2008 ENGINE

Engine Mechanical - 4.3L - Sierra & Silverado

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Nut to Stud	12 N.m	106 lb in
Accelerator Control Cable Bracket Nut to Throttle Body	9 N.m	80 lb in
Accelerator Control Cable Bracket Stud to Intake Manifold	6 N.m	53 lb in
Accelerator Control Cable Bracket Stud to Throttle Body	12 N.m	106 lb in
Air Cleaner Adapter Stud	8 N.m	71 lb in
Balance Shaft Driven Gear Bolt		
• First Pass	20 N.m	15 lb ft
• Final Pass	35 degrees	
Balance Shaft Retainer Bolt	12 N.m	106 lb in
Battery Cable Bracket Bolt to Oil Pan	12 N.m	106 lb in
Battery Negative Cable Bolt to Engine	25 N.m	18 lb ft
Battery Positive Cable Junction Block Bracket Bolt	25 N.m	18 lb ft
Belt Idler Pulley Bolt	50 N.m	37 lb ft
Camshaft Retainer Bolt	12 N.m	106 lb in
Camshaft Sensor Bolt	N.m	lb ft
Camshaft Sprocket Bolt	25 N.m	18 lb ft
Connecting Rod Bolt		
• First Pass	20 N.m	15 lb ft
• Final Pass	100 degrees	
Crankshaft Balancer Bolt	95 N.m	70 lb ft
Crankshaft Bearing Cap Bolt - Preferred Method		
• First Pass	20 N.m	15 lb ft
• Final Pass	73 degrees	

Crankshaft Bearing Cap Bolt	105 N.m	77 lb ft
Crankshaft Position Sensor Bolt	9 N.m	80 lb in
Crankshaft Pulley Bolt	58 N.m	43 lb ft
Crankshaft Rear Oil Seal Housing Bolt and Nut	12 N.m	106 lb in
Crankshaft Rear Oil Seal Housing Retainer Stud	6 N.m	53 lb in
Crossmember Bolt	100 N.m	74 lb ft
Cylinder Head Bolt - Preferred Method		
• All Bolts First Pass in Sequence	30 N.m	22 lb ft
• Long Bolts Final Pass in Sequence	75 degrees	
• Medium Bolts Final Pass in Sequence	65 degrees	
• Short Bolts Final Pass in Sequence	55 degrees	
Cylinder Head Core Hole Plug	20 N.m	15 lb ft
Distributor Cap Bolt	2.4 N.m	21 lb in
Distributor Clamp Bolt	25 N.m	18 lb ft
Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Left Side Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Left Rear Oil Gallery Plug	30 N.m	22 lb ft
Engine Block Right Rear Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Coolant Drain Hole Plug	20 N.m	15 lb ft
Engine Block Oil Gallery Plug	20 N.m	15 lb ft
Engine Coolant Heater Bolt/Screw	2 N.m	18 lb in
Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
Engine Flywheel Bolt	100 N.m	74 lb ft
Engine Front Cover Bolt	12 N.m	106 lb in
Engine Lift Front Bracket Stud	35 N.m	26 lb ft
Engine Mount Bolt to Engine Bracket	50 N.m	37 lb ft
Engine Mount Engine Bracket Bolt to Engine	50 N.m	37 lb ft
Engine Mount Frame Bracket Through-bolt	75 N.m	55 lb ft
Engine Mount Frame Side Mount Bolt	65 N.m	50 lb ft
Engine Oil Level Sensor	13 N.m	115 lb in
Engine Oil Pressure Gage Sensor	30 N.m	22 lb ft
Engine Oil Pressure Gage Sensor Fitting - Plus Required Angle	15 N.m	11 lb ft

Engine Shield Bolt	20 N.m	15 lb ft
Engine Wiring Harness Bracket Bolt to Battery Positive Cable Junction Block Bracket	9 N.m	80 lb in
Engine Wiring Harness Bracket Bolt to Generator and Drive Belt Tensioner Bracket	25 N.m	18 lb ft
Engine Wiring Harness Bracket Nut to Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	9 N.m	80 lb in
Engine Wiring Harness Bracket Nut to Intake Manifold Stud	12 N.m	106 lb in
Engine Wiring Harness Bracket Stud	25 N.m	18 lb ft
Engine Wiring Harness Clip Bolt	9 N.m	80 lb in
Engine Wiring Harness Ground Nut	16 N.m	12 lb ft
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud to Intake Manifold	10 N.m	89 lb in
Exhaust Manifold Bolt/Stud		
• First Pass	15 N.m	11 lb ft
• Final Pass	30 N.m	22 lb ft
Exhaust Manifold Heat Shield Bolt	9 N.m	80 lb in
Fan and Water Pump Pulley Bolt	25 N.m	18 lb ft
Frame Cross Bar Bolt	100 N.m	74 lb ft
Fuel Meter Body Bracket Bolt	10 N.m	89 lb in
Fuel Pipe Bracket Bolt	6 N.m	53 lb in
Fuel Pipe Retainer Nut	3 N.m	27 lb in
Fuel Supply Pipe Nut - Fuel Tank Side	30 N.m	22 lb ft
Generator and Drive Belt Tensioner Bracket Bolt to Engine	41 N.m	30 lb ft
Generator and Drive Belt Tensioner Bracket Stud to Engine	20 N.m	15 lb ft
Generator and Drive Belt Tensioner Bracket Stud Nut	41 N.m	30 lb ft
Ground Wire Bolt to Rear of Left Side Cylinder Head	16 N.m	12 lb ft
Ground Wire Nut to Rear of Right Side Cylinder Head	16 N.m	12 lb ft
Heater Hose Bracket Bolt to Generator and Drive		

Belt Tensioner Bracket	25 N.m	18 lb ft
Hood Hinge Bolt	25 N.m	18 lb ft
Ignition Coil Stud	12 N.m	106 lb in
Junction Block Bracket Bolt	25 N.m	18 lb ft
Knock Sensor	25 N.m	18 lb ft
Lift Bracket Bolts	15 N.m	11 lb ft
Lower Intake Manifold Bolt		
• First Pass in Sequence	3 N.m	27 lb in
• Second Pass in Sequence	12 N.m	106 lb in
• Final Pass in Sequence	15 N.m	11 lb ft
Oil Cooler Pipe Bracket to Oil Pan Bolt	12 N.m	106 lb in
Oil Filter	30 N.m	22 lb ft
Oil Filter Adapter	55 N.m	41 lb ft
Oil Filter Fitting	55 N.m	41 lb ft
Oil Level Indicator Tube Bolt	12 N.m	106 lb in
Oil Pan Baffle Bolt	12 N.m	106 lb in
Oil Pan Bolt and Nut	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan Skid Plate Bolt	20 N.m	15 lb ft
Oil Pump Bolt to Rear Crankshaft Bearing Cap	90 N.m	66 lb ft
Oil Pump Cover Bolt	12 N.m	106 lb in
Positive Battery Cable Clip Bolt	9 N.m	80 lb in
Positive Cable Generator Nut	18 N.m	13 lb ft
Power Steering Pump Bracket Bolt to Engine	41 N.m	30 lb ft
Power Steering Pump Bracket Stud to Engine	20 N.m	15 lb ft
Power Steering Pump Bracket Stud Nut	41 N.m	30 lb ft
Power Steering Pump Bolt	50 N.m	37 lb ft
Power Steering Pump Nut to Engine - Rear Bracket to Engine	41 N.m	30 lb ft
Power Steering Pump Rear Bracket Nut	50 N.m	37 lb ft
Secondary Air Injection (AIR) Check Valve Pipe Bracket Bolt to Exhaust Manifold	10 N.m	89 lb in
Secondary Air Injection (AIR) Check Valve Pipe Stud Nut	25 N.m	18 lb ft
Spark Plug	15 N.m	11 lb ft

Spark Plug Wire Support Bolt	12 N.m	106 lb in
Starter Motor Wiring Harness/Transmission Cooler Pipe Bracket to Oil Pan Bolt	9 N.m	80 lb in
Throttle Body Stud	9 N.m	80 lb in
Torque Converter Bolt	63 N.m	47 lb ft
Transmission Bolt	50 N.m	37 lb ft
Transmission Cover Bolt	12 N.m	106 lb in
Transmission Oil Cooler Line Bracket	9 N.m	80 lb in
Transmission to Oil Pan Bolt	47 N.m	35 lb ft
Upper Intake Manifold Stud		
• First Pass	5 N.m	44 lb in
• Final Pass	9 N.m	80 lb in
Valve Lifter Pushrod Guide Bolt	16 N.m	12 lb ft
Valve Rocker Arm Bolt	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolt	12 N.m	106 lb in
Water Outlet Stud	25 N.m	18 lb ft
Water Pump Bolt	45 N.m	33 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	90 degree V6	
• Displacement	4.3 L	262 CID
• RPO	LU3	
• VIN	X	
• Bore	101.60 mm	4.012 in
• Stroke	88.39 mm	3.480 in
• Compression Ratio	9.2:1	
• Firing Order	1-6-5-4-3-2	
• Spark Plug Gap	1.52 mm	0.060 in

Balance Shaft		
• Bearing Journal Diameter - Rear	38.085-38.100 mm	1.4994-1.500 in
• Bushing Bore Diameter - Rear	0.050-0.088 mm	0.0020-0.0035 in
Block		
• Crankshaft Main Bearing Bore Out-of-Round	0.050 mm	0.002 in
• Cylinder Bore Diameter	101.618-101.643 mm	4.0007-4.0017 in
• Cylinder Bore Out-of-Round - Production	0.017 mm	0.0007 in
• Cylinder Bore Out-of-Round - Service	0.05 mm	0.002 in
• Cylinder Bore Taper - Production Relief Side	0.025 mm	0.0010 in
• Cylinder Bore Taper - Production Thrust Side	0.012 mm	0.0005 in
• Cylinder Bore Taper - Service	0.025 mm	0.0010 in
• Cylinder Head Deck Surface Flatness	0.050-0.152 mm	0.002-0.006 in
Camshaft		
• Camshaft End Play	0.0254-0.2286 mm	0.0010-0.0090 in
• Camshaft Journal Diameter	47.440-47.490 mm	1.8677-1.8696 in
• Camshaft Journal Out-of-Round	0.008 mm	0.0003 in
• Camshaft Lobe Lift - Exhaust	7.0953 mm	0.2793 in
• Camshaft Lobe Lift - Intake	6.8678 mm	0.2704 in
• Camshaft Runout	0.100 mm	0.0039 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.038-0.078 mm	0.0015-0.0031 in
• Connecting Rod Bearing Clearance - Service	0.025-0.063 mm	0.0010-0.0025 in
• Connecting Rod Side Clearance	0.15-0.44 mm	0.006-0.017 in
Crankshaft		
• Connecting Rod Journal Diameter	57.116-57.148 mm	2.2487-2.2497 in
• Connecting Rod Journal Out-of-Round - Production	0.008 mm	0.0003 in
• Connecting Rod Journal Out-of-Round - Service	0.025 mm	0.0010 in

• Connecting Rod Journal Taper - Production	0.010 mm	0.0004 in
• Connecting Rod Journal Taper - Service	0.025 mm	0.0010 in
• Crankshaft End Play	0.050-0.20 mm	0.002-0.008 in
• Crankshaft Main Bearing Clearance #1 - Production	0.02-0.05 mm	0.0008-0.0020 in
• Crankshaft Main Bearing Clearance #2, #3, and #4 - Production	0.028-0.058 mm	0.0011-0.0023 in
• Crankshaft Main Bearing Clearance #1 - Service	0.0254-0.05 mm	0.0010-0.0020 in
• Crankshaft Main Bearing Clearance #2, #3, and #4 - Service	0.025-0.063 mm	0.0010-0.0025 in
• Crankshaft Main Journal Diameter #1	62.199-62.217 mm	2.4488-2.4495 in
• Crankshaft Main Journal Diameter #2 and #3	62.191-62.215 mm	2.4485-2.4494 in
• Crankshaft Main Journal Diameter #4	62.179-62.203 mm	2.4480-2.4489 in
• Crankshaft Main Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Crankshaft Main Journal Out-of-Round - Service	0.025 mm	0.0010 in
• Crankshaft Main Journal Taper	0.007 mm	0.0003 in
Exhaust Manifold		
• Surface Flatness - Flange to Flange	0.25 mm	0.010 in
• Surface Flatness - Individual Flange	0.05 mm	0.002 in
Intake Manifold		
• Surface Flatness	0.10 mm	0.004 in
Lubrication System		
• Oil Capacity with Filter	4.3 L	4.5 qt
• Oil Capacity without Filter	3.8 L	4 qt
• Oil Pressure - at 1,000 RPM	42 kPa	6 psi
• Oil Pressure - at 2,000 RPM	125 kPa	18 psi
• Oil Pressure - at 4,000 RPM	166 kPa	24 psi
Piston Rings		

• Piston Ring End Gap - First Compression Ring - Production	0.25-0.40 mm	0.010-0.016 in
• Piston Ring End Gap - Second Compression Ring - Production	0.38-0.58 mm	0.015-0.023 in
• Piston Ring End Gap - Oil Control Ring - Production	0.25-0.76 mm	0.010-0.029 in
• Piston Ring End Gap - First Compression Ring - Service	0.25-0.50 mm	0.010-0.020 in
• Piston Ring End Gap - Second Compression Ring - Service	0.38-0.80 mm	0.015-0.031 in
• Piston Ring End Gap - Oil Control Ring - Service	0.005-0.090 mm	0.0002-0.0035 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.030-0.070 mm	0.0012-0.0027 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.076-0.280 mm	0.0030-0.0110 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.046-0.196 mm	0.0018-0.0077 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.030-0.085 mm	0.0012-0.0033 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.030-0.085 mm	0.0012-0.0033 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.076-0.200 mm	0.0030-0.0079 in
Pistons and Pins		
• Piston - Piston to Bore Clearance - Production	0.018-0.061 mm	0.0007-0.0024 in
• Piston - Piston to Bore Clearance - Service	0.075 mm	0.0029 in
• Pin - Piston Pin Clearance to Connecting Rod Bore - Press Fit	0.012-0.048 mm	0.0005-0.0019 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Production	0.013-0.023 mm	0.0005-0.0009 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Service	0.025 mm	0.0010 in

• Pin - Piston Pin Diameter	23.545-23.548 mm	0.9270-0.9271 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Intake	1.016-1.651 mm	0.040-0.065 in
• Valves - Valve Seat Width - Exhaust	1.651-2.489 mm	0.065-0.098 in
• Valves - Valve Stem Oil Seal Installed Height	1-2 mm	0.03937-0.07874 in
• Valves - Valve Stem-to-Guide Clearance - Intake - Production	0.025-0.069 mm	0.0010-0.0027 in
• Valves - Valve Stem-to-Guide Clearance - Intake - Service	0.025-0.094 mm	0.0010-0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Exhaust - Production	0.025-0.069 mm	0.0010-0.0027 in
• Valves - Valve Stem-to-Guide Clearance - Exhaust - Service	0.025-0.094 mm	0.0010-0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.5:1	
• Valve Springs - Valve Spring Free Length	51.3 mm	2.02 in
• Valve Springs - Valve Spring Installed Height - Intake	42.92-43.43 mm	1.670-1.700 in
• Valve Springs - Valve Spring Installed Height - Exhaust	42.92-43.43 mm	1.670-1.700 in
• Valve Springs - Valve Spring Load - Closed	338-374 N @ 43.2 mm	76-84 lb @ 1.70 in
• Valve Springs - Valve Spring Load - Open	832-903 N @ 32.3 mm	187-203 lb @ 1.27 in

SEALERS, ADHESIVES, AND LUBRICANTS

Application	Type of Material	GM Part Number	
		United States	Canada
Balancer Shaft Driven Gear Bolt	Threadlock	12345382	10953489

Camshaft Retainer Bolt	Threadlock	12345382	10953489
Crankshaft Balancer Keyway	Adhesive	12346141	10953433
Cylinder Head Bolt	Sealant	12346004	10953480
Engine Block to the Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141	10953433
Engine Block to the Engine Front Cover Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141	10953433
Engine Block at the Lower Intake Manifold Sealing Surfaces	Adhesive	12346141	10953433
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480
Engine Block Core Hole Plug	Threadlock	12345382	10953489
Engine Block Oil Gallery Plug	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Gage Sensor	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004	10953480
Engine Oil	SAE 5W-30 Oil	12345610	993193
Engine Oil Pressure Sensor	Sealant	12346004	10953480
Engine Oil Pressure Sensor Fitting	Sealant	12346004	10953480
Engine Oil Supplement	Lubricant	1052367	992367
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	Threadlock	12345382	10953489
Exhaust Manifold Bolt/Stud	Threadlock	12345493	10953488
Expansion Cup Plug - Balance Shaft Rear Bearing Hole	Sealant	12346004	10953480
Expansion Cup Plug - Camshaft Rear Bearing Hole	Sealant	12346004	10953480
Fuel Meter Body Bracket Bolt	Threadlock	12345382	10953489
Fuel Pipe Bolt	Threadlock	12345382	10953489
Lower Intake Manifold Bolt	Threadlock	12345382	10953489
Oil Level Indicator Tube	Sealant	12346004	10953480
Oil Pump Screen Tube	Sealant	12346004	10953480
Throttle Body Stud	Threadlock	12345382	10953489
Upper Intake Manifold Stud	Threadlock	12345382	10953489
Valve Train Component Prelube	Lubricant	12345501	992704

Water Pump Bolt	Sealant	12346004	10953480

COMPONENT LOCATOR

DISASSEMBLED VIEWS

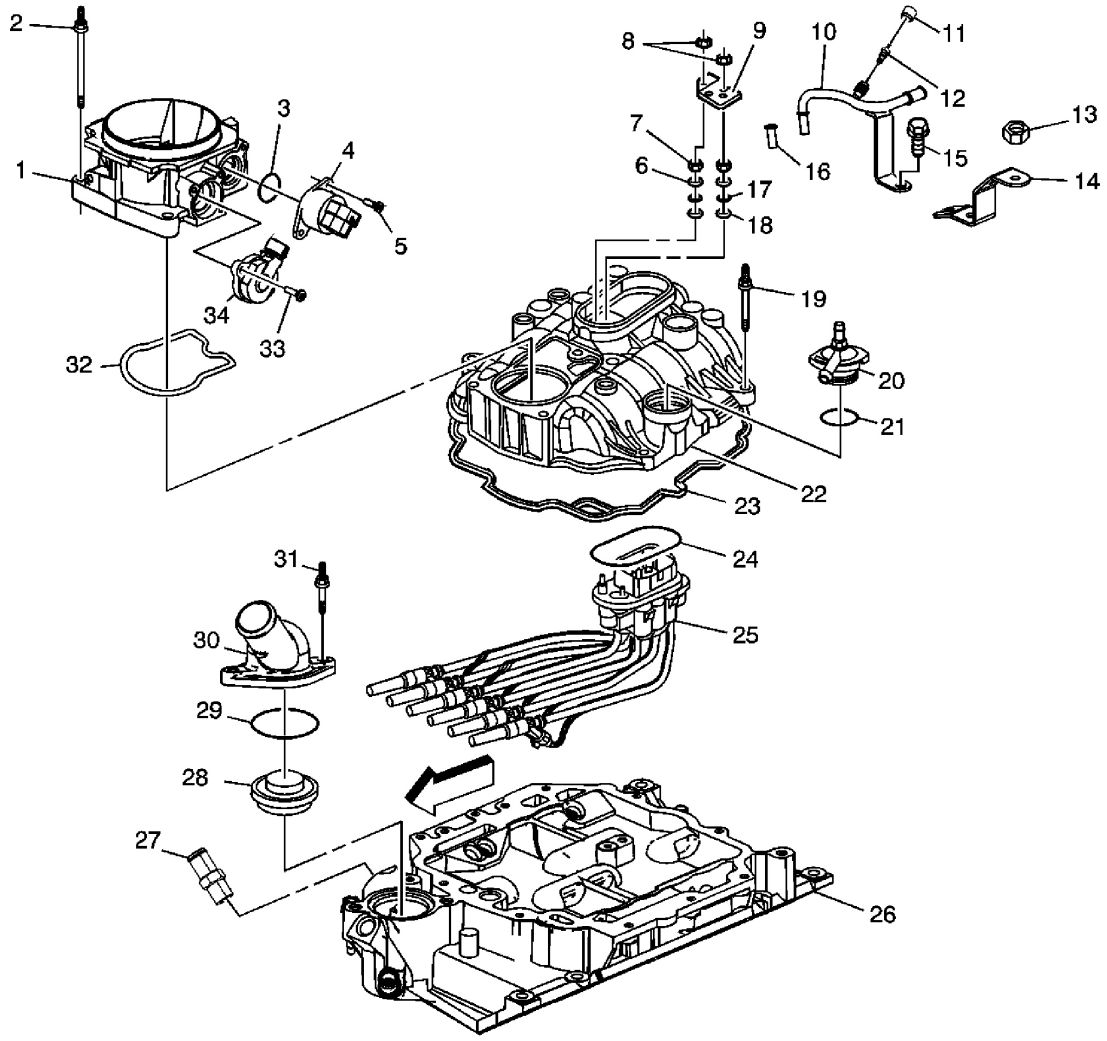


Fig. 1: Upper and Lower Intake Manifold View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Throttle Body
2	Throttle Body Stud
3	Idle Air Control Valve Seal

4	Idle Air Control Valve
5	Idle Air Control Valve Bolt
6	O-ring
7	Spacer
8	Fuel Injection Fuel Feed and Return Pipe Retainer Nut
9	Fuel Injection Fuel Feed and Return Pipe Retainer
10	Fuel Injection Fuel Feed and Return Pipe
11	Fuel Service Port Cap
12	Fuel Schrader Valve
13	Engine Wiring Harness Bracket Nut
14	Engine Wiring Harness Bracket
15	Fuel Injection Fuel Feed and Return Pipe Bolt
16	Fuel Injector Fuel Meter Fuel Passage Plug
17	Spacer
18	O-ring
19	Upper Intake Manifold Stud
20	Positive Crankcase Ventilation Valve Cover
21	Positive Crankcase Ventilation Valve Cover Seal
22	Upper Intake Manifold
23	Upper Intake Manifold Gasket
24	Fuel Injector Fuel Meter Body Seal
25	Fuel Injector Fuel Meter Body
26	Lower Intake Manifold
27	Heater Hose Fitting
28	Engine Coolant Thermostat
29	Engine Coolant Thermostat Seal
30	Water Outlet
31	Water Outlet Stud
32	Throttle Body Seal
33	Throttle Position Sensor Bolt
34	Throttle Position Sensor

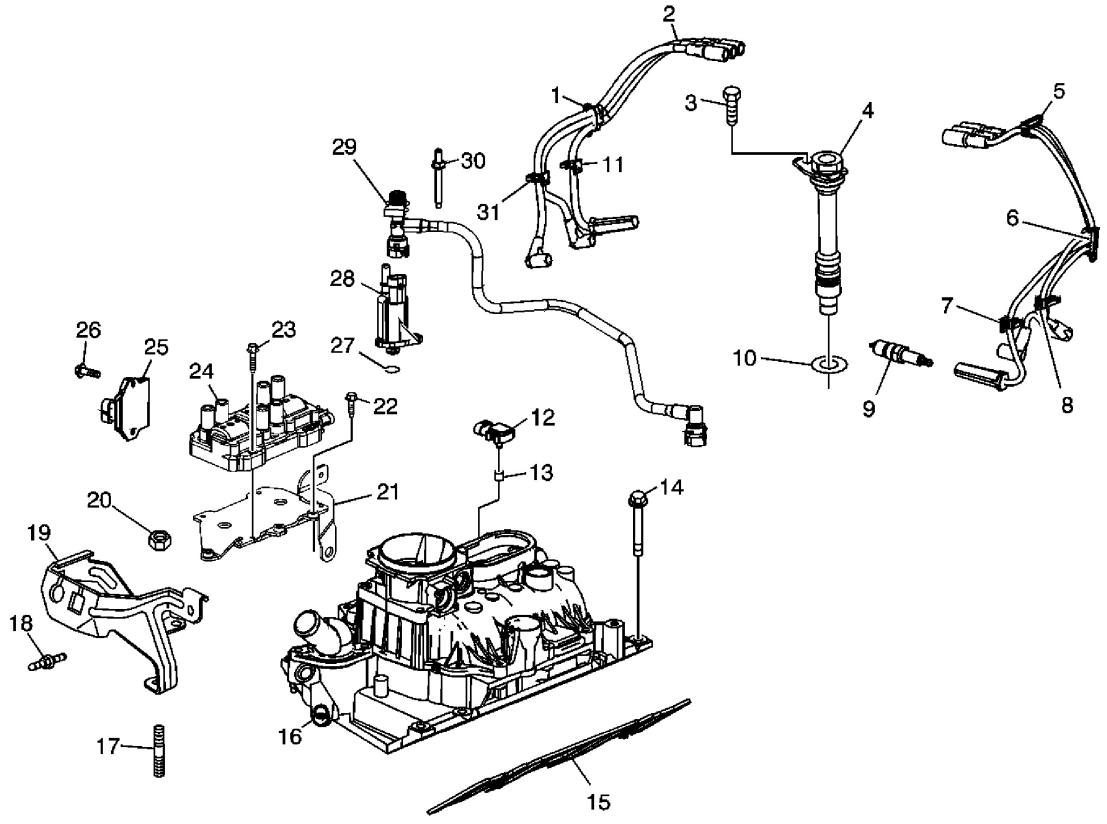


Fig. 2: Upper Engine View 1
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Spark Plug Wire Retainer
2	Spark Plug Wire Harness
3	Oil Pump Drive Shaft Clamp Bolt
4	Oil Pump Drive Shaft
5	Spark Plug Wire Harness
6	Spark Plug Wire Retainer
7	Spark Plug Wire Retainer
8	Spark Plug Wire Retainer
9	Spark Plug
10	Oil Pump Drive Shaft Gasket
11	Spark Plug Wire Retainer
12	Manifold Absolute Pressure Sensor
13	Manifold Absolute Pressure Sensor Seal

14	Lower Intake Manifold Bolt
15	Lower Intake Manifold Gasket
16	Intake Manifold Assembly
17	Accelerator Control Cable Bracket Stud
18	Accelerator Control Cable Bracket Bolt
19	Accelerator Control Cable Bracket
20	Accelerator Control Cable Bracket Nut
21	Ignition Coil Bracket
22	Ignition Coil Bracket Bolt
23	Ignition Coil Assembly to Bracket Bolt
24	Ignition Coil Assembly
25	Ignition Coil Module
26	Ignition Coil Module Bolt
27	EVAP Purge Valve Seal
28	EVAP Purge Valve
29	EVAP Purge Valve Hose
30	EVAP Purge Valve Bolt
31	Spark Plug Wire Retainer

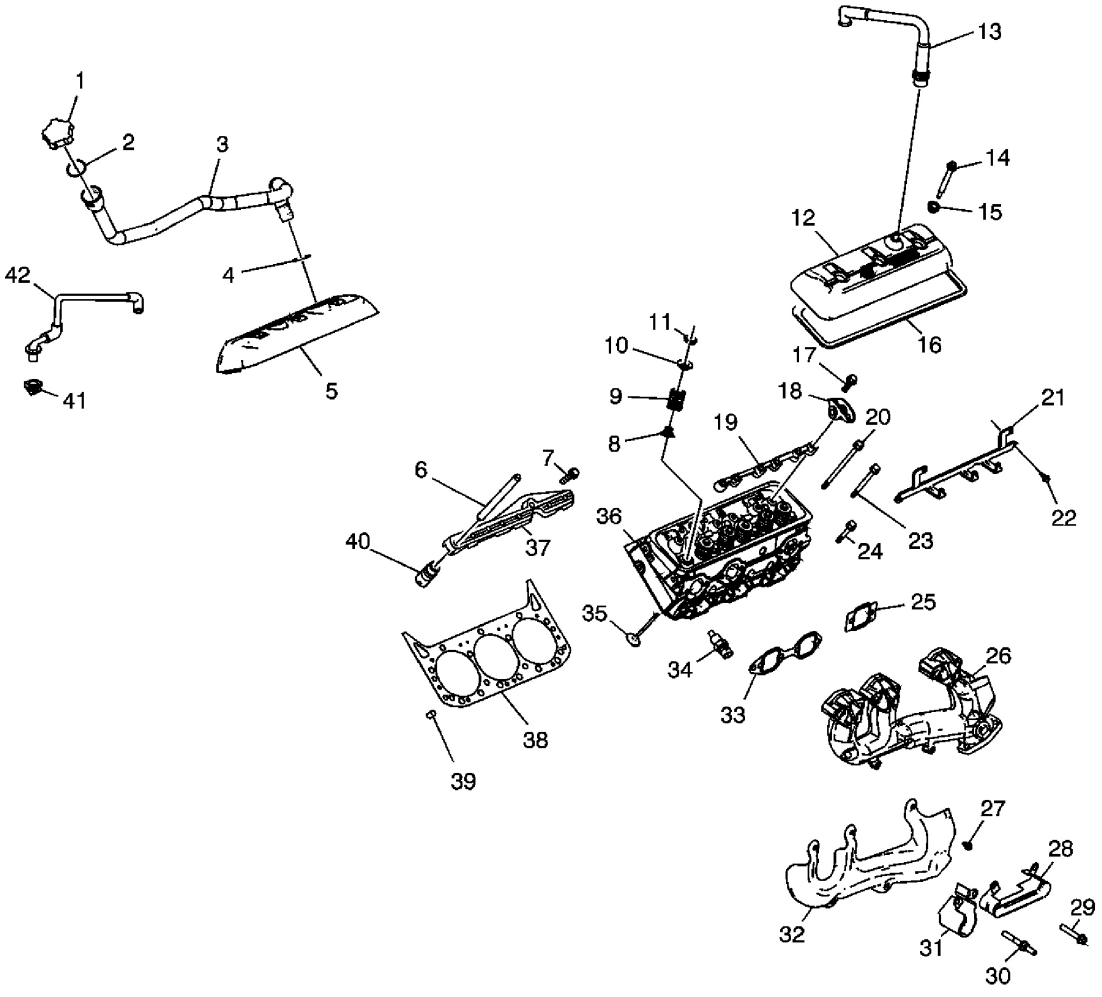


Fig. 3: Upper Engine View 2
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Oil Filler Cap
2	Oil Filler Cap Seal
3	Oil Filler Tube
4	Oil Filler Tube Seal
5	Valve Rocker Arm Cover
6	Valve Push Rod
7	Valve Lifter Guide Bolt
8	Valve Stem Oil Seal
9	Valve Spring

10	Valve Spring Cap
11	Valve Stem Key
12	Valve Rocker Arm Cover
13	Positive Crankcase Ventilation Tube
14	Valve Rocker Arm Cover Bolt
15	Valve Rocker Arm Cover Bolt Grommet
16	Valve Rocker Arm Cover Gasket
17	Valve Rocker Arm Bolt
18	Valve Rocker Arm
19	Valve Rocker Arm Pivot Support
20	Cylinder Head Bolt
21	Spark Plug Wire Support
22	Spark Plug Wire Support Bolt
23	Cylinder Head Bolt
24	Cylinder Head Bolt
25	Exhaust Manifold Gasket
26	Exhaust Manifold
27	Exhaust Manifold Heat Shield Bolt
28	Spark Plug Wire Shield
29	Exhaust Manifold Bolt
30	Exhaust Manifold Stud
31	Spark Plug Wire Shield
32	Exhaust Manifold Heat Shield
33	Exhaust Manifold Gasket
34	Engine Coolant Temperature Sensor
35	Valve
36	Cylinder Head
37	Valve Lifter Guide
38	Cylinder Head Gasket
39	Cylinder Head Location Pin
40	Valve Lifter
41	Positive Crankcase Ventilation Tube Grommet
42	Positive Crankcase Ventilation Tube

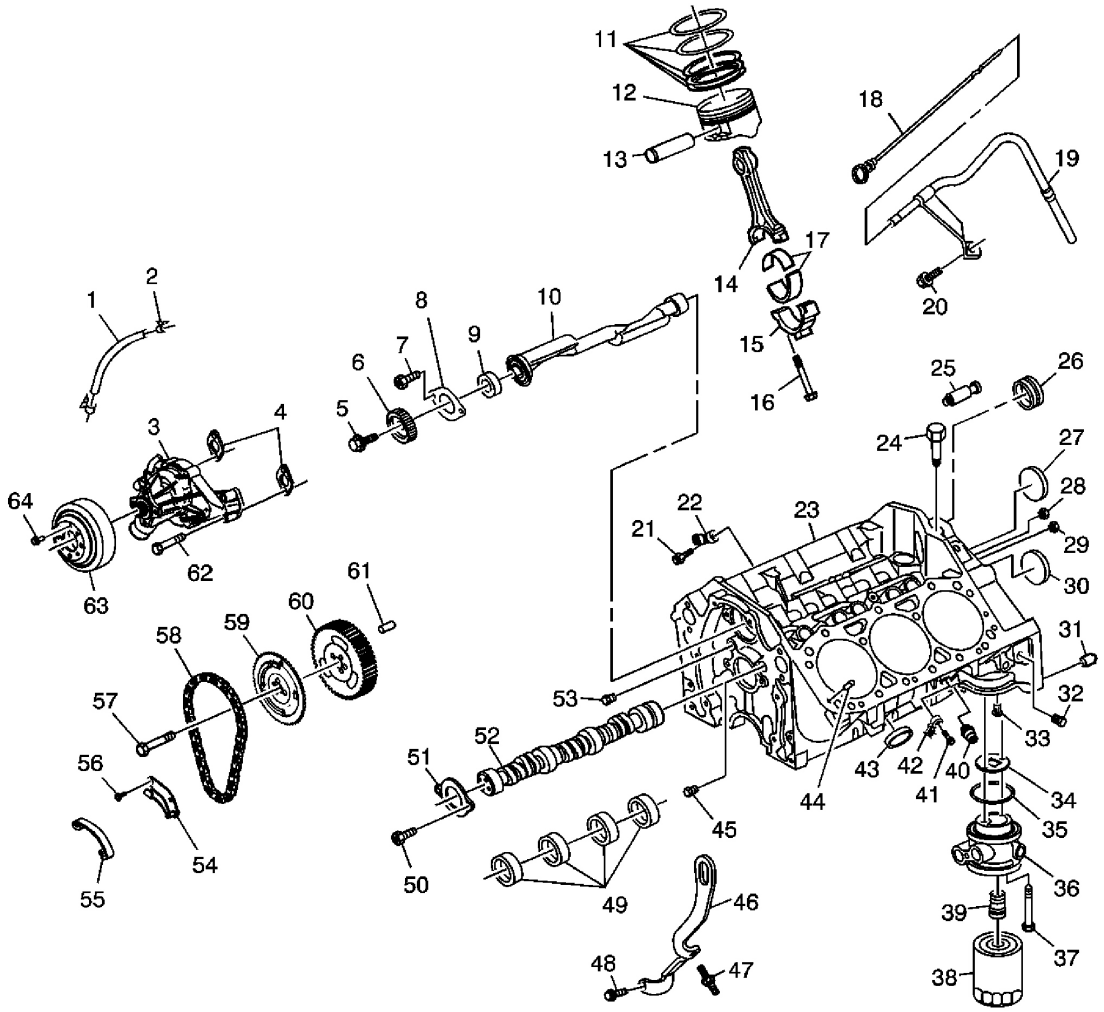


Fig. 4: Lower Engine View 1
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Thermostat Bypass Hose
2	Thermostat Bypass Pipe Clamp
3	Water Pump
4	Water Pump Gasket
5	Balance Shaft Gear Bolt
6	Balancer Shaft Driven Gear
7	Balance Shaft Retainer Bolt
8	Balancer Shaft Retainer
9	Balancer Shaft Front Bearing

10	Balance Shaft
11	Piston Ring Set
12	Piston
13	Piston Pin
14	Connecting Rod
15	Connecting Rod Bearing Cap
16	Connecting Rod Bolt
17	Connecting Rod Bearing
18	Oil Level Indicator
19	Oil Level Indicator Tube
20	Oil Level Indicator Tube Bolt
21	Knock Sensor Bolt
22	Knock Sensor
23	Engine Block
24	Engine Oil Pressure Indicator Switch Fitting
25	Engine Oil Pressure Indicator Switch
26	Balancer Shaft Rear Bearing
27	Engine Block Coolant Hole Plug
28	Engine Block Oil Gallery Plug
29	Engine Block Oil Gallery Plug
30	Engine Block Oil Gallery Plug
31	Transmission Locating Pin
32	Engine Block Oil Gallery Plug
33	Oil Filter Bypass Valve
34	Engine Oil Cooler Adapter Gasket
35	Engine Oil Cooler Adapter Seal
36	Engine Oil Cooler Adapter
37	Engine Oil Cooler Adapter Bolt
38	Oil Filter
39	Oil Pressure Relief Valve Spring Seat Pin
40	Block Heater
41	Knock Sensor Bolt
42	Knock Sensor
43	Engine Block Coolant Hole Plug
44	Cylinder Head Location Pin

	Engine Block Oil Gallery Plug
46	Engine Lift Front Bracket
47	Engine Lift Front Bracket Bolt
48	Engine Lift Front Bracket Bolt
49	Camshaft Bearing
50	Camshaft Thrust Bearing Bolt
51	Camshaft Thrust Plate
52	Camshaft
53	Engine Block Oil Gallery Plug
54	Timing Chain Tensioner Bracket
55	Timing Chain Tensioner Shoe
56	Timing Chain Tensioner Bolt
57	Camshaft Sprocket Bolt
58	Timing Chain
59	Camshaft Sprocket
60	Balancer Shaft Drive Gear
61	Camshaft Sprocket Location Pin
62	Water Pump Bolt
63	Water Pump Pulley
64	Water Pump Pulley Bolt

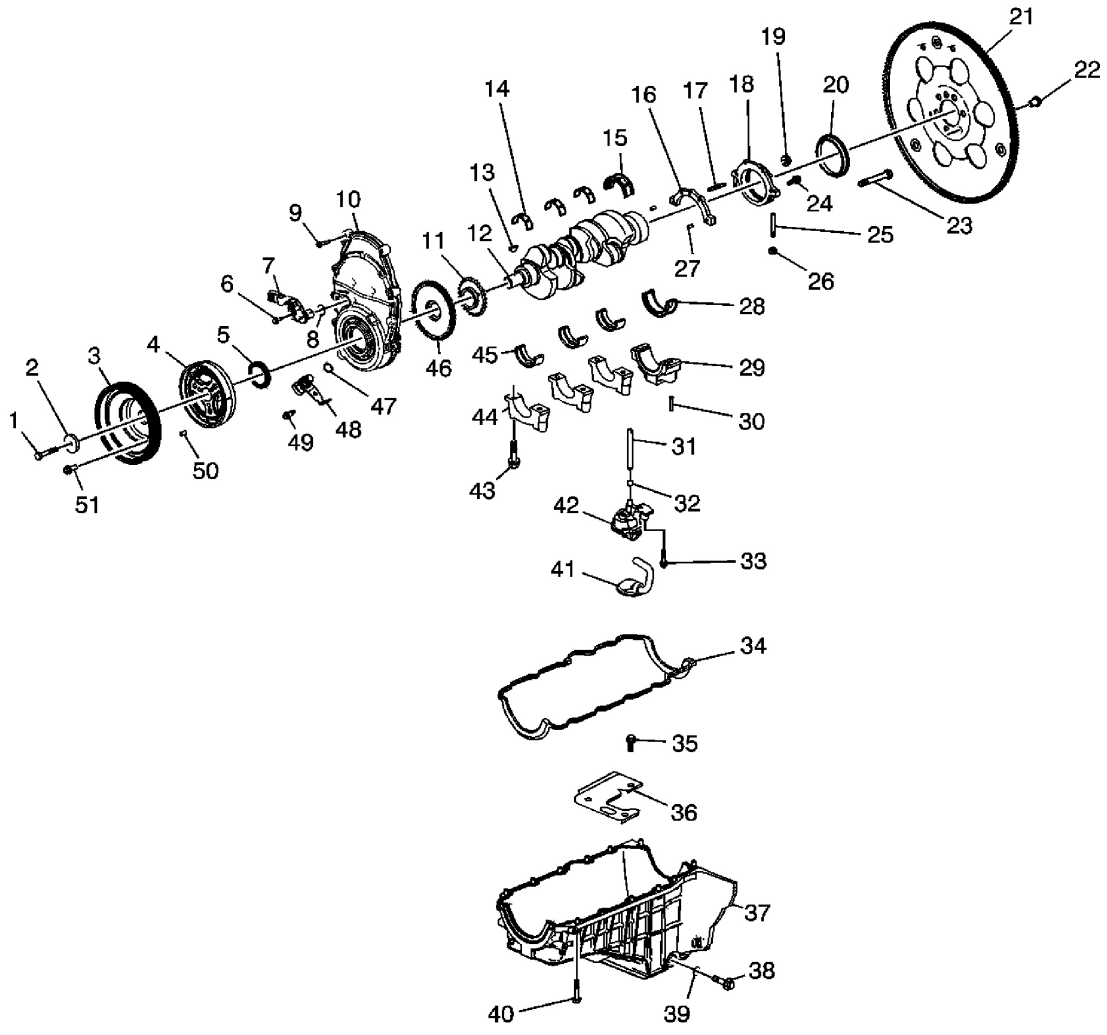


Fig. 5: Lower Engine View 2
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Crankshaft Balancer Bolt
2	Crankshaft Balancer Washer
3	Drive Belt Pulley
4	Crankshaft Balancer
5	Crankshaft Front Oil Seal
6	Camshaft Sensor Bolt
7	Camshaft Position Sensor Assembly
8	Camshaft Sensor Seal

9	Engine Front Cover Bolt
10	Engine Front Cover
11	Crankshaft Sprocket
12	Crankshaft
13	Crankshaft Balancer Key
14	Crankshaft Lower Bearing
15	Crankshaft Upper Bearing
16	Crankshaft Rear Oil Seal Housing Gasket
17	Crankshaft Rear Oil Seal Retainer Stud
18	Crankshaft Rear Oil Seal Housing
19	Crankshaft Rear Oil Seal Housing Bolt
20	Crankshaft Rear Oil Seal
21	Flywheel
22	Flywheel Bolt
23	Crankshaft Rear Oil Seal Housing Bolt
24	Crankshaft Rear Oil Seal Housing Bolt
25	Crankshaft Rear Oil Seal Housing Stud
26	Oil Pan Nut
27	Crankshaft Rear Oil Seal Housing Locating Pin
28	Crankshaft Upper Bearing
29	Crankshaft Bearing Cap
30	Oil Pump Location Pin
31	Oil Pump Drive Shaft
32	Oil Pump Drive Clamp Bolt
33	Oil Pump Bolt
34	Oil Pan Gasket
35	Oil Pan Baffle Bolt
36	Oil Pan Baffle
37	Oil Pan
38	Oil Pan Drain Plug
39	Oil Pan Drain Plug Seal
40	Oil Pan Bolt
41	Oil Pump Screen
42	Oil Pump
43	Crankshaft Bearing Cap Bolt

	Crankshaft Bearing Cap
45	Crankshaft Lower Bearing
46	Crankshaft Position Sensor Reluctor Ring
47	Crankshaft Position Sensor Seal
48	Crankshaft Position Sensor
49	Crankshaft Position Sensor Bolt
50	Crankshaft Balancer Weight
51	Drive Belt Pulley Bolt

ENGINE IDENTIFICATION

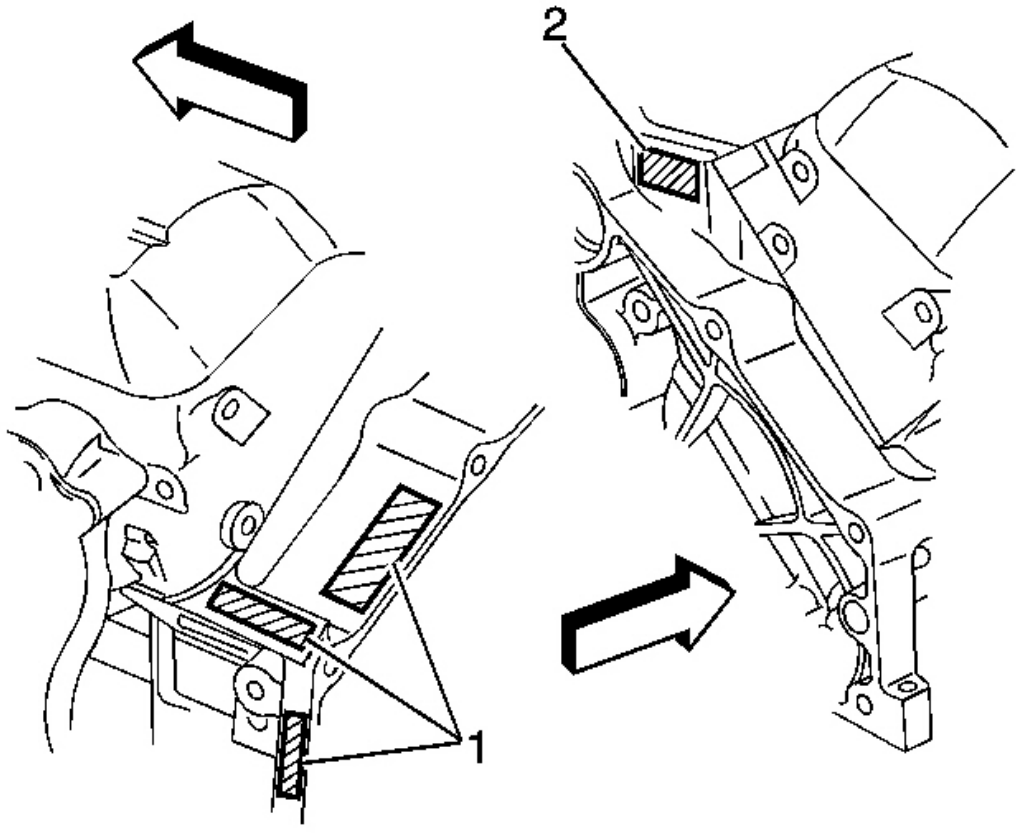


Fig. 6: Engine VIN Locations
Courtesy of GENERAL MOTORS CORP.

- The Vehicle Identification Number (VIN) Derivative is located on the left side rear of the engine block (1) or on the right side rear (2) and typically is a 9 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.

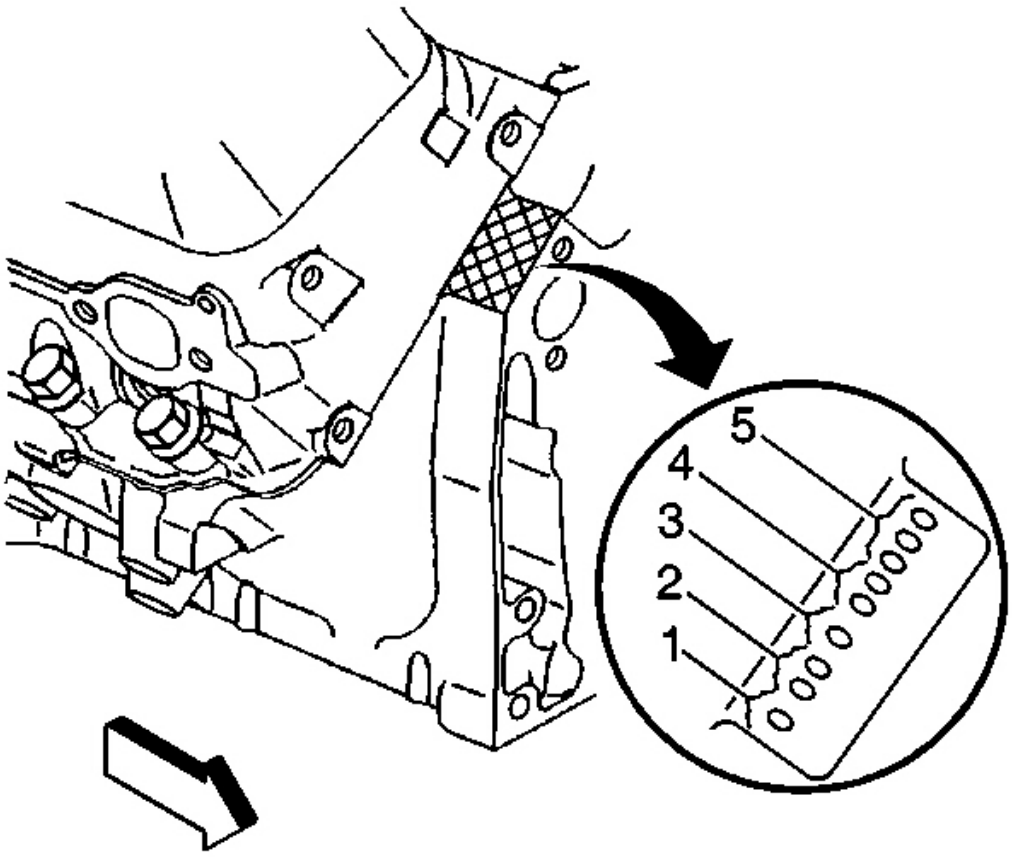


Fig. 7: Engine VIN Numerical Positions
Courtesy of GENERAL MOTORS CORP.

- Engines built at the Romulus engine plant have the engine identification number located at the right front top of the engine block.

- The first digit (1) is the source code.
- The second and third digits (2) are the month of build.
- The fourth digit (3) is the hour of the build.
- The fifth and sixth digits (4) are the date of build.
- The seventh, eighth, and ninth digits (5) are the broadcast code.

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 - Vehicle** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, **Engine Component Description**, **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 problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Strategy Based Diagnosis** .

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Engine Compression Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
High oil pressure	• Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to **Drive Belt Replacement**.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Damaged, loose or improperly installed crankshaft balancer A misfire DTC may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to **Crankshaft Balancer Replacement**.
Worn, damaged, or improperly installed crankshaft reluctor wheel A worn or damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the wear or damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no	• Inspect the crankshaft position sensor. • Inspect the crankshaft reluctor wheel. • Inspect the crankshaft. • Repair or replace damaged components as required.

loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery. A DTC P0300 or P0336 may be set.	
Damaged, loose or improperly installed engine flywheel A misfire DTC may be present without an actual misfire condition.	• Inspect the flywheel. • Repair or replace damaged components as required. Refer to **Engine Flywheel Replacement**.
Damaged, improperly installed or restricted exhaust system, collapsed or dented pipes, plugged mufflers or malfunctioning catalytic converters A DTC may be present without an actual fault condition.	• Inspect the exhaust system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed vacuum hoses	• Inspect the vacuum system components. • Repair or replace damaged components as required.
Damaged or improperly installed MAP sensor, sealing grommet nicked, torn or missing	• Inspect the MAP sensor. • Repair or replace damaged components as required.
Damaged or improperly installed throttle body	• Inspect the throttle body. • Repair or replace damaged components as required.
Damaged or improperly installed intake manifold	• Inspect the intake manifold. • Repair or replace damaged components as required.
Damaged or improperly installed cylinder head Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**.

	• Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as required.
Worn, damaged or loose valve rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn, damaged or loose valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Worn, damaged, loose or broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or loose timing chain and	• Inspect the timing chain and sprockets.

sprockets	• Repair or replace damaged components as required.
Worn, damaged or improperly installed piston 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. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to **Drive Belt Replacement**.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Worn, damaged, improperly installed or loose crankshaft balancer A misfire code may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to **Crankshaft Balancer Replacement**.
Worn, damaged, improperly installed or loose engine flywheel A misfire code may be present without an actual misfire condition.	• Inspect the engine flywheel. • Repair or replace damaged components as required. Refer to **Engine Flywheel Replacement**.
Worn, damaged or improperly installed piston	• Inspect the spark plugs. Refer to **Spark Plug Inspection** .

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. Oil consumption may or may not cause the engine to misfire.	• Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft thrust bearing A misfire code may be present without an actual misfire condition.	• Inspect the crankshaft. • Inspect the crankshaft thrust bearing. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn, damaged or loose rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.

Worn, damaged or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Damaged or improperly installed cylinder head Coolant consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn or damaged valve	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn, damaged or improperly installed piston rings Piston rings must be installed with the mark, or dimple, on the top of the piston ring, facing up.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.

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

Cause	Correction
Incorrect engine oil, viscosity	Install the correct engine oil and oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
Incorrect oil filter, without anti-drainback feature	Install the correct engine oil and oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
Worn, damaged, or improperly installed oil filter by-pass valve	1. Inspect the oil filter by-pass valve. 2. Repair or replace damaged components as required.
High valve lifter leak down rate	1. Inspect the valve lifters. 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed crankshaft thrust bearing	1. Inspect the crankshaft. 2. Inspect the crankshaft thrust bearing. 3. Repair or replace damaged components as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Improper lubrication of the valve train components	• Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. • Inspect the valve rocker arms. • Inspect the valve push rods. • Inspect the valve lifters. • Inspect the oil filter bypass valve. • Inspect the oil pump and pump screen. • Inspect the engine block oil galleries. • Repair or replace damaged components as required.

Worn, damaged or improperly installed valve rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn or damaged valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valves, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged or bent valve push rod	• Inspect the valve rocker arms. • Inspect the valve push rods. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Repair or replace damaged components as required.
Worn or damaged camshaft lobes	• Inspect the engine camshaft lobes. • Repair or replace damaged components as required.
Worn, damaged, improperly installed or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.
Worn, damaged or improperly installed timing chain tensioner, if equipped	• Inspect the timing chain tensioner. • Repair or replace damaged components

	as required.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components as required.
Detonation or spark knock	1. Verify the operation of the ignition controls system. Refer to **Diagnostic System Check - Vehicle** . 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments in the accessory drive belt	1. Inspect the accessory drive system components. 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive system components	1. Inspect the accessory drive system components. 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed crankshaft balancer	1. Inspect the crankshaft balancer. 2. Inspect the crankshaft. 3. Repair or replace damaged components as required.
Worn, damaged, or improperly installed engine flywheel	1. Inspect the engine flywheel. 2. Inspect the engine flywheel bolts. 3. Inspect the torque converter. 4. Inspect the torque converter bolts. 5. Inspect the crankshaft. 6. Repair or replace damaged components as required.
Worn, damaged, or improperly installed torque converter	1. Inspect the torque converter.

	2. Inspect the torque converter bolts. 3. Inspect the engine flywheel. 4. Repair or replace damaged components as required.
Damaged oil pan, contacting the oil pump screen-An oil pan that has been damaged may loosen, improperly position, or restrict oil flow at the oil pump screen, preventing proper oil flow to the oil pump	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace damaged components as required.
Worn, damaged, improperly installed or restricted oil pump screen-An oil pan that has been damaged may loosen, improperly position, or restrict oil flow at the oil pump screen, preventing proper oil flow to the oil pump	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace damaged components as required.
Worn, damaged, or improperly installed piston-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.	1. Inspect the spark plugs. Refer to **Spark Plug Inspection** . 2. Verify engine compression. Refer to **Engine Compression Test**. 3. Inspect the cylinder bores. 4. Inspect the pistons. 5. Inspect the piston pins. 6. Inspect the connecting rods. 7. Repair or replace damaged components as required.
Worn, damaged, or improperly installed connecting rod bearing	1. Inspect the connecting rods. 2. Inspect the connecting rod bearings. 3. Inspect the crankshaft connecting rod journals. 4. Repair or replace damaged components as required.
Worn, damaged, or improperly installed crankshaft bearing	1. Inspect the crankshaft bearings. 2. Inspect the crankshaft journals. 3. Repair or replace damaged components as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace as required.
Detonation or spark knock	1. Verify the correct operation of the ignition controls. Refer to **Diagnostic System Check - Vehicle** . 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed engine flywheel	1. Inspect the engine flywheel. 2. Inspect the engine flywheel bolts. 3. Inspect the torque converter. 4. Inspect the torque converter bolts. 5. Inspect the crankshaft. 6. Repair or replace damaged components as required.
Worn, damaged, or improperly installed torque converter	1. Inspect the torque converter. 2. Inspect the torque converter bolts. 3. Inspect the engine flywheel. 4. Repair or replace damaged components as required.
Worn, damaged, or improperly installed pistons-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.	1. Inspect the cylinder bores. 2. Inspect the pistons. 3. Inspect the piston pins. 4. Inspect the connecting rods. 5. Repair or replace damaged components as required.
Worn, damaged, or improperly installed connecting rod bearing	1. Inspect the connecting rods. 2. Inspect the connecting rod bearings. 3. Inspect the crankshaft connecting rod journals. 4. Repair or replace damaged components

	as required.
Worn, damaged, or improperly installed crankshaft bearing	1. Inspect the crankshaft bearings. 2. Inspect the crankshaft journals. 3. Repair or replace damaged components as required.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material	• Inspect cylinder for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod

	bearings. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
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. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
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

Cause	Correction
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. 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 **Lower Engine Noise, Regardless of Engine Speed**. 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. 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 **Engine Compression Test**.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
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. Ensure that the vehicle batteries are in good condition, and fully charged.
2. Operate the vehicle until the engine is at normal operating temperature.
3. Disconnect the positive ignition coil wire plug from the ignition coil.

4. Disconnect the fuel injector electrical connector.
5. Remove all of the spark plugs.

NOTE: Do not insert objects into the throttle plate opening. Damage to the throttle body can result, requiring replacement of the throttle body assembly.

6. Block the throttle linkage wide open.
7. Install the engine cylinder compression gage to the cylinder being tested.
8. Using the vehicle starter motor, rotate, or crank the engine for 4 compression strokes, or puffs, for the cylinder being tested. If the engine rotates for more than 4 compression strokes, test the cylinder again.
9. Record the compression reading.
10. Remove the engine cylinder compression gage from the cylinder being tested.
11. Repeat steps 8-11 for each additional cylinder. All cylinders must be tested to obtain valid test results.
12. If any cylinders have low compression, inject approximately 15 ml (1 oz) of engine oil into the cylinder through the spark plug hole.
13. Repeat steps 8-11 for all low compression cylinders.
14. 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 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). Multiply the highest cylinder pressure by 70 percent, 1035 kPa x 70 percent = 725 kPa (150 psi x 70 percent = 105 psi), in order to determine the lowest allowable pressure in any other cylinder.
    - Normal

      The compression builds up quickly and evenly to the specified compression.

    - Piston rings leaking

      Compression is low on the first compression stroke. The compression builds up on the following strokes, but does not reach normal. Compression improves considerably when you add oil.

    - Valves leaking

      Compression is low on the first compression stroke. The compression does not build up

on the following strokes, and does not reach normal. Compression does not improve much, if at all, when you add oil.

- Head gasket leaking

  Compression is low on the first stroke. The compression does not build up on the following strokes, and does not reach normal. Compression does not improve much, if at all, when you add oil. Adjacent cylinders have the same, or similar, low compression readings.

15. If one or more cylinders fails to meet the minimum specified compression, repair or replace all damaged or worn components and test the engine again.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester. See **Special Tools**.

Test

With the use of air pressure, a cylinder leakage test will aid in the diagnosis. Use the cylinder leakage test in conjunction with the engine compression test in order to isolate the cause of leaking cylinders.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** use for the 4.3L engine.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke, with both valves closed.
4. Install the **J 35667-A** . See **Special Tools**.

IMPORTANT: It may be necessary to hold the crankshaft balancer bolt to prevent piston movement.

5. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturer instructions. See **Special Tools**.

IMPORTANT: Perform the leakage test on all cylinders and record the values before doing any repairs.

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:
    1. Air leakage from the intake or exhaust system may indicate a worn or burnt valve or a broken valve spring.
        1. Remove the valve rocker arm cover of the suspect cylinder head. Refer to **Valve Rocker Arm Cover Replacement - Left Side** or **Valve Rocker Arm Cover Replacement - Right Side** .
        2. Ensure that both valves are closed.
        3. Inspect the cylinder head for a broken valve spring.
        4. Remove and inspect the suspect cylinder head. Refer to **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side** .
    2. Air leakage from the crankcase, oil level indicator, or oil fill tube may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
        1. Remove the piston from the suspect cylinder. Refer to **Piston, Connecting Rod, and Bearing Removal** or **Piston, Connecting Rod, and Bearing Installation** .
        2. Inspect the piston and connecting rod assembly. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection** .
        3. Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .
        4. Inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .
    3. Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
        1. Remove both cylinder heads. Refer to **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side** .
        2. Inspect both cylinder heads. Refer to **Cylinder Head Cleaning and Inspection** .
        3. Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .
7. Remove the **J 35667-A** . See **Special Tools**.
8. Install the spark plugs. Refer to **Spark Plug Replacement** use for the 4.3L engine.

CAUTION: Refer to Battery Disconnect Caution .

9. Connect the battery ground negative cable.

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 1 liter (1 quart) of engine oil within 3 200 kilometers (2,000 miles). However, during initial engine break-in periods 4 828-6 437 kilometers (3,000-4,000 miles), oil consumption may exceed 1 liter (1 quart) or more. The causes of excessive oil consumption include the following conditions:

- External oil leaks

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

- Incorrect oil level or improper reading of oil level indicator

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

- Improper oil viscosity

  Use recommended SAE viscosity for the prevailing temperatures.

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

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

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

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

- Piston improperly installed or miss-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

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

measure for a low engine oil level.

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

2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gage or the oil indicator light.

   Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
   - Engine oil diluted by moisture or unburned fuel mixtures
   - Improper engine oil viscosity for the expected temperature
   - Incorrect or faulty oil pressure gage sensor
   - Incorrect or faulty oil pressure gage
   - Plugged oil filter
   - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gage sensor or another engine block oil gallery plug.
5. Install an oil pressure gage.
6. Start the engine and then allow the engine to reach normal operation temperature.
7. Measure the engine oil pressure at the following RPM:

   Specification:
   1. 42 kPa (6 psig) minimum, at 1,000 RPM
   2. 125 kPa (18 psig) minimum, at 2,000 RPM
   3. 166 kPa (24 psig) minimum, at 4,000 RPM

8. If the engine oil pressure is below minimum specifications, inspect the engine for one or more of the following:
   - Oil pump worn or dirty
   - Malfunctioning oil pump pressure relief valve
   - Oil pump screen loose, plugged, or damaged
   - Excessive bearing clearance
   - Cracked, porous or restricted oil galleries
   - Engine block oil gallery plugs missing or incorrectly installed
   - Broken valve lifters

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
IMPORTANT: **You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.**			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the		

	approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 6**
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components		

	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use the **J 28428-E** 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. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets, where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces		

	2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Results Of Incorrect Operation

- A plugged positive crankcase ventilation (PCV) orifice or hose may cause the following conditions:
  - Rough idle
  - Stalling or slow idle speed
  - Oil leaks
  - Oil in air cleaner
  - Sludge in engine
- A leaking PCV orifice or hose may cause the following conditions:
  - Rough idle
  - Stalling
  - High idle speed

Functional Check

With these systems, any blow-by in excess of the system capacity, from a badly worn engine, sustained heavy load, etc., is exhausted into the air cleaner and is drawn into the engine.

Proper operation of the crankcase ventilation system depends upon a sealed engine. If oil slugging or dilution is noted and the crankcase ventilation system is functioning properly, check the engine for a possible cause. Correct any problems.

If an engine is idling rough, inspect for a clogged PCV orifice, a dirty vent filter, air cleaner element, or plugged hose. Replace as required. Use the following procedure:

1. Remove the PCV hose from the rocker arm cover.
2. Operate the engine at idle.

3. Place your thumb over the end of the hose in order to check for a vacuum. If there is no vacuum at the hose, inspect for the following items:
   - Plugged hoses
   - The manifold port
4. Turn OFF the engine.
5. Inspect the PCV orifice in the valve cover for debris or blockage.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

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

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

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

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

found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

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

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

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

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

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal:		

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

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

- A high pitched continuous noise.
- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	• If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. • If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**

5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications** . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 13**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis** . Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**

17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement** . Did you complete the repair?	Go to **Step 20**	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

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

3: This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts.

When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

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

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

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

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

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

Step	Action	Yes	No

NOTE:
Refer to Belt Dressing Notice .
 	
DEFINITION: The following items are indications of drive belt rumbling:
• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  ○ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
  ○ The separation of the drive belt
  ○ A damaged drive belt
 	
DEFINITION: The following items are indications of drive belt vibration:
• The vibration is engine-speed related.
• The vibration may be sensitive to accessory load.			

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**

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

9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications** . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement (LU3)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

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

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

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

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

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

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

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

Step	Action	Yes	No

	NOTE:
	Refer to Belt Dressing Notice .
	
	DEFINITION: The following items are indications of drive belt rumbling:
	• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
	• Heard once per revolution of the drive belt or a pulley.
	• Rumbling may be caused from:
	  ○ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
	  ○ The separation of the drive belt
	  ○ A damaged drive belt
	
	DEFINITION: The following items are indications of drive belt vibration:		

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

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

8	Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement (LU3)** or **Water Pump Replacement (LY6, L76 and L92)** or **Water Pump Replacement (LH6, LY2, LY5, and LMG)** or **Water Pump Replacement (LMM)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT TENSIONER DIAGNOSIS

Inspection Procedure

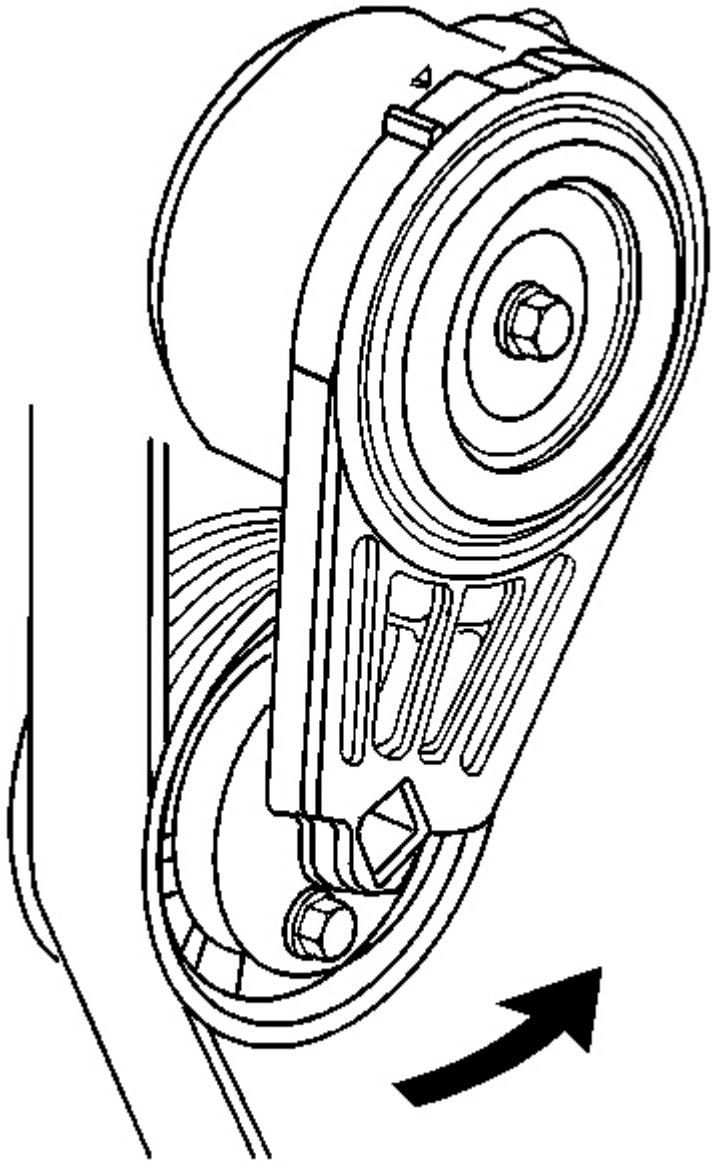


Fig. 8: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

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**.
2. Move the drive belt tensioner through it's full travel.
   - The movement should feel smooth
   - There should be no binding
   - The tensioner should return freely
3. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
4. Install the drive belt. Refer to **Drive Belt Replacement**.

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT

Removal Procedure

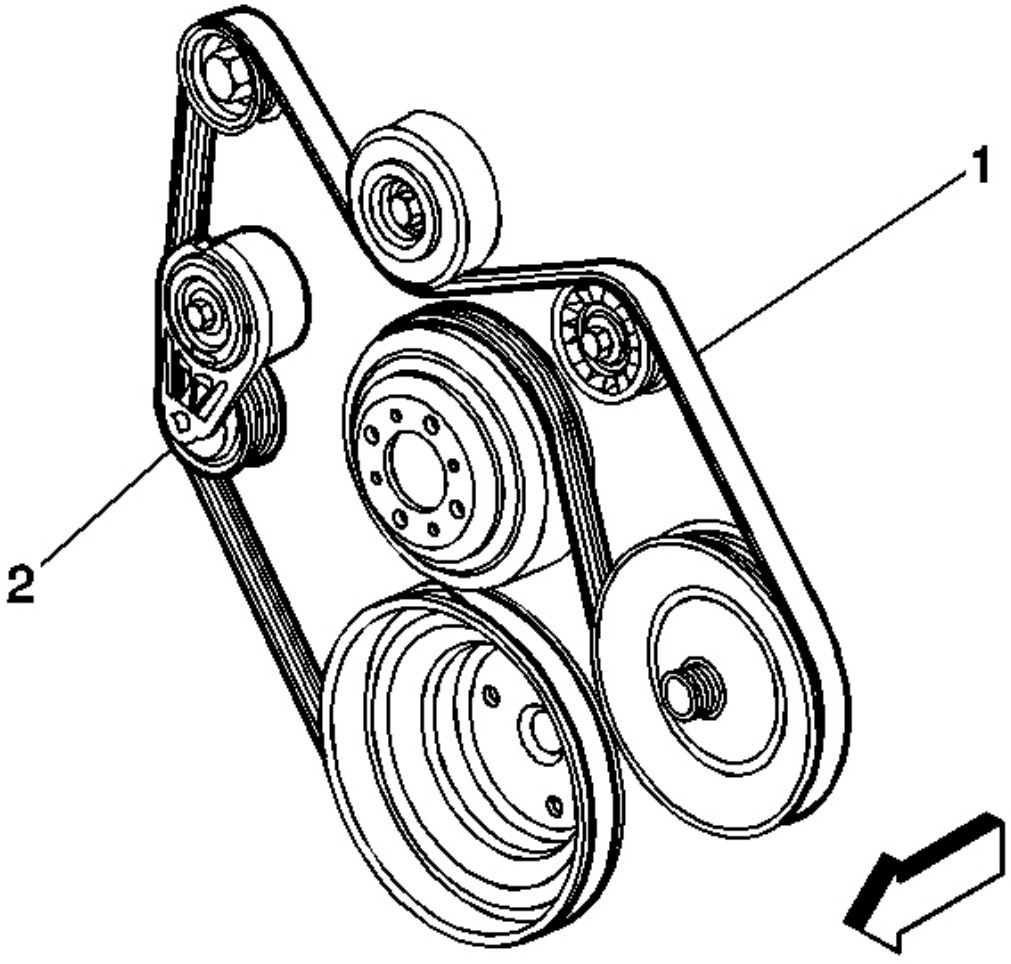


Fig. 9: Drive Belt & Tensioner (W/O A/C)
Courtesy of GENERAL MOTORS CORP.

1. Install a 3/8 inch drive breaker bar to the drive belt tensioner arm.
2. Rotate the drive belt tensioner (2) counterclockwise in order to relieve tension on the belt.
3. If equipped without air conditioning (A/C), remove the belt (1) from the pulleys and the drive belt tensioner.

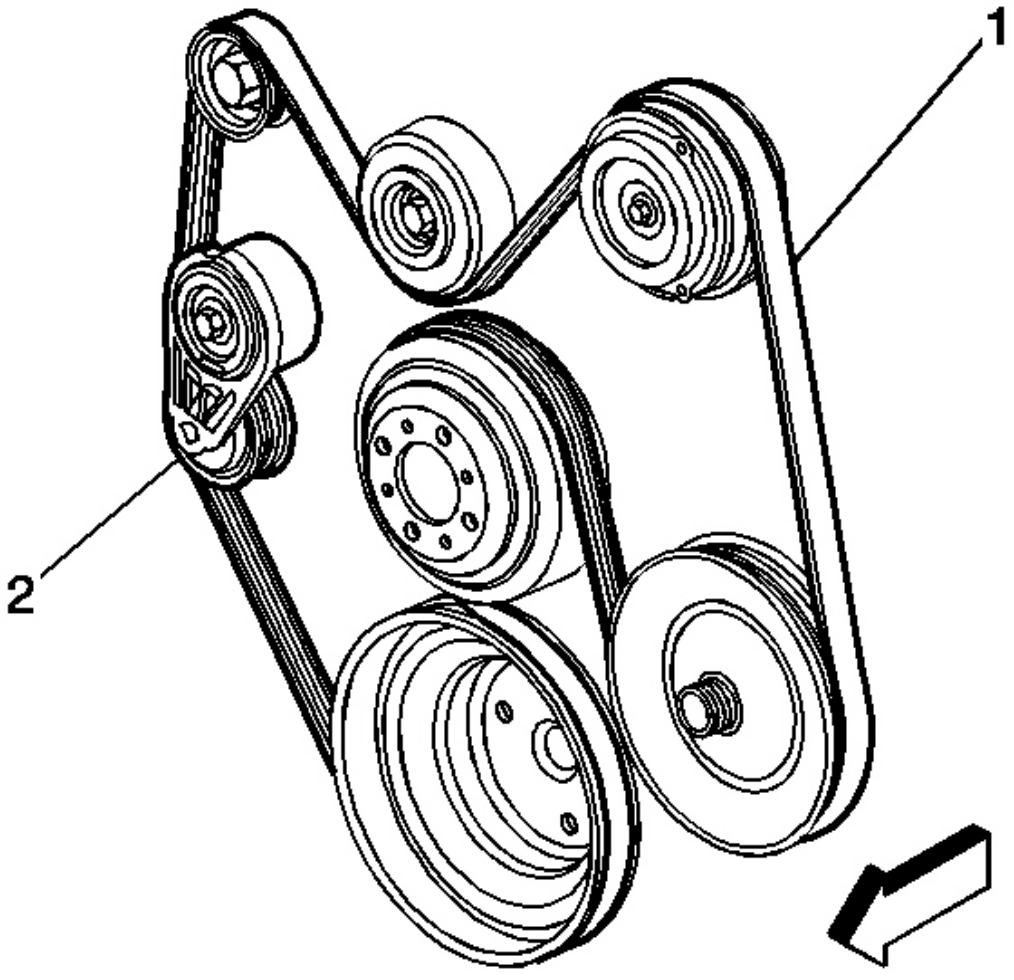


Fig. 10: Drive Belt & Tensioner (W/ A/C)
Courtesy of GENERAL MOTORS CORP.

4. If equipped with A/C, remove the belt (1) from the pulleys and the drive belt tensioner.
5. Slowly release the tension on the drive belt tensioner (2).
6. Remove the breaker bar from the drive belt tensioner.
7. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

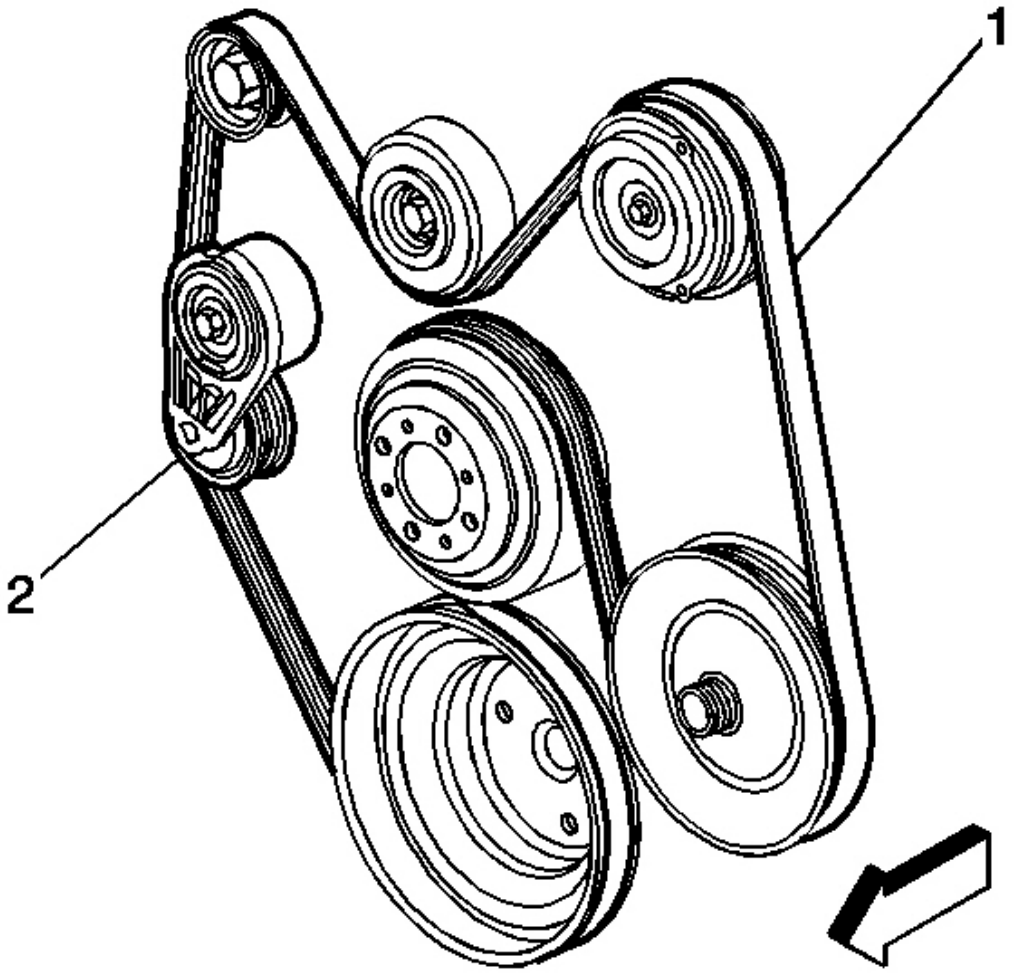


Fig. 11: Drive Belt & Tensioner (W/ A/C)
Courtesy of GENERAL MOTORS CORP.

1. Route the belt (1) around all the pulleys except the flat idler pulley.
2. Install a 3/8 inch drive breaker bar to the drive belt tensioner arm.
3. Rotate the belt tensioner (2) counterclockwise in order to relieve the tension on the tensioner.
4. If equipped with A/C, install the belt under the flat idler pulley.

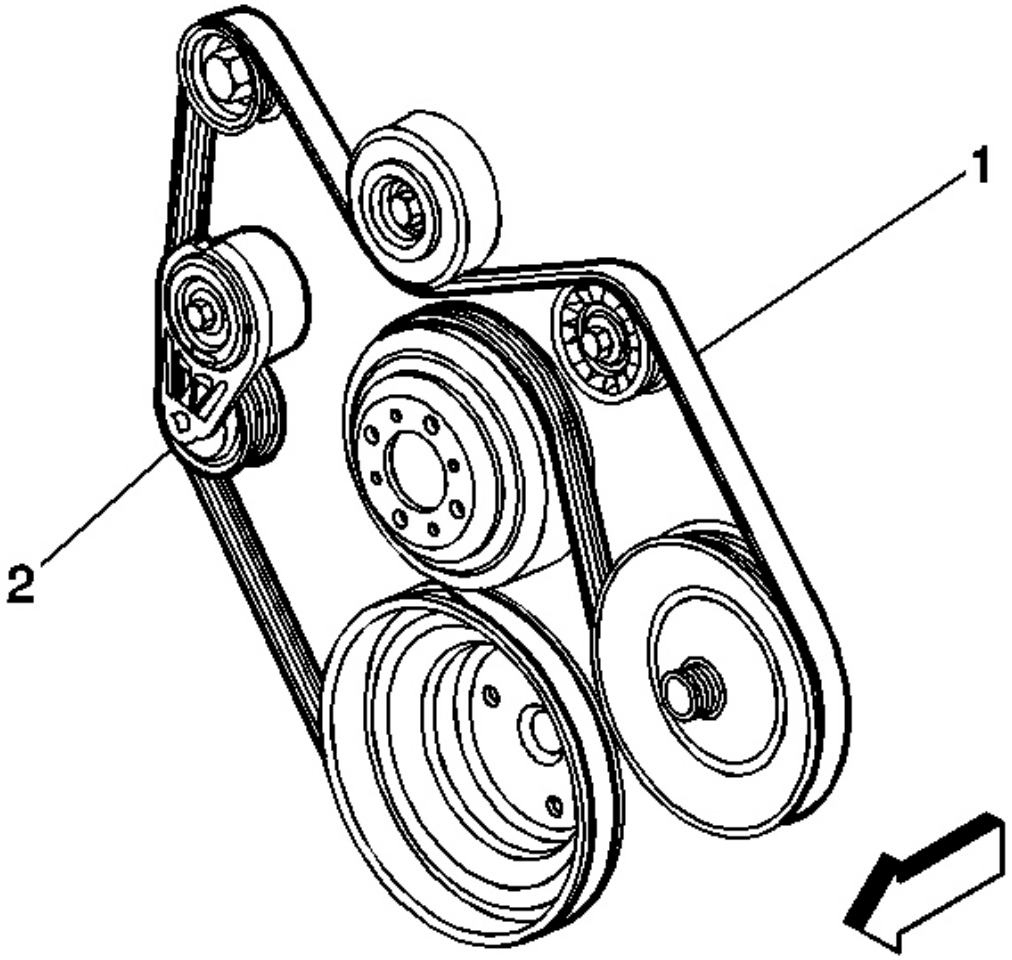


Fig. 12: Drive Belt & Tensioner (W/O A/C)
Courtesy of GENERAL MOTORS CORP.

5. If equipped without A/C, install the belt (1) to the pulleys and the drive belt tensioner.
6. Slowly release the tension on the belt tensioner (2).
7. Remove the breaker bar from the drive belt tensioner.
8. Inspect the drive belt for proper installation and alignment.

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

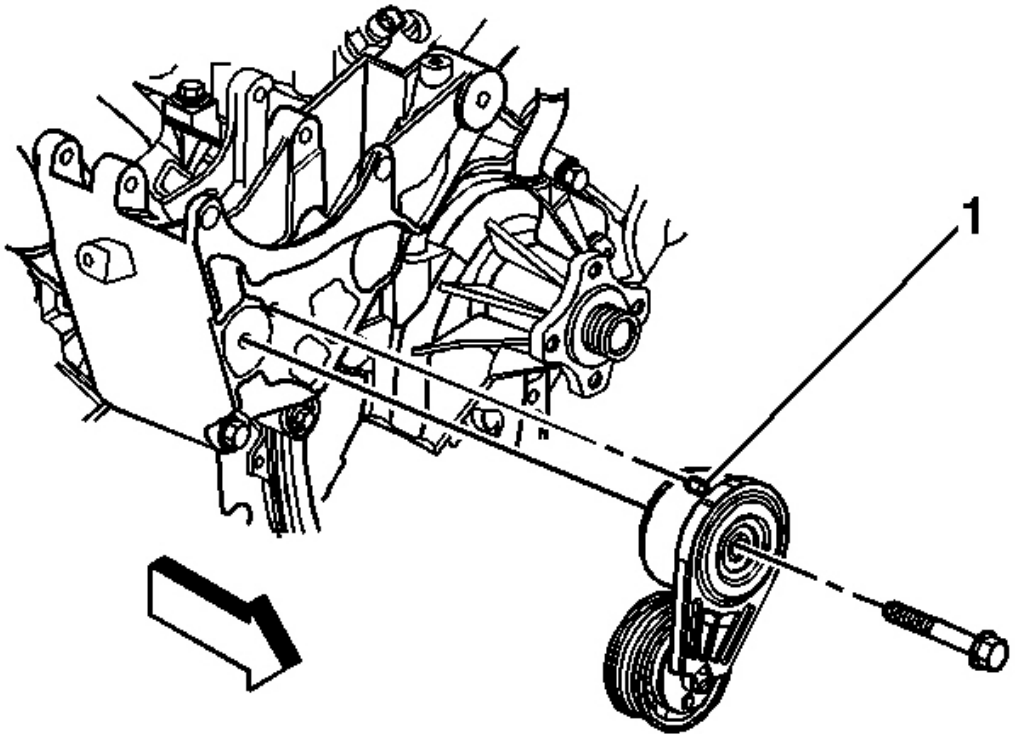


Fig. 13: Drive Belt Tensioner Locating Pin
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the belt tensioner bolt.
3. Remove the belt tensioner.

Ensure that there is a locating pin (1) on the tensioner.

Installation Procedure

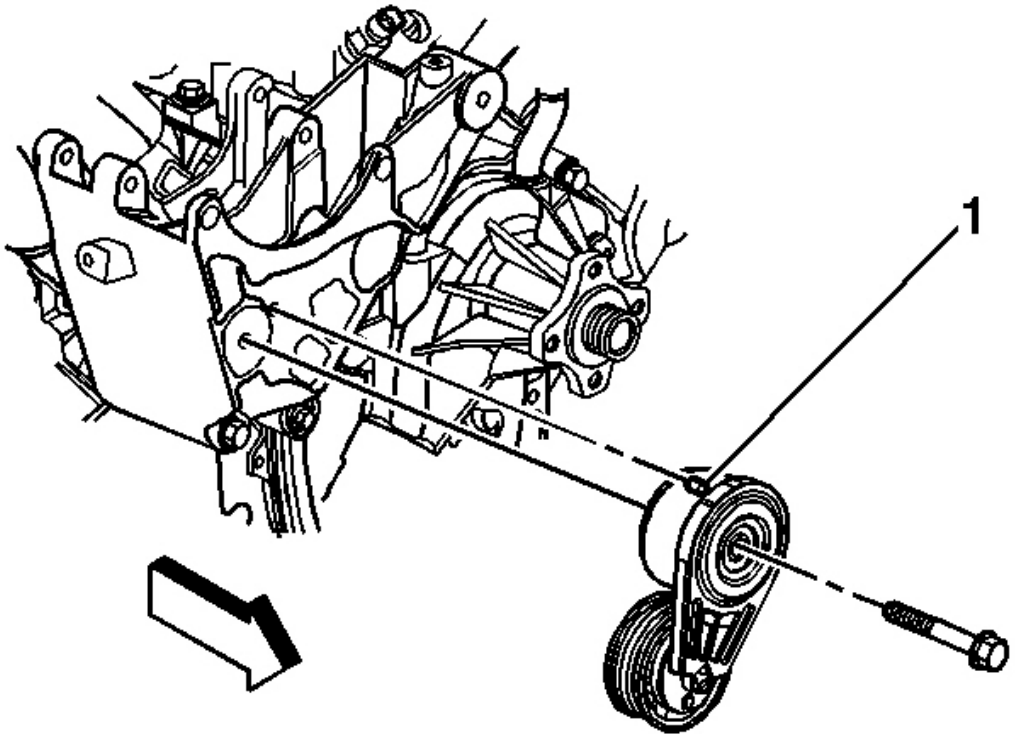


Fig. 14: Drive Belt Tensioner Locating Pin
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the belt tensioner. Position the locating pin (1) on the tensioner into the hole in the generator bracket.
2. Install the belt tensioner bolt.

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

3. Install the drive belt. Refer to **Drive Belt Replacement**.

DRIVE BELT IDLER PULLEY REPLACEMENT - RIGHT SIDE

Removal Procedure

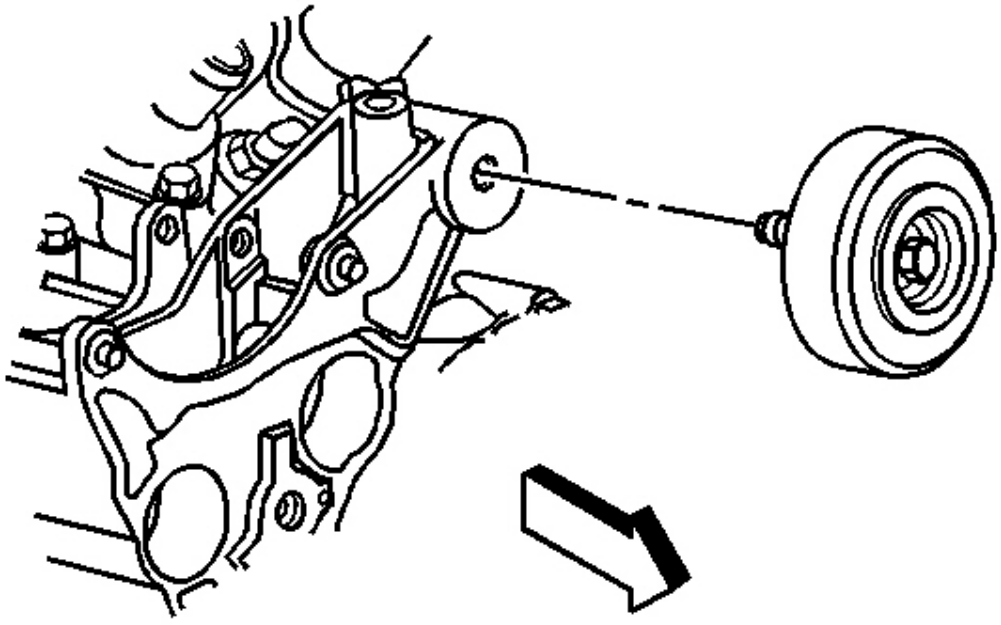


Fig. 15: Drive Belt Right Idler Pulley
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

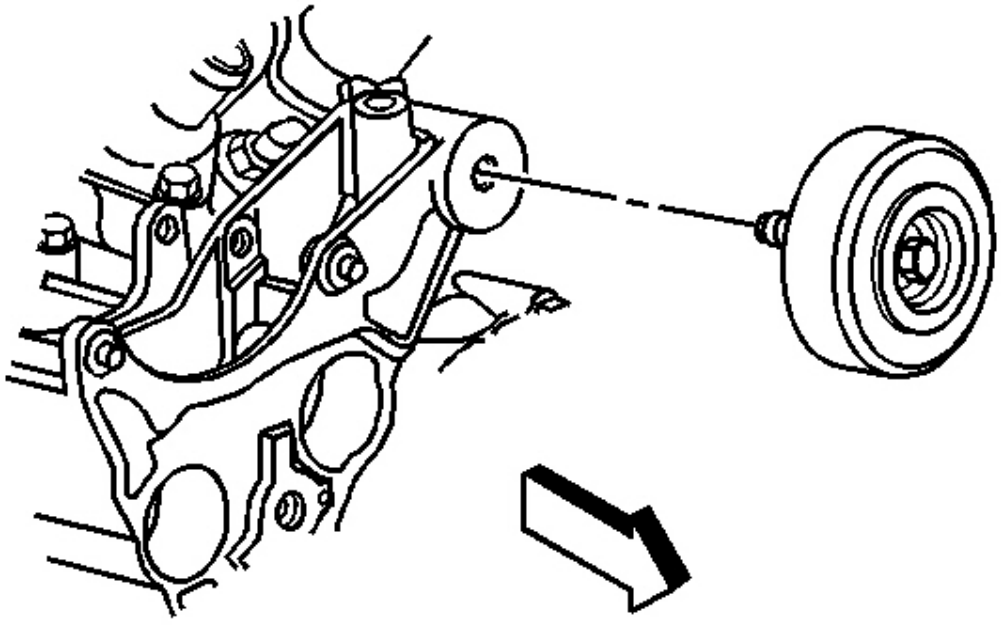


Fig. 16: Drive Belt Right Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Install the idler pulley.
2. Install the idler pulley bolt until snug.
3. Install the drive belt. Refer to **Drive Belt Replacement**.

NOTE: Refer to Fastener Notice .

4. Tighten the idler pulley bolt.

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

DRIVE BELT IDLER PULLEY REPLACEMENT - WITHOUT AIR CONDITIONING

Removal Procedure

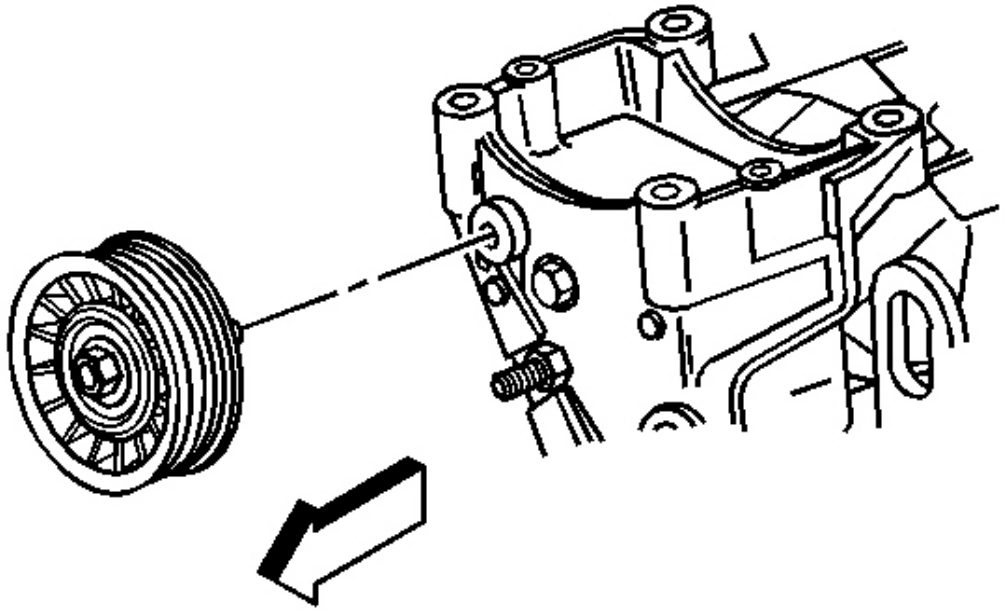


Fig. 17: Drive Belt Idler Pulley (W/O AC)
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

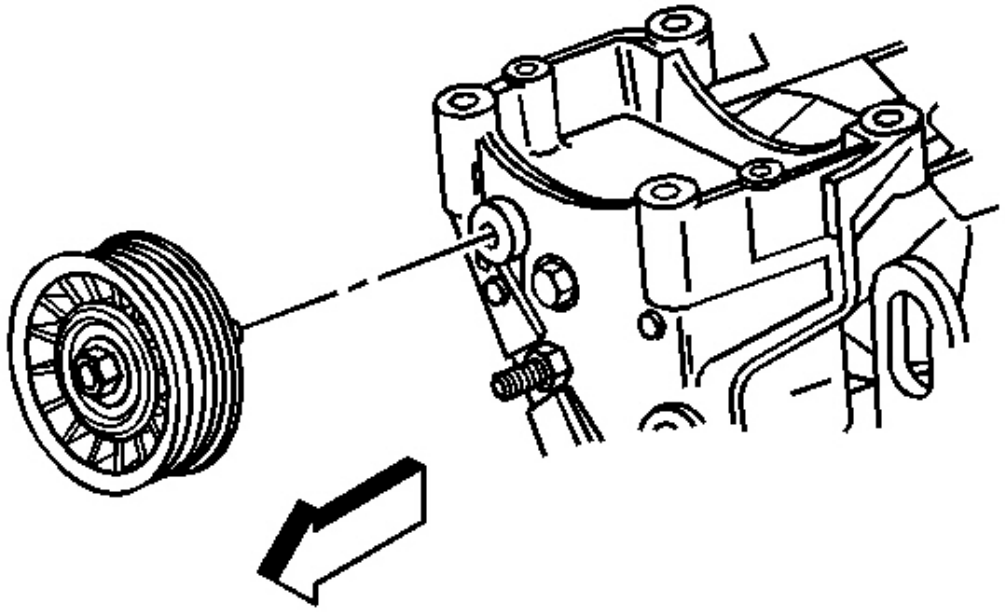


Fig. 18: Drive Belt Idler Pulley (W/O AC)
Courtesy of GENERAL MOTORS CORP.

1. Install the idler pulley.
2. Install the idler pulley bolt until snug.
3. Install the drive belt. Refer to **Drive Belt Replacement**.

NOTE: Refer to Fastener Notice .

4. Tighten the idler pulley bolt.

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

ENGINE MOUNT INSPECTION

NOTE: Refer to ENGINE MOUNTING NOTICE .

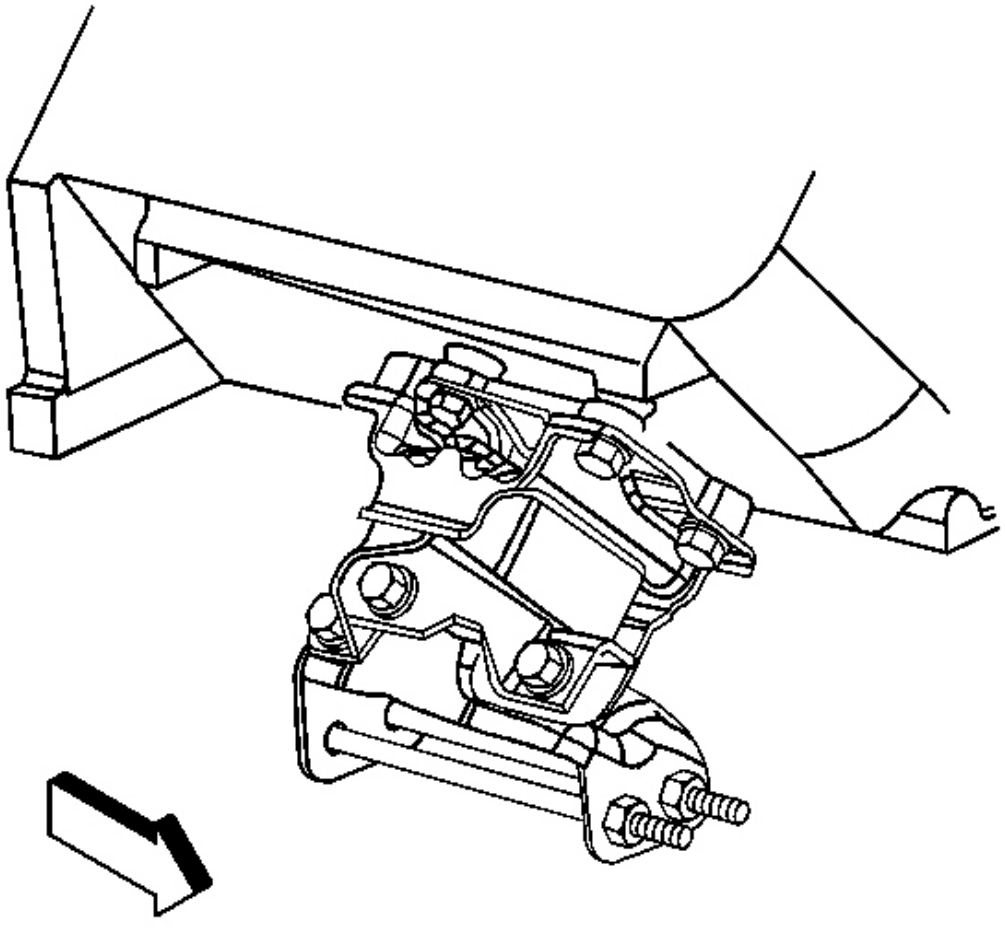


Fig. 19: Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Inspect for loose or missing bolts at the following locations:
   - Engine mount bracket to engine
   - Engine mount frame bracket to frame
   - Engine mount to engine mount bracket
   - Engine mount to engine mount frame bracket
3. Replace missing or loose bolts.

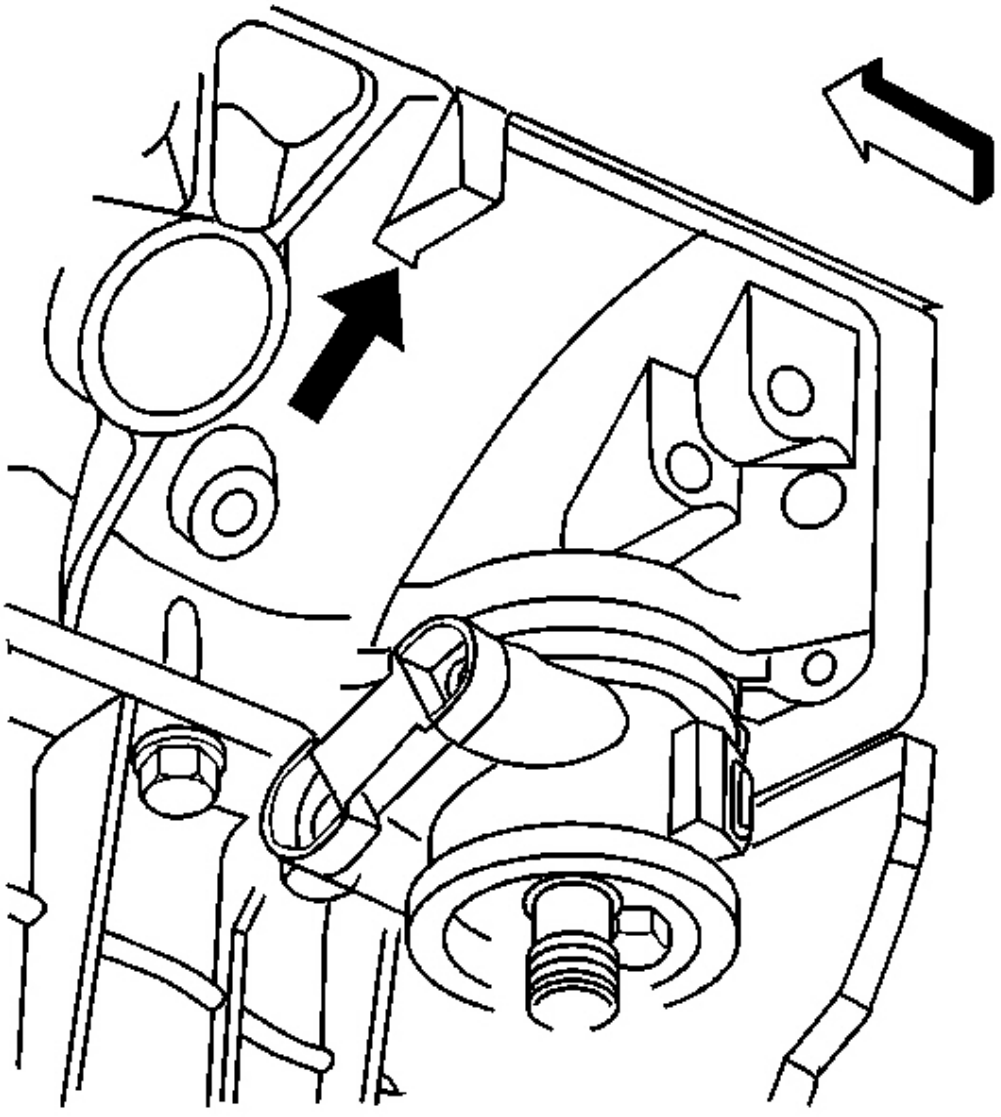


Fig. 20: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to ENGINE LIFTING NOTICE .

4. In order to access the square tab on the right side of the engine remove the starter. Refer to **Starter Motor Replacement (4.3L)** .

5. Using a jack on the square tab at the rear of the engine block (left side shown) raise the engine in order to complete the following tasks:
    - Remove weight from the engine mount.
    - Place a slight tension on the rubber cushion.
    - Observe the engine mount while raising the engine.
6. Replace the engine mount if the following conditions exist:
    - Heat check cracks cover the hard rubber surface.
    - The rubber cushion is separated from the metal plate of the engine mount.
    - There is a split through the rubber cushion.
7. Install the starter, if removed. Refer to **Starter Motor Replacement (4.3L)** .

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

NOTE: Refer to ENGINE MOUNTING NOTICE .

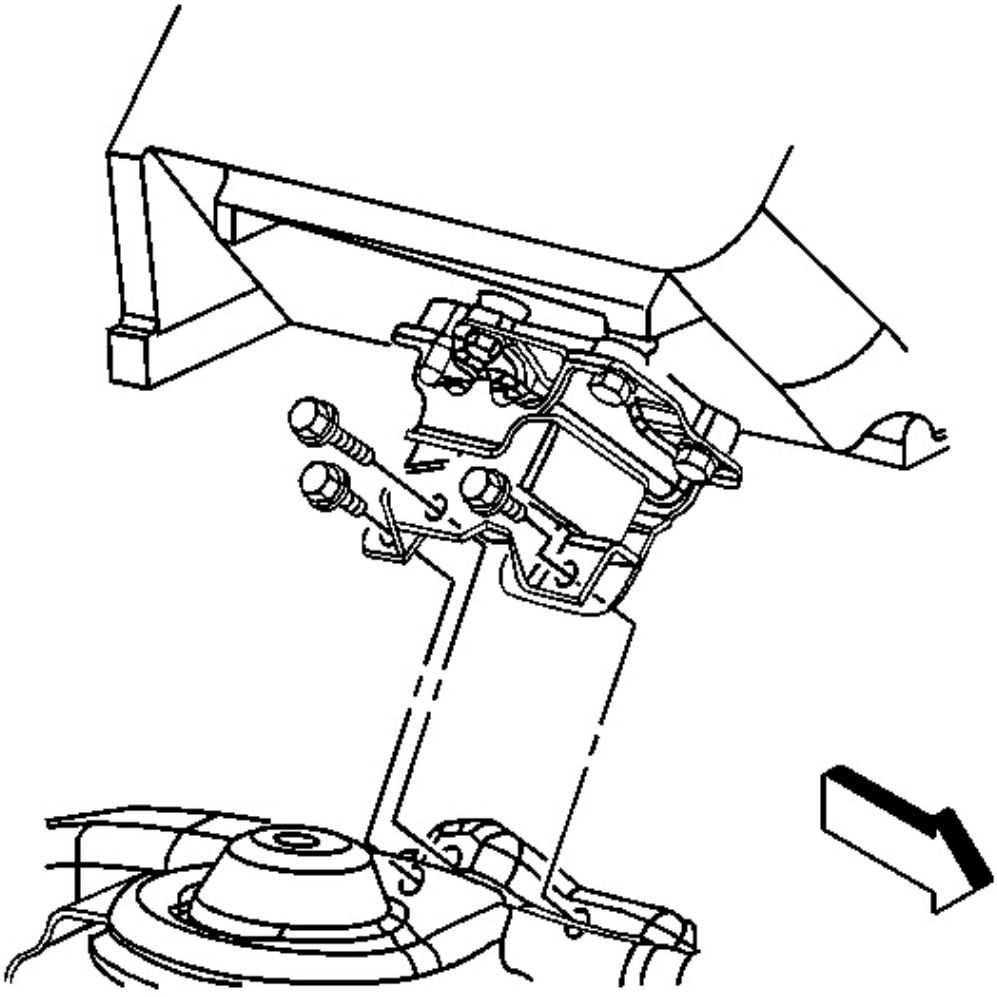


Fig. 21: Engine Mount To Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. From under the hood, remove the engine mount to engine mount bracket bolts. (right side shown, left side similar).

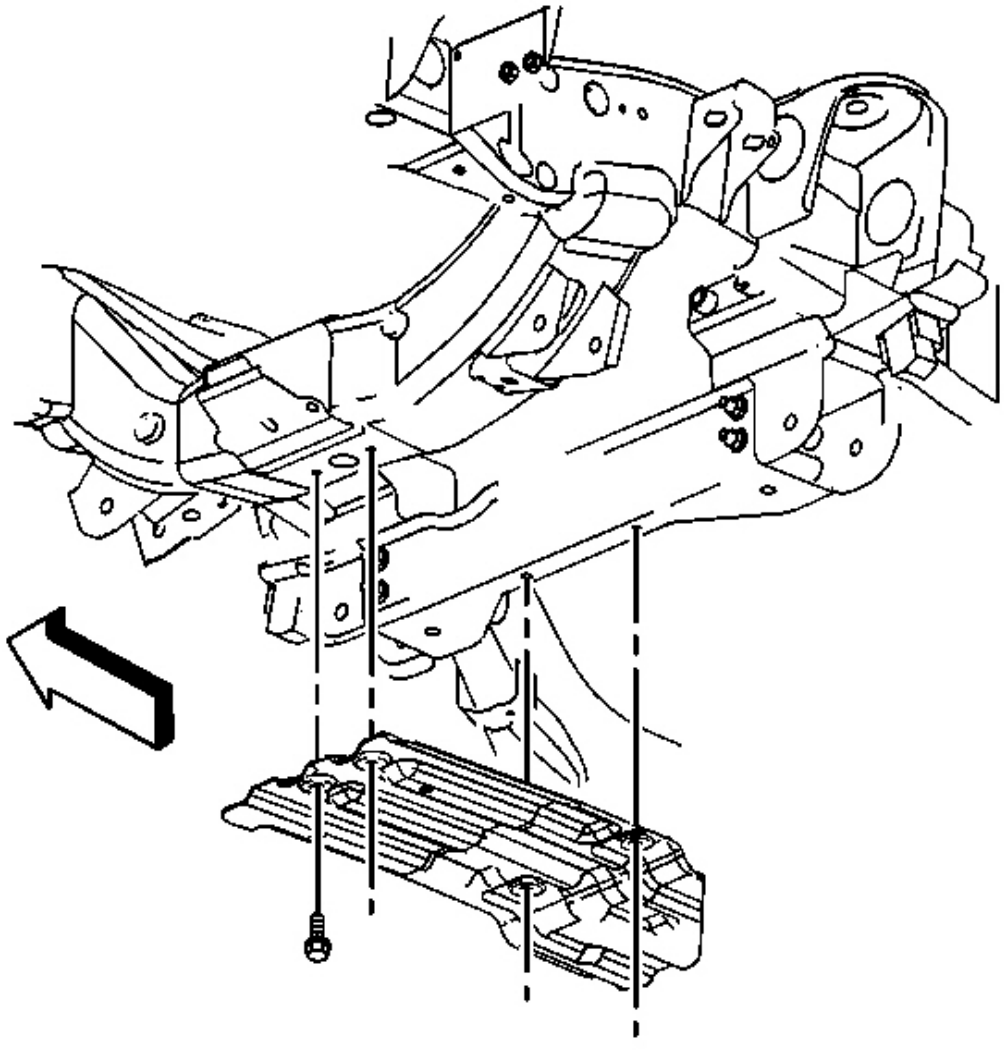


Fig. 22: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the oil pan skid plate bolts and plate.

NOTE: Refer to ENGINE LIFTING NOTICE .

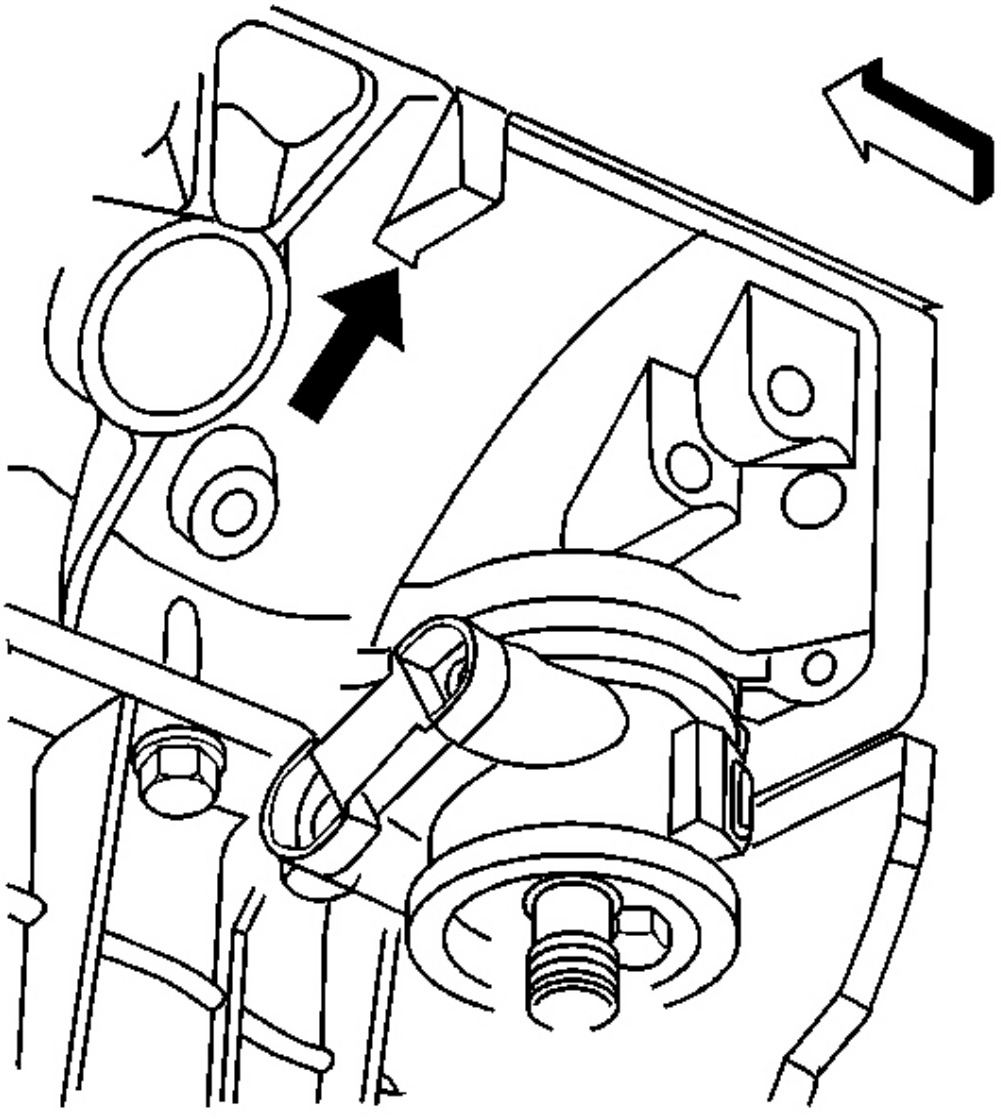


Fig. 23: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Using an adjustable jack on the square tab at the rear of the engine block, raise the engine.

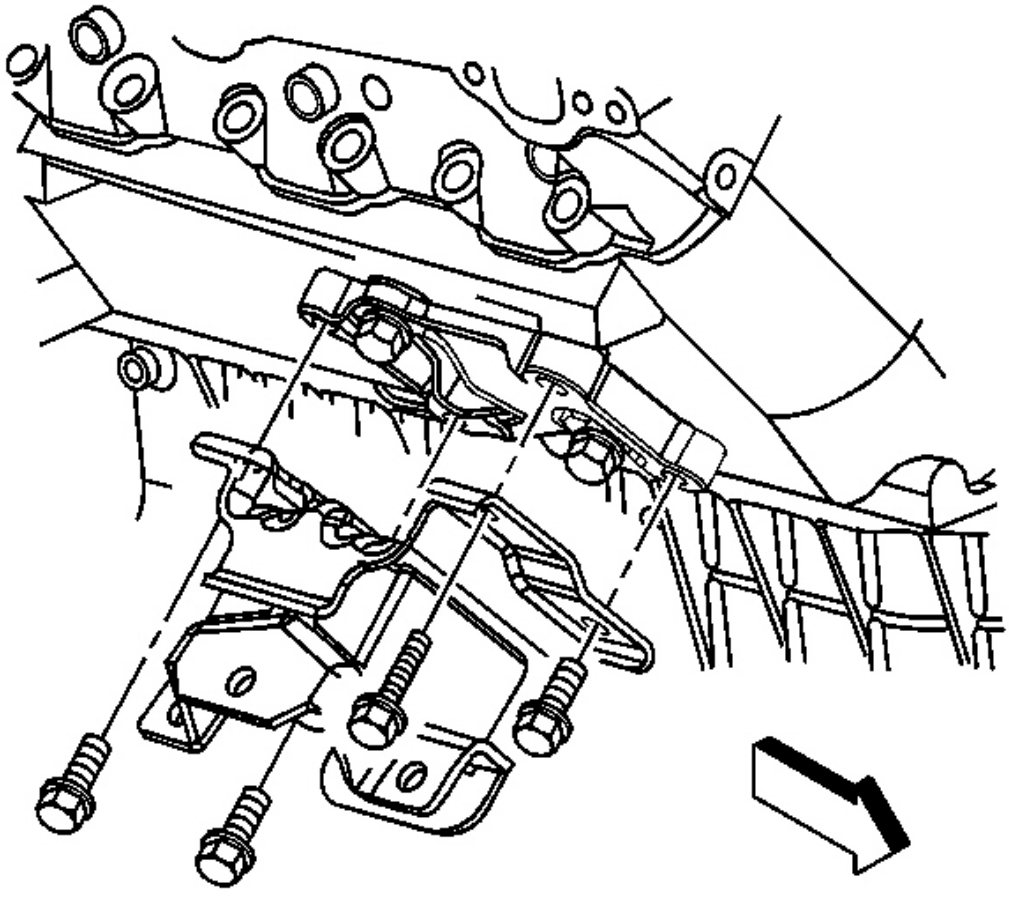


Fig. 24: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount bolts. (right side shown, left side similar).
6. Remove the engine mount.

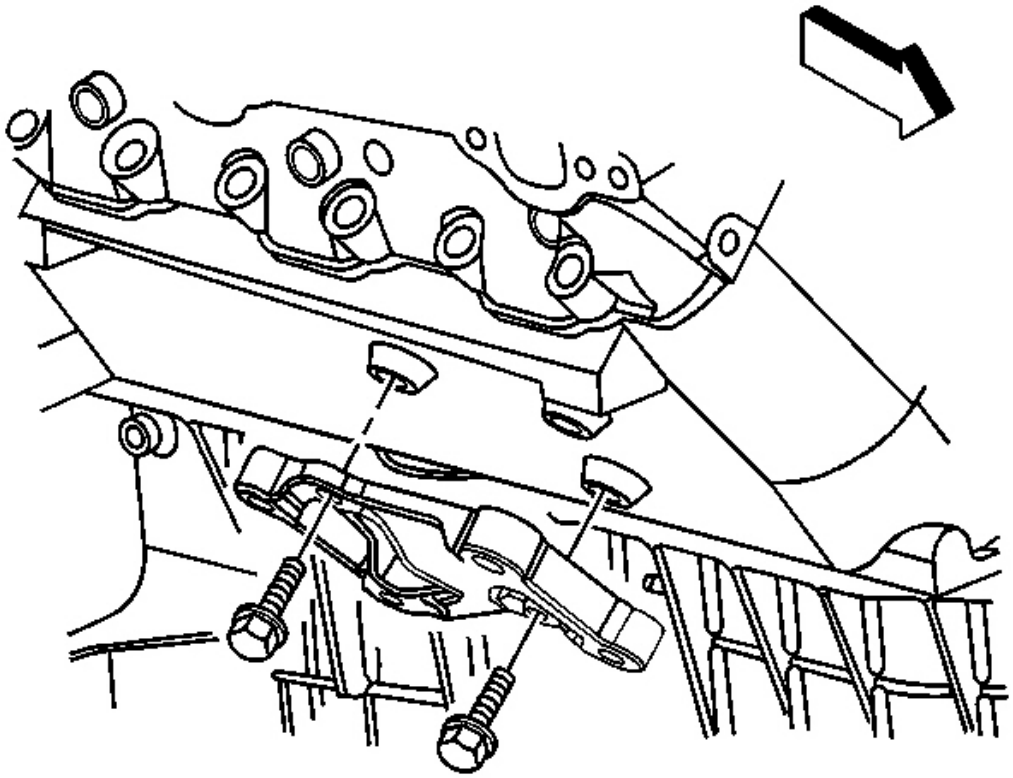


Fig. 25: Engine Mount Side Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

7. If equipped and necessary, remove the engine mount side bracket bolts and bracket. (right side shown, left side similar).

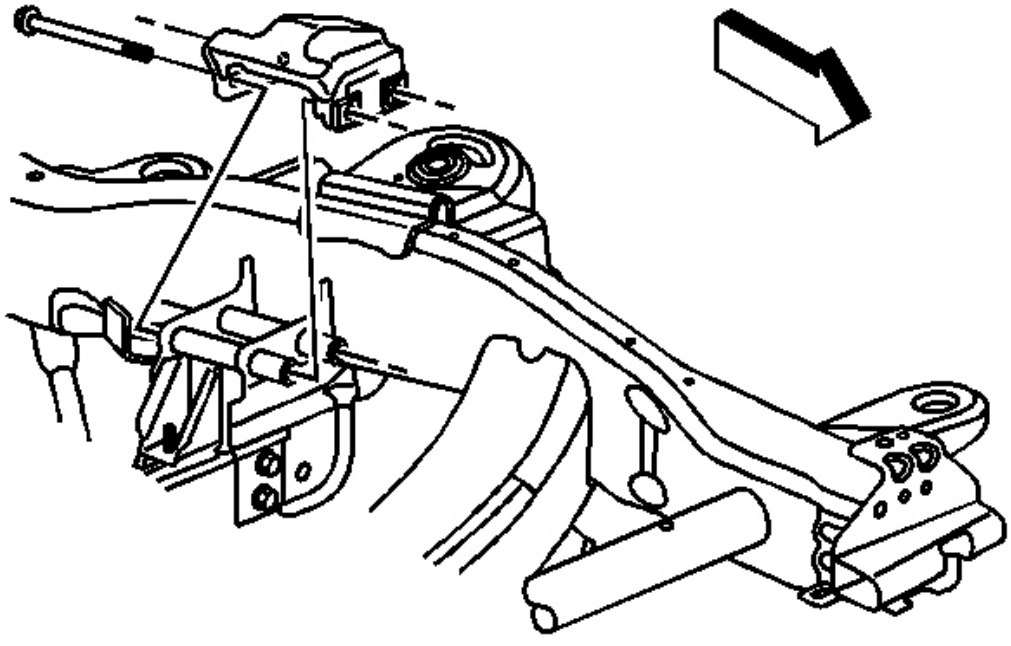


Fig. 26: Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount bracket bolts.
9. Remove the engine mount bracket.

Installation Procedure

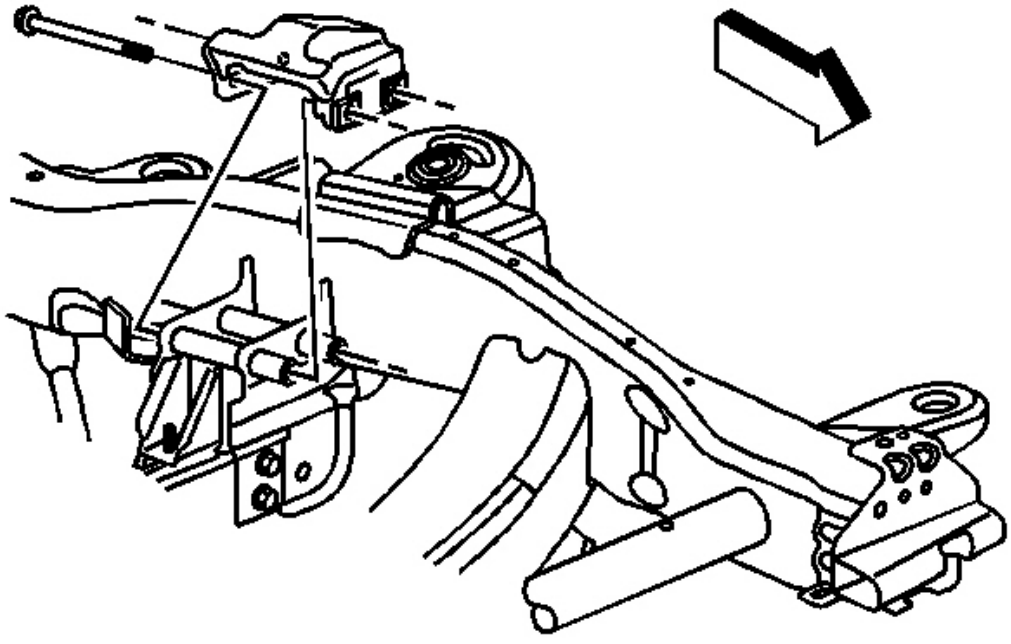


Fig. 27: Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice .

3. Install the engine mount bracket bolts.

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

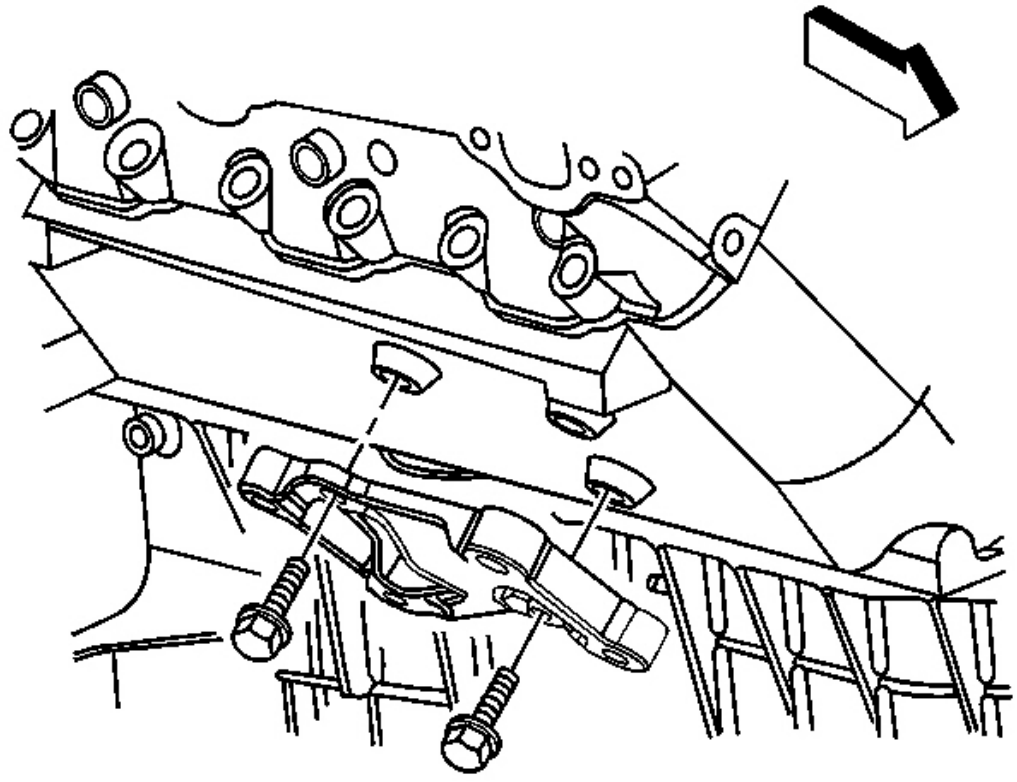


Fig. 28: Engine Mount Side Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Position the engine mount side bracket to the engine, if removed and equipped. (right side shown, left side similar).
5. Install the engine mount side bracket bolts.

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

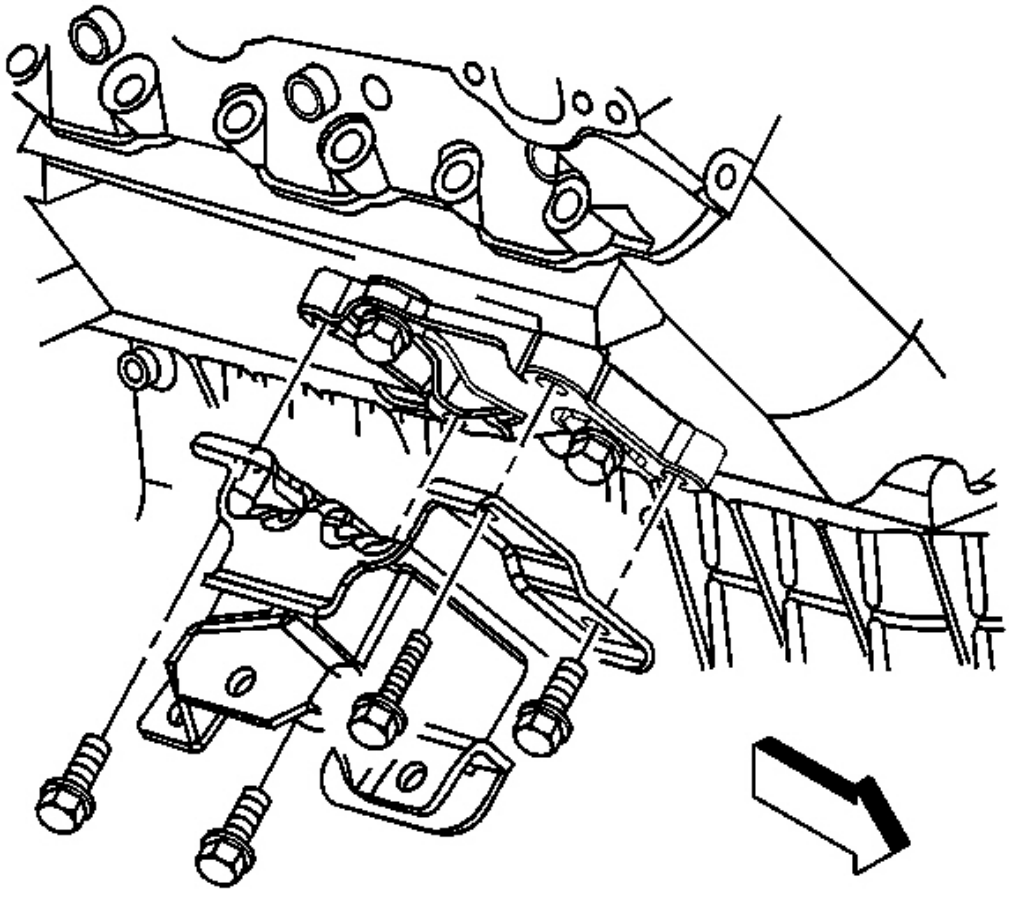


Fig. 29: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount. (right side shown, left side similar).
7. Install the engine mount bolts.

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

8. Lower the engine.

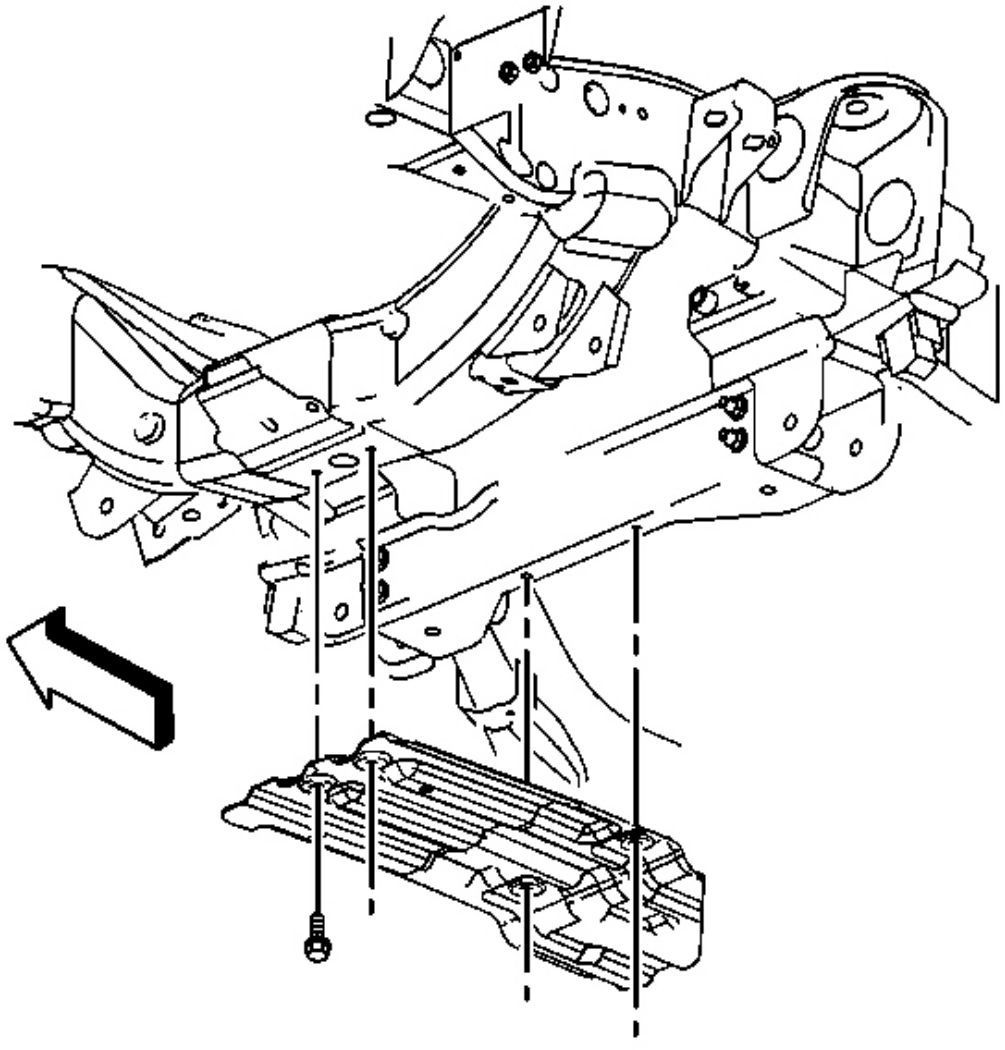


Fig. 30: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

9. Install the oil pan skid plate and bolts.

   Tighten: Tighten the oil pan skid plate bolts to 20 N.m (15 lb ft).

10. Lower the vehicle.

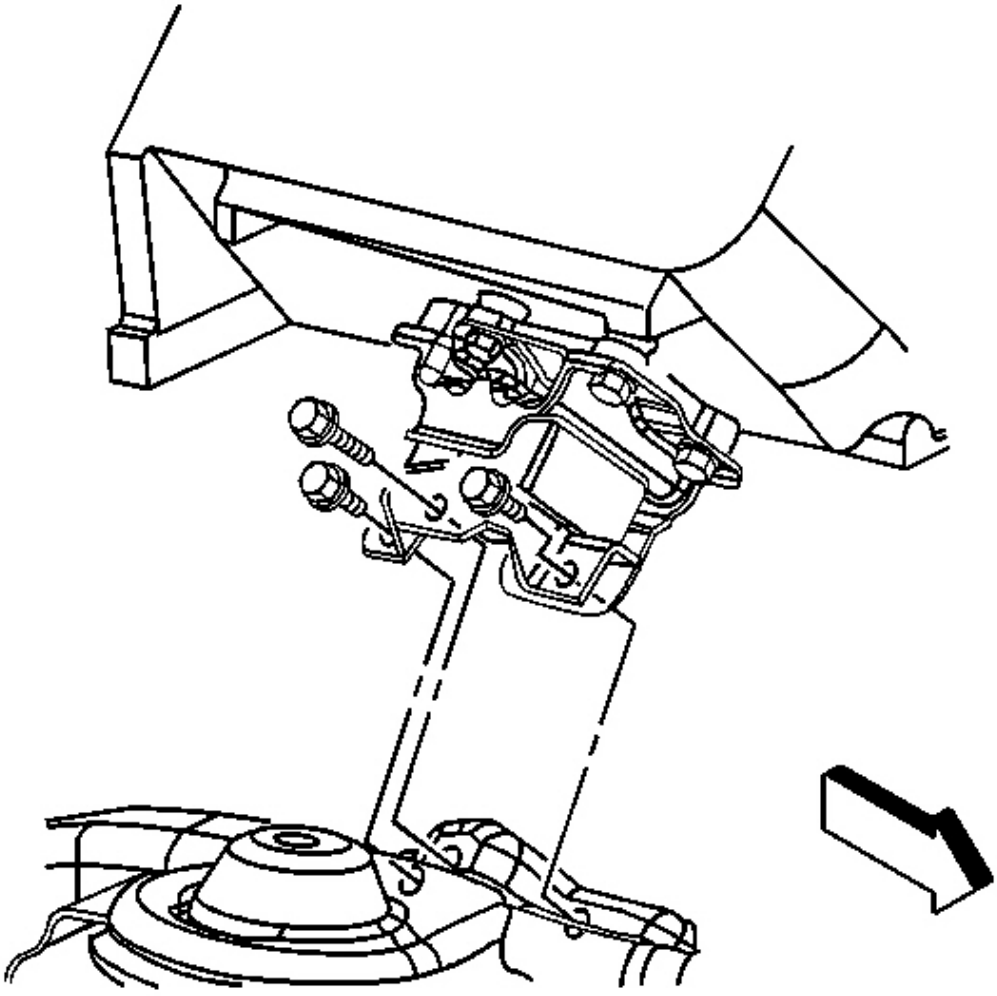


Fig. 31: Engine Mount To Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the engine mount to engine mount bracket bolts. (right side shown, left side similar).

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

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

NOTE: Refer to ENGINE MOUNTING NOTICE .

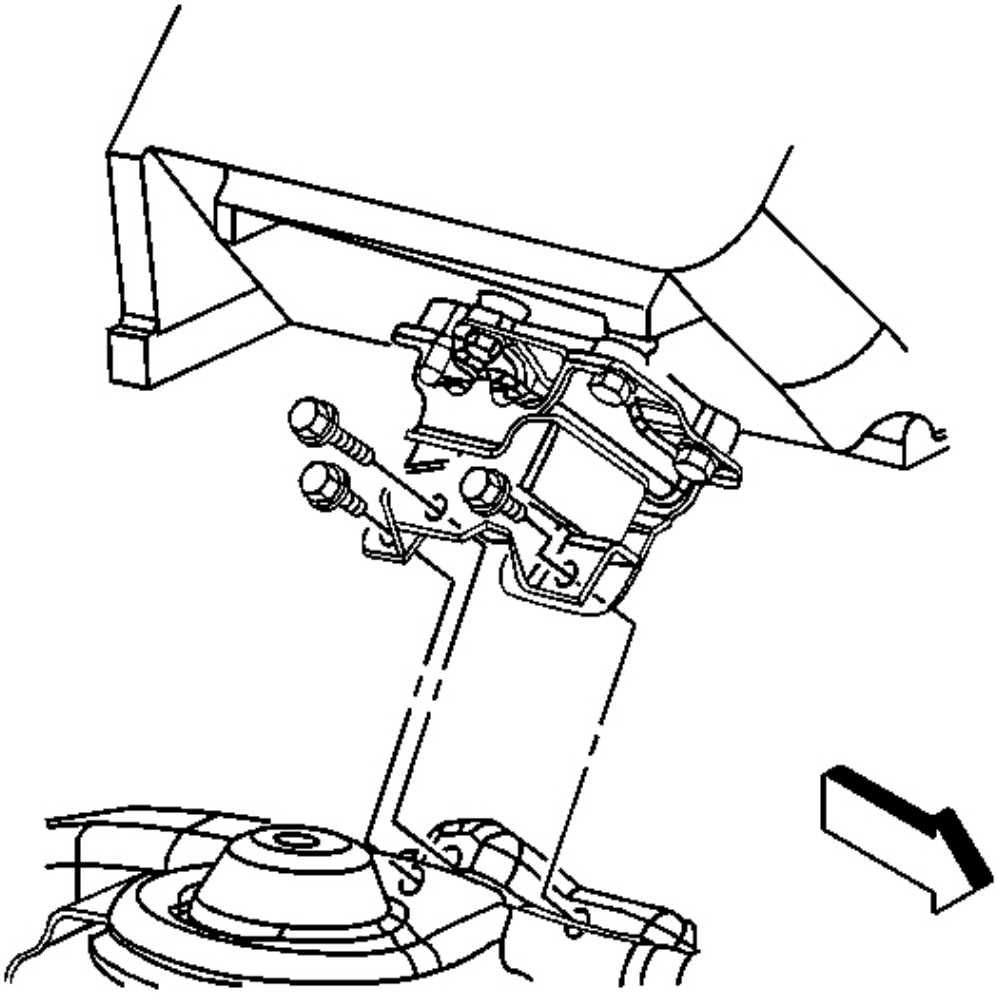


Fig. 32: Engine Mount To Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. From under the hood, remove the engine mount to engine mount bracket bolts. (left side shown, right side similar).

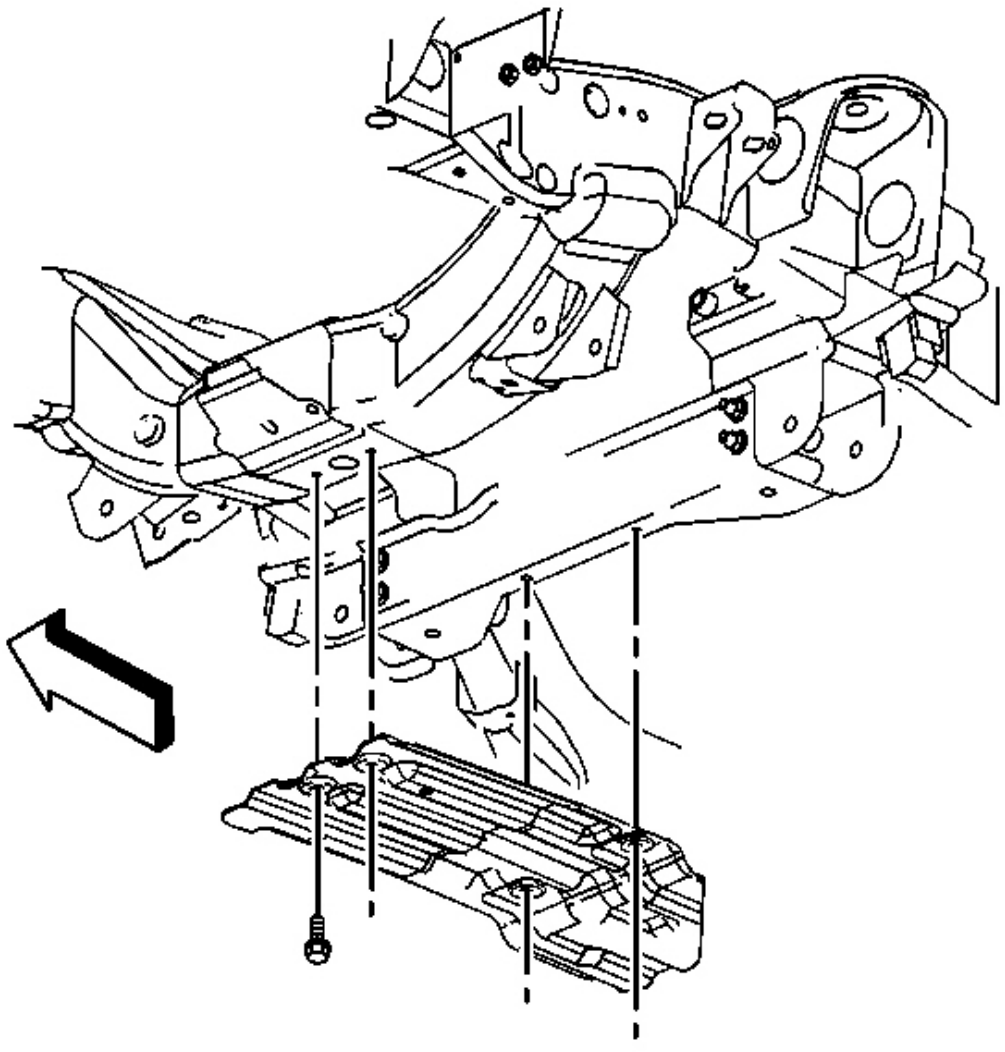


Fig. 33: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the oil pan skid plate bolts and plate.

NOTE: Refer to ENGINE LIFTING NOTICE .

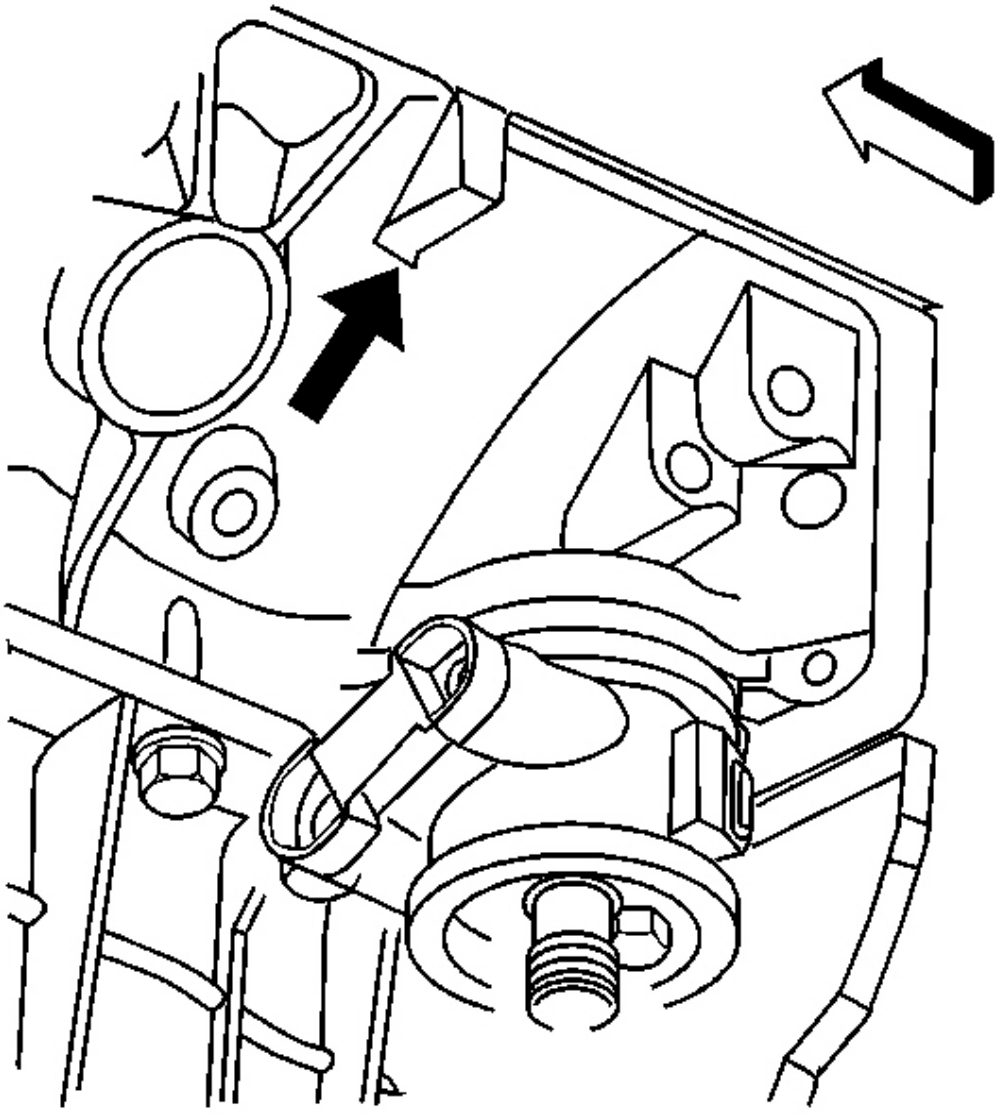


Fig. 34: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Using an adjustable jack on the square tab (left side shown) at the rear of the engine block, raise the engine. In order to access the square tab, remove the starter. (left side shown, right side similar). Refer to **Starter Motor Replacement (4.3L)** .

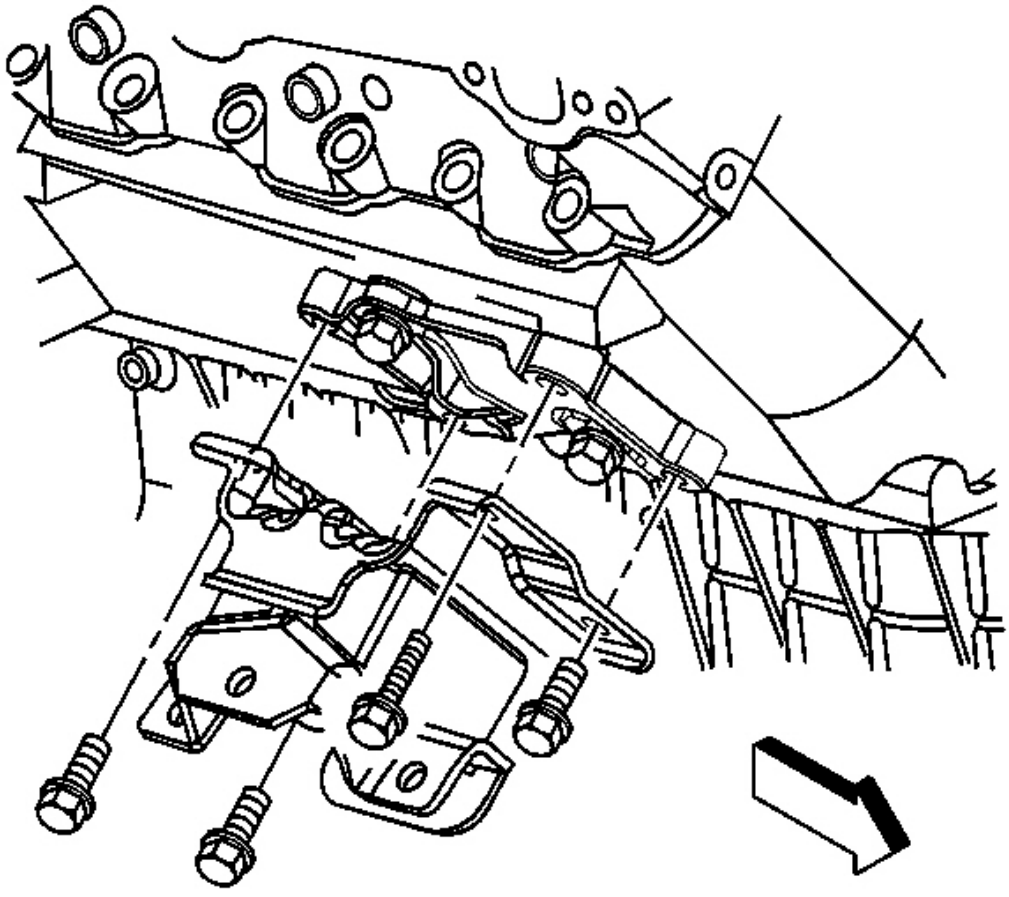


Fig. 35: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount bolts.
6. Remove the engine mount.

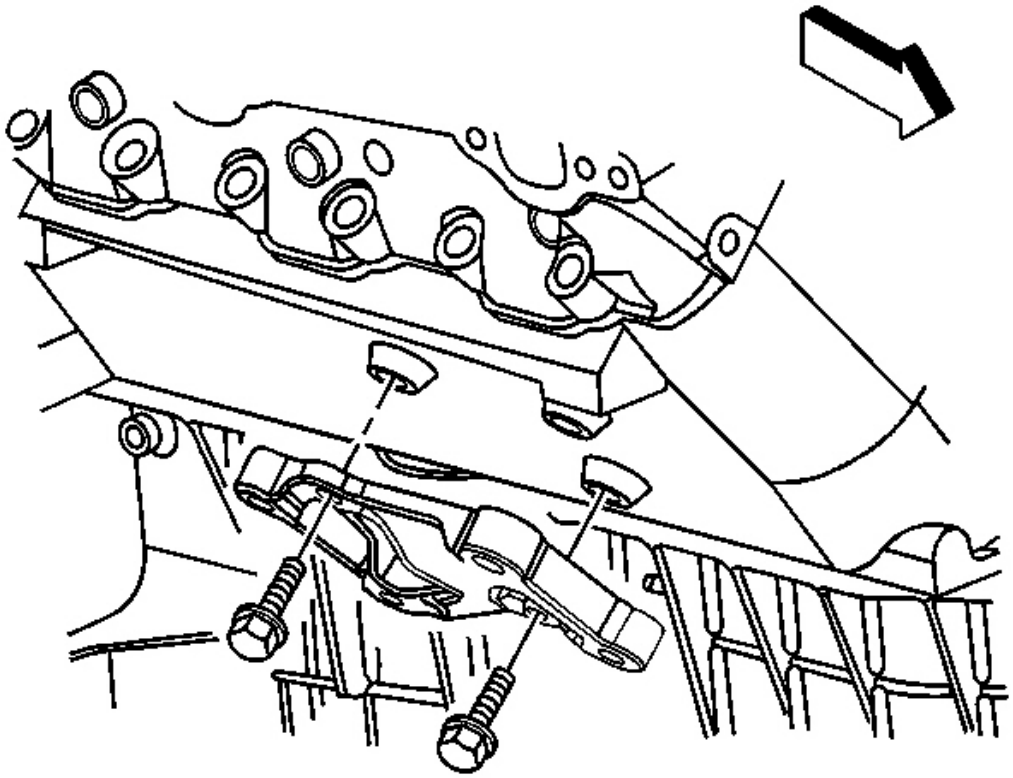


Fig. 36: Engine Mount Side Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

7. If necessary, remove the engine mount side bracket bolts and bracket.

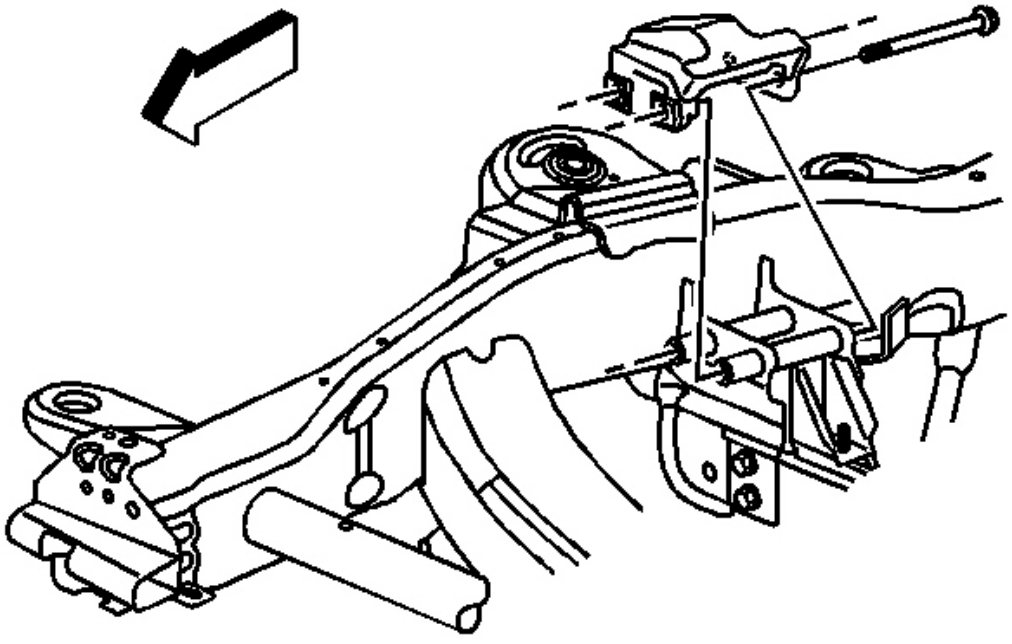


Fig. 37: Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount bracket bolts.
9. Remove the engine mount bracket.

Installation Procedure

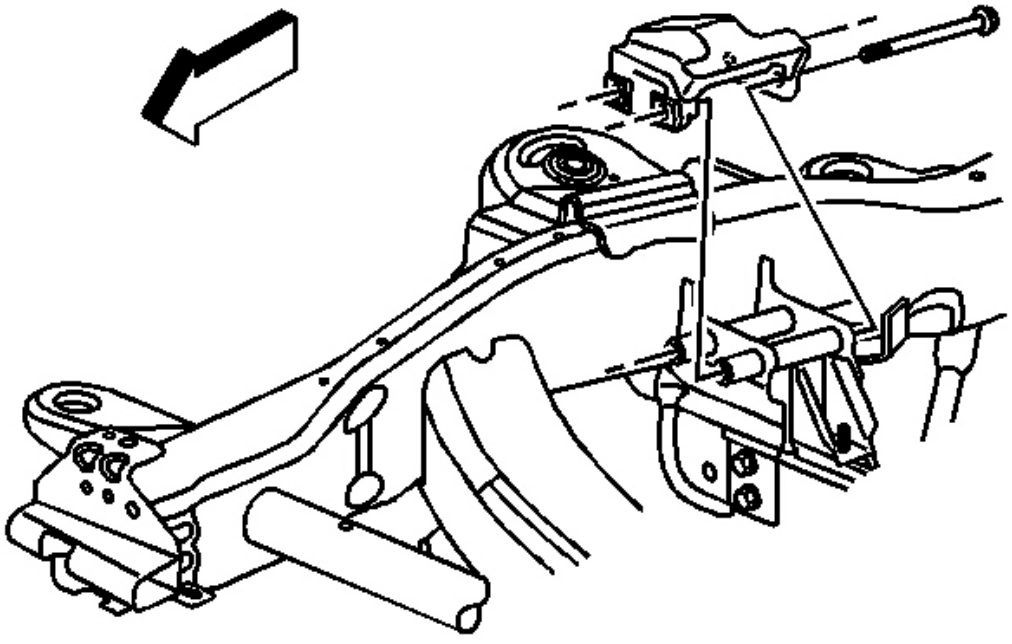


Fig. 38: Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice .

3. Install the engine mount bracket bolts.

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

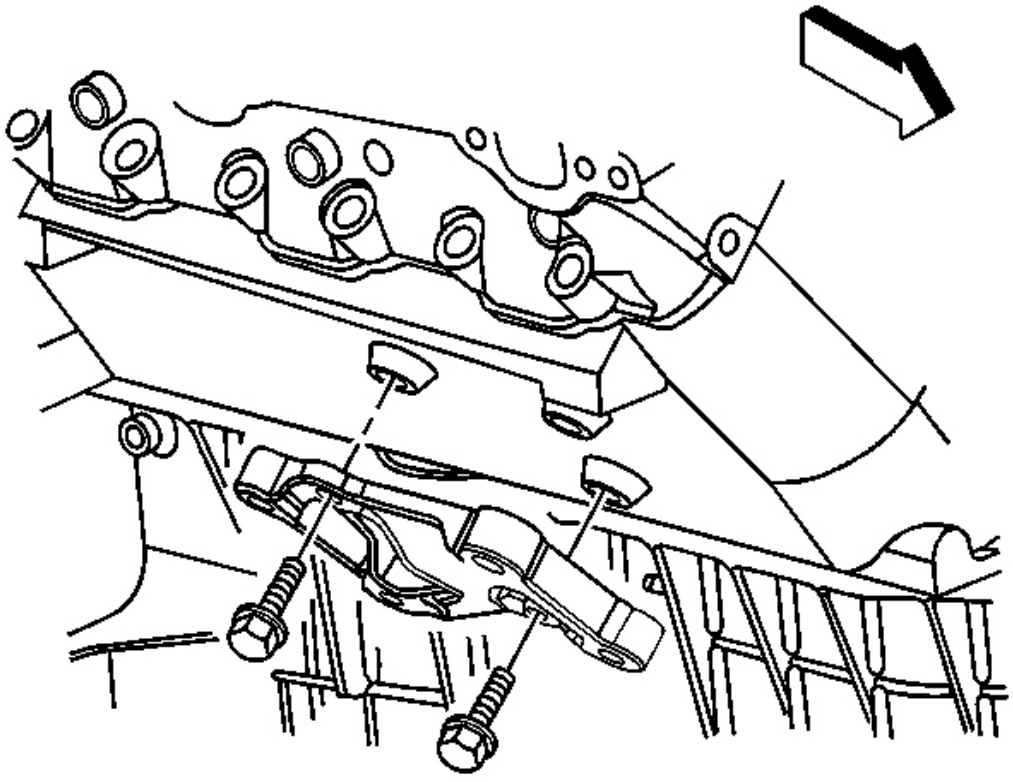


Fig. 39: Engine Mount Side Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Position the engine mount side bracket to the engine, if removed.
5. Install the engine mount side bracket bolts.

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

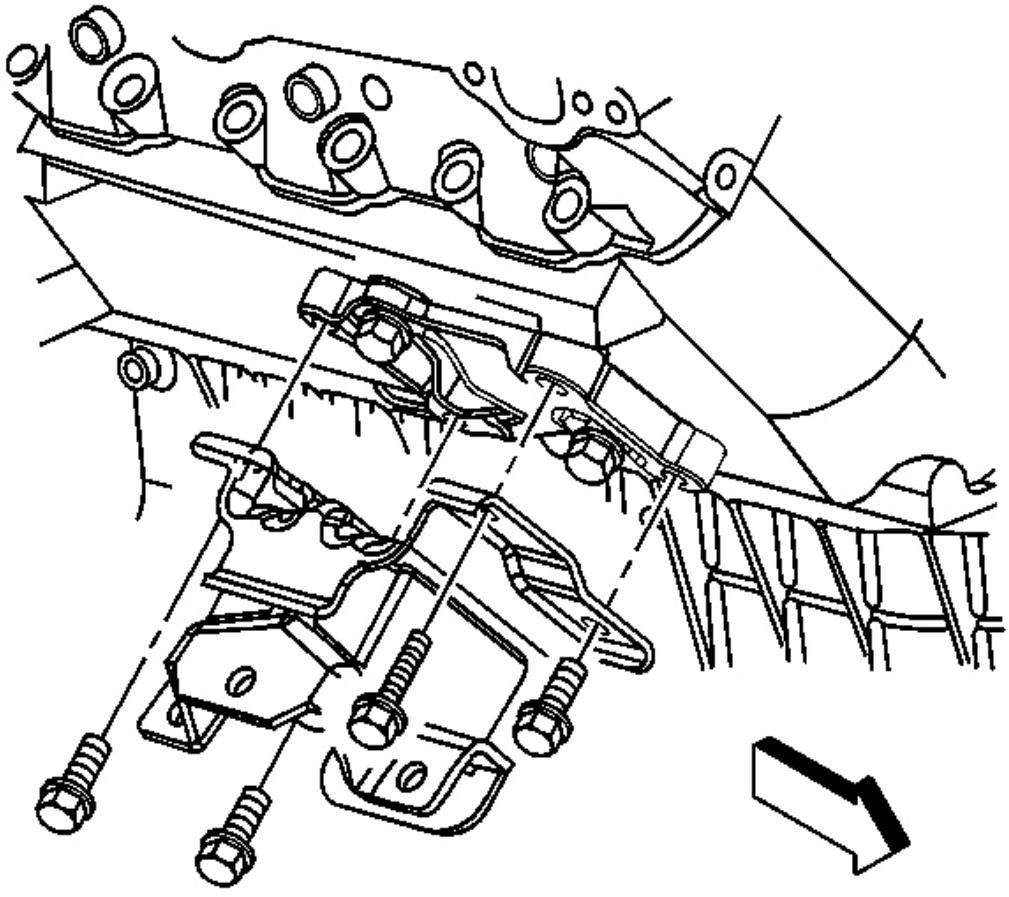


Fig. 40: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount.
7. Install the engine mount bolts.

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

8. Lower the engine.
9. Install the starter. Refer to **Starter Motor Replacement (4.3L)** .

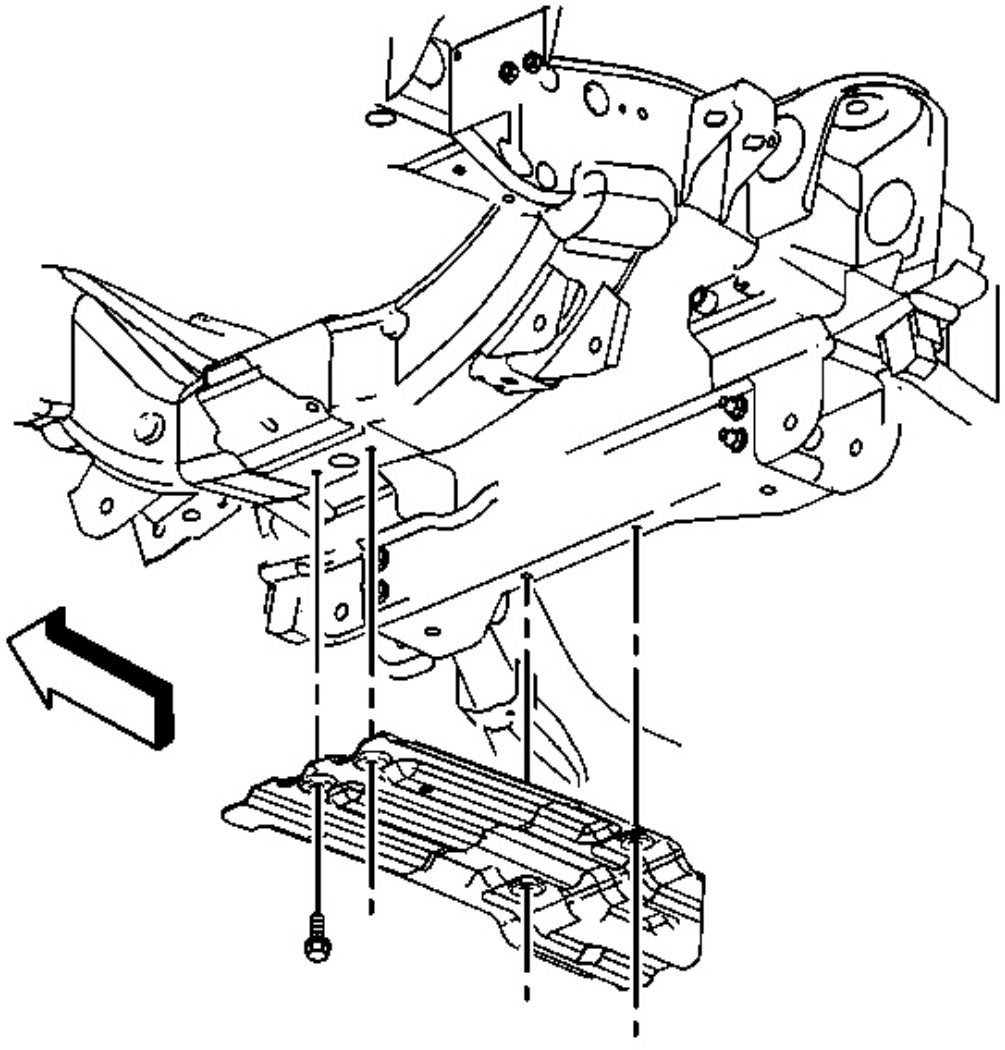


Fig. 41: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pan skid plate and bolts.

    Tighten: Tighten the oil pan skid plate bolts to 20 N.m (15 lb ft).

11. Lower the vehicle.

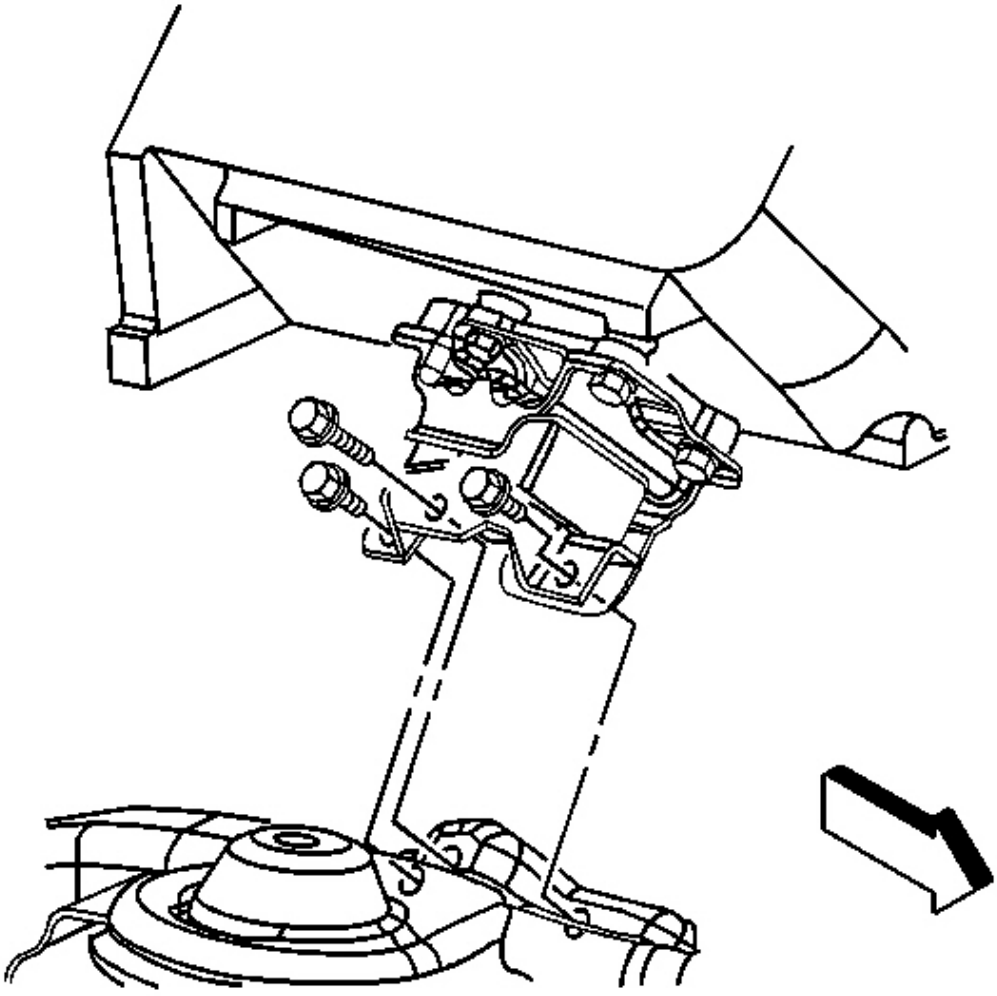


Fig. 42: Engine Mount To Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the engine mount to engine mount bracket bolts.

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

UPPER INTAKE MANIFOLD REPLACEMENT

Removal Procedure

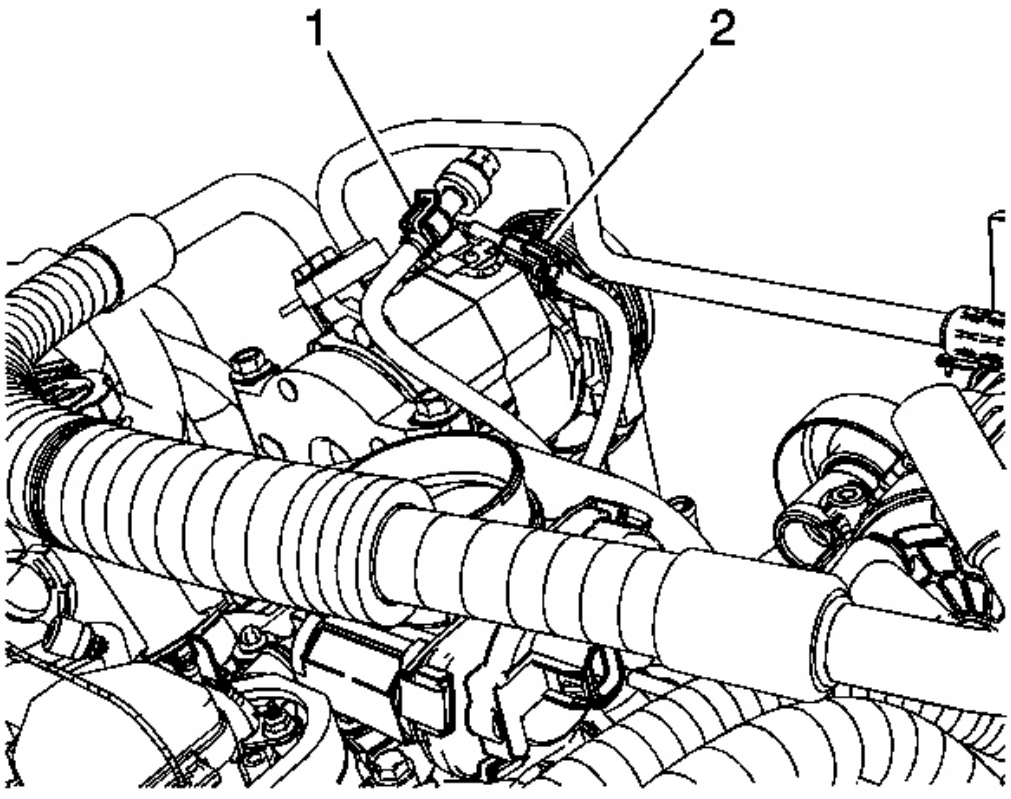


Fig. 43: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
2. Disconnect the following electrical connectors:
   - The A/C pressure switch (1), if equipped
   - The air conditioning (A/C) compressor clutch (2), if equipped

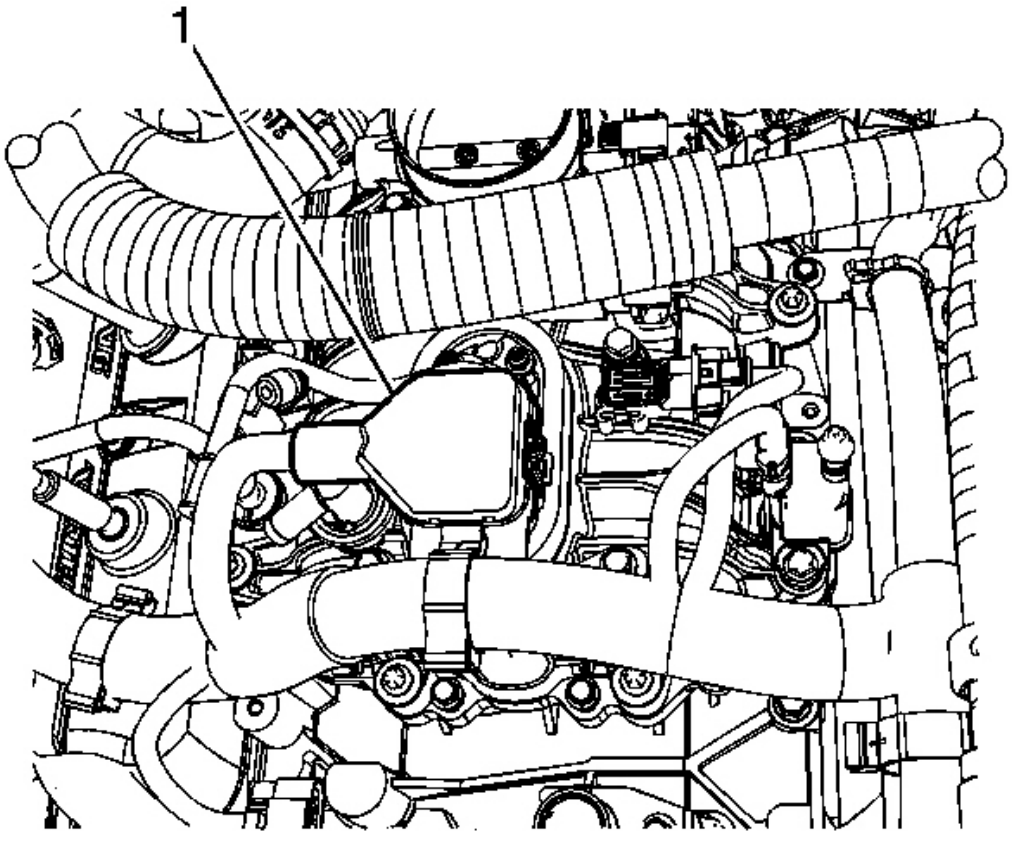


Fig. 44: Control Port Injector Module
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the control port injector module (1).

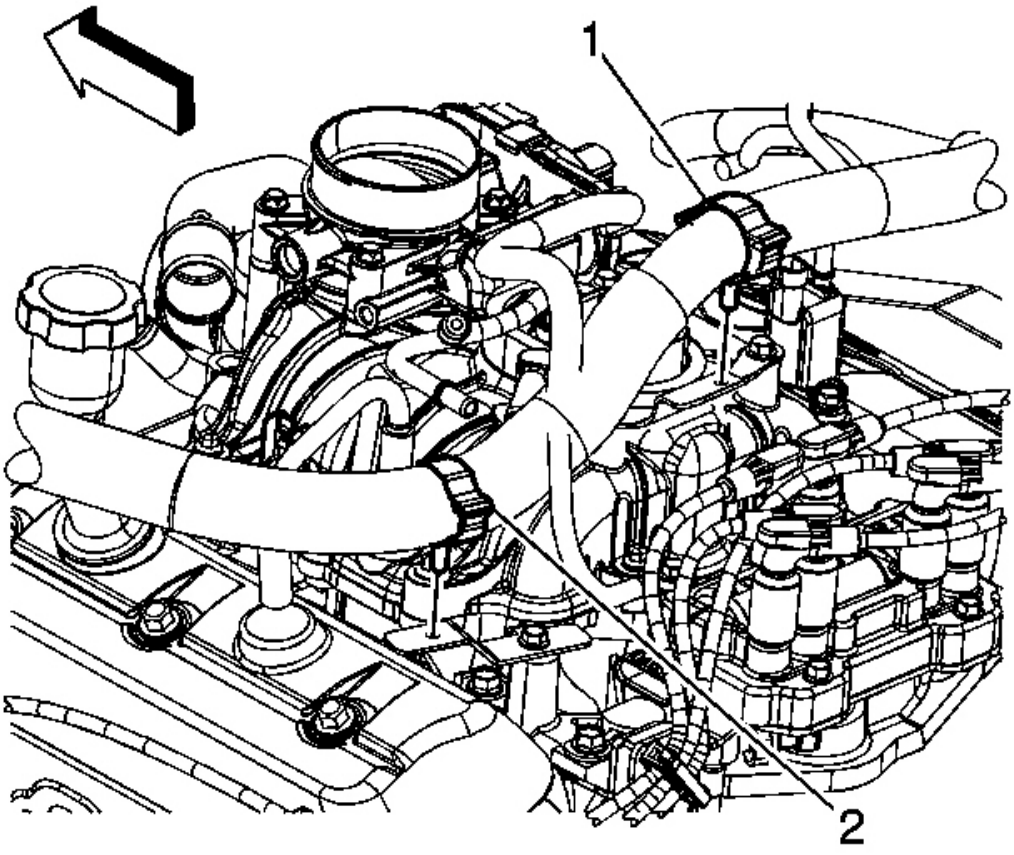


Fig. 45: View Of Engine Wiring Harness Clips
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine wiring harness clips (1, 2) from the engine harness brackets.

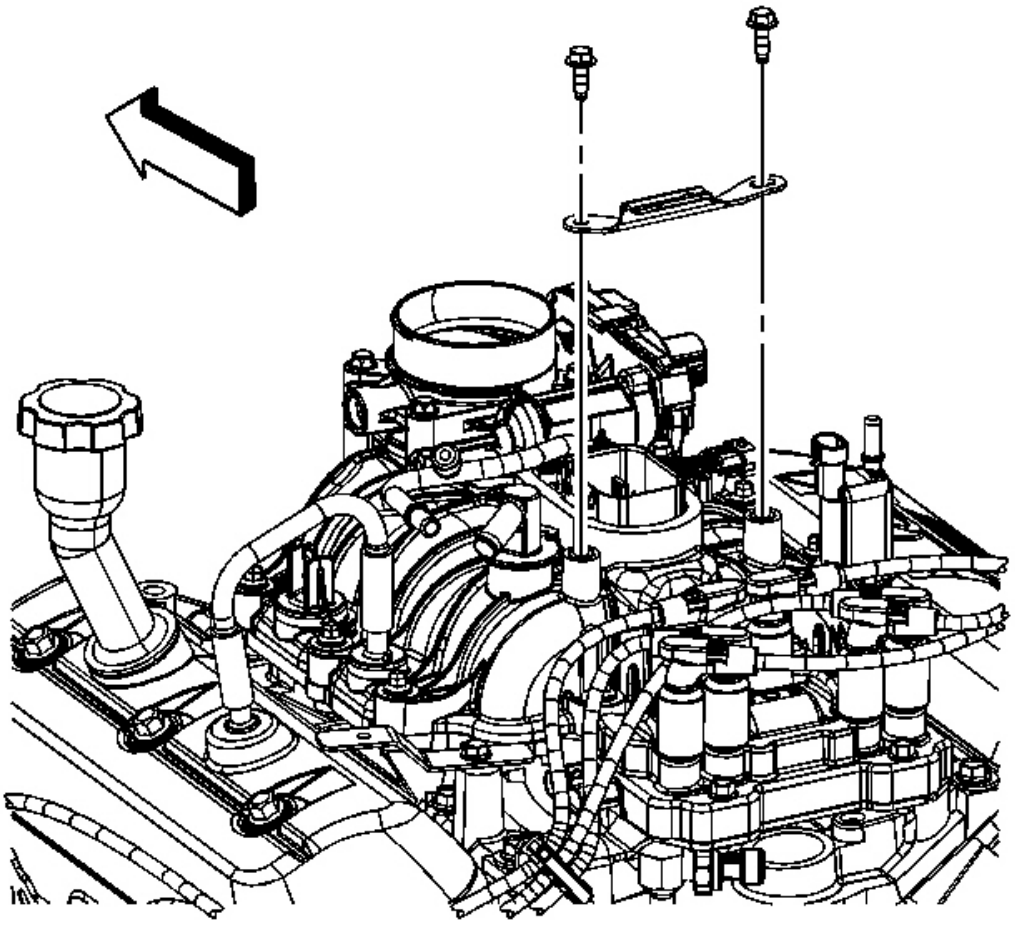


Fig. 46: View Of Engine Wiring Harness Rear Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine wiring harness rear bracket bolts and bracket.

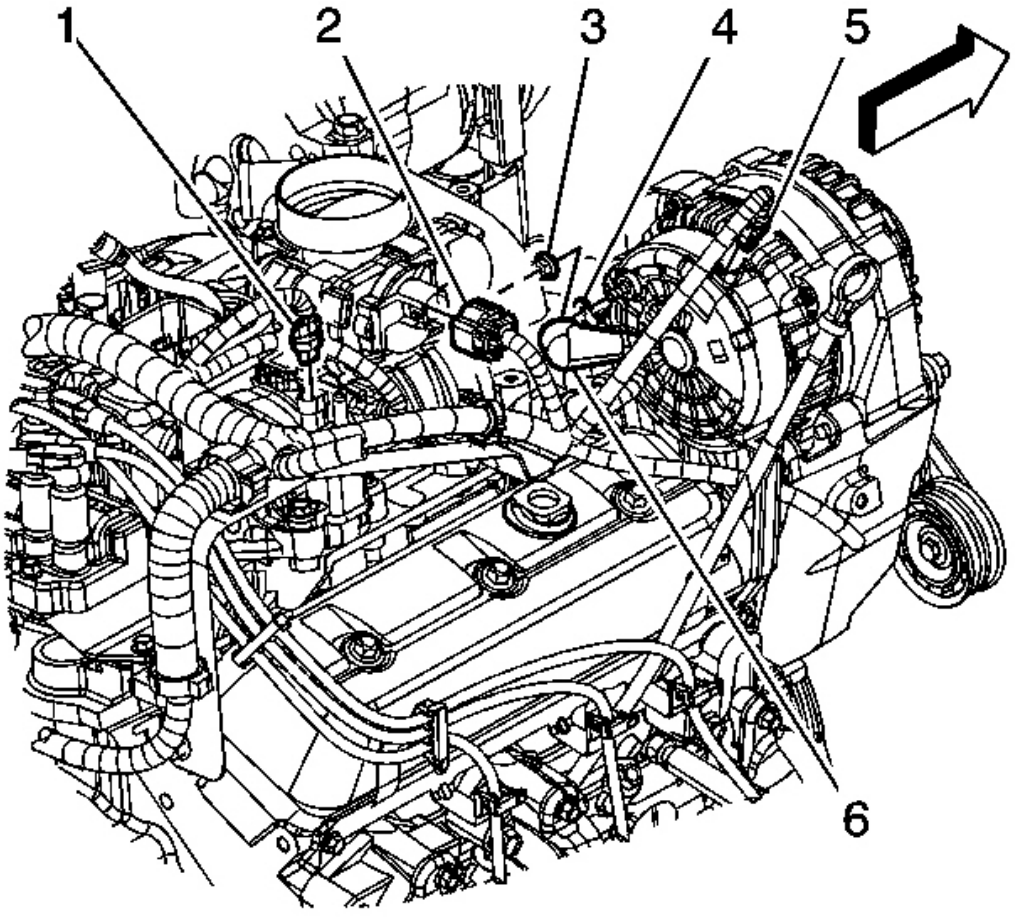


Fig. 47: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the following electrical connectors:
   - The evaporative emission (EVAP) canister purge solenoid valve (1)
   - The manifold absolute pressure (MAP) sensor

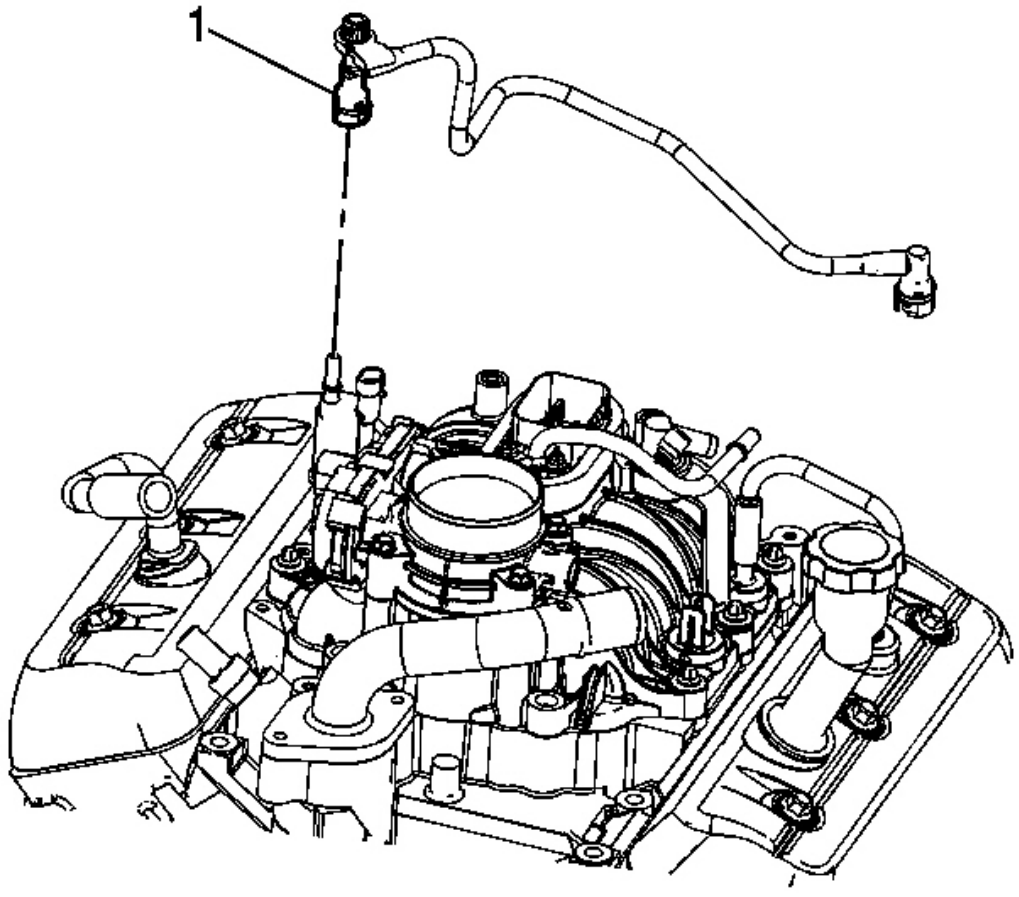


Fig. 48: View Of EVAP Canister Purge Solenoid Valve Tube Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the evaporative emission (EVAP) canister purge solenoid valve tube quick connect fitting (1) from the EVAP purge solenoid valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
8. Reposition the tube out of the way.

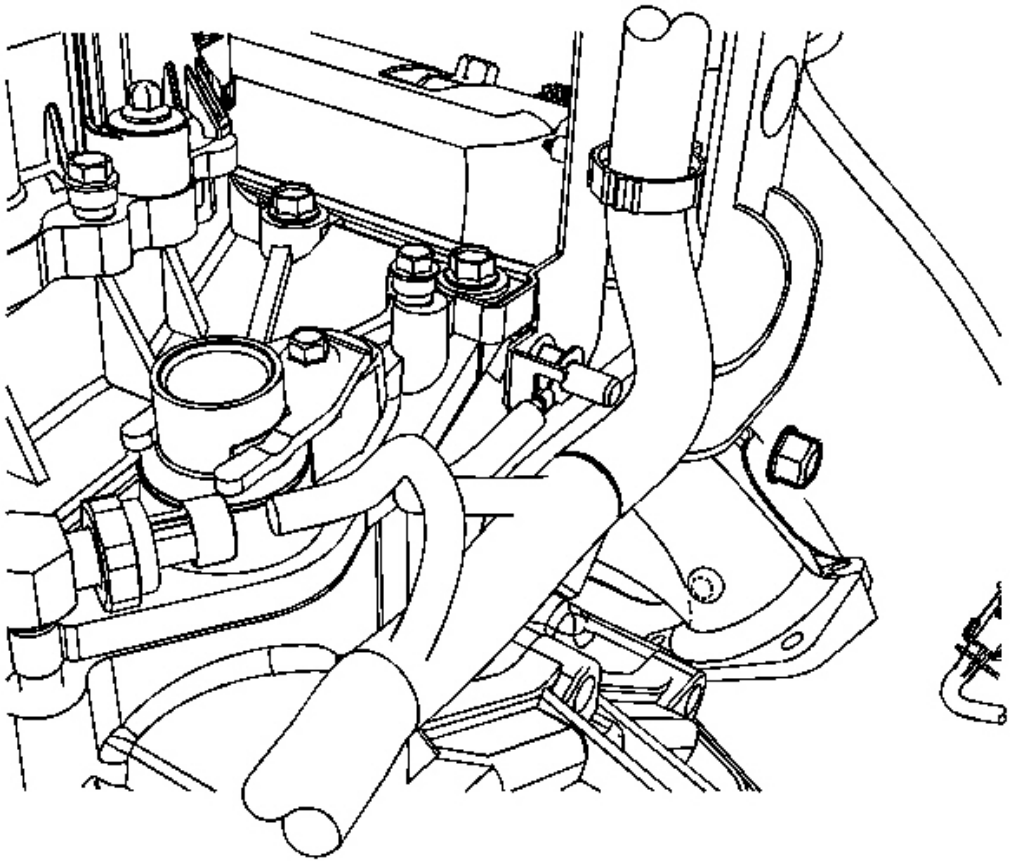


Fig. 49: Engine Wiring Harness Ground Nut
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine wiring harness ground nut and ground wire (1) from the rear of the right cylinder head.

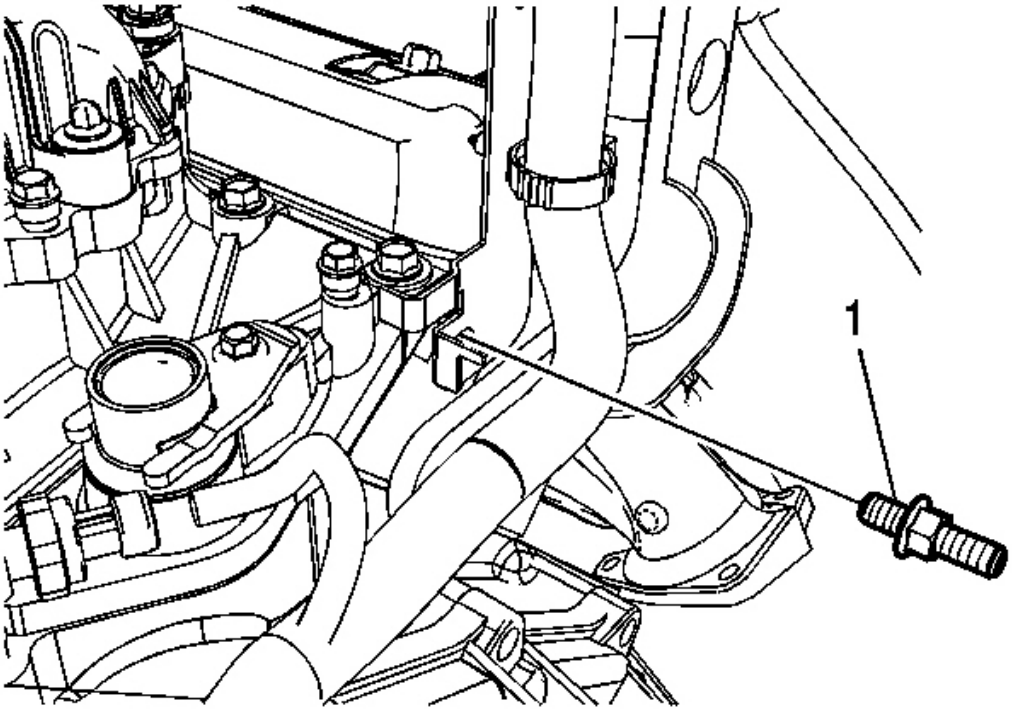


Fig. 50: Engine Wiring Harness Bracket Stud
Courtesy of GENERAL MOTORS CORP.

10. Remove the stud (1) holding the engine wiring harness bracket.
11. Reposition the engine wiring harness with the bracket aside.

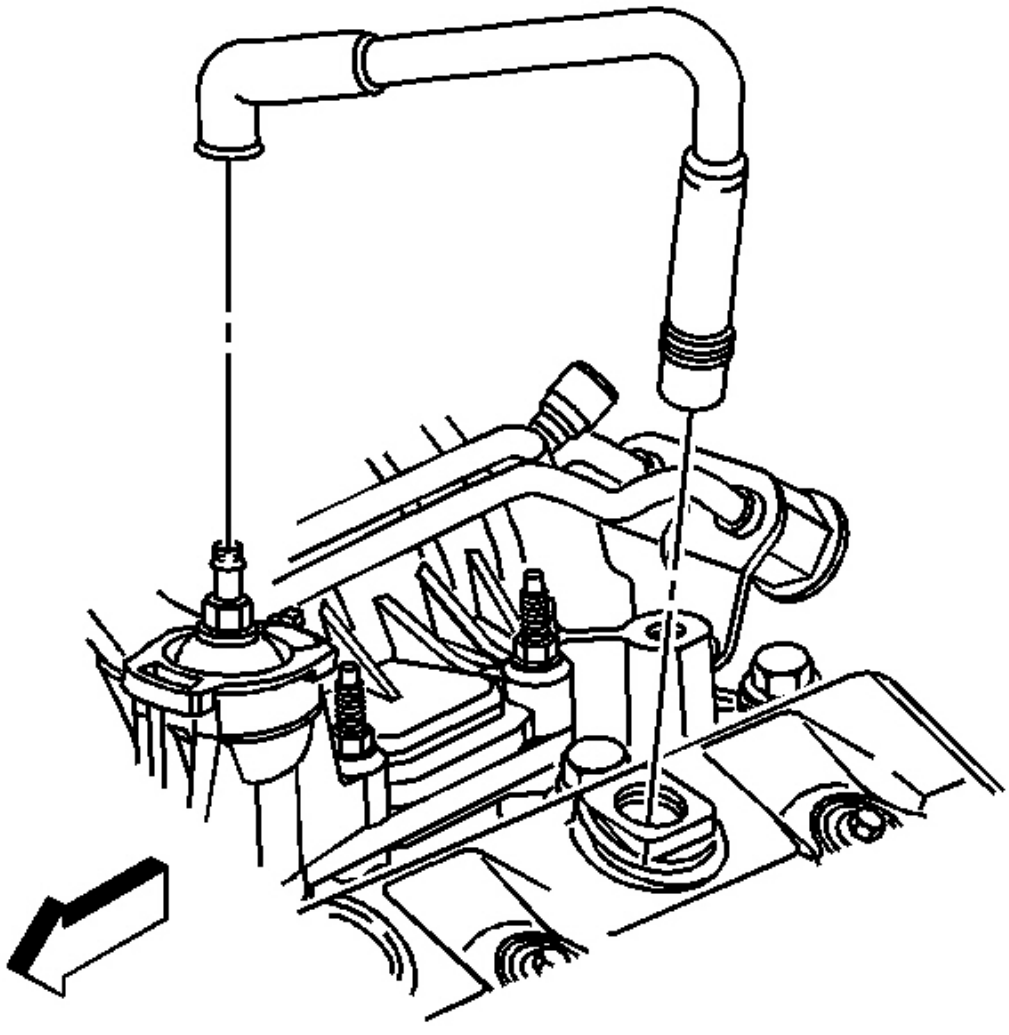


Fig. 51: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

12. Remove the positive crankcase ventilation (PCV) valve hose from the valve and rocker cover.
13. Disconnect the power brake booster vacuum hose from the vacuum fitting.

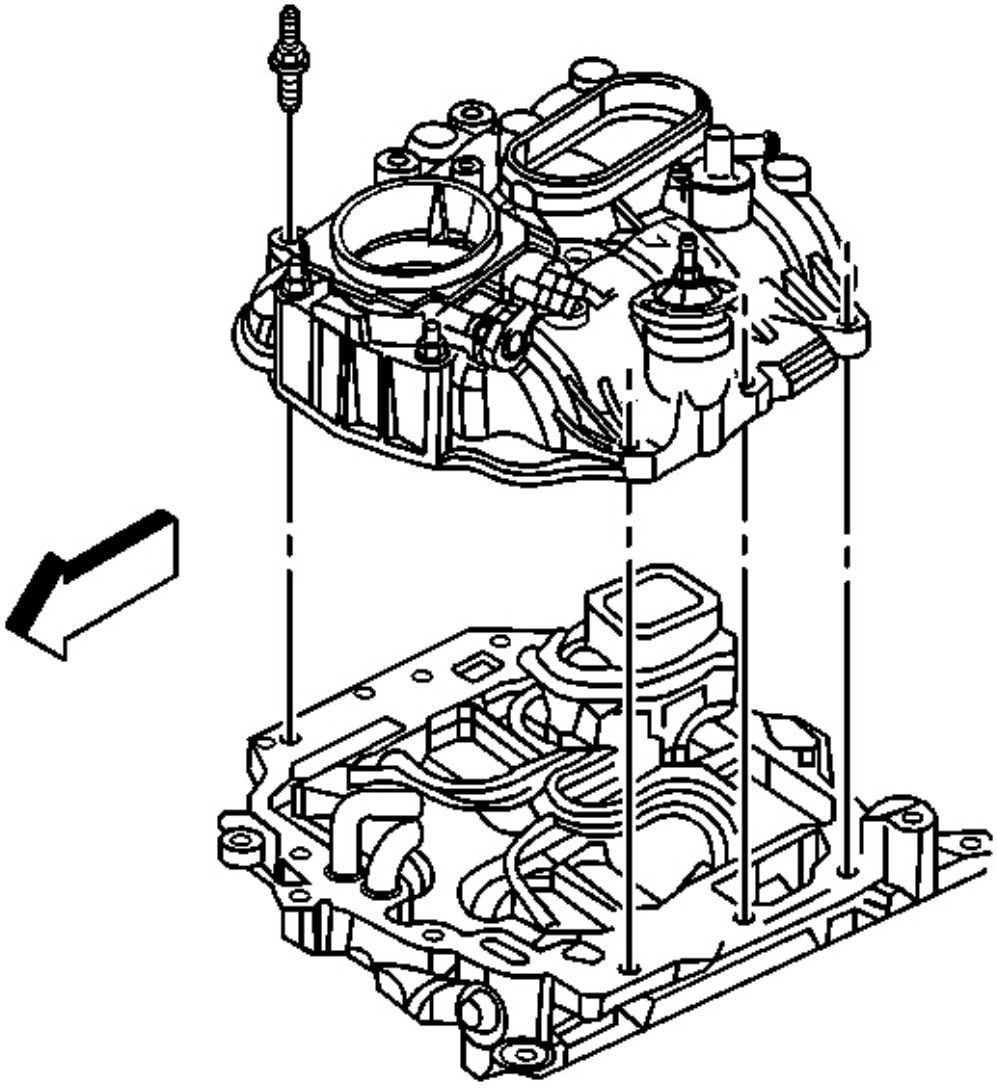


Fig. 52: Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

14. Remove the intake manifold - upper studs.
15. Remove the front 2 throttle body studs.
16. Remove the intake manifold - upper.

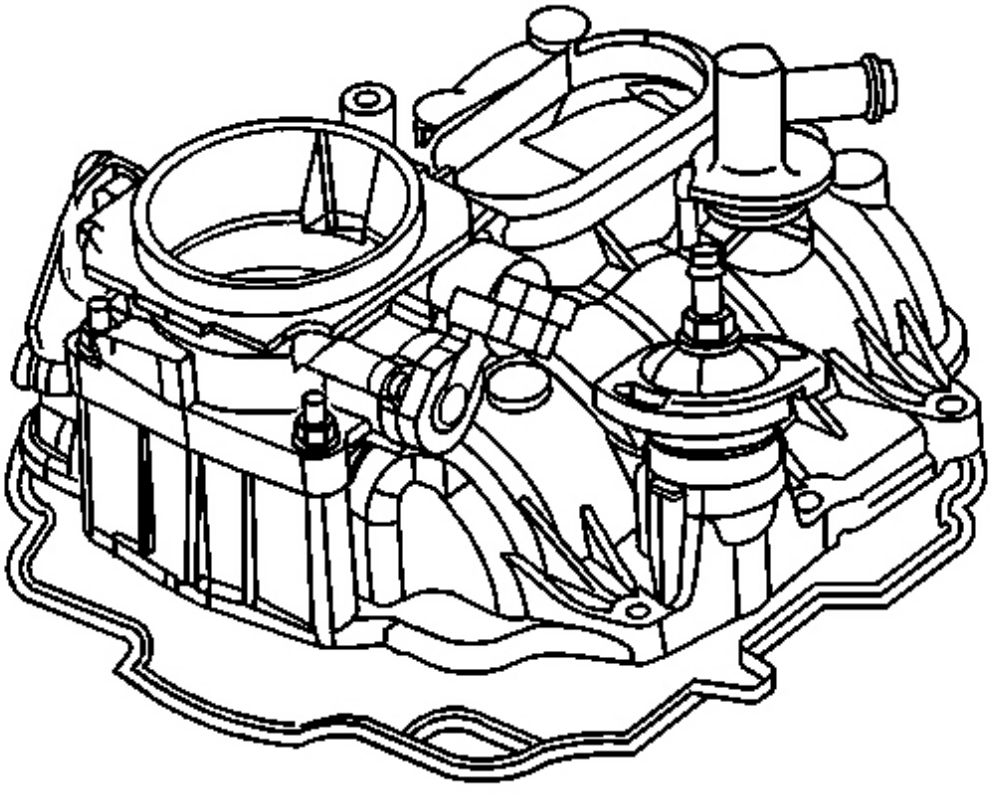


Fig. 53: Intake Manifold Upper Gasket
Courtesy of GENERAL MOTORS CORP.

17. Remove and discard the intake manifold - upper gasket.

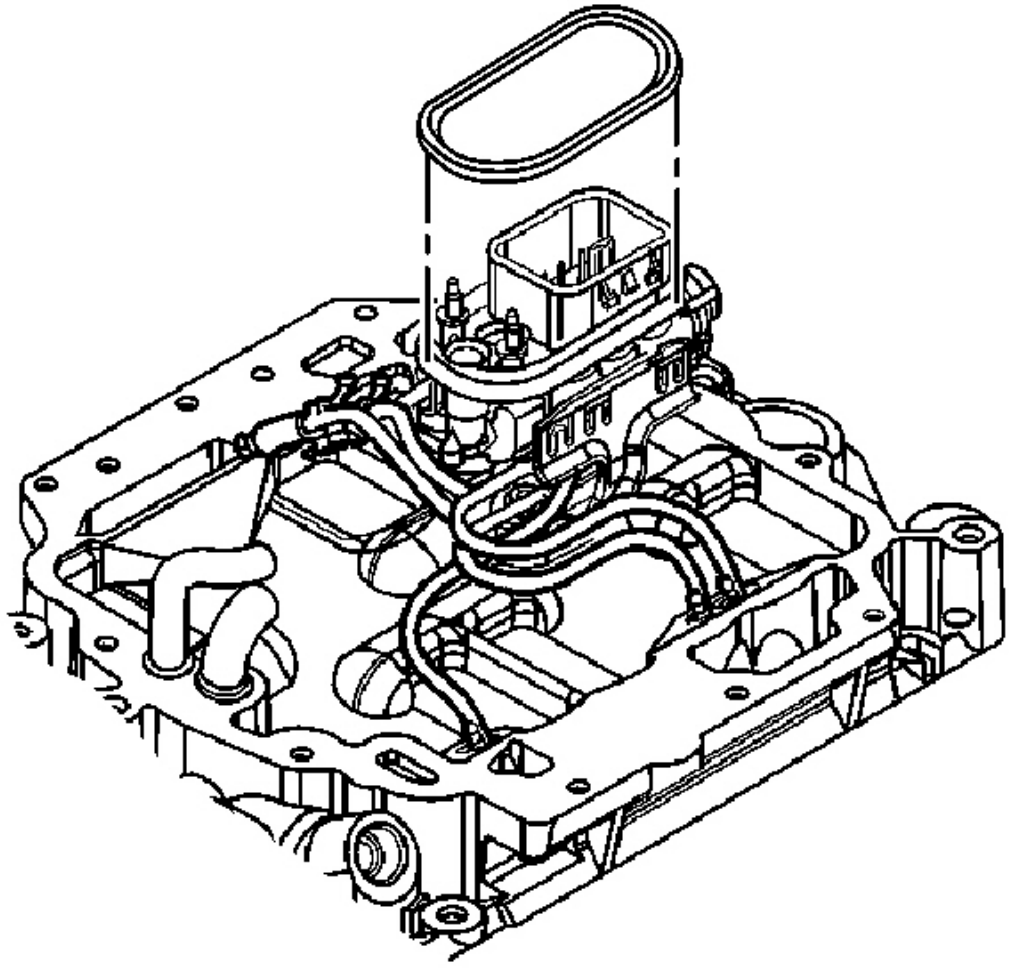


Fig. 54: Fuel Meter Body O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

18. Remove and discard the O-ring seal from the fuel meter body.

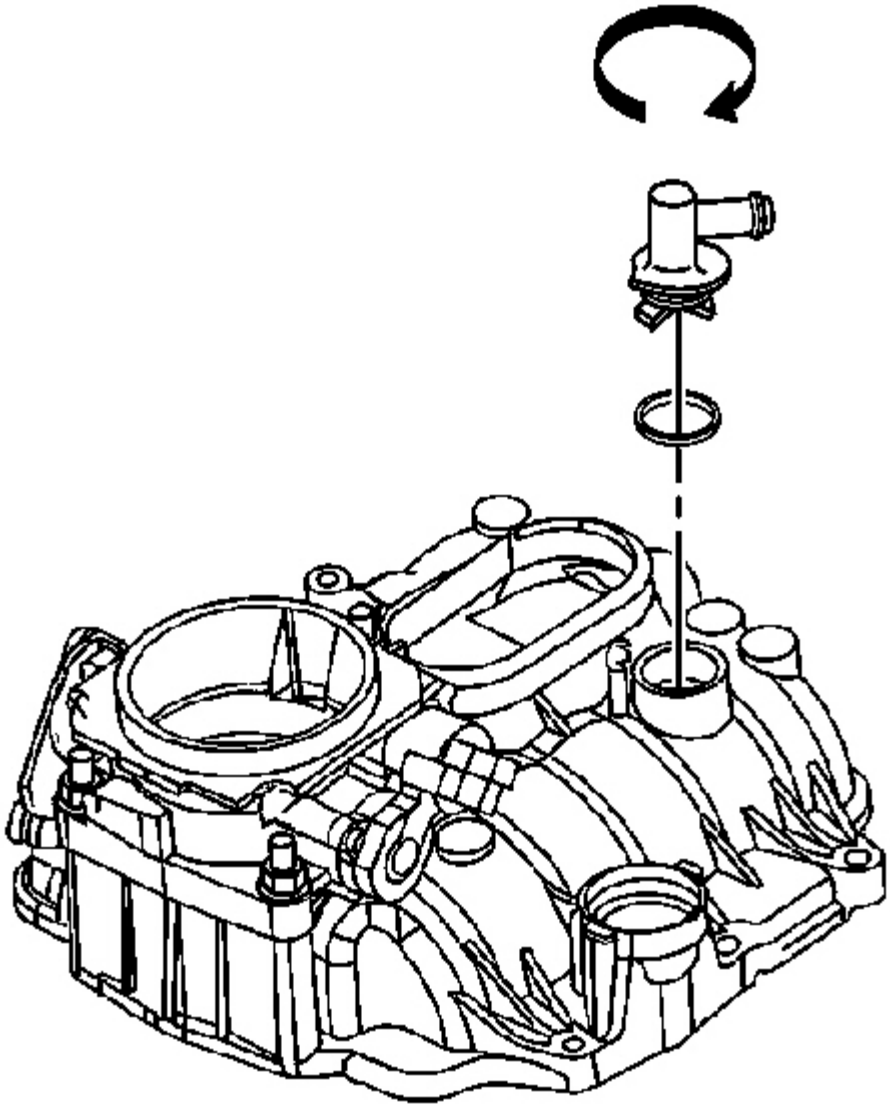


Fig. 55: Power Brake Booster Vacuum Fitting
Courtesy of GENERAL MOTORS CORP.

19. If required, remove the power brake booster vacuum fitting.
20. Remove and discard the O-ring seal.

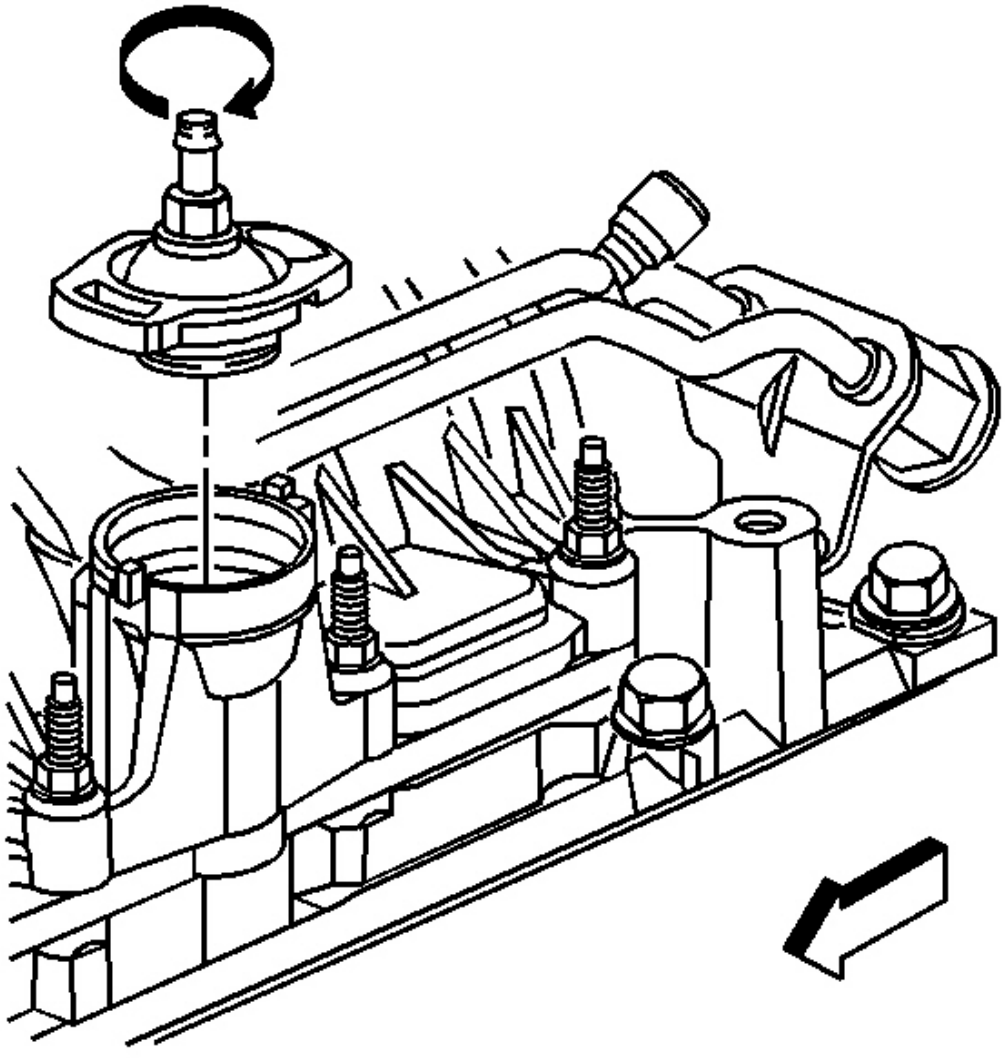


Fig. 56: PCV Valve Cover
Courtesy of GENERAL MOTORS CORP.

21. If required, remove the PCV valve cover.
22. Remove and discard the O-ring seal.

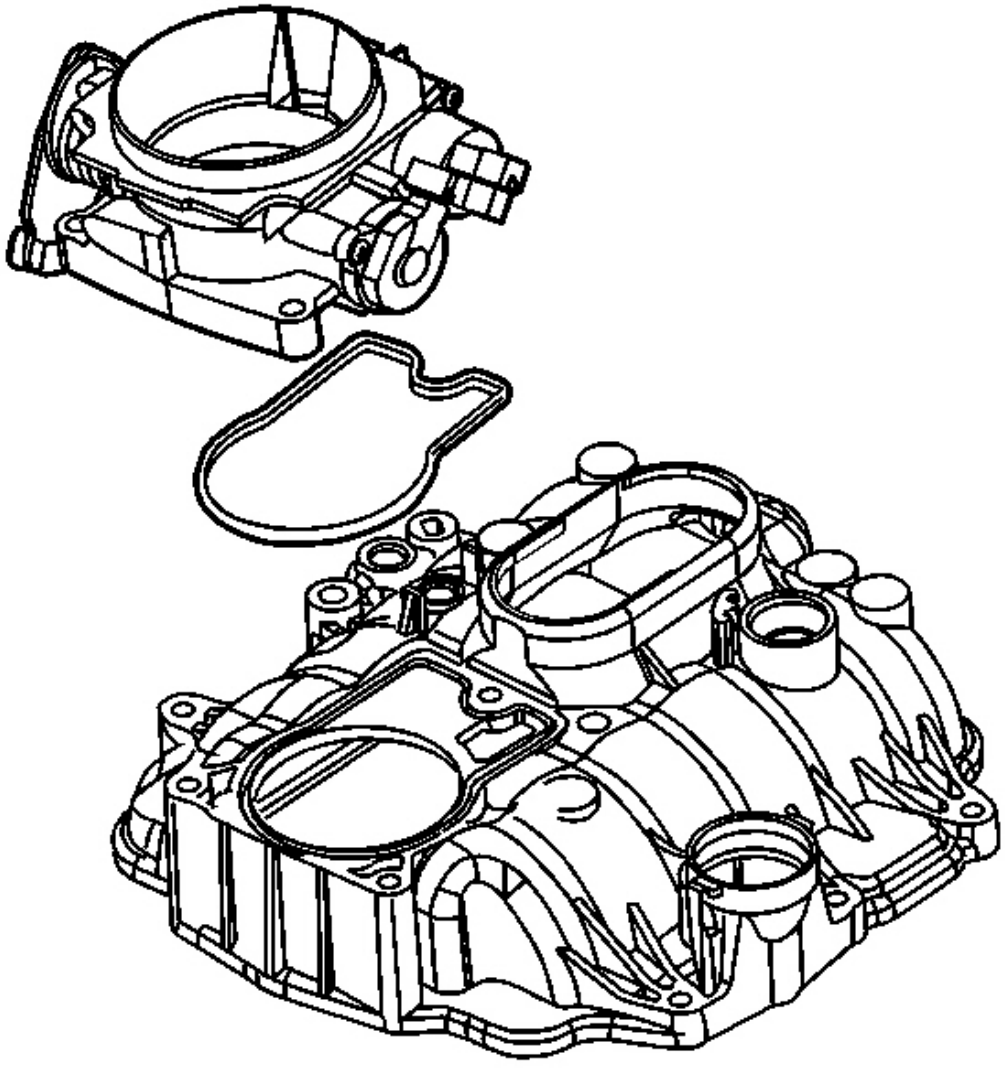


Fig. 57: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

23. If required, remove the rear throttle body stud.
24. Remove the throttle body.
25. Remove and discard the throttle body gasket.

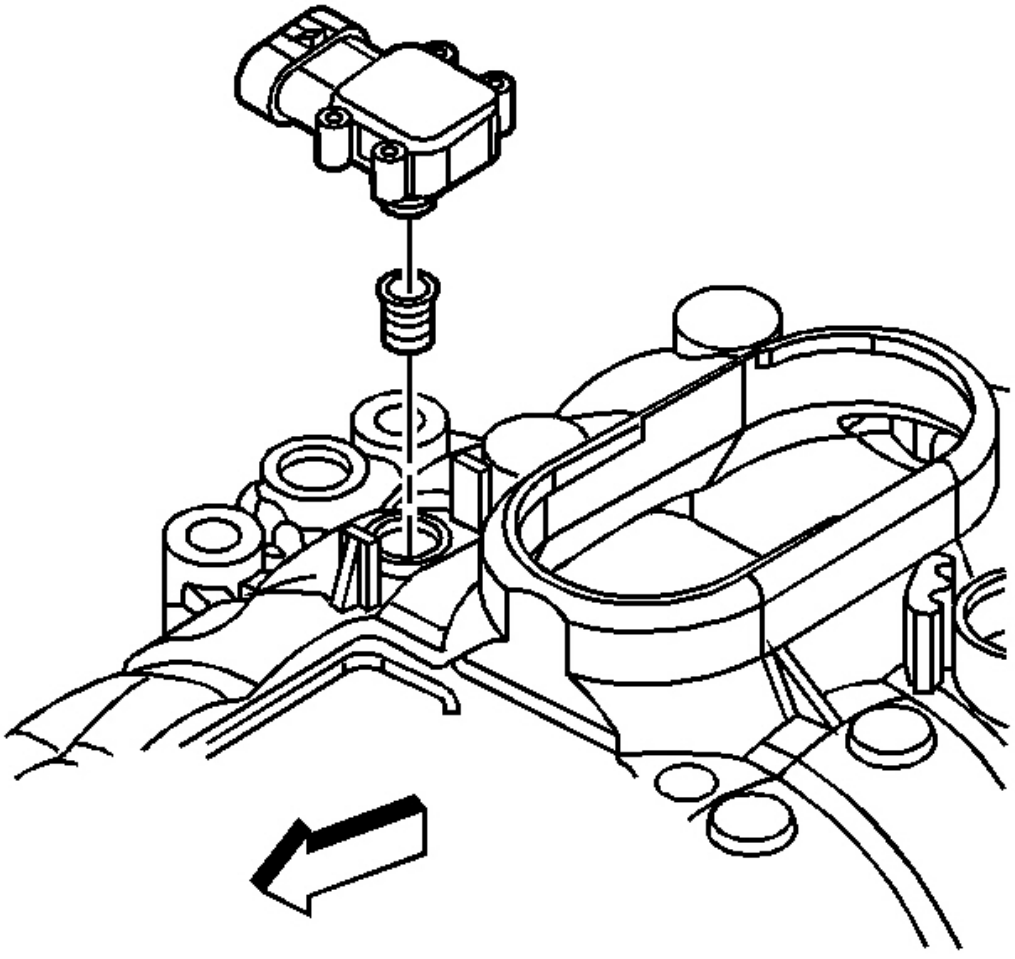


Fig. 58: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

26. If required, remove the MAP sensor.
27. Remove and discard the MAP sensor seal.

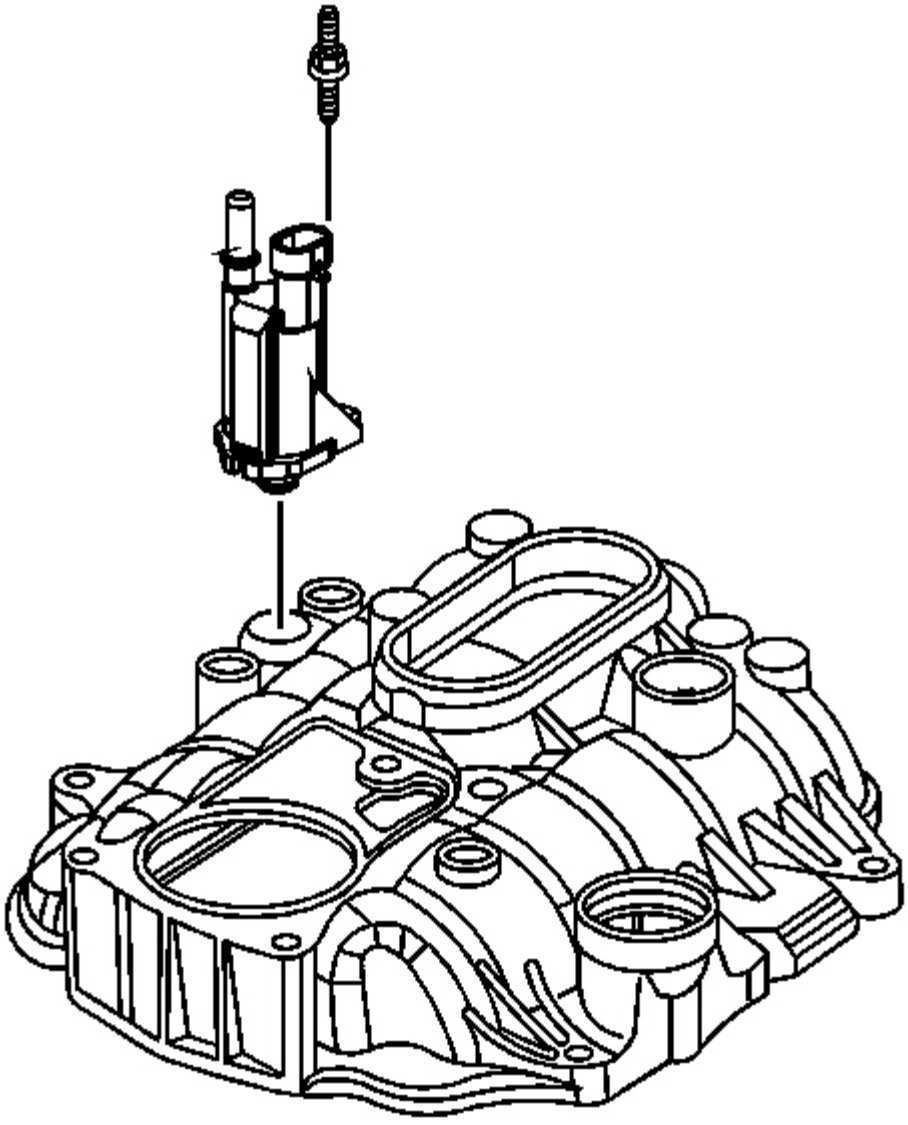


Fig. 59: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

28. If required, remove the EVAP canister purge solenoid valve studs.
29. Remove the purge solenoid valve.
30. Clean and inspect the intake manifold - upper, if necessary. Refer to **Intake Manifold**

Cleaning and Inspection.

Installation Procedure

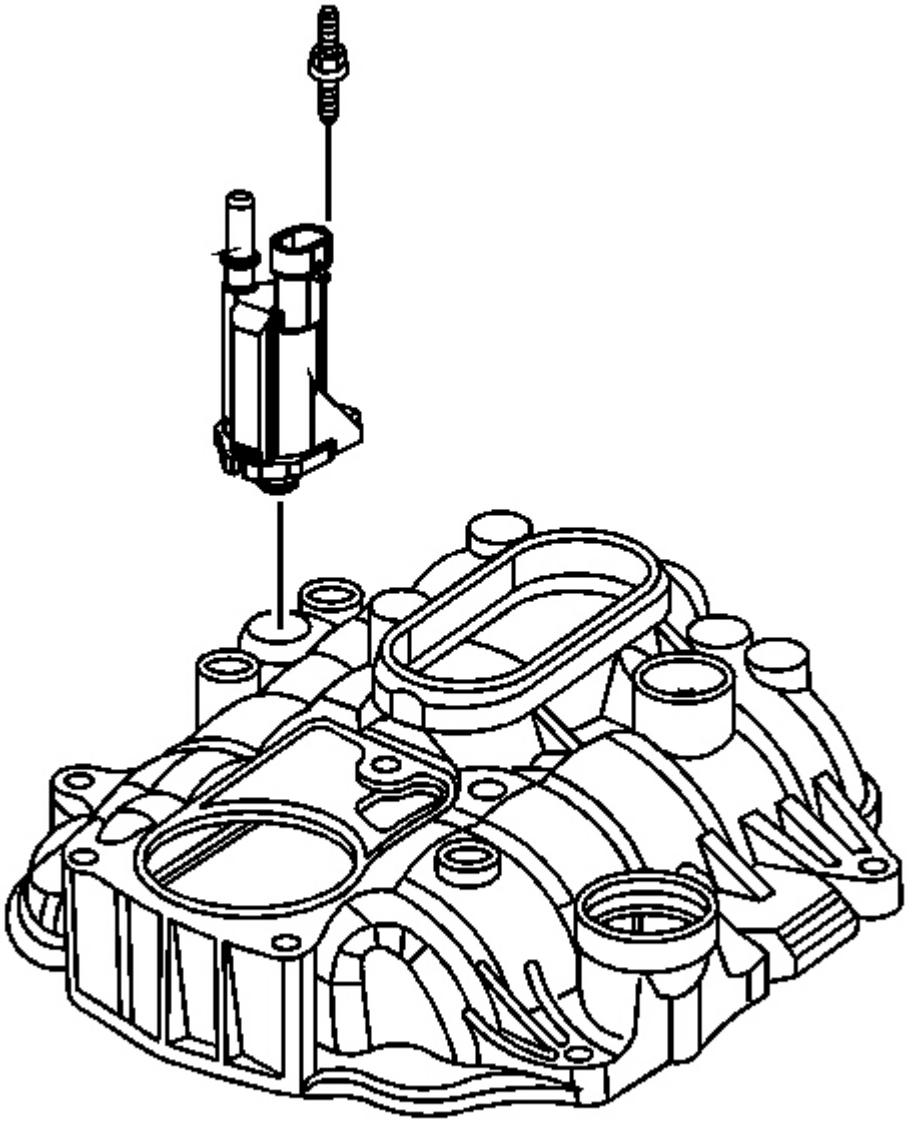


Fig. 60: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. If required, install the purge solenoid valve.
2. Install the EVAP canister purge solenoid valve studs. If reusing the old studs, apply threadlock to the threads. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

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

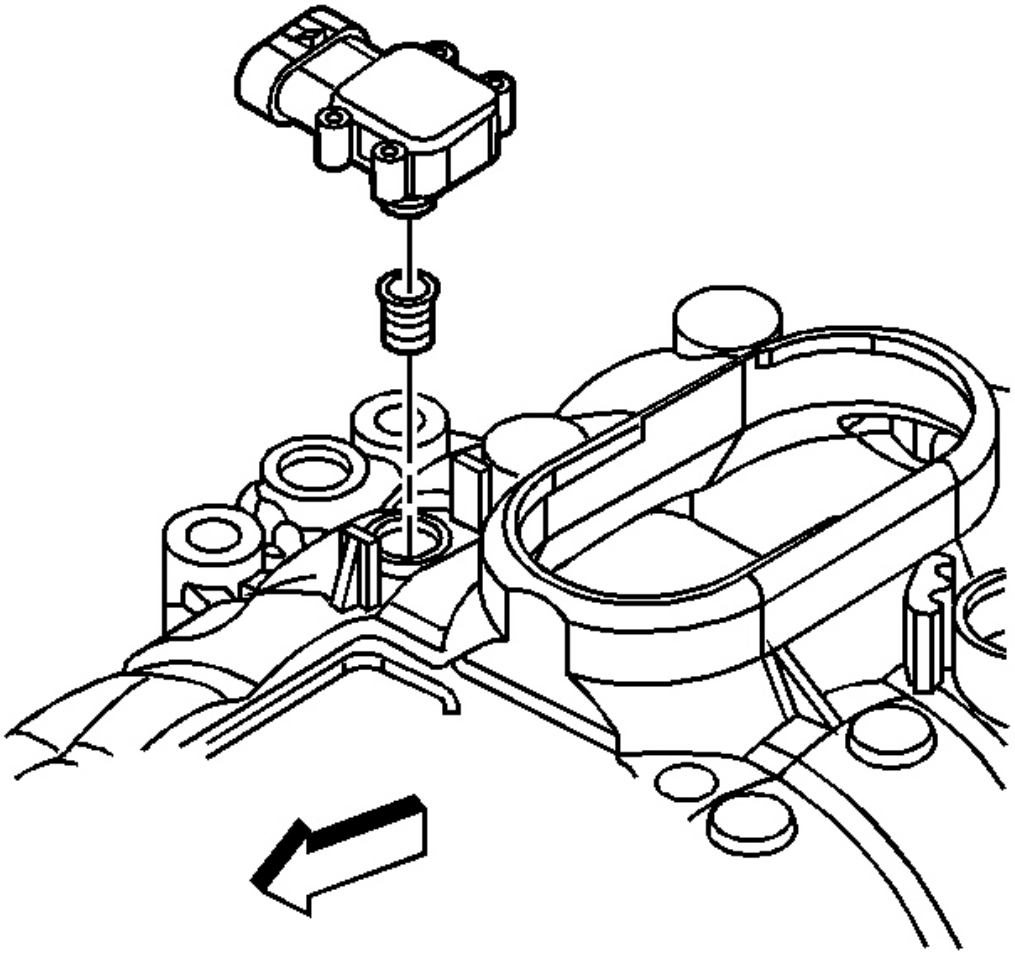


Fig. 61: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

3. If required, install a NEW MAP sensor seal. Apply a small drop of clean engine oil to the seal.
4. Install the MAP sensor.

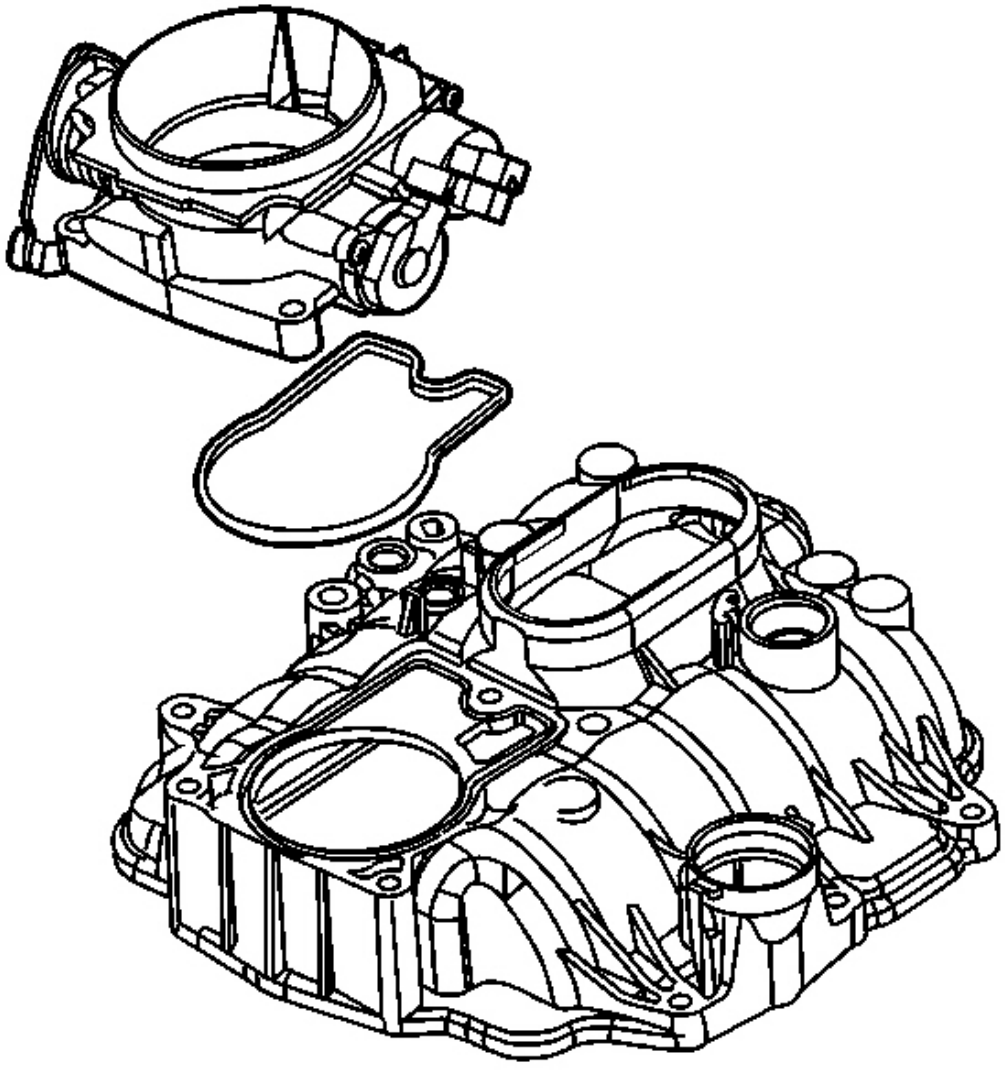


Fig. 62: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

5. If required, install a NEW throttle body gasket.

6. Install the throttle body.
7. Install the rear throttle body stud. If reusing the old stud, apply threadlock to the threads. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

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

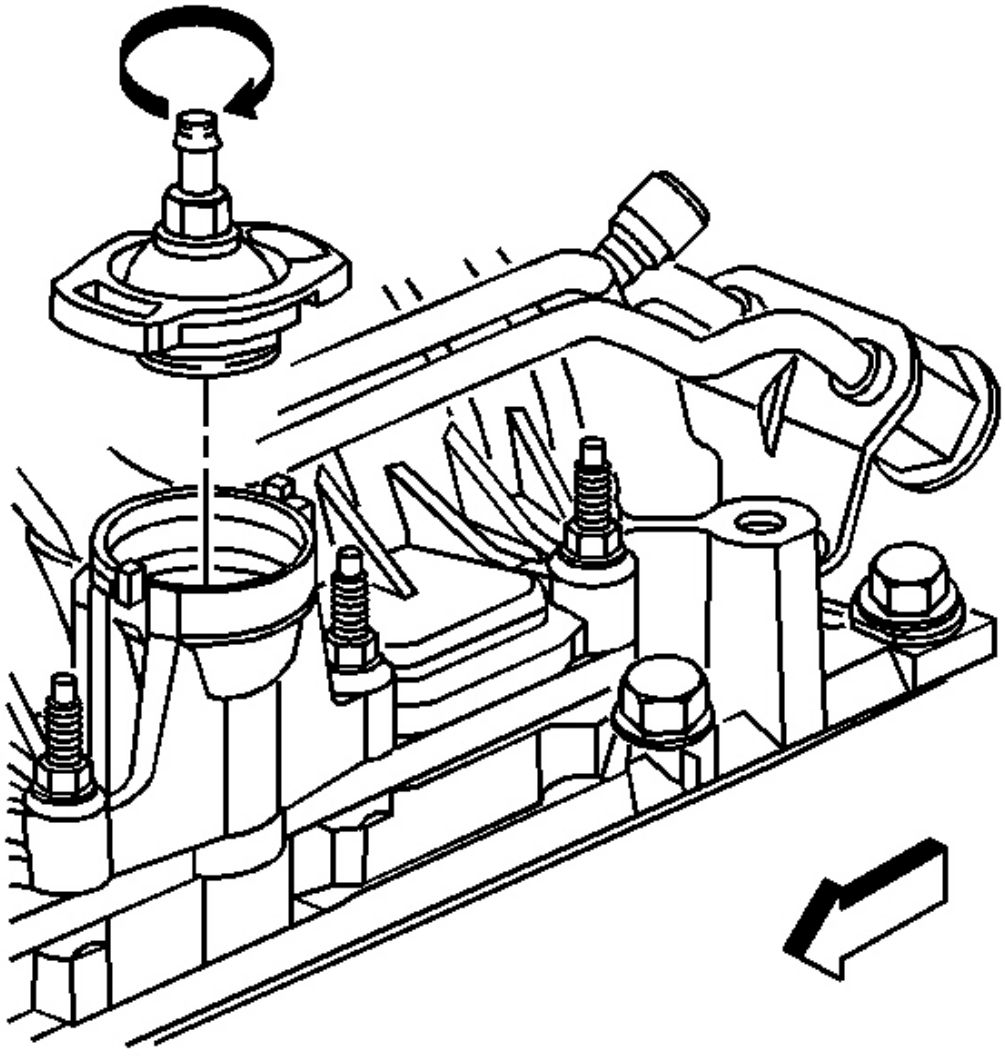


Fig. 63: PCV Valve Cover
Courtesy of GENERAL MOTORS CORP.

8. If required, install a NEW O-ring seal to the PCV cover. Apply clean engine oil to the seal.
9. Install the PCV valve cover.

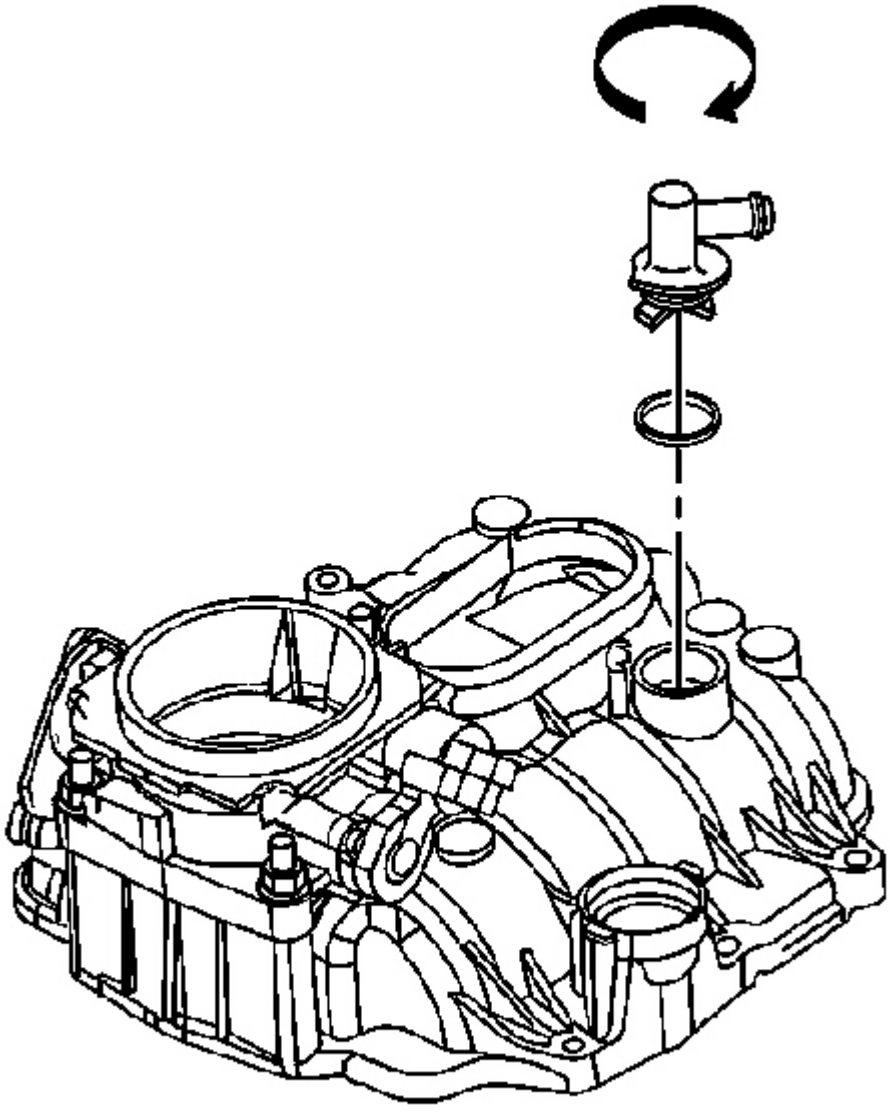


Fig. 64: Power Brake Booster Vacuum Fitting
Courtesy of GENERAL MOTORS CORP.

10. If required, install a NEW O-ring seal. Apply clean engine oil to the seal.
11. Install the power brake booster vacuum fitting.

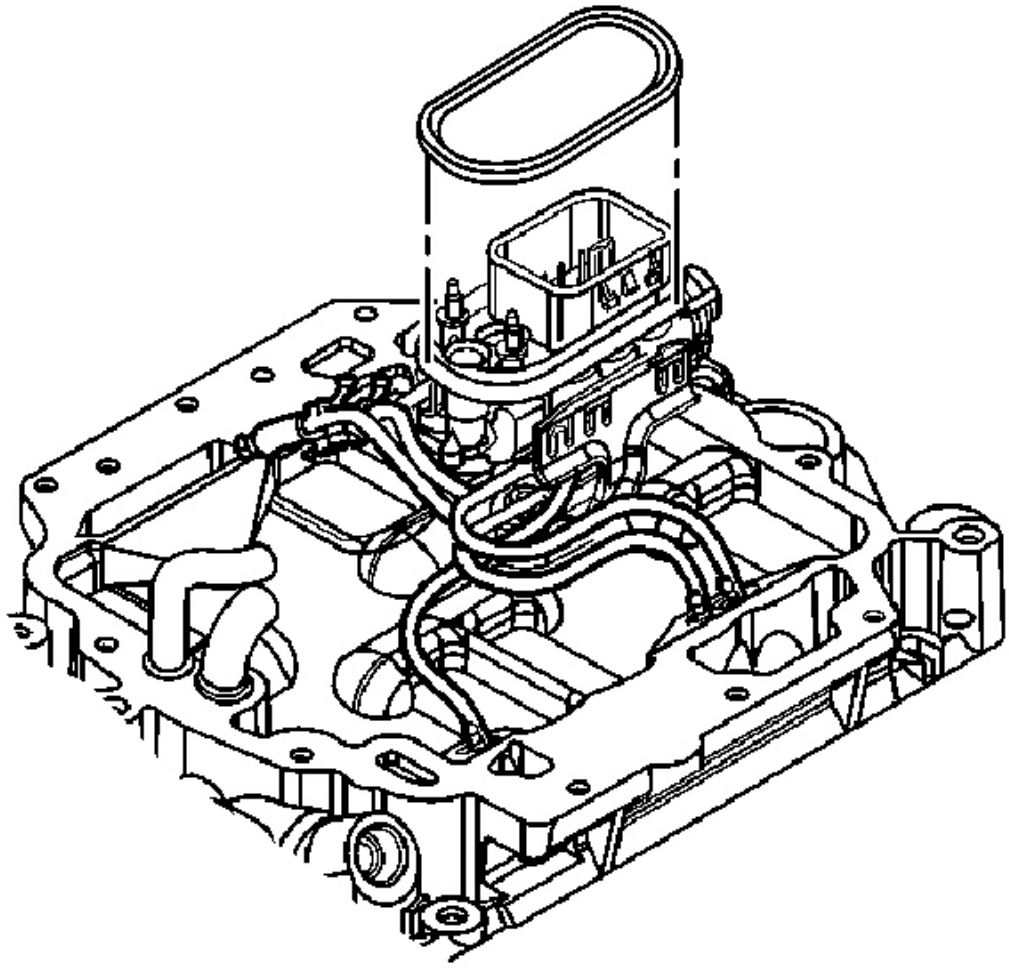


Fig. 65: Fuel Meter Body O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

12. Install a NEW O-ring seal to the fuel meter body.

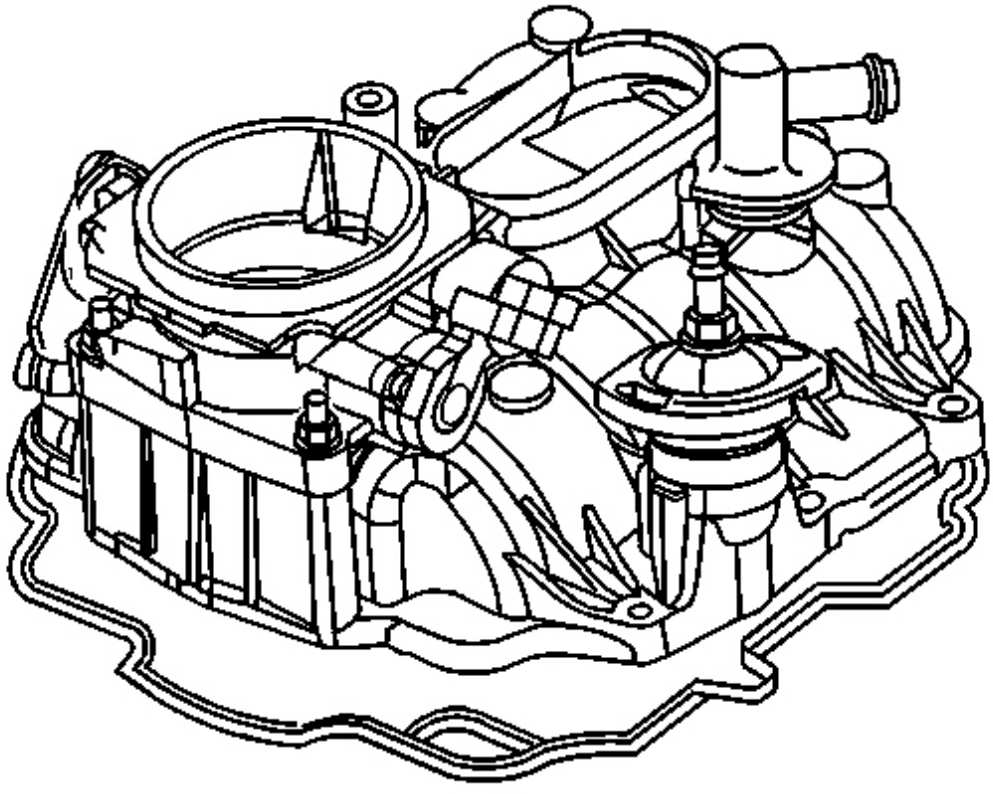


Fig. 66: Intake Manifold Upper Gasket
Courtesy of GENERAL MOTORS CORP.

13. Install a NEW upper intake manifold gasket.

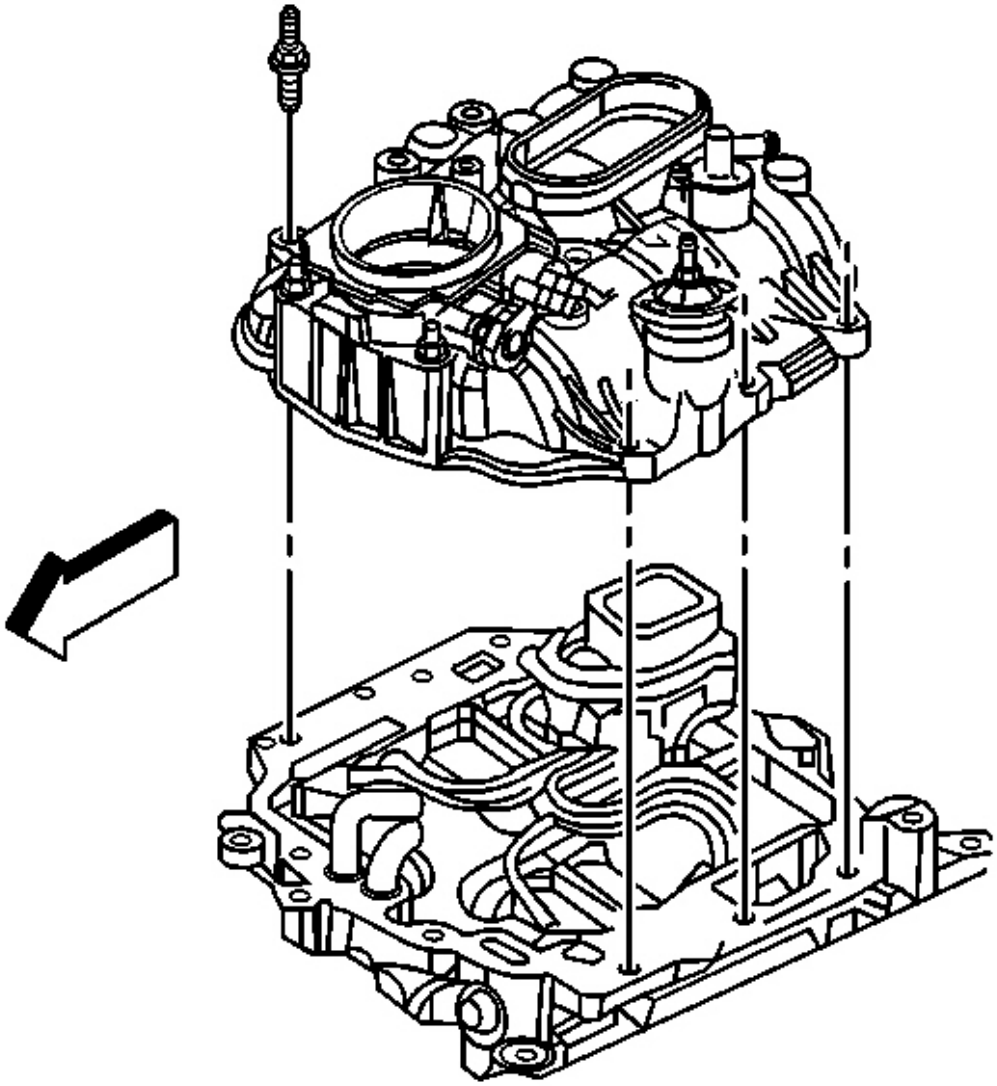


Fig. 67: Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

14. Install the intake manifold - upper.
15. If reusing the old throttle body/intake manifold studs, apply threadlock to the threads. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
16. Install the front two throttle body studs.

17. Install the intake manifold - upper studs.

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

18. Connect the power brake booster vacuum hose to the vacuum fitting.

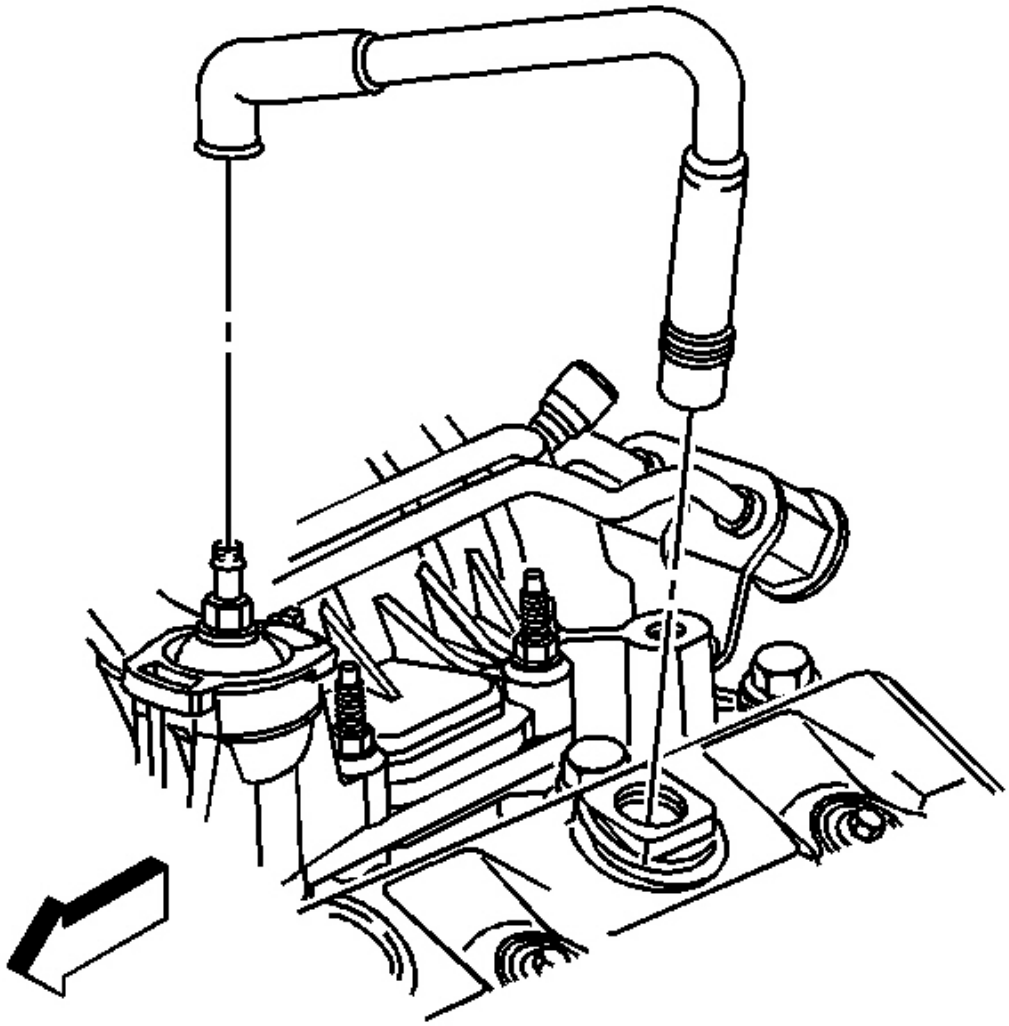


Fig. 68: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

19. Install the PCV valve hose to the valve cover and rocker cover.

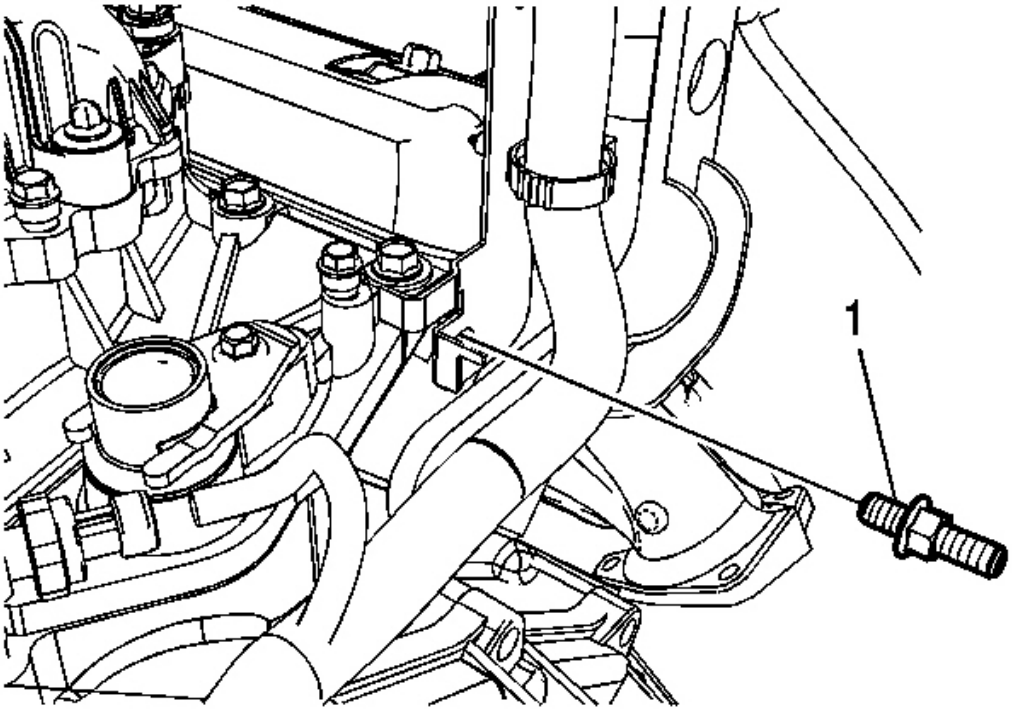


Fig. 69: Engine Wiring Harness Bracket Stud
Courtesy of GENERAL MOTORS CORP.

20. Position the engine wiring harness and bracket.
21. Install the engine wiring harness bracket stud (1).

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

22. Install the engine wiring harness rear bracket nut at the EVAP canister purge solenoid valve.

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

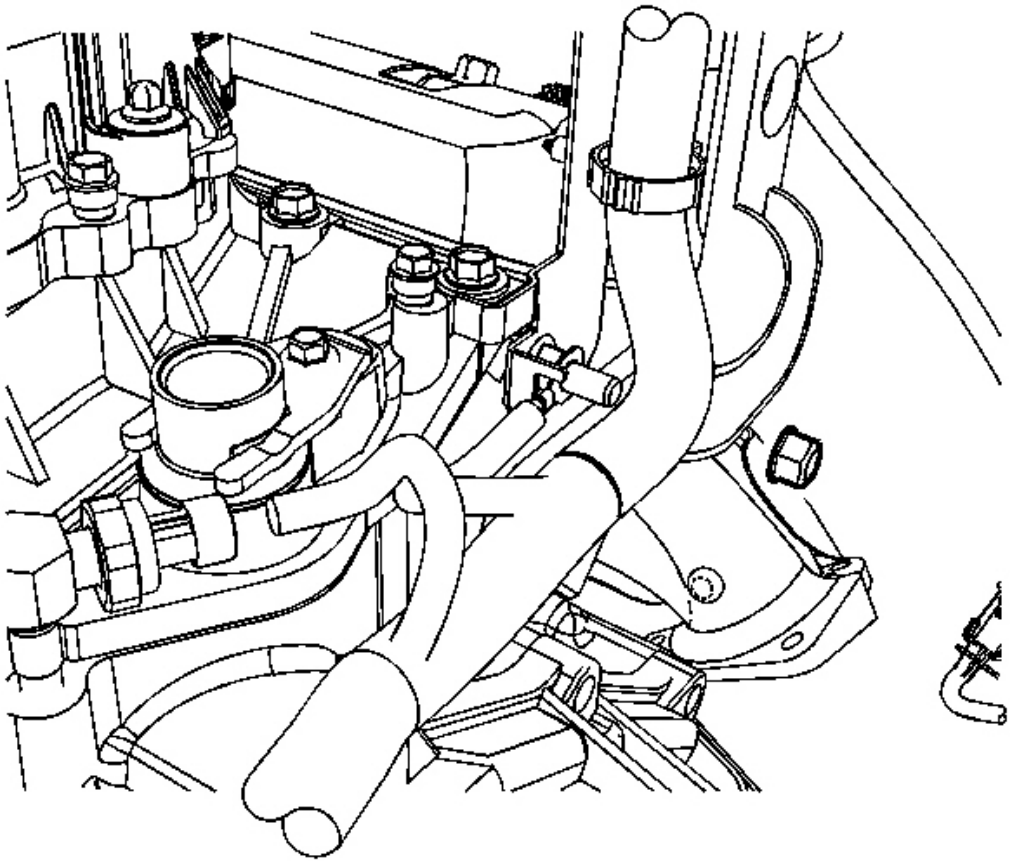


Fig. 70: Engine Wiring Harness Ground Nut
Courtesy of GENERAL MOTORS CORP.

23. Install the engine wiring harness ground nut and ground wire (1) to the rear of the right cylinder head.

    Tighten: Tighten the nut to 16 N.m (12 lb ft).

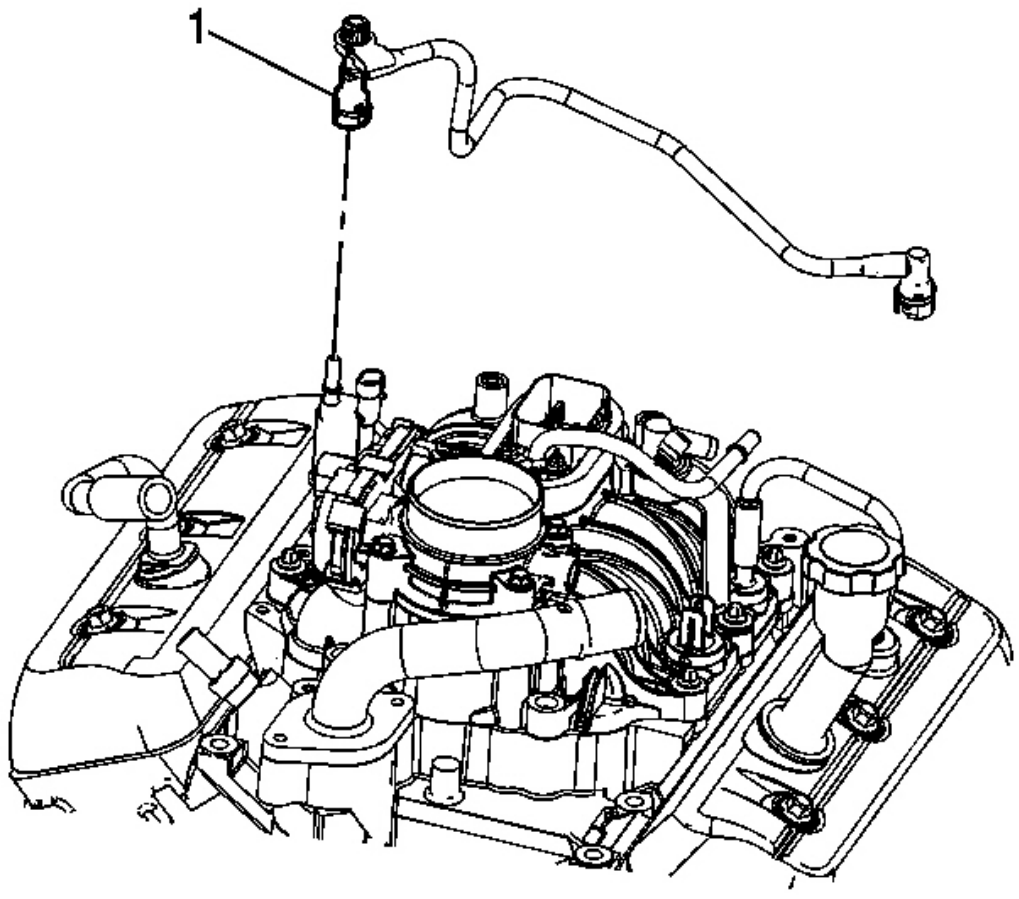


Fig. 71: View Of EVAP Canister Purge Solenoid Valve Tube Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

24. Position the EVAP canister purge solenoid tube, and connect the tube quick connect fitting (1) to the EVAP purge solenoid valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

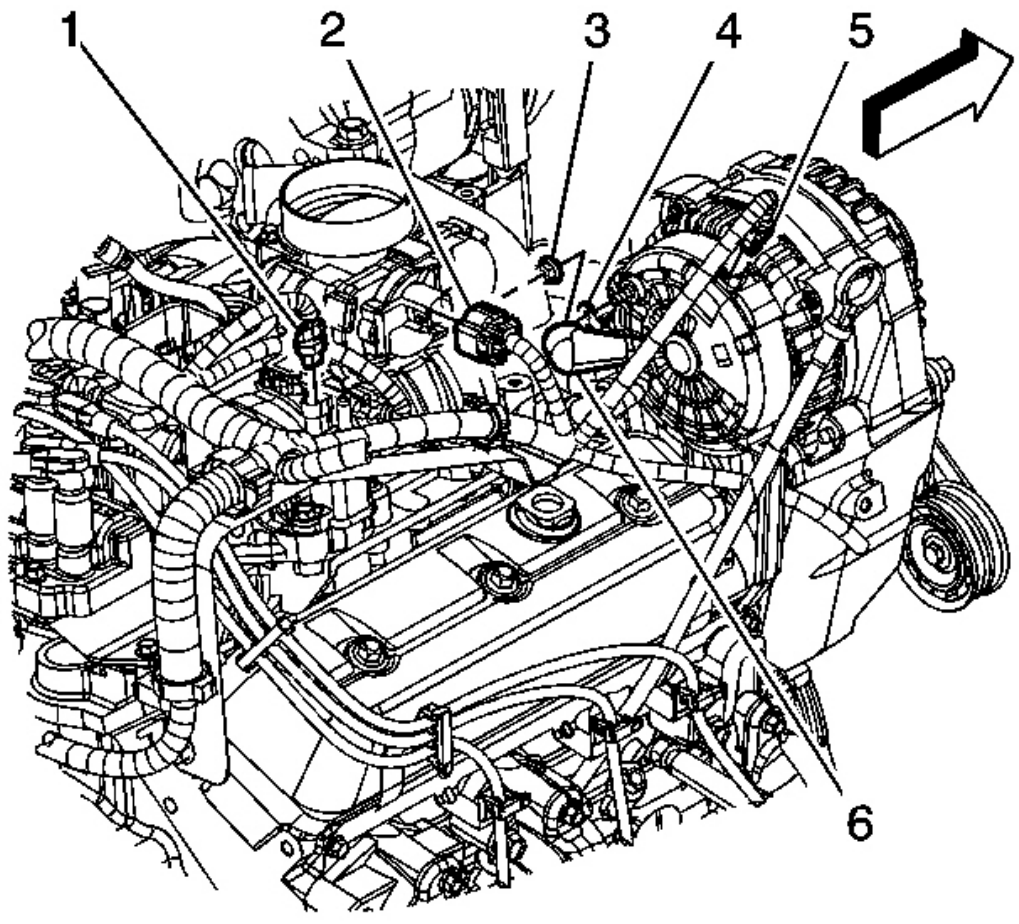


Fig. 72: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

25. Connect the following electrical connectors:
    - The EVAP canister purge solenoid valve (1)
    - The MAP sensor

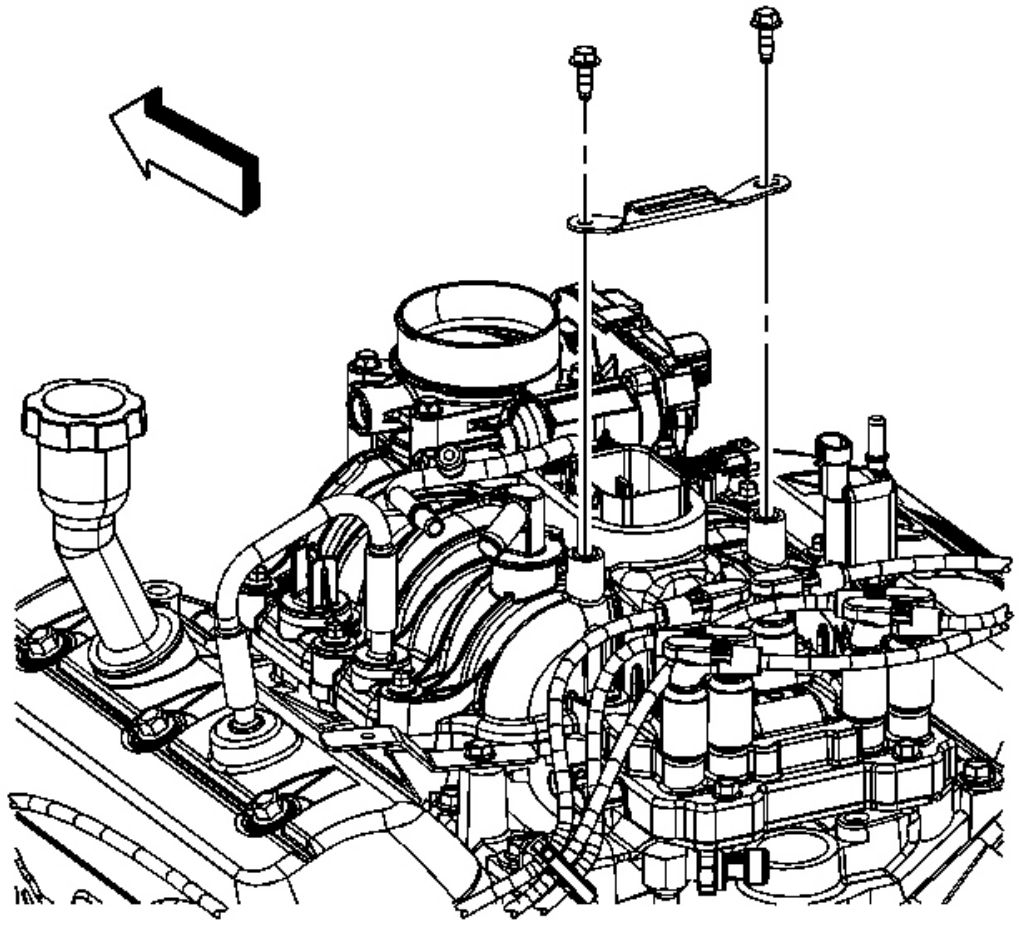


Fig. 73: View Of Engine Wiring Harness Rear Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

26. Place the engine wiring harness rear bracket onto the upper intake manifold and install the bolts.

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

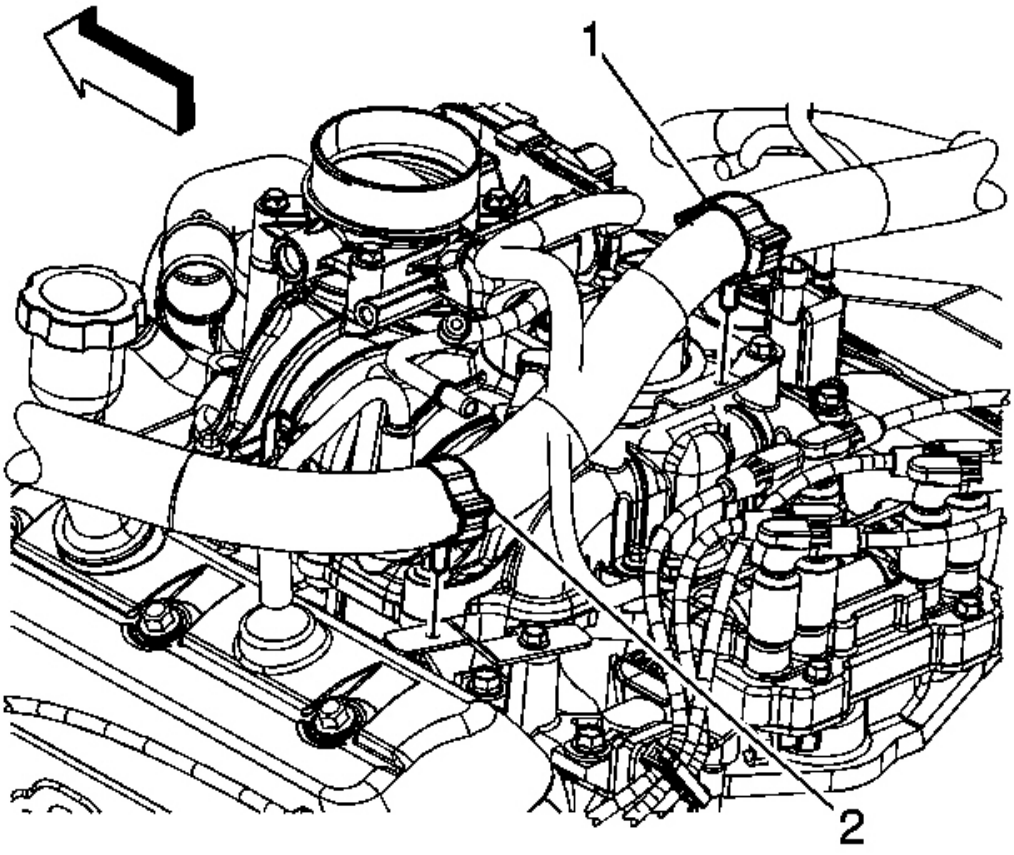


Fig. 74: View Of Engine Wiring Harness Clips
Courtesy of GENERAL MOTORS CORP.

27. Install the engine wiring harness clips (1, 2) to the engine harness brackets.

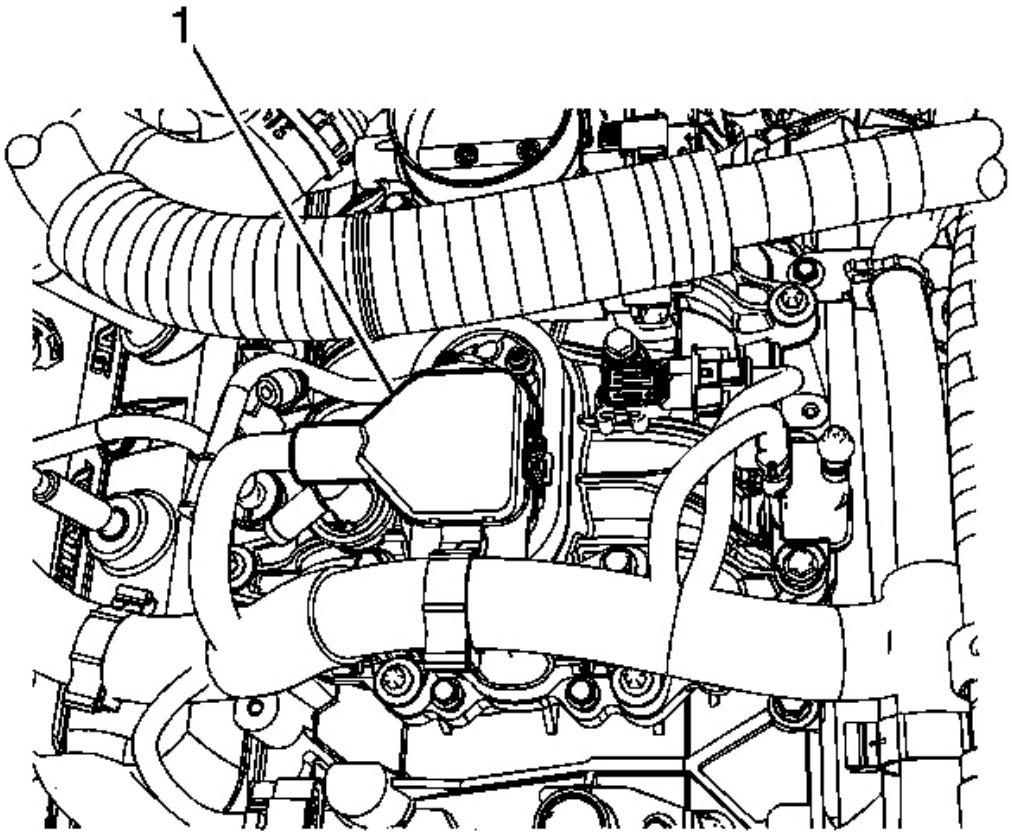


Fig. 75: Control Port Injector Module
Courtesy of GENERAL MOTORS CORP.

28. Connect the control port injector module (1).

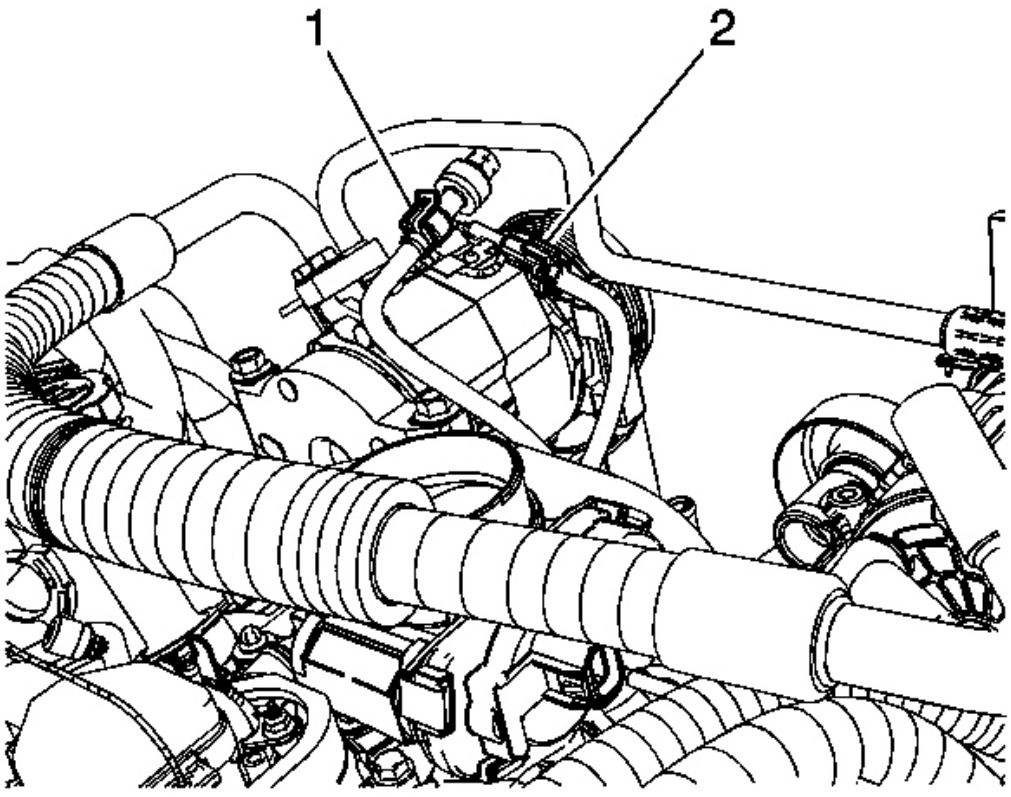


Fig. 76: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

29. Connect the following electrical connectors:
    - The A/C compressor clutch (2), if equipped
    - The A/C pressure switch (1), if equipped
30. Install the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .

LOWER INTAKE MANIFOLD REPLACEMENT

Removal Procedure

IMPORTANT:
- **The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless**

component service is required.

- **It is not necessary to remove the upper intake manifold in order to remove the lower intake manifold.**
- **Do not allow dirt or debris to enter the fuel system. Ensure that the ends of the fuel system are properly sealed.**
- **Do not disassemble the central sequential fuel injection (SFI) unit, unless service is required.**

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or **Cooling System Draining and Filling (Static Fill)** .
2. Remove the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
3. Remove the ignition coil assembly. Refer to **Ignition Coil Replacement** .
4. Remove the evaporative emission (EVAP) canister tube. Refer to **Evaporative Emission Hoses/Pipes Replacement - Engine** .

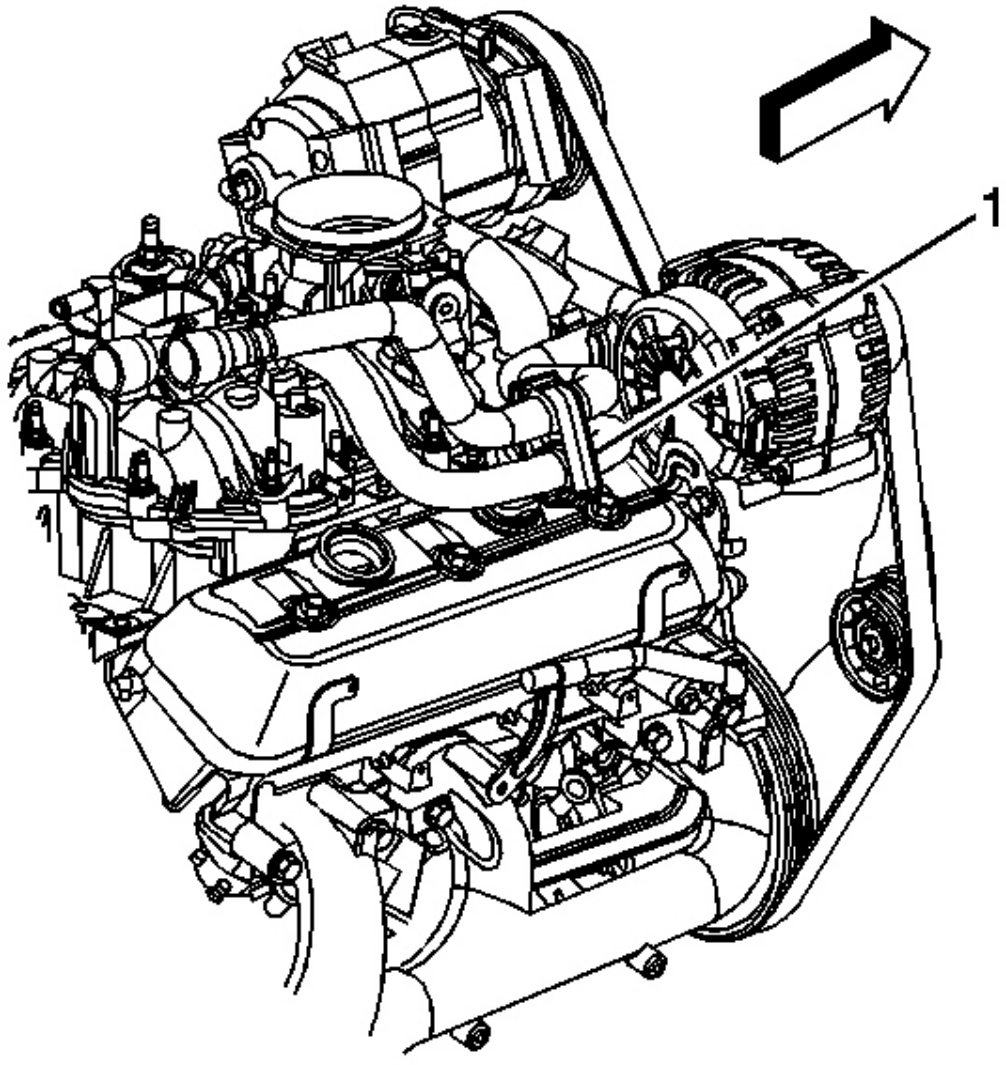


Fig. 77: Heater Hose Clamp
Courtesy of GENERAL MOTORS CORP.

5. Remove the heater hose clamp (1).

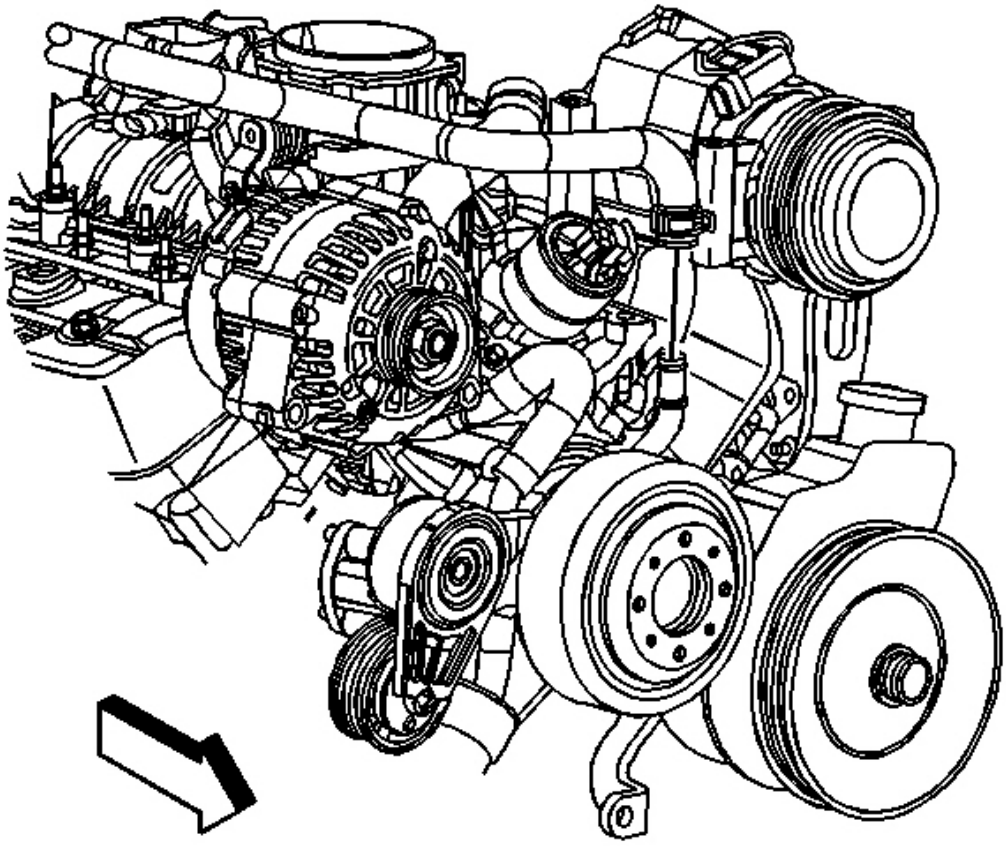


Fig. 78: Intake Manifold Hose
Courtesy of GENERAL MOTORS CORP.

6. Open the heater outlet hose clamp and remove the hose from the intake manifold.

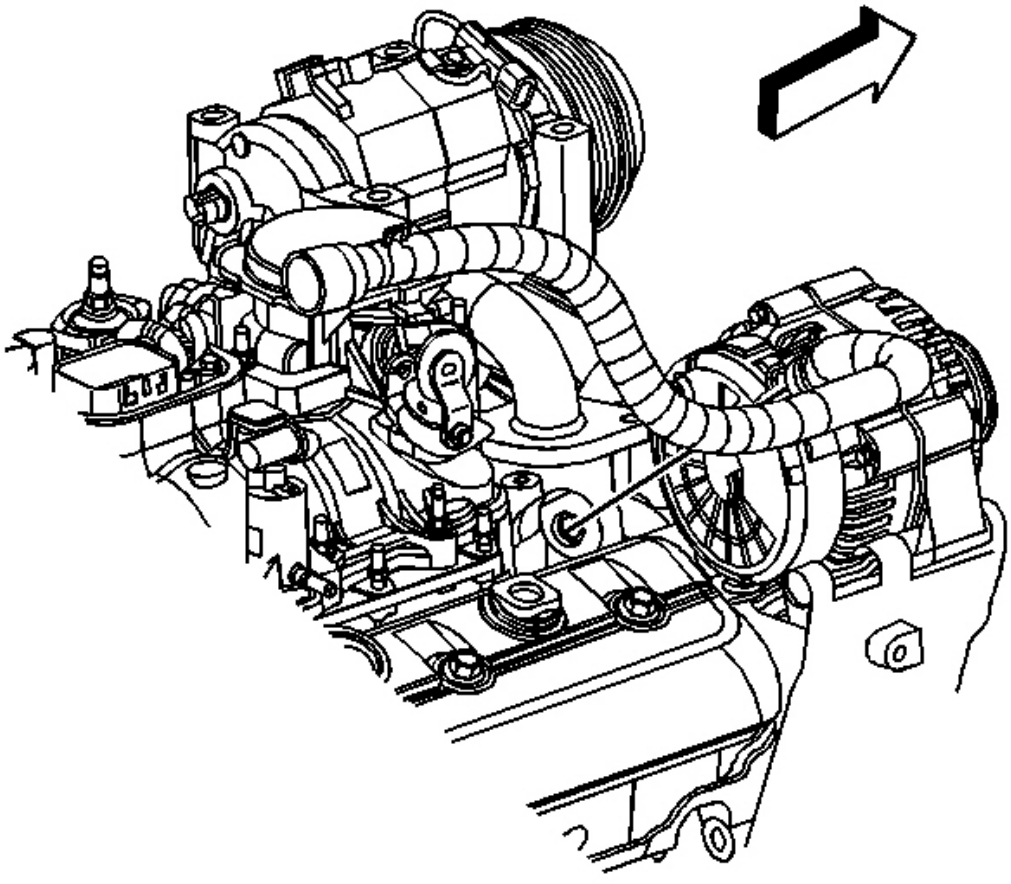


Fig. 79: Heater Inlet Hose At Water Pump
Courtesy of GENERAL MOTORS CORP.

7. Open the heater inlet hose clamp and remove the hose from the water pump.
8. Reposition the heater inlet and outlet hoses.

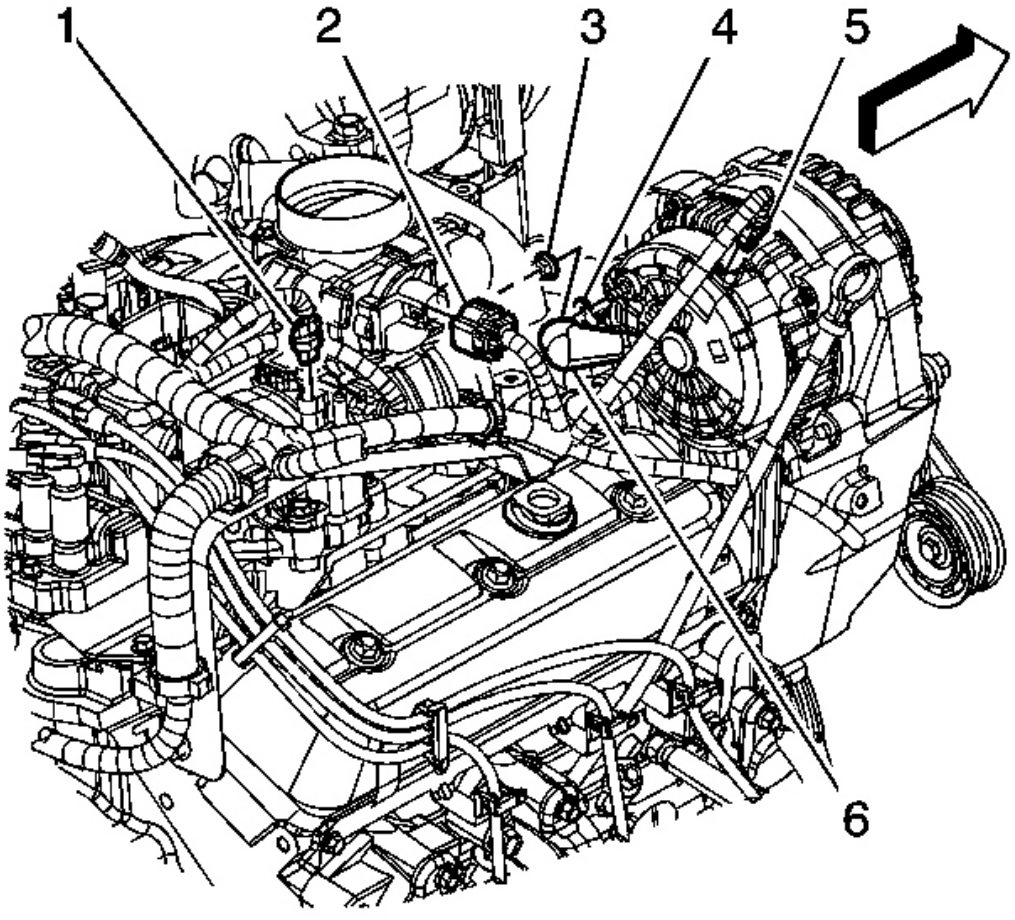


Fig. 80: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine wiring harness electrical connector (2) from the throttle body.

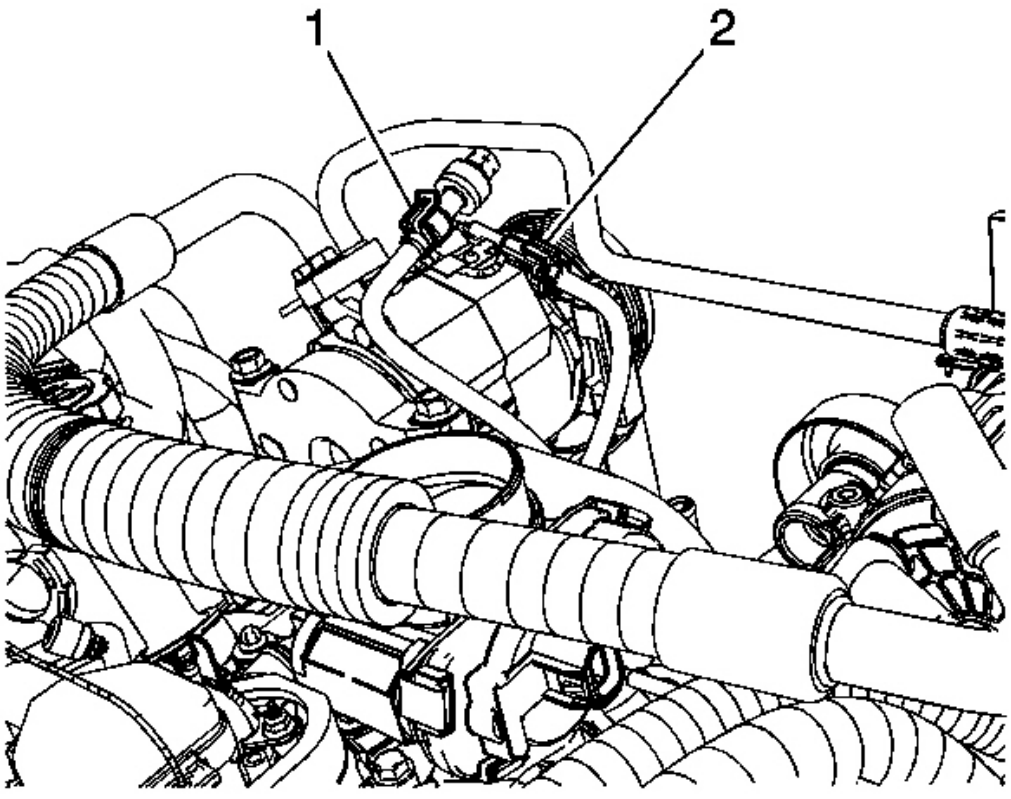


Fig. 81: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the following electrical connectors:
    - The A/C pressure switch (1), if equipped
    - The air conditioning (A/C) compressor clutch (2), if equipped

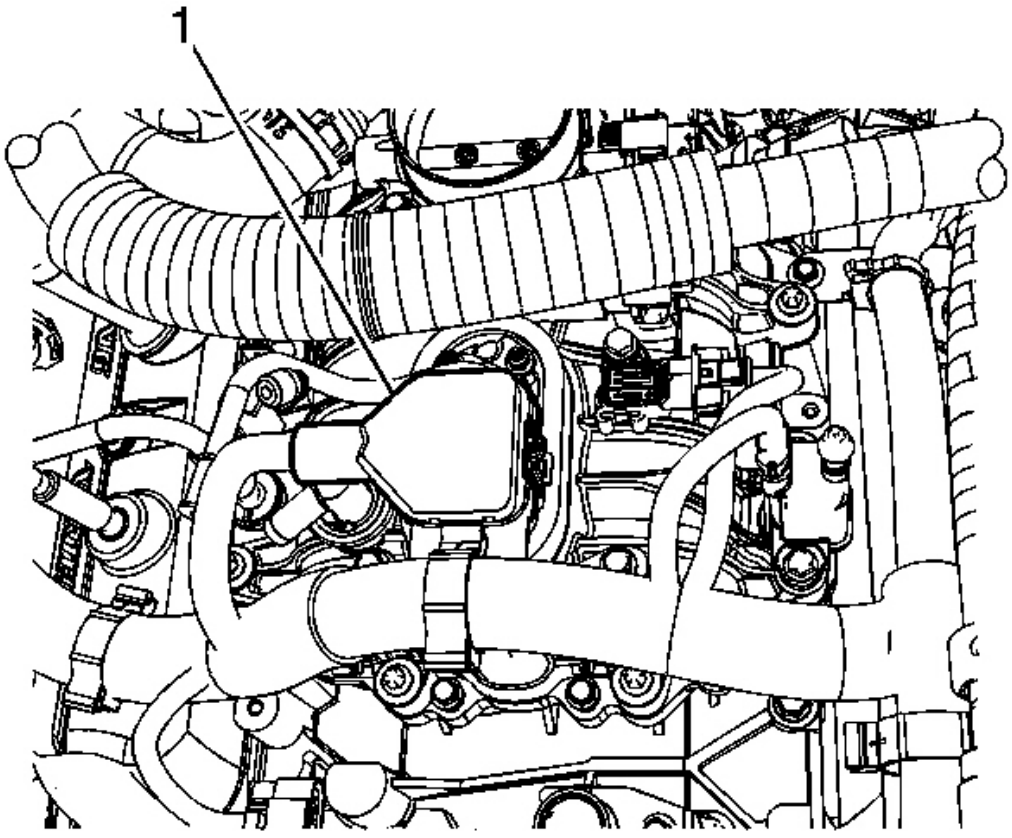


Fig. 82: Control Port Injector Module
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the control port injector module (1).

