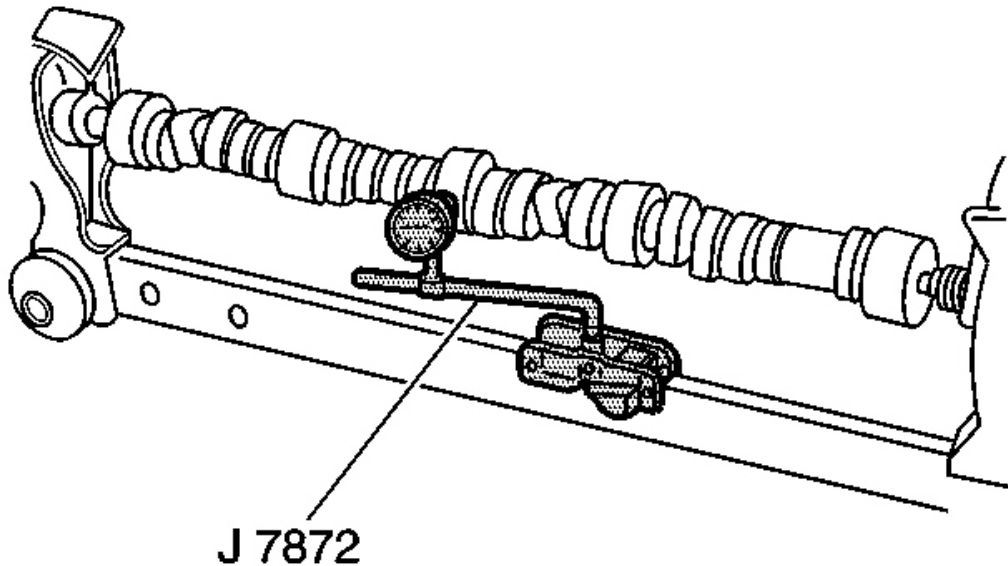
**Fig. 455: Measuring Camshaft Journals**  
Courtesy of GENERAL MOTORS CORP.

11. Measure the camshaft journals for wear and out-of-round with a micrometer.
  - If the camshaft bearing journals are more than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
  - If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the camshaft.



**Fig. 456: Measuring Camshaft Lobes**  
Courtesy of GENERAL MOTORS CORP.

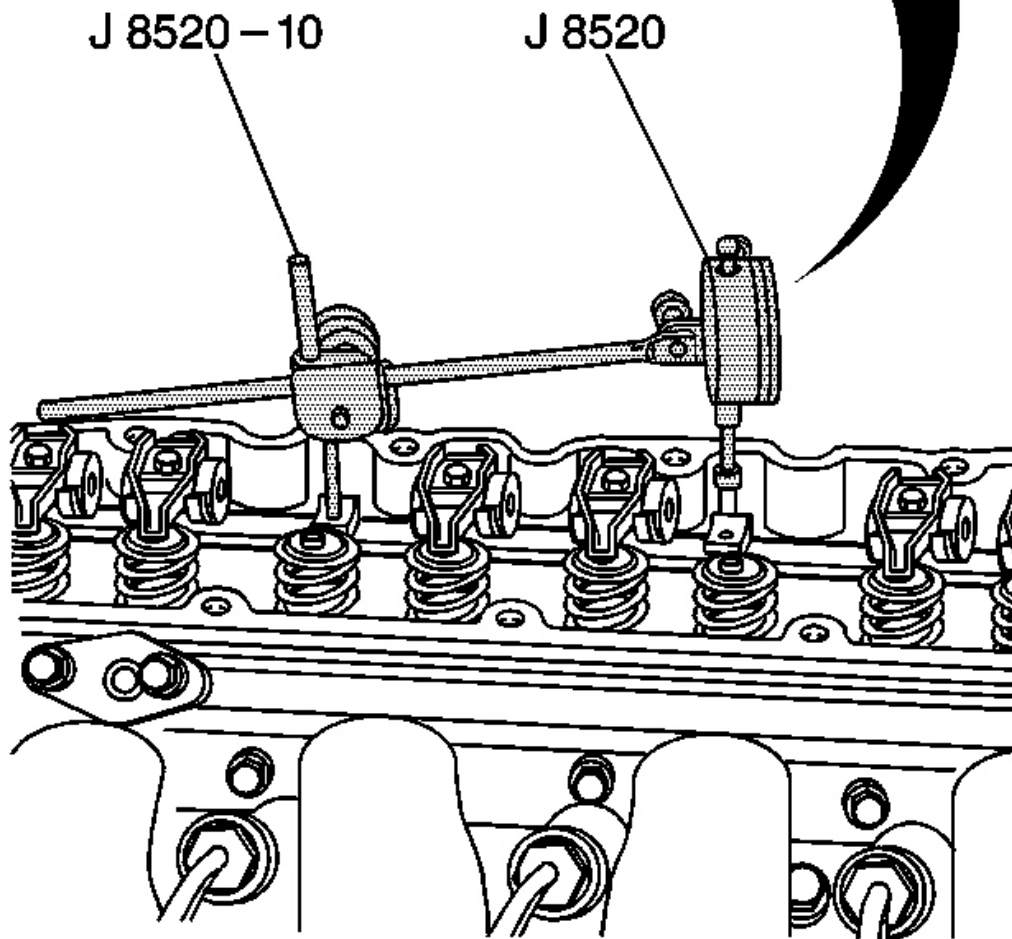
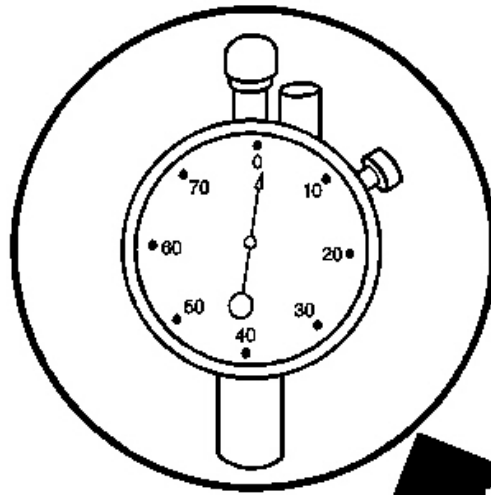
12. Measure the camshaft lobes for wear with a micrometer.
  - A 6.0L camshaft with an intake lobe that measures 46.31 mm (1.823 in) or less must be replaced.
  - A 6.0L camshaft with an exhaust lobe that measures 46.48 mm (1.830 in) or less must be replaced.



**Fig. 457: Measuring Camshaft Runout**  
Courtesy of GENERAL MOTORS CORP.

13. Measure the camshaft runout.
  1. Mount the camshaft in wooden V blocks or between centers on a fixture.
  2. Check the runout of the intermediate camshaft bearing journals using the **J 7872**.
  3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

#### **Measuring Camshaft Lobe Lift**



**Fig. 458: Measuring Camshaft Lobe Lift**  
Courtesy of GENERAL MOTORS CORP.

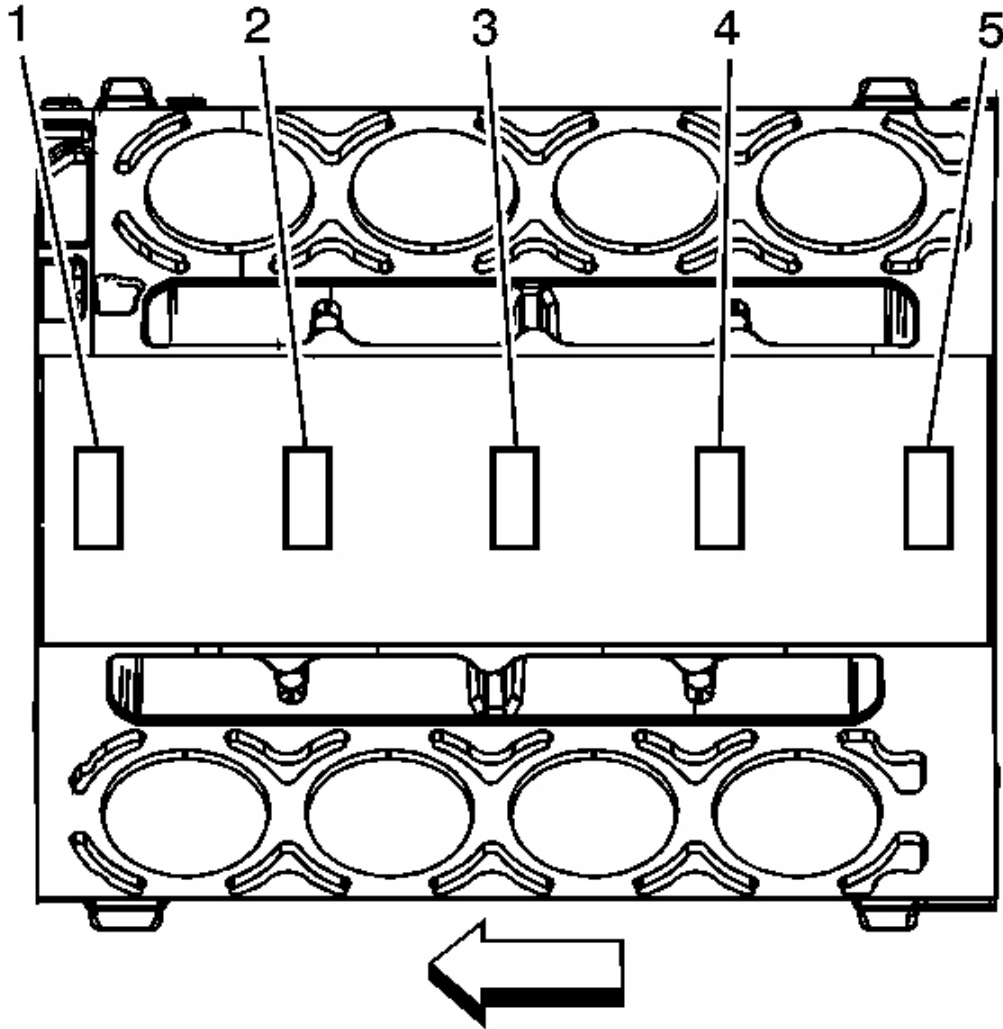
**IMPORTANT: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.**

1. Measure camshaft lobe lift using **J 8520** . See **Special Tools and Equipment** .
2. Remove the valve rocker arms and bolts
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the **J 8520** and position onto the stud. See **Special Tools and Equipment** .
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise until the dial indicator obtains its highest and lowest readings.
8. Compare the total lift shown to specifications:
  - The proper lobe lift for 6.0L intake lobes is 6.96 mm (0.274 in).
  - The proper lobe lift for 6.0L exhaust lobes is 7.13 mm (0.281 in).

## **CAMSHAFT BEARING INSTALLATION**

### **Tools Required**

**J 33049** Camshaft Bearing Service Set. See **Special Tools and Equipment** .



**Fig. 459: Engine Block Camshaft Bearing Bores**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Positions 1 and 5 are the largest diameter bores. Position 3 is the smallest diameter bore. Positions 2 and 4 are the intermediate size bores. The inside diameter (ID) for all camshaft bearings is the same size.

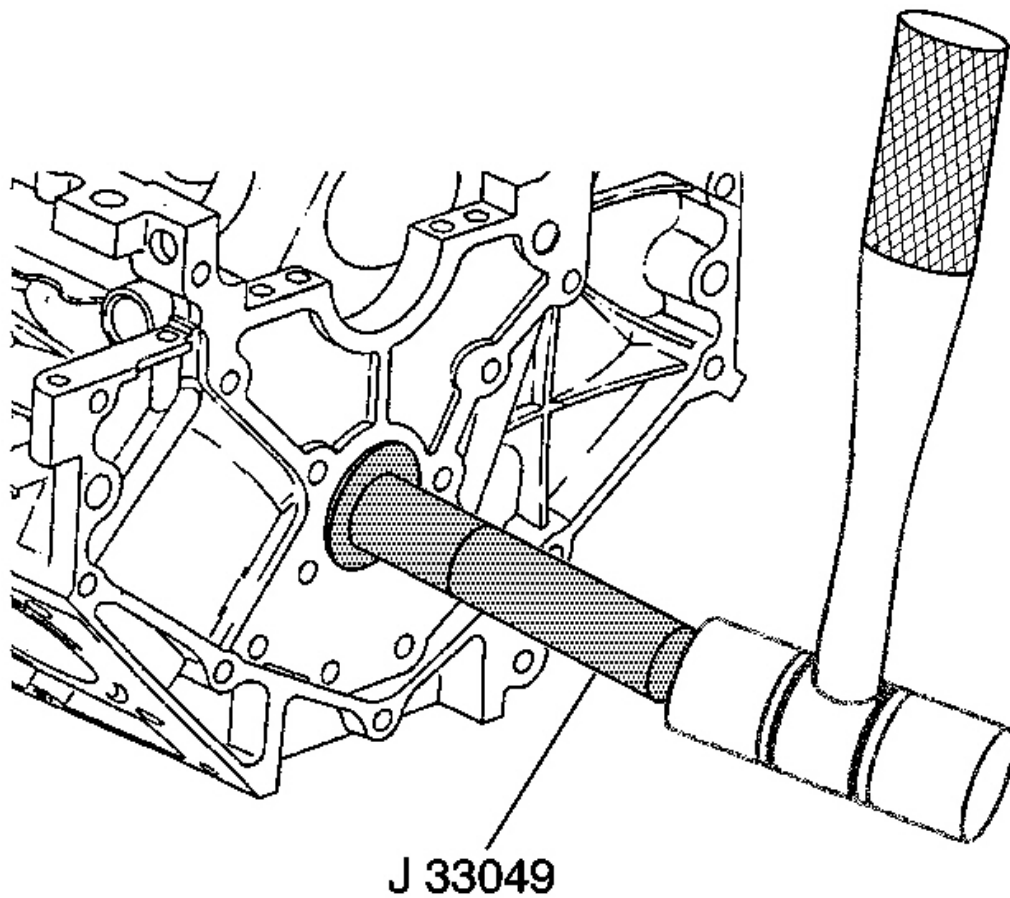
1. Measure the engine block camshaft bearing bores (1-5) to identify the correct OD size bearing for each





**Equipment** . Refer to **Camshaft Bearing Removal** .

3. Assemble the tool.



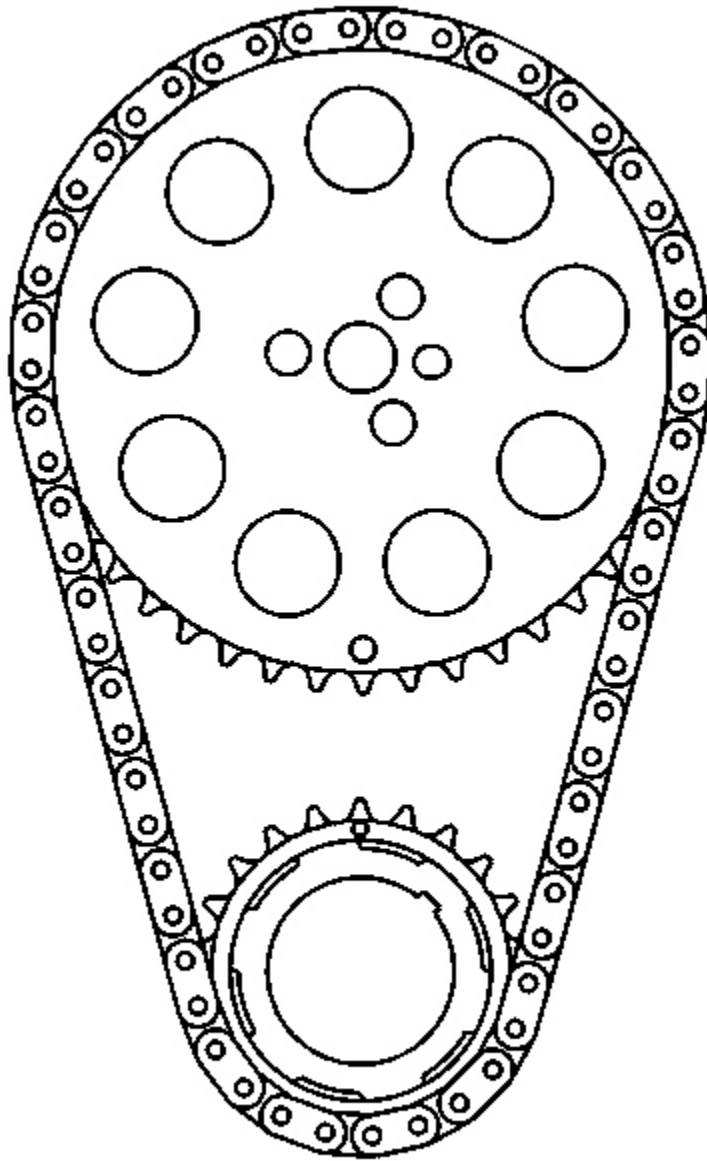
**Fig. 461: Driving Bearing From Block Bore**  
Courtesy of GENERAL MOTORS CORP.

4. Insert the tool through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone into the front camshaft bearing to align the tool.
7. Drive the bearing into the block bore.
8. Repeat the above procedures to install the remaining bearings.

1. Clean the components with cleaning solvent.

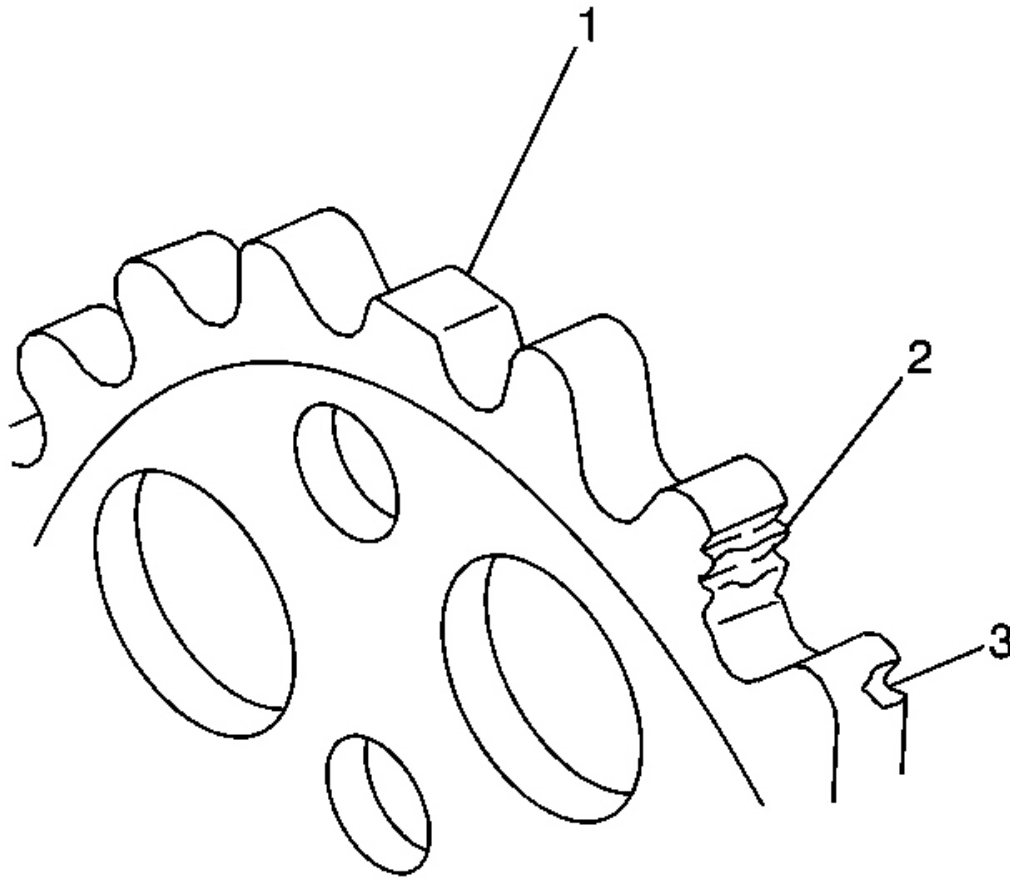
**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

2. Dry the components with compressed air.



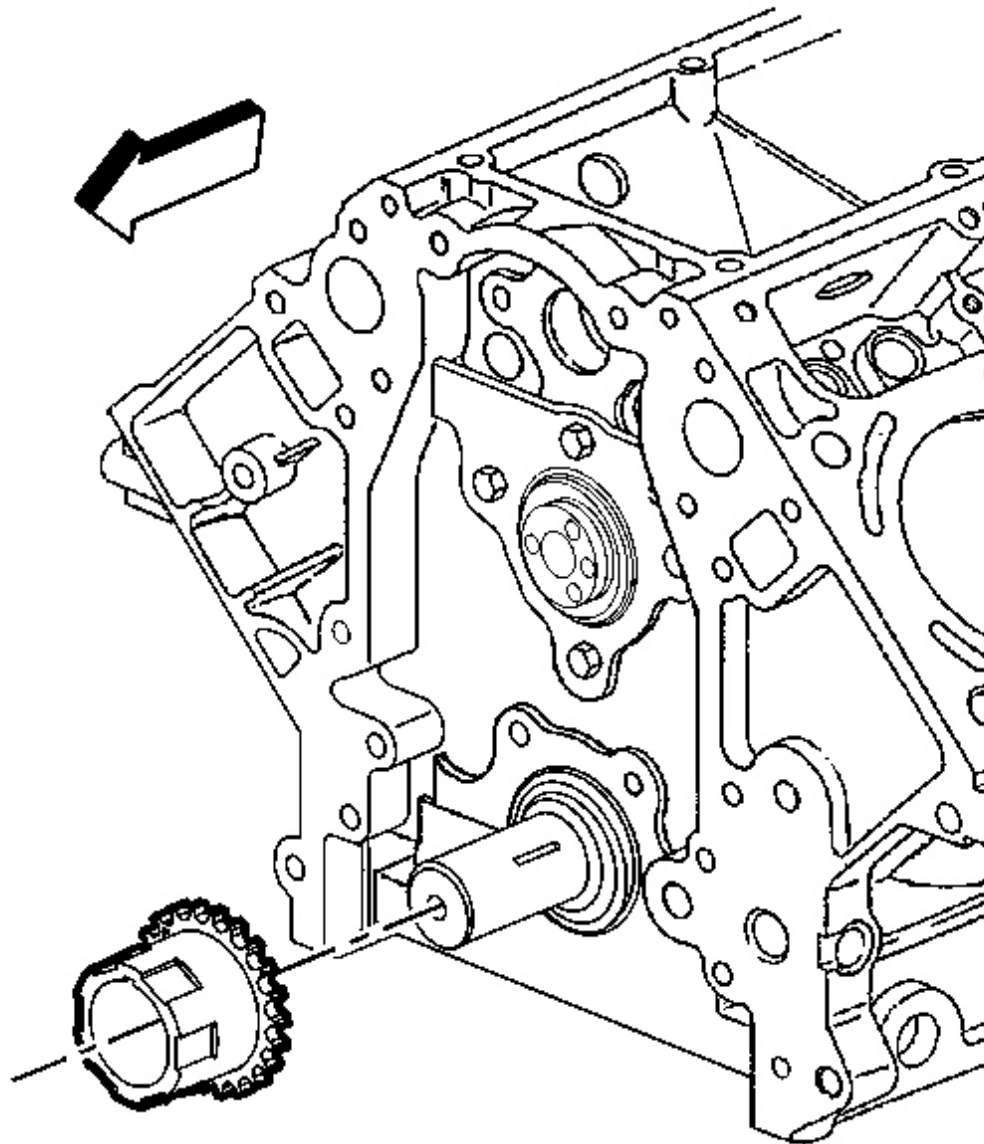
**Fig. 462: Camshaft & Crankshaft Sprockets Aligned**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the timing chain for binding or wear.



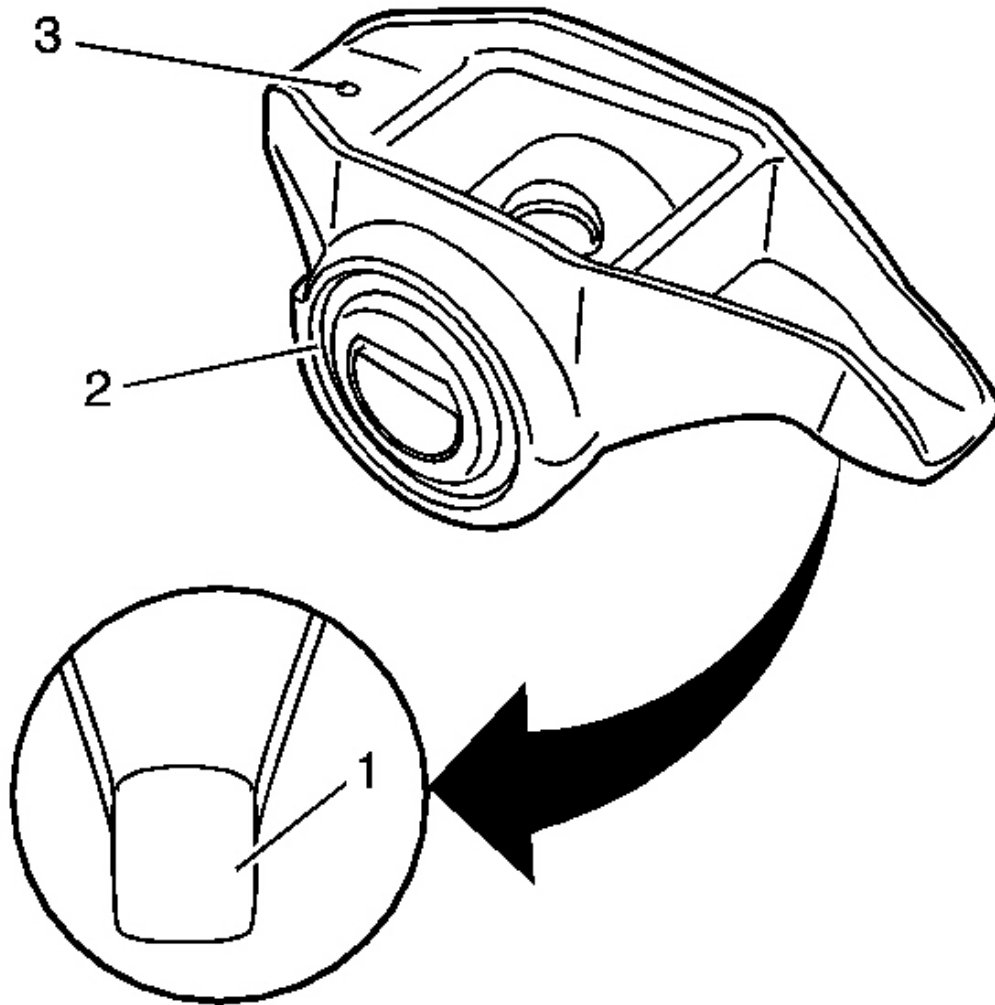
**Fig. 463: Inspecting Timing Chain Sprocket Teeth**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft and crankshaft sprockets for:
  - Worn teeth (1)
  - Damaged teeth (2)
  - Chipped teeth (3)
  - Worn valleys between the sprocket teeth



**Fig. 464: Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

5. Inspect the crankshaft sprocket keyway for wear.
6. Inspect the crankshaft sprocket oil pump drive splines for wear.



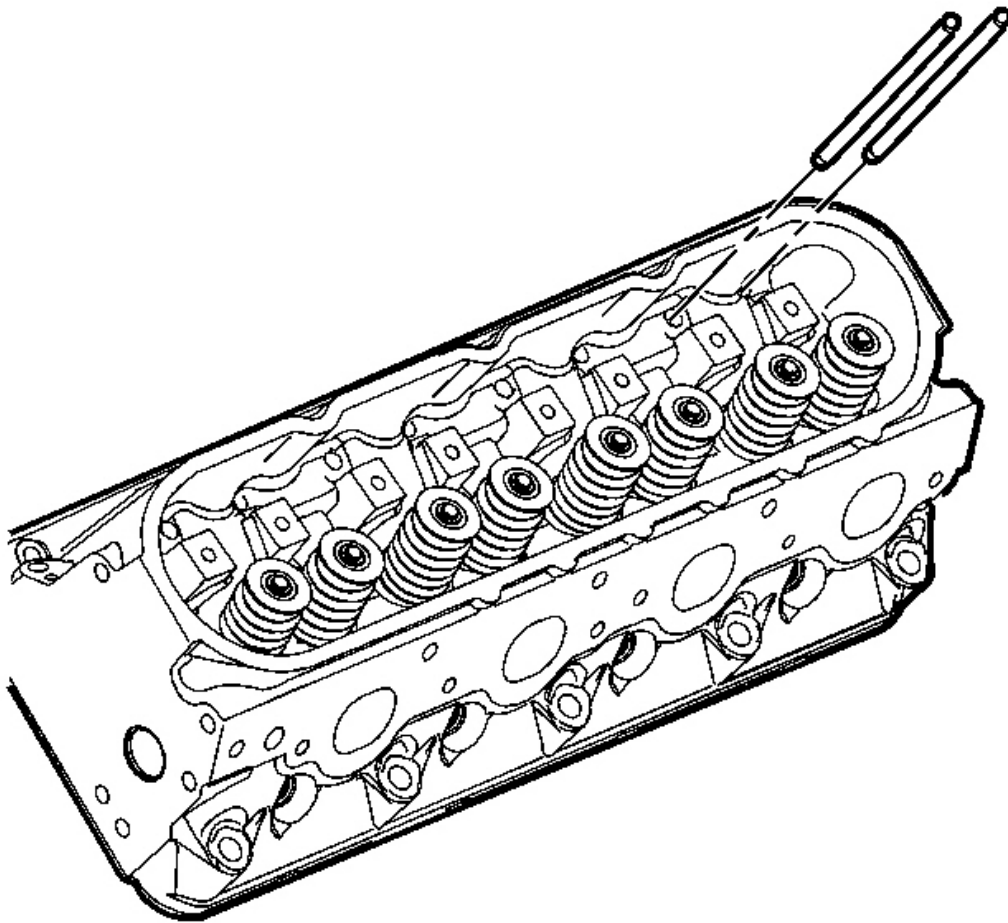
**Fig. 465: Valve Stem Mating Surfaces, Valve Rocker Arms Bearing & Pushrods**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Parts that are to be used again must be marked, sorted or organized for assembly.

1. Mark, sort, or organize the components for assembly. Refer to Separating Parts .
2. Clean the components with cleaning solvent.

**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

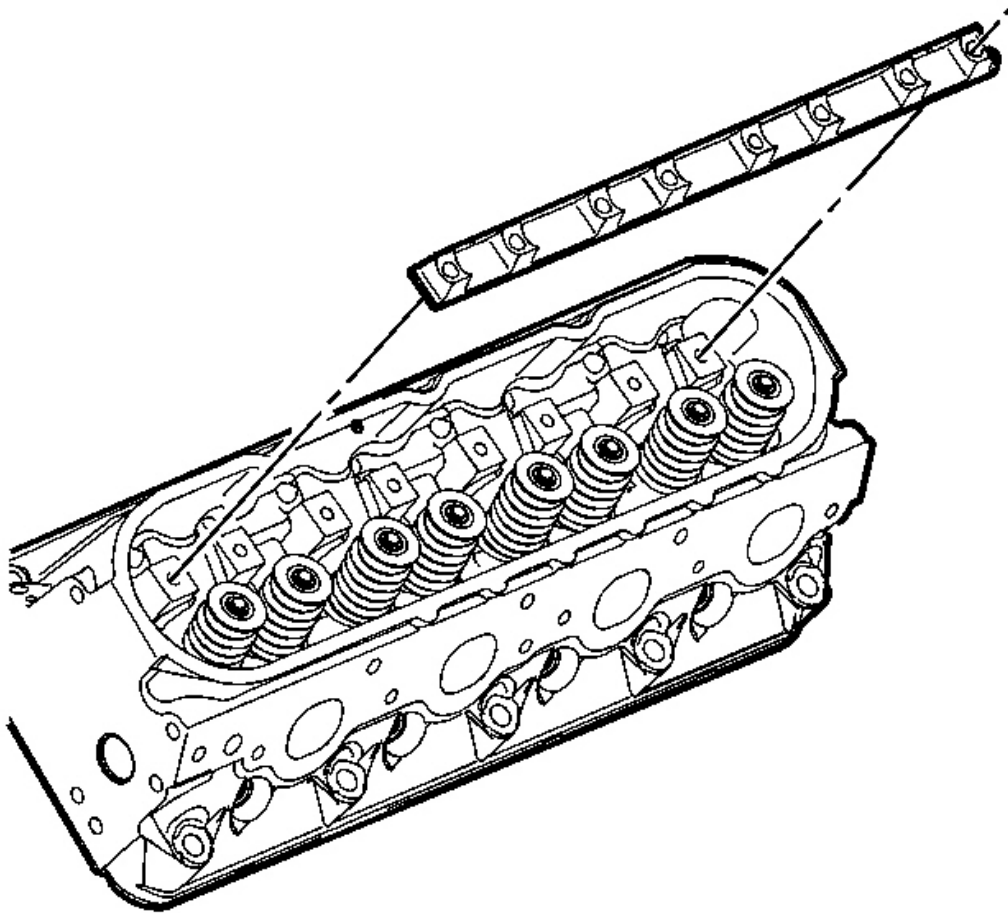
3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.



**Fig. 466: View Of Pushrods**  
Courtesy of GENERAL MOTORS CORP.

6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.





**Fig. 467: Valve Rocker Arm Pivot Support**  
Courtesy of GENERAL MOTORS CORP.

9. Inspect the pivot supports for cracks, wear, or other damage.

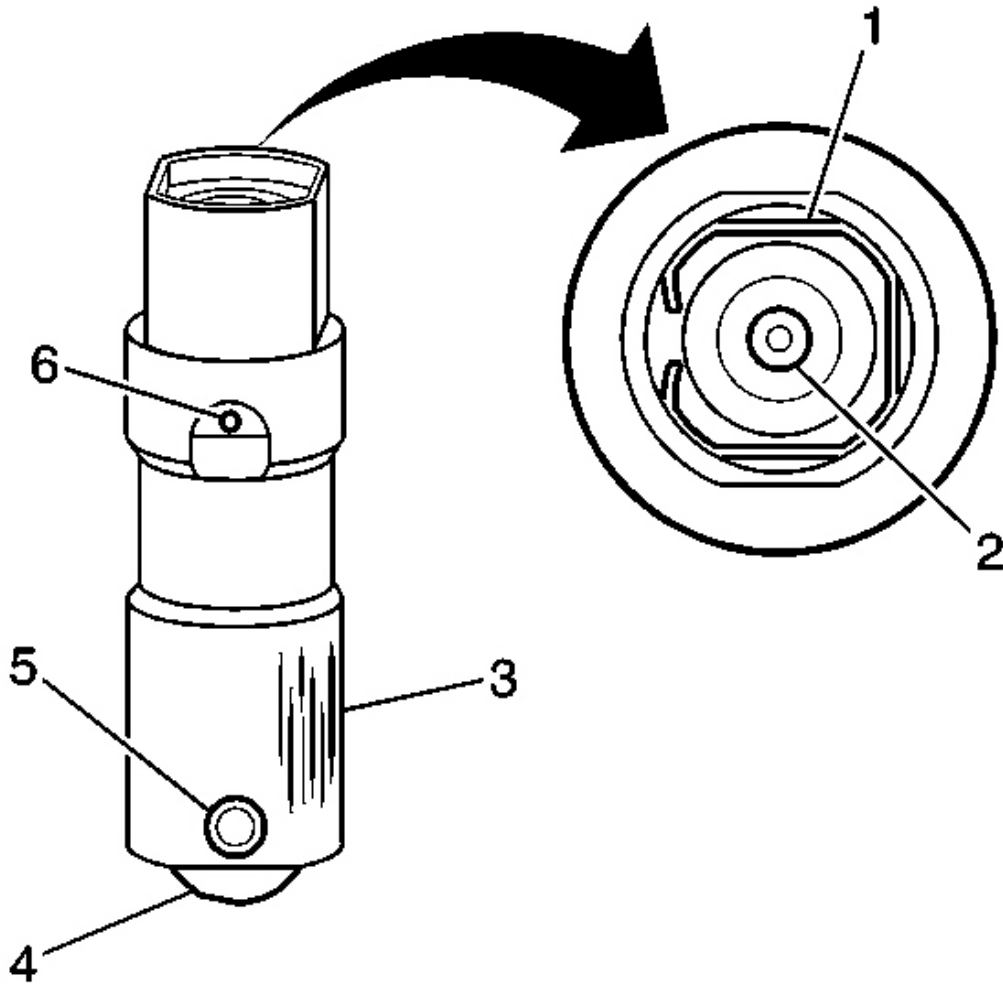
## VALVE LIFTERS AND GUIDES CLEANING AND INSPECTION

**IMPORTANT: Components that are to be used again must be marked, sorted or organized for assembly.**

1. Mark, sort, or organize the components for assembly. Refer to **Separating Parts** .
2. Clean the components in cleaning solvent.

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

3. Dry the components with compressed air.



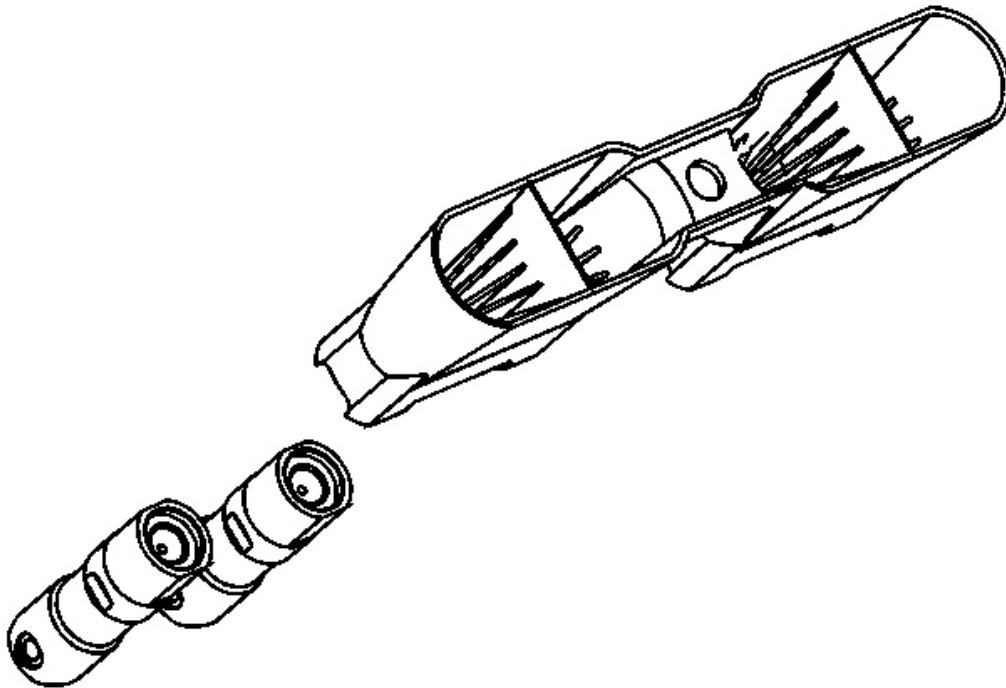
**Fig. 468: Inspecting Valve Lifters**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifters for the following conditions:
- Bent or broken clip (1)
  - Worn pushrod socket (2)
  - Scuffed or worn sides (3)

If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

- Flat spots on the roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)
- Worn or damaged roller bearing

The roller should rotate freely with no binding or roughness.



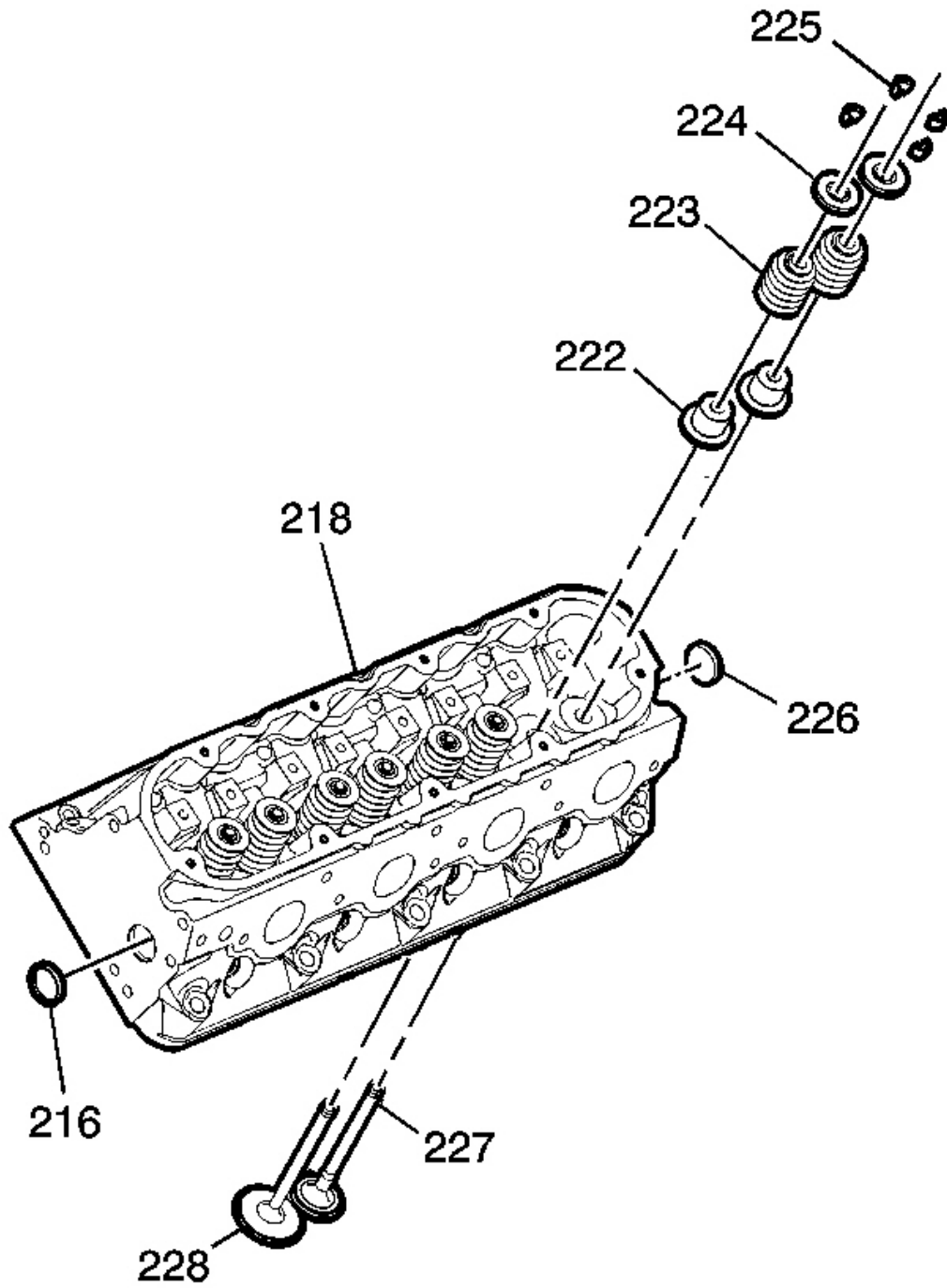
**Fig. 469: Valve Lifters & Lifter Guides**  
Courtesy of GENERAL MOTORS CORP.

5. Inspect the valve lifter guides for the following conditions:
  - For cracks or damage
  - Excessive wear in the lifter mounting bores

## CYLINDER HEAD DISASSEMBLE

### Tools Required

**J 8062 Valve Spring Compressor - Head Off. See Special Tools and Equipment .**

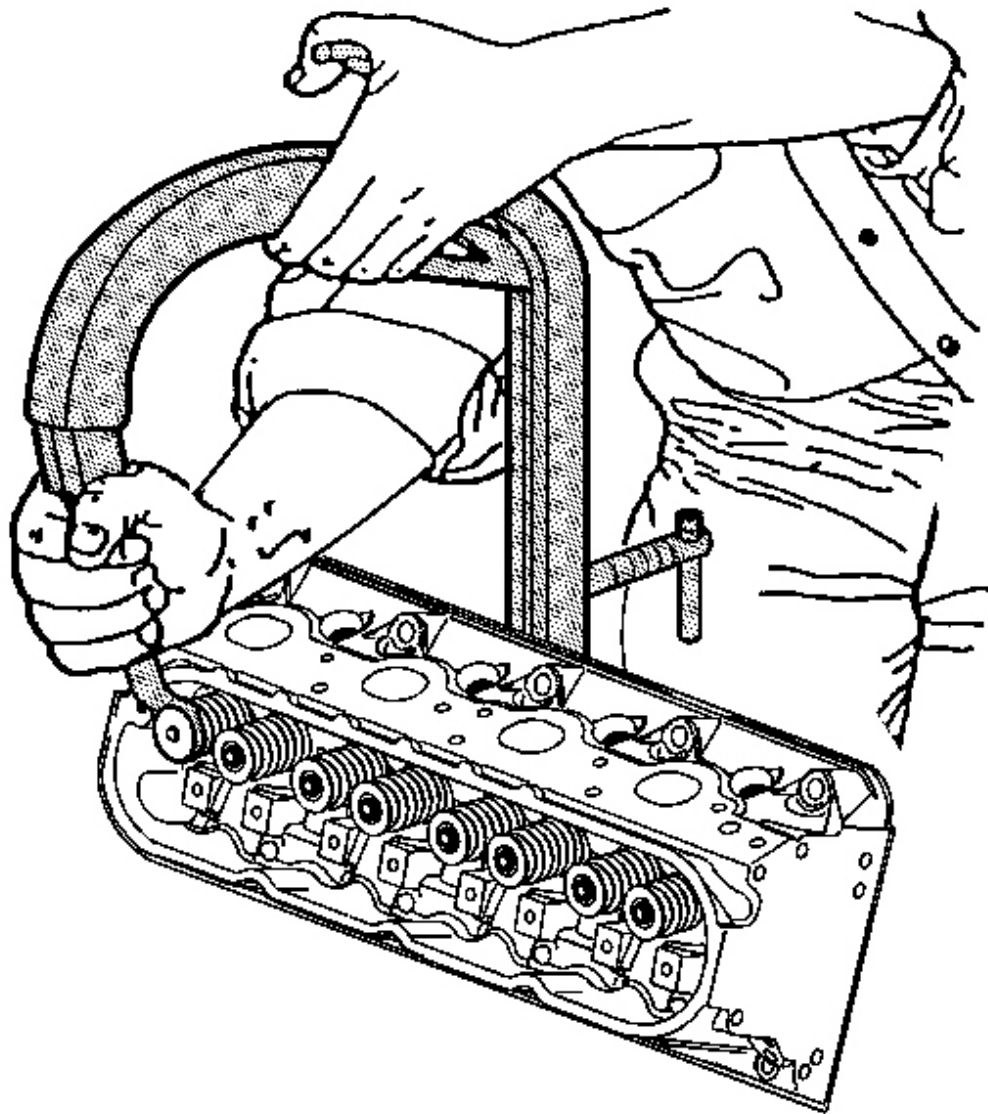


**Fig. 470: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

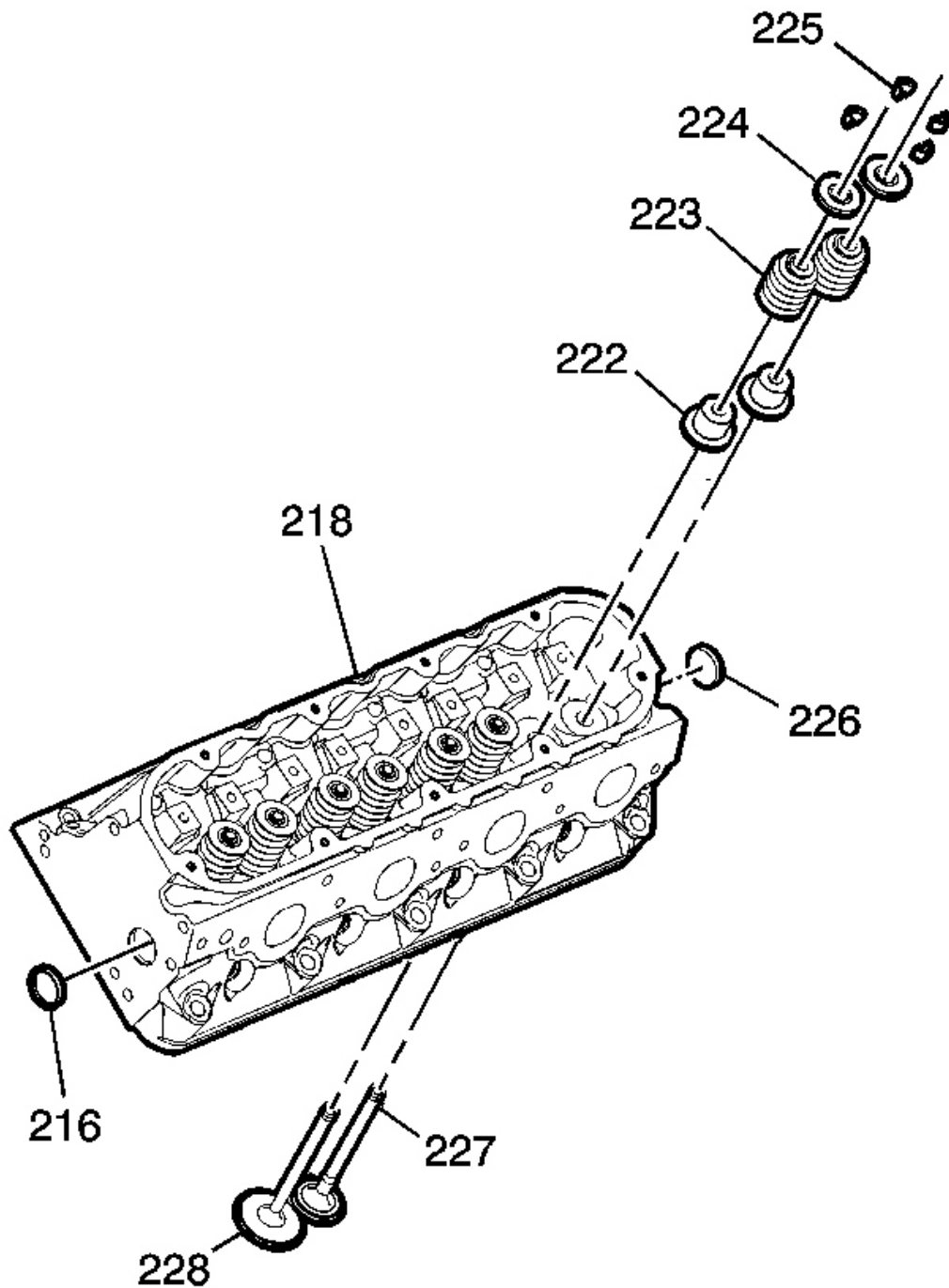
- Remove the spark plugs from the cylinder head with the components at room temperature.
- Mark, organize, or sort the cylinder head components for assembly. Return the components to their original location during assembly.
- Do not remove the cylinder head expansion plugs (226) unless service is required.

1. Remove the spark plugs from the cylinder heads.



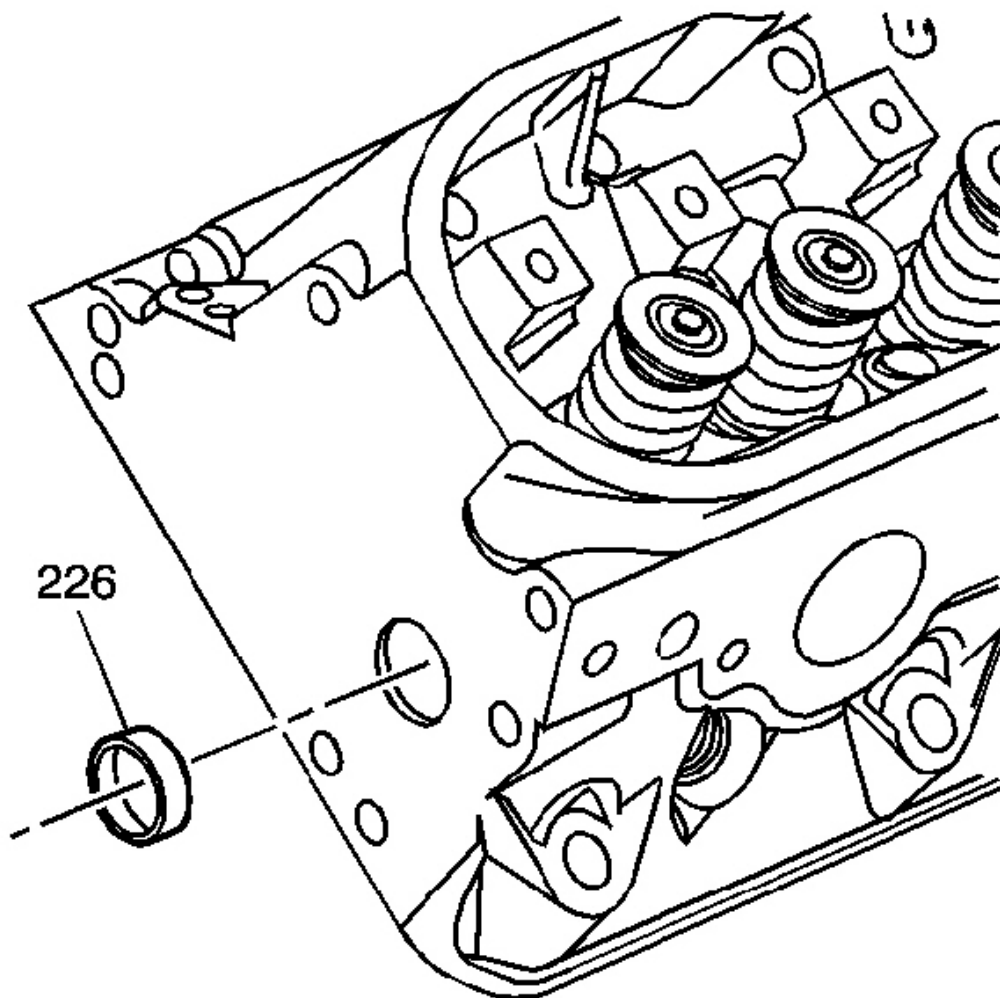
**Fig. 471: Compressing Valve Spring Using J 8062**  
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 8062** in order to compress the valve spring. See **Special Tools and Equipment** .



**Fig. 472: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

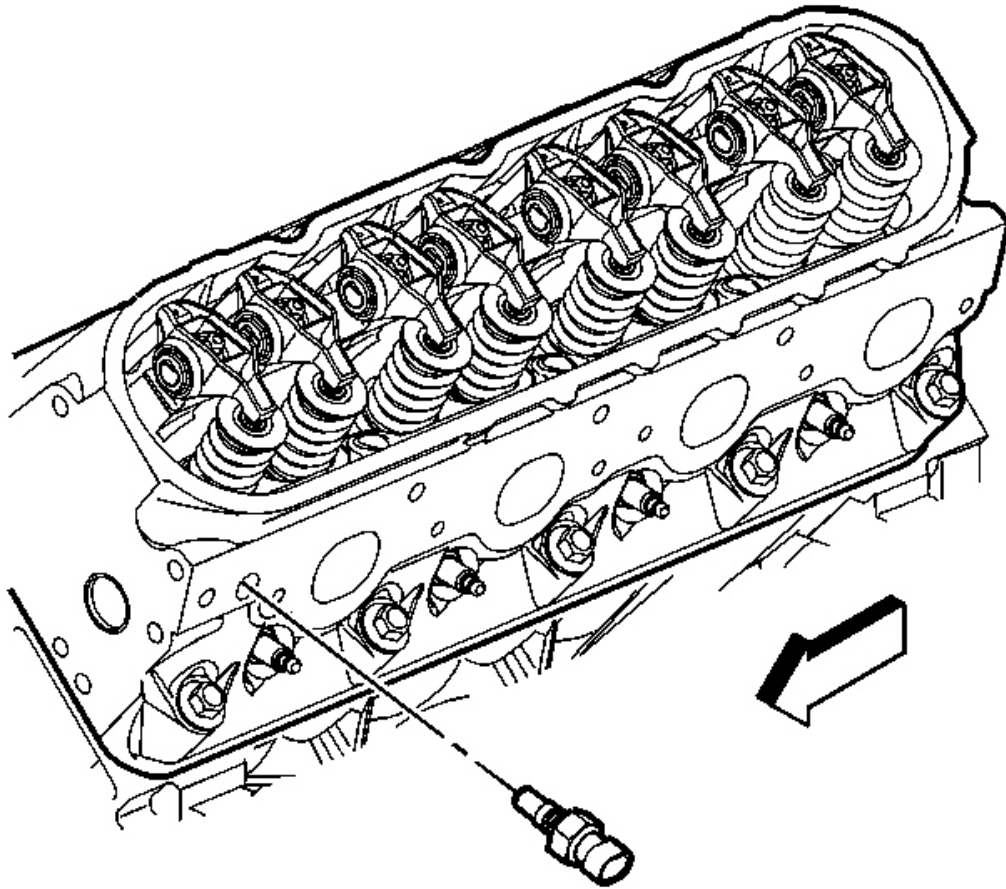
3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (227 and 228).
7. Remove the valve stem oil seal (222). Refer to **Separating Parts** .



**Fig. 473: Cylinder Head Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

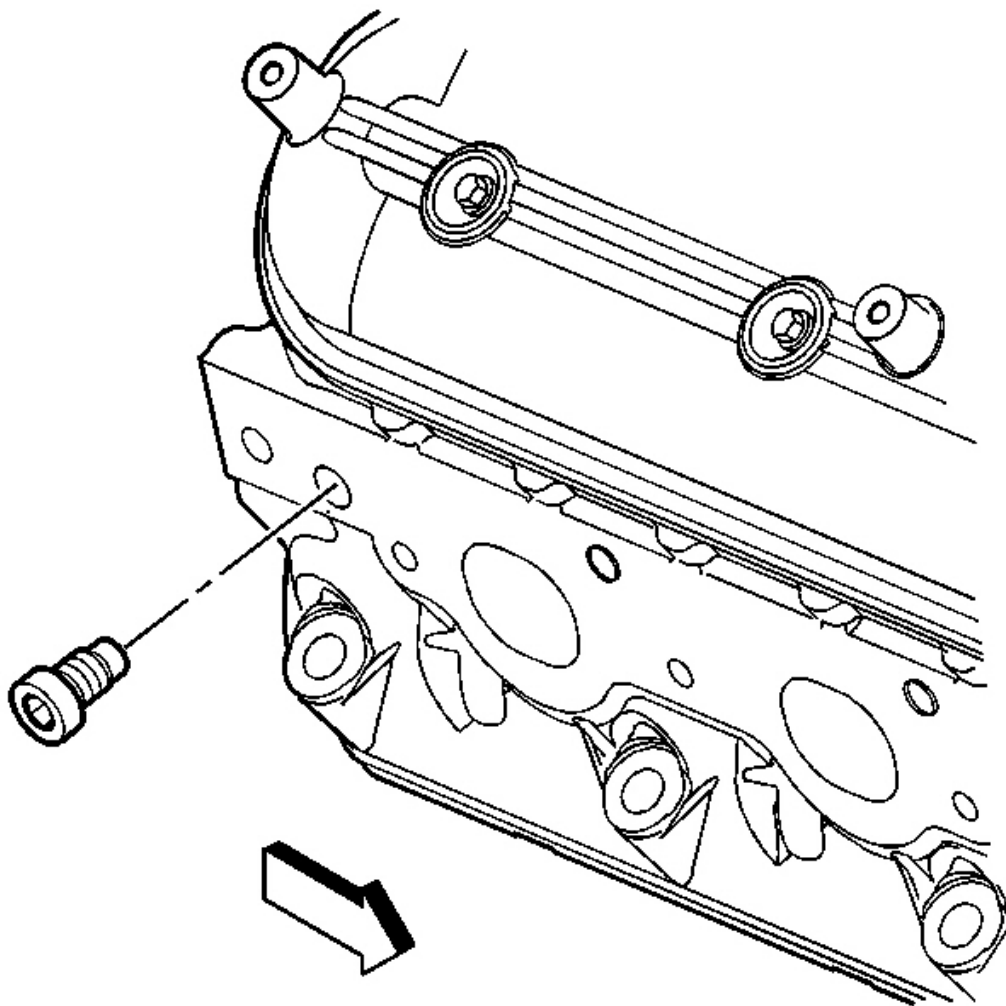
8. Remove the cylinder head expansion plugs (226), if required.





**Fig. 474: Coolant Temperature Sensor (Left Cylinder Head)**  
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor from the left cylinder head.



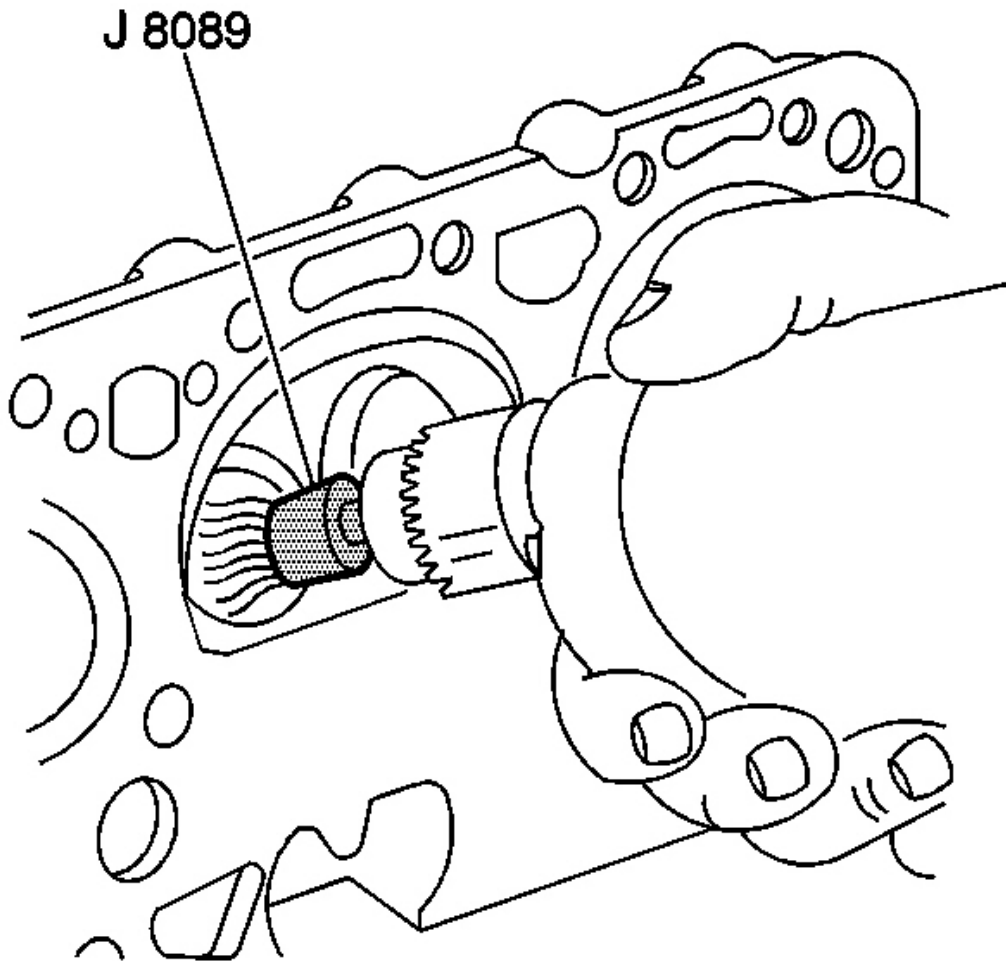
**Fig. 475: Coolant Plug (Right Cylinder Head)**  
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant plug from the right cylinder head.

## **CYLINDER HEAD CLEANING AND INSPECTION**

### **Tools Required**

- J 8089 Carbon Removal Brush
- J 9666 Valve Spring Tester



**Fig. 476: Cleaning Carbon Using J 8089**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** When cleaning a cylinder head in a thermal type oven, do not exceed 204° C (400°F).

1. Clean the following components:

**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

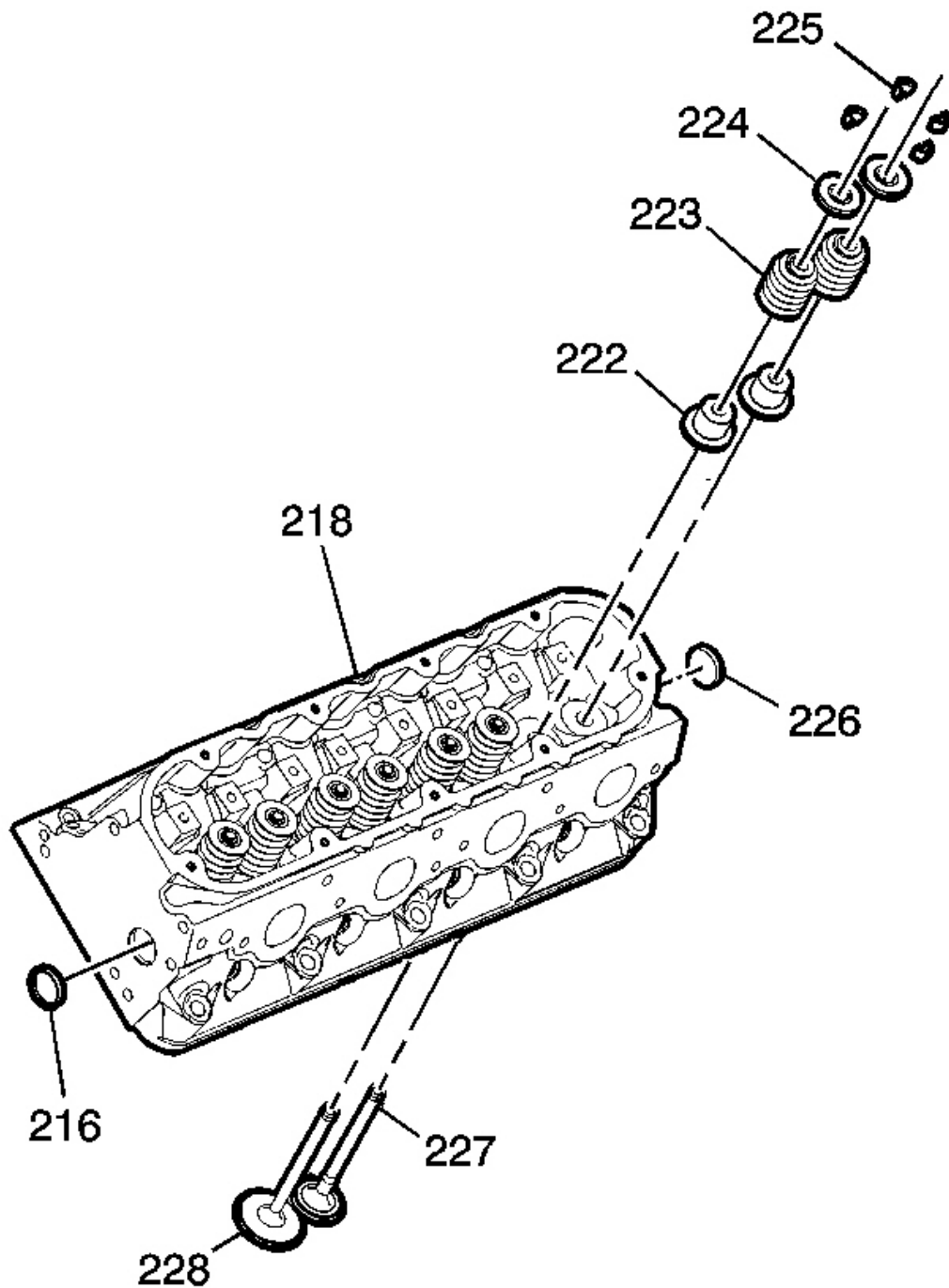
**IMPORTANT:** Be careful not to scuff the chamber.

- Use the J 8089 in order to remove the carbon from the combustion chambers.
- Gasket surfaces

Refer to **Replacing Engine Gaskets** .

- Valve stems and heads on a buffing wheel
- Bolt hole threads

Remove all dirt, debris, or threadlocking material from the bolt holes.



**Fig. 477: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

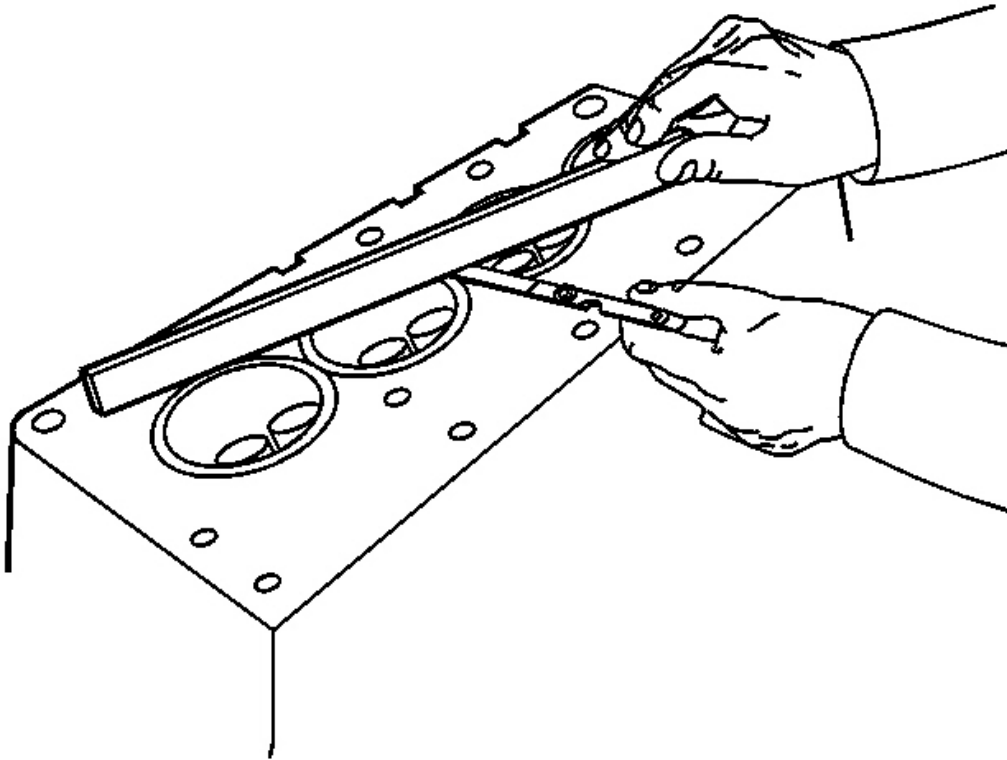
2. Inspect the following components:

1. The cylinder head (218) for cracks in the exhaust ports and combustion chambers
2. The cylinder head for external cracks in the water chambers
3. The gasket surfaces for excessive scratches or gouging

Refer to **Replacing Engine Gaskets** .

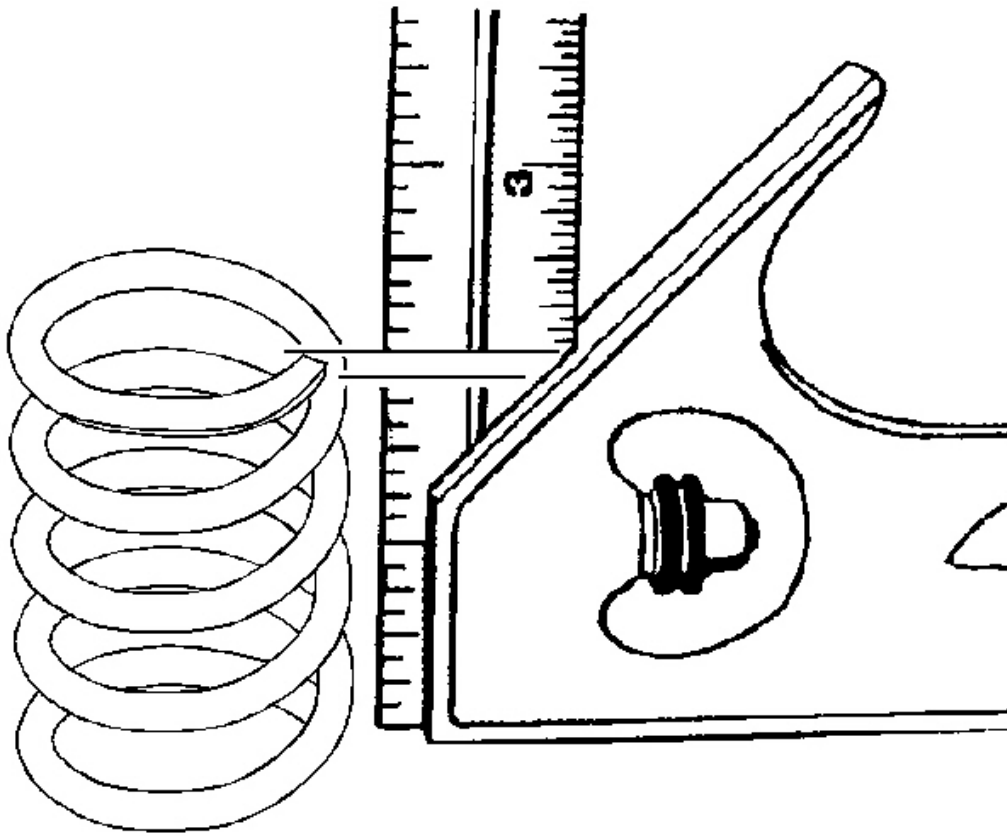
4. The bolt hole threads for debris or damaged threads

Refer to **Thread Repair** or **Thread Repair Specifications** .



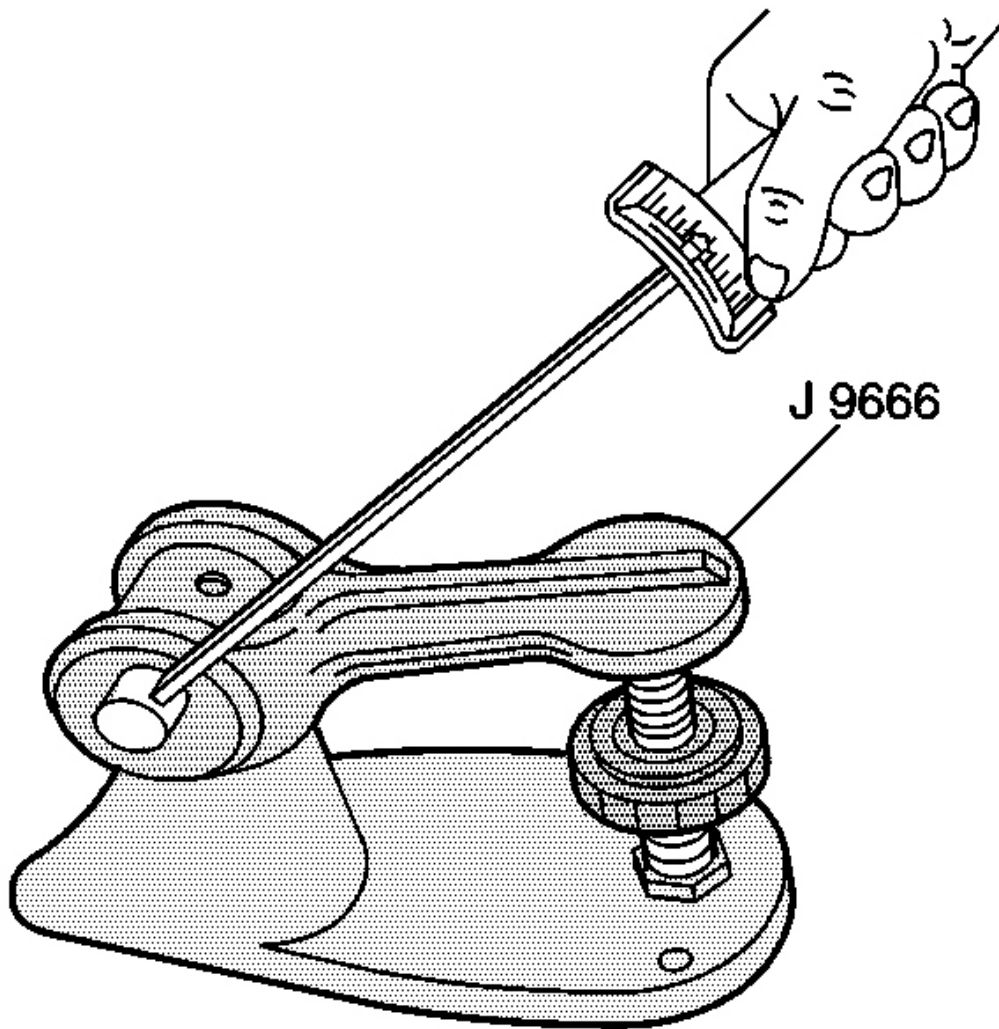
**Fig. 478: Measuring Cylinder Head For Warpage**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications** .



**Fig. 479: Inspecting Valve Spring For Squareness**  
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve springs for squareness.



**Fig. 480: Measuring The Valve Spring Using J 9666**  
Courtesy of GENERAL MOTORS CORP.

5. Use the J 9666 in order to measure the valve spring tension.

Replace the spring if the spring tension is less than 310 N (70 lb) at 45.75 mm (1.80 in).

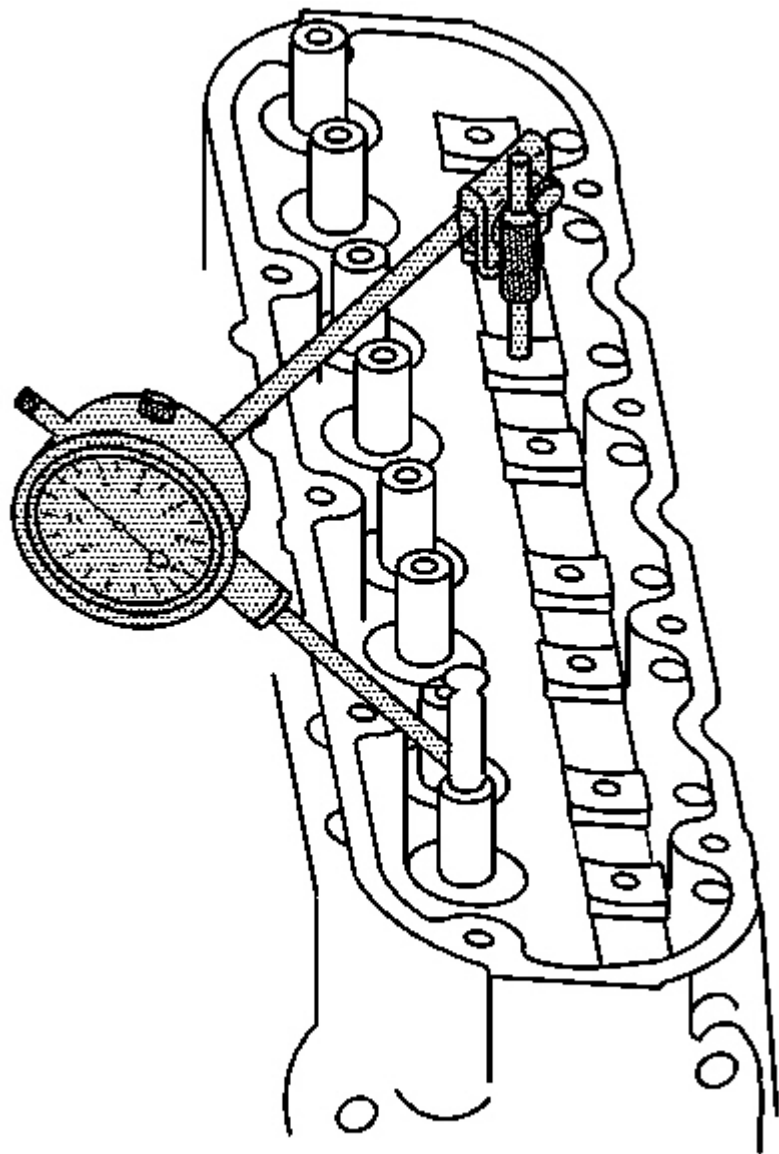
## VALVE GUIDE REAMING/VALVE AND SEAT GRINDING

### Tools Required



**J 37378-1** Valve Guide Reamer. See **Special Tools and Equipment** .

**Valve Guide Reaming**



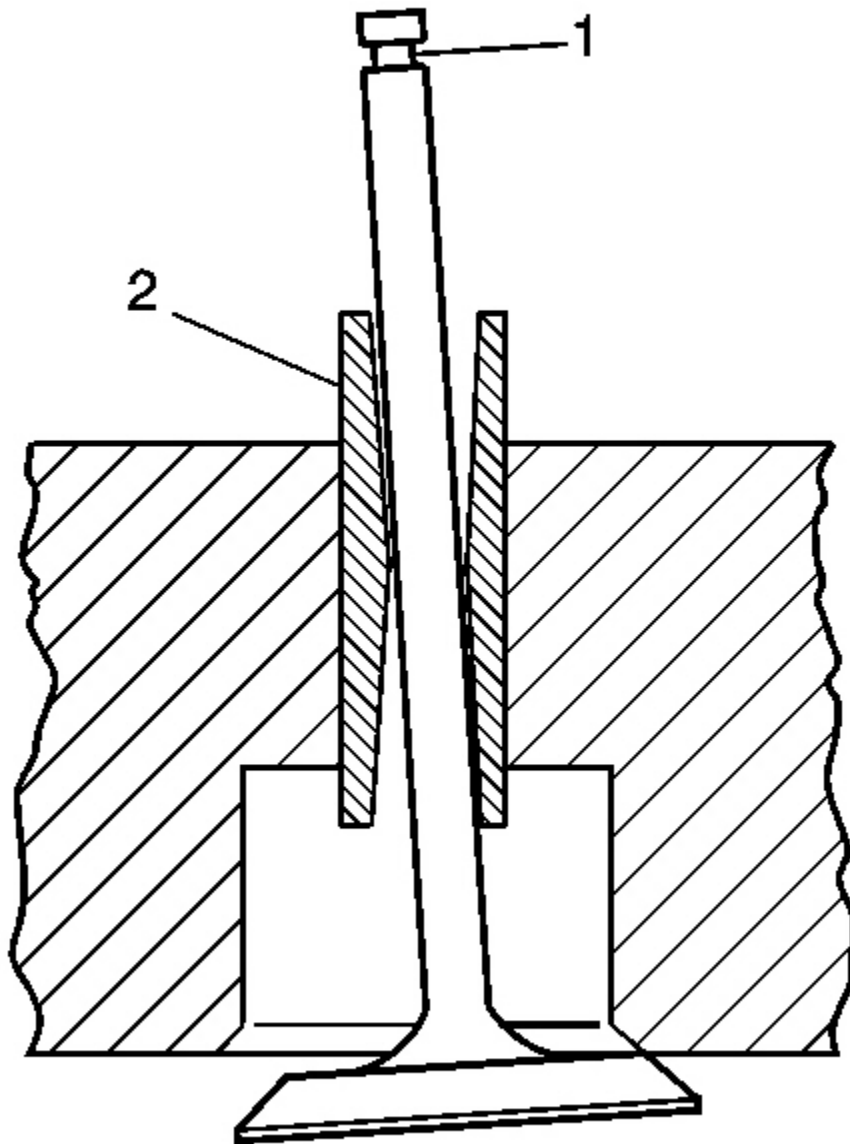
**Fig. 481: Measuring Valve Stem-To-Guide Clearance**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- **Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive engine oil consumption.**
- **Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.**

1. Measure the valve stem-to-guide clearance using a dial indicator. Position the tip of the dial indicator at the top of the valve guide.

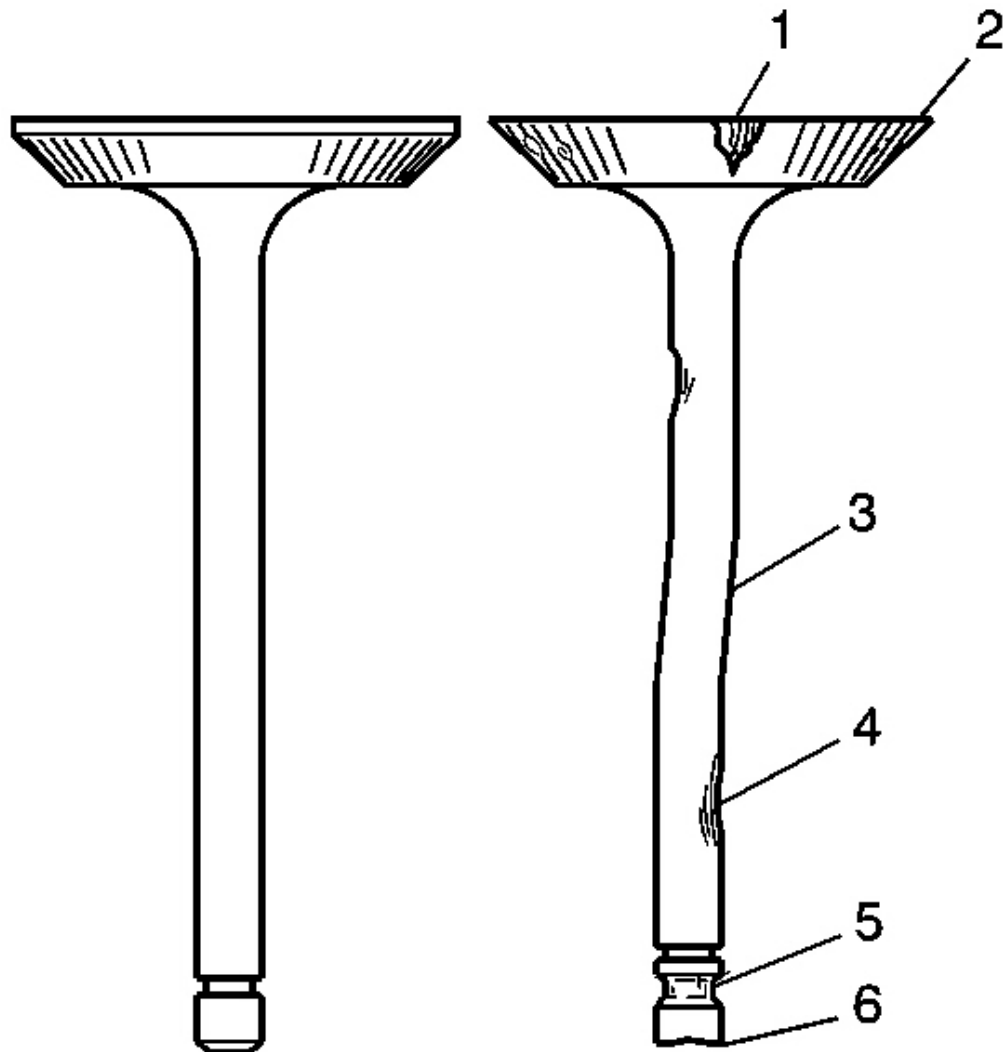
Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gauge to measure the guide bore.



**Fig. 482: Inspecting For Excessive Valve Stem To Guide Clearance**  
Courtesy of GENERAL MOTORS CORP.

2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the components replaced.

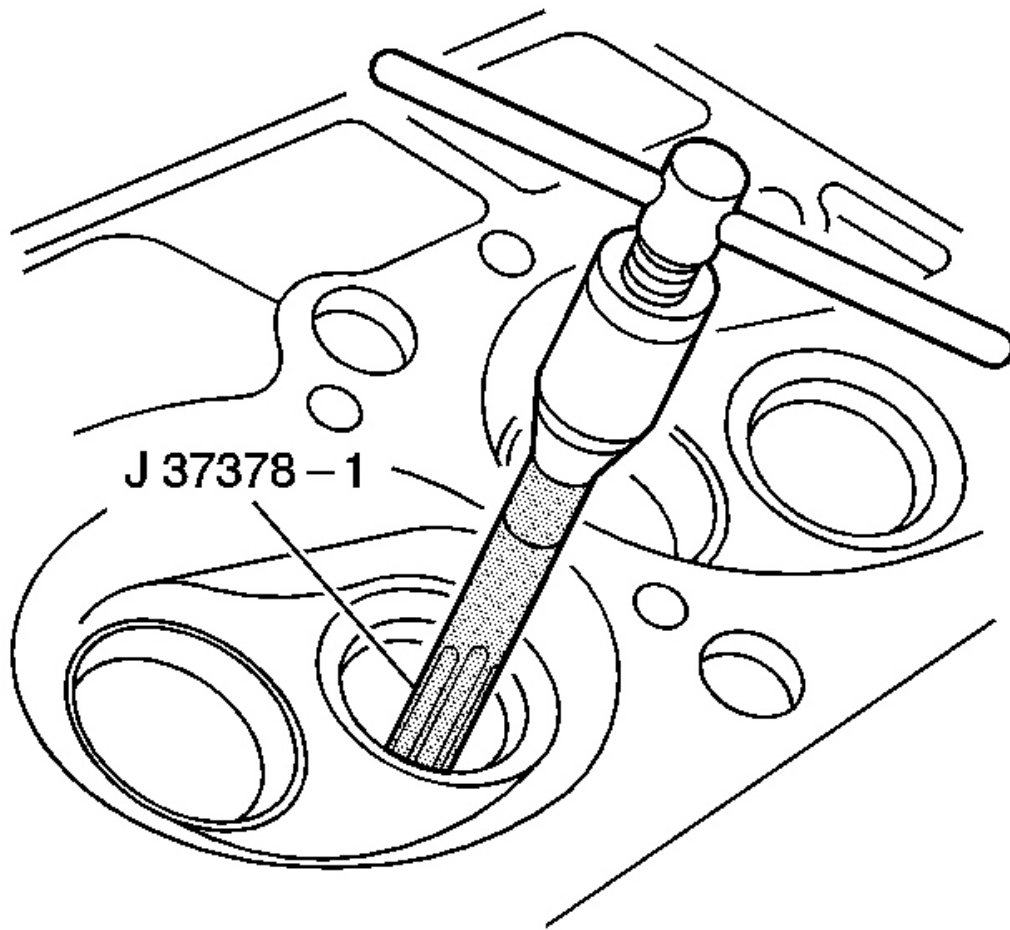
Refer to **Engine Mechanical Specifications** .



**Fig. 483: Inspecting Valves For Damage**  
Courtesy of GENERAL MOTORS CORP.

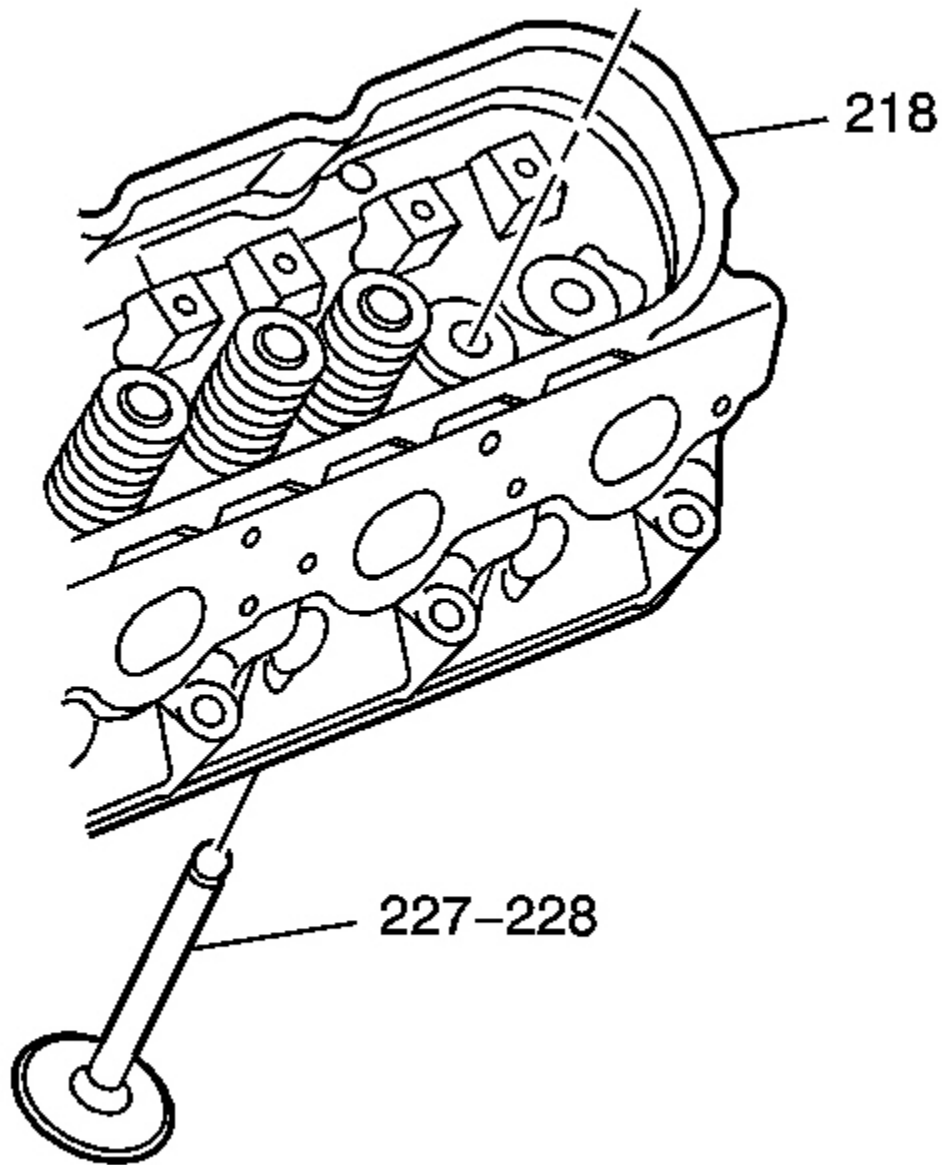
3. Inspect the valve stems for excessive scoring, wear, or warpage.
  - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
  - A valve guide that is worn and has excessive stem-to-guide clearance should be reamed and valves with oversize stems installed.
4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the valve guide must be reamed oversize and a valve with oversize stem installed.



**Fig. 484: Reaming Valve Guide Using J 37378-1**  
Courtesy of GENERAL MOTORS CORP.

5. Ream the valve guide using the **J 37378-1** . See **Special Tools and Equipment** .
6. Clean the guide bore of all metal shavings and debris.

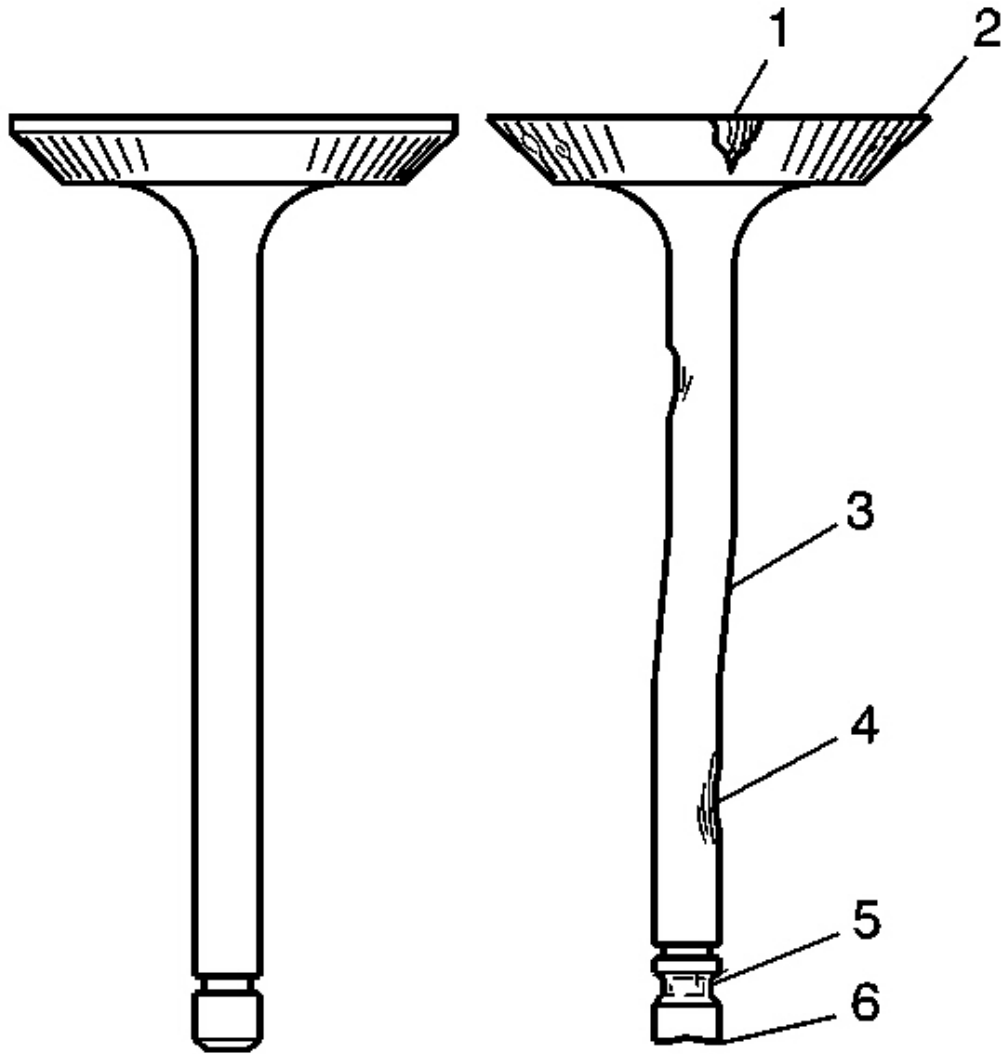


**Fig. 485: Valve & Cylinder Head**  
Courtesy of GENERAL MOTORS CORP.

7. Install the valve (227-228), with oversize stem, into the cylinder head (218).
8. Inspect the valve for the proper fit.

Move the valve back and forth in the guide. The valve should move freely with no resistance or drag.

