2009 ENGINE

Engine Mechanical - 3.9L - G6

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
A/C Compressor Bracket Bolt	50 N.m	37 lb ft
Camshaft Position Actuator Assembly Bolt	16 N.m	12 lb ft
Camshaft Position Actuator Magnet Bolt	10 N.m	89 lb in
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Camshaft Thrust Plate Screw	10 N.m	89 lb in
Clutch Pressure Plate Bolt	25 N.m	18 lb ft
Connecting Rod Bearing Cap Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	110 degrees	
Coolant Crossover Pipe Bolt	50 N.m	37 lb ft
Coolant Drain Plug	19 N.m	14 lb ft
Coolant Temperature Sensor	20 N.m	15 lb ft
Coolant Vent Pipe Bolt	10 N.m	89 lb in
Crankshaft Balancer Bolt		
• Installation Pass Using the Old Bolt to Ensure the Balancer is Completely Installed	125 N.m	92 lb ft
• First Pass - Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	125 N.m	92 lb ft
• Final Pass	130 degrees	
Crankshaft Main Bearing Cap Bolt/Stud		
• First Pass	50 N.m	37 lb ft
• Final Pass	77 degrees	
Crankshaft Oil Deflector Nut	25 N.m	18 lb ft
Crankshaft Position Sensor Stud	10 N.m	89 lb in
Cylinder Head Bolt		
• First Pass	60 N.m	44 lb ft
• Final Pass	140 degrees	
Drive Belt Idler Pulley Bolt - 13 mm	30 N.m	22 lb ft
Drive Belt Idler Pulley Bolt - 15 mm	50 N.m	37 lb ft

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Drive Belt Idler Pulley Bolt		
• Upper Right and Lower Left	50 N.m	37 lb ft
• Center Right	30 N.m	22 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Heater/Plug	60 N.m	44 lb ft
Engine Front Cover Bolt	25 N.m	18 lb ft
Engine Lift Bracket Bolt	70 N.m	52 lb ft
Engine Mount Bolts	50 N.m	37 lb ft
Engine Mount Bracket Bolts		
• Convertible	50 N.m	37 lb ft
• Except Convertible		
• Bracket to Engine Block	90 N.m	66 lb ft
• Bracket to Oil Pan	50 N.m	37 lb ft
Engine Oil Pressure Indicator Switch	16 N.m	12 lb ft
Engine Wiring Harness Bracket Bolt	13 N.m	115 lb in
EVAP Purge Valve Bolt	12 N.m	106 lb in
Exhaust Manifold Bolt	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolt	10 N.m	89 lb in
Exhaust Manifold Lower Heat Shield Bolt	10 N.m	89 lb in
Flywheel Bolt	70 N.m	52 lb ft
Front Oil Gallery Plug	33 N.m	24 lb ft
Fuel Injector Rail Bolt	10 N.m	89 lb in
Heated Oxygen Sensor	42 N.m	31 lb ft
Heater Inlet and Outlet Pipe Bolt - 10 mm	10 N.m	89 lb in
Heater Inlet and Outlet Pipe Bolt/Nut - 13 mm	25 N.m	18 lb ft
Ignition Coil Bracket Bolt/Nut/Stud	25 N.m	18 lb ft
Knock Sensor	25 N.m	18 lb ft
Lower Intake Manifold Bolt - Center		
• First Pass	13 N.m	10 lb ft
• Final Pass	20 N.m	15 lb ft
Lower Intake Manifold Bolt - Corner		
• First Pass	13 N.m	10 lb ft
• Final Pass	25 N.m	18 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Adapter Bolt	25 N.m	18 lb ft
Oil Filter Fitting	39 N.m	29 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Pan Bolt	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft

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Oil Pan Side Bolt		
• First Pass	50 N.m	37 lb ft
• Final Pass	50 degrees	
Oil Pan Support Bracket Bolt	50 N.m	37 lb ft
Oil Pump Cover Bolt	10 N.m	89 lb in
Oil Pump Drive Bolt	36 N.m	27 lb ft
Oil Pump Mounting Bolt	41 N.m	30 lb ft
Piston Oil Nozzle Bolt	10 N.m	89 lb in
Rear Oil Gallery Plug - 3/8 inch	33 N.m	24 lb ft
Spark Plug	15 N.m	11 lb ft
Starter Motor to Engine Block Bolts	40 N.m	30 lb ft
Throttle Body Bolt/Nut	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
Timing Chain Tensioner Bolt	21 N.m	15 lb ft
Transmission to Engine Bolts	75 N.m	55 lb ft
Transmission to Engine Brace Bolts	50 N.m	30 lb ft
Transmission Torque Converter Cover Bolts	7.5 N.m	66 lb in
Transmission Torque Converter to Flex Plate Bolts	62 N.m	46 lb ft
Upper Intake Manifold Bolt/Stud	25 N.m	18 lb ft
Valve Lifter Guide Bolt	10 N.m	89 lb in
Valve Lifter Oil Manifold Cover Plate Bolt	25 N.m	18 lb ft
Valve Rocker Arm Bolt	34 N.m	25 lb ft
Valve Rocker Arm Cover Bolt	10 N.m	89 lb in
Water Outlet Bolt/Stud	25 N.m	18 lb ft
Water Pump Bolt	10 N.m	89 lb in
Water Pump Pulley Bolt	25 N.m	18 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• Engine Type	60 degree V-6	
• Displacement	3.9L (E85)	238 cu in
• RPO	LZ9, LGD	
• VIN	1 (LZ9) W (LGD)	
• Bore	99 mm	3.90 in
• Stroke	84 mm	3.31 in
• Compression Ratio	9.8:1	

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• Firing Order	123456	
• Spark Plug Gap	1.00 mm	0.040 in
Block		
• Camshaft Bearing Bore Diameter - Front and Rear	55.26-55.31 mm	2.175-2.177 in
• Camshaft Bearing Bore Diameter - Middle #2, #3	54.75-54.80 mm	2.155-2.157 in
• Crankshaft Main Bearing Bore Diameter	72.1535-72.0695 mm	2.840-2.841 in
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.00031 in
• Cylinder Bore Diameter	99.000-99.018 mm	3.897-3.898 in
• Cylinder Bore Out-of-Round - Diameter - Production	0.026 mm	0.0010 in
• Cylinder Bore Out-of-Round - Diameter - Service	0.030 mm	0.0011 in
• Cylinder Bore Taper - Production	0.026 mm	0.0010 in
• Cylinder Bore Taper - Service	0.030 mm	0.0011 in
• Cylinder Head Deck Height	224 mm	8.818 in
• Cylinder Head Deck Surface Flatness	0.05 mm per 150 mm	0.0019 in per 5.905 in
• Valve Lifter Bore Diameter	21.417-21.455 mm	0.843-0.844 in
Camshaft		
• Camshaft Bearing Inside Diameter	51.500-51.525 mm	2.028-2.029 in
• Camshaft Journal Diameter	51.415-51.440 mm	2.024-2.025 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Exhaust	6.9263 mm	0.2727 in
• Camshaft Lobe Lift - Intake	6.9263 mm	0.2727 in
Cooling System		
• Thermostat Full Open Temperature	195 degrees	
Connecting Rod		
• Connecting Rod Bearing Clearance	0.018-0.062 mm	0.0007-0.0024 in
• Connecting Rod Bore Diameter	60.322-60.338 mm	2.375-2.376 in
• Connecting Rod Bore Out-of-Round	0.006 mm	0.00023 in
• Connecting Rod Length - Center to Center	150 mm	5.9 in
• Connecting Rod Side Clearance	0.200-0.241 mm	0.008-0.009 in
Crankshaft		
• Connecting Rod Journal Diameter	57.122-57.138 mm	2.248-2.249 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
	21.92-22.08 mm	0.863-0.869 in

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• Connecting Rod Journal Width		
• Crankshaft End Play	0.060-0.210 mm	0.0024-0.0083 in
• Crankshaft Main Bearing Clearance - Except #3	0.019-0.064 mm	0.0008-0.0025 in
• Crankshaft Main Bearing Clearance - #3 Thrust Bearing	0.032-0.077 mm	0.0012-0.0030 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Rear Flange Runout	0.04 mm	0.0016 in
Cylinder Head		
• Combustion Chamber Depth - at Measurement Point	2.2 mm	0.087 in
• Surface Finish - Maximum	2.8 RA	
• Surface Flatness - Block Deck	0.08 mm per 152 mm	0.003 in per 6 in
• Surface Flatness - Exhaust Manifold Deck	0.1 mm	0.004 in
• Surface Flatness - Intake Manifold Deck	0.1 mm	0.004 in
• Valve Guide Bore - Exhaust	8.01 mm	0.315 in
• Valve Guide Bore - Intake	8.01 mm	0.315 in
• Valve Guide Installed Height	16.6 mm	0.654 in
Lubrication System		
• Oil Capacity - with Filter	3.8 liter	4.0 quarts
• Oil Pressure - @ 1850 RPM	207-310 kPa	30-45 PSI
Oil Pump		
• Gear Diameter	50.749-50.800 mm	1.997-1.999 in
• Gear Pocket - Depth	26.274-26.332 mm	1.034-1.036 in
• Gear Pocket - Diameter	50.902-50.952 mm	2.004-2.005 in
• Gears Lash	0.094-0.195 mm	0.0037-0.0077 in
• Relief Valve-to-Bore Clearance	0.038-0.089 mm	0.0015-0.0035 in
Pin		
• Piston Pin Clearance to Connecting Rod Bore - Press Fit	-0.004 to -0.021 mm	-0.0001 to -0.0008 in
• Piston Pin Clearance to Piston Pin Bore	0.002-0.010 mm	0.00008-0.0004 in
• Piston Pin Diameter	23.952-23.955 mm	0.942-0.943 in
• Piston Pin Length	64.21-64.44 mm	2.57-2.53 in
Piston		
• Piston Diameter - Production	98.970-99.008 mm	3.896-3.897 in
• Piston Diameter - Service Limit	98.950 mm	3.895 in

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• Piston Pin Bore Diameter	23.957-23.962 mm	0.943 in
• Piston Ring Groove Width	1.22-1.24 mm	0.048-0.049 in
• Piston to Bore Clearance - Production	-0.008 to +0.048 mm	-0.0003 to +0.0018 in
• Piston to Bore Clearance - Service Limit - Maximum	0.080 mm	0.003 in
Piston Ring End Gap		
• First Compression Ring	0.15-0.30 mm	0.006-0.011 in
• Second Compression Ring	0.25-0.45 mm	0.009-0.017 in
• Oil Control Ring	0.15-0.65 mm	0.06-0.025 in
Piston Ring to Groove Clearance		
• First Compression Ring	0.03-0.065 mm	0.001-0.002 in
• Second Compression Ring	0.02-0.055 mm	0.0007-0.002 in
• Oil Control Ring	0.01 mm	0.004 in
Piston Ring Thickness		
• First Compression Ring	1.175-1.190 mm	0.046-0.047 in
• Second Compression Ring	1.475-1.490 mm	0.058 in
• Oil Control Ring - Maximum	2.50 mm	0.098 in
Valves		
• Valve Face Angle	45 degrees	
• Valve Seat Angle	46 degrees	
• Valve Seat Depth - Exhaust - From Deck Face	8.9-9.1 mm	0.350-0.358 in
• Valve Seat Depth - Intake - From Deck Face	7.9-8.1 mm	0.311-0.318 in
• Valve Seat Width - Exhaust	1.70-2.0 mm	0.067-0.079 in
• Valve Seat Width - Intake	1.55-1.80 mm	0.061-0.071 in
• Valve Stem-to-Guide Clearance	0.024-0.064 mm	0.0009-0.0025 in
Valve Lifters/Push Rods		
• Push Rod Length - Intake	147.51 mm	5.81 in
• Push Rod Length - Exhaust	154.87 mm	6.10 in
Valve Springs		
• Valve Spring Free Length	52.88 mm	2.08 in
• Valve Spring Assembly Installed Height	46.75 mm	1.84 in
• Valve Spring Load Check Height	45.75 mm	1.801 in
• Valve Spring Load - Closed - Without Damper	340±19 N 43.2 mm	76.4 lb 1.701 in
• Valve Spring Load - Open - Without Damper	1,023±44 N 32 mm	230 lb 1.260 in
• Valve Spring Total Number of Coils	8.01	

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ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Rear Bearing Hole Plug	Sealant	12377901	10953504
Coolant Drain Plug	Sealant	12346004	10953480
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Crankshaft Balancer Keyway	Sealant	12378521	88901148
Crankshaft Position Sensor Bolt/Stud Threads	Threadlock	12345382	10953489
Engine Block Coolant Drain Plug Threads	Sealant	12346004	10953480
Engine Block Oil Gallery Plug Threads	Sealant	12346004	10953480
Engine Front Cover Bolt Threads	Sealant	12346004	10953480
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Cooler Fitting Threads	Sealant	12346004	10953480
Engine Oil Supplement	Lubricant	1052367	992869
Intake Manifold Bolt Threads - Upper and Lower	Threadlock	12345382	10953489
Intake Manifold Coolant Pipe	Sealant	12345493	10953488
Intake Manifold to Engine Block Mating Surface	Sealant	12378521	88901148
Intake Manifold Tuning Valve	Lubricant	1051344	993037
Oil Filter Bypass Hole Plug Threads	Sealant	12346004	10953480
Oil Pan Surface at Front Cover - Block Mating Area	Sealant	12378521	88901148
Oil Pan Surface at Rear Crankshaft Main Bearing Cap	Sealant	12378521	88901148
Oil Pressure Switch Threads	Sealant	12346004	10953480
Oil Pan Side Bolts	Sealant	12346004	10953480
Oil Pump Suction Pipe	Sealant	12346004	10953480
Piston and Piston Pin	5W-30 Oil	12345610	993193
Rear Crankshaft Main Bearing Cap	Sealant	1052942	10953466
Throttle Body Stud and Bolts	Threadlock	12345382	10953489
Valve Lifter and Camshaft Prelube	Lubricant	12345501	992704
Valve Lifter Guide Bolt Threads	Threadlock	12345382	10953489
Valve Rocker Arm Cover Notch at Cylinder Head and Lower Intake Manifold	Sealant	12378521	88901148

COMPONENT LOCATOR

DISASSEMBLED VIEWS

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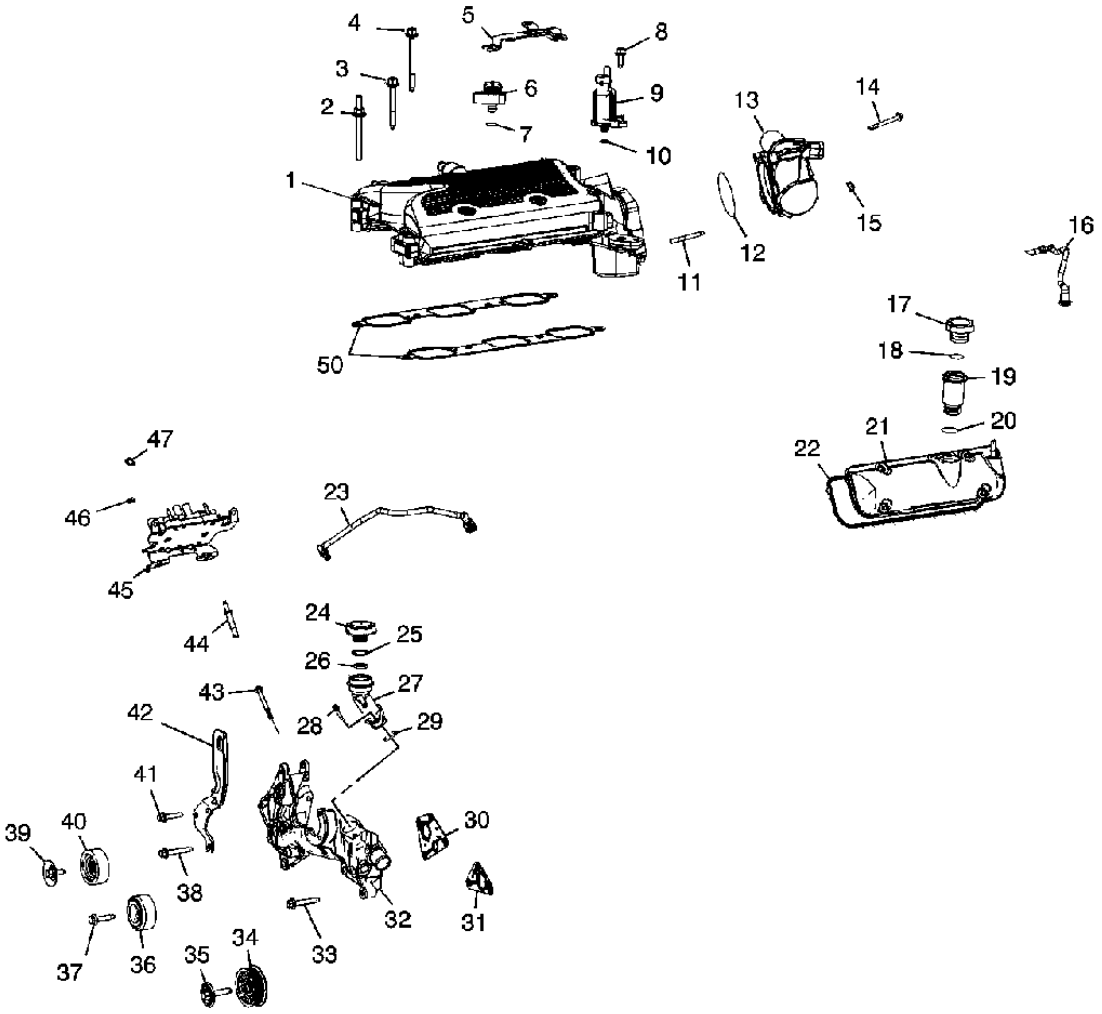

Fig. 1: Exploded View Of Upper Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Upper Intake Manifold
2	Upper Intake Manifold Stud
3	Upper Intake Manifold Bolt
4	Upper Intake Manifold Bolt
5	Manifold Absolute Pressure Sensor Bracket
6	Manifold Absolute Pressure Sensor
7	Manifold Absolute Pressure Sensor Seal
8	Evaporative Emission Canister Purge Solenoid Valve Bolt
9	Evaporative Emission Canister Purge Solenoid Valve
10	Evaporative Emission Canister Purge Solenoid Valve Seal
11	Throttle Body Stud

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12	Throttle Body Seal
13	Throttle Body
14	Throttle Body Bolt
15	Throttle Body Nut
16	Positive Crankcase Ventilation Tube
17	Oil Filler Cap
18	Oil Filler Cap Seal
19	Oil Filler Tube
20	Oil Filler Tube Seal
21	Valve Rocker Arm Cover
22	Valve Rocker Arm Cover Gasket
23	Positive Crankcase Ventilation Tube
24	Engine Coolant Filler Cap
25	Engine Coolant Filler Tube Adapter Seal
26	Engine Coolant Filler Tube Adapter Seal
27	Engine Coolant Filler Tube Adapter
28	Engine Coolant Filler Tube Adapter Bolt
29	Engine Coolant Filler Tube Adapter Seal
30	Engine Coolant Crossover Pipe Gasket
31	Engine Coolant Crossover Pipe Gasket
32	Engine Coolant Crossover Pipe
33	Engine Coolant Crossover Pipe Bolt
34	Belt Idler Pulley
35	Belt Idler Pulley Bolt
36	Belt Idler Pulley
37	Belt Idler Pulley Bolt
38	Engine Lift Front Bracket Bolt
39	Belt Idler Pulley Bolt
40	Belt Idler Pulley
41	Engine Lift Front Bracket Bolt
42	Engine Lift Front Bracket
43	Water Outlet Bolt
44	Ignition Coil Stud
45	Ignition Coil
46	Ignition Coil Nut
47	Ignition Coil Bolt
50	Upper Intake Manifold Gasket

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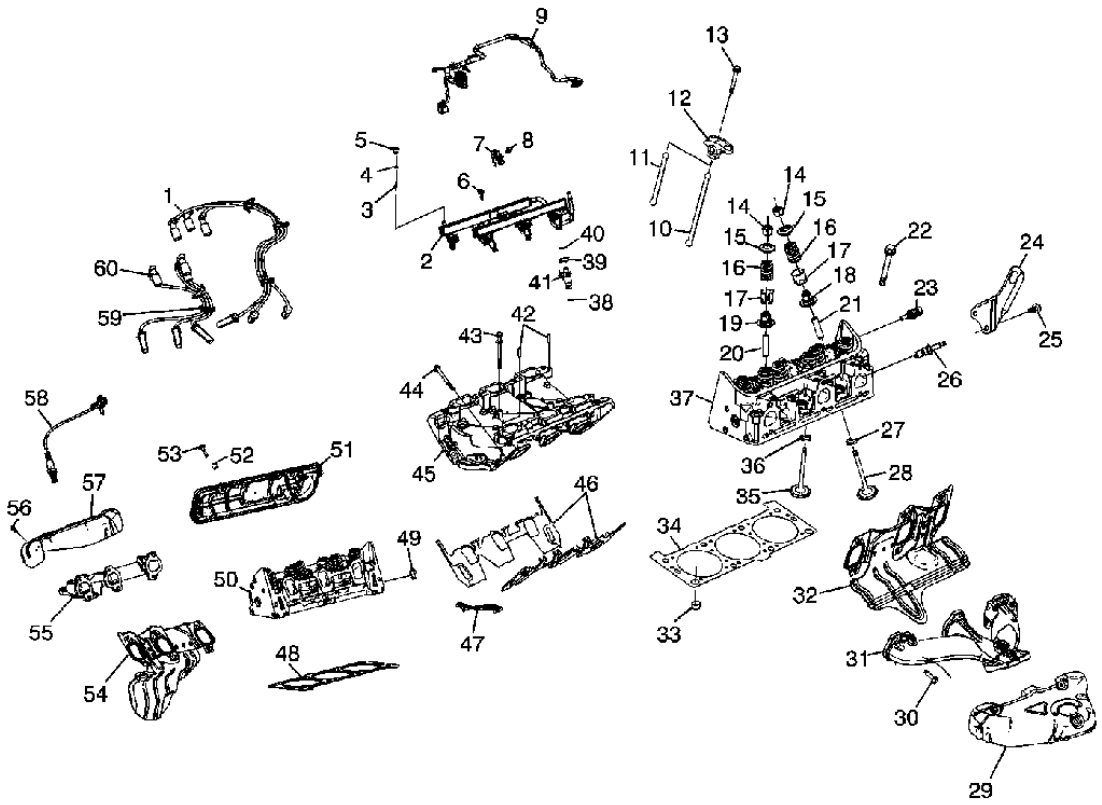

Fig. 2: Lower Intake Manifold, Cylinder Head, and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Spark Plug Wire Harness
2	Sequential Multiport Fuel Injection Fuel Rail
3	Fuel Schrader Valve
4	Fuel Pressure Service Valve Cap Seal
5	Fuel Pressure Service Valve Cap
6	Fuel Injection Fuel Rail Bolt
7	Fuel Injector Wiring Harness Connector Bracket
8	Fuel Injector Wiring Harness Connector Bracket Bolt
9	Fuel Injector Wiring Harness
10	Valve Push Rod
11	Valve Push Rod
12	Valve Rocker Arm
13	Valve Rocker Arm Bolt
14	Valve Stem Key
14	Valve Stem Key
15	Valve Spring Cap

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15	Valve Spring Cap
16	Valve Spring
16	Valve Spring
17	Valve Spring Damper
17	Valve Spring Damper
18	Valve Stem Oil Seal
19	Valve Stem Oil Seal
20	Valve Guide
21	Valve Guide
22	Cylinder Head Bolt
23	Engine Coolant Temperature Sensor
24	Engine Lift Bracket - Rear
25	Engine Lift Bracket Bolt - Rear
26	Spark Plug
27	Exhaust Valve Seat
28	Exhaust Valve
29	Exhaust Manifold Heat Shield
30	Exhaust Manifold Bolt
31	Exhaust Manifold
32	Exhaust Manifold Gasket
33	Cylinder Head Location Pin
34	Cylinder Head Gasket
35	Intake Valve
36	Intake Valve Seat
37	Cylinder Head
38	Fuel Injector Seal
39	Fuel Injector Retainer
40	Fuel Injector Seal
41	Sequential Multiport Fuel Injector
42	Lower Intake Manifold Location Pin
43	Lower Intake Manifold Bolt
44	Lower Intake Manifold Bolt
45	Lower Intake Manifold
46	Lower Intake Manifold Gasket
47	Lower Intake Manifold Seal
48	Cylinder Head Gasket
49	Cylinder Head Core Hole Plug
50	Cylinder Head
51	Valve Rocker Arm Cover
52	Valve Rocker Arm Cover Bolt Grommet
53	Valve Rocker Arm Cover Bolt
54	

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	Exhaust Manifold Gasket
55	Exhaust Manifold
56	Exhaust Manifold Heat Shield Bolt
57	Exhaust Manifold Heat Shield
58	Oxygen Sensor
59	Spark Plug Wire Support
60	Spark Plug Wire Harness

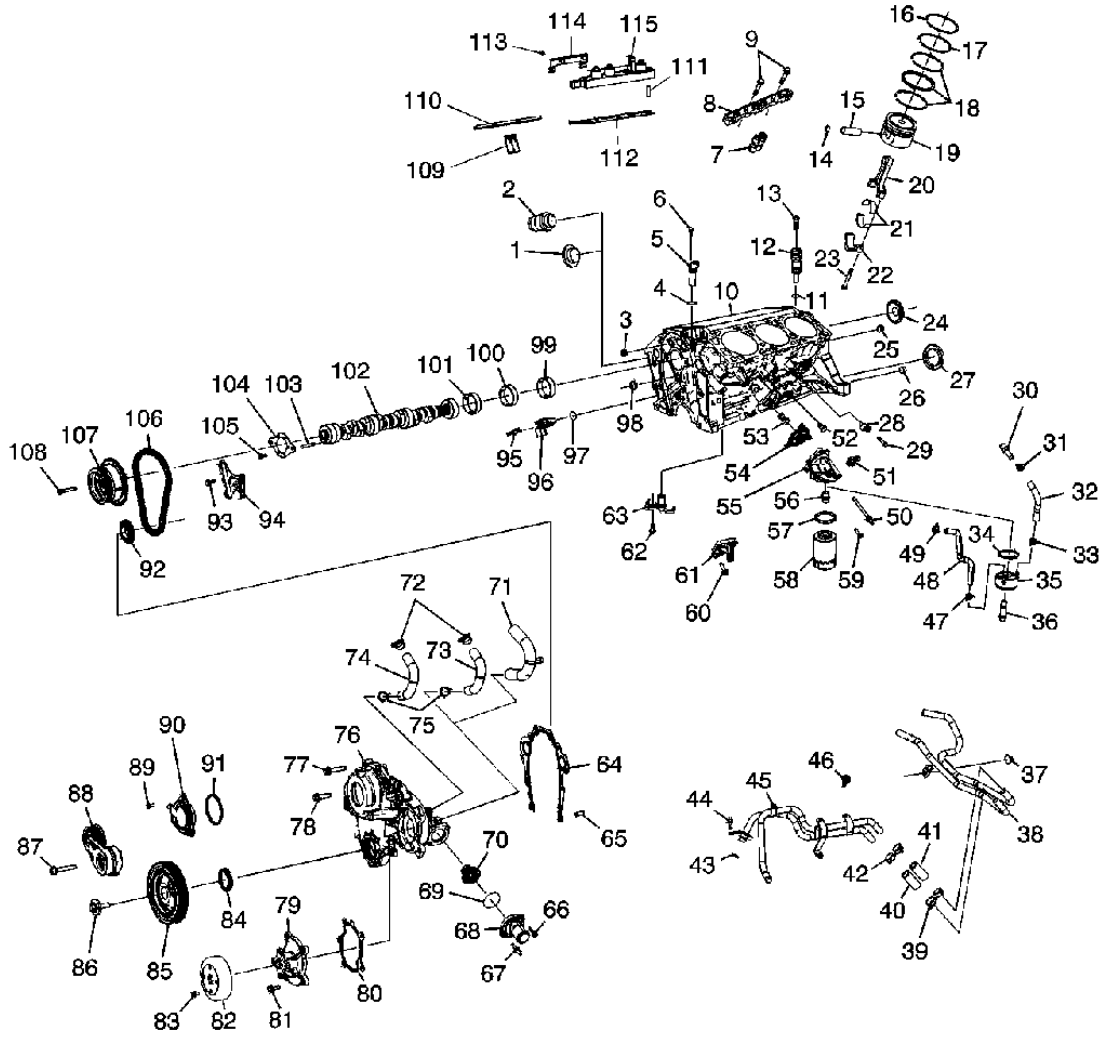

Fig. 3: Identifying Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Engine Block Coolant Hole Plug
2	Engine Block Heater
3	Engine Block Oil Gallery Plug

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4	Camshaft Sensor Seal
5	Crankshaft Position Sensor
6	Crankshaft Position Sensor Bolt
7	Valve Lifter
8	Valve Lifter Guide
9	Valve Lifter Guide Bolt
10	Engine Block
11	Oil Pump Drive Seal
12	Oil Pump Drive
13	Oil Pump Drive Clamp Bolt
14	Piston Pin Retainer
15	Piston Pin
16	Piston Compression Upper Ring
17	Piston Compression Lower Ring
18	Piston Oil Ring Rail
19	Piston
20	Connecting Rod
21	Connecting Rod Bearing
22	Connecting Rod Bearing Cap
23	Connecting Rod Bolt
24	Camshaft Rear Bearing Hole Plug
25	Engine Block Oil Gallery Plug
26	Crankshaft Rear Oil Seal
27	Transmission Locating Pin
28	Knock Sensor
29	Knock Sensor Bolt
30	Engine Oil Cooler Fitting
31	Engine Oil Cooler Hose Clamp
32	Engine Oil Cooler Inlet Hose
33	Engine Oil Cooler Hose Clamp
34	Engine Oil Cooler Gasket
35	Engine Oil Cooler
36	Engine Oil Cooler Connector
37	Heater Inlet and Outlet Pipe Nut
38	Heater Inlet and Outlet Pipe
39	Heater Outlet Hose Clamp
40	Heater Outlet Front Hose
41	Heater Outlet Front Hose
42	Heater Outlet Hose Clamp
43	Heater Inlet Pipe Adapter Seal
44	Heater Inlet Pipe Bolt

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	Heater Inlet and Outlet Pipe
46	Heater Inlet Pipe Bolt
47	Engine Oil Cooler Hose Clamp
48	Engine Oil Cooler Outlet Hose
49	Engine Oil Cooler Hose Clamp
50	Oil Filter Adapter Stud
51	Engine Oil Pressure Indicator Switch
52	Engine Block Coolant Hole Plug
53	Oil Filter Bypass Valve
54	Oil Filter Adapter Gasket
55	Oil Filter Adapter
56	Oil Filter Fitting
57	Oil Filter Gasket
58	Oil Filter
59	Oil Filter Adapter Bolt
60	Air Conditioning Compressor Bracket Bolt
61	Air Conditioning Compressor Bracket
62	Piston Oil Nozzle Bolt
63	Piston Oil Nozzle
64	Engine Front Cover Gasket
65	Engine Front Cover Location Pin
66	Water Outlet Bolt
67	Water Outlet Stud
68	Water Outlet
69	Engine Coolant Thermostat Seal
70	Engine Coolant Thermostat
71	Thermostat Bypass Hose
72	Thermostat Bypass Pipe Clamp
73	Thermostat Bypass Hose
74	Thermostat Bypass Hose
75	Thermostat Bypass Pipe Clamp
76	Engine Front Cover
77	Engine Front Cover Bolt
78	Engine Front Cover Bolt
79	Water Pump
80	Water Pump Gasket
81	Water Pump Bolt
82	Water Pump Pulley
83	Water Pump Pulley Bolt
84	Crankshaft Front Oil Seal
85	Crankshaft Balancer
86	

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	Crankshaft Balancer Bolt
87	Drive Belt Tensioner Bolt
88	Drive Belt Tensioner
89	Camshaft Position Actuator Magnet Bolt
90	Camshaft Position Actuator Magnet
91	Camshaft Position Actuator Magnet Gasket
92	Crankshaft Sprocket
93	Timing Chain Tensioner Bolt
94	Timing Chain Tensioner
95	Crankshaft Position Sensor Stud
96	Crankshaft Position Sensor
97	Crankshaft Position Sensor Seal
98	Engine Block Oil Gallery Plug
99	Camshaft Bearing
100	Camshaft Bearing
101	Camshaft Bearing
102	Camshaft
103	Camshaft Position Actuator Solenoid Valve Filter
104	Camshaft Thrust Plate
105	Camshaft Thrust Plate Bolt
106	Timing Chain
107	Camshaft Position Actuator
108	Camshaft Position Actuator Bolt
109	Valve Lifter - For Right Bank on AFM™ Applications
110	Valve Lifter Guide - For Right Bank on AFM™ Applications
111	Valve Lifter Oil Filter
112	Valve Lifter Lower Oil Manifold Gasket
113	Valve Lifter Oil Manifold Retainer Bolt
114	Valve Lifter Oil Manifold Retainer
115	Valve Lifter Oil Manifold

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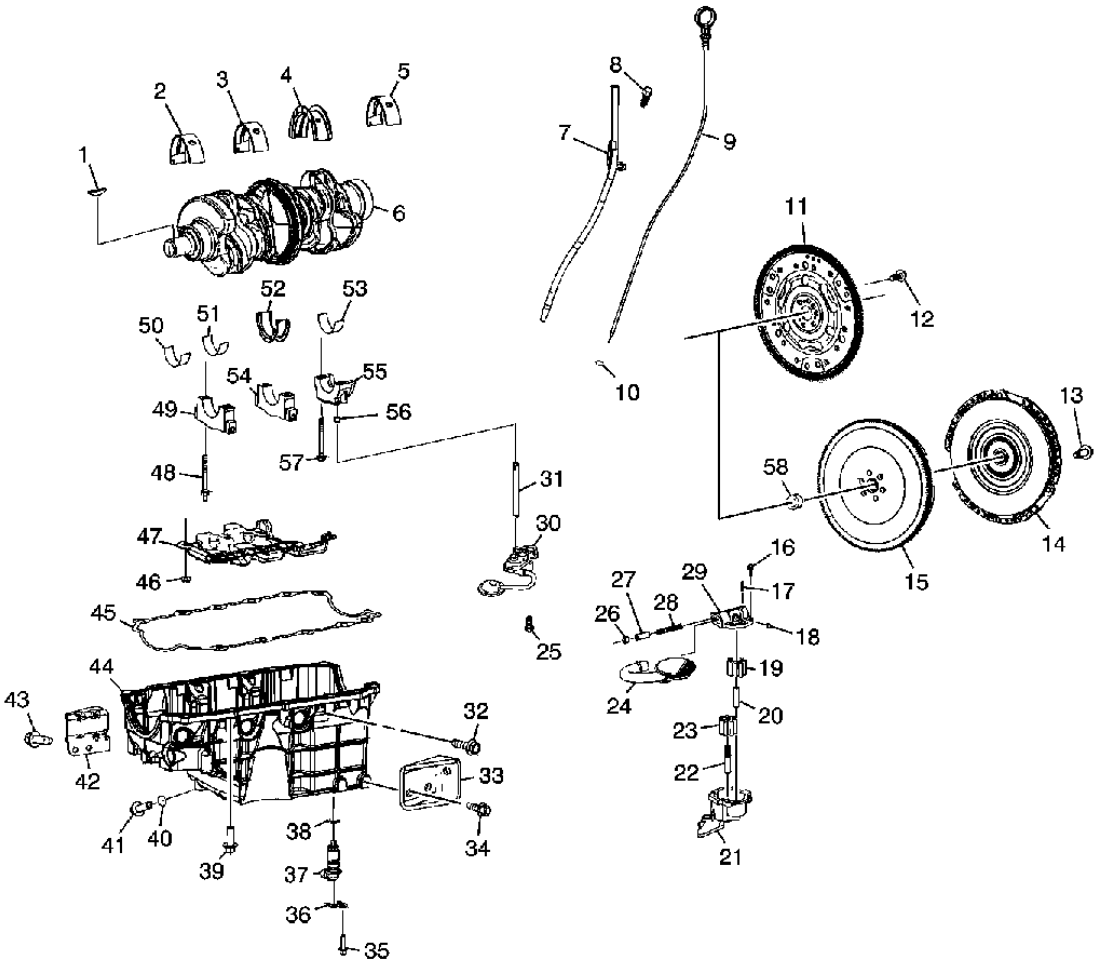