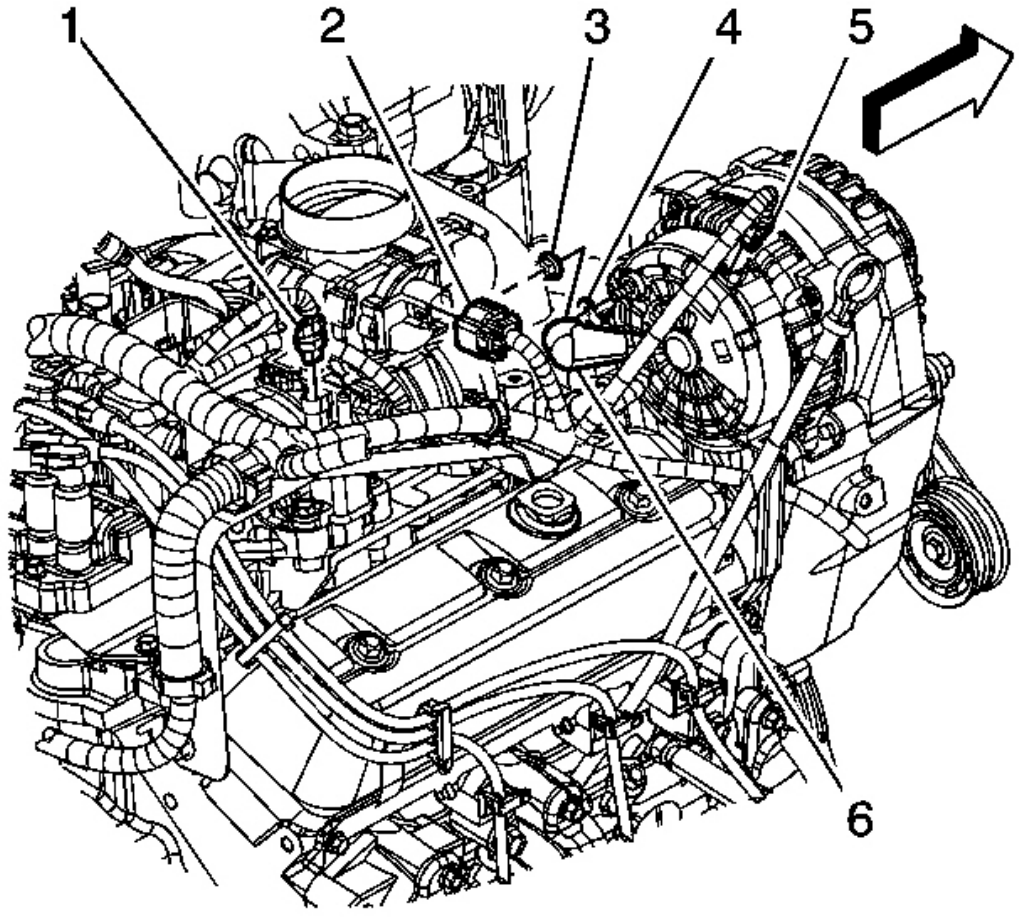


Fig. 83: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the following electrical connectors:
    - The EVAP canister purge solenoid valve (1)
    - The manifold absolute pressure (MAP) sensor

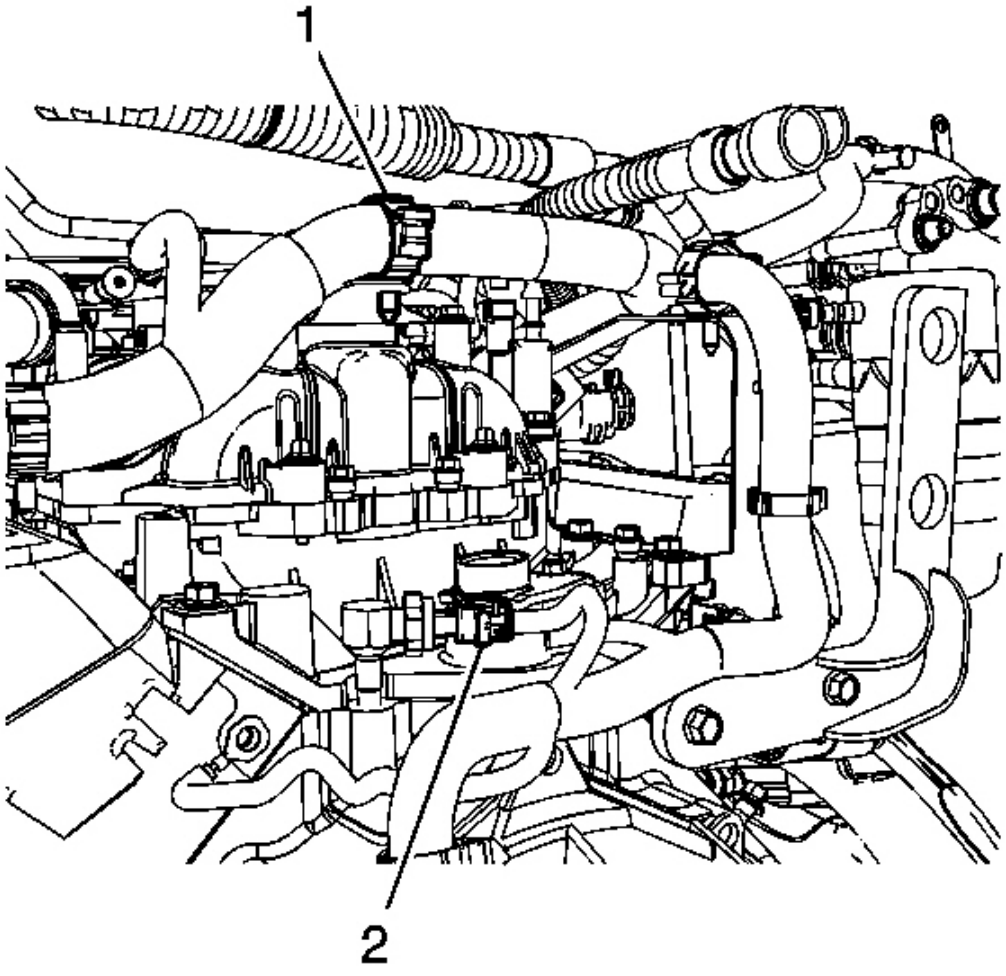


Fig. 84: Oil Pressure Sensor Electrical Connector & Clamp
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine harness clamp (1) from the bracket.
14. Disconnect the oil pressure sensor electrical connector (2).

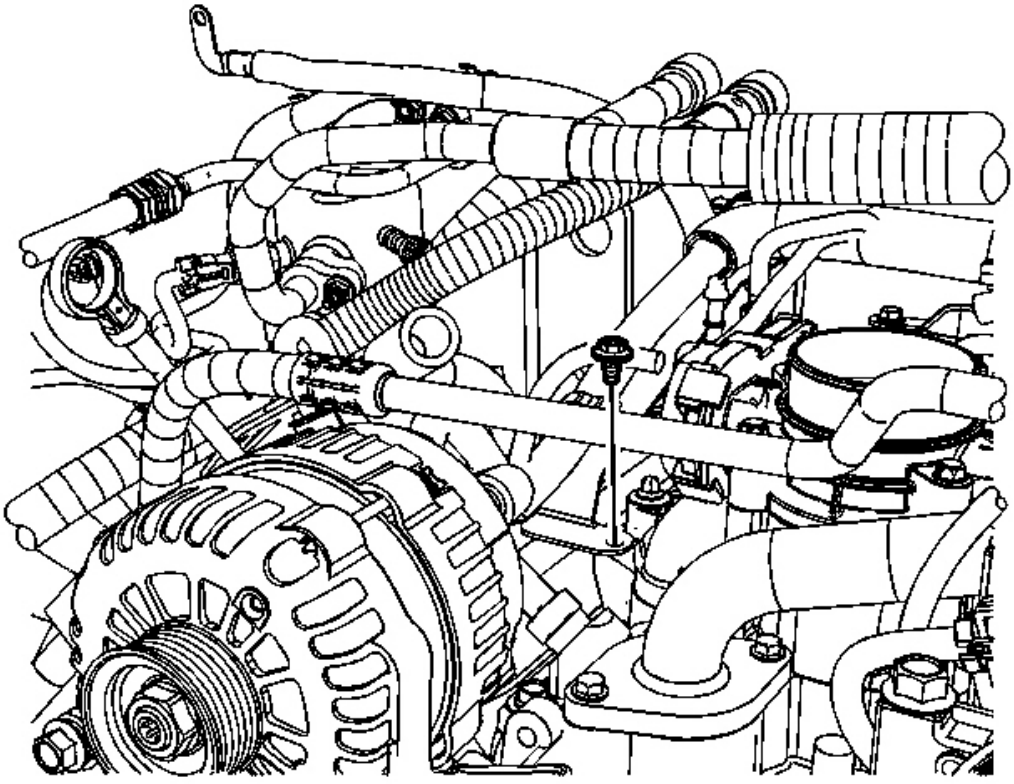


Fig. 85: Engine Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

15. Remove the engine wiring harness bracket bolt (1).

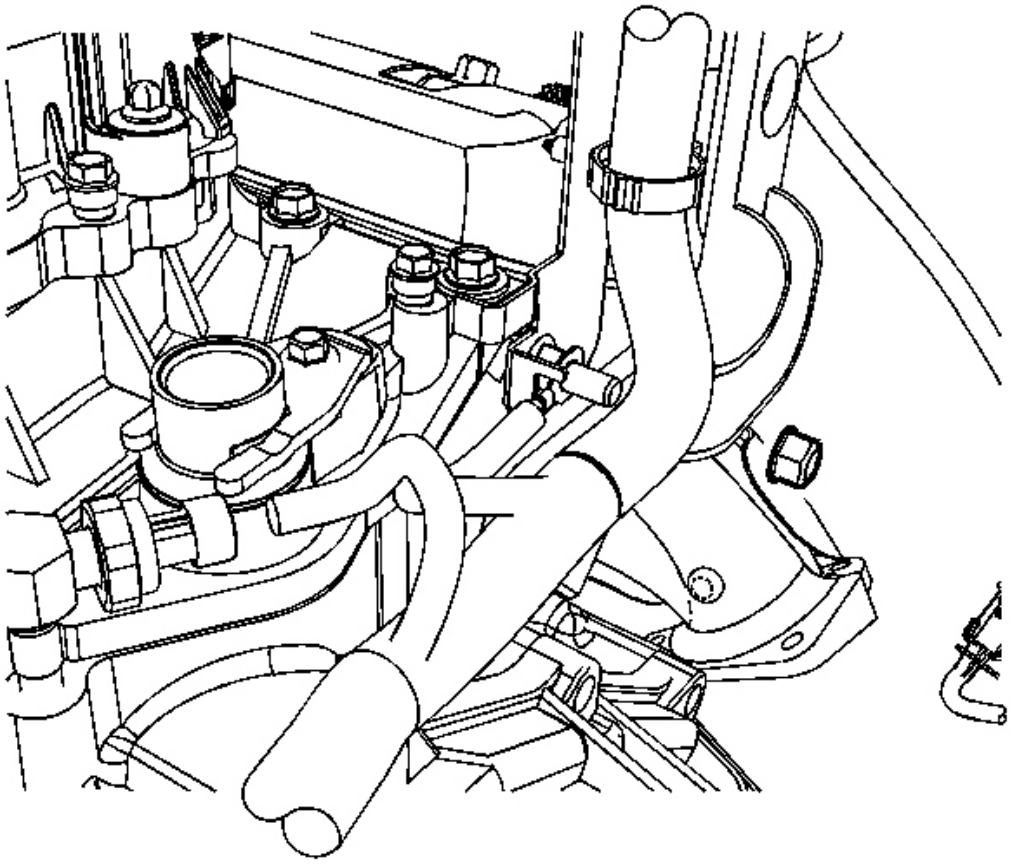


Fig. 86: Engine Wiring Harness Ground Nut
Courtesy of GENERAL MOTORS CORP.

16. Remove the engine wiring harness ground nut and ground wire (1) from the rear of the right cylinder head.

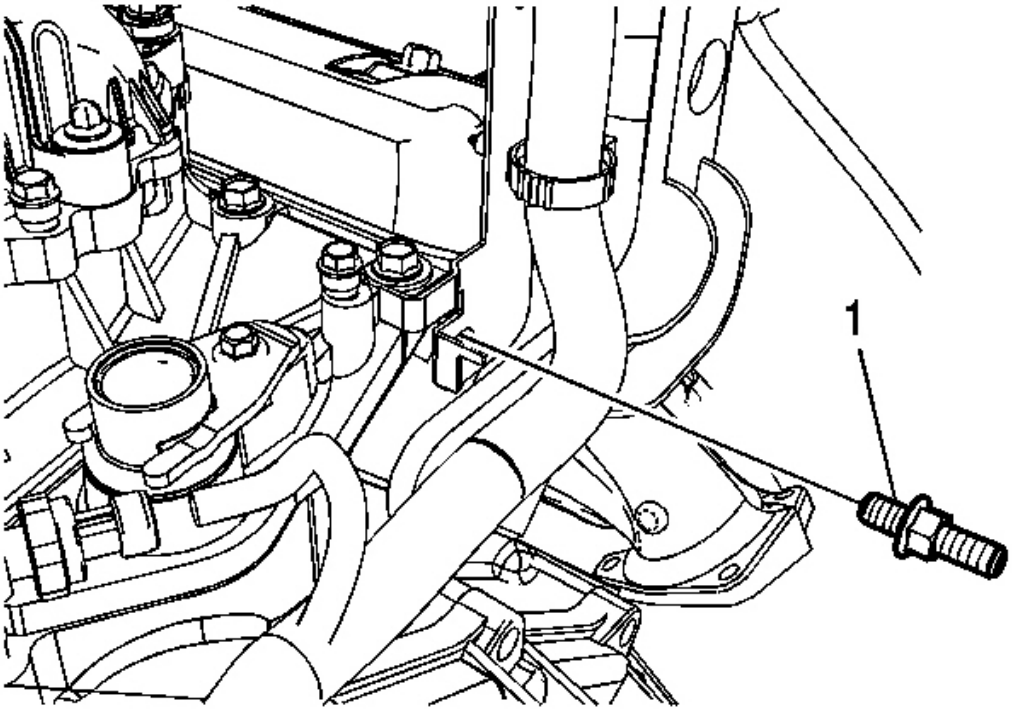


Fig. 87: Engine Wiring Harness Bracket Stud
Courtesy of GENERAL MOTORS CORP.

17. Remove the stud (1) holding the engine wiring harness bracket.
18. Reposition the engine wiring harness with the bracket aside.

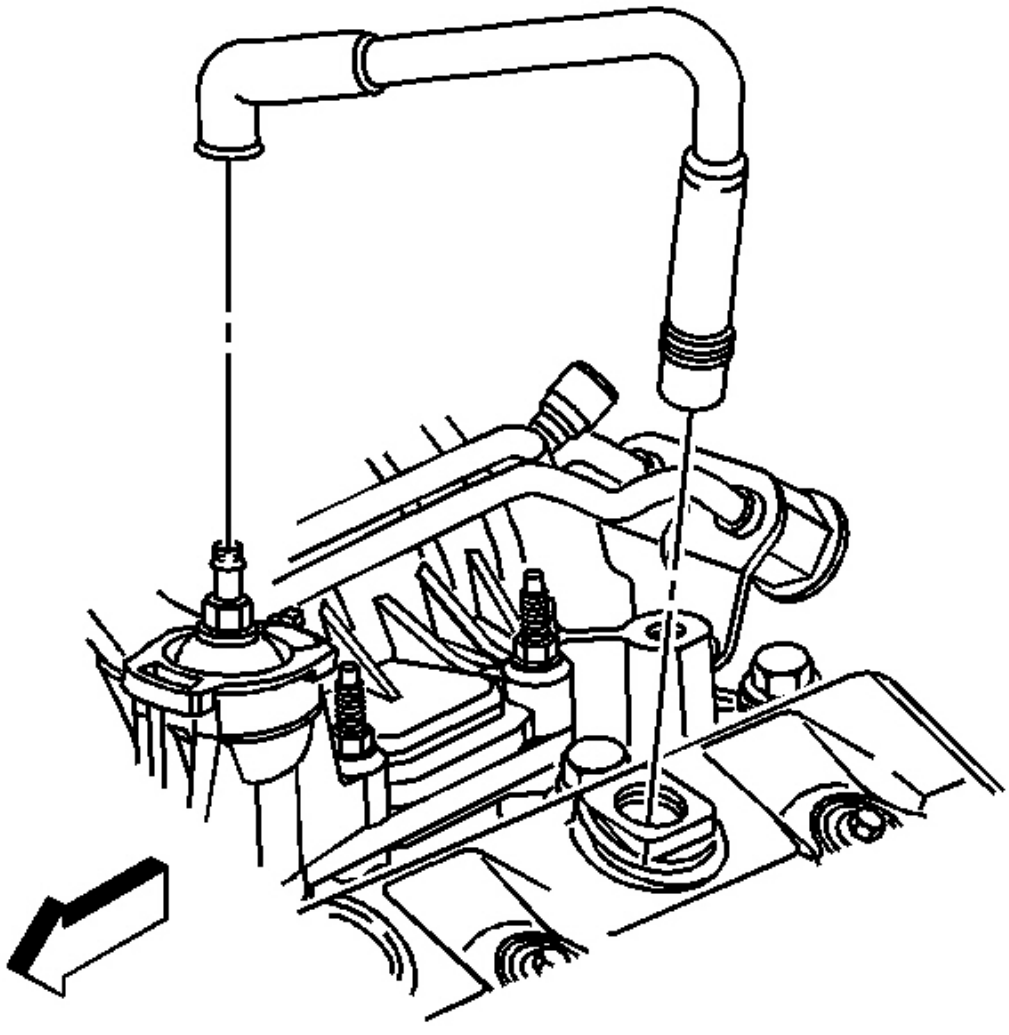


Fig. 88: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

19. Remove the positive crankcase ventilation (PCV) valve hose from the valve cover and rocker cover.
20. Disconnect the power brake booster vacuum hose from the vacuum fitting.

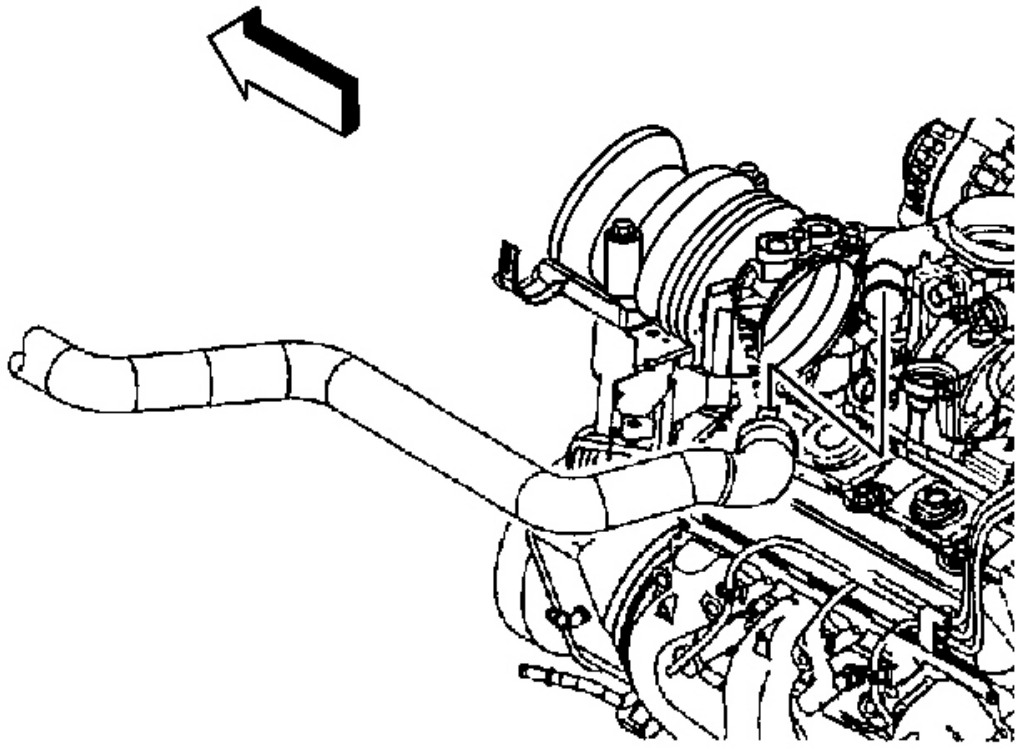


Fig. 89: View Of Radiator Inlet Hose, Clamps & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

21. Reposition the radiator inlet hose clamps.
22. Remove the radiator inlet hose from the thermostat housing.

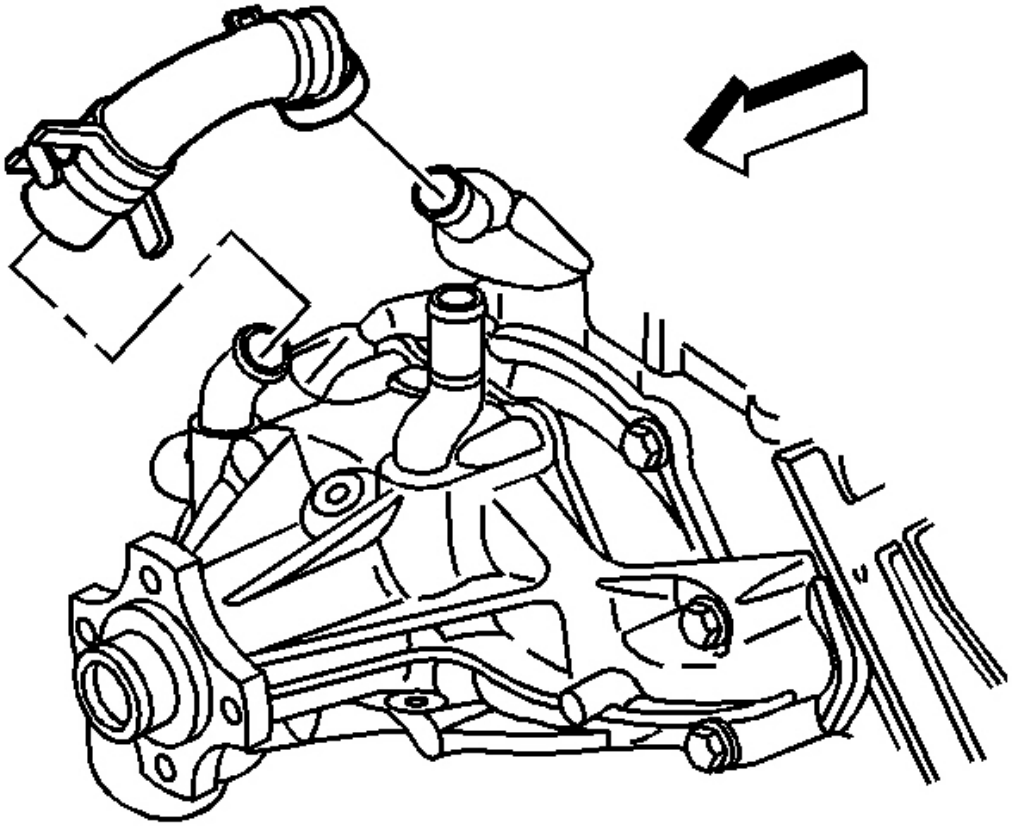


Fig. 90: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

23. Reposition the water pump inlet hose clamps.
24. Remove the water pump inlet hose.

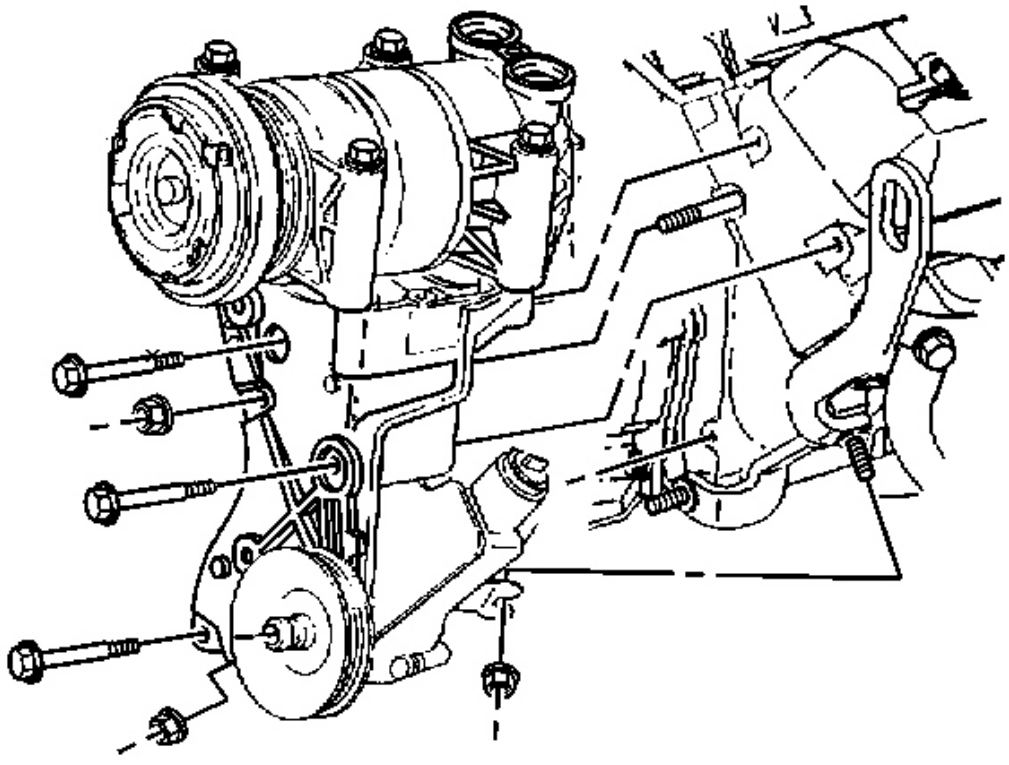


Fig. 91: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

25. In order to remove the front intake manifold bolt, perform the following:
    1. Remove the drive belt. Refer to **Drive Belt Replacement**.
    2. Loosen the power steering (P/S) pump rear bracket nut.
    3. Remove the P/S pump rear bracket front nut.
    4. Remove the bolts and the nut for the P/S pump bracket.
    5. Leave the A/C compressor, if equipped, and the P/S pump on the bracket.
    6. Slide the P/S pump bracket forward to access the front intake manifold bolt.

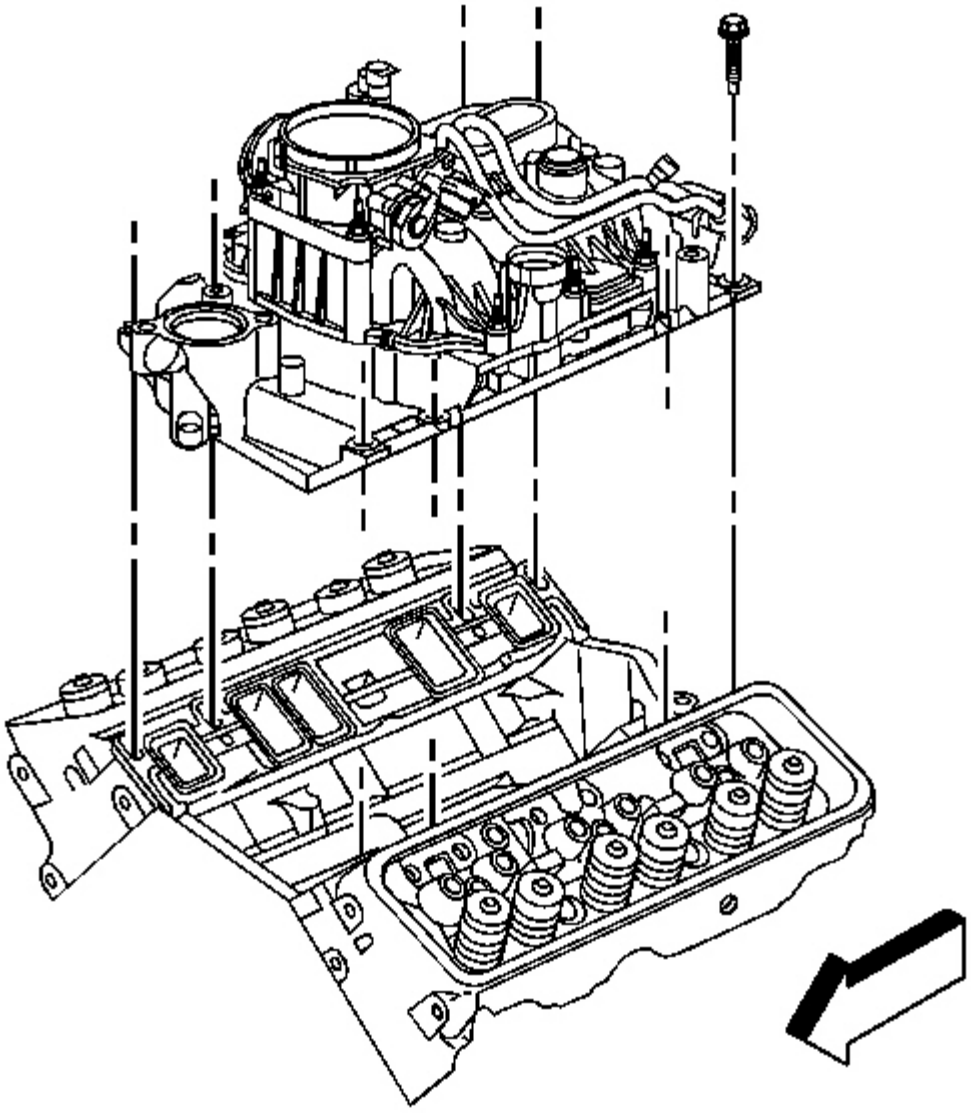


Fig. 92: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

26. Remove the intake manifold - lower bolts.
27. Remove the intake manifold.
28. Remove and discard the intake manifold gaskets.

29. Clean and inspect the intake manifold - lower, if necessary. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

NOTE: Apply the proper amount of the sealant when assembling this component. Excessive use of the sealant can prohibit the component from sealing properly. A component that is not sealed properly can leak leading to extensive engine damage.

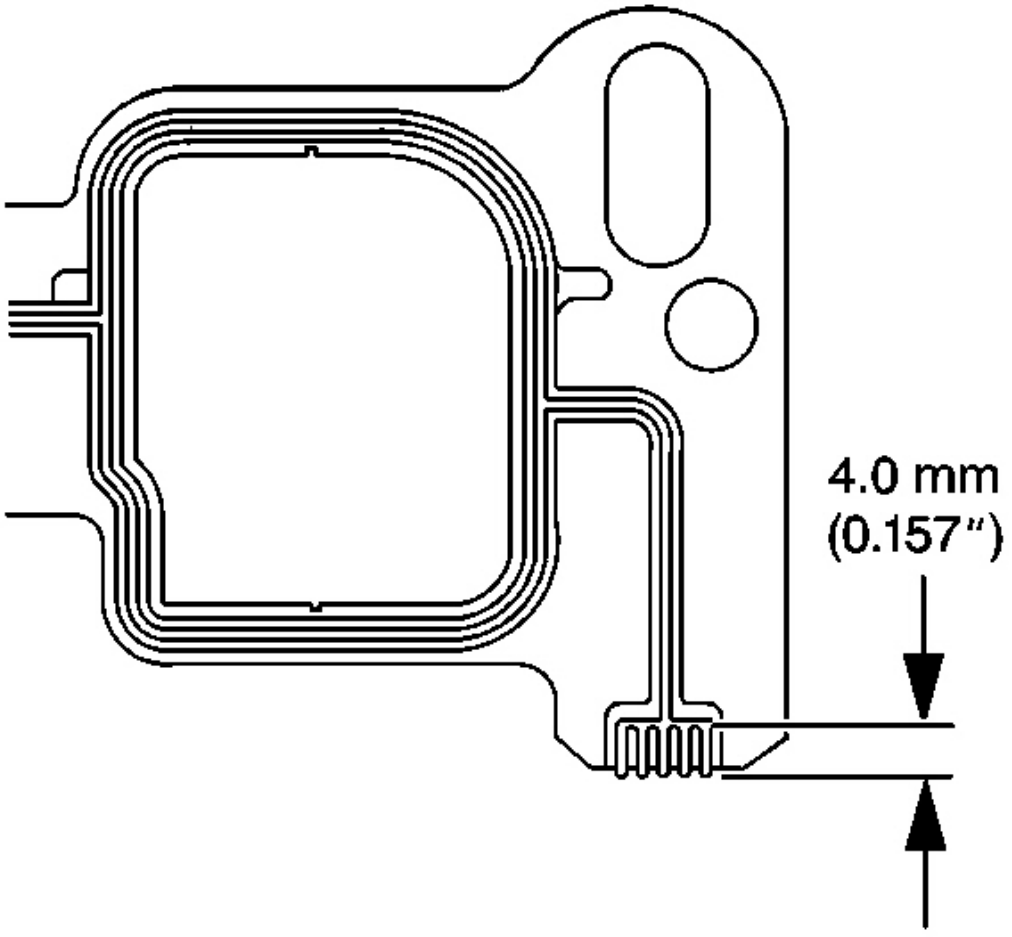


Fig. 93: Applying Patch Of Adhesive To Cylinder Head Side Of Intake Manifold

Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold gasket must be installed while the adhesive is still wet to the touch.

1. Apply a 4.0 mm (0.157 in) patch of adhesive to the cylinder head side of the intake manifold gasket at each end. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install the intake manifold gasket onto the cylinder head. Use the gasket locating pins in order to properly seat the gasket.

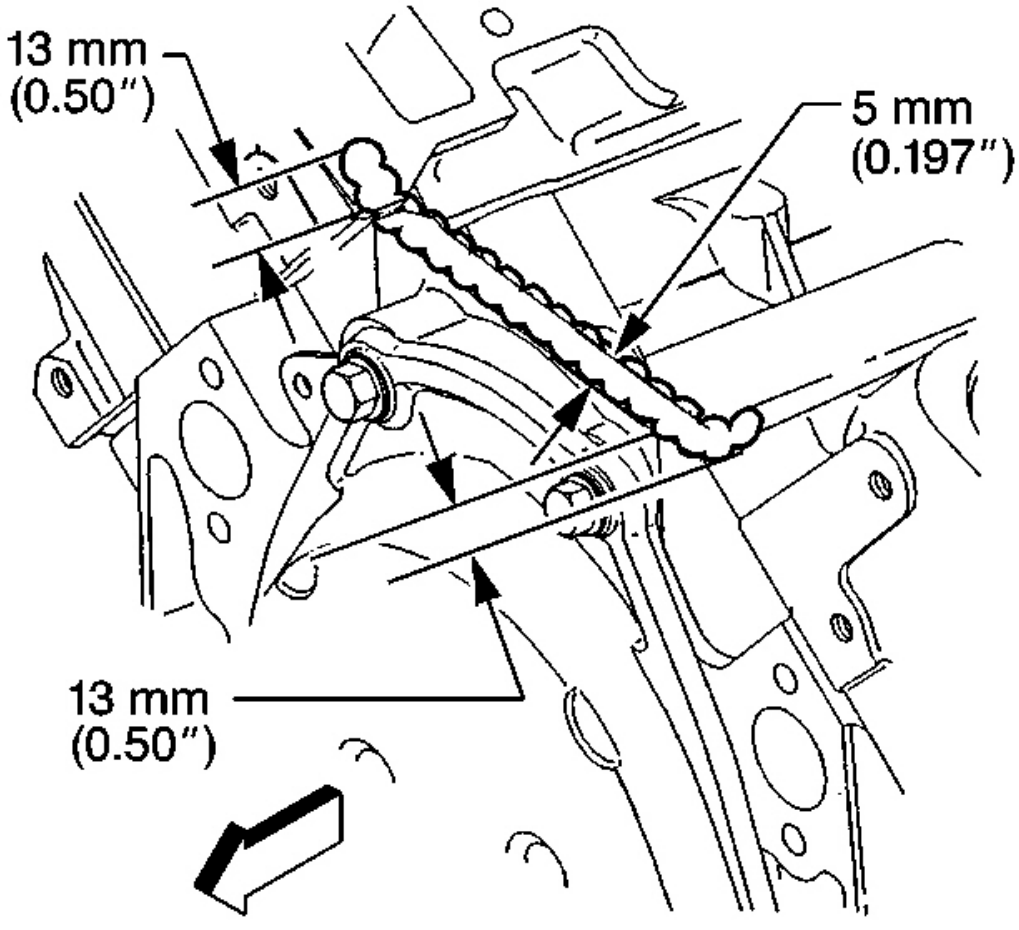


Fig. 94: Applying Adhesive To Front Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Apply a 5 mm (0.197 in) bead of adhesive to the front top of the engine block. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
4. Extend the adhesive bead 13 mm (0.50 in) up onto each intake manifold gasket.

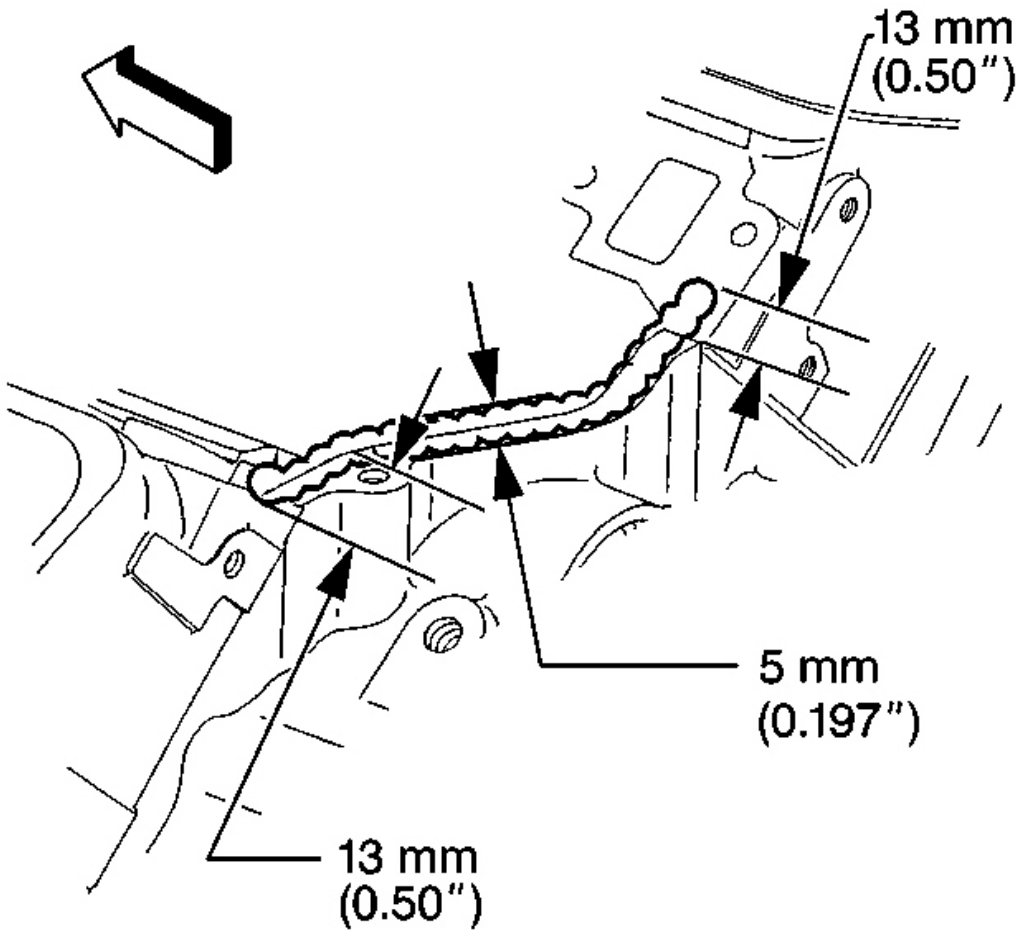


Fig. 95: Applying Adhesive To Rear Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.197 in) bead of adhesive to the rear top of the engine block. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Extend the adhesive bead 13 mm (0.50 in) up onto each intake manifold gasket.

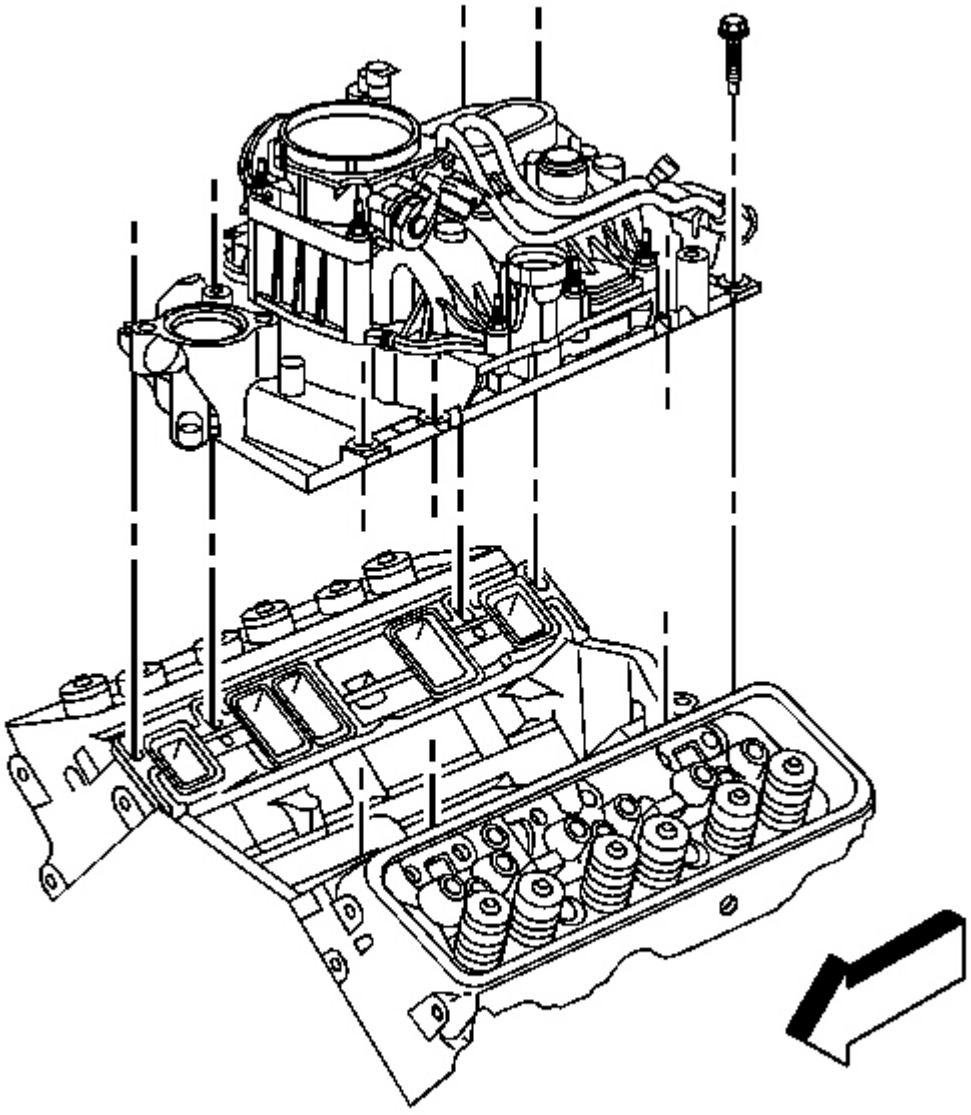


Fig. 96: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. Install the intake manifold.
8. If reusing the old fasteners, apply threadlock to the threads of the intake manifold - lower bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
9. Install the intake manifold - lower bolts.

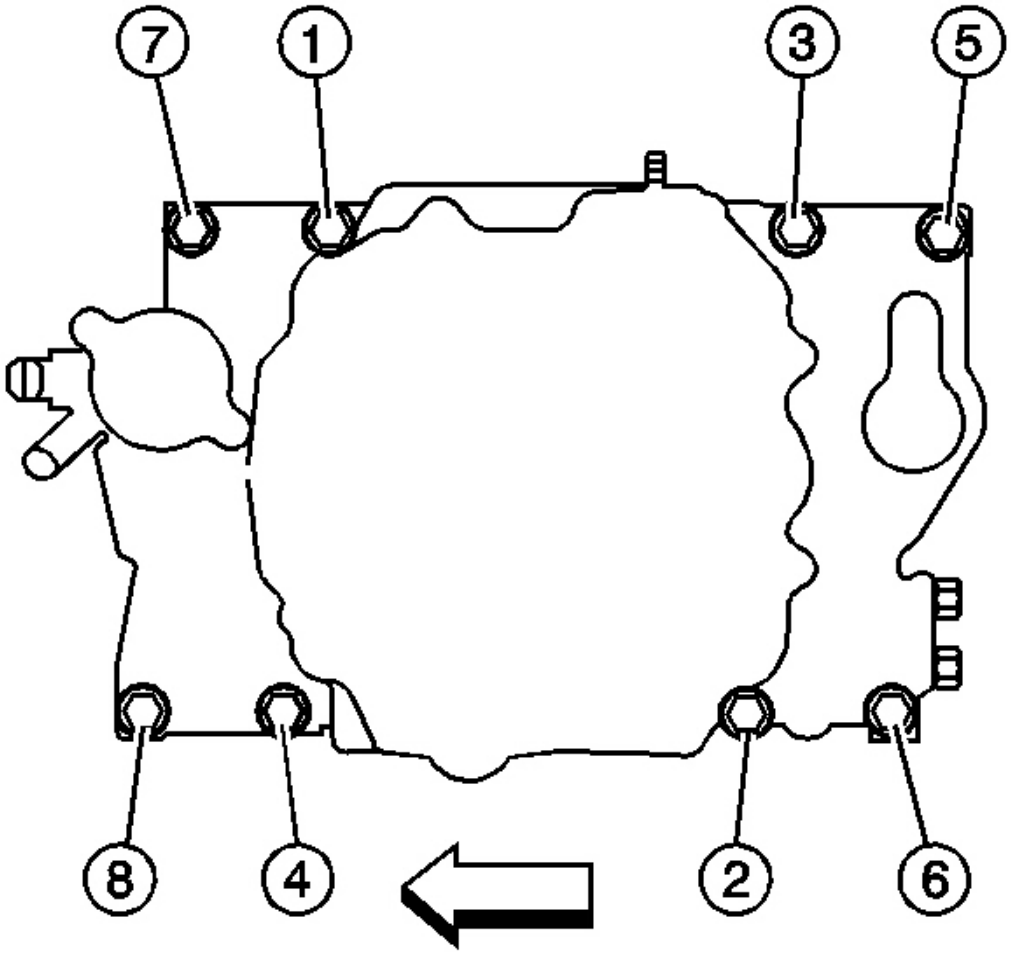


Fig. 97: Intake Manifold Lower Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and

torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

NOTE: Refer to Fastener Notice .

10. Tighten the intake manifold - lower bolts in the sequence shown.

Tighten:

1. Tighten the bolts a first pass to 3 N.m (27 lb in).
2. Tighten the bolts a second pass to 12 N.m (106 lb in).
3. Tighten the bolts a final pass to 15 N.m (11 lb ft).

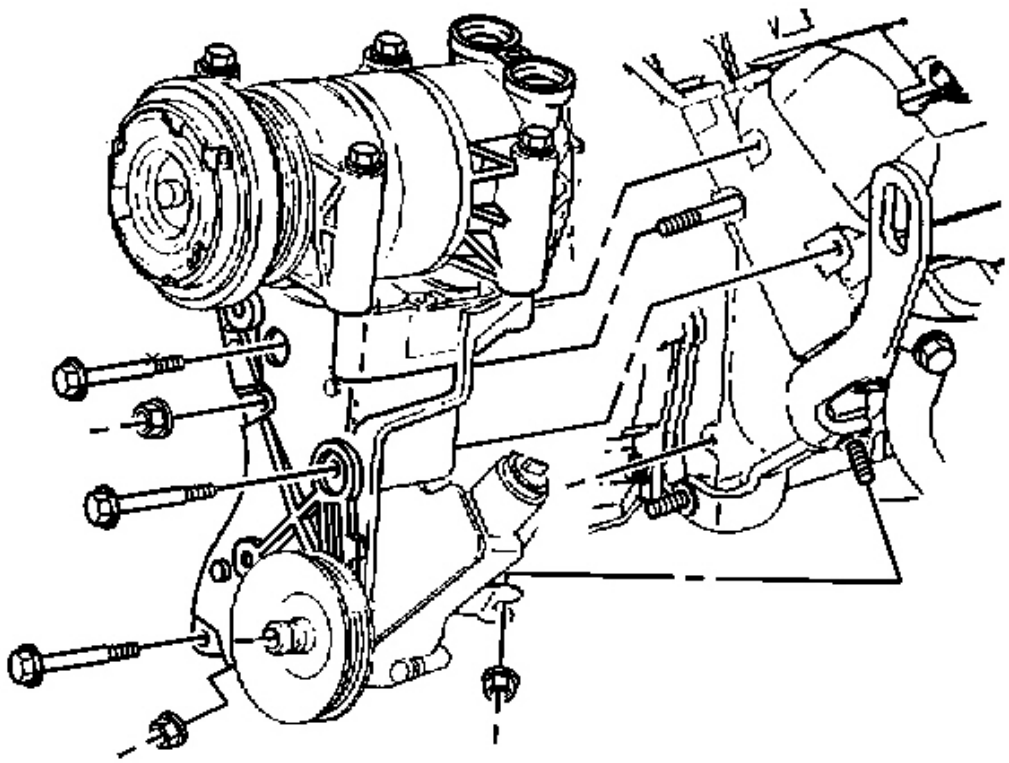


Fig. 98: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

11. Slide the P/S pump bracket rearward.
12. Install the bolts and the nut for the P/S pump bracket.
13. Install the P/S pump rear bracket front nut.
14. Tighten the P/S pump rear bracket nut.

    Tighten: Tighten the bolts and nuts to 41 N.m (30 lb ft).

15. Install the drive belt. Refer to **Drive Belt Replacement**.

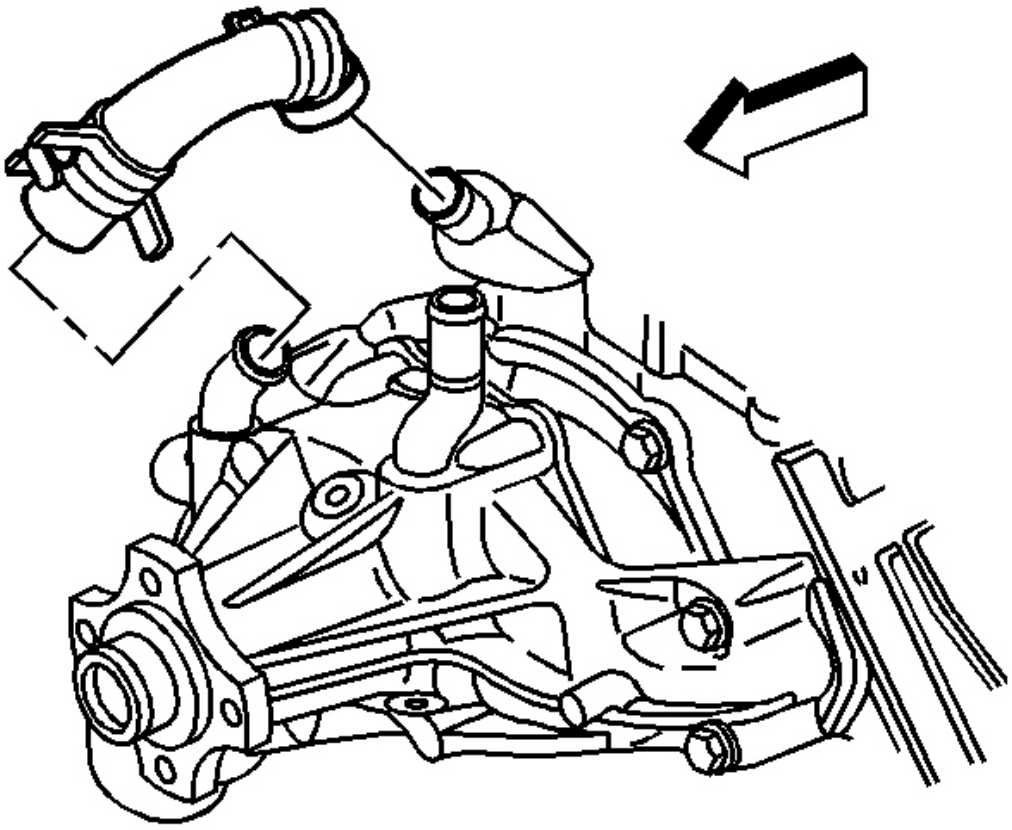


Fig. 99: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

16. Install the water pump inlet hose.
17. Position the water pump inlet hose clamps.

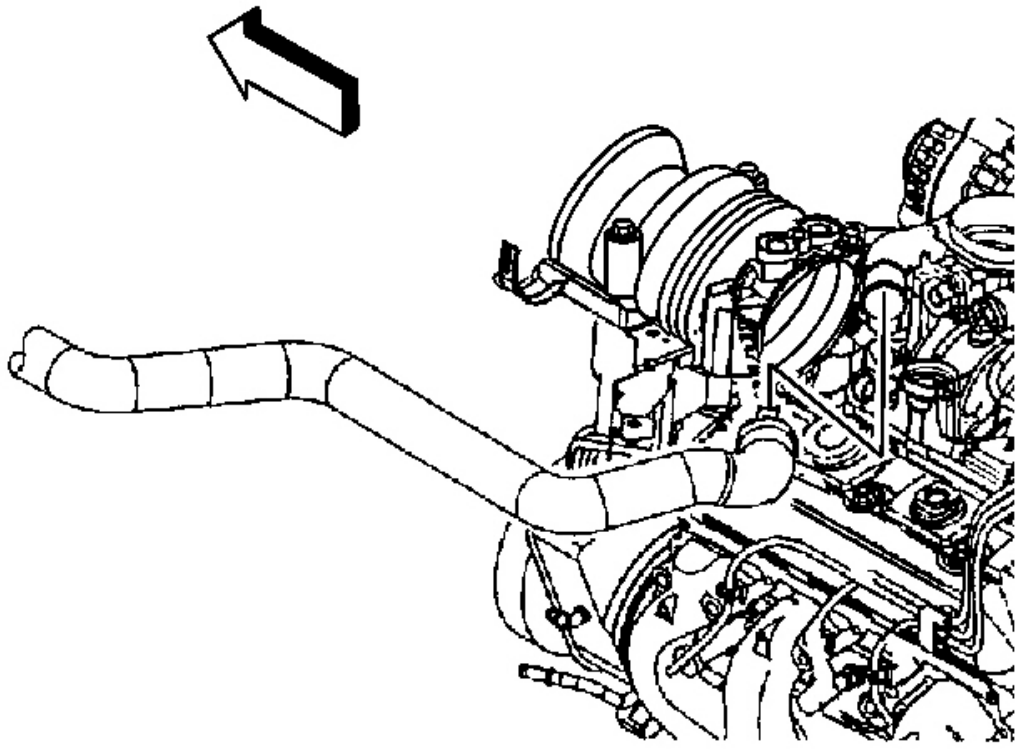


Fig. 100: View Of Radiator Inlet Hose, Clamps & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

18. Install the radiator inlet hose to the thermostat housing.
19. Position the radiator inlet hose clamps.
20. Connect the power brake booster vacuum hose to the vacuum fitting.

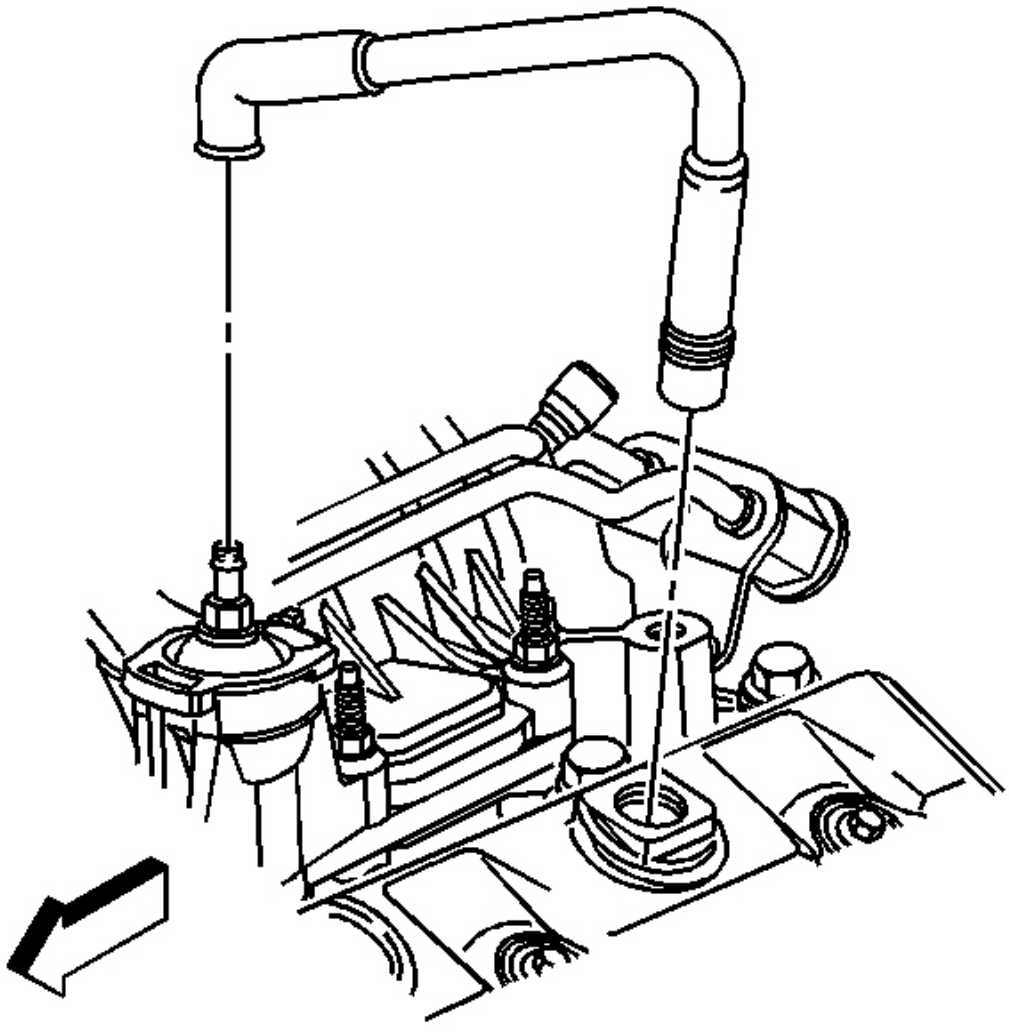


Fig. 101: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

21. Install the PCV valve hose to the valve cover and rocker cover.

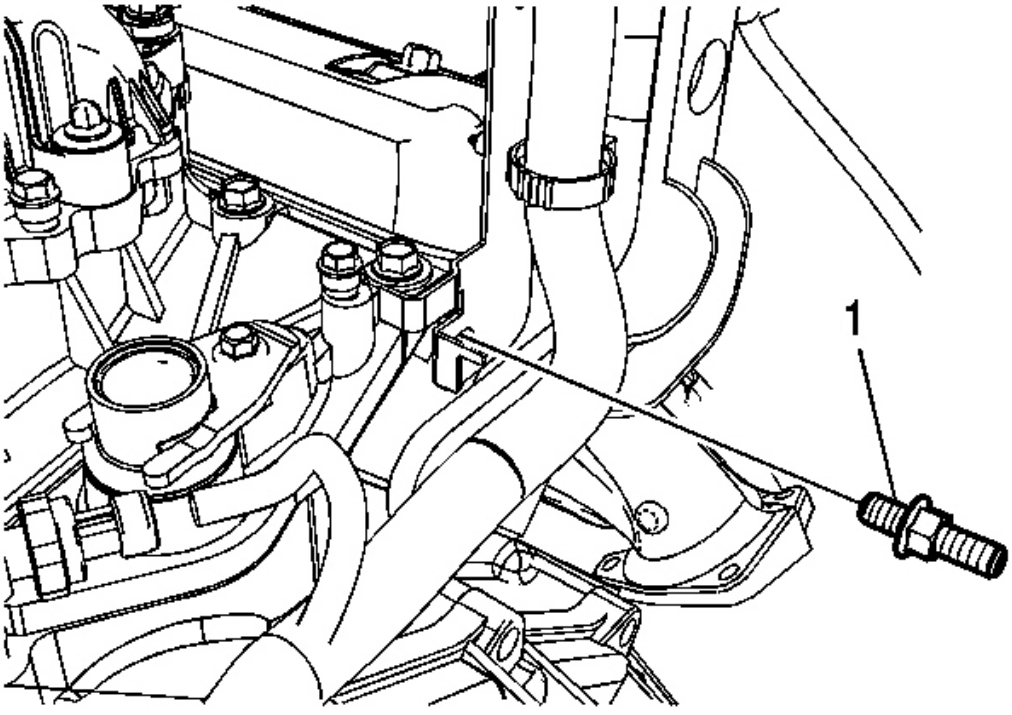


Fig. 102: Engine Wiring Harness Bracket Stud
Courtesy of GENERAL MOTORS CORP.

22. Position the engine wiring harness and bracket.
23. Install the engine wiring harness bracket stud (1).

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

24. Install the engine wiring harness rear bracket nut at the EVAP canister purge solenoid valve.

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

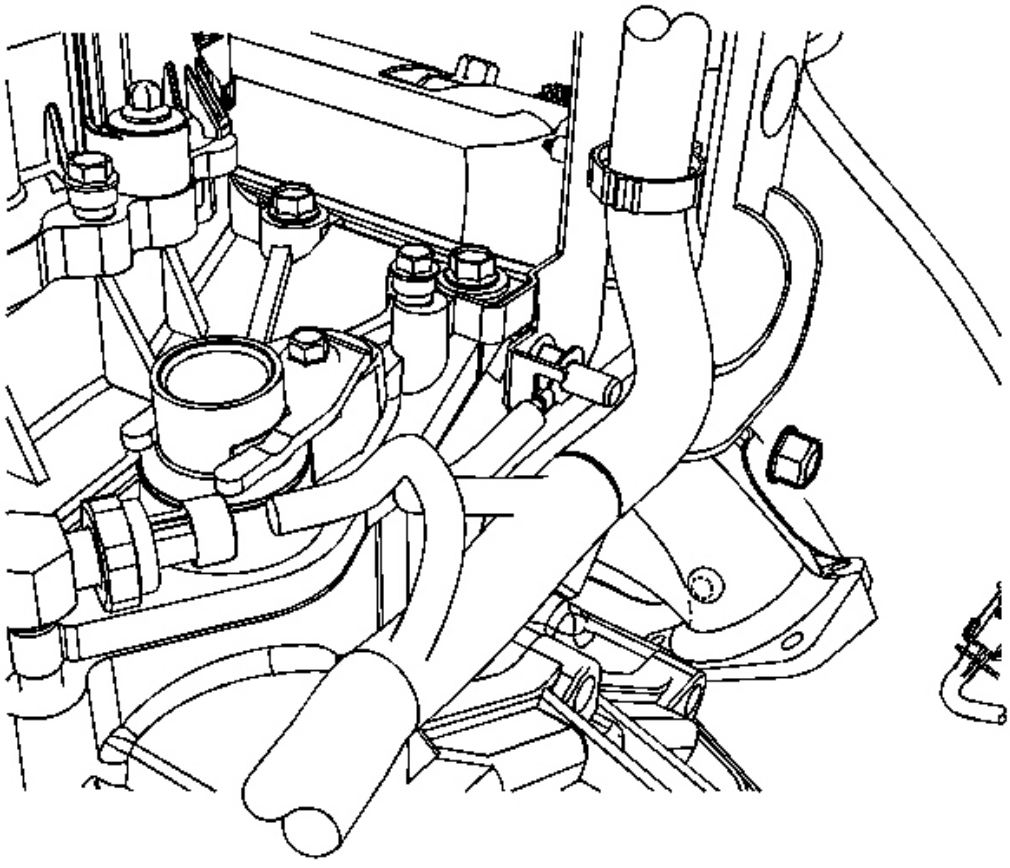


Fig. 103: Engine Wiring Harness Ground Nut
Courtesy of GENERAL MOTORS CORP.

25. Install the engine wiring harness ground nut and ground wire (1) to the rear of the right cylinder head.

    Tighten: Tighten the nut to 16 N.m (12 lb ft).

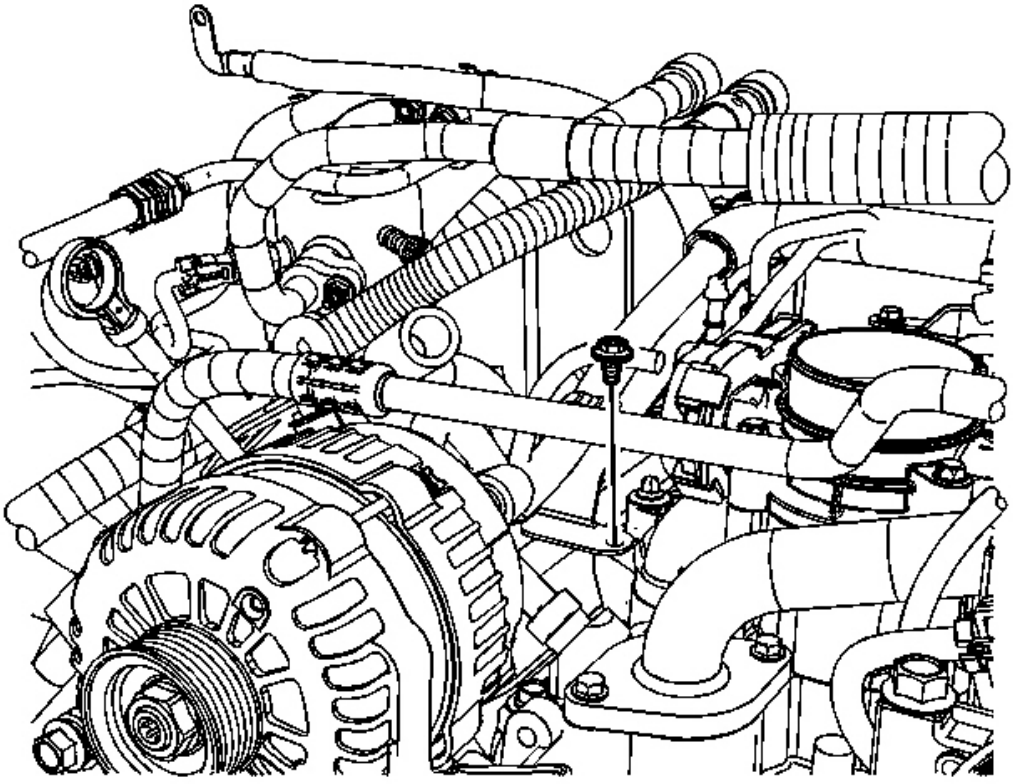


Fig. 104: Engine Wiring Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

26. Install the engine wiring harness bracket bolt (1).

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

27. Install the EVAP canister tube. Refer to **Evaporative Emission Hoses/Pipes Replacement - Engine** .

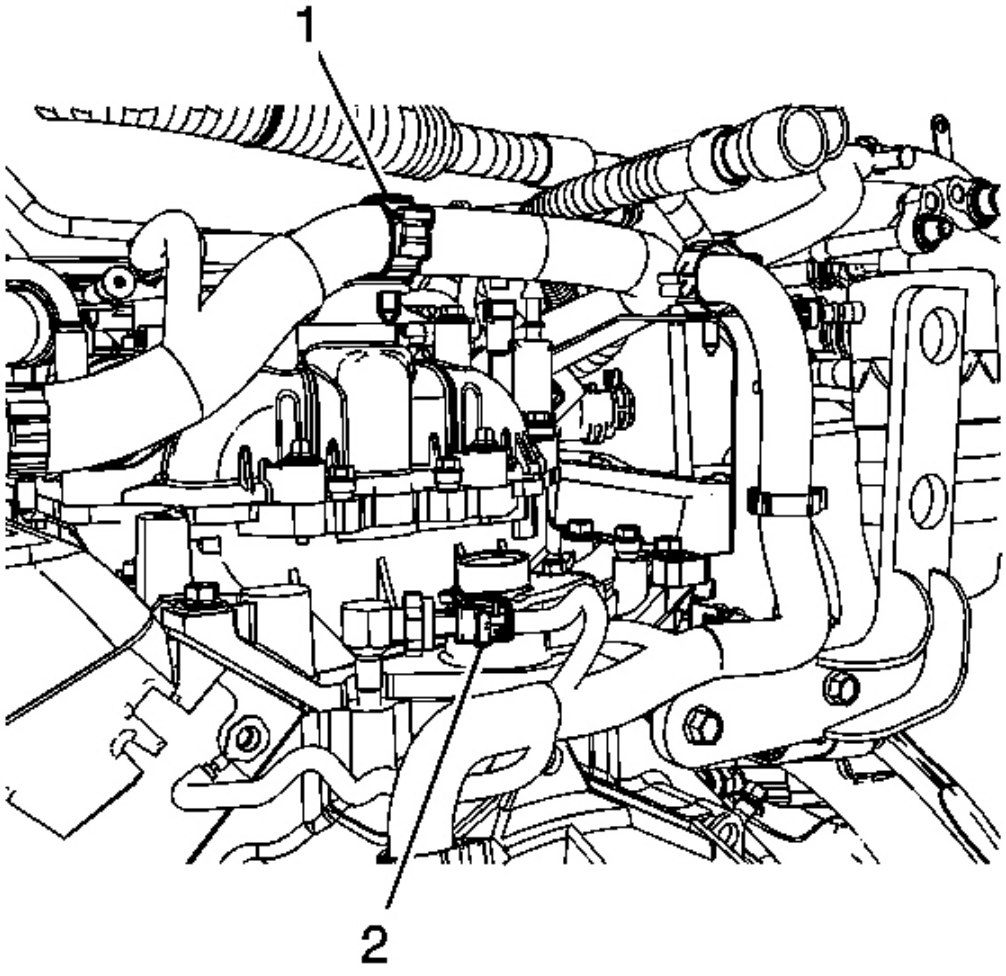


Fig. 105: Oil Pressure Sensor Electrical Connector & Clamp
Courtesy of GENERAL MOTORS CORP.

28. Connect the oil pressure sensor electrical connector (2).
29. Install the engine harness clamp (1) to the bracket.

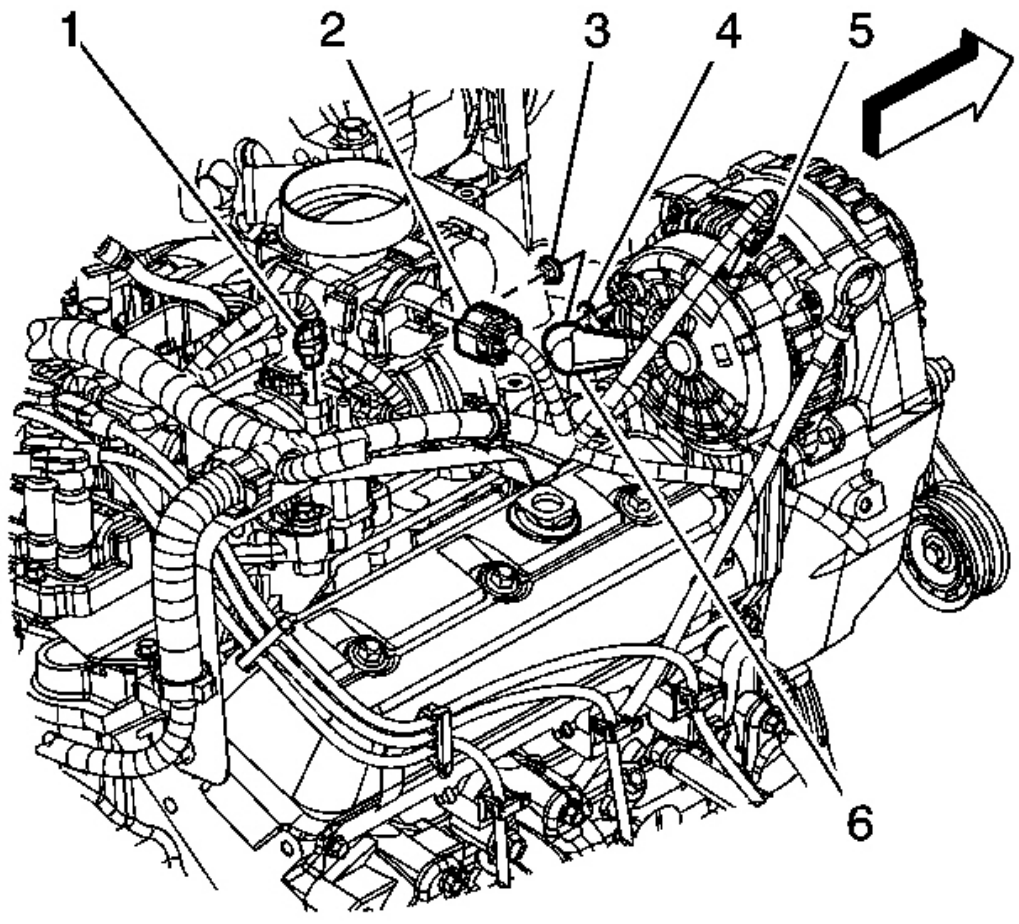


Fig. 106: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

30. Connect the following electrical connectors:
    - The EVAP canister purge solenoid valve (1)
    - The MAP sensor

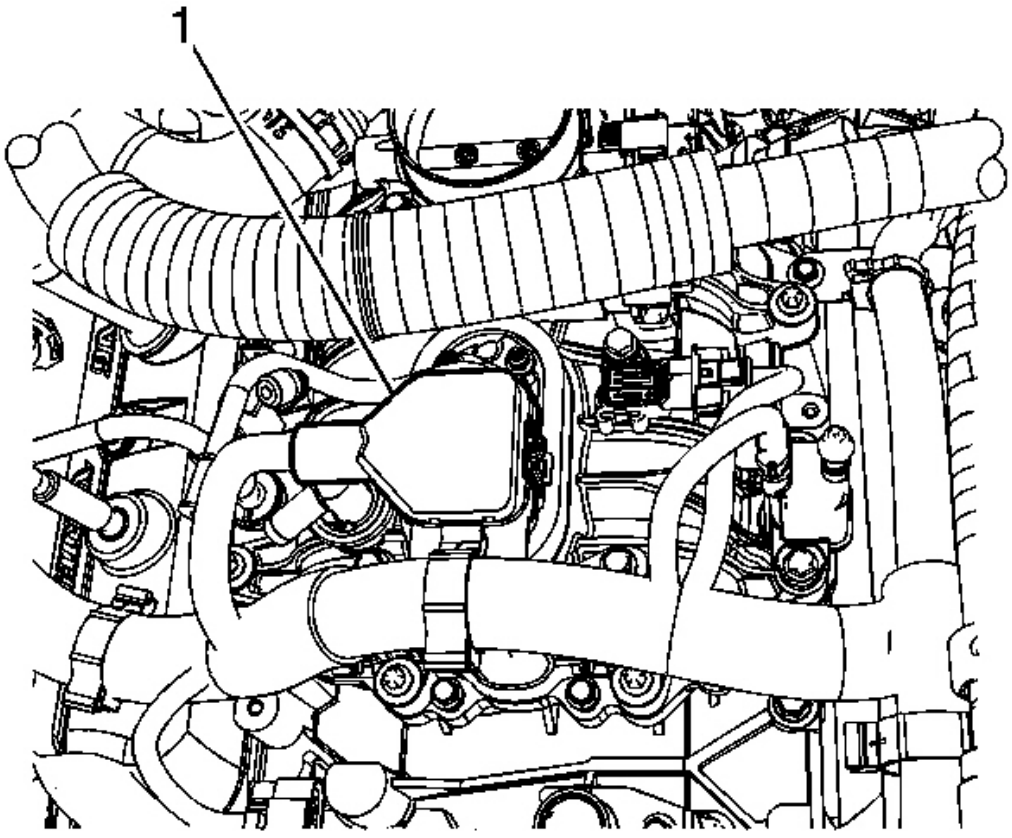


Fig. 107: Control Port Injector Module
Courtesy of GENERAL MOTORS CORP.

31. Connect the control port injector module (1).

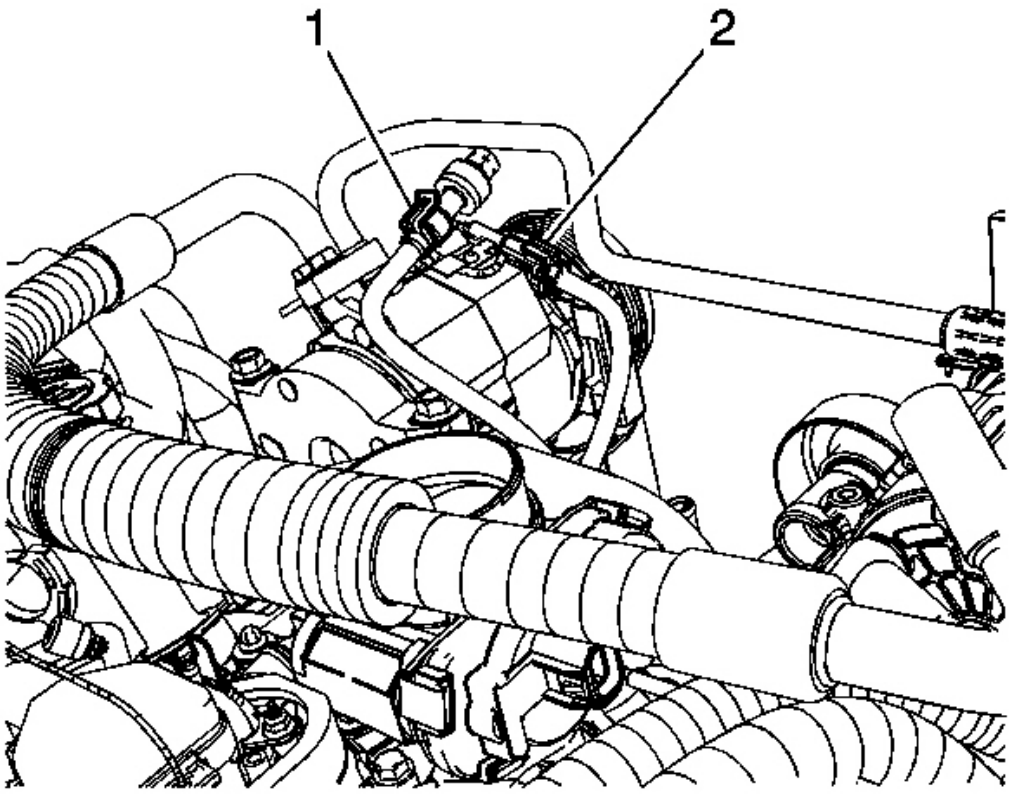


Fig. 108: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

32. Connect the following electrical connectors:
    - The A/C compressor clutch (2), if equipped
    - The A/C pressure switch (1), if equipped

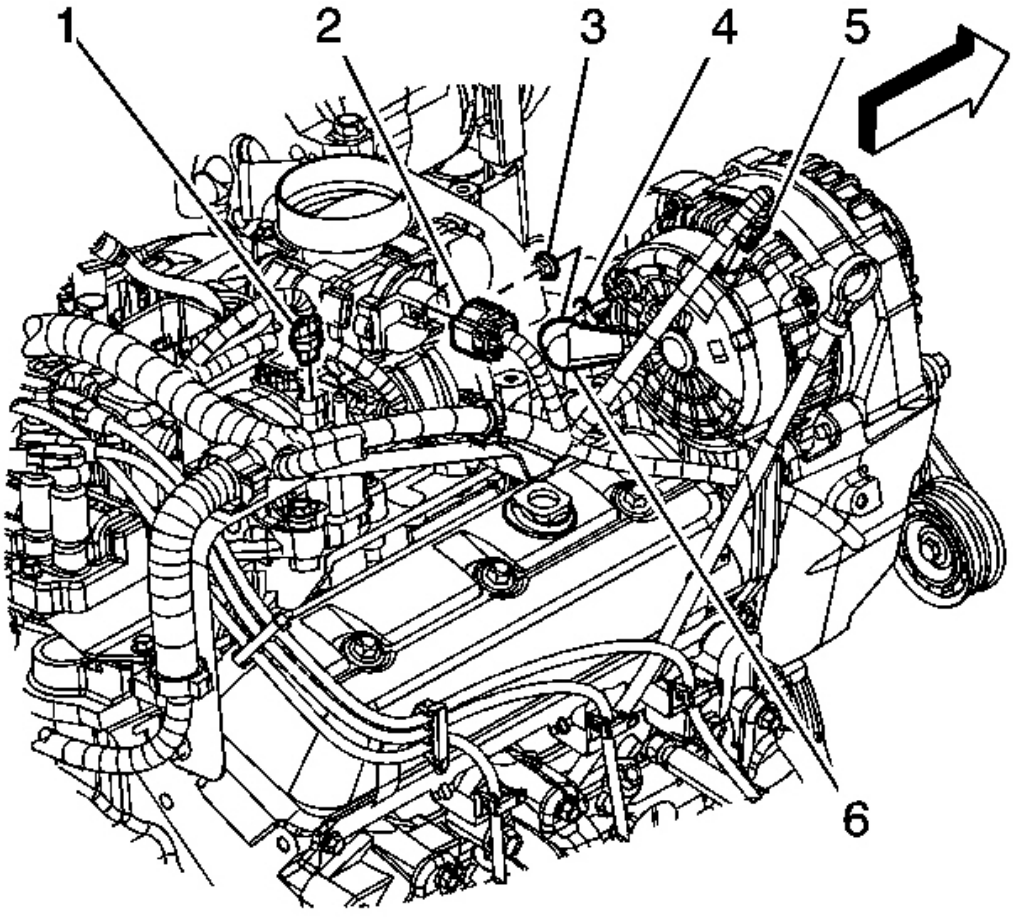


Fig. 109: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

33. Connect the engine wiring harness electrical connector (2) to the throttle body.

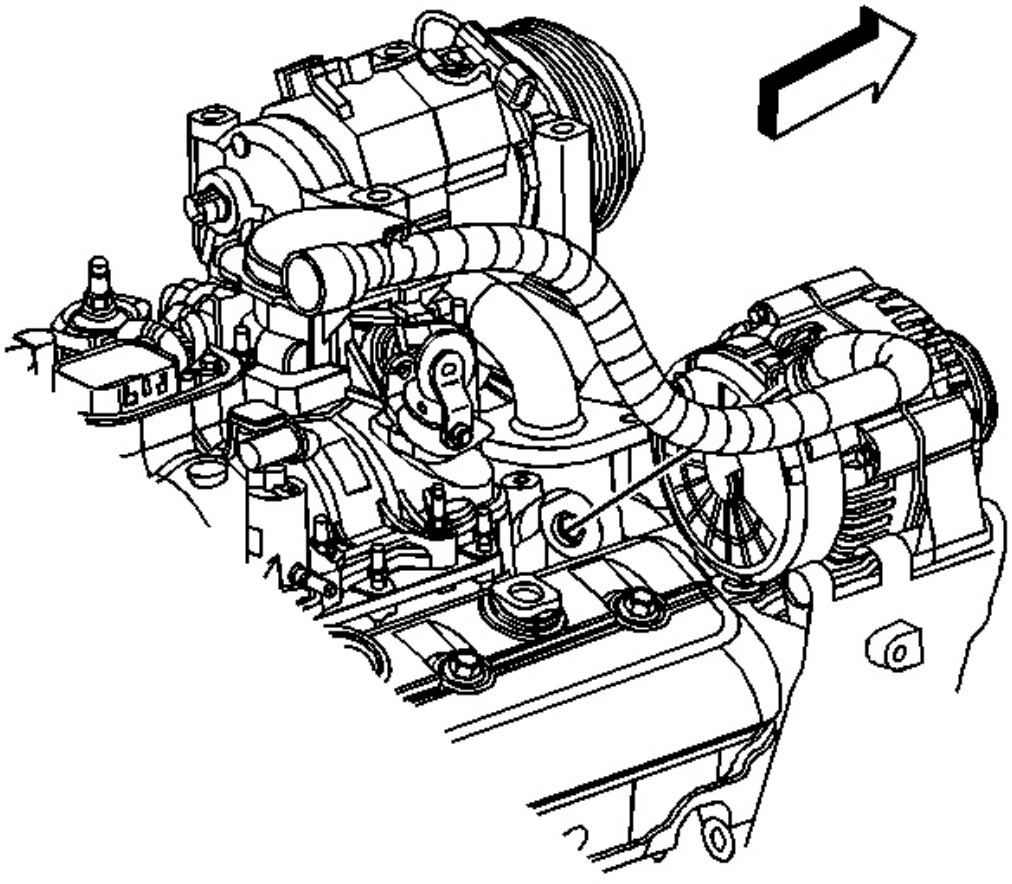


Fig. 110: Heater Inlet Hose At Water Pump
Courtesy of GENERAL MOTORS CORP.

34. Position the heater inlet and outlet hoses.
35. Open the heater inlet hose clamp and install the hose to the water pump.

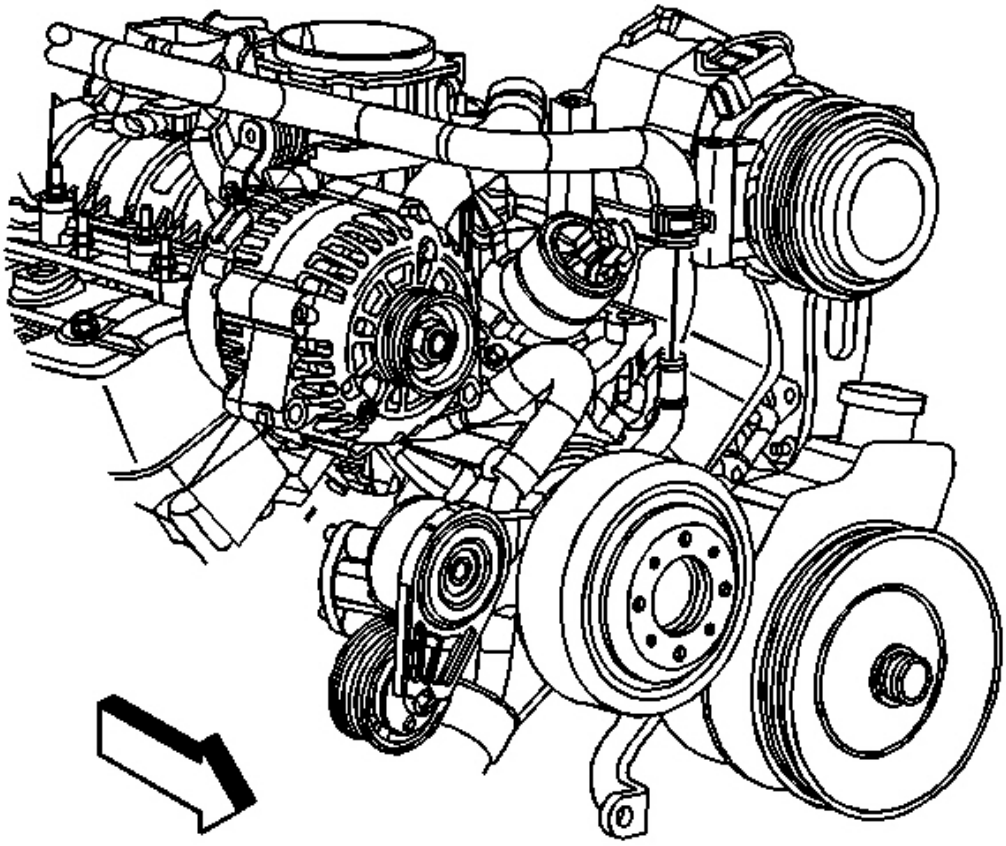


Fig. 111: Intake Manifold Hose
Courtesy of GENERAL MOTORS CORP.

36. Open the heater outlet hose clamp and install the hose to the intake manifold.

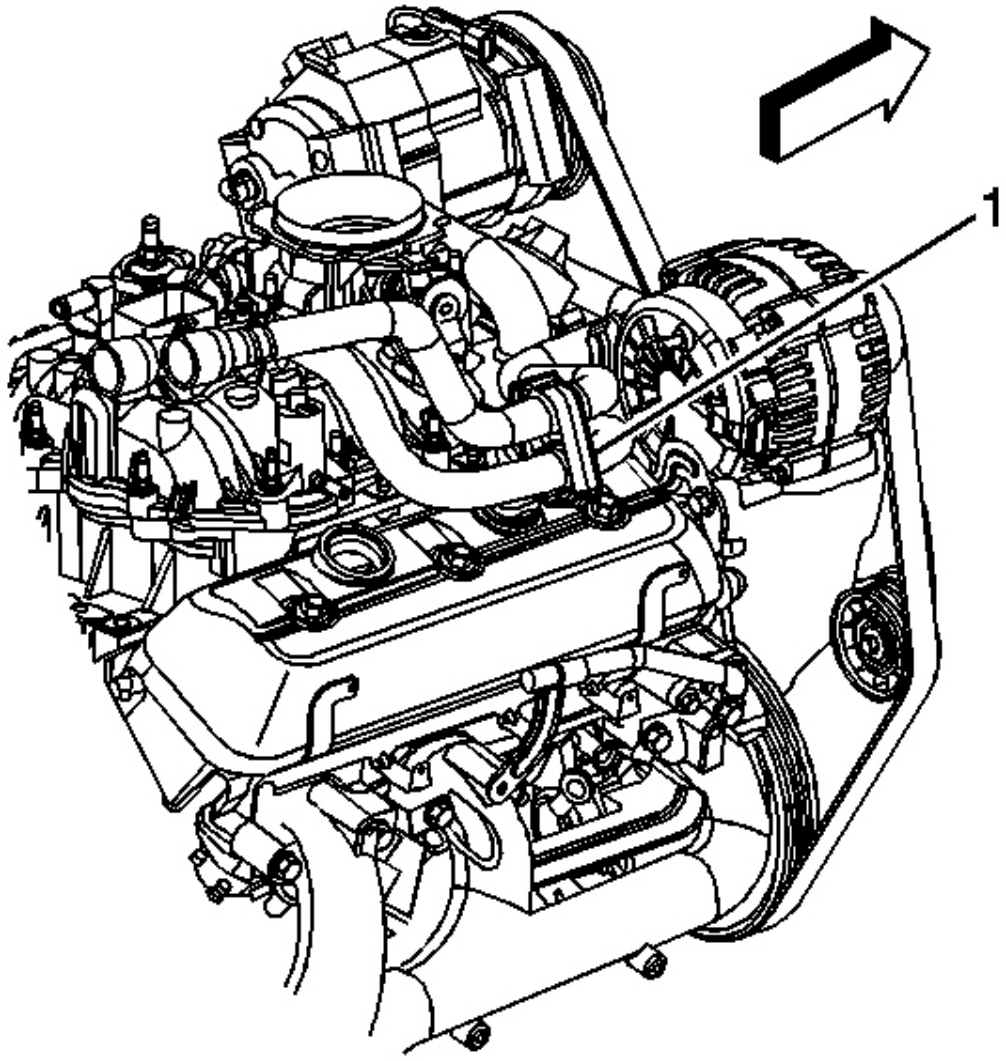


Fig. 112: Heater Hose Clamp
Courtesy of GENERAL MOTORS CORP.

37. Install the heater hose clamp (1).
38. Install the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
39. Install the ignition coil assembly. Refer to **Ignition Coil Replacement** .
40. Fill the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or

Cooling System Draining and Filling (Static Fill) .

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

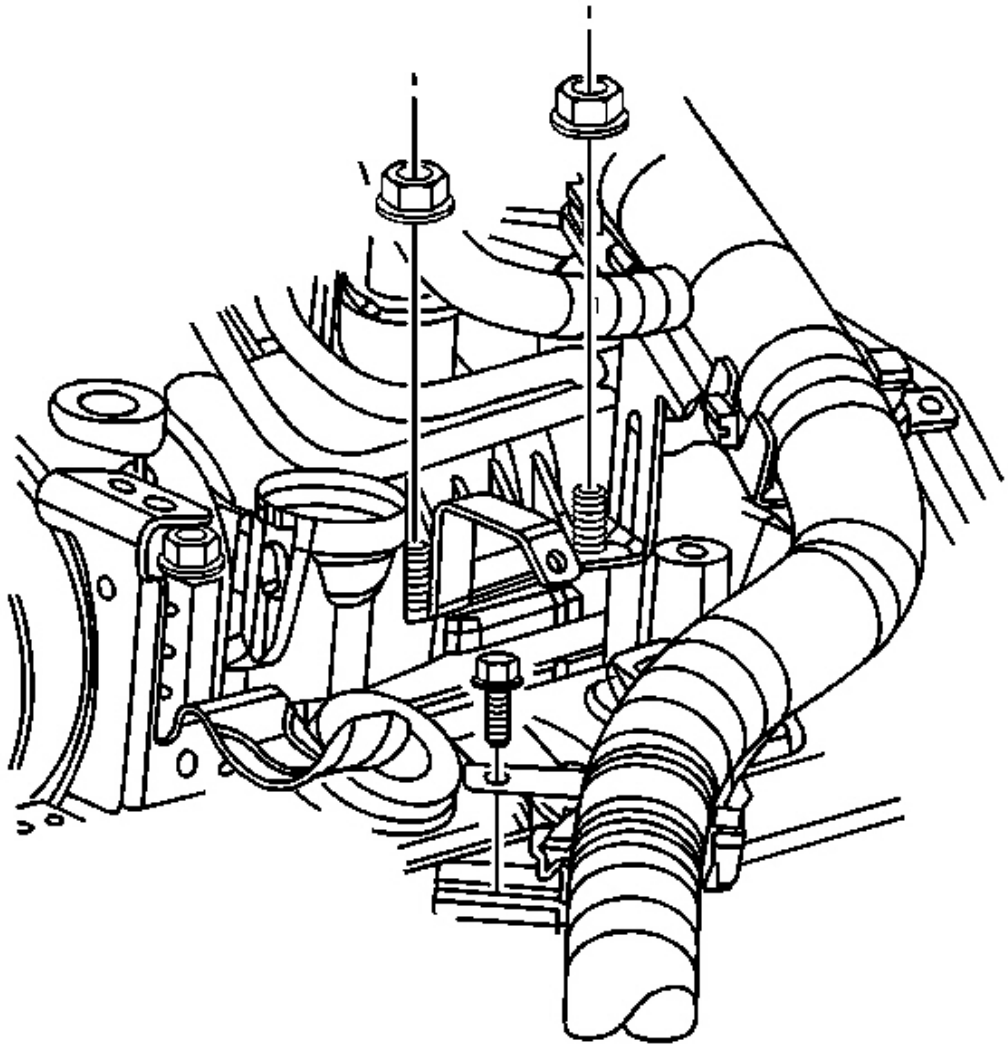


Fig. 113: View Of Engine Wiring Harness Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine wiring harness bracket nuts.

2. Remove the engine wiring harness bracket.

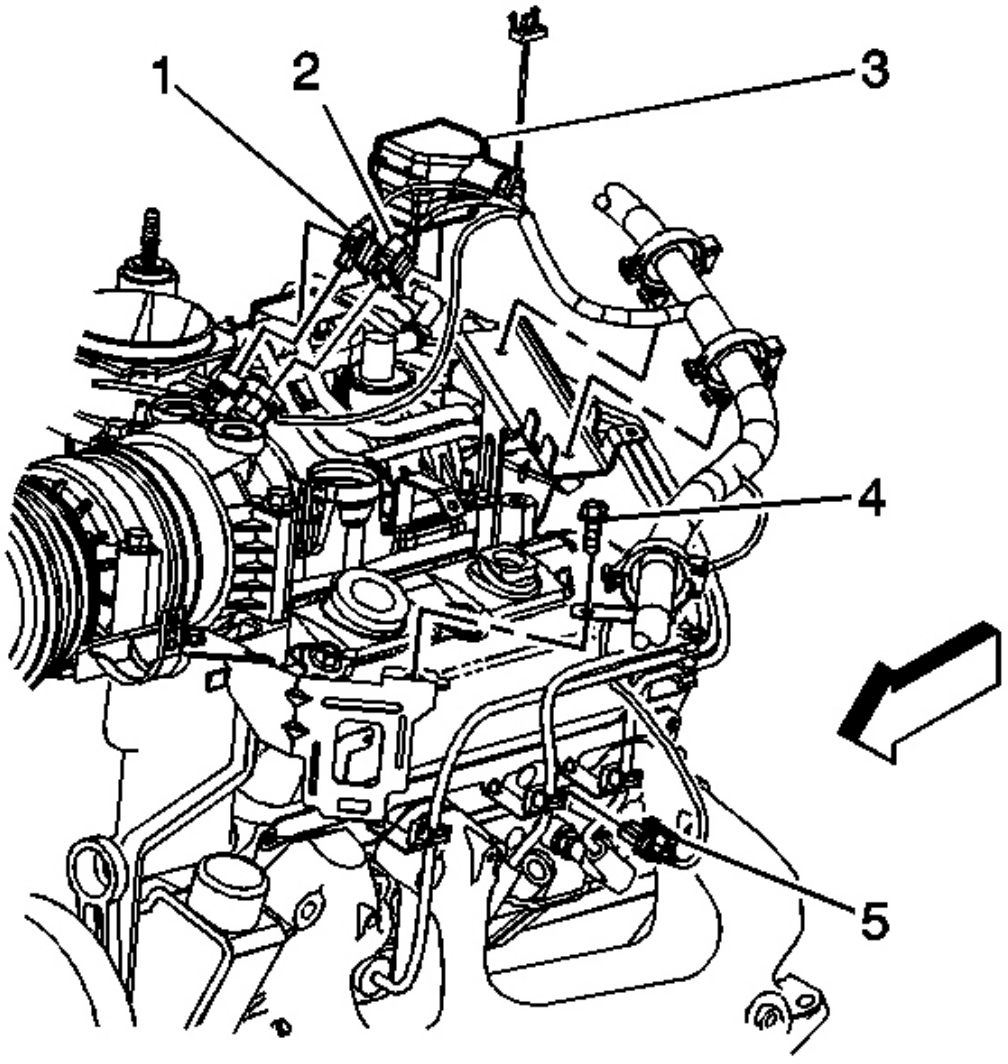


Fig. 114: View Of TP Sensor, IAC Motor, ECT Sensor, Control Port Injector Module & Engine Harness Clip Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine wiring harness clip bolt (4).
4. Disconnect the engine coolant temperature (ECT) sensor electrical connector (5).

5. Reposition the engine wiring harness and bracket.
6. Disconnect the power brake booster vacuum hose from the vacuum fitting.

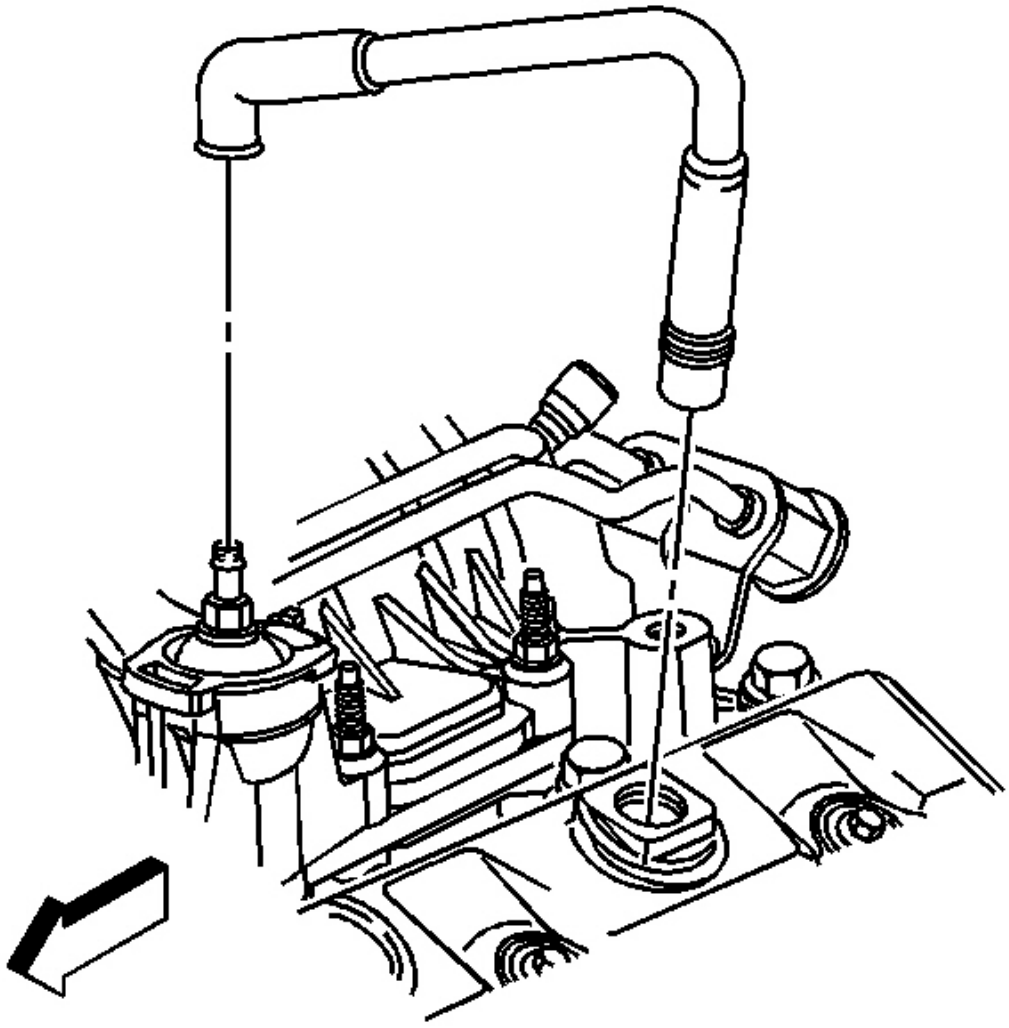


Fig. 115: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

7. Remove the positive crankcase ventilation (PCV) valve hose from the valve cover and rocker cover.

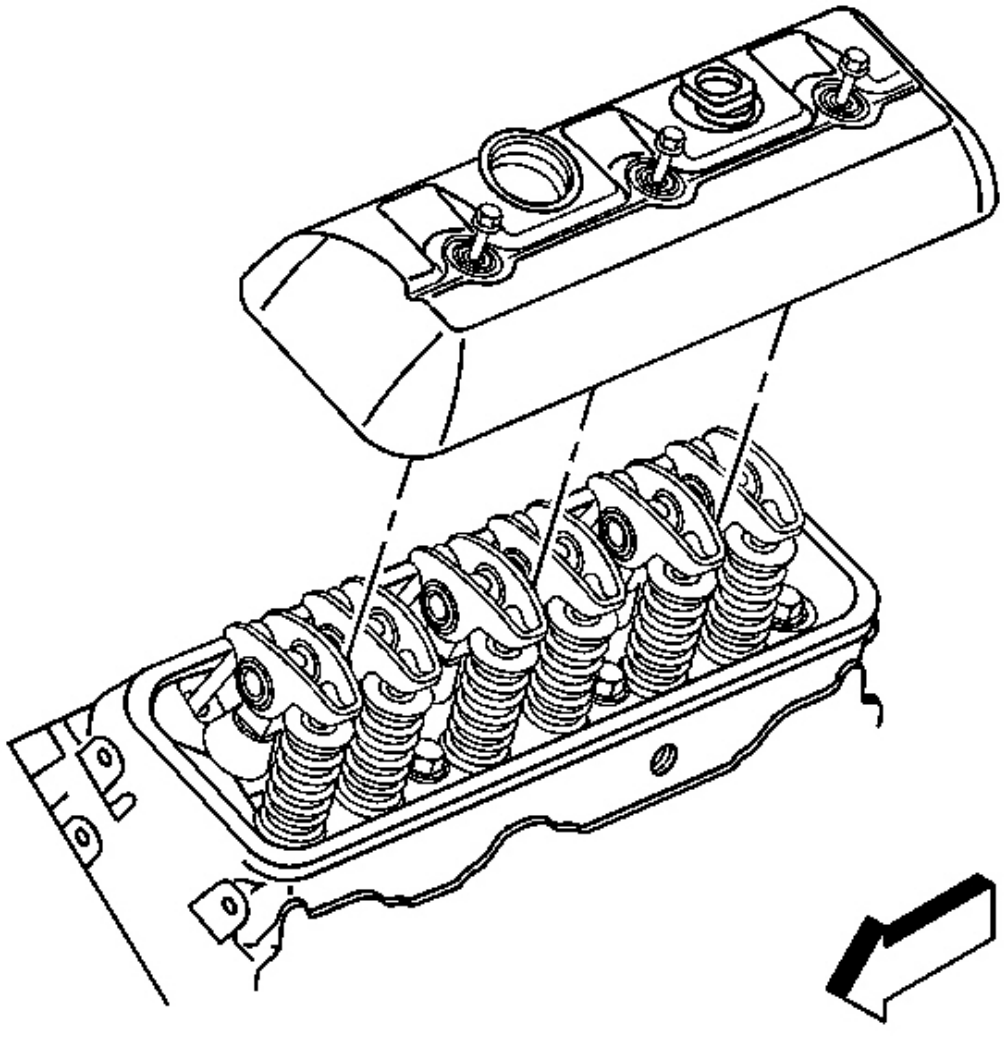


Fig. 116: Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

8. Remove the rocker arm cover bolts.
9. Remove and discard the rocker arm cover bolt grommets, if necessary.
10. Remove the rocker arm cover.

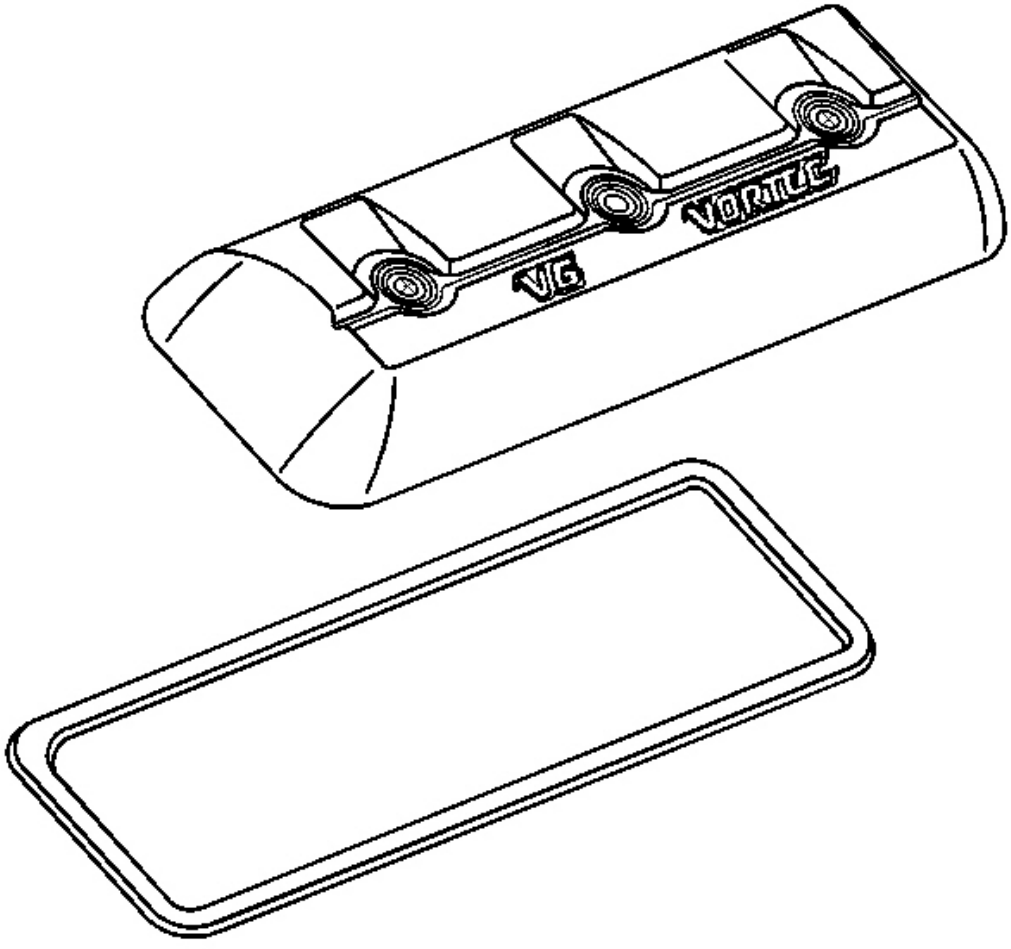


Fig. 117: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the rocker arm cover gasket.
12. Clean and inspect the rocker arm cover, if necessary. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Do not reuse the rocker cover gasket or the rocker arm cover bolt grommets.

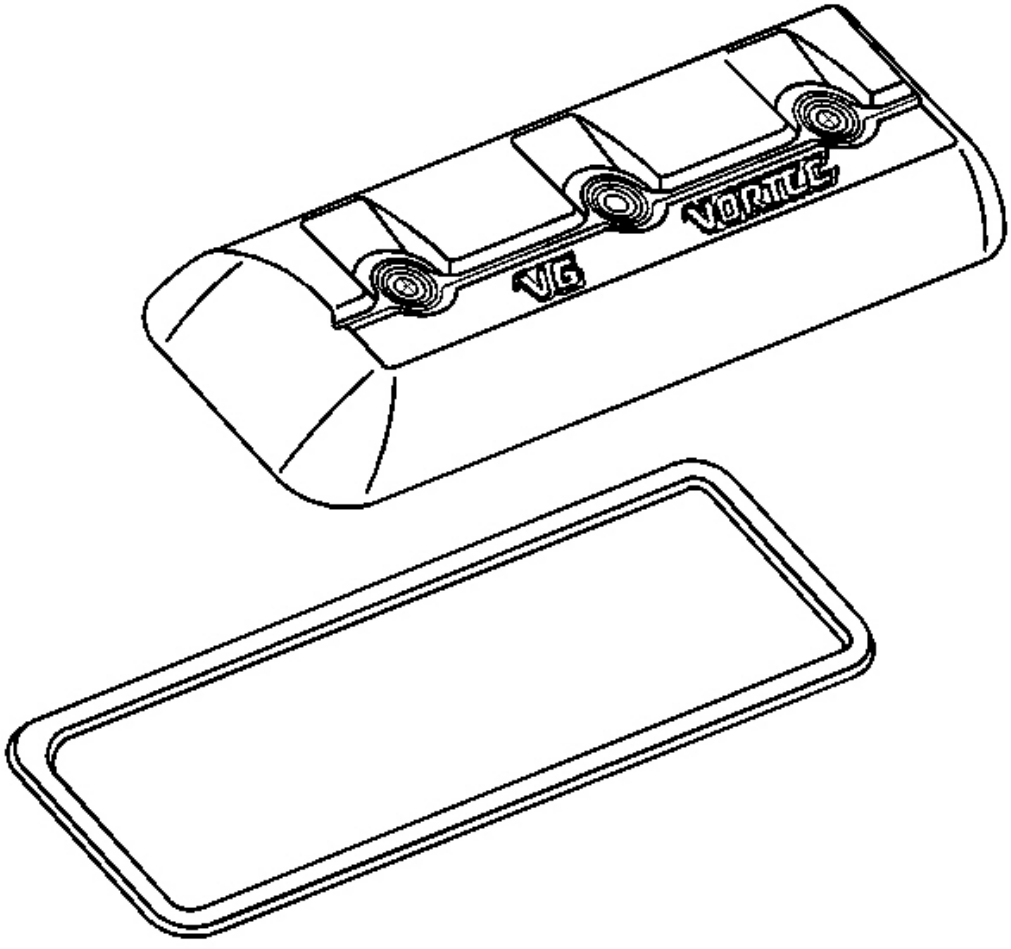


Fig. 118: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW rocker arm cover gasket to the cover.
2. Install NEW rocker arm cover bolt grommets to the cover, if necessary.

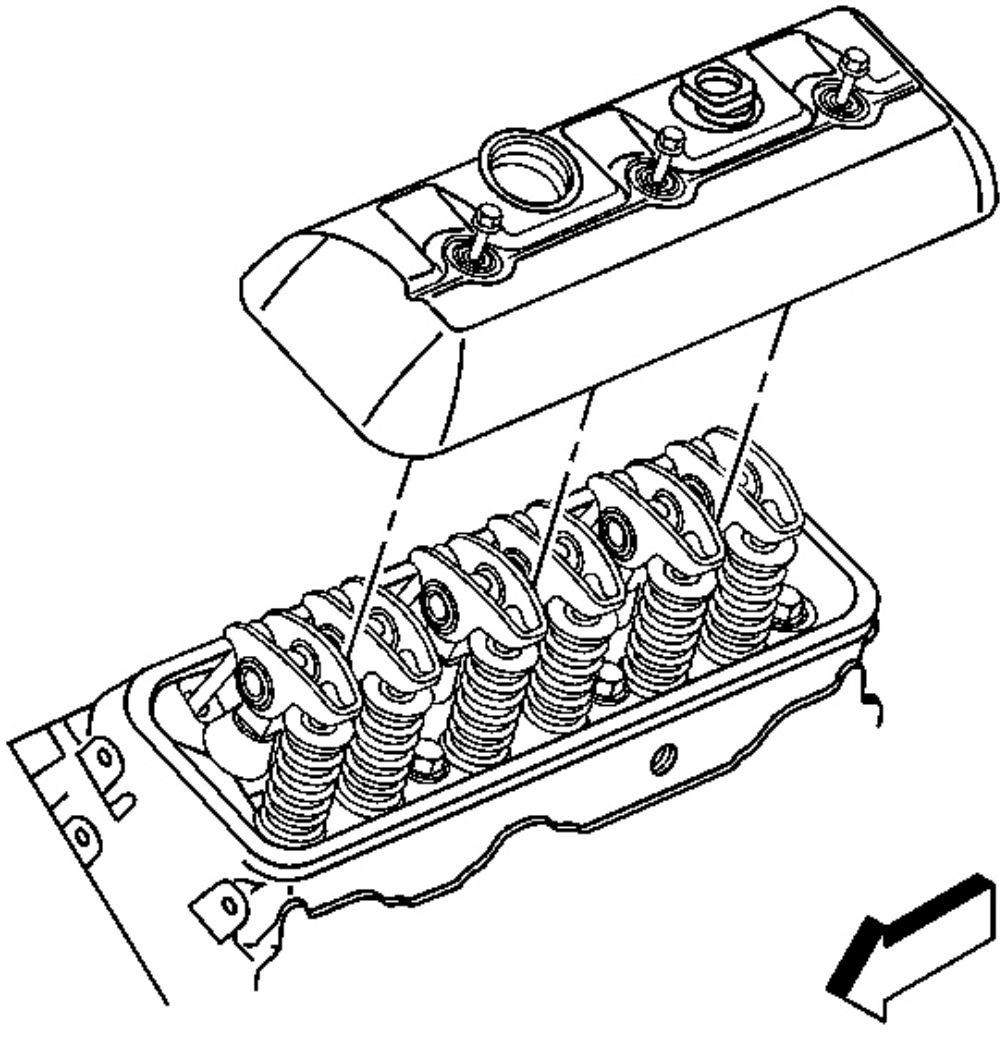


Fig. 119: Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the rocker arm cover.
4. Install the rocker arm cover bolts.

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

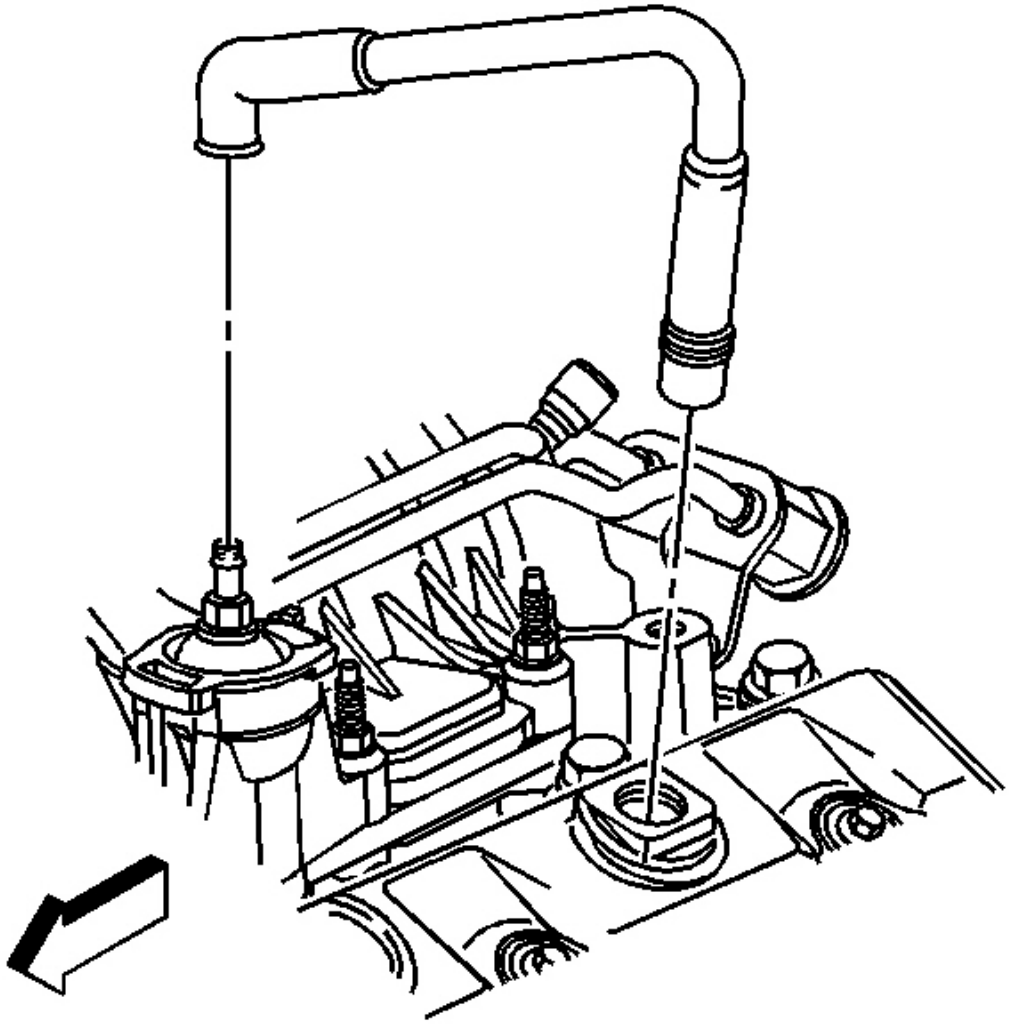


Fig. 120: Locating PCV Valve Hose At Valve & Rocker Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the PCV valve hose to the valve cover and rocker cover.
6. Connect the power brake booster vacuum hose to the vacuum fitting.

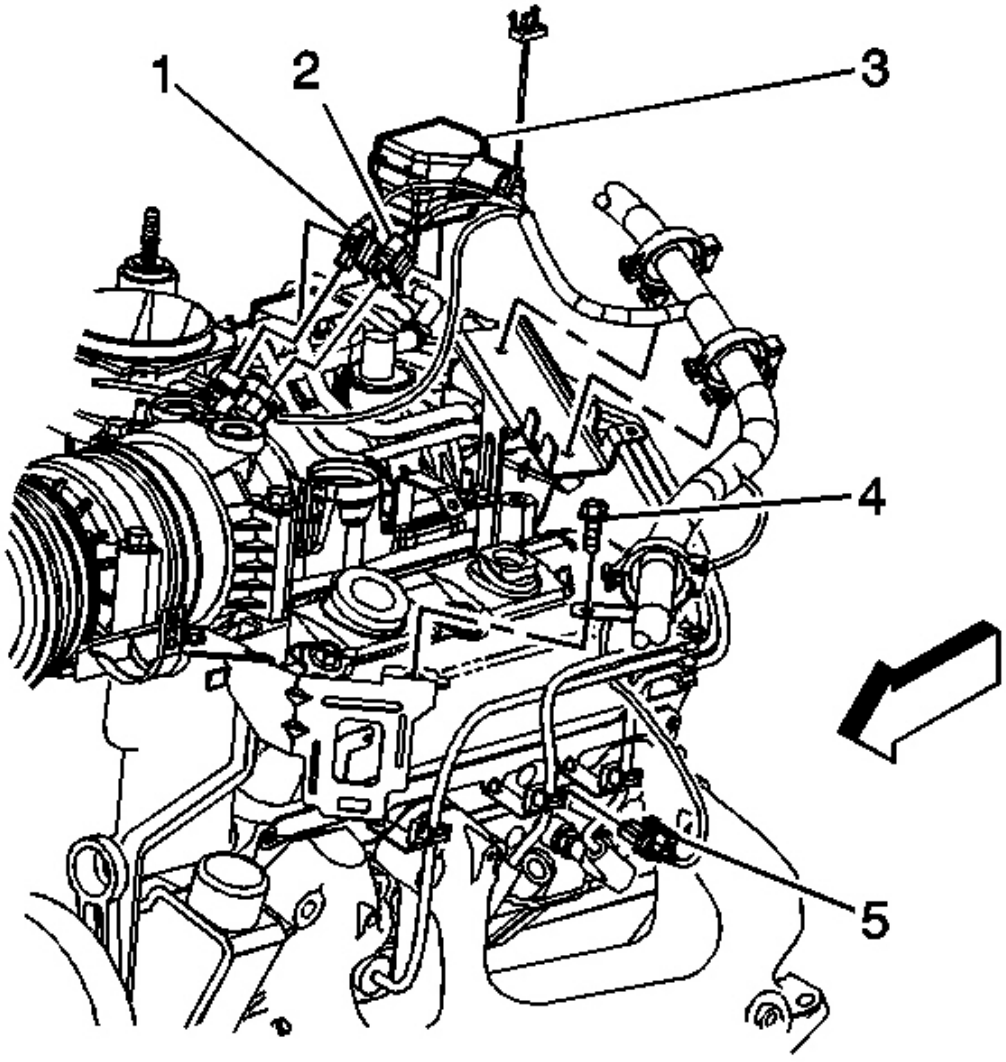


Fig. 121: View Of TP Sensor, IAC Motor, ECT Sensor, Control Port Injector Module & Engine Harness Clip Bolt
Courtesy of GENERAL MOTORS CORP.

7. Position the engine wiring harness and bracket.
8. Connect the ECT sensor electrical connector (5).
9. Install the engine wiring harness clip bolt (4).

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

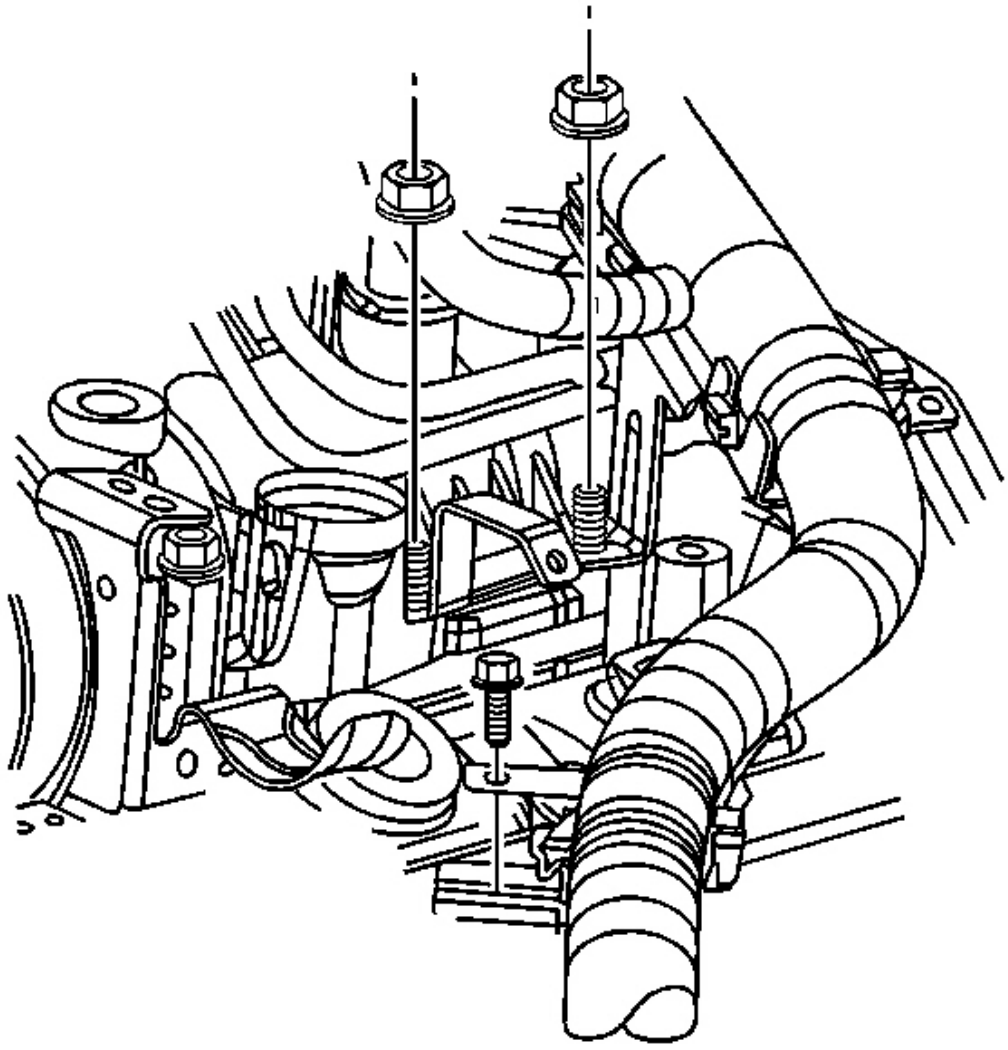


Fig. 122: View Of Engine Wiring Harness Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

10. Install the engine wiring harness bracket.
11. Install the engine wiring harness bracket nuts.

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

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

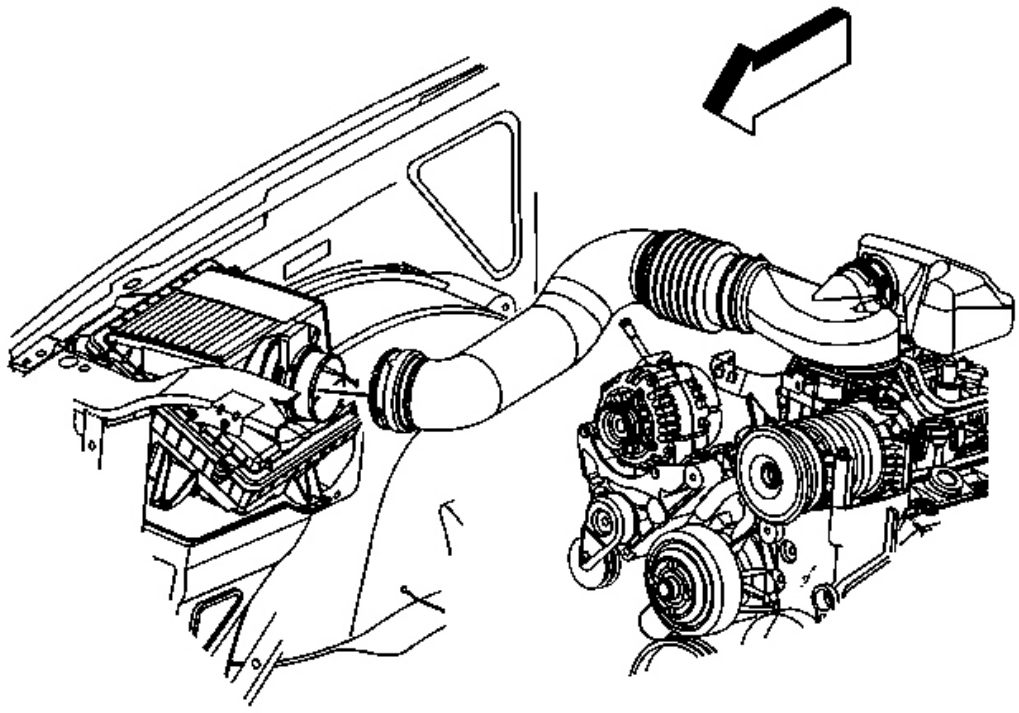


Fig. 123: View Of Air Cleaner Outlet Duct Clamp
Courtesy of GENERAL MOTORS CORP.

1. Loosen the air cleaner outlet duct clamp at the mass airflow (MAF)/intake air temperature (IAT) sensor.

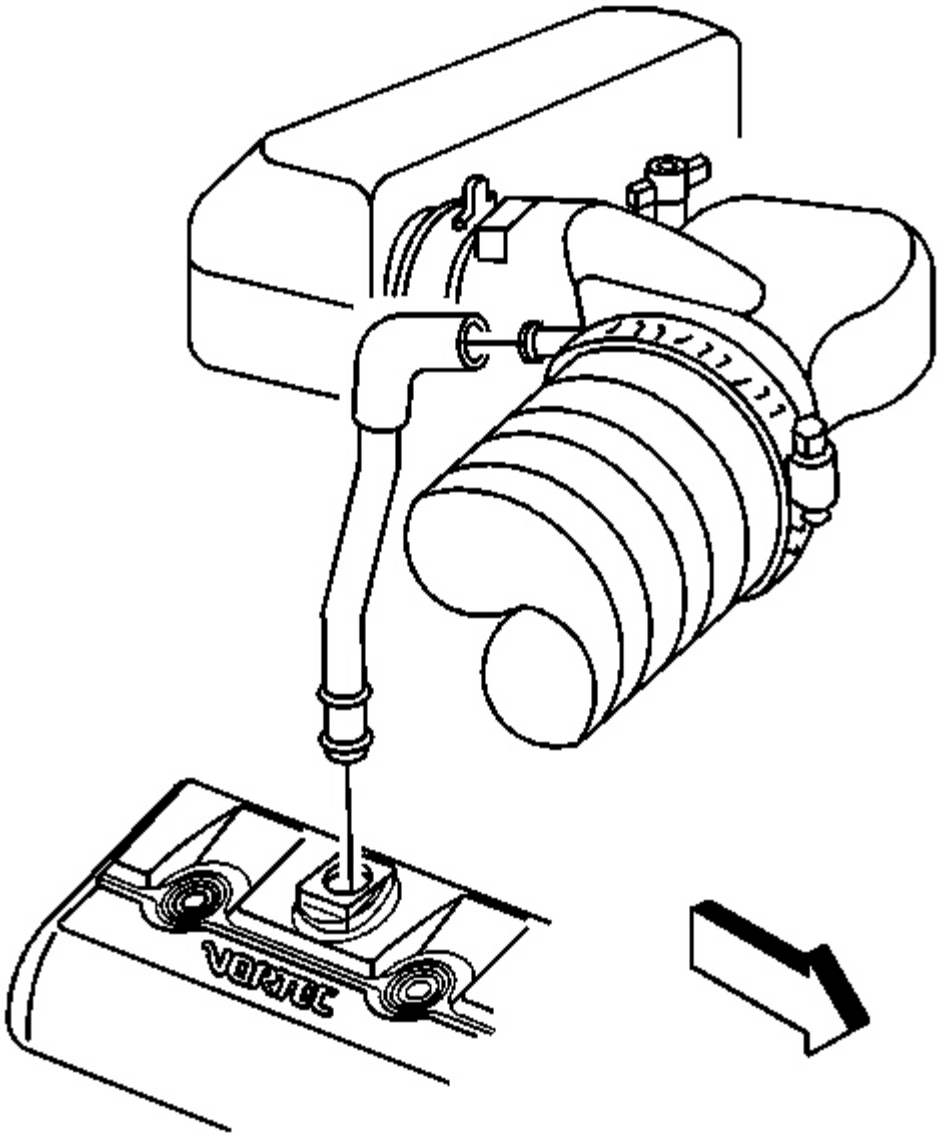


Fig. 124: Identifying PCV Hose
Courtesy of GENERAL MOTORS CORP.

2. Remove the positive crankcase ventilation (PCV) hose.

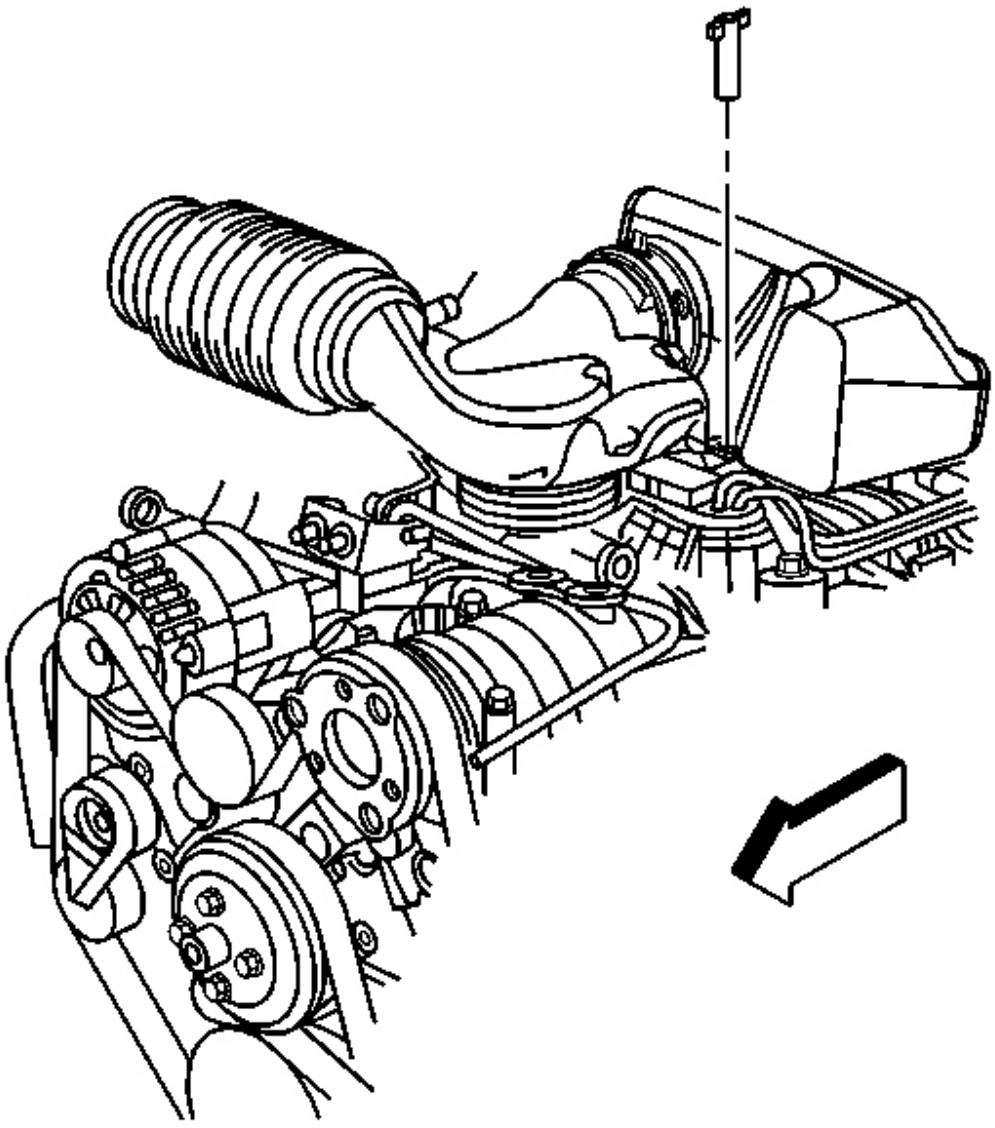


Fig. 125: View Of Air Cleaner Adapter Nut
Courtesy of GENERAL MOTORS CORP.

3. Remove the air cleaner adapter nut.

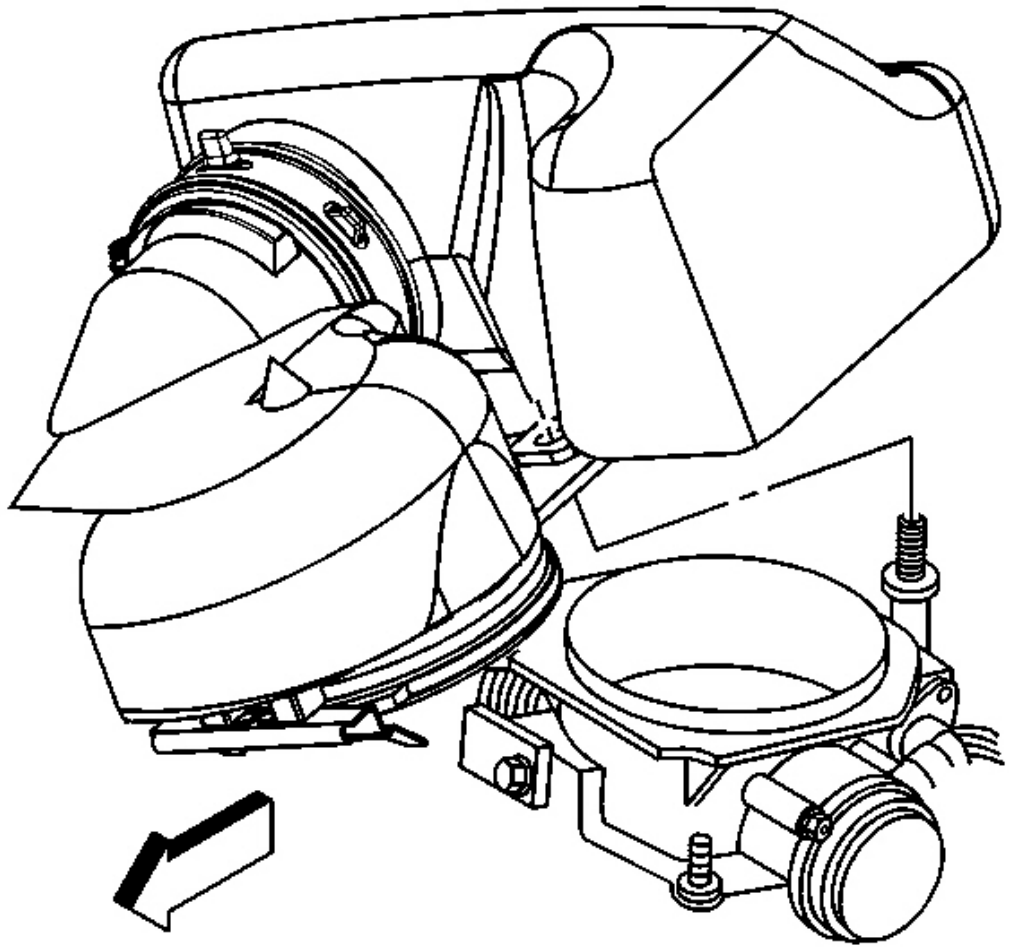


Fig. 126: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

4. In order to remove the air cleaner outlet duct, pivot the duct upward until the hinge clip releases from the lip on the throttle body.

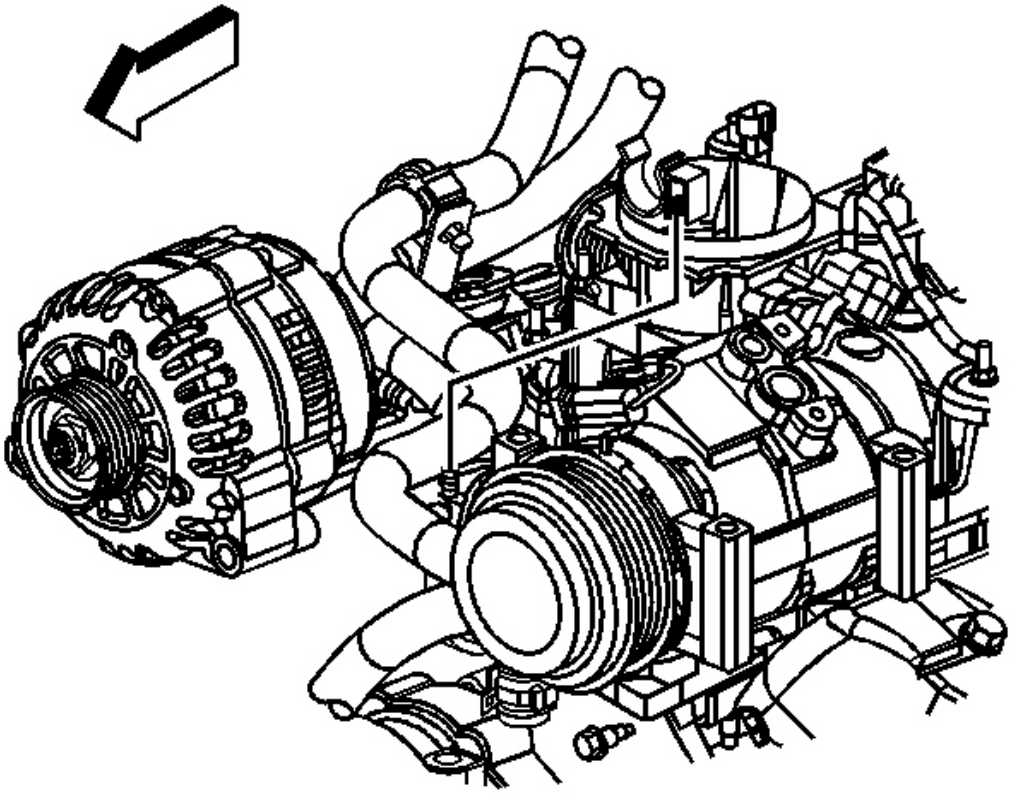


Fig. 127: Heater Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

5. Remove the heater outlet hose from the clip.
6. Move and secure the heater hoses out of the way.

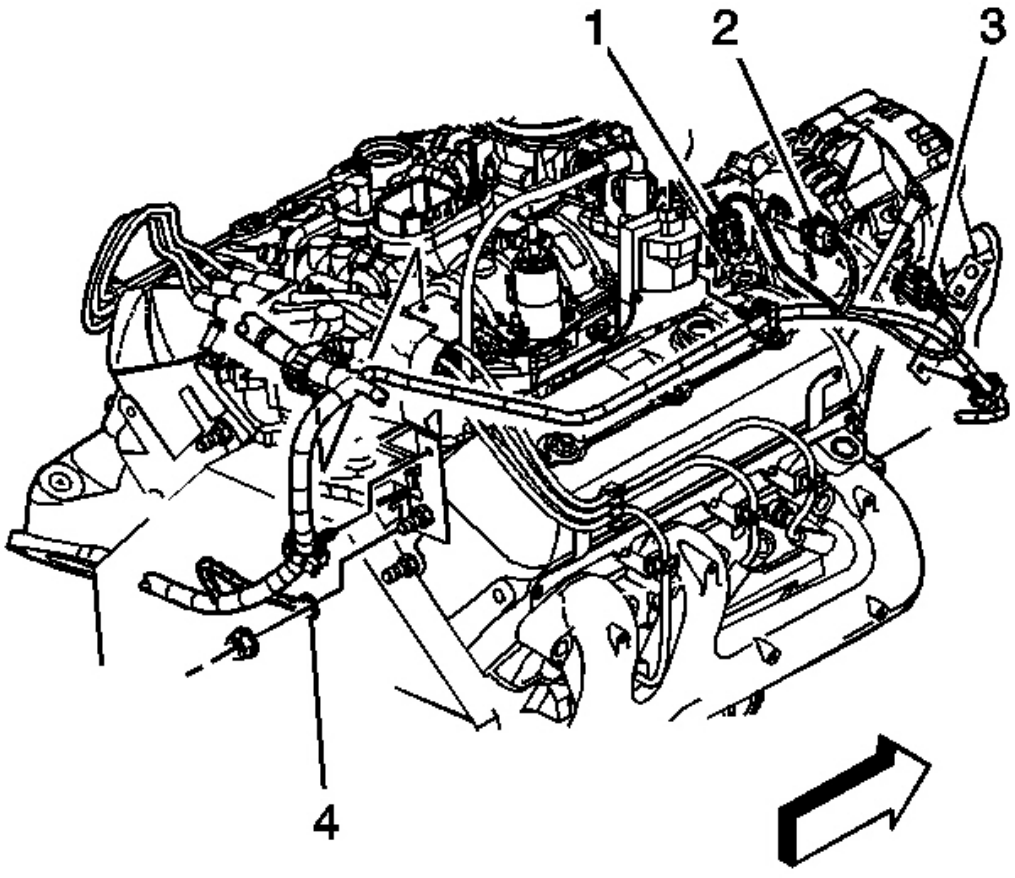


Fig. 128: Ignition Coil, Ignition Coil Driver, Ground Nut/Cable & Generator Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the following electrical connectors:
   - The ignition coil (1)
   - The ignition coil drive (2)
   - The generator (3)
8. Disconnect the engine wiring harness clips.
9. Reposition the engine wiring harness.

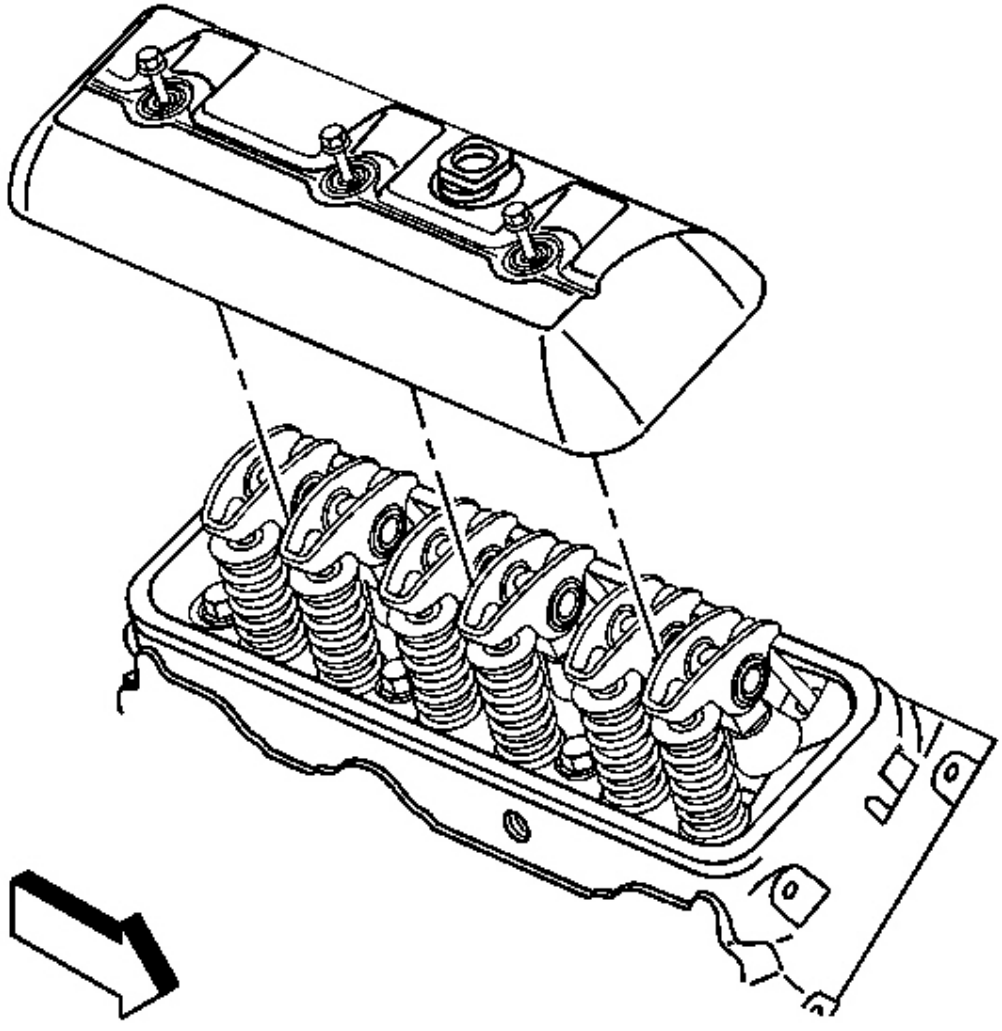


Fig. 129: Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

10. Remove the rocker arm cover bolts.
11. Remove and discard the rocker arm cover bolt grommets, if necessary.
12. Remove the rocker arm cover.

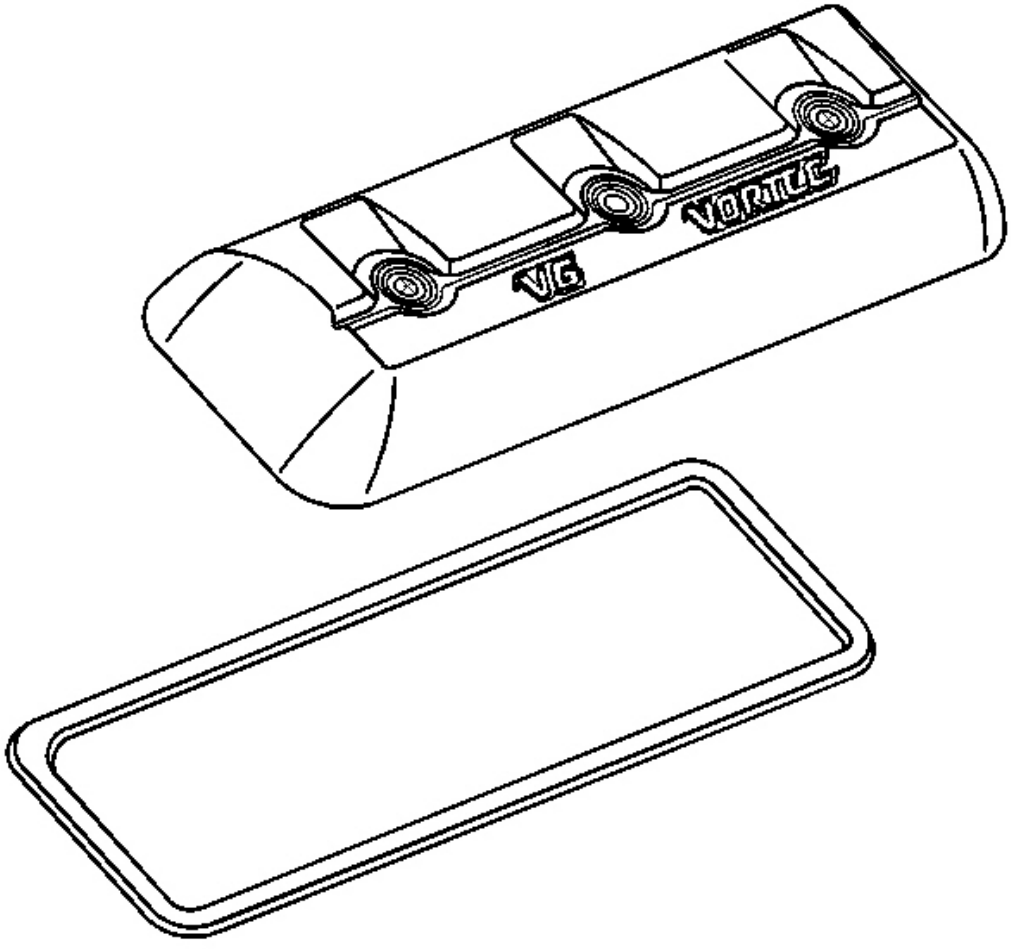


Fig. 130: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the rocker arm cover gasket.
14. Clean and inspect the rocker arm cover, if necessary. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Do not reuse the cover gasket or the valve rocker arm cover bolt grommets.

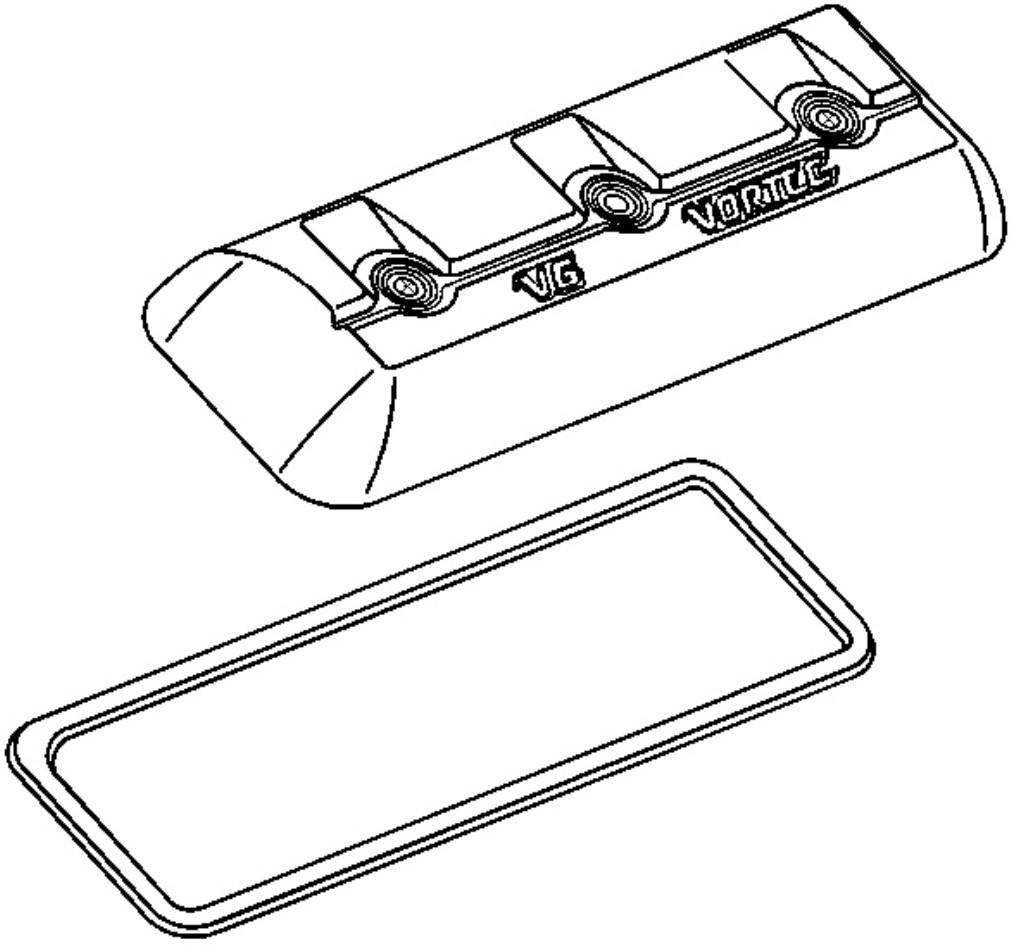


Fig. 131: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW rocker arm cover gasket.
2. Install NEW rocker arm cover bolt grommets, if necessary.

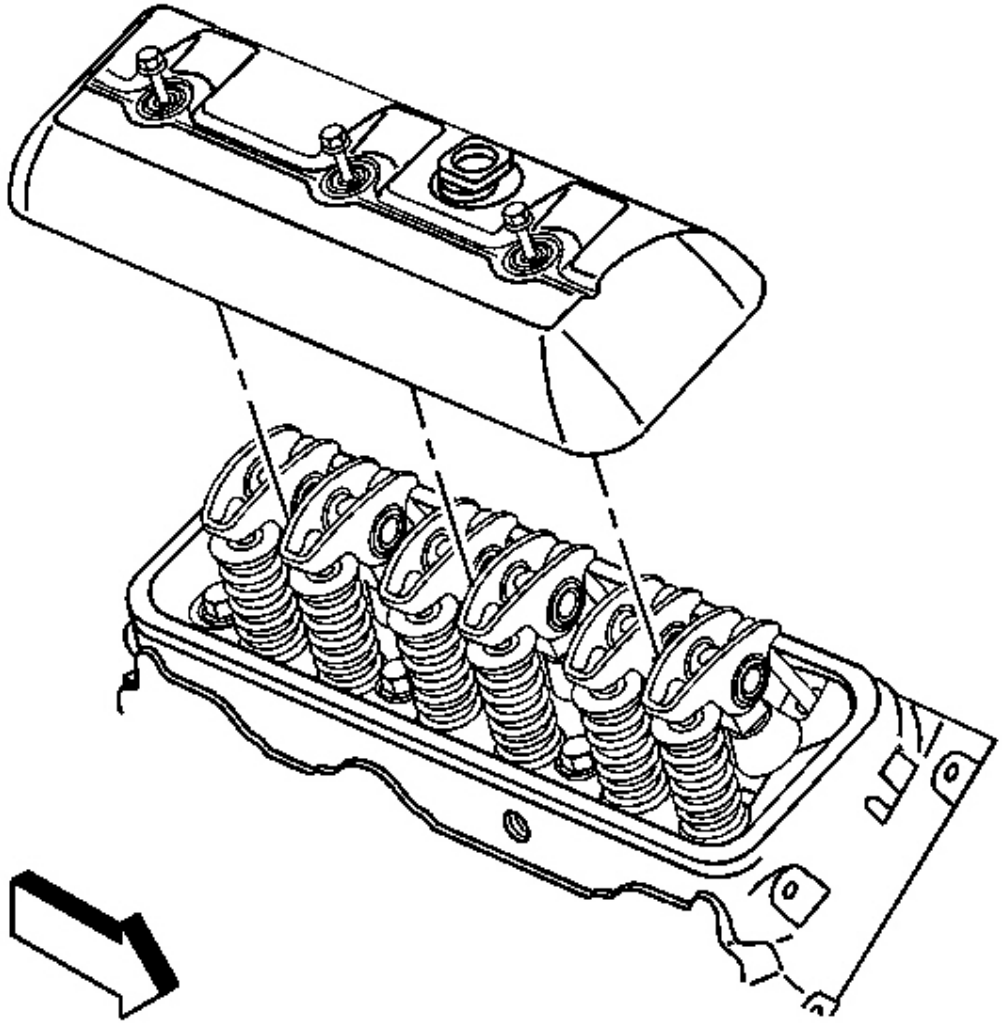


Fig. 132: Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the rocker arm cover.
4. Install the rocker arm cover bolts.

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

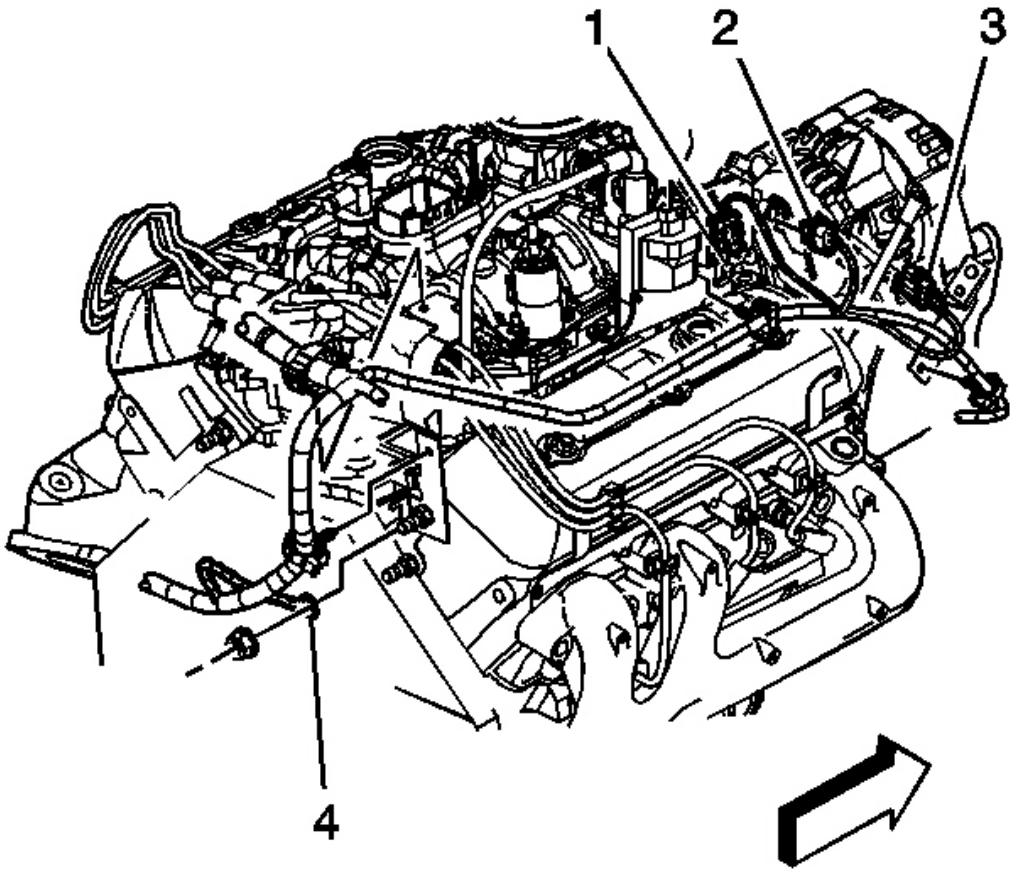


Fig. 133: Ignition Coil, Ignition Coil Driver, Ground Nut/Cable & Generator Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

5. Position the engine wiring harness.
6. Connect the engine wiring harness clips.
7. Connect the following electrical connectors:
   - The ignition coil (1)
   - The ignition coil drive (2)
   - The generator (3)

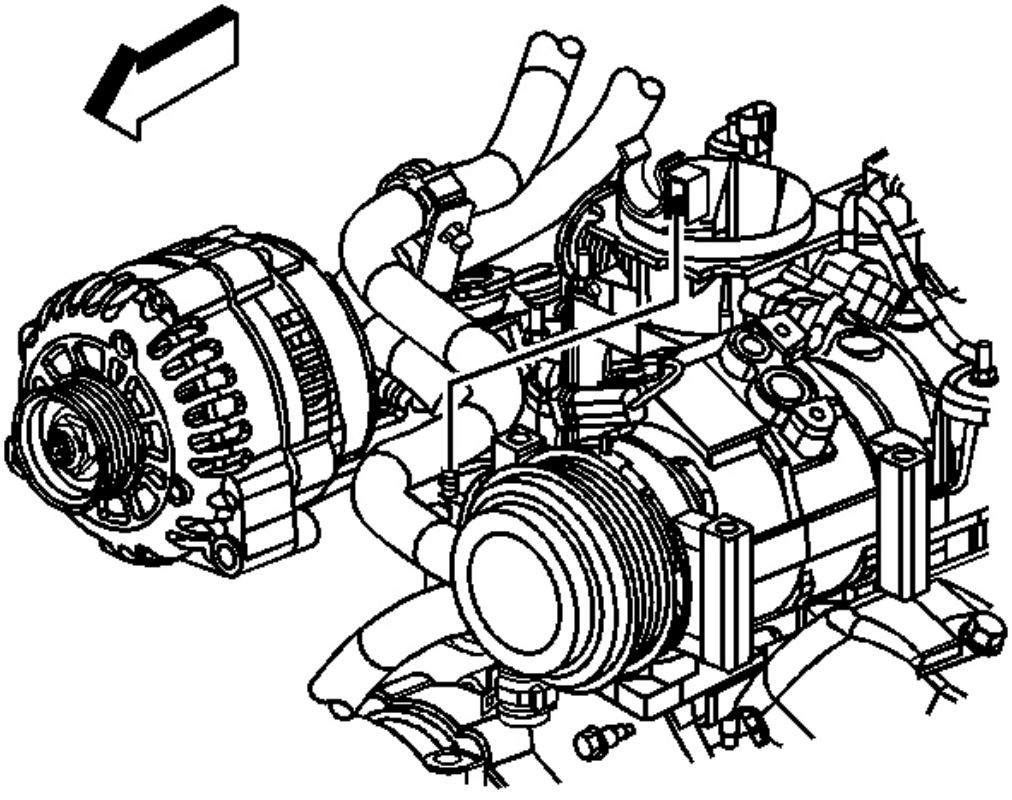


Fig. 134: Heater Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

8. Position the heater hoses.
9. Install the heater outlet to the hose clip.

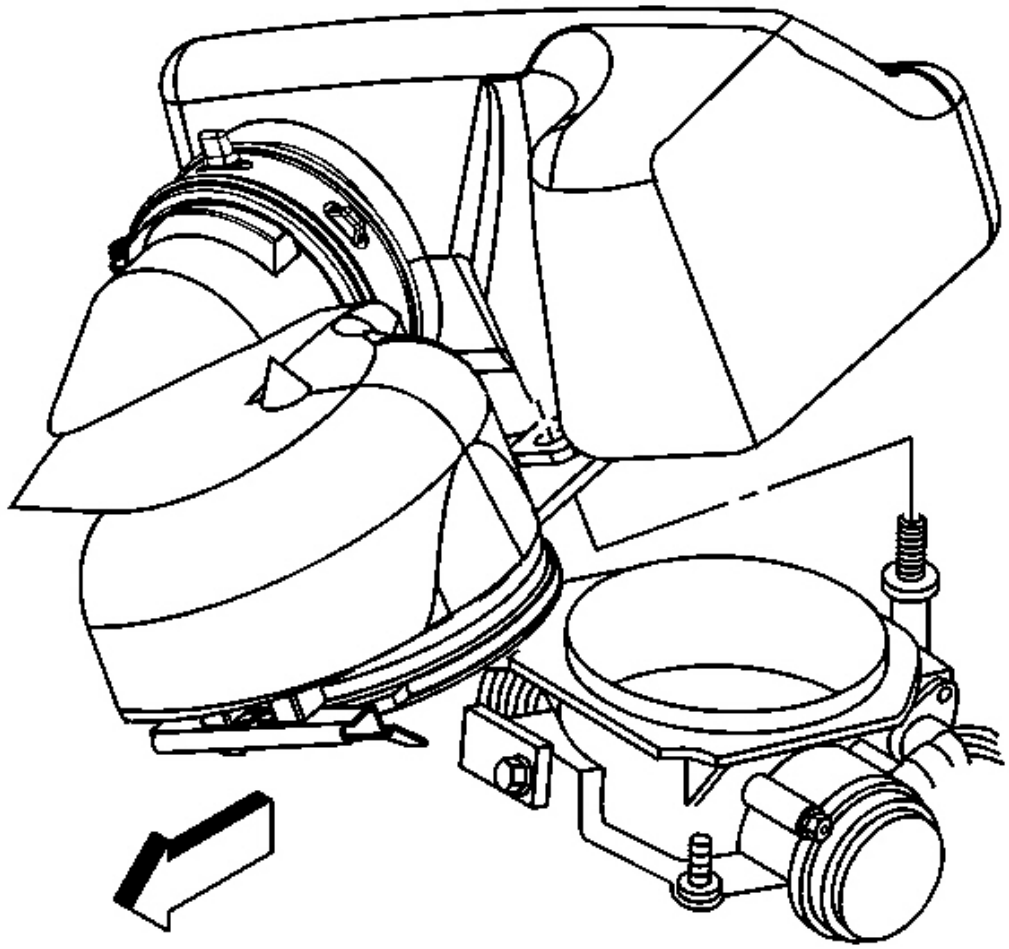


Fig. 135: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

10. Align the hinge clip with the lip on the throttle body.

    In order to install the air cleaner outlet duct, pivot the air cleaner outlet duct downward until the mounting stud is through the hole.

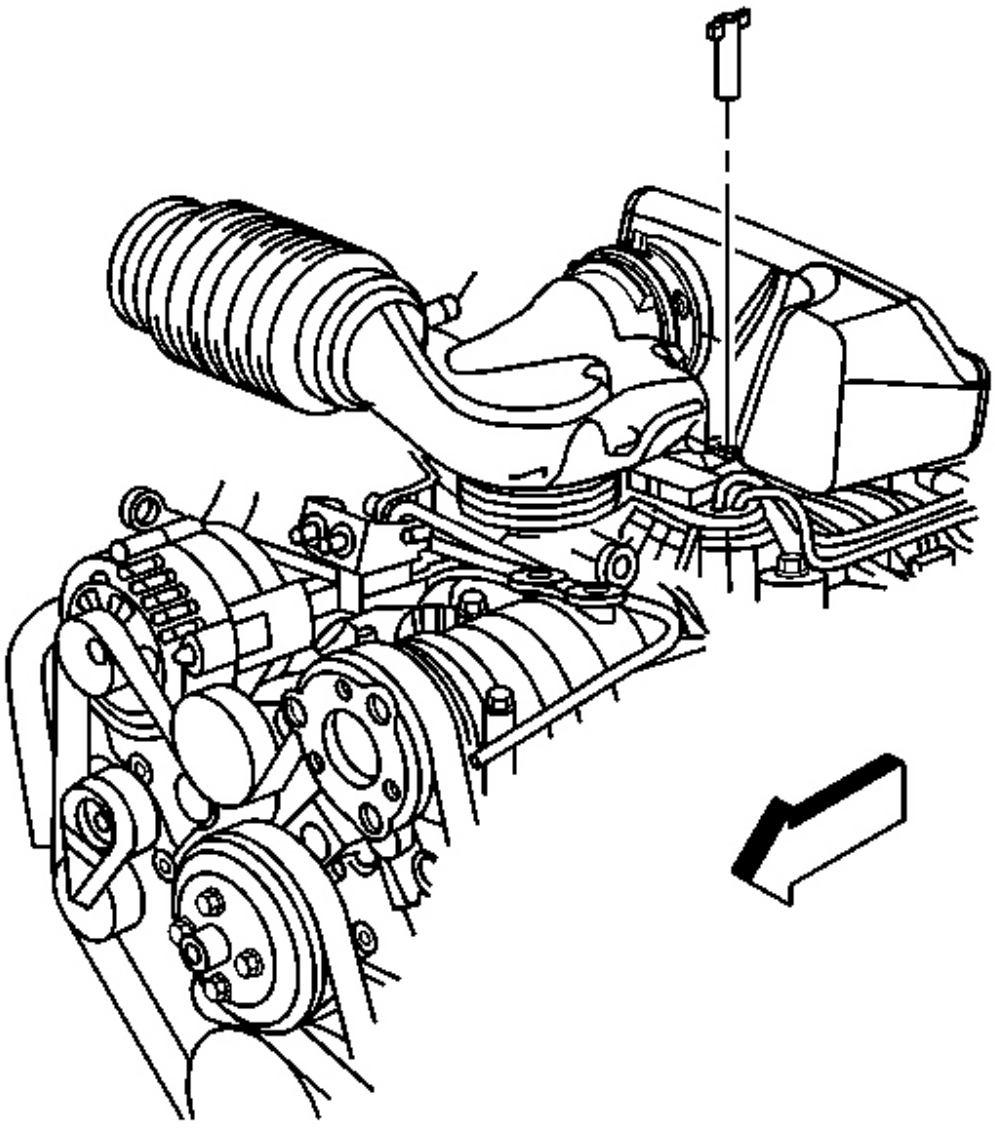


Fig. 136: View Of Air Cleaner Adapter Nut
Courtesy of GENERAL MOTORS CORP.

11. Install the air cleaner adapter nut.

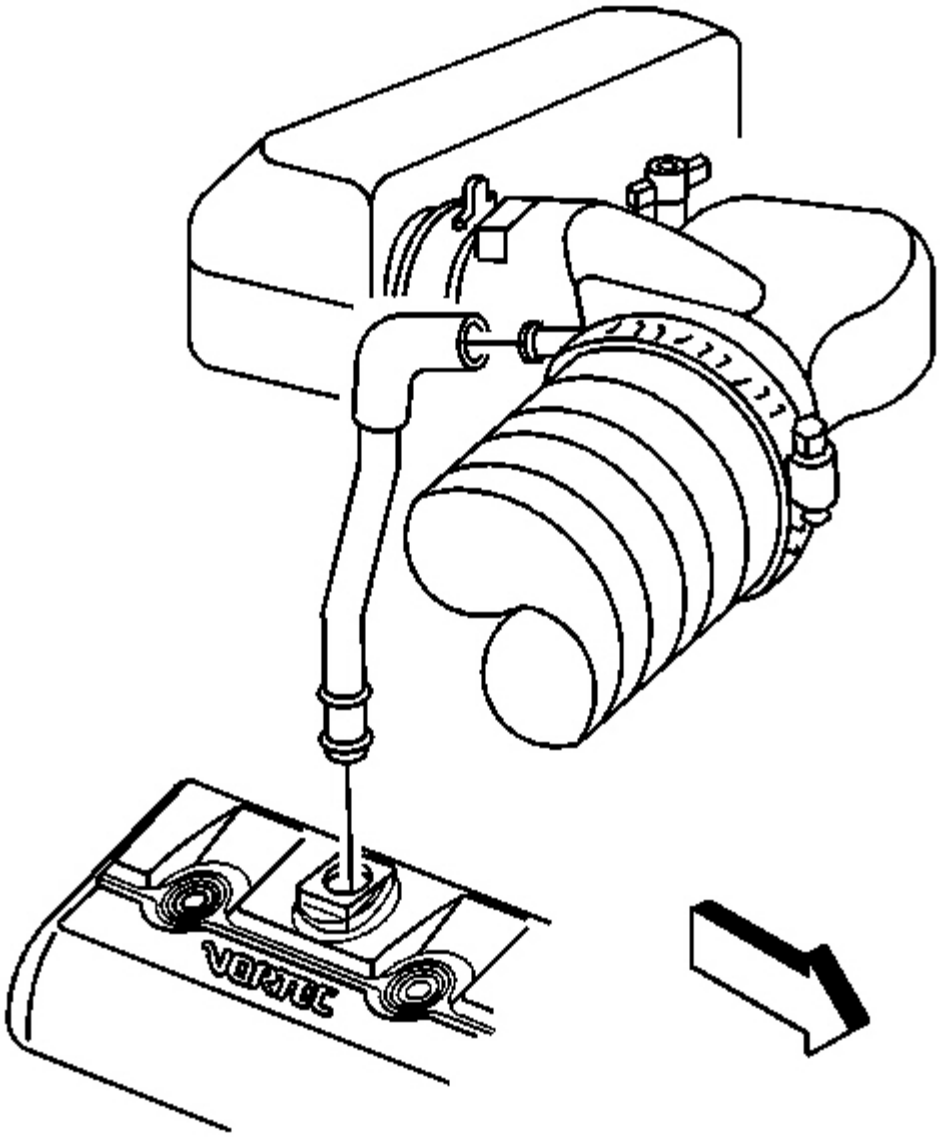


Fig. 137: Identifying PCV Hose
Courtesy of GENERAL MOTORS CORP.

12. Install the PCV hose.

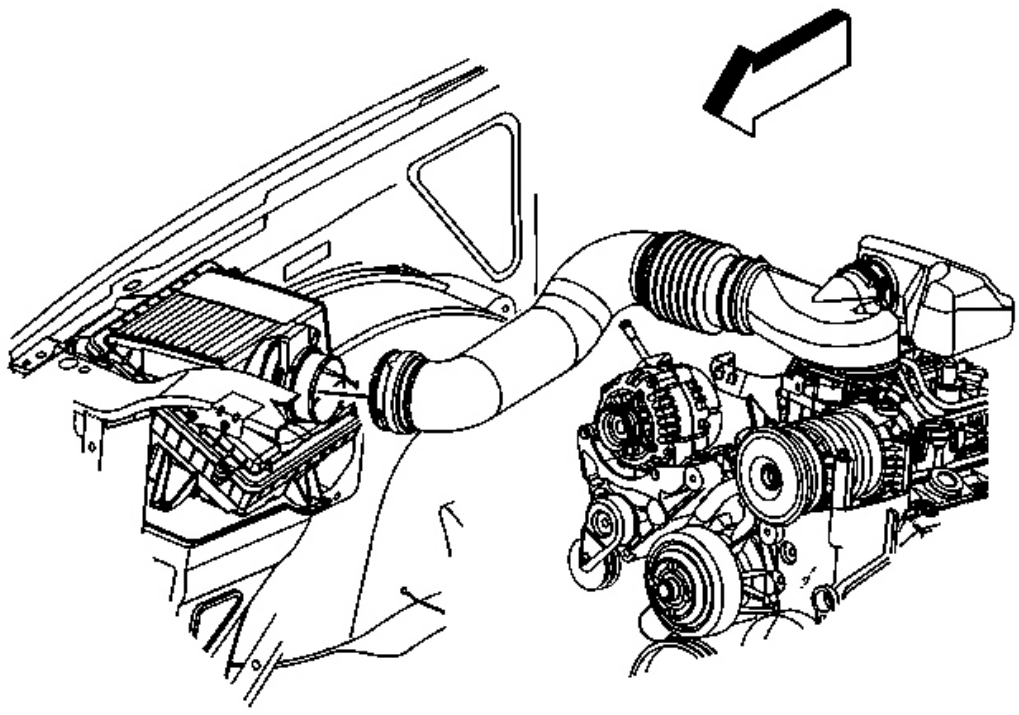


Fig. 138: View Of Air Cleaner Outlet Duct Clamp
Courtesy of GENERAL MOTORS CORP.

13. Tighten the air cleaner outlet duct clamp at the MAF/IAT sensor.

    Tighten: Tighten the clamp to 4 N.m (35 lb in).

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

IMPORTANT: Mark, sort, and organize all the components for assembly.

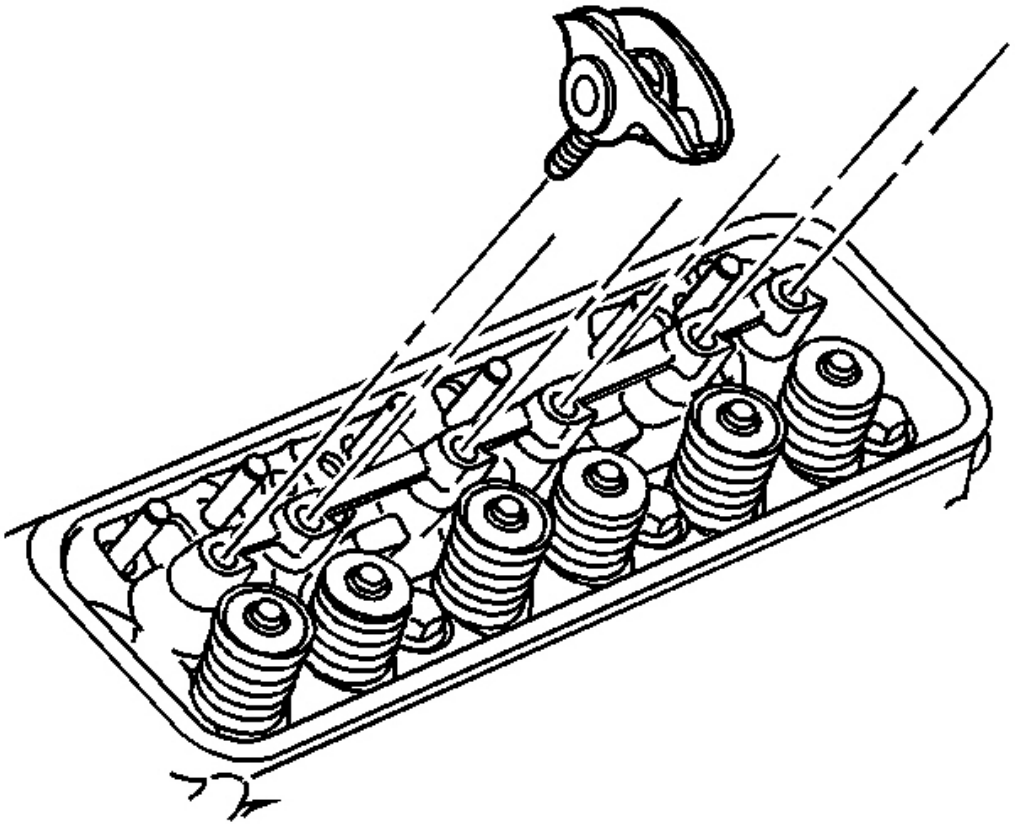


Fig. 139: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

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

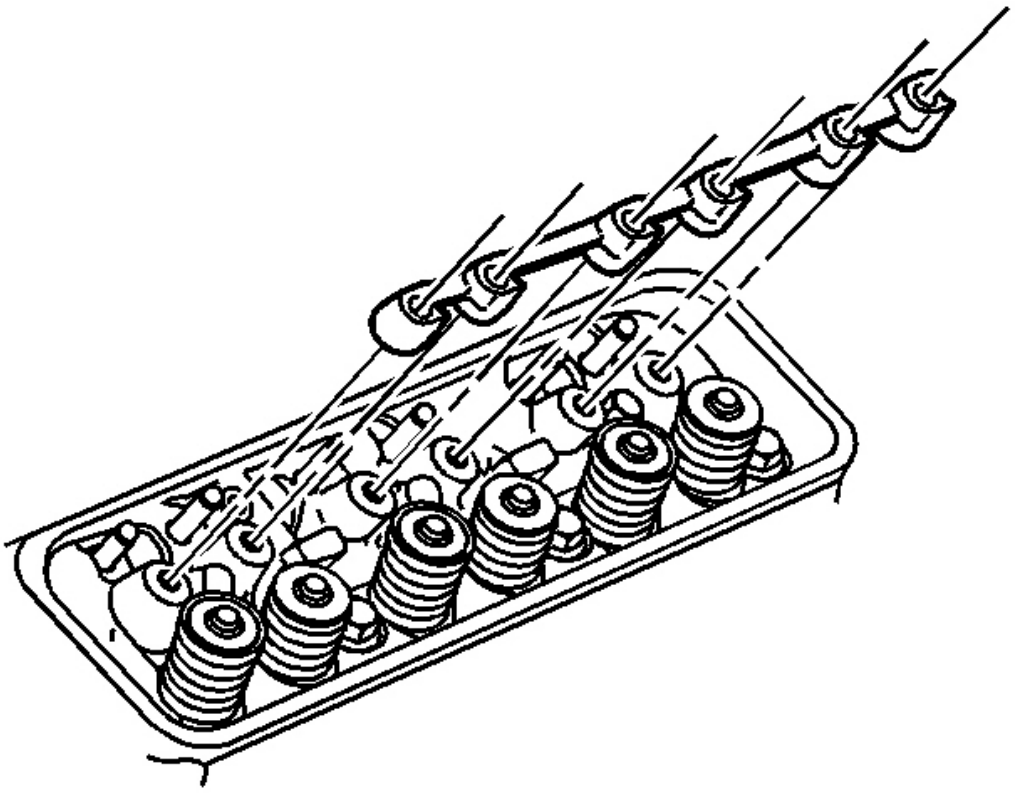


Fig. 140: View Of Valve Rocker Arm Supports
Courtesy of GENERAL MOTORS CORP.

3. Remove the rocker arm supports.

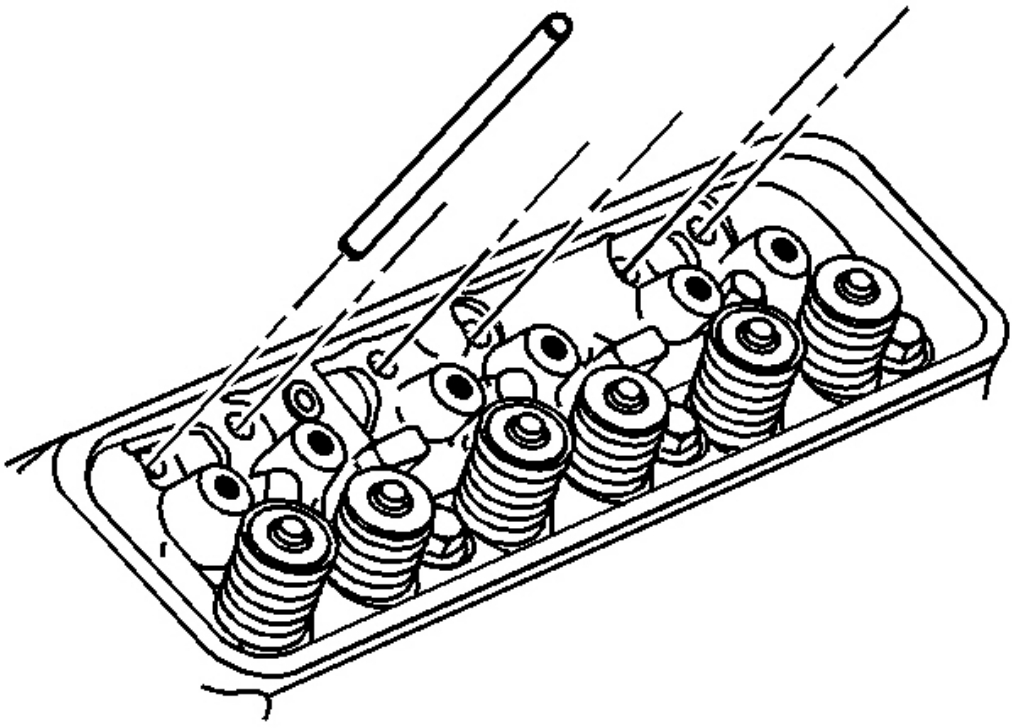


Fig. 141: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.
5. Clean and inspect the rocker arms and/or pushrods, if necessary. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Be sure to keep parts in order. Parts must be reinstalled into the original location and position.

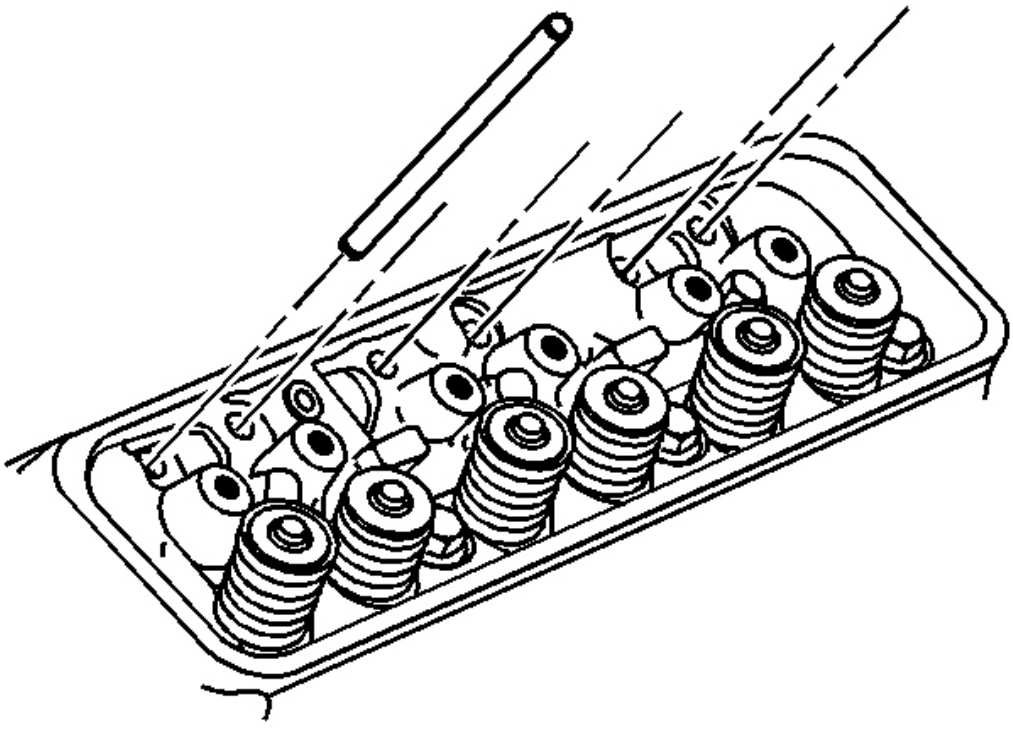


Fig. 142: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

1. Install the pushrods.

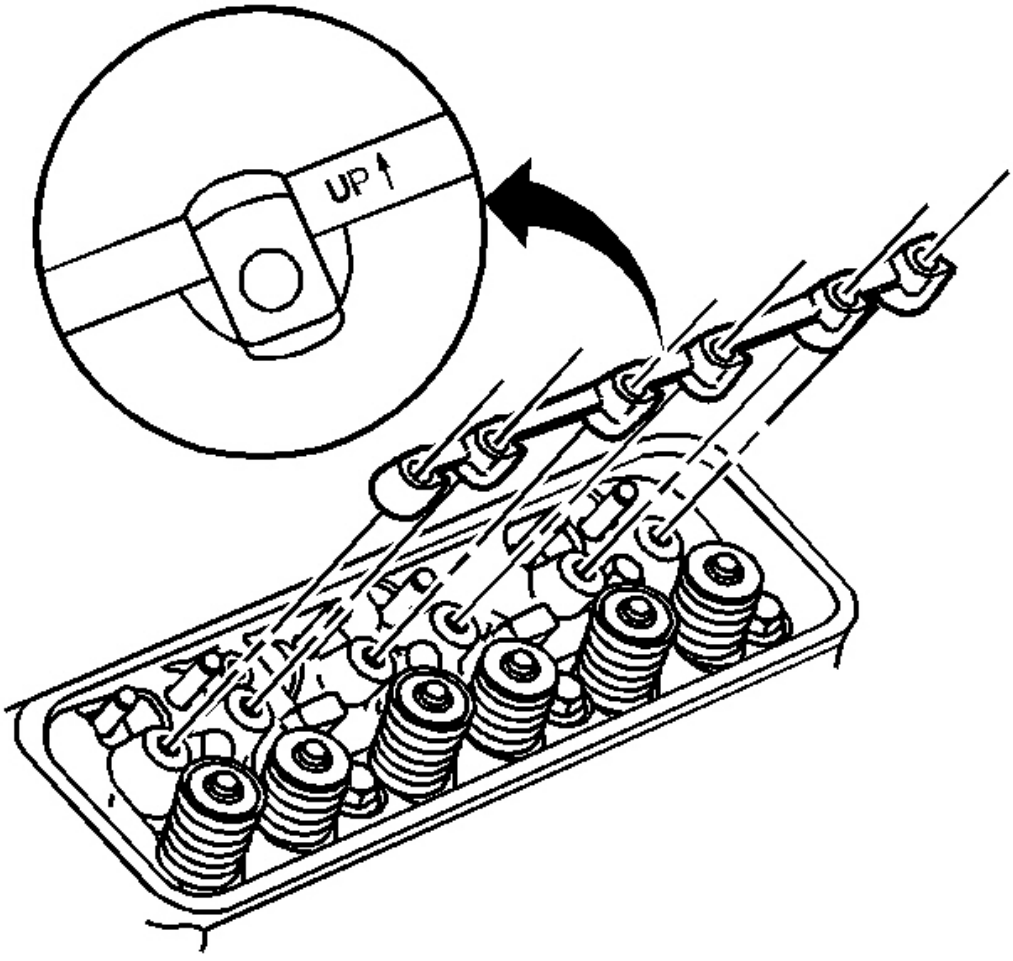


Fig. 143: Locating Arrow On Valve Rocker Arm Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure that the arrow on the rocker arm support is in the up position.

2. Install the rocker arm supports.

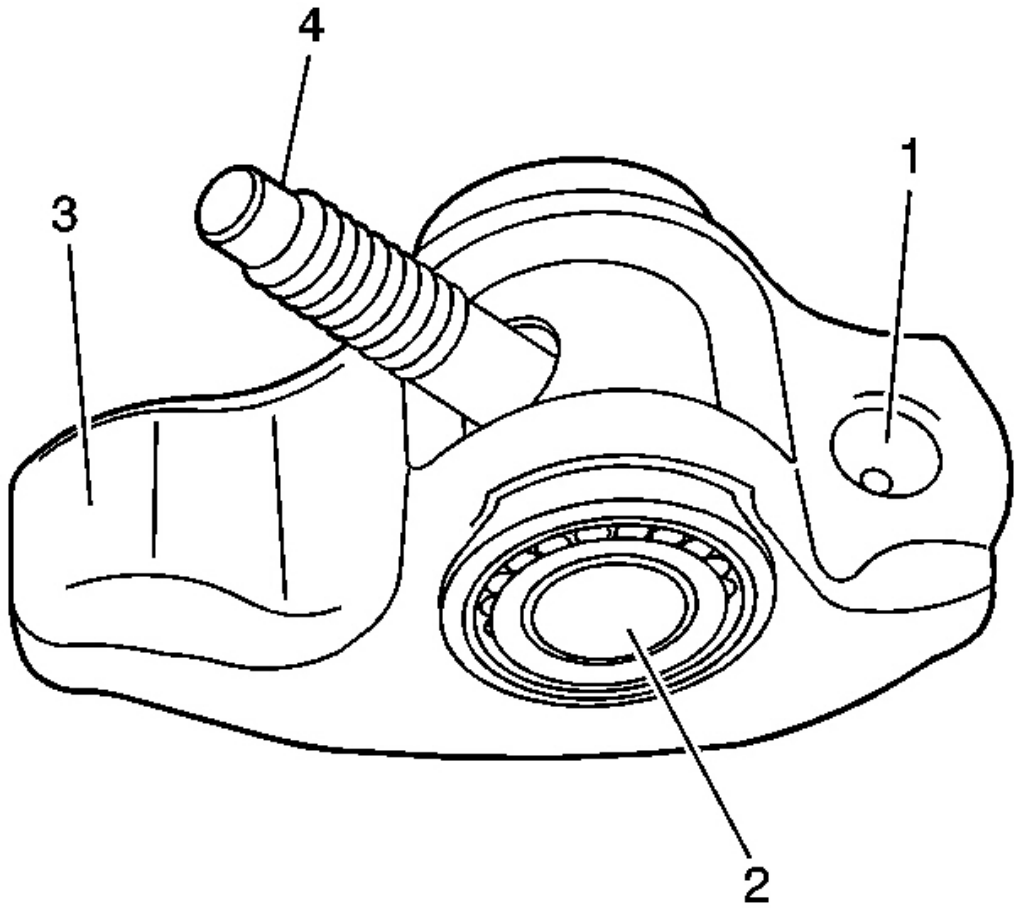


Fig. 144: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS CORP.

3. Apply lubricant to the following rocker arm contact surfaces:
   - Pushrod socket (1)
   - Roller pivot (2)
   - Valve stem tip (3)

   Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

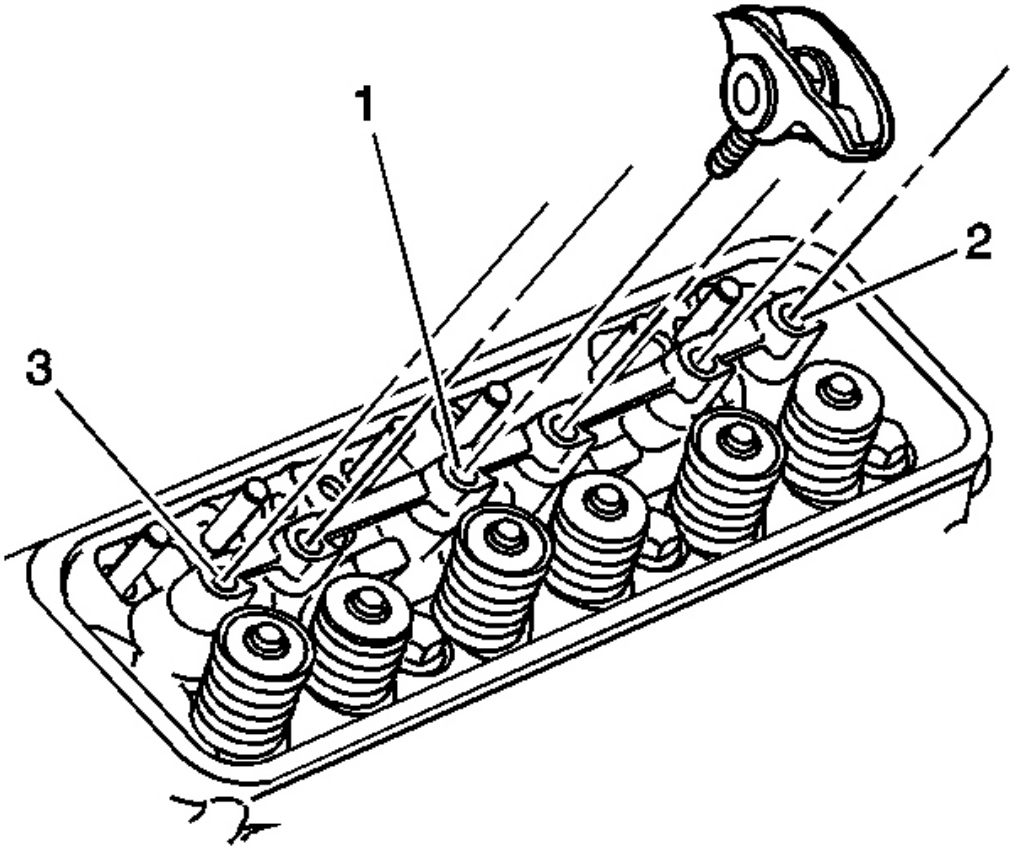


Fig. 145: Valve Rocker Arm Assemblies
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the rocker arms as follows:
    1. Finger start the bolt at location (1)
    2. Finger start the bolt at location (2)
    3. Finger start the bolt at location (3)
    4. Finger start the remaining rocker arm bolts

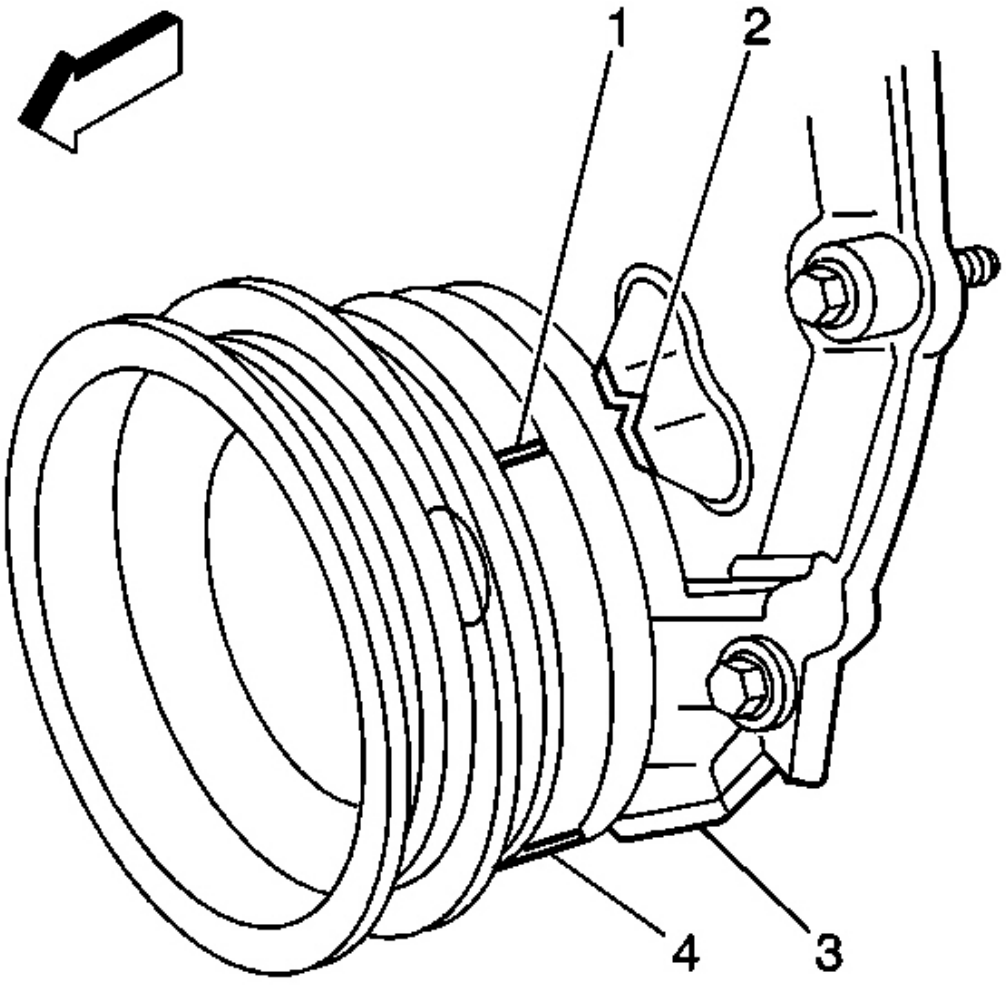


Fig. 146: View Of Crankshaft Balancer Alignment Mark & Engine Front Cover Alignment Tab
Courtesy of GENERAL MOTORS CORP.

5. Rotate the crankshaft balancer to position the crankshaft balancer alignment mark (1) 57-63 degrees clockwise or counterclockwise from the engine front cover alignment tab (2).

IMPORTANT: Once the rocker arms are installed and properly torqued, no additional valve lash adjustment is required.

6. Tighten the rocker arm bolts.

   Tighten: Tighten bolts to 30 N.m (22 lb ft).

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

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **J 22794** Spark Plug Port Adapter. See **Special Tools**.
- **J 38606** Valve Spring Compressor. See **Special Tools**.
- **J 5892-D** Valve Spring Compressor. See **Special Tools**.
- **J 42073** Valve Stem Oil Seal Installer. See **Special Tools**.

Removal Procedure

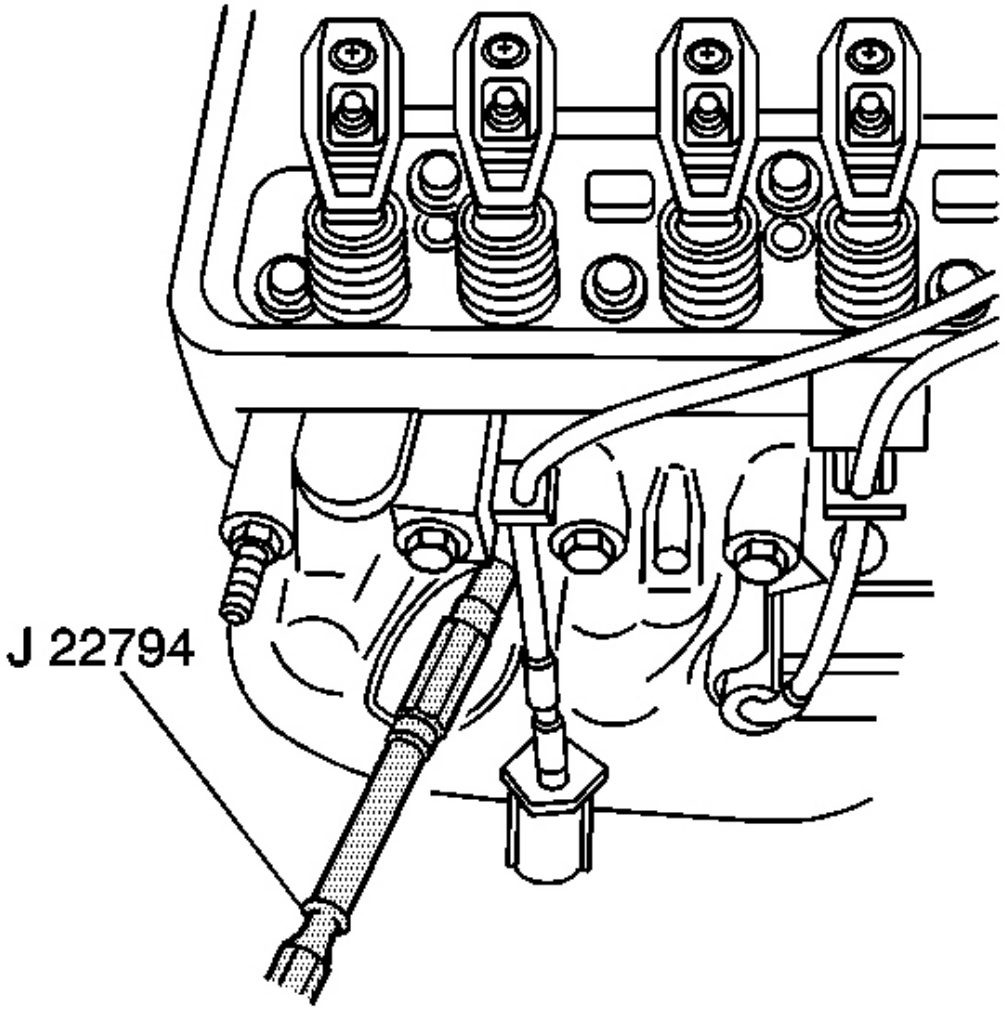


Fig. 147: Installing J 22794 Into Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

1. Remove the required valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Remove the required spark plugs. Refer to **Spark Plug Replacement** .
3. Install the **J 22794** into the spark plug hole. See **Special Tools**.
4. Connect a shop air supply hose and apply compressed air in order to hold the valves in place.

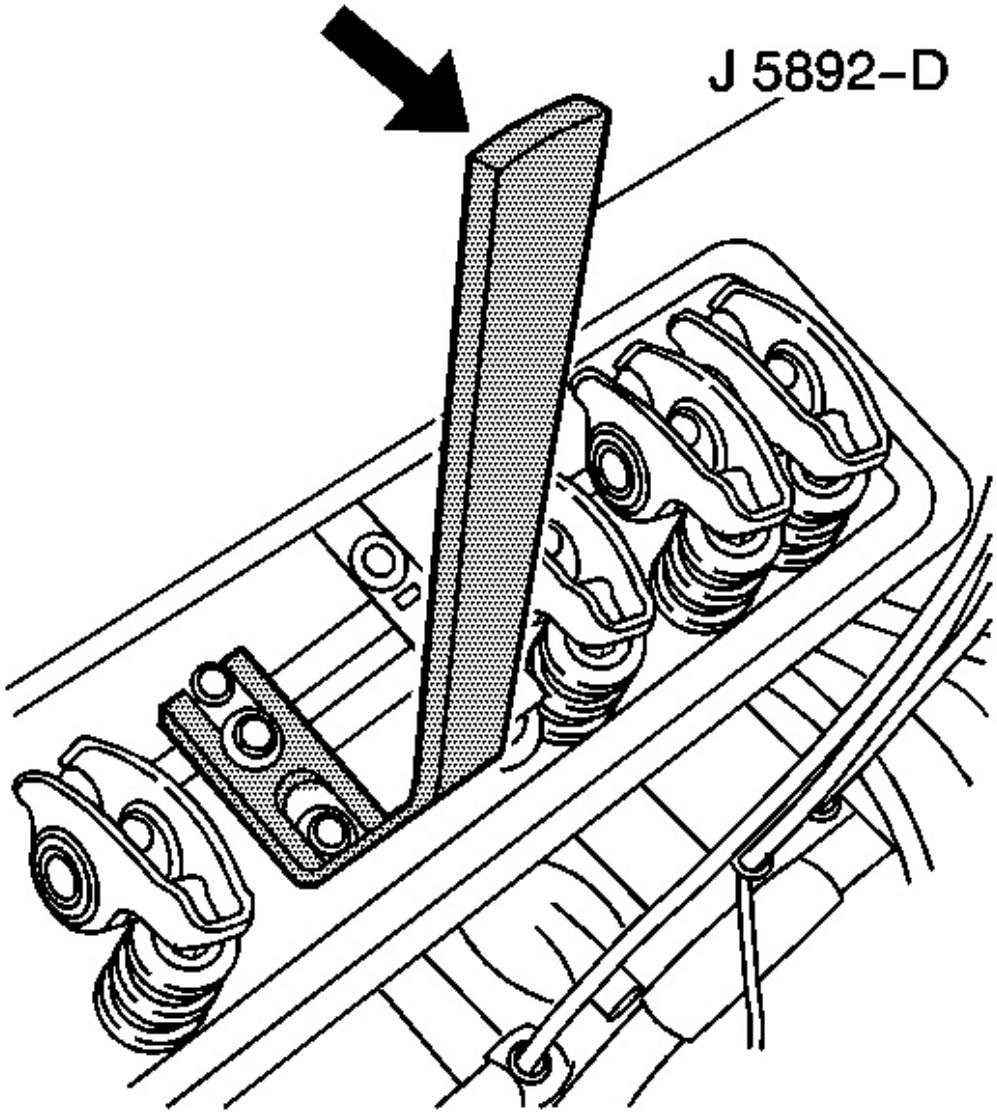


Fig. 148: Installing J 5892-D Under Washer On Rocker Arm Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install a flat washer onto the removed rocker arm bolt.
6. Install the bolt and rocker arm for the valve spring requiring removal.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

7. Using **J 5892-D** compress the valve spring. See **Special Tools**.
    1. Hook the slotted end of **J 5892-D** under the washer on the rocker arm bolt. See **Special Tools**.
    2. Apply steady pressure on the valve spring cap until the valve keys are accessible.

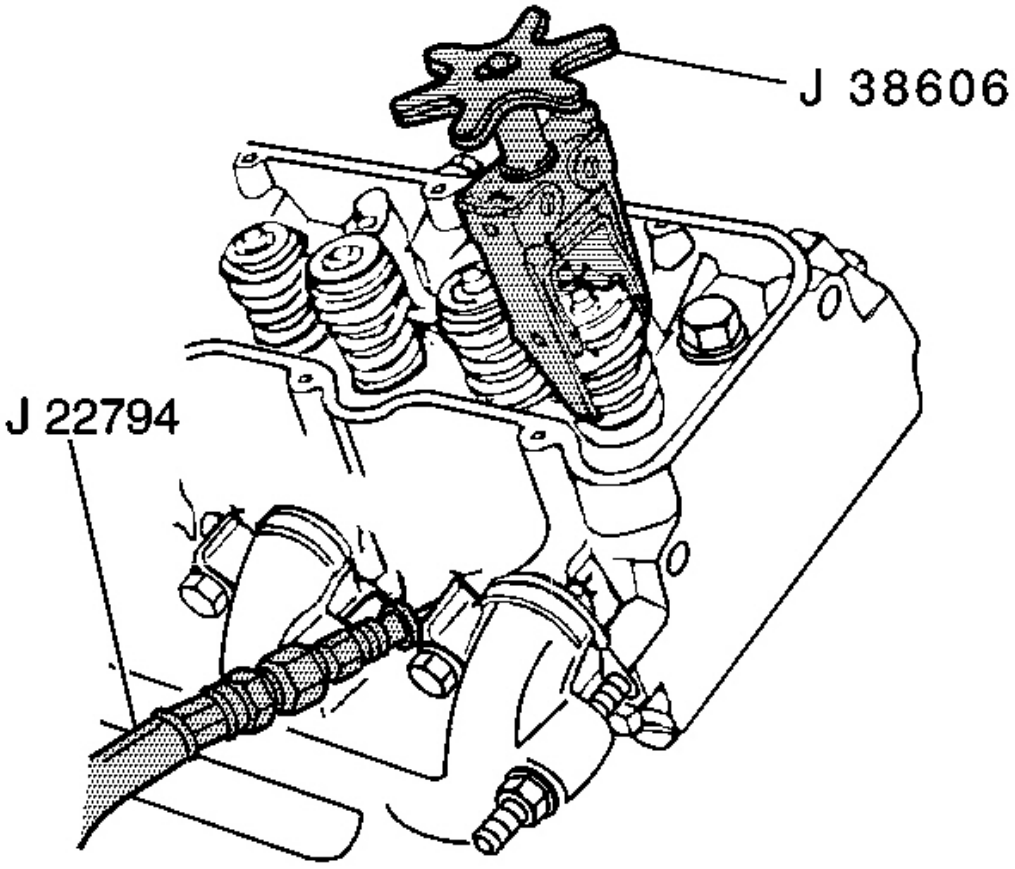


Fig. 149: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

NOTE: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

8. Use **J 38606** when **J 5892-D** will not fit. See **Special Tools**.

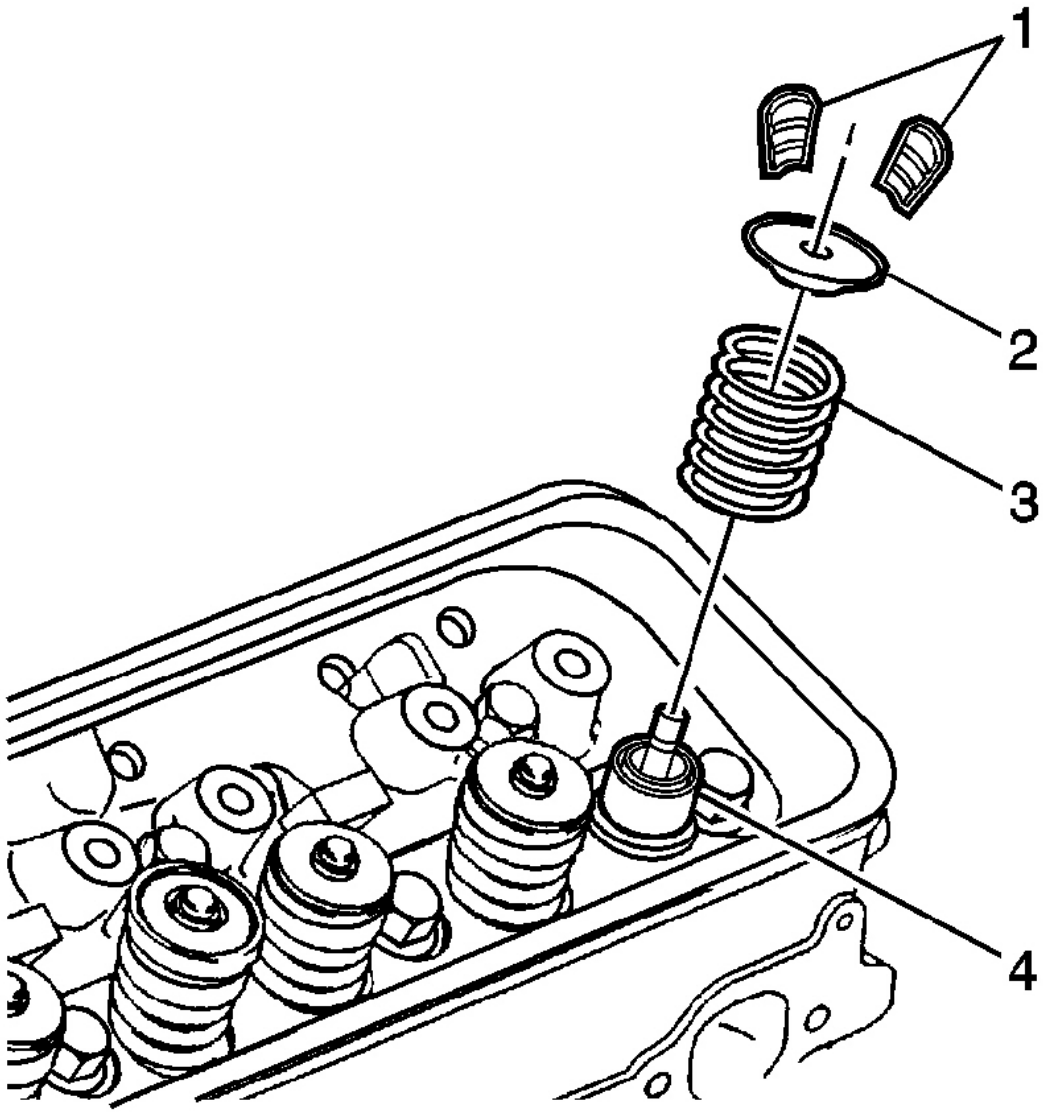


Fig. 150: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve keys (1).
10. Carefully release the valve spring tension.
11. Remove the **J 5892-D** or the **J 38606** . See **Special Tools**.
12. Remove the valve spring cap (2) and valve spring (3).
13. Remove the valve stem oil seal (4).

Installation Procedure

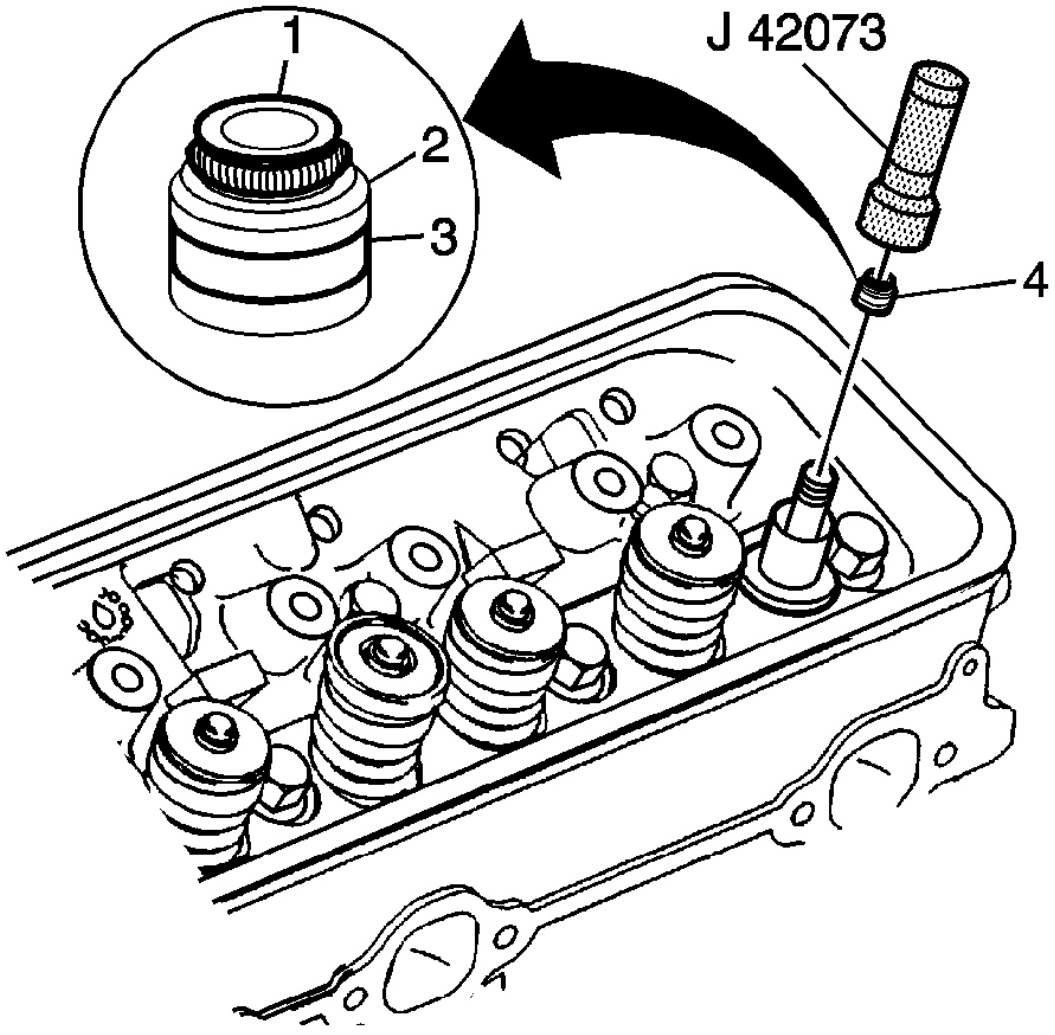


Fig. 151: Exhaust Valve Oil Stem Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal, or the material may be red in color (2) with no paint stripe. The intake valve oil seal is black in color.

1. Assemble the valve into the proper valve guide.
2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.
4. Assemble the valve stem oil seal onto the valve stem.

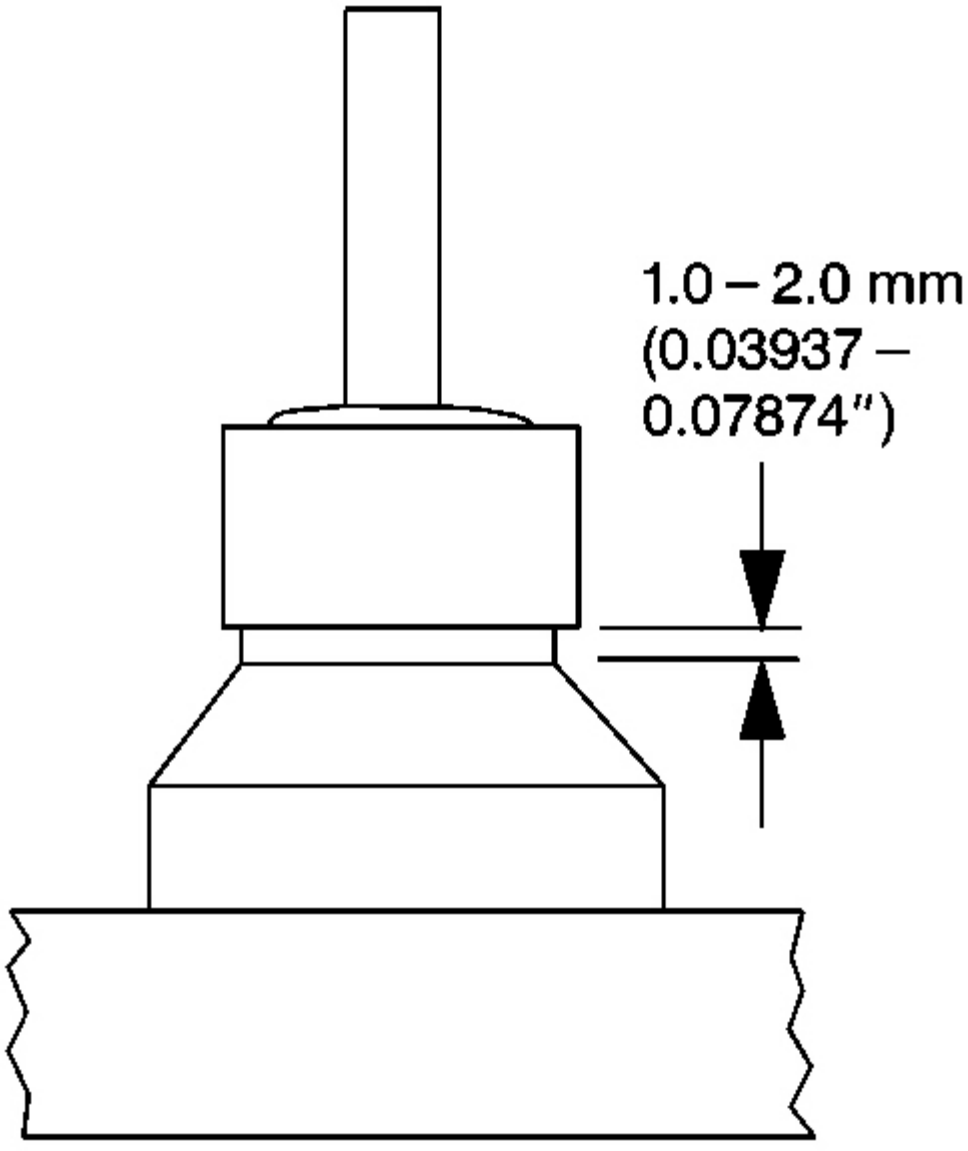


Fig. 152: Valve Stem Oil Seal Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 42073** , install the valve stem oil seal onto the valve guide. See **Special Tools**.
    1. Tap the valve stem oil seal onto the valve guide until the **J 42073** bottoms against the valve spring seat. See **Special Tools**.

2. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

   There should be a 1-2 mm (0.03937-0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

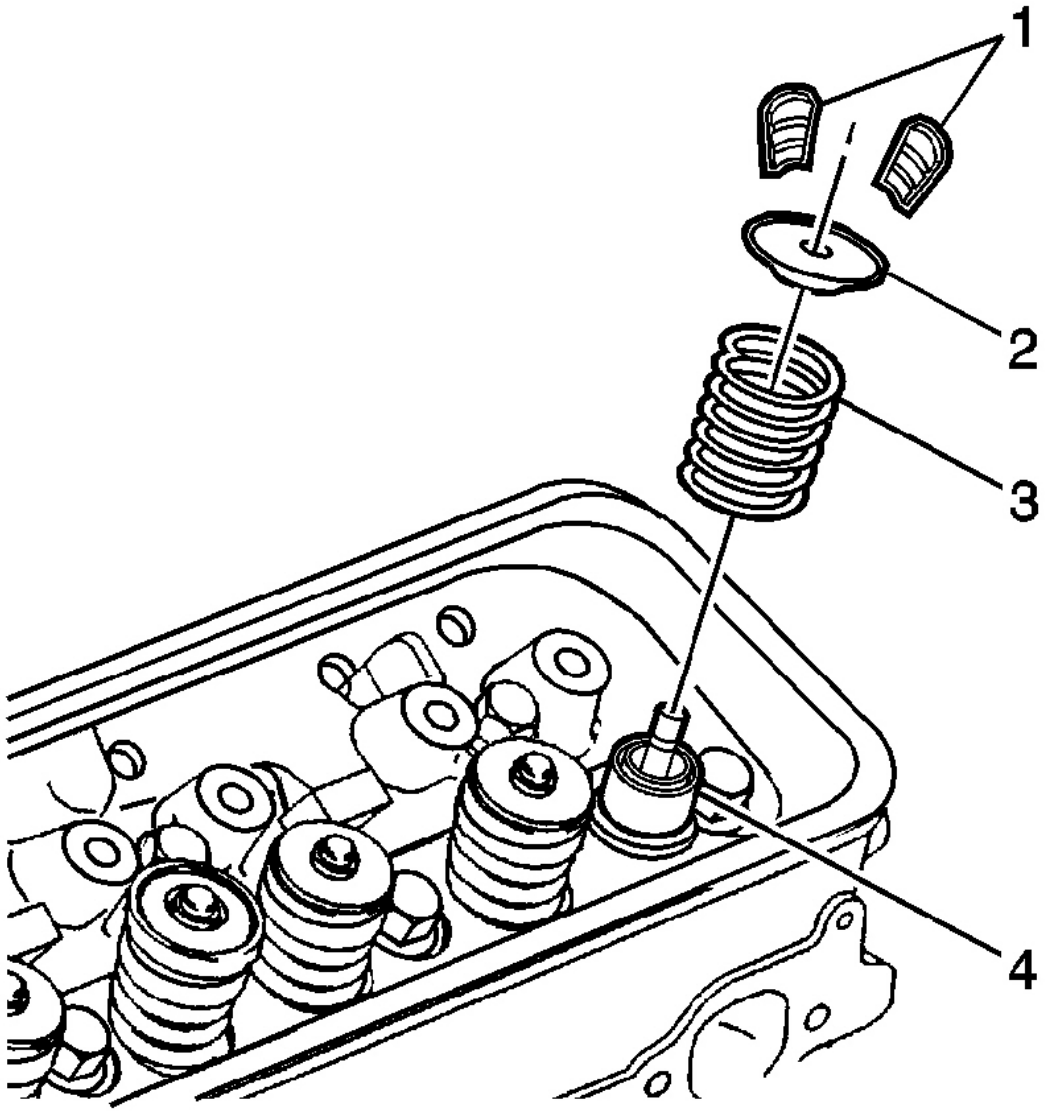


Fig. 153: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

6. Install the valve spring (3).
7. Install the valve spring cap (2) onto the valve spring (3), over the valve stem.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

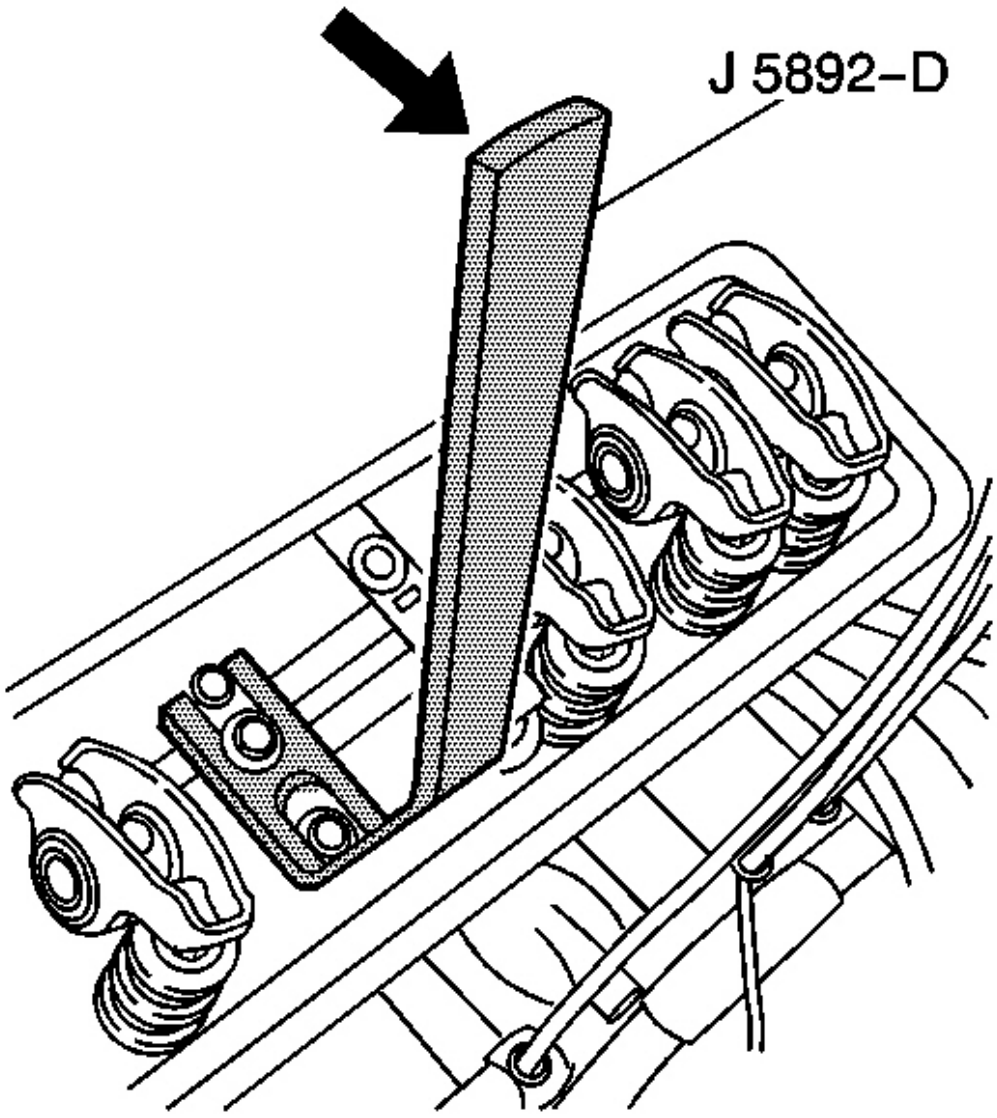


Fig. 154: Installing J 5892-D Under Washer On Rocker Arm Bolt
Courtesy of GENERAL MOTORS CORP.

8. Use the **J 5892-D** in order to compress the valve spring. See **Special Tools**.

   Hook the slotted end of **J 5892-D** under the washer on the valve rocker arm bolt. See **Special Tools**.

9. Apply steady pressure on the valve spring cap until the valve keys are accessible.

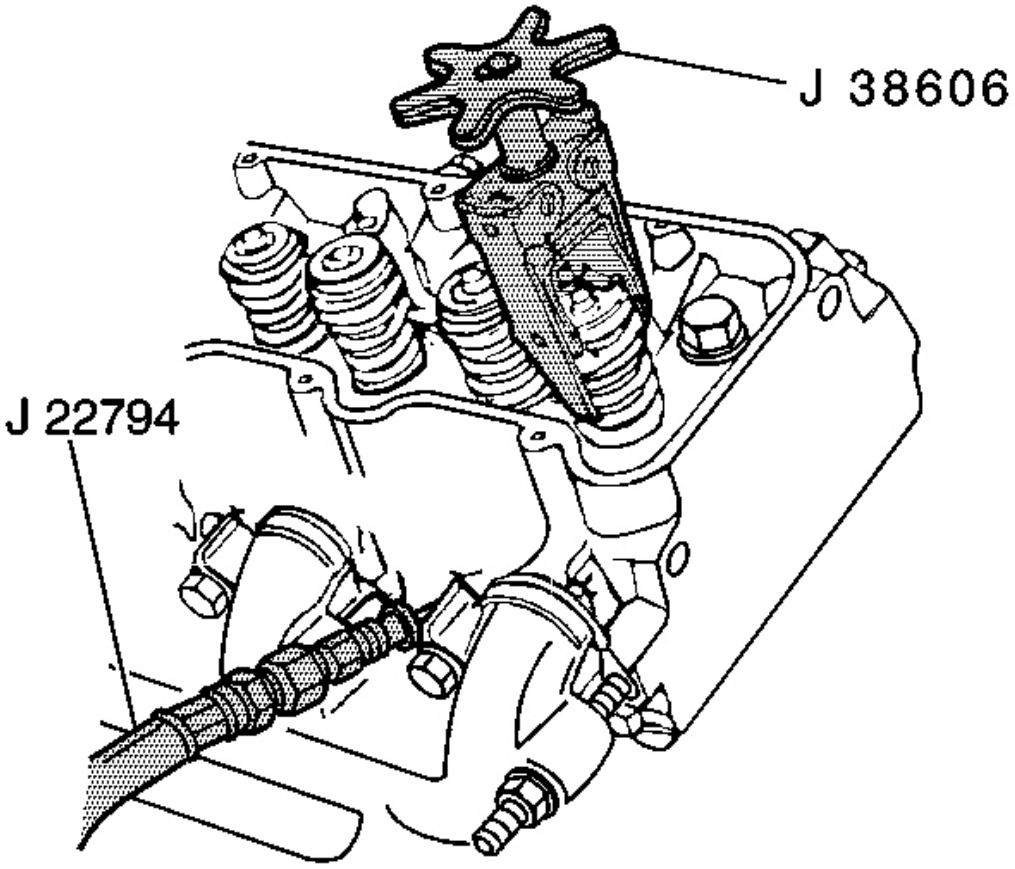


Fig. 155: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

NOTE: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

10. Use the **J 38606** if the clearance does not permit use of the **J 5892-D** . See **Special Tools**.
11. Install the valve stem O-ring seal.
12. Install the valve stem keys.

Use grease in order to hold the valve stem keys in place.

13. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.

NOTE: The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

14. Remove the **J 5892-D** or the **J 38606** . See **Special Tools**.
    1. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
    2. Tap the end of the valve stem with a plastic faced hammer in order to seat the valve stem keys, if necessary.

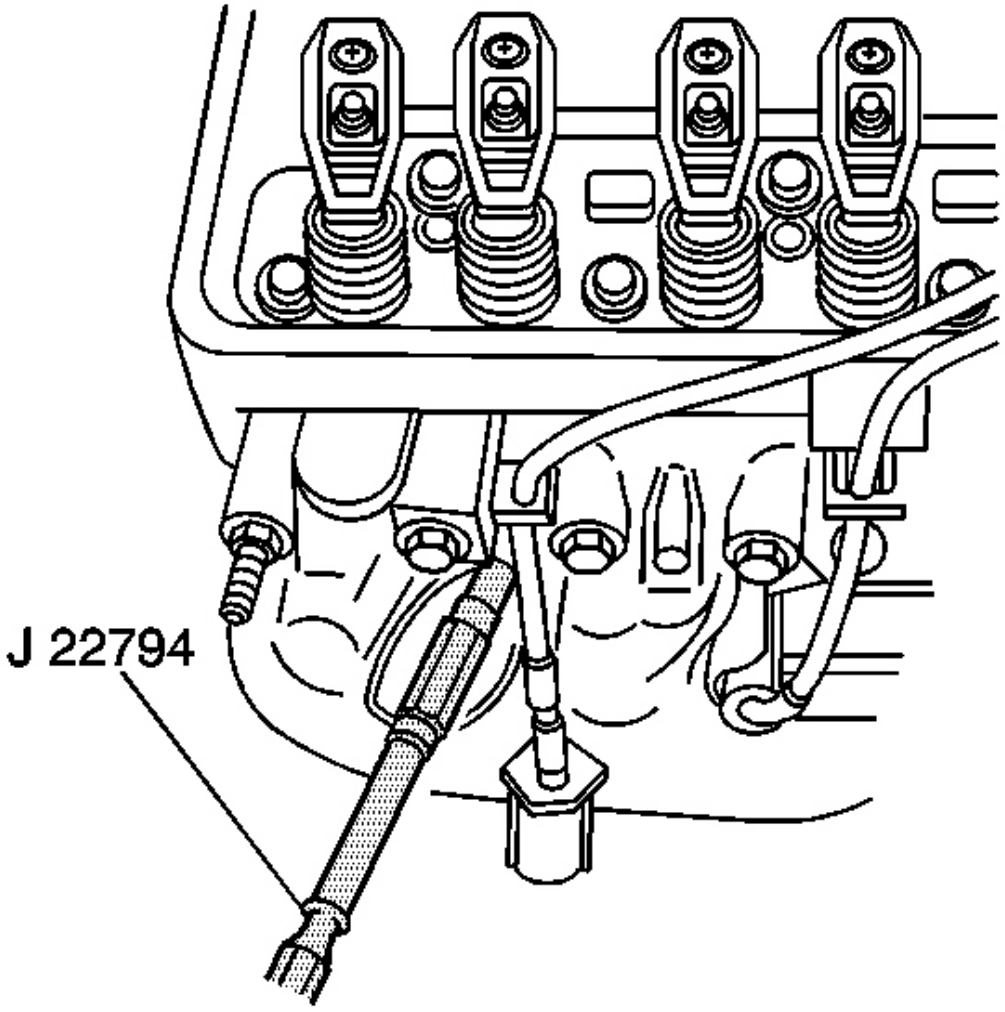


Fig. 156: Installing J 22794 Into Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

15. Remove the **J 22794** . See **Special Tools**.
16. Install the spark plugs. Refer to **Spark Plug Replacement** .
17. Install the valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.

VALVE LIFTER REPLACEMENT

Tools Required

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

Removal Procedure

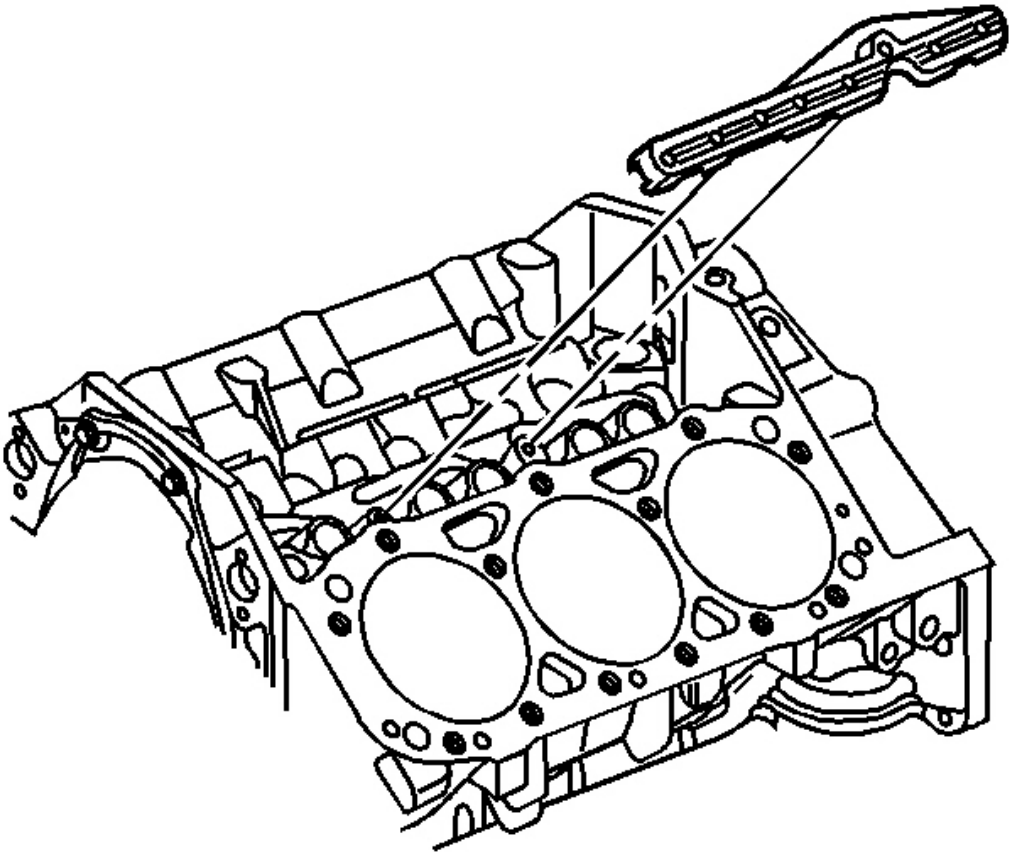


Fig. 157: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Lower Intake Manifold Replacement**.
2. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

IMPORTANT: Place the components in a rack so that the components can be installed to their original location.

3. Remove the bolts and lifter pushrod guide.

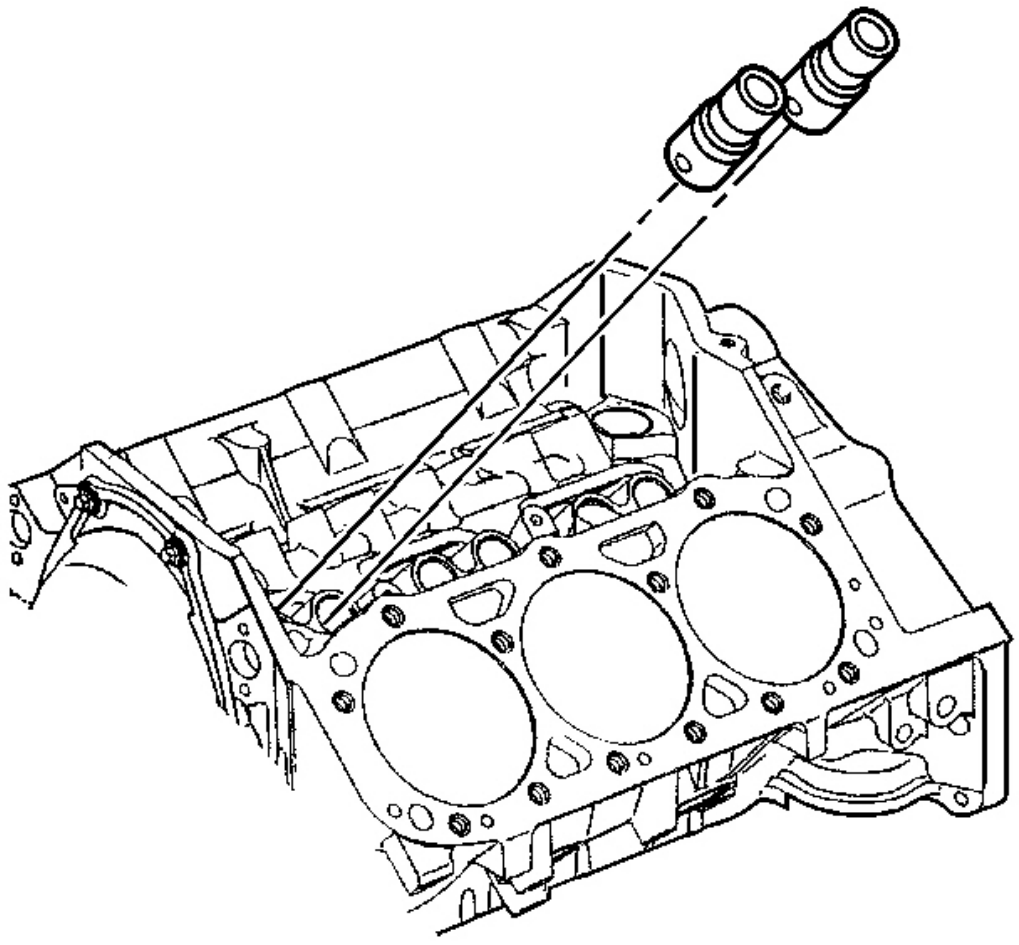


Fig. 158: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifters.

4. Remove the lifters.

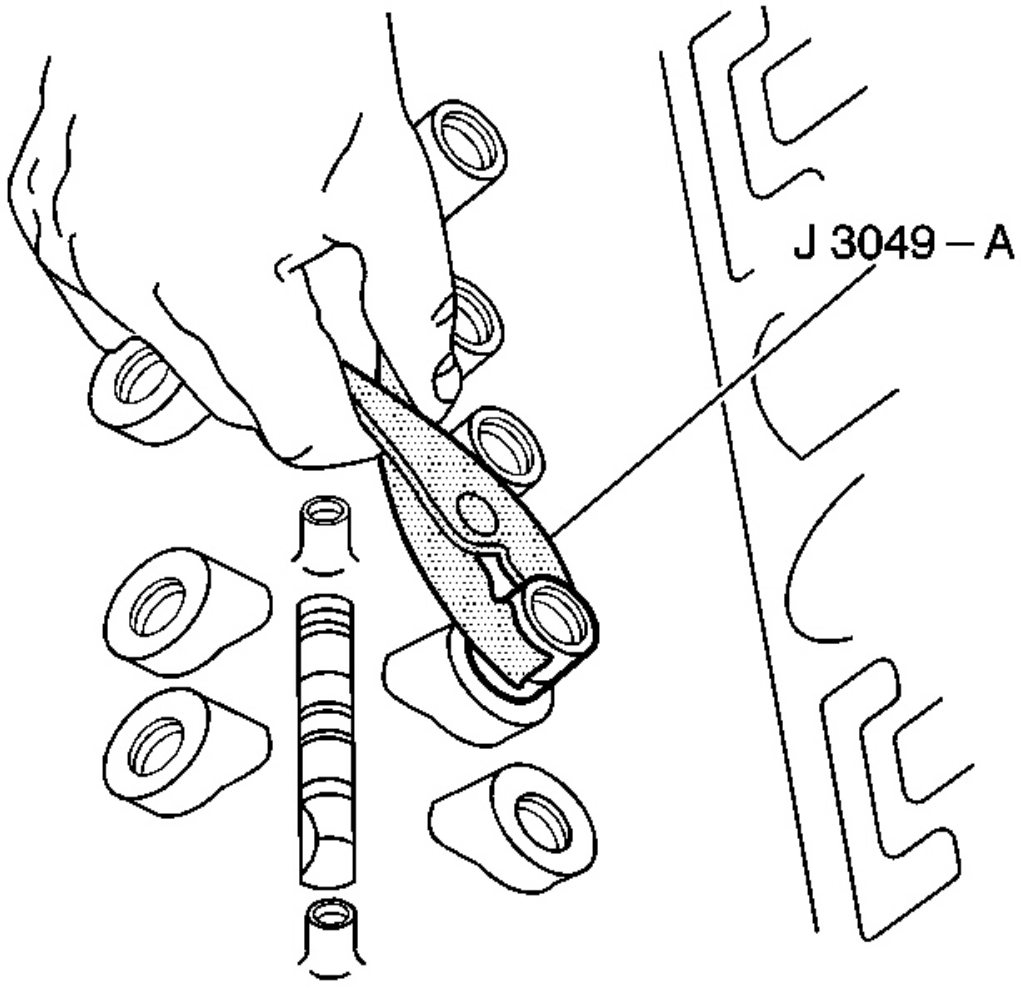


Fig. 159: Using J 3049-A To Remove Sticking Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits and may require the use of J 3049-A for removal. See Special Tools.

5. Use the **J 3049-A** in order to remove the stuck valve lifters. See **Special Tools**.
6. Use a cleaning solvent and a shop towel to clean any varnish from the valve lifter bores.
7. Inspect the lifter bores for excessive wear or scoring. Replace the engine block if there is

excessive wear or deep scoring.

8. Inspect the camshaft for wear or damage. If the wear is questionable remove the camshaft and inspect. Refer to **Camshaft and Bearings Cleaning and Inspection**.
9. Clean and inspect the lifters, if necessary. Refer to **Valve Lifters and Guides Cleaning and Inspection**.

Installation Procedure

IMPORTANT: It is normal for NEW lifters to make a slight ticking noise when the engine is first started. Increasing the engine RPM slightly to raise oil pressure should stop the noise.

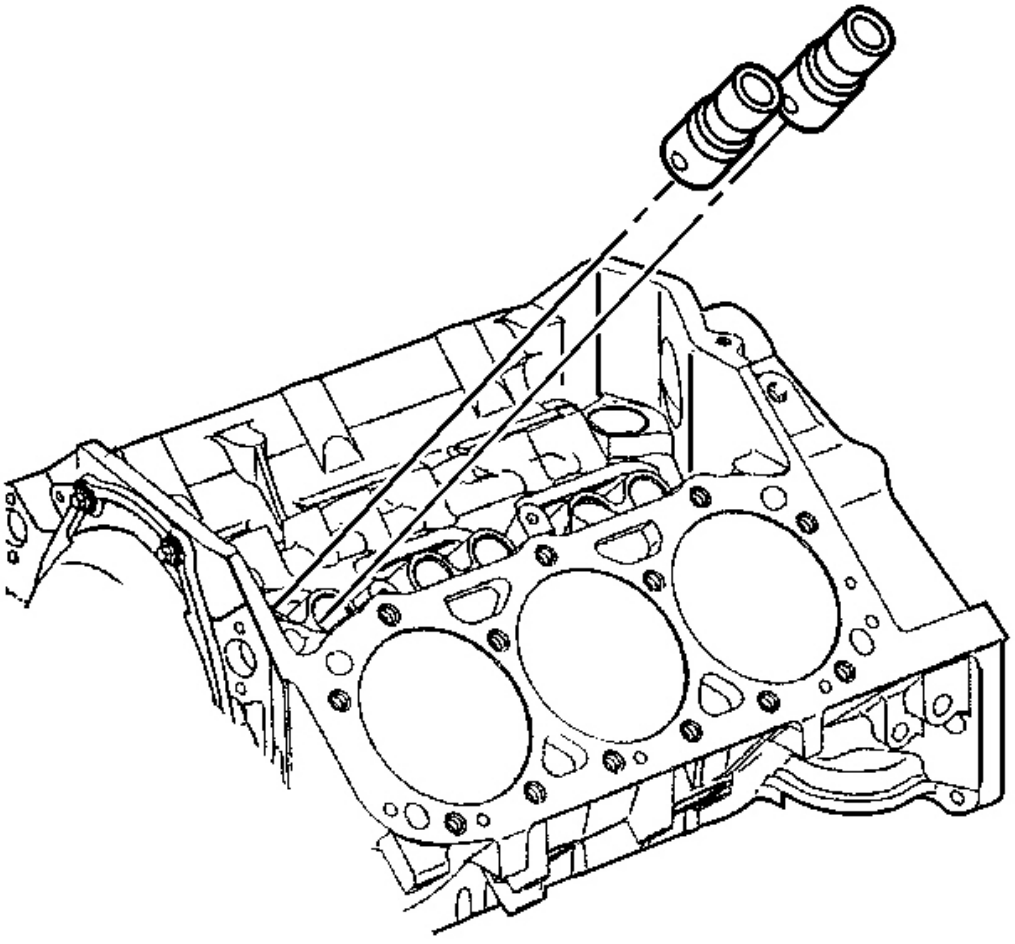


Fig. 160: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

1. Apply lubricant to the lifter rollers. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

IMPORTANT: If reusing the lifters, install the lifters to their original positions.

2. Install the lifters.

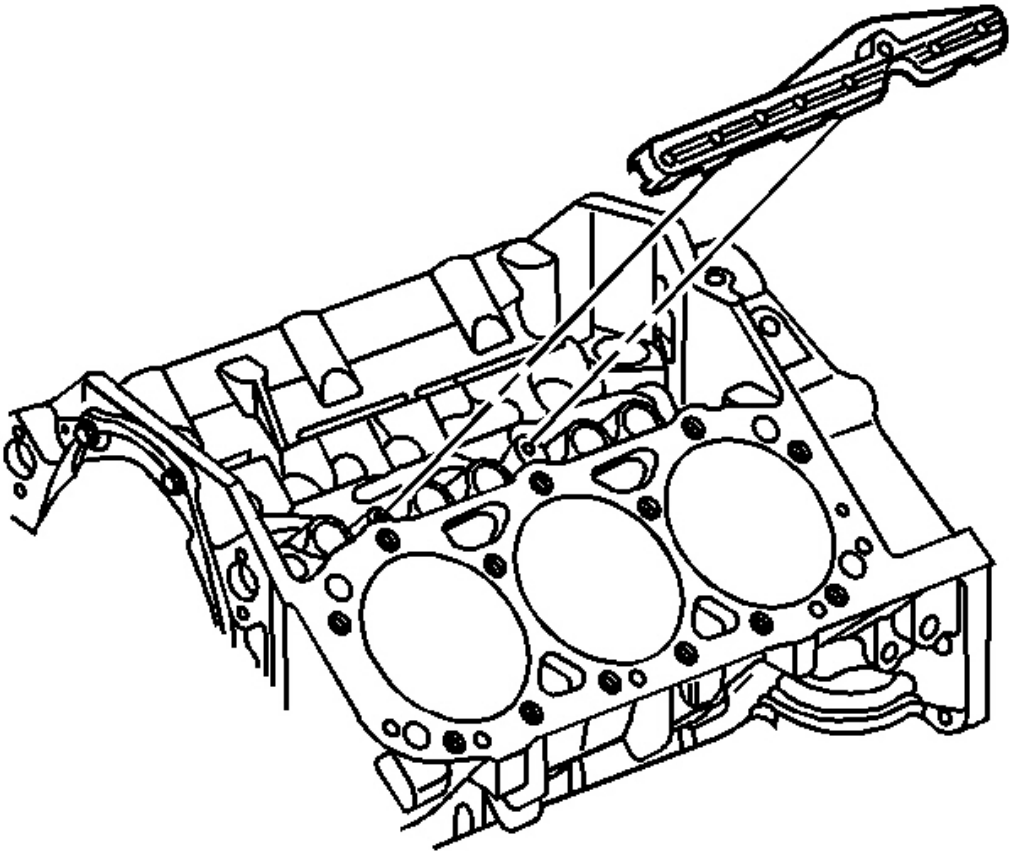


Fig. 161: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the lifter pushrod guides.

   Tighten: Tighten the bolts to 16 N.m (12 lb ft).

4. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. Install the intake manifold. Refer to **Lower Intake Manifold Replacement**.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Special Tools

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

Removal Procedure

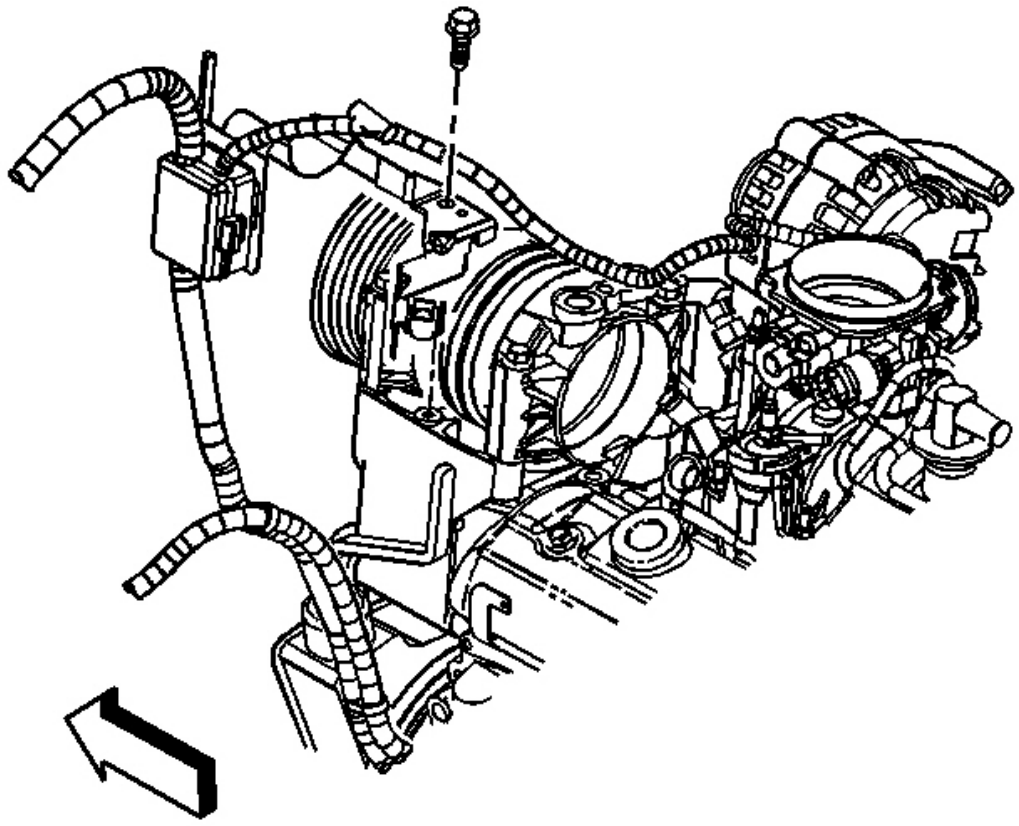


Fig. 162: View Of Junction Block Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or **Cooling System Draining and Filling (Static Fill)** .
2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
4. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (4.3L)** .
5. Remove the left side pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
6. Remove the junction block bracket bolt.
7. Position the bracket and wiring harness aside.

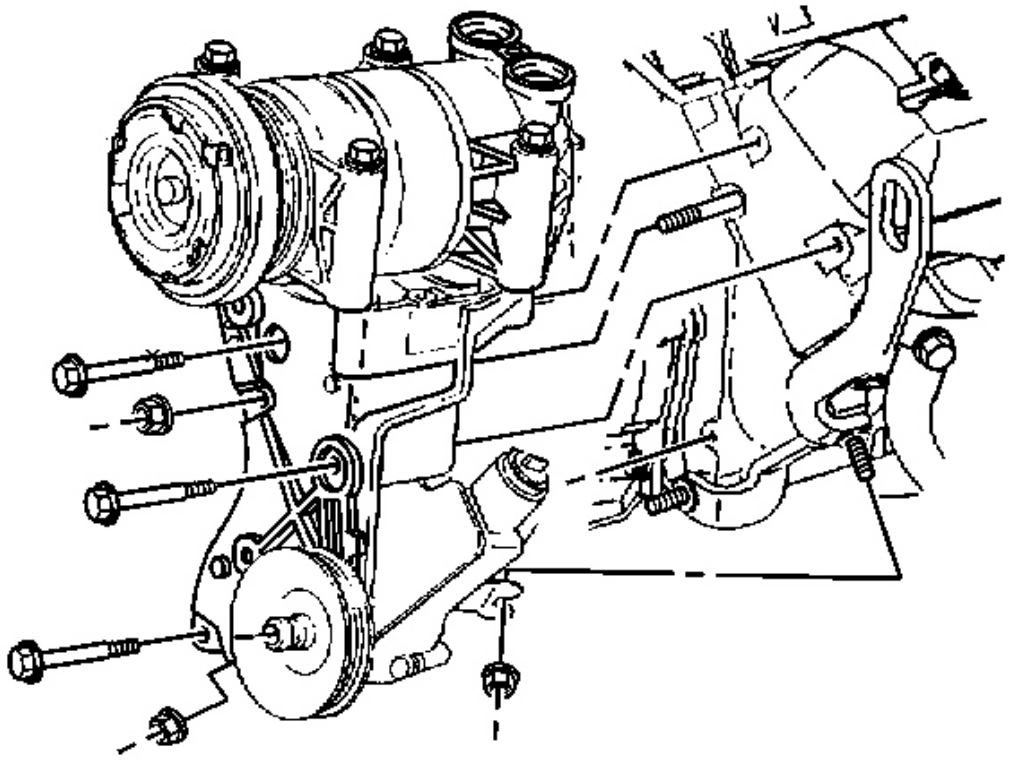


Fig. 163: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

8. Loosen the power steering (P/S) pump rear bracket nut.
9. Remove the P/S pump rear bracket front nut.
10. Remove the bolts and nut for the P/S pump bracket.
11. Leave the air conditioning (A/C) compressor, if equipped, and the P/S pump on the bracket.
12. Slide the P/S pump bracket off of the stud and set aside.

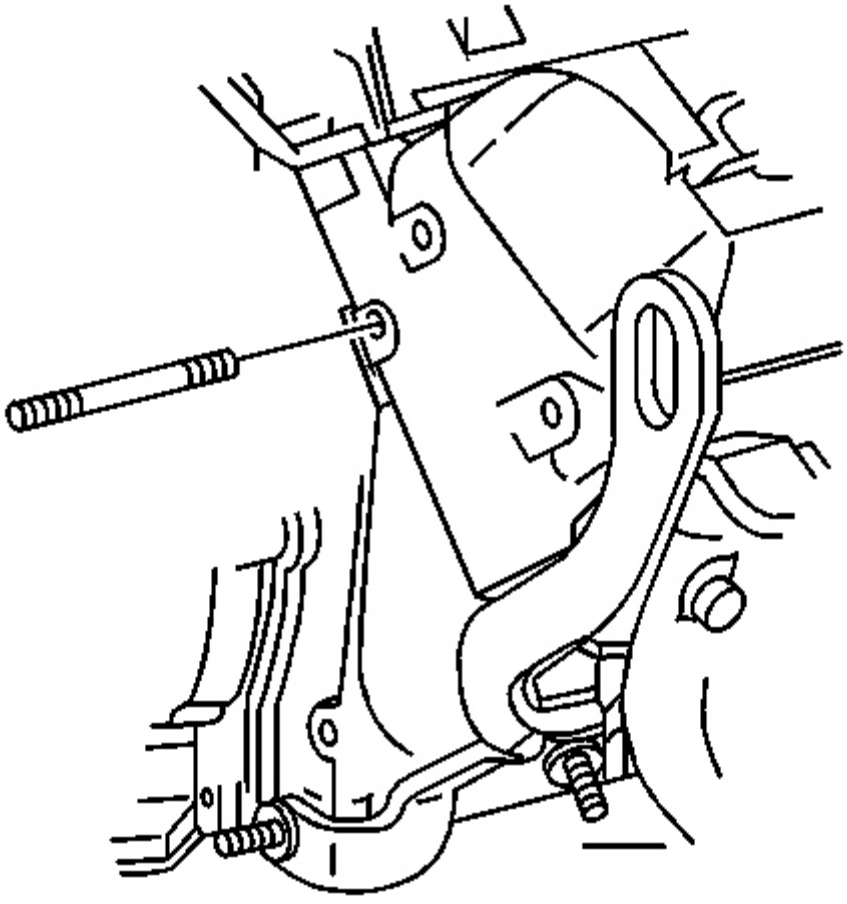


Fig. 164: Locating Power Steering Pump Mounting Bracket Stud
Courtesy of GENERAL MOTORS CORP.

13. Remove the P/S pump bracket stud.

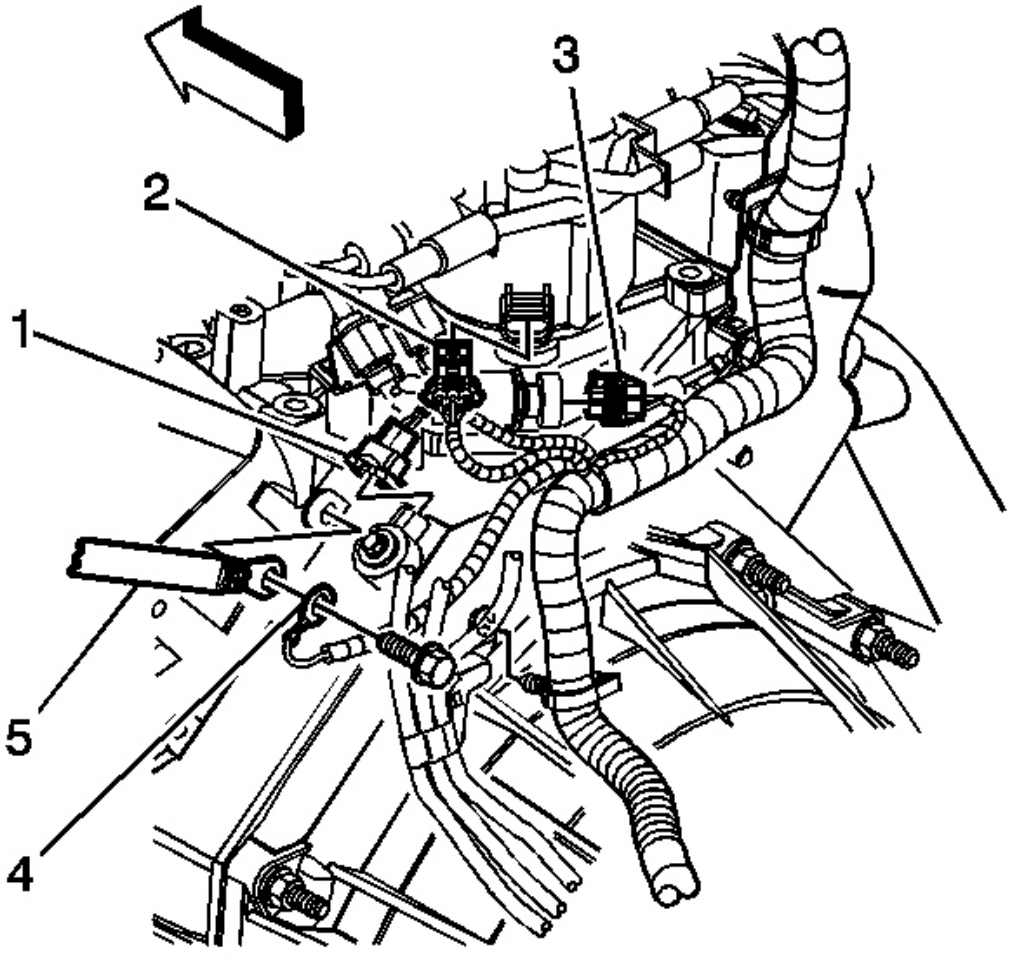


Fig. 165: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

14. Remove the harness ground bolt.
15. Position the harness ground (4) and ground strap (5).

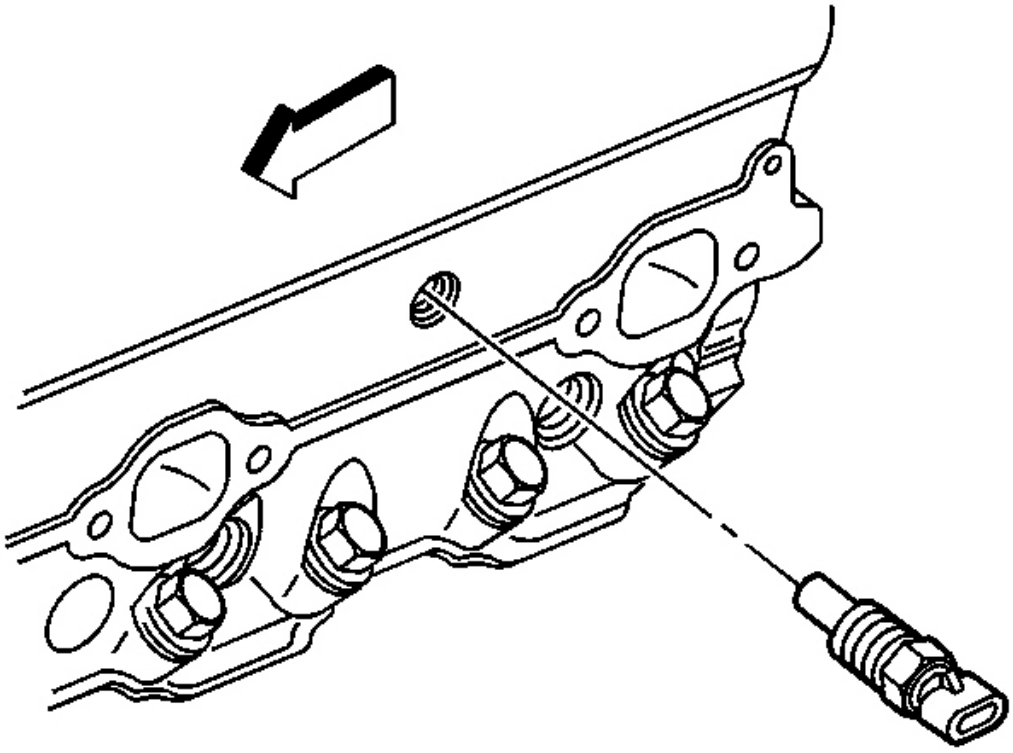


Fig. 166: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

16. Remove the engine coolant temperature (ECT) sensor.

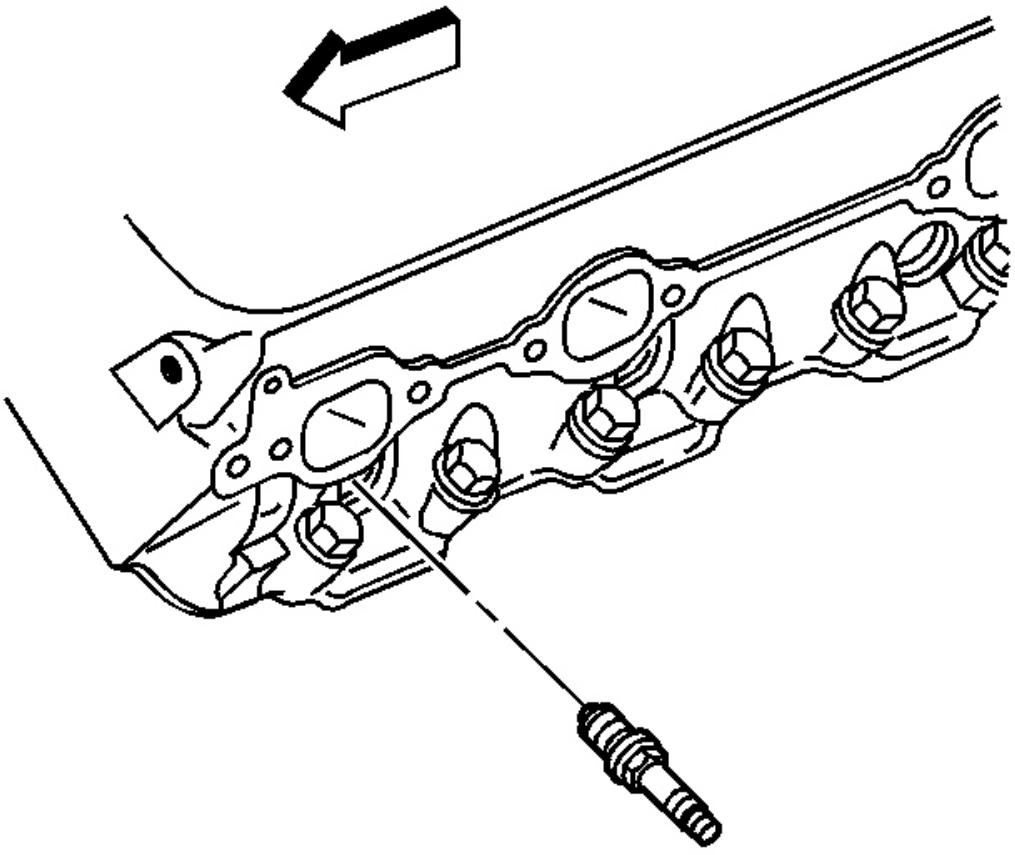


Fig. 167: View Of Spark Plugs (Left)
Courtesy of GENERAL MOTORS CORP.

17. Remove the spark plugs.

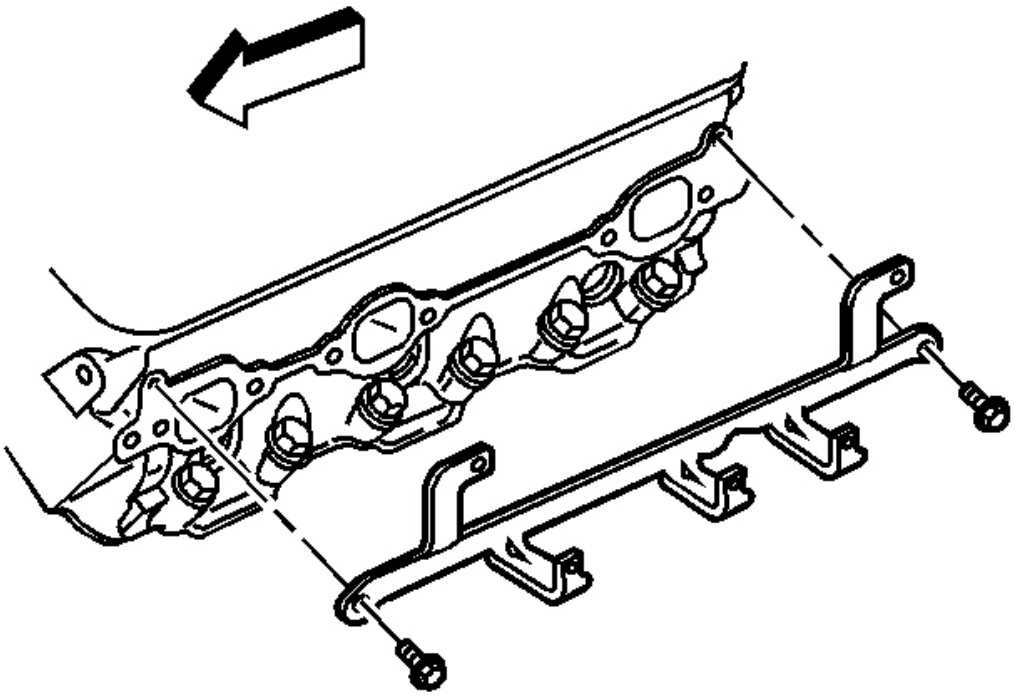


Fig. 168: Locating Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

18. Remove the spark plug wire support bolts and support.

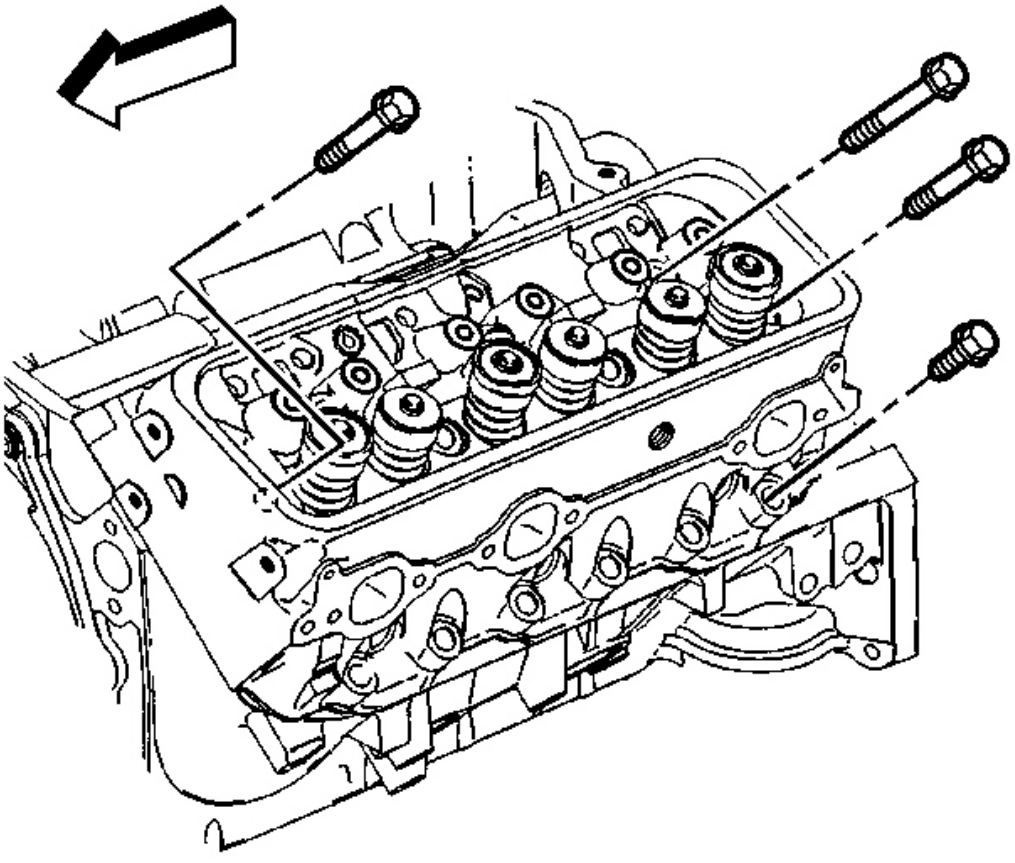


Fig. 169: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

19. Remove and discard the cylinder head bolts.

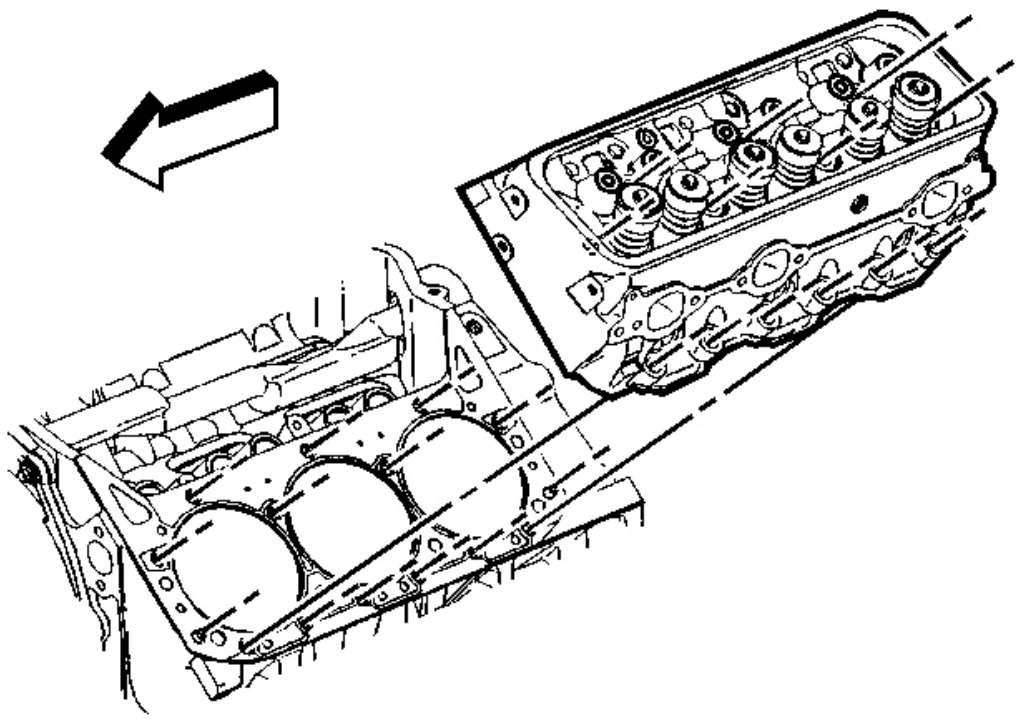


Fig. 170: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

20. Remove the cylinder head.

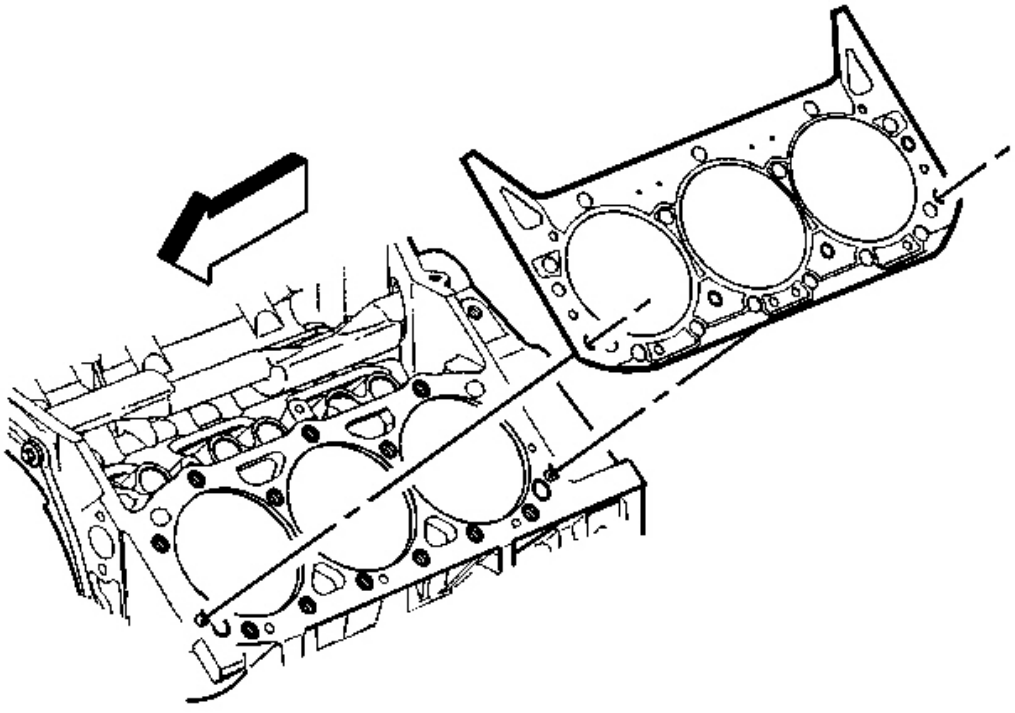


Fig. 171: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

21. Remove and discard the cylinder head gasket.

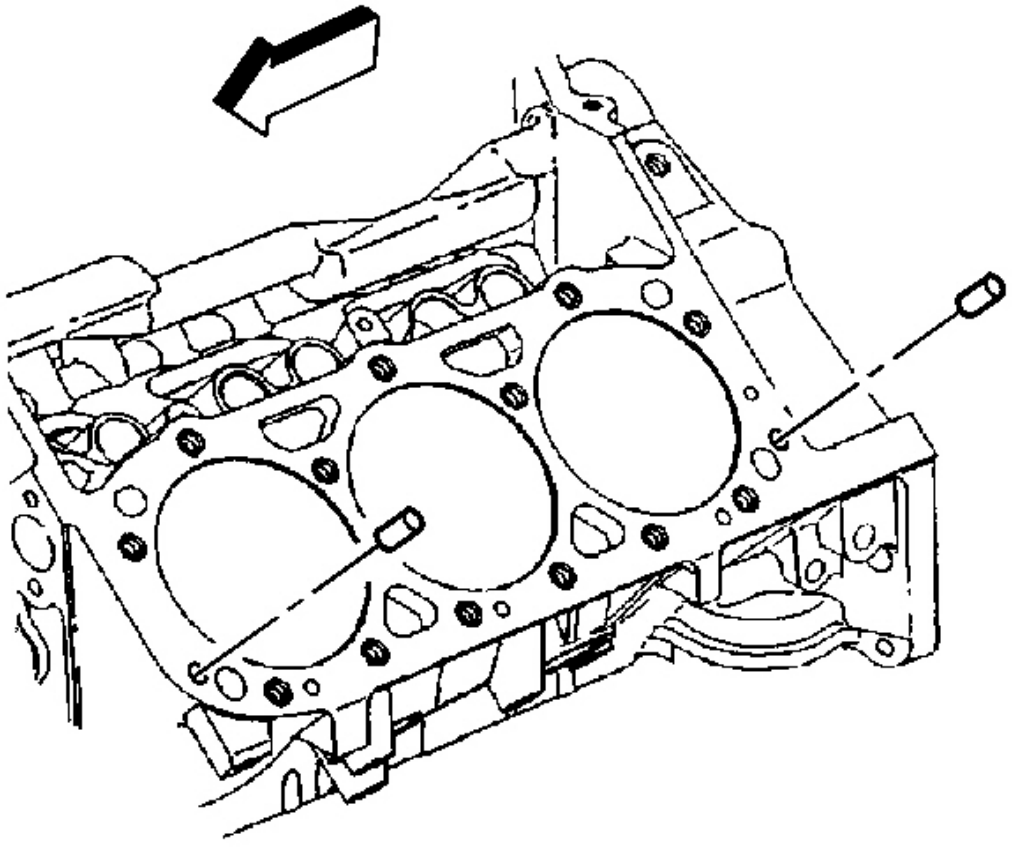


Fig. 172: View Of Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

22. Remove the cylinder head locator pins, if necessary.
23. Clean and inspect the cylinder head, if necessary. Refer to **Cylinder Head Cleaning and Inspection**.
24. Disassemble the cylinder head, if necessary. Refer to **Cylinder Head Disassemble**.

Installation Procedure

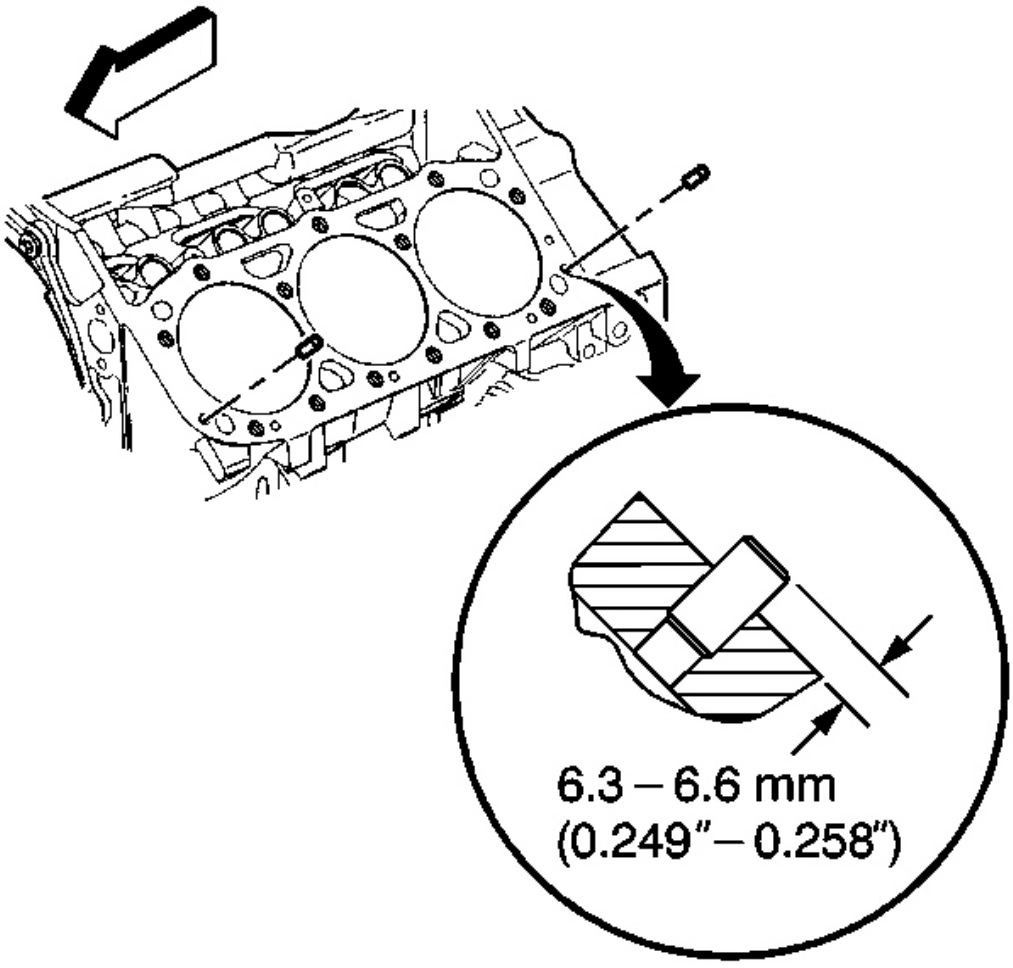


Fig. 173: Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

1. Assemble the cylinder head, if necessary. Refer to **Cylinder Head Assemble**.
2. Install the cylinder head locator pins, if necessary.

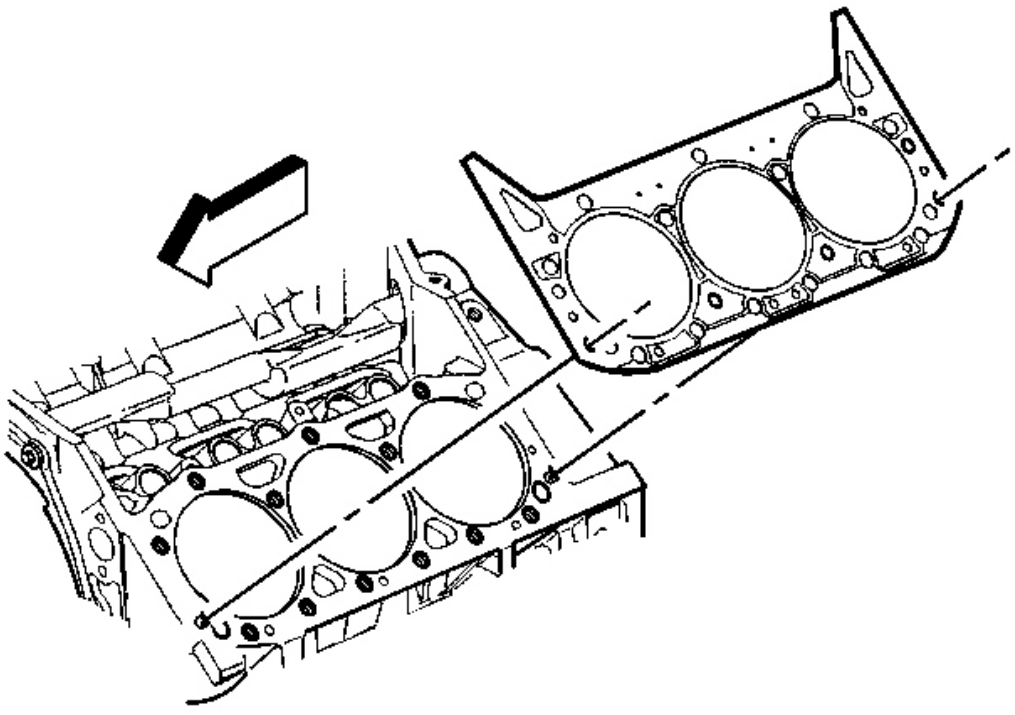


Fig. 174: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type of sealer on the cylinder head gasket.

3. Install a NEW cylinder head gasket.

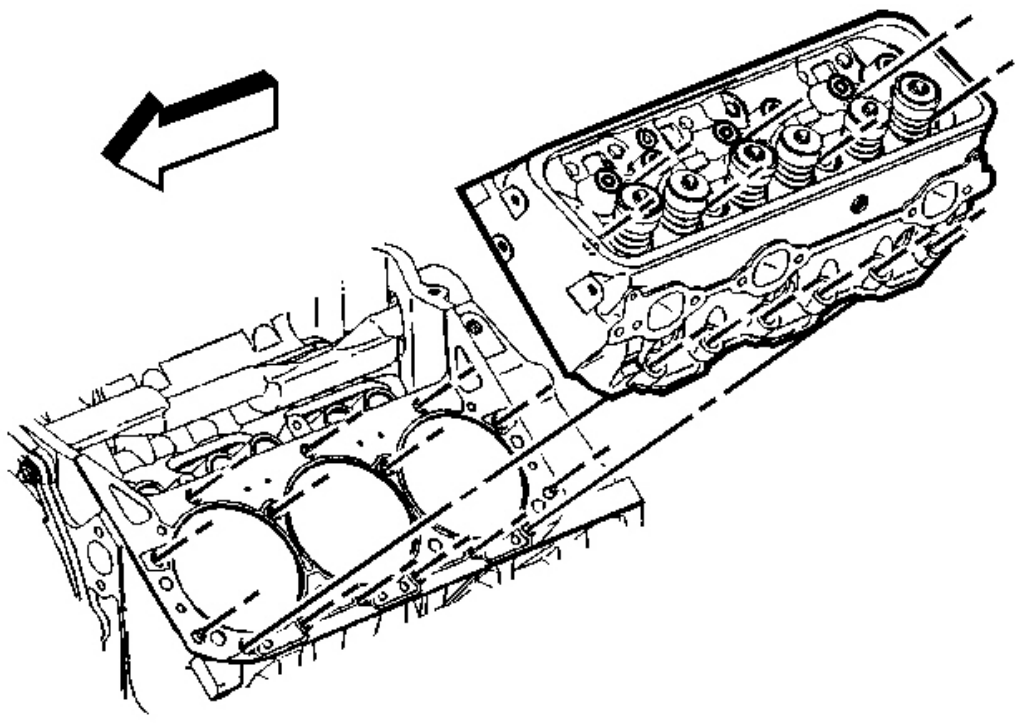


Fig. 175: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

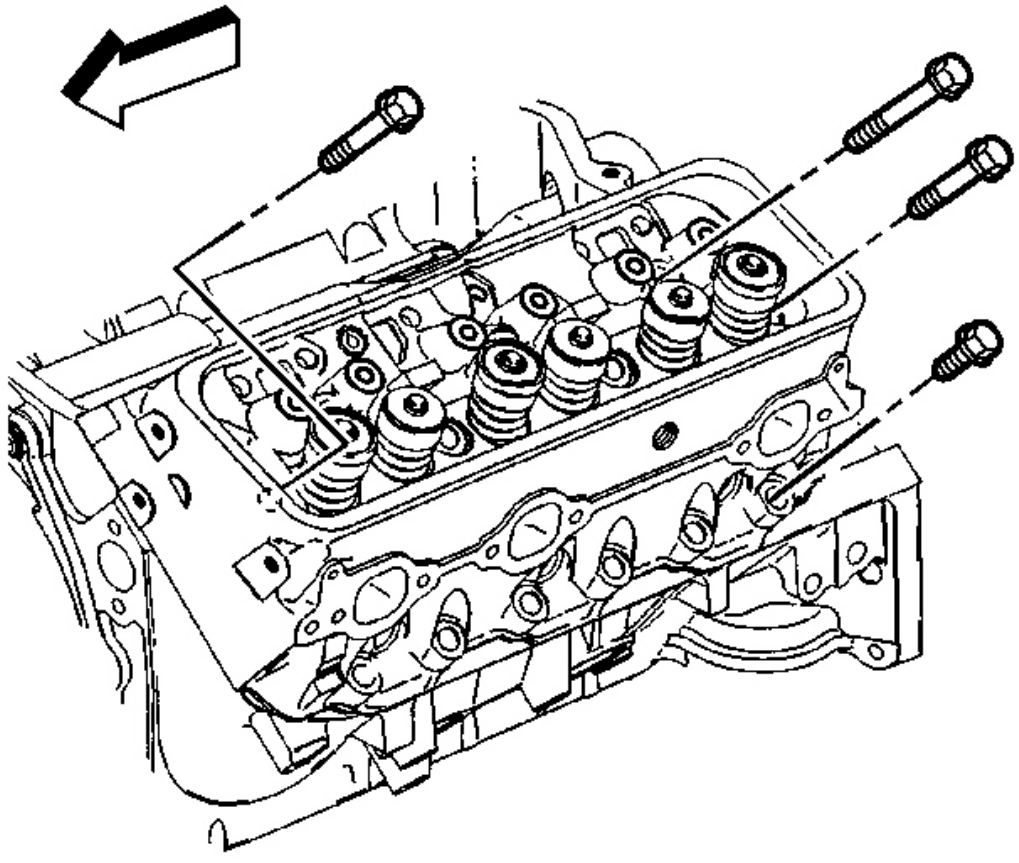


Fig. 176: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant to the threads of the **NEW** cylinder head bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Install the cylinder head bolts finger tight.