### Valve and Seat Grinding



**Fig. 486: Inspecting Valves For Damage**  
Courtesy of GENERAL MOTORS CORP.

#### **IMPORTANT:**

- Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and

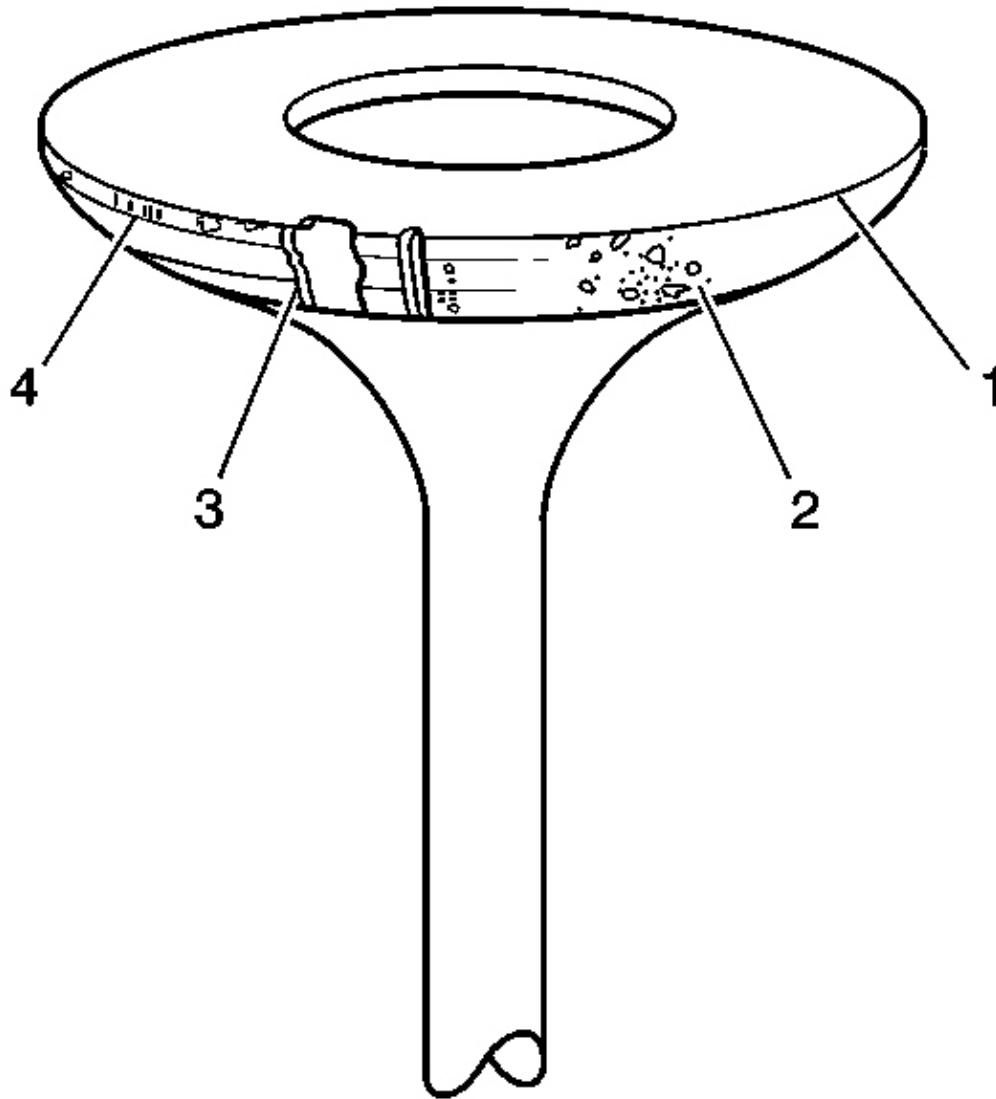
performance. Several different types of equipment are available for grinding valve seats.

- Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.
- The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.
- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.
- Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment should be carefully followed to obtain the proper results.
- **DO NOT** reface intake valves. Intake valves with excessive wear or damage **MUST** be replaced.

1. Inspect the valve for the following conditions:

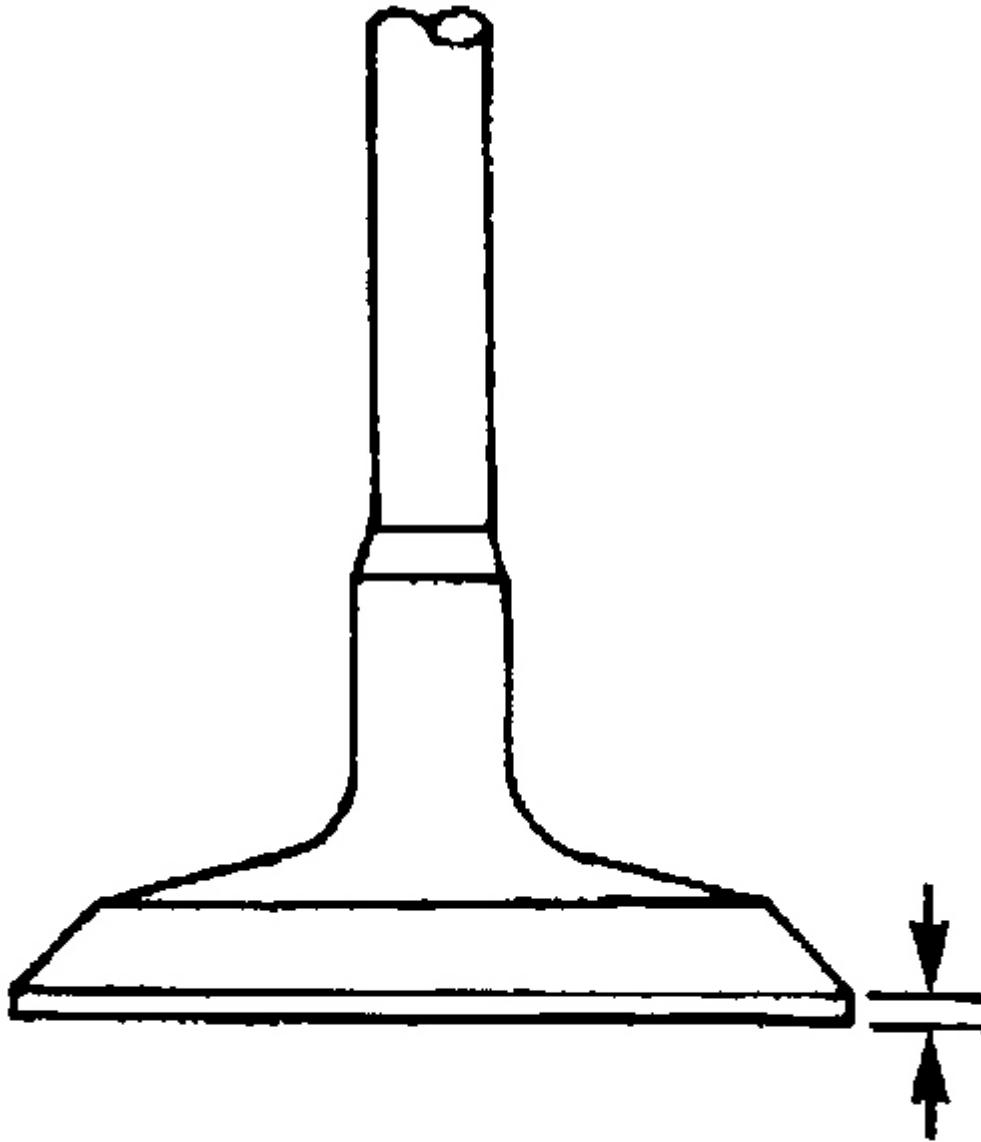
- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)





**Fig. 487: Inspecting Valve Face**  
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
  - Worn or no margin (1 or 4)
  - Pitted surfaces (2)
  - Burnt or eroded areas (3)

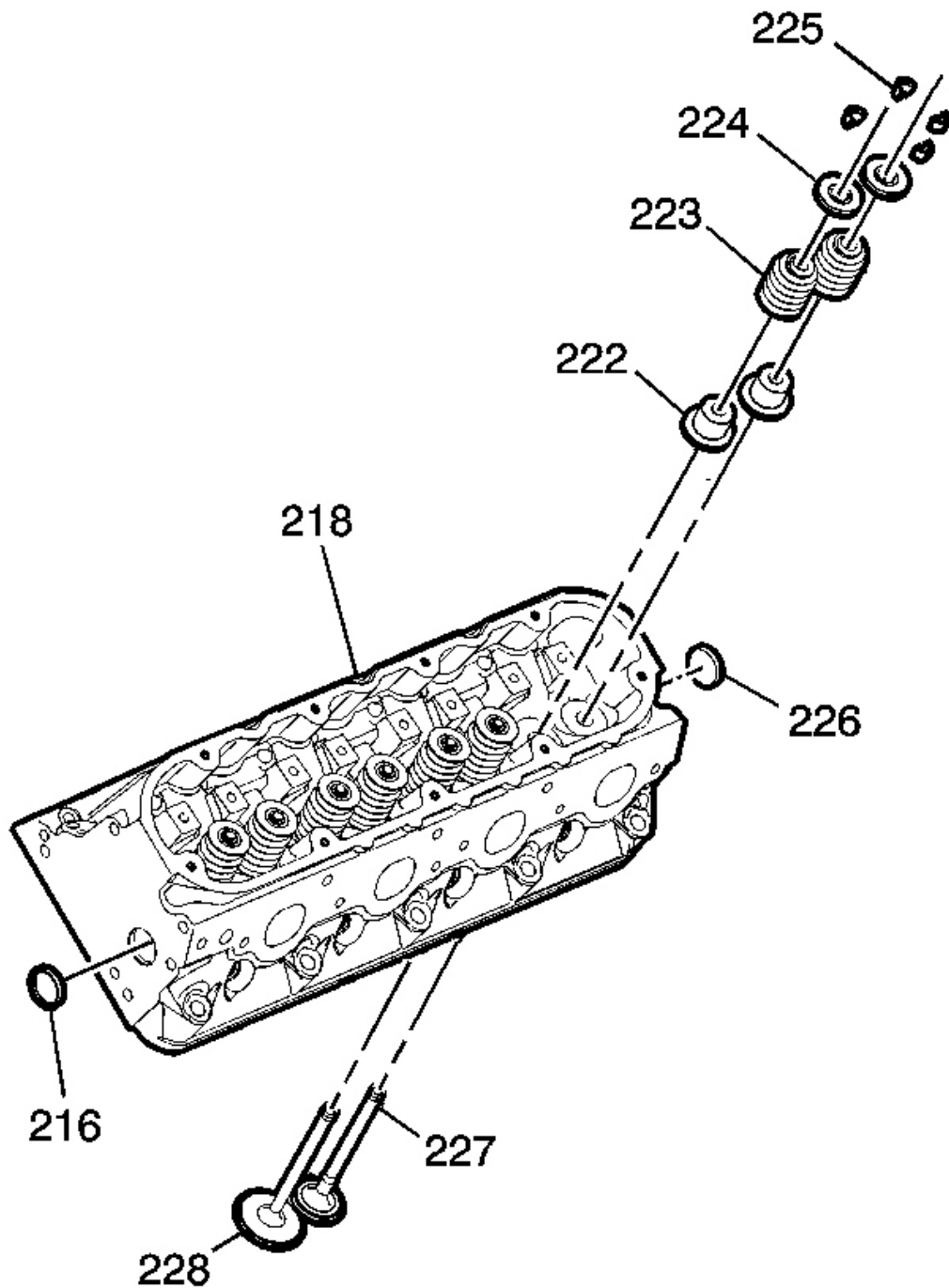


**Fig. 488: Inspecting Valve Seating**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve margin.

The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.

4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring to obtain the proper spring installed height. Refer to **Cylinder Head Disassemble** .



**Fig. 489: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

7. Inspect for a loose valve seat in the cylinder head (218). The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

The valve guide must be clean for the seat grinding tool to obtain proper results.

9. Grind the valve seat.

The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.

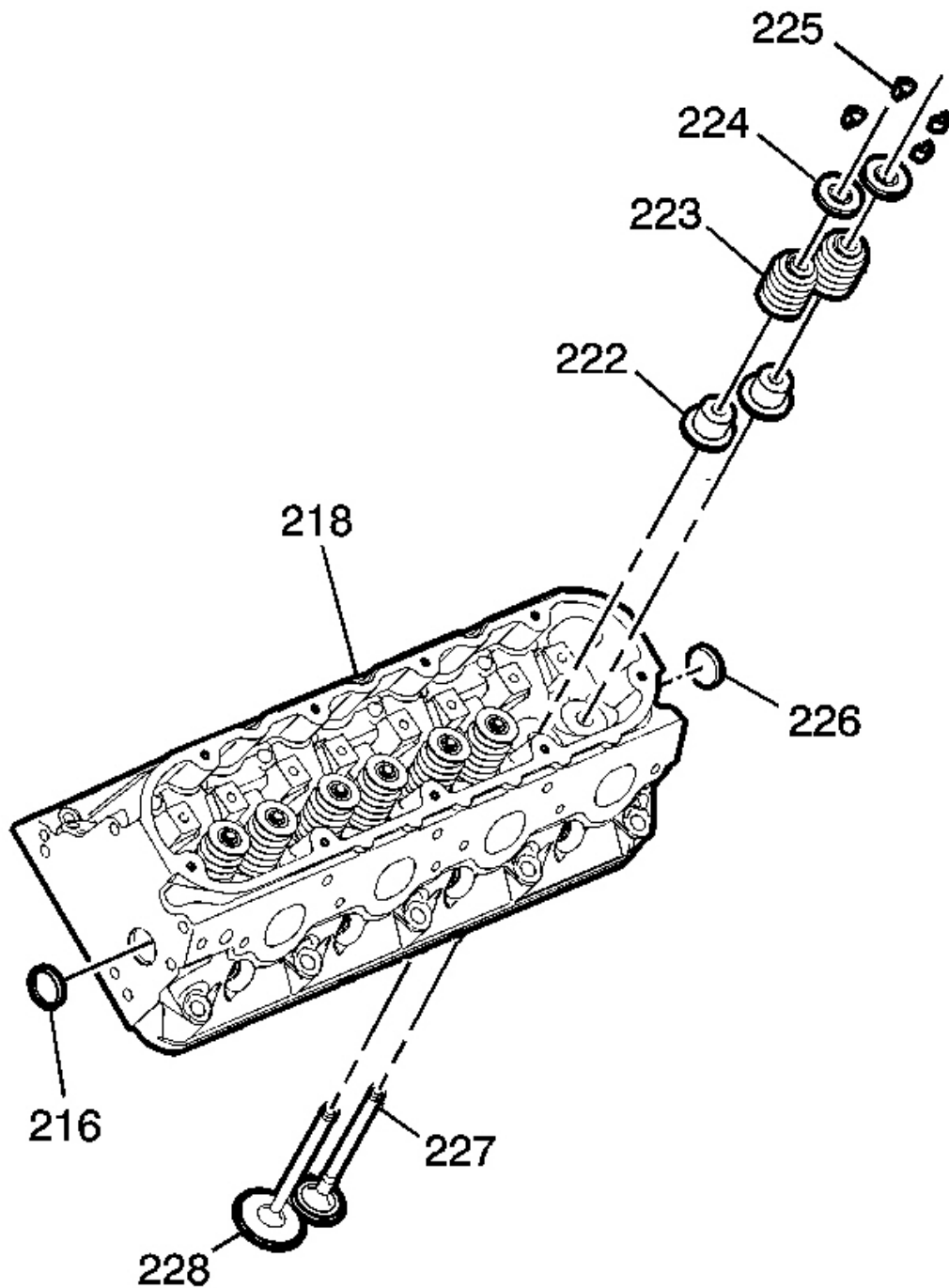
10. Inspect the valve seats.
  - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
  - If the valve seat has been ground, it may be necessary to shim the valve spring to attain the proper spring installed height.

Refer to **Cylinder Head Disassemble** .

## **CYLINDER HEAD ASSEMBLE**

### **Tools Required**

**J 8062** Valve Spring Compressor - Head Off. See **Special Tools and Equipment** .



**Fig. 490: Cylinder Head Components**  
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring shim area.

**IMPORTANT: When using the valves and related components again, install the parts to their original location.**

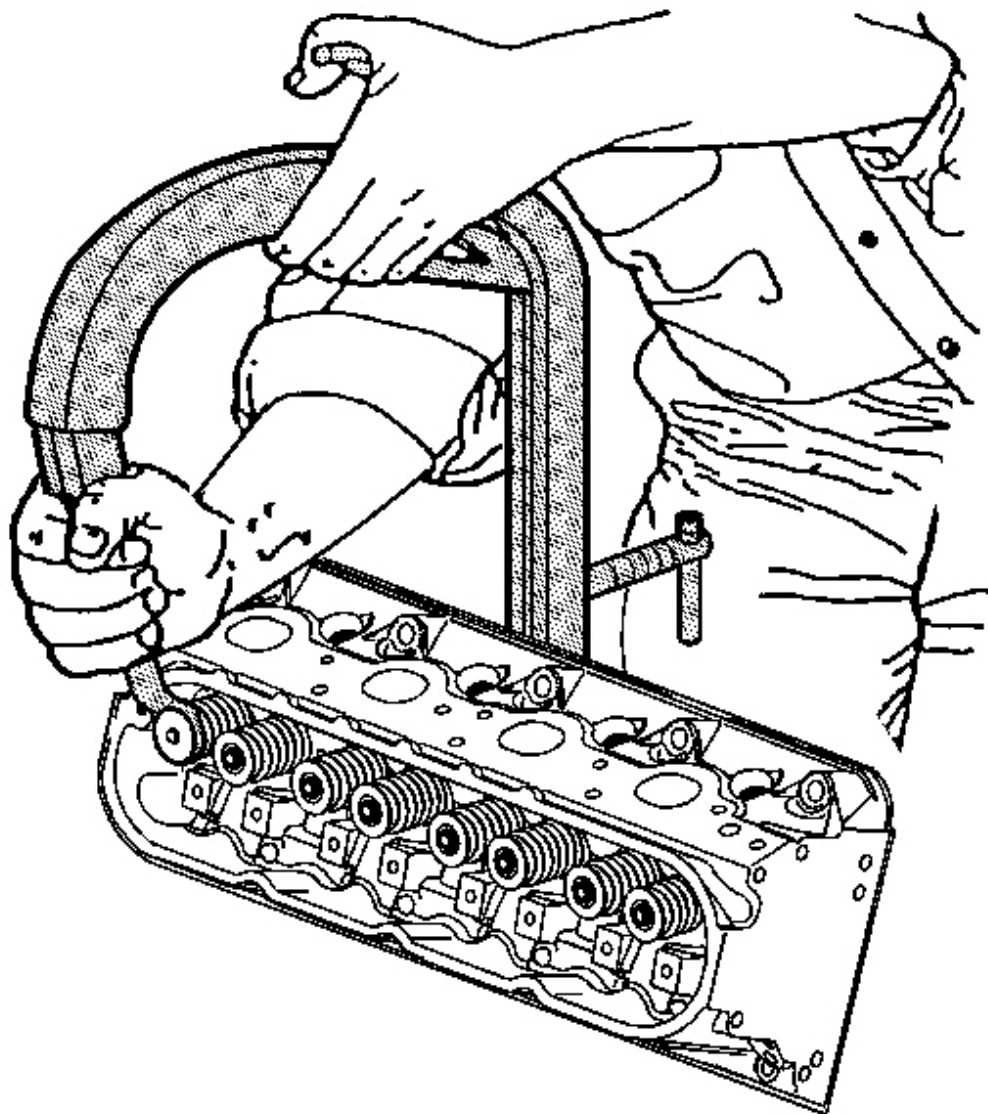
2. Install the valves (227 and 228) into the proper port.

Refer to Separating Parts .

**IMPORTANT: The valve stem oil seal alignment and position on the valve guide is critical.**

**An improperly installed valve stem oil seal may lead to excessive oil consumption, increased vehicle emissions, or component damage.**

3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).

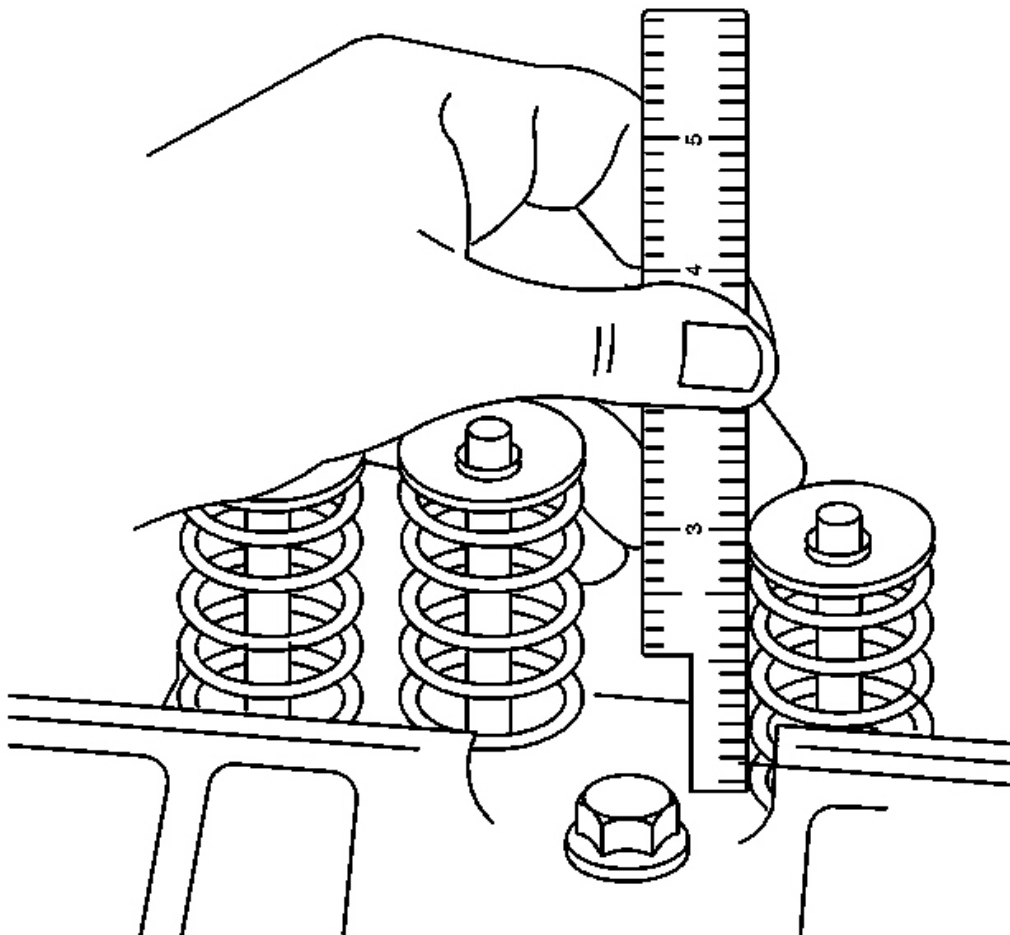


**Fig. 491: Compressing Valve Spring Using J 8062**  
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve spring using the **J 8062** . See **Special Tools and Equipment** .
7. Install the valve stem keys.
  1. Use grease to hold the keys in place and remove the **J 8062** . See **Special Tools and Equipment** .
  2. Ensure the keys seat properly in the groove of the valve stem.



3. Tap the end to the valve stem with a plastic faced hammer to seat the keys, if necessary.



**Fig. 492: Measuring Valve Spring Installed Height**  
Courtesy of GENERAL MOTORS CORP.

8. Measure the valve spring installed height using a ruler.

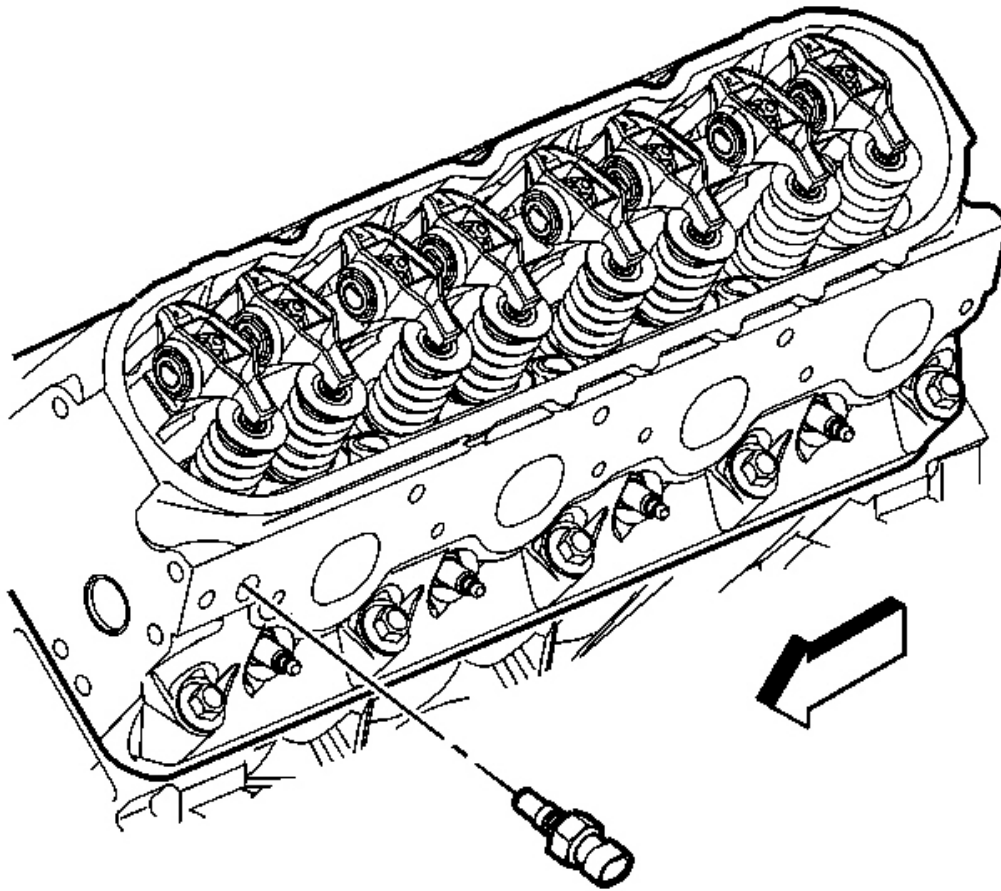
Measure from the base of the valve spring to the top of the valve spring.

**Specification:**

- If the installed height exceeds 46.25 mm (1.82 in), install a valve spring shim of approximately 0.5 mm (0.02 in) thick.
- Do not shim the valve spring to obtain less than the specified height.

Do not assemble the components without a spring shim on the cylinder head.

9. Install the remaining valves, springs, and other components.



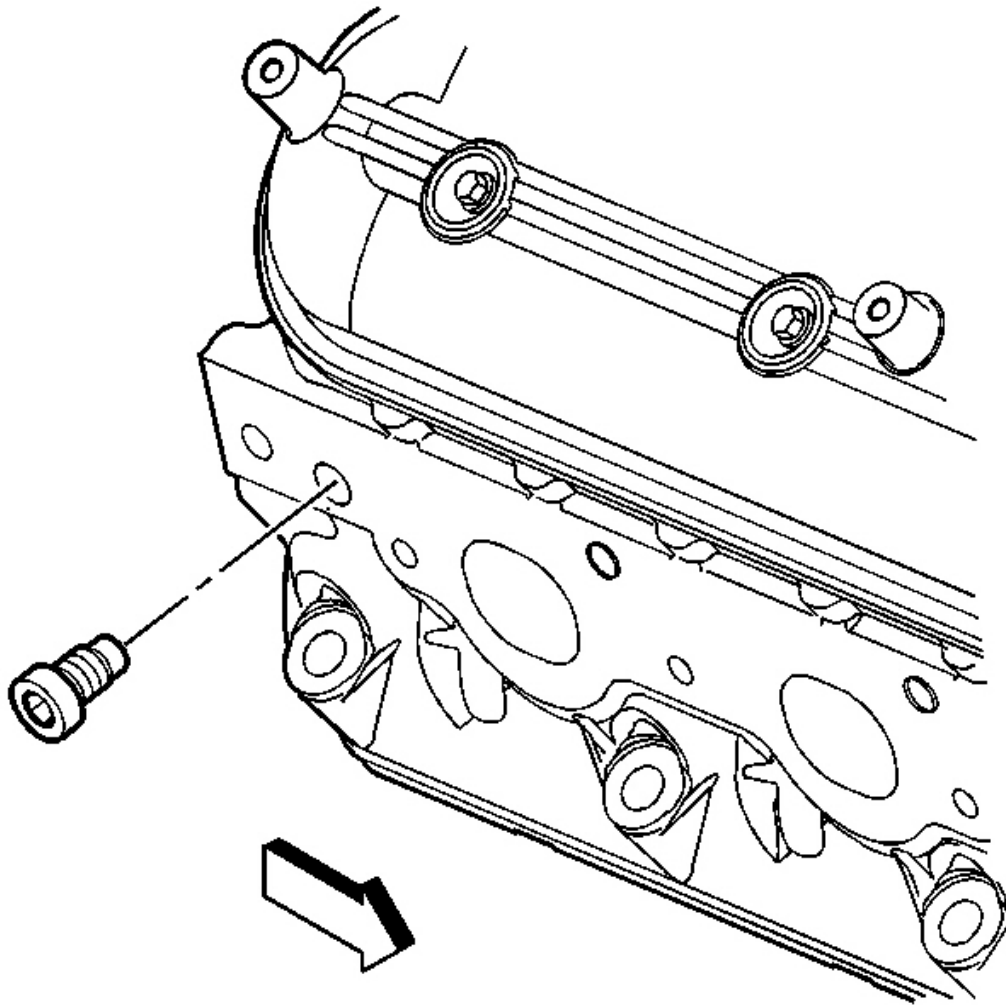
**Fig. 493: Coolant Temperature Sensor (Left Cylinder Head)**  
Courtesy of GENERAL MOTORS CORP.

10. Install sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the coolant sensor.

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

11. Install the coolant temperature sensor into the left cylinder head.

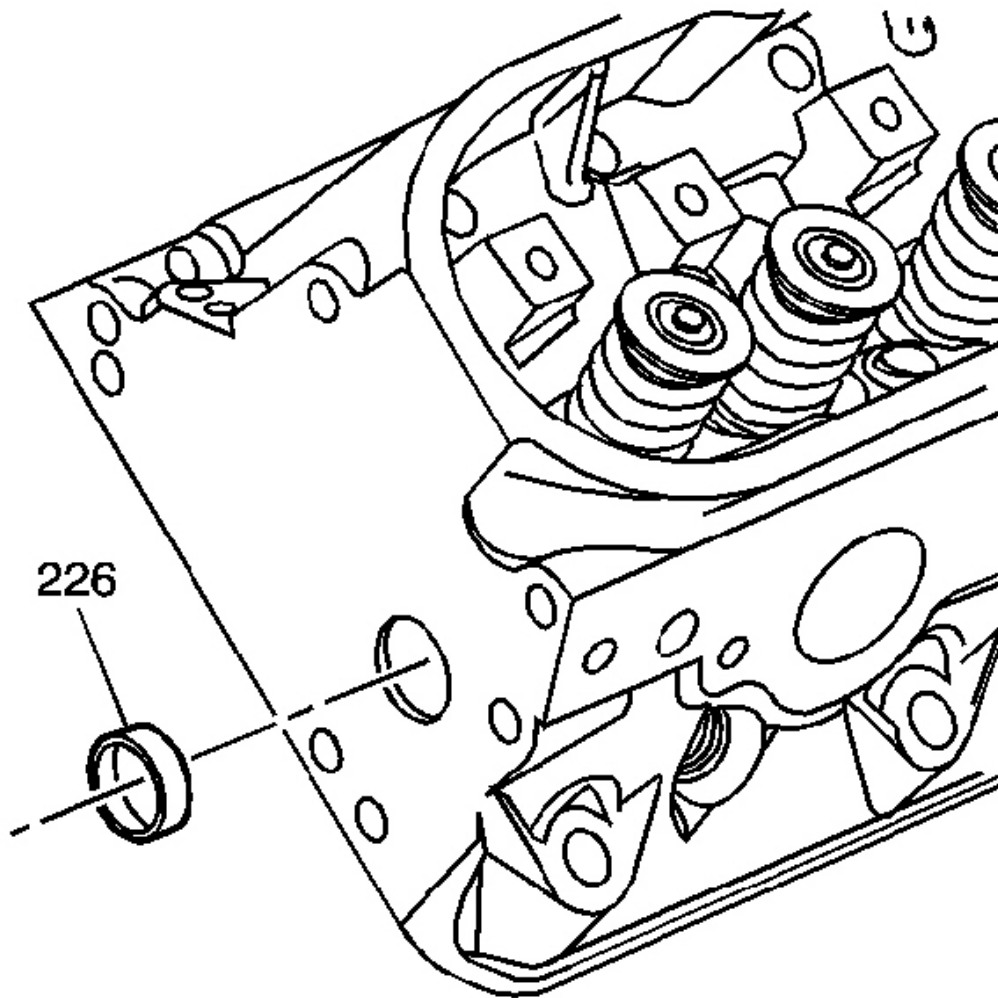
**Tighten:** Tighten the coolant temperature sensor to 20 N.m (15 lb ft).



**Fig. 494: Coolant Plug (Right Cylinder Head)**  
Courtesy of GENERAL MOTORS CORP.

12. Install sealant GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the plug.
13. Install the coolant plug to the right cylinder head.

**Tighten:** Tighten the coolant plug to 20 N.m (15 lb ft).

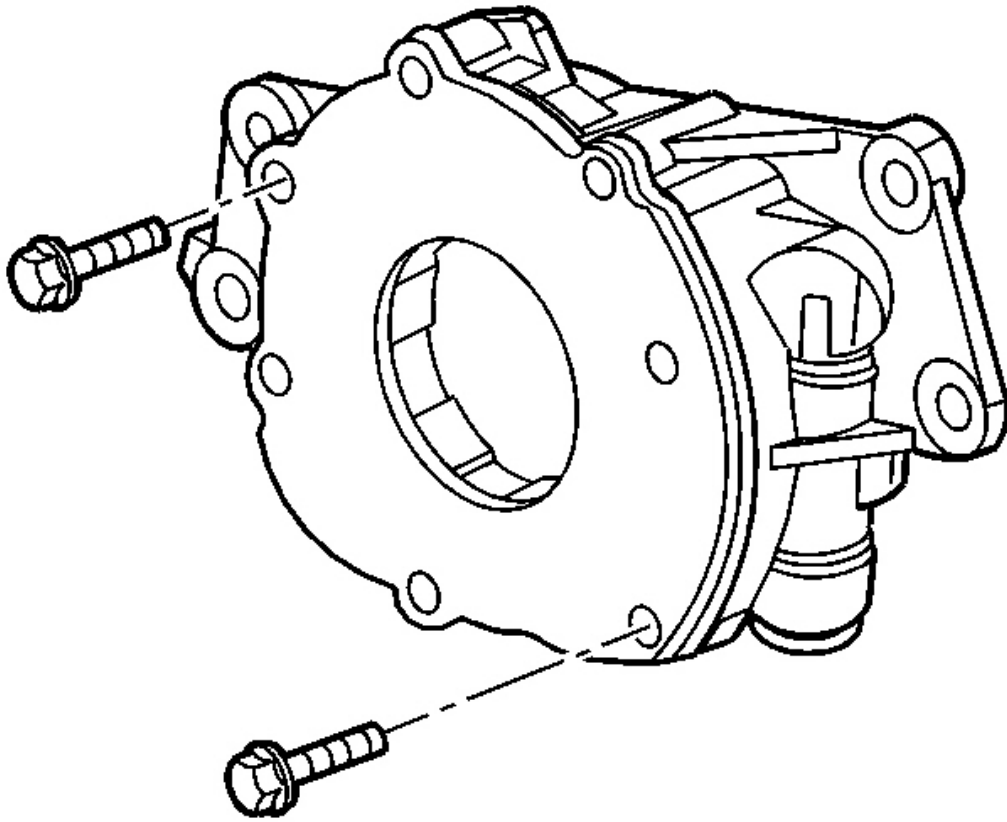


**Fig. 495: Cylinder Head Expansion Plugs**  
Courtesy of GENERAL MOTORS CORP.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the sides of the cylinder head expansion plugs (226).
15. Install the expansion plugs into the cylinder head.

A properly installed plug should be installed 2.5 mm (0.1 in) below the end face of the head.

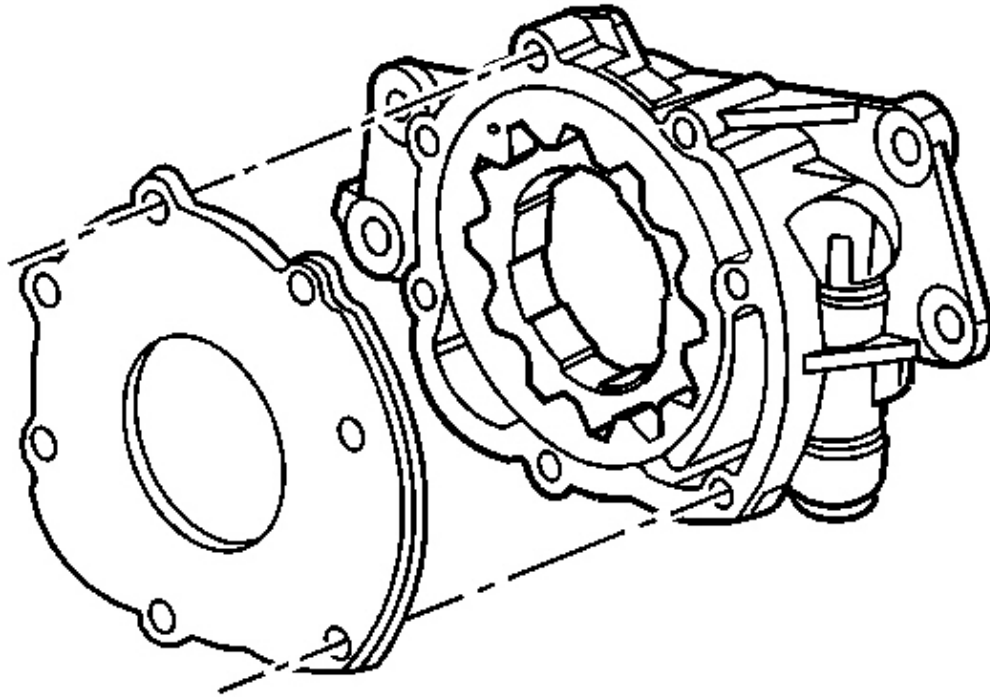
## **OIL PUMP DISASSEMBLE**



**Fig. 496: Oil Pump Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

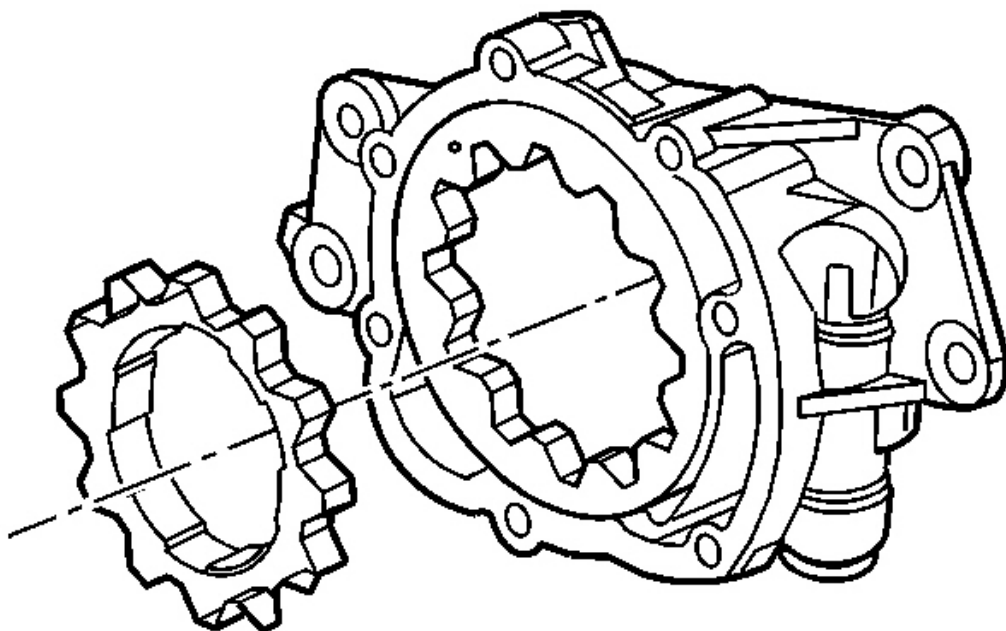
**IMPORTANT:** The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts.



**Fig. 497: Oil Pump & Cover**  
**Courtesy of GENERAL MOTORS CORP.**

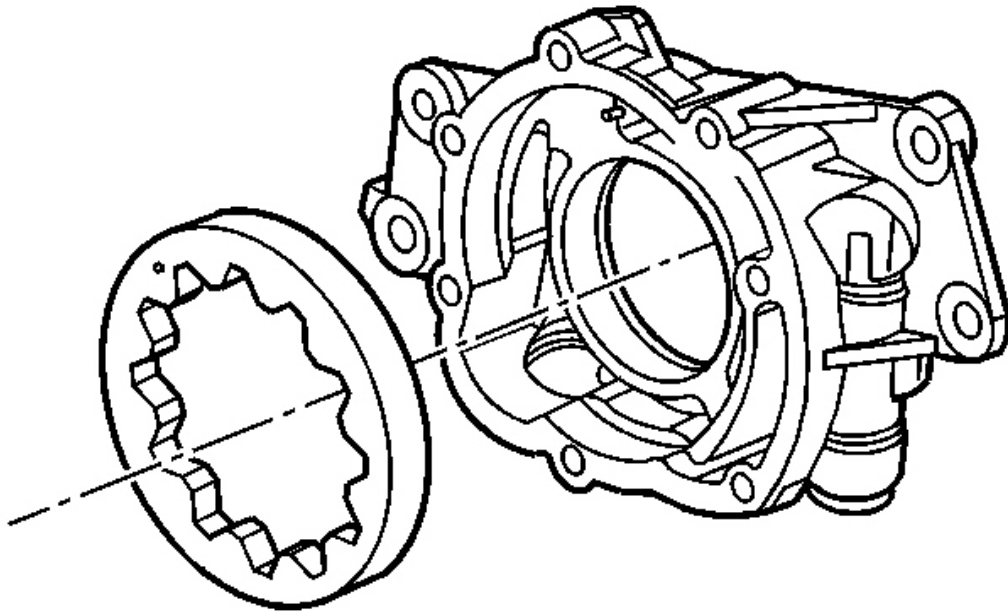
2. Remove the oil pump cover.



**Fig. 498: Oil Pump Drive Gear**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Mark or identify the gears for assembly. Refer to Separating Parts .**

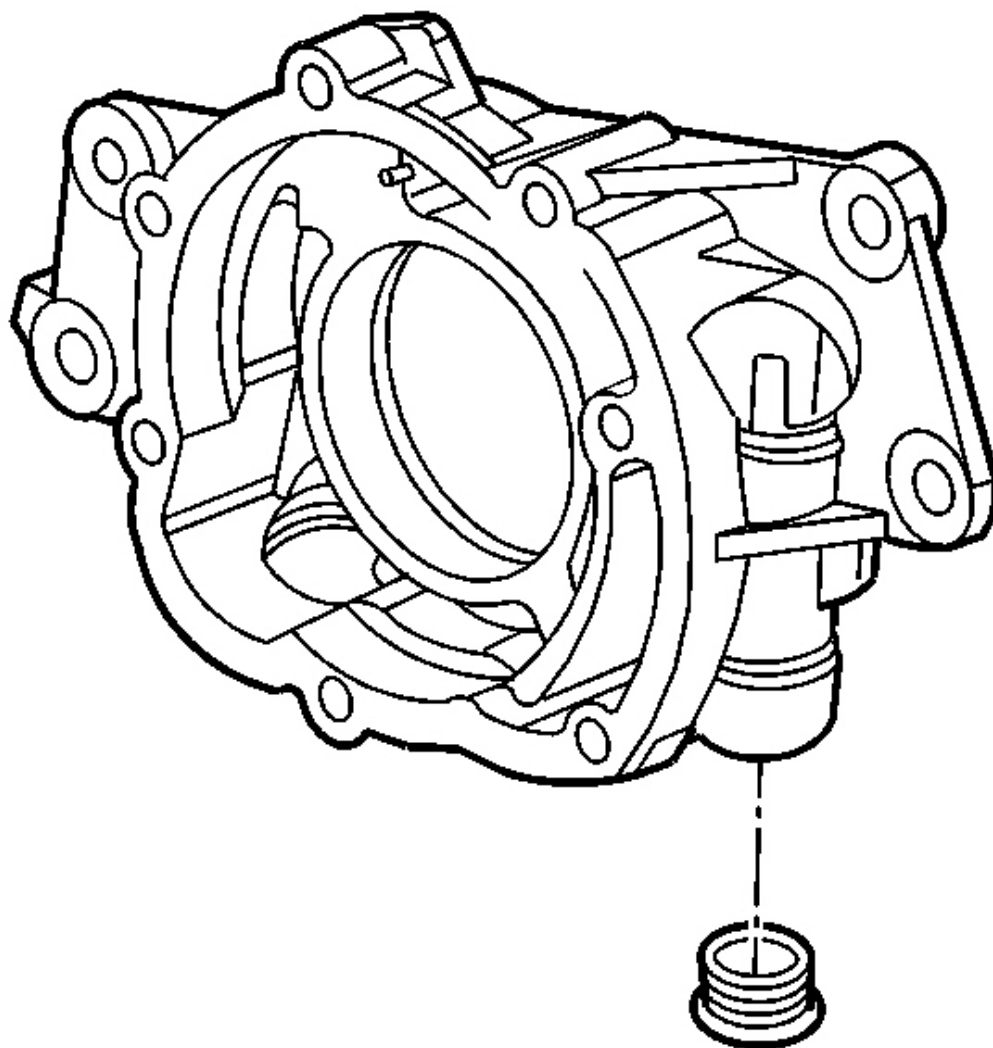
3. Remove the drive gear.



**Fig. 499: Oil Pump Driven Gear**  
Courtesy of GENERAL MOTORS CORP.

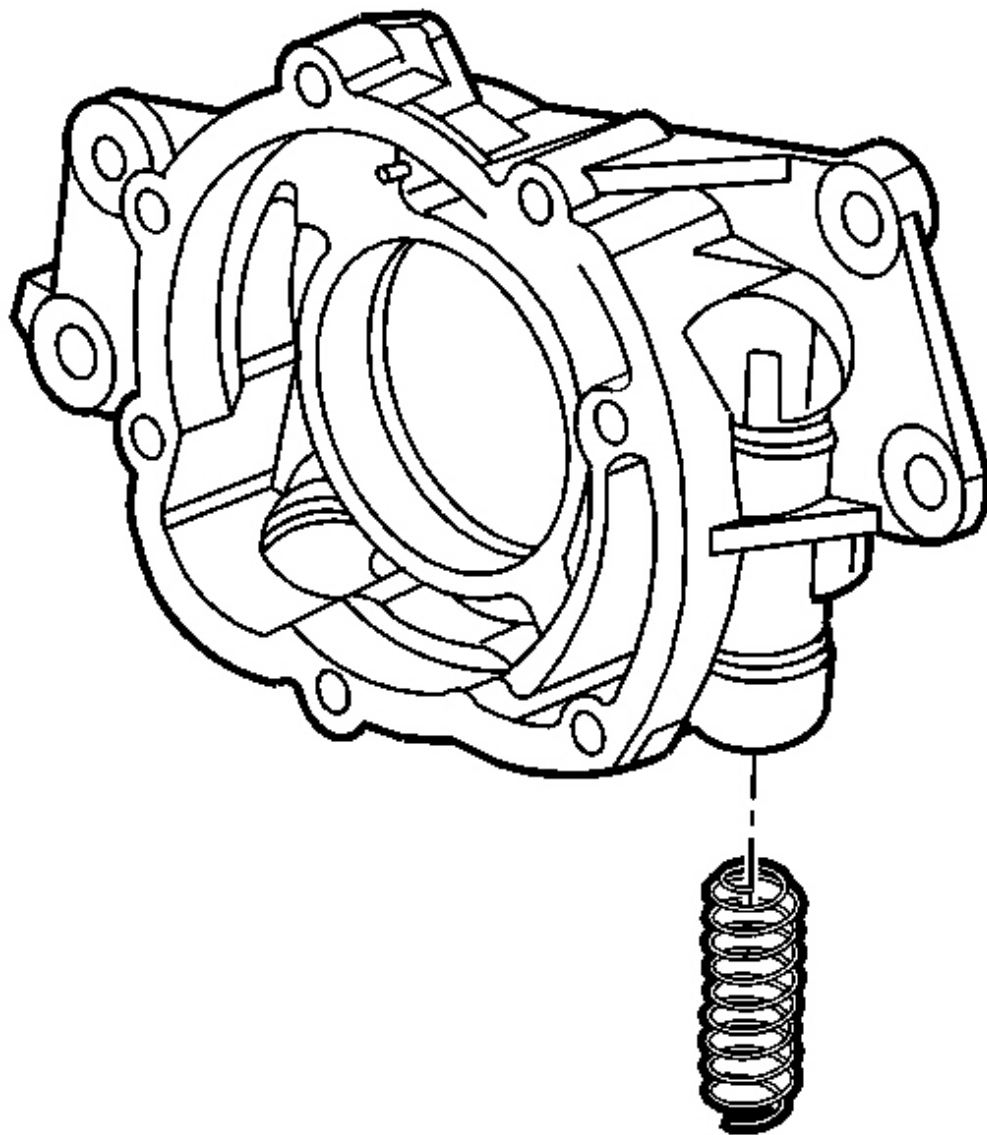
4. Remove the driven gear.





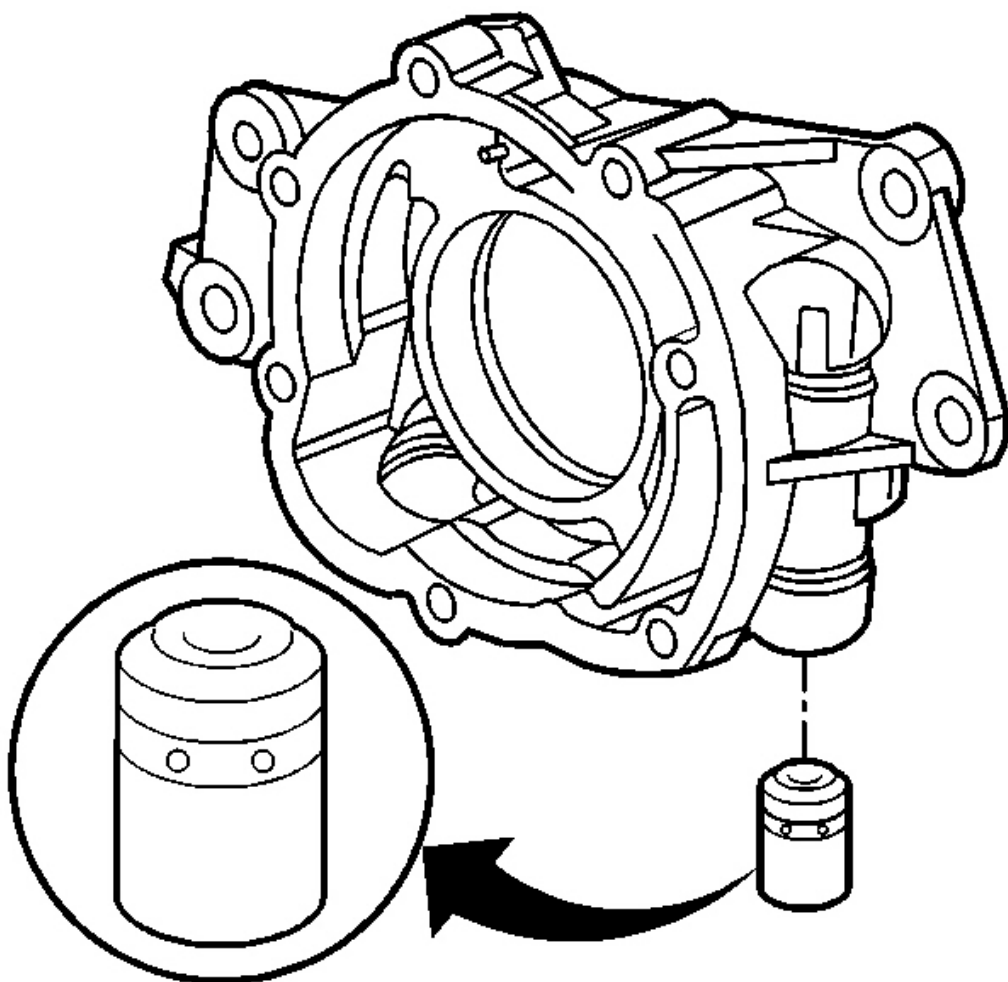
**Fig. 500: Oil Pump Pressure Relief Valve Plug**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the pressure relief valve plug.



**Fig. 501: Oil Pump Pressure Relief Valve Spring**  
Courtesy of GENERAL MOTORS CORP.

6. Remove the pressure relief valve spring.



**Fig. 502: Oil Pump Pressure Relief Valve**  
Courtesy of GENERAL MOTORS CORP.

7. Remove the pressure relief valve.
8. Inspect the oil pump components. Refer to Oil Pump Cleaning and Inspection .

## OIL PUMP CLEANING AND INSPECTION

### IMPORTANT:

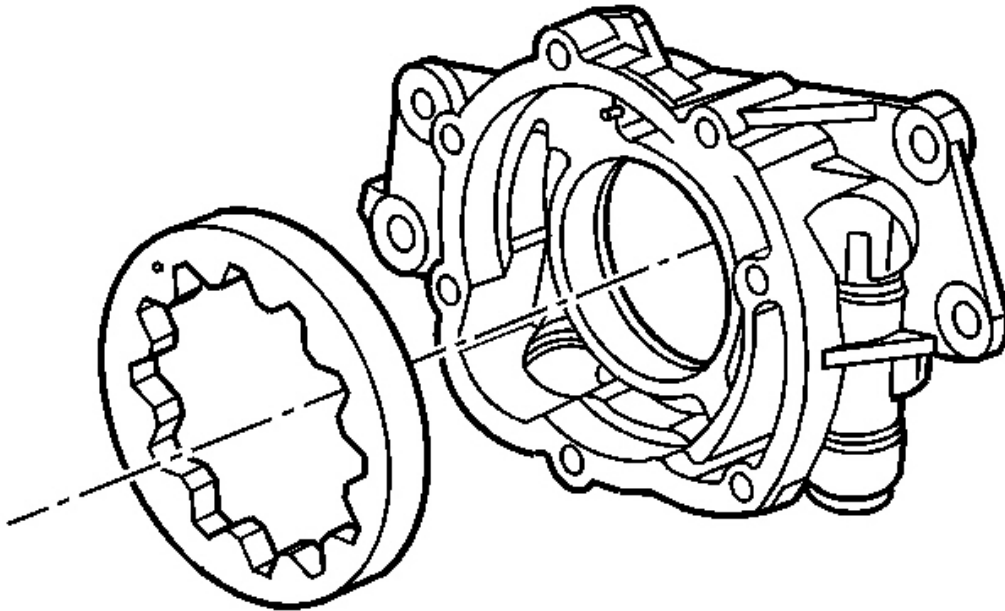
- The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

- The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.

1. Clean the parts in solvent.

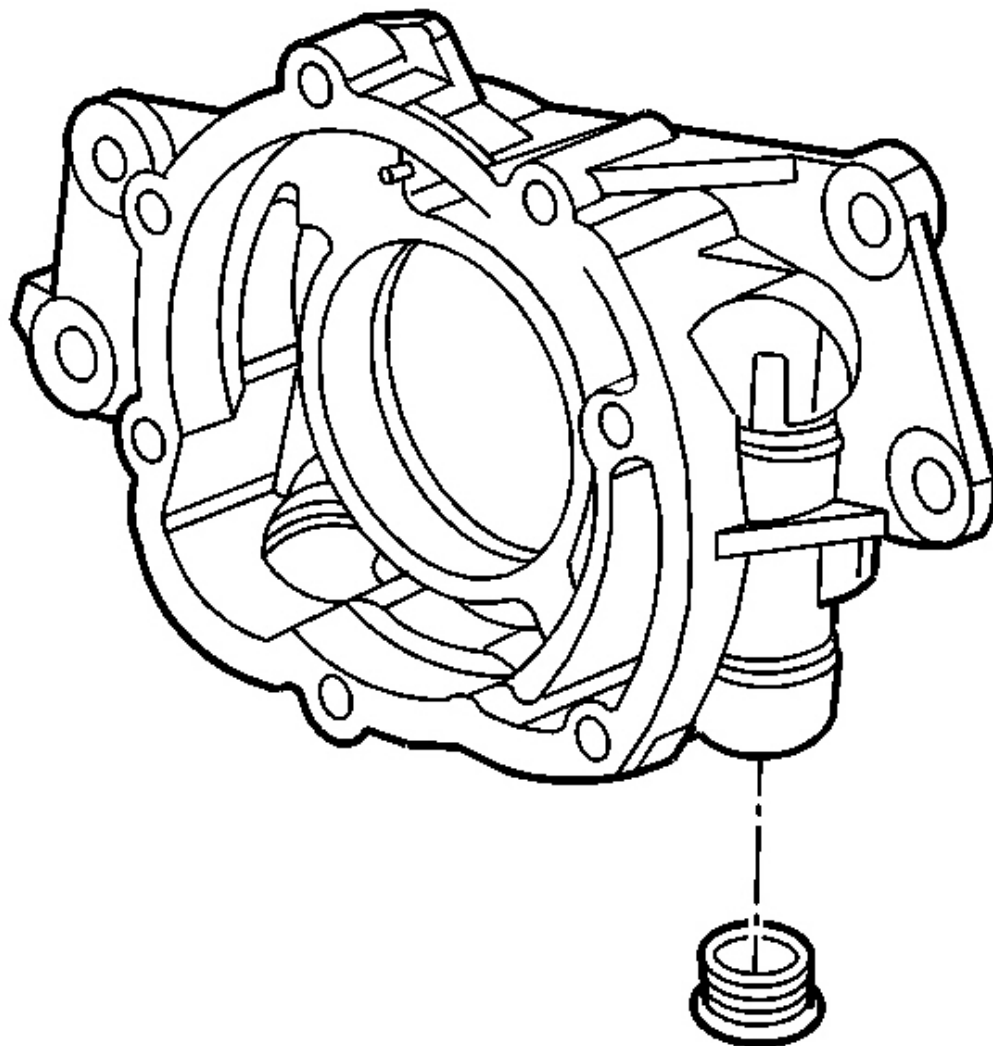
**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the parts with compressed air.



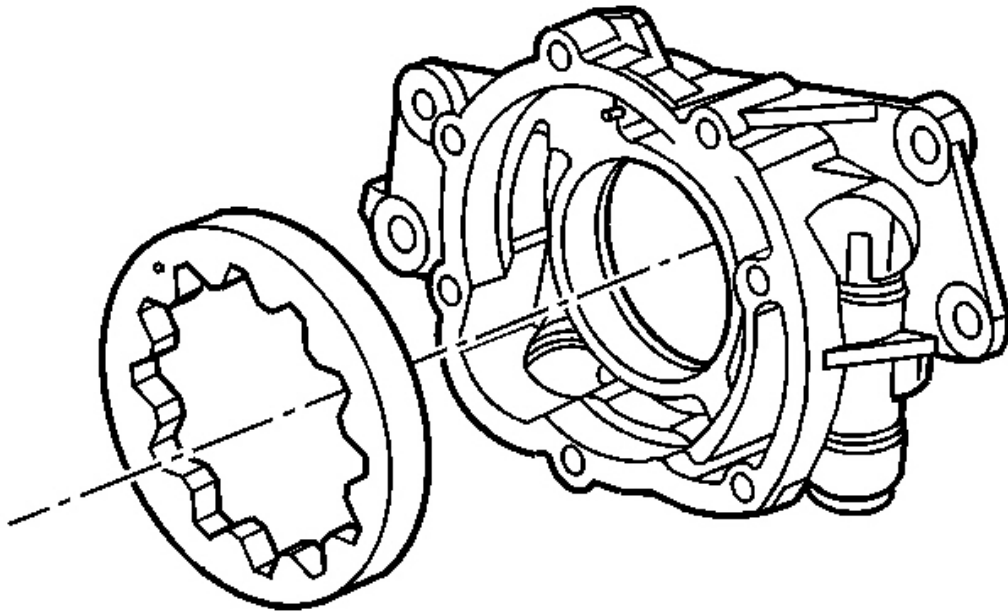
**Fig. 503: Oil Pump Driven Gear**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil pump housing and the cover for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.



**Fig. 504: Oil Pump Pressure Relief Valve Plug**  
Courtesy of GENERAL MOTORS CORP.

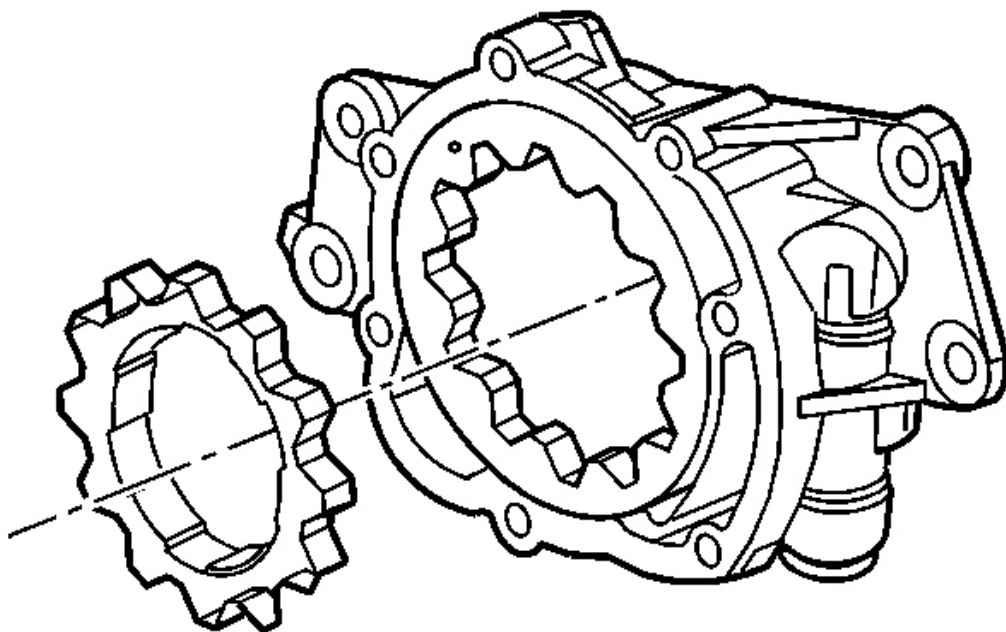
6. Inspect the relief valve plug and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.



**Fig. 505: Oil Pump Driven Gear**  
**Courtesy of GENERAL MOTORS CORP.**

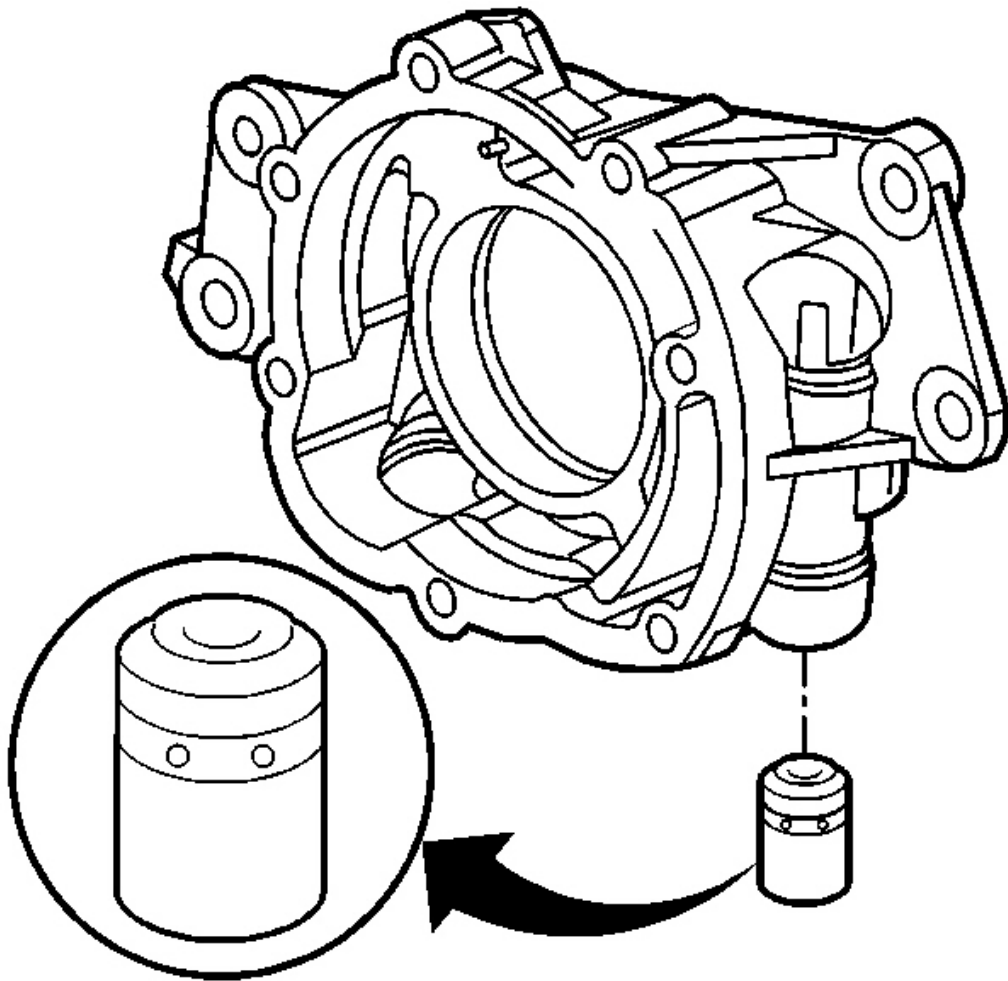
8. Inspect the drive gear and driven gear for chipping, galling or wear.

Minor burrs or imperfections on the gears may be removed with a fine oil stone.



**Fig. 506: Oil Pump Drive Gear**  
Courtesy of GENERAL MOTORS CORP.

9. Inspect the drive gear splines for excessive wear.

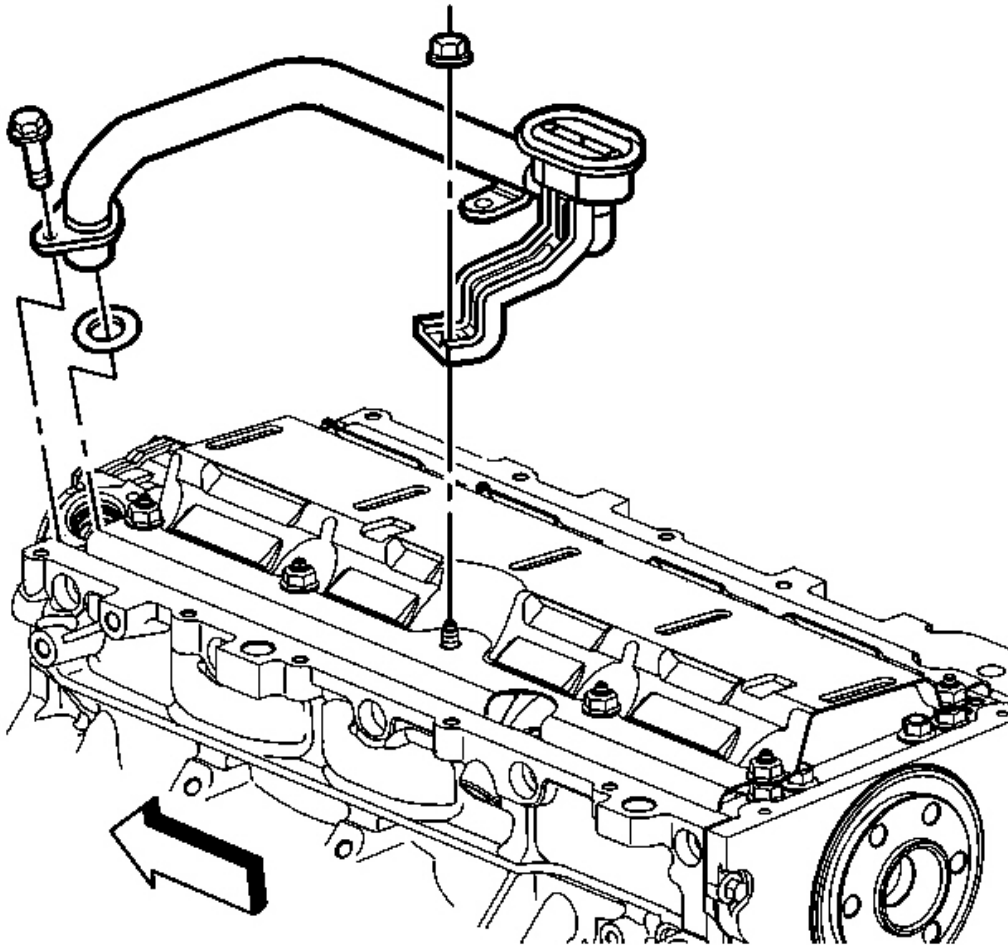


**Fig. 507: Oil Pump Pressure Relief Valve**  
Courtesy of GENERAL MOTORS CORP.

10. Inspect the pressure relief valve and bore for scoring or wear.

The valve must move freely in the bore with no restrictions.

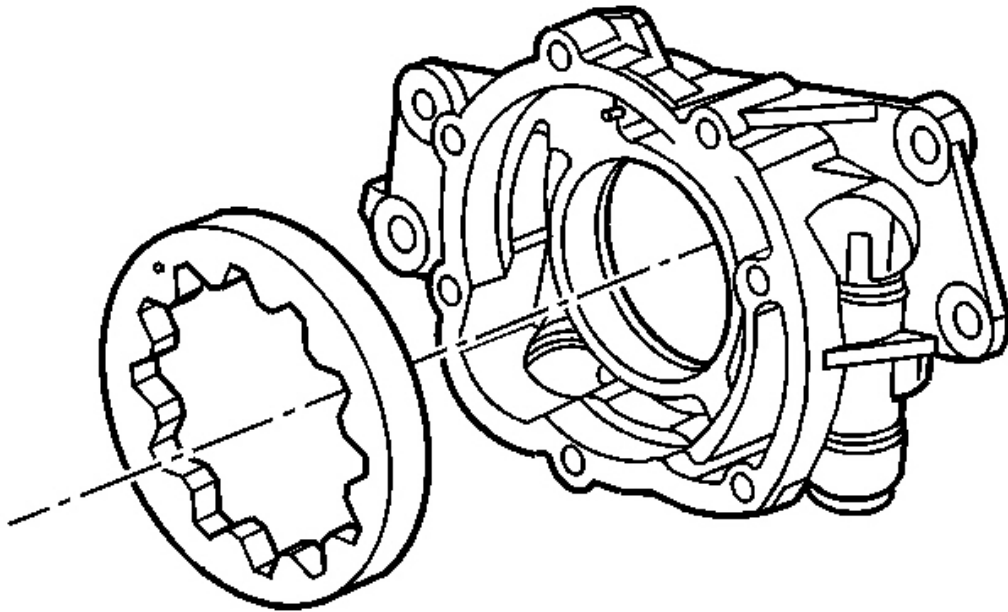




**Fig. 508: Oil Pump Screen**  
Courtesy of GENERAL MOTORS CORP.

11. Inspect the oil pump screen for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.

## **OIL PUMP ASSEMBLE**

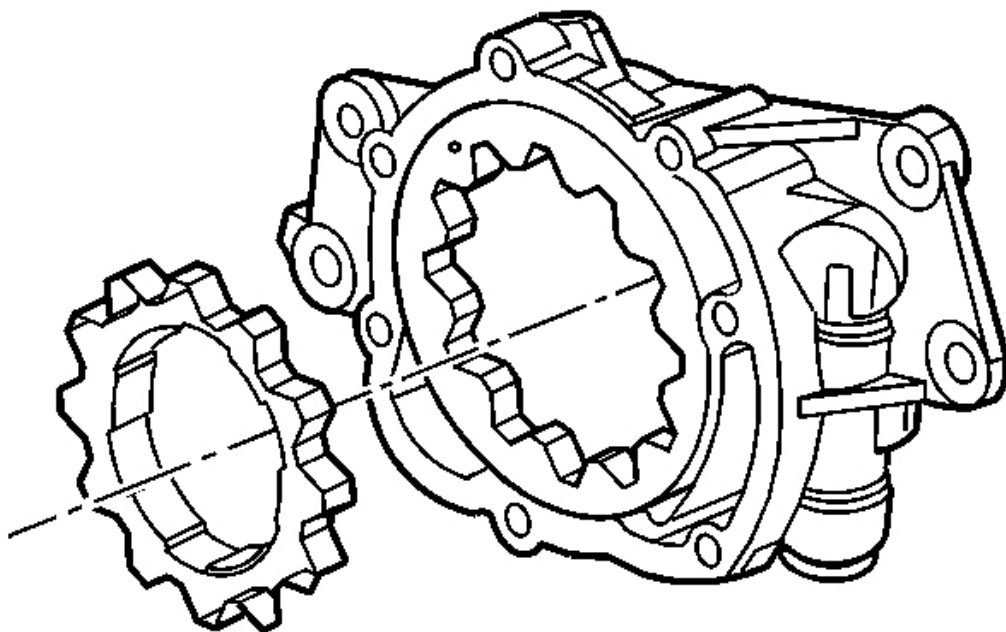


**Fig. 509: Oil Pump Driven Gear**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

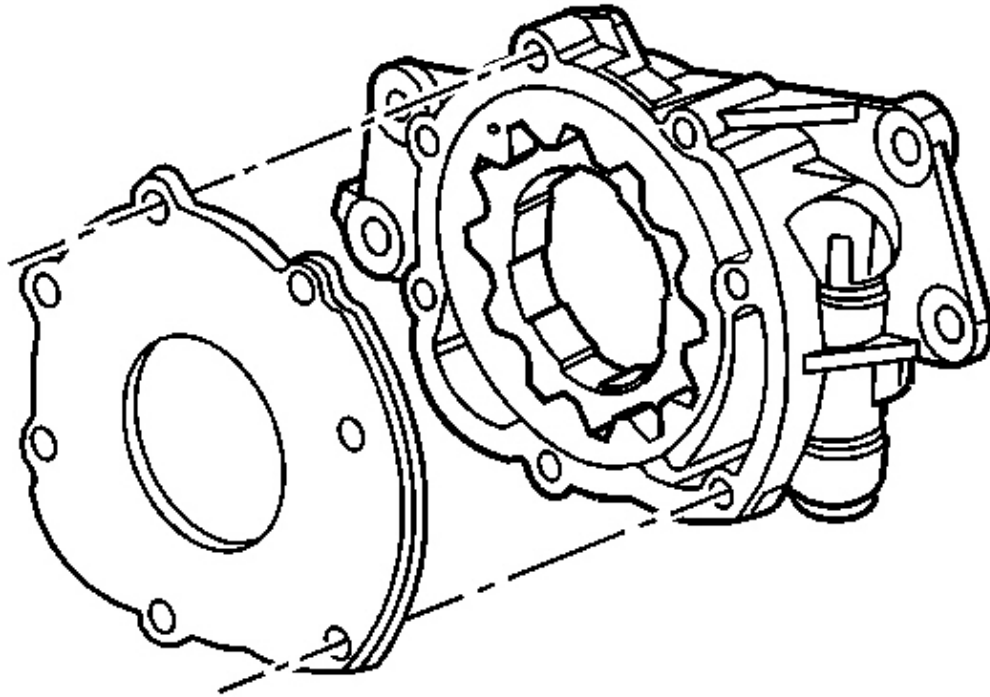
1. Install the driven gear into the pump housing.

Install the driven gear with the orientation mark facing the pump cover.



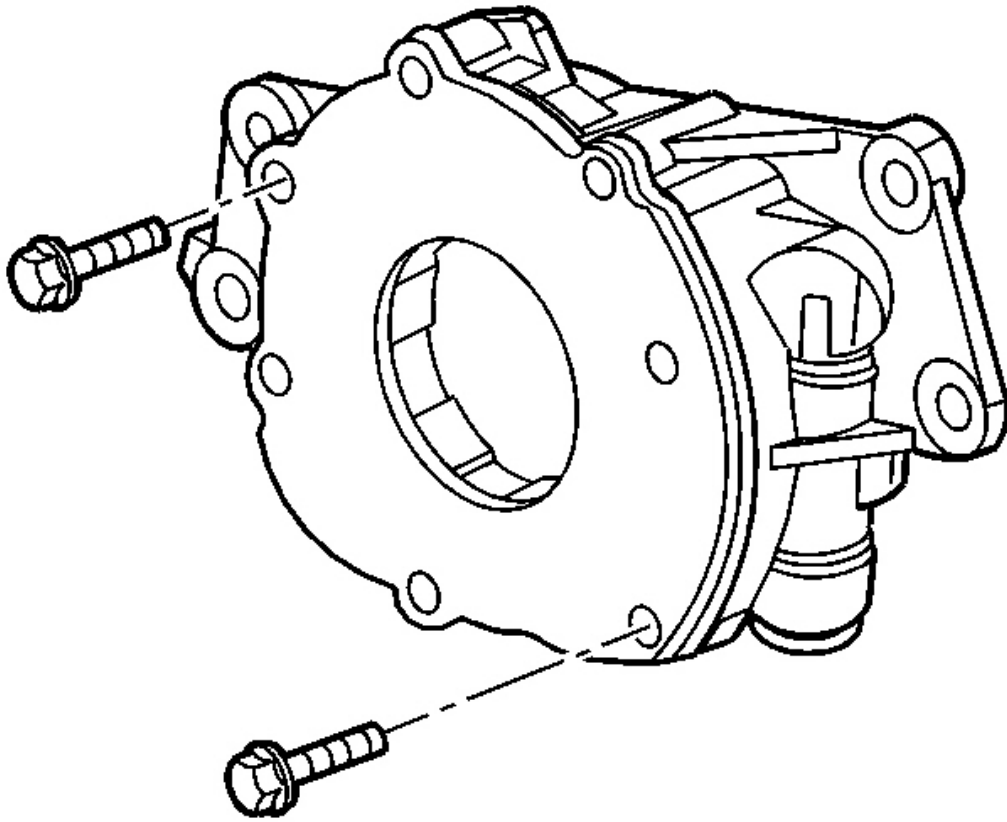
**Fig. 510: Oil Pump Drive Gear**  
**Courtesy of GENERAL MOTORS CORP.**

2. Install the drive gear into the pump housing.



**Fig. 511: Oil Pump & Cover**  
**Courtesy of GENERAL MOTORS CORP.**

3. Install the oil pump cover.

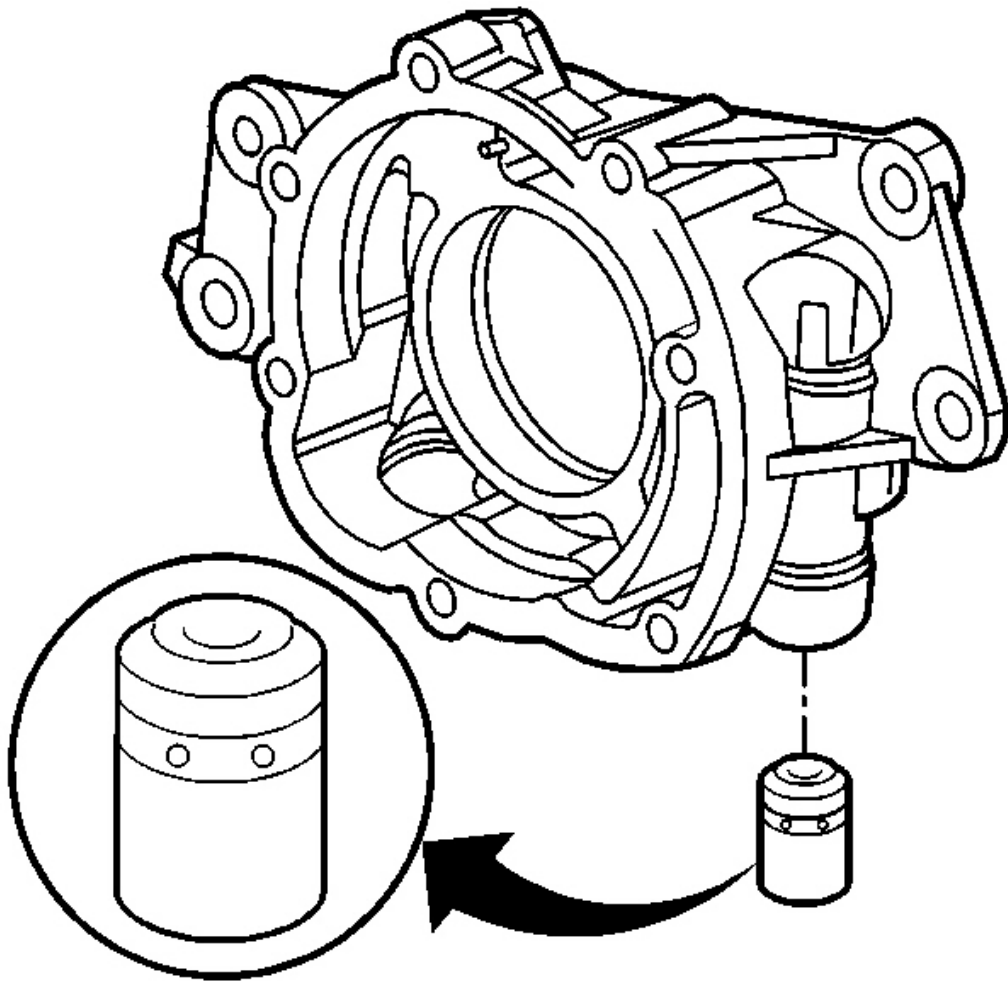


**Fig. 512: Oil Pump Cover Bolts**  
Courtesy of GENERAL MOTORS CORP.

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

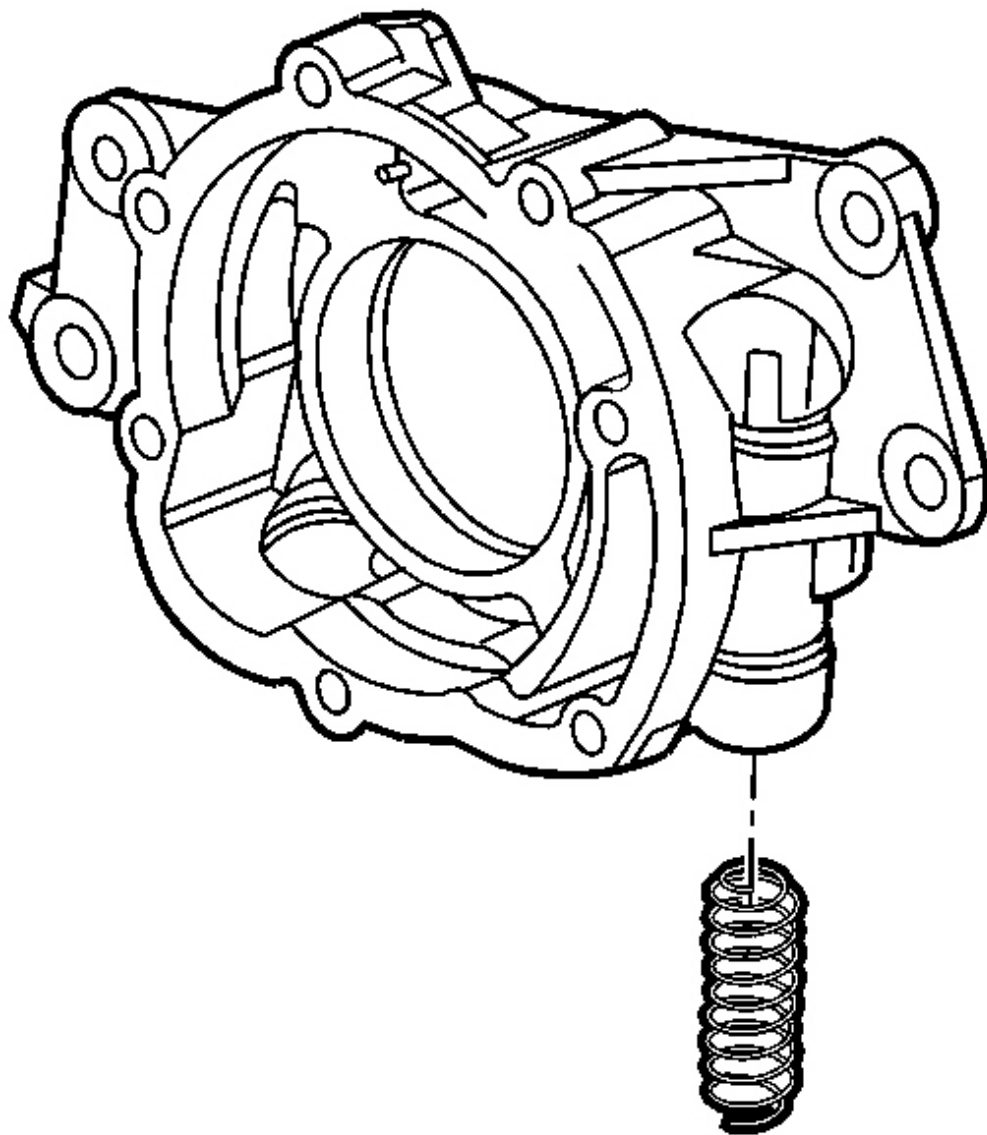
4. Install the pump cover bolts.

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



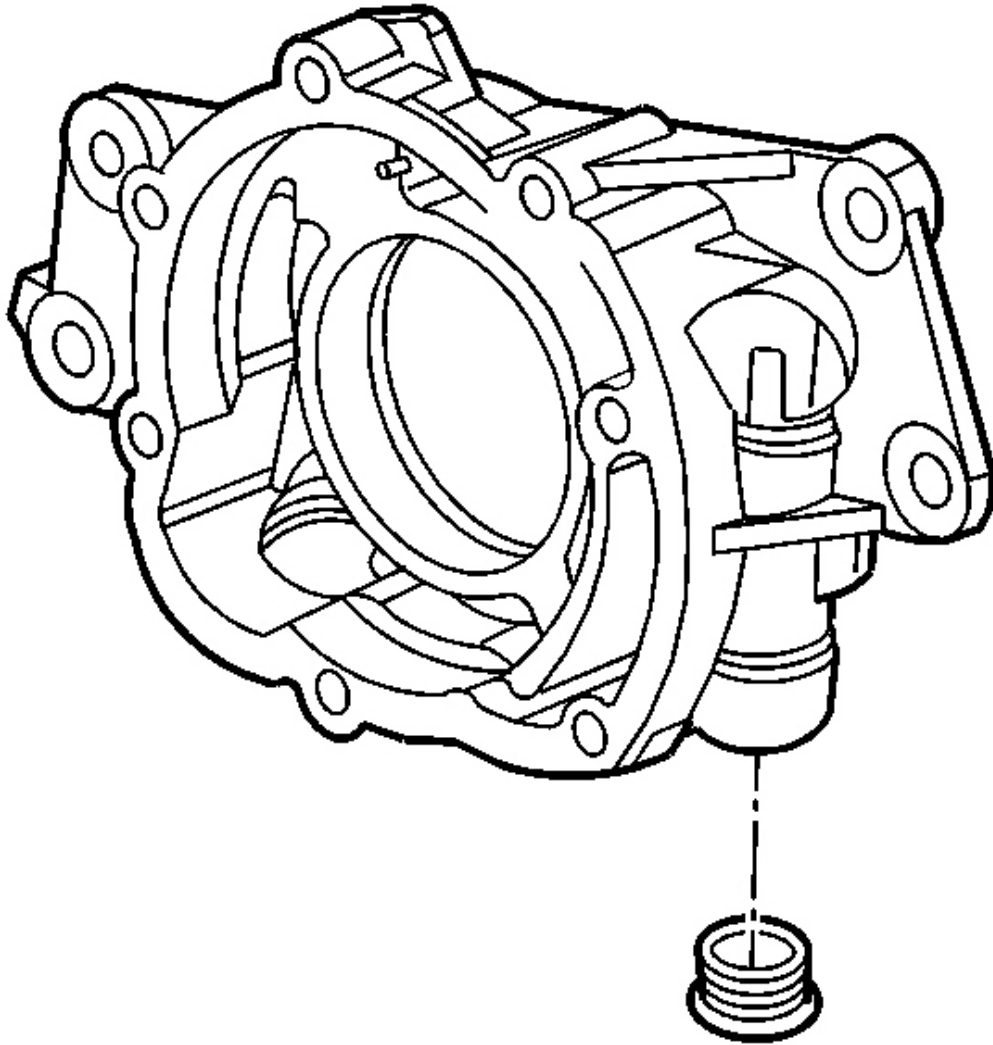
**Fig. 513: Oil Pump Pressure Relief Valve**  
Courtesy of GENERAL MOTORS CORP.

5. Install the regulator valve.



**Fig. 514: Oil Pump Pressure Relief Valve Spring**  
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW regulator valve spring.



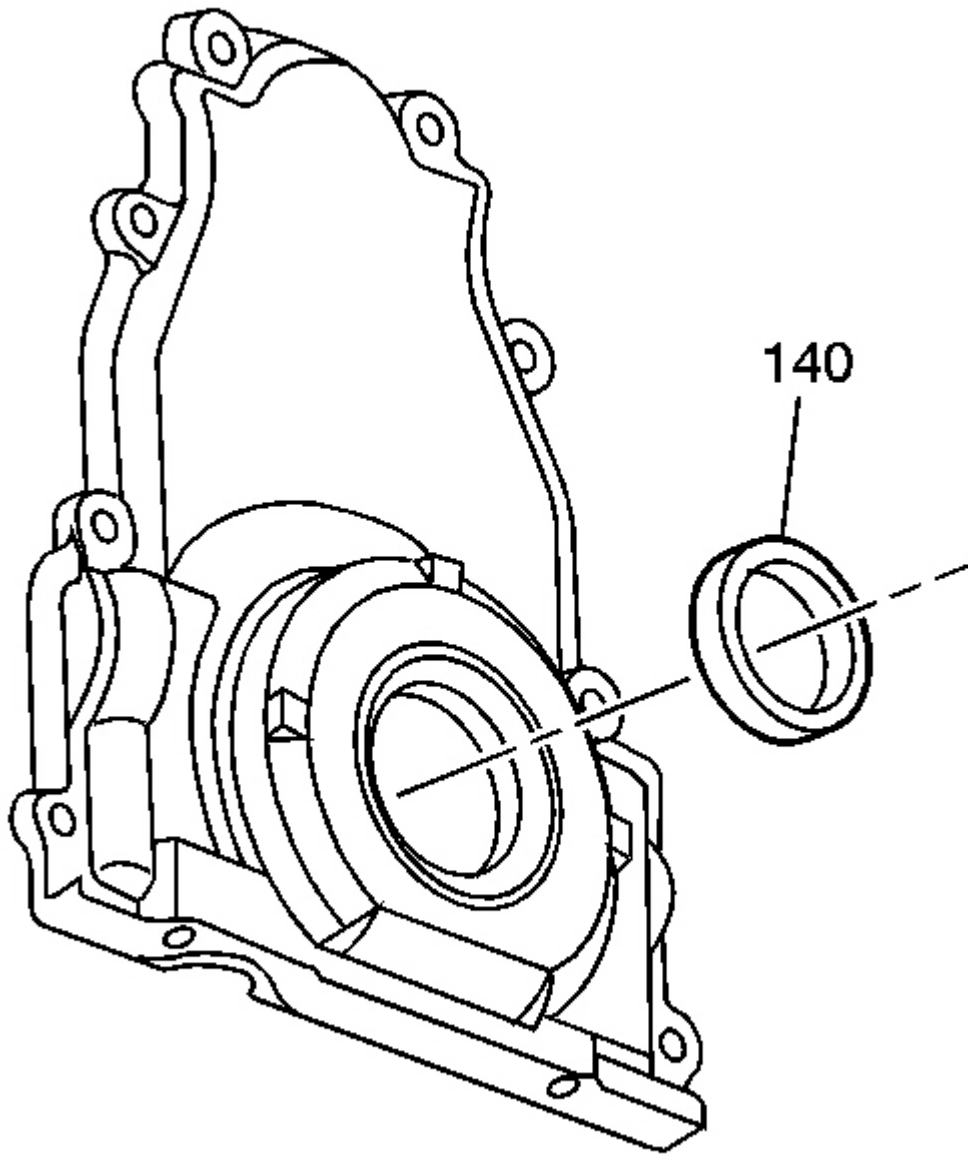
**Fig. 515: Oil Pump Pressure Relief Valve Plug**  
Courtesy of GENERAL MOTORS CORP.

7. Install the pressure relief valve plug.

**Tighten:** Tighten the pressure relief valve plug to 12 N.m (106 lb in).

8. Inspect the oil pump for smooth operation by rotating the drive gear.





**Fig. 516: Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Do not use the crankshaft oil seal again. Install a **NEW** crankshaft oil seal during assembly.
- Do not use the front cover-to-engine block gasket again. Install a

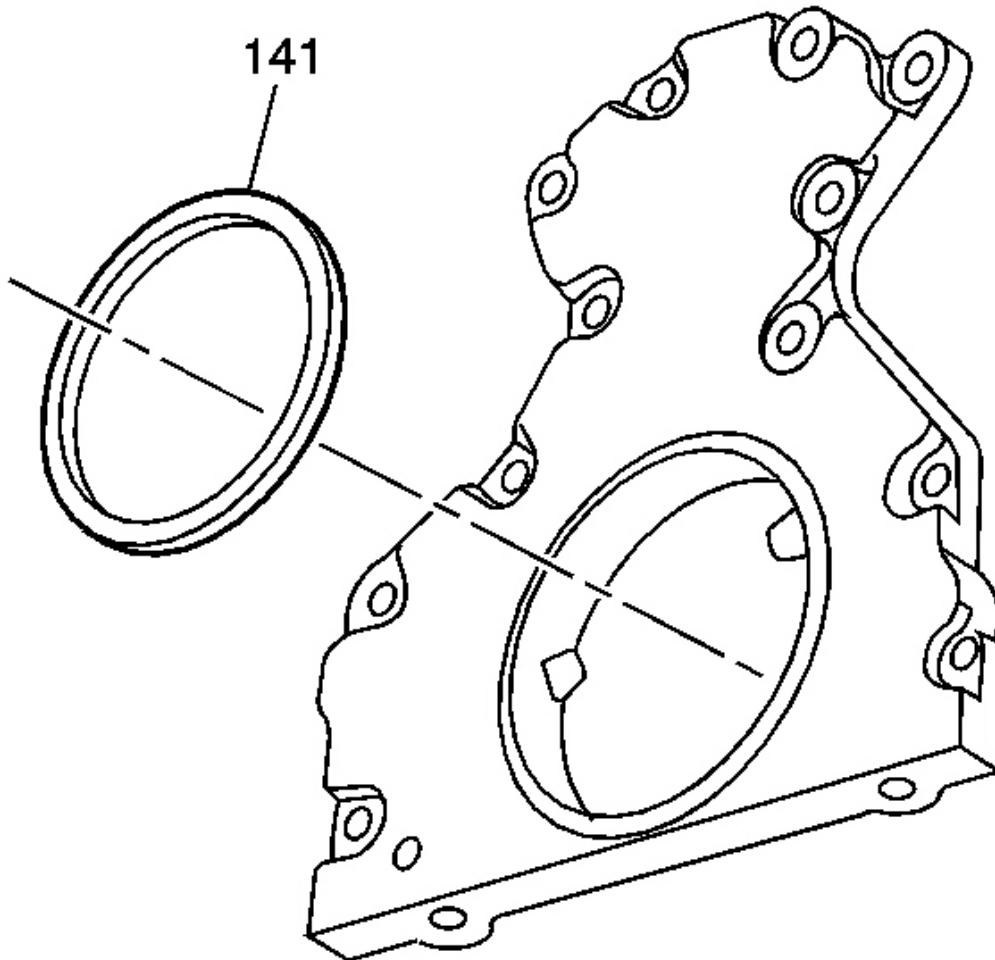
## **NEW gasket during assembly.**

1. Remove the crankshaft oil seal (140) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets** .

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

## **ENGINE REAR COVER CLEANING AND INSPECTION**



**Fig. 517: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

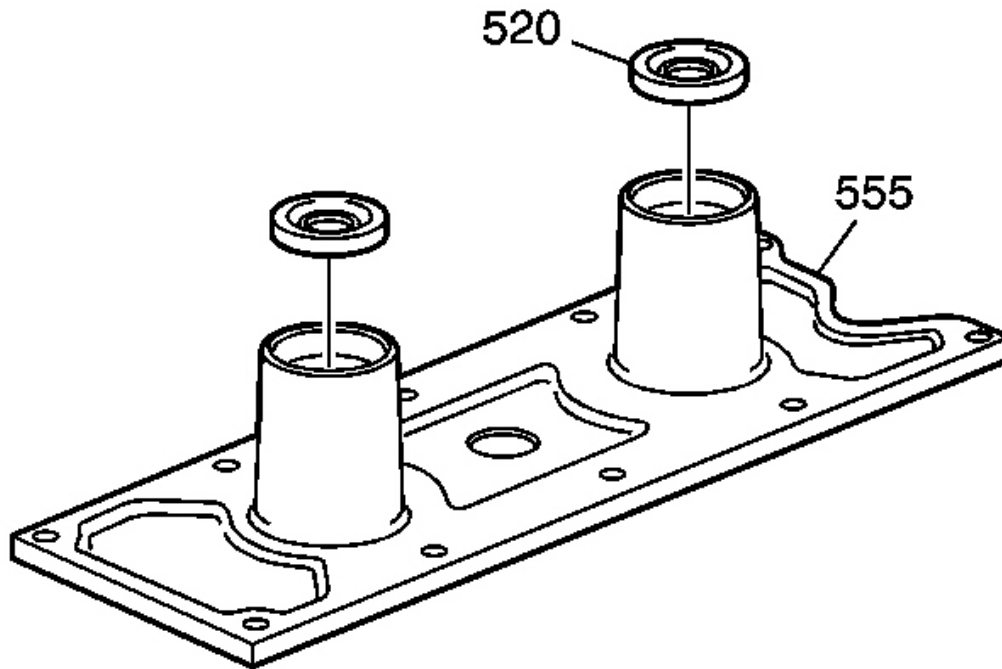
- Do not use the crankshaft oil seal again. Install a **NEW** crankshaft oil seal during assembly.
- Do not use the rear cover-to-engine block gasket again. Install a **NEW** gasket during assembly.

1. Remove the crankshaft oil seal (141) from the rear cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets** .

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

## **ENGINE VALLEY COVER CLEANING AND INSPECTION**



**Fig. 518: Knock Sensor Oil Seals & Valley Cover**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Do not use the valley cover knock sensor oil seals again. Install **NEW** oil seals during assembly.
- Do not use the valley cover gasket again. Install a **NEW** gasket during assembly.