Fig. 4: Crankshaft and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Crankshaft Balancer Key
2	Crankshaft Upper No. 1 Bearing
3	Crankshaft Upper No. 2 Bearing
4	Crankshaft Upper No. 3 Bearing
5	Crankshaft Upper No. 4 Bearing
6	Crankshaft
7	Oil Level Indicator Tube
8	Oil Level Indicator Tube Bolt
9	Oil Level Indicator
10	Oil Level Indicator Seal
11	Flywheel
12	Flywheel Bolt

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13	Clutch Pressure Plate Bolt
14	Clutch Pressure Plate
15	Flywheel
16	Oil Pump Cover Bolt
17	Oil Pressure Relief Valve Spring Seat Pin
18	Oil Pressure Relief Valve Bore Plug
19	Oil Pump Driven Gear
20	Oil Pump Driven Gear Shaft
21	Oil Pump Housing
22	Oil Pump Drive Shaft
23	Oil Pump Drive Gear
24	Oil Pump Screen
25	Oil Pump Bolt
26	Oil Pressure Relief Valve Bore Plug
27	Oil Pressure Relief Valve
28	Oil Pressure Relief Valve Spring
29	Oil Pump Cover
30	Oil Pump
31	Oil Pump Drive Shaft
32	Oil Pan Bolt
33	Oil Pan Support Bracket
34	Oil Pan Support Bracket Bolt
35	Engine Oil Level Indicator Switch Bolt
36	Engine Oil Level Indicator Switch Clip
37	Engine Oil Level Indicator Switch
38	Engine Oil Level Indicator Switch Seal
39	Oil Pan Bolt
40	Oil Pan Drain Plug Seal
41	Oil Pan Drain Plug
42	Oil Pan Support Bracket
43	Oil Pan Support Bracket Bolt
44	Oil Pan
45	Oil Pan Gasket
46	Crankshaft Oil Deflector Nut
47	Crankshaft Oil Deflector
48	Crankshaft Bearing Cap Stud
49	Crankshaft No. 1 Bearing Cap
50	Crankshaft Lower No. 1 Bearing
51	Crankshaft Lower No. 2 Bearing
52	Crankshaft Lower No. 3 Bearing
53	Crankshaft Lower No. 4 Bearing
54	

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	Crankshaft Bearing Cap
55	Crankshaft No. 4 Bearing Cap
56	Oil Pump Location Pin
57	Crankshaft Bearing Cap Bolt
58	Clutch Pilot Bearing

ENGINE IDENTIFICATION

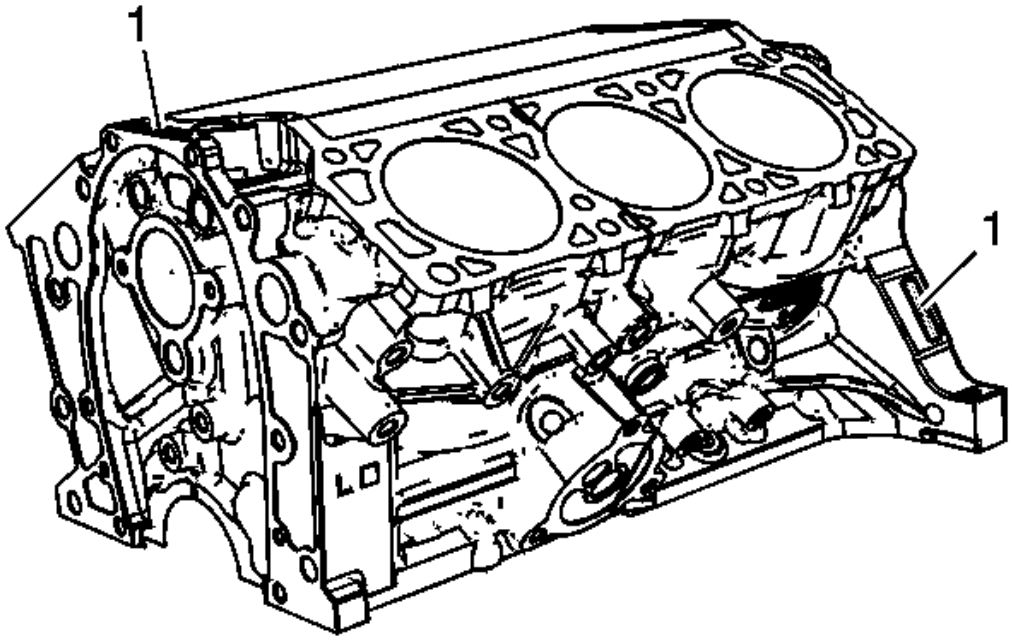

Fig. 5: Locating Engine Identification Tags
Courtesy of GENERAL MOTORS CORP.

The Vehicle Identification Number - VIN derivative (1) for 3900 LZ9 is stamped or laser etched on the front and left side of the engine block. The Vehicle Identification Number - VIN derivative is nine digits long and can be used to determine if a vehicle contains the original engine.

- 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 Vehicle Identification Number - VIN.

DIAGNOSTIC INFORMATION AND PROCEDURES

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DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform A **Diagnostic Starting Point - Engine Controls** before using the symptom tables - if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, **Engine Component Description** , **Drive Belt System Description** and **Lubrication Description** .

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system 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**

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- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **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**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **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**
- **Valve Rocker Arm Cover Replacement - Left Side**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Engine oil level overfull, causing aeration	Drain excess oil and adjust oil level to proper specification.
Abnormalities - severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Tensioner Replacement**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC-A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer-A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
Restricted exhaust system-A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.

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Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Worn or loose rocker arms-The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Worn or bent pushrods	Replace the pushrods.
Stuck valves-Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or out of time timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure-A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . 2. Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages-Refer to **Diagnostic Starting Point - Engine Cooling** . Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Inspect the cylinder heads, engine block, and/or head gaskets. 3. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to identify the cause. 4. Repair or replace as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities-severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Tensioner Replacement**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout-A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer-A misfire code may be present	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement**

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without an actual misfire condition.	or **Crankshaft Balancer Replacement**.
Worn piston rings-Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace as required.
Worn crankshaft thrust bearings- Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Engine oil level overfull, causing aeration	Drain excess oil and adjust oil level to proper specification.
Worn or loose rocker arms-The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Worn or bent pushrods	Replace the pushrods.
Stuck valves-Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.
Malfunctioning camshaft position actuator-Improper viscosity oil, contaminated oil, or a plugged or missing camshaft position actuator filter can cause the camshaft position actuator locking pin to malfunction.	• Verify correct oil viscosity by changing the engine oil and oil filter and re-evaluating the concern. • Inspect for a missing or plugged camshaft position actuator filter. • If filter is missing, replace the filter, replace the camshaft position actuator, and change the engine oil and oil filter. • If filter is plugged, replace the filter, and change the engine oil and oil filter. • If no problem is found with the camshaft position actuator filter, replace the camshaft position actuator and change the engine oil and oil filter.

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BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages-Refer to **Diagnostic Starting Point - Engine Cooling** . Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Perform a cylinder leak down test. 3. Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. 4. Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace as required.
Worn piston rings-Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace as required.

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

Cause	Correction
IMPORTANT: **The camshaft position actuator may make a slight tapping noise upon cold startup. This is due to the viscosity of the oil that has not yet warmed to proper operating temperatures, and should be considered normal for the first 3.5 minutes of cold engine operation.**	
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
Worn crankshaft thrust bearing	1. Inspect the thrust bearing and crankshaft. 2. Repair or replace as required.
High valve lifter leak down rate	Replace the lifters as required.
Excessive crank/rod bearing clearances	1. Inspect the crankshaft and rod bearings. 2. Repair or replace as required.

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UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
IMPORTANT: **The camshaft position actuator may make a slight tapping noise upon cold startup. This is due to the viscosity of the oil that has not yet warmed to proper operating temperatures, and should be considered normal for the first 3.5 minutes of cold engine operation.**	
Engine oil level overfull, causing aeration	Drain excess oil and adjust oil level to proper specification.
Low oil pressure	1. Perform an oil pressure test. Refer **Oil Pressure Diagnosis and Testing** . 2. Repair or replace as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm stud, nut, or bolt. 2. Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Bent or damaged push rod	Inspect the following components, and replace as required: • The valve rocker arm • The valve push rod • The valve lifter
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn timing chain tensioner, if applicable	Replace the timing chain tensioners as required.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft and valve lifters as required.
Damaged, broken, or dirty, balance shaft sprocket teeth, if applicable	Inspect the following components, and repair as required: • The balance shaft gear

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	• The camshaft gear • The balance shaft rear bushing
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck Valves-Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components, and repair as required: • The valves • The valve guides
Malfunctioning camshaft position actuator-Improper viscosity oil, contaminated oil, or a plugged or missing camshaft position actuator filter can cause the camshaft position actuator locking pin to malfunction.	1. Verify correct oil viscosity by changing the engine oil and oil filter and re-evaluating the concern. 2. Inspect for a missing or plugged camshaft position actuator filter. 3. If filter is missing, replace the filter, replace the camshaft position actuator, and change the engine oil and oil filter. 4. If filter is plugged, replace the filter, and change the engine oil and oil filter. 5. If no problem is found with the camshaft position actuator filter, replace the camshaft position actuator and change the engine oil and oil filter.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** . 2. Repair or replace damaged components as required.
Worn accessory drive components-Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to **Electronic Ignition System Diagnosis** .

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Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen-An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation-Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
IMPORTANT: **The camshaft position actuator may make a slight tapping noise upon cold startup. This is due to the viscosity of the oil that has not yet warmed to proper operating temperatures, and should be considered normal for the first 3.5 minutes of cold engine operation.**	
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing** .

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	2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to **Electronic Ignition System Diagnosis** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair as required.
Cracked flywheel - automatic transmission	1. Inspect the flywheel bolts and flywheel. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore
Malfunctioning camshaft position actuator-Improper viscosity oil, contaminated oil, or a plugged or missing camshaft position actuator filter can cause the camshaft position actuator locking pin to malfunction.	1. Verify correct oil viscosity by changing the engine oil and oil filter and reevaluating the concern. 2. Inspect for a missing or plugged camshaft position actuator filter. 3. If filter is missing, replace the filter, replace the camshaft position actuator, and change the engine oil and oil filter. 4. If filter is plugged, replace the filter, and change the engine oil and oil filter. 5. If no problem is found with the camshaft position actuator filter, replace the camshaft position actuator and change the engine oil and oil filter.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belt or belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.

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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 or gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector and/or leaking fuel regulator.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or timing chain gears	1. Inspect timing chain and gears. 2. Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect crankshaft. 2. 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 Leakage 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.

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Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
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 Leakage 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.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, or block, porosity	Replace the components as required.

ENGINE COMPRESSION TEST

Tools Required

J 38722 Compression Tester

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

Test

IMPORTANT: Remove the powertrain control module (PCM) and the ignition fuses from

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the instrument panel (I/P) fuse block. Refer to Electrical Center Identification Views .

1. Disable the ignition.
2. Disable the fuel systems.
3. Remove the spark plugs from all the cylinders.
4. Remove the air duct from the throttle body.
5. Block the throttle plate in the open position.
6. Measure the engine compression, using the following procedure:
    1. Firmly install the compression gage to the spark plug hole.
    2. Have an assistant crank the engine through at least 4 compression strokes in the testing cylinder.
    3. Record the readings on the gage at each stroke.
    4. Disconnect the gage.
    5. Repeat the compression test for each cylinder.
7. Using the **J 38722** record the compression readings from all of the cylinders.
    - The lowest reading should not be less than 70 percent of the highest reading.
    - No cylinder reading should be less than 689 kPa (100 psi).
8. The following list contains examples of the possible measurements:
    - When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    - When the compression is low on the first stroke and tends to build up on the following strokes, but does not reach the normal compression, the piston rings may be the cause.
    - If the compression improves considerably with the addition of 3 squirts of oil, the piston rings may be the cause.
    - When the compression is low on the first stroke and does not build up in the following strokes, the valves may be the cause.
    - The addition of oil does not affect the compression, the valves may be the cause.
    - When the compression is low on 2 adjacent cylinders, or coolant is present in the crankcase, the head gasket may be the cause.
9. Remove the block from the throttle plate.
10. Install the air duct to the throttle body.
11. Install the spark plugs.
12. Install the powertrain control module (PCM) fuse.
13. Install the ignition fuse to the I/P fuse block.

CYLINDER LEAKAGE TEST

Special Tools

J-35667-A: Cylinder Head Leakdown Tester

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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.

Test

WARNING: Refer to Battery Disconnect Warning .

1. Disconnect the negative battery cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .
3. Install the **J-35667-A:** Cylinder Head Leakdown Tester.
4. Measure each cylinder on the compression stroke, with both valves closed.

NOTE: Hold the crankshaft balancer bolt in order to prevent piston movement.

5. Apply air pressure, using the **J-35667-A:** Tester. Refer to the manufacturer's instructions.
6. Record the cylinder leakage readings for each cylinder.

NOTE:
- **Normal cylinder leakage is from 12-18 percent.**
- **Make a note of any cylinder with more leakage than the other cylinders.**
- **Any cylinder with 30 percent leakage or more requires service.**

7. Inspect the 4 primary areas in order to properly diagnose a leaking cylinder.
8. If air is heard from the intake or exhaust system, perform the following procedure:
   - Remove the valve rocker arm cover of the suspect cylinder head.
     - Ensure that both valves are closed.
     - Inspect the cylinder head for a broken valve spring.
   - Remove and inspect the suspect cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .
9. If air is heard from the crankcase system at the crankcase - oil filler tube, perform the following procedure:
   1. Remove the piston from the suspect cylinder.
   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** .
10. If bubbles are found in the radiator, perform the following procedure:
    - Remove and inspect both cylinder heads. Refer to **Cylinder Head Cleaning and Inspection** .
    - Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .
11. Remove the **J-35667-A:** Tester.
12. Install the spark plugs. Refer to **Spark Plug Replacement** .

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13. Connect the negative battery cable.

OIL CONSUMPTION DIAGNOSIS

An engine that has excessive oil consumption uses 0.9 L (1 qt) of oil, or more, within 3 200 km (2,000 mi). The following list indicates the conditions and corrections of excessive oil consumption:

- An improperly read oil level indicator dipstick
  - Inspect the oil level while the vehicle is parked on a level surface.
  - Allow adequate drain-down time.
- Improper oil viscosity

  Use the recommended SAE viscosity for prevailing temperatures.

- Continuous high-speed driving
- Severe hauling, such as a trailer. This causes decreased oil mileage.
- A malfunctioning crankcase ventilation system
- External oil leaks
  - Tighten the bolts, as needed.
  - Replace the gaskets and seals, as needed.
- Worn or omitted valve guides and/or valve stem seals
  - Ream the guides.
  - Install oversized service valves and/or new valve stem seals.
- Broken or worn piston rings
- Improperly installed or unseated piston rings
- Improperly installed or improperly fitted piston
- Plugged cylinder head gasket oil drain holes
- Damaged intake gaskets

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **J-21867-6** Oil Pressure Adapter Fitting
- **J 25087-C** Oil Pressure Tester and Pump Primer

If the vehicle has low oil pressure complete the following steps:

1. Inspect the oil level.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the oil filter.
4. Assemble the plunger valve in the large hole of the **J 25087-C** base. Insert the hose in the small hole of

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the **J 25087-C** base. Connect the gage to the end of the hose.

5. Insert the flat side of the rubber plug in the bypass valve without depressing the bypass valve.
6. Install the **J 25087-C** and **J-21867-6** on the filter mounting pad.
7. Start the engine.
8. Inspect the overall oil pressure, the oil pressure switch, and for noisy lifters. Ensure that the engine is at operating temperature before inspecting the oil pressure. Refer to **Engine Mechanical Specifications** for proper oil pressure specifications.
9. If adequate oil pressure is indicated, test the oil pressure switch.
10. If a low reading is indicated, press the valve on the tester base in order to isolate the oil pump and/or its components from the lubricating system. An adequate reading at this time indicates a good pump and the previous low pressure was due to worn bearings, etc. A low reading while pressing the valve indicates a faulty pump.

Low or No Oil Pressure

The following conditions may cause low or no oil pressure:

- Low oil level-Fill to the full mark on the oil level indicator.
- Incorrect or malfunctioning oil pressure switch-Replace the oil pressure switch.
- Incorrect or malfunctioning oil pressure gage-Replace the oil pressure gage.
- Improper oil viscosity or diluted oil
  - Install oil of proper viscosity for expected temperature.
  - Install new oil if the oil is diluted.
- A worn or dirty oil pump-Clean or replace the oil pump.
- A plugged oil filter-Replace the oil filter.
- A loose or plugged oil pickup screen-Replace the oil pickup screen.
- A hole in the oil pickup tube-Replace the oil pickup tube.
- Excessive rod, main, or cam bearing clearance-Replace the bearings.
- Cracked, porous, or plugged oil gallery-Repair or replace the engine block.
- Missing or improperly installed gallery plugs-Install or repair the plugs as needed.
- A stuck pressure regulator valve
  - Inspect the pressure regulator valve for sticking in the bore.
  - Inspect the bore for scoring and burrs.
- A worn or poorly machined camshaft-Replace the camshaft.
- Worn valve guides-Repair the valve guides as needed.

Oil Pressure Testing

OIL LEAK DIAGNOSIS

Tools Required

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J 28428-E High Intensity Black Light Kit

You may 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 leak and the cause of leak.

Locating and Identifying the Leak

Use the visual inspection method in order to determine if the leaking fluid is one of the following items:

- Engine oil
- Transmission fluid
- Power steering fluid
- Brake fluid
- Some other fluid

Visual Inspection Method

Complete the following steps in order to perform the visual inspection method:

1. Bring the vehicle to normal operating temperature.
2. Park the vehicle over a large sheet of paper, or other clean surface.
3. Wait several minutes, then inspect for dripping fluids.
4. Identify the type of fluid, and the approximate location of the leak.
5. Visually inspect the suspected area. Use a small mirror if necessary.
6. Inspect for leaks at sealing surfaces, fittings, or from cracked or damaged components.
7. If you cannot locate the leak, perform the following steps:
    1. Completely clean the entire engine and surrounding components.
    2. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
    3. Park the vehicle over a large sheet of paper, or other clean surface.
    4. Wait several minutes, then inspect for dripping fluids.
    5. Identify the type of fluid, and the approximate location of the leak.
    6. Visually inspect the suspected area. Use a small mirror if necessary.
8. If you still cannot locate the leak, use the powder method or the black light and dye method.

Powder Method

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 miles at normal operation 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.

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

   Refer to "**Possible Causes for Leaks**" if necessary.

Black Light and Dye Method

A dye and light kit is available for finding leaks.

1. Use the **J 28428-E** or the equivalent. Refer to the manufacturer's instructions when using the tool.
2. Visually inspect the suspected area. Use a small mirror if necessary

   Refer to **Possible Causes for Leaks** if necessary.

Possible Causes for Leaks

Inspect the vehicle for the following conditions:

- 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

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process, instead of venting them into the atmosphere. Fresh filtered air from the intake duct is supplied to the crankcase, mixed with blow-by gasses, and the passed through a calibrated orifice into the intake manifold.

Step	Action	Yes	No
	DEFINITION: The following items are the result of incorrect operation: A plugged or restricted ventilation system may cause the following conditions: • Oil consumption • Rough idle • Stalling or slow idle speed		

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- Oil leaks
- Oil accumulation in the air intake duct
- Sludge in the engine

A leaking crankcase ventilation system may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

1	Does the vehicle exhibit any of the following conditions? • Oil consumption • Rough idle • Stalling or slow idle speed • Oil leaks • Oil accumulation in the air intake duct • Sludge in the engine • High idle speed	Go to **Step 2**	System OK
2	Inspect the crankcase ventilation system hoses for kinks and broken or disconnected fittings. Did you find any kinked or damaged hoses?	Go to **Step 3**	Go to **Step 4**
3	1. Relieve any kinks by rerouting the hoses. 2. Replace the hoses, if necessary. Did you correct the condition?	System OK	Go to **Step 4**
4	Check the metering orifice for blockage. Is the orifice blocked?	Go to **Step 5**	Go to **Step 6**
5	Repair the blockage of the metering orifice. Did you correct the condition?	System OK	Go to **Step 6**
6	Inspect the valve cover seals and oil pan gasket for leaks. Did you find any leaks?	Go to **Step 7**	Go to **Step 8**
7	Repair the gasket and seal leaks as needed. Did you correct the condition?	System OK	Go to **Step 8**
8	Inspect for blocked passages in the throttle body connections. Did you find any blocked passages?	Go to **Step 9**	Go to **Diagnostic Starting Point - Engine Mechanical**
9	Clean blocked throttle body passages. Did you correct the condition?	System OK	Go to **Diagnostic Starting Point - Engine Mechanical**

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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

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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
CAUTION: **Refer to Belt Dressing Caution .** 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		

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	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	**CAUTION:** **Refer to Fastener Caution .** 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 19**
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
	Replace the bent pulley.		

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18	Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**. 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 A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

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

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

Test Description

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

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

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

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

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

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

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

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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
CAUTION: **Refer to Belt Dressing Caution .** 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: o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove o The separation of the drive belt o 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	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 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**

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6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**. 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	**CAUTION:** **Refer to Fastener Caution .** 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 (LZ4/LZ9)** or **Water Pump Replacement (LE5)** . 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

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

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

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

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

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

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

Test Description

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

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

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

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

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

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

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

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

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

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

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

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17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
1	Remove the drive belt. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

INTAKE MANIFOLD COVER REPLACEMENT

Removal Procedure

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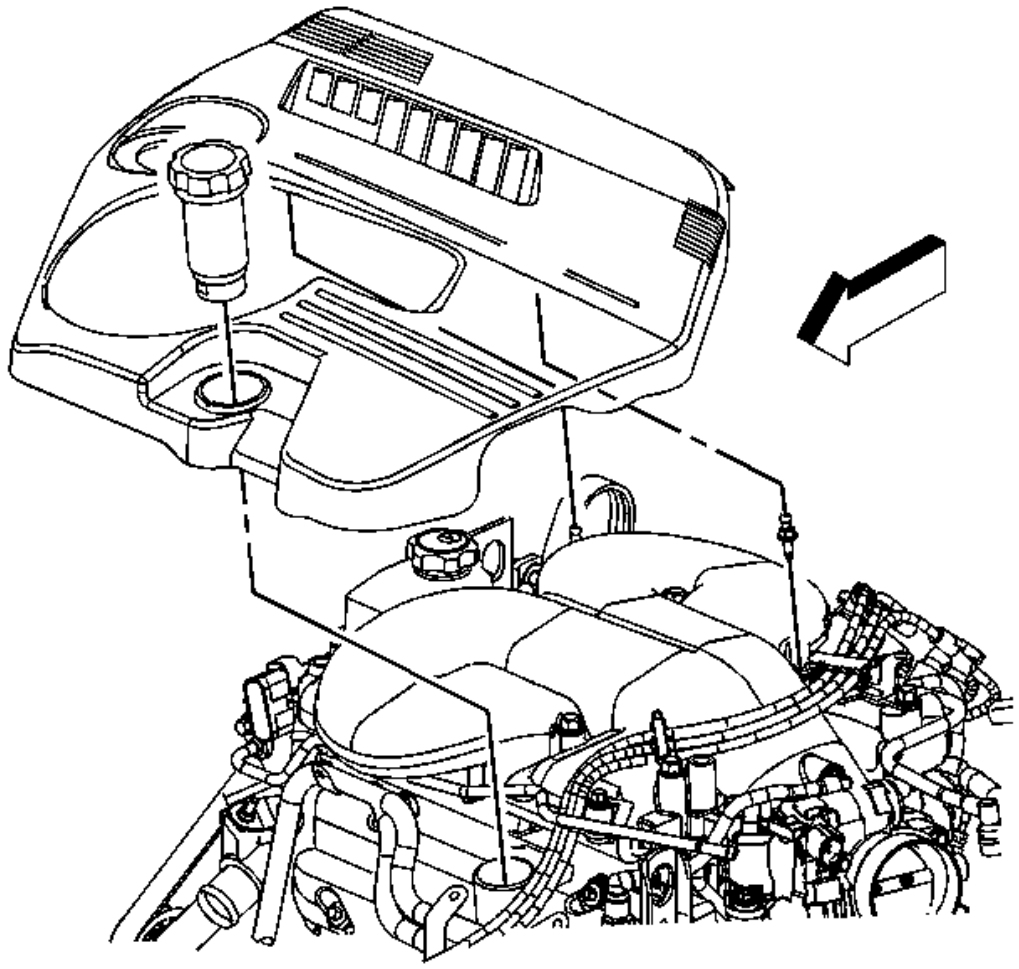

Fig. 6: Identifying Intake Manifold Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine oil fill cap and tube.
2. Grasp the cover by the sides and pull up, disengaging the cover grommets from the ball studs.

Installation Procedure

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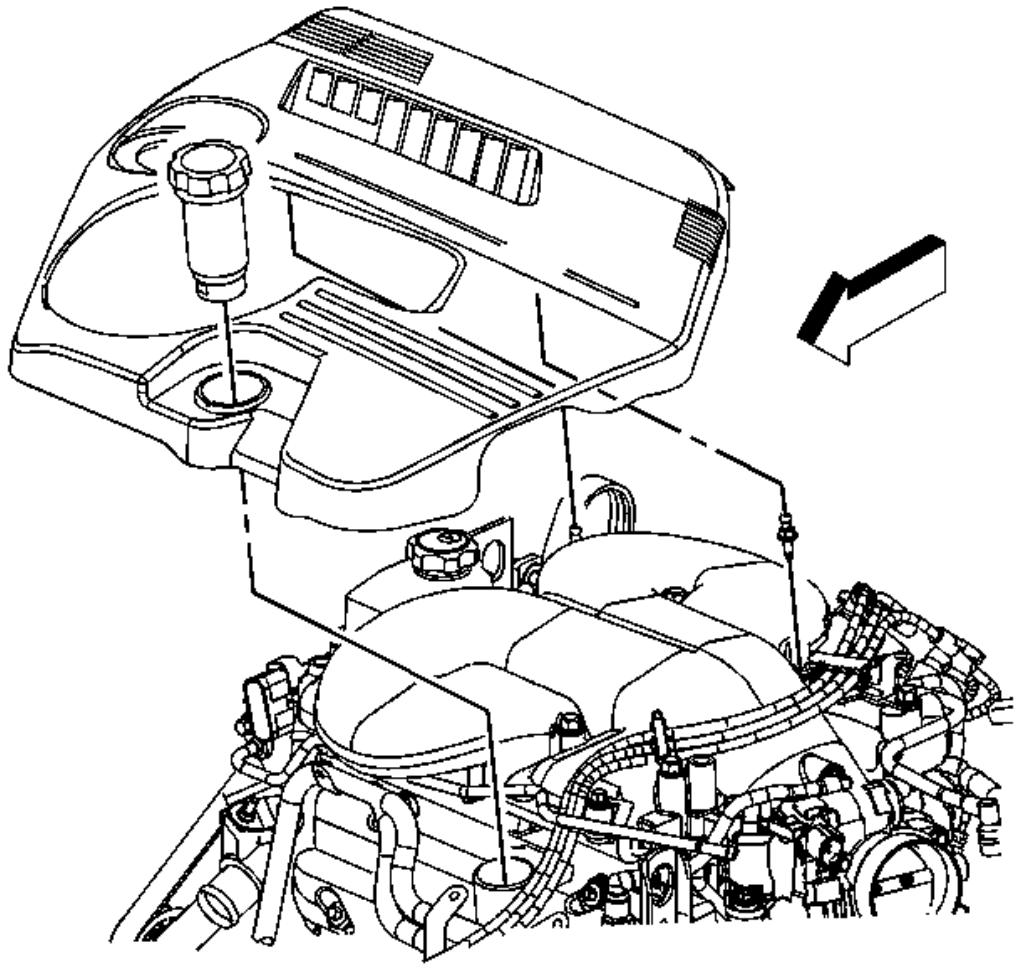

Fig. 7: Identifying Intake Manifold Cover
Courtesy of GENERAL MOTORS CORP.

1. Place the cover over the ball studs, aligning the cover with the power steering reservoir cap and the oil fill tube opening.
2. Push down on the cover above the studs in order to engage to cover grommets to the studs.
3. Install the engine oil fill cap and tube.

DRIVE BELT REPLACEMENT (COUPE)

Removal Procedure

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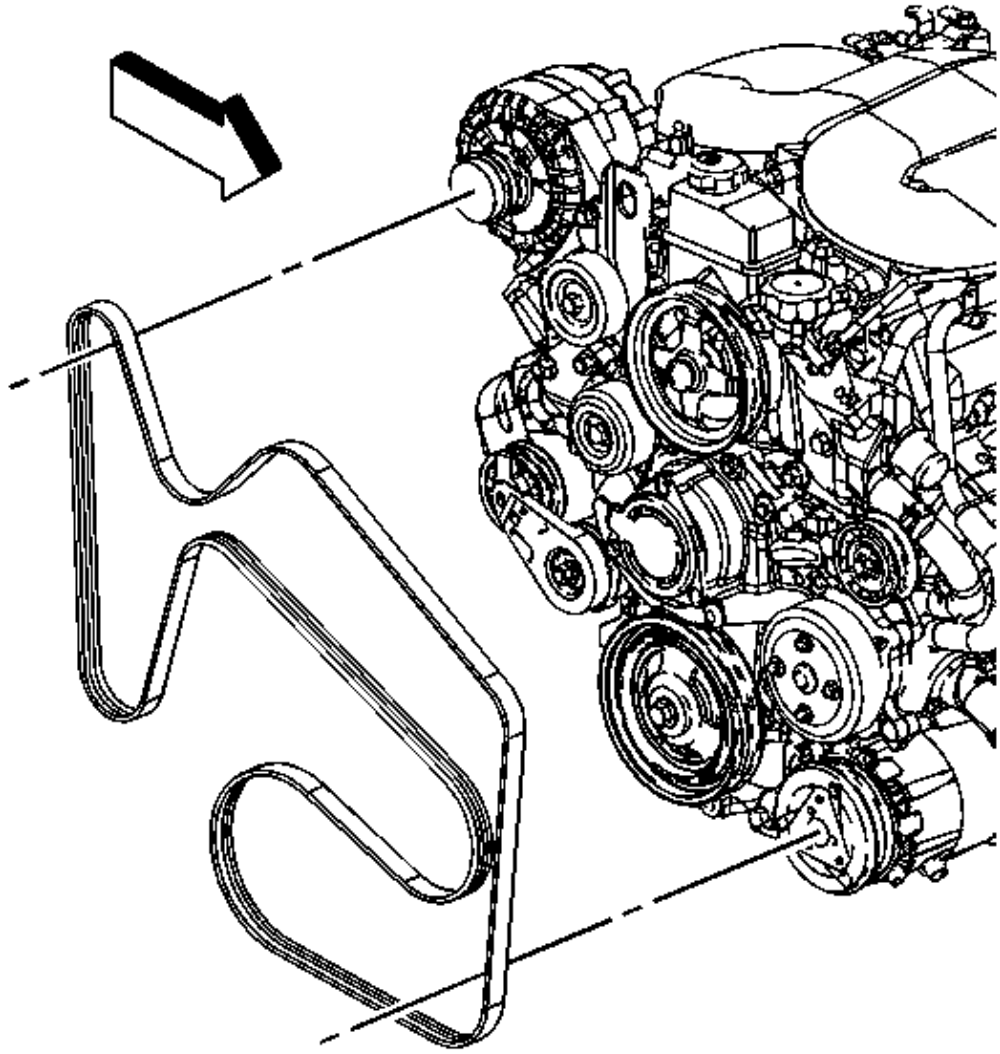

Fig. 8: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner. Refer to **Air Cleaner Assembly Replacement** .
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
3. Remove the engine mount snubber. Refer to **Engine Mount Snubber Bracket Replacement**.
4. Rotate the drive belt tensioner counterclockwise in order to release the tensioner spring tension.
5. Remove the drive belt.