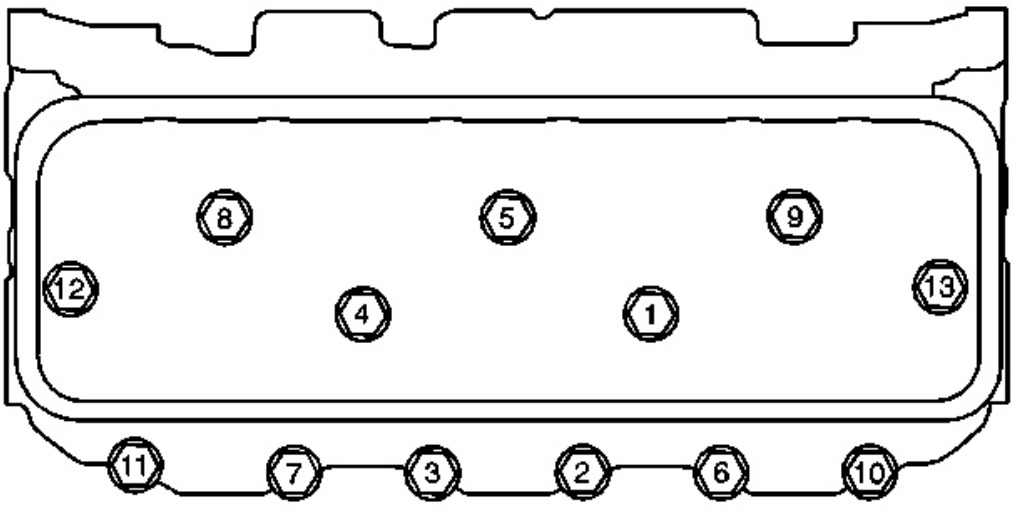


Fig. 177: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Tighten the cylinder head bolts using the sequence shown.

Tighten:

1. Tighten the bolts a first pass to 30 N.m (22 lb ft).
2. Tighten the long bolts (1, 4, 5, 8, 9) a final pass to 75 degrees using **J 45059** . See **Special Tools**.
3. Tighten the medium bolts (12, 13) a final pass to 65 degrees using **J 45059** . See **Special Tools**.
4. Tighten the short bolts (2, 3, 6, 7, 10, 11) a final pass to 55 degrees using **J 45059** . See **Special Tools**.

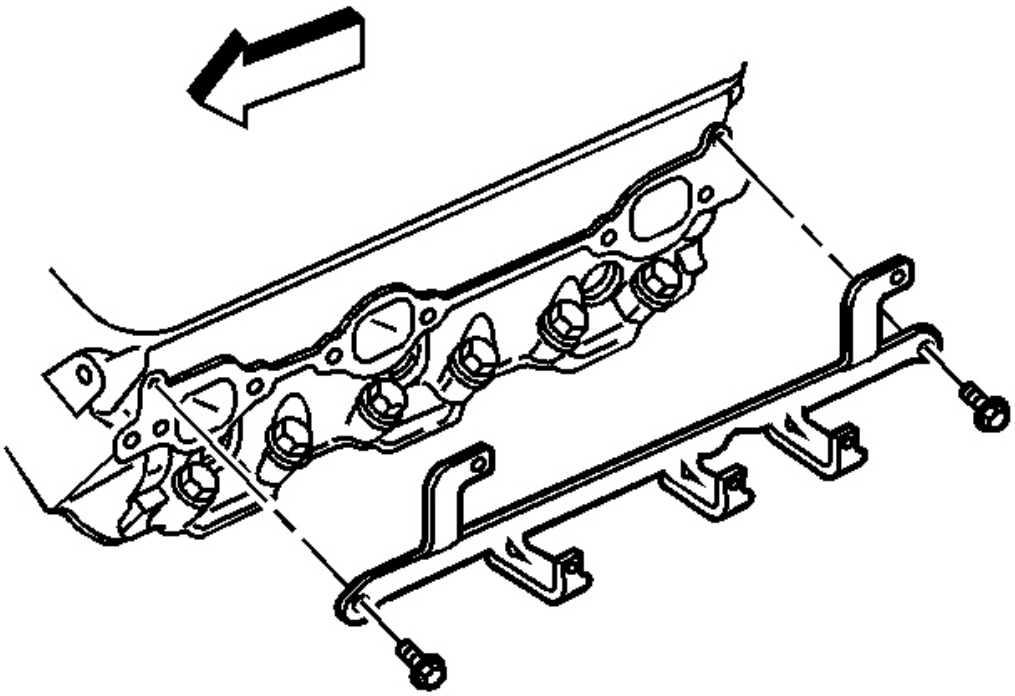


Fig. 178: Locating Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

8. Install the spark plug wire support and bolts.

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

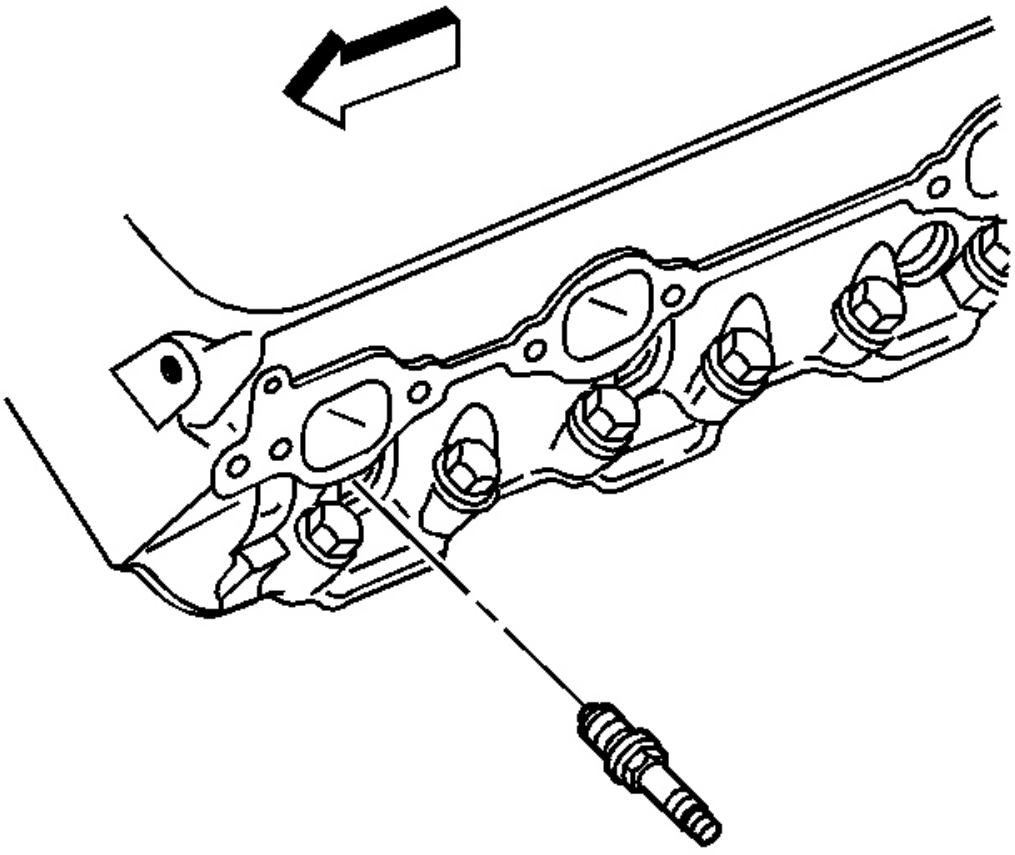


Fig. 179: View Of Spark Plugs (Left)
Courtesy of GENERAL MOTORS CORP.

9. Install the spark plugs.
10. If installing NEW spark plugs measure for the correct gap. Adjust the spark plug gap if necessary.

    Specification: Spark plug gap to 1.52 mm (0.060 in).

    Tighten:

    - Tighten the plugs in a USED cylinder head to 15 N.m (11 lb ft).
    - Tighten the plugs on the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

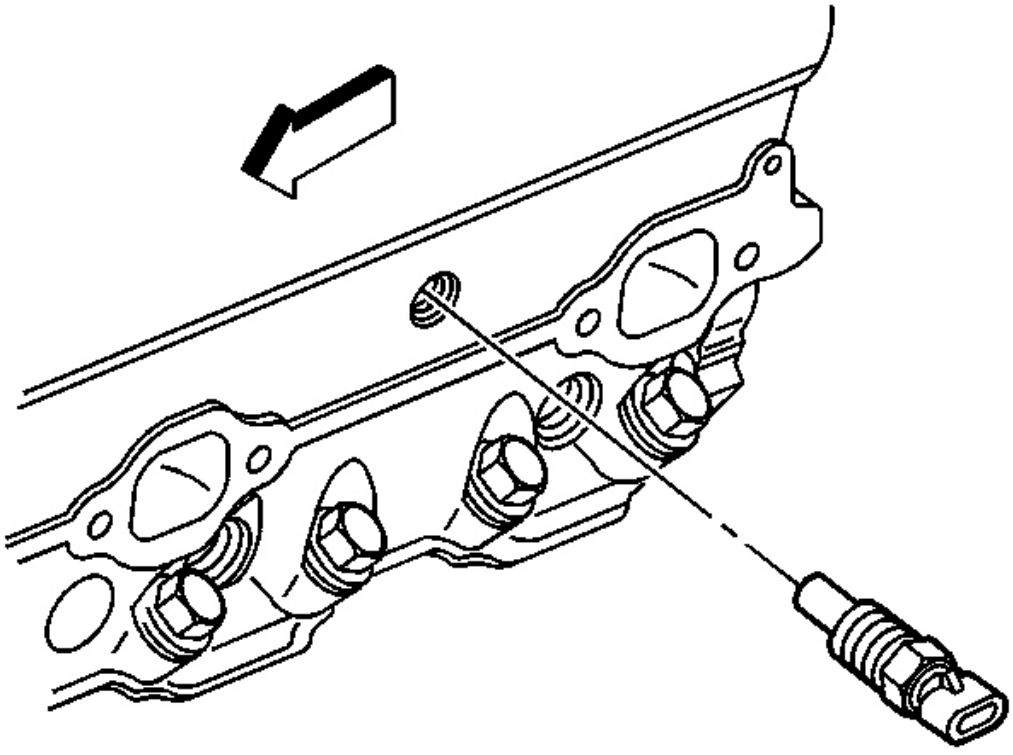


Fig. 180: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the ECT sensor. If reusing the old sensor, apply sealant to the threads. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

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

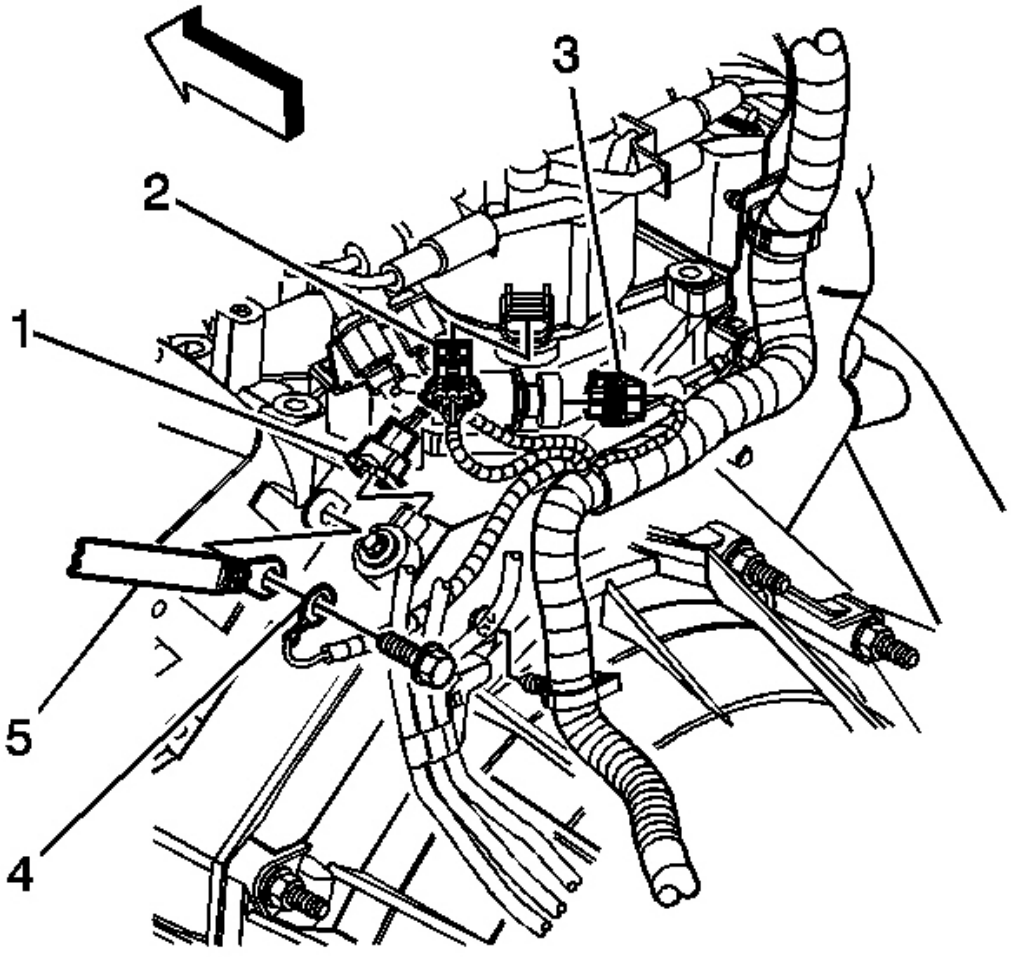


Fig. 181: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

12. Position the ground strap (5) and harness ground (4).
13. Install the harness ground bolt.

Tighten: Tighten the bolt to 16 N.m (12 lb ft).

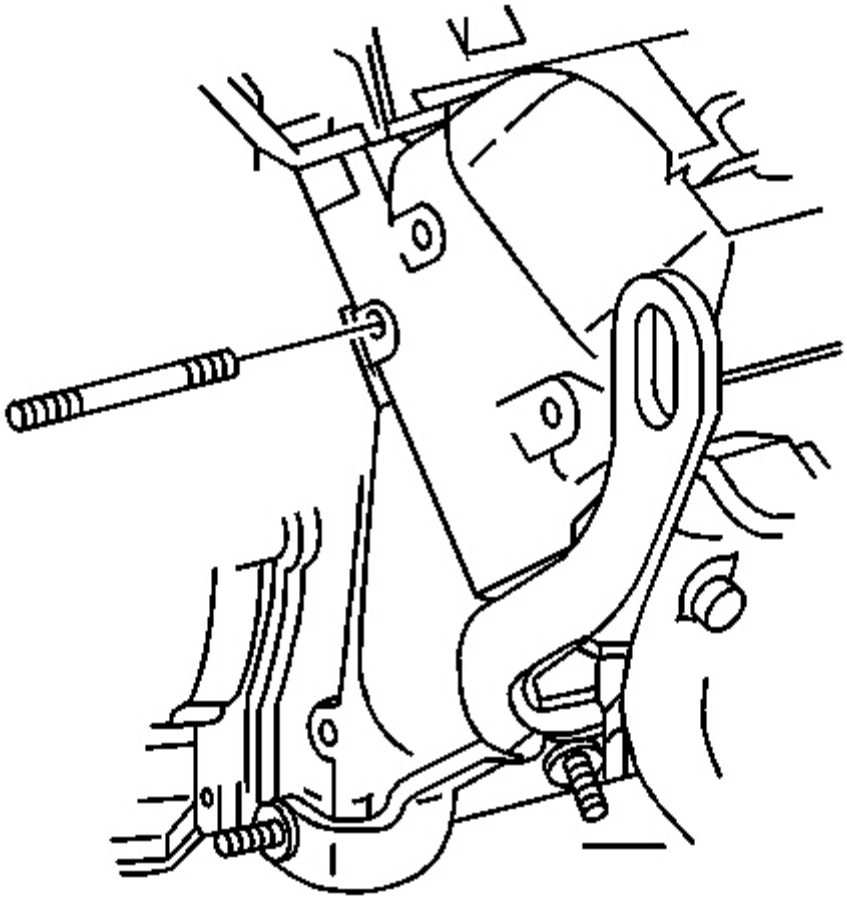


Fig. 182: Locating Power Steering Pump Mounting Bracket Stud
Courtesy of GENERAL MOTORS CORP.

14. Install the P/S pump bracket stud.

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

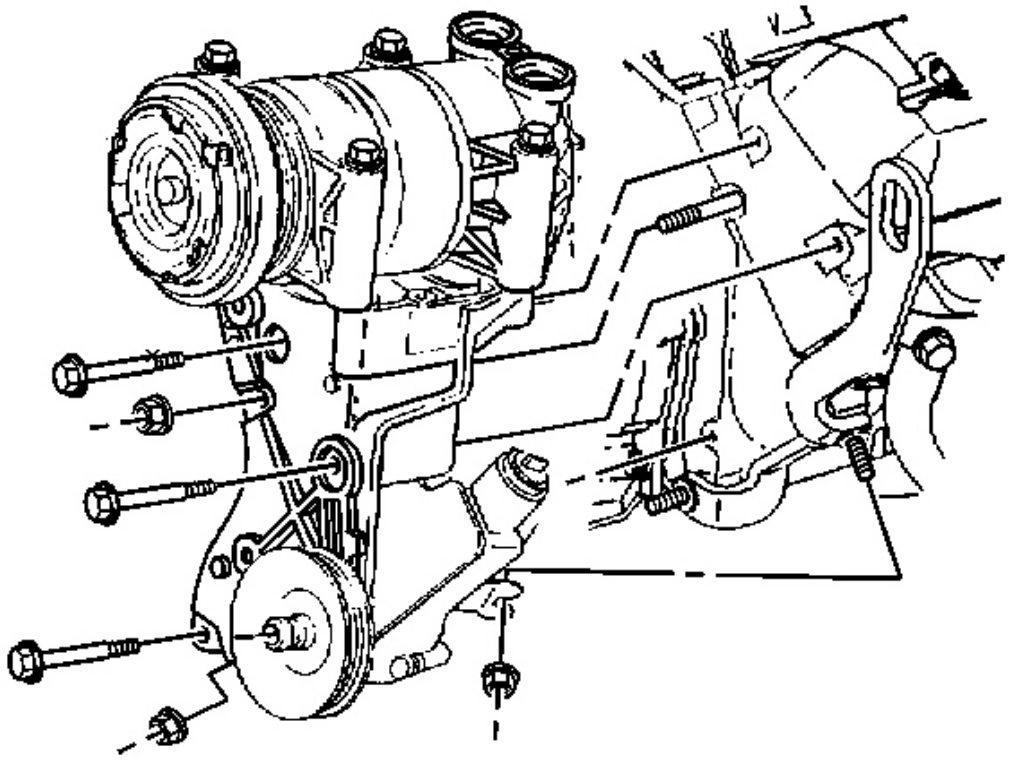


Fig. 183: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

15. Slide the P/S pump bracket rearward.
16. Install the bolts and nuts for the P/S pump bracket.
17. Install the P/S pump rear bracket front nut.
18. Tighten the P/S pump rear bracket nut.

Tighten: Tighten the bolts and nuts to 41 N.m (30 lb ft).

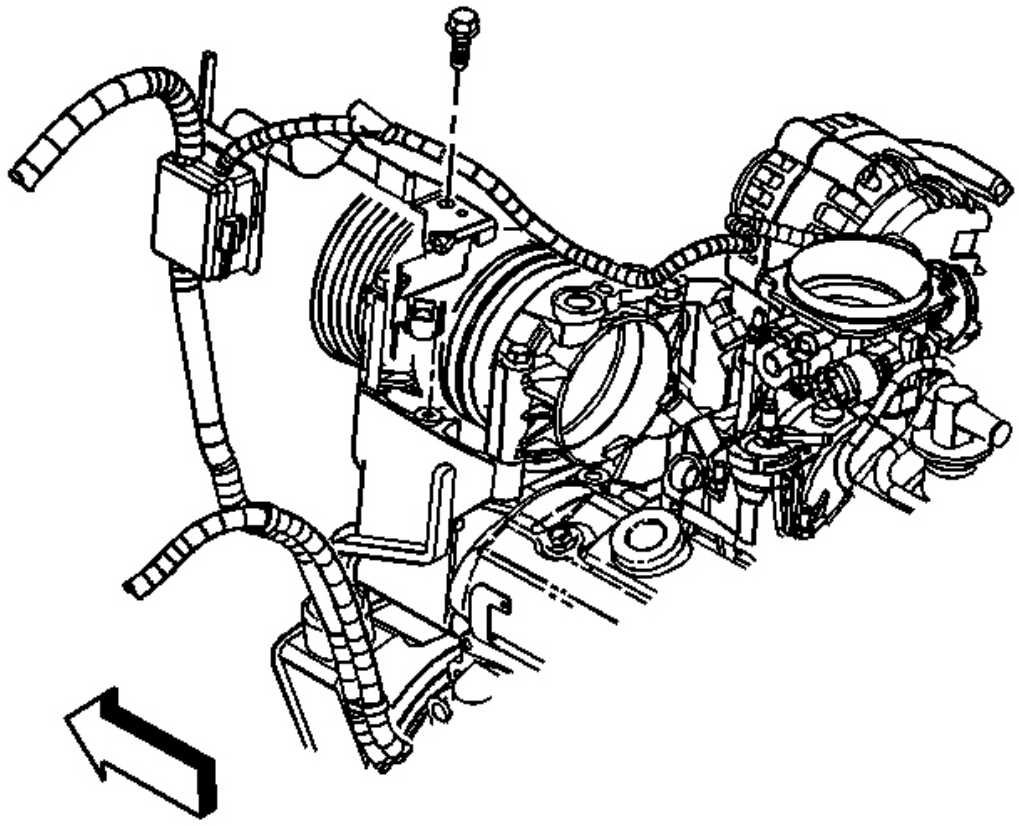


Fig. 184: View Of Junction Block Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

19. Position the bracket and wiring harness.
20. Install the junction block bracket bolt.

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

21. Install the left side pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
22. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (4.3L)** .
23. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
24. Install the drive belt. Refer to **Drive Belt Replacement**.
25. Fill the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or

Cooling System Draining and Filling (Static Fill) .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Special Tools

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

Removal Procedure

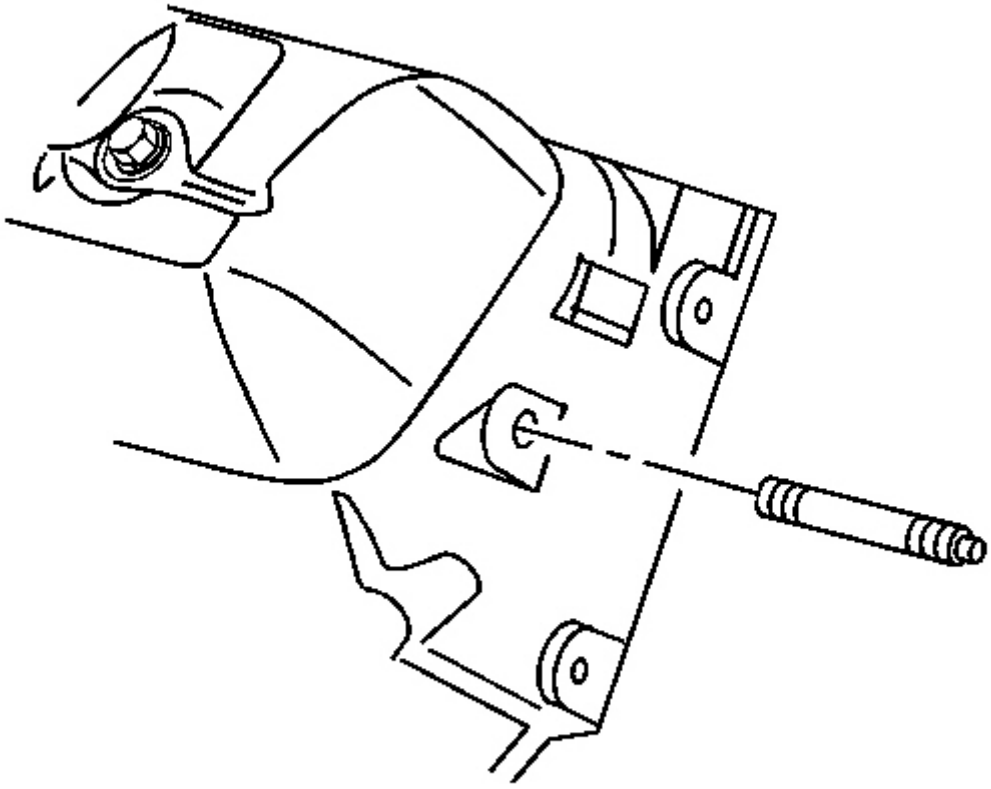


Fig. 185: View Of Generator Bracket Stud
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or **Cooling System Draining and Filling (Static Fill)** .

2. Remove the generator bracket. Refer to **Generator Bracket Replacement (4.3L)** .
3. Remove the intake manifold. Refer to **Lower Intake Manifold Replacement**.
4. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (4.3L)** .
5. Remove the right pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
6. Remove the generator bracket stud from the cylinder head.

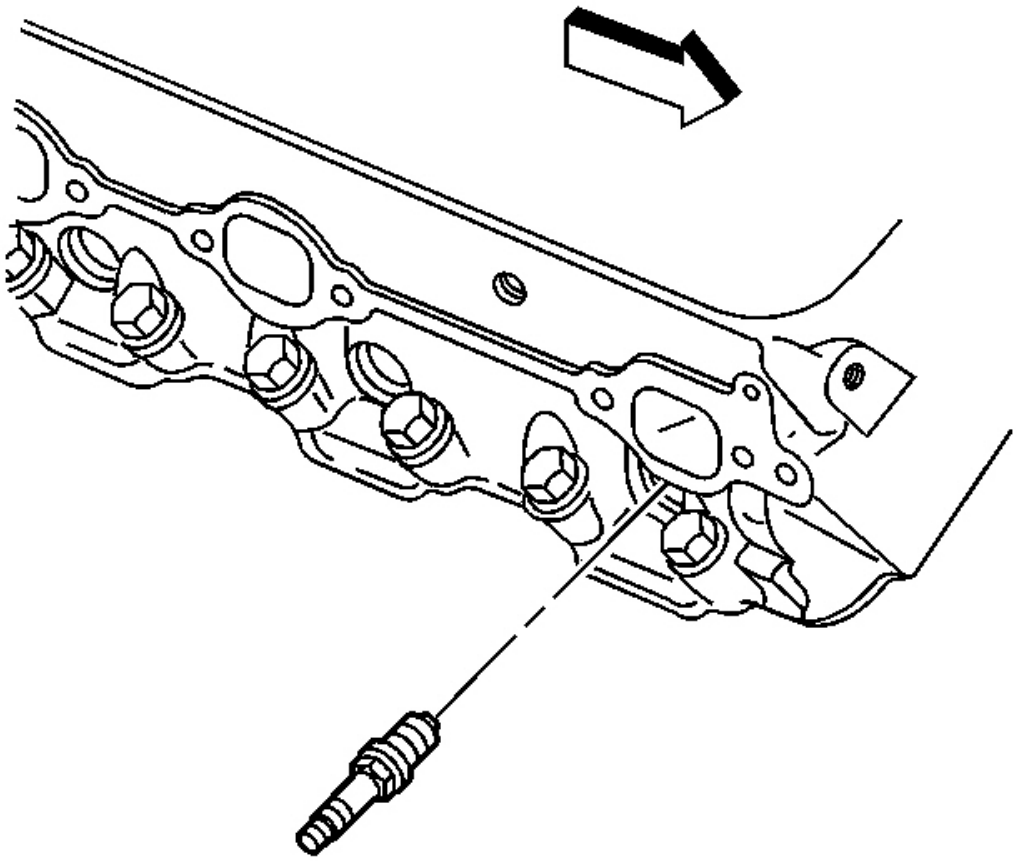


Fig. 186: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the spark plugs.

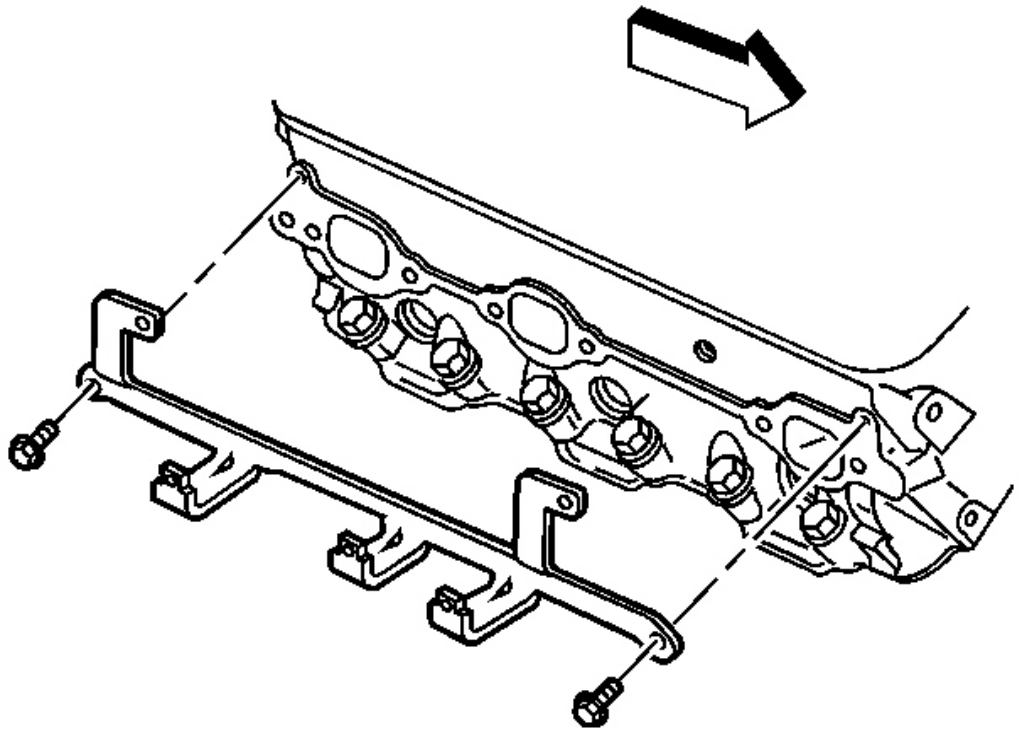


Fig. 187: Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

8. Remove the spark plug wire support bolts and support.

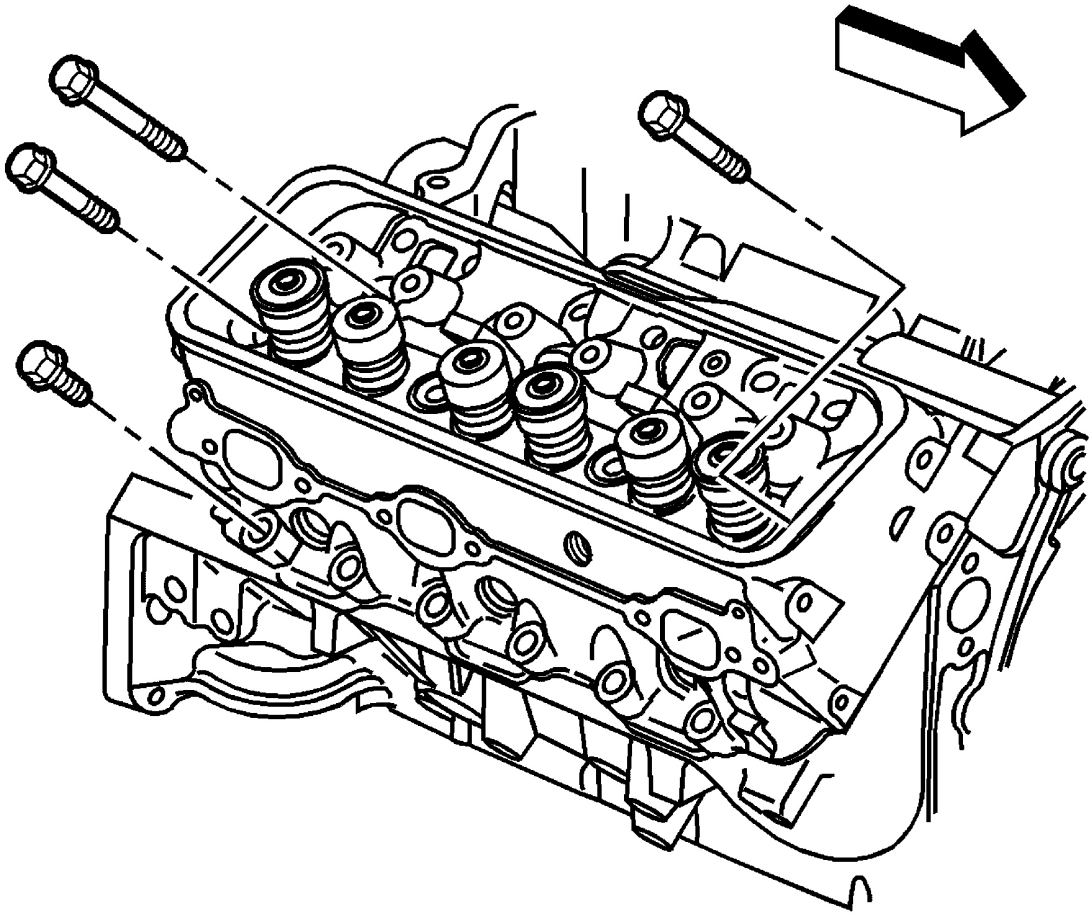


Fig. 188: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the cylinder head bolts.

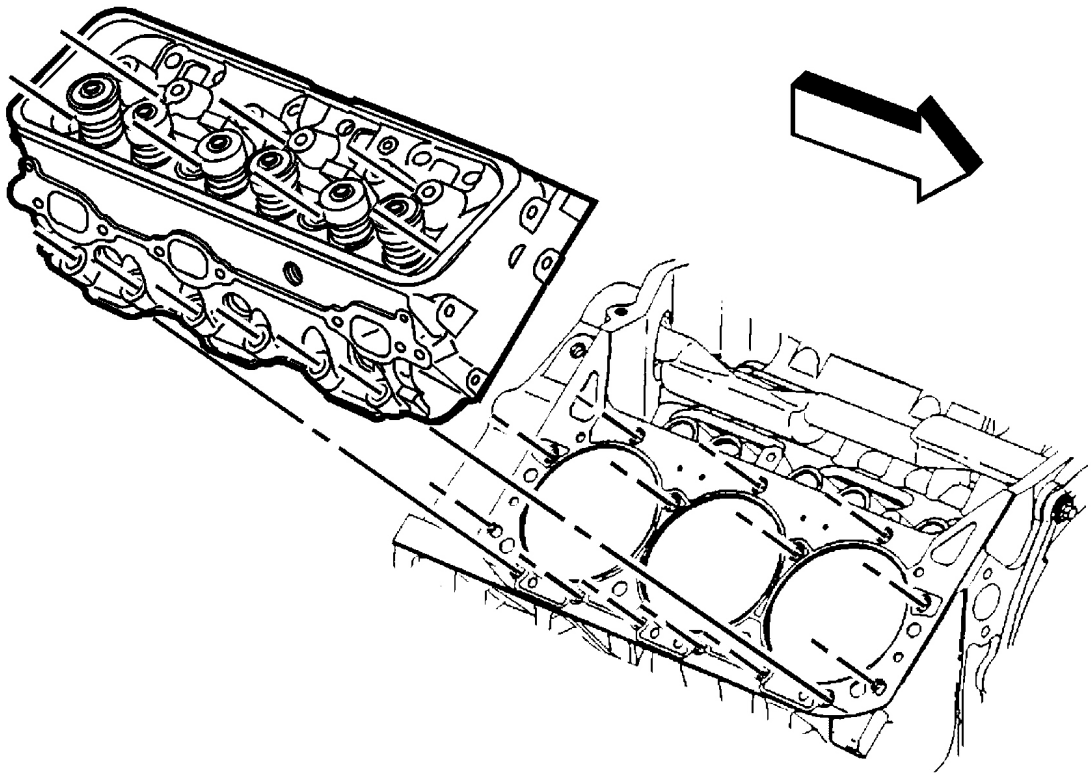


Fig. 189: Removing/Installing Cylinder Head (Right)
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head.

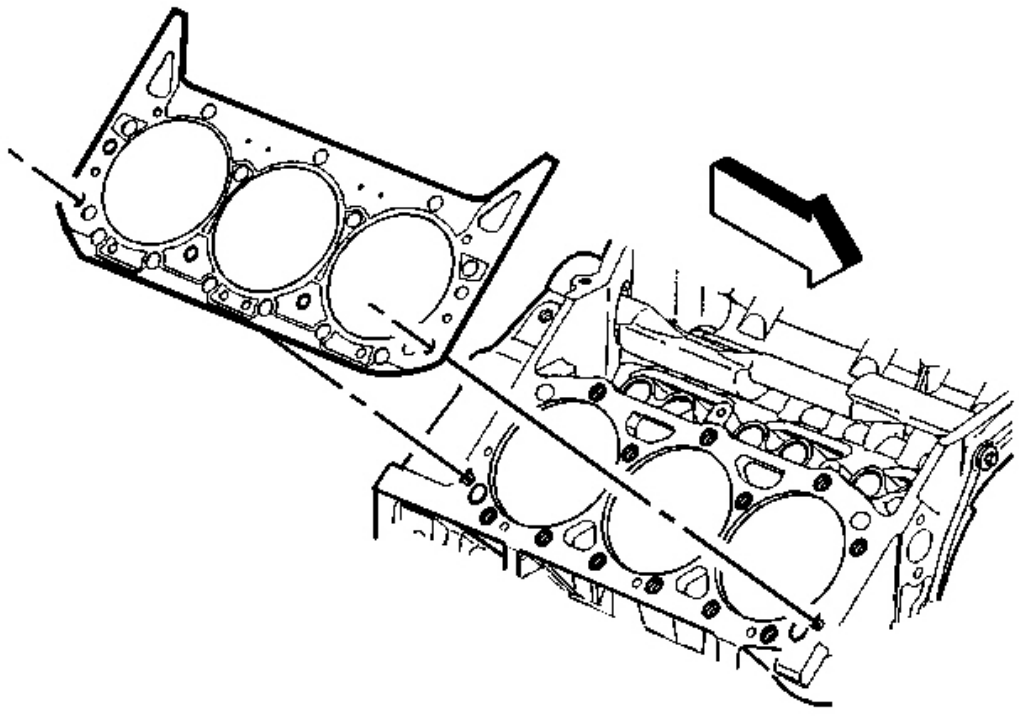


Fig. 190: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the cylinder head gasket.

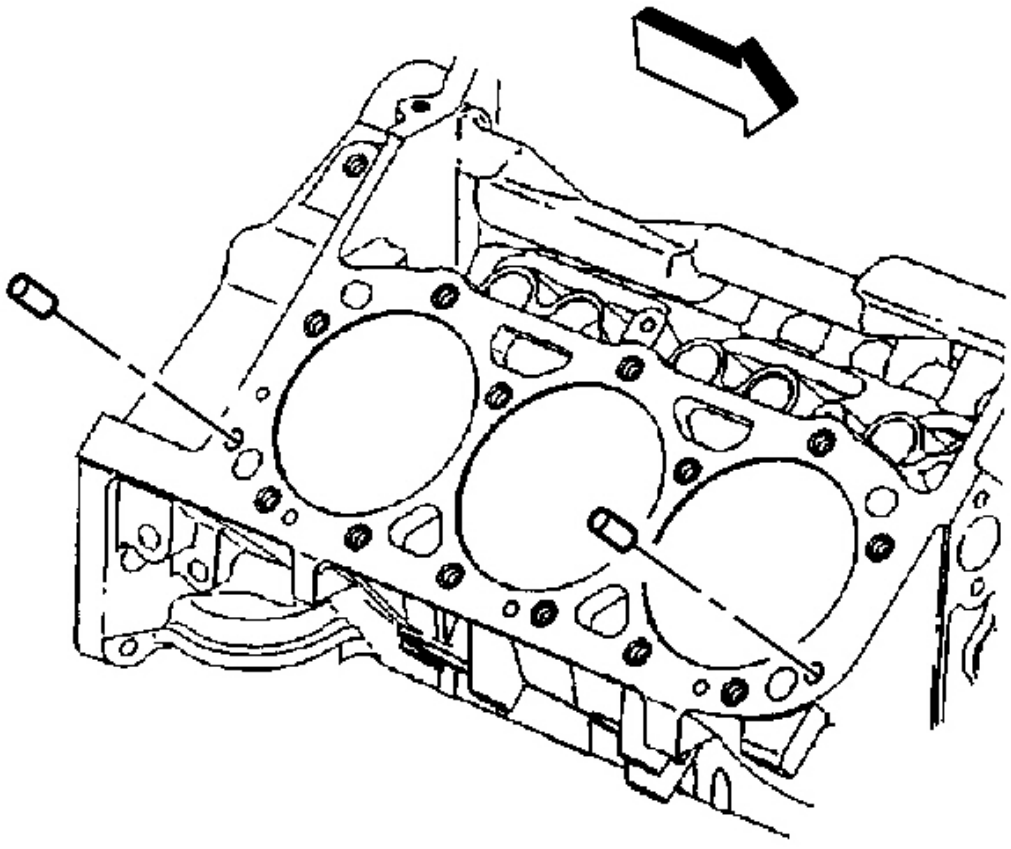


Fig. 191: Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

12. Remove the cylinder head locator pins, if necessary.
13. Clean and inspect the cylinder head, if necessary. Refer to **Cylinder Head Cleaning and Inspection**.
14. Disassemble the cylinder head, if necessary. Refer to **Cylinder Head Disassemble**.

Installation Procedure

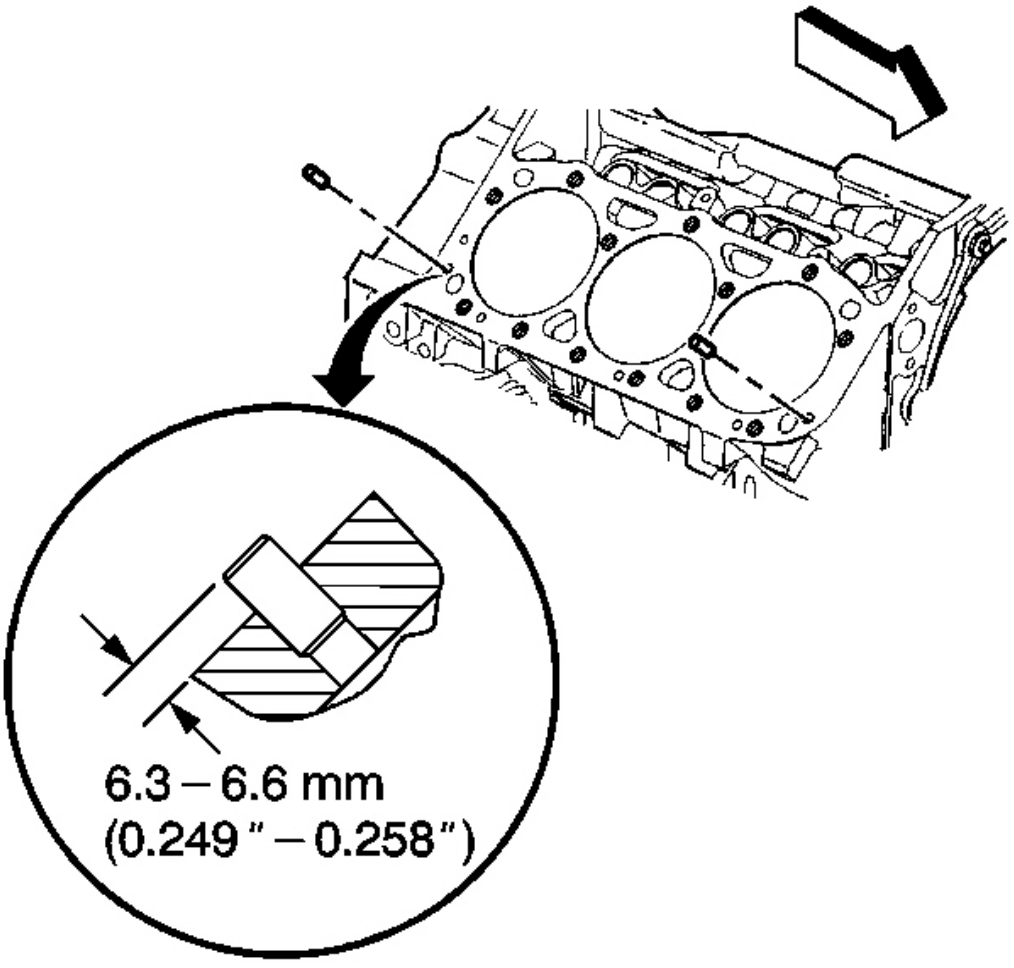


Fig. 192: Cylinder Head Dowel Pin Measurement
Courtesy of GENERAL MOTORS CORP.

1. Assemble the cylinder head, if necessary. Refer to **Cylinder Head Assemble**.
2. Install the cylinder head locator pins, if necessary.

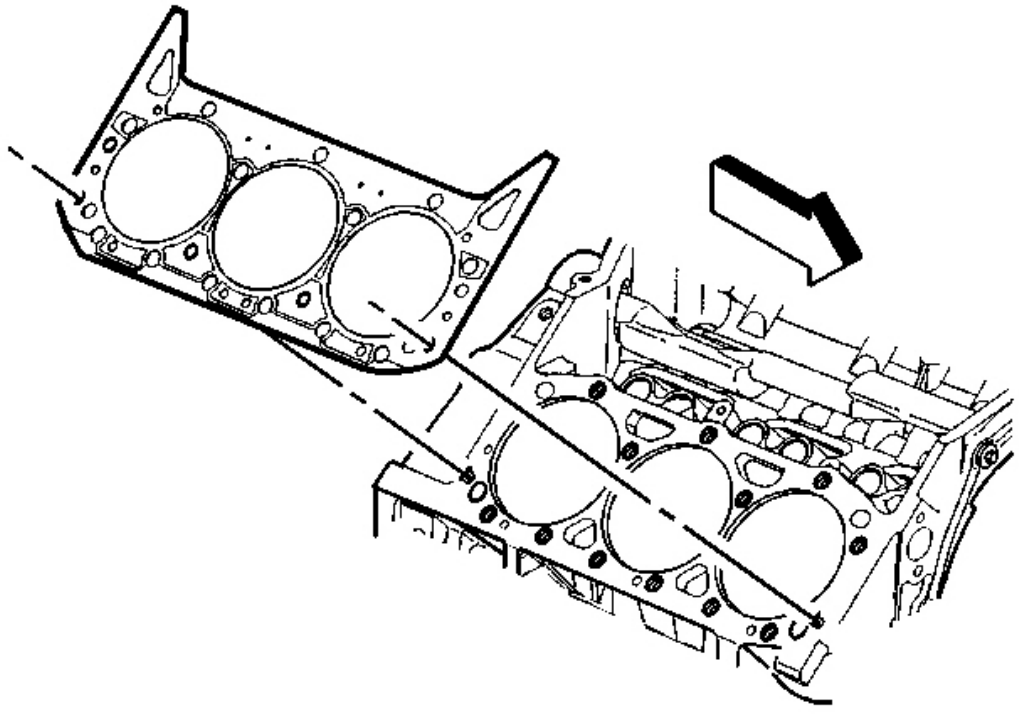


Fig. 193: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type of sealer on the cylinder head gasket.

3. Install a NEW cylinder head gasket.

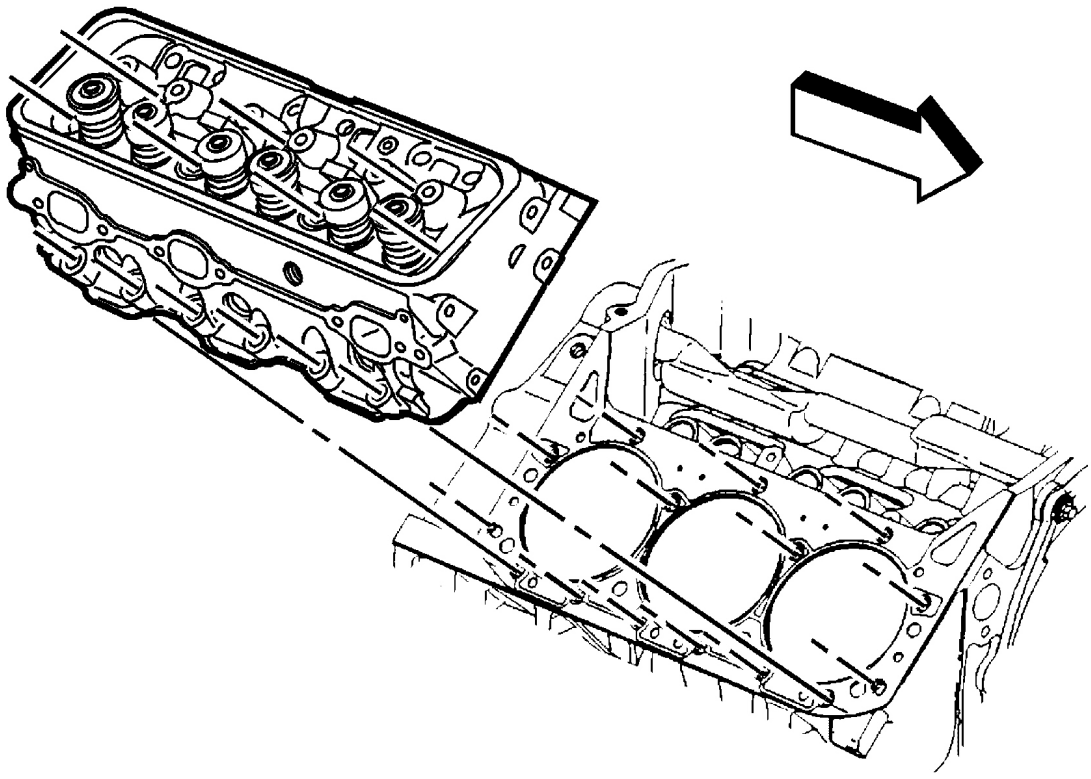


Fig. 194: Removing/Installing Cylinder Head (Right)
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

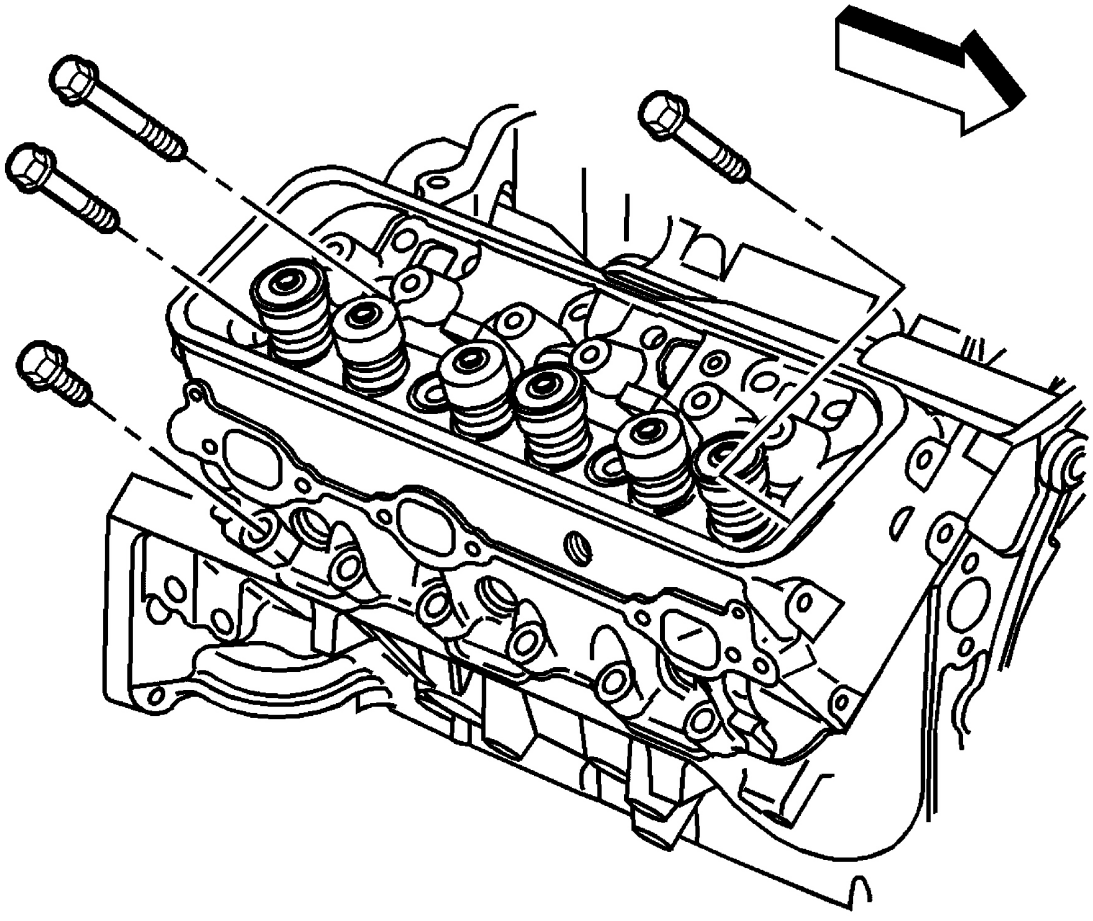


Fig. 195: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant to the threads of the **NEW** cylinder head bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Install the cylinder head bolts finger tight.

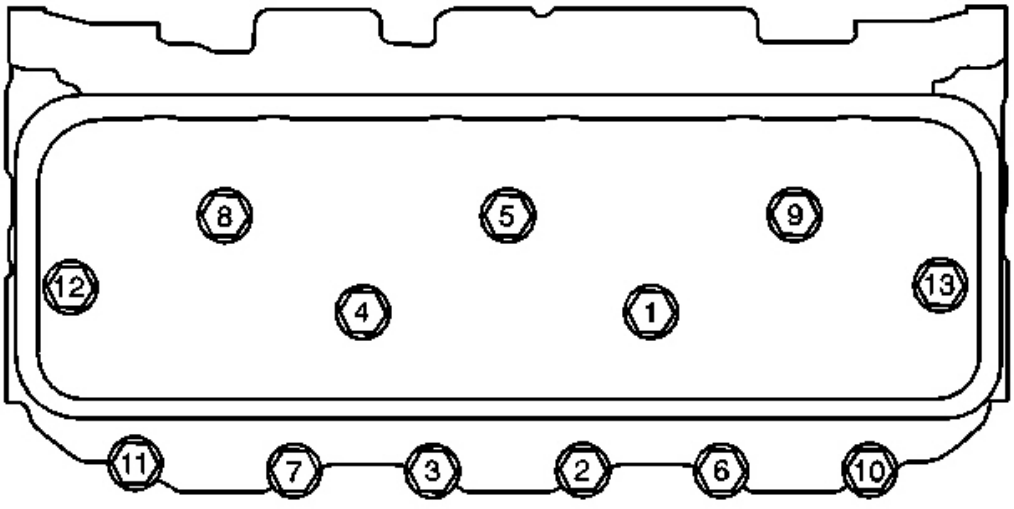


Fig. 196: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Tighten the cylinder head bolts using the sequence shown.

Tighten:

- Tighten the bolts a first pass to 30 N.m (22 lb ft).
- Tighten the long bolts (1, 4, 5, 8, 9) a final pass to 75 degrees using **J 45059** . See **Special Tools**.
- Tighten the medium bolts (12, 13) a final pass to 65 degrees using **J 45059** . See **Special Tools**.
- Tighten the short bolts (2, 3, 6, 7, 10, 11) a final pass to 55 degrees using **J 45059** . See **Special Tools**.

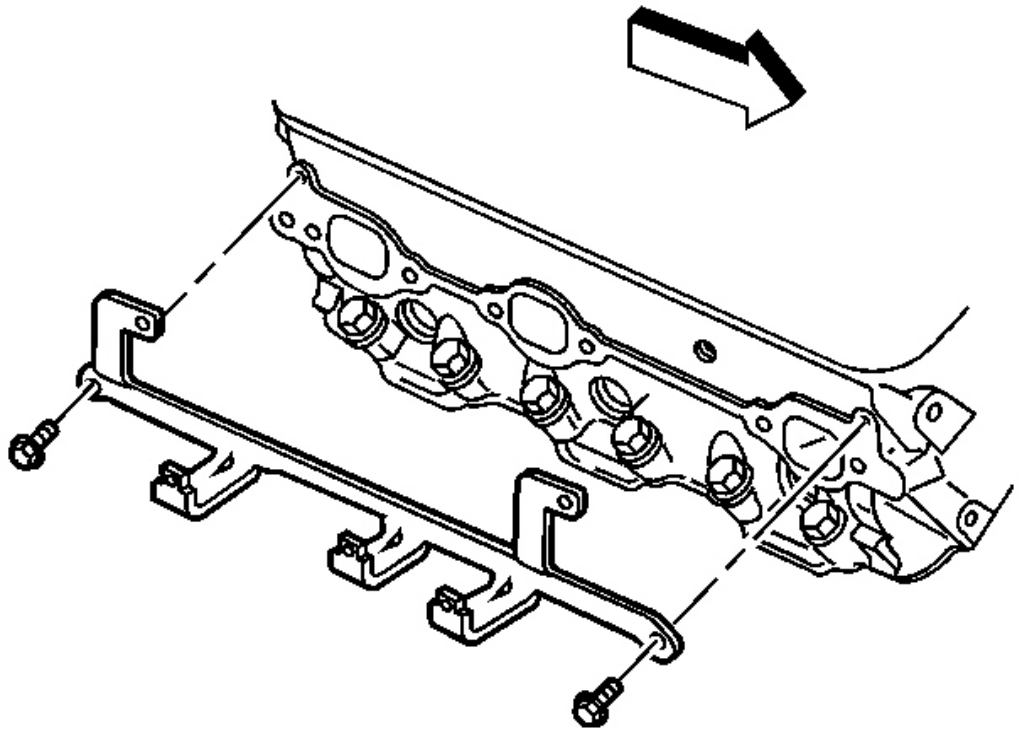


Fig. 197: Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

8. Install the spark plug wire support and bolts.

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

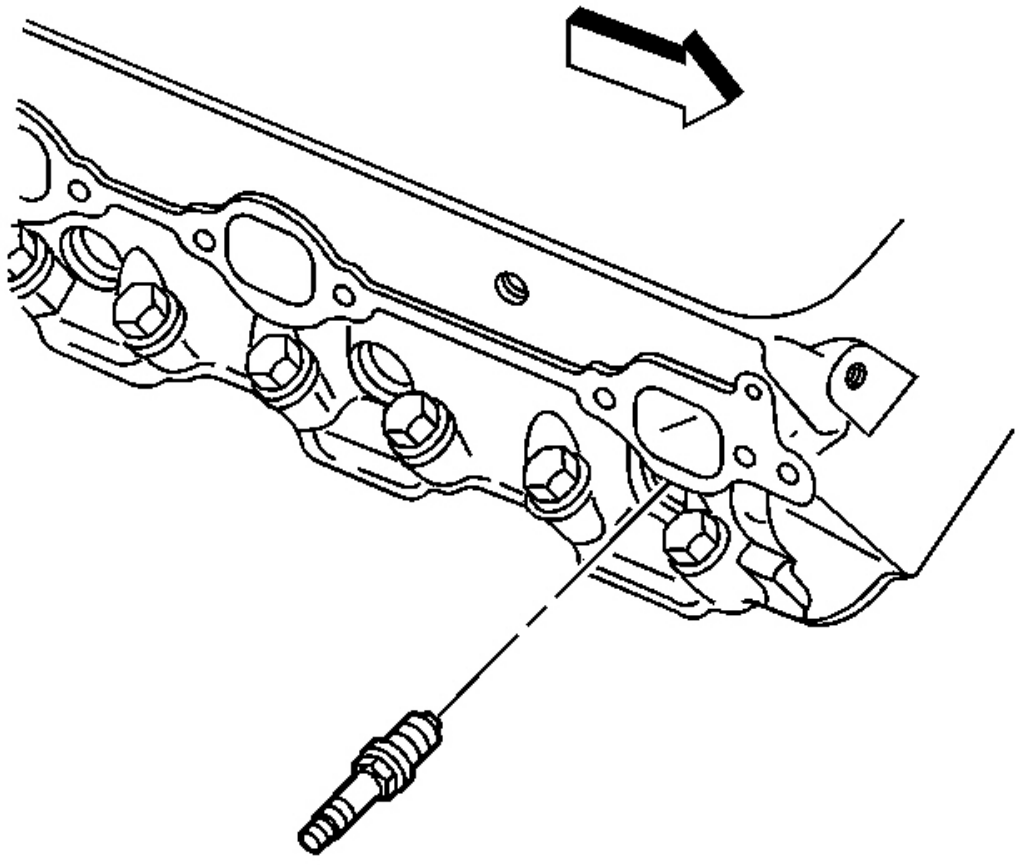


Fig. 198: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

9. Install the spark plugs.
10. If installing NEW spark plugs measure for the correct gap. Adjust the spark plug gap, if necessary.

Specification: Spark plug gap to 1.52 mm (0.060 in).

Tighten:

- Tighten the plugs on a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the plugs on the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

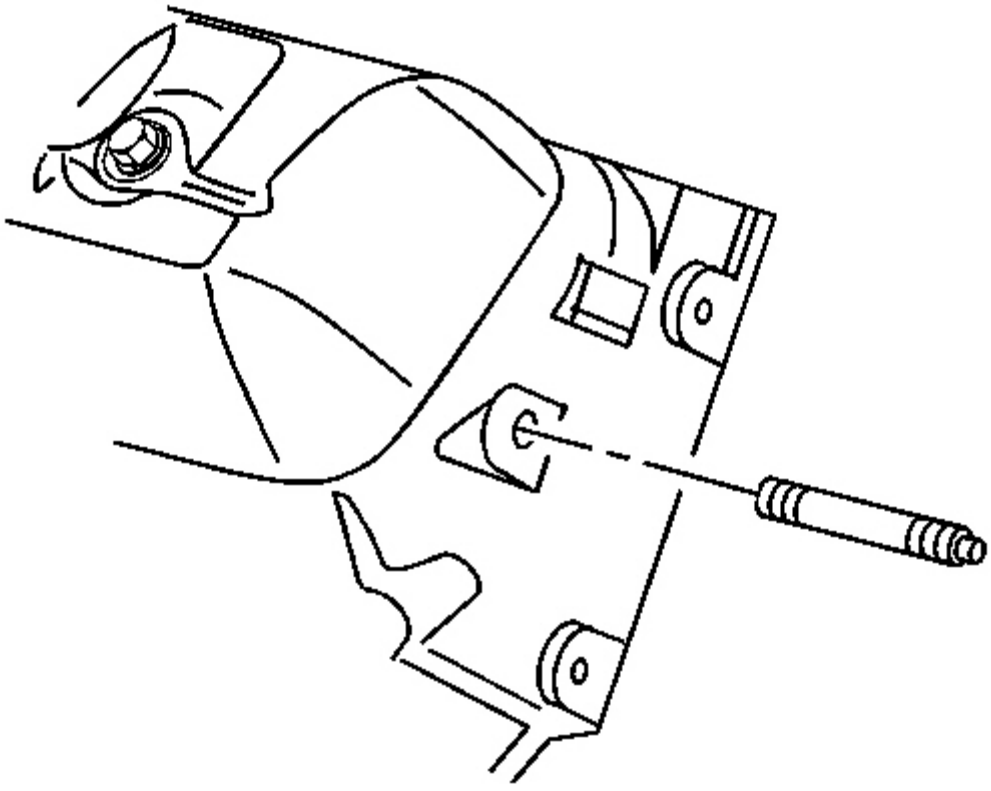


Fig. 199: View Of Generator Bracket Stud
Courtesy of GENERAL MOTORS CORP.

11. Install the generator bracket stud.

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

12. Install the right pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
13. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (4.3L)** .
14. Install the intake manifold. Refer to **Lower Intake Manifold Replacement**.
15. Install the generator bracket. Refer to **Generator Bracket Replacement (4.3L)** .
16. Fill the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or

Cooling System Draining and Filling (Static Fill) .

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

J 23523-F Crankshaft Balancer Remover and Installer. See **Special Tools**.

Removal Procedure

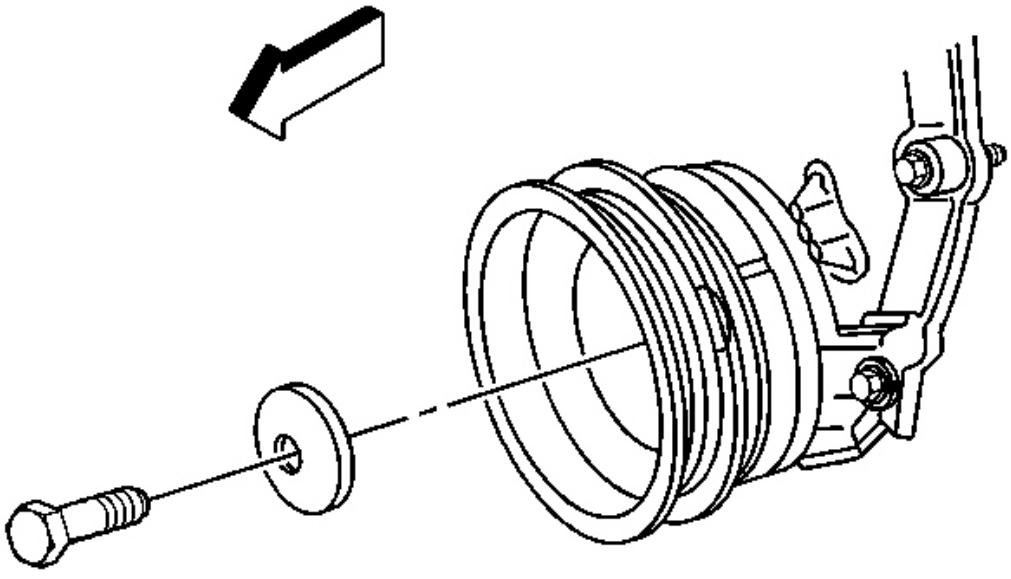


Fig. 200: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the cooling fan. Refer to **Fan Replacement (Diesel)** or **Fan Replacement (Mechanical)** .

NOTE: To prevent damage to the end of the crankshaft when using a crankshaft balancer removal tool install a bolt in the crankshaft. Use a shorter bolt with the same threads as the crankshaft balancer bolt. This bolt will allow a place for the

tool to push against. The shorter bolt is to keep from going past the threads in the crankshaft and damaging the crankshaft threads.

3. Remove the crankshaft balancer bolt and washer.

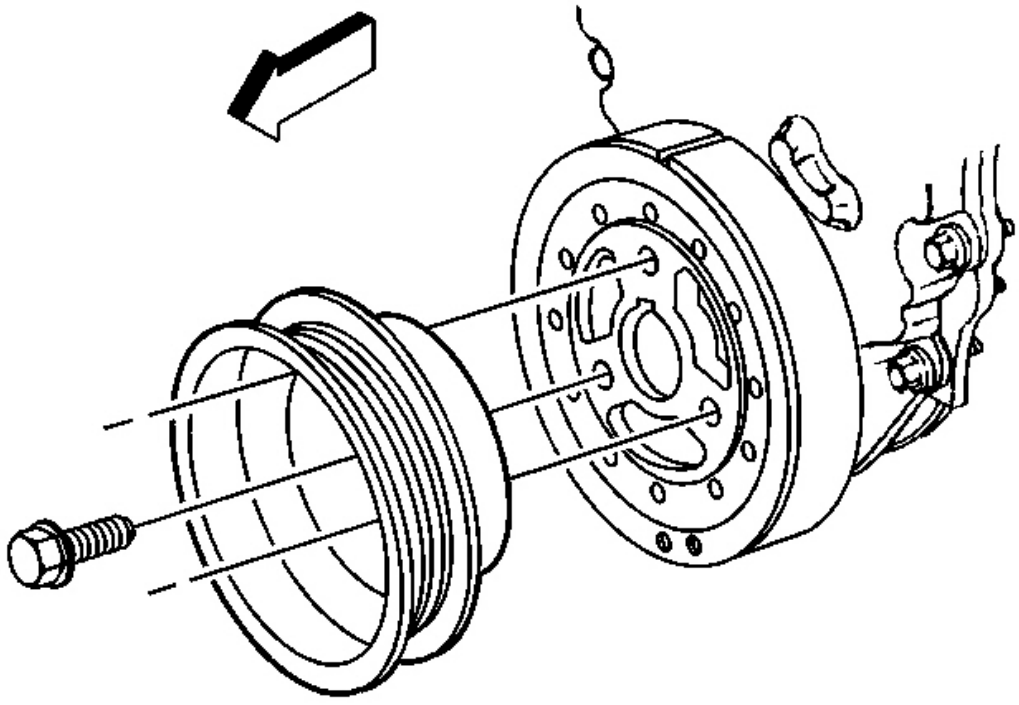


Fig. 201: View Of Crankshaft Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft pulley bolts and pulley.

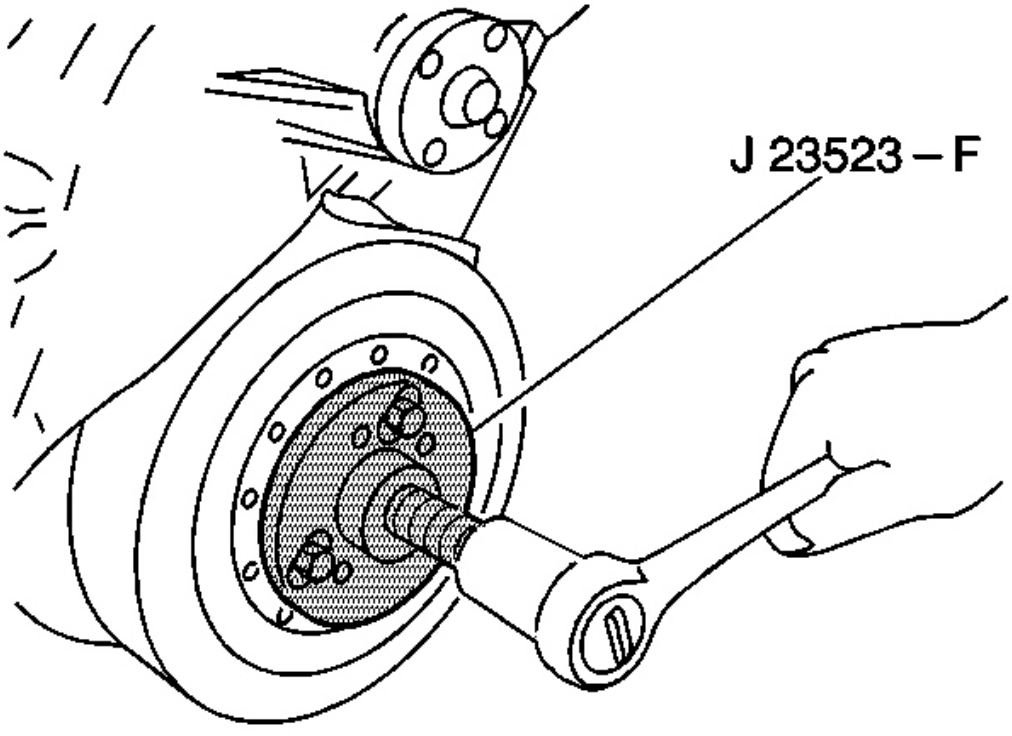


Fig. 202: Removing Crankshaft Balancer Using J 23523-F
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Using **J 23523-F** , remove the crankshaft balancer. See **Special Tools**.
    1. Install the **J 23523-F** plate and bolts onto the crankshaft balancer. See **Special Tools**.

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

    2. Install the **J 23523-F** forcing screw into the plate. See **Special Tools**.
    3. Rotate the **J 23523-F** forcing screw clockwise in order to remove the crankshaft balancer. See **Special Tools**.
6. Remove the **J 23523-F** from the crankshaft balancer. See **Special Tools**.

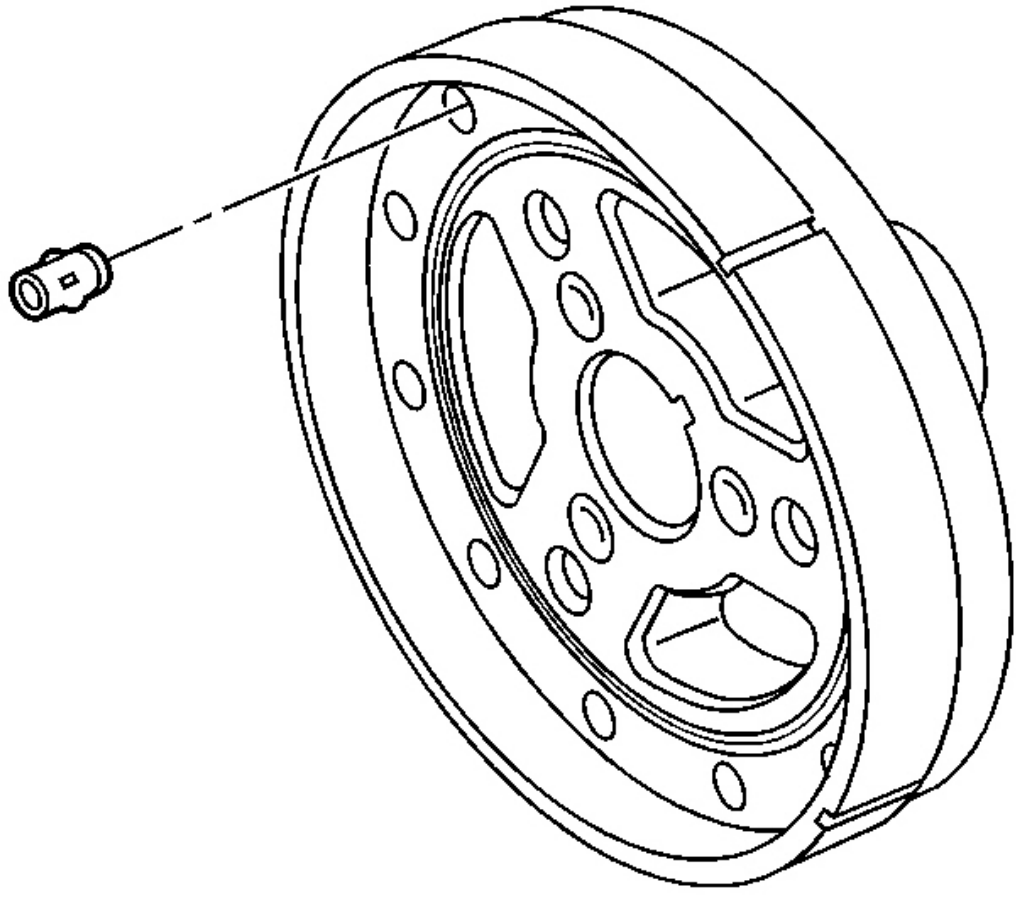


Fig. 203: View Of Crankshaft Balancer Weights
Courtesy of GENERAL MOTORS CORP.

7. Note the position and length of any crankshaft balancer weights, if necessary.
8. Clean and inspect the crankshaft balancer, if necessary. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

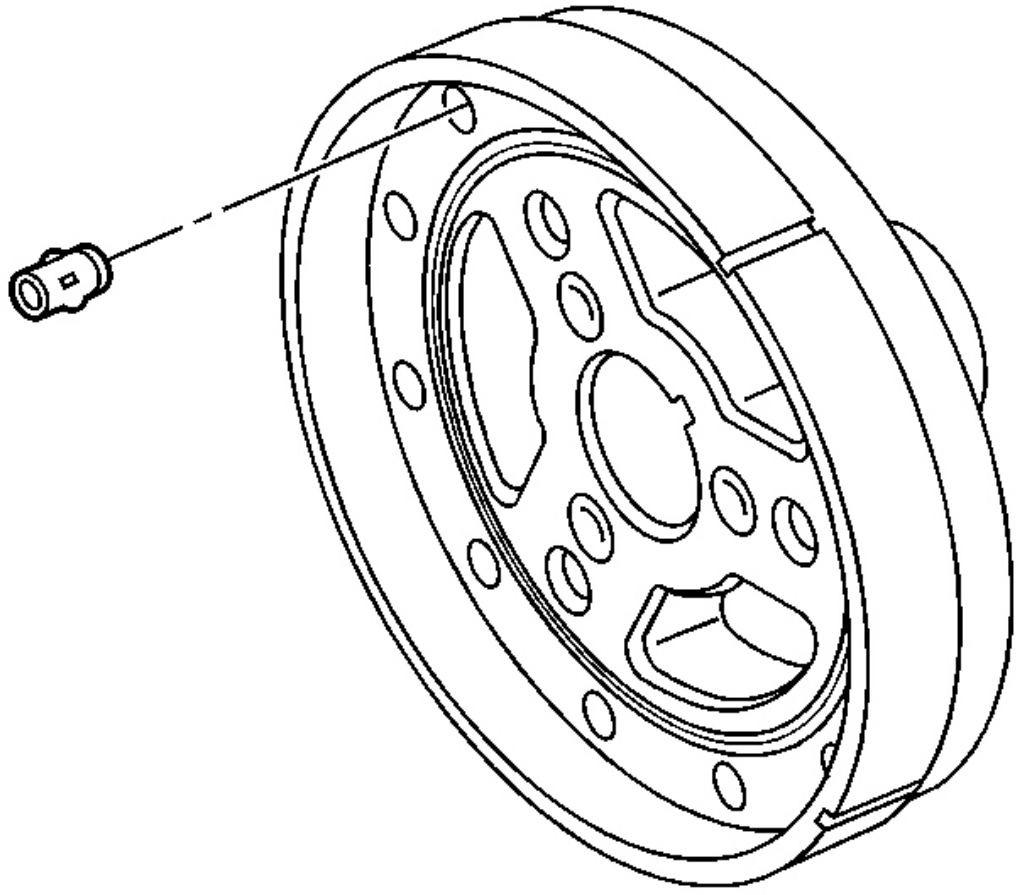


Fig. 204: View Of Crankshaft Balancer Weights
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The length and location of the weight(s) must be the same as the original.

1. Apply a small amount of grease to the crankshaft front cover seal sealing surface if reusing the seal.
2. Ensure that the crankshaft balancer weight(s) is installed in the proper location, if necessary.

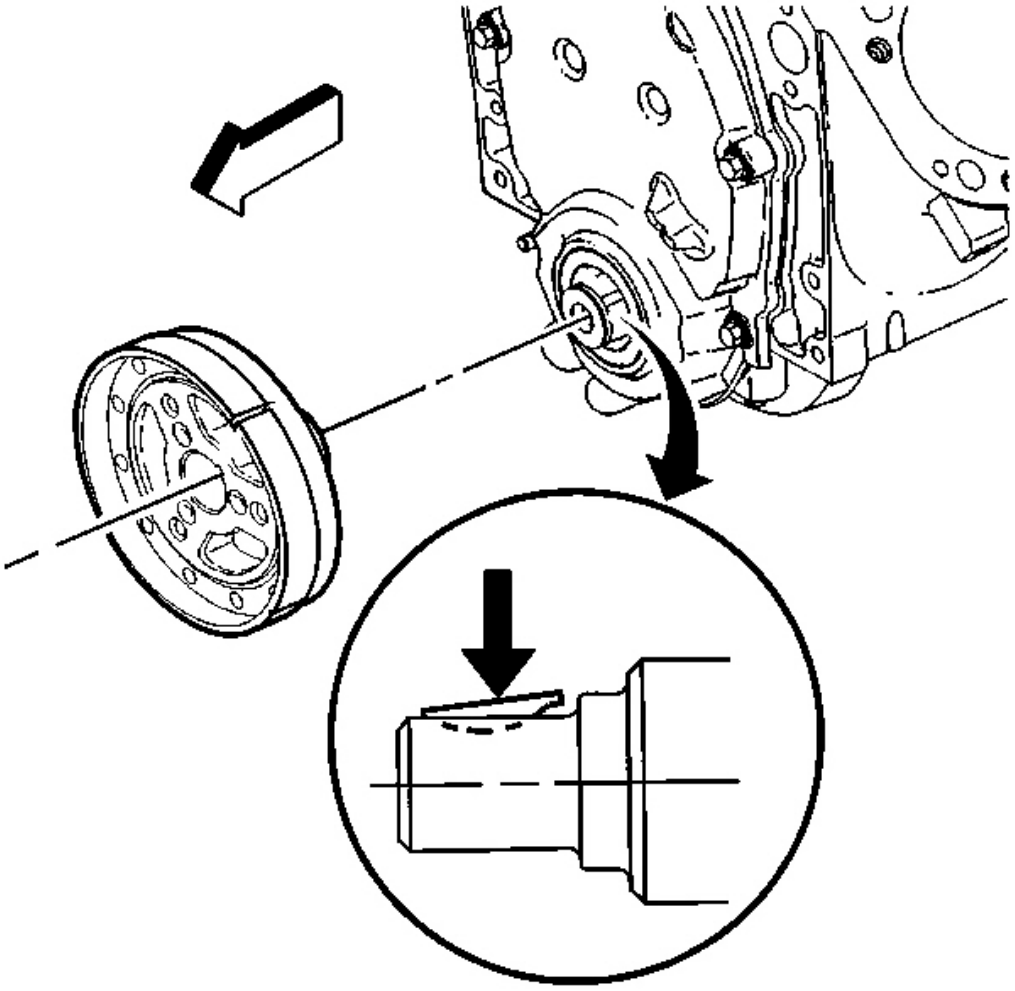


Fig. 205: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

3. Apply a small amount of adhesive into the crankshaft balancer keyway in order to seal the

crankshaft balancer keyway and crankshaft joint. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

4. Align the keyway of the crankshaft balancer with the crankshaft balancer key.
5. Install the crankshaft balancer onto the end of the crankshaft.

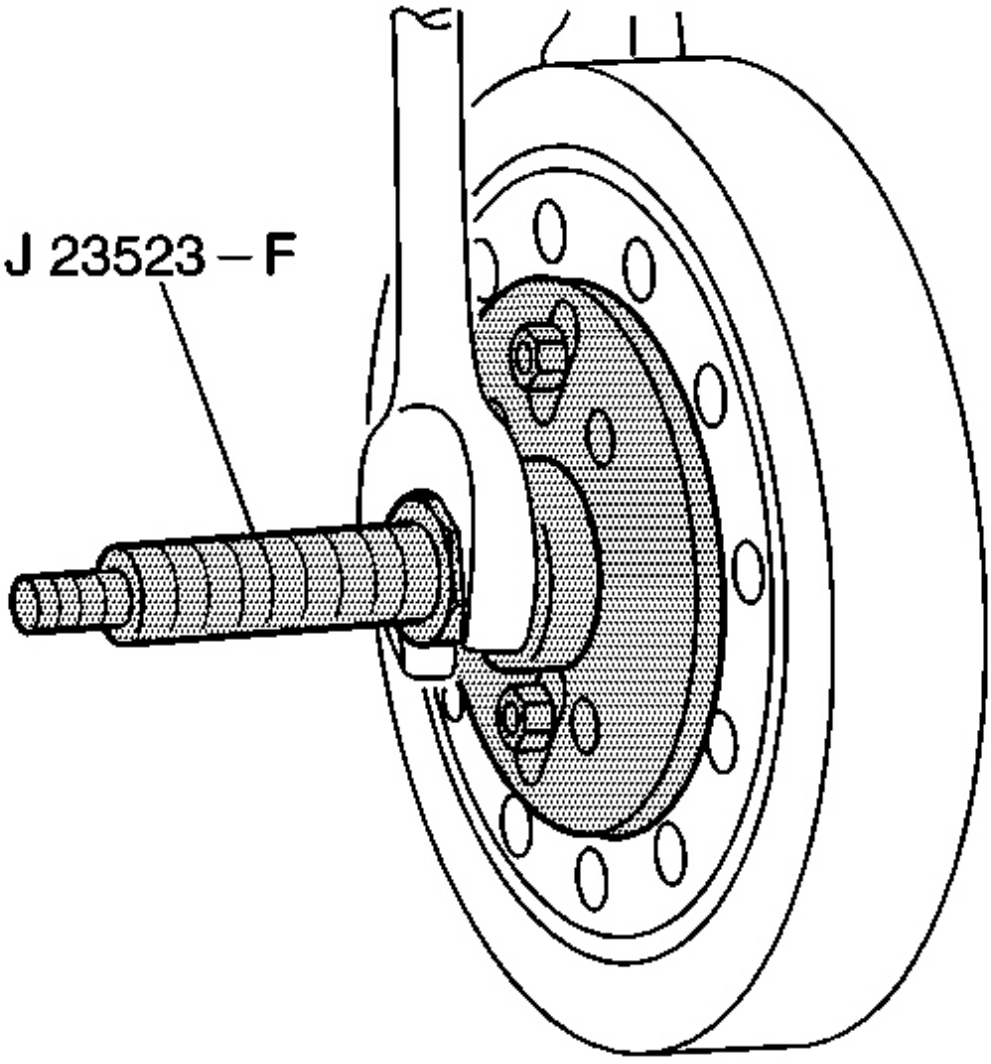


Fig. 206: Pressing Crankshaft Balancer Onto Crankshaft Using J 23523-F
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Using **J 23523-F** , press the crankshaft balancer onto the crankshaft. See **Special Tools**.
   1. Install the **J 23523-F** plate and bolts onto the front of the crankshaft balancer. See **Special Tools**.

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

   2. Install the **J 23523-F** forcing screw into the end for the crankshaft. See **Special Tools**.
   3. Install the **J 23523-F** bearing, the washer, and the nut onto the forcing screw. See **Special Tools**.
   4. Rotate the **J 23523-F** nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring. See **Special Tools**.
7. Remove the **J 23523-F** . See **Special Tools**.

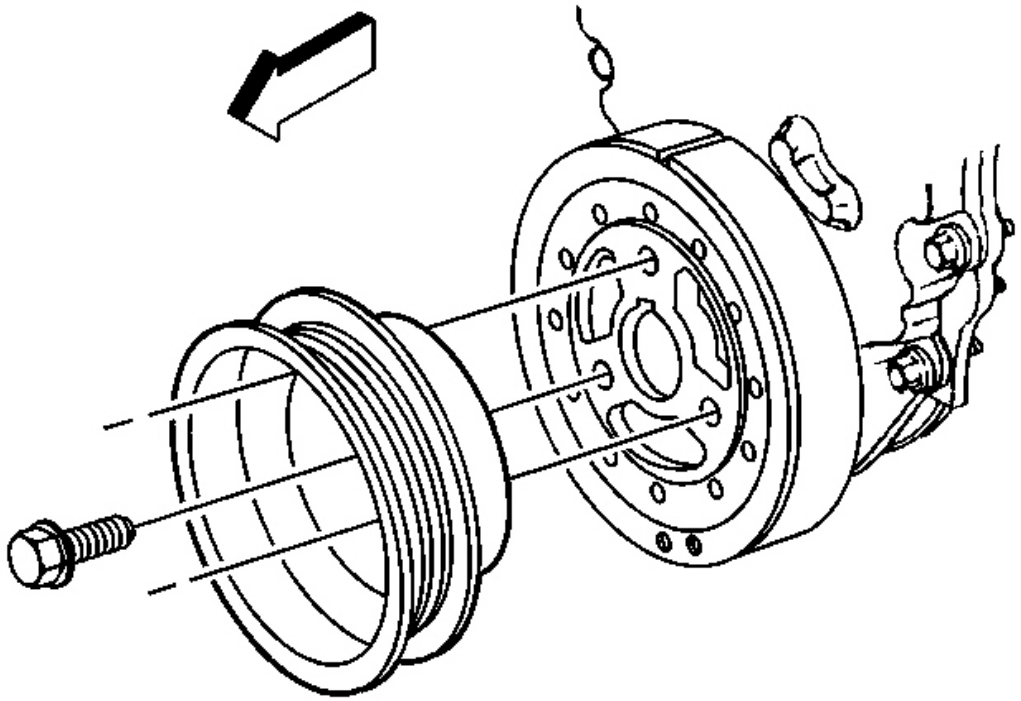


Fig. 207: View Of Crankshaft Pulley & Bolts

Courtesy of GENERAL MOTORS CORP.

8. Install the crankshaft pulley and bolts. Finger tighten all bolts until snug in order to fully seat the pulley.
9. Tighten the bolts.

   Tighten: Tighten the bolts to 58 N.m (43 lb ft).

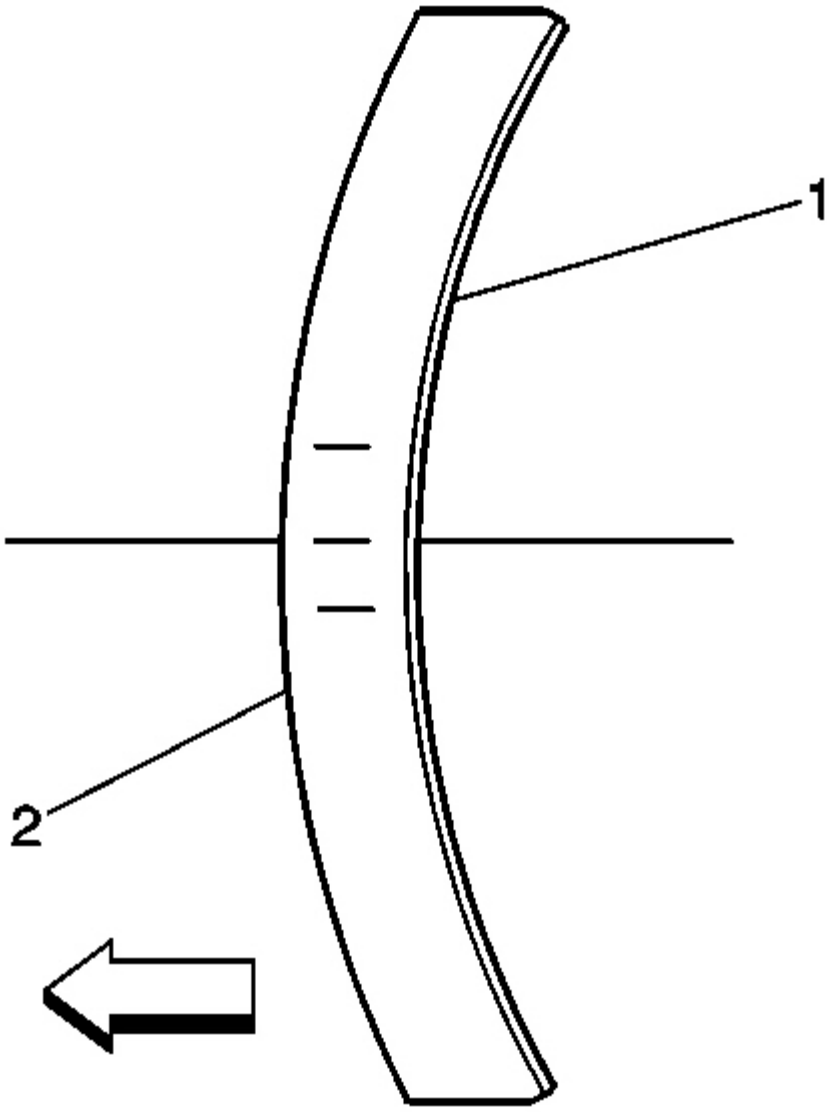


Fig. 208: Crankshaft Balancer Washer
Courtesy of GENERAL MOTORS CORP.

10. Ensure that the crown of the crankshaft balancer washer (2) is faced away from the engine.

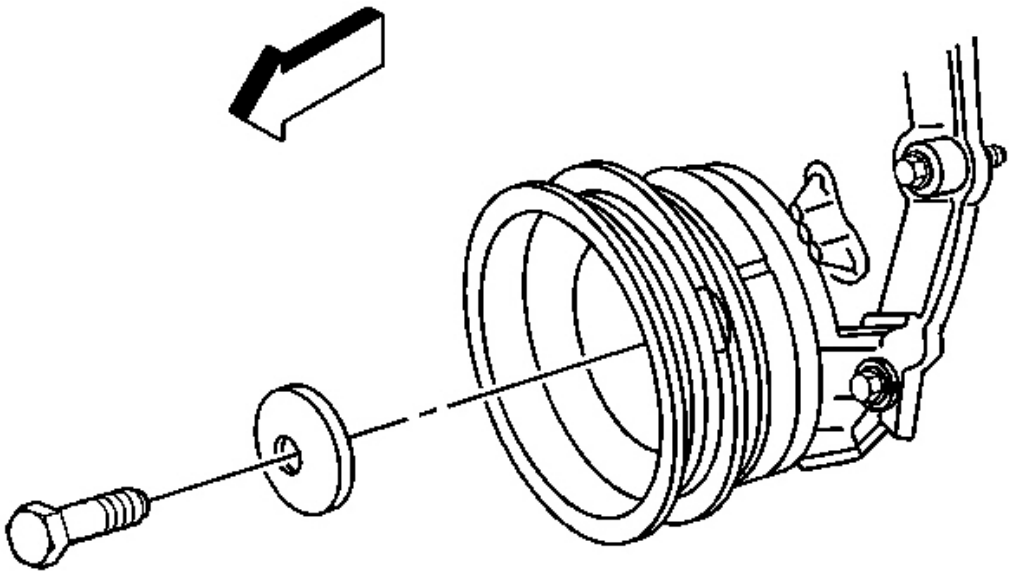


Fig. 209: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Install the crankshaft balancer washer and bolt.

    Tighten: Tighten the bolt to 95 N.m (70 lb ft).

12. Install the cooling fan. Refer to **Fan Replacement (Diesel)** or **Fan Replacement (Mechanical)** .
13. Install the drive belt. Refer to **Drive Belt Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

J 35468 Cover Aligner and Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Inspect the engine front cover seal bore area for damage.

3. Use a suitable seal puller, remove the crankshaft front oil seal.

Installation Procedure

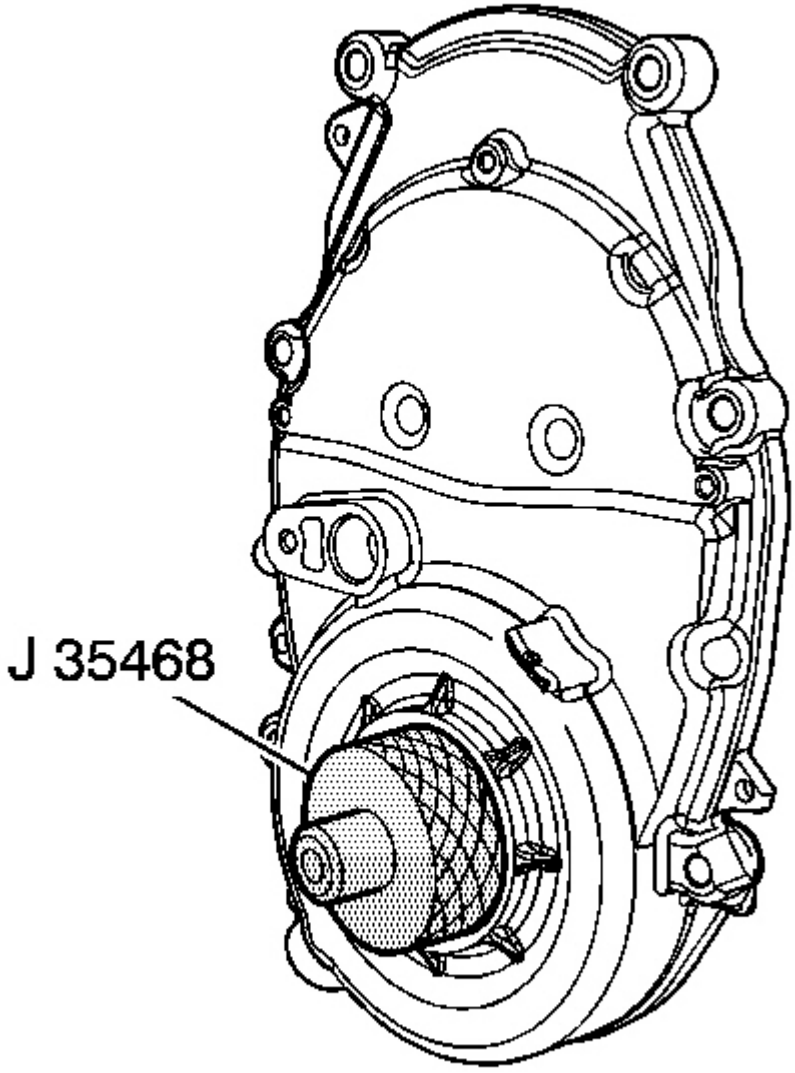


Fig. 210: Installing Front Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the exterior of the NEW seal with clean engine oil.

2. Using **J 35468** and a hammer, install the crankshaft front oil seal. See **Special Tools**.
3. Ensure the crankshaft front oil seal is flush and square to the engine front cover.
4. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Removal Procedure

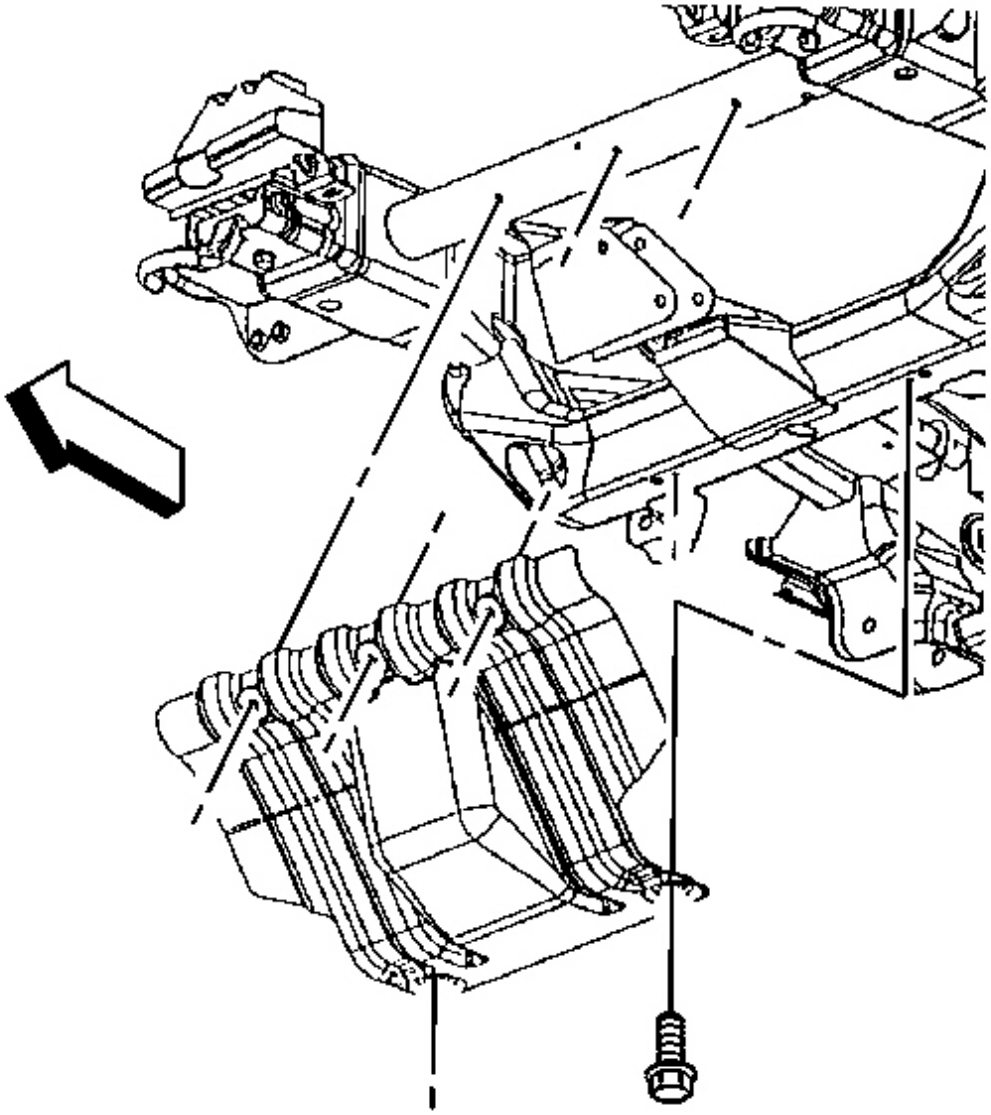


Fig. 211: View Of Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement (LU3)** .
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the oil pan. Refer to **Oil Pan Replacement**.

4. Remove the engine shield bolts and shield.

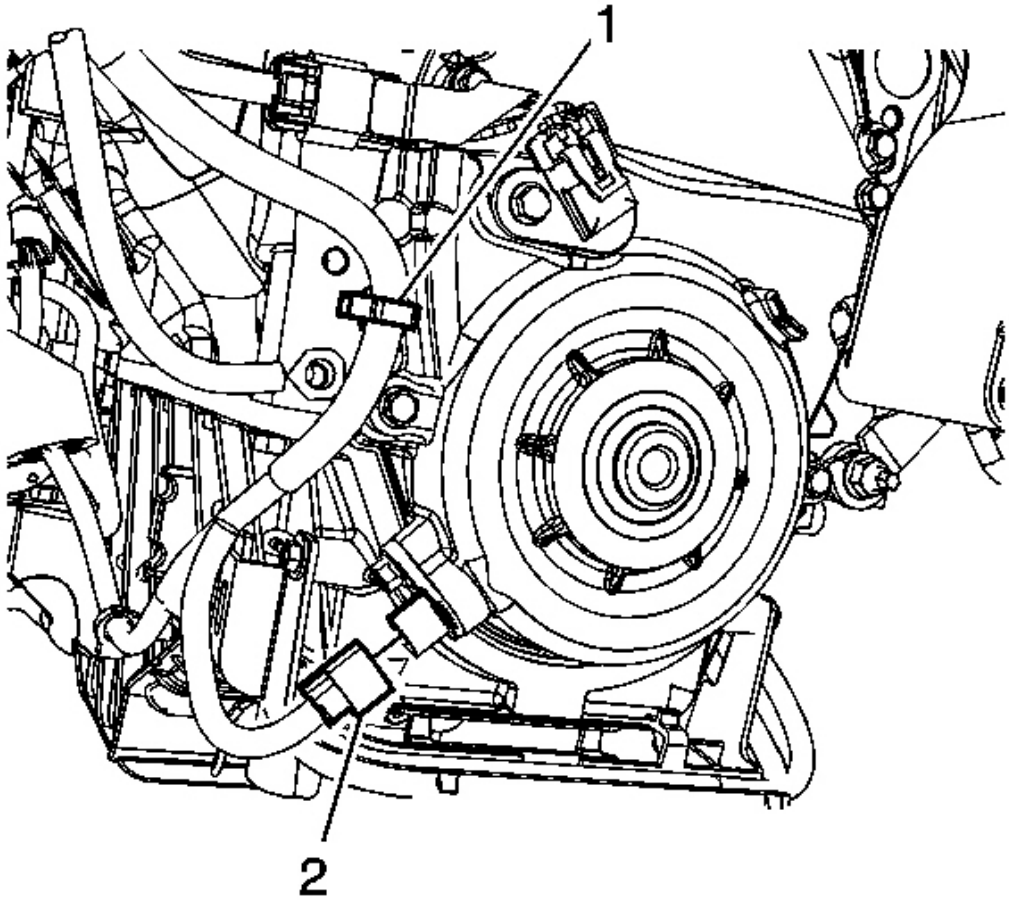


Fig. 212: Crankshaft Position (CKP) Sensor Electrical Connector & Clip
Courtesy of GENERAL MOTORS CORP.

5. Remove engine wire harness clip (1) from front cover.
6. Disconnect the crankshaft position (CKP) sensor electrical connector (2).

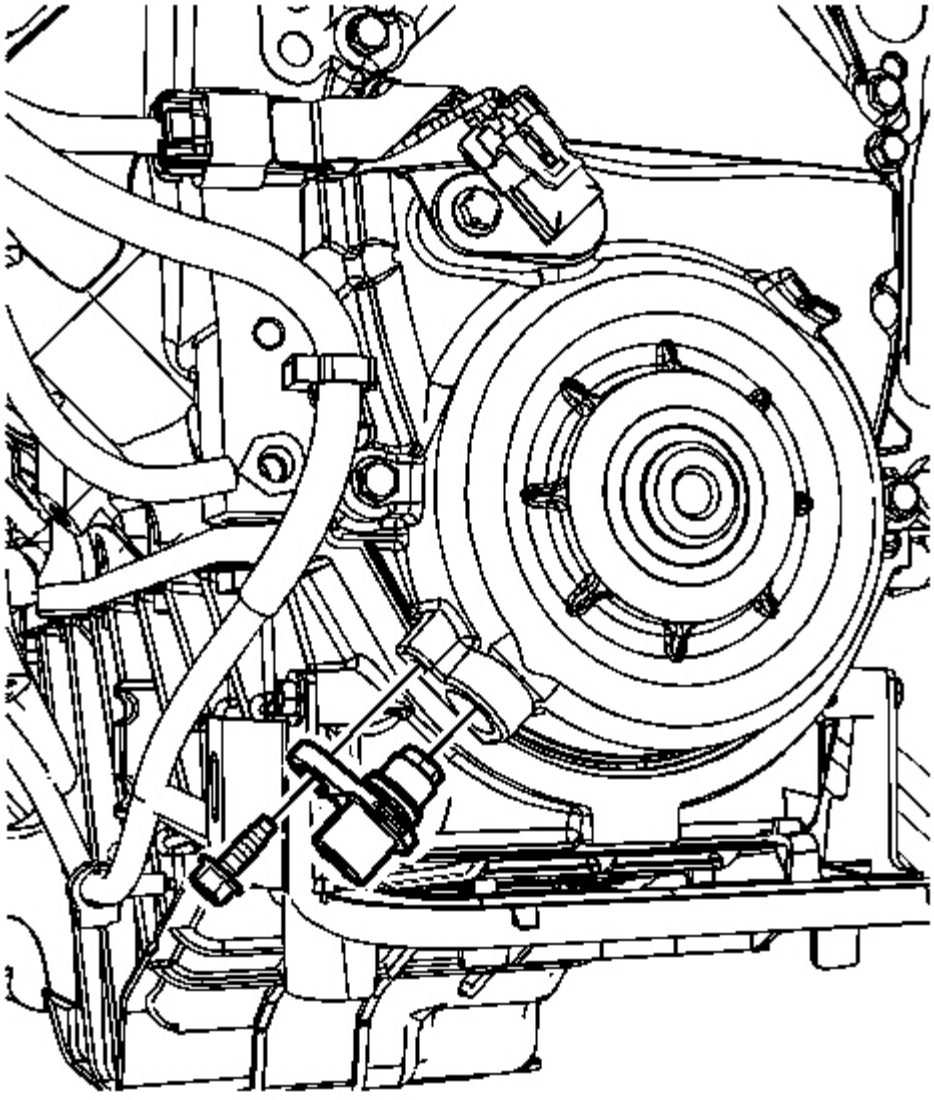


Fig. 213: CKP Sensor Bolt And Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the CKP sensor bolt and sensor.

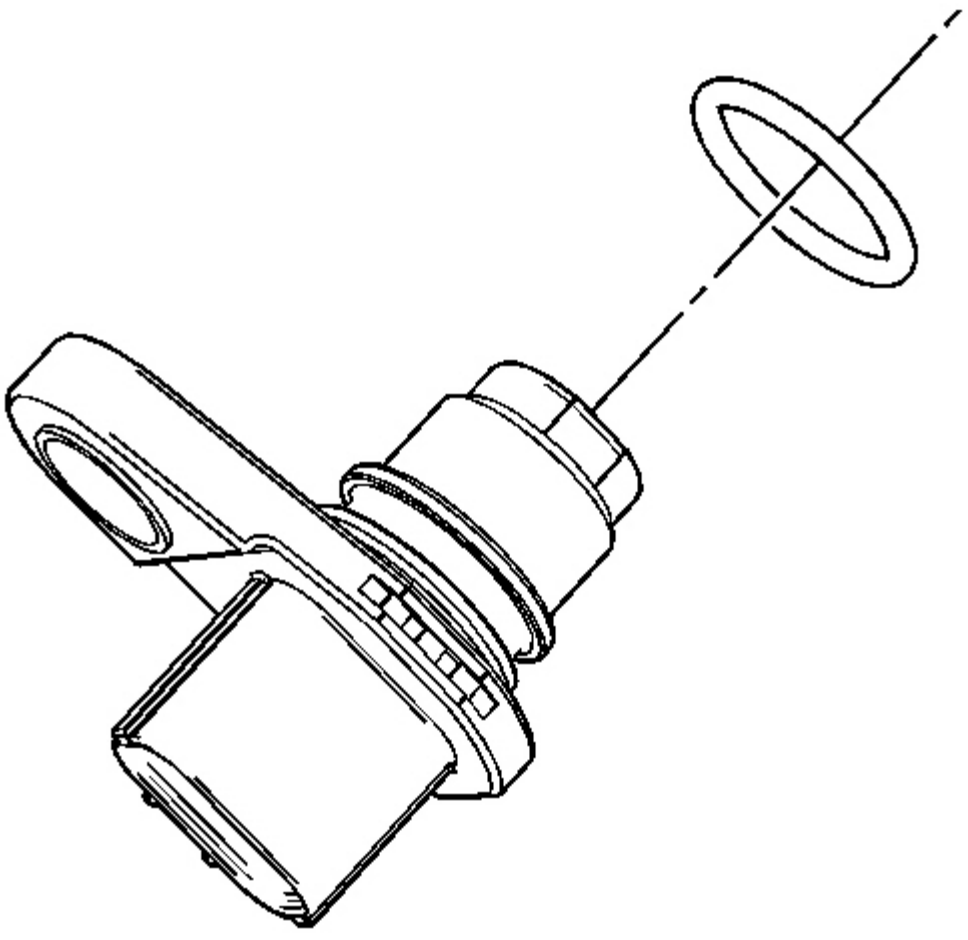


Fig. 214: CKP Sensor O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the CKP sensor O-ring seal.

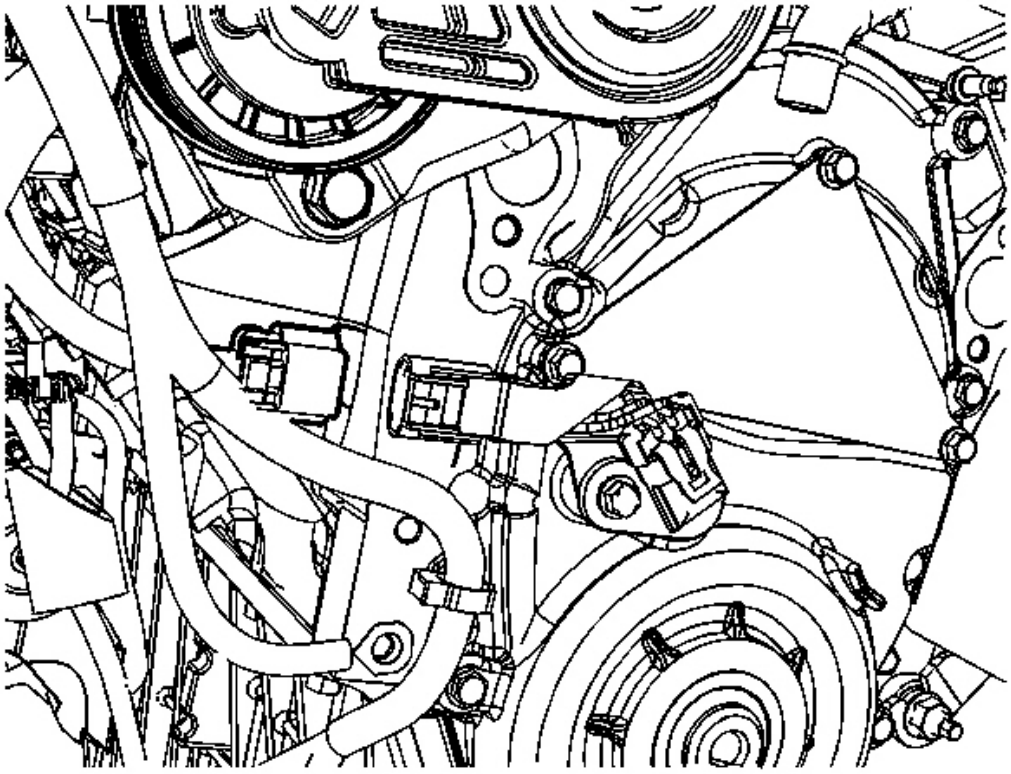


Fig. 215: Camshaft Position (CMP) Sensor Wiring Harness Jumper
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine wiring harness electrical connector from the camshaft position (CMP) sensor wiring harness jumper.

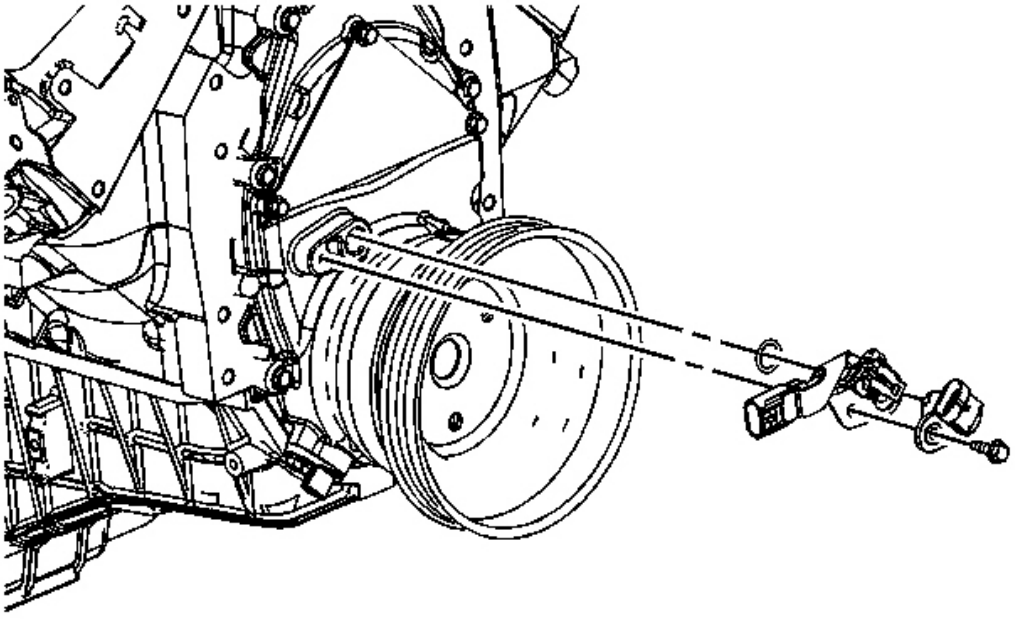


Fig. 216: View Of CMP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove the CMP sensor bolt.
11. Remove the CMP sensor and wiring harness jumper from the engine front cover.
12. Disconnect the CMP sensor wiring harness jumper from the CMP sensor.
13. Remove the CMP sensor from the wiring harness jumper.

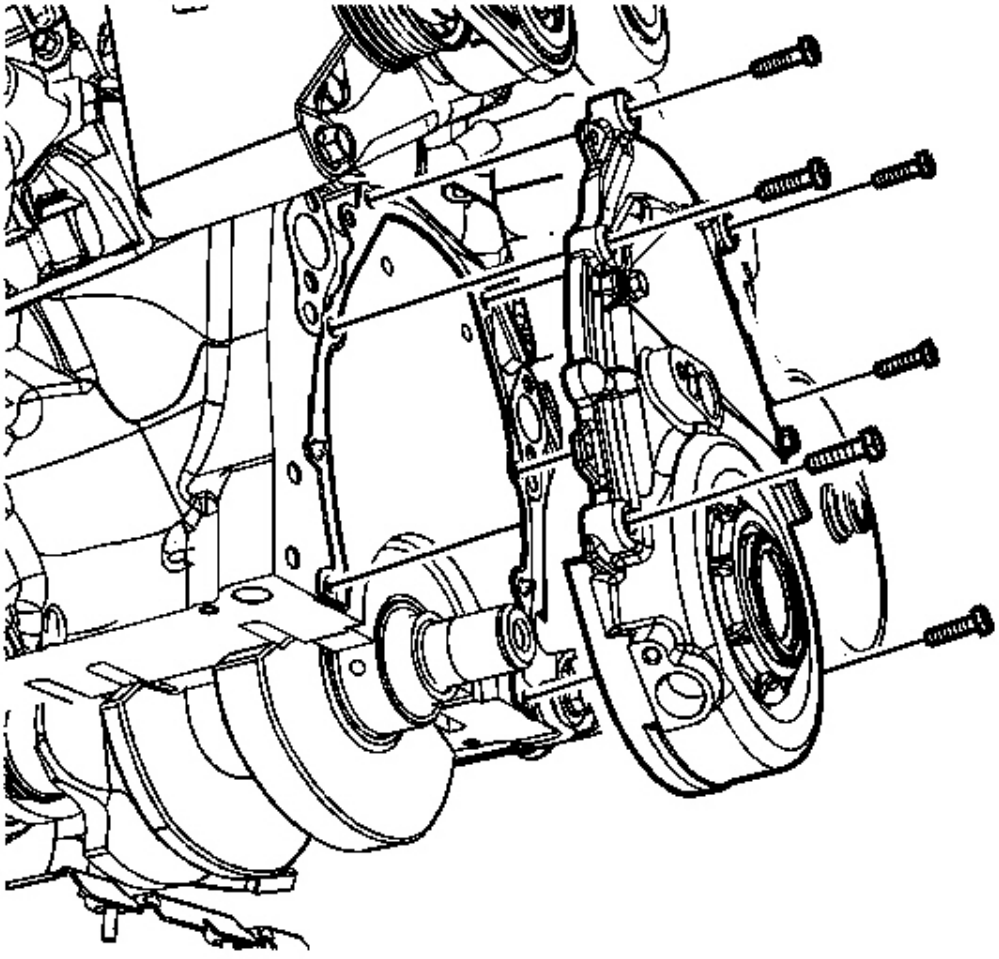


Fig. 217: Front Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the front cover bolts.

IMPORTANT: After the composite front cover is removed do not reinstall the front cover. Always install a NEW front cover.

15. Remove and discard the front cover.
16. Clean all sealing surfaces.

Installation Procedure

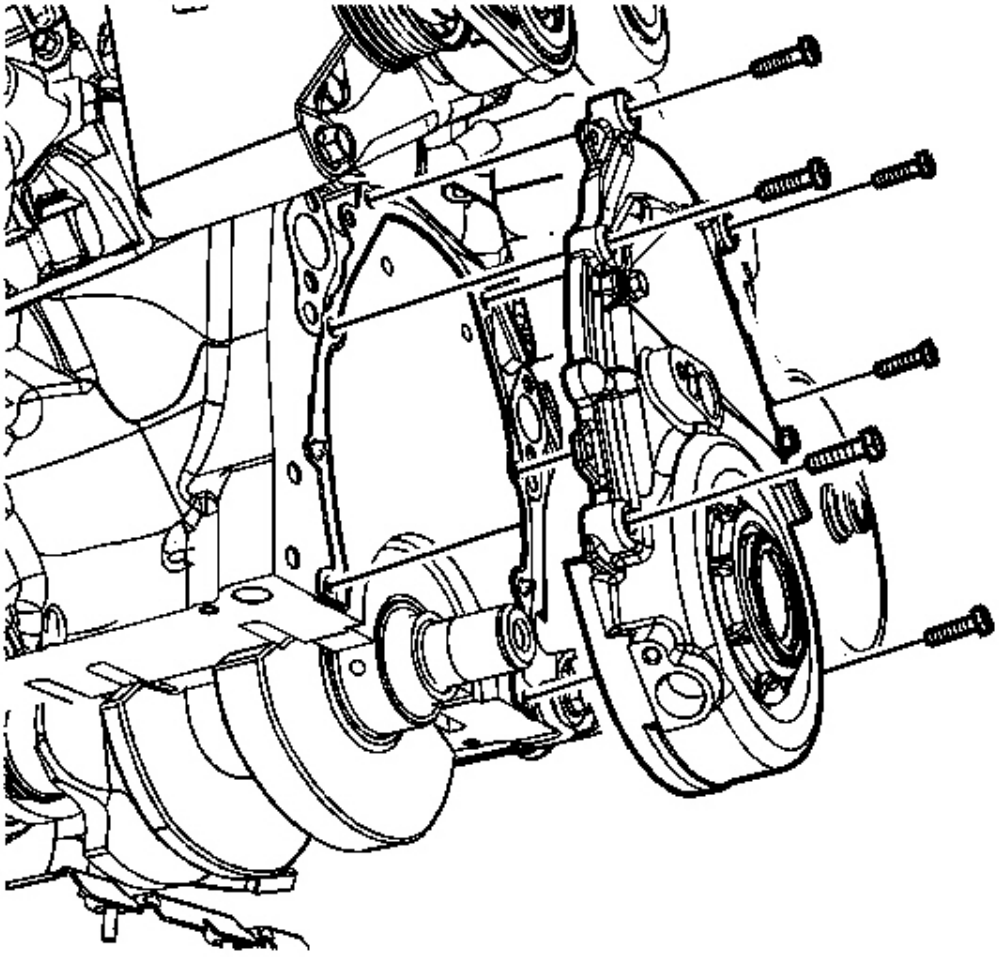


Fig. 218: Front Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install a NEW front cover.
2. Install the front cover bolts.

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

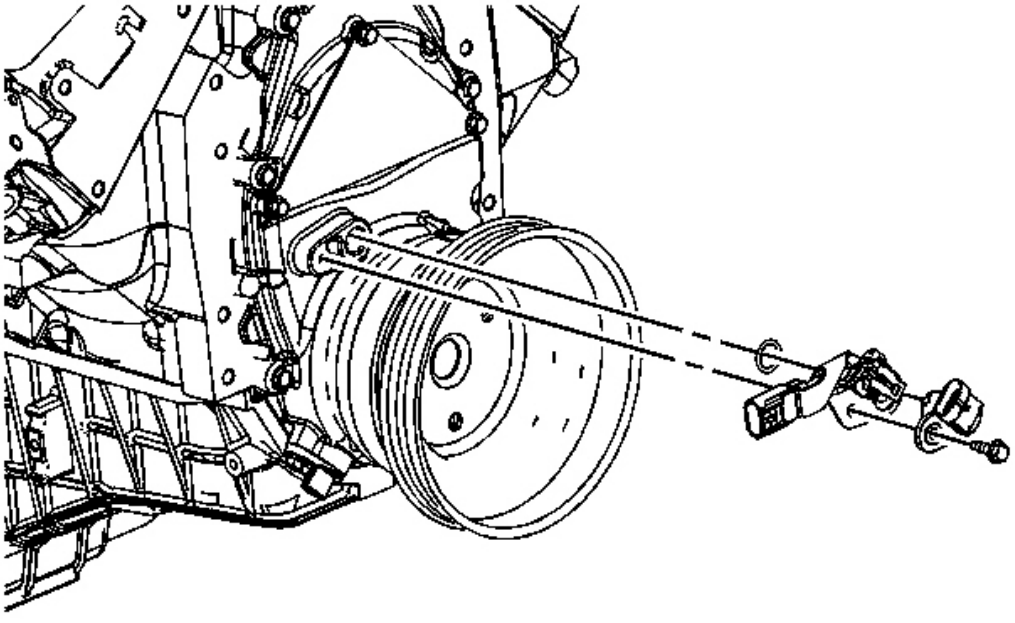


Fig. 219: View Of CMP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the original O-ring seal.

3. If reinstalling the old CMP sensor, install a NEW O-ring seal onto the sensor.
4. Install the CMP sensor to the wiring harness jumper.
5. Connect the CMP sensor wiring harness jumper to the CMP sensor.
6. Lubricate the O-ring seal with clean engine oil.
7. Install the CMP sensor and wiring harness jumper to the engine front cover.
8. Install the CMP sensor bolt.

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

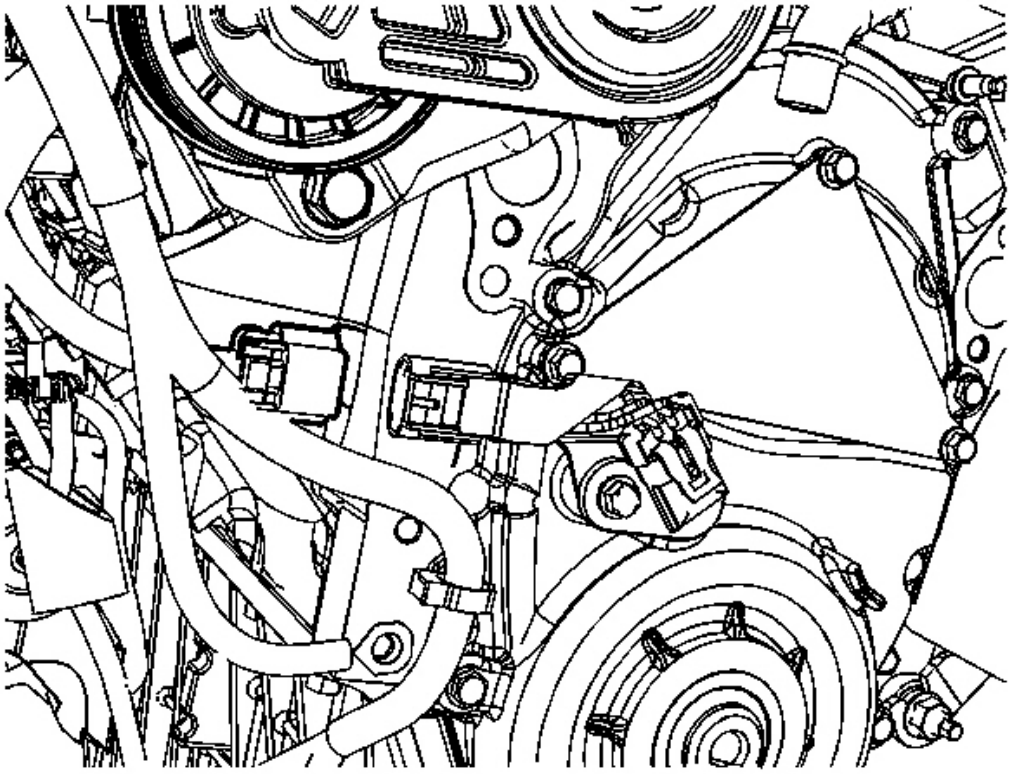


Fig. 220: Camshaft Position (CMP) Sensor Wiring Harness Jumper
Courtesy of GENERAL MOTORS CORP.

9. Connect the engine wiring harness electrical connector from the CMP sensor wiring harness jumper.

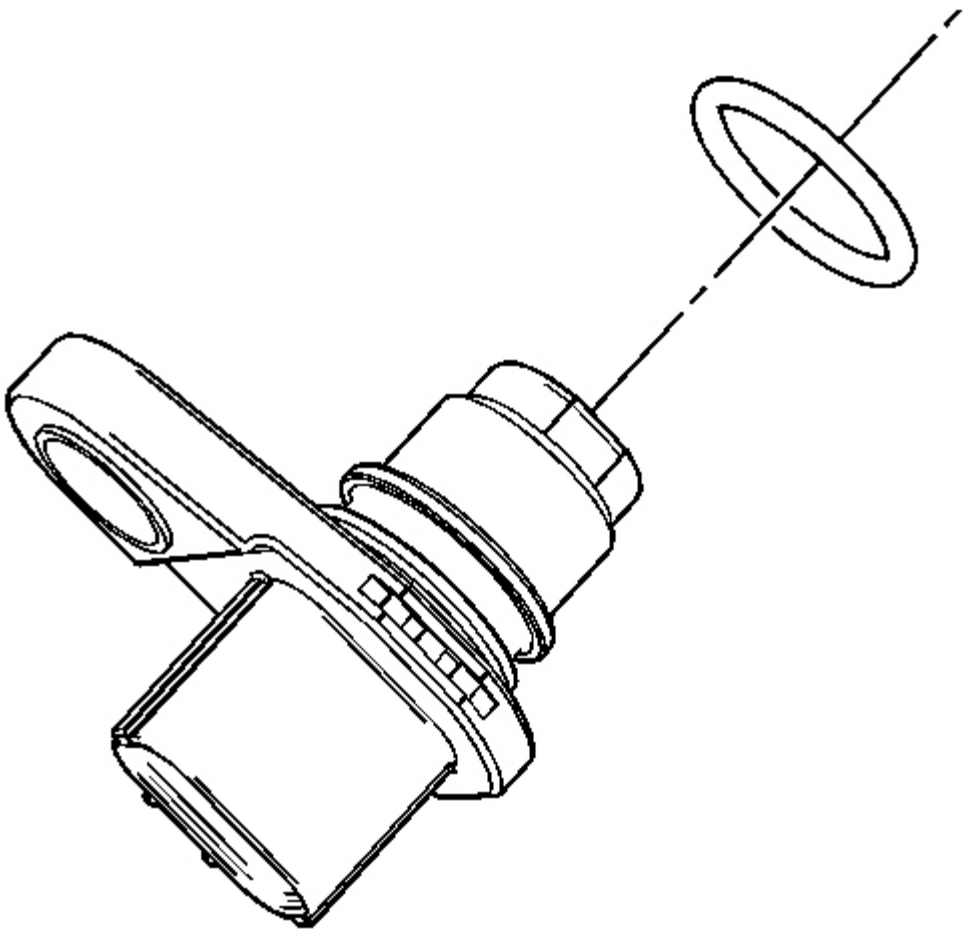


Fig. 221: CKP Sensor O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the original CKP sensor O-ring seal.

10. Lubricate a NEW CKP sensor O-ring seal with clean engine oil.
11. Install the NEW O-ring seal onto the CKP sensor.

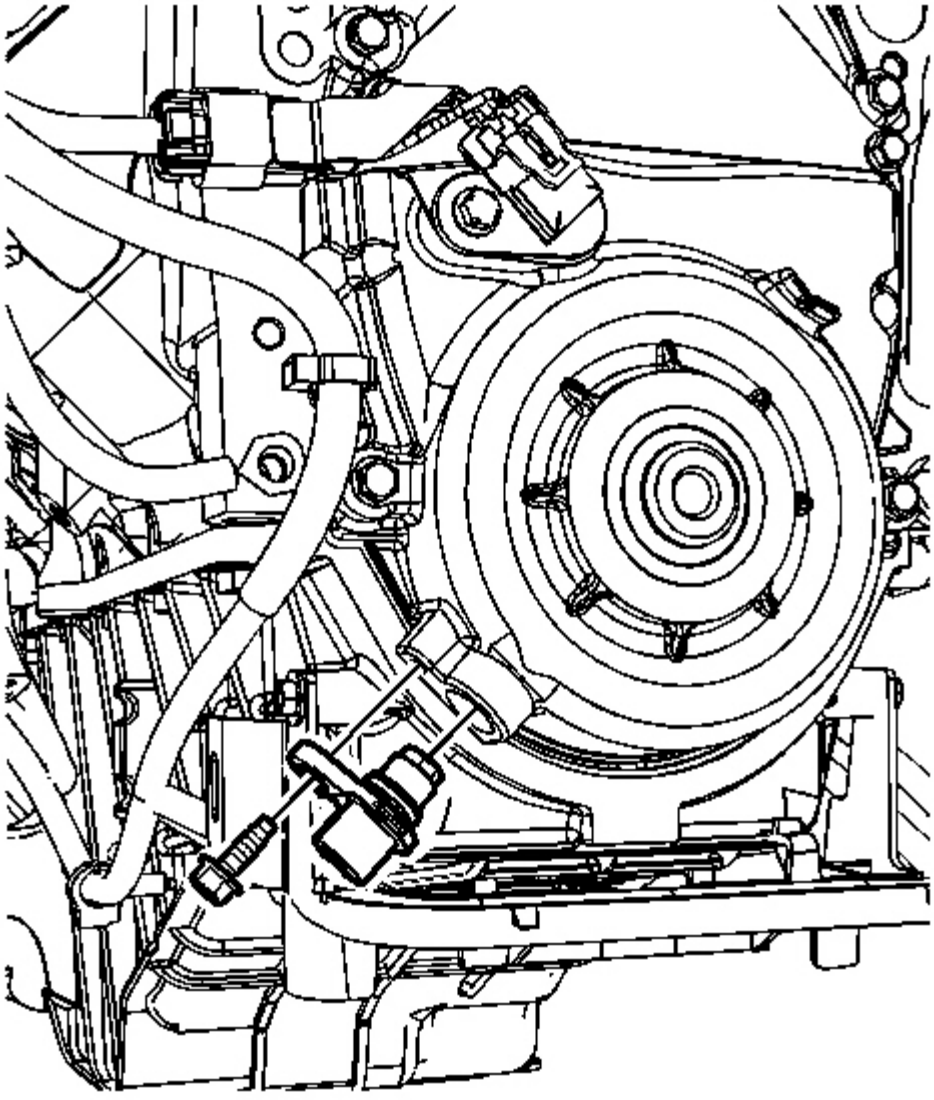


Fig. 222: CKP Sensor Bolt And Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing the CKP sensor, make sure the sensor is fully seated before tightening the bolt. A poorly seated sensor may perform erratically and may set false DTCs.

12. Install the CKP sensor and bolt.

    Tighten: Tighten the bolt to 8 N.m (71 lb in).

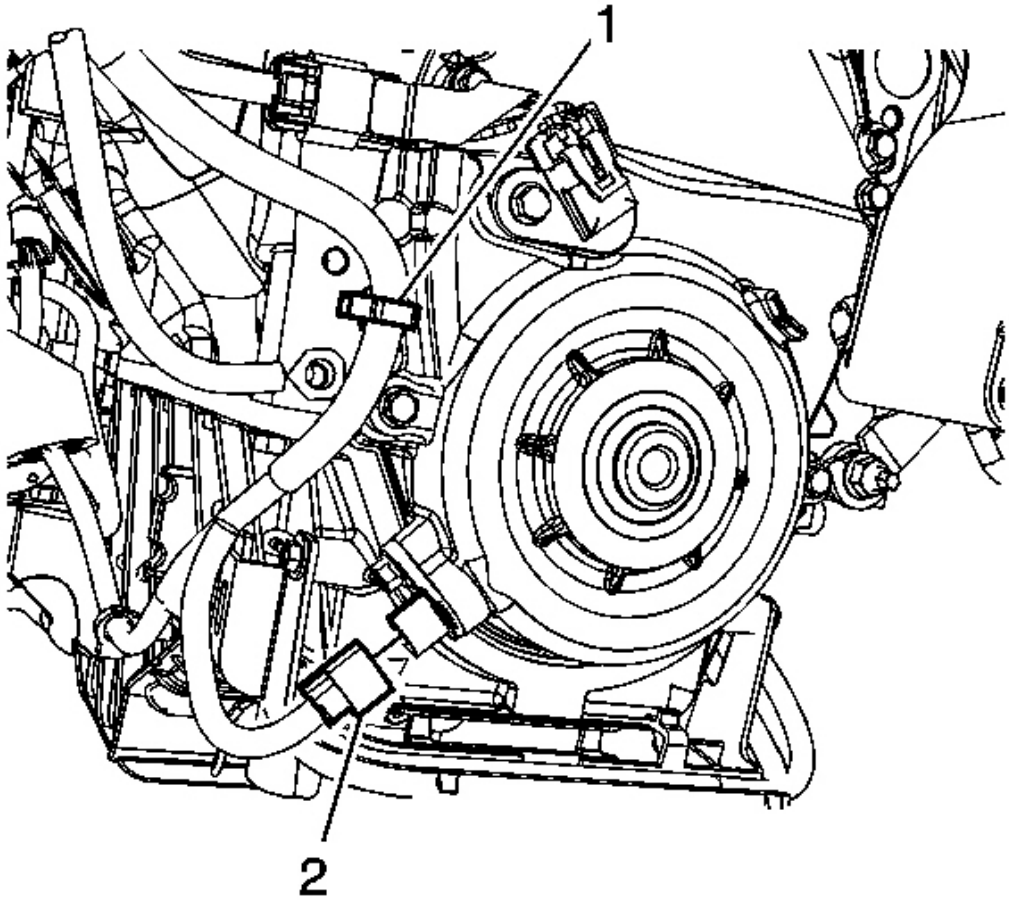


Fig. 223: Crankshaft Position (CKP) Sensor Electrical Connector & Clip
Courtesy of GENERAL MOTORS CORP.

13. Connect the CKP sensor electrical connector (2).
14. Install the engine wire harness clip (1) to front cover.

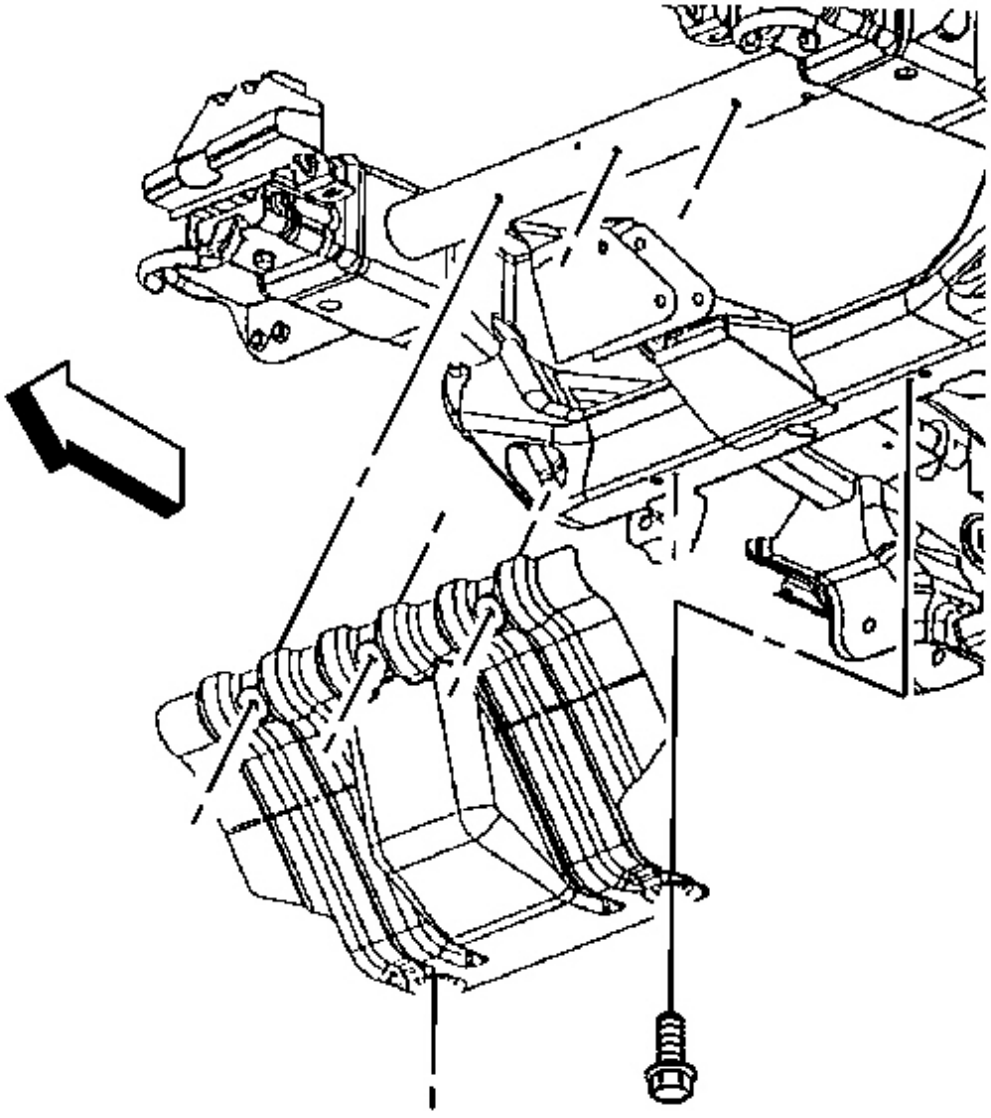


Fig. 224: View Of Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

15. Install the engine shield and bolts.

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

16. Install the oil pan. Refer to **Oil Pan Replacement**.
17. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
18. Install the water pump. Refer to **Water Pump Replacement (LU3)** .

CRANKSHAFT POSITION SENSOR RELUCTOR RING REPLACEMENT

Tools Required

J 5590 Rear Pinion Bearing Race Installer. See **Special Tools**.

Removal Procedure

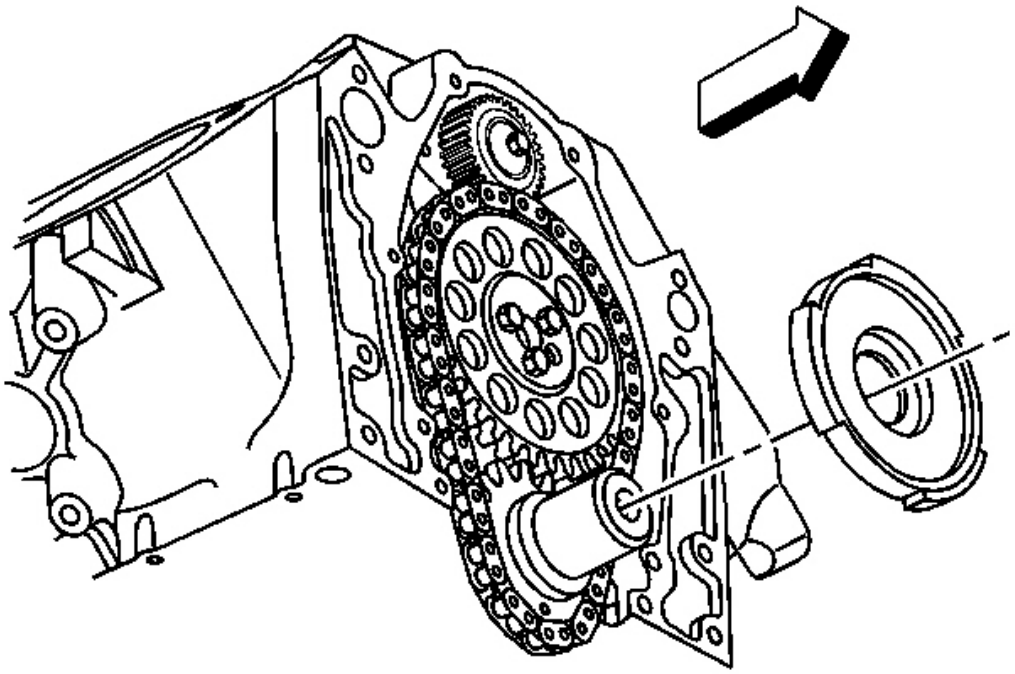


Fig. 225: CKP Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the crankshaft position (CKP) sensor reluctor ring.

Installation Procedure

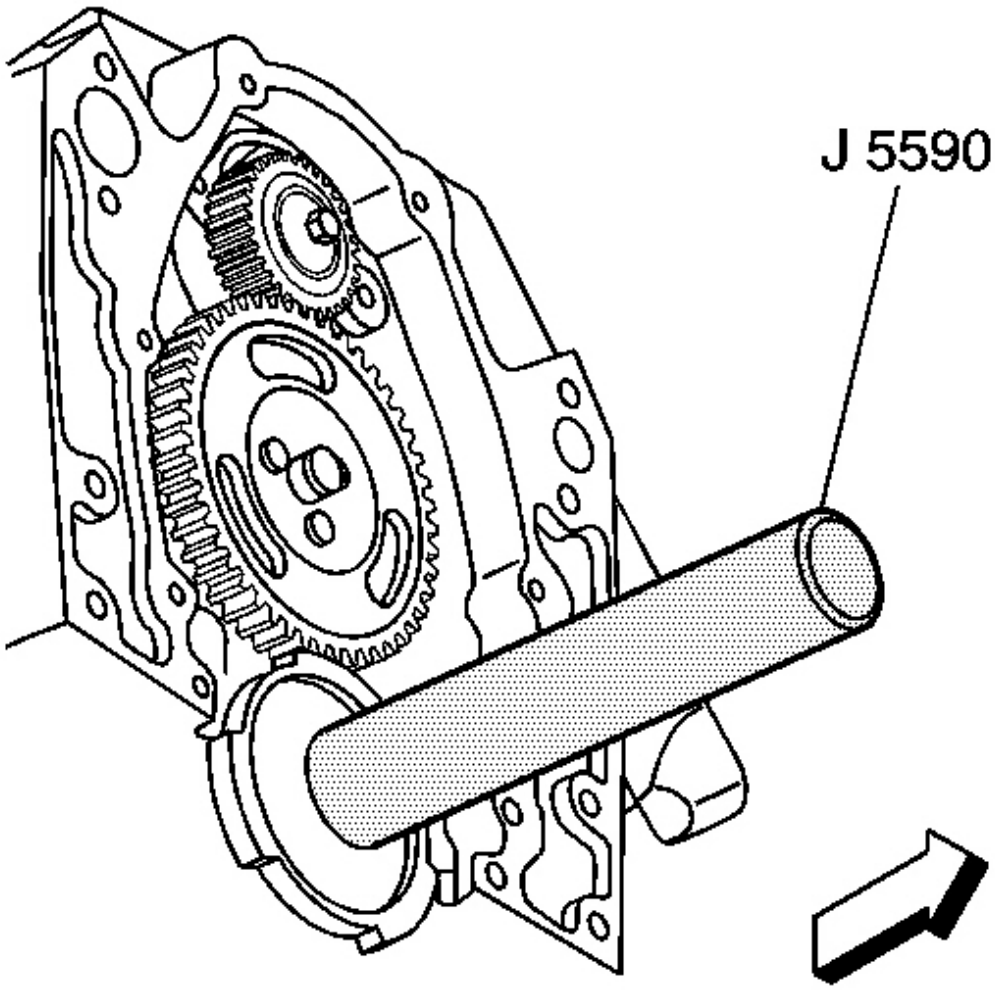


Fig. 226: Installing CKP Sensor Ring
Courtesy of GENERAL MOTORS CORP.

NOTE: Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

IMPORTANT: The reluctor ring is shaped like a dish. The dish must face the engine front cover. Failure to do so will damage the front

cover and the reluctor ring.

1. Install the CKP sensor reluctor ring.
    1. Align the keyway on the CKP sensor reluctor ring with the key in the crankshaft.
    2. Using **J 5590** , push the CKP sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket. See **Special Tools**.
2. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

Tools Required

J 5590 Rear Pinion Bearing Race Installer. See **Special Tools**.

Removal Procedure

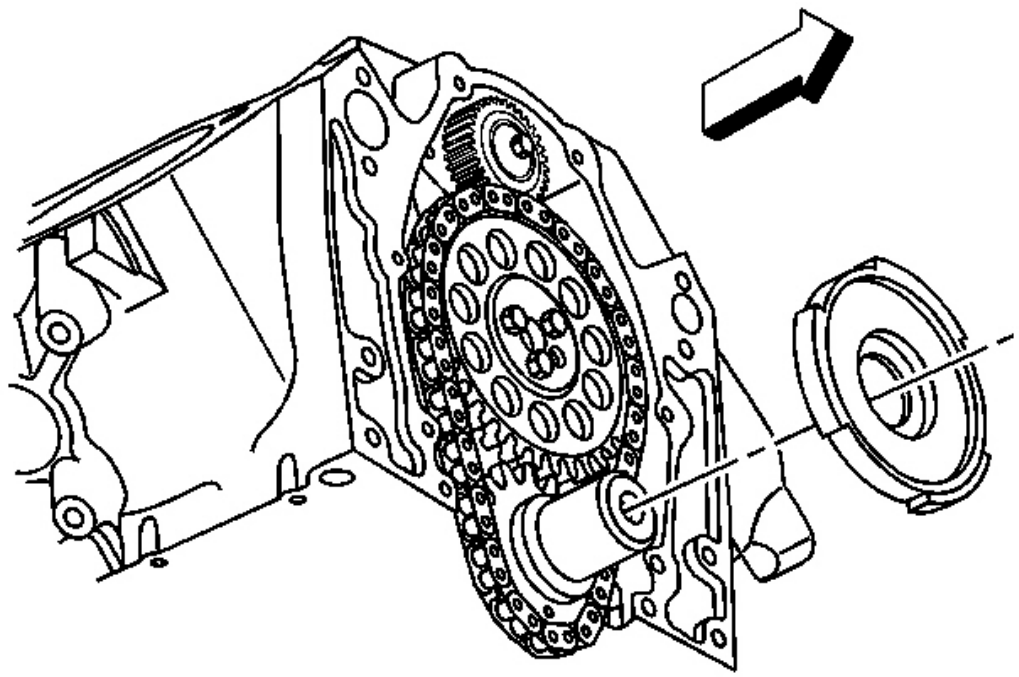


Fig. 227: CKP Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the crankshaft position (CKP) sensor reluctor ring.

Installation Procedure

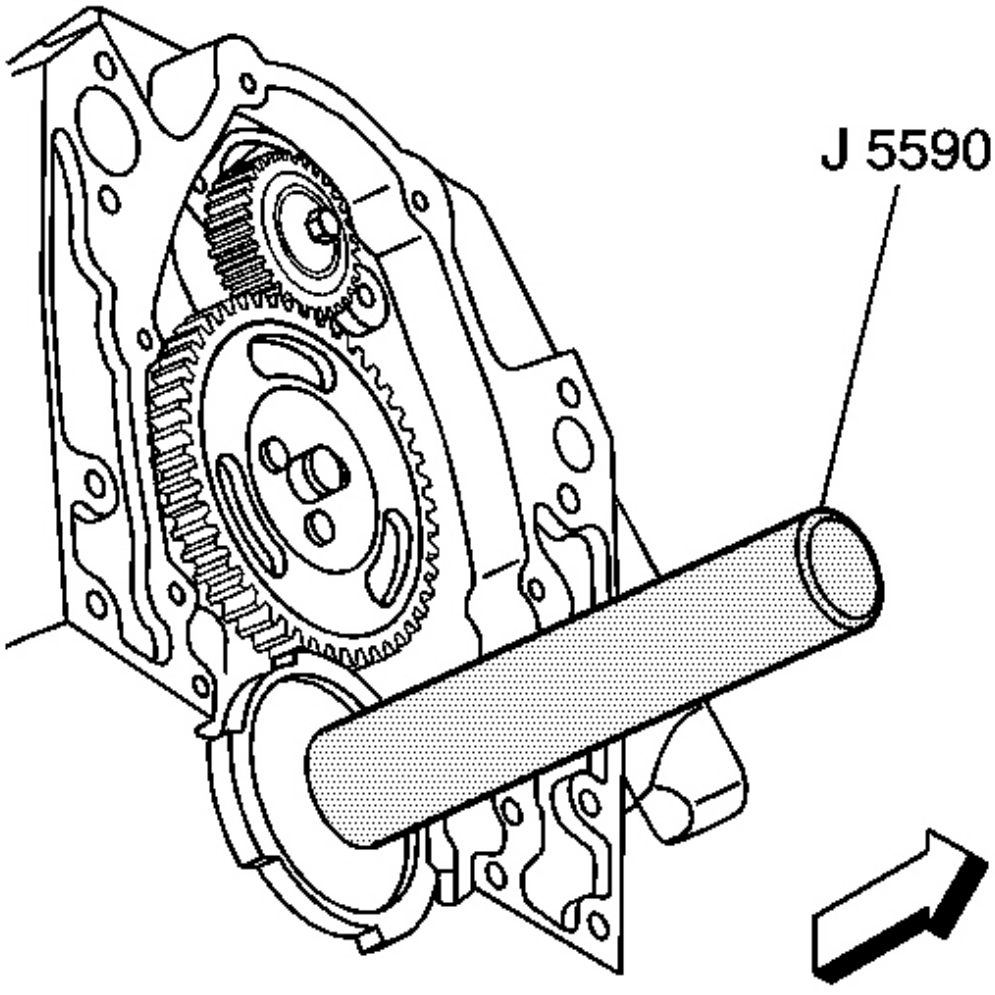


Fig. 228: Installing CKP Sensor Ring
Courtesy of GENERAL MOTORS CORP.

NOTE: Failure to properly align the crankshaft position sensor

reluctor ring may result in component damage and effect OBD II system performance.

IMPORTANT: The reluctor ring is shaped like a dish. The dish must face the engine front cover. Failure to do so will damage the front cover and the reluctor ring.

1. Install the CKP sensor reluctor ring.
    1. Align the keyway on the CKP sensor reluctor ring with the key in the crankshaft.
    2. Using **J 5590** , push the CKP sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket. See **Special Tools**.
2. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

BALANCE SHAFT REPLACEMENT

Tools Required

- **J 8092** Universal Driver Handle
- **J 36996** Balance Shaft Installer. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

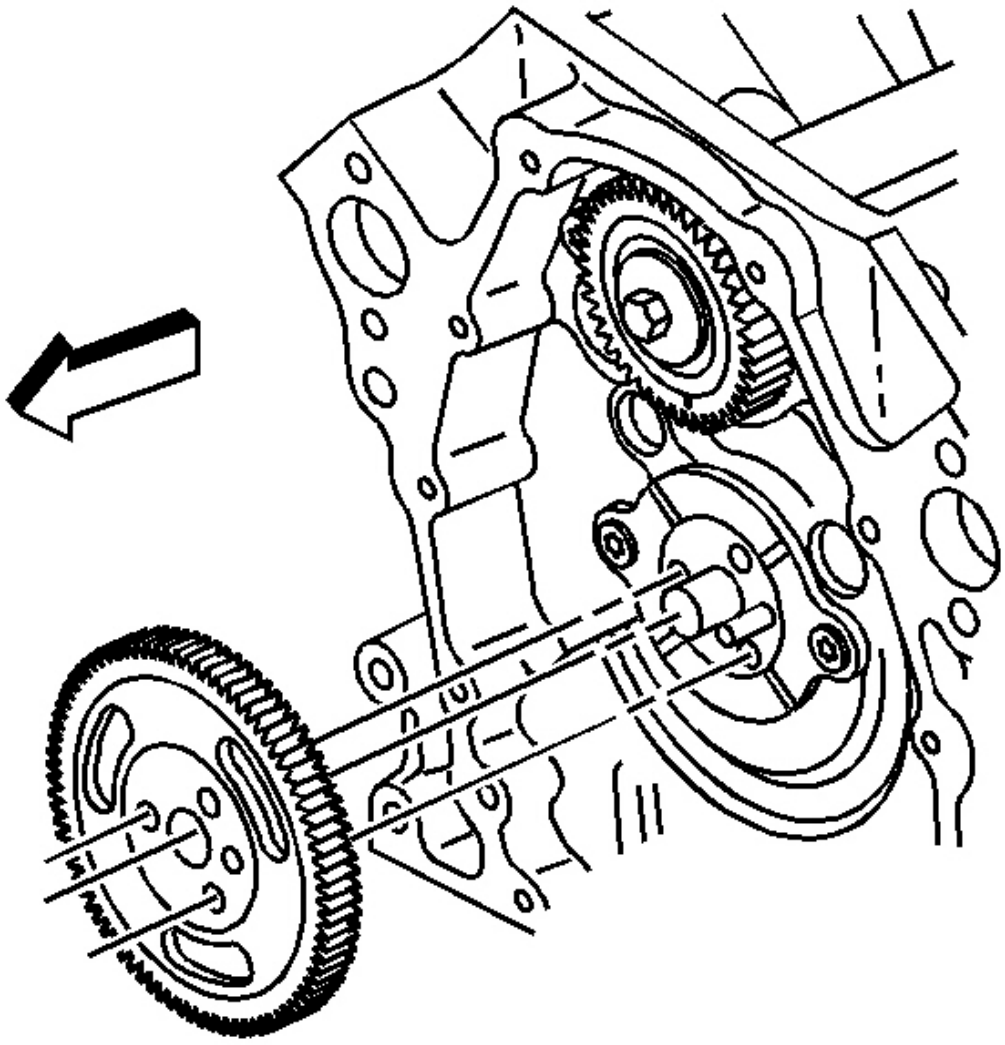


Fig. 229: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

1. Remove the radiator. Refer to **Radiator Replacement (4.3, 4.8, 5.3, and 6.0L)** .
2. Remove the air conditioning (A/C) condenser. Refer to **Condenser Replacement** .
3. Remove the lifter pushrod guide. Refer to **Valve Lifter Replacement**.
4. Remove the timing chain and camshaft sprocket. Refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.

5. Remove the balance shaft drive gear.

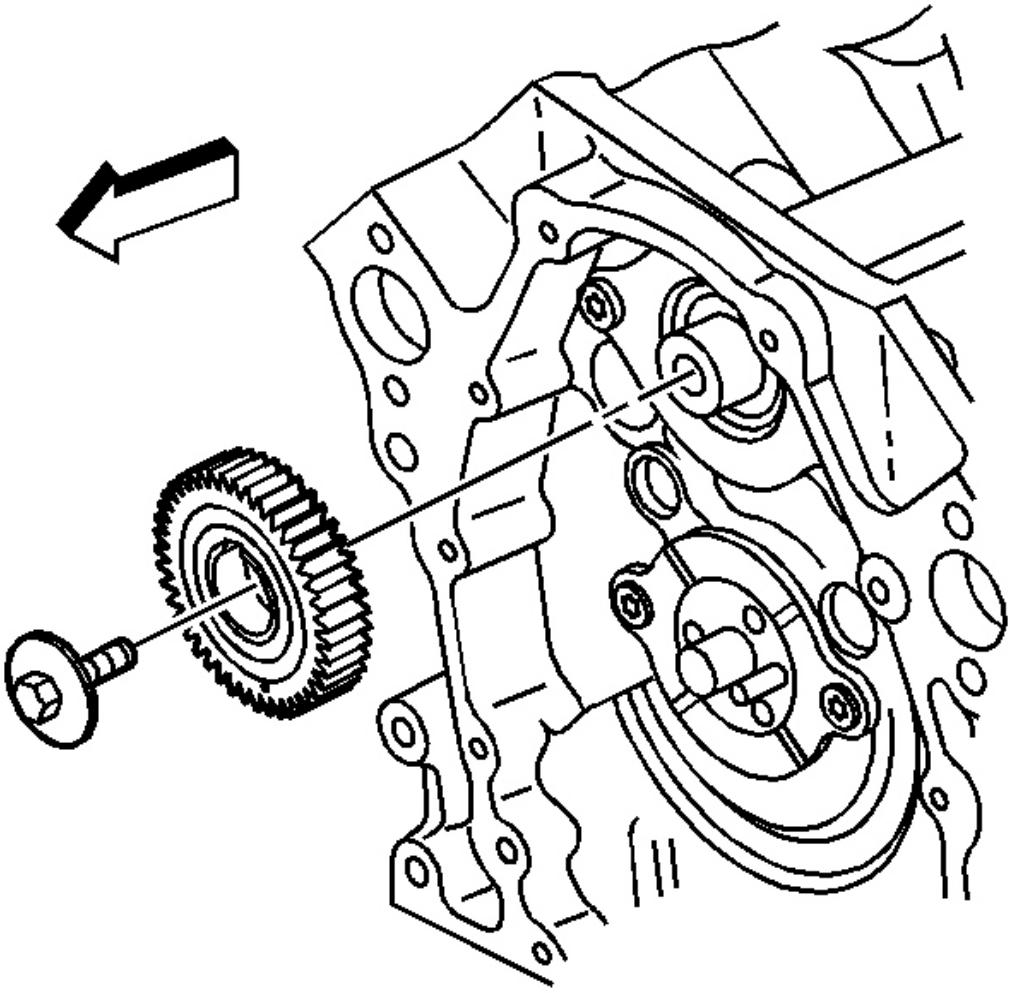


Fig. 230: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

6. Remove the balance shaft driven gear bolt.
    1. Use a wrench in order to secure the balance shaft.

       Place the wrench onto the balance shaft near to the balance shaft front bearing.

2. Remove the balance shaft bolt.
3. Remove the wrench from the balance shaft.

7. Remove the balance shaft driven gear.

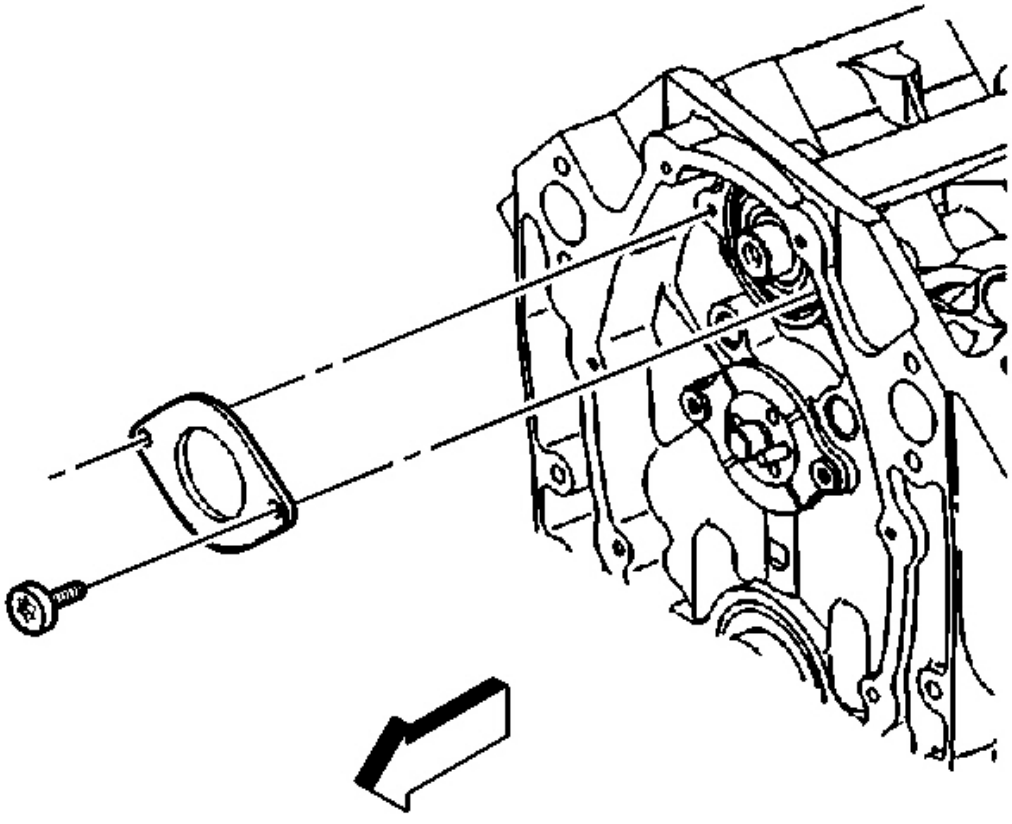


Fig. 231: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the balance shaft retainer bolts and retainer.

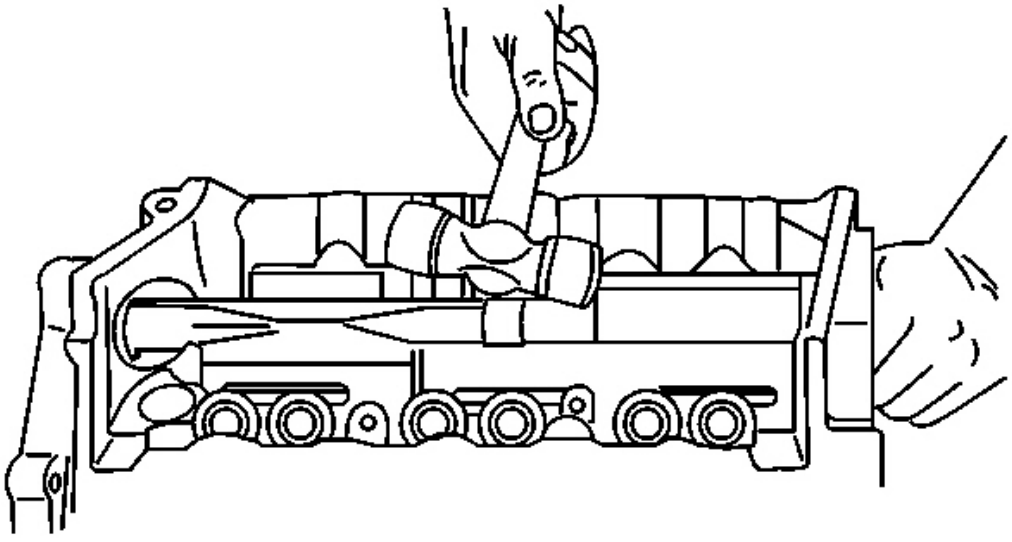


Fig. 232: Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as a package. Do not remove the balance shaft front bearing from the balance shaft.

9. Use a soft-faced hammer in order to remove the balance shaft from the engine block.
10. Clean and inspect the balance shaft, if necessary. Refer to **Balance Shaft Cleaning and Inspection**.

Installation Procedure

IMPORTANT: The balance shaft drive and balance shaft driven gears are serviced as a set. The set includes the balance shaft driven gear bolt.

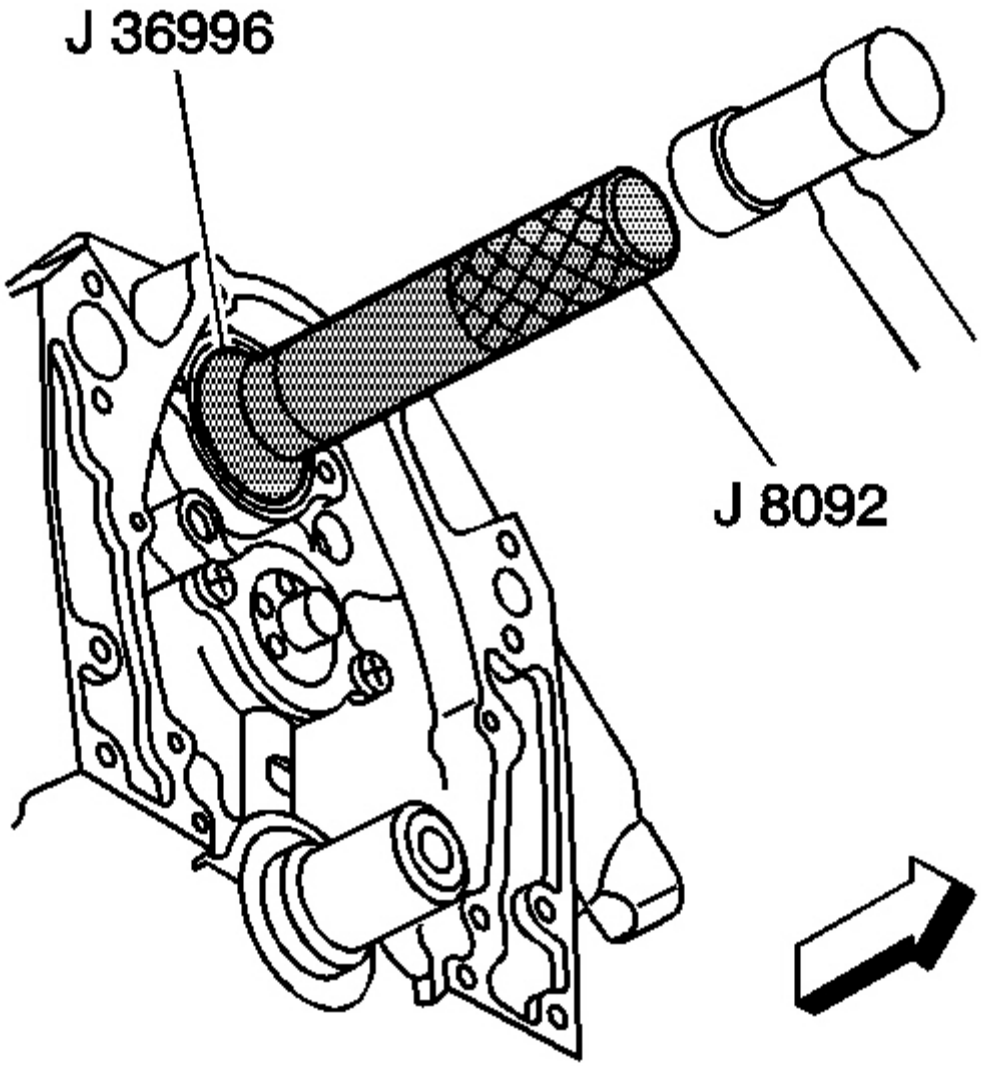


Fig. 233: Balance Shaft
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the balance shaft front bearing.
2. Using **J 36996** and **J 8092** , install the balance shaft. See **Special Tools**.

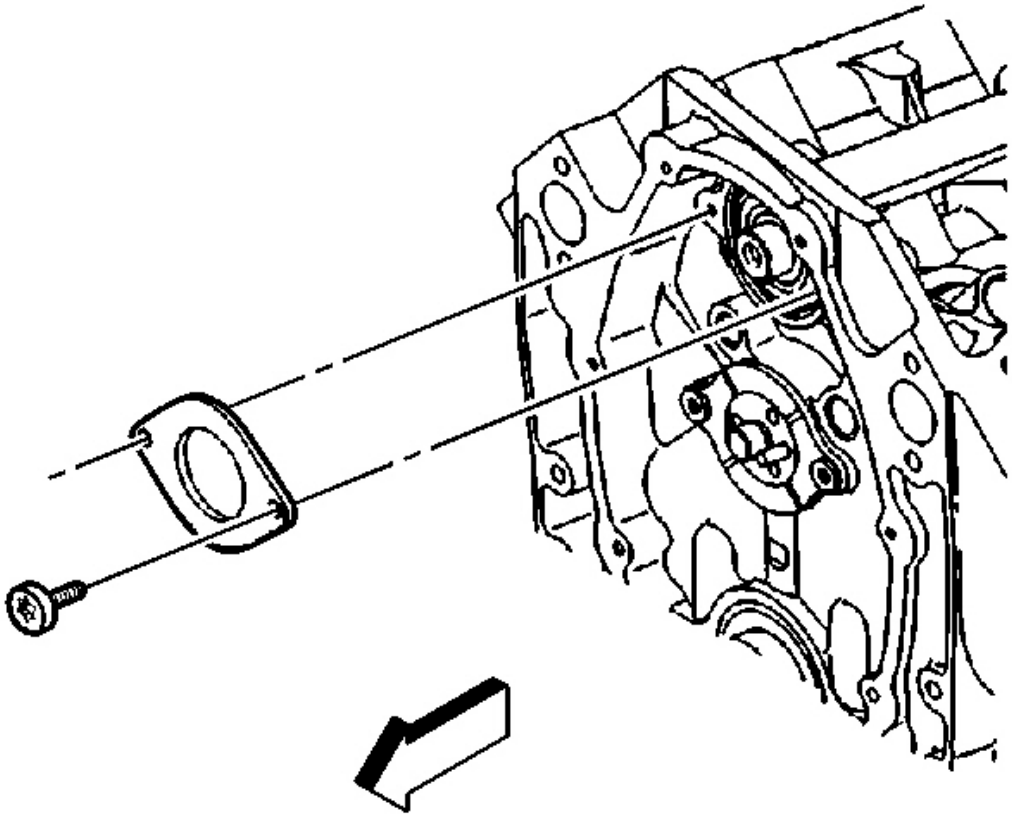


Fig. 234: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the balance shaft retainer and bolts.

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

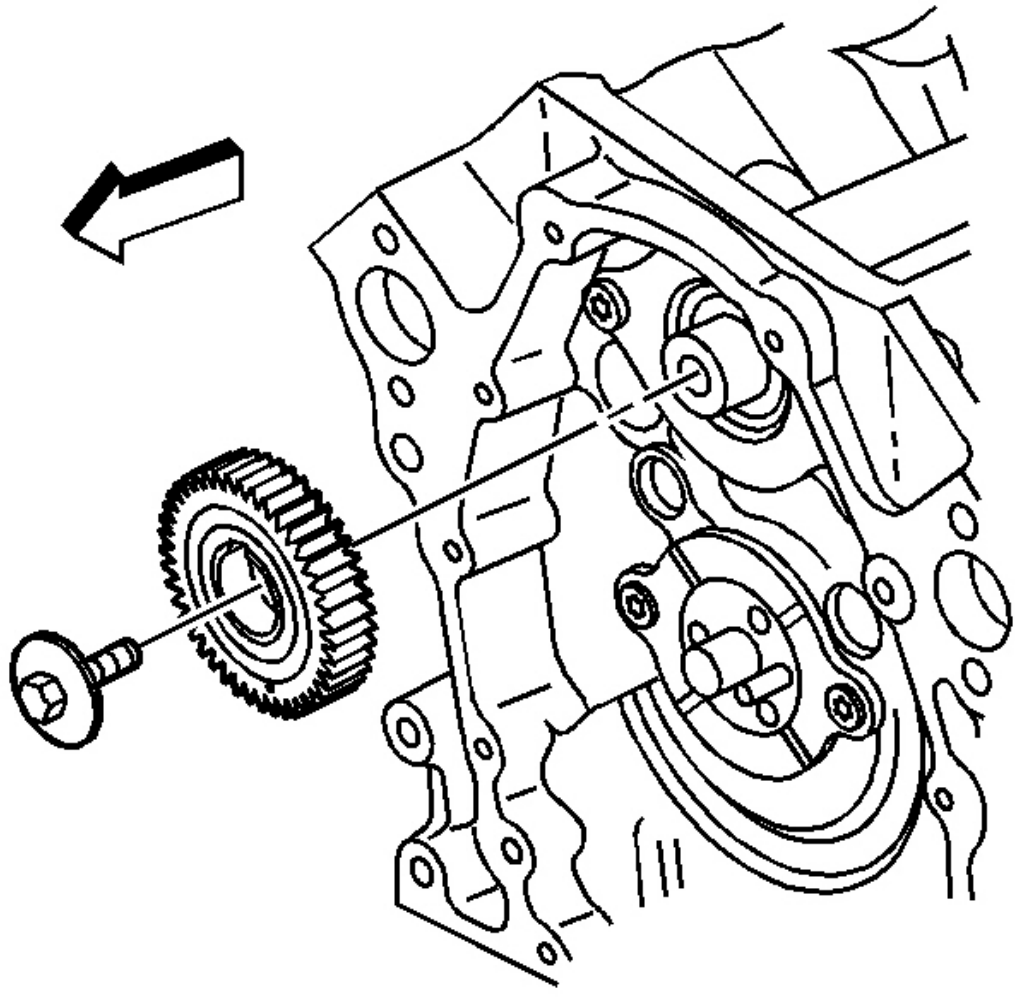


Fig. 235: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Install the balance shaft driven gear.
5. If reusing the fastener, apply threadlocker to the threads of the balance shaft driven gear bolt. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Install the balance shaft driven gear bolt.
    1. Use a wrench to secure the balance shaft.

       Place the wrench onto the balance shaft near to the balance shaft front bearing.

2. Install the balance shaft driven gear bolt.

   Tighten:

   1. Tighten the bolt a first pass to 20 N.m (15 lb ft).
   2. Tighten the bolt a final pass an additional 35 degrees using **J 45059** . See **Special Tools**.

7. Remove the wrench from the balance shaft.
8. Rotate the balance shaft by hand in order to ensure that there is clearance between the balance shaft and the valve lifter pushrod guide. If the balance shaft does not rotate freely, check to ensure that the retaining ring on the balance shaft front bearing is seated on the case.

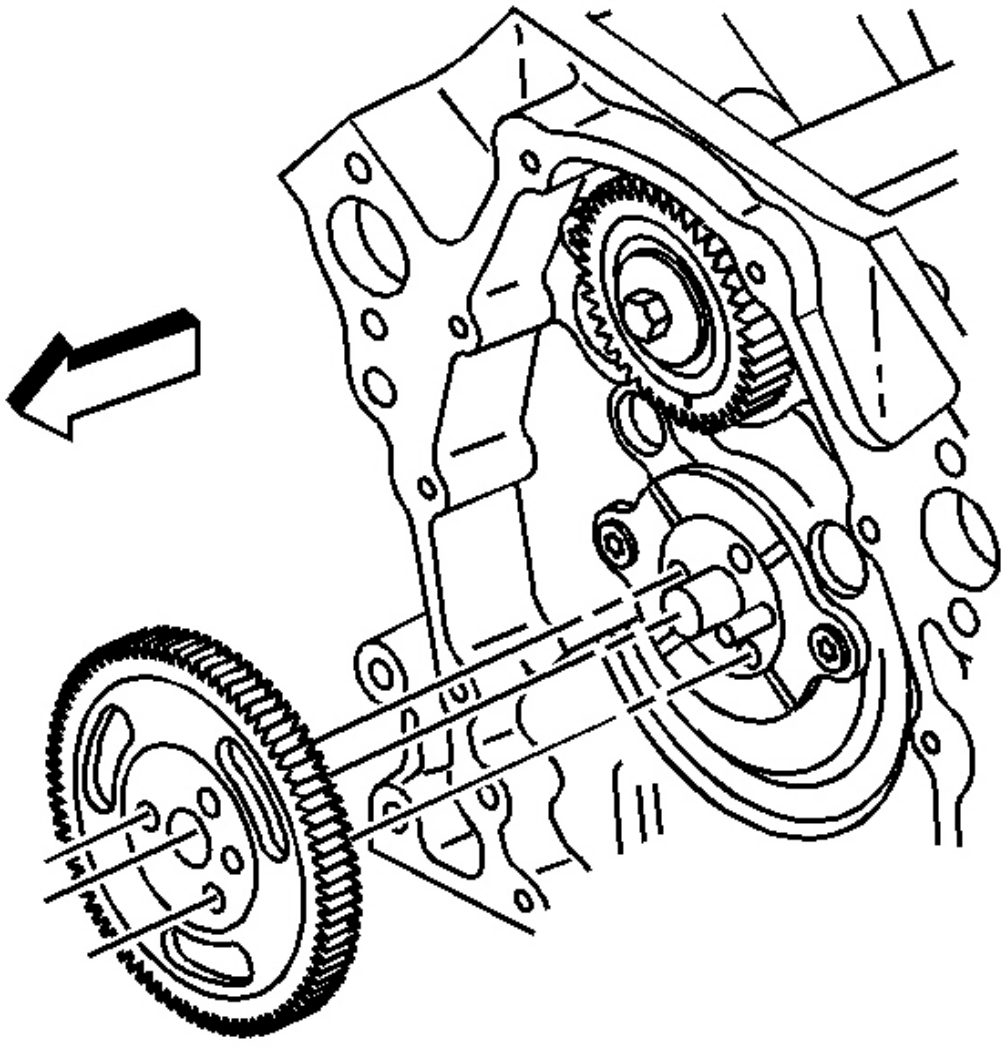


Fig. 236: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

9. Install the balance shaft drive gear. DO NOT install the camshaft sprocket bolts at this time.

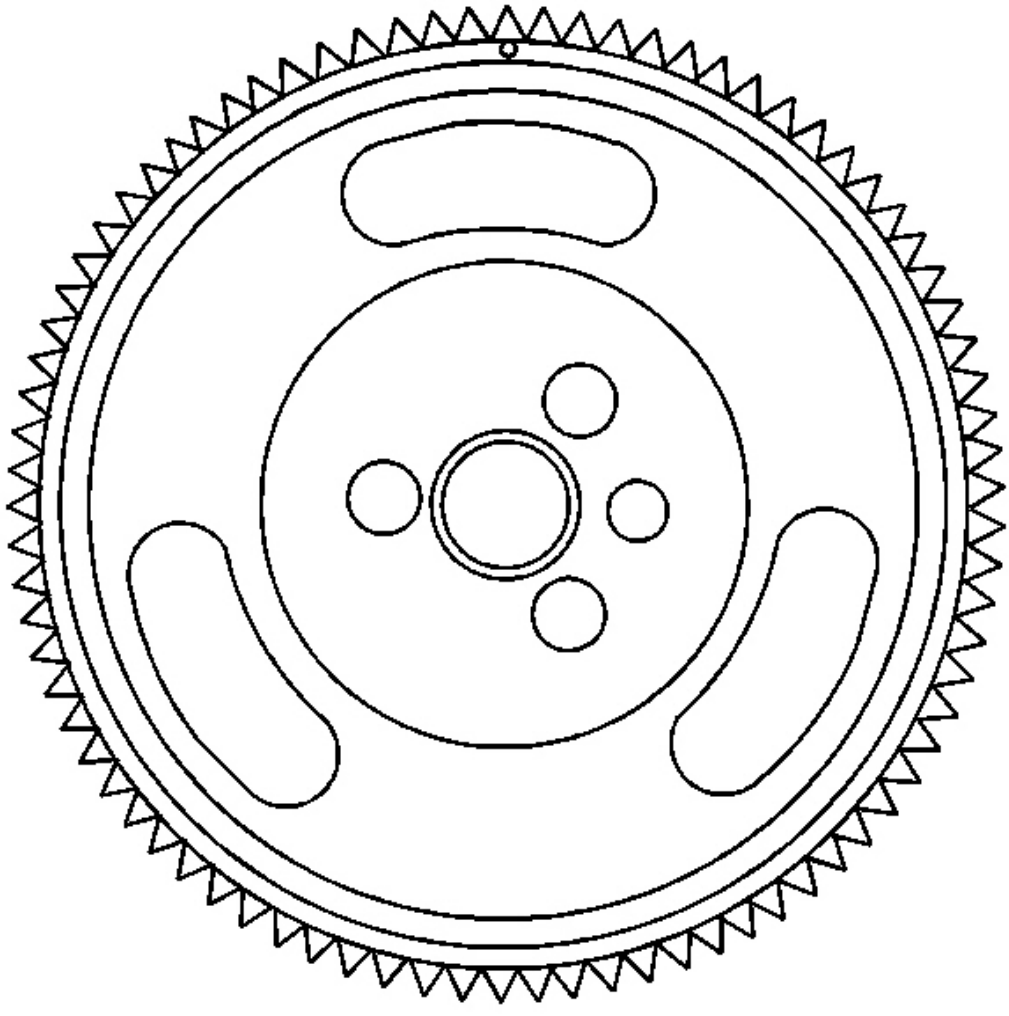


Fig. 237: Balance Shaft Drive Gear Camshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

10. Rotate the camshaft so that the timing mark on the balance shaft drive gear is in the 12 o'clock position.

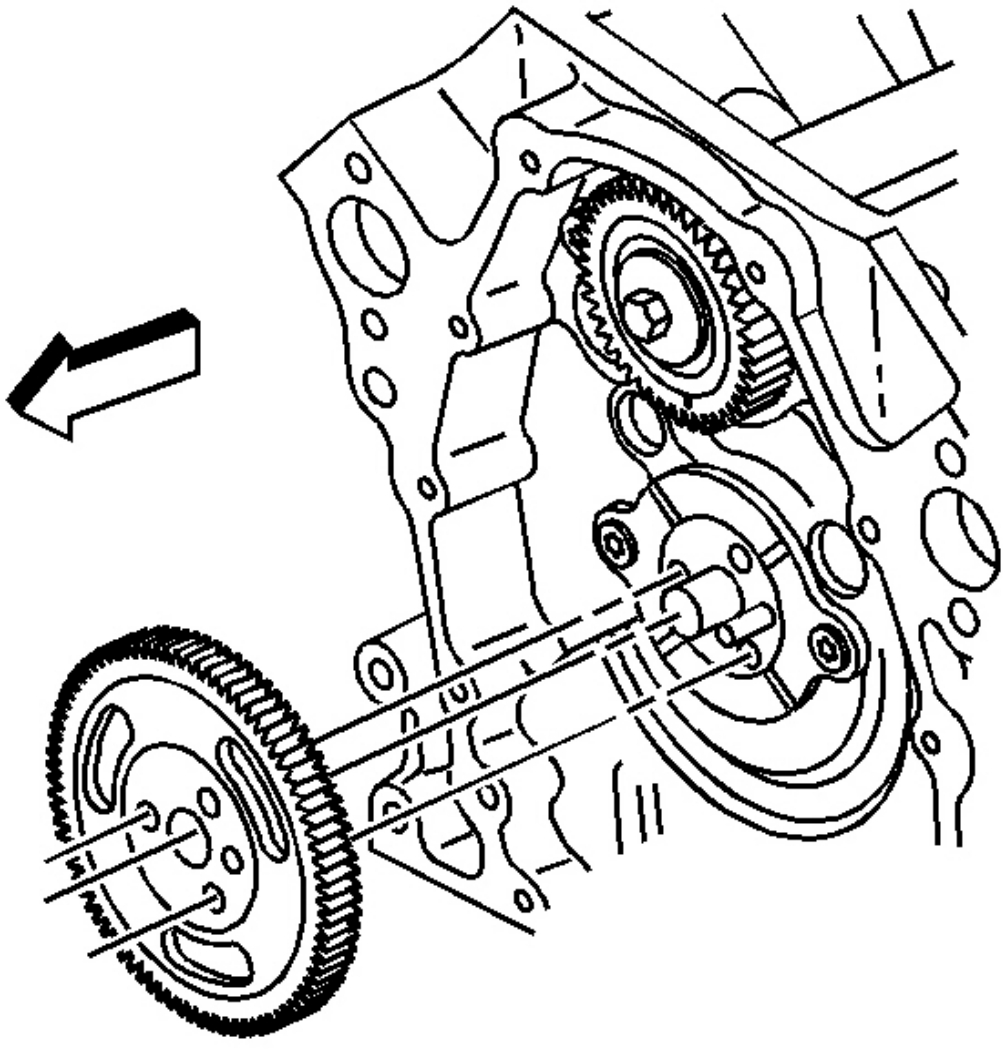


Fig. 238: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

11. Remove the balance shaft drive gear.

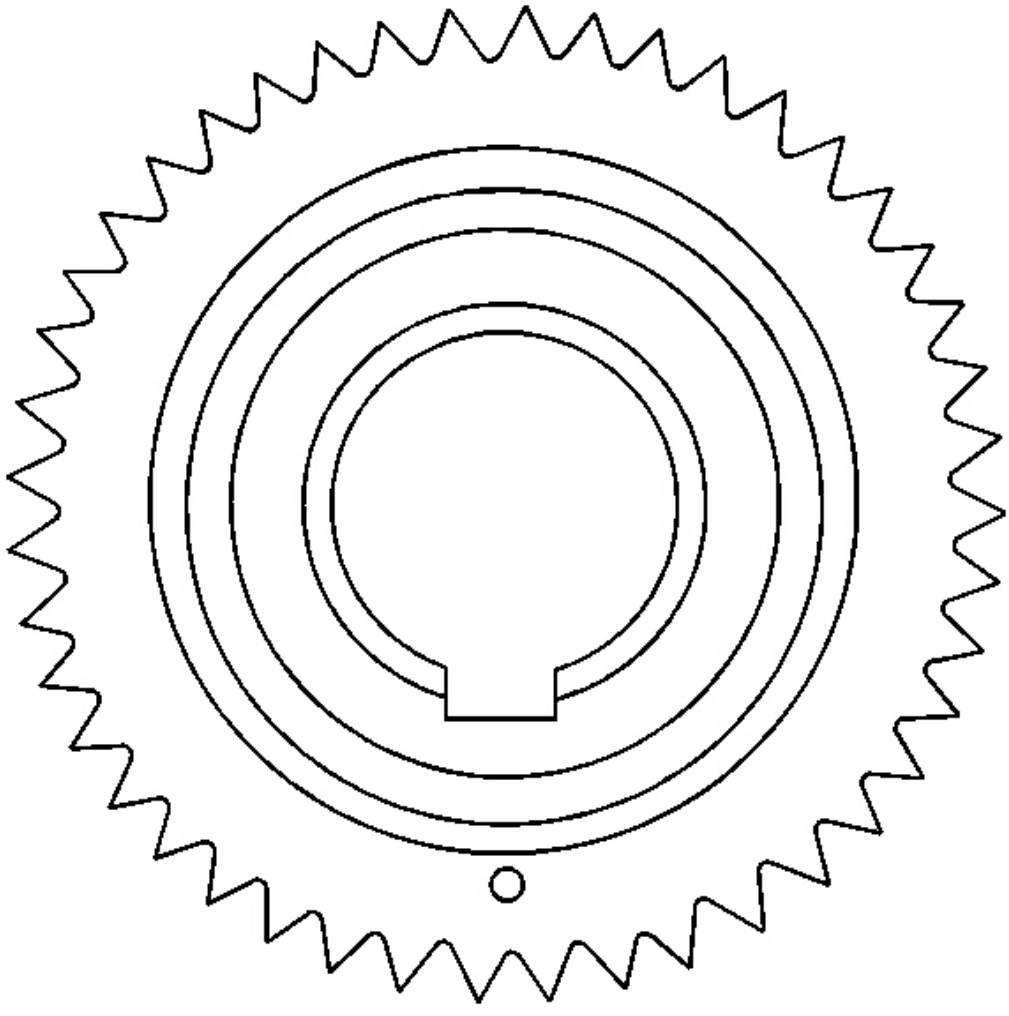


Fig. 239: Balance Shaft Driven Gear Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Rotate the balance shaft so that the timing mark on the balance shaft driven gear is in the 6 o'clock position.

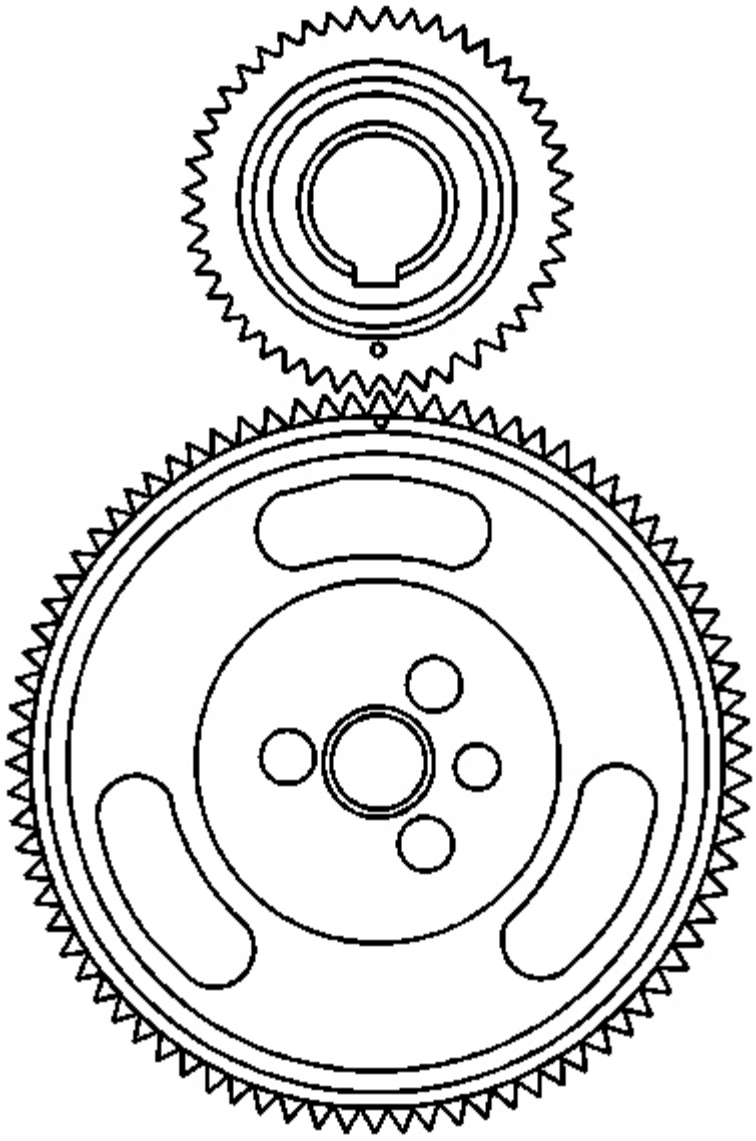


Fig. 240: Aligning Balance Shaft Drive Gear & Balance Shaft Driven Gear Timing Marks
Courtesy of GENERAL MOTORS CORP.

13. Position the balance shaft drive gear onto the engine camshaft.
14. Look to ensure that the balance shaft drive gear and the balance shaft driven gear timing

marks are aligned.

15. Install the timing chain and the camshaft sprocket. Refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.
16. Install the valve lifter pushrod guide. Refer to **Valve Lifter Replacement**.
17. Install the A/C condenser. Refer to **Condenser Replacement** .
18. Install the radiator. Refer to **Radiator Replacement (4.3, 4.8, 5.3, and 6.0L)** .

BALANCE SHAFT BEARING AND/OR BUSHING REPLACEMENT

Tools Required

- **J 26941** Bushing and Bearing Remover
- **J 38834** Balance Shaft Service Kit. See **Special Tools**.

Removal Procedure

IMPORTANT: The balance shaft and the front bearing are serviced only as a package. Do not remove the bearing from the balance shaft.

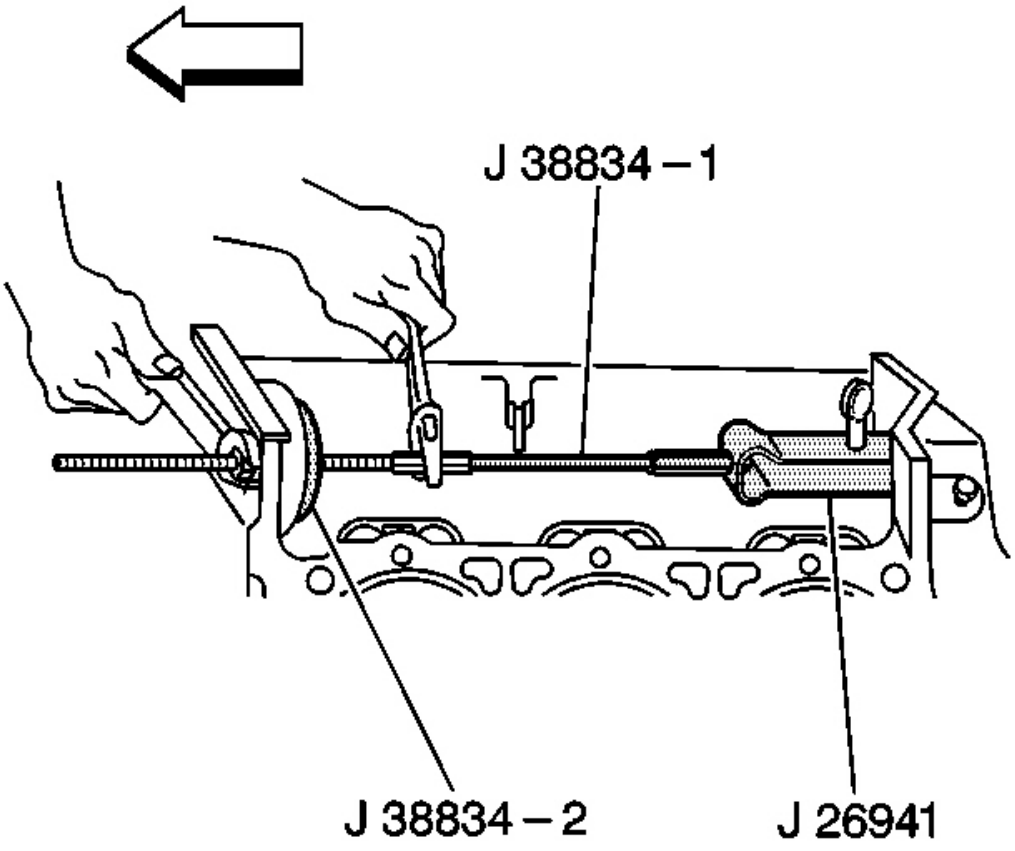


Fig. 241: Removing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft. Refer to **Balance Shaft Replacement**.
2. Using **J 26941** and the **J 38834** , remove the balance shaft rear bearing. See **Special Tools**.
    1. Install the **J 26941** legs behind the balance shaft rear bearing and secure.
    2. Install the J 38834-1 with the short threaded end through the balance shaft bore in the front of the engine block.
    3. Install J 38834-1 into the **J 26941** .
    4. Slide the J 38834-2 onto the J 38834-1 and into the balance shaft bore of the engine block.
    5. Install the **J 38834** bearing, washer, and nut onto the J 38834-1. See **Special Tools**.

6. Using a wrench, secure the J 38834-1, and then rotate the **J 38834** nut clockwise until the balance shaft rear bearing is removed from the engine block. See **Special Tools**.
7. Remove the **J 26941** from the balance shaft rear bearing.

3. Discard the balance shaft rear bearing.

Installation Procedure

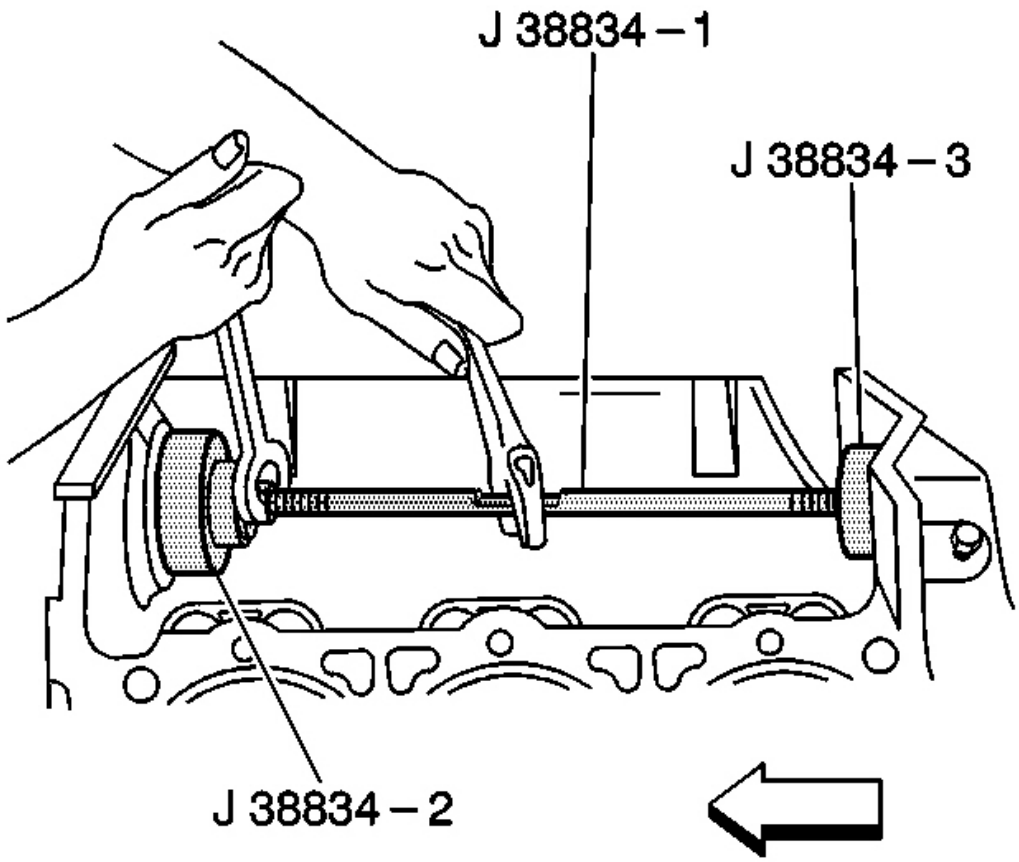


Fig. 242: Installing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

1. Using **J 38834** , install the balance shaft rear bearing. See **Special Tools**.
   1. Install the J 38834-3 onto the short threaded end of the J 38834-1.
   2. Install the **J 38834** nut, the washer, and the bearing on the long threaded end of the J

38834-1. See **Special Tools**.

3. Install the J 38834-2 onto the J 38834-1 so that the smaller diameter of the J 38834-2 will be facing the front of the engine block.
4. Install the J 38834-2 on the inside of the balance shaft front bearing bore.
5. Lubricate the NEW balance shaft rear bearing with clean engine oil.
6. Install the balance shaft rear bearing onto the J 38834-2.
7. Align the balance shaft rear bearing for installation.
8. Using a wrench, secure the J 38834-1 into place.
9. Rotate the **J 38834** nut until the balance shaft rear bearing is properly and completely pushed into the balance shaft rear bearing bore. See **Special Tools**.

2. Remove the **J 38834** . See **Special Tools**.
3. Install the balance shaft. Refer to **Balance Shaft Replacement**.

CAMSHAFT REPLACEMENT

Removal Procedure

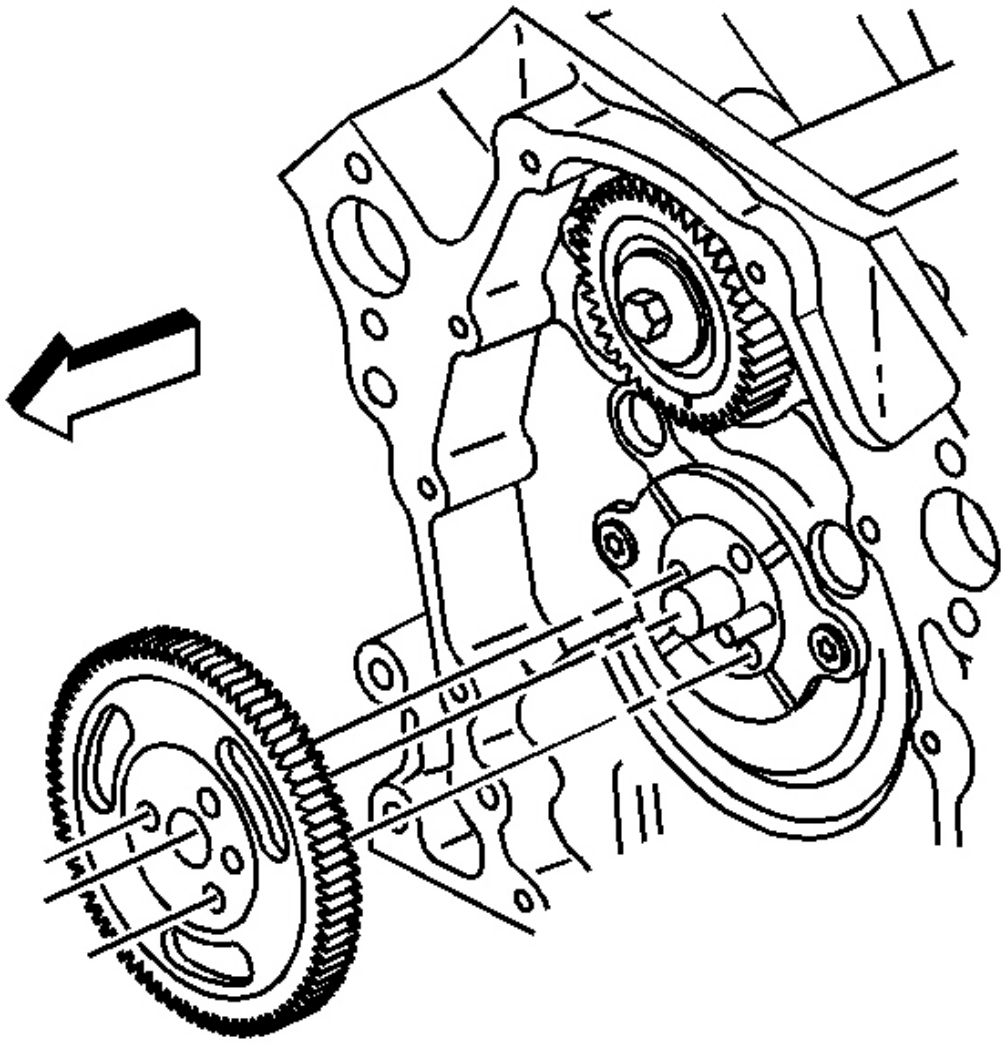


Fig. 243: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

1. Remove the radiator. Refer to **Radiator Replacement (4.3, 4.8, 5.3, and 6.0L)** .
2. Remove the air conditioning (A/C) condenser. Refer to **Condenser Replacement** .
3. Remove the lifters. Refer to **Valve Lifter Replacement**.
4. Remove the timing chain and the camshaft sprocket. Refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.

5. Remove the balance shaft drive gear.

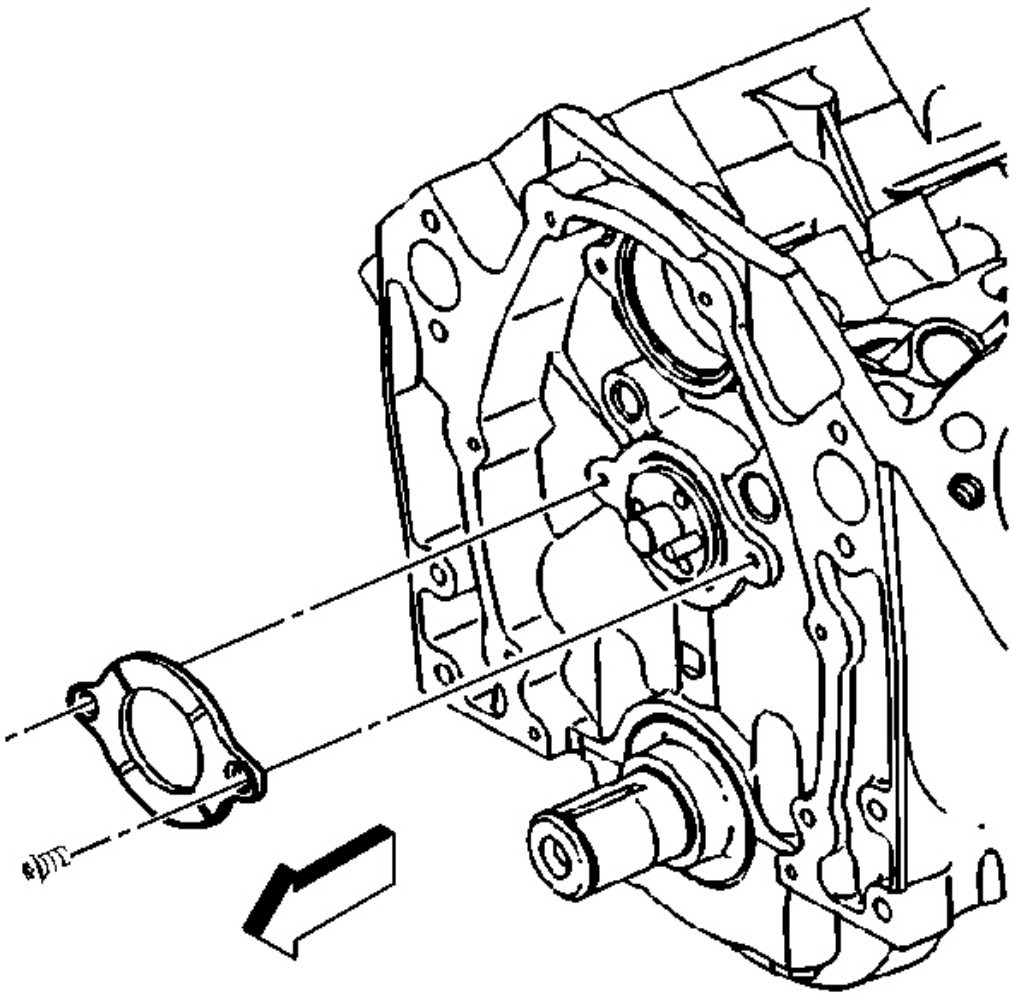


Fig. 244: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft retainer bolts and retainer.

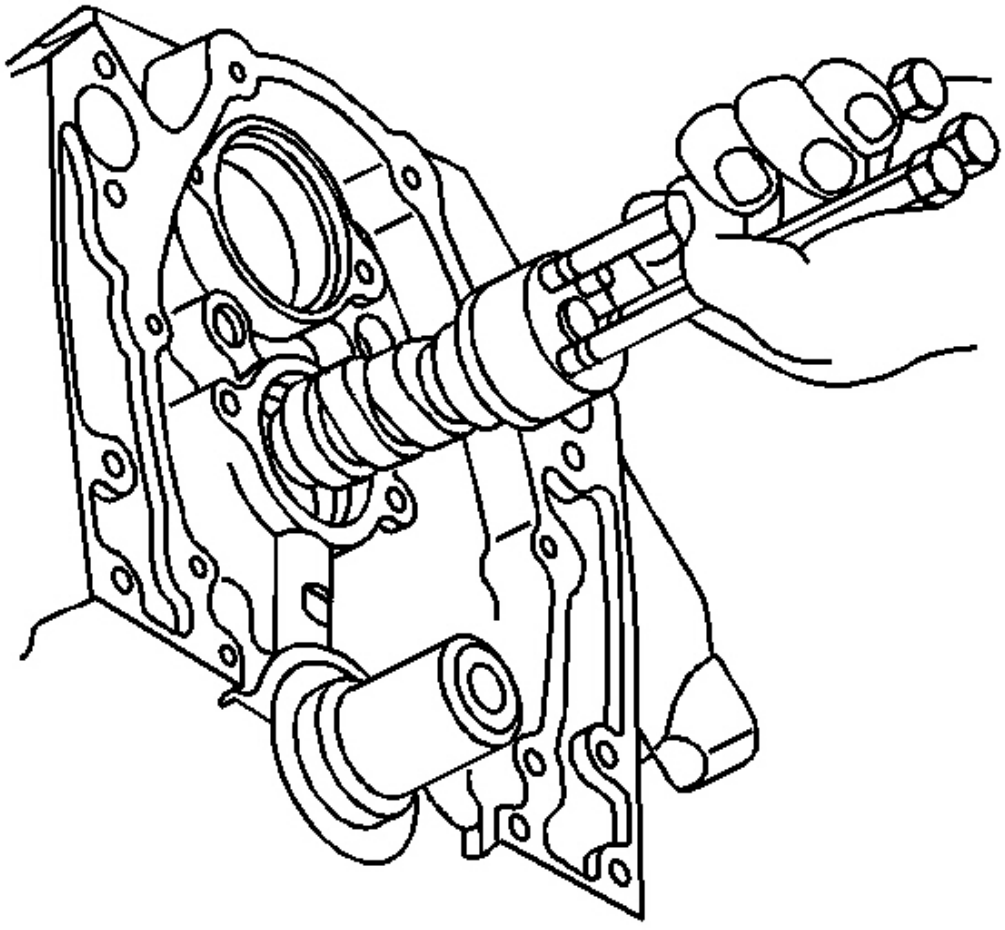


Fig. 245: Using Bolts To Handle Camshaft
Courtesy of GENERAL MOTORS CORP.

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.

7. Remove the engine camshaft.
    1. Install the three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.
    2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.

3. Remove the bolts from the front of the engine camshaft.
4. Clean and inspect the camshaft and/or bearings, if necessary. Refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

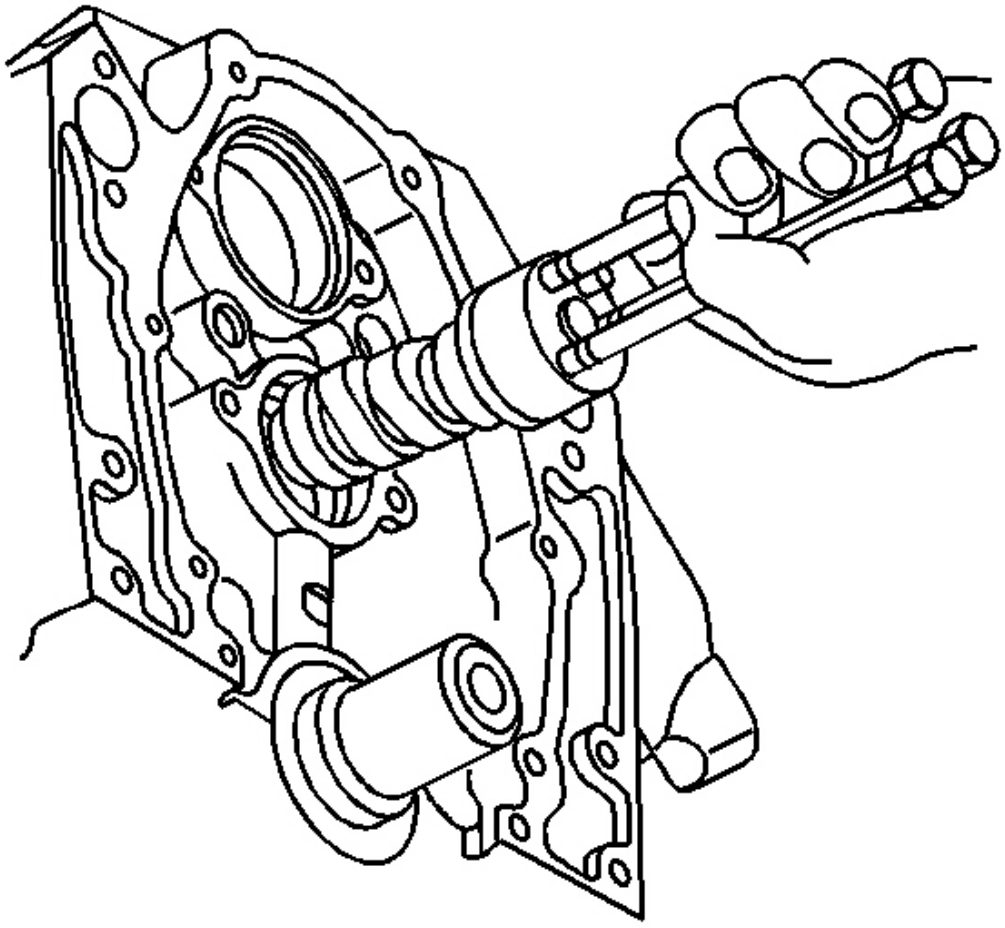


Fig. 246: Using Bolts To Handle Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Whenever a new camshaft is installed, perform the following:

- **Change the engine oil and filter.**
- **Add engine oil supplement to the engine oil. Refer to Sealers, Adhesives, and Lubricants for the correct part number.**

1. Apply lubricant or engine oil supplement to the following components:
   - The engine camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

   Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install three 5/16-18 x 4.0 inch bolts into the engine 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, install the engine camshaft.
4. Remove the 3 bolts from the front of the engine camshaft.

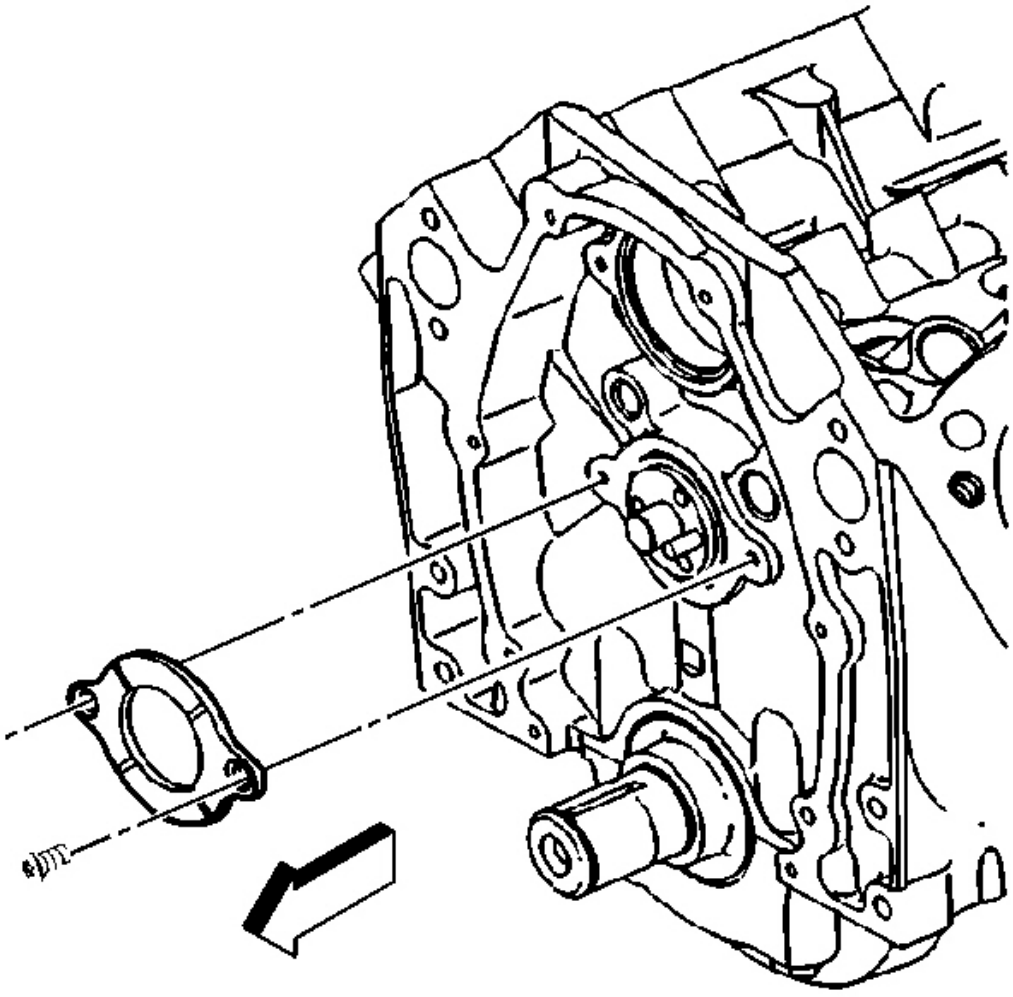


Fig. 247: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

5. If reusing the fasteners, apply threadlocker to the threads of the camshaft retainer bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

NOTE: Refer to Fastener Notice .

6. Install the camshaft retainer and bolts.

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

7. Install the balance shaft drive gear. Refer to **Balance Shaft Installation**, for alignment of the balance shaft drive gear and the driven gear.
8. Install the timing chain and camshaft sprocket. Refer to **Camshaft Timing Chain, Sprocket, and Tensioner Replacement**.
9. Install the lifters. Refer to **Valve Lifter Replacement**.
10. Install the A/C condenser. Refer to **Condenser Replacement** .
11. Install the radiator. Refer to **Radiator Replacement (4.3, 4.8, 5.3, and 6.0L)** .

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

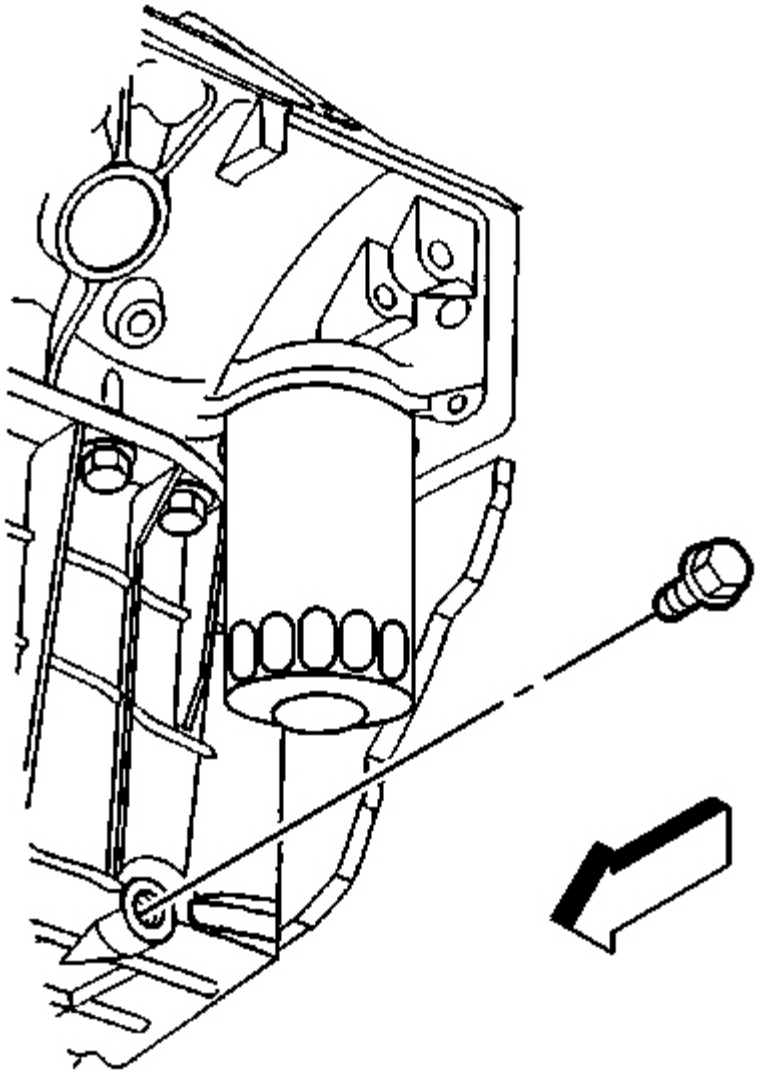


Fig. 248: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the oil pan drain plug and drain the oil into a suitable container.

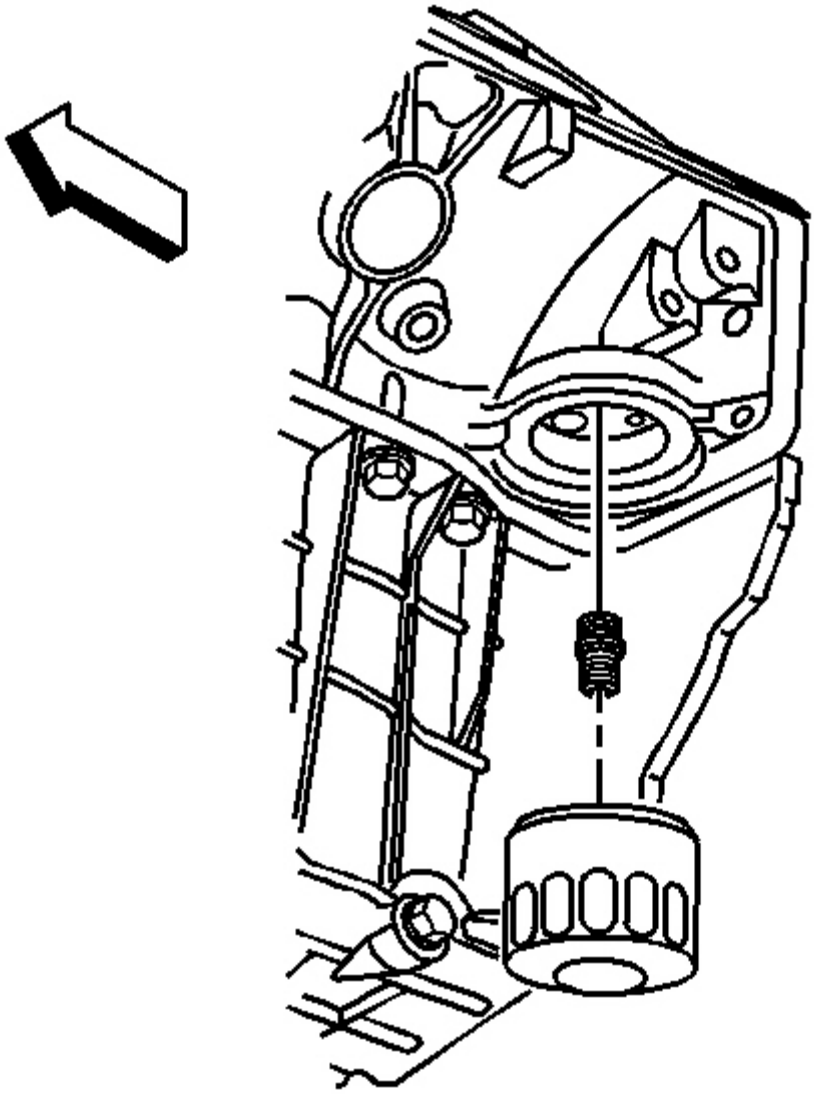


Fig. 249: View Of Oil Filter & Adapter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.
4. Remove the oil filter adapter.

Installation Procedure

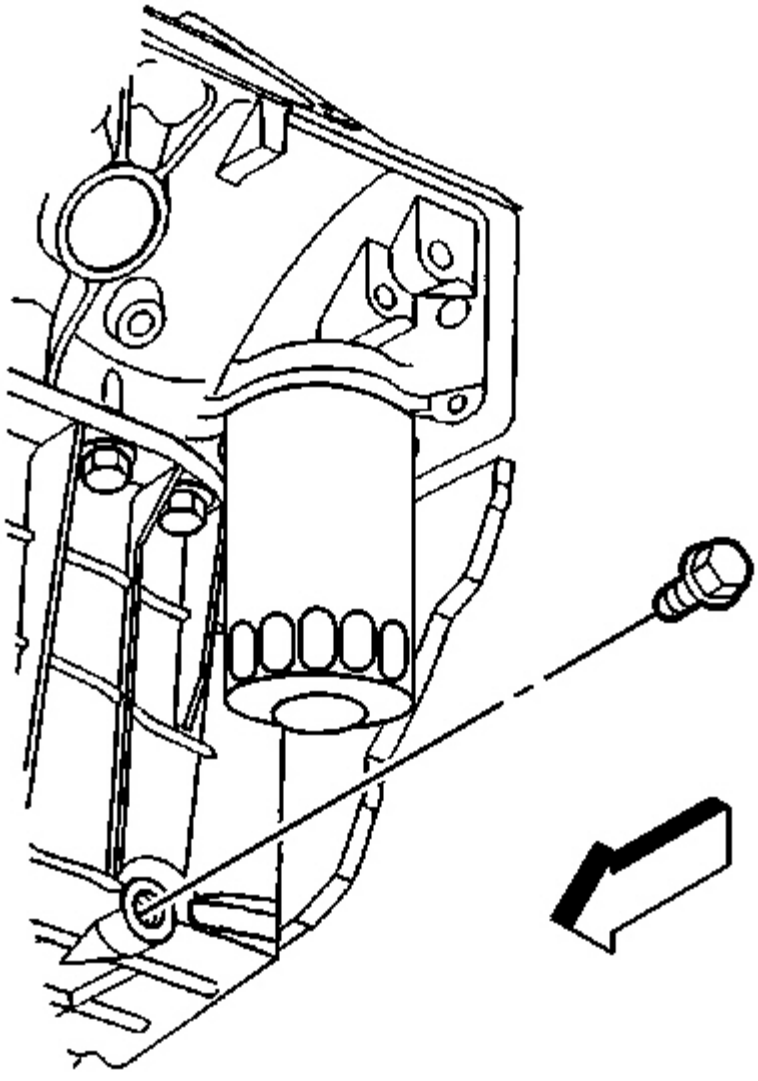


Fig. 250: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil pan drain plug into the drain pan.

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

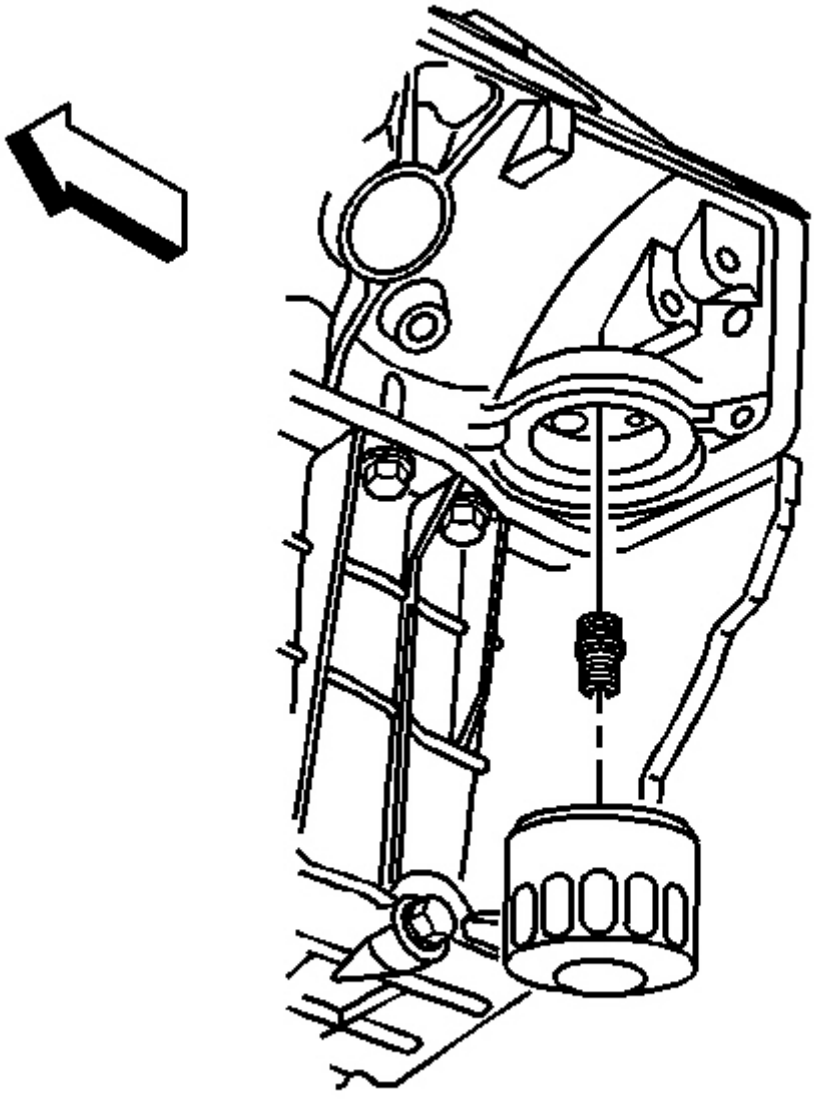


Fig. 251: View Of Oil Filter & Adapter
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter adapter.

Tighten: Tighten the adapter to 55 N.m (41 lb ft).

3. Install the oil filter.

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

4. Lower the vehicle.
5. Fill the engine with the proper quantity and quality of engine oil. Refer to **Approximate Fluid Capacities** .

OIL FILTER BYPASS VALVE REPLACEMENT

Removal Procedure

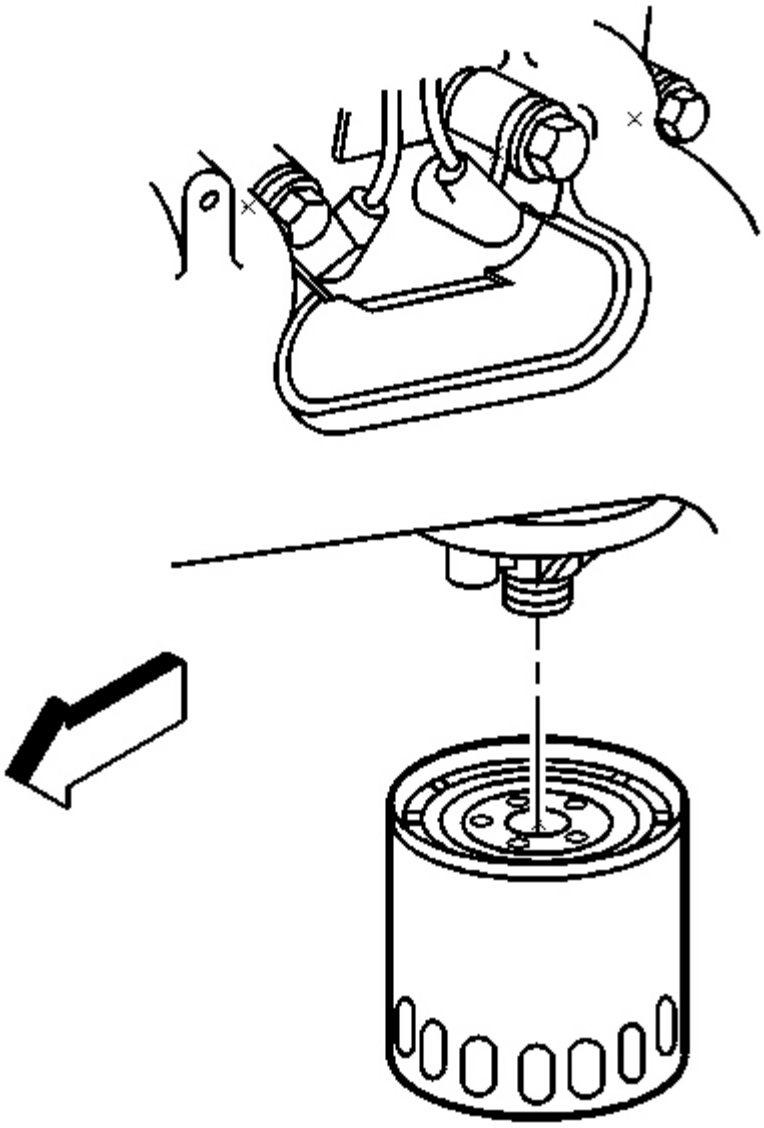


Fig. 252: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Position a suitable container under the vehicle to catch the oil.
3. Remove the oil filter.

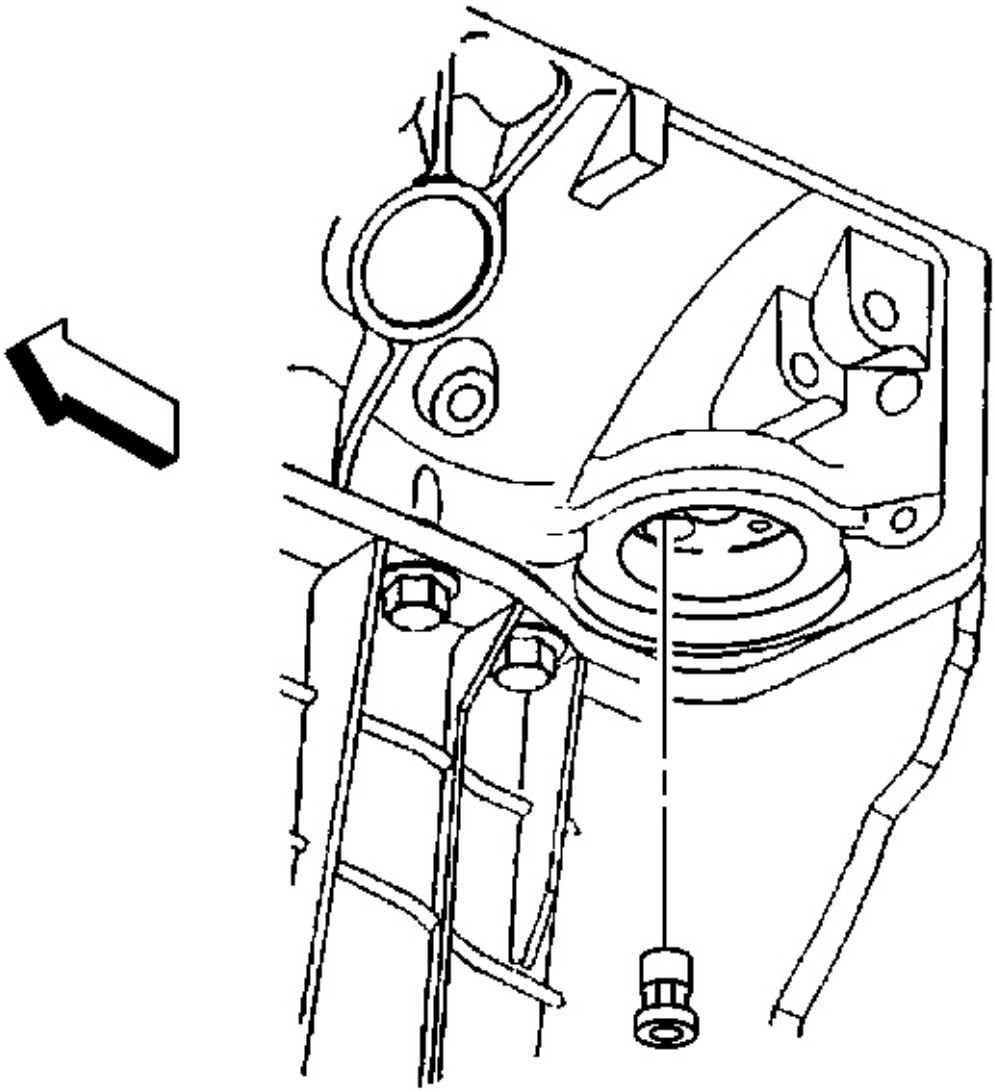


Fig. 253: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

4. Using a suitable prying tool, remove the oil filter bypass valve.
5. Clean and inspect the valve bore for damage.

Installation Procedure

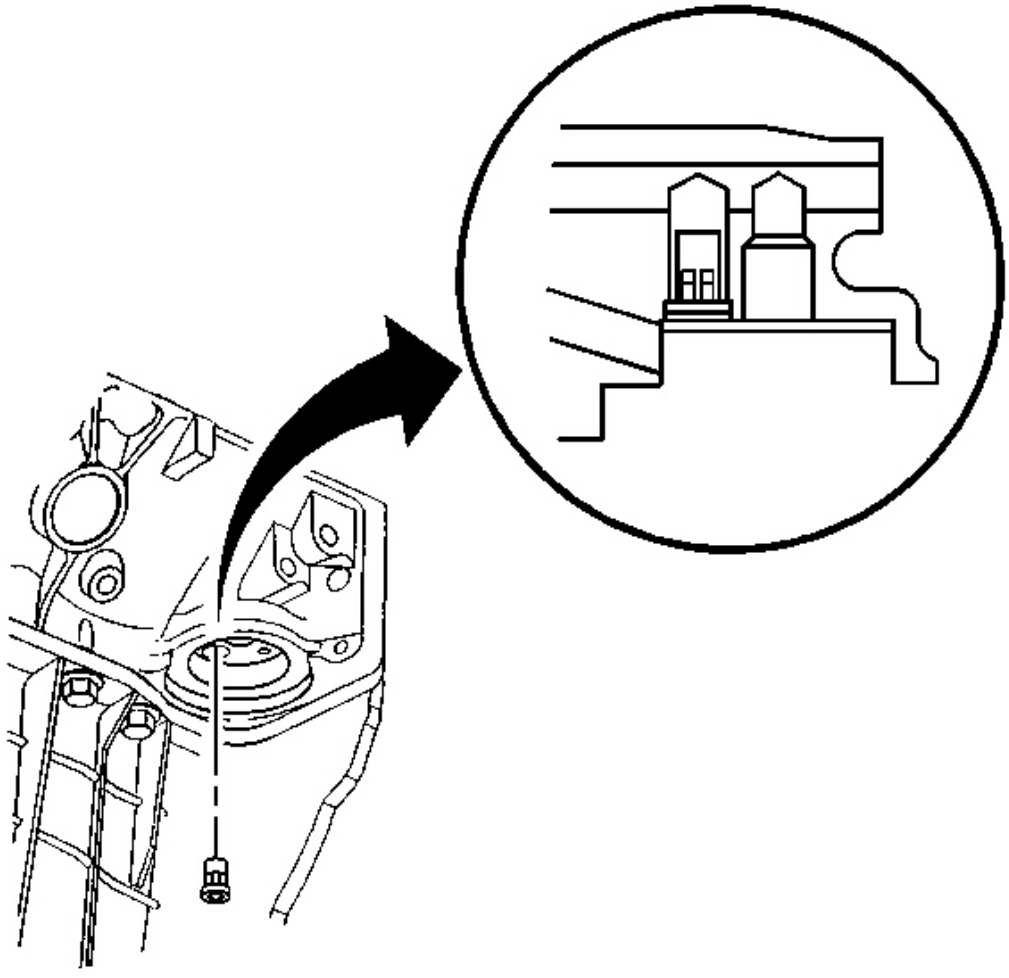


Fig. 254: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil filter bypass valve using the following procedure:
    1. Use a brass drift that is the same diameter as the outside diameter of the oil filter bypass valve.
    2. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
    3. Using a pointed punch, stake the engine block area around the oil filter bypass valve.

Stake in 3 locations 120 degrees apart.

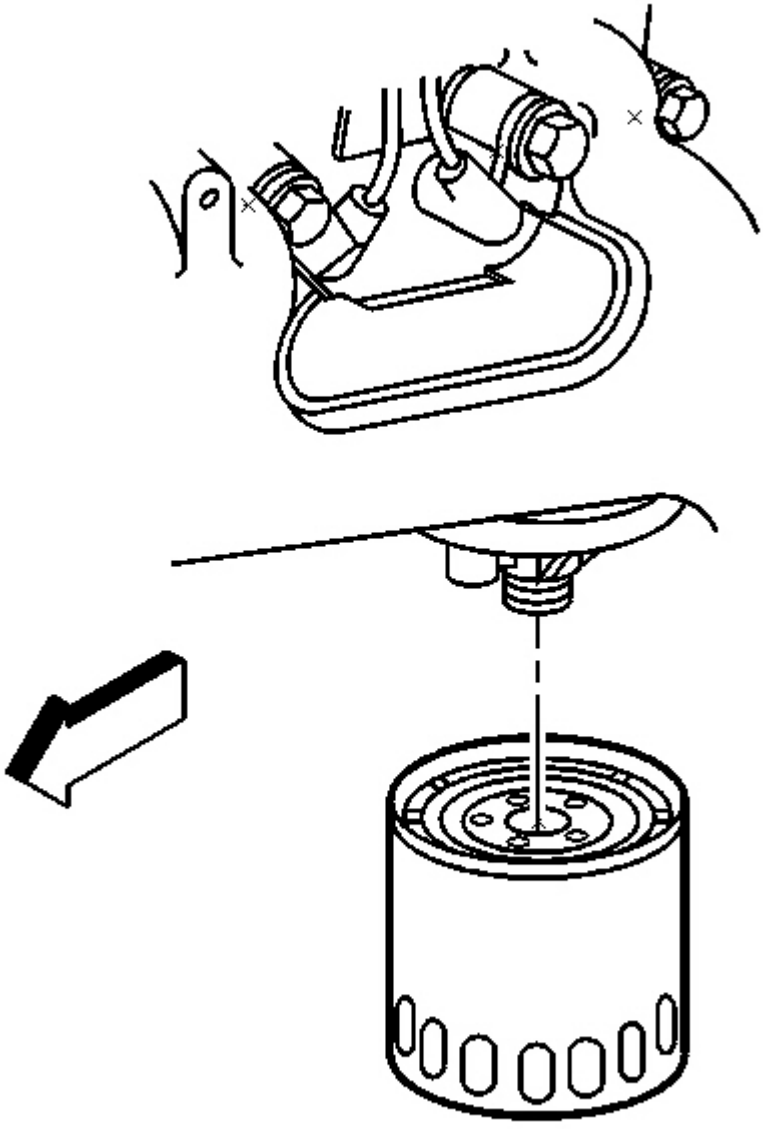


Fig. 255: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

3. Lower the vehicle.

OIL PAN REPLACEMENT

Removal Procedure

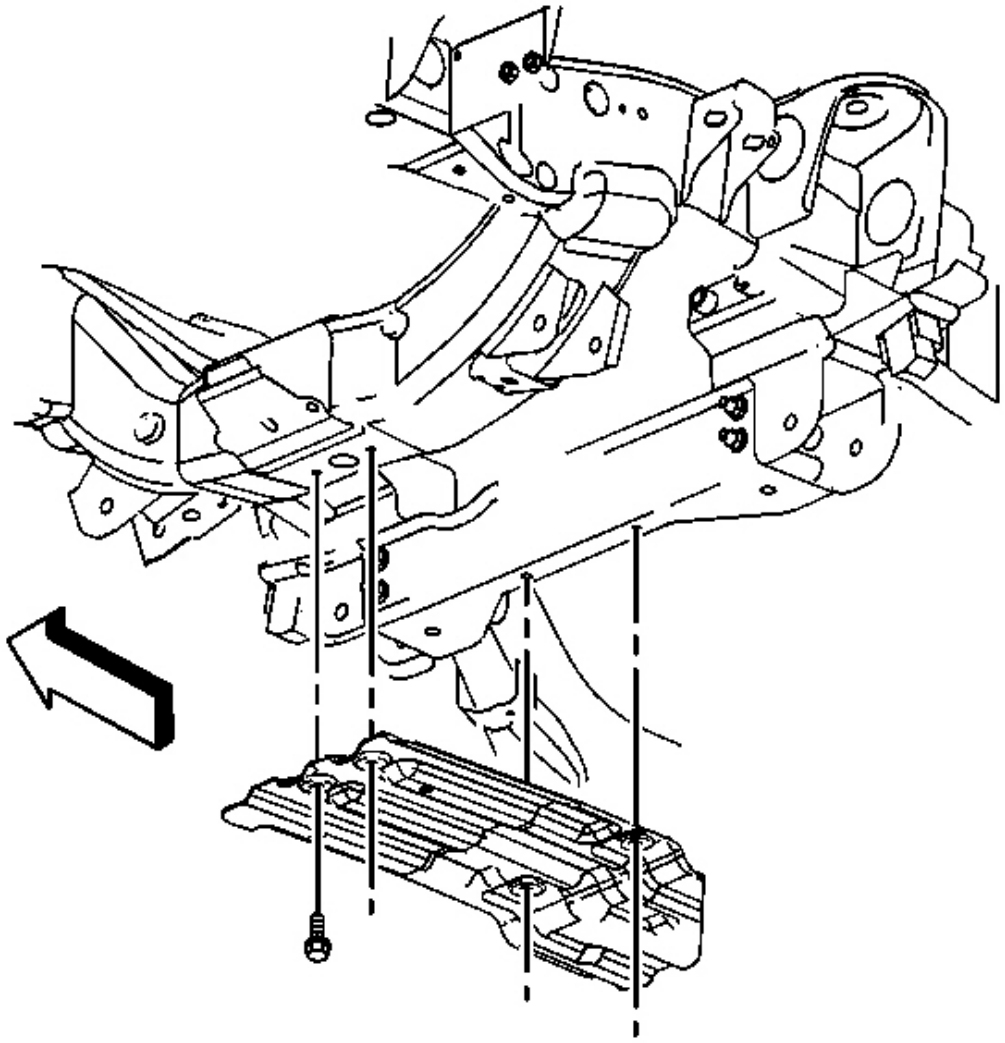


Fig. 256: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. If equipped, remove the oil pan skid plate bolts and plate.

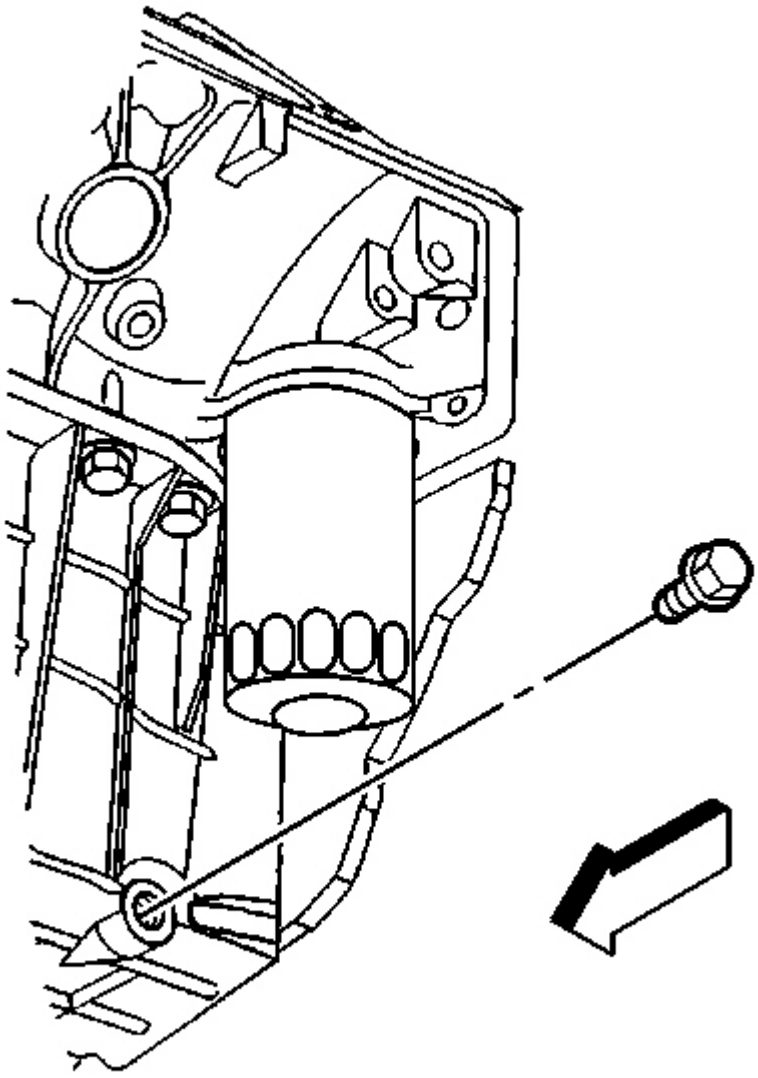


Fig. 257: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the drain plug and drain the oil into a suitable container.

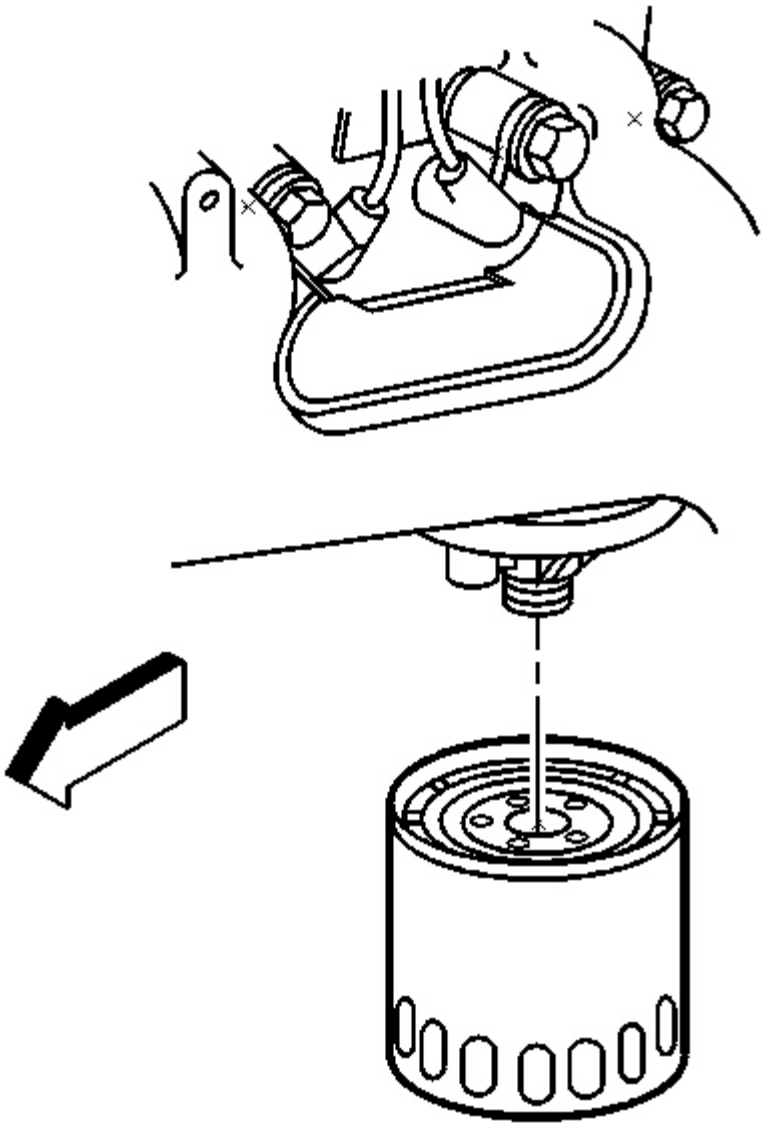


Fig. 258: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter.

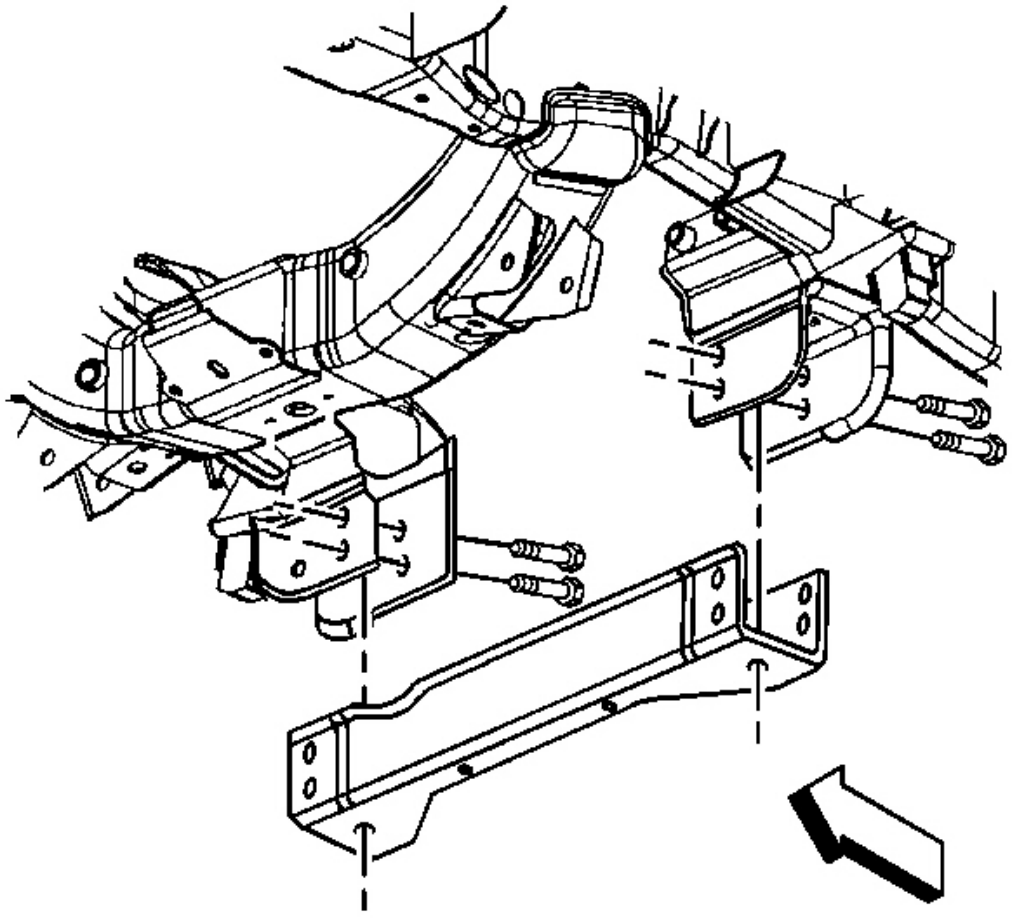


Fig. 259: View Of Crossbar Bolts & Bar (2WD)
Courtesy of GENERAL MOTORS CORP.

5. If equipped with 2-wheel drive (2WD), remove the crossmember bolts and bar.

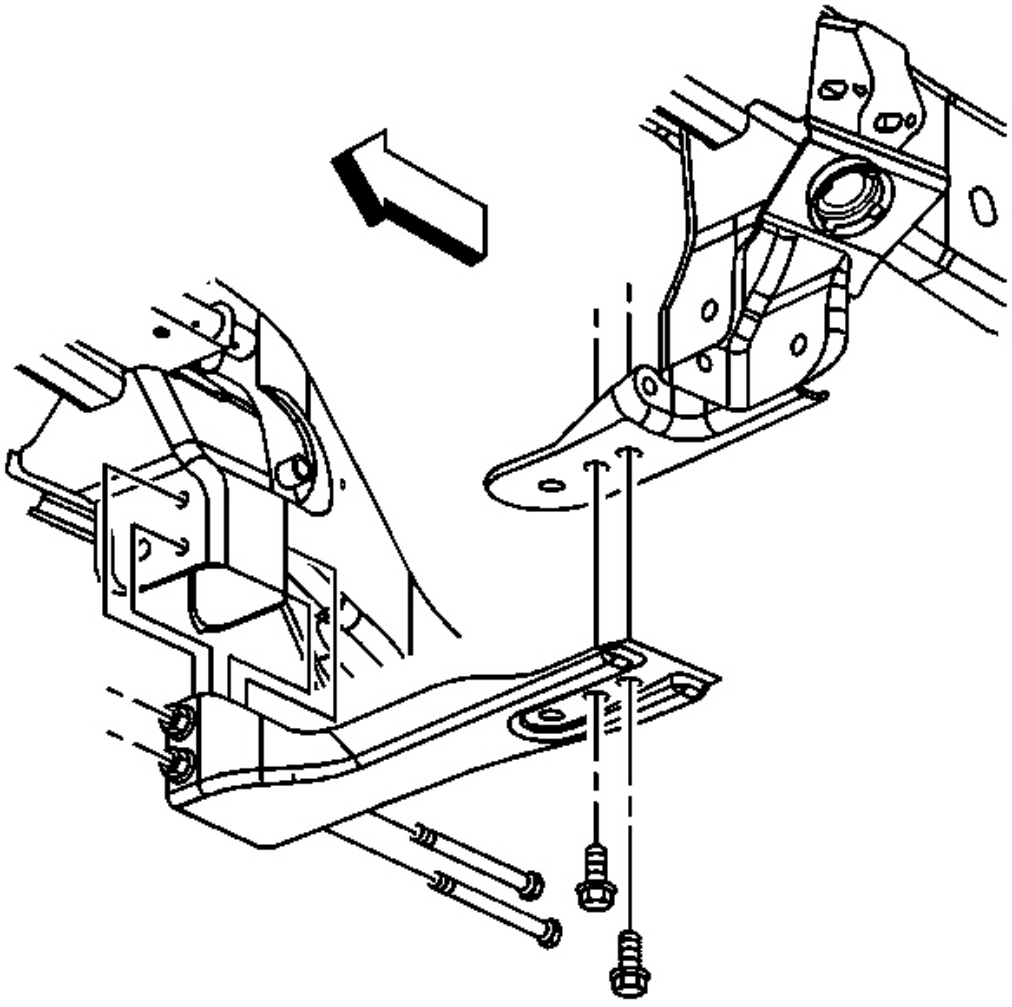


Fig. 260: View Of Crossmember Bolts & Bar (4WD)
Courtesy of GENERAL MOTORS CORP.

6. If equipped with 4-wheel drive (4WD), remove the crossmember bolts and bar.
7. If equipped with 4WD, remove the front differential carrier. Refer to **Differential Carrier Assembly Replacement (1500 FWD)** or **Differential Carrier Assembly Replacement (2500 4WD)** .

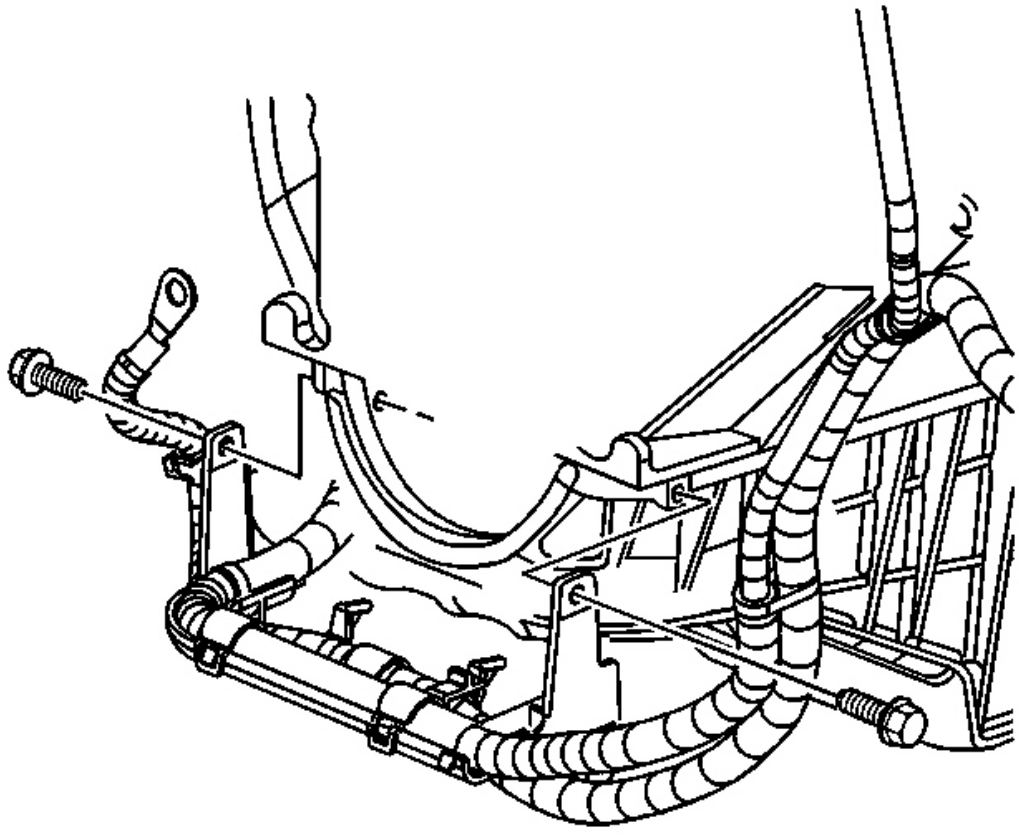


Fig. 261: View Of Battery Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine harness bracket bolts.
9. Remove the starter. Refer to **Starter Motor Replacement (4.3L)** .

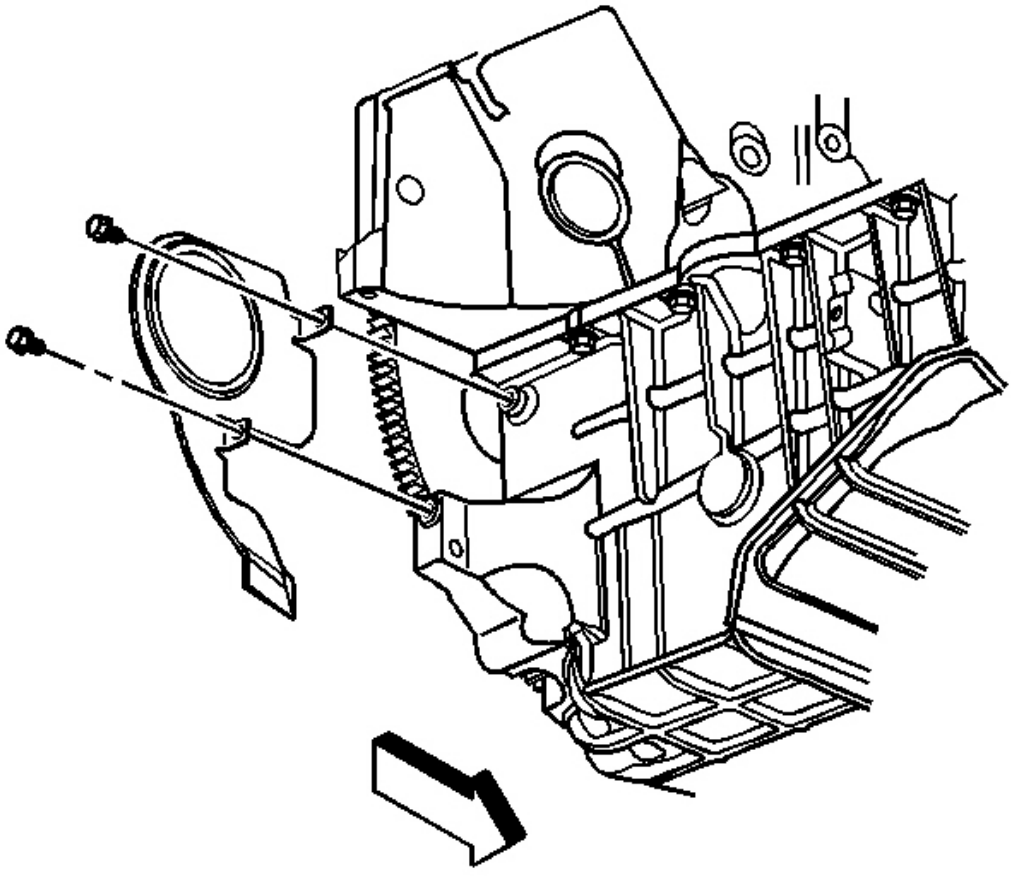


Fig. 262: Transmission Cover
Courtesy of GENERAL MOTORS CORP.

10. Remove the transmission cover.

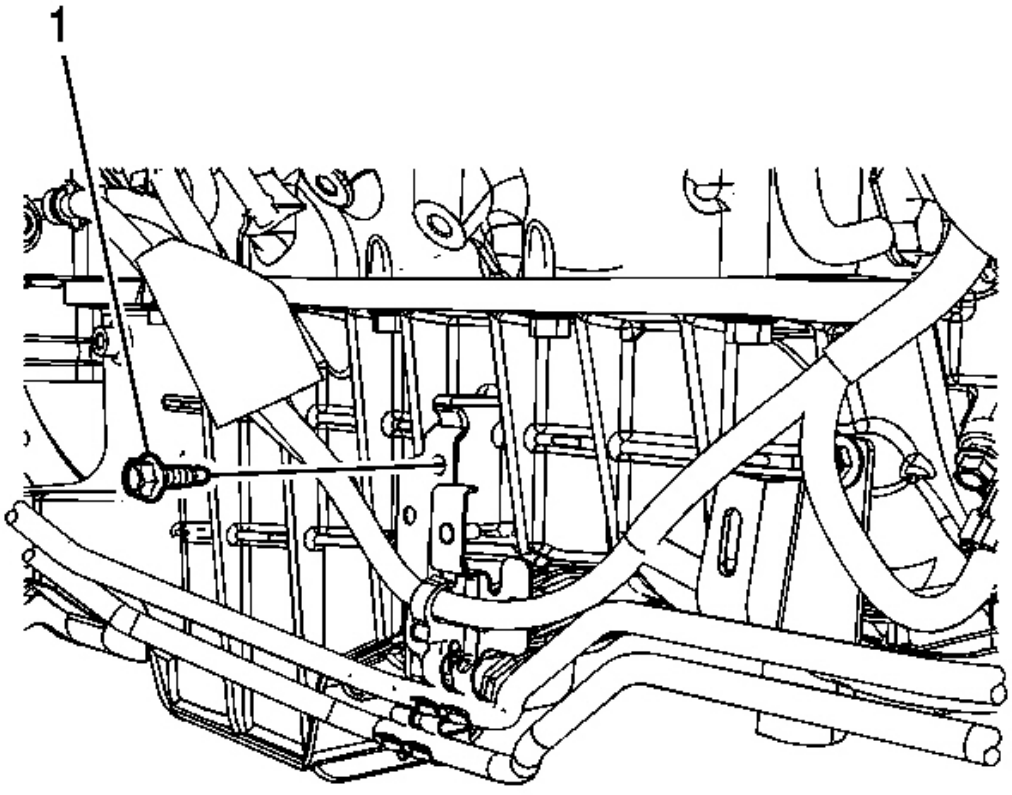


Fig. 263: Transmission Tube Bracket
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine harness and transmission tube bracket (1).

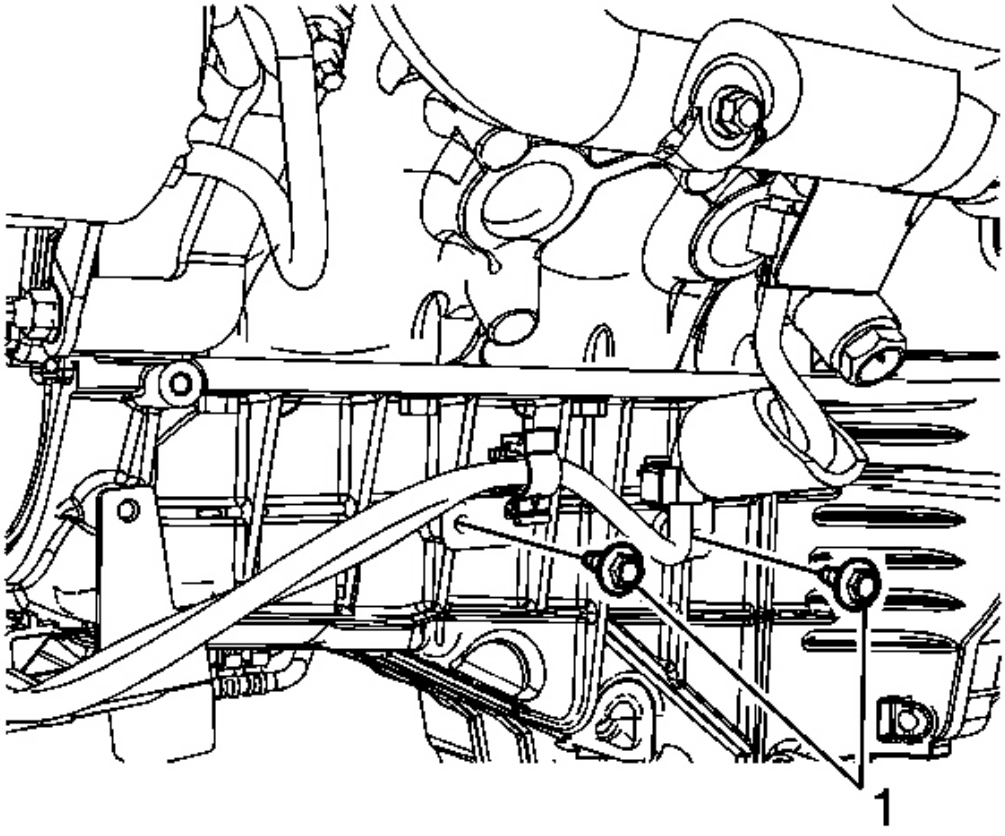


Fig. 264: Engine Wire Harness Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove two engine wire harness bracket bolts (1).

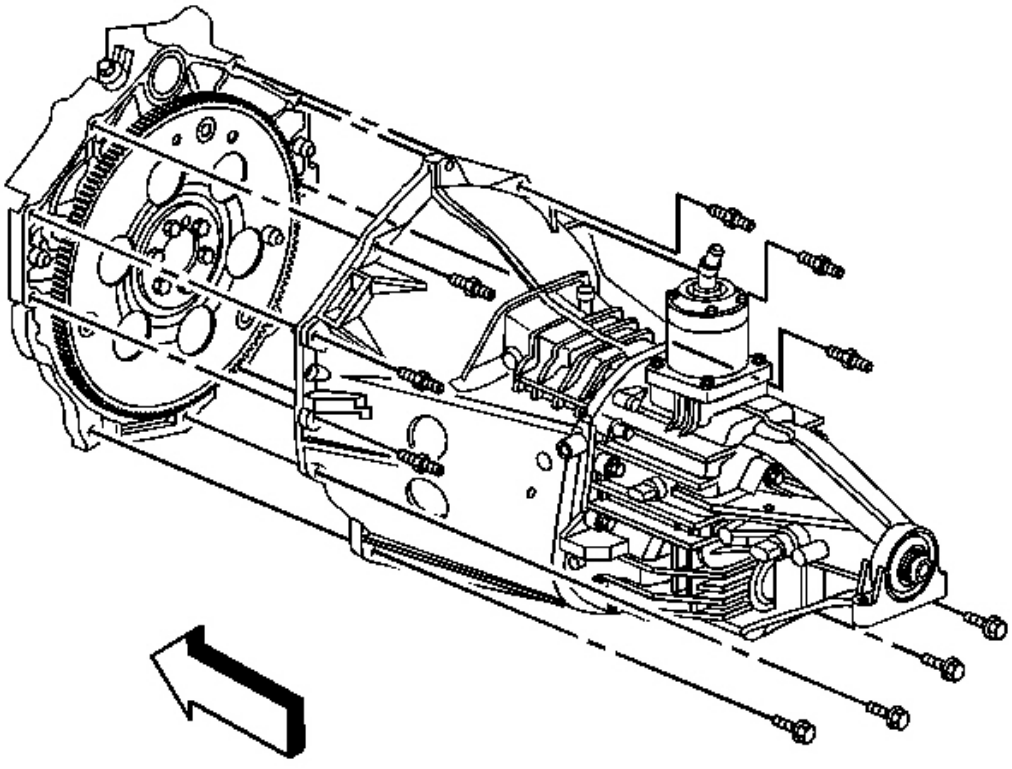


Fig. 265: Manual Transmission Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the manual transmission bolts, if equipped.

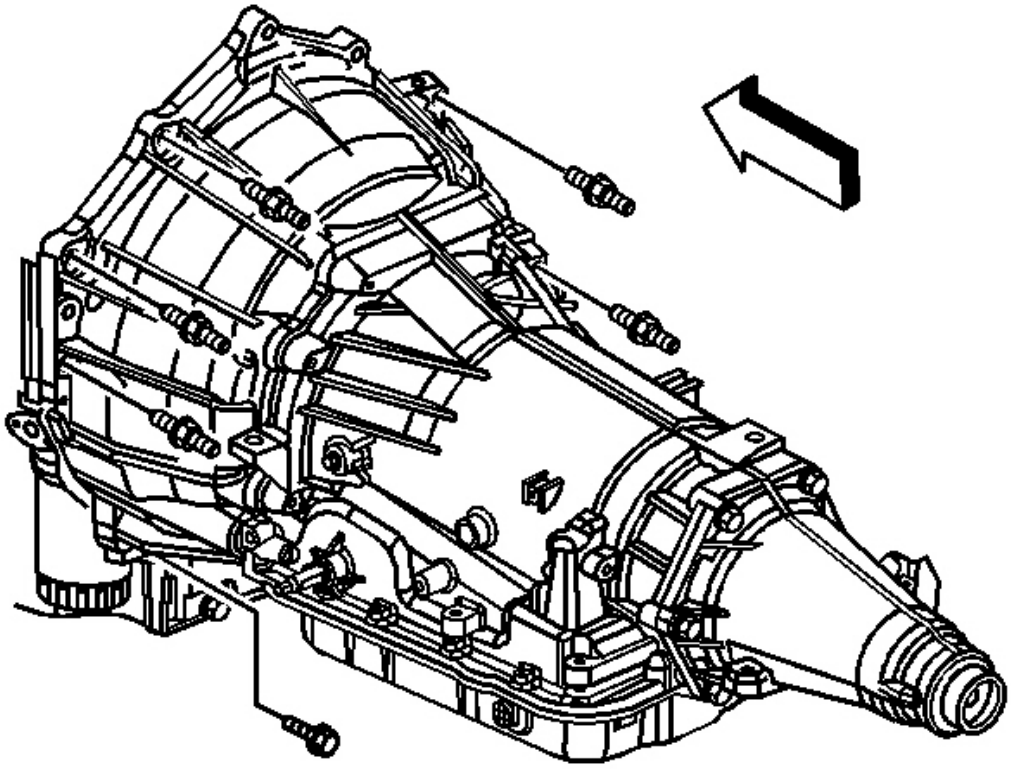


Fig. 266: Automatic Transmission Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the automatic transmission bolts, if equipped.

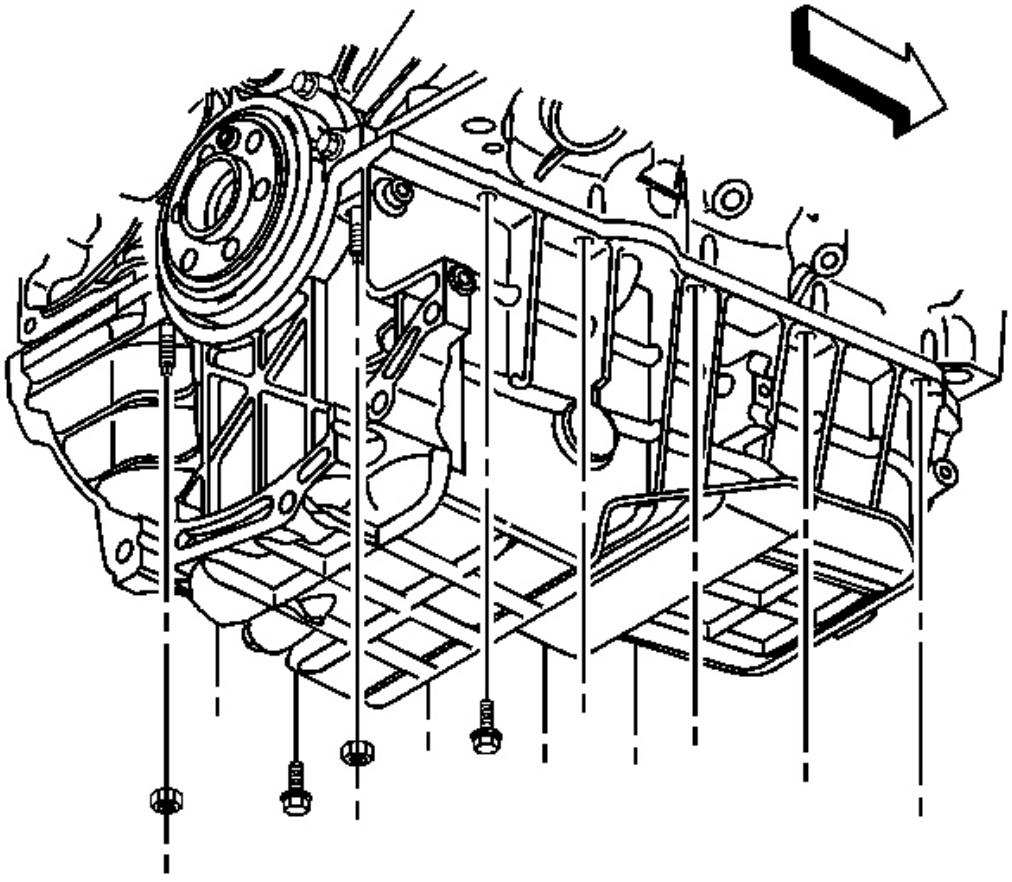


Fig. 267: Oil Pan Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

15. Remove the oil pan bolts and nuts.

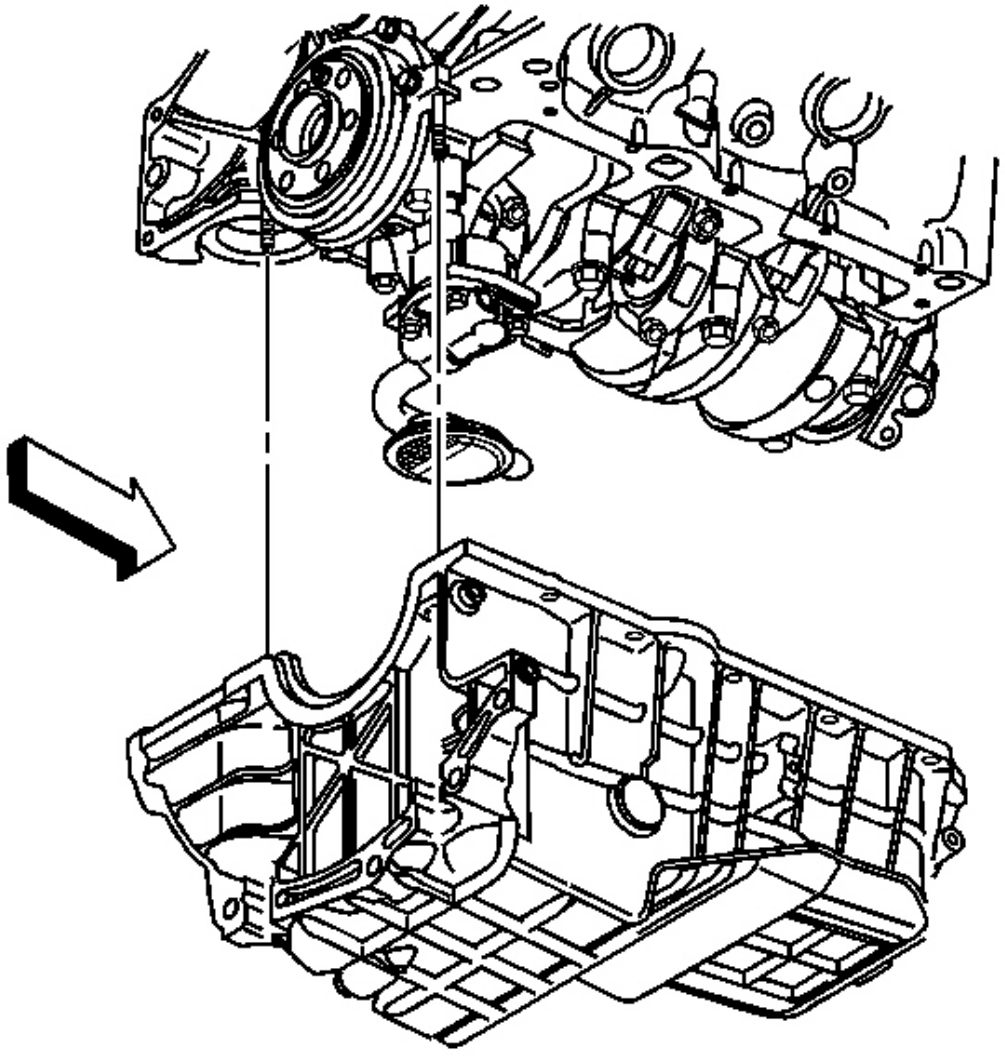


Fig. 268: Oil Pan
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil pan.

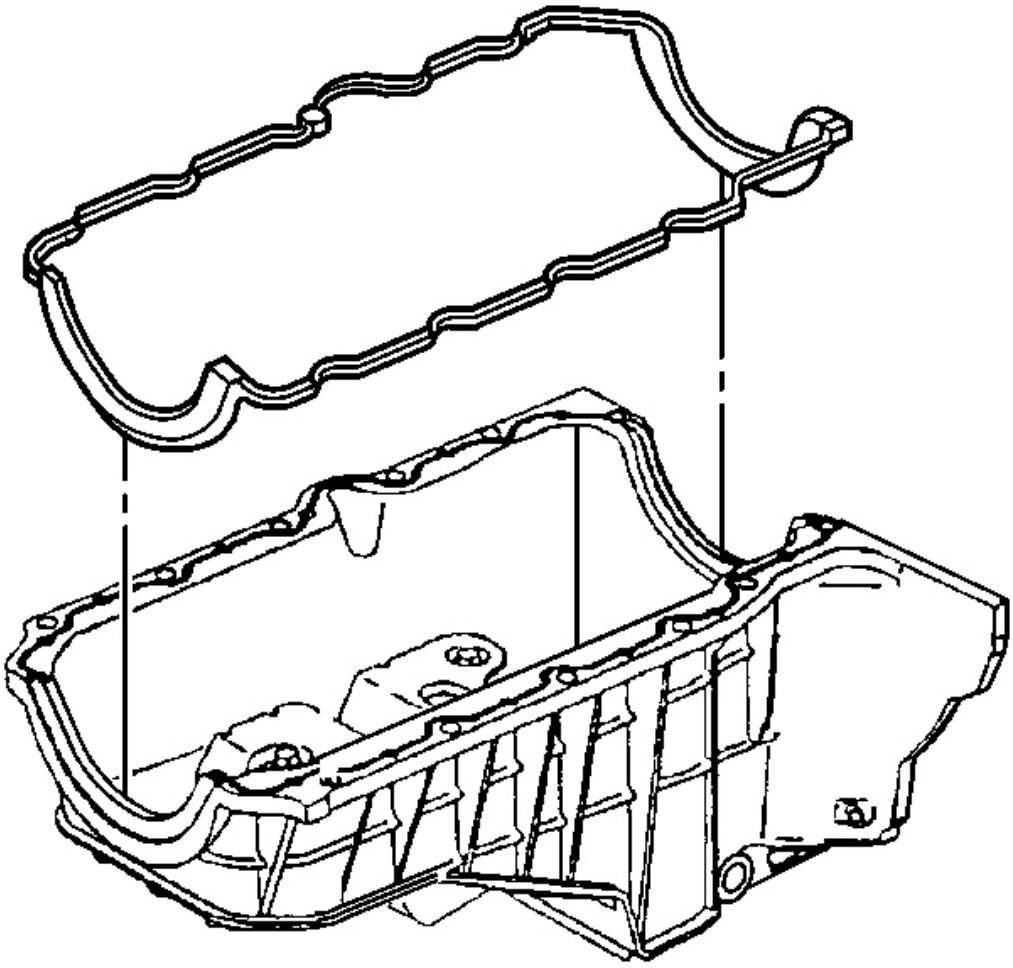


Fig. 269: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

17. Remove and discard the oil pan gasket.
18. Clean and inspect the oil pan, if necessary. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

NOTE: Any time the transmission and the engine oil pan are off of the engine at the same time, install the transmission before the oil pan. This is to allow for the proper oil pan alignment. Failure to achieve

the correct oil pan alignment can result in transmission failure.

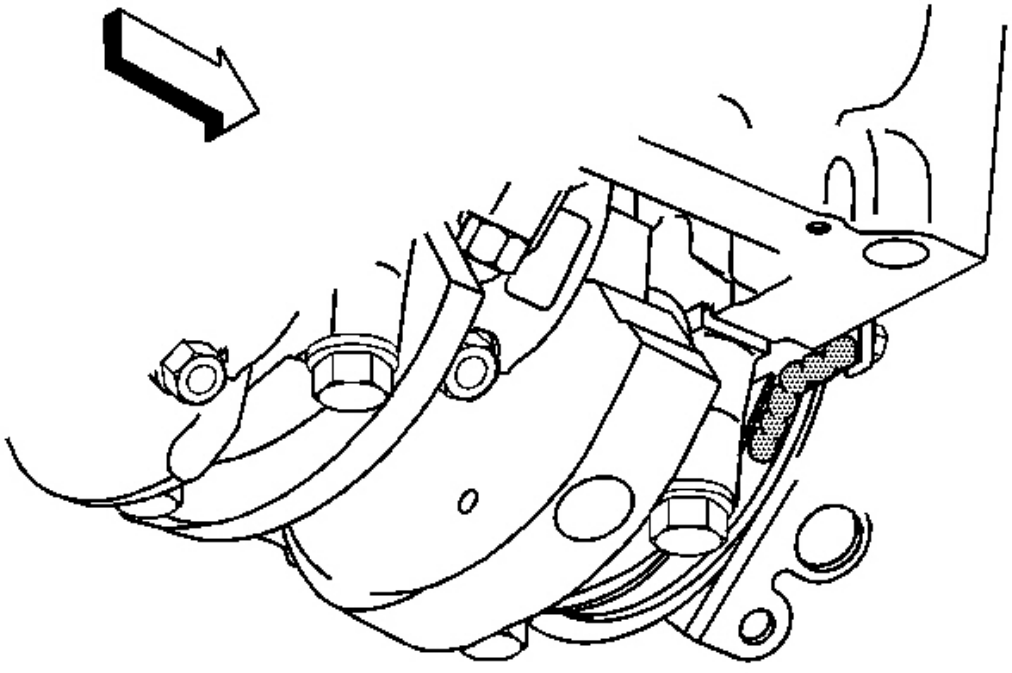


Fig. 270: Applying Adhesive To Sides Of Front Cover To Engine Block Junction At Oil Pan Sealing Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive to both the right and left sides of the front cover to engine block junction at the oil pan sealing surfaces. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

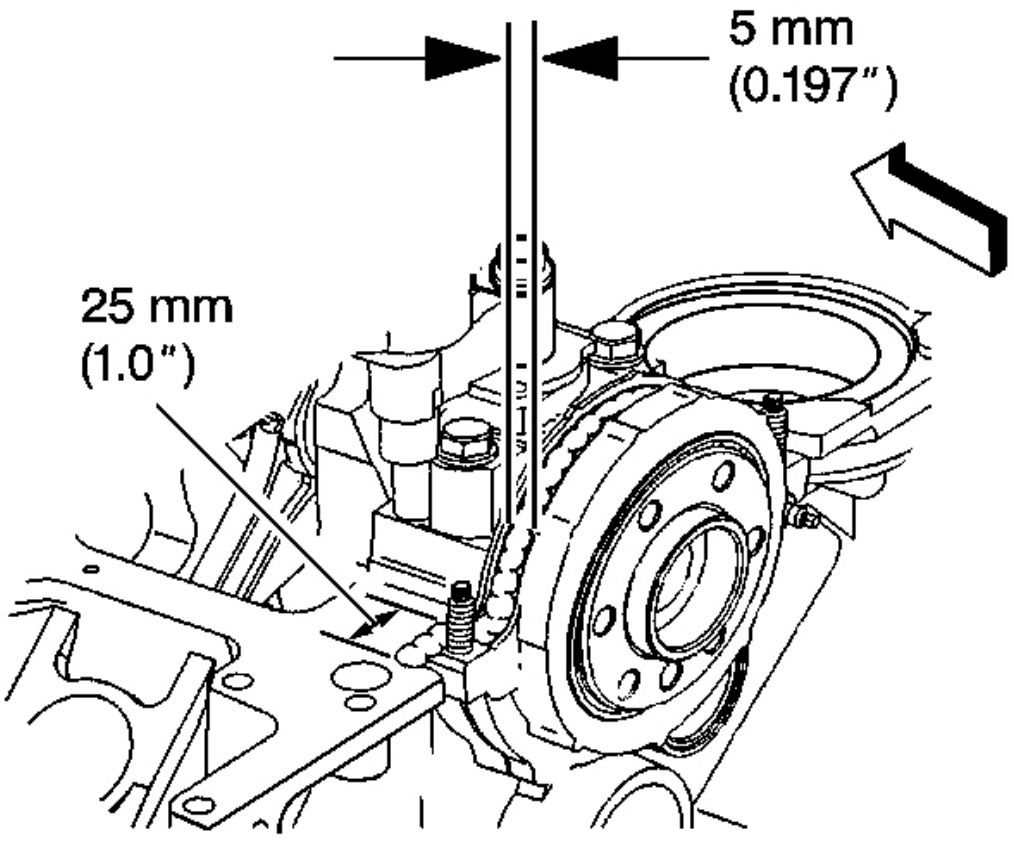


Fig. 271: Applying Adhesive To Entire Length Of Rear Oil Seal Housing To Engine Block Junction At Oil Pan Sealing Surfaces
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive to the entire length of rear oil seal housing to engine block junction at the oil pan sealing surfaces. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

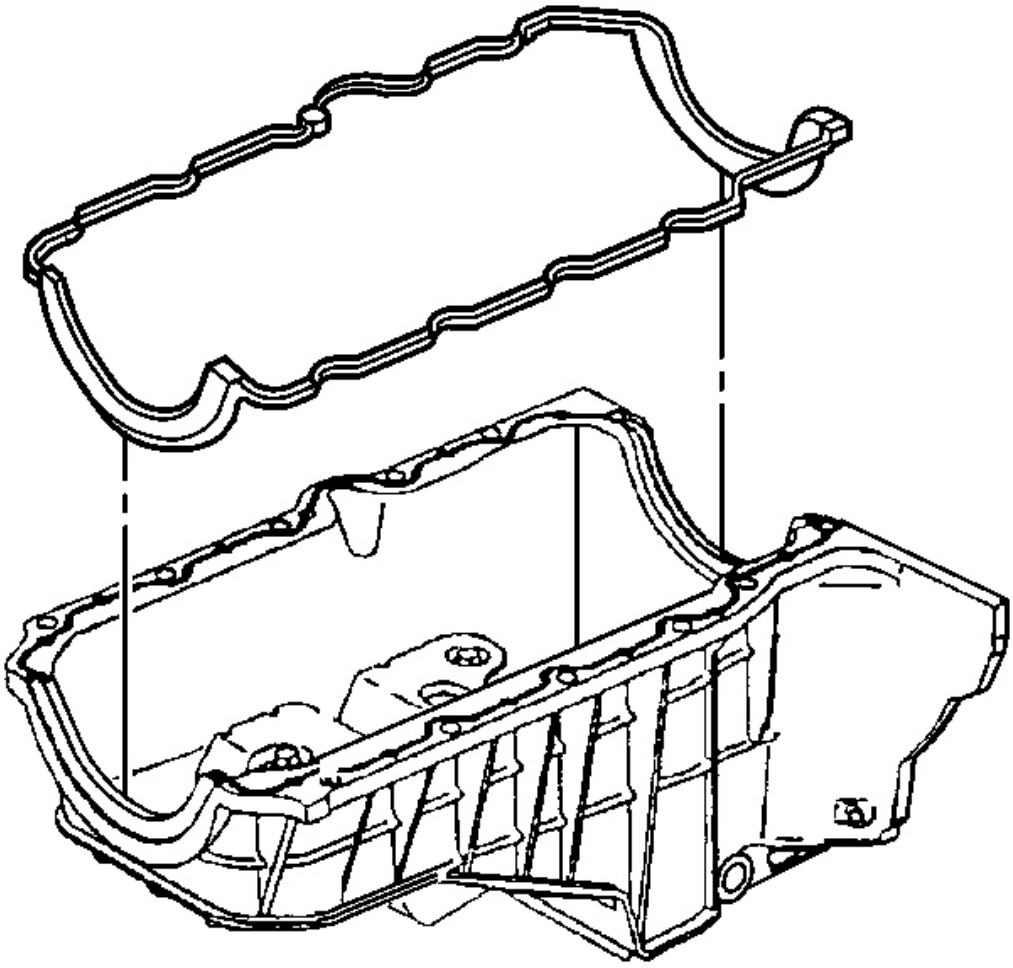


Fig. 272: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install a NEW oil pan gasket.
The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Install a NEW oil pan gasket into the groove in the oil pan.