1. Remove the knock sensor oil seals (520) from the valley cover (555).

2. Clean the valley cover in solvent.

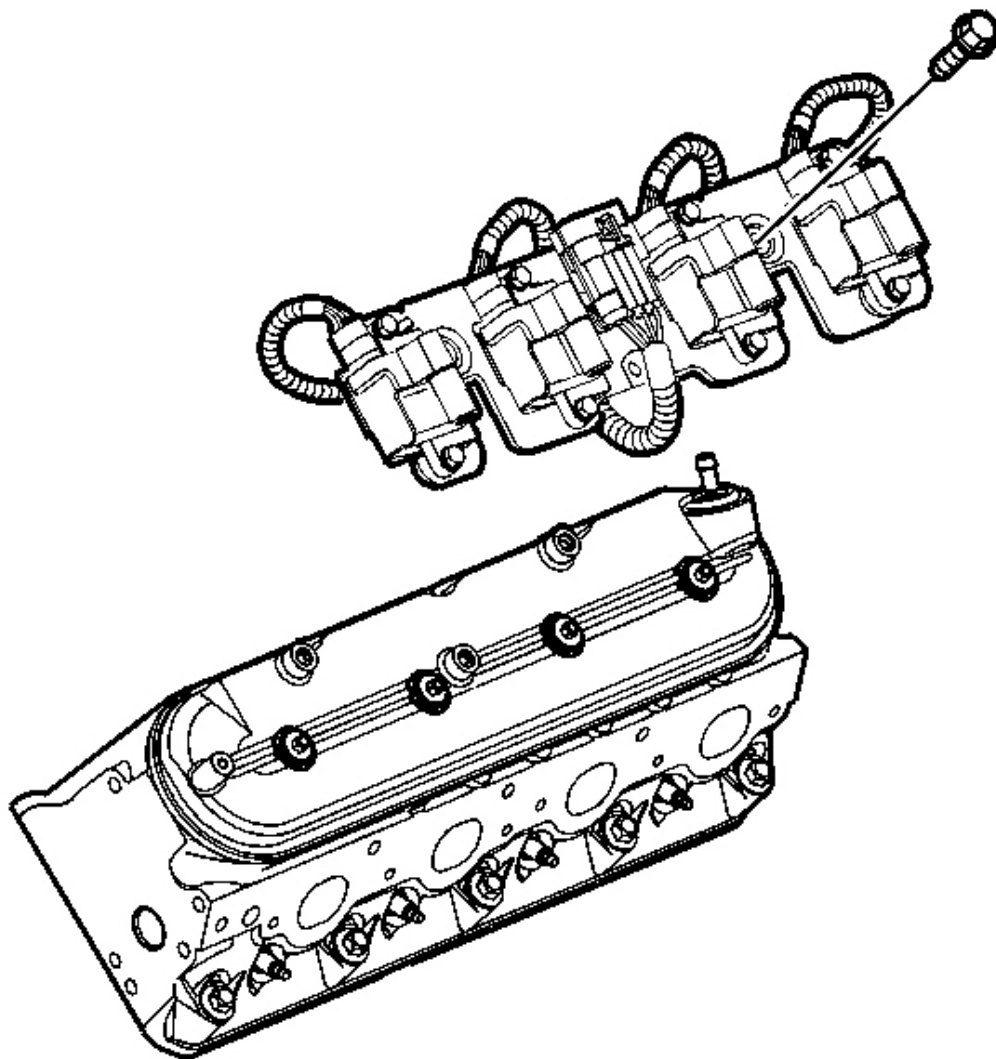
**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

3. Dry the valley cover with compressed air.

4. Inspect the gasket sealing surfaces for excessive scratches or gouging. Refer to **Replacing Engine Gaskets** .

5. Inspect the valley cover oil seal bores for excessive scratches or gouging.

## **VALVE ROCKER ARM COVER CLEANING AND INSPECTION**



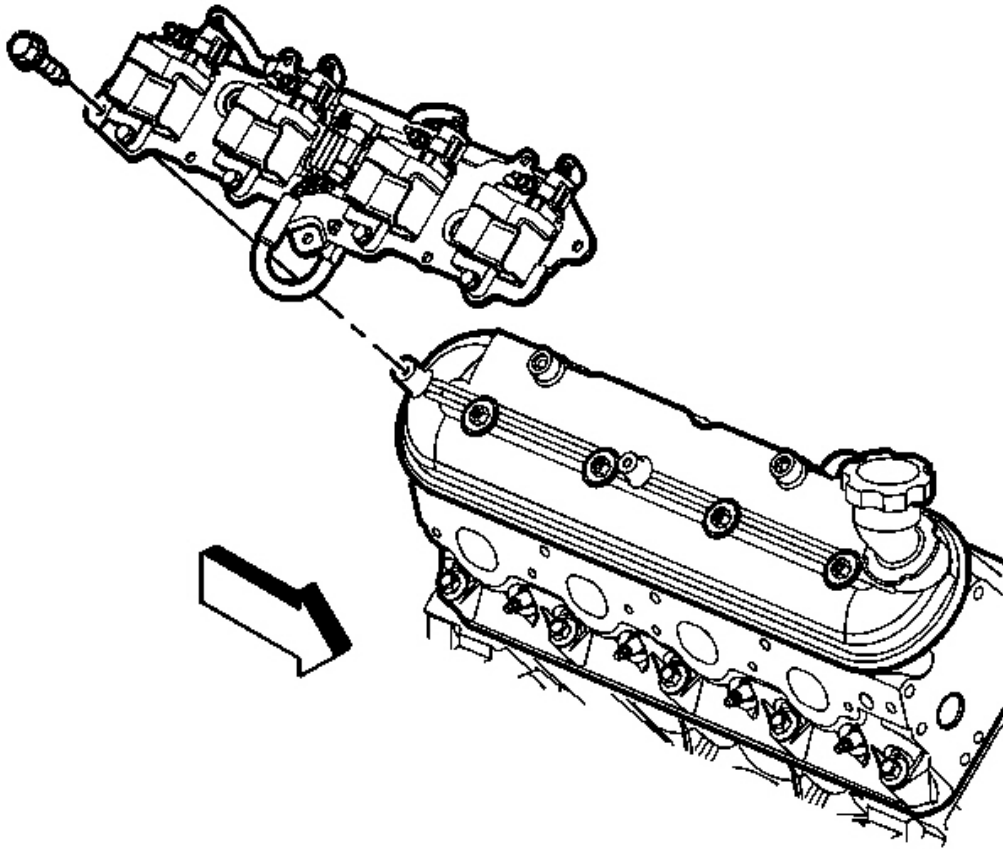
**Fig. 519: Ignition Coil & Bracket Assembly (Left)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Do not use the valve rocker arm cover gasket again. Install a **NEW** gasket during assembly.
- Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.
- Do not remove the oil fill tube or crankcase vent valve grommet from the covers unless service is required.

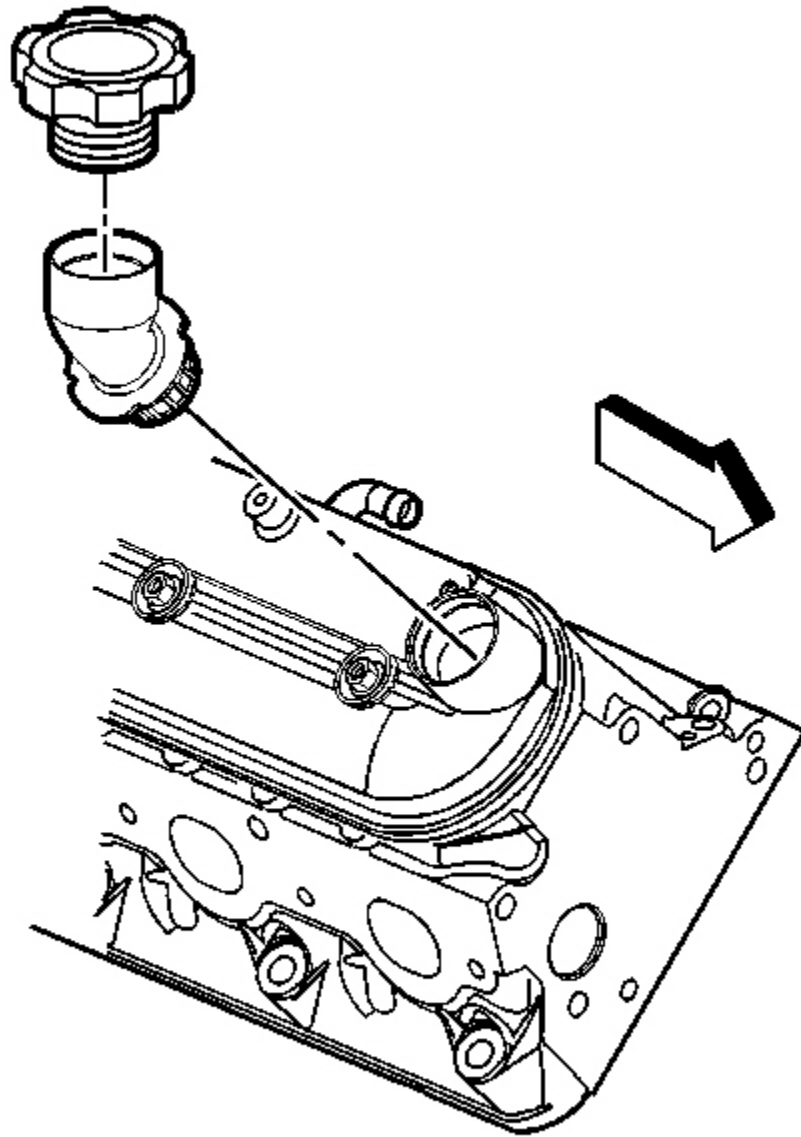
- If the oil fill tube or crankcase vent valve grommet have been removed from the rocker arm covers, install a NEW tube or grommet during assembly.

1. Remove the ignition coil and bracket assembly, bolts, and wire harness from the left cover, if required.



**Fig. 520: Ignition Coil & Bracket Assembly (Right)**  
Courtesy of GENERAL MOTORS CORP.

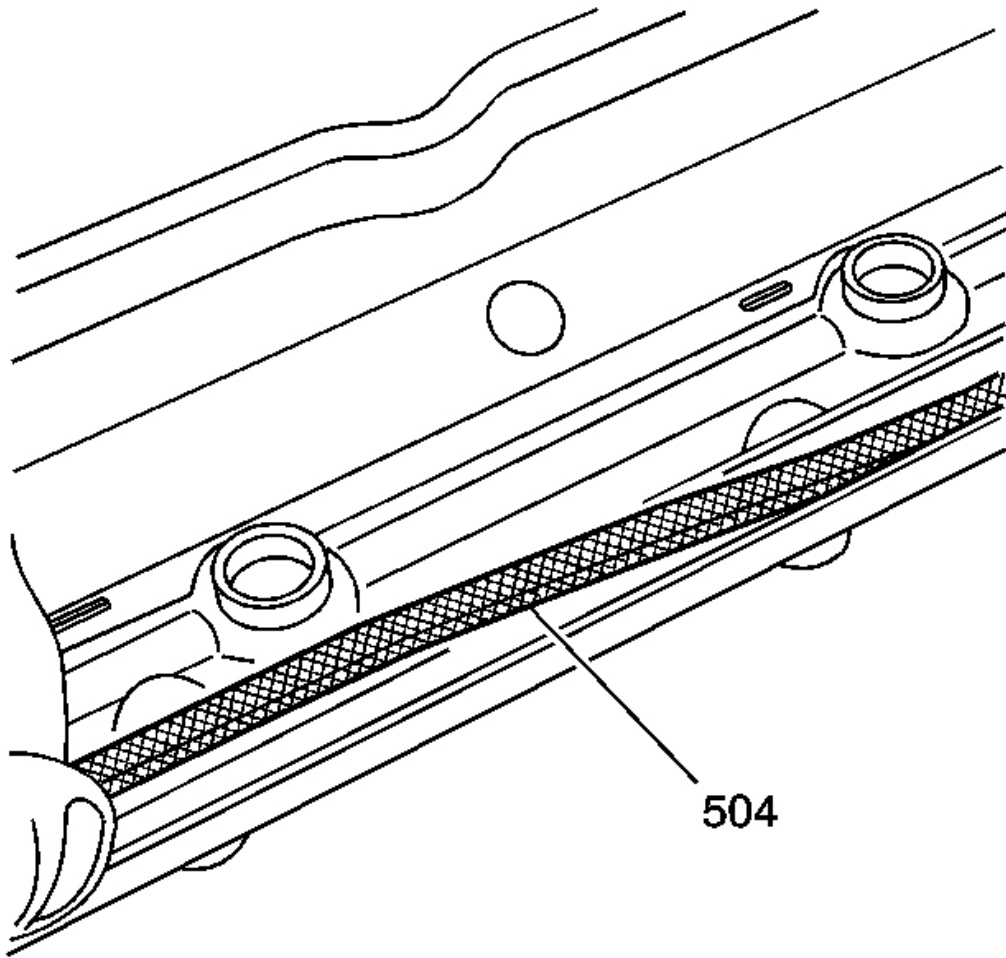
2. Remove the ignition coil and bracket assembly, bolts, and wire harness from the right cover, if required.



**Fig. 521: View Of Oil Fill Tube**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the tube for a loose fit or damage.
4. Remove the oil fill cap and tube from the right cover, if required.



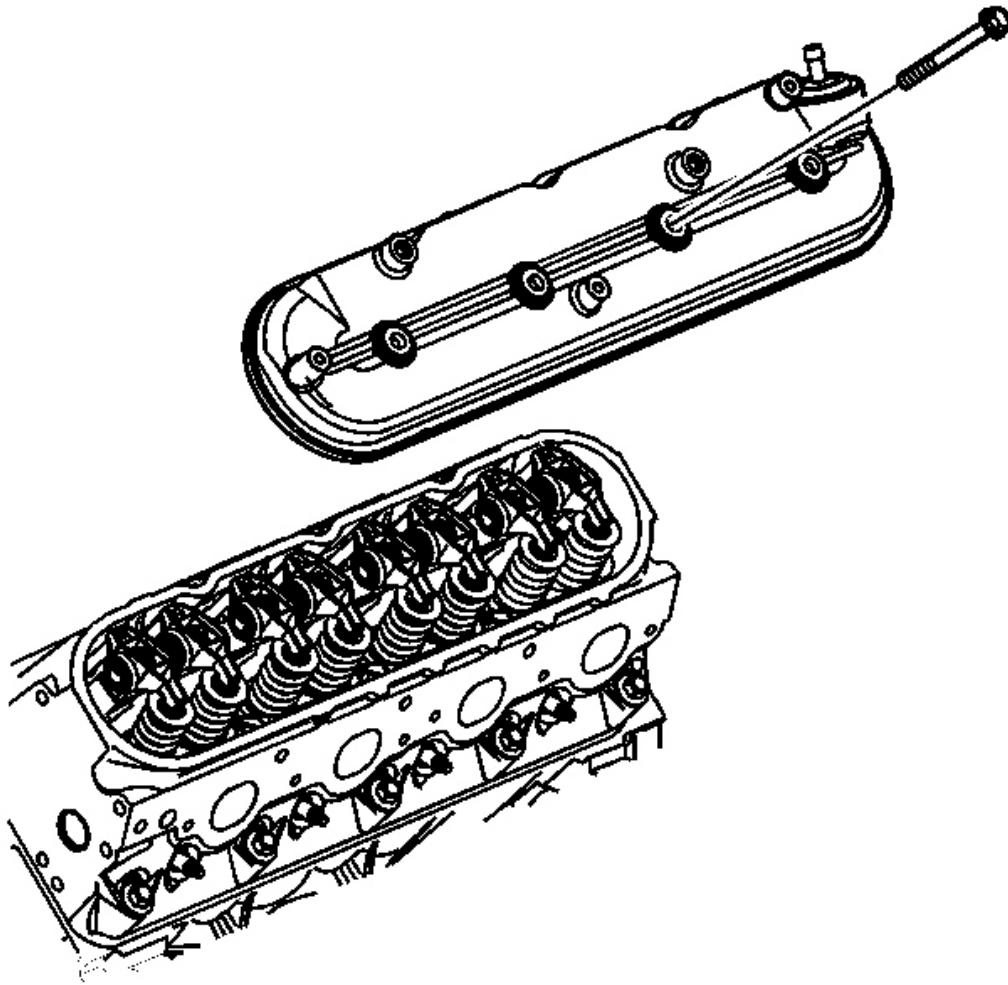


**Fig. 522: Valve Rocker Arm Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the gaskets (504) from the covers.
6. Remove the cover mounting bolts, with grommets.

Cover mounting bolts and grommets that are not damaged may be used again during assembly.

7. Clean the covers in solvent.

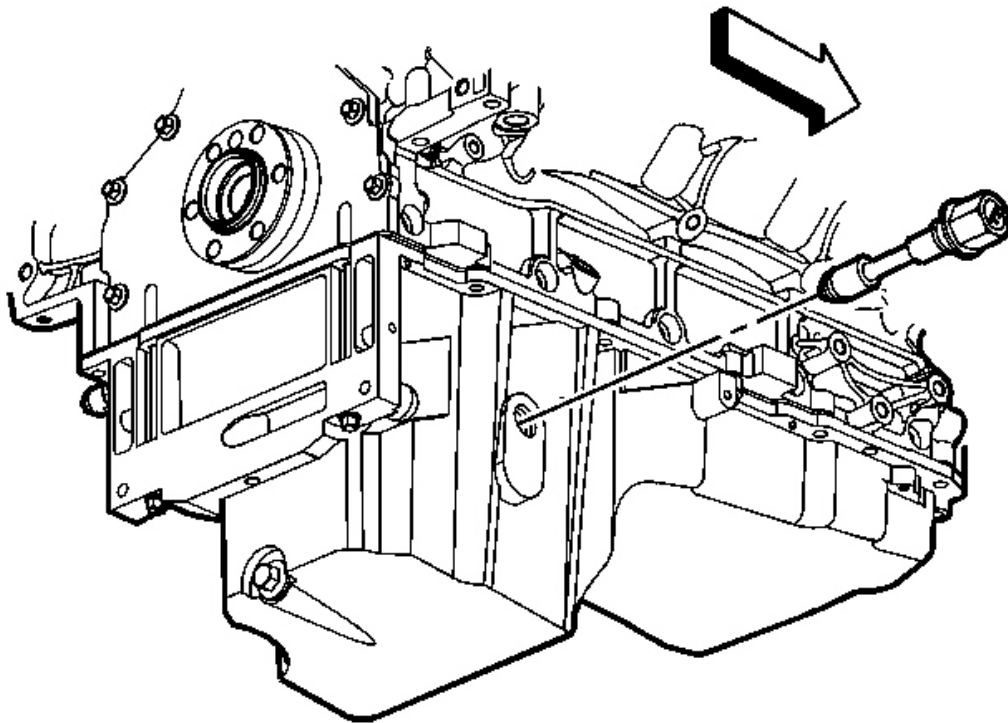


**Fig. 523: Valve Rocker Arm Cover (Left)**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

8. Dry the covers with compressed air.
9. Inspect the ventilation system passages for restrictions.
10. Inspect the gasket grooves for damage.
11. Inspect the coil bracket threaded bolt holes for damage or debris.

## OIL PAN CLEANING AND INSPECTION



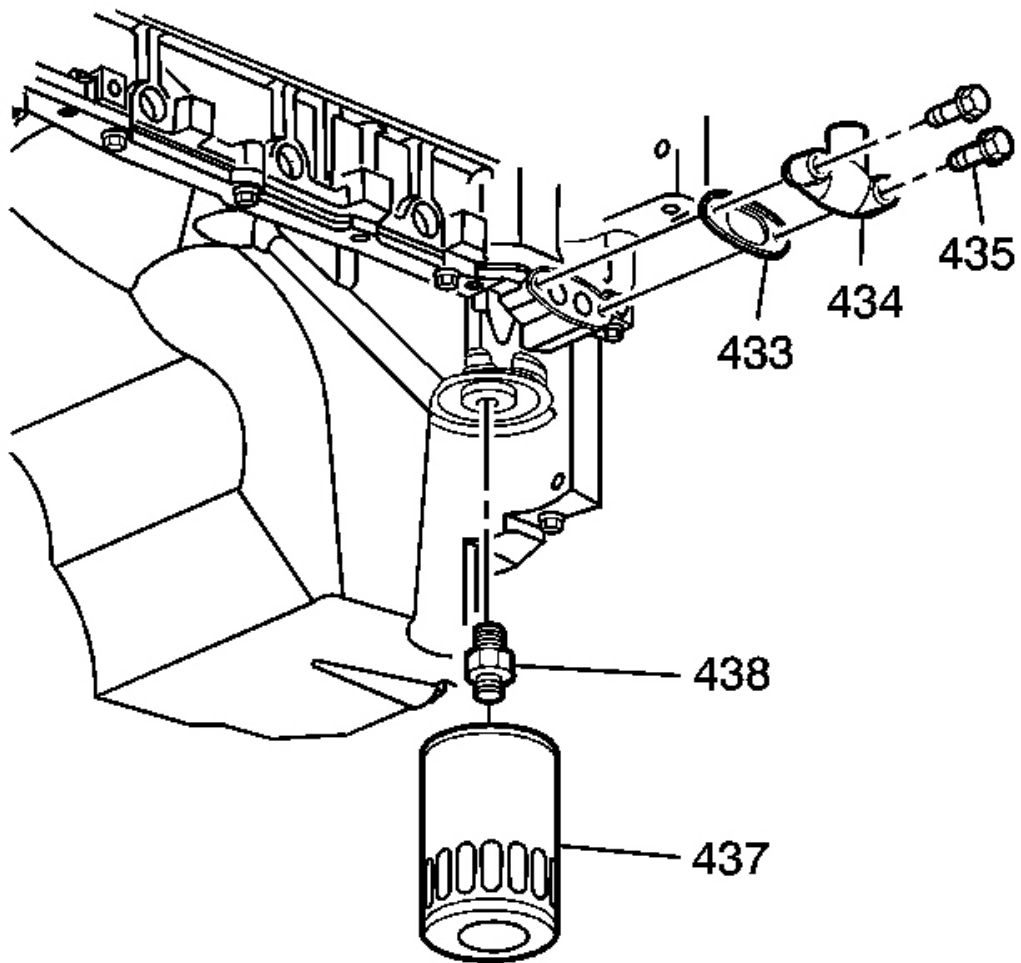
**Fig. 524: Oil Level Sensor**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

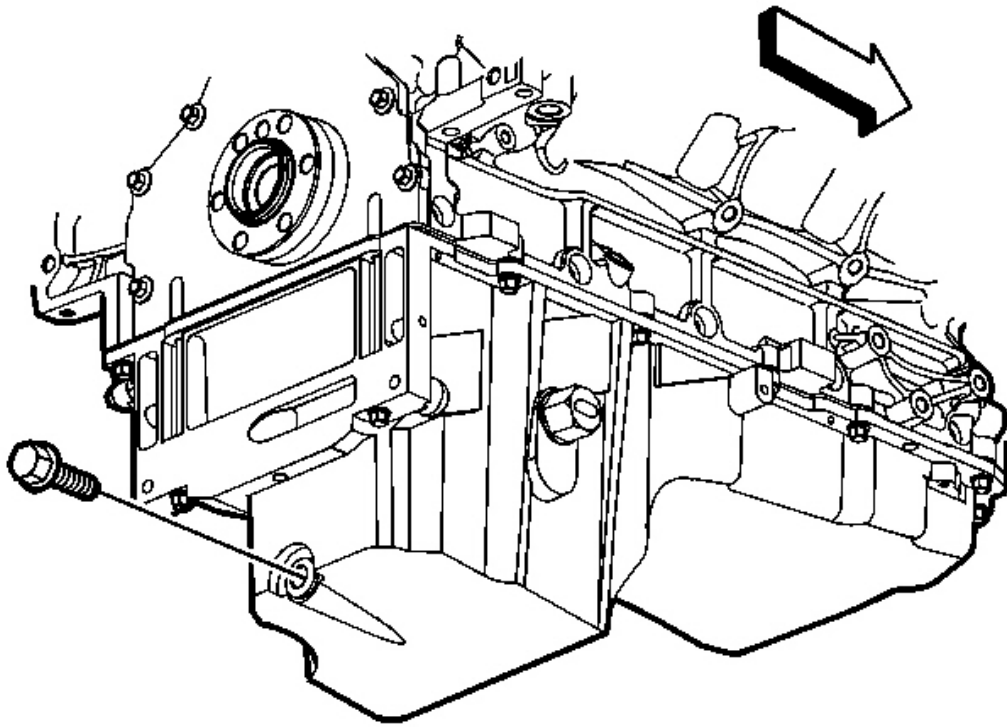
- Do not use the oil pan cover gasket again. Install a **NEW** cover gasket during assembly.
- Do not use the oil pan to engine block gasket again. Install a **NEW** gasket during assembly.
- When installing a **NEW** oil pan gasket, it is not necessary to install the rivets that retain the **NEW** gasket to the pan.

1. Remove the oil level sensor from the pan.



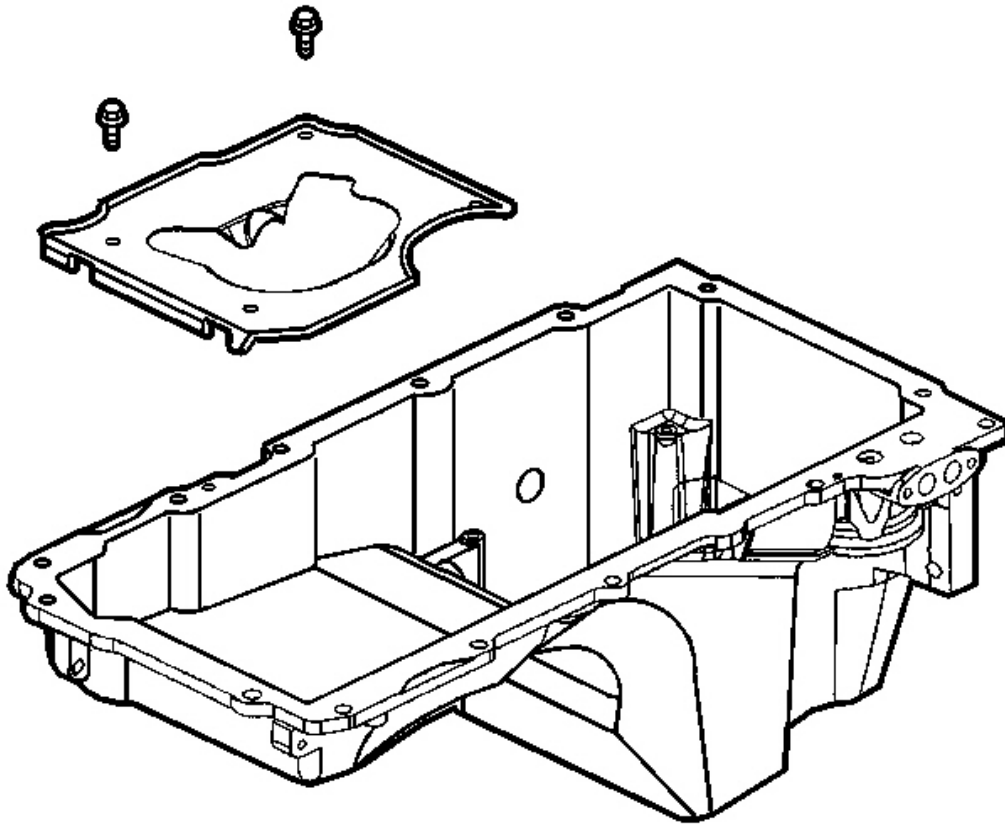
**Fig. 525: Oil Pan Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan cover (434), gasket (433), and bolts (435), if required.



**Fig. 526: Oil Pan Drain Plug & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan drain plug and O-ring seal.

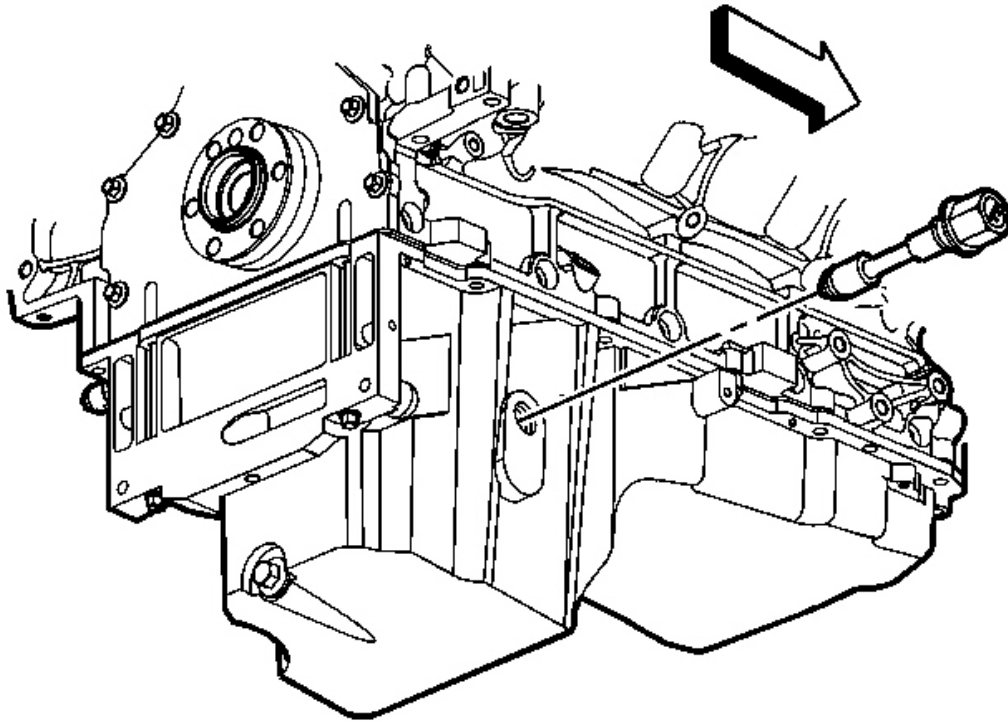


**Fig. 527: Oil Pan Baffle & Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan baffle and bolts.
5. Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.
6. Clean the oil pan gasket surfaces. Refer to **Replacing Engine Gaskets** .

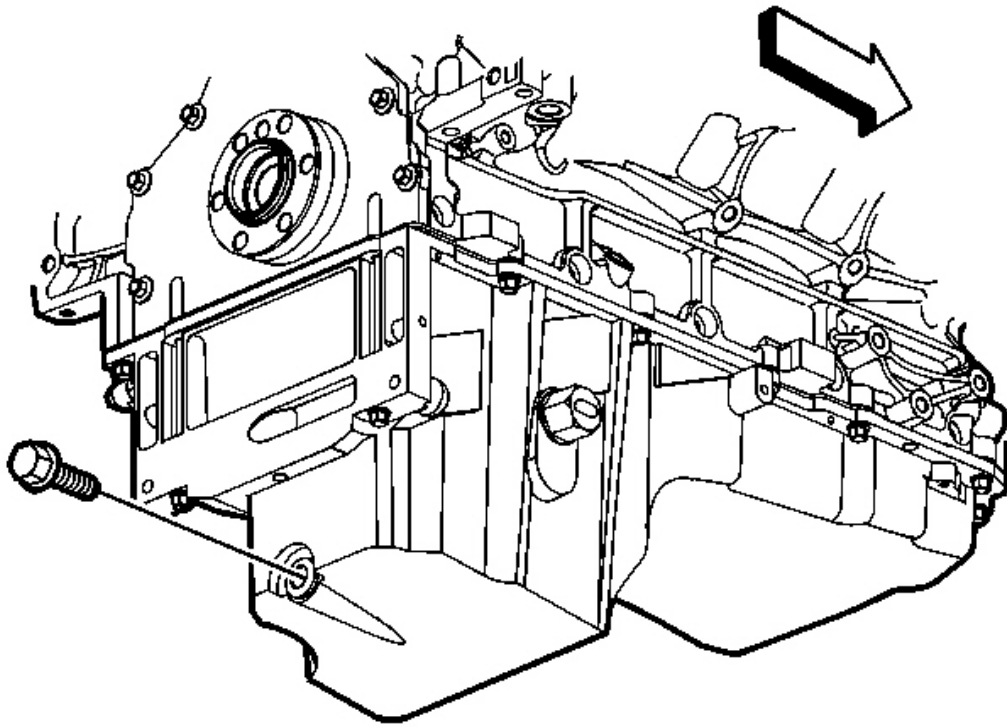
**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

7. Dry the oil pan with compressed air.
8. Inspect the gasket sealing surfaces for excessive scratches or gouging. Refer to **Replacing Engine Gaskets** .



**Fig. 528: Oil Level Sensor**  
Courtesy of GENERAL MOTORS CORP.

9. Inspect the oil level sensor seal surface and threads for damage.

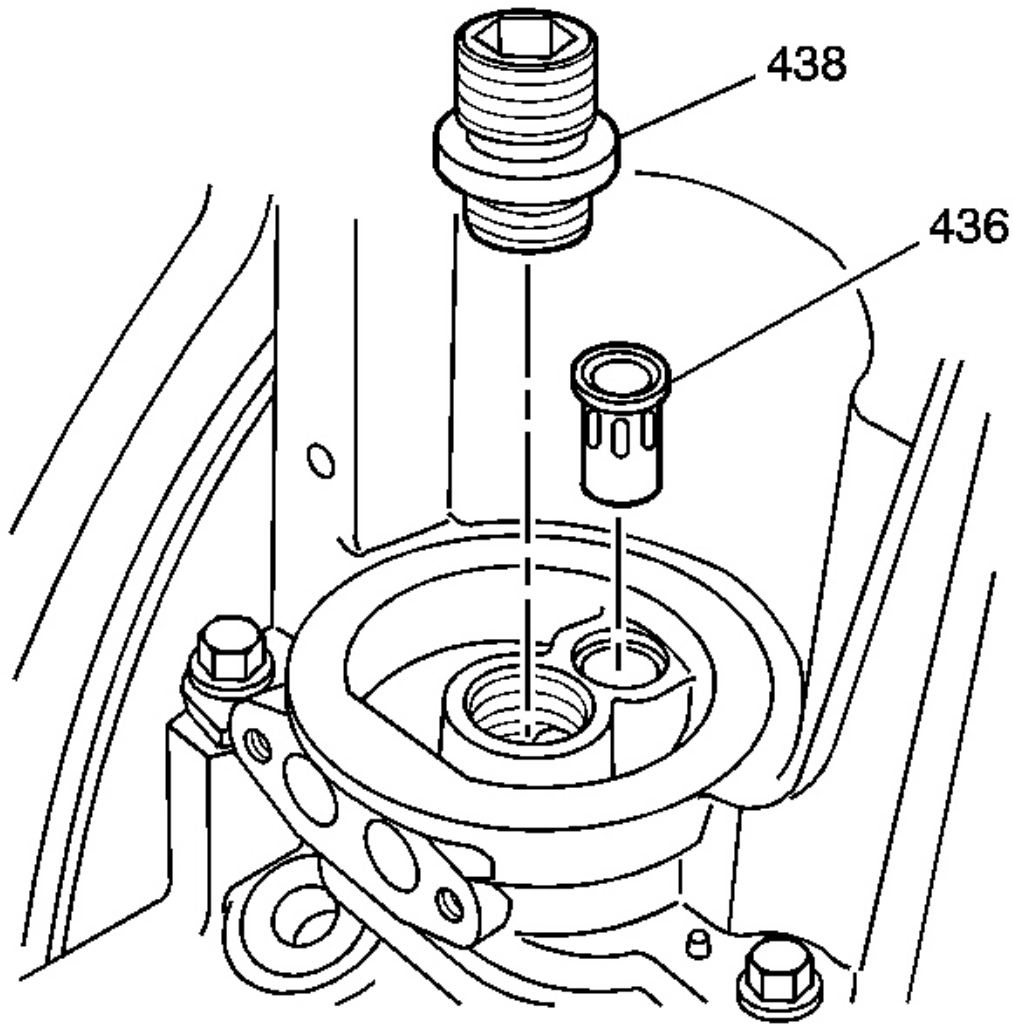


**Fig. 529: Oil Pan Drain Plug & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

10. Inspect the oil pan drain plug and threaded drain hole for damaged threads.

The drain plug O-ring seal may be used again if not cut or damaged.





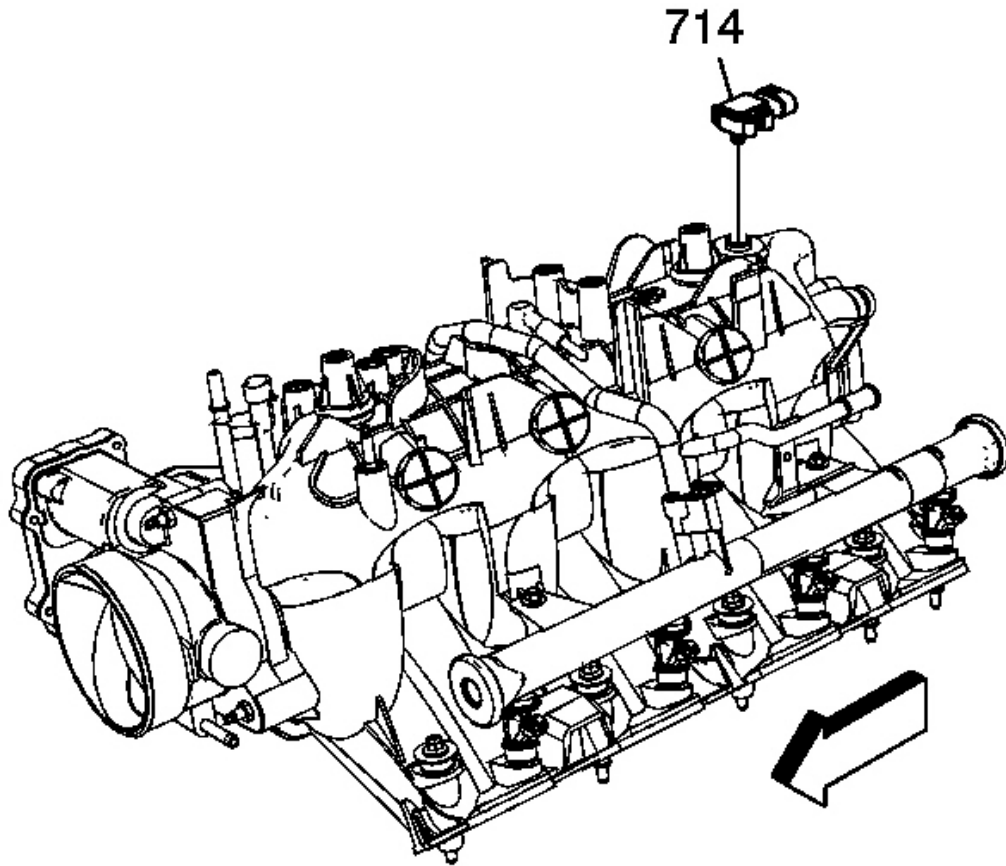
**Fig. 530: Oil Filter Fitting & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

11. Inspect the oil filter sealing surface for scratches or gouging.
12. Inspect the oil filter fitting (438) for a loose fit or damaged threads.
13. Inspect the oil passages for restrictions.
14. Inspect the oil filter bypass valve (436) for proper operation.

Lightly depress the bypass valve. The valve spring should seat the valve to the proper position.

# INTAKE MANIFOLD CLEANING AND INSPECTION

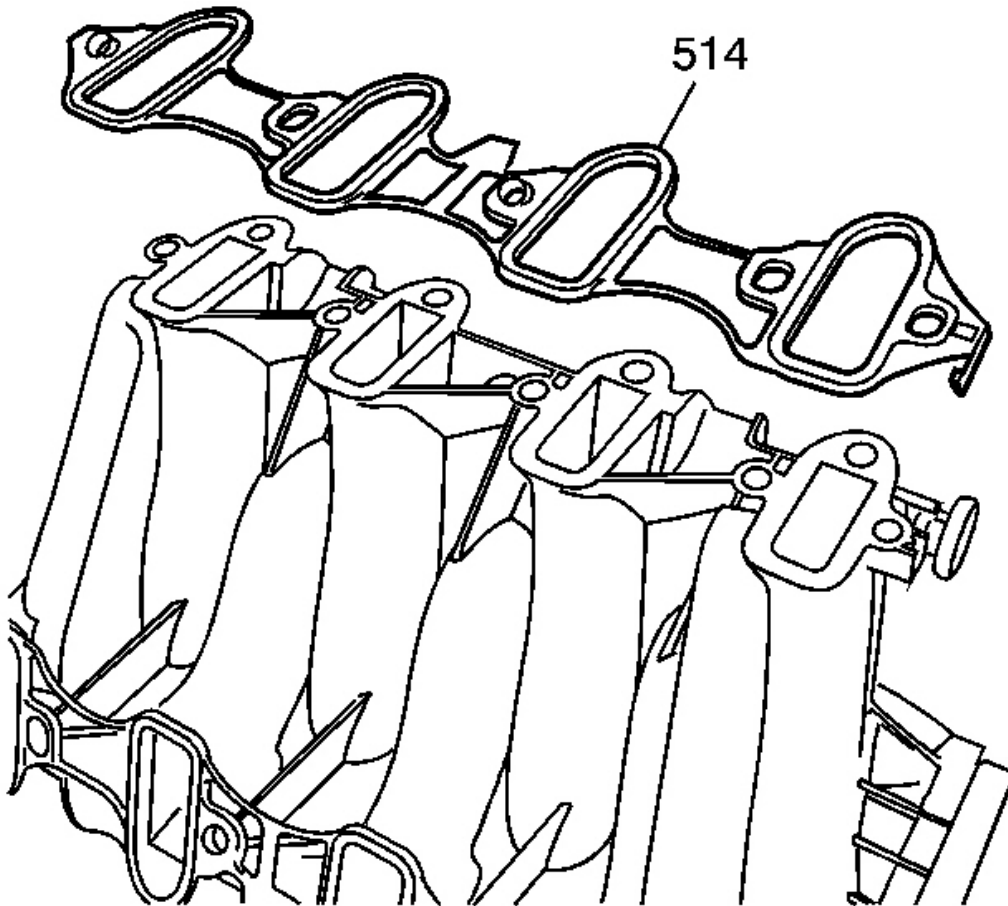
## Cleaning Procedure



**Fig. 531: View Of MAP Sensor**  
Courtesy of GENERAL MOTORS CORP.

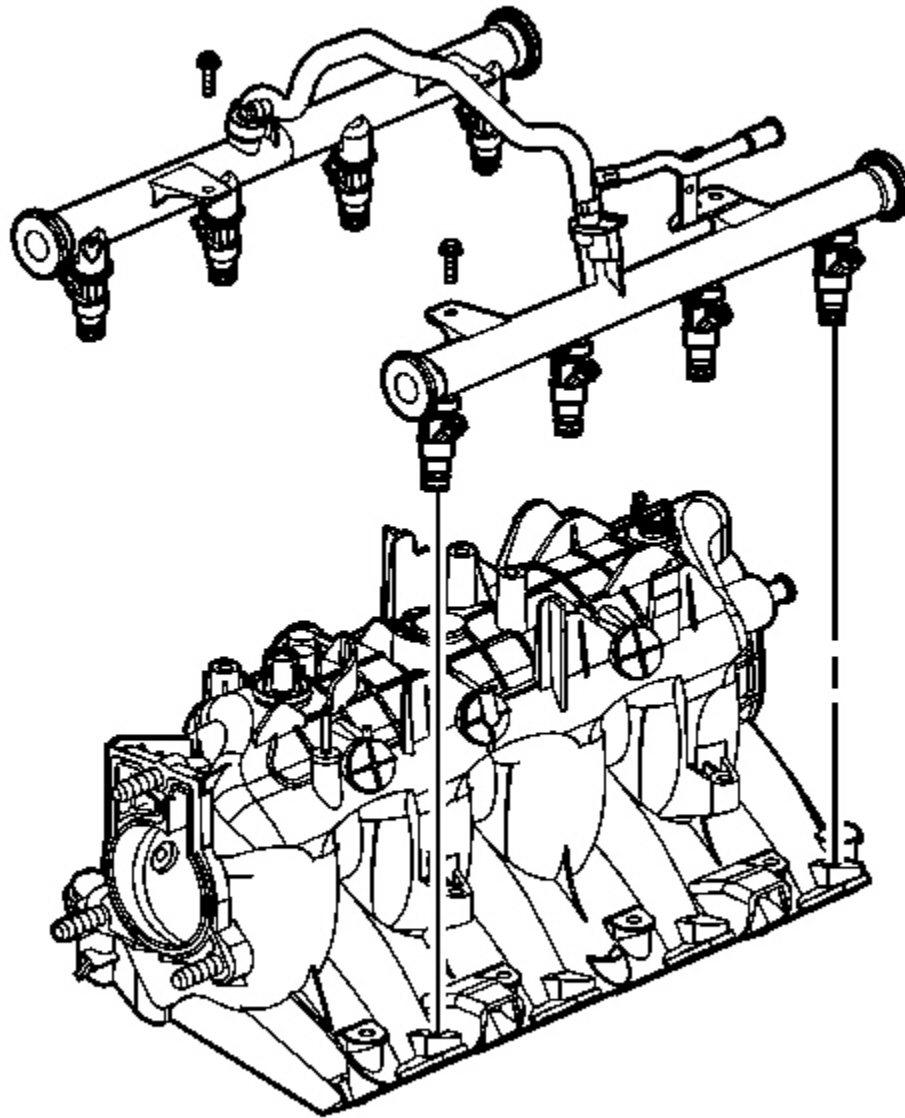
**IMPORTANT: Do not use the intake manifold-to-cylinder head sealing gaskets again.**

1. Remove the manifold absolute pressure (MAP) sensor (714) from the rear of the intake. The MAP sensor is to be reinstalled upon completion of the cleaning and inspection procedures.
2. Inspect the sealing grommet on the MAP sensor. The grommet should not be torn or damaged.



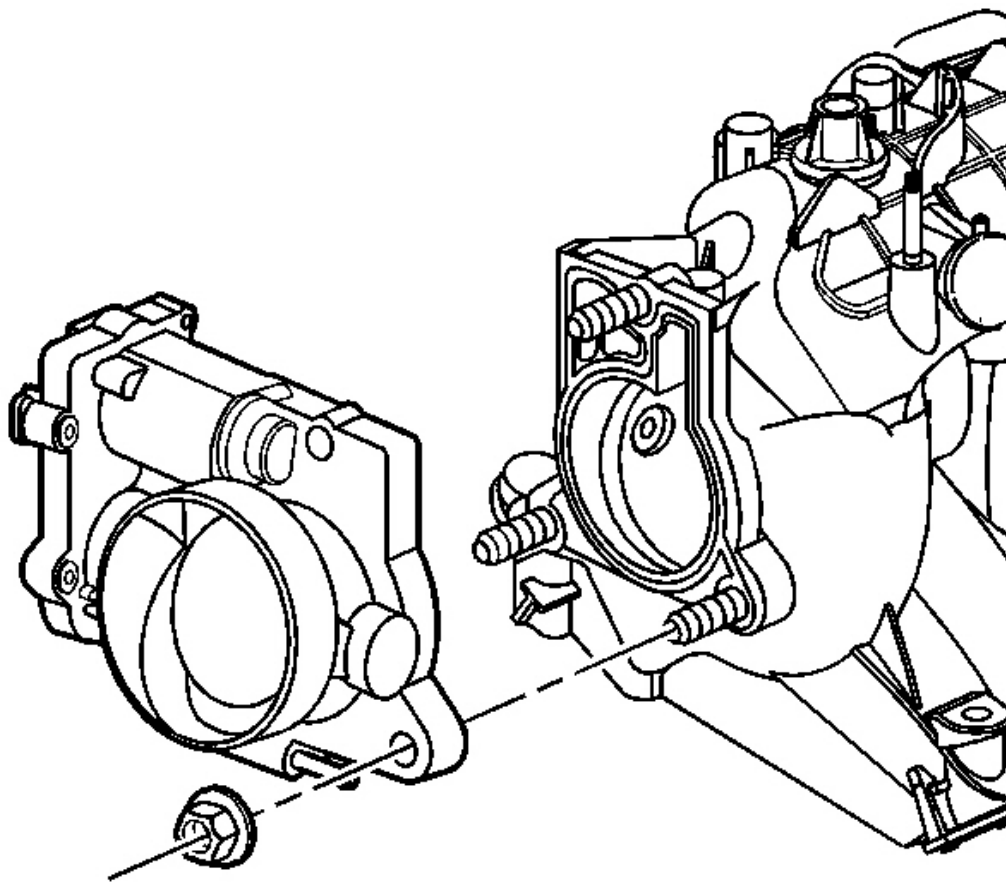
**Fig. 532: Intake Manifold-To-Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the intake manifold-to-cylinder head gaskets (514).



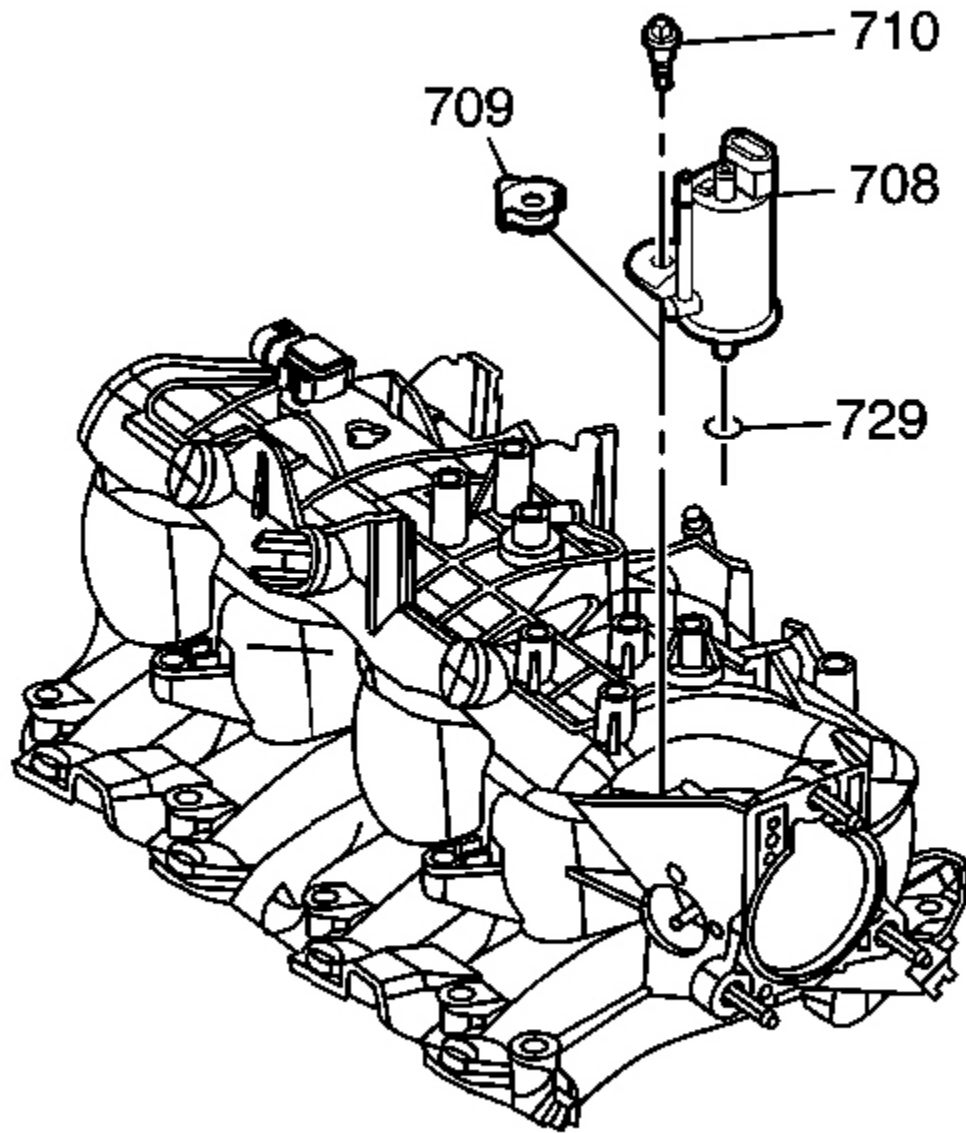
**Fig. 533: Fuel Rail & Injectors**  
Courtesy of GENERAL MOTORS CORP.

4. Remove the fuel rail with injectors. Refer to **Fuel Rail and Injectors Removal** .



**Fig. 534: Throttle Body & Nuts**  
Courtesy of GENERAL MOTORS CORP.

5. Remove the throttle body and gasket. Refer to **Throttle Body Removal** .



**Fig. 535: EVAP Purge Solenoid, Bolt & Isolator**  
Courtesy of GENERAL MOTORS CORP.

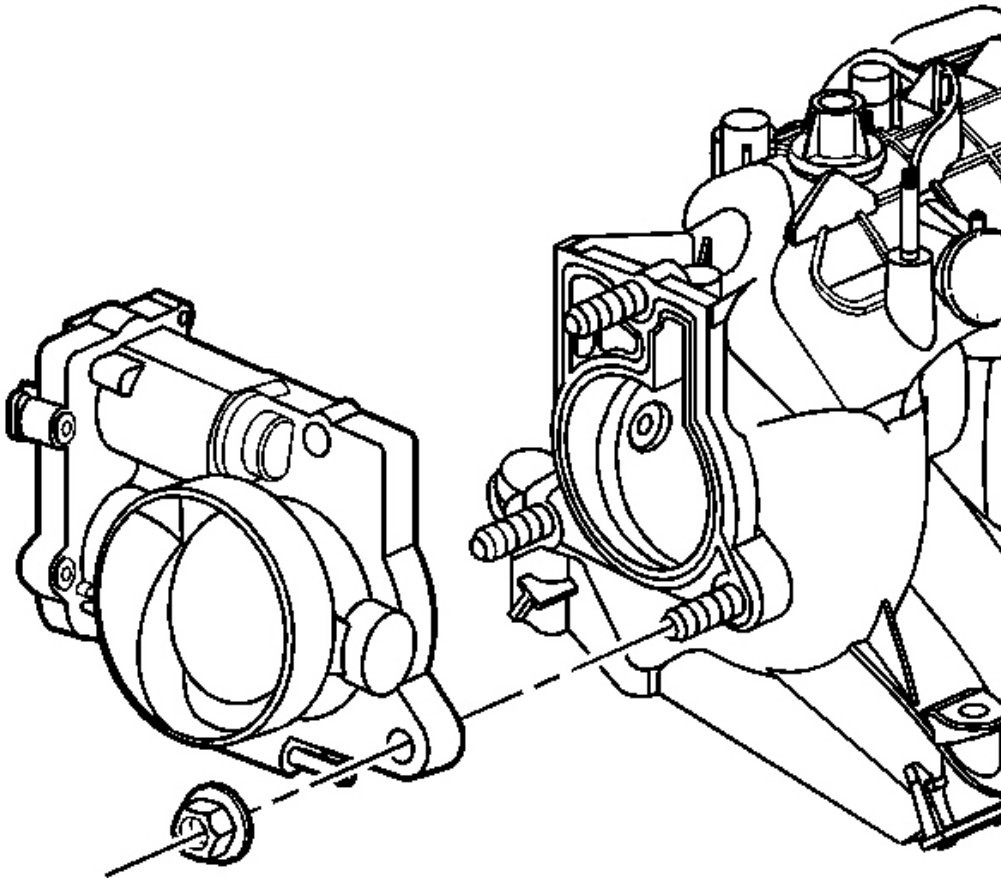
6. Remove the evaporative emissions (EVAP) purge solenoid (708), bolt (710), and isolator (709).
7. Clean the intake manifold in solvent.
  - Clean the intake manifold gasket surfaces.

- Clean the intake manifold internal passages.

**CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.**

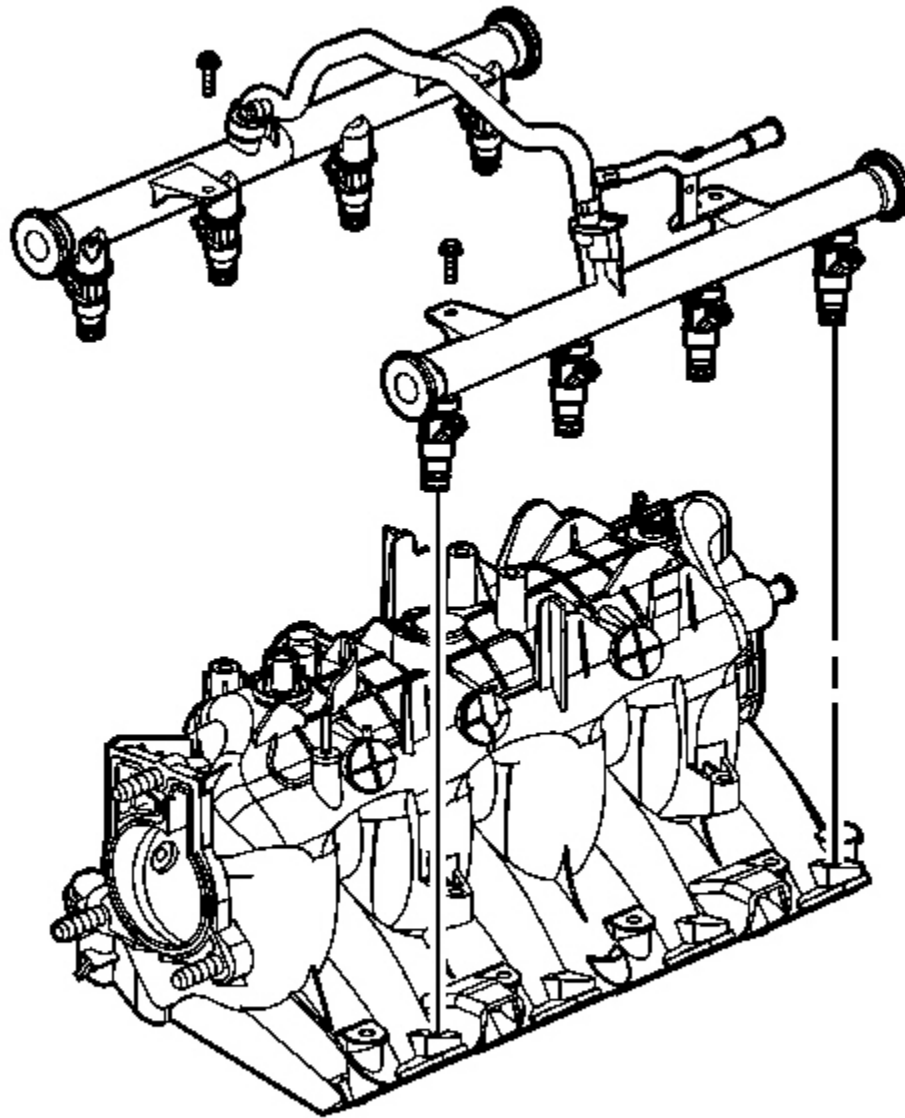
8. Dry the intake manifold with compressed air.

### Inspection Procedure



**Fig. 536: Throttle Body & Nuts**  
Courtesy of GENERAL MOTORS CORP.

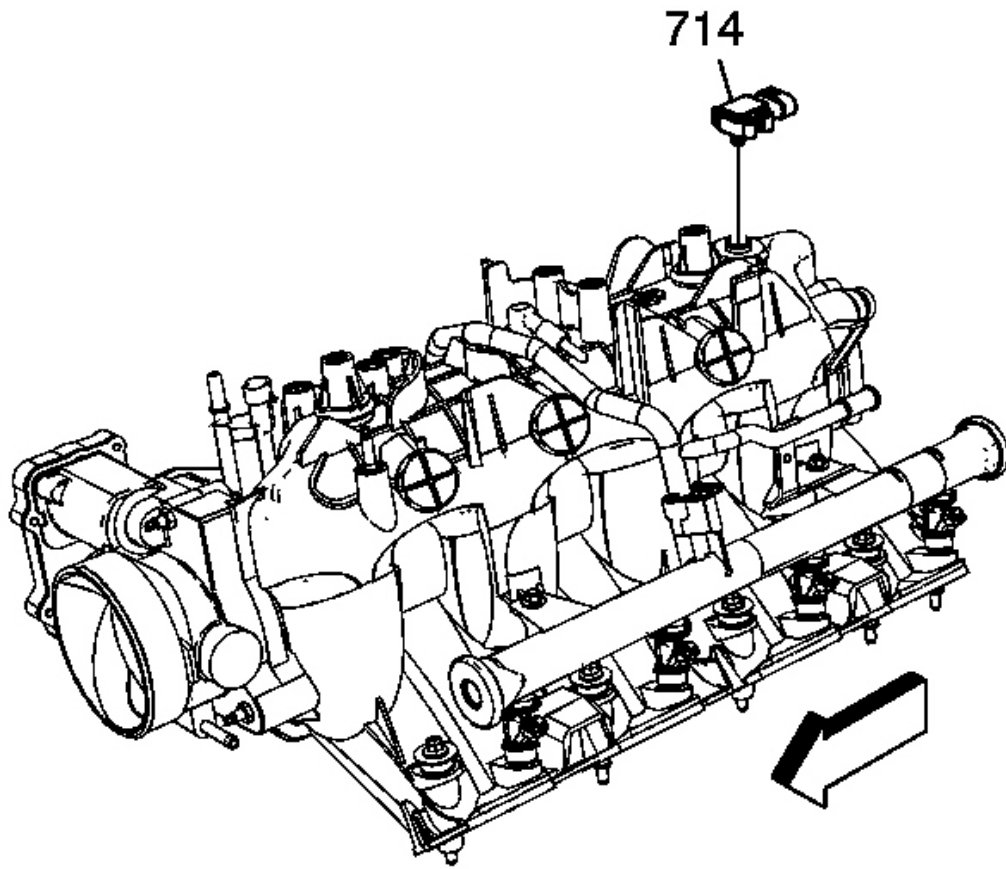
1. Inspect the throttle body studs and threaded inserts for looseness or damaged threads.
2. Inspect the wire harness stud and threaded insert for looseness or damaged threads.



**Fig. 537: Fuel Rail & Injectors**  
Courtesy of GENERAL MOTORS CORP.

3. Inspect the fuel rail bolt inserts for looseness or damaged threads.
4. Inspect the intake manifold vacuum passages for debris or restrictions.



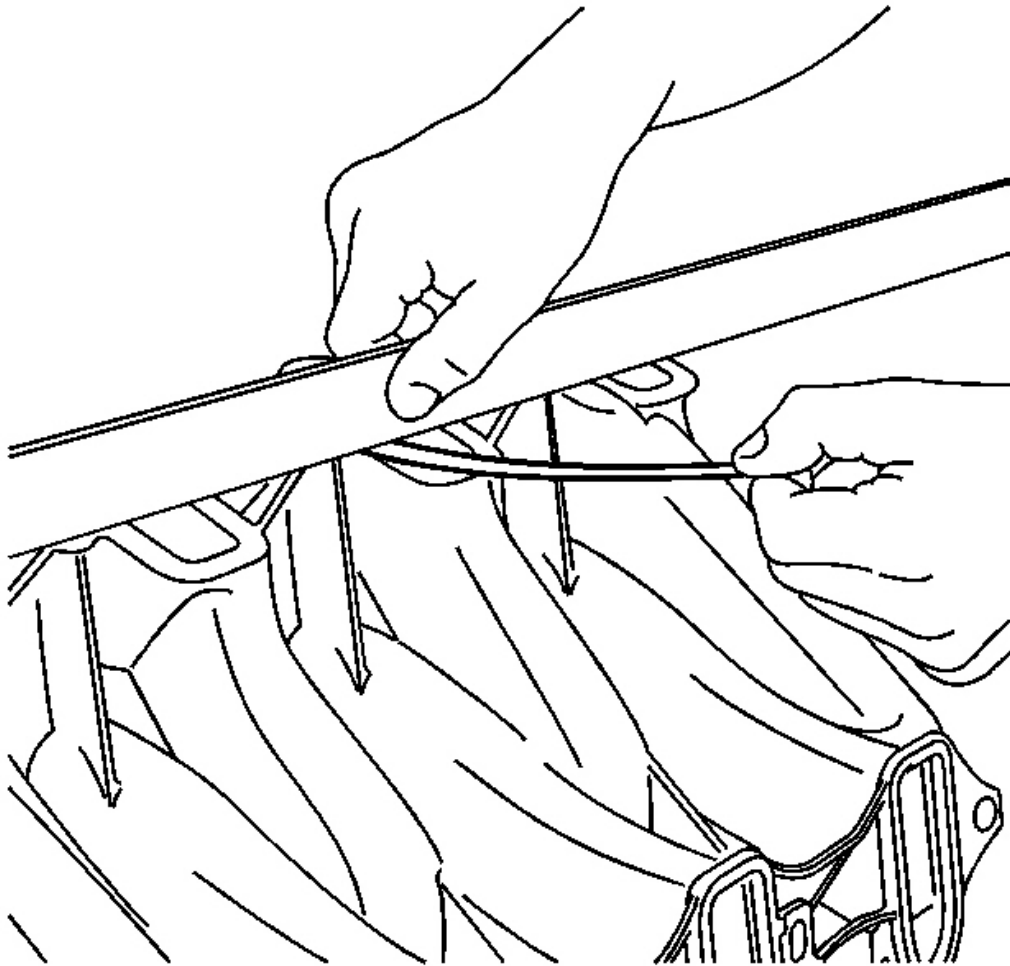


**Fig. 538: View Of MAP Sensor**  
**Courtesy of GENERAL MOTORS CORP.**

5. Inspect for damaged or broken vacuum fittings, damaged MAP sensor (714) mounting bore, or broken MAP sensor retaining tabs.
6. Inspect the composite intake manifold assembly for cracks or other damage.

Inspect the areas between the intake runners.

7. Inspect all the gasket sealing surfaces for damage.



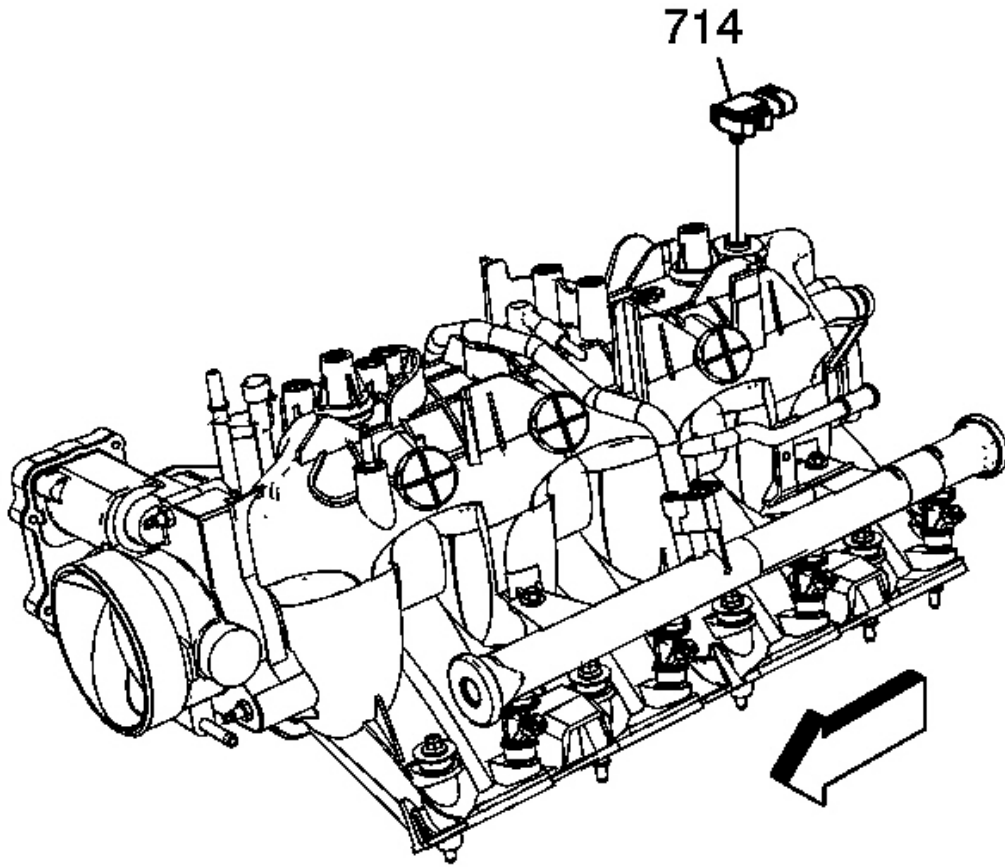
**Fig. 539: Inspecting Fuel Injector Bores For Excessive Scoring Or Damage**  
Courtesy of GENERAL MOTORS CORP.

8. Inspect the fuel injector bores for excessive scoring or damage.
9. Inspect the intake manifold cylinder head deck for warpage.
  1. Locate a straight edge across the intake manifold cylinder head deck surface.

Position the straight edge across a minimum of two runner port openings.

2. Insert a feeler gauge between the intake manifold and the straight edge.

A intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.



**Fig. 540: View Of MAP Sensor**  
Courtesy of GENERAL MOTORS CORP.

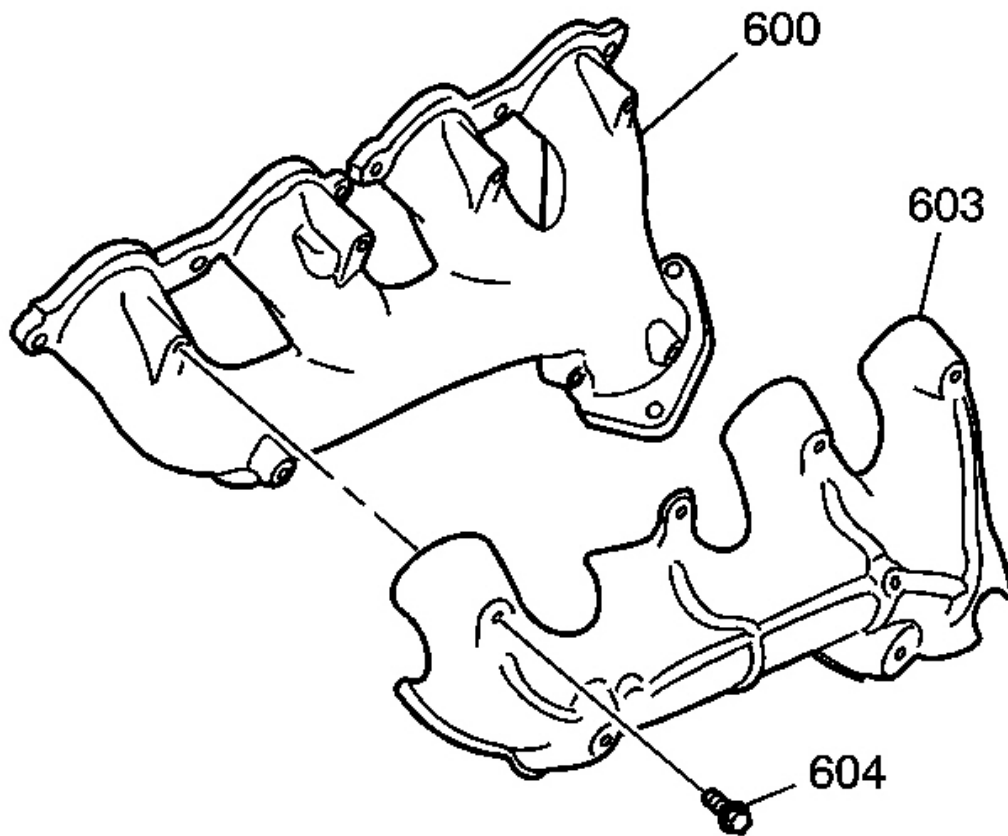
10. Install the MAP sensor (714).

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

11. Install the EVAP solenoid, bolt, and isolator.

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

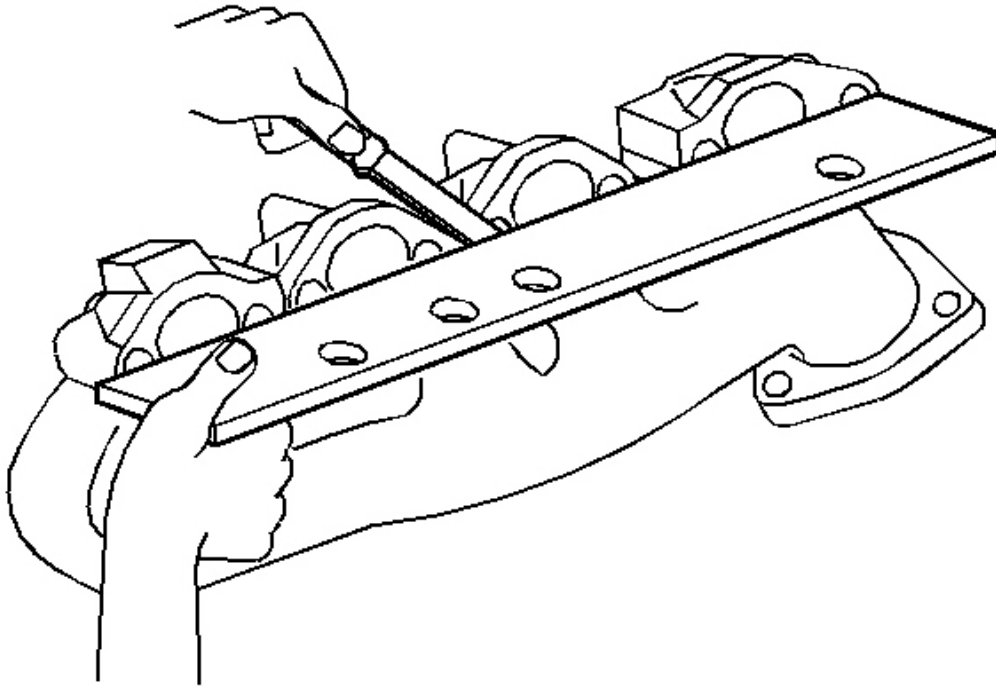
## EXHAUST MANIFOLD CLEANING AND INSPECTION



**Fig. 541: Exhaust Manifold & Heat Shield**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a **NEW** gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.

1. Clean the exhaust manifold (600) and heat shield (603) in solvent.
2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose or damaged heat shield (603).
5. Inspect the take down studs for damaged threads.

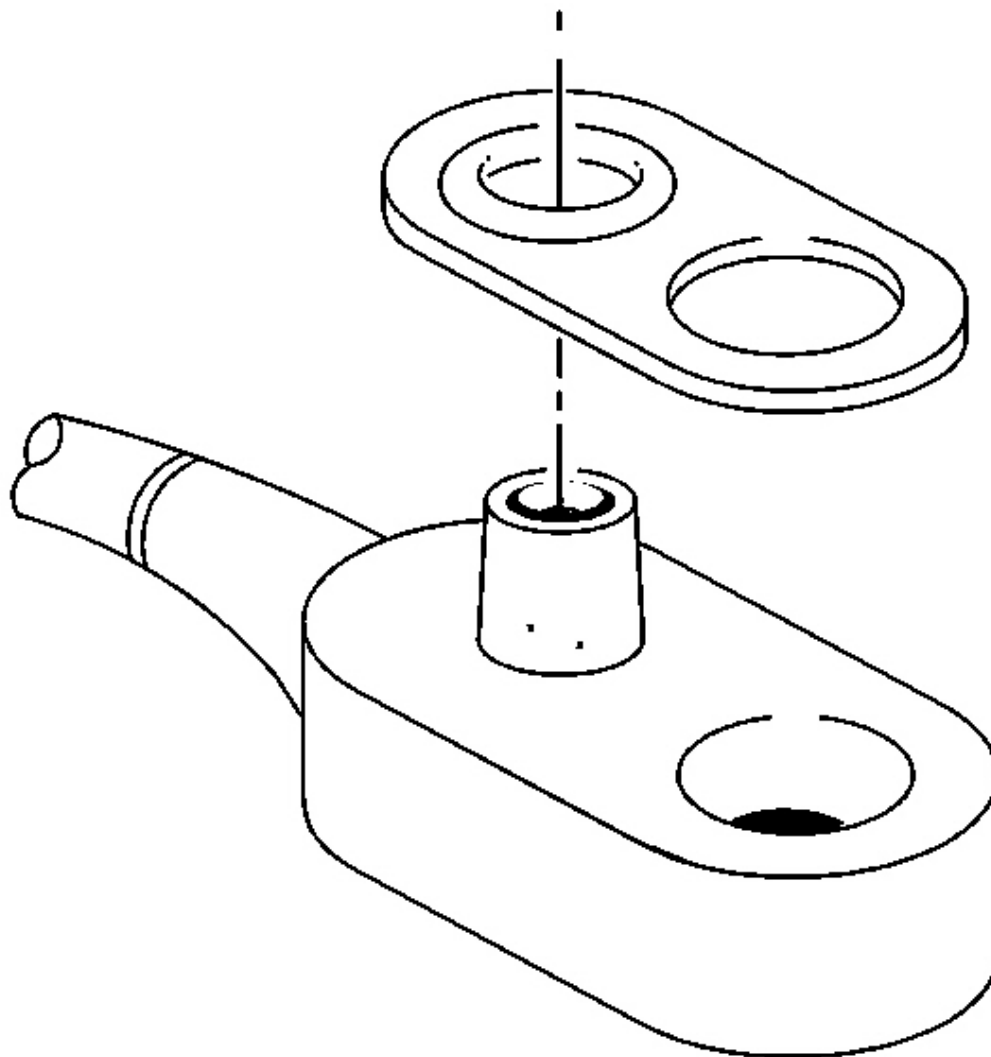


**Fig. 542: Measuring Exhaust Manifold To Cylinder Head For Warpage**  
Courtesy of GENERAL MOTORS CORP.

6. Use a straight edge and a feeler gauge and measure the exhaust manifold cylinder head deck for warpage.

An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the two front or two rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

## **COOLANT AIR BLEED PIPE CLEANING AND INSPECTION**



**Fig. 543: View Of Pipe & Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

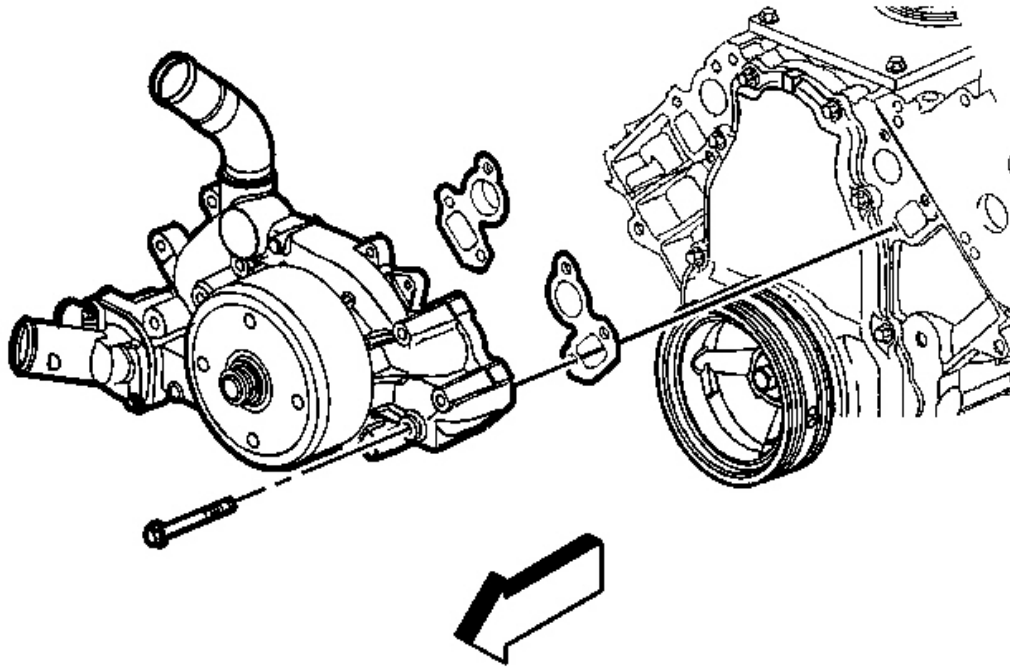
**IMPORTANT: Do not use the engine coolant air bleed pipe and cover gaskets again.  
Upon installation of the pipe and covers, install NEW gaskets.**

1. Remove the sealing gaskets from the pipe.
2. Remove the sealing gaskets from the covers.



The hose may be used again if it is not damaged.

## WATER PUMP CLEANING AND INSPECTION

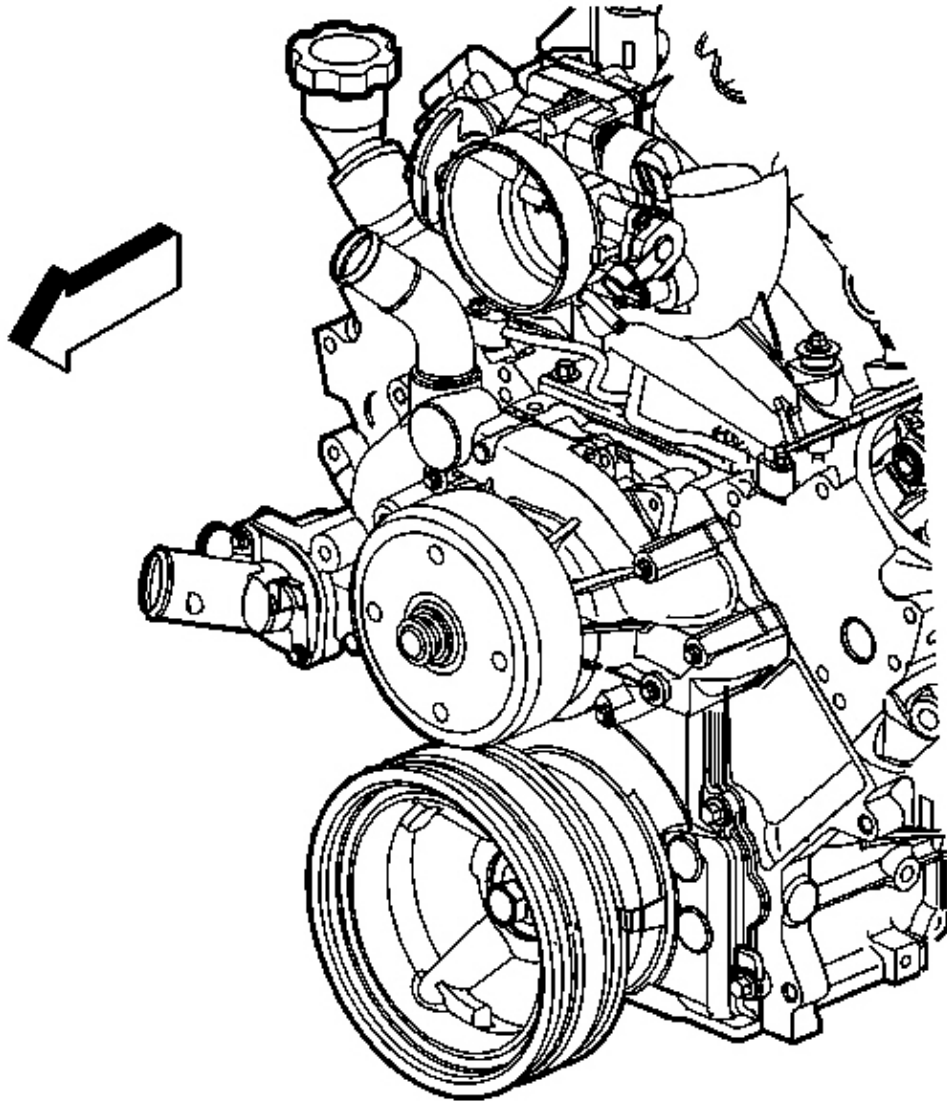


**Fig. 545: Water Pump, Bolts & Gaskets**  
Courtesy of GENERAL MOTORS CORP.

1. Remove the old gasket from the water pump sealing surfaces. Refer to **Replacing Engine Gaskets** .
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
  - Gasket and hose sealing surfaces for excessive scratches or gouging
  - Restrictions within the internal coolant passages
  - Excessive side-to-side play in the pulley shaft
  - Leakage at the water outlet housing or rear cover gasket
  - Leakage at the water pump vent hole

A stain around the vent hole is acceptable. If leakage, dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.





**Fig. 546: Inspecting Water Pump Pulley For Wear Or Damage**  
Courtesy of GENERAL MOTORS CORP.

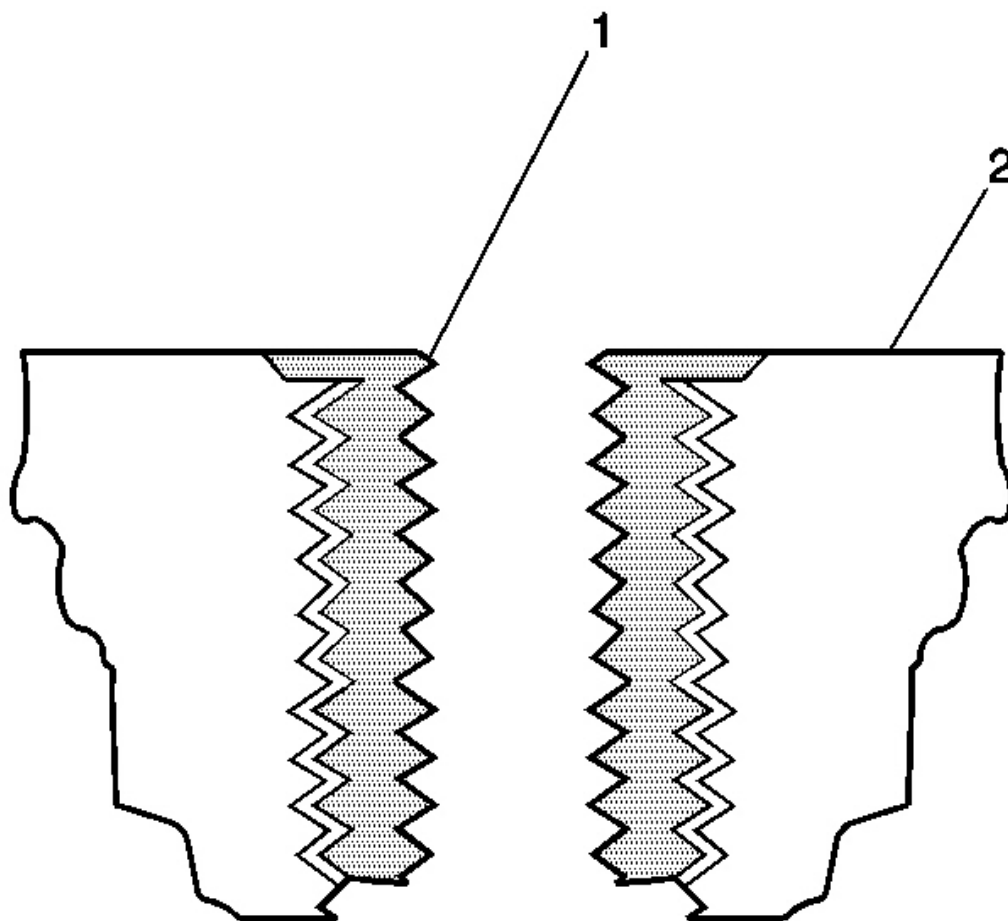
4. Inspect the water pump pulley for wear or damage in the belt tracking area.

## **THREAD REPAIR**

### **Tools Required**

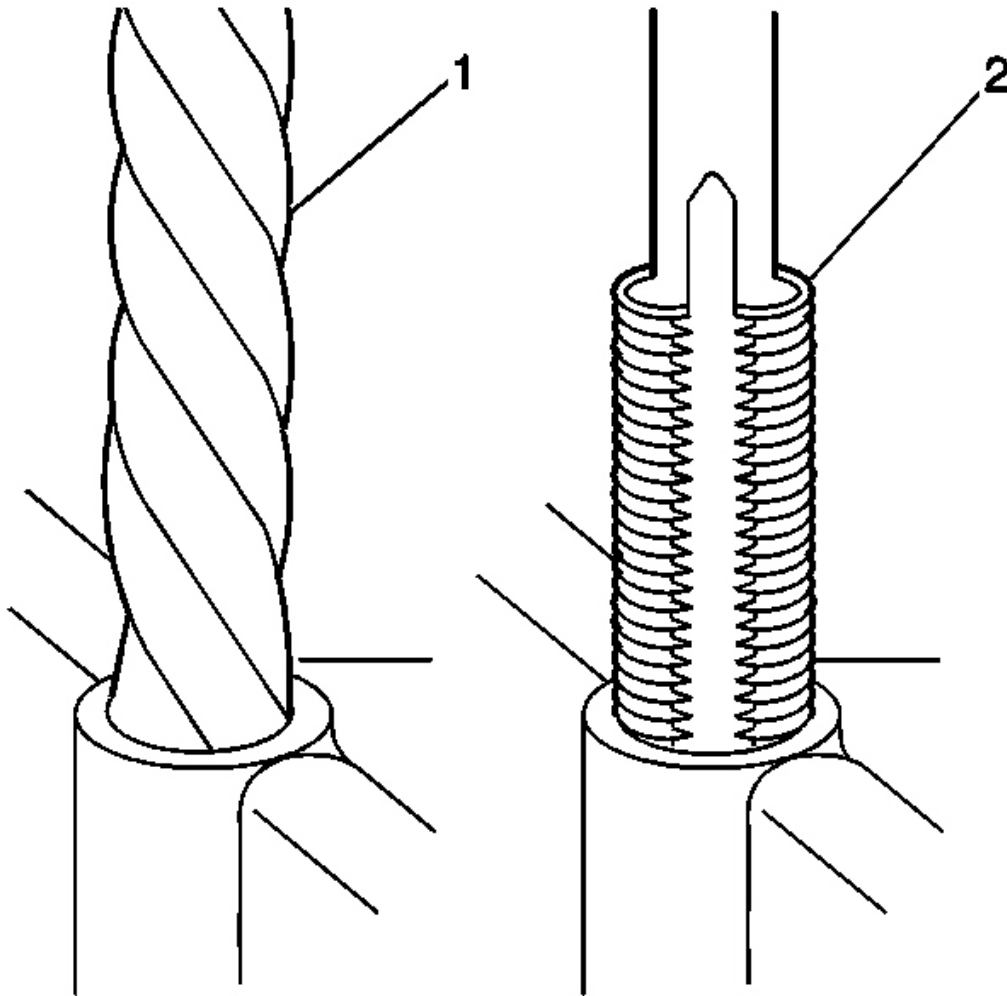
- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools and Equipment** .
- **J 42385-200** General Threads Kit. See **Special Tools and Equipment** .
- **J 42385-300** Fixtures/Hardware Kit. See **Special Tools and Equipment** .

### General Thread Repair



**Fig. 547: Bushing Type Insert & Base Material**  
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.



**Fig. 548: Removing Damaged Threads**  
Courtesy of GENERAL MOTORS CORP.

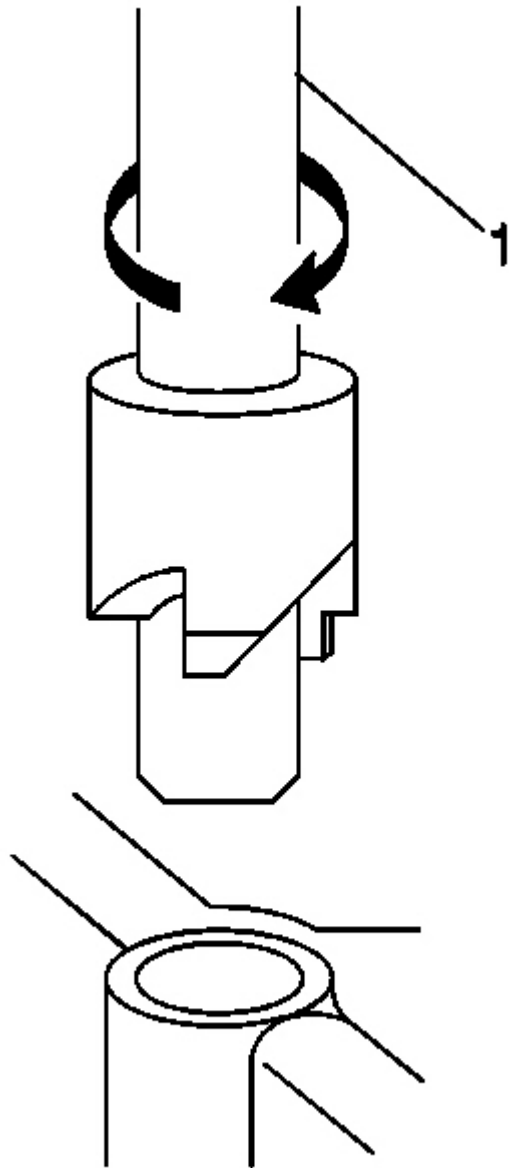
**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

**IMPORTANT:**

- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40(R), or equivalent is recommended when performing the drilling, counterboring, and tapping procedures.
- Driver oil **MUST** be used on the installer driver tool.

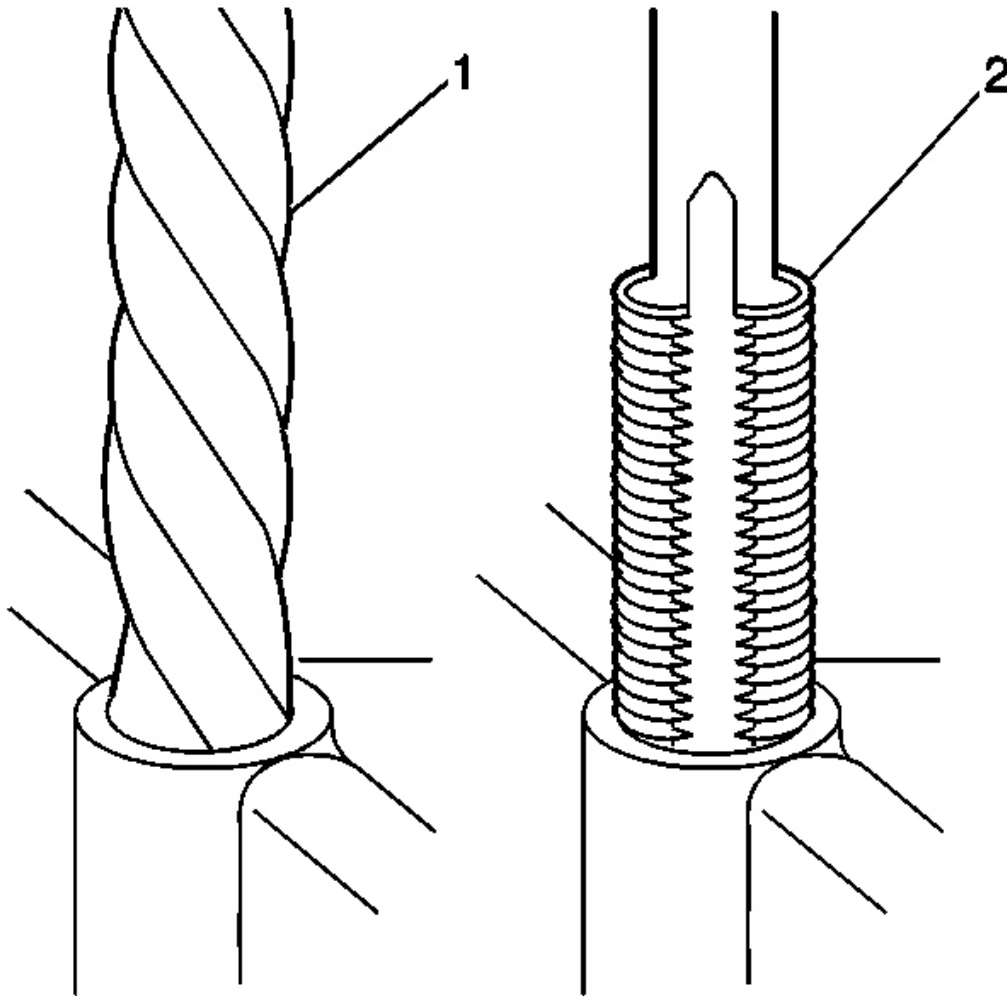
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

1. Drill out the threads of the damaged hole (1).
  - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
  - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
  - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.



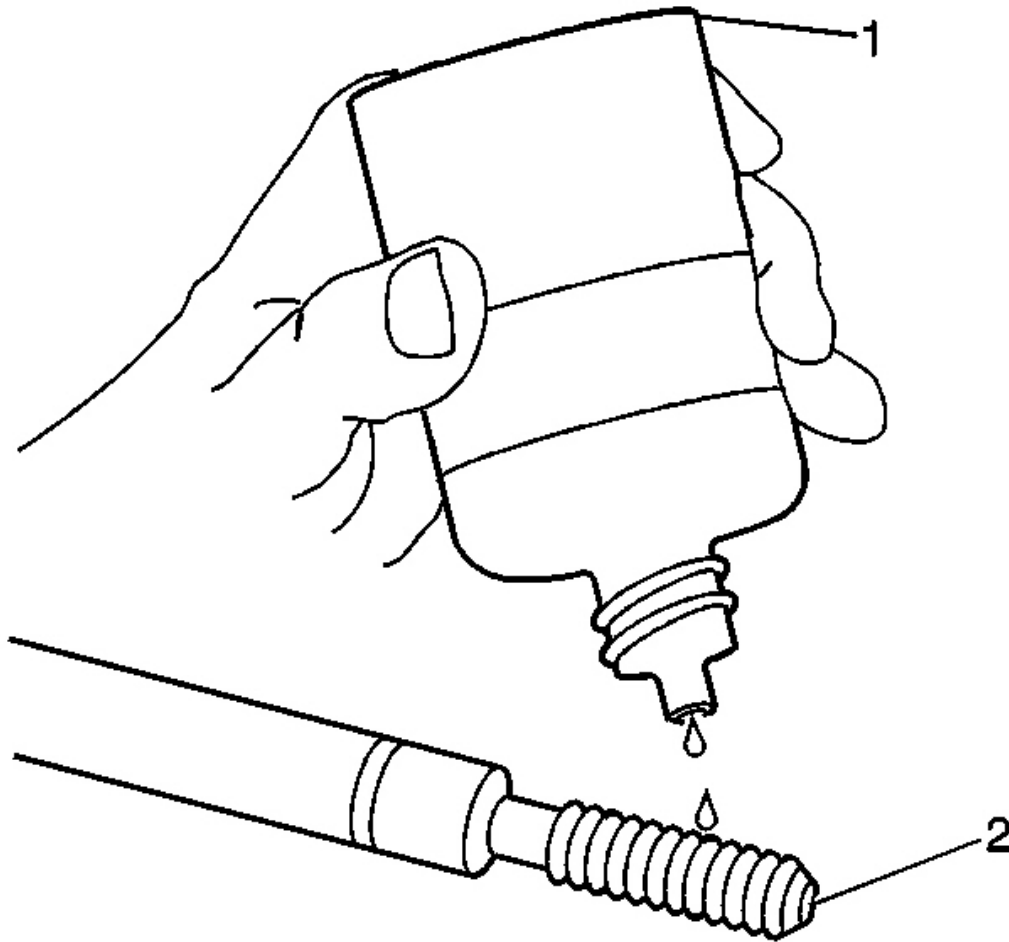
**Fig. 549: View Of Counterbore Drill**  
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.