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Installation Procedure

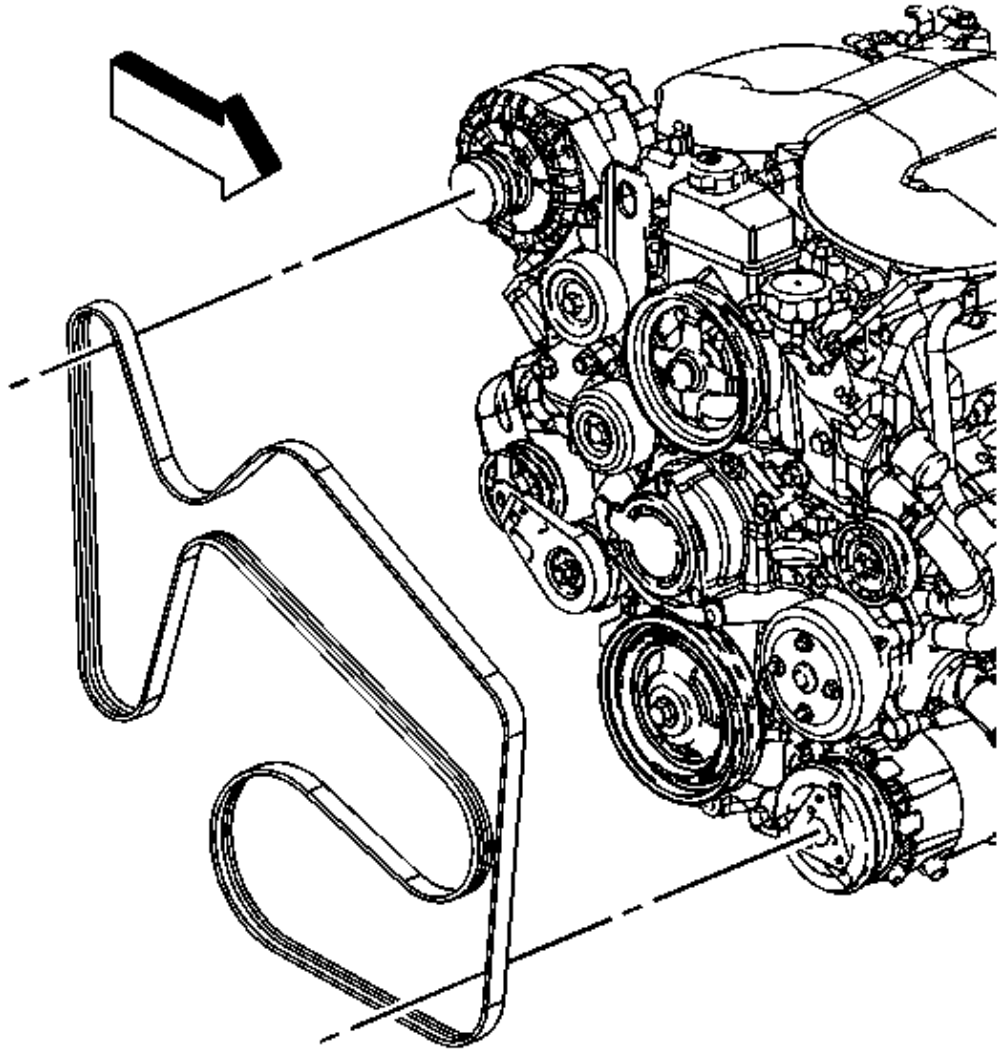

Fig. 9: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Rotate the drive belt tensioner counterclockwise in order to release the tensioner spring tension.
2. Install the drive belt.
3. Install the engine mount snubber. Refer to **Engine Mount Snubber Bracket Replacement**.
4. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

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5. Install the air cleaner. Refer to **Air Cleaner Assembly Replacement** .

DRIVE BELT REPLACEMENT (CONVERTIBLE)

Removal Procedure

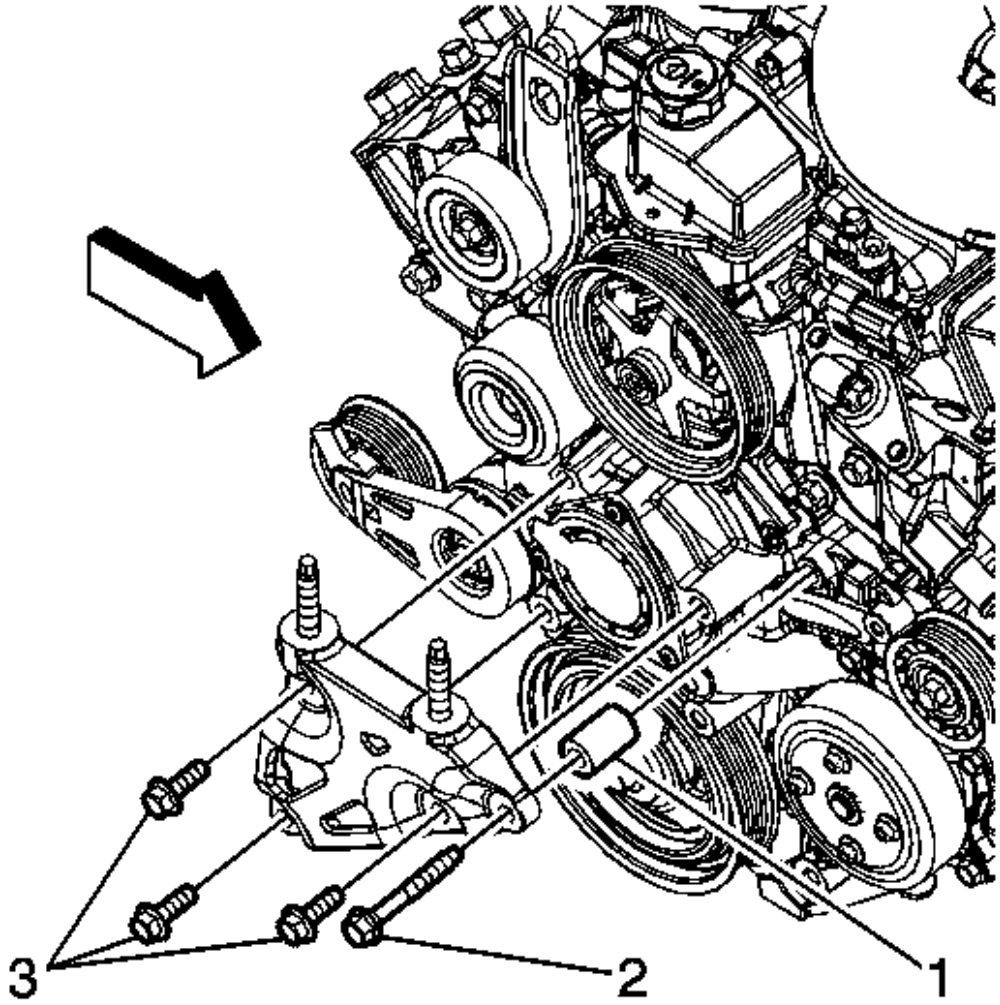

Fig. 10: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

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3. Remove the engine mount bracket bolt (2).
4. Remove the engine mount bracket spacer (1).

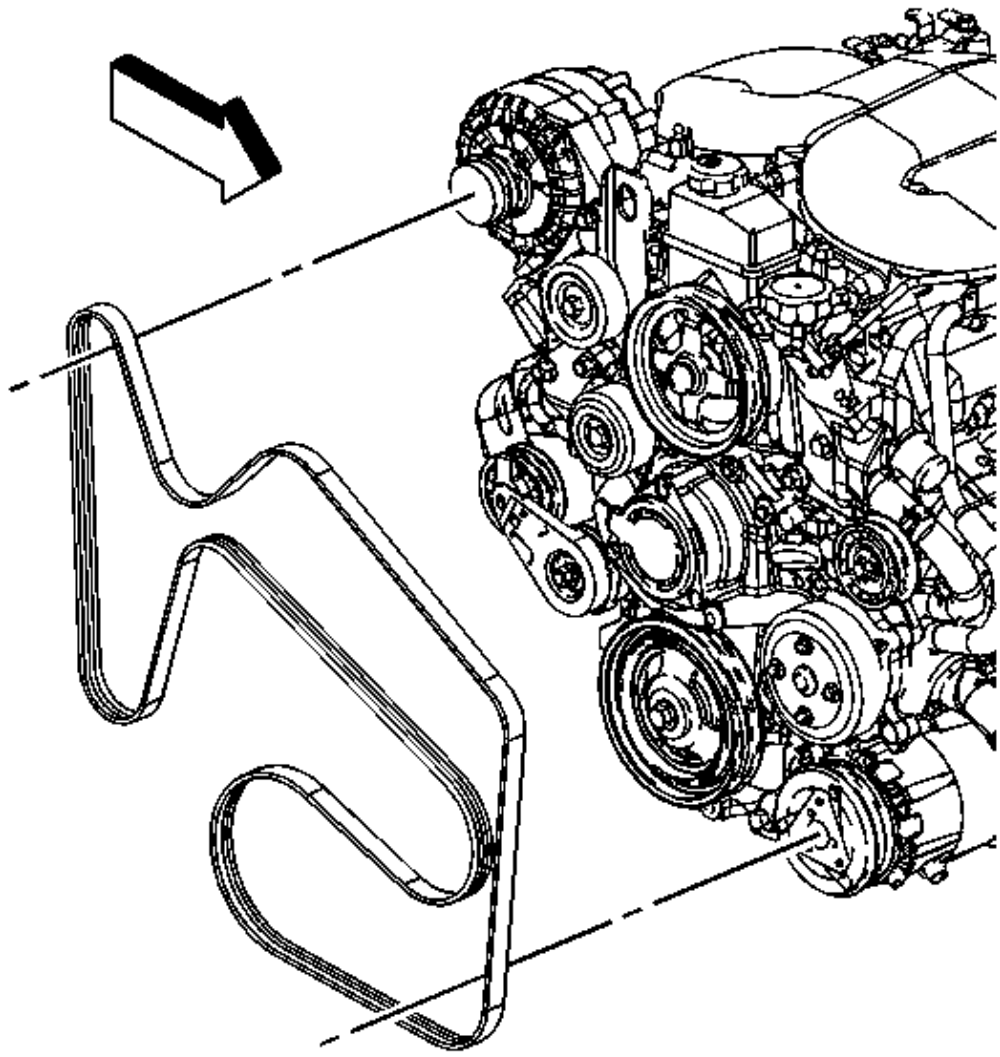

Fig. 11: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

5. Rotate the drive belt tensioner counterclockwise in order to release the tensioner spring tension.
6. Remove the drive belt.

Installation Procedure

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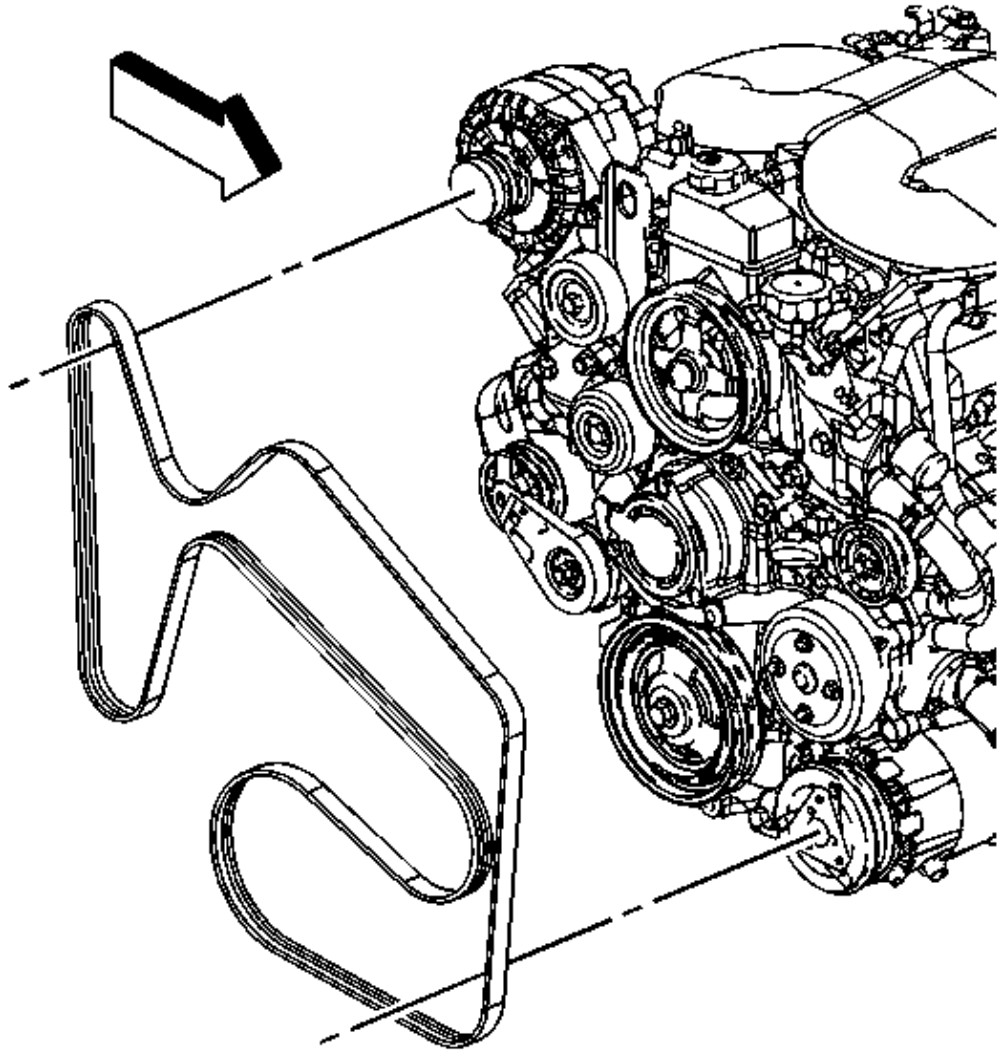

Fig. 12: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Rotate the drive belt tensioner counterclockwise in order to release the tensioner spring tension.
2. Install the drive belt.

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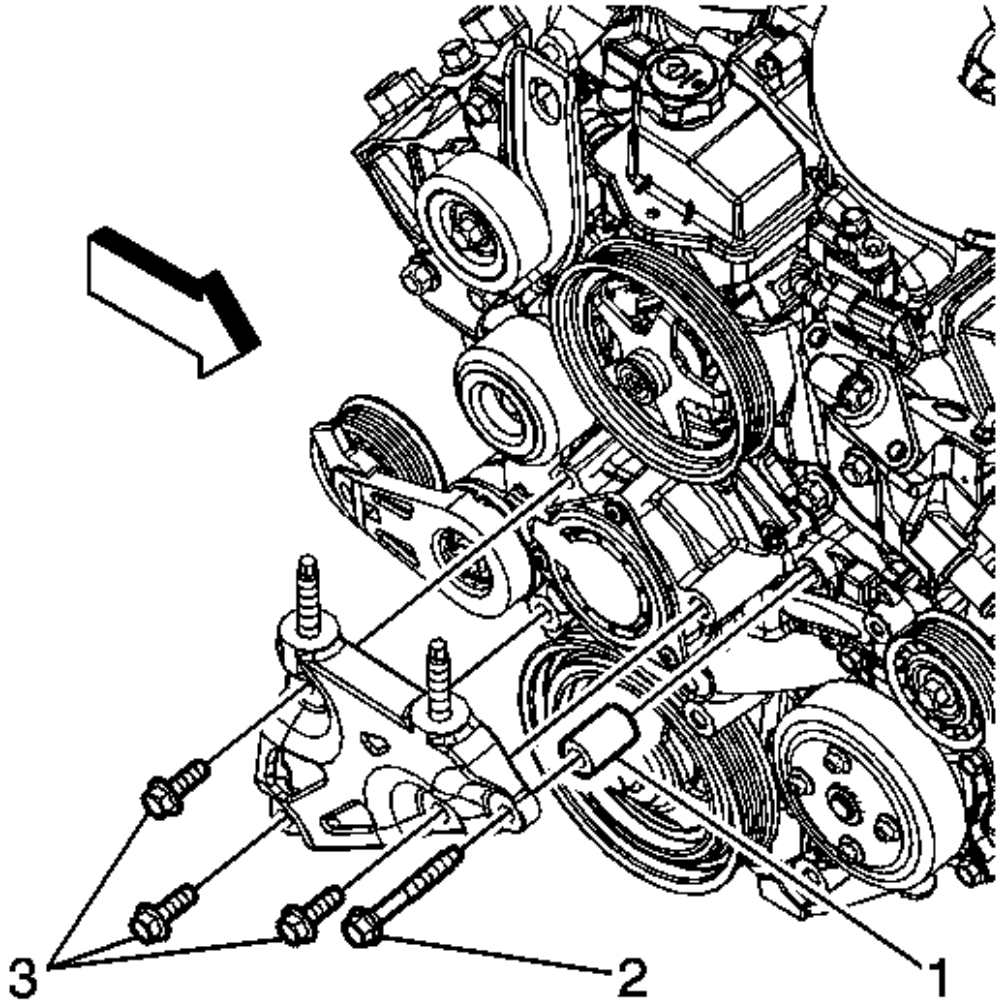

Fig. 13: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: The spacer has a nominal length of 36.0 mm (1.42 in). If the spacer cannot be reinstalled, the spacer will require the ends to be buffed slightly using a crocus cloth or emery paper in order to bring the length to a minimum of 35.80 mm (1.41 in).

3. Install the engine mount bracket spacer (1).

CAUTION: Refer to Fastener Caution .

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4. Install the engine mount bracket bolt (2).

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

5. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
6. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

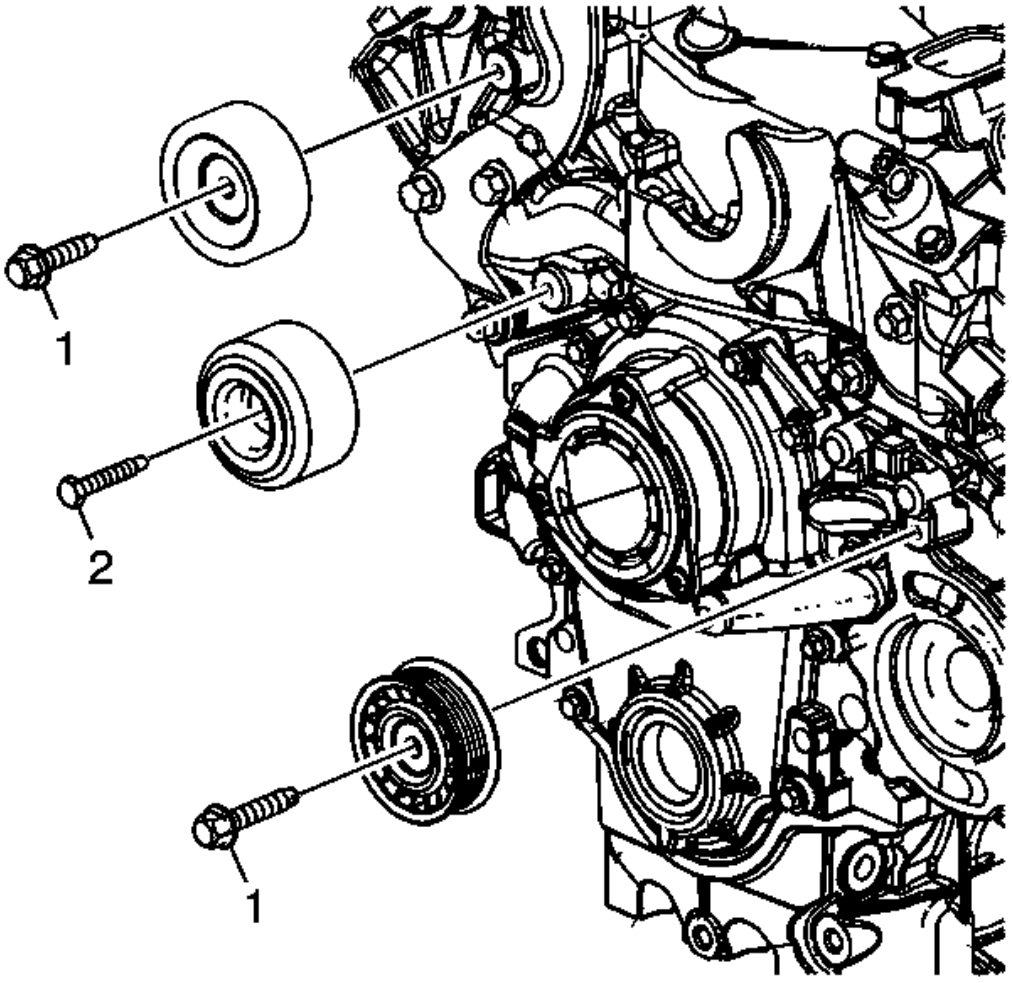

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Fig. 14: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
2. Loosen the appropriate drive belt idler pulley bolt (1, 2).
3. Remove the appropriate drive belt idler pulley.

Installation Procedure

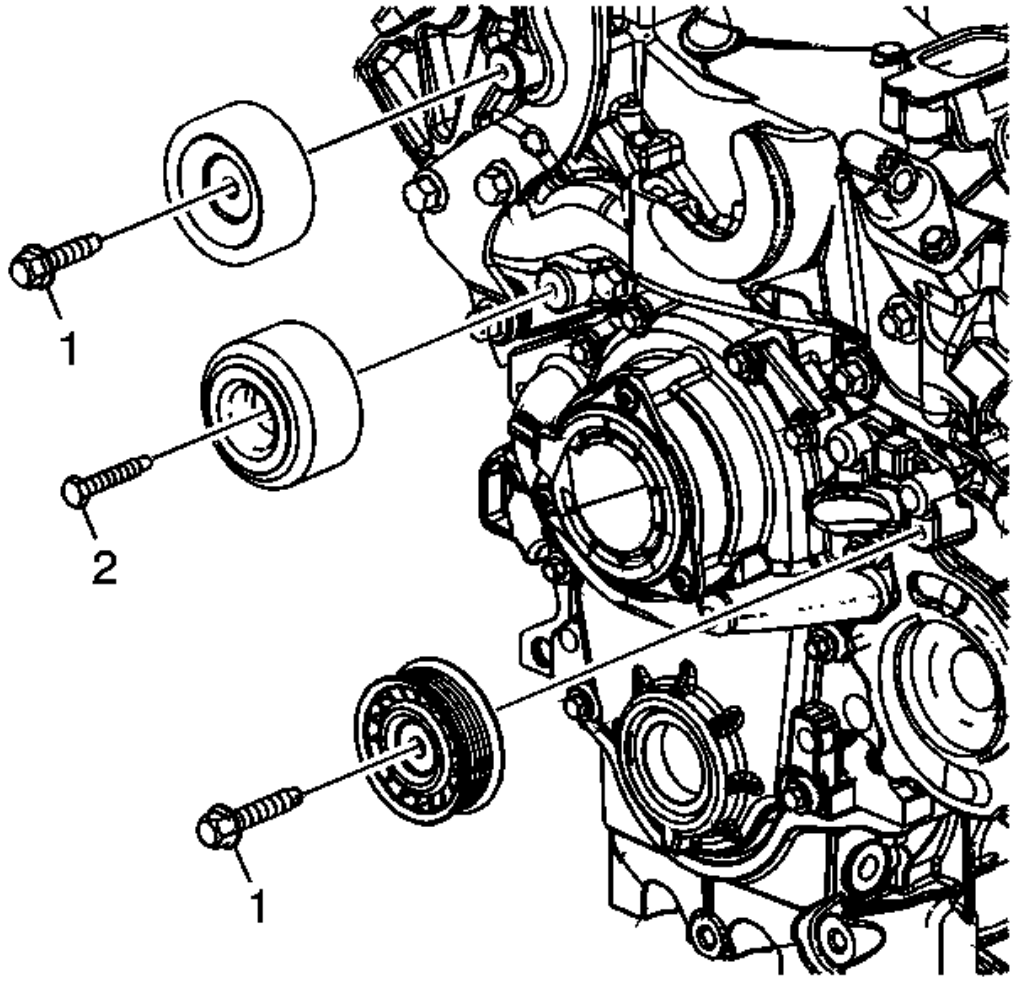

Fig. 15: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

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CAUTION: Refer to Fastener Caution .

1. Install the appropriate drive belt idler pulley.
2. Tighten the appropriate drive belt idler pulley bolt (1, 2).

   Tighten:
   - Tighten the bolt (1) to 50 N.m (37 lb ft).
   - Tighten the bolt (2) to 30 N.m (22 lb ft).

3. Install the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

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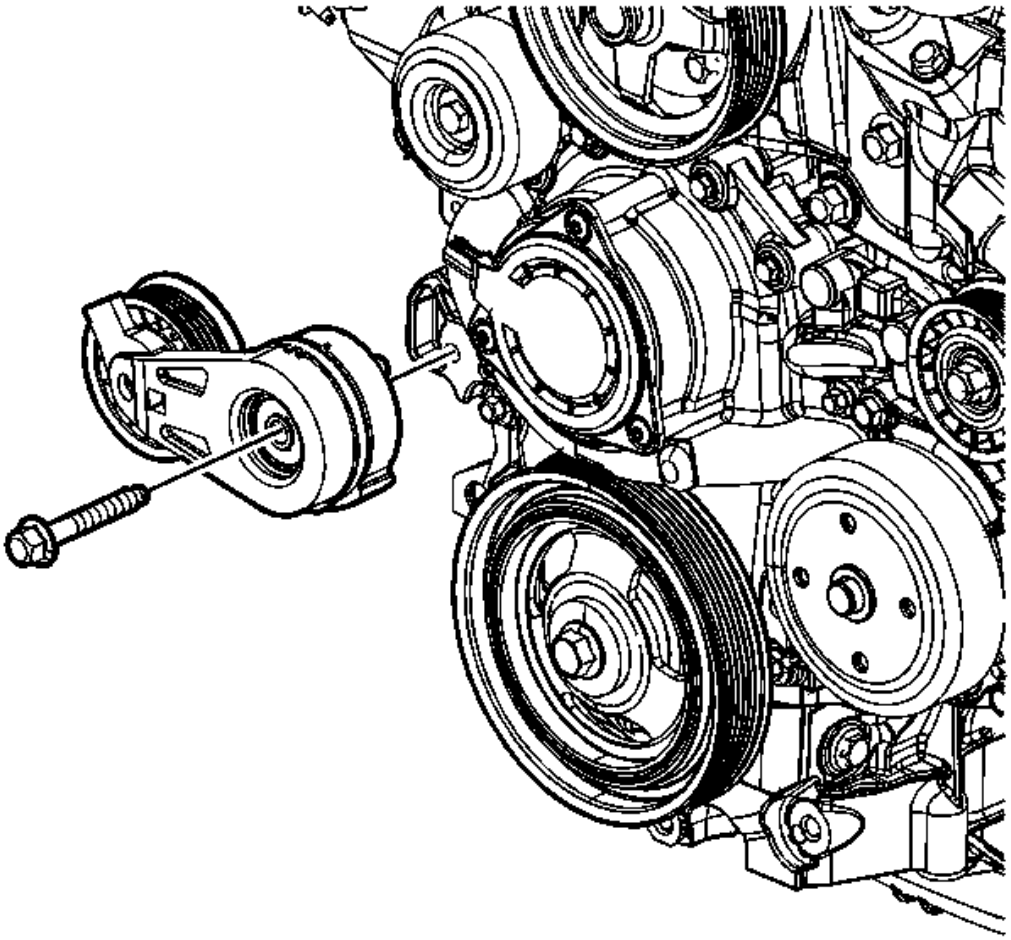

Fig. 16: Identifying Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
2. Remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.

Installation Procedure

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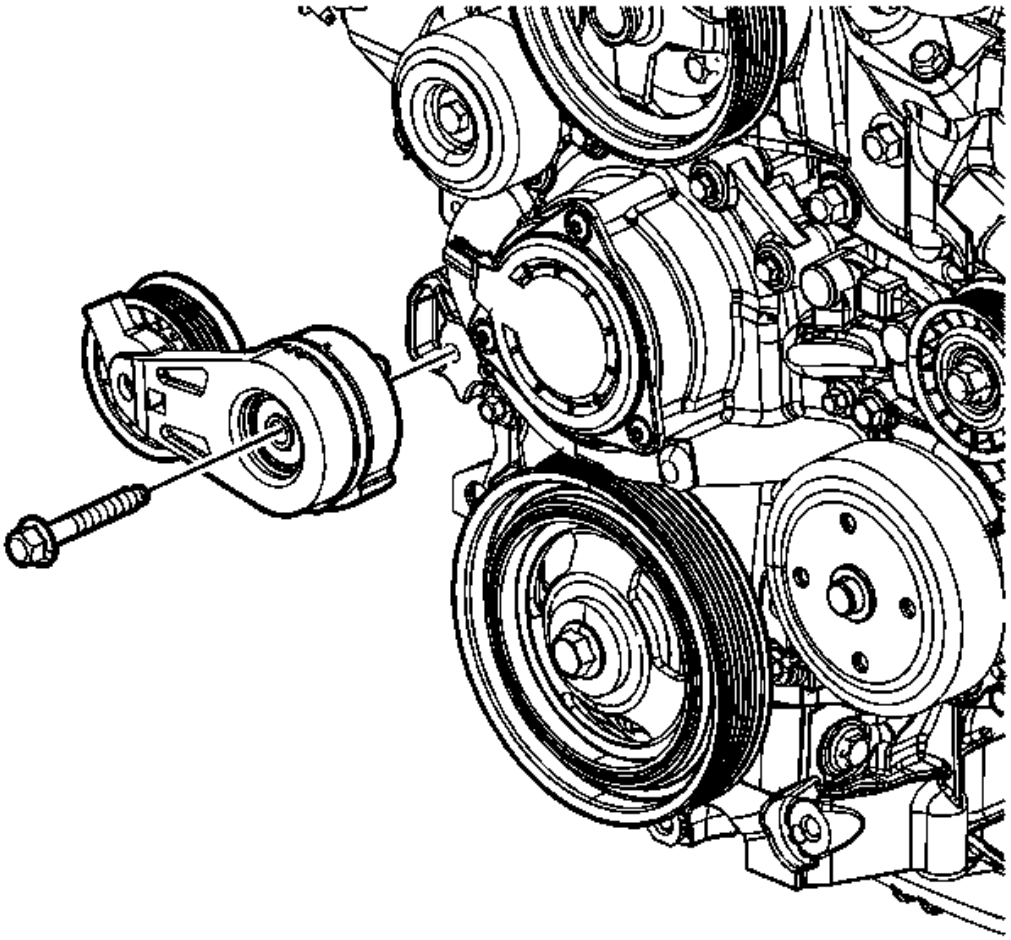

Fig. 17: Identifying Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

   CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt.

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

3. Install the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.

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ENGINE SUPPORT FIXTURE

Tools Required

- **J 28467-B** Engine Support Fixture
- **J 36462** Engine Support Adapter Leg

Procedure

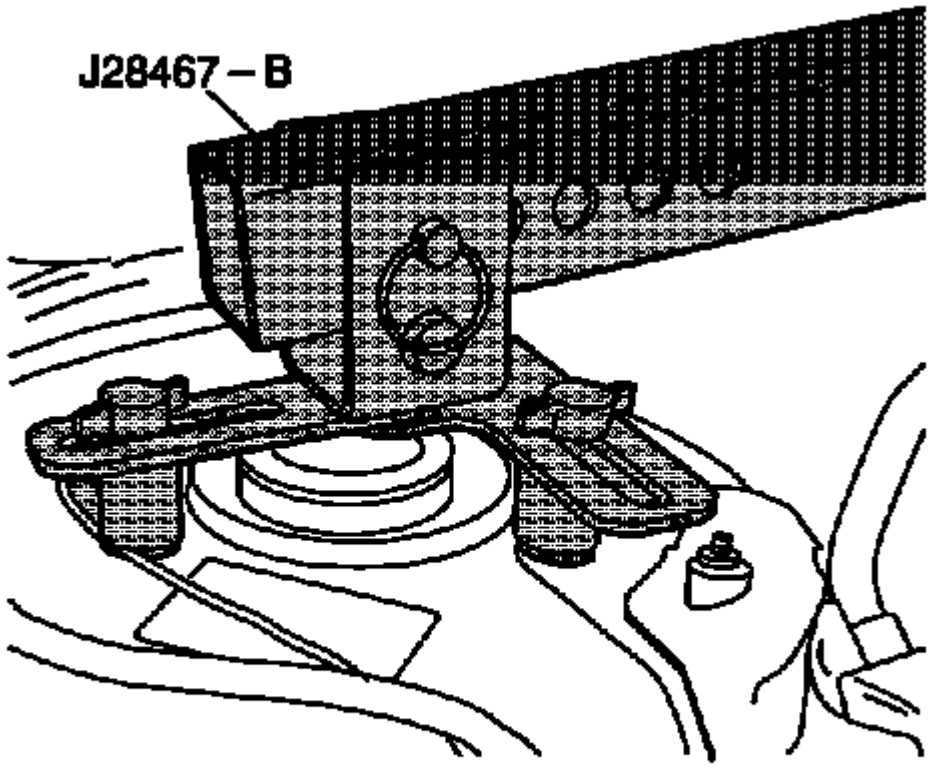

Fig. 18: Installing Thread Support Nuts (J 28467-33A)
Courtesy of GENERAL MOTORS CORP.

1. Raise the hood.
2. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
4. Install the thread support nuts J 28467-33A onto the strut attaching studs.
5. Install the strut tower support assemblies J 28467-5A over the thread support nuts J 28467-33A.
6. Install the T-bolts J 28467-5 with 5/16 inch washers through the strut tower support assemblies J 28467-

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5A into the thread support nuts J 28467-33A. Hand tighten the bolts.

7. Install the 2 cross bracket assemblies J 28467-1A over the strut tower tube J 28467-3.
8. Install the strut tower tube J 28467-3 into the strut tower support assemblies J 28467-5A.
9. Install the 1/2 inch x 2.5 inch quick release pin J 28467-10 through the strut tower support assemblies J 28467-5A and the strut tower tube J 28467-3 on one side only.

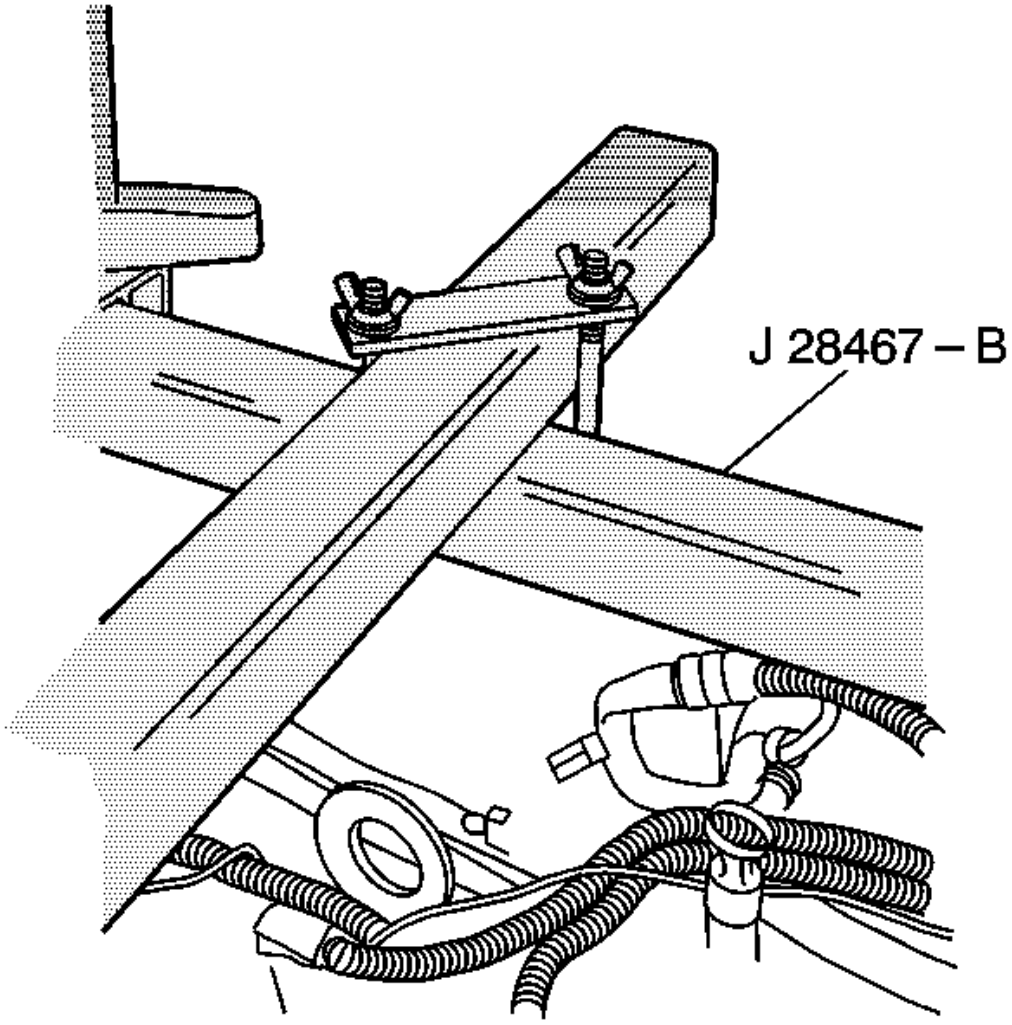

Fig. 19: Installing Radiator Shelf Tube (J 28467-2A)
Courtesy of GENERAL MOTORS CORP.