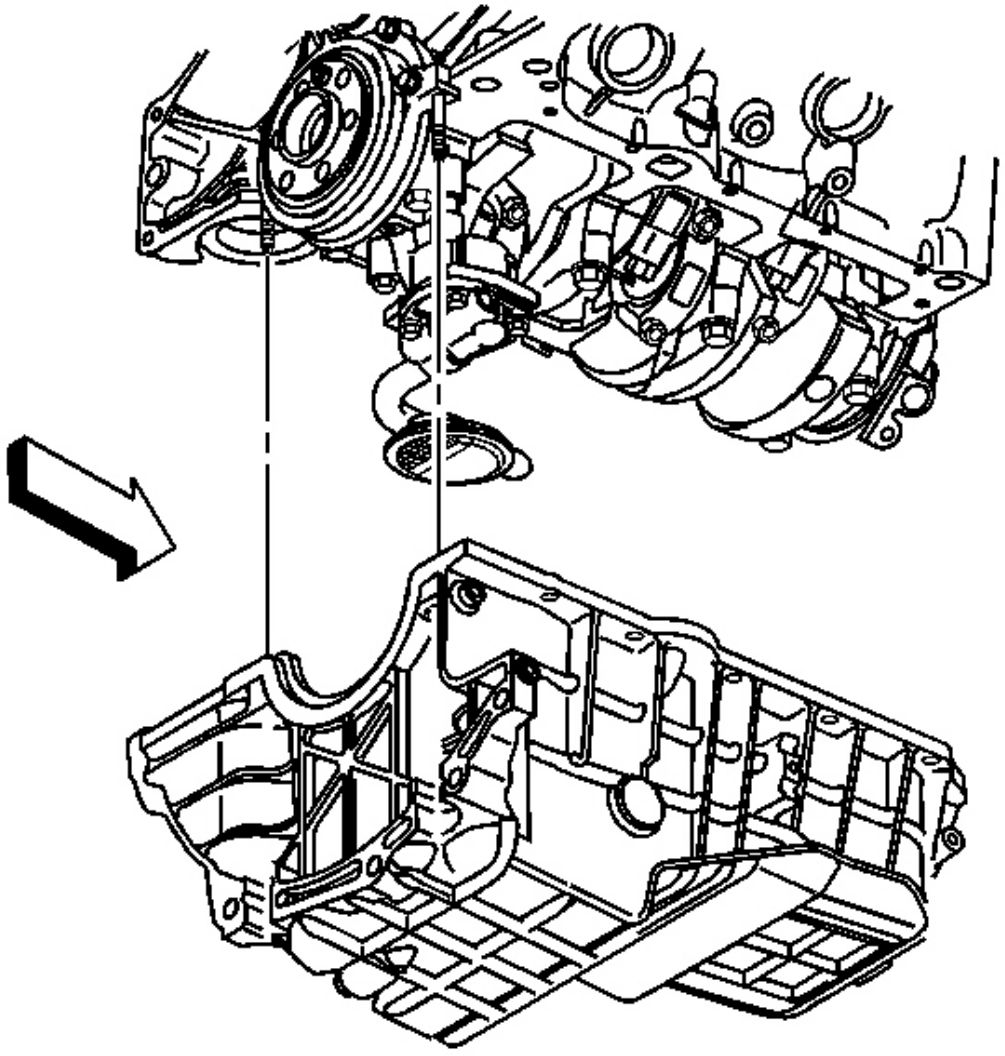


Fig. 273: Oil Pan
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan alignment must always be flush or forward no more than 0.3 mm (0.011 in) from the rear face of the engine block.

4. Install the oil pan.

Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.

5. Slide the oil pan back against a suitable straight edge.

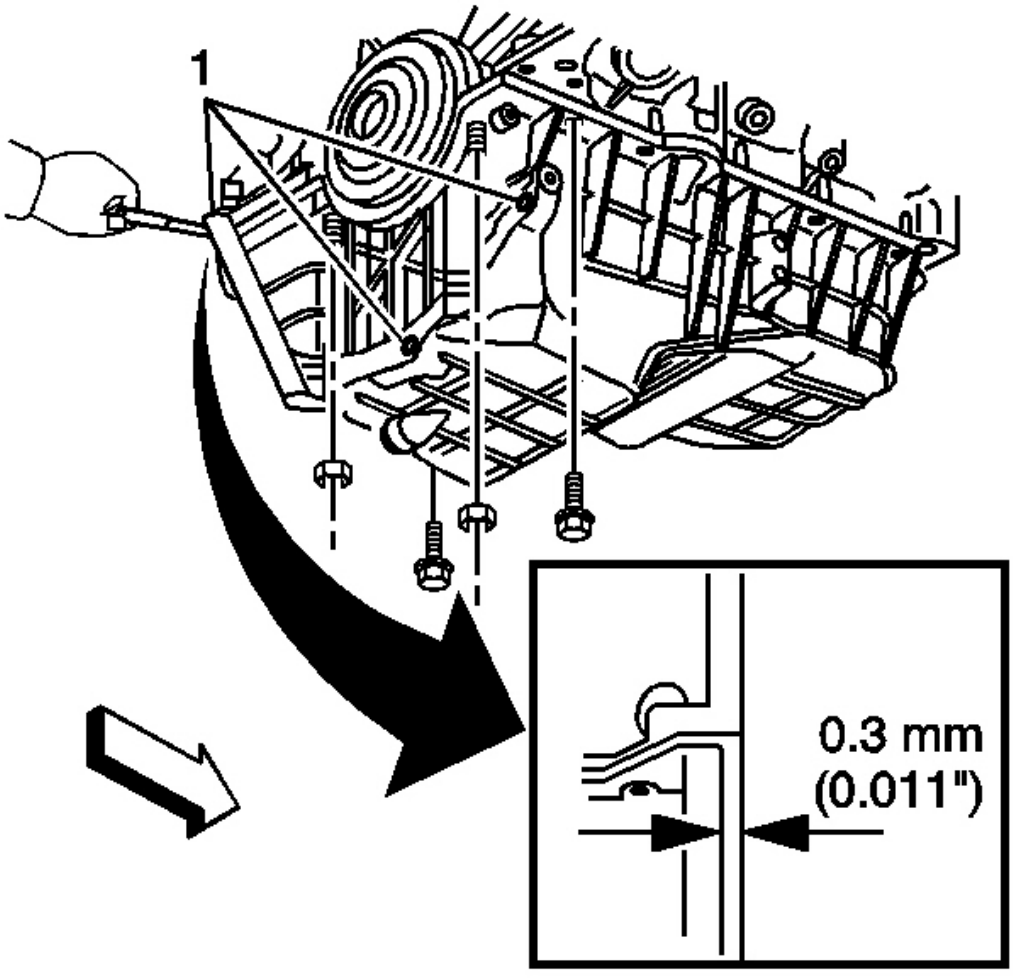


Fig. 274: Measuring Oil Pan-To-Transmission Housing Clearance
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan bolts and nuts until snug.
7. Measure the oil pan-to-transmission housing clearance using a feeler gage and a straight edge.

Use the feeler gage to check the clearance at the oil pan-to-transmission housing measurement points (1). If the clearance exceeds 0.3 mm (0.011 in) at any of the oil pan-to-transmission housing measurement points (1), then repeat the step until the oil pan-to-transmission housing clearance is within specifications. The oil pan must always be forward of the rear face of the engine block.

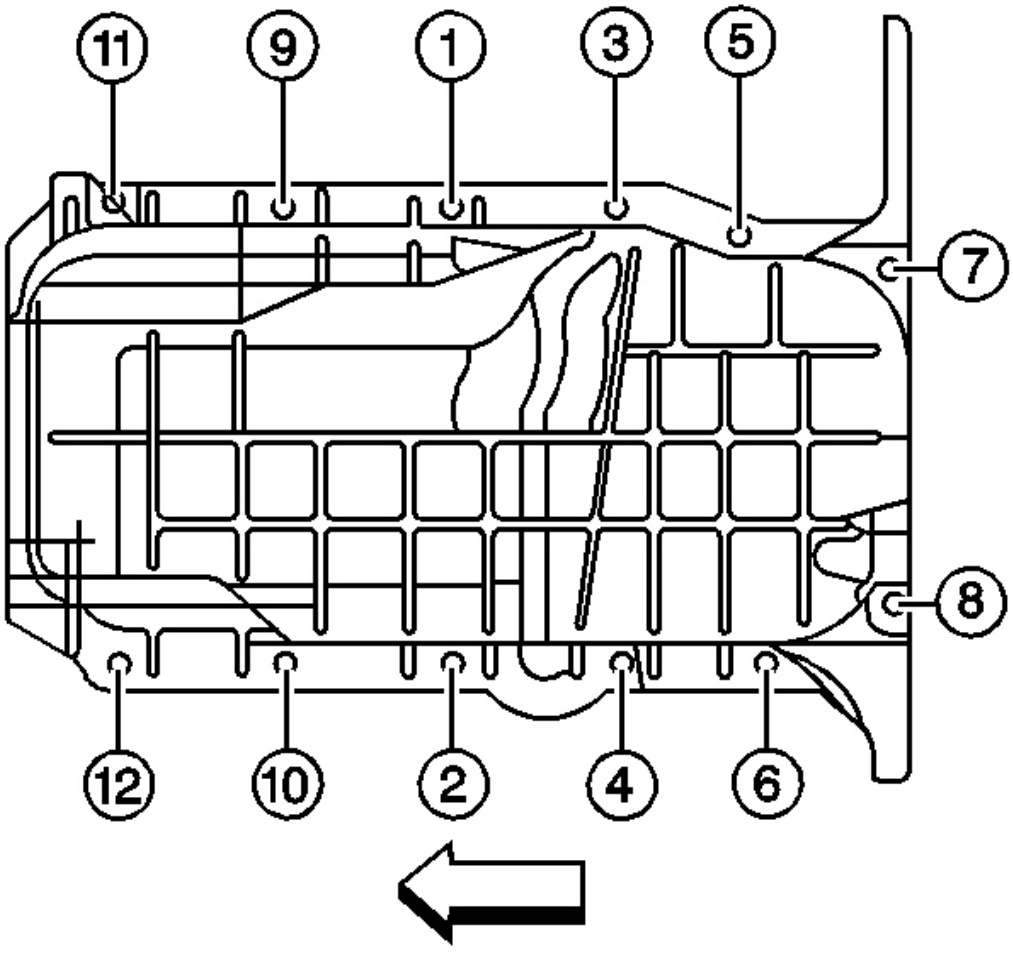


Fig. 275: Oil Pan Bolts & Nuts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the oil pan bolts and nuts in the sequence shown.

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

9. Measure the clearance at the oil pan-to-transmission housing measurement points in order to ensure proper alignment.

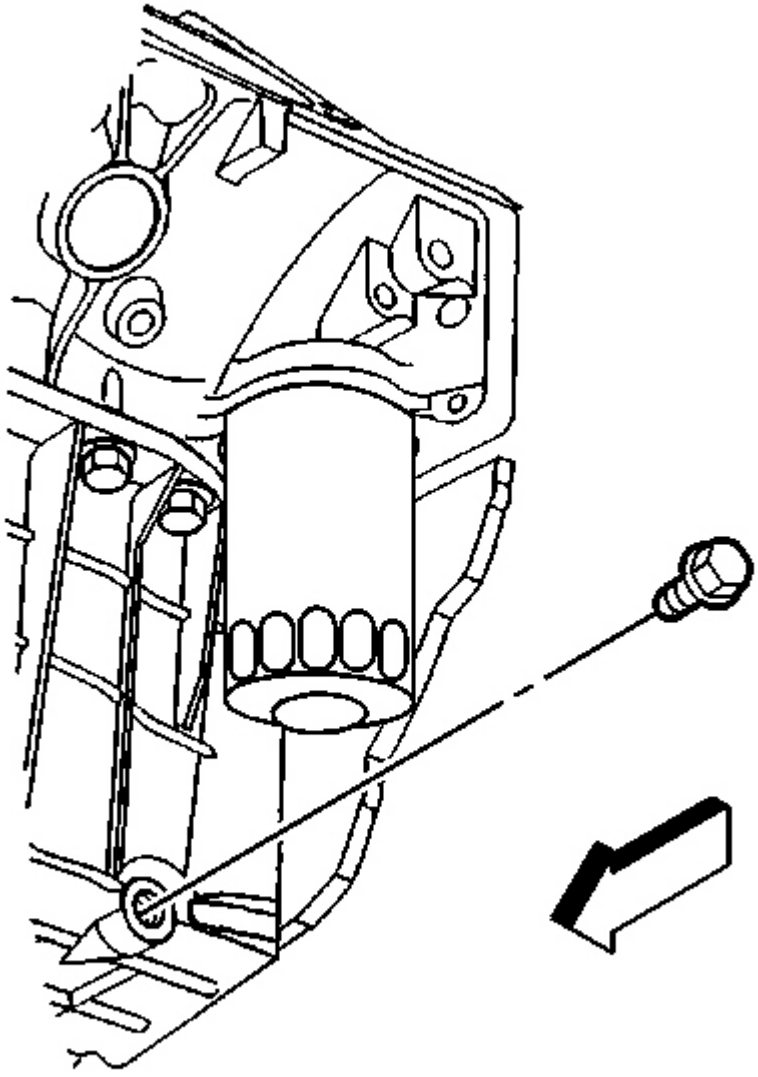


Fig. 276: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

10. Install a NEW drain plug O-ring seal onto the drain plug.
11. Install the drain plug.

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

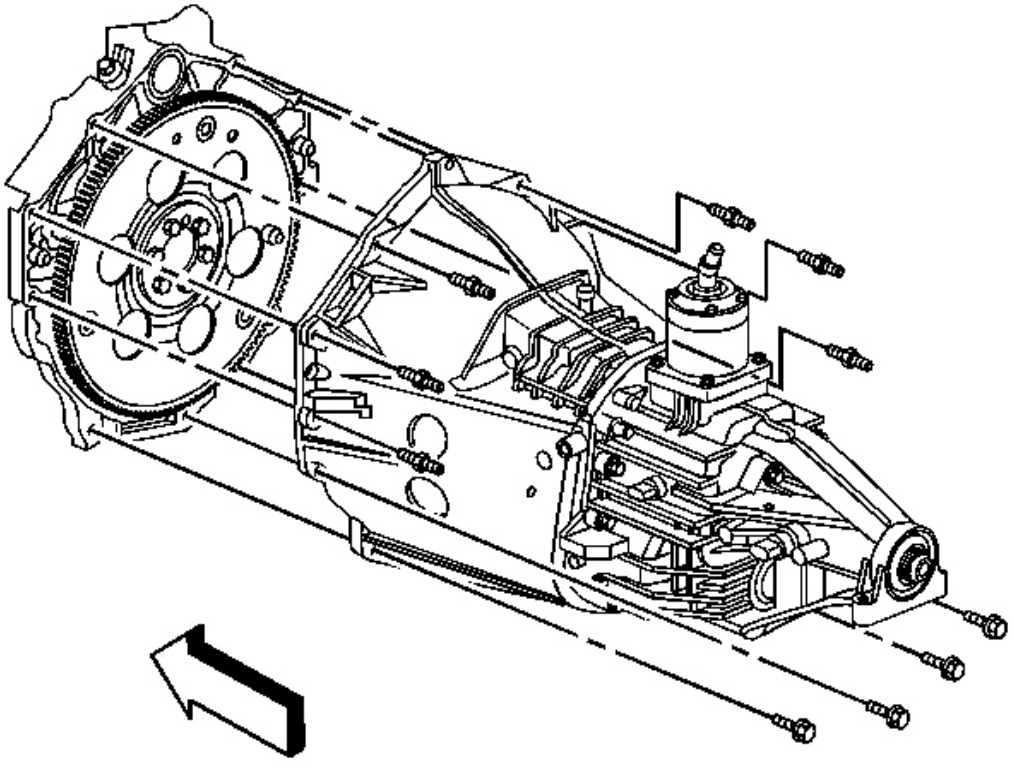


Fig. 277: Manual Transmission Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the transmission cover.

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

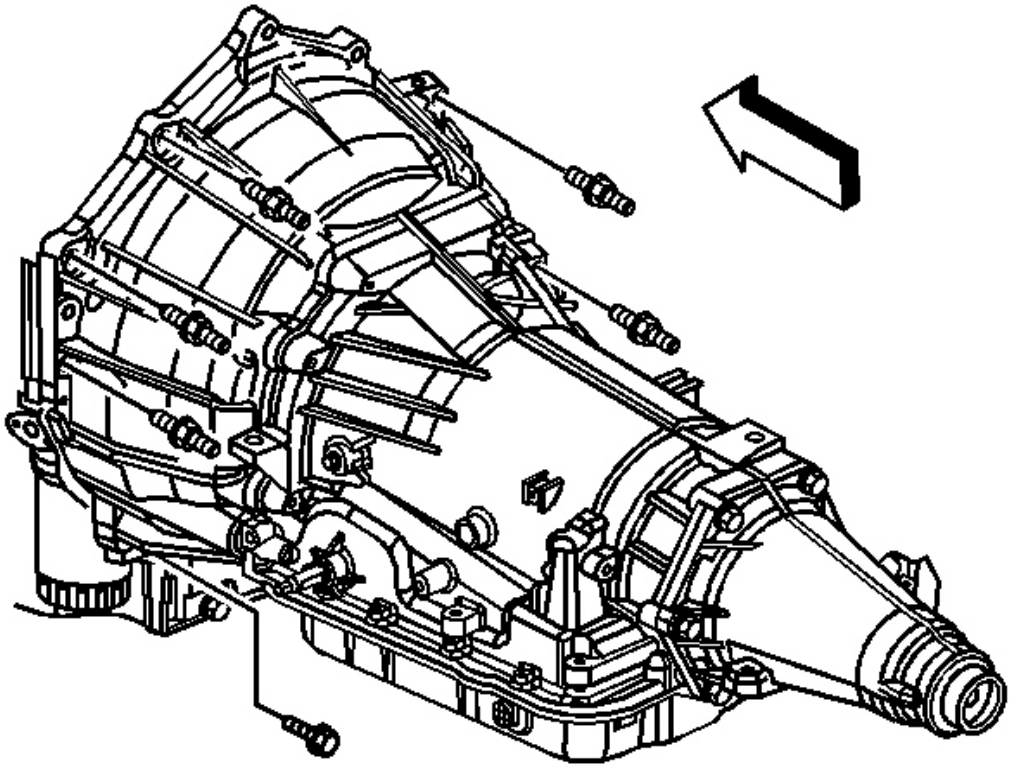


Fig. 278: Automatic Transmission Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the automatic transmission bolts, if equipped.

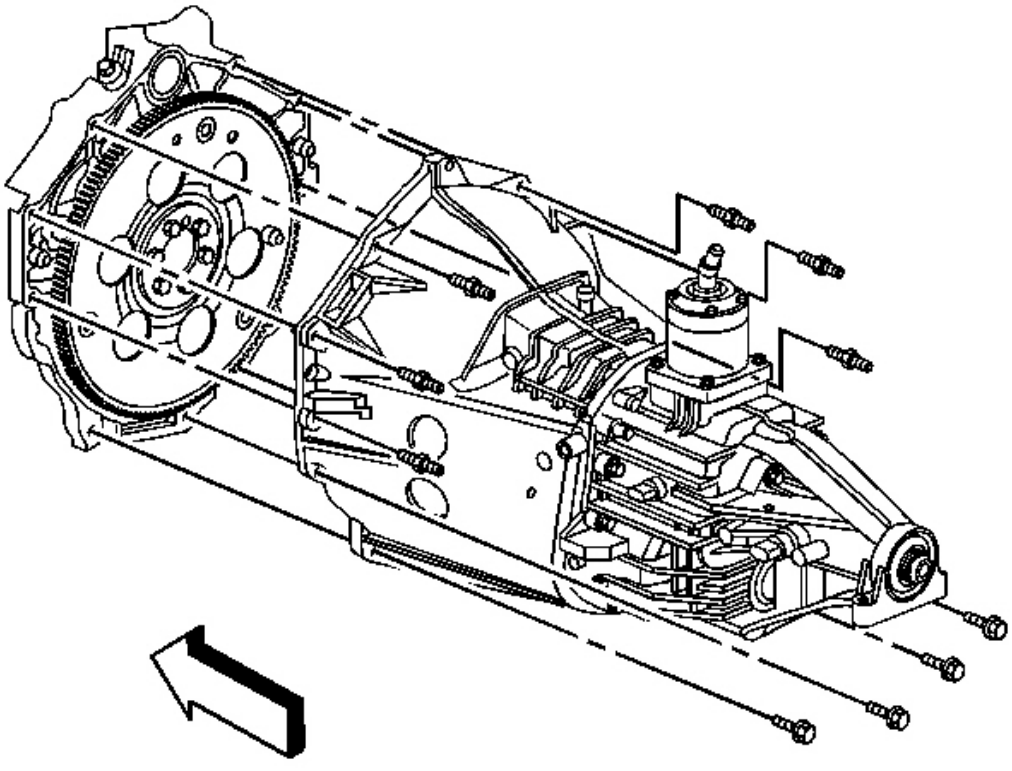


Fig. 279: Manual Transmission Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the manual transmission bolts, if equipped.

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

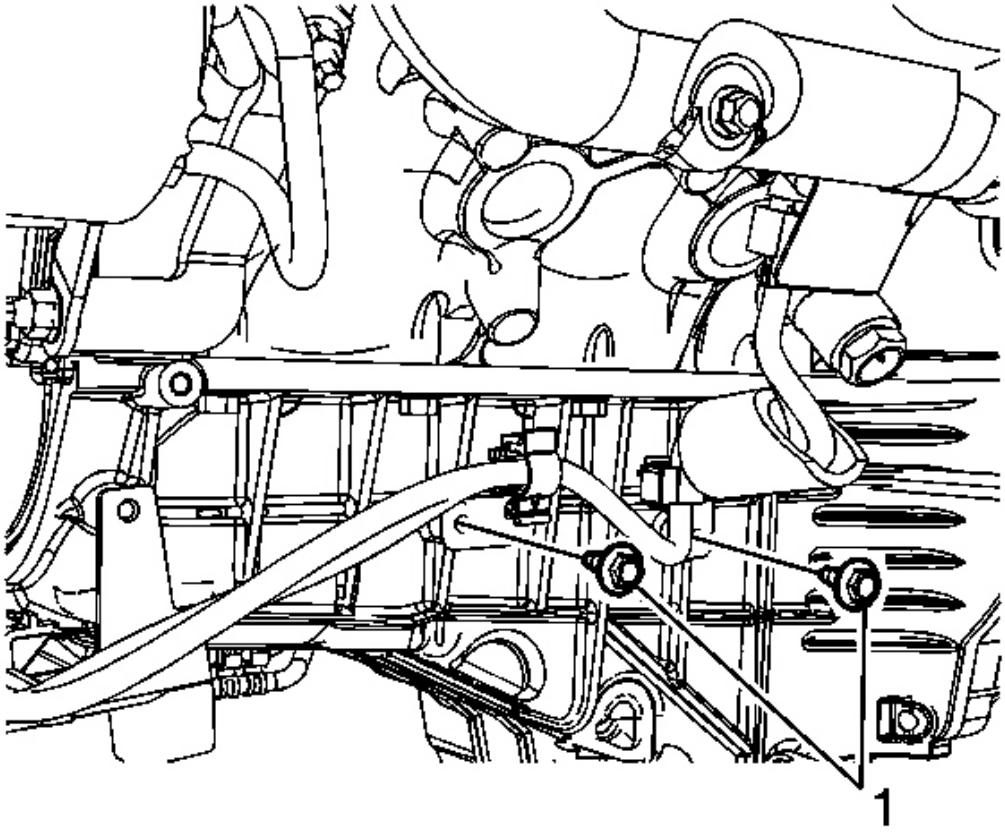


Fig. 280: Engine Wire Harness Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

15. Install two engine wire harness bracket bolts (1).

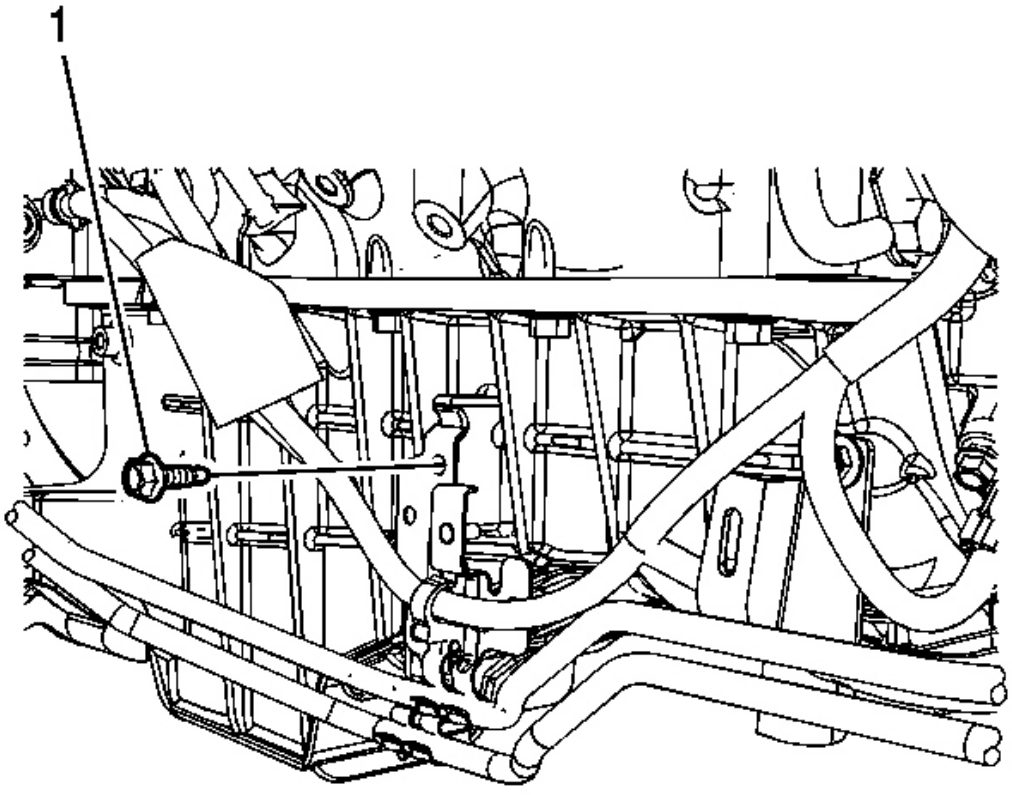


Fig. 281: Transmission Tube Bracket
Courtesy of GENERAL MOTORS CORP.

16. Install the engine harness and transmission tube bracket bolt (1).

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

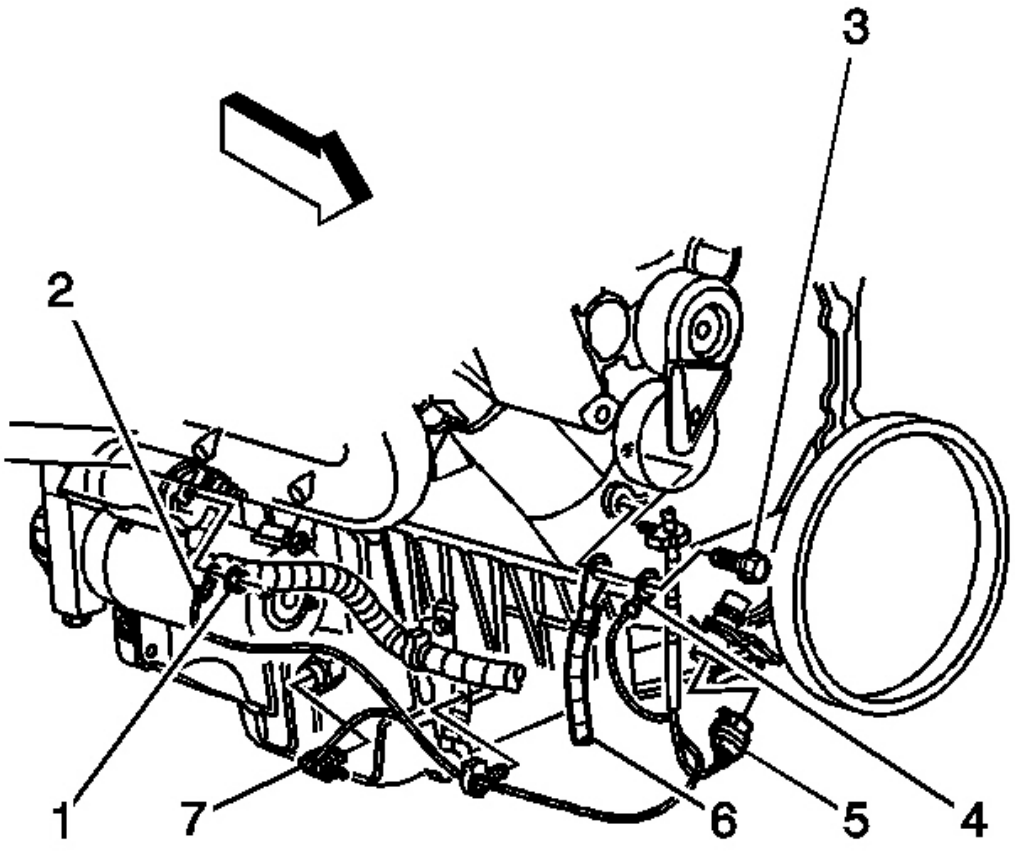


Fig. 282: View Of Oil Level Sensor Electrical Connector, CKP Electrical Connector & Battery Ground Bolt
Courtesy of GENERAL MOTORS CORP.

17. Install the starter. Refer to **Starter Motor Replacement (4.3L)** .
18. Connect the oil level sensor electrical connector (7).

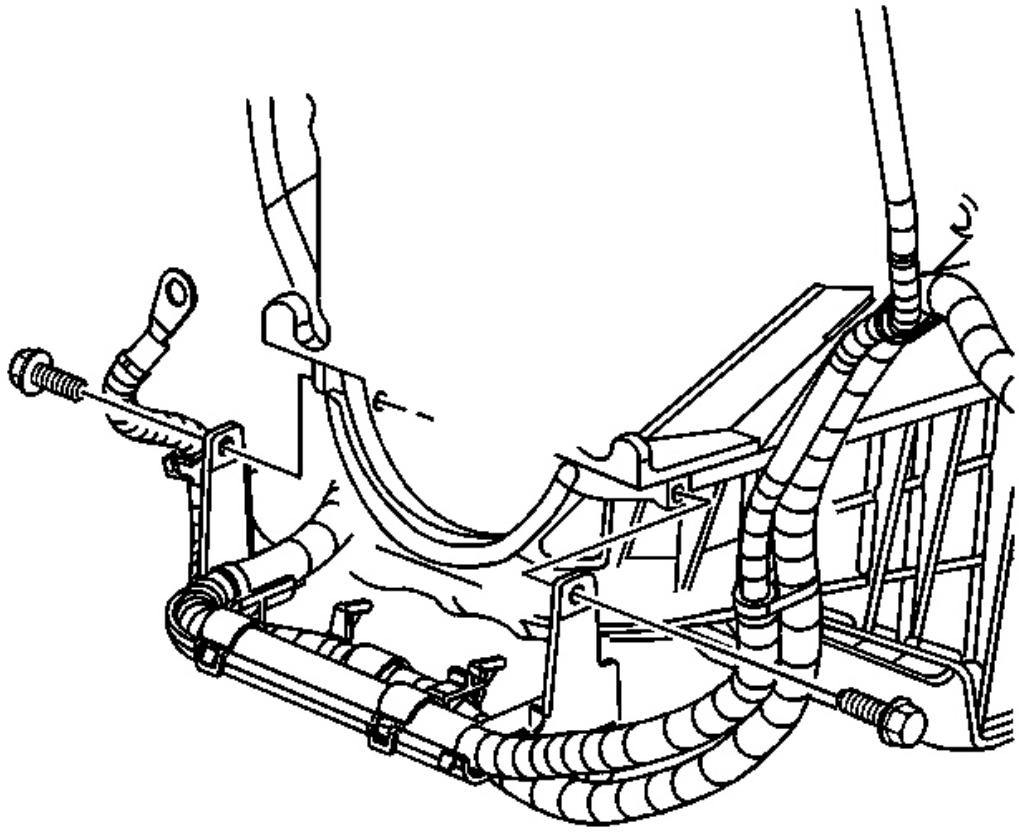


Fig. 283: View Of Battery Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

19. Install the engine harness bracket bolts.

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

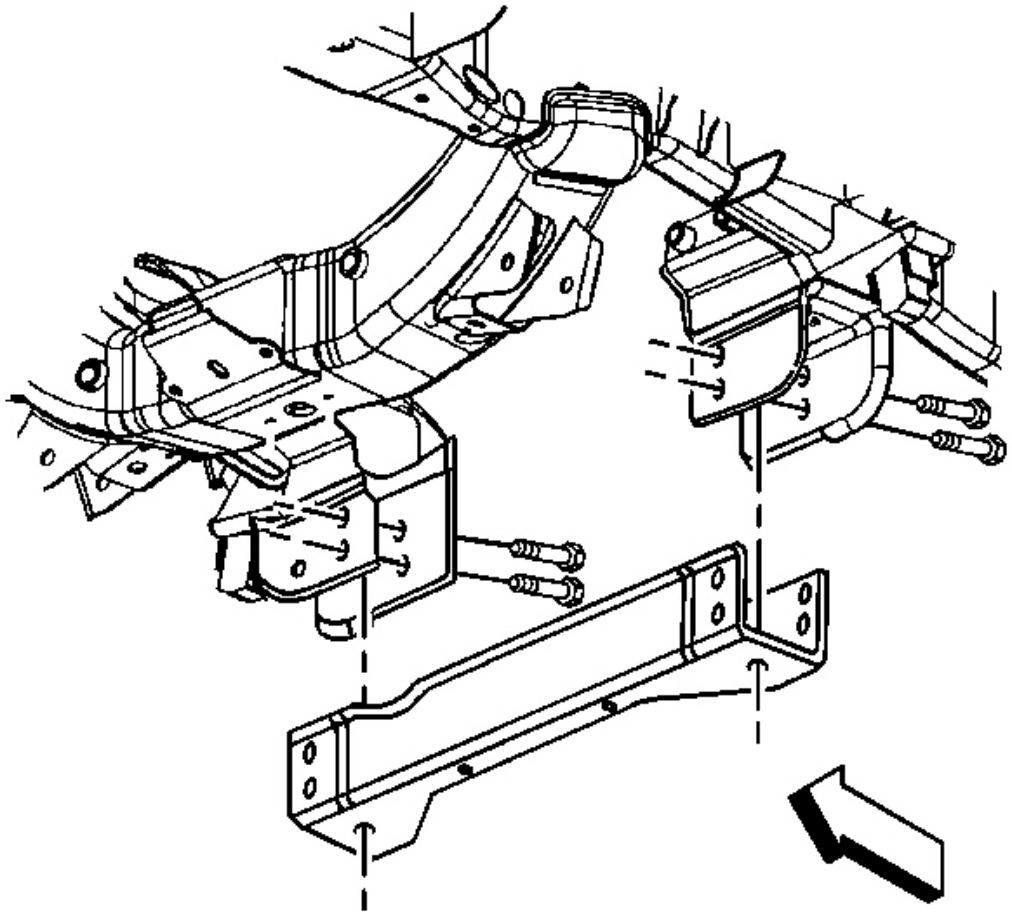


Fig. 284: View Of Crossbar Bolts & Bar (2WD)
Courtesy of GENERAL MOTORS CORP.

20. If equipped with 2WD, install the crossmember and bolts.

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

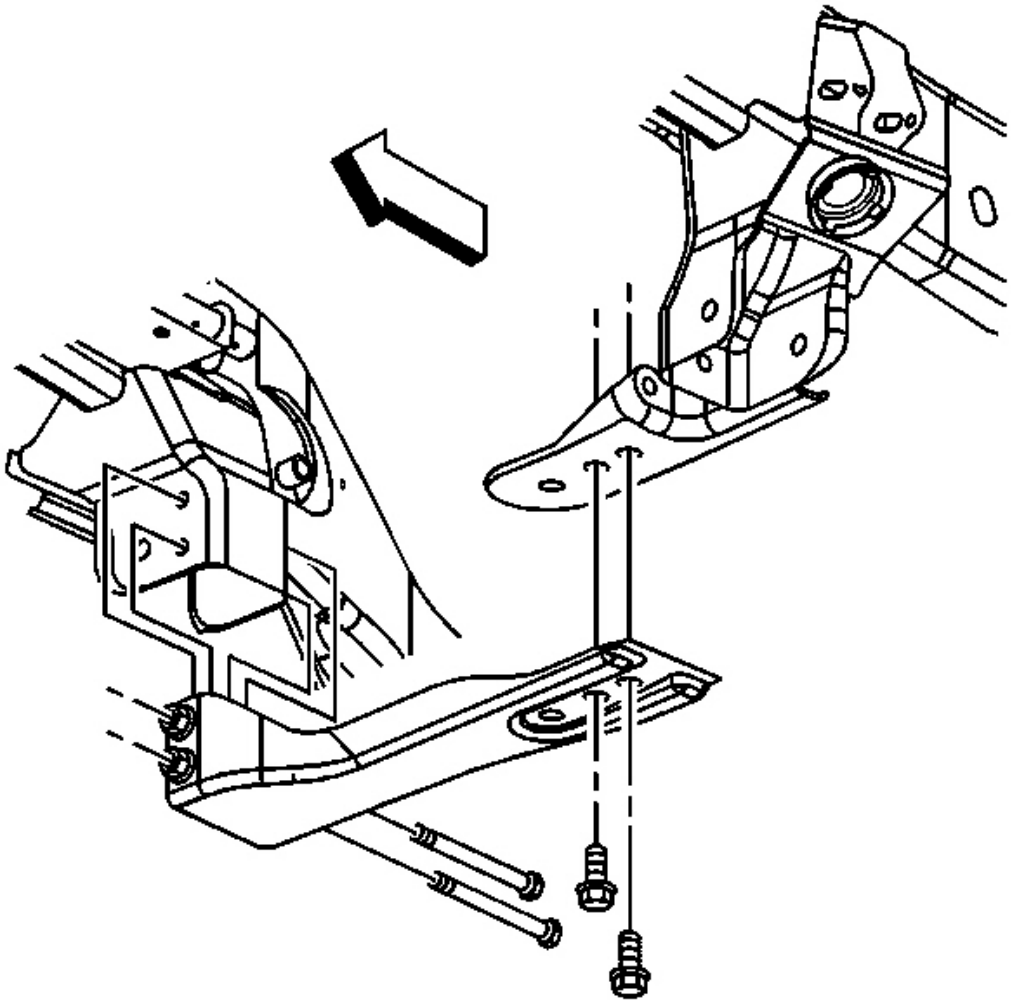


Fig. 285: View Of Crossmember Bolts & Bar (4WD)
Courtesy of GENERAL MOTORS CORP.

21. Install the front differential carrier, if equipped with 4WD. Refer to **Differential Carrier Assembly Replacement (1500 FWD)** or **Differential Carrier Assembly Replacement (2500 4WD)** .
22. If equipped with 4WD, install the crossmember and bolts.

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

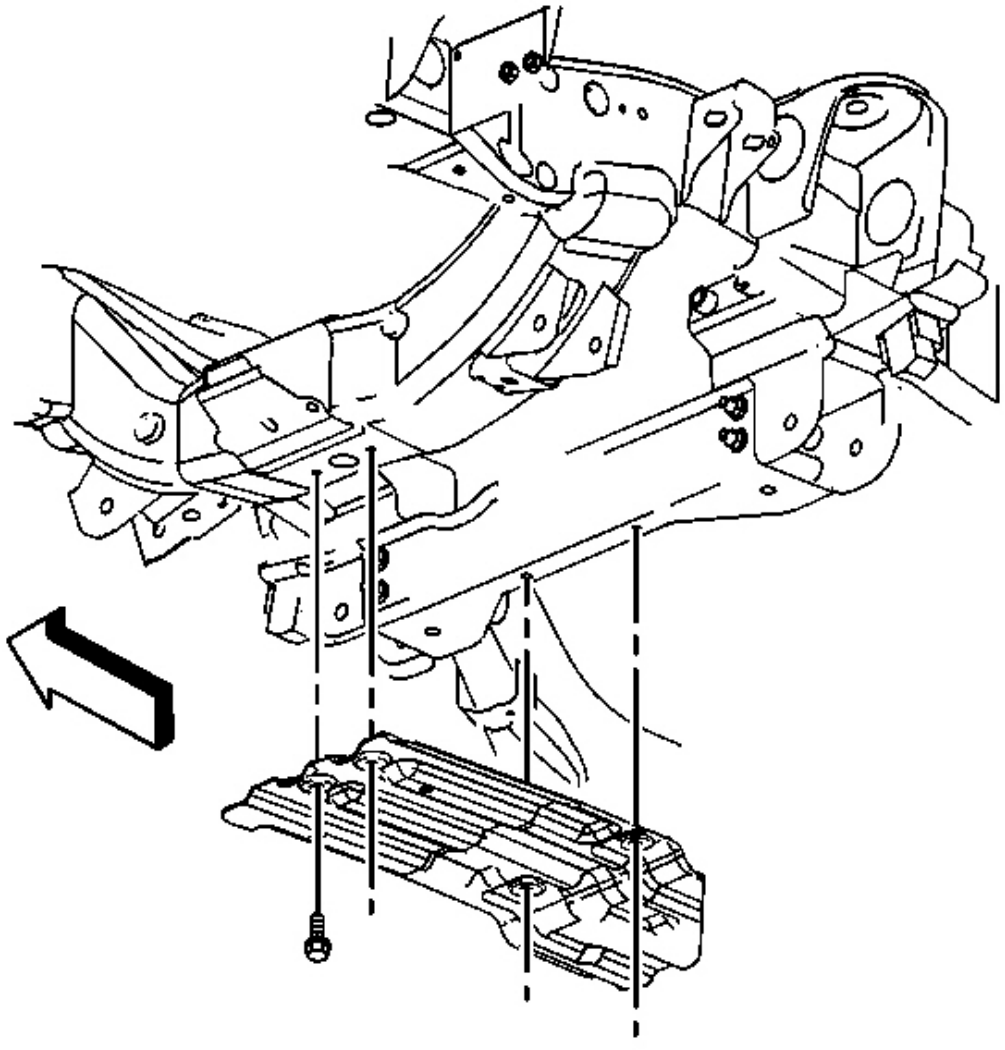


Fig. 286: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

23. If equipped, install the oil pan skid plate and bolts.

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

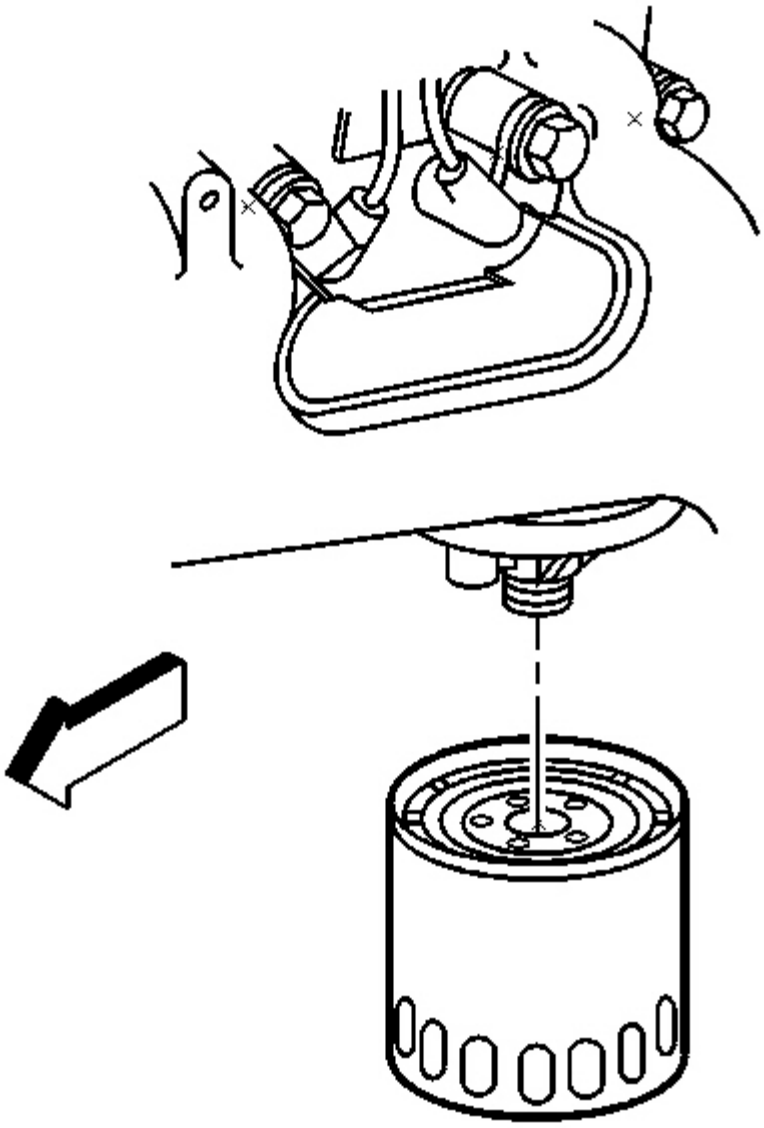


Fig. 287: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

24. Lubricate the oil filter gasket with clean engine oil.
25. Install the oil filter.

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

26. Lower the vehicle.
27. Fill the engine with the proper capacity and quality of engine oil. Refer to **Approximate Fluid Capacities** .

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Tools Required

J 41712 Oil Pressure Switch Socket. See **Special Tools**.

Removal Procedure

IMPORTANT: Clean the area around the oil pressure sensor. Do not allow debris to enter the engine.

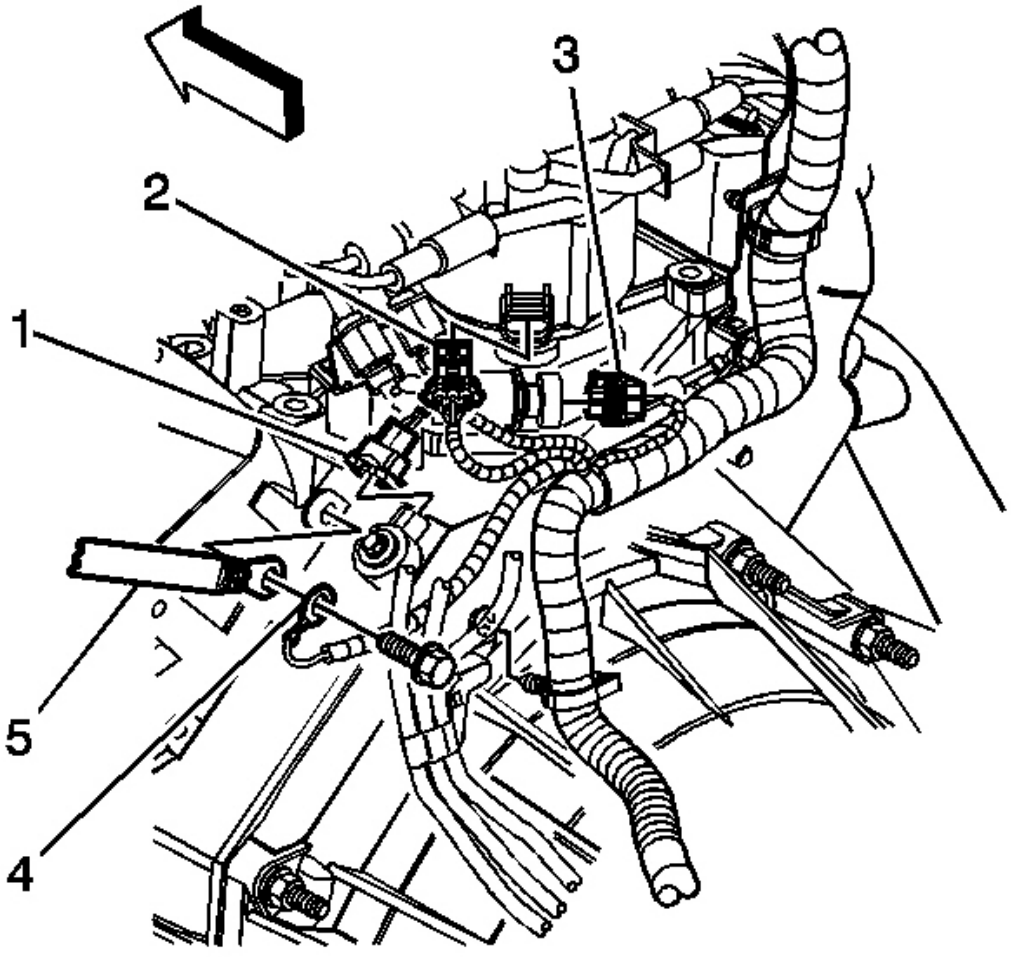


Fig. 288: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the fuel pump/oil pressure sensor electrical connector (3).

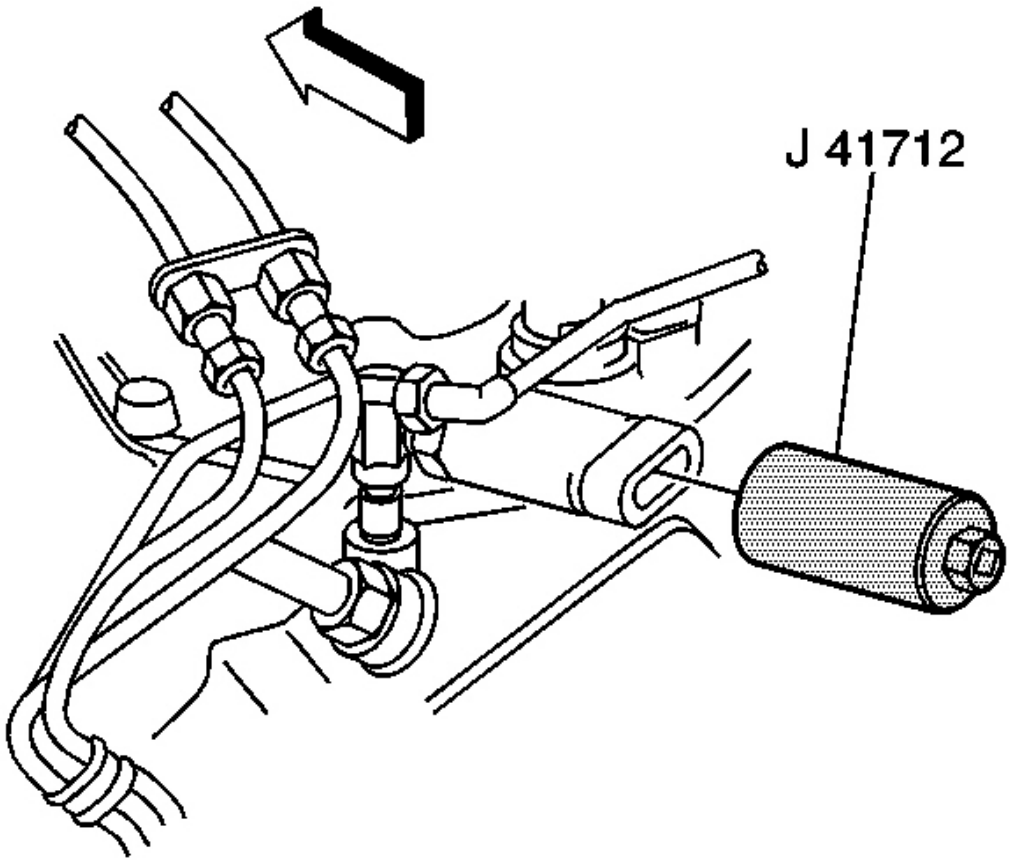


Fig. 289: J 41712
Courtesy of GENERAL MOTORS CORP.

2. Using **J 41712** , remove the fuel pump/oil pressure sensor. See **Special Tools**.

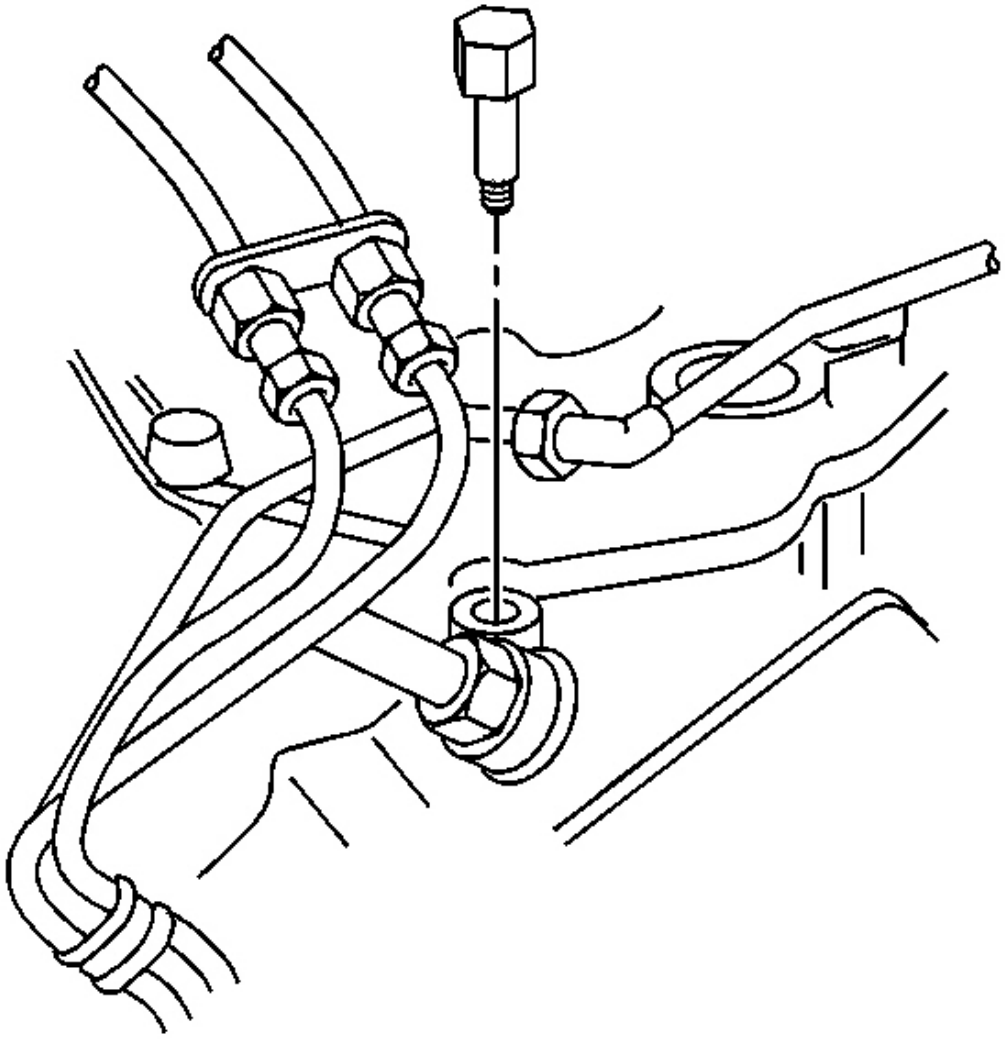


Fig. 290: Fuel Pump/Oil Pressure Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the alignment of the engine oil pressure sensor fitting prior to removal.

3. Remove the fuel pump/oil pressure sensor fitting, if necessary.

Installation Procedure

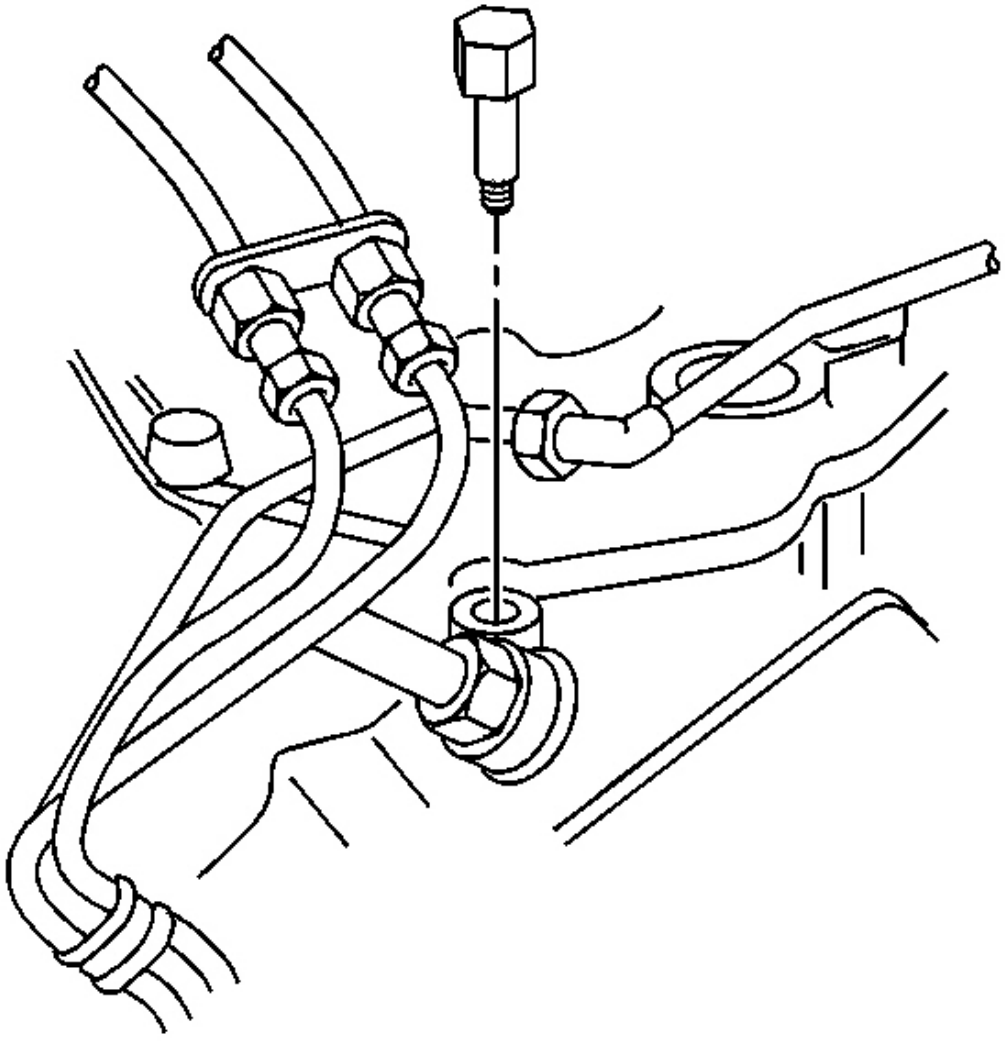


Fig. 291: Fuel Pump/Oil Pressure Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

1. If installing the old fitting, apply sealant to the threads of the fitting. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install the fitting until snug, if necessary.

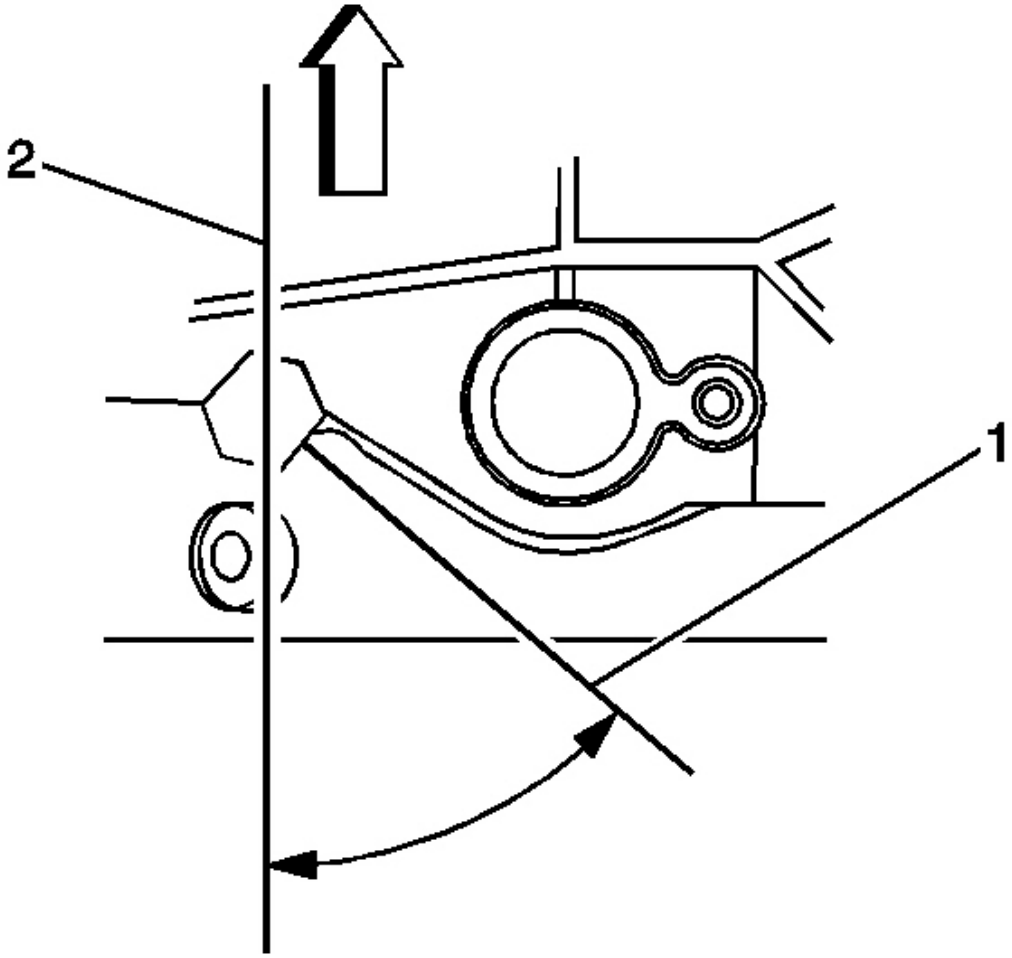


Fig. 292: Fitting Centerline & Crankshaft Centerline
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Tighten the fuel pump/oil pressure sensor fitting.

Tighten:

1. Tighten the fitting to 15 N.m (11 lb ft).
2. Increase torque until the centerline of the fitting (1) is 50 degrees from the centerline

of the crankshaft (2).

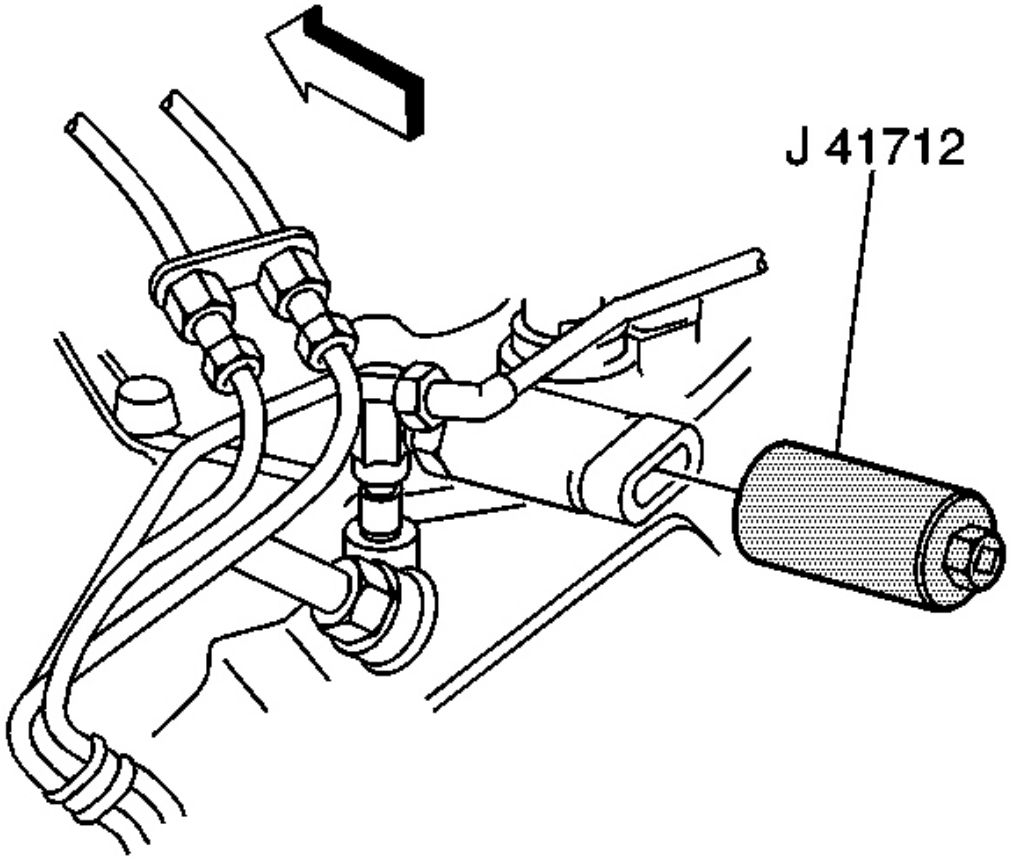


Fig. 293: J 41712
Courtesy of GENERAL MOTORS CORP.

4. If installing the old sensor, apply sealant to the threads of the sensor. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
5. Using **J 41712** , install the sensor. See **Special Tools**.

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

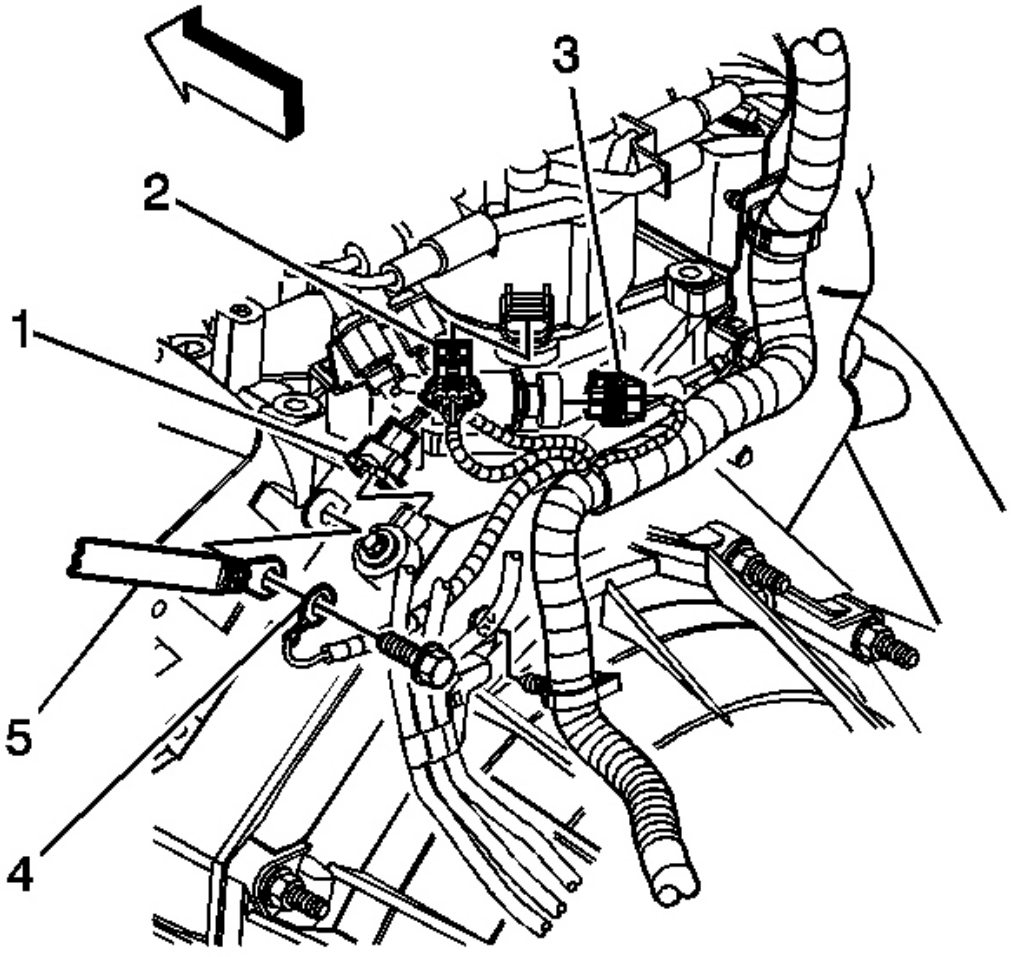


Fig. 294: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

6. Connect the fuel pump/oil pressure sensor electrical connector (3).
7. Check and adjust the engine oil level, if necessary.

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure

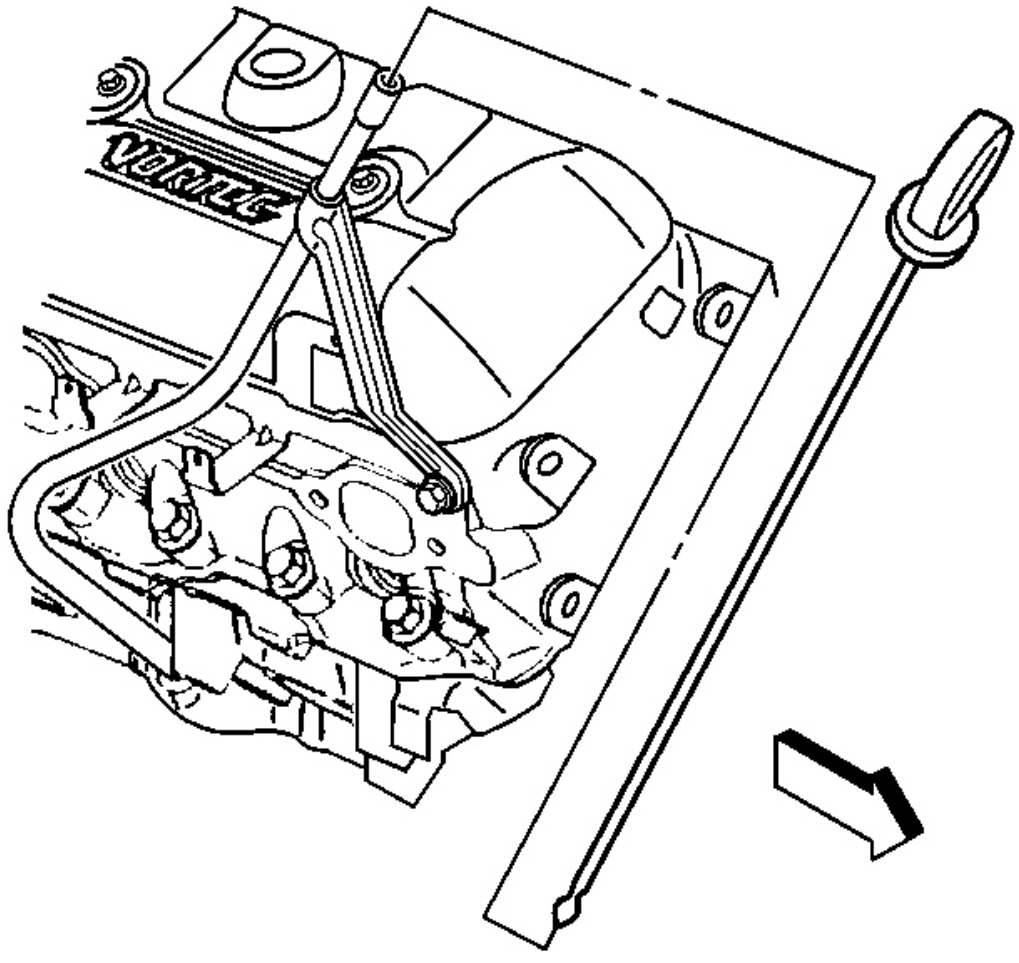


Fig. 295: Locating Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (4.3L)** .

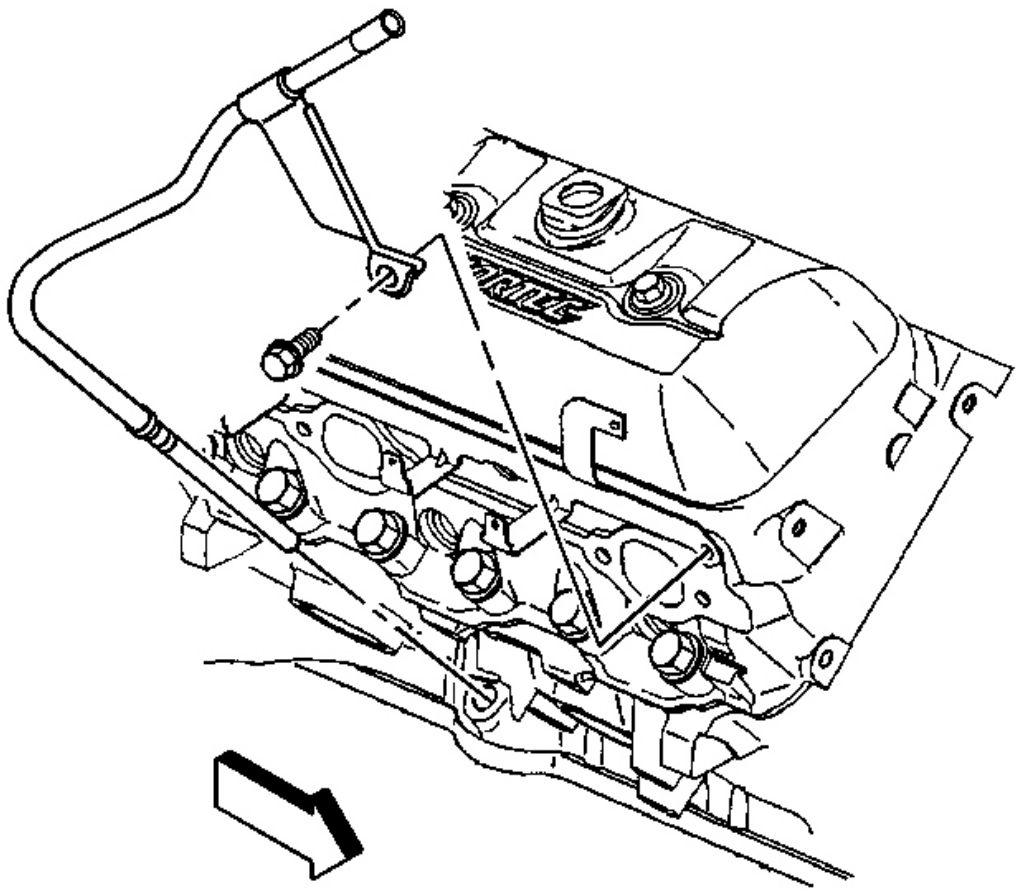


Fig. 296: Locating Oil Level Indicator Tube Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube using a twisting motion.
5. Clean the old sealer from the indicator tube and engine block.

Installation Procedure

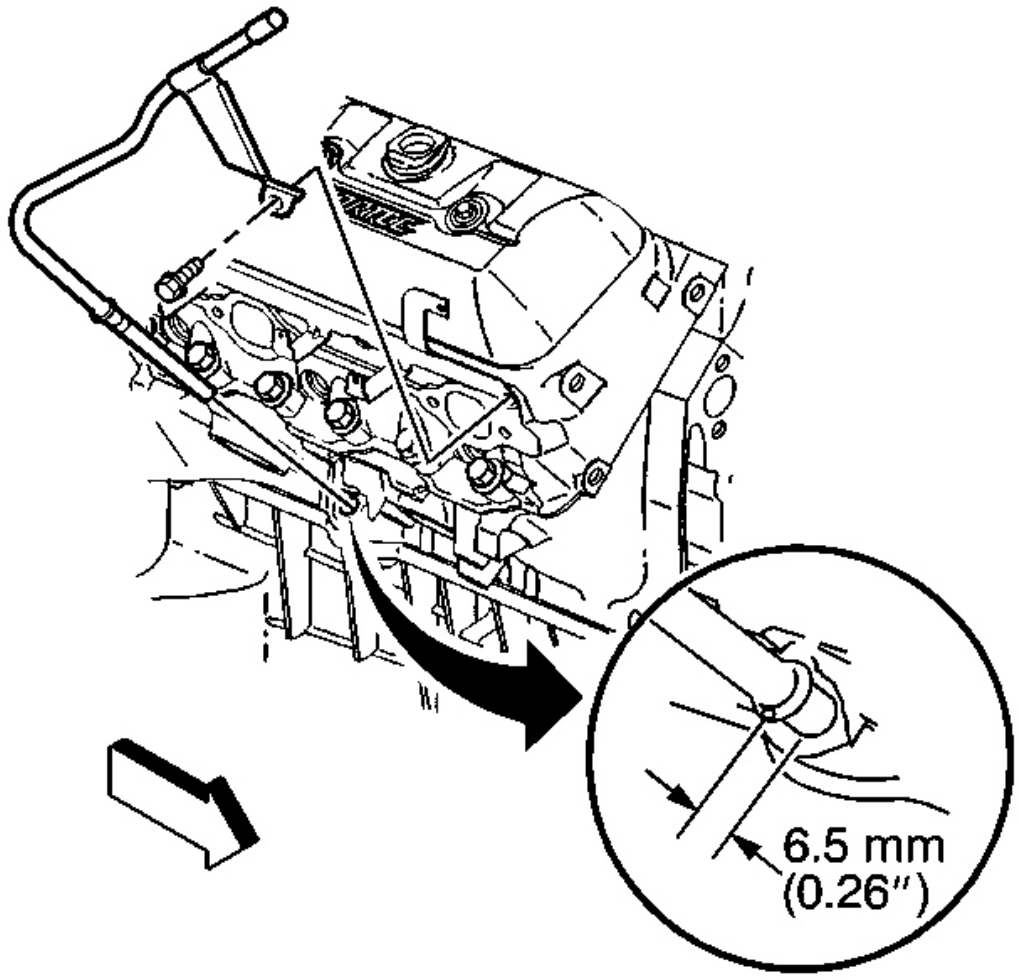


Fig. 297: Oil Level Indicator Tube Sealant
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant around the indicator tube 13 mm (0.5 in) below the tube bead. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install the indicator tube. Rotate the oil level indicator tube into position.

NOTE: Refer to Fastener Notice .

3. Install the indicator tube bolt.

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

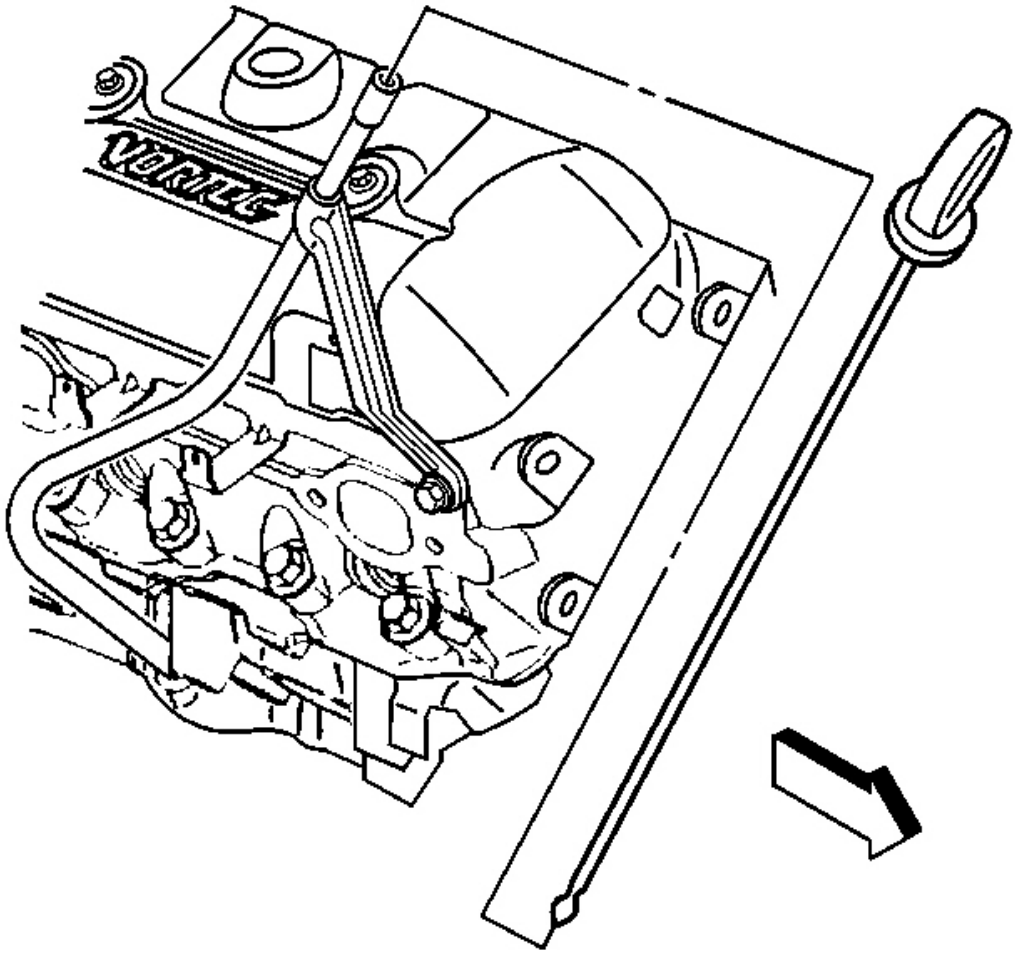


Fig. 298: Locating Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

4. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (4.3L)** .
5. Install the oil level indicator.

OIL PUMP REPLACEMENT

Removal Procedure

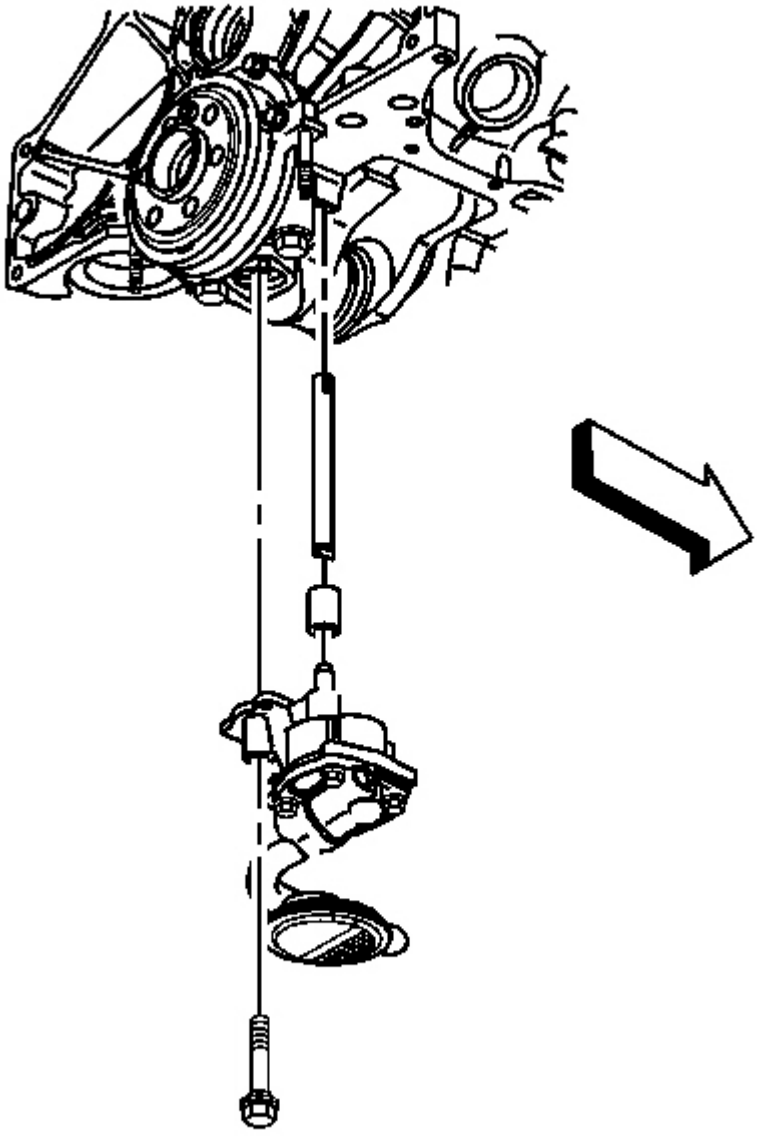


Fig. 299: Oil Pump & Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the oil pump bolt.
3. Remove the oil pump.

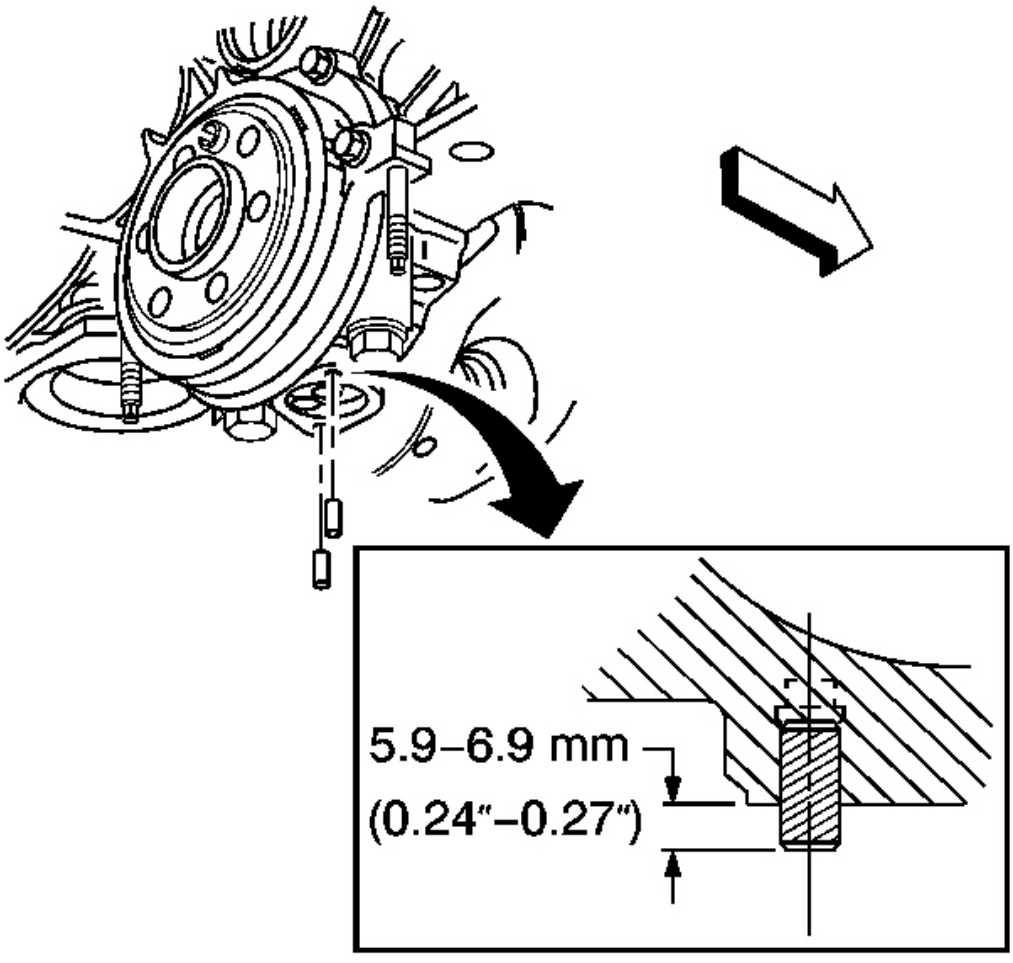


Fig. 300: Oil Pump Locator Pins
Courtesy of GENERAL MOTORS CORP.

4. Inspect the oil pump locator pins for damage, and replace if required.
5. Clean and inspect the oil pump, if necessary.

Installation Procedure

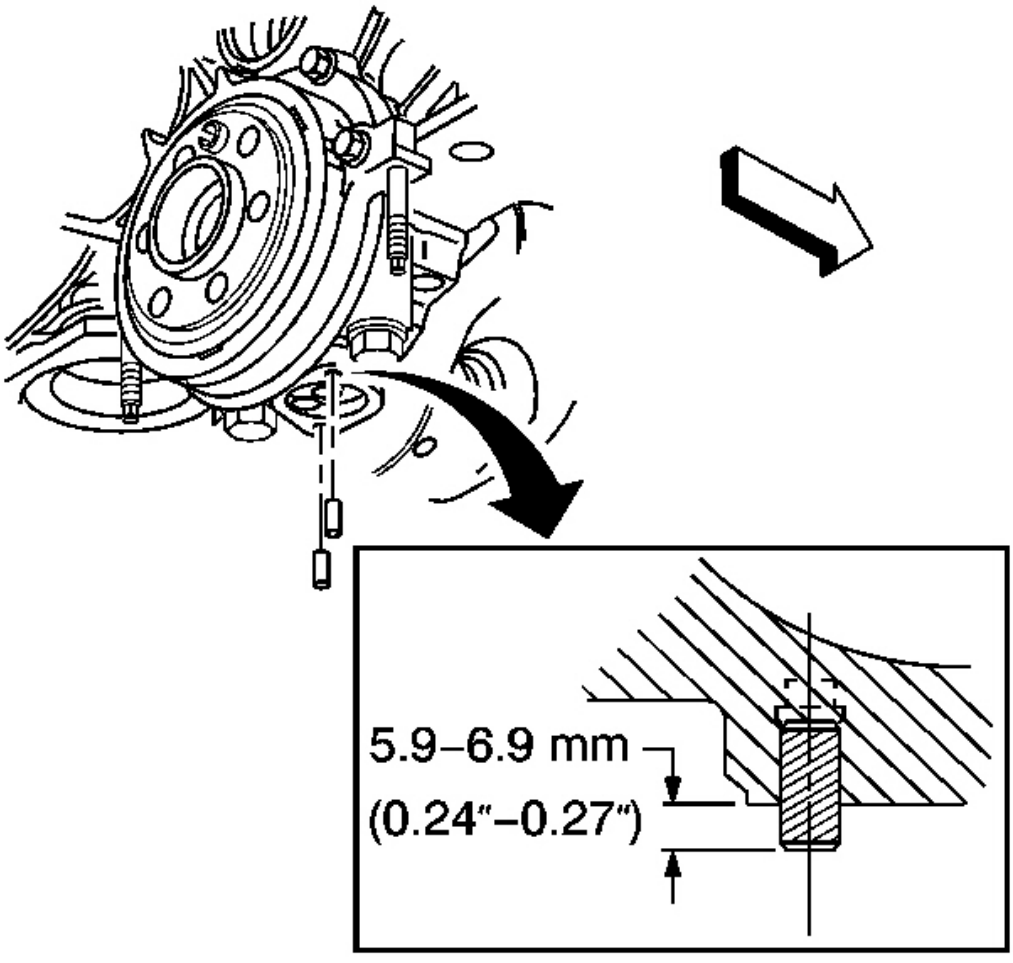


Fig. 301: Oil Pump Locator Pins
Courtesy of GENERAL MOTORS CORP.

1. Inspect for properly installed oil pump locator pins.

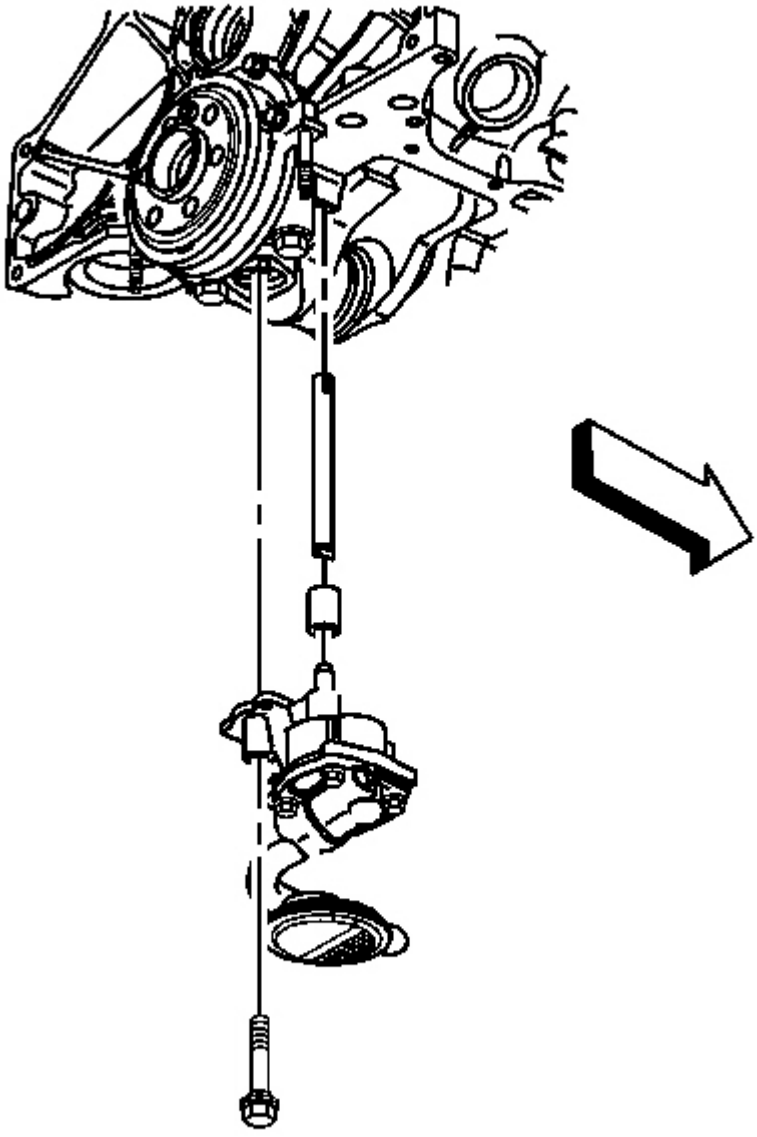


Fig. 302: Oil Pump & Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the oil pump driveshaft retainer. During assembly, install a NEW oil pump driveshaft retainer.

NOTE: Refer to Fastener Notice .

2. Install the oil pump. Position the oil pump onto the locator pins.
3. Install the oil pump bolt.

   Tighten: Tighten the bolt to 90 N.m (66 lb ft).

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

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

J 35621-B Rear Main Seal Installer. See **Special Tools**.

Removal Procedure

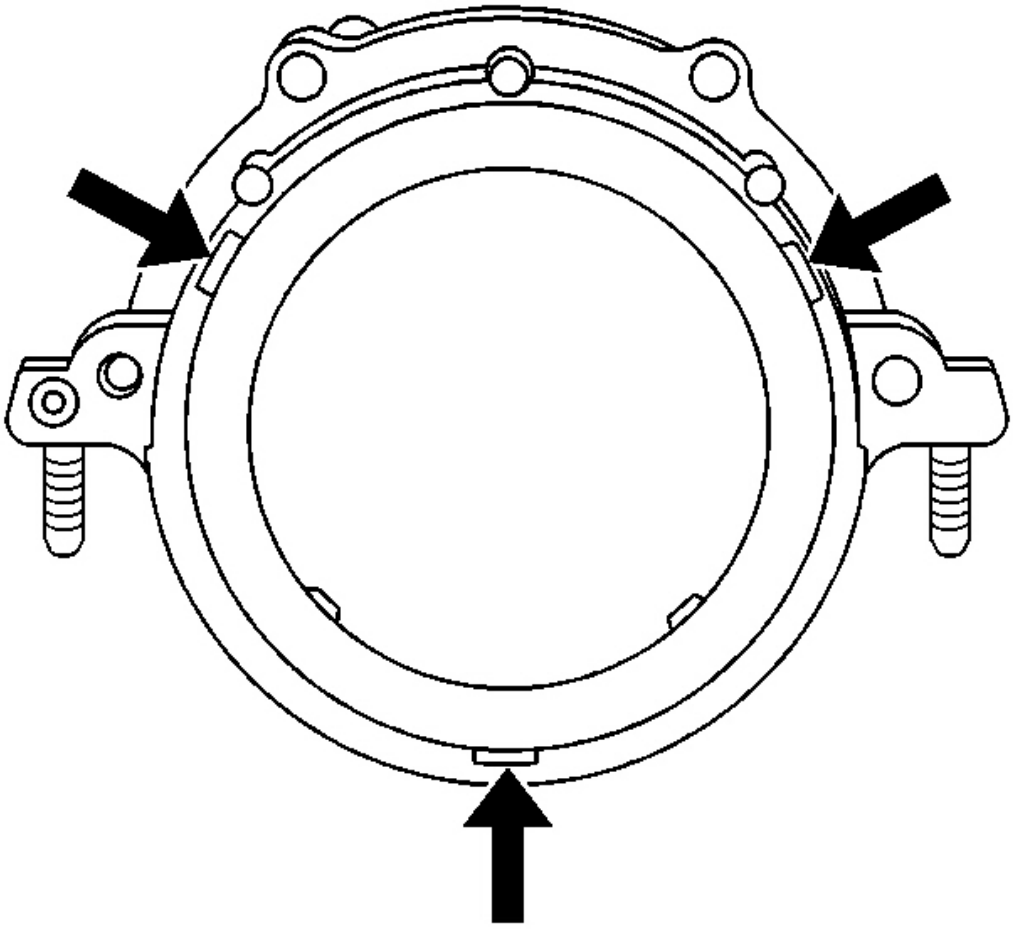


Fig. 303: Crankshaft Rear Oil Seal Notches
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.
2. Insert a flat-tipped screwdriver into the access notches and carefully pry the seal from the housing.
3. Discard the seal.
4. Clean off any dirt or rust in the area.

Installation Procedure

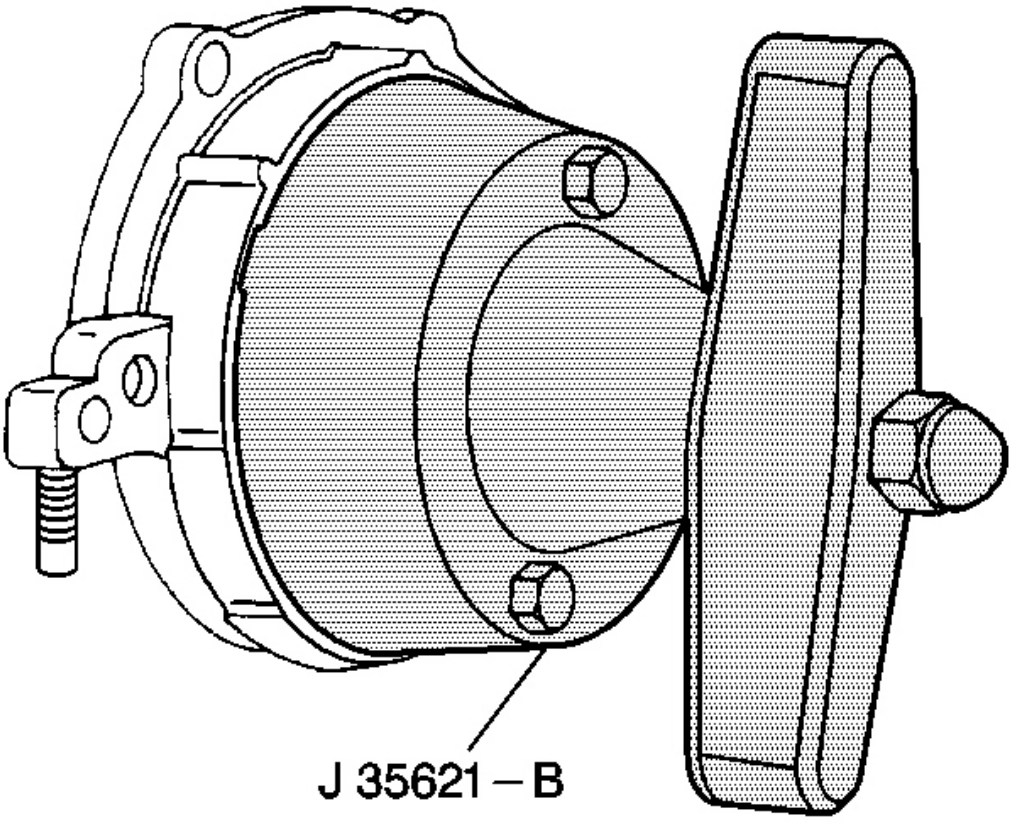


Fig. 304: Installing Crankshaft Rear Oil Seal Using J 35621-B
Courtesy of GENERAL MOTORS CORP.

1. Apply 2 to 3 drops of clean engine oil to the bore of the housing.
2. Apply 2 to 3 drops of clean engine oil to the outside diameter of the engine flywheel pilot flange.
3. Apply 1 drop of clean engine oil to the outside diameter of the flywheel locator pin.
4. Apply 2 to 3 drops of clean engine oil to the crankshaft seal surface.

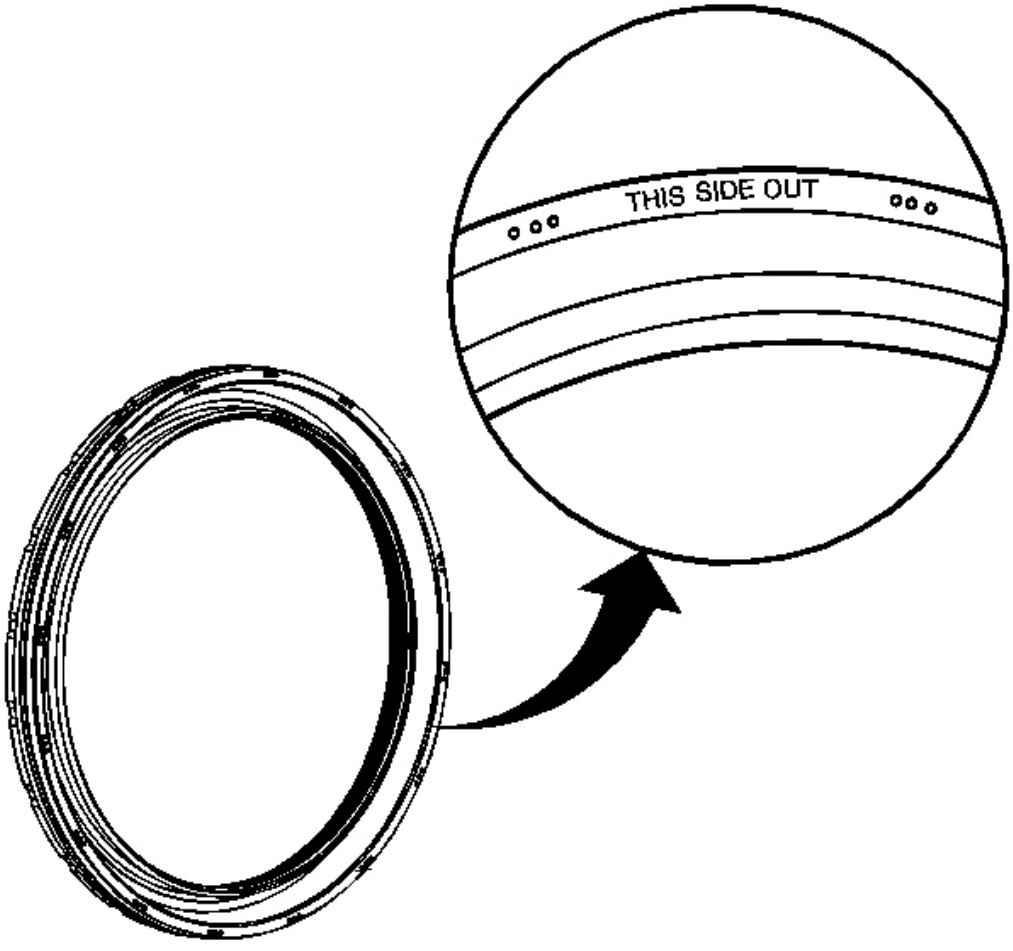


Fig. 305: Identifying Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Notice the direction of the rear oil seal. The new design seal is a reverse style as opposed to what has been used in the past. THIS SIDE OUT has been stamped into the seal as shown in the graphic.

5. Inspect the **J 35621-B** flange for imperfections that may damage the NEW seal. See **Special Tools**.

Minor imperfections may be removed with a fine grade emery cloth.

IMPORTANT: DO NOT allow oil or any other lubricants to contact the seal lip surface of the seal.

6. Remove the sleeve from the seal.
7. Apply 2 to 3 drops of clean engine oil to the outside diameter of the seal.
8. Install the seal onto the **J 35621-B** . See **Special Tools**.
9. Install the **J 35621-B** onto the rear of the crankshaft and hand tighten the tool bolts until snug. See **Special Tools**.

NOTE: Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

10. Install the seal onto the crankshaft and into the housing:
    1. Turn the **J 35621-B** wing nut clockwise until the seal is installed close to flush and square to the housing. See **Special Tools**.

       Increased resistance will be felt when the seal has reached the bottom of the housing bore.

    2. Turn the **J 35621-B** wing nut counterclockwise to release the **J 35621-B** from the seal. See **Special Tools**.
11. Remove the **J 35621-B** . See **Special Tools**.
12. Wipe off any excess engine oil with a clean rag.
13. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

CRANKSHAFT REAR OIL SEAL HOUSING REPLACEMENT

Removal Procedure

IMPORTANT: Do not remove the crankshaft rear oil seal housing if only replacing the crankshaft rear oil seal.

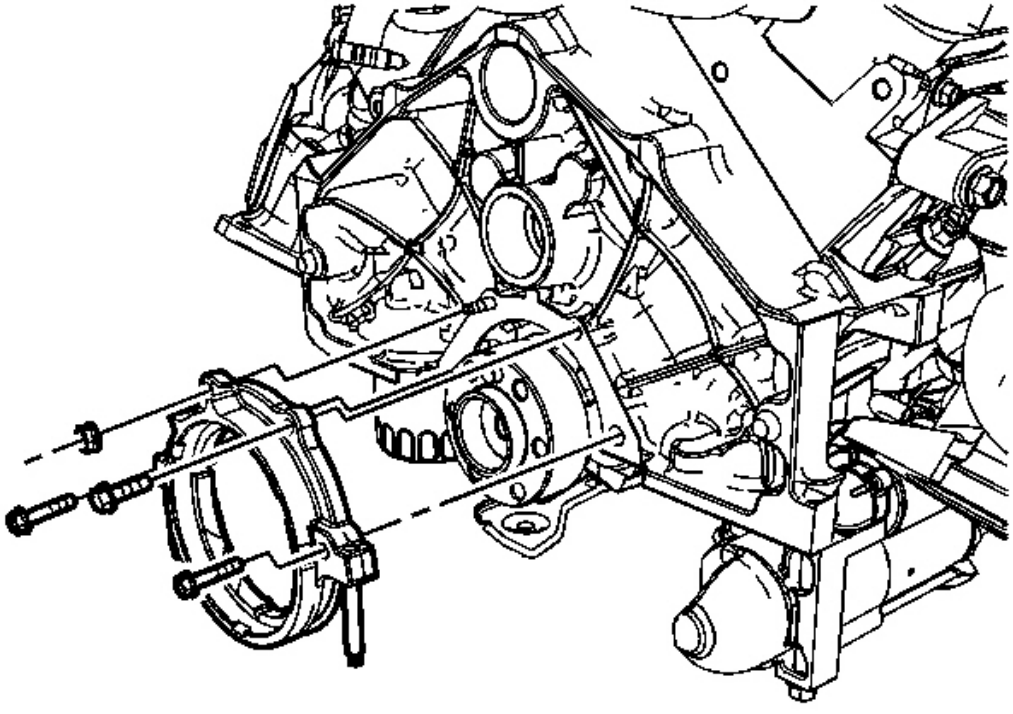


Fig. 306: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
3. Remove the housing bolts and nut.
4. Remove the housing.

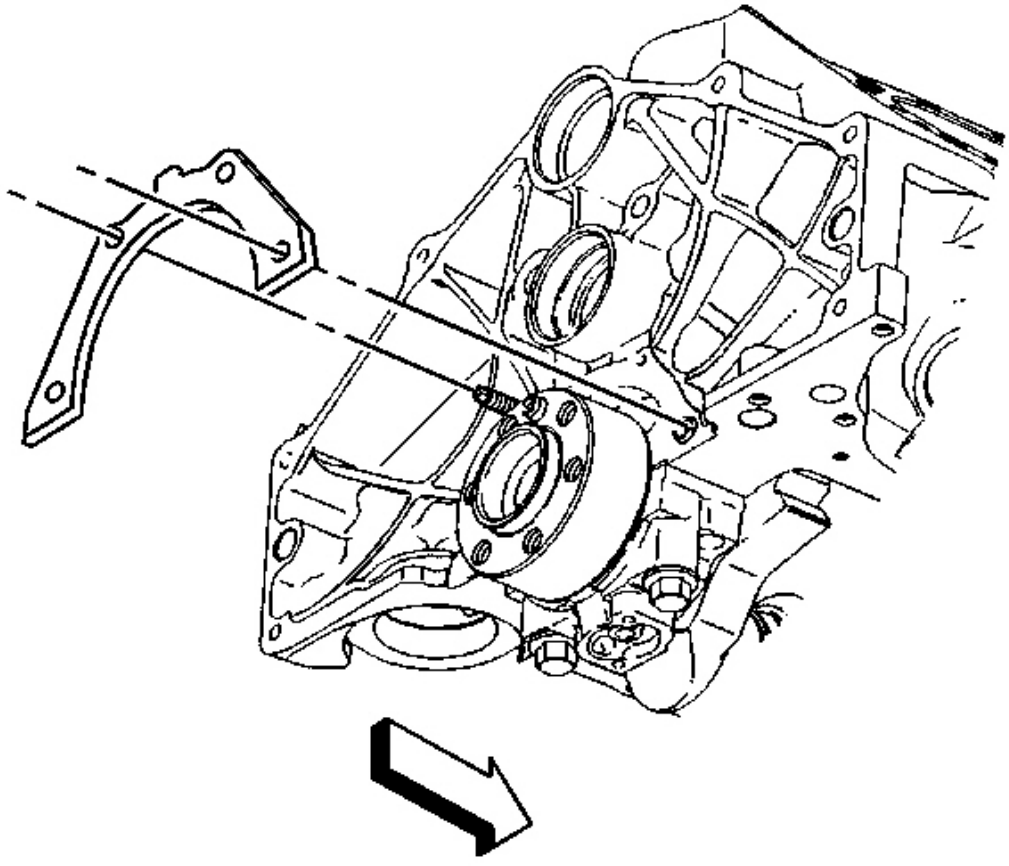


Fig. 307: Locating Crankshaft Rear Oil Seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the housing gasket.
6. Clean all the sealing surfaces.
7. Inspect and replace the housing for warping, cracks, wear, or damage.

Installation Procedure

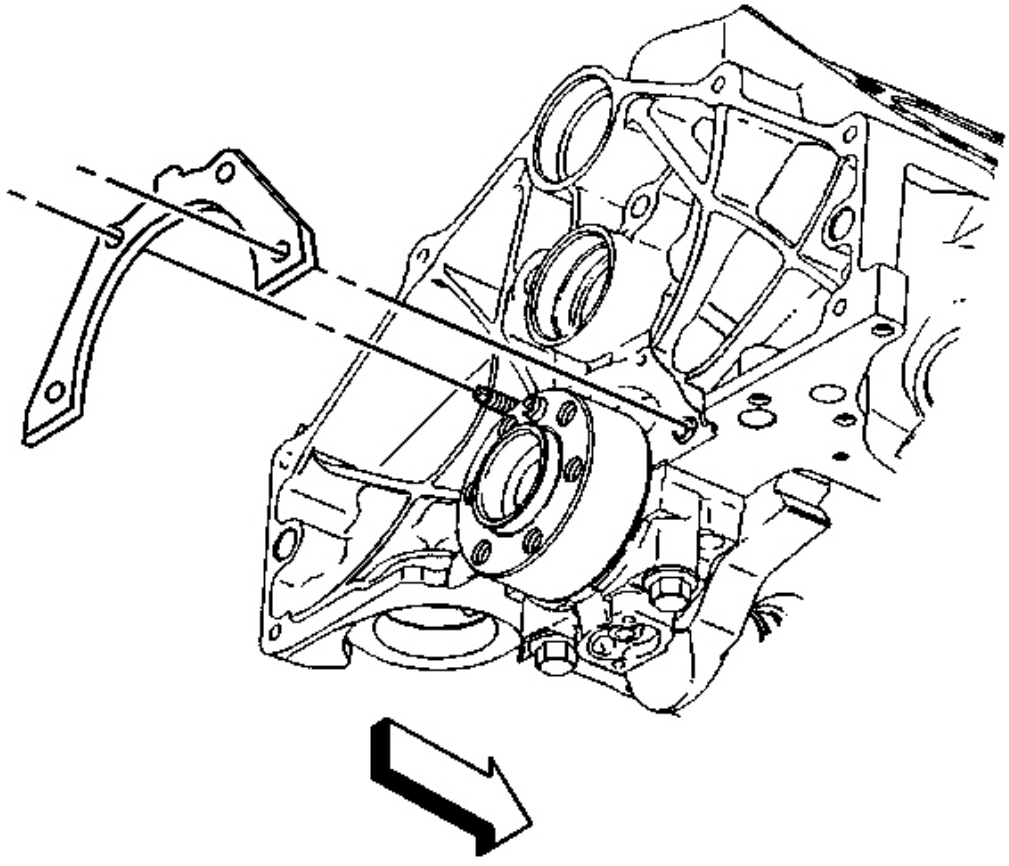


Fig. 308: Locating Crankshaft Rear Oil Seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing a NEW housing the seal will come with the housing. If reusing the housing and then installing a NEW seal follow the instructions for installing the housing and than refer to Crankshaft Rear Oil Seal Replacement to install the seal.

1. Install a NEW housing gasket.

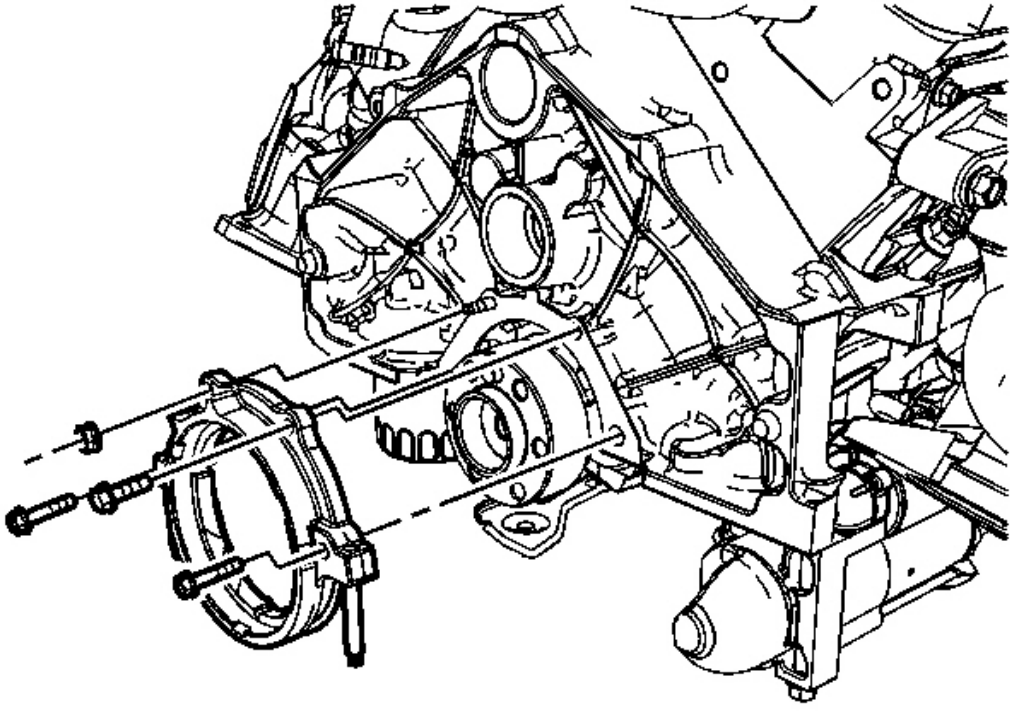


Fig. 309: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW housing with the seal using the following procedure.

IMPORTANT: Do not oil or grease the seal lip or the crankshaft seal area.

1. Leave the sleeve in the seal and use the sleeve as a guide to ease installing the seal lip over the end of the crankshaft.
2. Push the housing fully onto the crankshaft until the housing is against the seal gasket and the engine.
3. Remove the sleeve.

NOTE: Refer to Fastener Notice .

3. Install the crankshaft rear oil seal housing bolts and nut.

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

4. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.
5. Install the oil pan. Refer to **Oil Pan Replacement**.

ENGINE FLYWHEEL REPLACEMENT

Removal Procedure

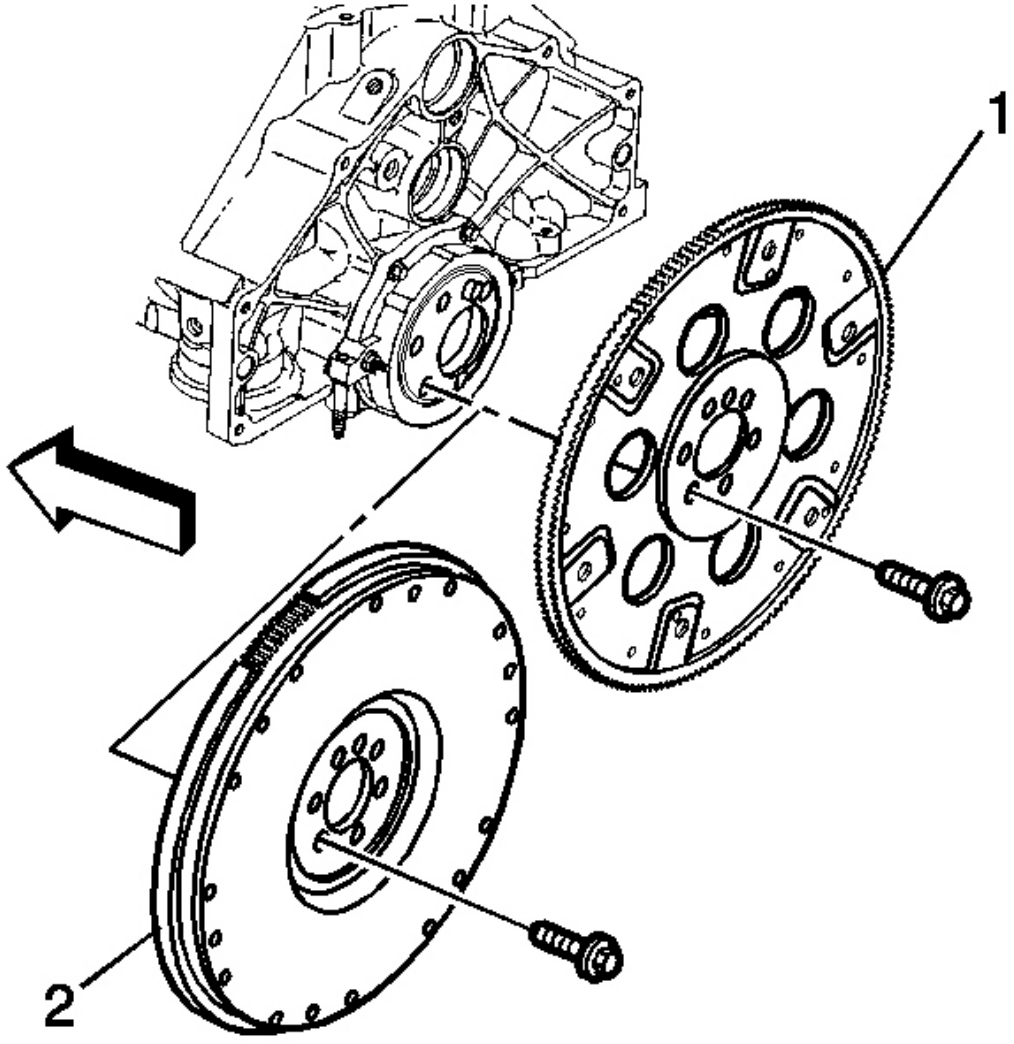


Fig. 310: View Of Flywheels

Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transmission. Refer to **Transmission Replacement** .
2. Remove the flywheel bolts.
3. Remove the flywheel (1 or 2).
4. Clean and inspect the flywheel, if necessary. Refer to **Engine Flywheel Cleaning and Inspection**.

Installation Procedure

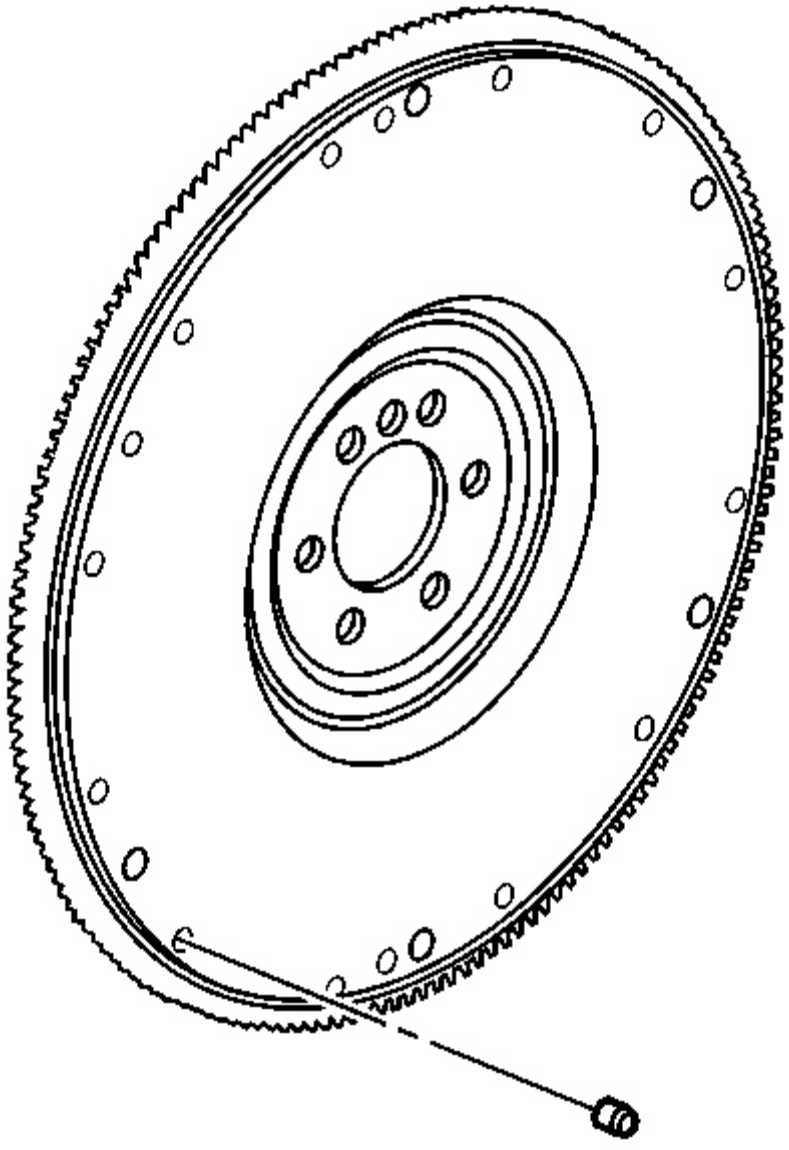


Fig. 311: Locating Flywheel Weights
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Flywheel weights of the same length must be installed into the NEW flywheel in the same location as the old weights were in the old flywheel.

1. Note the position of the old flywheel weights and install the NEW flywheel weights as required.

   A properly installed flywheel weight will be flush or slightly below flush with the face of the flywheel.

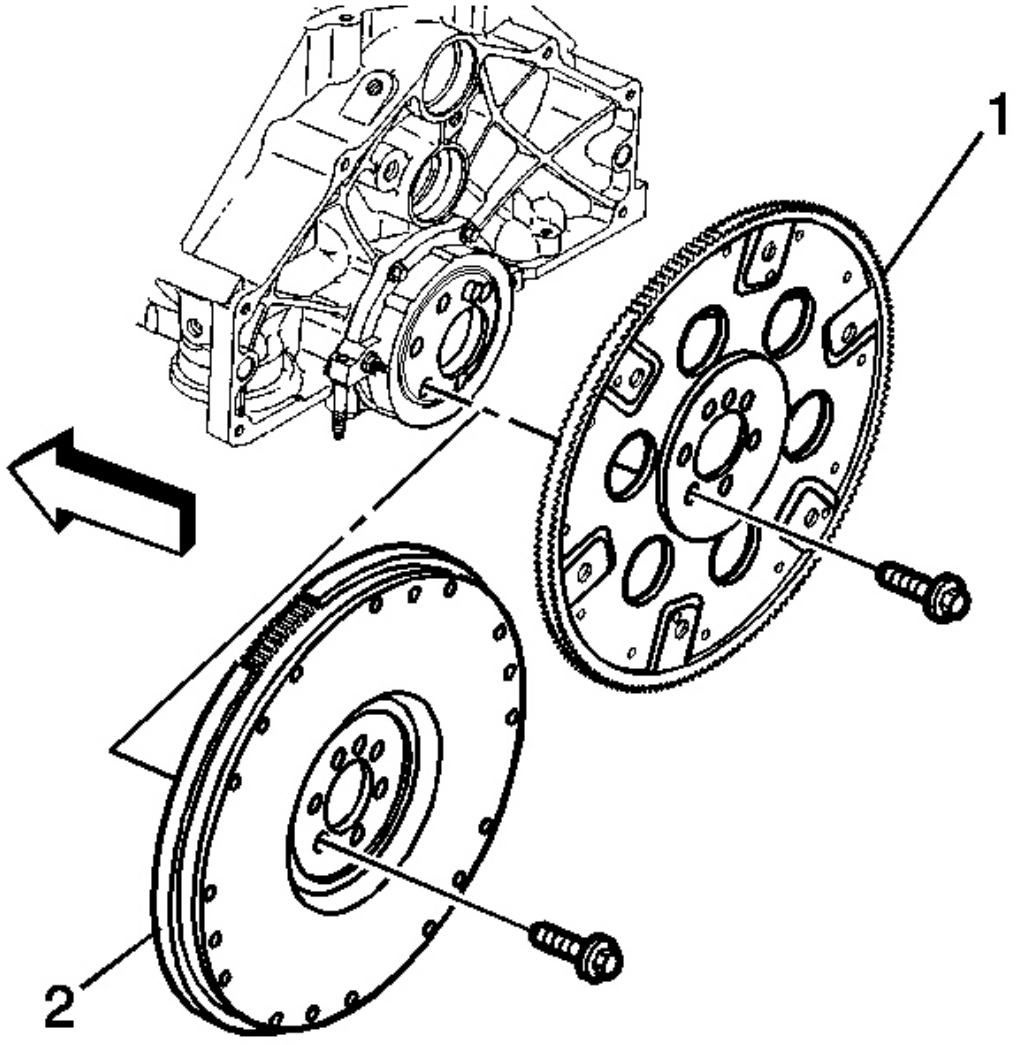


Fig. 312: View Of Flywheels
Courtesy of GENERAL MOTORS CORP.

2. Install the flywheel (1 or 2).

   Align the flywheel locator hole to the flywheel locator pin.

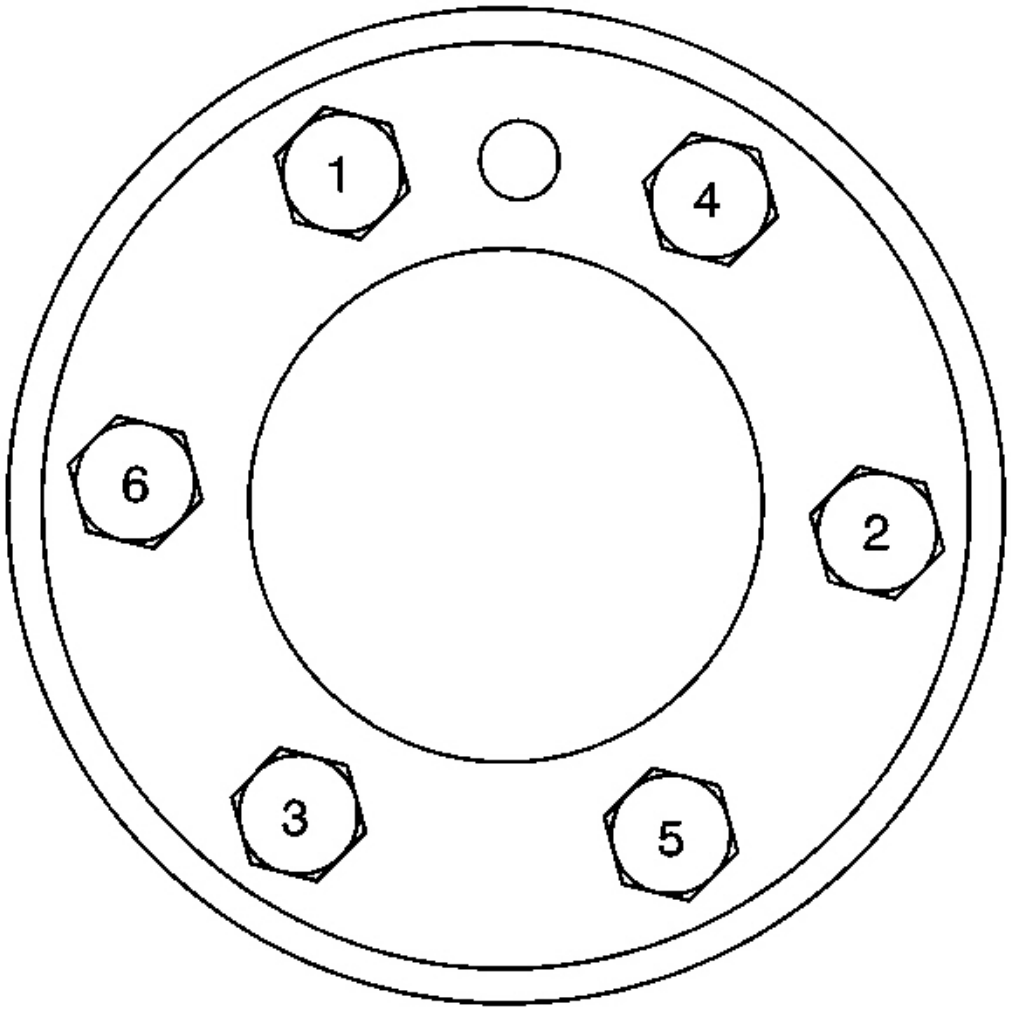


Fig. 313: Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the flywheel bolts.

Tighten: Tighten the bolts in the sequence shown to 100 N.m (74 lb ft).

4. Install the automatic transmission. Refer to **Transmission Replacement** .

ENGINE REPLACEMENT

Tools Required

J 41427 Engine Lift Brackets

Removal Procedure

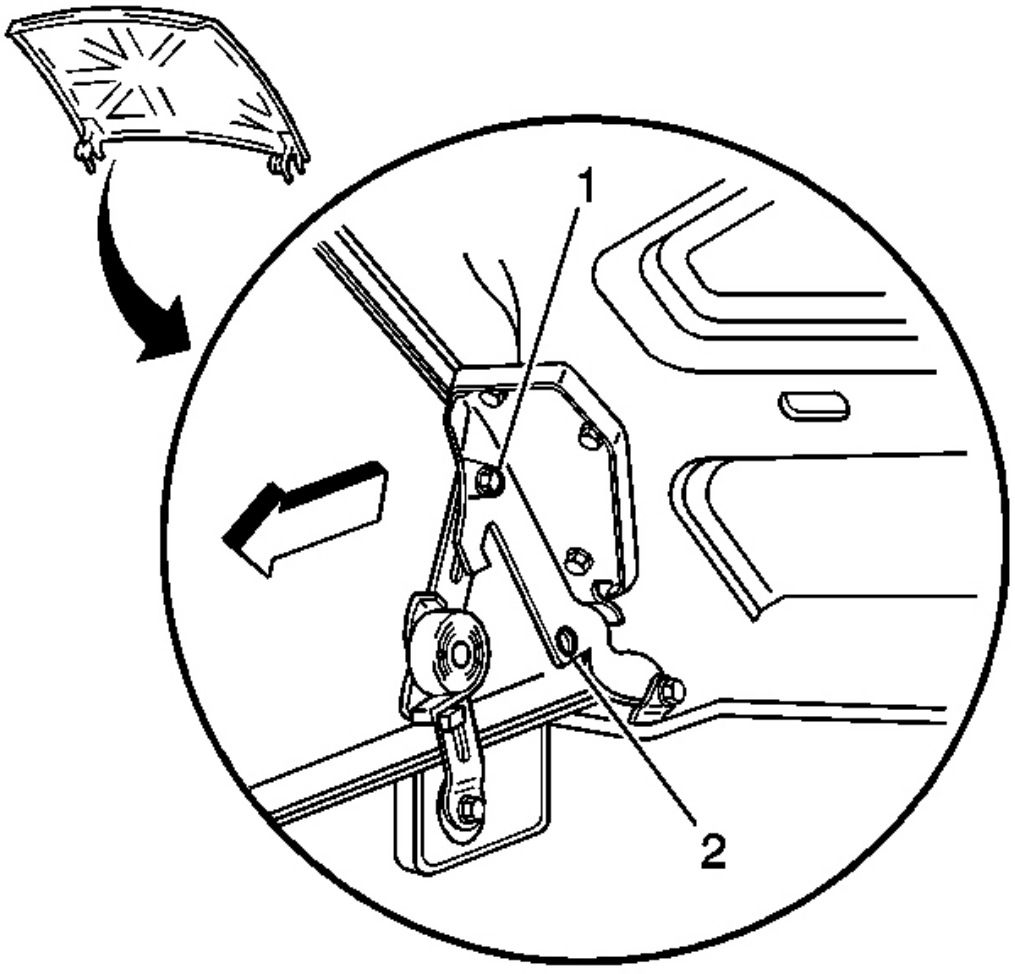


Fig. 314: Identifying Hood Hinge Normal And Service Position Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Raise the hood to the service position, perform the following:
    1. Remove the hood hinge bolts (1).
    2. Raise the hood until vertical.
    3. Install the hood hinge bolts until snug in the service position (2).
2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (w/Single Battery)** or **Battery Negative Cable Disconnection and Connection (w/Auxiliary Battery)** or **Battery Negative Cable Disconnection and Connection (w/Dual Batteries)** .
3. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or **Cooling System Draining and Filling (Static Fill)** .
4. Remove the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
5. Remove the lower fan shroud. Refer to **Engine Coolant Fan Lower Shroud Replacement (Mechanical)** .
6. Remove the drive belt. Refer to **Drive Belt Replacement**.
7. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

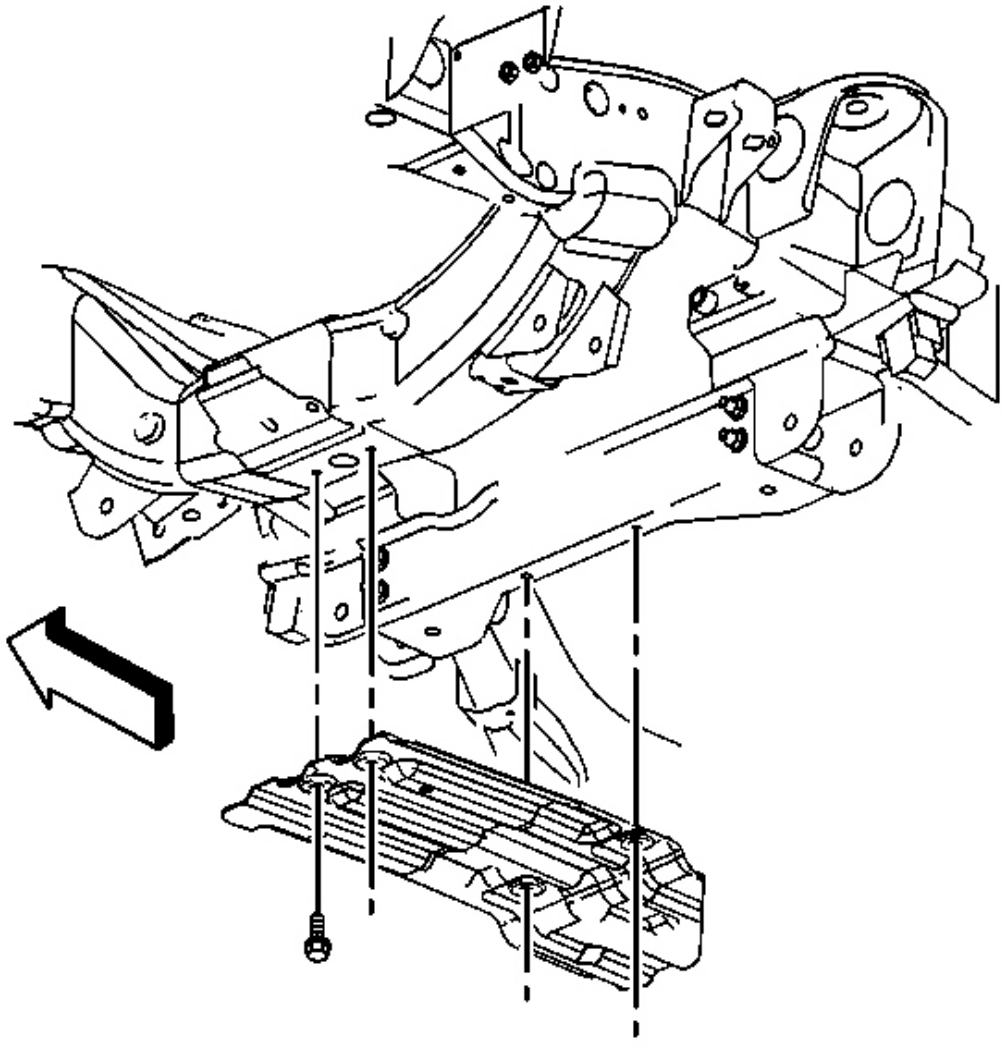


Fig. 315: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

8. If equipped, remove the oil pan skid plate bolts and plate.
9. If equipped, remove the engine shield. Refer to **Engine Shield Replacement** .
10. Remove the starter. Refer to **Starter Motor Replacement (4.3L)** .

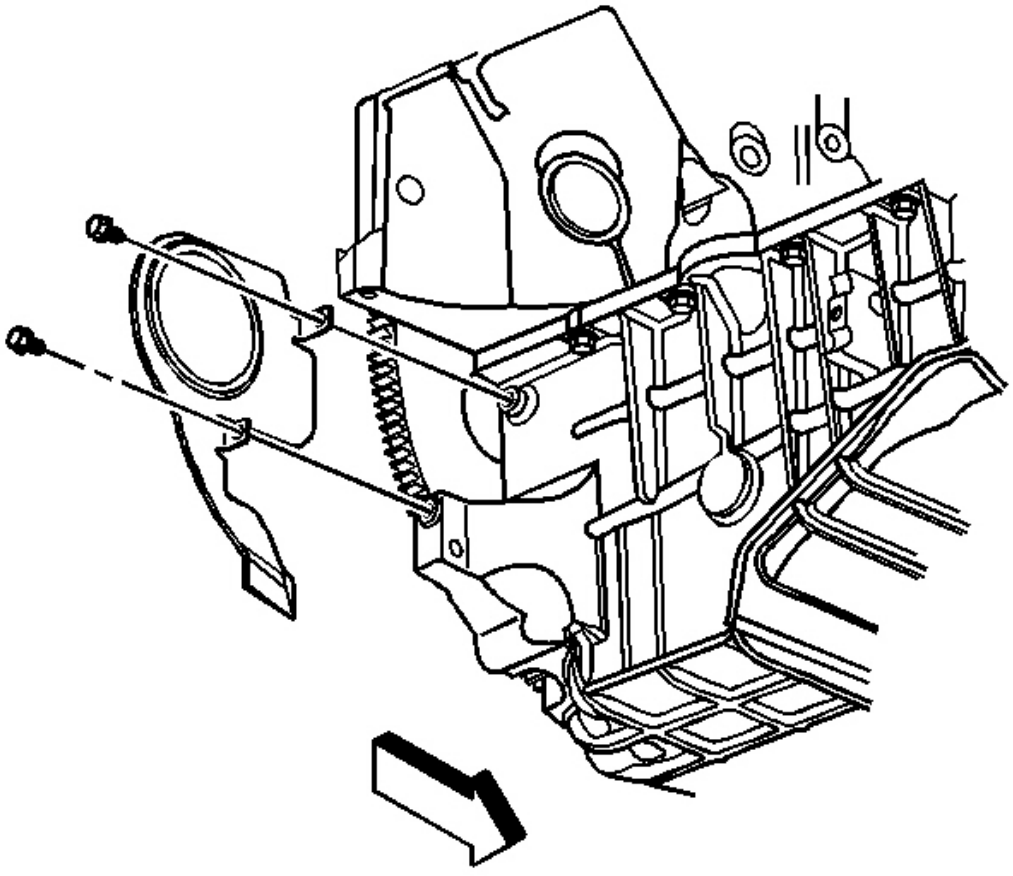


Fig. 316: Transmission Cover
Courtesy of GENERAL MOTORS CORP.

11. Remove the transmission cover.

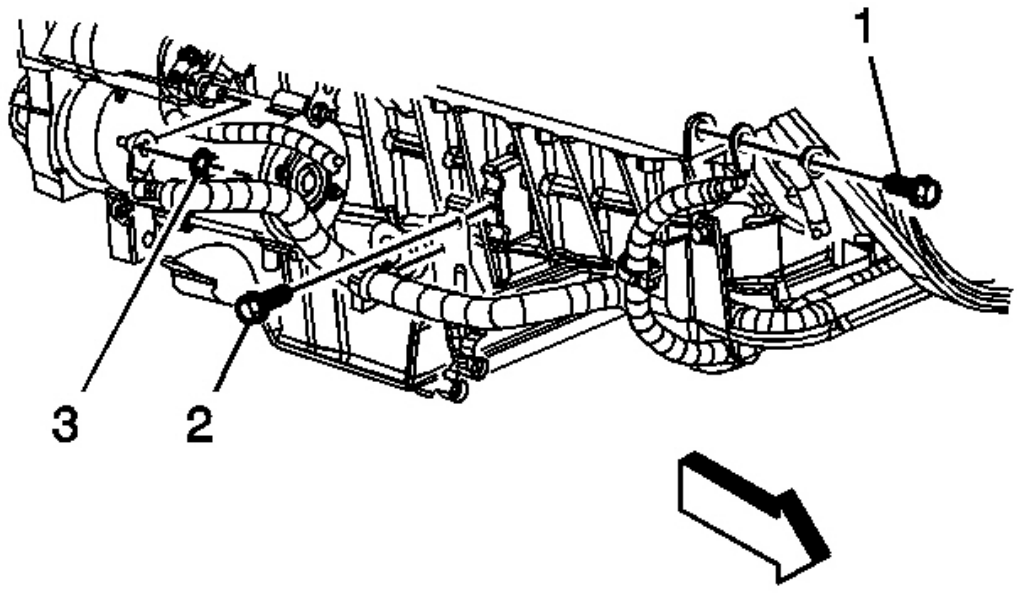


Fig. 317: Positive Battery Cable Clip Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the positive battery cable clip bolt (2).
13. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (4.3L)** .

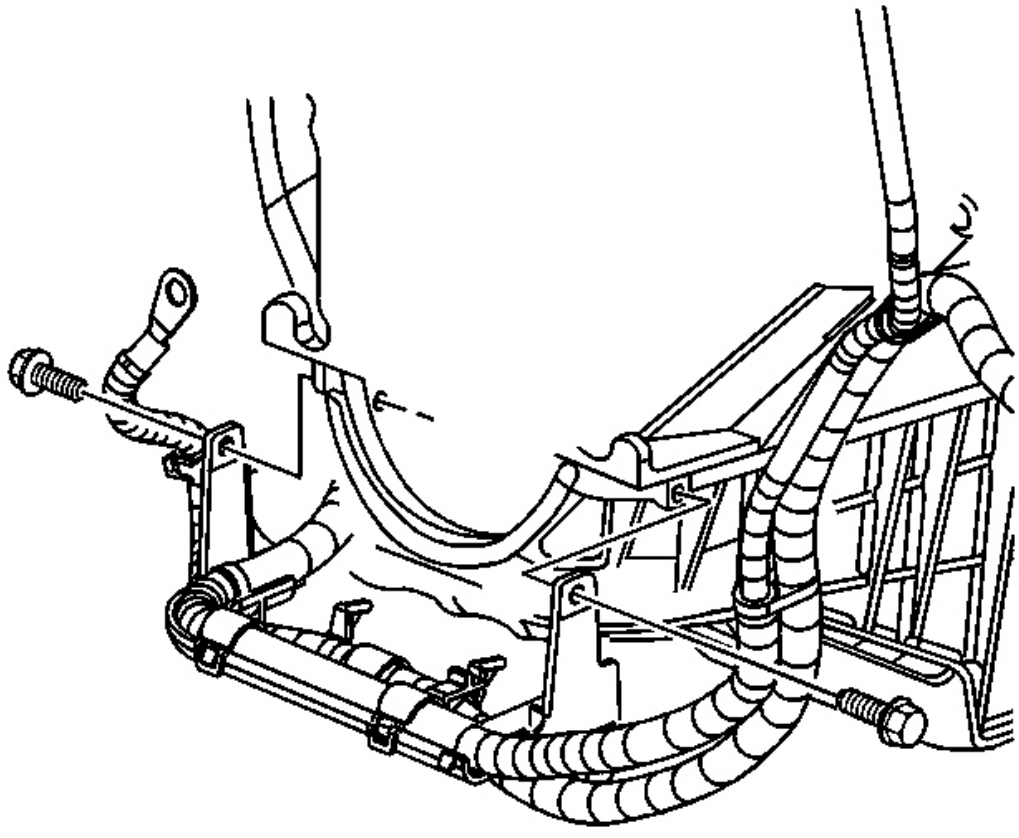


Fig. 318: View Of Battery Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the battery cable bracket bolts.

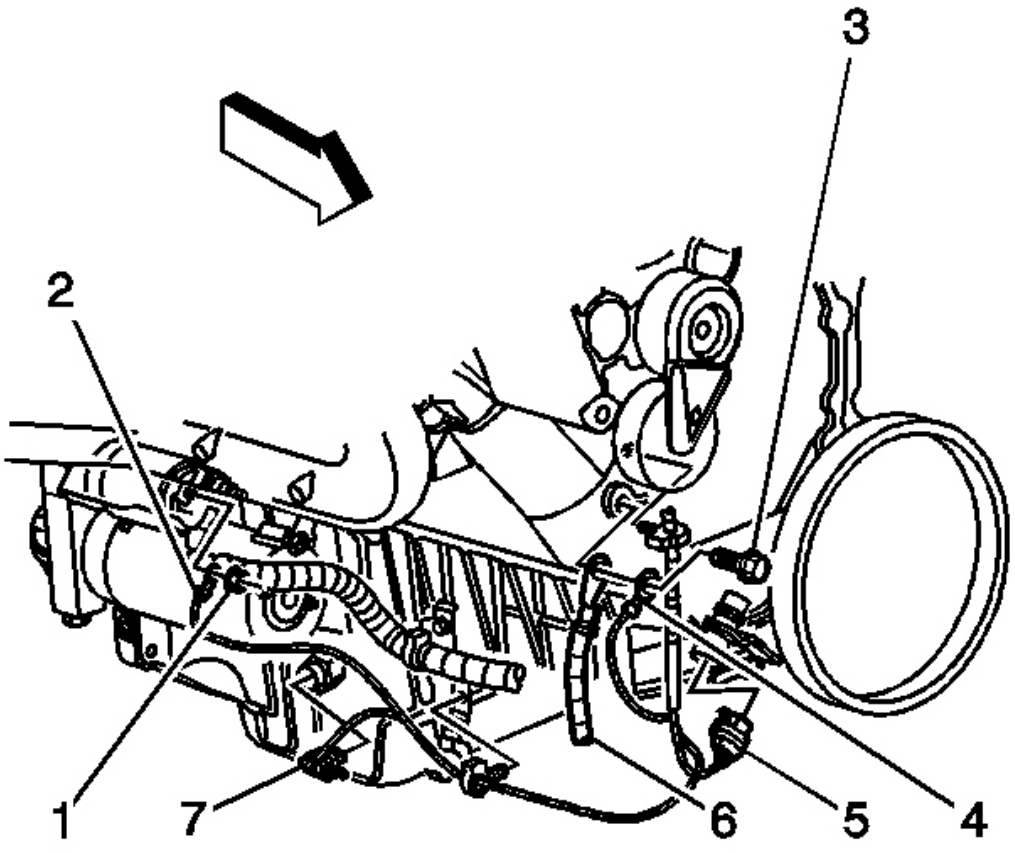


Fig. 319: View Of Oil Level Sensor Electrical Connector, CKP Electrical Connector & Battery Ground Bolt
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the crankshaft position (CKP) sensor electrical connector (5) and remove the harness from the retainer clip.
16. Remove the ground bolt (3) holding the negative battery cable (6) and ground cable (4) to the engine.

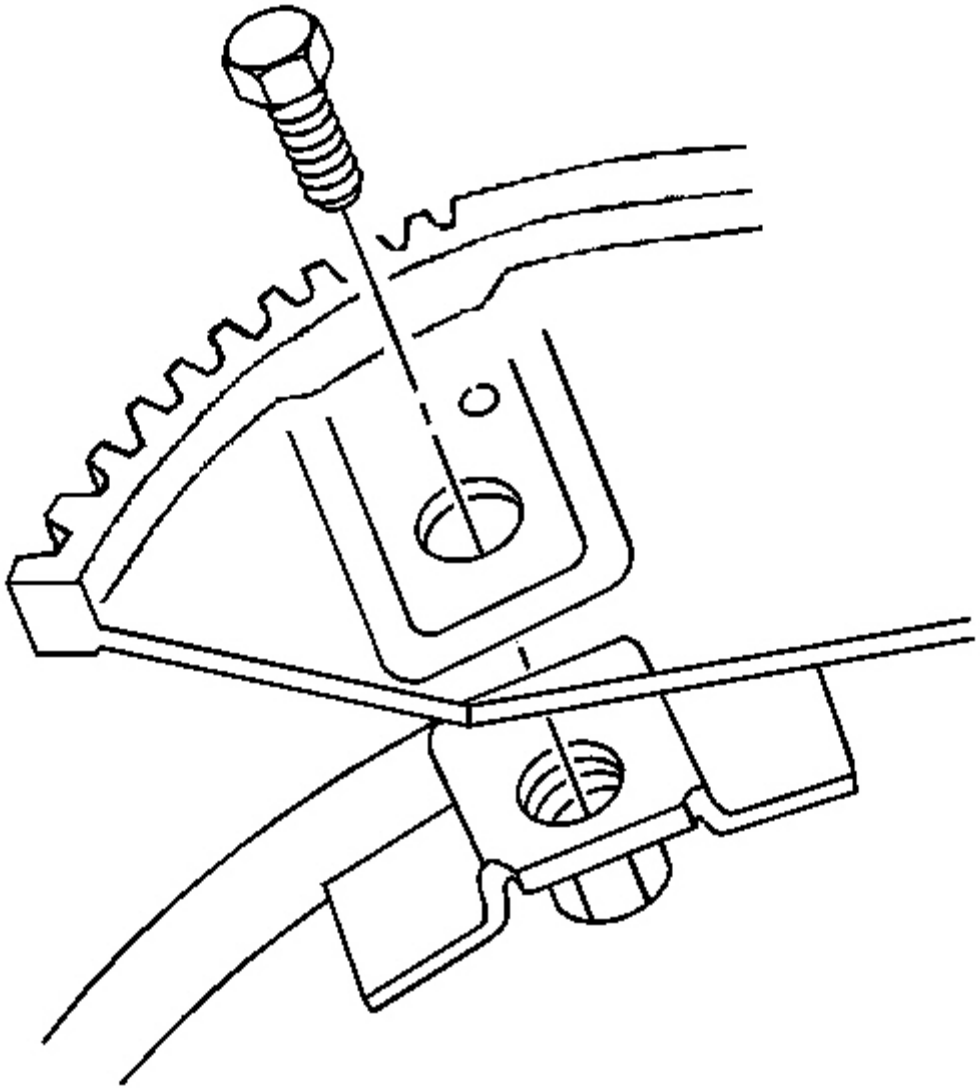


Fig. 320: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

17. If equipped, remove the torque converter bolts.
18. Remove the transmission bolts.
19. Lower the vehicle.

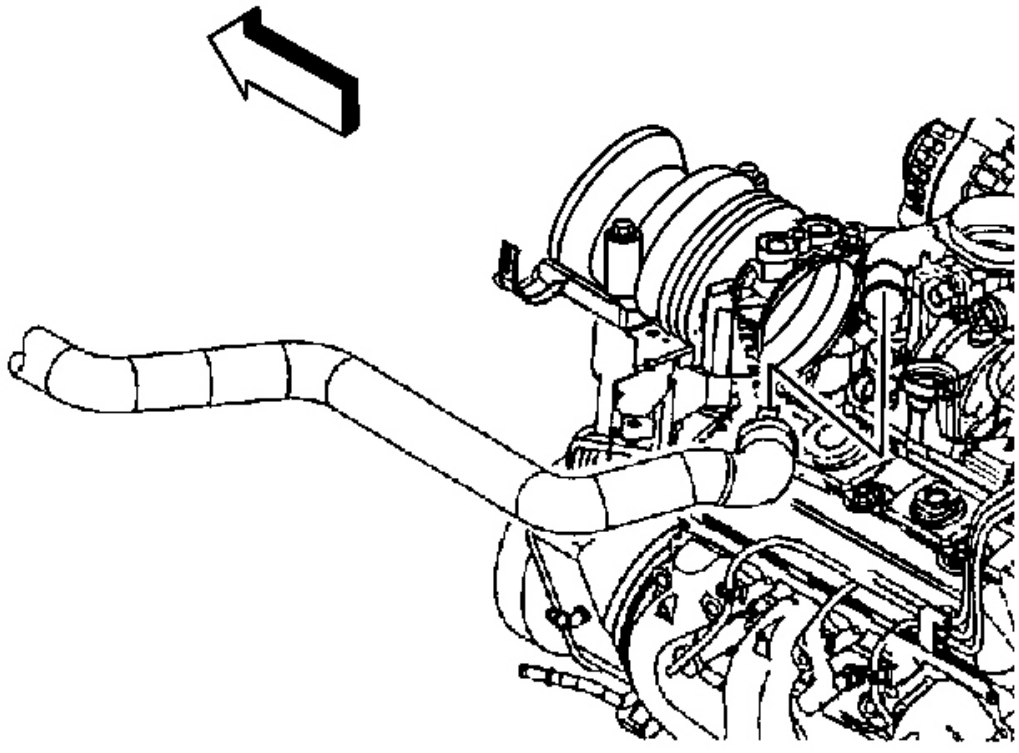


Fig. 321: View Of Radiator Inlet Hose, Clamps & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

20. Reposition the radiator inlet hose clamp.
21. Remove the radiator inlet hose from the thermostat housing.

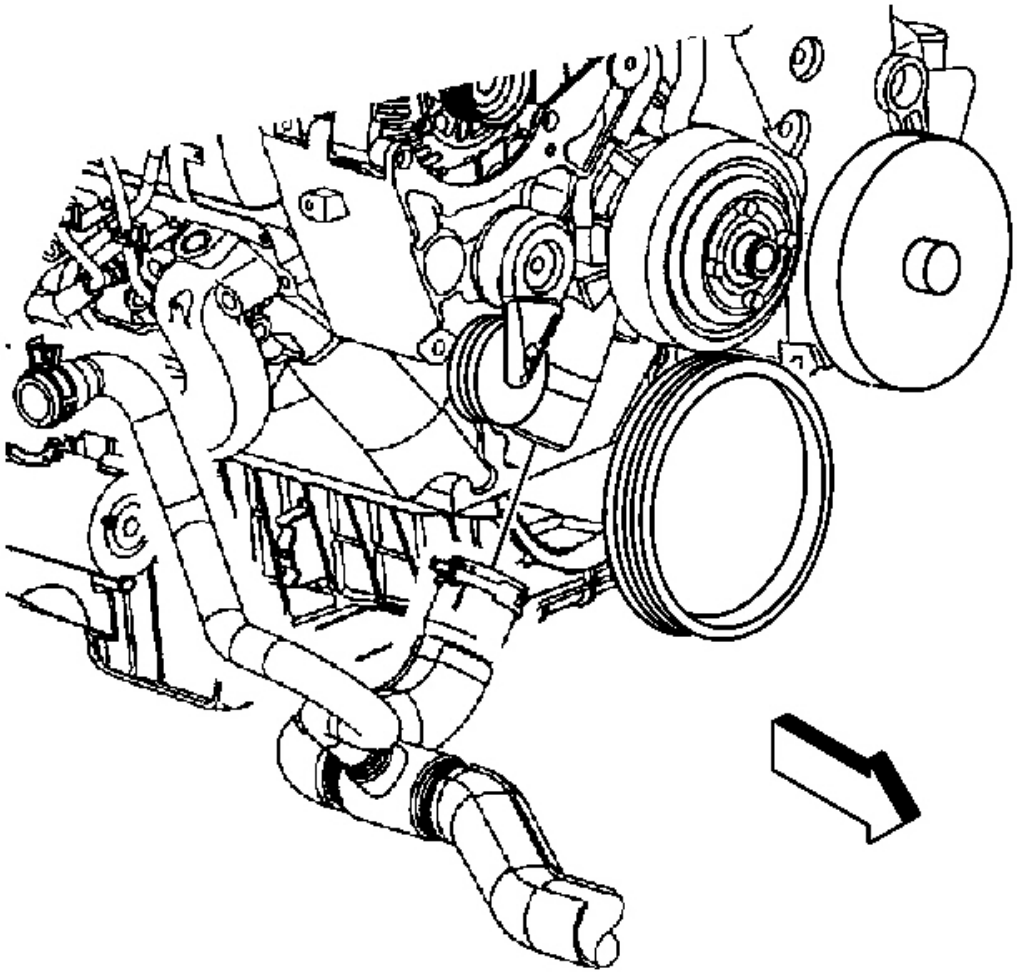


Fig. 322: View Of Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

22. Reposition the radiator outlet hose clamps.
23. Remove the radiator outlet hose from the surge tank.
24. Remove the radiator outlet hose from the water pump.

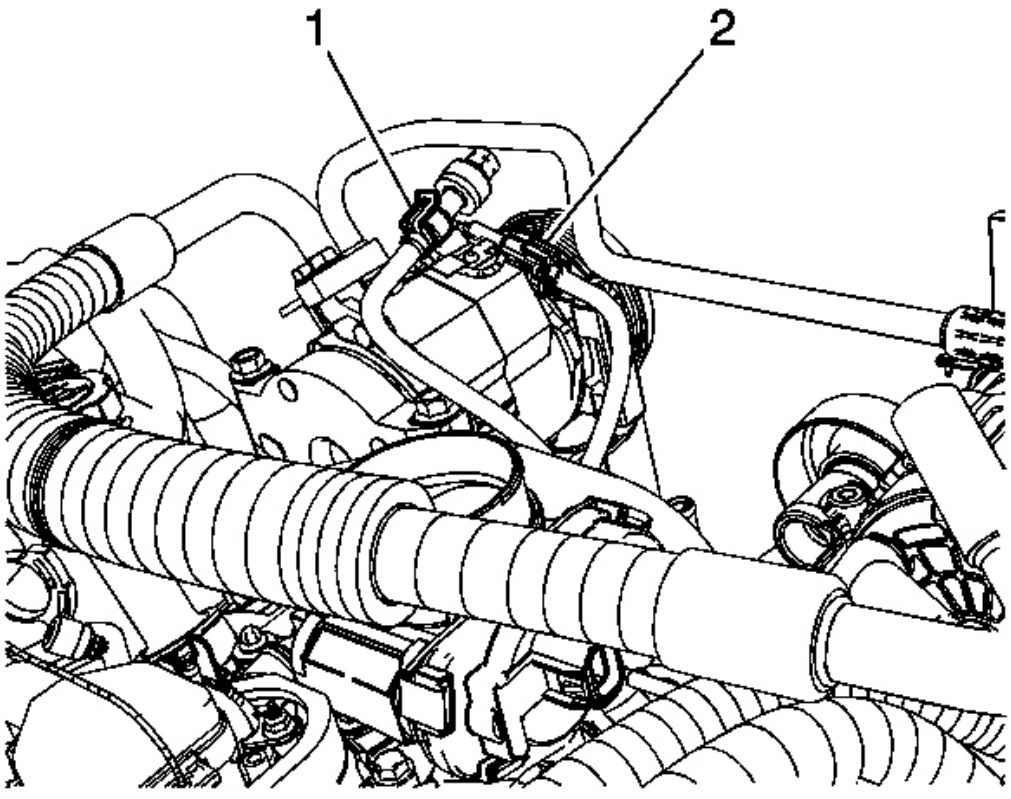


Fig. 323: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

25. Disconnect the following electrical connectors:
    - The A/C pressure switch (1), if equipped
    - The air conditioning (A/C) compressor clutch (2), if equipped
26. If equipped, remove the air conditioning (A/C) hoses.
27. Remove the positive cable nut and cable from the generator.

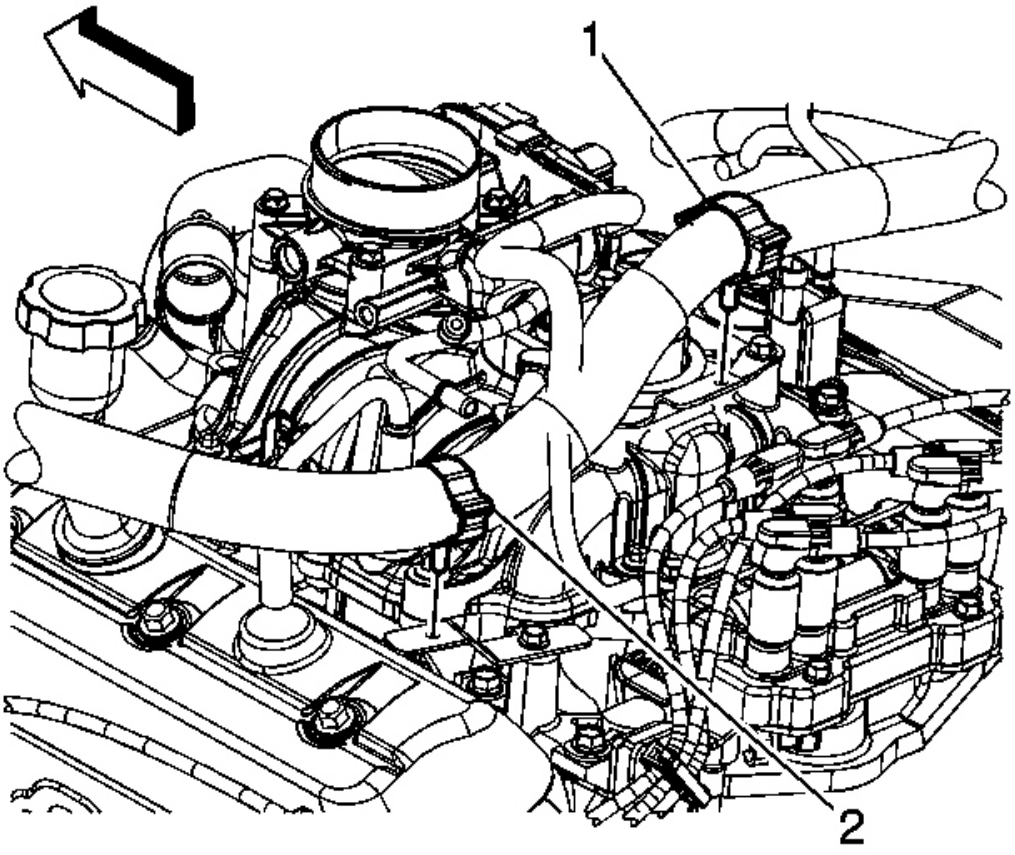


Fig. 324: View Of Engine Wiring Harness Clips
Courtesy of GENERAL MOTORS CORP.

28. Remove the engine wiring harness clips (1, 2) from the engine harness brackets.

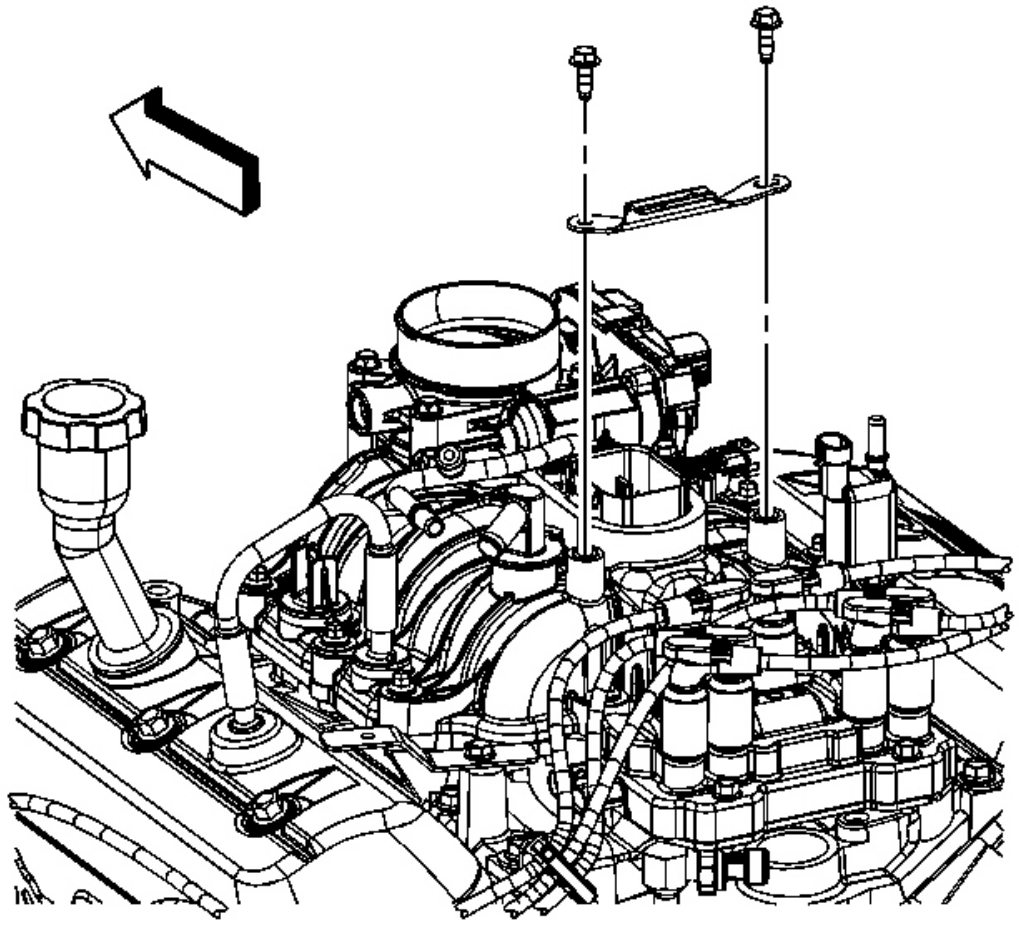


Fig. 325: View Of Engine Wiring Harness Rear Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

29. Remove the engine wiring harness rear bracket bolts and bracket.

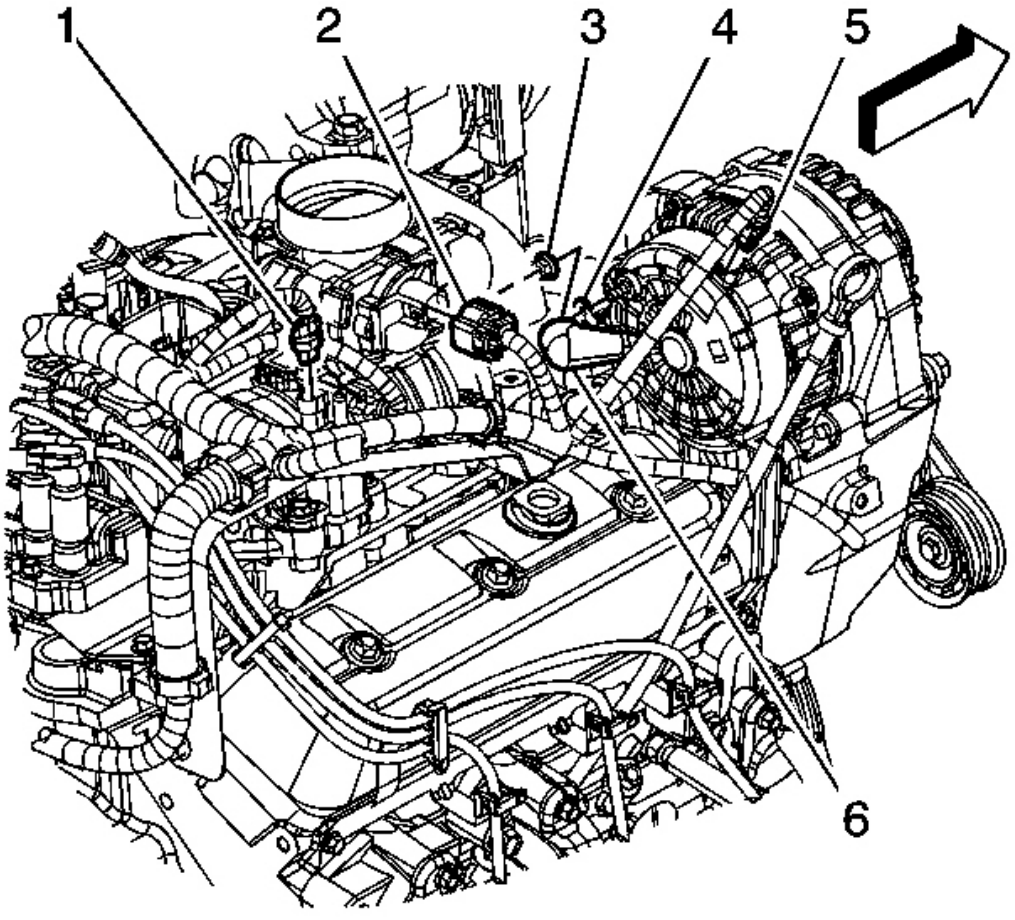


Fig. 326: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

30. Disconnect the following electrical connectors:
    - Evaporative emission (EVAP) canister purge solenoid valve (1)
    - Manifold absolute pressure (MAP) sensor
31. Disconnect the engine wiring harness electrical connector (2) from the throttle body.

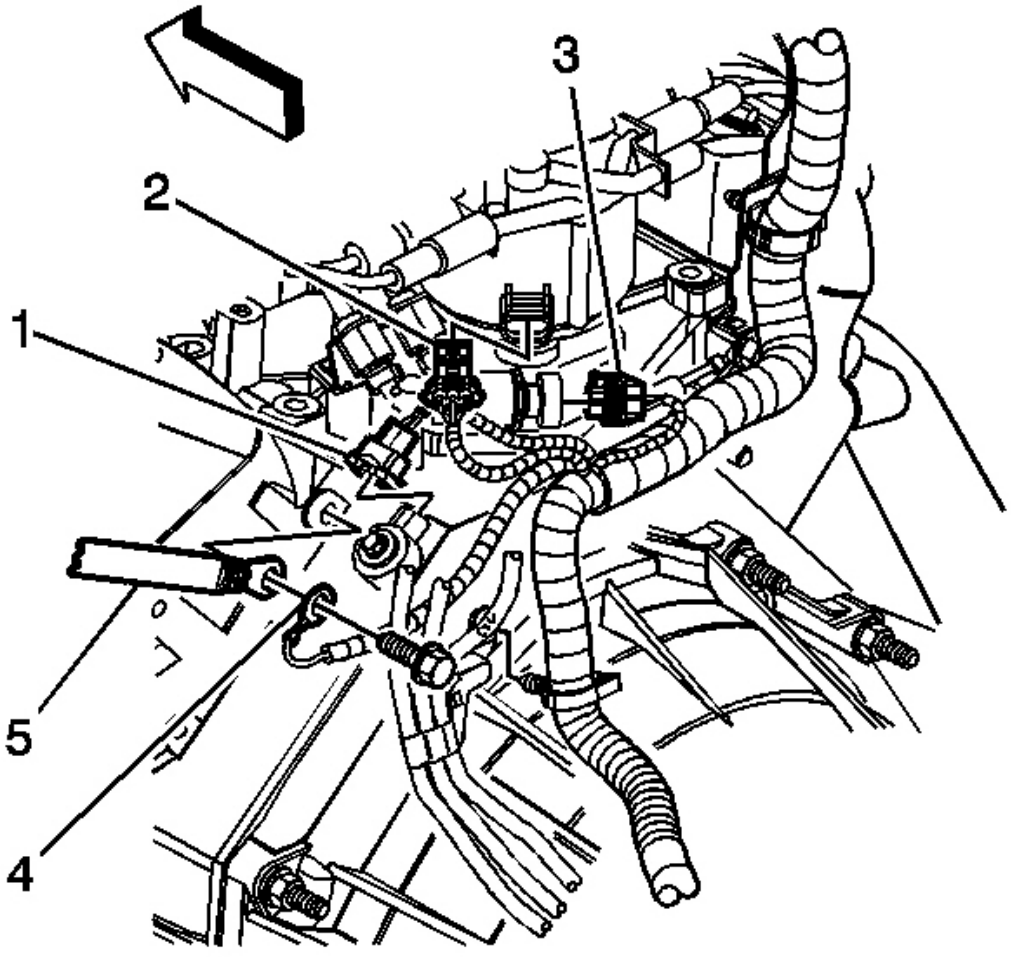


Fig. 327: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

32. Disconnect the following electrical connectors:
    - Knock sensor (1)
    - Camshaft position (CMP) sensor (2)
    - Fuel pump/oil pressure sensor (3)
33. Remove the harness ground bolt.
34. Reposition the harness ground (4) and ground strap (5).

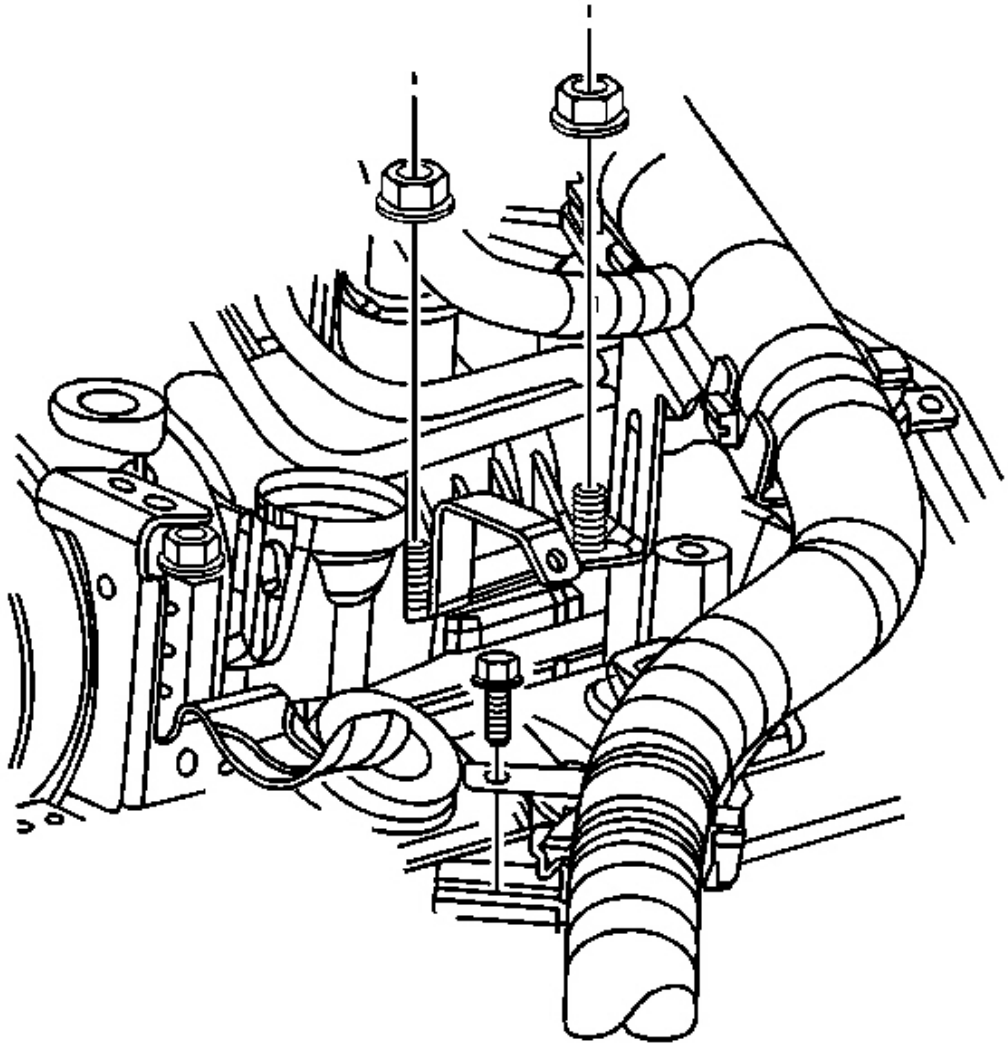


Fig. 328: View Of Engine Wiring Harness Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

35. Remove the engine wiring harness bracket nuts.
36. Remove the engine wiring harness bracket from the studs.

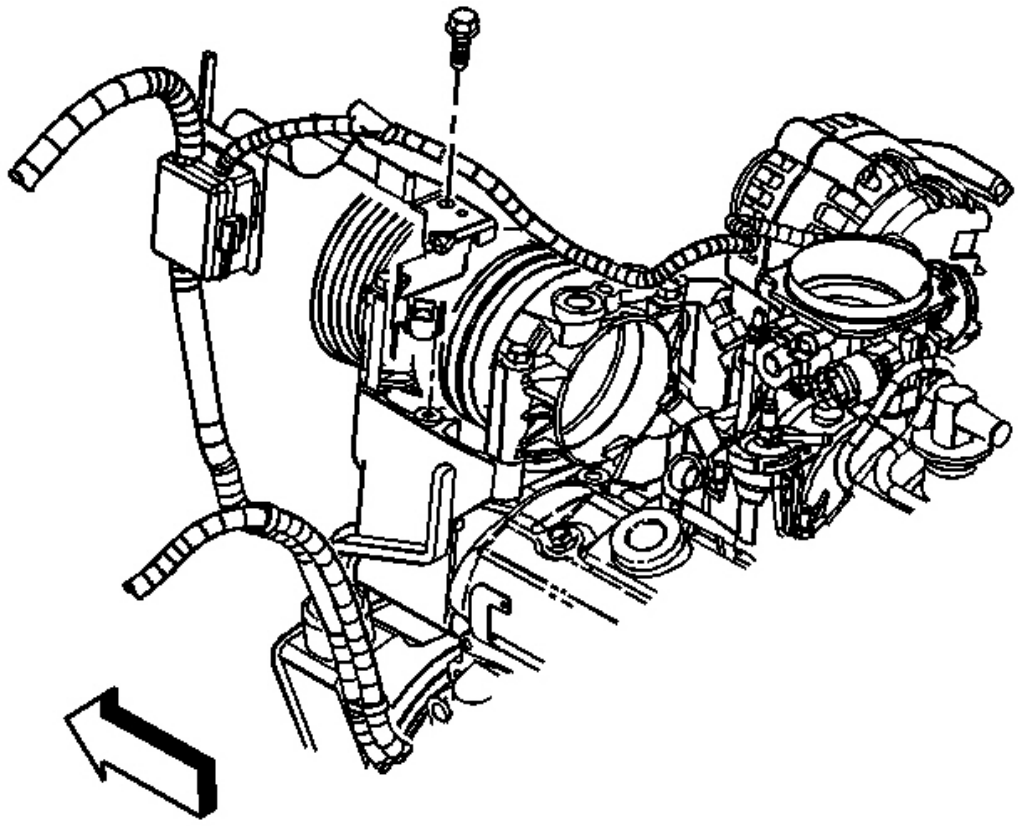


Fig. 329: View Of Junction Block Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

37. Remove the junction block bracket bolt.
38. Reposition the bracket and wiring harness aside.

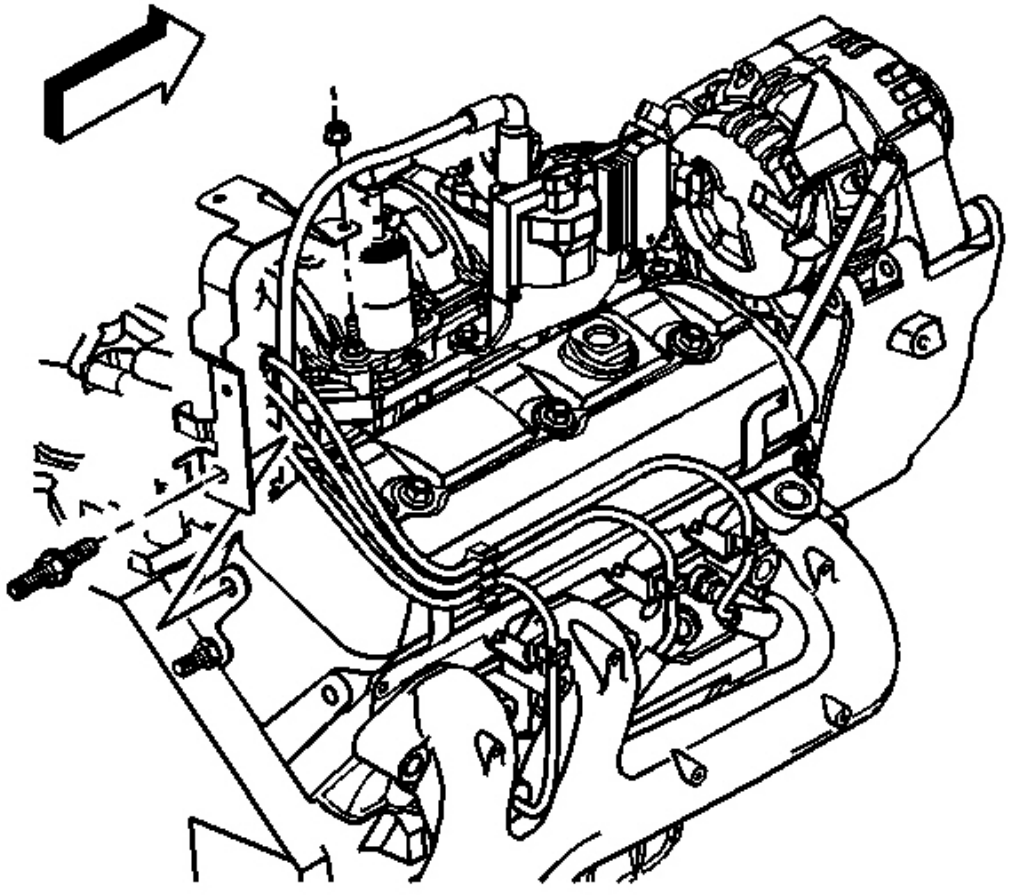


Fig. 330: Engine Wiring Harness Rear Bracket Nut & Stud Holding Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

39. Remove the engine wiring harness rear bracket nut at the EVAP canister purge solenoid valve.
40. Remove the stud holding the engine wiring harness bracket.
41. Reposition the engine wiring harness with the bracket aside.
42. Remove the heater hoses. Refer to **Heater Inlet Hose Replacement (Non-HP2)** and **Heater Outlet Hose Replacement** .

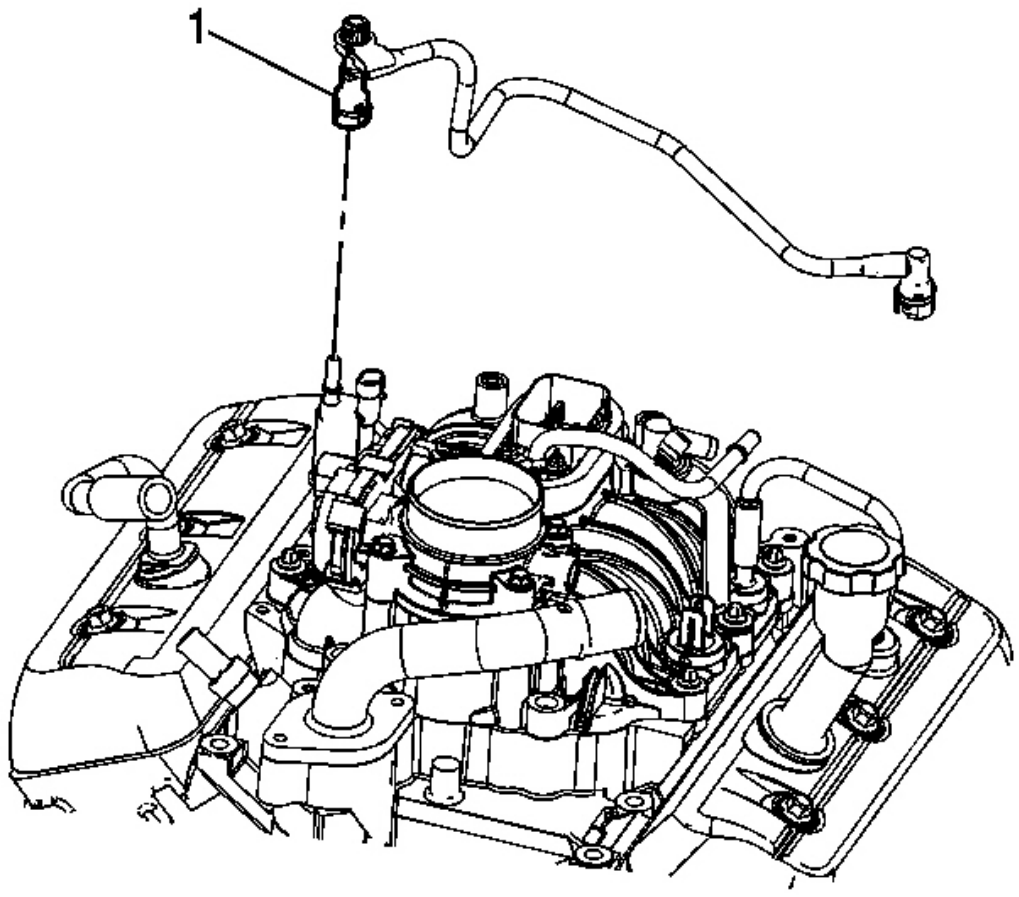


Fig. 331: View Of EVAP Canister Purge Solenoid Valve Tube Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

43. Disconnect the EVAP canister harness (1) from the purge solenoid valve.

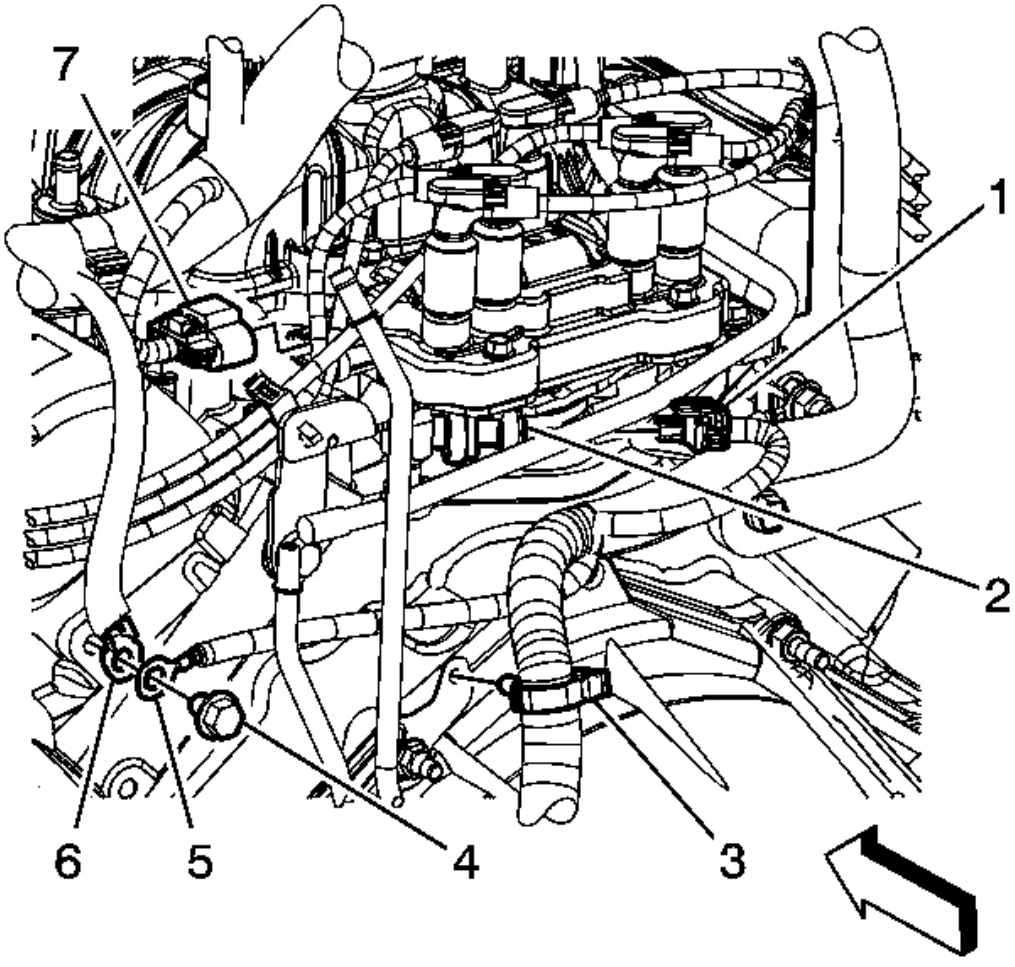


Fig. 332: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

44. Disconnect the engine wiring harness electrical connector (7) from the ignition coil.
45. Disconnect the power brake booster vacuum hose from the vacuum fitting.

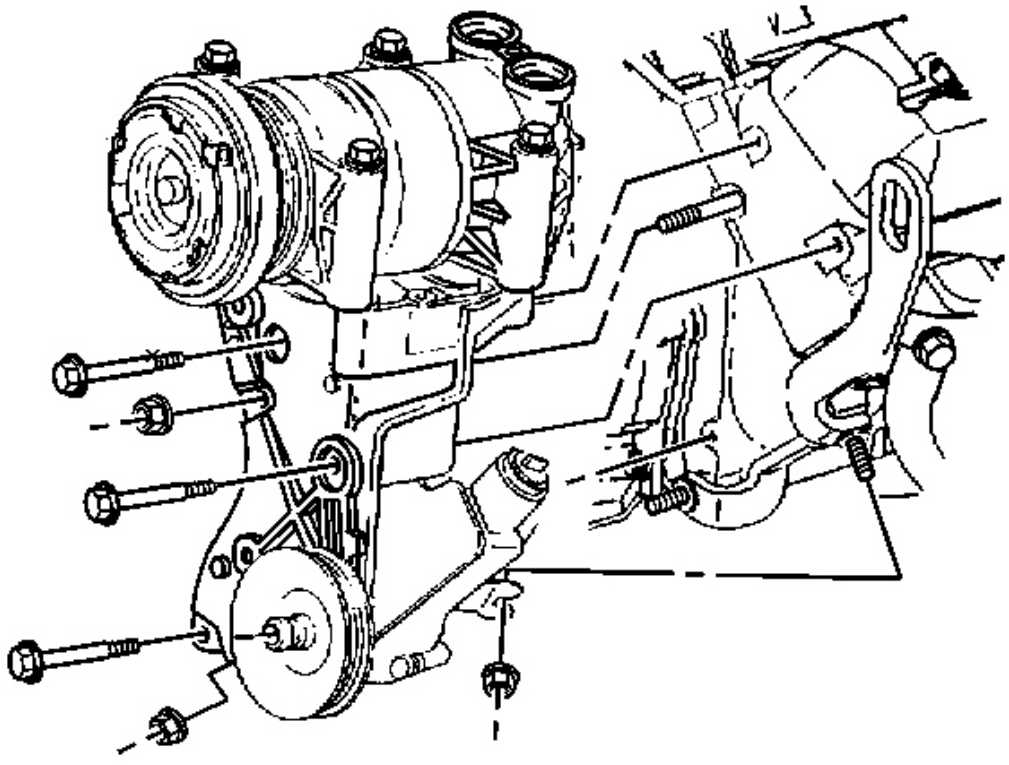


Fig. 333: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

46. Loosen the power steering (P/S) pump rear bracket nut.
47. Remove the P/S pump rear bracket front nut.
48. Remove the bolts and the nut for the P/S pump bracket.
49. Leave the A/C compressor, if equipped, and the P/S pump on the bracket.
50. Slide the P/S pump bracket forward off the stud and set aside.
51. Remove the thermostat and water outlet. Refer to **Engine Coolant Thermostat Replacement** .

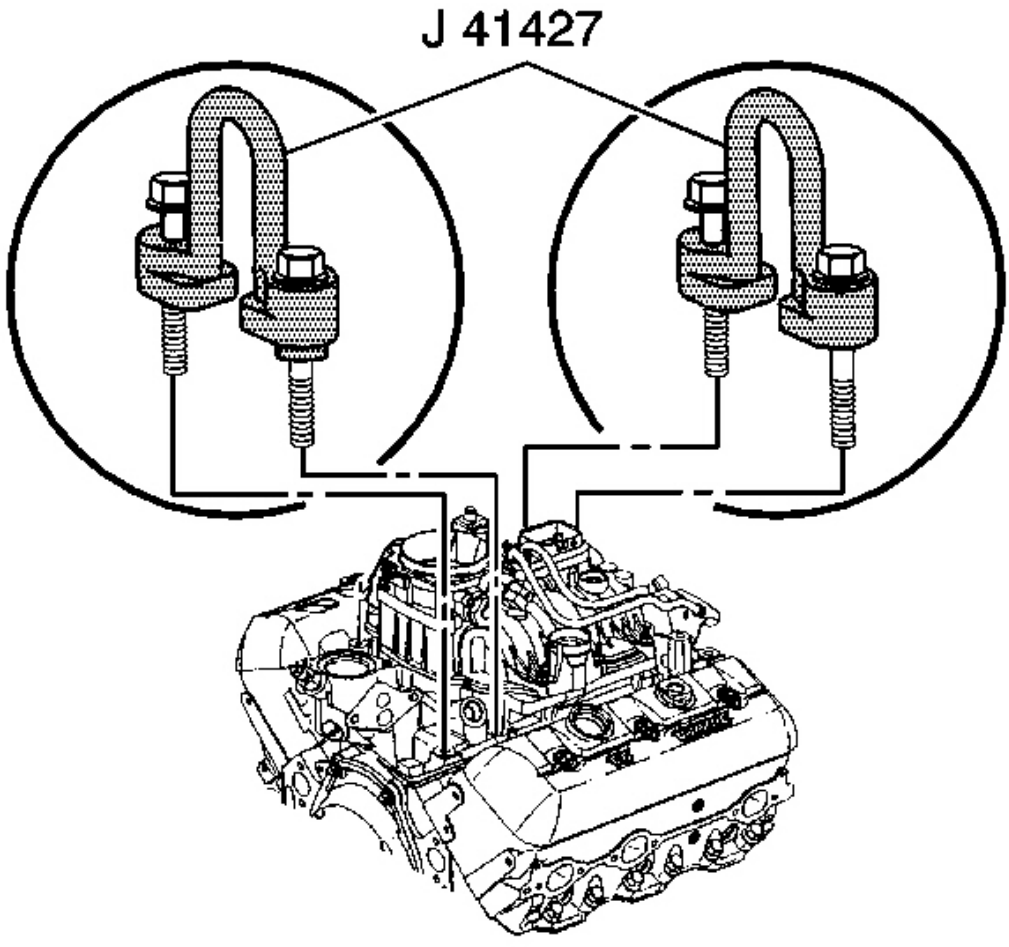


Fig. 334: Engine Lift Brackets J 41427
Courtesy of GENERAL MOTORS CORP.

52. Remove the left front and right rear intake manifold lower bolts.
53. Install **J 41427** to the left front and right rear intake manifold bolts, using the following procedure:
    1. Install the **J 41427** marked RIGHT REAR.

       NOTE: Refer to Fastener Notice .

    2. Install the lift bracket bolts.

Tighten: Tighten the bolts to 15 N.m (11 lb ft).

3. Install the **J 41427** marked LEFT FRONT with the arrow pointing to the front of the engine.
4. Install the lift bracket bolts.

   Tighten: Tighten the bolts to 15 N.m (11 lb ft).

54. Install a suitable lifting devise to the engine lift brackets.

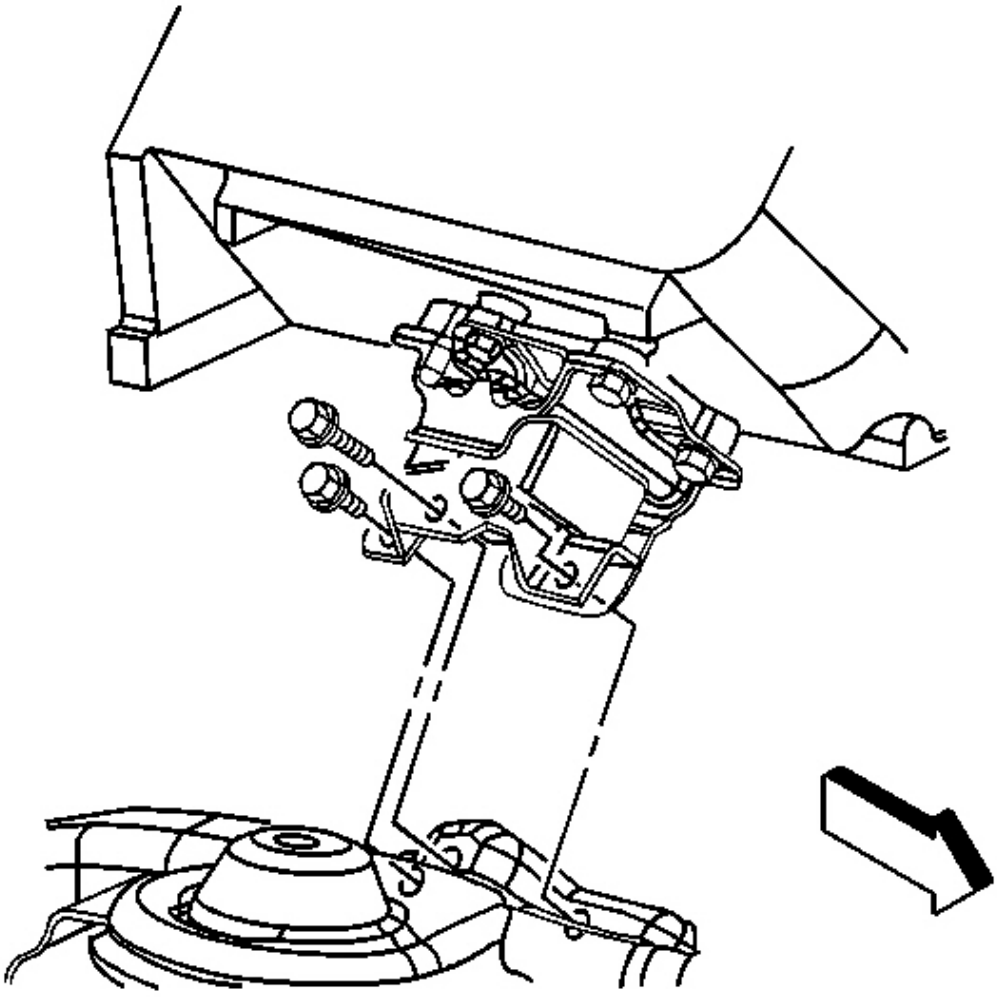


Fig. 335: Engine Mount To Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

55. Remove the engine mount to engine mount bracket nuts.
56. Support the transmission with a suitable floor jack.
57. Remove the engine.

Installation Procedure

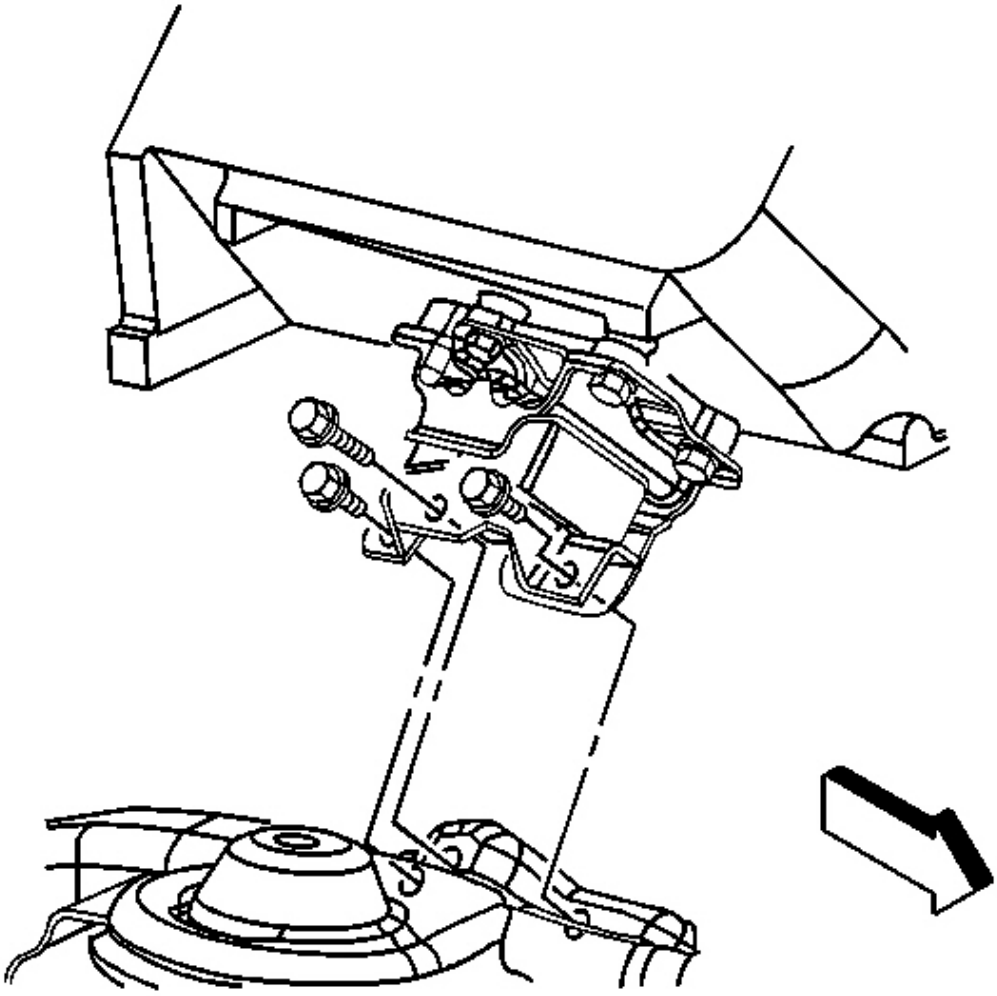


Fig. 336: Engine Mount To Engine Mount Bracket & Bolts

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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

Tighten: Tighten the bolts to 65 N.m (48 lb ft).

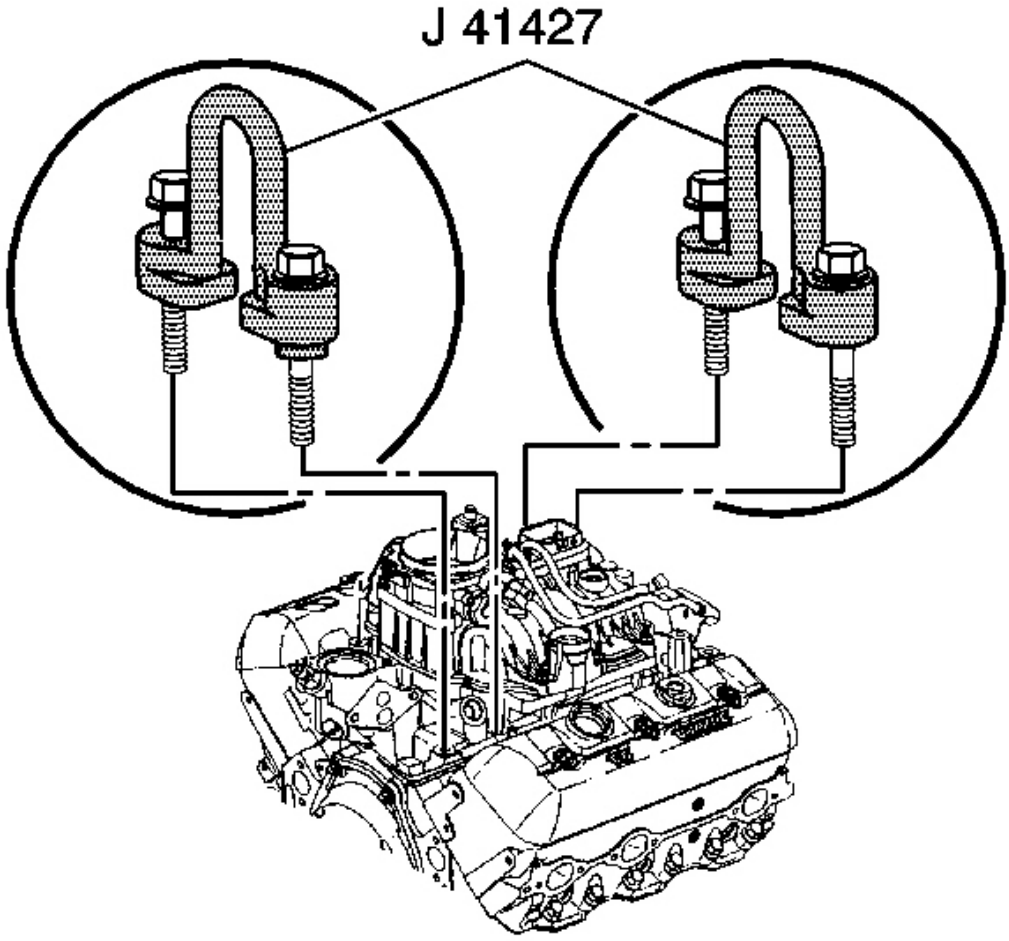


Fig. 337: Engine Lift Brackets J 41427
Courtesy of GENERAL MOTORS CORP.

3. Remove the lifting devise and the **J 41427** .
4. Apply threadlock to the threads of the intake manifold lower bolts.
5. Install the intake manifold bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

   Tighten:

   1. Tighten the bolts a first pass to 3 N.m (27 lb in).
   2. Tighten the bolts a second pass to 12 N.m (106 lb in).
   3. Tighten the bolts a final pass to 15 N.m (11 lb ft).

6. Install one transmission bolt until snug.
7. Remove the support jack from under the transmission.
8. Install the thermostat and water outlet. Refer to **Engine Coolant Thermostat Replacement** .

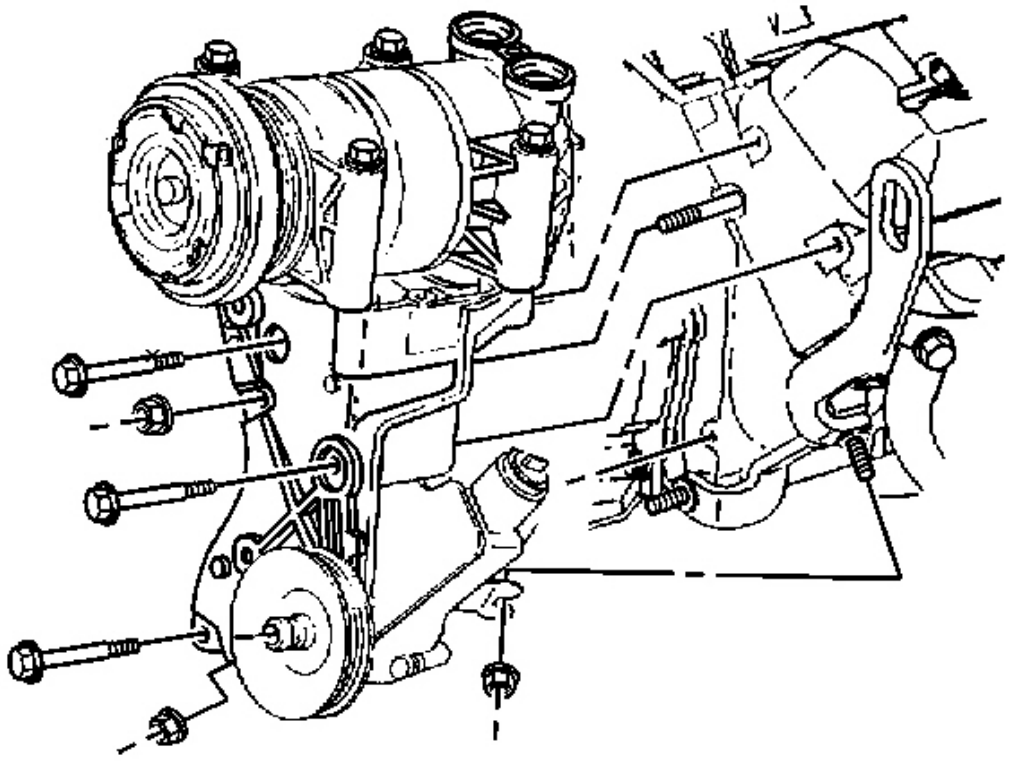


Fig. 338: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

9. Slide the P/S pump bracket onto the stud.
10. Install the bolts and the nut for the P/S pump bracket.
11. Install the P/S pump rear bracket front nut.
12. Tighten the P/S pump rear bracket nut.

    Tighten: Tighten the bolts and nuts to 41 N.m (30 lb ft).

13. Connect the power brake booster vacuum hose to the vacuum fitting.

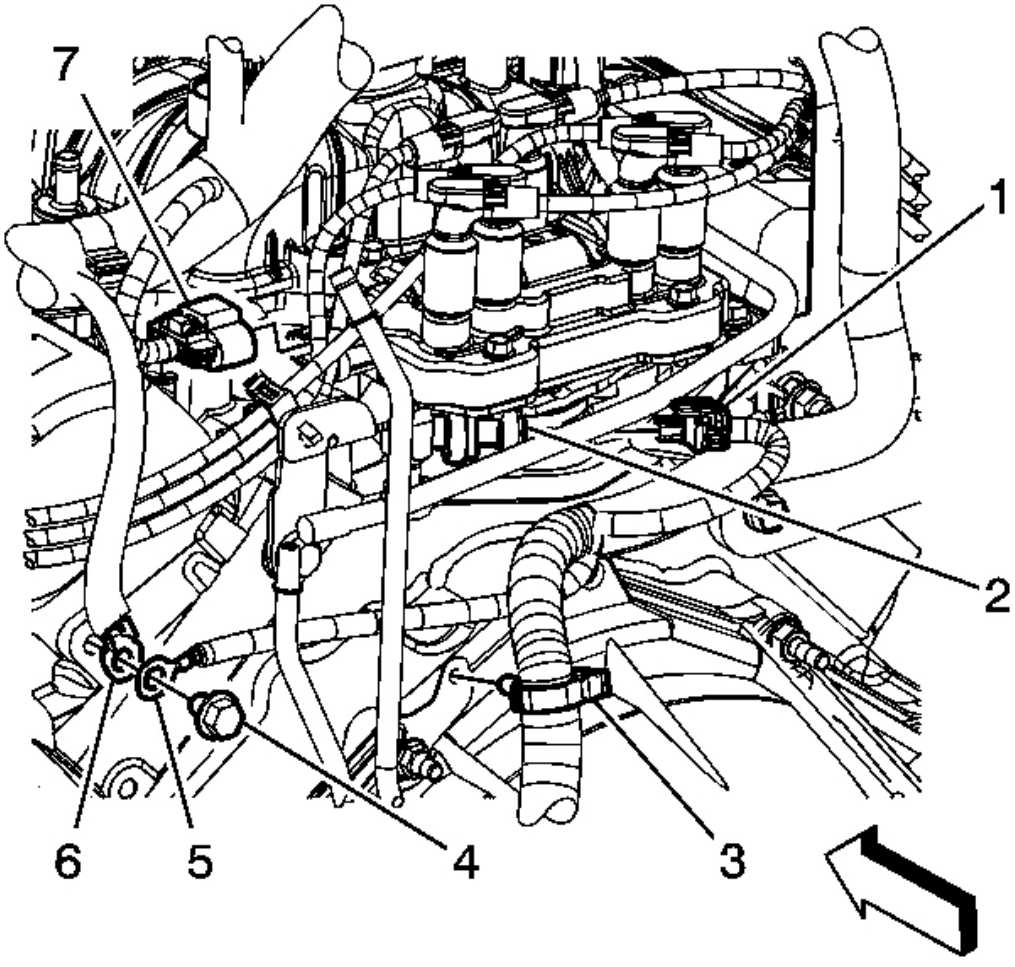


Fig. 339: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

14. Connect the engine wiring harness electrical connector (7) from the ignition coil.

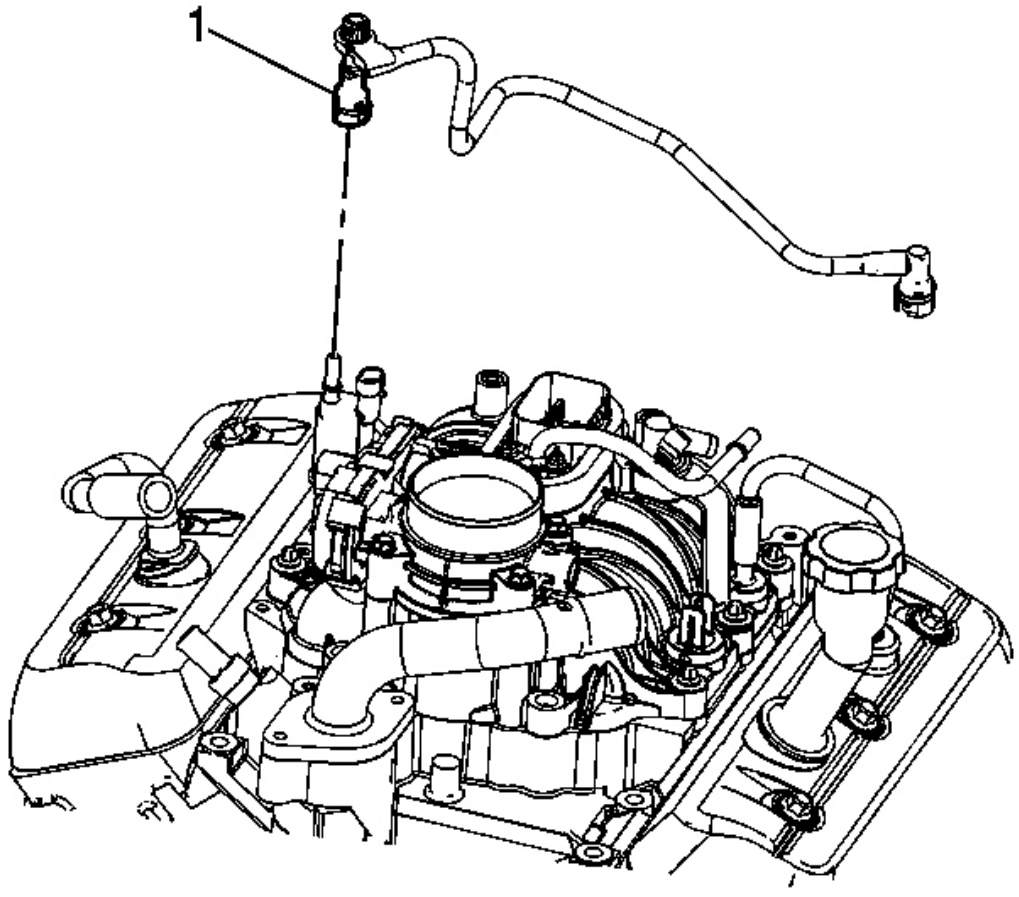


Fig. 340: View Of EVAP Canister Purge Solenoid Valve Tube Quick Connect Fitting
Courtesy of GENERAL MOTORS CORP.

15. Connect the EVAP canister harness (1) to the purge solenoid valve.
16. Install the heater hoses. Refer to **Heater Inlet Hose Replacement (Non-HP2)** and **Heater Outlet Hose Replacement** .

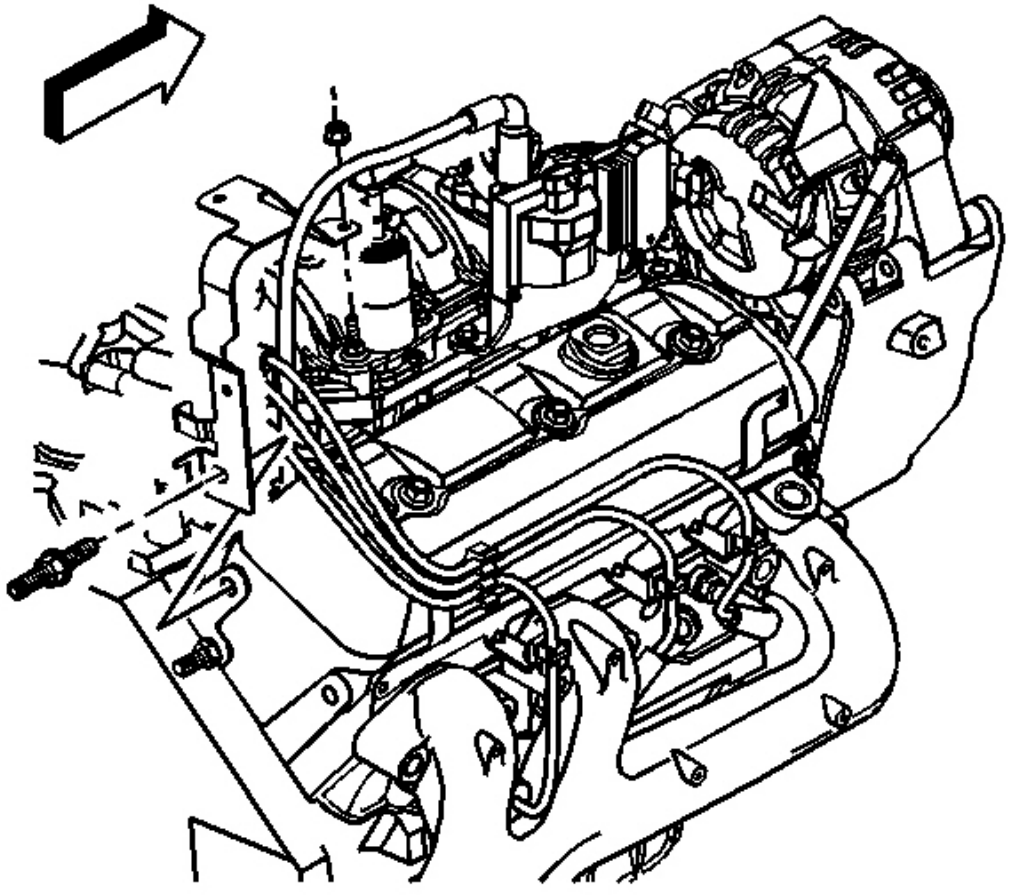


Fig. 341: Engine Wiring Harness Rear Bracket Nut & Stud Holding Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

17. Position the engine wiring harness.
18. Install the stud holding the engine wiring harness bracket.
19. Install the engine wiring harness rear bracket nut at the EVAP canister purge solenoid valve.

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

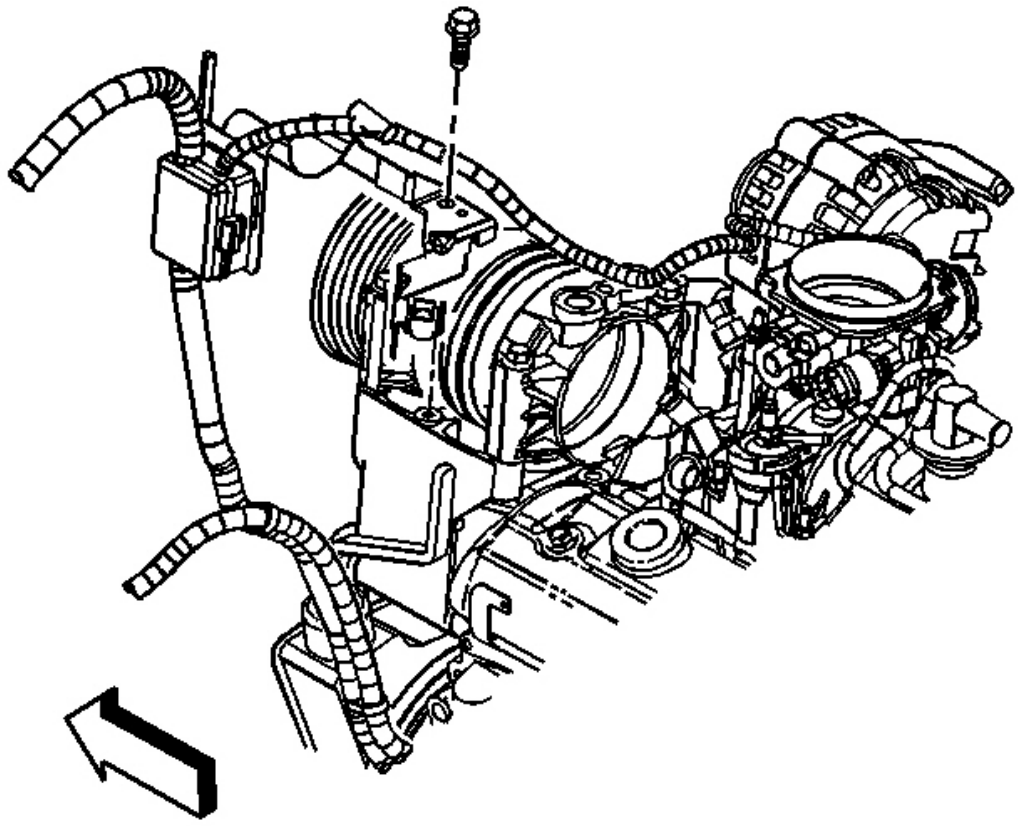


Fig. 342: View Of Junction Block Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

20. Position the bracket and wiring harness.
21. Install the junction block bracket bolt.

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

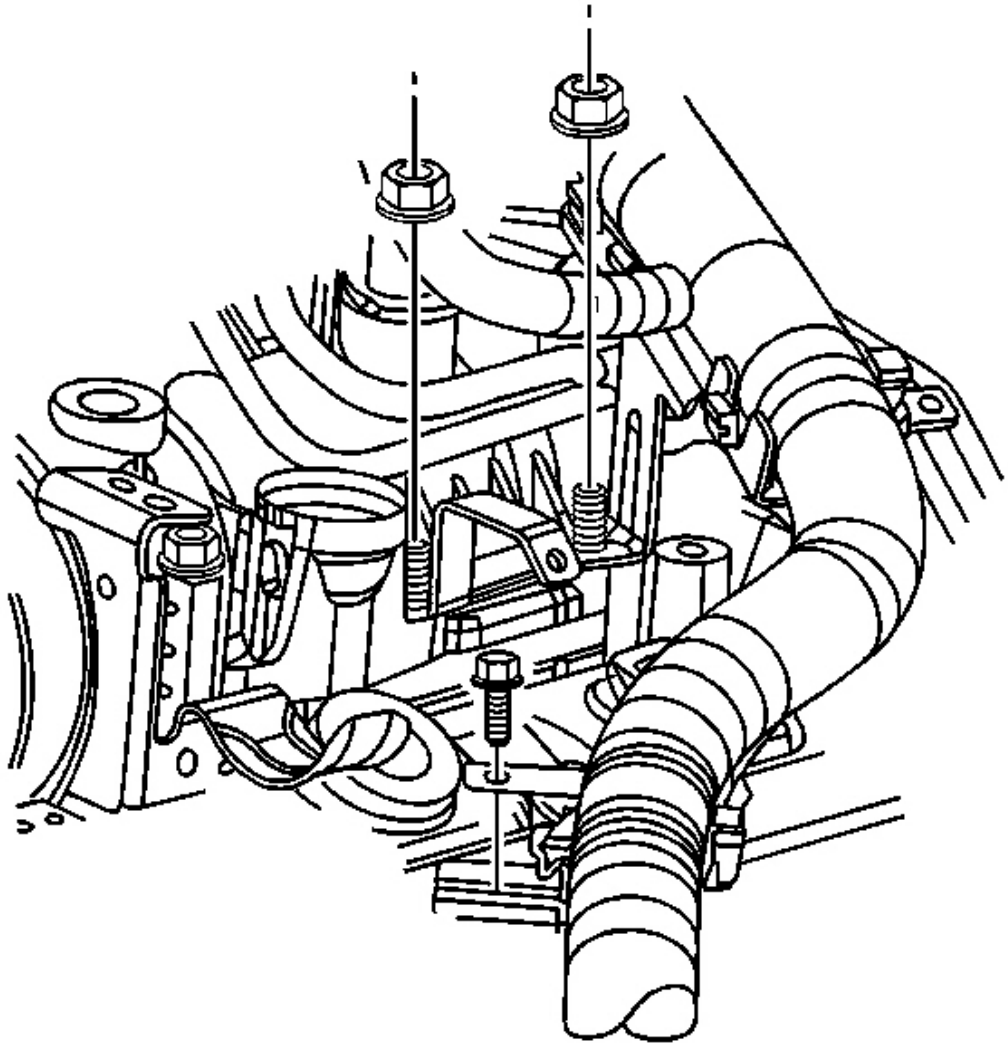


Fig. 343: View Of Engine Wiring Harness Bracket & Nuts
Courtesy of GENERAL MOTORS CORP.

22. Install the engine wiring harness bracket to the studs.
23. Install the engine wiring harness bracket nuts.

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

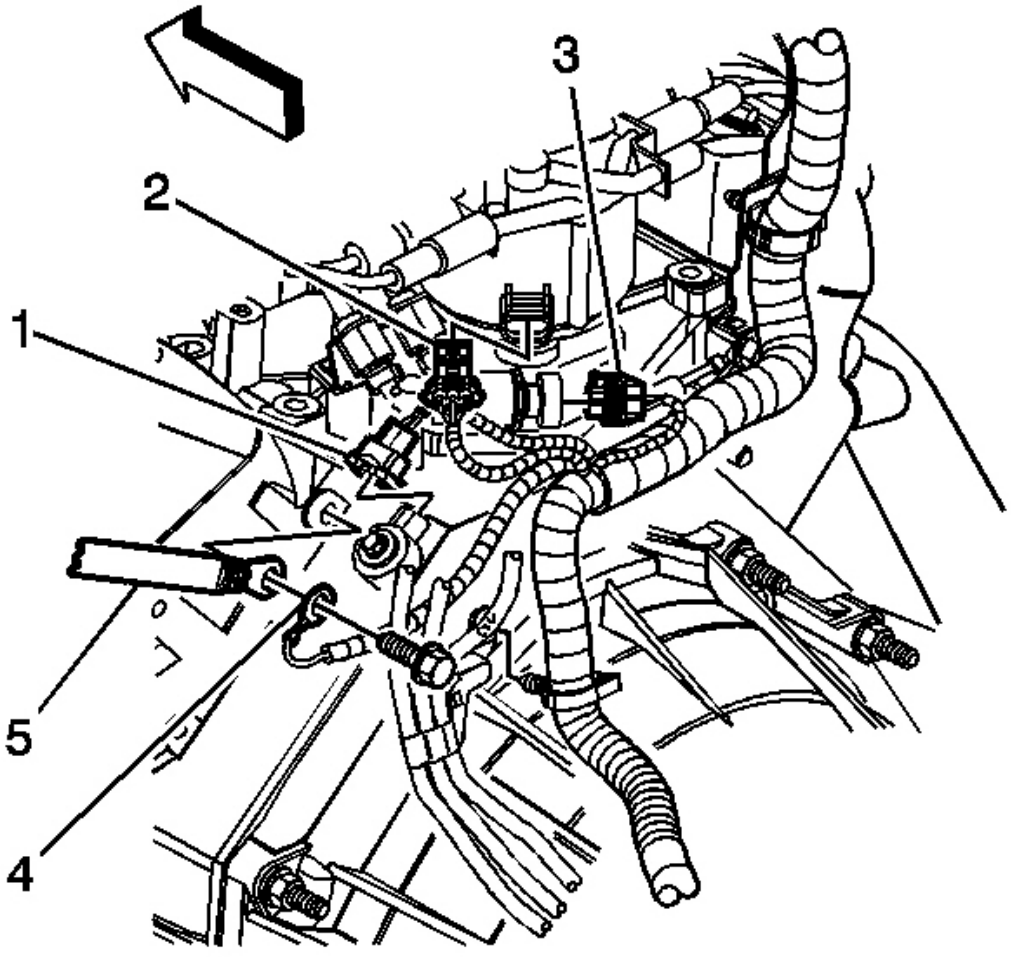


Fig. 344: View Of Ground Strap And CMP & Fuel Pump/Oil Pressure Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

24. Position the harness ground (4) and ground strap (5).
25. Install the harness ground bolt.

    Tighten: Tighten the bolt to 16 N.m (12 lb ft).

26. Connect the following electrical connectors:
    - Knock sensor (1)

- CMP sensor (2)
- Fuel pump/oil pressure sensor (3)

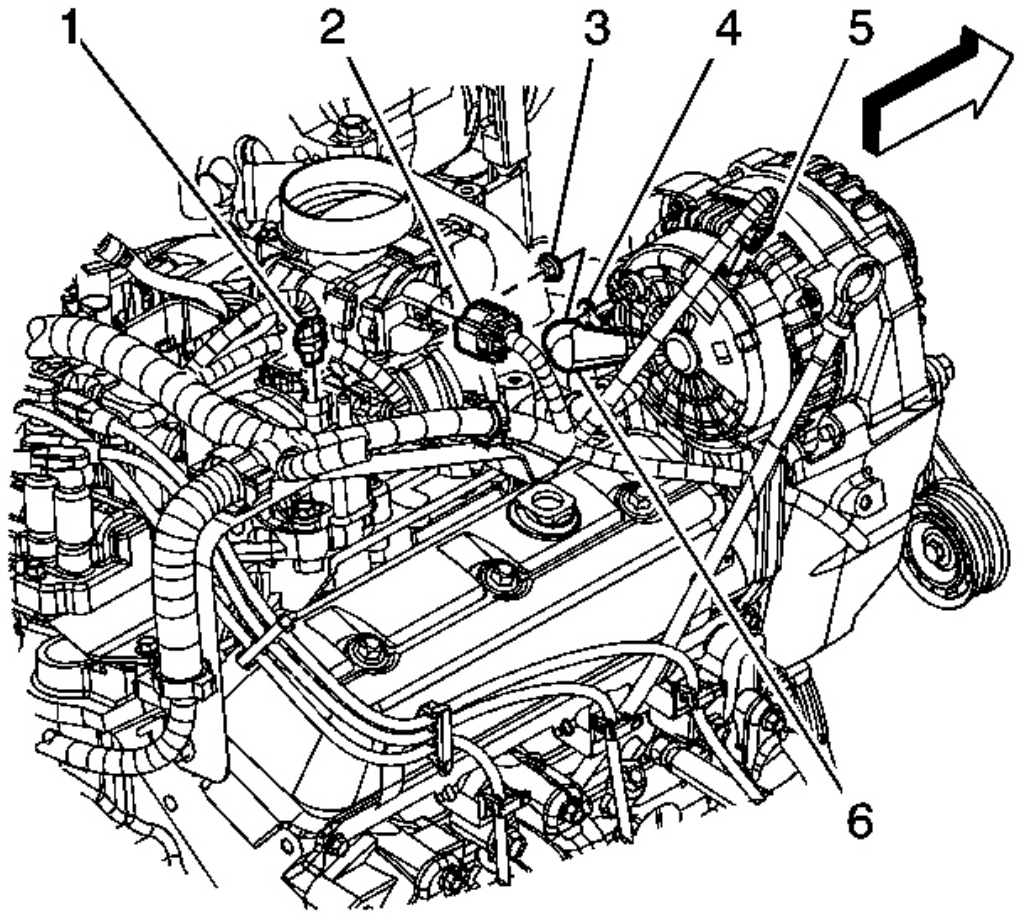


Fig. 345: View Of Engine Wiring Harness & Components
Courtesy of GENERAL MOTORS CORP.

27. Connect the engine wiring harness electrical connector (2) to the throttle body.
28. Connect the following electrical connectors:
    - EVAP canister purge solenoid valve (1)
    - MAP sensor

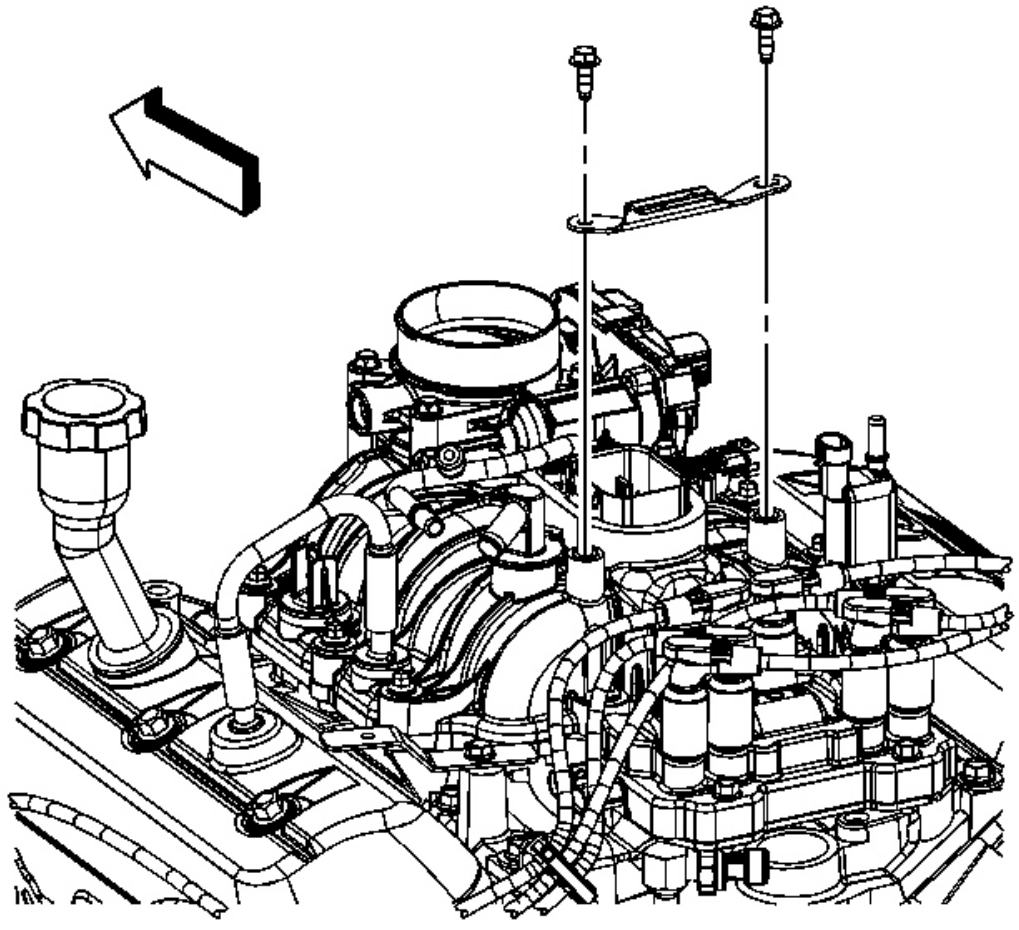


Fig. 346: View Of Engine Wiring Harness Rear Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

29. Place the engine wiring harness rear bracket onto the upper intake manifold and install the bolts.

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

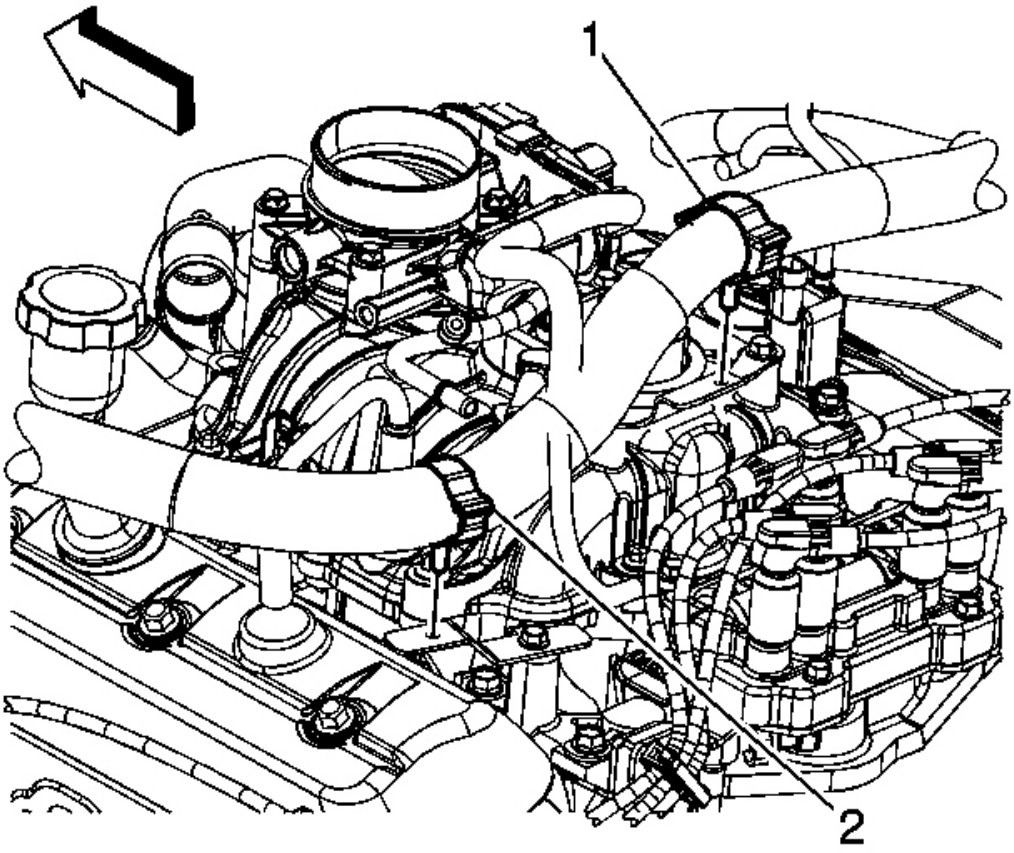


Fig. 347: View Of Engine Wiring Harness Clips
Courtesy of GENERAL MOTORS CORP.

30. Install the engine wiring harness clips (1, 2) to the engine harness brackets.

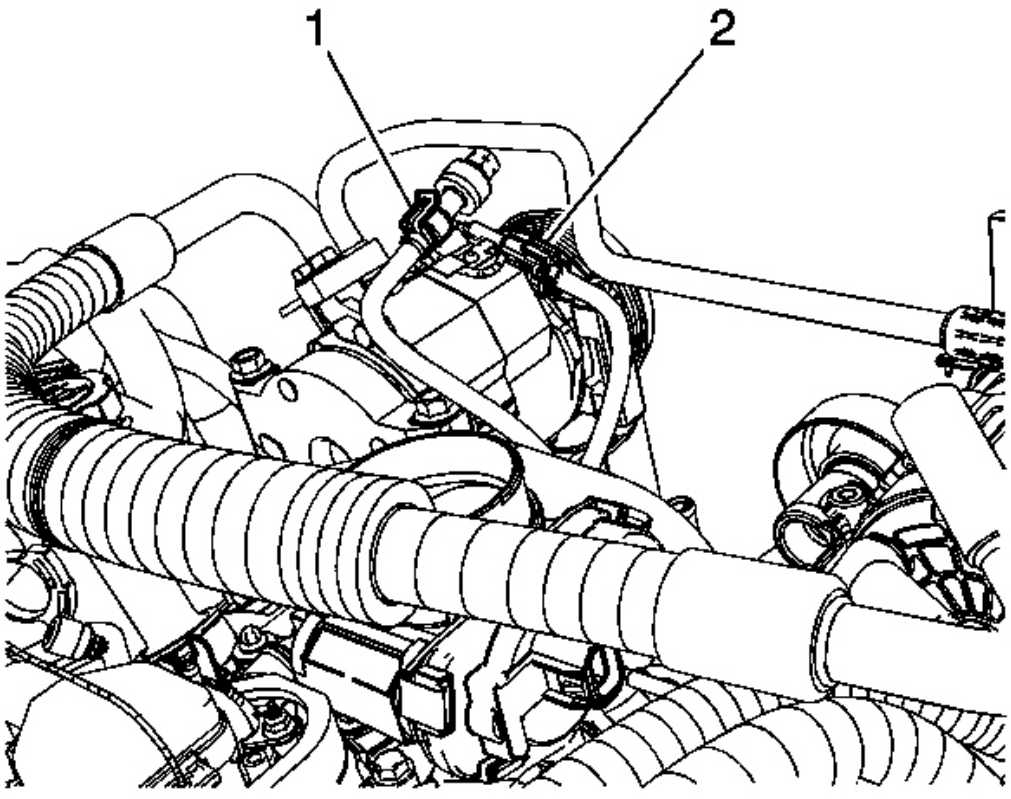


Fig. 348: View Of A/C Pressure Switch & Compressor Clutch Connectors
Courtesy of GENERAL MOTORS CORP.

31. If equipped, install the A/C hoses.
32. Connect the following electrical connectors:
    - The A/C compressor clutch (2), if equipped
    - The A/C pressure switch (1), if equipped

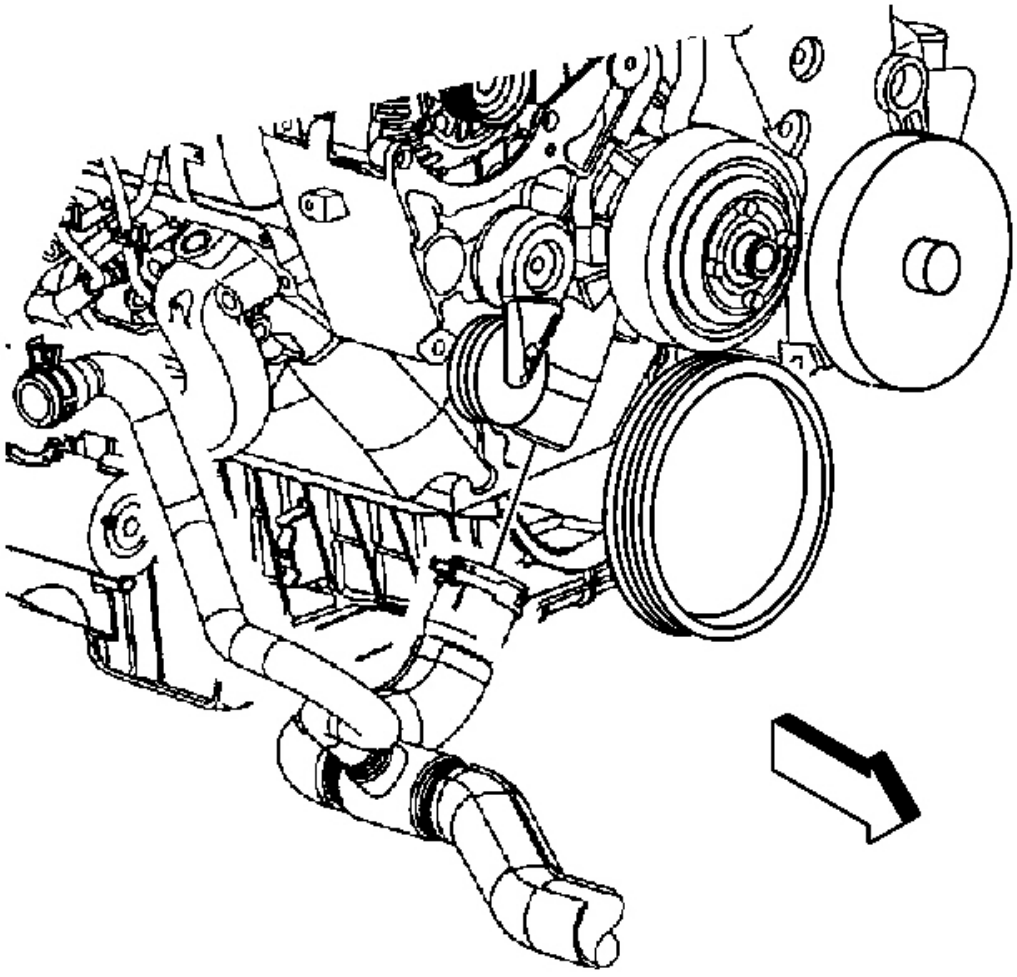


Fig. 349: View Of Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

33. Install the radiator outlet hose to the water pump.
34. Install the radiator outlet hose to the surge tank.
35. Position the radiator outlet hose clamps.

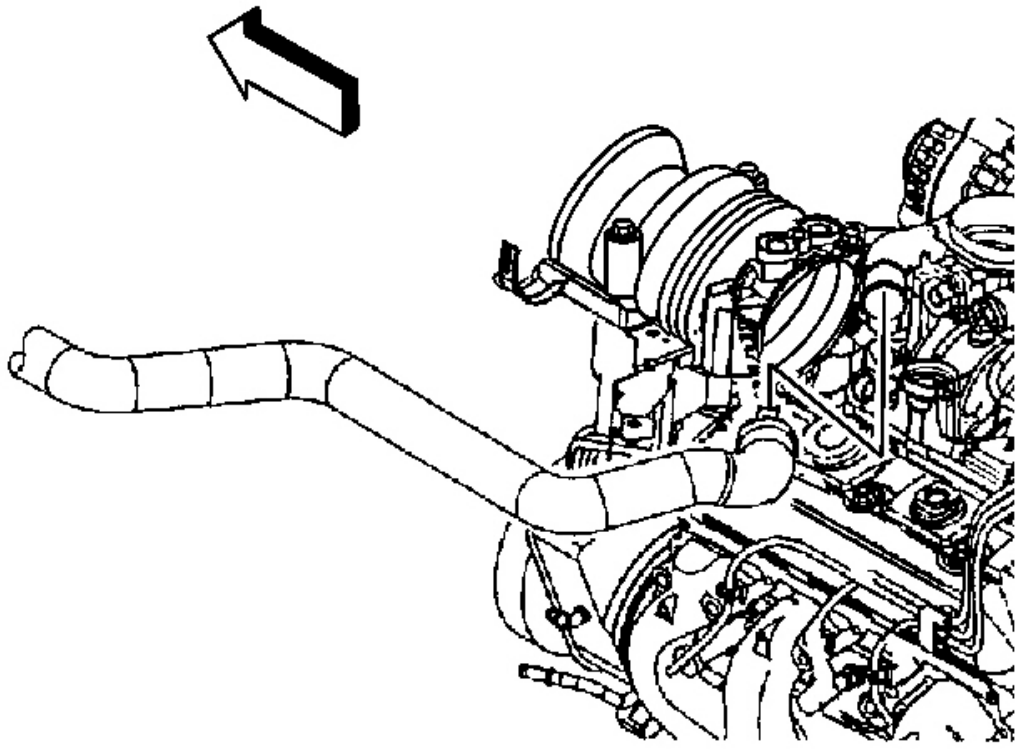


Fig. 350: View Of Radiator Inlet Hose, Clamps & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

36. Install the radiator inlet hose to the thermostat housing.
37. Position the radiator inlet hose clamp.
38. Install the drive belt. Refer to **Drive Belt Replacement**.
39. Install the lower fan shroud. Refer to **Engine Coolant Fan Lower Shroud Replacement (Mechanical)** .
40. Install the fuel pipes/hoses. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .

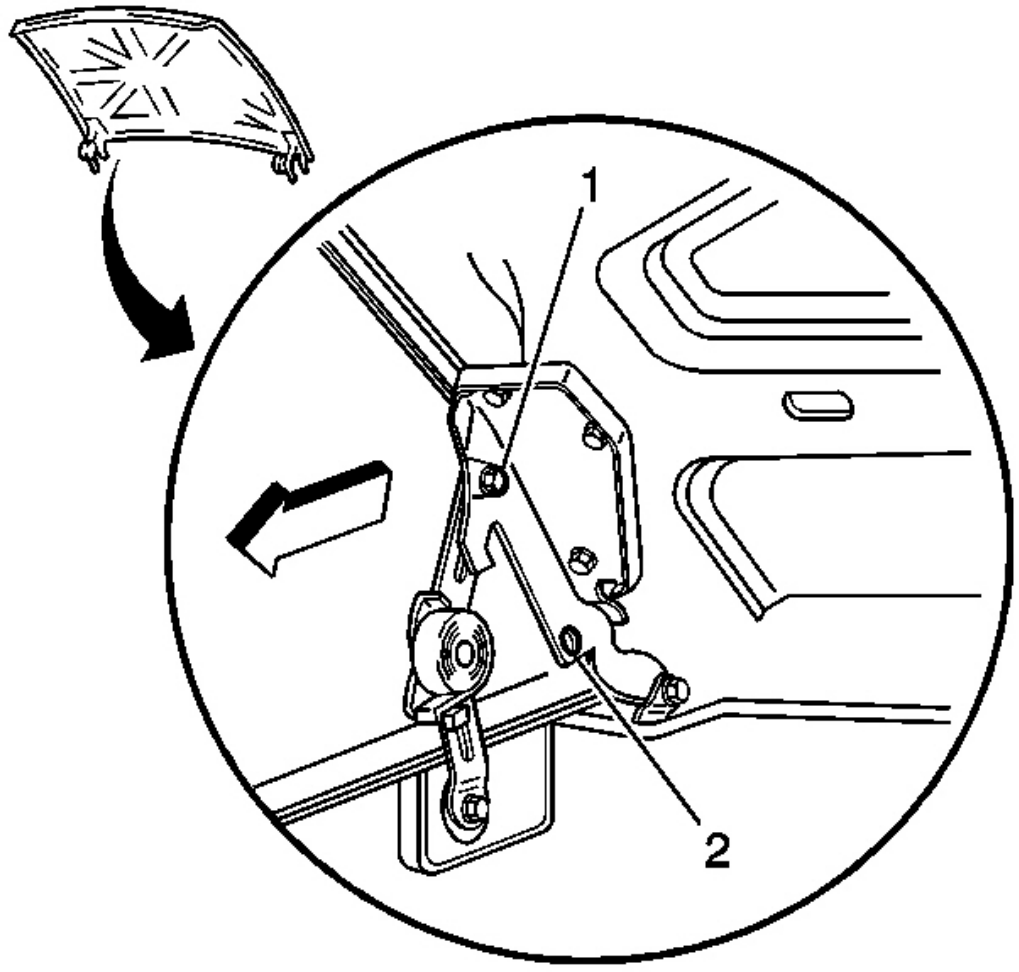


Fig. 351: Identifying Hood Hinge Normal And Service Position Bolt Holes
Courtesy of GENERAL MOTORS CORP.

41. Remove the hood hinge bolt from the service position (2).
42. Lower the hood to the normal position.
43. Install the hood hinge bolts.

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

44. Raise the vehicle.

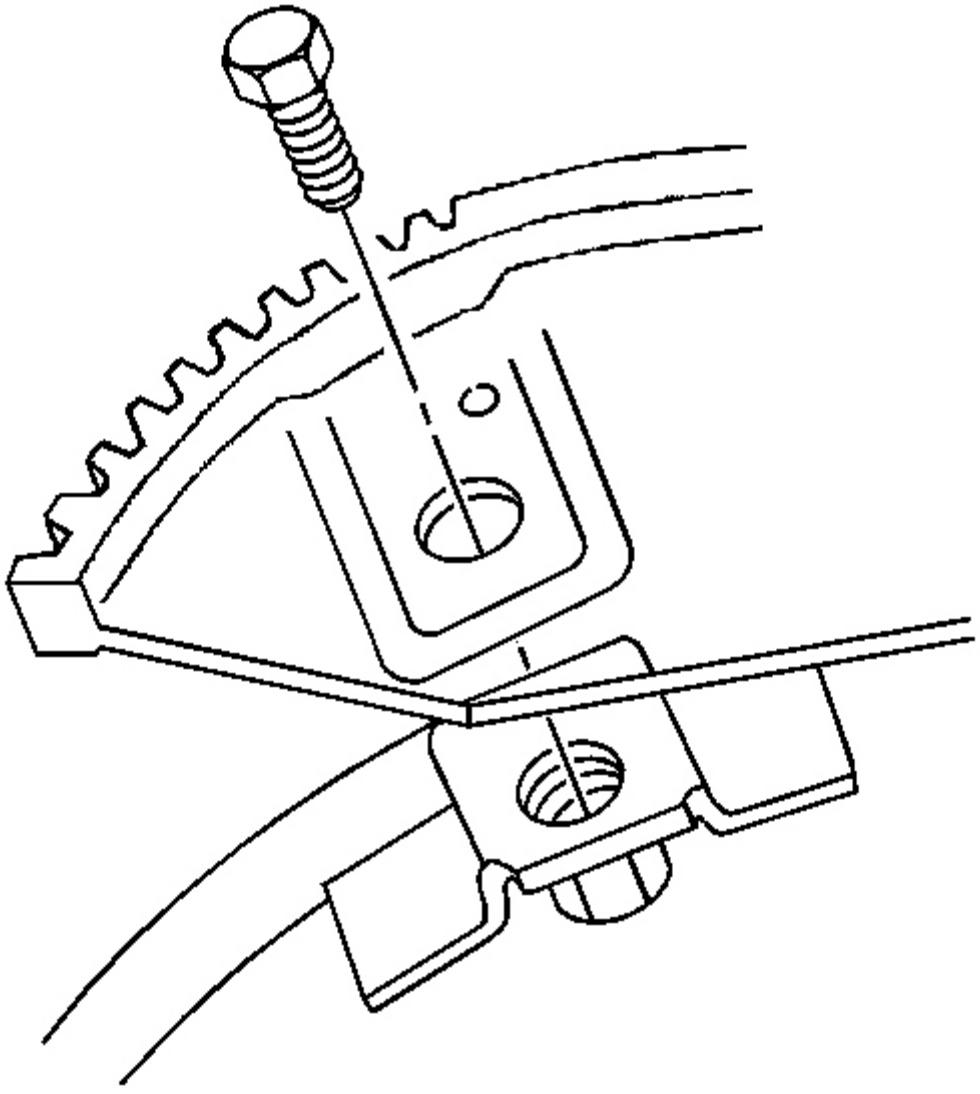


Fig. 352: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

45. Install the transmission bolts.

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

46. If equipped, install the torque converter bolts.

    Tighten: Tighten the bolts to 63 N.m (47 lb ft).

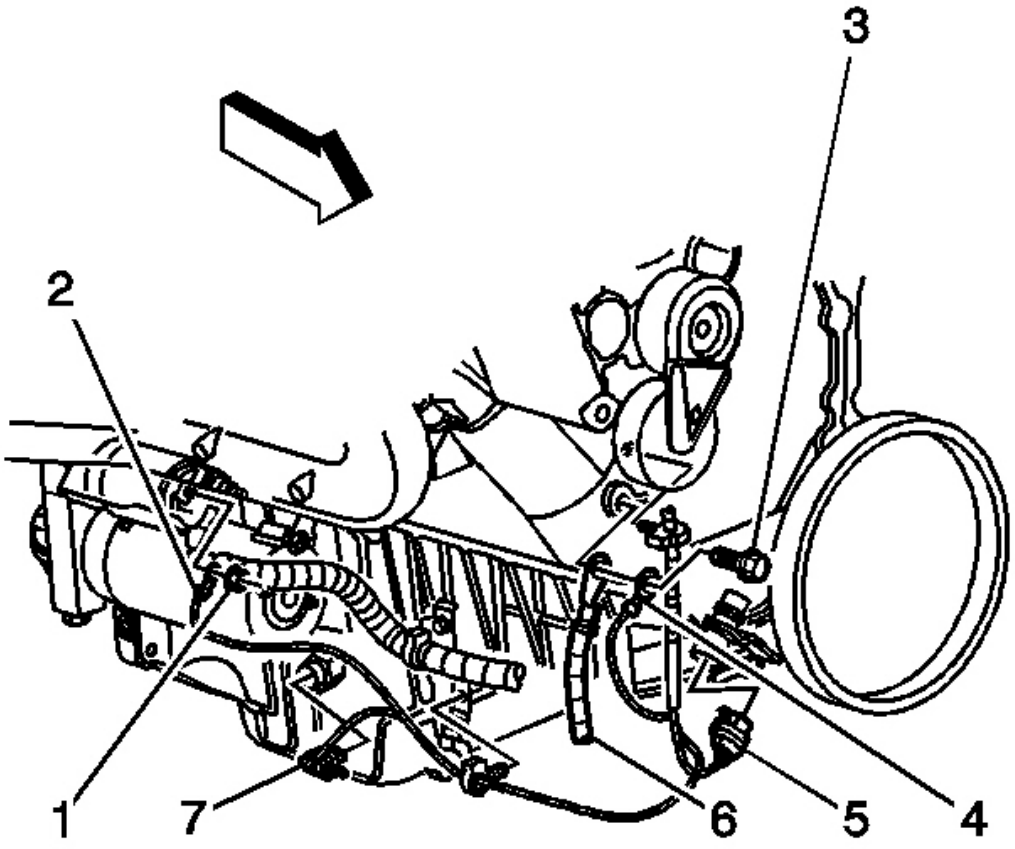


Fig. 353: View Of Oil Level Sensor Electrical Connector, CKP Electrical Connector & Battery Ground Bolt
Courtesy of GENERAL MOTORS CORP.

47. Install the ground bolt (3) holding the negative battery cable (6) and ground cable (4) to the engine.
48. Connect the CKP sensor electrical connector (5) and install the harness to the retainer clip.

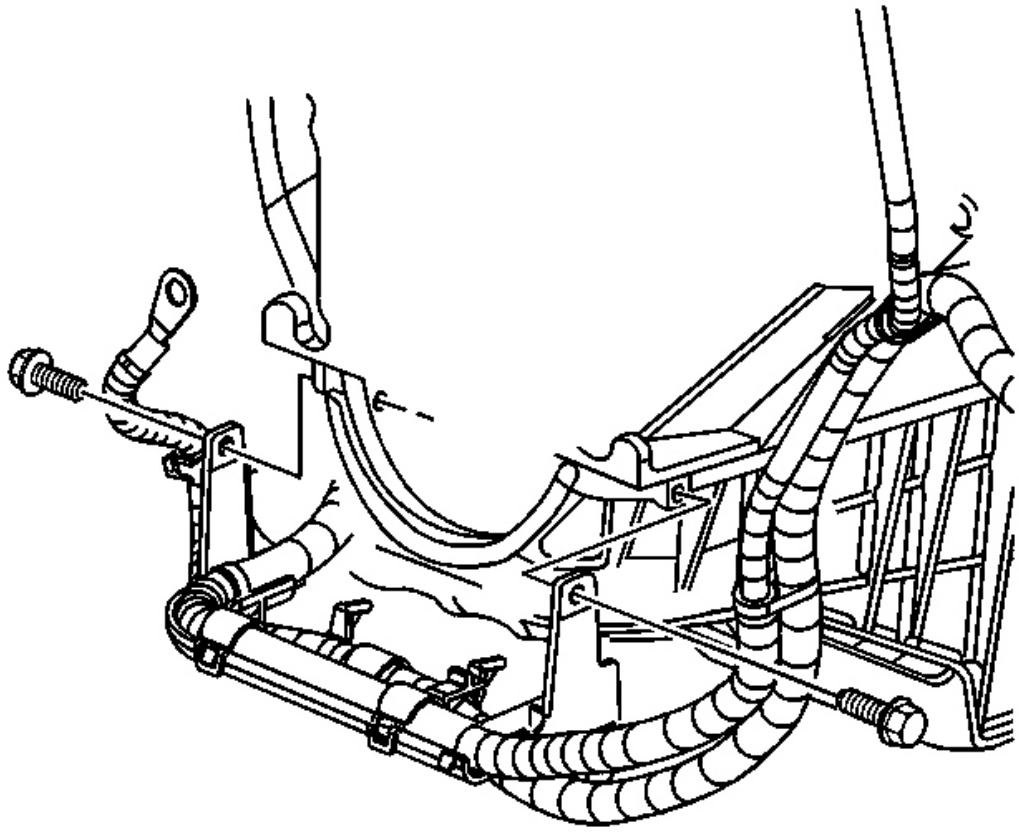


Fig. 354: View Of Battery Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

49. Install the battery cable bracket bolts.

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

50. Install the catalytic converter. Refer to **Catalytic Converter Replacement (4.3L)** .

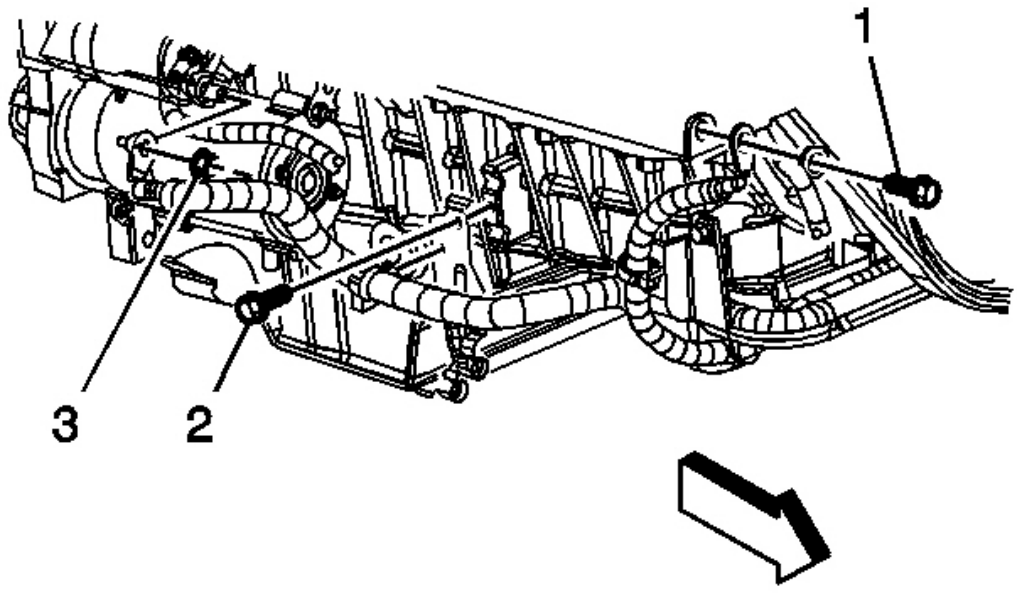


Fig. 355: Positive Battery Cable Clip Bolt
Courtesy of GENERAL MOTORS CORP.

51. Install the positive battery cable clip bolt (2).

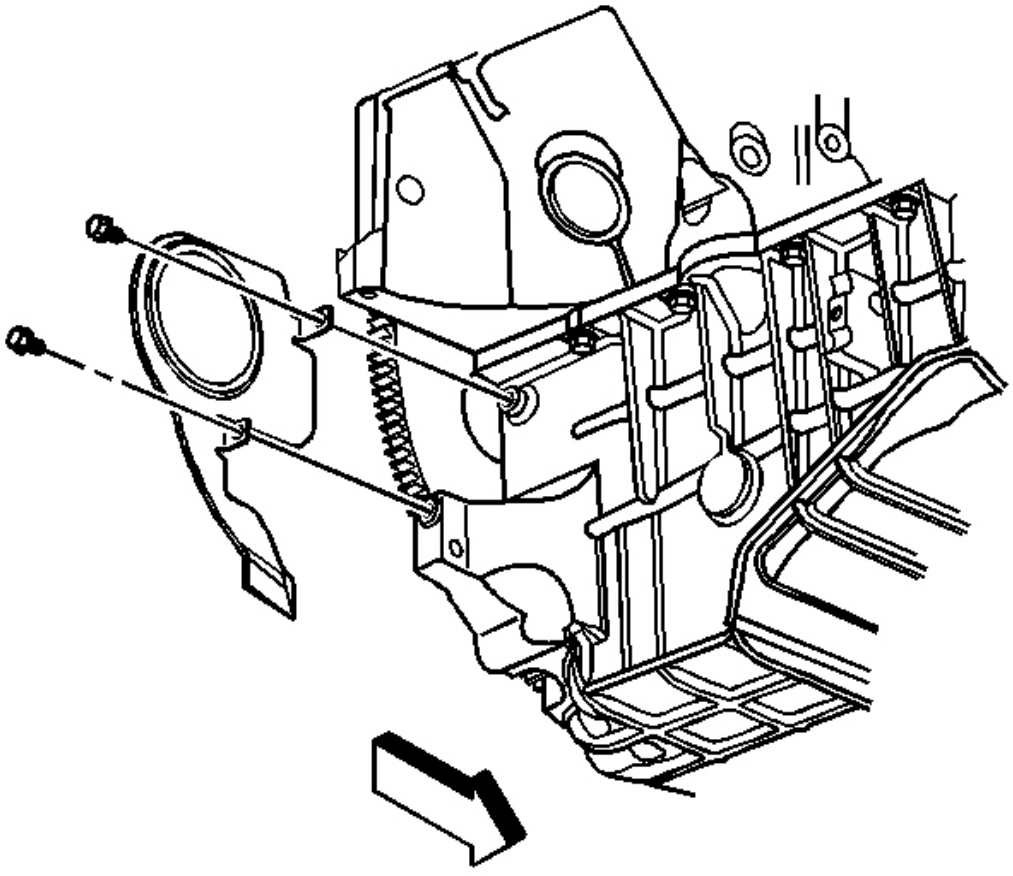


Fig. 356: Transmission Cover
Courtesy of GENERAL MOTORS CORP.

52. Install the transmission cover.

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

53. Install the starter. Refer to **Starter Motor Replacement (4.3L)** .
54. If equipped, install the engine shield. Refer to **Engine Shield Replacement** .

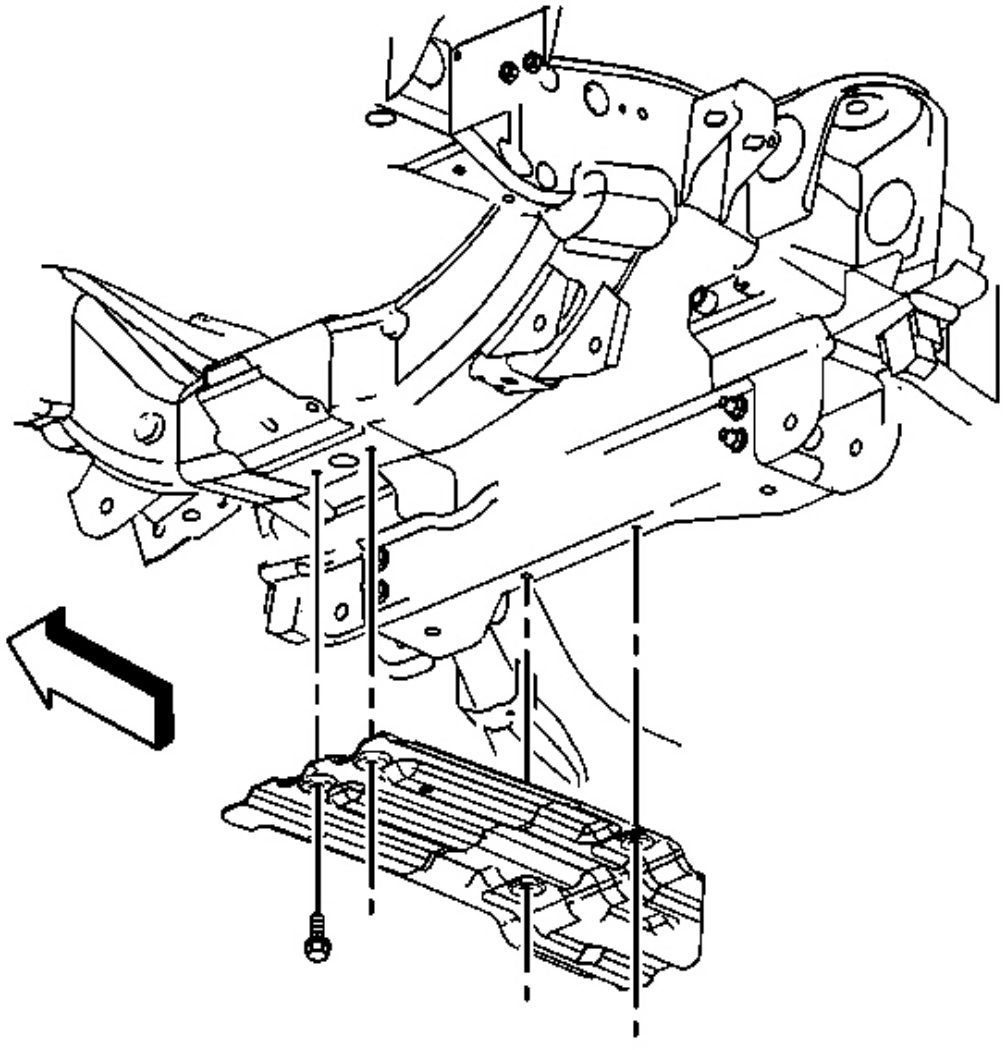


Fig. 357: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

55. If equipped, install the oil pan skid plate and bolts.

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

56. Lower the vehicle.
57. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and**

Connection (w/Single Battery) or **Battery Negative Cable Disconnection and Connection (w/Auxiliary Battery)** or **Battery Negative Cable Disconnection and Connection (w/Dual Batteries)** .

58. Perform the engine prelube procedure. Refer to **Engine Prelubing**.
59. Add engine oil supplement to the engine oil. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
60. Fill the cooling system. Refer to **Cooling System Draining and Filling (Vac-N-Fill)** or **Cooling System Draining and Filling (Static Fill)** .
61. Recharge the A/C system. Refer to **Refrigerant Recovery and Recharging** .

IMPORTANT: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.

62. Disable the ignition system.
63. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
64. Start the engine and listen for unusual noises.
65. Check the oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
66. If necessary, install an oil pressure gage and measure the oil pressure.
67. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
68. Listen for sticking valve lifters, or other unusual noises.
69. Inspect for fuel, oil, and/or coolant leaks while the engine is running.
70. Perform a final inspection for the proper oil and coolant levels.
71. Close the hood.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

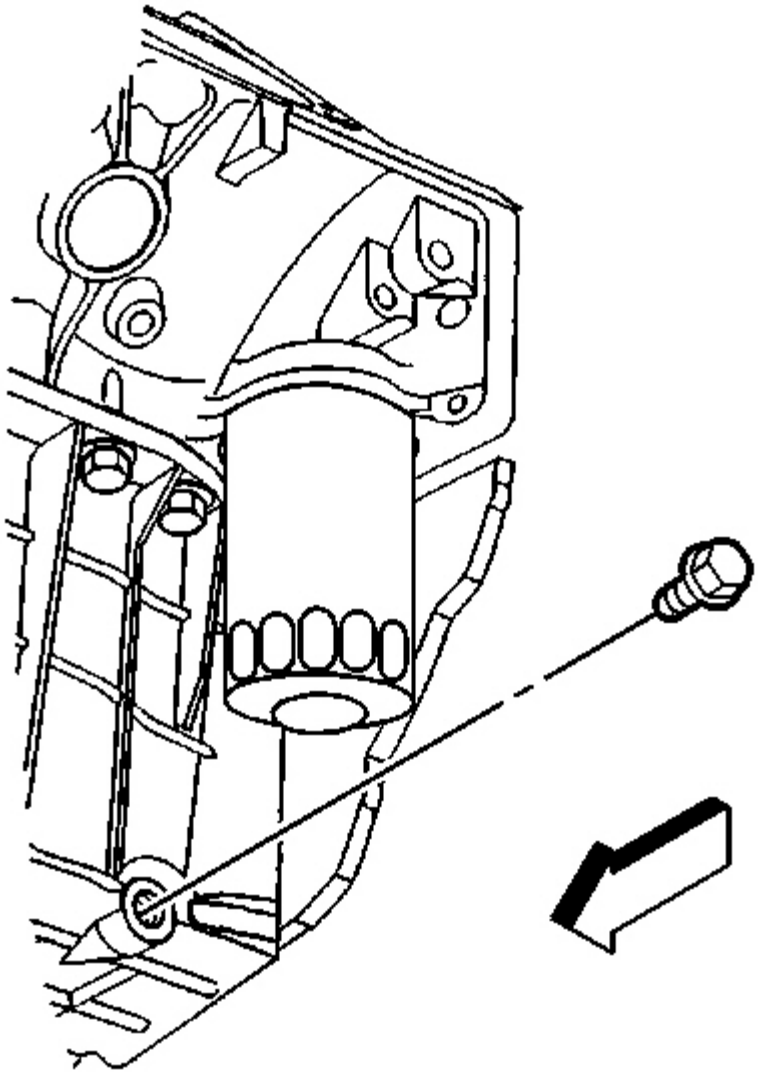


Fig. 358: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the drain plug and drain the engine oil in a suitable container.

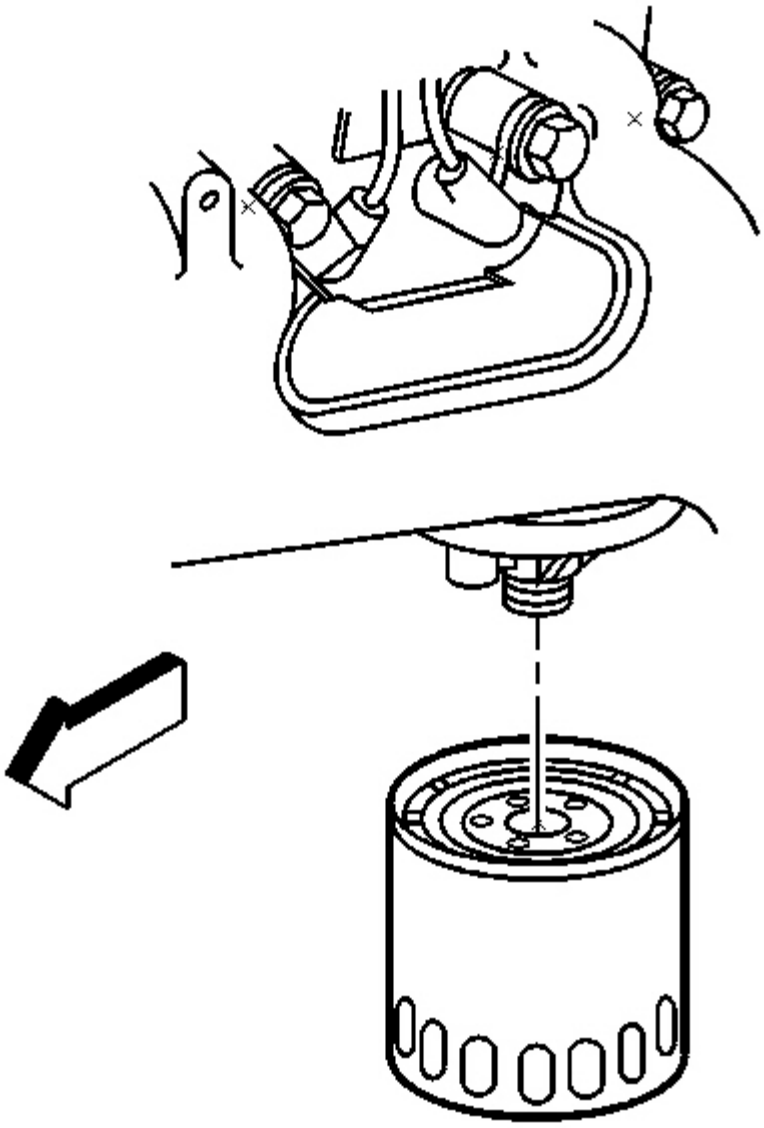


Fig. 359: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.
4. Inspect to ensure the engine oil filter gasket is removed.

Installation Procedure

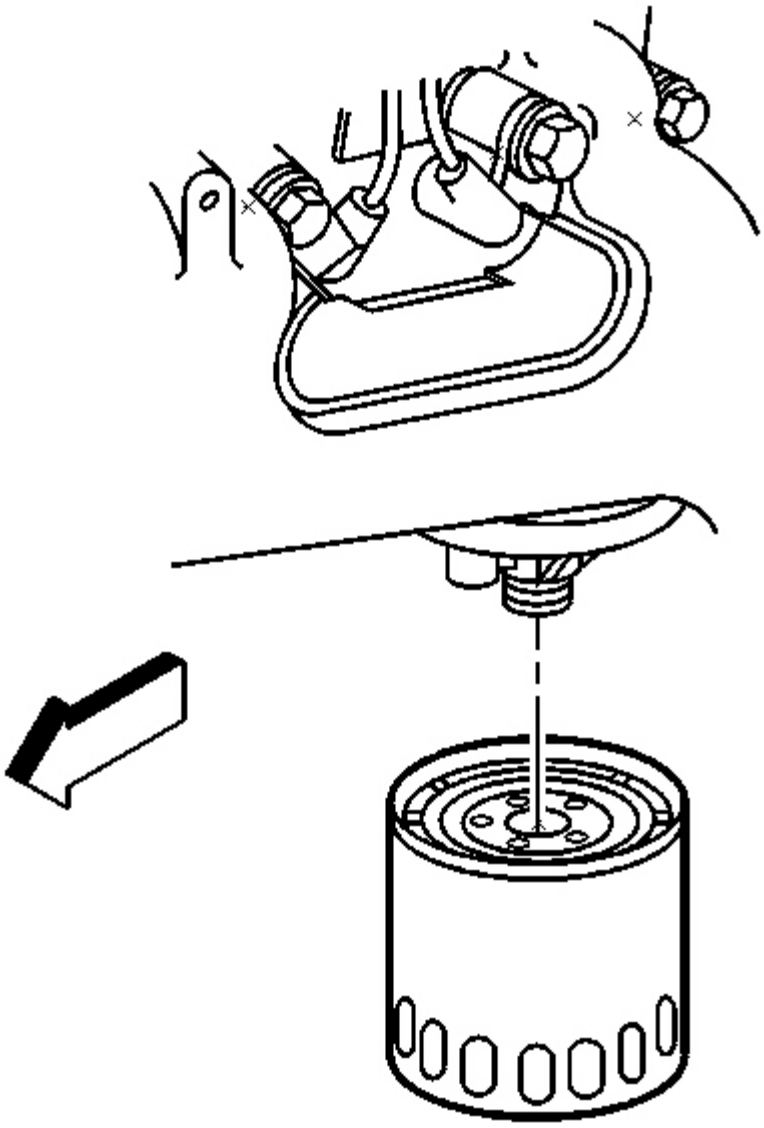


Fig. 360: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Lubricate the oil filter gasket with clean engine oil.
2. Install the oil filter.

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

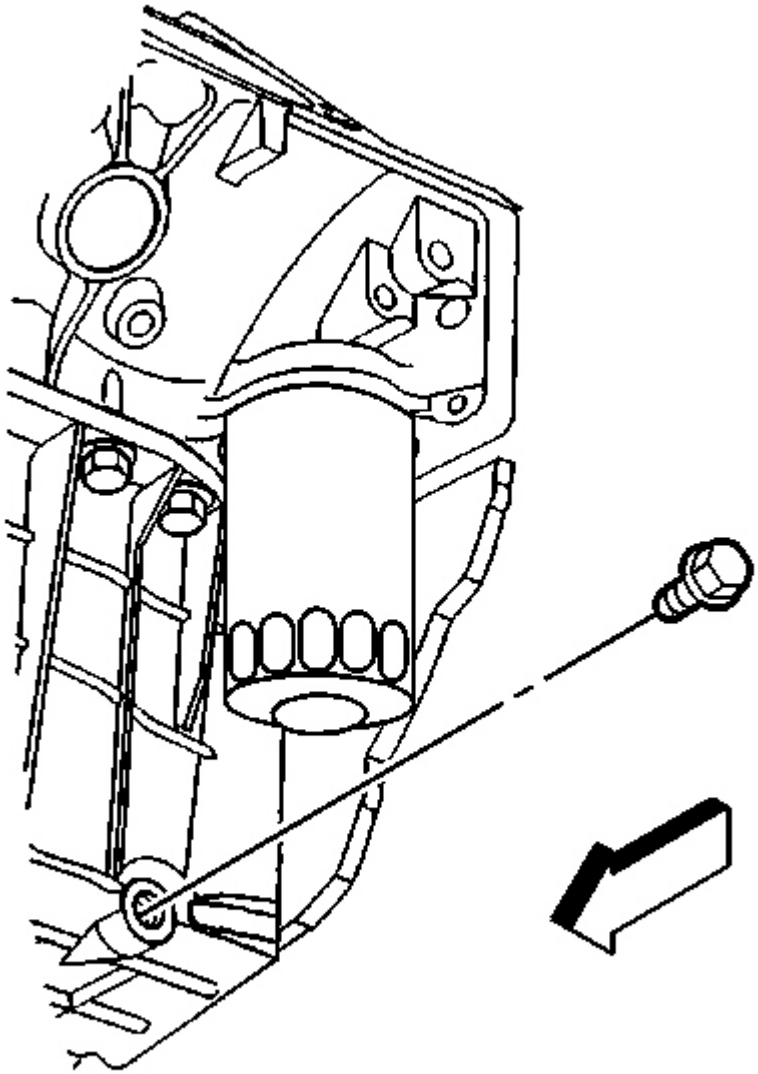


Fig. 361: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Install the drain plug.

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

4. Lower the vehicle.
5. Fill the engine with the proper capacity and quality of engine oil. Refer to **Approximate Fluid Capacities** .
6. Operate the engine, check for leaks, and oil pressure.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

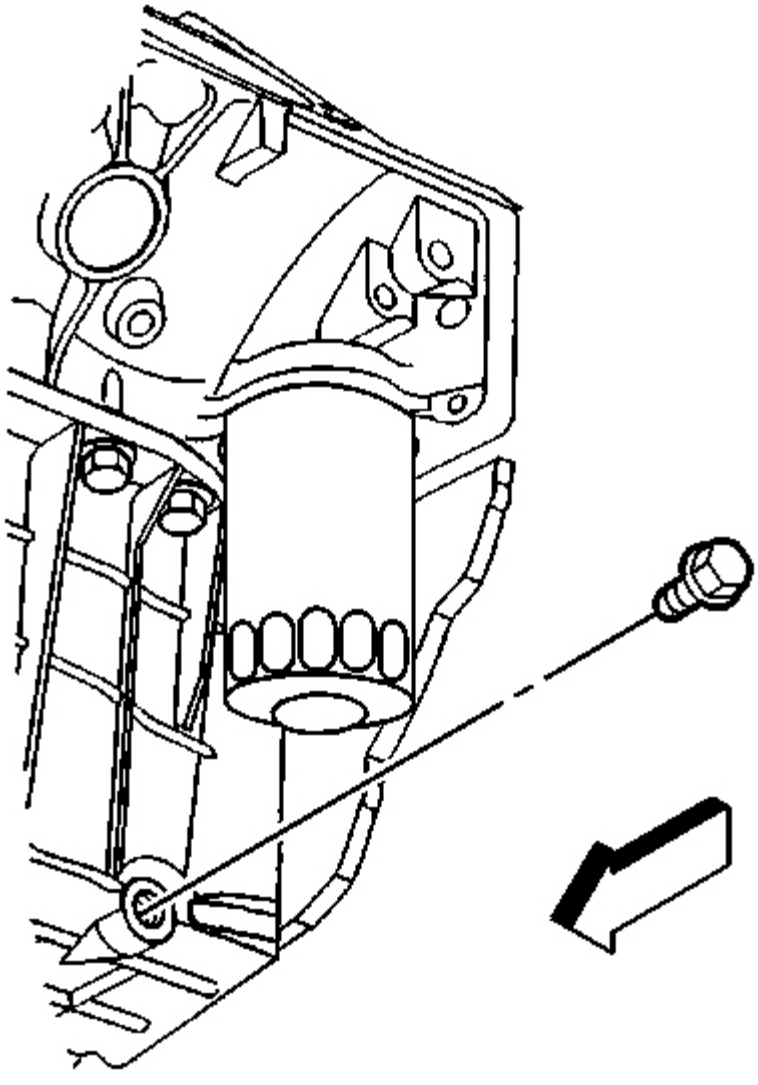


Fig. 362: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug and allow the engine oil to drain into a suitable container.

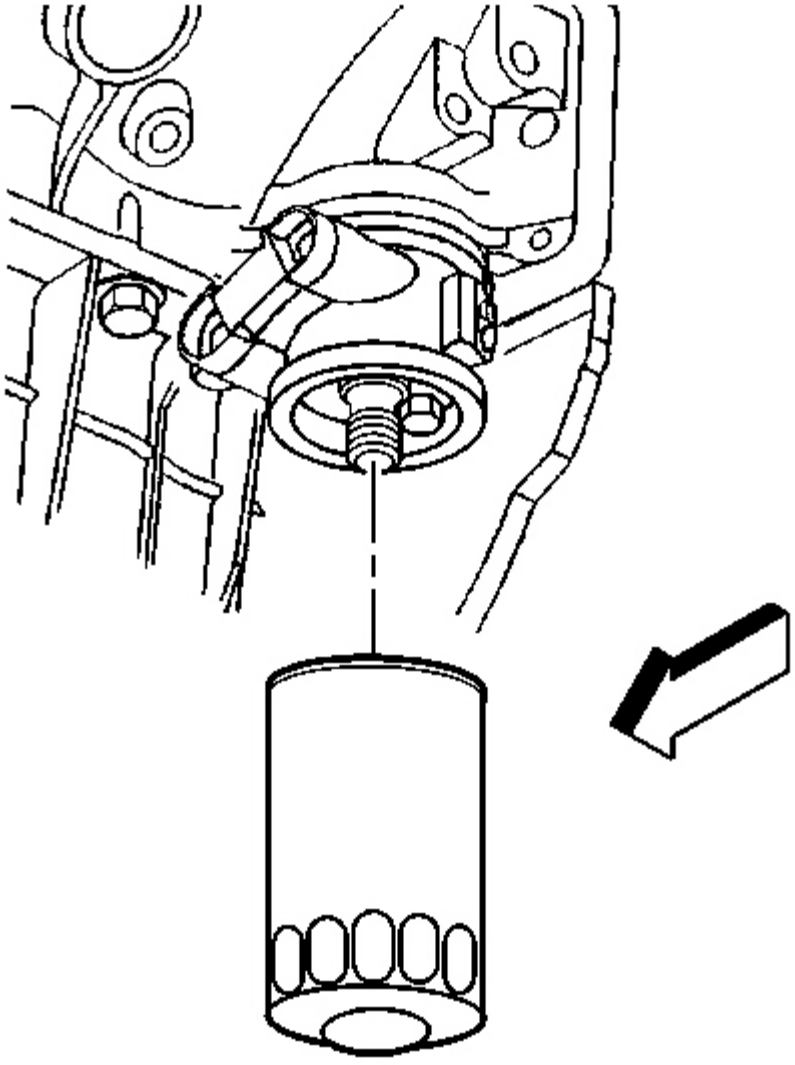


Fig. 363: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter.
3. Discard the oil filter.

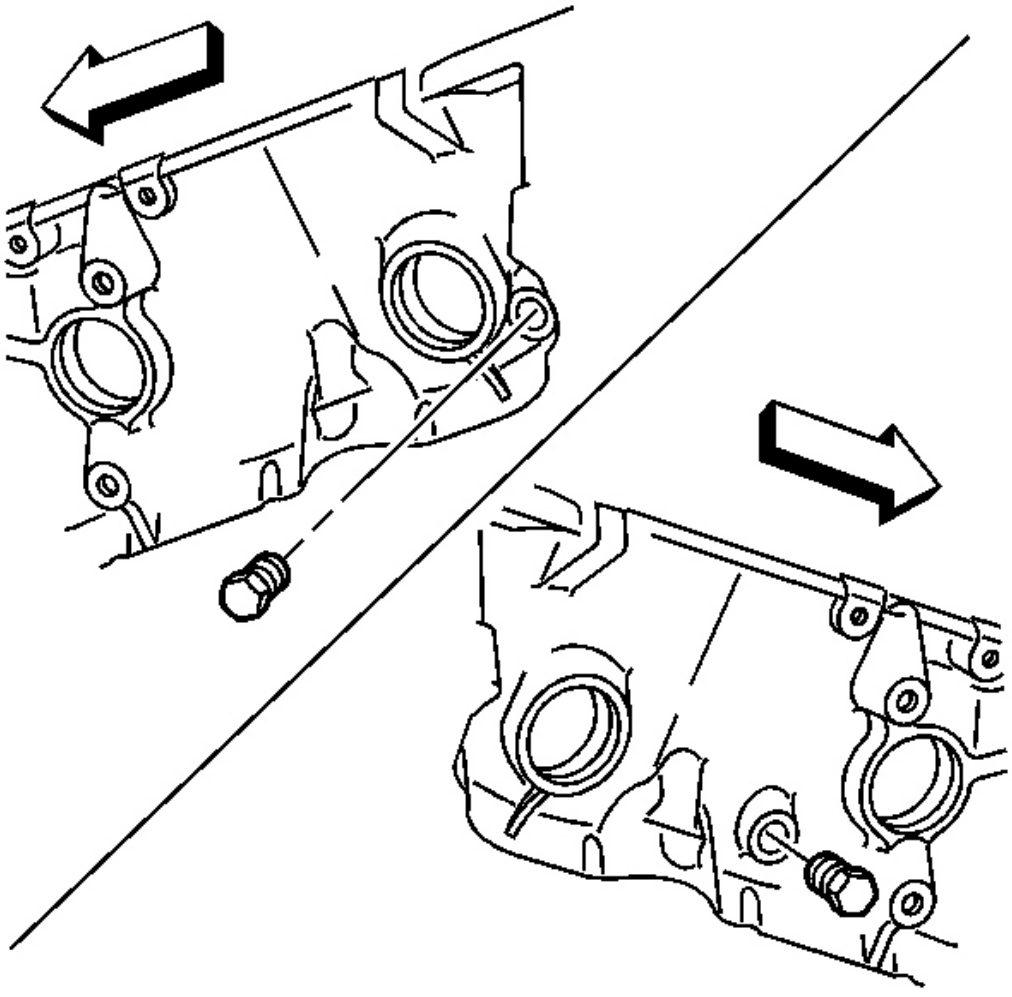


Fig. 364: View Of Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS CORP.

4. Remove both the engine block coolant drain hole plugs and allow the coolant to drain into a suitable container.

ENGINE FLYWHEEL REMOVAL

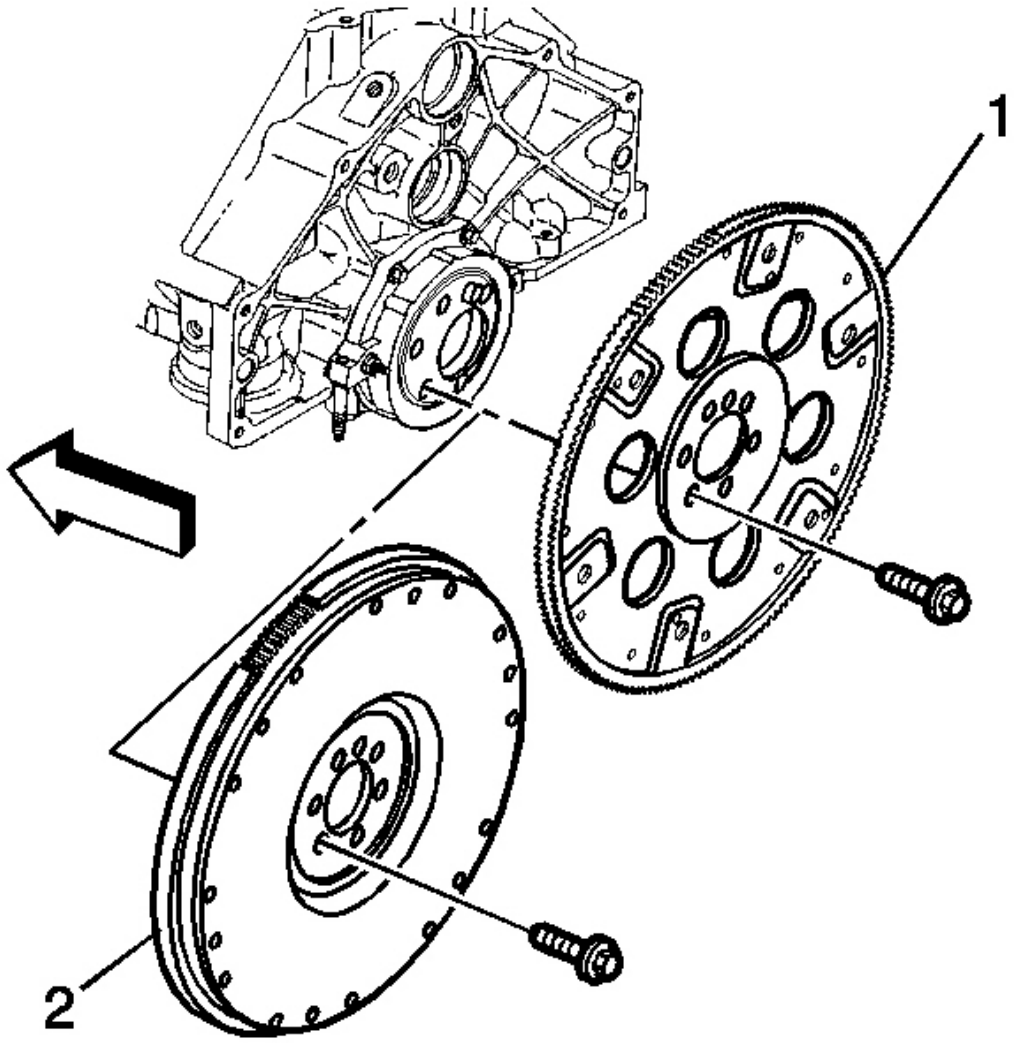


Fig. 365: View Of Flywheels
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel (1), automatic transmission, if applicable.
3. Remove the engine flywheel (2), manual transmission, if applicable.