**Fig. 550: Removing Damaged Threads**  
Courtesy of GENERAL MOTORS CORP.

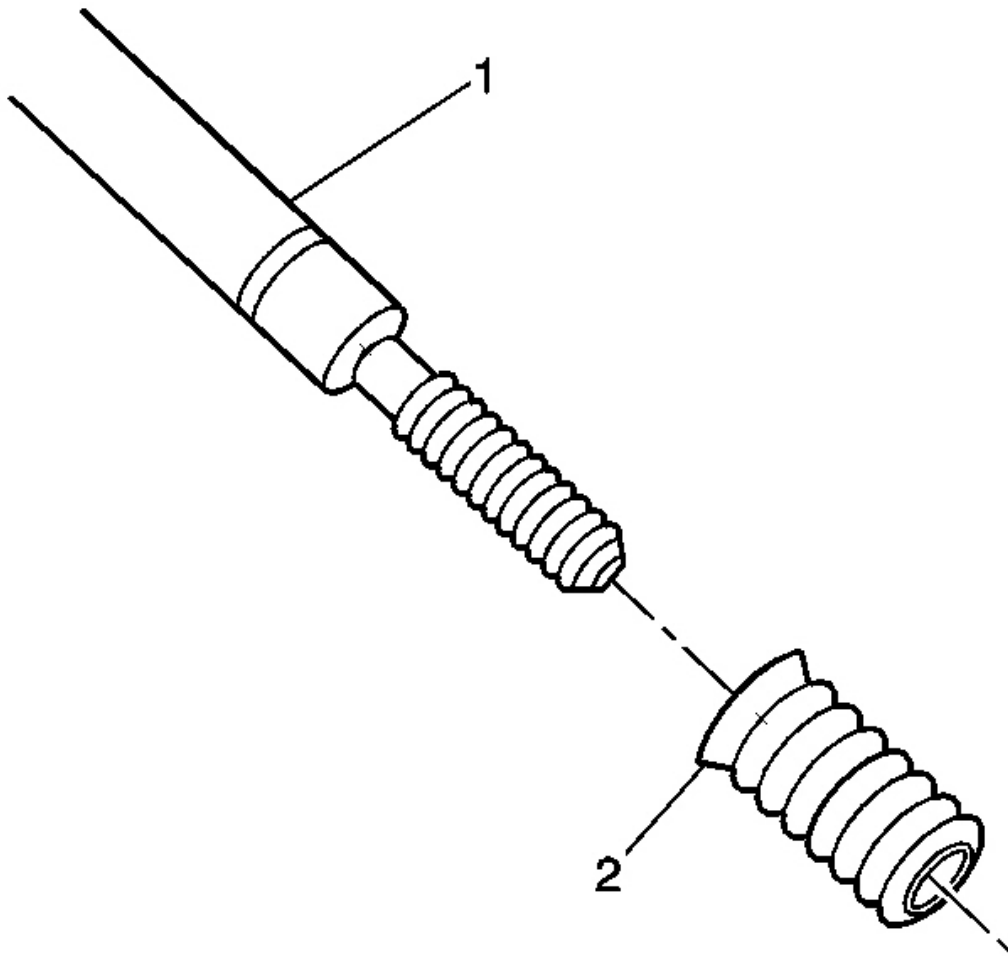
5. Using a tap wrench (2), tap the threads of the drilled hole.
  - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
  - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
  - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 551: 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.**

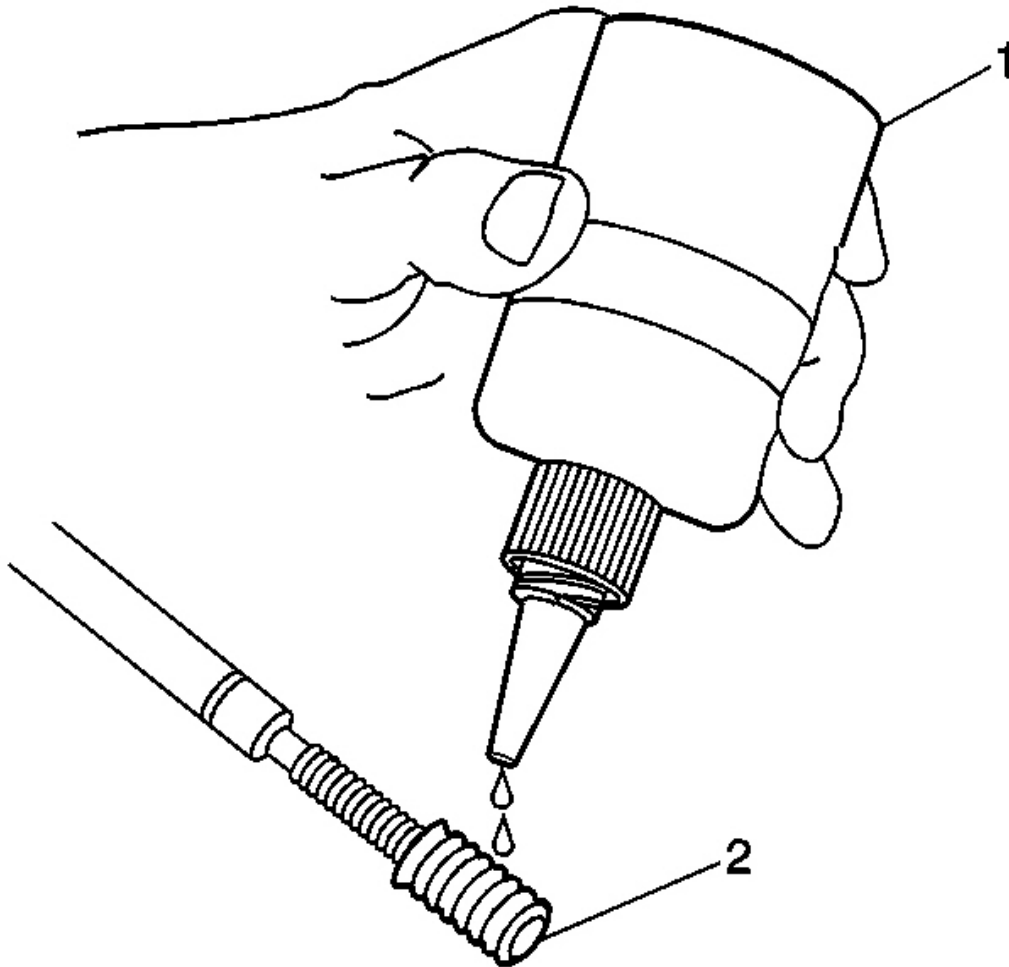
9. Lubricate the threads of the installer tool (2) with the driver oil (1).



**Fig. 552: Bushing Type Insert & Driver Tool**  
Courtesy of GENERAL MOTORS CORP.

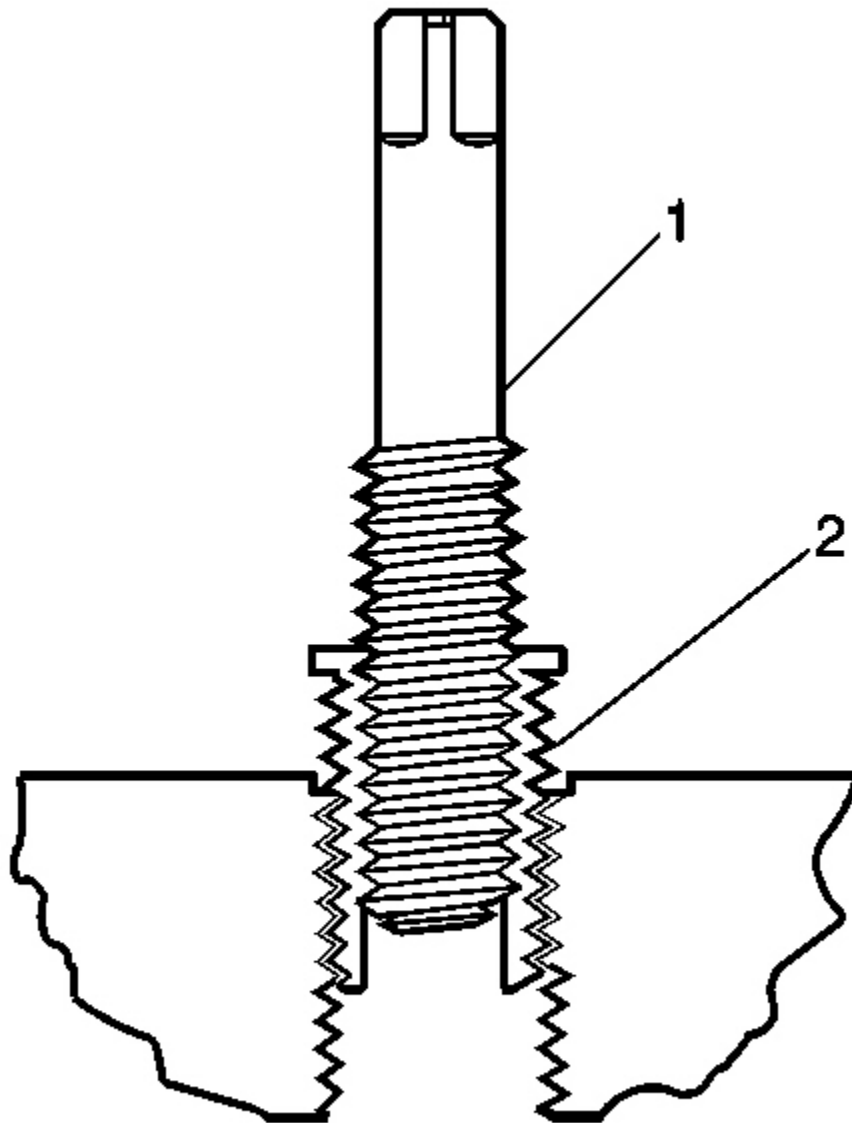
10. Install the insert (2) onto the driver tool (1).





**Fig. 553: Applying Threadlock To Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

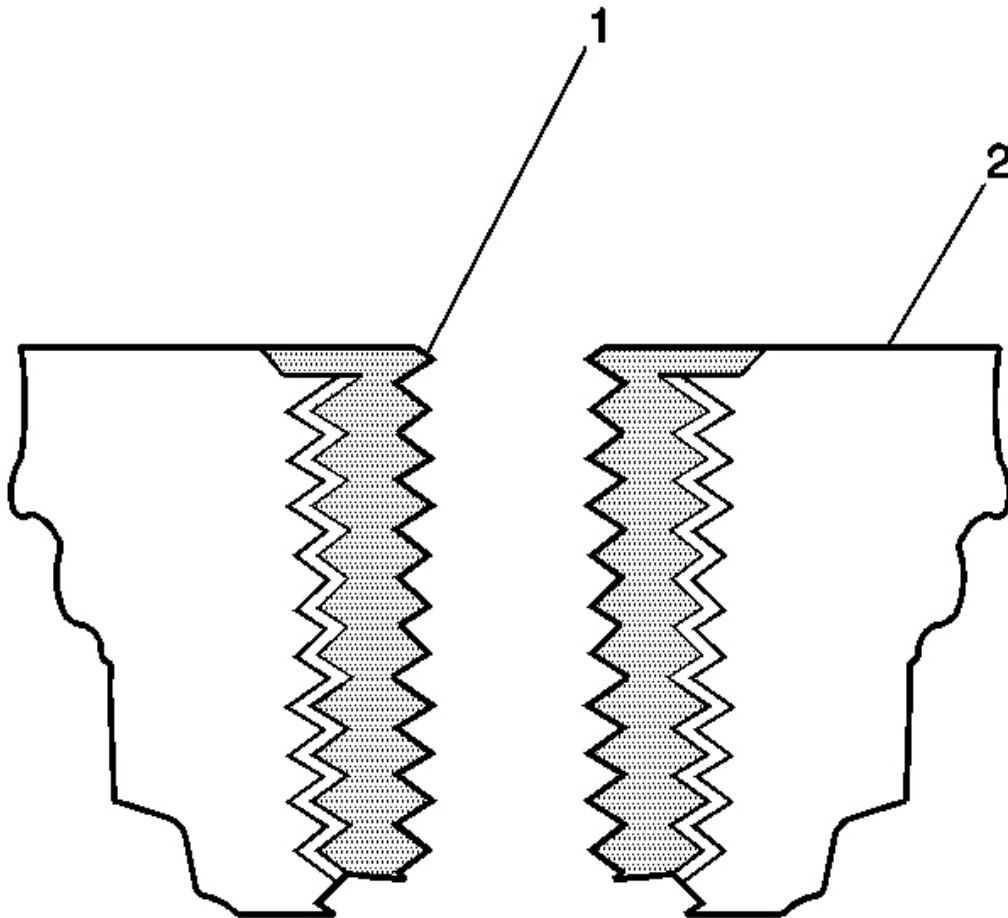


**Fig. 554: Installing Insert Into Bolt Hole Using Installer Tool**  
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

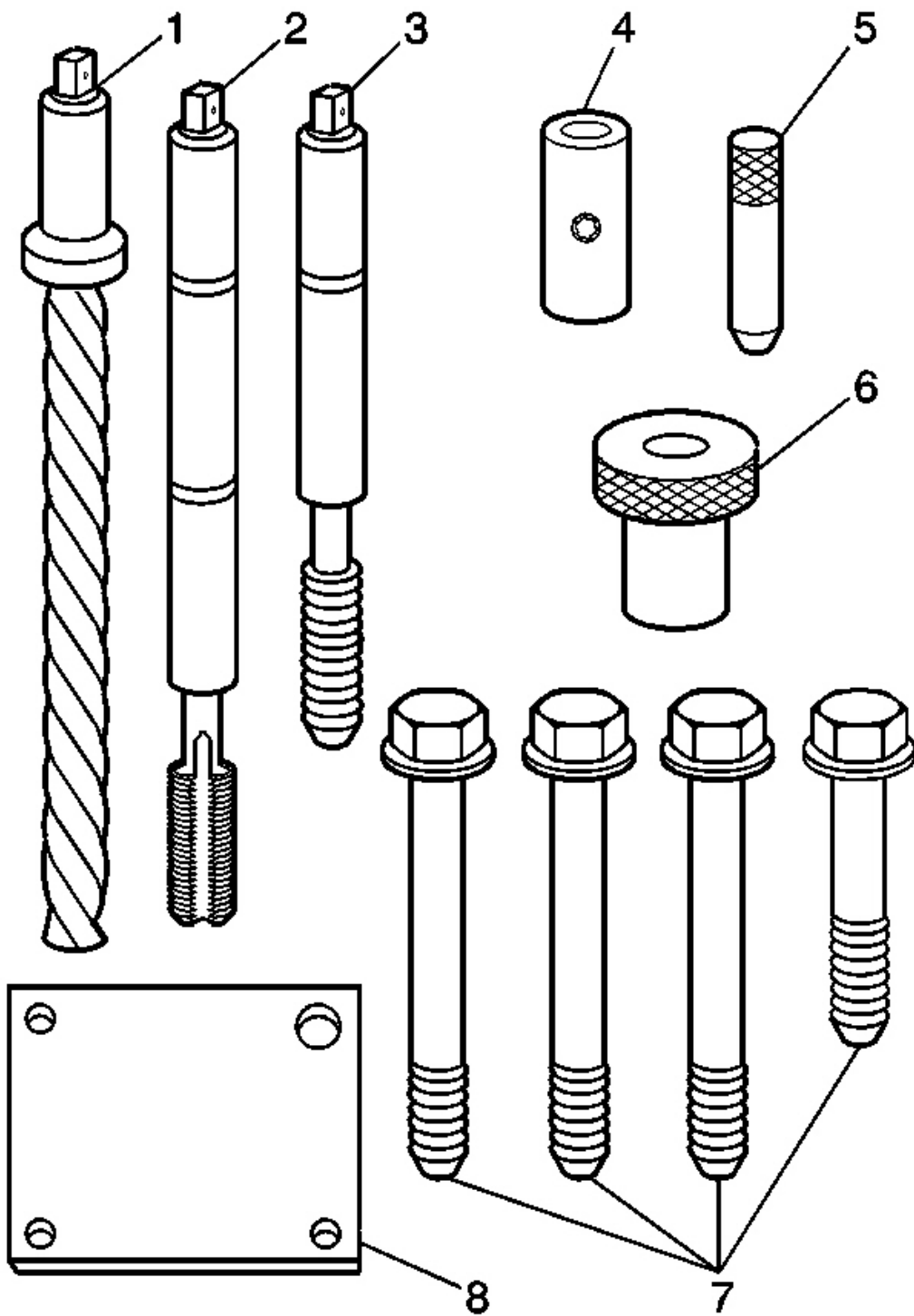
The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.



**Fig. 555: Bushing Type Insert & Base Material**  
Courtesy of GENERAL MOTORS CORP.

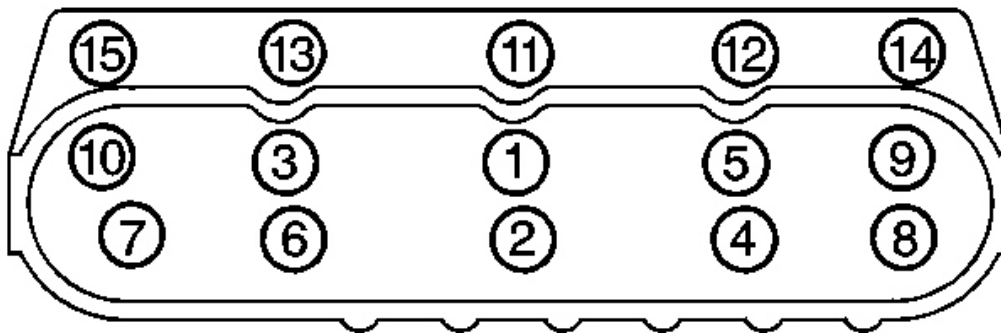
13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).



**Fig. 556: Cylinder Head Bolt Hole Thread Repair Kit**  
Courtesy of GENERAL MOTORS CORP.

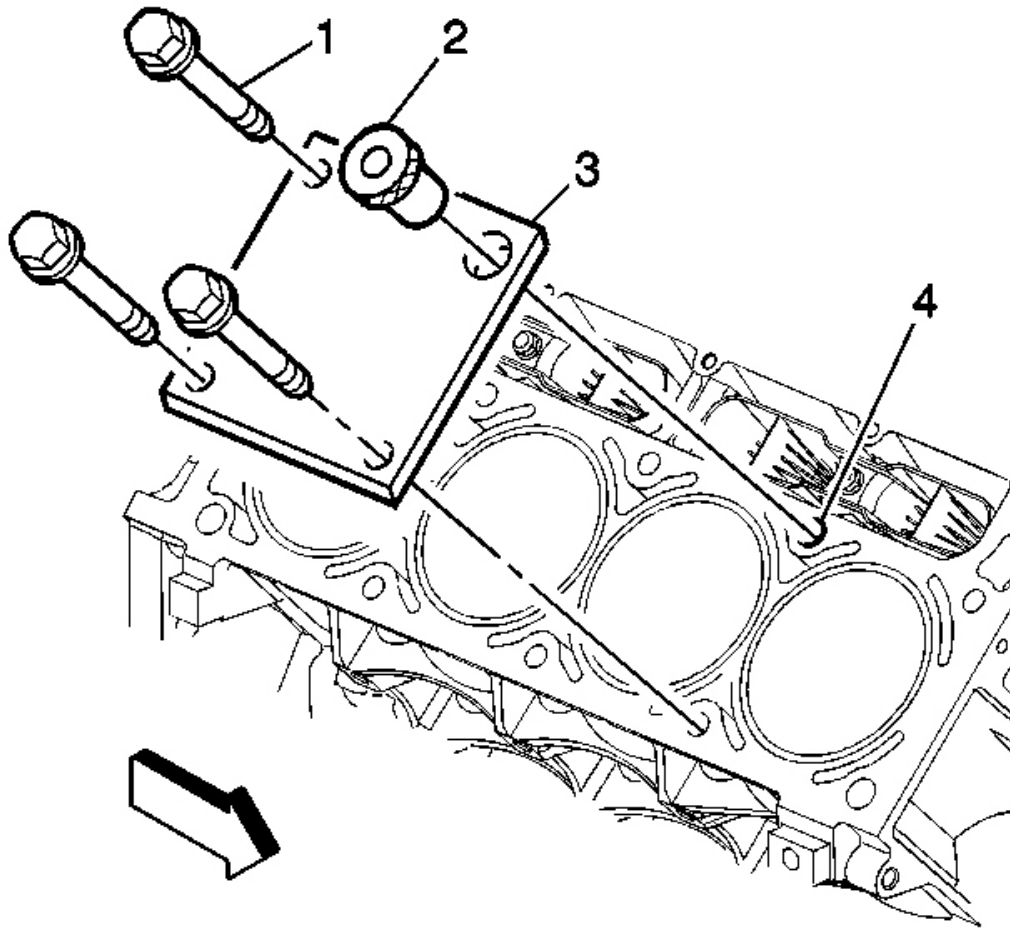
1. The cylinder head bolt hole thread repair kit consists of the following items:
  - The drill (1)
  - The tap (2)
  - The installer (3)
  - The sleeve (4)
  - The alignment pin (5)
  - The bushing (6)
  - The bolts (7)
  - The fixture plate (8)



**Fig. 557: Cylinder Head Bolt Tightening Sequence (Right)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** First design engine blocks have different drill and tap depths using both medium length 100 mm (3.94 in) and long 155 mm (6.1 in) M11 cylinder head bolts. Second design engine blocks use only the medium length 100 mm (3.94 in) bolt with a common drill and tap depth.

2. Measure the depth of the cylinder head bolt holes (1-10) to determine the proper drill and tap depths. Refer to **Thread Repair Specifications** .



**Fig. 558: Fixture Plate, Bolts, Bushing & Cylinder Hole**  
Courtesy of GENERAL MOTORS CORP.

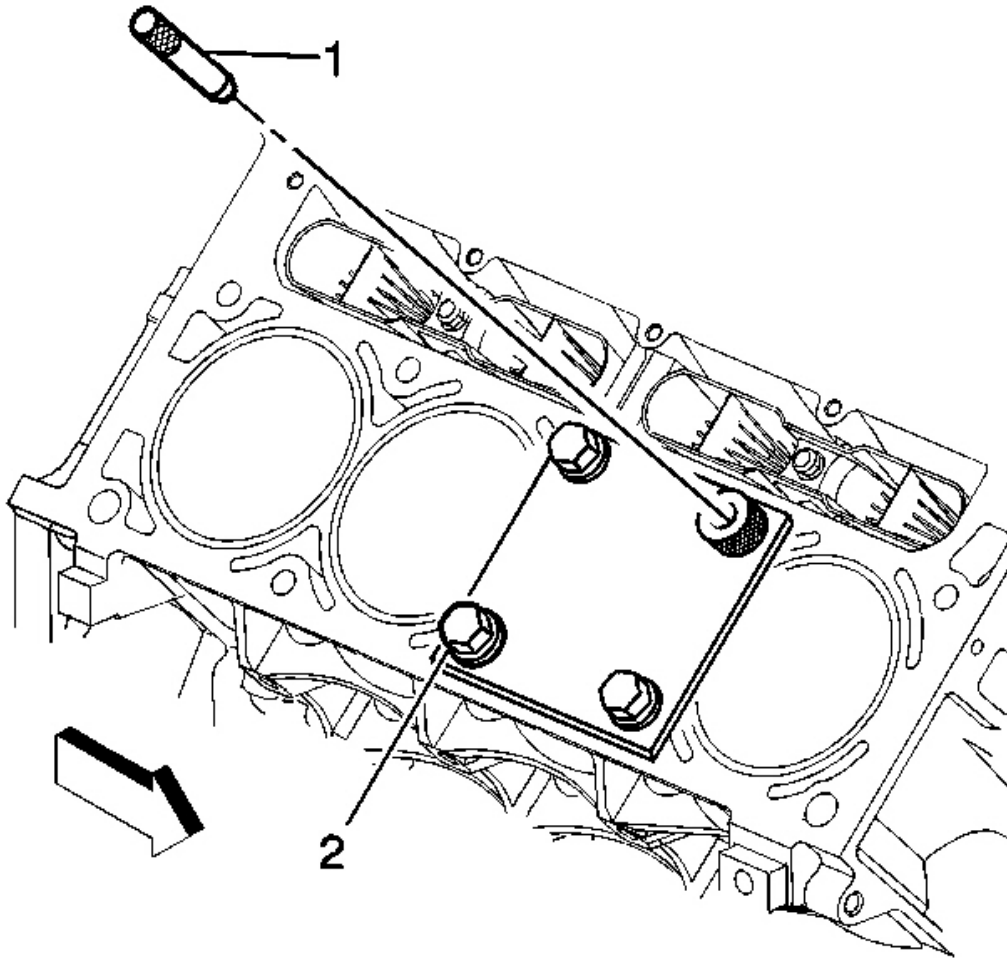
**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

**IMPORTANT:**

- The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40(R), or equivalent is recommended when performing the drilling and tapping procedures.
- Driver oil **MUST** be used on the installer driver tool.
- The tool kits are designed for use with either a suitable tap wrench or drill motor.

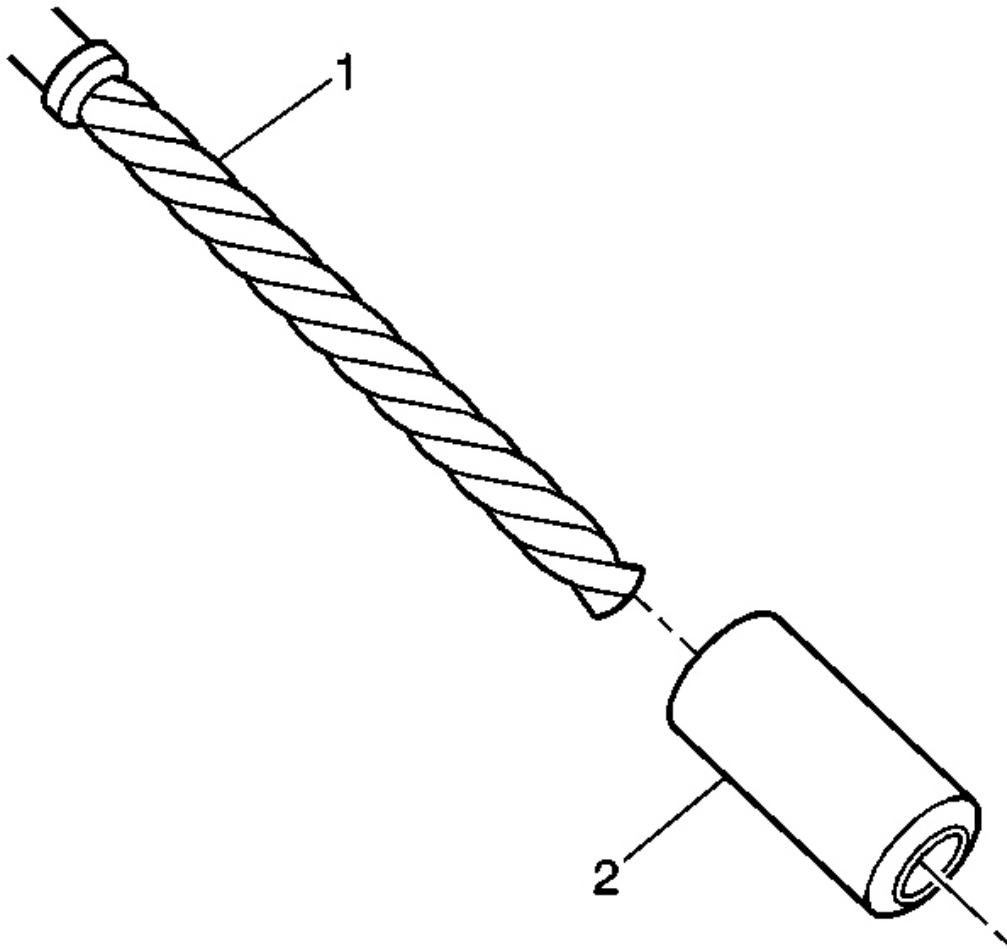
3. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

Position the fixture plate and bushing over the hole that is to be repaired (4).



**Fig. 559: Alignment Pin & Fixture Retaining Bolt**  
Courtesy of GENERAL MOTORS CORP.

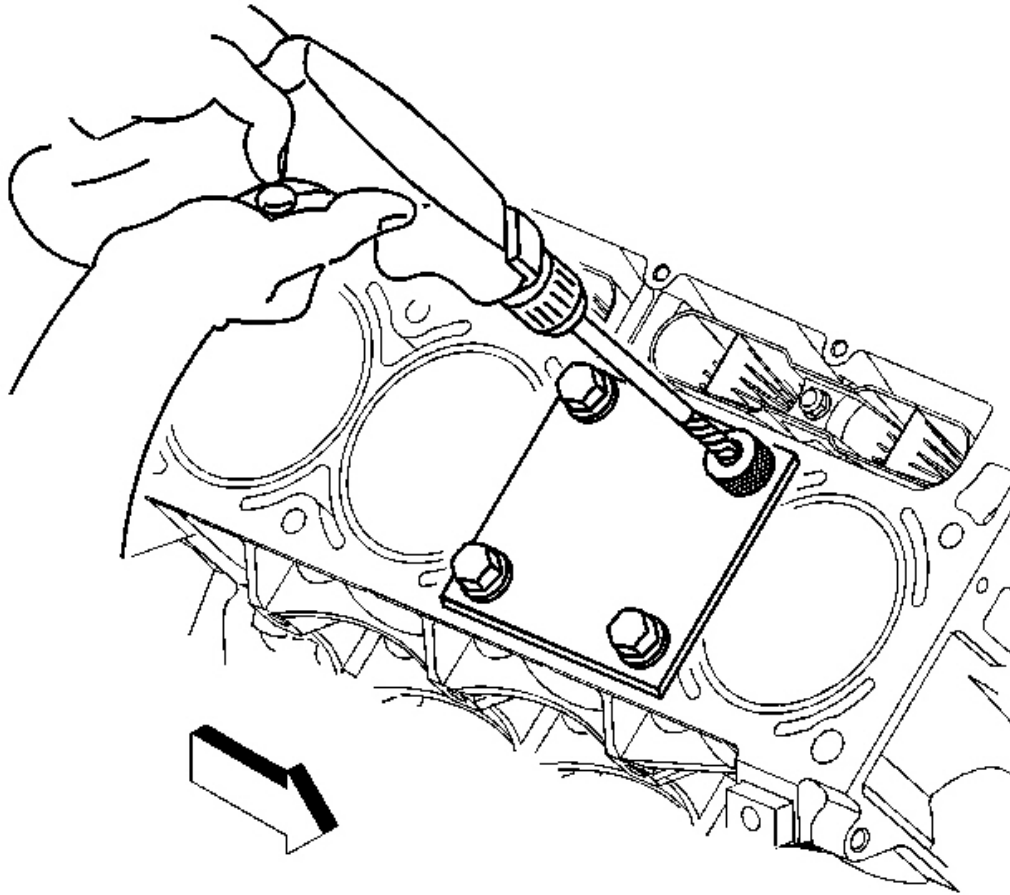
4. Position the alignment pin (1) through the bushing and into the hole.
5. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
6. Remove the alignment pin from the hole.



**Fig. 560: Identifying Repair Kit Sleeve**  
Courtesy of GENERAL MOTORS CORP.

7. Install the sleeve (2) onto the drill (1), if required.





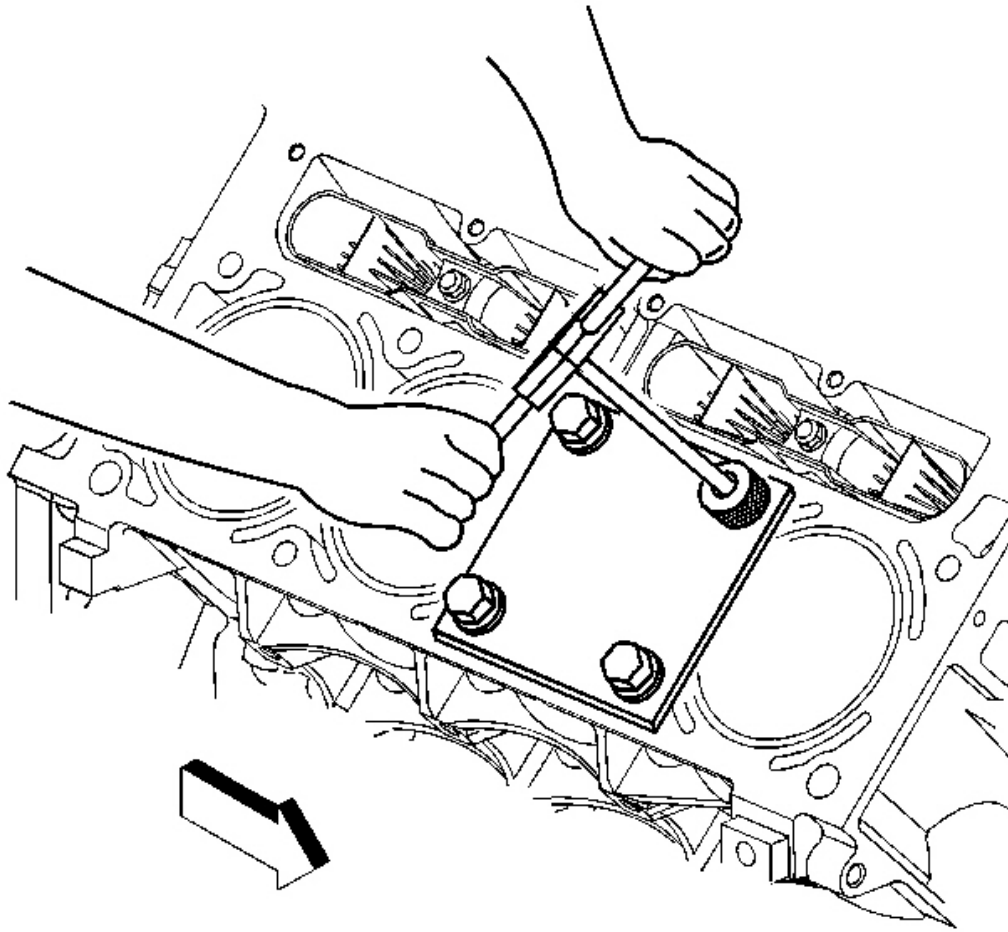
**Fig. 561: Drilling Cylinder Head Bolt Hole**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

8. Drill out the threads of the damaged hole.

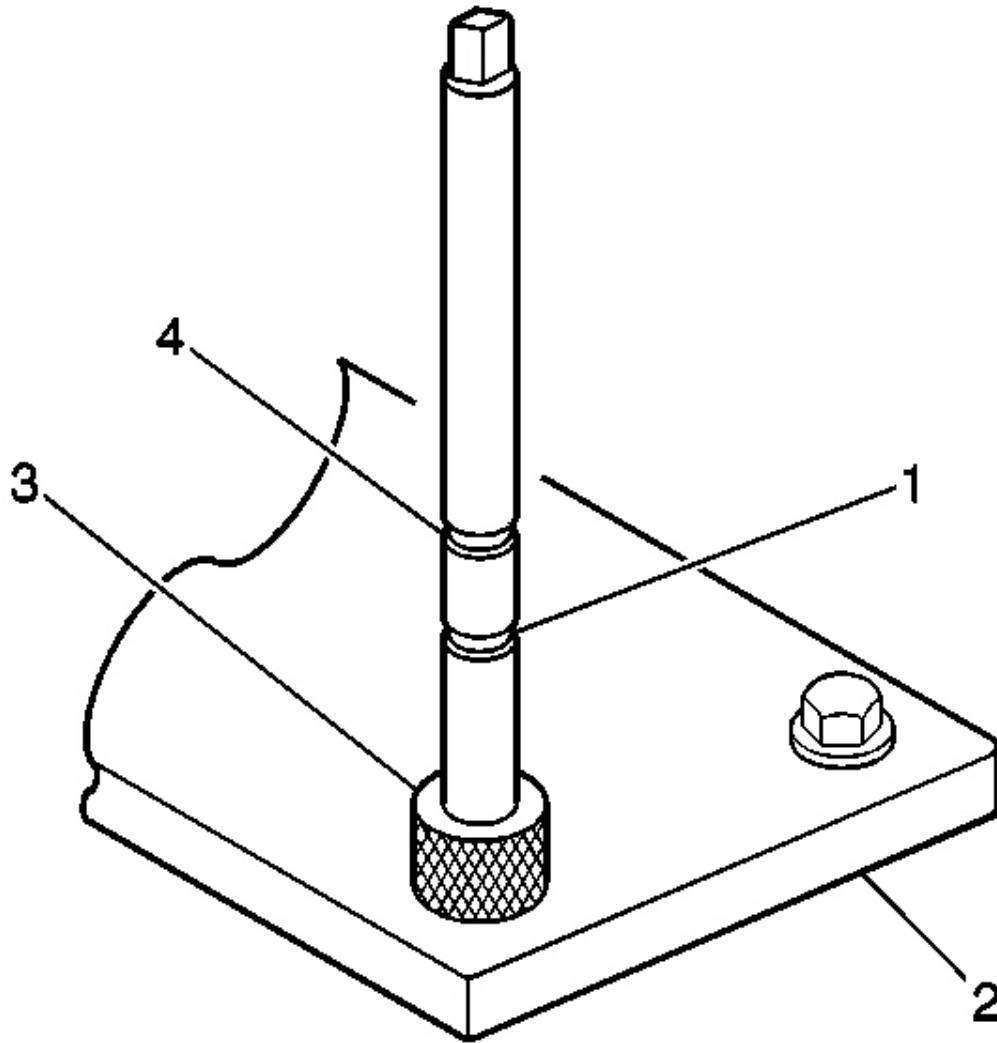
Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

9. Using compressed air, clean out any chips.



**Fig. 562: Tapping Cylinder Head Drilled Hole Using Tap Wrench**  
Courtesy of GENERAL MOTORS CORP.

10. Using a tap wrench, tap the threads of the drilled hole.



**Fig. 563: Tap Upper & Lower Marks, Fixture Plate Bushing**  
Courtesy of GENERAL MOTORS CORP.

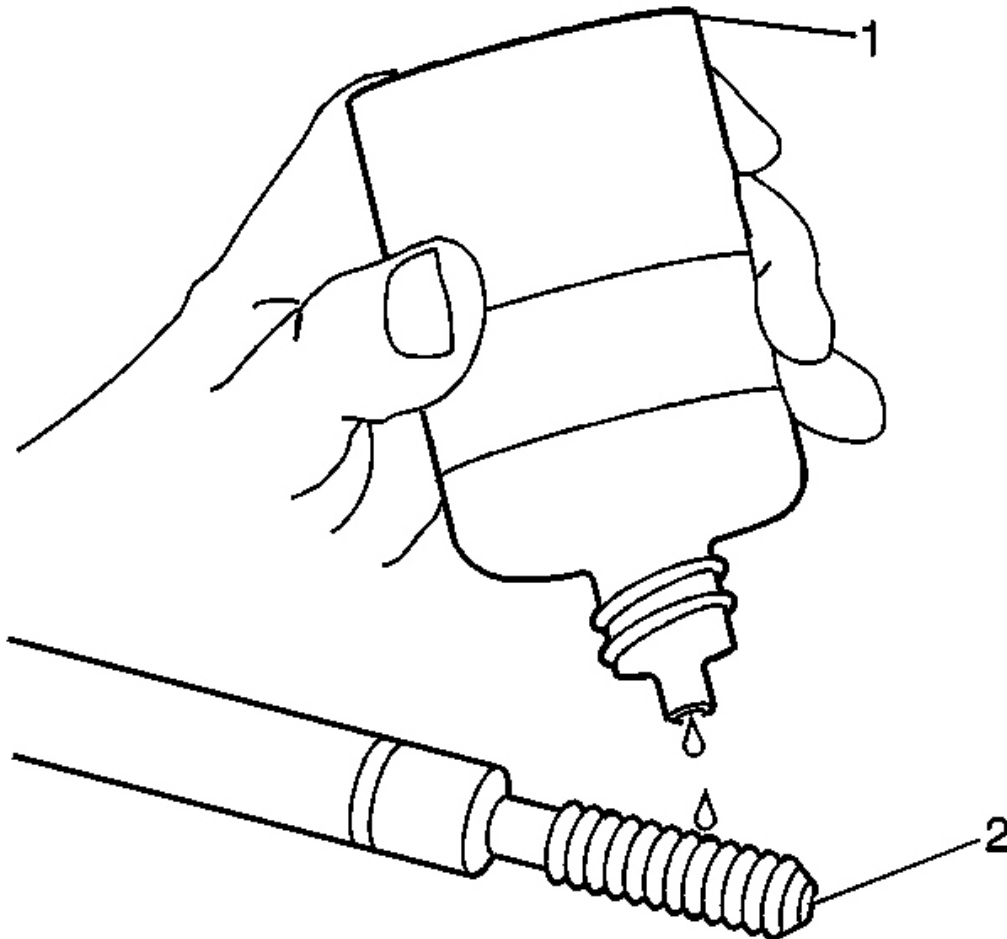
11. In order to tap the new threads to the proper depth, rotate the tap into the hole until the marks (1 or 4) on the tap align with the top of the drill bushing (3).

For the deeper cylinder head bolt holes, rotate the tap until the upper mark on the tap (4) aligns with the top of the drill bushing.

For the shallower cylinder head bolt holes, rotate the tap until the lower mark on the tap (1) aligns with

the top of the drill bushing.

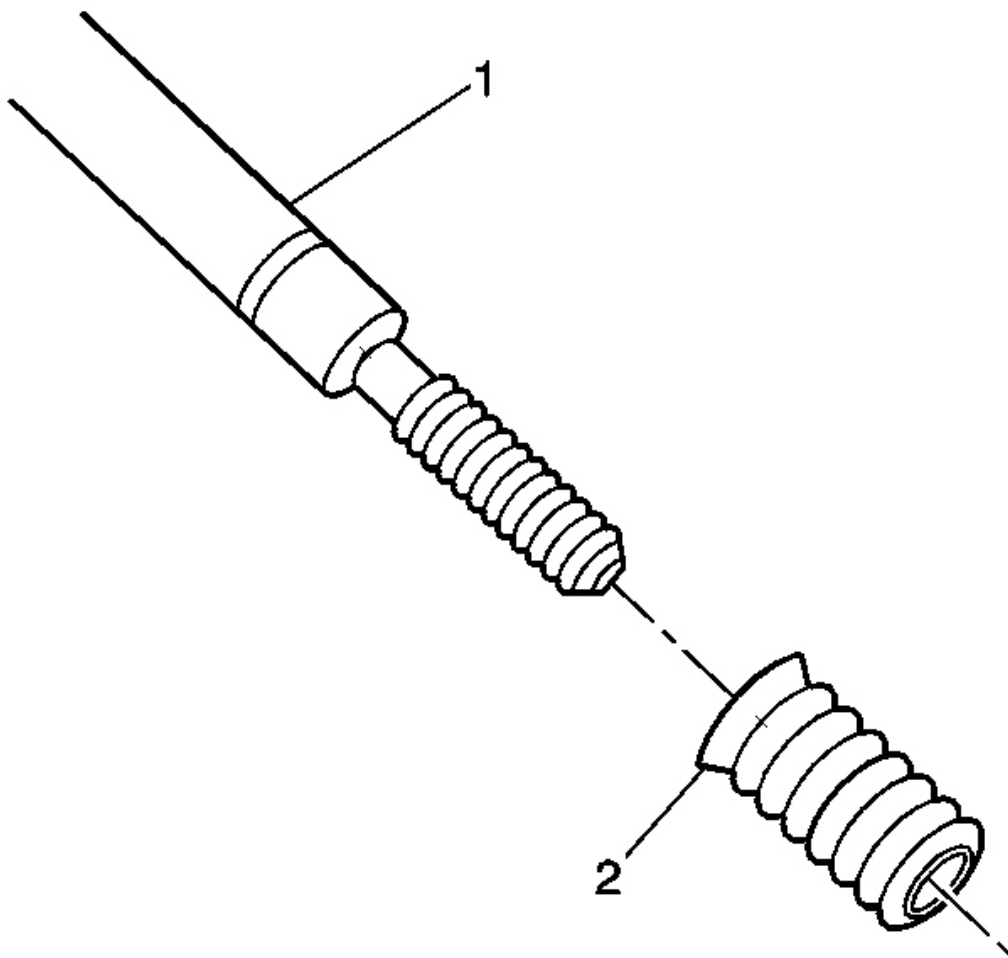
12. Remove the fixture plate (2), bushing (3), and bolts.
13. Using compressed air, clean out any chips.
14. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
15. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 564: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS CORP.

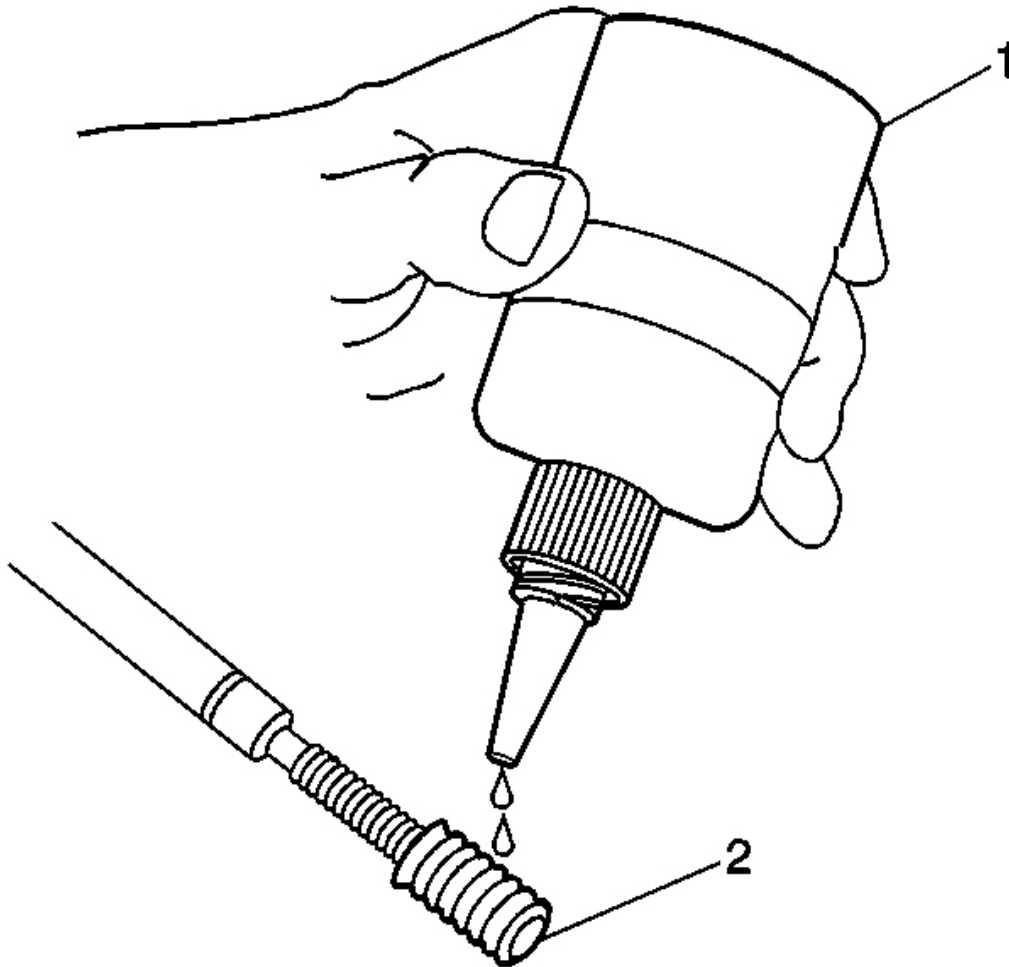
**IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

16. Lubricate the threads of the installer tool (2) with the driver oil (1).



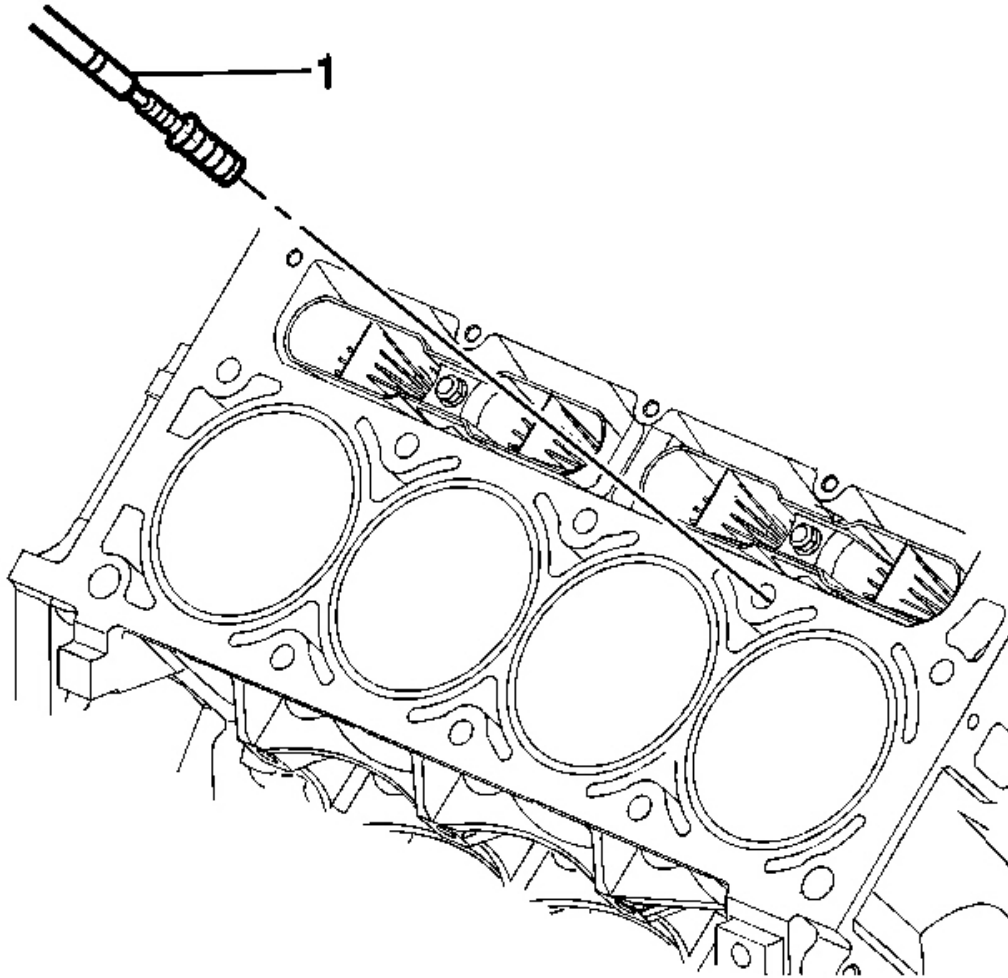
**Fig. 565: Bushing Type Insert & Driver Tool**  
**Courtesy of GENERAL MOTORS CORP.**

17. Install the insert (2) onto the driver tool (1).



**Fig. 566: Applying Threadlock To Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

18. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

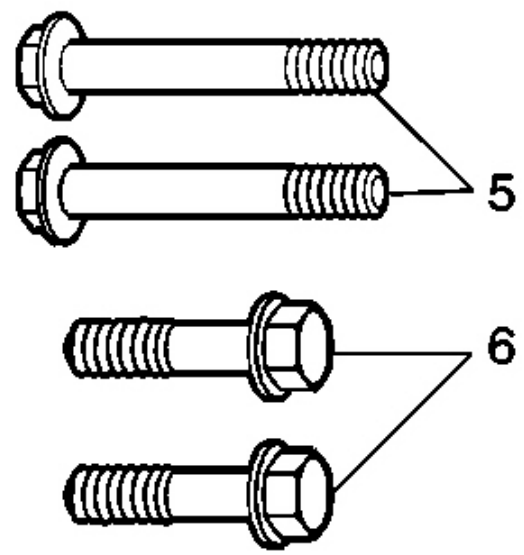
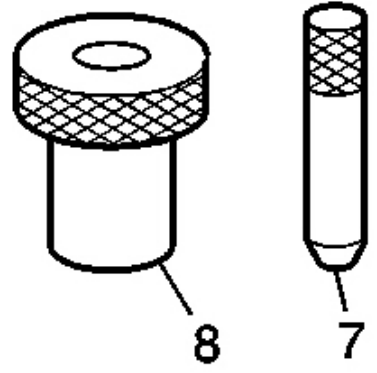
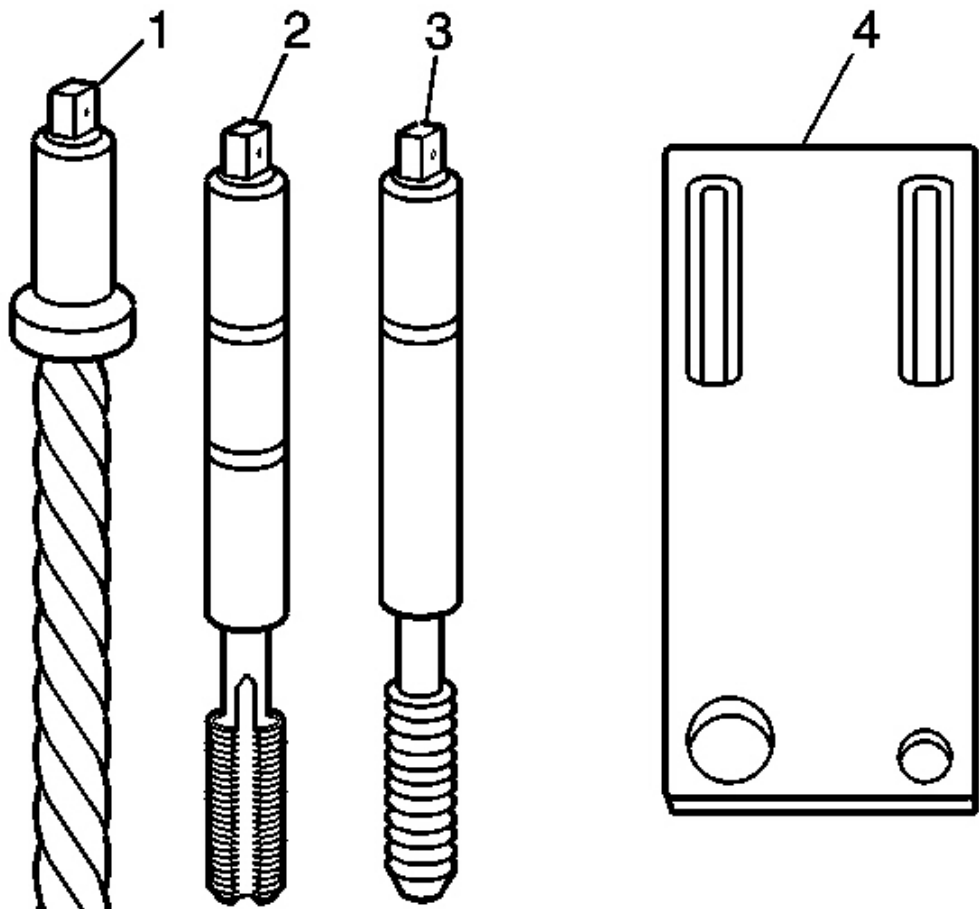


**Fig. 567: Installing Insert & Driver Into Cylinder Bolt Hole**  
Courtesy of GENERAL MOTORS CORP.

19. Install the insert and driver (1) into the hole.

Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

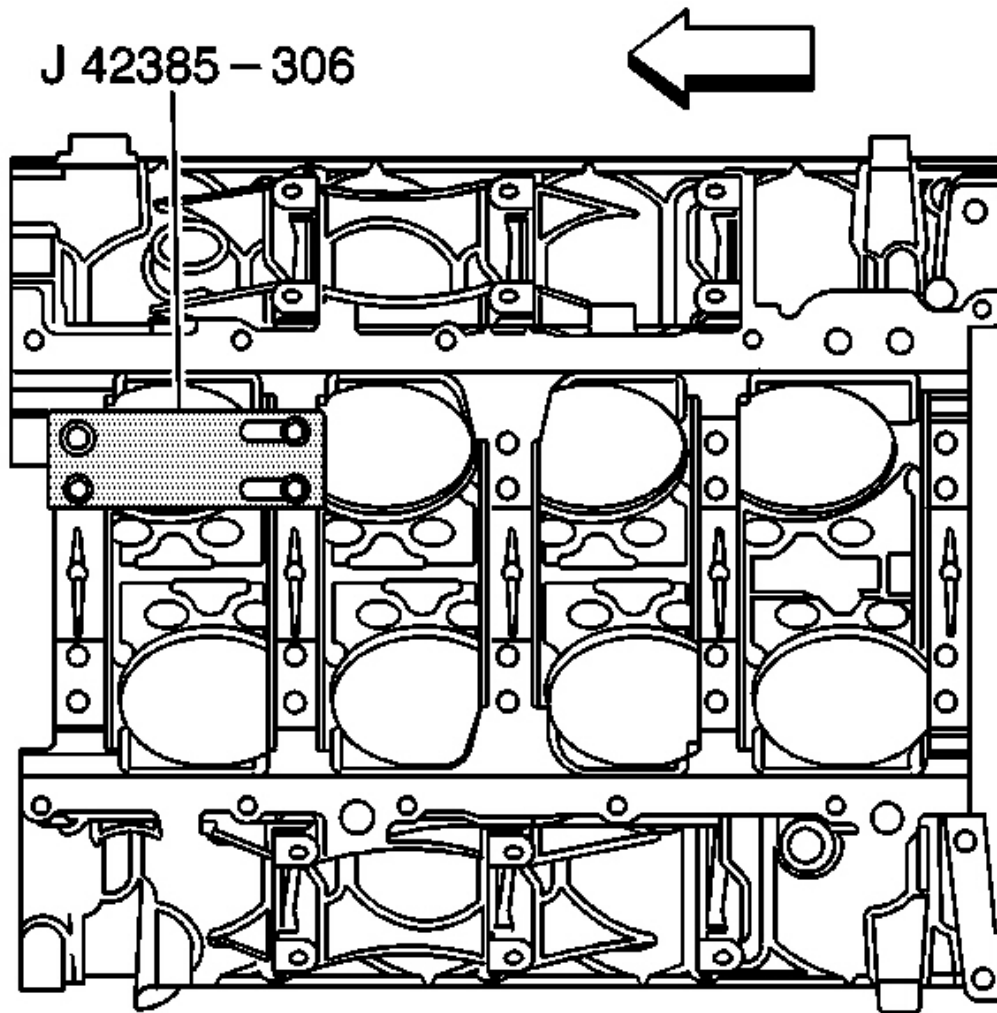
The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.





**Fig. 568: Main Cap Bolt Hole Thread Repair Kit**  
**Courtesy of GENERAL MOTORS CORP.**

1. The main cap bolt hole thread repair kit consists of the following items:
  - The drill (1)
  - The tap (2)
  - The installer (3)
  - The fixture plate (4)
  - The long bolts (5)
  - The short bolts (6)
  - The alignment pin (7)
  - The bushing (8)

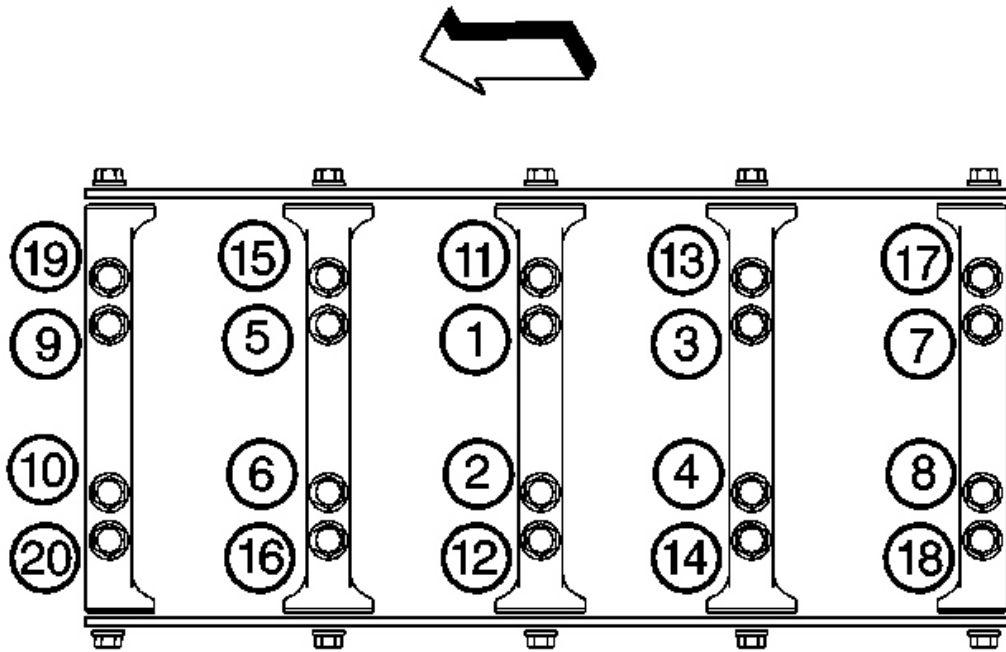


**Fig. 569: Fixture Plate, Bolt & Bushing**  
Courtesy of GENERAL MOTORS CORP.

2. Install the fixture plate, bolt, and bushing, onto the engine block.

Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.



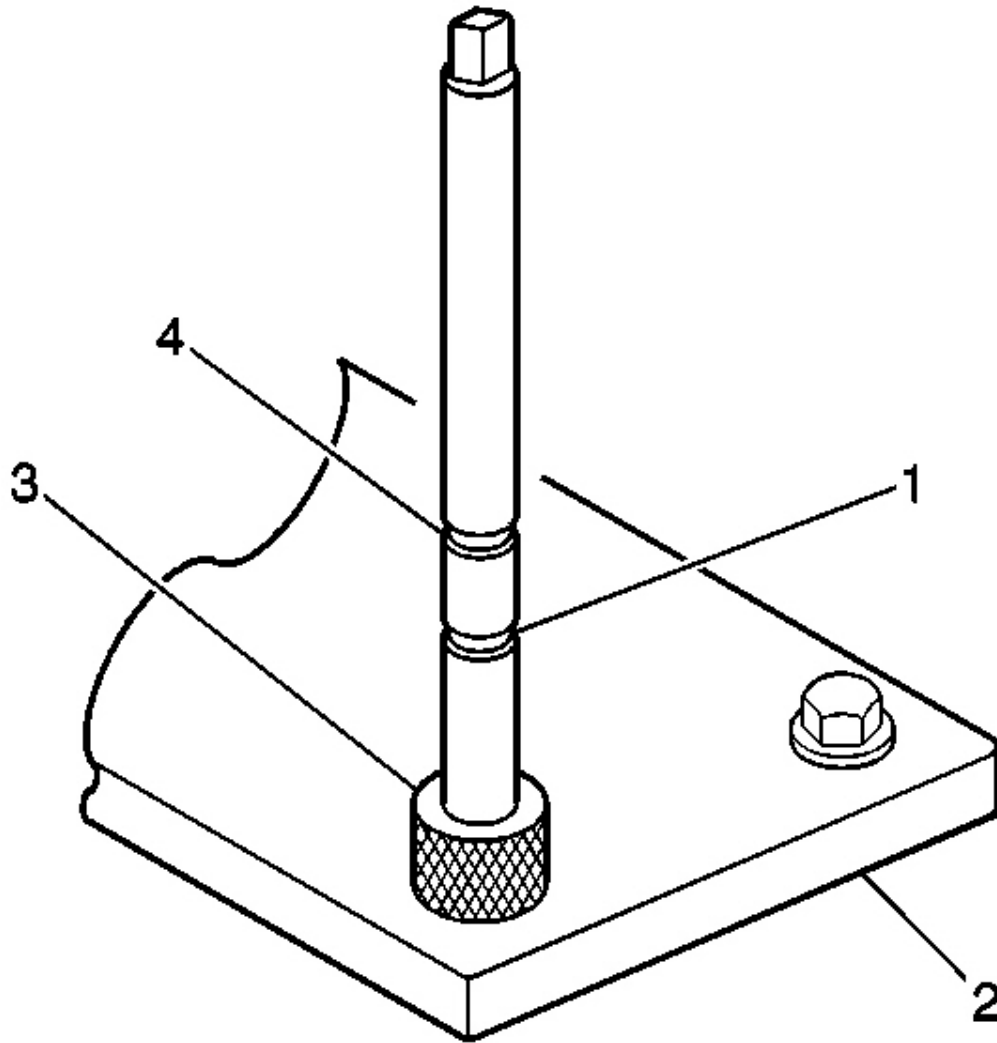
**Fig. 570: Main Cap Bolt Hole Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

4. Drill out the damaged hole.

The outer bolt hole locations (11-20) have the shallower counterbores. Use sleeve J 42385-316 with the drill.

Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.



**Fig. 571: Tap Upper & Lower Marks, Fixture Plate Bushing**  
Courtesy of GENERAL MOTORS CORP.

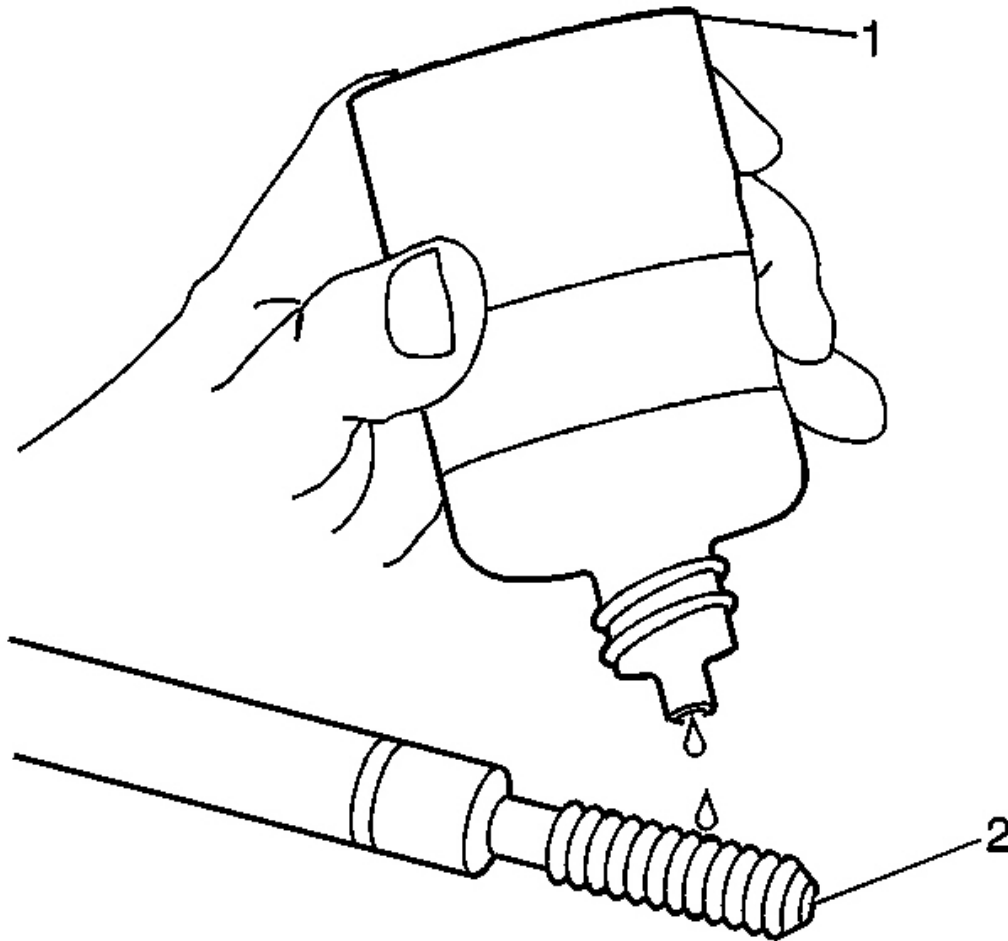
6. Using a tap wrench, tap the threads of the drilled hole.

In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

For the deeper main cap holes (1-10), rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

For the shallower main cap holes (11-20), rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

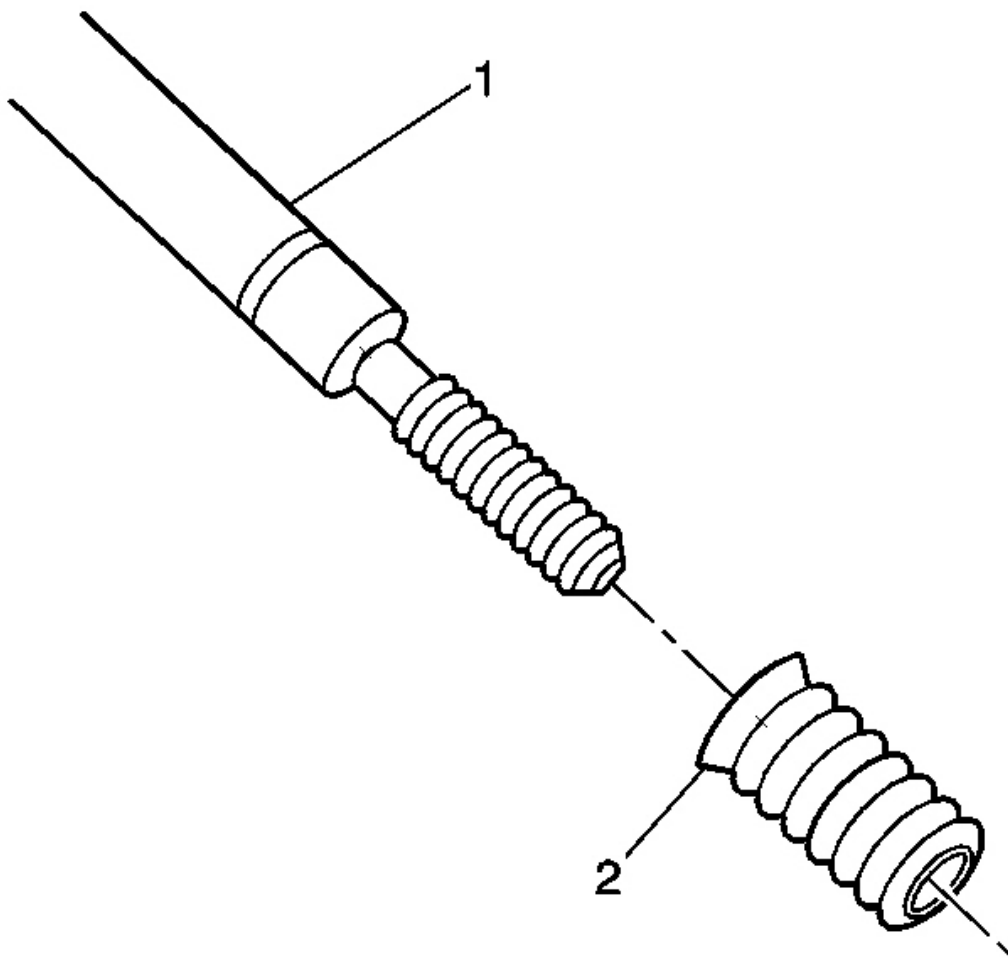
7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463) or equivalent into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.



**Fig. 572: Lubricating Installer Tool Using Driver Oil**  
Courtesy of GENERAL MOTORS CORP.

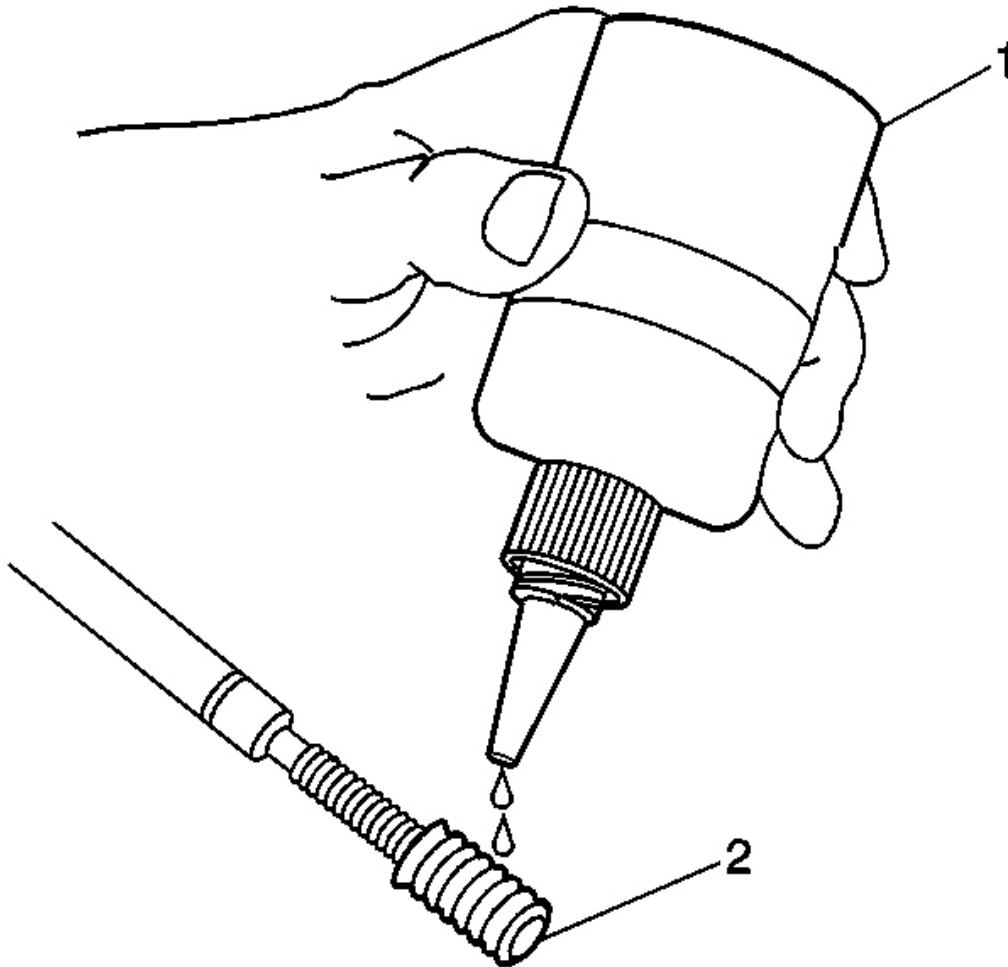
**IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

10. Lubricate the threads of the installer tool (2) with the driver oil (1).



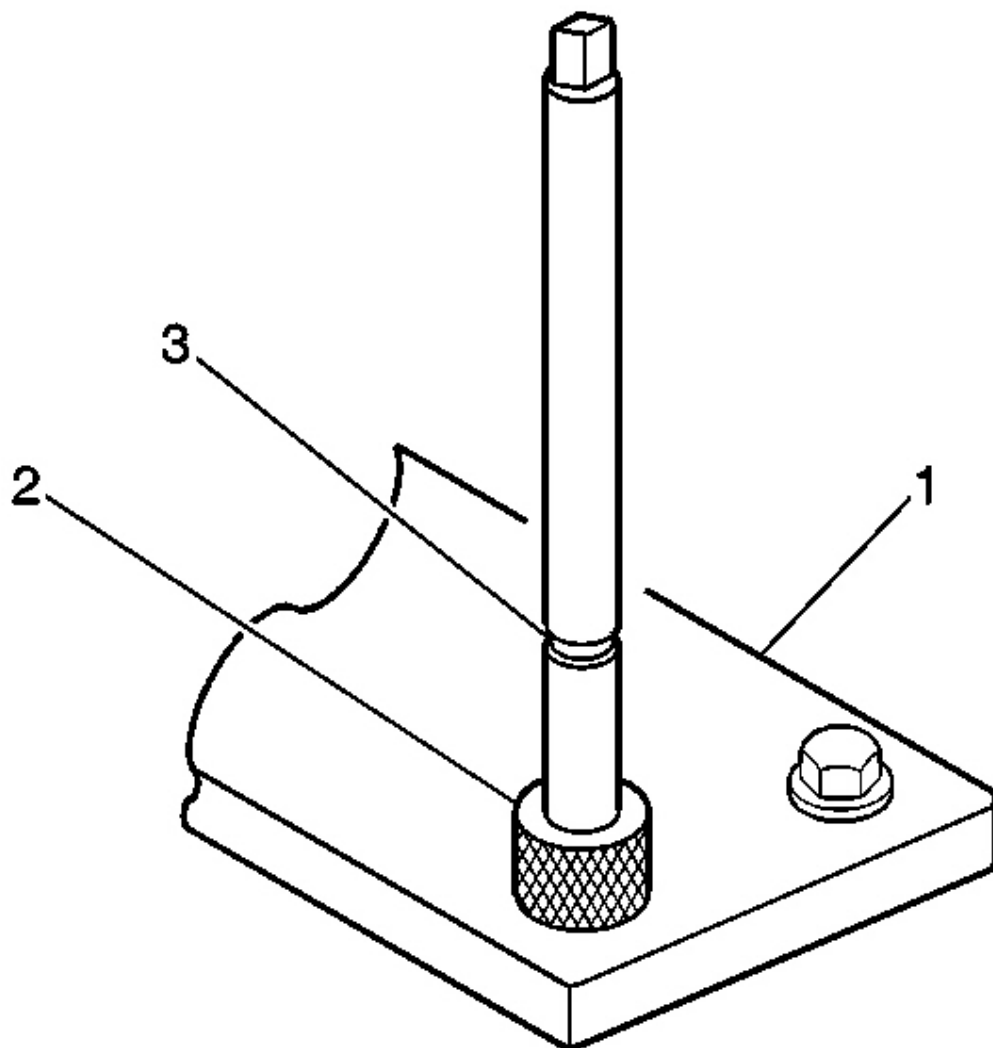
**Fig. 573: Bushing Type Insert & Driver Tool**  
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) onto the driver tool (1).



**Fig. 574: Applying Threadlock To Insert OD Threads**  
Courtesy of GENERAL MOTORS CORP.

12. Apply threadlock LOCTITE(tm) 277, J 42385-109 (1), or equivalent to the insert OD threads (2).



**Fig. 575: Driver, Bushing & Tool Marking**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.**

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).



The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

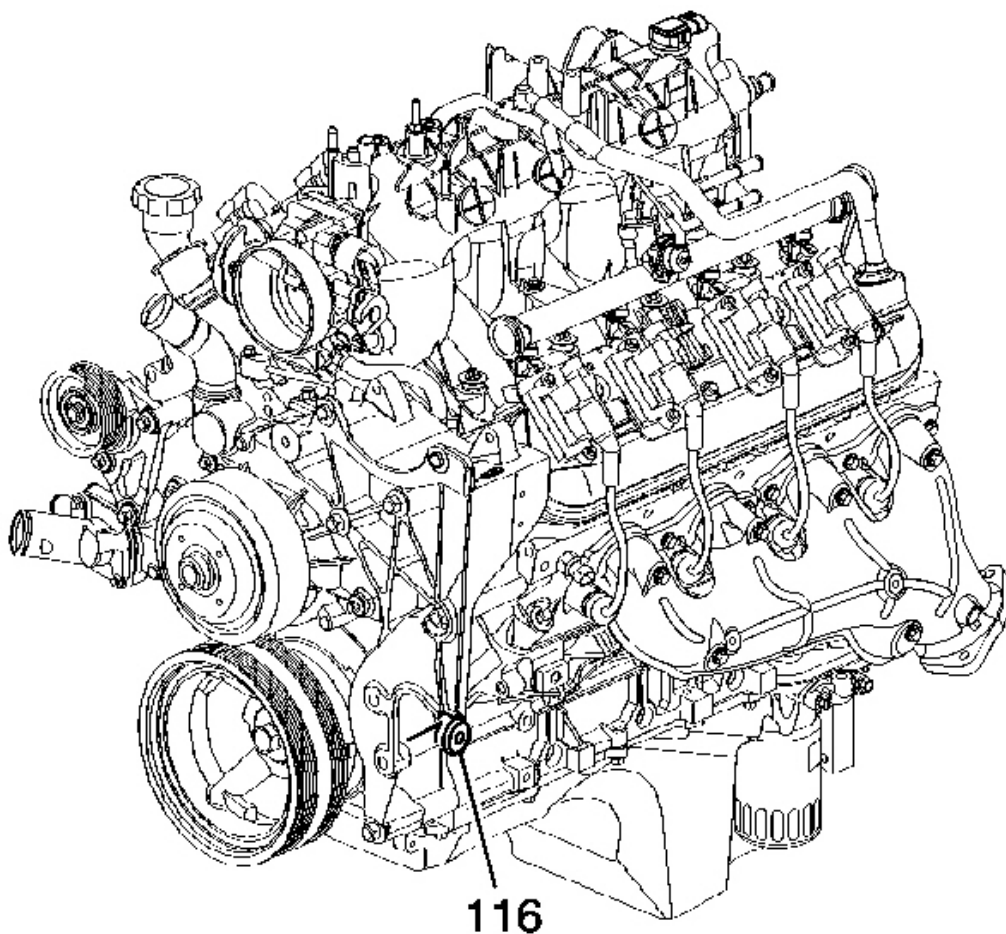
## **SERVICE PRIOR TO ASSEMBLY**

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all the components. Refer to **Cleanliness and Care** .
- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to **Separating Parts** .
- During assembly, lubricate all the moving parts with clean engine oil. This will provide initial lubrication when the engine is first started.

## **ENGINE PRELUBING**

### **Tools Required**

**J 45299** Engine Pre-Luber. See **Special Tools and Equipment** .



**Fig. 576: Engine Block Left Front Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

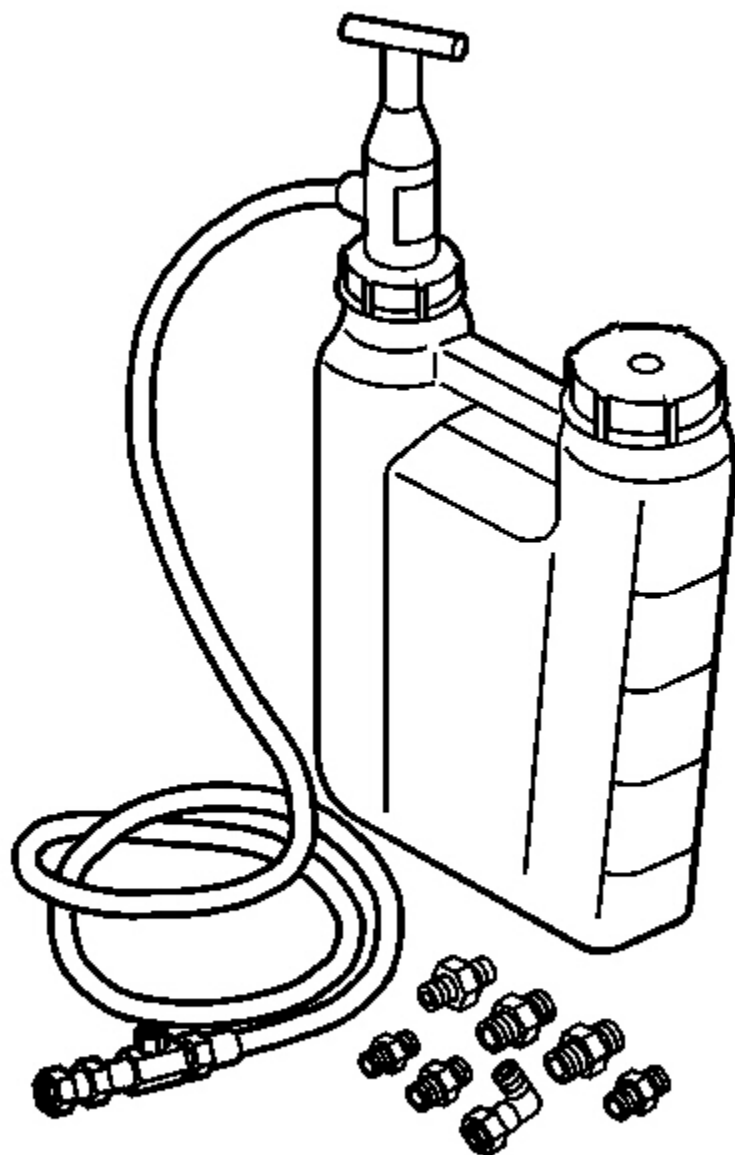
1. Remove the engine oil filter, fill with clean engine oil.

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

2. Install the oil filter.

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

3. Locate the engine block left front oil gallery plug (116).
4. Install the M16 x 1.5 adapter P/N 509375.



**Fig. 577: Identifying J 45299**

**Courtesy of GENERAL MOTORS CORP.**

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the **J 45299** in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly. See **Special Tools and Equipment** .
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine.

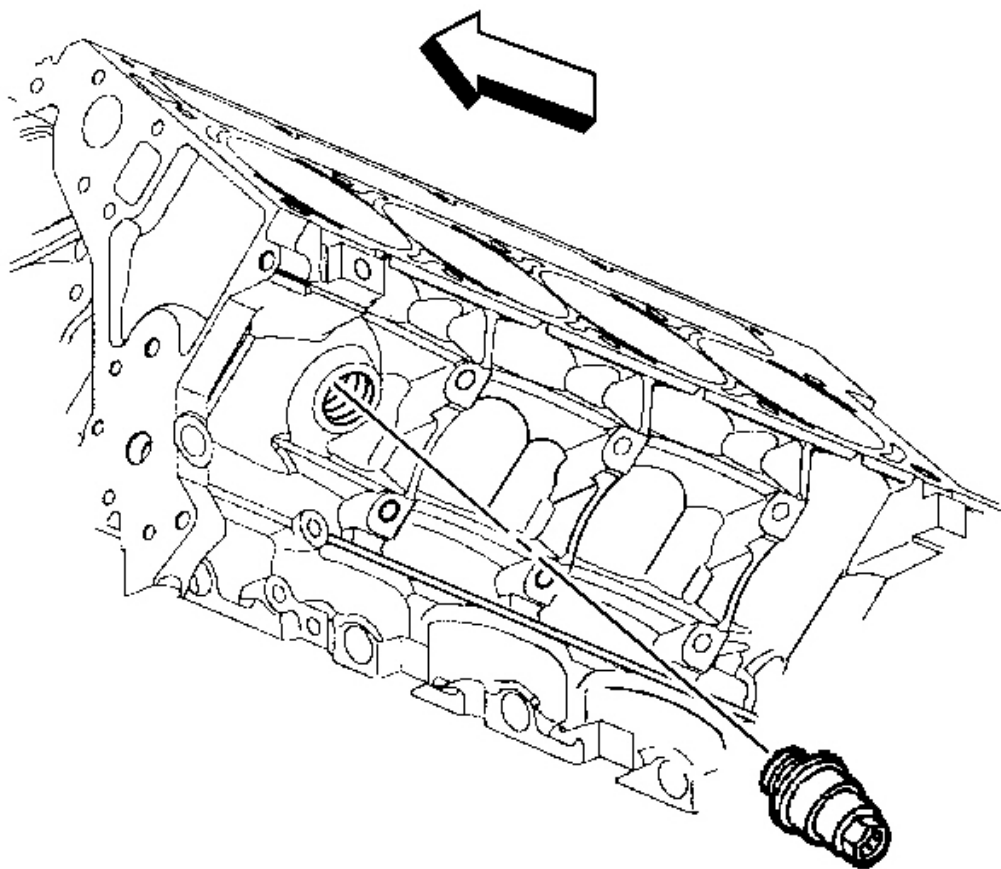
**Tighten:** Tighten the oil gallery plug to 60 N.m (44 lb ft).

9. Top-off the engine oil to the proper level.

**ENGINE BLOCK PLUG INSTALLATION**

**Tools Required**

J 41712 Oil Pressure Switch Socket or equivalent



**Fig. 578: Engine Block Coolant Heater**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

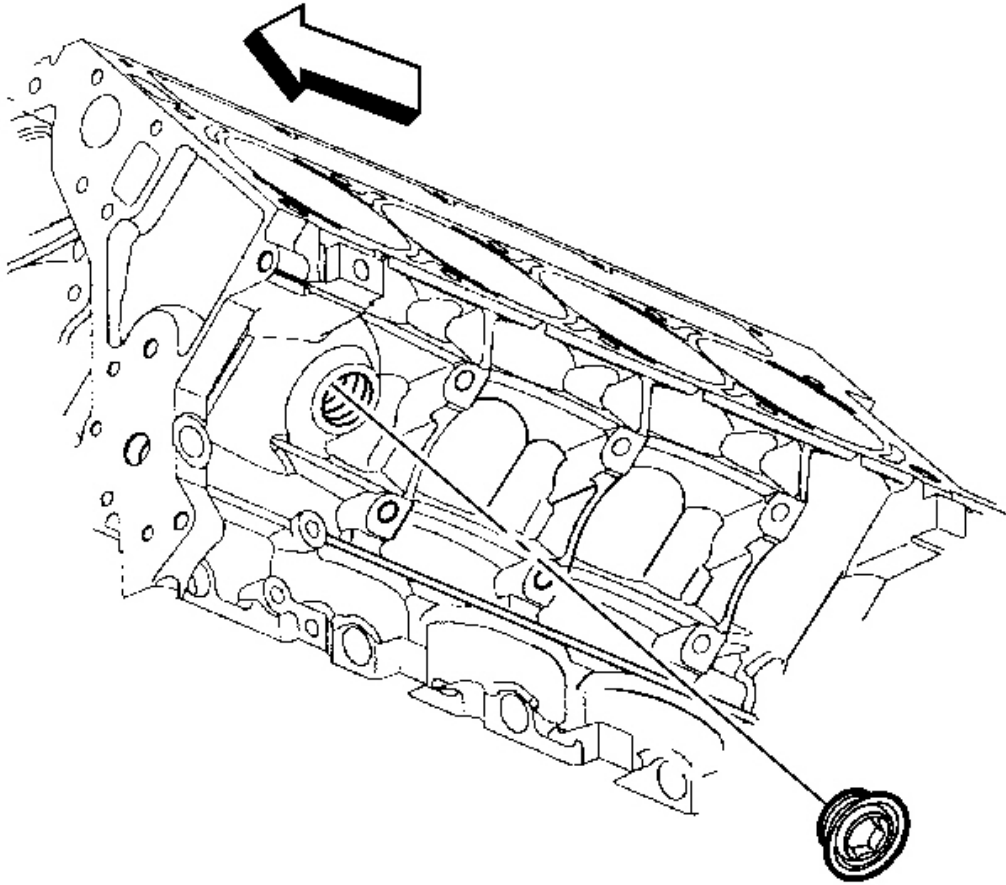
- Engine block plug, oil gallery and coolant, sealing washers may be used again if not bent, scored or otherwise damaged.
- Apply the proper amount and type of sealant to the sealing washer as recommended in the service procedure.

1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer, if applicable. Refer to **Sealers, Adhesives, and Lubricants** .

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

2. Install the engine block coolant heater to the engine block, if applicable.

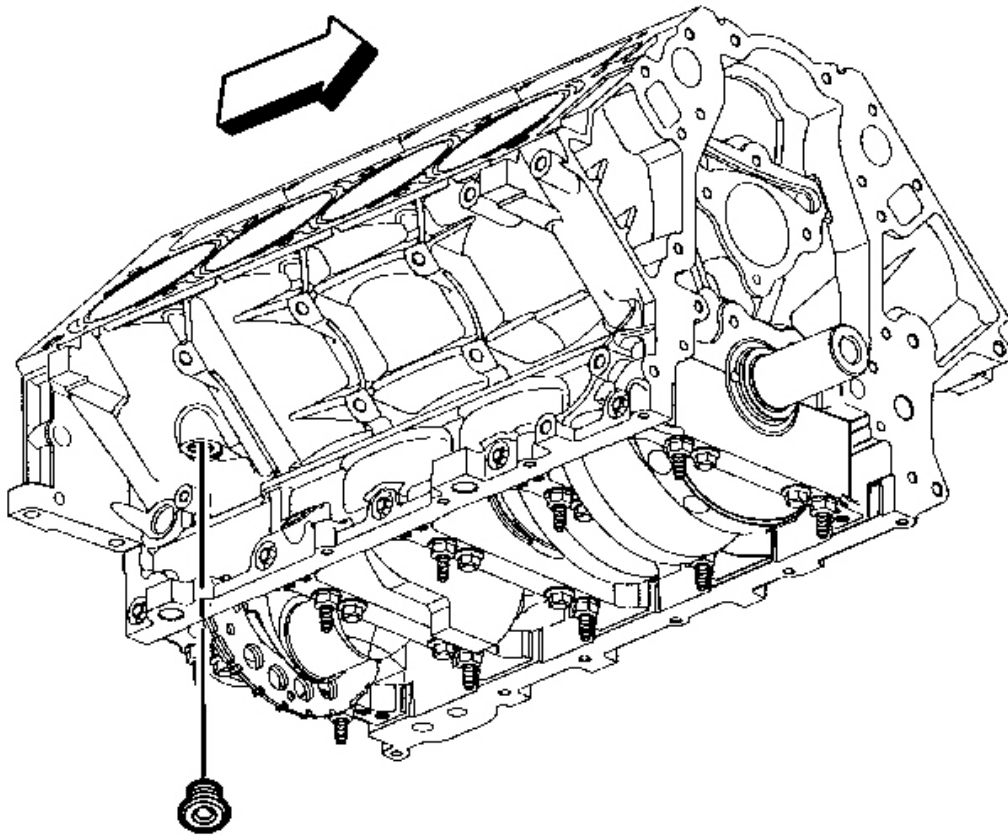
**Tighten:** Tighten the block coolant heater to 40 N.m (30 lb ft).



**Fig. 579: Engine Block Left Rear Coolant Drain Hole Plug**  
Courtesy of GENERAL MOTORS CORP.

3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front coolant drain hole plug sealing washer, if applicable.
4. Install the engine block left front coolant drain hole plug, if applicable.

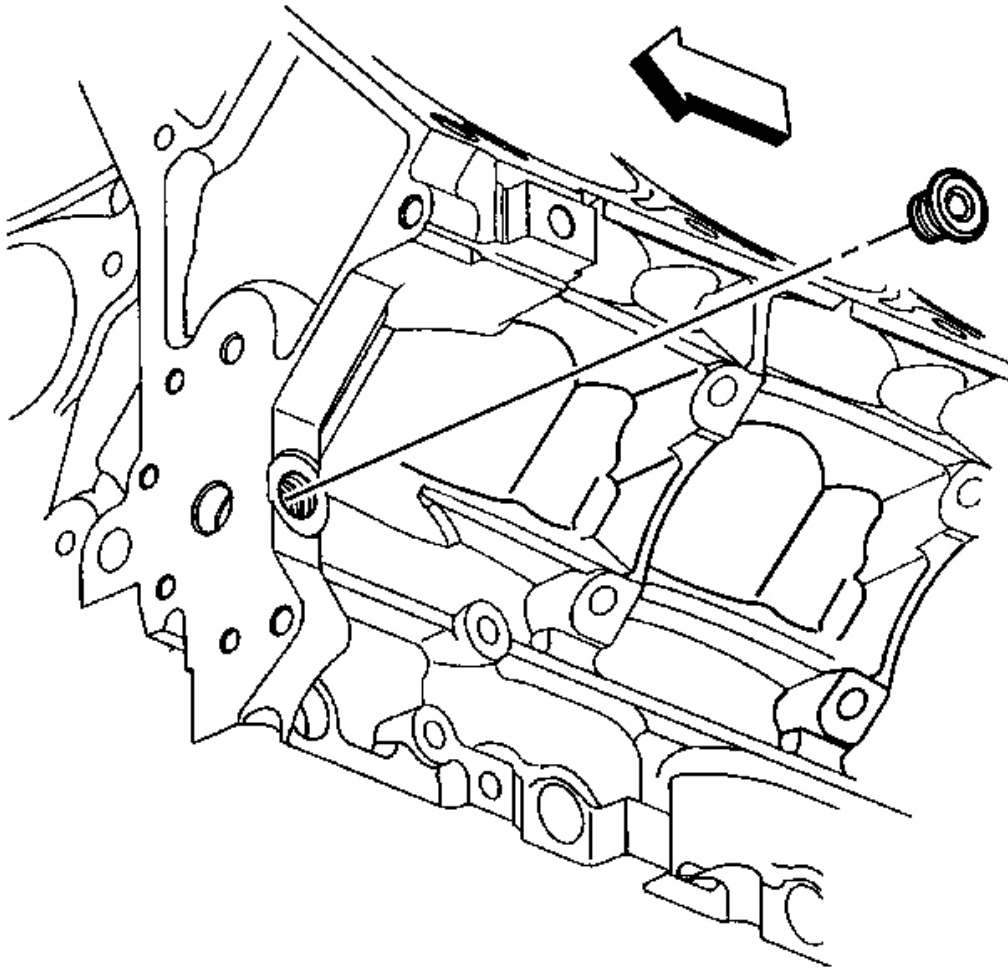
**Tighten:** Tighten the block left front coolant drain hole plug to 60 N.m (44 lb ft).



**Fig. 580: Identifying Plug Location On Underside Of Block**  
Courtesy of GENERAL MOTORS CORP.

5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block right rear coolant drain hole plug sealing washer.
6. Install the engine block right rear coolant drain hole plug.