10. Install the radiator shelf tube J 28467-2A through the driver side cross bracket assembly J 28467-1A on the top of the strut tower tube J 28467-3.

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11. Place the rubber padded foot of the front support assembly J 28467-4A on the vehicle radiator shelf. The foot position used in the front support assembly J 28467-4A depends on the vehicle application.
12. Install the 7/16 inch x 2.0 inch quick release pin J 28467-9 through the hole in the front support assembly J 28467-4A in order to level the radiator shelf tube J 28467-2A. The hole used in the front support assembly J 28467-4A depends on the vehicle application.
13. Install the lift hook J 28467-7A through the lift hook bracket J 28467-6A.
14. Install the 1/2 inch lift hook washer and lift hook wing nut J 28467-34 onto the lift hook J 28467-7A.
15. Install the assembled lift hook bracket J 28467-6A over the radiator shelf tube J 28467-2A.
16. Adjust the radiator shelf tube J 28467-2A and the assemblage lift hook bracket J 28467-6A in order to align the hook with the left (front), rear of engine, lift hook bracket part of the left engine mount strut bracket.
17. Hand tighten the driver side cross bracket assembly J 28467-1A wing nuts.
18. Install the second radiator shelf tube J 28467-2A through the passenger side cross bracket assembly (J 28467-1A) on the top of the strut tower tube J 28467-3.
19. Place the rubber padded foot of the front support assembly J 28467-4A on the vehicle radiator shelf. The foot position used in the front support assembly J 28467-4A depends on the vehicle application.
20. Install the 7/16 inch x 2.0 inch quick release pin J 28467-9 through the hole in the front support assembly J 28467-4A in order to level the radiator shelf tube J 28467-2A. The hole used in the front support assembly J 28467-4A depends on the vehicle application.
21. Install the lift hook J 28467-7A through the lift hook bracket J 28467-6A.
22. Install the 1/2 inch lift hook washer and lift hook wing nut J 28467-34 onto the lift hook J 28467-7A.
23. Install the assemblage lift hook bracket J 28467-6A over the radiator shelf tube J 28467-2A.
24. Adjust the radiator shelf tube J 28467-2A and the assemblage lift hook bracket J 28467-6A in order to align the hook with the right rear, front of engine, lift hook bracket located next to the generator.
25. Hand tighten the passenger side cross bracket assembly J 28467-1A wing nuts.
26. Hand tighten the lift hook wing nuts J 28467-34 securely in order to remove all slack from the engine support fixture assembly.

ENGINE MOUNT INSPECTION

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

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The engine mount itself is leaking fluid.

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4. For engine mount replacement. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.

ENGINE MOUNT REPLACEMENT (COUPE)

Removal Procedure

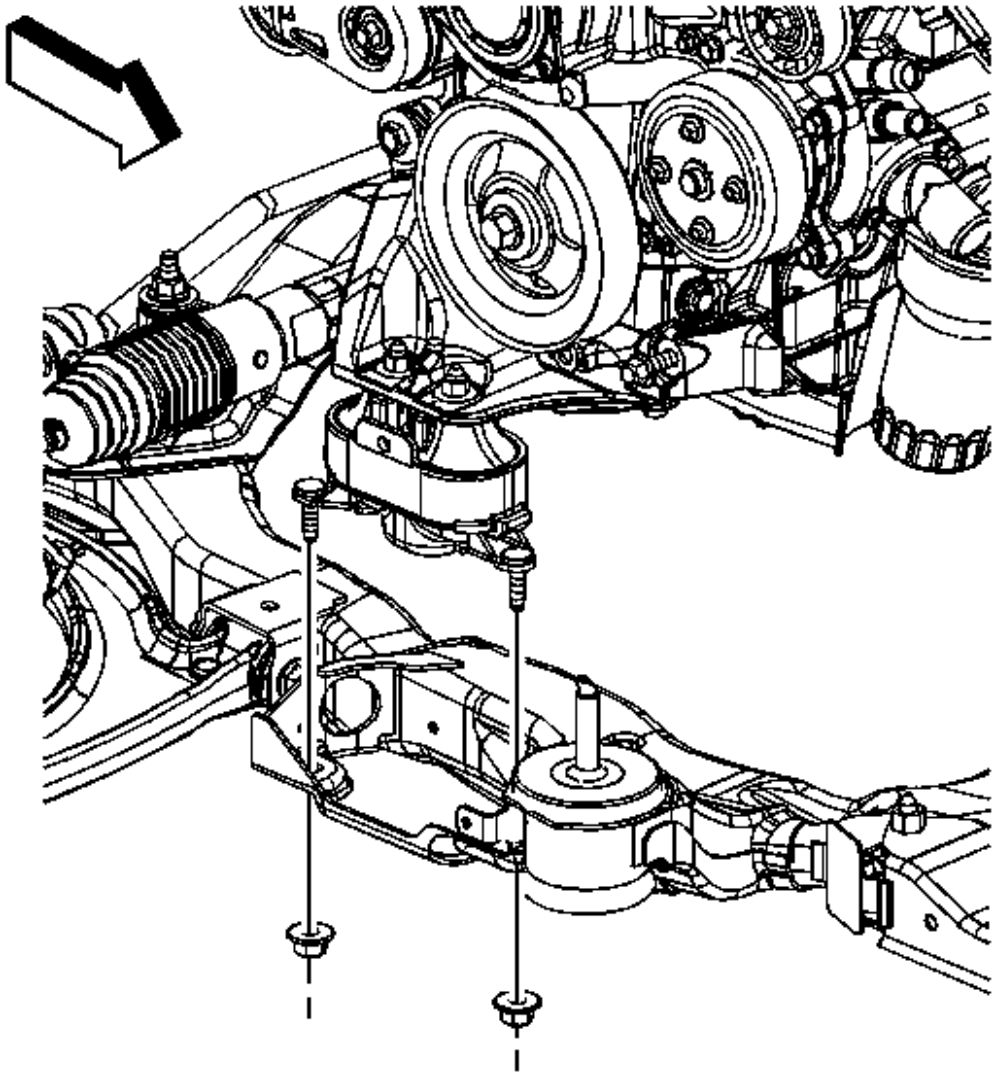

Fig. 20: Identifying Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

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1. Remove the tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
2. Remove the engine splash shield. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .
3. Remove the engine mount to engine mount bracket nuts.
4. Remove the engine mount to frame nuts.
5. Using an adjustable jack, raise the engine.
6. Remove the engine mount from the frame.

Installation Procedure

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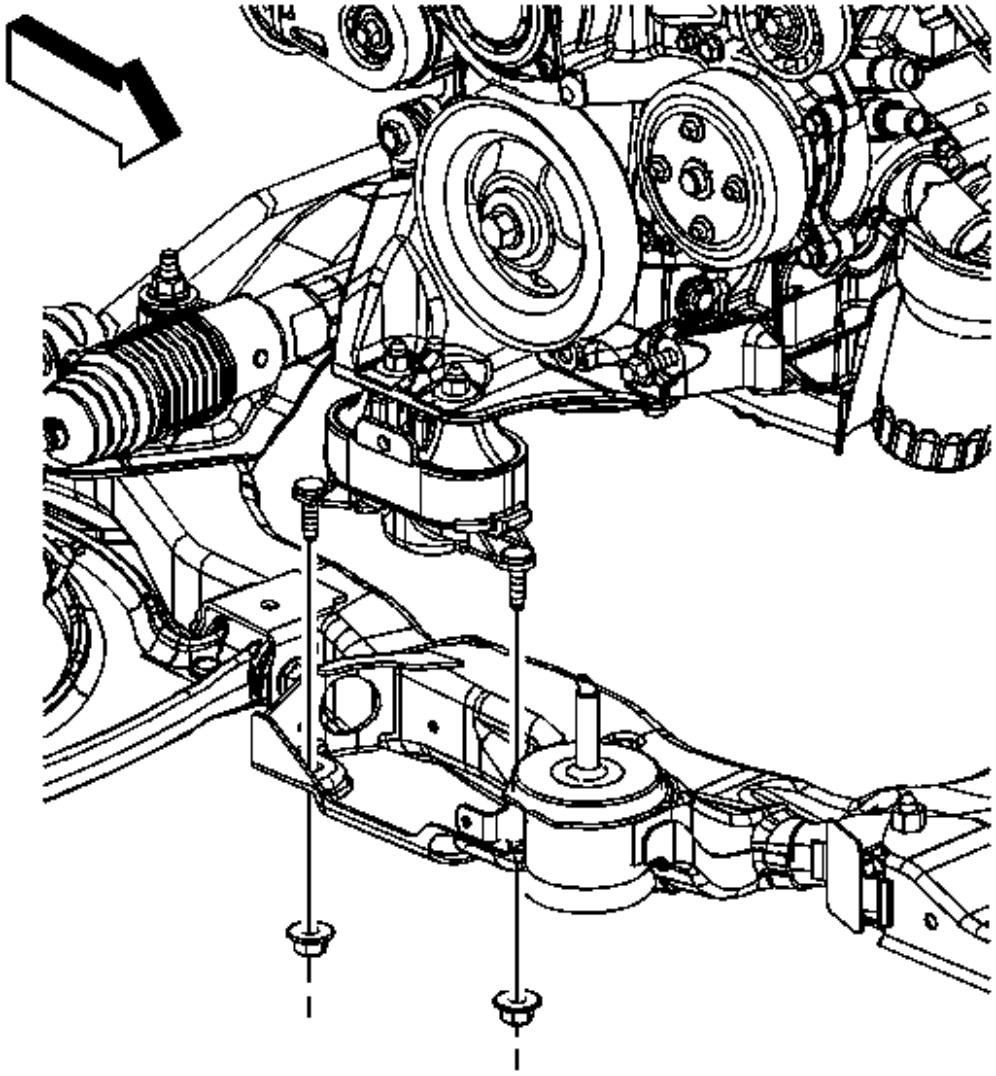

Fig. 21: Identifying Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount onto the frame
2. Lower the engine using the adjustable jack.

CAUTION: Refer to Fastener Caution .

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3. Install the engine mount to frame nuts.

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

4. Install the engine mount to engine mount bracket nuts.

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

5. Remove the adjustable jack from under the vehicle.
6. Install the engine splash shield. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .
7. Install the tire and wheel. Refer to **Tire and Wheel Removal and Installation** .

ENGINE MOUNT REPLACEMENT (CONVERTIBLE)

Removal Procedure

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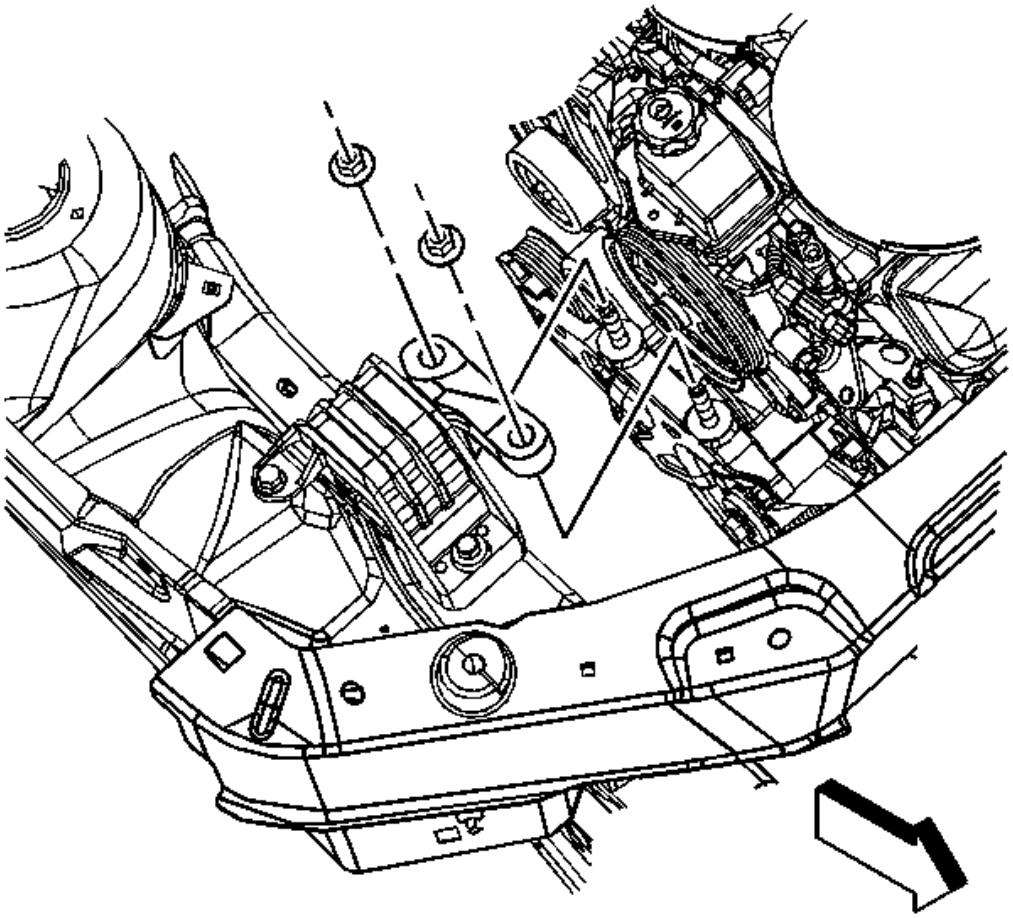

Fig. 22: Identifying Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Place a block of wood on a adjustable floor jack, and place the jack under the oil pan in order to support the engine.
3. Remove the engine mount to engine mount bracket nuts.

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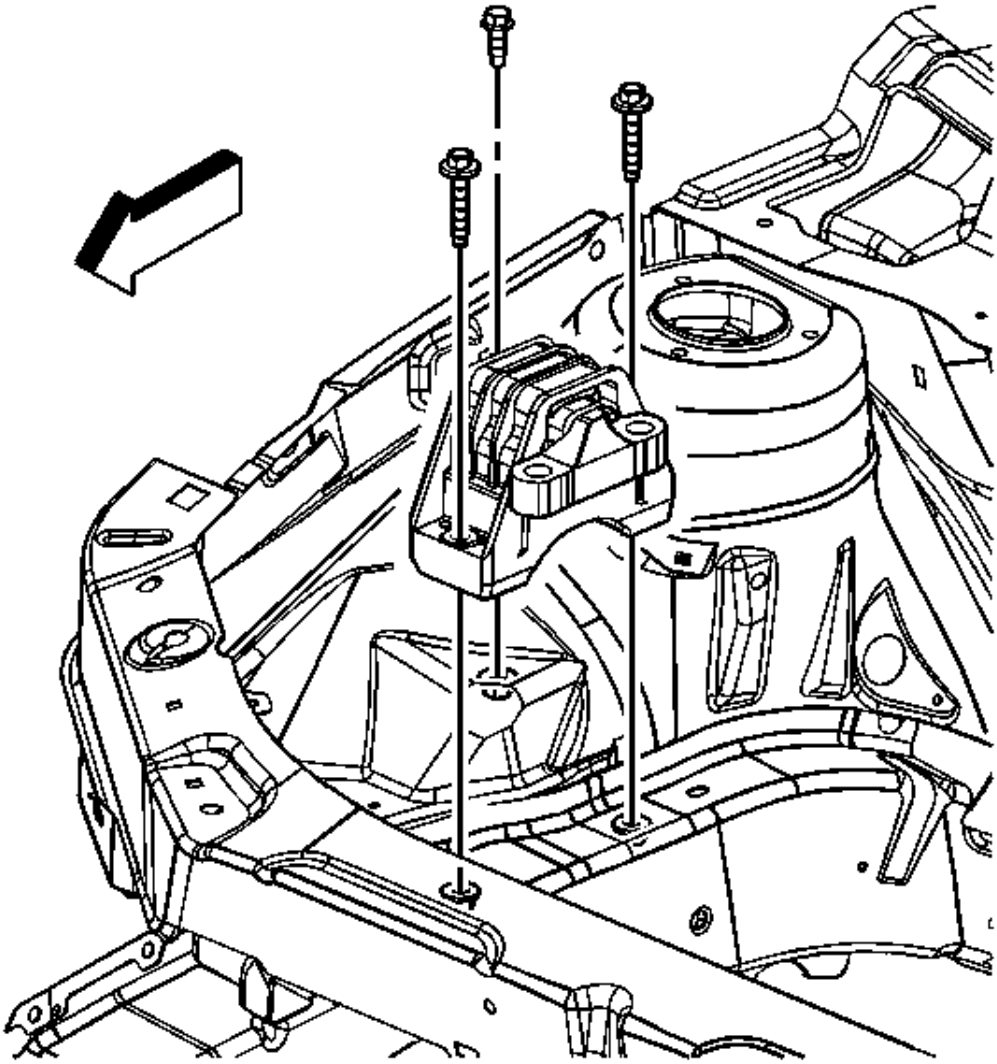

Fig. 23: Identifying Front Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount bolts.
5. Remove the engine mount.

Installation Procedure

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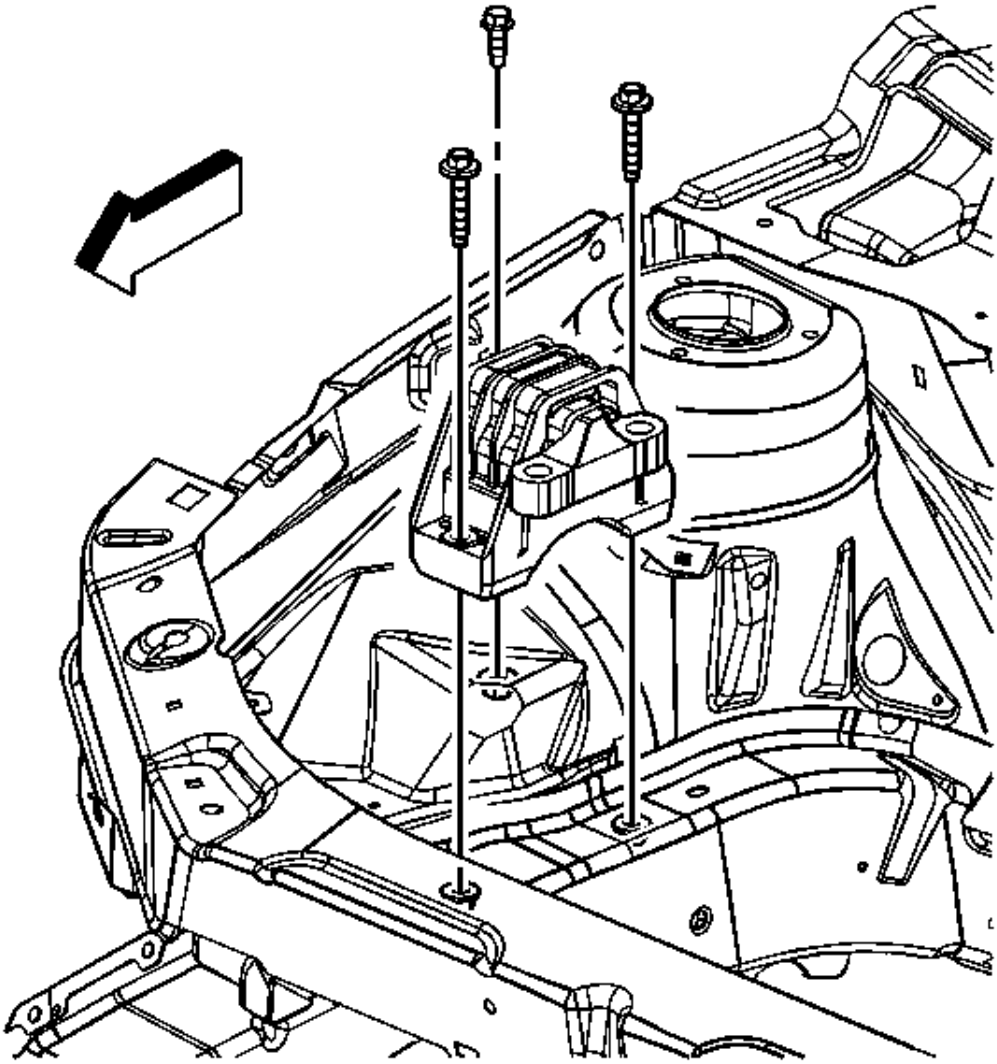

Fig. 24: Identifying Front Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

1. Place the engine mount into position on the engine compartment side rail.

CAUTION: Refer to Fastener Caution .

2. Install the engine mount bolts.

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

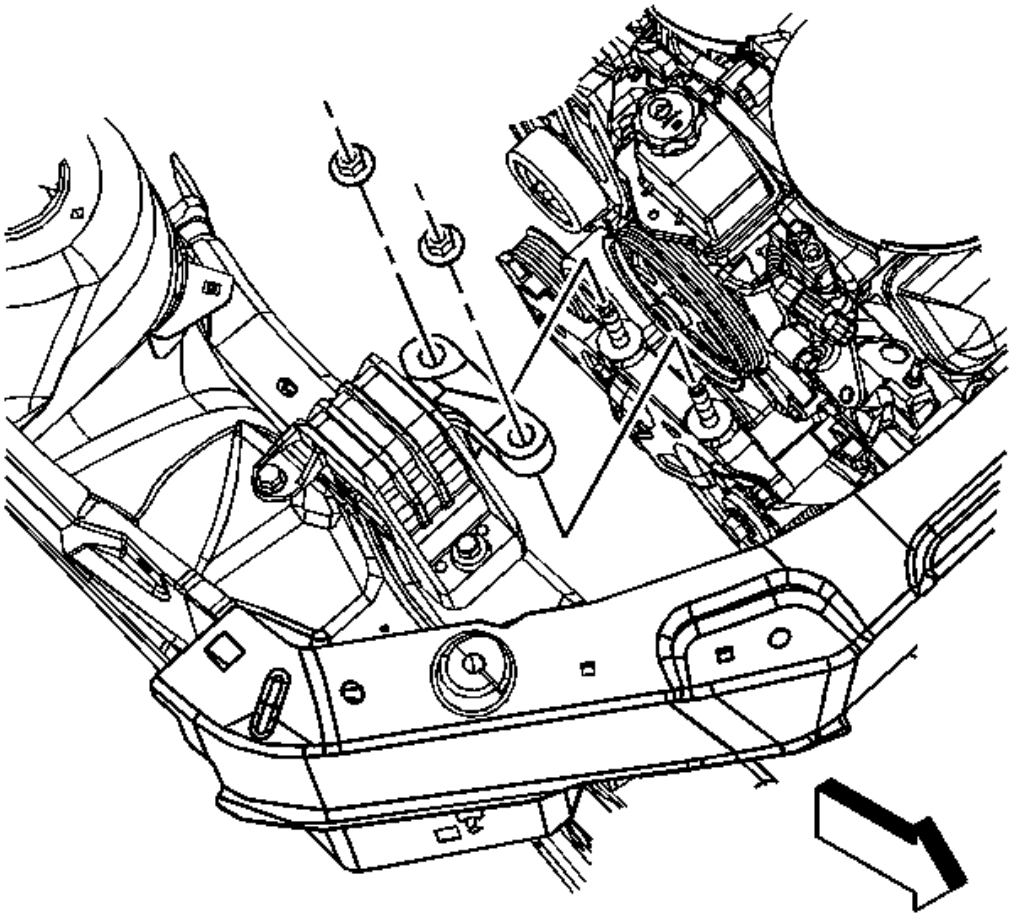

Fig. 25: Identifying Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to engine mount bracket nuts.

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

4. Remove the floor jack and block of wood from under the oil pan.
5. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

ENGINE MOUNT BRACKET REPLACEMENT (CONVERTIBLE)

Removal Procedure

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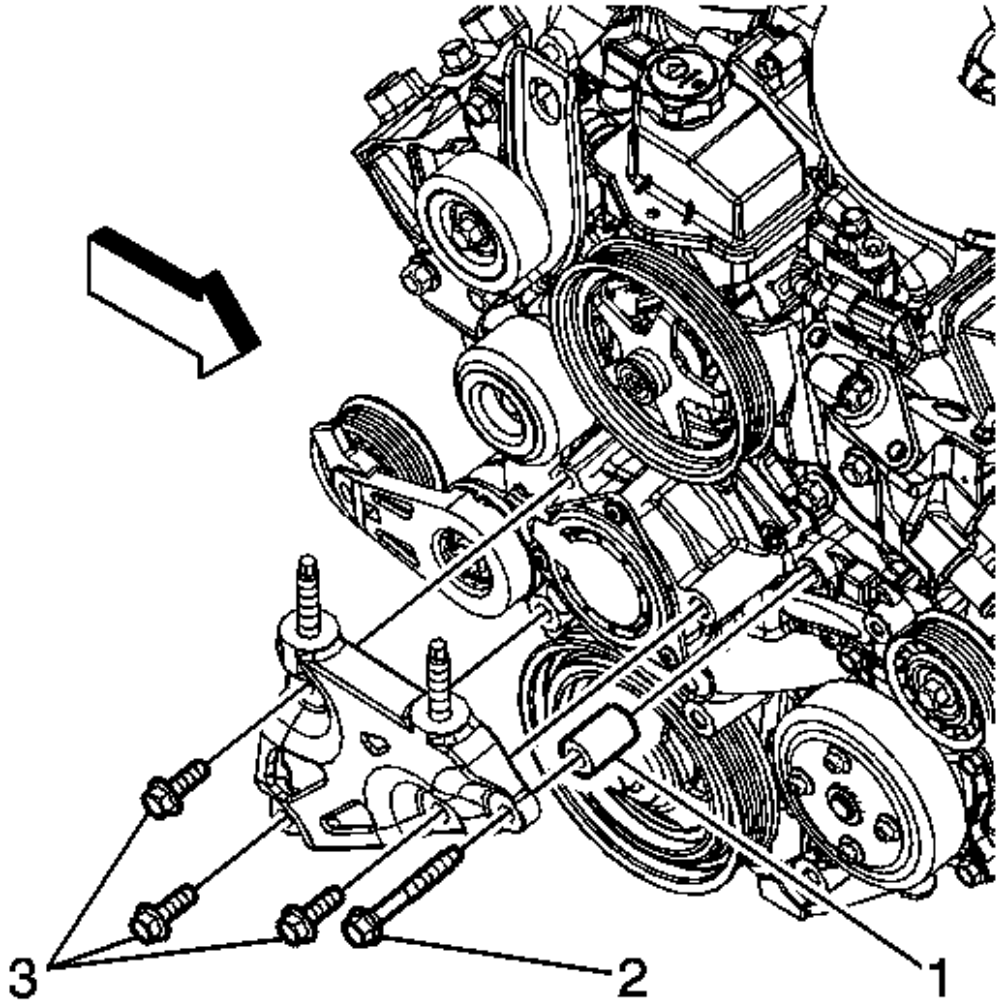

Fig. 26: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.
2. Remove the engine mount bracket bolts (2, 3) from the engine.
3. Remove the engine mount bracket and spacer (1).

Installation Procedure

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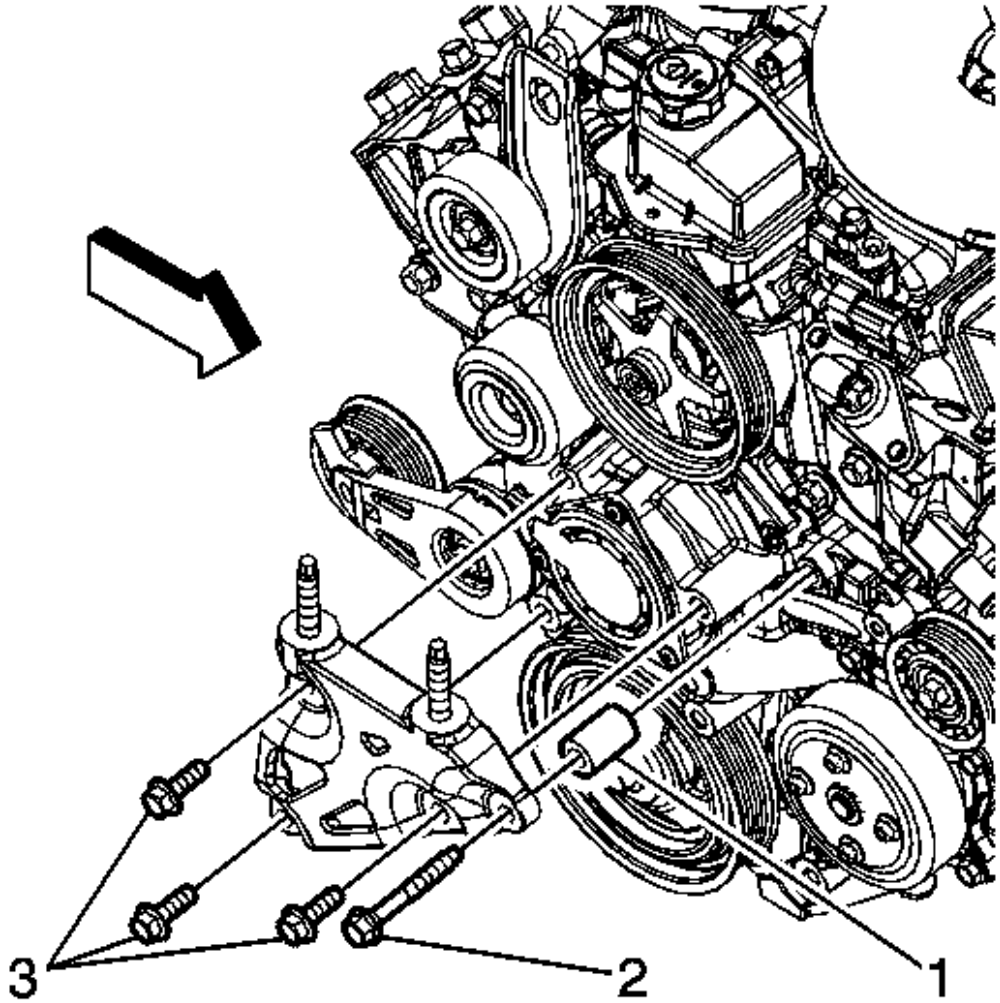

Fig. 27: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket and spacer (1) to the engine front cover.
2. Hold the bracket firmly to the engine front cover and install the engine mount bracket bolts (2, 3).

CAUTION: Refer to Fastener Caution .

3. Tighten the engine mount bracket bolts.

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Tighten: Tighten the bolts to 90 N.m (66 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.

ENGINE MOUNT BRACKET REPLACEMENT (COUPE)

Removal Procedure

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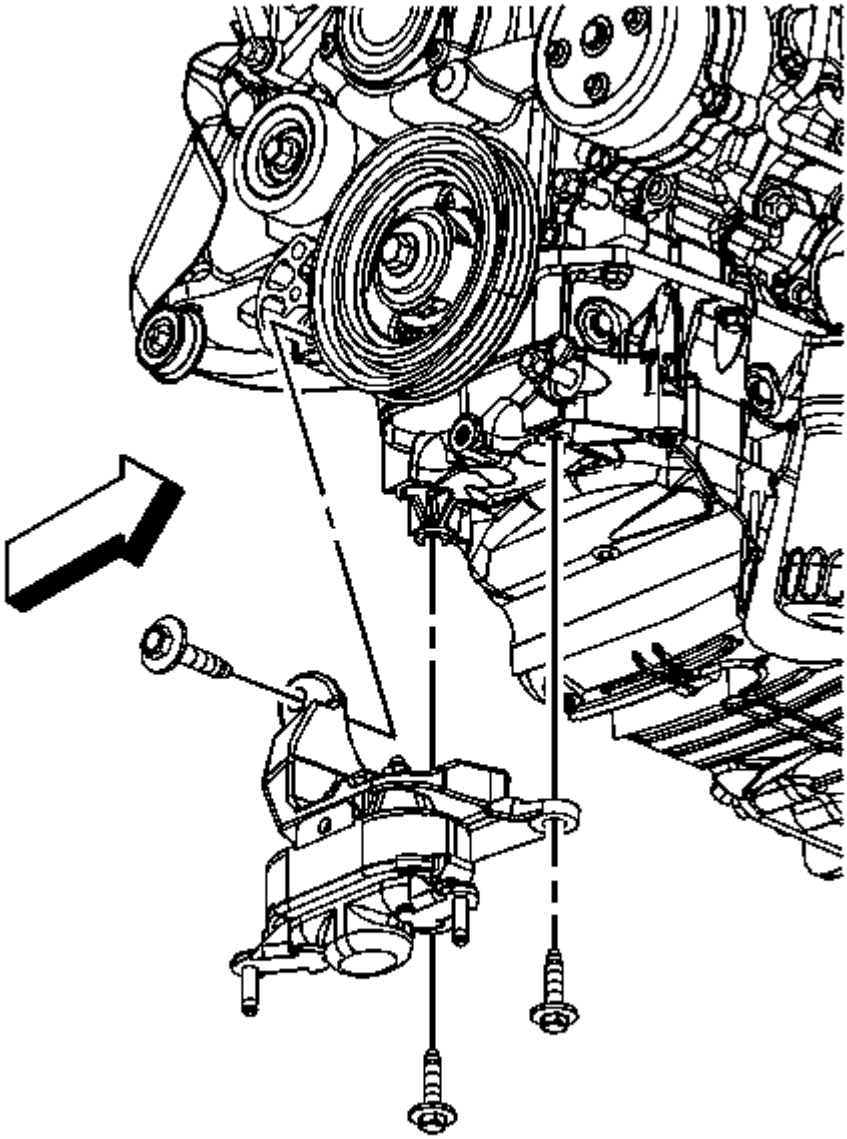

Fig. 28: Identifying Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.
2. Remove the engine mount bracket bolt from the engine.
3. Remove the engine mount bracket bolts from the oil pan.

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4. Remove the engine mount bracket from the vehicle.