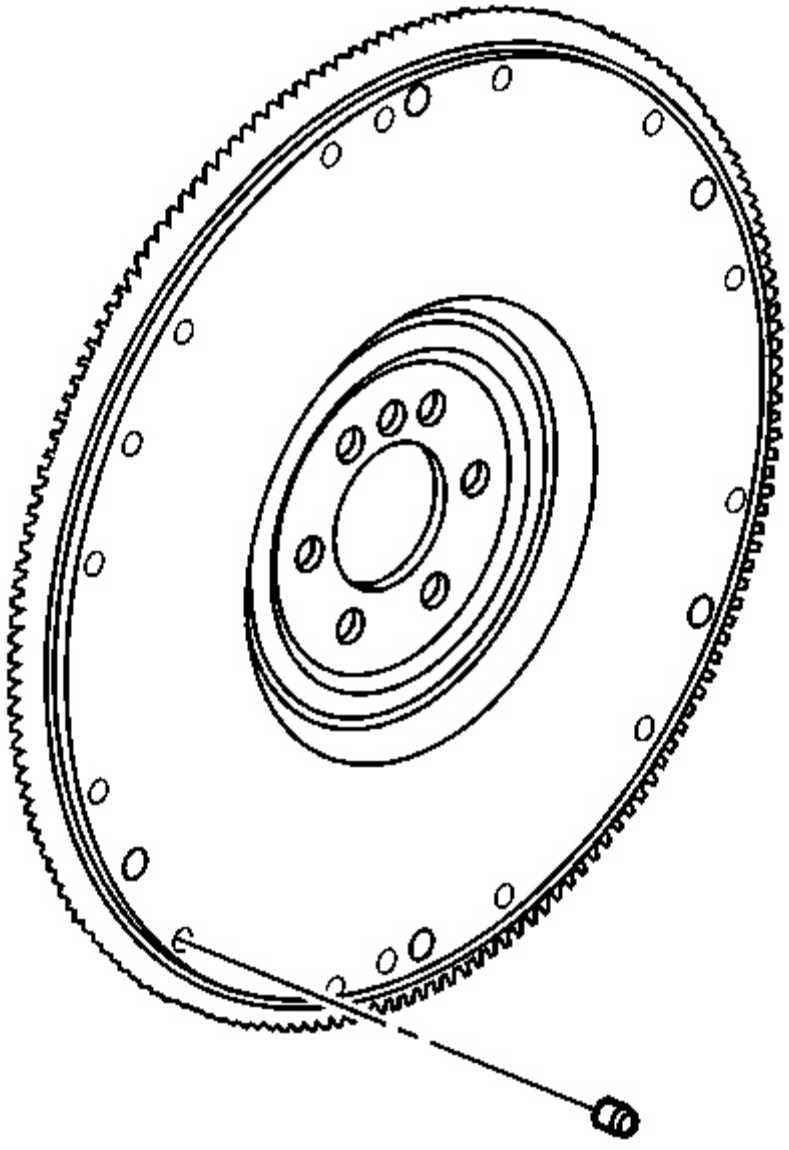


Fig. 366: Locating Flywheel Weights
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If replacing the engine flywheel, manual transmission, NEW flywheel weights must be installed into the NEW engine flywheel in the same location as the old flywheel weights in

the old engine flywheel.

4. Note the position of any flywheel weights for assembly, if applicable.

CLUTCH PILOT BEARING REMOVAL

Tools Required

J 43276 Clutch Pilot Bearing Remover. See **Special Tools**.

Removal

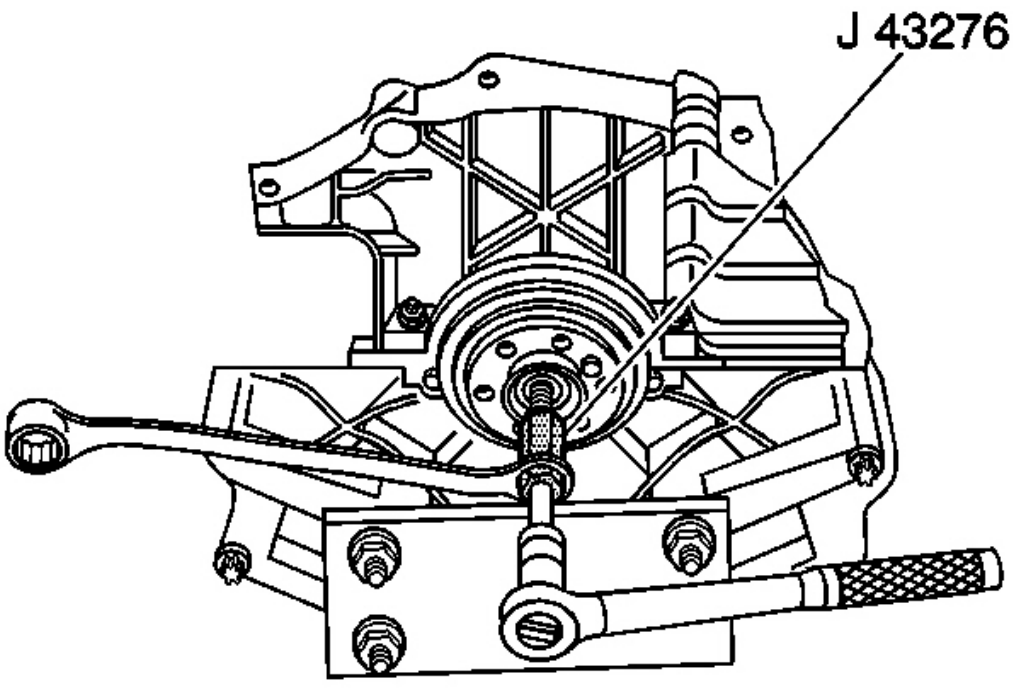


Fig. 367: Removing Clutch Pilot Bearing Using J 43276
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

NOTE: When using the J 43276 Clutch Pilot Bearing Remover, always

secure the J 43276-1 Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the J 43276-1 tool body to rotate. Failing to do so causes damage to the J 43276-1 tool body.

1. Remove the clutch pilot bearing using the **J 43276** . See **Special Tools**.
    1. Install the J 43276-1 tool body into the clutch pilot bearing.
    2. Using a wrench secure the J 43276-1 tool body.
    3. Insert the J 43276-2 forcing screw into the J 43276-1 tool body.
    4. Rotate the J 43276-2 forcing screw clockwise into the J 43276-1 tool body until the clutch pilot bearing is completely removed from the crankshaft.
    5. Rotate the J 43276-2 forcing screw counterclockwise to remove the J 43276-2 forcing screw from the J 43276-1 tool body.
    6. Remove the J 43276-1 tool body from the clutch pilot bearing.
2. Discard the clutch pilot bearing.

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

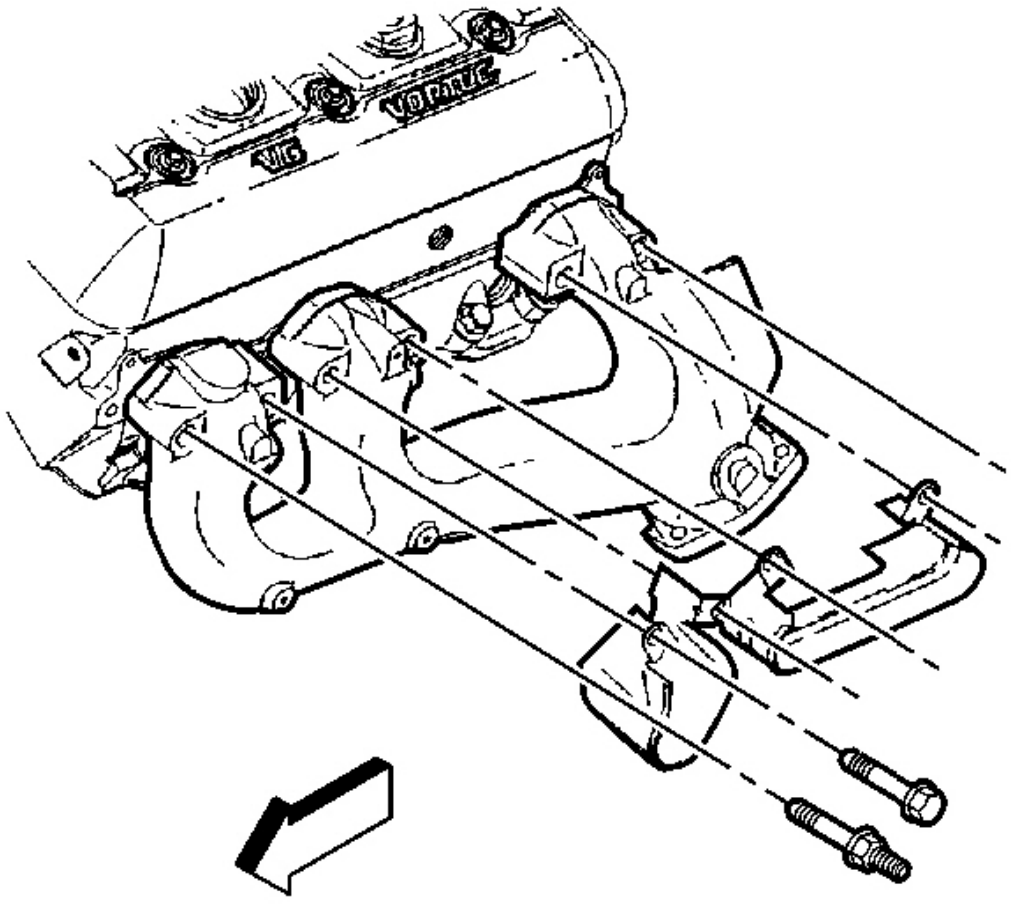


Fig. 368: View Of Exhaust Manifold Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
    1. Rotate the spark plug wire boot one half turn.
    2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the spark plug wires from the spark plug wire retainers.

3. Remove the exhaust manifold bolts and the stud.
4. Remove the spark plug wire shields, if applicable, and the exhaust manifold.

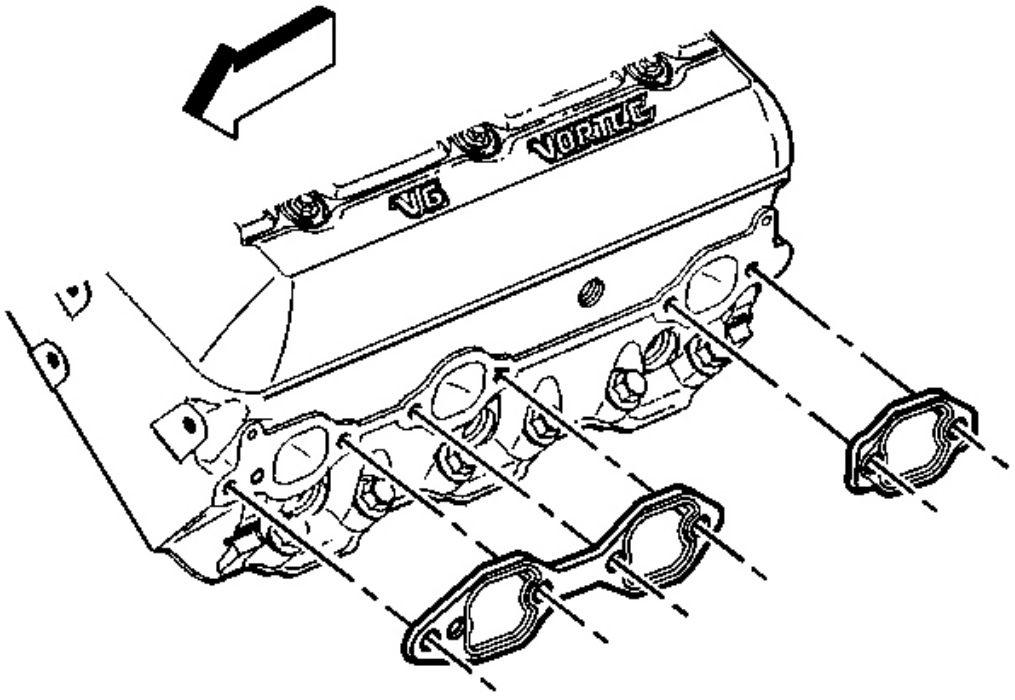


Fig. 369: Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the exhaust manifold gaskets.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

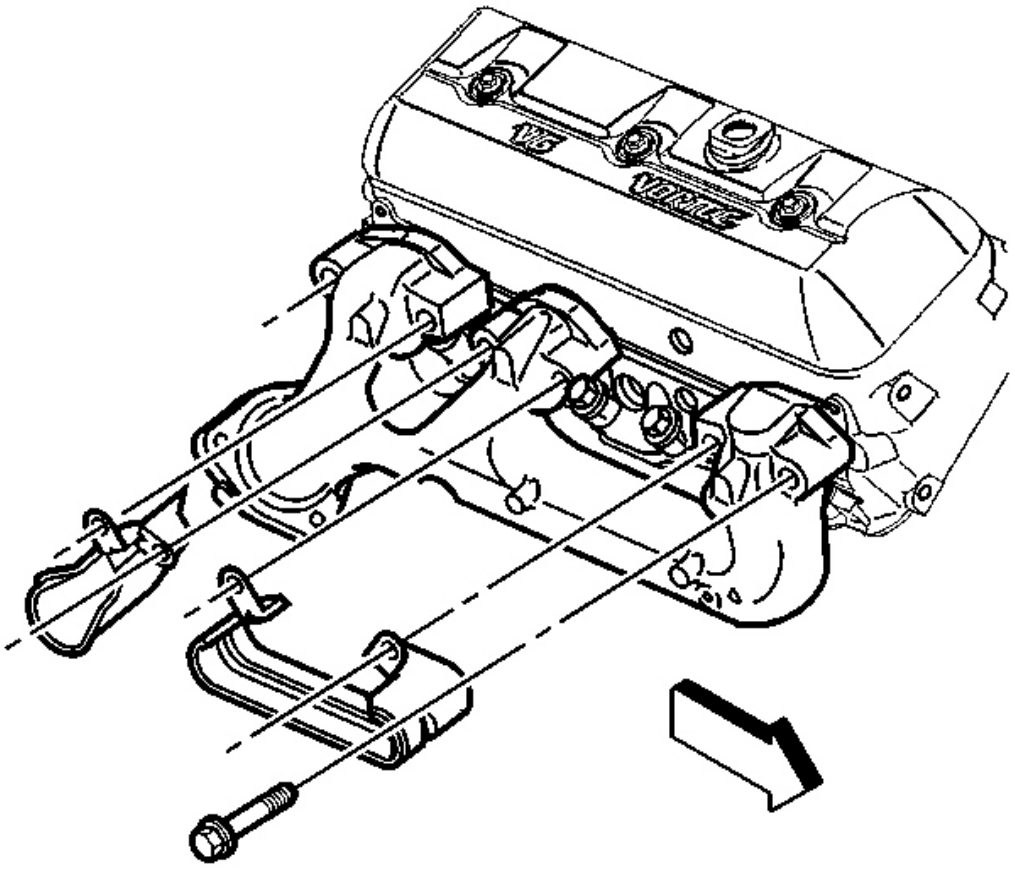


Fig. 370: Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
    1. Rotate the spark plug wire boot one half turn.
    2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the spark plug wires from the spark plug wire retainers.
3. Remove the exhaust manifold bolts.

4. Remove the spark plug wire shields and the exhaust manifold.

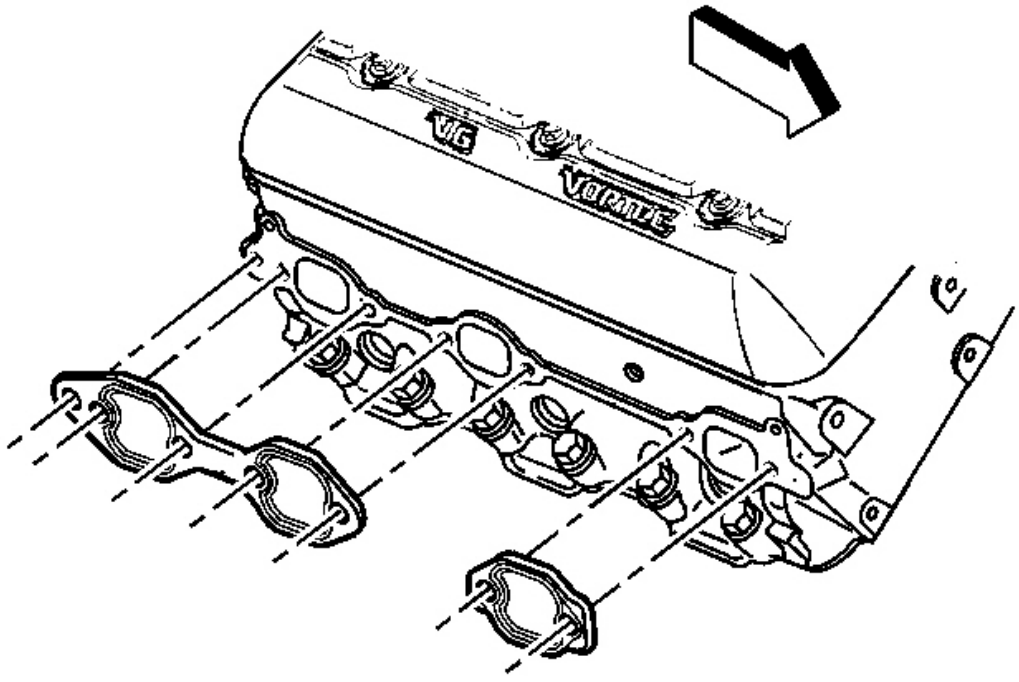


Fig. 371: Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the exhaust manifold gaskets.

OIL LEVEL INDICATOR AND TUBE REMOVAL

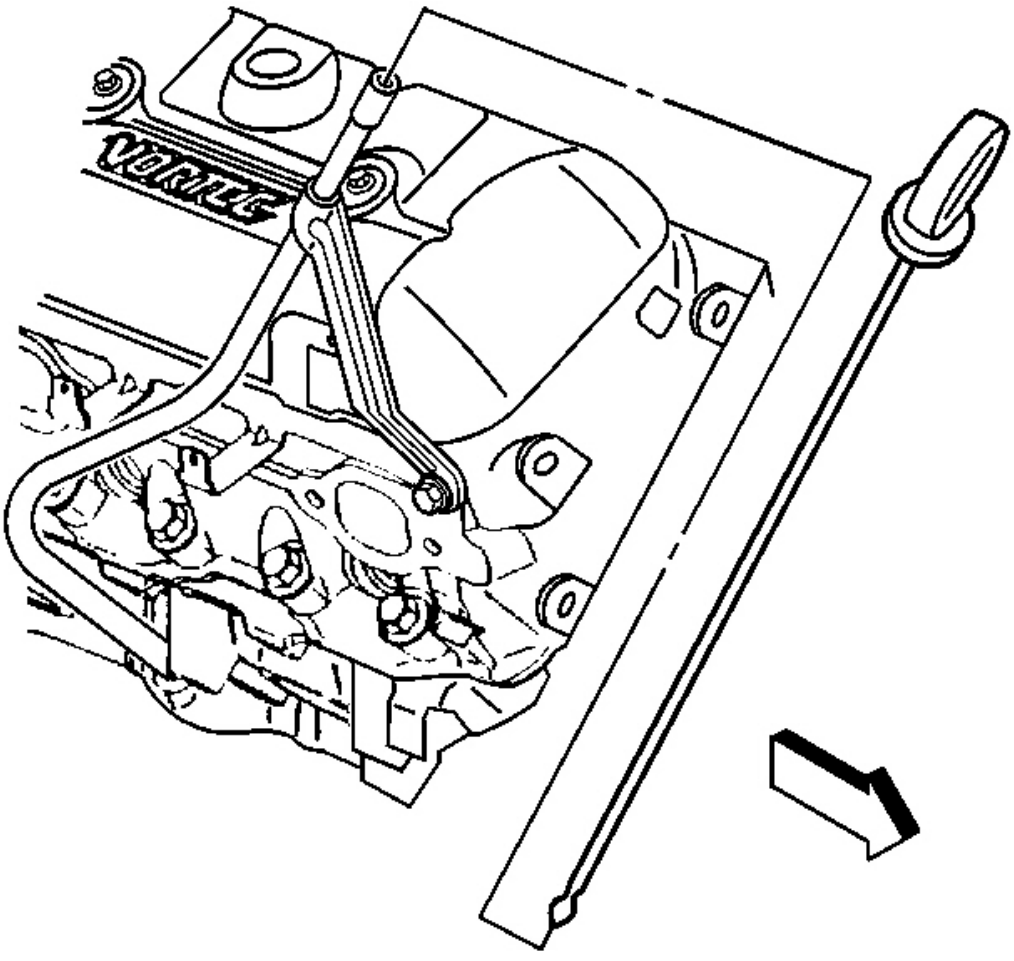


Fig. 372: Locating Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the oil level indicator tube, if required.

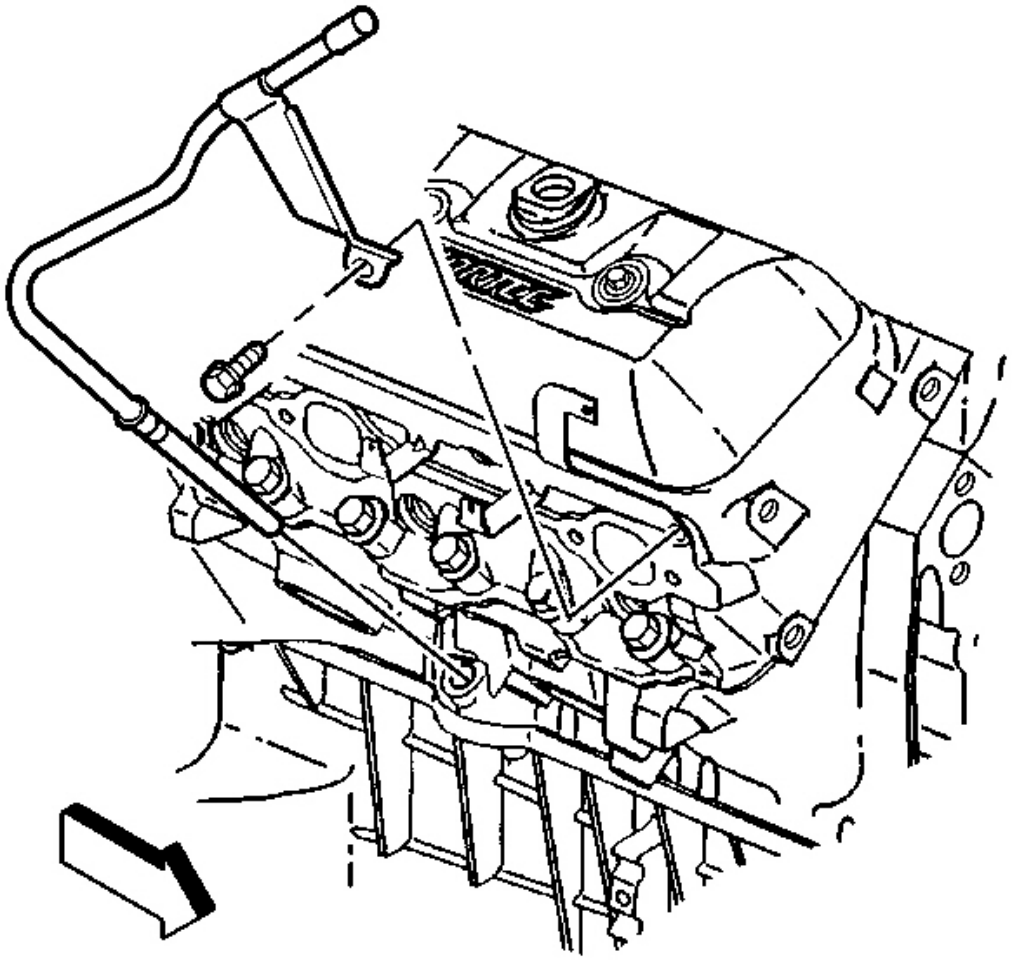


Fig. 373: View Of Oil Level Indicator Tube Bolt
Courtesy of GENERAL MOTORS CORP.

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

WATER PUMP REMOVAL

Tools Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools**.

Removal

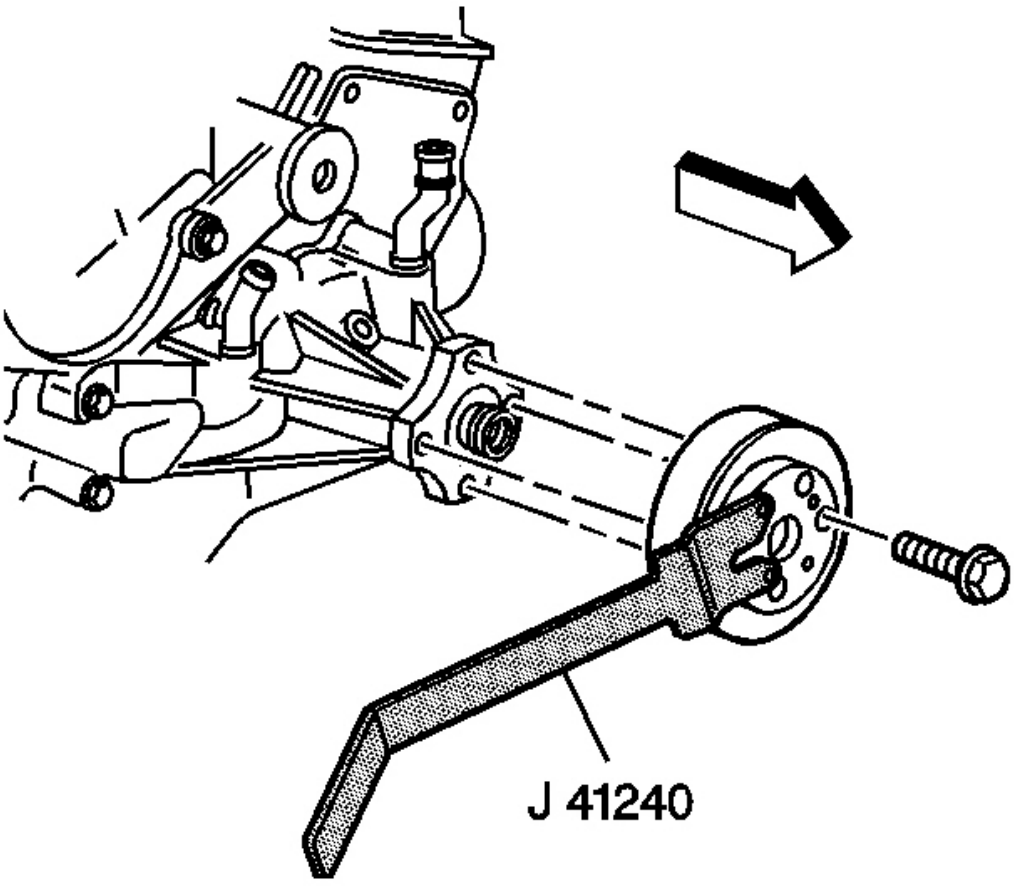


Fig. 374: View Of Fan, Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts and the fan and water pump pulley using the **J 41240** . See **Special Tools**.

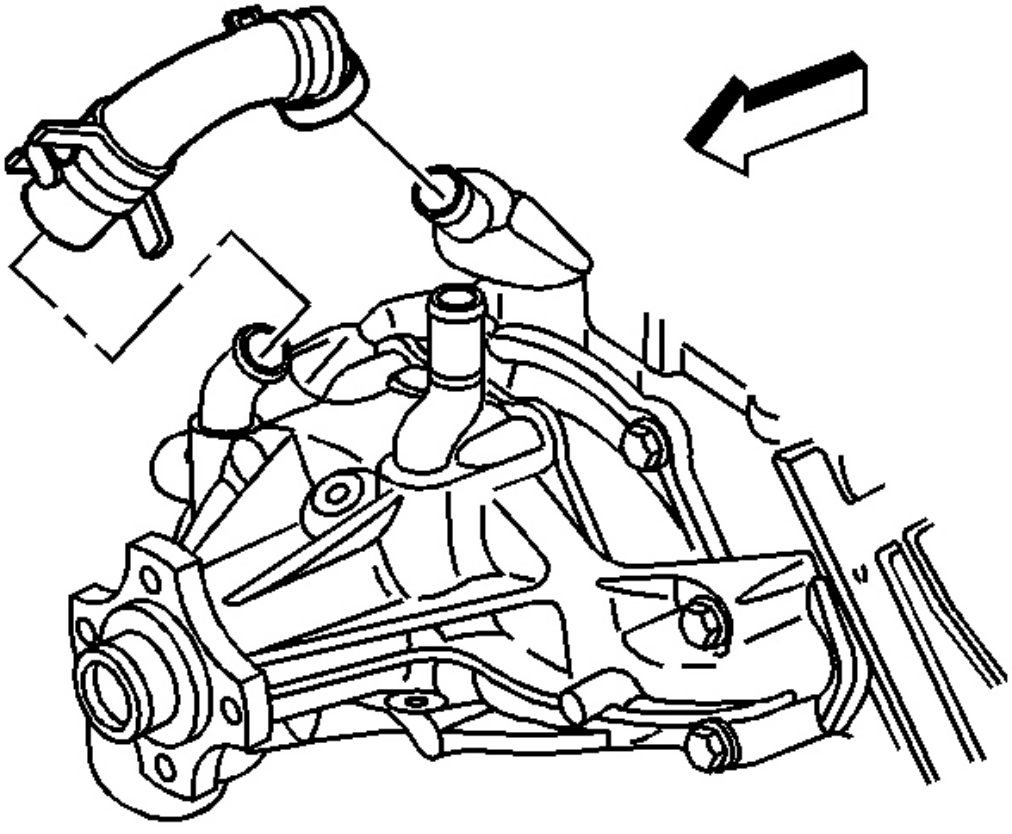


Fig. 375: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

2. Remove the clamps and the water pump inlet hose.

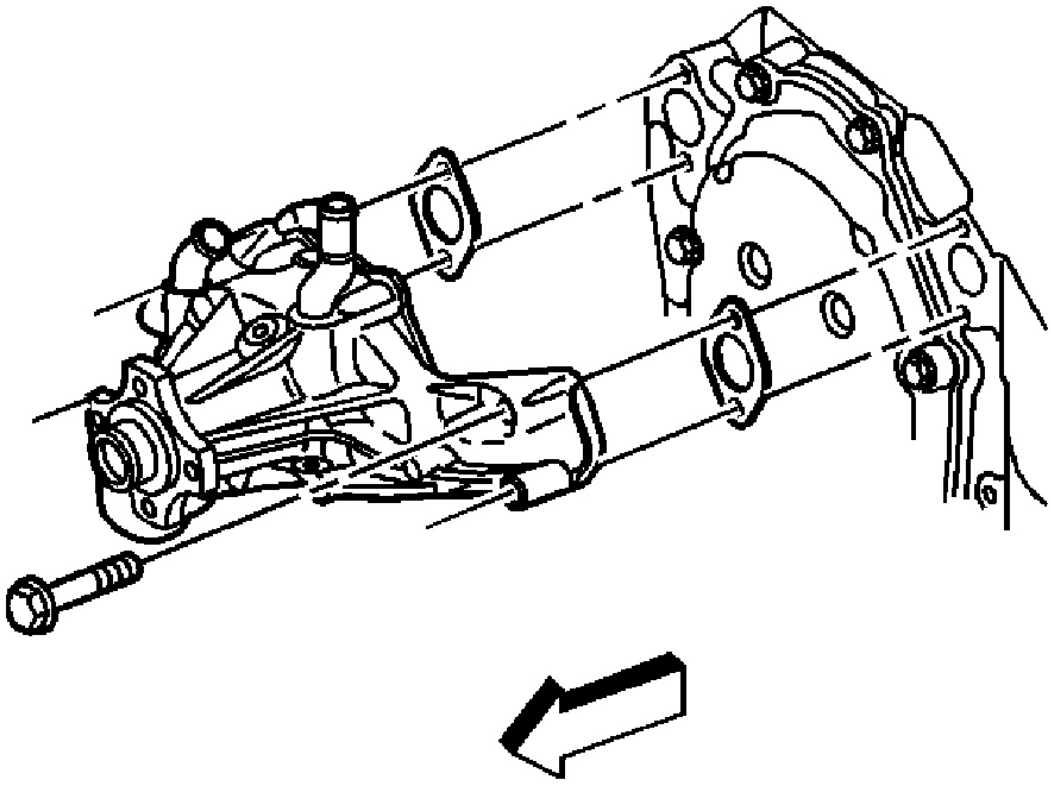


Fig. 376: View Of Water Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gaskets.
6. Discard the water pump gaskets.

CRANKSHAFT BALANCER REMOVAL

Tools Required

J 23523-F Balancer Remover and Installer

Removal

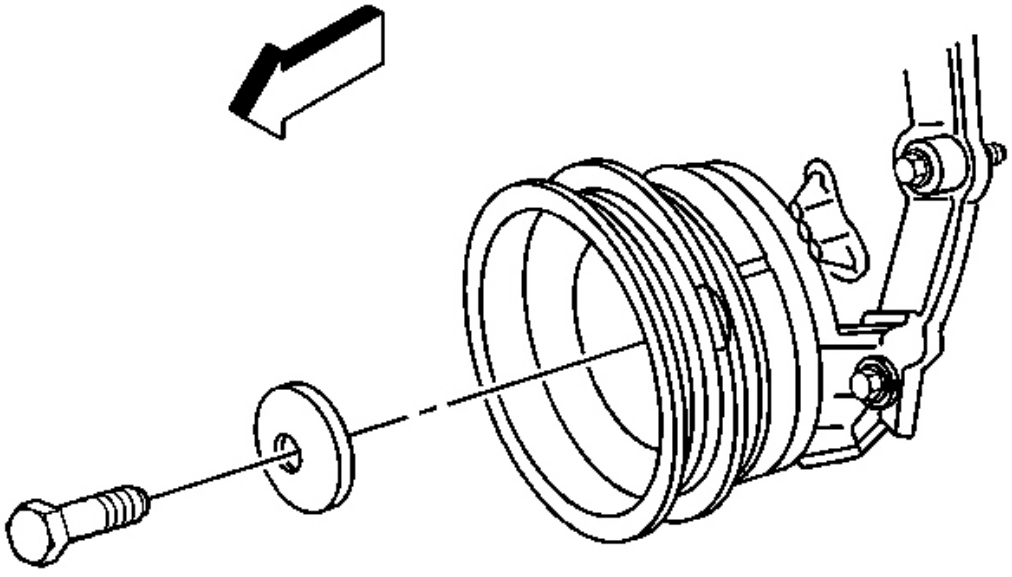


Fig. 377: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt and washer.

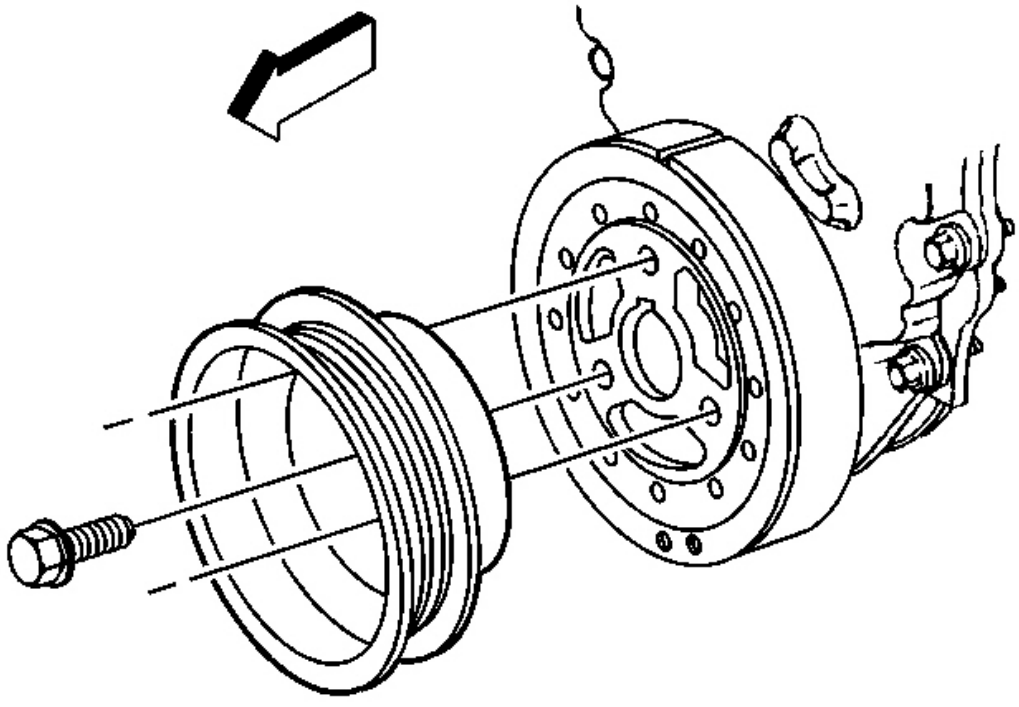


Fig. 378: View Of Crankshaft Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts and the crankshaft pulley.

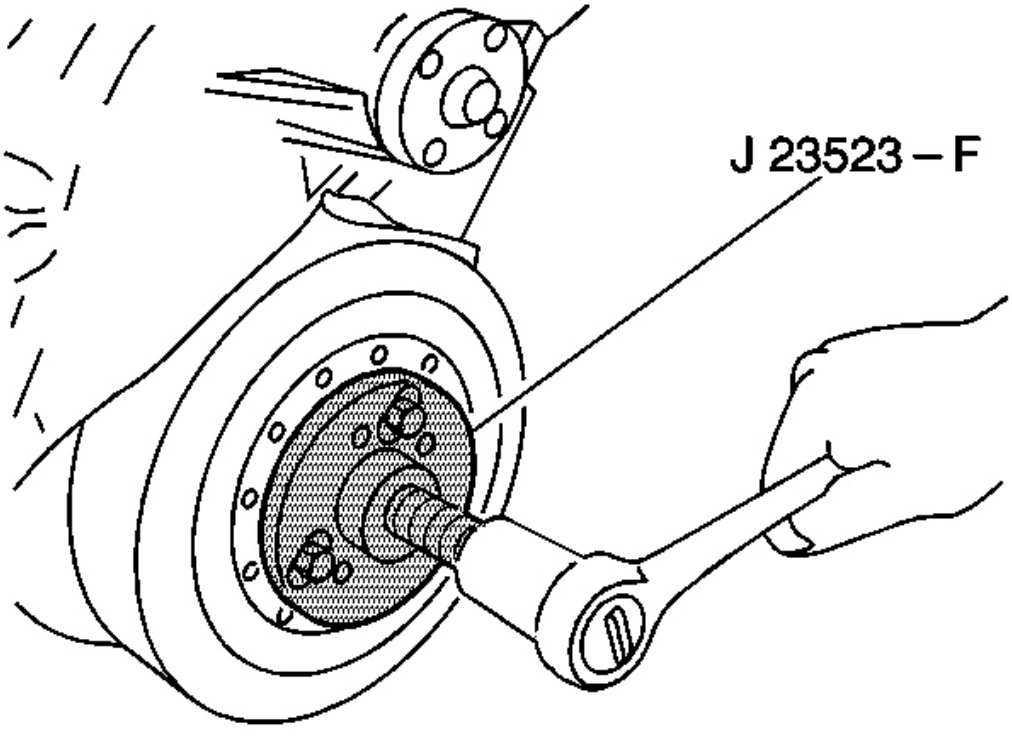


Fig. 379: Removing Crankshaft Balancer Using J 23523-F
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Use the **J 23523-F** in order to remove the crankshaft balancer.
    1. Install the **J 23523-F** plate and bolts onto the crankshaft balancer.

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

    2. Install the **J 23523-F** forcing screw into the plate.
    3. Rotate the **J 23523-F** forcing screw clockwise in order to remove the crankshaft balancer.
4. Remove the **J 23523-F** from the crankshaft balancer.

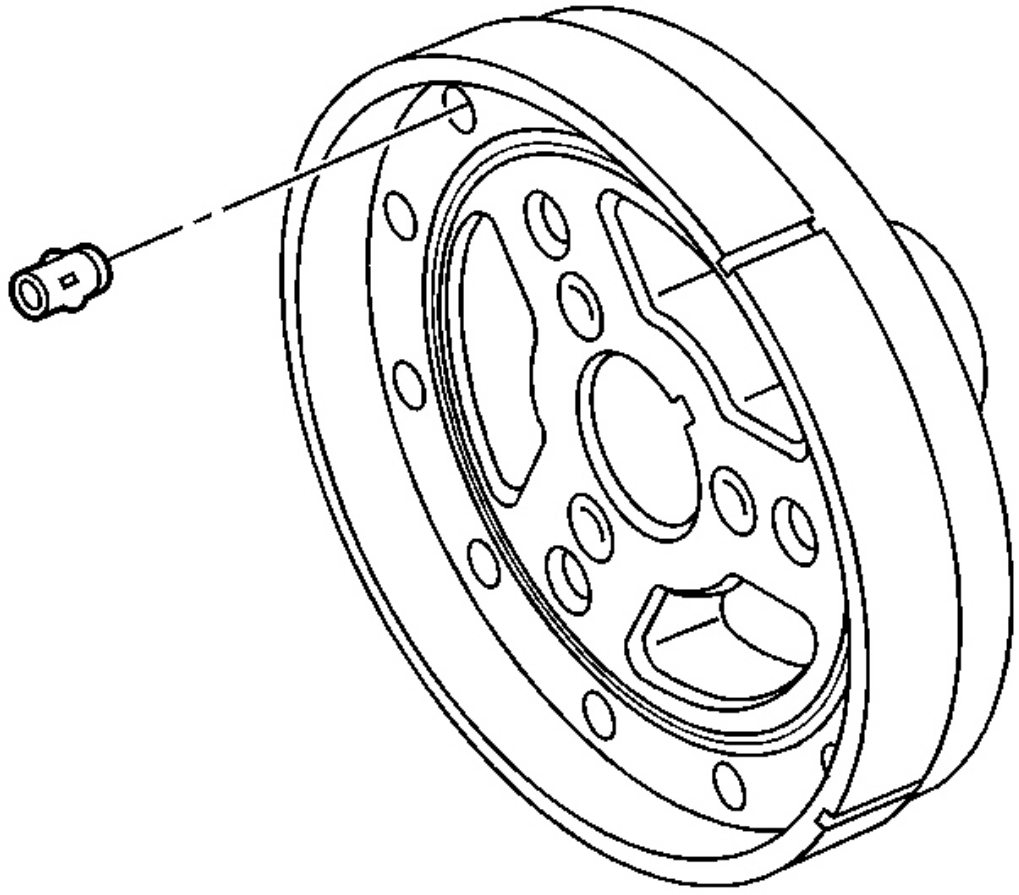


Fig. 380: View Of Crankshaft Balancer Weights
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If replacing the crankshaft balancer, NEW weights must be installed into the NEW crankshaft balancer, in the same location as the old weights in the old balancer.

5. Note the position and length of any crankshaft balancer front groove pins, if applicable.

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

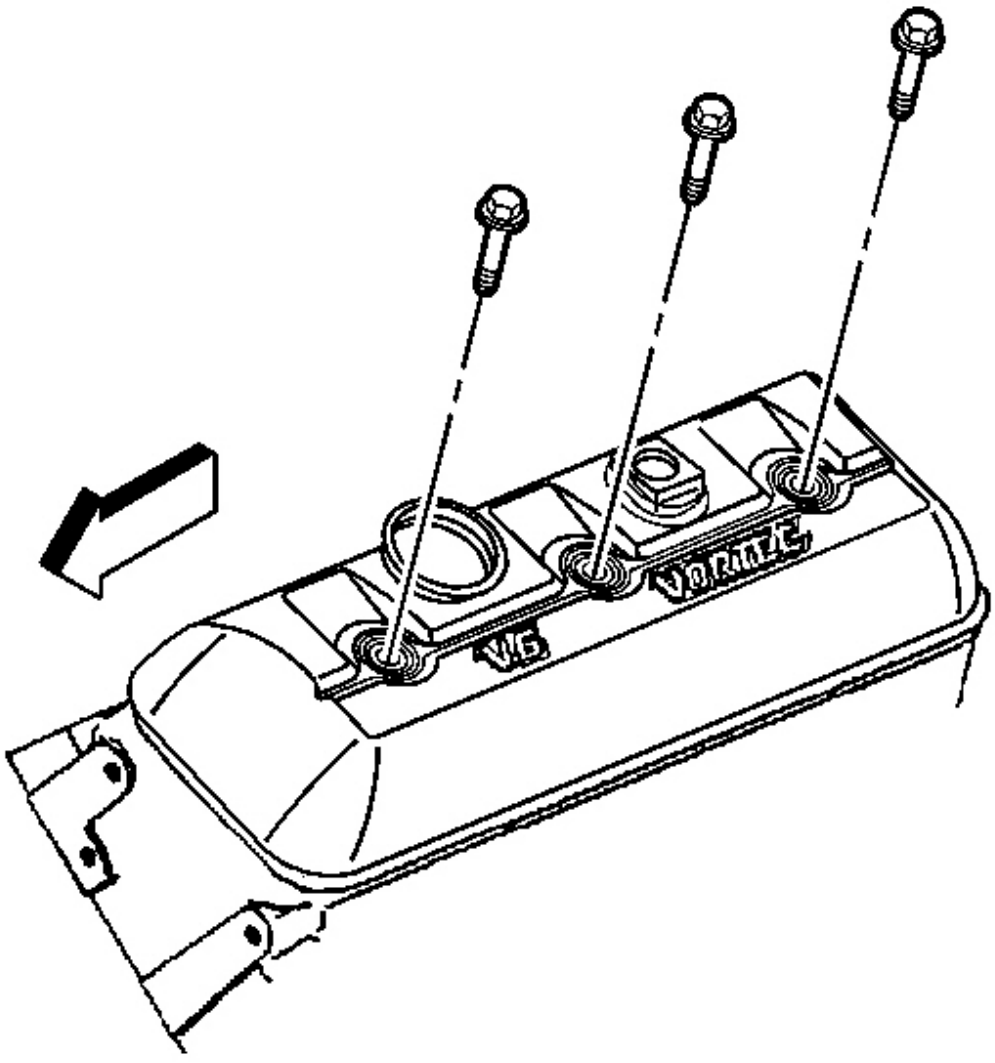


Fig. 381: Valve Rocker Arm Cover Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

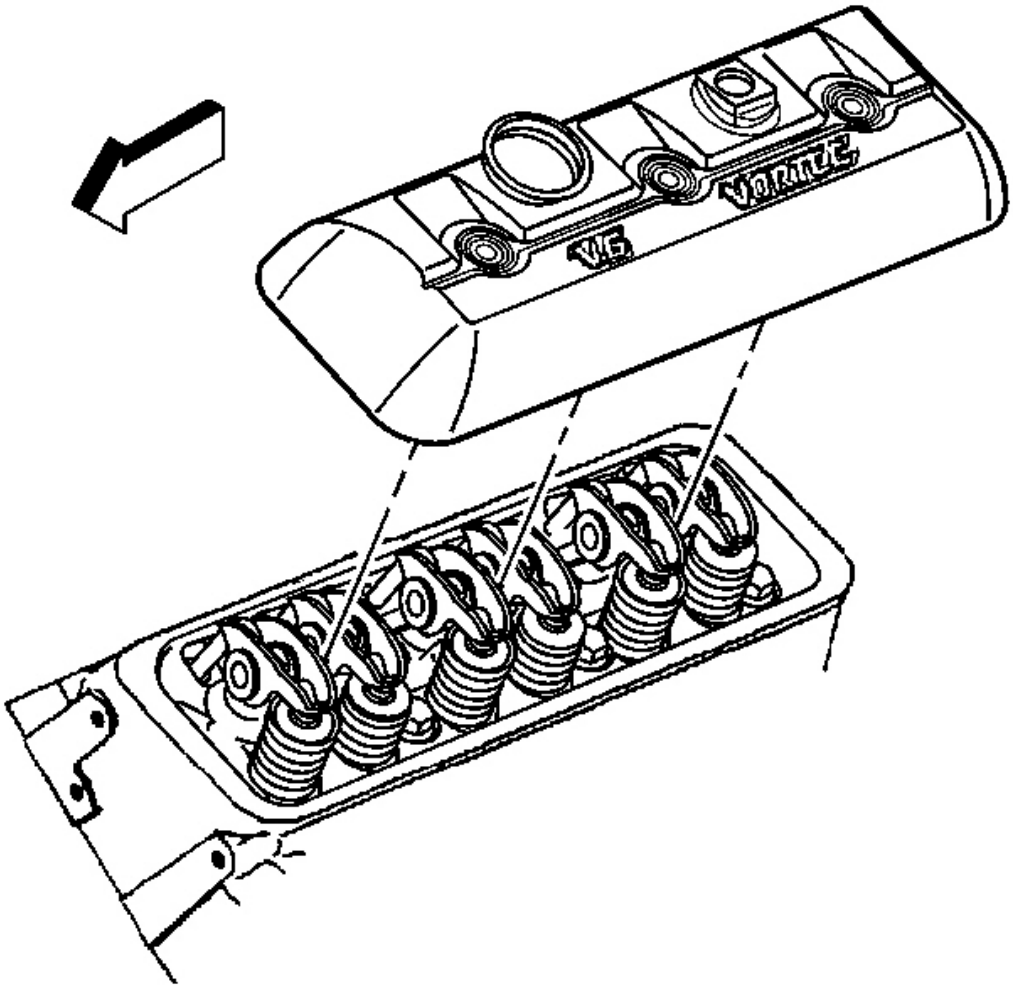


Fig. 382: Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm cover.

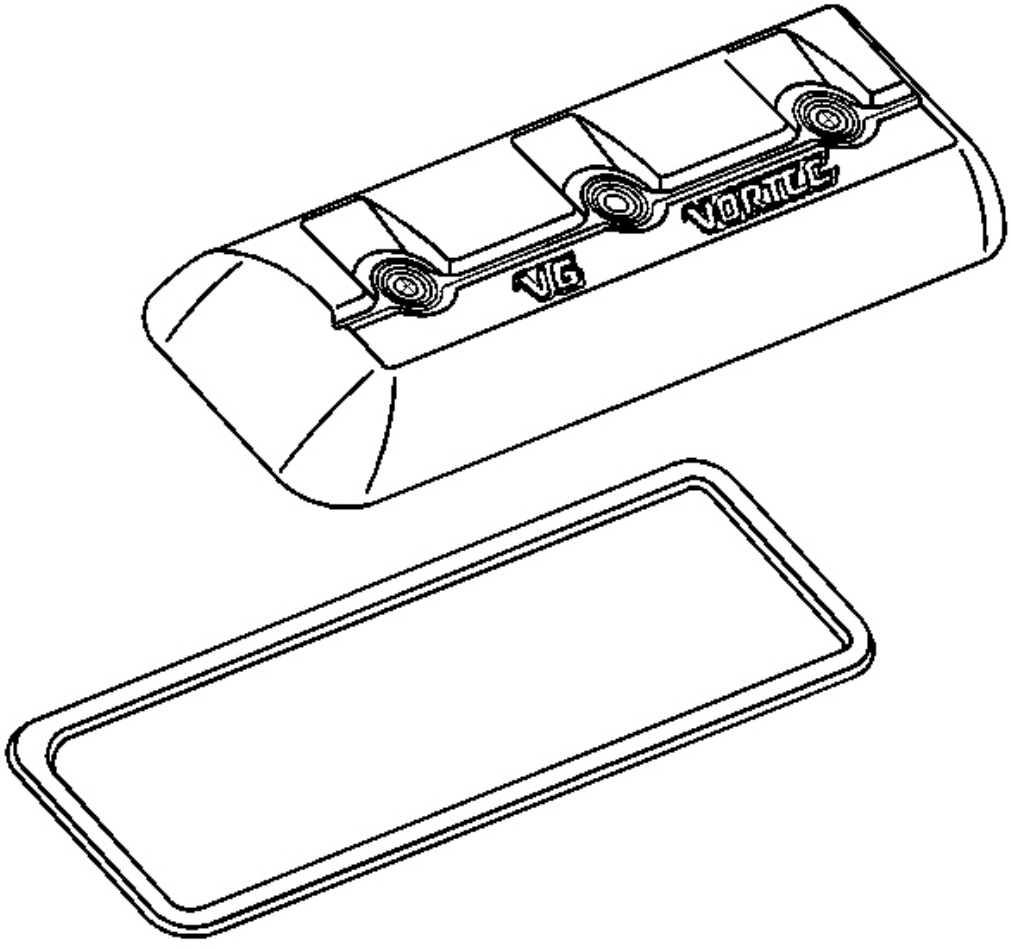


Fig. 383: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

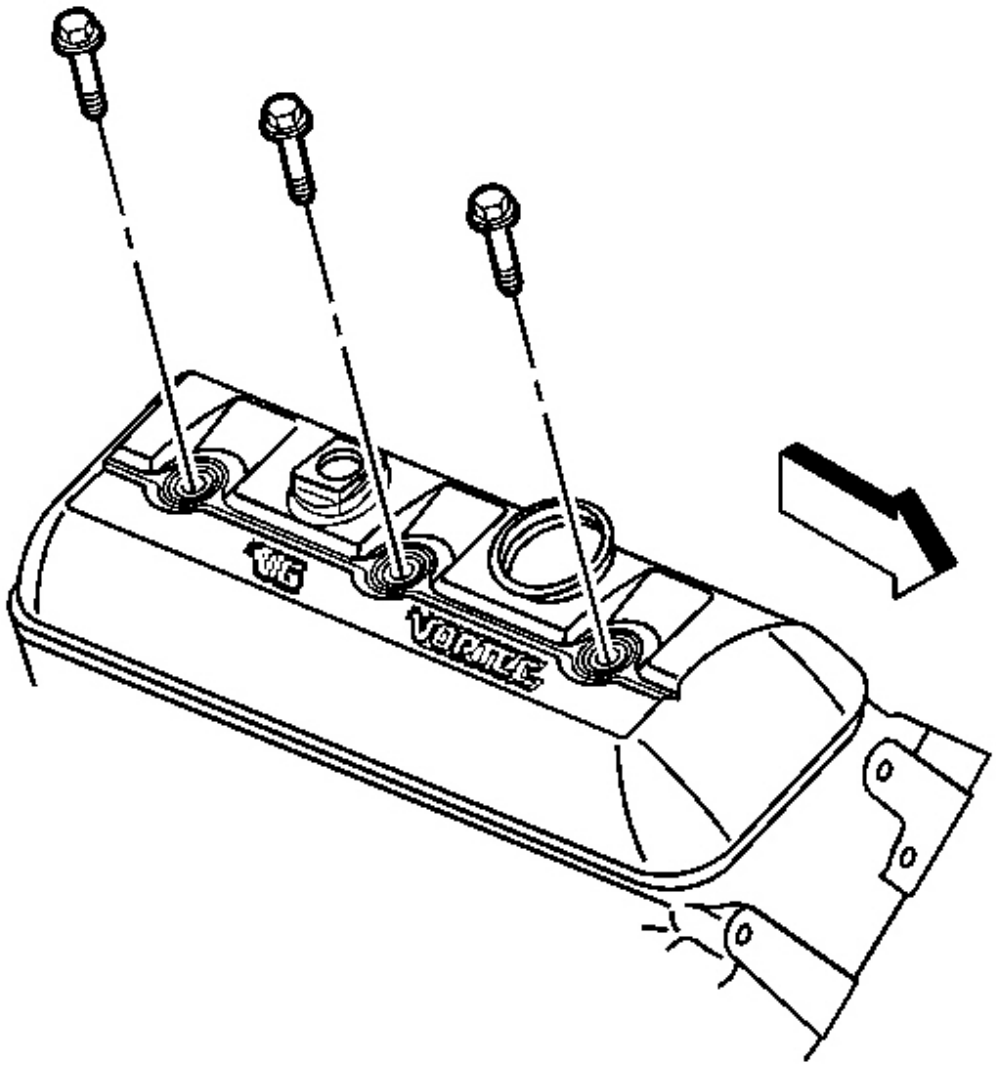


Fig. 384: View Of Valve Rocker Arm Cover Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

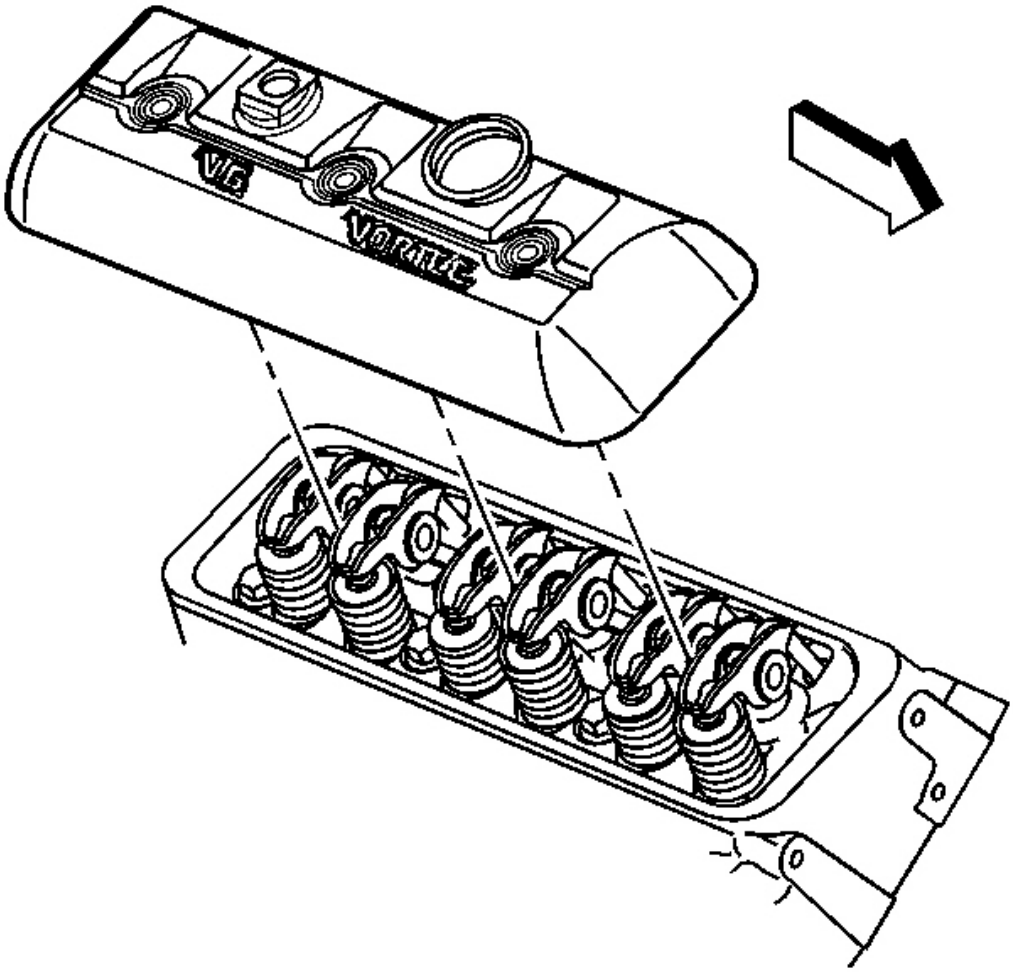


Fig. 385: Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm cover.

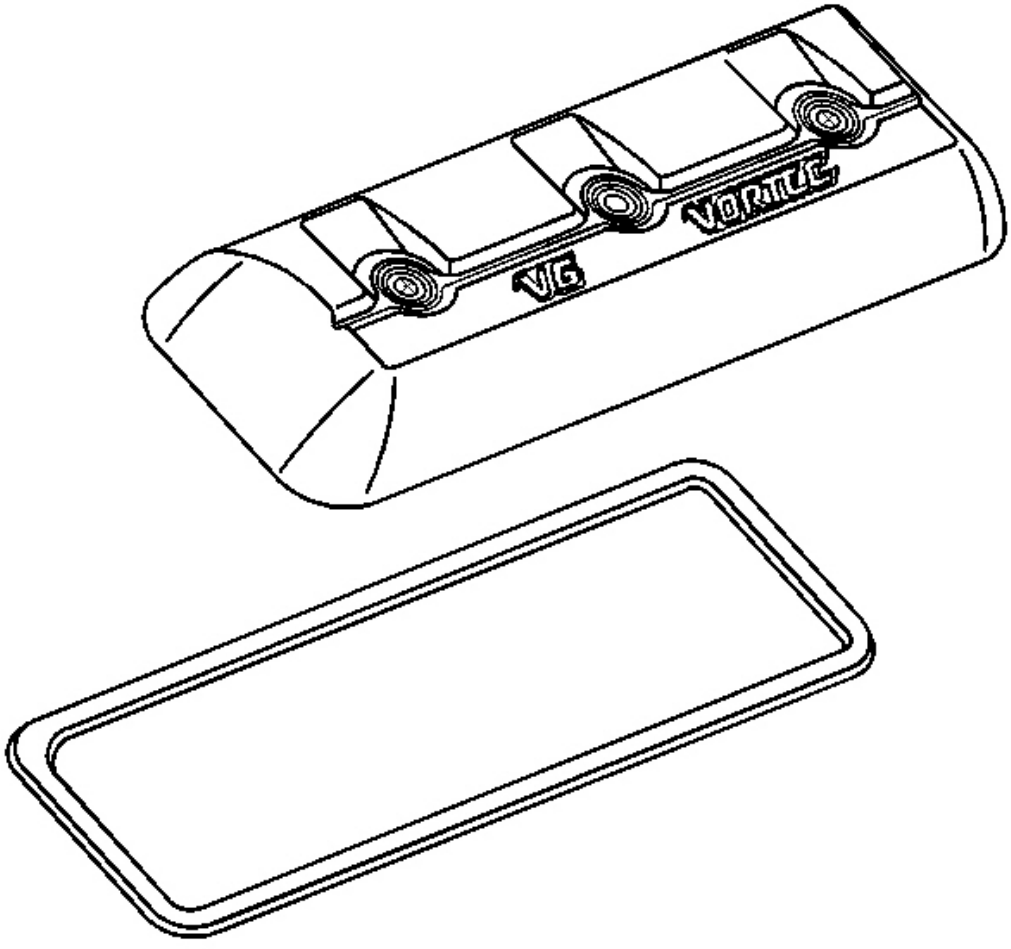


Fig. 386: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

INTAKE MANIFOLD REMOVAL

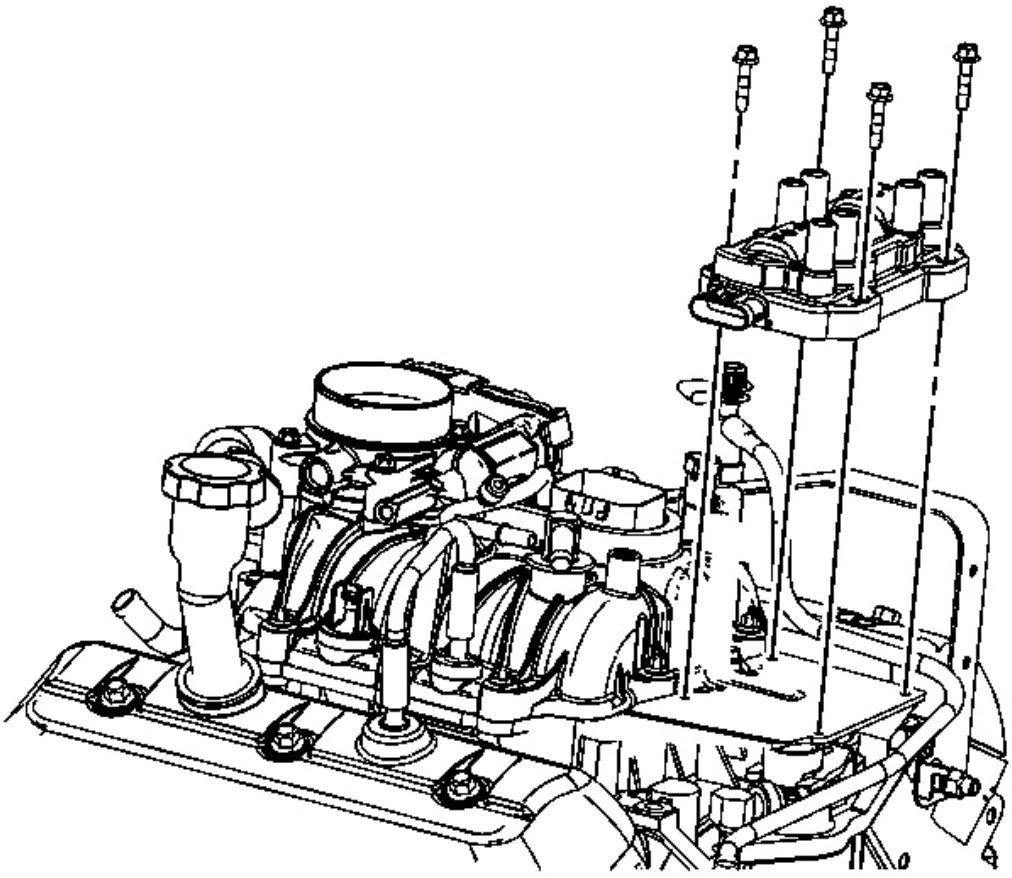


Fig. 387: View Of Ignition Coil & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil bolts and coil from the bracket.

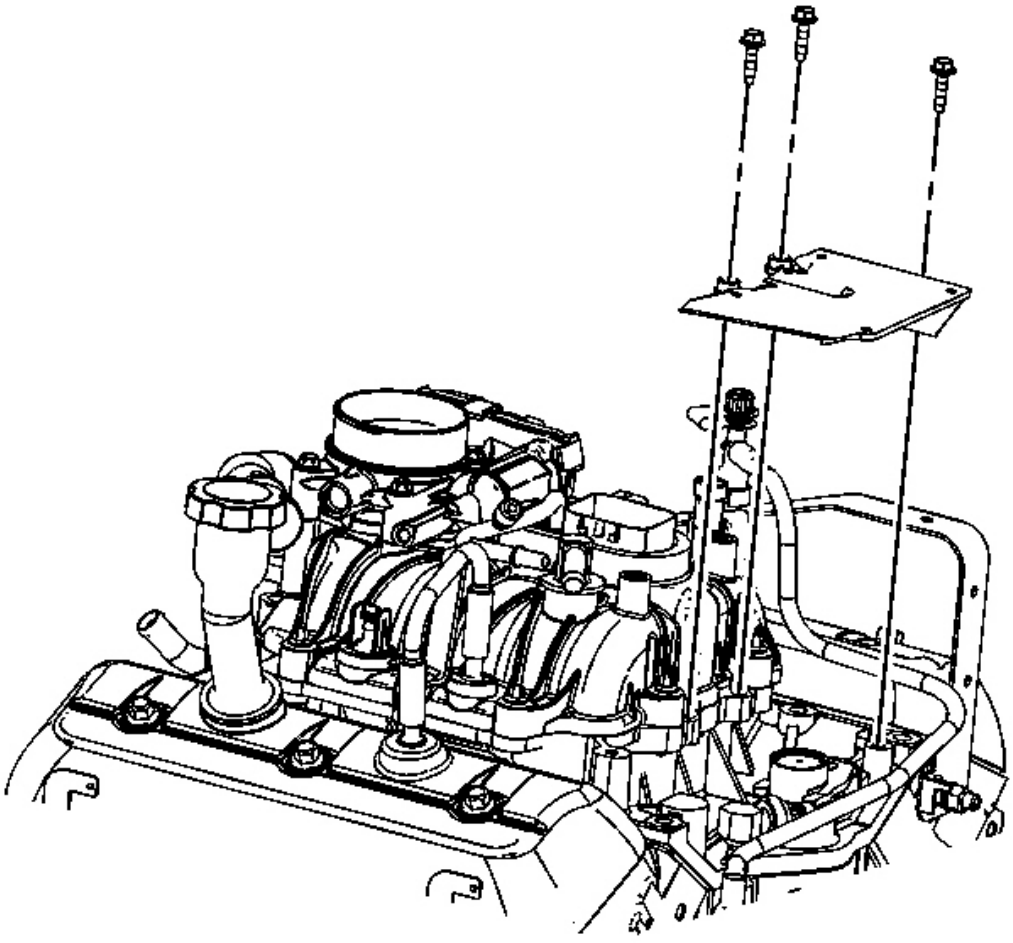


Fig. 388: View Of Ignition Coil Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. If required, remove the ignition coil bracket bolts and bracket.

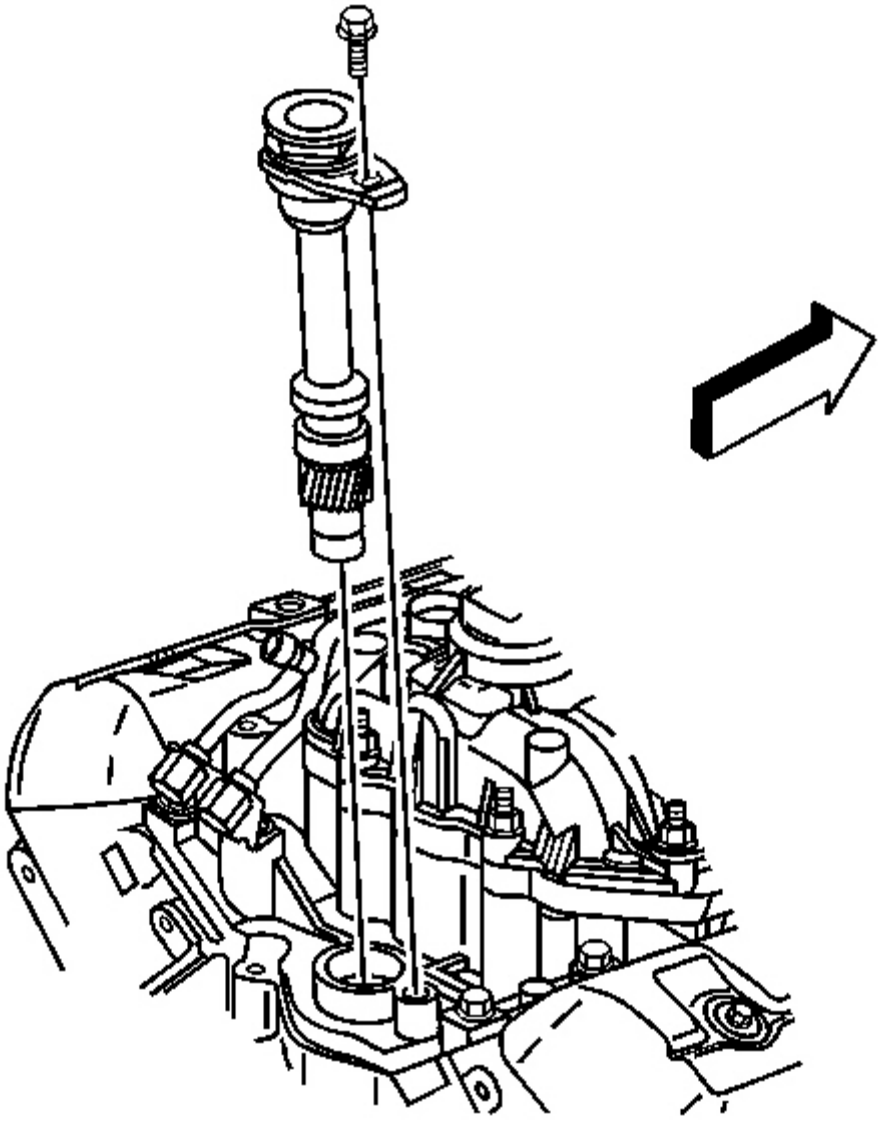


Fig. 389: View Of Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump drive shaft bolt.
4. Remove the oil pump drive shaft with clamp.

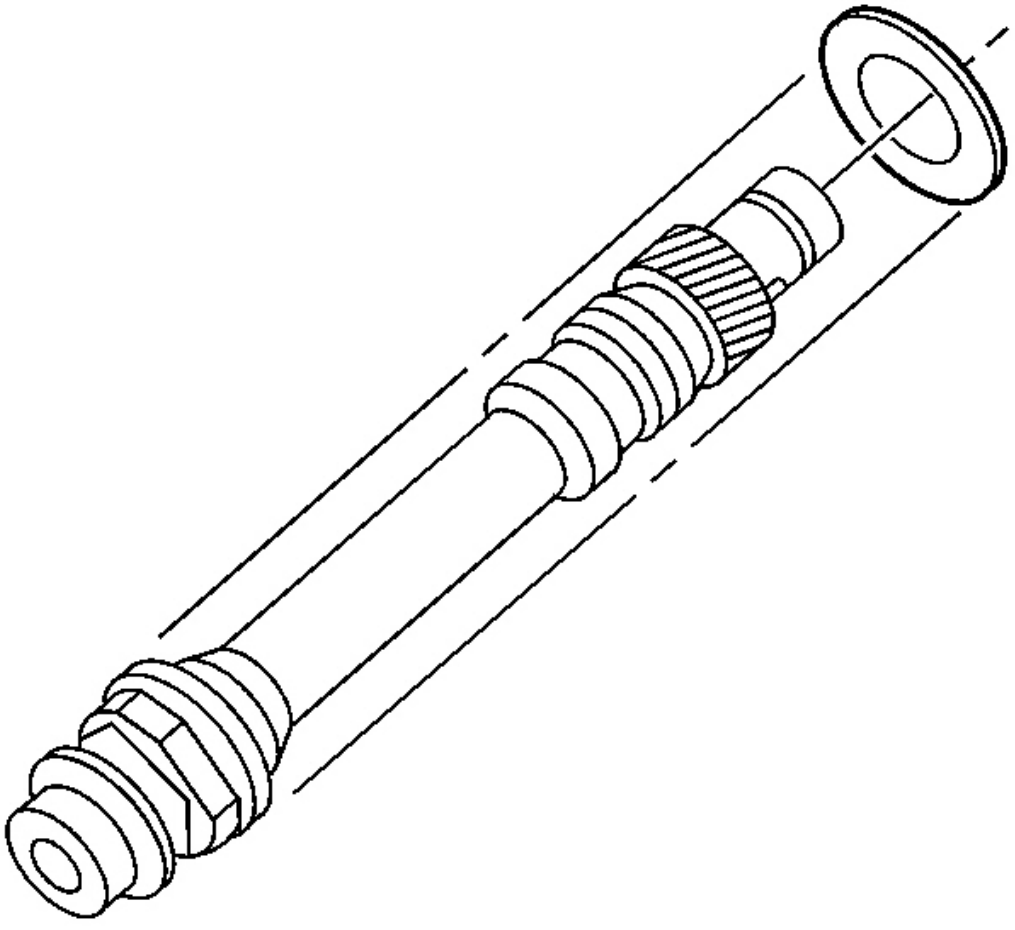


Fig. 390: Oil Pump Drive Shaft & Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive shaft gasket and discard.

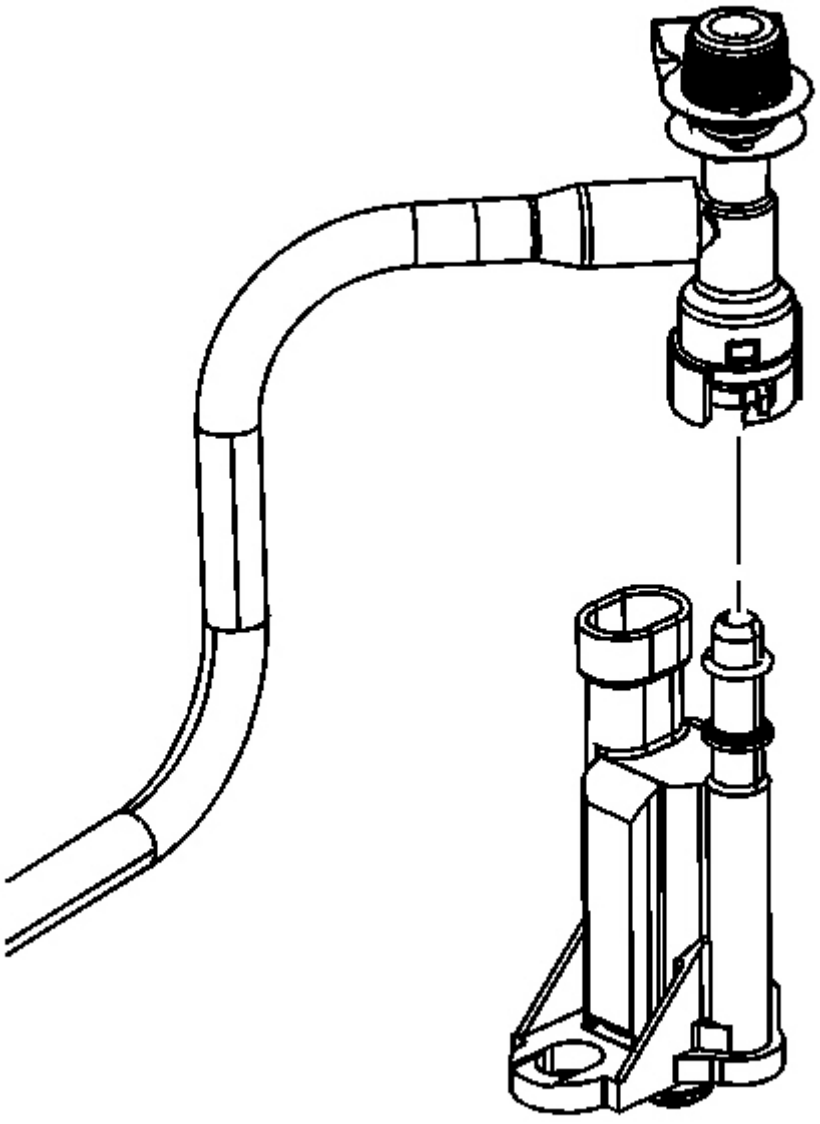


Fig. 391: Evaporative Emission Canister Solenoid Valve & Harness
Courtesy of GENERAL MOTORS CORP.

6. Remove the evaporative emission (EVAP) canister purge solenoid valve harness.
    1. Push the quick disconnect clip and hold in place.
    2. Pull outward on the harness elbow.

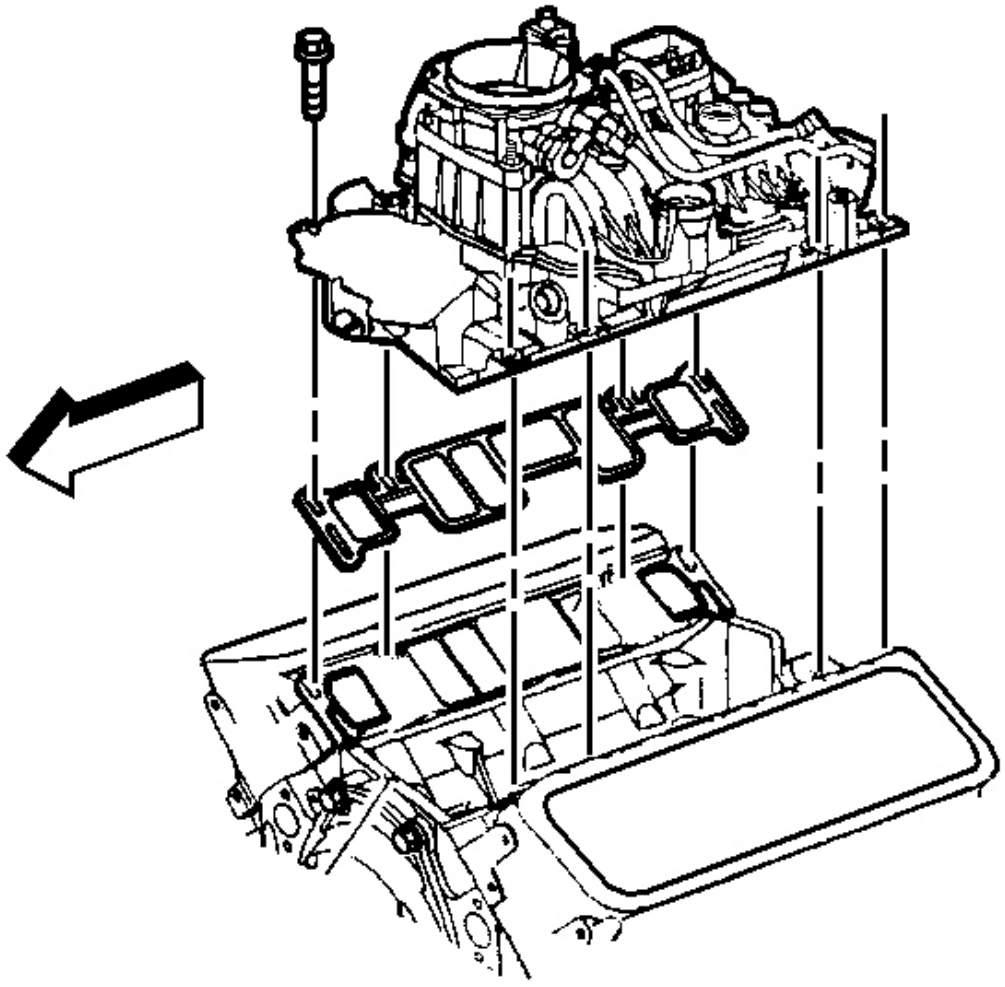


Fig. 392: View Of Intake Manifold Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine coolant temperature (ECT) sensor wire connector, if equipped, from the engine wiring harness bracket.
8. Remove the lower intake manifold bolts.

IMPORTANT:

- **The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless component service is required.**

- **Do not allow dirt or debris to enter the fuel system. Ensure that the ends of the fuel system are properly sealed.**

9. Remove the intake manifold assembly.
10. Remove and discard the lower intake manifold gaskets.

VALVE ROCKER ARM AND PUSH ROD REMOVAL

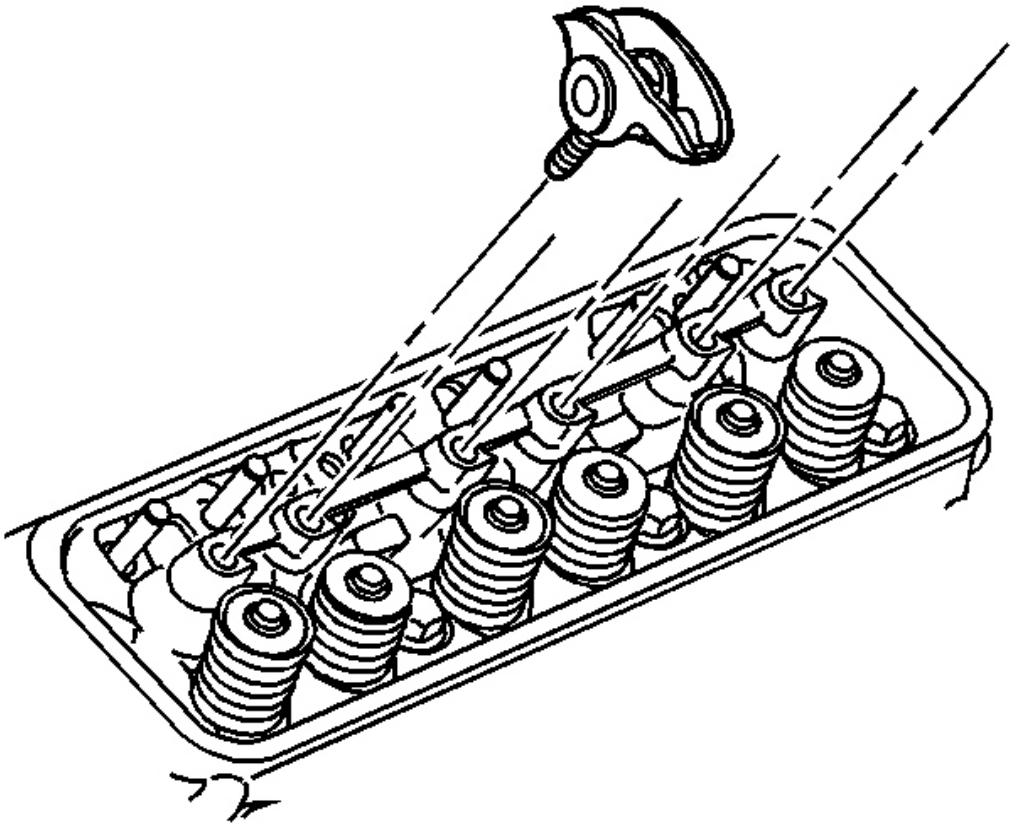


Fig. 393: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, and organize all the components for assembly.

1. Remove the valve rocker arms.

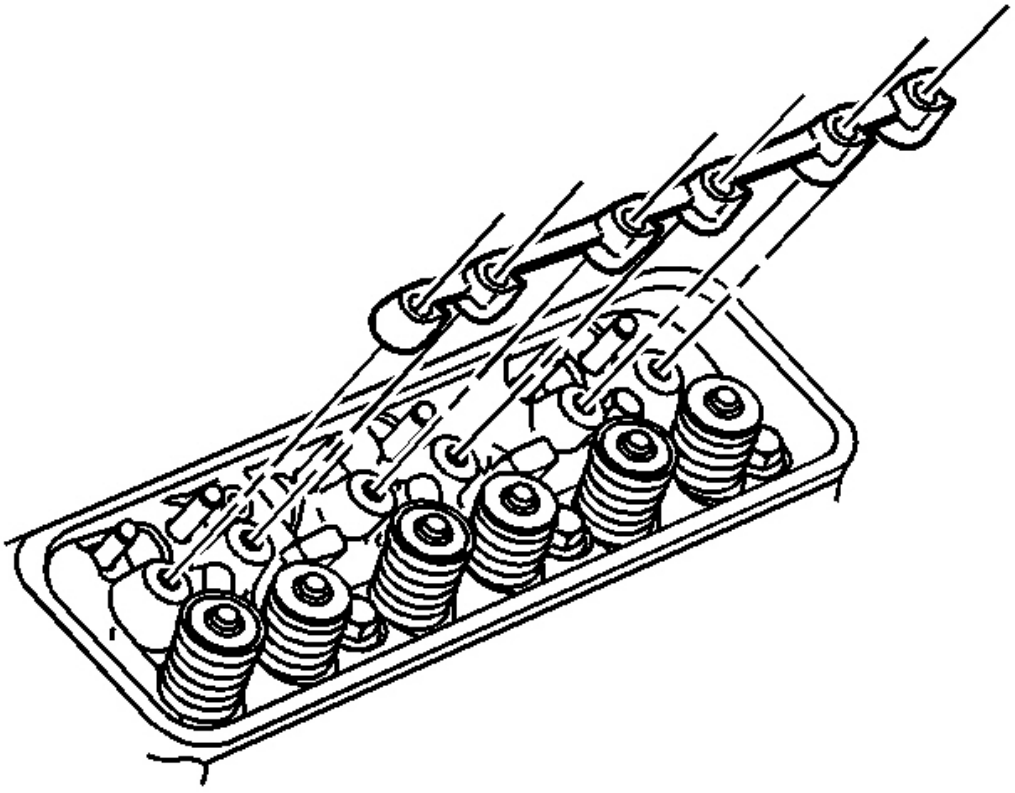


Fig. 394: View Of Valve Rocker Arm Supports
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve rocker arm supports.

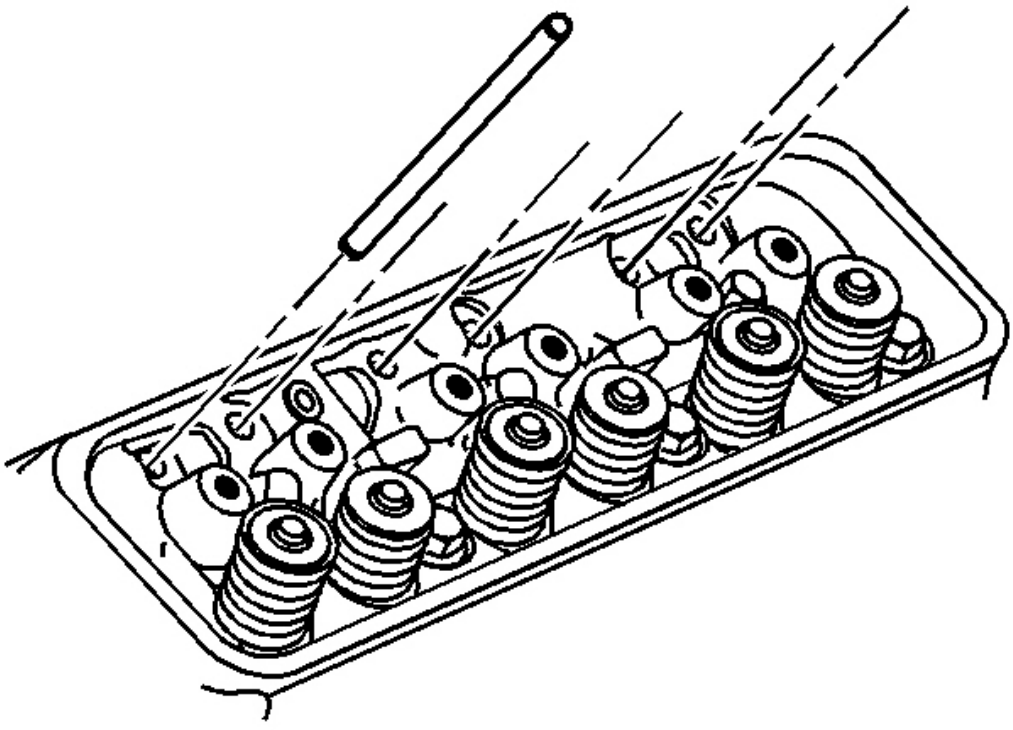


Fig. 395: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve pushrods.

CYLINDER HEAD REMOVAL - LEFT SIDE

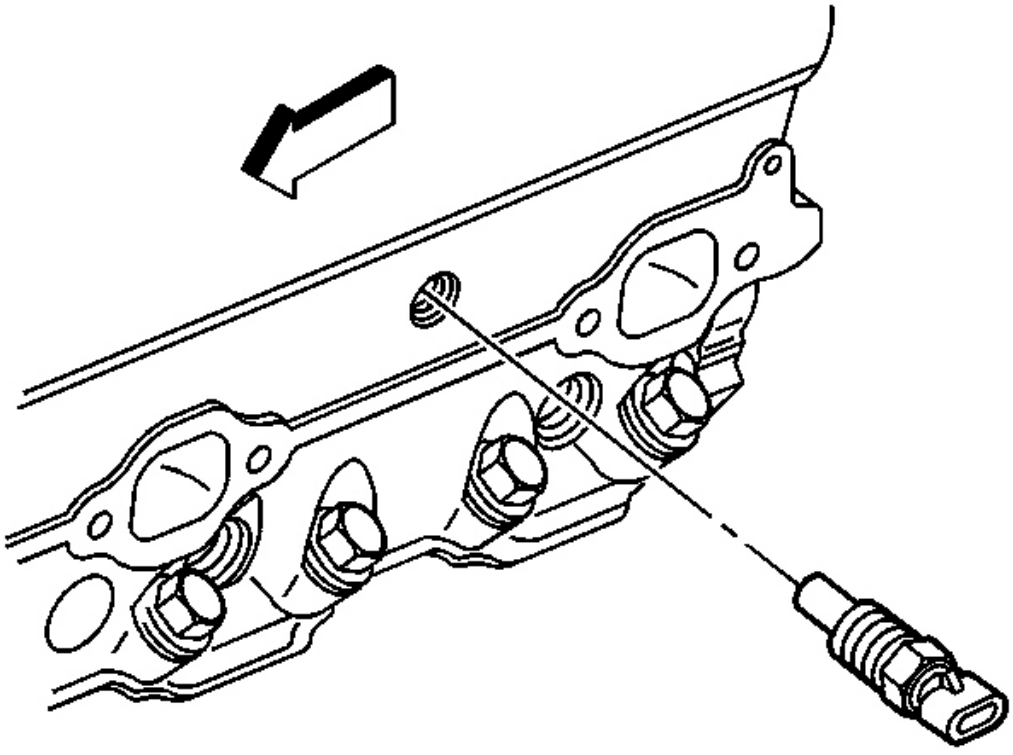


Fig. 396: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor, if applicable.

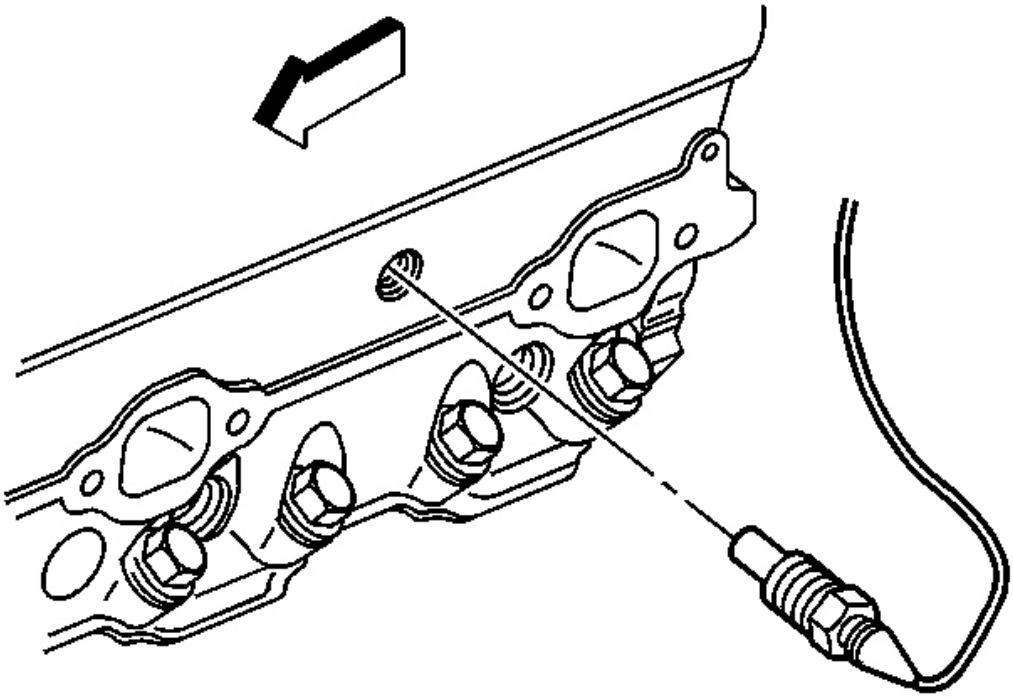


Fig. 397: Engine Coolant Temperature Gage Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine coolant temperature gage sensor, if applicable.

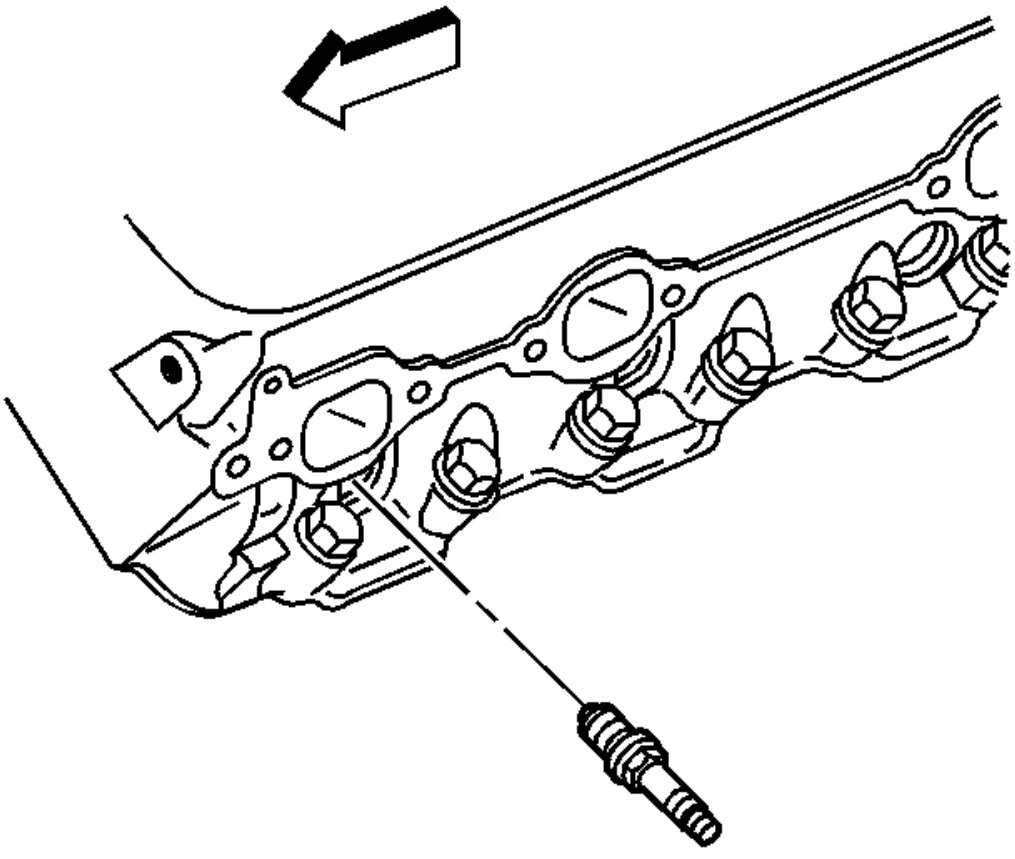


Fig. 398: View Of Spark Plugs (Left)
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs.

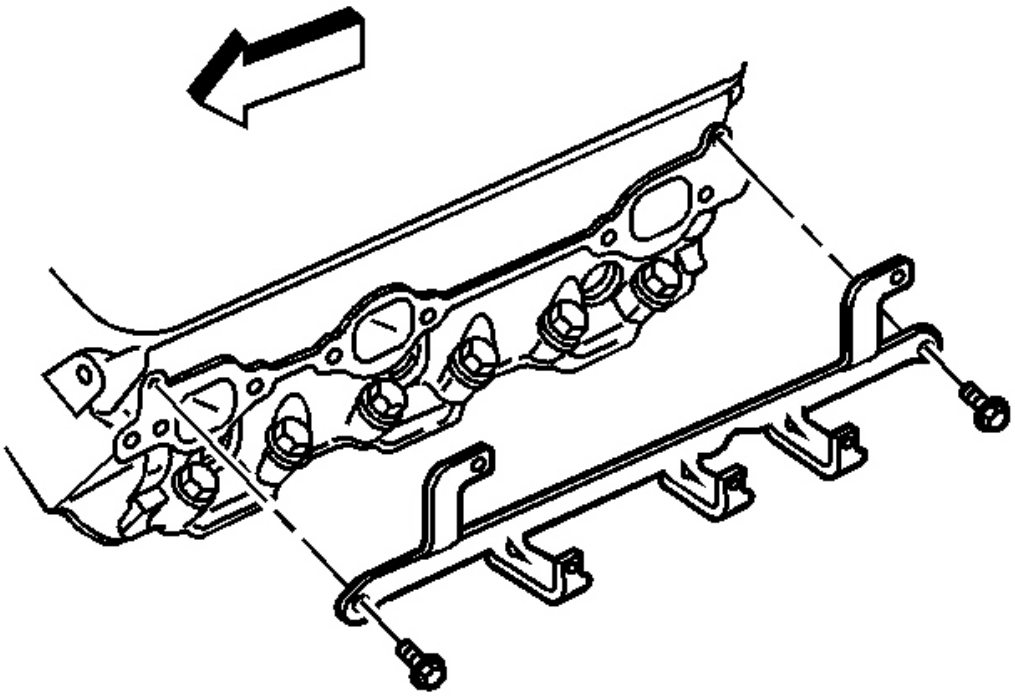


Fig. 399: Locating Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and the spark plug wire support.

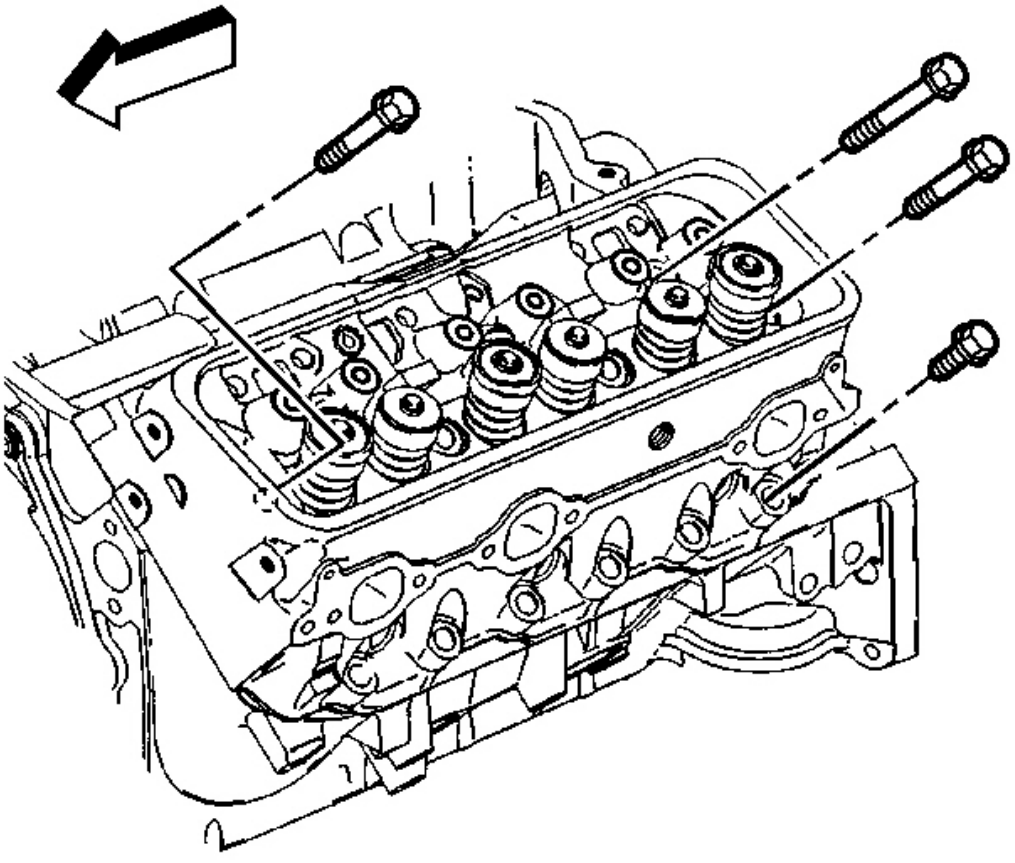


Fig. 400: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

5. Remove the cylinder head bolts and discard.

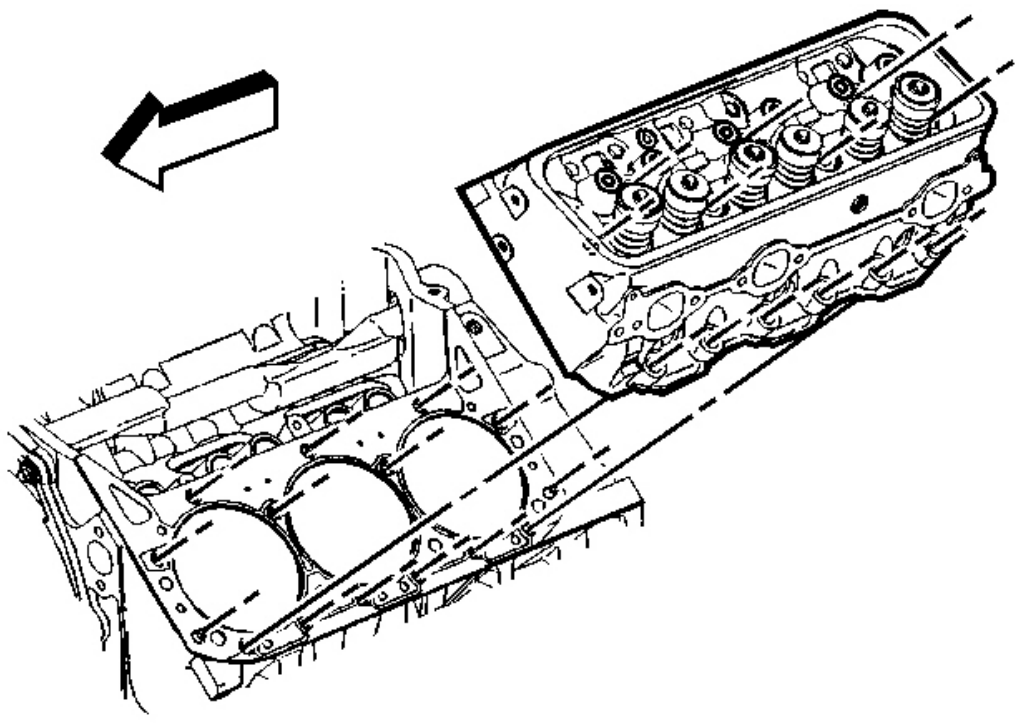


Fig. 401: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

6. Remove the cylinder head.

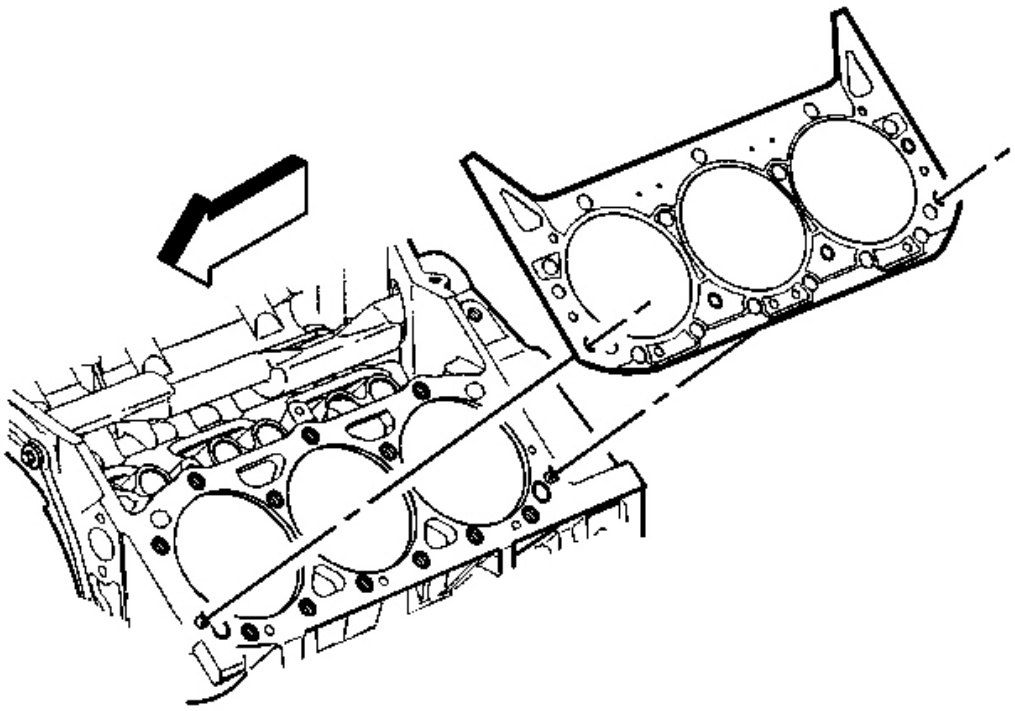


Fig. 402: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the cylinder head gasket.

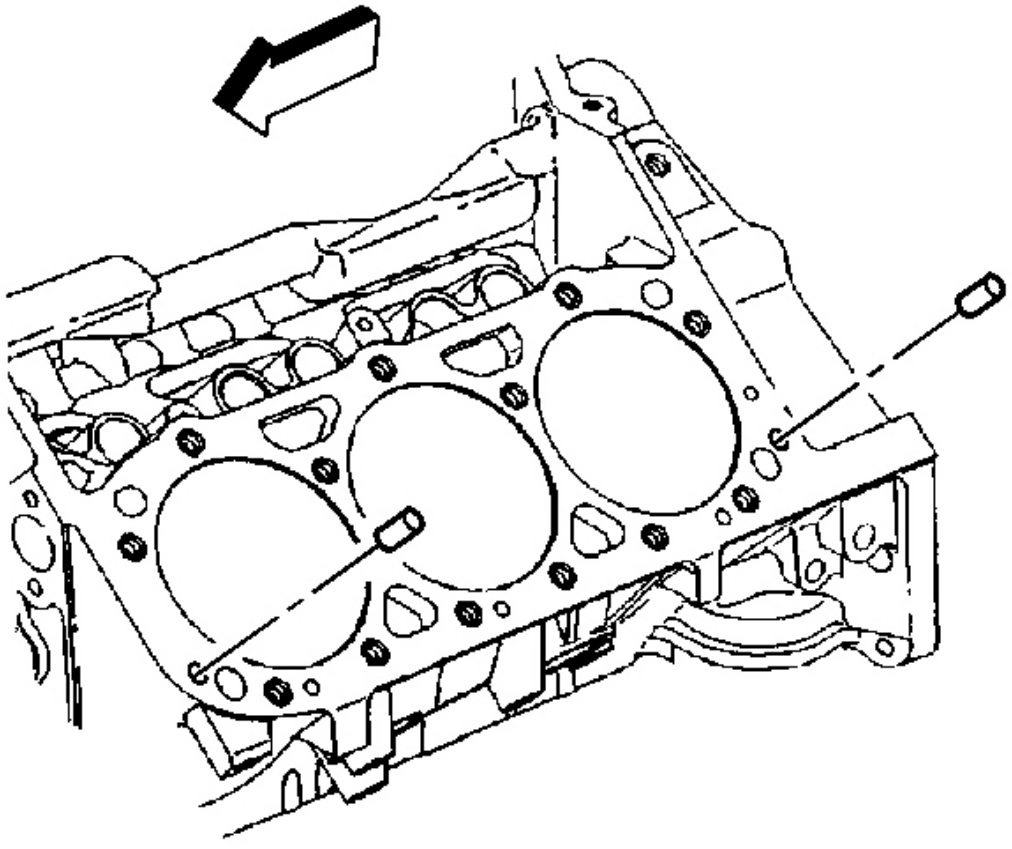


Fig. 403: View Of Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head locator dowel pins, if required.

CYLINDER HEAD REMOVAL - RIGHT SIDE

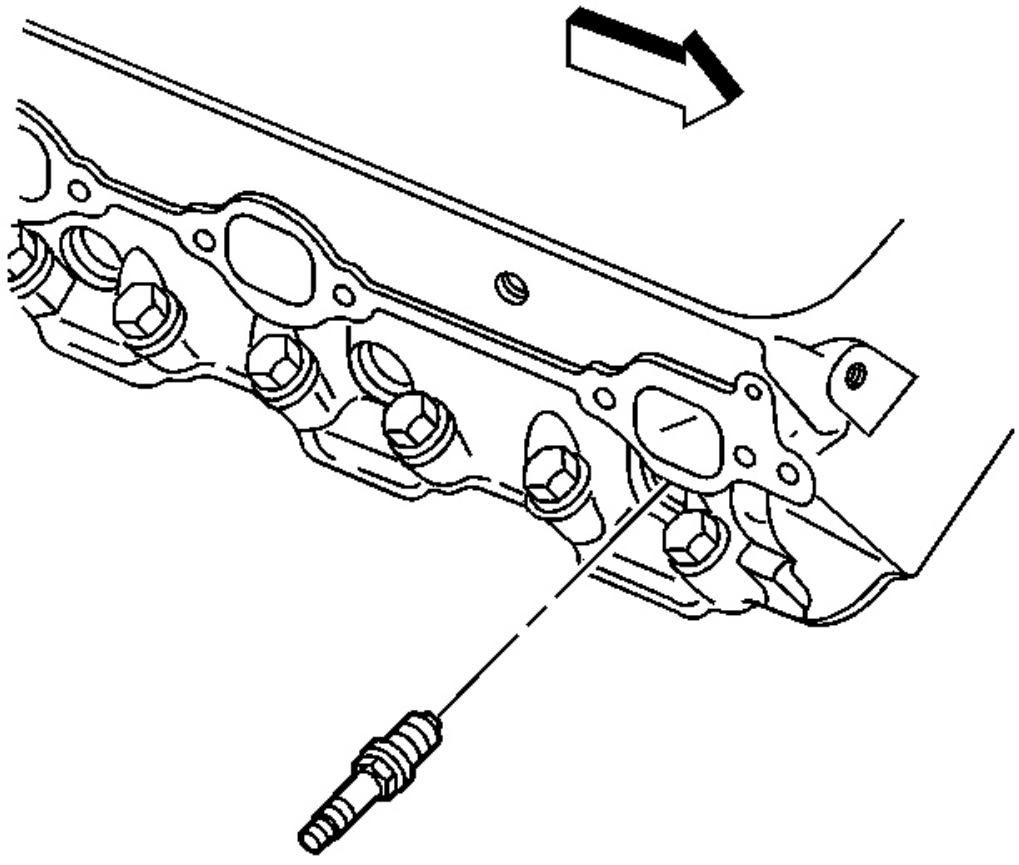


Fig. 404: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.

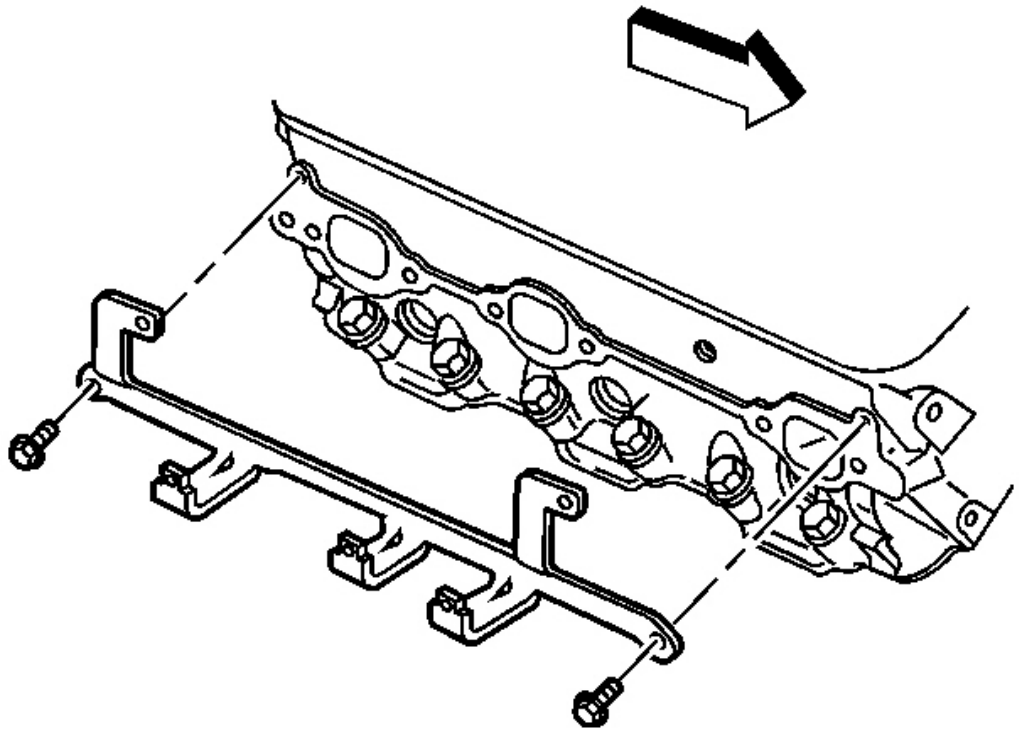


Fig. 405: Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear bolt and the spark plug wire support.

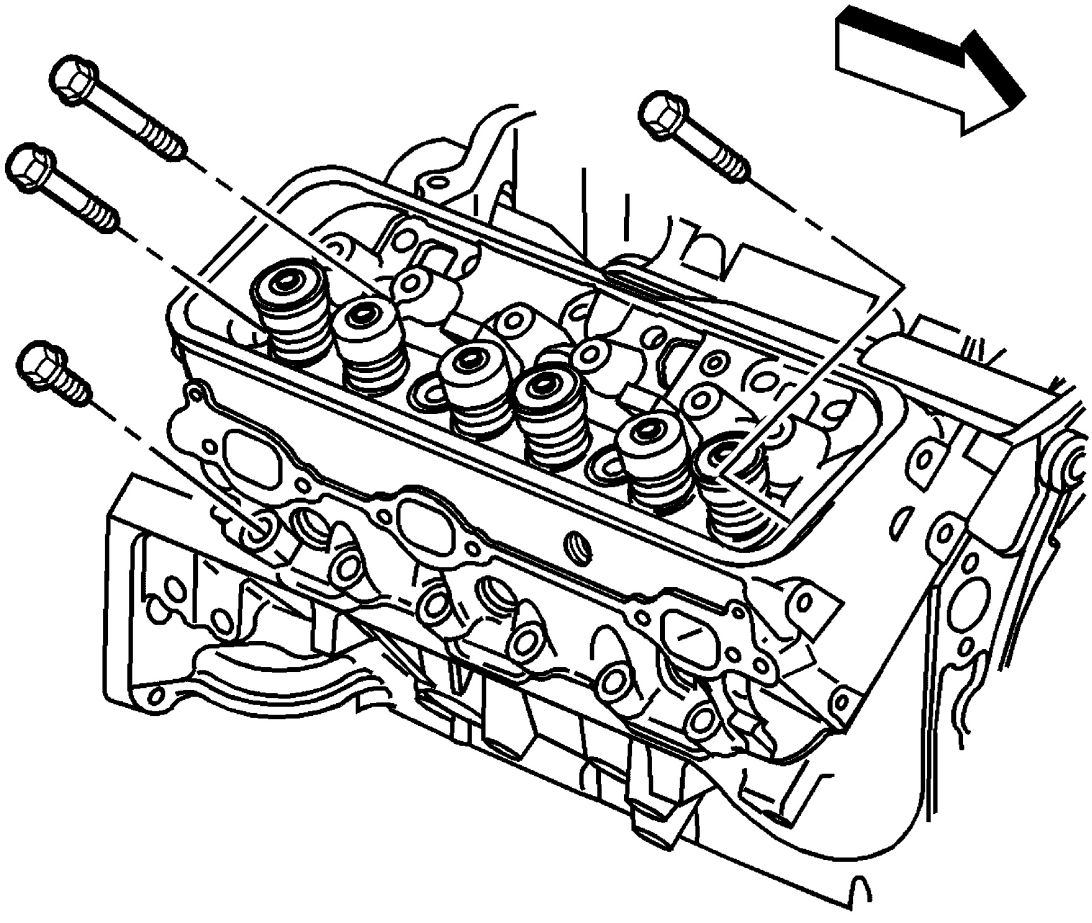


Fig. 406: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head bolts and discard.

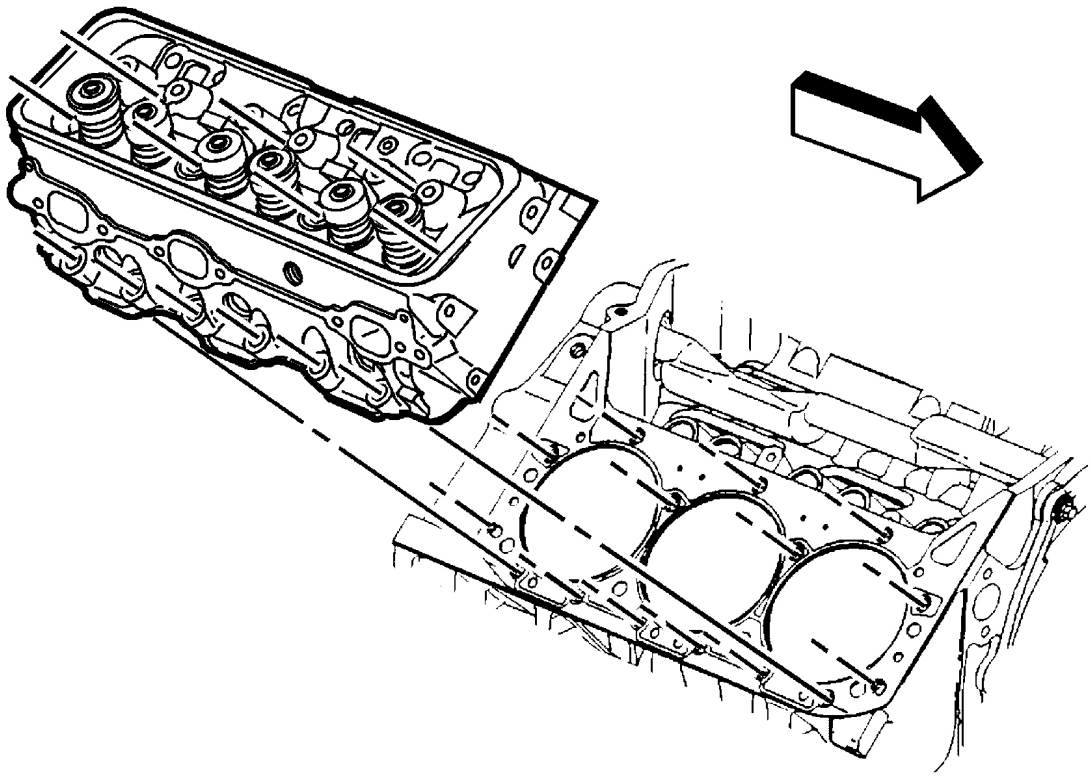


Fig. 407: Removing/Installing Cylinder Head (Right)
Courtesy of GENERAL MOTORS CORP.

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

4. Remove the cylinder head.

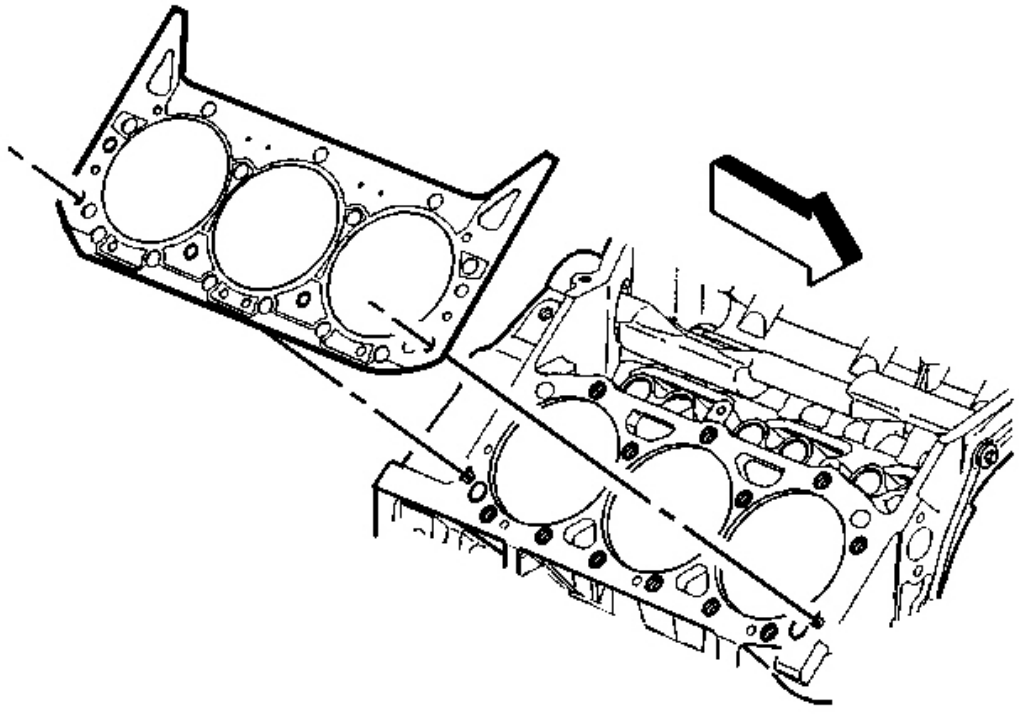


Fig. 408: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the cylinder head gasket.

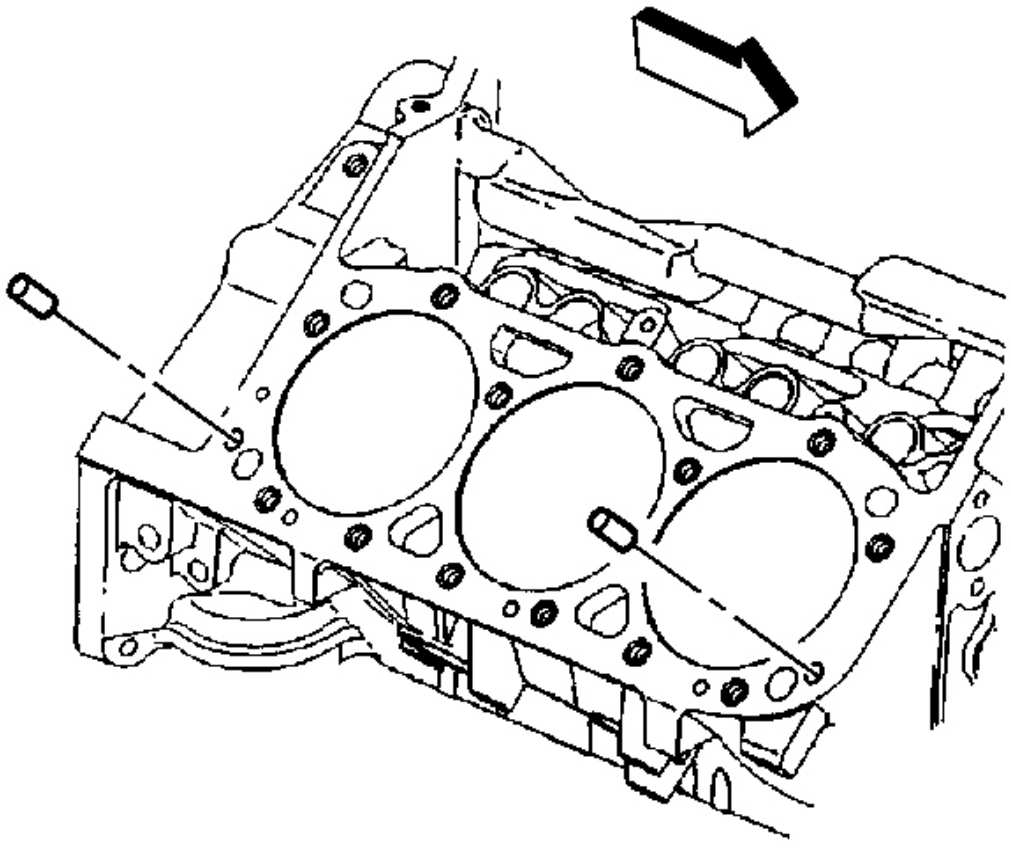


Fig. 409: Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

6. Remove the cylinder head locator dowel pins, if required.

VALVE LIFTER REMOVAL

Tools Required

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

Removal

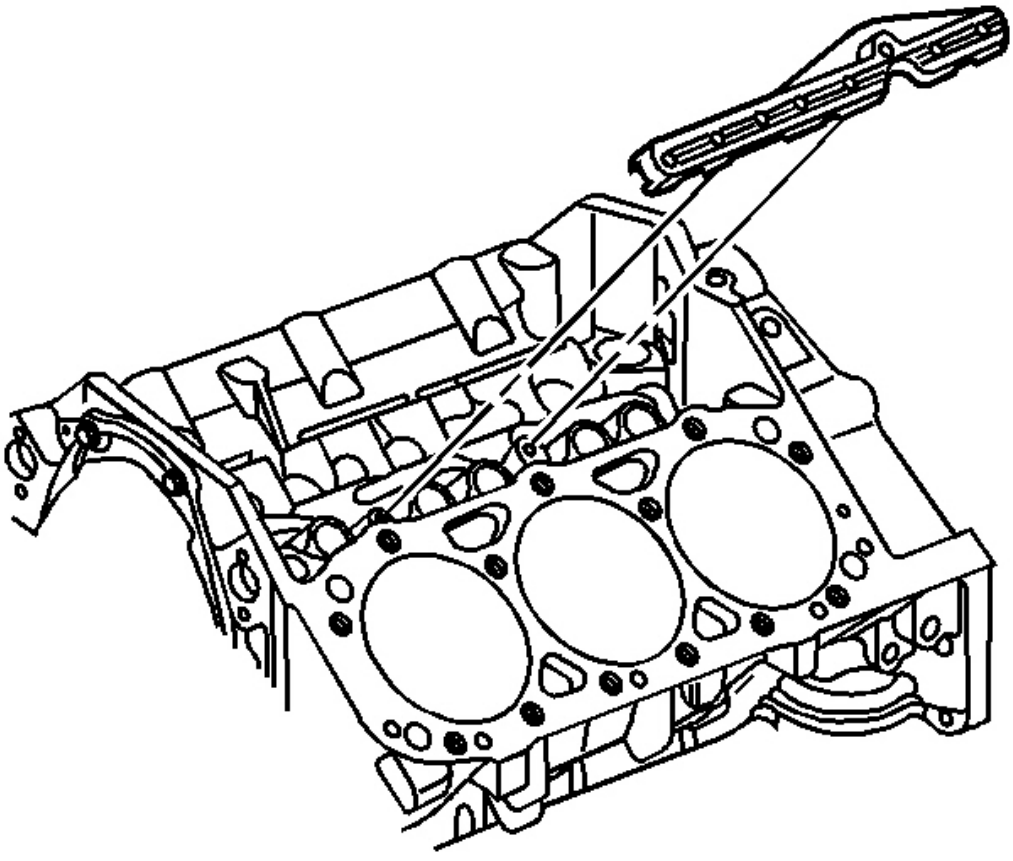


Fig. 410: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the components in a rack so that the components can be reinstalled to their original location.

1. Remove the bolts and valve lifter pushrod guide.

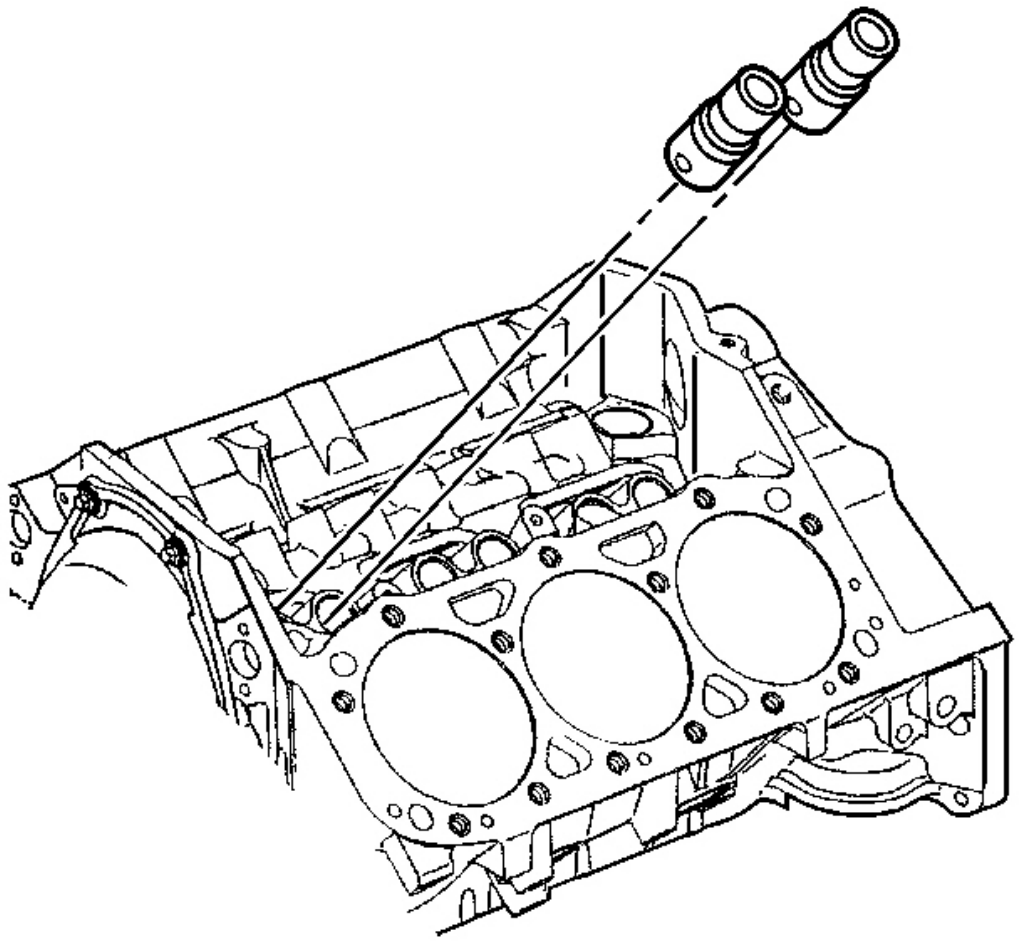


Fig. 411: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifters.

2. Remove the valve lifters.

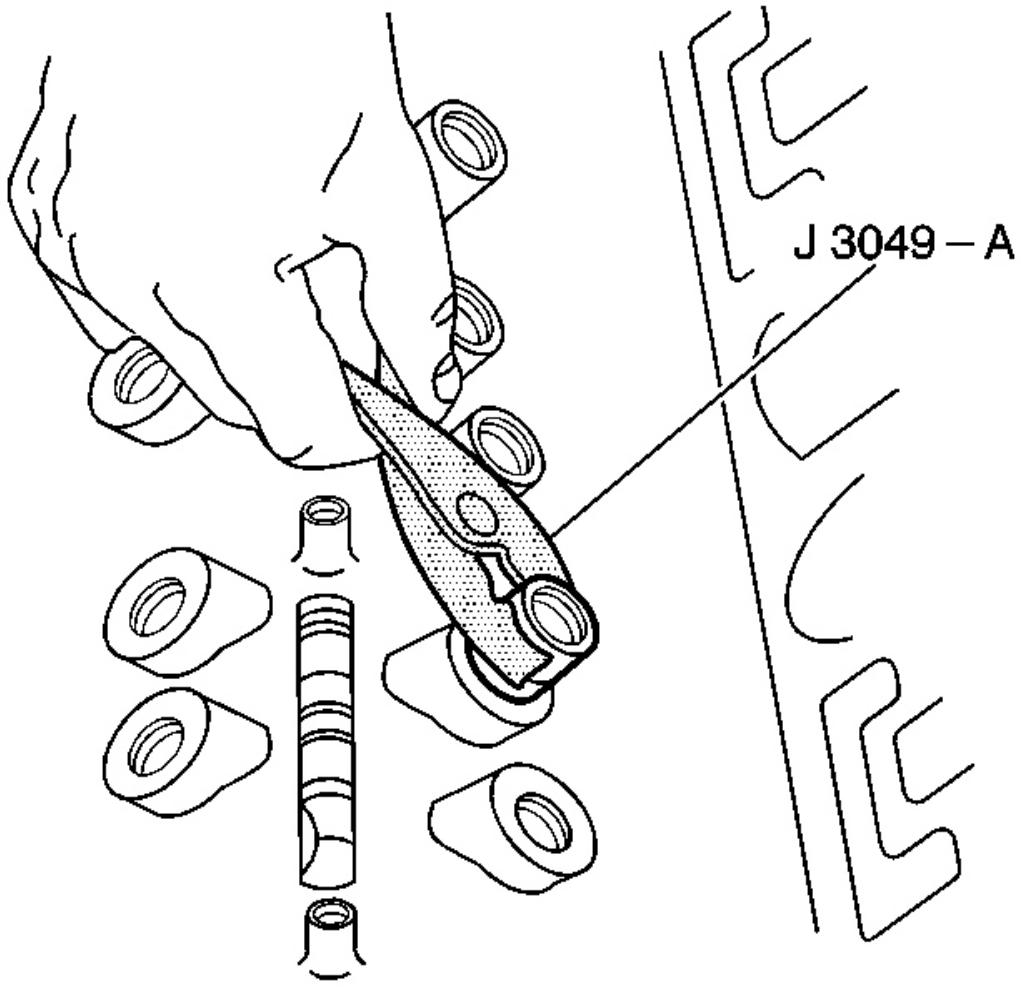


Fig. 412: Using J 3049-A To Remove Sticking Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits and may require the use ofJ 3049-A for removal. See Special Tools.

3. Use the **J 3049-A** in order to remove the stuck valve lifters. See **Special Tools**.

OIL PAN REMOVAL

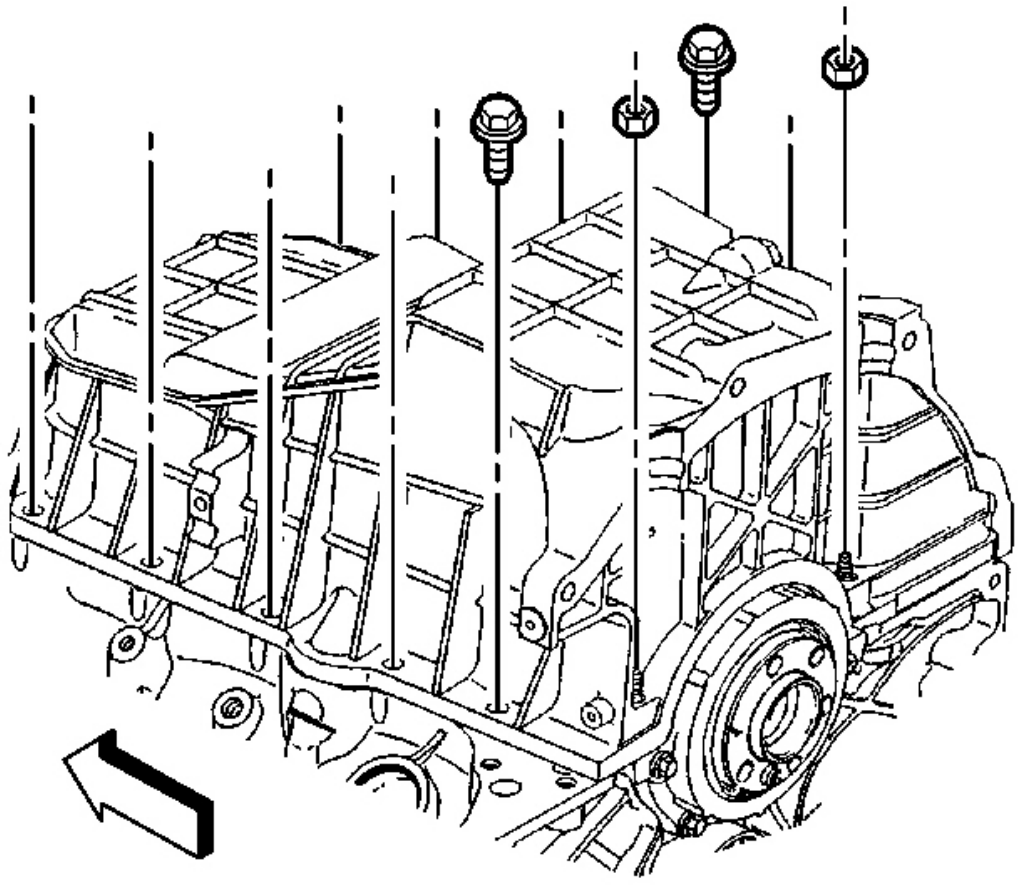


Fig. 413: Locating Oil Pan Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts and nuts.

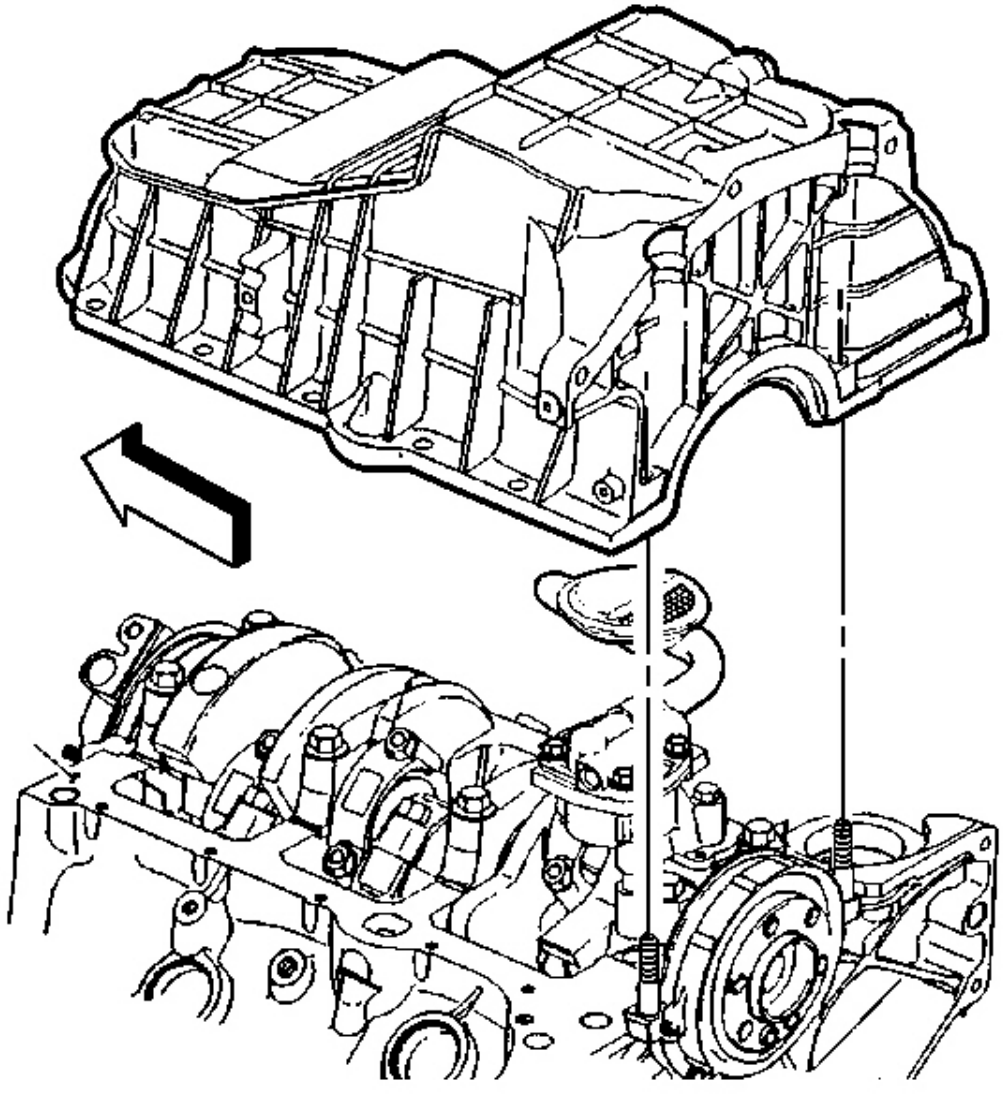


Fig. 414: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan.

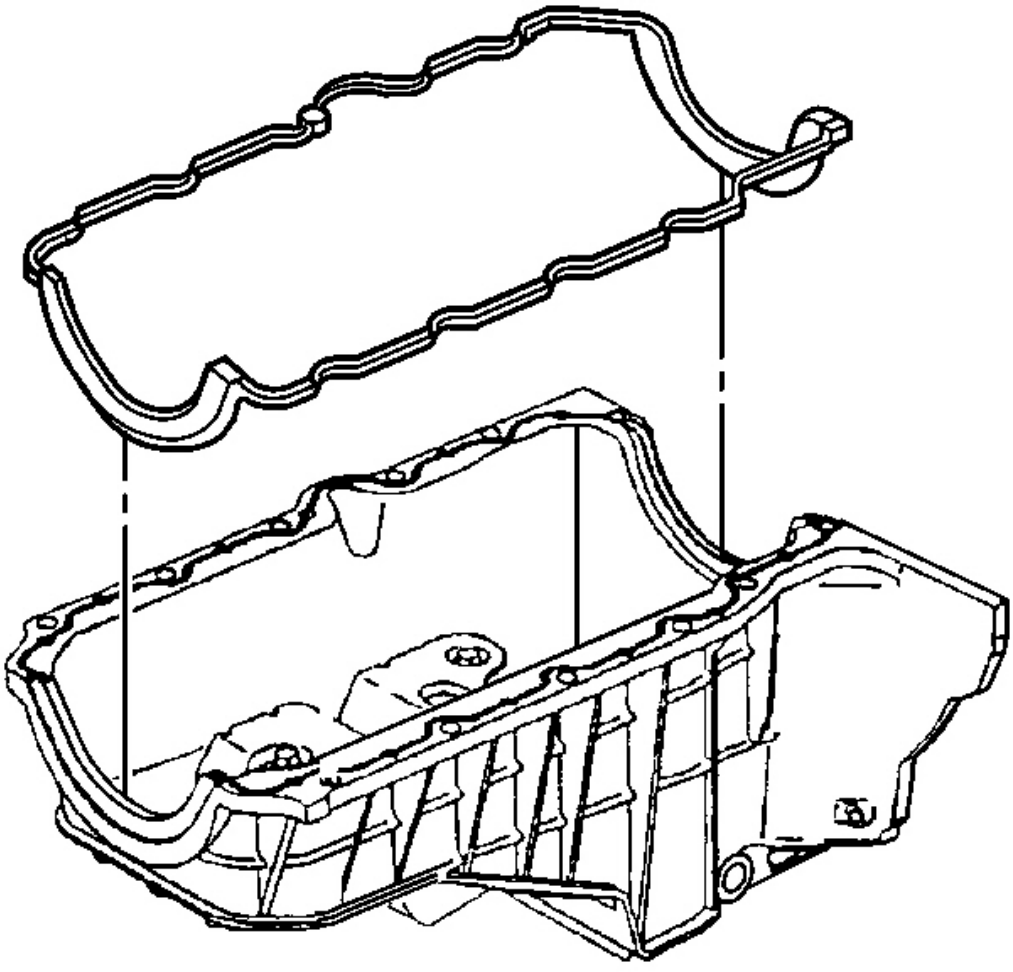


Fig. 415: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan gasket.
4. Discard the oil pan gasket.

OIL PUMP REMOVAL

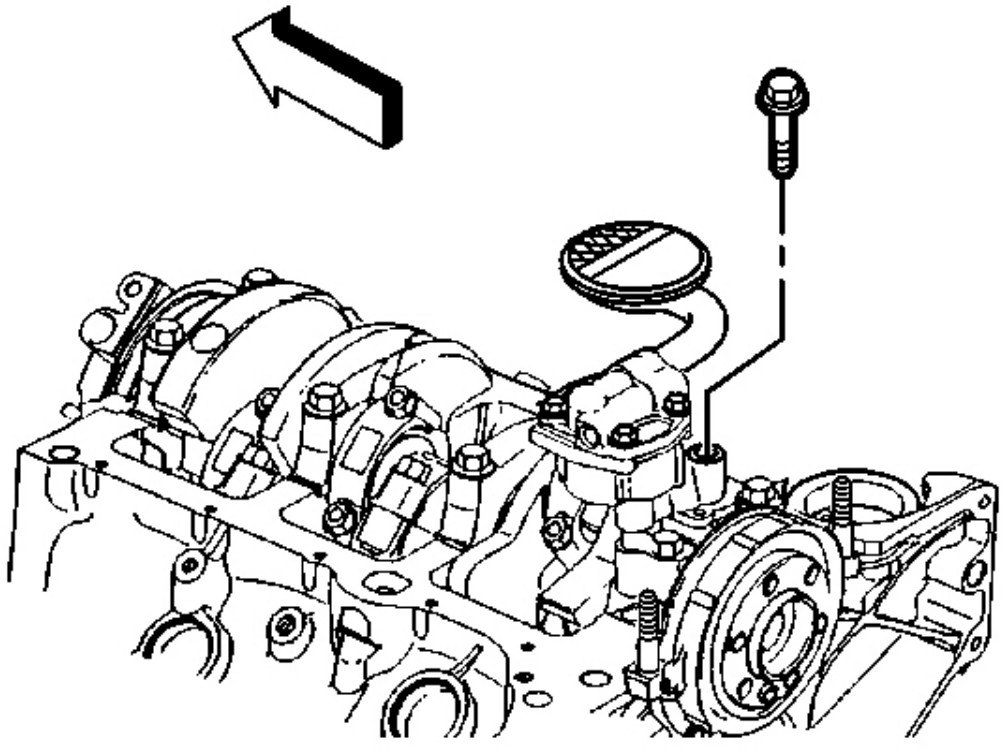


Fig. 416: View Of Oil Pump Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolt.

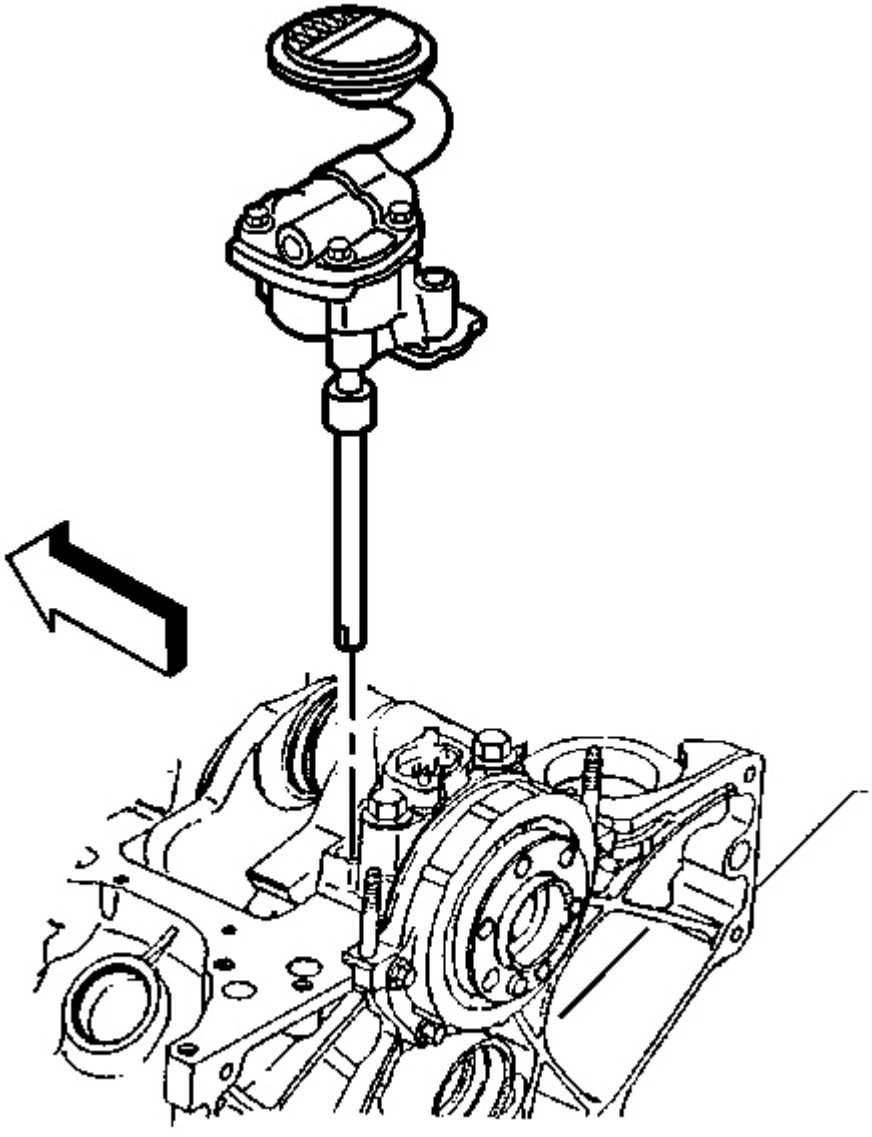


Fig. 417: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump.

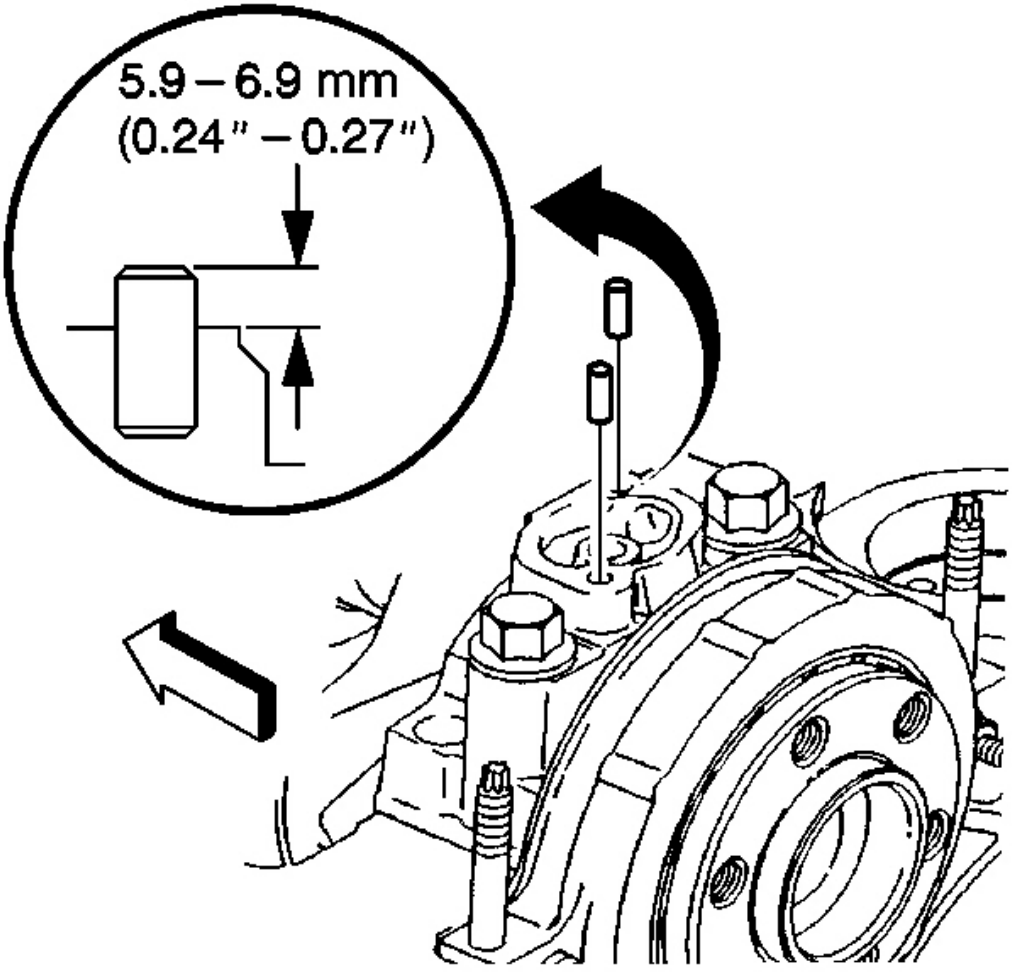


Fig. 418: Oil Pump Locator Pins
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil pump locator pins for damage, and replace the pins if required.

ENGINE FRONT COVER REMOVAL

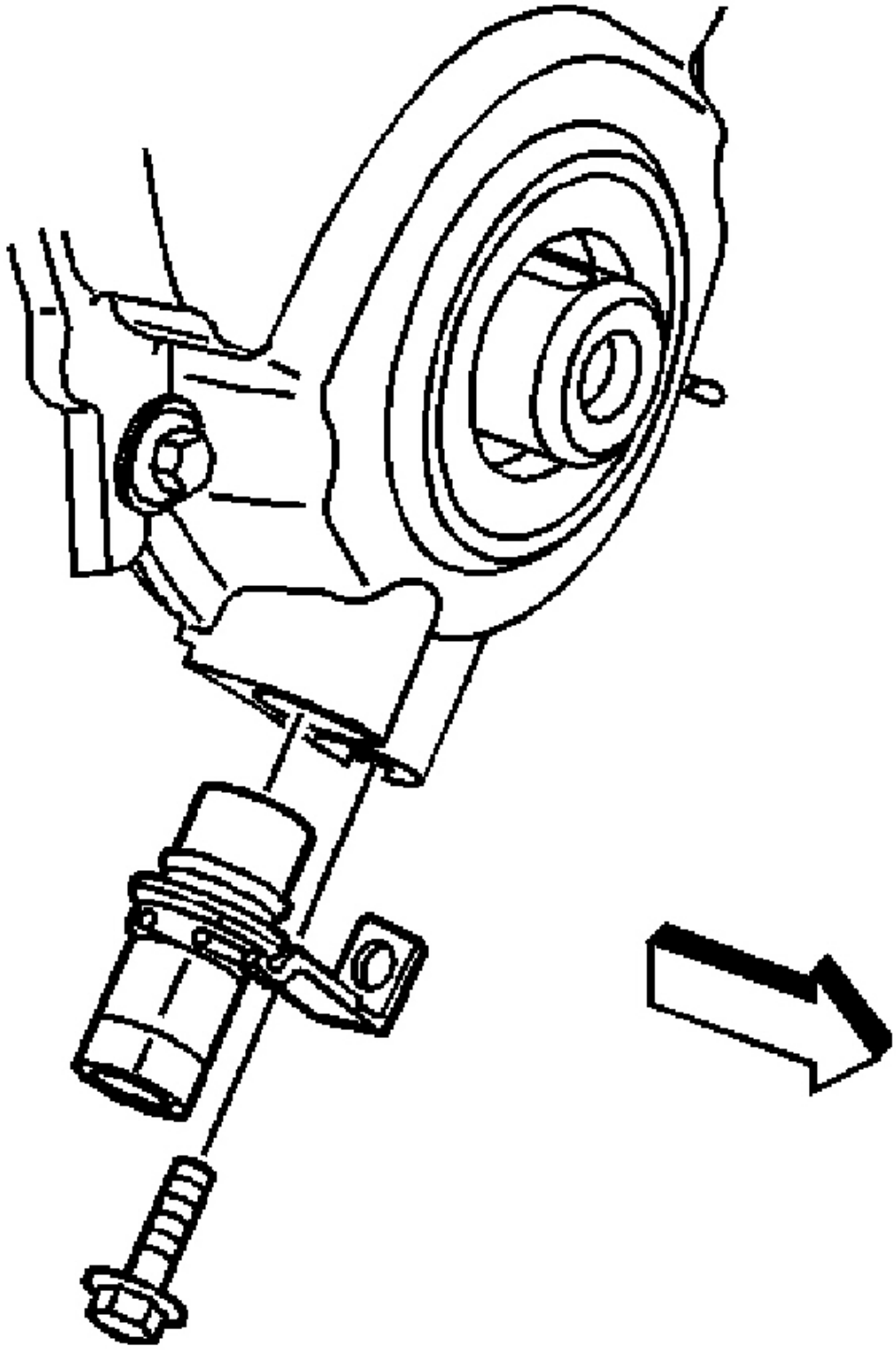


Fig. 419: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor bolt.
2. Remove the crankshaft position sensor.

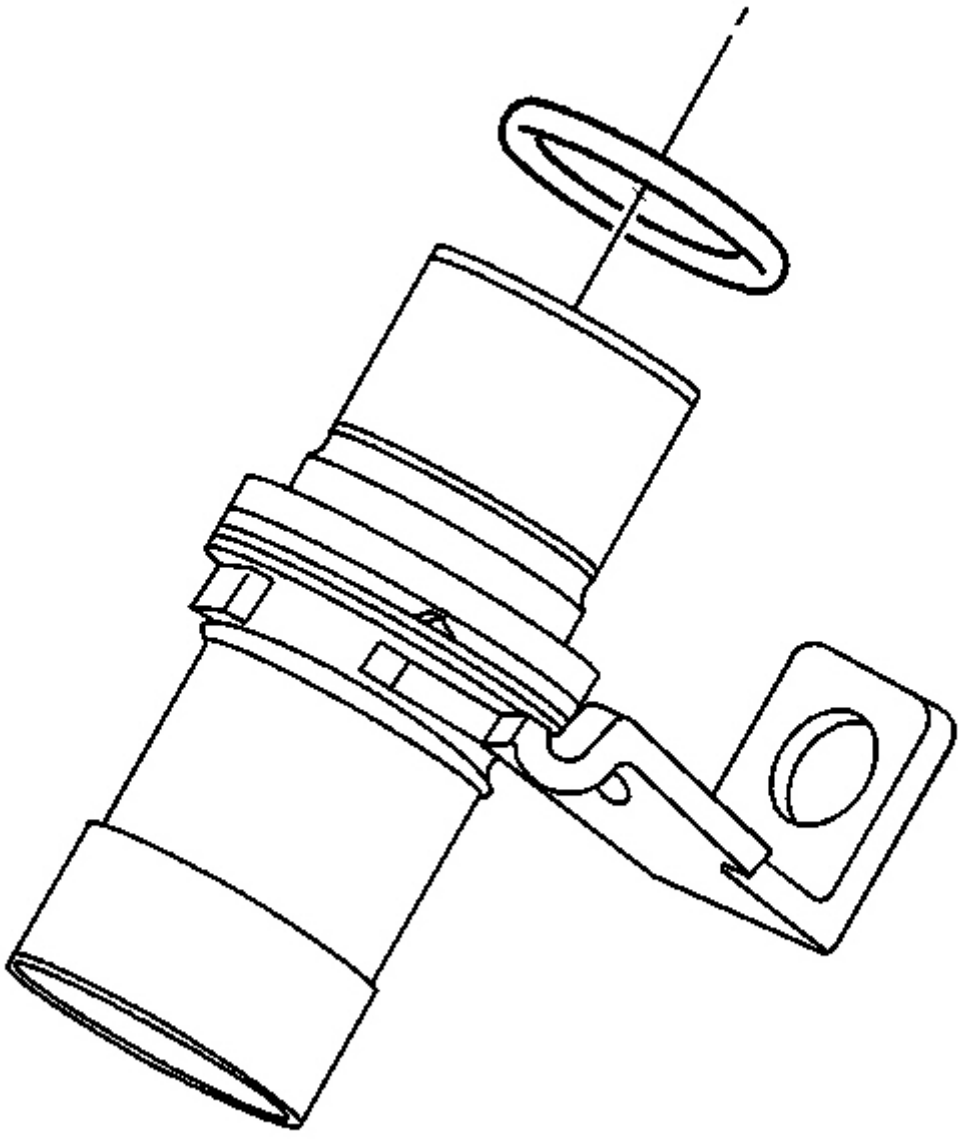


Fig. 420: View Of Crankshaft Position Sensor Seal O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft position sensor seal, O-ring.
4. Discard the crankshaft position sensor seal, O-ring.

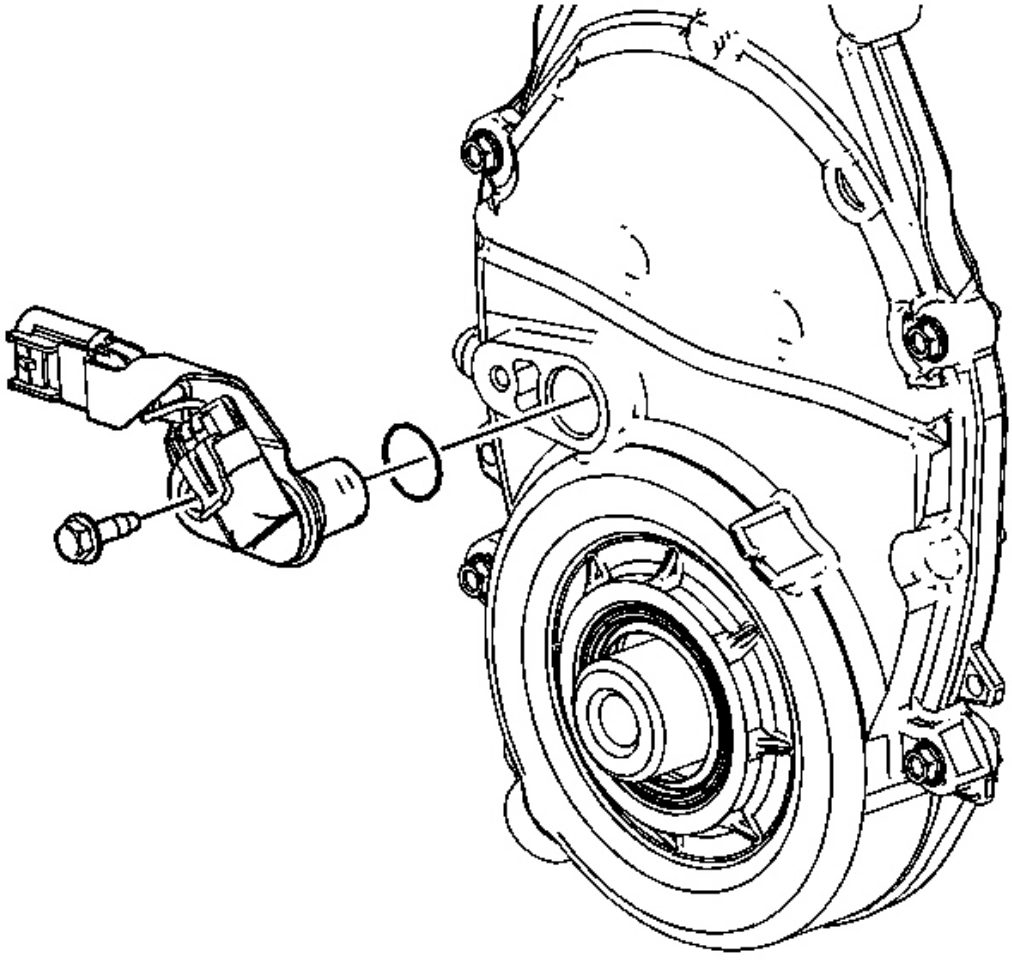


Fig. 421: camshaft position sensor & bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft position sensor bolt.
6. Remove the camshaft position sensor assembly.

7. Remove the camshaft position sensor O-ring seal and discard.

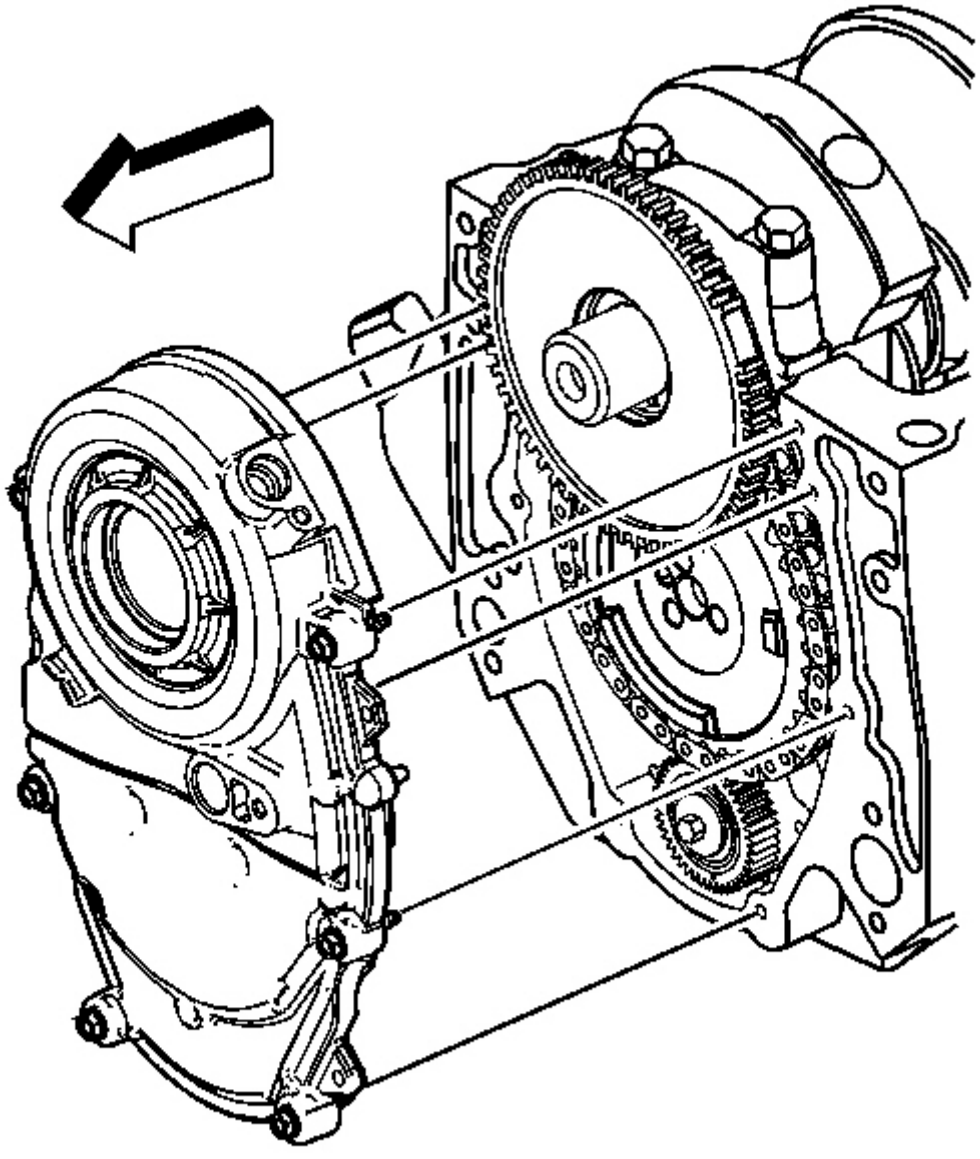


Fig. 422: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine front cover bolts.

IMPORTANT: After the composite engine front cover is removed do not reinstall the engine front cover. Always install a NEW engine front cover.

9. Remove the engine front cover.
10. Discard the engine front cover.

TIMING CHAIN AND SPROCKETS REMOVAL

Special Tools

J 5825-A Crankshaft Gear Remover. See **Special Tools**.

Removal

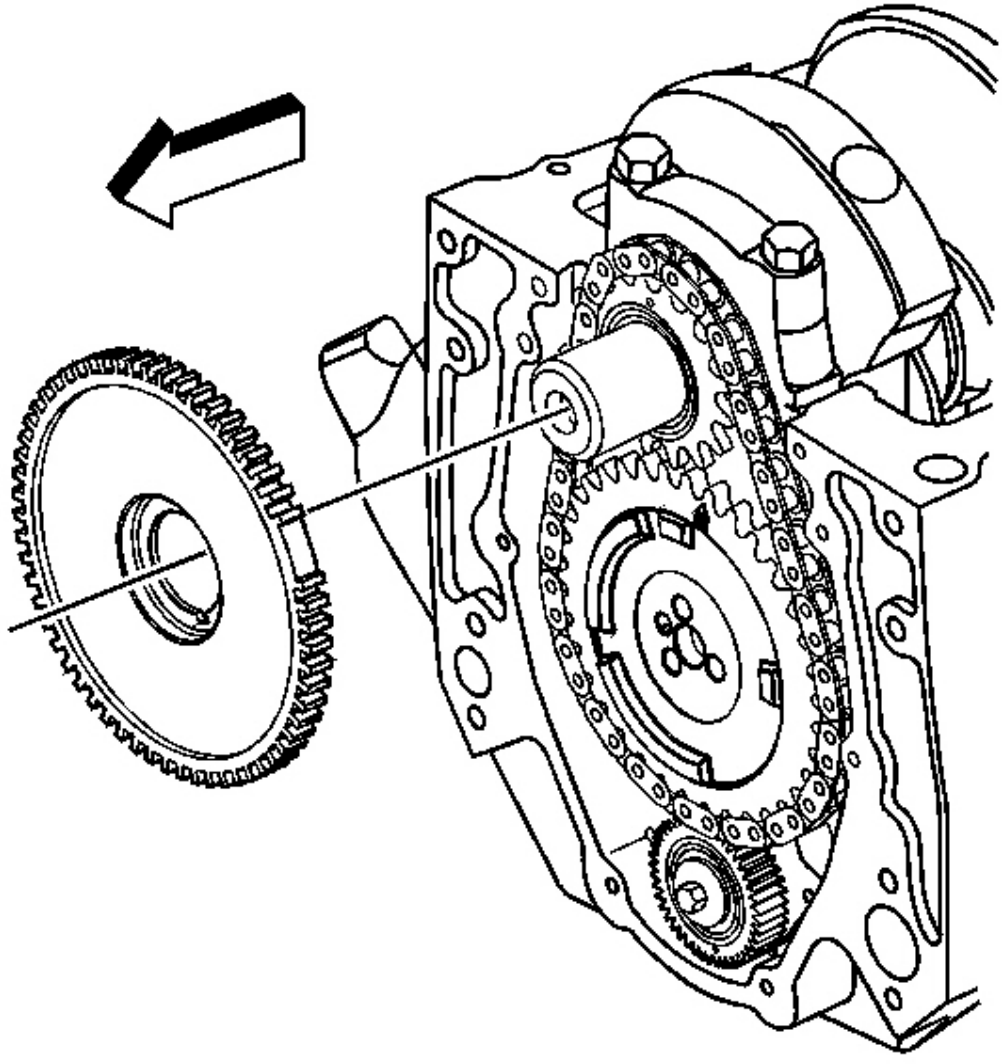


Fig. 423: View Of Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor reluctor ring.

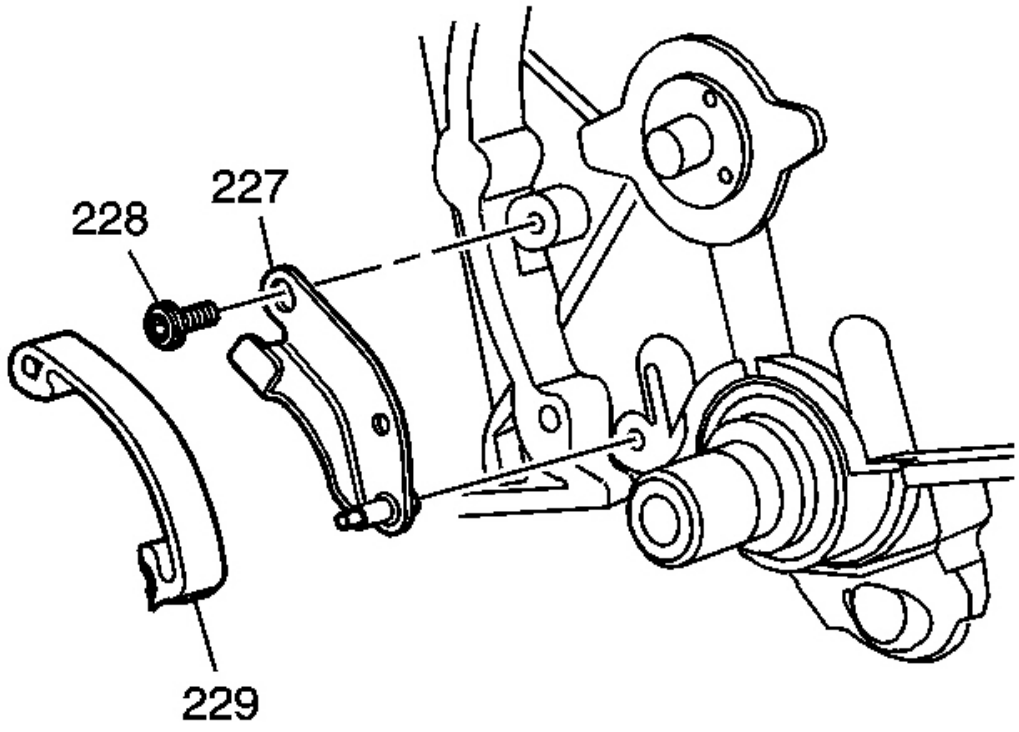


Fig. 424: View Of Timing Chain Tensioner Bracket, Bolt & Shoe
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing chain tensioner shoe (229) using a downward motion.
3. Remove the timing chain tensioner bracket bolt and bracket (227 and 228).

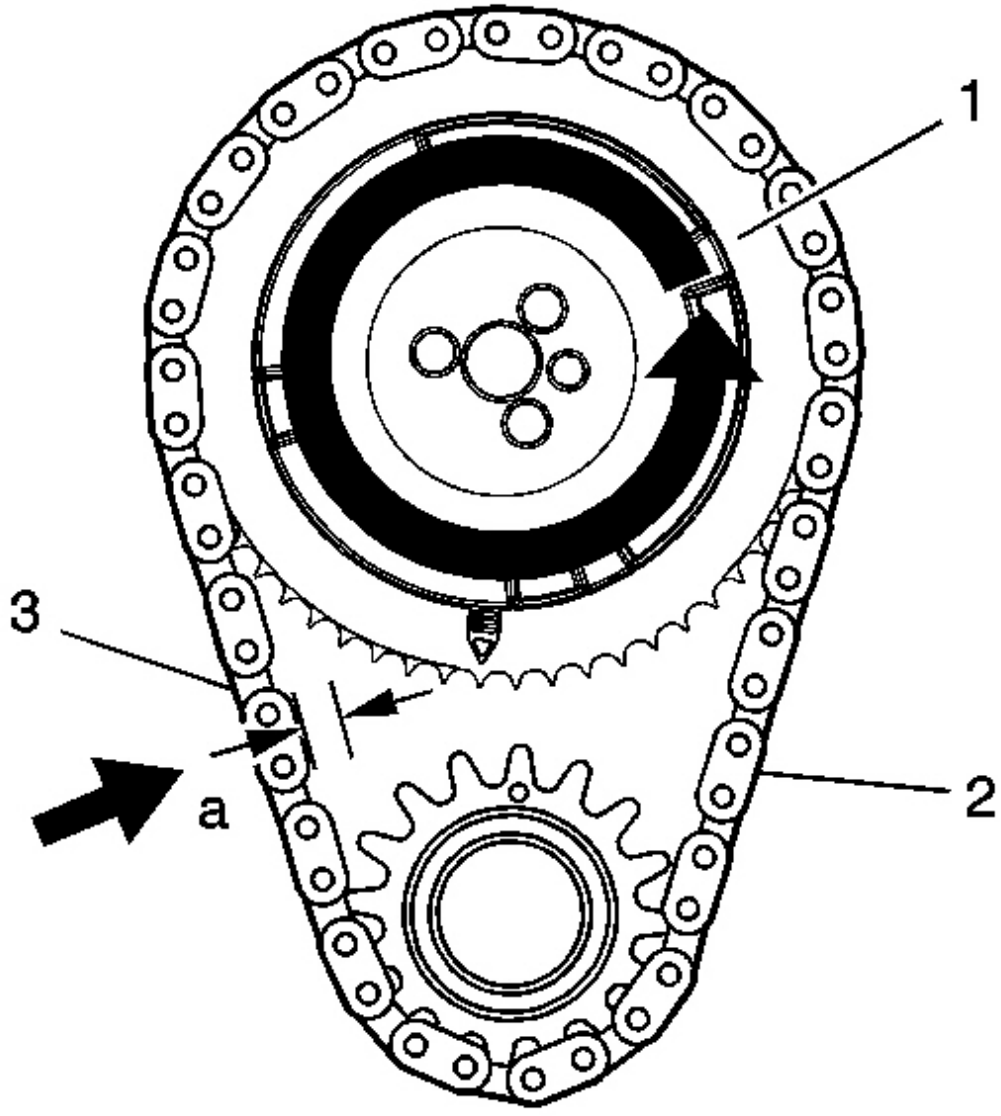


Fig. 425: Checking Camshaft Timing Chain Free Play
Courtesy of GENERAL MOTORS CORP.

4. Check the camshaft timing chain free play.
    1. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).

2. Measure the free play on the slack side (3) of the camshaft timing chain.

   If the camshaft timing chain can be moved side to side in excess of 11 mm (0.43 in), dimension a, replacement of the camshaft timing chain and the sprockets is recommended during assembly.

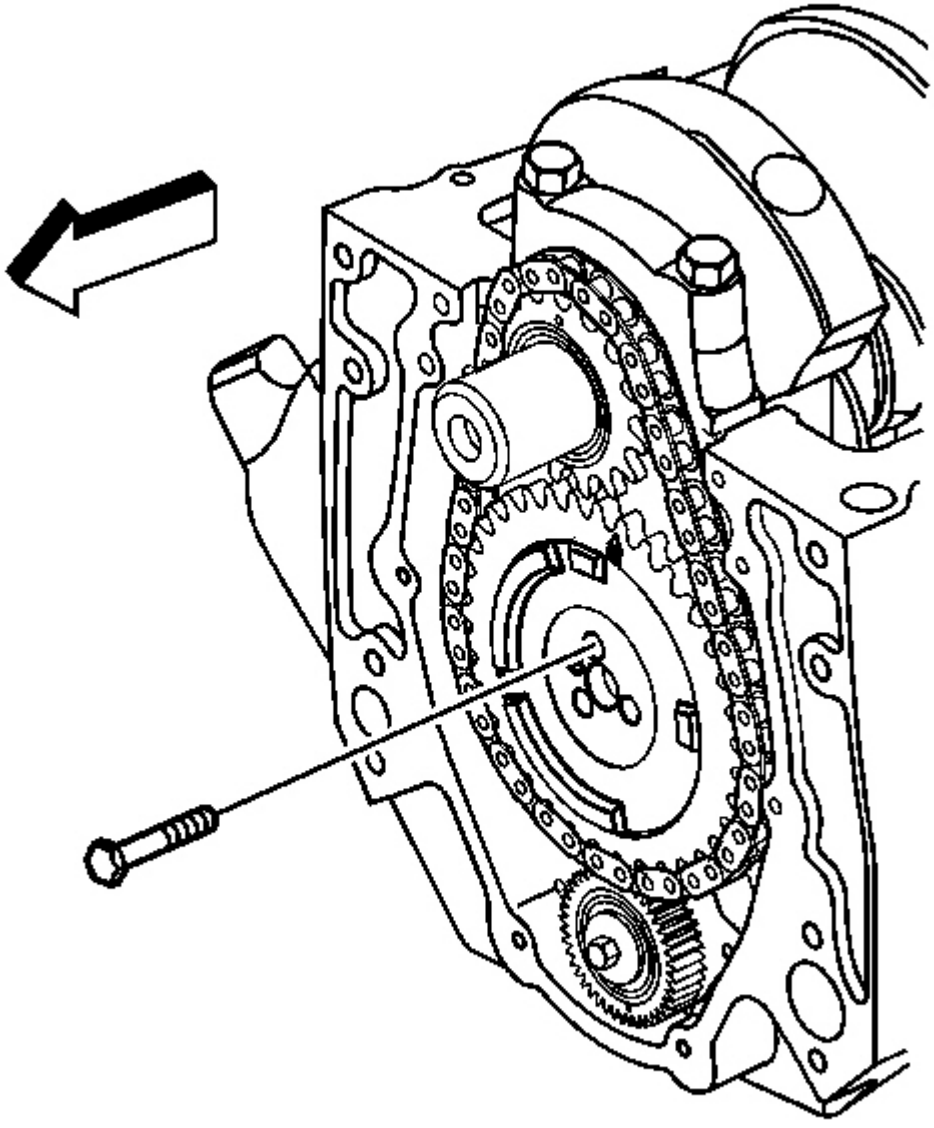


Fig. 426: Camshaft Sprocket & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft sprocket bolts.

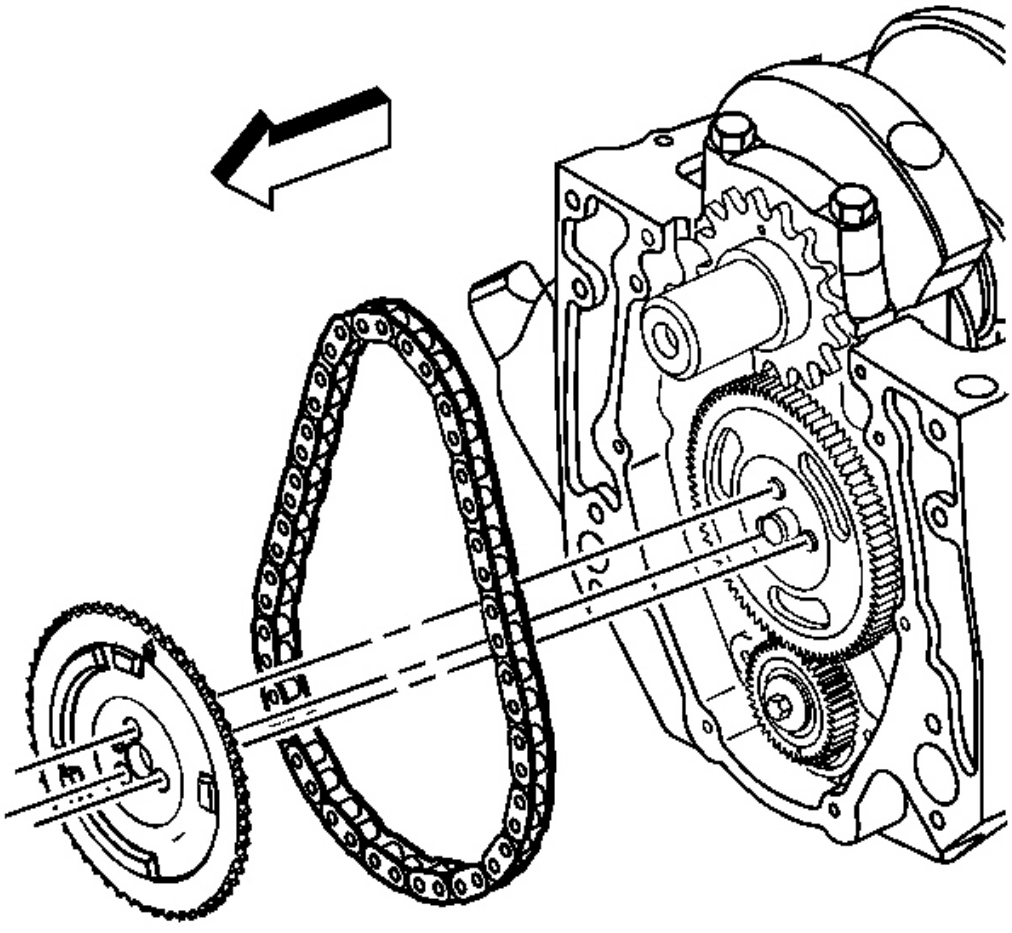


Fig. 427: Camshaft Sprocket And The Camshaft Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft sprocket and the camshaft timing chain.

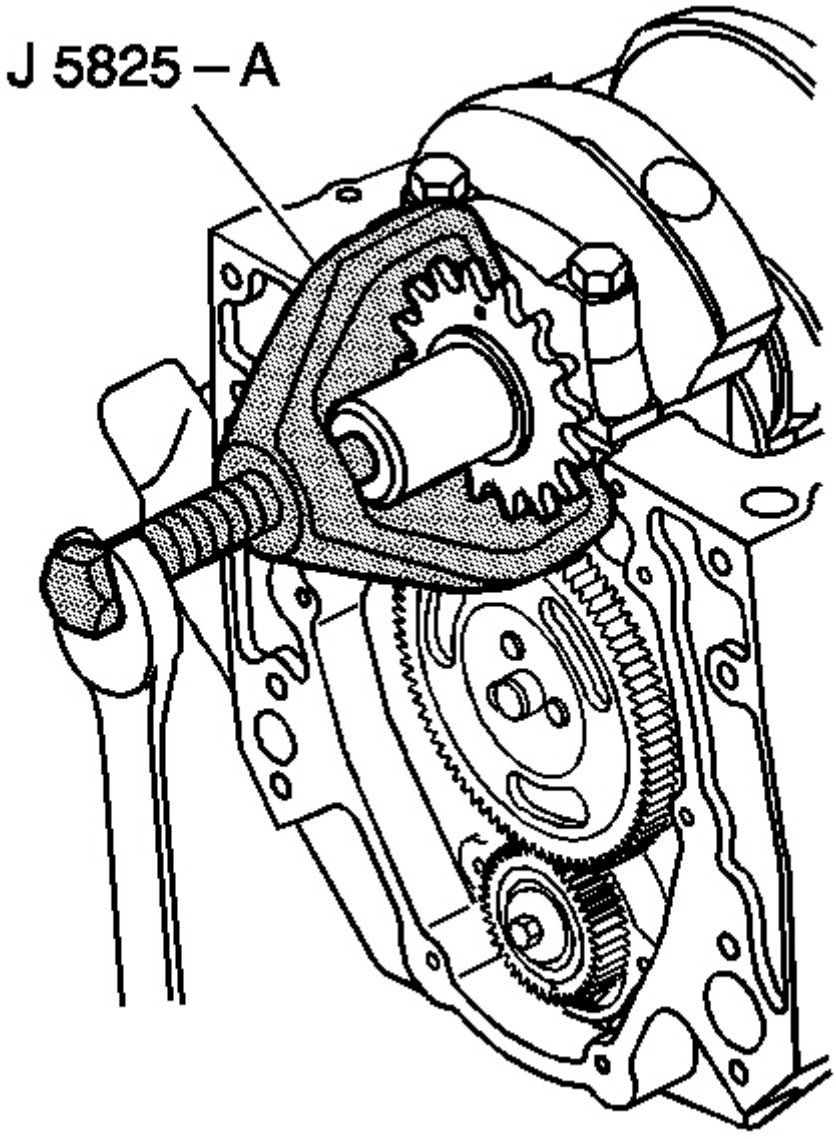


Fig. 428: J 5825-A
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

7. Remove the crankshaft sprocket using the **J 5825-A** . See **Special Tools**.

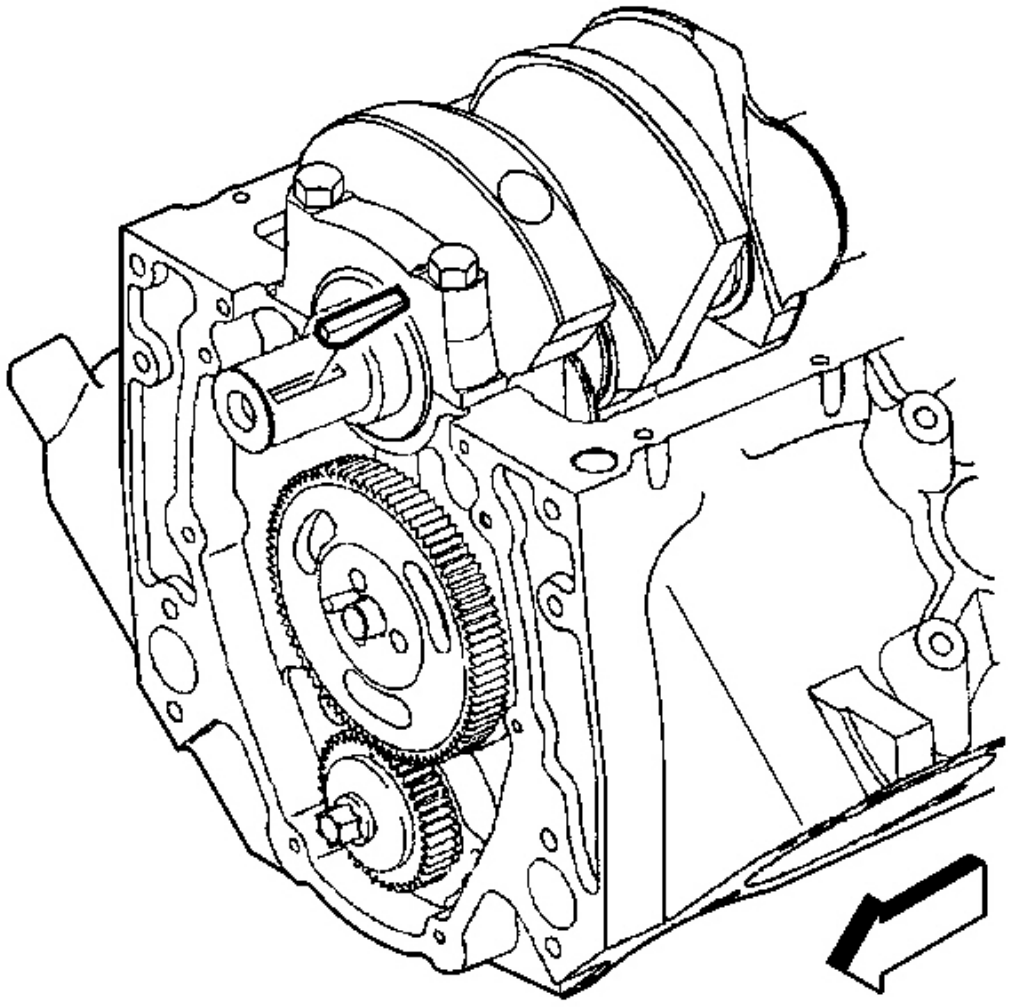


Fig. 429: Locating Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer key.

BALANCE SHAFT REMOVAL

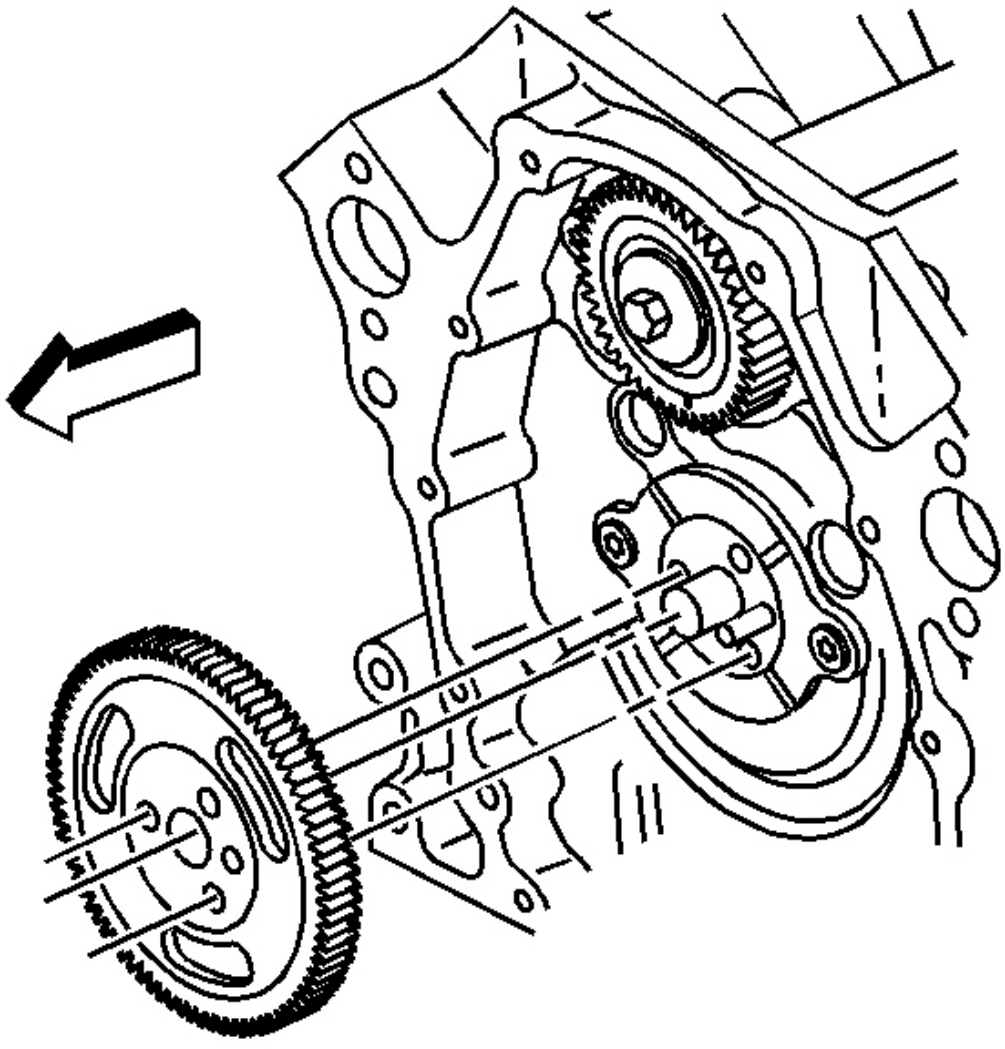


Fig. 430: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft drive gear.

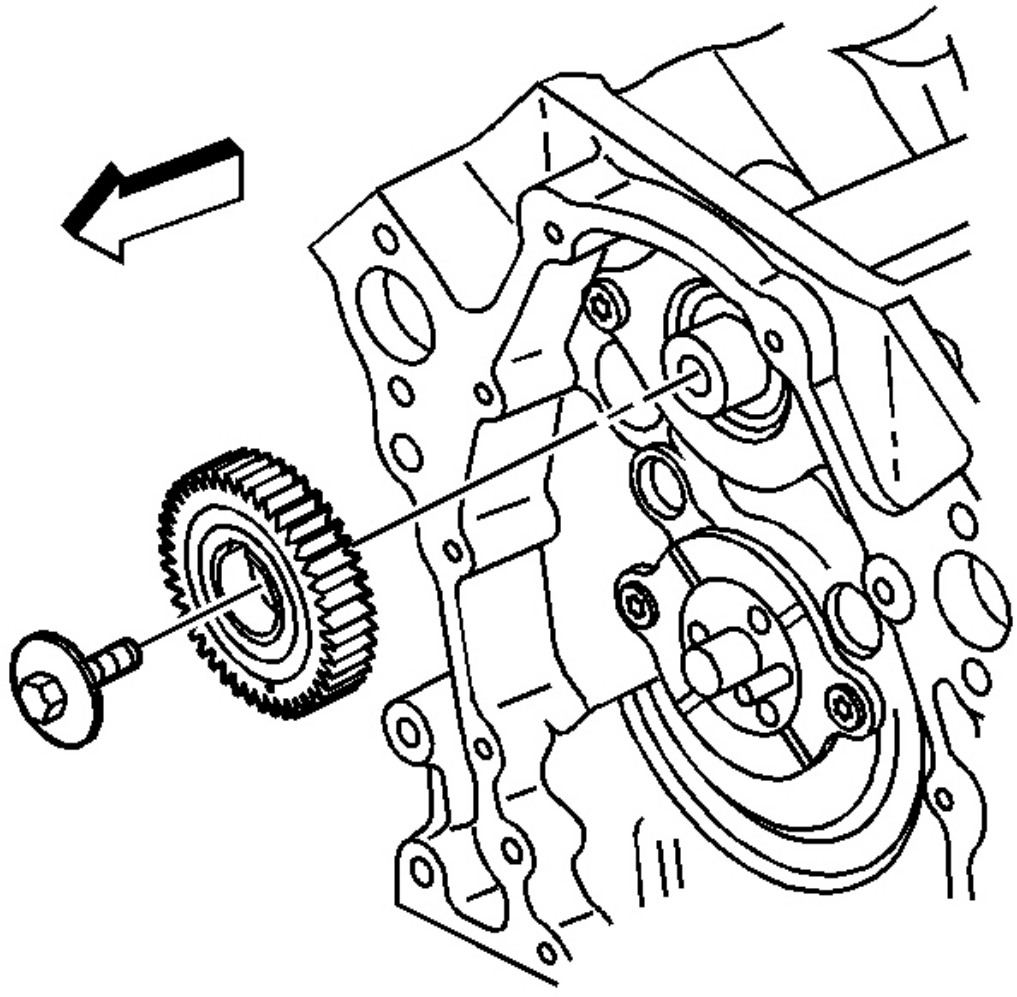


Fig. 431: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft drive and balance shaft driven gears are serviced as a set. The set includes the balance shaft driven gear bolt.

2. Remove the balance shaft driven gear bolt from the balance shaft.
    1. Use a wrench in order to secure the balance shaft.

Place the wrench onto the balance shaft near to the balance shaft front bearing.

2. Remove the balance shaft bolt.
3. Remove the wrench from the balance shaft.

3. Remove the balance shaft driven gear from the balance shaft.

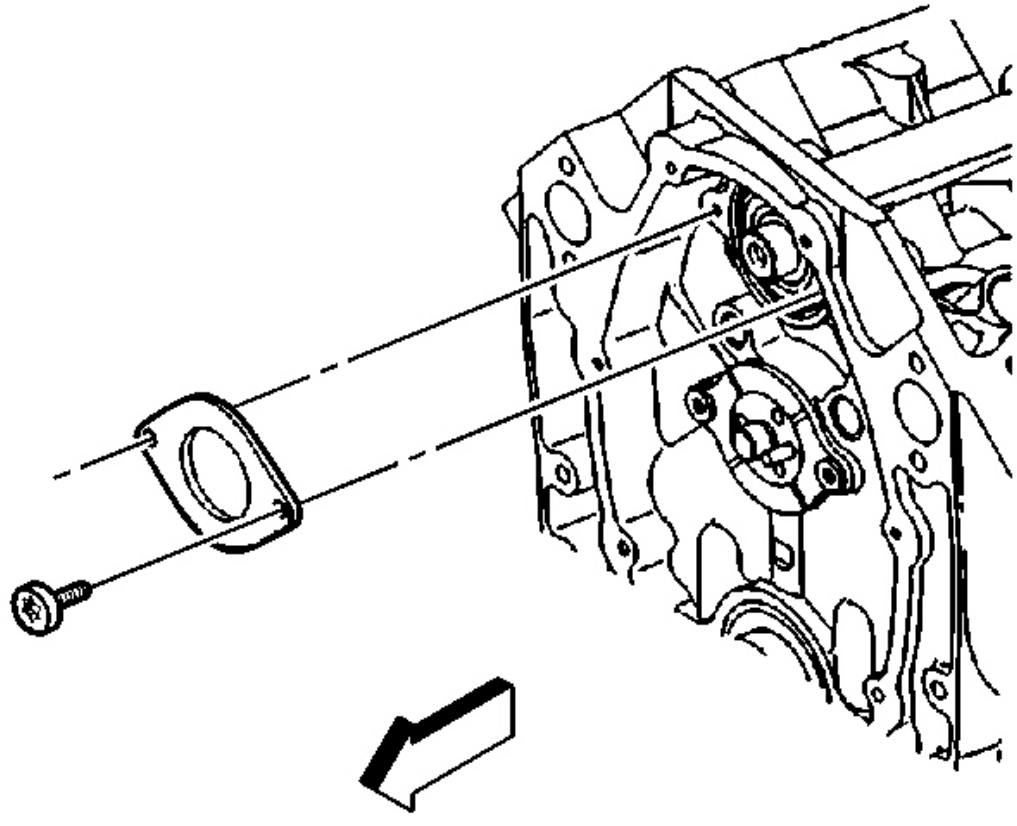


Fig. 432: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and the balance shaft retainer.

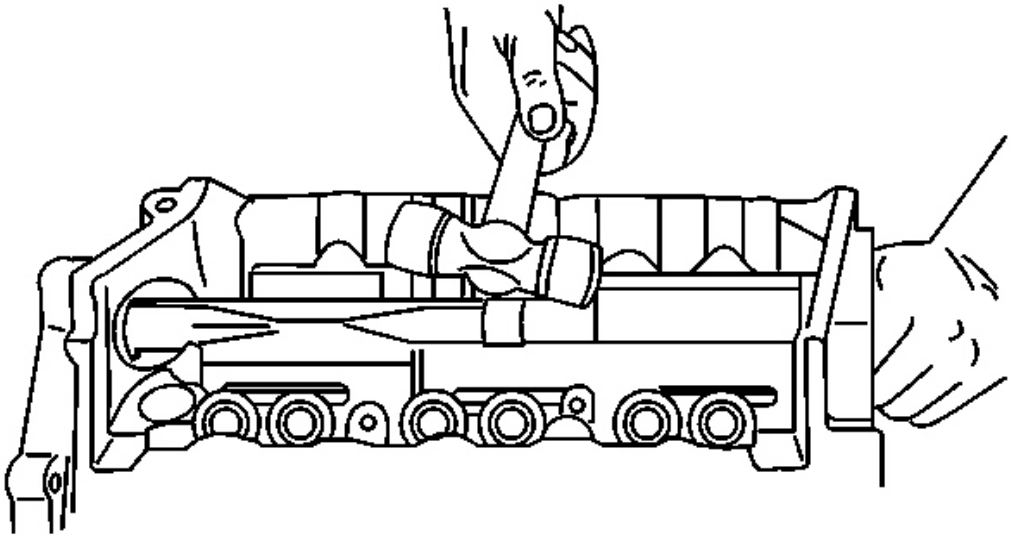


Fig. 433: Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as a package. Do not remove the balance shaft front bearing from the balance shaft.

5. Use a soft-faced hammer in order to remove the balance shaft from the engine block.

CAMSHAFT REMOVAL

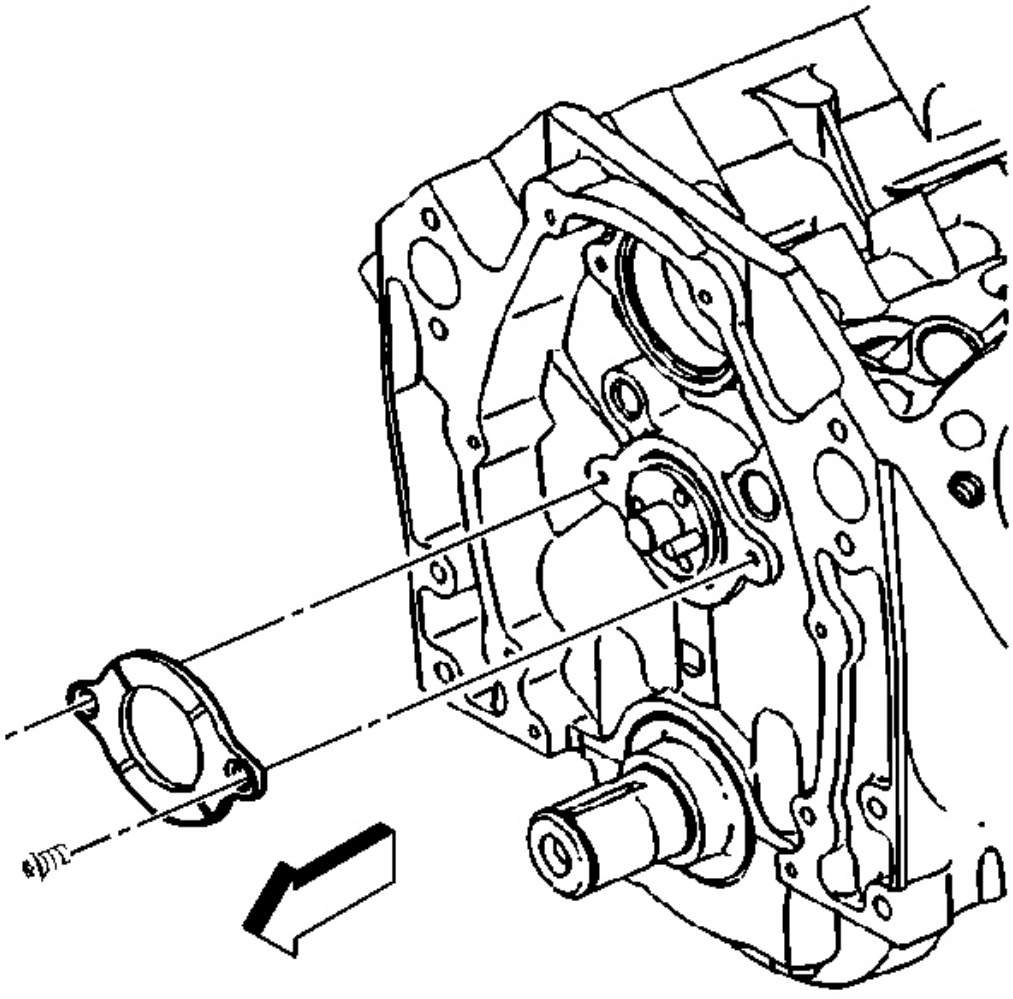


Fig. 434: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts and retainer.

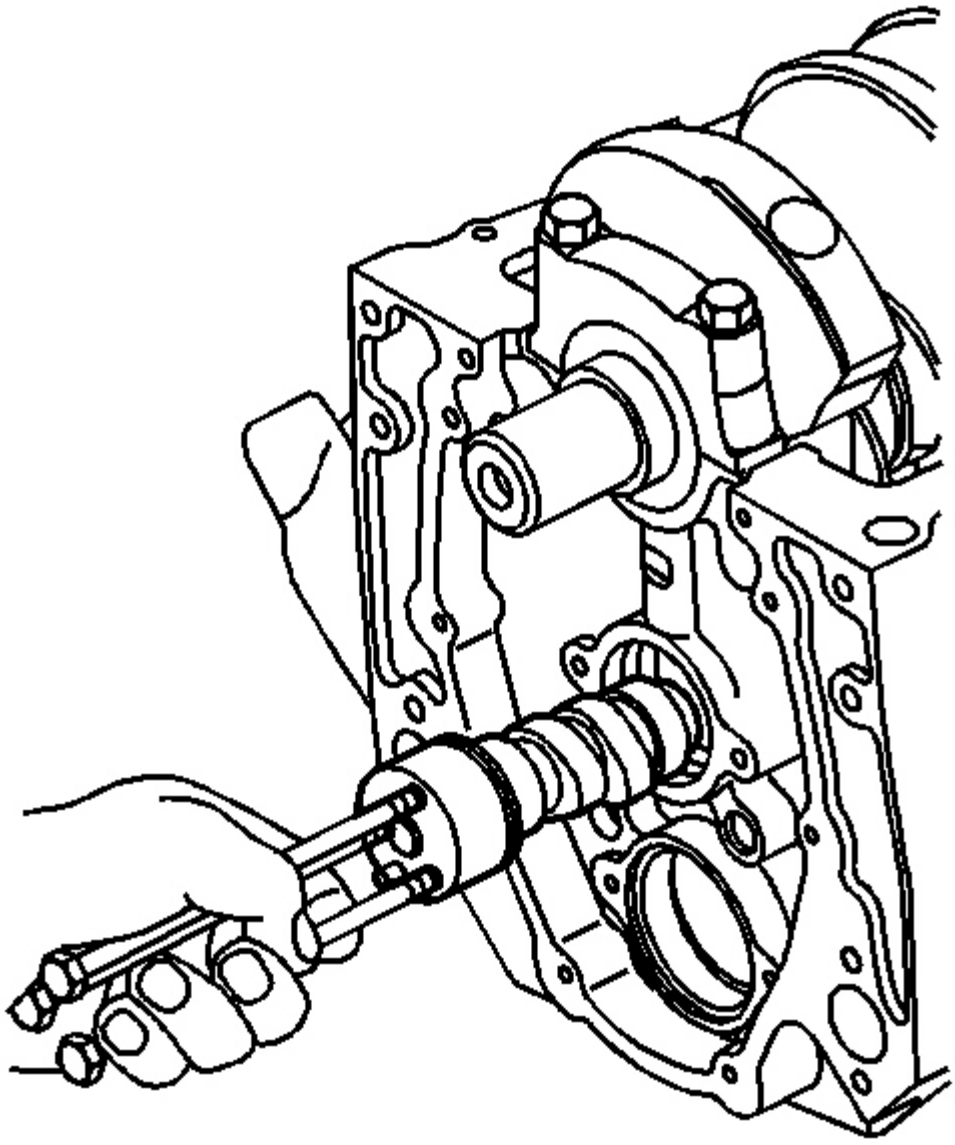


Fig. 435: View Of Engine Camshaft Front Bolts
Courtesy of GENERAL MOTORS CORP.

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.

2. Remove the engine camshaft.
    1. Install the three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.
    2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
    3. Remove the bolts from the front of the engine camshaft.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

J 24270 Cylinder Bore Ridge Reamer. See **Special Tools**.

Removal

IMPORTANT: Powdered metal connecting rod, piston, and piston pin are to be serviced as an assembly.

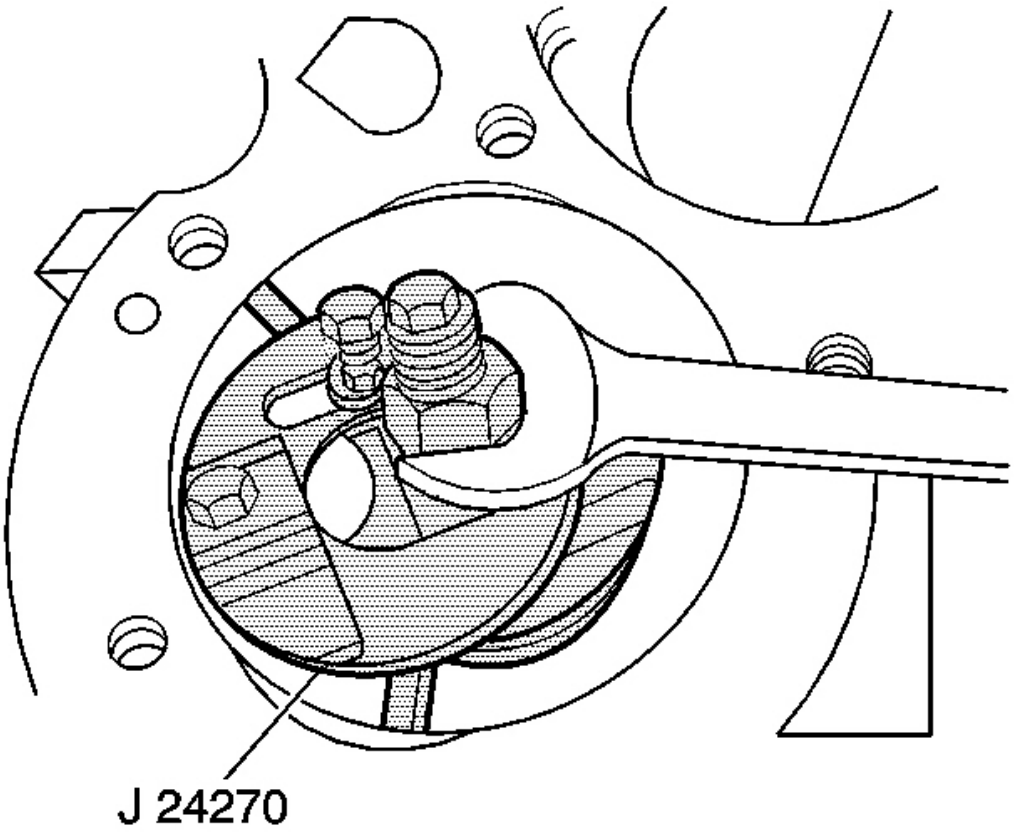


Fig. 436: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 24270** in order to remove the cylinder ring ridge. See **Special Tools**.
    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** to remove all of the cylinder ring ridge. See **Special Tools**.
    4. Turn the crankshaft so the piston is at the top of the stroke.
    5. Remove the cloth.
    6. Remove the cutting debris.

IMPORTANT: The connecting rods and rod bearing caps are NOT interchangeable. Using a paint stick or etching tool, place

match marks or numbers on the connecting rods and the connecting rod bearing caps prior to removal to ensure that they are assembled in their original position and direction, with the connecting rod/rod bearing cap mating surfaces properly oriented and aligned.

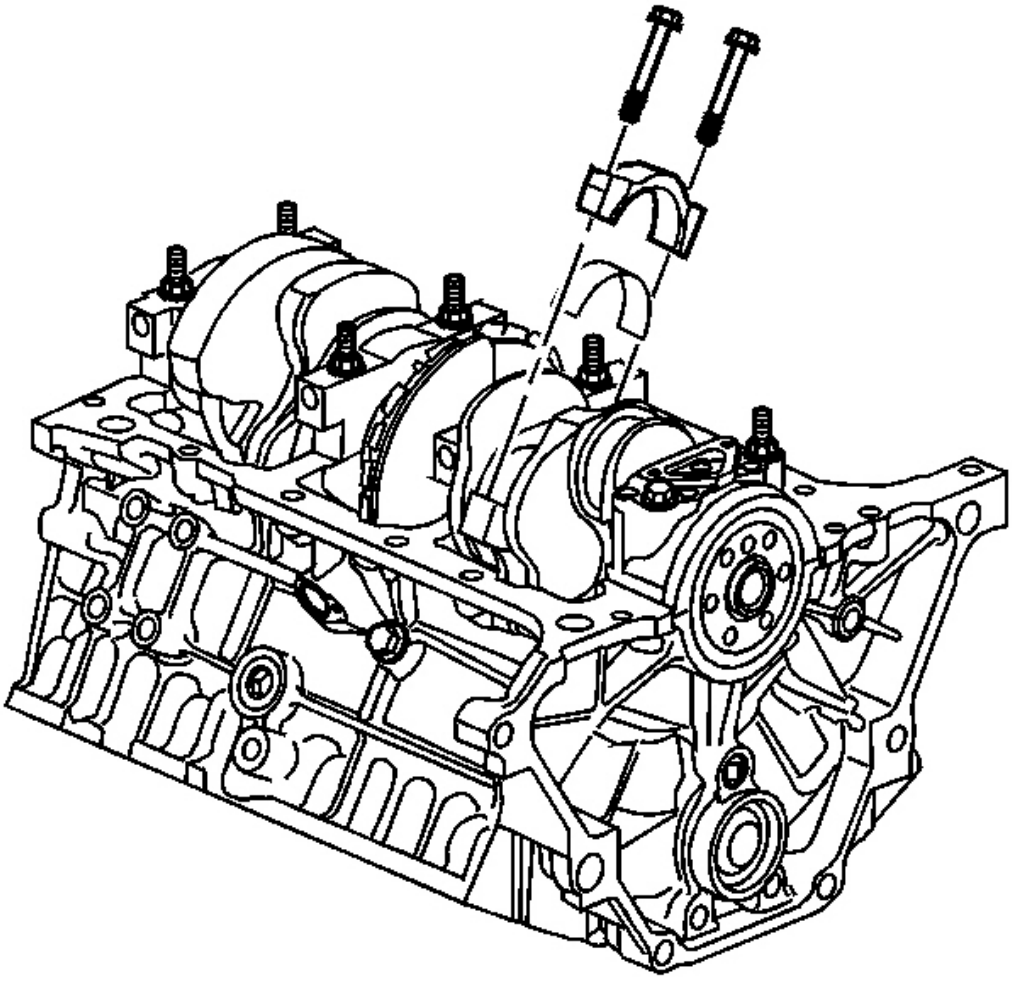


Fig. 437: View Of Bearing, Bearing Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the connecting rod bolts, cap, and bearing.

IMPORTANT: Wrap a clean, lint free towel around the connecting rod ends when removing the piston from the cylinder so as not to damage the crankshaft journals or cylinder bore.

3. Remove the connecting rod and the piston out of the top of the engine block.
4. Remove the connecting rod bearings from the connecting rod.
    - Keep all connecting rod bearings and rod bearing caps with the original connecting rods, and in the original orientation at the connecting rod/rod bearing cap mating area.
    - Wipe the oil from the connecting rod bearings.
    - Wipe the oil from the crankpins.

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

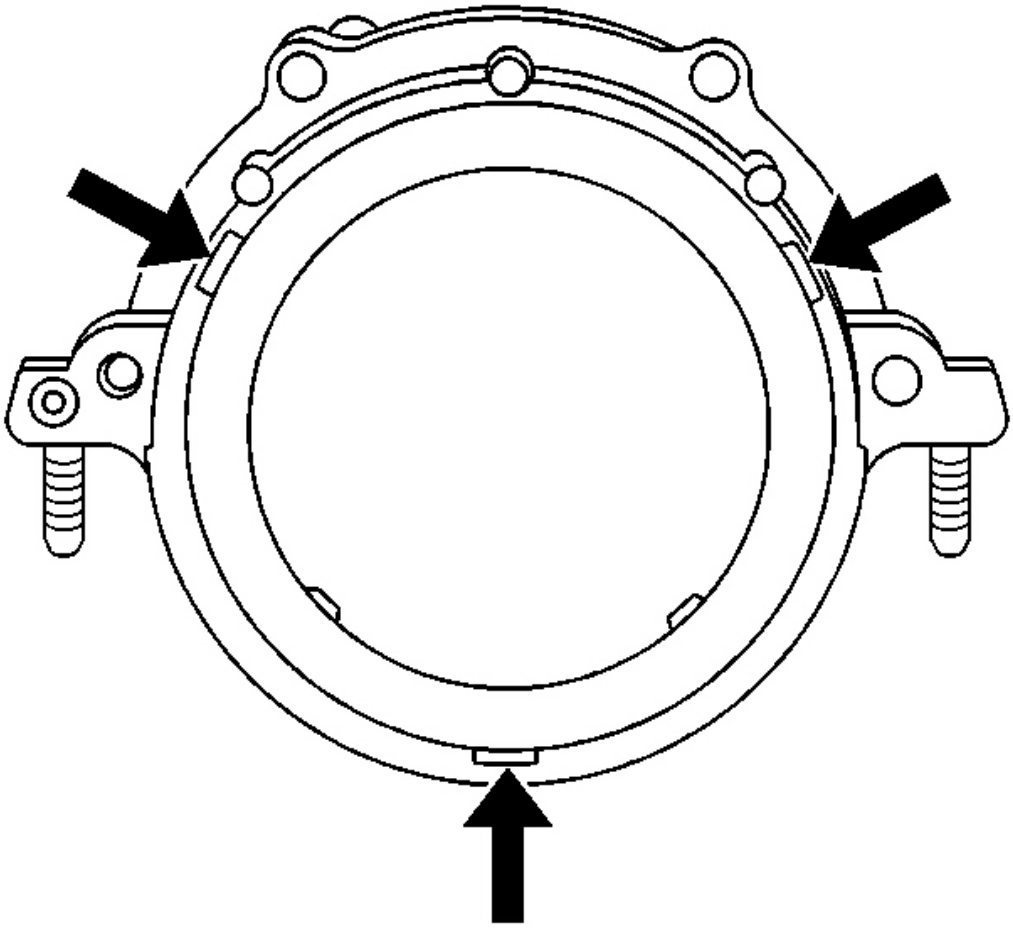


Fig. 438: Crankshaft Rear Oil Seal Notches
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

   Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.

2. Discard the crankshaft rear oil seal.

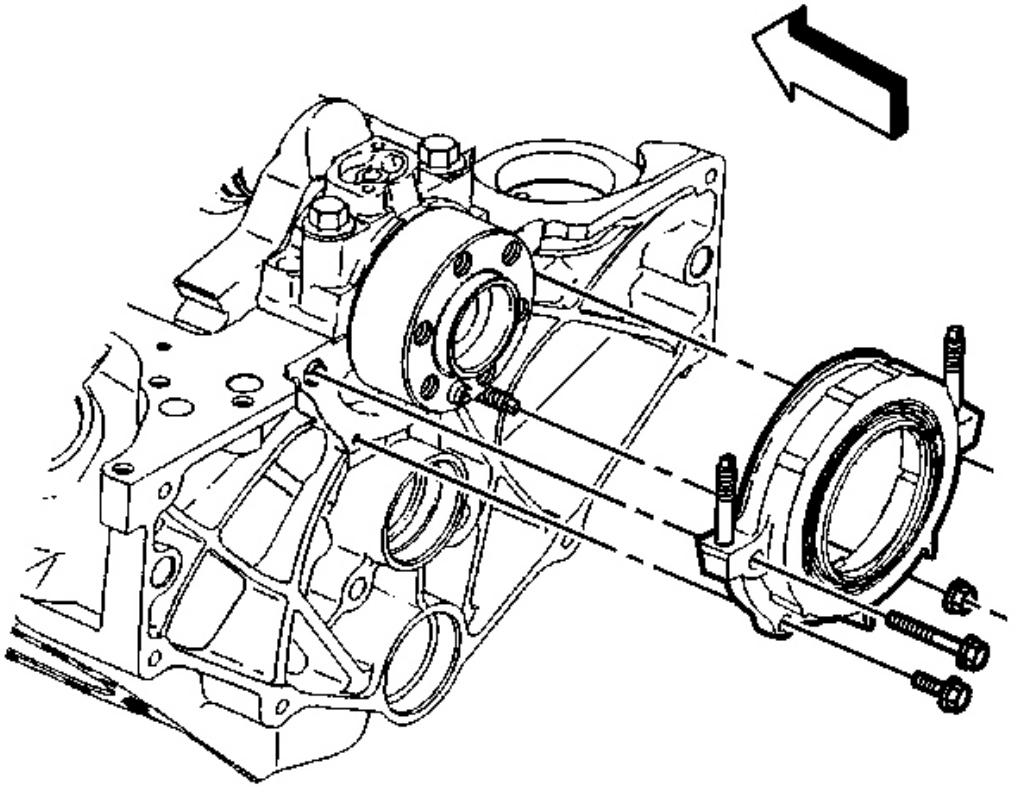


Fig. 439: View Of Crankshaft Rear Oil Seal Housing Nut & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft rear oil seal housing nut and bolts.
4. Remove the crankshaft rear oil seal housing.

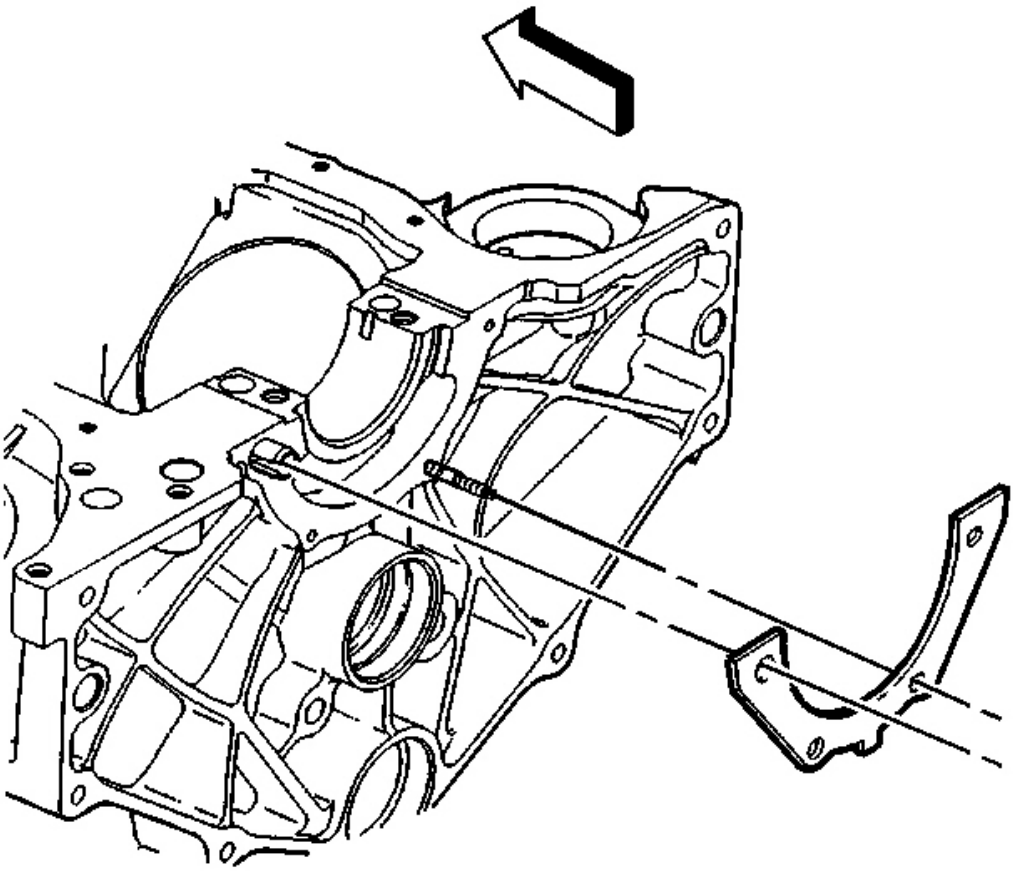


Fig. 440: Identifying Crankshaft Rear Oil Seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft rear oil seal housing gasket.
6. Discard the crankshaft rear oil seal housing gasket.

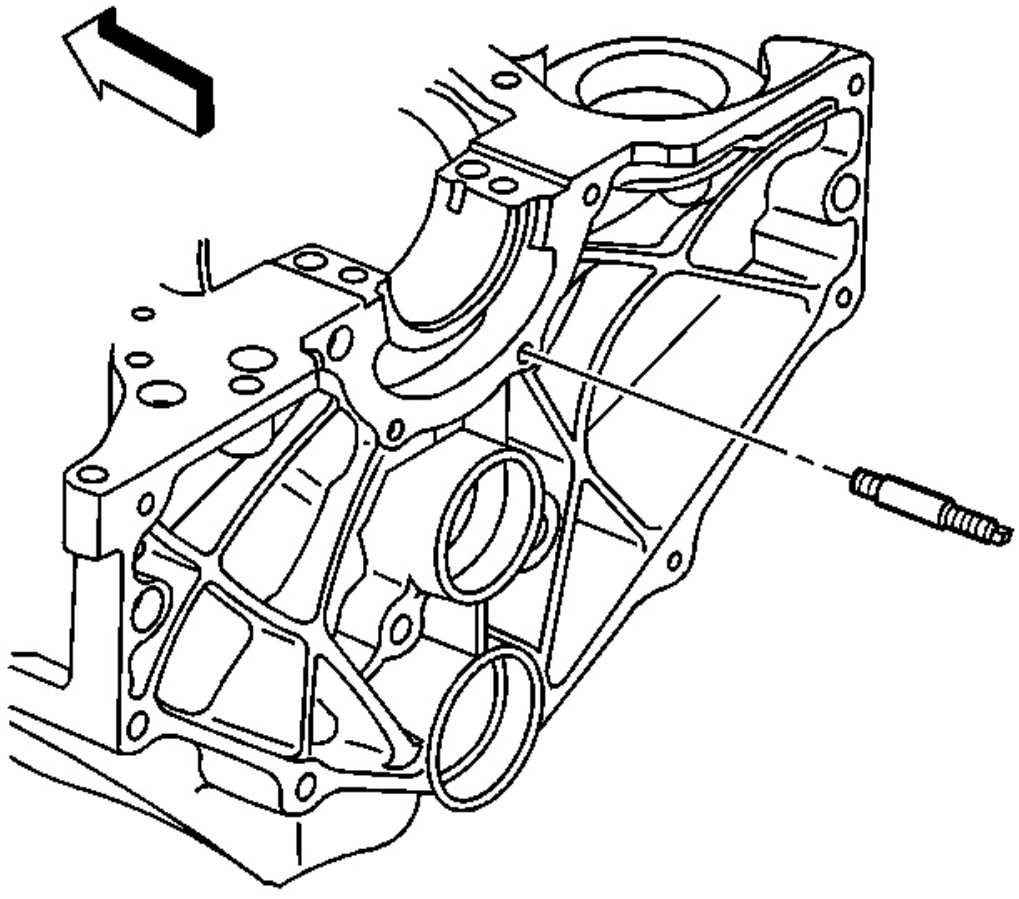


Fig. 441: Locating Crankshaft Rear Oil Seal Housing Retainer Stud
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft rear oil seal housing retainer stud from the engine block.

CRANKSHAFT AND BEARING REMOVAL

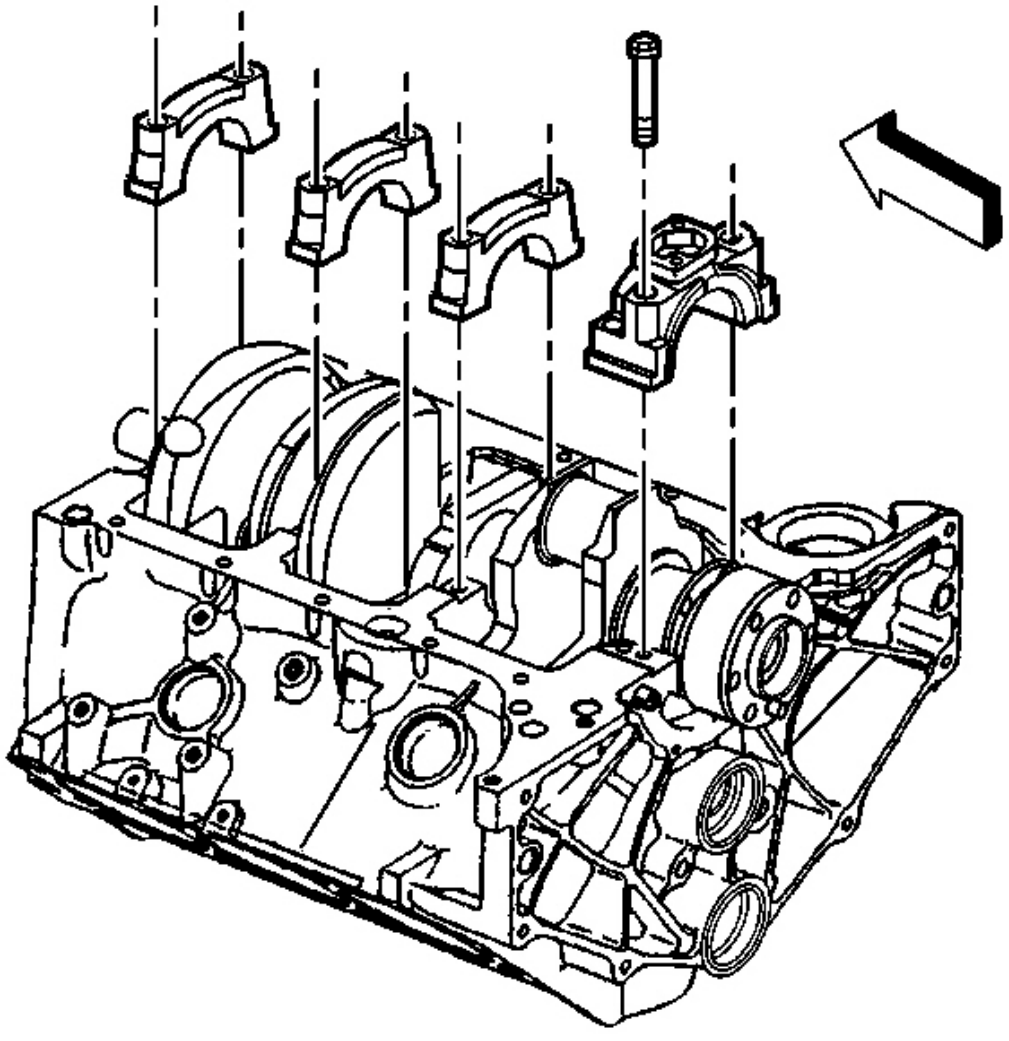


Fig. 442: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Mark or identify the crankshaft bearing cap locations, direction, and positions for assembly.
2. Remove the crankshaft bearing cap bolts and discard.
3. Remove the crankshaft bearing caps.

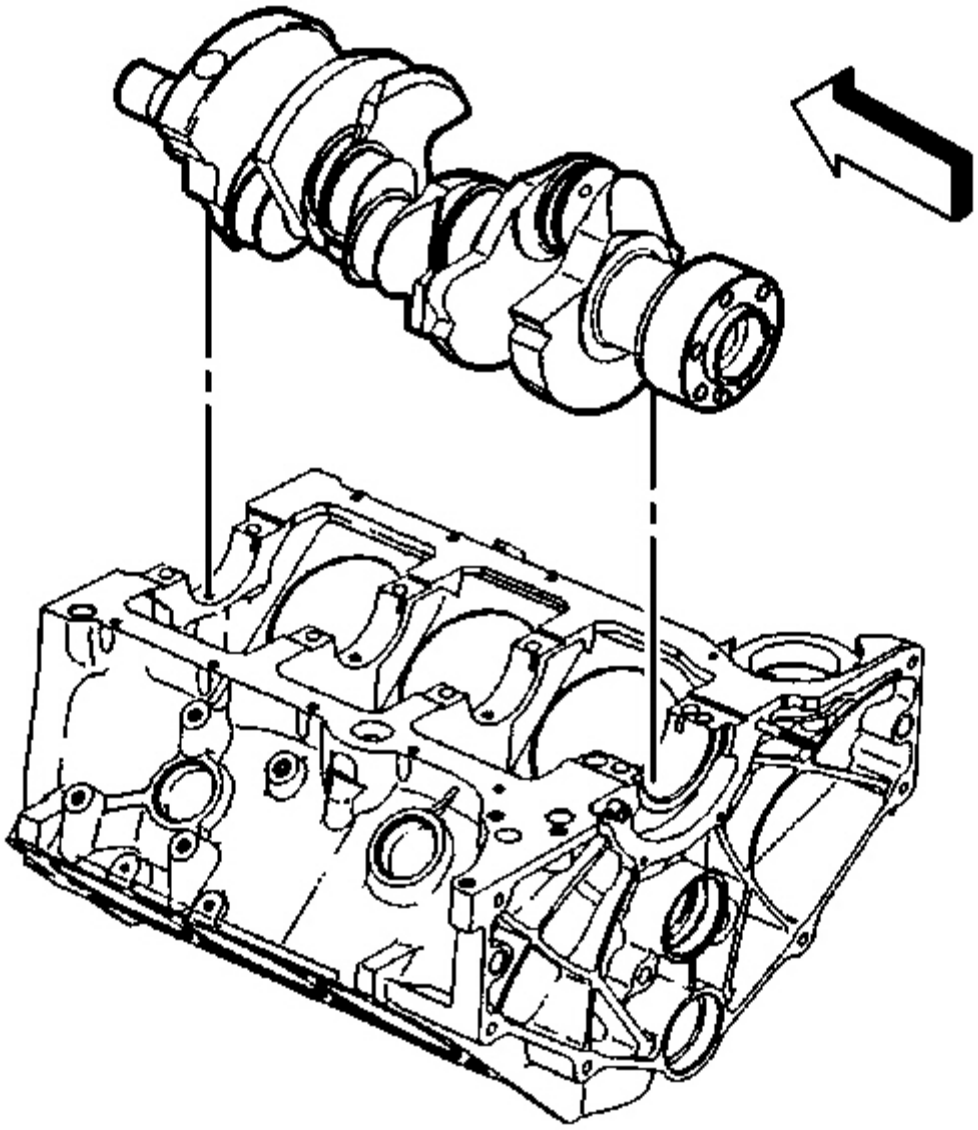


Fig. 443: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft.

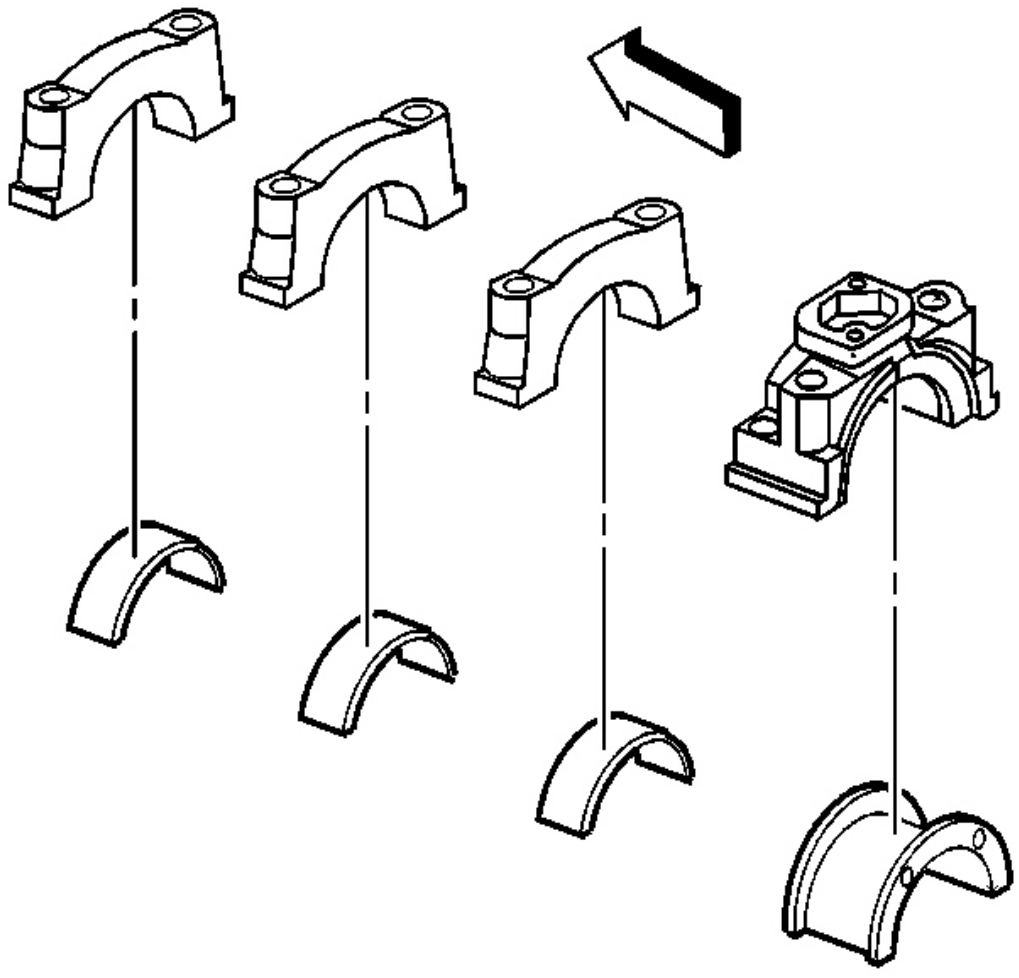


Fig. 444: View Of Crankshaft Bearings & Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft bearings from the crankshaft bearing caps.

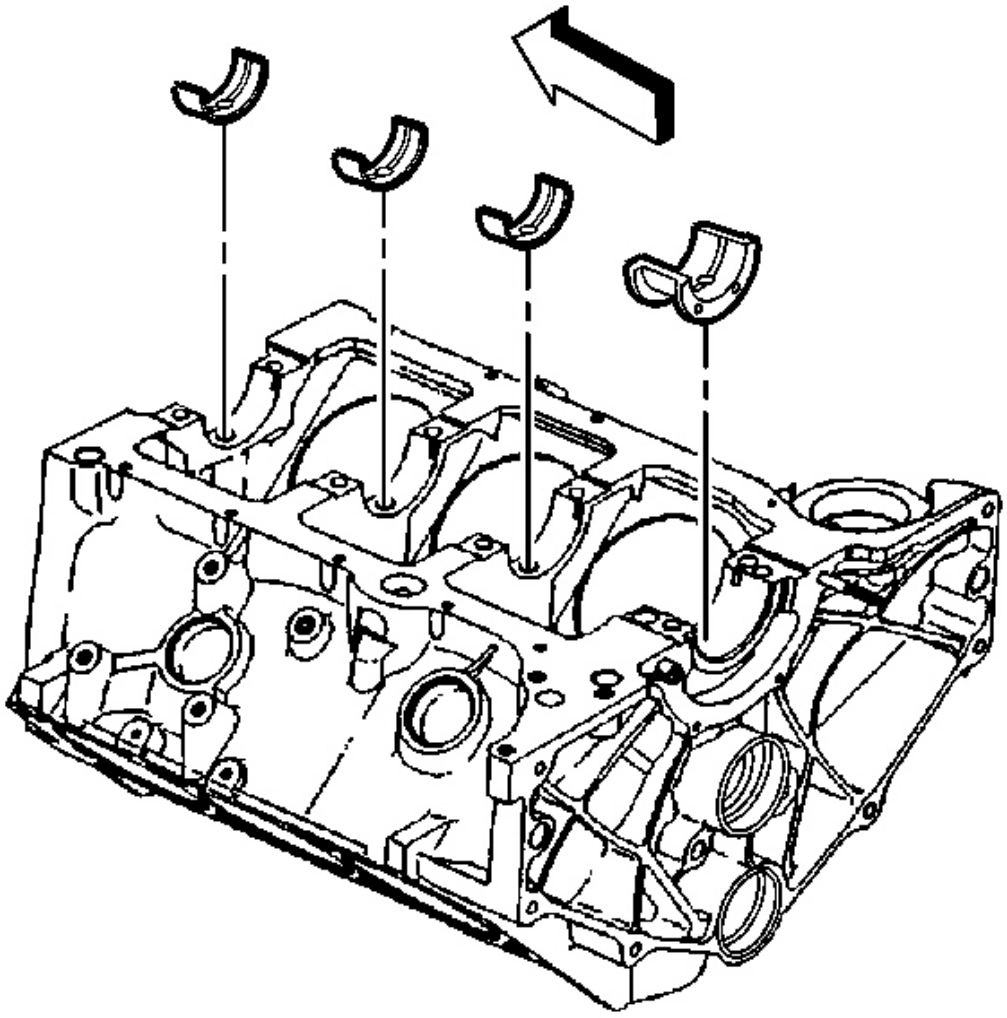


Fig. 445: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft bearings from the engine block.

ENGINE BLOCK PLUG REMOVAL

Special Tools

J 41712 Oil Pressure Switch Socket. See **Special Tools**.

Removal

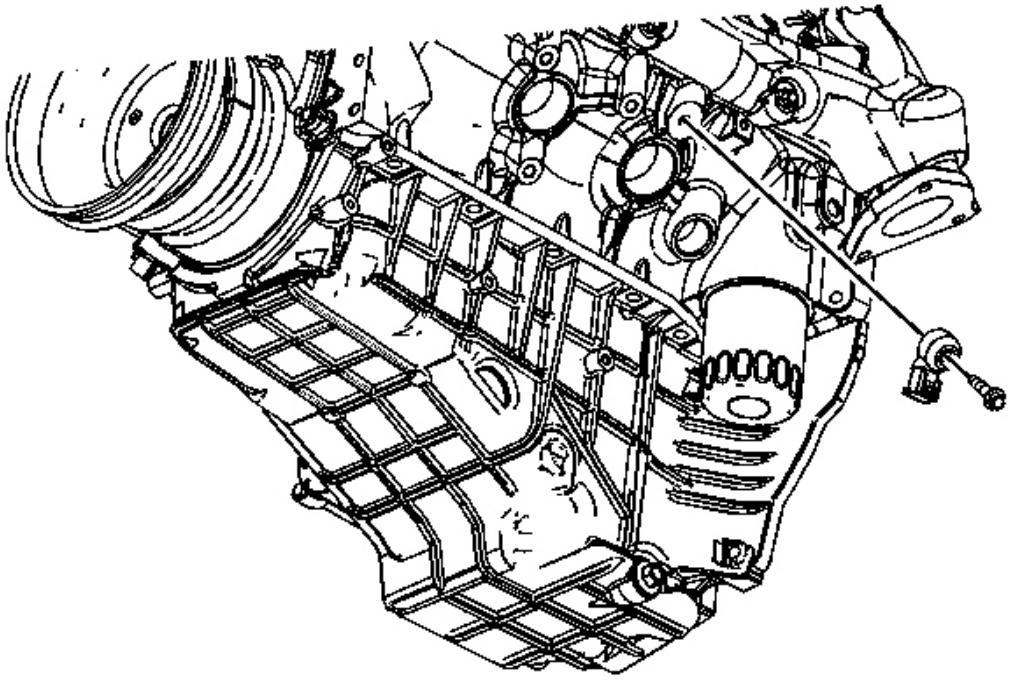


Fig. 446: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Remove the knock sensor bolt and knock sensor from the left side of the lower engine block.

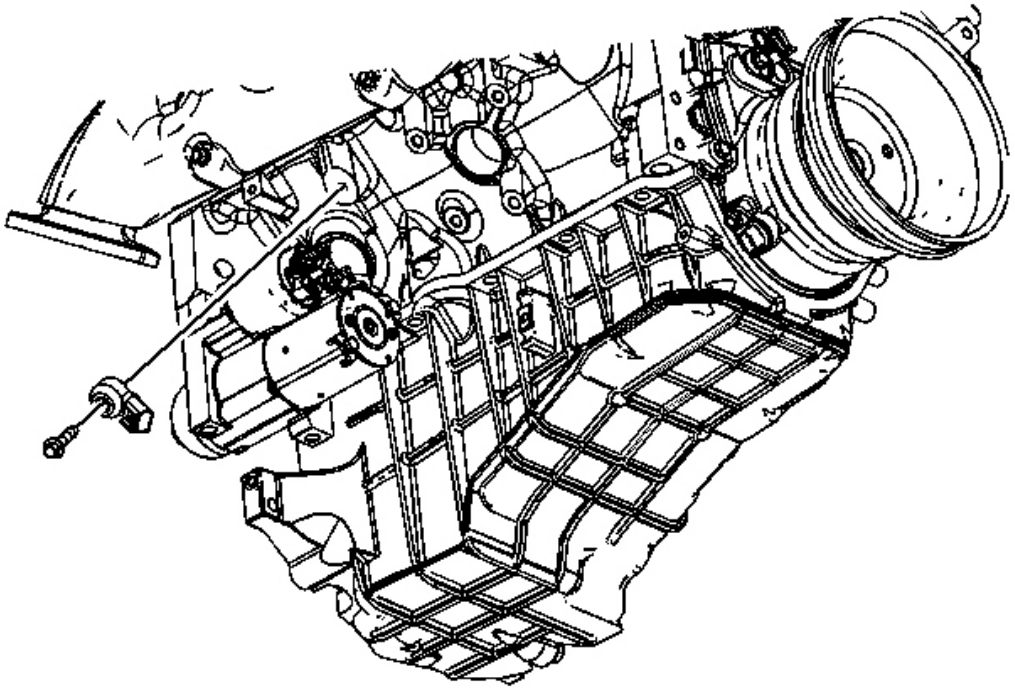


Fig. 447: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the knock sensor bolt and knock sensor from the right side of the lower engine block.

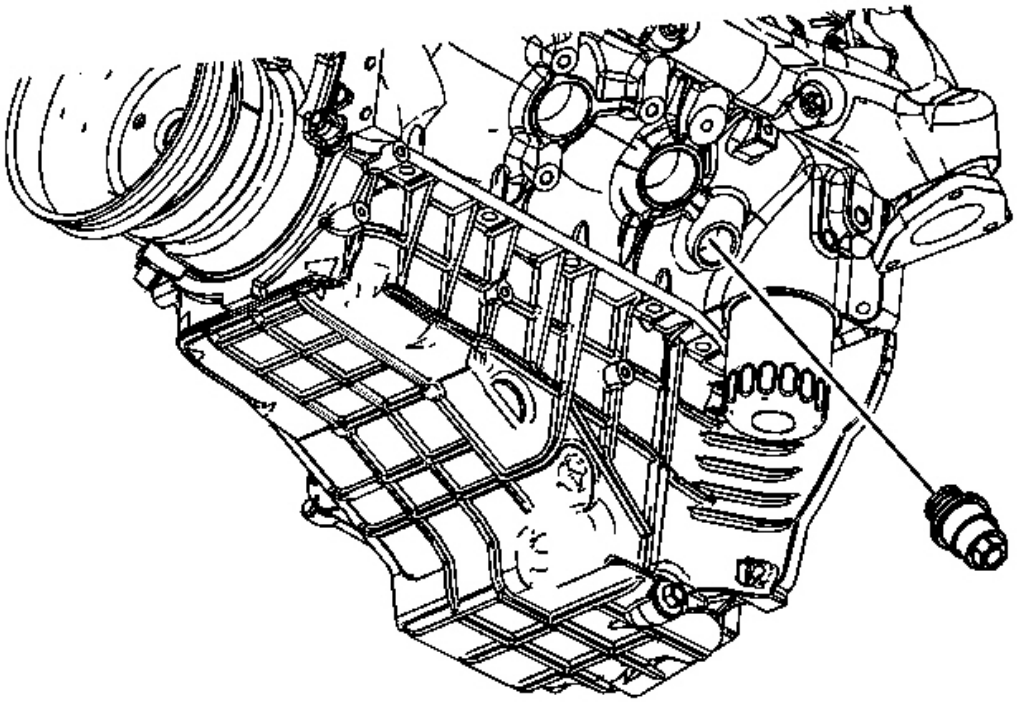


Fig. 448: Block Heater
Courtesy of GENERAL MOTORS CORP.

3. Remove the block heater from the right side of the lower engine block.

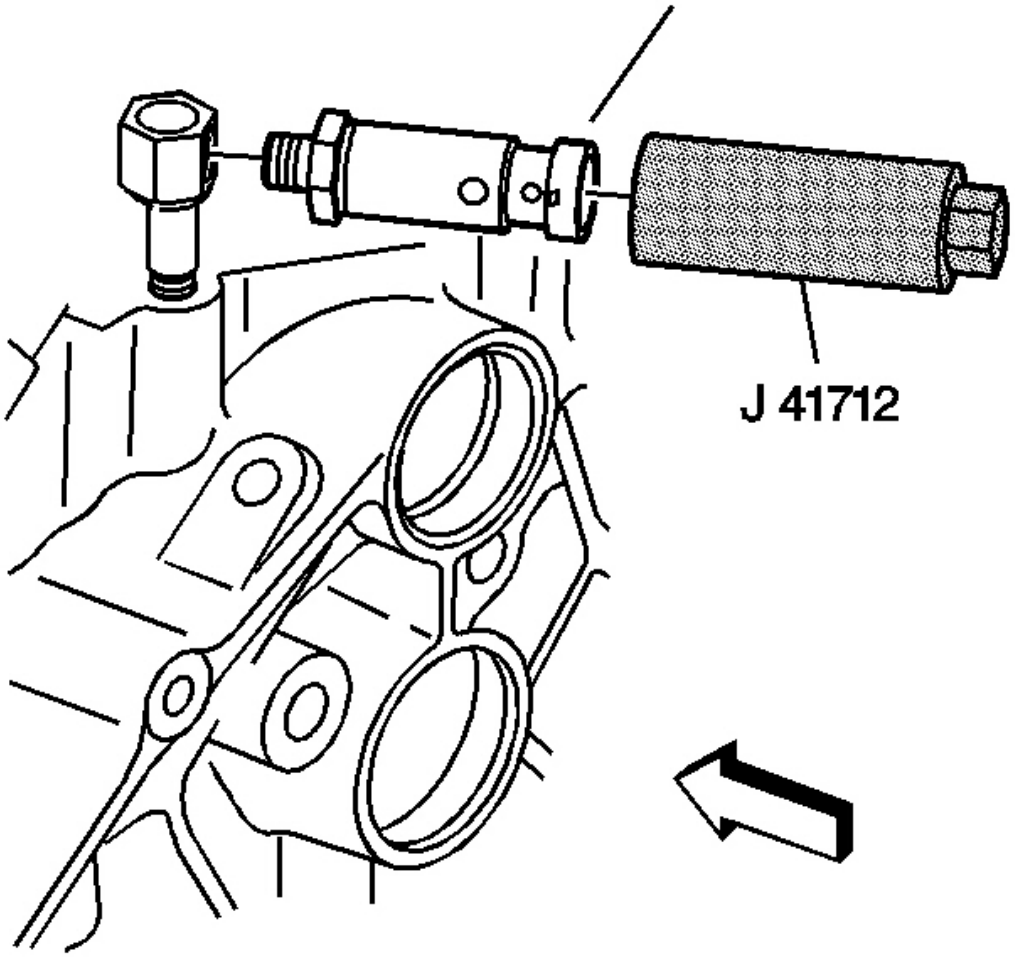


Fig. 449: View Of Engine Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine oil pressure gage sensor using the **J 41712** . See **Special Tools**.

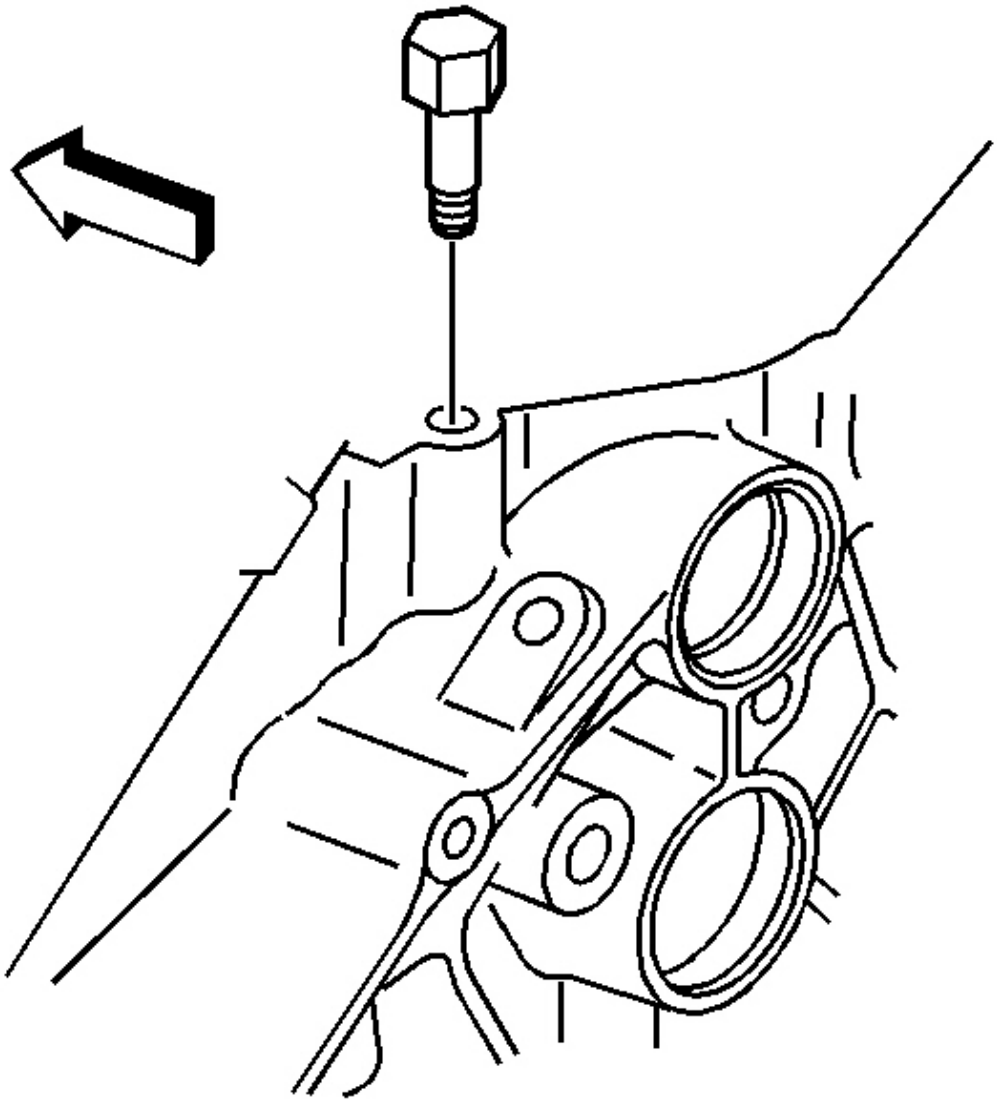


Fig. 450: Engine Oil Pressure Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine oil pressure sensor fitting.

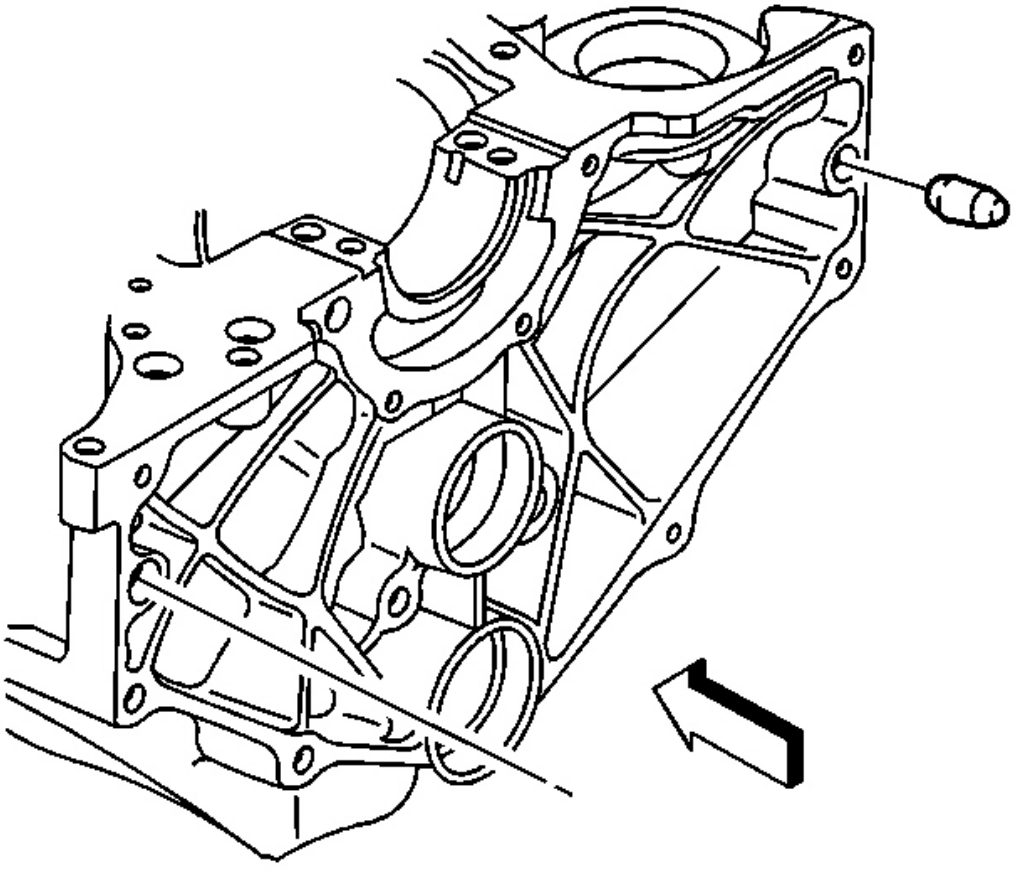


Fig. 451: Identifying Transmission Locator Dowel Straight Pin
Courtesy of GENERAL MOTORS CORP.

6. Remove the transmission locator dowel straight pins, if required.

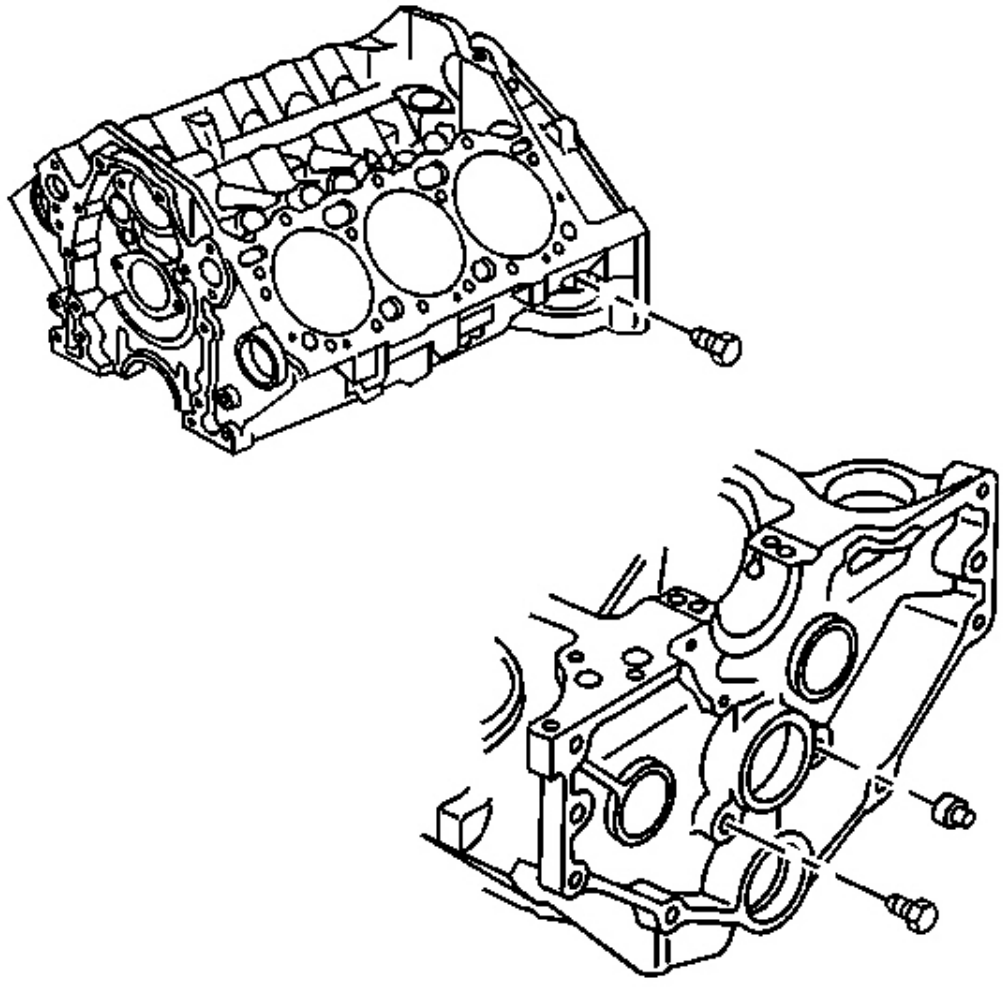


Fig. 452: Engine Block Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine block left side oil gallery plug.
8. Remove the engine block left rear oil gallery plug.
9. Remove the engine block right rear oil gallery plug.

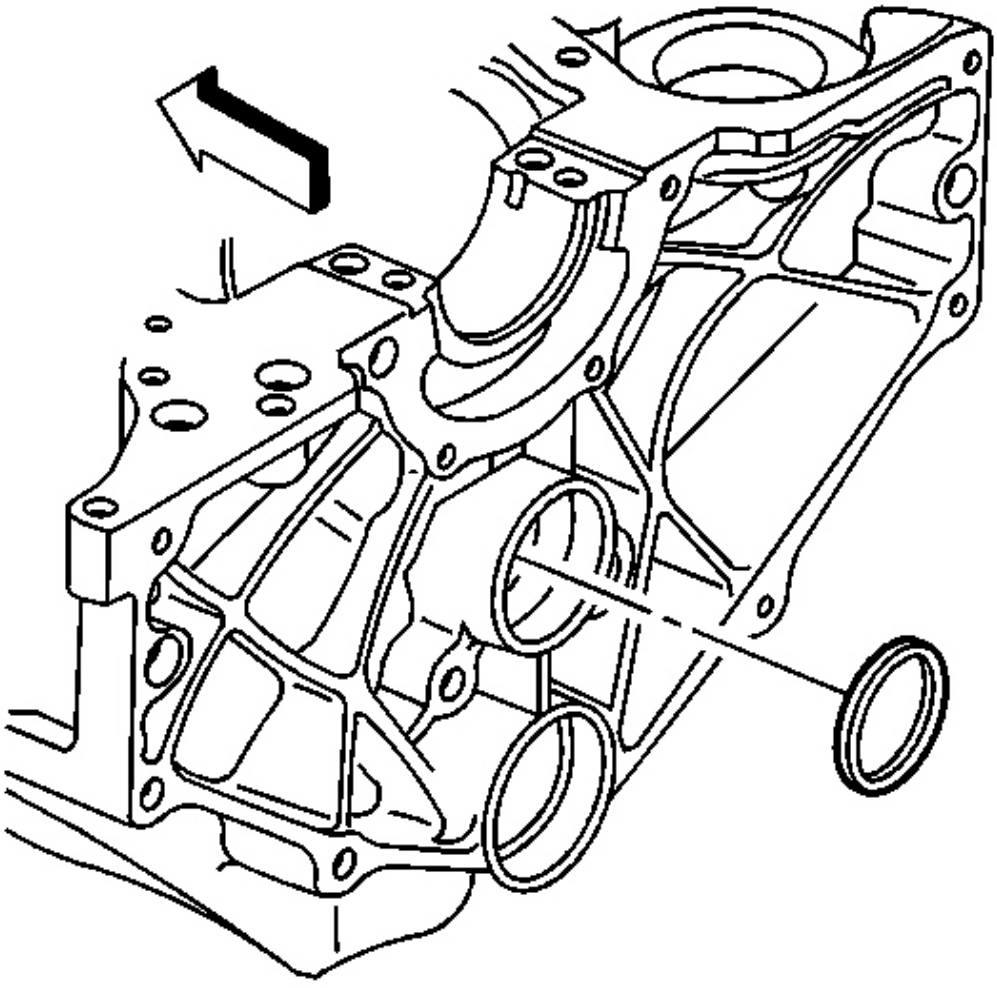


Fig. 453: Identifying Camshaft Rear Bearing Hole Expansion Cup Plug
Courtesy of GENERAL MOTORS CORP.

10. Remove the expansion cup plug from the camshaft rear bearing hole and discard.

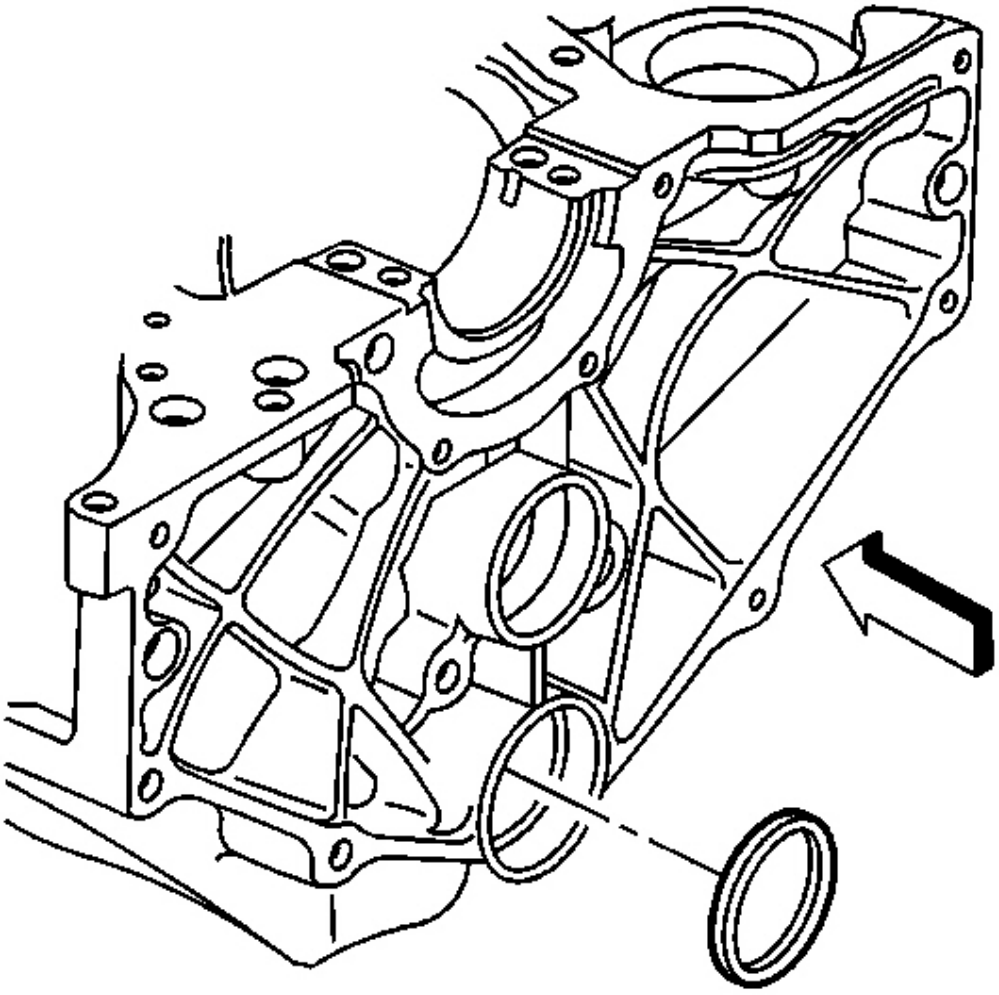


Fig. 454: View Of Balance Shaft Rear Bearing Hole Expansion Cup Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the expansion cup plug from the balance shaft rear bearing hole and discard.

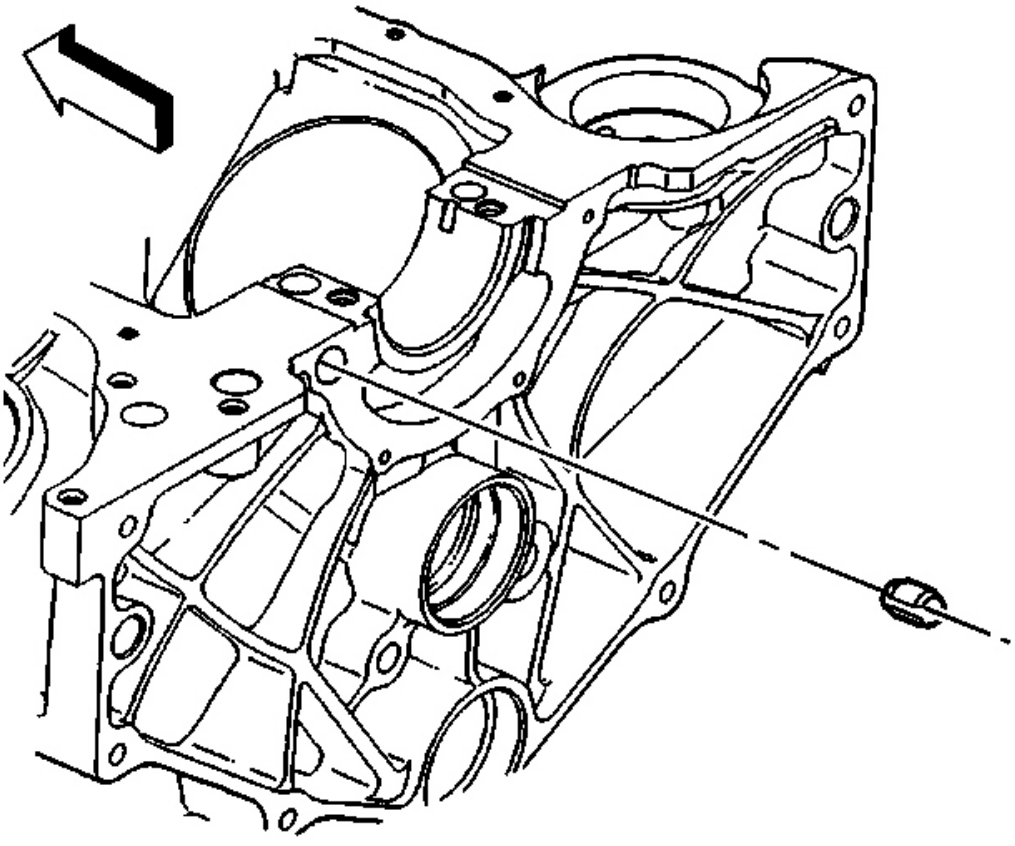


Fig. 455: Crankshaft Rear Oil Seal Housing Locator Spring
Courtesy of GENERAL MOTORS CORP.

12. Remove the crankshaft rear oil seal housing locator spring type S pin, if required.

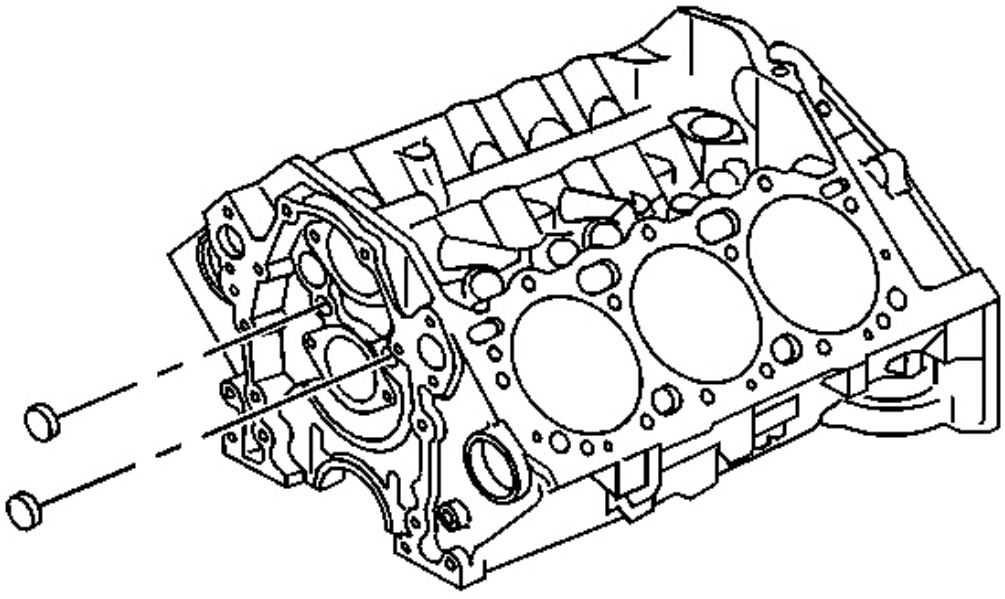


Fig. 456: Front Of Engine Block Front Oil Gallery Plugs Or Balls
Courtesy of GENERAL MOTORS CORP.

13. Remove the front oil gallery plugs or balls from the front of the engine block and discard.

    Insert a 3/8 x 26 inch rod into the rear oil gallery holes in order to drive out the front oil gallery plugs or balls.

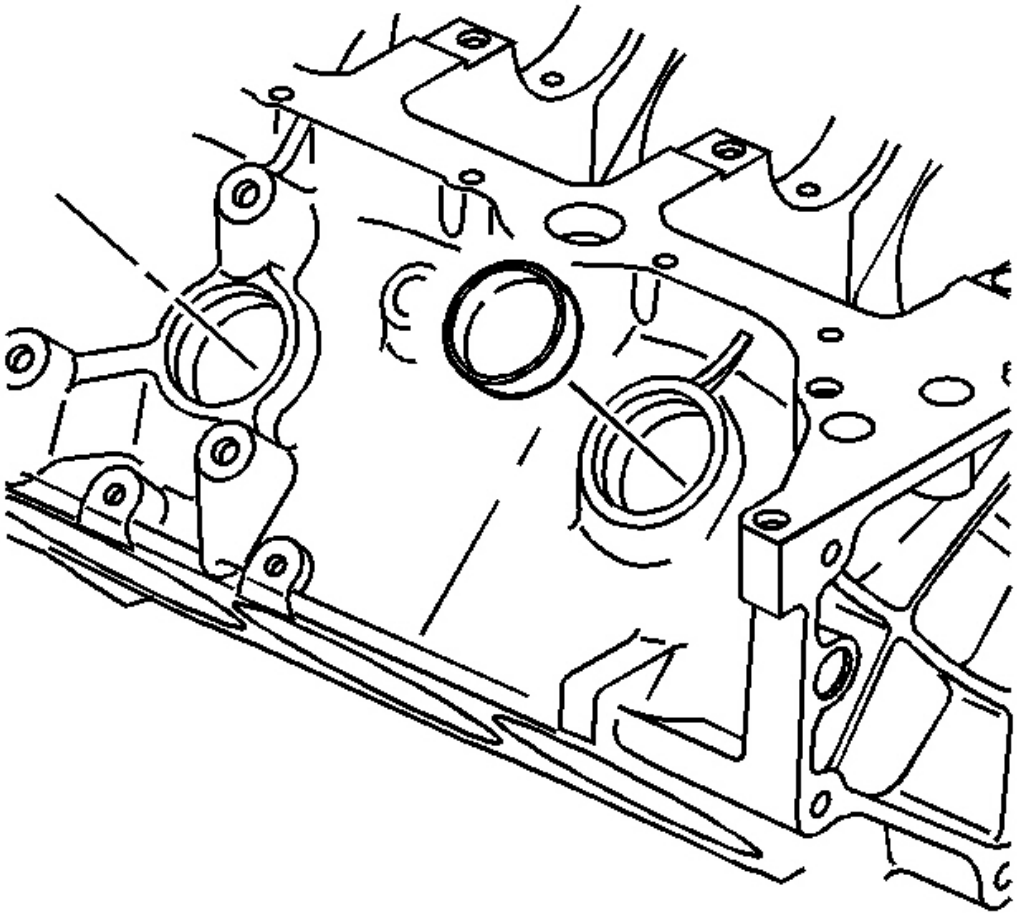


Fig. 457: Engine Block Core Hole Plugs
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine block core hole plugs.
    1. Use a suitable tool in order to drive the engine block core hole plugs into the coolant jacket.
    2. Use a suitable tool in order to pull the engine block core hole plugs from the coolant jacket.
    3. Discard the engine block core hole plugs.

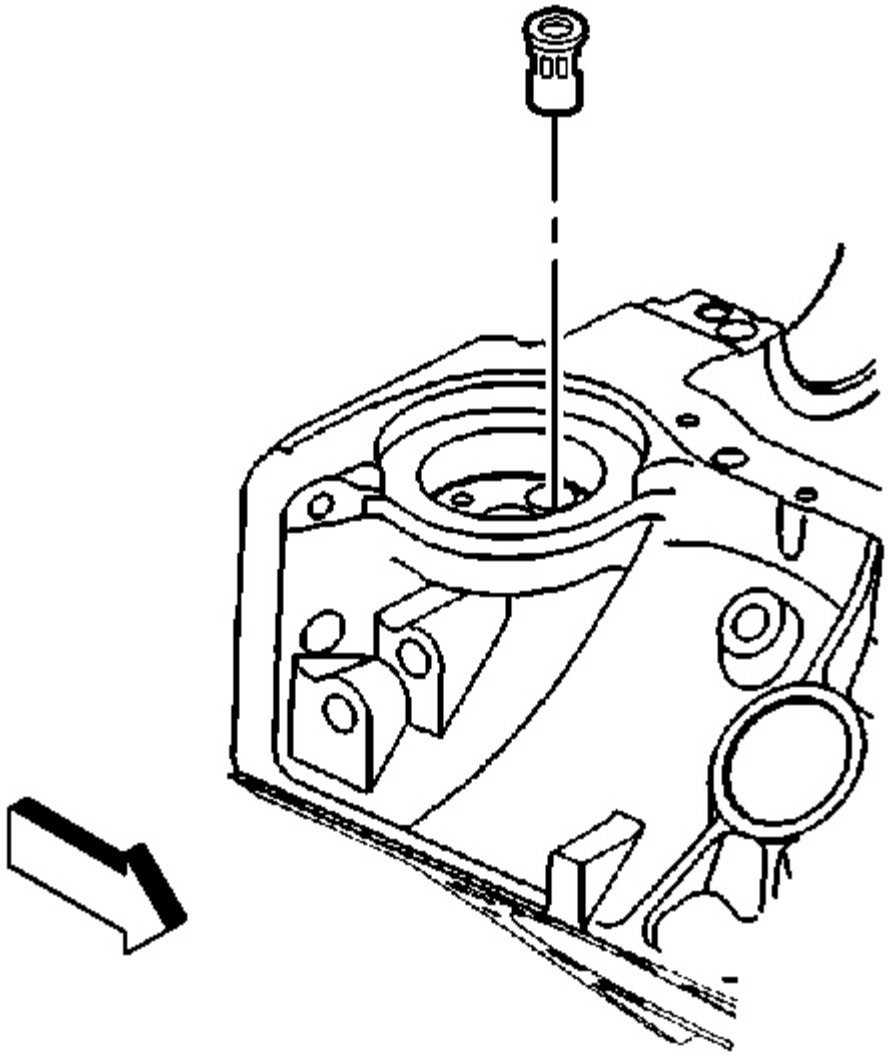


Fig. 458: Identifying Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

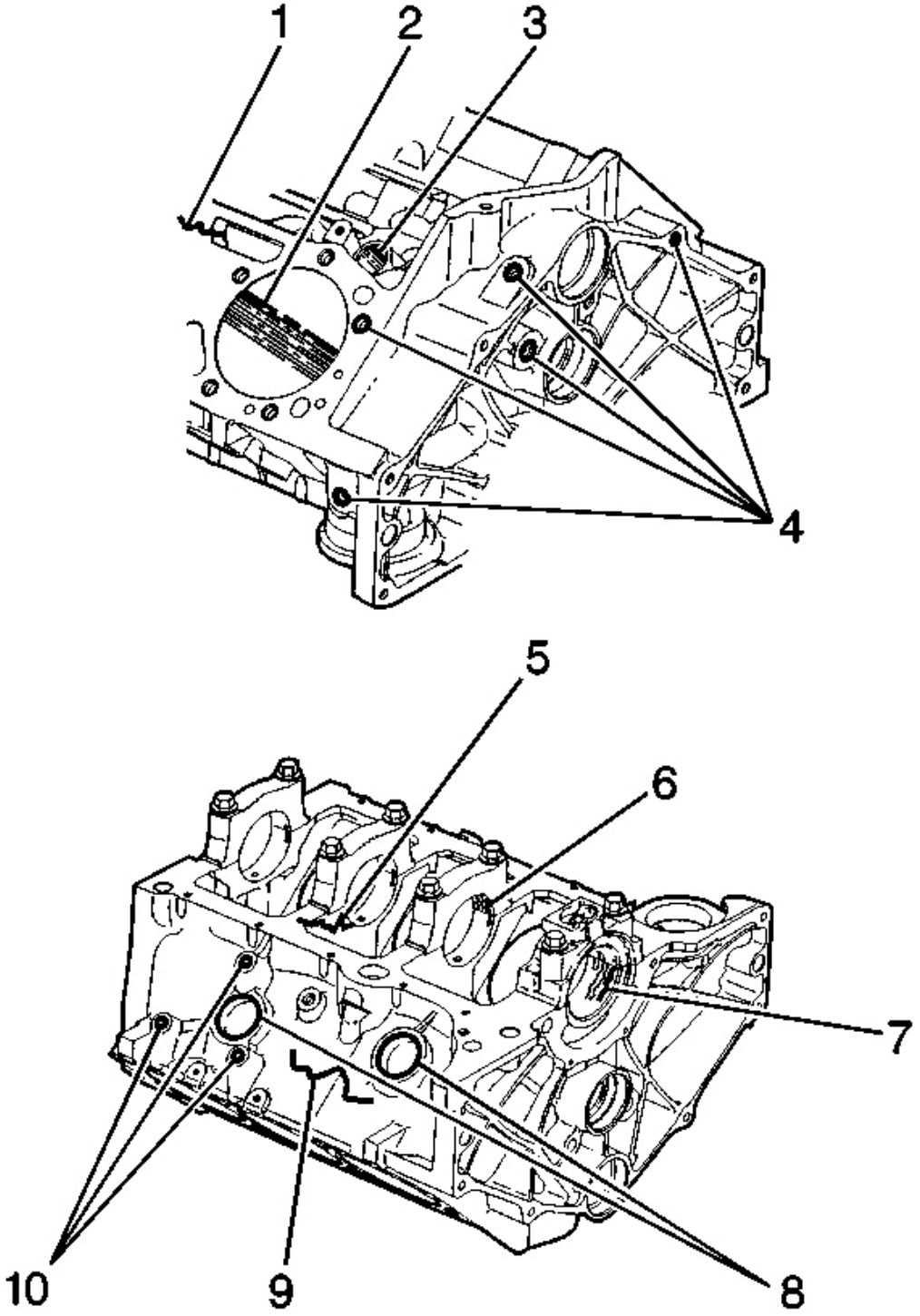
15. Remove the oil filter bypass valve and discard.

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

J 8087 Cylinder Bore Gage

Cleaning and Inspection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2
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10

Fig. 459: Engine Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean all the remaining sealing or gasket material from the sealing surfaces.
2. Clean the engine block with cleaning solvent.
3. Flush the engine block with clean water or steam.
4. Clean the cylinder bores.
5. Clean the oil galleries and the oil passages.
6. Clean the scale and the deposits from the coolant passages.

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.

7. Clean the engine block cylinder head bolt holes.
8. After cleaning the engine block, spray or wipe the cylinder bores and the machined surfaces with clean engine oil.
9. Inspect the following areas:
   - Coolant jackets (1) for cracks
   - Cylinder bores (2) for scratches or gouging
   - Valve lifter bores (3) for excessive scoring or wear
   - Threaded holes (4) for damage
   - Crankshaft bearing webs (5) for cracks
   - Crankshaft bearing caps (6) and the crankshaft bearing bores (7) for damage
     - The crankshaft bearing bores should be round and uniform when measuring the inside diameter (ID).
     - The surface where the crankshaft bearings contact the crankshaft bearing bore should be smooth.
     - If a crankshaft bearing cap is damaged and requires replacement, replace the crankshaft bearing cap first, then rebore the engine block crankshaft bearing bores and check for the proper alignment. Finally, check the crankshaft for the proper clearances.

- Engine block core hole plug bores (8) for damage
- Engine block (9) for cracks or damage
- Engine mount bosses (10) for damage

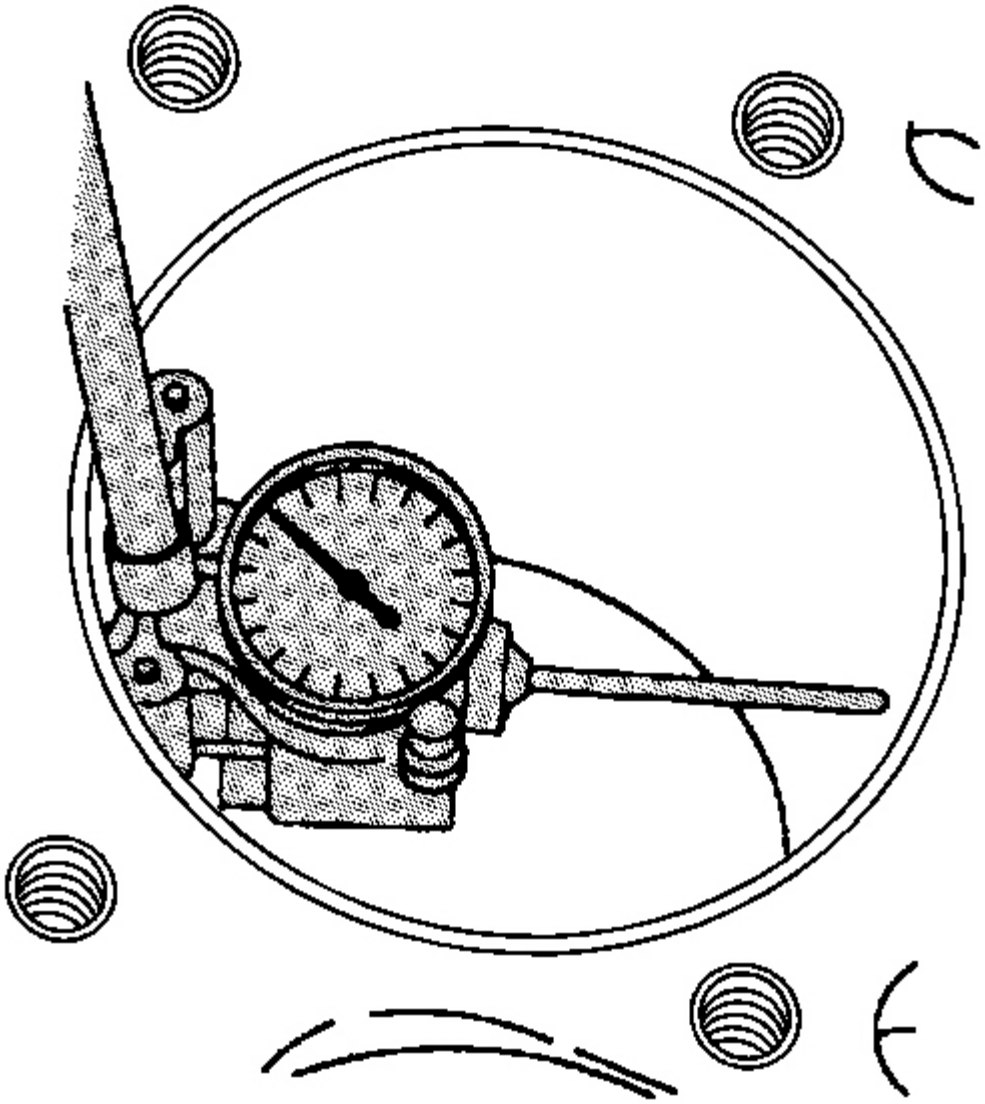


Fig. 460: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

10. Measure the cylinder bores for taper and out-of-round.
    1. Depress the plunger on the **J 8087** to 7 mm (0.275 in) or until the **J 8087** enters the cylinder bore.
    2. Center the **J 8087** in the cylinder bore and turn the indicator dial to 0.
    3. Move the **J 8087** up and down the cylinder bore to determine the cylinder bore taper. Refer to **Engine Mechanical Specifications** .
    4. Turn the **J 8087** to different points around the cylinder bore to determine the cylinder bore out-of-round condition. Refer to **Engine Mechanical Specifications** .

CYLINDER BORING AND HONING

Honing Procedure

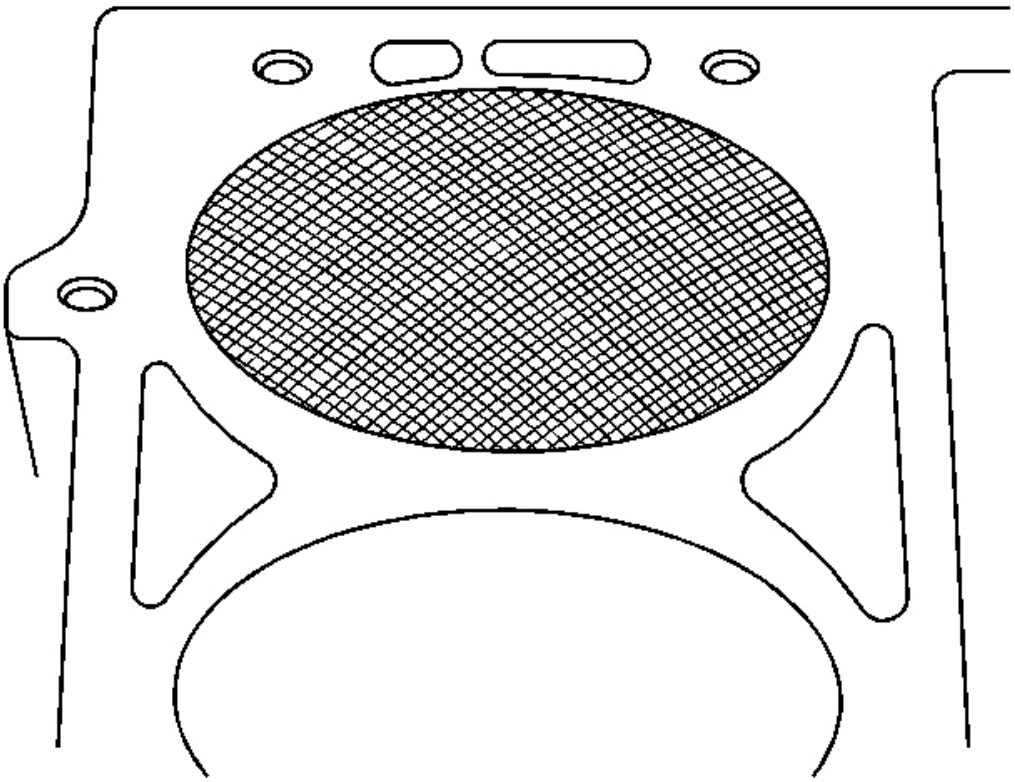


Fig. 461: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
   - Use only clean sharp stones of the proper grade for the amount of material to be removed.
   - Dull, dirty stones cut unevenly and generate excessive heat.
   - DO NOT hone to a final grade with a coarse or medium-grade stone.
   - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
   - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45-65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
   - Repeatedly check the cylinder bore fit with the selected piston.
   - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.

   Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

   - The finish marks should be clean but not sharp.
   - The finish marks should be free from imbedded particles or torn or folded metal.
4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
5. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
   1. Scrub the cylinder bores with a stiff bristle brush.
   2. Rinse the cylinder bores thoroughly with clean hot water.
   3. Dry the cylinder bores with a clean rag.
   4. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear

of the bearings.

6. Perform final measurements of the piston and the cylinder bore.
7. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Boring Procedure

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Before starting the honing or reboring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. File the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding use of the boring equipment.
4. When reboring the cylinders, make sure all the crankshaft bearing caps are installed in the original position and direction.
5. Tighten the crankshaft bearing caps to the proper torque specifications in order to avoid distortion of the cylinder bores in the final assembly.
6. When making the final cut with the boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. Carefully perform the honing and boring operation in order to maintain the specified clearances between the pistons, the piston rings, and the cylinder bores.

PISTON AND CONNECTING ROD DISASSEMBLE

Tools Required

J 24086-C Piston Pin Remover/Installer. See **Special Tools**.

Disassemble

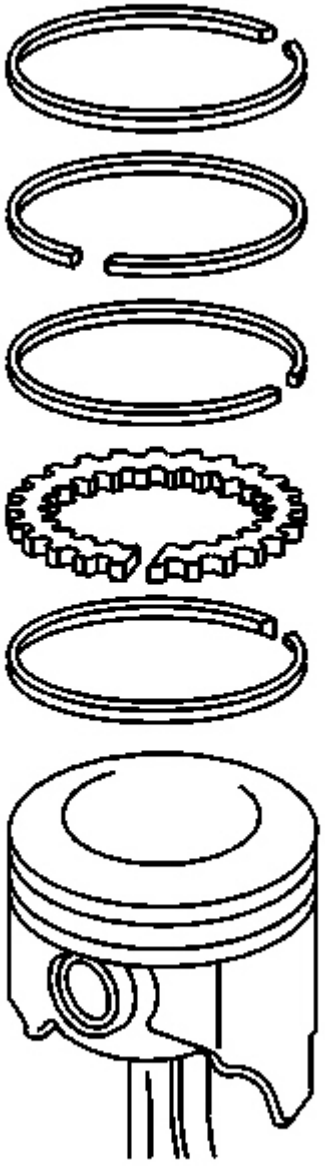


Fig. 462: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Remove the piston rings from the pistons.

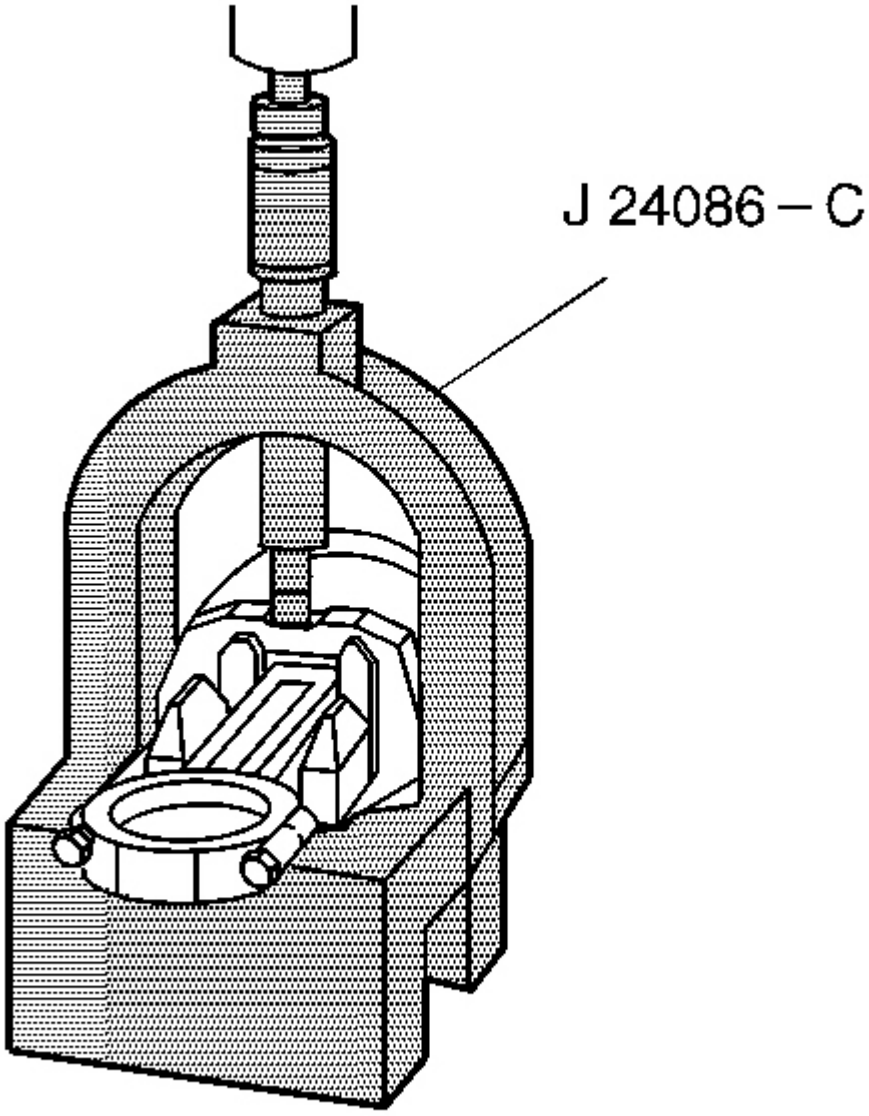


Fig. 463: Pressing Piston Pin From Connecting Rod Using J 24086-C
Courtesy of GENERAL MOTORS CORP.

2. Press the piston pin from the connecting rod using the **J 24086-C** . See **Special Tools**.

The piston pin has an interference fit into the connecting rod, and is full floating in the piston.

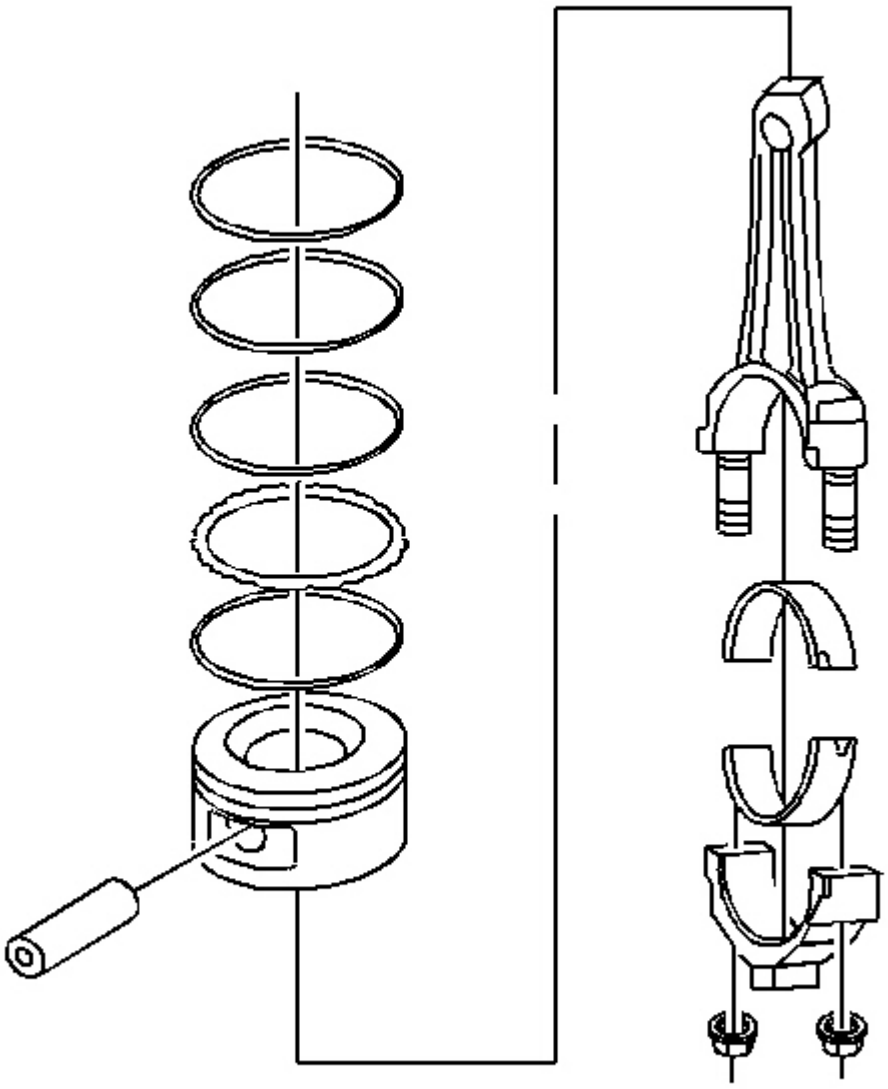


Fig. 464: Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

3. Mark, separate, and organize the parts for assembly.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

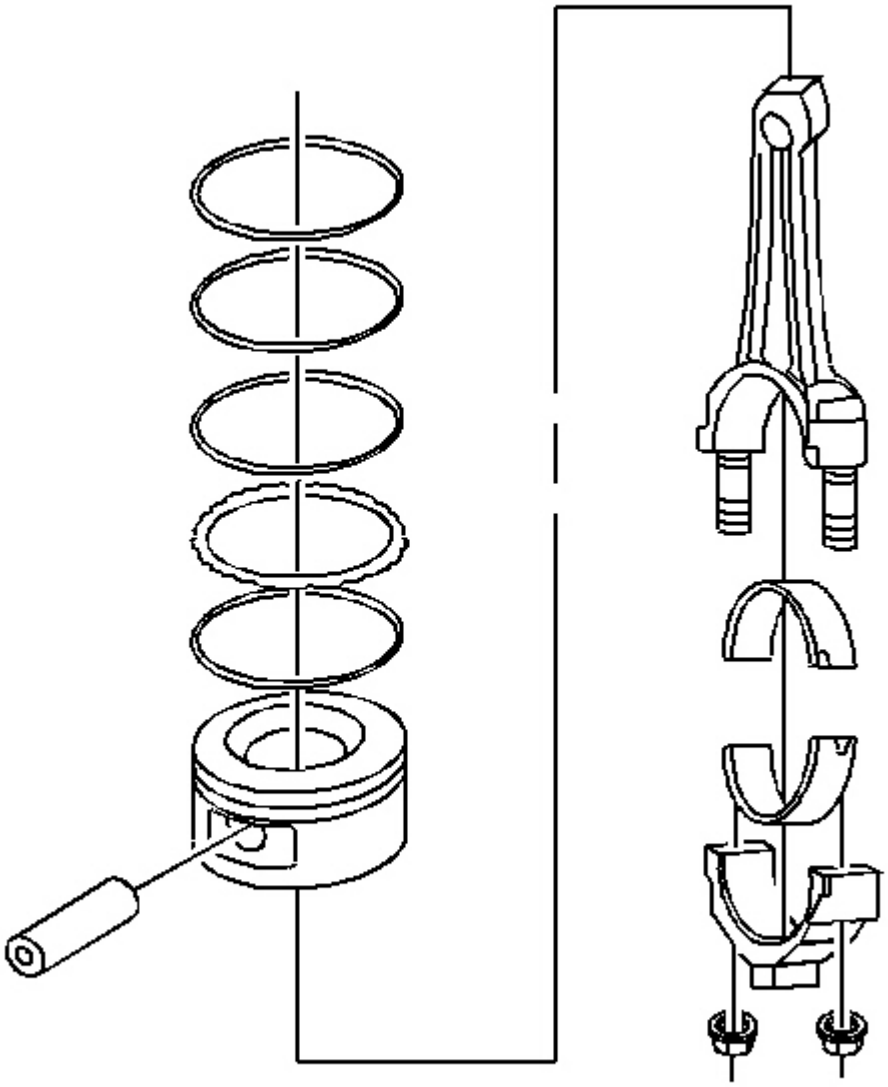


Fig. 465: Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurement of all components should be taken with the components at room temperature.

Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston and connecting rod in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION .

2. Dry the components with compressed air.

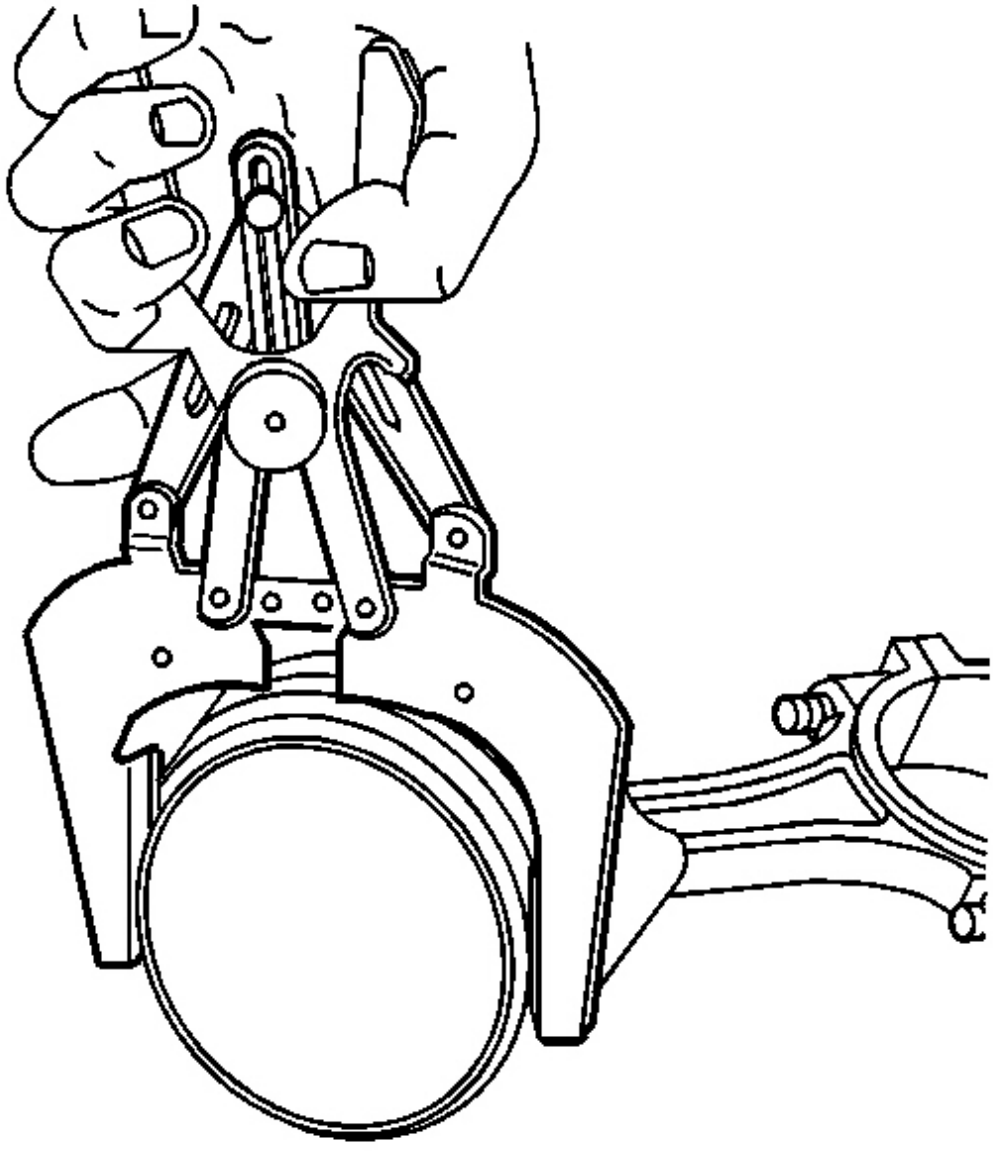


Fig. 466: Cleaning Piston Ring Grooves
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.

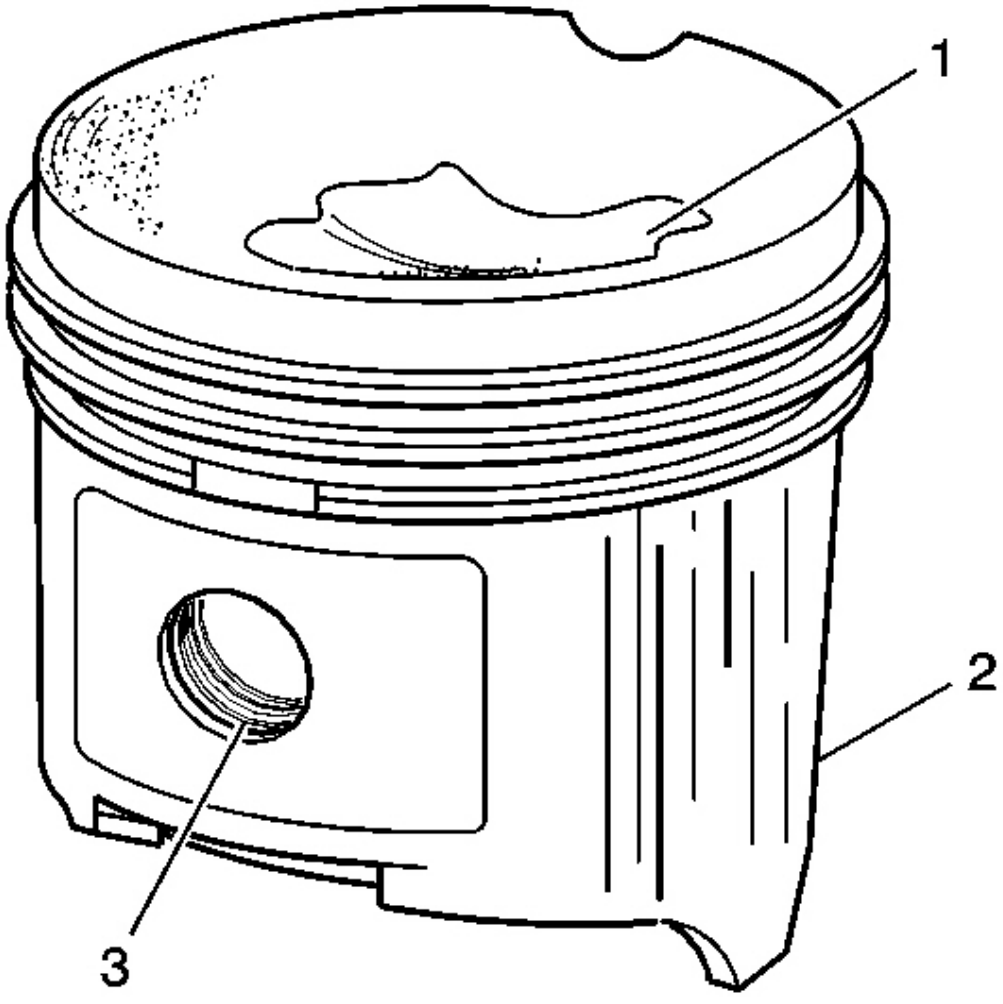


Fig. 467: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

4. Clean the piston oil lubrication holes and slots.
5. Inspect the piston for the following:
   - Eroded areas (1) on the top of the piston
   - Scuffed or damaged skirt (2)
   - Damage to the pin bore (3)
   - Cracks in the piston ring lands, the piston skirt, or the pin bosses

- Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind

6. Inspect the piston pin for scoring, wear or other damage.

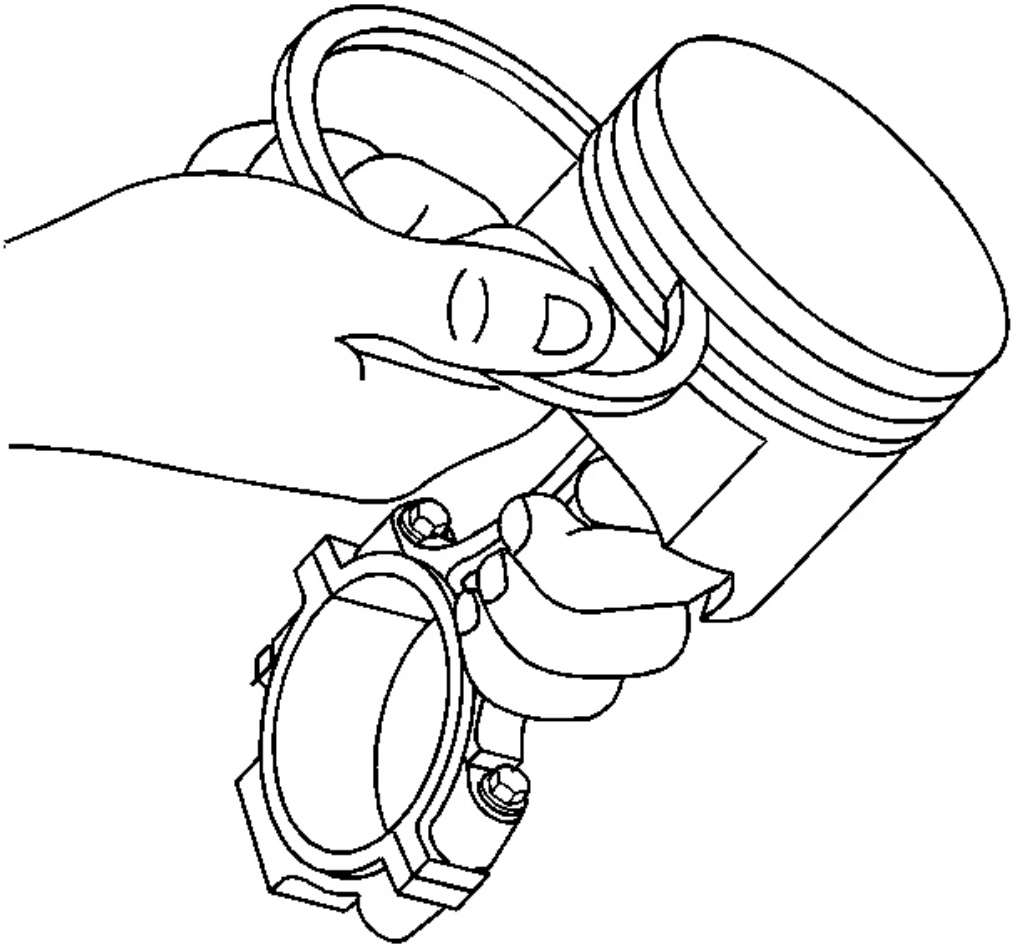


Fig. 468: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring-to-piston ring groove side clearance.
    1. Insert the edge of the piston ring into the piston ring groove.
    2. Roll the piston ring completely around the piston.
        - If binding is caused by a distorted piston ring groove, MINOR imperfections may

be removed with a fine file.

- If binding is caused by a distorted piston ring, replace the piston ring.

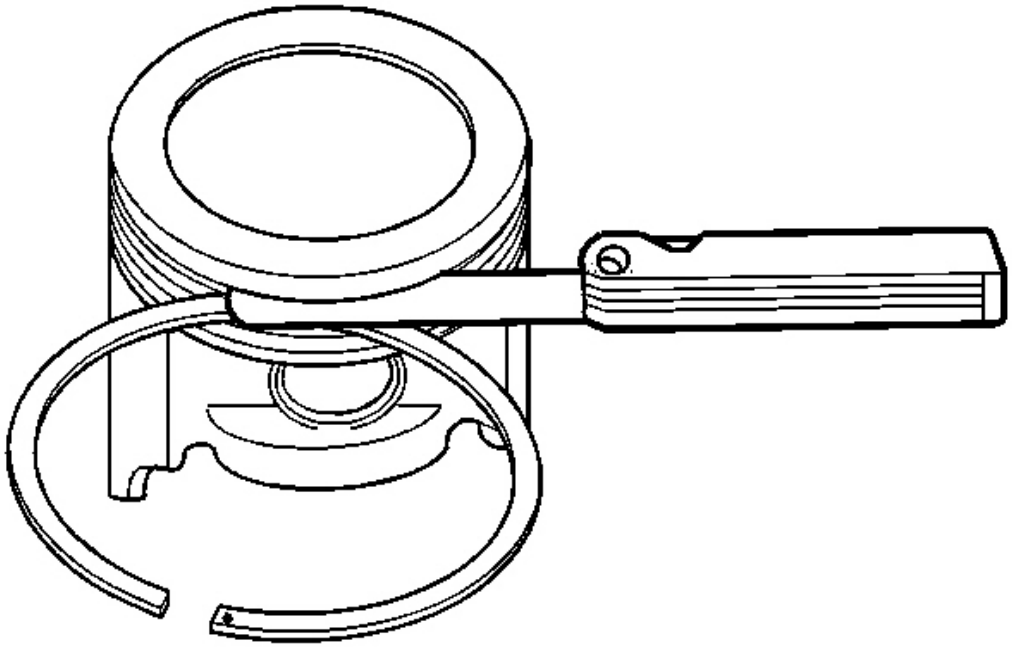


Fig. 469: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gauge.
9. If the side clearance is too small, try another piston ring set.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
11. To determine the proper piston ring side clearance, refer to **Engine Mechanical Specifications**.

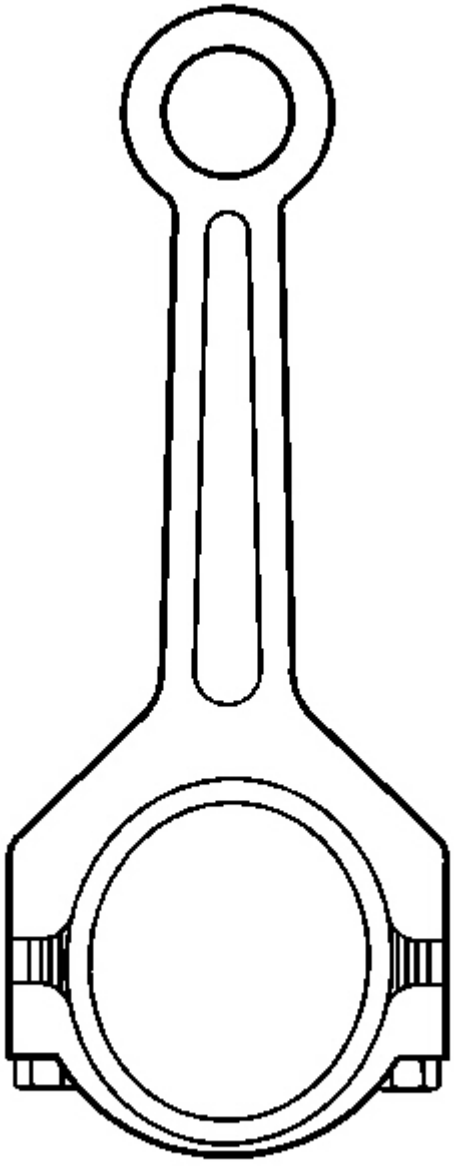


Fig. 470: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

12. Inspect the connecting rod for an out-of-round bearing bore. Refer to **Engine Mechanical Specifications**.

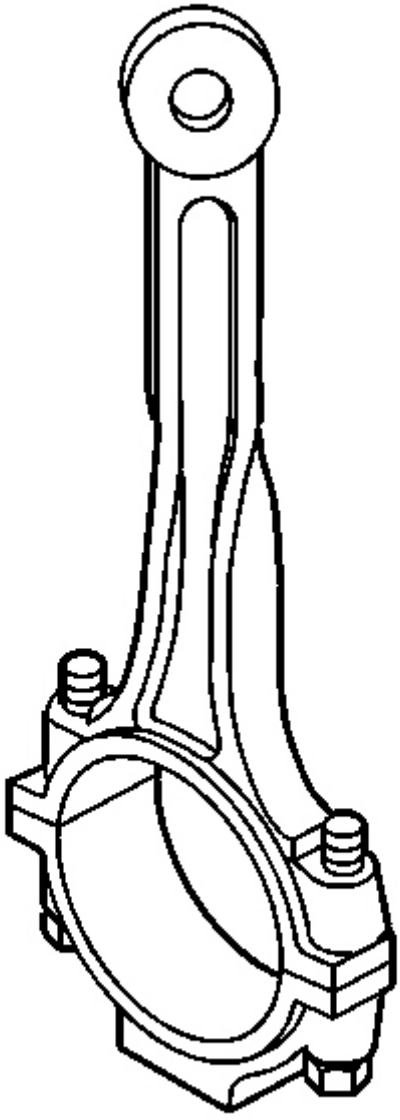


Fig. 471: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

13. Inspect the connecting rod for twisting.
14. Inspect the connecting rod for damage to the bearing cap and bolt threads.

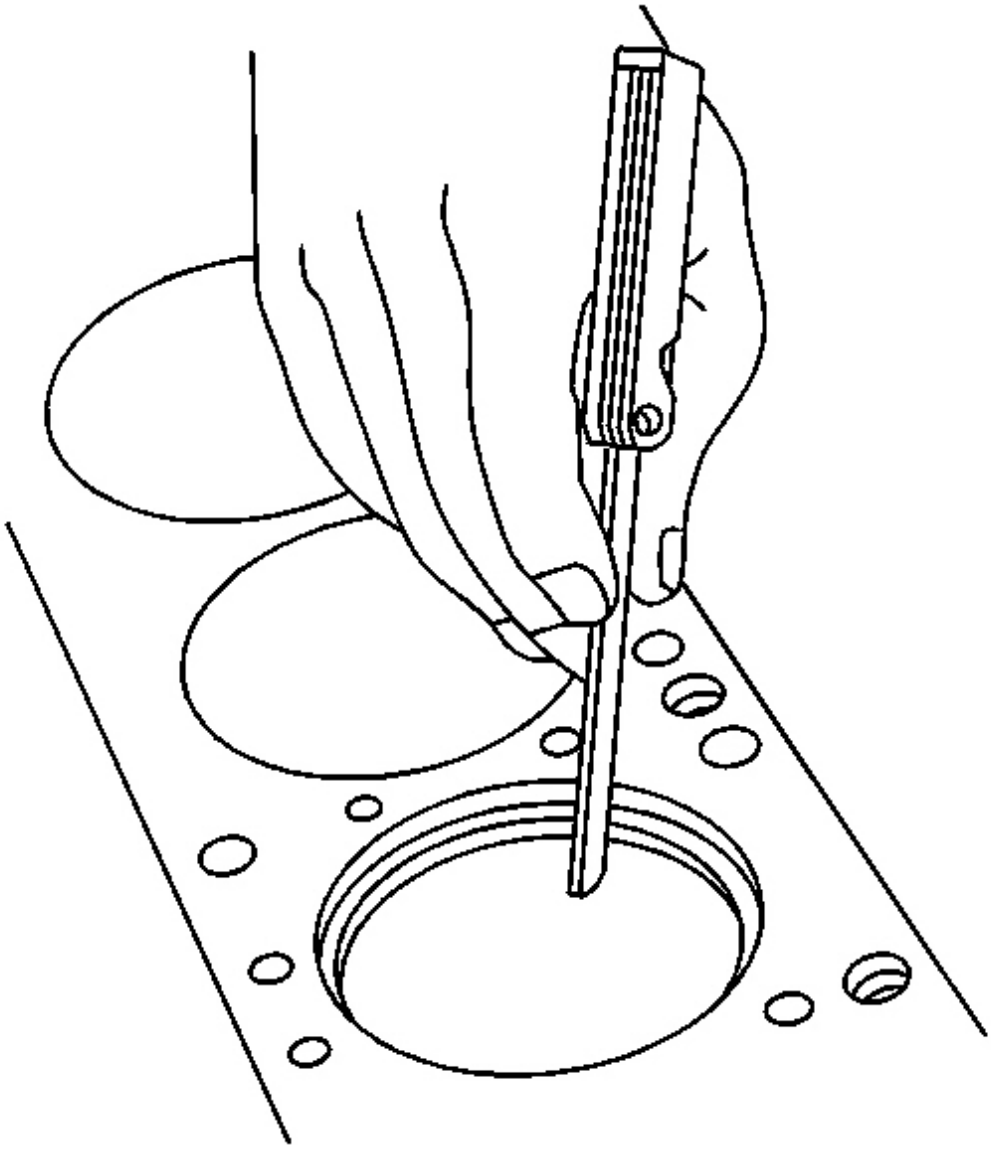


Fig. 472: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

15. Measure the piston compression ring end gap.

IMPORTANT: Fit each compression ring to the cylinder in which it will

be used.

1. Place the compression ring into the cylinder bore.
2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.

   The ring must be square to the cylinder wall.

3. Use a feeler gage in order to measure the end gap.
4. Select another size ring set if the end gap exceeds specifications. Refer to **Engine Mechanical Specifications** .

PISTON AND CONNECTING ROD ASSEMBLE

Tools Required

J 24086-C Piston Pin Remover/Installer. See **Special Tools**.

Assemble

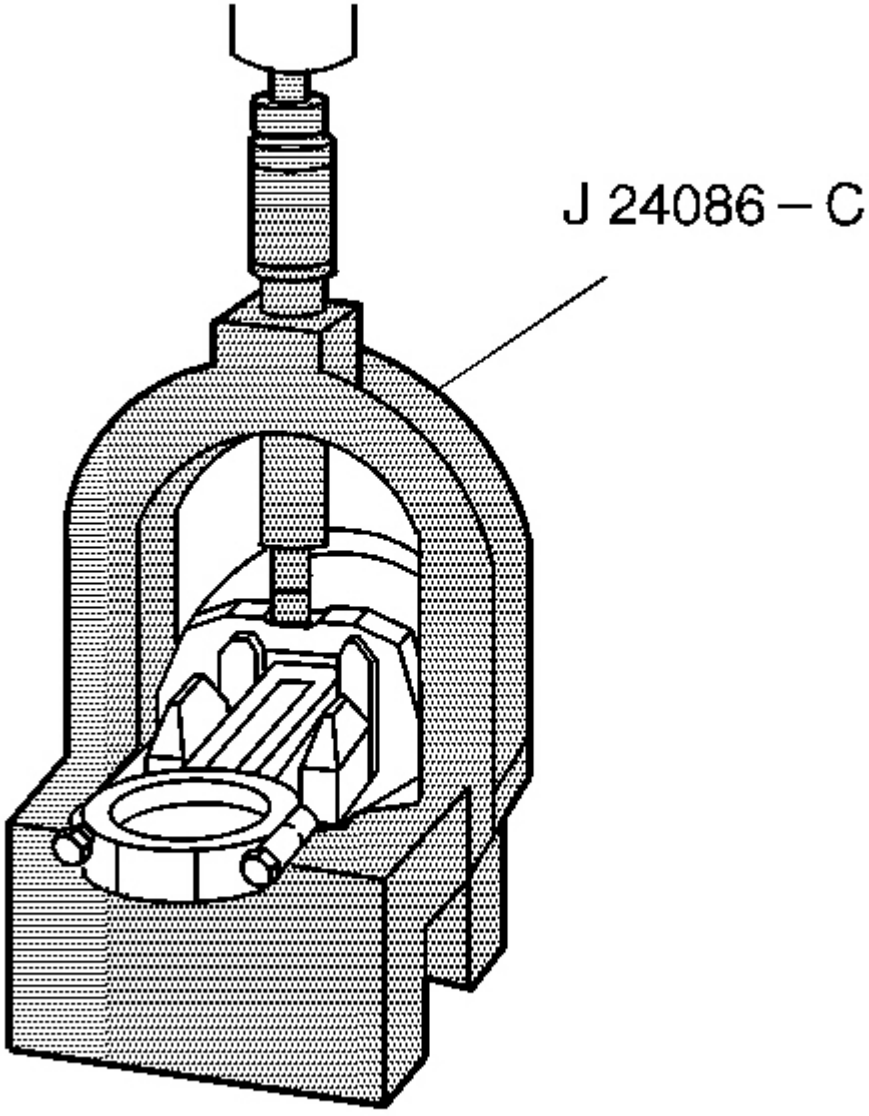


Fig. 473: Pressing Piston Pin From Connecting Rod Using J 24086-C
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: After the J 24086-C installer hub bottoms on the support assembly, DO NOT exceed 35,000 kPa (5,000 psi) or the tool may be damaged.

IMPORTANT: When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.
The new piston pin has an interference fit into the connecting rod and is full floating in the piston.

1. Install the new piston pin and connecting rod assembly.
    1. Lubricate the piston pin bores with clean engine oil.
    2. Use a torch and apply MILD heat to the piston pin end of the connecting rod.
    3. Use the **J 24086-C** in order to press the new piston pin into the piston and connecting rod assembly. See **Special Tools**.
    4. Inspect for the proper installation of the piston and piston pin.

       The piston must move freely on the new piston pin with no binding or interference.

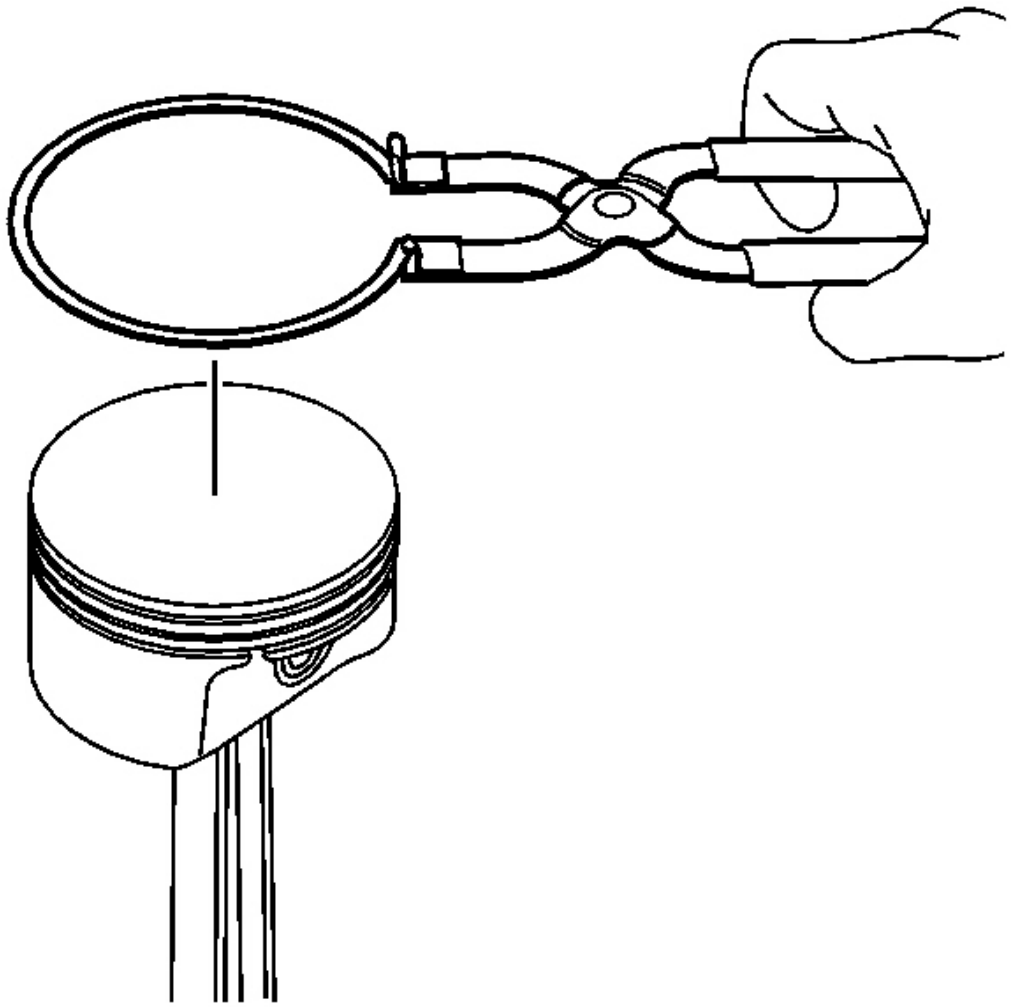


Fig. 474: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

2. Install the piston rings onto the piston.
    1. Install the oil control piston ring spacer.
    2. Install the lower oil control piston ring.

3. Install the upper oil control piston ring.
4. Install the lower compression piston ring.

   The mark on the side of the piston ring should face the top of the piston.

5. Install the upper compression piston ring.

   The mark on the side of the piston ring should face the top of the piston.

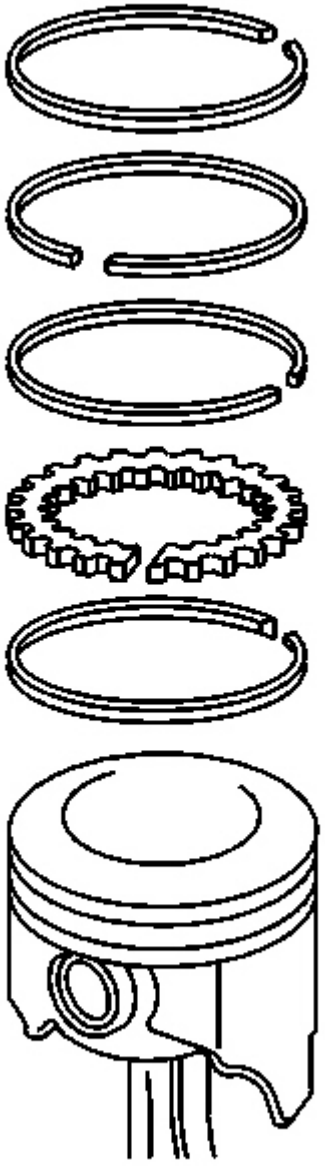


Fig. 475: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

3. Space the compression piston ring end gaps 120 degrees apart.
4. Space the oil control piston ring end gaps a minimum of 90 degrees apart.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator
- **J 43690** Rod Bearing Clearance Checking Tool. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Cleaning

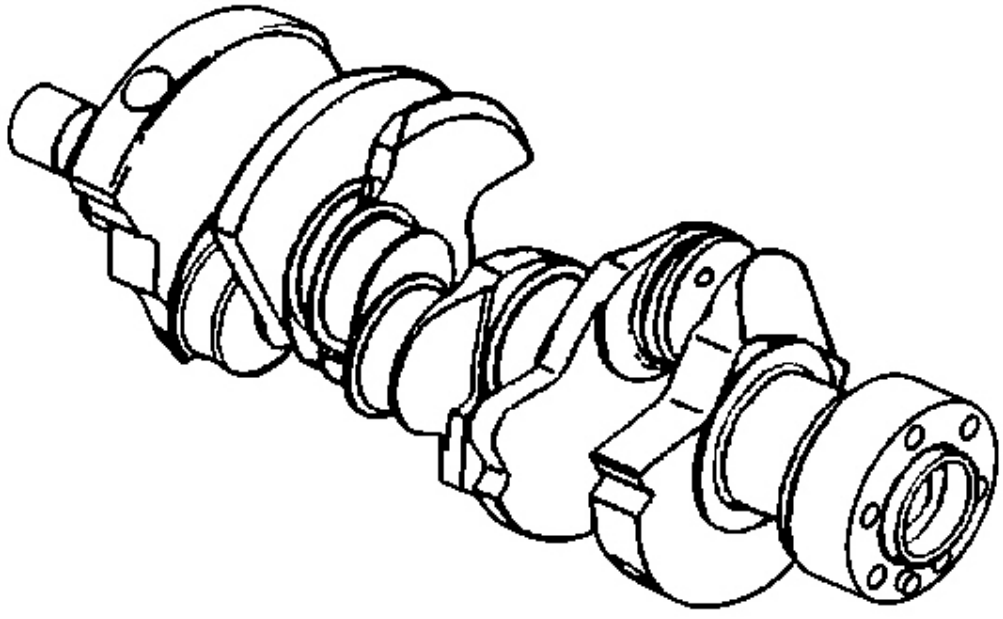


Fig. 476: Crankshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the crankshaft bearing surfaces.

1. Clean the crankshaft in cleaning solvent. Remove all sludge or restrictions from the oil passages.
2. Dry the crankshaft with compressed air.

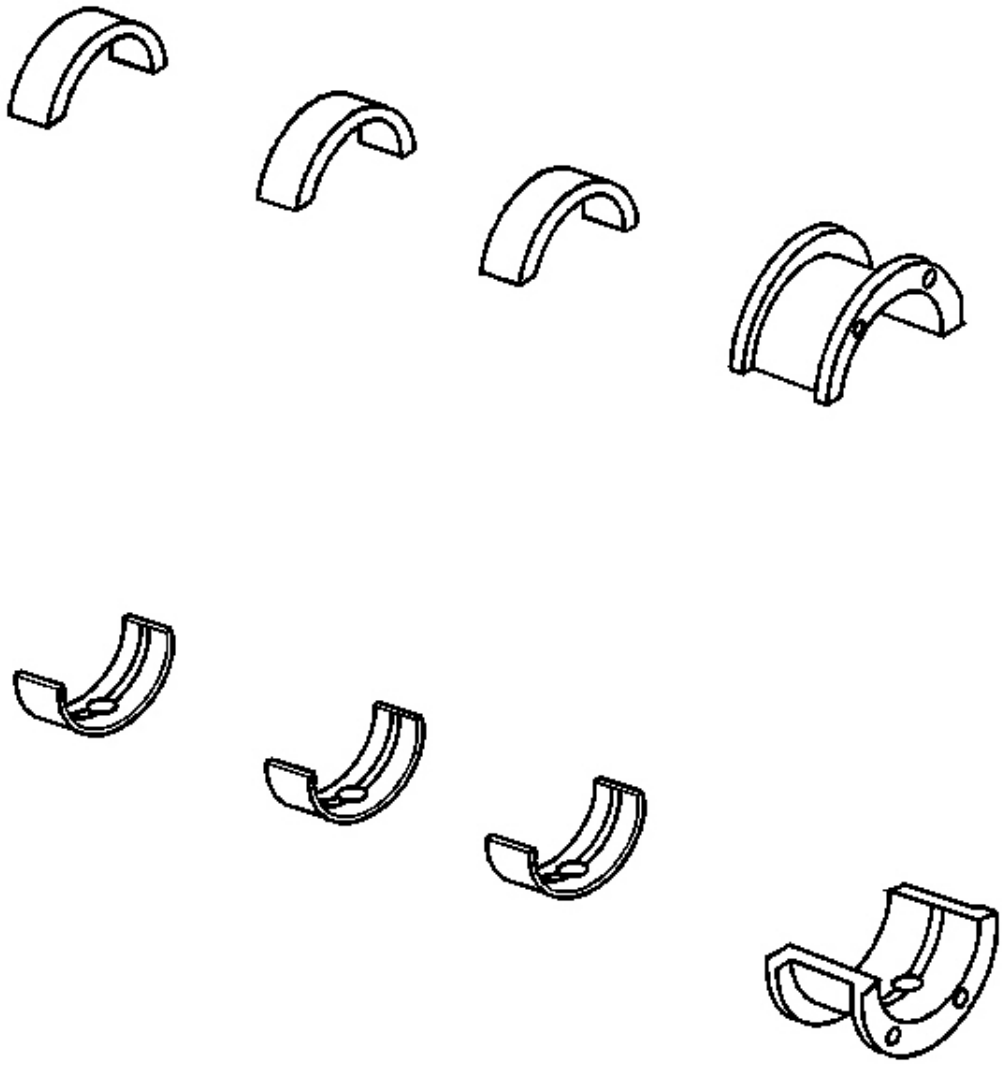


Fig. 477: Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

3. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a

soft cloth, do not scratch the crankshaft bearing surfaces.

4. Dry the crankshaft bearings with compressed air.

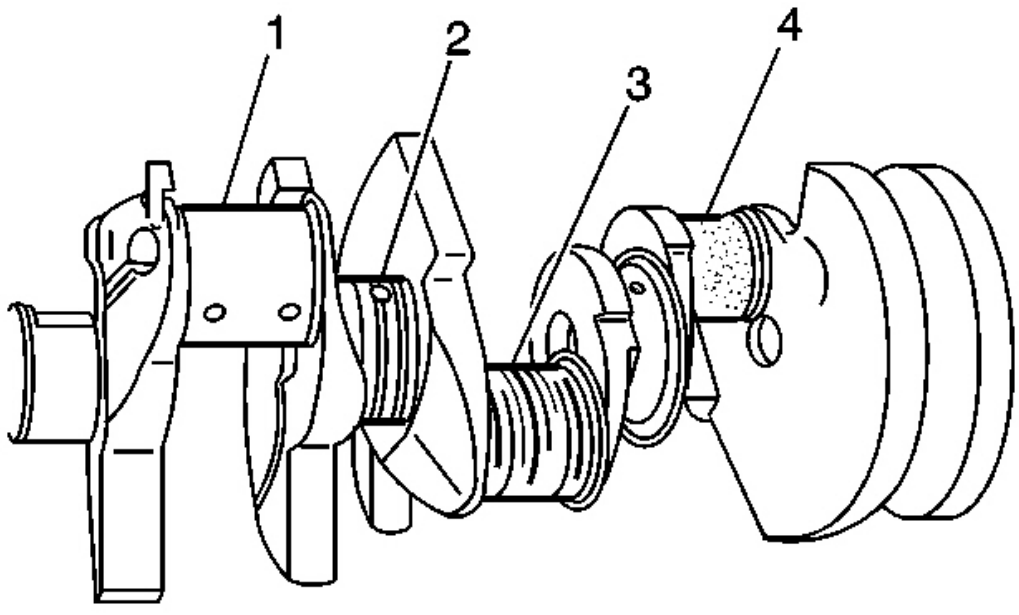


Fig. 478: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

5. Inspect the crankshaft for the following:
   - Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
   - Deep grooves (2)
   - Scratches or uneven wear (3)
   - Pitted surfaces (4)
   - Wear or damage to the thrust journal surfaces
   - Scoring or damage to the rear seal surface
   - Restrictions to the oil passages
   - Damage to the threaded bolt holes

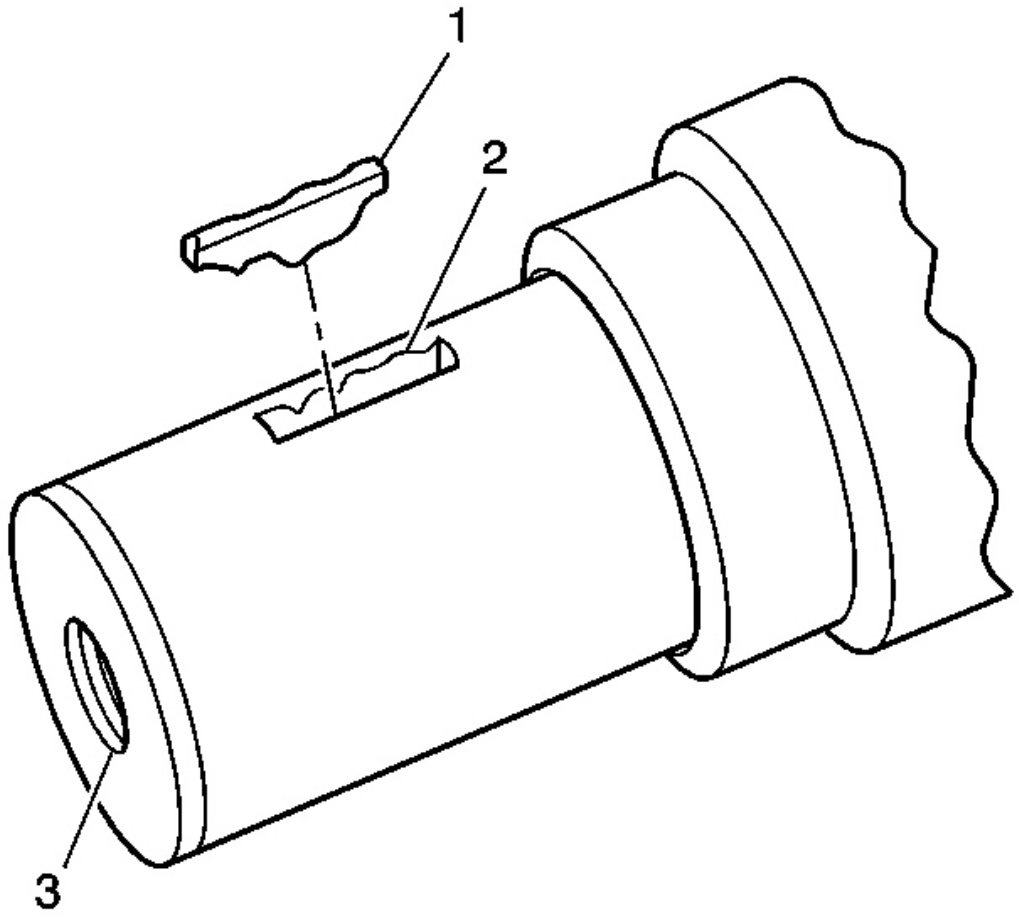


Fig. 479: Crankshaft Balancer Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

6. Inspect the crankshaft balancer key (1), the keyway (2), and the threaded hole (3) for damage.

   Repair or replace the crankshaft as necessary.

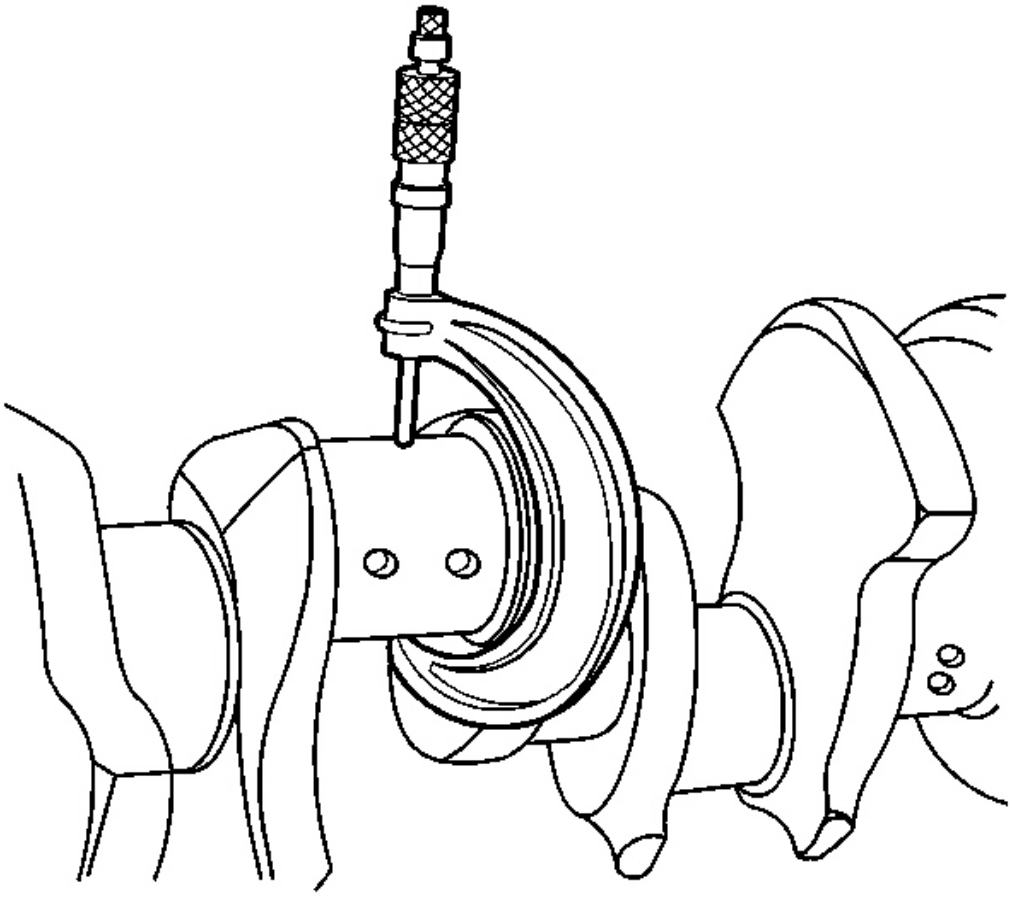


Fig. 480: Measuring Crankpins For Out-Of-Round & Taper
Courtesy of GENERAL MOTORS CORP.

7. Measure the crankpins for out-of-round and taper. Refer to **Engine Mechanical Specifications**.

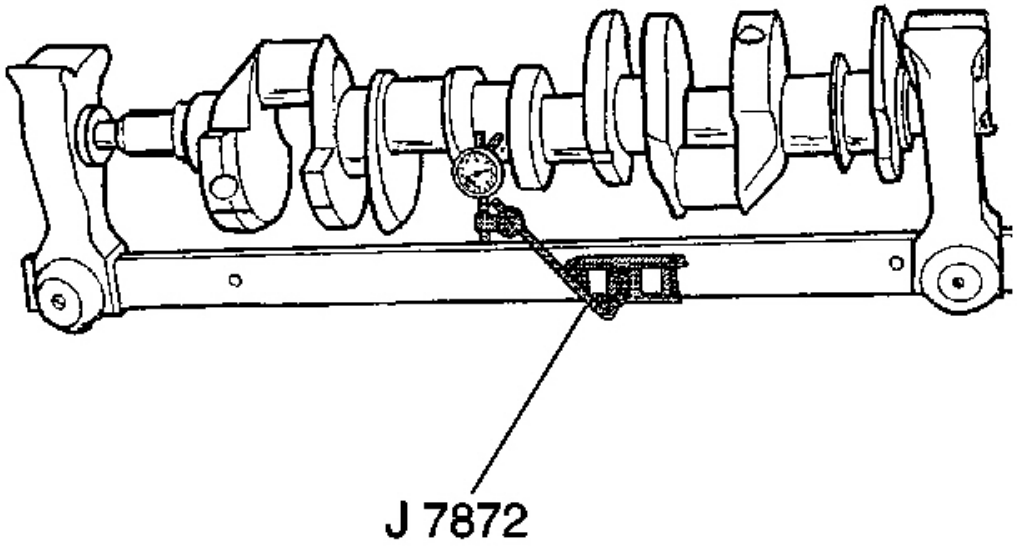


Fig. 481: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

8. Use a suitable support to support the crankshaft on the front and rear journals.
9. Use the **J 7872** in order to measure the crankshaft journal runout. The proper crankshaft journal runout is 0.025 mm maximum (0.0010 in maximum).

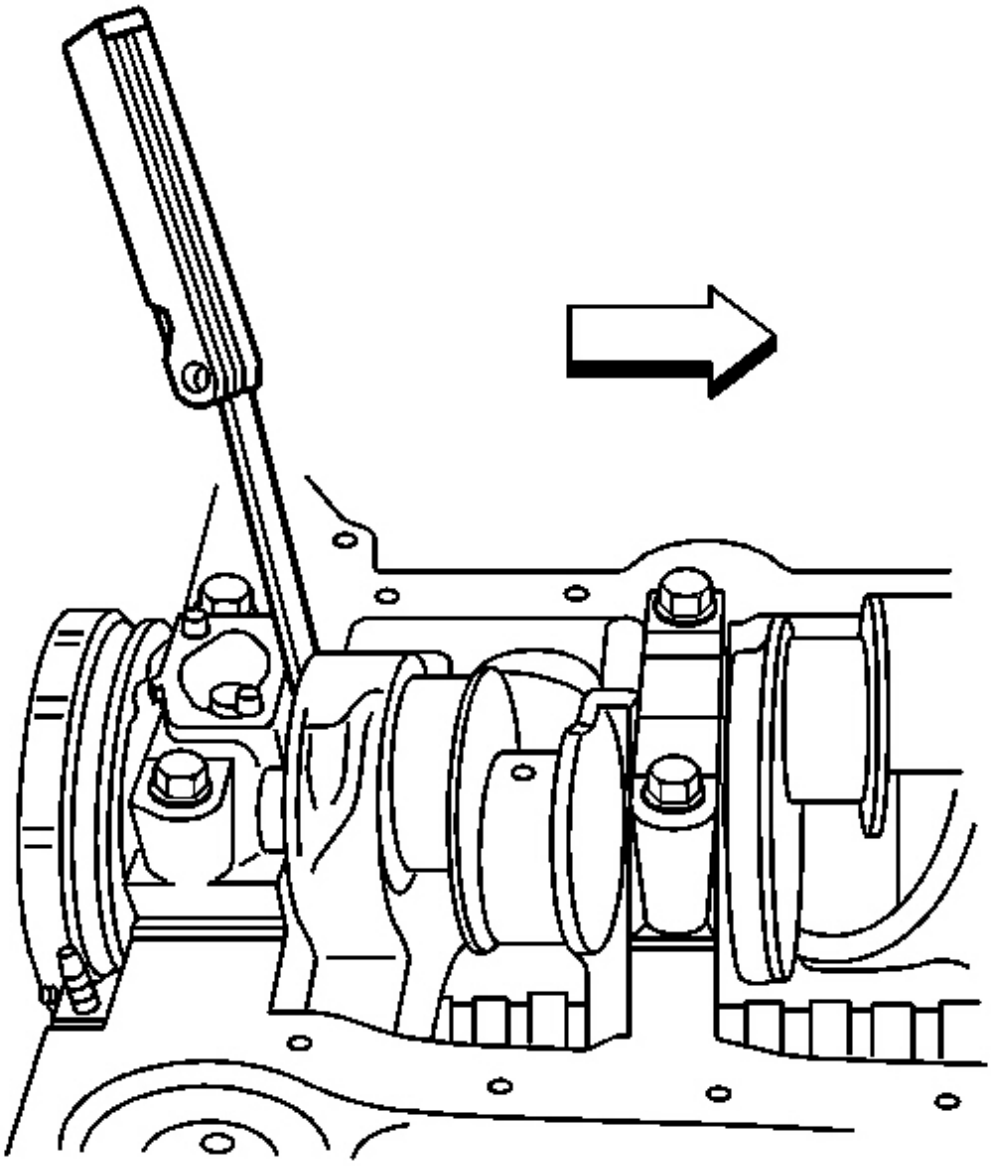


Fig. 482: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft end play.

IMPORTANT: In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings, the crankshaft bearing caps, and the crankshaft bearing cap bolts must be installed into the engine block and the bolts tightened using J 45059 . See Special Tools. The proper crankshaft bearing cap bolt tightening specification first pass is 20 N.m (15 lb ft), final pass is 73 degrees.

1. Firmly thrust the crankshaft first rearward, then forward. This will align the crankshaft rear bearings and the crankshaft thrust surfaces.
2. With the crankshaft pushed forward, insert a feeler gage between the crankshaft and the crankshaft bearing surface and then measure the clearance. The proper crankshaft end play clearance specification is 0.050-0.20 mm (0.002-0.008 in).
3. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, then loosen the crankshaft bearing cap bolts, one crankshaft bearing cap at a time, until the tight crankshaft bearing is located.

   Burrs on the crankshaft bearing cap or engine block, foreign matter between the crankshaft bearing and the crankshaft bearing cap or the engine block, or a faulty crankshaft bearing could cause a lack of clearance between the crankshaft and crankshaft bearing.

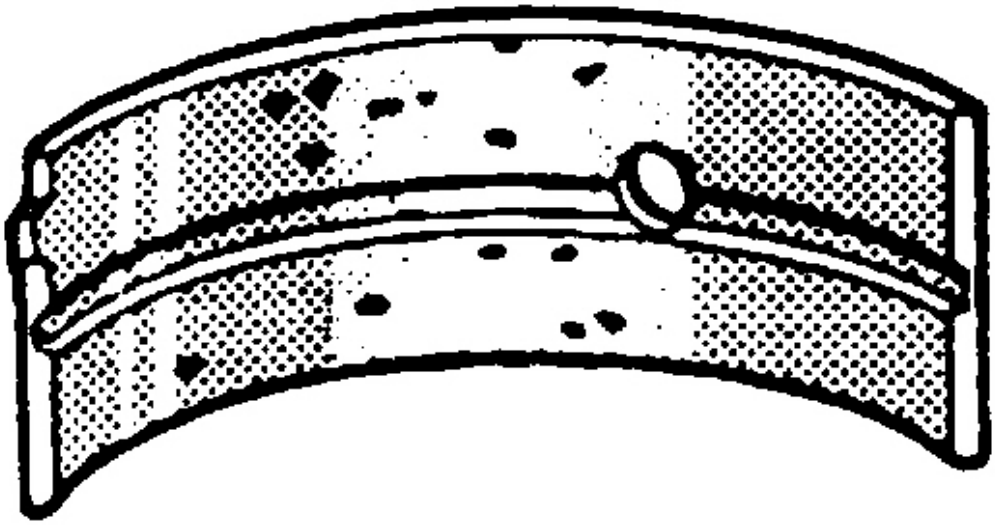


Fig. 483: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

11. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.

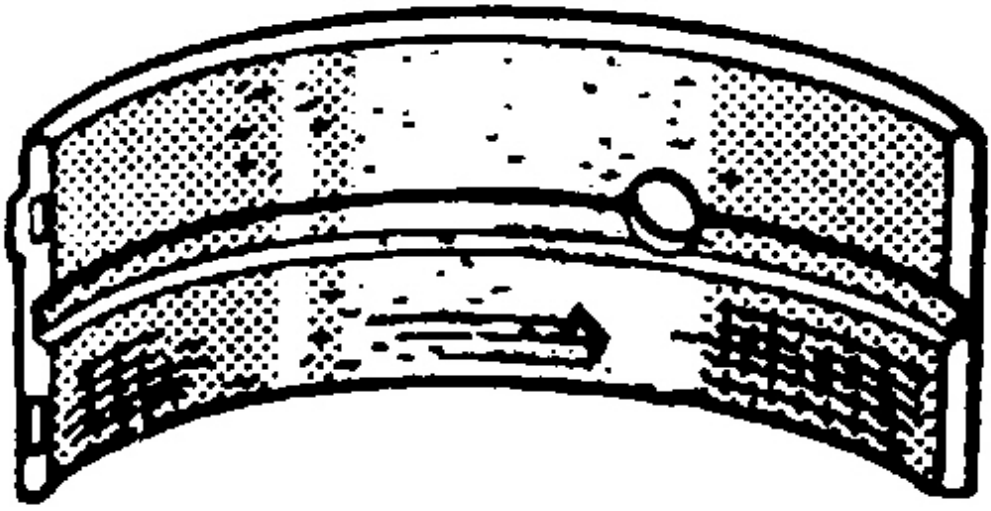


Fig. 484: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

12. Inspect the crankshaft bearings for excessive scoring or discoloration.
13. Inspect the crankshaft bearings for dirt or debris imbedded into the crankshaft bearing material.

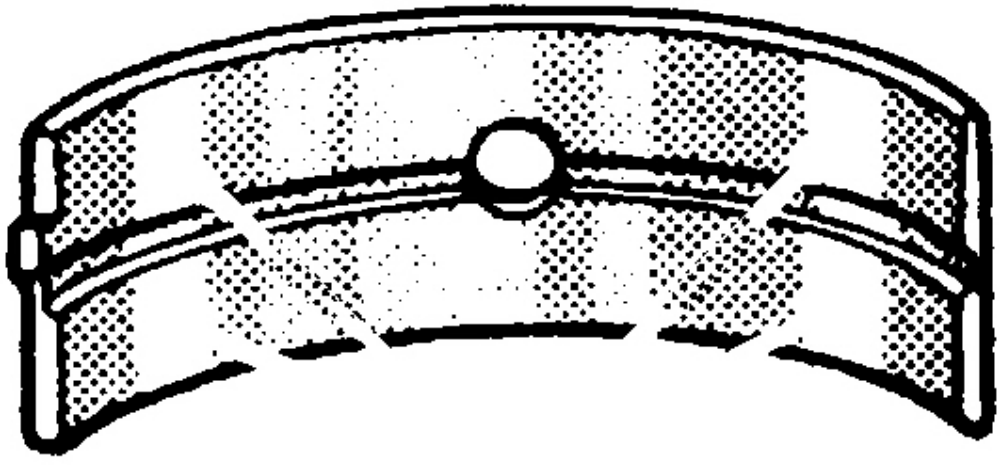


Fig. 485: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

14. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the crankshaft bearings.
    - If the lower half of the crankshaft bearing is worn or damaged, both the upper and lower halves of the crankshaft bearing should be replaced.
    - Generally, if the lower half of the crankshaft bearing is suitable for use, the upper half of the crankshaft bearing should also be suitable for use.

Measuring Crankshaft Bearing Clearances

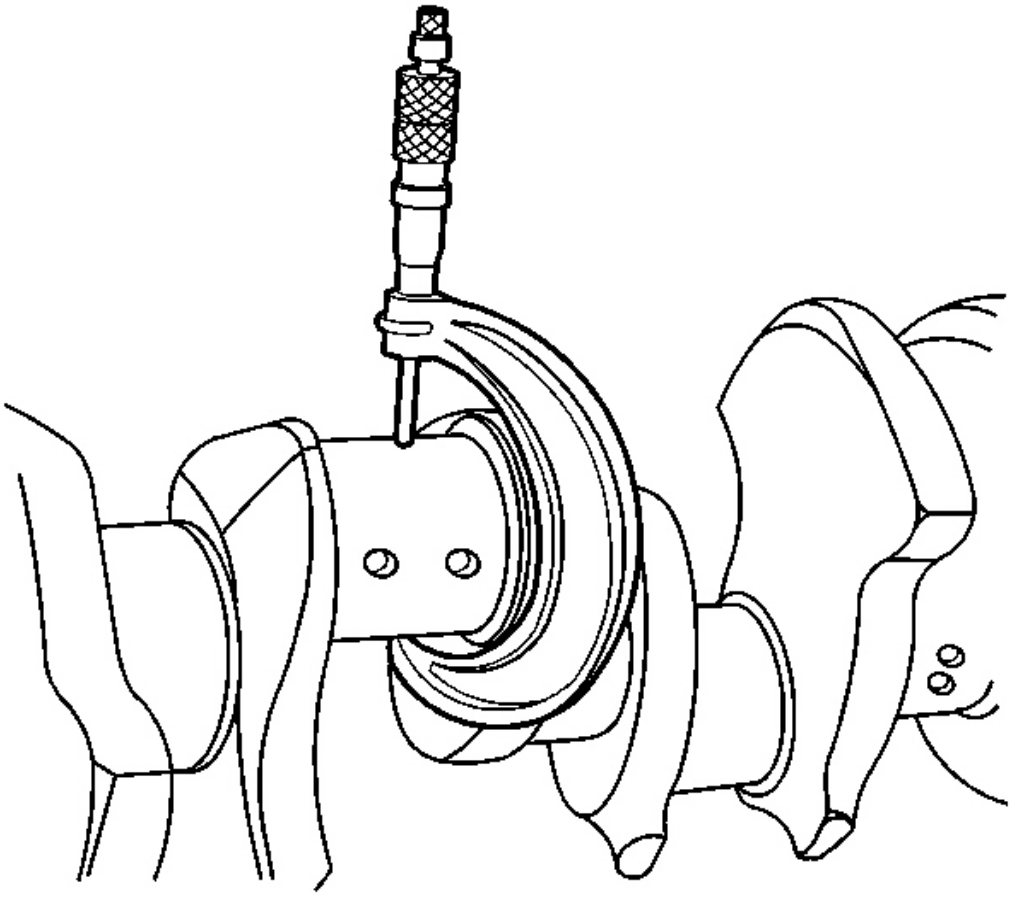


Fig. 486: Measuring Crankpins For Out-Of-Round & Taper
Courtesy of GENERAL MOTORS CORP.

- The crankshaft bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, then new upper and lower crankshaft bearings will be required. The service crankshaft bearings are available in the standard size and an undersize.
- The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of an undersize crankshaft bearing.
- In order to determine the correct replacement bearing size, the bearing clearance must be measured accurately. When checking main bearing clearances, either the micrometer or plastic gage method may be used; however, the micrometer method gives more reliable

results and is preferred. When checking connecting rod bearing clearances, the plastic gage method will result in unreliable measurements. The use of **J 43690** is preferred. See **Special Tools**.

- Normally the crankshaft bearing journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round crankshaft bearing journal, be sure to fit to the maximum diameter of the crankshaft bearing journal. If the crankshaft bearing is fitted to the minimum diameter and the crankshaft bearing journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft bearing journal will result in rapid crankshaft bearing failure.
- If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory. If the clearance is not within specifications, replace the crankshaft bearing. Always replace both the upper and lower crankshaft bearings as a set.
- A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.

Measuring Crankshaft Bearing Clearances - Micrometer Method

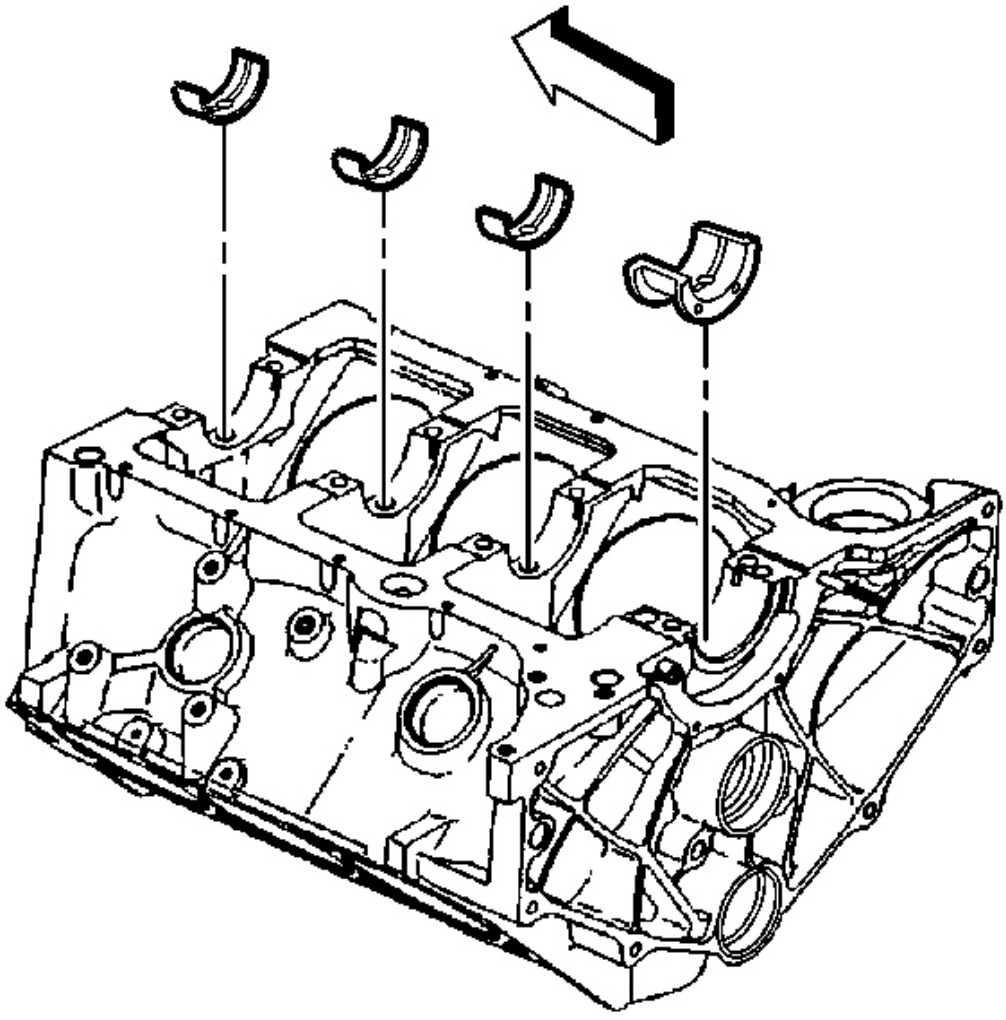


Fig. 487: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Measure the crankshaft journal diameter with a micrometer in several places, approximately 90 degrees apart. Average the measurements.
2. Determine the taper and out-of-round of the journal. Refer to **Engine Mechanical Specifications**.
3. Install the bearings into the engine block or connecting rod assembly.

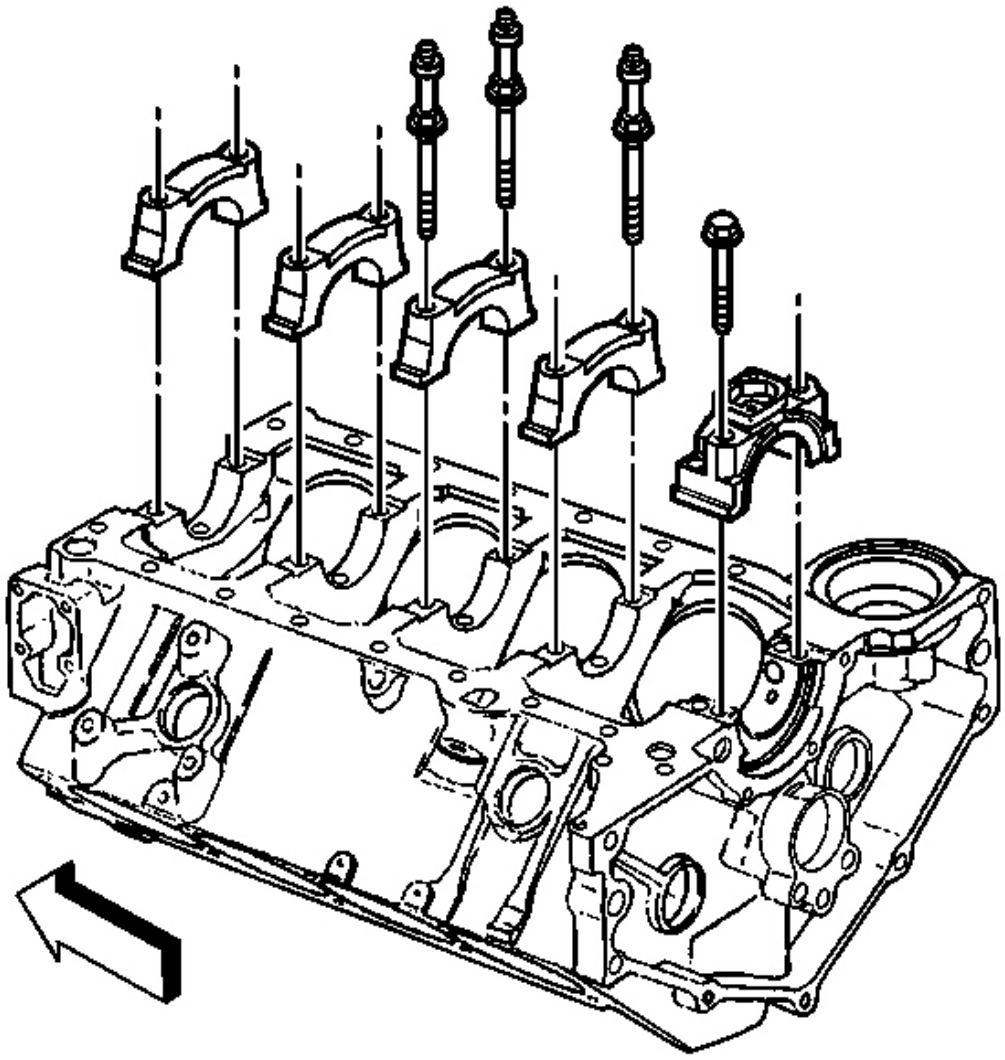


Fig. 488: Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the bearing cap bolts and tighten to specifications. Refer to **Fastener Tightening Specifications**.
5. Measure the bearing inside diameter (ID) at two points 90 degrees apart. Average the measurements.
6. In order to determine the bearing clearance, subtract the average journal diameter from the

average bearing inside diameter.

7. Compare the readings to specifications. Refer to **Engine Mechanical Specifications**.
8. Replace bearing halves as required to obtain the proper bearing clearances.

Measuring Connecting Rod Bearing Clearances - J 43690 Method

1. Remove the oil pan and other necessary components to gain access to the connecting rods. Remove the oil pump assembly.
2. Rotate the crankshaft until the crankshaft journal/connecting rod to be measured is in the 10 o'clock position.

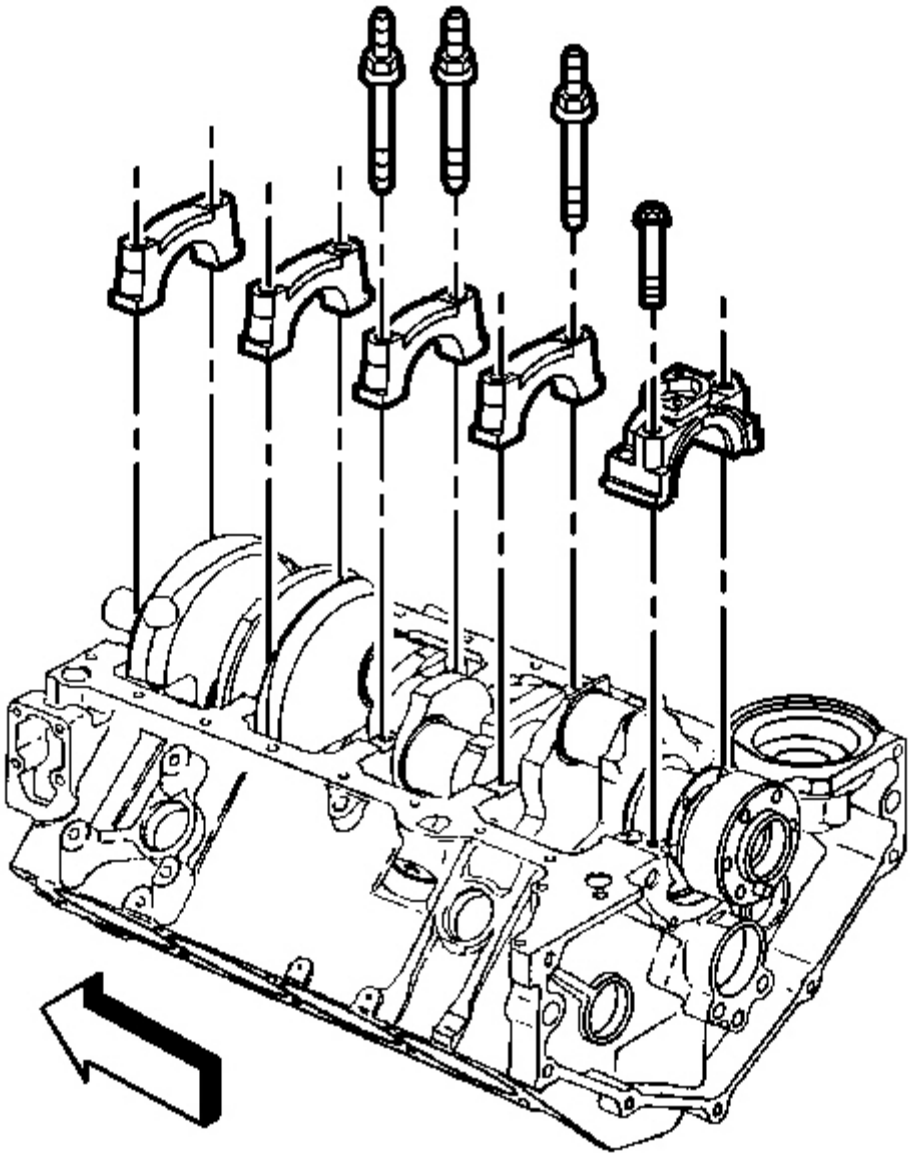


Fig. 489: Bearing Cap Bolts, Cap & Bearing Half
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading. Remove an

intermediate bearing cap, as required, in order to secure the crankshaft and allow measurement of connecting rod bearing clearances.

3. Remove the bearing cap bolts, cap and bearing half.

NOTE: Refer to Fastener Notice .

4. Insert a piece of paper card stock onto the crankshaft journal. Install the bearing half, bearing cap, and bolts. Refer to **Fastener Tightening Specifications**.

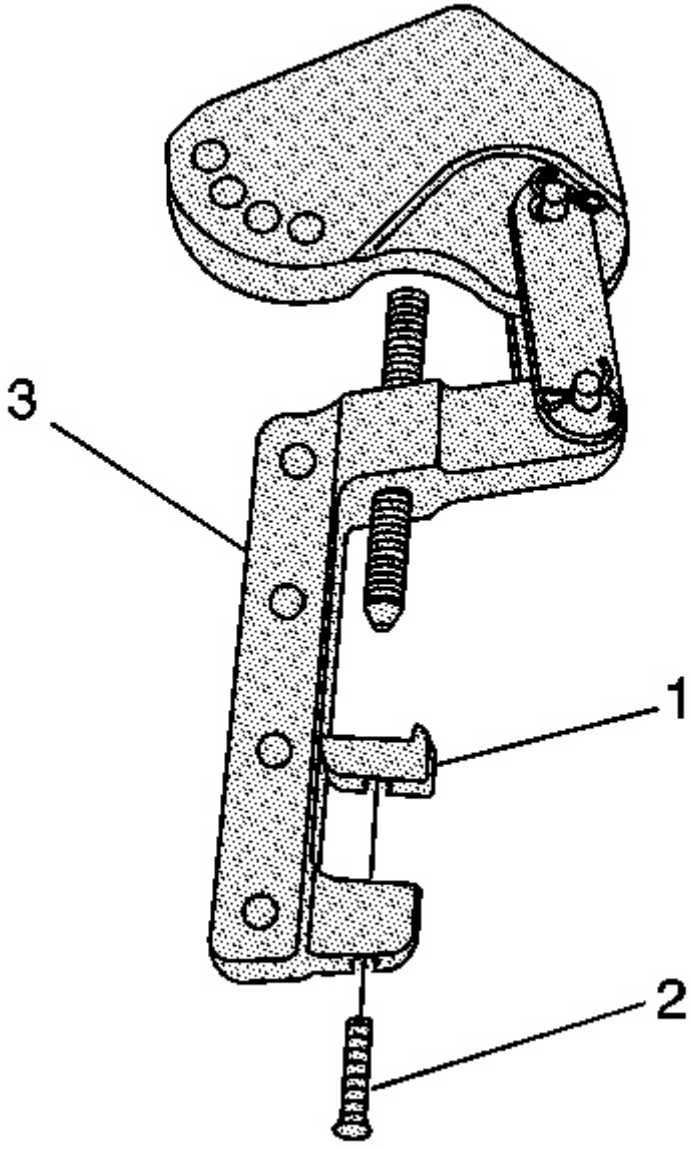


Fig. 490: Pivot Arm Assembly Foot & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the foot (1) and bolt (2) to the pivot arm assembly (3). Tighten the bolt until snug.

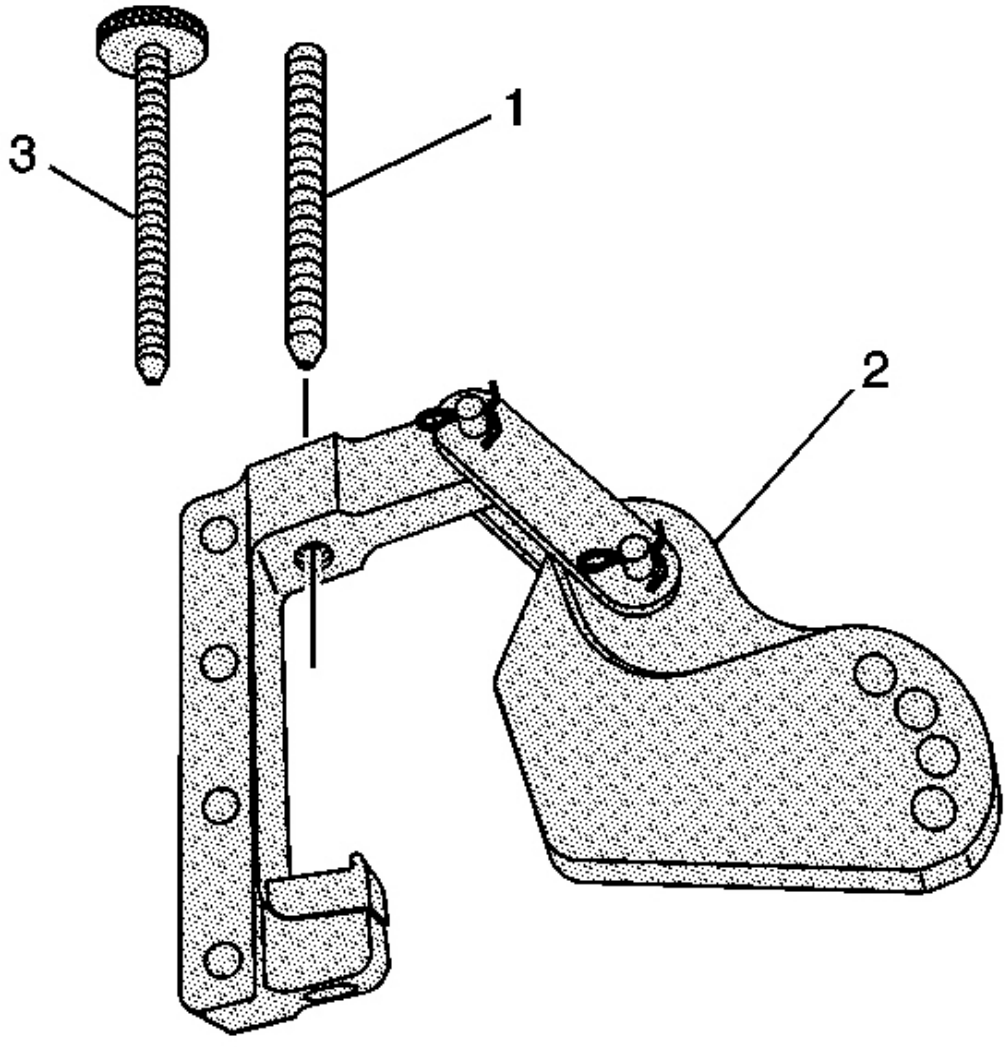


Fig. 491: Pivot Arm Assembly Screw
Courtesy of GENERAL MOTORS CORP.

6. Install the screw (1 or 3) to the pivot arm assembly (2).

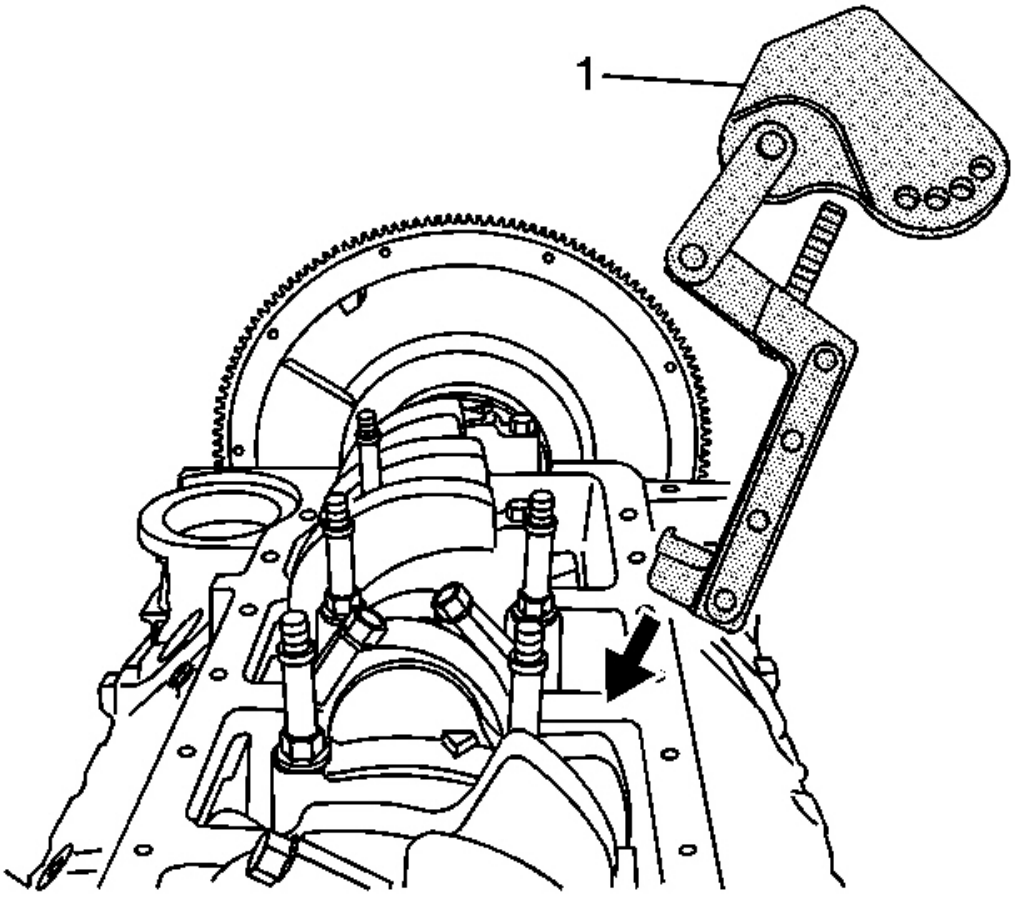


Fig. 492: Pivot Arm Assembly & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

7. Install the pivot arm assembly (1) onto the connecting rod.

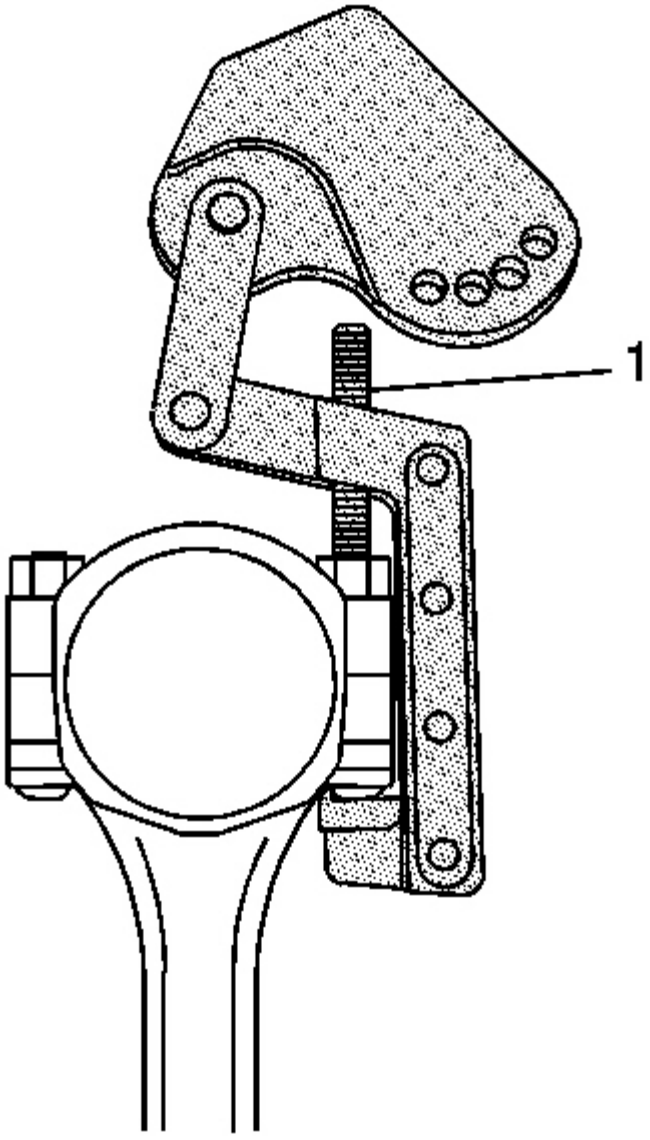


Fig. 493: Positioning Screw Onto Small End Of Connecting Rod Bolt
Courtesy of GENERAL MOTORS CORP.

8. Position the foot of the pivot arm assembly over the large end of the connecting rod bolt.
9. Position the screw (1) onto the small end of the connecting rod bolt and tighten securely.

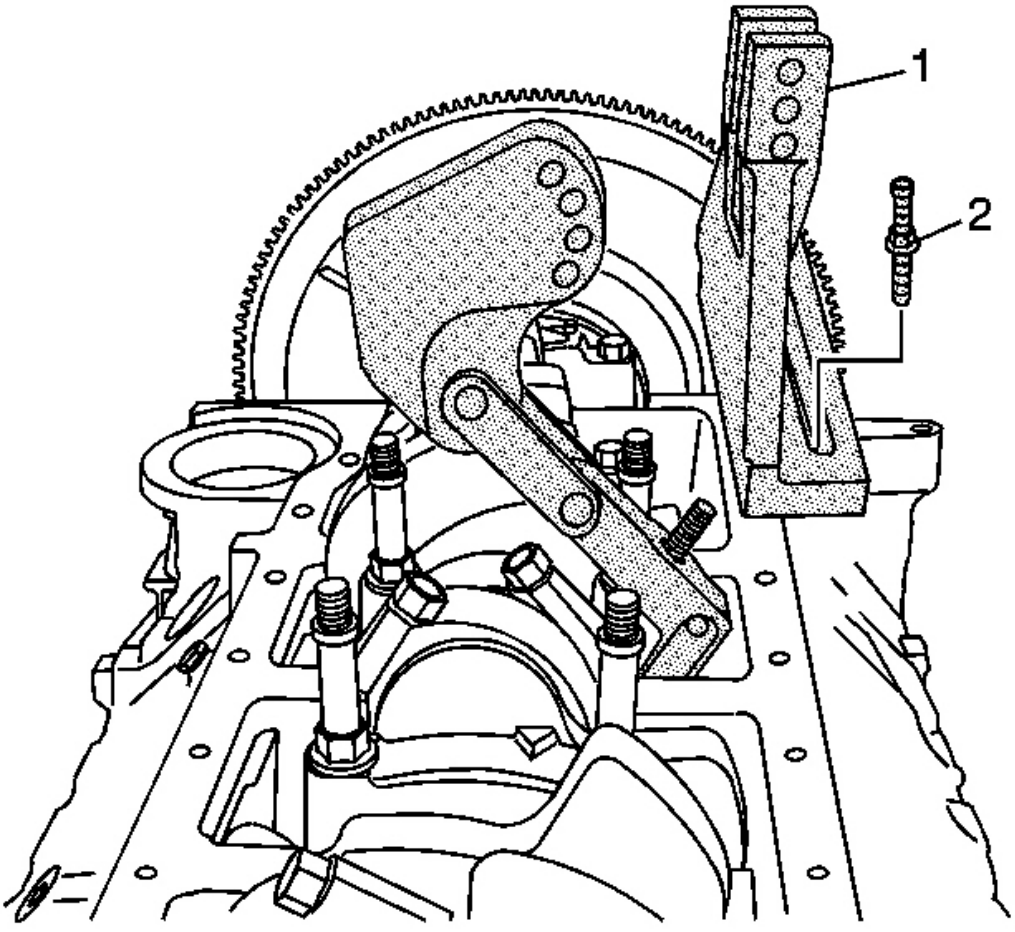


Fig. 494: Installing Base & Bolt To Oil Pan Rail
Courtesy of GENERAL MOTORS CORP.

10. Install the base (1) and bolt (2) to the oil pan rail.

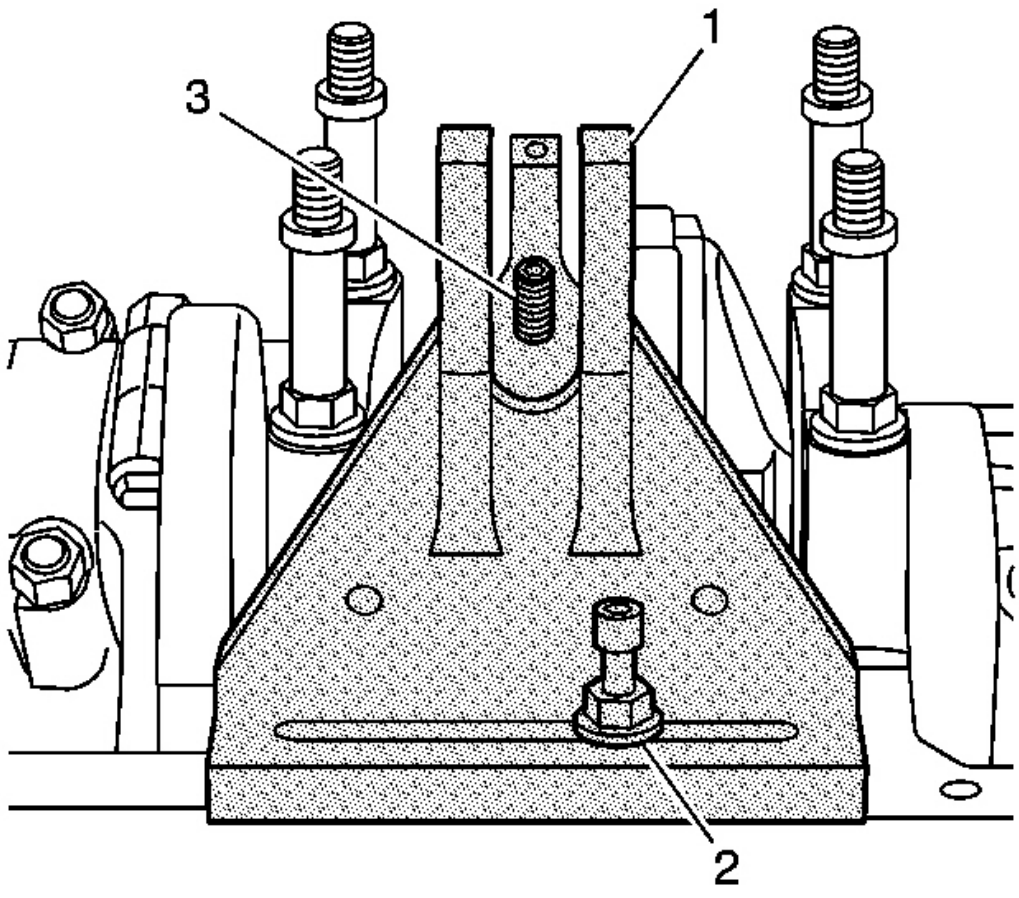


Fig. 495: Aligning Center Of Base W/Pivot Arm Assembly Screw
Courtesy of GENERAL MOTORS CORP.

11. Align the center of the base (1) with the screw (3) of the pivot arm assembly. Tighten the bolt (2) until snug.

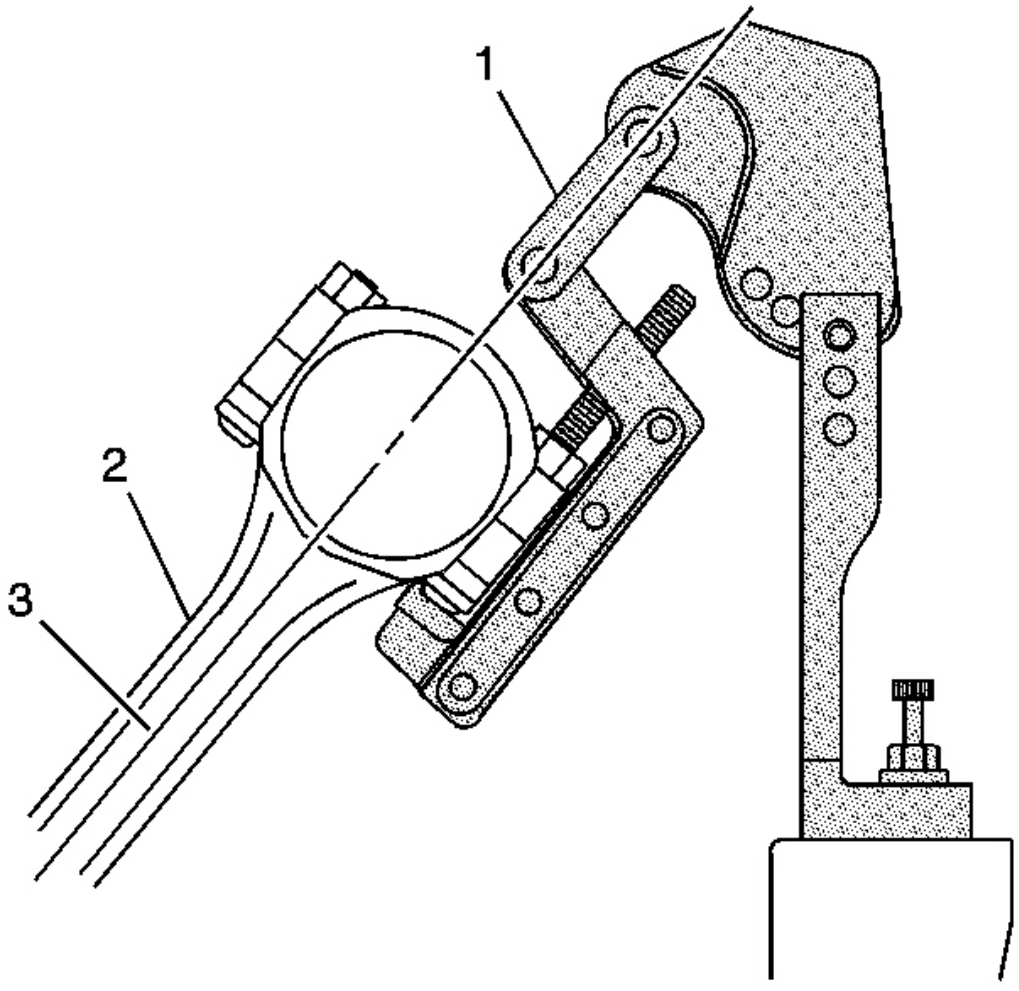


Fig. 496: Aligning Pivot Arm Assembly Link On Connecting Rod Beam Plane
Courtesy of GENERAL MOTORS CORP.

12. Align the link (1) of the pivot arm assembly on a plane (3) equal to that of the connecting rod beam (2).

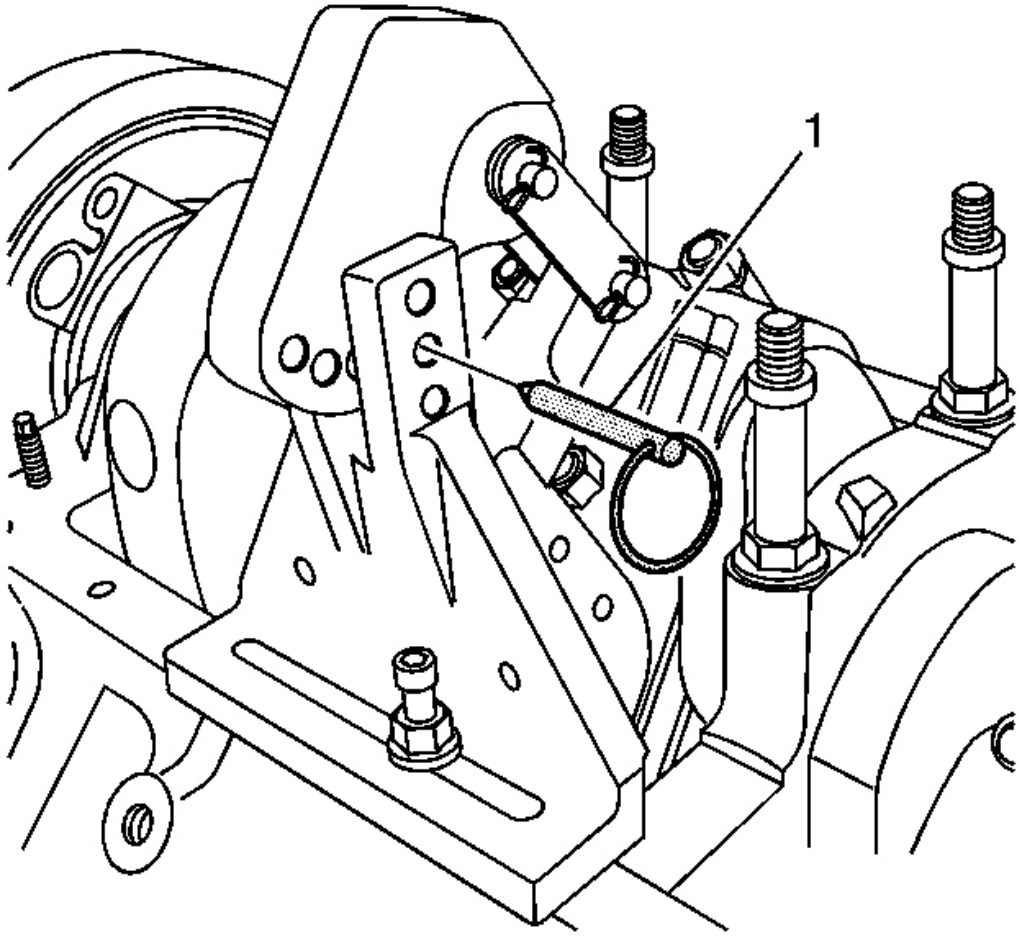


Fig. 497: Positioning Pivot Arm To Base & Inserting Pin
Courtesy of GENERAL MOTORS CORP.

13. With the link of the pivot arm assembly aligned to the beam of the connecting rod, position the pivot arm to the base and insert the pin (1).

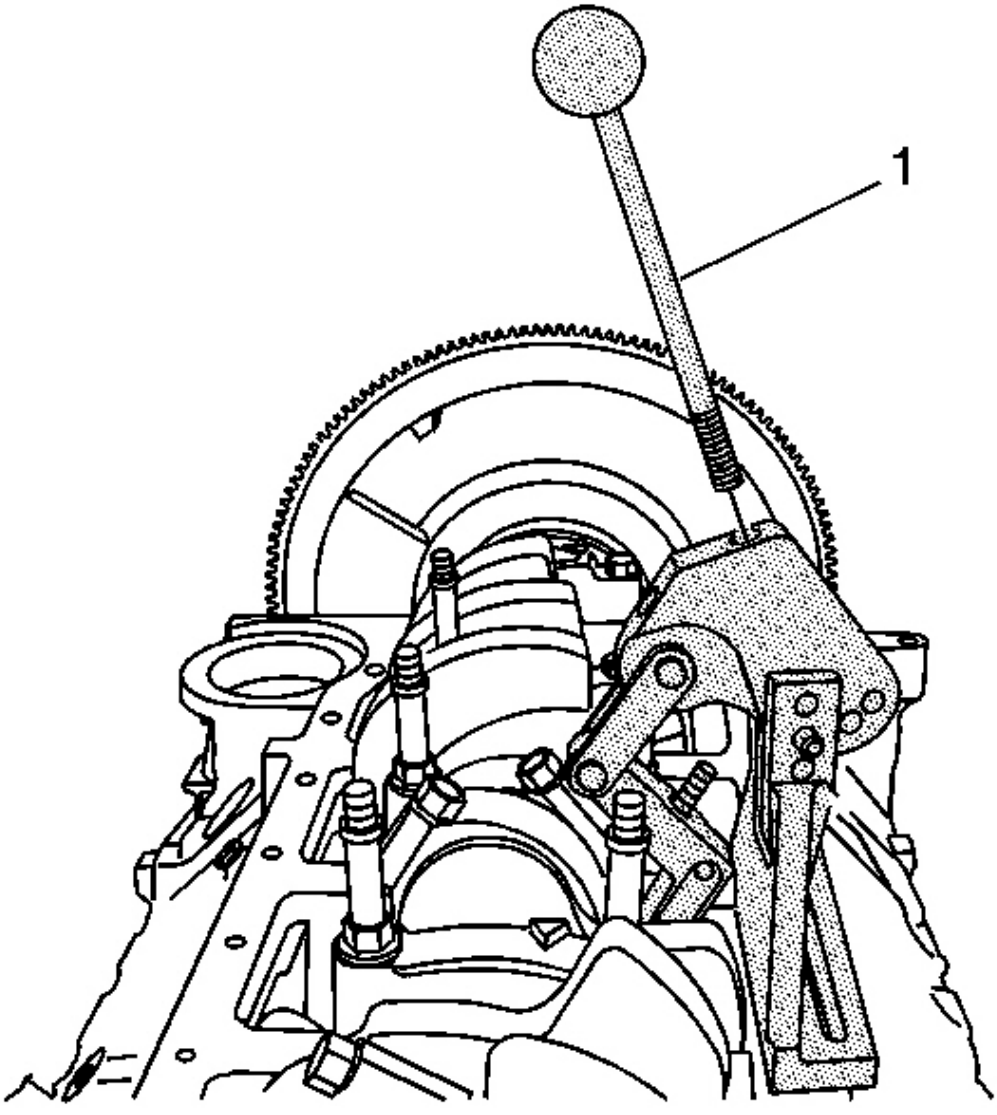


Fig. 498: Pivot Arm Assembly Handle
Courtesy of GENERAL MOTORS CORP.

14. Insert the handle (1) to the pivot arm assembly.

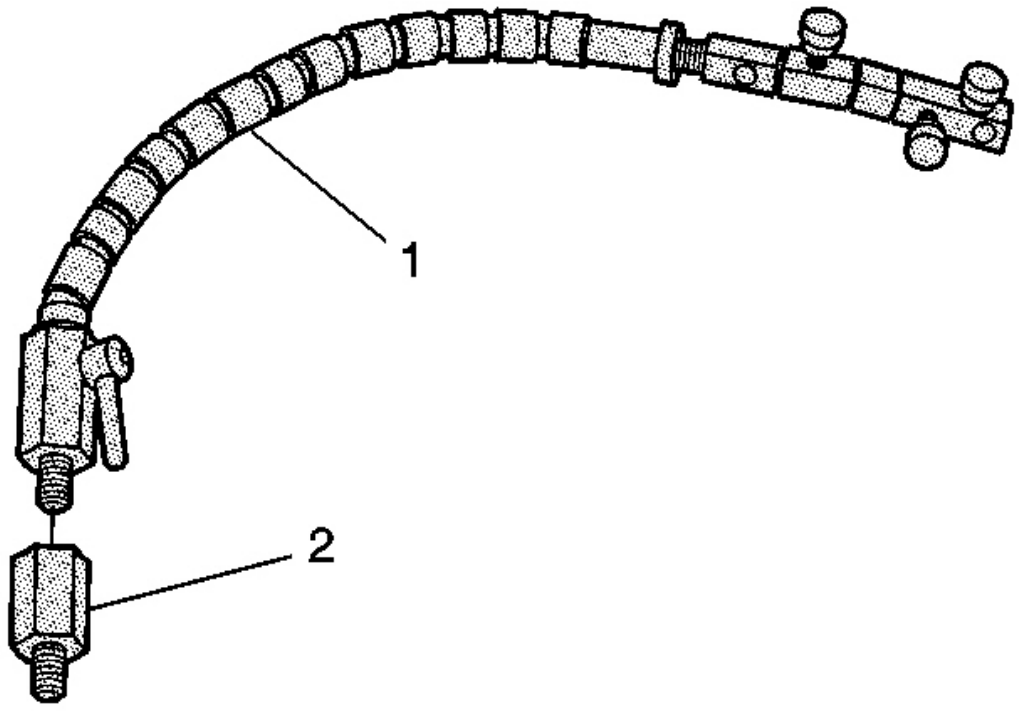


Fig. 499: View Of Adapter & Swivel Base
Courtesy of GENERAL MOTORS CORP.

15. Select the adapter (2), as required, and install to the swivel base (1). Tighten until snug.

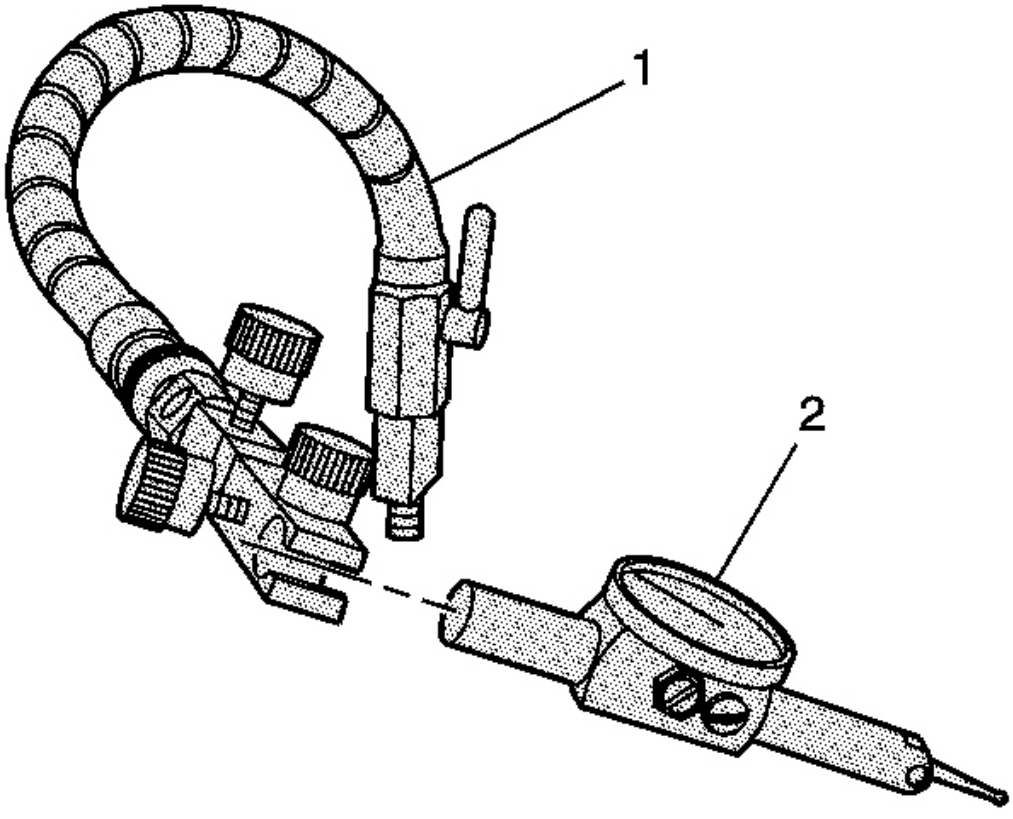


Fig. 500: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The clamp of the swivel base and the shaft of the indicator should be free of oil or other debris. A loose or improperly clamped indicator may indicate incorrect readings.

16. Install the indicator (2) to the swivel base (1). Tighten the clamp of the base until snug.

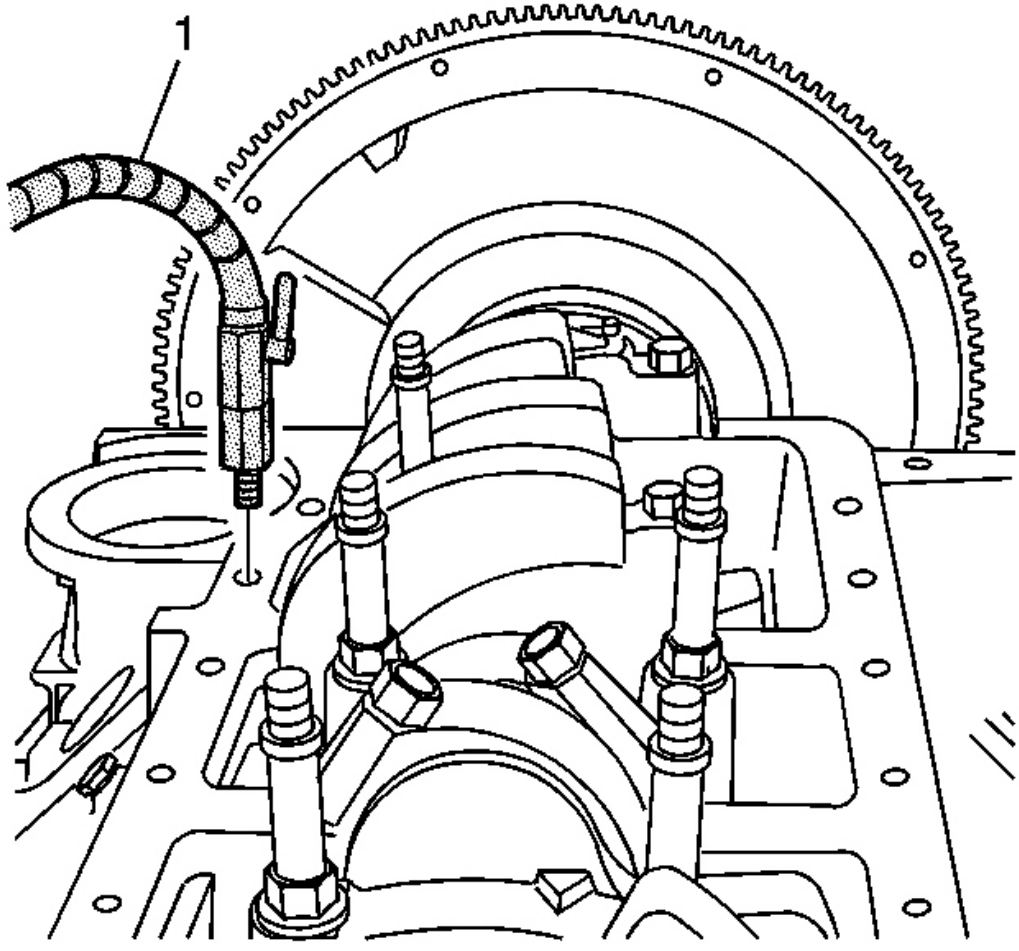


Fig. 501: View Of Swivel Base & Oil Pan Rail
Courtesy of GENERAL MOTORS CORP.

17. Install the swivel base (1) to the oil pan rail of the engine block. Tighten until snug.

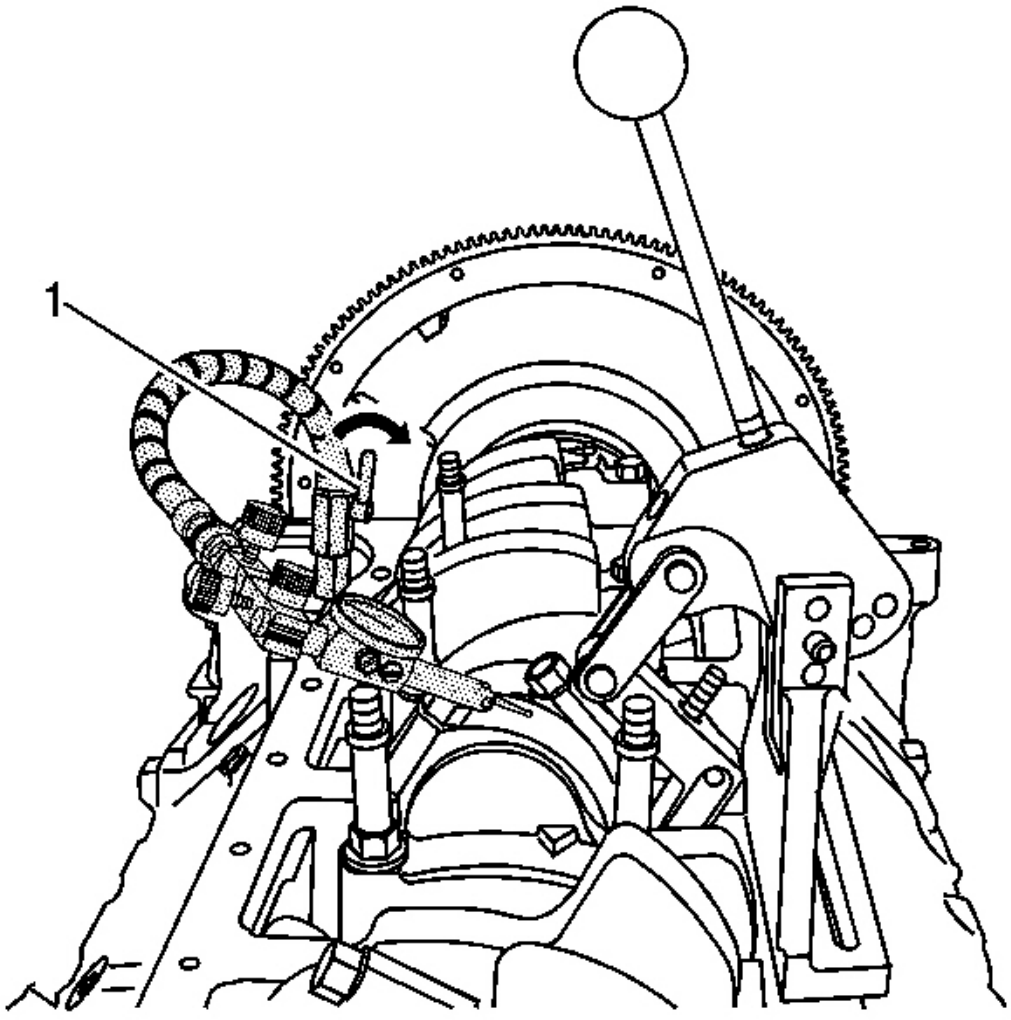


Fig. 502: Swivel Base Locking Lever
Courtesy of GENERAL MOTORS CORP.

18. Adjust the swivel base as required and position the indicator tip slightly above the connecting rod cap. Lock the swivel base in position by rotating the locking lever (1). Do not allow the tip of the indicator to contact the connecting rod at this time.

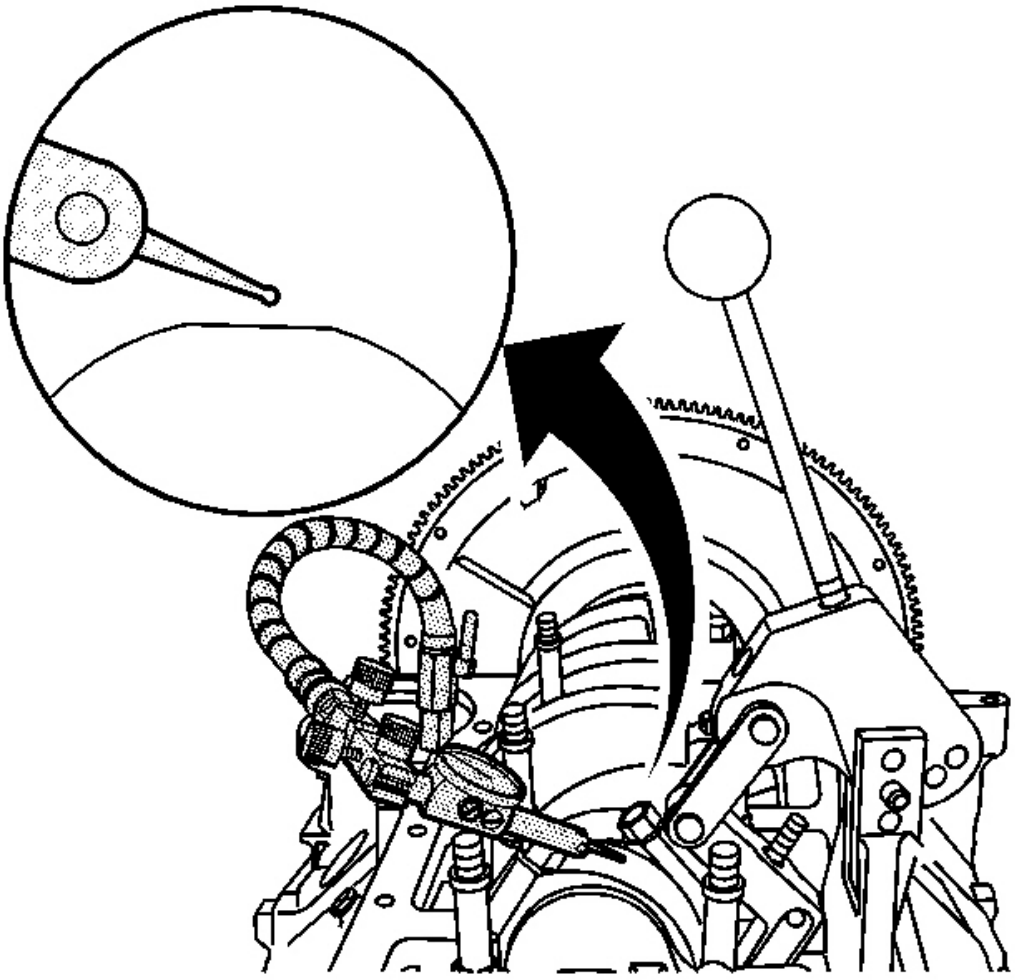


Fig. 503: Proper Indicator Positioning
Courtesy of GENERAL MOTORS CORP.

19. The tip of the indicator should be positioned above and NOT in contact with the cap end of the connecting rod.

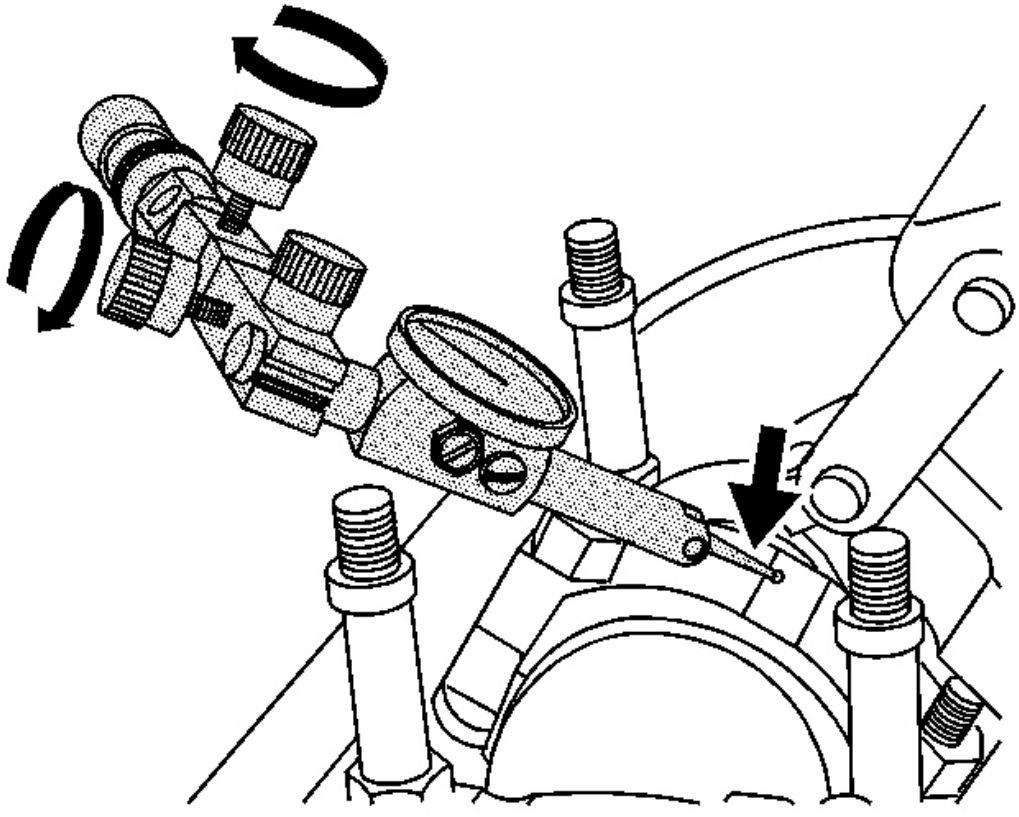


Fig. 504: Swivel Base Fine Adjustment Knobs
Courtesy of GENERAL MOTORS CORP.

20. Rotate the fine adjustment knobs on the dial indicator end of the swivel base to position the tip of the indicator in contact with the connecting rod.

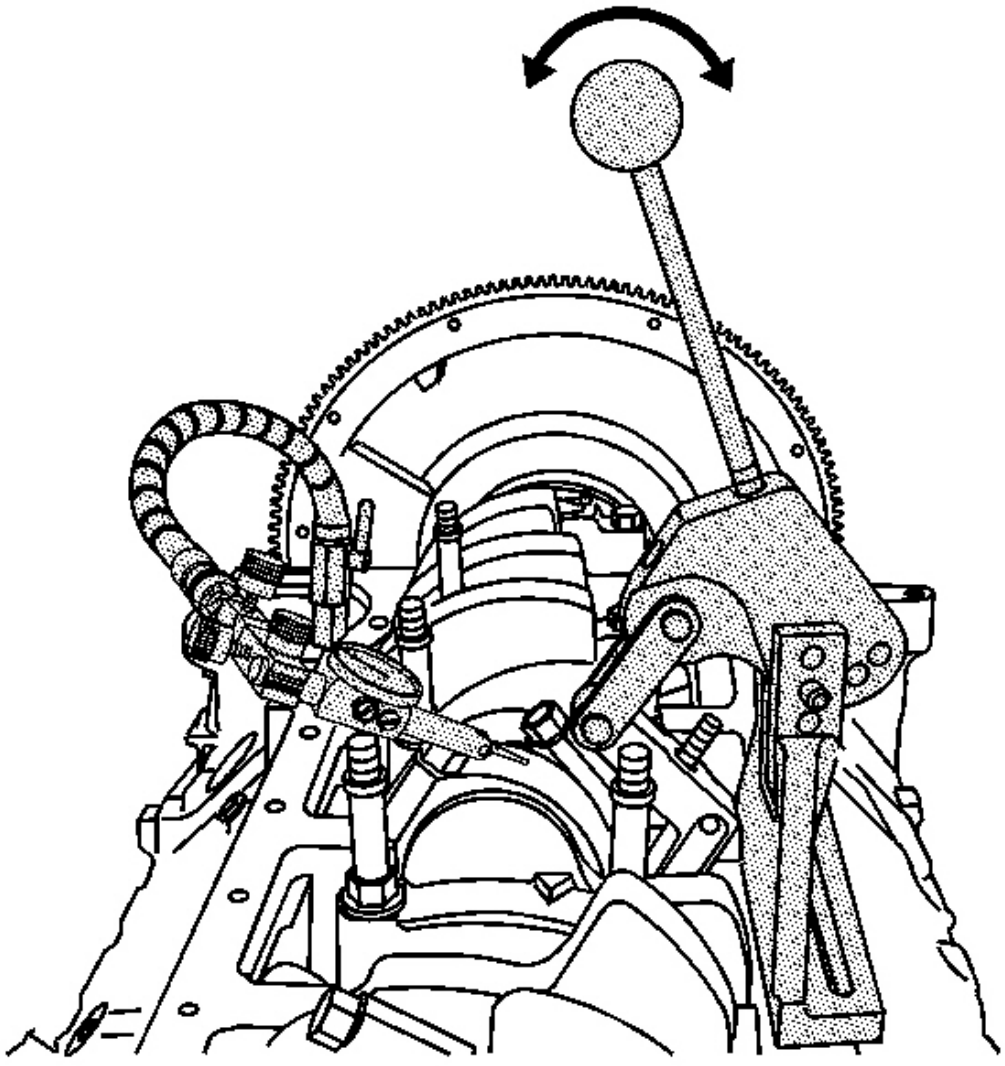


Fig. 505: Actuating Pivot Arm Assembly Handle
Courtesy of GENERAL MOTORS CORP.

21. Lightly actuate the handle of the pivot arm assembly, multiple times in both directions, to ensure the oil film is removed from the journal.

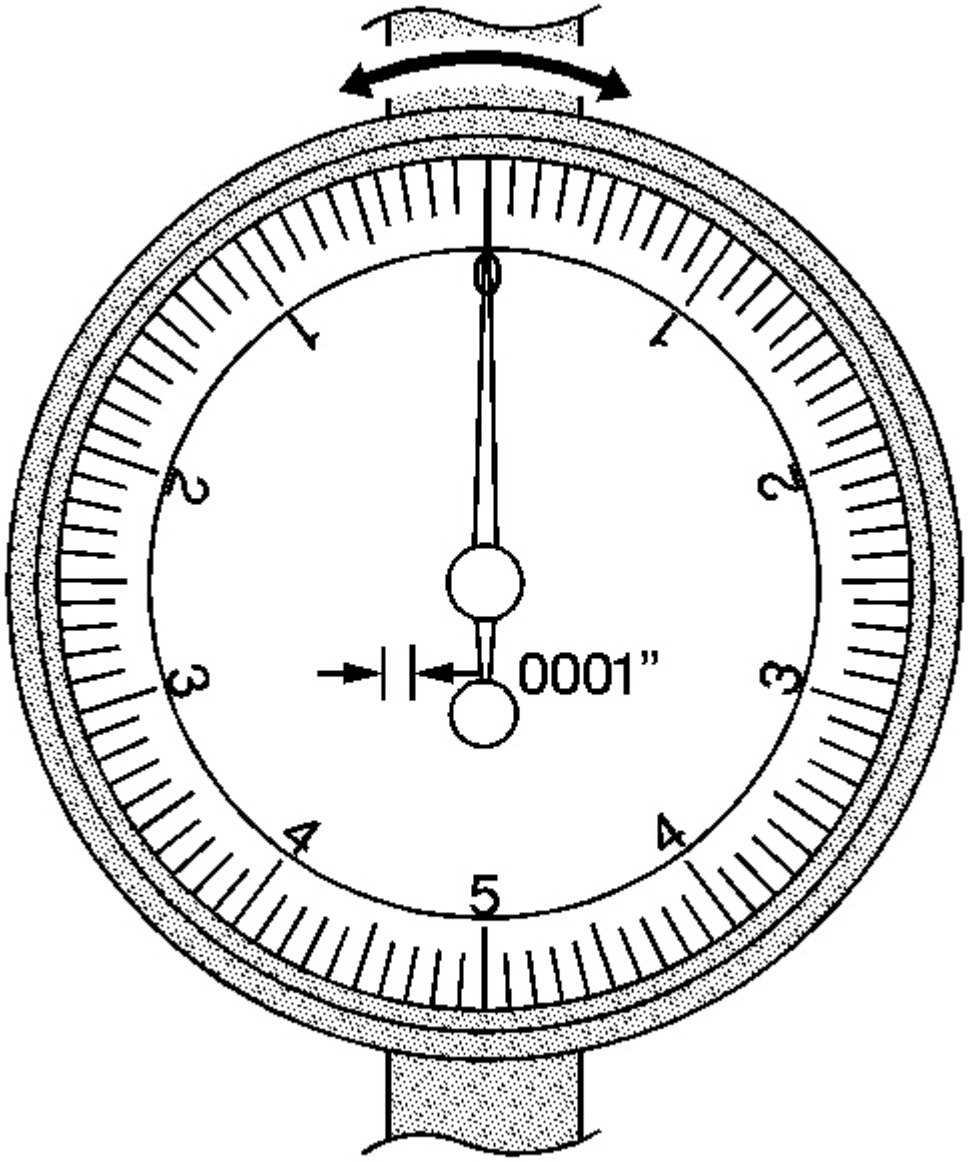


Fig. 506: Dial Indicator
Courtesy of GENERAL MOTORS CORP.

22. Load the handle in the forward position and zero the dial indicator. Load the handle multiple times in both directions and record the reading.

IMPORTANT: During this procedure, card stock may enter the crankshaft journal oil galleries. Be sure to remove all card stock from the bearing journal and oil galleries prior to reassembly.

23. Remove the bearing cap bolts, cap, and paper stock.
24. Replace bearing halves as required to obtain the proper bearing clearances.
25. Install the bearings, cap, and bolts. Refer to **Fastener Tightening Specifications**.

Measuring Crankshaft Bearing Clearances - Plastic Gage Method

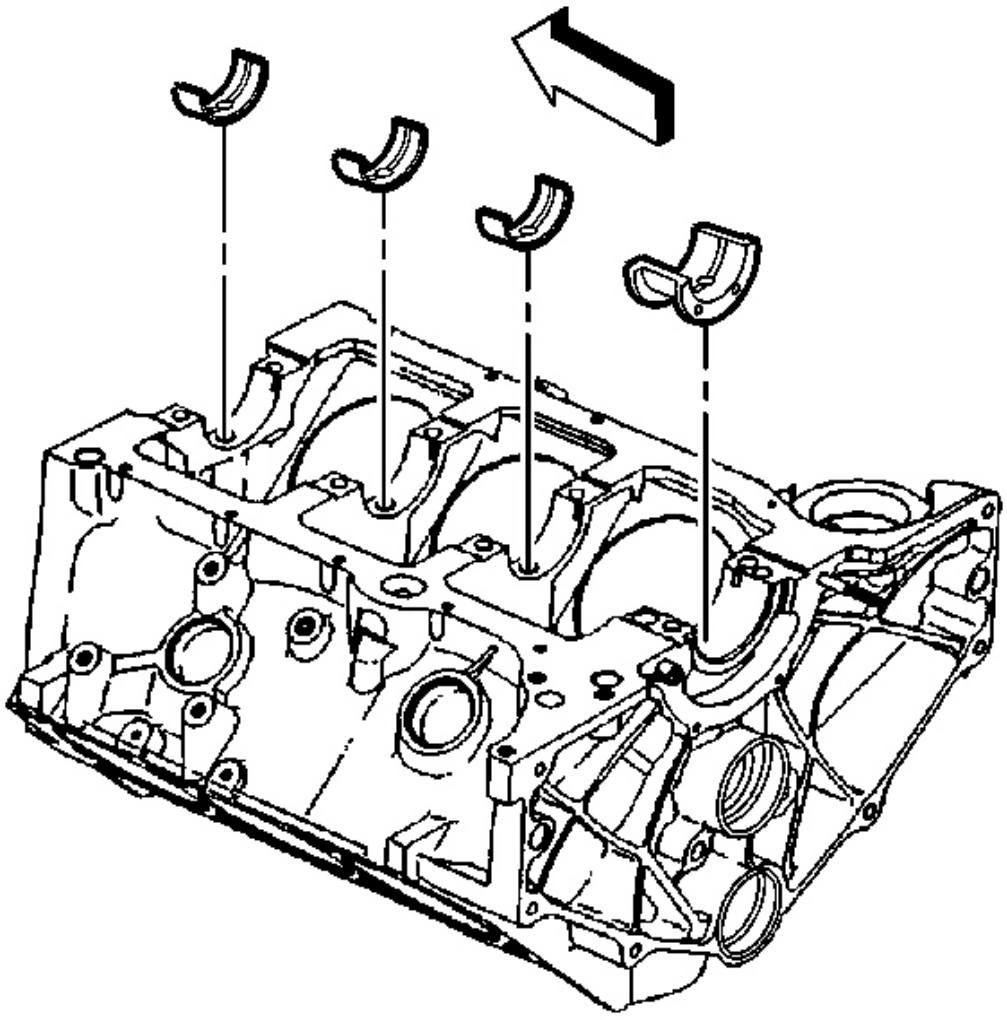


Fig. 507: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft bearings into the engine block.

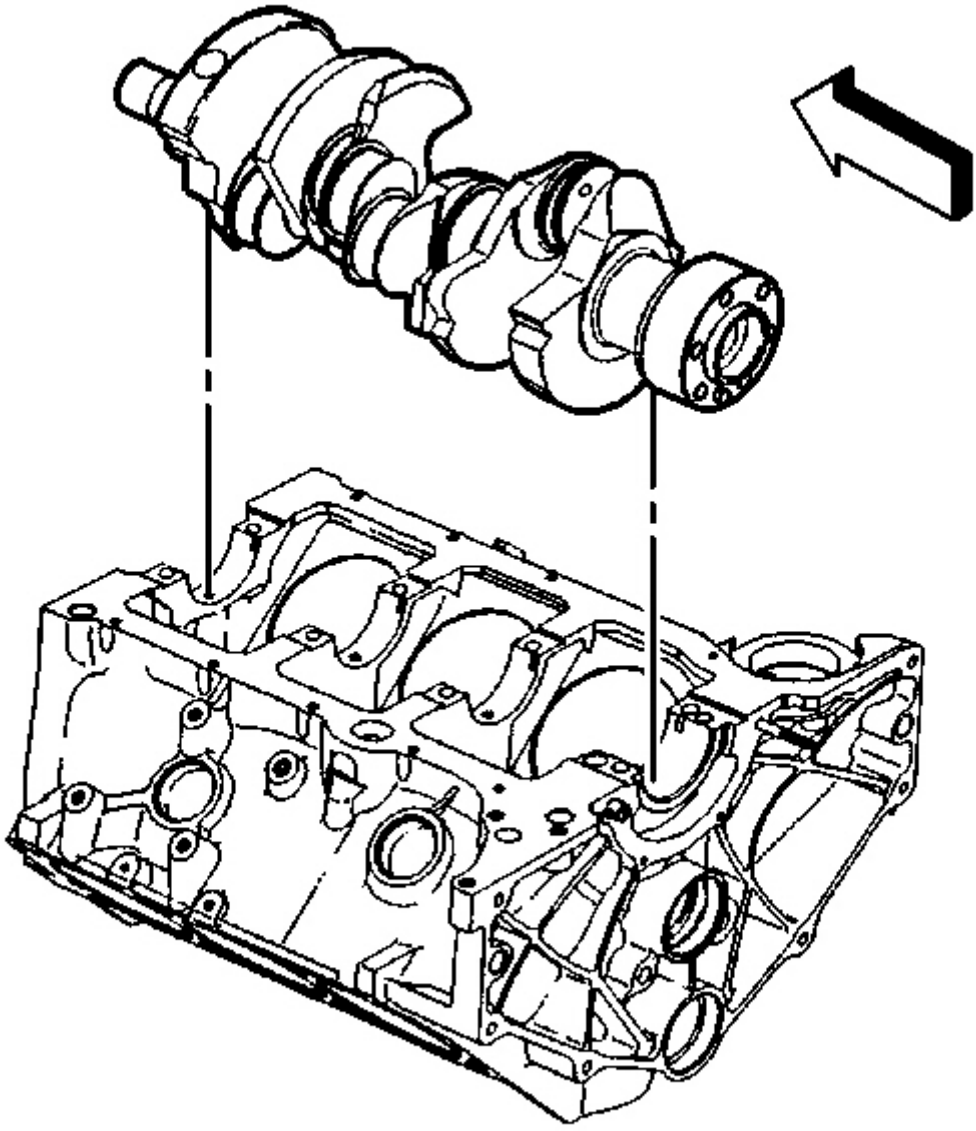


Fig. 508: View Of Crankshaft

Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft.

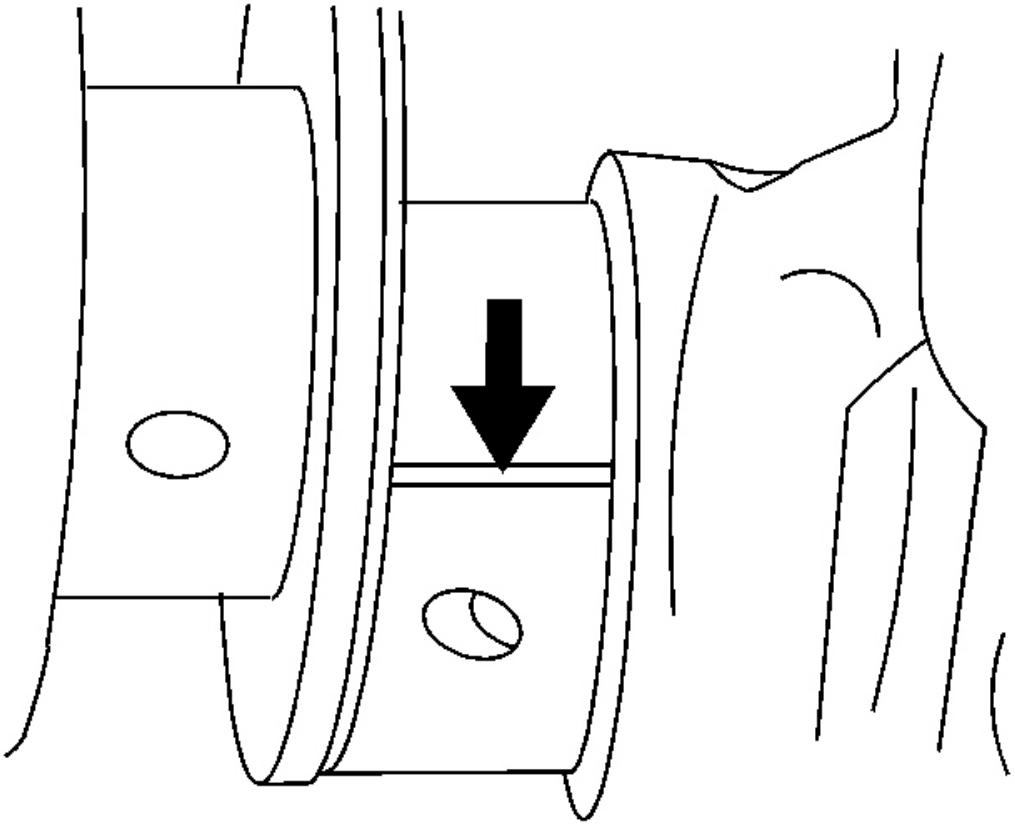


Fig. 509: Installing Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

3. Install the gaging plastic the full width of the journal.

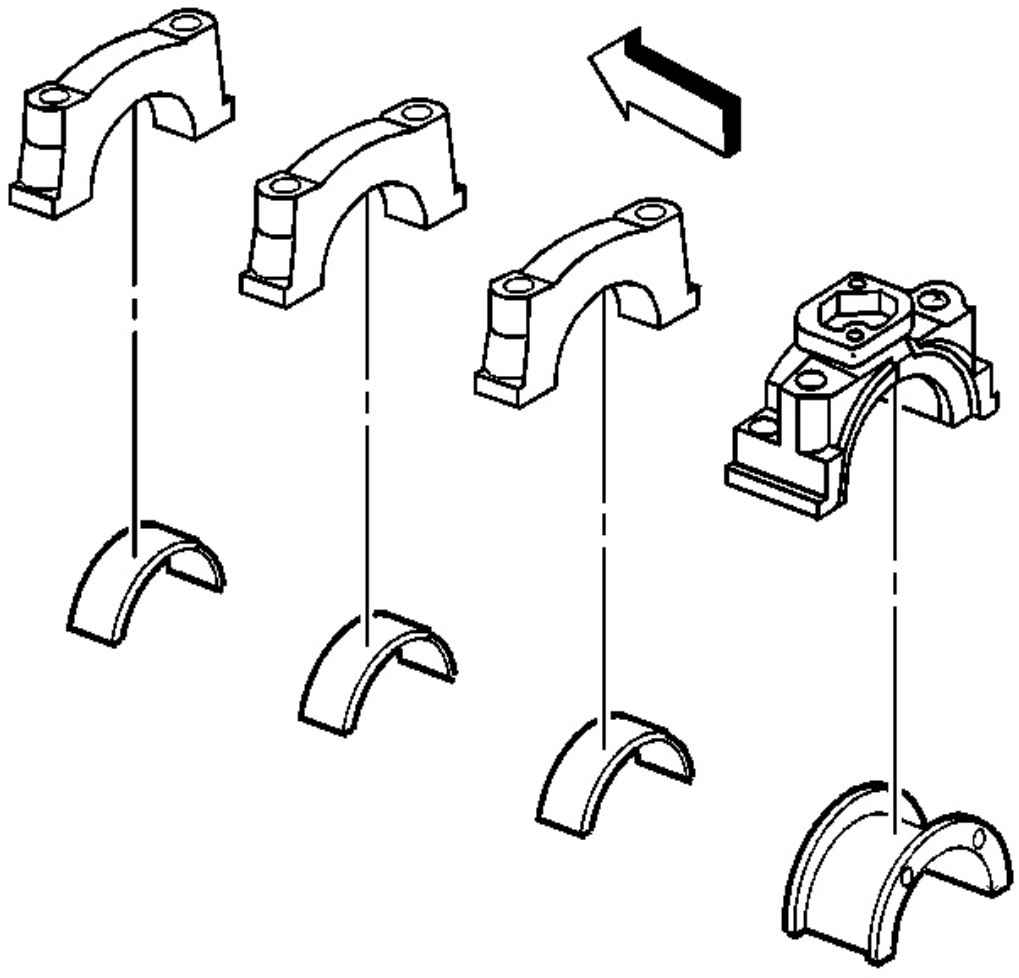


Fig. 510: View Of Crankshaft Bearings & Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft bearings into the crankshaft bearing caps.

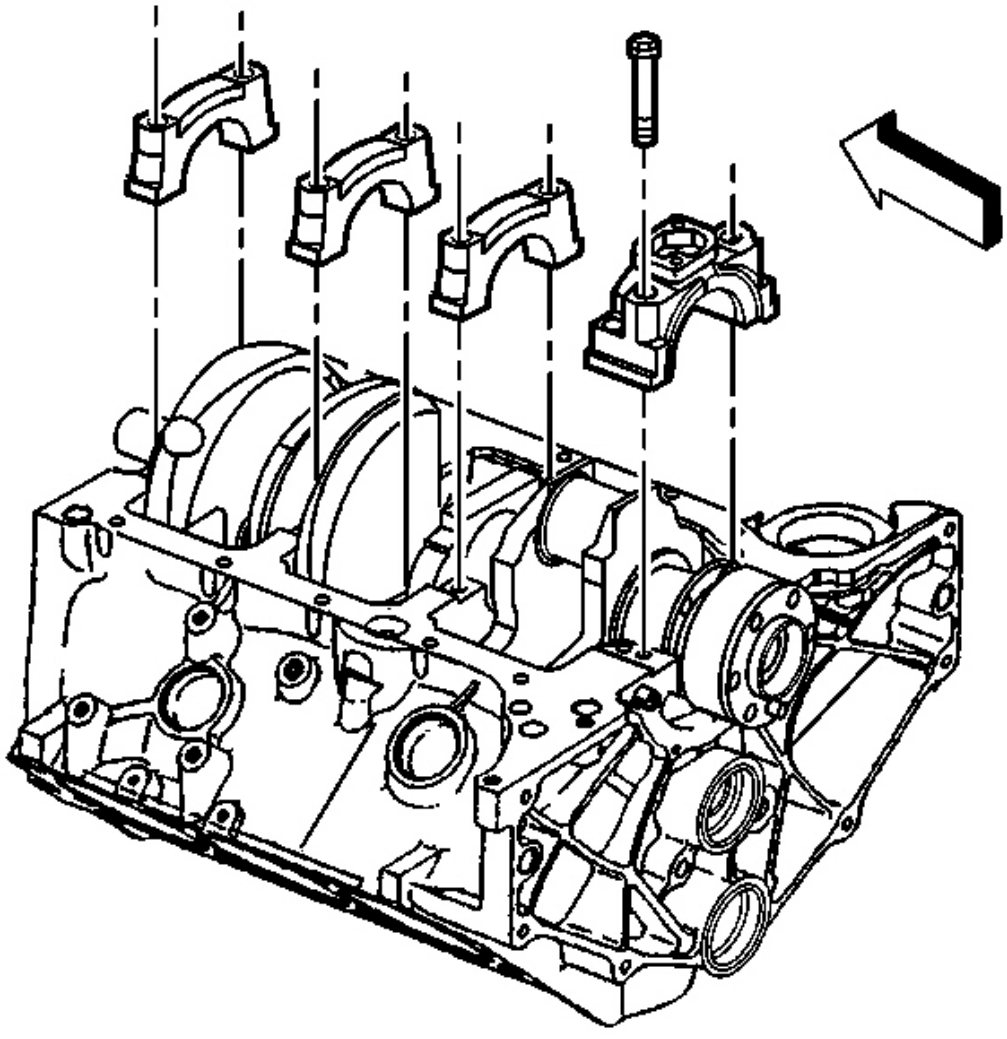


Fig. 511: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.

Tighten: Tighten the crankshaft bearing caps to 105 N.m (77 lb ft).

7. Remove the crankshaft bearing cap bolts.
8. Remove the crankshaft bearing caps. The gaging plastic may adhere to either the crankshaft bearing journal or the crankshaft bearing surface.

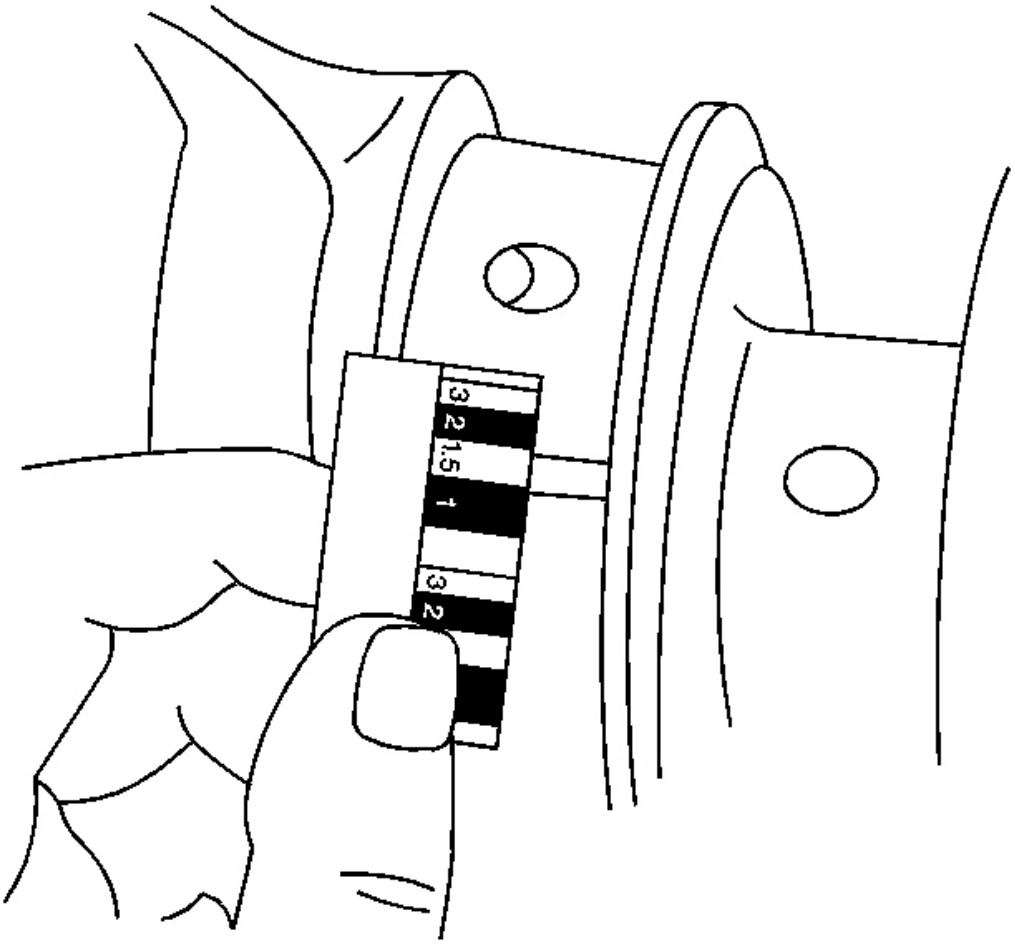


Fig. 512: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

9. Without removing the gaging plastic, measure the compressed width at the widest point using the graduated scale on the edge of the gaging plastic envelope.

   If the flattened gaging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft

bearing or the crankshaft bearing journal.

10. Remove the flattened gaging plastic.
11. Measure the remaining crankshaft bearing journals.

Measuring Connecting Rod Bearing Side Clearance

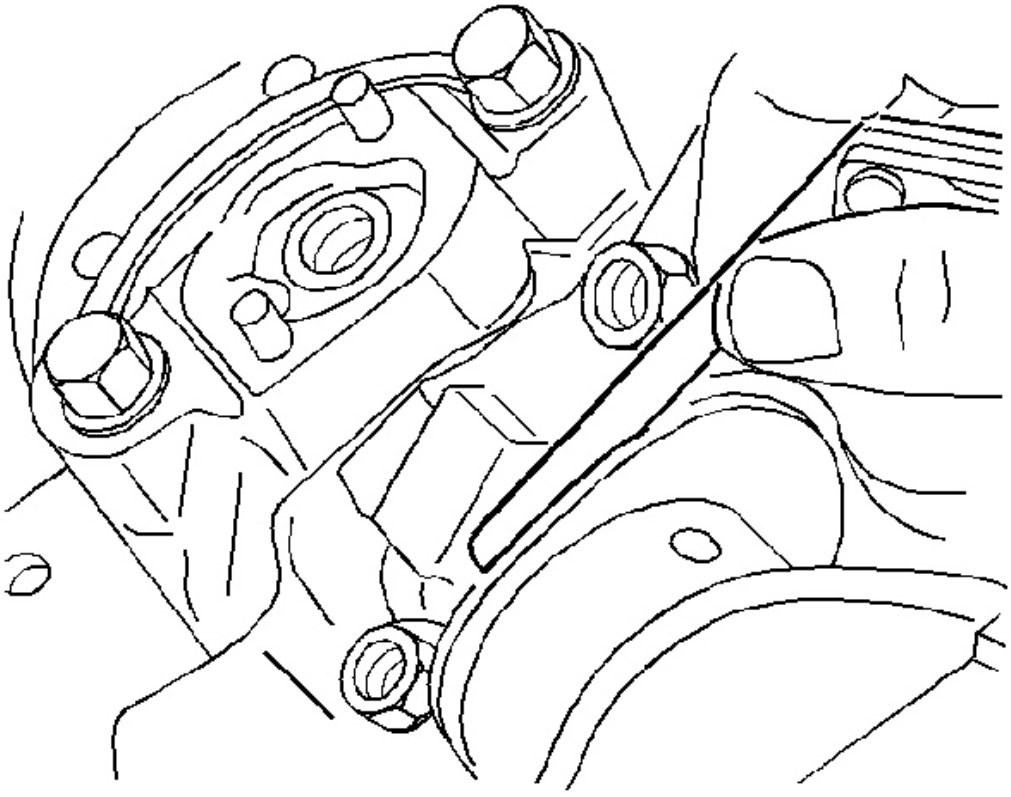


Fig. 513: Measuring Connecting Side Clearance
Courtesy of GENERAL MOTORS CORP.

1. Insert a feeler gage between the connecting rod caps and measure the connecting rod side clearance. The proper connecting rod side clearance specification is 0.15-0.44 mm (0.006-0.017 in).
2. Connecting rod side clearances may also be measured with a dial indicator set.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

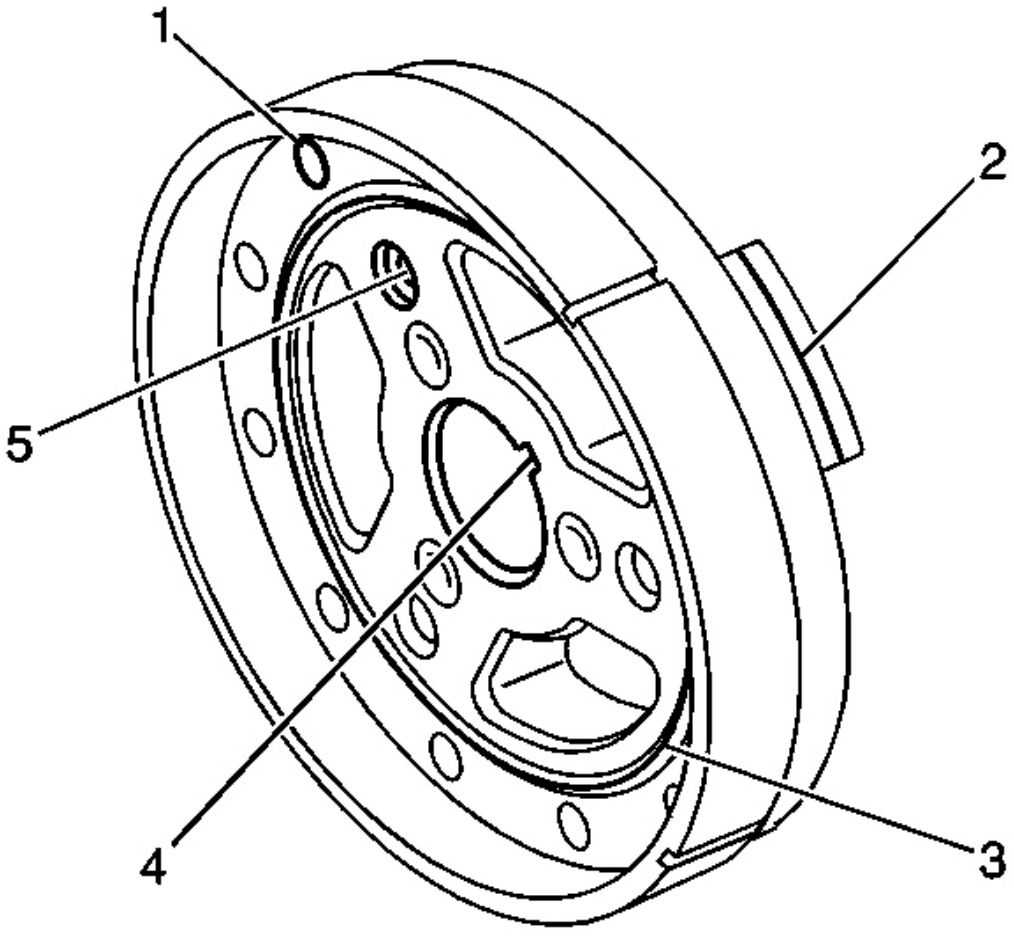


Fig. 514: Crankshaft Balancer Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the crankshaft balancer in cleaning solvent.
2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
    - Loose or improperly installed crankshaft balancer front groove pin (1)

A properly installed front groove pin should be installed until flush or below flush with the face of the crankshaft balancer.

IMPORTANT: A crankshaft front oil sealing surface with excessive scoring, grooves, rust, or other damage must be replaced.

- Worn, grooved, or damaged crankshaft front oil sealing surface (2)

  Minor imperfections on the crankshaft balancer crankshaft front oil seal surface may be removed with a polishing compound or fine grade emery cloth.

- Worn, chunking, or deteriorated rubber (3) between the hub and the outer ring
- Worn or damaged keyway (4)
- Worn or damaged bolt hole threads (5)

ENGINE FLYWHEEL CLEANING AND INSPECTION

IMPORTANT: In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.

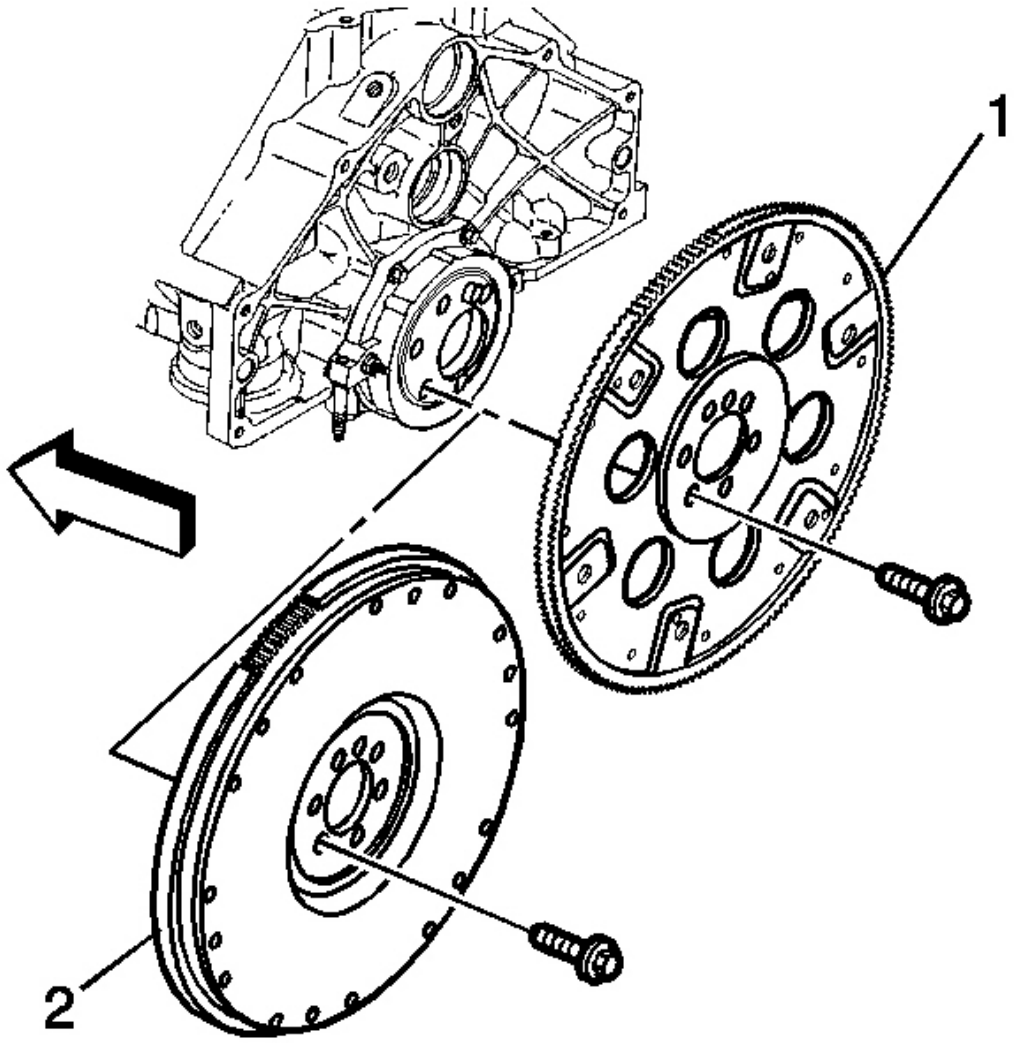


Fig. 515: View Of Flywheels
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the engine flywheel (1 or 2) in cleaning solvent.
2. Dry the engine flywheel with compressed air.

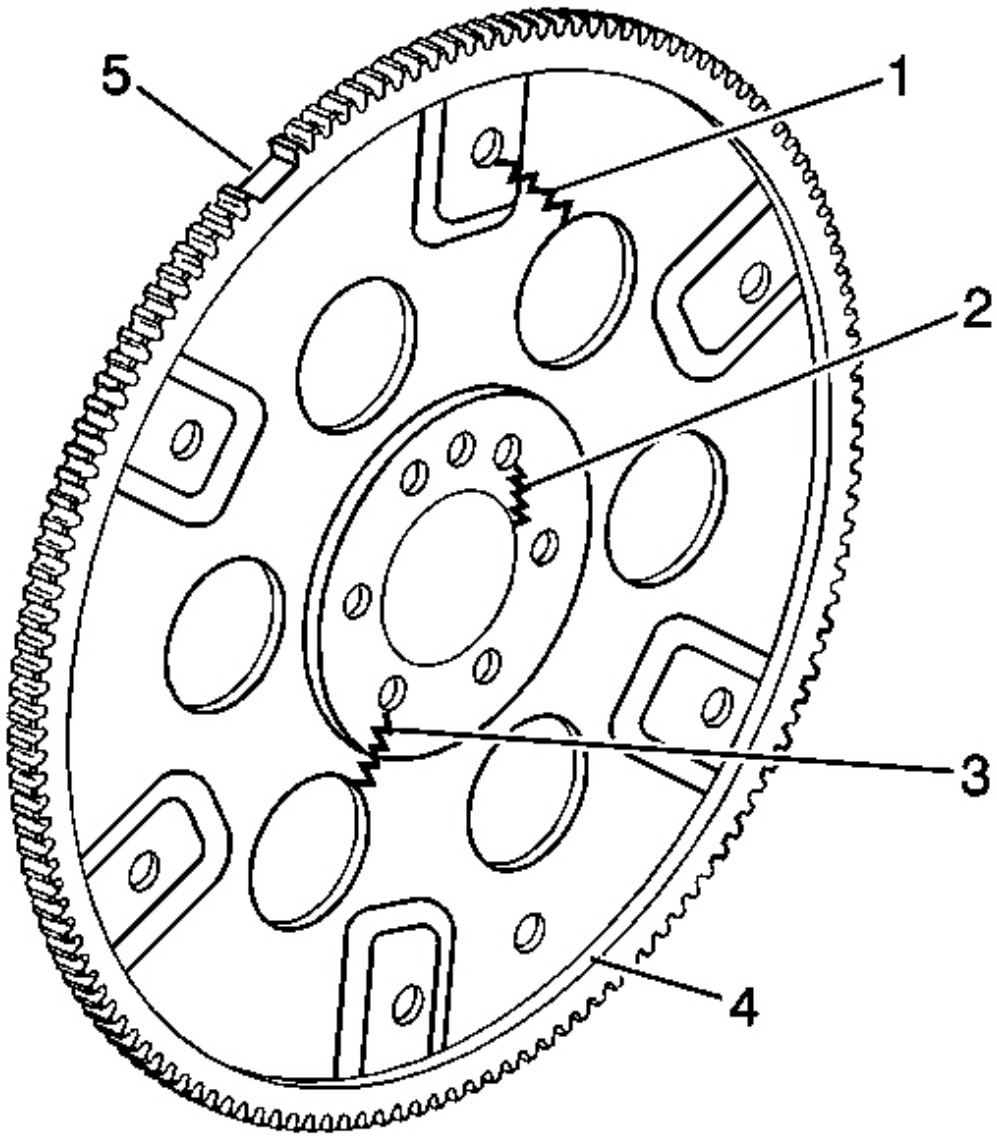


Fig. 516: Flywheel Inspection Areas (Automatic Transmission)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to repair the welded areas, if present, that retain the ring gear to the engine flywheel plate. Always install a NEW engine flywheel.

3. Inspect the engine flywheel, automatic transmission, if equipped, for the following:
   - Stress cracks around the engine flywheel-to-torque converter bolt hole locations (1)
   - Missing balance weights
   - Stress cracks around the engine flywheel-to-crankshaft bolt hole locations (2 or 3)
   - Welded areas that retain the ring gear onto the engine flywheel for cracking (4), if present
   - Damaged ring gear teeth (5)

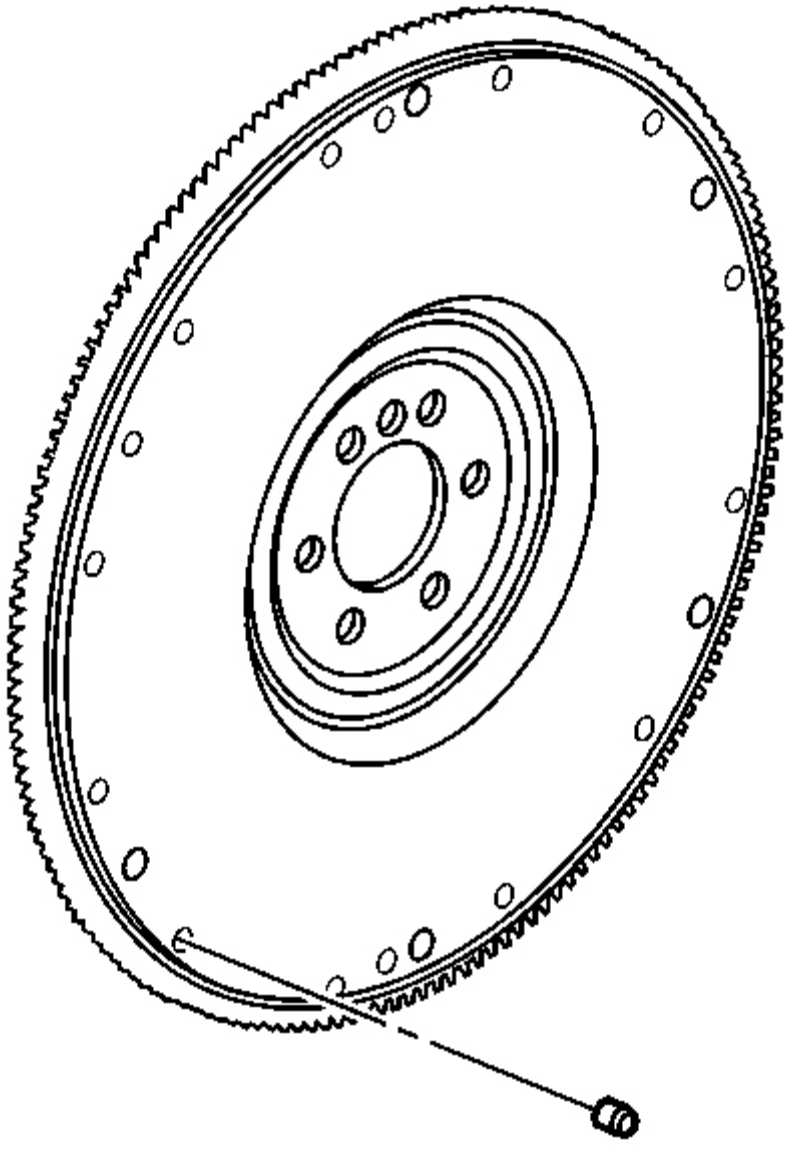


Fig. 517: Locating Flywheel Weights (Manual Transmission)
Courtesy of GENERAL MOTORS CORP.

4. Inspect the engine flywheel, manual transmission, if equipped, for loose or improperly installed flywheel weights, if applicable.

A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

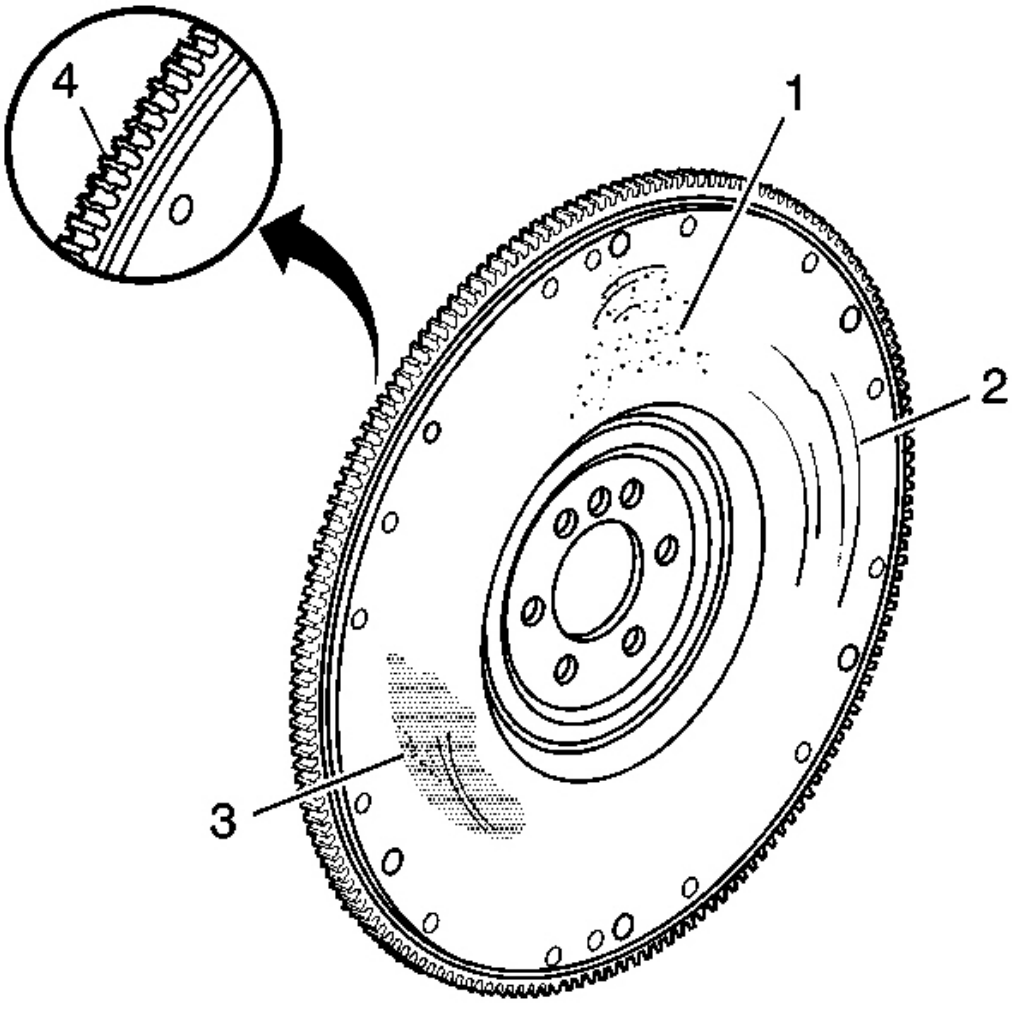


Fig. 518: Flywheel Inspection Areas (Manual Transmission)
Courtesy of GENERAL MOTORS CORP.

5. Inspect the engine flywheel, manual transmission, if equipped, for the following:
   - Pitted friction surface (1)
   - Scoring or grooves (2)
   - Rust or other surface damage (3)

- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the engine flywheel and the ring gear should be positioned completely flat against the flange of the engine flywheel.

CAMSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator

Cleaning and Inspection

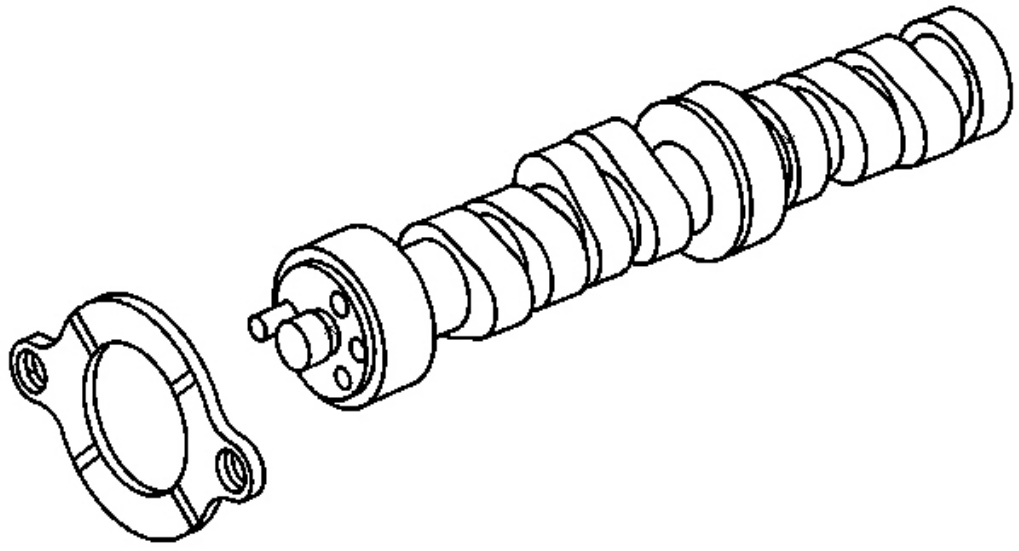


Fig. 519: Camshaft & Retainer Plate
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the engine camshaft in cleaning solvent.

2. Dry the engine camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.

   If the camshaft retainer plate is damaged, replace as necessary.

4. Inspect the camshaft bearings for correct fit into the engine block camshaft bearing bores.

   The camshaft bearings have an interference fit to the engine block camshaft bearing bores and must not be loose in the engine block camshaft bearing bores.

IMPORTANT: If any camshaft bearing is excessively worn or scored, replace all the camshaft bearings.

5. Inspect the camshaft bearings for excessive wear or scoring.

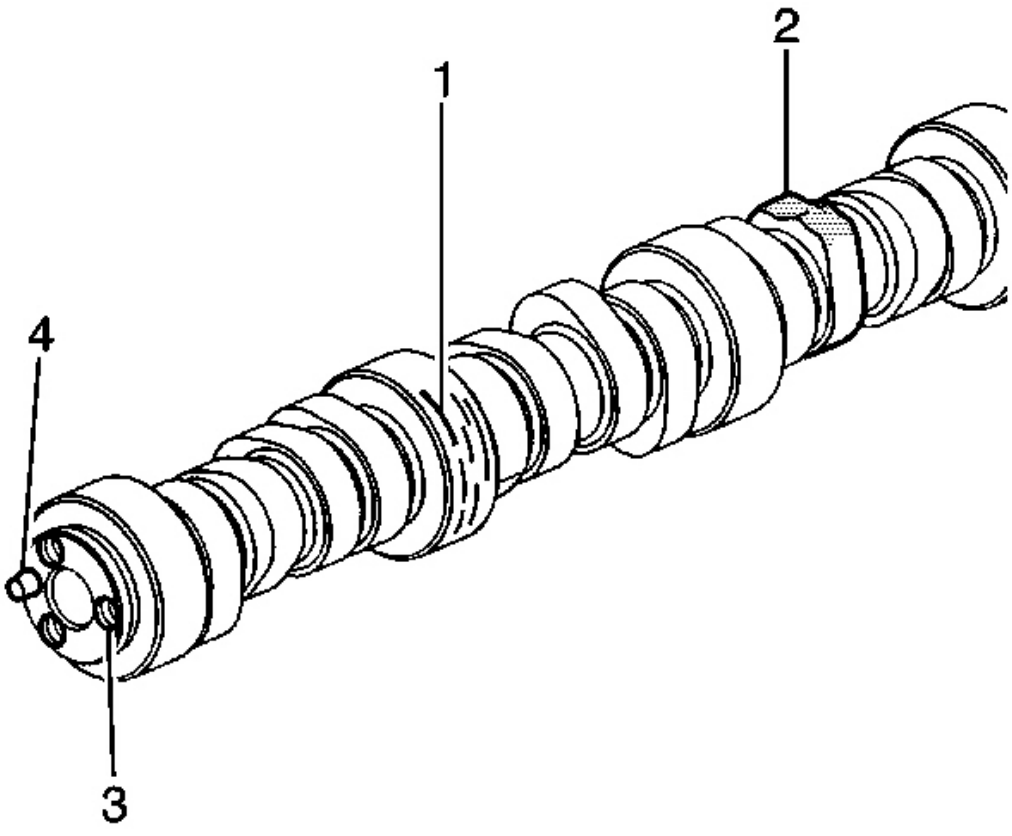


Fig. 520: Camshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

6. Inspect the engine camshaft for the following:
   - Worn, scored, or damaged bearing journals (1)
   - Worn engine camshaft lobes (2)
   - Damaged bolt hole threads (3)
   - Damaged camshaft sprocket locator pin (4)

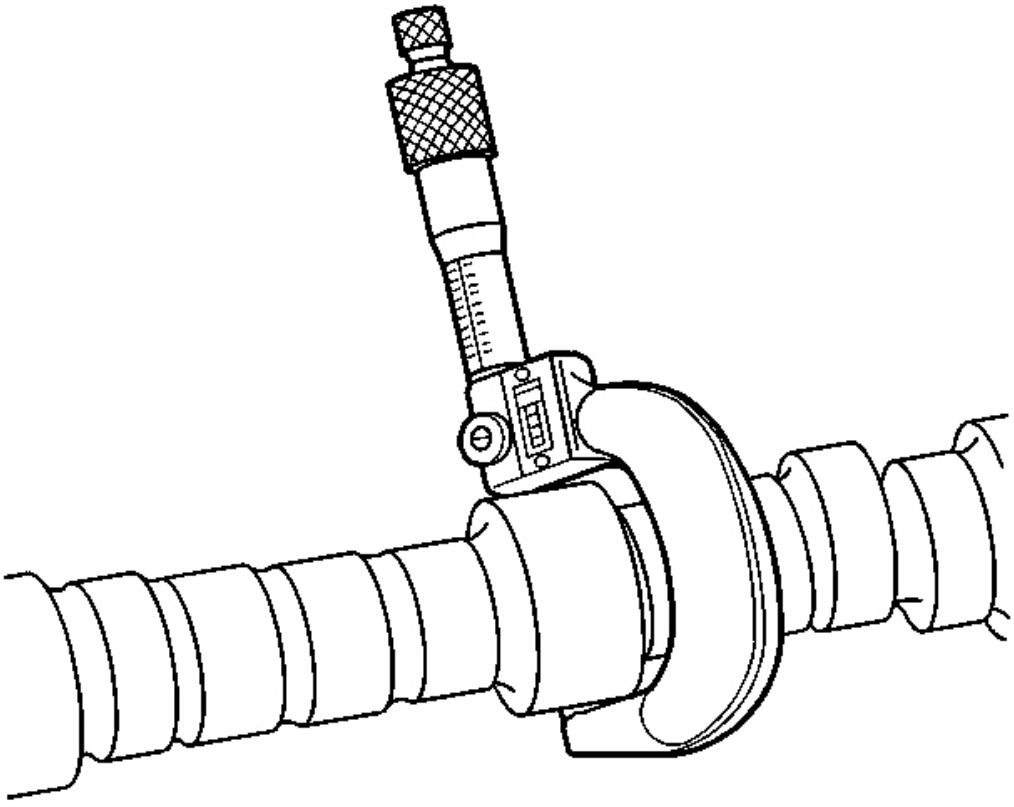


Fig. 521: Measuring Engine Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

7. Measure the engine camshaft journals with a micrometer.

   If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.

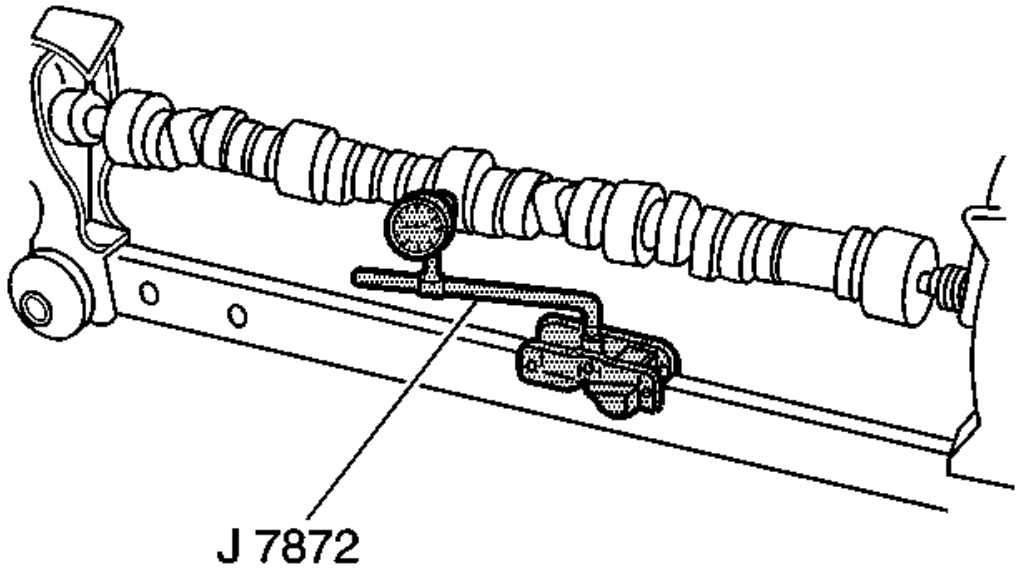


Fig. 522: Measuring For Bent Engine Camshaft Or Excessive Engine Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

8. Measure for a bent engine camshaft or excessive engine camshaft runout using the **J 7872** .
    1. Mount the engine camshaft in a suitable stand between centers.
    2. Use the **J 7872** in order to check the intermediate engine camshaft journals.

       If the runout exceeds 0.065 mm (0.0026 in), the engine camshaft is bent and must be replaced.

9. Measure the engine camshaft lobe lift using the **J 7872** .
    1. Place the engine camshaft on the V-blocks.
    2. Use the **J 7872** in order to measure the engine camshaft lobe lift.
10. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications. Refer to **Engine Mechanical Specifications**.

CAMSHAFT BEARING REMOVAL

Tools Required

J 33049 Camshaft Bearing Service Kit. See **Special Tools**.

Removal

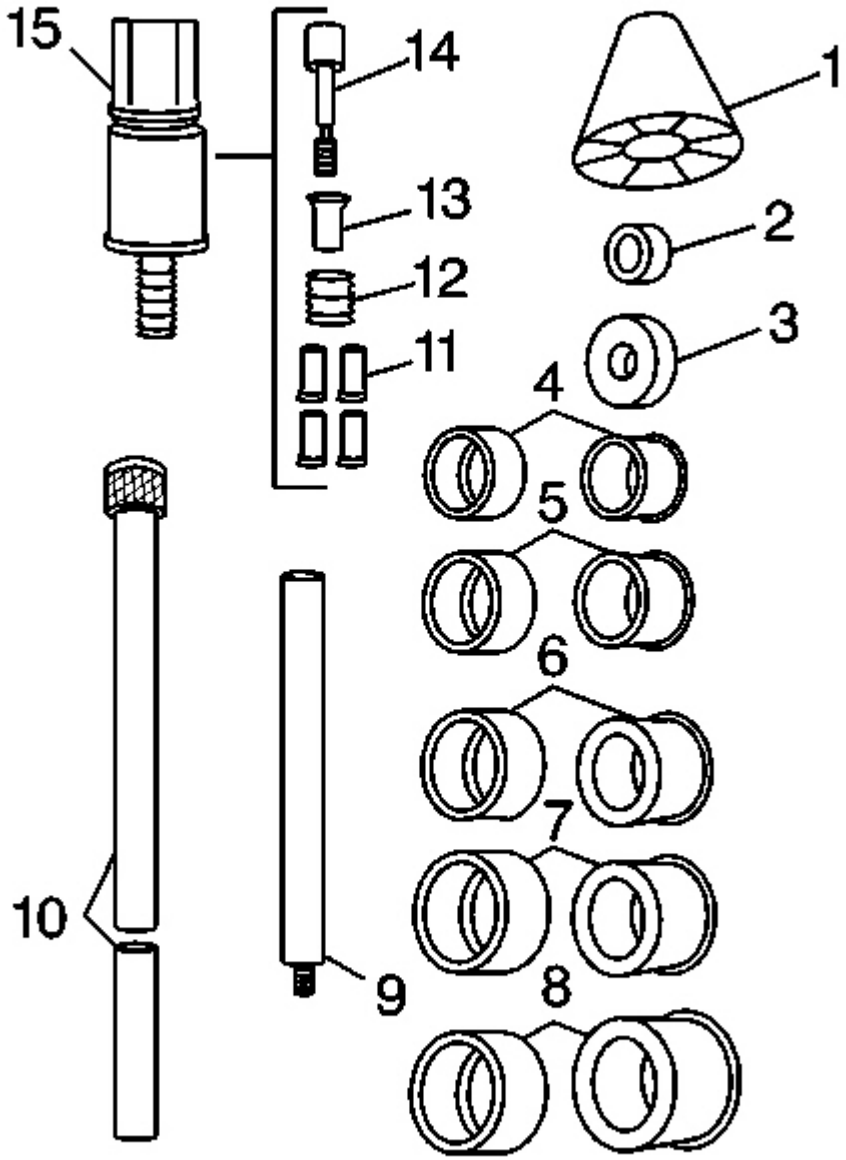


Fig. 523: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

1. Select the cone (1), the handle (10), the expanding driver (4-8), the washer (2 or 3), and the expander assembly (15) from the **J 33049** . See **Special Tools**.
2. Assemble the **J 33049** . See **Special Tools**.

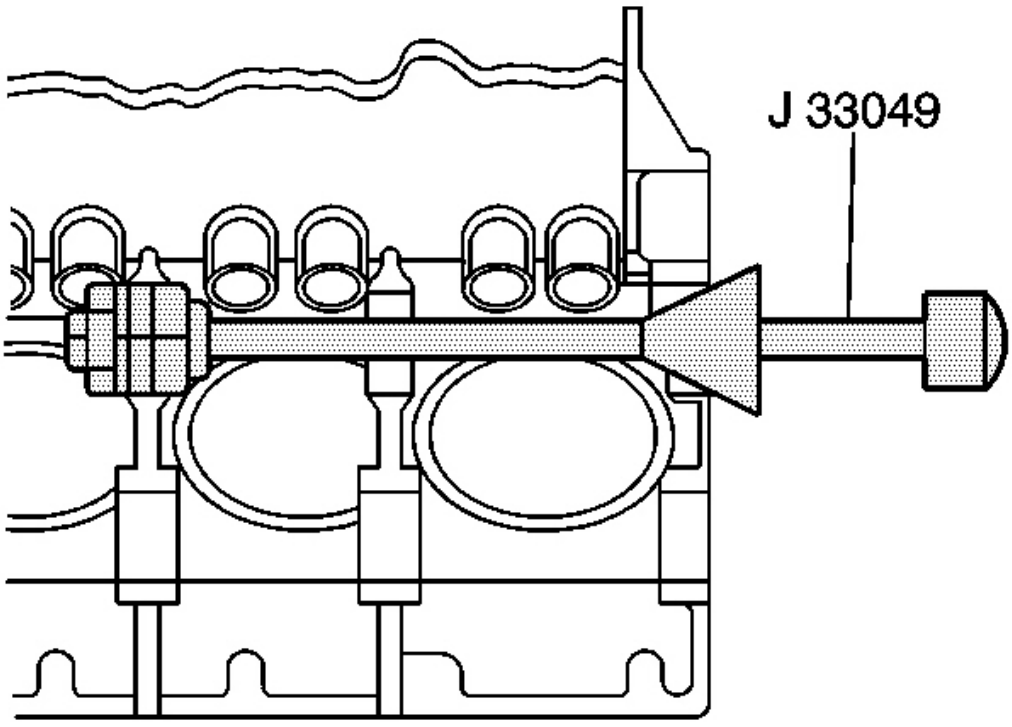


Fig. 524: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT:

- **A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block camshaft bearing bore.**
- **Always remove the camshaft inner bearings #2 and #3 first. The camshaft outer bearings #1 and #4 serve as a**

guide for the J 33049 . See Special Tools.

3. Remove the camshaft inner bearings #2 and #3.
    1. Insert the **J 33049** through the front of the engine block and into the camshaft inner bearing #2. See **Special Tools**.
    2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    3. Push the **J 33049** guide cone into the camshaft front bearing in order to align the **J 33049** . See **Special Tools**.
    4. Drive the camshaft inner bearing #2 from the camshaft inner bearing bore #2.
    5. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
    6. Remove the camshaft inner bearing #2 from the **J 33049** expander assembly. See **Special Tools**.
    7. Insert the **J 33049** expander assembly into the camshaft inner bearing #3. See **Special Tools**.
    8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    9. Push the **J 33049** guide cone into the camshaft front bearing in order to align the **J 33049** . See **Special Tools**.
    10. Drive the camshaft inner bearing #3 from the camshaft inner bearing bore #3.
    11. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
    12. Remove the camshaft inner bearing #3 from the **J 33049** expander assembly. See **Special Tools**.
4. Remove the **J 33049** from the engine block. See **Special Tools**.
5. Remove the camshaft outer bearings #1 and #4.
    1. Insert the **J 33049** into the camshaft outer bearing #1. See **Special Tools**.
    2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    3. Drive the camshaft outer bearing #1 from the camshaft outer bearing bore #1.
    4. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
    5. Remove the camshaft outer bearing #1 from the **J 33049** expander assembly. See **Special Tools**.
    6. Remove the **J 33049** from the engine block. See **Special Tools**.
    7. Insert the **J 33049** into the camshaft outer bearing #4. See **Special Tools**.
    8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    9. Drive the camshaft outer bearing #4 from the camshaft outer bearing bore #4.

10. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
11. Remove the camshaft outer bearing #4 from the **J 33049** expander assembly. See **Special Tools**.

6. Remove the **J 33049** from the engine block. See **Special Tools**.
7. Discard the camshaft bearings.

CAMSHAFT BEARING INSTALLATION

Tools Required

J 33049 Camshaft Bearing Service Kit. See **Special Tools**.

Installation

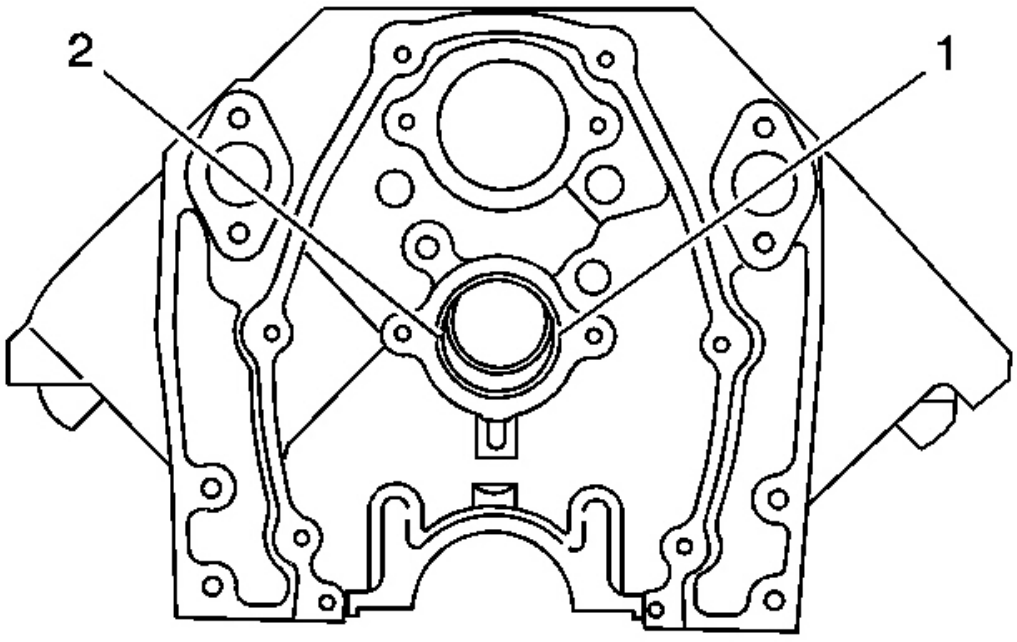


Fig. 525: Locating Camshaft Bearing Lubrication Hole At 3 & 9 O'clock Positions
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing the camshaft bearings, always look in order to ensure that the camshaft bearing lubrication hole is located

above the 3 o'clock position (1) or the 9 o'clock position (2). The proper positioning of the camshaft bearing lubrication hole is in order to ensure the best lubrication of the engine camshaft journals.

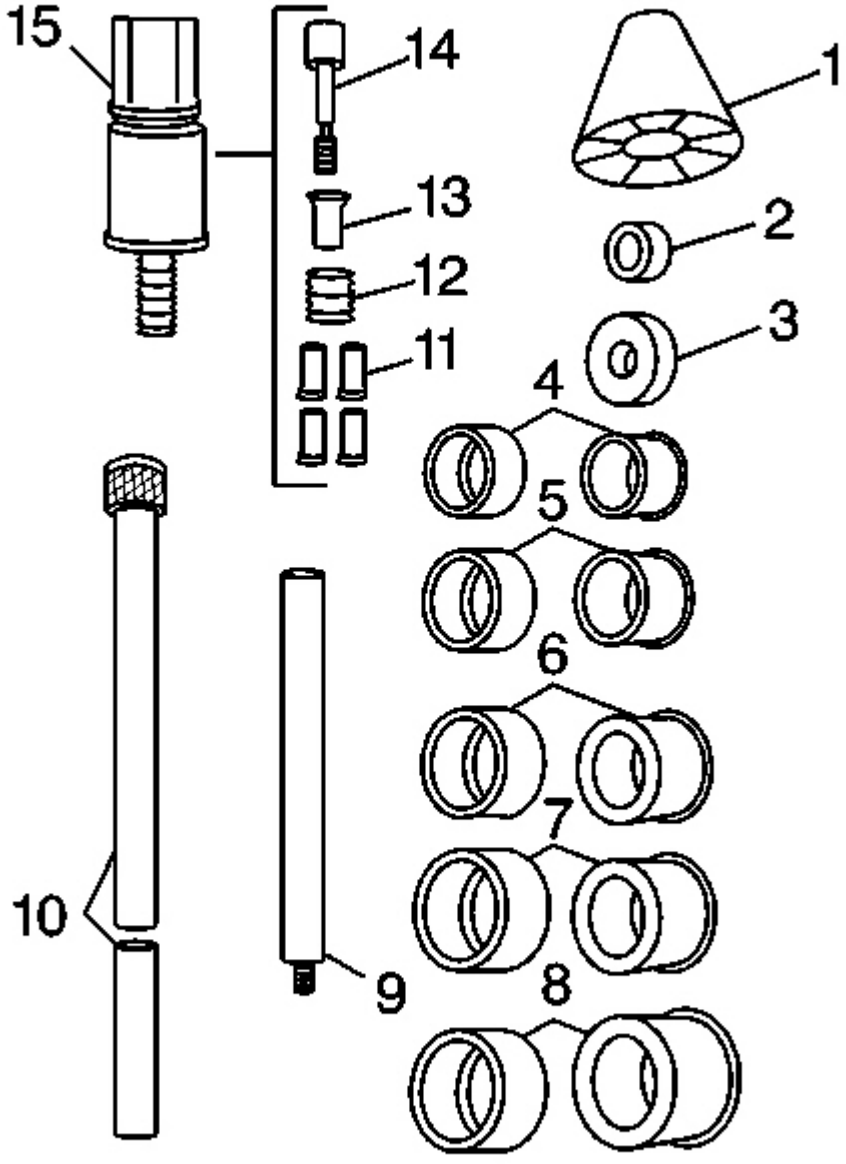


Fig. 526: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

1. Assemble the **J 33049** handle (10), the expanding driver (4-8), the washer (2 or 3), and the expander assembly (15). See **Special Tools**.

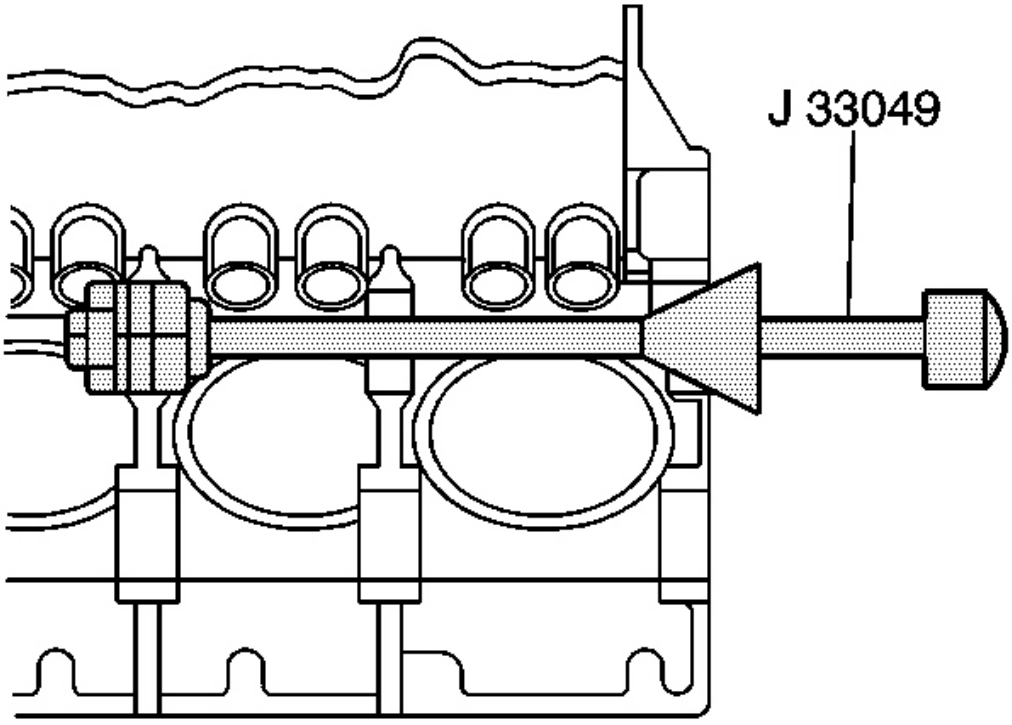


Fig. 527: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: The camshaft bearings vary in size. When ordering the new camshaft bearings, be sure to order the correct camshaft bearings for the application to be serviced.
Always install the camshaft outer bearings #1 and #4 first.
The camshaft outer bearings serve as a guide for the J 33049

and help center the camshaft inner bearings during the installation process. See Special Tools.

2. Install the NEW camshaft outer bearings #4 and #1.
    1. Install the NEW camshaft outer bearing #4 onto the **J 33049** expander assembly. See **Special Tools**.
    2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    3. Align the lubrication hole of the camshaft outer bearing #4 above the 3 o'clock position or the 9 o'clock position of the camshaft outer bearing bore #4 at the rear of the engine block.
    4. Drive the camshaft outer bearing #4 into the camshaft outer bearing bore #4 at the rear of the engine block.
    5. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
    6. Remove the camshaft outer bearing #4 from the **J 33049** expander assembly. See **Special Tools**.
    7. Install the NEW camshaft outer bearing #1 onto the **J 33049** expander assembly. See **Special Tools**.
    8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    9. Align the lubrication hole of the camshaft outer bearing #1 above the 3 o'clock position or the 9 o'clock position of the camshaft outer bearing bore #1 at the front of the engine block.
    10. Drive the camshaft outer bearing #1 into the camshaft outer bearing bore #1 at the front of the engine block.
    11. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
    12. Carefully slide the **J 33049** into the engine block until the **J 33049** expander assembly is positioned between the camshaft inner bearing bores. See **Special Tools**.
3. Install the NEW camshaft inner bearings #3 and #2.
    1. Install the NEW camshaft inner bearing #3 onto the **J 33049** expander assembly. See **Special Tools**.
    2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
    3. Align the lubrication hole of the camshaft inner bearing #3 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #3 of the engine block.
    4. Push the **J 33049** guide cone into the camshaft front bearing bore #1 in order to align the **J 33049** . See **Special Tools**.

5. Drive the camshaft inner bearing #3 into the camshaft inner bearing bore #3.
6. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
7. Carefully slide the **J 33049** until the **J 33049** expander assembly is positioned between the camshaft inner bearing bore #2 and the camshaft outer bearing bore #1. See **Special Tools**.
8. Install the NEW camshaft inner bearing #2 onto the **J 33049** expander assembly. See **Special Tools**.
9. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
10. Align the lubrication hole of the camshaft inner bearing #2 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #2 of the engine block.
11. Push the **J 33049** guide cone into the camshaft front bearing bore #1 in order to align the **J 33049** . See **Special Tools**.
12. Drive the camshaft inner bearing #2 into the camshaft inner bearing bore #2.
13. Loosen the **J 33049** expander assembly nut. See **Special Tools**.

4. Carefully remove the **J 33049** from the engine block. See **Special Tools**.

BALANCE SHAFT BEARING AND/OR BUSHING REMOVAL

Tools Required

- **J 26941** Bushing/Bearing Remover. See **Special Tools**.
- **J 38834** Balance Shaft Service Kit. See **Special Tools**.

Removal

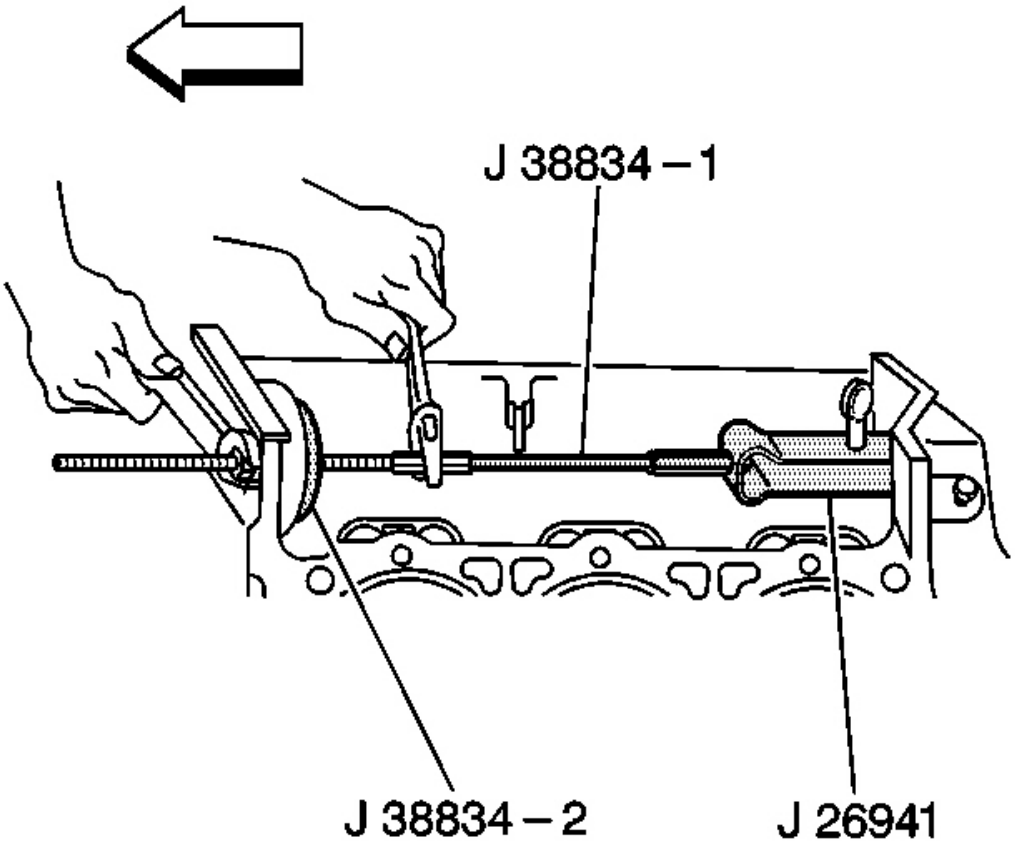


Fig. 528: Removing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Use the **J 38834** and the **J 26941** in order to remove the balance shaft rear bearing. See **Special Tools**.
    1. Install **J 26941** legs behind the balance shaft rear bearing and secure. See **Special Tools**.
    2. Install the J 38834-1 with the short threaded end through the balance shaft bore in the front of the engine block.
    3. Install the J 38834-1 into **J 26941** . See **Special Tools**.

4. Slide the J 38834-2 onto the J 38834-1 and into the balance shaft bore of the engine block.
5. Install the **J 38834** bearing, washer, and nut onto the J 38834-1. See **Special Tools**.
6. Using a wrench secure the J 38834-1 and then rotate the **J 38834** nut clockwise until the balance shaft rear bearing is removed from the engine block. See **Special Tools**.
7. Remove the **J 26941** from the balance shaft rear bearing. See **Special Tools**.

2. Discard the balance shaft rear bearing.

BALANCE SHAFT CLEANING AND INSPECTION

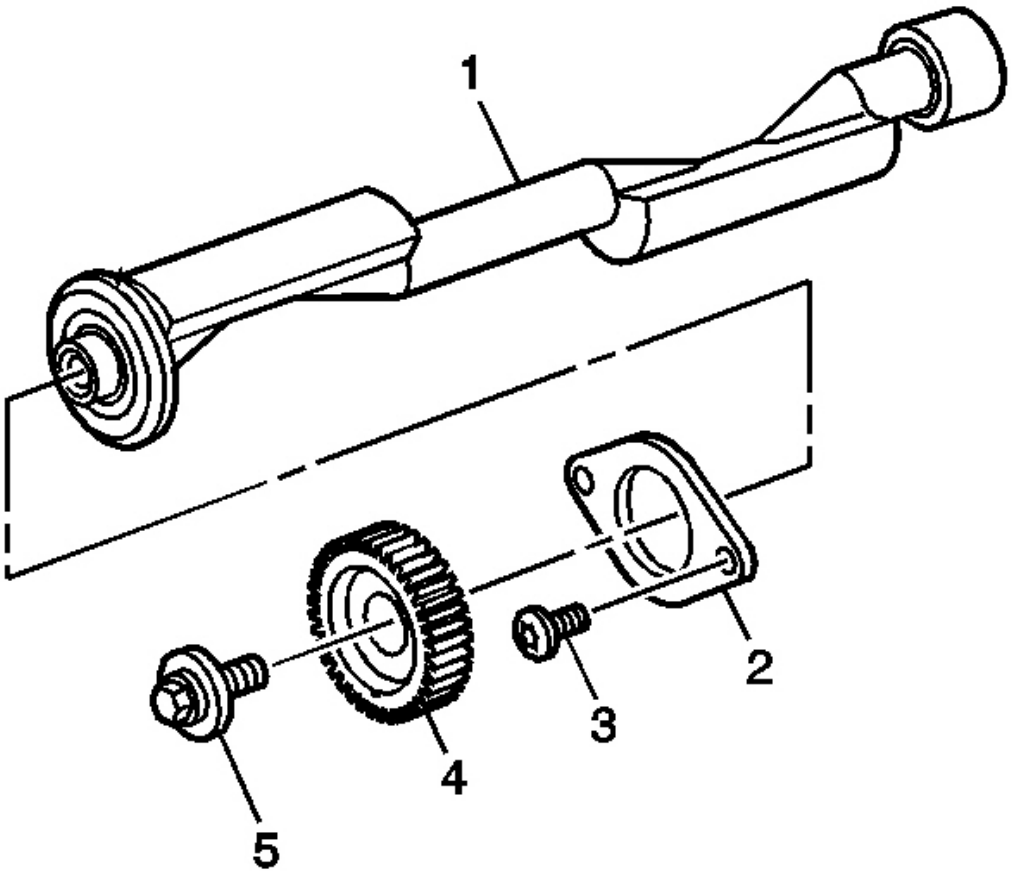


Fig. 529: Balance Shaft Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as an assembly. Do not remove the balance shaft front bearing from the balance shaft.

1. Clean the following components in cleaning solvent:
   - The balance shaft (1)
   - The balance shaft retainer (2)
   - The balance shaft rear bearing
   - The balance shaft driven gear (4)
   - The balance shaft drive gear
2. Dry the following components with compressed air:
   - The balance shaft (1)
   - The balance shaft retainer (2)
   - The balance shaft rear bearing
   - The balance shaft driven gear (4)
   - The balance shaft drive gear
3. Inspect the balance shaft bearings for the following:
   - Front ball bearing for damage or wear
   - Front ball bearing for smoothness of operation
   - Rear sleeve bearing for wear, scoring, or other damage
4. Inspect the balance shaft (1) for the following:
   - Wear or scoring on the rear bearing journal
   - Damaged bolt hole threads
   - Damage to the balance shaft driven gear locator pin
5. Inspect the balance shaft retainer (2) for wear or damage.
6. Inspect the balance shaft retainer bolts (3) for damaged threads.
7. Inspect the driven gear (4) for the following:
   - Excessive wear or damage
   - Nicks, burrs, or scoring
8. Inspect the driven gear bolt (5) for damaged threads.

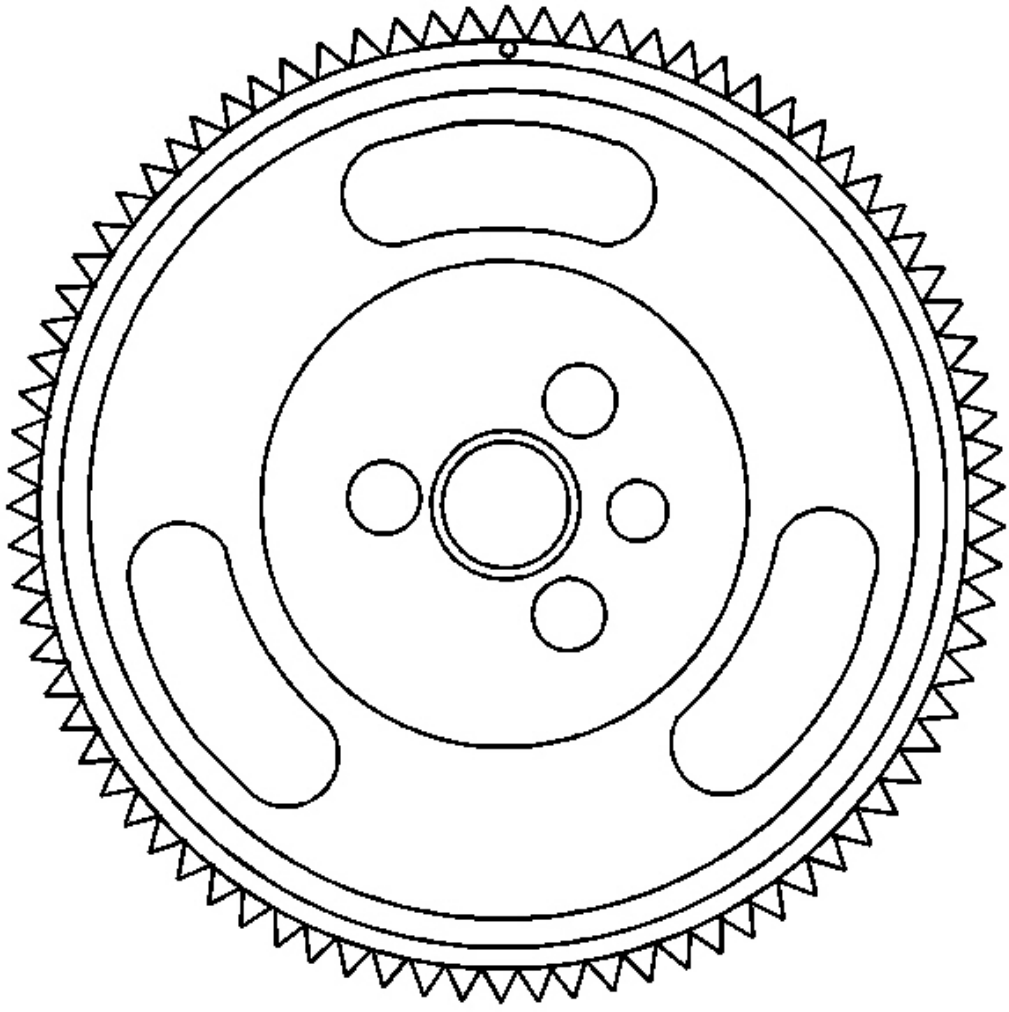


Fig. 530: Balance Shaft Drive Gear Camshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

9. Inspect the balance shaft drive gear for the following:
    - Excessive wear or damage
    - Nicks, burrs, or scoring

BALANCE SHAFT BEARING AND/OR BUSHING INSTALLATION

Tools Required

J 38834 Balance Shaft Service Kit. See **Special Tools**.

Installation

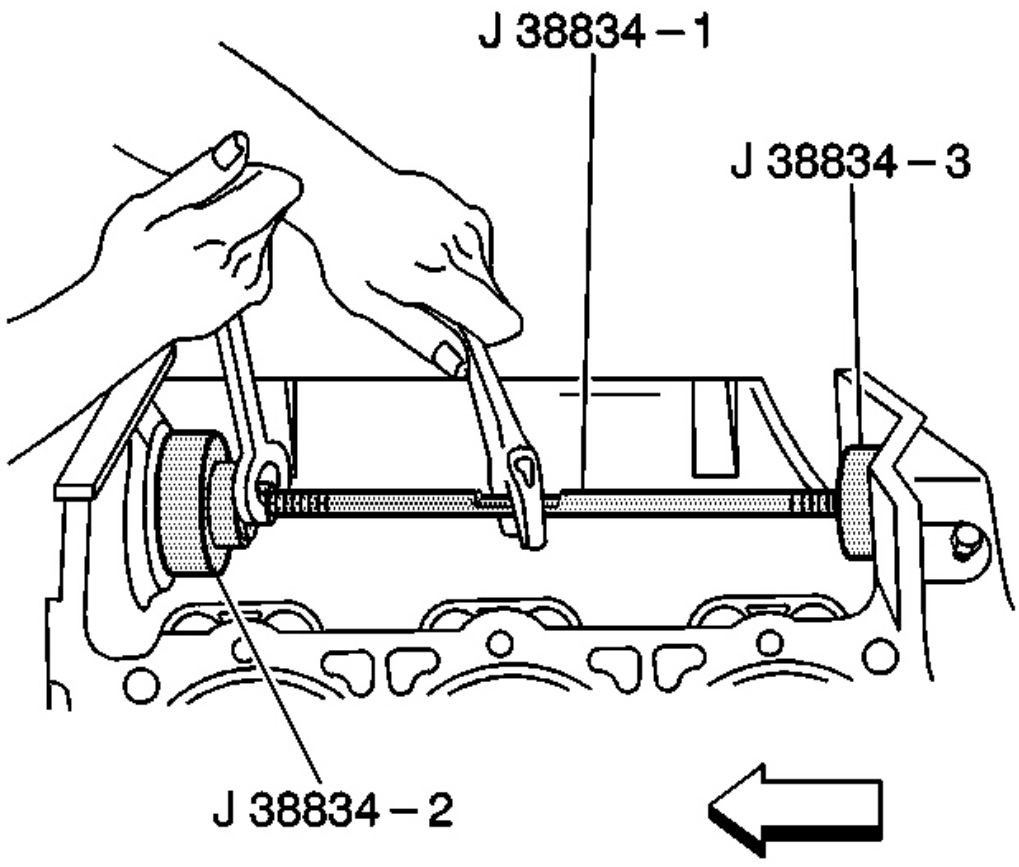


Fig. 531: Installing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Use the **J 38834** in order to install the balance shaft rear bearing. See **Special Tools**.
    1. Install the J 38834-3 onto the short threaded end of the J 38834-1.
    2. Install the **J 38834** nut, the washer, and the bearing on the long threaded end of the J 38834-1. See **Special Tools**.

3. Install the J 38834-2 onto the J 38834-1 so that the smaller diameter of the J 38834-2 will be facing the front of the engine block.
4. Install the J 38834-2 on the inside of the balance shaft front bearing bore.
5. Lubricate the NEW balance shaft rear bearing with clean engine oil.
6. Install the balance shaft rear bearing onto the J 38834-2.
7. Align the balance shaft rear bearing for installation.
8. Using a wrench secure the J 38834-1 into place.
9. Rotate the **J 38834** nut until the balance shaft rear bearing is properly and completely pushed into the balance shaft rear bearing bore. See **Special Tools**.

2. Remove the **J 38834** . See **Special Tools**.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

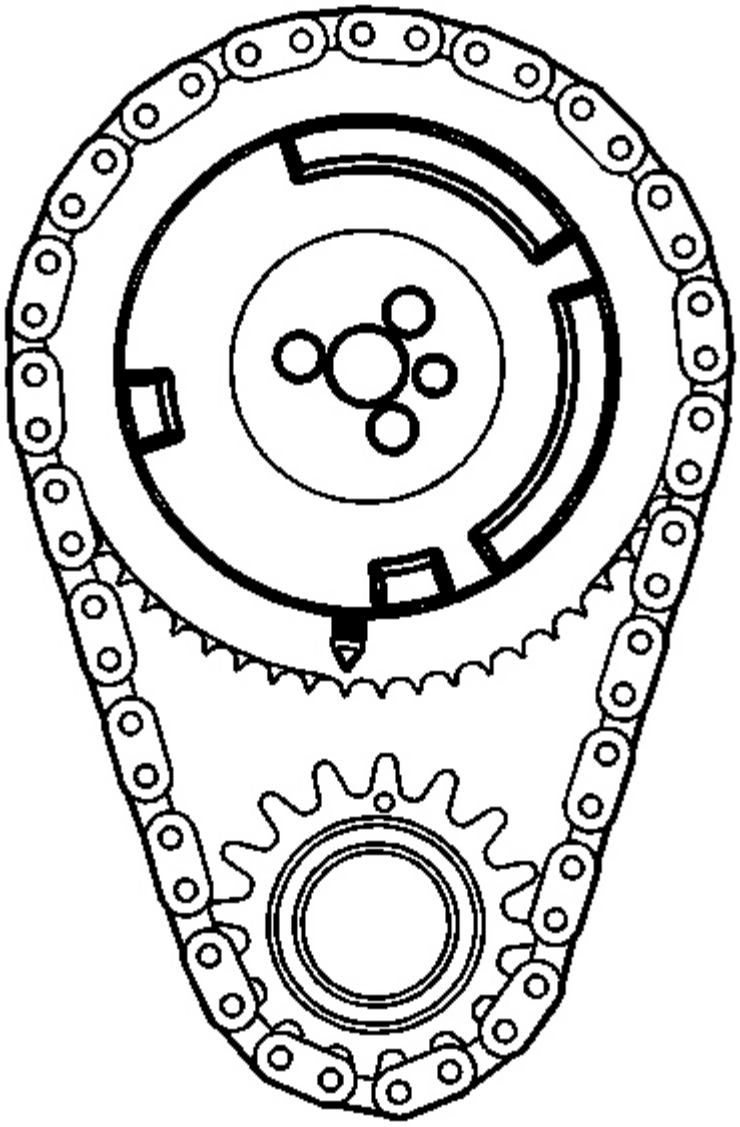


Fig. 532: View Of Sprockets & Chain
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the components with cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.

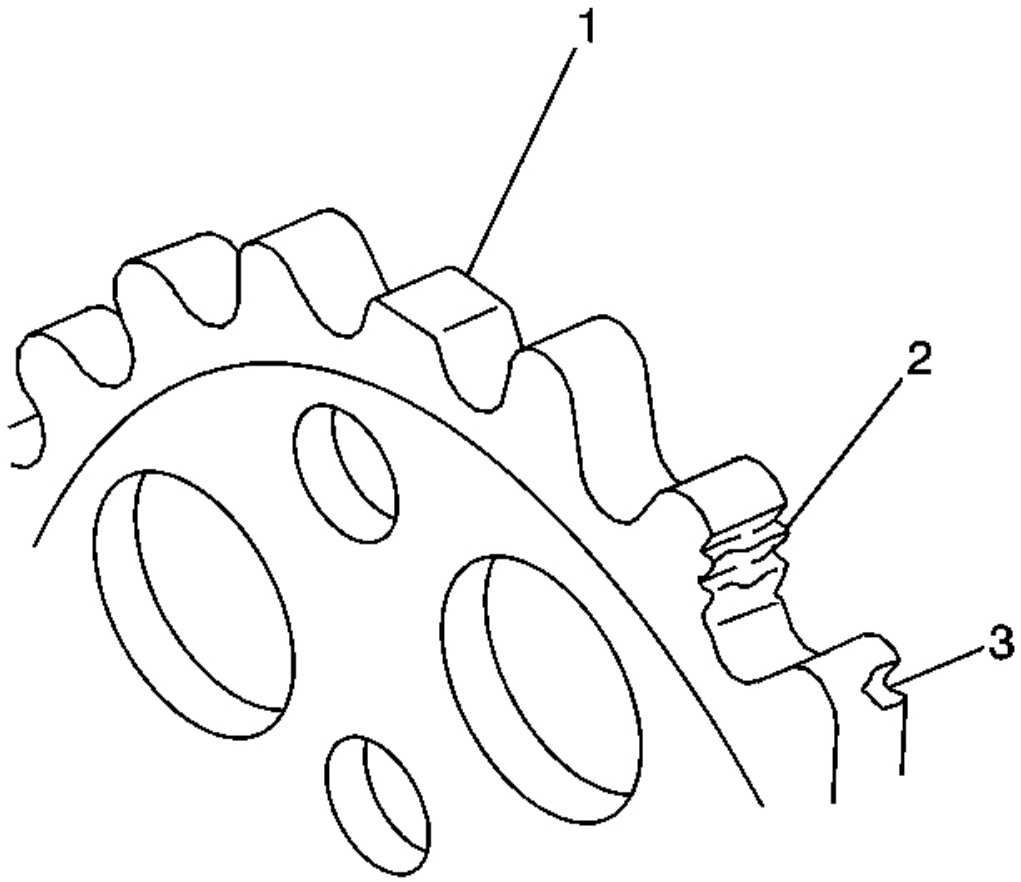


Fig. 533: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft sprocket and the crankshaft sprocket for:
   - Broken teeth (1)
   - Damaged teeth (2)
   - Chipped teeth (3)
   - Worn teeth

- Uneven wear on the edge of the teeth
- Worn valleys between the sprocket teeth
- Crankshaft sprocket keyway for wear

5. Inspect the timing chain tensioner bracket and shoe for cracking and wear.

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

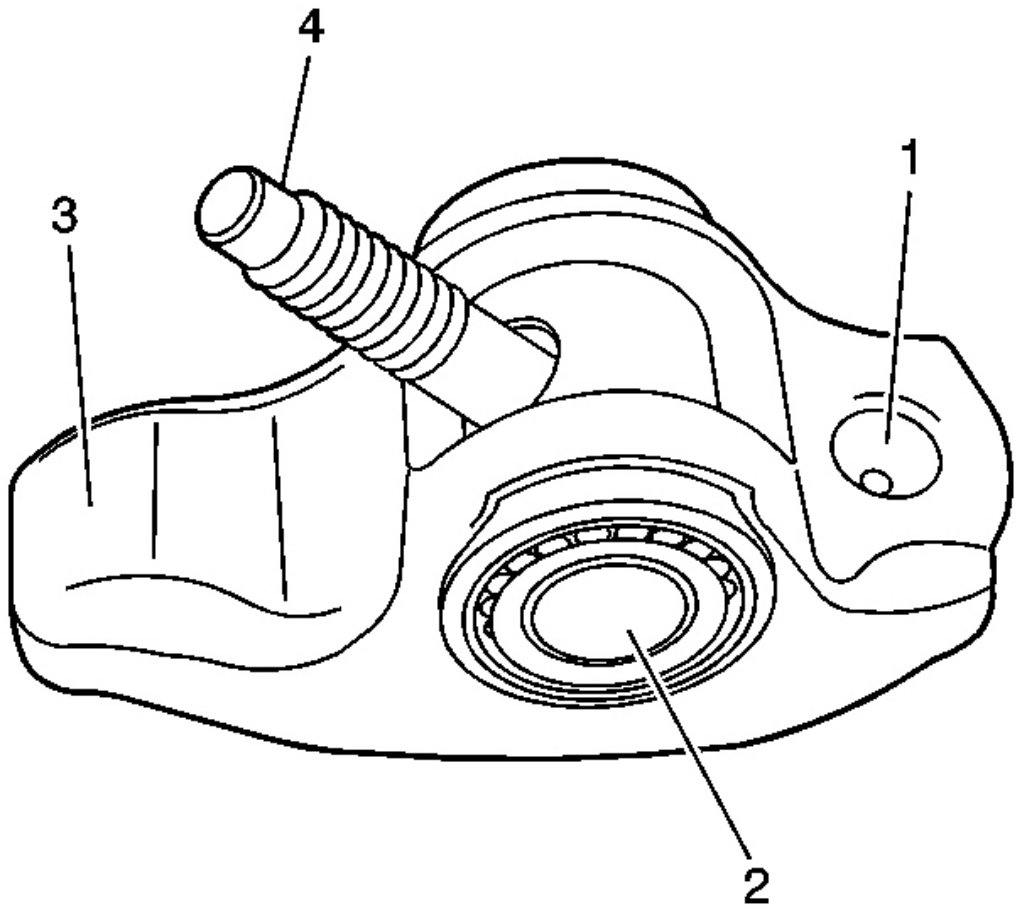


Fig. 534: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Parts that are to be reused must be marked, sorted, and organized for assembly.

1. Mark, sort, and organize the components for assembly.

CAUTION: Refer to SAFETY GLASSES CAUTION .

2. Clean the components with cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve rocker arm components for the following:
   - Valve rocker arm valve pushrod socket contact surface (1)

     The contact surface must be smooth with no scoring or excessive wear.

   - Valve rocker arm roller pivot for binding or damage (2)
   - Valve rocker arm valve stem contact surface (3)

     The contact surface should be smooth with no scoring or excessive wear.

   - Valve rocker arm bolt threads for damage (4)

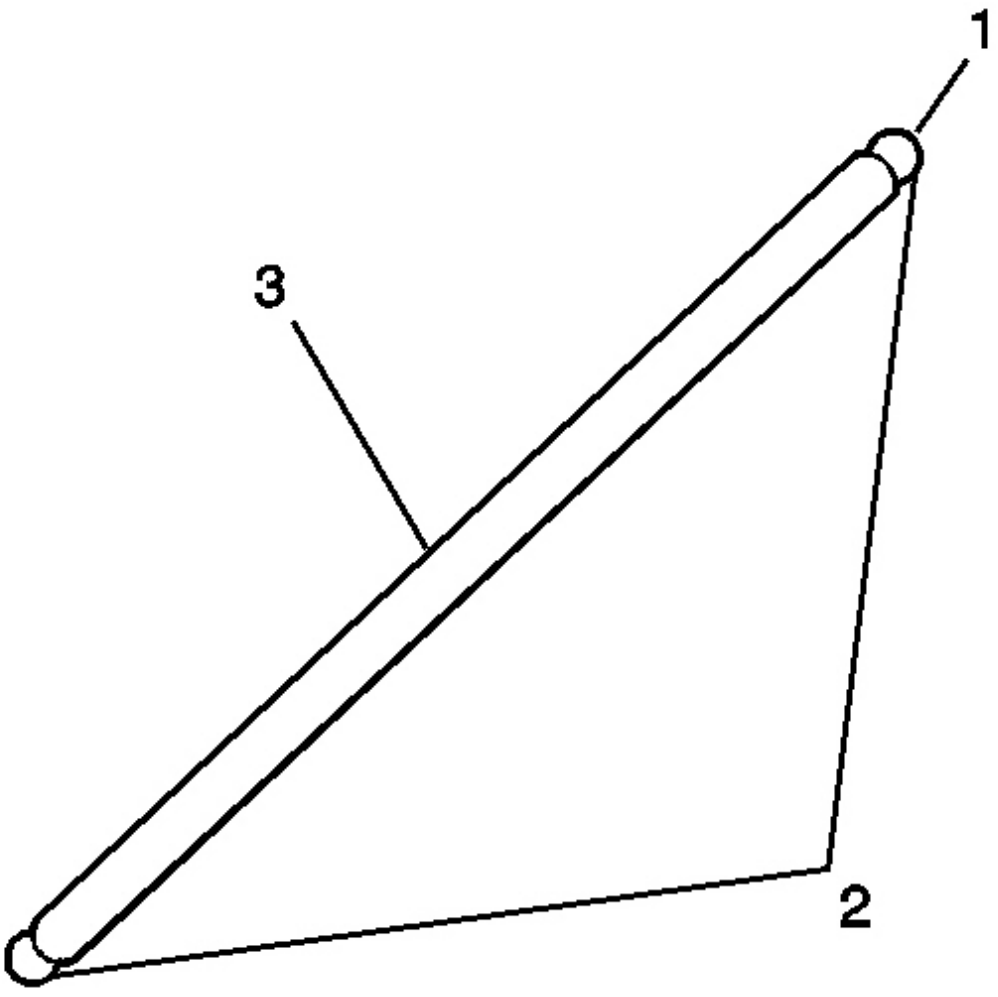


Fig. 535: Pushrod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the valve pushrods for the following:
   - Restriction of the oil passage (1)
   - Wear or scoring of the end contact surfaces (2)

   The end contact surfaces must be smooth with no scoring or excessive wear.

- Shaft for bends (3)

  Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.

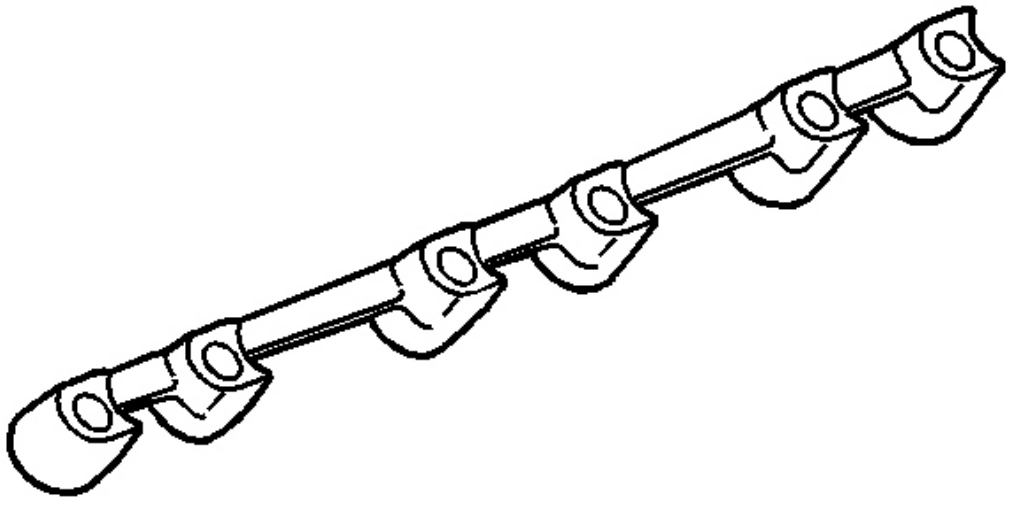


Fig. 536: Valve Rocker Support
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve rocker support for excessive wear or damage.

VALVE LIFTERS AND GUIDES CLEANING AND INSPECTION

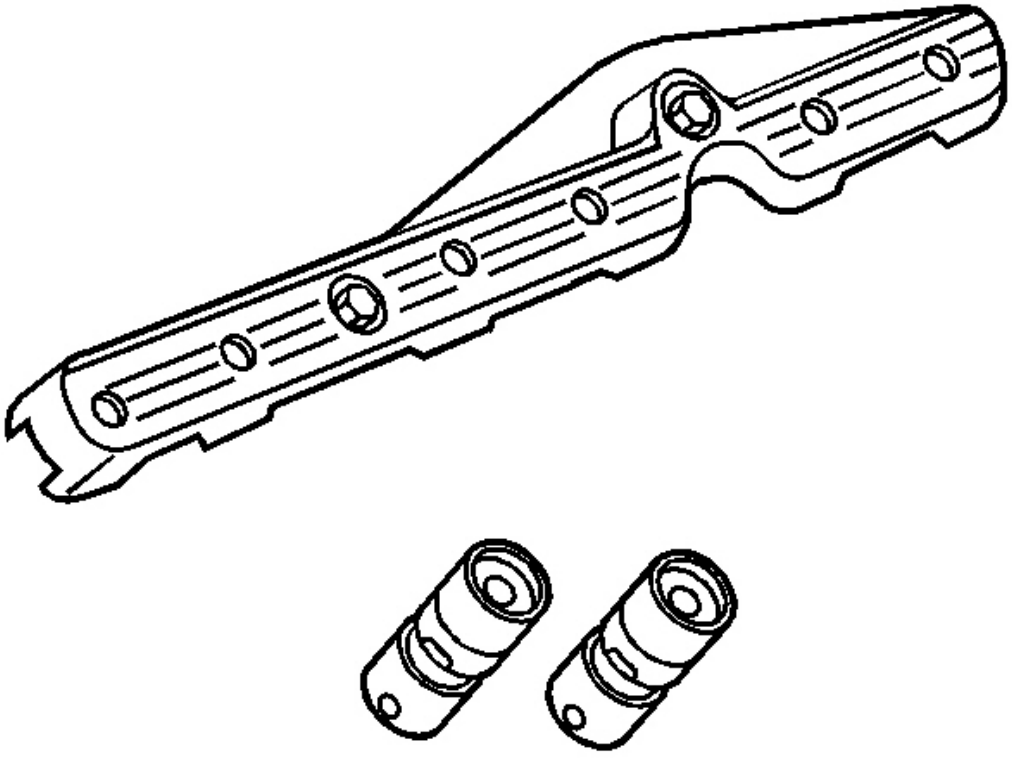


Fig. 537: Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Mark, sort, and organize the components for assembly.

CAUTION: Refer to SAFETY GLASSES CAUTION

2. Clean the components in cleaning solvent.
3. Dry the components with compressed air.

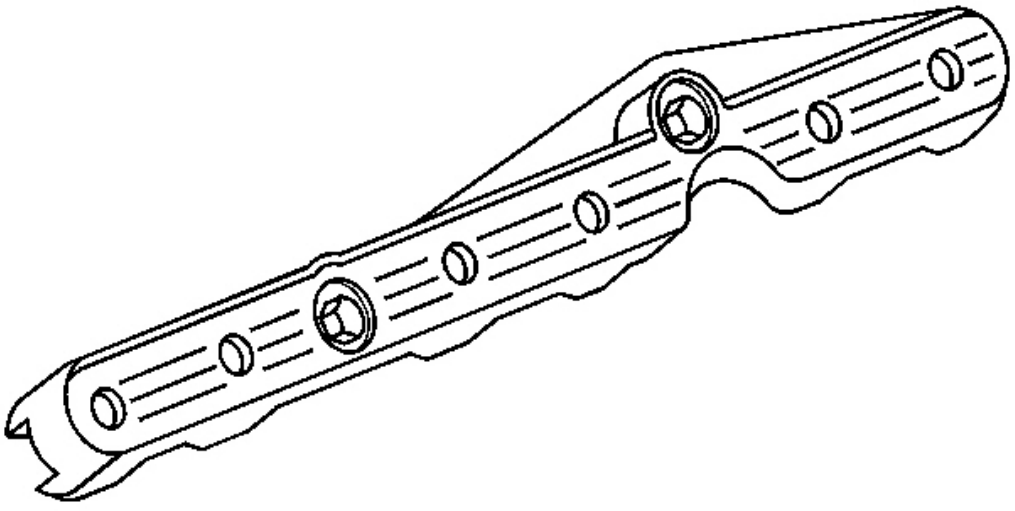


Fig. 538: Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter pushrod guides for excessive wear.
5. Inspect the valve lifter pushrod guides for cracks or damage.

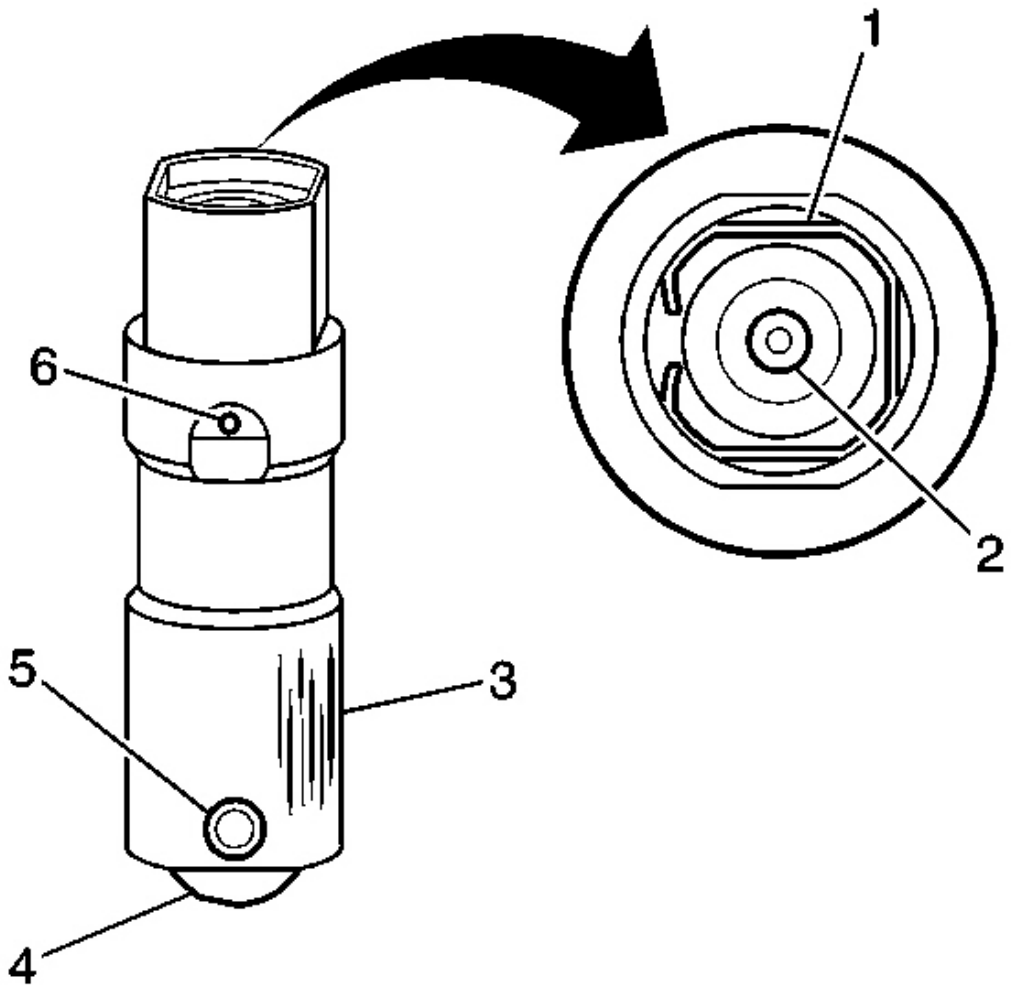


Fig. 539: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve lifter for the following:
   - Broken or damaged clip (1)
   - Worn pushrod socket (2)
   - Scuffed or worn lifter body (3)

   If the valve lifter shows scuffing or wear, inspect the engine block valve lifter bores for wear.

- Worn roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)

CYLINDER HEAD DISASSEMBLE

Tools Required

J 8062 Valve Spring Compressor. See **Special Tools**.

Disassemble

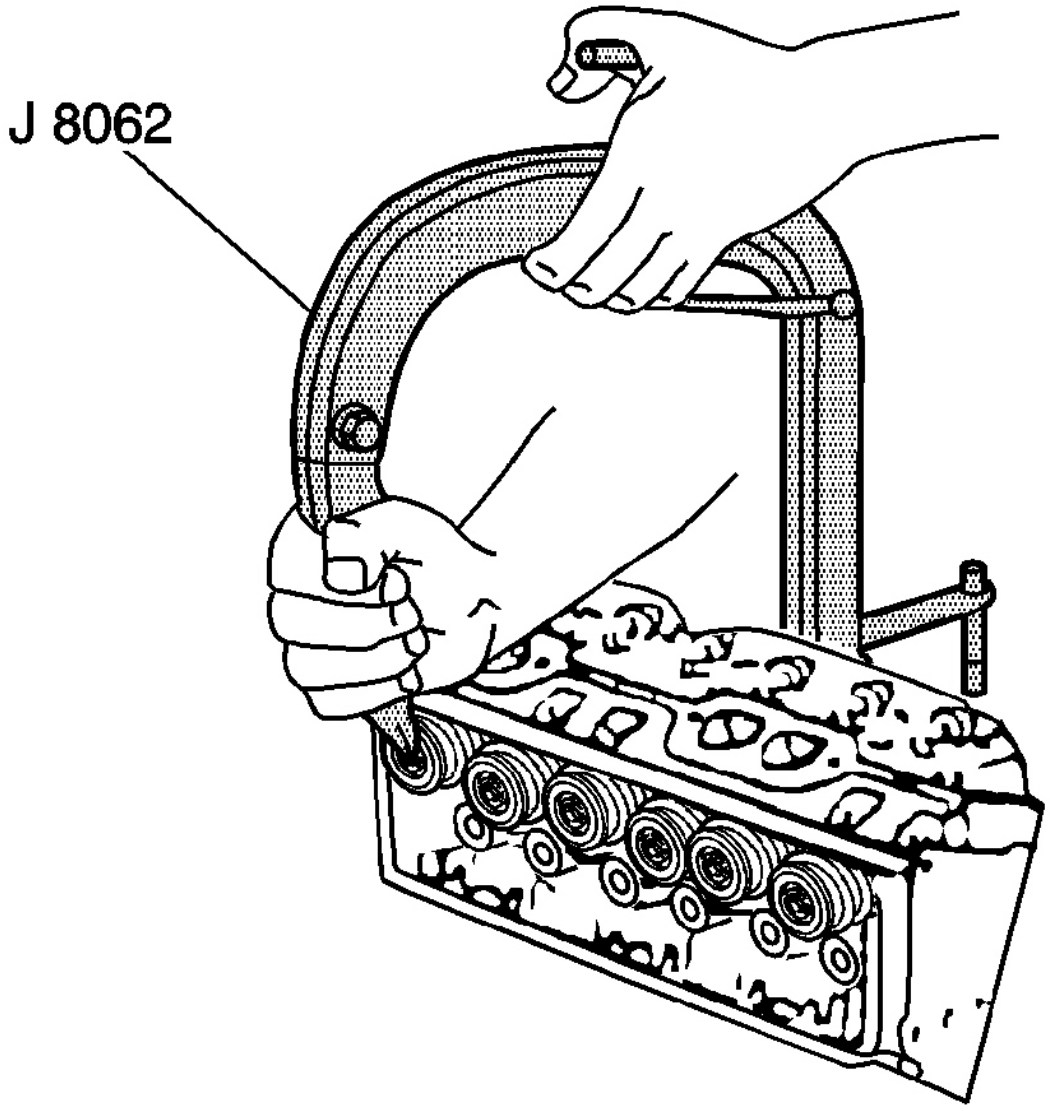


Fig. 540: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve

spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Use the **J 8062** in order to compress the valve springs. See **Special Tools**.

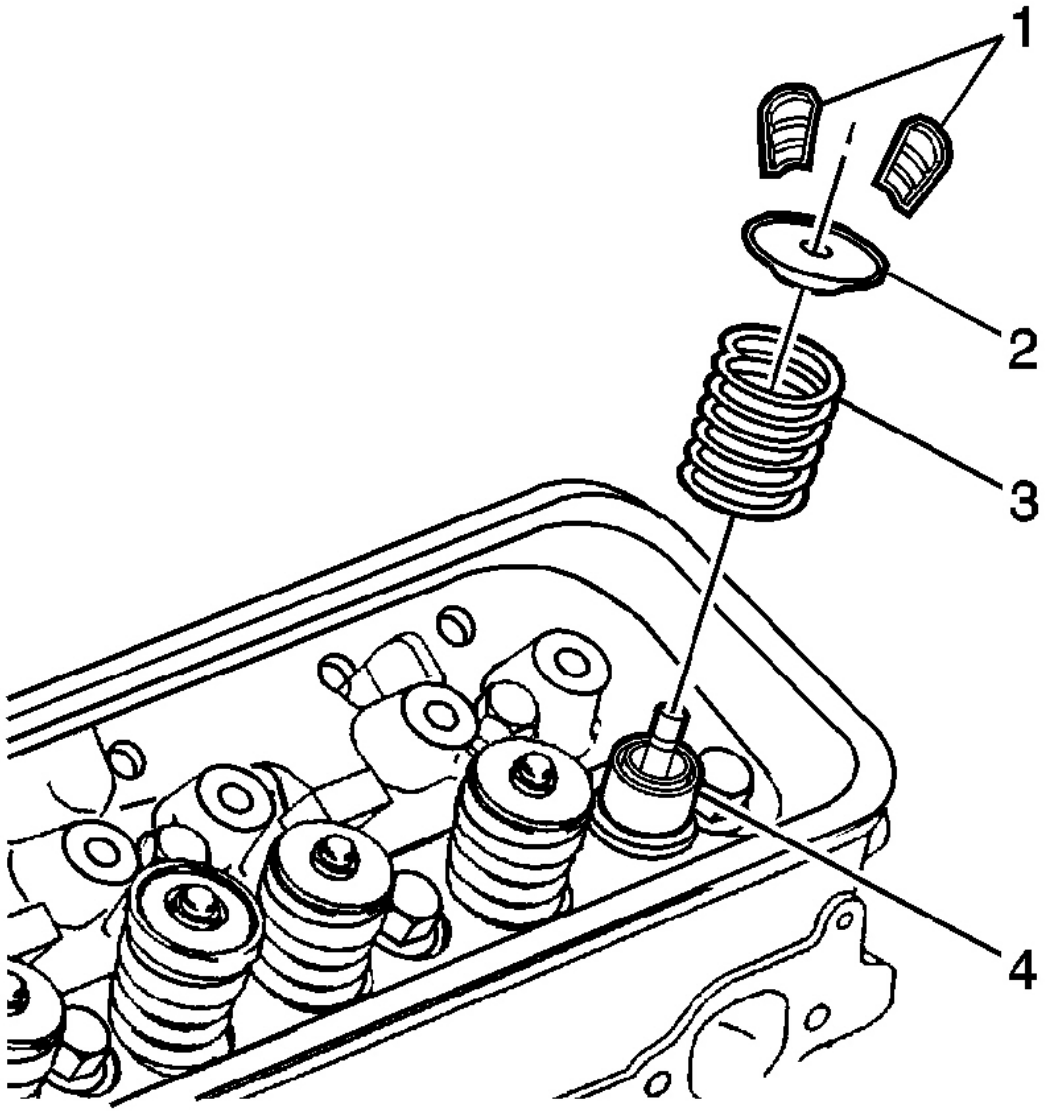


Fig. 541: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, and organize the components so that the components can be reinstalled in their original location and position.

2. Remove the valve stem keys (1).
3. Remove the **J 8062** from the cylinder head. See **Special Tools**.
4. Remove the valve spring cap (2).
5. Remove the valve spring (3).
6. Remove the valve stem oil seal (4).
7. Discard the valve stem oil seal.
8. Remove the valve.

CYLINDER HEAD CLEANING AND INSPECTION

Tools Required

- **J 8001** Dial Indicator Set
- **J 8089** Carbon Removing Brush
- **J 9666** Valve Spring Tester. See **Special Tools**.

Cleaning and Inspection

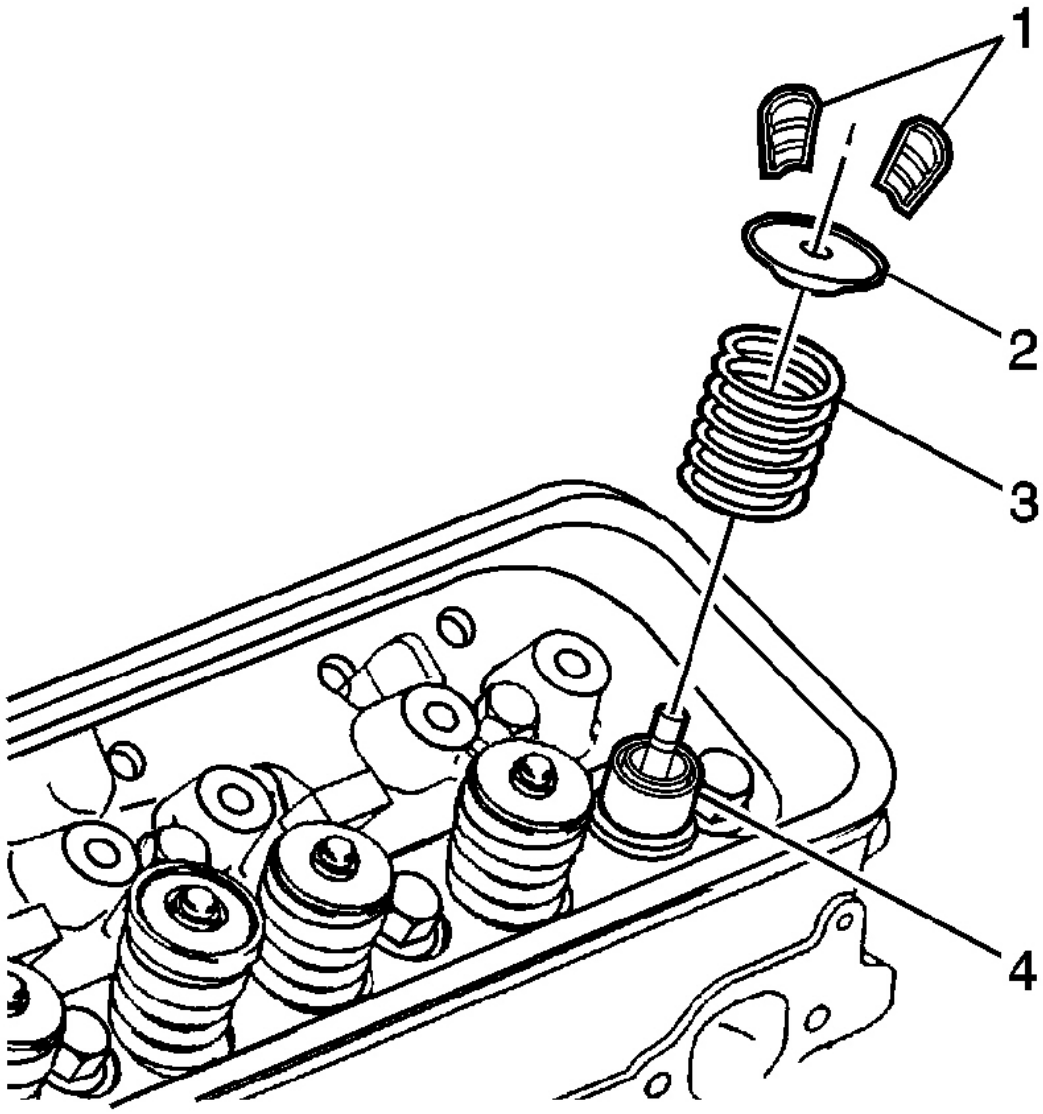


Fig. 542: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:

- Valve stem keys (1)
- Valve spring cap (2)
- Valve spring (3)
- Cylinder head

3. Dry the components with compressed air.

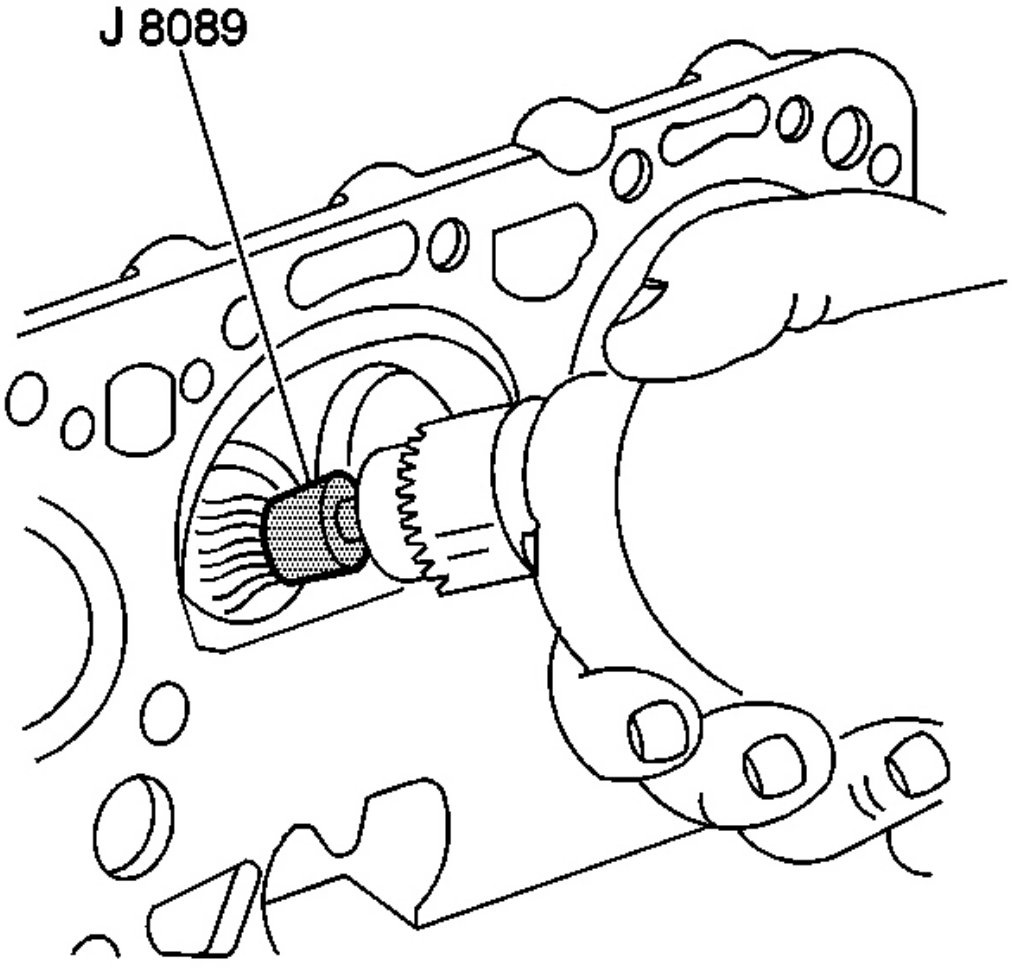


Fig. 543: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 8089** to clean the carbon from the cylinder head combustion chambers.

Be careful not to scuff the combustion chambers.

5. Inspect the cylinder head for the following:
   - Damage to the gasket surfaces
   - Damage to the threaded bolt holes
   - Burnt or eroded areas in the combustion chamber
   - Cracks in the exhaust ports and combustion chambers
   - External cracks in the water chamber
   - Restrictions in the intake or exhaust passages
   - Restrictions in the cooling system passages
   - Rusted, damaged, or leaking core plugs

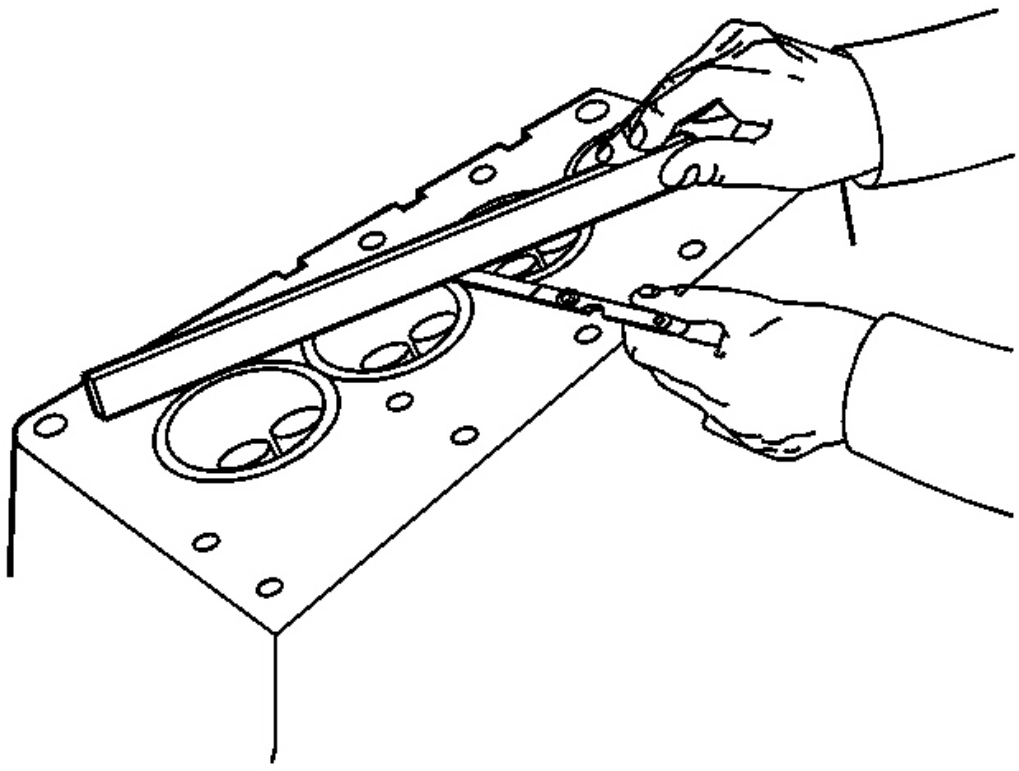


Fig. 544: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Measure the cylinder head for warpage with a straight edge and feeler gage.
   - A cylinder head block deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head exhaust manifold deck with warpage in excess of 0.05 mm (0.002 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head intake manifold deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.

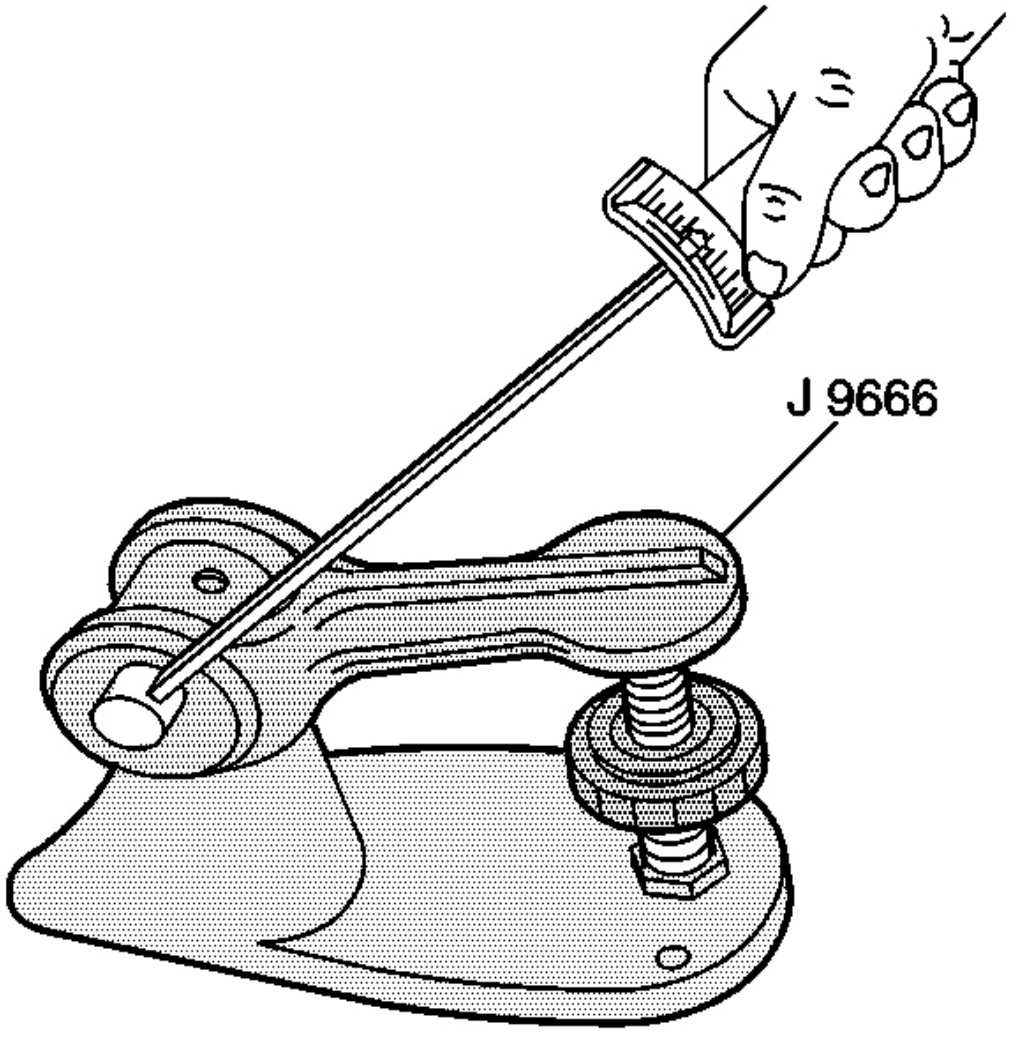


Fig. 545: Measuring Valve Spring Tension

Courtesy of GENERAL MOTORS CORP.

7. Use the **J 9666** in order to measure the valve spring. See **Special Tools**.

   Replace the valve spring if the valve spring tension is less than 338 N (76 lb) at 43.2 mm (1.70 in).

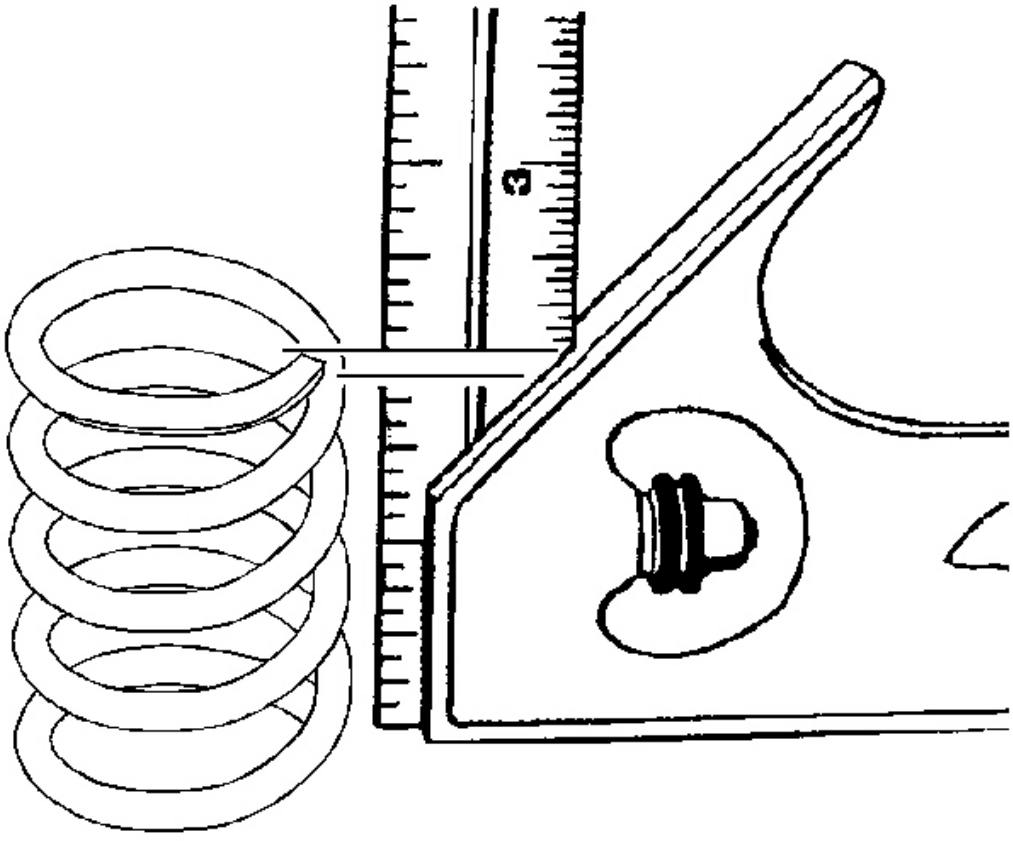


Fig. 546: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

8. Inspect the valve springs for squareness.

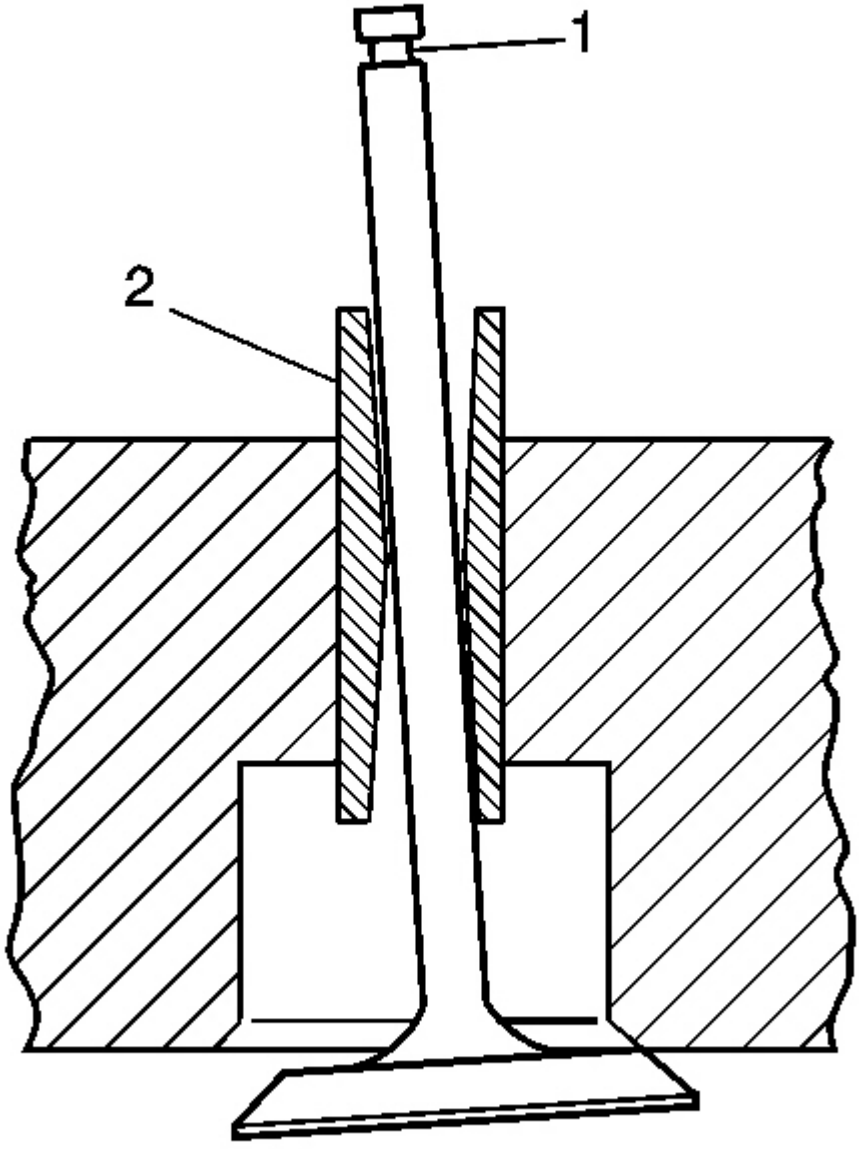


Fig. 547: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

9. Valve stems (1) with excessive valve guide (2) clearance must be repaired or the cylinder head replaced.

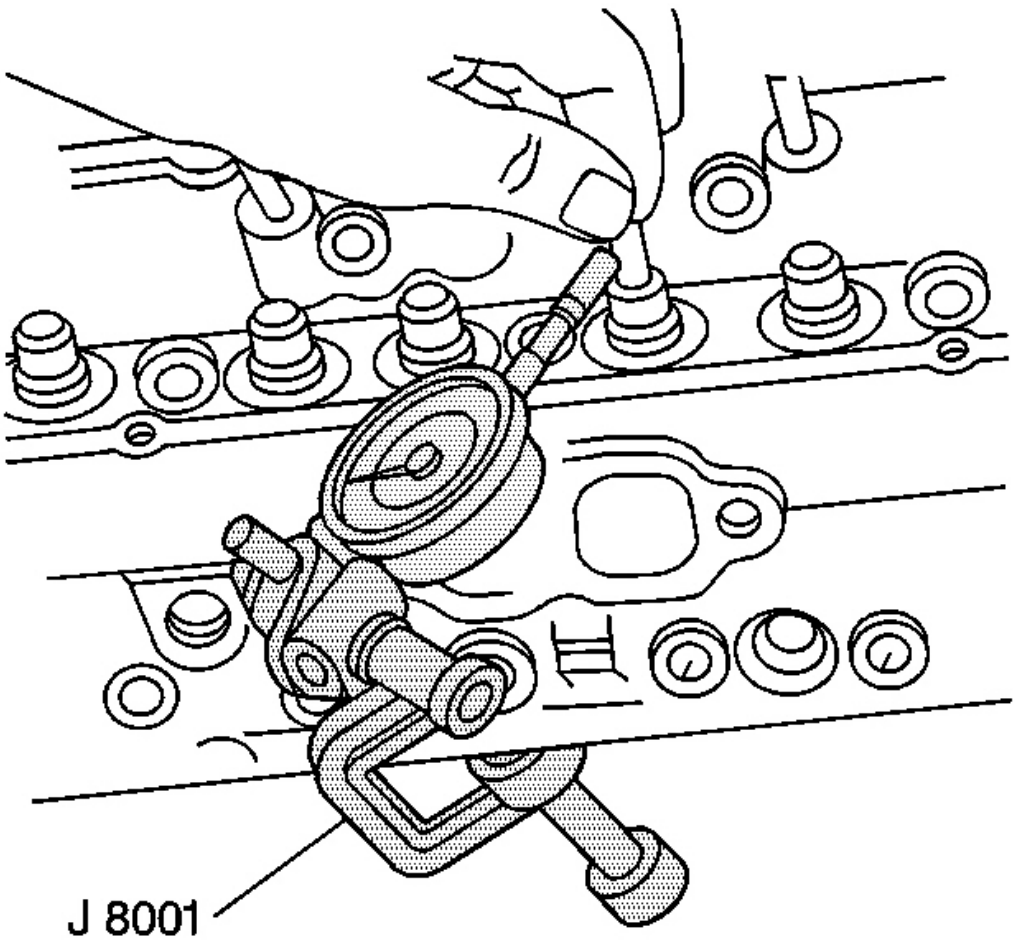


Fig. 548: Measuring Valve Stem-To-Guide Clearance Using J 8001
Courtesy of GENERAL MOTORS CORP.

10. Measure the valve stem-to-guide clearance.

    Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

    1. Clamp the **J 8001** on the exhaust port side of the cylinder head.
    2. Position the dial indicator so that the movement of the valve stem from side to side, crosswise to the cylinder head, will cause a direct movement of the dial indicator stem.

The dial indicator stem must contract the side of the valve stem just above the valve guide.

3. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.
4. Use light pressure and move the valve stem from side to side in order to obtain a valve stem-to-guide clearance reading. Refer to **Engine Mechanical Specifications** .

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Tools Required

J 5830-02 Valve Guide Reamer Set. See **Special Tools**.

Servicing

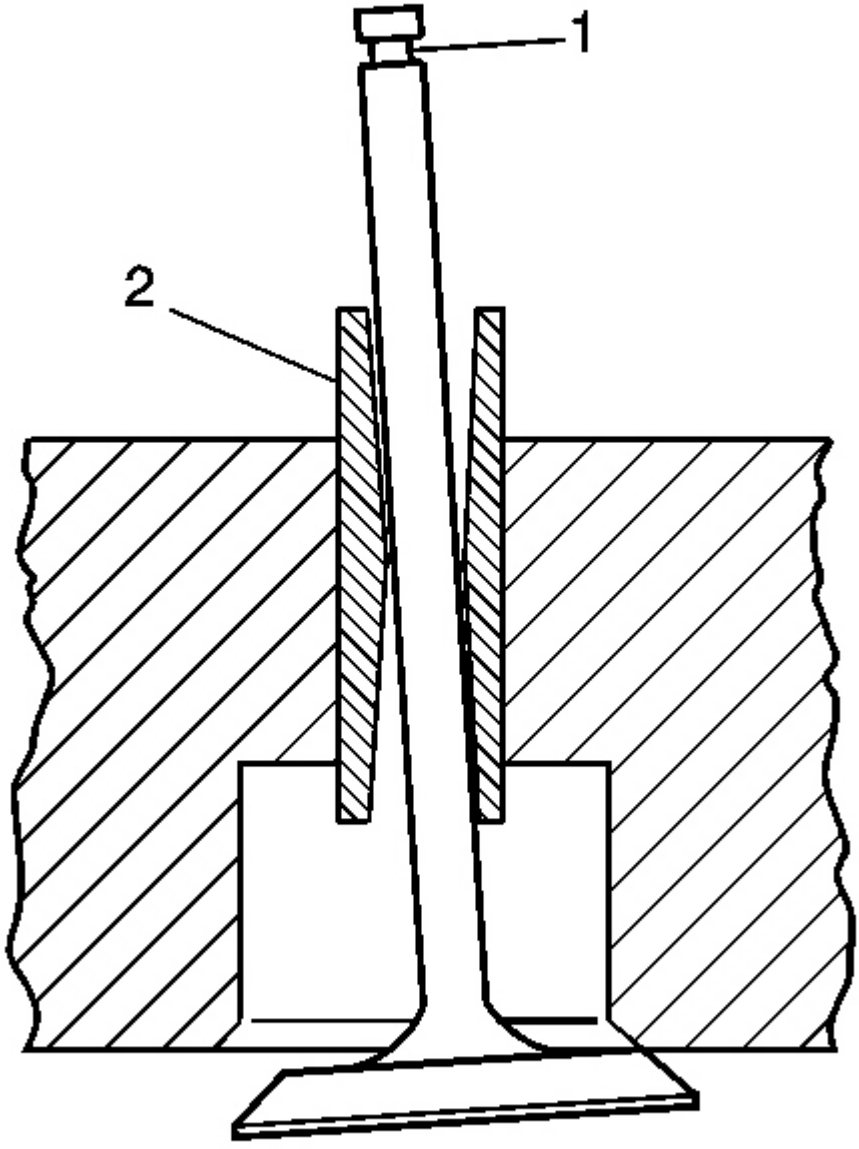


Fig. 549: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem-to-guide clearance. Refer to **Cylinder Head Cleaning and Inspection**.
2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.

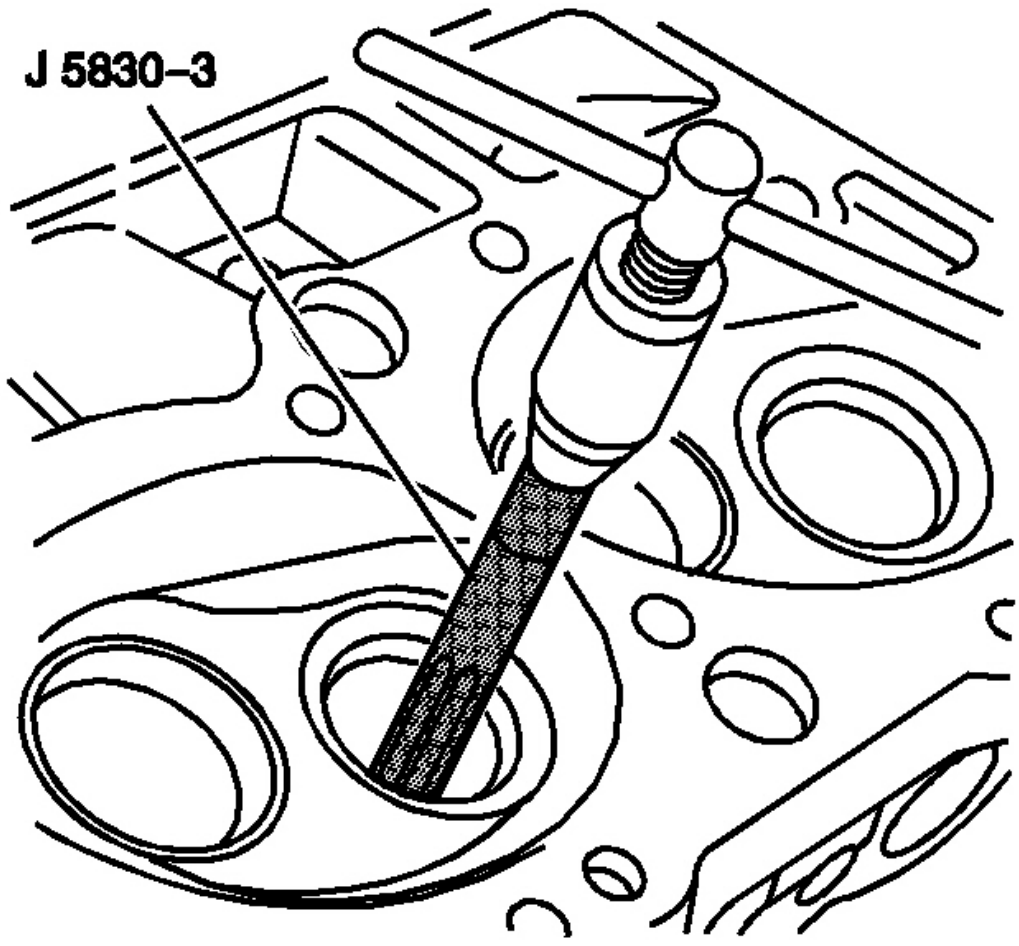


Fig. 550: Reaming Exhaust Valve Guide Using J 5830-3
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: Exhaust valves with excessive valve stem-to-guide clearance must be replaced with the available service valve that has an 0.774 mm (0.0305 in) oversize valve stem. The intake valves are NOT available with oversize valve stems. Replace the cylinder head if after using a NEW intake valve in order to

measure the valve stem-to-guide clearance, the valve stem-to-guide clearance is not within specifications.

3. Use the J 5830-3 in order to ream the exhaust valve guide in order to achieve the correct valve stem-to-guide clearance.
4. Always recondition the exhaust valve seat after reaming the exhaust valve guide bores and installing new exhaust valves.

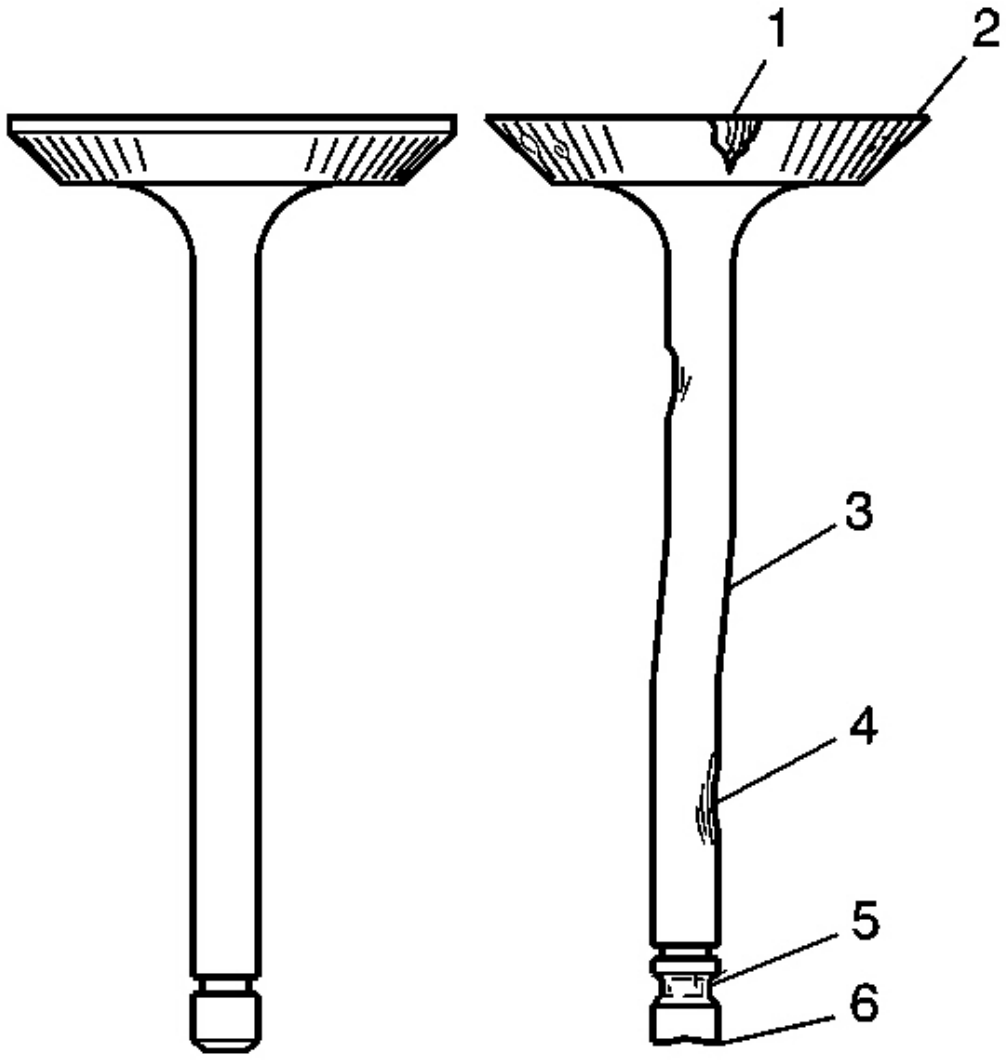


Fig. 551: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

5. Inspect the valves for the following:
    - Burnt or damaged areas (1)
    - Undersized margin (2)
    - Bent stem (3)
    - Scoring or other damage to the stem (4)
    - Worn key groove (5)
    - Worn stem tip (6)

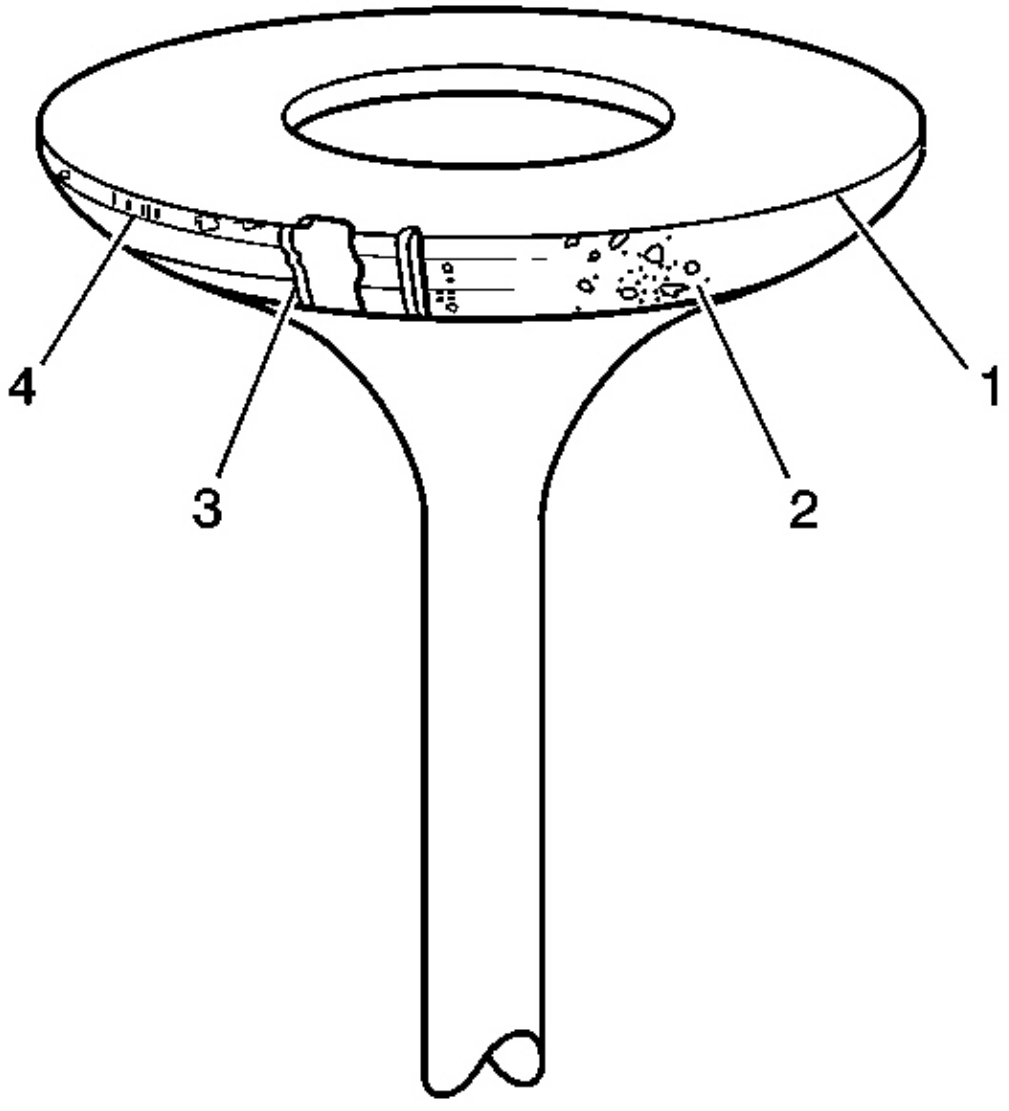


Fig. 552: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve contact surface for the following:
   - Undersized margin (1)
   - Pitted surface (2)
   - Burnt or eroded areas (3)

- Acceptable edge margin (4)

  Valves with excessive damage must be replaced.

  Minor imperfections of the valve or valve seat may be repaired.

7. Reconditioning of the valves and valve seats:
   - The valves must seat perfectly for the engine to deliver optimum power and performance.
   - Cooling the valve heads is another important factor. Good contact between each valve and valve seat in the cylinder head is necessary to insure that the heat in the valve head is properly carried away.
   - Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt in order to ensure the proper centering of the pilot in the valve guide.