**Tighten:** Tighten the block right rear coolant drain hole plug to 60 N.m (44 lb ft).

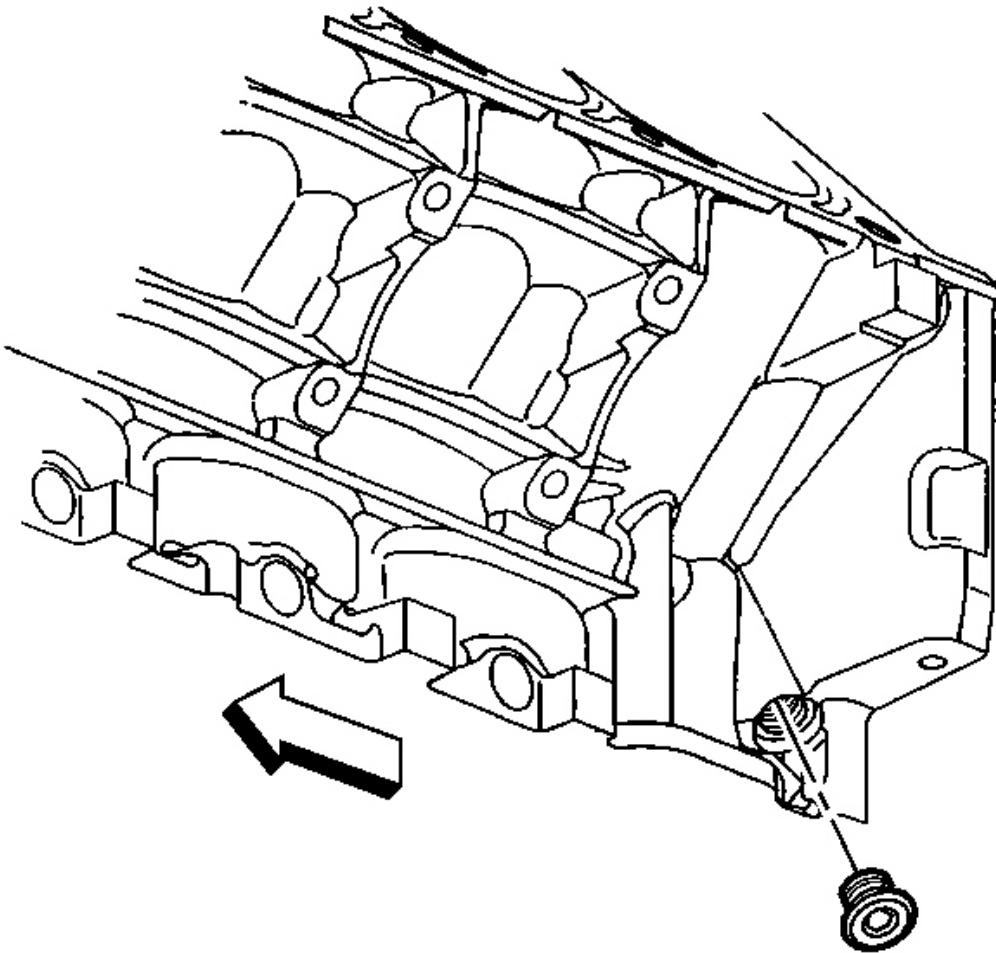


**Fig. 581: Engine Block Left Front Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer.
8. Install the engine block left front oil gallery plug.

**Tighten:** Tighten the block left front oil gallery plug to 60 N.m (44 lb ft).

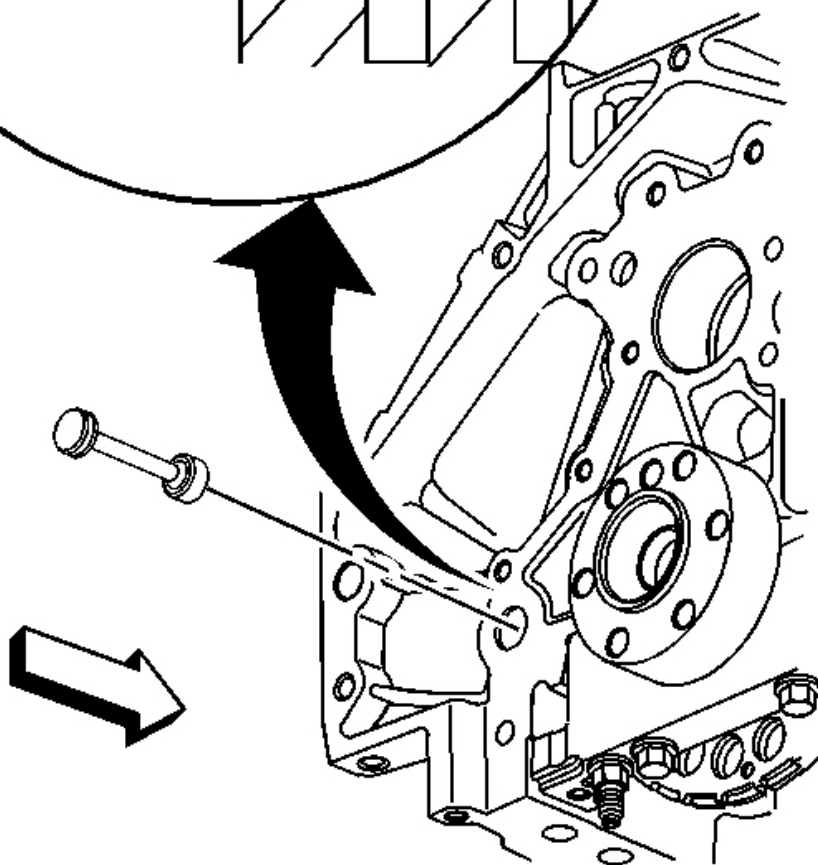
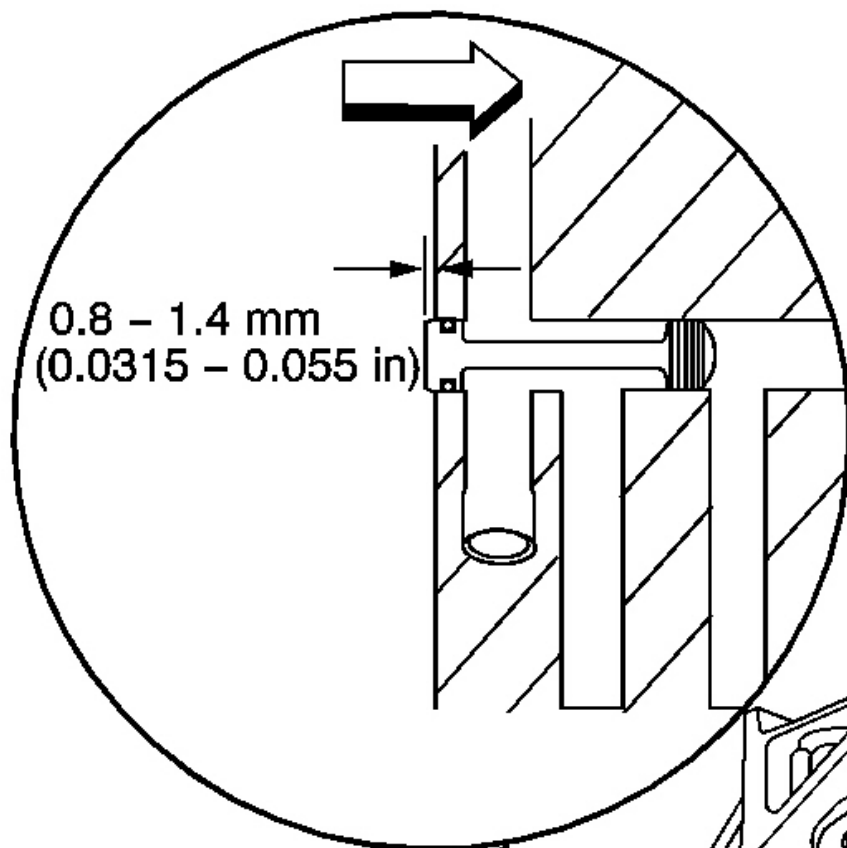




**Fig. 582: Engine Block Left Rear Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

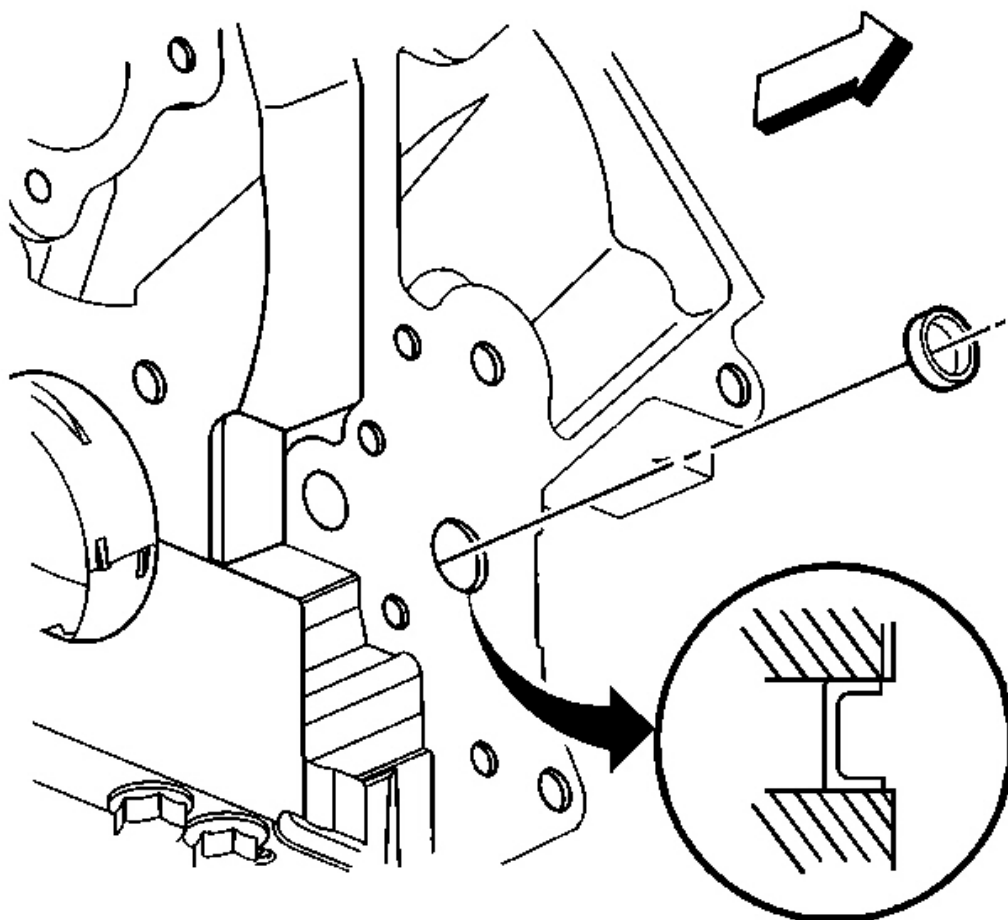
9. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer.
10. Install the engine block left rear oil gallery plug.

**Tighten:** Tighten the block left rear oil gallery plug to 60 N.m (44 lb ft).



**Fig. 583: Engine Block Rear Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

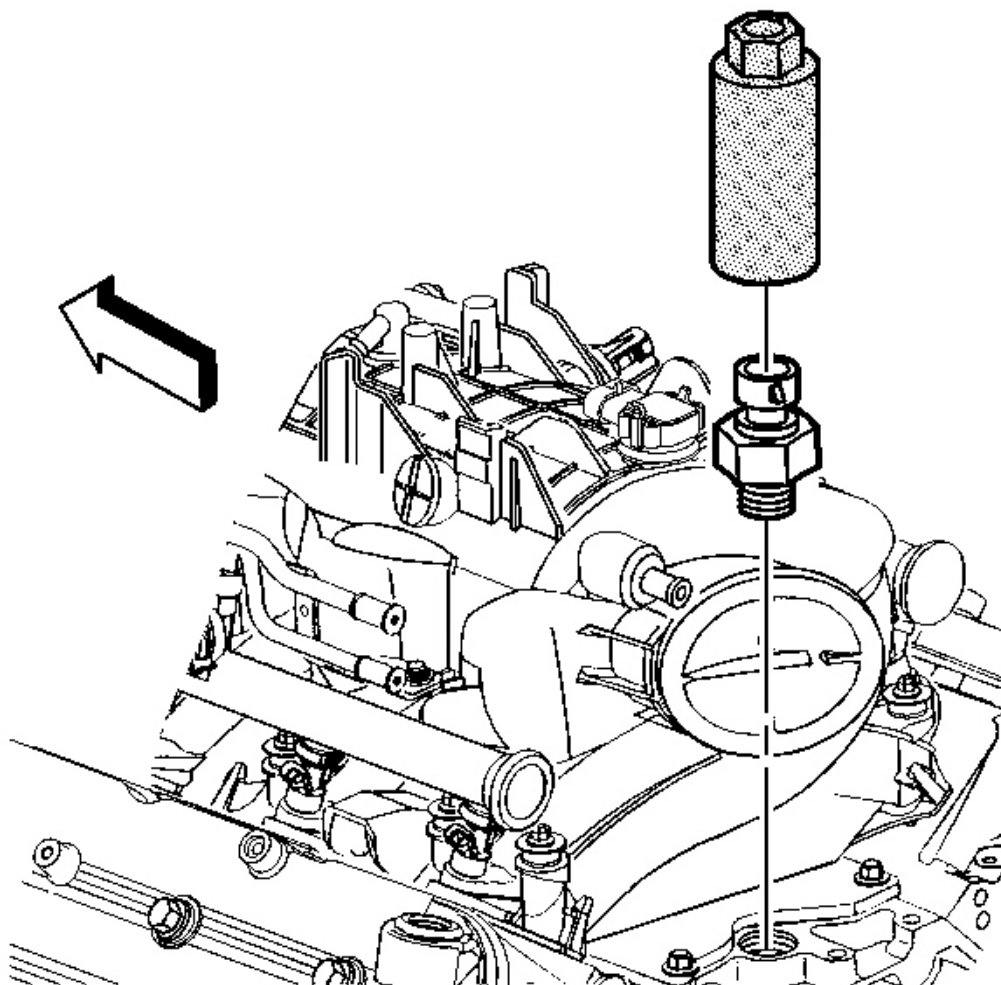
11. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be used again.
12. Lubricate the O-ring seal with clean engine oil.
13. Install the block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.



**Fig. 584: Engine Block Front Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The engine block front oil gallery plug should not be removed unless service is required.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug.
15. Install a NEW engine block front oil gallery plug, if required. Install the front oil gallery plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.



**Fig. 585: Oil Pressure Sensor & J 41712**  
Courtesy of GENERAL MOTORS CORP.

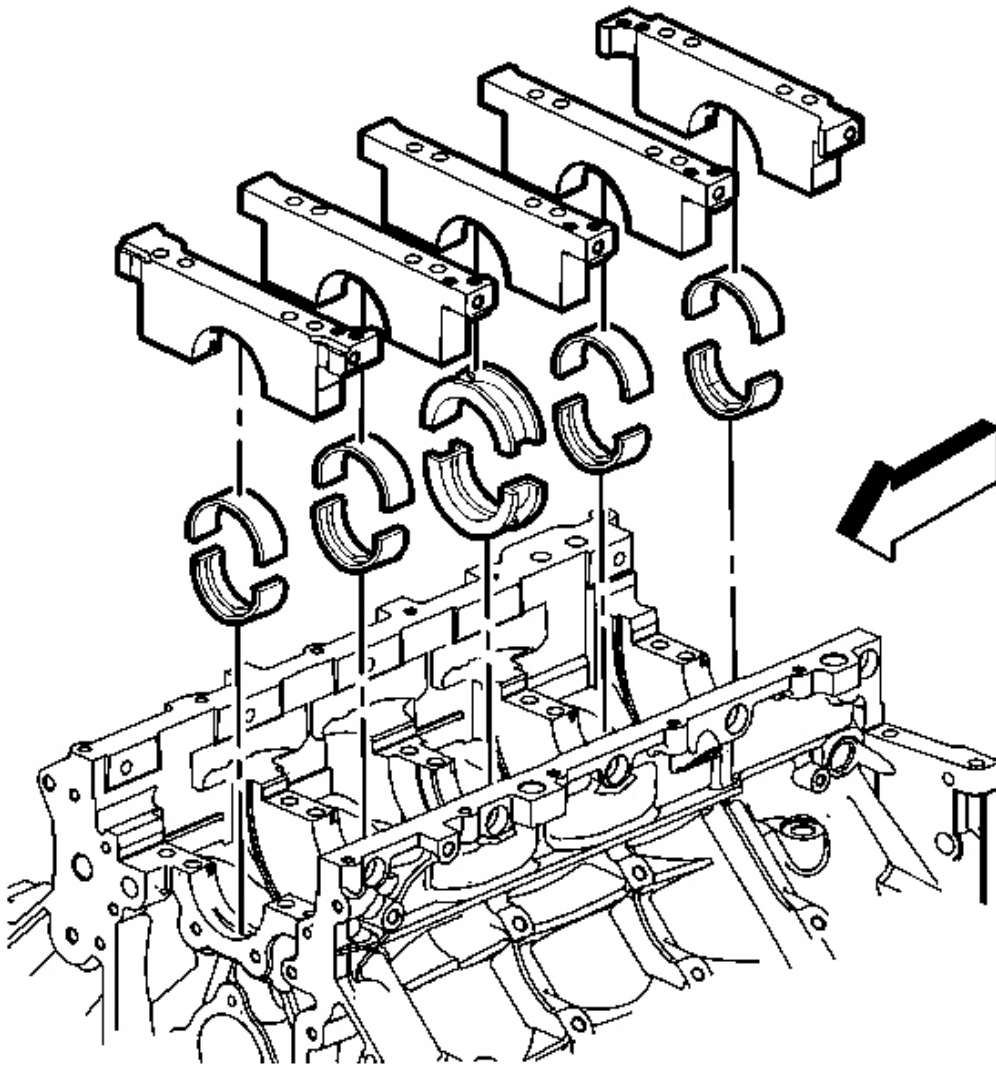
16. Apply sealant to the threads of the oil pressure sensor.
17. Use the J 41712 or equivalent in order to install the oil pressure sensor.

**Tighten:** Tighten the oil pressure sensor to 20 N.m (15 lb ft).

## CRANKSHAFT AND BEARINGS INSTALLATION

### Tools Required

J 45059 Angle Meter. See Special Tools and Equipment .



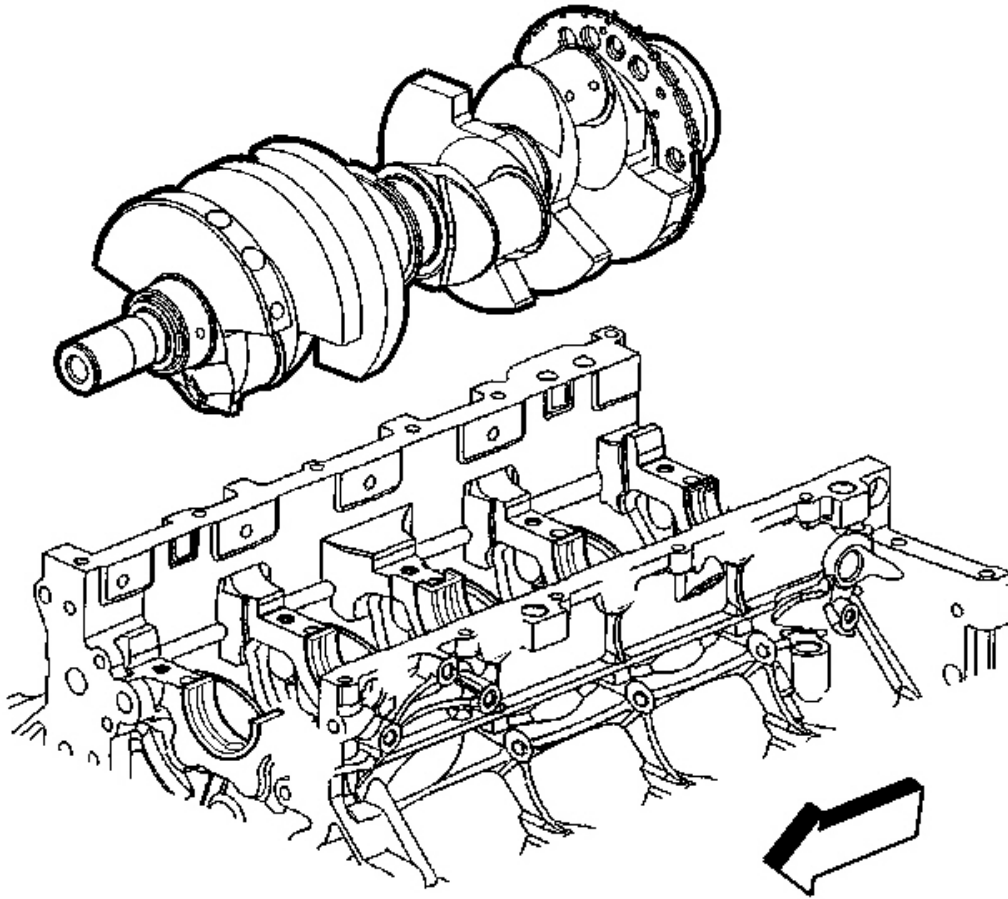
**Fig. 586: Crankshaft Bearings & Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- **Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may effect crankshaft position (CKP) sensor signals and/or On-Board Diagnostics (OBD) II system performance.**
- **Crankshaft bearing caps must be installed to the proper location and direction.**
- **When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.**
- **Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.**
- **To prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.**

**The crankshaft bearing cap M8 side bolts have a sealant patch applied to the bolt flange.**

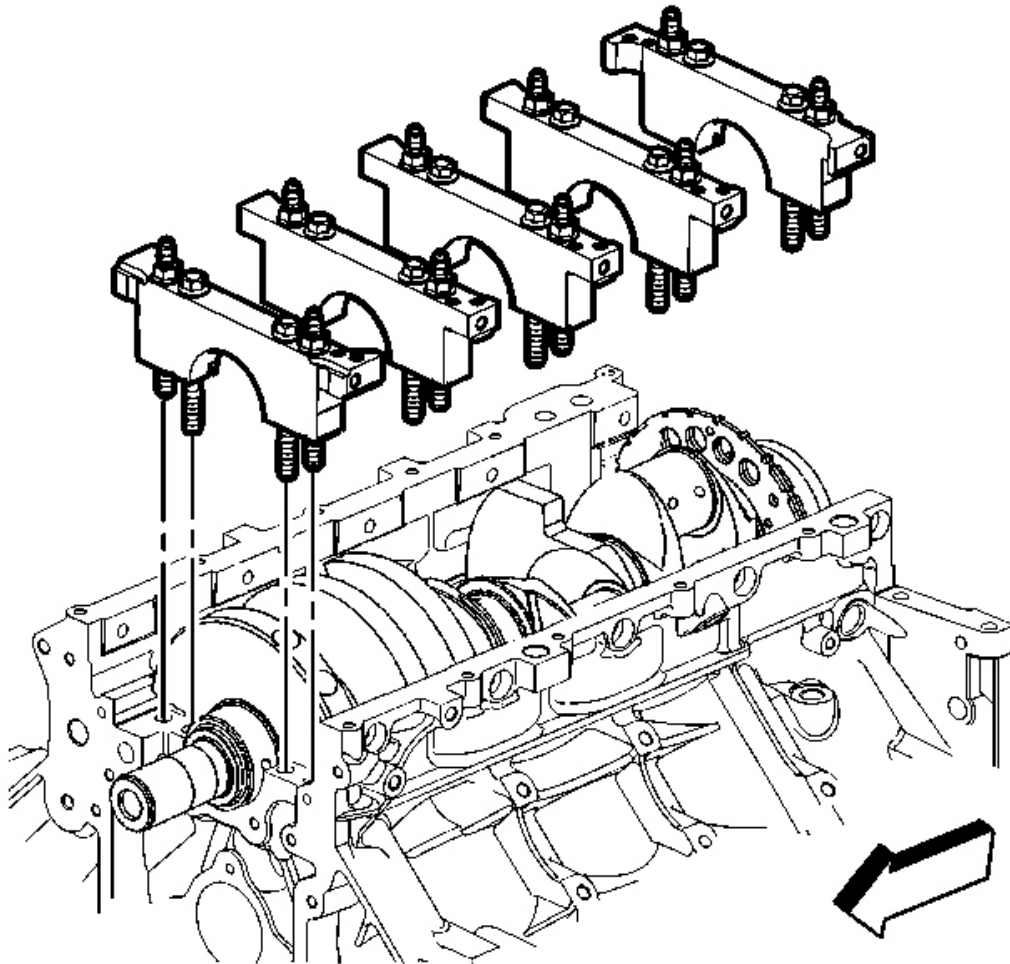
1. Install the crankshaft thrust bearings to the engine block and center bearing cap.
2. Install the remaining crankshaft bearings to the engine block and bearing caps.
3. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.



**Fig. 587: Crankshaft & Engine Block**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

4. Install the crankshaft.

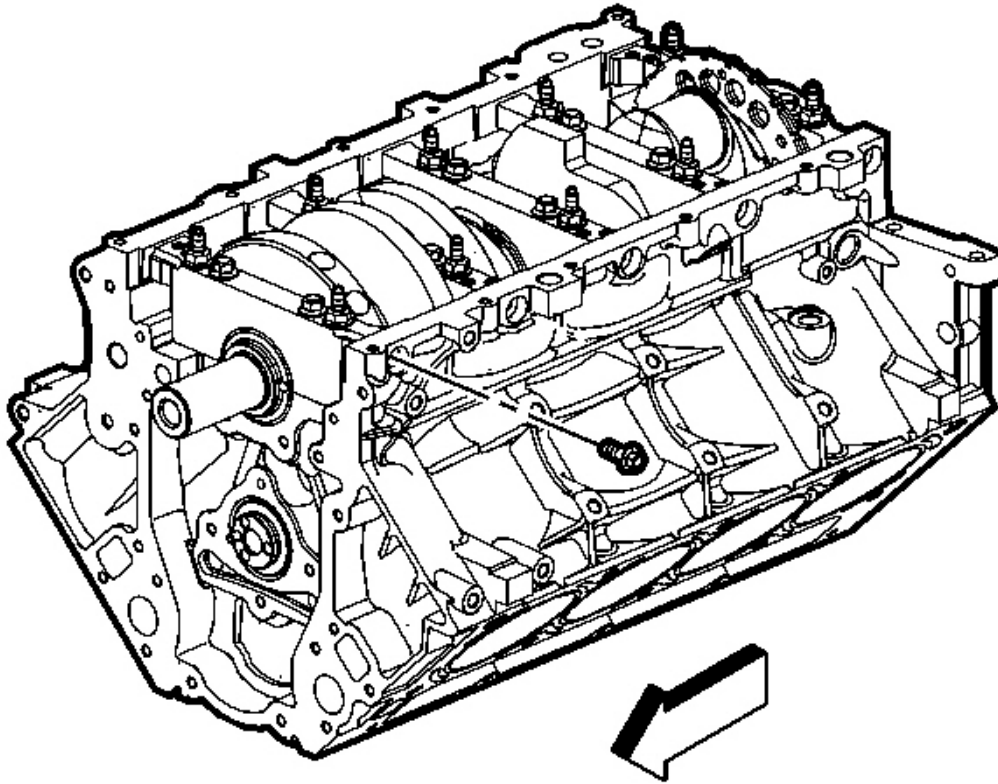


**Fig. 588: View Of Bearing Caps**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The bearing caps must be installed in the proper location and direction.

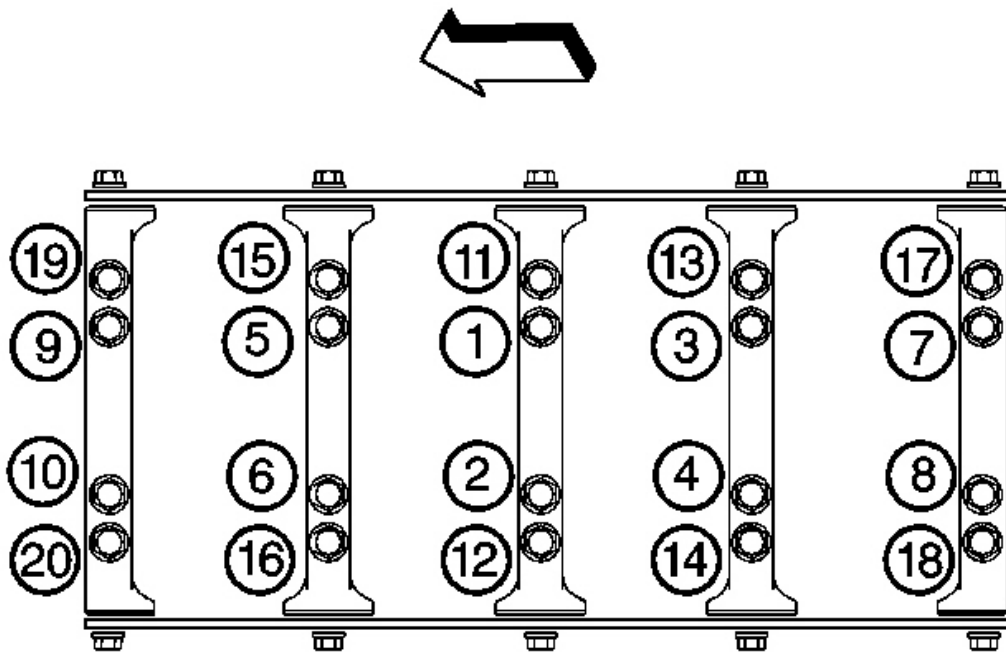
5. Install the crankshaft bearing caps, with bearings, into the engine block.
6. Start the M10 bolts and studs.
7. Tap the bearing caps into place with a plastic-face hammer.





**Fig. 589: Bearing Cap Bolts & Studs**  
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW M8 bearing cap side bolts.



**Fig. 590: Main Cap Bolt Hole Tightening Sequence**  
 Courtesy of GENERAL MOTORS CORP.

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

9. Tighten the bearing cap M10 bolts and studs.

**Tighten:** Tighten the M10 bolts (1-10) a first pass in sequence to 20 N.m (15 lb ft).

**IMPORTANT:** To properly align the crankshaft thrust bearings, the final thrust of the crankshaft **MUST** be in the forward direction.

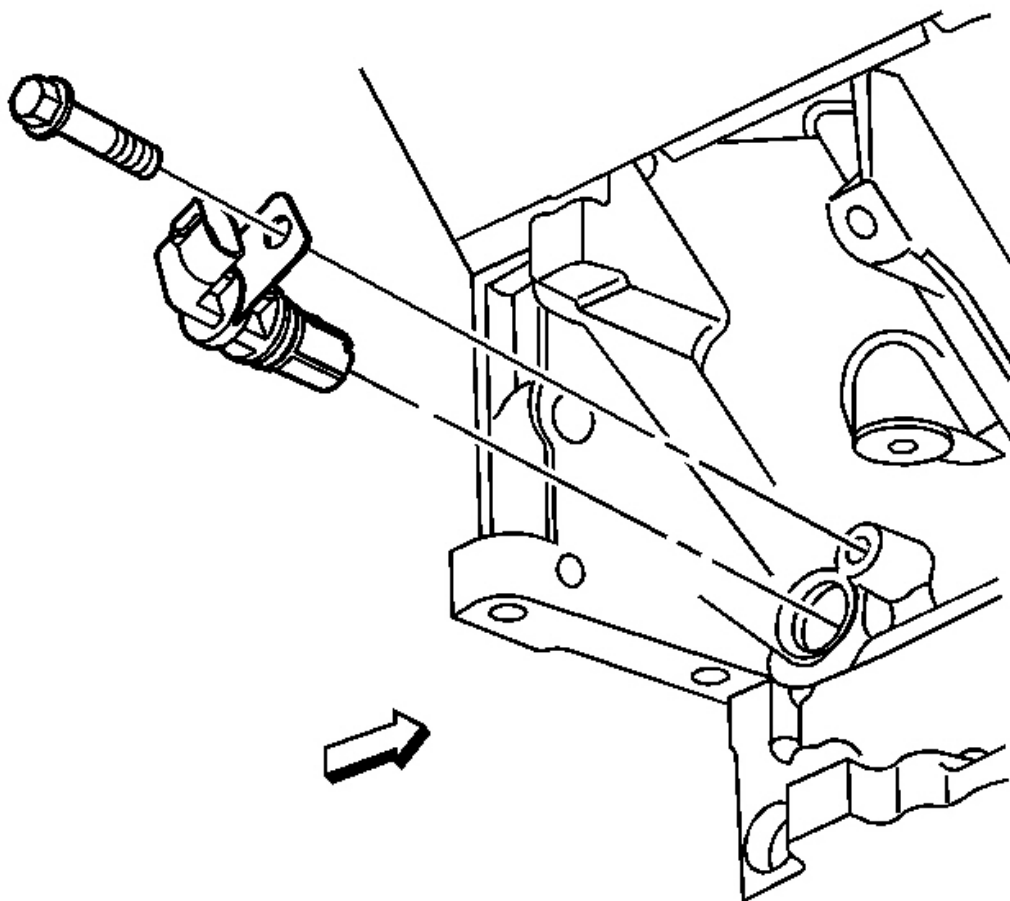
10. Using a plastic faced hammer, tap the crankshaft rearward then forward to align the thrust bearings.

**Tighten:**

1. Tighten the M10 bolts (1-10) a final pass in sequence 80 degrees using the **J 45059** . See **Special Tools and Equipment** .
2. Tighten the M10 studs (11-20) a first pass in sequence to 20 N.m (15 lb ft).
3. Tighten the M10 studs (11-20) a final pass in sequence 51 degrees using the **J 45059** . See **Special Tools and Equipment** .

4. Tighten the M8 bolts to 25 N.m (18 lb ft).

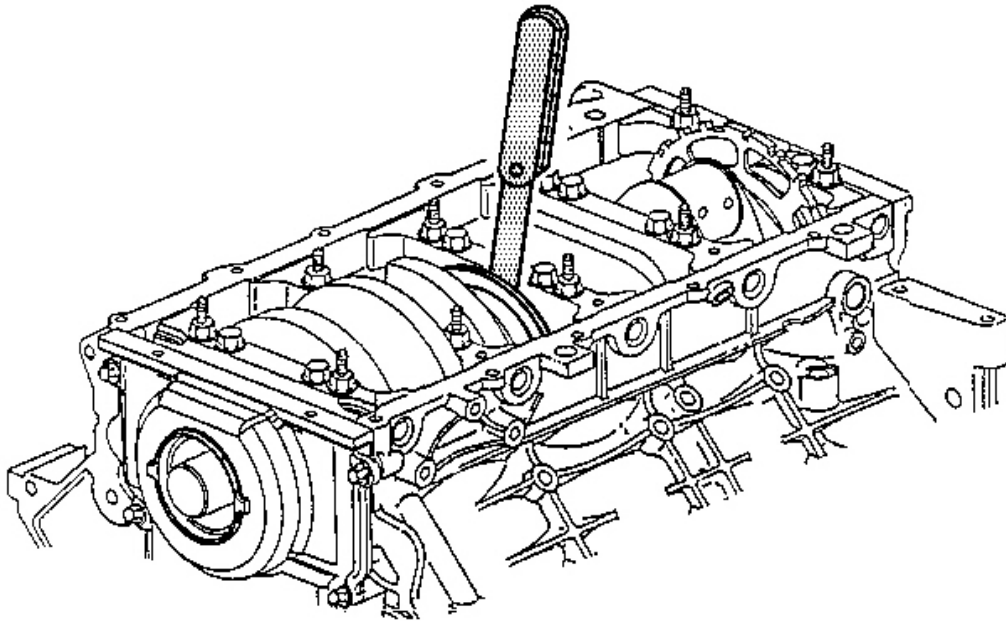
Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.



**Fig. 591: CKP Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.

11. Install the CKP sensor.
  1. Inspect the CKP sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used.
  2. Coat the O-ring seal with clean engine oil.
  3. Install the sensor. Align the notch in the sensor retaining bracket with the bolt hole in the block.
  4. Install the sensor bolt.

**Tighten:** Tighten the CKP sensor bolt to 25 N.m (18 lb ft).



**Fig. 592: Measuring Crankshaft End Play**  
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft end play.
  1. Thrust the crankshaft forward or rearward.
  2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

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.

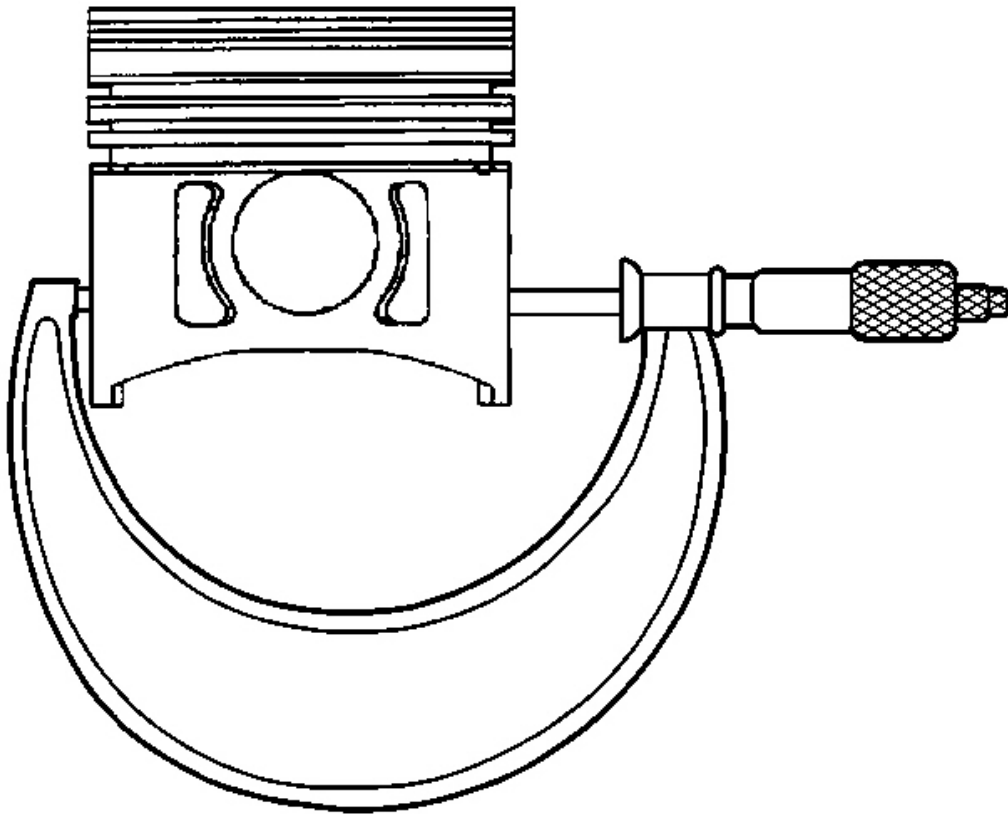
## **PISTON, CONNECTING ROD, AND BEARING INSTALLATION**

### **Tools Required**

- **J 8037** Piston Ring Compressor. See **Special Tools and Equipment** .
- **J 8087** Cylinder Bore Gauge. See **Special Tools and Equipment** .

- **J 41556** Connecting Rod Guide. See Special Tools and Equipment .
- **J 45059** Angle Meter. See Special Tools and Equipment .

### Piston Selection

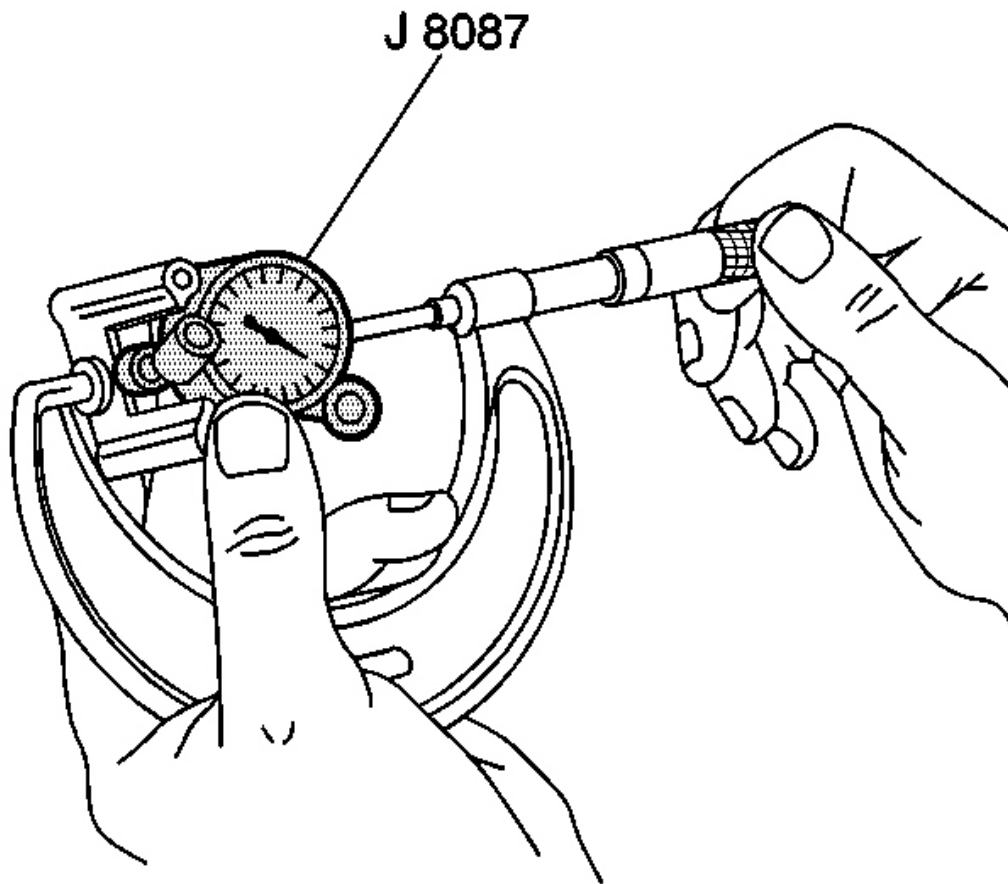


**Fig. 593: Measuring Piston**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.

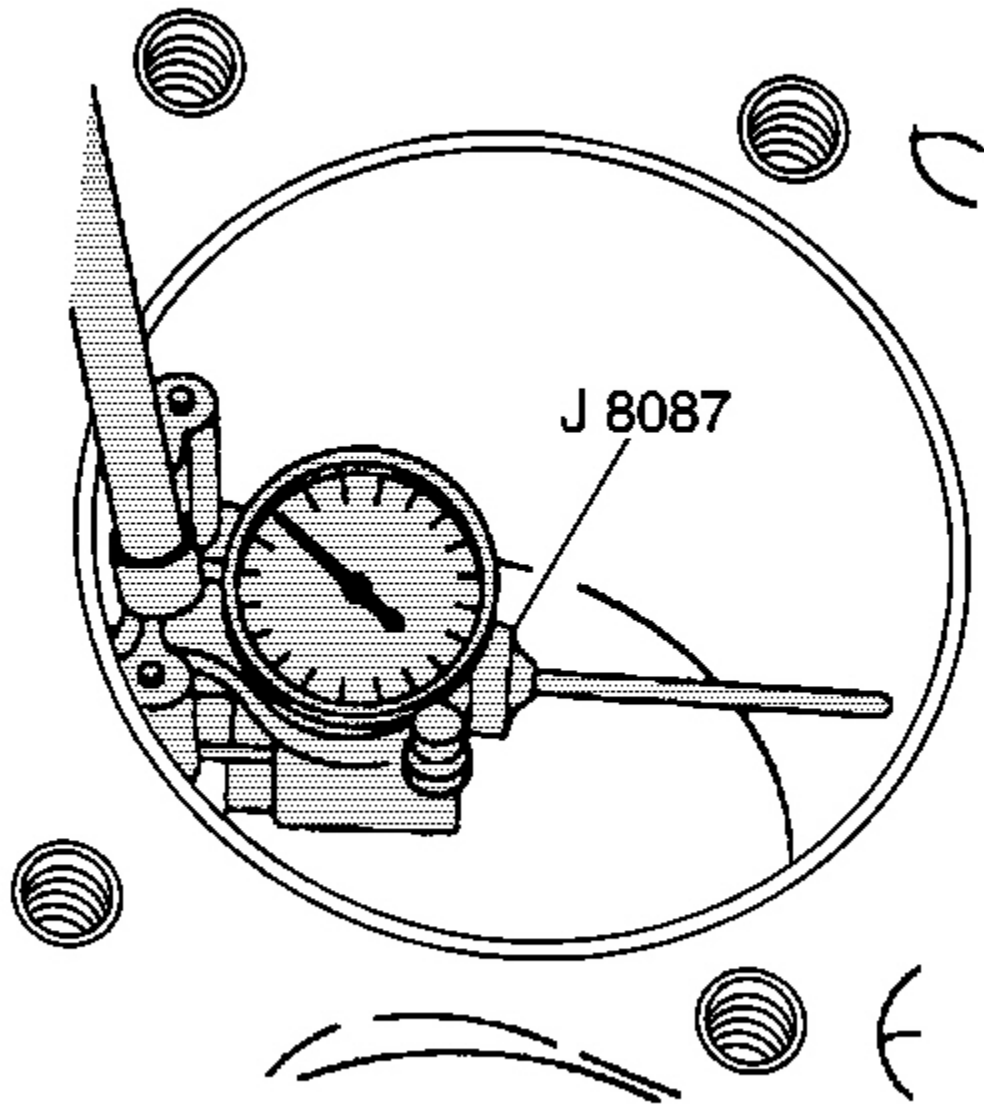
1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to Engine Mechanical Specifications .

2. Record the piston OD.



**Fig. 594: Measuring J 8087 Dimension**  
Courtesy of GENERAL MOTORS CORP.

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **J 8087** into the micrometer and zero the gauge dial. See **Special Tools and Equipment** .



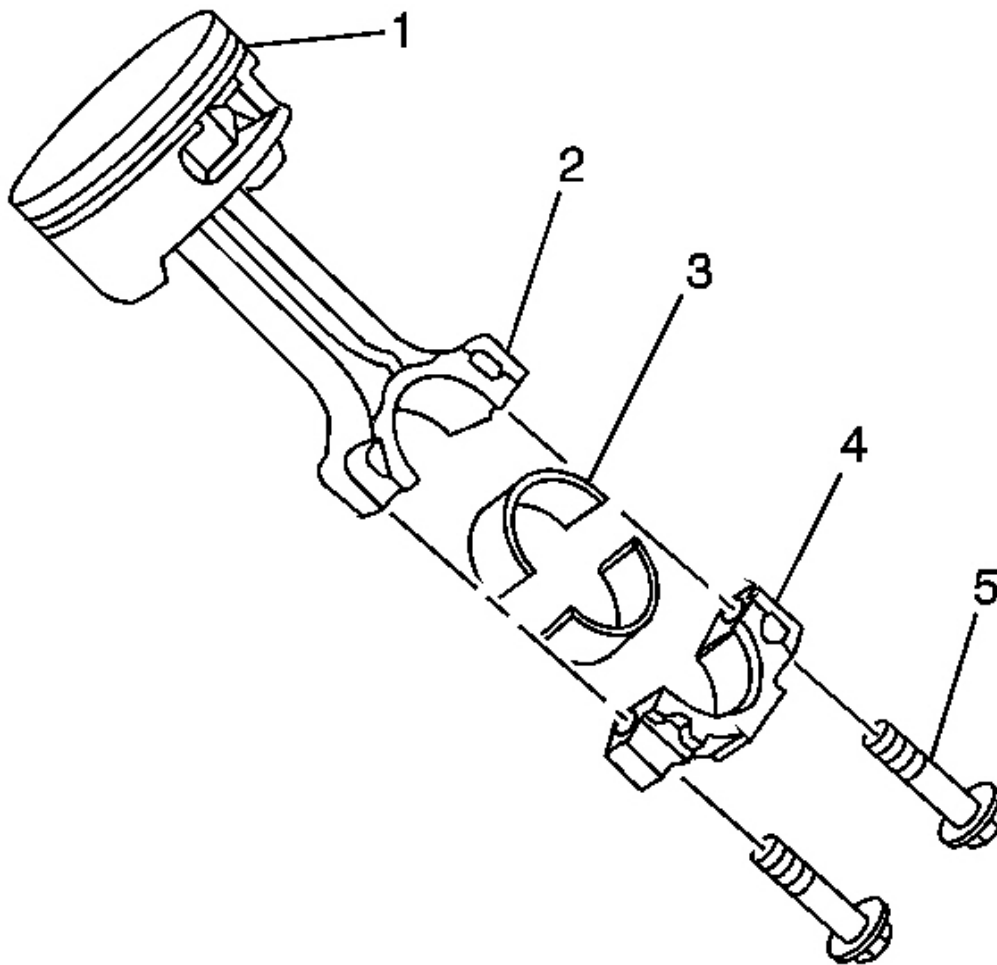
**Fig. 595: Determining Cylinder Bore Out-Of-Round Using J 8087**  
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 8087** , measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder. See **Special Tools and Equipment** .
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID to determine the piston-to-bore clearance. Refer to

### **Engine Mechanical Specifications .**

8. If the proper clearance cannot be obtained, select another piston, pin, and connecting rod assembly and again measure the clearances. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

#### **Piston, Pin, and Connecting Rod Installation**

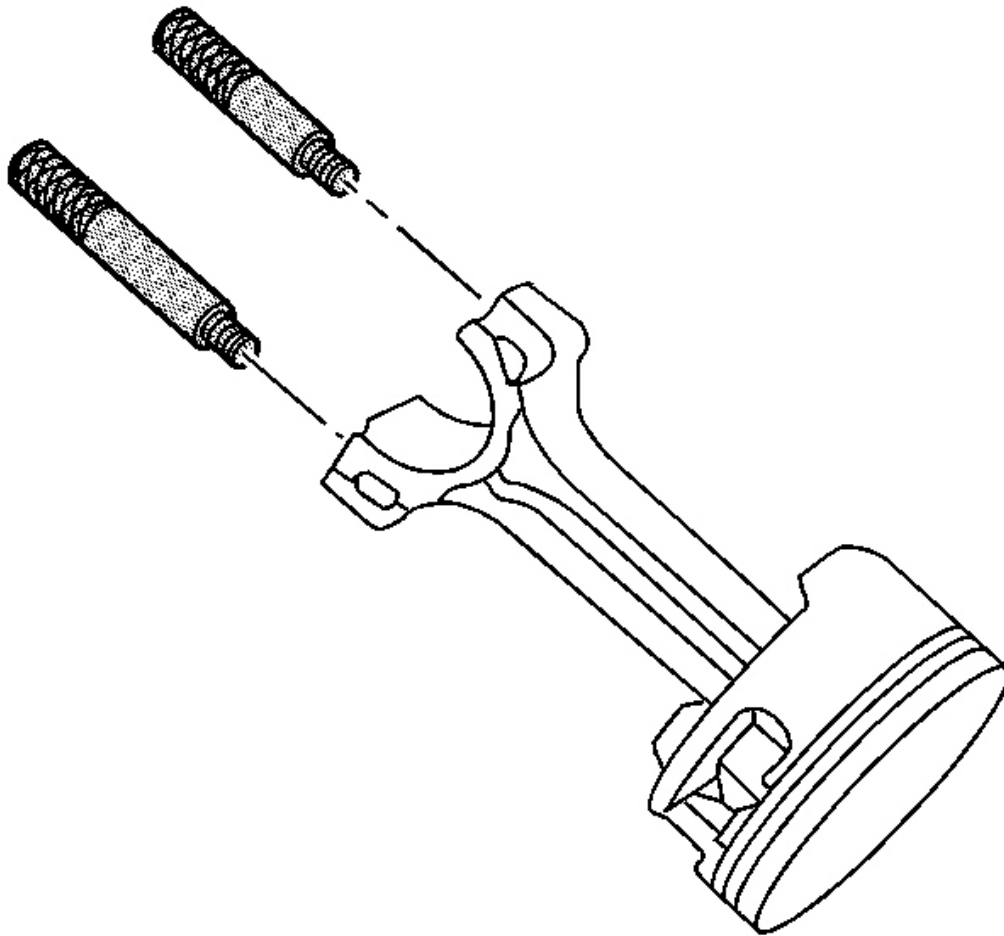


**Fig. 596: Piston & Connecting Rod Components**  
**Courtesy of GENERAL MOTORS CORP.**

1. Lightly lubricate the following components with clean engine oil:
  - Piston (1)

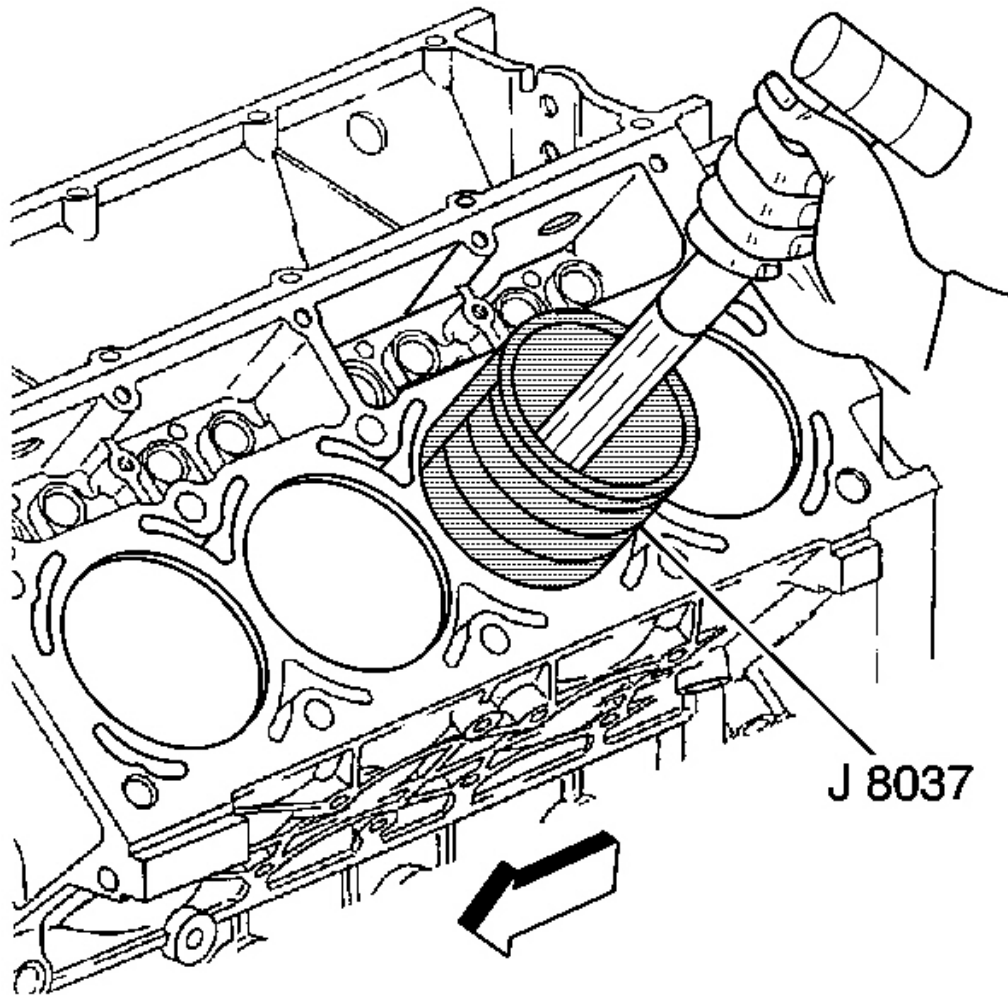


- Piston rings
  - Cylinder bore
  - Bearings (3) and bearing surfaces
2. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
  3. Position the compression ring end gaps 180 degrees opposite each other.



**Fig. 597: View Of J 41556 & Connecting Rod**  
**Courtesy of GENERAL MOTORS CORP.**

4. Install the **J 41556** to the connecting rod. See **Special Tools and Equipment** .

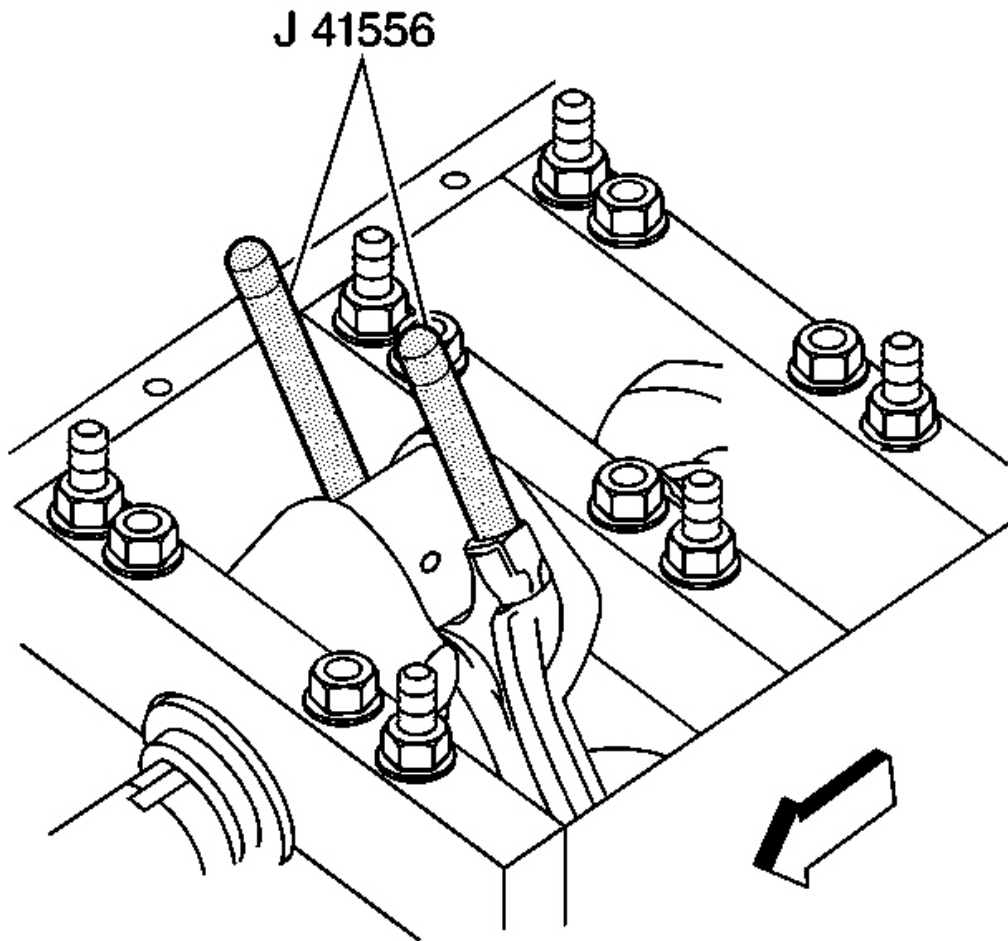


**Fig. 598: Installing Piston Using J 8037**  
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools and Equipment** .

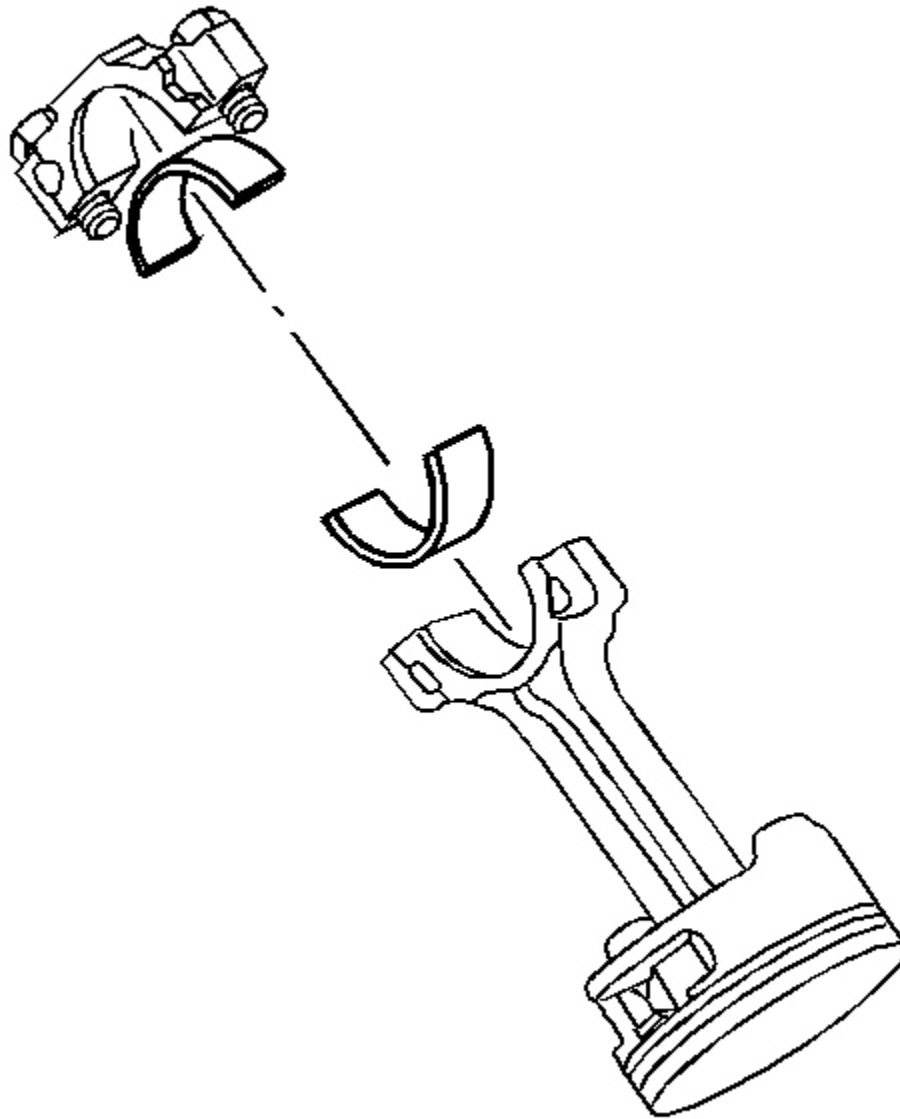
**IMPORTANT:** The piston alignment mark **MUST** face the front of the engine block.

6. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all the piston rings have entered the cylinder bore.



**Fig. 599: View Of J 41556**  
Courtesy of GENERAL MOTORS CORP.

7. Use the **J 41556** to guide the connecting rod onto the crankshaft journal. See **Special Tools and Equipment** .
8. Remove the **J 41556** from the connecting rod. See **Special Tools and Equipment** .



**Fig. 600: Connecting Rod & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** Use the correct fastener in the correct location. Replacement fasteners must be the correct part number for that application. Fasteners requiring replacement or fasteners requiring the use of thread locking compound or sealant are identified in the service procedure. Do not use paints,

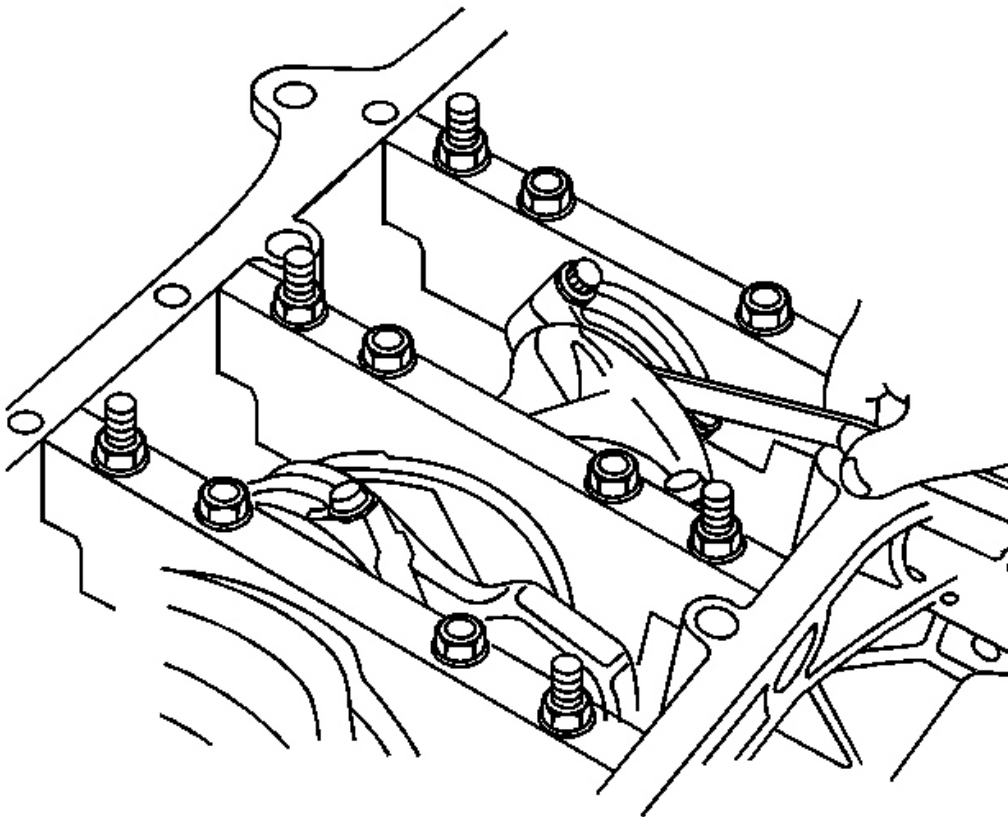
lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

**IMPORTANT:** The connecting rod and cap must be assembled with the mating surfaces properly aligned.

9. Install the bearing cap, bearing half, and bolts.

**Tighten:**

1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
2. Tighten the bolts a final pass to 75 degrees using the **J 45059** . See **Special Tools and Equipment** .

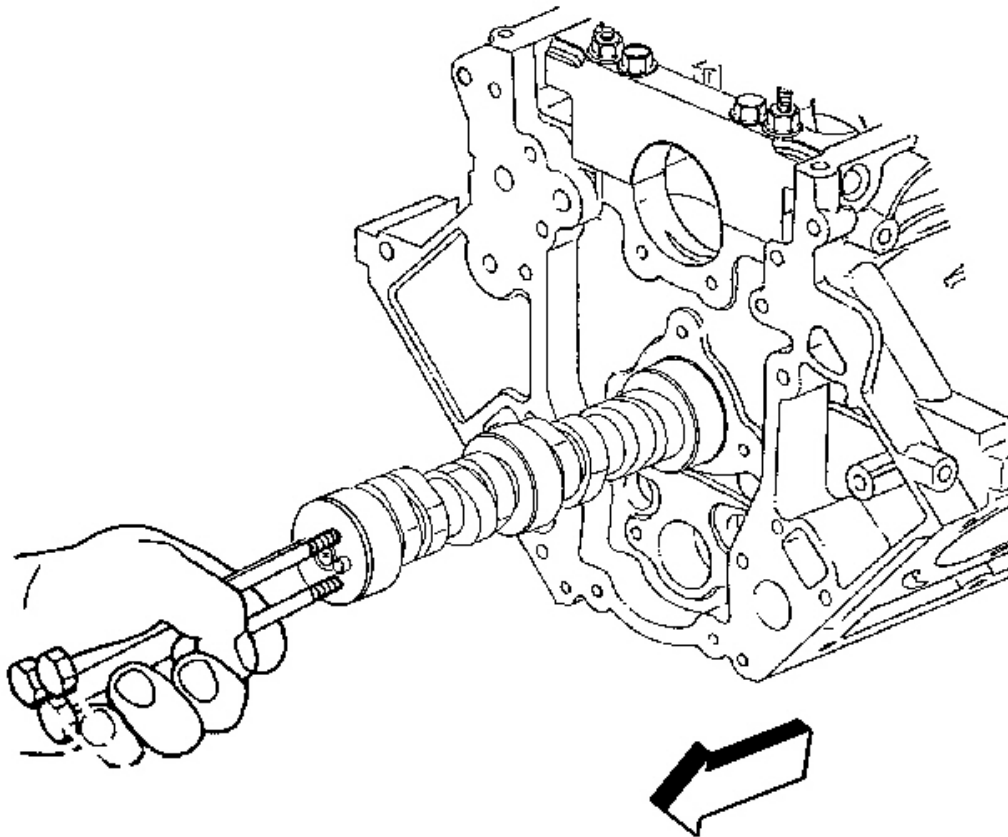


**Fig. 601: Measuring Connecting Rods Side Clearance**

Courtesy of GENERAL MOTORS CORP.

10. Measure the connecting rods for the proper side clearance. Refer to Engine Mechanical Specifications .

## CAMSHAFT INSTALLATION



**Fig. 602: Camshaft Front Bolt Holes**  
Courtesy of GENERAL MOTORS CORP.

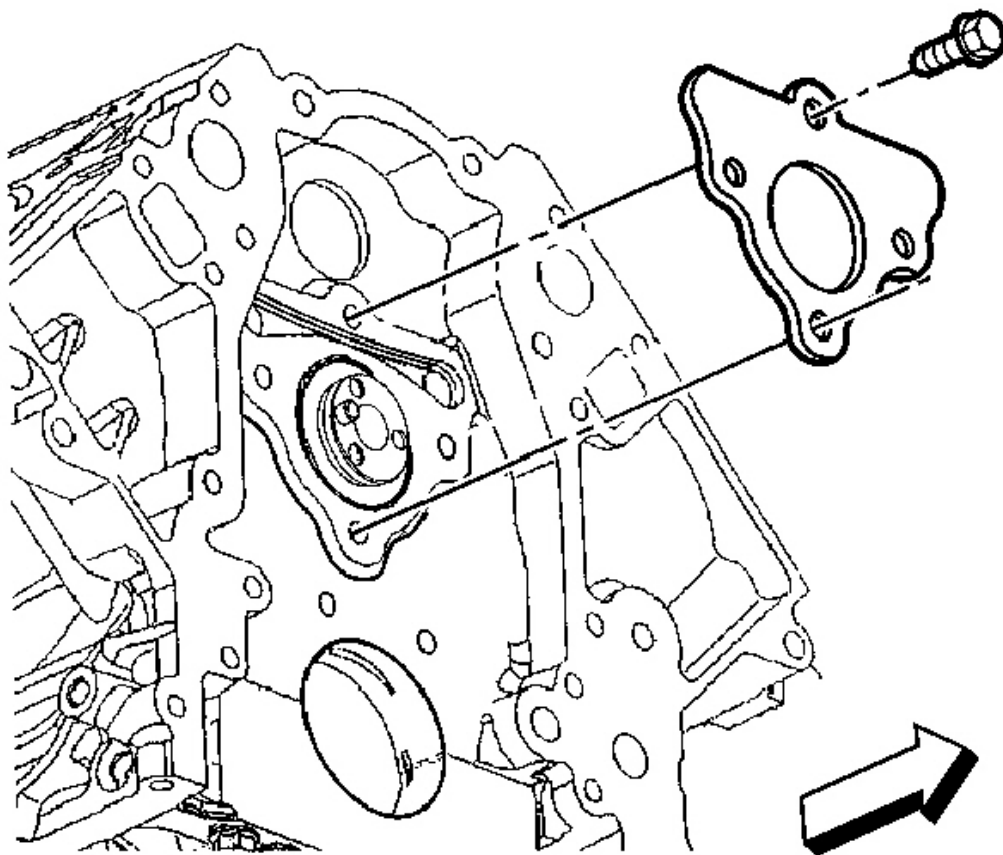
**IMPORTANT:** If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install 3 M8 - 1.25 x 100 mm (M8 - 1.25 x 4.0 in) bolts into the camshaft front bolt holes.

**NOTE:** All camshaft journals are the same diameter, so care must be used in

removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the 3 bolts from the front of the camshaft.



**Fig. 603: Camshaft Retainer & Bolts**  
Courtesy of GENERAL MOTORS CORP.

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

**IMPORTANT:**

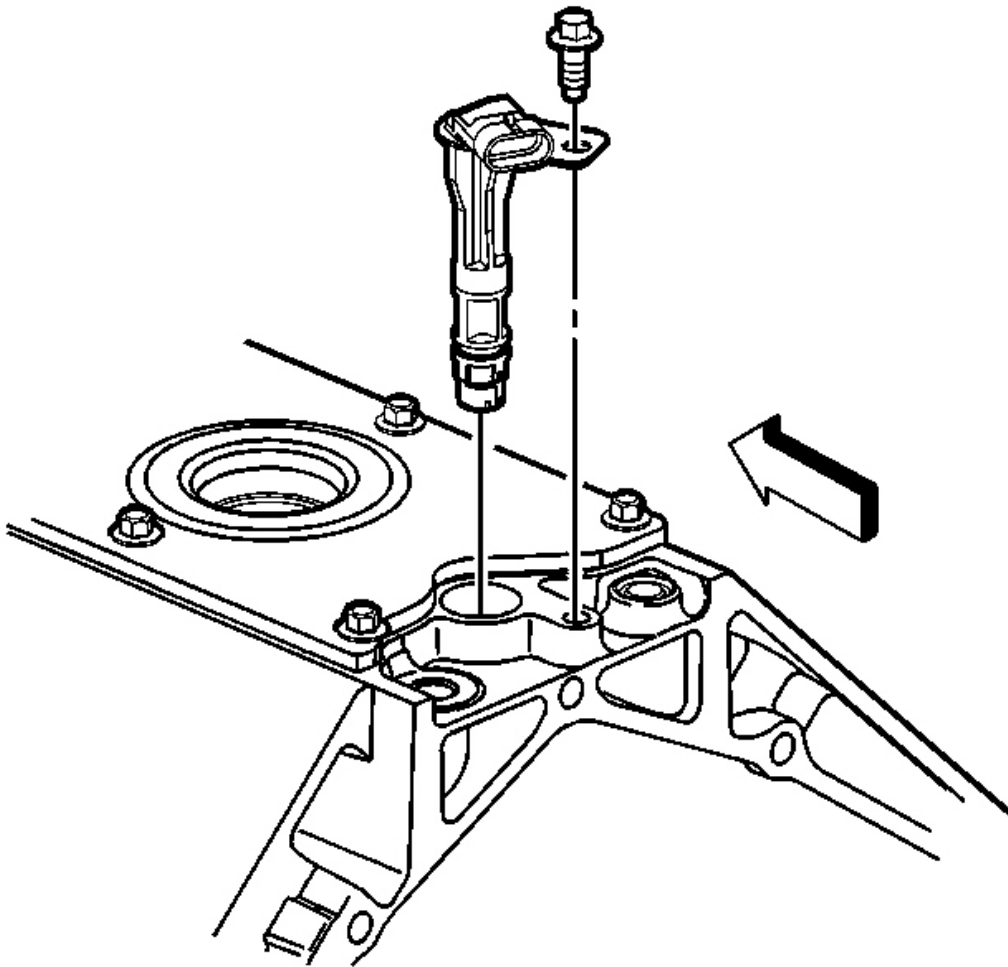
- Install the retainer plate with the sealing gasket facing the engine block.
- The gasket surface on the engine block should be clean and free of

**dirt or debris.**

5. Install the camshaft retainer and the bolts.

**Tighten:** Tighten the camshaft retainer bolts to 25 N.m (18 lb ft).

6. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be used again.
7. Lubricate the O-ring seal with clean engine oil.



**Fig. 604: Camshaft Sensor & Bolt**  
Courtesy of GENERAL MOTORS CORP.



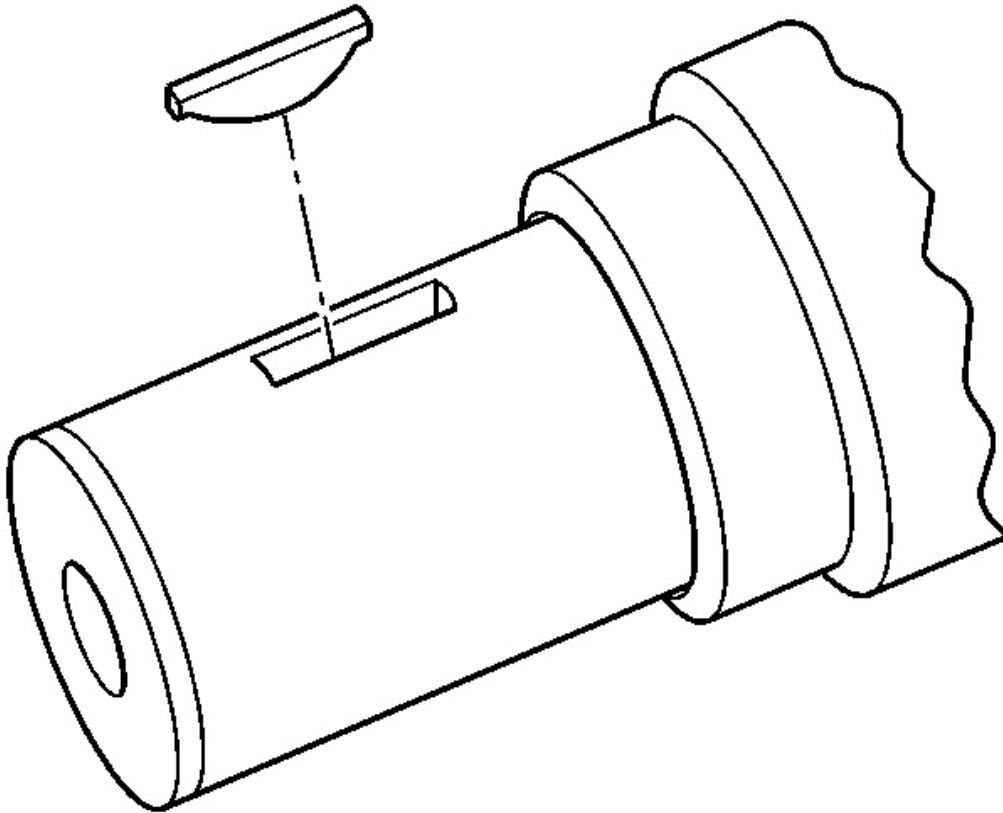
8. Install the camshaft position (CMP) sensor and bolt.

**Tighten:** Tighten the CMP sensor bolt to 25 N.m (18 lb ft).

## TIMING CHAIN AND SPROCKETS INSTALLATION

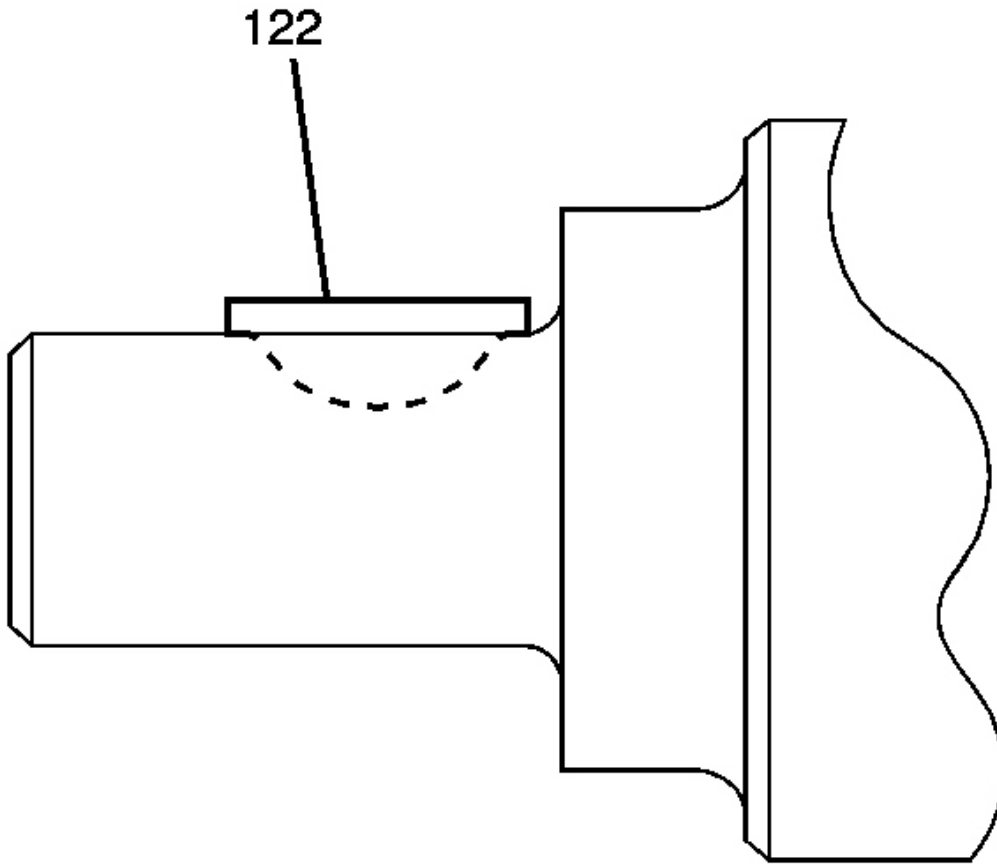
### Tools Required

**J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools and Equipment** .



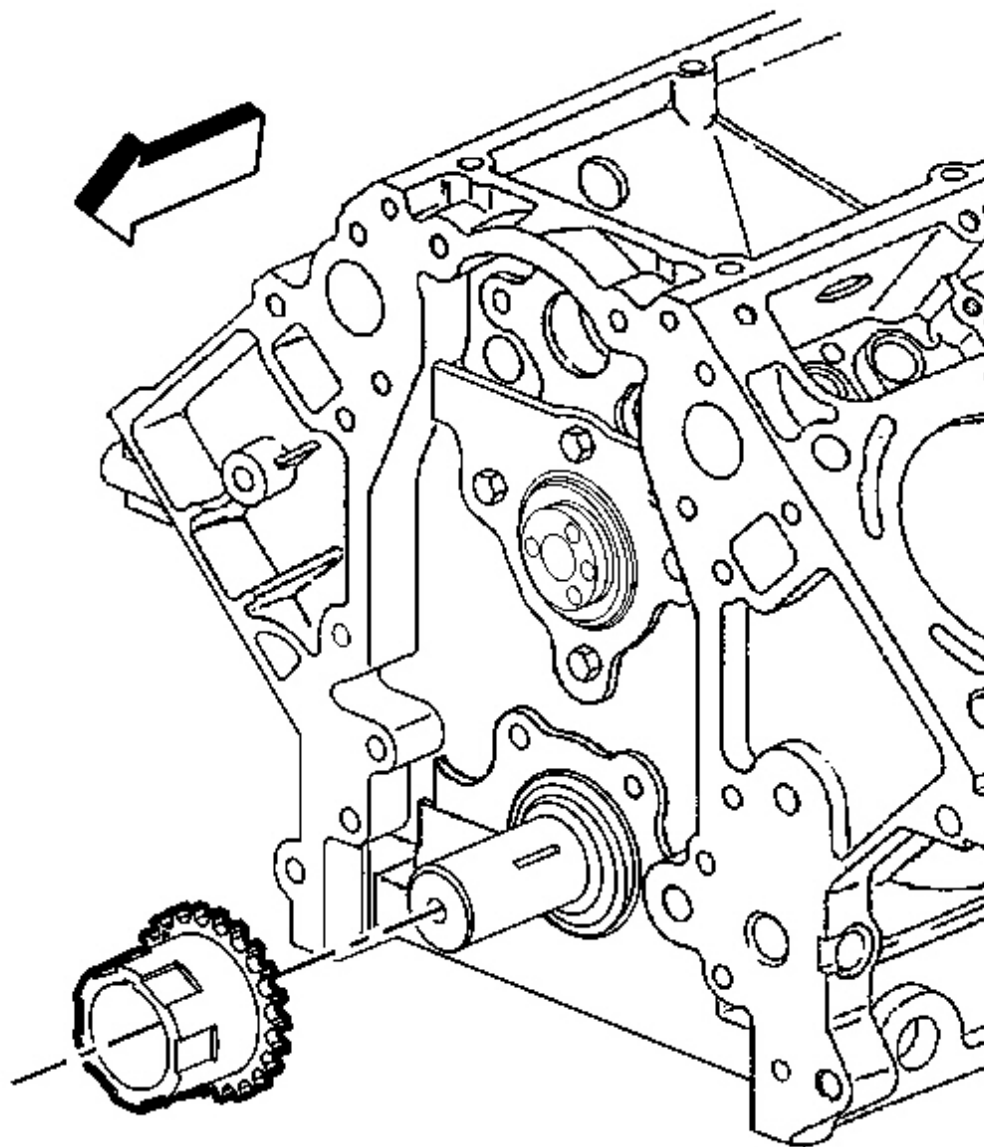
**Fig. 605: Crankshaft Sprocket Key**  
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.



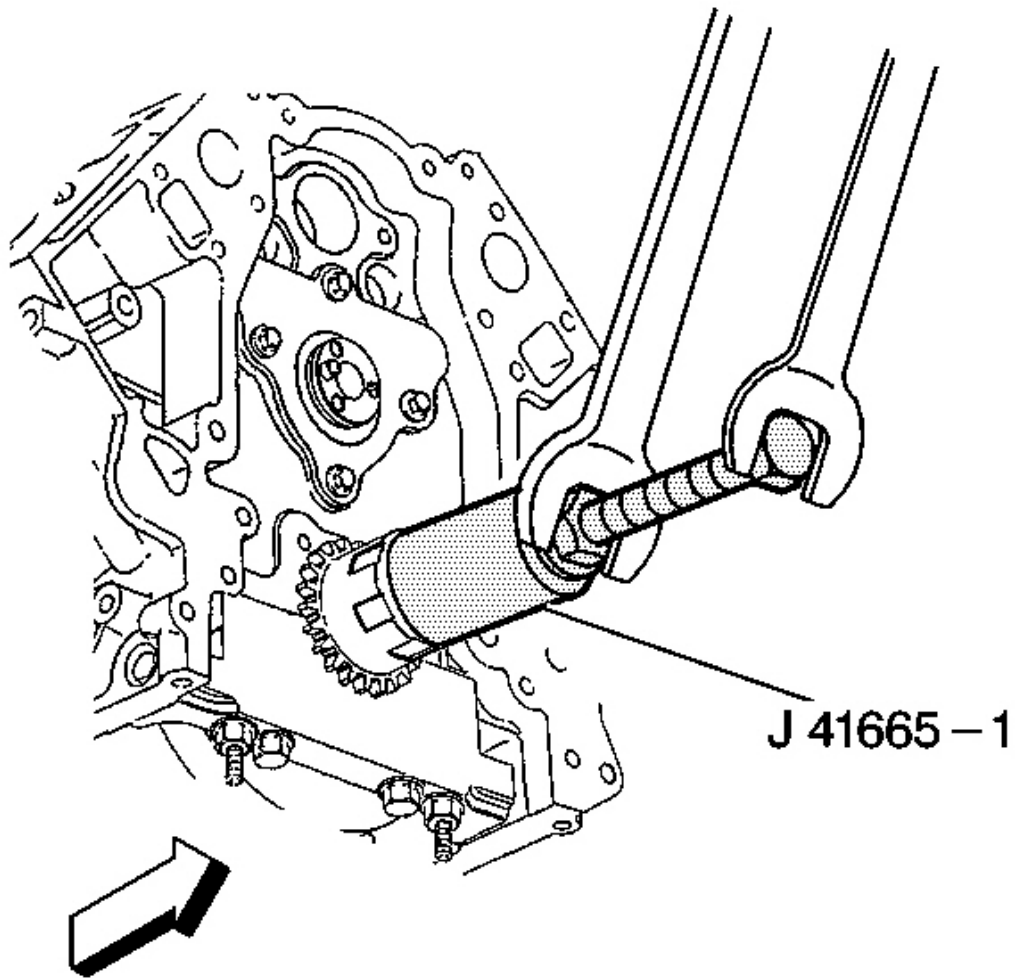
**Fig. 606: Installed Crankshaft Key**  
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.



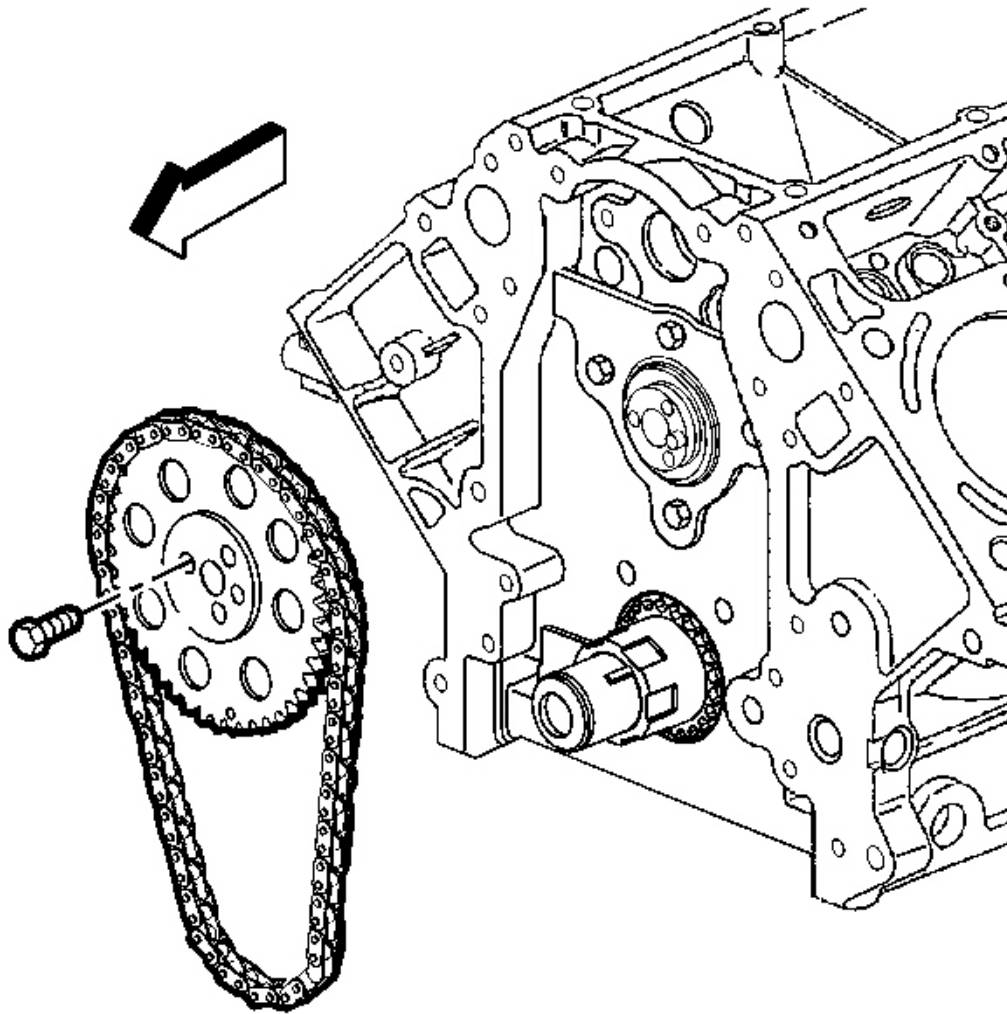
**Fig. 607: Crankshaft Sprocket**  
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.



**Fig. 608: Installing Crankshaft Sprocket Using J 41665**  
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41665** in order to install the crankshaft sprocket. See **Special Tools and Equipment** .  
Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.



**Fig. 609: Camshaft Sprocket, Bolt & Timing Chain**  
Courtesy of GENERAL MOTORS CORP.

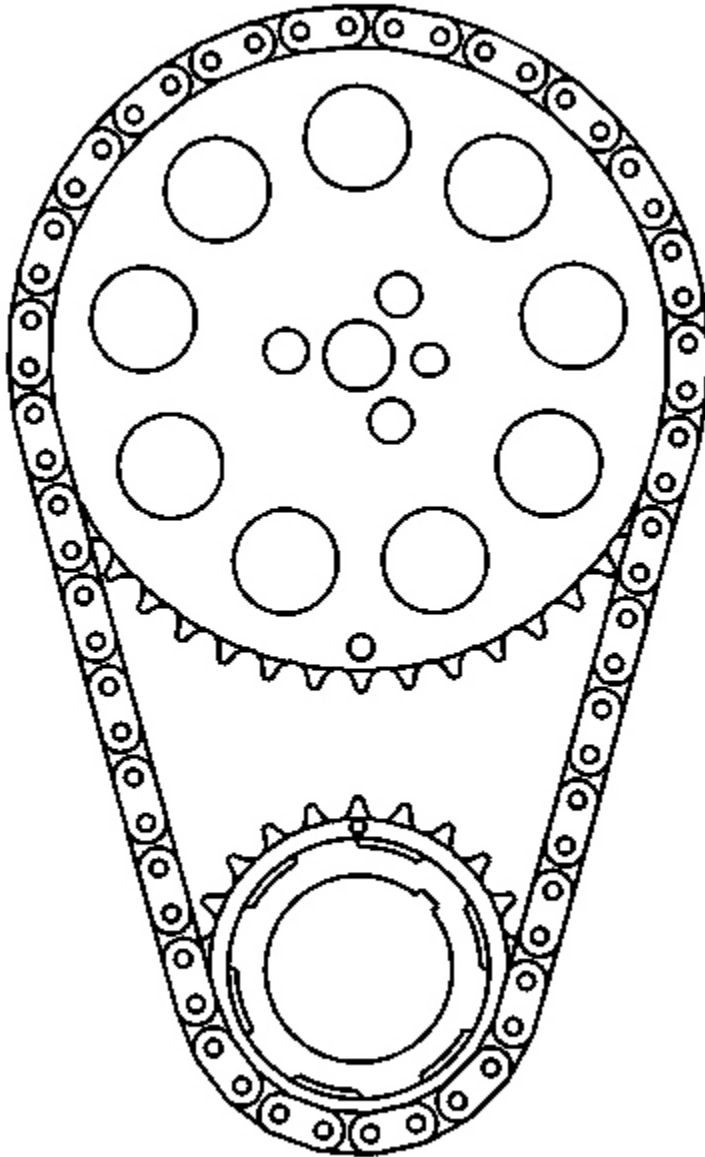
**IMPORTANT:**

- Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

Locate the camshaft sprocket alignment mark in the 6 o'clock

position.

6. Install the camshaft sprocket and timing chain.



**Fig. 610: Camshaft & Crankshaft Sprockets Aligned**  
Courtesy of GENERAL MOTORS CORP.

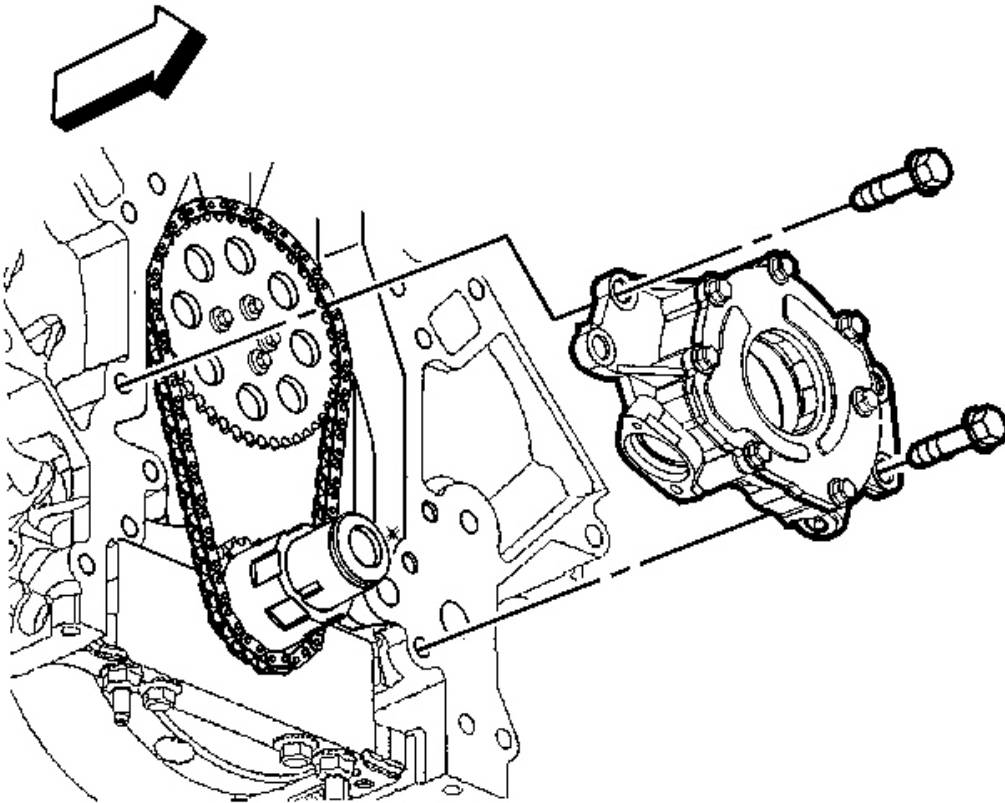
7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

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

8. Install the camshaft sprocket bolts.

**Tighten:** Tighten the camshaft sprocket bolts to 35 N.m (26 lb ft).

## OIL PUMP, PUMP SCREEN AND DEFLECTOR INSTALLATION



**Fig. 611: Oil Pump & Bolt**  
Courtesy of GENERAL MOTORS CORP.

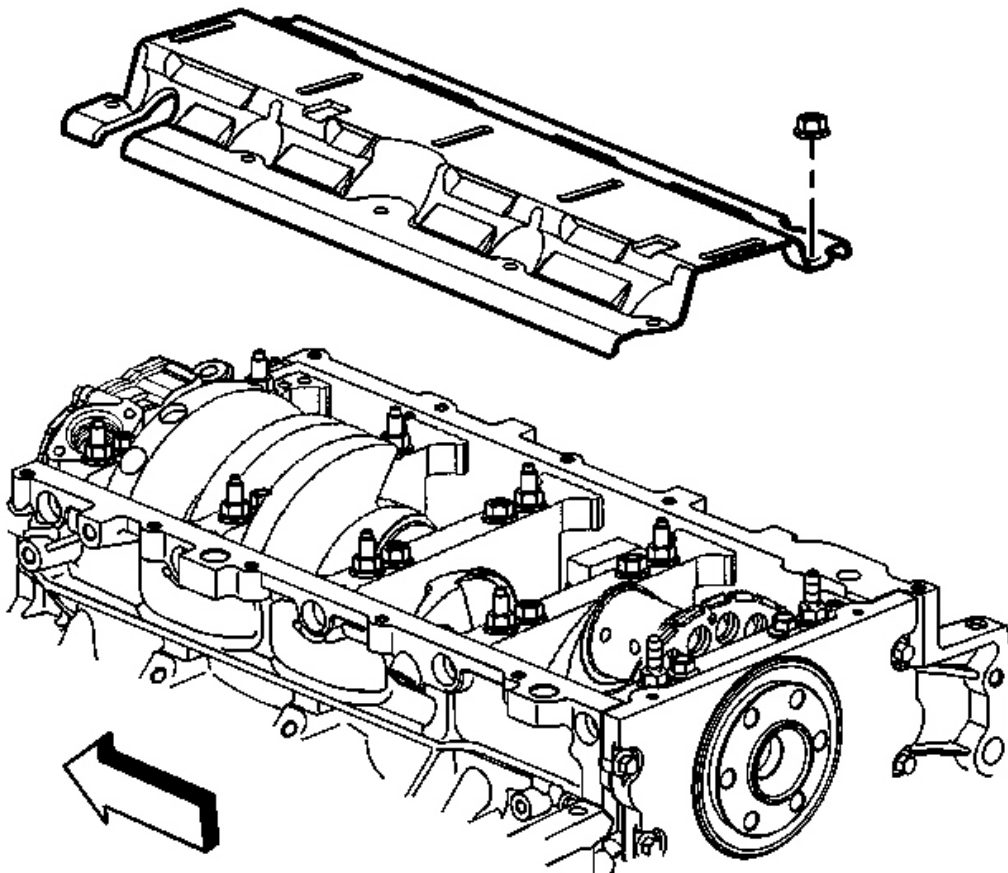
**IMPORTANT:** Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

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

3. Install the oil pump bolts.

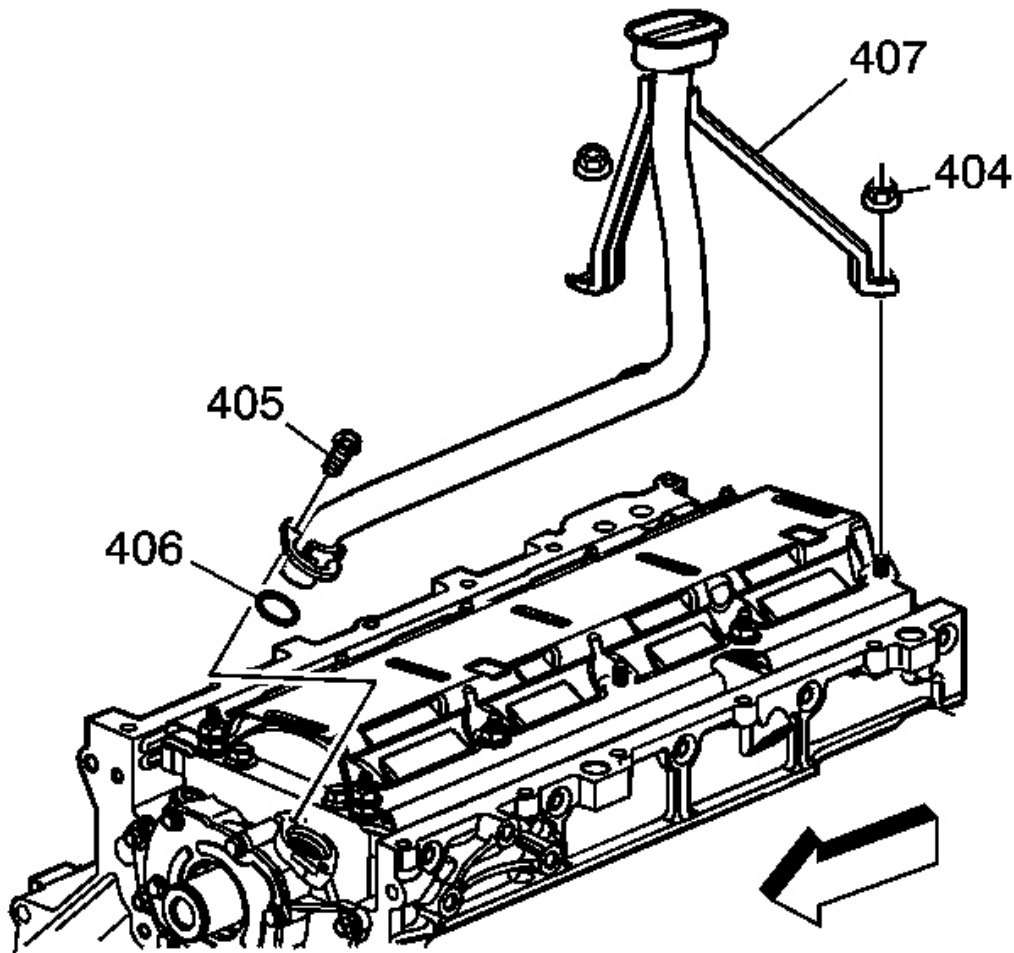
**Tighten:** Tighten the oil pump bolts to 25 N.m (18 lb ft).