Installation Procedure

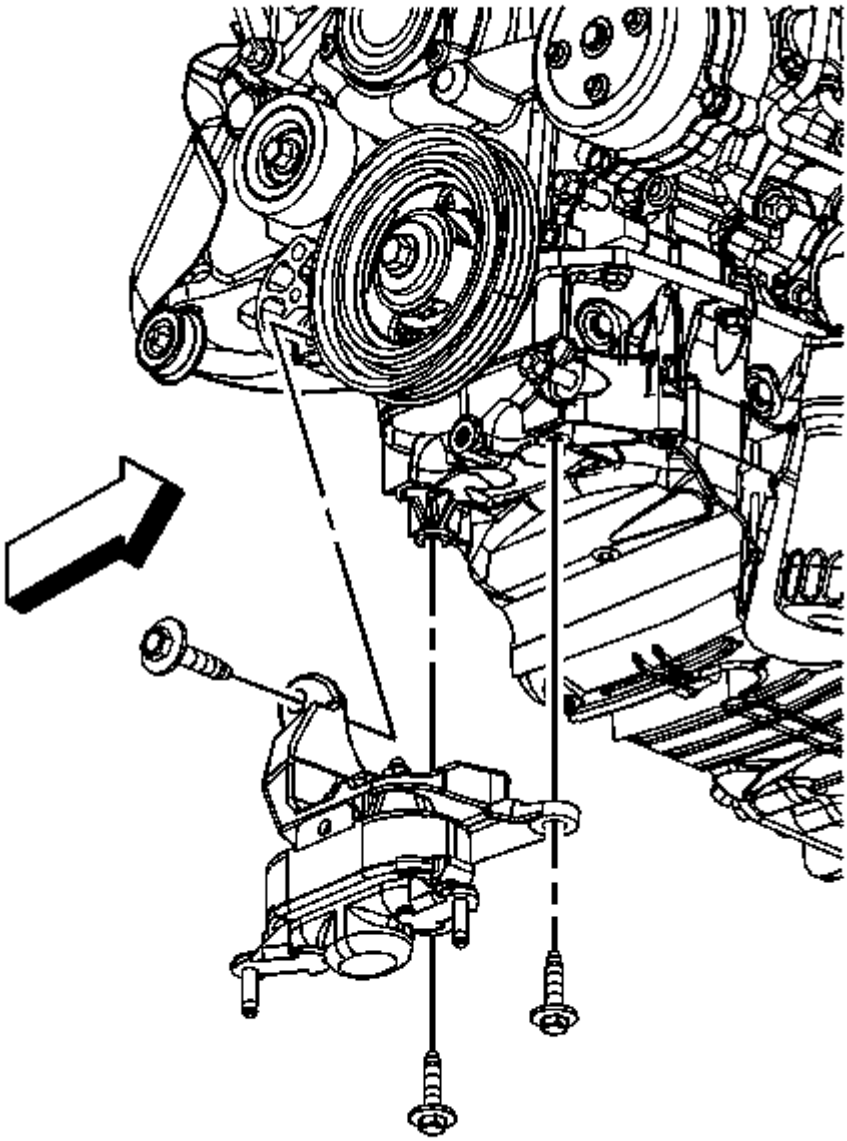

Fig. 29: Identifying Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

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1. Position the engine mount bracket to the engine.
2. Loose assemble the engine mount bracket to oil pan and engine.
3. Hold the bracket firmly to the front of the engine and snug the engine mount bracket bolts.

CAUTION: Refer to Fastener Caution .

4. Tighten the engine mount bracket bolts.

   Tighten:
   1. Tighten the engine mount bracket to engine bolt to 90 N.m (66 lb ft).
   2. Tighten the engine mount bracket to oil pan bolts to 50 N.m (37 lb ft).

5. Install the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.

ENGINE MOUNT POSITION ADJUSTMENT

Special Tools

J 23498-A Driveshaft Inclinometer. See **Special Tools**.

NOTE: If for some reason there is pressure or preload against the powertrain, it can be put out of design position and this will put stress on the flex coupling in the exhaust system when the vehicle is driven and the out of position powertrain may cause the exhaust downpipe to hit the heat shield in the exhaust tunnel during torque loads.

NOTE: When lifting the vehicle to perform this procedure, the vehicle MUST be lifted using a frame contact hoist, in order for the wheels and suspension to hang free.

Adjustment

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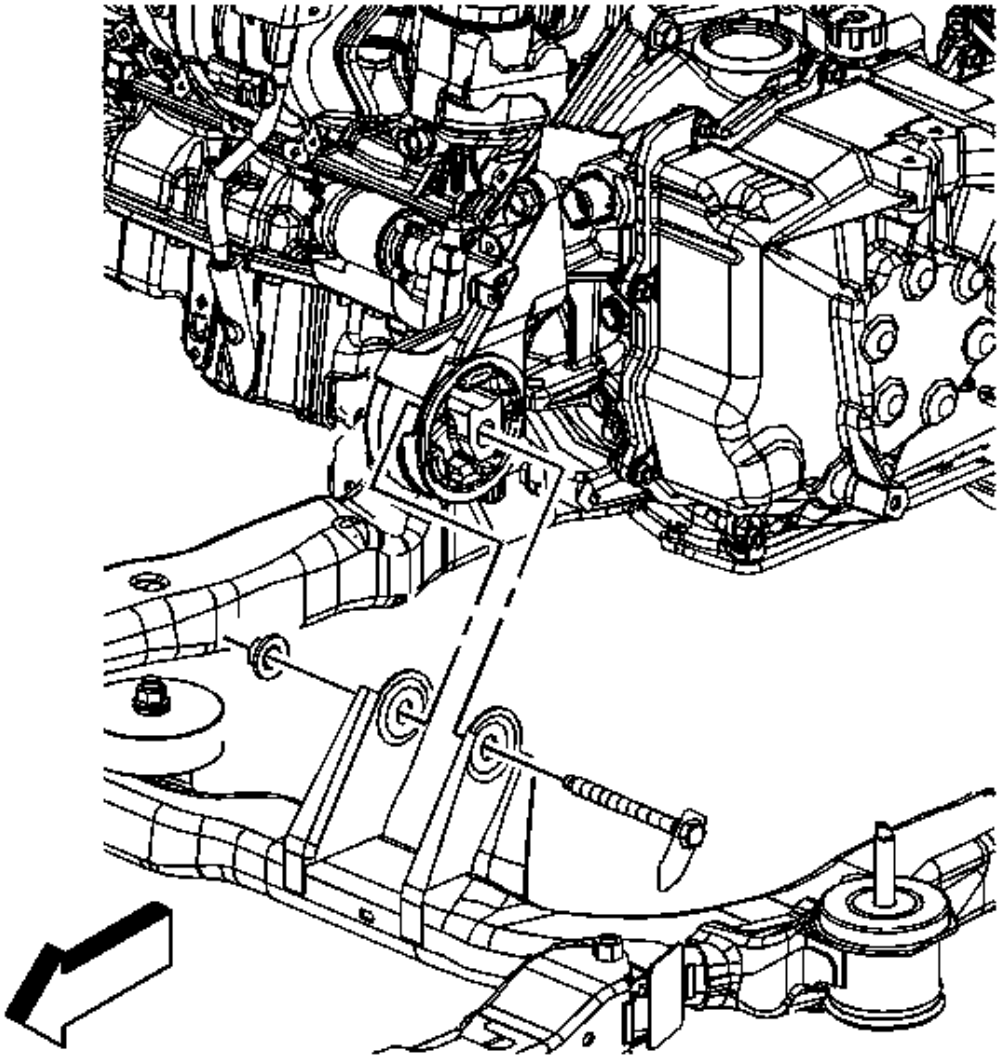

Fig. 30: Identifying Front Transmission Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Loosen, but DO NOT REMOVE the front transaxle mount through bolt.

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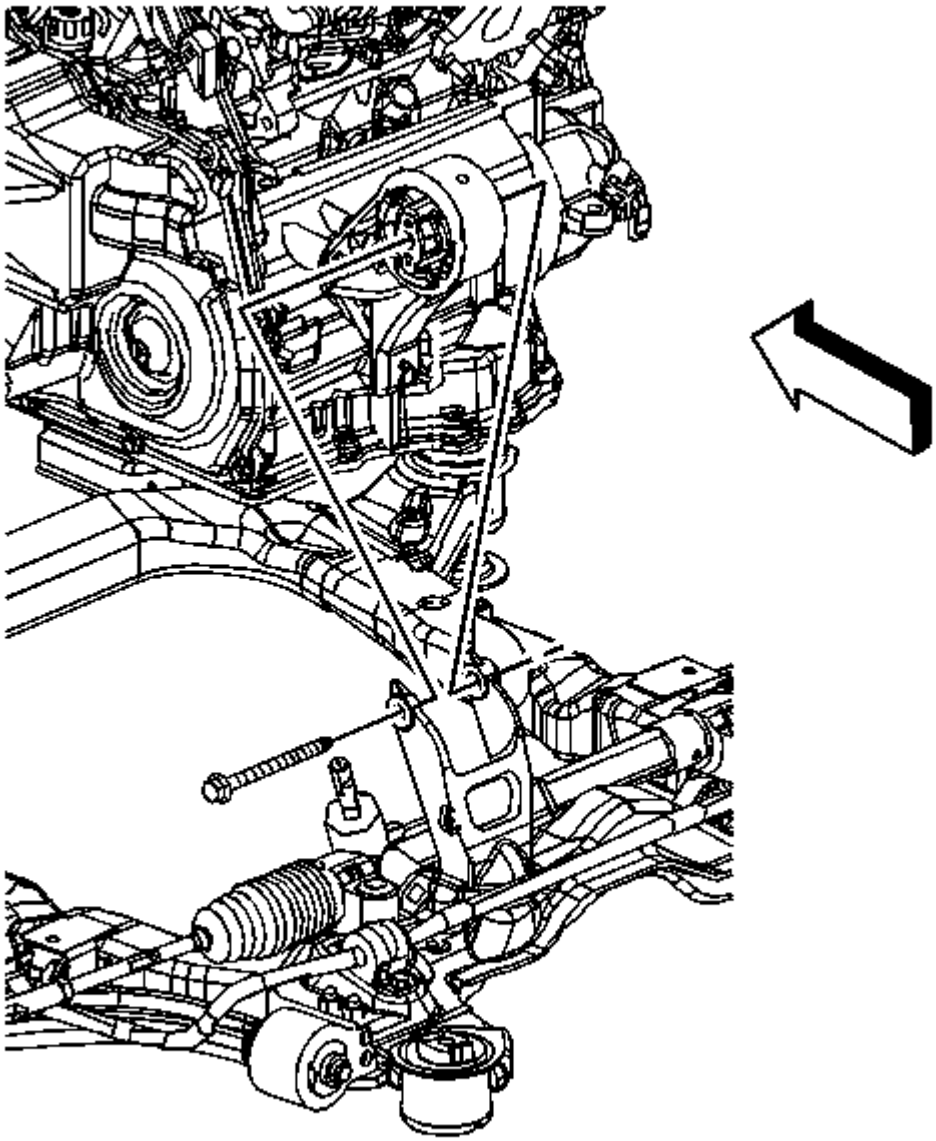

Fig. 31: Identifying Rear Transmission Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen, but DO NOT REMOVE the rear transaxle mount through bolt.
4. Install the **J 23498-A** on the bottom of the flex coupling of the exhaust pipe. See **Special Tools**.
5. Rock the engine by hand until the **J 23498-A** reading is as close to "0" degrees as possible. See **Special Tools**.

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CAUTION: Refer to Fastener Caution .

6. While still holding the powertrain in position, tighten the front through bolt.
7. Tighten the rear through bolt.
8. After the through bolts have been tightened, re-check the angle.
9. There should be no more then "5" degrees of angle in the flex coupling with the powertrain in the static position.
10. If there is no more then "5" degrees of angle, tighten the through bolts to specifications.

    Tighten: Tighten the bolts to 90 N.m (66 lb ft).

11. If there is more then "5" degrees of angle, loosen the through bolts and return to step 5.

ENGINE MOUNT SNUBBER REPLACEMENT

Removal Procedure

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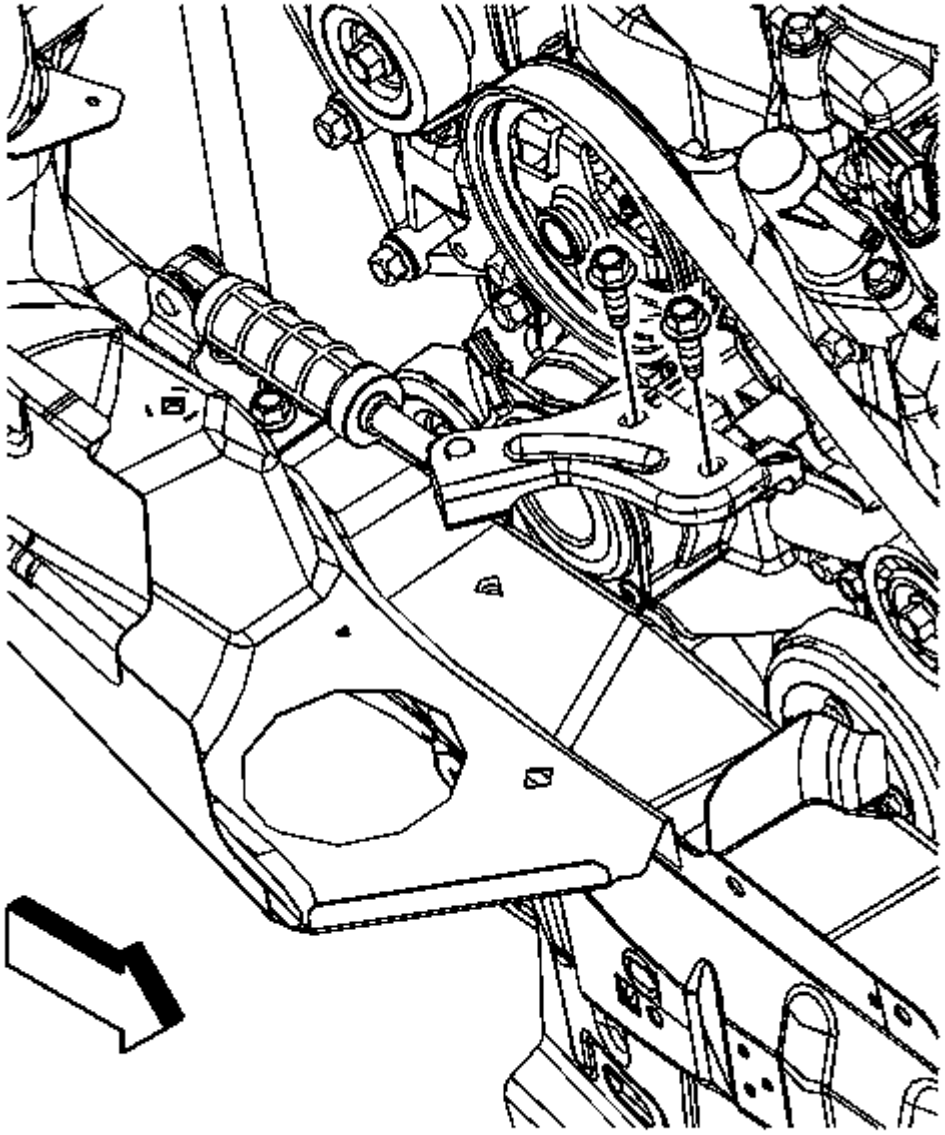

Fig. 32: View Of Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner. Refer to **Air Cleaner Assembly Replacement** .
2. Remove the engine mount snubber to engine mount snubber bracket bolts.
3. Lift the engine mount snubber into the vertical position.

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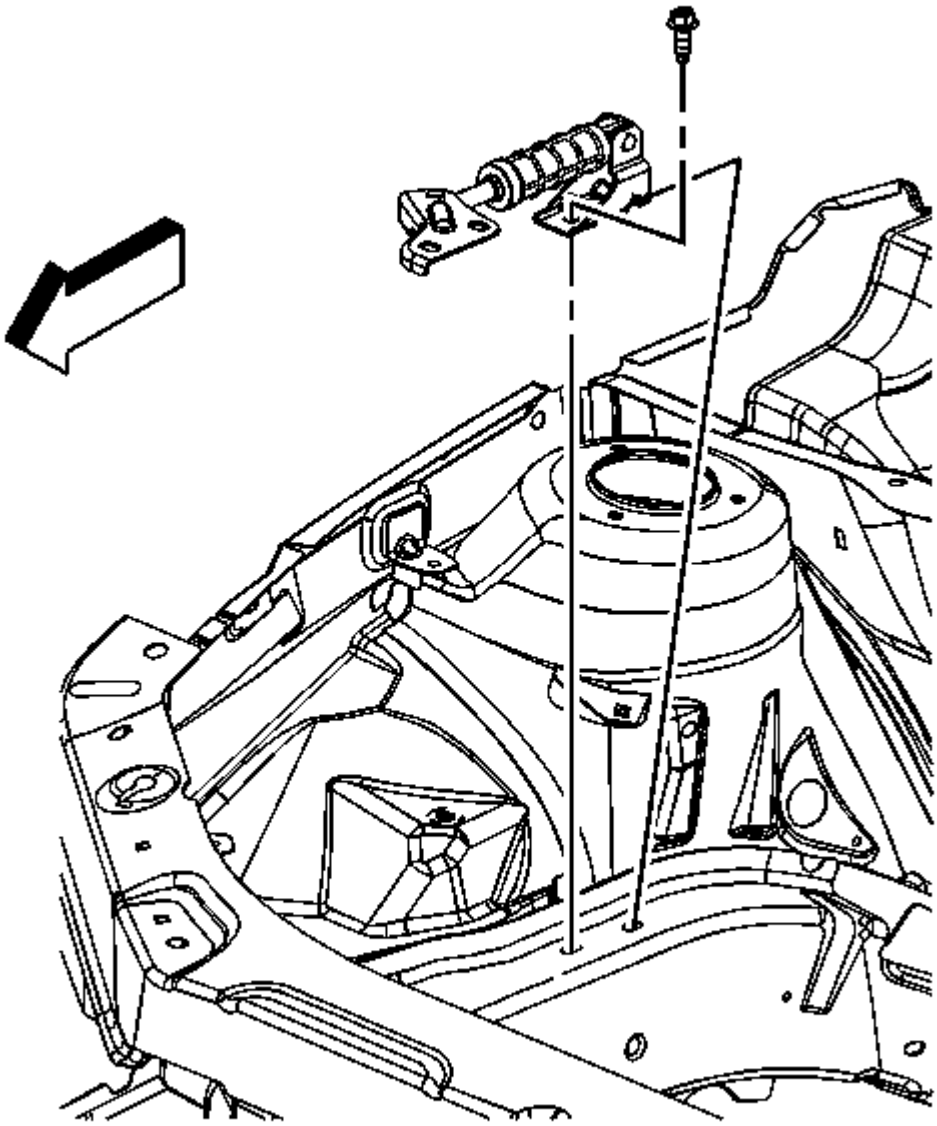

Fig. 33: View Of Engine Mount Strut & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount snubber to engine compartment side rail bolt.
5. Slide the engine mount snubber rearward and remove.

Installation Procedure

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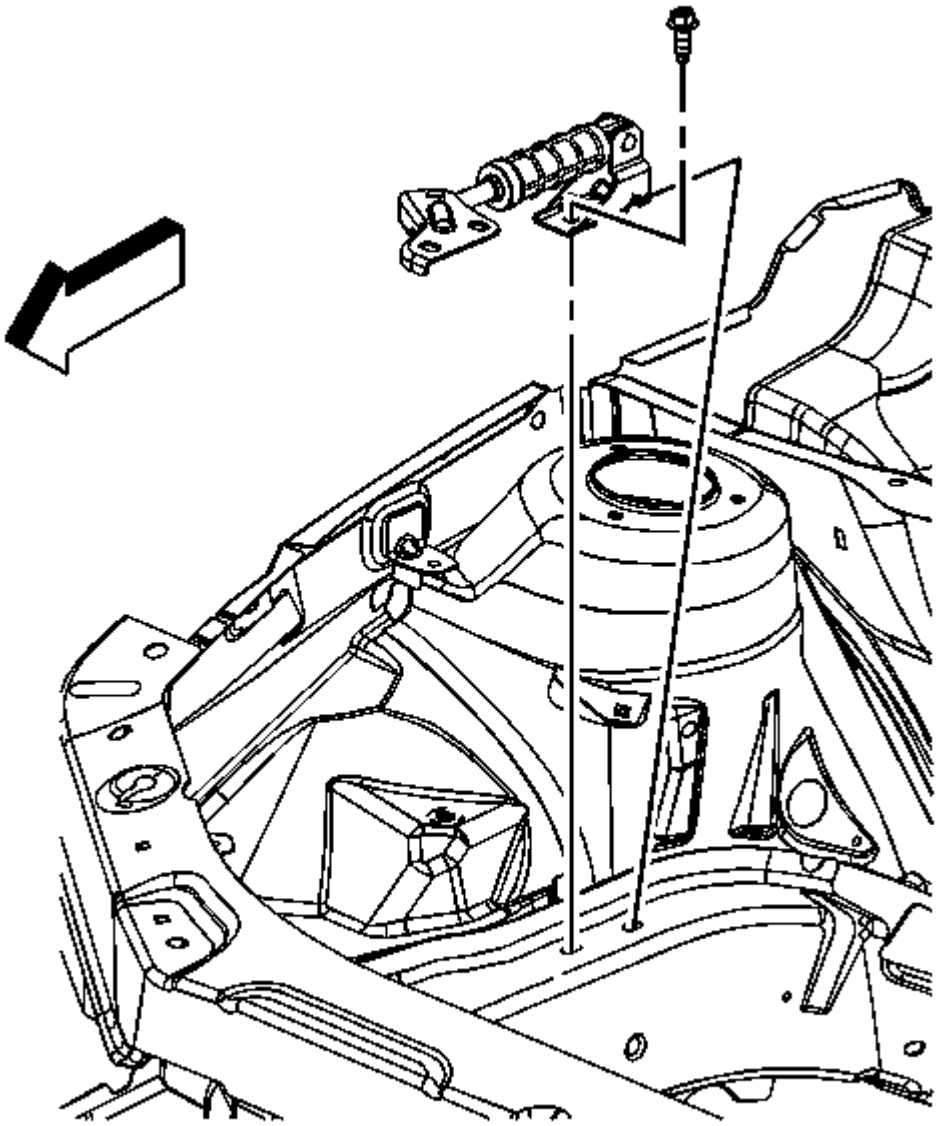

Fig. 34: View Of Engine Mount Strut & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount snubber tab into the hole and slide the snubber forward until the bolt hole aligns.

CAUTION: Refer to Fastener Caution .

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2. Install and tighten the engine mount snubber to engine compartment side rail bolt to 50 N.m (37 lb ft).
3. Push the engine mount snubber into the horizontal position.

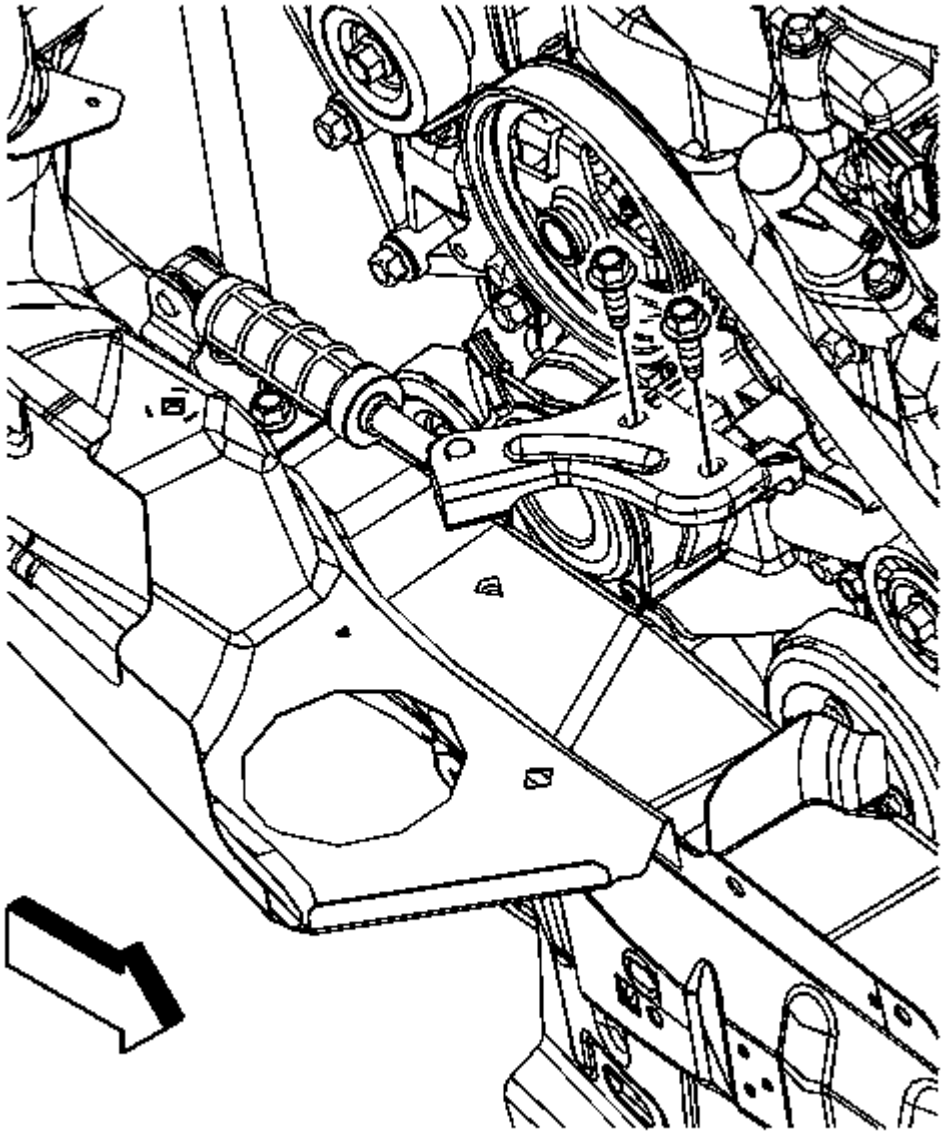

Fig. 35: View Of Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

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4. Install the engine mount snubber to engine mount snubber bracket bolts and tighten to 50 N.m (37 lb ft).
5. Install the air cleaner. Refer to **Air Cleaner Assembly Replacement** .

ENGINE MOUNT SNUBBER BRACKET REPLACEMENT

Removal Procedure

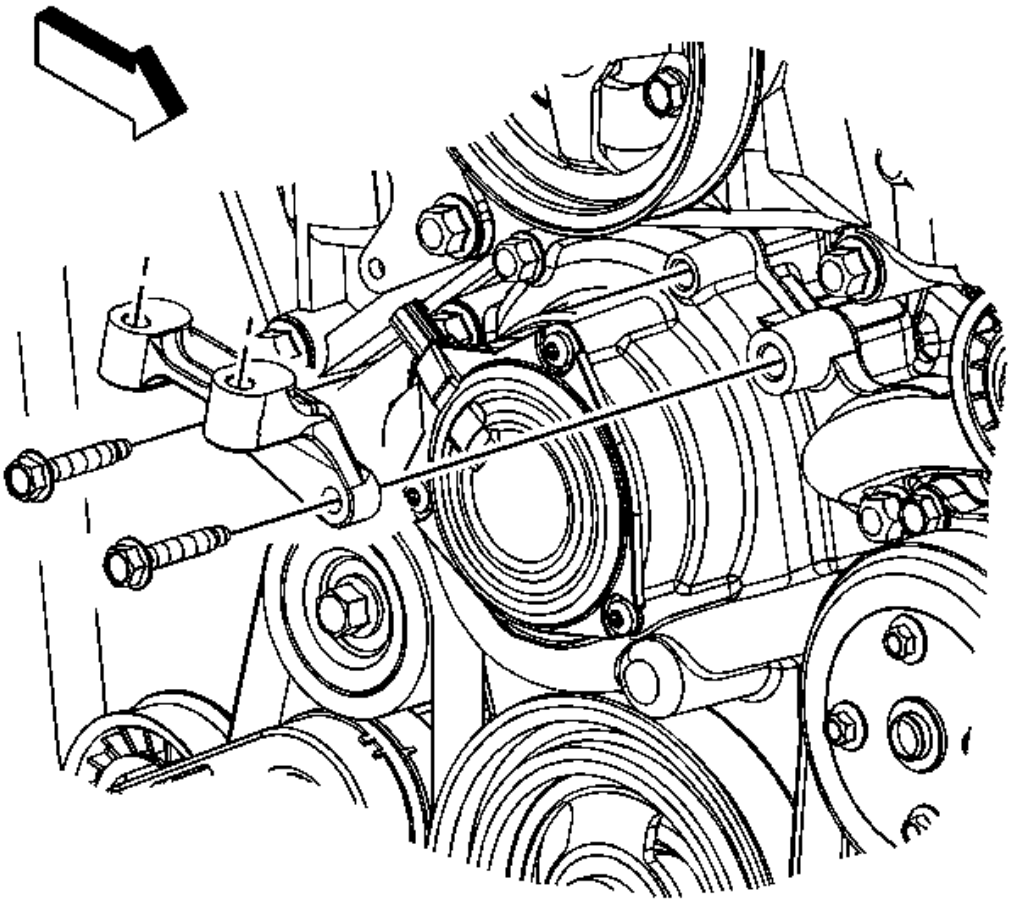

Fig. 36: Identifying Engine Mount Strut Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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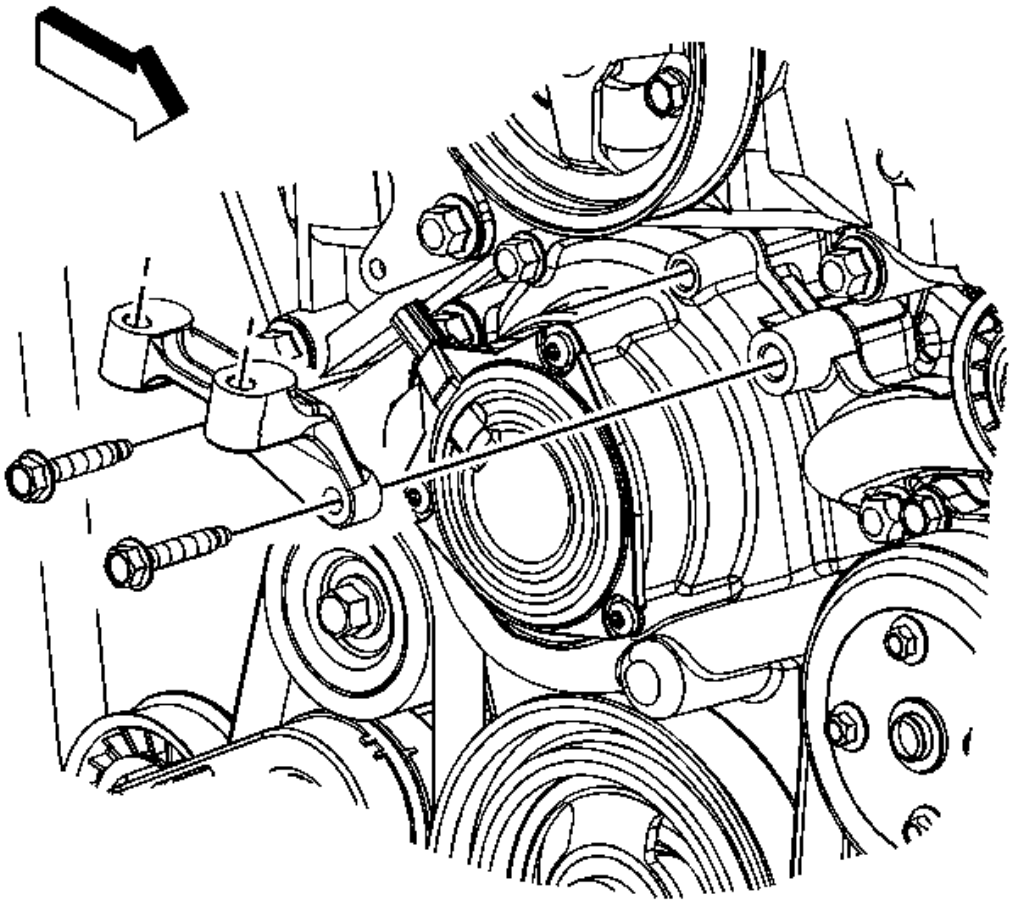

Fig. 37: Identifying Engine Mount Strut Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Position the engine mount snubber bracket to the engine.
2. Install the engine mount snubber bracket to engine bolts and tighten to 25 N.m (18 lb ft).
3. Install the engine mount snubber. Refer to **Engine Mount Snubber Replacement**.

OIL FILTER ADAPTER AND BYPASS VALVE ASSEMBLY REPLACEMENT

Removal Procedure

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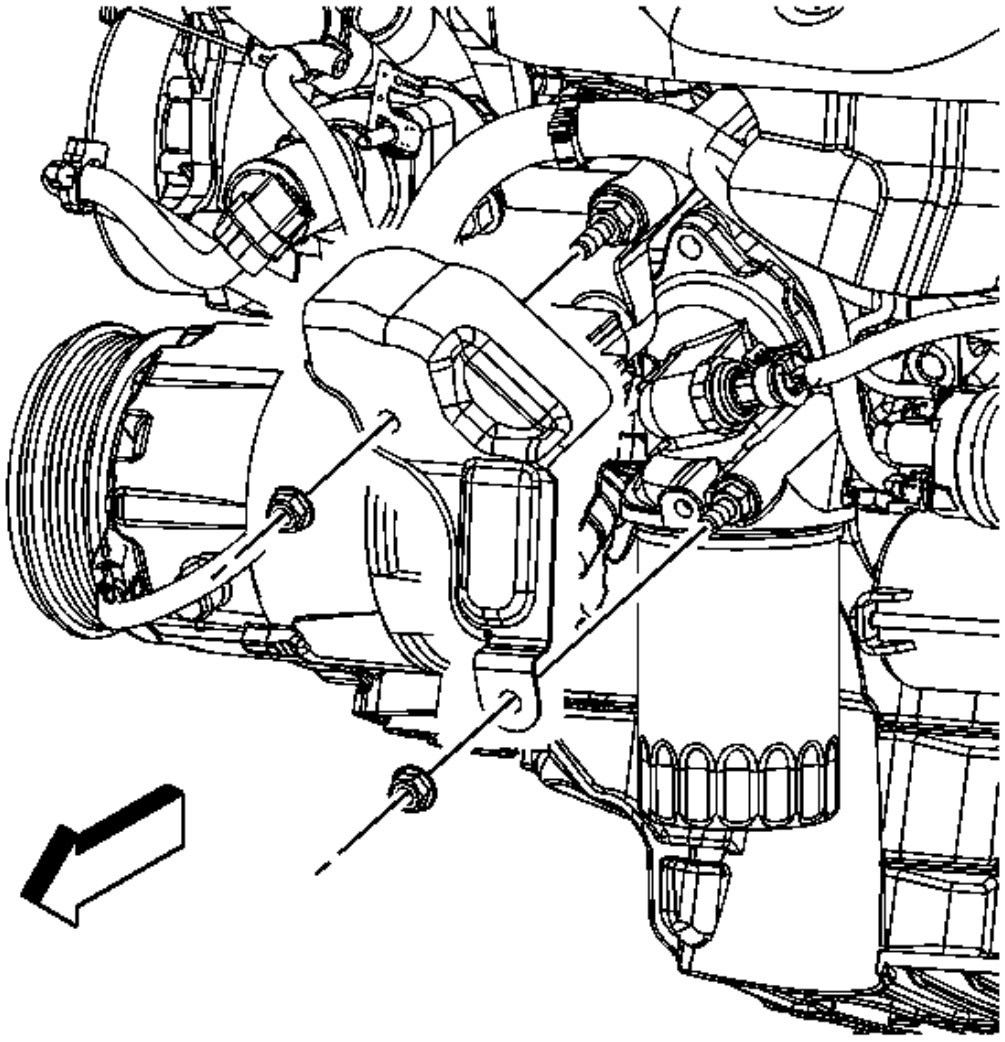

Fig. 38: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the oil pressure sensor heat shield bolts and shield.