     The valve seats should be concentric to within 0.05 mm (0.002 in) total indicator reading.

   - Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the valve head and the valve stem.

     Replace the valve if the valve stem is excessively worn or warped.

     Replace the valve if the edge margin (4) of the valve head is less than 0.79 mm (0.031 in) thick after grinding.

   - Several different types of equipment are available for reconditioning valves and valve seats. Follow the equipment manufacturer's recommendations for equipment use to attain the proper results.

CYLINDER HEAD ASSEMBLE

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 42073** Valve Stem Seal Installer. See **Special Tools**.

Assemble

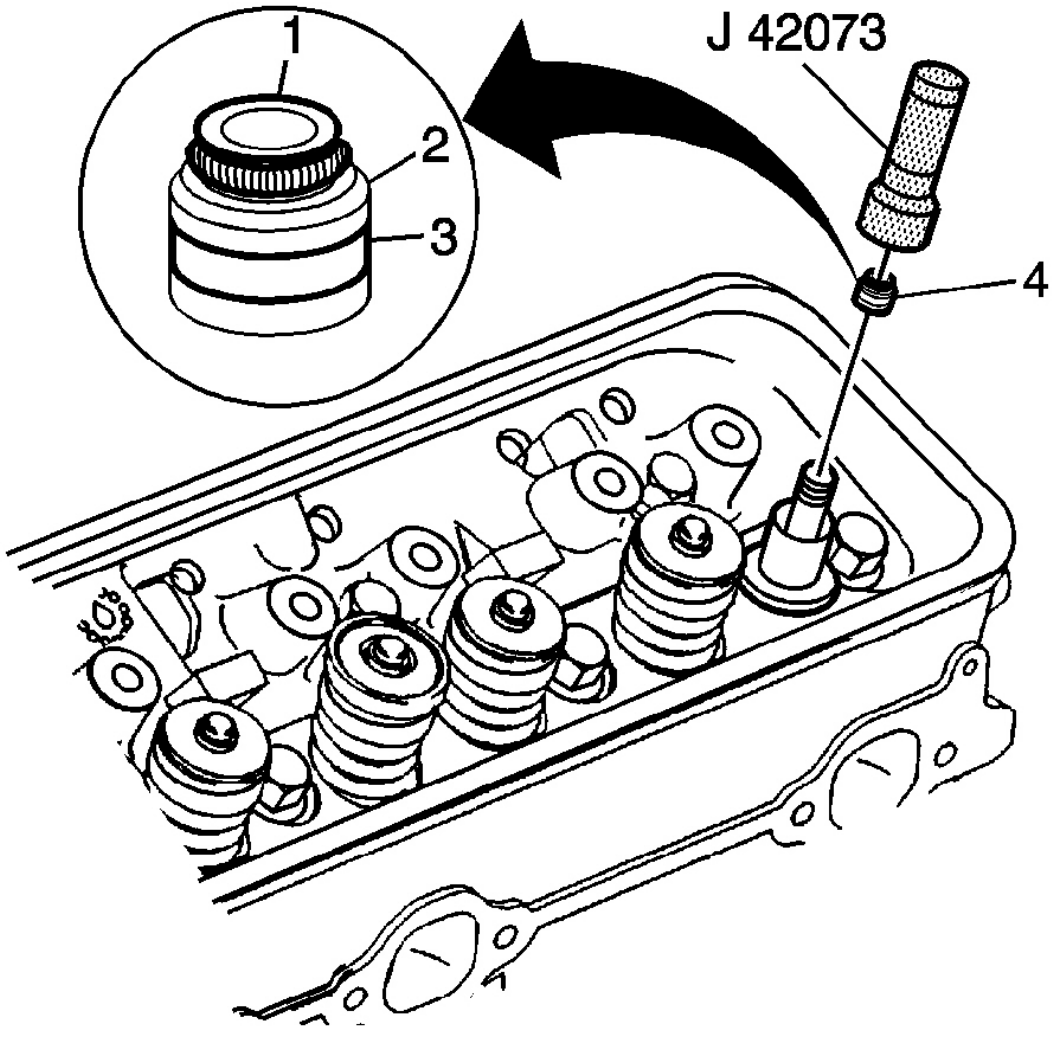


Fig. 553: Exhaust Valve Oil Stem Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal, or the material may be red in color (2) with no paint stripe. The intake valve oil seal is black in color.

1. Assemble the valve into the proper valve guide.

2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.
4. Assemble the valve stem oil seal onto the valve stem.

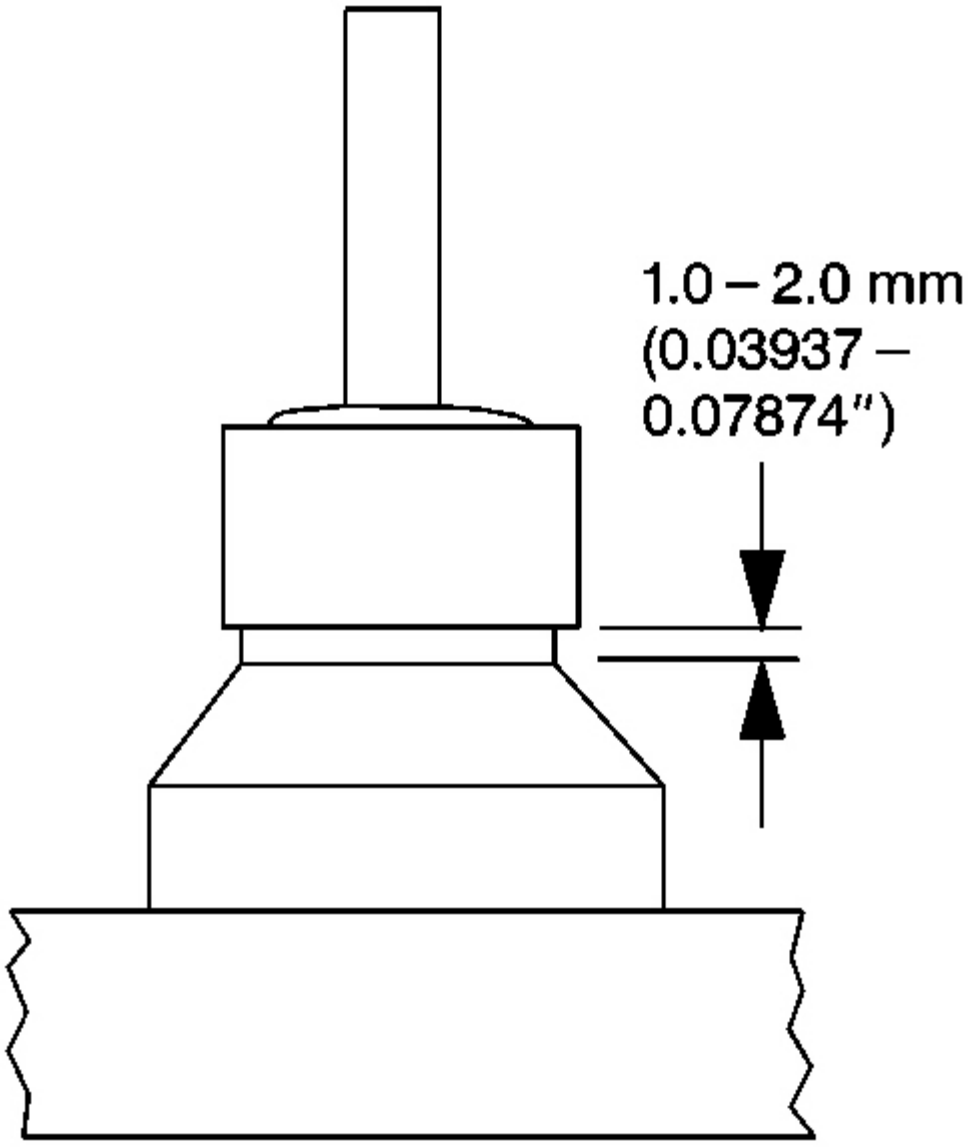


Fig. 554: Valve Stem Oil Seal Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

5. Using the **J 42073** , install the valve stem oil seal onto the valve guide. See **Special Tools**.
    1. Tap the valve stem oil seal onto the valve guide until the **J 42073** bottoms against the valve spring seat. See **Special Tools**.
    2. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

       There should be a 1-2 mm (0.03937-0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

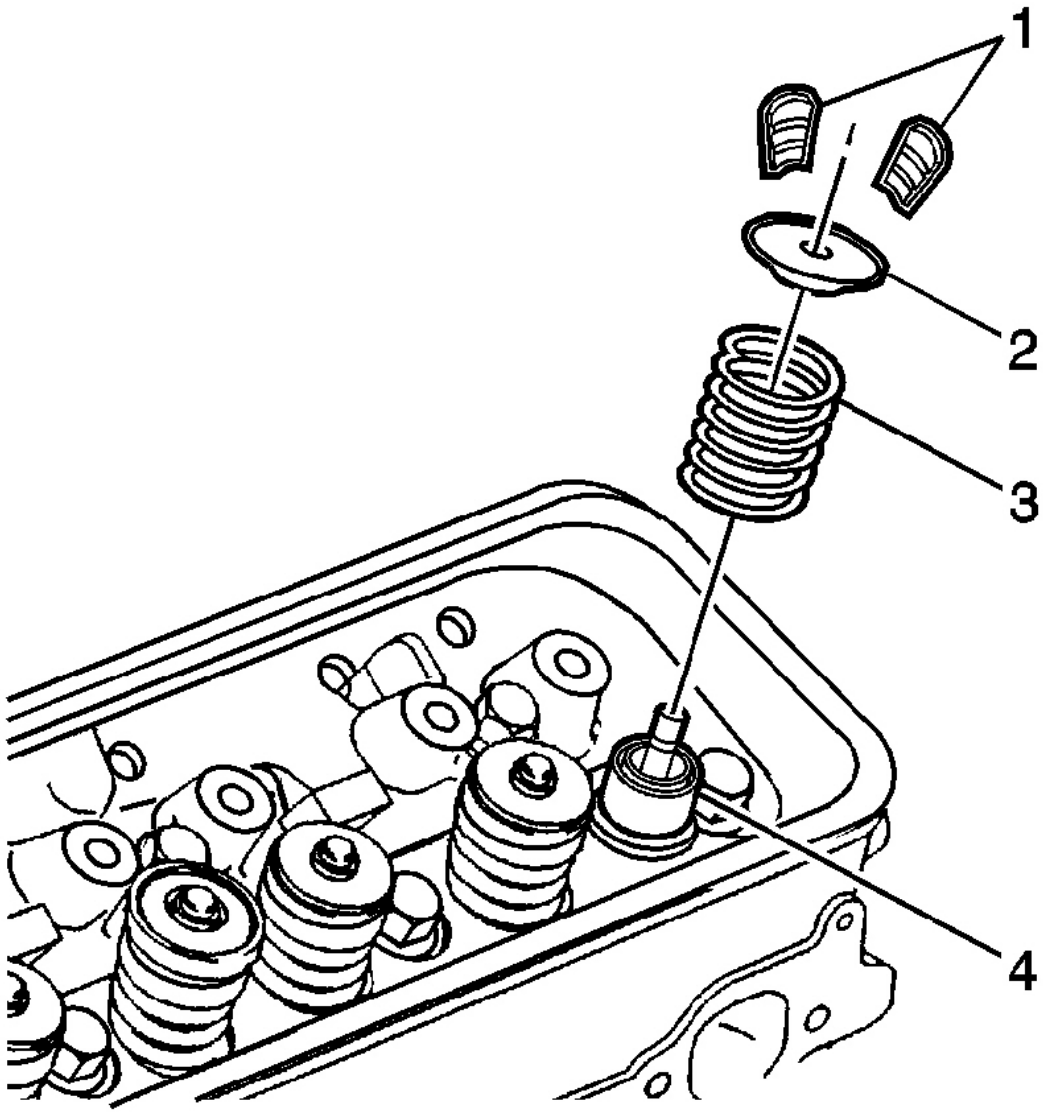


Fig. 555: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

6. Install the valve spring (3).
7. Install the valve spring cap (2) onto the valve spring (3), over the valve stem.

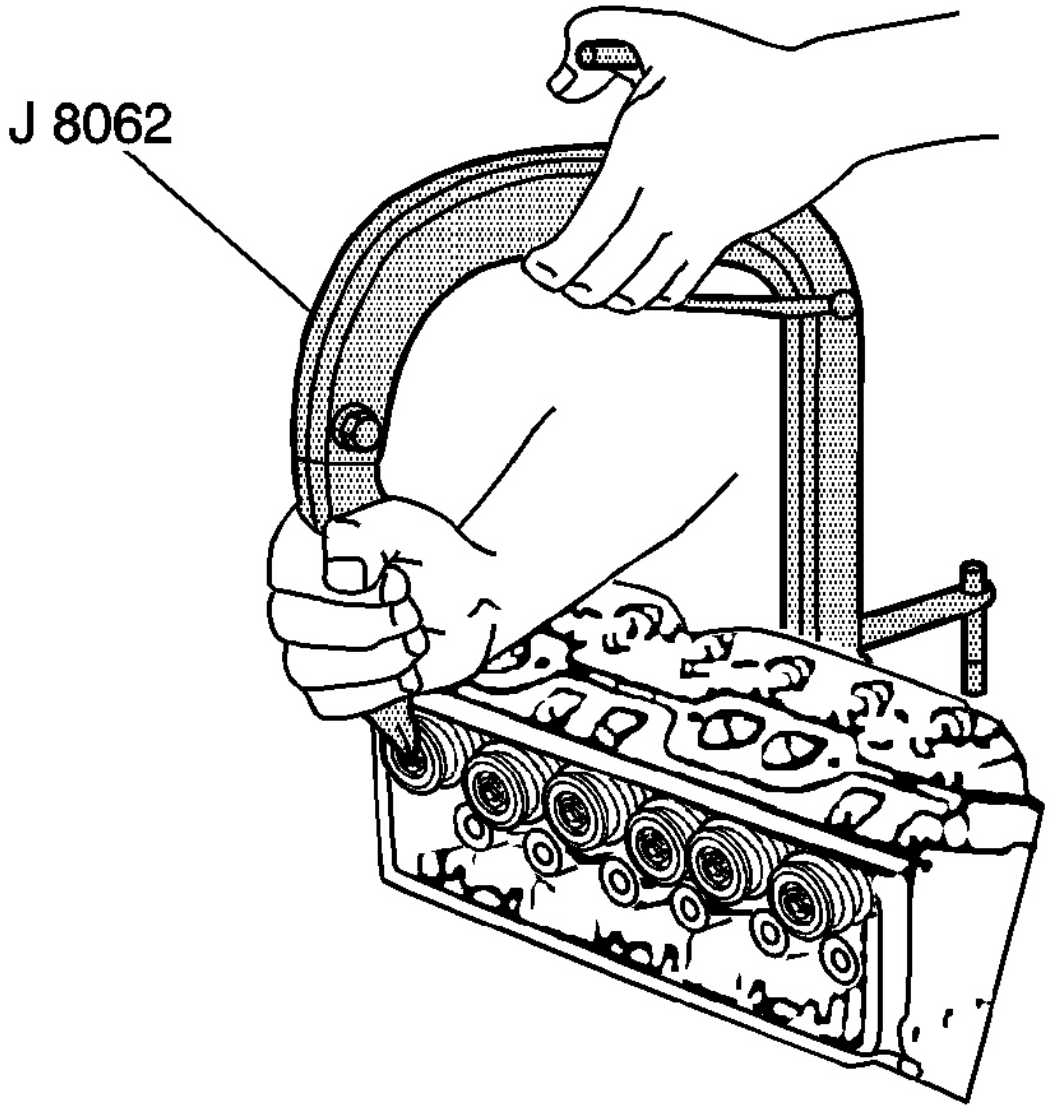


Fig. 556: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve

spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

8. Use the **J 8062** to compress the valve spring. See **Special Tools**.
9. Install the valve stem O-ring seal.
10. Install the valve stem keys.
    1. Use grease to hold the valve stem keys in place while disconnecting the **J 8062** . See **Special Tools**.
    2. Tap the end of the valve stem with a plastic-faced hammer to seat the valve stem keys.
    3. Inspect the valve stem keys to ensure that they are seated in the upper groove of the valve stem.

OIL PUMP DISASSEMBLE

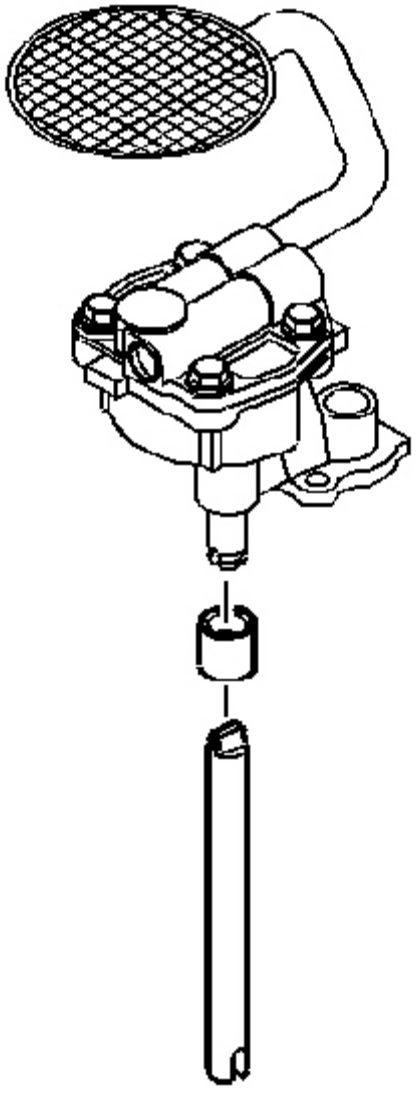


Fig. 557: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

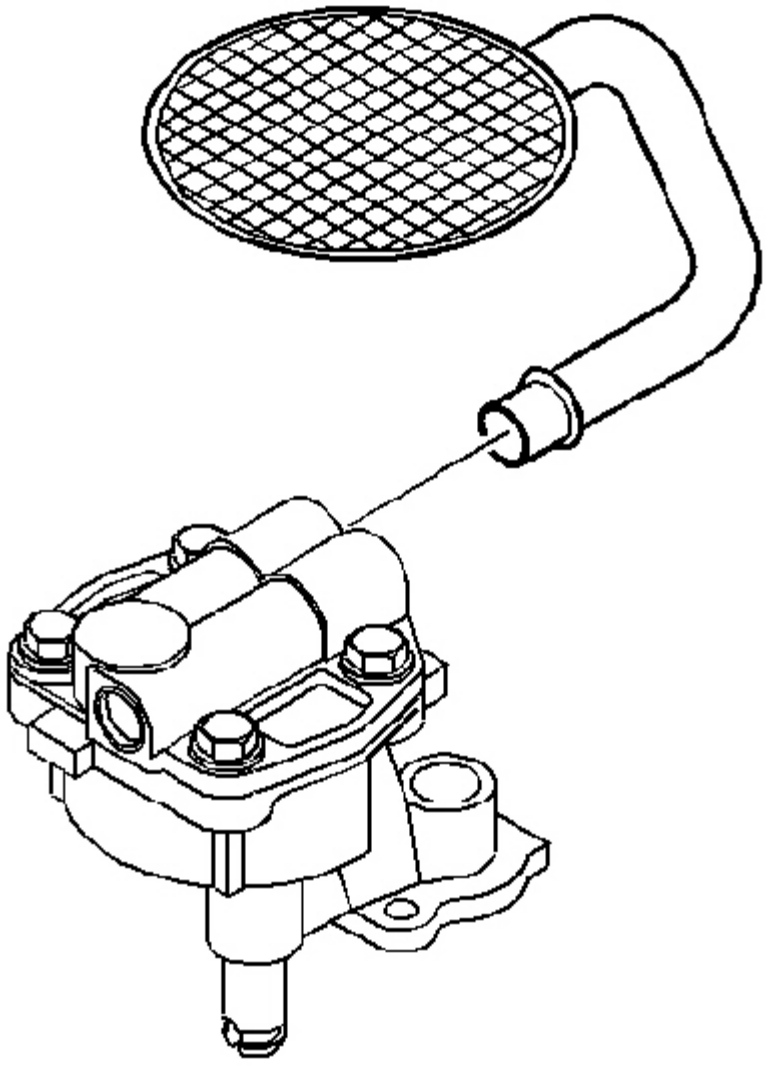


Fig. 558: View Of Oil Pump Pipe & Screen
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

2. Remove the oil pump pipe, if necessary. The oil pump pipe has a press fit into the oil pump cover.

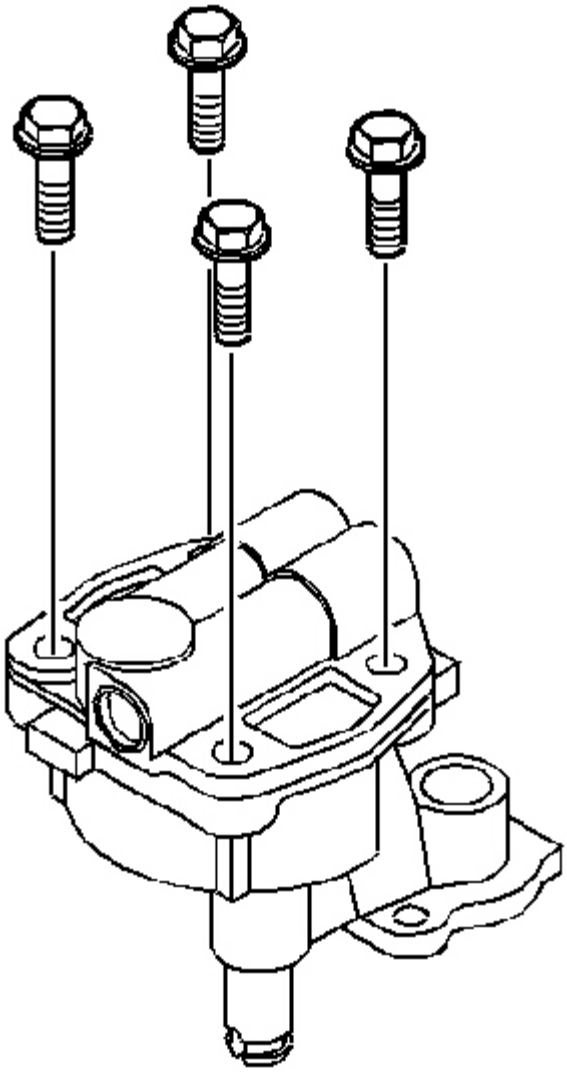


Fig. 559: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover bolts.

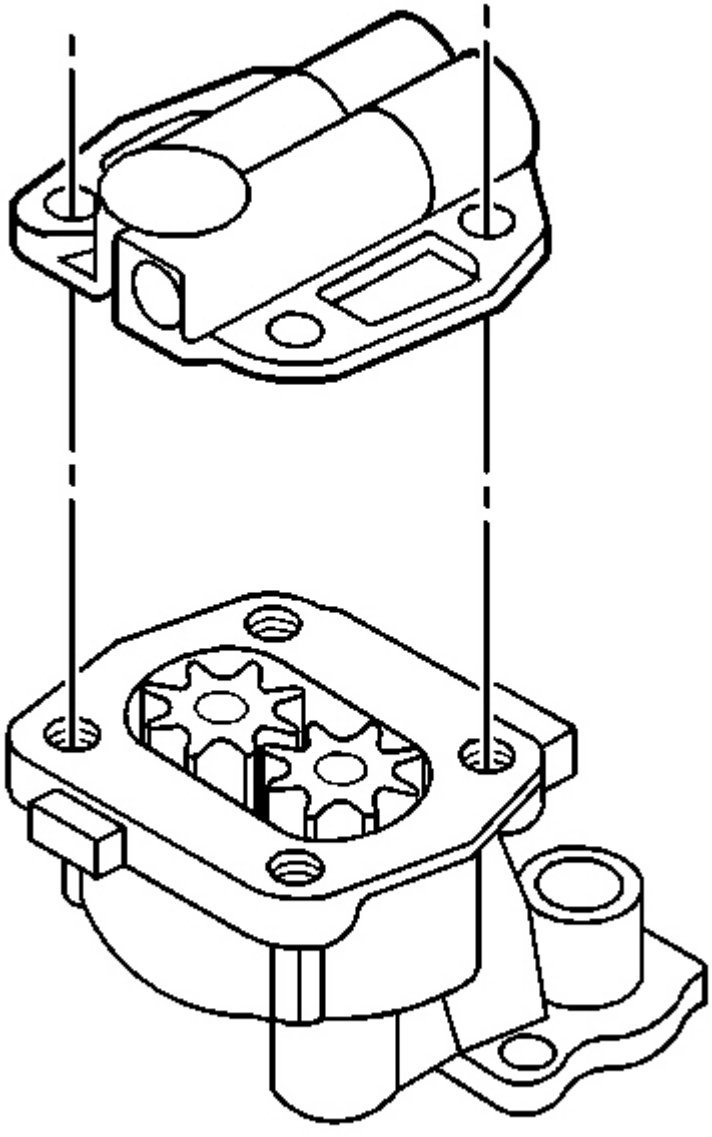


Fig. 560: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover.

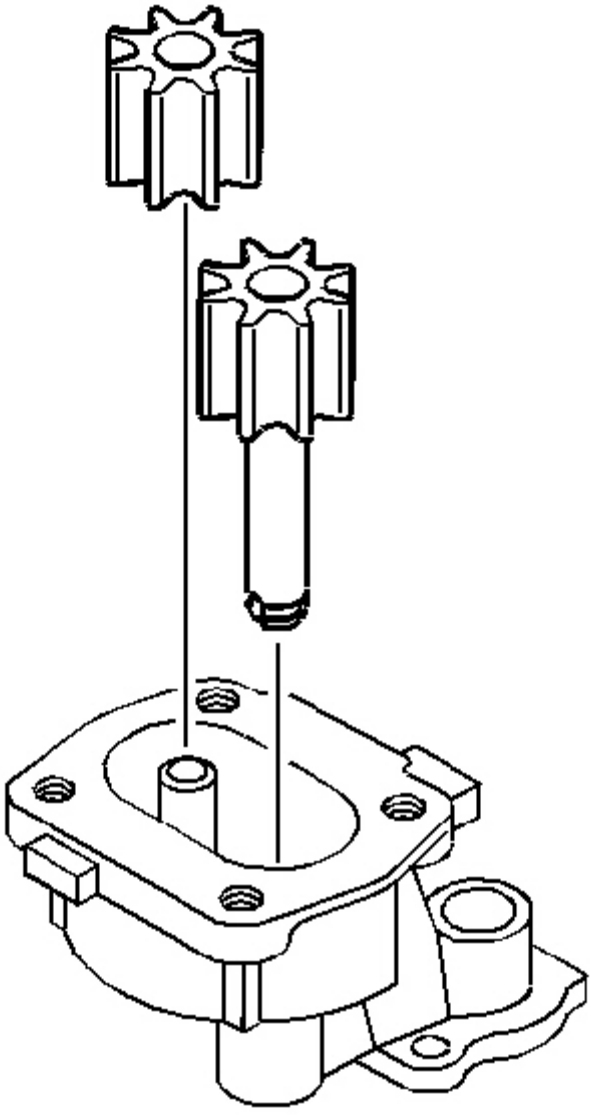


Fig. 561: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

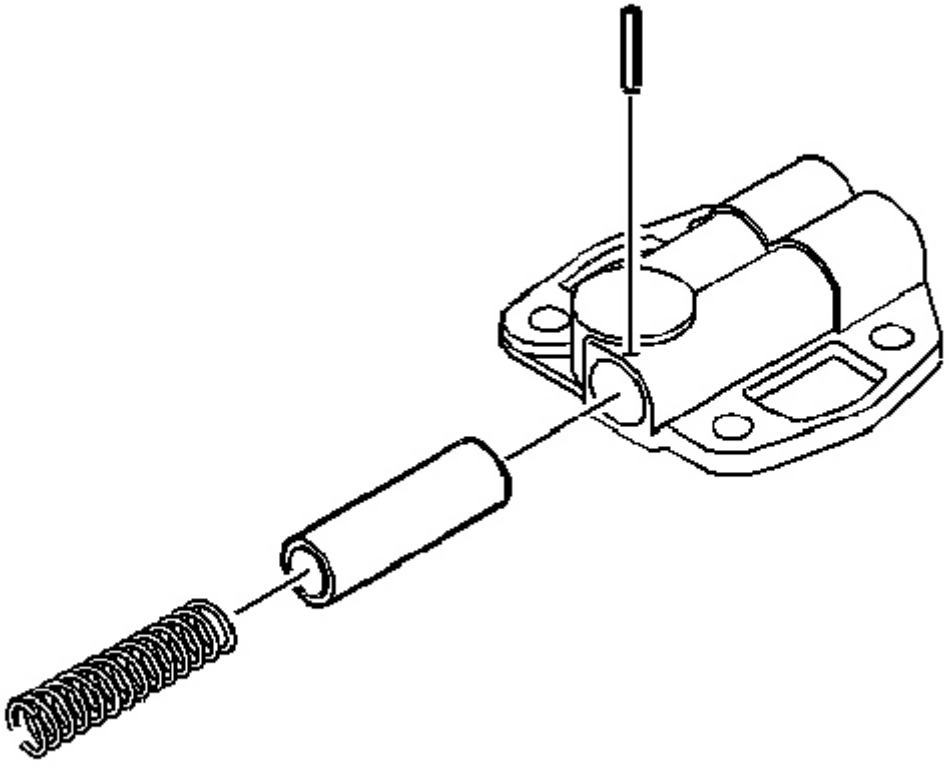


Fig. 562: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

7. Remove the following items:
    1. The oil pump pressure relief valve spring straight pin
    2. The oil pump pressure relief spring
    3. The oil pump pressure relief valve

OIL PUMP CLEANING AND INSPECTION

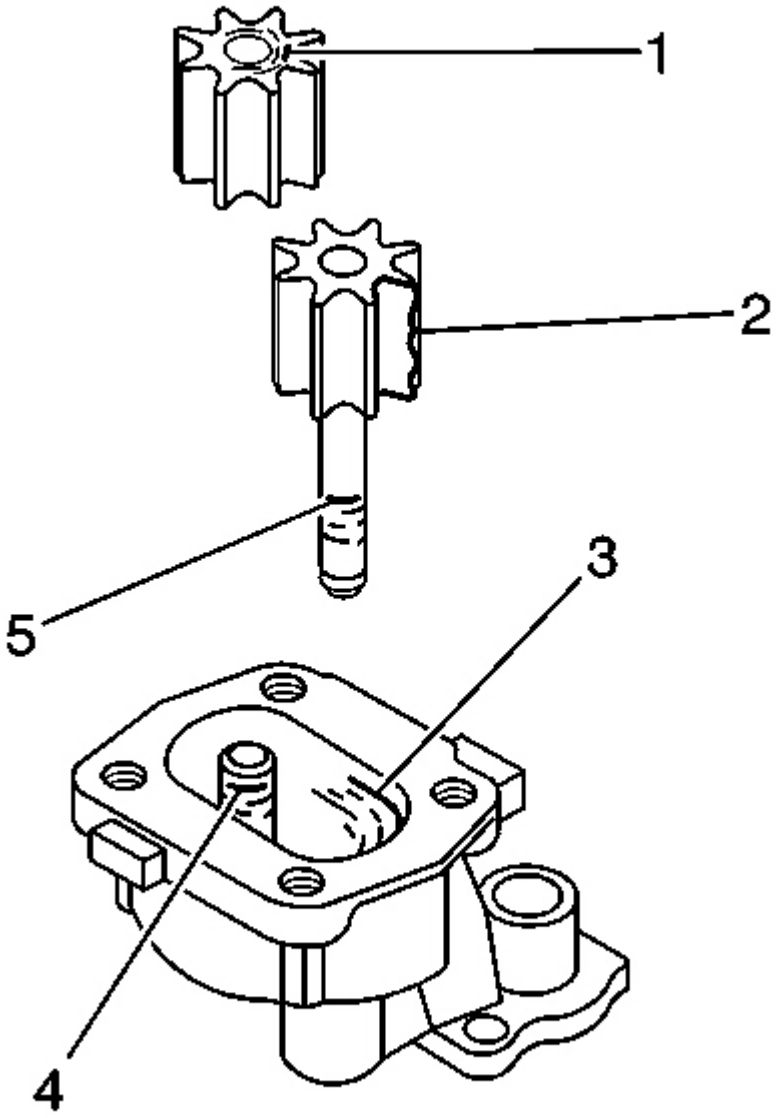


Fig. 563: Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
    - Scoring on the top of the gears (1)
    - Damaged gears (2) for the following:
        - Chipping
        - Galling
        - Wear
    - Scoring, damage or casting imperfections to the body (3)
    - Damaged or scored gear shaft (4)
    - Damaged or scored gear shaft (5)
    - Damaged bolt hole threads
    - Worn oil pump driveshaft bore
    - Damaged or sticking oil pump pressure relief valve

      Minor imperfections may be removed with a fine oil stone.

    - Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
5. During oil pump installation, install a NEW oil pump driveshaft retainer.

OIL PUMP ASSEMBLE

Tools Required

J 21882 Oil Suction Pipe Installer. See **Special Tools**.

Assemble

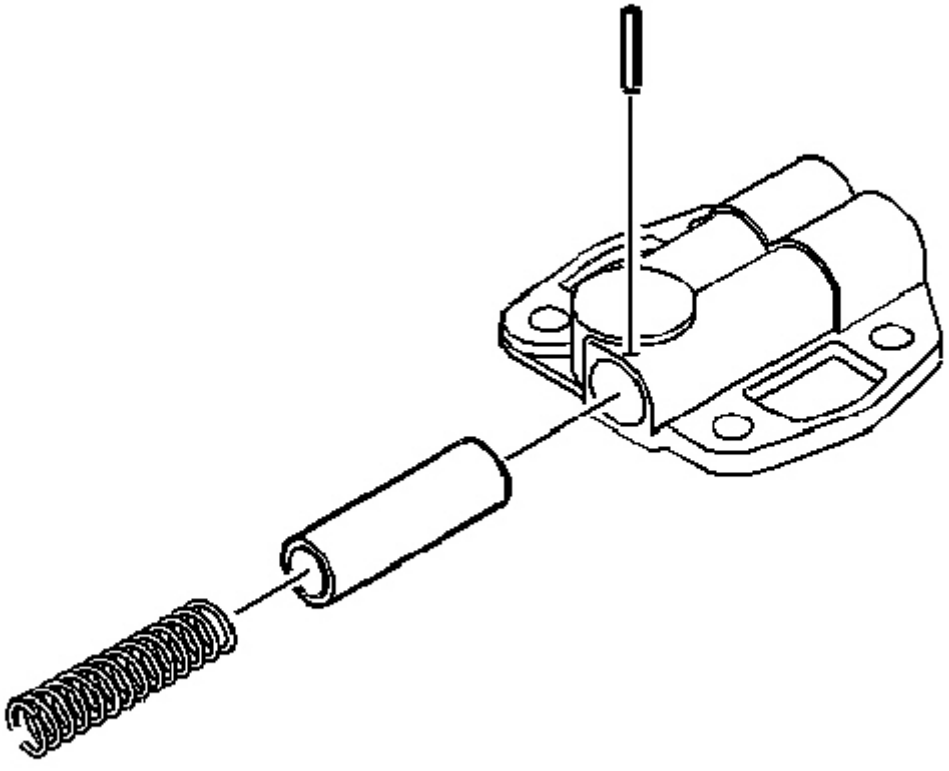


Fig. 564: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 9931930) or equivalent, to the oil pump pressure relief valve, oil pump pressure relief valve spring, and oil pump body.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: Replace the oil pump pressure relief valve spring when you reuse the oil pump.

2. Install the following items:
    1. The oil pump pressure relief valve

2. The oil pump pressure relief valve spring
3. The oil pump pressure relief valve spring straight pin

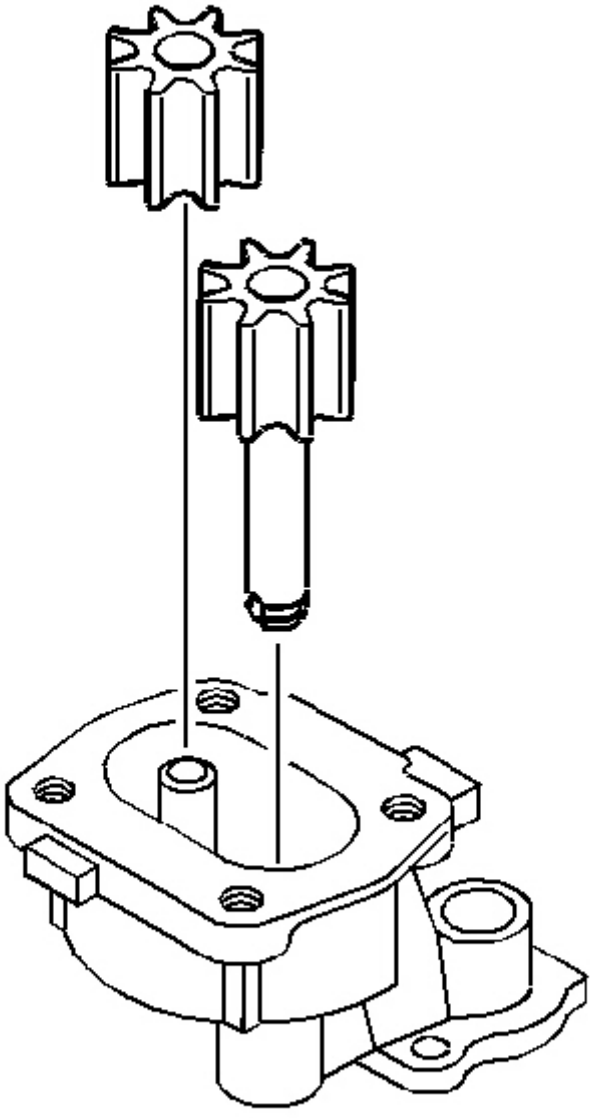


Fig. 565: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

3. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, to the oil pump drive gear, the oil pump driven gear, and the oil pump body internal surfaces.
4. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
    1. Align the matchmarks on the oil pump drive and driven gears.
    2. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.

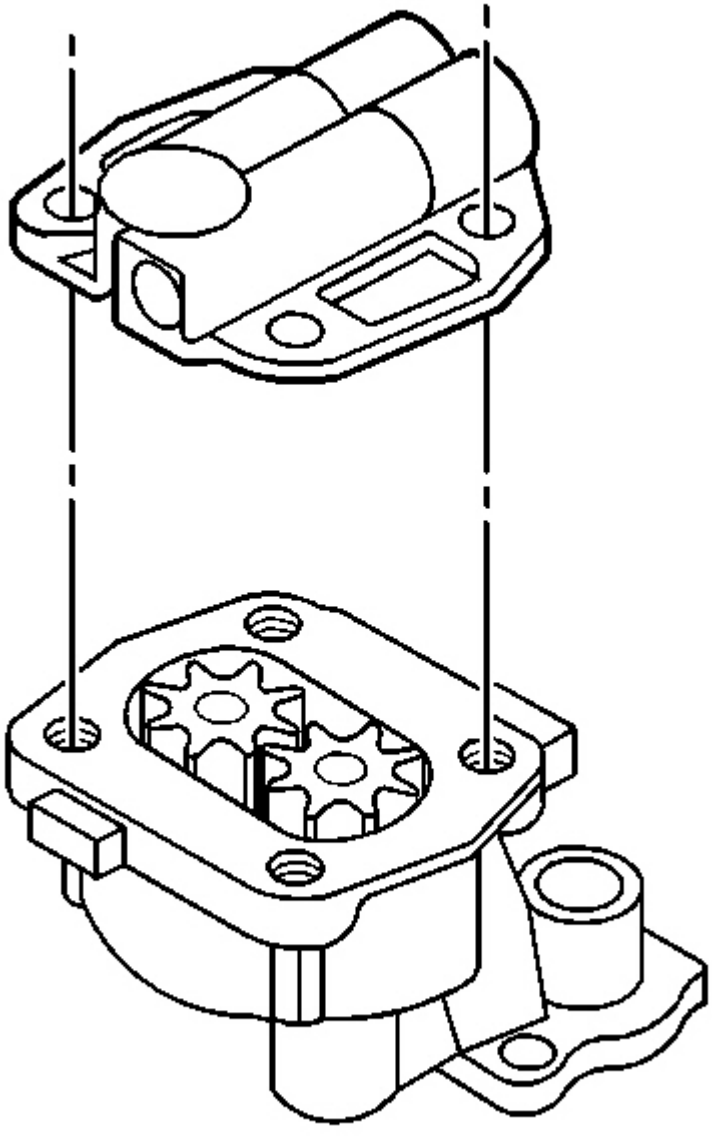


Fig. 566: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pump cover.

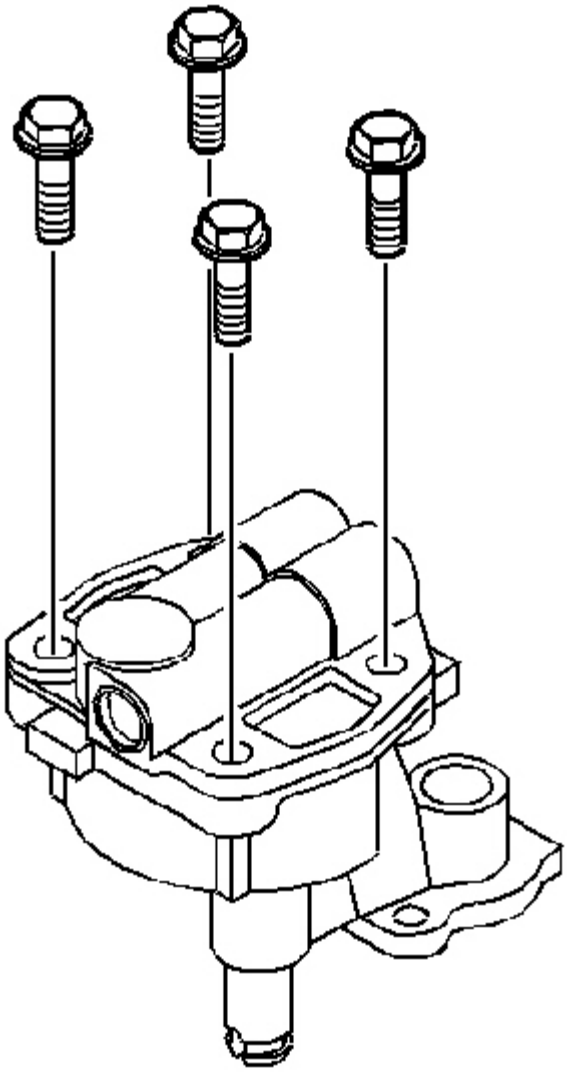


Fig. 567: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the oil pump cover bolts.

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

7. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.

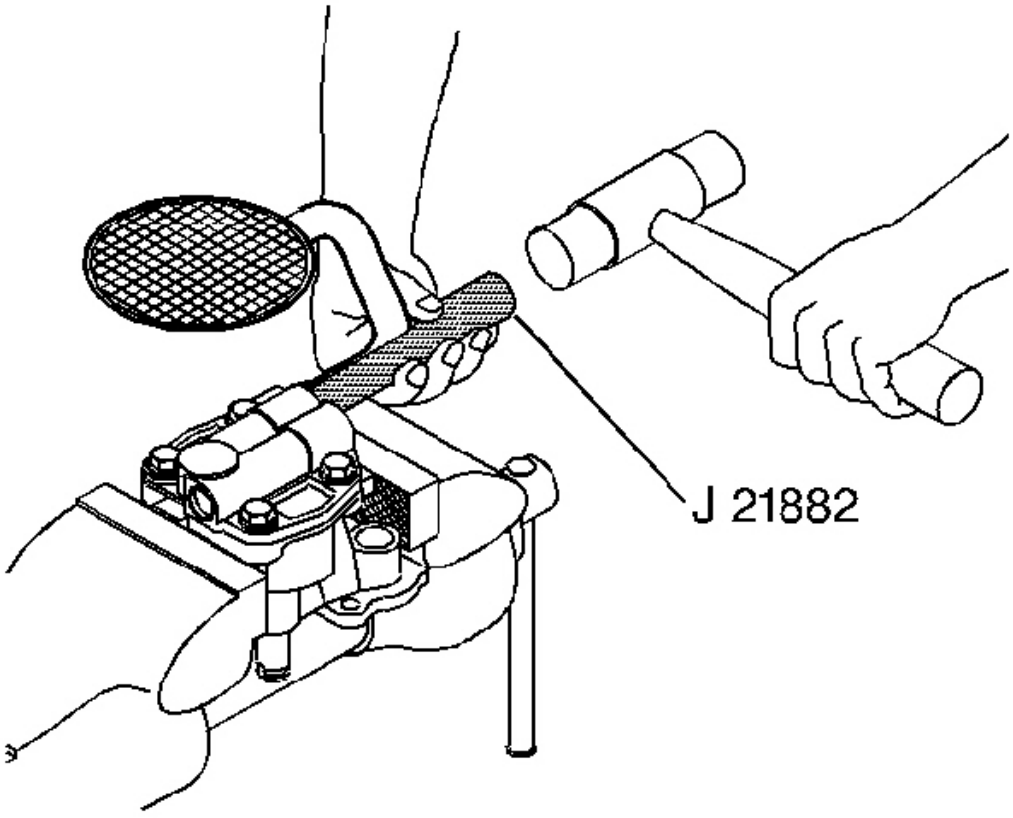


Fig. 568: Installing Oil Pump Screen Into Pump Body
Courtesy of GENERAL MOTORS CORP.

8. Install the oil pump screen.
    1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
    2. Mount the oil pump in a soft jawed vise.
    3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the end of the oil pump screen pipe.
    4. Use the **J 21882** and a soft-faced hammer in order to tap the oil pump screen into the pump body. See **Special Tools**.

The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.

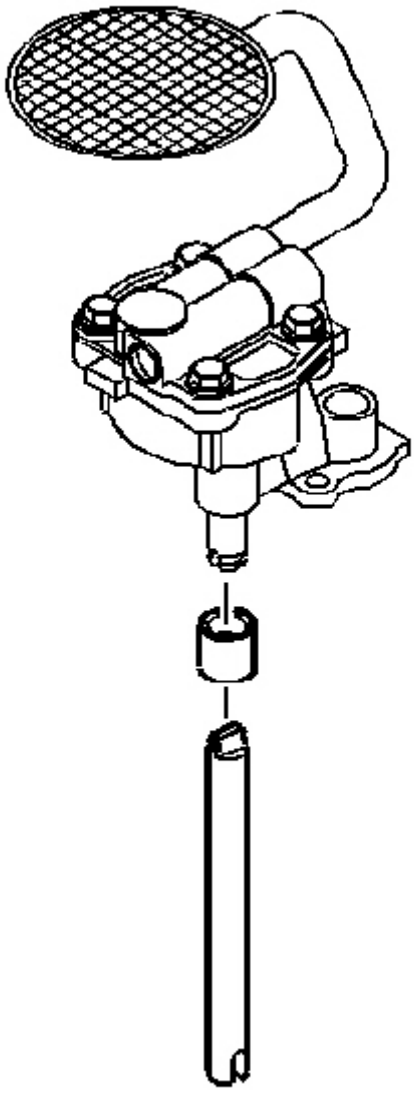


Fig. 569: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a NEW oil pump driveshaft retainer during assembly.

9. Install the oil pump driveshaft and the NEW oil pump driveshaft retainer.

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

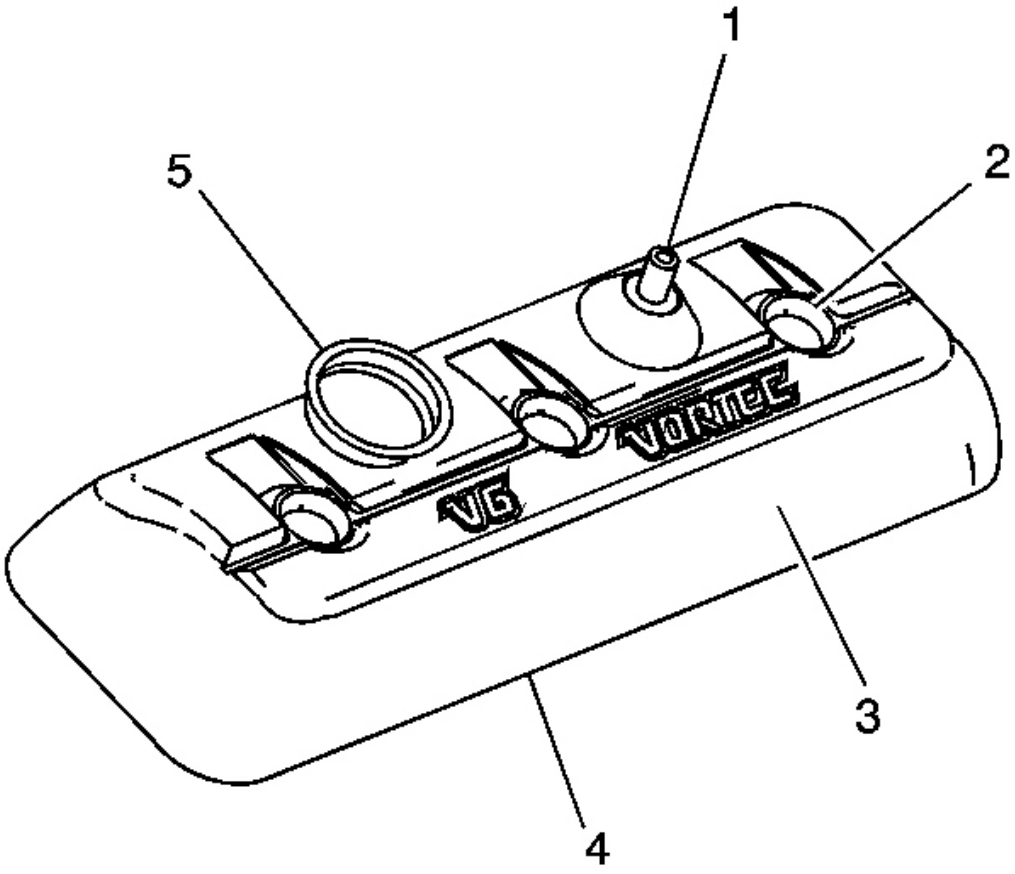


Fig. 570: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: The positive crankcase ventilation (PCV) orifice is part of the valve cover and cannot be removed. If damaged, replace the valve cover.

1. Clean the valve rocker arm cover in cleaning solvent.
2. Dry the valve rocker arm cover with compressed air.
3. Inspect the valve rocker arm cover for the following:
    - Damage to the PCV orifice (1)
    - Damage to the bolt holes (2)

      A damaged valve rocker arm cover may interfere with the valve rocker arms.

    - Damage to the exterior of the valve rocker arm cover (3)
    - Gouges or damage to the sealing surface (4)
    - Damage to the oil fill tube grommet (5)
    - Restrictions to the ventilation system passages

OIL PAN CLEANING AND INSPECTION

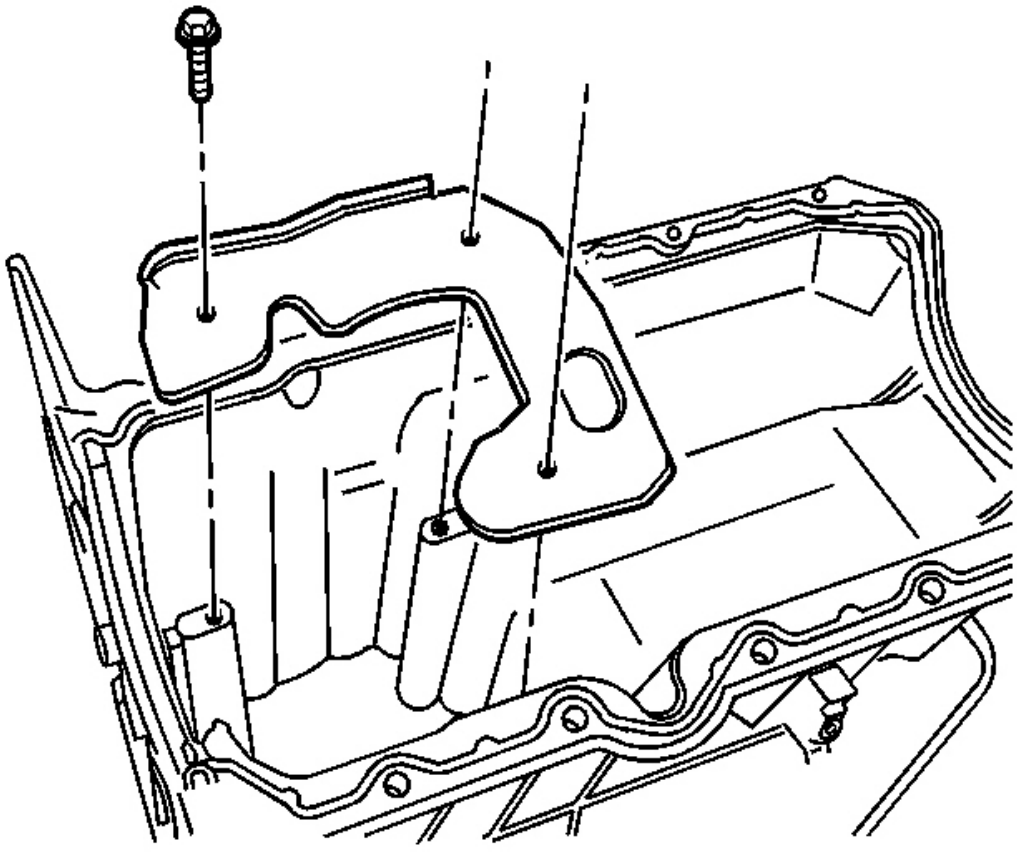


Fig. 571: View Of Oil Pan Baffle Bolts & Baffle
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan baffle bolts and the oil pan baffle.

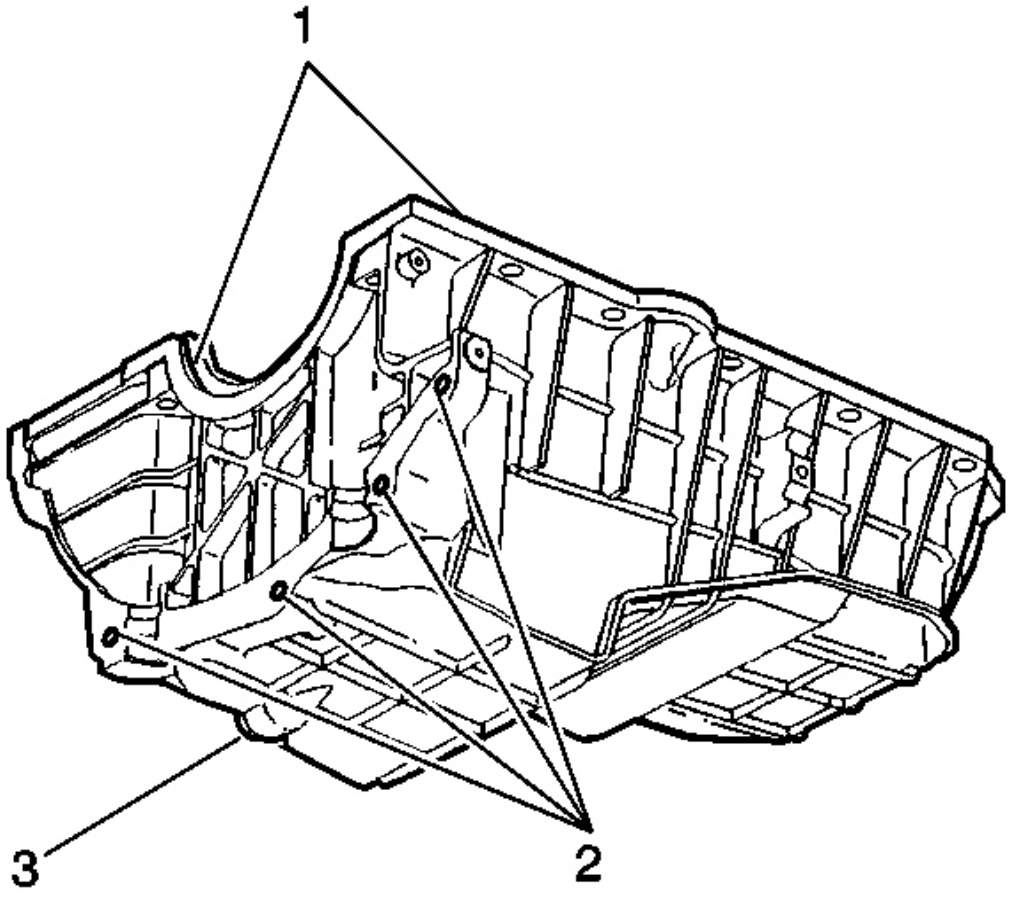


Fig. 572: Oil Pan Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION

2. Clean the oil pan and oil pan baffle in cleaning solvent.
3. Dry the oil pan and oil pan baffle with compressed air.
4. Inspect the oil pan for the following:
    - Gouges or damage to the oil pan sealing surfaces (1)
    - Damage to the threaded holes (2)

- Damaged oil pan drain hole threads (3)
- Damage to the oil pan baffle
- Damage to the exterior of the oil pan

A damaged oil pan may interfere with the proper position of the oil pump screen, or may not distribute oil properly in the oil pan sump area.

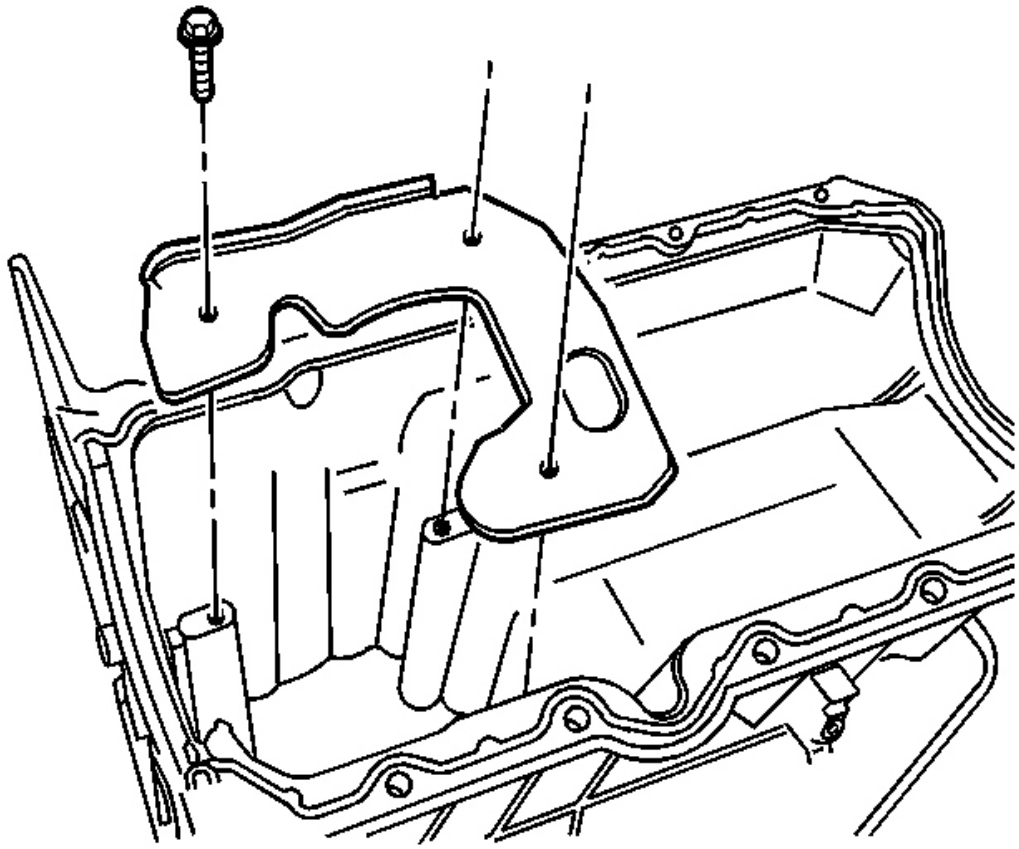


Fig. 573: View Of Oil Pan Baffle Bolts & Baffle
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Install the oil pan baffle and the bolts.

Tighten: Tighten the oil pan baffle bolts to 12 N.m (106 lb in).

INTAKE MANIFOLD DISASSEMBLE

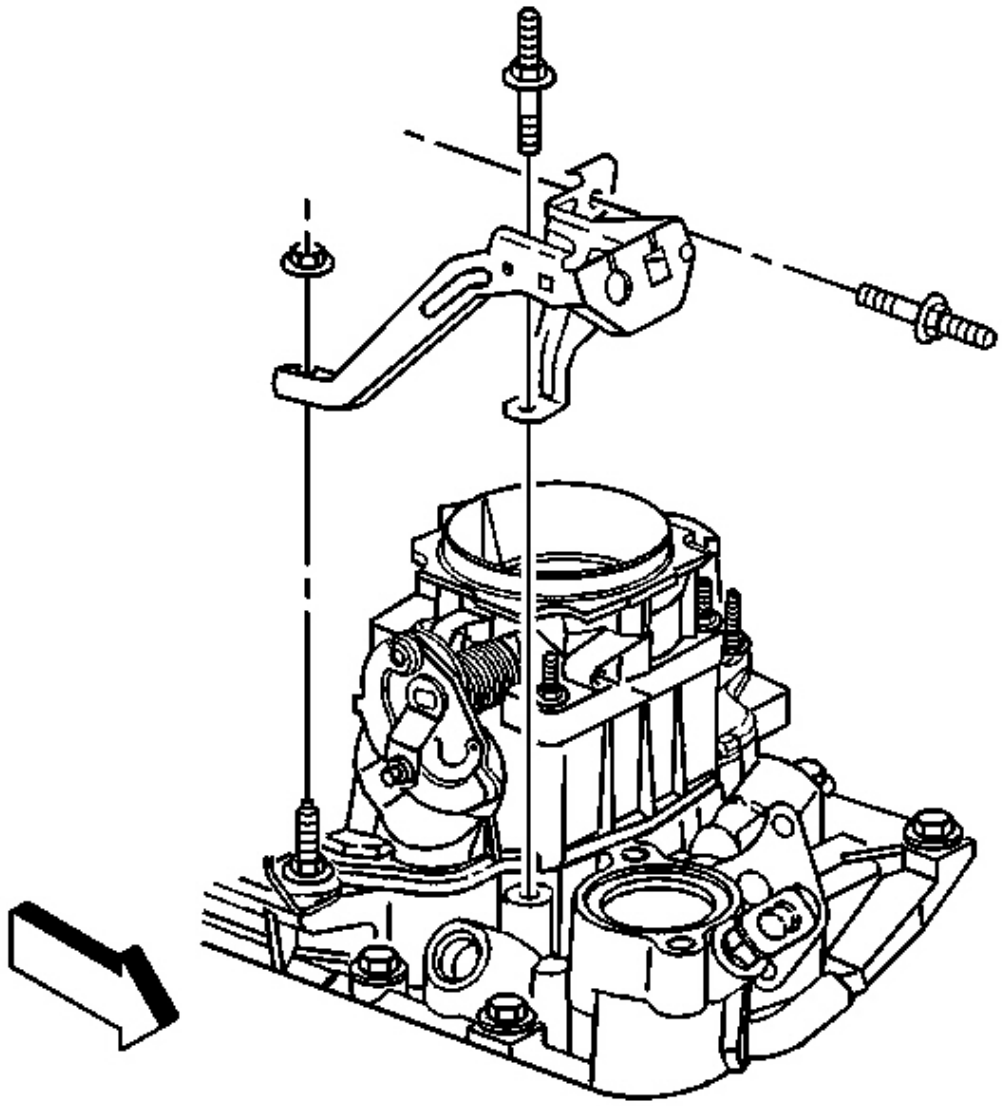


Fig. 574: View Of Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the nuts, the studs, and the accelerator control cable bracket.

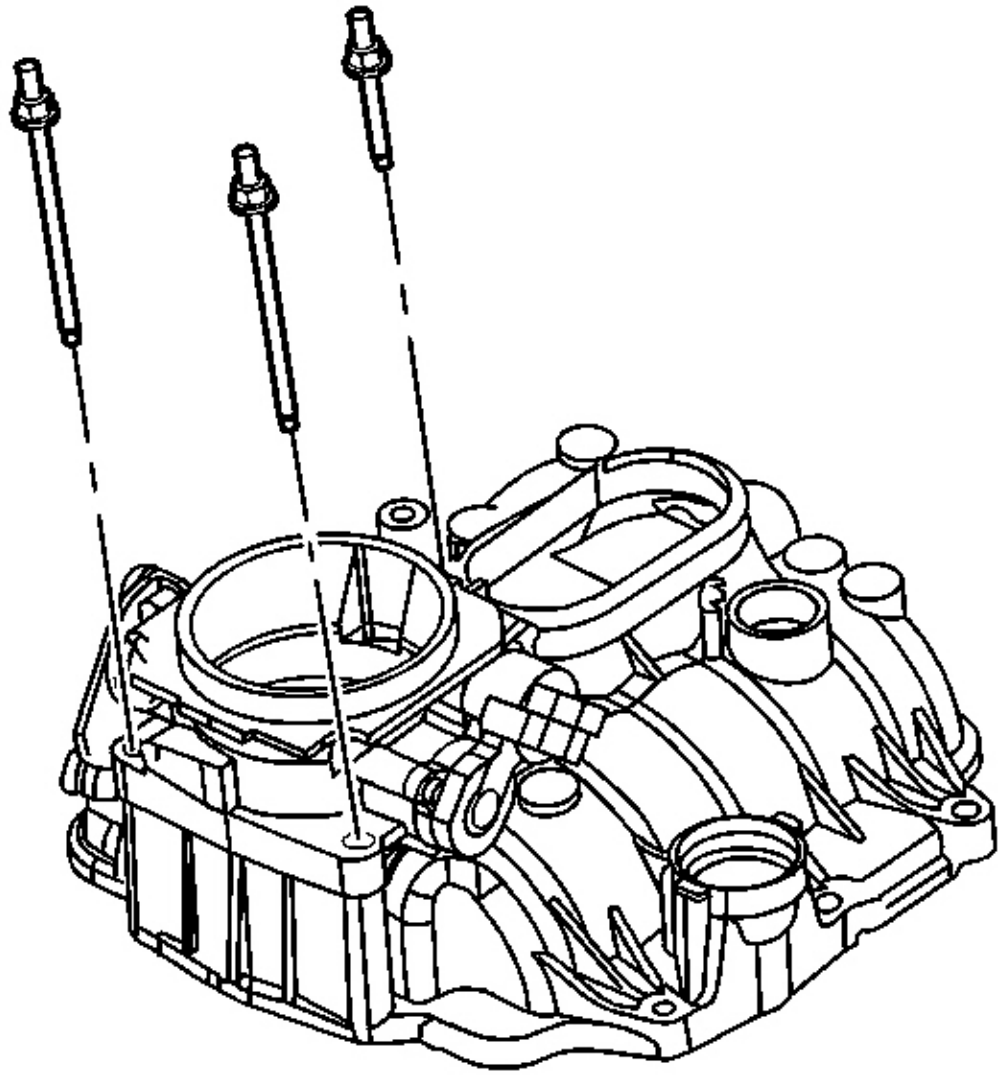


Fig. 575: View Of Throttle Body & Attaching Studs
Courtesy of GENERAL MOTORS CORP.

2. Remove the throttle body attaching studs.

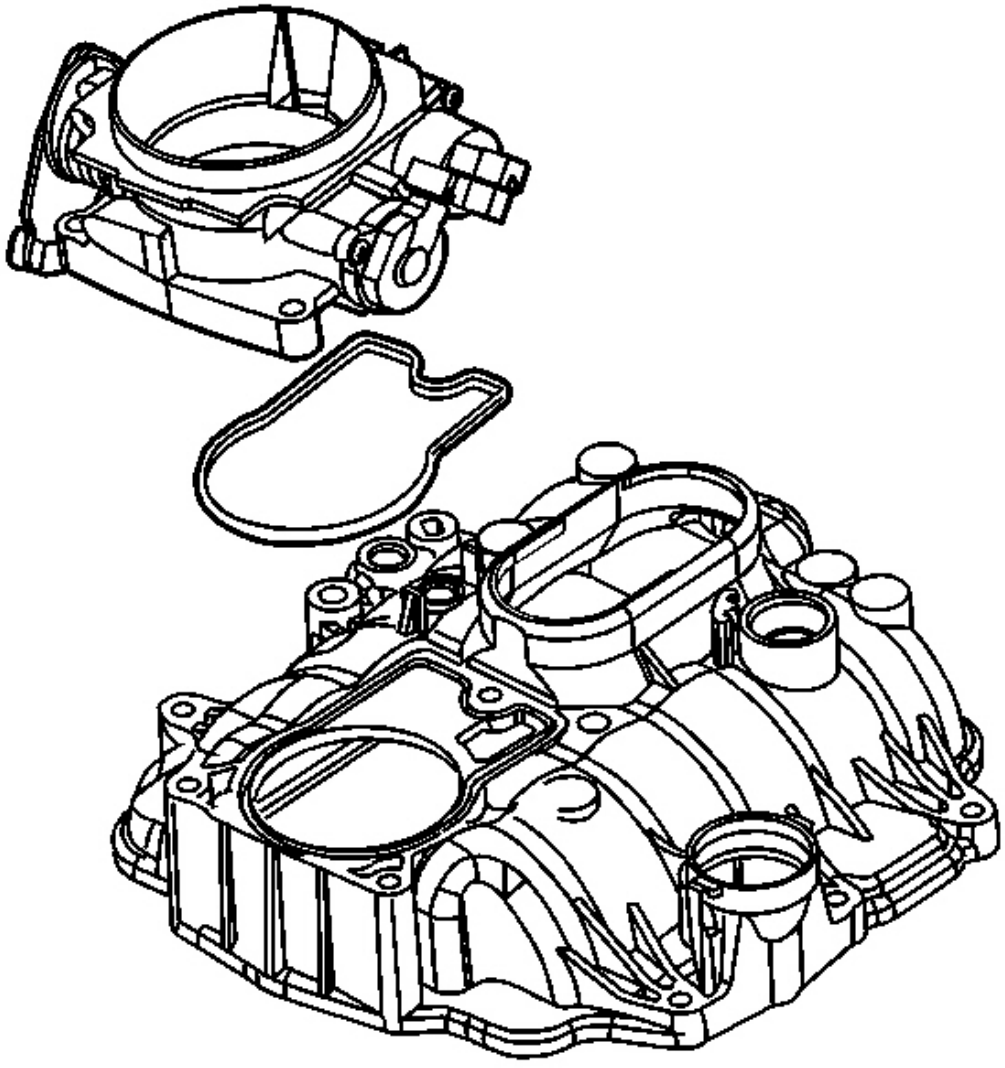


Fig. 576: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body.
4. Remove the throttle body to upper intake manifold gasket.
5. Discard the throttle body to upper intake manifold gasket.

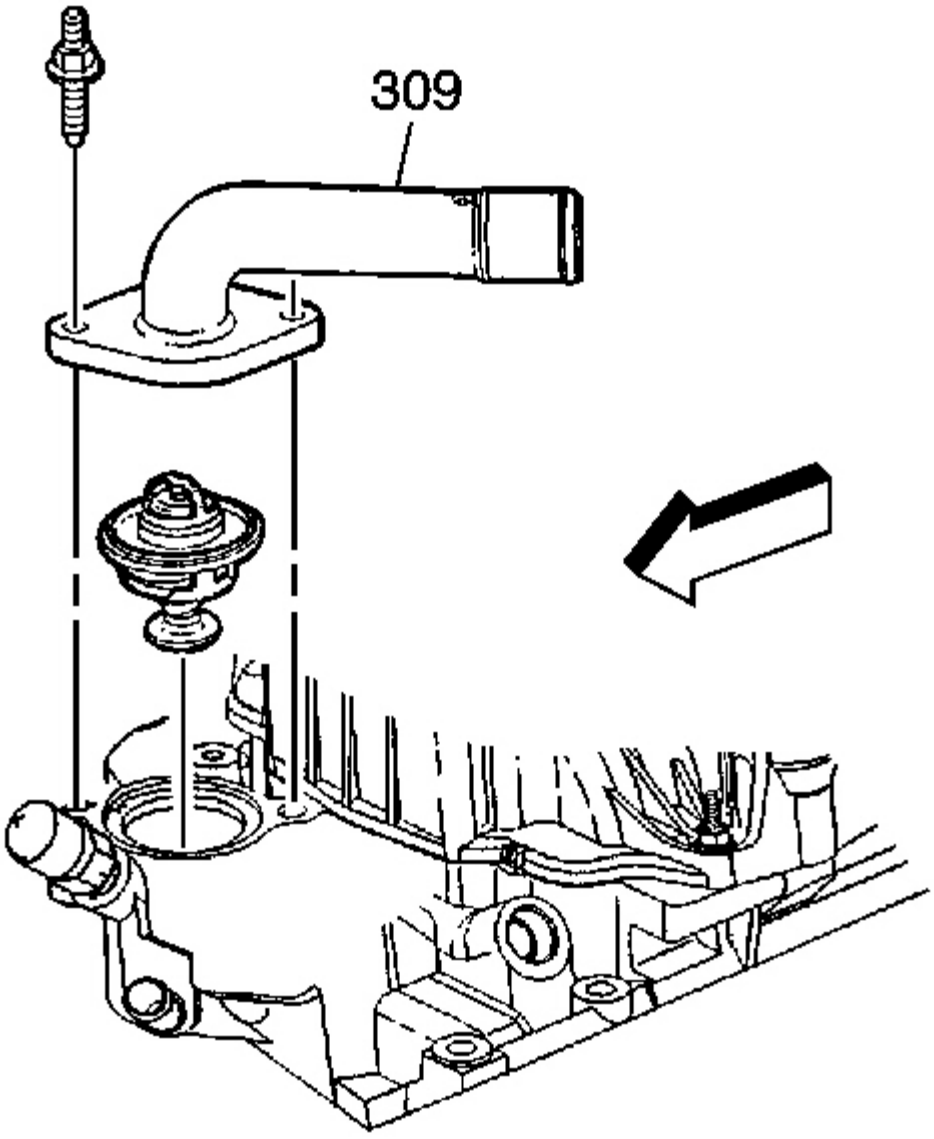


Fig. 577: Engine Coolant Thermostat
Courtesy of GENERAL MOTORS CORP.

6. Remove the water outlet studs.
7. Remove the water outlet (309).
8. Remove the engine coolant thermostat.

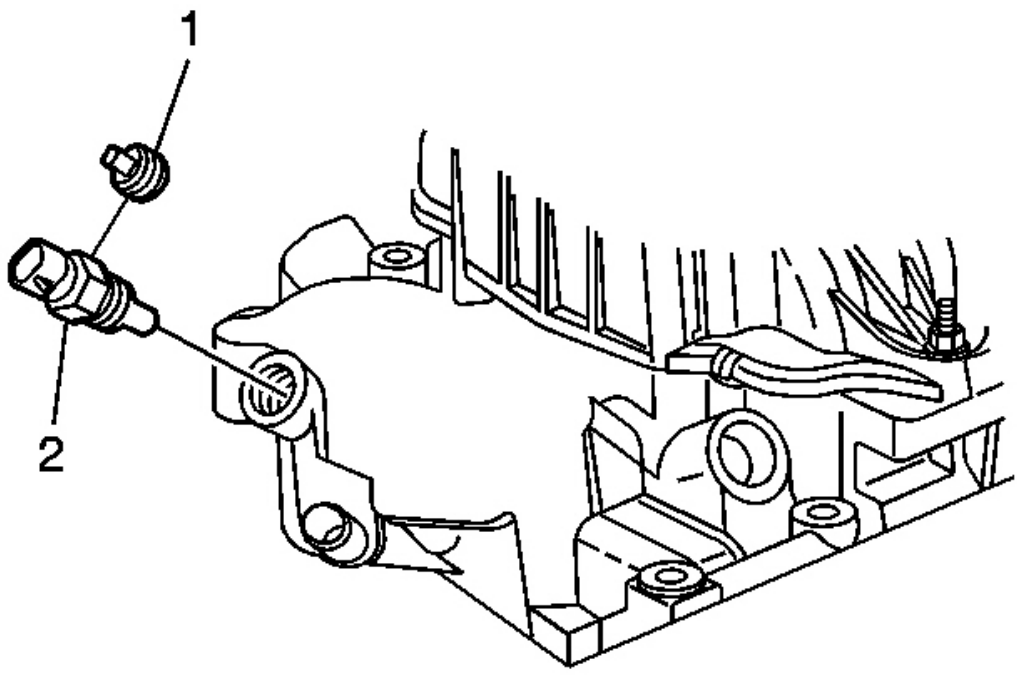


Fig. 578: ECT Sensor & Plug
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2) from the front of the lower intake manifold, if equipped.

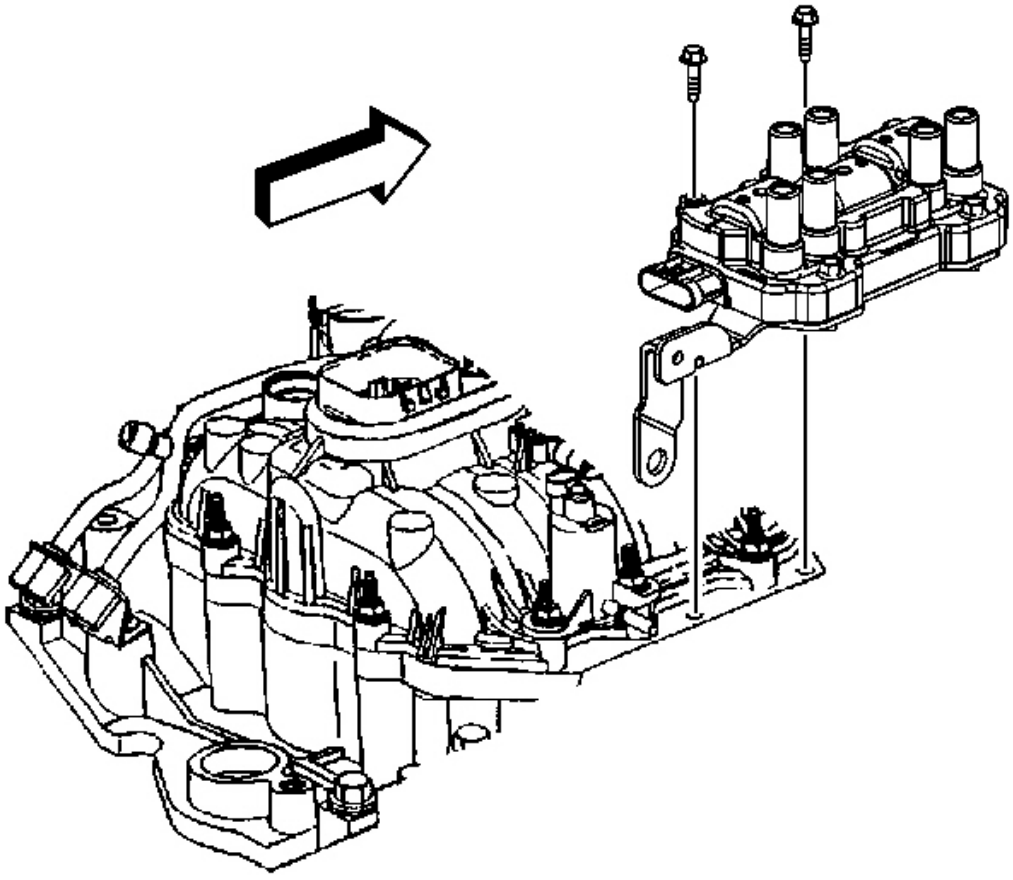


Fig. 579: View Of Studs And Ignition Coil
Courtesy of GENERAL MOTORS CORP.

10. Remove the studs and the ignition coil.

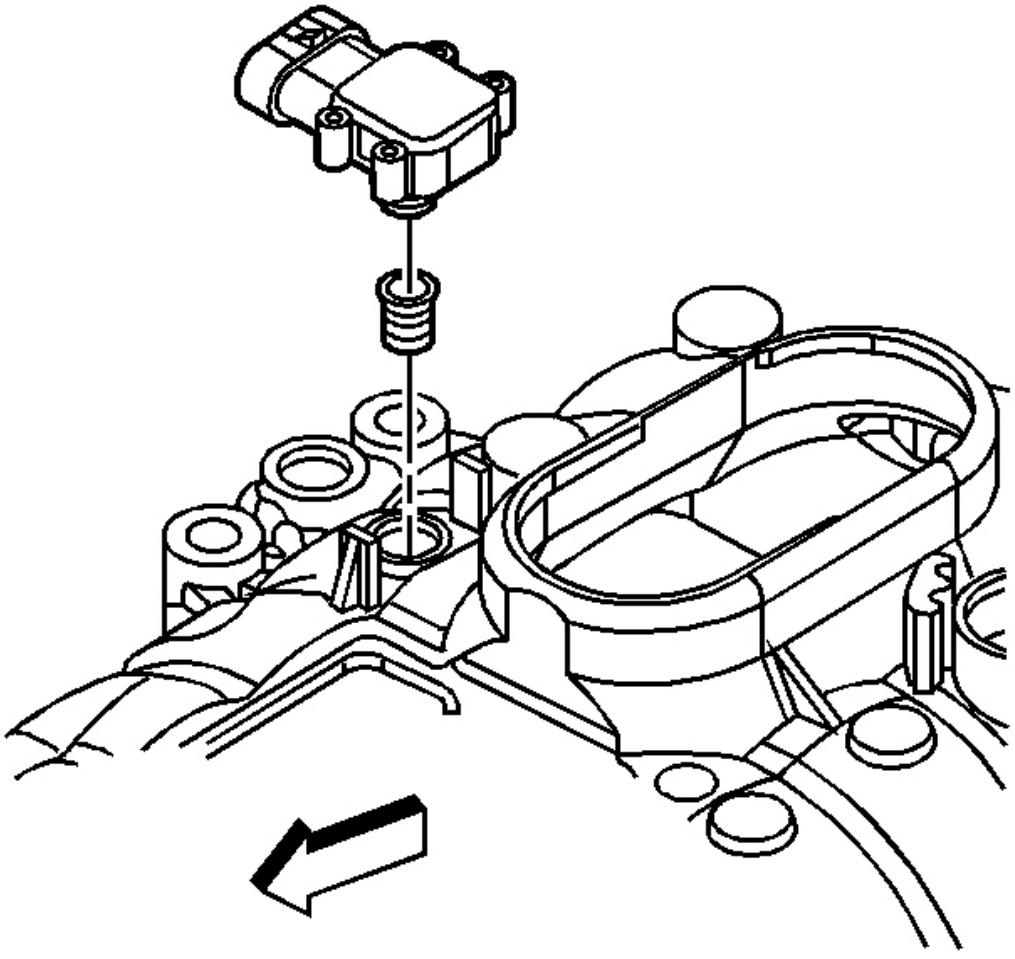


Fig. 580: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

11. Remove the manifold absolute pressure (MAP) sensor.
12. Remove the MAP sensor seal from the MAP sensor.
13. Discard the MAP sensor seal.

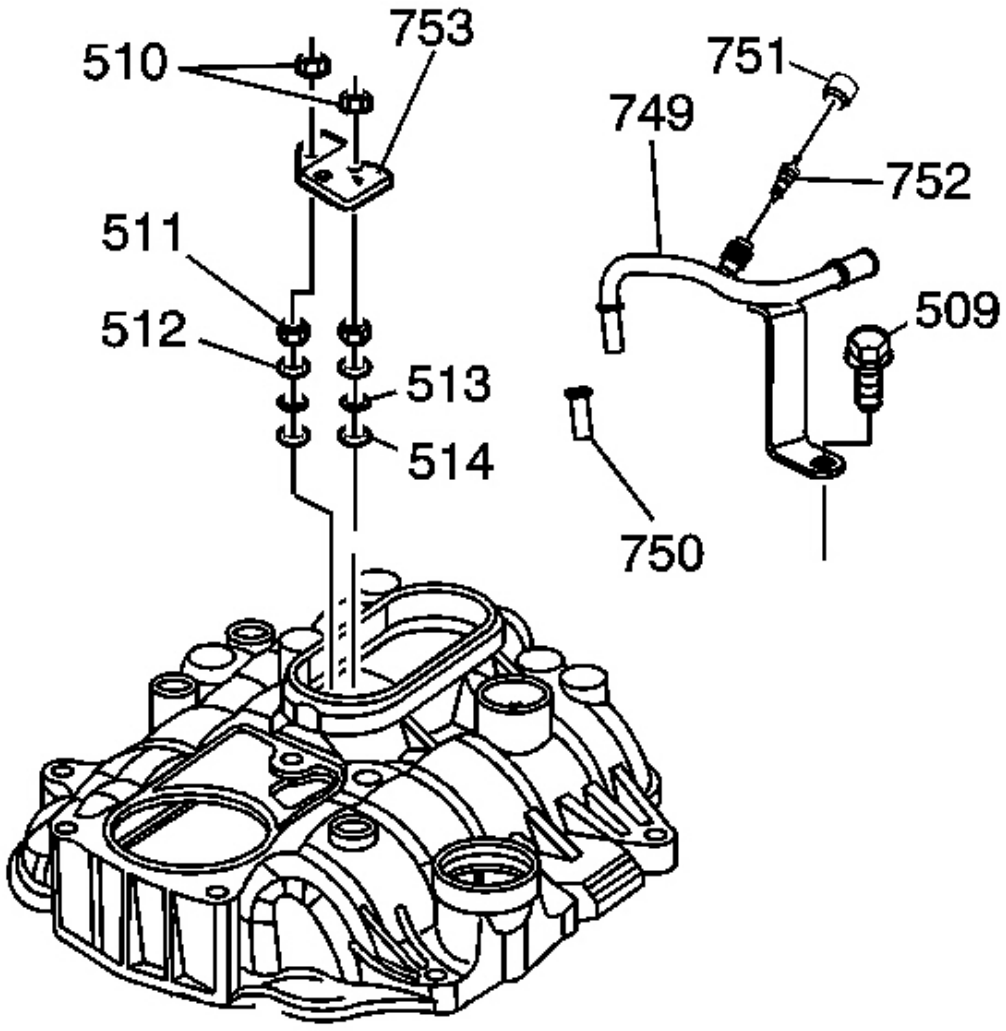


Fig. 581: Fuel Pipes & Seals
Courtesy of GENERAL MOTORS CORP.

14. Remove the fuel pipe bolt (509).
15. Remove the fuel service port cap (751) and schreder valve (752), if required.
16. Remove the fuel pipe retainer nuts (510).
17. Remove the fuel pipe retainer (753).
18. Remove the fuel pipe (749).

19. Remove the fuel pipe plug (750), if required.
20. Remove and discard the fuel seal retainers (511).
21. Remove and discard the fuel seals (512), yellow O-rings.
22. Remove and discard the spacer rings (513), flat washers.
23. Remove and discard the fuel seals (514), black O-rings.

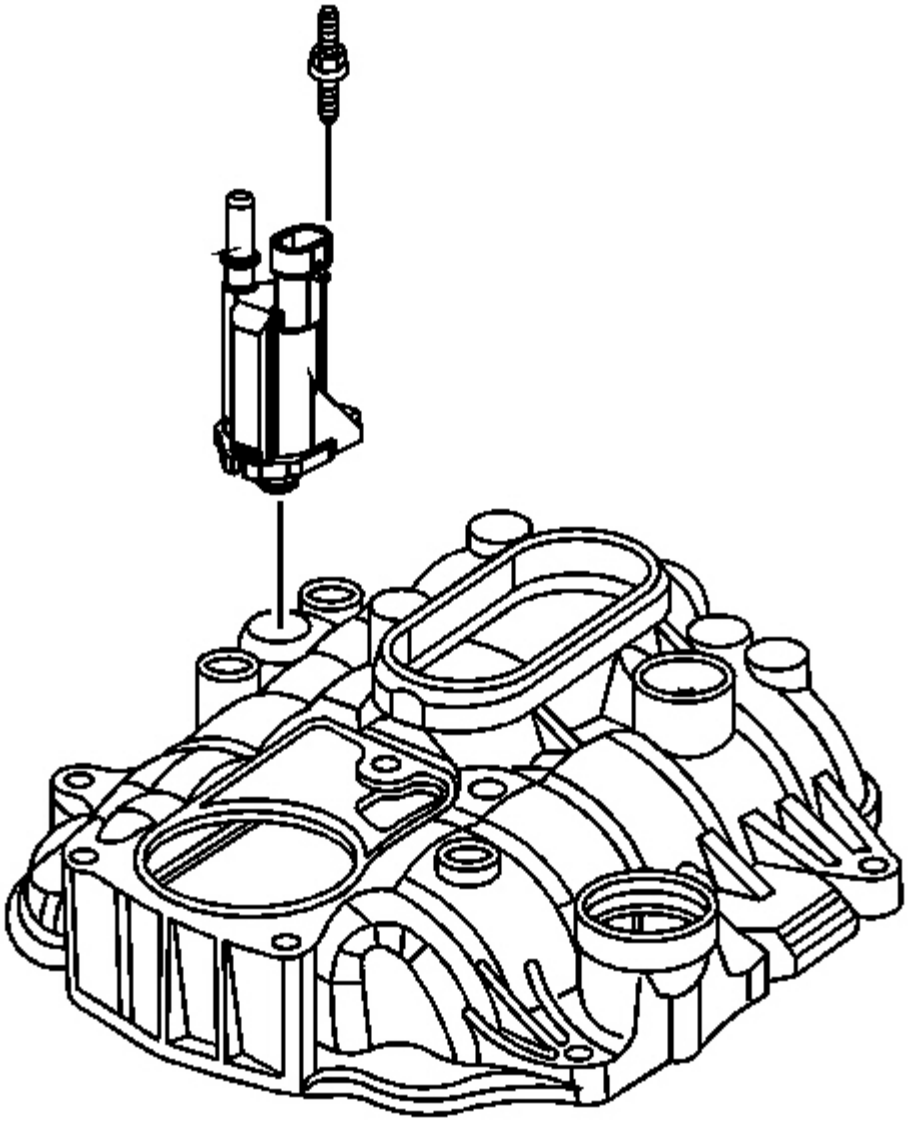


Fig. 582: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

24. Remove the studs and the evaporative emission (EVAP) canister purge solenoid valve.
25. Remove the nut and the engine wiring harness bracket.

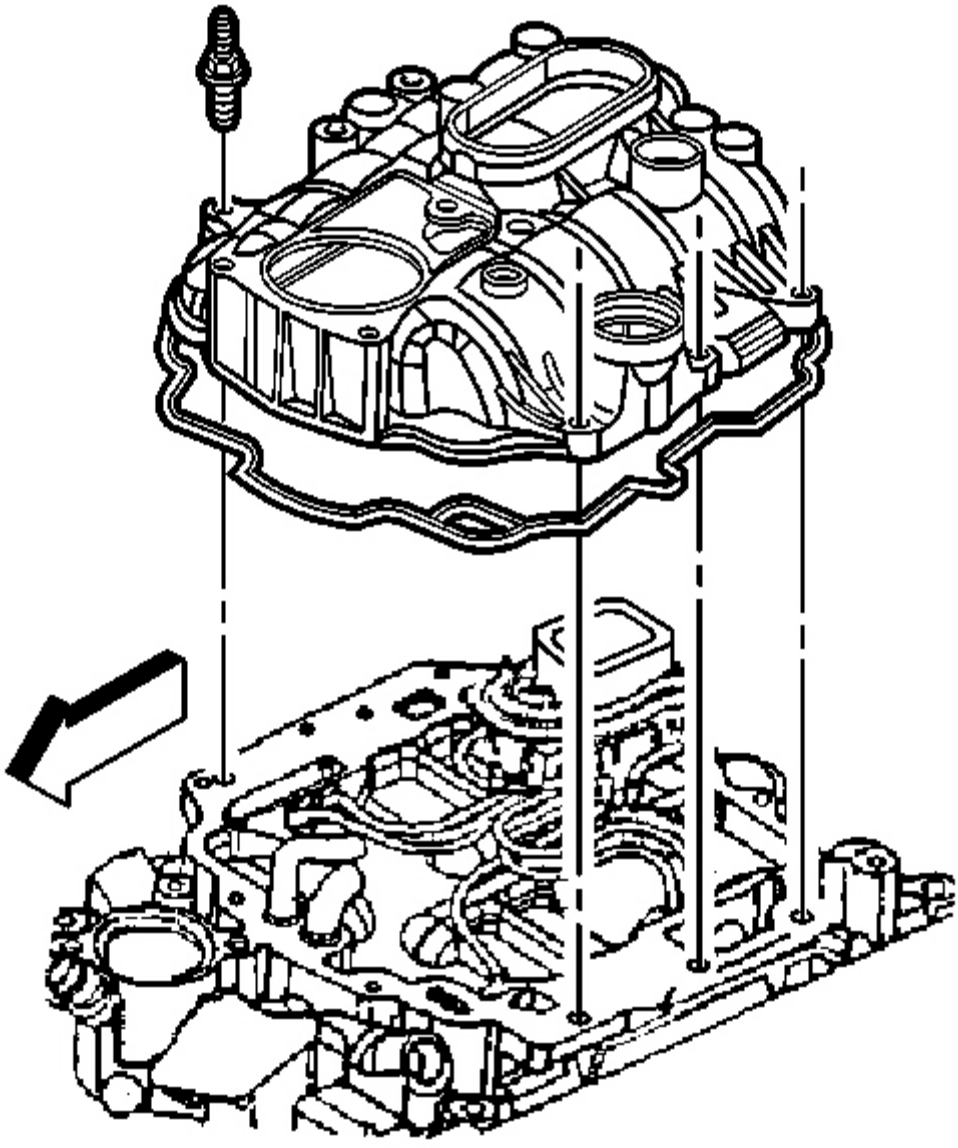


Fig. 583: Identifying Upper Intake Manifold Attaching Studs
Courtesy of GENERAL MOTORS CORP.

26. Remove the upper intake manifold attaching studs.
27. Remove the upper intake manifold.

28. Remove the upper intake manifold to lower intake manifold gasket.
29. Discard the upper intake manifold to lower intake manifold gasket.

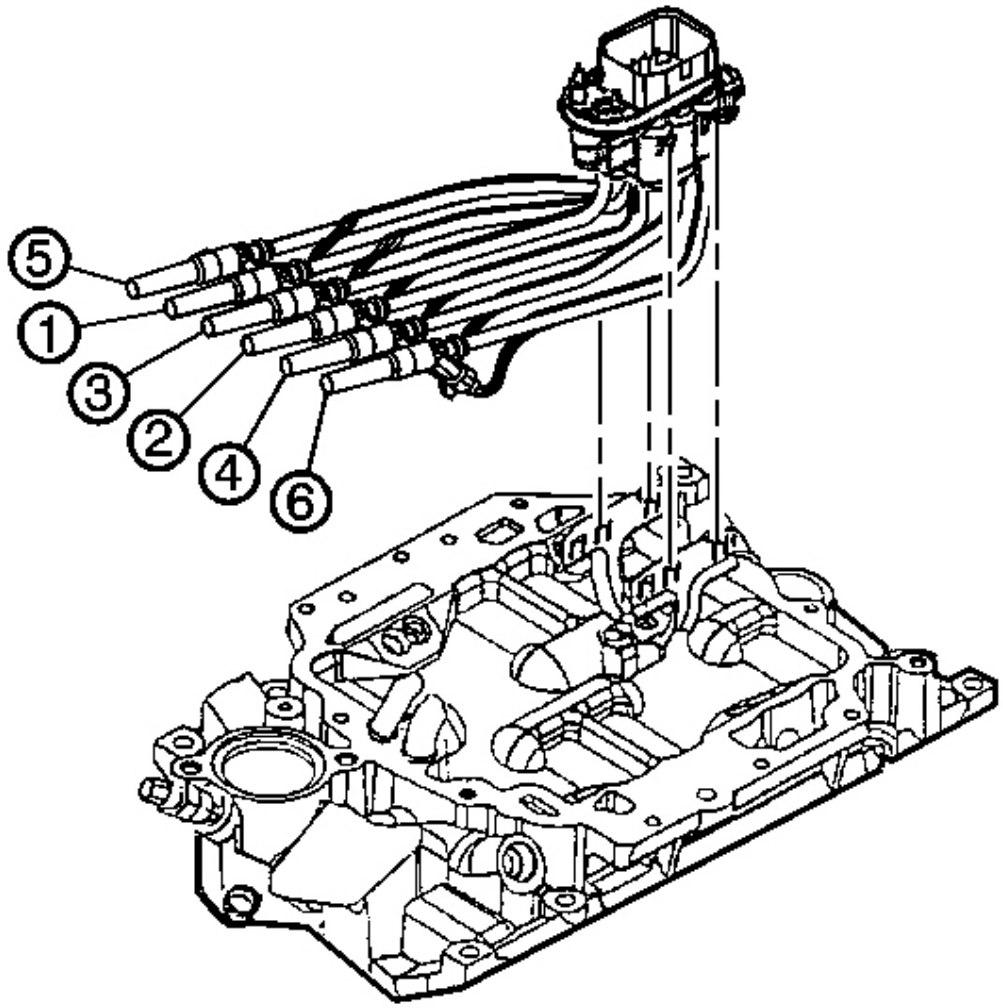


Fig. 584: Injectors At Lower Intake Manifold Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the removal of the fuel injector assembly, the retainers that hold the injectors into the intake manifold may become worn. This is OK. Upon installation of the upper

intake manifold, the injectors will be held fully seated, thus keeping them from backing out of the lower intake manifold.

30. Remove the fuel meter body seal and discard.
31. Remove the 6 injectors from the lower intake manifold bores.
32. Remove the fuel meter body.
33. Remove the bolt and the fuel meter body bracket.

INTAKE MANIFOLD CLEANING AND INSPECTION

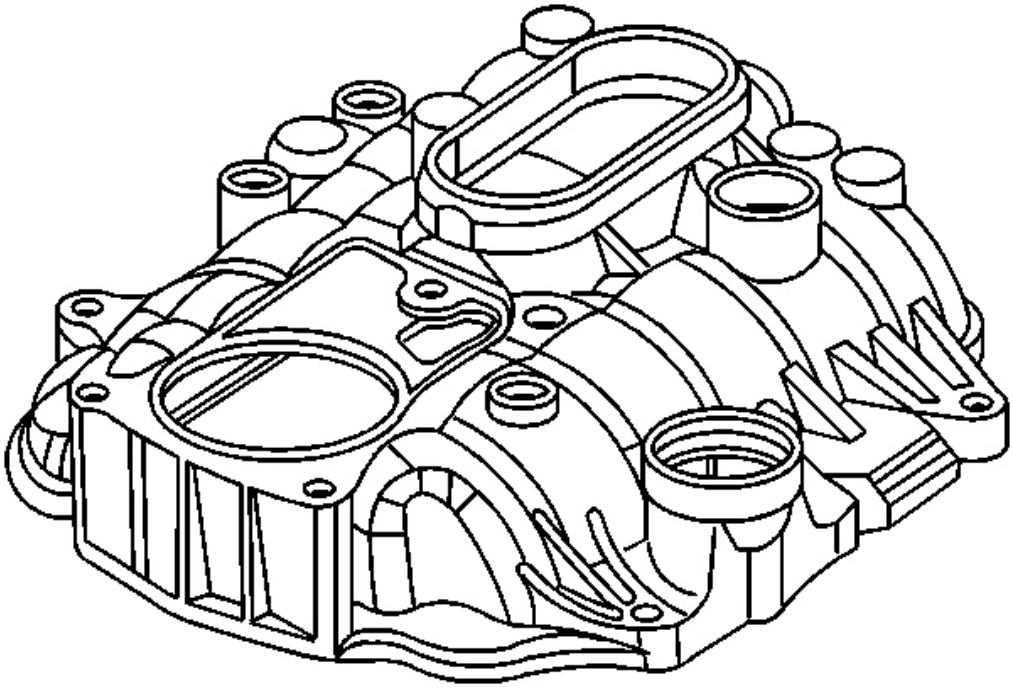


Fig. 585: Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Clean the upper intake manifold in cleaning solvent.

2. Dry the upper intake manifold with compressed air.

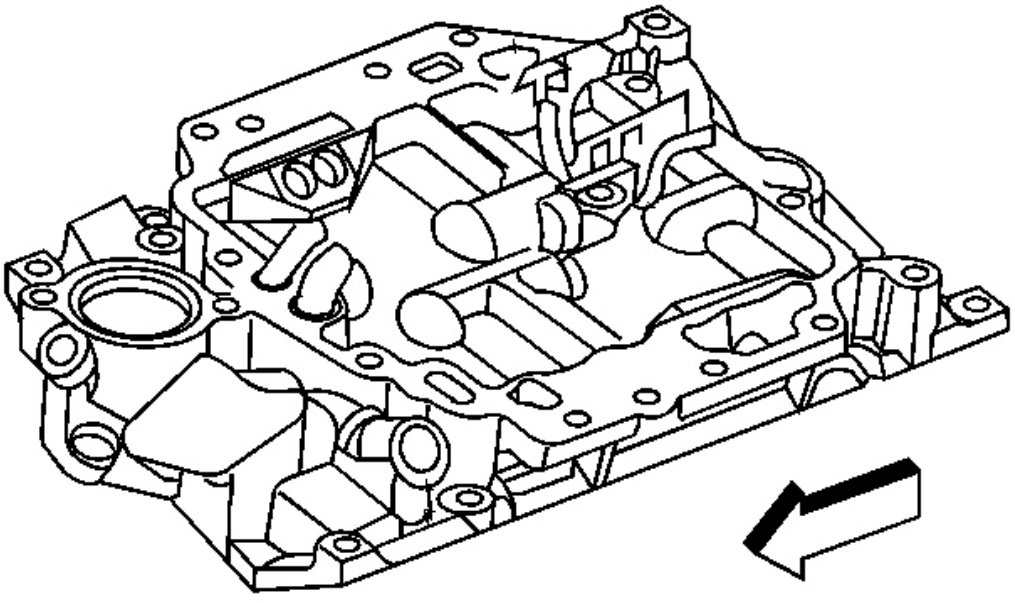


Fig. 586: Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

3. Clean the lower intake manifold in cleaning solvent.
4. Dry the lower intake manifold with compressed air.

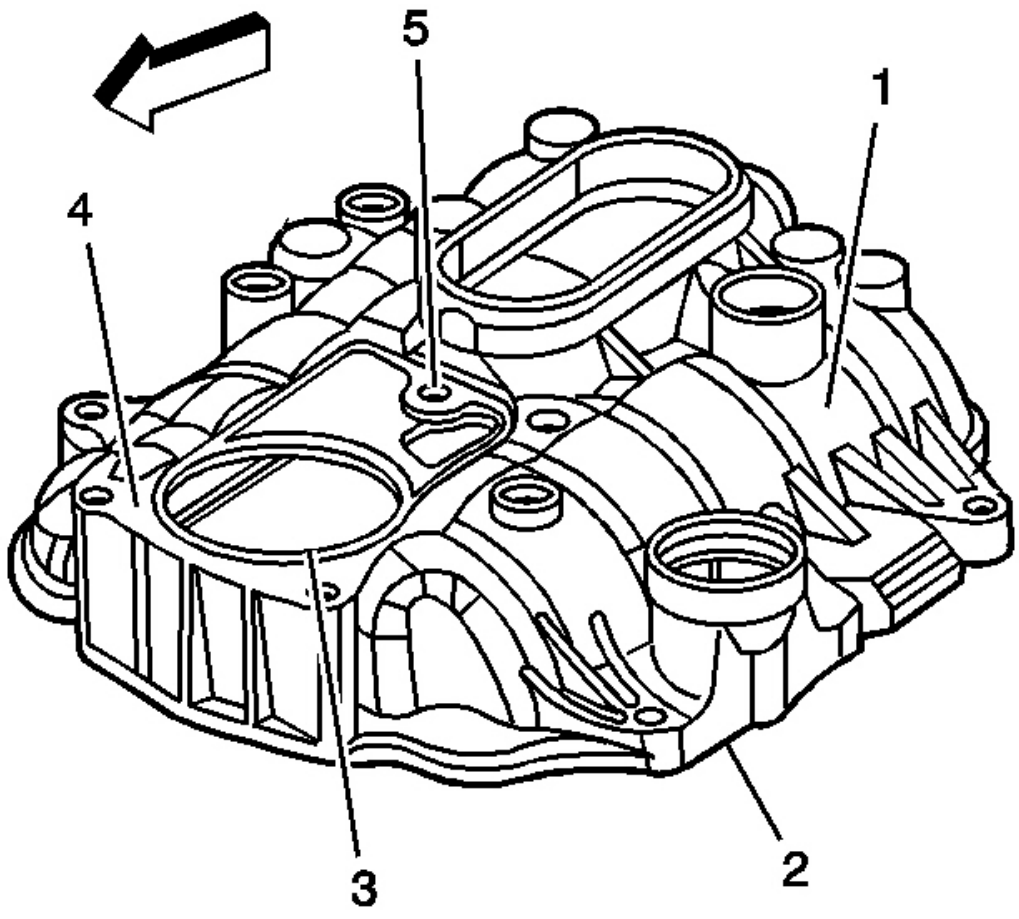


Fig. 587: Upper Intake Manifold Damage
Courtesy of GENERAL MOTORS CORP.

5. Inspect the upper intake manifold for the following:
    - Cracks or other damage to the exterior (1)
    - Cracking or damage in the gasket grooves (2) and (3)
    - Damage to the throttle body mounting surface (4)
    - Loose or damaged bolt hole thread inserts (5)

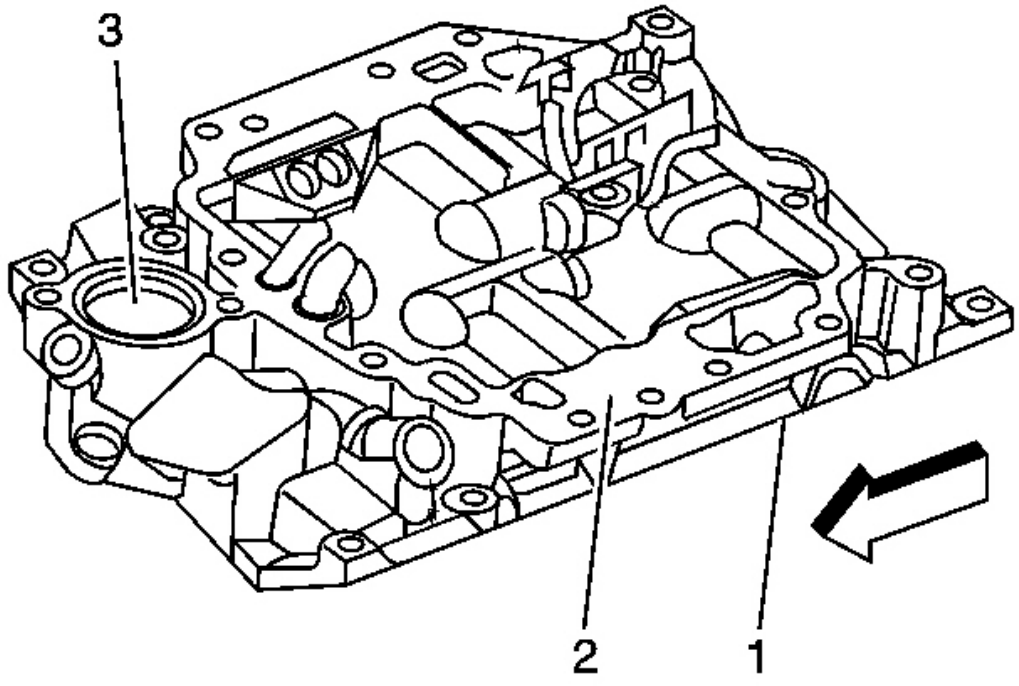


Fig. 588: Lower Intake Manifold Damage
Courtesy of GENERAL MOTORS CORP.

6. Inspect the lower intake manifold for the following:
    - Damage to the gasket sealing surfaces (1) and (2)
    - Restricted cooling system passages (3)
    - Cracks or damage
    - Damage to the threaded bolt holes

INTAKE MANIFOLD ASSEMBLE

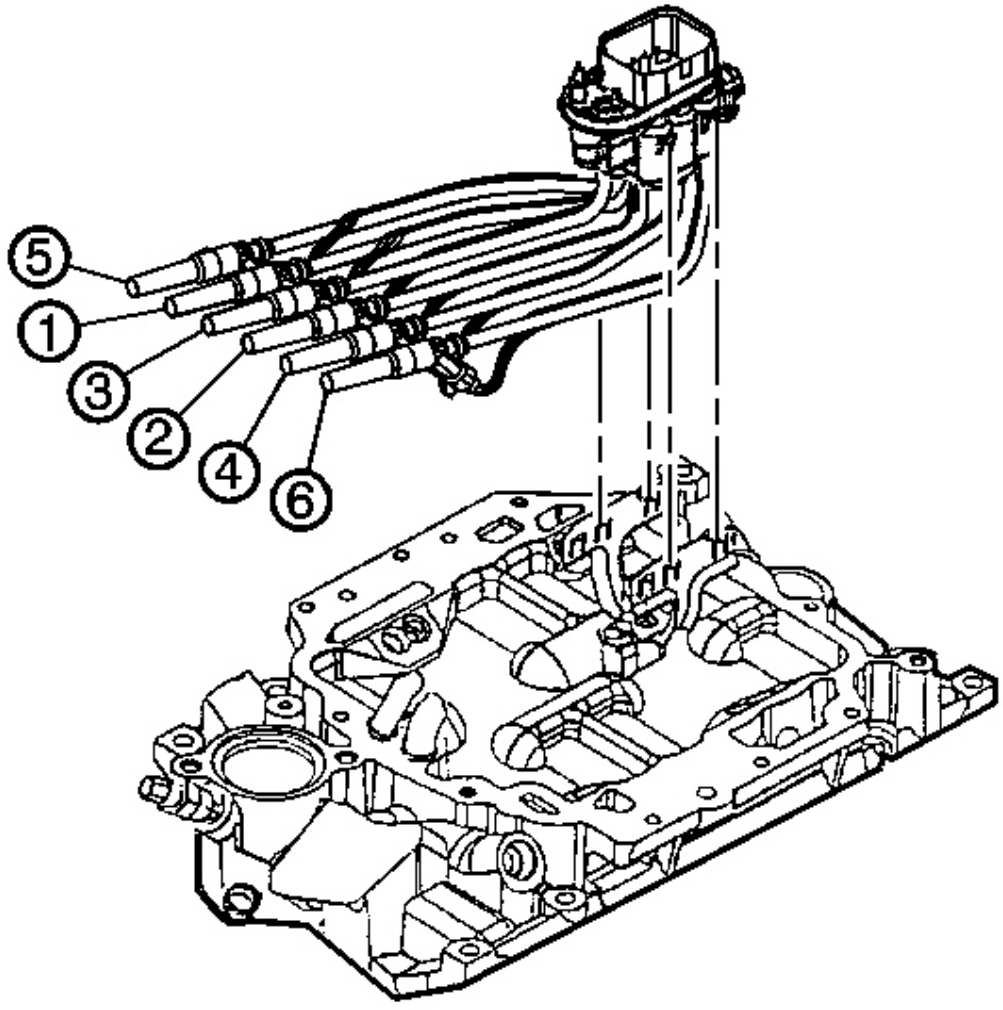


Fig. 589: Injectors At Lower Intake Manifold Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the removal of the fuel injector assembly, the retainers that hold the injectors into the intake manifold may become worn. This is OK. Upon installation of the upper intake manifold, the injectors will be held fully seated, thus keeping them from backing out of the lower intake manifold.

1. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the fuel meter body bracket bolt.

   NOTE: Refer to Fastener Notice .

2. Install the fuel meter body bracket and bolt.

   Tighten: Tighten the fuel meter bracket bolt to 10 N.m (89 lb in).

   IMPORTANT: All injector lines must face forward as the fuel meter body is snapped into the bracket. Also, the number 3 fuel tube must be positioned behind the number 1 fuel tube to eliminate interference with the upper intake manifold when installed.

3. Install the fuel meter body into the fuel meter body bracket.
4. Install the 6 injectors into the proper lower intake manifold bores in proper sequence (3, 5, 1, 2, 4, 6).
5. Inspect the injectors in order to ensure that they are firmly seated and locked in the lower intake manifold bores.
6. Ensure that the electrical connections of the injectors are positioned so that they do not interfere with each other, and are pointing towards the center of the intake manifold. Rotate the electrical connector inboard if necessary. Also, ensure there is no tension on the injector wires.

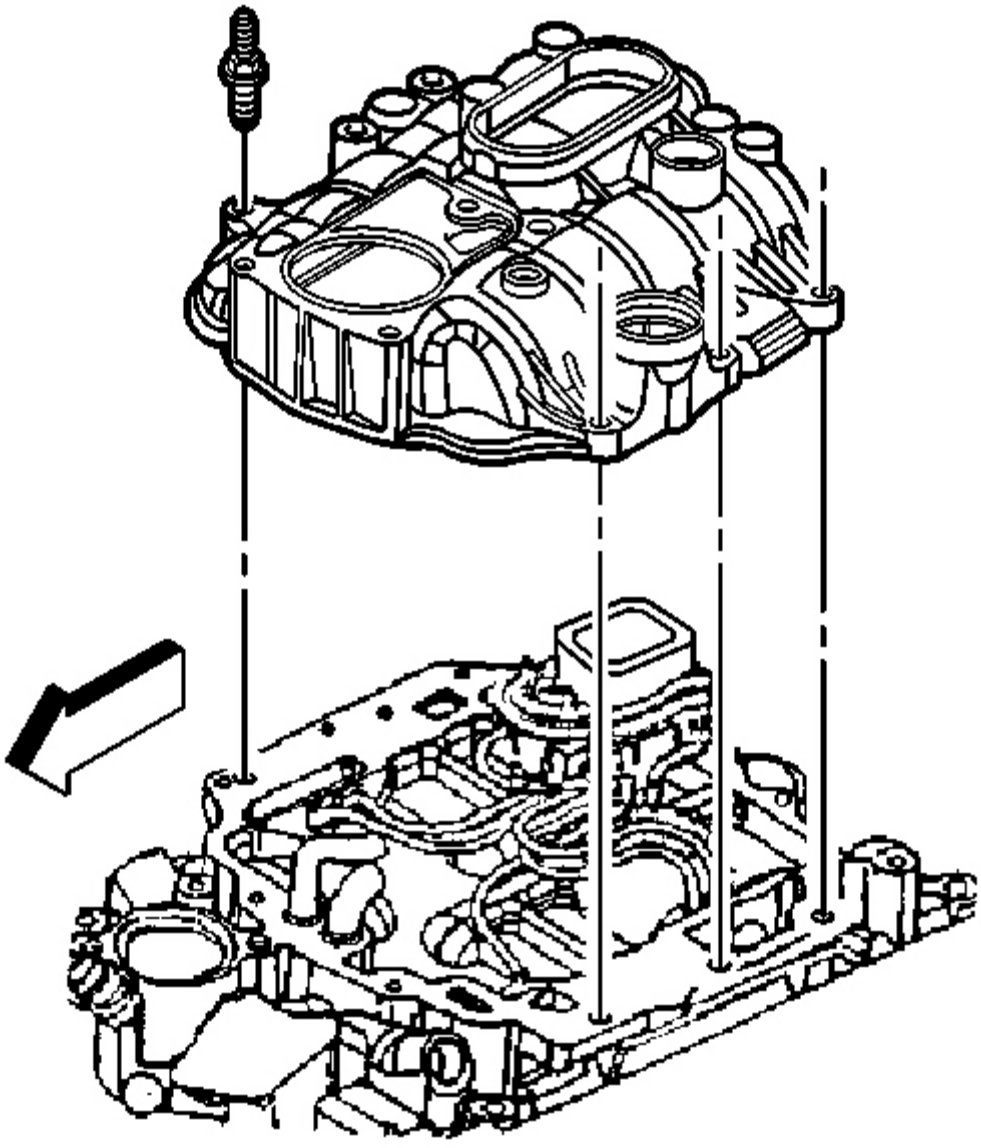


Fig. 590: Identifying Upper Intake Manifold Attaching Studs
Courtesy of GENERAL MOTORS CORP.

7. Install a NEW upper intake manifold to lower intake manifold gasket into the groove of the upper intake manifold.
8. Install the upper intake manifold onto the lower intake manifold.

9. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the upper intake manifold attaching studs.
10. Install the upper intake manifold attaching studs.

Tighten:

1. Tighten the upper intake manifold attaching studs on the first pass to 5 N.m (44 lb in).
2. Tighten the upper intake manifold attaching studs on the final pass to 9 N.m (80 lb in).

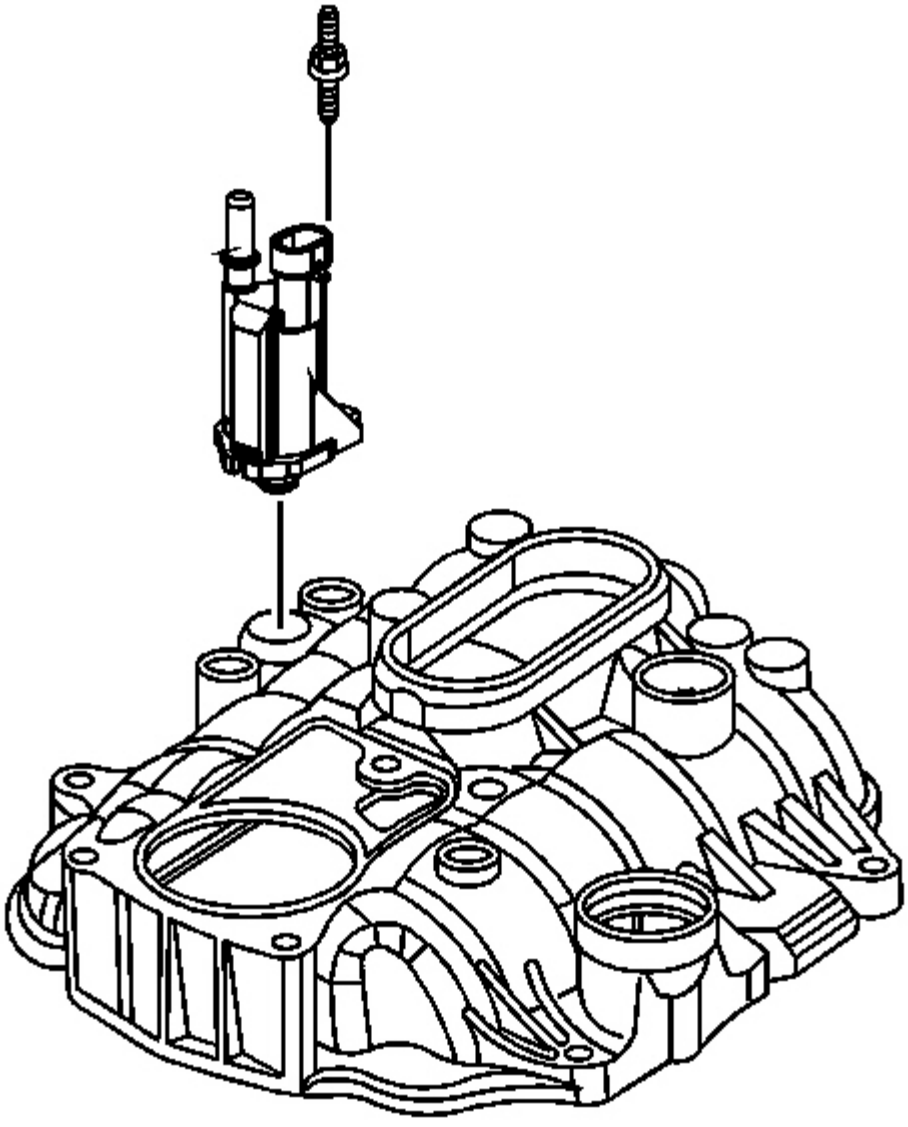


Fig. 591: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

11. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the evaporative emission (EVAP) canister purge solenoid valve studs.

12. Install the EVAP canister purge solenoid valve and studs.

    Tighten: Tighten the EVAP canister purge solenoid valve studs to 10 N.m (89 lb in).

13. Install the engine wiring harness bracket and nut.

    Tighten: Tighten the engine wiring harness bracket nut to 12 N.m (106 lb in).

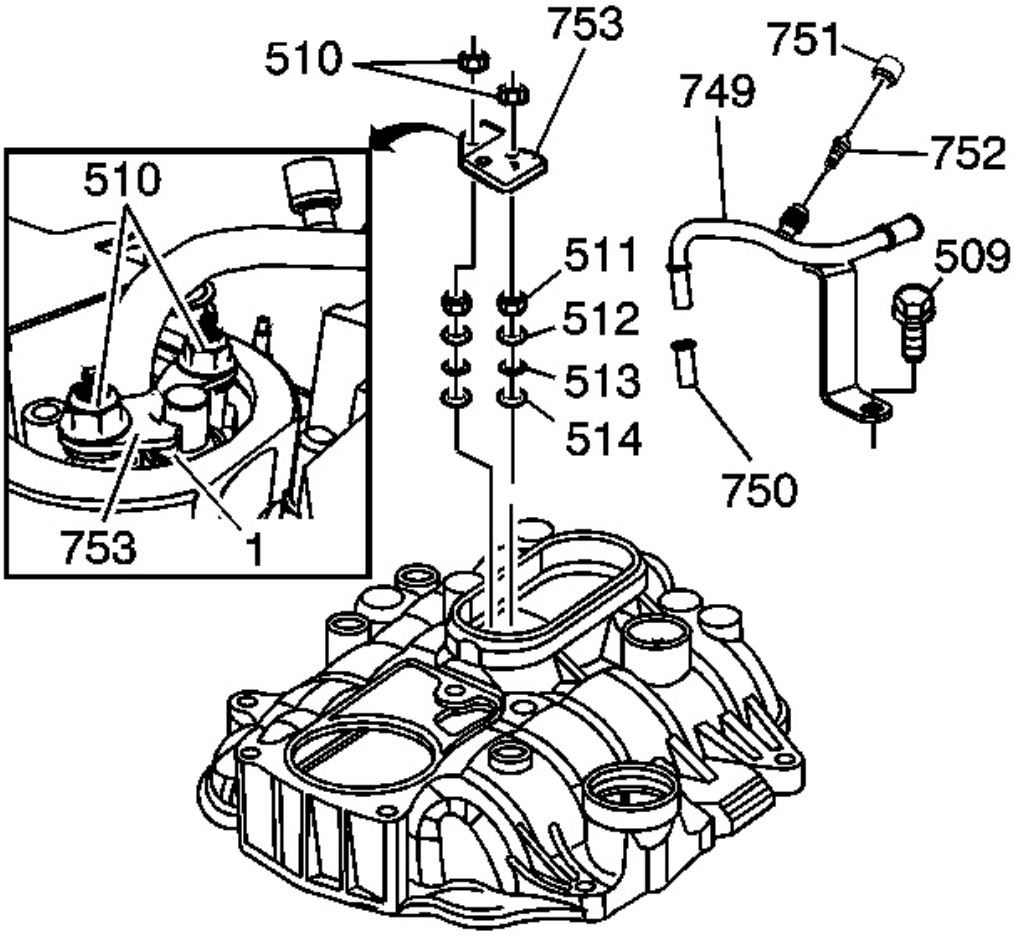


Fig. 592: Fuel Pipes & New Seals
Courtesy of GENERAL MOTORS CORP.

14. Install the NEW fuel seals (514), black O-rings, into the fuel meter body.

15. Install the NEW spacer rings (513), flat washers, into the fuel meter body.
16. Install the NEW fuel seals (512), yellow O-rings, into the fuel meter body.
17. Install the NEW fuel seal retainers (511) into the fuel meter body.
18. Install the fuel pipe plug (750), if required.
19. Install the fuel pipe (749) into the fuel meter body.

IMPORTANT: Make sure to properly align the fuel line retainer flanges (1) to face downward towards the fuel meter body, and that flanges rest on the shoulders of the fuel plug and the fuel line. Failure to do so may cause the fuel plug and the fuel line to come out of the fuel meter body, resulting in fuel spillage.

20. Install the fuel pipe retainer bracket (753) onto the fuel pipe.
21. Install the fuel pipe retainer bracket nuts (510).
22. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the fuel pipe bolt.
23. Install the fuel service port cap (751) and schrader valve (752), if required.
24. Install the fuel pipe bolt (509).

Tighten:

1. Tighten the fuel pipe bracket nuts to 3 N.m (27 lb in).
2. Tighten the fuel pipe bolt to 6 N.m (53 lb in).

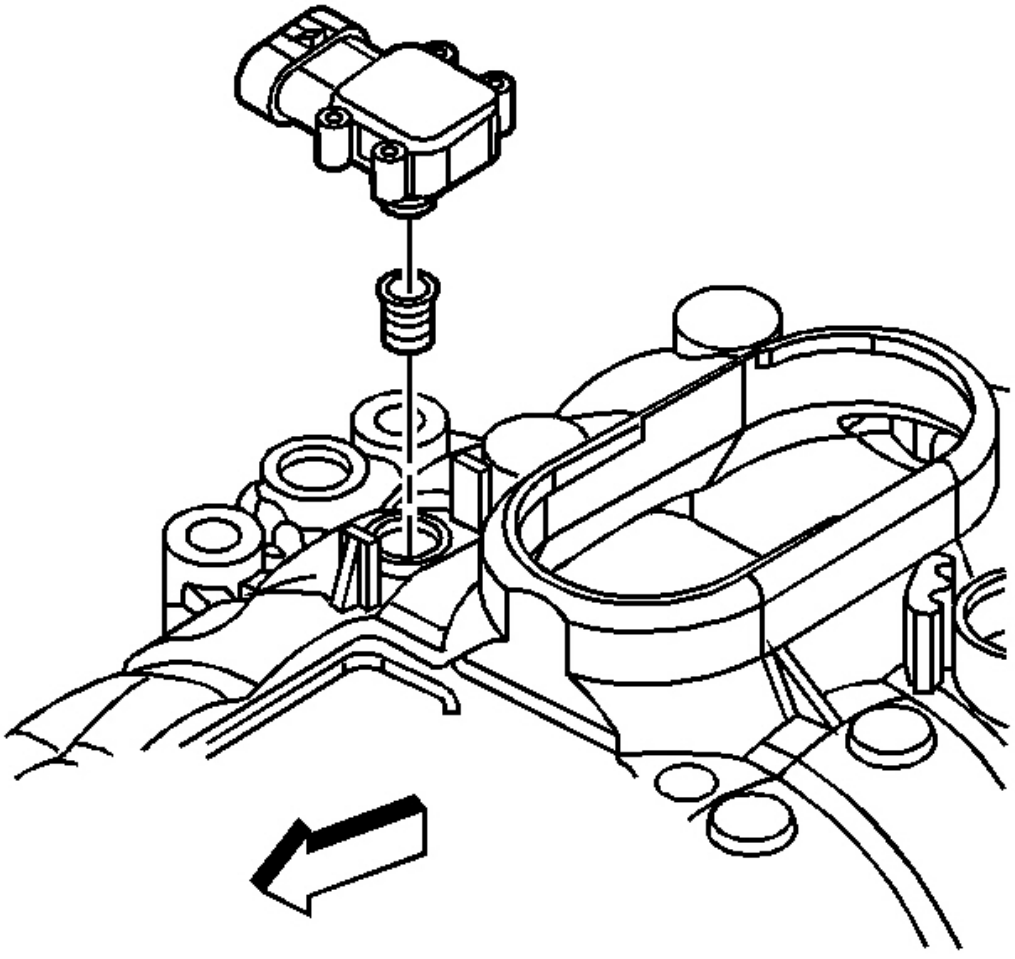


Fig. 593: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

25. Install a NEW manifold absolute pressure (MAP) sensor seal onto the MAP sensor.
26. Apply a small amount, approximately 1 drop, of clean engine oil to the MAP sensor seal.
27. Install the MAP sensor into the upper intake manifold.

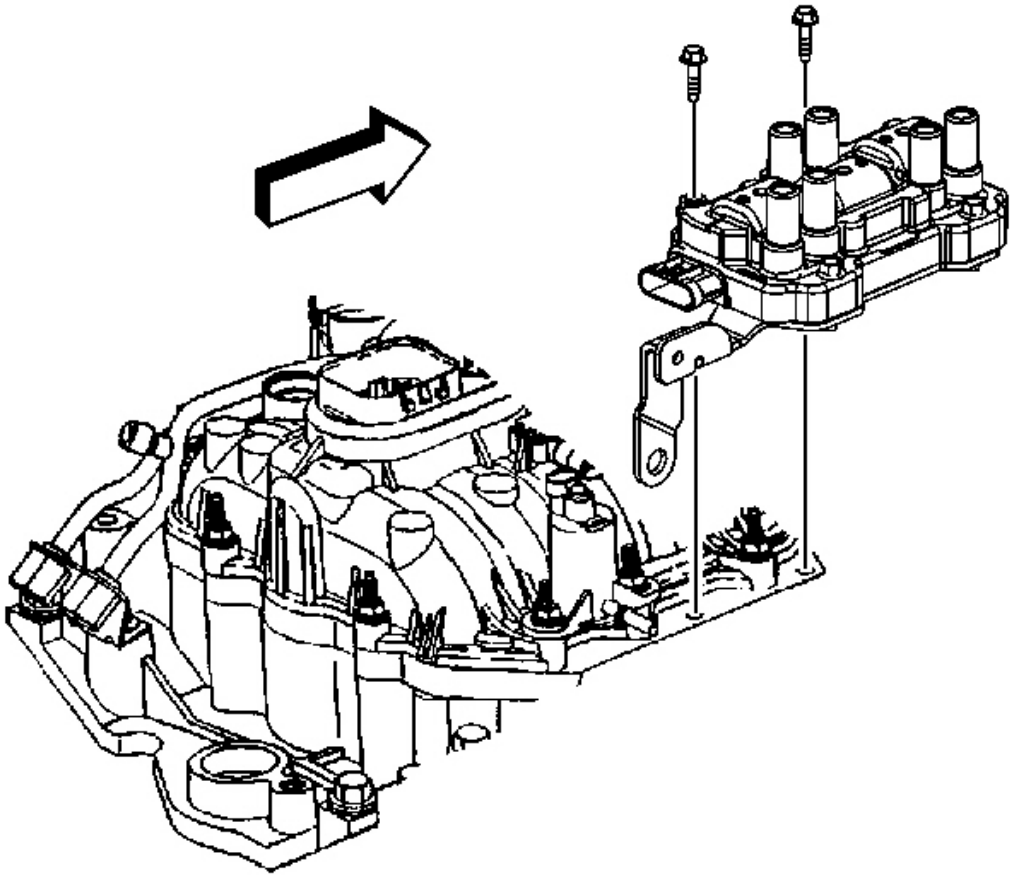


Fig. 594: View Of Studs And Ignition Coil
Courtesy of GENERAL MOTORS CORP.

28. Install the ignition coil and studs.

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

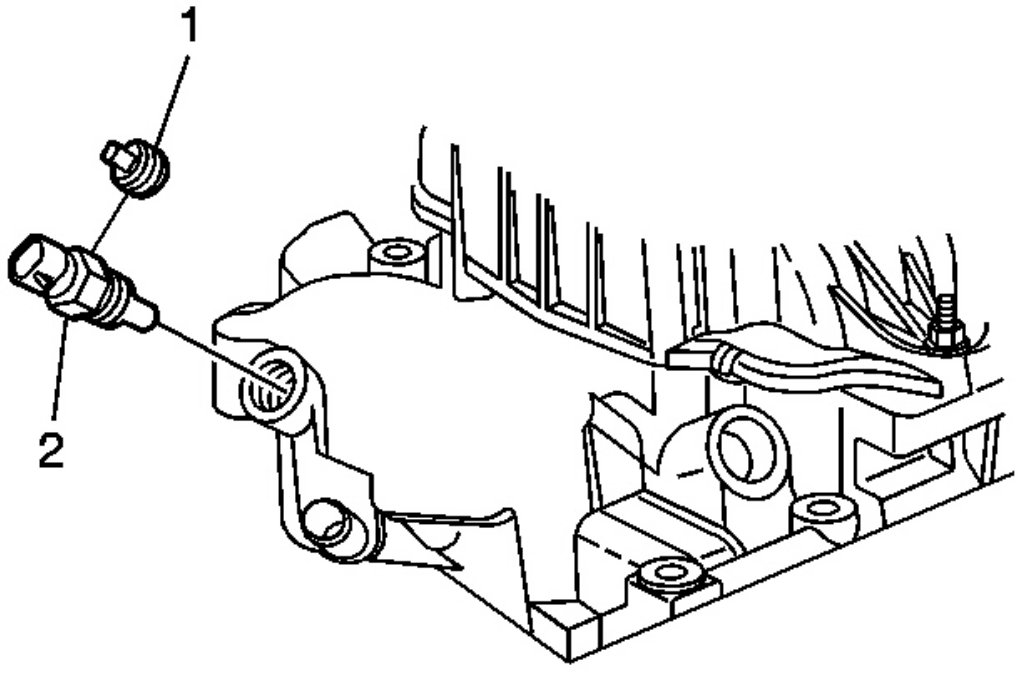


Fig. 595: ECT Sensor & Plug
Courtesy of GENERAL MOTORS CORP.

29. If reusing the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2), if equipped, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the ECT sensor plug (1) or the ECT sensor (2).
30. Install the ECT sensor or plug, if equipped, into the front of the lower intake manifold.

    Tighten: Tighten the ECT sensor or plug to 20 N.m (15 lb ft).

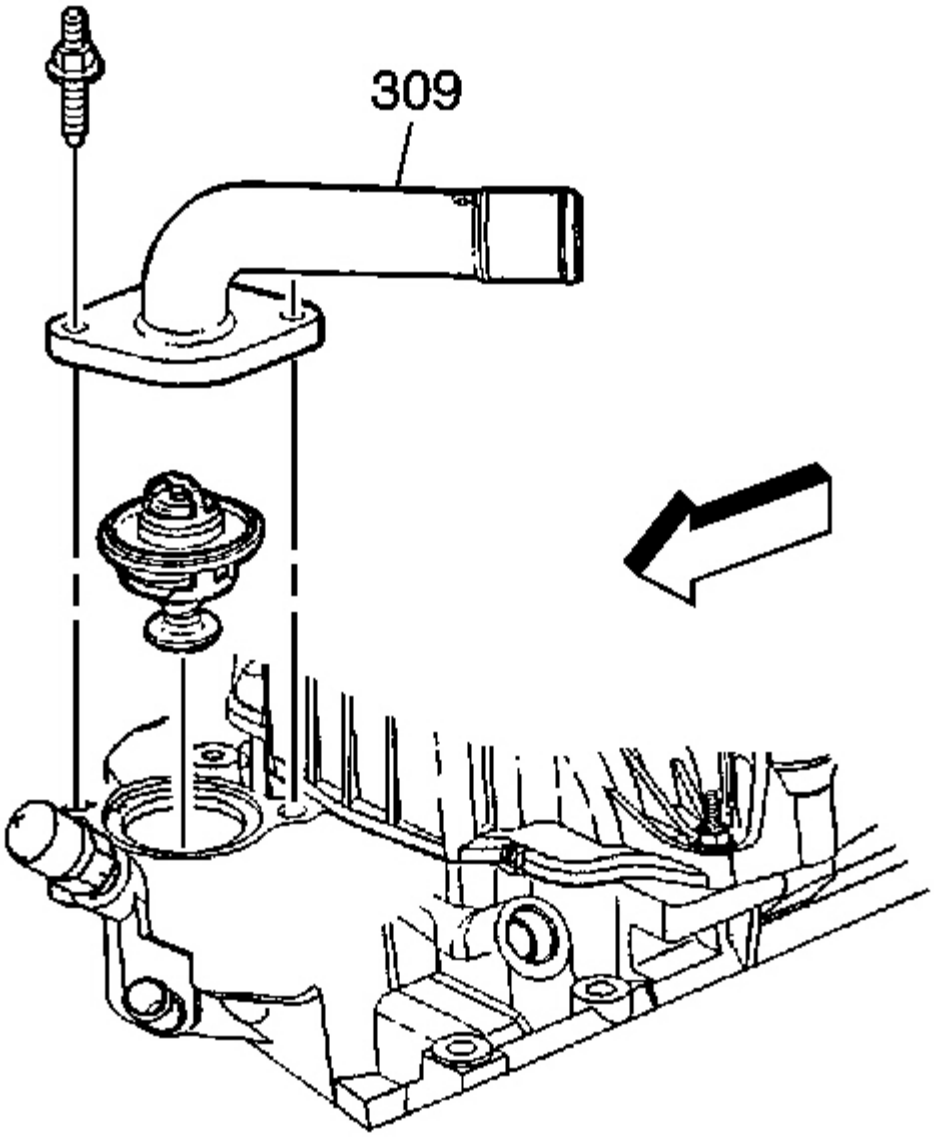


Fig. 596: Engine Coolant Thermostat
Courtesy of GENERAL MOTORS CORP.

31. Install the engine coolant thermostat.
32. Install the water outlet (309).
33. Install the water outlet studs.

Tighten: Tighten the water outlet studs to 25 N.m (18 lb ft).

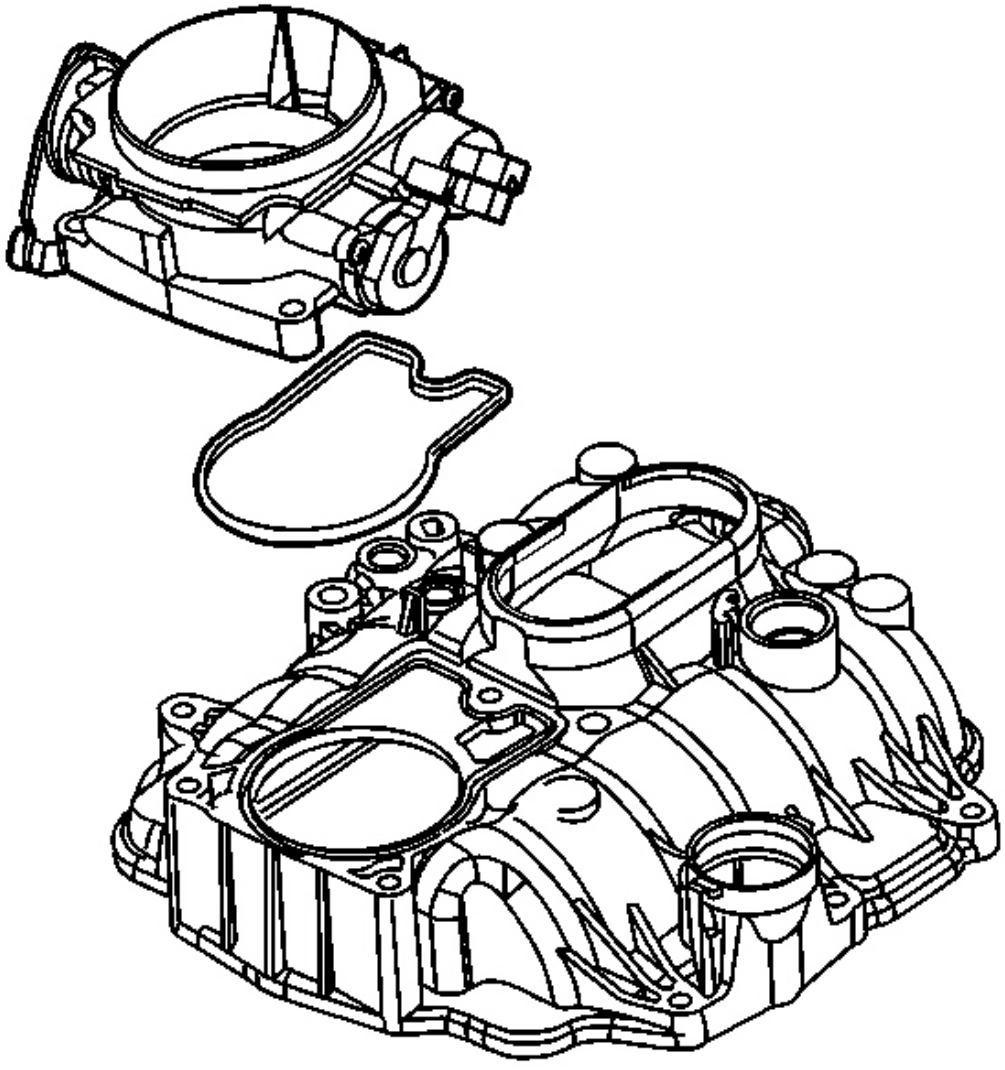


Fig. 597: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

34. Install a NEW throttle body gasket into the groove in the upper intake manifold.
35. Install the throttle body onto the upper intake manifold.

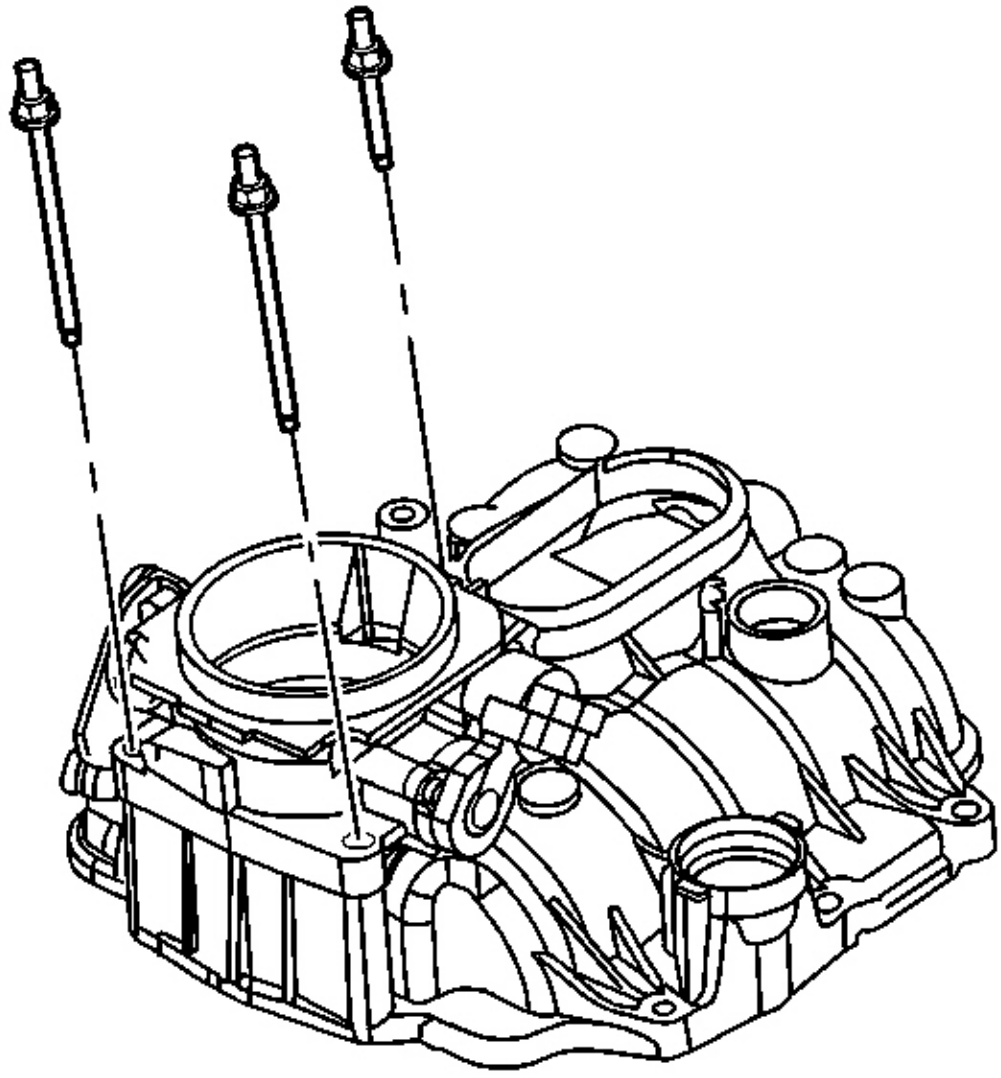


Fig. 598: View Of Throttle Body & Attaching Studs
Courtesy of GENERAL MOTORS CORP.

36. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the throttle body attaching studs.
37. Install the throttle body attaching studs.

Tighten: Tighten the throttle body attaching studs to 9 N.m (80 lb in).

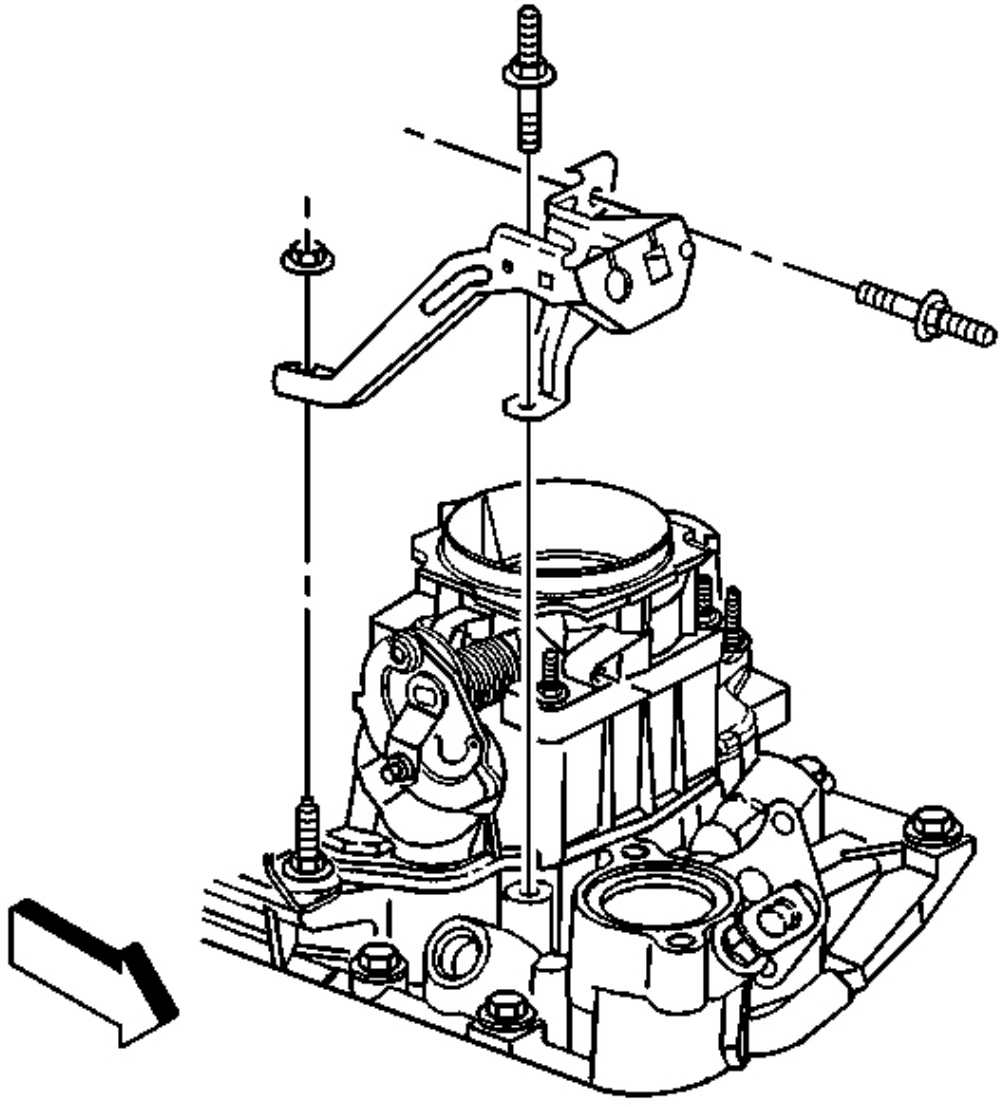


Fig. 599: View Of Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

38. Install the accelerator control cable bracket, the studs, and the nuts.

Tighten:

1. Tighten the accelerator control cable bracket stud to the intake manifold to 6 N.m (53

lb in).

2. Tighten the accelerator control cable bracket nuts to 12 N.m (106 lb in).
3. Tighten the accelerator control cable bracket stud to the throttle body to 12 N.m (106 lb in).

EXHAUST MANIFOLD CLEANING AND INSPECTION

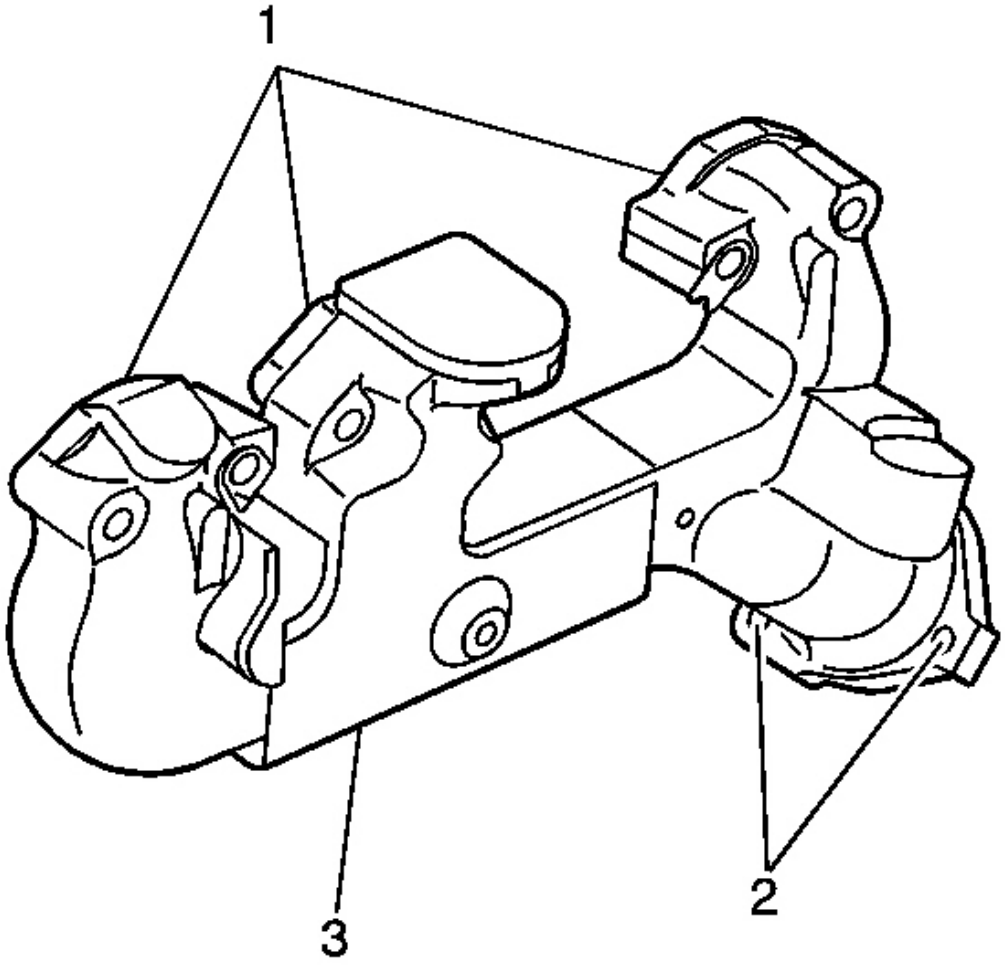


Fig. 600: Exhaust Manifold Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Clean the exhaust manifolds in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
   - Damage to the gasket sealing surfaces (1)
   - Damage to the threaded holes (2)
   - Restrictions within exhaust passages
   - Broken or damaged exhaust manifold heat shields (3), if applicable
   - Broken or damaged exhaust manifold

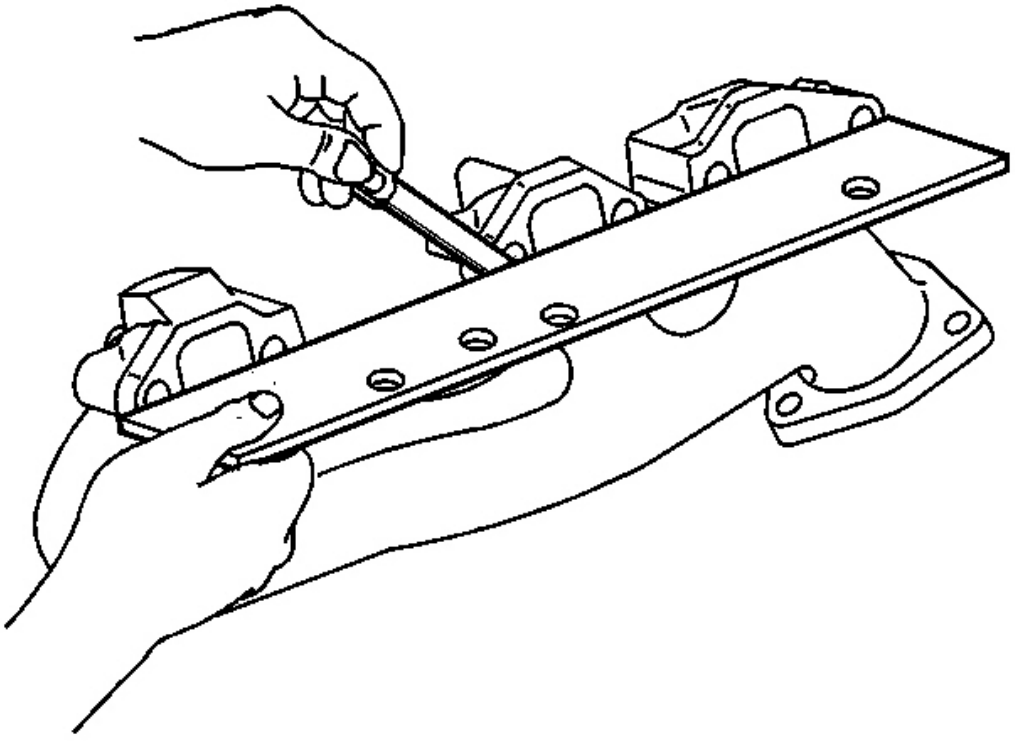


Fig. 601: Measuring Exhaust Manifold Flanges Alignment
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges using a straight

edge and a feeler gage. Refer to **Engine Mechanical Specifications**.

If the surface flatness is not within the specifications, the exhaust manifold is warped and must be replaced.

WATER PUMP CLEANING AND INSPECTION

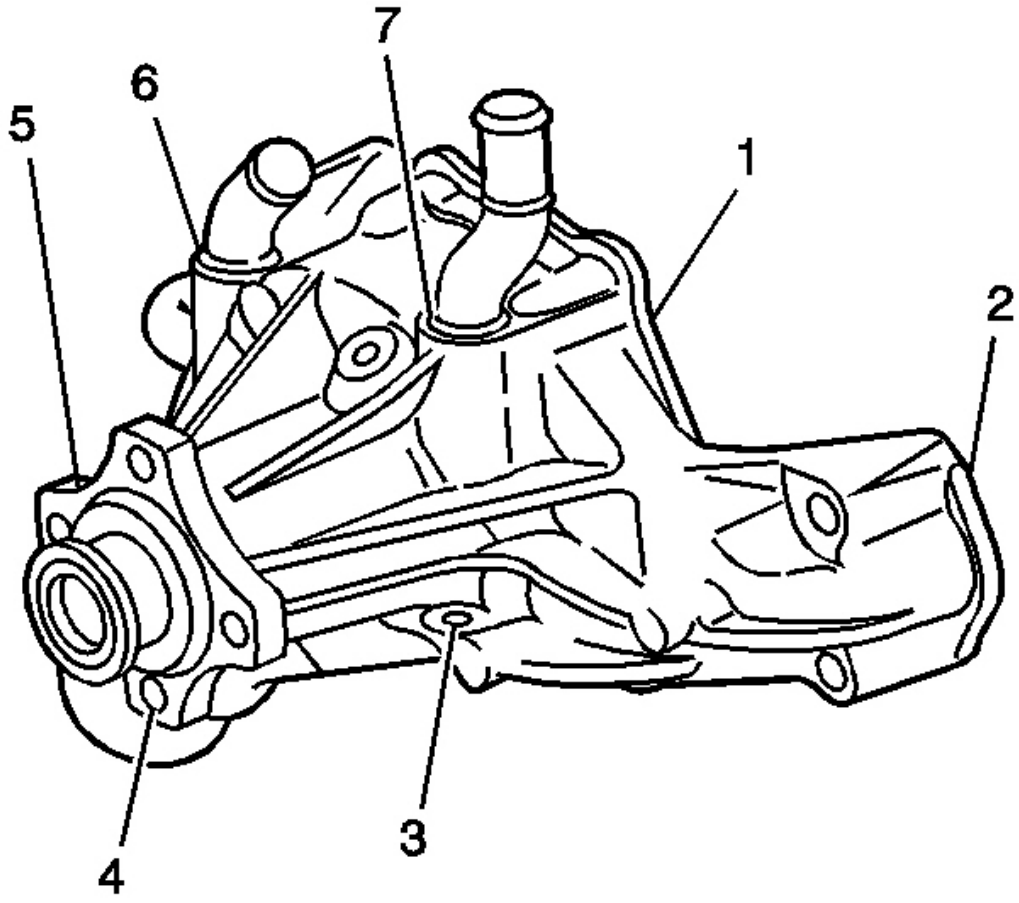


Fig. 602: Water Pump Inspection Areas
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all the dirt and any debris from the water pump.
3. Inspect the water pump for the following:
   - Leakage or damage to the housing cover or gasket (1)
   - Excessive scratches or gouging to the gasket sealing surfaces (2)
   - Leakage from the water pump vent hole (3)

     A stain around the vent hole is acceptable. If leakage occurred (dripping) with the engine operating and the cooling system pressurized, then replace the water pump.

   - Damaged bolt hole threads (4)
   - Excessive side-to-side movement of the water pump shaft (5)
   - Leakage around the water inlet pipe (6)
   - Leakage around the heater hose pipe (7)
   - Restrictions within the internal coolant passages

THREAD REPAIR

General purpose thread repair kits are available commercially.

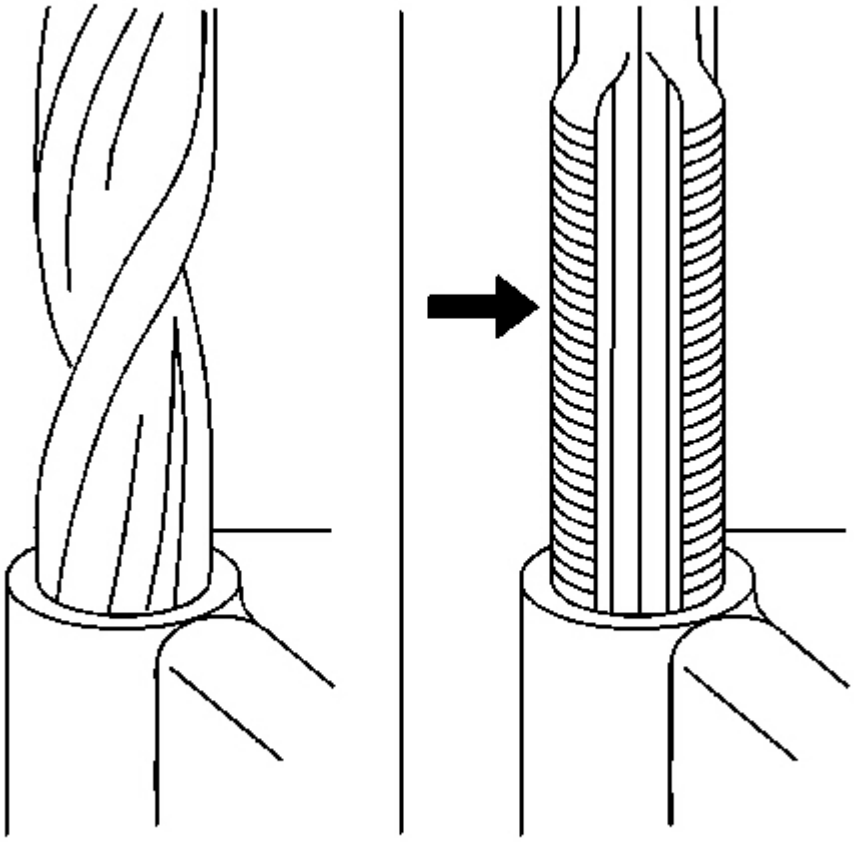


Fig. 603: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

IMPORTANT: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use. Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread.

2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
3. Drill out the damaged thread.
4. Remove the chips.
5. Apply clean engine oil to the top thread.
6. Use the tap in order to cut new thread.
7. Clean the thread.

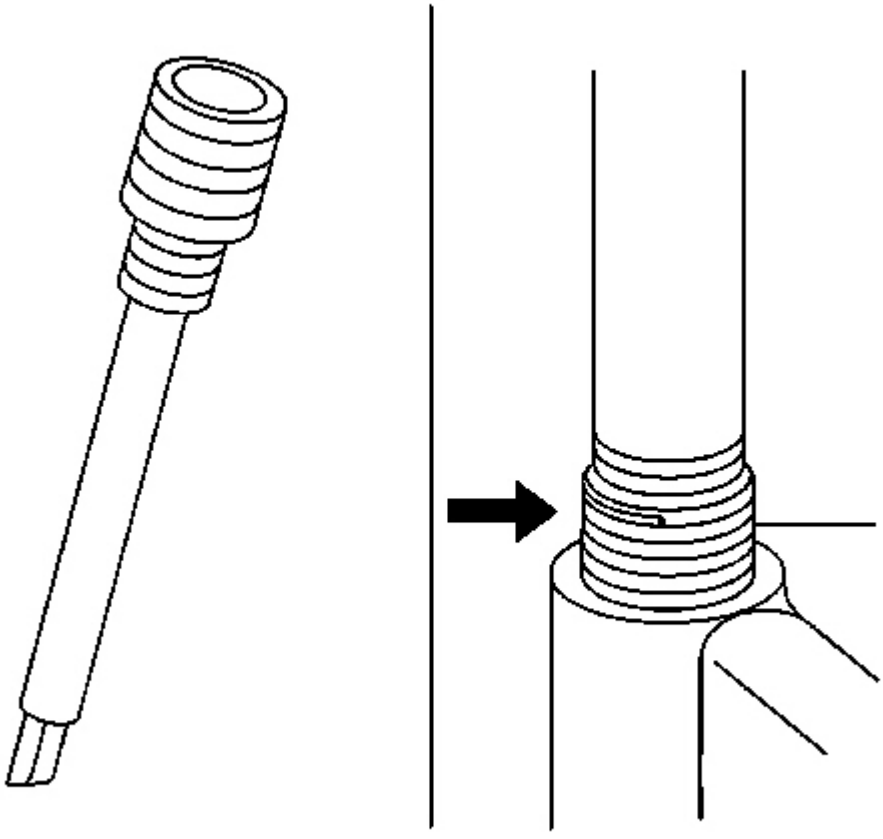


Fig. 604: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the

thread insert onto the end of the mandrel.

IMPORTANT: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

SERVICE PRIOR TO ASSEMBLY

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are re-installed into an engine, return the components to the original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil, unless otherwise specified. The engine oil will provide the initial lubrication when the engine is first started.

ENGINE BLOCK PLUG INSTALLATION

Special Tools

J 41712 Oil Pressure Switch Socket. See **Special Tools**.

Installation

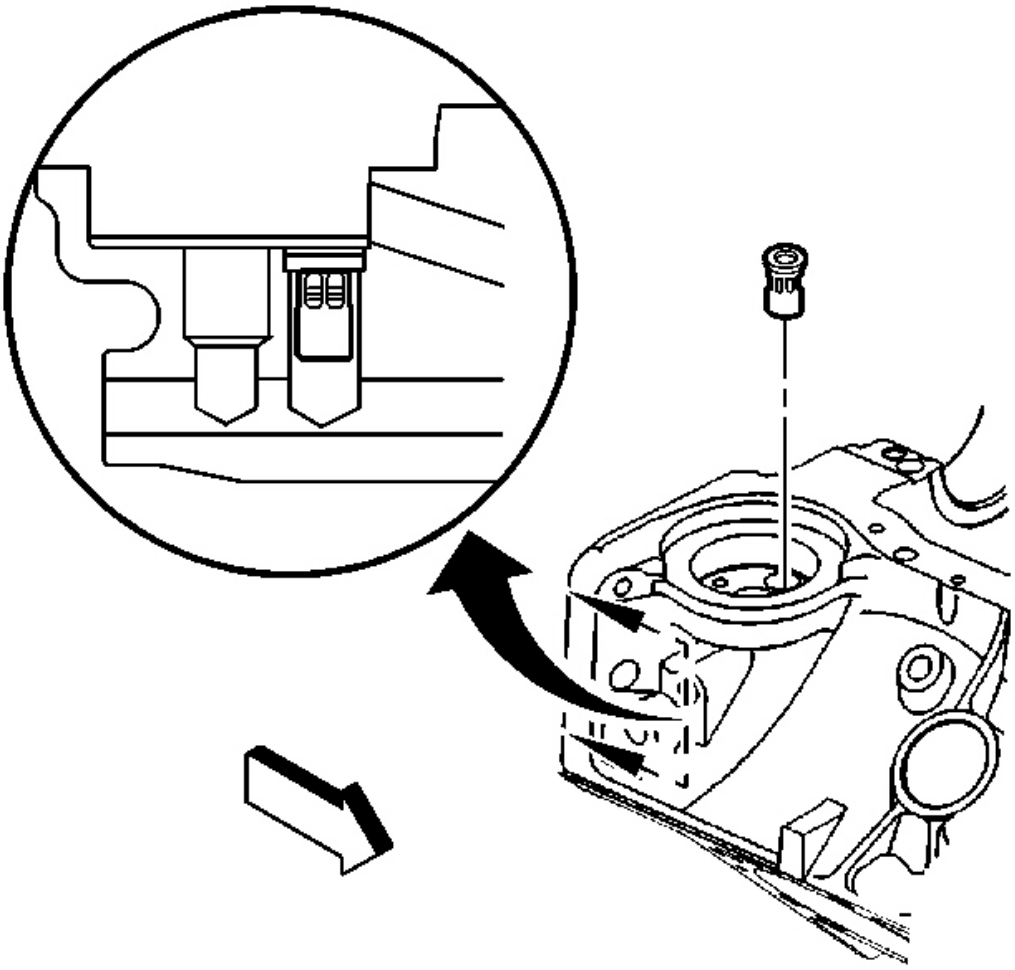


Fig. 605: Locating Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Install a NEW oil filter bypass valve.
    1. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
    2. Using a pointed punch, stake the engine block area around the oil filter bypass valve.

Stake in 3 locations 120 degrees apart.

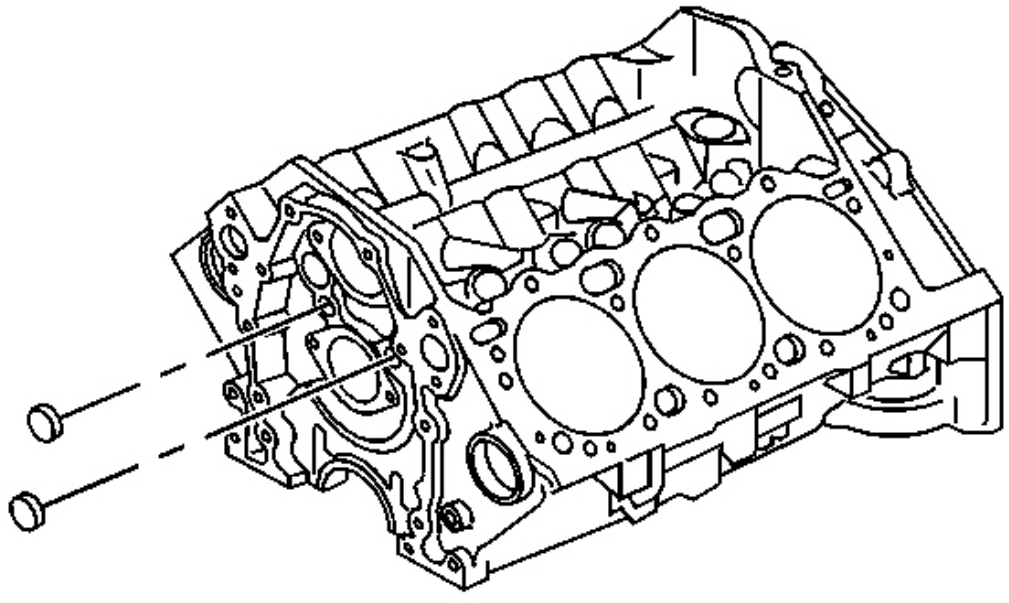


Fig. 606: Front Of Engine Block Front Oil Gallery Plugs Or Balls
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW front engine oil gallery plugs.
3. Install the NEW front engine block oil gallery plugs.

   A properly installed front engine oil gallery plug must be installed slightly below flush with the front face of the engine block.

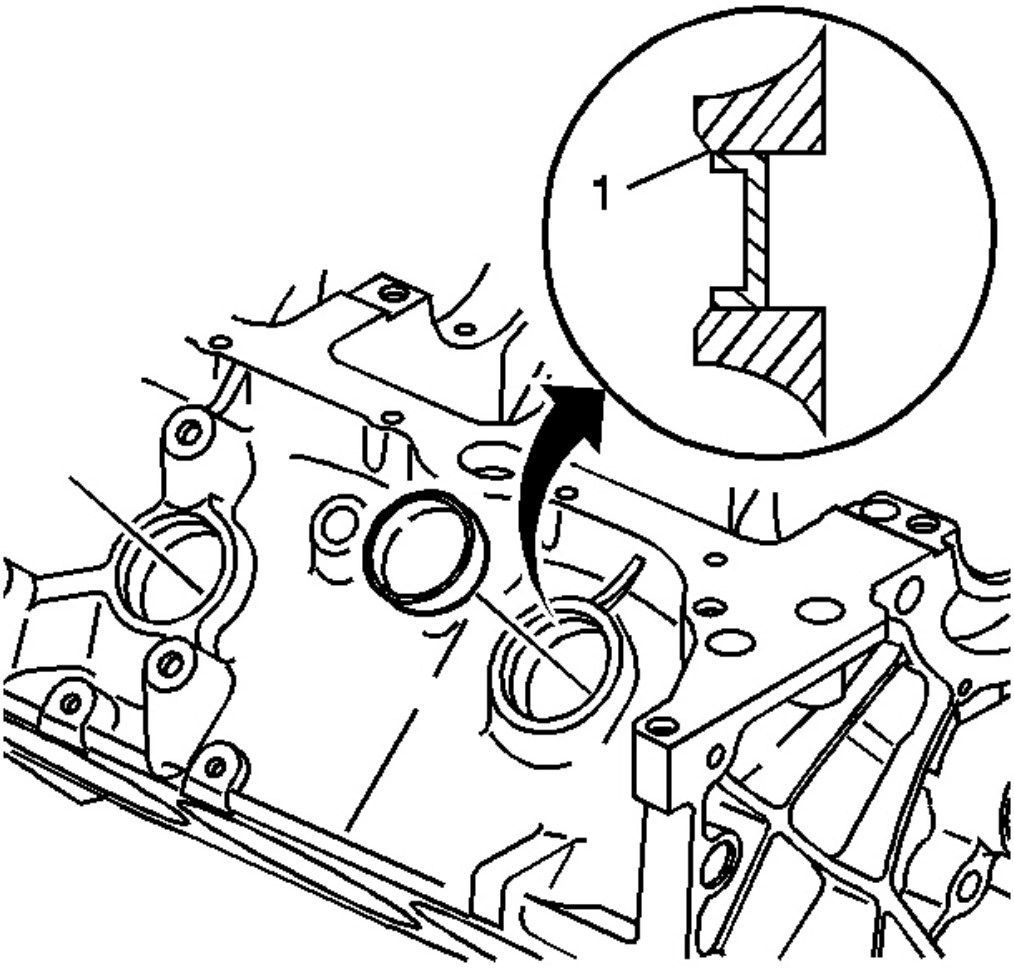


Fig. 607: Engine Block Core Hole Chamfer
Courtesy of GENERAL MOTORS CORP.

4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the outside diameter of the NEW engine block core hole plugs.
5. Install the NEW engine block core hole plugs.

   A properly installed engine block core hole plug must be installed flush or below the bottom of the chamfer (1) of the engine block core hole.

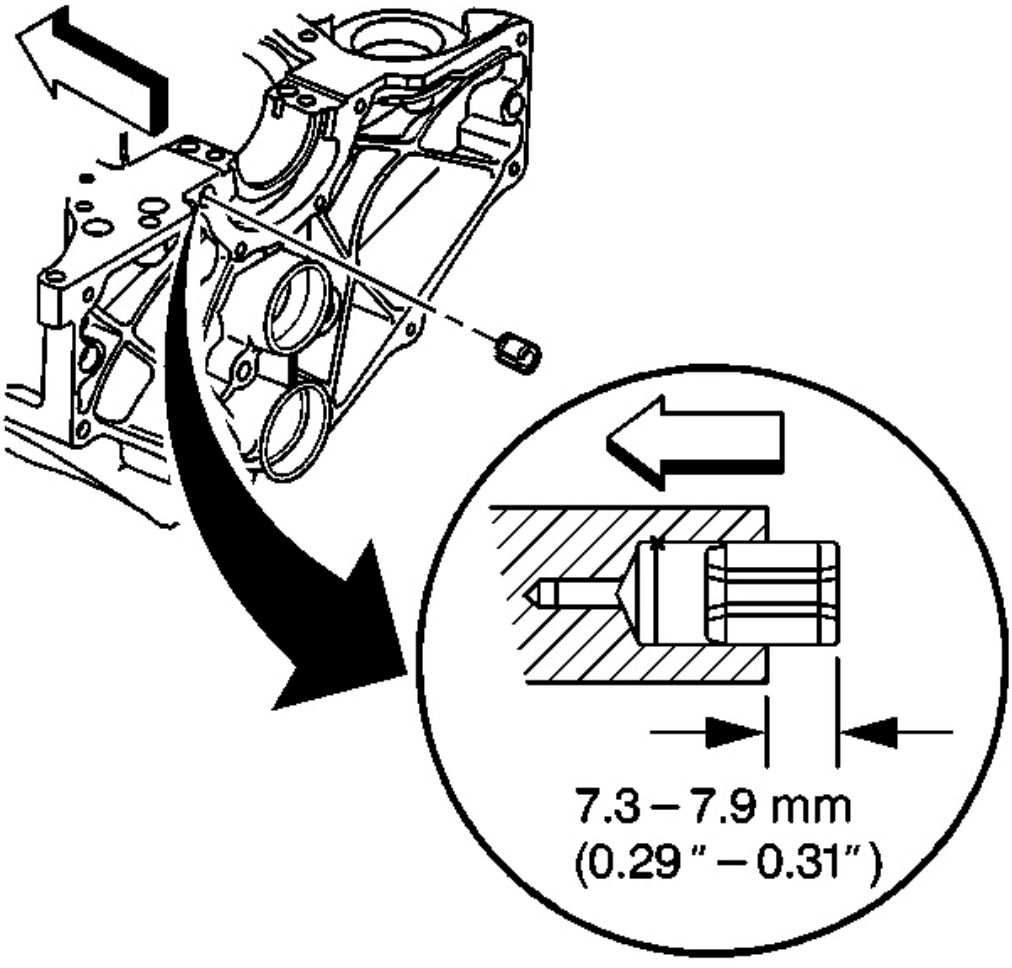


Fig. 608: Installing Crankshaft Rear Oil Seal Housing Locator Spring
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft rear oil seal housing locator spring type S pin, if required.

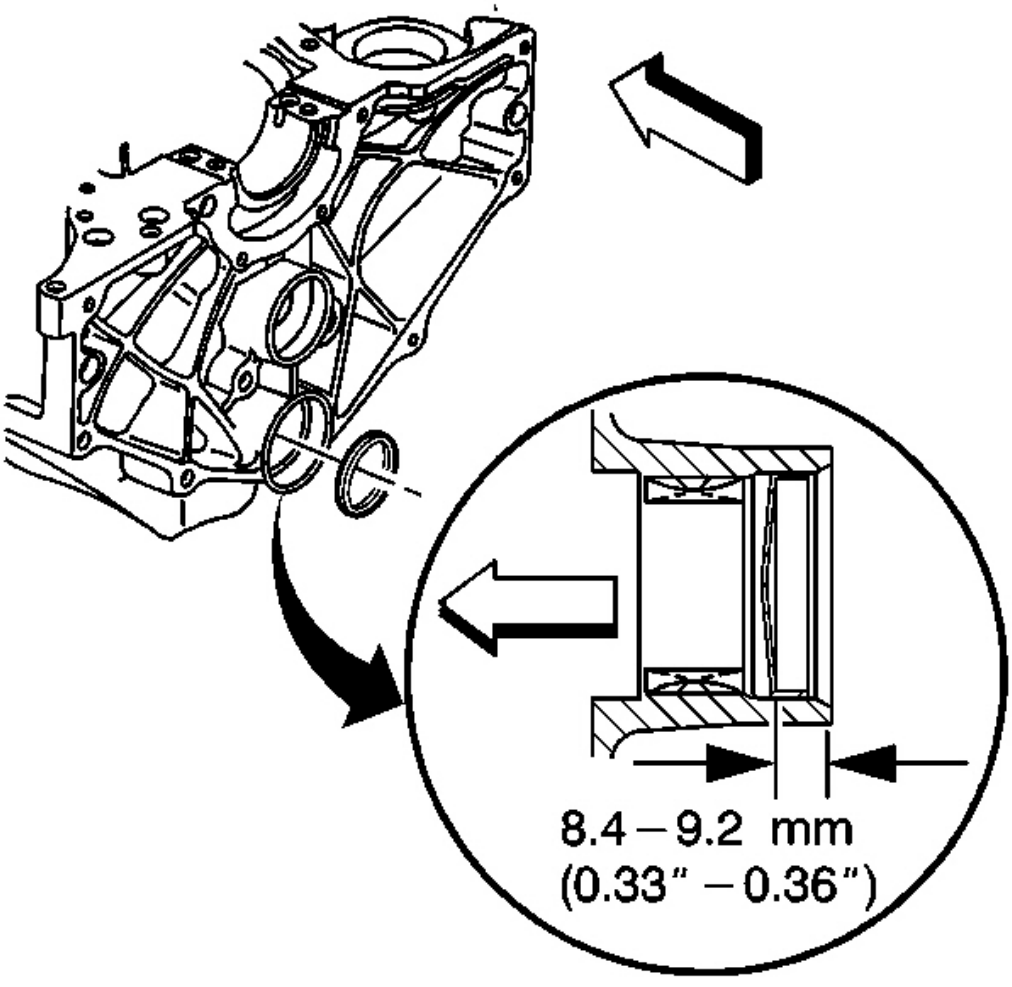


Fig. 609: Installing Expansion Cup Plug Into Balance Shaft Rear Bearing Bole
Courtesy of GENERAL MOTORS CORP.

7. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW expansion cup plug.
8. Install the NEW expansion cup plug into the balance shaft rear bearing hole.

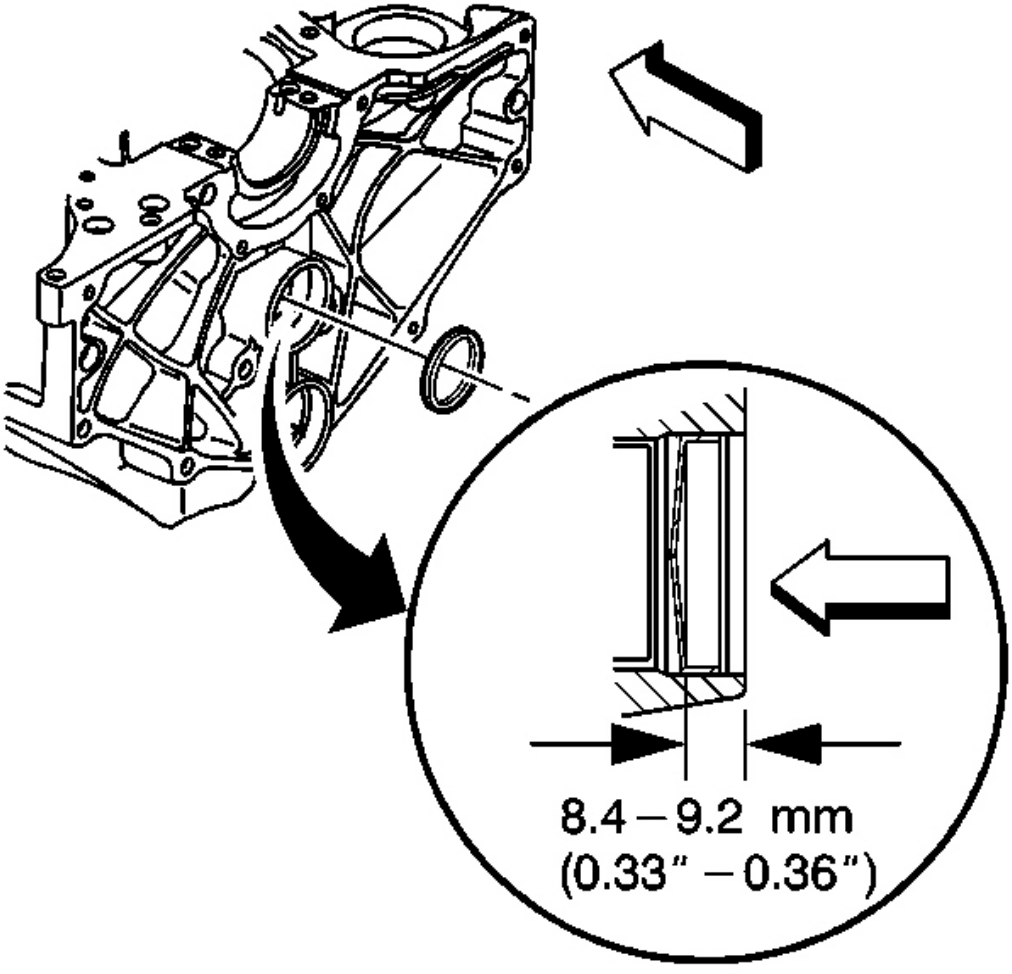


Fig. 610: Installing Expansion Cup Plug Into Camshaft Rear Bearing Hole
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW expansion cup plug.
10. Install the NEW expansion cup plug into the camshaft rear bearing hole.

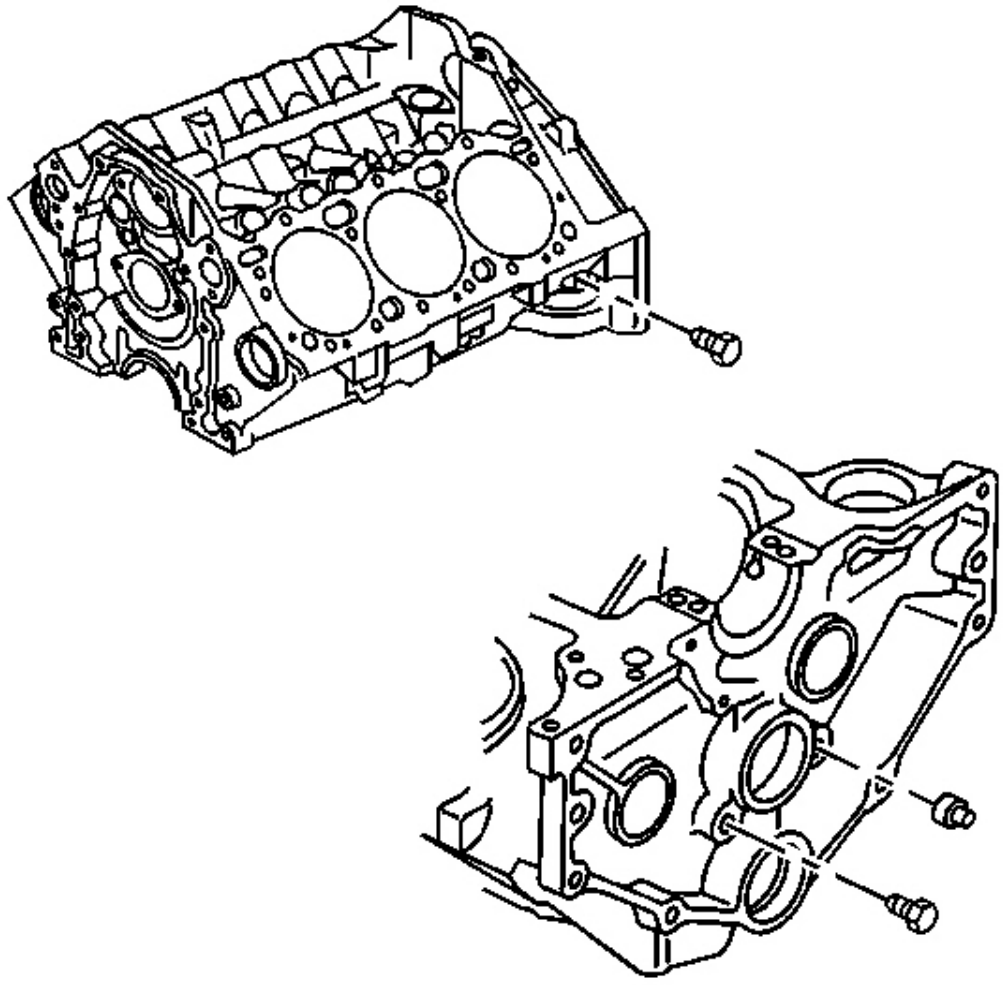


Fig. 611: Engine Block Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

11. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

NOTE: Refer to Fastener Notice .

12. Install the engine block right rear oil gallery plug, the engine block left rear oil gallery plug,

and the engine block left side oil gallery plug.

Tighten:

- Tighten the engine block left side oil gallery plug and the engine block right rear oil gallery plug to 20 N.m (15 lb ft).
- Tighten the engine block left rear oil gallery plug to 30 N.m (22 lb ft).

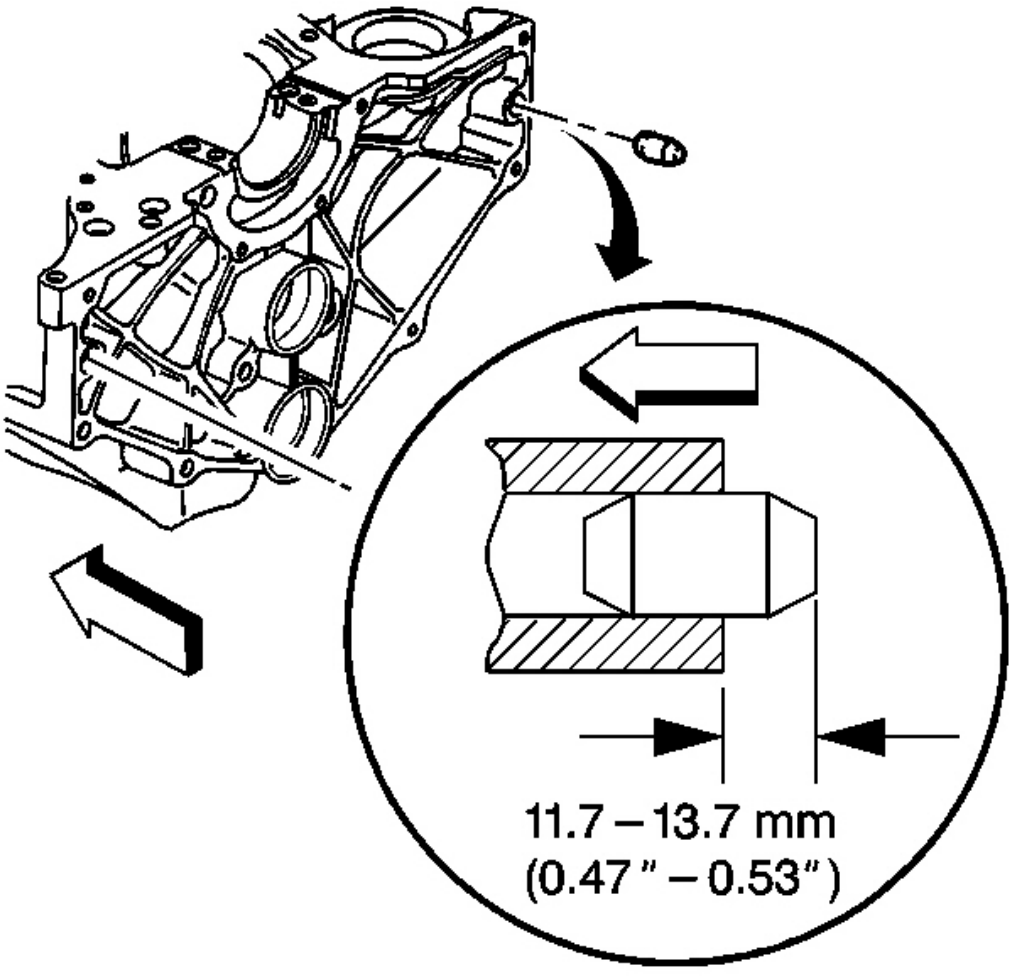


Fig. 612: Installing Transmission Locator Dowel Straight Pins
Courtesy of GENERAL MOTORS CORP.

13. Install the transmission locator dowel straight pins, if required.

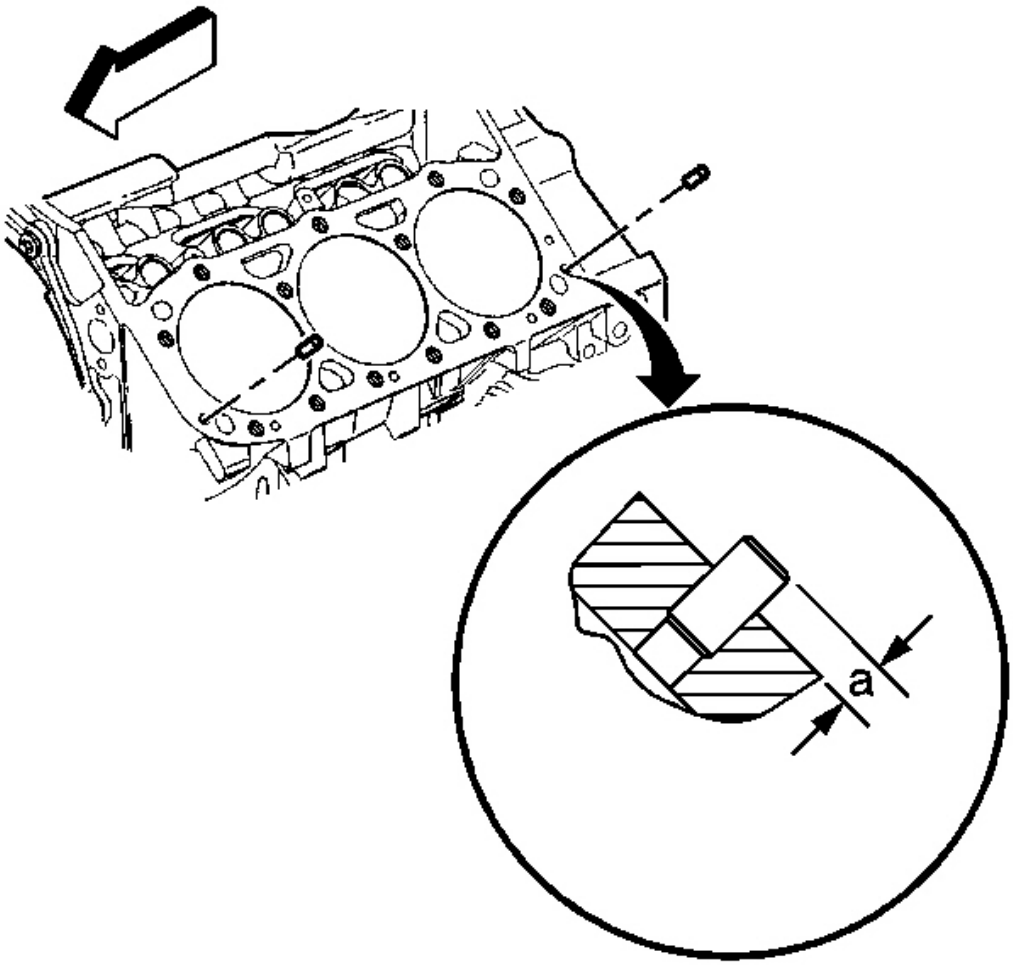


Fig. 613: Left Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

14. Install the left side cylinder head locator dowel pins, if required.

    The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

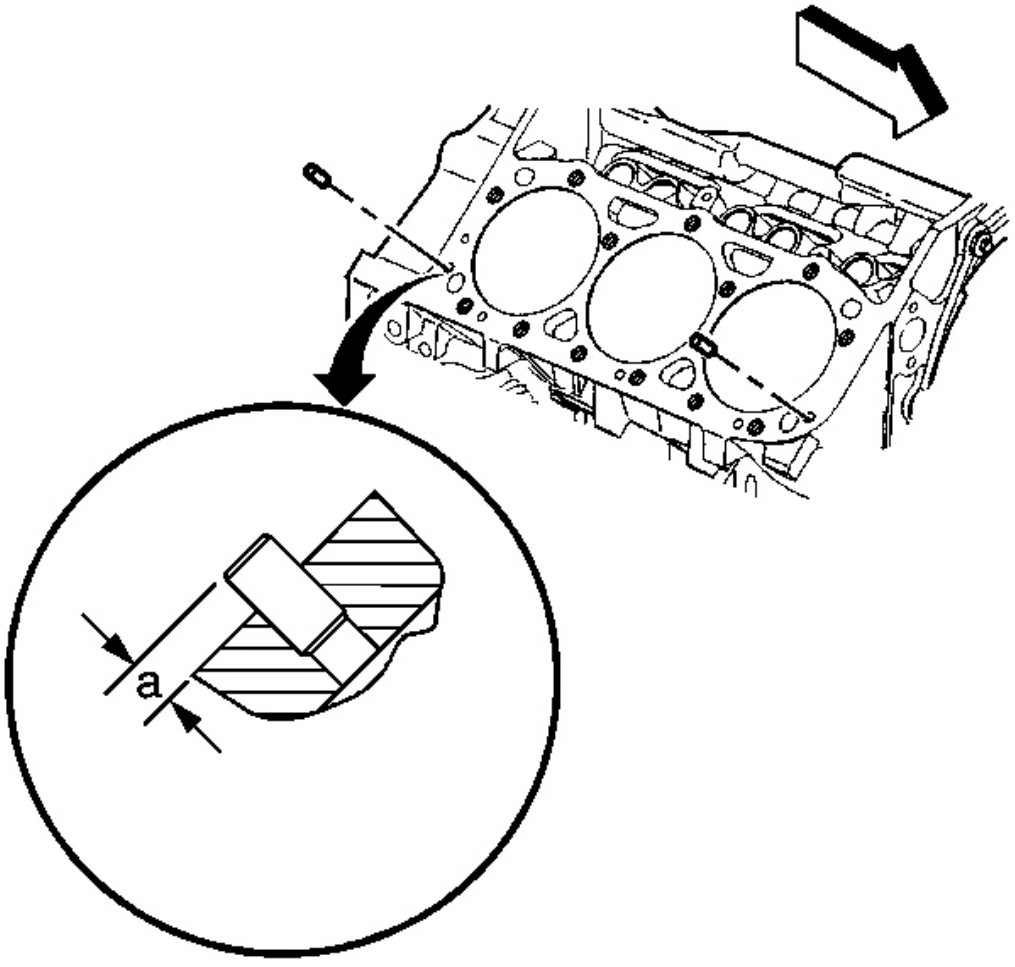


Fig. 614: Right Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

15. Install the right side cylinder head locator dowel pins, if required.

    The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

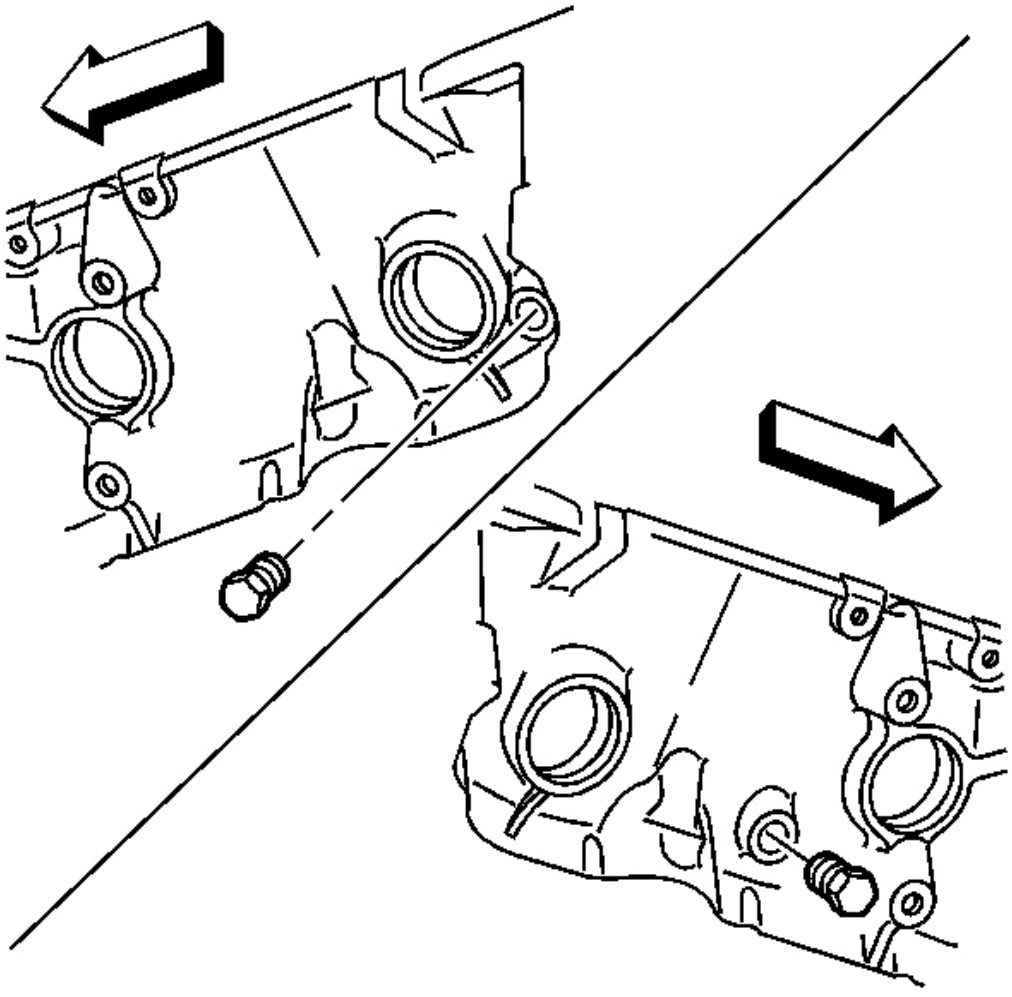


Fig. 615: View Of Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS CORP.

16. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine block coolant drain hole plugs.
17. Install the engine block coolant drain hole plugs.

Tighten: Tighten the engine block coolant hole plugs to 20 N.m (15 lb ft).

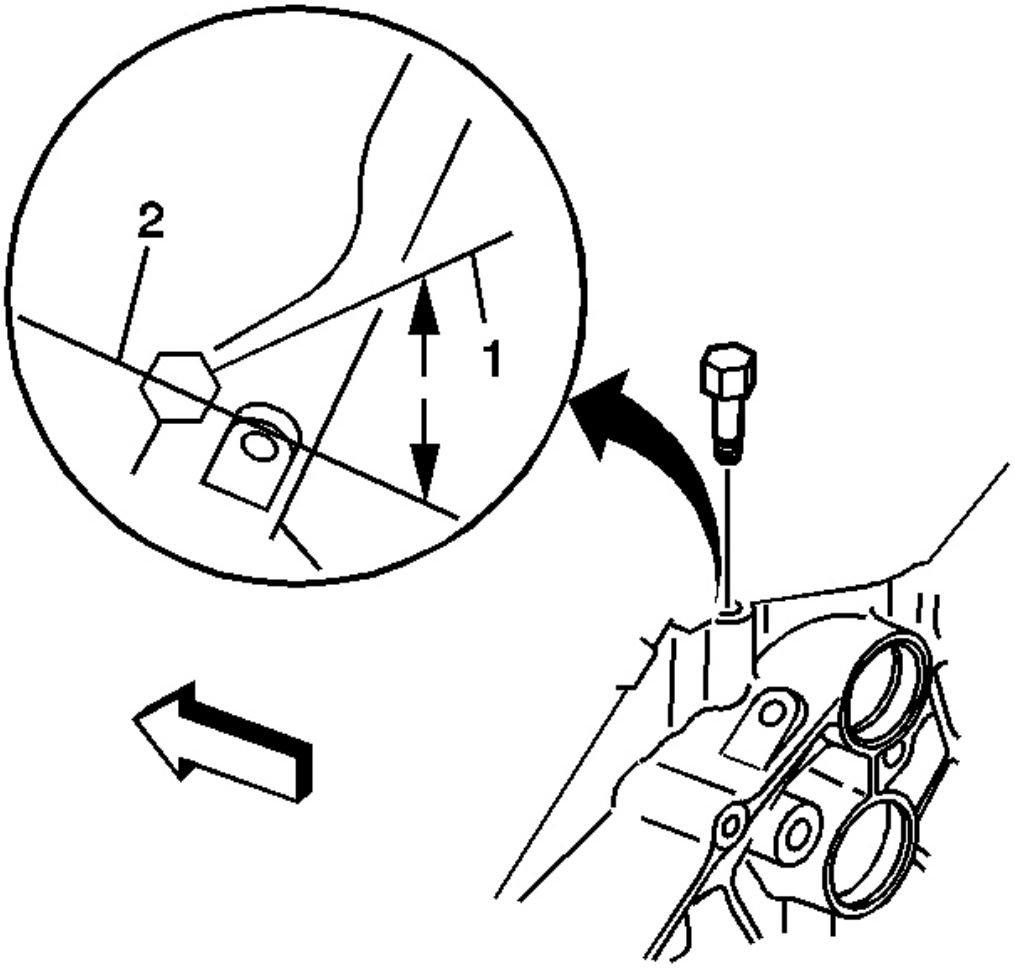


Fig. 616: Engine Oil Pressure Sensor Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

18. If reusing the engine oil pressure sensor fitting, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine oil pressure sensor fitting.

IMPORTANT: Do not loosen the engine oil pressure fitting after the initial torque has been obtained.

19. Install the engine oil pressure sensor fitting.

Tighten: Tighten the engine oil pressure sensor fitting to 15 N.m (11 lb ft).

IMPORTANT: Do not rotate the engine oil pressure fitting clockwise more than 359 degrees after the initial torque has been obtained.

20. Rotate the engine oil pressure sensor fitting clockwise to the proper position (1), 50 degrees from the centerline (2).

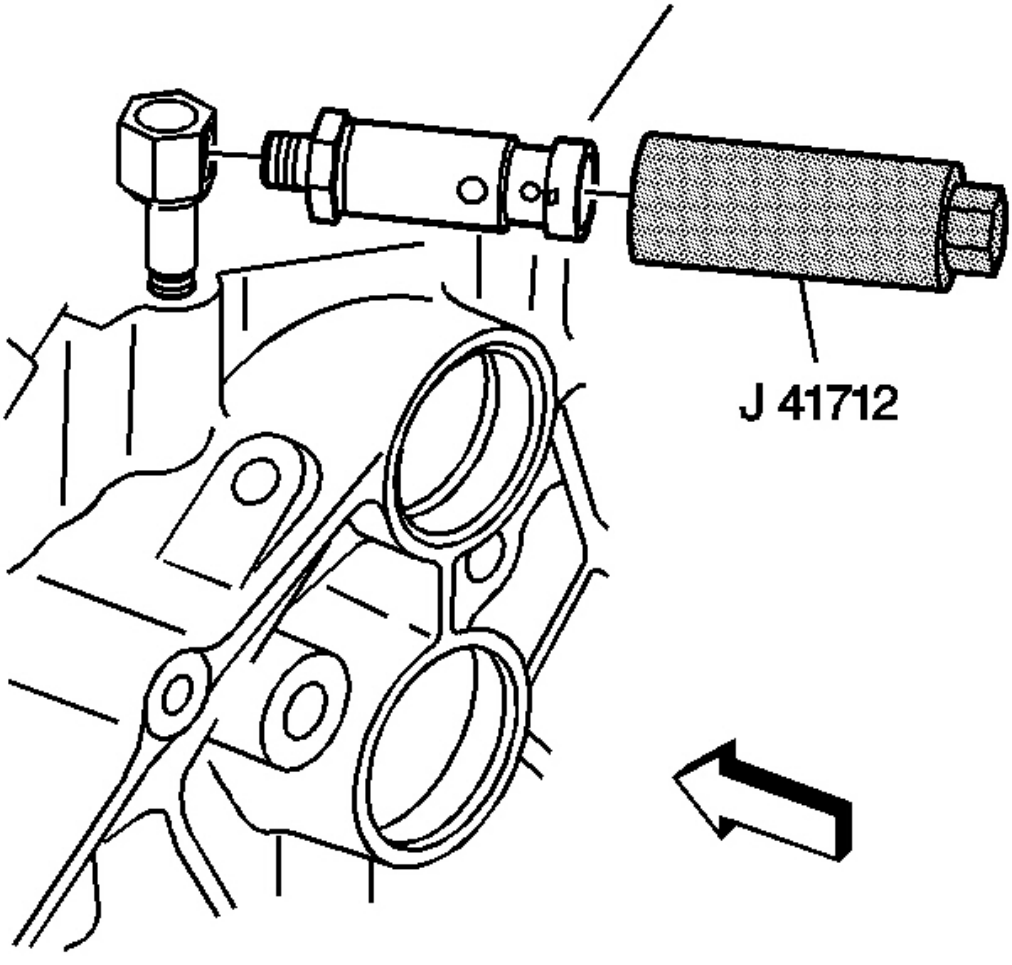


Fig. 617: View Of Engine Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

21. If reusing the engine oil pressure gage sensor, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine oil pressure gage sensor.
22. Install the engine oil pressure gage sensor using the **J 41712** . See **Special Tools**.

    Tighten: Tighten the engine oil pressure gage sensor to 30 N.m (22 lb ft).

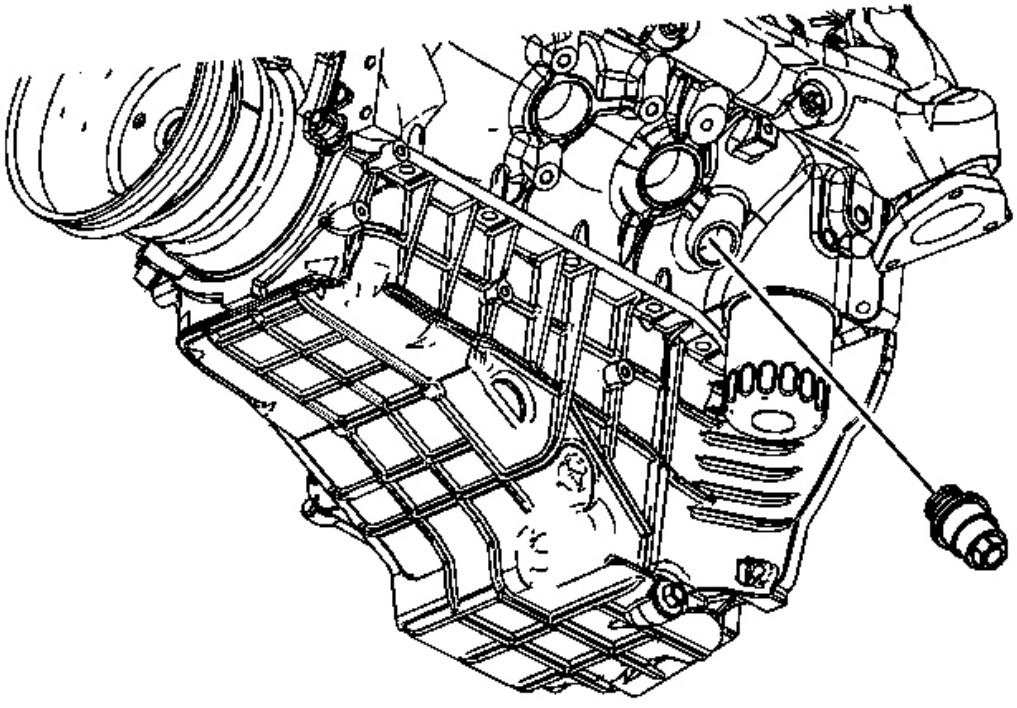


Fig. 618: Block Heater
Courtesy of GENERAL MOTORS CORP.

23. Install the block heater from the right side of the lower engine block.

    Tighten: Tighten the block heater to XX N.m (XX lb ft).

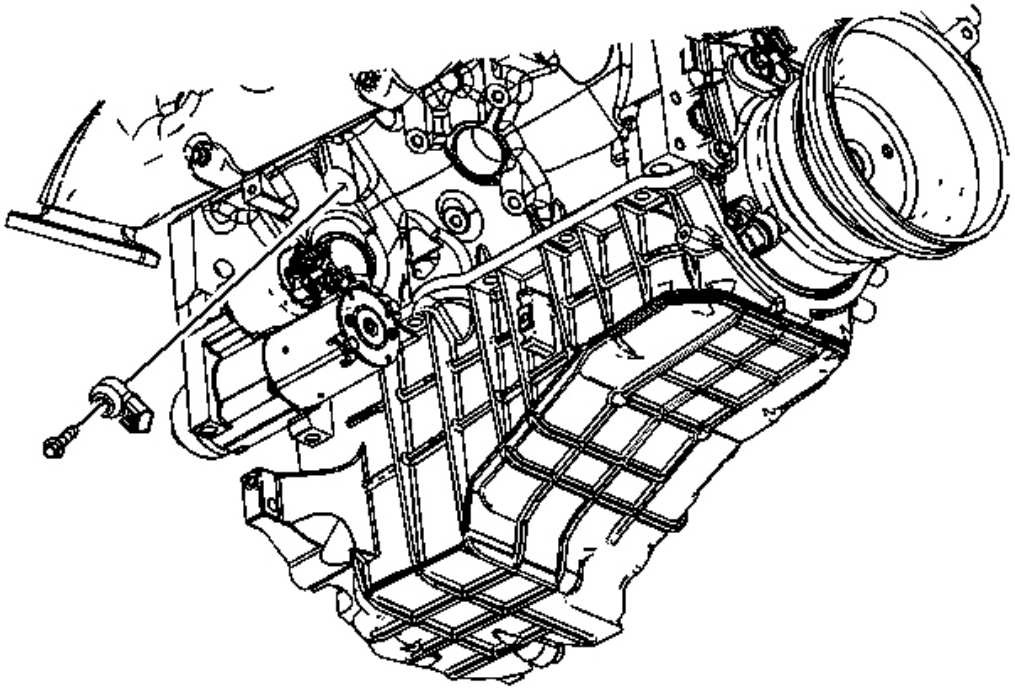


Fig. 619: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

24. Install the knock sensor on the right side of the lower engine block.
25. Install the knock sensor bolt.

Tighten: Tighten the knock sensor to 25 N.m (18 lb ft).

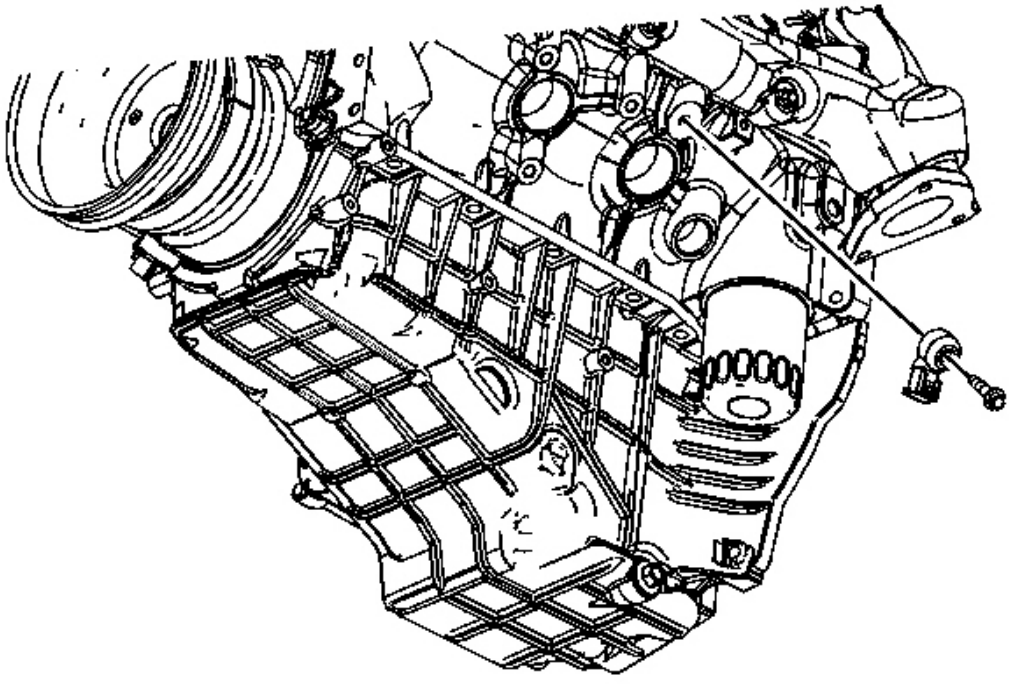


Fig. 620: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

26. Install the knock sensor on the left side of the lower engine block.
27. Install the knock sensor bolt.

Tighten: Tighten the knock sensor to 25 N.m (18 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Tools Required

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

Installation

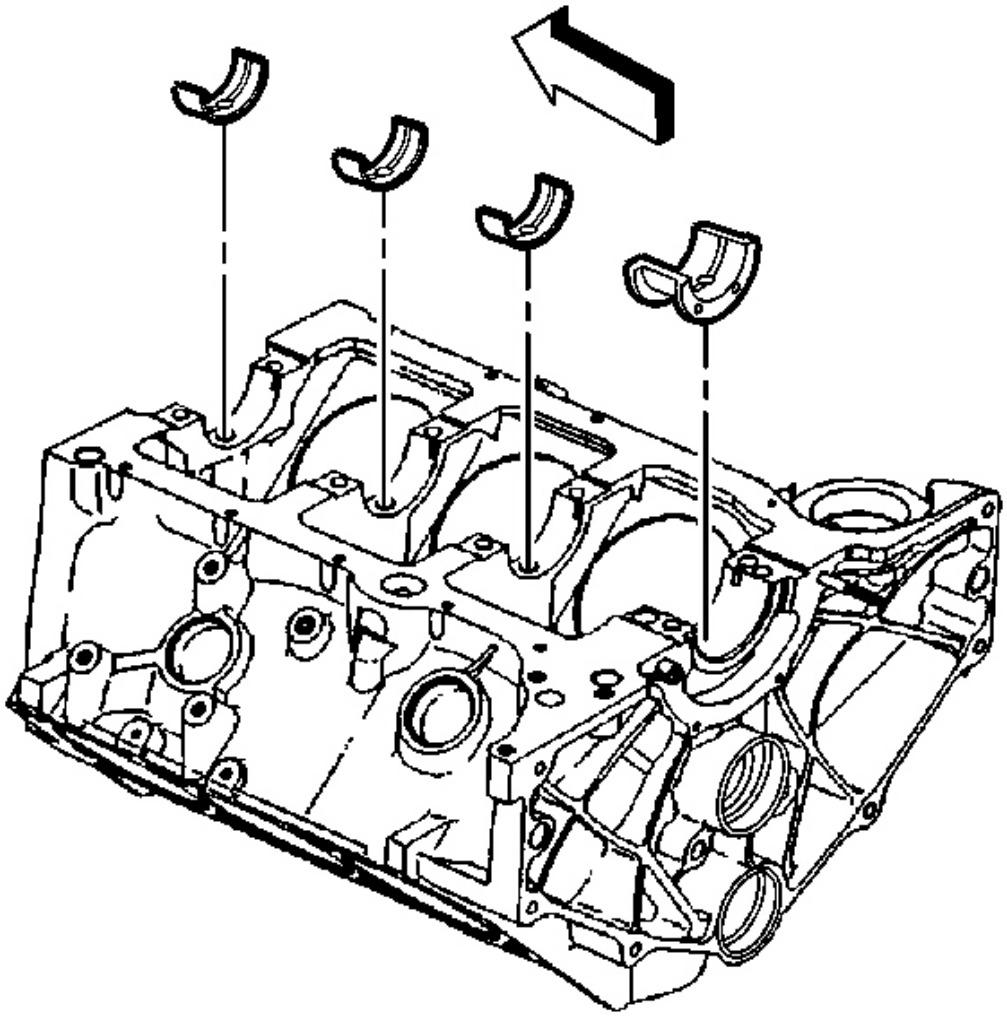


Fig. 621: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil to the crankshaft bearings.

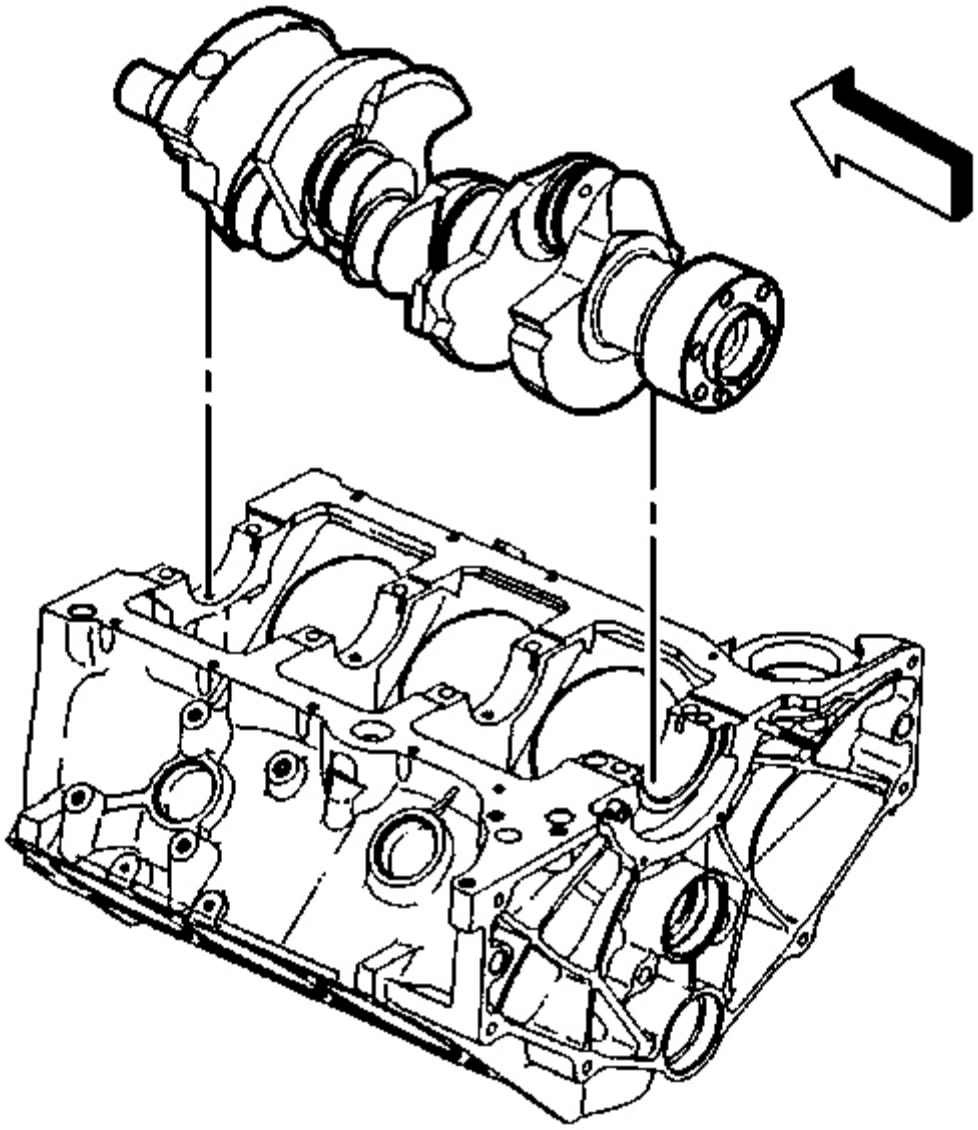


Fig. 622: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Apply clean engine oil to the crankshaft bearing journals.
4. Install the crankshaft.

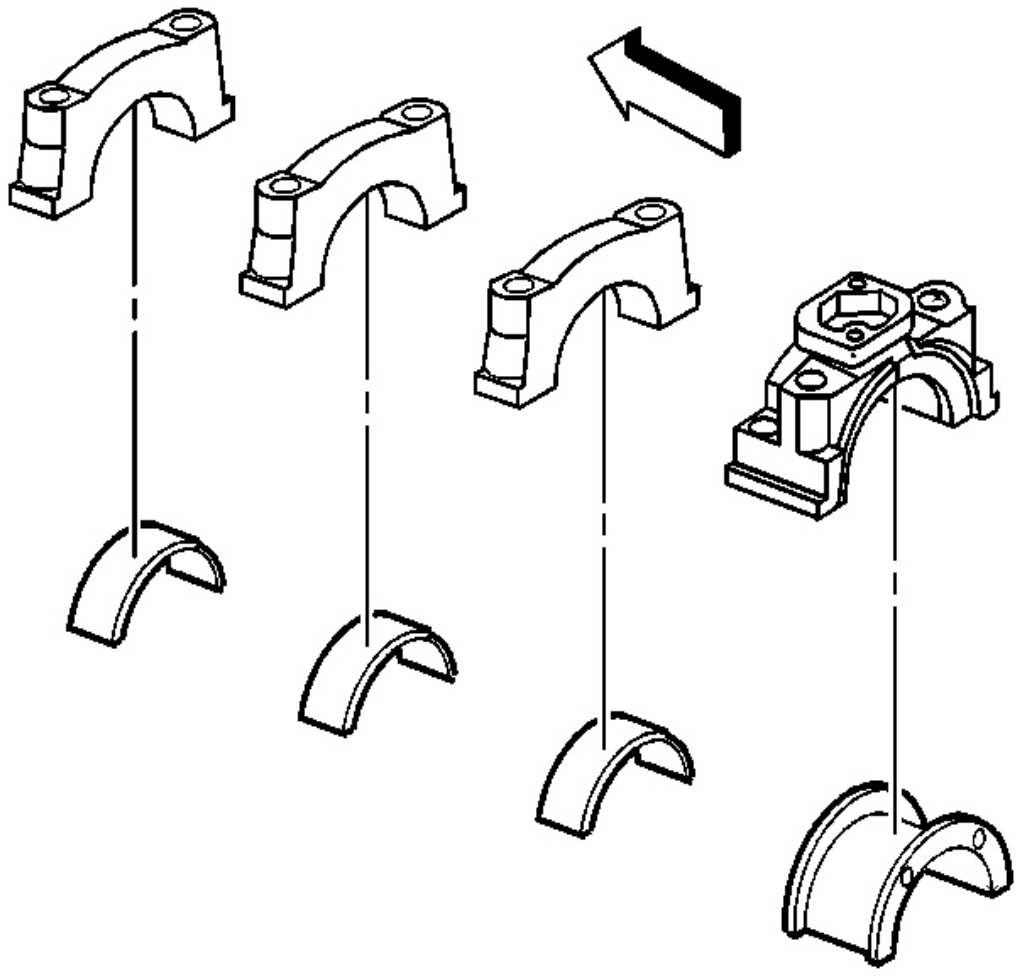


Fig. 623: View Of Crankshaft Bearings & Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil to the crankshaft bearings.

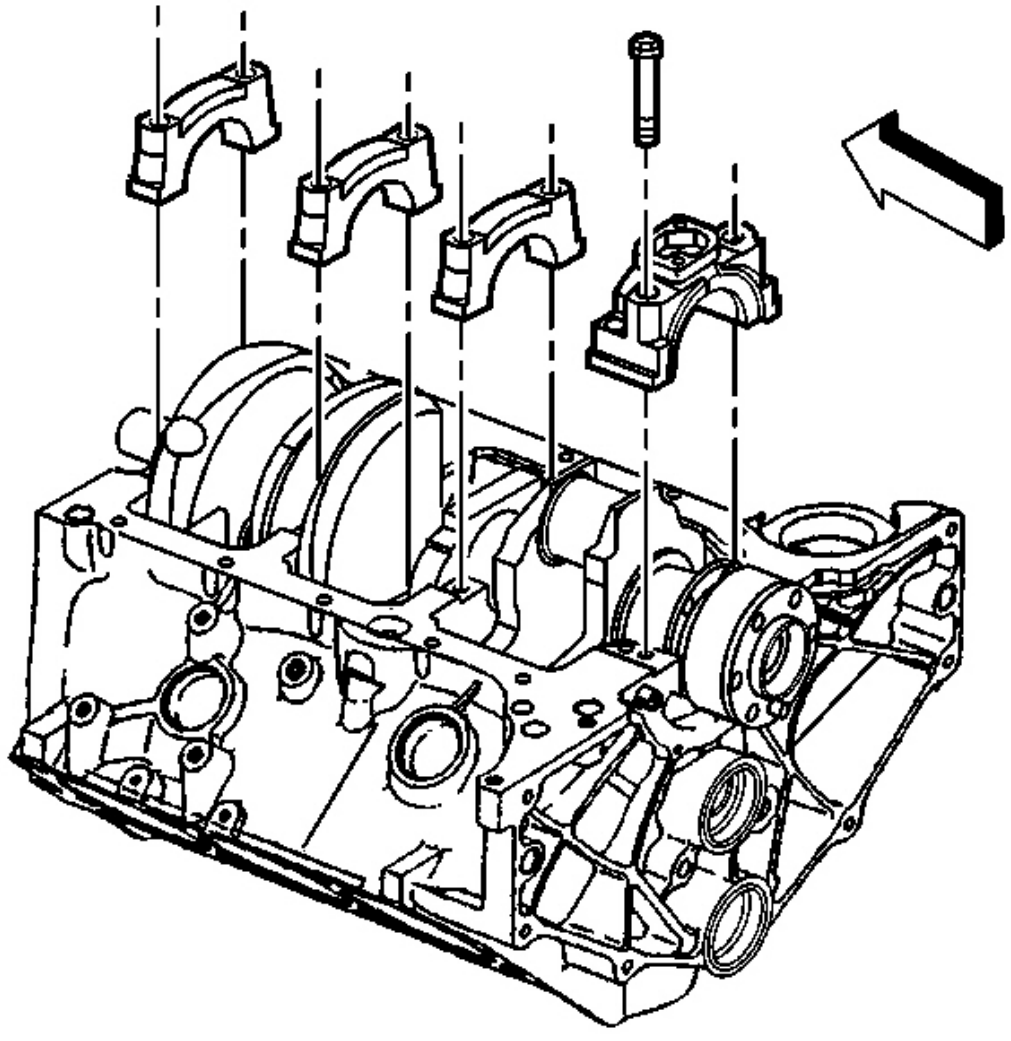


Fig. 624: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft bearing caps in the original position and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
8. Install the NEW crankshaft bearing cap bolts until snug.
9. Thrust the crankshaft rearward in order to set and align the crankshaft thrust bearings and the crankshaft bearing caps.
10. Thrust the crankshaft forward in order to align the rear faces of the crankshaft thrust

bearings.

NOTE: Refer to Fastener Notice .

11. Tighten the crankshaft bearing cap bolts.

Tighten:

1. Tighten the crankshaft bearing cap bolts on the first pass to 20 N.m (15 lb ft).
2. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the **J 45059** . See **Special Tools**.

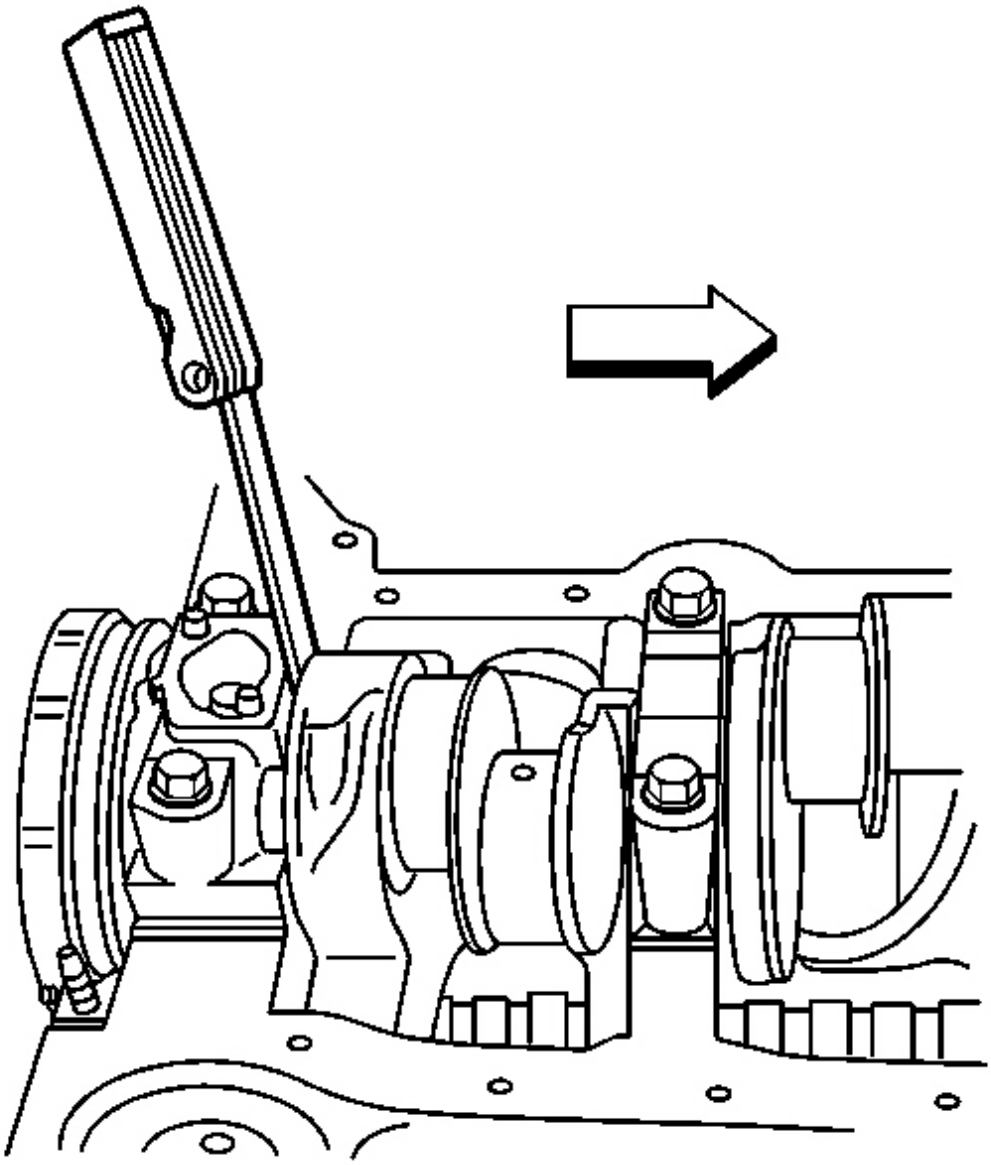


Fig. 625: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft end play.
    1. Firmly thrust the crankshaft rearward, and then forward.

This will align the crankshaft rear bearing thrust surfaces.

2. With the crankshaft pushed forward, insert a feeler gage between the crankshaft and the crankshaft rear bearing thrust surface to measure the clearance.

   Specification: Crankshaft end play 0.05-0.20 mm (0.002-0.008 in)

13. Rotate the crankshaft in order to check for binding.

    A bent crankshaft or lack of proper crankshaft bearing clearance may cause binding.

14. If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts on 1 crankshaft bearing cap at a time in order to determine the location of the binding.

    A lack of proper crankshaft bearing clearance may be caused by the following:

    - Burrs on the crankshaft bearing cap
    - Foreign material between the crankshaft bearing and the engine block
    - Foreign material between the crankshaft bearing and the crankshaft bearing cap
    - Damaged crankshaft bearing
    - Improper size crankshaft bearing

CRANKSHAFT REAR OIL SEAL AND HOUSING INSTALLATION

Tools Required

J 35621-B Rear Main Seal Installer. See **Special Tools**.

Installation

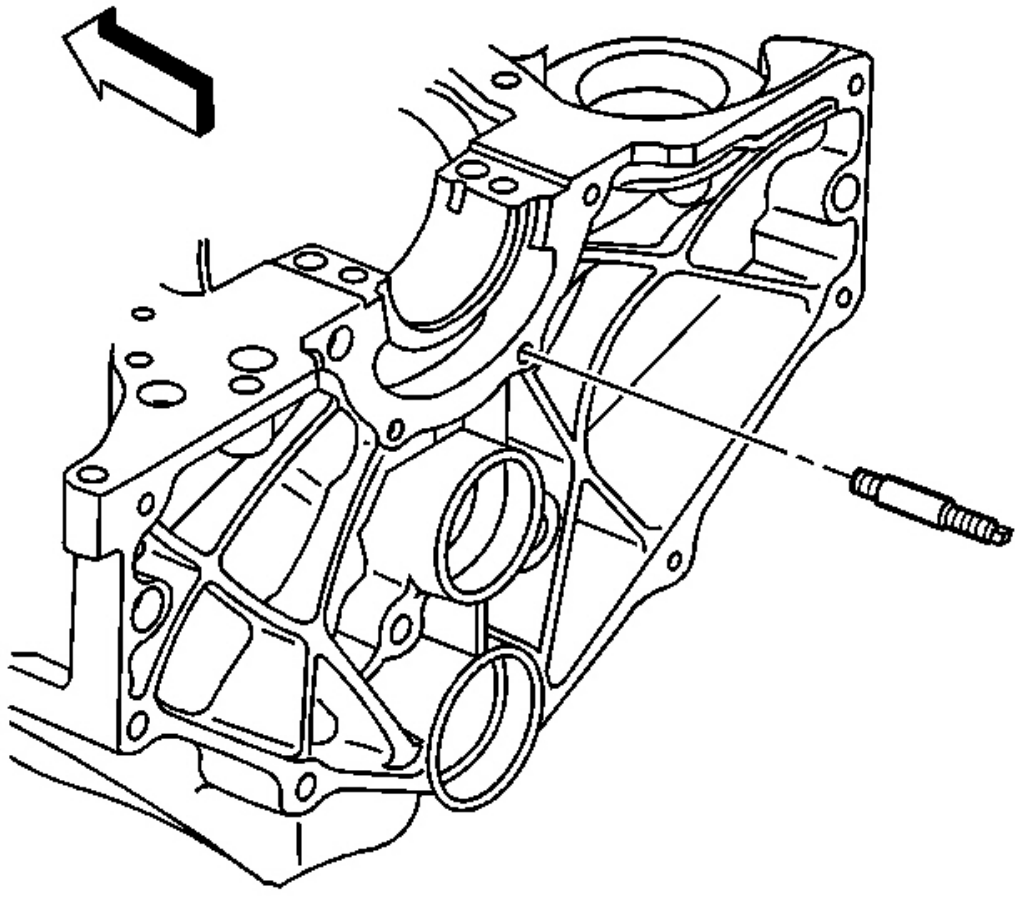


Fig. 626: Locating Crankshaft Rear Oil Seal Housing Retainer Stud
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the crankshaft rear oil seal housing retainer stud.

   Tighten: Tighten the crankshaft rear oil seal housing retainer stud to 6 N.m (53 lb in).

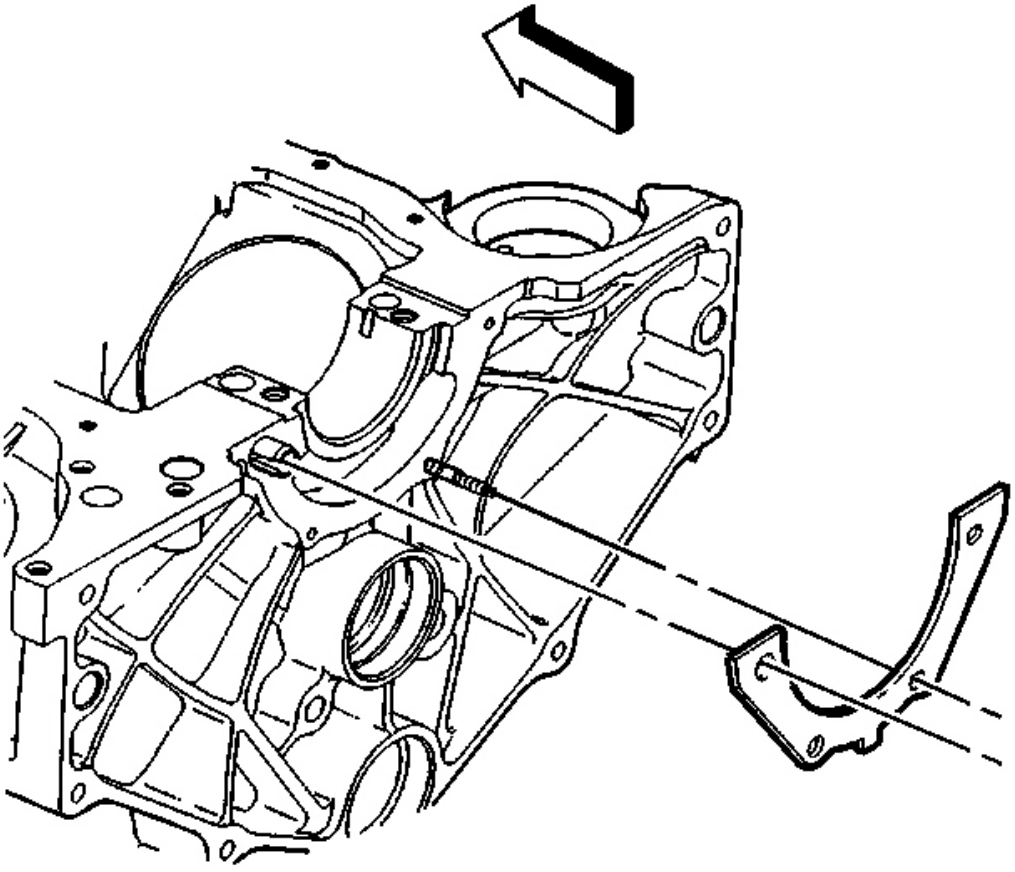


Fig. 627: Identifying Crankshaft Rear Oil Seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always use a NEW crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

2. Install the NEW crankshaft rear oil seal housing gasket.

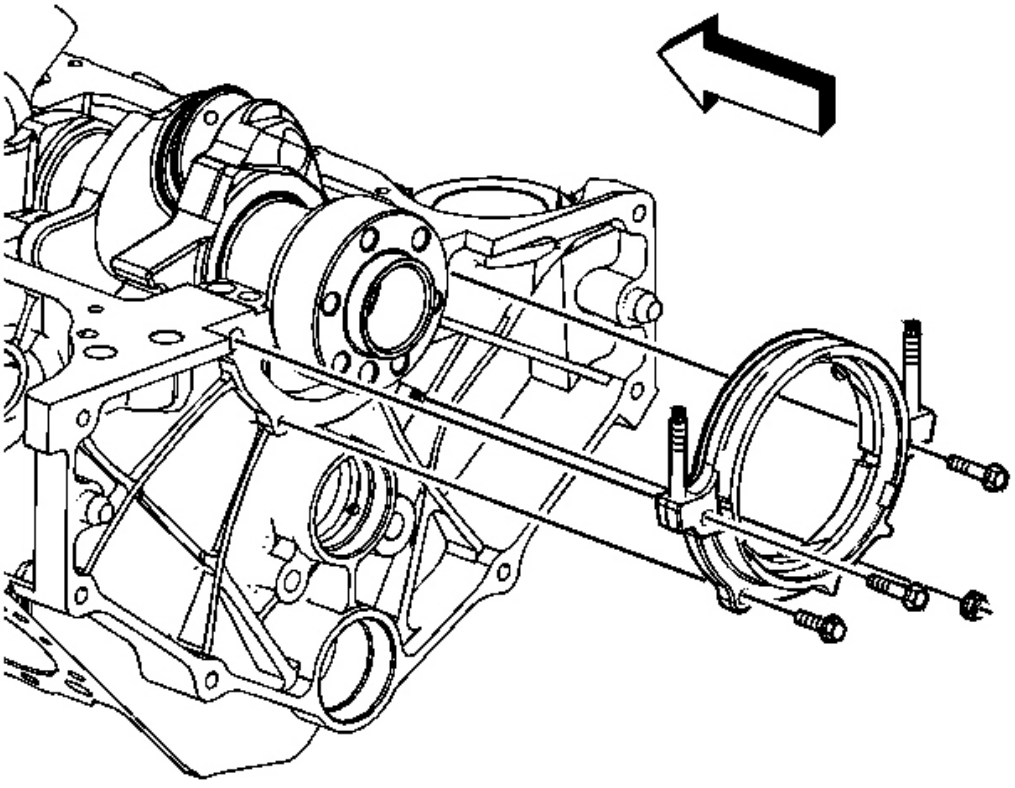


Fig. 628: View Of Crankshaft Rear Oil Housing
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft rear oil housing onto the crankshaft rear oil seal housing retainer stud.
4. Install the crankshaft rear oil seal housing nut and bolts.

Tighten: Tighten the crankshaft rear oil seal housing nut and bolts to 12 N.m (106 lb in).

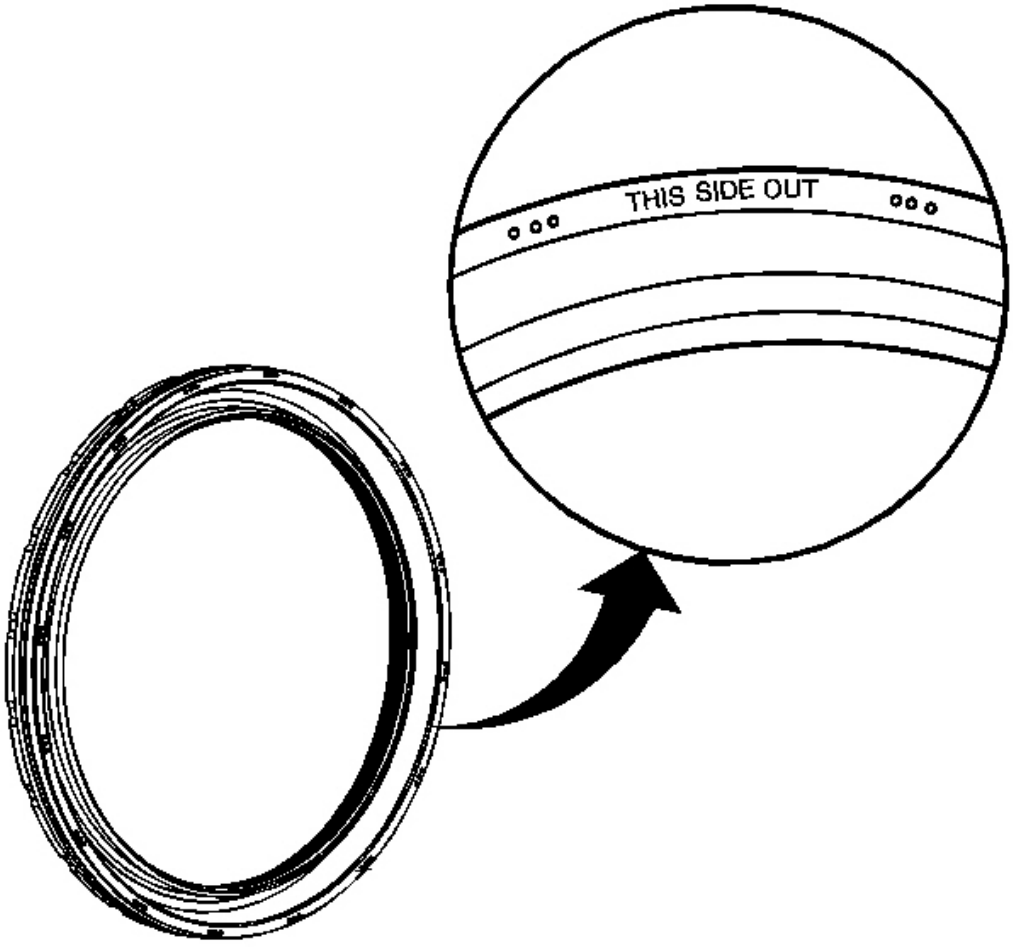


Fig. 629: Identifying Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Notice the direction of the rear oil seal. The new design seal is a reverse style as opposed to what has been used in the past. "THIS SIDE OUT" has been stamped into the seal as shown in the graphic.

5. Inspect the **J 35621-B** flange for imperfections that may damage the crankshaft rear oil seal. See **Special Tools**. Minor imperfections may be removed with a fine grade emery cloth.
6. Clean the crankshaft sealing surface with a clean, lint free towel. Inspect the lead-in edge of

the crankshaft for burrs or sharp edges that could damage the rear main oil seal. Remove the burrs or sharp edges with a fine grade emery cloth before proceeding.

IMPORTANT: Do not apply or use any oil lubrication on the crankshaft rear oil seal or seal installer. Do not touch the sealing lip of the oil seal once the protective sleeve is removed.

7. Carefully remove the protection sleeve from the NEW crankshaft rear oil seal.

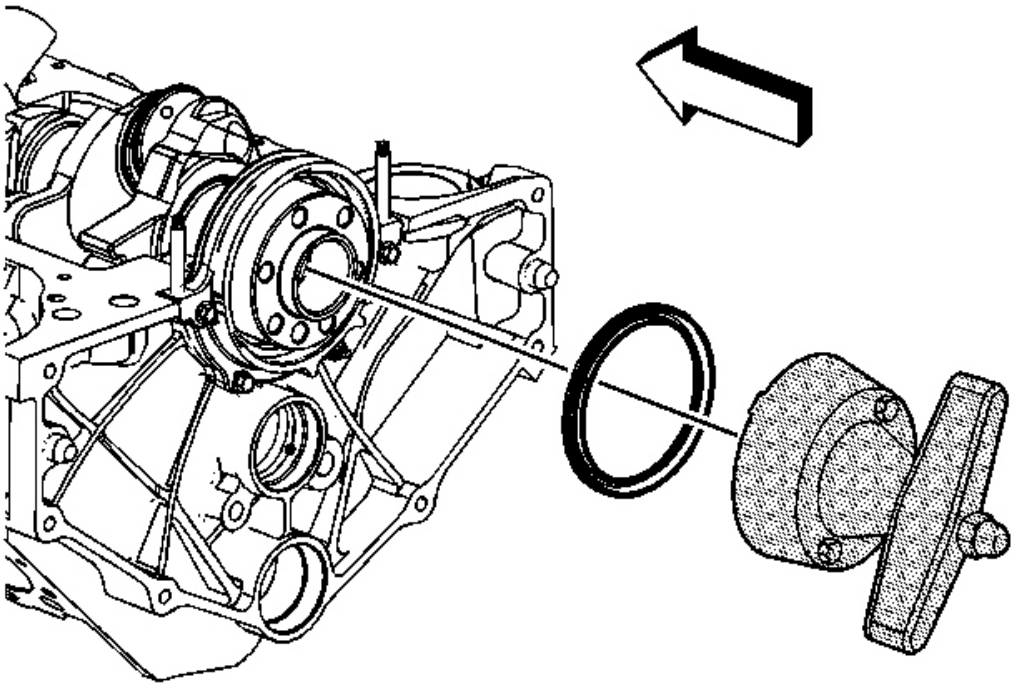


Fig. 630: Identifying Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

8. Install the crankshaft rear oil seal onto the **J 35621-B** . See **Special Tools**.
9. Install the **J 35621-B** onto the rear of the crankshaft and hand tighten the tool bolts until snug. See **Special Tools**.

NOTE: Proper alignment of the crankshaft rear oil seal is critical.

Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

10. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
    1. Turn the **J 35621-B** wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing. See **Special Tools**. Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.
    2. Turn the **J 35621-B** wing nut counterclockwise to release the **J 35621-B** from the crankshaft rear oil seal. See **Special Tools**.
11. Remove the **J 35621-B** from the crankshaft. See **Special Tools**.
12. Wipe off any excess engine oil with a clean rag.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Tools Required

- **J 8037** Ring Compressor. See **Special Tools**.
- **J 8087** Cylinder Bore Gage
- **J 45059** Angle Meter. See **Special Tools**.

IMPORTANT: Powdered metal connecting rods and rod bearing caps are NOT interchangeable, and must be assembled with the mating surfaces properly oriented and aligned. Piston, piston pin, and connecting rod are to be serviced as an assembly.

Piston Selection

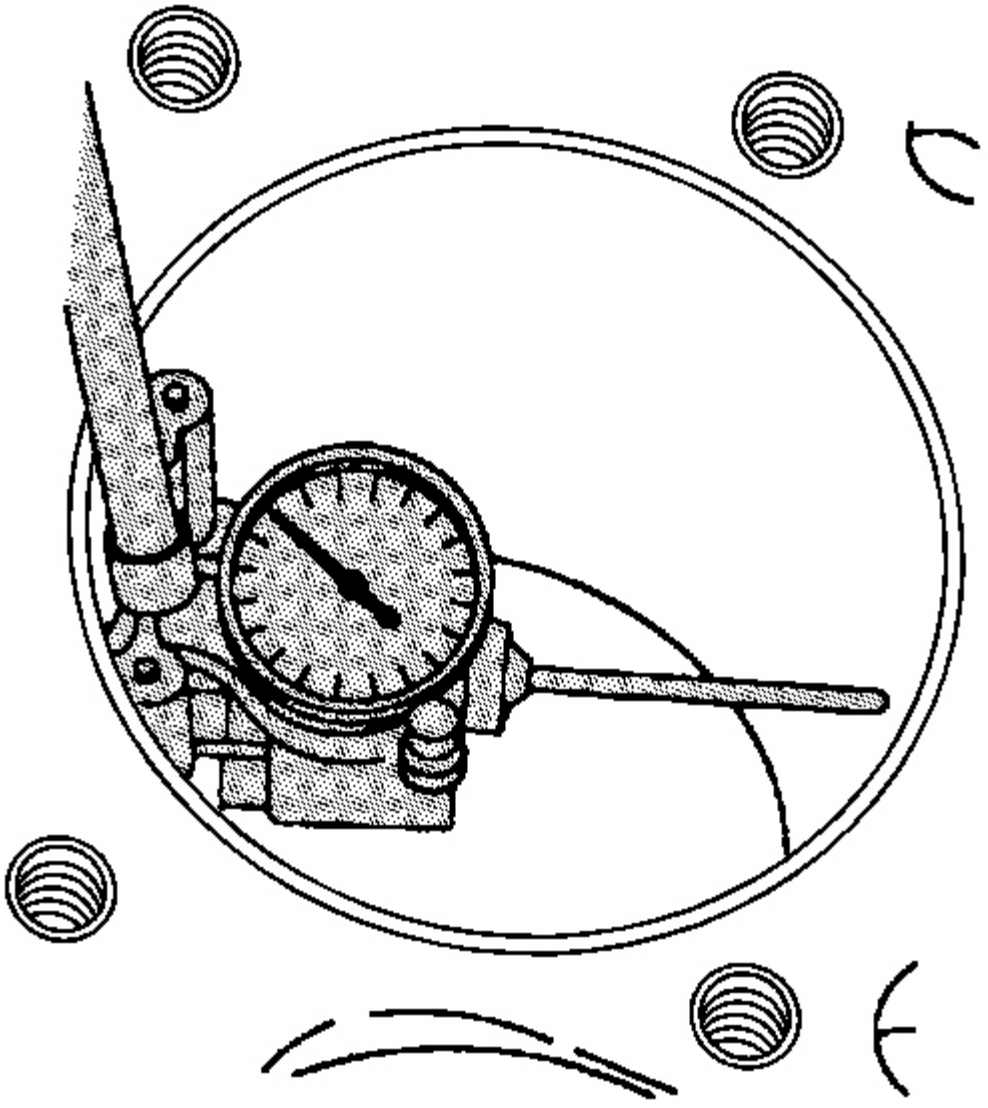


Fig. 631: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.
For proper piston fit, the engine block cylinder bores should

not have excessive wear or taper.
A used piston and piston pin set may be reinstalled if, after cleaning and inspection, the piston and piston pin are within specifications.

1. Use the **J 8087** in order to measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore and 90 degrees to the crankshaft centerline.

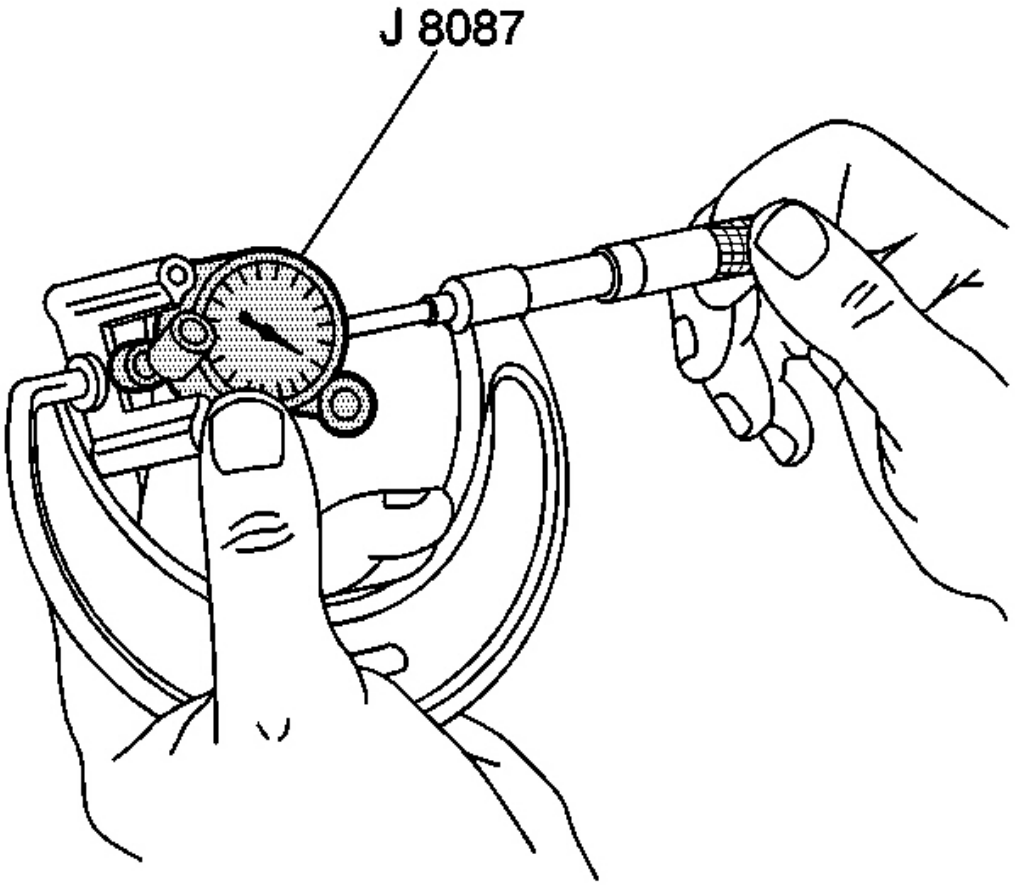


Fig. 632: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

2. Measure the **J 8087** with a micrometer and record the reading.

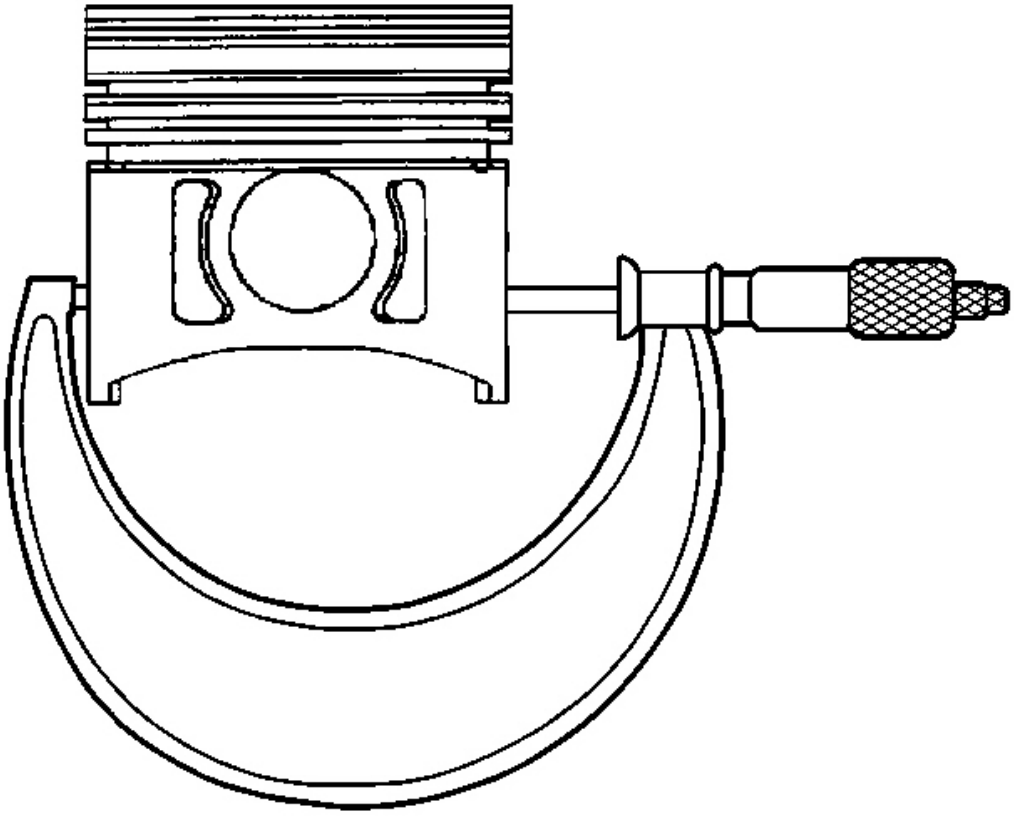


Fig. 633: Measuring Piston Outside Diameter Using Micrometer
Courtesy of GENERAL MOTORS CORP.

3. With a micrometer or caliper at a right angle to the piston pin bore, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
4. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
5. If the proper clearance cannot be obtained, then select another piston and measure the clearances.

   If the proper fit cannot be obtained, the cylinder bore may require honing or boring.

6. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.

Installation Procedure

1. Apply clean engine oil to the following components:
   - The piston
   - The piston rings
   - The cylinder bore
   - The bearing surfaces

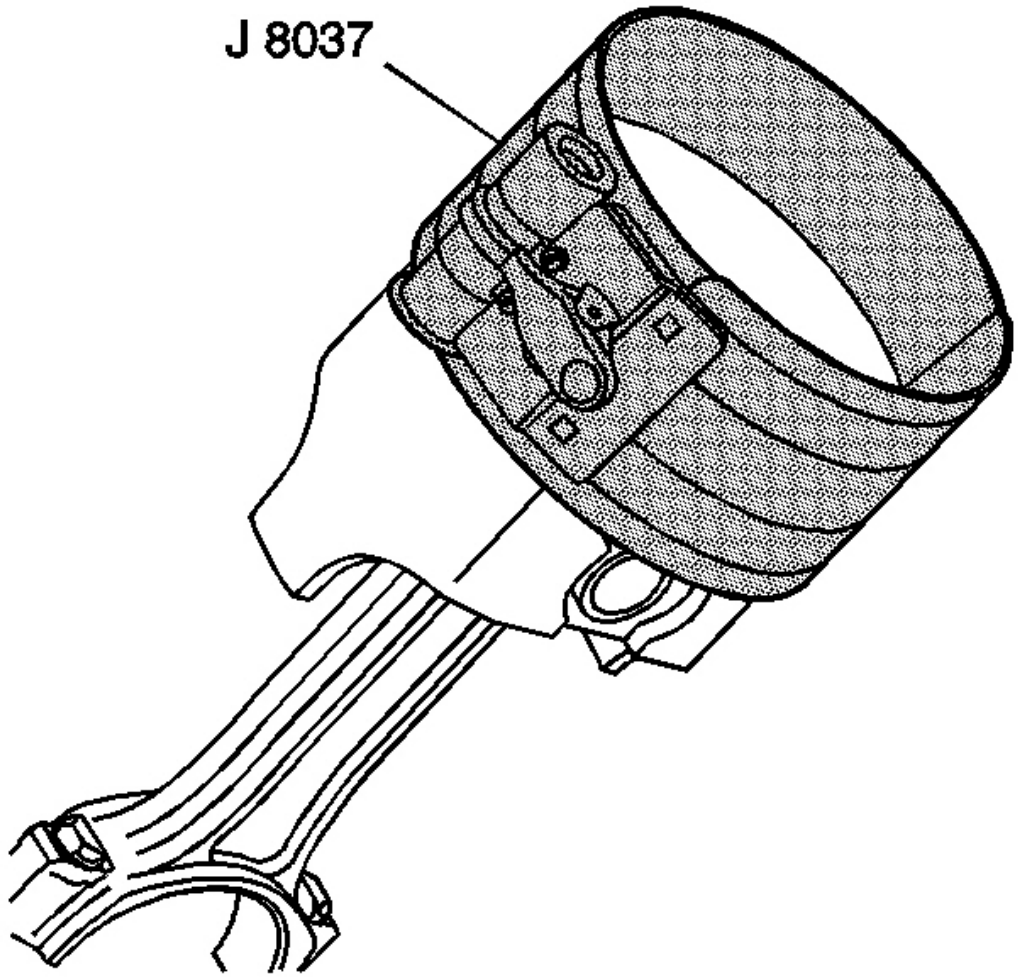


Fig. 634: Compressing The Piston Rings Using J 8037
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools**.

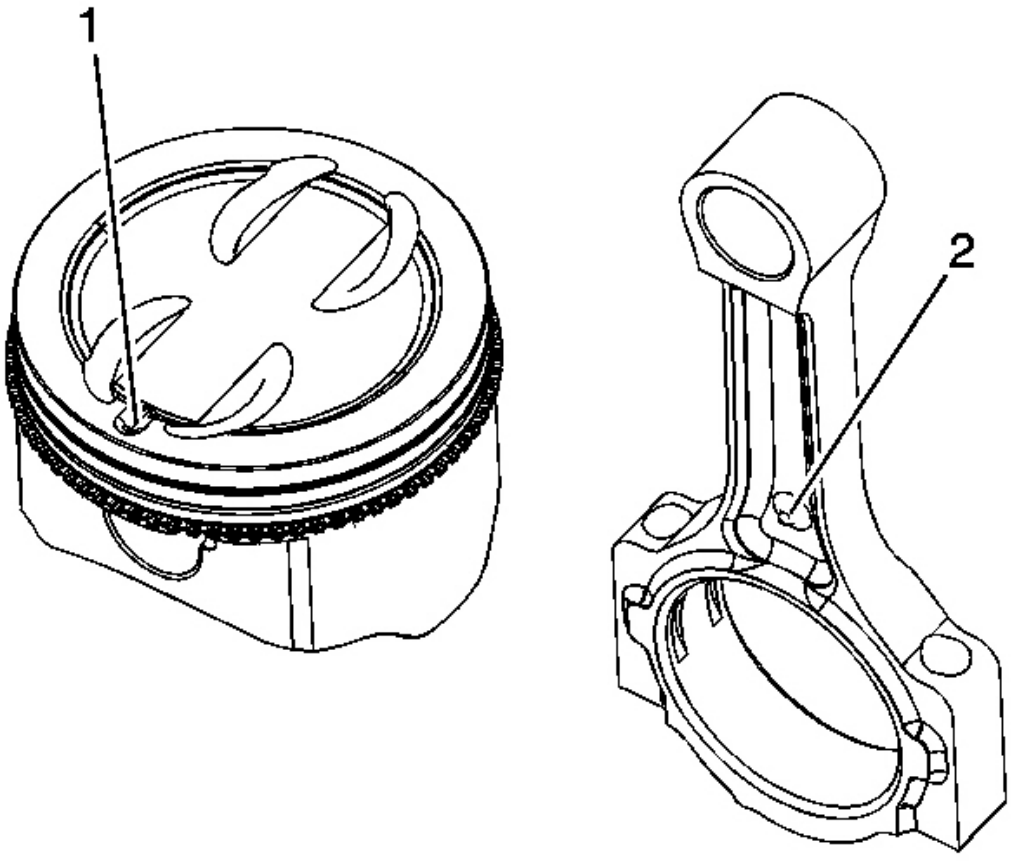


Fig. 635: View Of Piston
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When assembled, the following reference marks must be addressed; the reference mark on top of the piston (1) must face the front of the engine block. The dimple on the connecting rod (2) must face the front of the engine block on cylinders 2, 4, and 6, and towards the rear of the engine block on cylinders 1, 3, and 5. Wrap a clean, lint free towel around the connecting rod ends when installing the piston into the cylinder so as not to damage the crankshaft journals

or cylinder bore.

3. Check reference marks prior to installation into the block.

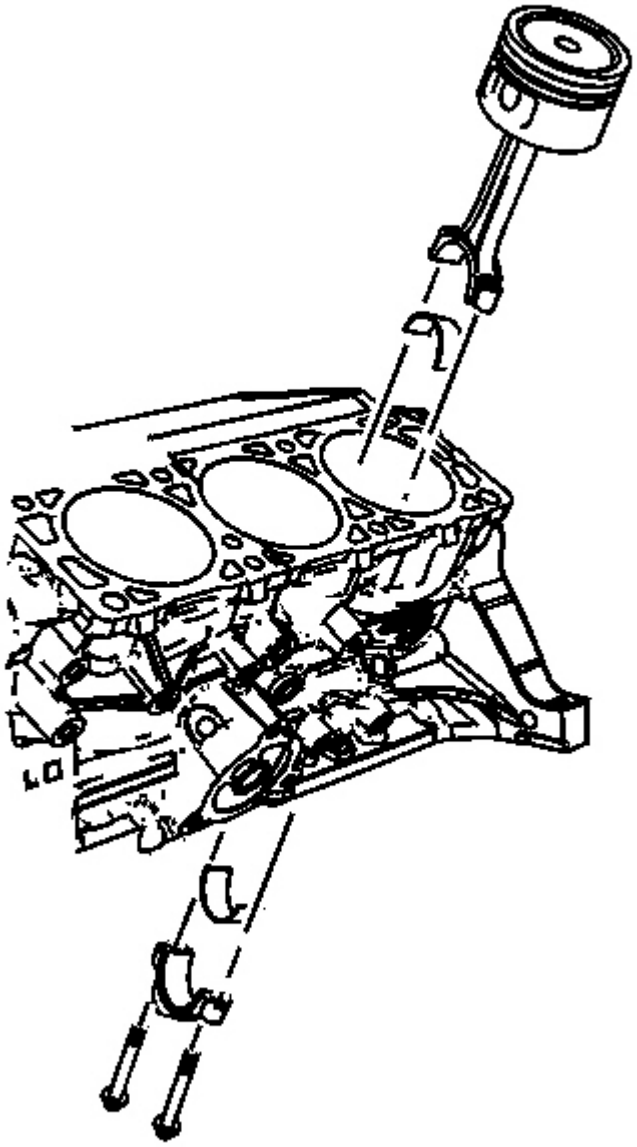


Fig. 636: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

4. Install the piston and connecting rod assembly, and the **J 8037** into the proper cylinder bore. See **Special Tools**.

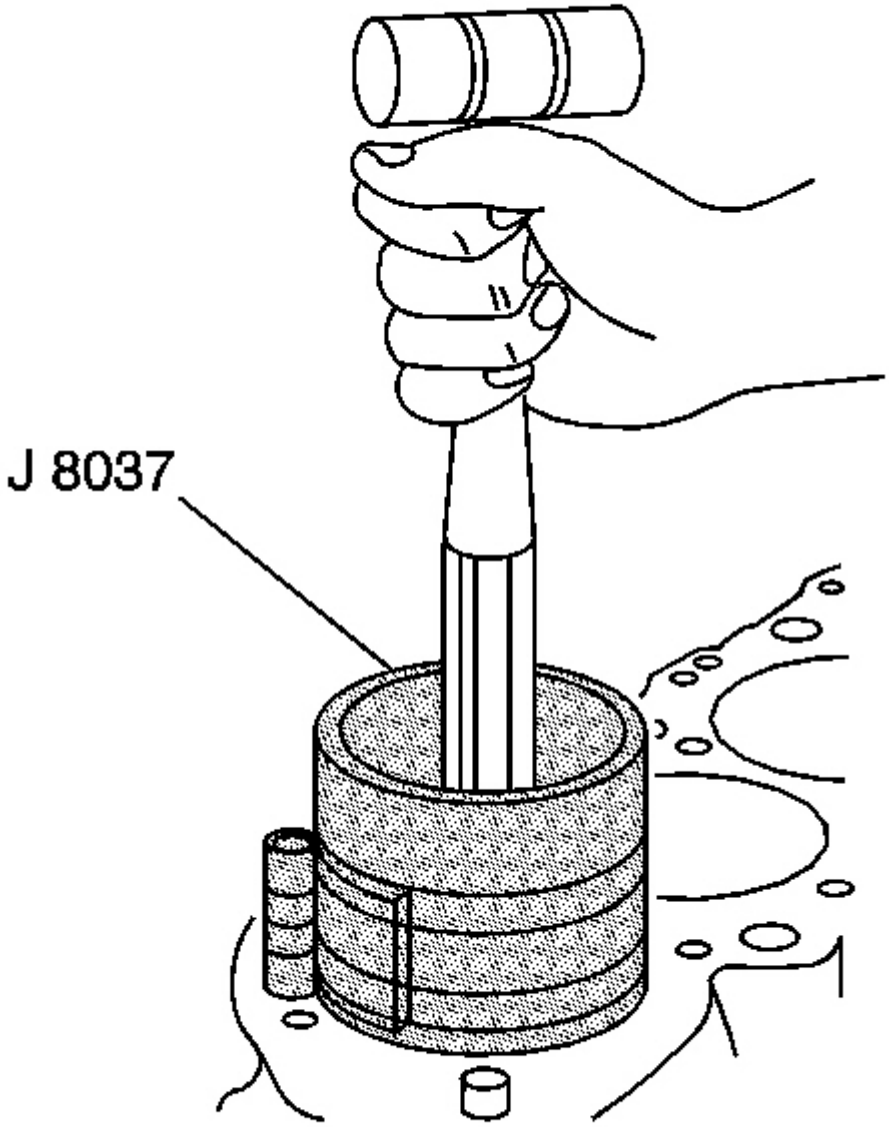


Fig. 637: Installing Piston & Connecting Rod Assembly Into Engine
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 8037** and lightly tap the top of the piston with a wooden hammer handle. See **Special Tools**.

   Hold the **J 8037** firmly against the engine block until all of the piston rings have entered the cylinder bore. See **Special Tools**.

IMPORTANT: The connecting rods and rod bearing caps are NOT interchangeable. Reference the match marks on the connecting rods and the connecting rod bearing caps made in the removal procedure to ensure that they are assembled in their original position and direction, with the connecting rod/rod bearing cap mating surfaces properly oriented and aligned.

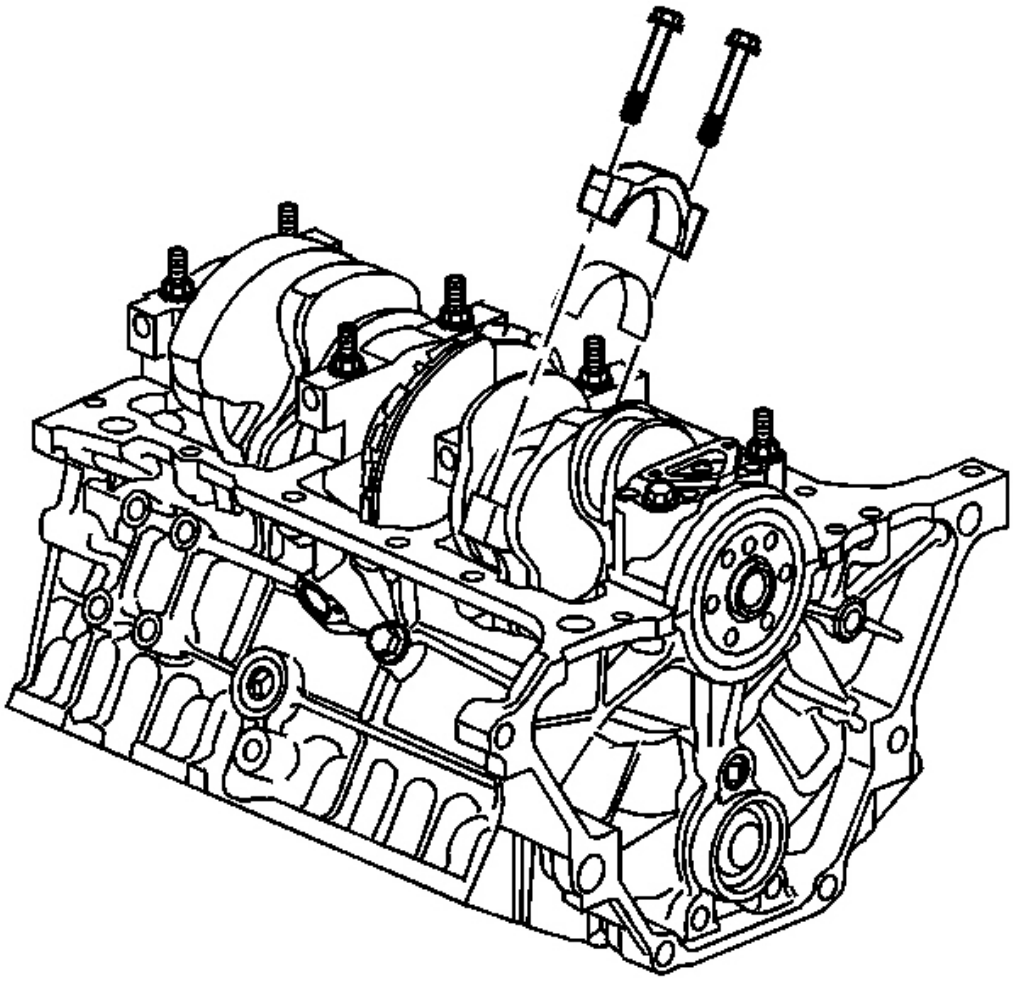


Fig. 638: View Of Bearing, Bearing Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the connecting rod bearing, cap, and bolts.

Tighten:

1. Tighten the bolts evenly on the first pass to 20 N.m (15 lb ft).
2. Use the **J 45059** in order to tighten the bolts on the final pass an additional 100

degrees. See **Special Tools**.

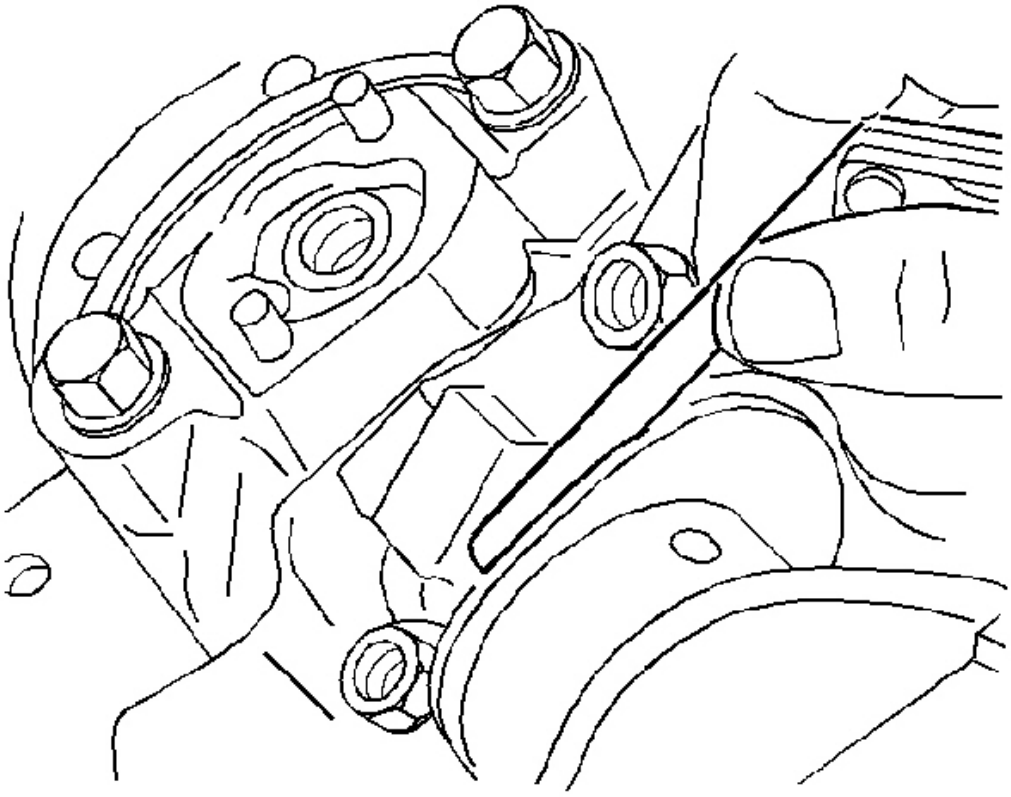


Fig. 639: Measuring Connecting Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. After the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly, parallel to the crankpin, in order to ensure that the connecting rods have side clearance.
8. Use a feeler gage or a dial indicator to measure the connecting rod side clearance between the connecting rod caps. The connecting rod side clearance should be 0.15-0.44 mm (0.006-0.017 in).

CAMSHAFT INSTALLATION

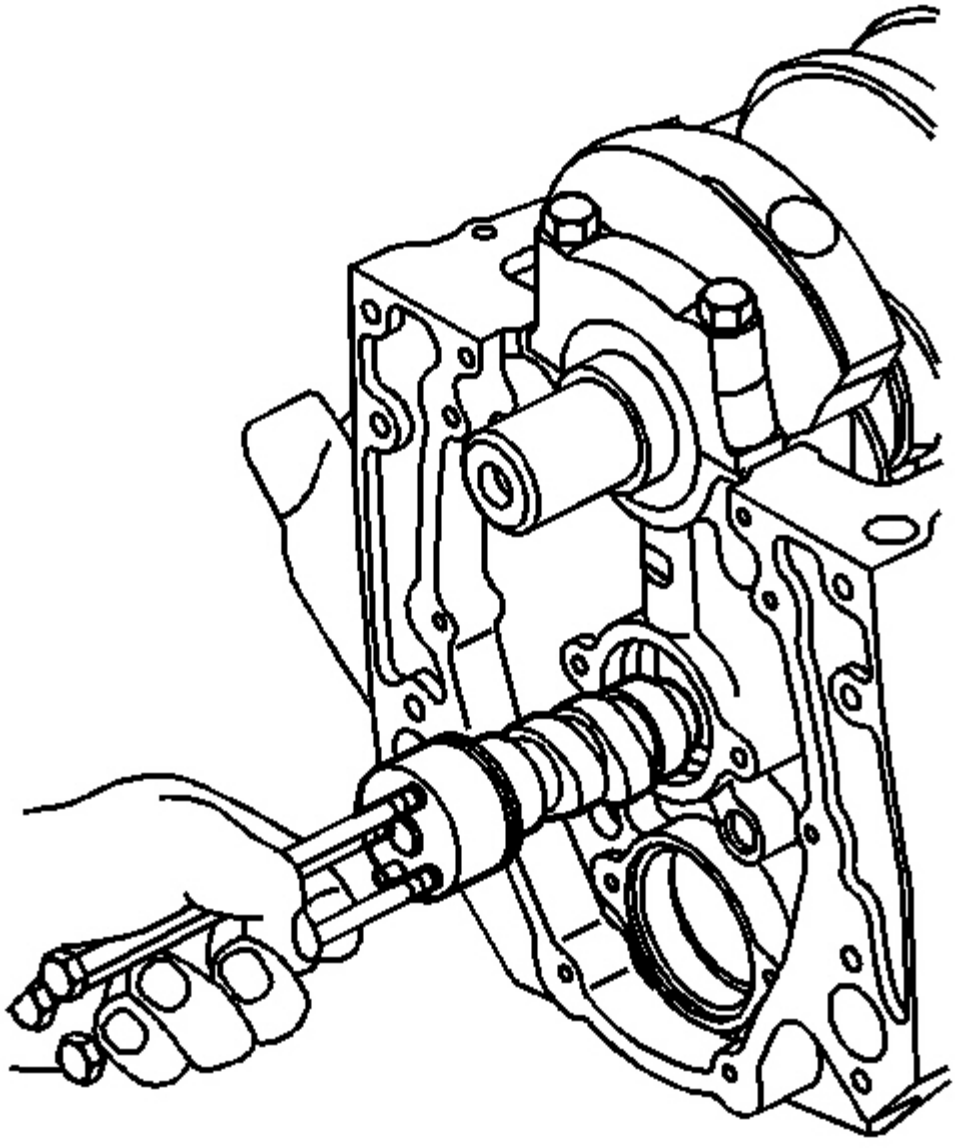


Fig. 640: View Of Engine Camshaft Front Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, or engine oil supplement GM P/N 1052367 (Canadian P/N 992367) or equivalent, to the following components:

- The engine camshaft lobes
- The camshaft bearing journals
- The camshaft bearings
- The distributor drive gear

2. Install three 5/16-18 x 4.0 inch bolts into the engine 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. Use the bolts as a handle in order to install the engine camshaft.
4. Remove the 3 bolts from the front of the engine camshaft.

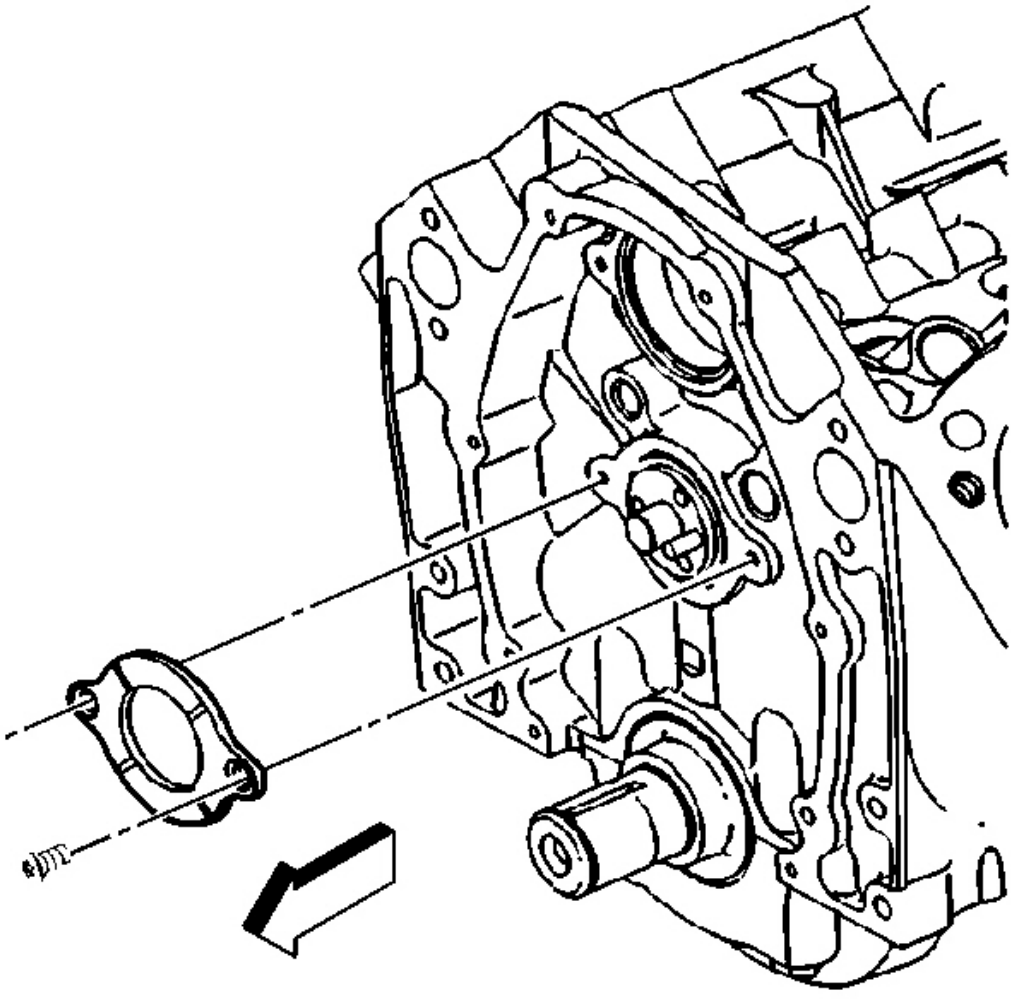


Fig. 641: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

5. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the camshaft retainer bolts.

NOTE: **Refer to Fastener Notice .**

6. Install the camshaft retainer and bolts.

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

BALANCE SHAFT INSTALLATION

Tools Required

- **J 8092** Universal Driver Handle
- **J 36996** Balance Shaft Installer. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Installation

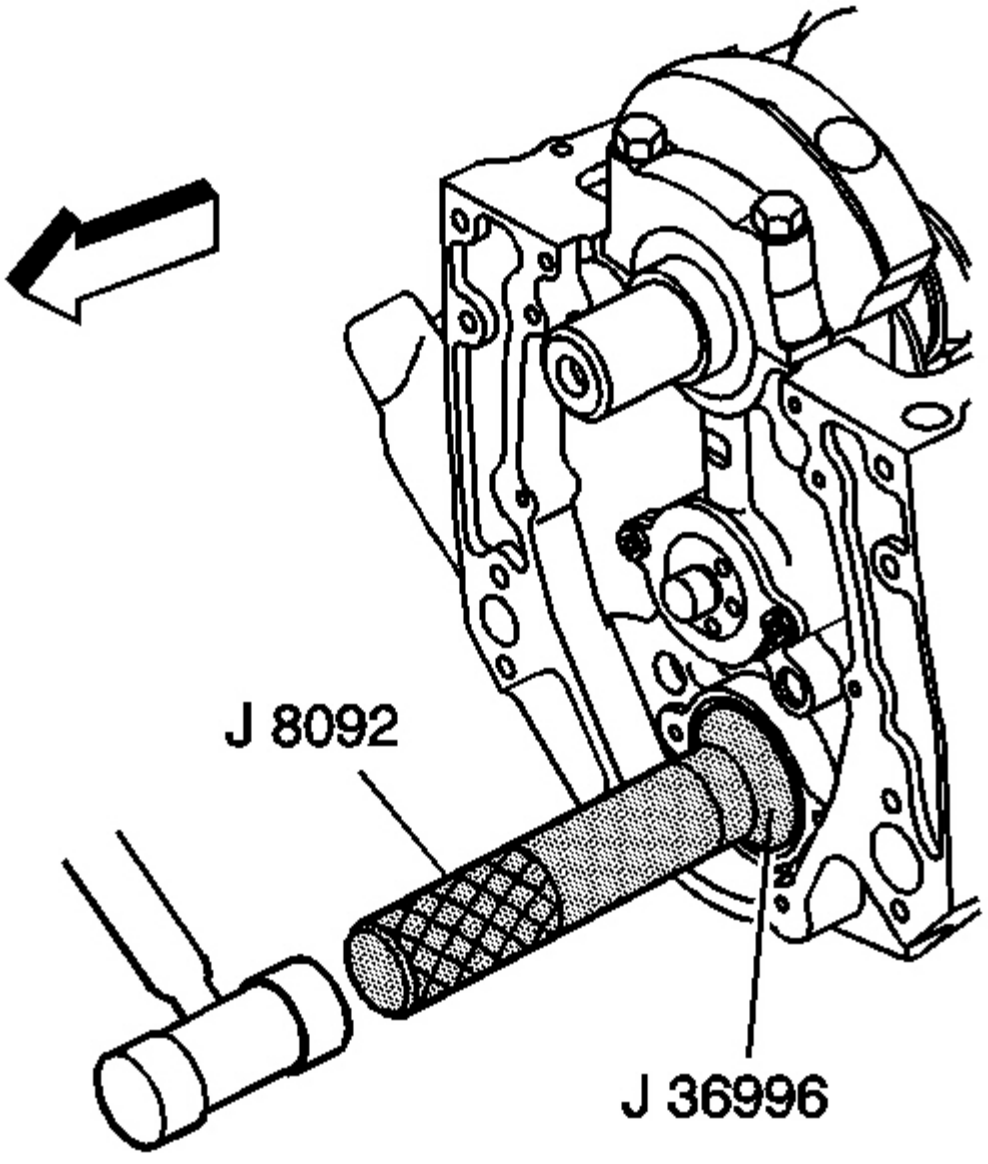


Fig. 642: Installing Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as an assembly. Do not remove the balance

shaft front bearing from the balance shaft.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, to the balance shaft front bearing.

CAUTION: Refer to SAFETY GLASSES CAUTION .

2. Use the **J 36996** and the **J 8092** in order to install the balance shaft. See **Special Tools**.

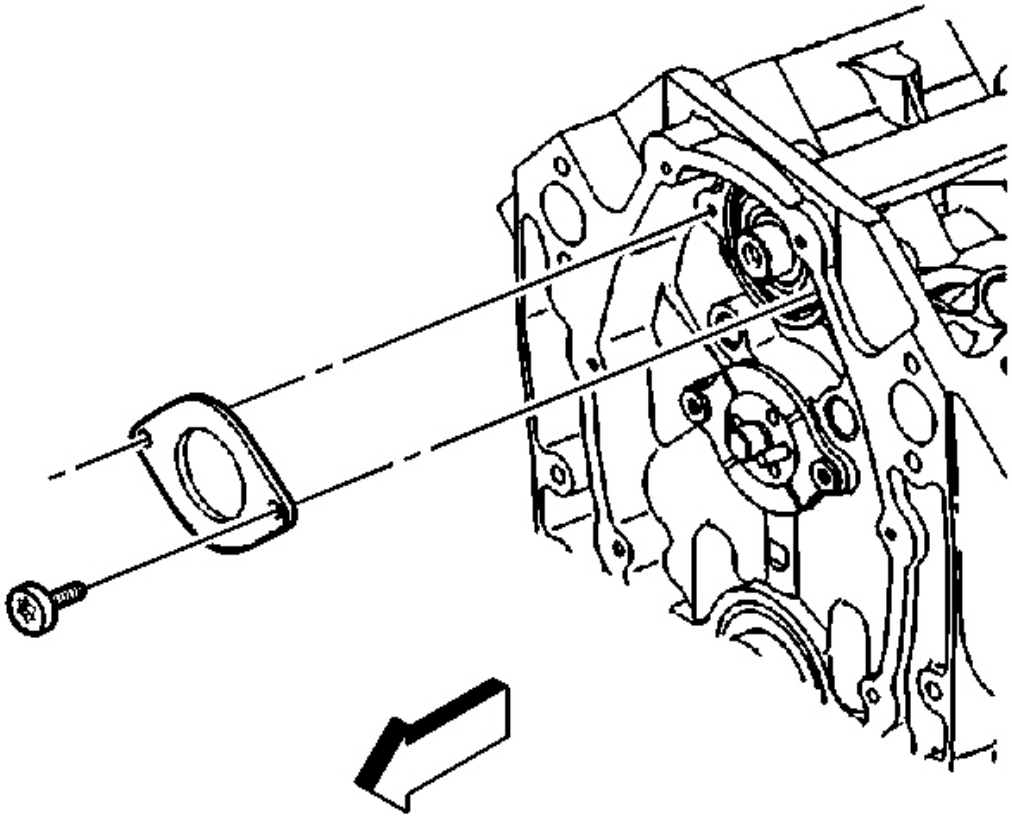


Fig. 643: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the balance shaft retainer and bolts.

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

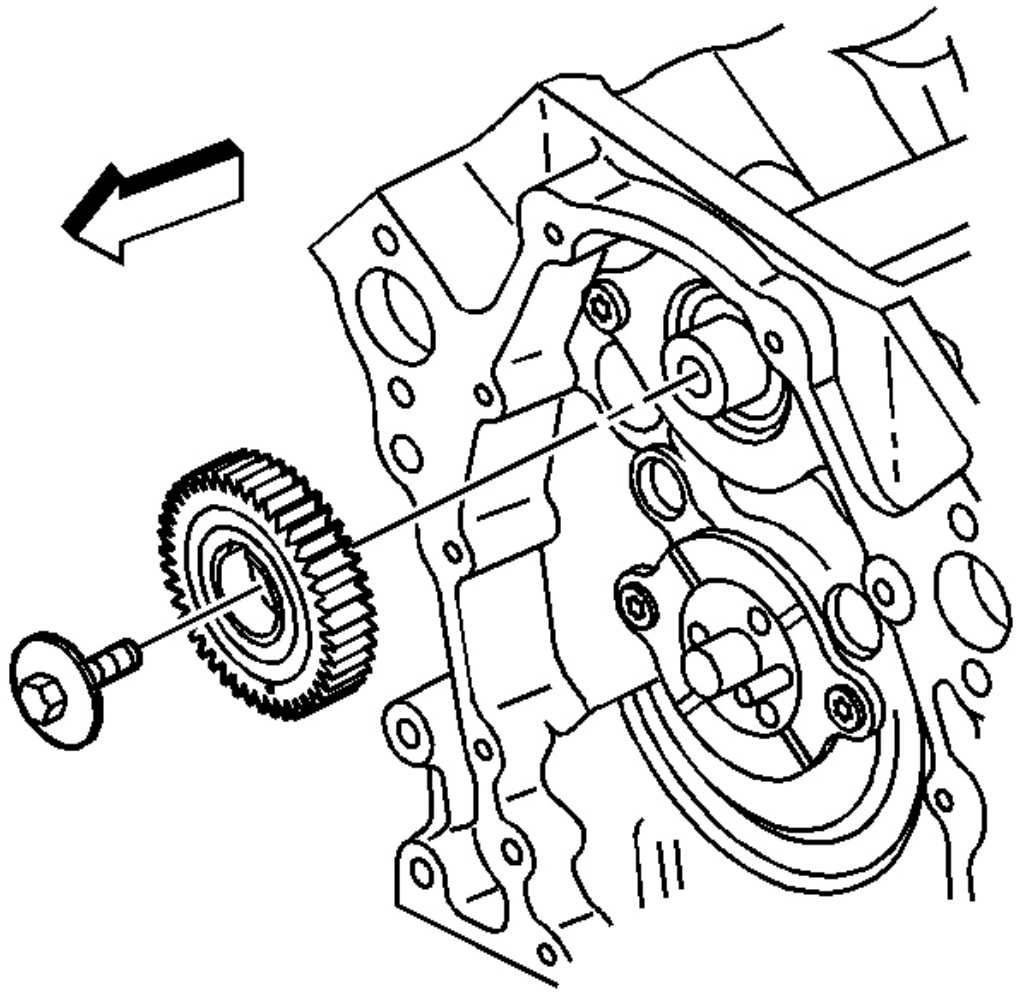


Fig. 644: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Install the balance shaft driven gear onto the balance shaft.
5. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the balance shaft driven gear bolt.