**Fig. 612: Crankshaft Oil Deflector**  
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.





**Fig. 613: Oil Pump Screen, Bolt, Nuts & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

**IMPORTANT:**

- Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.
- Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.

7. Install the oil pump screen (407).
8. Install the oil pump screen bolt (405) and the deflector nuts (404).

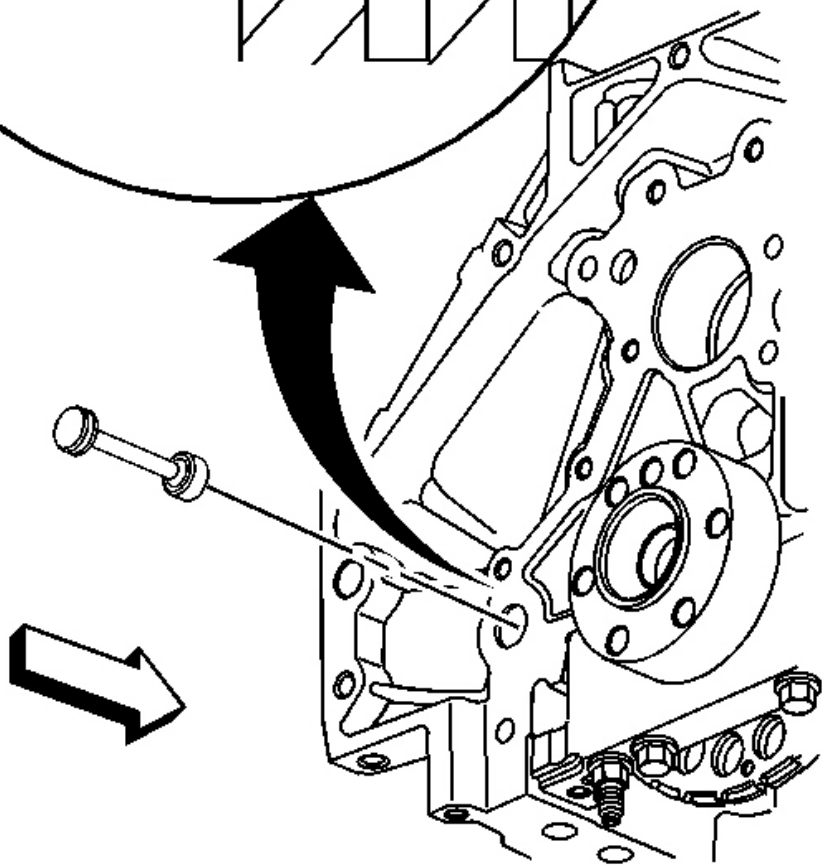
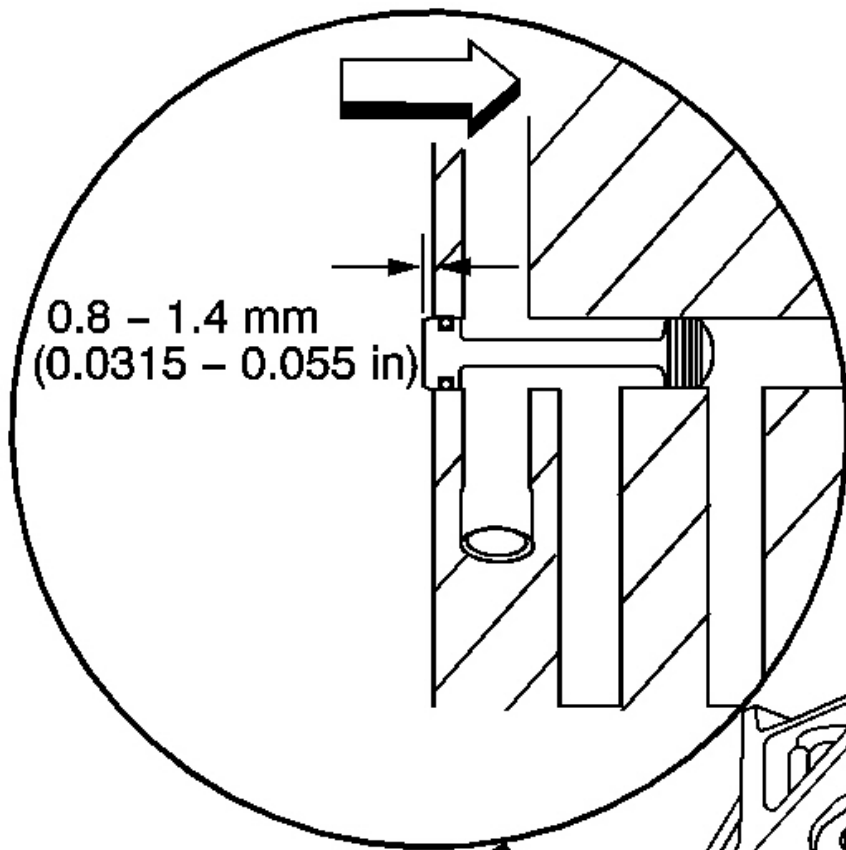
**Tighten:**

1. Tighten the oil pump screen bolt (405) to 12 N.m (106 lb in).
2. Tighten the crankshaft oil deflector nuts (404) to 25 N.m (18 lb ft).

## **ENGINE REAR COVER INSTALLATION**

### **Tools Required**

- **J 41480** Front and Rear Cover Alignment - Oil Pan Surface. See **Special Tools and Equipment** .
- **J 41476** Front and Rear Cover Alignment Tool - Crankshaft Oil Seal Area. See **Special Tools and Equipment** .

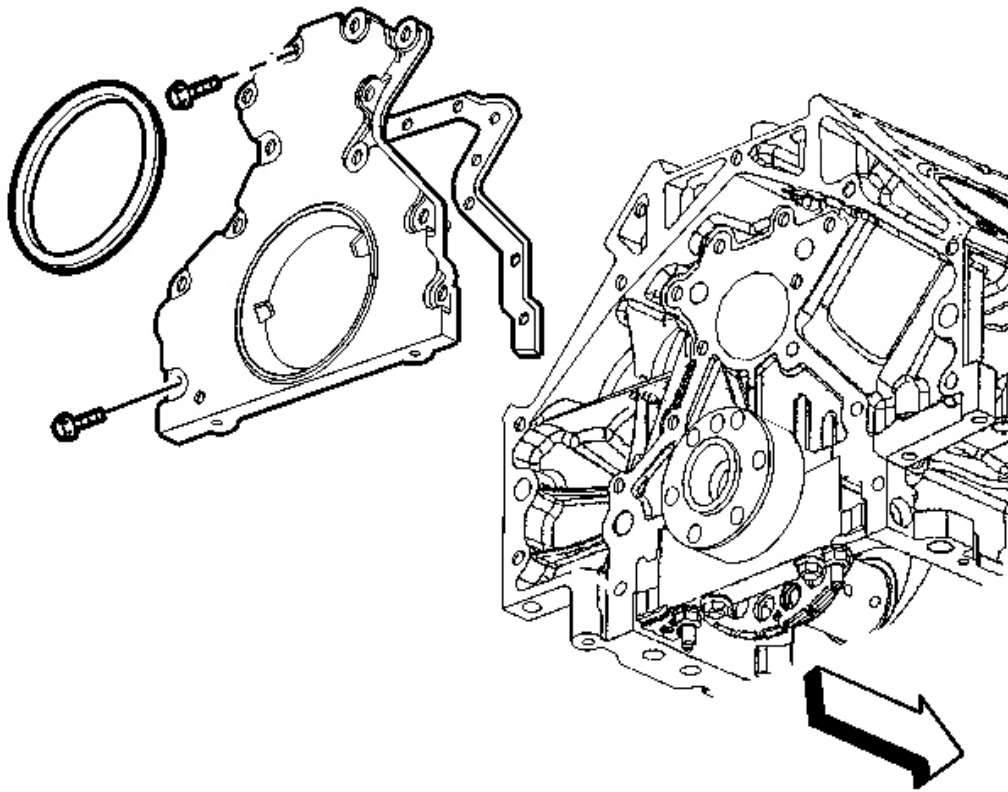


**Fig. 614: Engine Block Rear Oil Gallery Plug**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

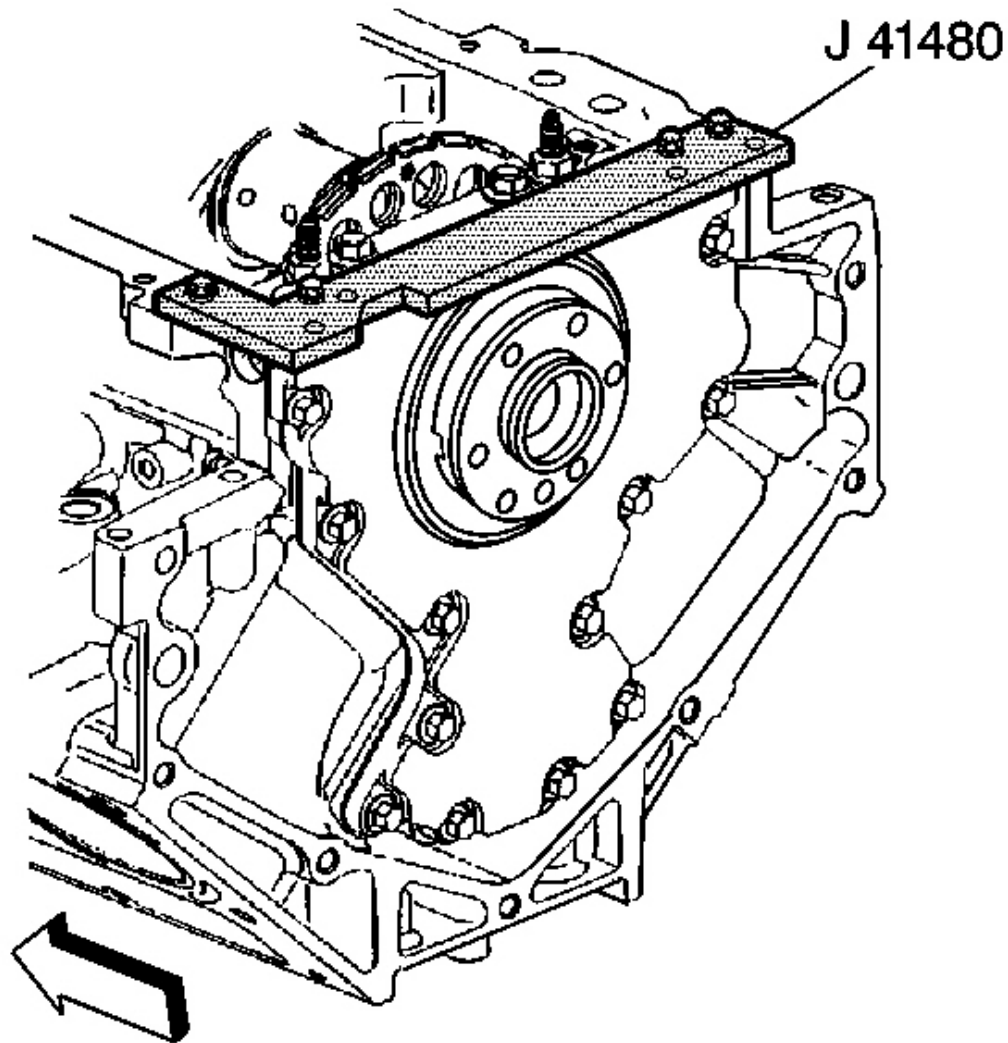
- Do not use the crankshaft rear oil seal or the engine rear cover gasket again.
- Do not apply any type sealant to the rear cover gasket, unless specified.
- The special tools in this procedure are used to properly align the engine rear cover at the oil pan surface and to center the crankshaft rear oil seal.
- The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned. Install the rear cover without the crankshaft oil seal.
  - The crankshaft rear oil seal **MUST** be centered in relation to the crankshaft.
  - The oil pan sealing surface at the rear cover and engine block **MUST** be aligned within specifications.
  - An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.

1. Inspect the rear oil gallery plug for proper installation.



**Fig. 615: Rear Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket, rear cover and bolts.
3. Tighten the bolts finger tight. Do not overtighten.



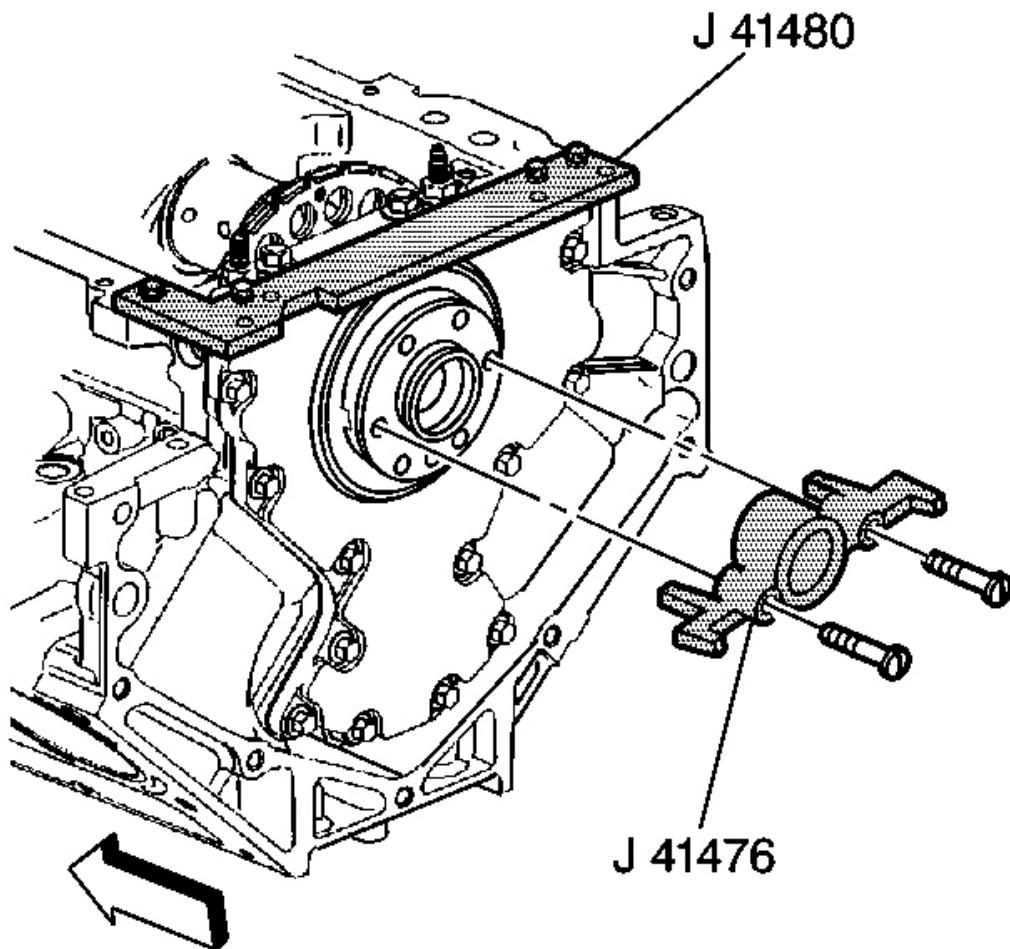
**Fig. 616: View Of J 41480 Installed**  
Courtesy of GENERAL MOTORS CORP.

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

**IMPORTANT:** Start the J 41480 tool-to-rear cover bolts. Do not tighten the bolts at this time. See Special Tools and Equipment .

4. Install the **J 41480** and bolts. See Special Tools and Equipment .

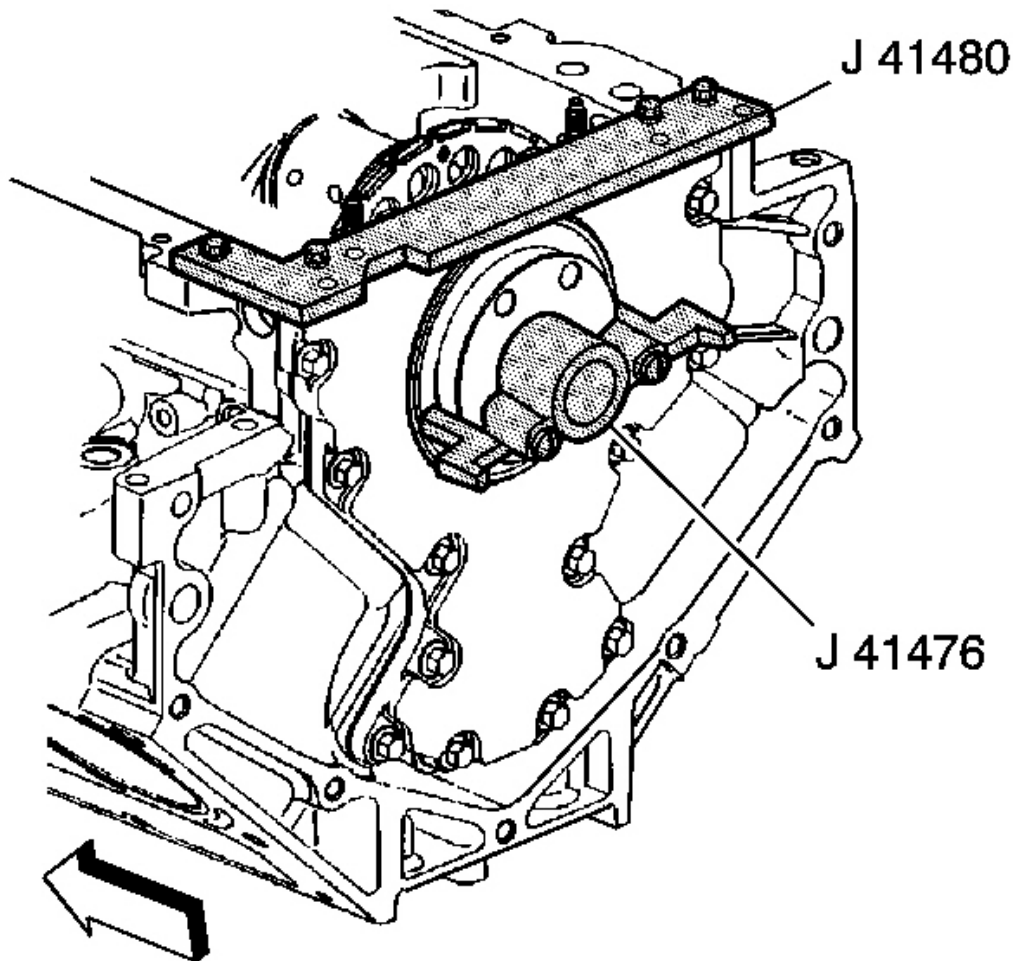
**Tighten:** Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).



**Fig. 617: View Of J 41480 & J 41476**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** To properly align the rear cover, the J 41476 must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface. See Special Tools and Equipment .

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.



**Fig. 618: View Of J 41480 & J 41476 Installed**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The tapered legs of the alignment tool must enter the rear cover oil seal bore.

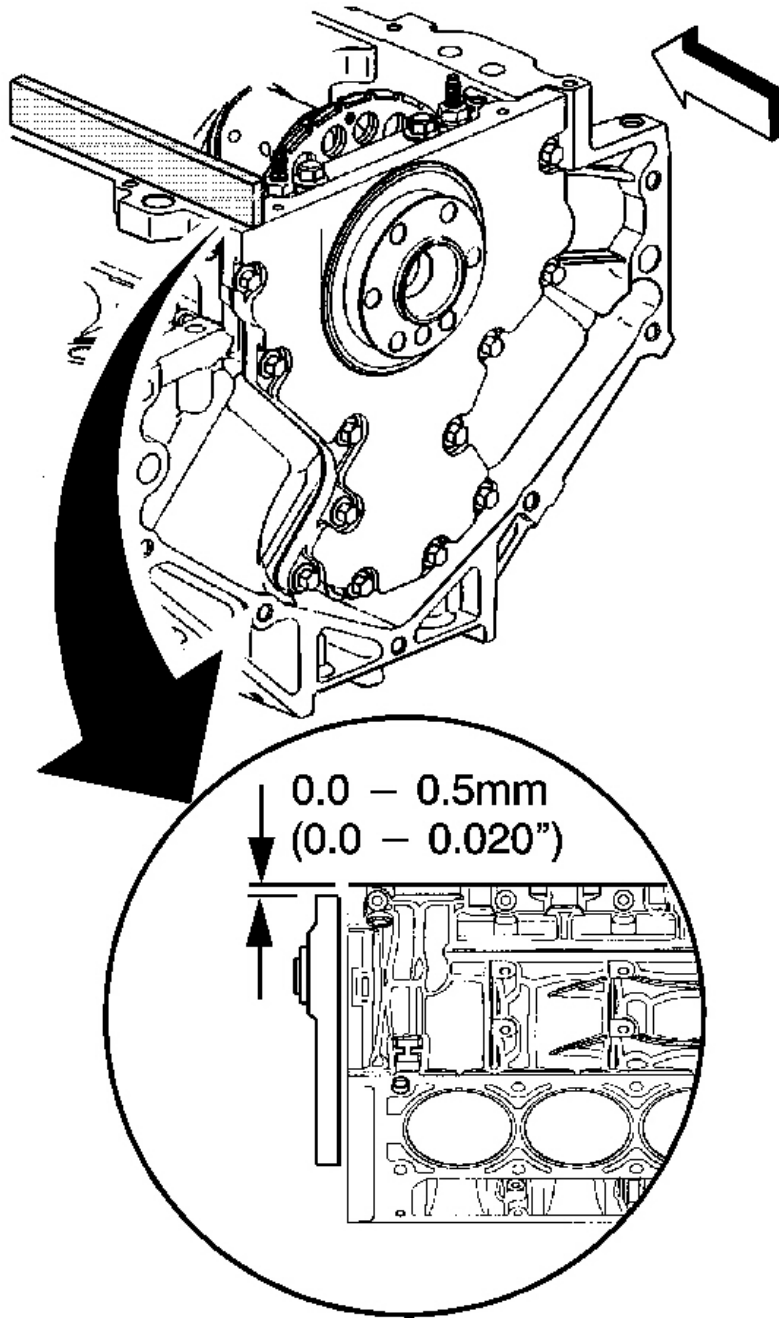
6. Install the **J 41476** and bolts onto the rear of the crankshaft. See Special Tools and Equipment .

**Tighten:**

1. Tighten the tool mounting bolts until snug. Do not overtighten.
2. Tighten the **J 41480** tool-to-rear cover bolts evenly to 12 N.m (106 lb in).
3. Tighten the rear cover bolts to 25 N.m (18 lb ft).



7. Remove the tools.



**Fig. 619: Rear Cover-To-Engine Block Proper Installation Position**  
Courtesy of GENERAL MOTORS CORP.

8. Measure the rear cover-to-engine block oil pan surface for flatness.
  1. Place a straight edge onto the engine block and rear cover oil pan sealing surfaces.

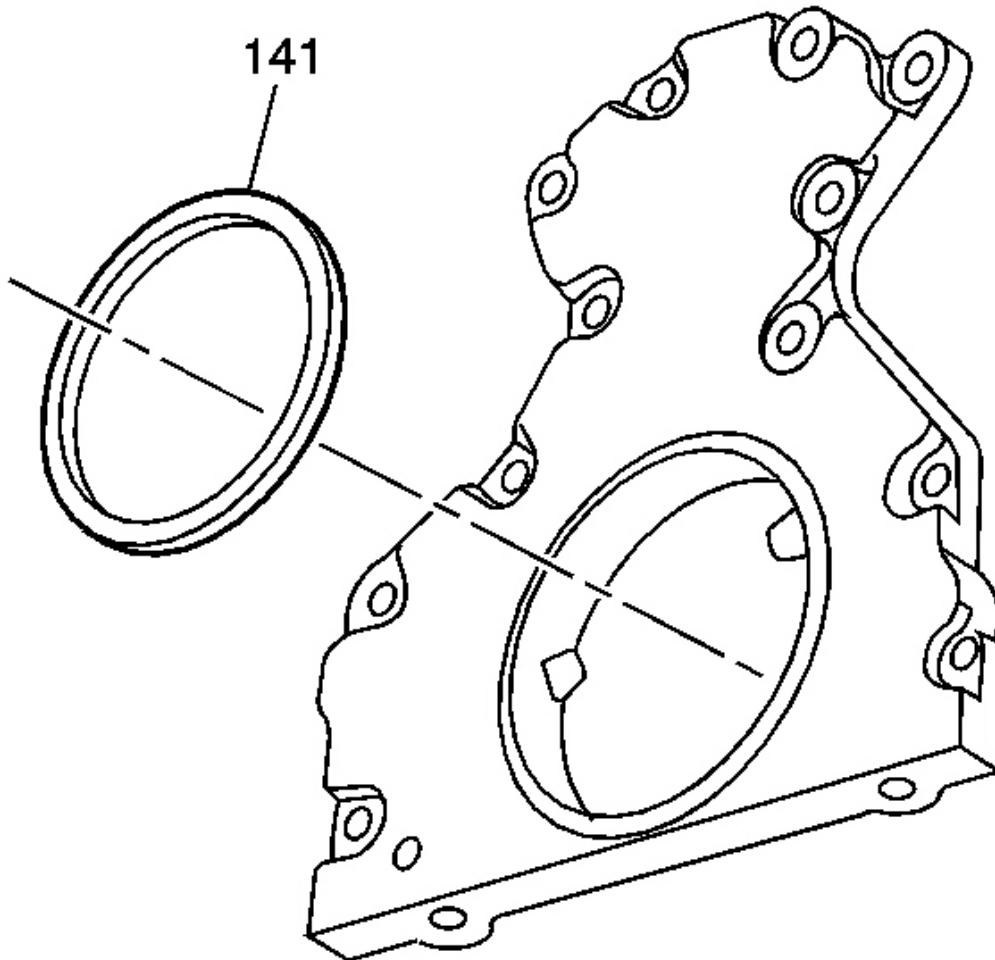
Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

2. Insert a feeler gauge between the rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
10. If the correct rear cover-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear cover.

## **CRANKSHAFT REAR OIL SEAL INSTALLATION**

### **Tools Required**

**J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools and Equipment** .



**Fig. 620: Crankshaft Rear Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

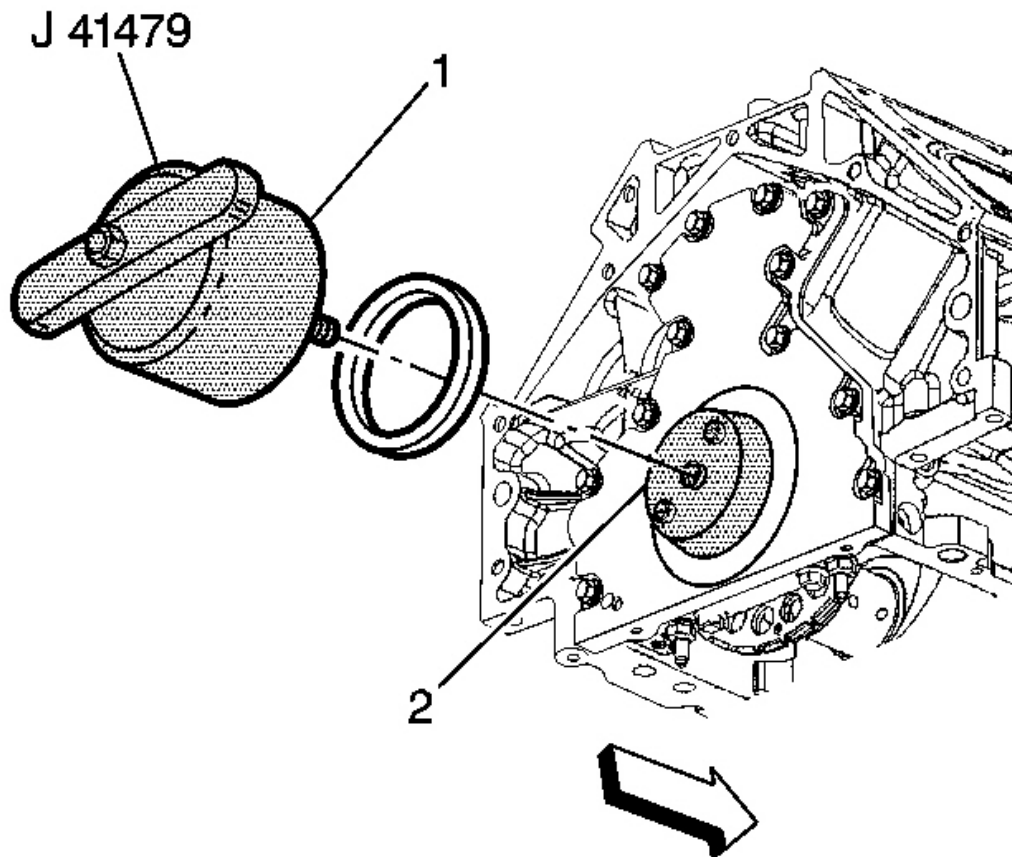
- Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.
- Do not use the crankshaft rear oil seal again.

1. Lubricate the outside diameter (OD) of the oil seal (141) with clean engine oil.

DO NOT allow oil or other lubricants to contact the seal surface.

2. Lubricate the rear cover oil seal bore with clean engine oil.

DO NOT allow oil or other lubricants to contact the crankshaft surface.



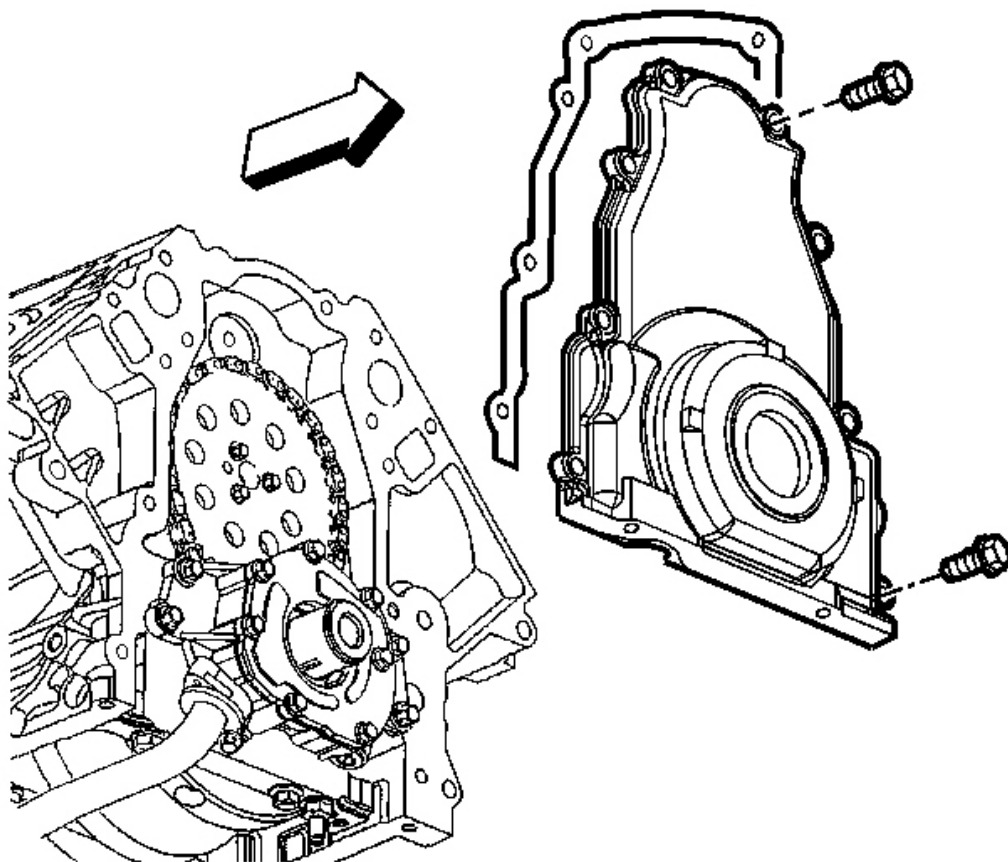
**Fig. 621: View Of J 41479**  
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools and Equipment** .
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools and Equipment** .
7. Align the oil seal onto the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the tool.

## ENGINE FRONT COVER INSTALLATION

### Tools Required

- **J 41480** Front and Rear Cover Alignment - Oil Pan Surface. See Special Tools and Equipment .
- **J 41476** Front and Rear Cover Alignment Tool - Crankshaft Oil Seal Area. See Special Tools and Equipment .



**Fig. 622: Front Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

### IMPORTANT:

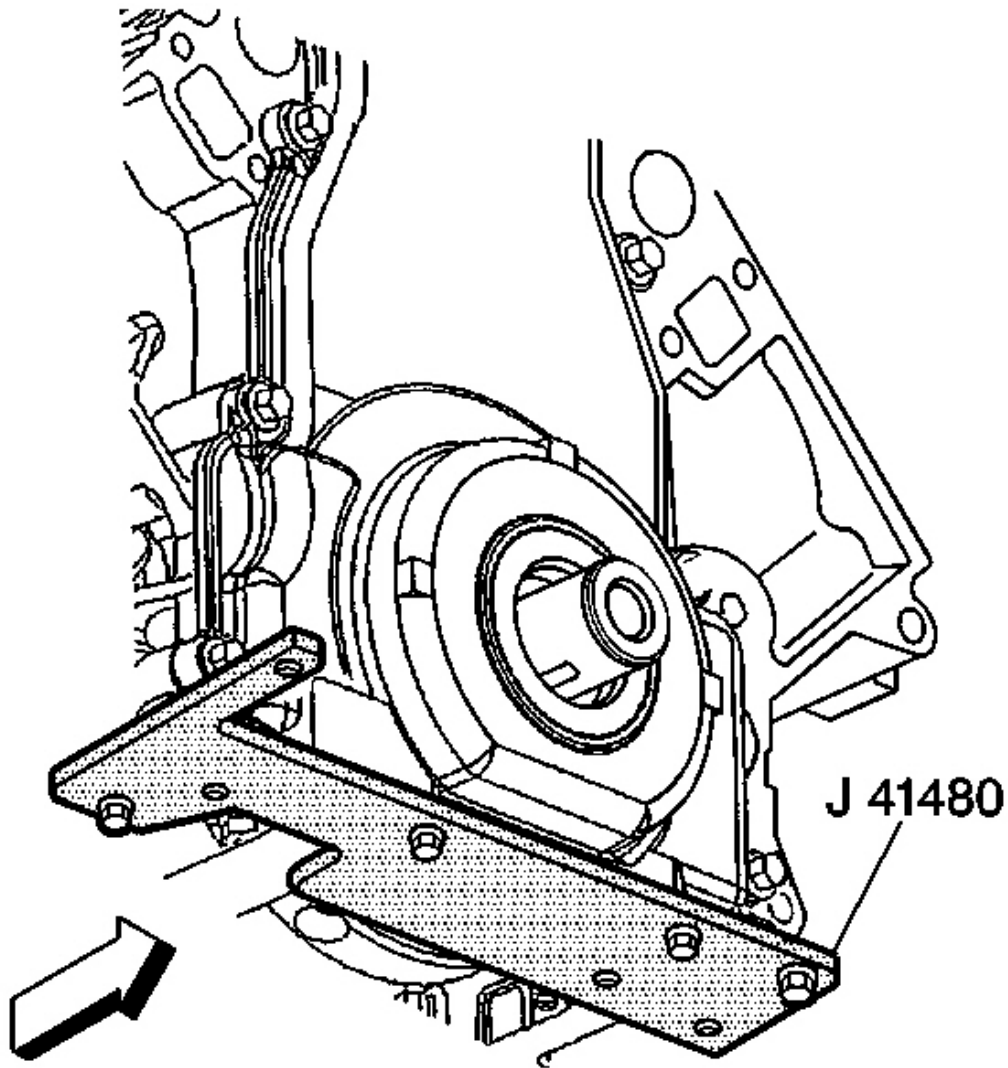
- Do not use the crankshaft oil seal or the engine front cover gasket again.
- Do not apply any type sealant to the front cover gasket, unless specified.

- **The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.**
  - **All gasket surfaces should be free of oil or other foreign material during assembly.**

**The crankshaft front oil seal MUST be centered in relation to the crankshaft.**

- **The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.**
- **An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.**

1. Install the front cover gasket, cover, and bolts onto the engine.
2. Tighten the cover bolts finger tight. Do not overtighten.



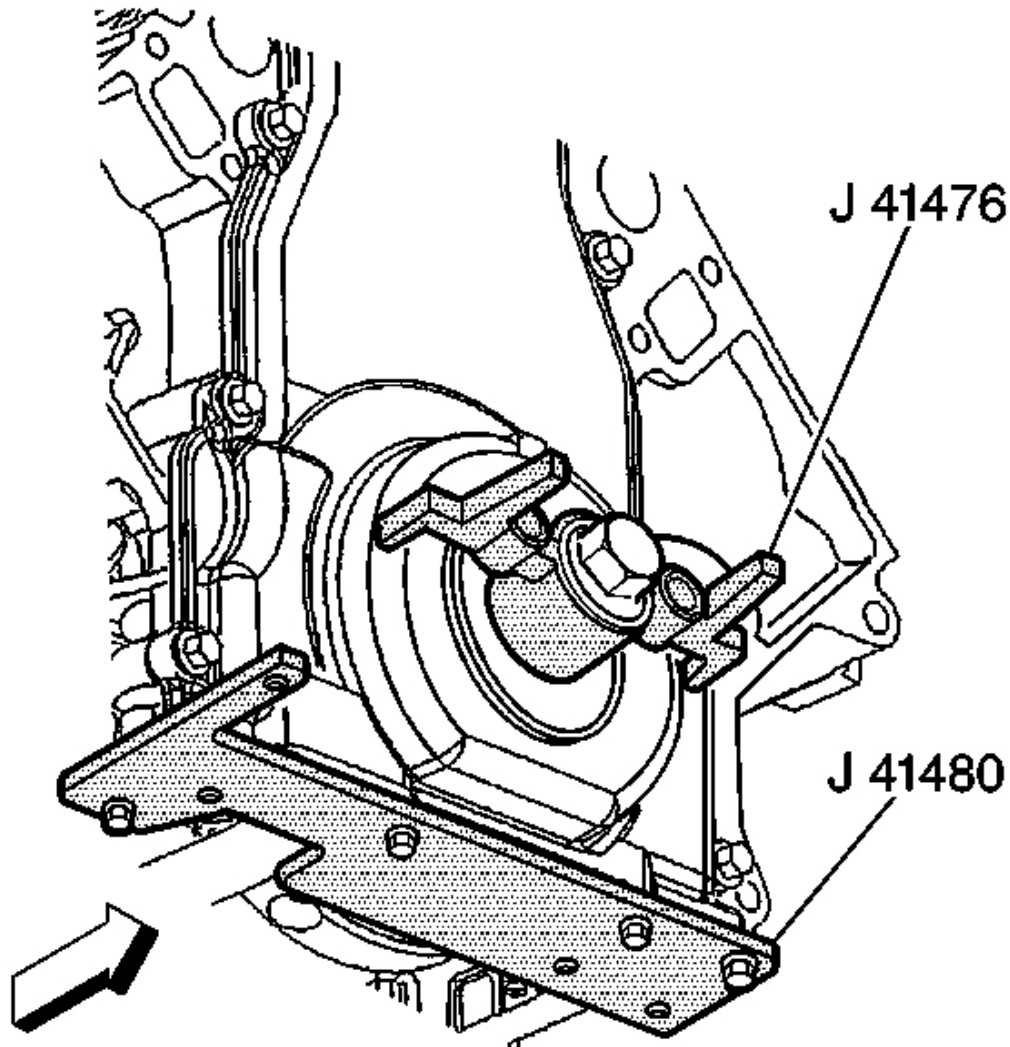
**Fig. 623: View Of J 41480 Installed**  
Courtesy of GENERAL MOTORS CORP.

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

**IMPORTANT:** Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

3. Install the J 41480 . See Special Tools and Equipment .

**Tighten:** Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).



**Fig. 624: View Of J 41476 & J 41480 Installed**  
Courtesy of GENERAL MOTORS CORP.

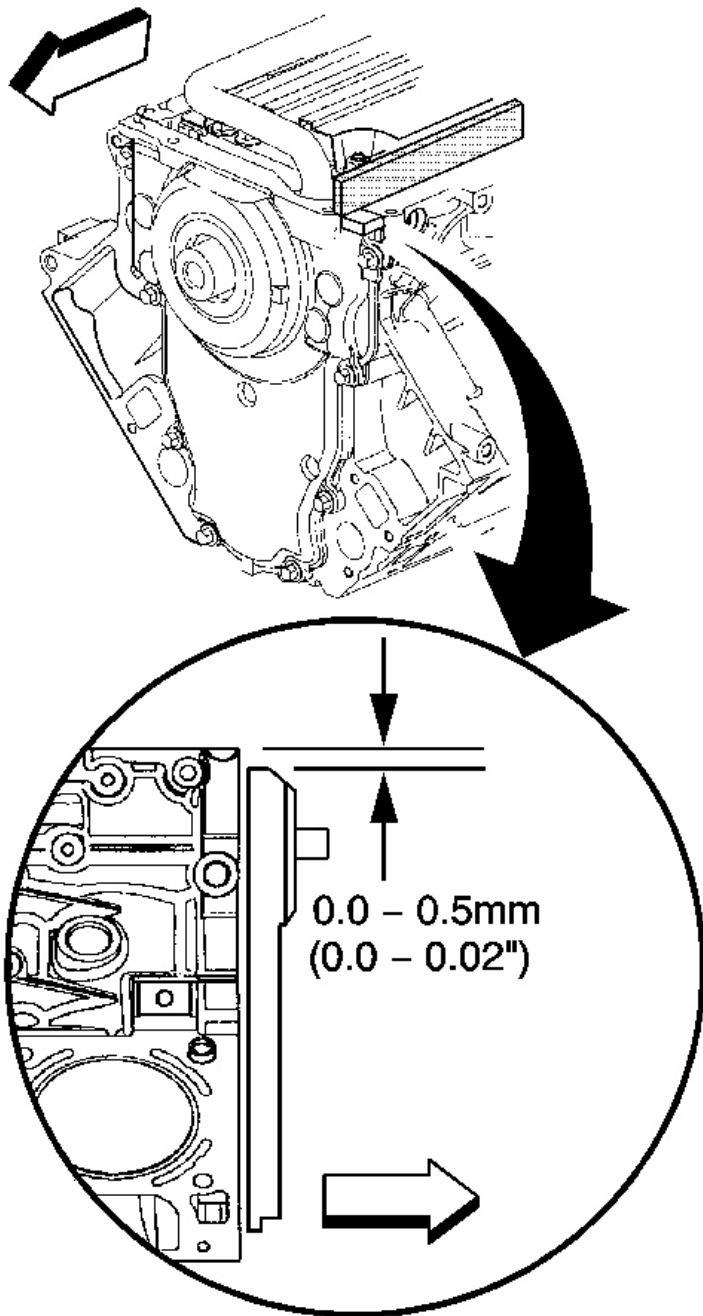
**IMPORTANT:** Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

4. Install the J 41476 . See Special Tools and Equipment .
5. Install the crankshaft balancer bolt.



**Tighten:**

1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
  2. Tighten the **J 41480** . See **Special Tools and Equipment** .
  3. Tighten the engine front cover bolts to 25 N.m (18 lb ft).
- 
6. Remove the tools.



**Fig. 625: Front Cover-To-Engine Block Proper Installation Position**  
Courtesy of GENERAL MOTORS CORP.

7. Measure the oil pan surface flatness, front cover-to-engine block.

1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

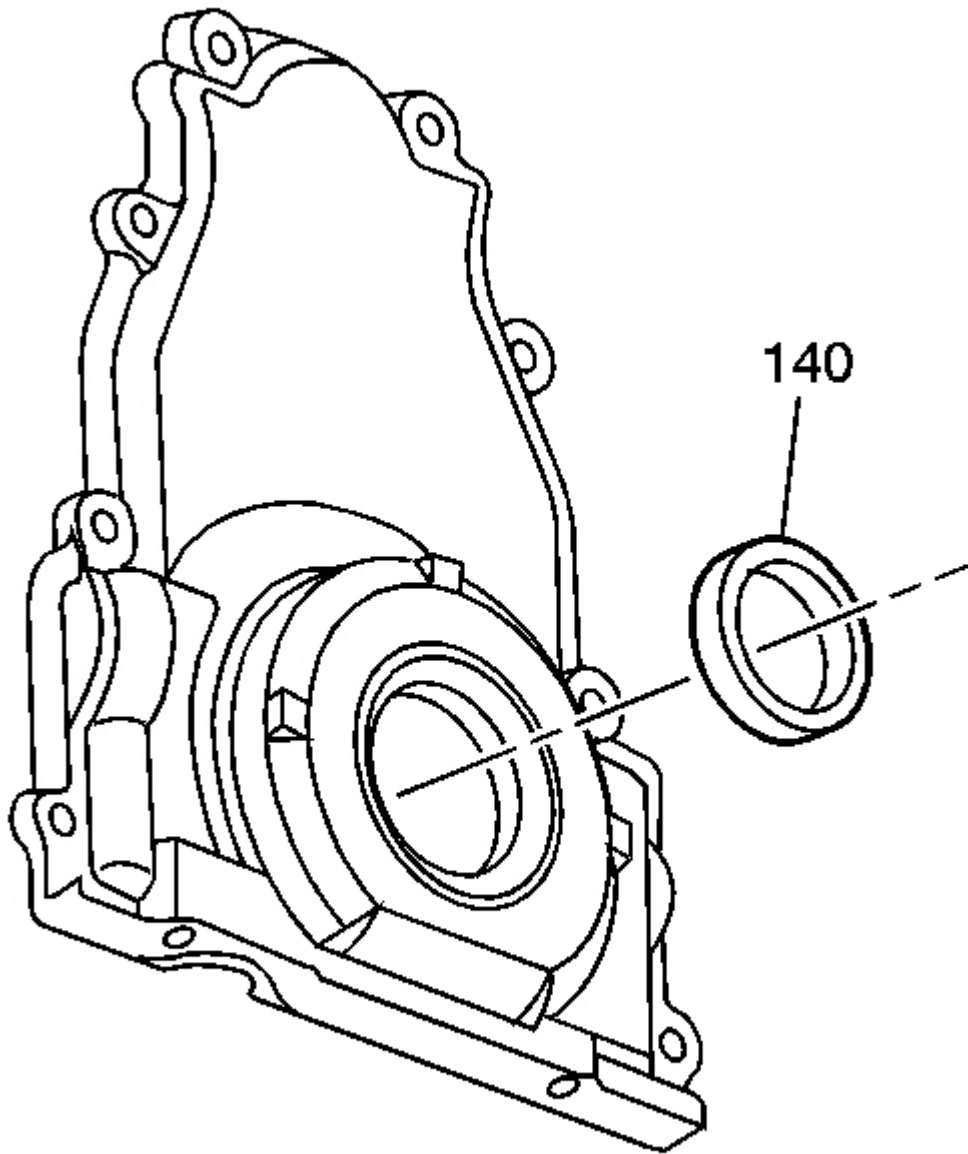
Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

2. Insert a feeler gauge between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no more than 0.5 mm (0.02 in) below flush.
8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.

## **CRANKSHAFT FRONT OIL SEAL INSTALLATION**

### **Tools Required**

**J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools and Equipment** .

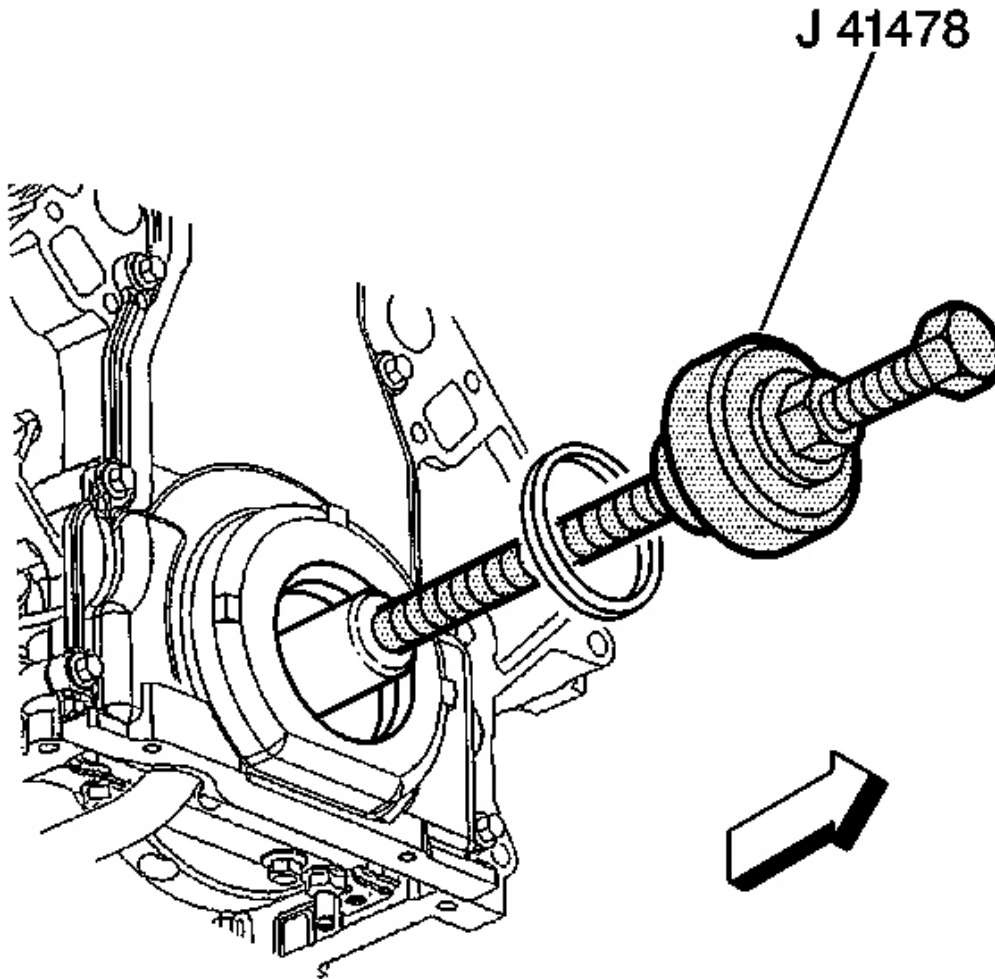


**Fig. 626: Crankshaft Front Oil Seal**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Do not lubricate the oil seal sealing surface.
- Do not use the crankshaft front oil seal again.

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

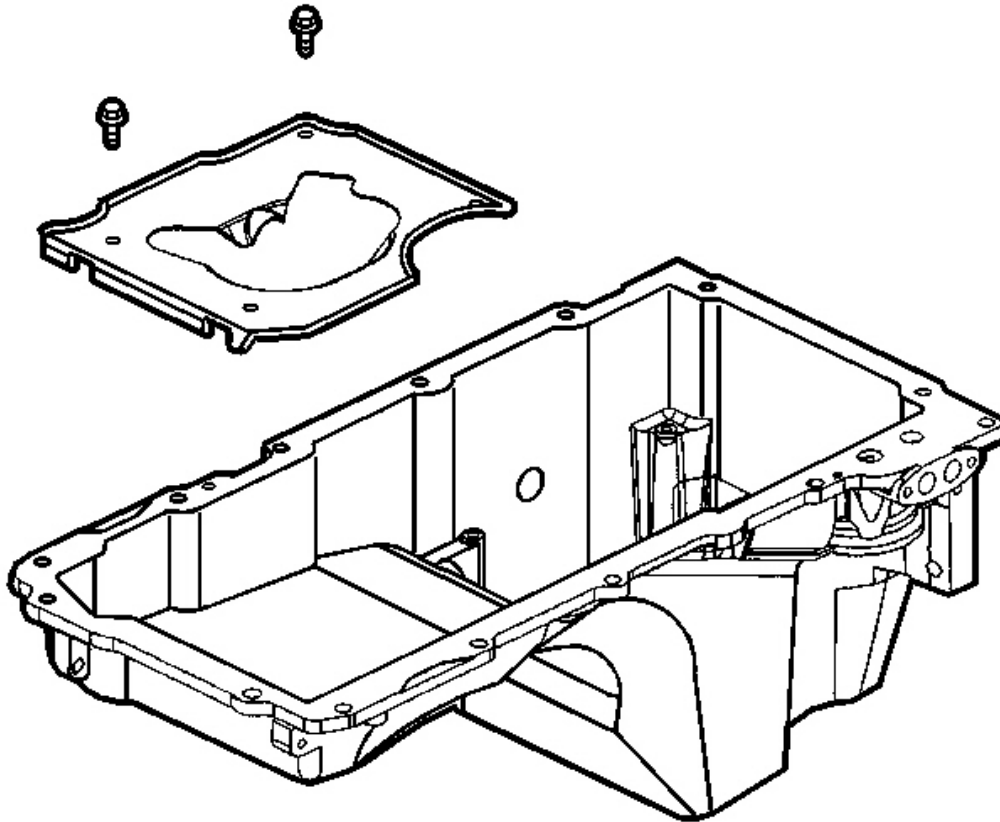


**Fig. 627: View Of J 41478**  
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal onto the **J 41478** guide. See **Special Tools and Equipment** .
4. Install the **J 41478** threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft. See **Special Tools and Equipment** .
5. Use the **J 41478** in order to install the oil seal into the cover bore. See **Special Tools and Equipment** .
  1. Use a wrench and hold the hex on the installer bolt.

2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
3. Remove the tool.
4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

## OIL PAN INSTALLATION



**Fig. 628: Oil Pan Baffle & Bolts**  
Courtesy of GENERAL MOTORS CORP.

### **IMPORTANT:**

- The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must **NEVER** protrude beyond the engine block and transmission housing

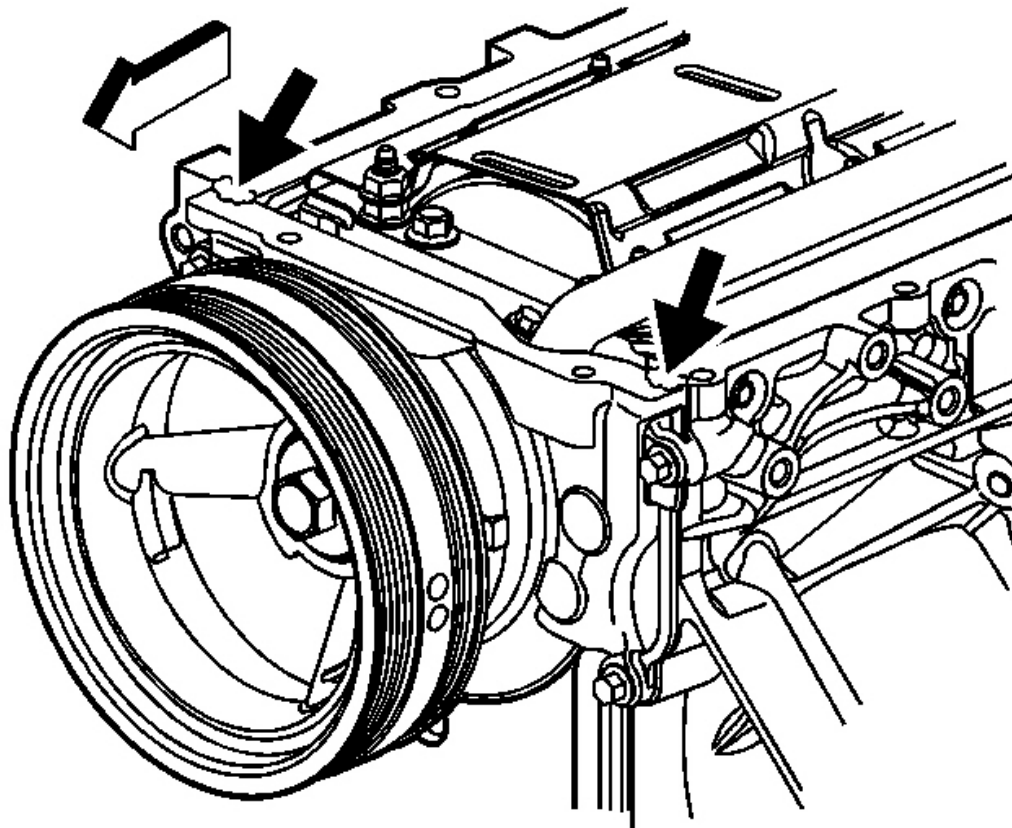
plane.

- Do not use the oil pan gasket again.
- It is not necessary to rivet the NEW gasket to the oil pan.
- It is not necessary to remove the oil level sensor prior to oil pan installation.

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

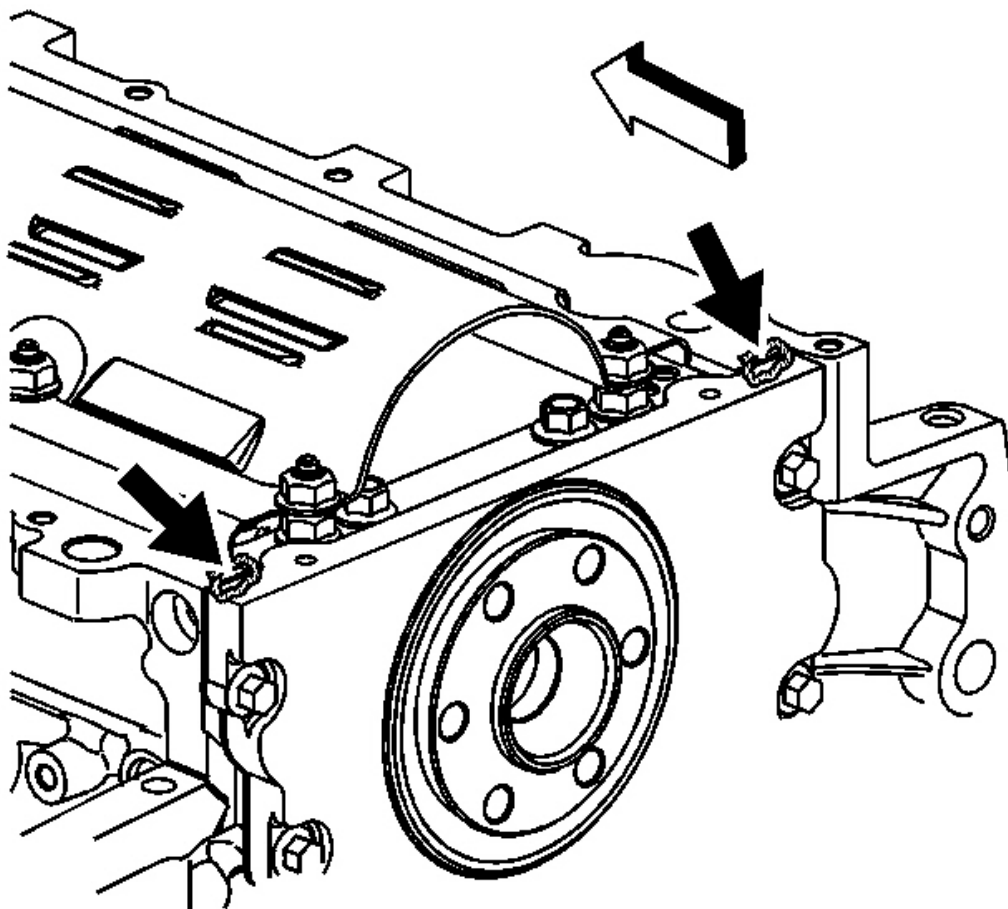
1. Install the oil pan baffle and bolts, if previously removed.

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



**Fig. 629: Sealant On Engine Front Cover Gasket Tabs**  
Courtesy of GENERAL MOTORS CORP.

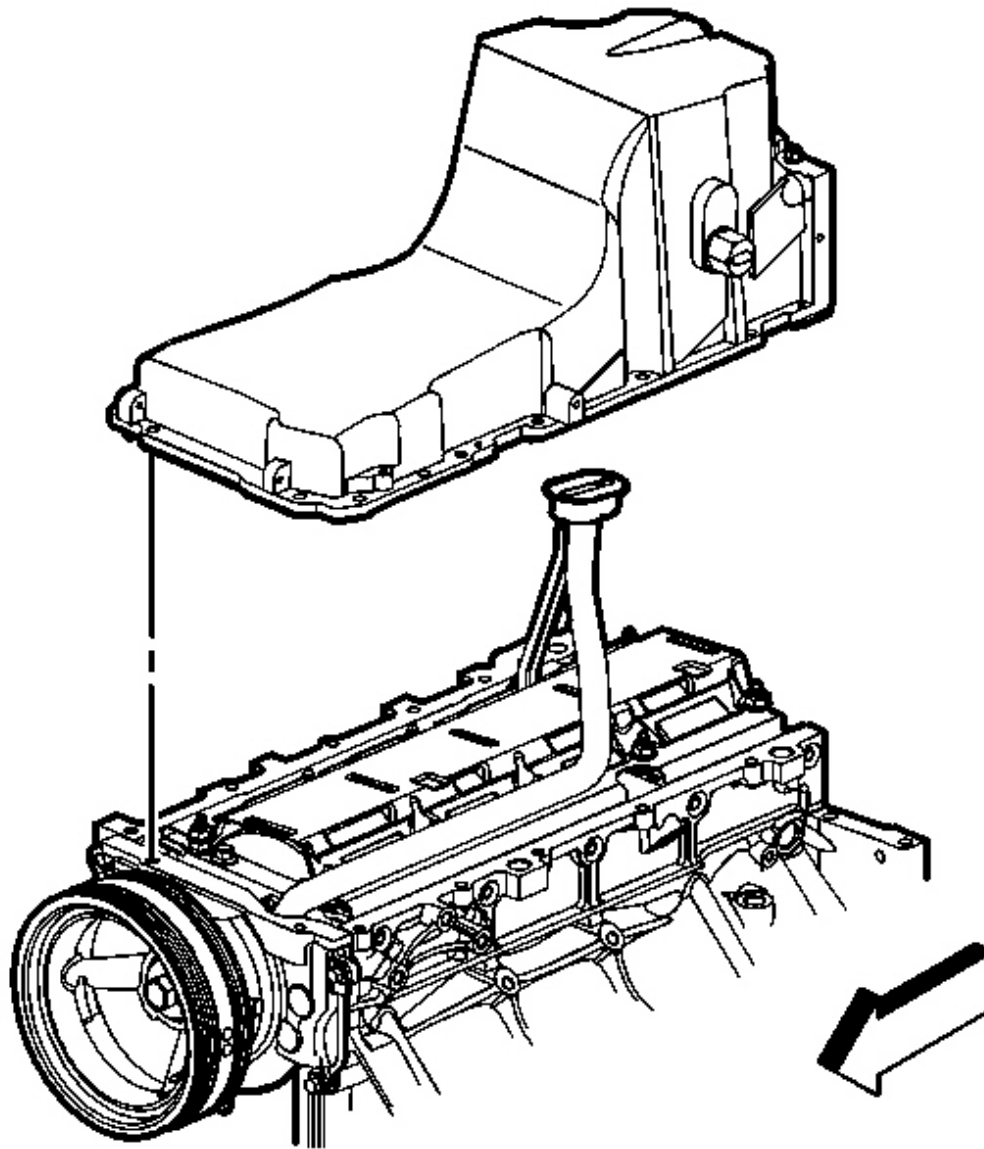
2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to [Sealers, Adhesives, and Lubricants](#) .



**Fig. 630: Sealant On Engine Rear Cover Gasket Tabs**  
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrude into the oil pan surface.



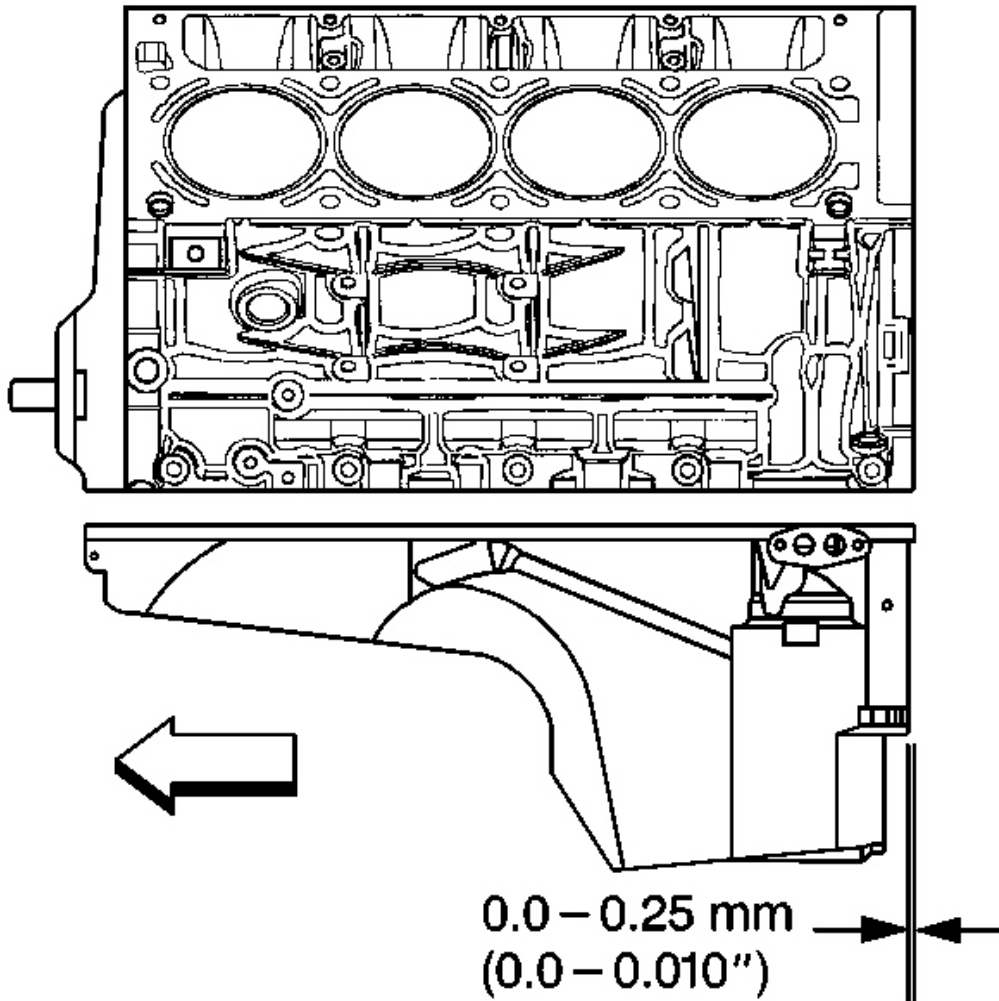


**Fig. 631: View Of Oil Pan**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

1. Install the gasket onto the oil pan.
2. Install the oil pan bolts to the pan and through the gasket.
5. Install the oil pan, gasket and bolts to the engine block.
6. Tighten bolts finger tight. Do not overtighten.
7. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.



**Fig. 632: Aligning Oil Pan**  
Courtesy of GENERAL MOTORS CORP.

8. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.

**Tighten:**

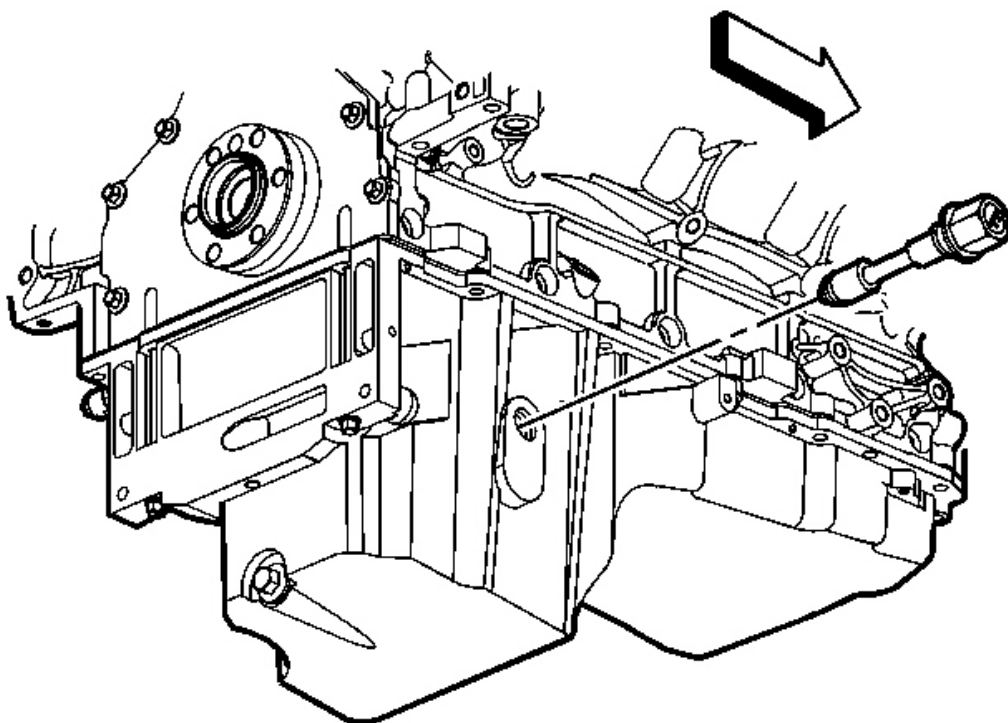
1. Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N.m (18 lb ft).
2. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).

9. Measure the oil pan-to-engine block alignment.

1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

**IMPORTANT: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.**

2. Insert a feeler gauge between the straight edge and the oil pan transmission housing mounting surface and check to make sure that there is no more than a 0.25 mm (0.01 in) gap between the pan and straight edge.
3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

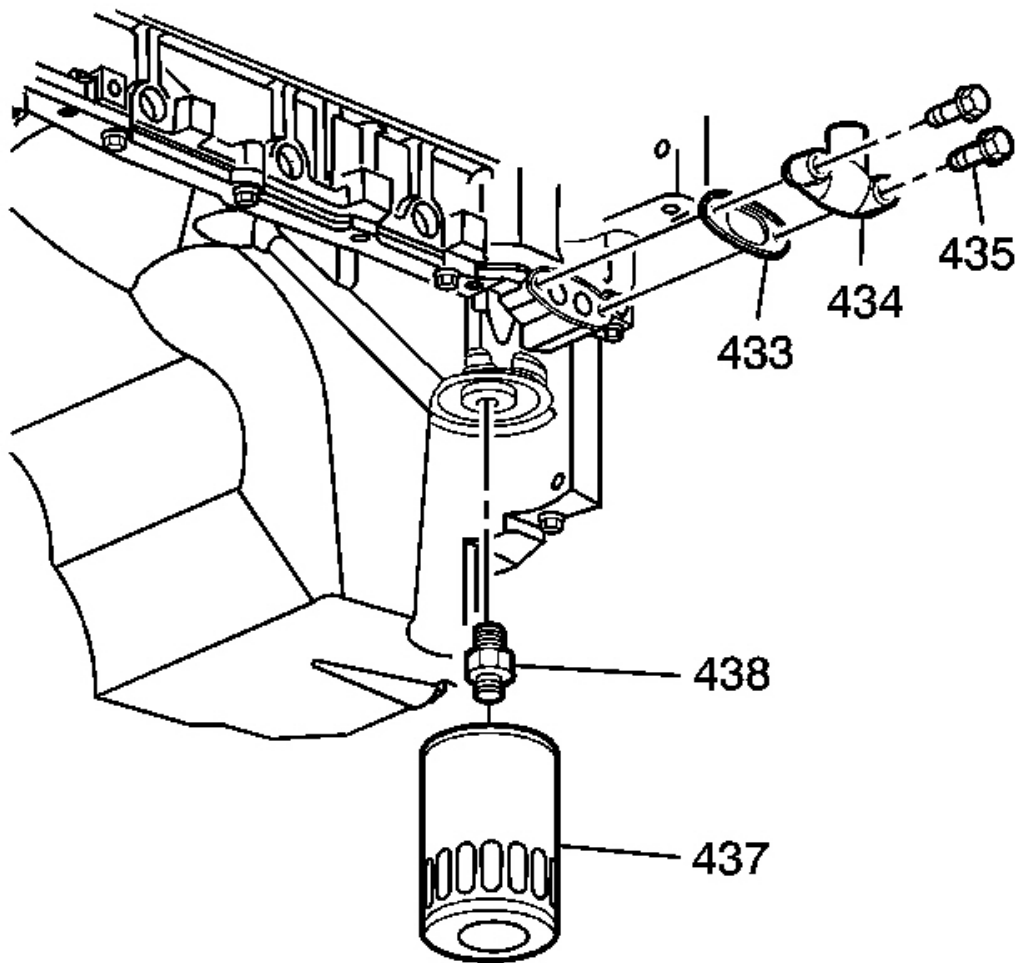


**Fig. 633: Oil Level Sensor**  
Courtesy of GENERAL MOTORS CORP.

10. Install the oil level sensor.

**Tighten:** Tighten the oil level sensor to 13 N.m (115 lb in).

#### **OIL FILTER, ADAPTER, PAN COVER INSTALLATION**

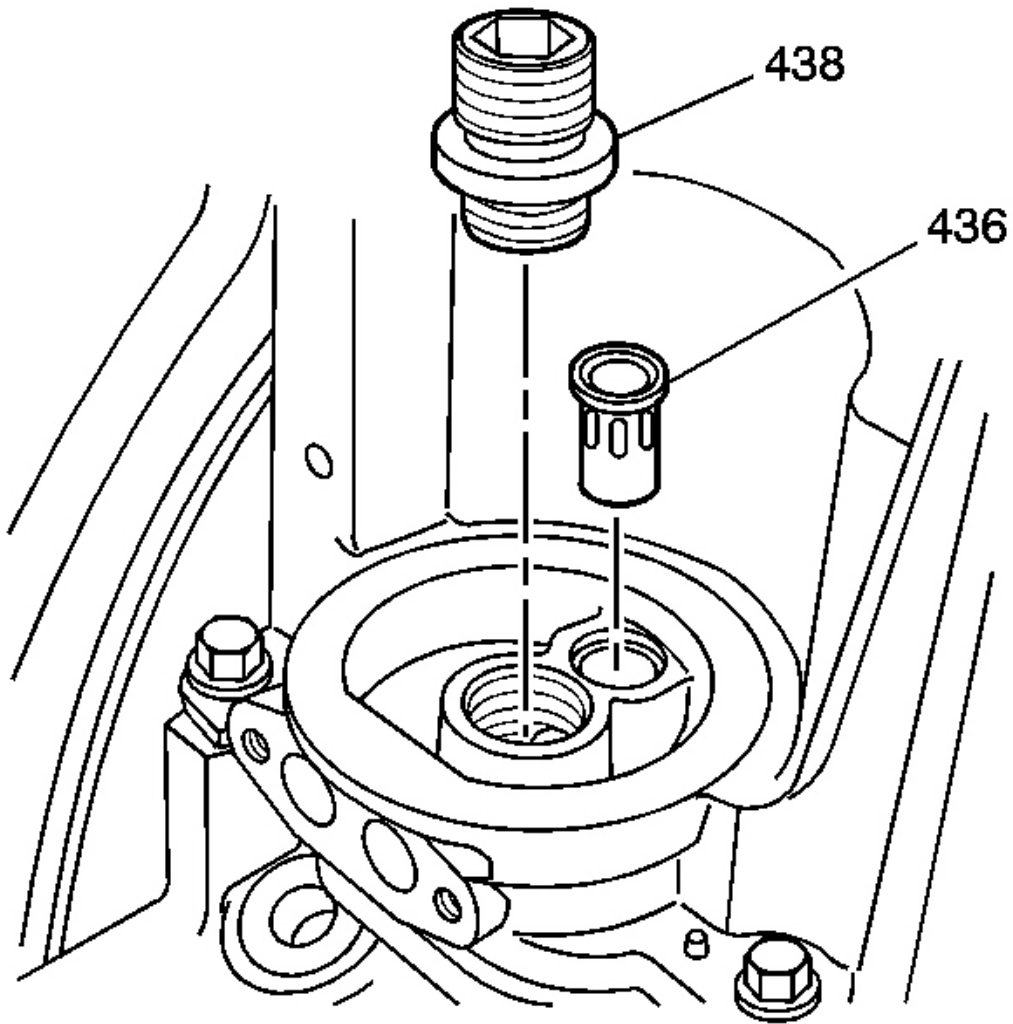


**Fig. 634: Oil Pan Cover, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil pan cover (434), bolts (435), and a NEW oil pan cover gasket (433).

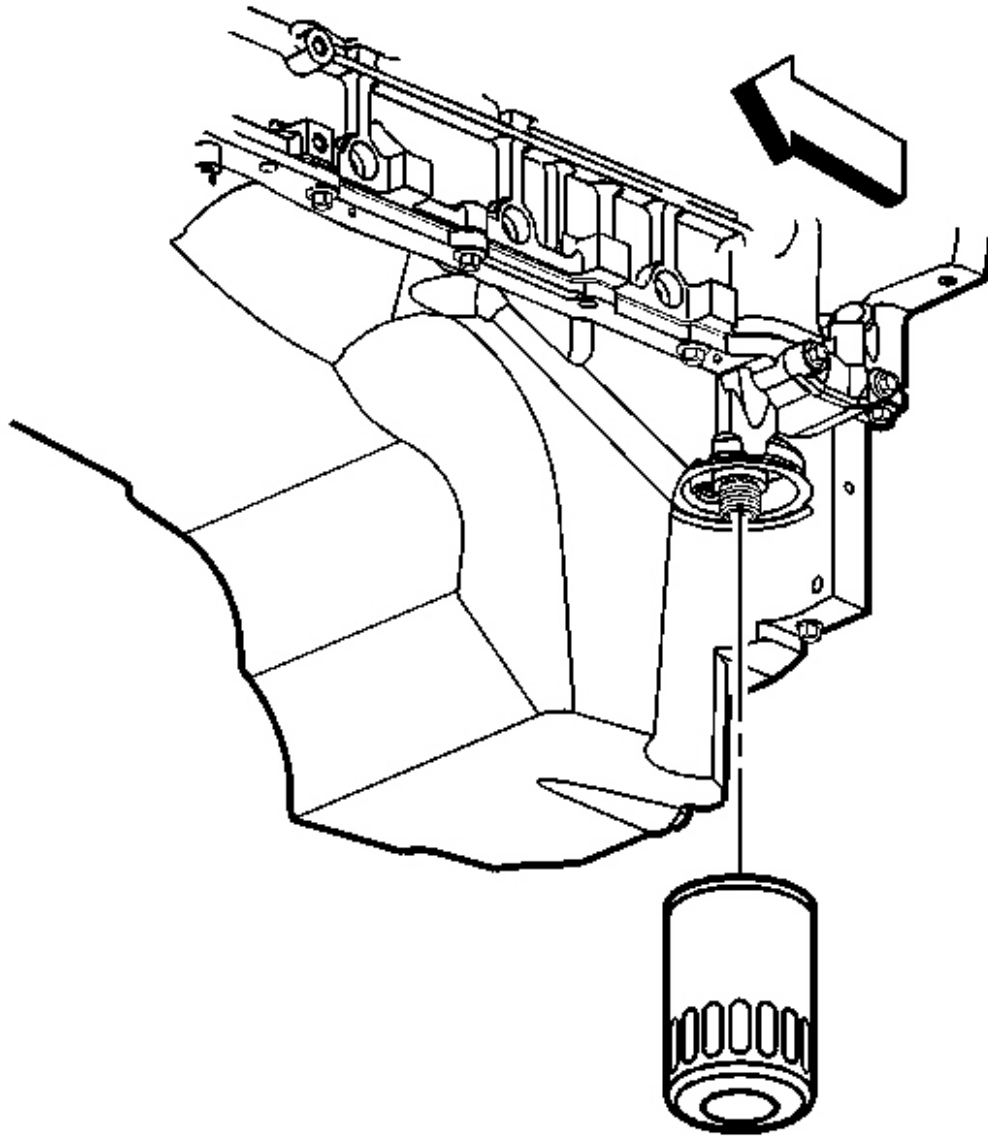
**Tighten:** Tighten the oil pan cover bolts to 12 N.m (106 lb in).



**Fig. 635: Oil Filter Fitting & Bypass Valve**  
Courtesy of GENERAL MOTORS CORP.

2. Install a new oil filter bypass valve (436) into the oil pan, if required.
3. Install the oil filter fitting (438).

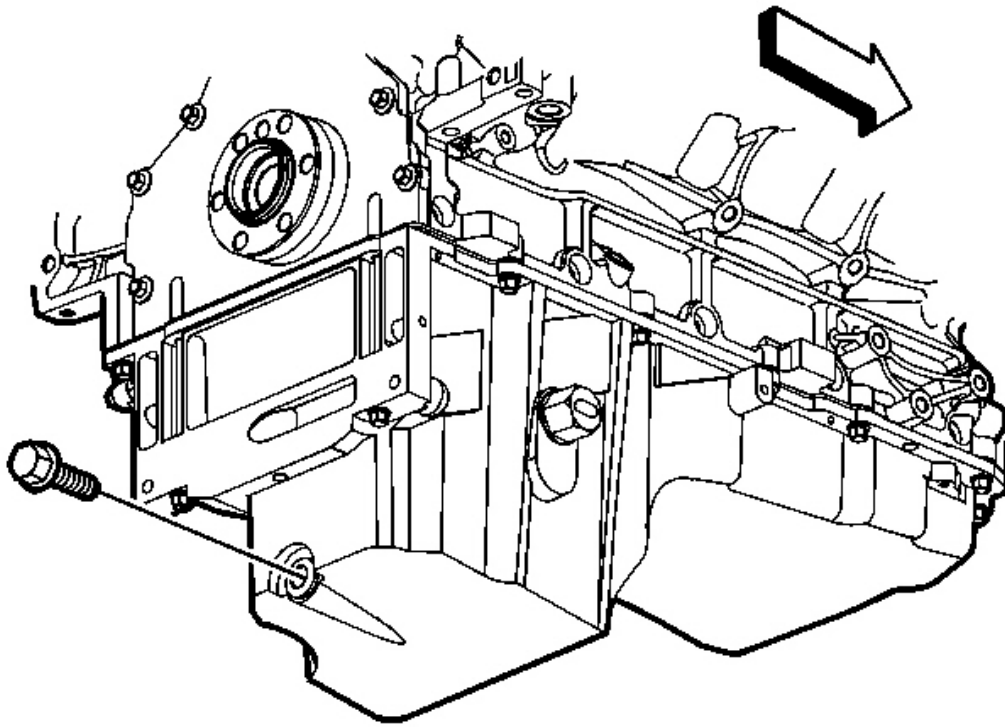
**Tighten:** Tighten the oil filter fitting to 55 N.m (40 lb ft).



**Fig. 636: View Of Engine Oil Filter**  
Courtesy of GENERAL MOTORS CORP.

4. Lubricate the oil filter seal with clean engine oil.
5. Install the oil filter.

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



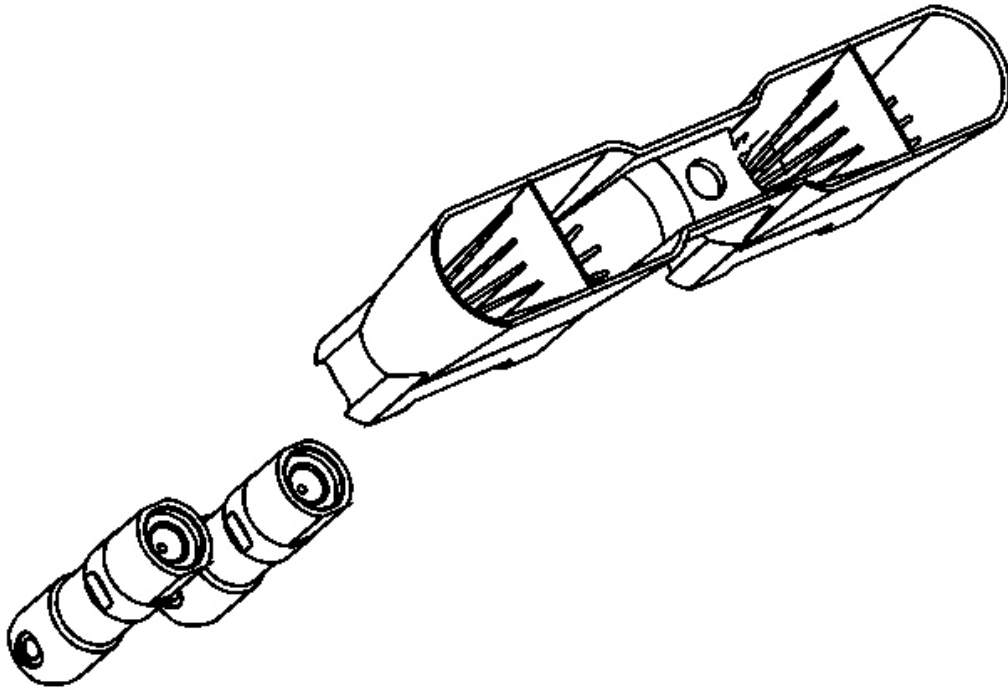
**Fig. 637: Oil Pan Drain Plug & O-Ring Seal**  
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug.

**Tighten:** Tighten the oil pan drain plug to 25 N.m (18 lb ft).

## VALVE LIFTER INSTALLATION





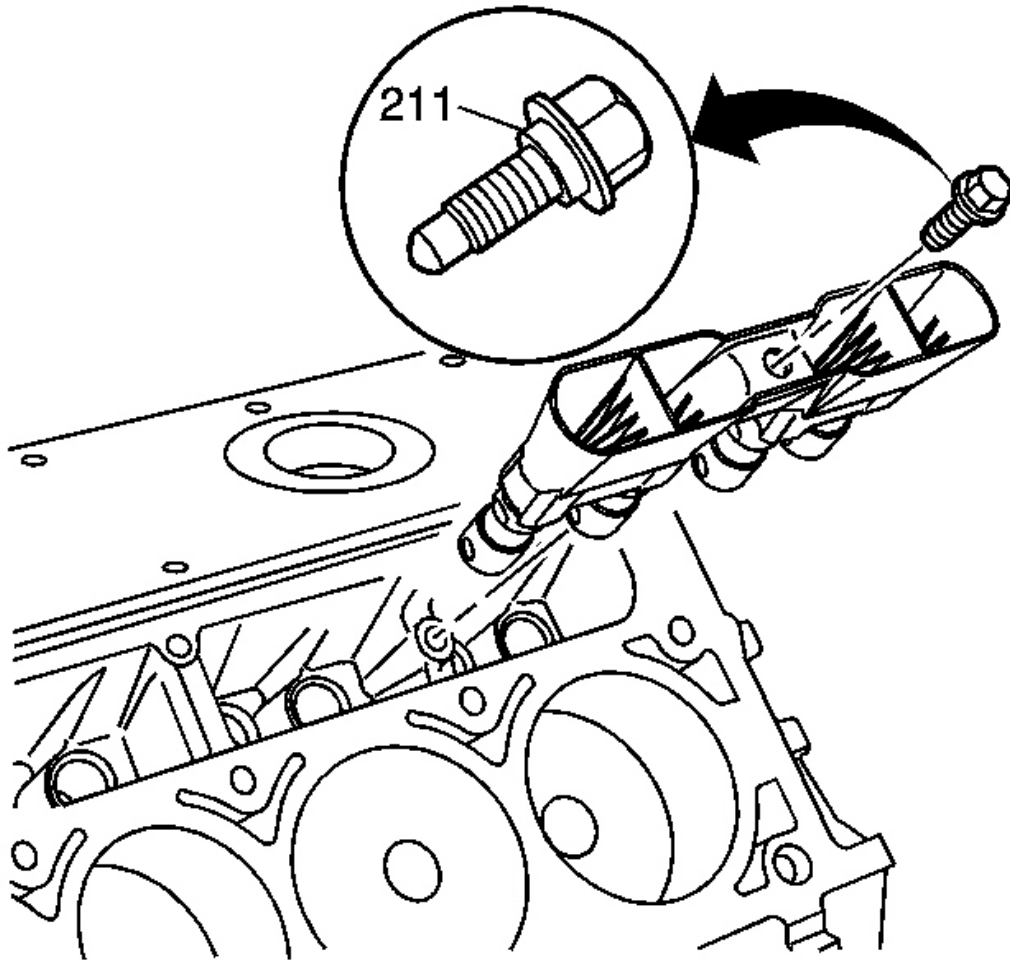
**Fig. 638: Valve Lifters & Lifter Guides**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- When using the valve lifters again, install the lifters to their original locations.
- If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the valve lifters and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides.

Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.



**Fig. 639: Valve Lifters, Guide & Guide Bolts**  
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifters and guide assembly to the engine block.

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

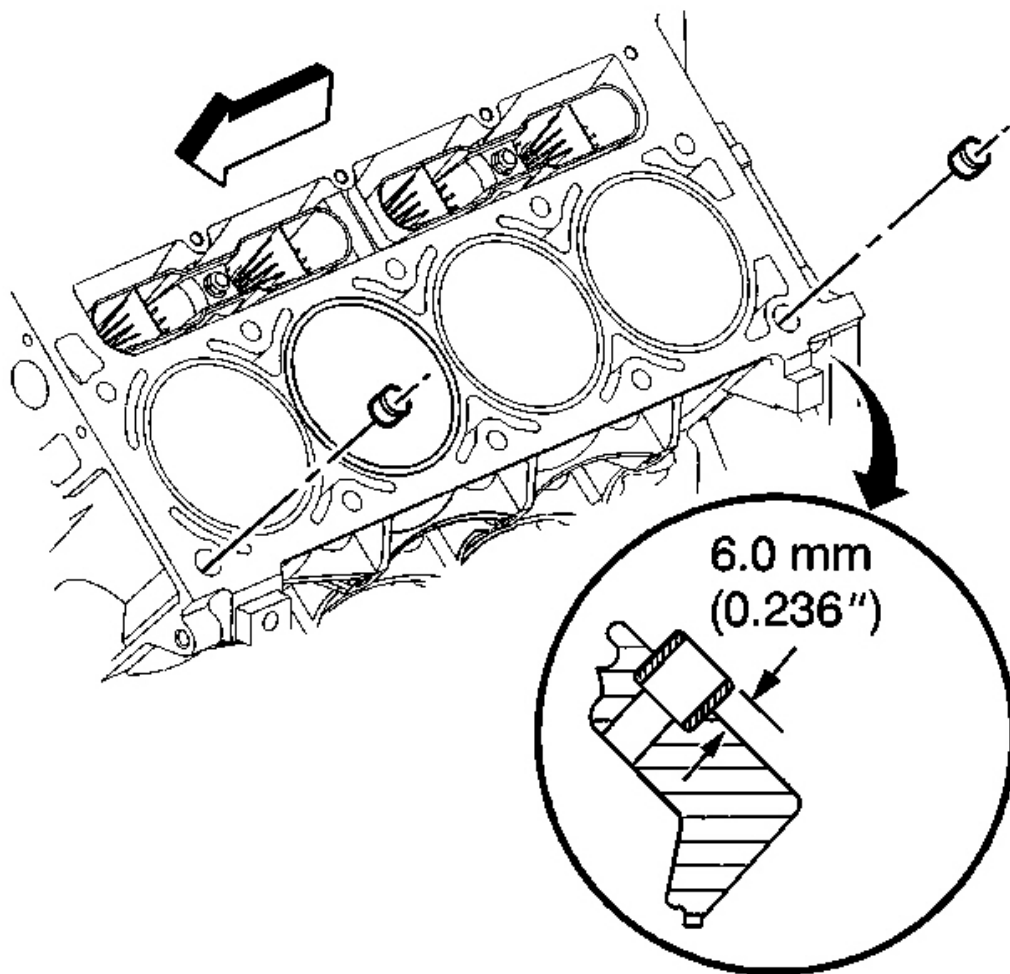
4. Install the valve lifter guide bolt (211).

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

**CYLINDER HEAD INSTALLATION - LEFT**

## Tools Required

- J 42385-100 Head/Main Bolt Thread Repair Kit. See Special Tools and Equipment .
- J 45059 Angle Meter. See Special Tools and Equipment .



**Fig. 640: Cylinder Head Locating Pins Installation Position**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

**NOTE:** Clean all dirt, debris, and coolant from the engine block cylinder head bolt

**holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.**

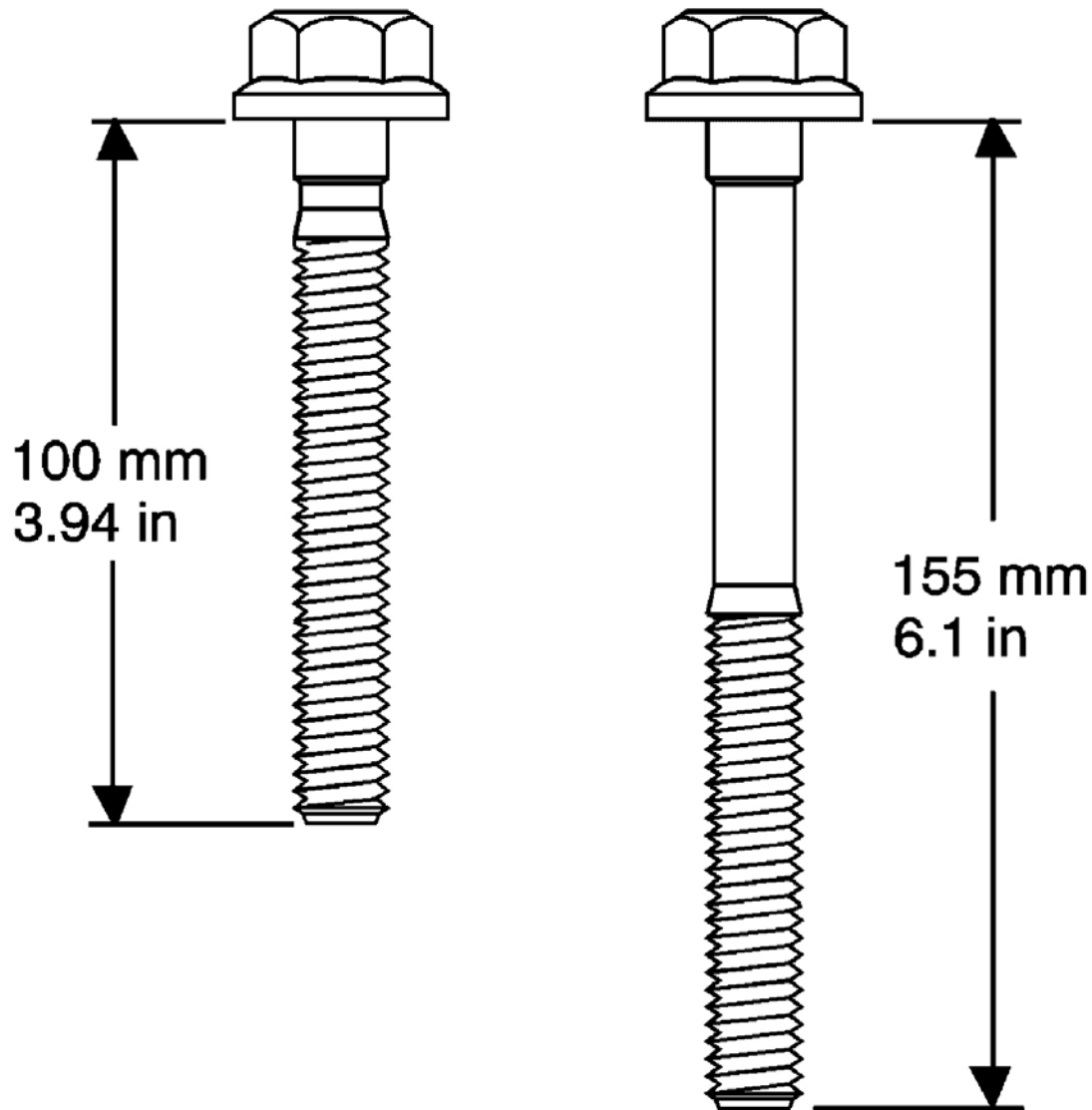
**IMPORTANT:**

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type sealant on the cylinder head gasket, unless specified.**
- **The cylinder head gaskets must be installed in the proper direction and position.**

1. Clean the engine block cylinder head bolt holes, if required.

Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

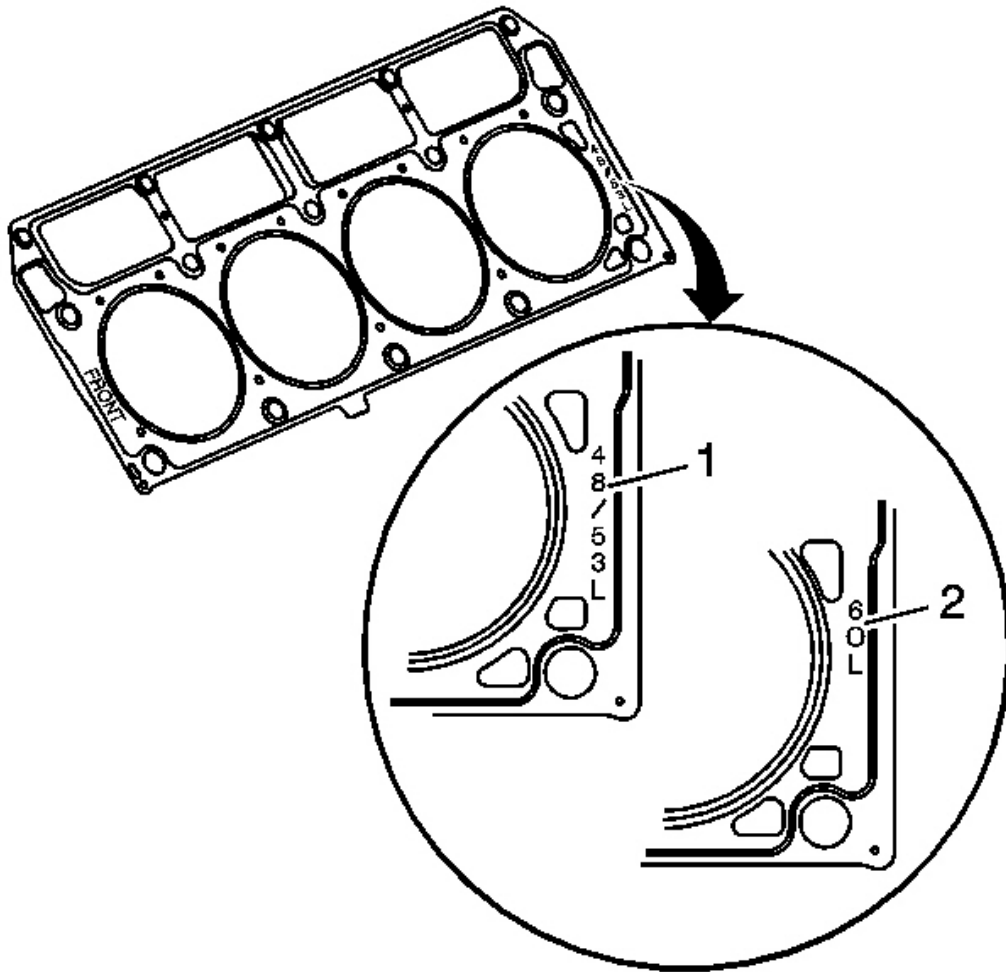
2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.