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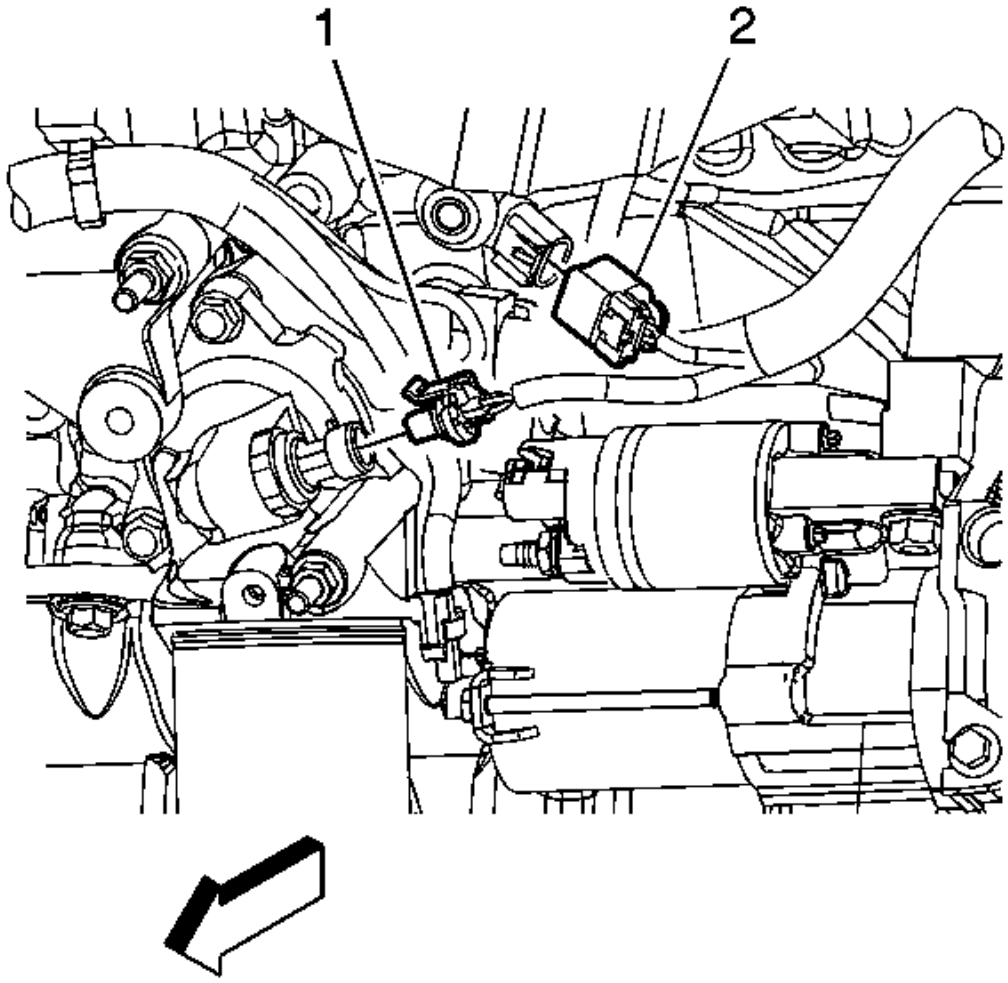

Fig. 39: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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

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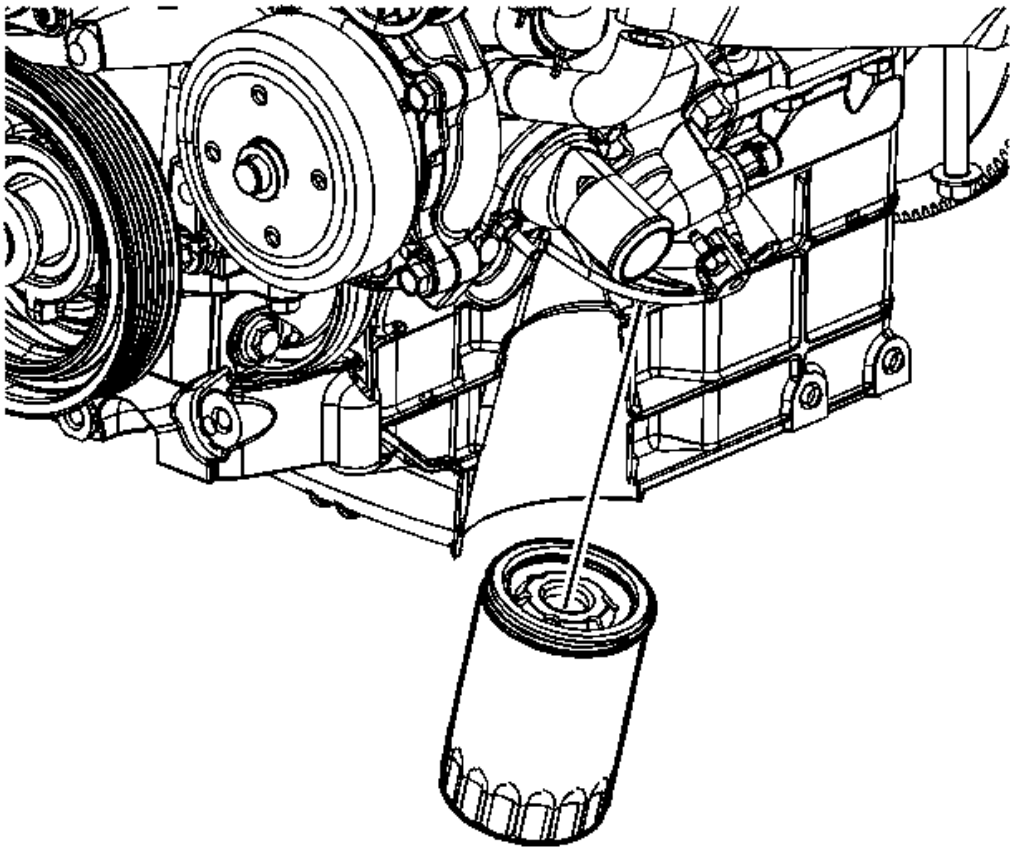

Fig. 40: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter.

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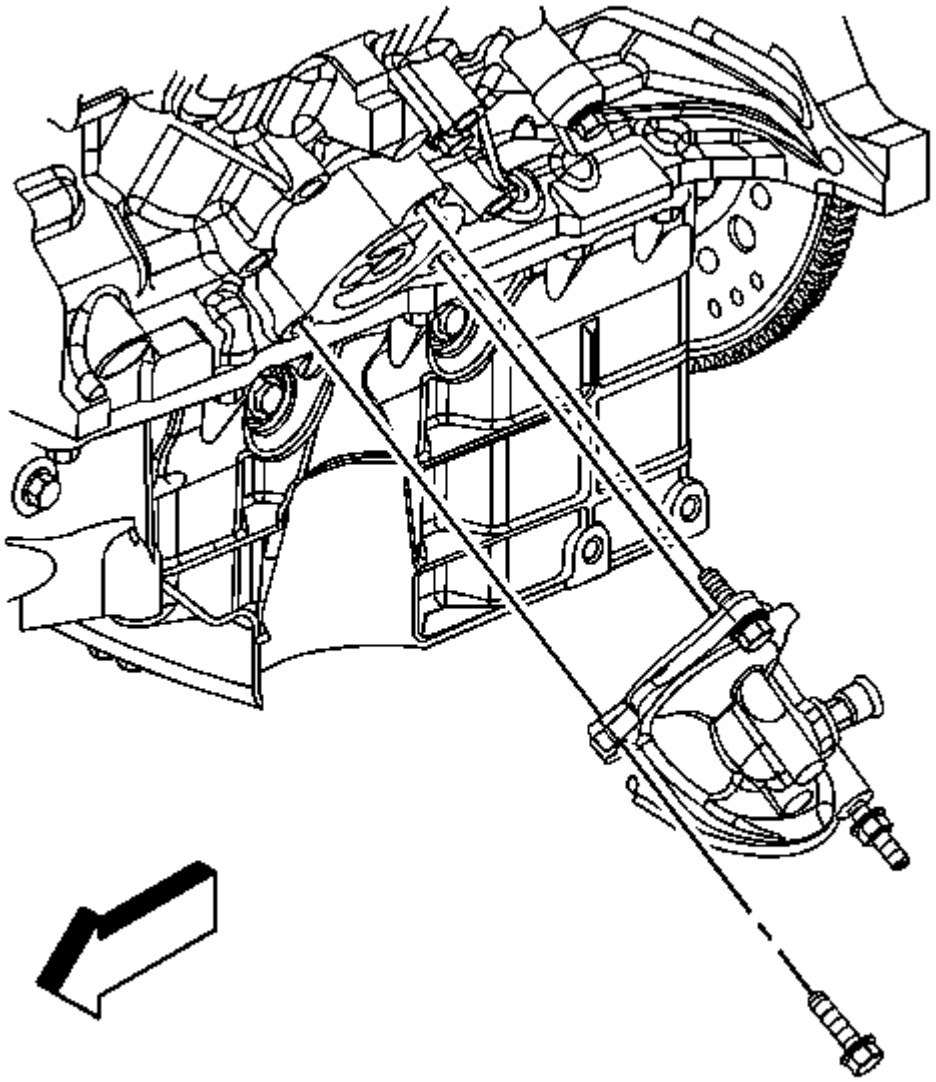

Fig. 41: Identifying Oil Filter Adapter Bolts & Stud
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil filter adapter bolts and stud.
6. Remove the oil filter adapter and gasket.

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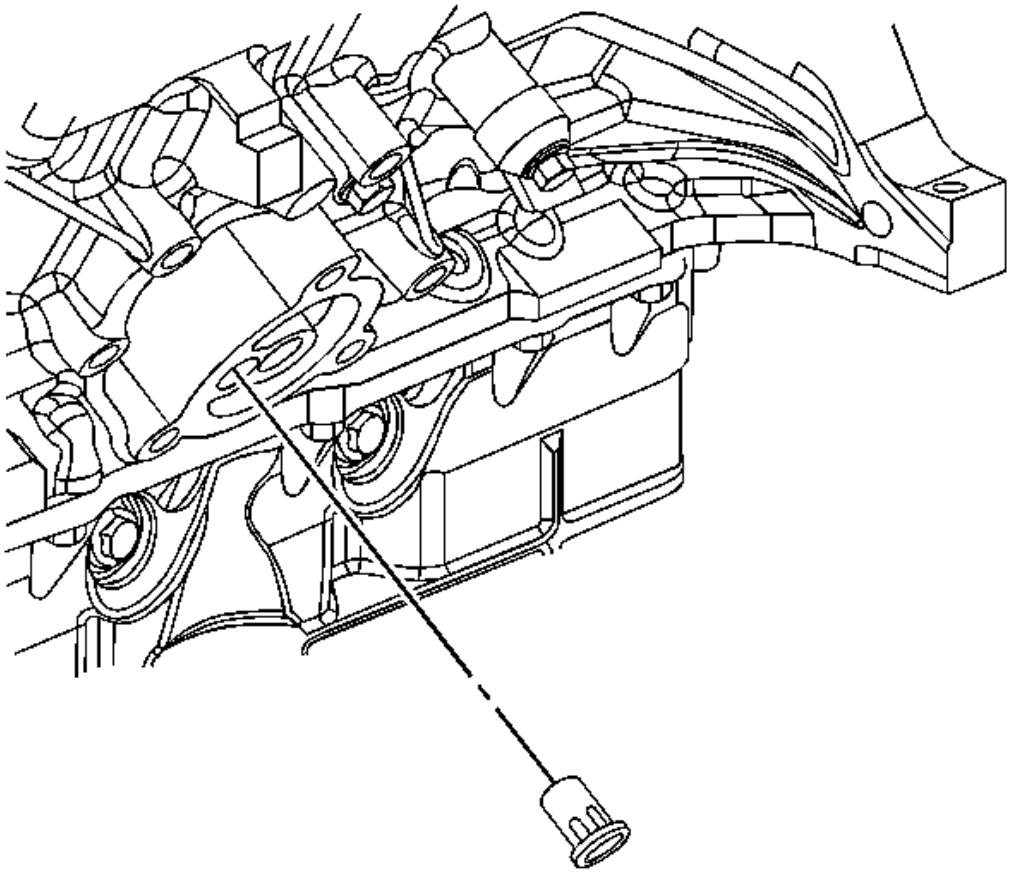

Fig. 42: Locating Oil Filter Bypass Hole & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

7. Insert a flat-bladed tool into the oil filter bypass hole and remove the oil filter bypass valve.

Installation Procedure

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

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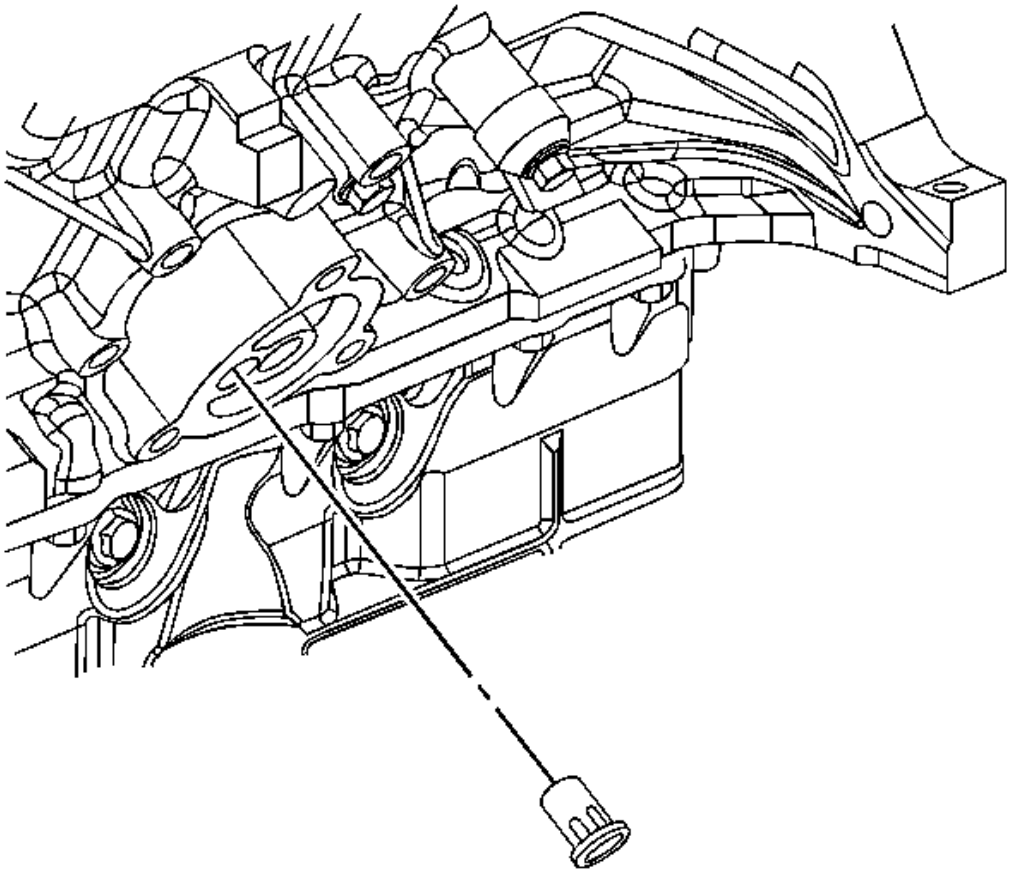

Fig. 43: Locating Oil Filter Bypass Hole & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil filter bypass valve. Seat the valve fully below the bypass valve hole chamfer.

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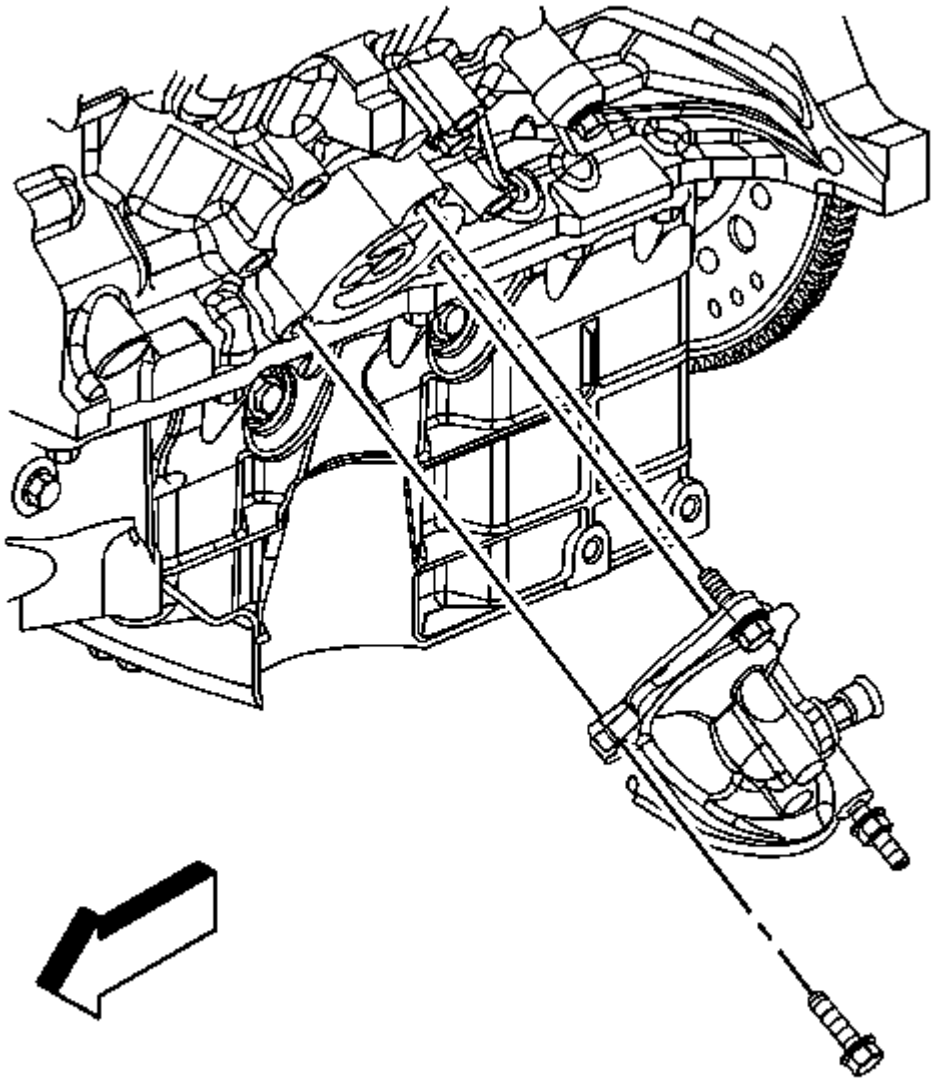

Fig. 44: Identifying Oil Filter Adapter Bolts & Stud
Courtesy of GENERAL MOTORS CORP.

2. Position the oil filter adapter and gasket to the engine.
3. Apply threadlock to the bolt/stud threads, if required. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

CAUTION: Refer to Fastener Caution .

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4. Install the oil filter adapter bolts and stud.

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

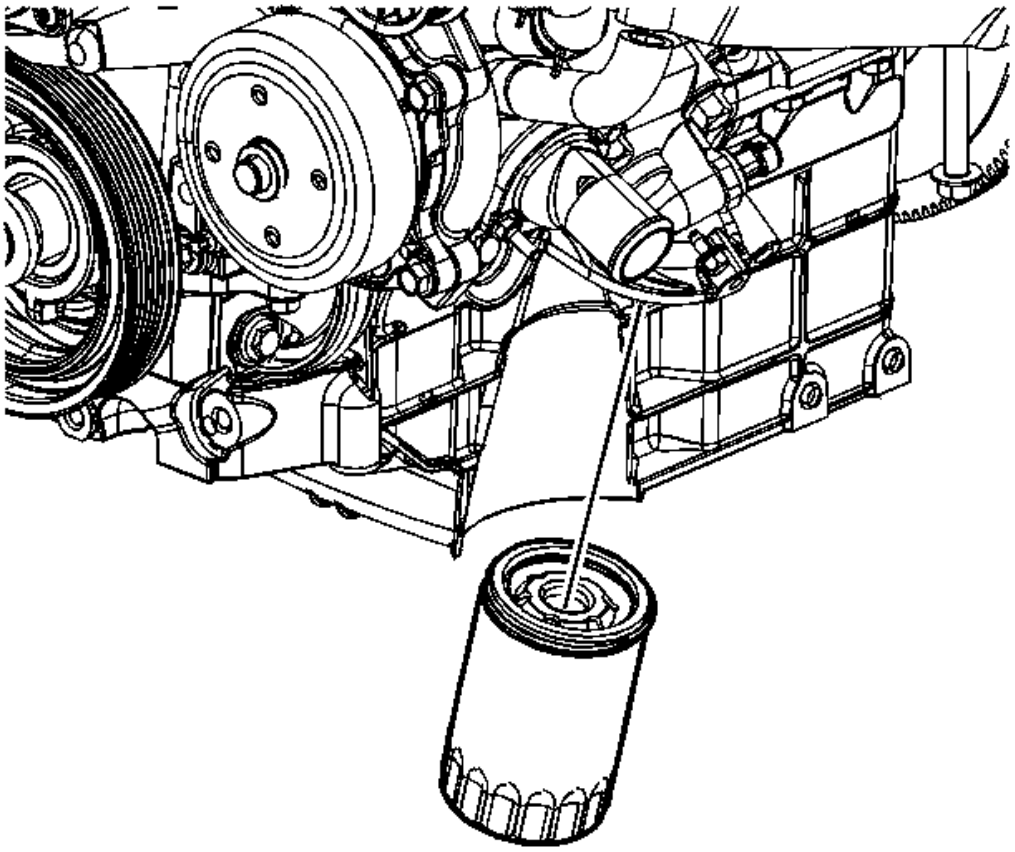

Fig. 45: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

5. Install the oil filter.

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

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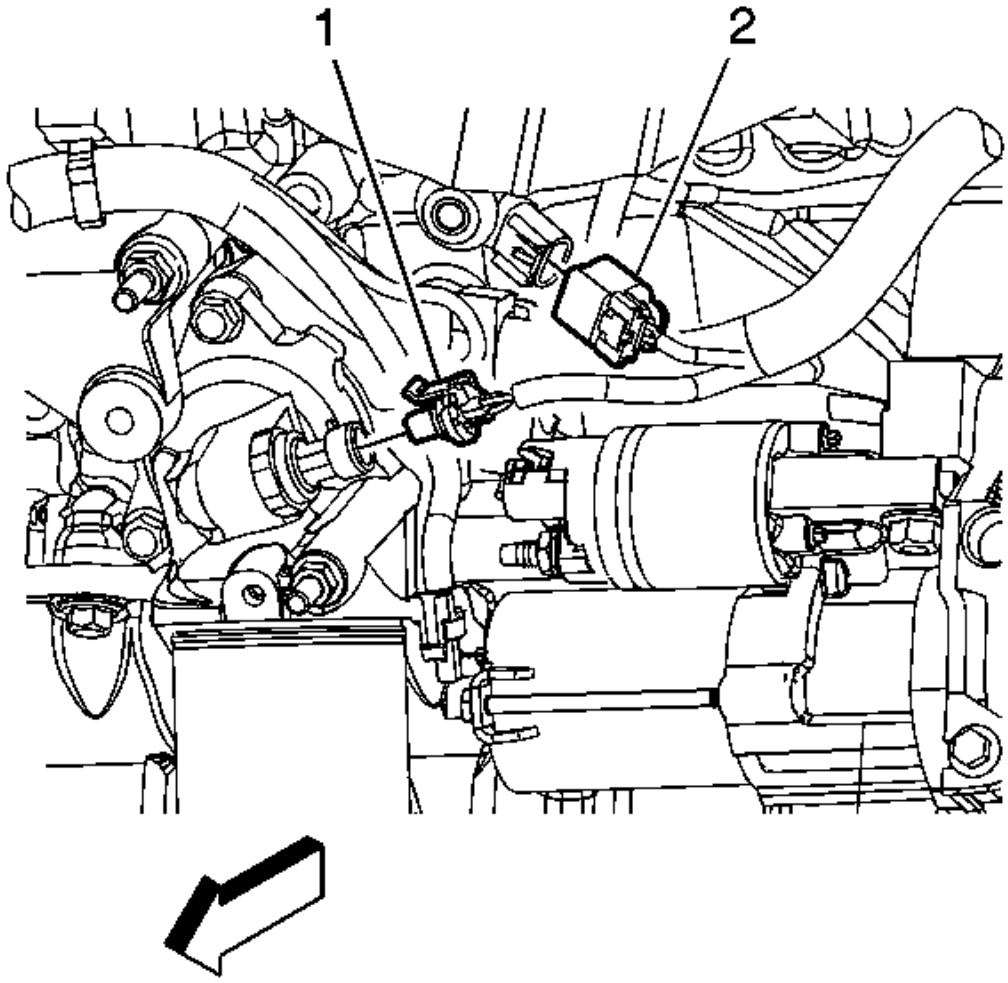

Fig. 46: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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

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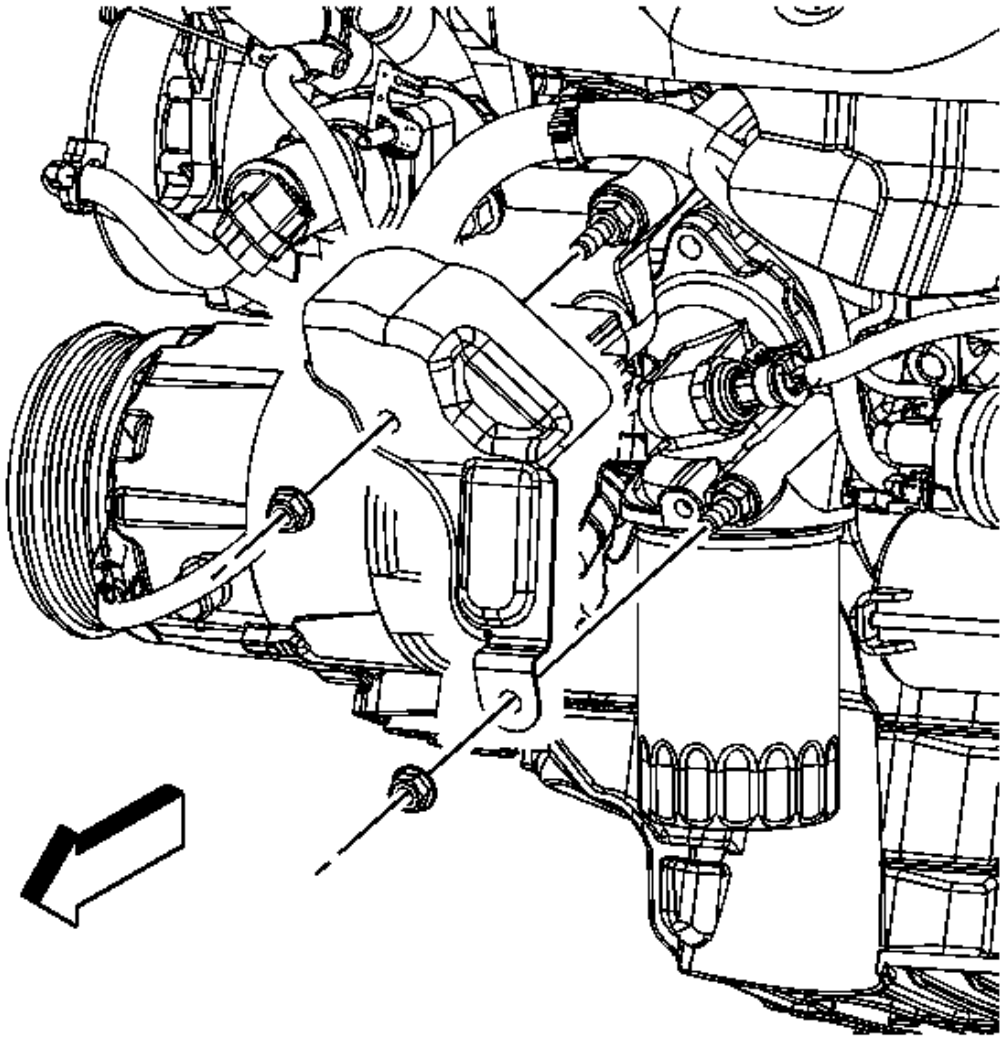

Fig. 47: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the oil pressure sensor heat shield and bolts.

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

8. Lower the vehicle.
9. Check and fill the crankcase, if necessary.

ENGINE OIL COOLER REPLACEMENT

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Removal Procedure

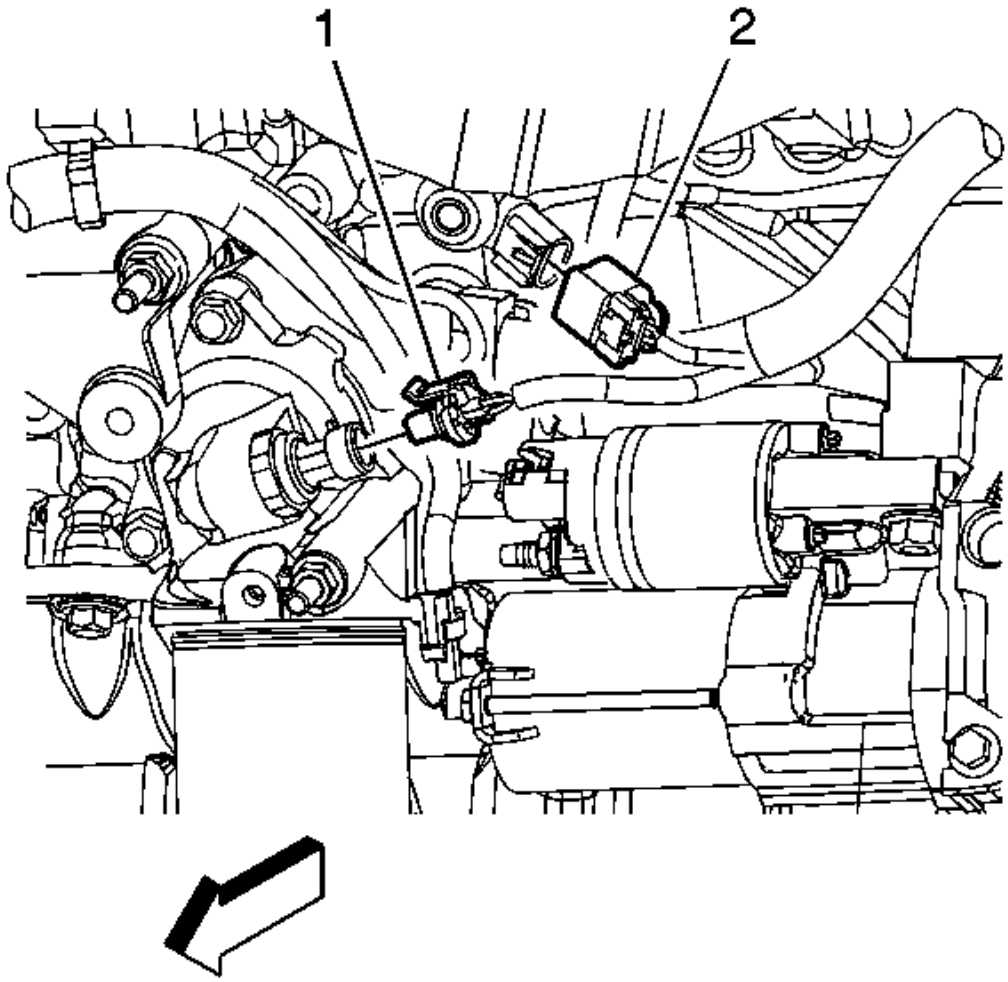

Fig. 48: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
2. Disconnect the oil pressure sensor electrical connector (1).