6. Install the balance shaft driven gear bolt.
    1. Use a wrench to secure the balance shaft.

       Place the wrench onto the balance shaft near to the balance shaft front bearing.

    2. Install the balance shaft driven gear bolt.

       Tighten:
        1. Tighten the balance shaft driven gear bolt on the first pass to 20 N.m (15 lb ft).
        2. Tighten the balance shaft driven gear bolt on the final pass using the **J 45059** an additional 35 degrees. See **Special Tools**.

7. Remove the wrench from the balance shaft.
8. Rotate the balance shaft by hand in order to ensure that there is clearance between the balance shaft and the valve lifter pushrod guide. If the balance shaft does not rotate freely, check to ensure that the retaining ring on the balance shaft front bearing is seated on the case.

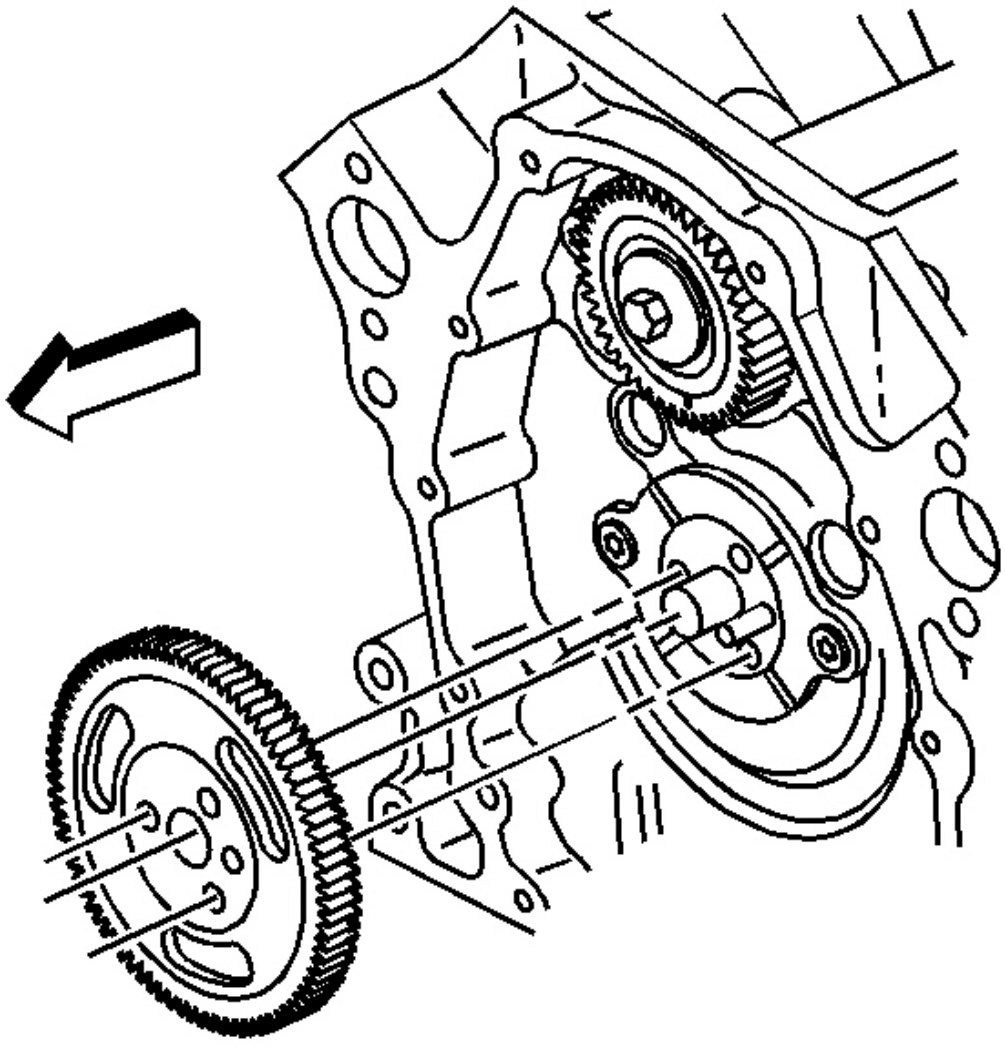


Fig. 645: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT install the camshaft sprocket bolts at this time.

9. Install the balance shaft drive gear.

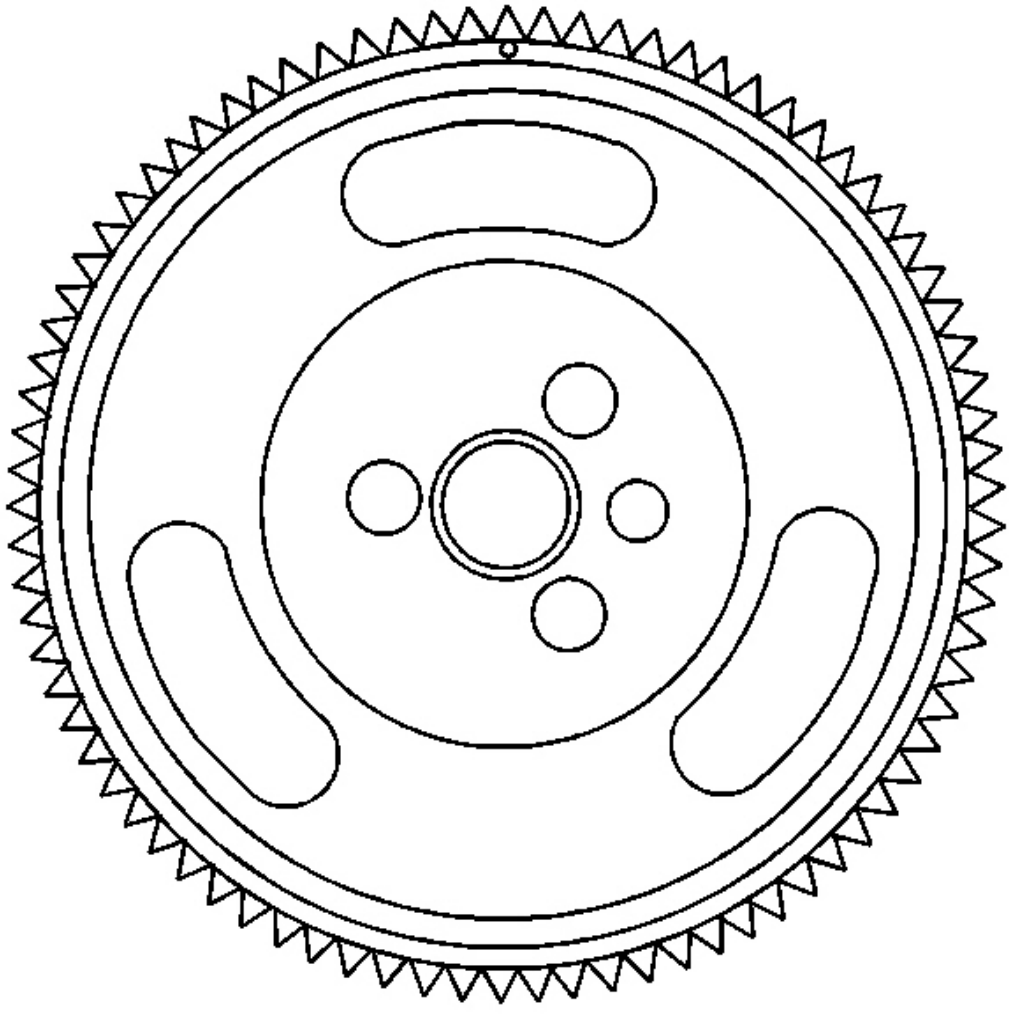


Fig. 646: Balance Shaft Drive Gear Camshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

10. Rotate the engine camshaft so that the timing mark on the balance shaft drive gear is in the 12 o'clock position.

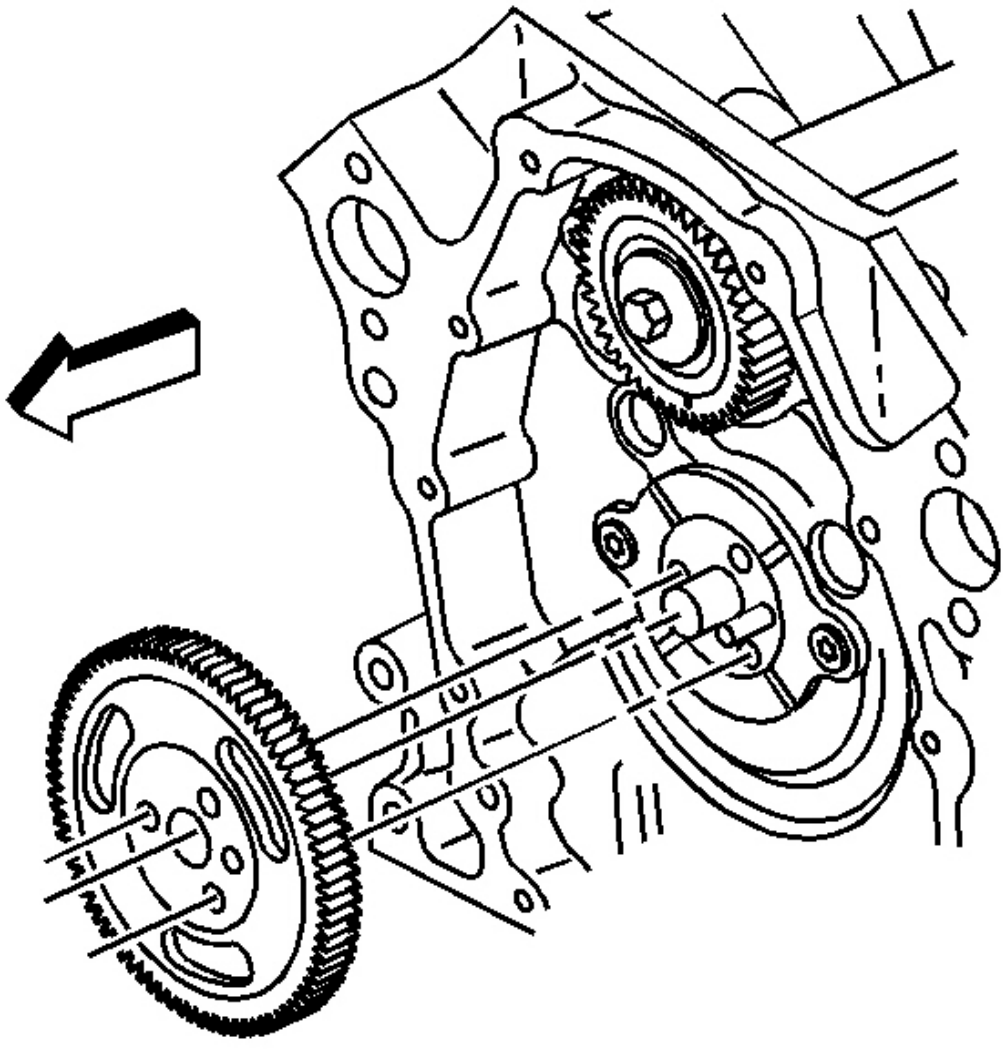


Fig. 647: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

11. Remove the balance shaft drive gear.

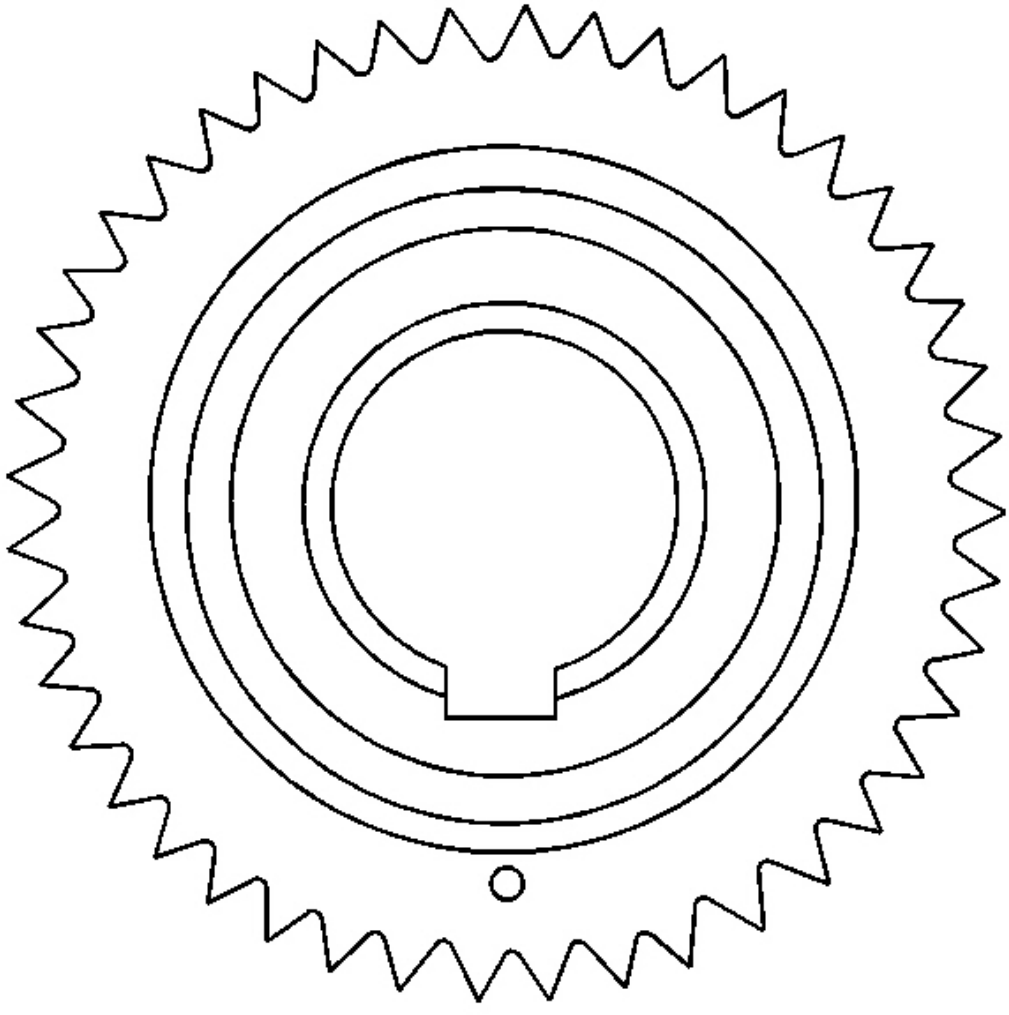


Fig. 648: Balance Shaft Driven Gear Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Rotate the balance shaft so that the timing mark on the balance shaft driven gear is in the 6 o'clock position.

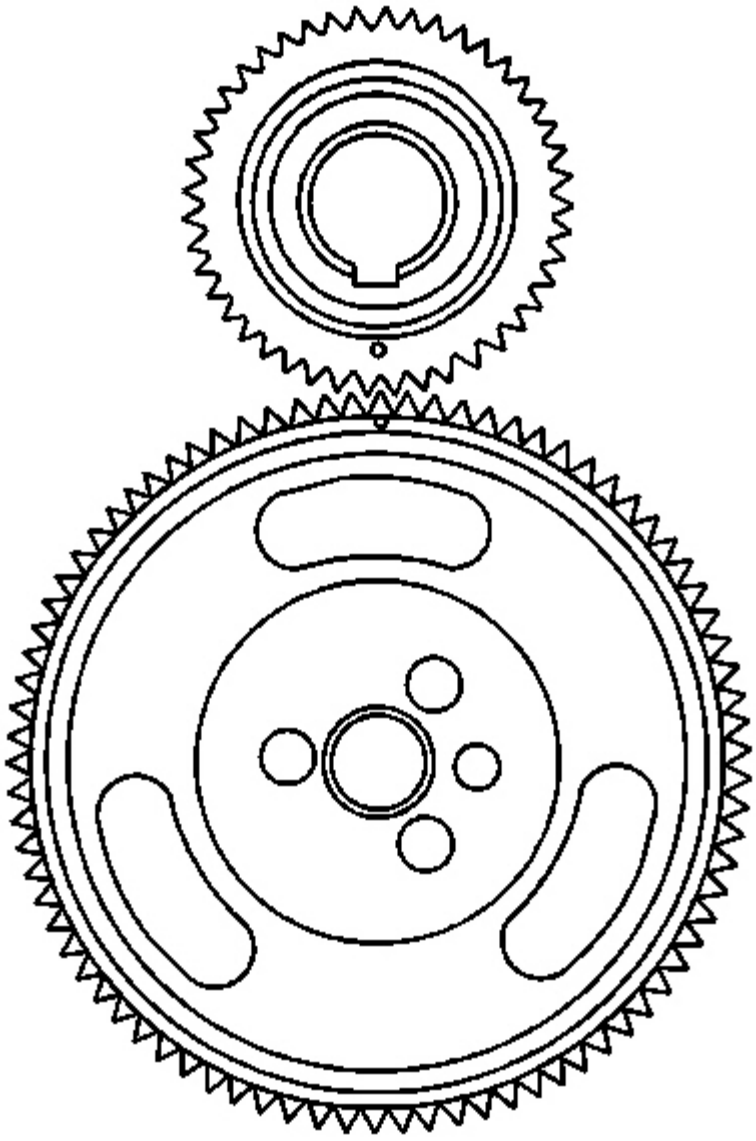


Fig. 649: Aligning Balance Shaft Drive Gear & Balance Shaft Driven Gear Timing Marks
Courtesy of GENERAL MOTORS CORP.

13. Position the balance shaft drive gear onto the engine camshaft.
14. Look to ensure that the balance shaft drive gear and the balance shaft driven gear timing

marks are aligned.

TIMING CHAIN AND SPROCKETS INSTALLATION

Tools Required

J 5590 Pinion Bearing Race Installer - Rear. See **Special Tools**.

Installation

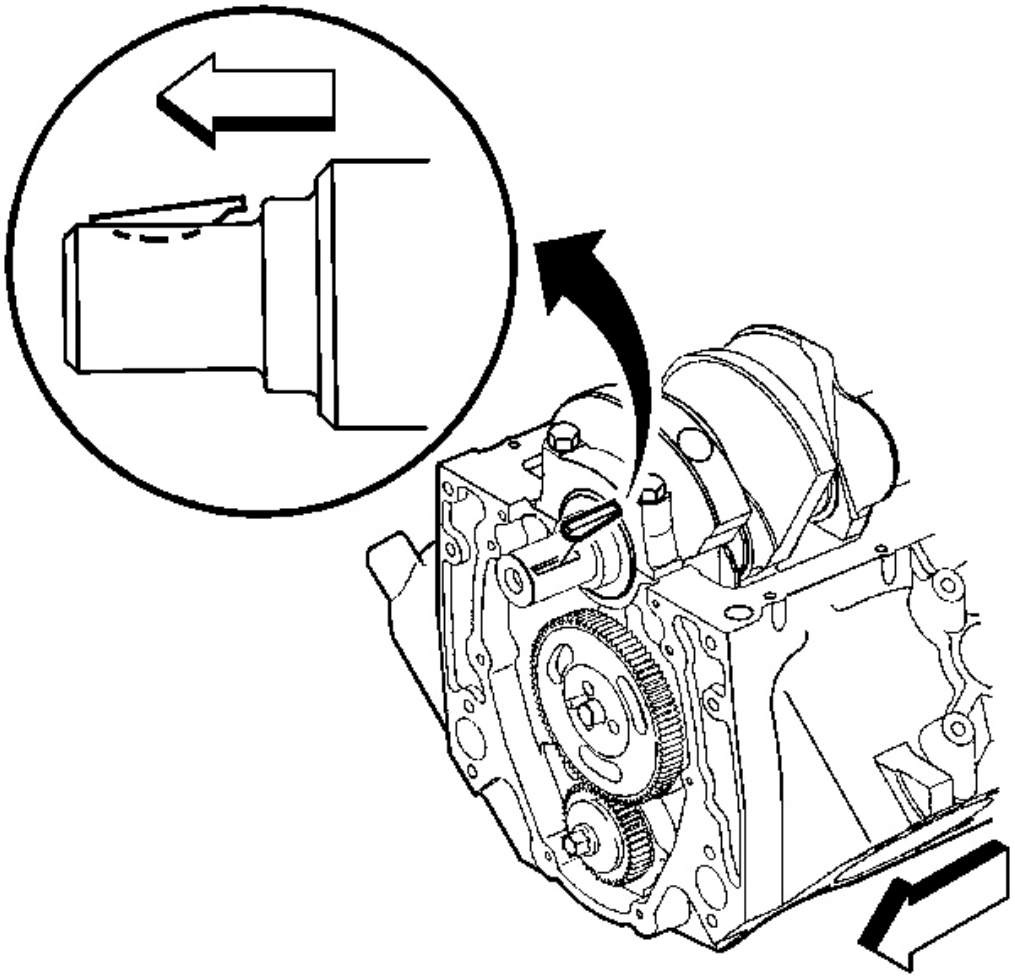


Fig. 650: Locating Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft balancer key into the crankshaft keyway.

   The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.

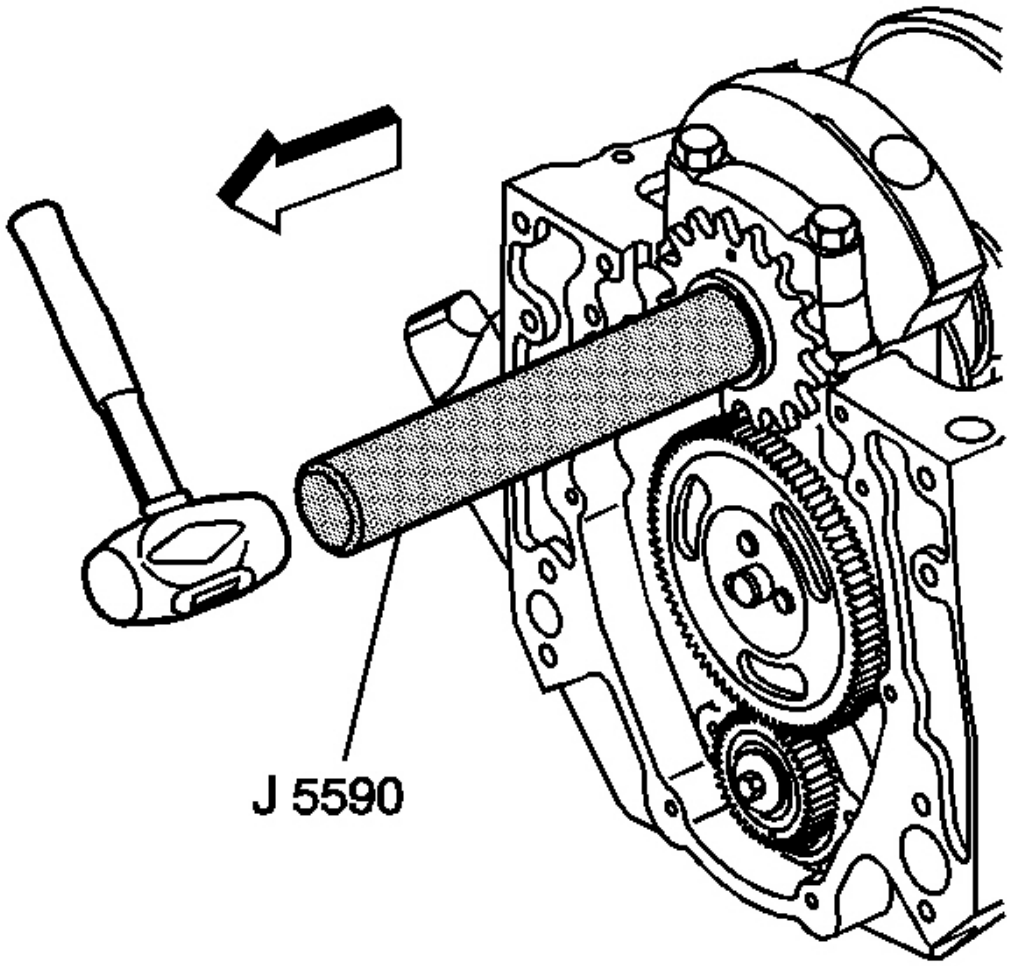


Fig. 651: Installing Crankshaft Sprocket Using J 5590
Courtesy of GENERAL MOTORS CORP.

2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.

CAUTION: Refer to SAFETY GLASSES CAUTION .

3. Use the **J 5590** in order to install the crankshaft sprocket. See **Special Tools**.

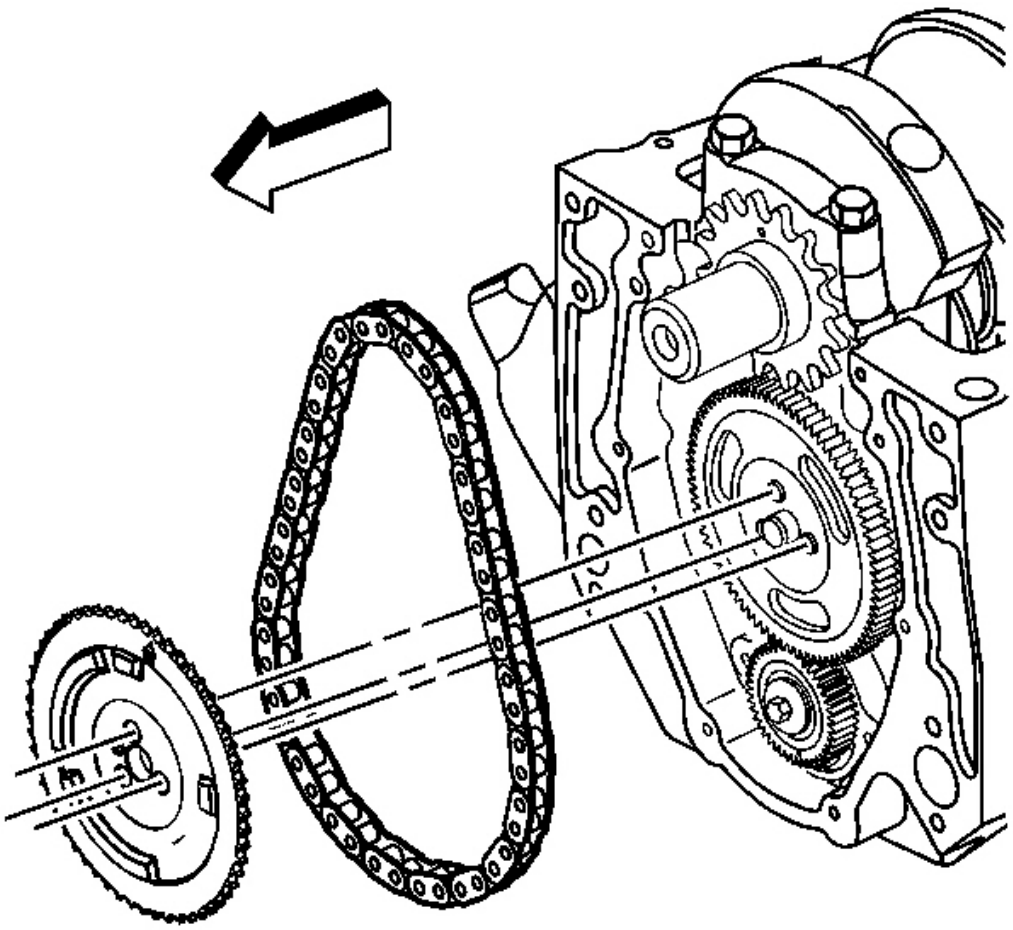


Fig. 652: Camshaft Sprocket And Camshaft Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Rotate the crankshaft until the crankshaft sprocket alignment mark is at the 12 o'clock position.

IMPORTANT: Install the camshaft sprocket with the alignment mark at the 6 o'clock position.

5. Install the camshaft sprocket and the camshaft timing chain.

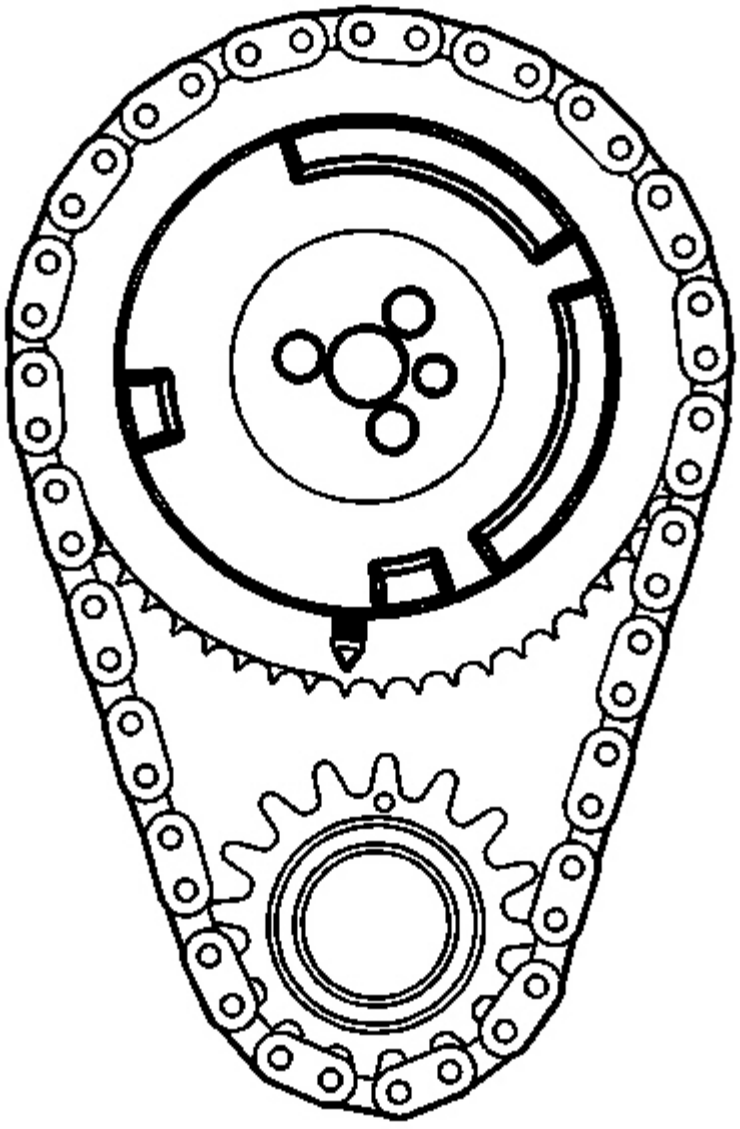


Fig. 653: View Of Sprockets & Chain
Courtesy of GENERAL MOTORS CORP.

6. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and camshaft sprocket is aligned at the 6 o'clock position.

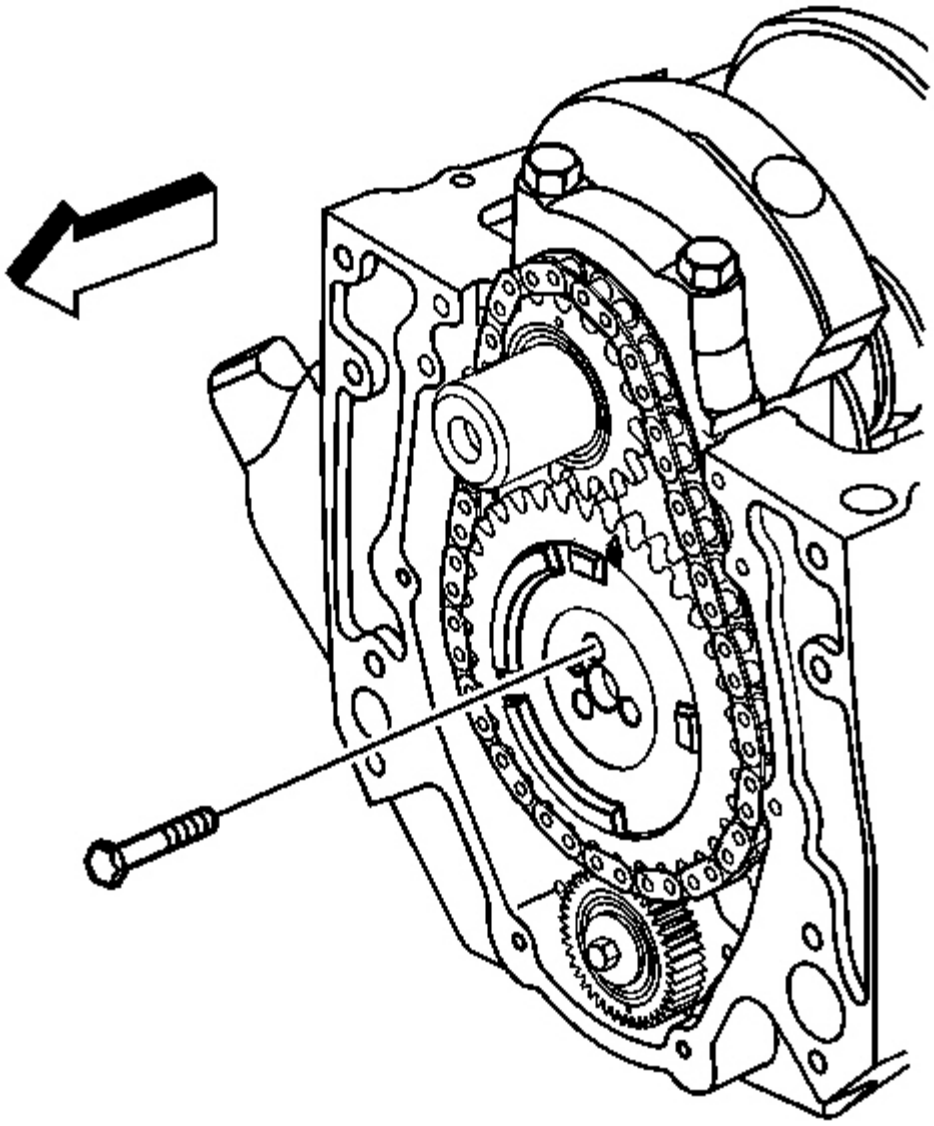


Fig. 654: Camshaft Sprocket & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Do not use a hammer to install the camshaft sprocket onto

the camshaft. To do so may dislodge the expansion cup plug, camshaft rear bearing hole.

7. Install camshaft sprocket bolts.

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

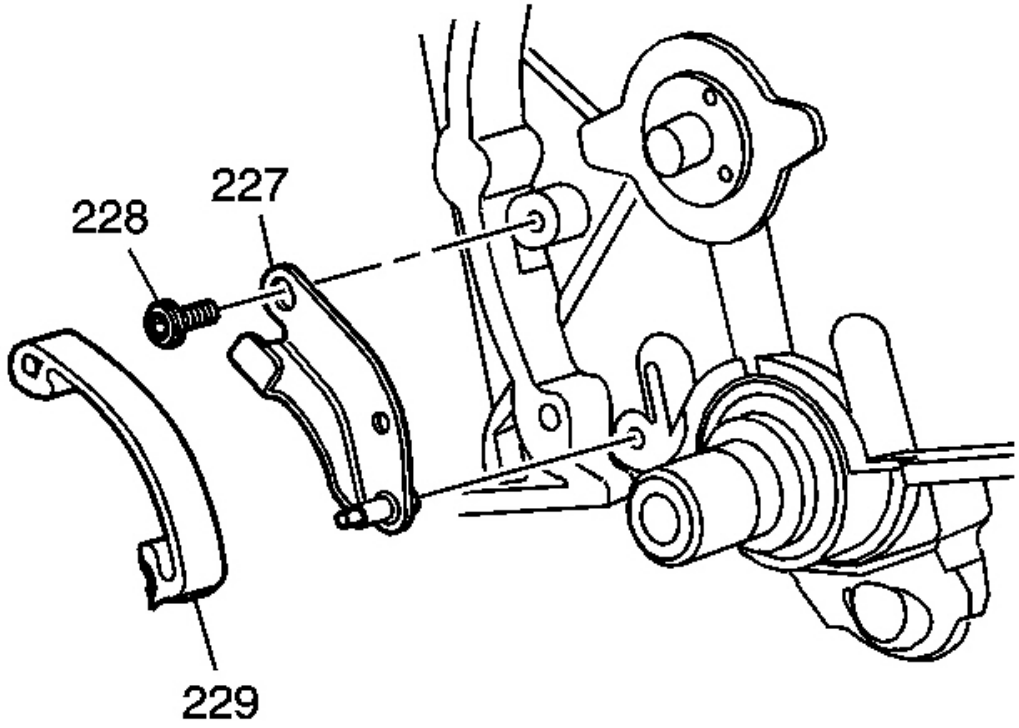


Fig. 655: View Of Timing Chain Tensioner Bracket, Bolt & Shoe
Courtesy of GENERAL MOTORS CORP.

8. Install the timing chain tensioner bracket and bolt (227 and 228).

   Tighten: Tighten the timing chain tensioner bracket bolt to 12 N.m (106 lb in).

IMPORTANT: The timing chain tensioner shoe snaps onto the tensioner bracket. Ensure that the shoe is fully seated before proceeding.

9. Install the timing chain tensioner shoe (229) using an upwards motion.

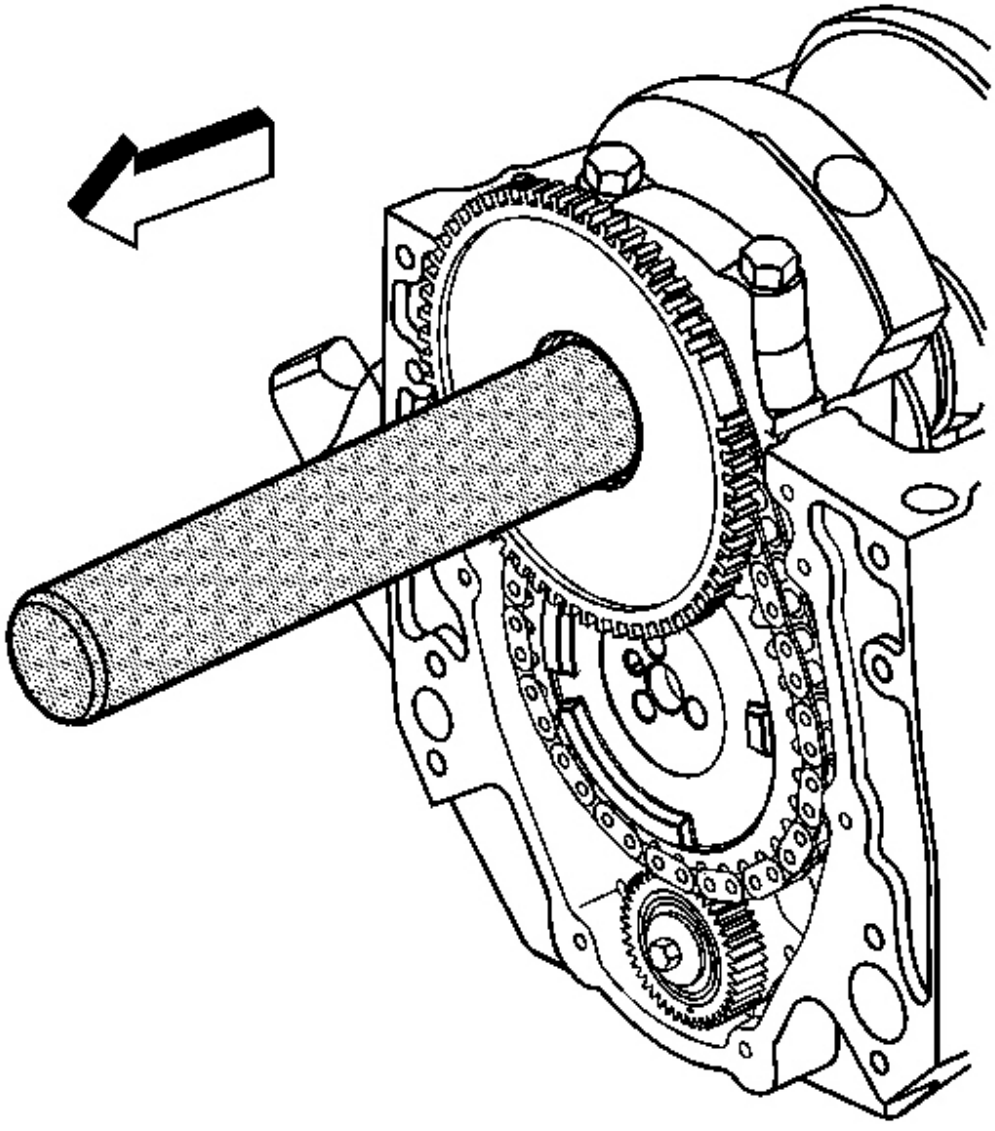


Fig. 656: Installing Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft position sensor reluctor ring.

1. Align the keyway on the crankshaft position sensor reluctor ring with the crankshaft balancer key in the crankshaft.
2. Use the **J 5590** in order to push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket. See **Special Tools**.

ENGINE FRONT COVER INSTALLATION

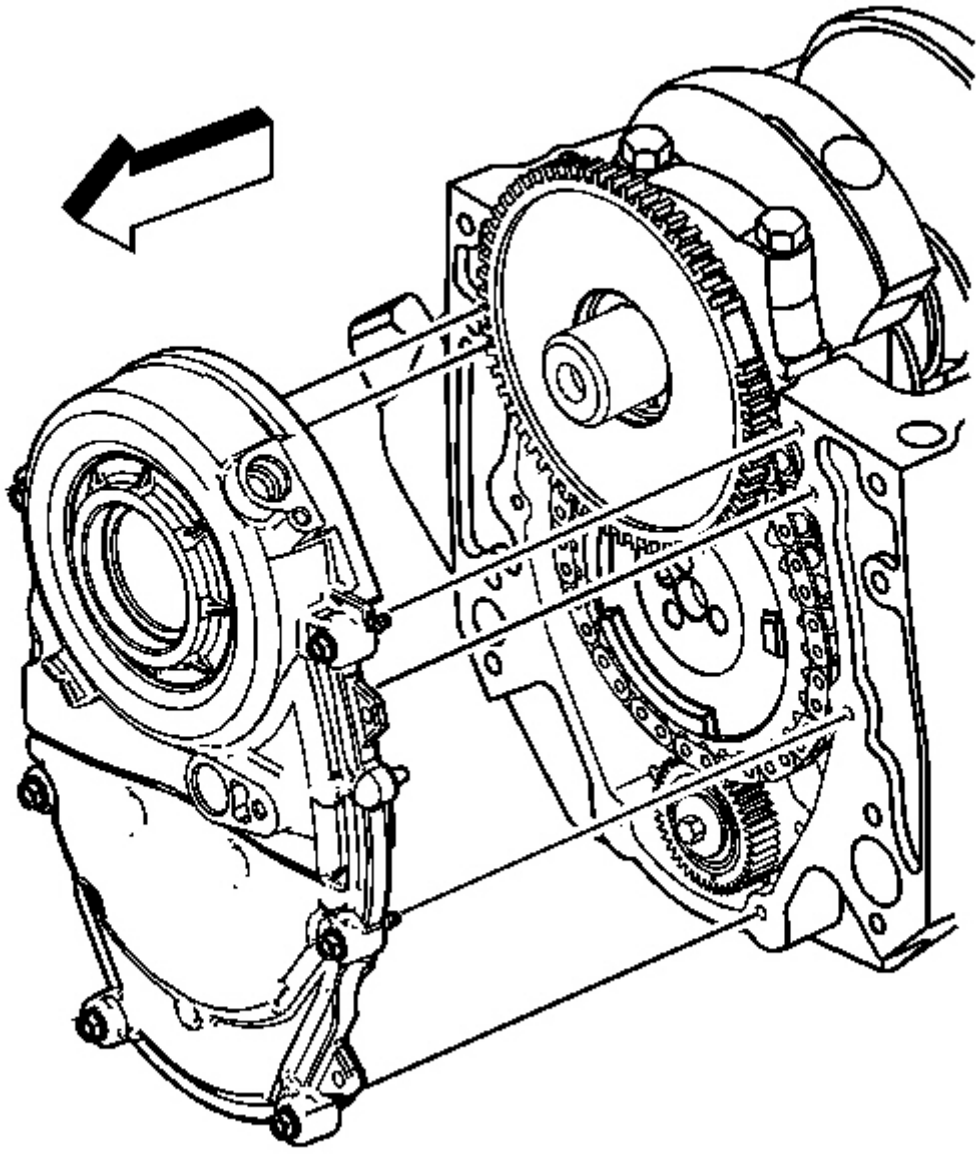


Fig. 657: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Once the composite engine front cover is removed DO NOT reinstall the engine front cover. Always install a NEW engine

front cover.

1. Install the NEW engine front cover.

NOTE: Refer to Fastener Notice .

2. Install the engine front cover bolts.

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

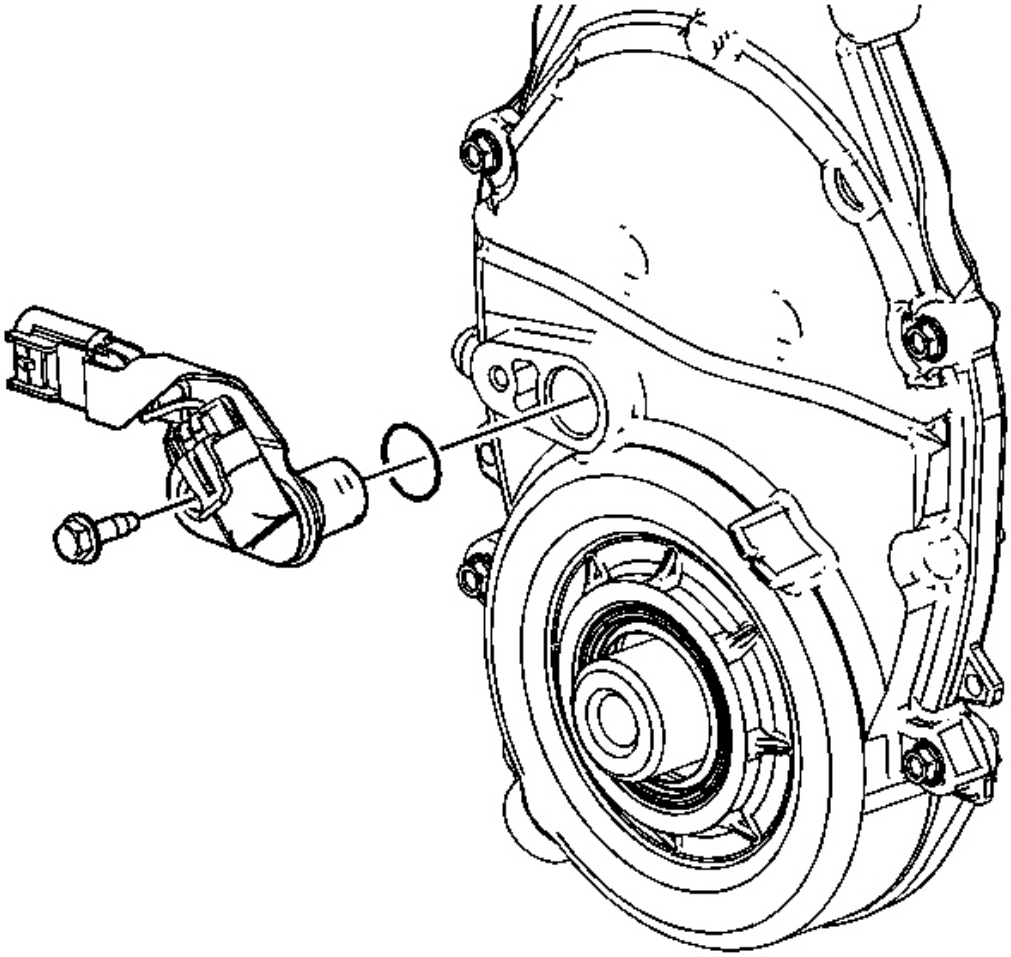


Fig. 658: camshaft position sensor & bolt

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the original camshaft position sensor O-ring seal. When installing the camshaft position sensor assembly be sure the camshaft position sensor assembly is fully seated and held stationary in the engine front cover camshaft position sensor bore. A camshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

3. Lubricate the NEW camshaft position sensor O-ring seal with clean engine oil.
4. Install the NEW camshaft position sensor O-ring seal onto the camshaft position sensor assembly.
5. Install the camshaft position sensor assembly until fully seated into the engine front cover.
6. Install camshaft position sensor bolt.

Tighten: Tighten the camshaft position sensor bolt to N.m (lb in).

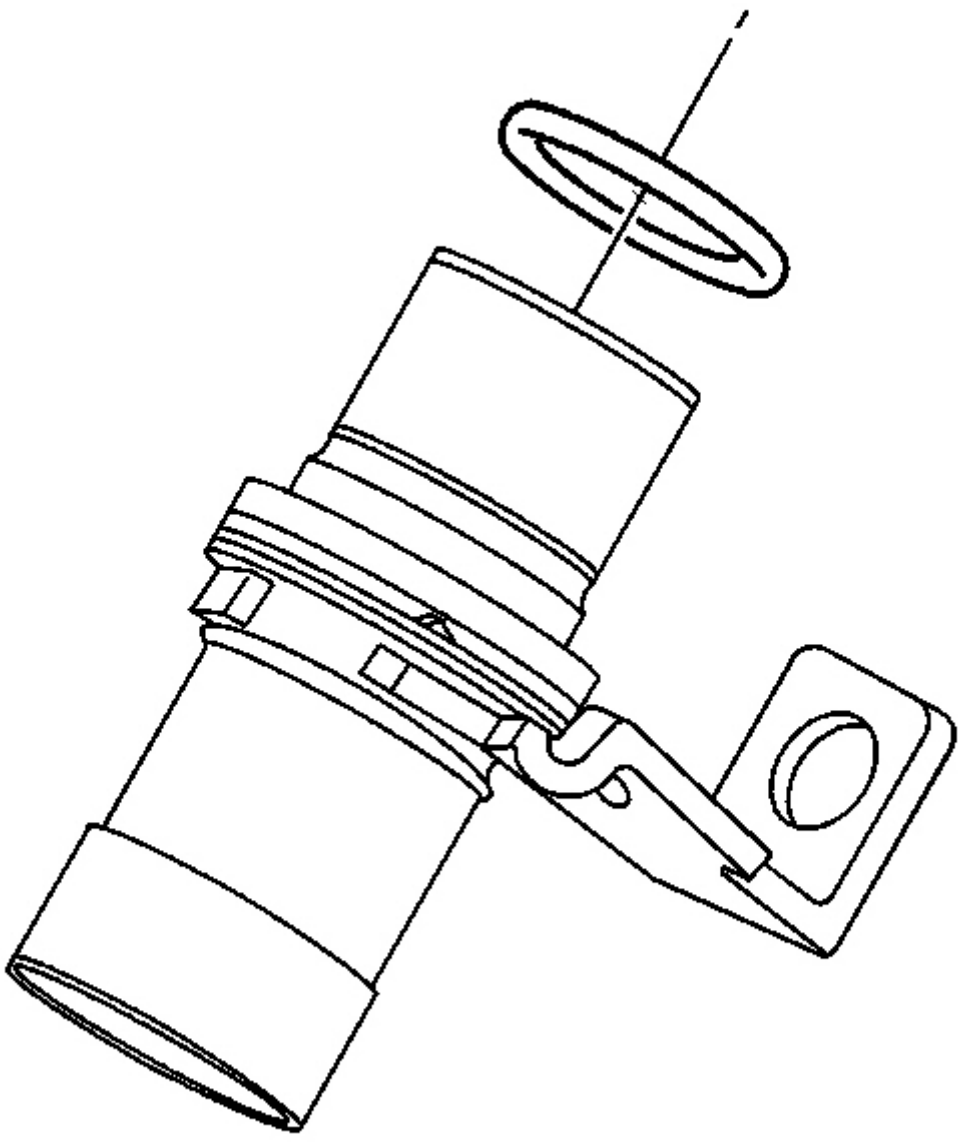


Fig. 659: View Of Crankshaft Position Sensor Seal O-Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the original crankshaft position sensor seal, O-ring. When installing the crankshaft position sensor be sure the crankshaft position sensor is fully seated and held

stationary in the engine front cover crankshaft position sensor bore. A crankshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

7. Lubricate the NEW crankshaft position sensor seal, O-ring, with clean engine oil.
8. Install the NEW crankshaft position sensor seal, O-ring, onto the crankshaft position sensor.

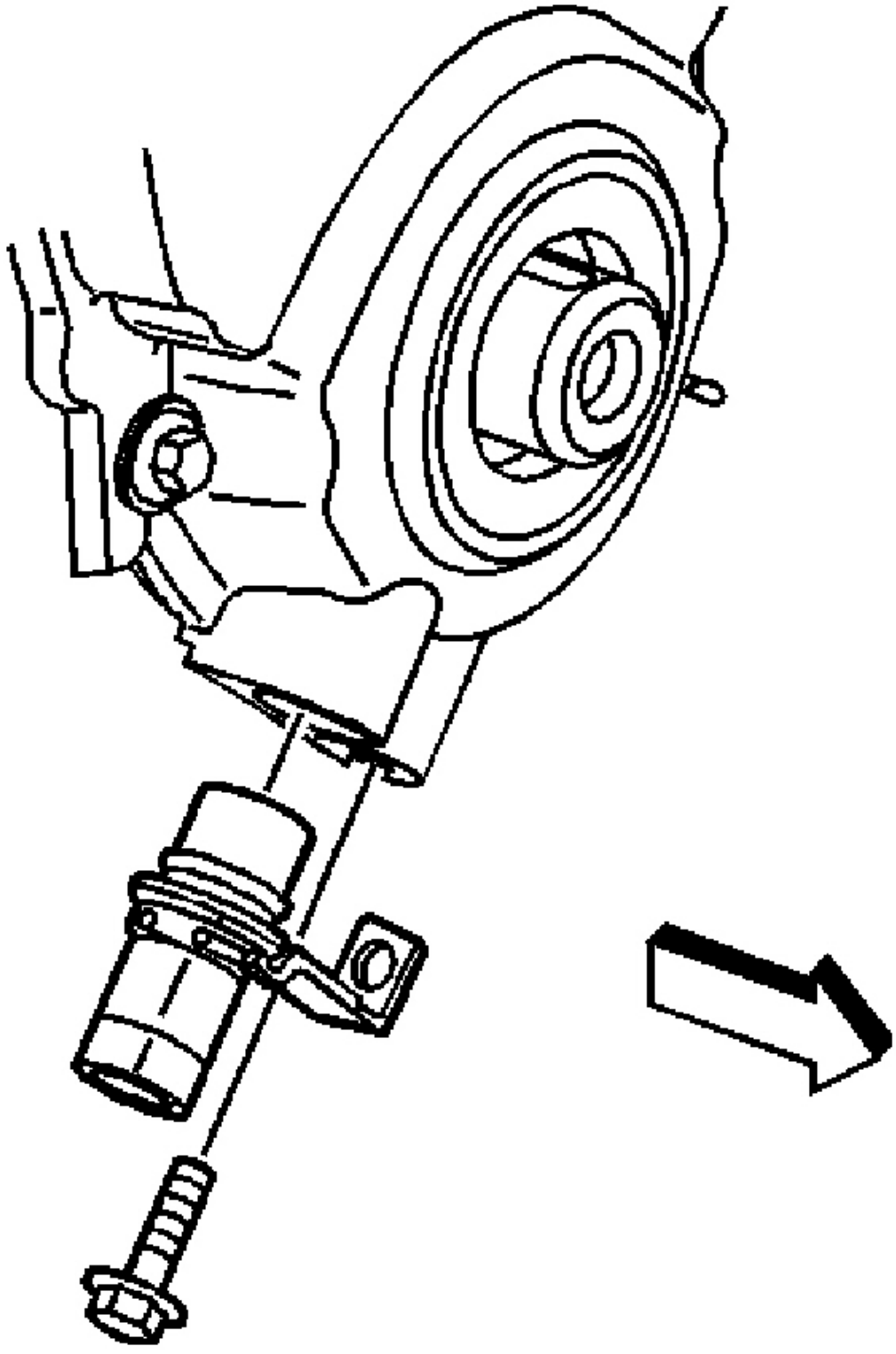


Fig. 660: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install crankshaft position sensor until fully seated into the engine front cover.
10. Install crankshaft position sensor bolt.

Tighten: Tighten the crankshaft position sensor bolt to 8 N.m (71 lb in).

OIL PUMP INSTALLATION

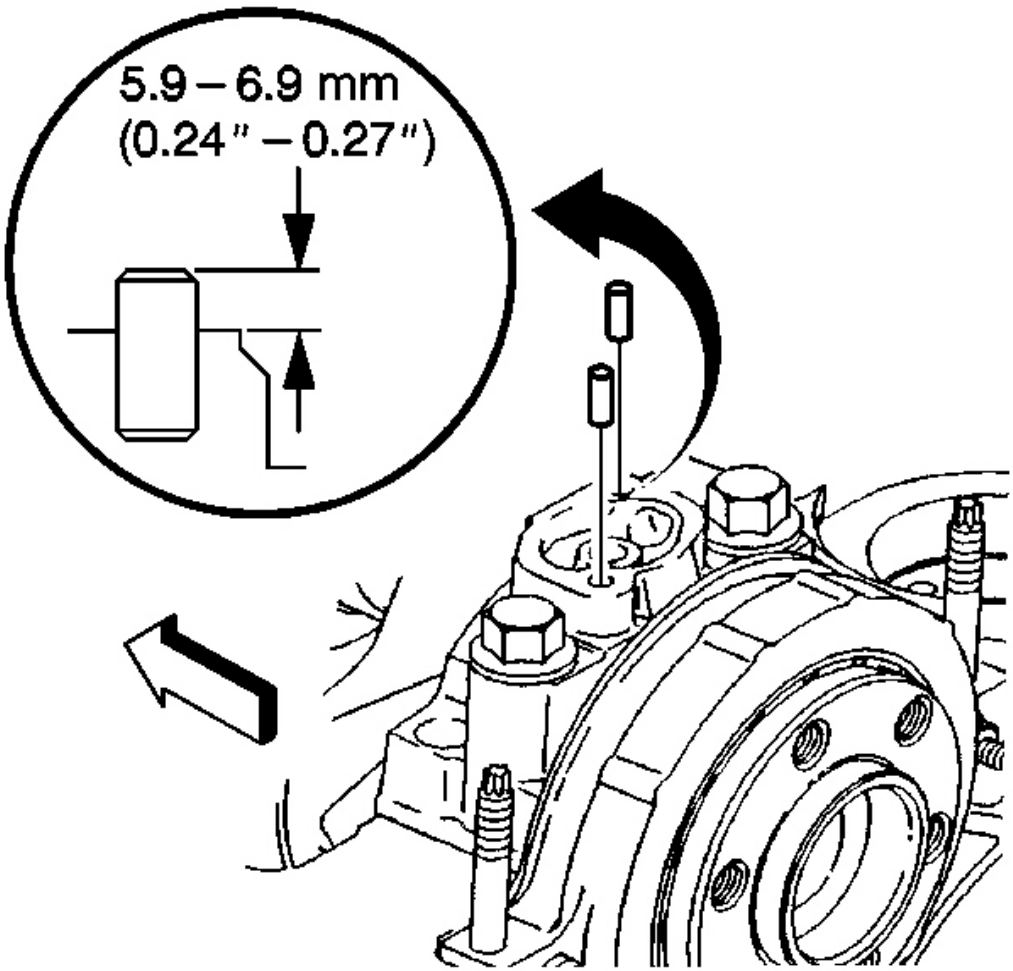


Fig. 661: Oil Pump Locator Pins

Courtesy of GENERAL MOTORS CORP.

1. Inspect for properly installed oil pump locator pins.

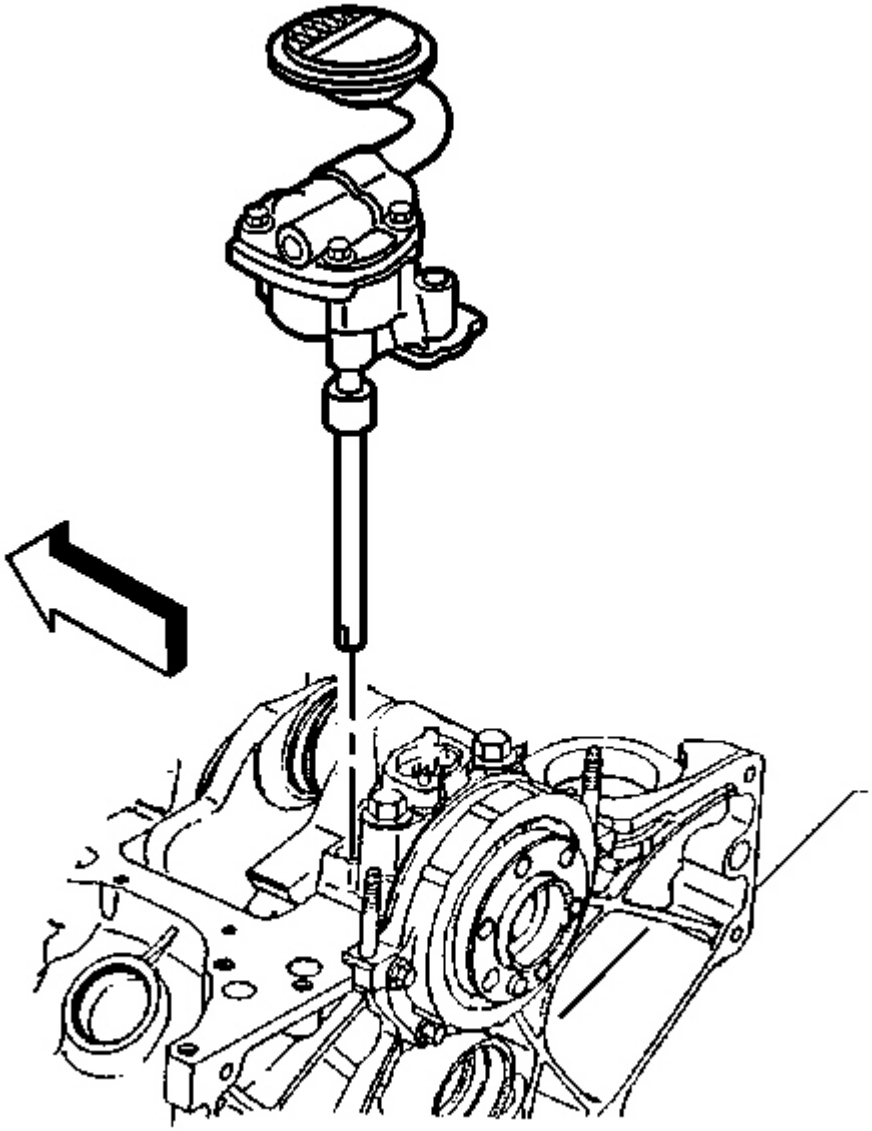


Fig. 662: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the oil pump driveshaft retainer.
During assembly, install a NEW oil pump driveshaft retainer.

2. Install the oil pump.
3. Position the oil pump onto the pins.

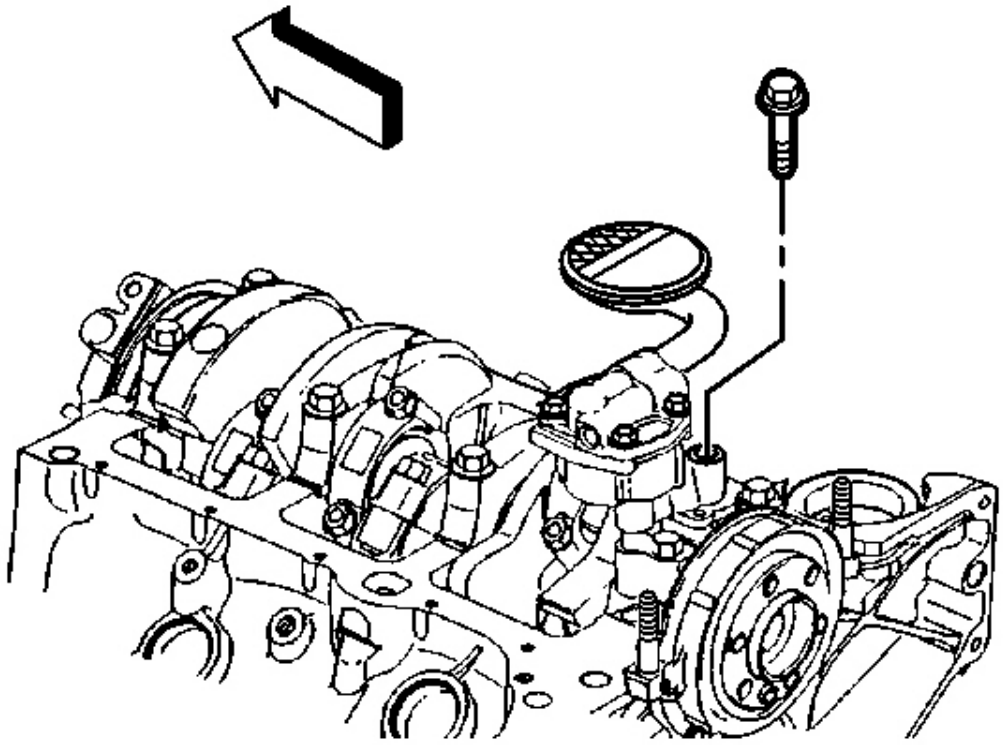


Fig. 663: View Of Oil Pump Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the oil pump bolt attaching the oil pump to the rear crankshaft bearing cap.

Tighten: Tighten the oil pump bolt to 90 N.m (66 lb ft).

OIL PAN INSTALLATION

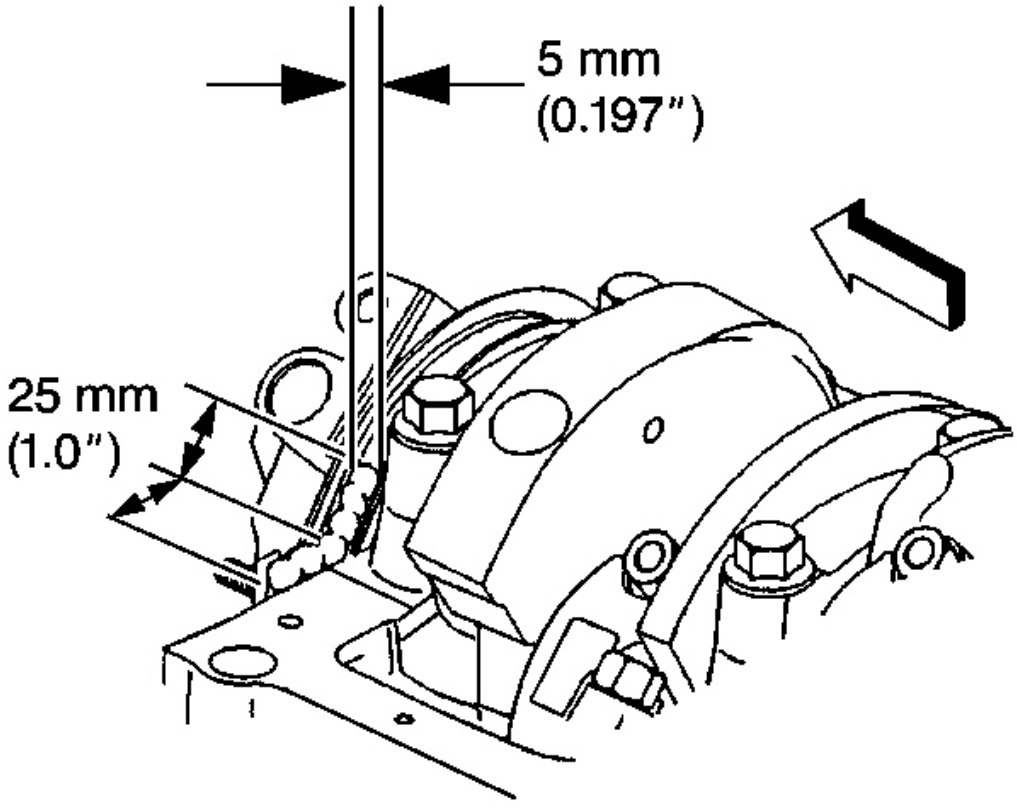


Fig. 664: Applying Adhesive To Engine Sides Front Cover To Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to both the right and left sides of the engine front cover to engine block junction at the oil pan sealing surfaces.

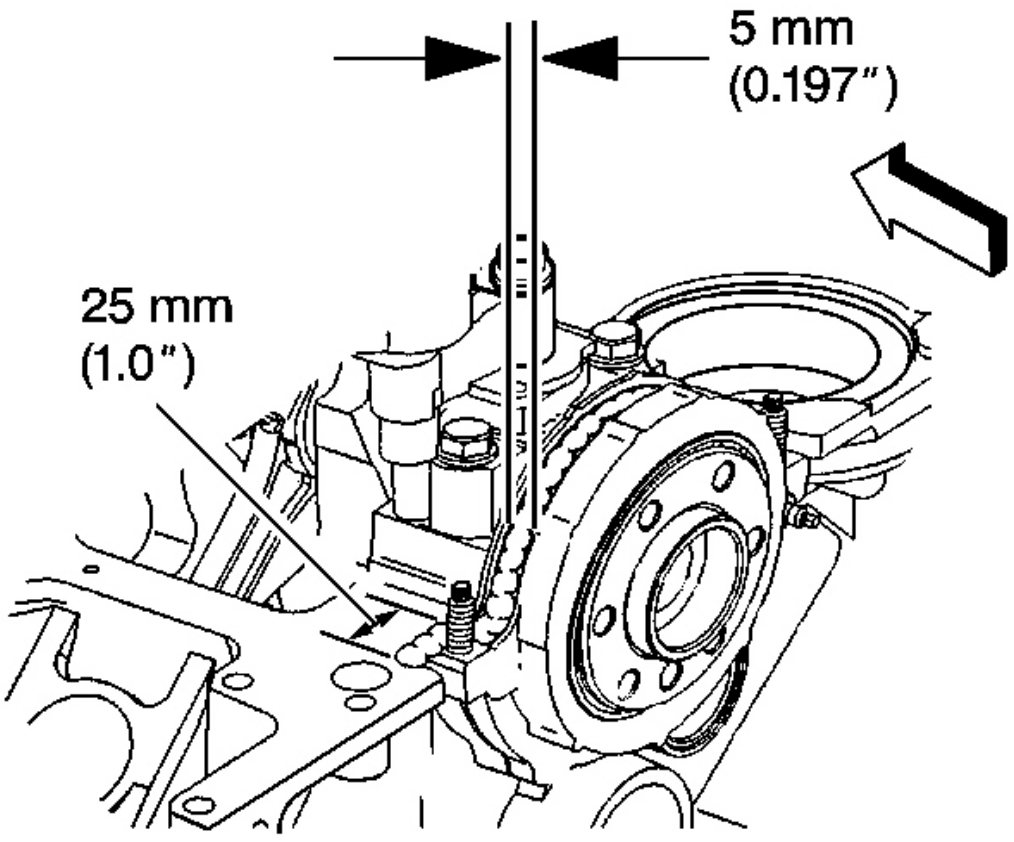


Fig. 665: Applying Adhesive To Entire Length Of Rear Oil Seal Housing To Engine Block Junction At Oil Pan Sealing Surfaces
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the entire crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.

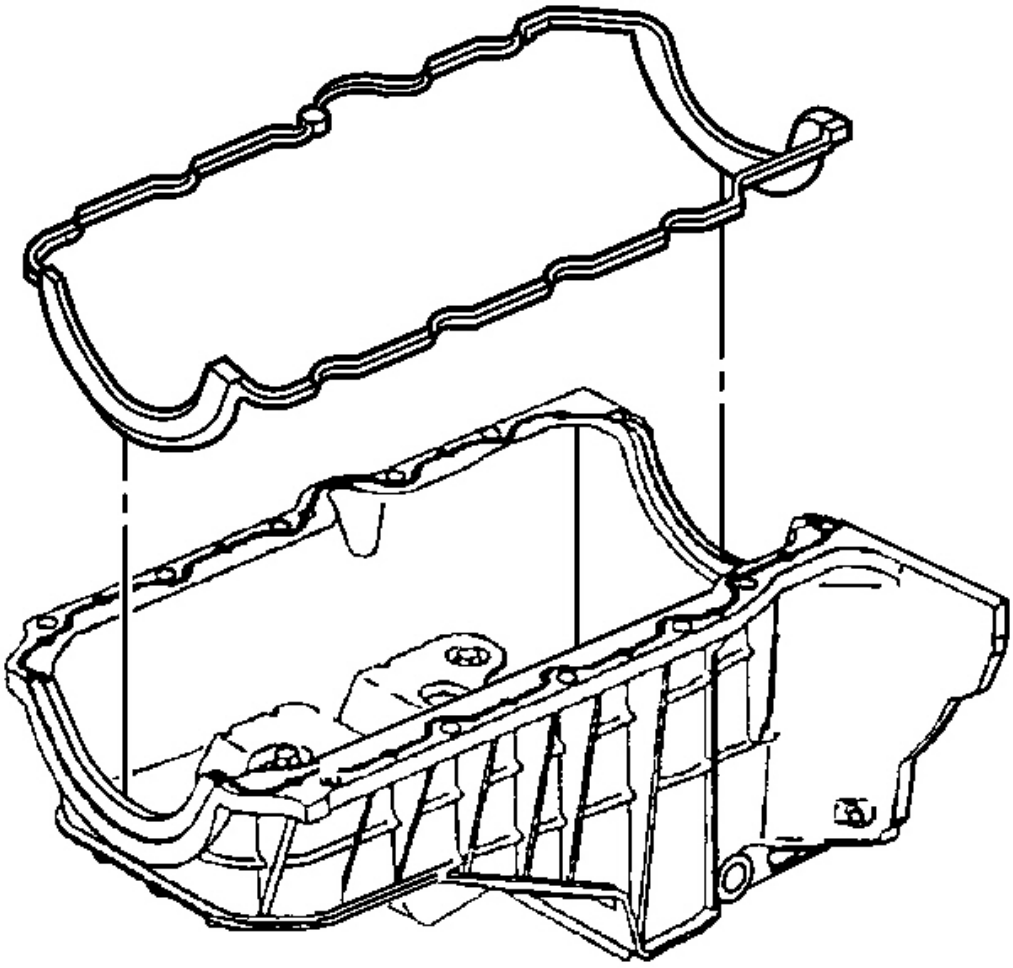


Fig. 666: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install a NEW oil pan gasket.
The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Install the NEW oil pan gasket into the groove in the oil pan.

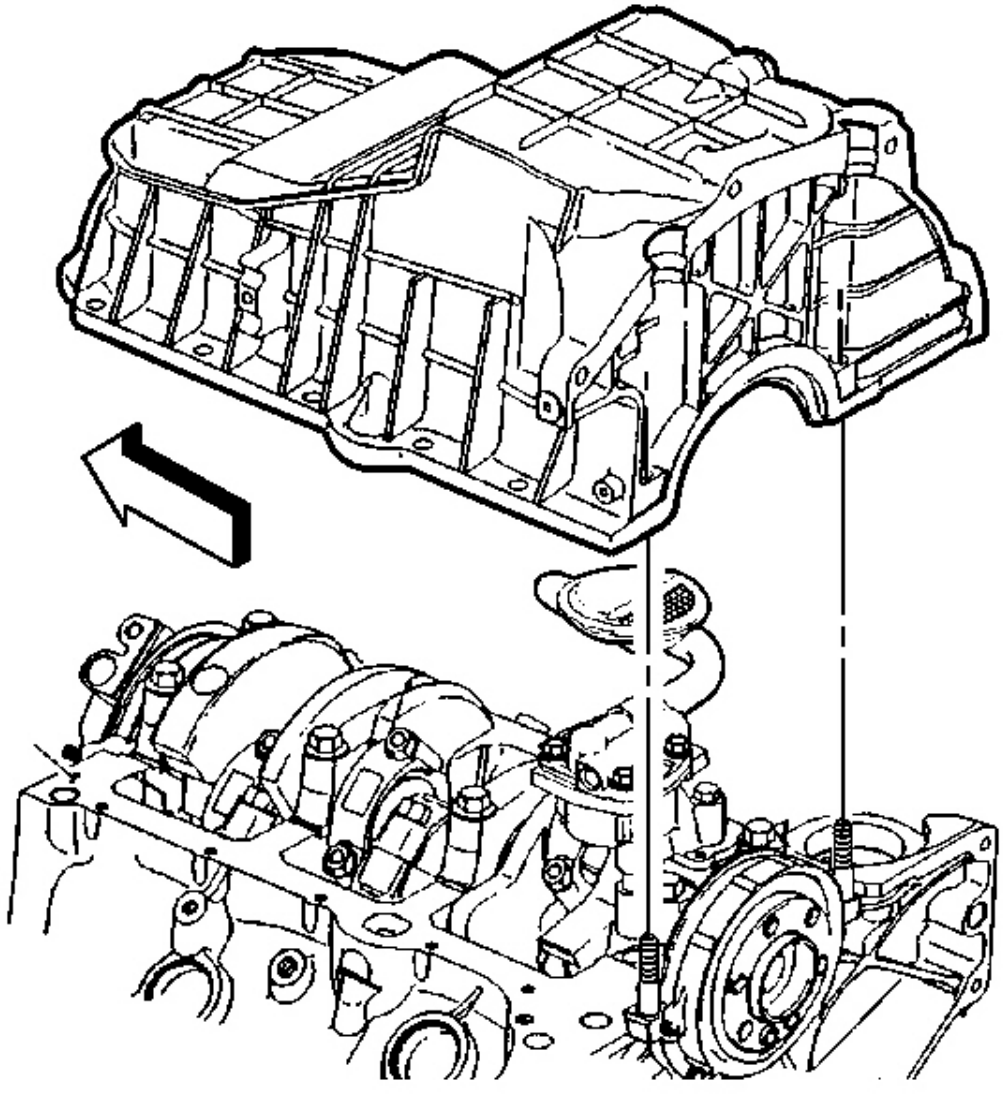


Fig. 667: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan alignment must always be flush or forward no more than 0.3 mm (0.011 in) from the rear face of the engine block.

4. Install the oil pan onto the engine block.

Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.

5. Slide the oil pan back against a suitable straight edge.

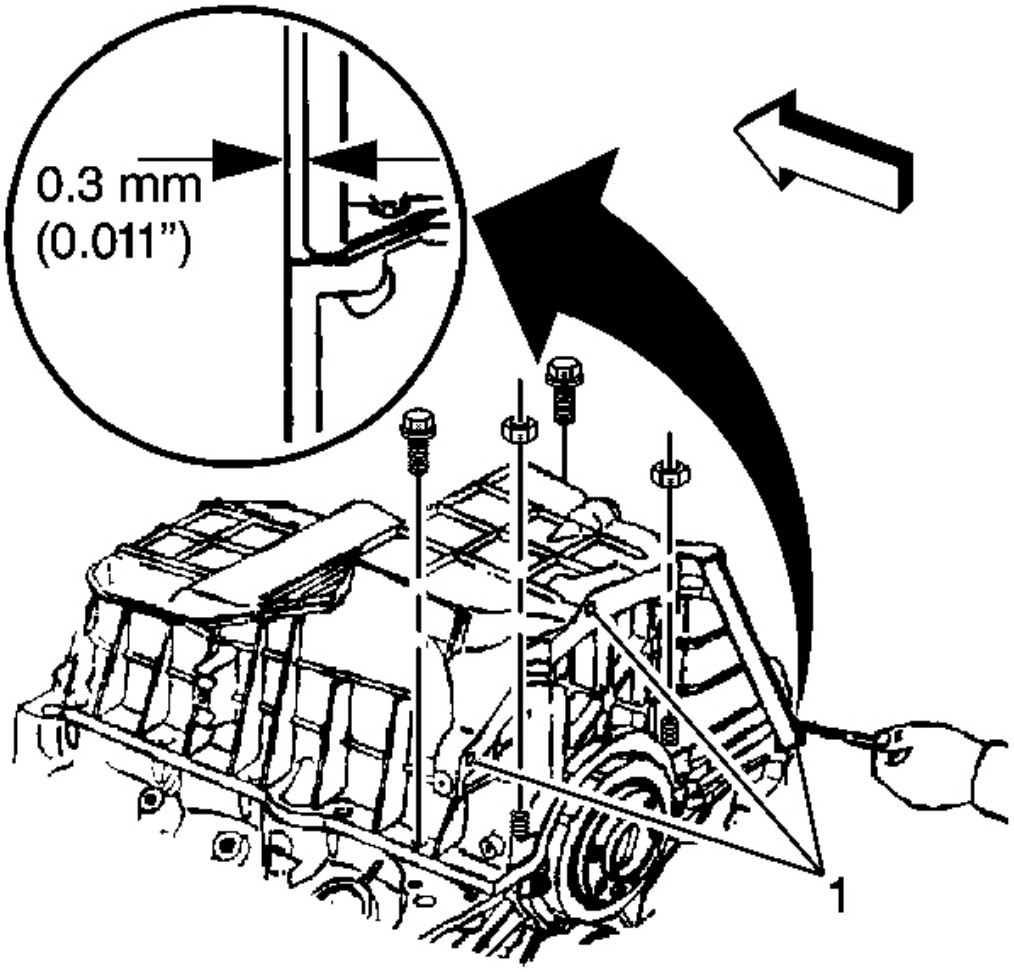


Fig. 668: Measuring Pan-To-Transmission Housing Clearance
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan bolts and nuts, but do not tighten.
7. Measure the pan-to-transmission housing clearance using a feeler gage and a straight edge.

Use a feeler gage to check the clearance between the oil pan-to-transmission housing measurement points. If the clearance exceeds 0.3 mm (0.011 in) at any of the 3 oil pan-to-transmission housing measurement points (1), then repeat the step until the oil pan-to-transmission housing clearance is within the specification. The oil pan must always be forward of the rear face of the engine block.

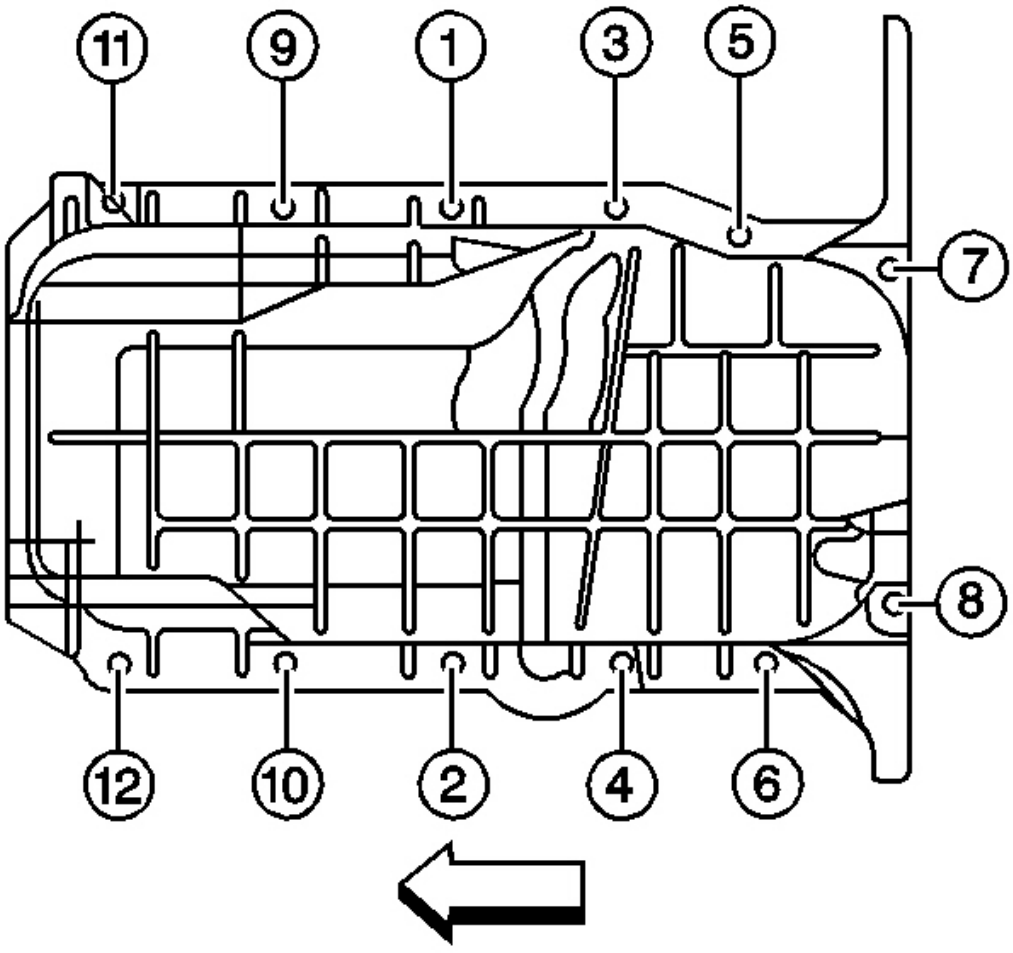


Fig. 669: Oil Pan Bolts & Nuts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: The alignment of the mating components is crucial. An offset greater than 0.30 mm (0.011 in) between the rear faces of the

oil pan and block is not acceptable. Offsets greater than 0.30 mm (0.011 in) will affect the alignment between the engine assembly and the transmission. Mis-alignment of the engine assembly to the transmission can lead to internal and external damage to the engine assembly and/or transmission.

NOTE: Refer to Fastener Notice .

8. Tighten the oil pan bolts and nuts in sequence (1-12).

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

9. Measure the clearance between the 3 oil pan-to-transmission housing measurement points in order to ensure proper alignment.

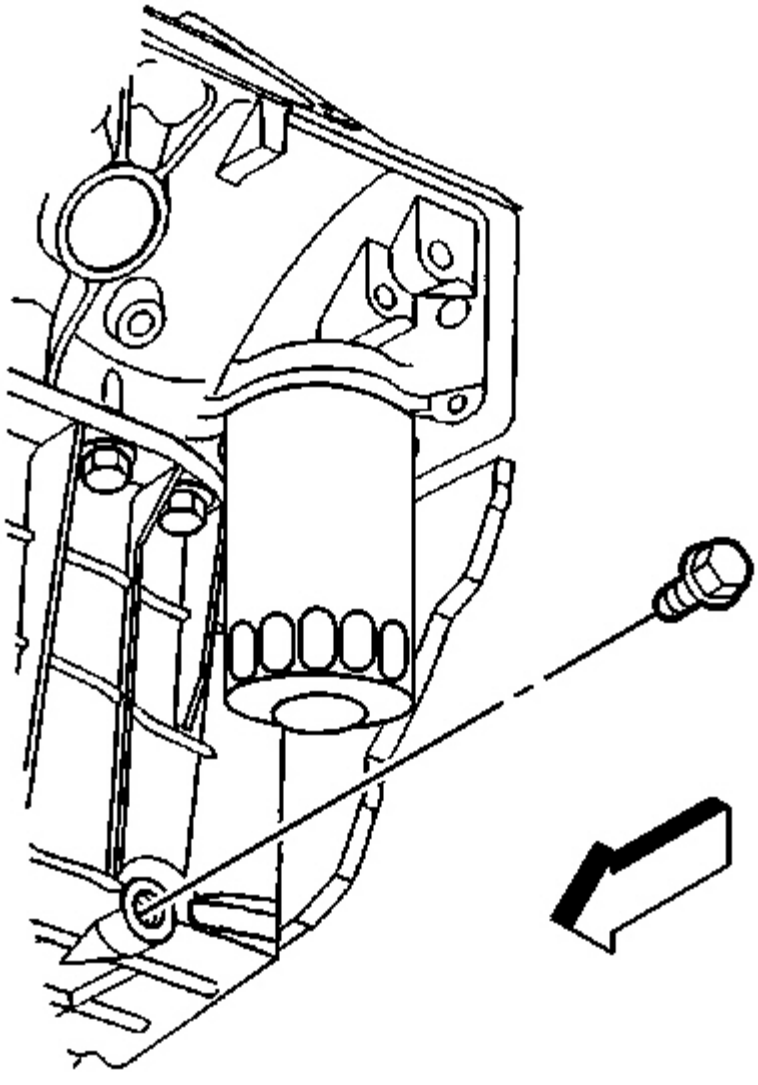


Fig. 670: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

10. Install a NEW oil pan drain plug seal, O-ring, onto the oil pan drain plug.
11. Install the oil pan drain plug into the oil pan.

Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

CRANKSHAFT BALANCER INSTALLATION

Tools Required

J 23523-F Balancer Remover and Installer

Installation

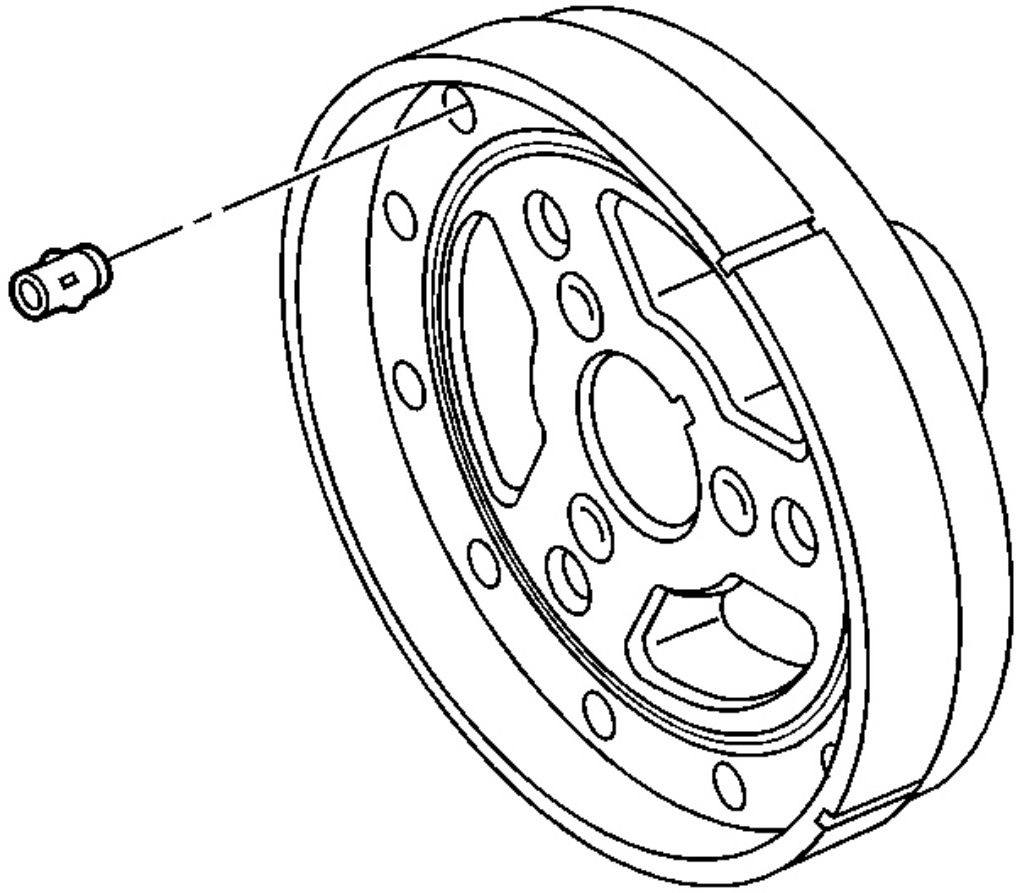


Fig. 671: View Of Crankshaft Balancer Weights
Courtesy of GENERAL MOTORS CORP.

1. Look to ensure that the crankshaft balancer front groove pin is installed in the proper location, if applicable.

The length and location of the pins must be the same as the original length and location.

NOTE: The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material. The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

2. Apply a small amount of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, onto the crankshaft balancer keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
3. Align the keyway of the crankshaft balancer with the crankshaft balancer key.
4. Install the crankshaft balancer onto the end of the crankshaft.

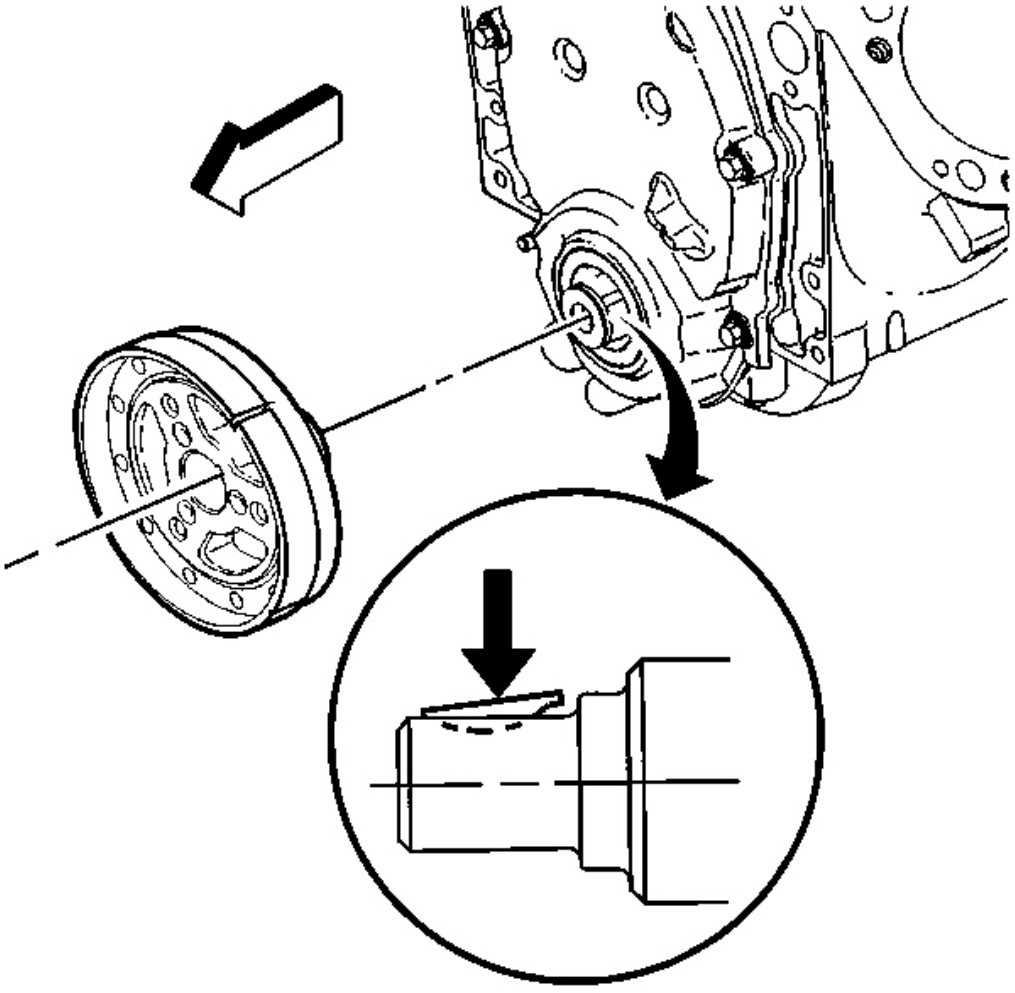


Fig. 672: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

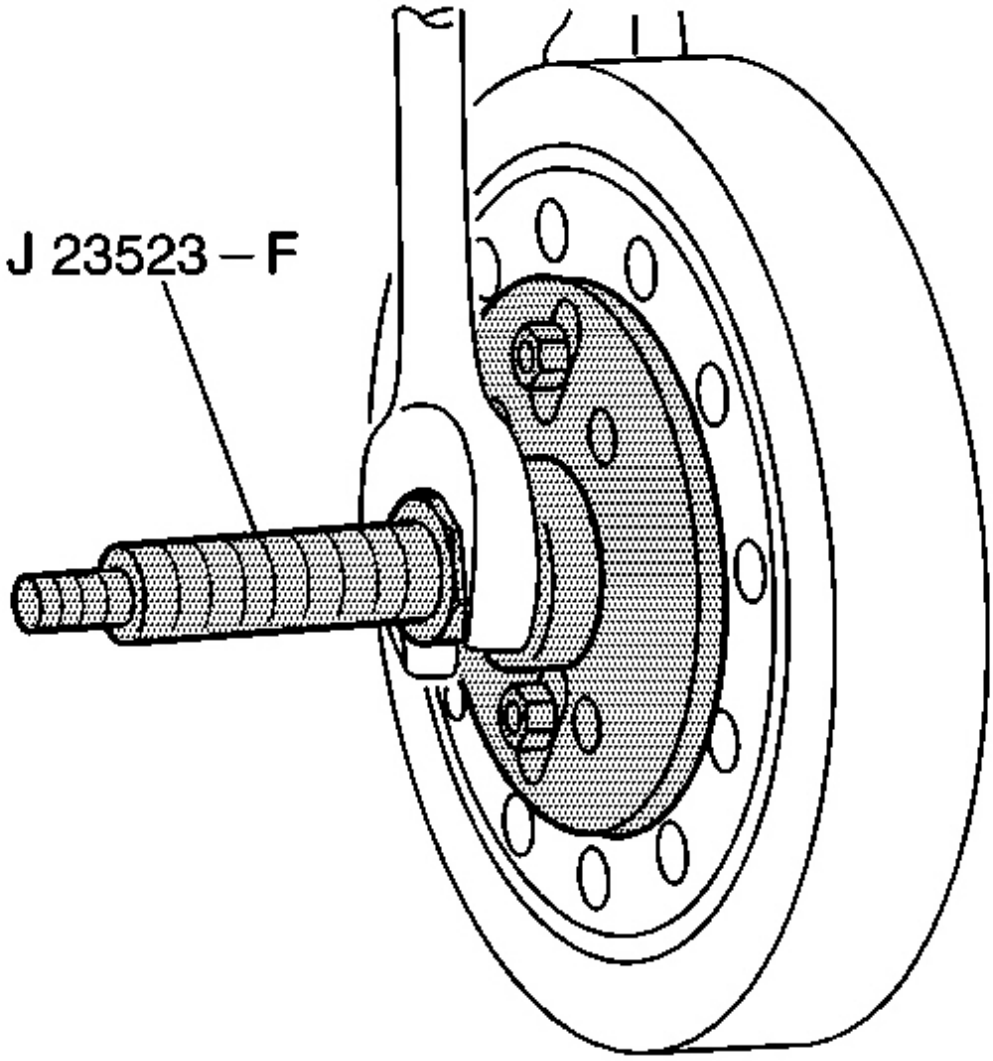


Fig. 673: Pressing Crankshaft Balancer Onto Crankshaf Using J 23523-F
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Use the **J 23523-F** in order to press the crankshaft balancer onto the crankshaft.
    1. Install the **J 23523-F** plate and bolts onto the front of the crankshaft balancer.

Tighten: Tighten the **J 23523-F** plate bolts to 25 N.m (18 lb ft).

2. Install the **J 23523-F** screw into the end for the crankshaft.
3. Install the **J 23523-F** bearing, the washer, and the nut onto the **J 23523-F** screw.
4. Rotate the **J 23523-F** nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.

6. Remove the **J 23523-F** .

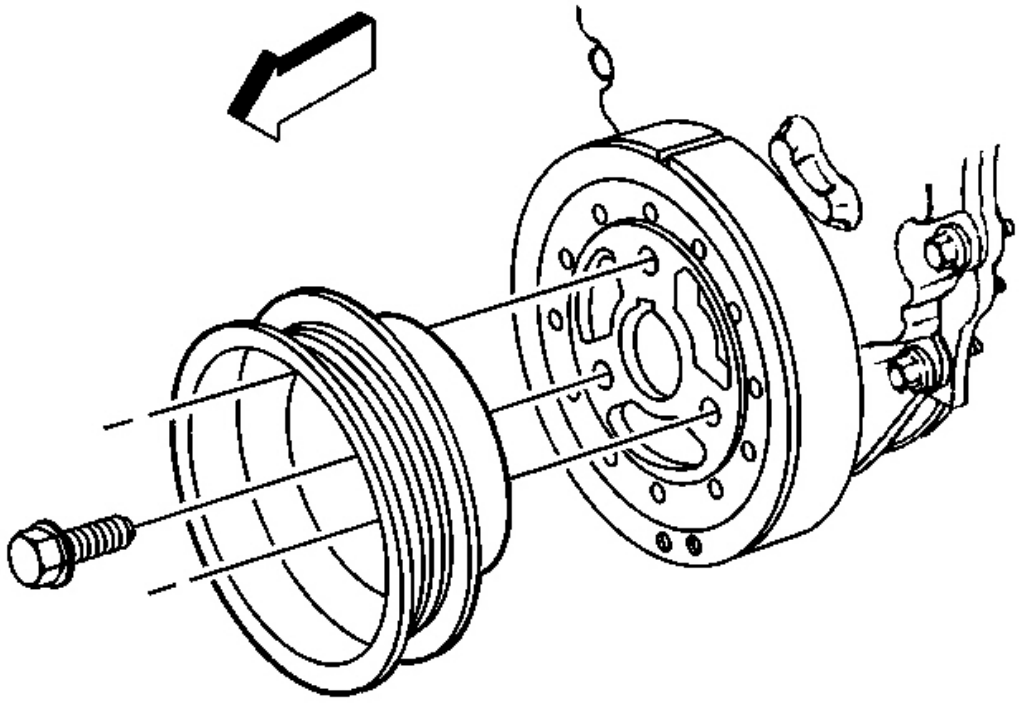


Fig. 674: View Of Crankshaft Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft pulley and bolts. Finger tighten all bolts until snug.

Tighten: Tighten the crankshaft pulley bolts to 58 N.m (43 lb ft).

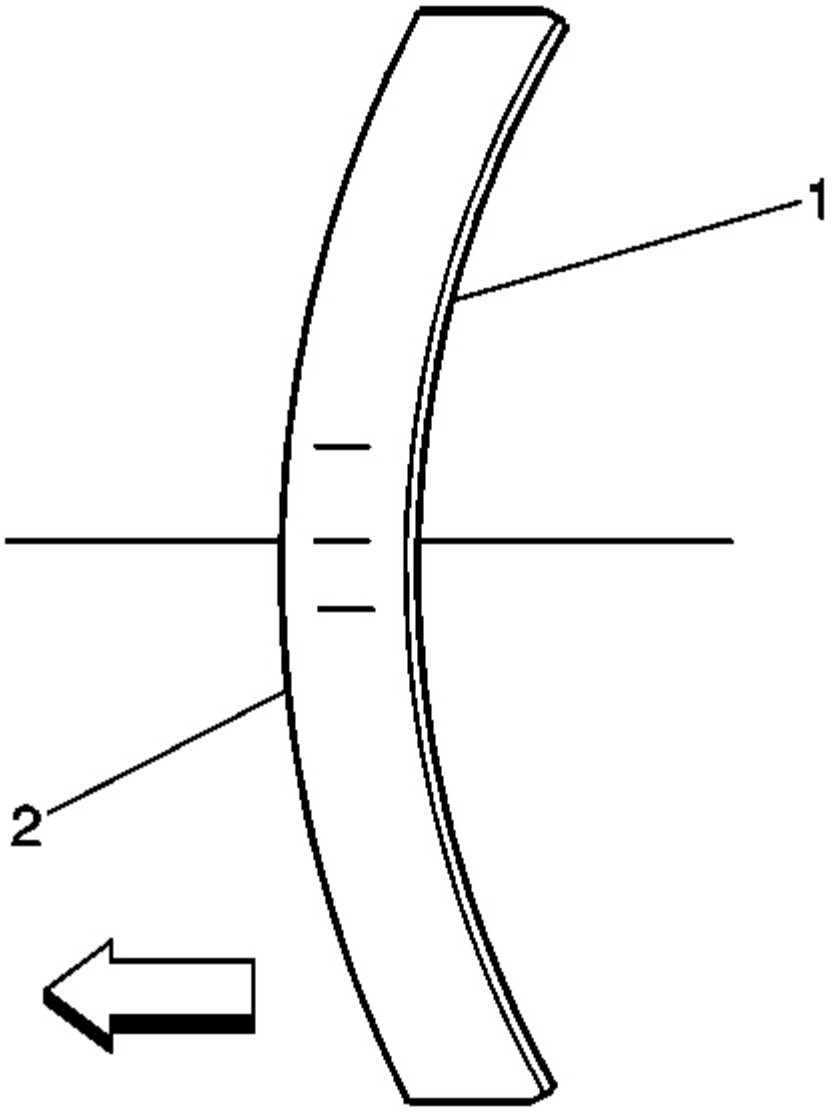


Fig. 675: Crankshaft Balancer Washer
Courtesy of GENERAL MOTORS CORP.

8. Ensure that the crown of the crankshaft balancer washer (2) is faced away from the engine.

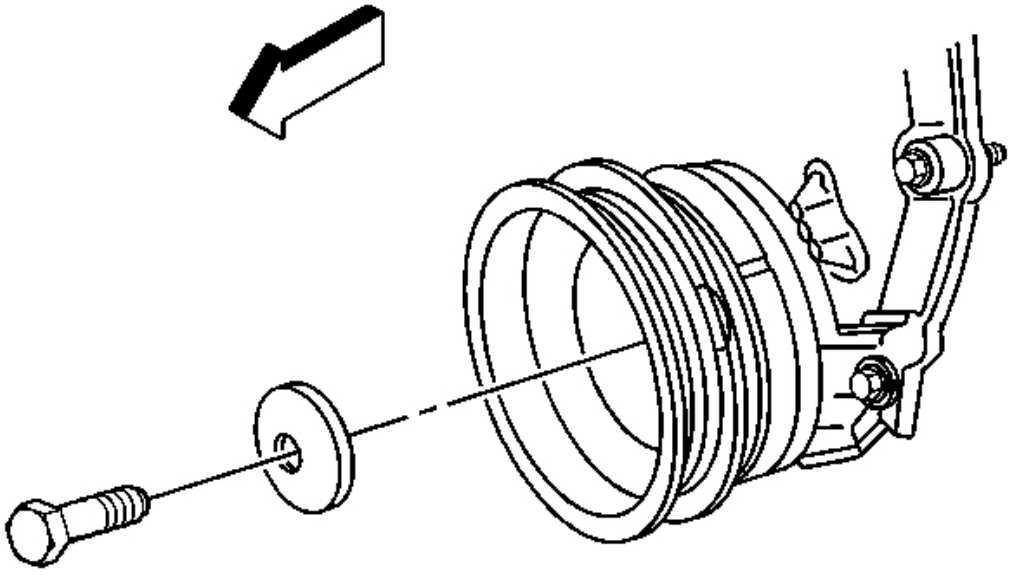


Fig. 676: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the crankshaft balancer washer and the bolt.

   Tighten: Tighten the crankshaft balancer bolt to 95 N.m (70 lb ft).

VALVE LIFTER INSTALLATION

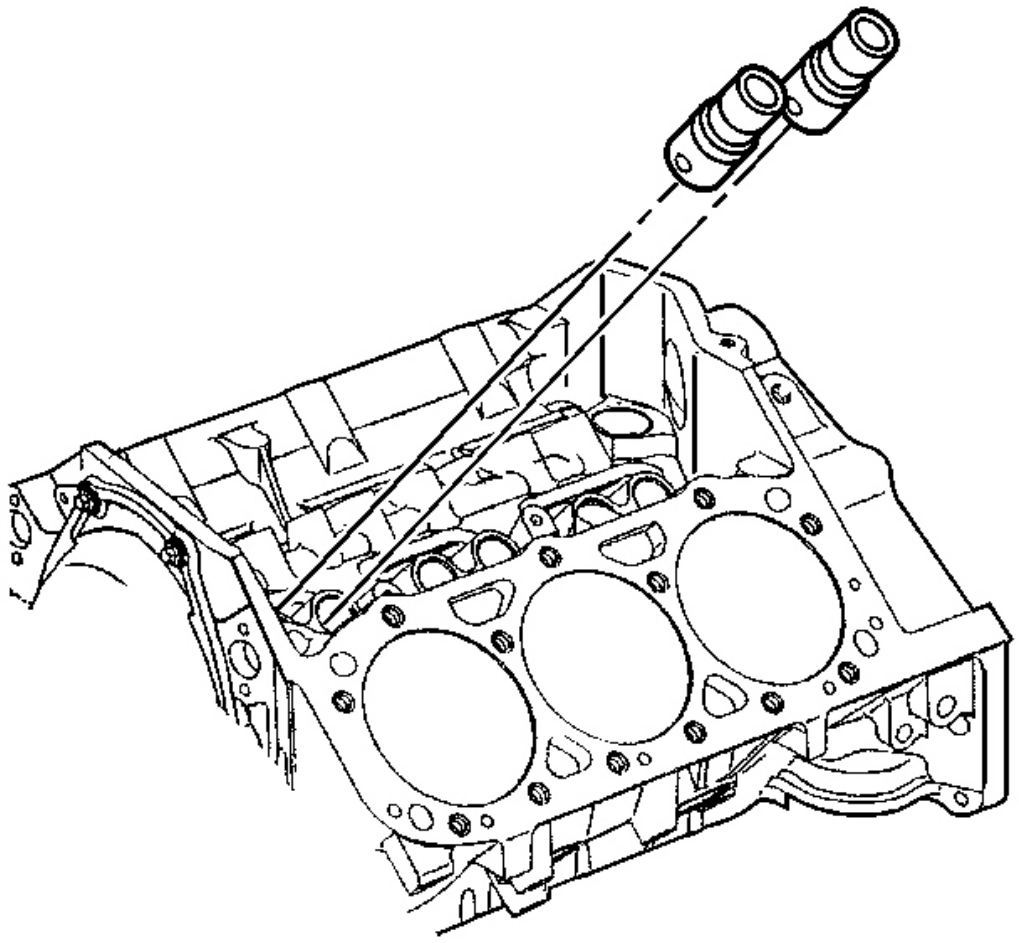


Fig. 677: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

1. Apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent, to the valve lifter rollers.

IMPORTANT: If reusing the valve lifters, install the valve lifters in the original positions.

2. Install the valve lifters.

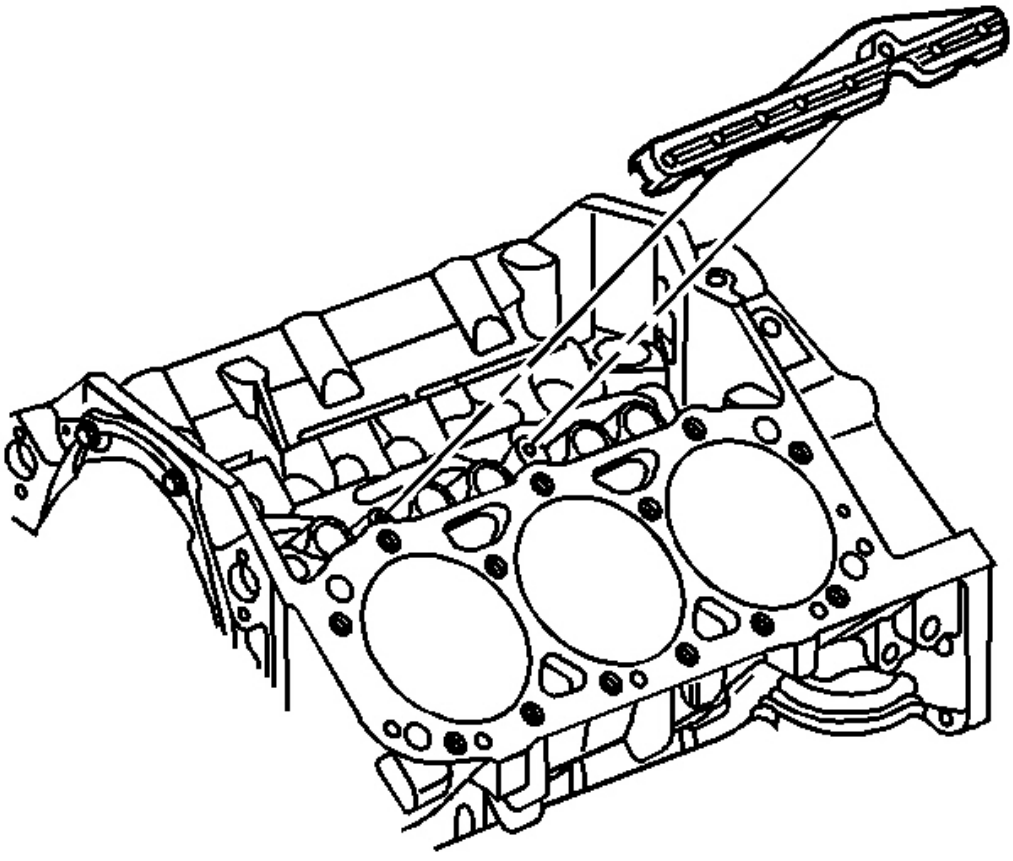


Fig. 678: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the valve lifter pushrod guides.

Tighten: Tighten the valve lifter pushrod guide bolts to 16 N.m (12 lb ft).

CYLINDER HEAD INSTALLATION - LEFT SIDE

Tools Required

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

Installation

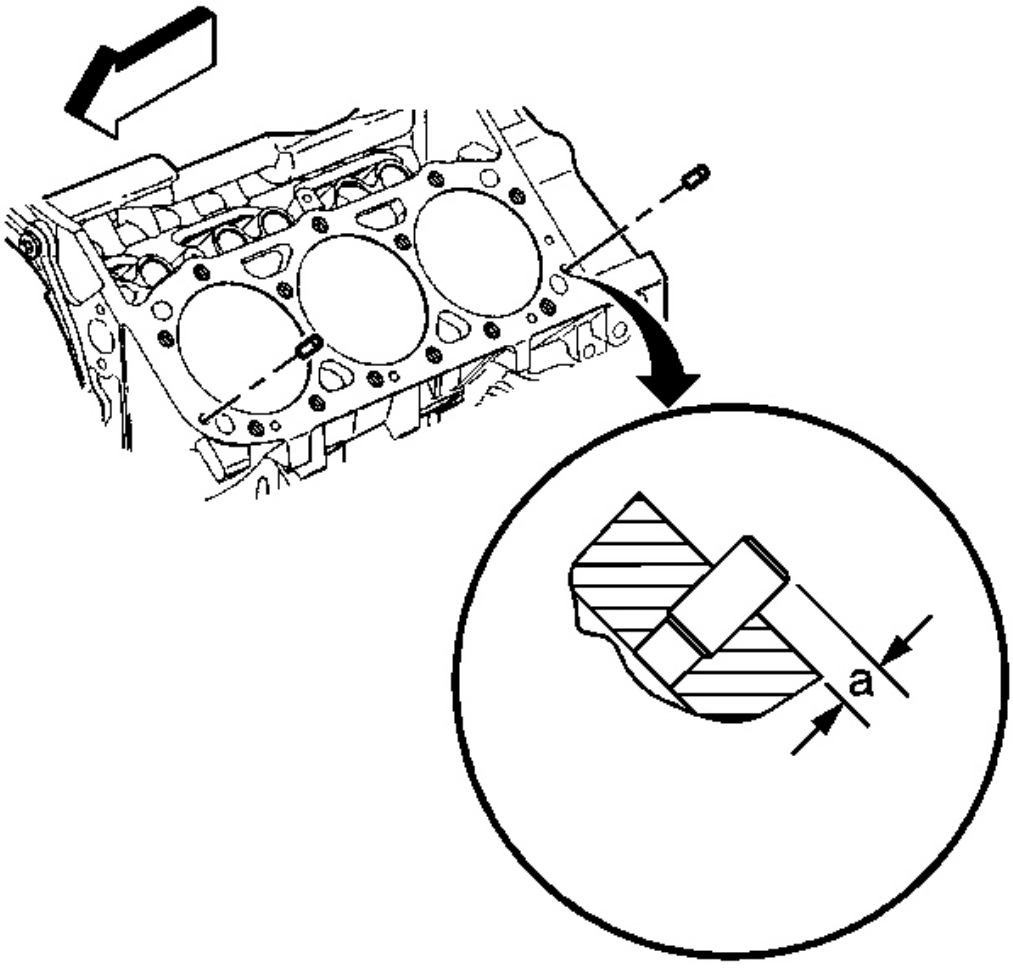


Fig. 679: Left Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the cylinder head locator dowel pins for proper installation.

   The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

3. Clean the cylinder head gasket surfaces on the cylinder head.

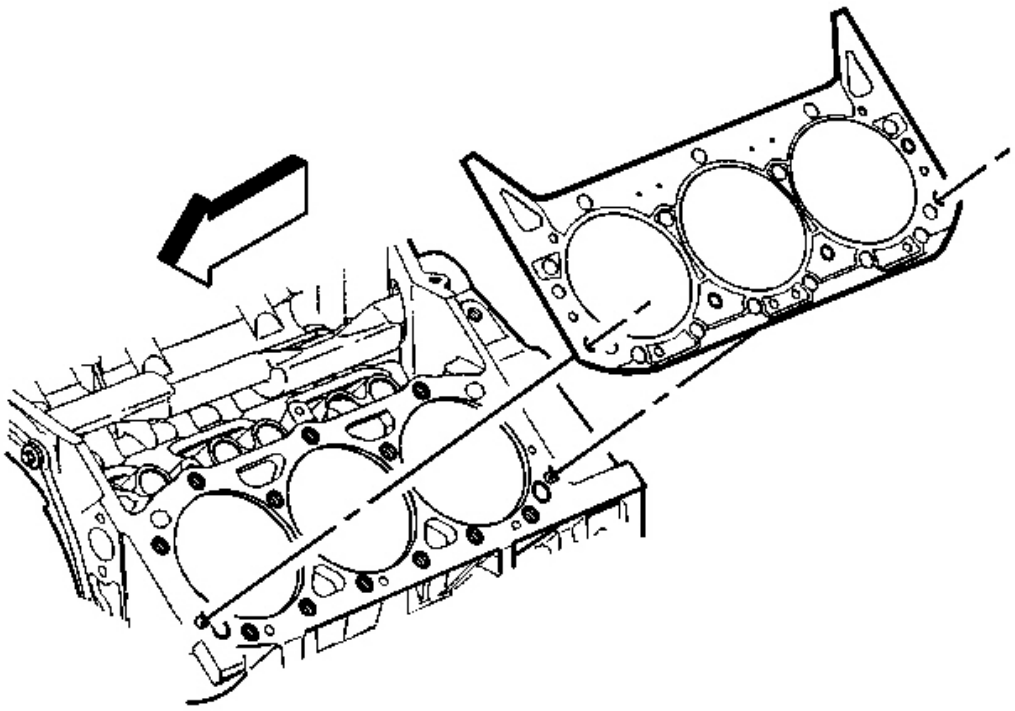


Fig. 680: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type sealer on the cylinder head gasket, unless specified.

4. Install the NEW cylinder head gasket in position over the cylinder head locator dowel pins.

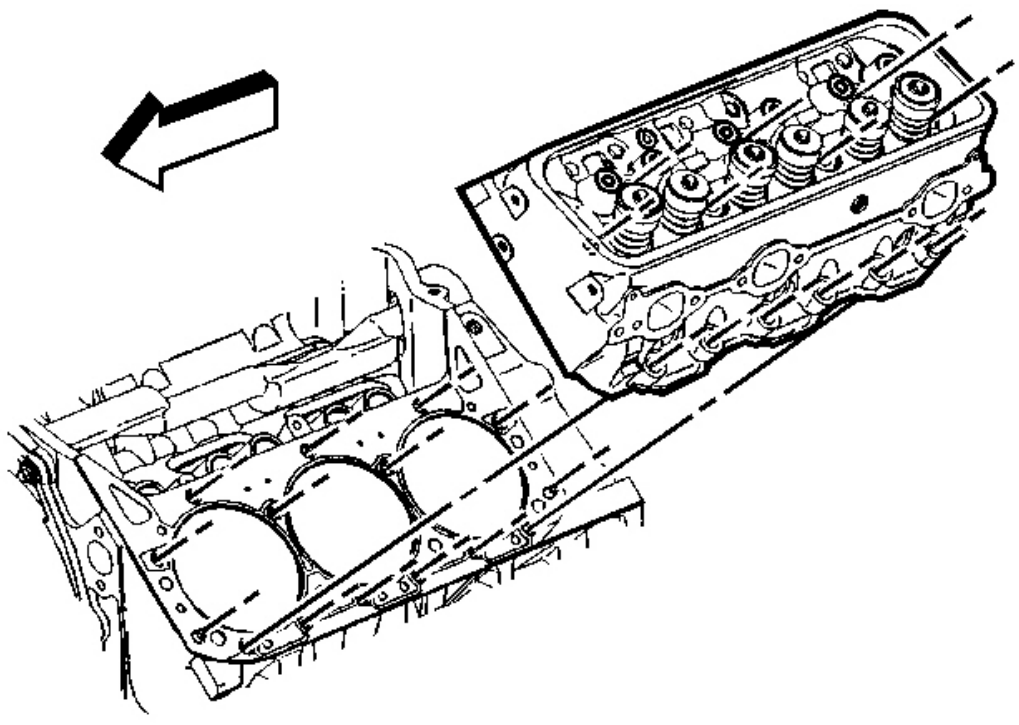


Fig. 681: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

5. Install the cylinder head onto the engine block.

   Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

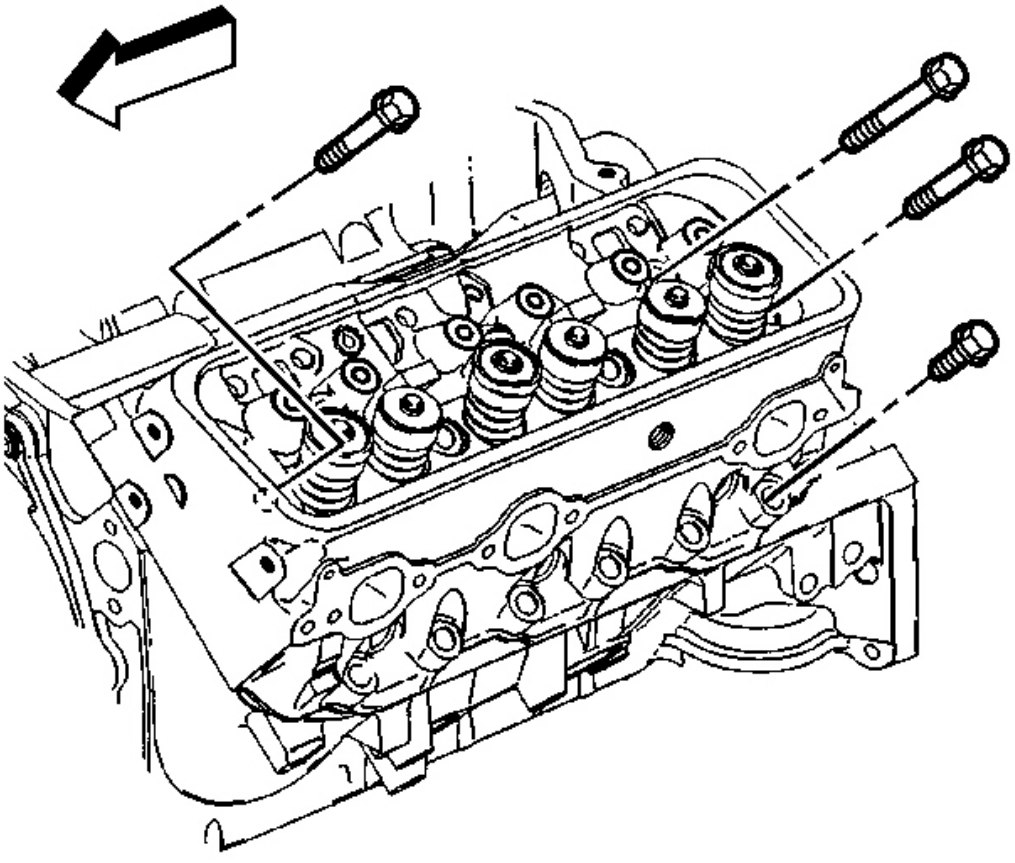


Fig. 682: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the NEW cylinder head bolts.
7. Install the NEW cylinder head bolts finger tight.

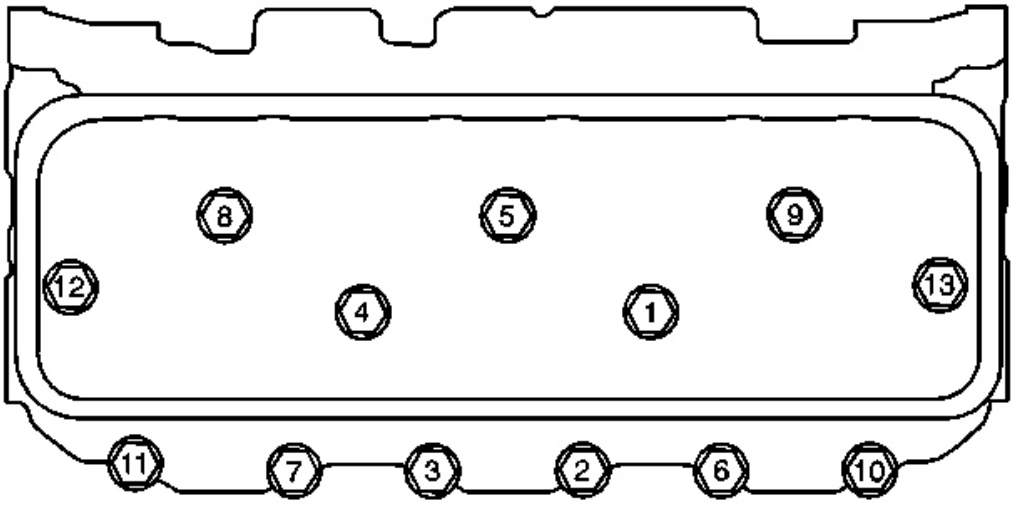


Fig. 683: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the cylinder head bolts in sequence on the first pass.

   Tighten: Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the **J 45059** in order to tighten the cylinder head bolts in sequence on the final pass. See **Special Tools**.

   Tighten:

   - Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
   - Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
   - Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

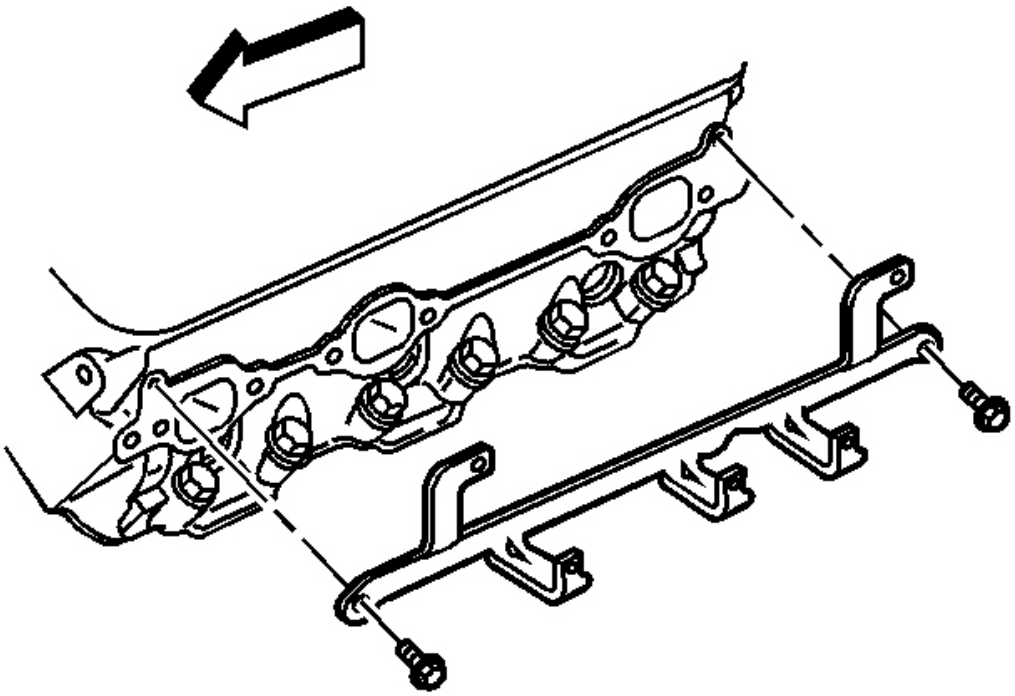


Fig. 684: Locating Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

10. Install the spark plug wire support and bolts.

    Tighten: Tighten the spark plug wire support bolts to 12 N.m (106 lb in).

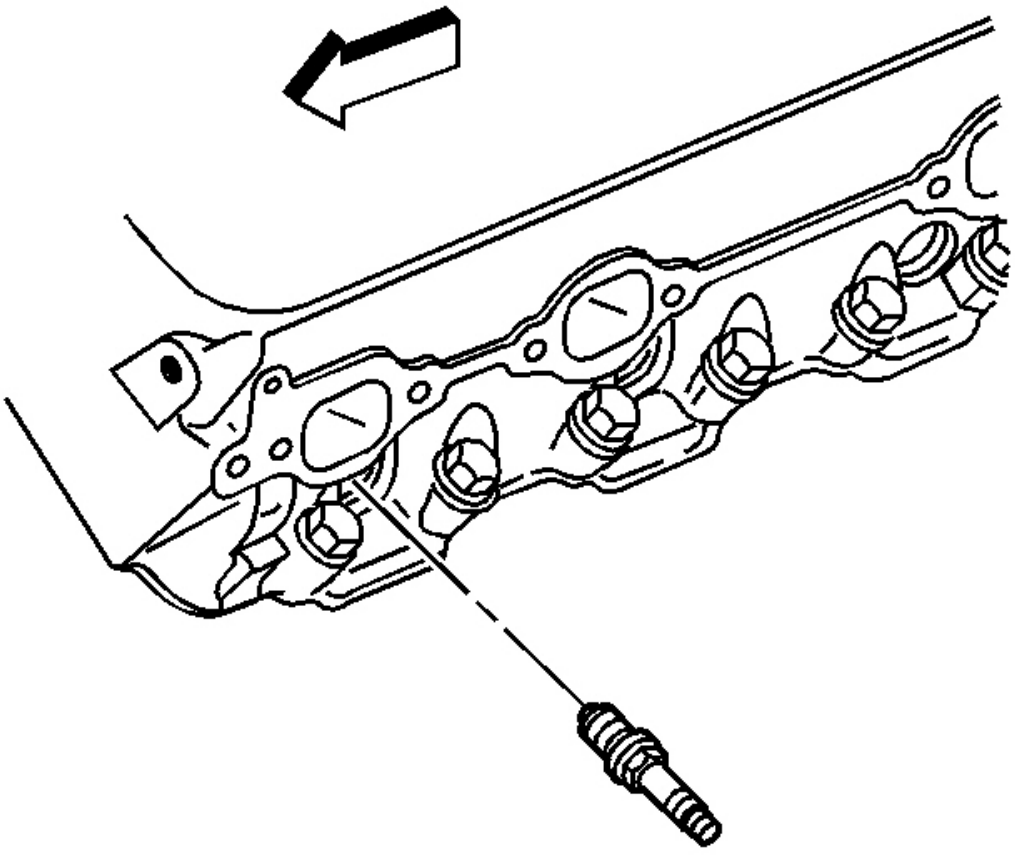


Fig. 685: View Of Spark Plugs (Left)
Courtesy of GENERAL MOTORS CORP.

11. Measure the spark plugs for the proper gap.

    Adjust the spark plug gap if necessary.

    Specification: Spark plug gap to 1.52 mm (0.060 in).

12. Install the spark plugs.

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

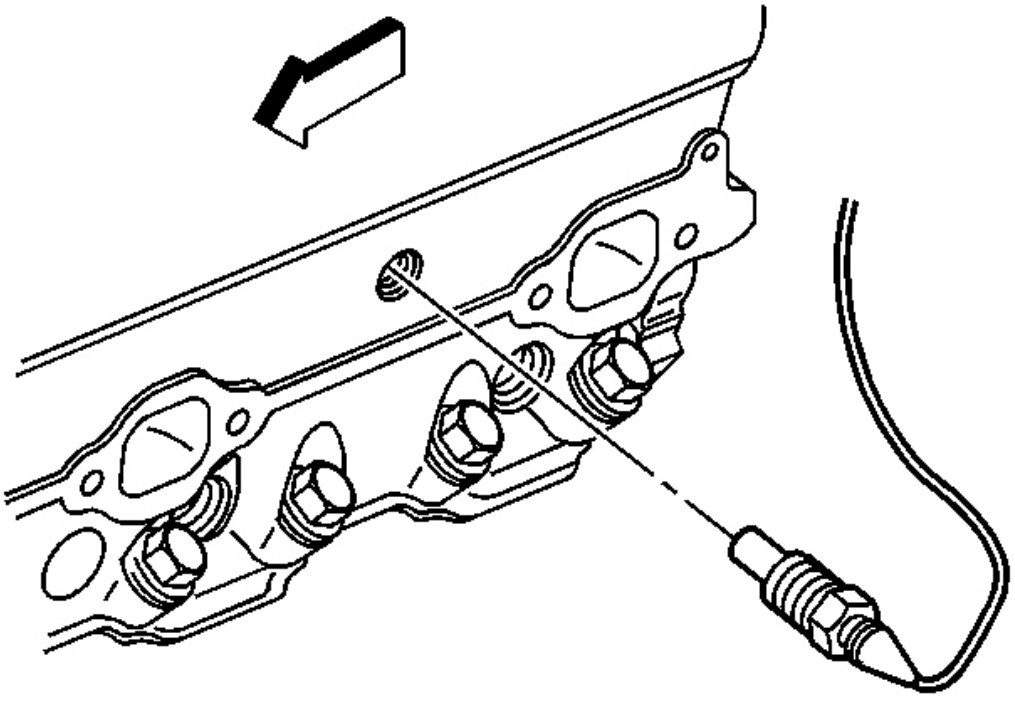


Fig. 686: Engine Coolant Temperature Gage Sensor
Courtesy of GENERAL MOTORS CORP.

13. If reusing the engine coolant temperature gage sensor, if applicable, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine coolant temperature gage sensor.
14. Install the engine coolant temperature gage sensor, if applicable.

    Tighten: Tighten the engine coolant temperature gage sensor to 20 N.m (15 lb ft).

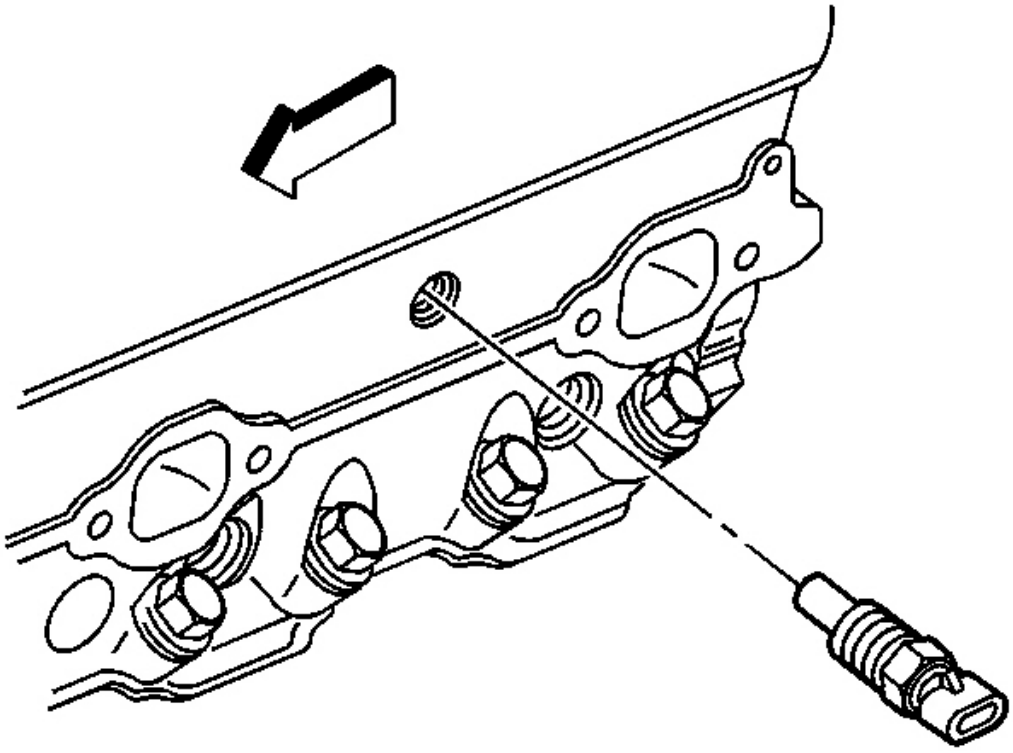


Fig. 687: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

15. If reusing the engine coolant temperature sensor, if applicable, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine coolant temperature gage sensor.
16. Install the engine coolant temperature sensor, if applicable.

    Tighten: Tighten the engine coolant temperature sensor to 20 N.m (15 lb ft).

CYLINDER HEAD INSTALLATION - RIGHT SIDE

Tools Required

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

Installation

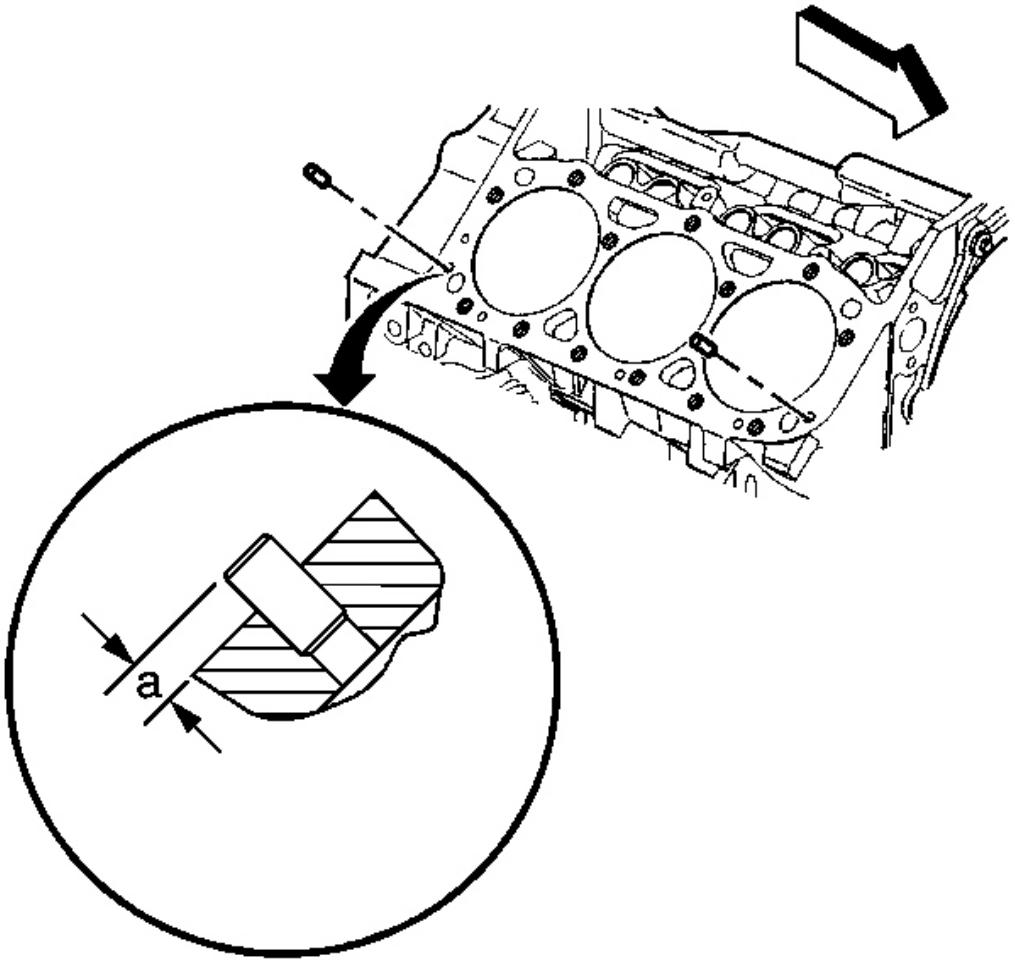


Fig. 688: Right Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the cylinder head locator dowel pins for proper installation.

   The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

3. Clean the cylinder head gasket surfaces on the cylinder head.

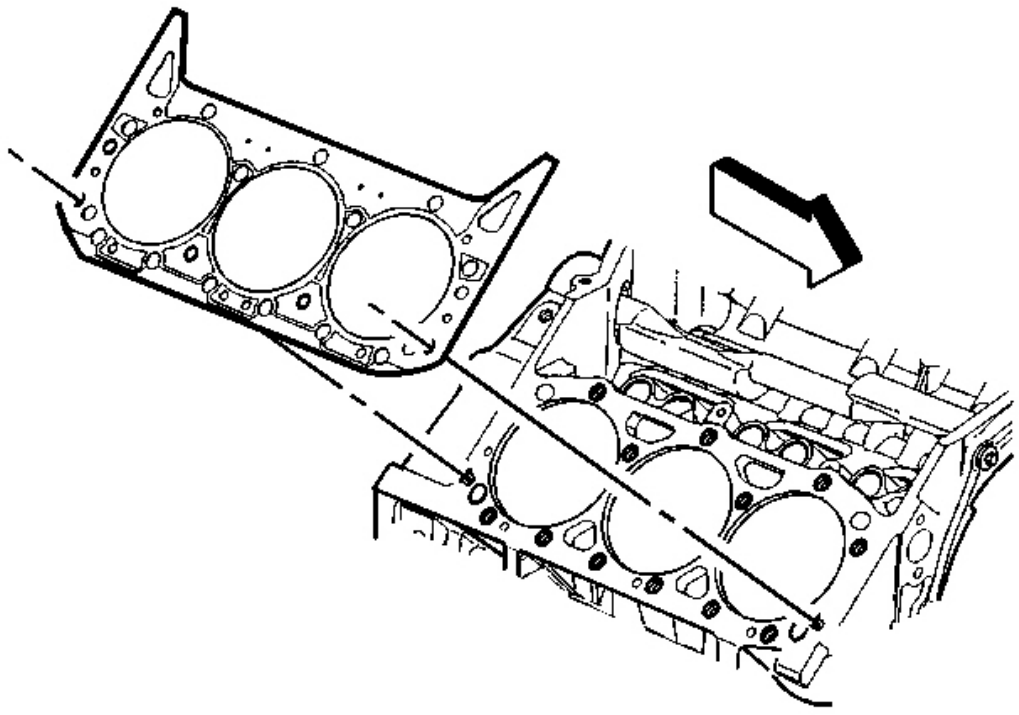


Fig. 689: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type sealer on the cylinder head gasket, unless specified.

4. Install the NEW cylinder head gasket in position over the cylinder head locator dowel pins.

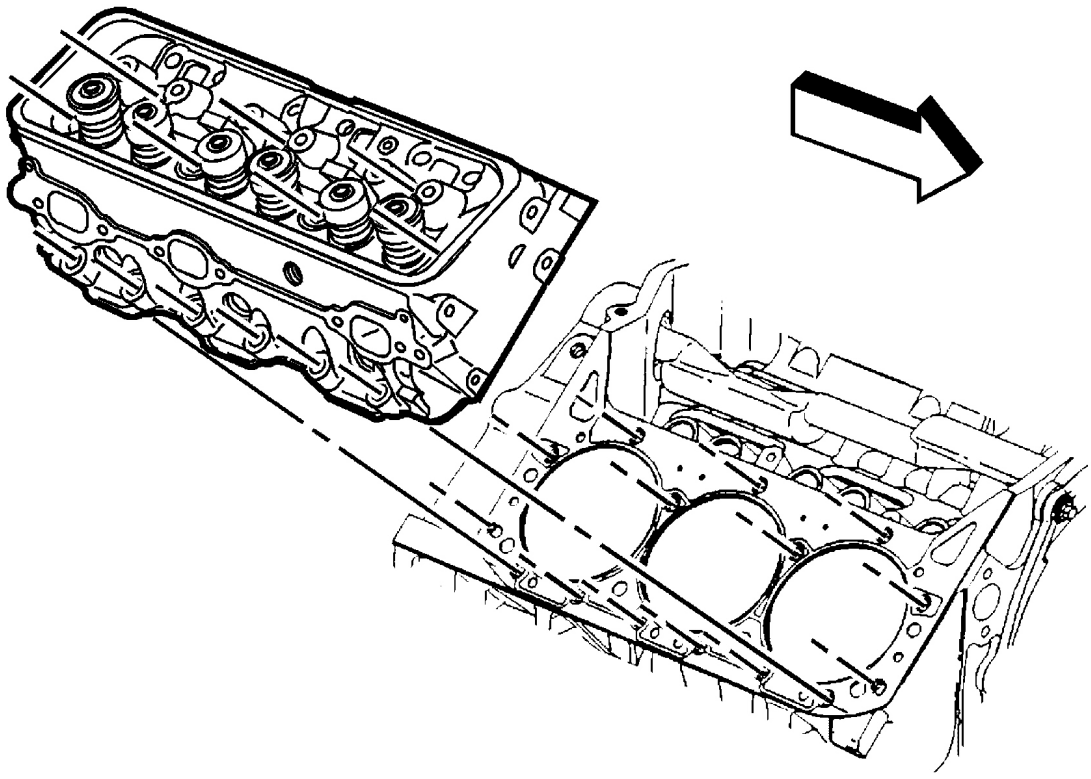


Fig. 690: Removing/Installing Cylinder Head (Right)
Courtesy of GENERAL MOTORS CORP.

5. Install the cylinder head onto the engine block.

   Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

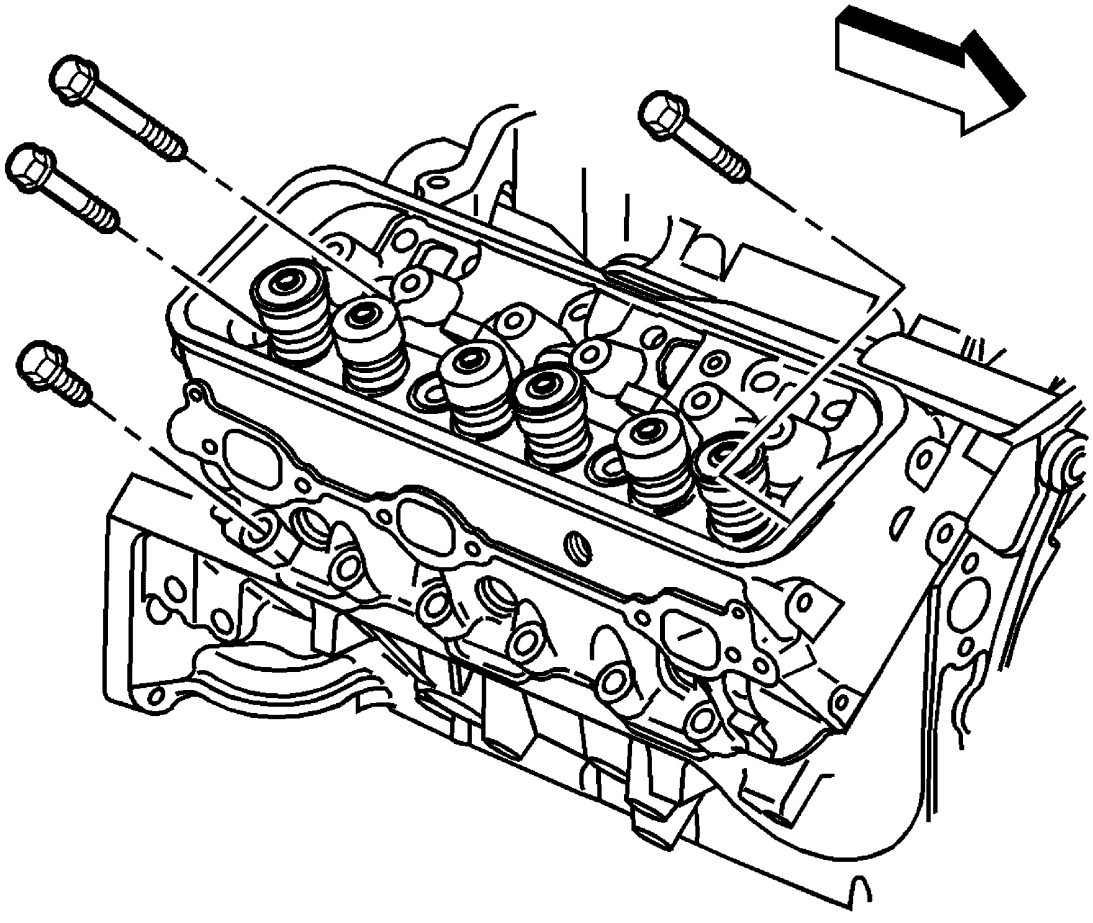


Fig. 691: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the NEW cylinder head bolts.
7. Install the NEW cylinder head bolts finger tight.

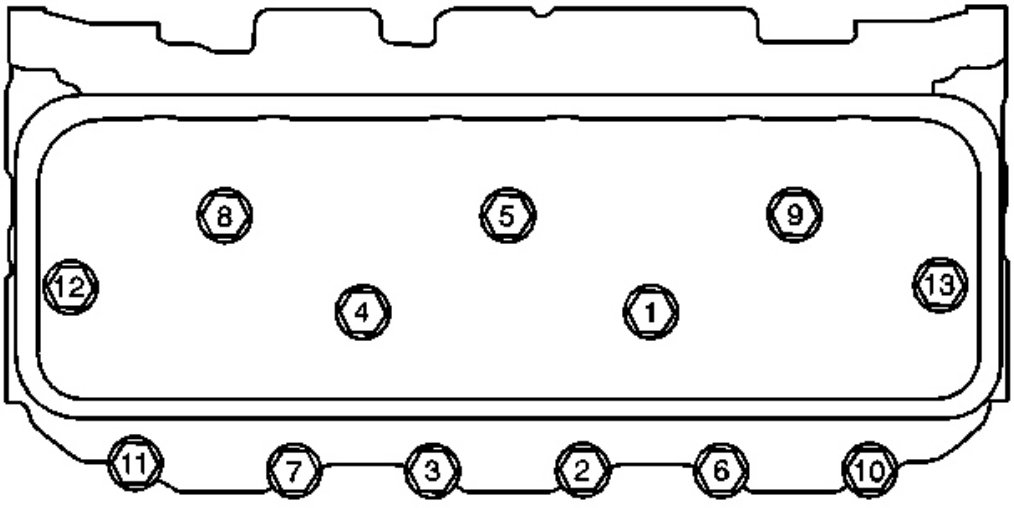


Fig. 692: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the cylinder head bolts in sequence on the first pass.

   Tighten: Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the **J 45059** in order to tighten the cylinder head bolts in sequence on the final pass. See **Special Tools**.

   Tighten:

   - Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
   - Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
   - Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

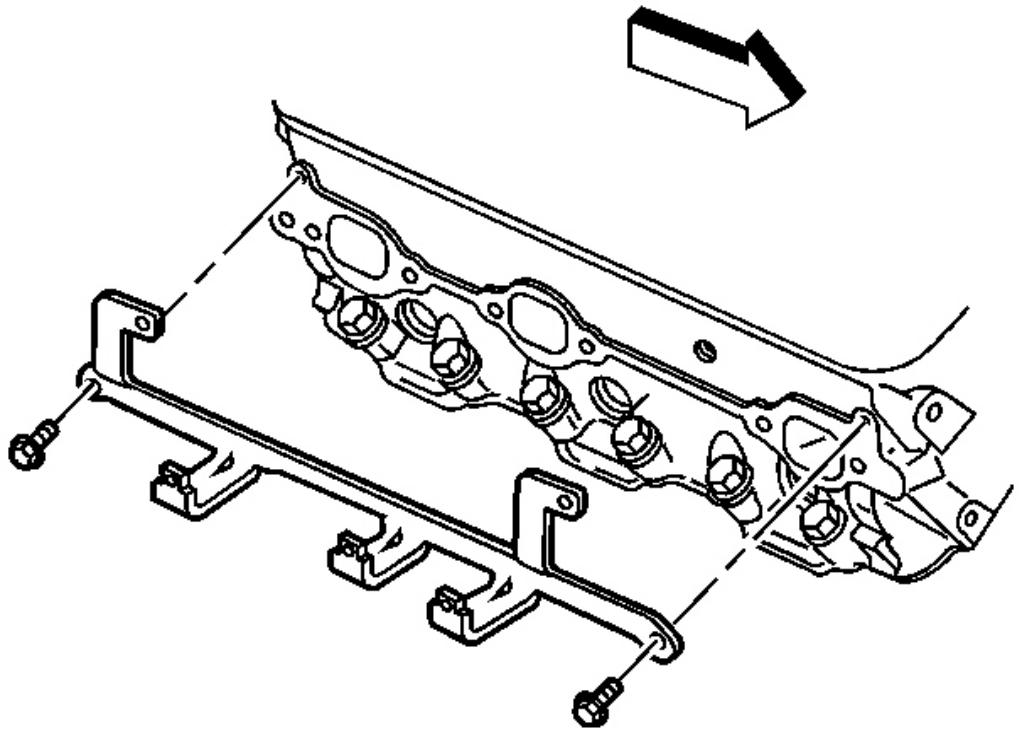


Fig. 693: Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

10. Install the spark plug wire support and bolts.

    Tighten: Tighten only the rear spark plug wire support bolt to 12 N.m (106 lb in).

11. Remove the front spark plug wire support bolt.

    The front spark plug wire support bolt is used to fasten the oil level indicator tube, and will be installed within the oil level indicator tube installation procedure.

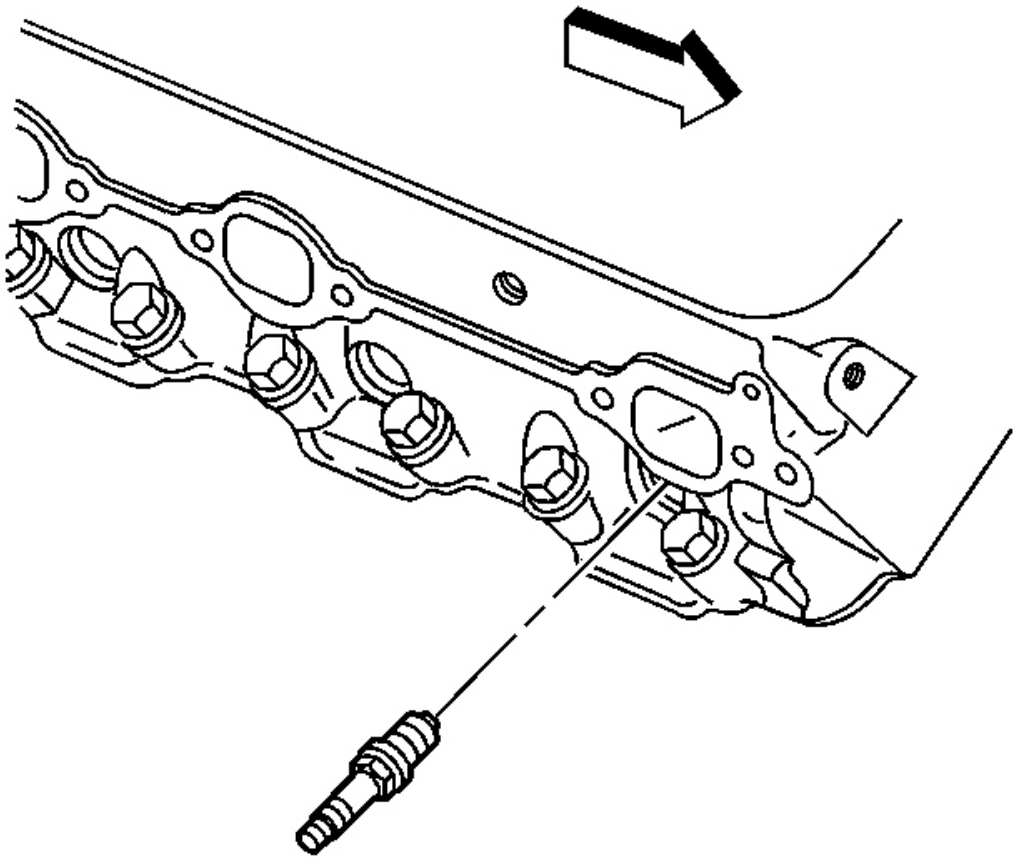


Fig. 694: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

12. Measure the spark plugs for the proper gap.

    Adjust the spark plug gap if necessary.

    Specification: Spark plug gap to 1.52 mm (0.060 in).

13. Install the spark plugs.

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

VALVE ROCKER ARM AND PUSH ROD INSTALLATION

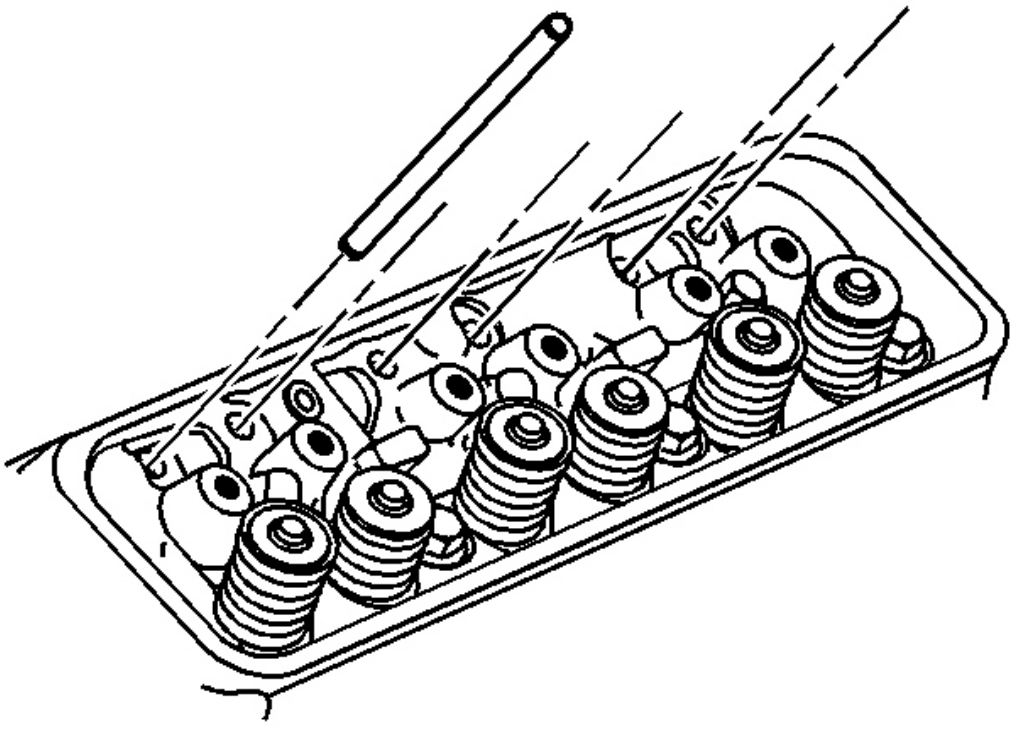


Fig. 695: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to keep parts in order. Parts must be reinstalled into the original location and position.

1. Install the valve pushrods.

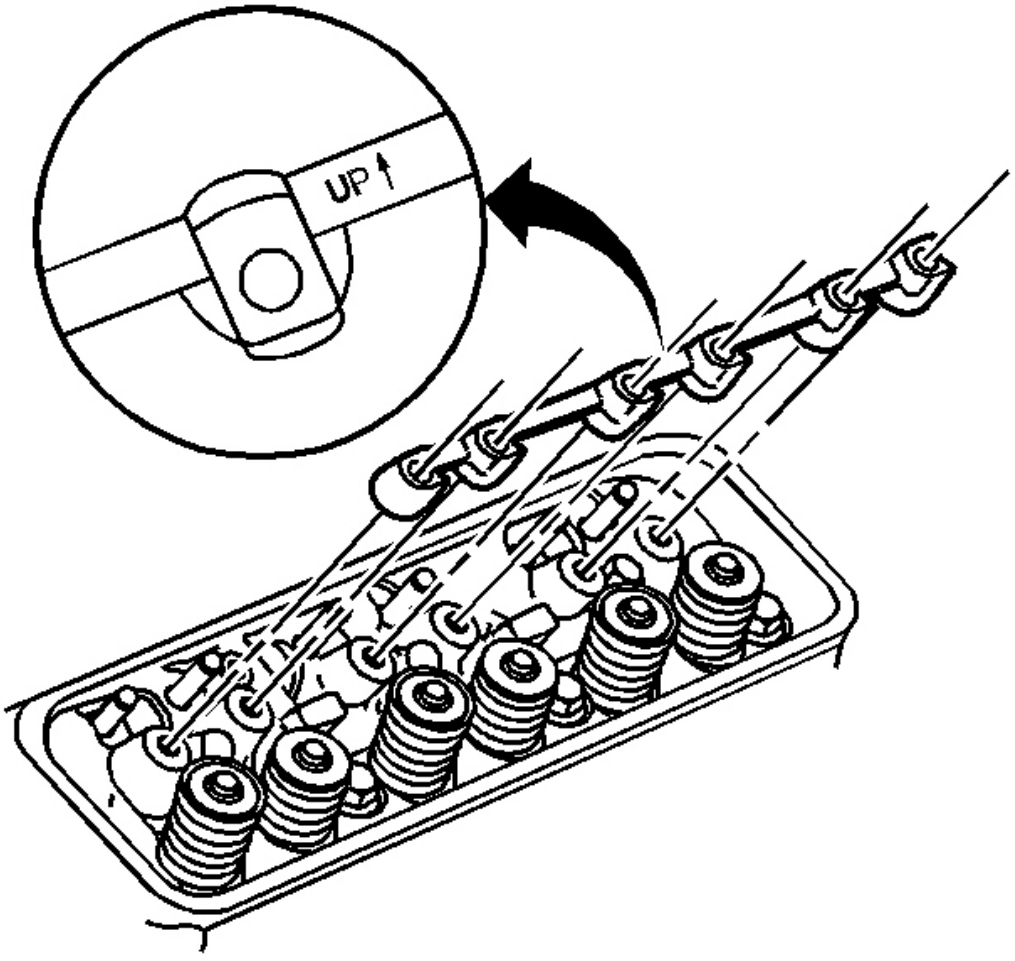


Fig. 696: Locating Arrow On Valve Rocker Arm Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure that the arrow on the valve rocker arm support is in the up position.

2. Install the valve rocker arm supports.

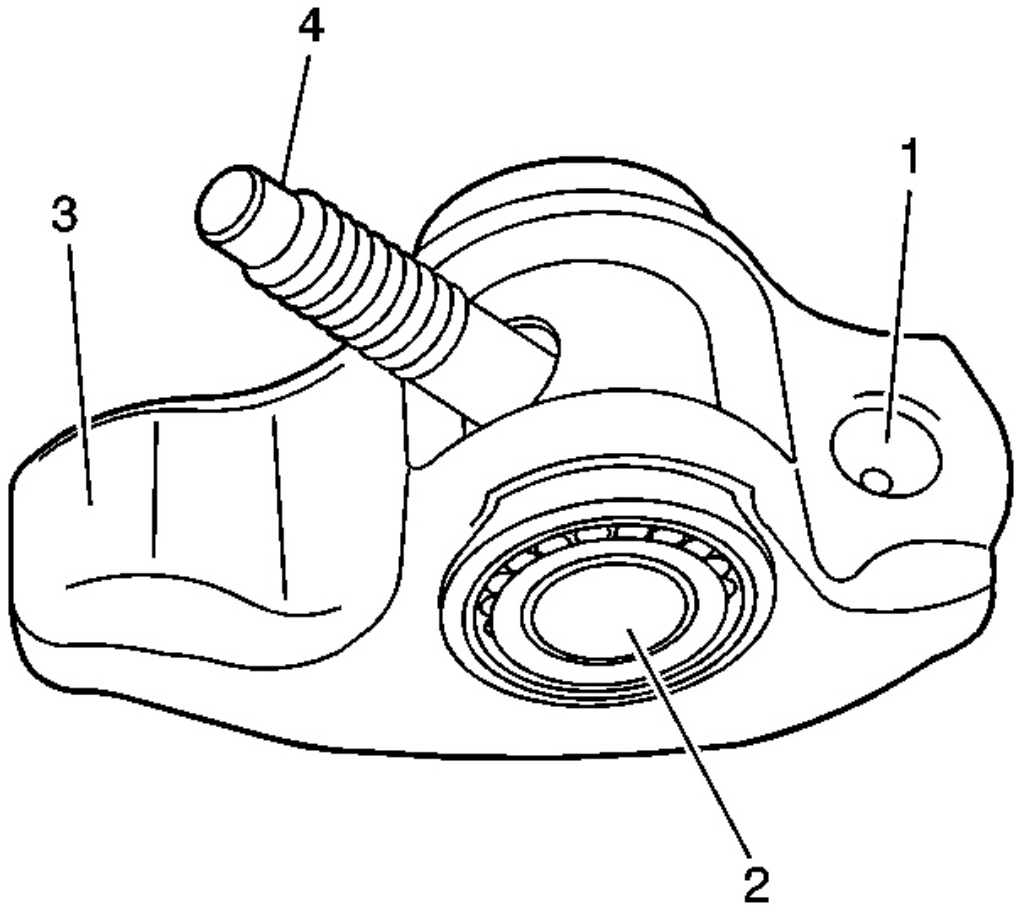


Fig. 697: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS CORP.

3. Apply prelube GM P/N 12345501 (Canadian P/N 992704) or equivalent, to the following valve rocker arm contact surfaces:
   - Valve pushrod socket (1)
   - Roller pivot (2)
   - Valve stem tip (3)

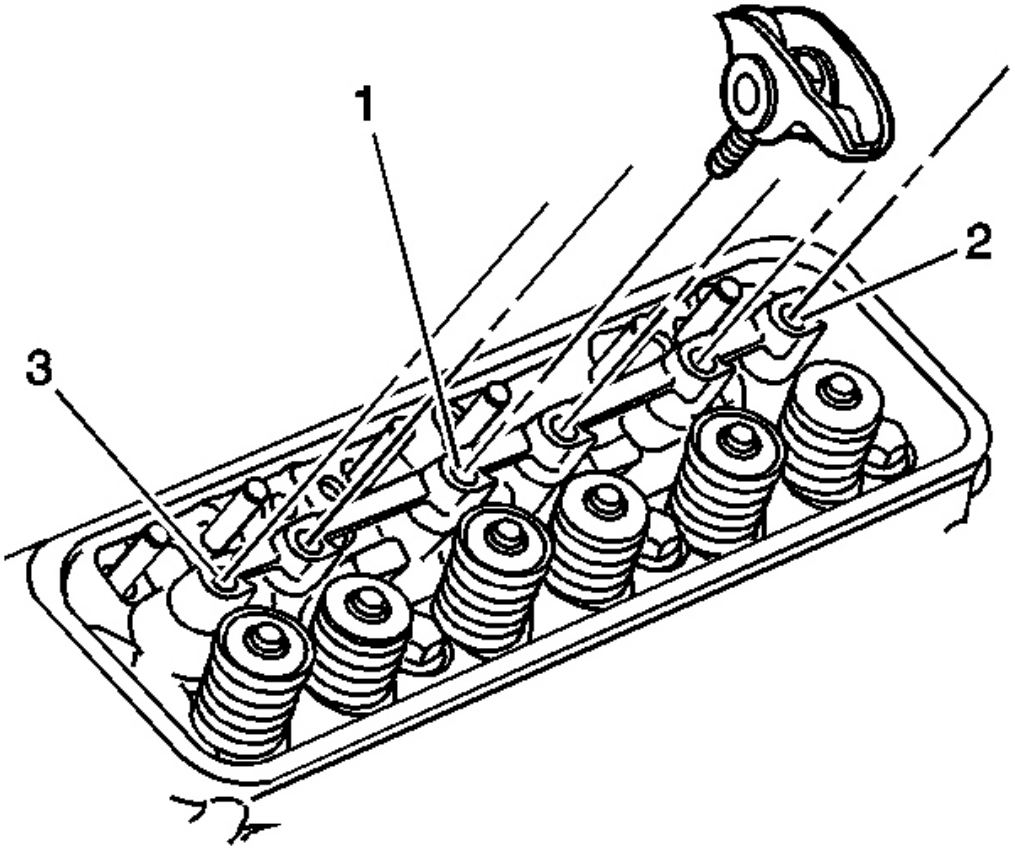


Fig. 698: Valve Rocker Arm Assemblies
Courtesy of GENERAL MOTORS CORP.

4. Install the valve rocker arm assemblies as follows:
    1. Finger start the bolt at location (1)
    2. Finger start the bolt at location (2)
    3. Finger start the bolt at location (3)
    4. Finger start the remaining valve rocker arm bolts

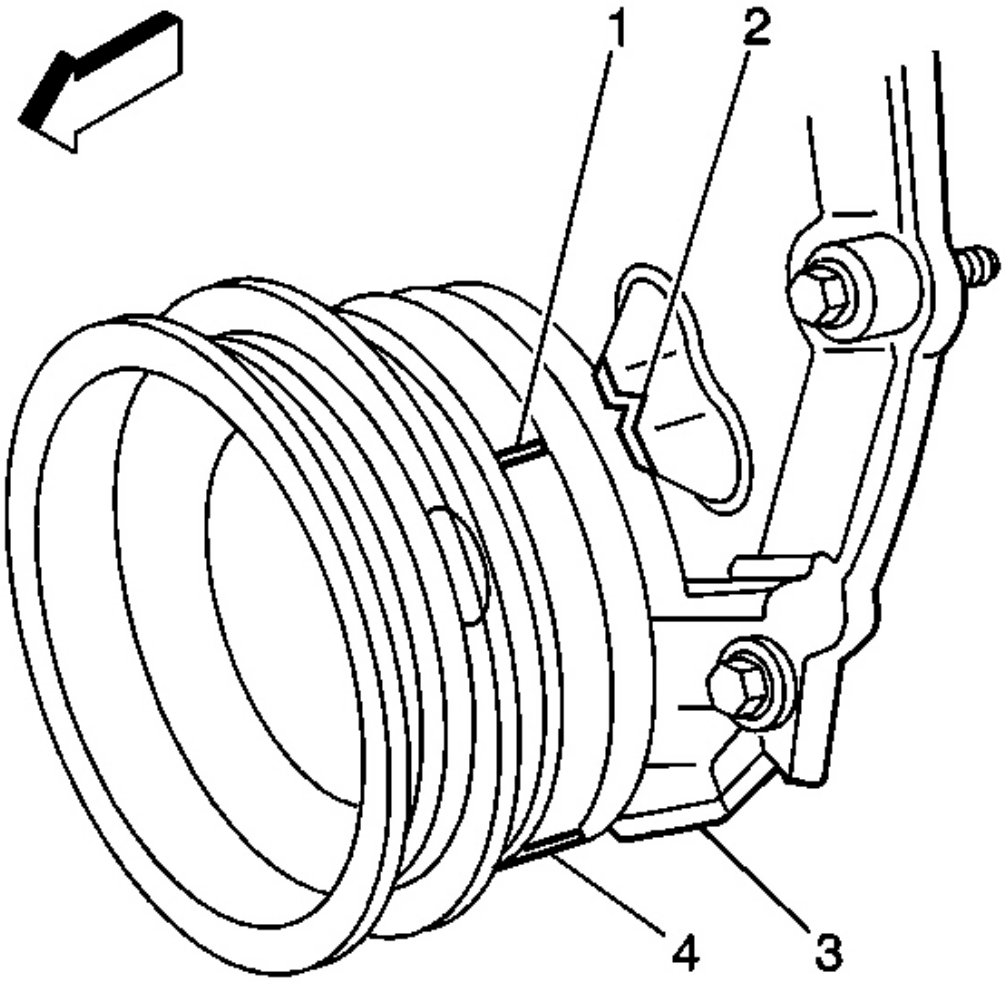


Fig. 699: View Of Crankshaft Balancer Alignment Mark & Engine Front Cover Alignment Tab
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rotate the number 1 cylinder to top dead center (TDC) of the compression stroke. The engine front cover has 2 alignment tabs and the crankshaft balancer has 2 alignment marks which are spaced 90 degrees apart that are used for positioning the number 1 piston at TDC.

5. Rotate the crankshaft balancer clockwise until the alignment marks on the crankshaft balancer are aligned with the tabs on the engine front cover, 1 with 2 and 3 with 4. At that point the number 1 piston should be at TDC of the compression stroke.

   NOTE: Refer to Fastener Notice .

   IMPORTANT: Once the valve rocker arm assemblies are installed and properly torqued, no additional valve lash adjustment is required.

6. Tighten the valve rocker arm bolts.

   Tighten: Tighten valve rocker arm bolts to 30 N.m (22 lb ft).

INTAKE MANIFOLD INSTALLATION

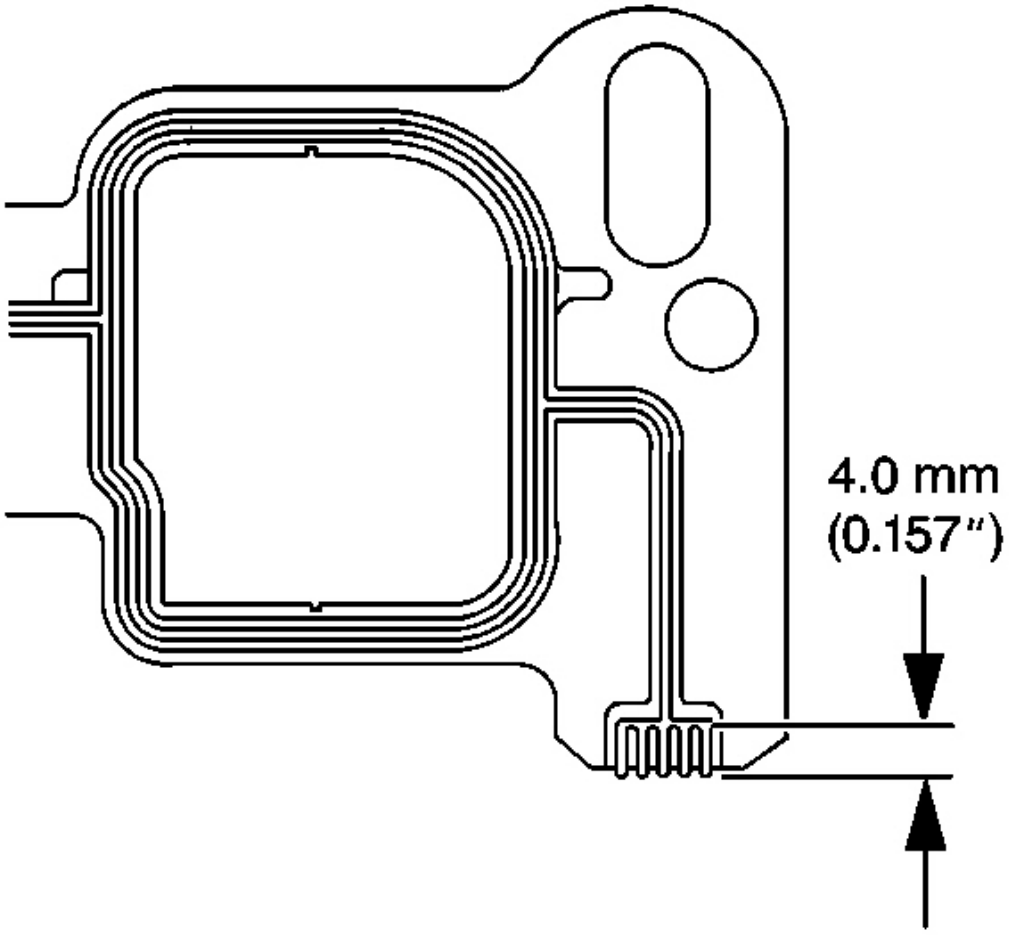


Fig. 700: Applying Patch Of Adhesive To Cylinder Head Side Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: Apply the proper amount of the sealant when assembling this component. Excessive use of the sealant can prohibit the component from sealing properly. A component that is not sealed properly can leak leading to extensive engine damage.

1. Apply a 4.0 mm (0.157 in) patch of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the cylinder head side of the lower intake manifold gasket at each end.

IMPORTANT: The lower intake manifold gasket must be installed while the adhesive is still wet to the touch.

2. Install the lower intake manifold gasket onto the cylinder head.

   Use the gasket locator pins in order to properly seat the lower intake manifold gasket on the cylinder head.

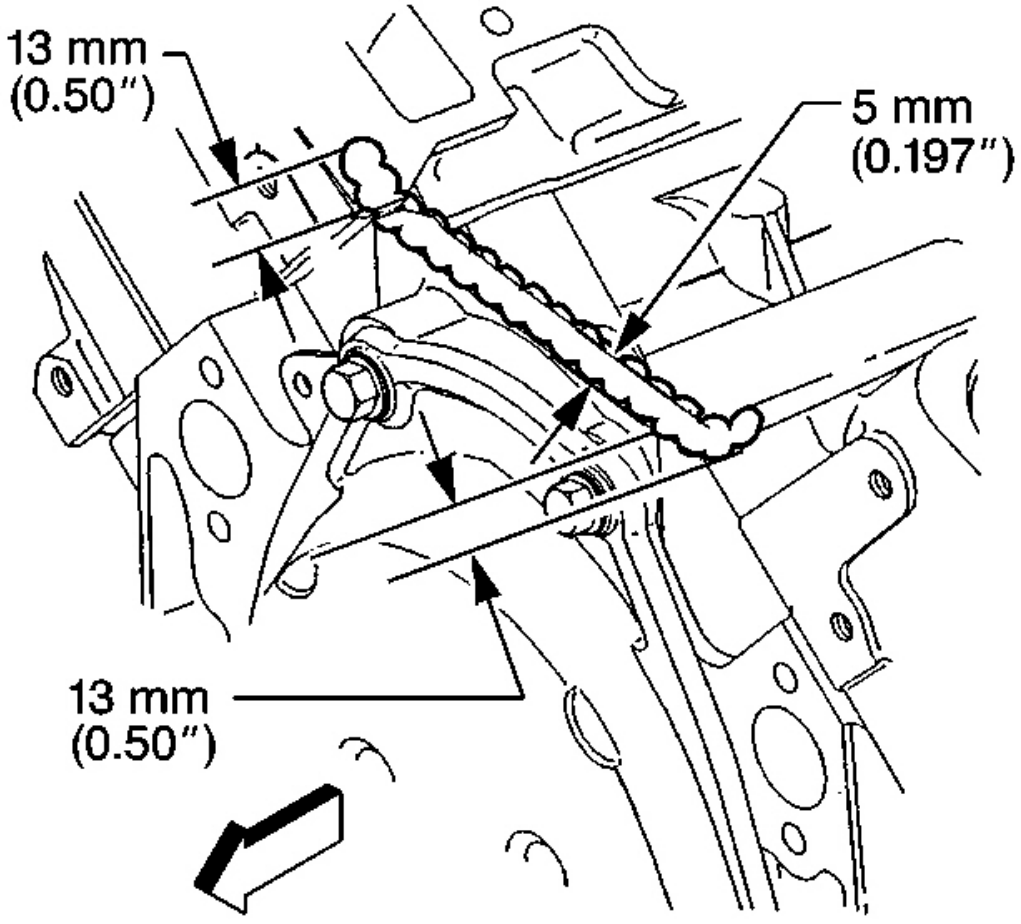


Fig. 701: Applying Adhesive To Front Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The lower intake manifold must be installed and the

fasteners tightened while the adhesive is still wet to the touch.

3. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the front top of the engine block.
4. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

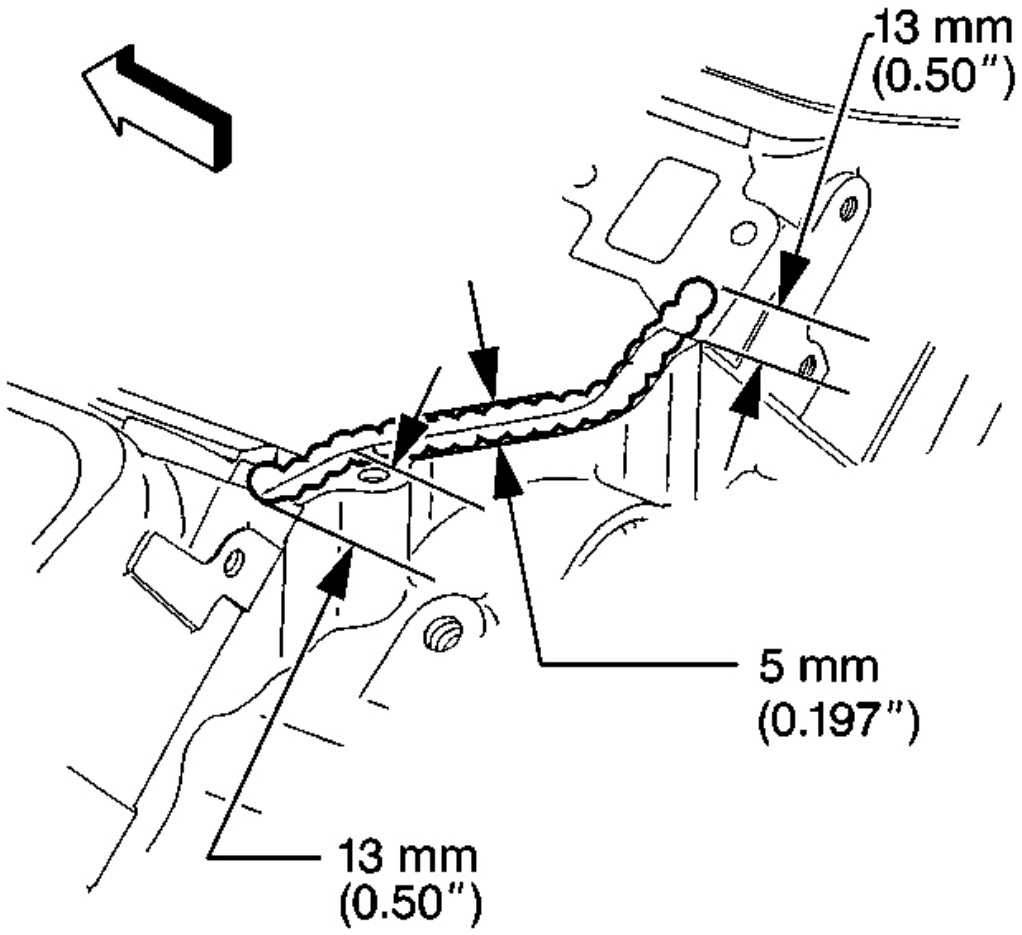


Fig. 702: Applying Adhesive To Rear Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the rear top of the engine block.

6. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

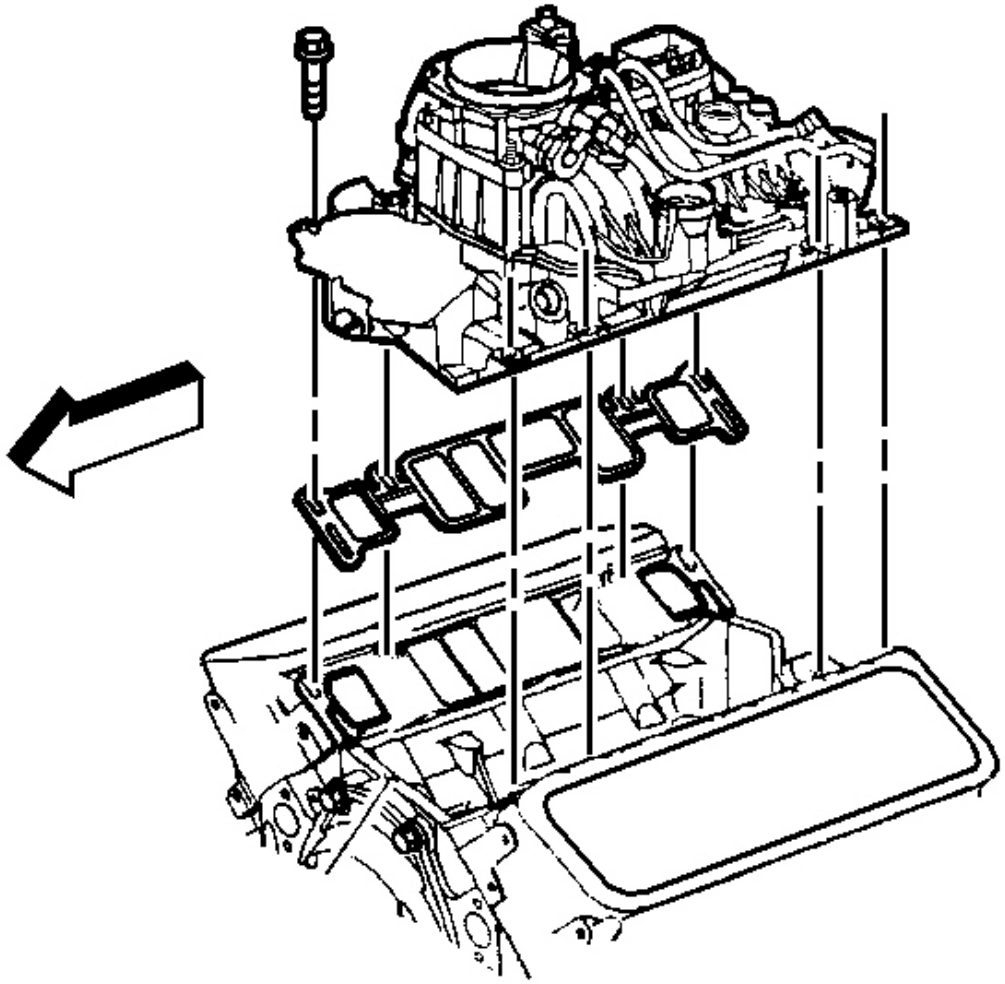


Fig. 703: View Of Intake Manifold Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the lower intake manifold onto the engine block.
8. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the lower intake manifold bolts.
9. Install the lower intake manifold bolts.

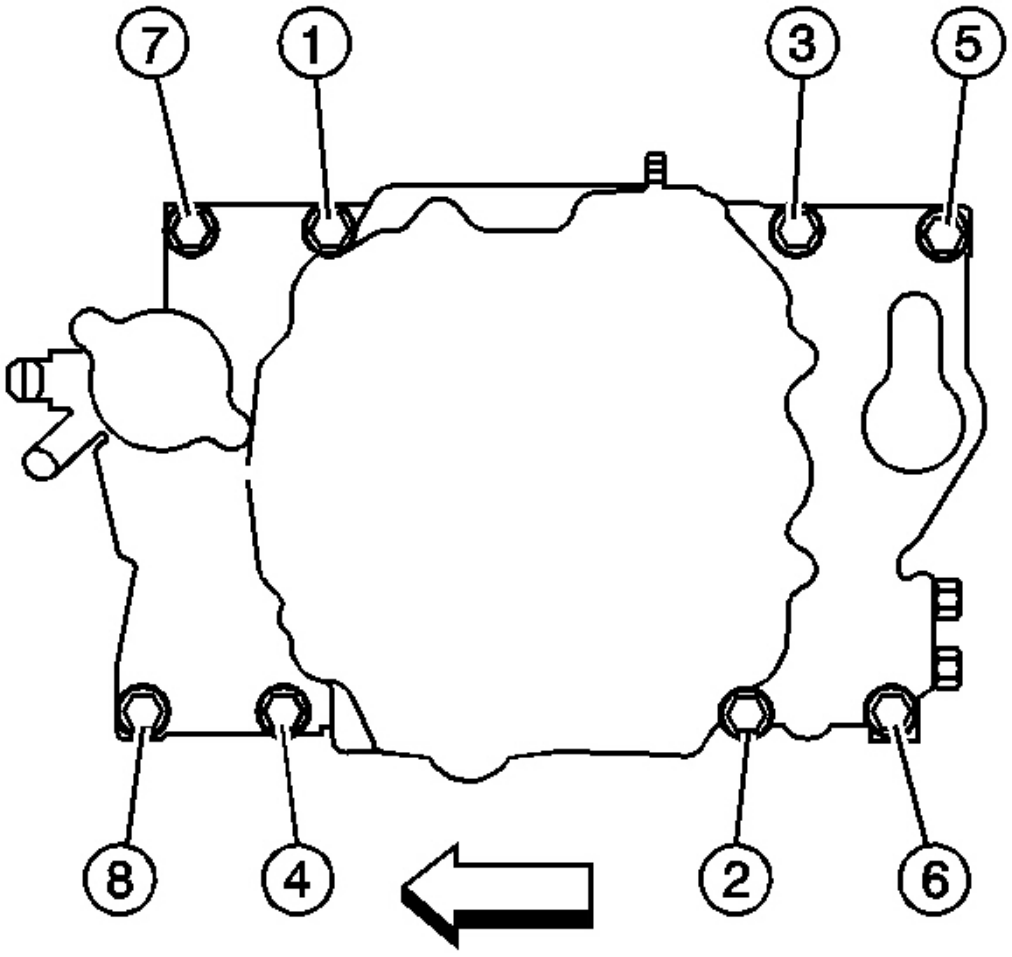


Fig. 704: Intake Manifold Lower Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

NOTE: Refer to Fastener Notice .

10. Tighten the lower intake manifold bolts.

Tighten:

1. Tighten the bolts on the first pass in sequence (1-8) to 3 N.m (27 lb in).
2. Tighten the bolts on the second pass in sequence (1-8) to 12 N.m (106 lb in).
3. Tighten the bolts on the final pass in sequence (1-8) to 15 N.m (11 lb ft).

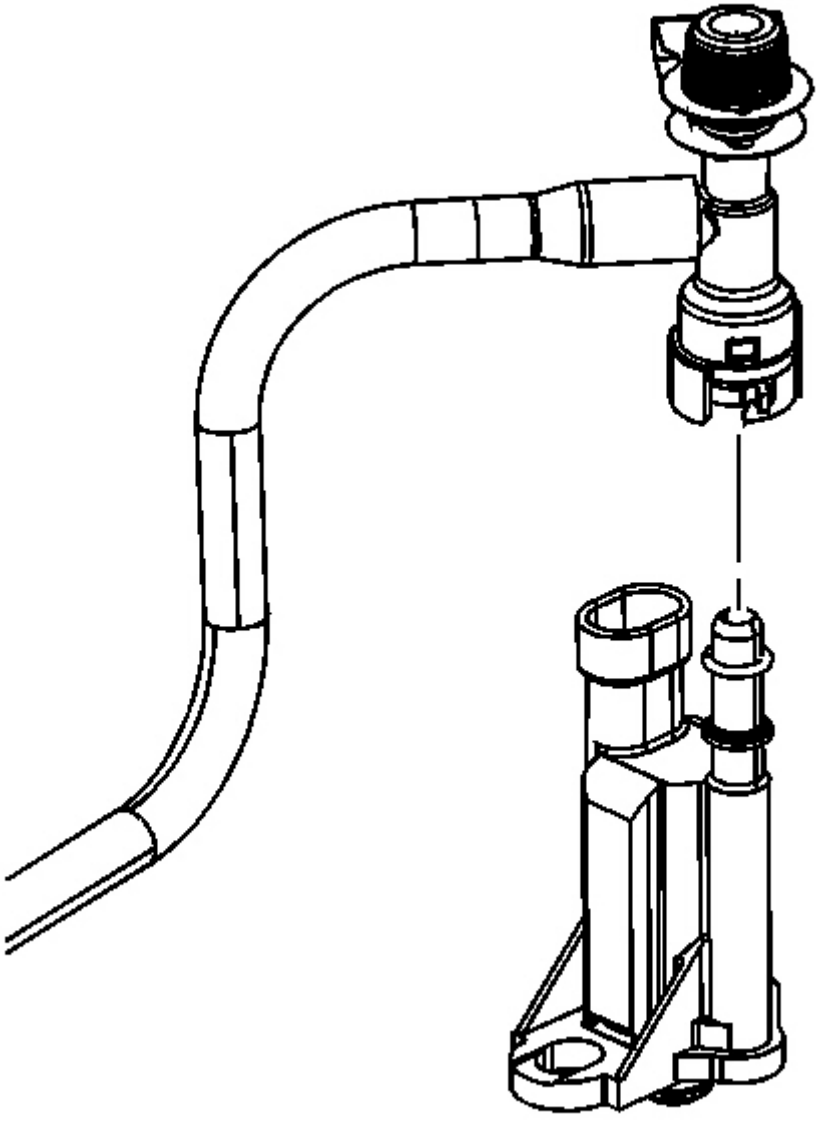


Fig. 705: Evaporative Emission Canister Solenoid Valve & Harness
Courtesy of GENERAL MOTORS CORP.

11. Connect the evaporative emission (EVAP) canister solenoid valve harness.
    1. Push the elbow inward until the quick connect snaps into place.
    2. Pull the elbow outward in order to ensure proper connection.

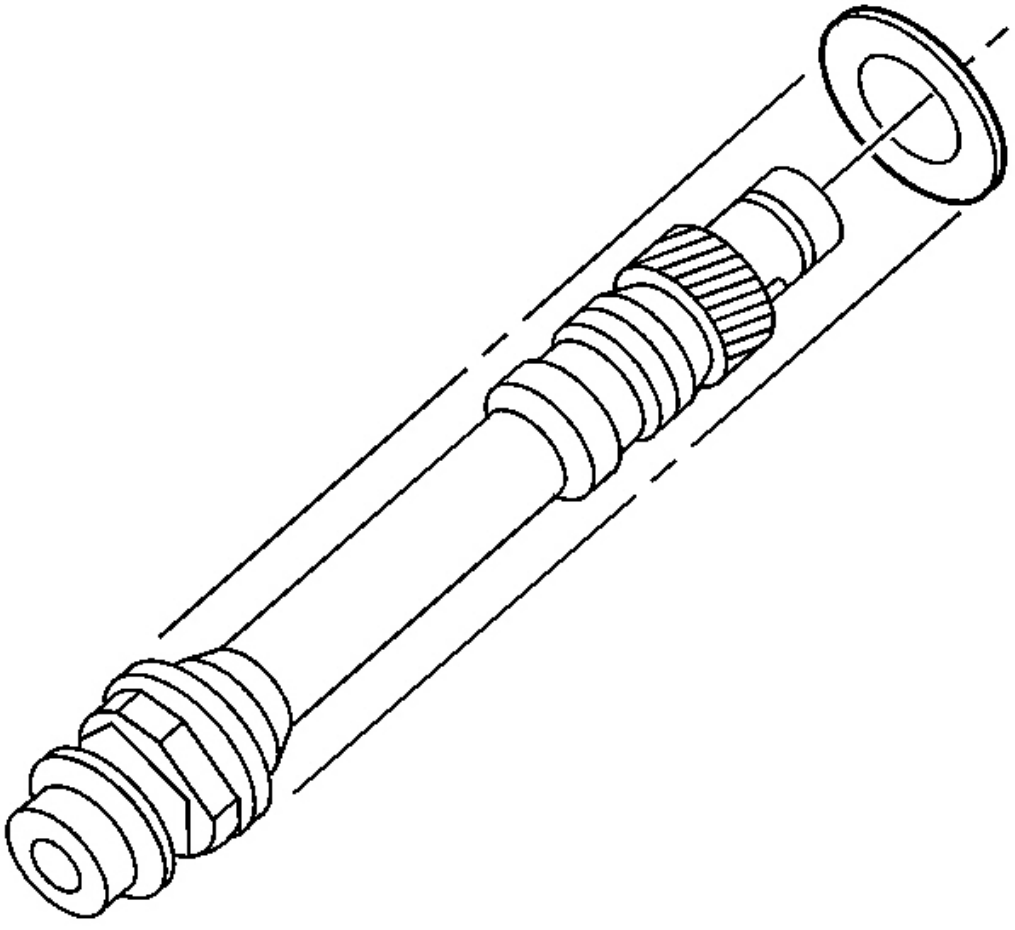


Fig. 706: Oil Pump Drive Shaft & Gasket
Courtesy of GENERAL MOTORS CORP.

12. Install a NEW oil pump drive shaft gasket onto the oil pump drive shaft.

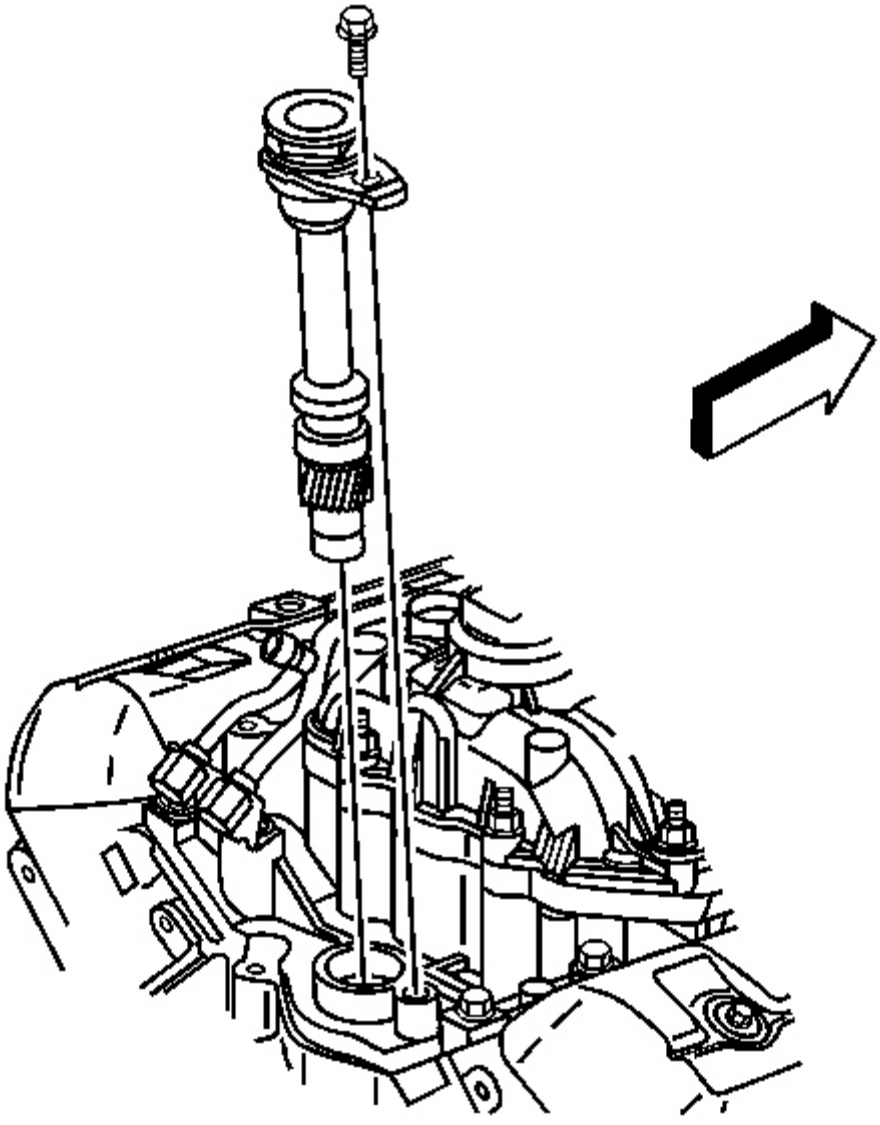


Fig. 707: View Of Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

13. Install the oil pump drive shaft and oil pump drive shaft clamp.
14. Install the oil pump drive shaft bolt.

Tighten: Tighten the oil pump drive shaft clamp bolt to 25 N.m (18 lb ft).

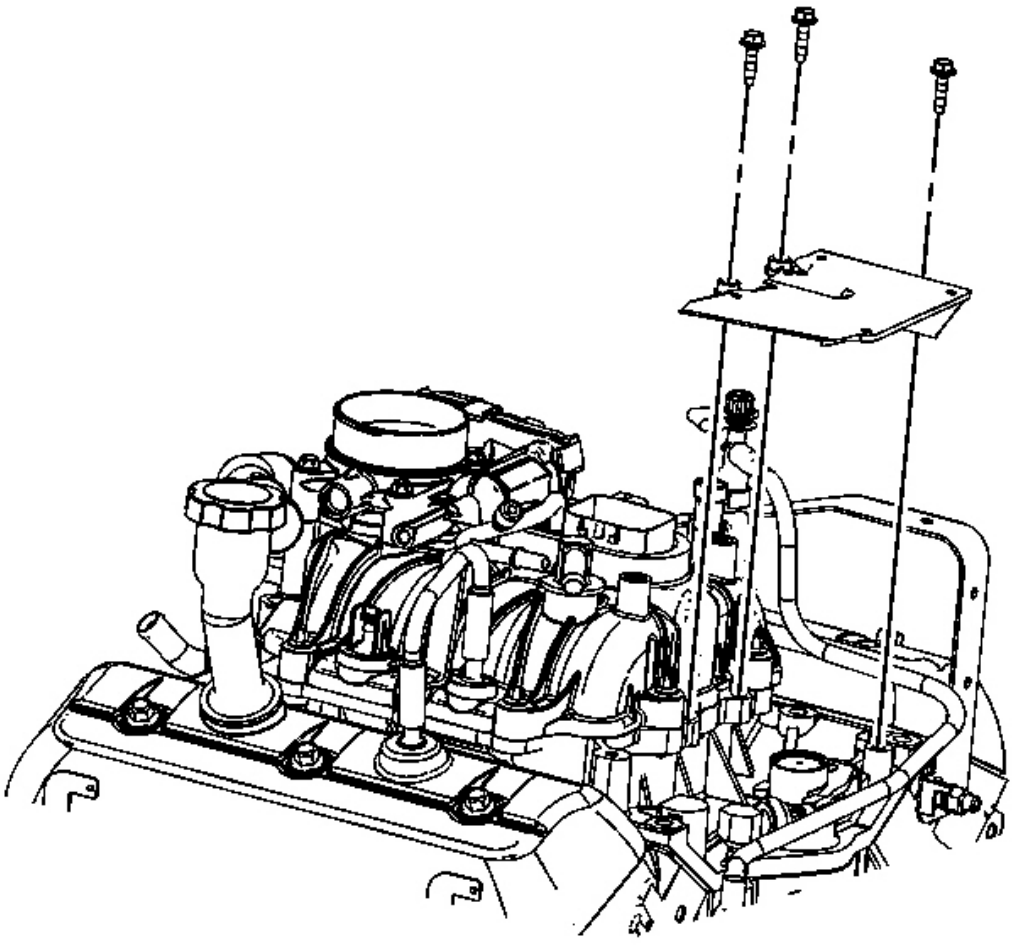


Fig. 708: View Of Ignition Coil Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

15. If required, install the ignition coil bracket and bolts.

    Tighten: Tighten the ignition coil bracket bolts to 12 N.m (106 lb in).

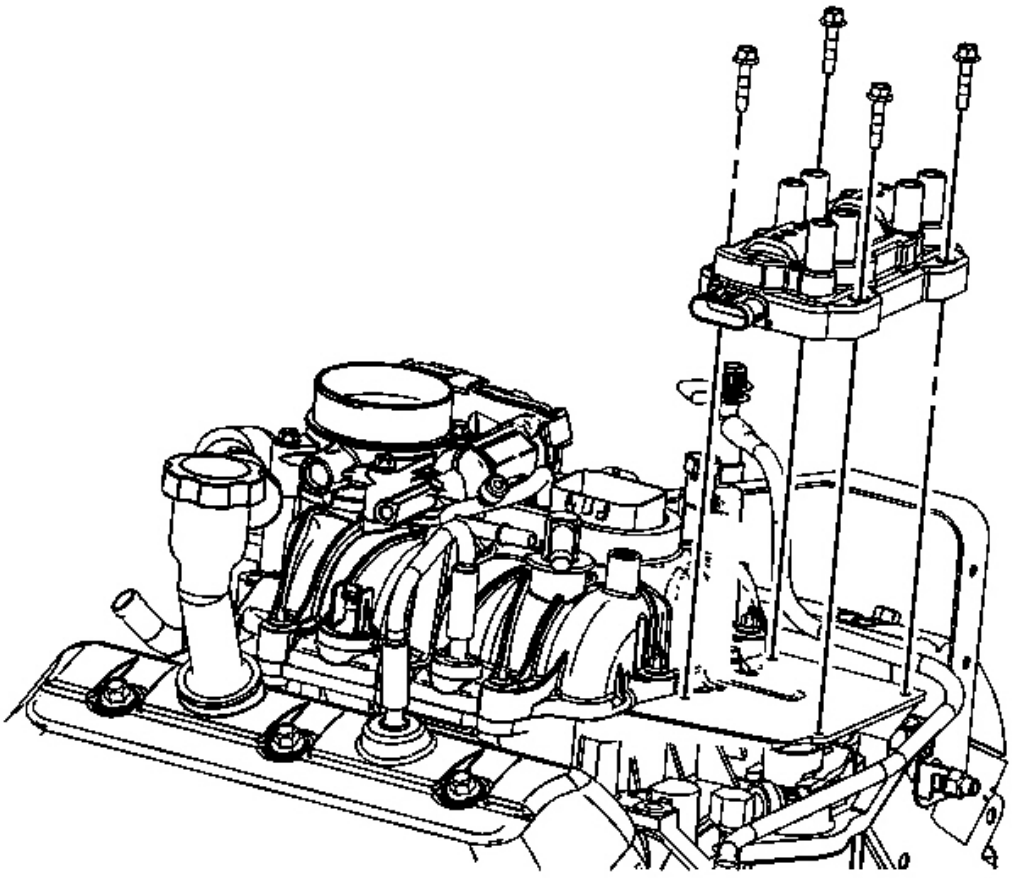


Fig. 709: View Of Ignition Coil & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the ignition coil and ignition coil bolts.

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

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

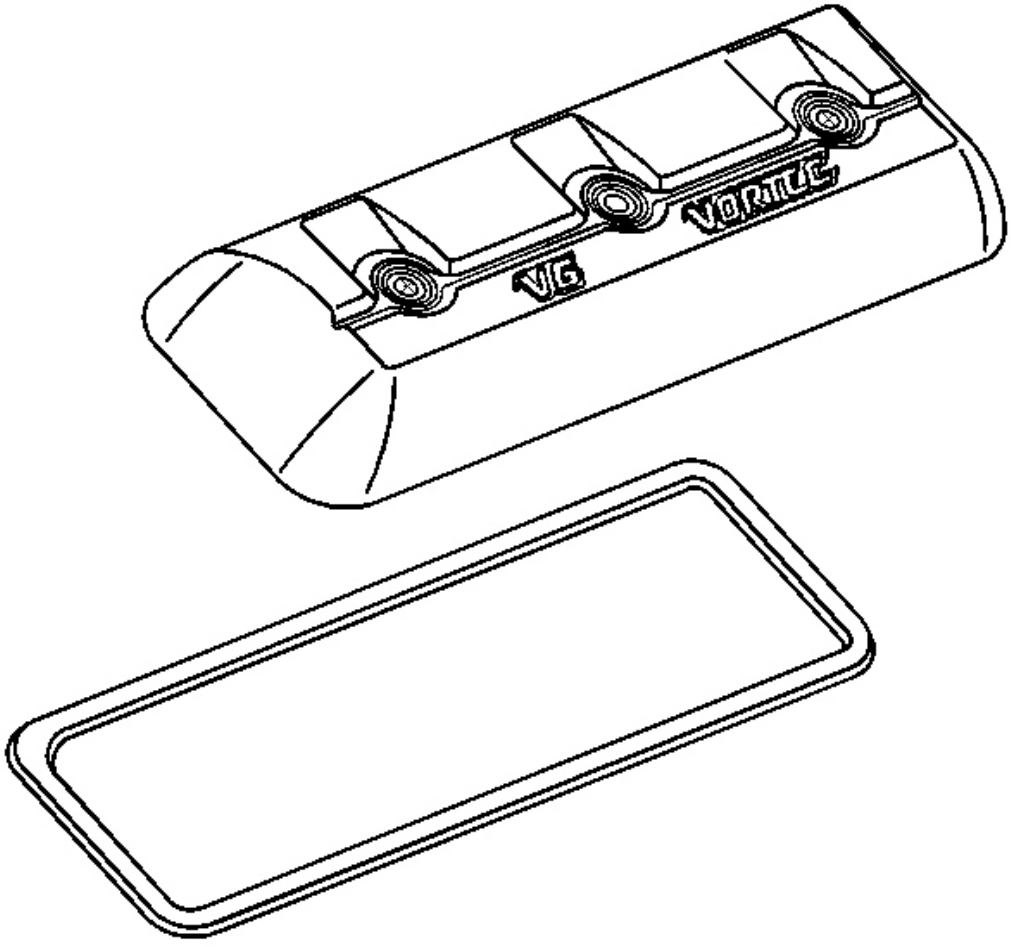


Fig. 710: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

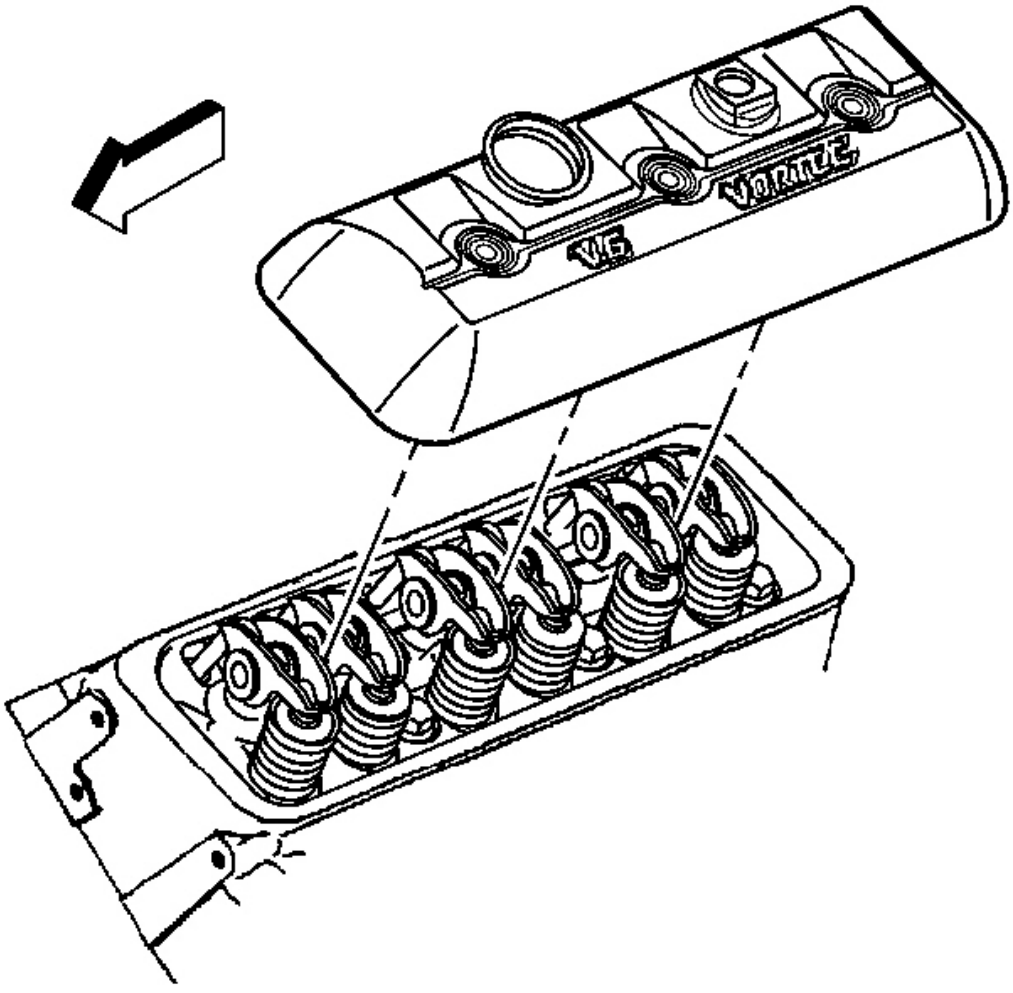


Fig. 711: Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

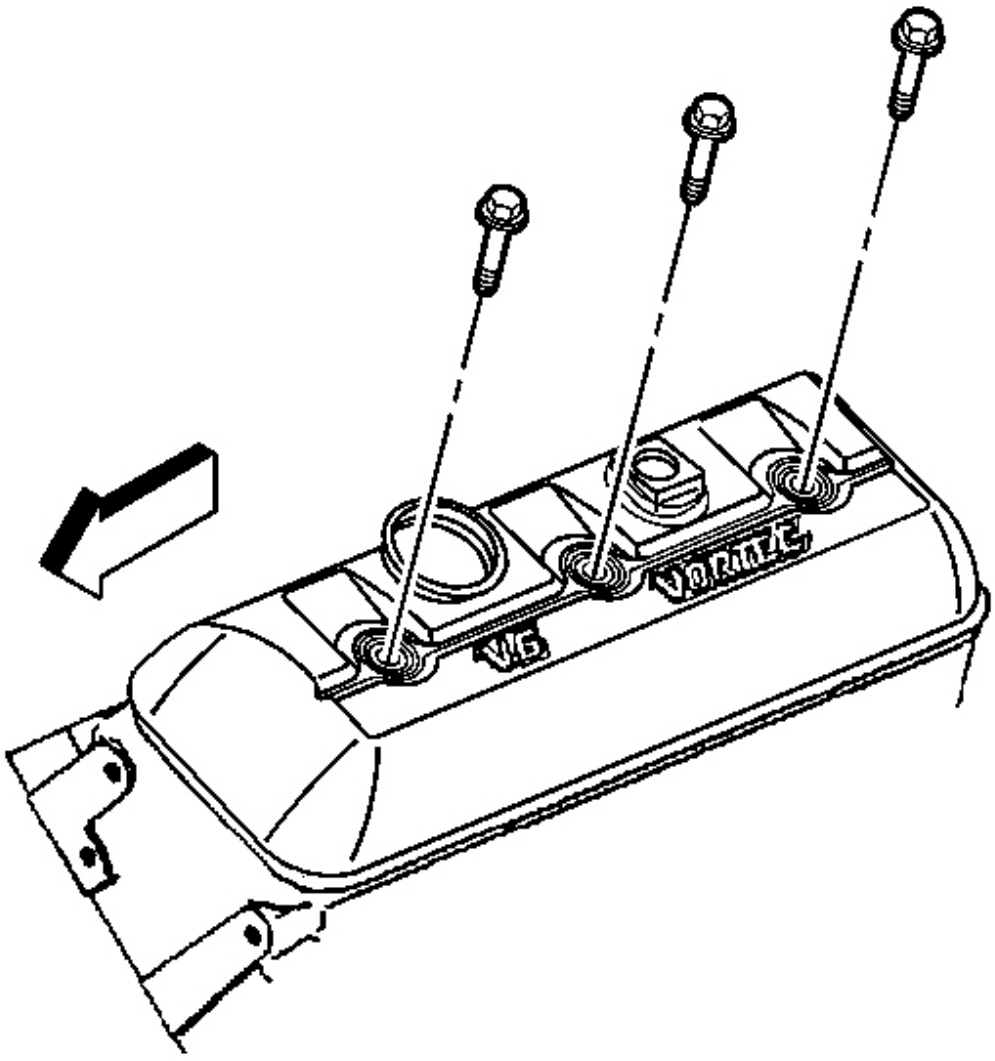


Fig. 712: Valve Rocker Arm Cover Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

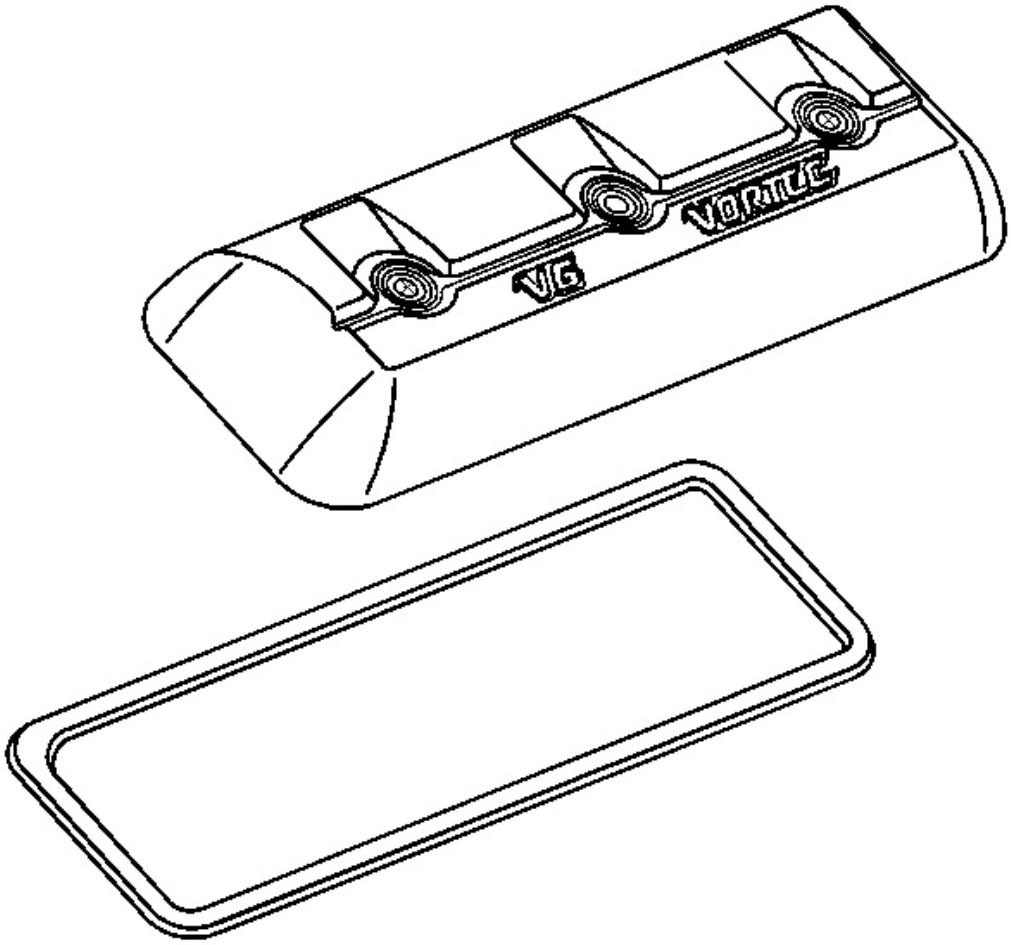


Fig. 713: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

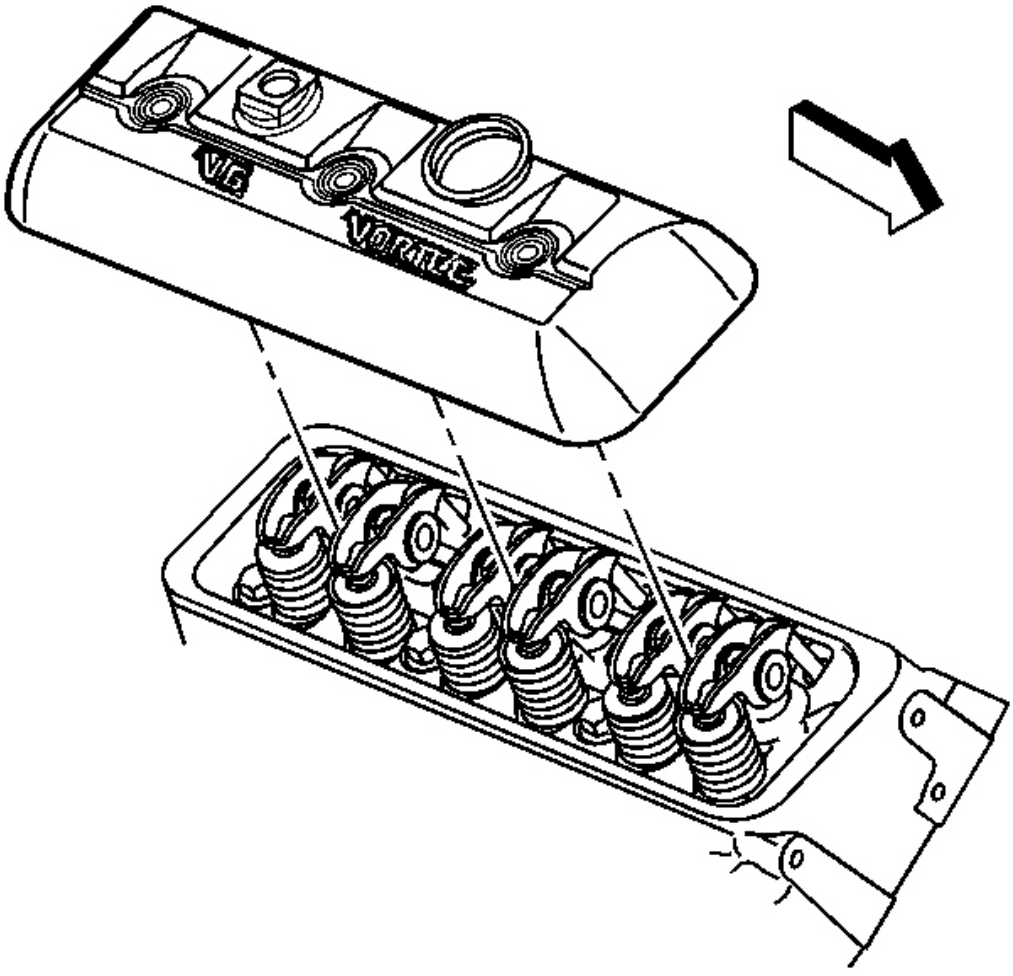


Fig. 714: Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

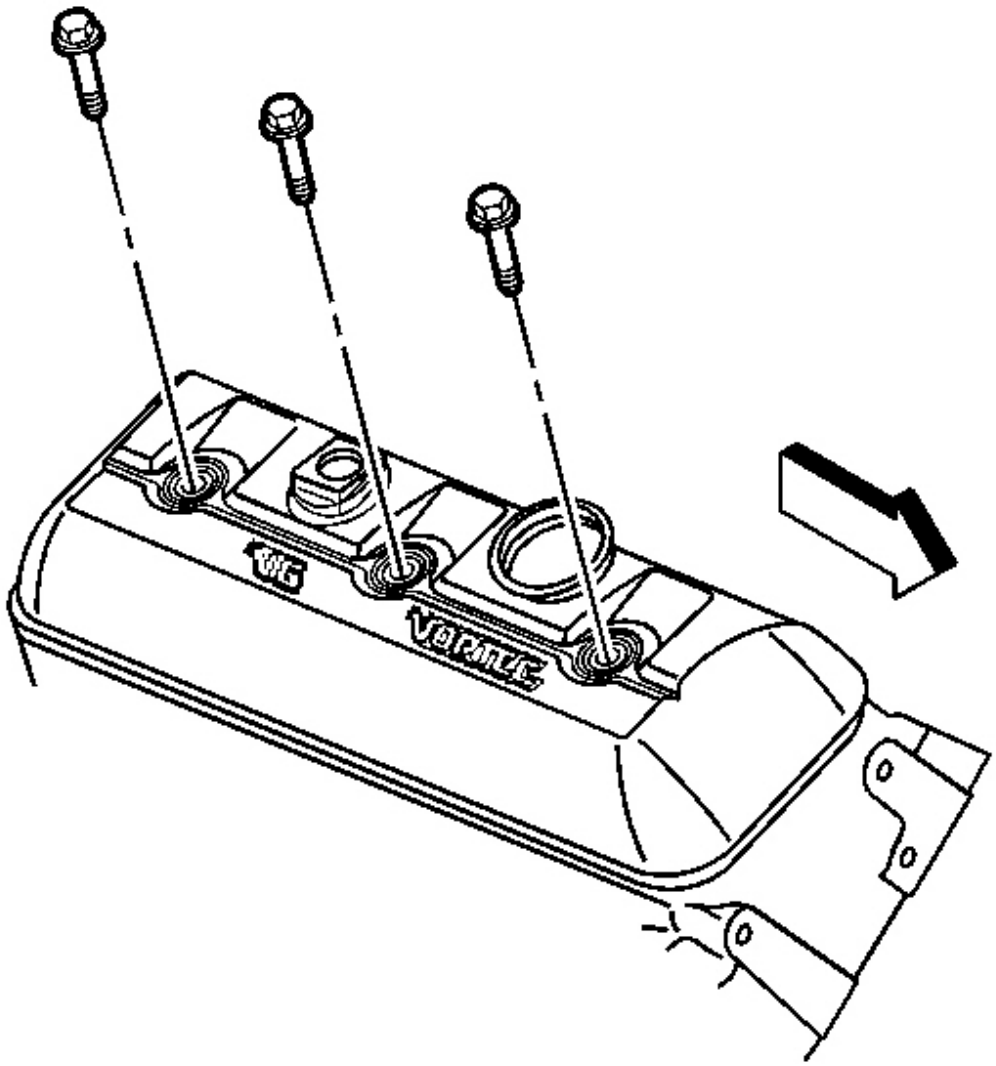


Fig. 715: View Of Valve Rocker Arm Cover Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

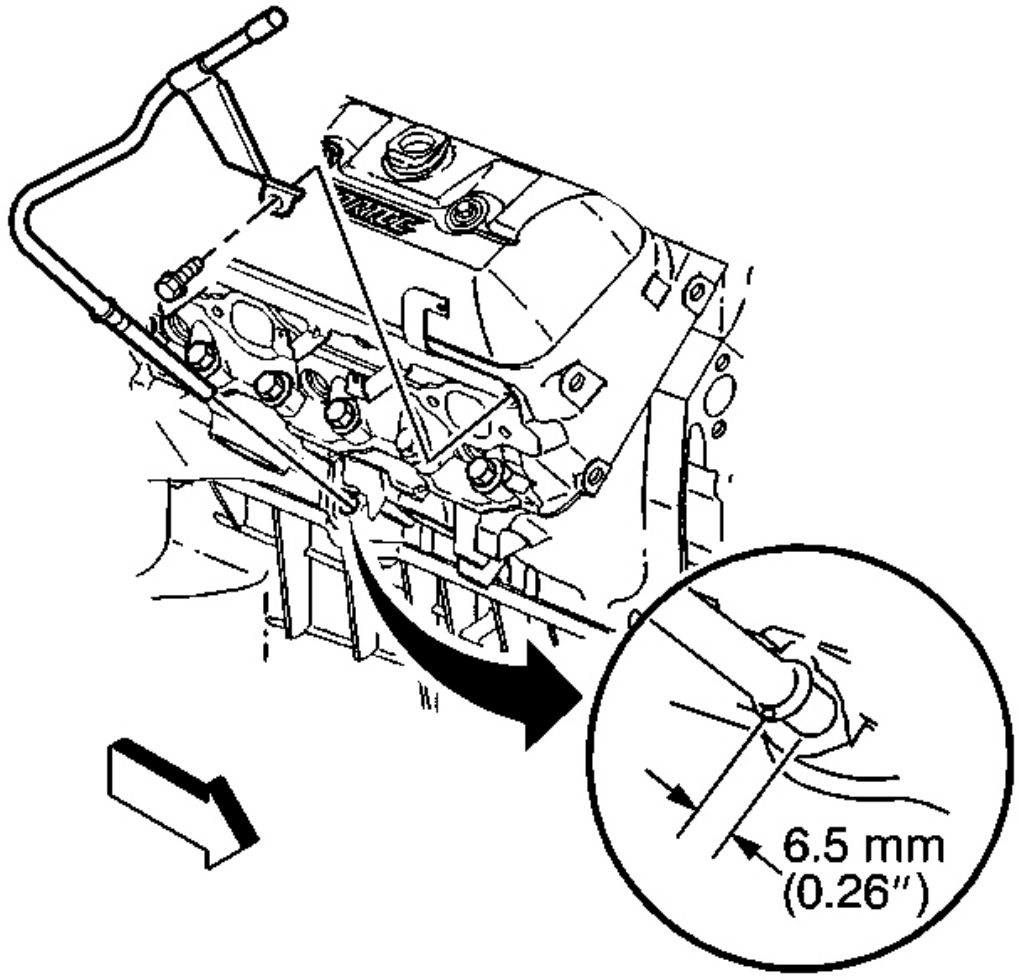


Fig. 716: Oil Level Indicator Tube Sealant
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, around the oil level indicator tube 13 mm (0.5 in) below the tube bead.
2. Install the oil level indicator tube into the engine block. Rotate the oil level indicator tube into position.

NOTE: Refer to Fastener Notice .

3. Install the oil level indicator tube bolt.

   Tighten: Tighten the oil level indicator tube bolt to 12 N.m (106 lb in).

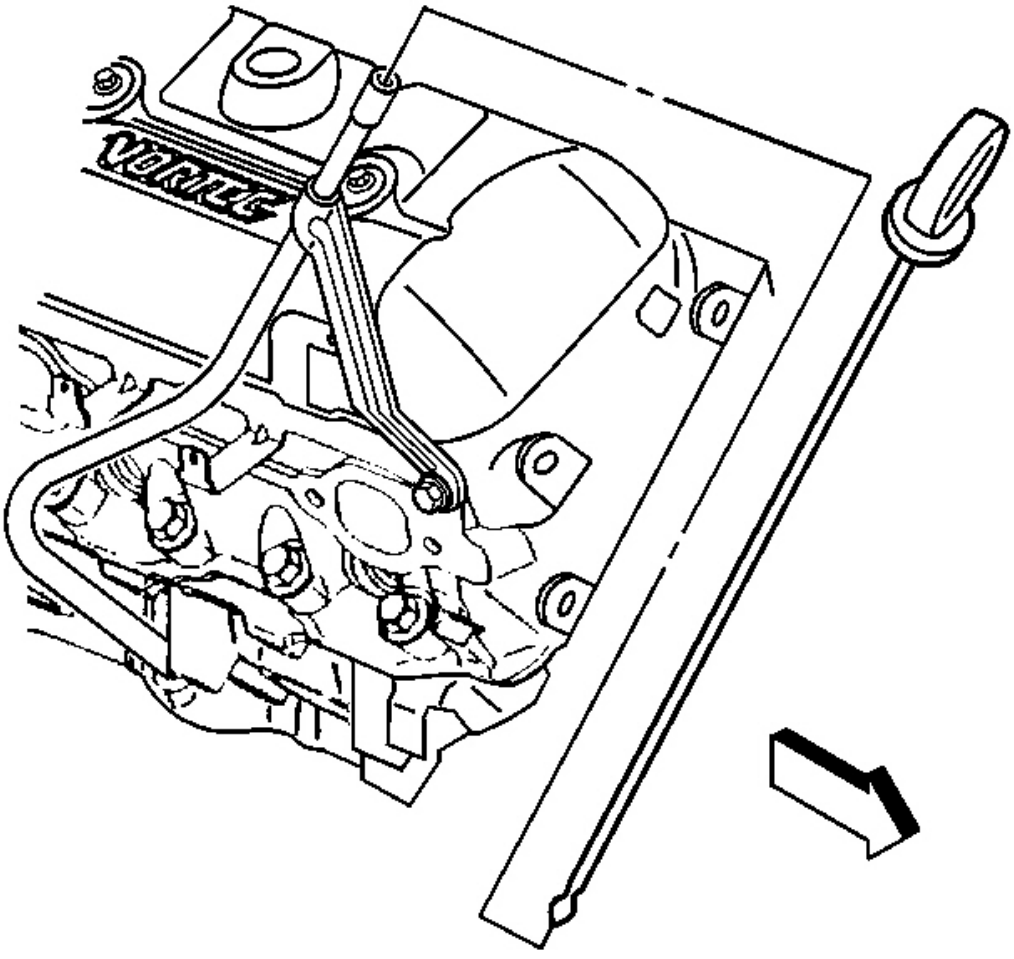


Fig. 717: Locating Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

4. Install the oil level indicator into the oil level indicator tube, if required.

WATER PUMP INSTALLATION

Tools Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools**.

Installation

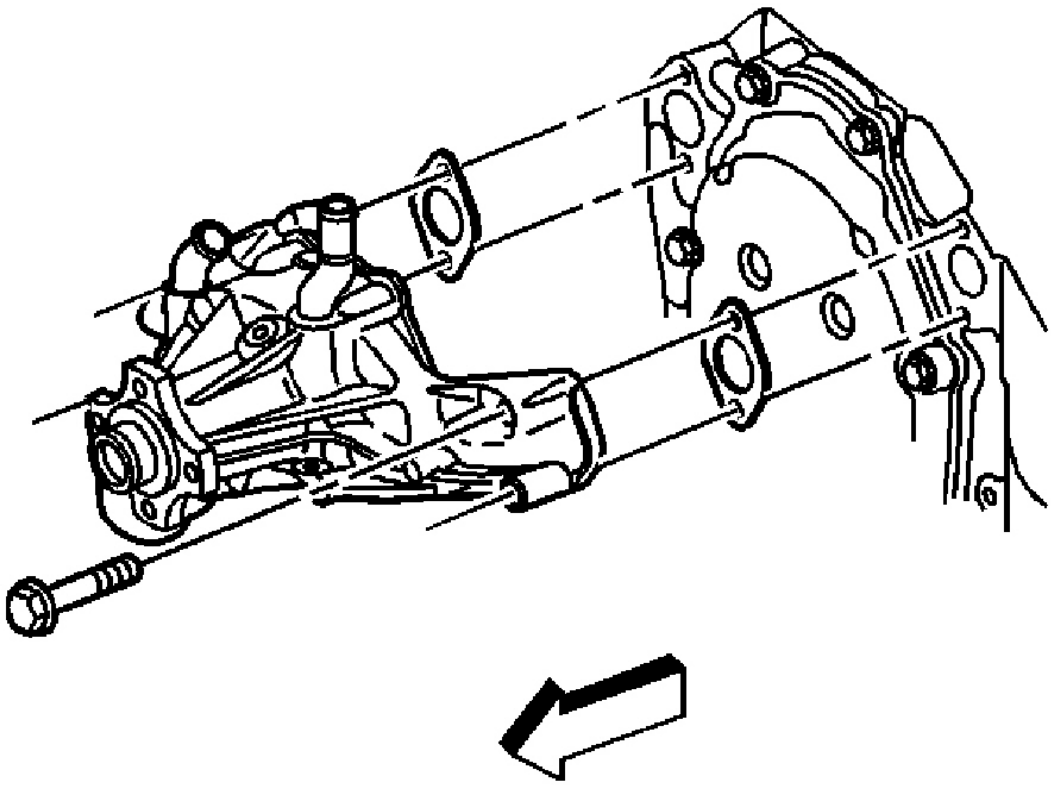


Fig. 718: View Of Water Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

1. If reusing the fasteners, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the water pump bolts.
2. Install the water pump and the NEW water pump gaskets.

NOTE: Refer to Fastener Notice

3. Install the water pump bolts.

Tighten: Tighten the water pump bolts to 45 N.m (33 lb ft).

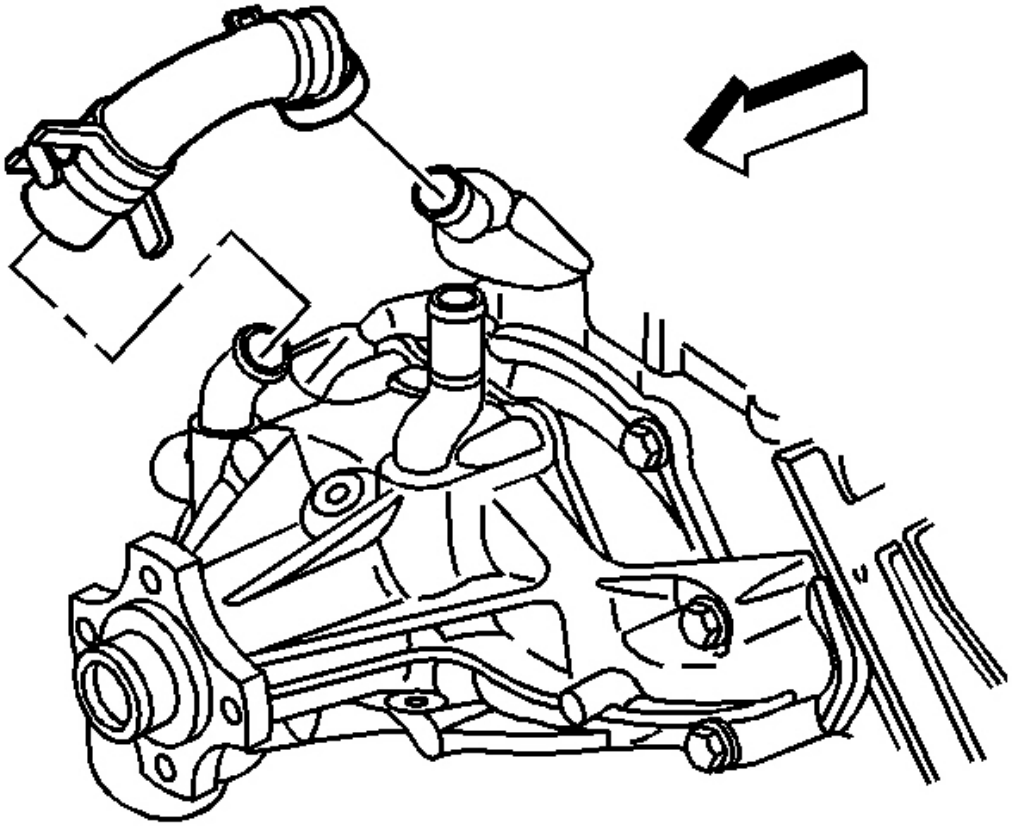


Fig. 719: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: After final assembly, the water pump inlet hose clamp tangs, water pump end, must point forward and the upper tang should be level with the outside diameter of the water pump inlet hose.

4. Install the water pump inlet hose and the water pump inlet hose clamps.

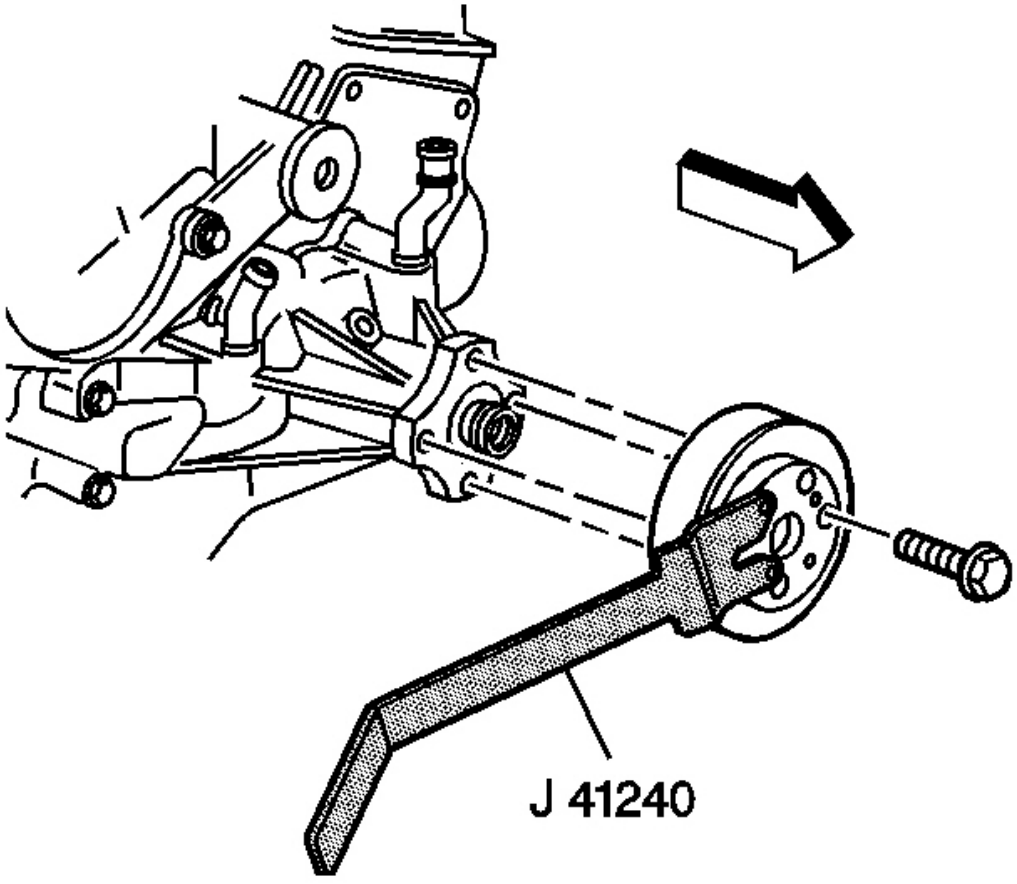


Fig. 720: View Of Fan, Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the fan and water pump pulley and bolts using the **J 41240** . See **Special Tools**.

   Tighten: Tighten the fan and water pump pulley bolts to 25 N.m (18 lb ft).

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

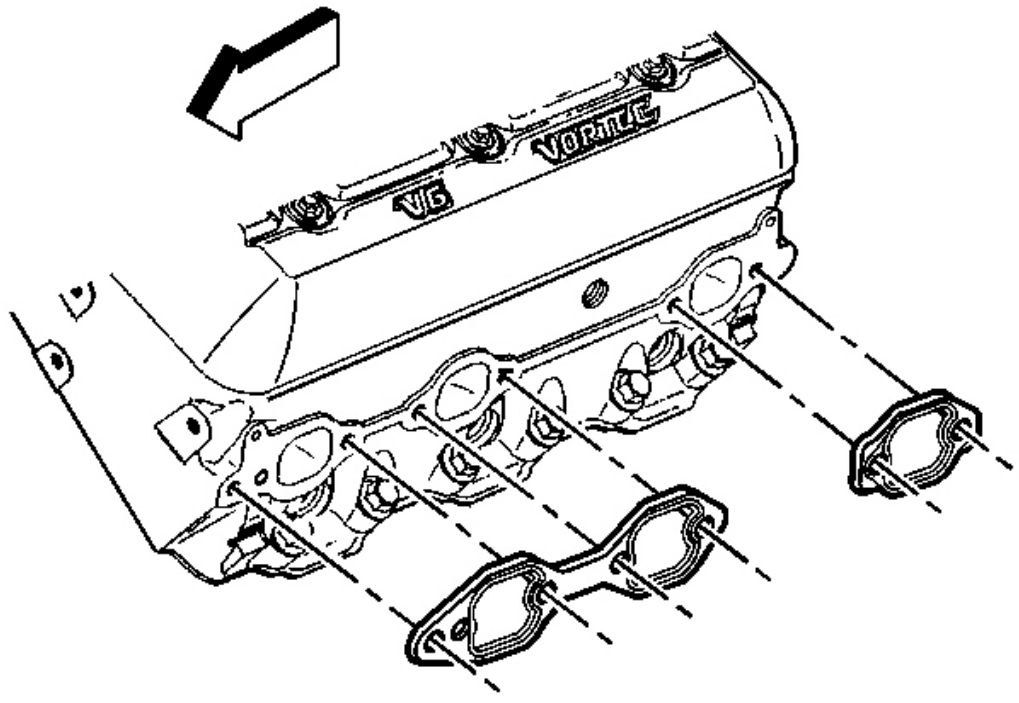


Fig. 721: Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW exhaust manifold gaskets.

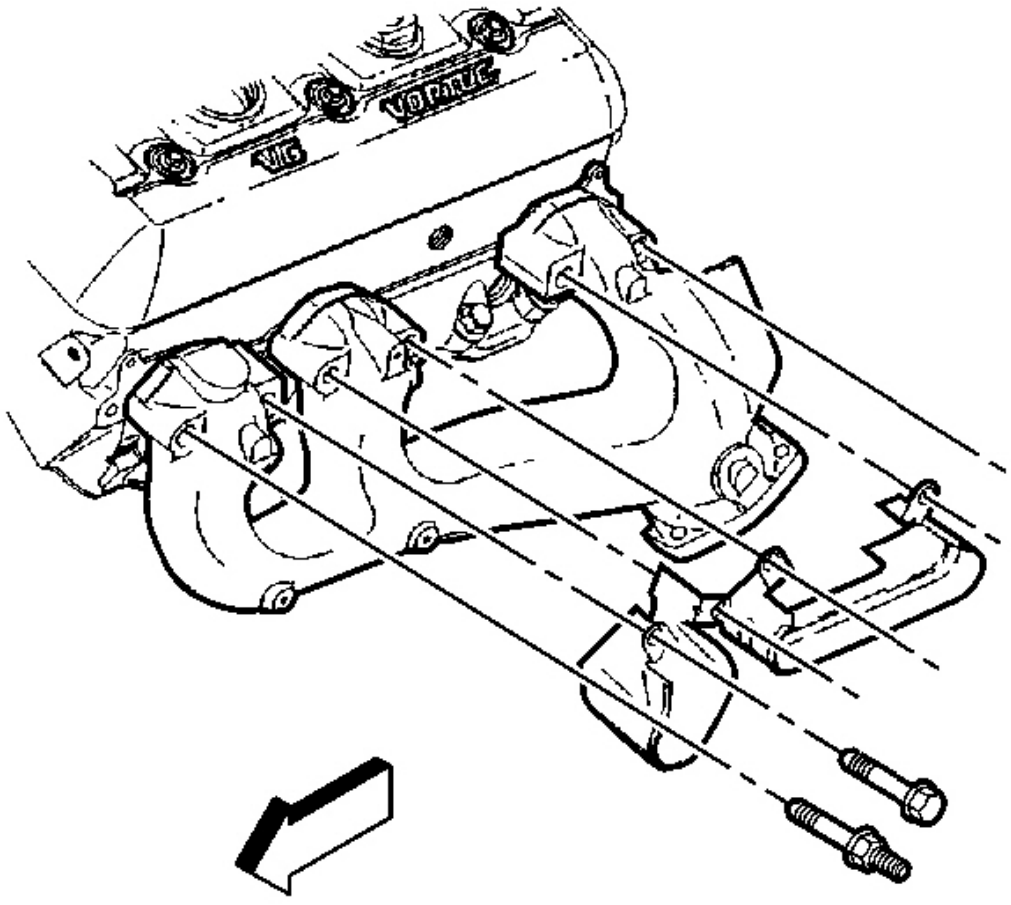


Fig. 722: View Of Exhaust Manifold Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. If reusing the fasteners, apply threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the threads of the exhaust manifold bolts and stud.

NOTE: Refer to Fastener Notice .

5. Install the exhaust manifold bolts and stud.

Tighten:

1. Tighten the exhaust manifold bolts and stud on the first pass to 15 N.m (11 lb ft).
2. Tighten the exhaust manifold bolts and stud on the final pass to 30 N.m (22 lb ft).

6. Install the spark plug wires to the spark plug wire retainers.
7. Install the spark plug wires onto the spark plugs.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

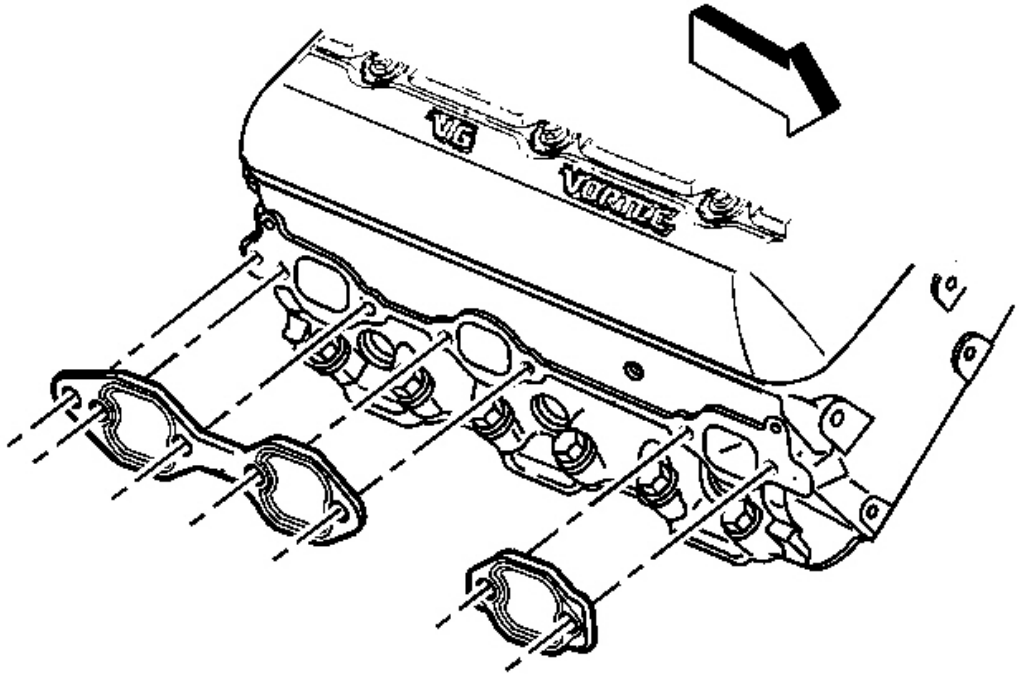


Fig. 723: Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW exhaust manifold gaskets.

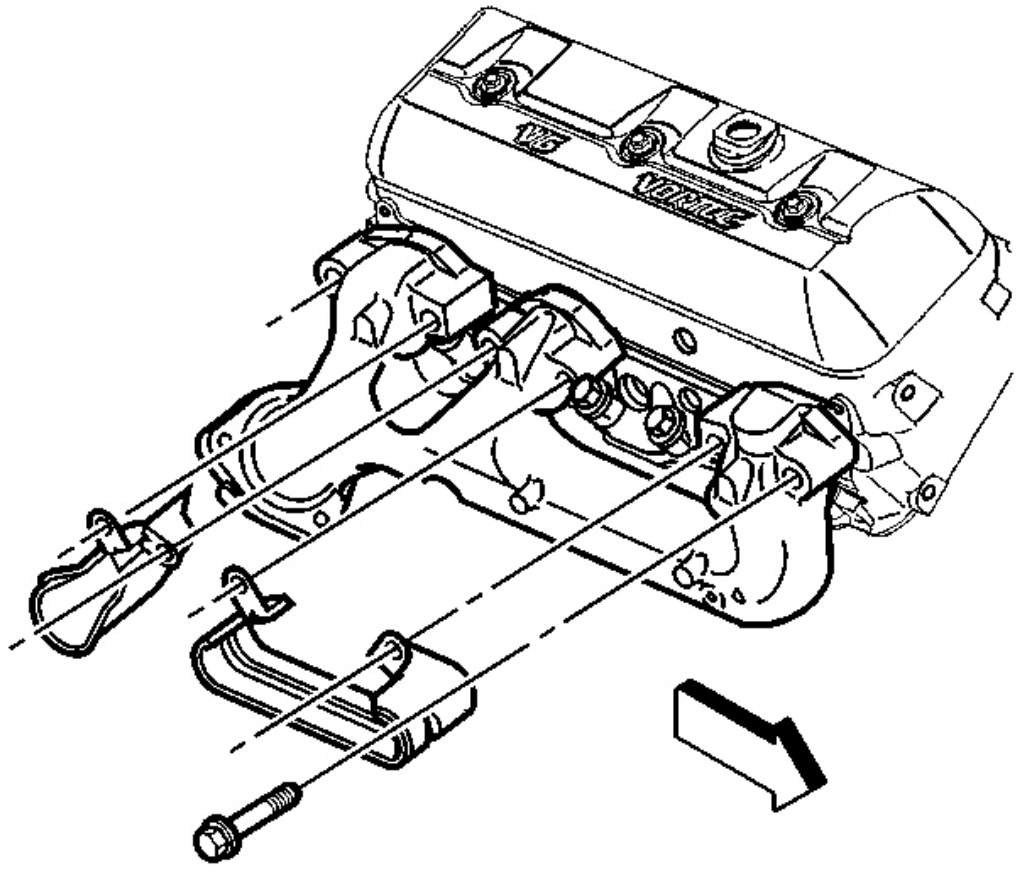


Fig. 724: Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. If reusing the fasteners, apply threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the threads of the exhaust manifold bolts.

NOTE: Refer to Fastener Notice .

5. Install the exhaust manifold bolts.

Tighten:

1. Tighten the exhaust manifold bolts on the first pass to 15 N.m (11 lb ft).
2. Tighten the exhaust manifold bolts on the final pass to 30 N.m (22 lb ft).

6. Install the spark plug wires to the spark plug wire retainers.
7. Install the spark plug wires onto the spark plugs.

CLUTCH PILOT BEARING INSTALLATION

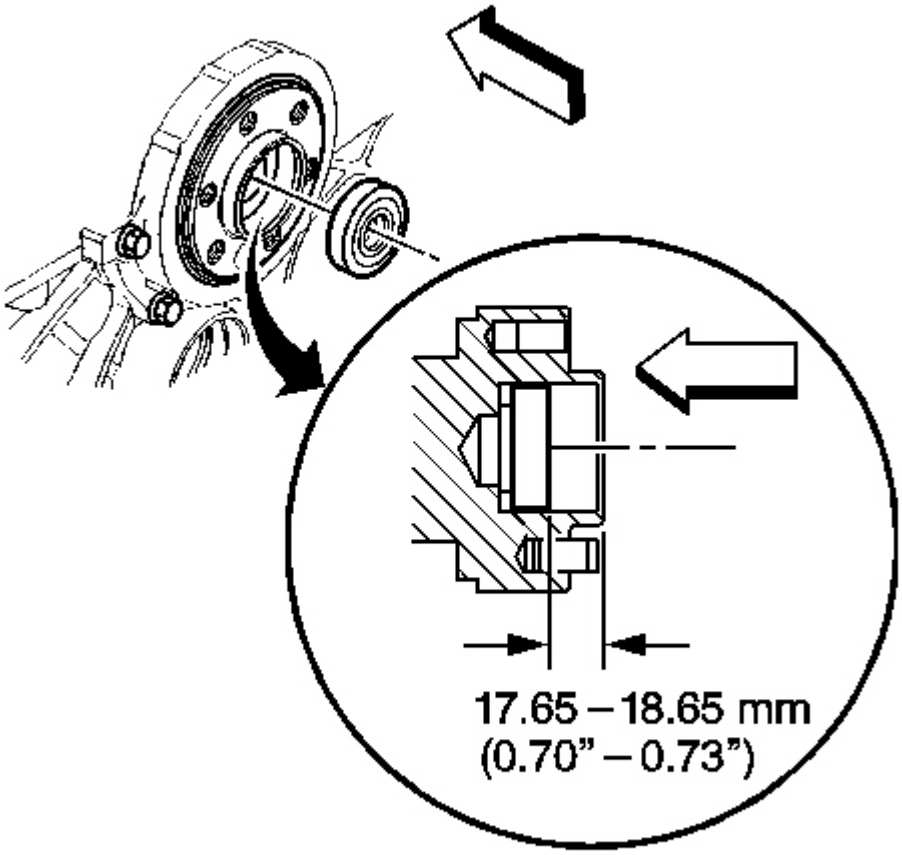


Fig. 725: Clutch Pilot Bearing Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION .

1. Install the NEW clutch pilot bearing using a suitable clutch pilot bearing installation tool.
2. Measure to ensure the proper installation depth is obtained.

ENGINE FLYWHEEL INSTALLATION

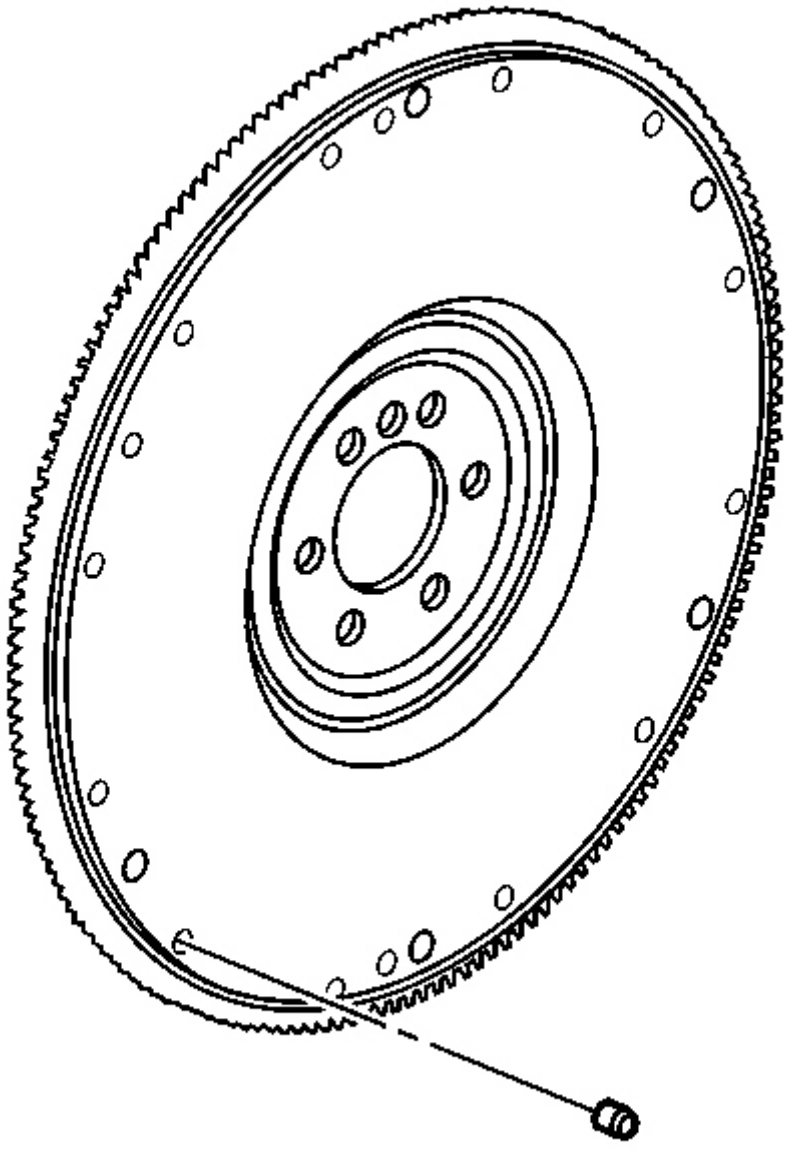


Fig. 726: Locating Flywheel Weights (Manual Transmission)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If replacing the engine flywheel, manual transmission, note the position and length of the original flywheel weights, if applicable. Flywheel weights of the same length must be installed into the new engine flywheel in the same location as the old flywheel weights were in the old engine flywheel.

1. Note the position of the flywheel weights and install the NEW flywheel weights as required.

   A properly installed flywheel weight will be flush or slightly below flush with the face of the engine flywheel.

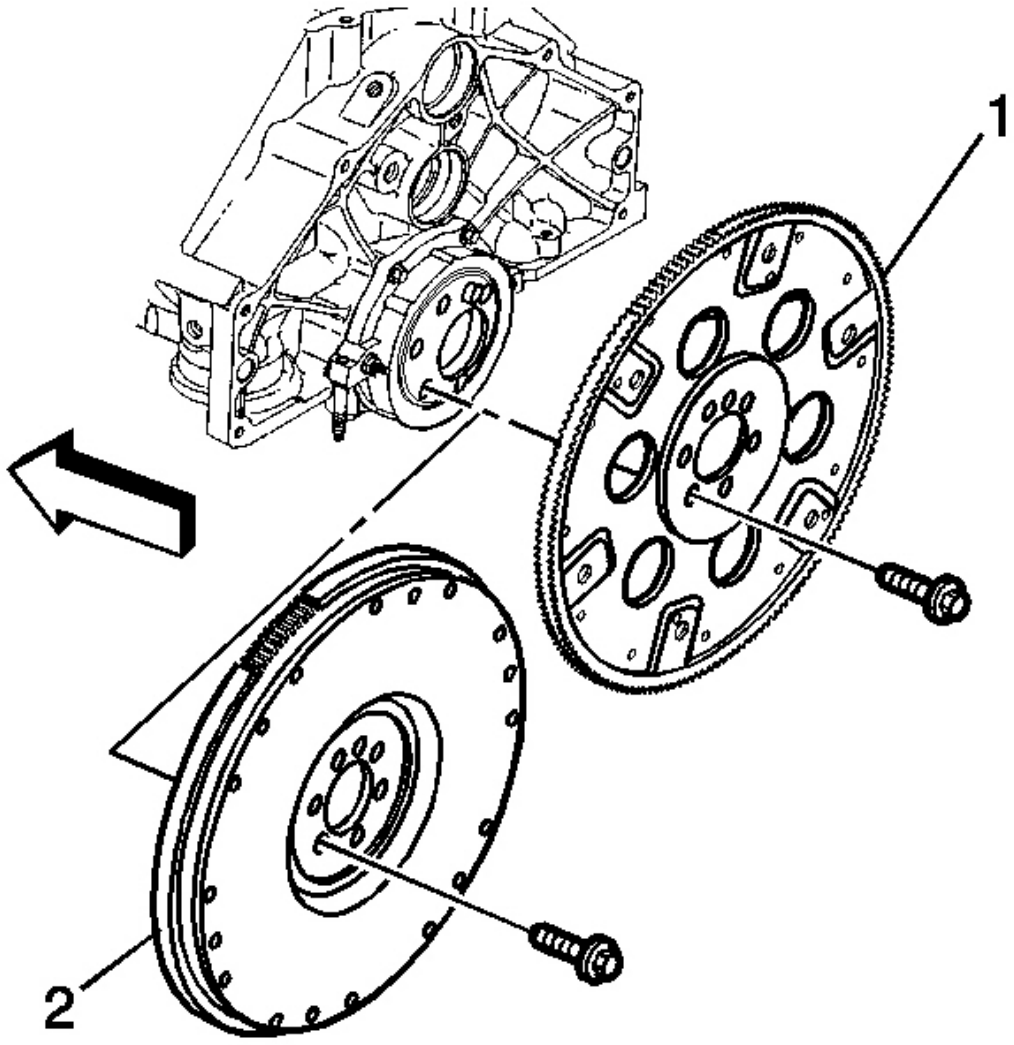


Fig. 727: View Of Flywheels
Courtesy of GENERAL MOTORS CORP.

2. Install the engine flywheel (1 or 2) to the crankshaft.

   Align the engine flywheel locator hole to the flywheel locator pin.

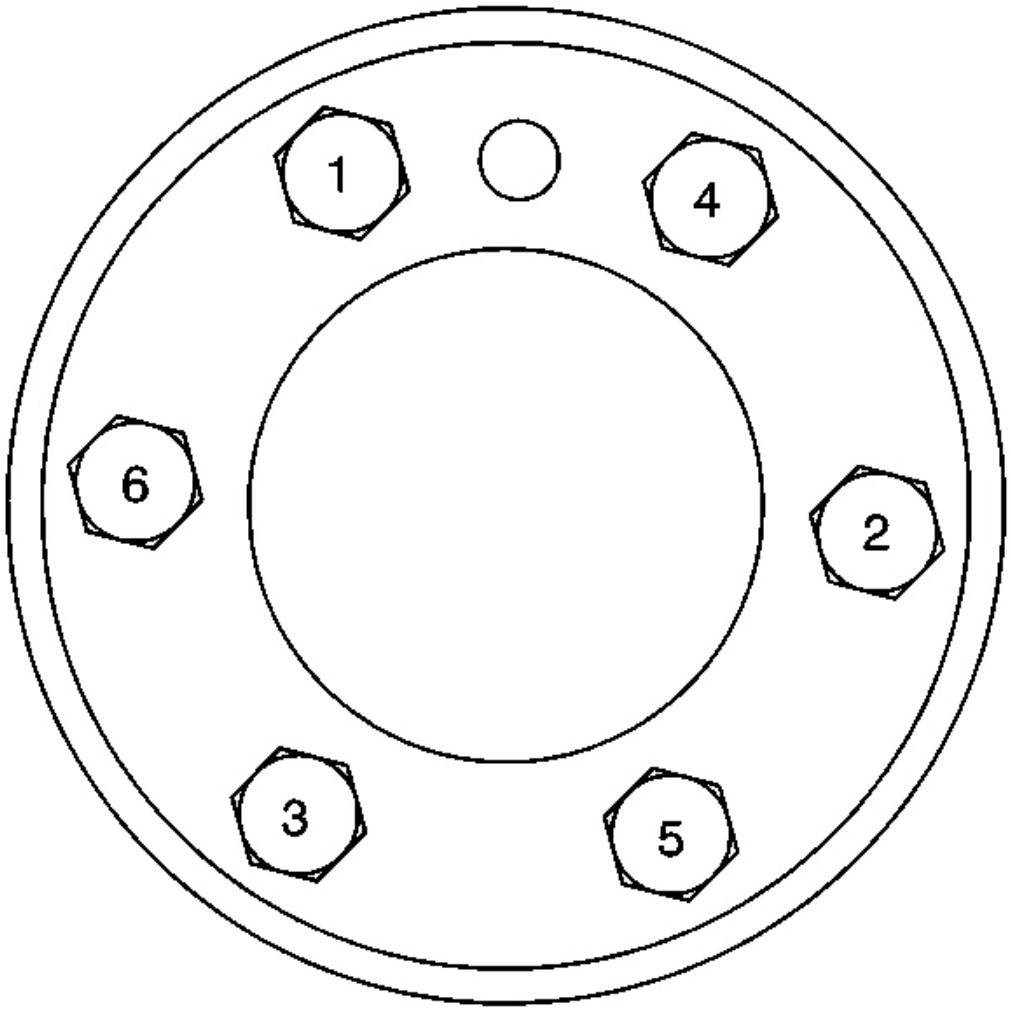


Fig. 728: Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the engine flywheel bolts.

Tighten: Tighten the engine flywheel bolts in sequence to 100 N.m (74 lb ft).

ENGINE PRELUBING

Tools Required

J 45299 Engine Preluber. See **Special Tools**.

Prelubing

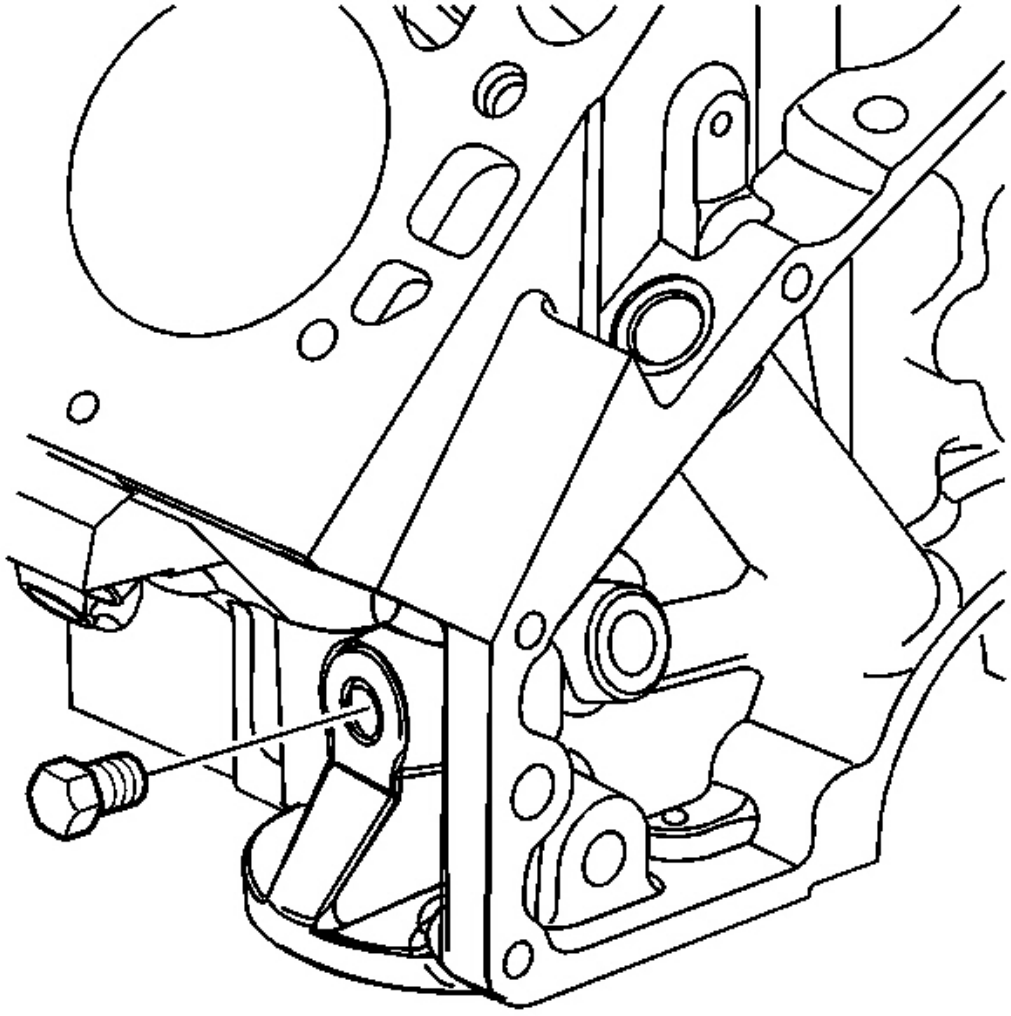


Fig. 729: View Of Engine Block Left Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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 and fill with clean engine oil.

NOTE: Refer to Fastener Notice .

2. Install the oil filter.

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

3. Locate the engine block left oil gallery plug and remove.
4. Install the M16 x 1.5 adapter P/N 509375.

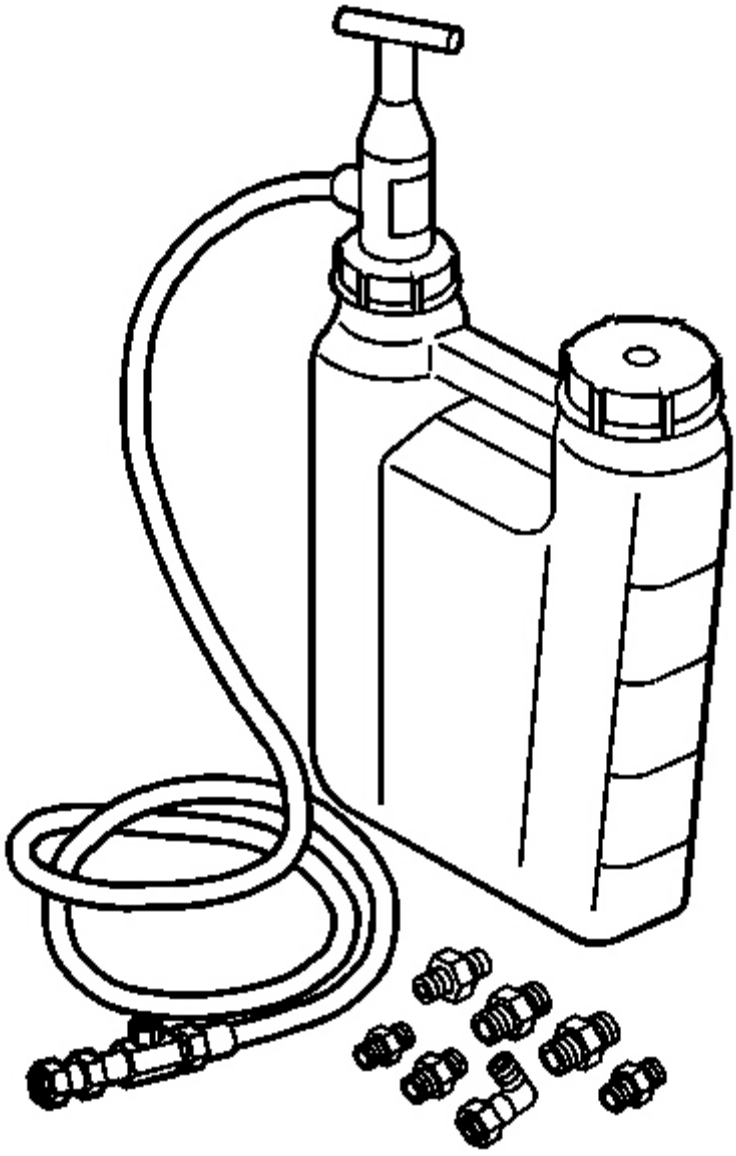


Fig. 730: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

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. See **Special Tools**.9

liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.

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.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to the atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the valve cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling

- High idle speed

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
  - The power steering pump, if belt driven
  - The generator
  - The A/C compressor, if equipped
  - The engine cooling fan, if belt driven
  - The water pump, if belt driven
  - The vacuum pump, if equipped
  - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM, and have different layers or plys containing either fiber cloth or cords for reinforcement.

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

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

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Balance Shaft

The cast iron balance shaft is mounted in the crankcase above and in-line with the camshaft. A camshaft gear drives the gear attached to the balance shaft. The front end of the balance shaft is supported by a ball-type bearing. The rear end of the balance shaft uses a sleeve-type bearing.

Camshaft

The steel camshaft is supported by four bearings pressed into the engine block. The camshaft timing chain sprocket mounted to the front of the camshaft is driven by the crankshaft sprocket through a camshaft timing chain.

Crankshaft

The cast nodular iron crankshaft is supported by four crankshaft bearings. The number four crankshaft bearing at the rear of the engine is the end thrust bearing. The crankshaft bearings are retained by bearing caps that are machined with the engine block for proper alignment and clearances. The crankshaft position sensor reluctor ring has three lugs used for crankshaft timing and is constructed of powdered metal. The crankshaft position sensor reluctor ring has a slight interference fit onto the crankshaft and an internal keyway for correct positioning.

Cylinder Heads

The cast iron cylinder heads have one intake and one exhaust valve for each cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides and seats are integral to the cylinder head. The 4.3L heavy duty applications have pressed in exhaust valve seats. The valve rocker arms are positioned on the valve rocker arm supports and retained by a bolt.

Engine Block

The cast iron engine block has six cylinders arranged in a V shape with three cylinders in each bank. Starting at the front side of the engine block, the cylinders in the left bank are numbered 1-3-5 and cylinders in the right bank are numbered 2-4-6, when viewed from the rear. The firing order of the cylinders is 1-6-5-4-3-2. The cylinders are encircled by coolant jackets.

Exhaust Manifolds

The cast iron exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system.

Intake Manifold

The intake manifold is a two-piece design. The upper portion is made from a composite material and the lower portion is cast aluminum. The throttle body attaches to the upper manifold. The Central Multipoint Flexible Injection system uses multiple fuel injectors to meter and distribute fuel to each engine cylinder. The Central (MFI) is retained by a bracket bolted to the lower intake manifold. The fuel meter body also houses the pressure regulator. Metal inlet and outlet fuel lines and nylon delivery tubes connect to the Central (MFI) unit. The delivery tubes independently distribute fuel to each cylinder through injectors located at the port entrance of each manifold runner where the fuel is atomized.

Piston and Connecting Rod Assemblies

The cast aluminum pistons use two compression rings and one oil control assembly. The piston is a low friction, lightweight design with a flat top and barrel shaped skirt. The piston pins are offset 0.9 mm (0.0354 in) toward the major thrust side, right side, to reduce piston slap as the connecting rod travels from one side of the piston to the other side after a stroke. The piston pins have a floating fit in the piston and are retained by a press fit in the connecting rod. Powdered metal connecting rods were introduced into production in late 2006. Powdered metal connecting rods and rod bearing caps are NOT interchangeable. They must be assembled with the mating surfaces properly oriented and aligned, and the piston, piston pin, and connecting rod are to be serviced as an assembly.

Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and the tubular valve pushrods to the roller type valve rocker arms. The roller type valve rocker arm pivots on a needle type bearing in order to open the valve. The valve rocker arms for each bank of cylinders are mounted to a one piece valve rocker arm support. Each valve rocker arm is retained on the valve rocker arm support and the cylinder head by a bolt. The hydraulic valve lifters keep all the parts of the valve train in constant contact. Each hydraulic valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

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:

- A component comparison from the previous year
- Fastener changes

- 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

Component Comparison

Powdered metal connecting rods have replaced forged connecting rods.

Torque Values and/or Fastener Tightening Strategies

Addition of powdered metal connecting rod torque specification.

Changed Engine Specifications

No changes for 2007.

New Sealants and/or Adhesives

No new sealants or adhesives for 2007.

Disassembly and Assembly Procedure Revisions

Instructions added specific to powdered metal connecting rod service.

Engine Mechanical Diagnostic Procedure Revisions

No changes for 2007.

New Special Tools Required

No changes for 2007.

LUBRICATION DESCRIPTION

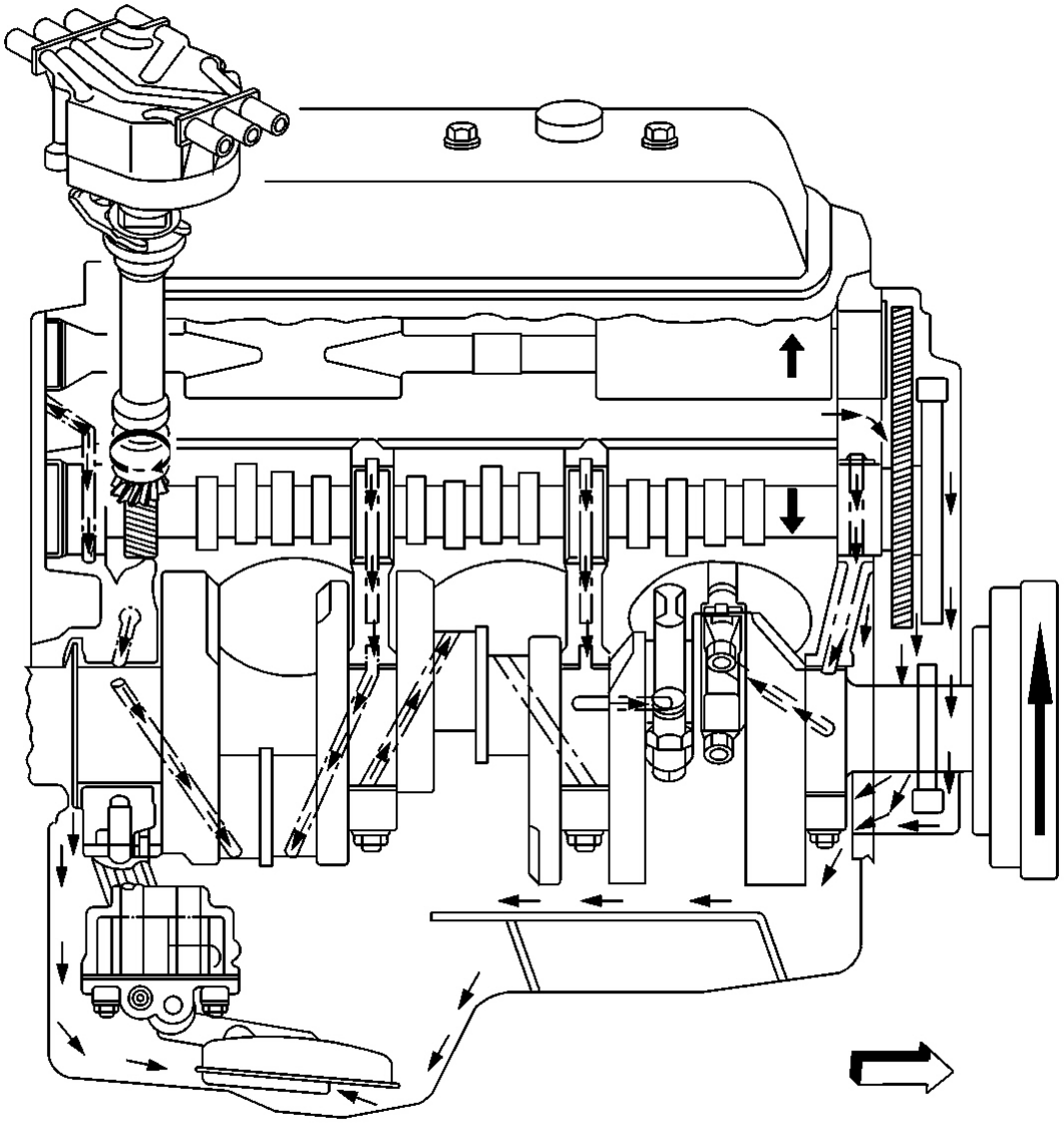


Fig. 731: Engine Lubrication
Courtesy of GENERAL MOTORS CORP.

Full pressure lubrication, through a full-flow oil filter is supplied by a gear-type oil pump. Oil is drawn up through the oil pump screen and passes through the pump to the oil filter. The oil filter is a full-flow paper element unit with an anti-drain back valve. An oil filter bypass valve is used to ensure adequate oil supply, in the event the filter becomes plugged or develops excessive pressure drop. Filtered oil flows into the main gallery and then to the camshaft, the balance shaft, the rear bearing, and the crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the valve lifters through the hollow valve pushrods to the valve rocker

arms. Oil drains back to the crankcase through the oil drain holes in the cylinder head. The camshaft timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

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, the components should be marked, organized or retained in a specific order for re-assembly.
- At the time of installation, the 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. The surfaces should be protected to avoid component damage.
- Apply a liberal amount of clean engine oil to friction areas during assembly.
- Proper lubrication will protect and lubricate friction areas during initial operation.

SEPARATING PARTS

IMPORTANT: Many internal engine components will develop specific wear patterns on their friction surfaces.
When disassembling the engine, internal components MUST be separated, marked and organized in a way to ensure reinstallation to original location and position.

Mark or identify the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the specific cylinder bore
- Connecting rod to the crankshaft journal
- Connecting rod to connecting rod cap
- Crankshaft bearings and connecting rod bearings
- Engine camshaft and valve lifters

- Valve lifters, valve rocker arms, and valve rocker arm supports
- Valve to the valve guide
- Valve spring to cylinder head location
- Engine block bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

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

Cleaning Gasket Surfaces

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

  Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.

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

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service

procedure.

- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Sealant Types

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

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

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

Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant

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

Use the following information when using RTV sealant:

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

NOTE: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

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

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

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

IMPORTANT: Do not overtighten the fasteners.

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

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled

and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

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

  The surfaces to be sealed must be clean and dry.

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

IMPORTANT:

- **Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.**
- **Do not overtighten the fasteners.**
  - **Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.**
  - **Tighten the fasteners in sequence, if specified, and to the proper torque specifications.**
  - **After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.**

Anaerobic Type Threadlock Sealant

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

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant

container.

- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

IMPORTANT:

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

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

Anaerobic Type Pipe Sealant

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

Use the following information when using pipe sealant:

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

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

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

IMPORTANT: Do not overtighten the fasteners.

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

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. The tools (or the equivalents) are specially designed to quickly and safely accomplish the operations for which the tools are intended. The use of special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

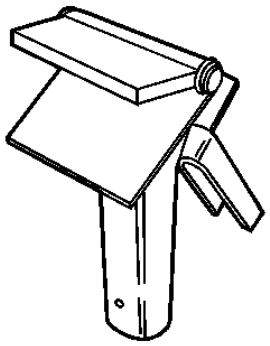
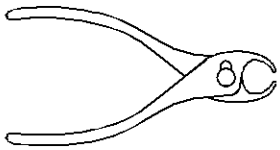
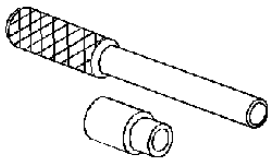
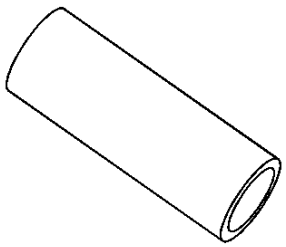
To properly service the engine assembly, the following items should be readily available:

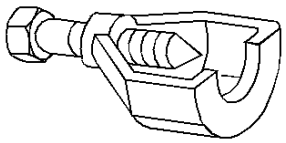
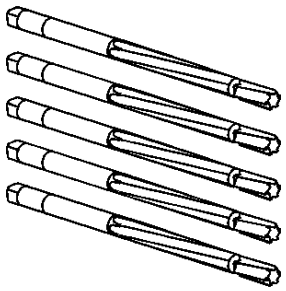
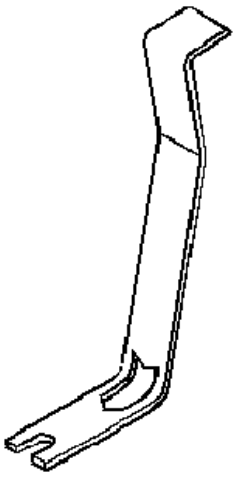
- Approved eye protection and safety gloves
- A clean, well-lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

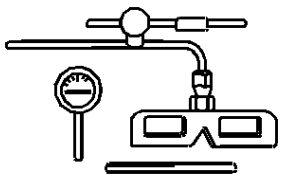
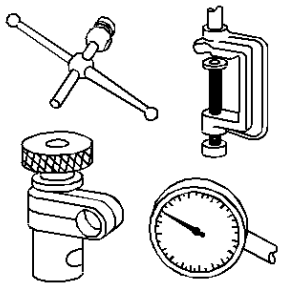
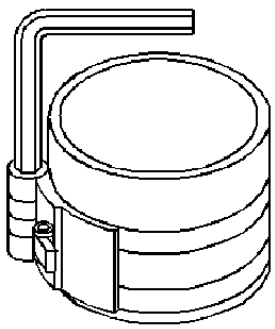
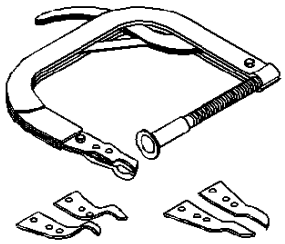
SPECIAL TOOLS AND EQUIPMENT

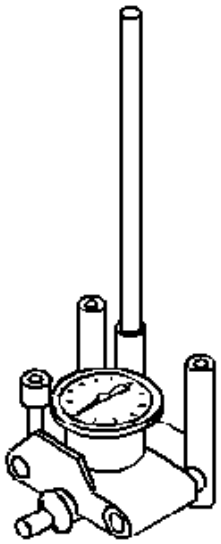
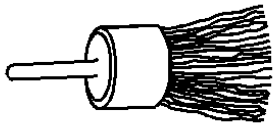
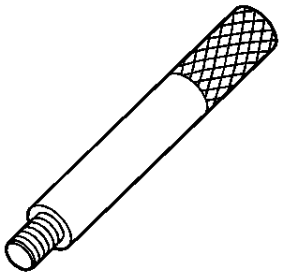
SPECIAL TOOLS

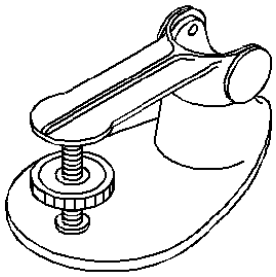
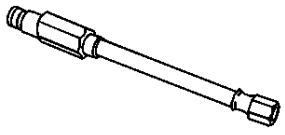
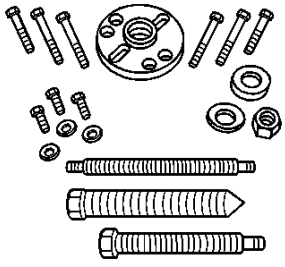
Illustration	Tool Number/ Description
	GE-48326 Sealant Dispenser

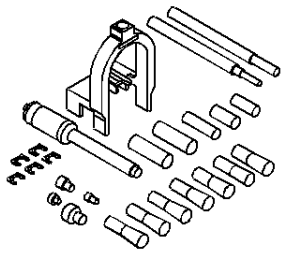
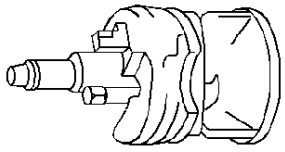
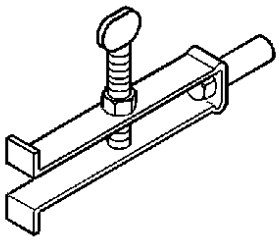
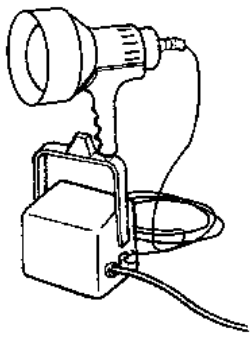
	
	J 3049-A Valve Lifter Remover
	J 5239 Connecting Rod Bolt Guide Set
	J 5590 Pinion Bearing Race Installer - Rear
	J 5825-A Crankshaft Gear Remover

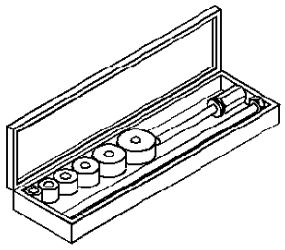
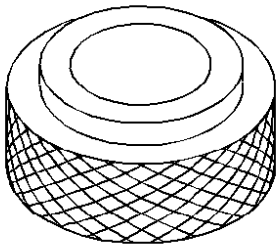
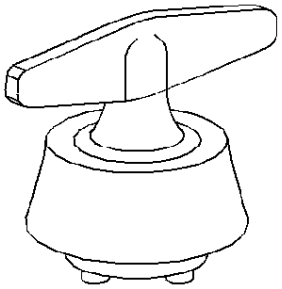
	
	J 5830-02 Valve Guide Reamer Set
	J 5892-D Valve Spring Compressor
	J 7872 Magnetic Base Dial Indicator

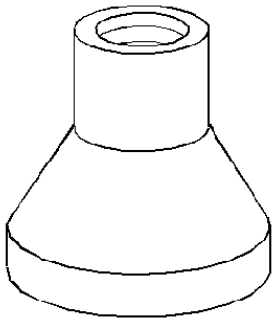
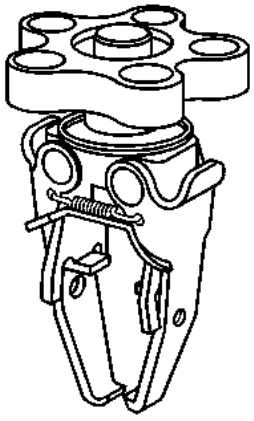
	
	J 8001 Dial Indicator Set
	J 8037 Ring Compressor
	J 8062 Valve Spring Compressor

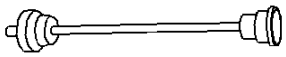
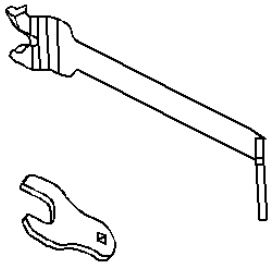
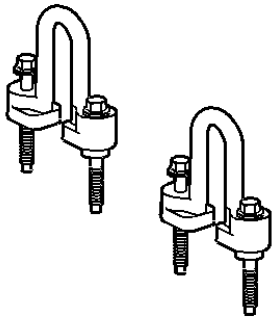
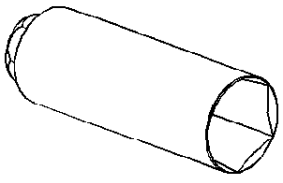
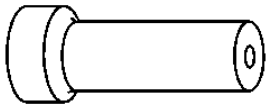
	J 8087 Cylinder Bore Gage
	J 8089 Carbon Removing Brush
	J 8092 Universal Driver Handle

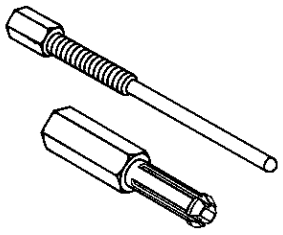
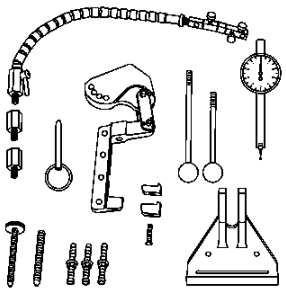
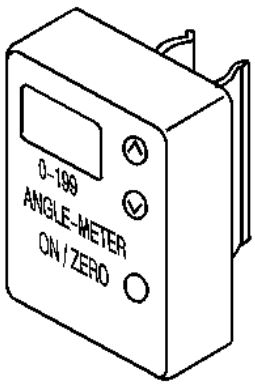
	J 9666 Valve Spring Tester
	J 21882 Oil Suction Pipe Installer
	J 22794 Spark Plug Port Adapter
	J 23523-F Balancer Remover and Installer
	J 24086-C Piston Pin Remover/Installer

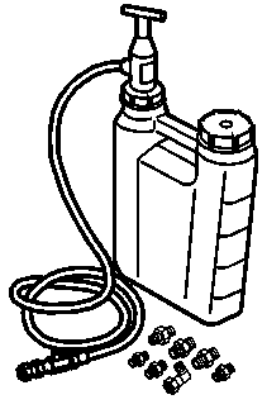
	
	J 24270 Cylinder Bore Ridge Reamer
	J 26941 Bushing/Bearing Remover
	J 28428-E High Intensity Black Light

	J 33049 Camshaft Bearing Service Kit
	J 35468 Cover Aligner/Seal Installer
	J 35621-B Rear Main Seal Installer
	J 35667-A Cylinder Head Leakdown Tester

	
	J 36996 Balance Shaft Installer
	J 38606 Valve Spring Compressor

	J 38834 Balance Shaft Service Kit
	J 41240 Fan Clutch Remover and Installer
	J 41427 Engine Lift Bracket
	J 41712 Oil Pressure Switch Socket
	J 42073 Valve Stem Seal Installer

	J 43276 Clutch Pilot Bearing Remover
	J 43690 Rod Bearing Clearance Checking Tool
	J 45059 Angle Meter
	J 45299

	Engine Preluber