**Fig. 641: 100 mm & 155 mm Bolts**  
Courtesy of GENERAL MOTORS CORP.

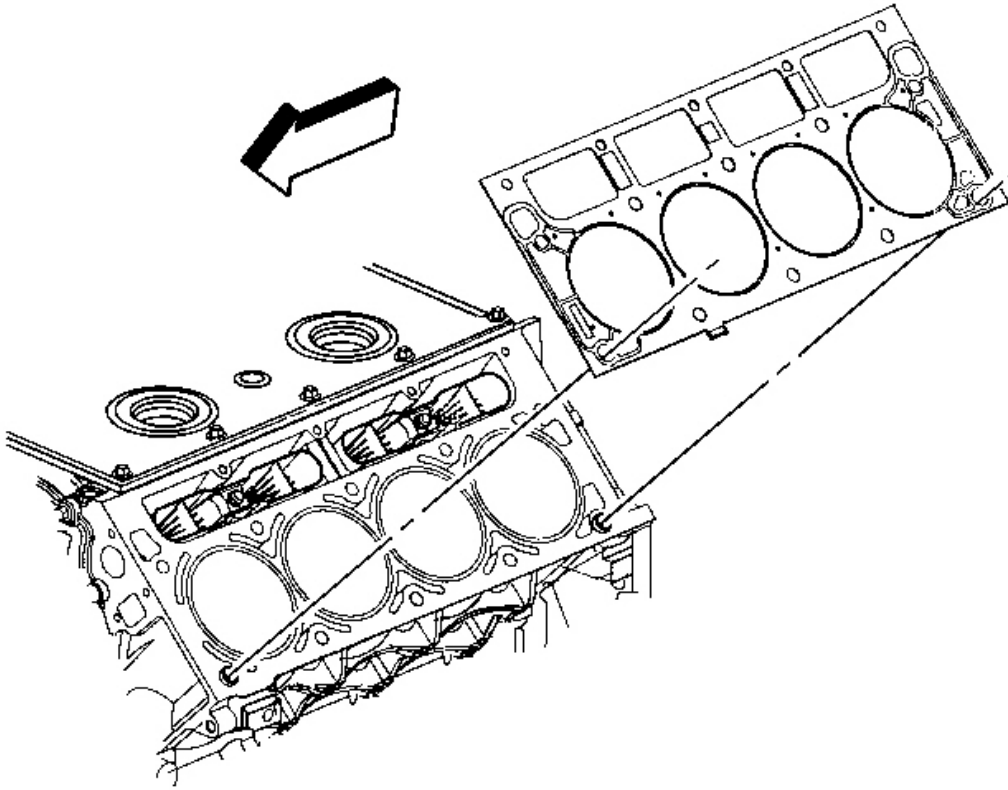
**IMPORTANT:** First design engine blocks have different drill and tap depths using both medium length 100 mm (3.94 in) and long 155 mm (6.1 in) M11 cylinder head bolts. Second design engine blocks use only the medium length 100 mm (3.94 in) bolt with a common drill and tap depth.

4. Measure the depth of the cylinder head bolt holes (1-10) and select the correct length bolts as required.
5. Check the cylinder head locating pins for proper installation.



**Fig. 642: Cylinder Head Gasket Displacement Markings**  
Courtesy of GENERAL MOTORS CORP.

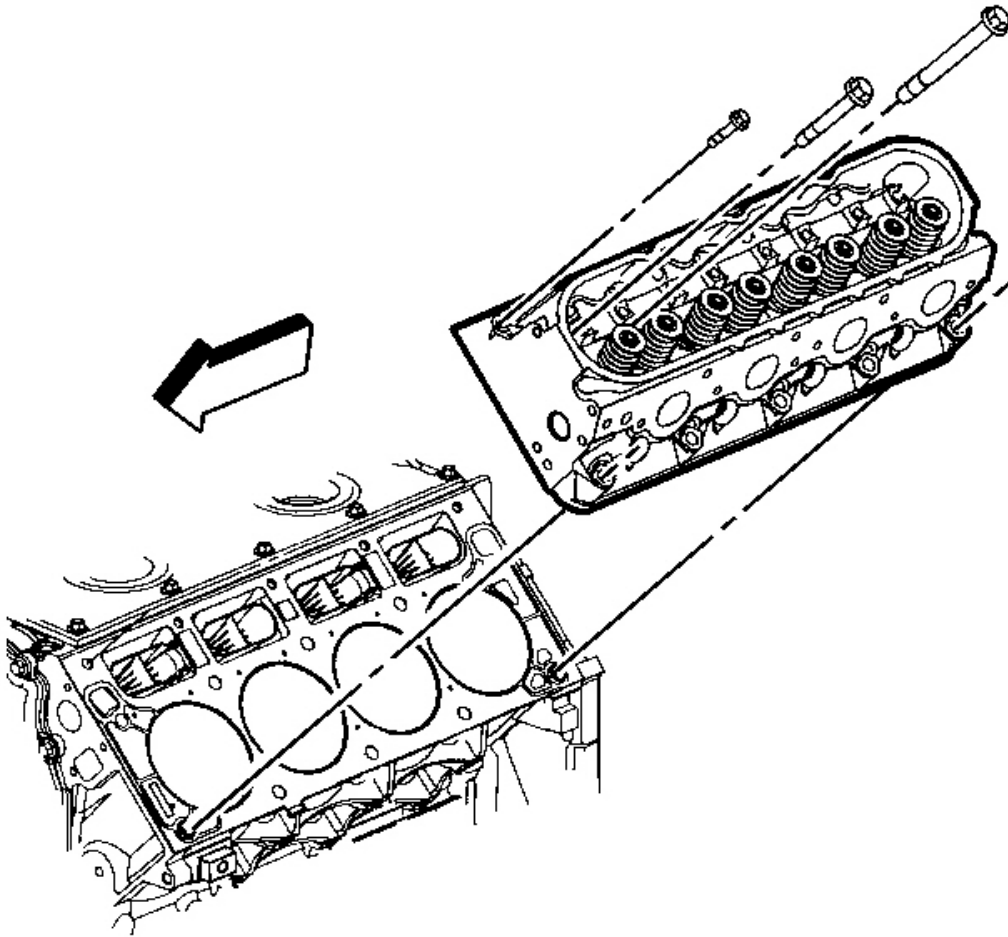
6. Inspect the displacement markings (1) on the gasket, for proper usage.



**Fig. 643: Cylinder Head Gasket (Left)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** When properly installed, the tab on the left cylinder head gasket will be located left of center, or closer to the front of the engine.

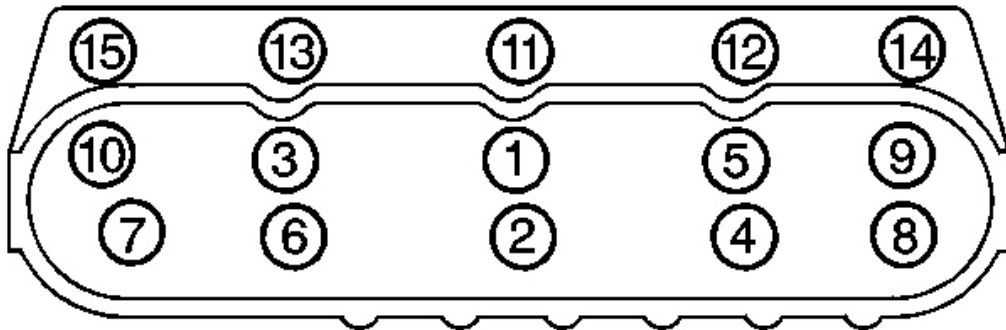
7. Install the NEW left cylinder head gasket onto the locating pins.



**Fig. 644: Cylinder Head & Bolts (Left)**  
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts.





**Fig. 645: Cylinder Head Bolt Tightening Sequence (Right)**  
 Courtesy of GENERAL MOTORS CORP.

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

10. Tighten the first design cylinder head bolts.

**Tighten:**

1. Tighten the first design M11 cylinder head bolts a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the first design M11 cylinder head bolts a second pass in sequence to 90 degrees using the **J 45059** . See **Special Tools and Equipment** .
3. Tighten the first design M11 cylinder head bolts (1,2,3,4,5,6,7,8) to 90 degrees and the M11 cylinder head bolts (9 and 10) to 50 degrees a final pass in sequence to using the **J 45059** . See **Special Tools and Equipment** .
4. Tighten the M8 cylinder head bolts (11,12,13,14,15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

11. Tighten the second design cylinder head bolts.

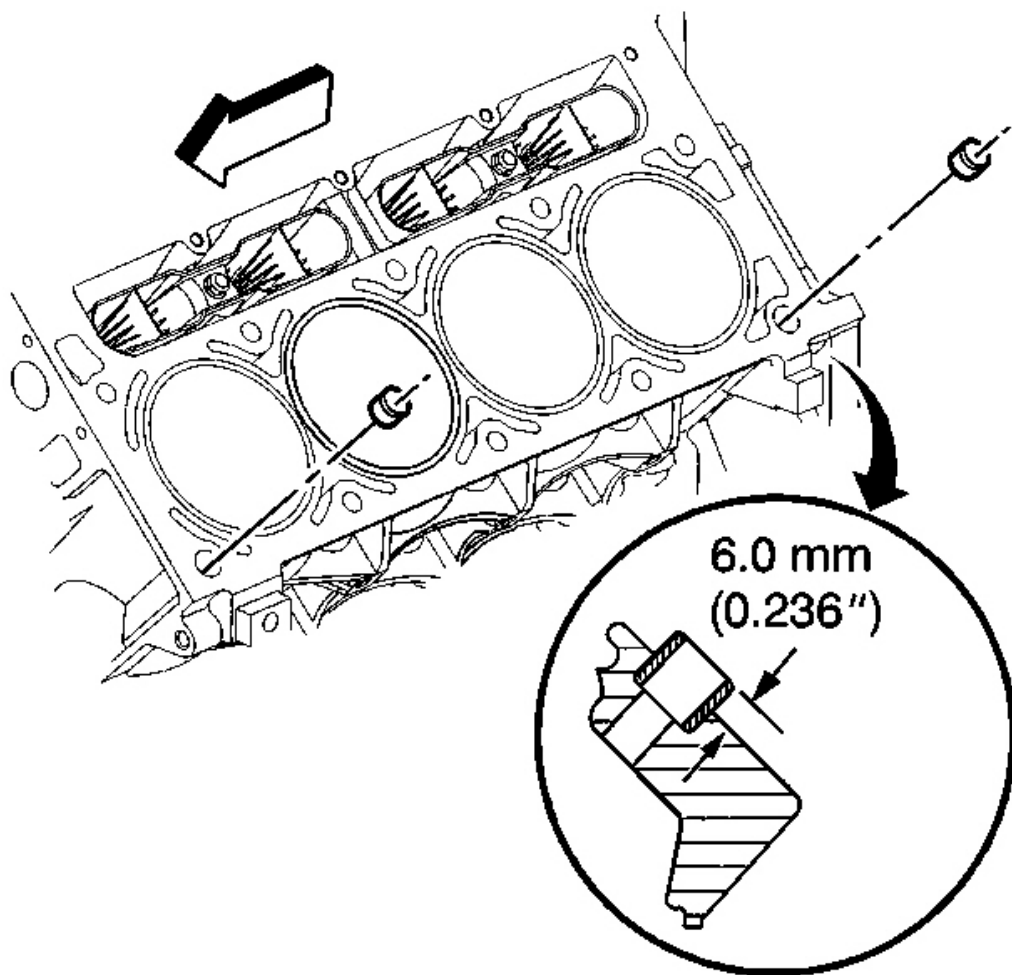
**Tighten:**

1. Tighten the second design M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the second design M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** . See **Special Tools and Equipment** .
3. Tighten the second design M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** . See **Special Tools and Equipment** .
4. Tighten the M8 cylinder head bolts (11,12,13,14,15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

## CYLINDER HEAD INSTALLATION - RIGHT

### Tools Required

- J 42385-100 Head/Main Bolt Thread Repair Kit. See Special Tools and Equipment .
- J 45059 Angle Meter. See Special Tools and Equipment .



**Fig. 646: Cylinder Head Locating Pins Installation Position**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Safety Glasses Caution in Cautions and Notices.

**NOTE:** Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

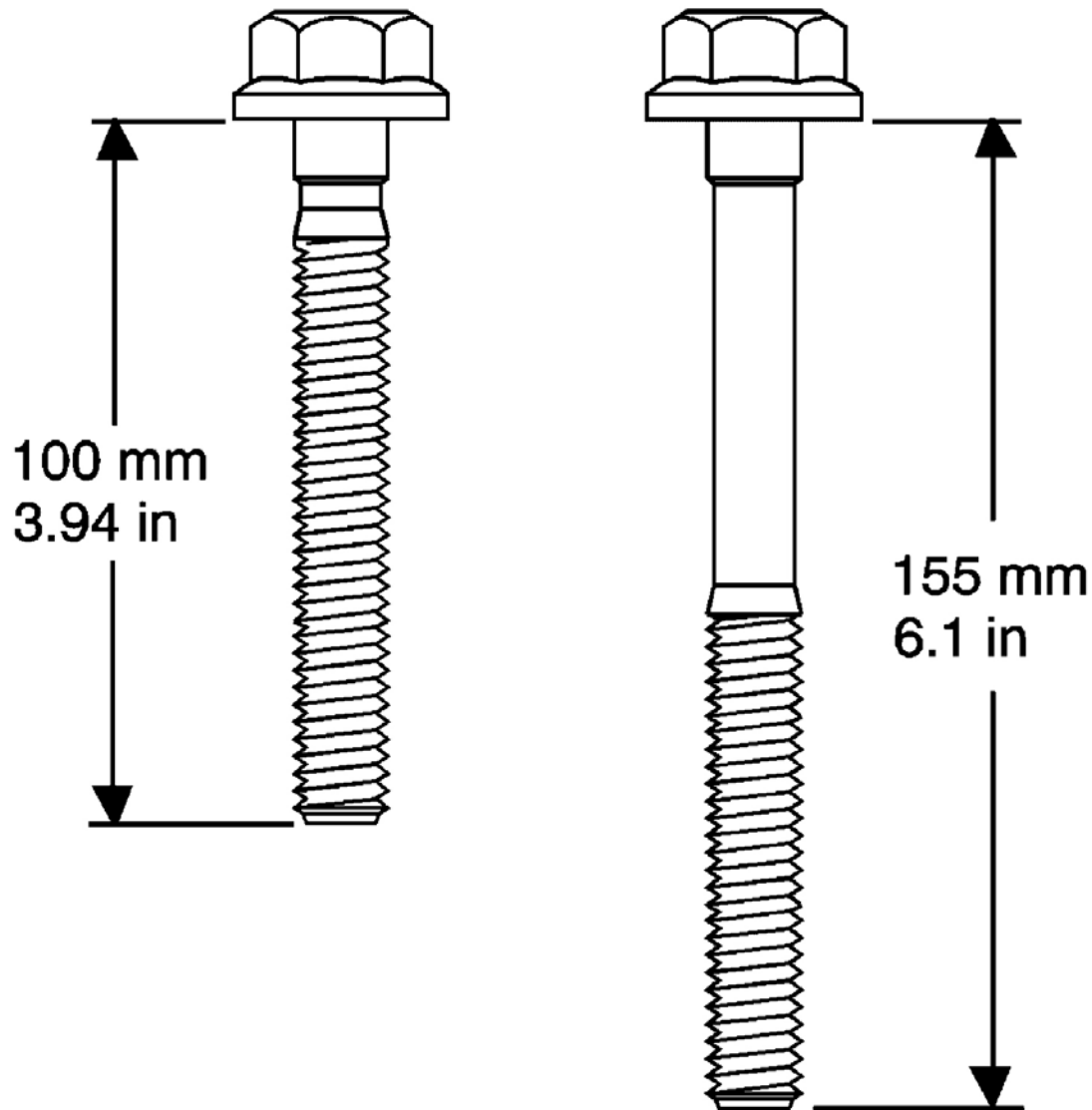
**IMPORTANT:**

- Do not use the cylinder head bolts again. Install **NEW** cylinder head bolts during assembly.
- Do not use any type sealant on the cylinder head gasket, unless specified.
- The cylinder head gaskets must be installed in the proper direction and position.

1. Clean the engine block cylinder head bolt holes, if required.

Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

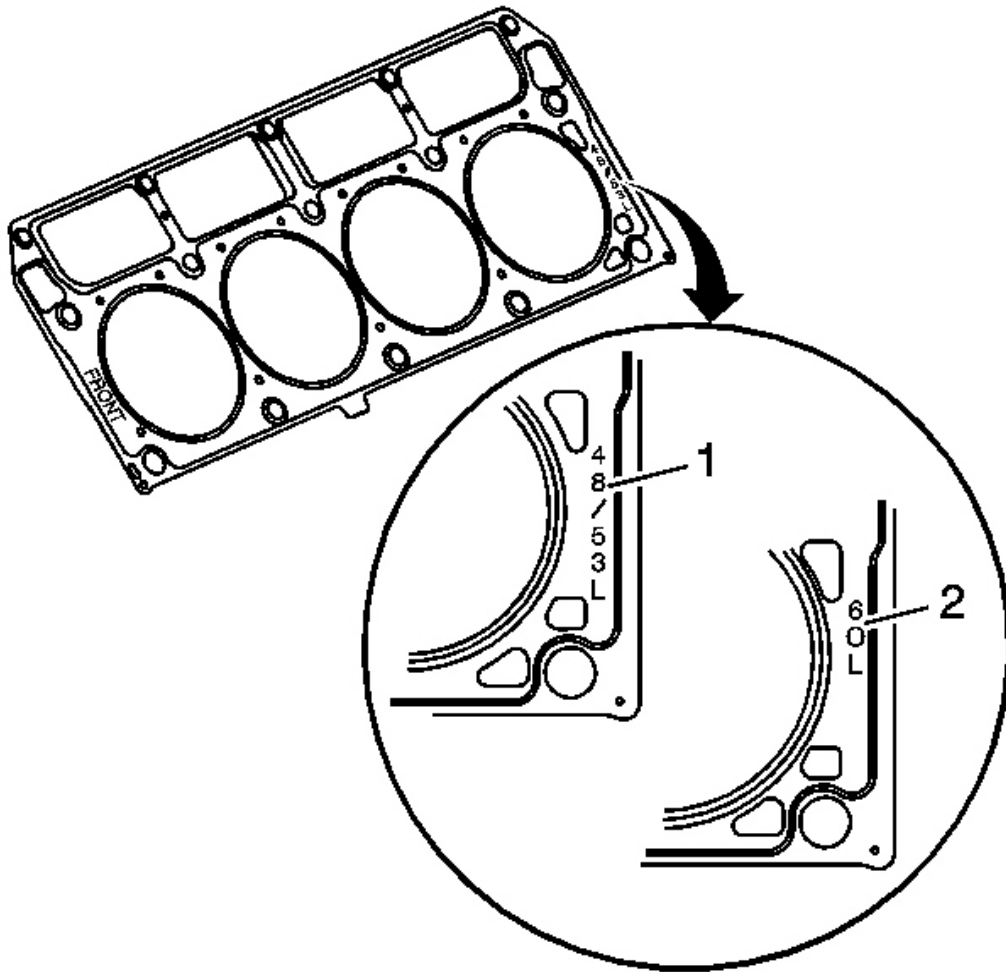
2. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.



**Fig. 647: 100 mm & 155 mm Bolts**  
Courtesy of GENERAL MOTORS CORP.

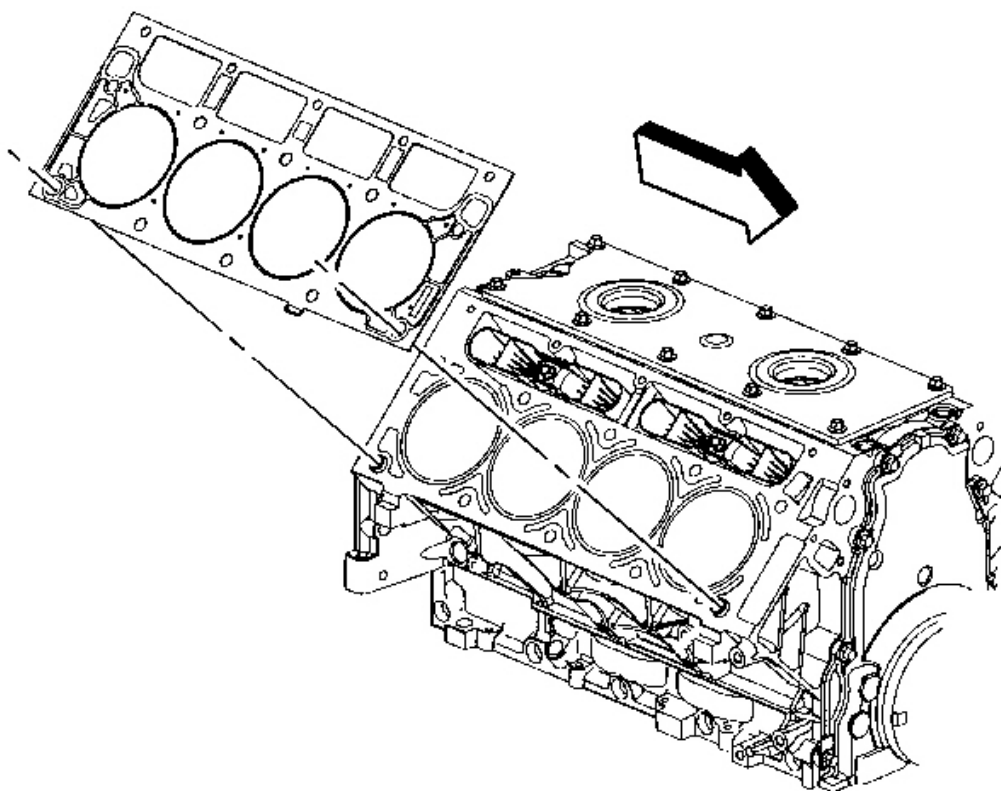
**IMPORTANT:** First design engine blocks have different drill and tap depths using both medium length 100 mm (3.94 in) and long 155 mm (6.1 in) M11 cylinder head bolts. Second design engine blocks use only the medium length 100 mm (3.94 in) bolt with a common drill and tap depth.

4. Measure the depth of the cylinder head bolt holes (1-10) and select the correct length bolts as required.
5. Check the cylinder head locating pins for proper installation.



**Fig. 648: Cylinder Head Gasket Displacement Markings**  
Courtesy of GENERAL MOTORS CORP.

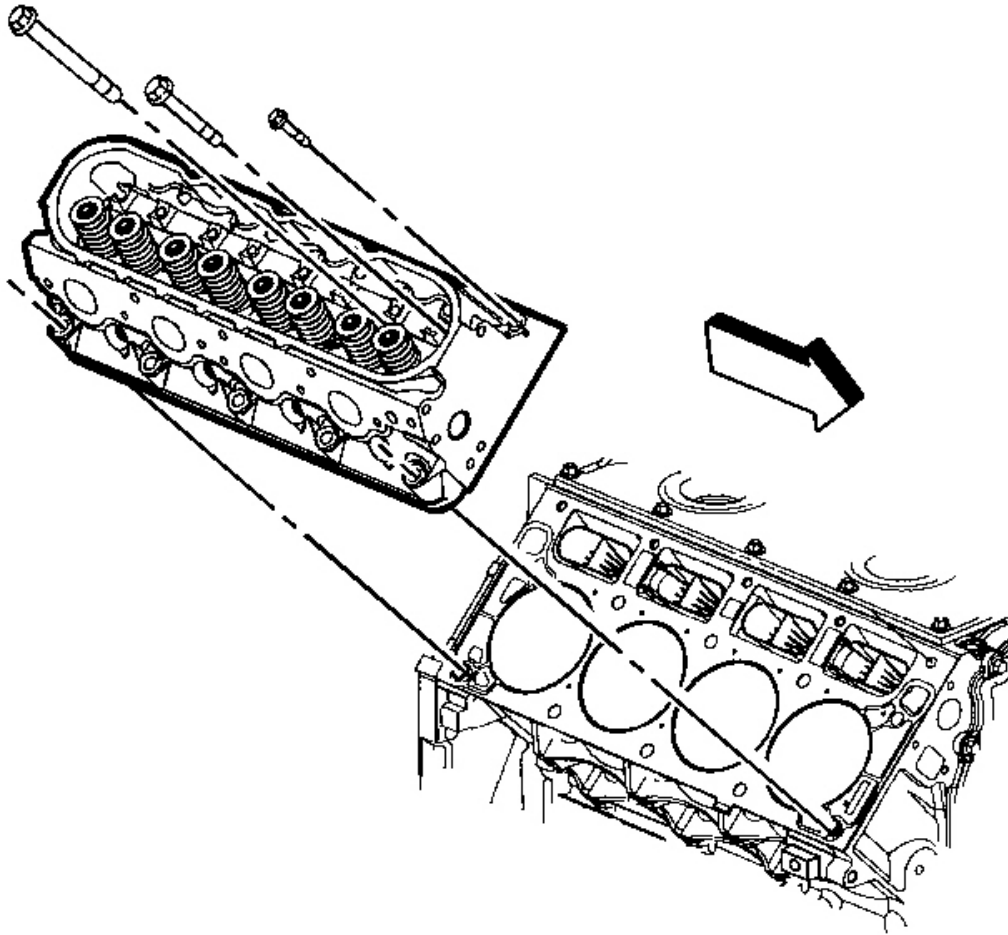
6. Inspect the displacement markings (1) on the gasket, for proper usage.



**Fig. 649: Cylinder Head Gasket (Right)**  
Courtesy of GENERAL MOTORS CORP.

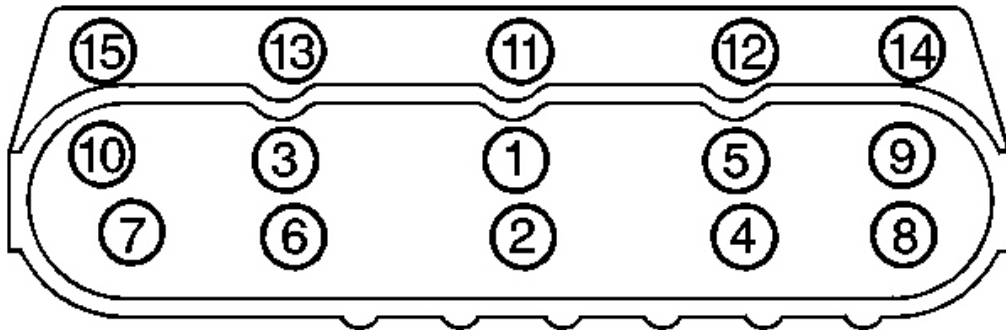
**IMPORTANT:** When properly installed, the tab on the right cylinder head gasket will be located right of center or closer to the front of the engine.

7. Install the NEW right cylinder head gasket onto the locating pins.



**Fig. 650: Cylinder Head & Bolts (Right)**  
**Courtesy of GENERAL MOTORS CORP.**

8. Install the cylinder head onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts.



**Fig. 651: Cylinder Head Bolt Tightening Sequence (Right)**  
 Courtesy of GENERAL MOTORS CORP.

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

10. Tighten the first design cylinder head bolts.

**Tighten:**

1. Tighten the first design M11 cylinder head bolts a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the first design M11 cylinder head bolts a second pass in sequence to 90 degrees using the **J 45059** . See **Special Tools and Equipment** .
3. Tighten the first design M11 cylinder head bolts (1,2,3,4,5,6,7,8) to 90 degrees and the M11 cylinder head bolts (9 and 10) to 50 degrees a final pass in sequence to using the **J 45059** . See **Special Tools and Equipment** .
4. Tighten the M8 cylinder head bolts (11,12,13,14,15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

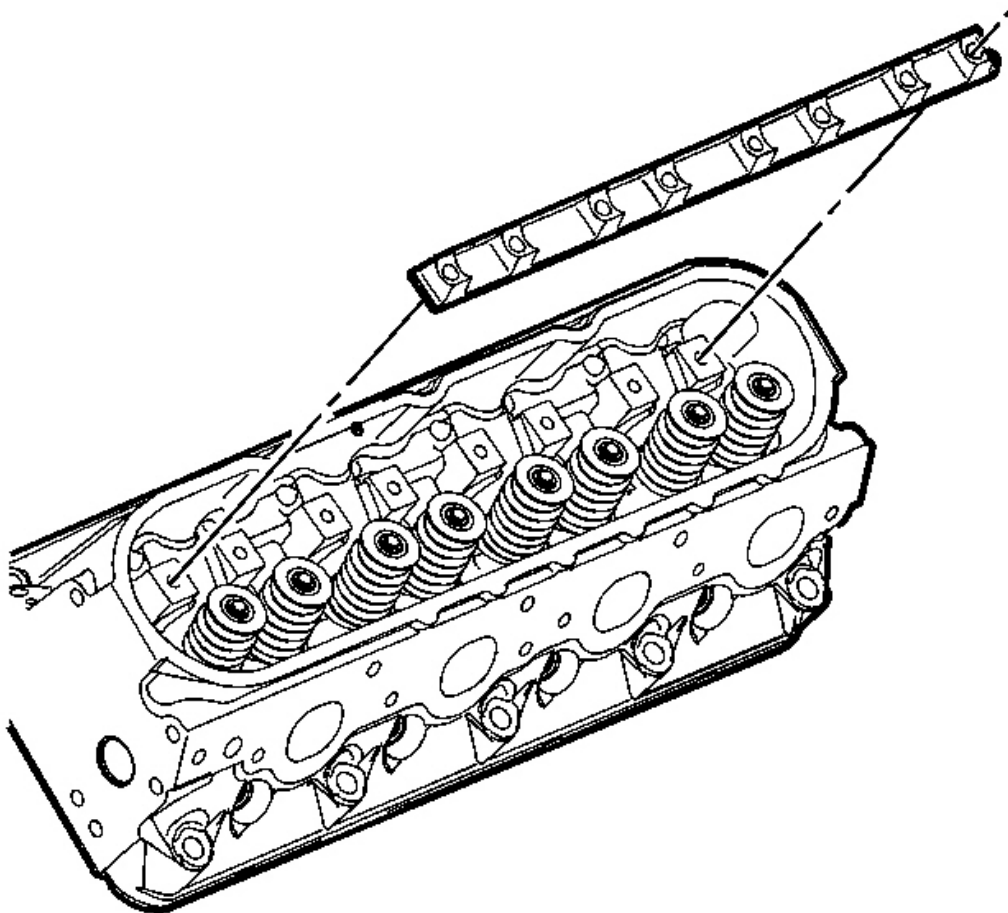
11. Tighten the second design cylinder head bolts.

**Tighten:**

1. Tighten the second design M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the second design M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** . See **Special Tools and Equipment** .
3. Tighten the second design M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** . See **Special Tools and Equipment** .
4. Tighten the M8 cylinder head bolts (11,12,13,14,15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.



## VALVE ROCKER ARM AND PUSH ROD INSTALLATION



**Fig. 652: Valve Rocker Arm Pivot Support**  
Courtesy of GENERAL MOTORS CORP.

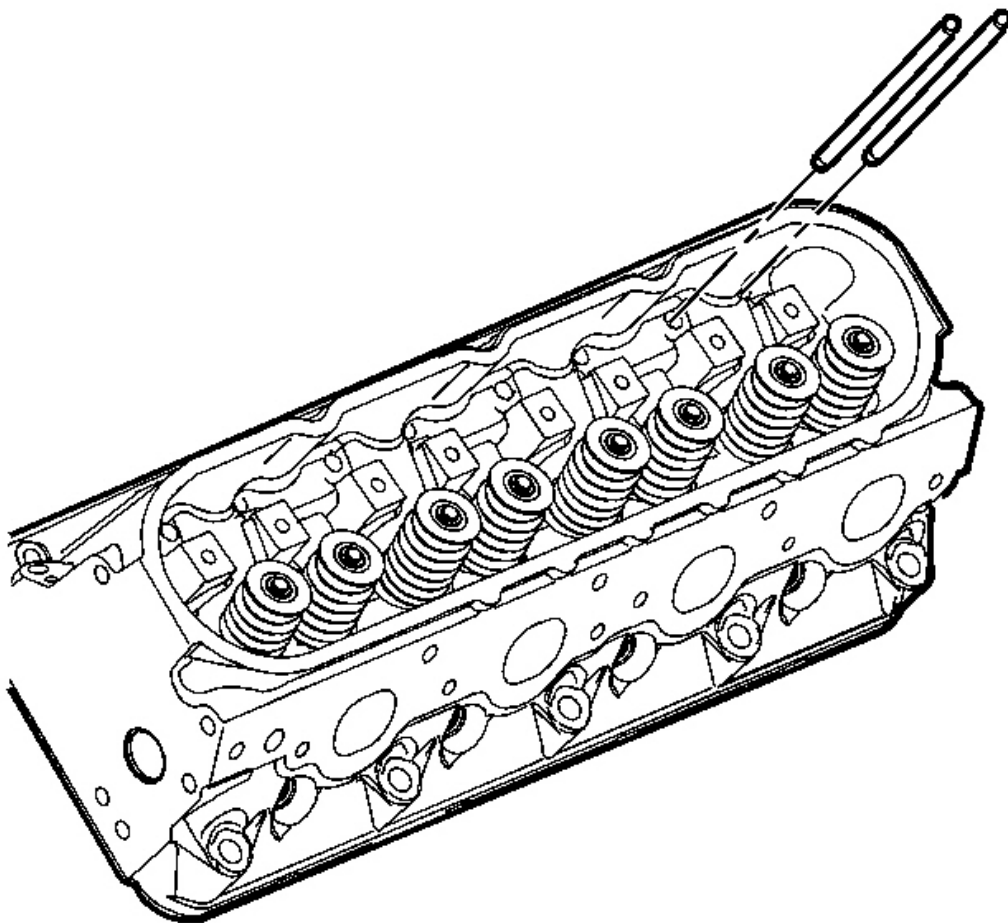
**IMPORTANT:**

- When using the valve train components again, always install the components to the original location and position.
- Valve lash is net build, no valve adjustment is required.

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.

Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.

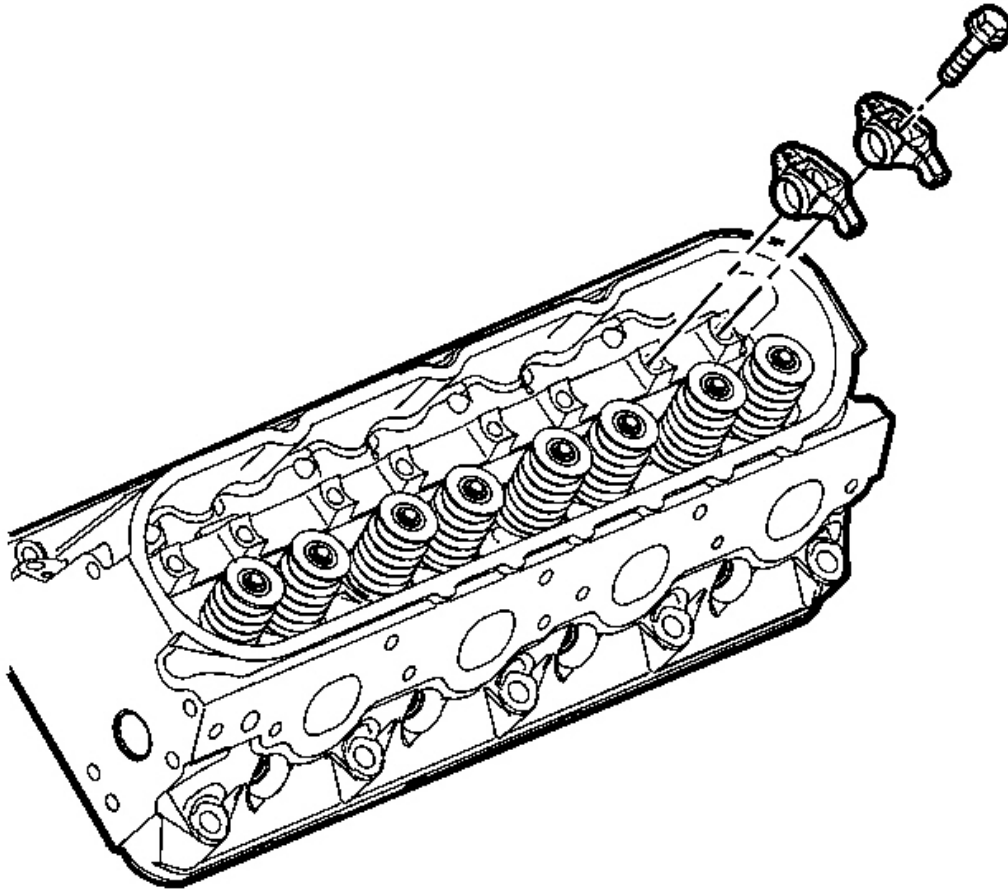
3. Install the valve rocker arm pivot support.



**Fig. 653: View Of Pushrods**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** Ensure that the pushrods seat properly to the valve lifter sockets.

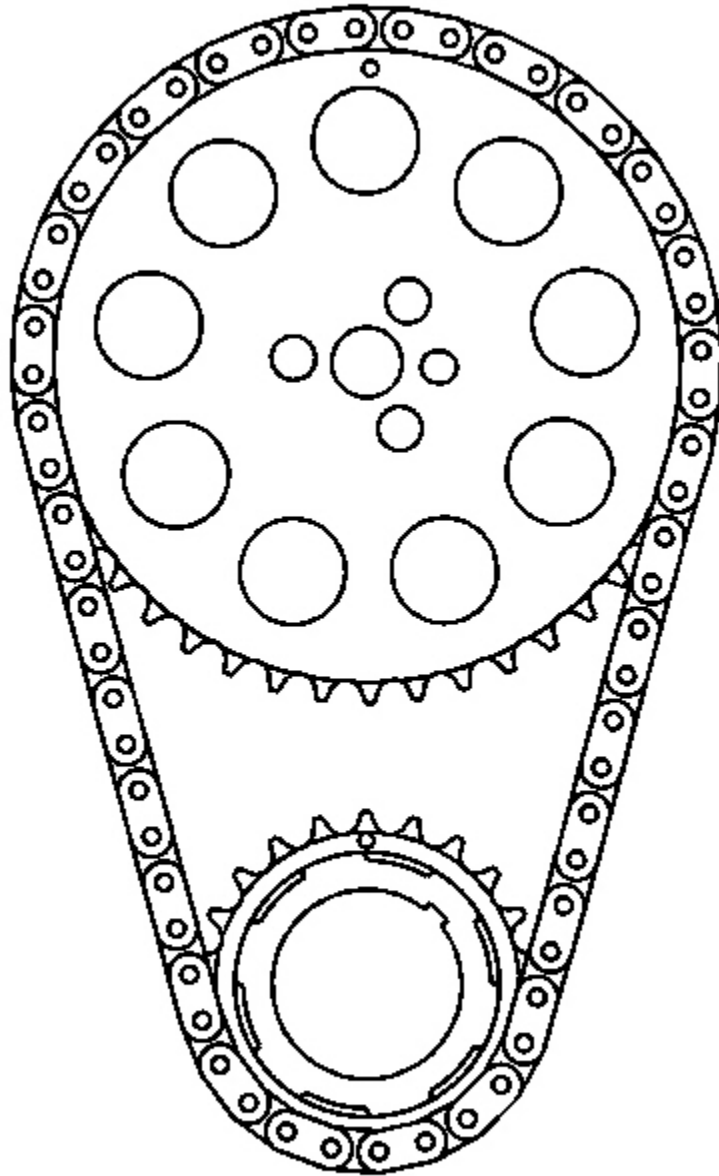
4. Install the pushrods.



**Fig. 654: Valve Rocker Arms**  
Courtesy of GENERAL MOTORS CORP.

- IMPORTANT:**
- Ensure that the pushrods seat properly to the ends of the rocker arms.
  - **DO NOT** tighten the rocker arm bolts at this time.

5. Install the rocker arms and bolts.



**Fig. 655: View Of Crankshaft**  
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number one piston is at top dead center of compression stroke.

In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key

will be at the 1:30 position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

Cylinders 1, 3, 5 and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

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

7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

**Tighten:**

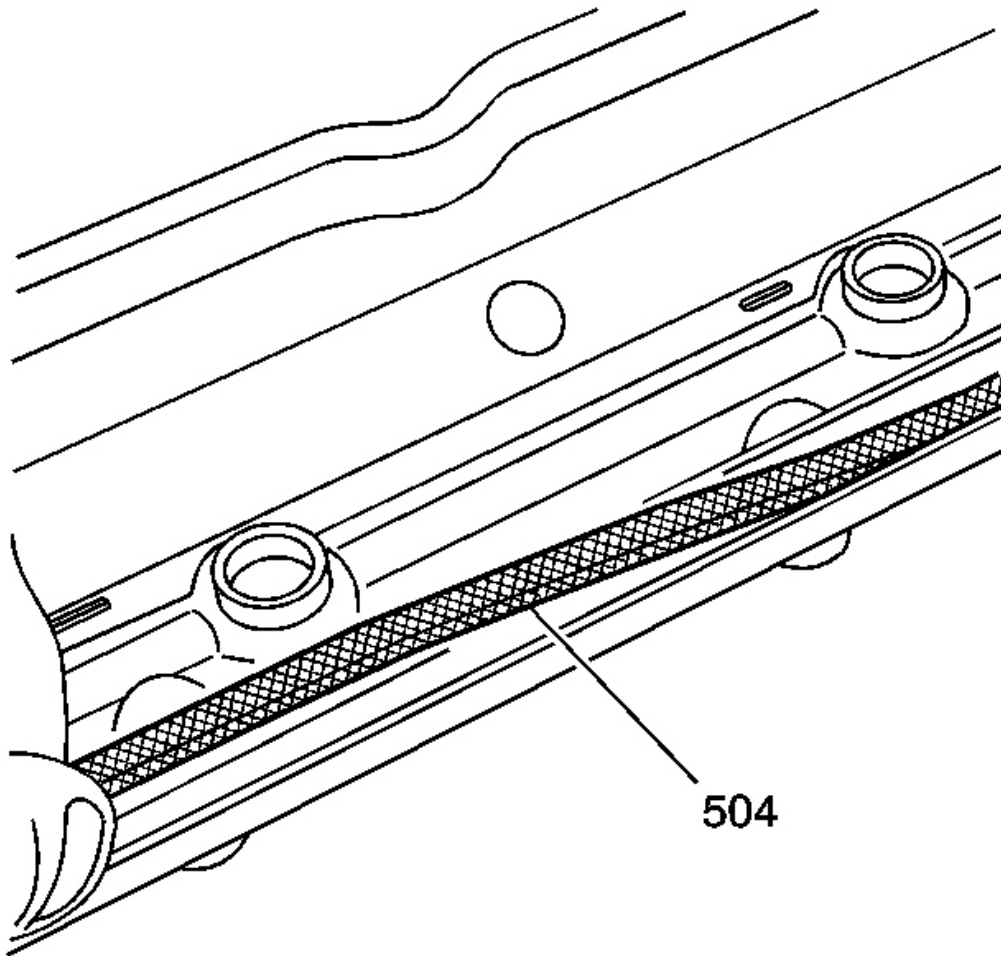
- Tighten exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N.m (22 lb ft).

8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

**Tighten:**

- Tighten exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

## **VALVE ROCKER ARM COVER INSTALLATION - LEFT**

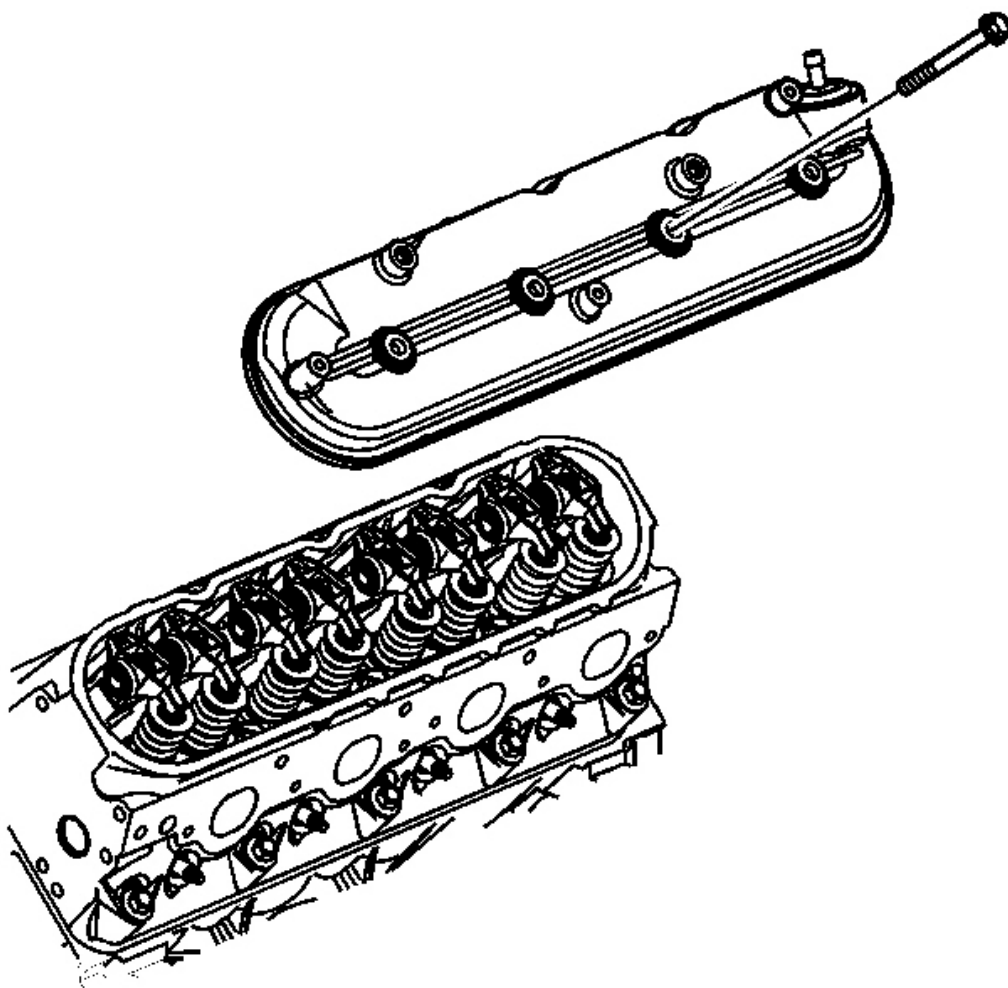


**Fig. 656: Valve Rocker Arm Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- All gasket surfaces should be free of oil or other foreign material during assembly.
- **DO NOT** use the valve rocker arm cover gasket again.
- The valve rocker arm cover bolt grommets may be used again.
- If the vapor vent grommet has been removed from the valve rocker arm cover, install a **NEW** vapor vent grommet during assembly.

1. Install a **NEW** cover gasket (504) into the left valve rocker arm cover.



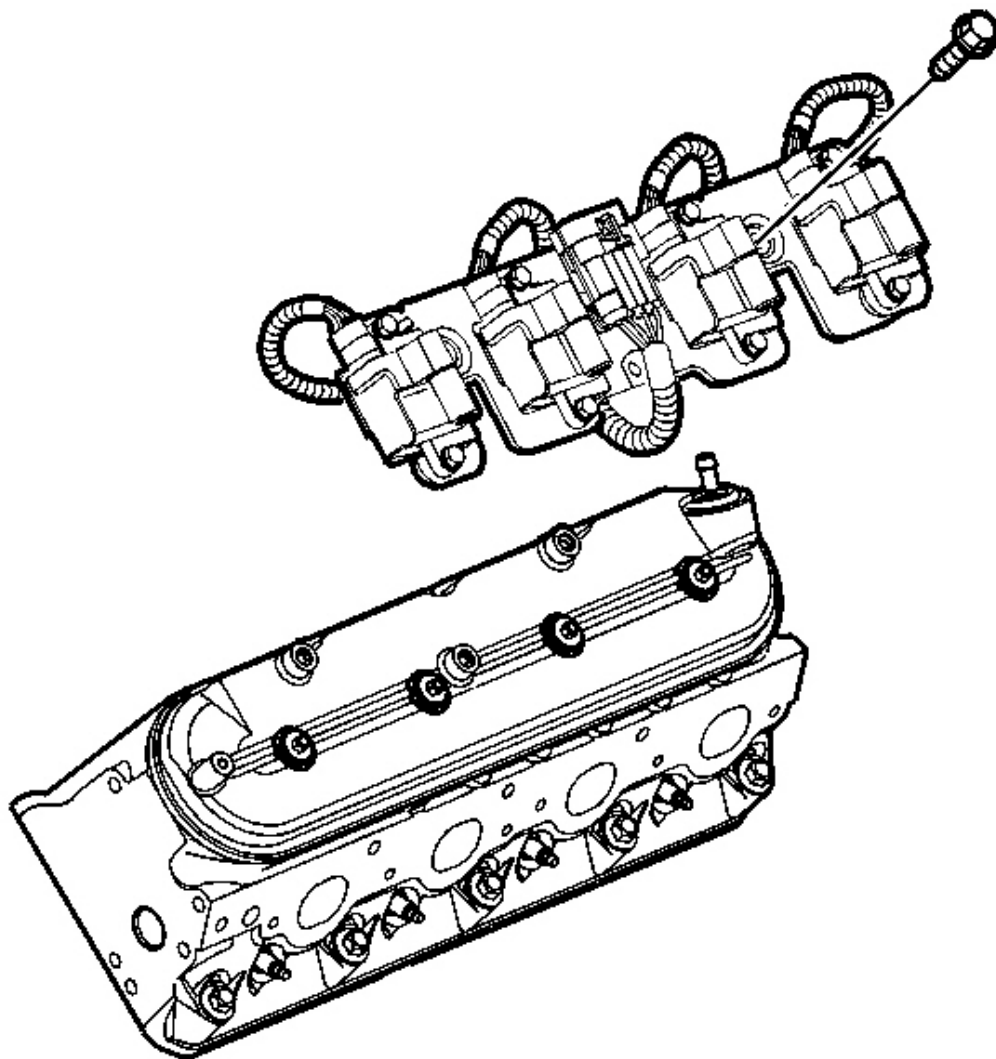
**Fig. 657: Valve Rocker Arm Cover (Left)**  
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.

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

3. Install the cover bolts with grommets.

**Tighten:** Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).



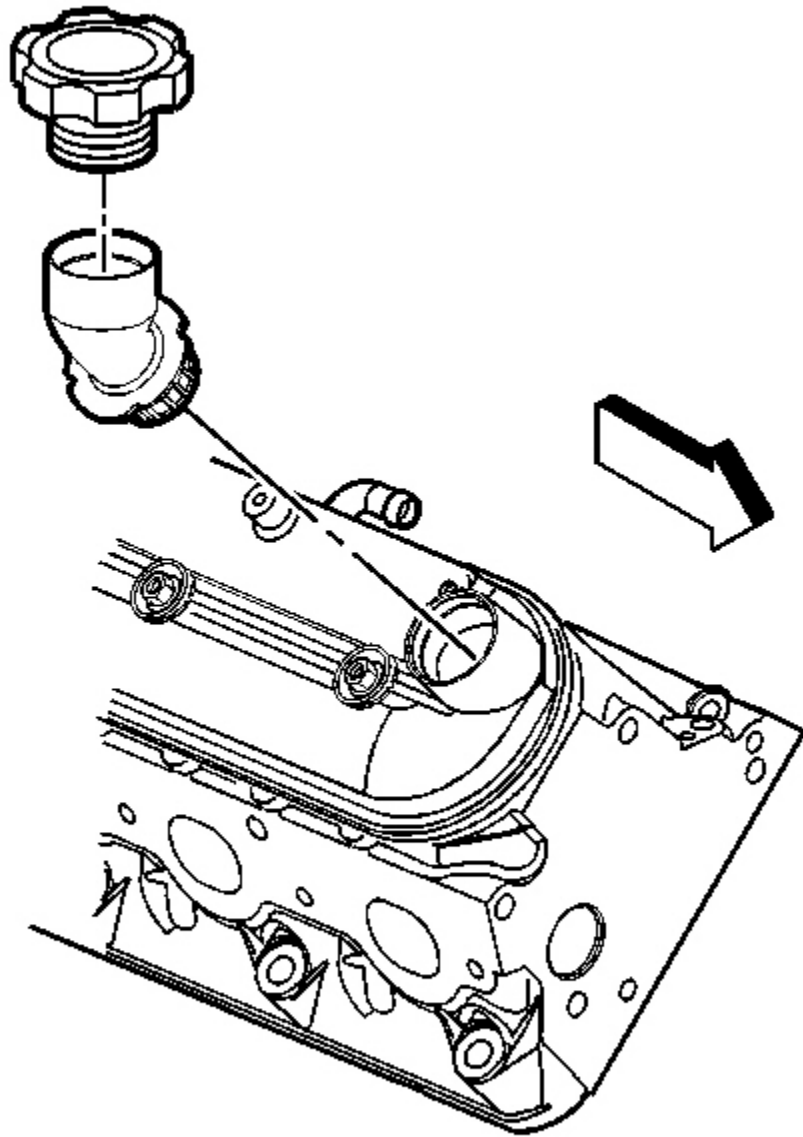
**Fig. 658: Ignition Coil & Bracket Assembly (Left)**  
Courtesy of GENERAL MOTORS CORP.

4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
5. Install the ignition coils and bracket assembly and bolts.

**Tighten:** Tighten the ignition coil and bracket assembly bolts to 12 N.m (106 lb in).



## VALVE ROCKER ARM COVER INSTALLATION - RIGHT



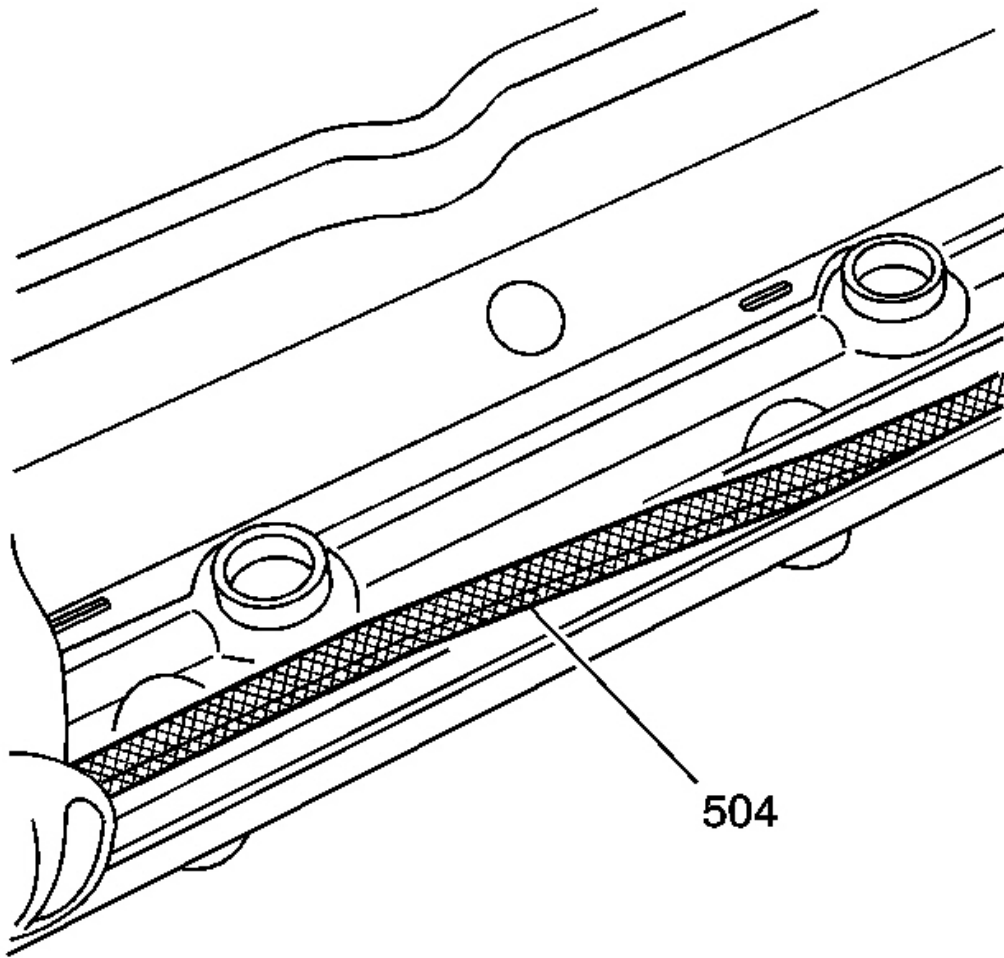
**Fig. 659: View Of Oil Fill Tube**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**     • All gasket surfaces should be free of oil or other foreign material

during assembly.

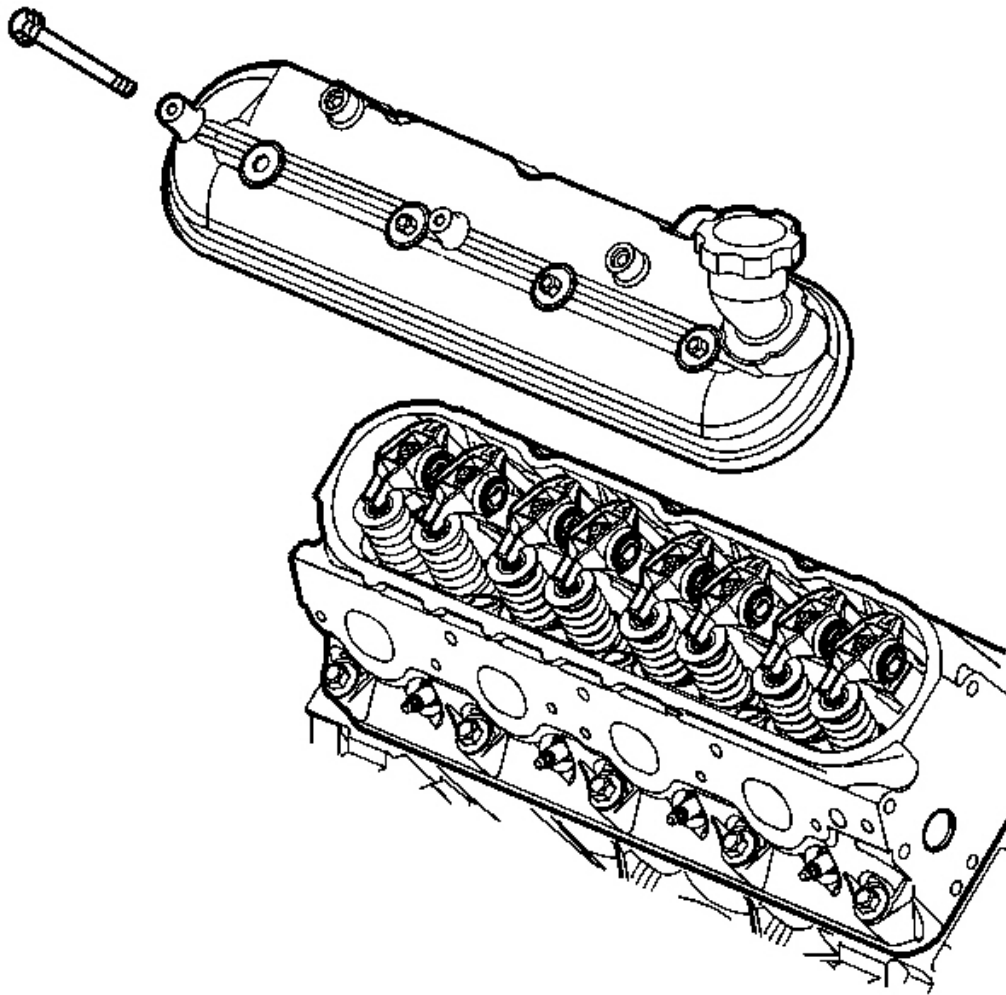
- **Do not use the valve rocker arm cover gasket again.**
- **Do not remove the ignition coils and bracket from the valve rocker arm cover unless required.**
- **The valve rocker arm cover bolt grommets may be used again.**
- **If the oil fill tube has been removed from the valve rocker arm cover, install a NEW oil fill tube during assembly.**

1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.
2. Insert the NEW oil fill tube into the rocker arm cover and rotate the tube clockwise until locked in the proper position.
3. Install the oil fill cap into the tube and rotate clockwise until locked in the proper position.



**Fig. 660: Valve Rocker Arm Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW cover gasket (504) into the right valve rocker arm cover.



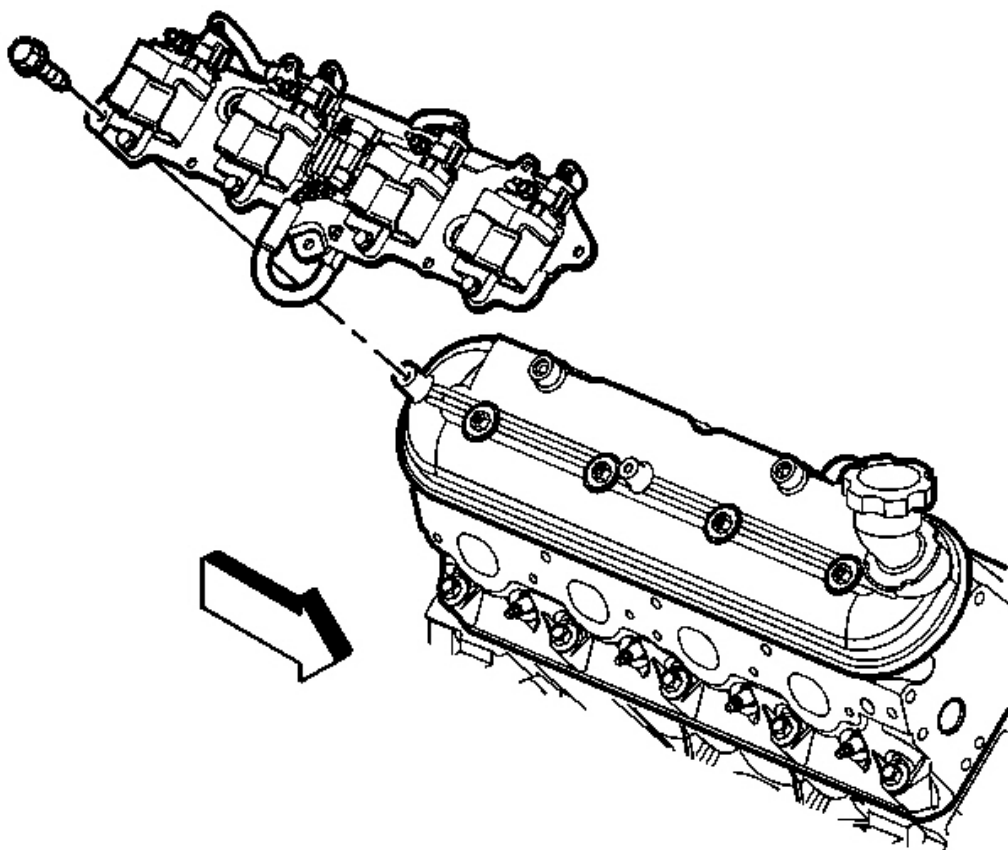
**Fig. 661: Valve Rocker Arm Cover & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

5. Install the valve rocker arm cover onto the cylinder head.

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

6. Install the cover bolts with grommets.

**Tighten:** Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

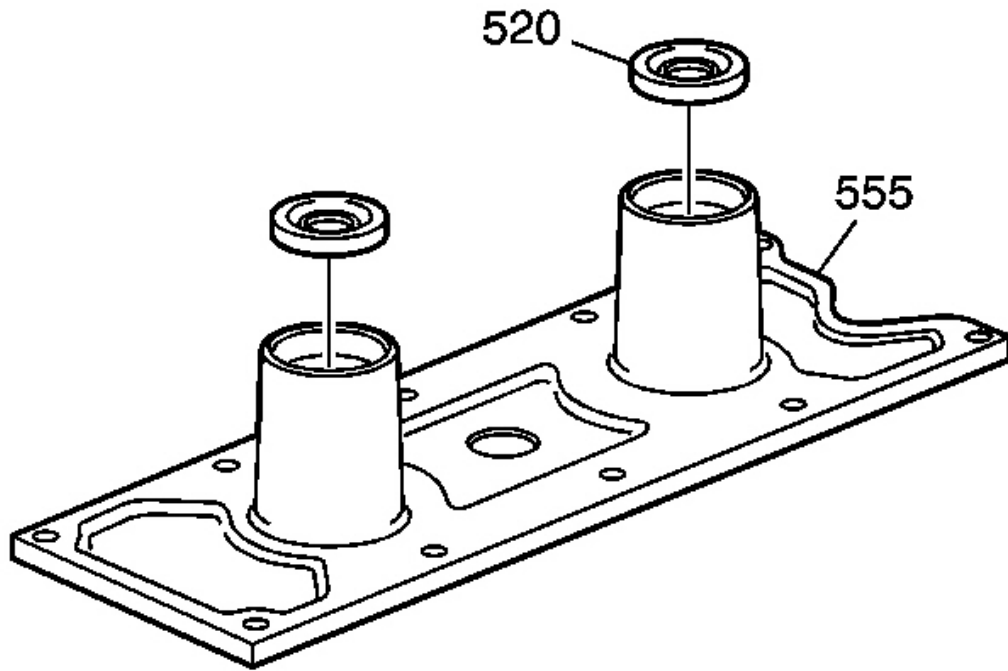


**Fig. 662: Ignition Coil & Bracket Assembly (Right)**  
Courtesy of GENERAL MOTORS CORP.

7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
8. Install the ignition coil and bracket assembly and bolts.

**Tighten:** Tighten the ignition coil and bracket assembly studs to 12 N.m (106 lb in).

## ENGINE VALLEY COVER INSTALLATION

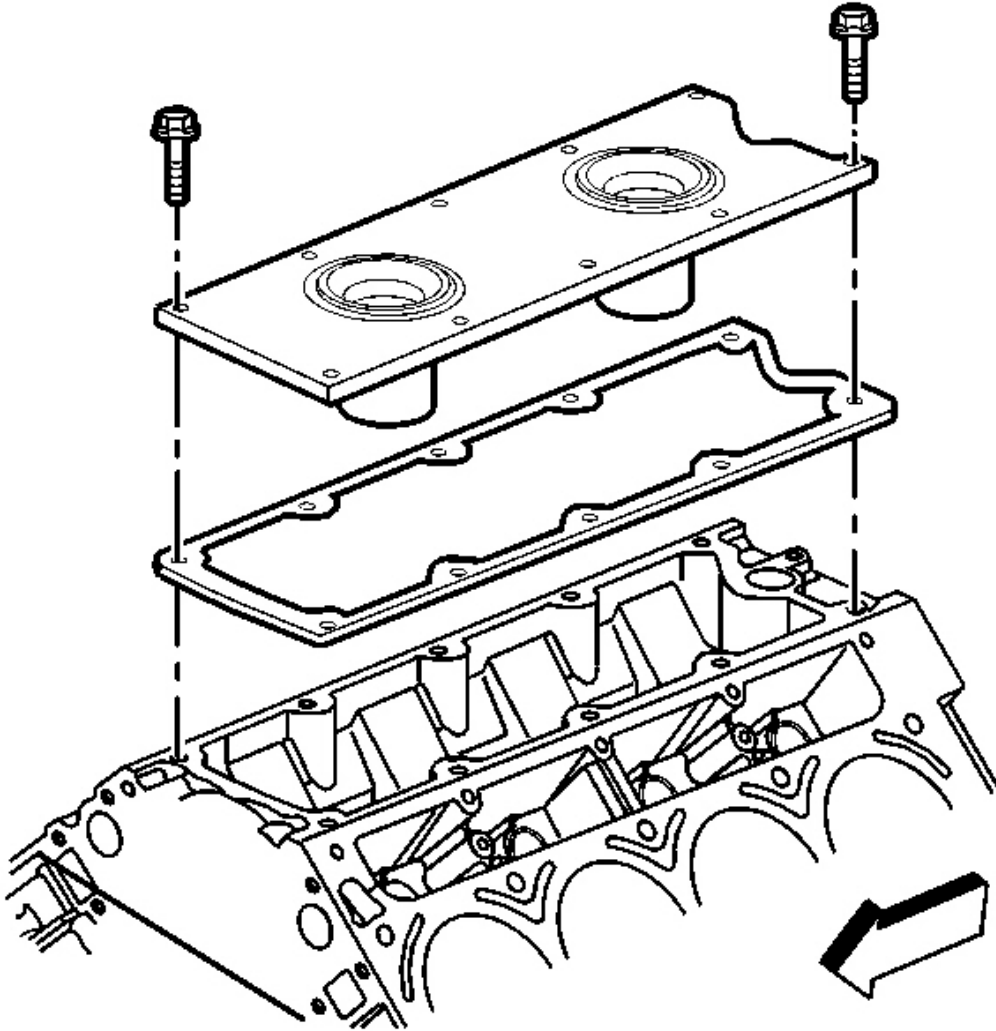


**Fig. 663: Knock Sensor Oil Seals & Valley Cover**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: All gasket surfaces should be free of oil or other foreign material during assembly.**

1. Install NEW knock sensor oil seals (520) into the valley cover (555).

Lubricate the seal surfaces with clean engine oil.



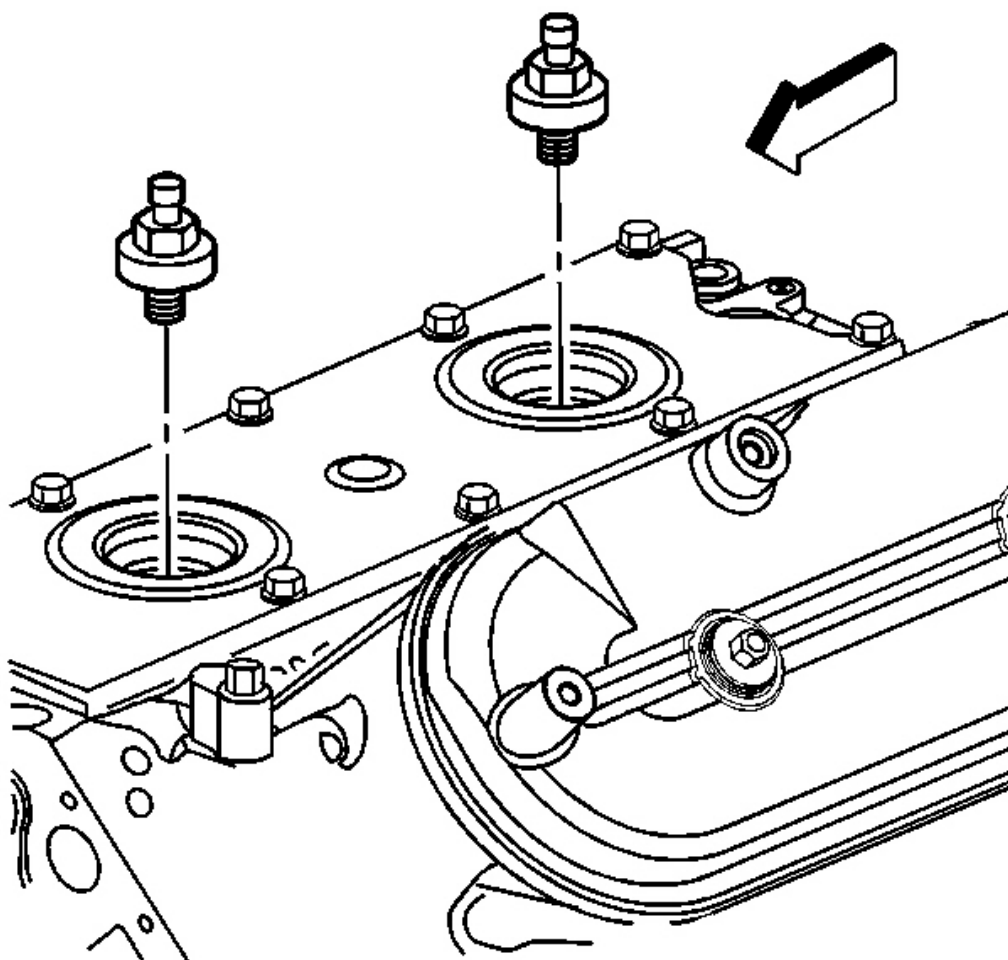
**Fig. 664: Engine Valley Cover & Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install the valley cover and NEW gasket.

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

3. Install the valley cover bolts.

**Tighten:** Tighten the valley cover bolts to 25 N.m (18 lb ft).

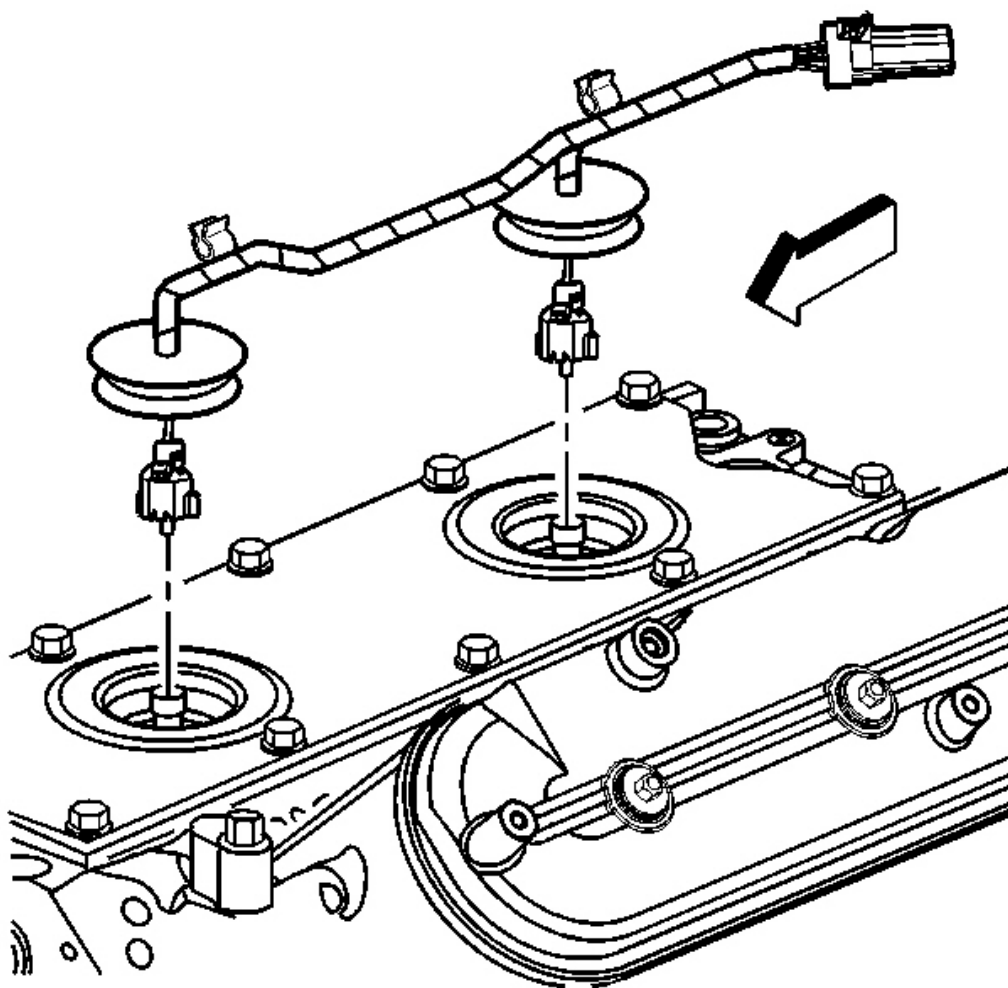


**Fig. 665: Knock Sensors**  
Courtesy of GENERAL MOTORS CORP.

4. Install the knock sensors.

**Tighten:** Tighten the knock sensors to 20 N.m (15 lb ft).

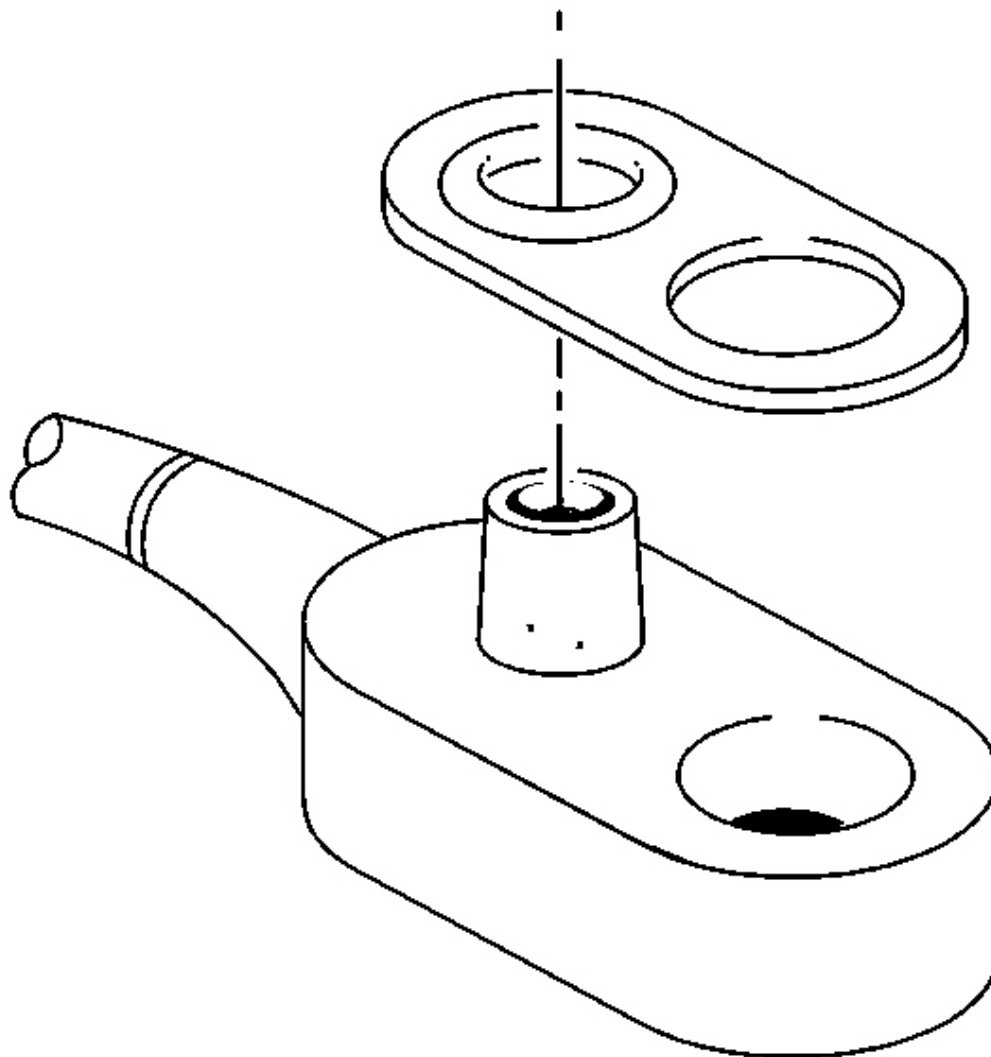




**Fig. 666: Knock Sensor Wire Harness**  
Courtesy of GENERAL MOTORS CORP.

5. Install the knock sensor wire harness.

#### COOLANT AIR BLEED PIPE INSTALLATION

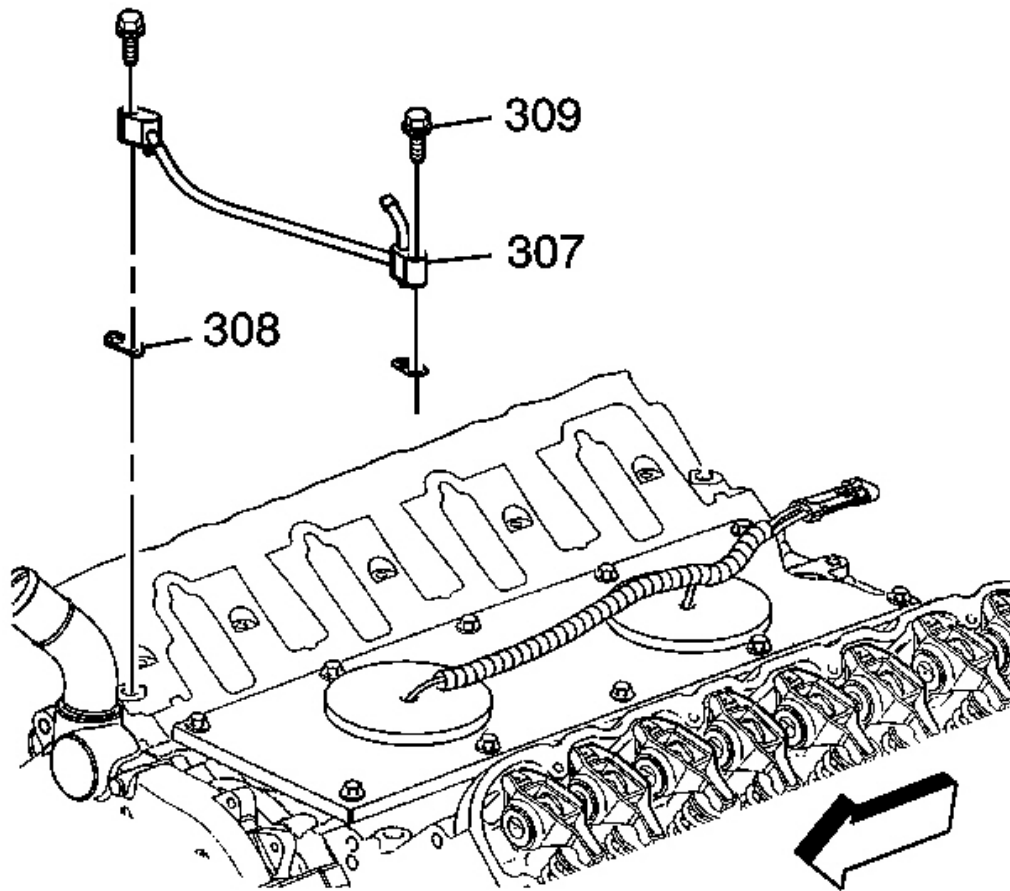


**Fig. 667: View Of Pipe & Cover Gasket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Install the pipe gaskets properly onto the pipe and covers.
- Position the gasket O-ring seal onto the nipple portion of the pipe.

1. Install the gaskets onto the engine coolant air bleed pipe and covers.



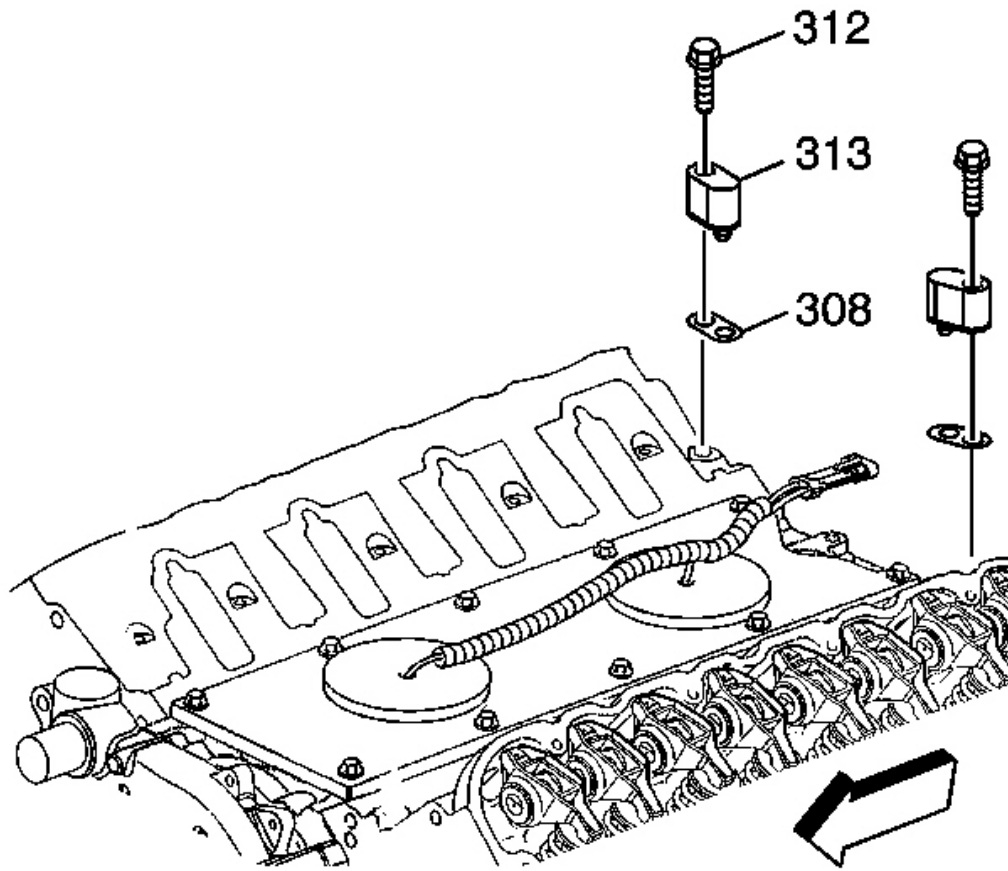
**Fig. 668: Air Bleed Pipe, Bolts & Gasket**  
Courtesy of GENERAL MOTORS CORP.

2. Install the pipe (307) and gaskets (308) onto the cylinder heads.

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

3. Install the pipe bolts (309).

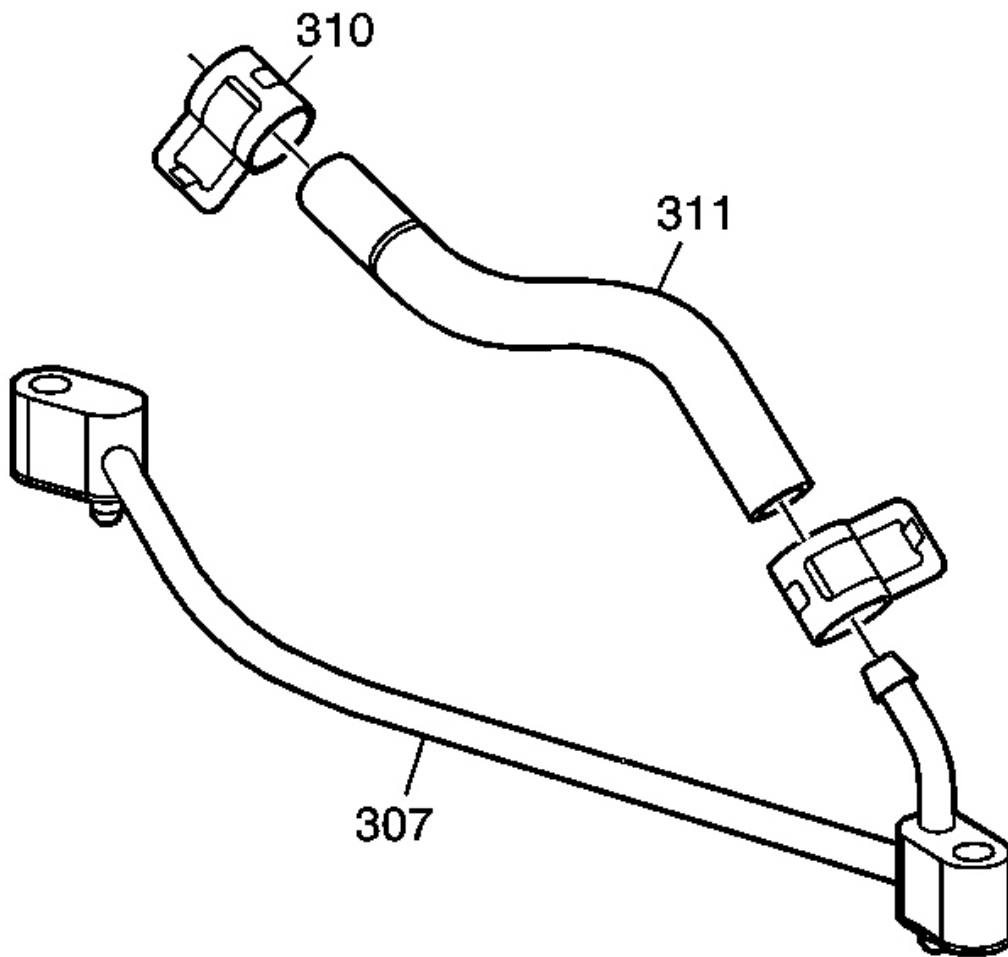
**Tighten:** Tighten the pipe bolts to 12 N.m (106 lb in).



**Fig. 669: Engine Coolant Air Bleed Cover, Gasket & Bolts**  
Courtesy of GENERAL MOTORS CORP.

4. Install the covers (313), gaskets (308), and bolts (312) onto the rear of the engine.

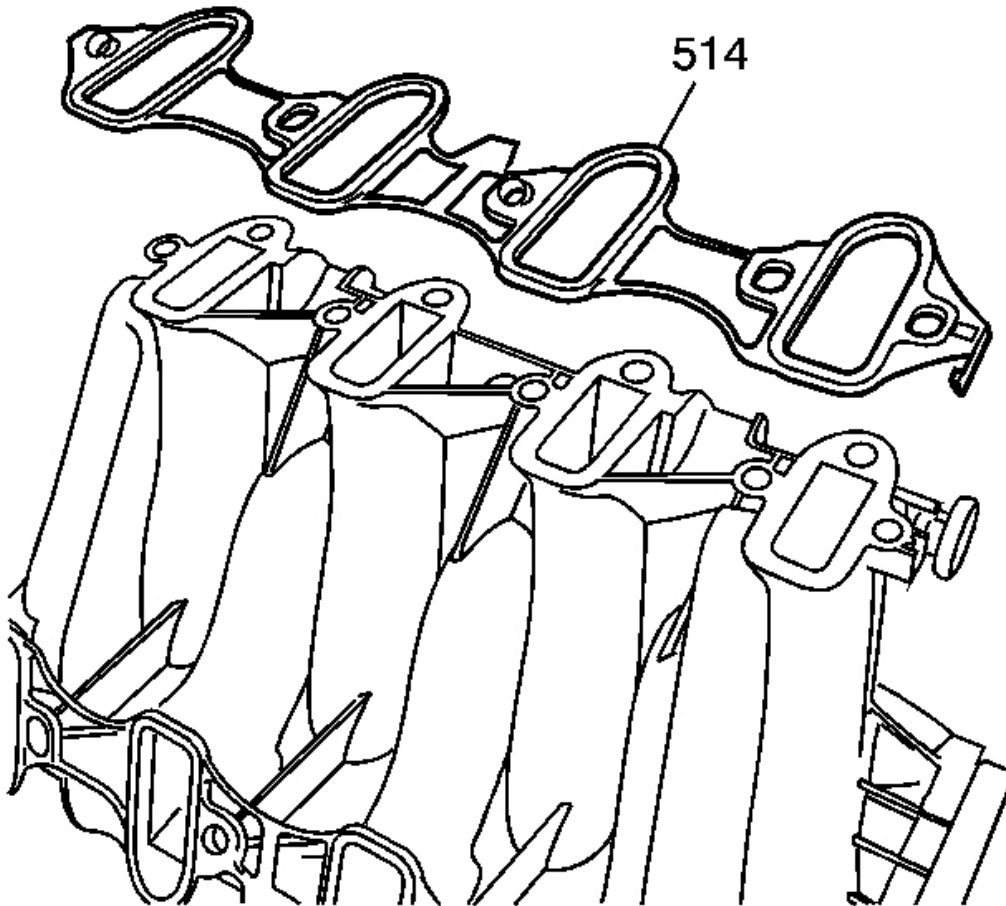
**Tighten:** Tighten the cover bolts to 12 N.m (106 lb in).



**Fig. 670: Air Bleed Pipe, Hose & Clamp**  
Courtesy of GENERAL MOTORS CORP.

5. Install the hose (311) and clamps (310) onto the pipe (307).

#### **INTAKE MANIFOLD INSTALLATION**

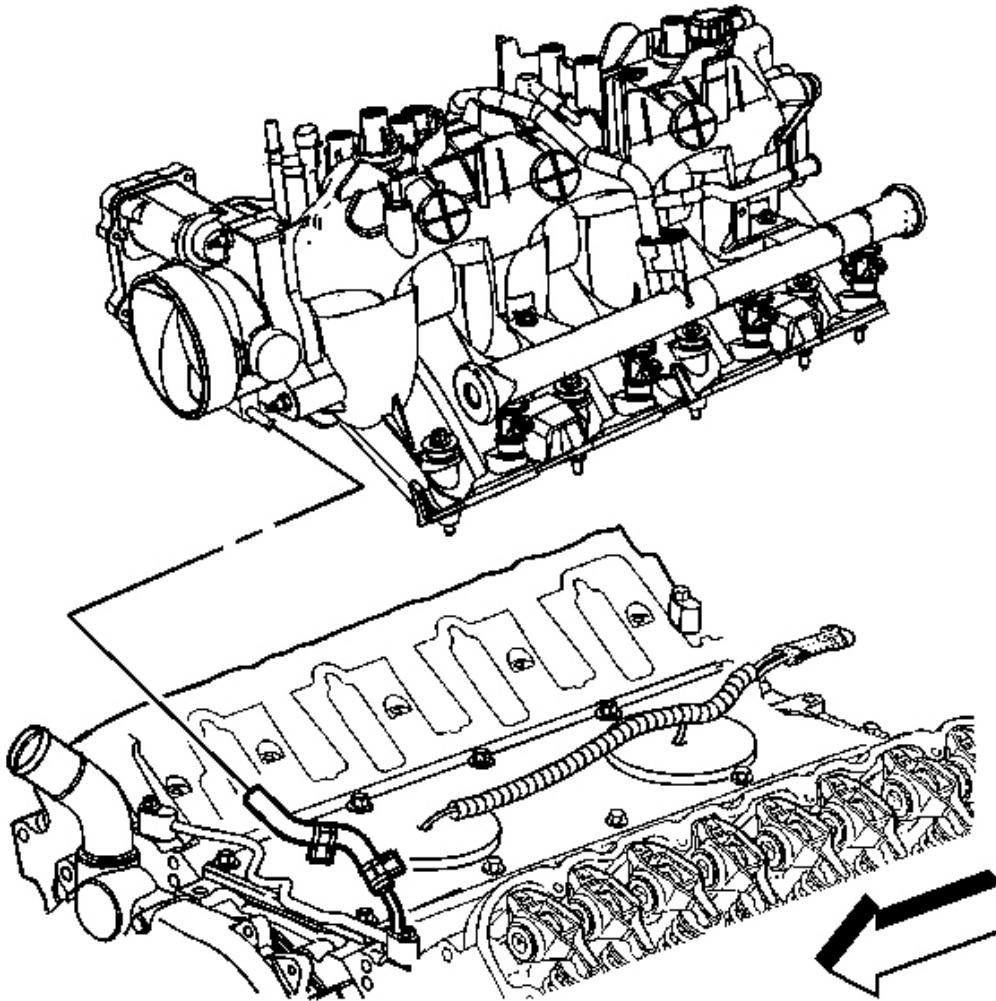


**Fig. 671: Intake Manifold-To-Cylinder Head Gasket**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

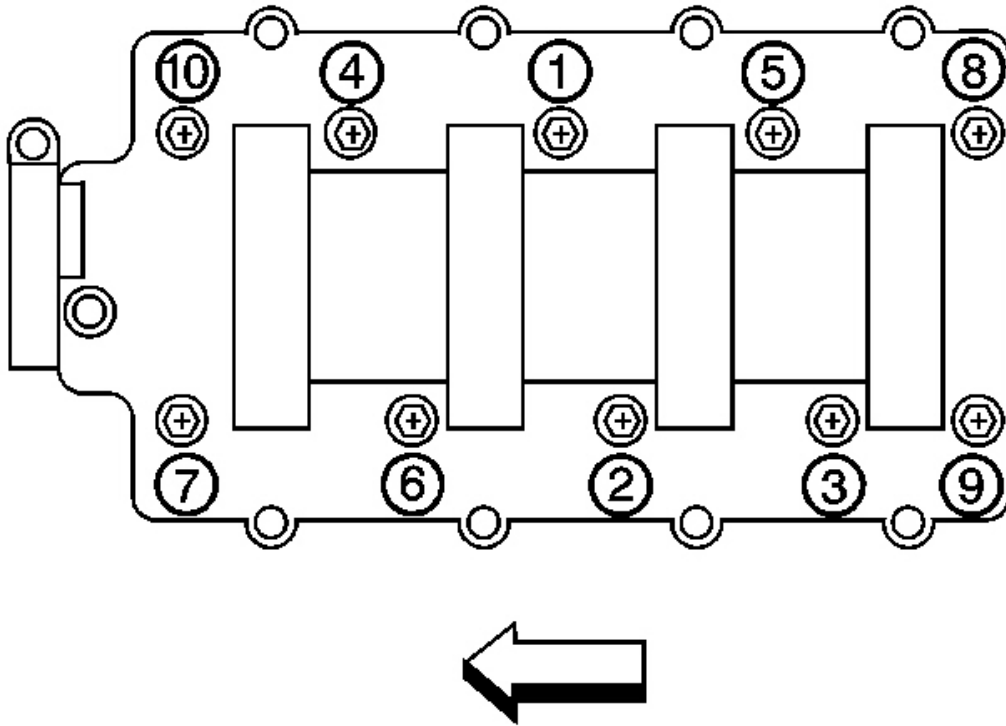
- The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.
- **DO NOT** use the old intake manifold gaskets again. Install **NEW** intake manifold-to-cylinder head gaskets.