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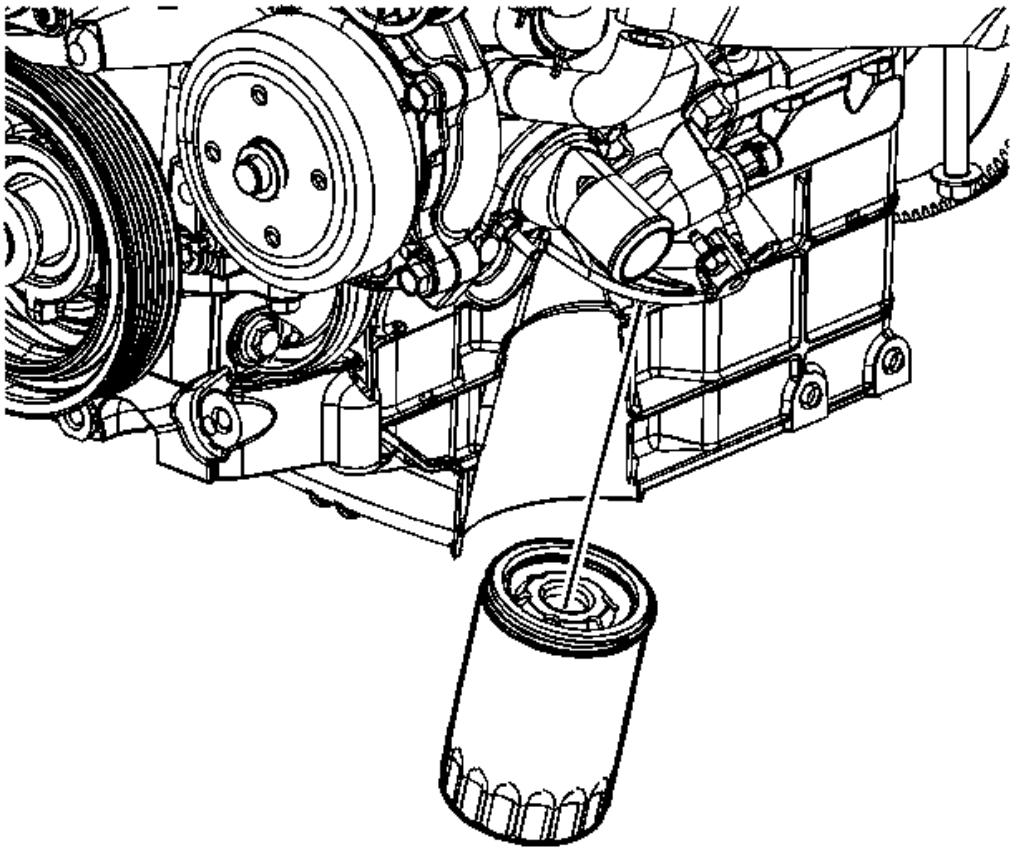

Fig. 49: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

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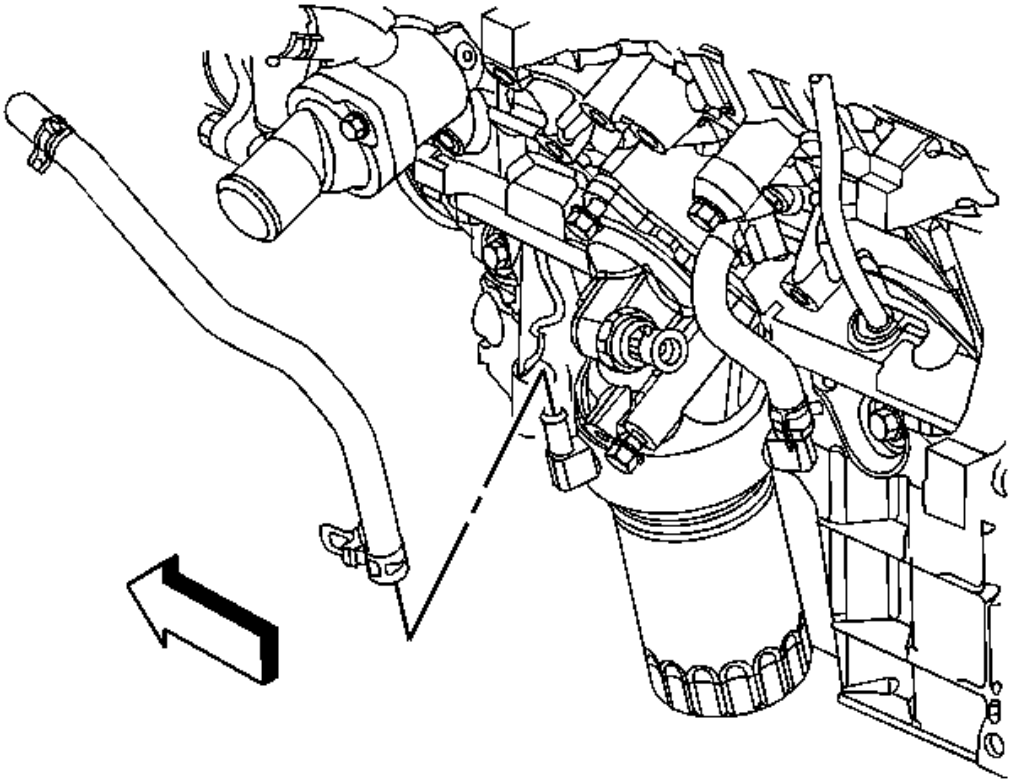

Fig. 50: Identifying Oil Cooler Outlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

4. Reposition the oil cooler outlet hose clamp at the oil cooler.
5. Remove the oil cooler outlet hose from the oil cooler fitting.

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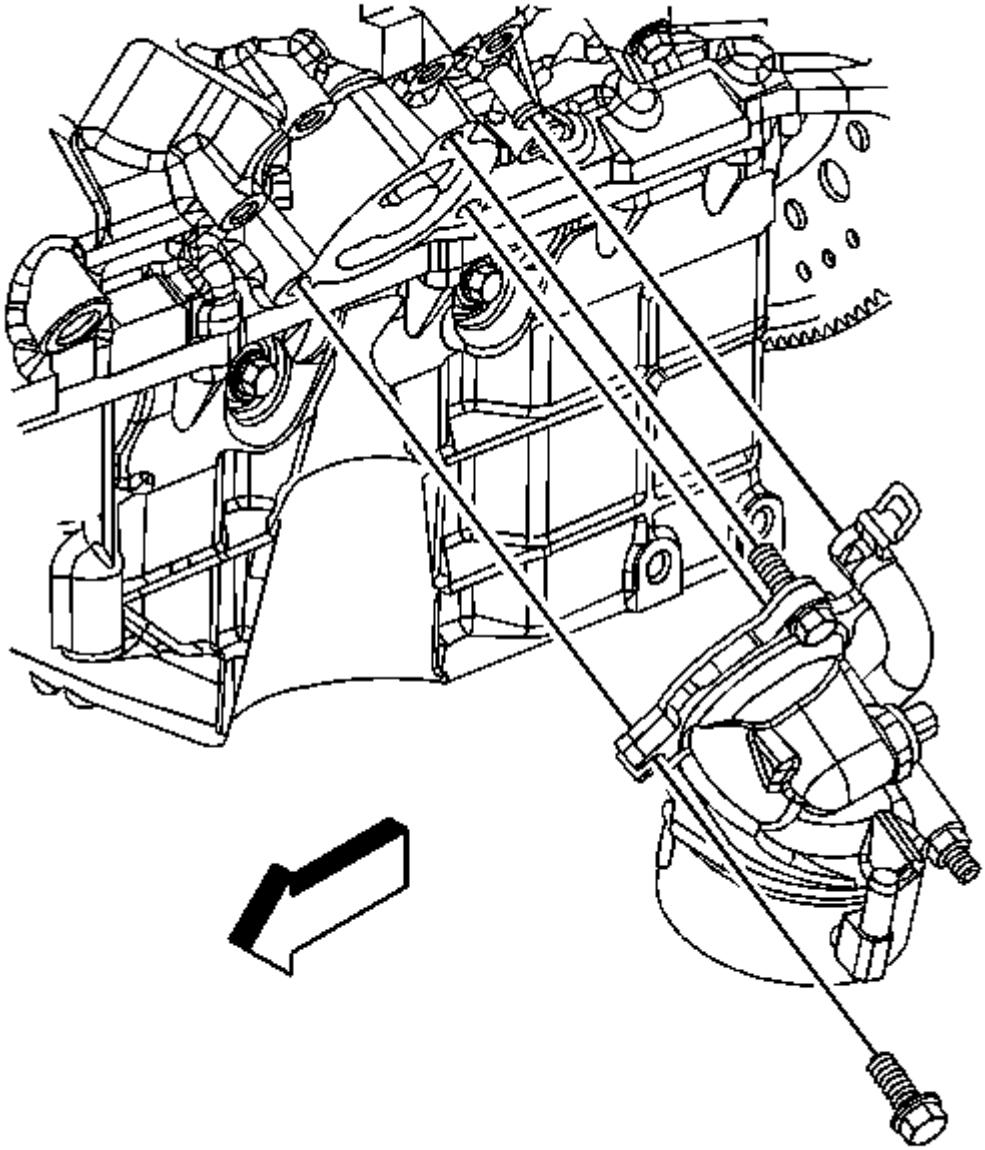

Fig. 51: View Of Oil Cooler Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

6. Reposition the oil cooler inlet hose at the engine.
7. Remove the oil cooler inlet hose from the engine fitting.
8. Remove the oil cooler bolts and stud.
9. Remove the oil cooler and gasket.

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Installation Procedure

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

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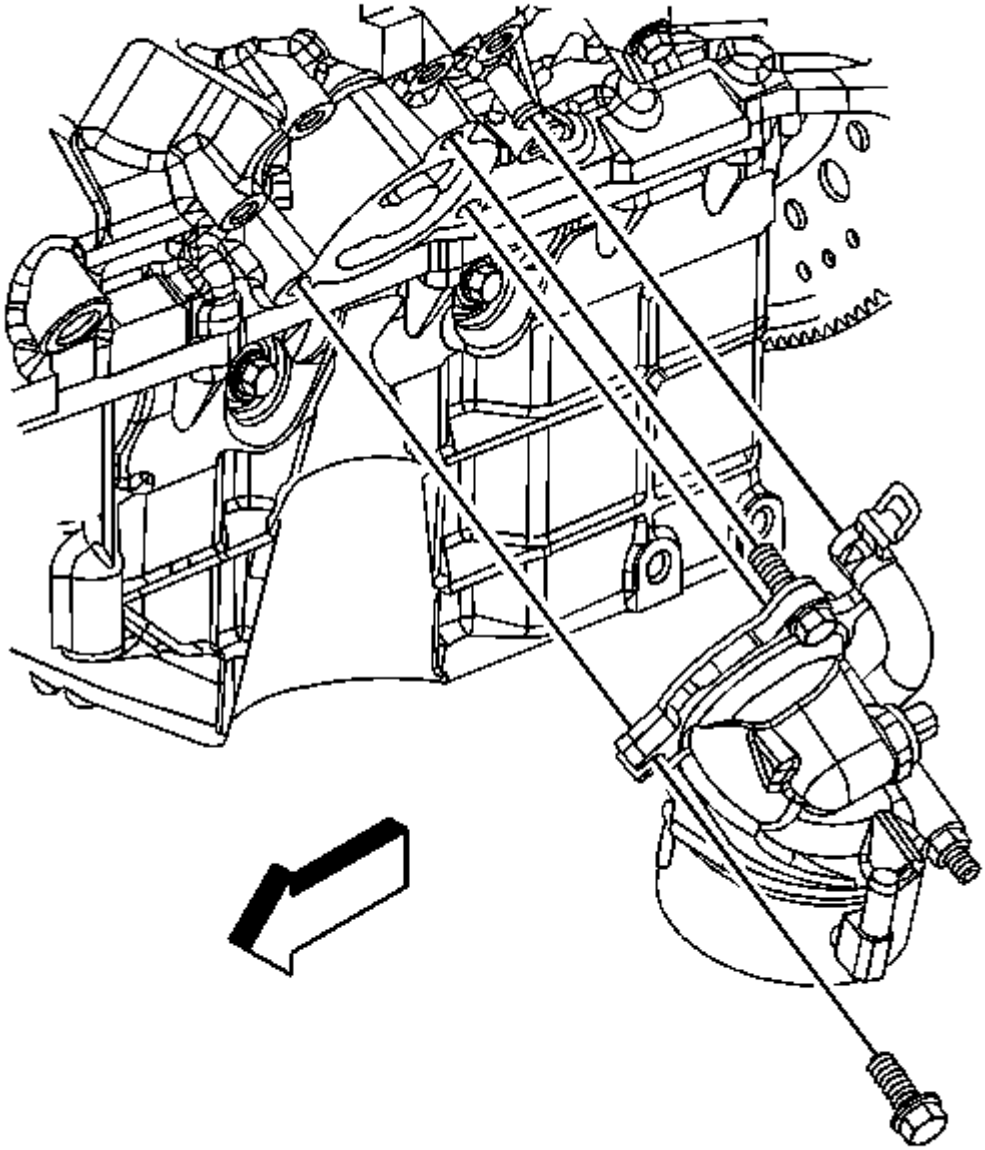

Fig. 52: View Of Oil Cooler Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Apply threadlock to the bolt/stud threads, if required. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
2. Position the oil cooler and gasket to the engine.

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CAUTION: Refer to Fastener Caution .

3. Install the oil cooler bolts and stud.

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

4. Install the oil cooler inlet hose to the engine fitting.
5. Position the oil cooler inlet hose at the engine.

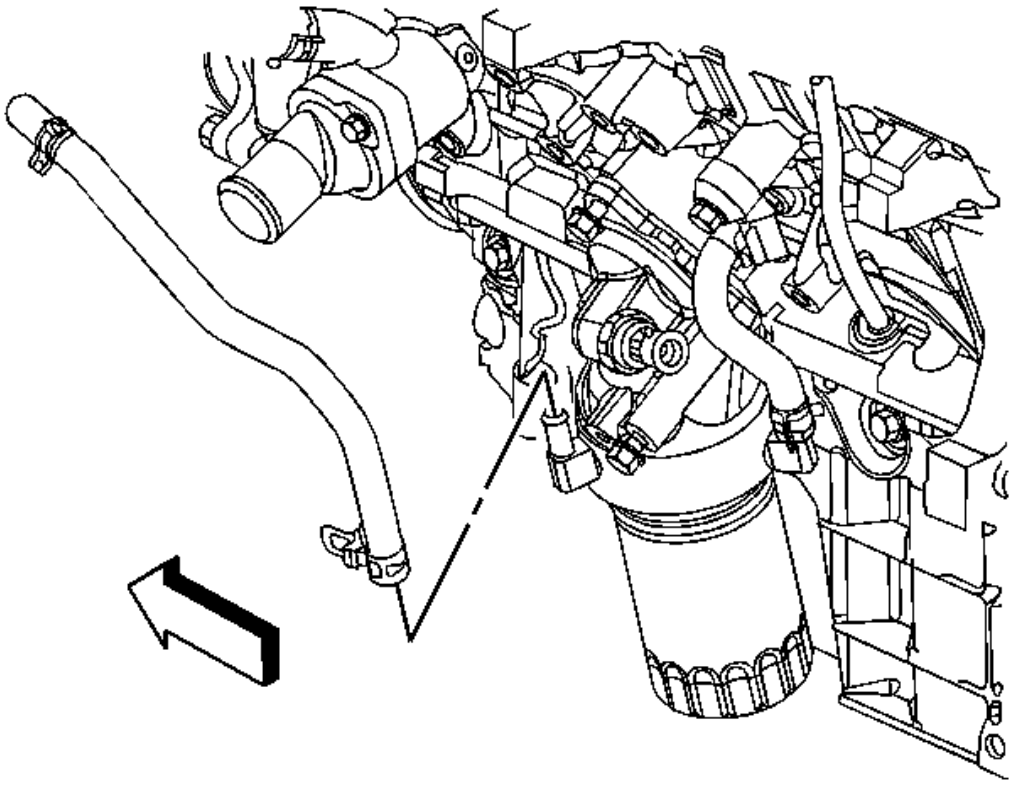

Fig. 53: Identifying Oil Cooler Outlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

6. Install the oil cooler outlet hose to the oil cooler fitting.
7. Position the oil cooler outlet hose clamp at the oil cooler.

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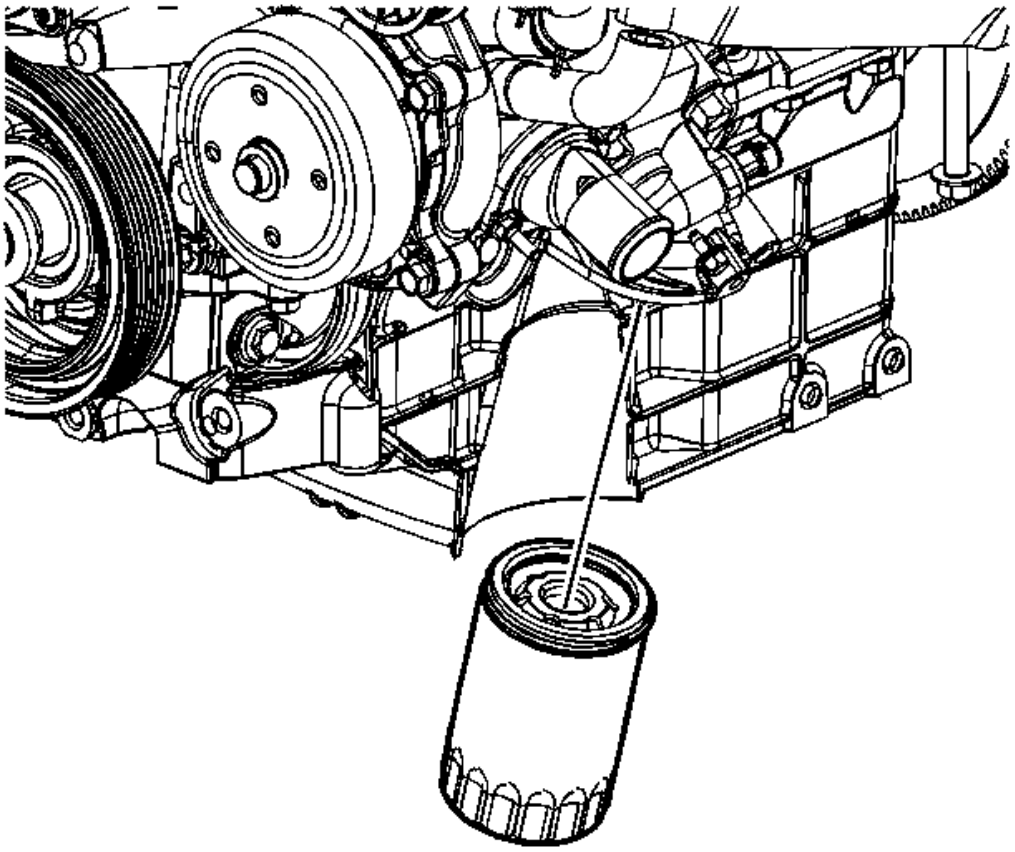

Fig. 54: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

8. Install the oil filter.

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

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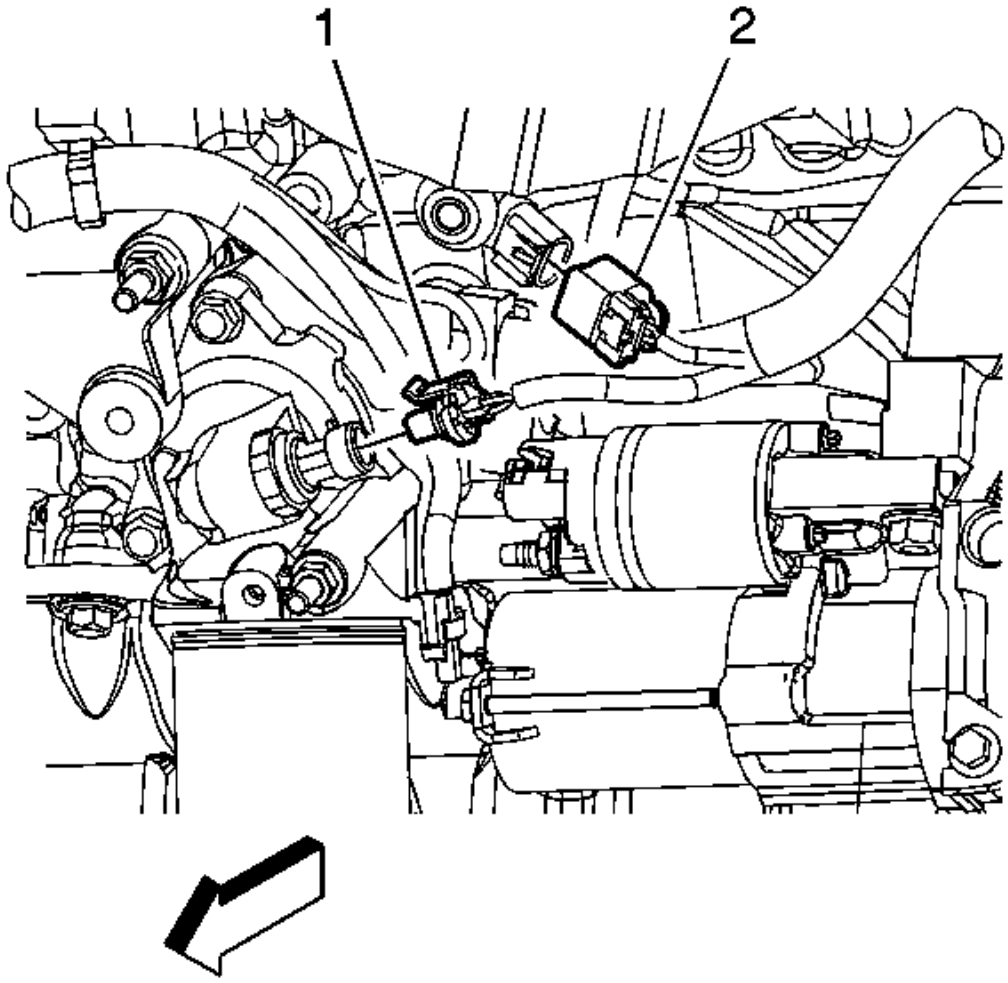

Fig. 55: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the oil pressure sensor electrical connector (1).
10. Fill the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
11. Check and fill the crankcase, if necessary.

OIL LEVEL INDICATOR TUBE REPLACEMENT

Removal Procedure

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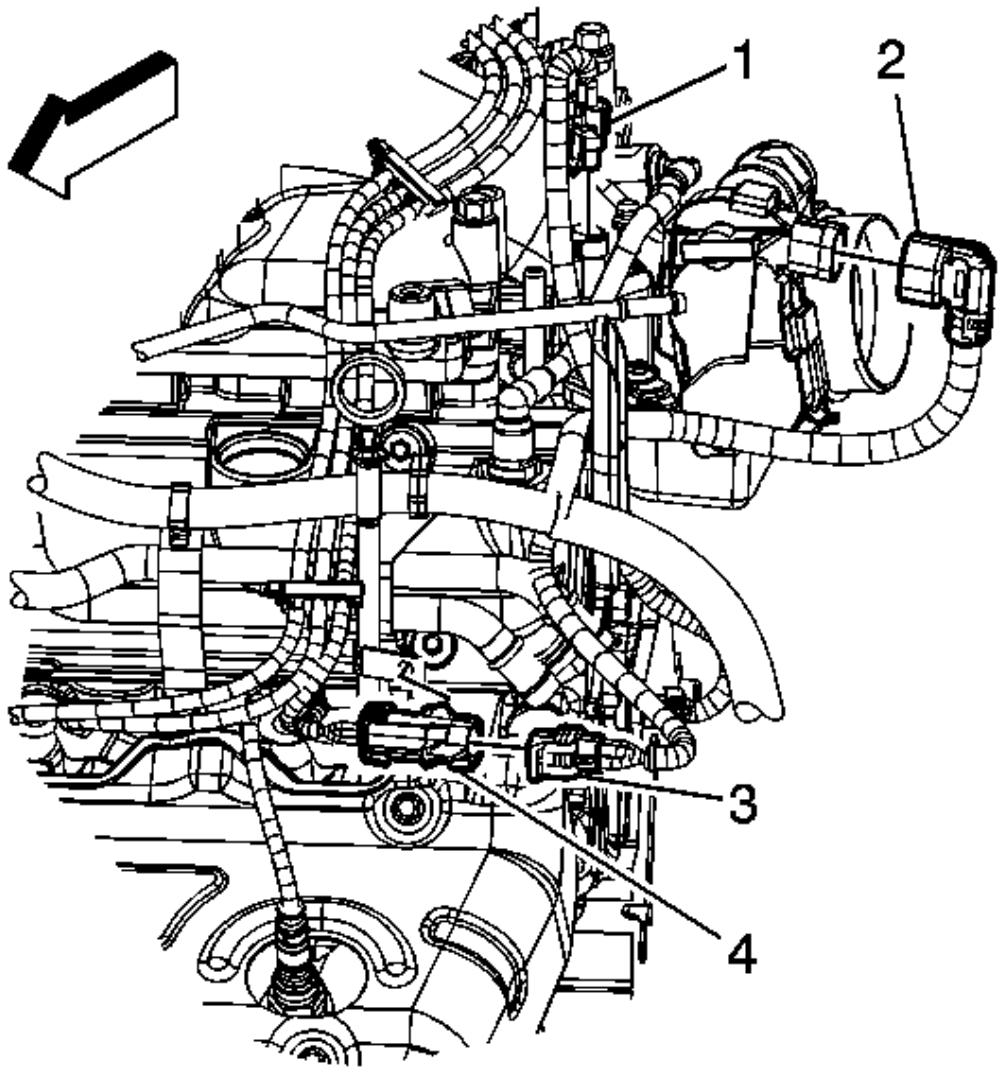

Fig. 56: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wire from the number 6 cylinder spark plug.
2. Remove the heated oxygen sensor (HO2S) clip (3) from the fill tube bracket.

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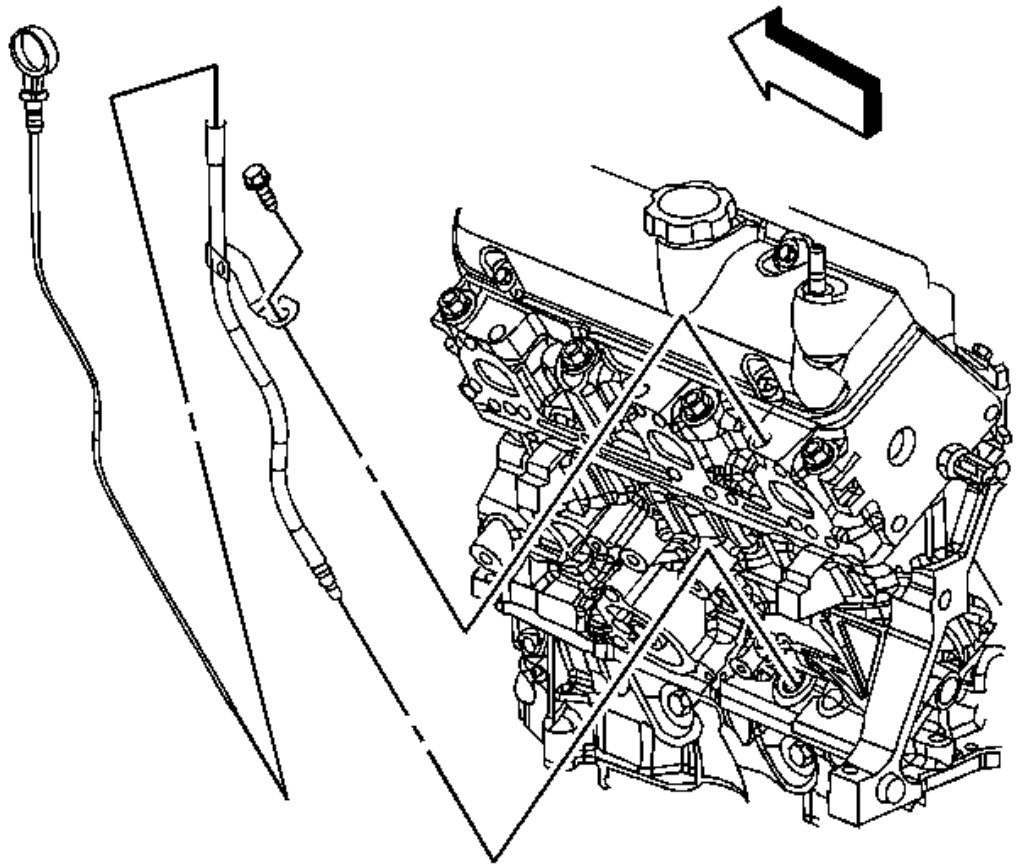

Fig. 57: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level indicator.
4. Remove the oil level indicator tube bracket bolt.
5. Remove the oil level indicator tube.
6. Inspect the oil level indicator tube O-ring seal, for damage, replace as necessary.

Installation Procedure

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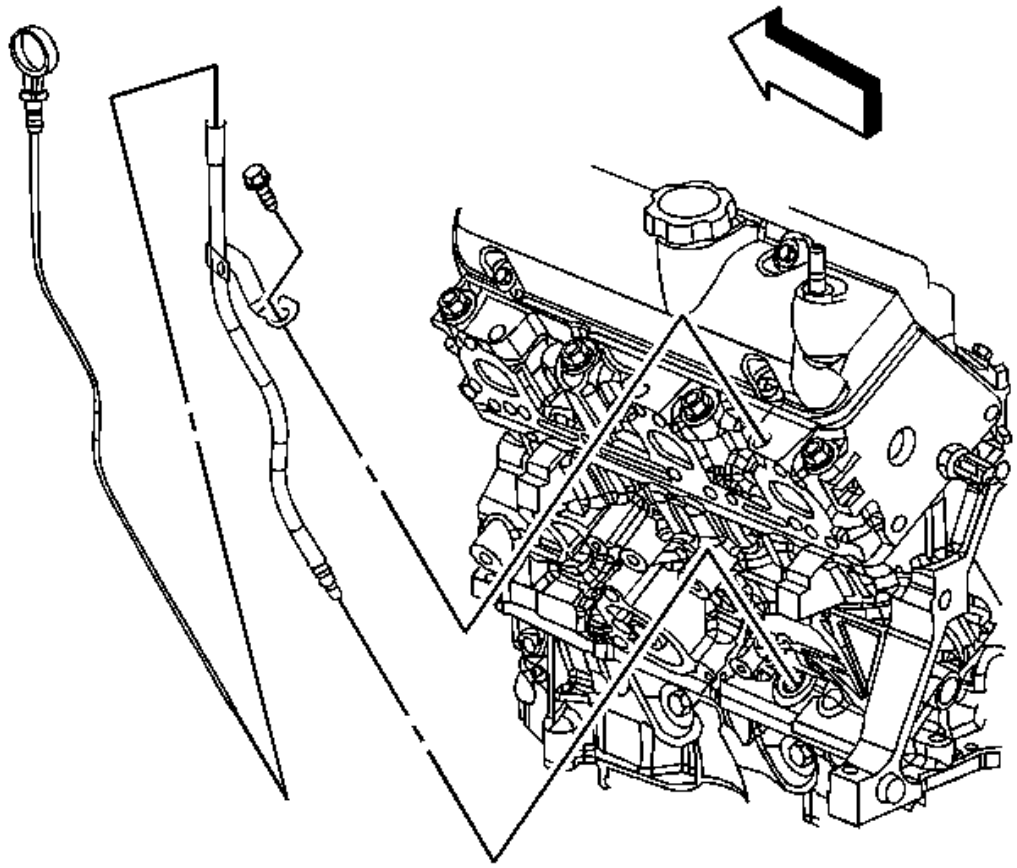

Fig. 58: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring seal with clean engine oil.
2. Install the oil level indicator tube into the engine block.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bracket bolt.

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

4. Install the oil level indicator.

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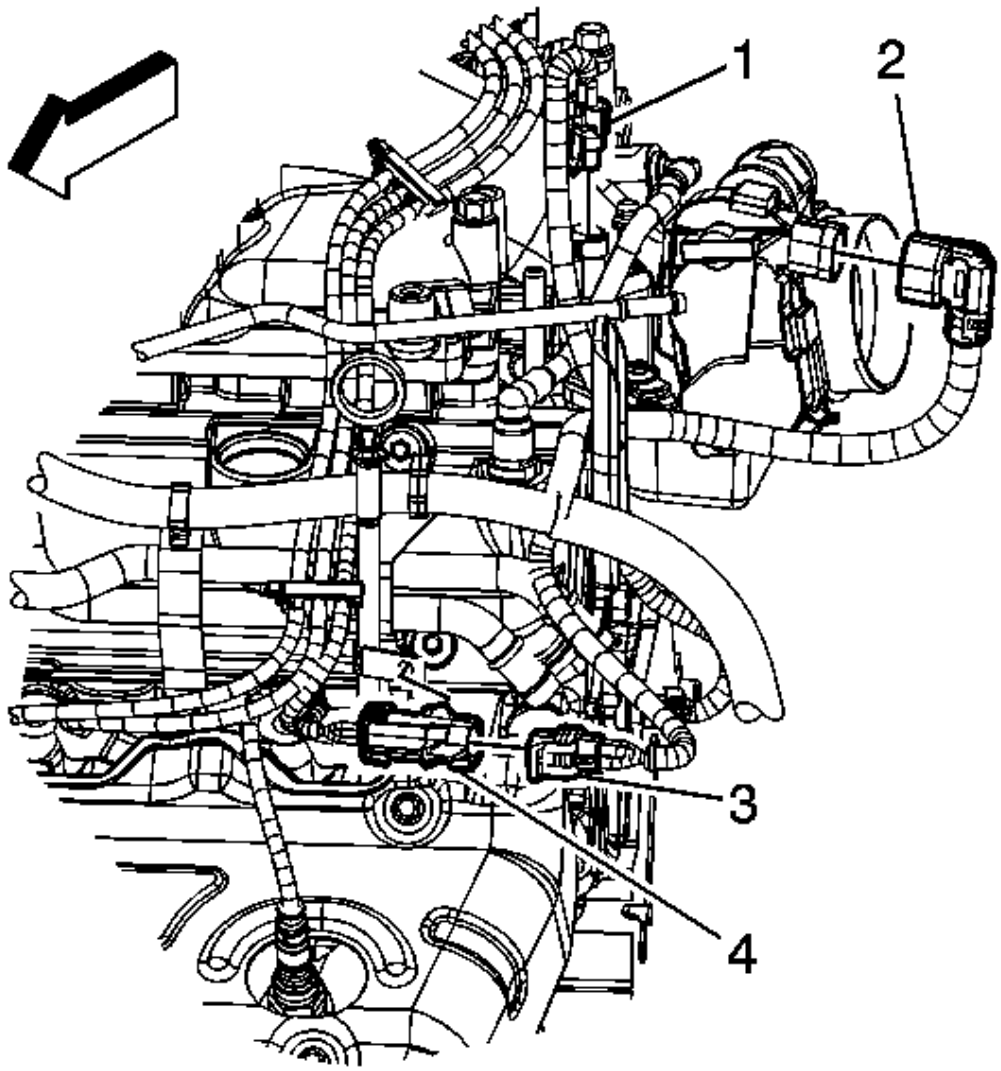

Fig. 59: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

5. Install the HO2S clip (3) to the fill tube bracket.
6. Install the spark plug wire to the number 6 cylinder spark plug.

UPPER INTAKE MANIFOLD REPLACEMENT

Removal Procedure

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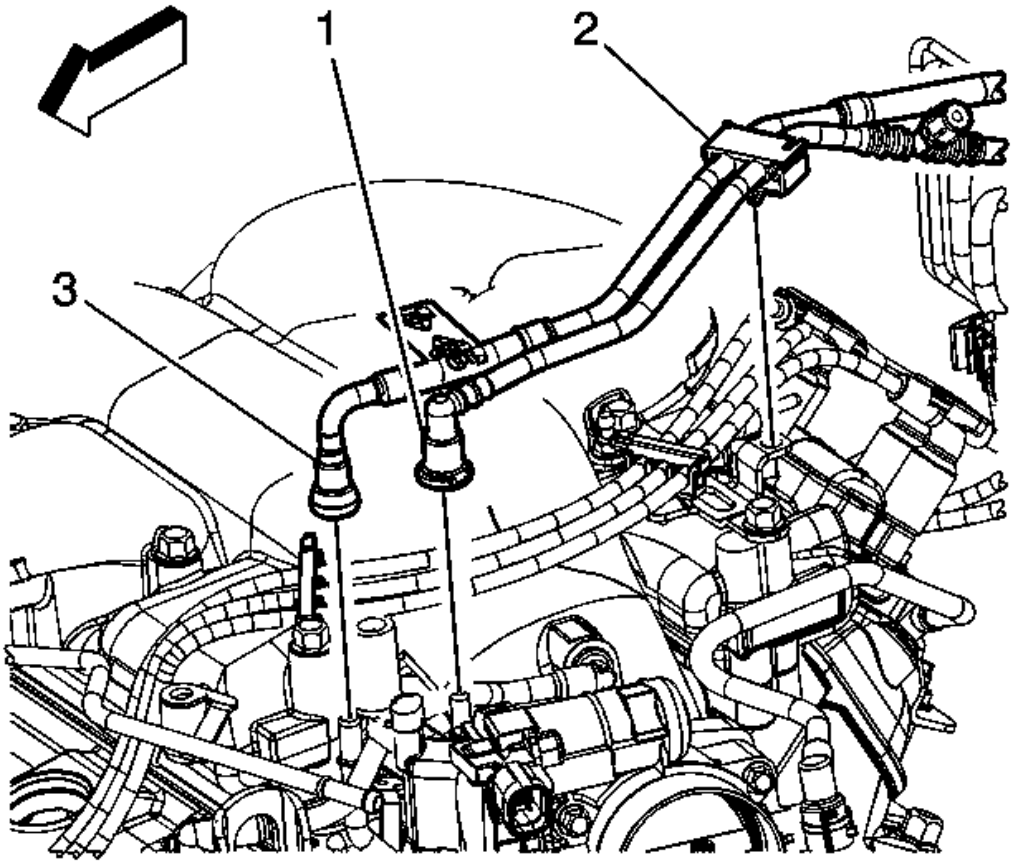

Fig. 60: View Of Fuel Feed/EVAP Pipes
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief (Without CH 48027)** or **Fuel Pressure Relief (With CH 48027)** .
3. Disconnect the fuel feed pipe (3) quick connect fitting from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
4. Disconnect the evaporative (EVAP) emission pipe (1) from the purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Open the retaining clip (2), and remove the fuel and EVAP pipes from the clip.