1. Install **NEW** intake manifold-to-cylinder head gaskets (514).



**Fig. 672: View Of Intake Manifold**  
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the intake manifold bolts. Refer to **Sealers, Adhesives, and Lubricants** .



**Fig. 673: Intake Manifold Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

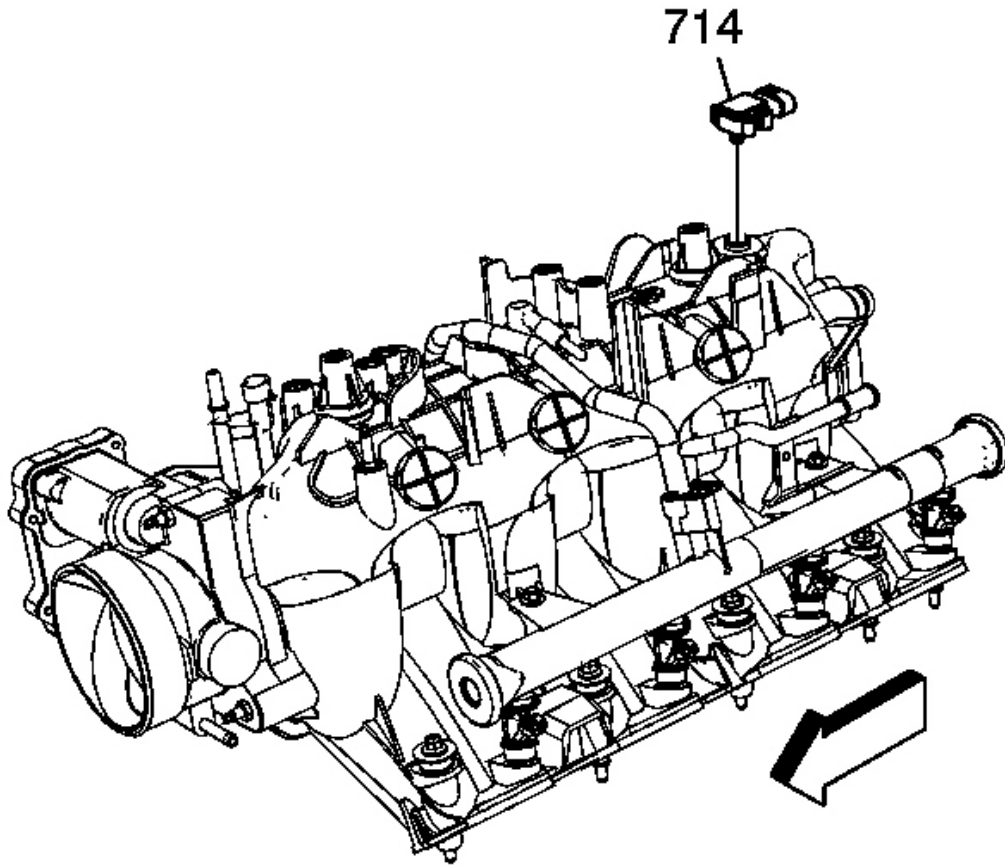
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

4. Install the intake manifold bolts.

**Tighten:**

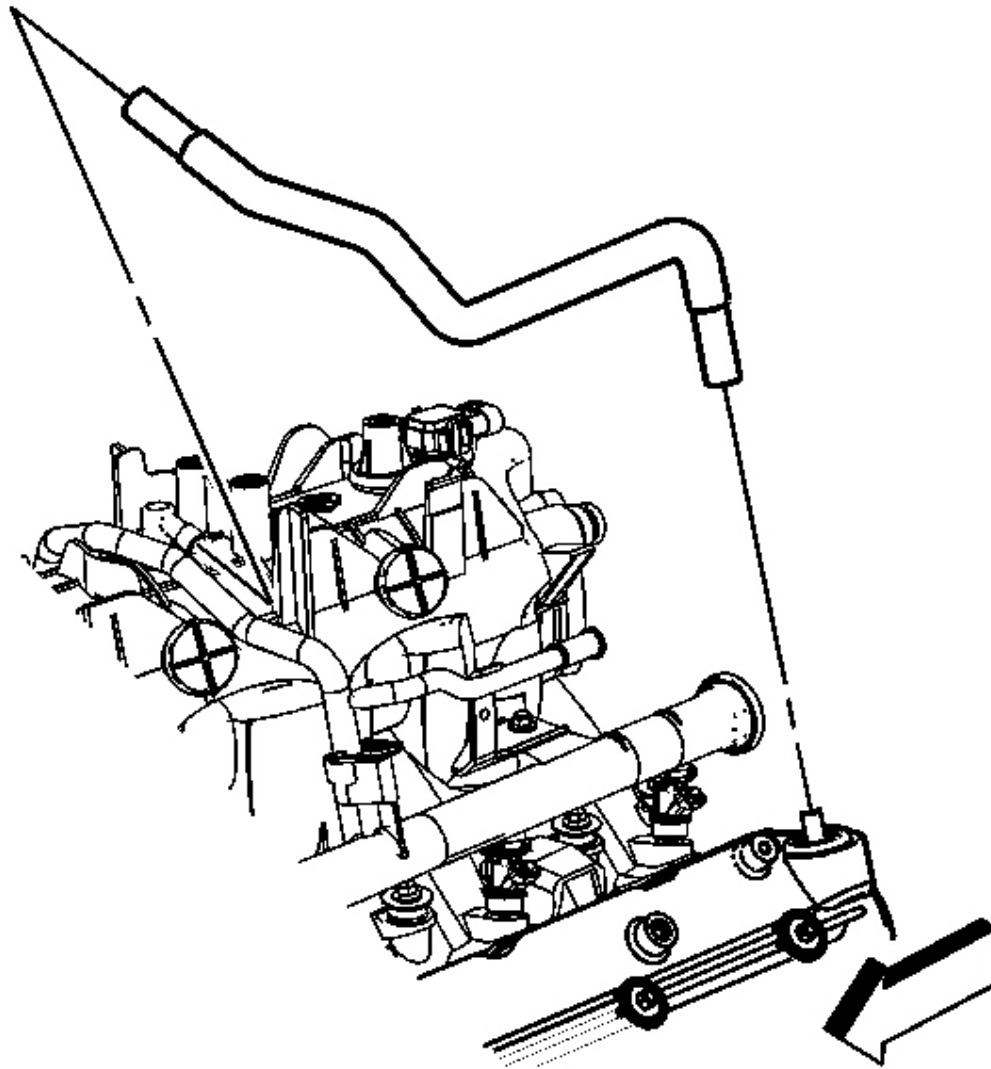
1. Tighten intake manifold bolts first pass in sequence to 5 N.m (44 lb in).
2. Tighten intake manifold bolts final pass in sequence to 10 N.m (89 lb in).





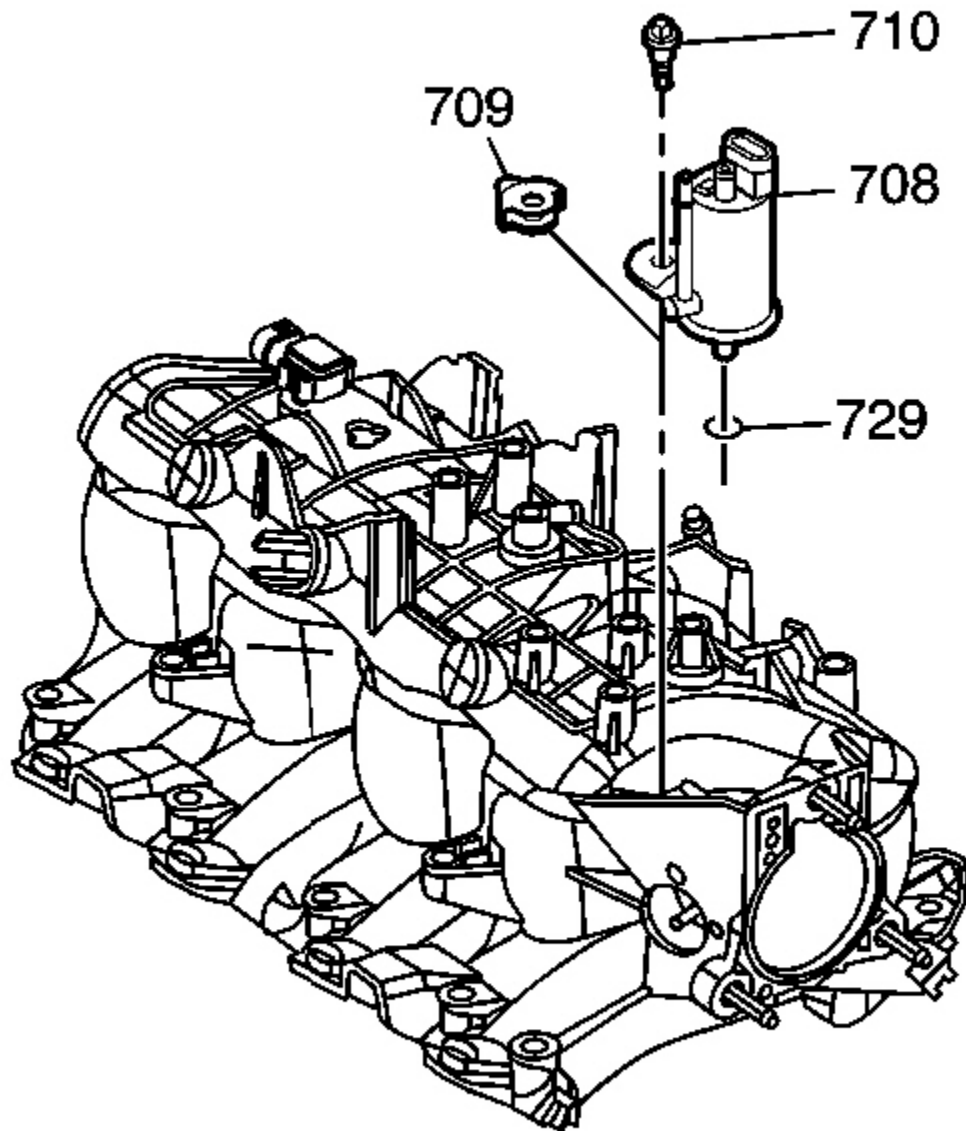
**Fig. 674: View Of MAP Sensor**  
**Courtesy of GENERAL MOTORS CORP.**

5. Install the manifold absolute pressure (MAP) sensor (714), if previously removed.  
The electrical connector end of the sensor should be facing the front of the engine.



**Fig. 675: Identifying PCV Hose**  
Courtesy of GENERAL MOTORS CORP.

6. Install the positive crankcase ventilation (PCV) dirty air hose.
7. Install the engine coolant air bleed hose and clamp onto the throttle body.

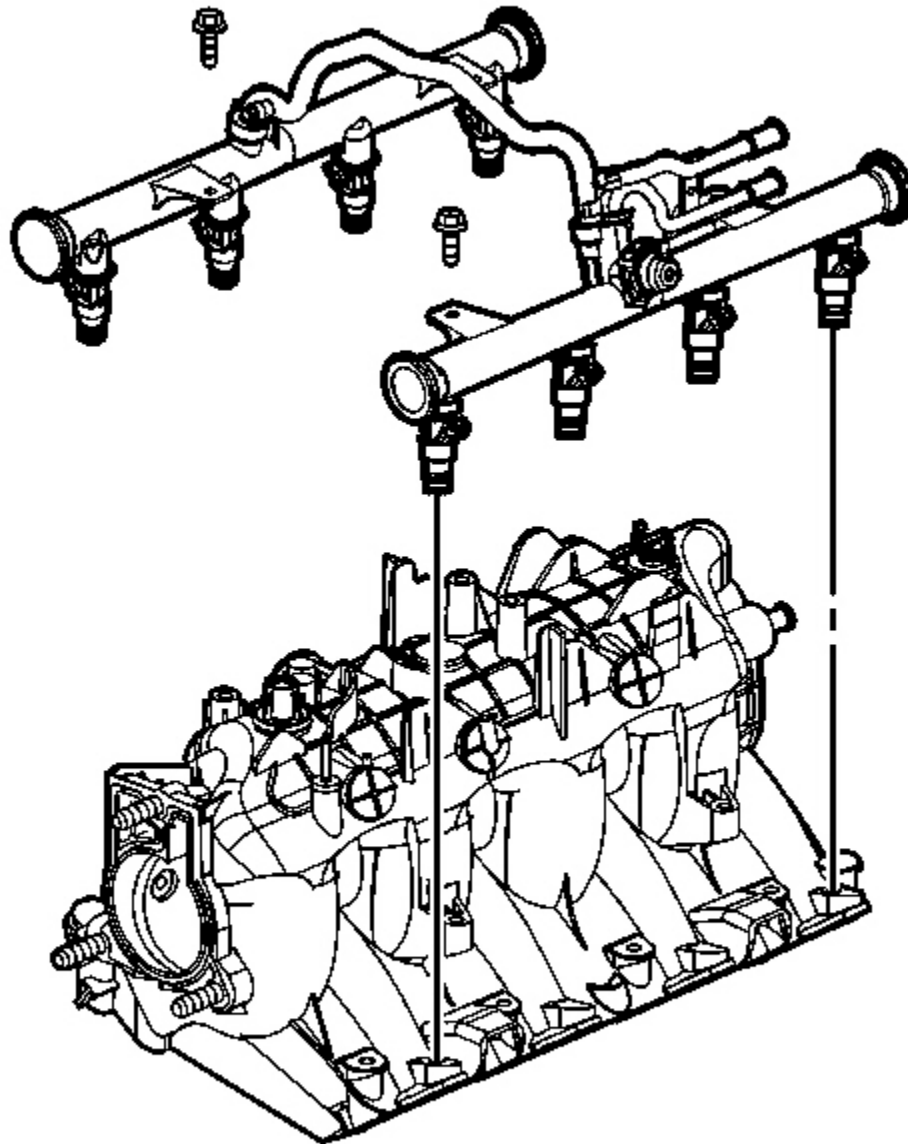


**Fig. 676: EVAP Purge Solenoid, Bolt & Isolator**  
Courtesy of GENERAL MOTORS CORP.

8. Install the evaporative emission (EVAP) purge solenoid (708), bolt (710), and isolator (709).

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

## FUEL RAIL AND INJECTORS INSTALLATION



**Fig. 677: Fuel Injector Rail**  
Courtesy of GENERAL MOTORS CORP.

**CAUTION:** Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and

## Notices.

**IMPORTANT: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.**

1. Lubricate the NEW fuel injector O-ring seals with clean engine oil.
2. Install the O-ring seals onto the fuel injectors.
3. Install a new O-ring seal to the right side of the crossover tube.
4. Assemble the crossover tube and bolt to the right fuel rail.
5. Install the fuel rail, with fuel injectors, into the intake manifold.

Press evenly on both sides of the fuel rail until all of the injectors are seated in their bores.

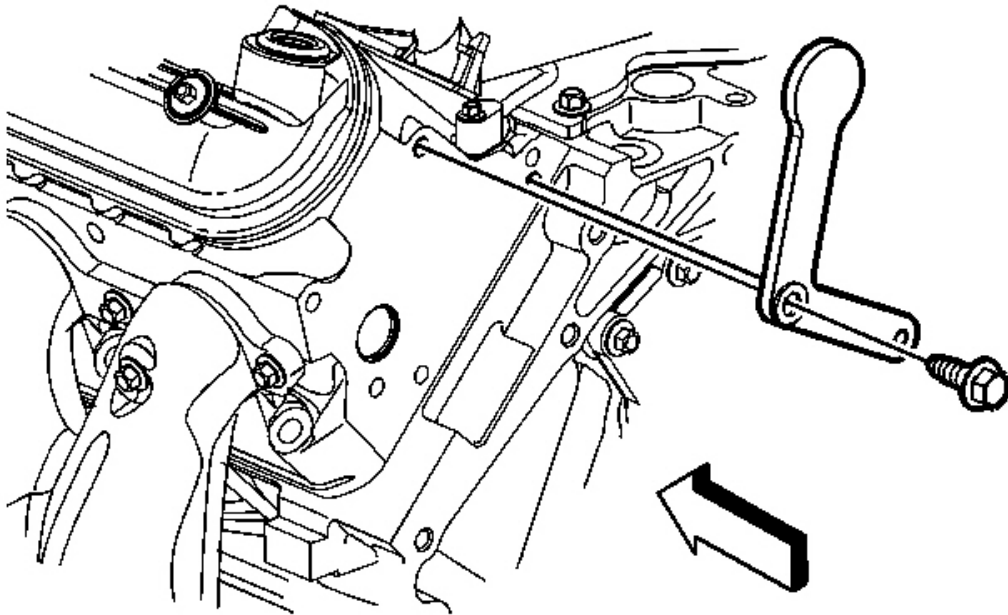
6. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the fuel rail bolts. Refer to **Sealers, Adhesives, and Lubricants** .

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

7. Install the fuel rail bolts.

### **Tighten:**

1. Tighten the fuel rail bolts to 10 N.m (89 lb in).
2. Tighten the crossover tube right side retaining bolt to 3.8 N.m (34 lb in).

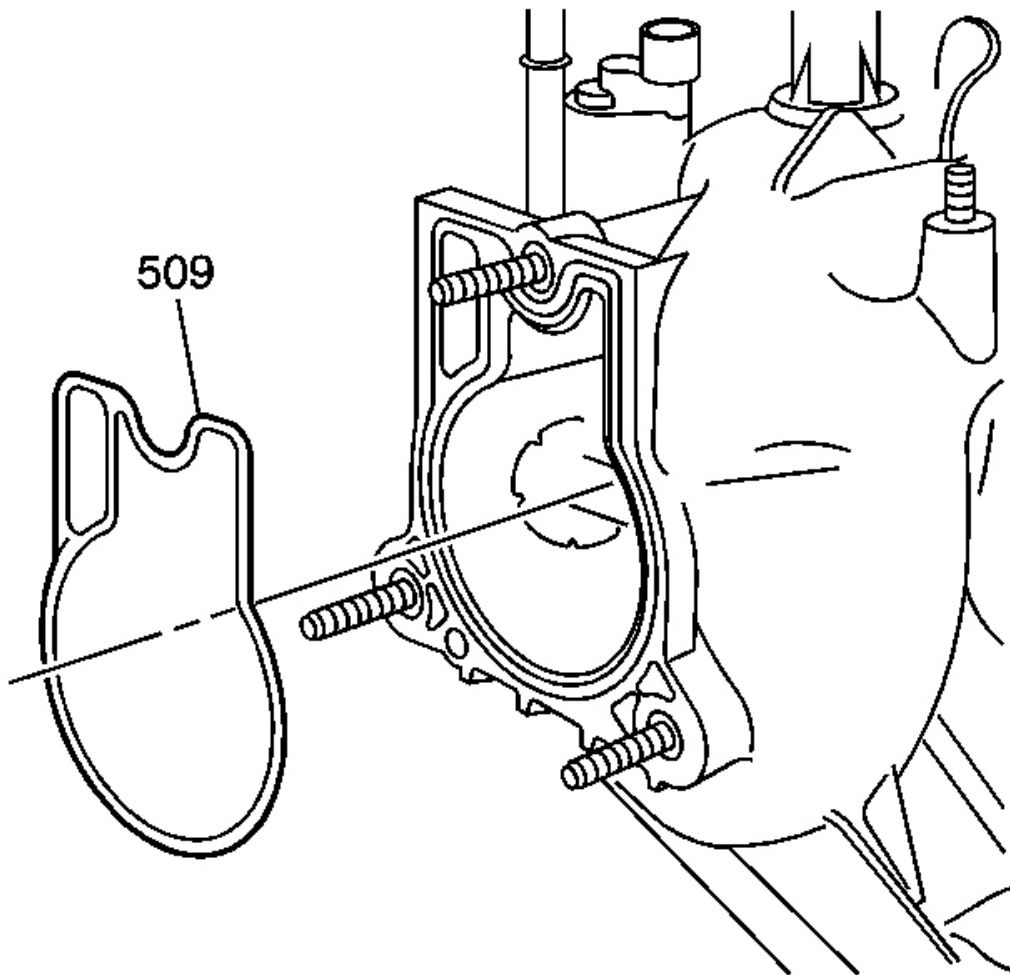


**Fig. 678: Fuel Rail Stop Bracket & Bolt**  
Courtesy of GENERAL MOTORS CORP.

8. Install the fuel rail stop bracket and bolt.

**Tighten:** Tighten the fuel rail stop bracket bolt to 50 N.m (37 lb ft).

## **THROTTLE BODY INSTALLATION**



**Fig. 679: Throttle Body Gasket**  
Courtesy of GENERAL MOTORS CORP.

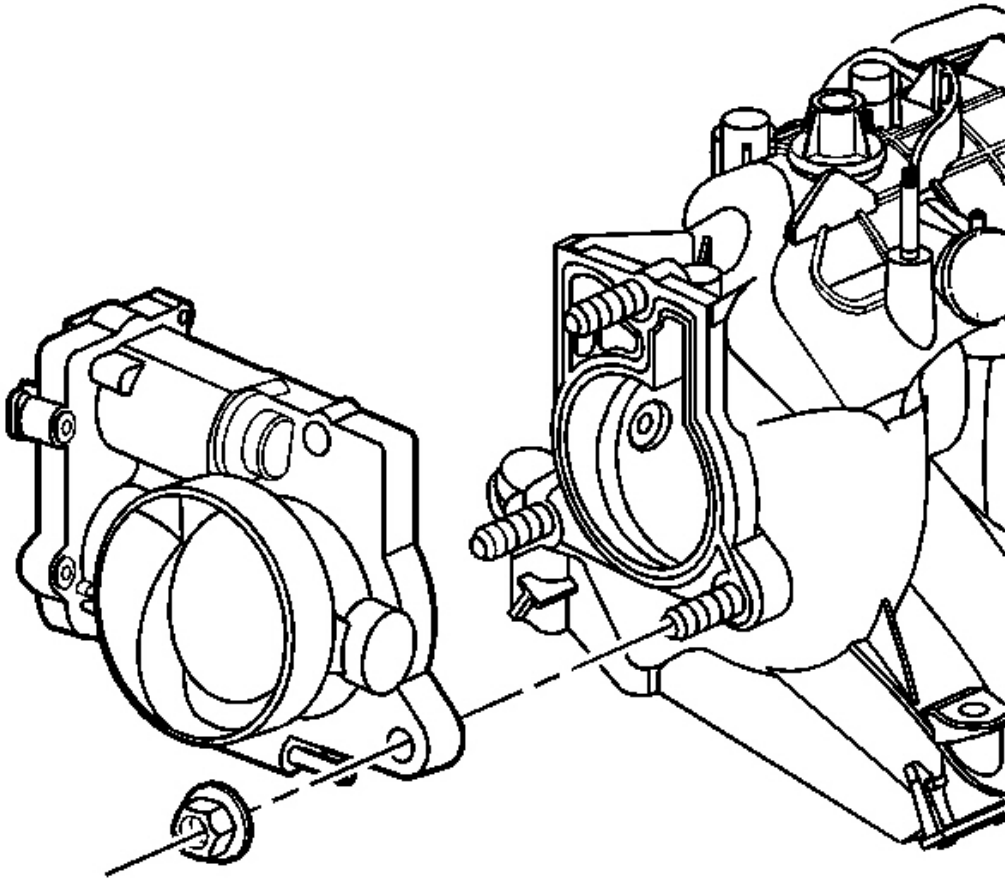
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

1. Install the throttle body studs, if required.

**Tighten:** Tighten the throttle body studs to 6 N.m (53 lb in).

**IMPORTANT: DO NOT** use the throttle body gasket again. Install a **NEW** gasket during assembly.

2. Install the throttle body gasket (509) to the intake manifold.



**Fig. 680: Throttle Body & Nuts**  
Courtesy of GENERAL MOTORS CORP.

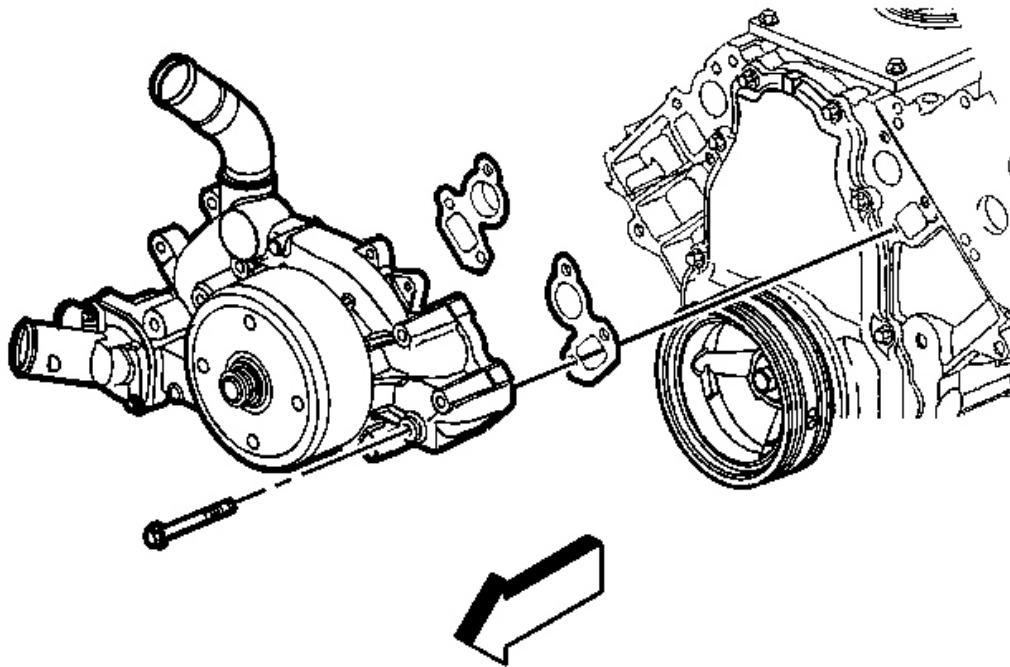
3. Install the throttle body and nuts.

**Tighten:** Tighten the throttle body nuts to 10 N.m (89 lb in).

4. Install the engine coolant air bleed hose and clamp to the throttle body.

## WATER PUMP INSTALLATION





**Fig. 681: Water Pump, Bolts & Gaskets**  
Courtesy of GENERAL MOTORS CORP.

**NOTE:** DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

**IMPORTANT:** All gasket surfaces to be free of oil or other foreign material during assembly.

1. Install the water pump and NEW gaskets.

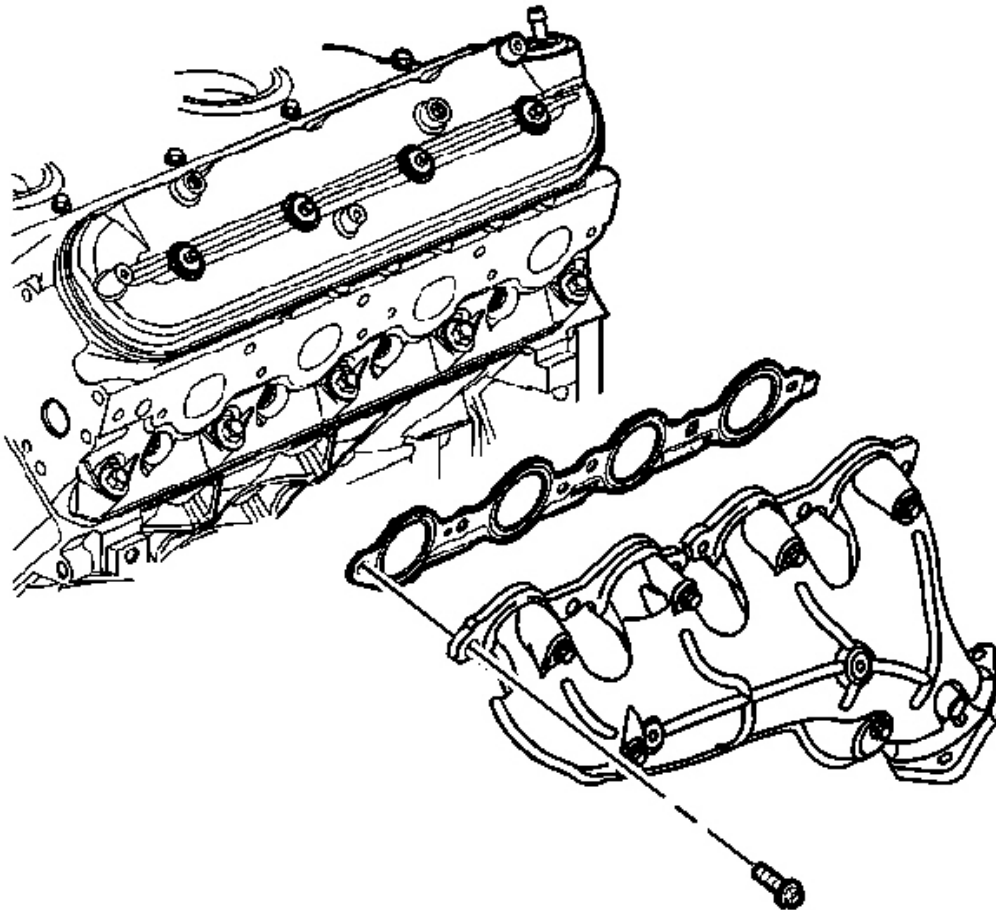
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

2. Install the water pump bolts.

**Tighten:**

1. Tighten the water pump bolts first pass to 15 N.m (11 lb ft).
2. Tighten the water pump bolts final pass to 30 N.m (22 lb ft).

## EXHAUST MANIFOLD INSTALLATION - LEFT



**Fig. 682: Exhaust Manifold, Gasket & Bolt (Left)**  
Courtesy of GENERAL MOTORS CORP.

### **IMPORTANT:**

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean

and free of debris or threadlocking material.

**IMPORTANT: Do not apply sealant to the first three threads of the bolt.**

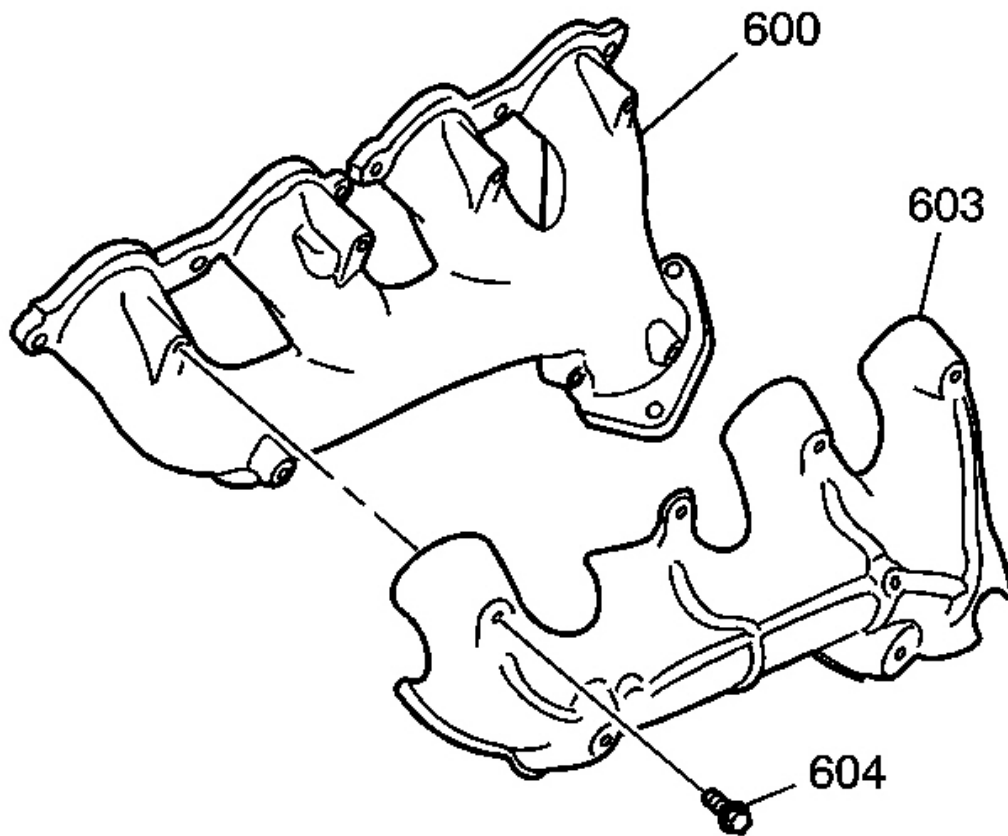
1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants** .
2. Install the exhaust manifold and NEW exhaust manifold gasket.

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

3. Install the exhaust manifold bolts.

**Tighten:**

1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
  2. Tighten the exhaust manifold bolts a final pass to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

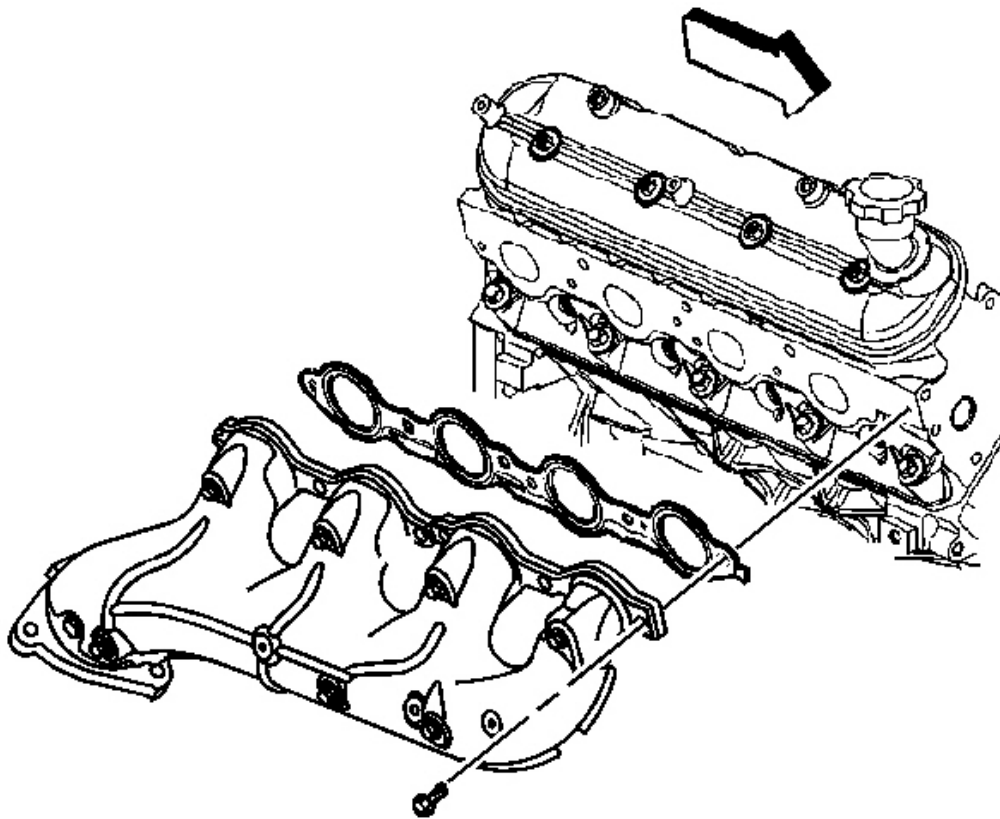


**Fig. 683: Exhaust Manifold & Heat Shield**  
Courtesy of GENERAL MOTORS CORP.

5. Install the heat shield (603) and bolts (604).

**Tighten:** Tighten the heat shield bolts to 9 N.m (80 lb in).

#### EXHAUST MANIFOLD INSTALLATION - RIGHT



**Fig. 684: Exhaust Manifold, Gasket & Bolt (Right)**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

- Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.
- The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.

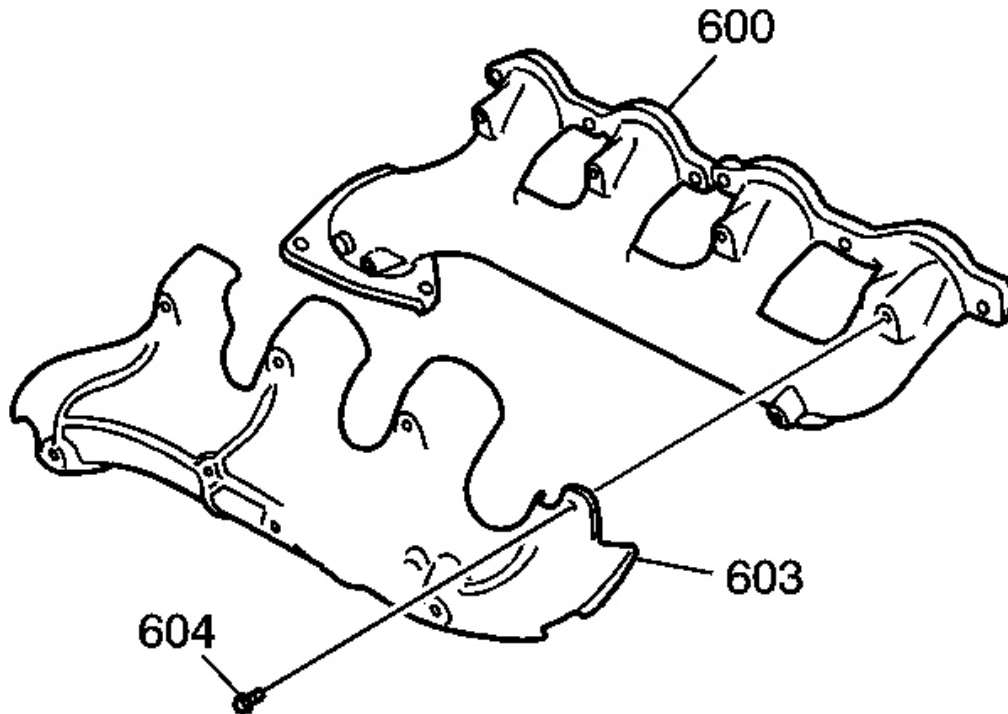
1. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants** .
2. Install the exhaust manifold gasket and exhaust manifold.

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

3. Install the exhaust manifold bolts.

**Tighten:**

1. Tighten the exhaust manifold bolts first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
  2. Tighten the exhaust manifold bolts final pass to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
4. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the front of the right cylinder head.

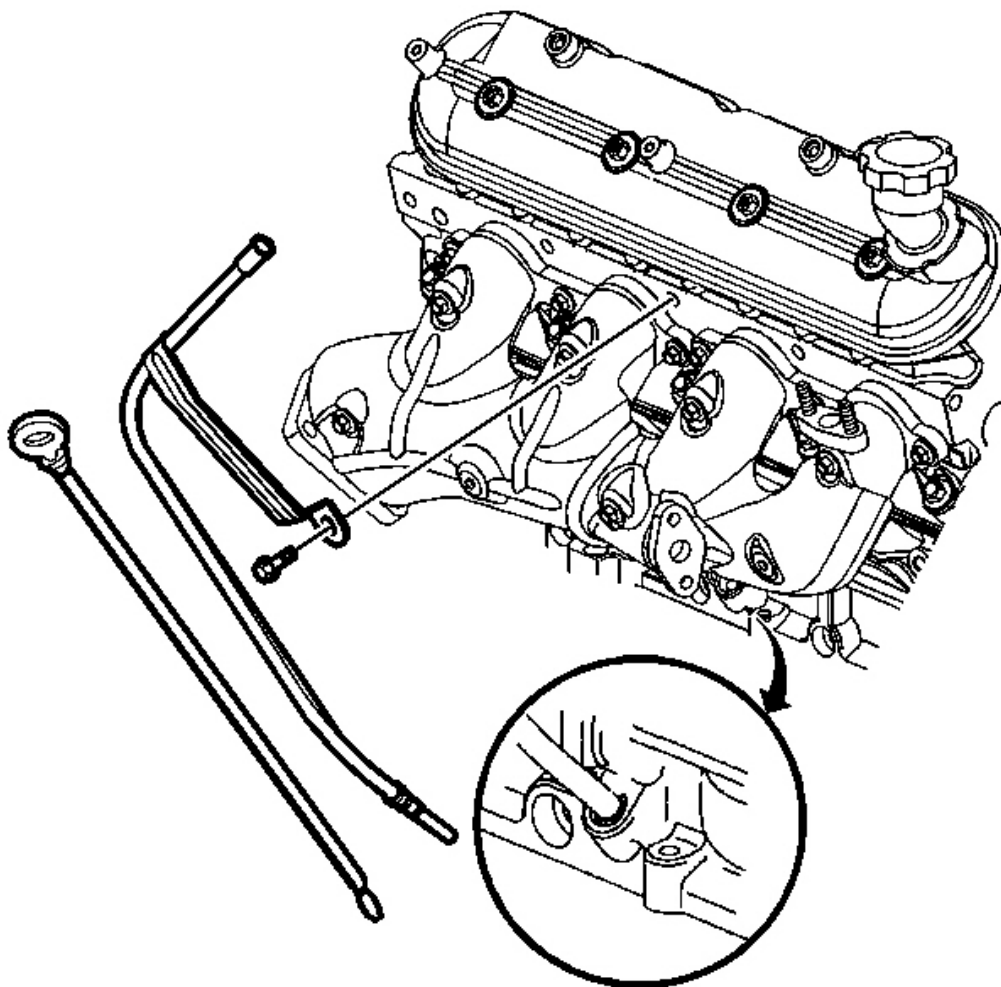


**Fig. 685: Manifold, Heat Shield & Bolts (Right)**  
Courtesy of GENERAL MOTORS CORP.

5. Install the heat shield (603) and bolts (604).

**Tighten:** Tighten the heat shield bolts to 9 N.m (80 lb in).

## OIL LEVEL INDICATOR AND TUBE INSTALLATION



**Fig. 686: Oil Level Indicator & Tube**  
Courtesy of GENERAL MOTORS CORP.

1. Inspect the O-ring seal for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be reused.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube.
4. Install the oil level indicator tube into the engine block and rotate into proper position.

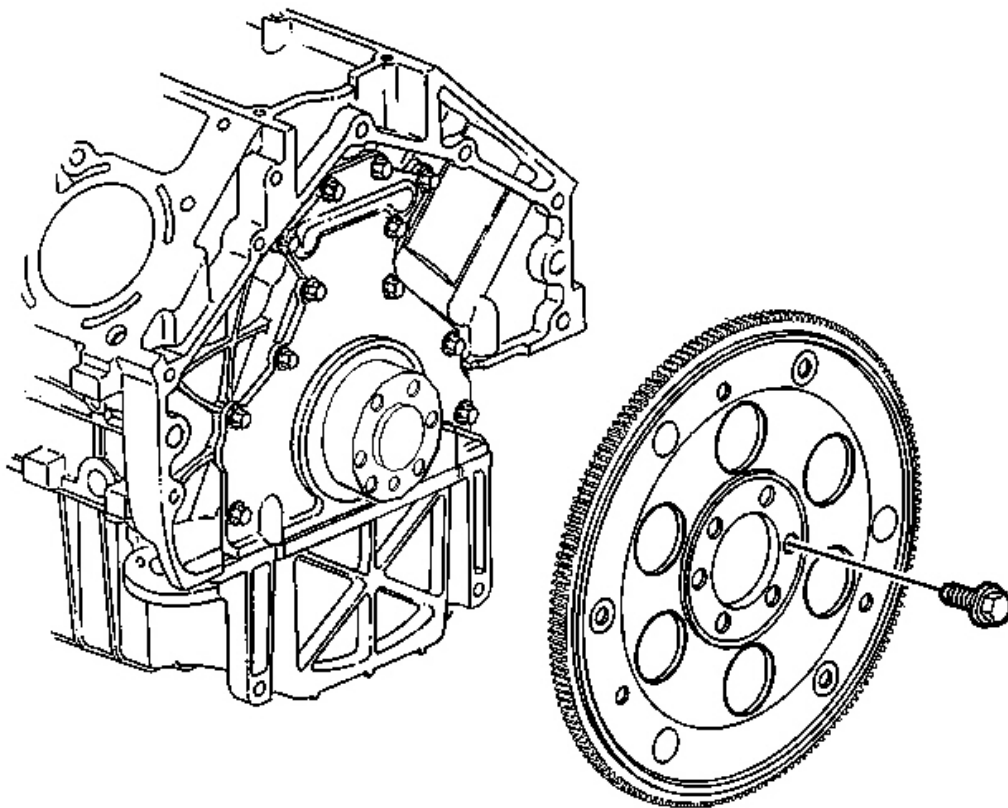
**NOTE:** Refer to Fastener Notice in Cautions and Notices.

5. Install the tube bolt.

**Tighten:** Tighten the oil level indicator tube bolt to 25 N.m (18 lb ft).

6. Install the oil level indicator into the tube.

## ENGINE FLYWHEEL INSTALLATION



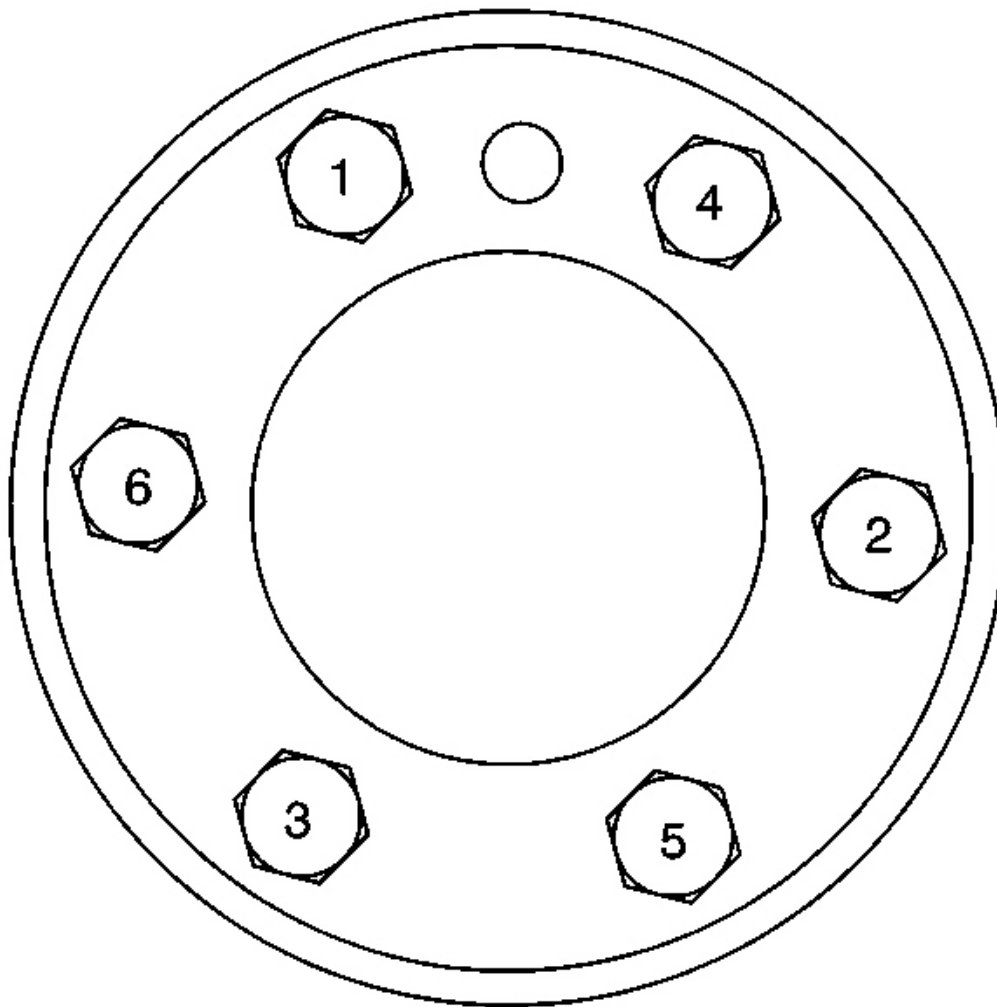
**Fig. 687: Engine Flywheel & Bolts (Automatic Transmission)**

Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The flywheel does not use a locating pin for alignment, and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.



1. Install the automatic transmission engine flywheel to the crankshaft.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.



**Fig. 688: Flywheel Bolt Tightening Sequence**  
Courtesy of GENERAL MOTORS CORP.

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

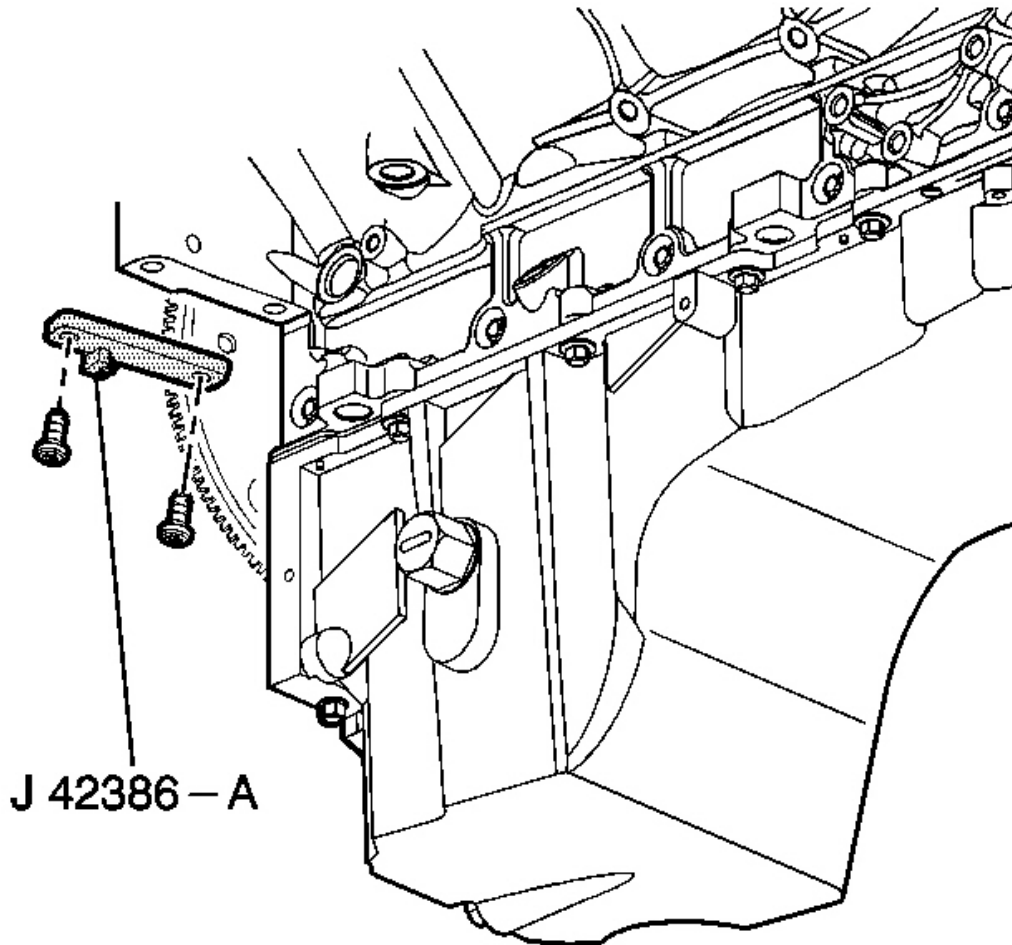
3. Install the engine flywheel bolts.

**Tighten:**

1. Tighten the engine flywheel bolts first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine flywheel bolts second pass in sequence to 50 N.m (37 lb ft).
3. Tighten the engine flywheel bolts final pass in sequence to 100 N.m (74 lb ft).

**CRANKSHAFT BALANCER INSTALLATION****Tools Required**

- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools and Equipment** .
- J 42386-A Flywheel Holding Tool
- **J 45059** Angle Meter. See **Special Tools and Equipment** .



**Fig. 689: View Of J 42386-A & Bolts**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:**

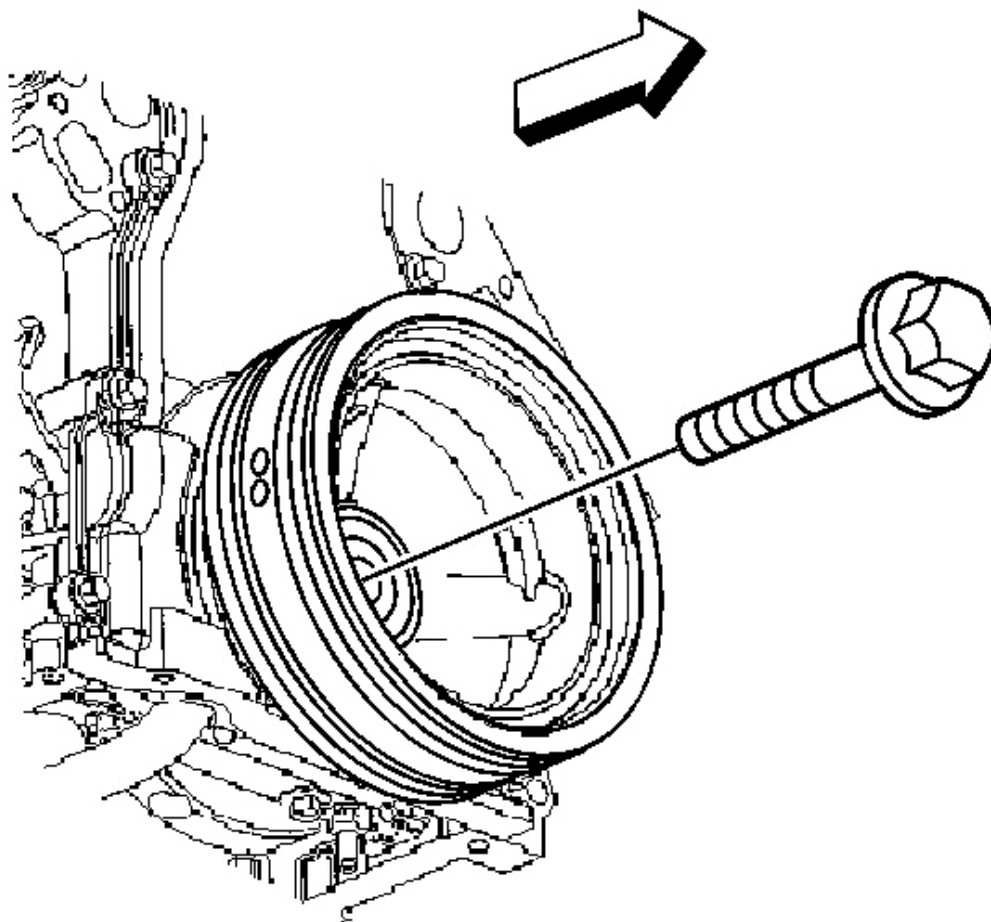
- The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.
- The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third and fourth passes tighten the new bolt to the proper torque.
- The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW crankshaft balancer bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.
- Ensure the teeth of the tool engage the engine flywheel teeth.

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

1. Install the J 42386-A and bolts.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

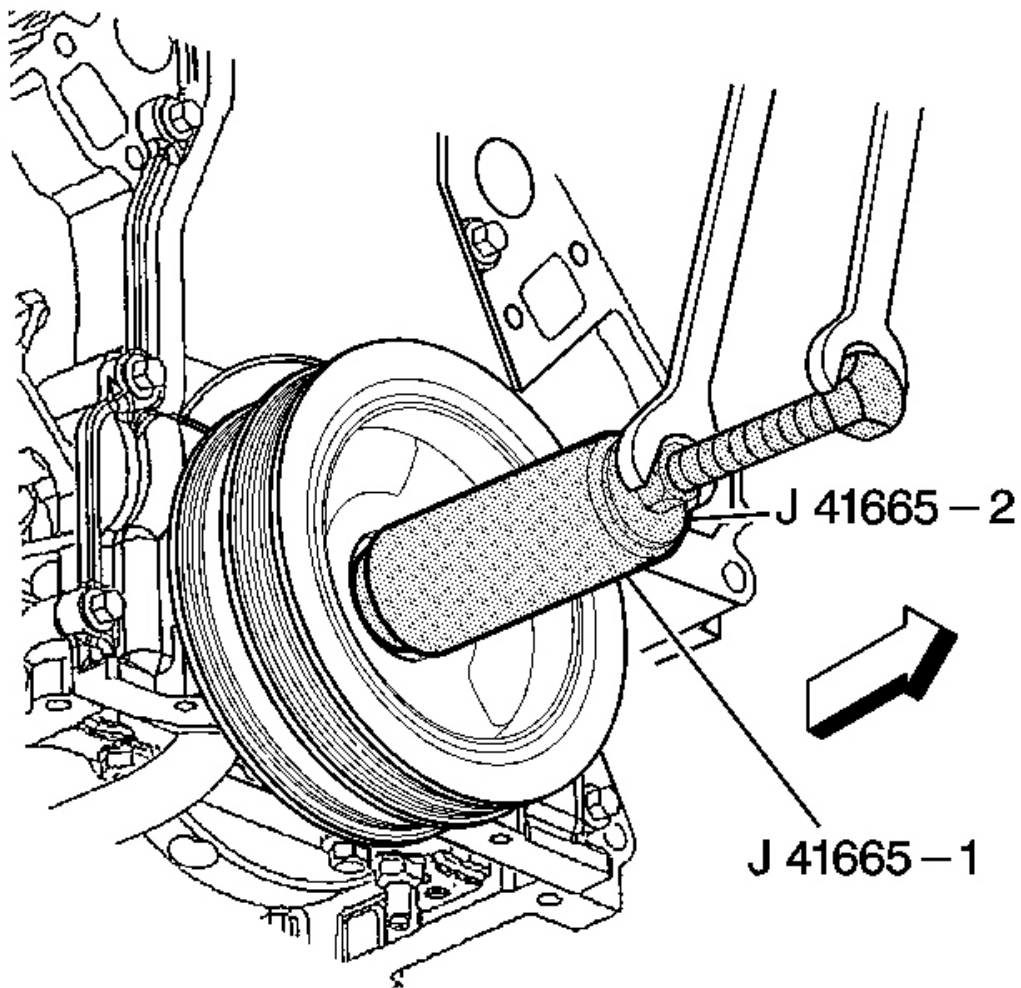
**Tighten:** Tighten the J 42386-A bolts to 50 N.m (37 lb ft).



**Fig. 690: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Install the balancer onto the end of the crankshaft.



**Fig. 691: View Of J 41665**

Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41665** in order to install the balancer. See **Special Tools and Equipment** .

1. Assemble the threaded rod, nut, washer and installer.

Insert the smaller end of the installer into the front of the balancer.

2. Use a wrench and hold the hex end of the threaded rod.

3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto crankshaft.

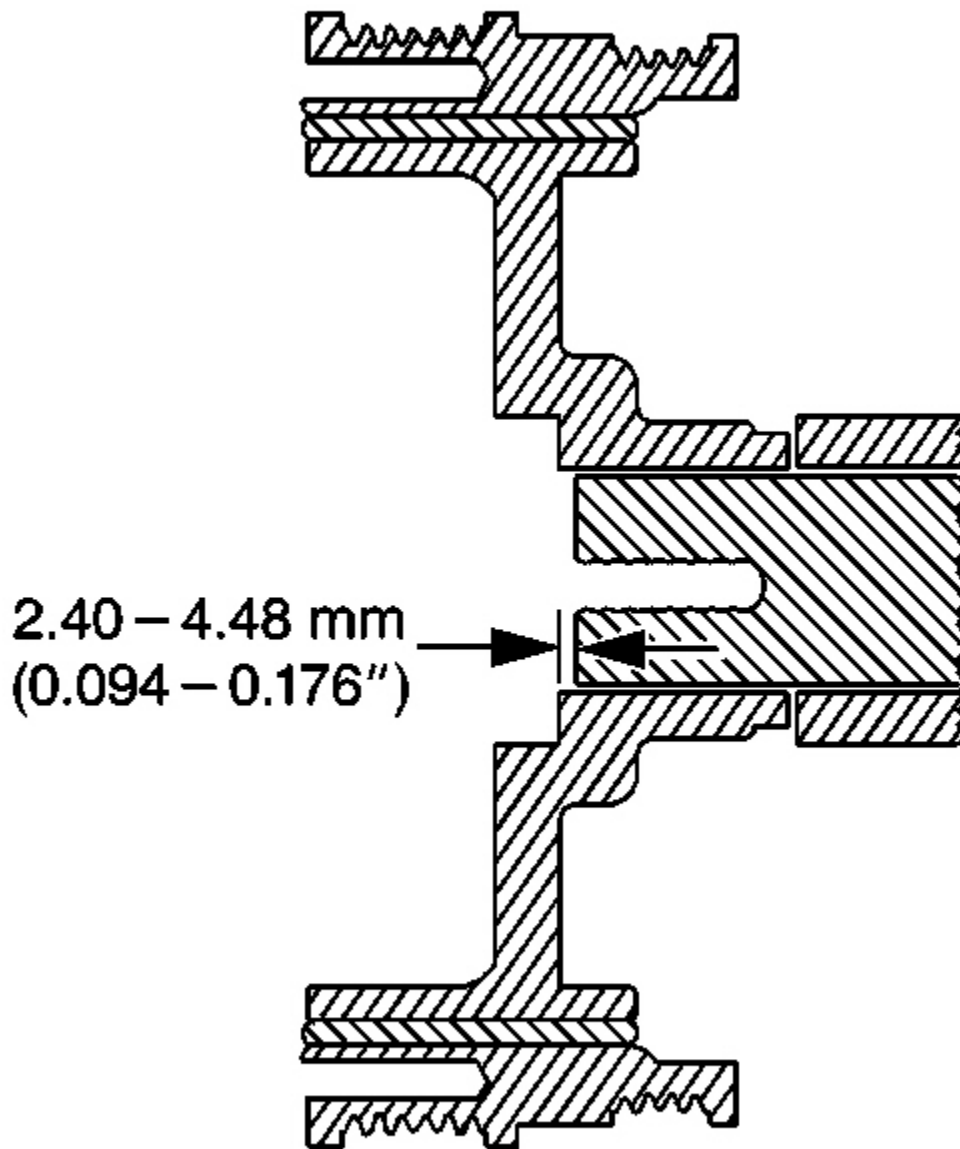
4. Remove the tool and reverse the installation tool.

Position the larger end of the installer against the front of the balancer.

5. Use a wrench and hold the hex end of the threaded rod.
  6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
  7. Remove the balancer installation tool.
4. Install the used crankshaft balancer bolt.

**Tighten:** Tighten the crankshaft balancer bolt to 330 N.m (240 lb ft).

5. Remove the used crankshaft balancer bolt.

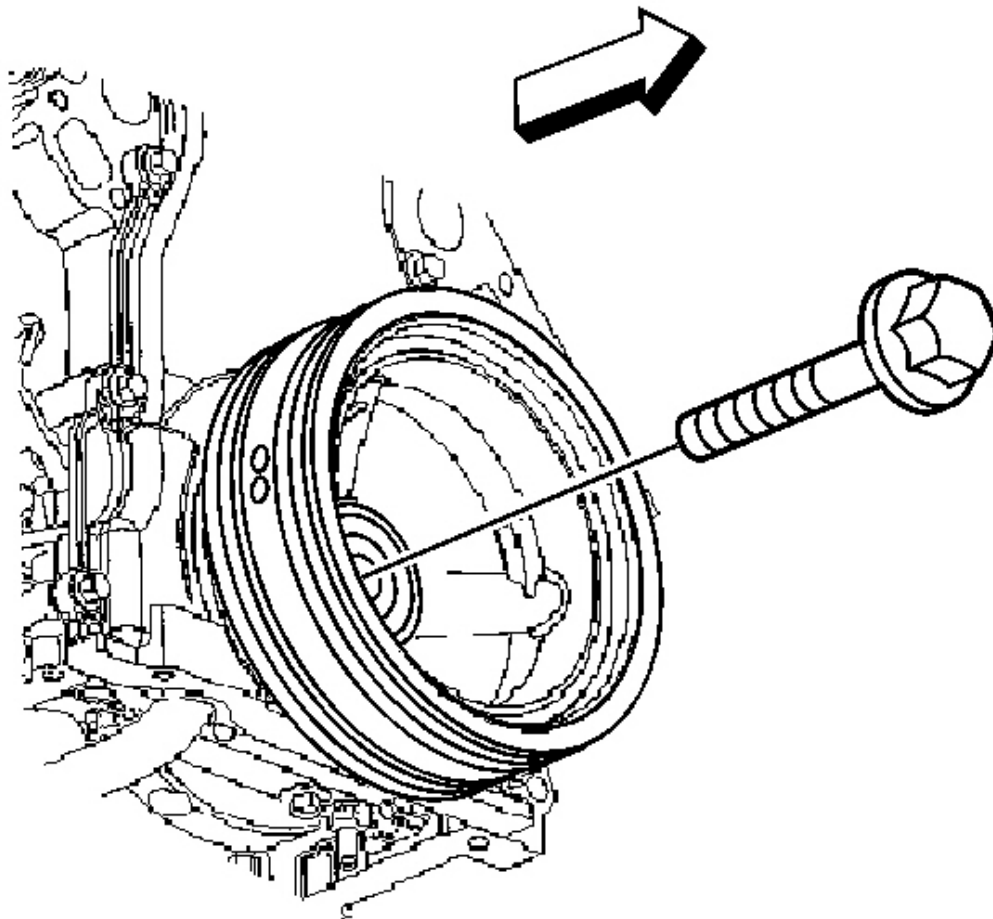


**Fig. 692: Balancer Proper Installation Position**  
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT:** The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.

6. Measure for a correctly installed balancer.

If the balancer is not installed to the proper dimensions, install the **J 41665** and repeat the installation procedure. See **Special Tools and Equipment** .



**Fig. 693: View Of Crankshaft Balancer**  
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW crankshaft balancer bolt.

**Tighten:**

1. Tighten the crankshaft balancer bolt a first pass to 50 N.m (37 lb ft).
2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the **J 45059** . See **Special**



## **Tools and Equipment .**

8. Remove the J 42386-A .

## **DESCRIPTION AND OPERATION**

### **CRANKCASE VENTILATION SYSTEM DESCRIPTION**

A closed crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from up-stream of the throttle blade to the front of the right rocker arm cover via a formed rubber hose. To reduce the potential of oil pullover into the throttle bore area due to back flow of the ventilation system, the fitting in the right rocker arm cover is shielded from the rocker arms. From there fresh air and gases are routed through the crankcase and up to the opposite rocker arm cover where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a hose to the intake manifold.

### **DRIVE BELT SYSTEM DESCRIPTION**

or

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

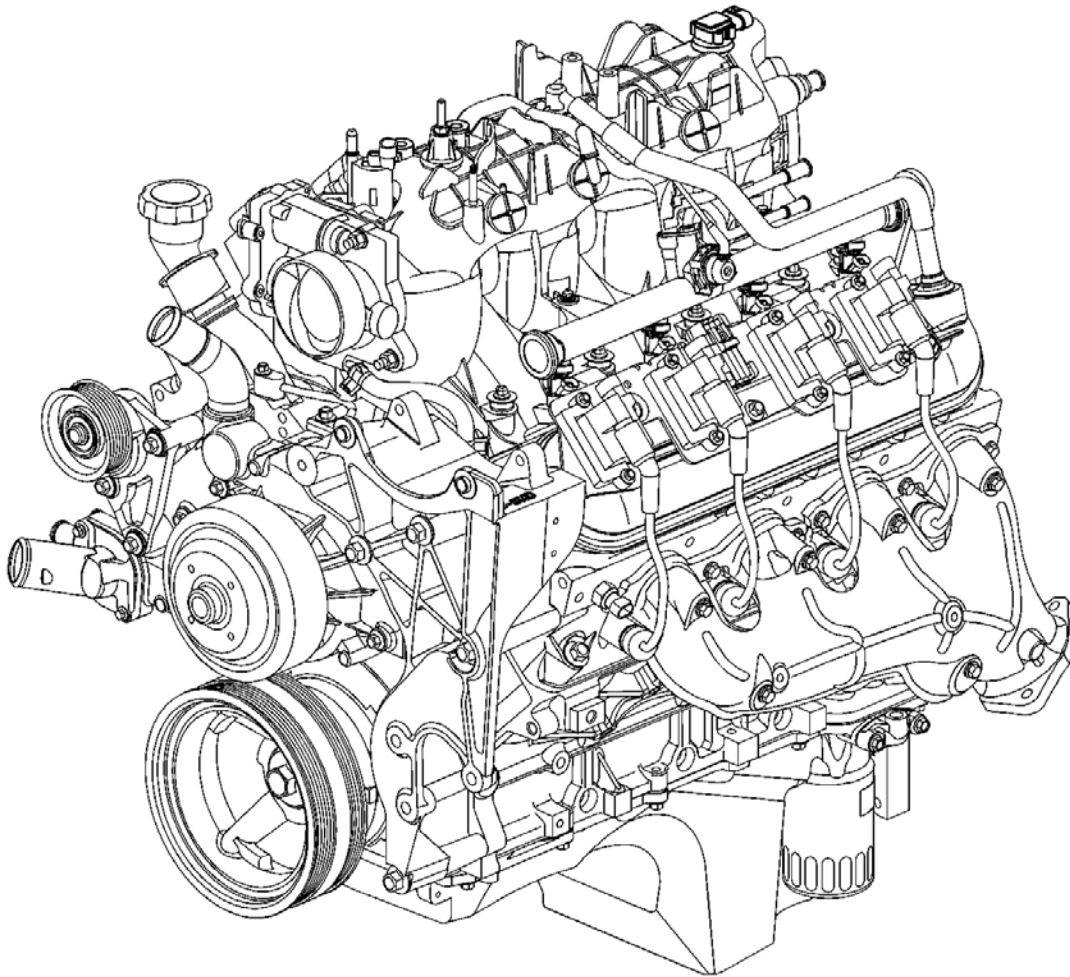
The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers - 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**



**Fig. 694: The 6.0 Liter V8 Engine**  
Courtesy of GENERAL MOTORS CORP.

The 6.0 Liter V8 engine is identified as RPO LQ4 VIN U.

### **Camshaft and Drive System**

A billet steel one piece camshaft is supported by five bearings pressed into the engine block. The camshaft has a machined camshaft sensor reluctor ring incorporated between the fourth and fifth bearing journals. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the camshaft timing chain. The splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket splines drive the oil pump driven gear. A retaining plate mounted to the front of the engine block maintains camshaft location.

### **Crankshaft**

The crankshaft is cast nodular iron. The crankshaft is supported by five crankshaft bearings. The bearings are \_\_\_\_\_

retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A crankshaft position reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately. All crankshafts will have a short rear flange, at the crankshaft rear oil seal area.

### **Cylinder Heads**

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. Passages for the engine coolant air bleed system are at the front of each cylinder head. The valve rocker arm covers are retained to the cylinder head by four center mounted rocker arm cover bolts.

### **Engine Block**

The engine block is a cam-in-block deep skirt 90 degree V configuration with five crankshaft bearing caps. The engine block is cast iron. The five crankshaft bearing caps each have four vertical M10 and two horizontal M8 mounting bolts. The camshaft is supported by five camshaft bearings pressed into the block. First design engine blocks have different drill and tap depths using both medium length 100 mm (3.94 in) and long 155 mm (6.1 in) M11 cylinder head bolts. Second design engine blocks use only the medium length 100 mm (3.94 in) bolt with a common drill and tap depth.

### **Exhaust Manifolds**

The exhaust manifolds are a one piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

### **Intake Manifold**

The intake manifold is a one piece composite design that incorporates brass threaded inserts for mounting the fuel rail, throttle body, evaporative emission (EVAP) solenoid, wire harness stud, engine sight shield and sight shield bracket. Each side of the intake manifold is sealed to the cylinder head by a nonreusable silicone sealing gasket and nylon carrier assembly. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a one piece push in place silicone gasket. The fuel rail assembly with eight separate fuel injectors is retained to the intake by four bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. A fuel rail stop bracket is retained to the rear of the left cylinder head by a mounting bolt. The manifold absolute pressure (MAP) sensor is installed and retained to the top rear of the intake manifold and sealed by an O-ring seal. The EVAP solenoid is mounted to the top front of the intake manifold and retained by one bolt. There are no coolant passages within the intake manifold.

### **Oil Pan**

The structural oil pan is cast aluminum. Incorporated into the design are the oil filter mounting boss, drain plug opening, oil level sensor mounting bore, and oil pan baffle. The oil pan transfer cover and oil level sensor mount to the sides of the oil pan. The alignment of the structural oil pan to the rear of the engine block and transmission bell housing is critical.

### **Piston and Connecting Rod Assembly**

The pistons are cast aluminum. The pistons use 2 compression rings and a 3-piece oil control ring assembly. The piston is a low friction, lightweight design with a barrel shaped skirt. All applications use pistons with graphite-coated skirts. The piston pins are chromium steel. First design applications use a piston pin that is floating fit to the piston and press fit to the connecting rod. Second design applications use a pin that is full-floating to both the piston and connecting rod. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance. The first design piston, pin, and connecting rod are to be serviced as an assembly.

### **Valve Rocker Arm Cover Assemblies**

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the coil and bracket assemblies. Incorporated into the left cover is the positive crankcase ventilation (PCV) system passage. Incorporated into the right cover is the oil fill tube and engine fresh air passage.

### **Valve Train**

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve lifter guides position and retain the valve lifters. The valve rocker arms for each bank of cylinders are mounted on pedestals, pivot supports. Each rocker arm is retained on the pivot support and cylinder head by a bolt. Valve lash is net build.

## **NEW PRODUCT INFORMATION**

The purpose of New Product Information is to highlight or indicate important product changes from the previous model year.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

### **Torque Values and/or Fastener Tightening Strategies**

- All fasteners and threaded holes on the 6.0 liter engine utilize metric threads.
- Cylinder head, connecting rod, crankshaft balancer, and main bearing cap bolts now apply a torque angle strategy.
- Certain fasteners should not be reused. Bolts, studs, or other fasteners that must be replaced will be called out in the specific service procedure.
- First design engine blocks cylinder head bolts have different torque/angle specifications using both

medium length 100 mm (3.94 in) and long 155 mm (6.1 in) M11 cylinder head bolts. Second design engine blocks use only the medium length 100 mm (3.94 in) bolt with a common torque/angle specification.

- Refer to **Fastener Tightening Specifications** and **Thread Repair Specifications** .

#### **Disassembly and Assembly Procedure Revisions**

- Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore.
- The piston, pin, and connecting rod are to be serviced as an assembly.
- Newer design pistons have a graphite coated piston skirt. The coated skirt outside diameter (OD) may be slightly larger than the cylinder bore inside diameter (ID) and the piston assembly may have a slight interference fit to the cylinder bore during initial installation.

#### **Engine Mechanical Diagnostic Procedure Revisions**

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. For a detailed explanation, refer to **Strategy Based Diagnosis** in General Information or **Diagnostic Starting Point - Engine Mechanical** .

#### **New Special Tools Required**

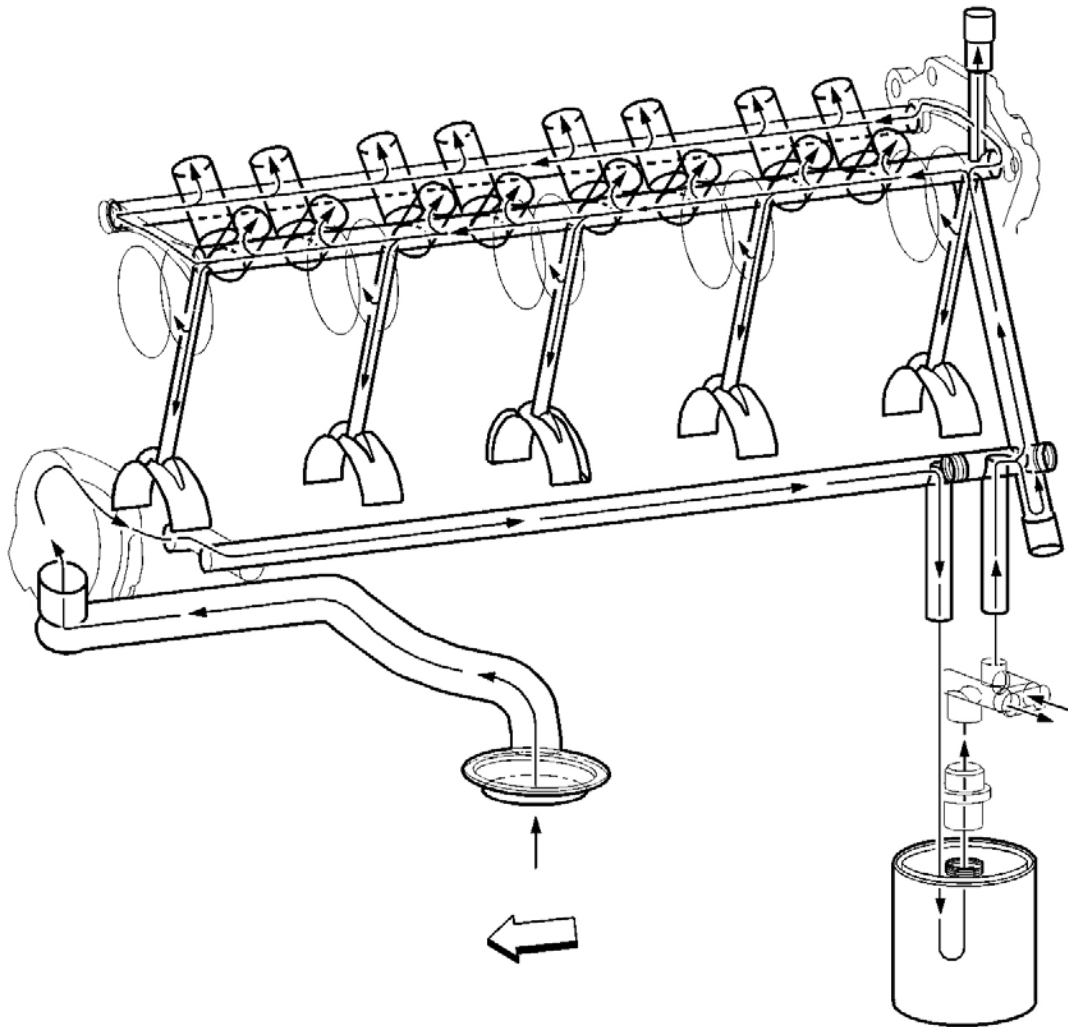
Angle Meter **J 45059** has been developed to provide technicians with a convenient method to tighten bolts that require the torque angle tightening strategy. See **Special Tools and Equipment** .

#### **A Component Comparison from the Previous Year**

- Exhaust gas recirculation (EGR) system has been deleted on all applications.
- All 2004 applications use a piston with a graphite-coated skirt.
- The positive crankcase ventilation (PCV) valve is a non-serviceable fitting in the left rocker arm cover.
- The fuel rails for all engines are returnless fuel systems. The fuel pressure regulator is now a part of the fuel pump module.
- First design applications use a piston pin that is floating fit to the piston and press fit to the connecting rod. Second design applications use a piston pin that is full-floating to both the piston and connecting rod.
- The first design piston, pin, and connecting rod are to be serviced as an assembly.

## **LUBRICATION DESCRIPTION**

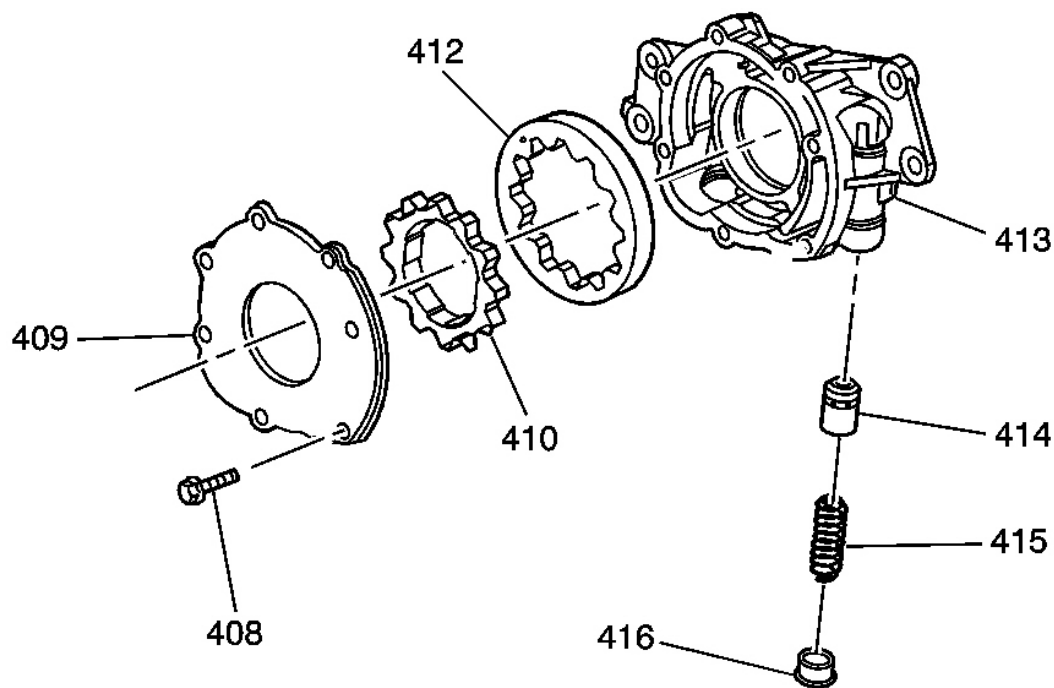
### **Lubrication Flow Schematic**



**Fig. 695: Lubrication Flow**  
 Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block oil galleries. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range. Pressurized oil is directed through the lower gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan, at the oil filter boss, which will permit oil flow in the event the filter becomes restricted. At the rear of the block, oil is then directed to the upper main oil galleries which are drilled just above the camshaft assembly. From there oil is then directed to the crankshaft and camshaft bearings. Oil that has entered the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. Oil pressure and crankcase level are each monitored by individual sensors.

An external oil cooler is available on certain applications, all 6.0L. Oil is directed from the oil pump, through the lower main oil gallery to the full flow oil filter. Oil is then directed through the oil pan outlet oil gallery, located in the left rear of the oil pan, and to the external oil cooler via a hose assembly. Oil flows through the oil cooler and returns to the engine at the oil pan inlet oil gallery, located in the left rear of the oil pan. Oil is then directed to the upper main oil galleries and the remainder of the engine assembly.



**Fig. 696: Oil Pump Assembly**

Courtesy of GENERAL MOTORS CORP.

**Callouts For Fig. 696**

Callout	Component Name
408	Cover Bolt
409	Cover
410	Drive Gear
412	Driven Gear
413	Oil Pump
414	Pressure Relief Valve
415	Pressure Relief Valve Spring
416	Plug

**CLEANLINESS AND CARE**



- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for assembly. Refer to **Separating Parts** .
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

## SEPARATING PARTS

### IMPORTANT:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **Many internal engine components will develop specific wear patterns on their friction surfaces.**
- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location

- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

## **REPLACING ENGINE GASKETS**

### **Tools Required**

**J 28410** Gasket Remover. See **Special Tools and Equipment** .

### **Gasket Use and Applying Sealants**

- Do not use any gasket again unless specified.
- Gaskets that can be used again will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

### **Separating Components**

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

### **Cleaning Gasket Surfaces**

- Remove all gasket and sealing material from the part using the **J 28410** or equivalent. See **Special Tools and Equipment** .
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
  - This grit is abrasive and has been known to cause internal engine damage.

### **Assembling Components**

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

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.

- Tighten bolts to specifications. Do not overtighten.

## USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

### Pipe Joint Compound

**IMPORTANT:** Three types of sealer are commonly used in engines. They are Room Temperature Vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. **DO NOT** interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where two non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

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

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

### RTV Sealer

- RTV sealant hardens when exposed to air. This type sealer is used where two non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

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

- Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes.
- Assemble components while RTV is still wet, within 3 minutes. Do not wait for RTV to skin over.

- Tighten bolts to specifications. Do not overtighten.

### **Anaerobic Sealer**

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be sealed must be clean and dry.

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

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

**IMPORTANT: Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.**

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

### **TOOLS AND EQUIPMENT**

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

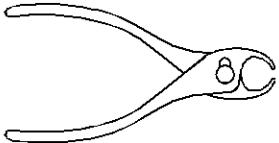
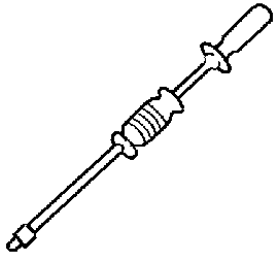
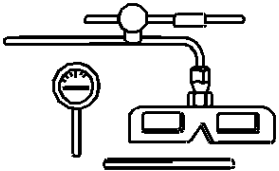
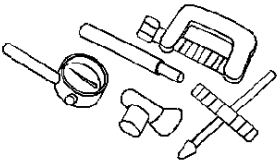
To properly service the engine assembly, the following items should be readily available:

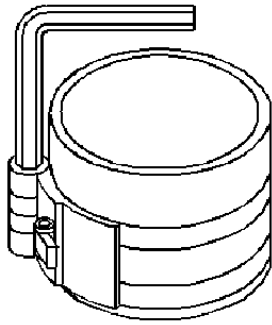
- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

# SPECIAL TOOLS AND EQUIPMENT

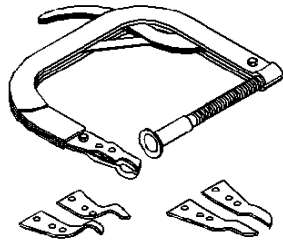
## SPECIAL TOOLS

### Special Tools

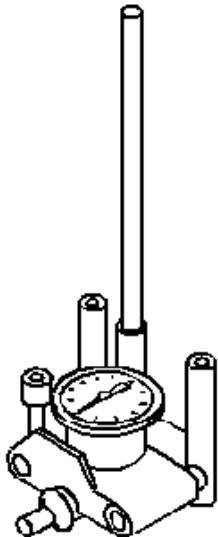
Illustration	Tool Number/Description
	<p>J 3049-A Valve Lifter Remover</p>
	<p>J 6125-1B Slide Hammer</p>
	<p>J 7872 Magnetic Base Dial Indicator Set</p>
	<p>J 8001 Dial Indicator Set</p>



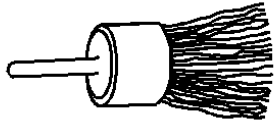
J 8037  
Piston Ring Compressor



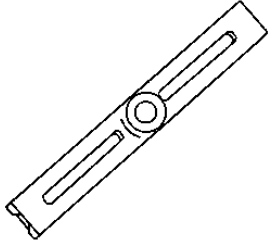
J 8062  
Valve Spring Compressor - Head Off



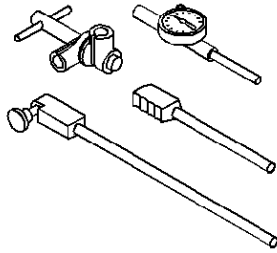
J 8087  
Cylinder Bore Gauge



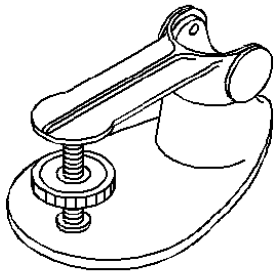
J 8089  
Carbon Removal Brush



J 8433-1  
Puller Bar

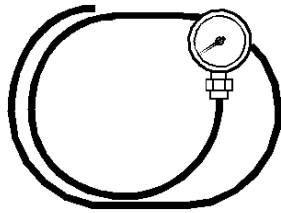
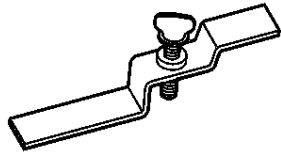


J 8520  
Cam Lobe Lift Indicator

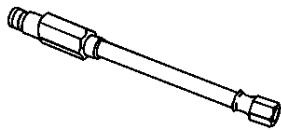


J 9666  
Valve Spring Tester

J 21366  
Converter Holding Strap



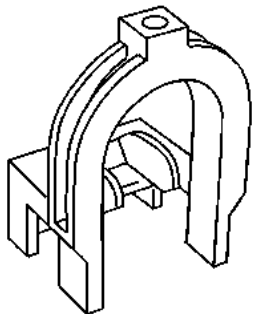
J 21867  
Pressure Gauge



J 22794  
Spark Plug Port Adapter

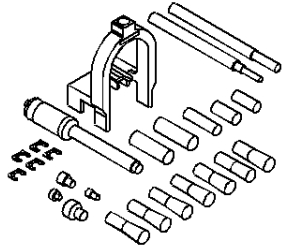


J 24086-9  
Adjustable Installer

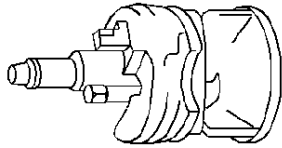


J 24086-10  
Piston Pin Remover Installer Base

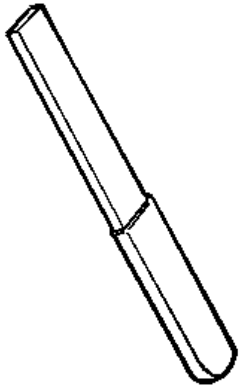




J 24086-C  
Piston Pin Remover/Installer Set

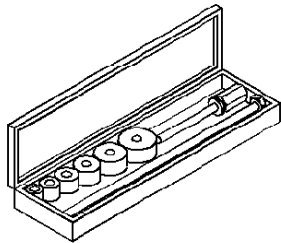
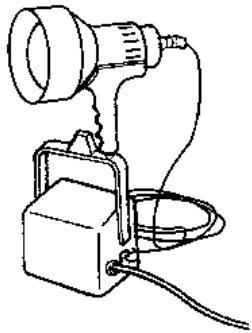


J 24270  
Cylinder Bore Ridge Reamer



J 28410  
Gasket Remover

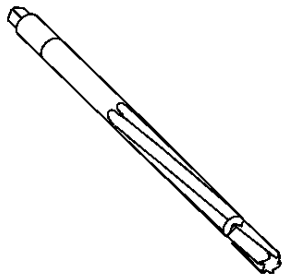
J 28428-E  
High-Intensity Black Light Kit



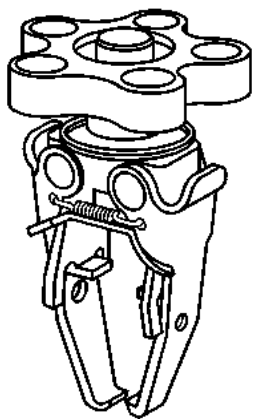
J 33049  
Camshaft Bearing Service Set



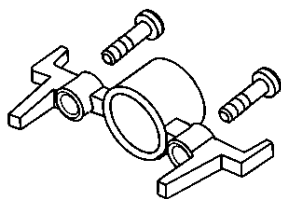
J 35667-A  
Cylinder Head Leakdown Tester



J 37378-1  
Valve Guide Reamer

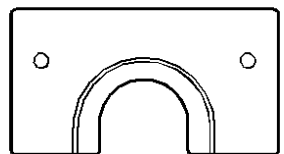
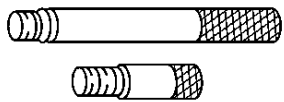
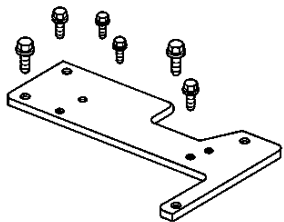
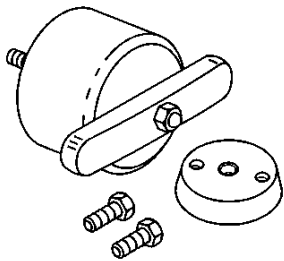
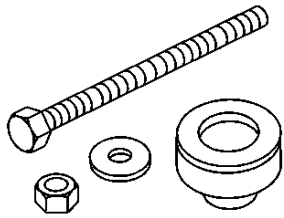


J 38606  
Valve Spring Compressor



J 41476  
Front and Rear Cover Alignment - at crankshaft seal area

J 41478  
Crankshaft Front Oil Seal Installer

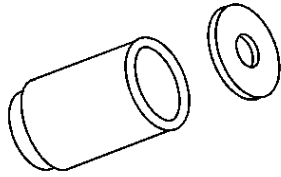


J 41479  
Crankshaft Rear Oil Seal Installer

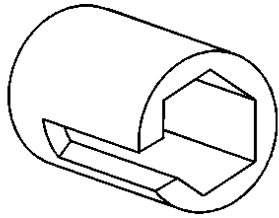
J 41480  
Front and Rear Cover Alignment - at oil pan surface

J 41556  
Connecting Rod Guide

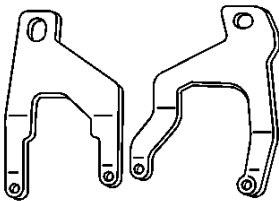
J 41558  
Crankshaft Sprocket Remover



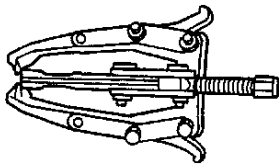
J 41665  
Crankshaft Balancer and Sprocket Installer



J 41712  
Oil Pressure Switch Socket

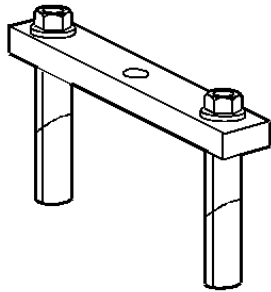
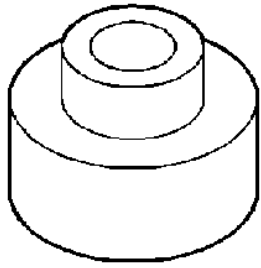


J 41798  
Engine Lift Brackets

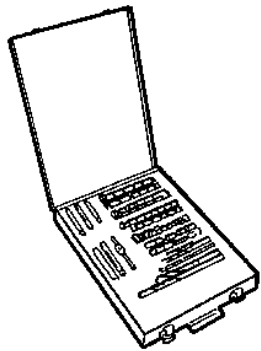


J 41816  
Crankshaft Balancer Remover

J 41816-2  
Crankshaft End Protector



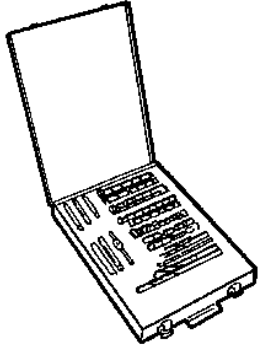
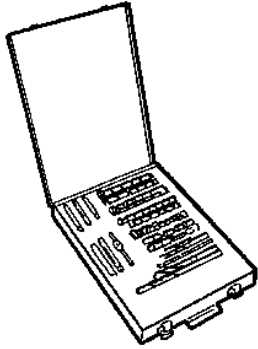
J 41818  
Crankshaft Bearing Cap Remover



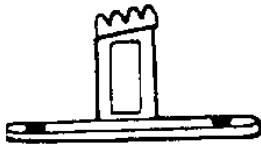
J 42385-100  
Head/Main Bolt Thread Repair Kit

J 42385-200

Common Thread Repair Kit

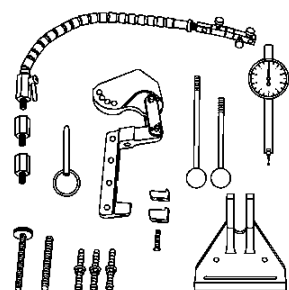
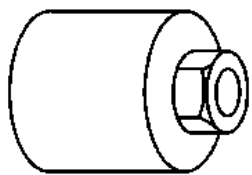


J 42385-300  
Fixtures and Hardware Kit

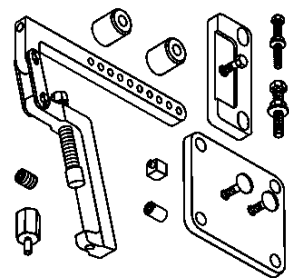


J 42386-A  
Flywheel Holding Tool

J 42907  
Oil Pressure Testing Tool



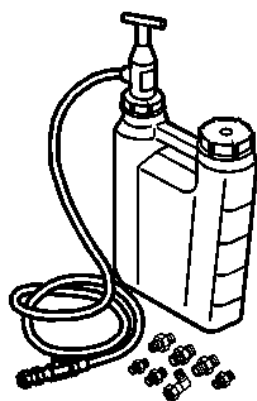
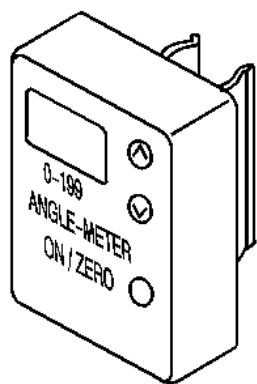
J 43690  
Rod Bearing Checking Tool



J 43690-100  
Rod Bearing Checking Tool - Adapter Kit

J 45059  
Angle Meter





J 45299  
Engine Preluber