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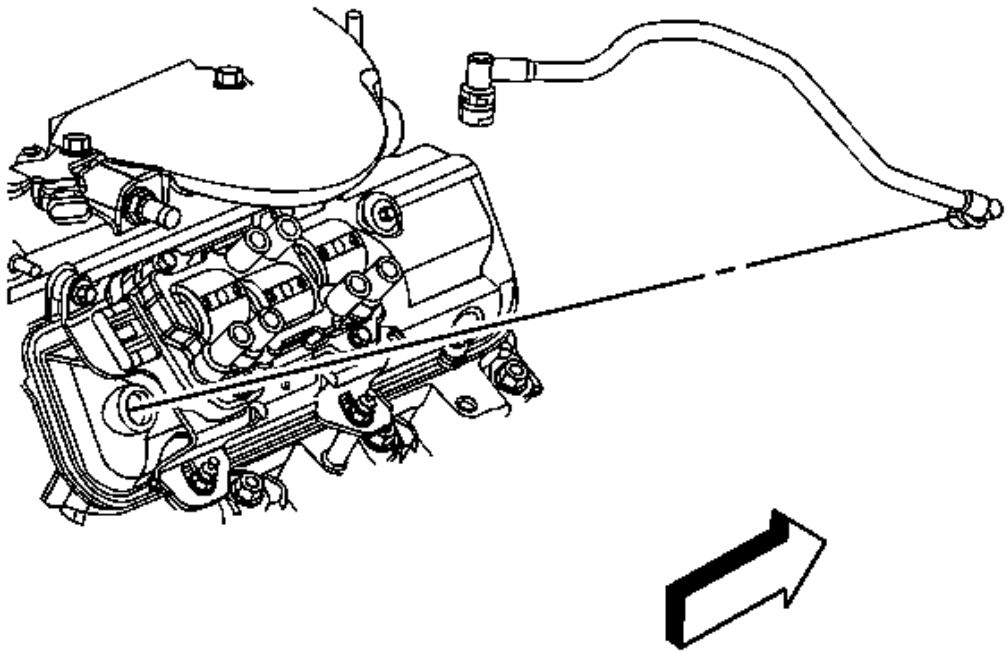

Fig. 61: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

6. Drain the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
7. Remove the positive crankcase ventilation (PCV) fresh air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

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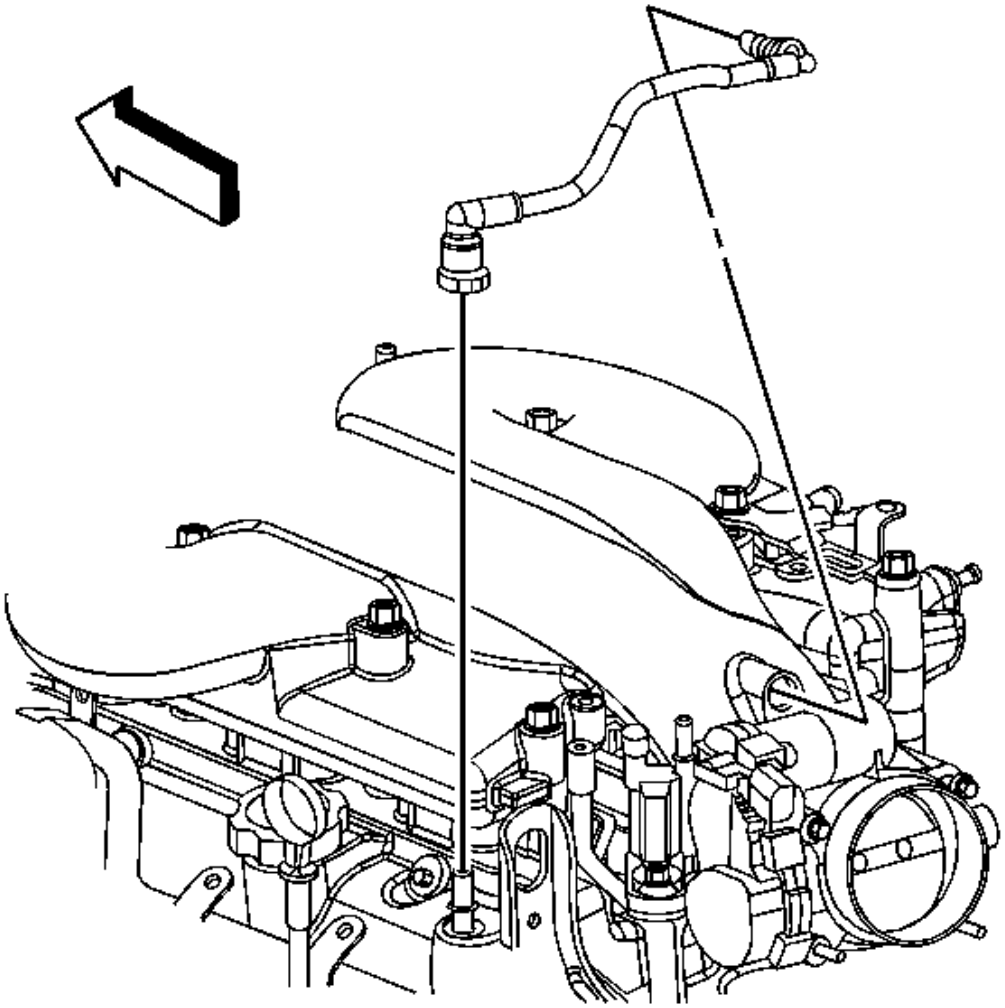

Fig. 62: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the PCV foul air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

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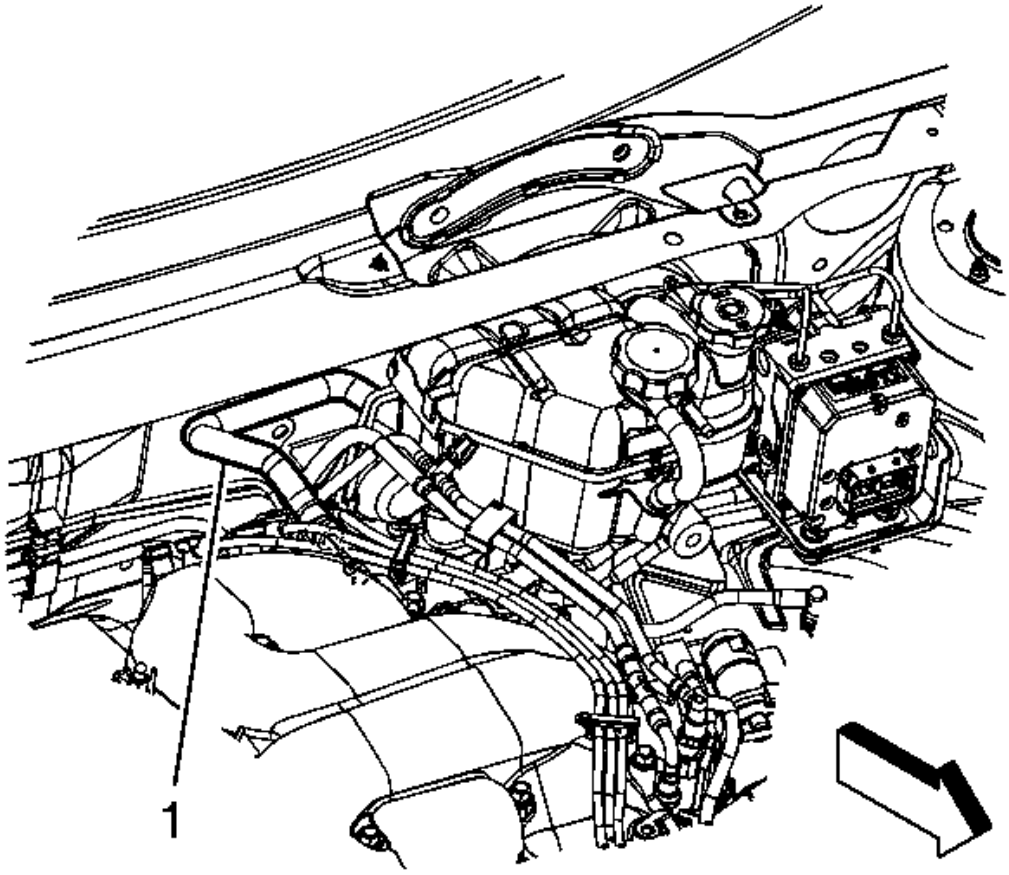

Fig. 63: Identifying Brake Booster Vacuum Hose To Intake Manifold
Courtesy of GENERAL MOTORS CORP.

9. Reposition the brake booster vacuum hose clamp at the intake manifold.
10. Remove the vacuum hose (1) from the intake manifold.

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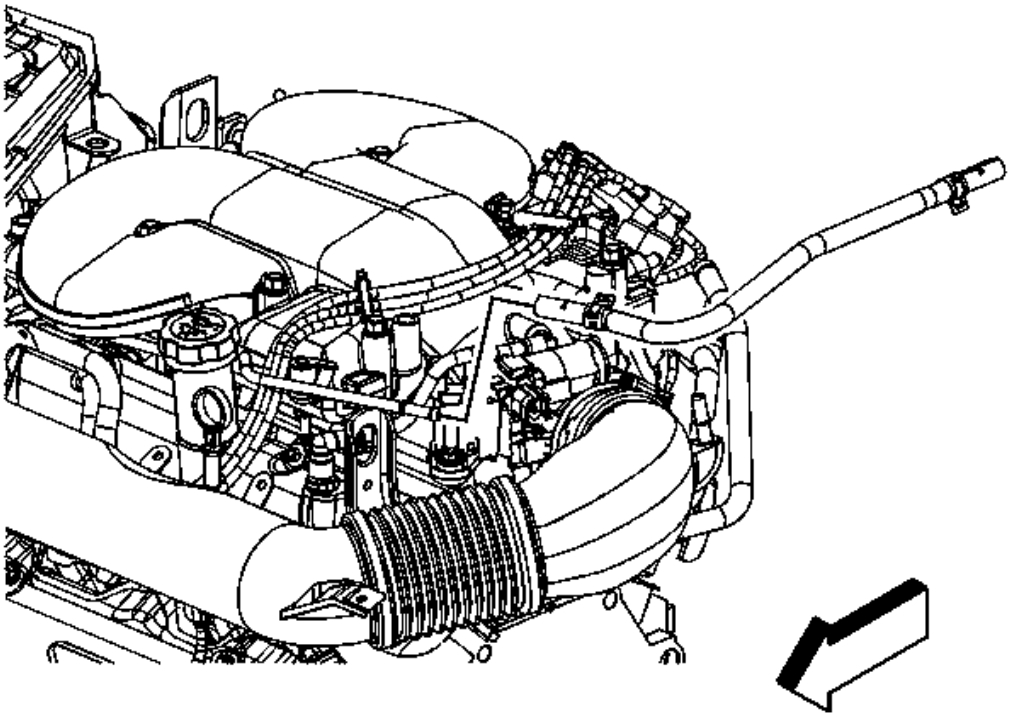

Fig. 64: View Of Radiator Surge Tank Inlet Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

11. Reposition the radiator surge tank inlet hose clamp.
12. Remove the radiator surge tank inlet hose from the inlet pipe.

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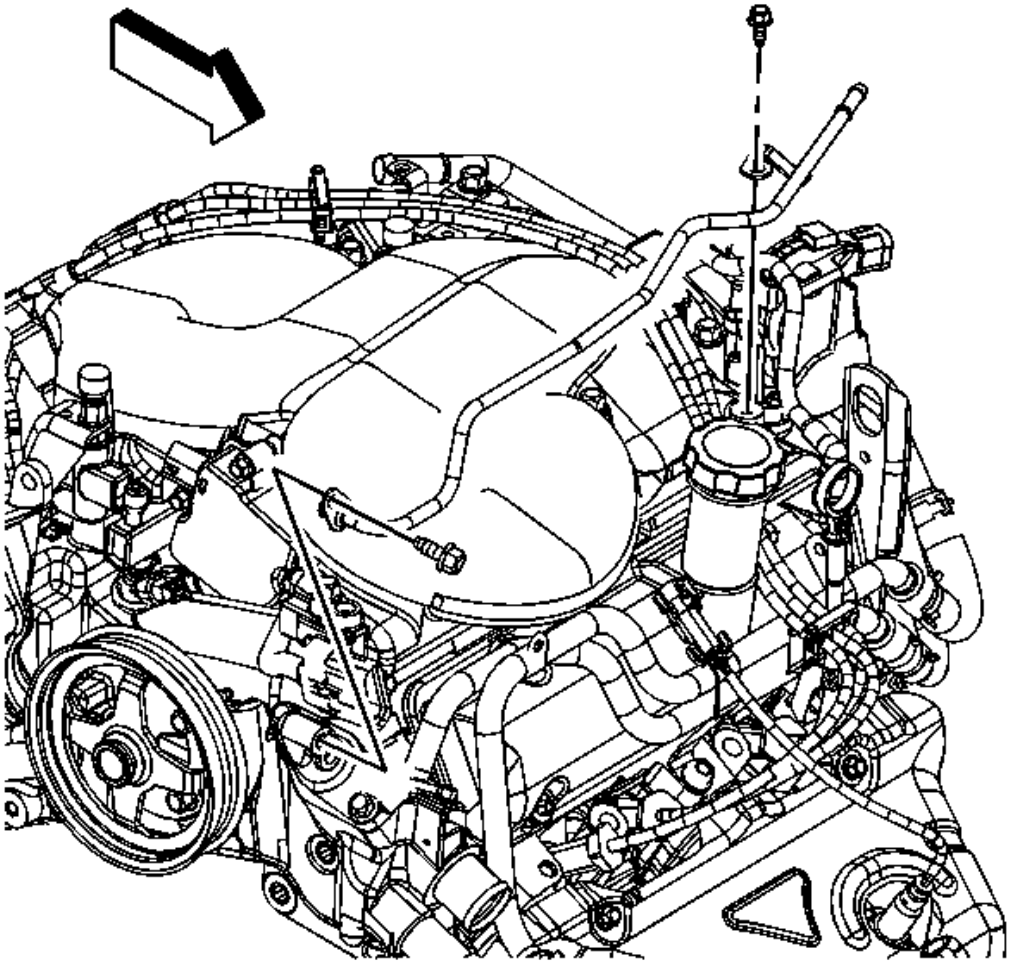

Fig. 65: Identifying Radiator Surge Tank Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the radiator surge tank inlet pipe bolts.
14. Remove the radiator surge tank inlet pipe.

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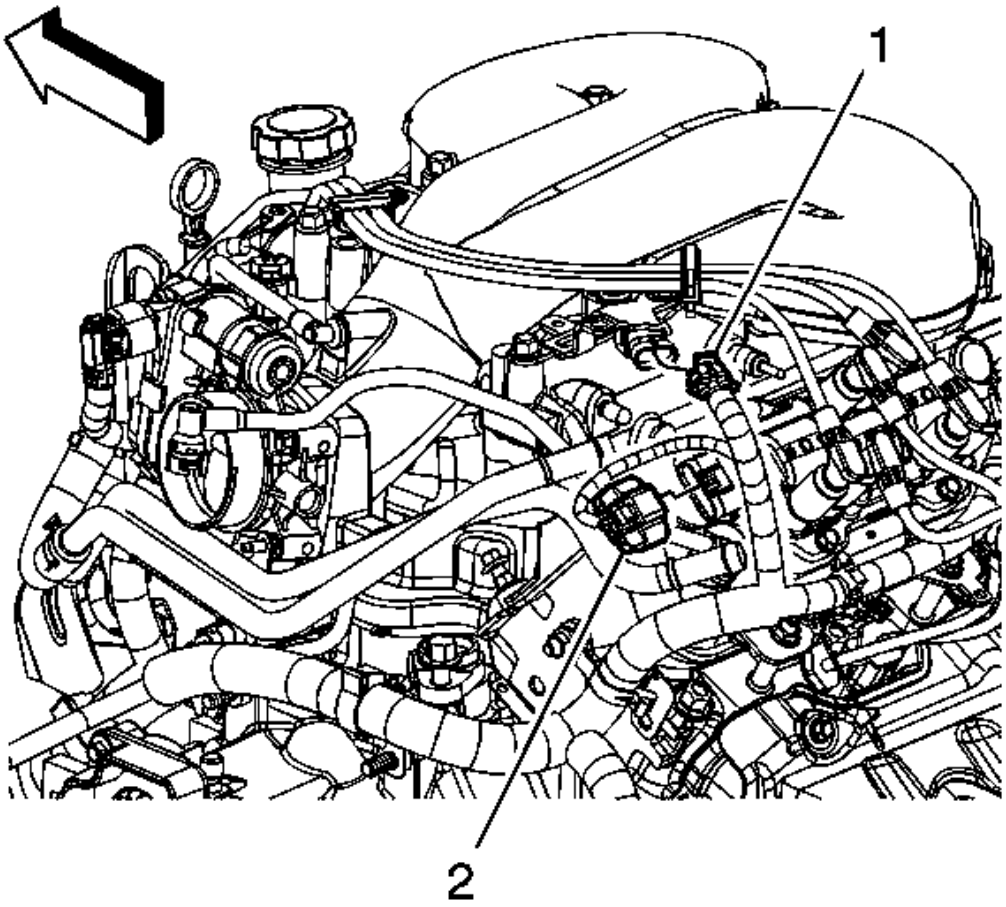

Fig. 66: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (1).

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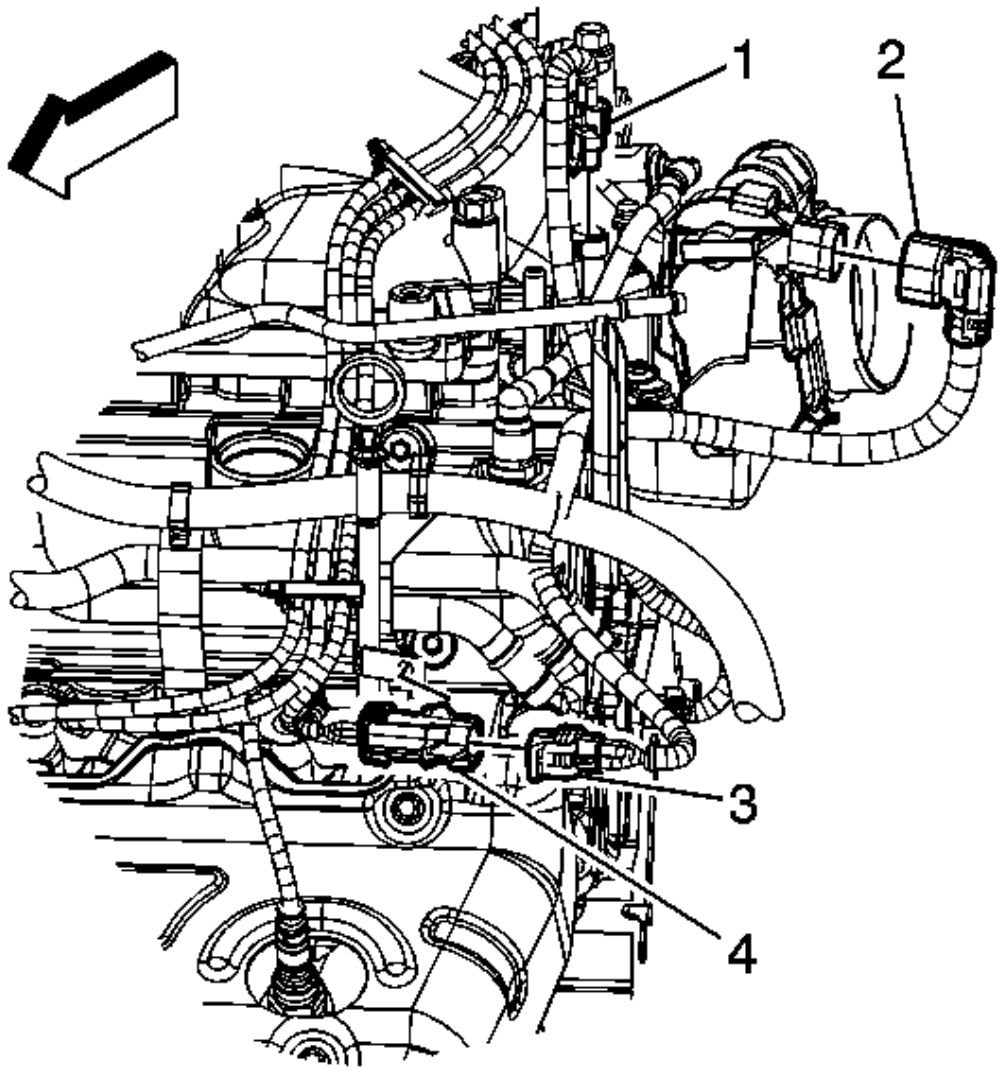

Fig. 67: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

16. Disconnect the evaporative emission (EVAP) canister purge solenoid electrical connector (1).
17. Disconnect the electronic throttle control (ETC) electrical connector (2).

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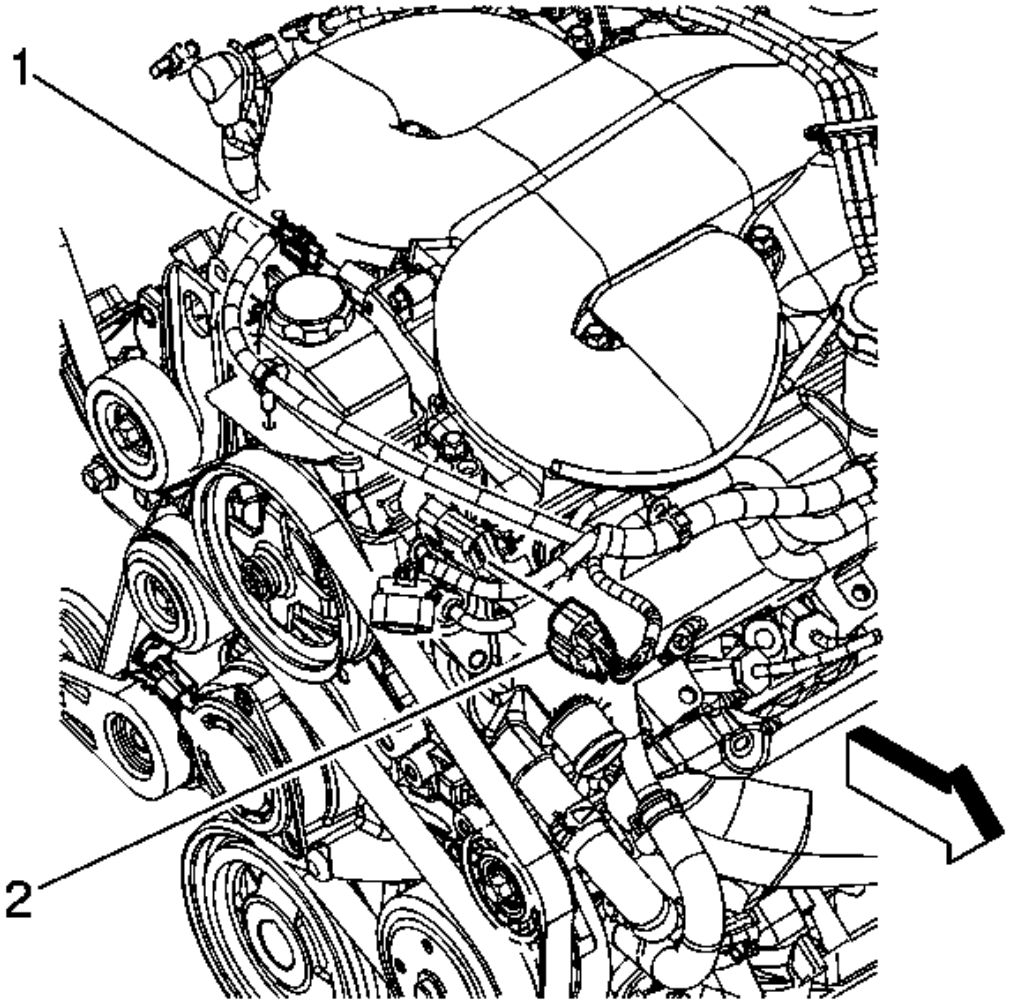

Fig. 68: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the inlet manifold valve electrical connector (1).

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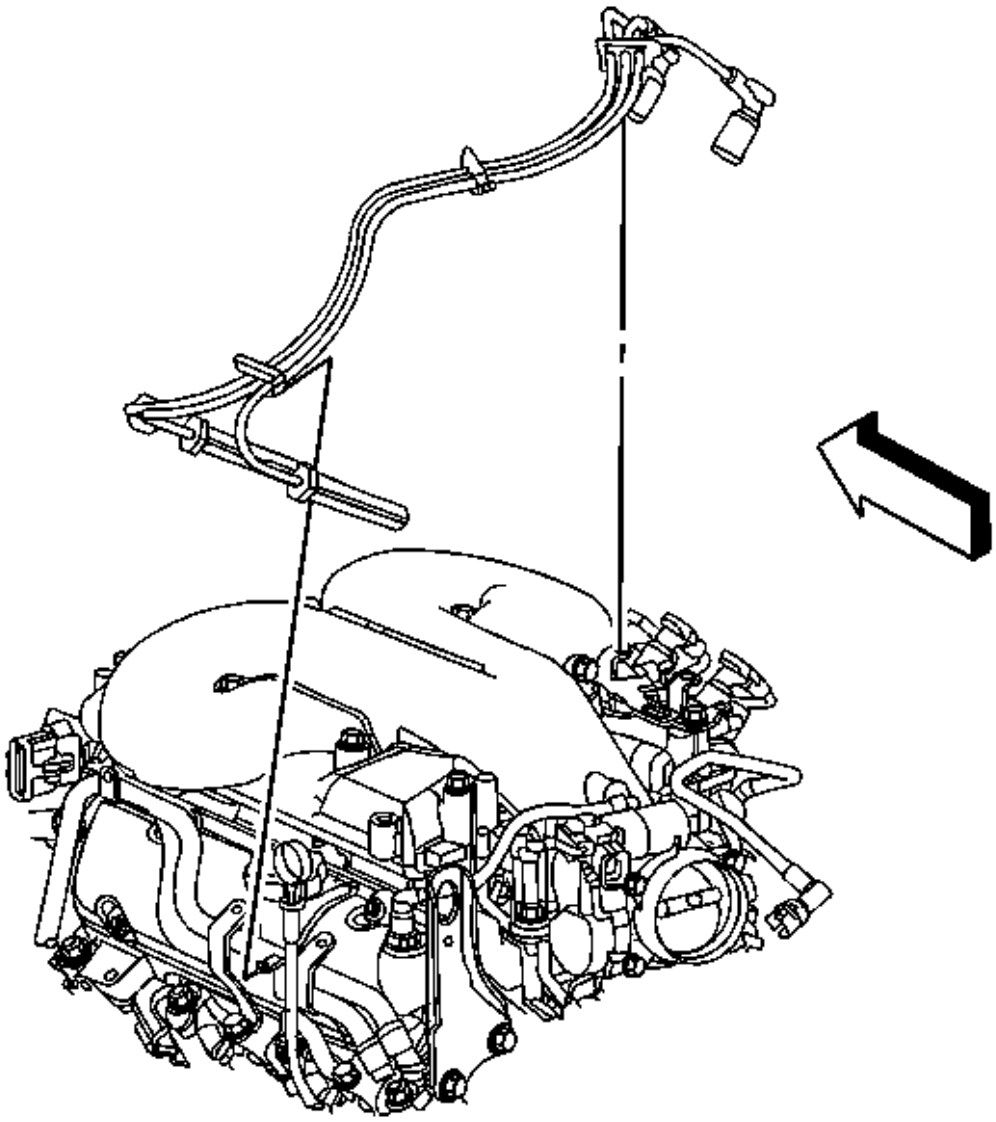

Fig. 69: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

19. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
20. Disconnect the left side spark plug wires from the spark plugs.
21. Disconnect the left side spark plug wires from the ignition coil.
22. Disengage the spark plug wire retainer clips from the intake manifold bracket and the heater inlet/outlet pipe.

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23. Remove the left side spark plug wires.

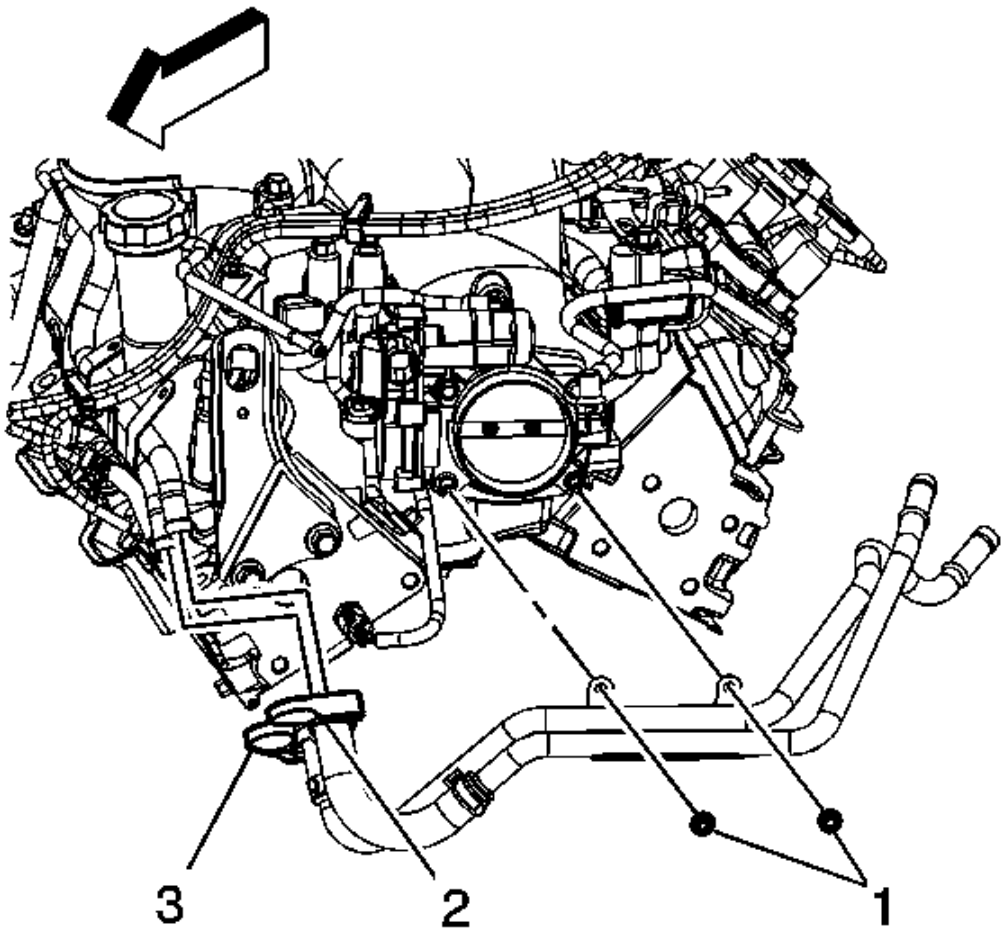

Fig. 70: View Of Inlet & Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

24. Remove the heater inlet and outlet pipe nuts (1) from the throttle body studs.
25. Remove the inlet and outlet pipe (2, 3) from the studs.

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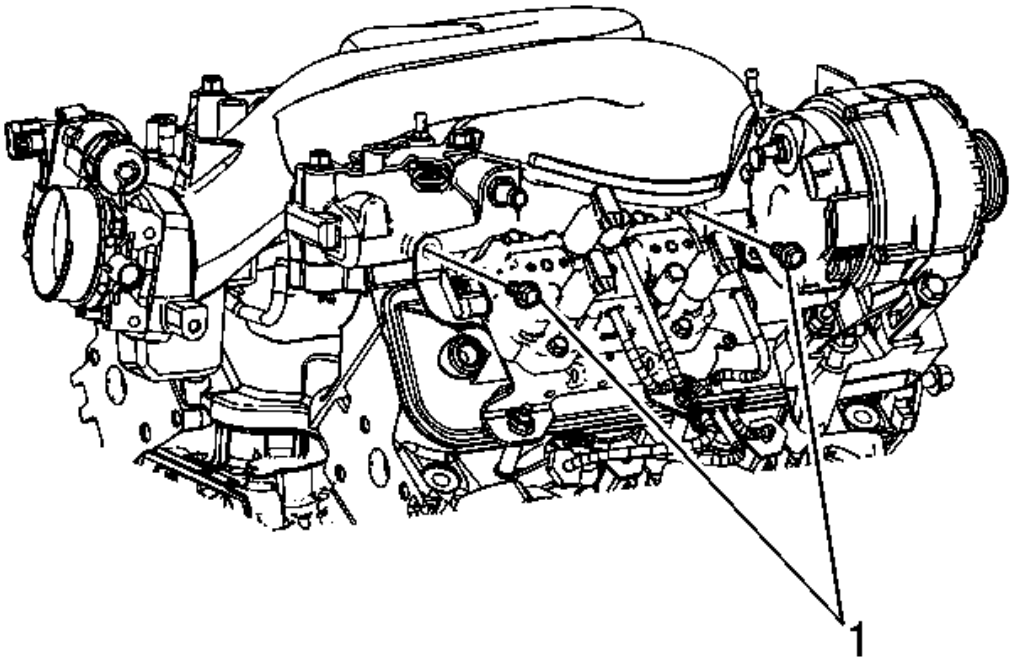

Fig. 71: Identifying Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

26. Remove the 2 ignition coil bolts (1).

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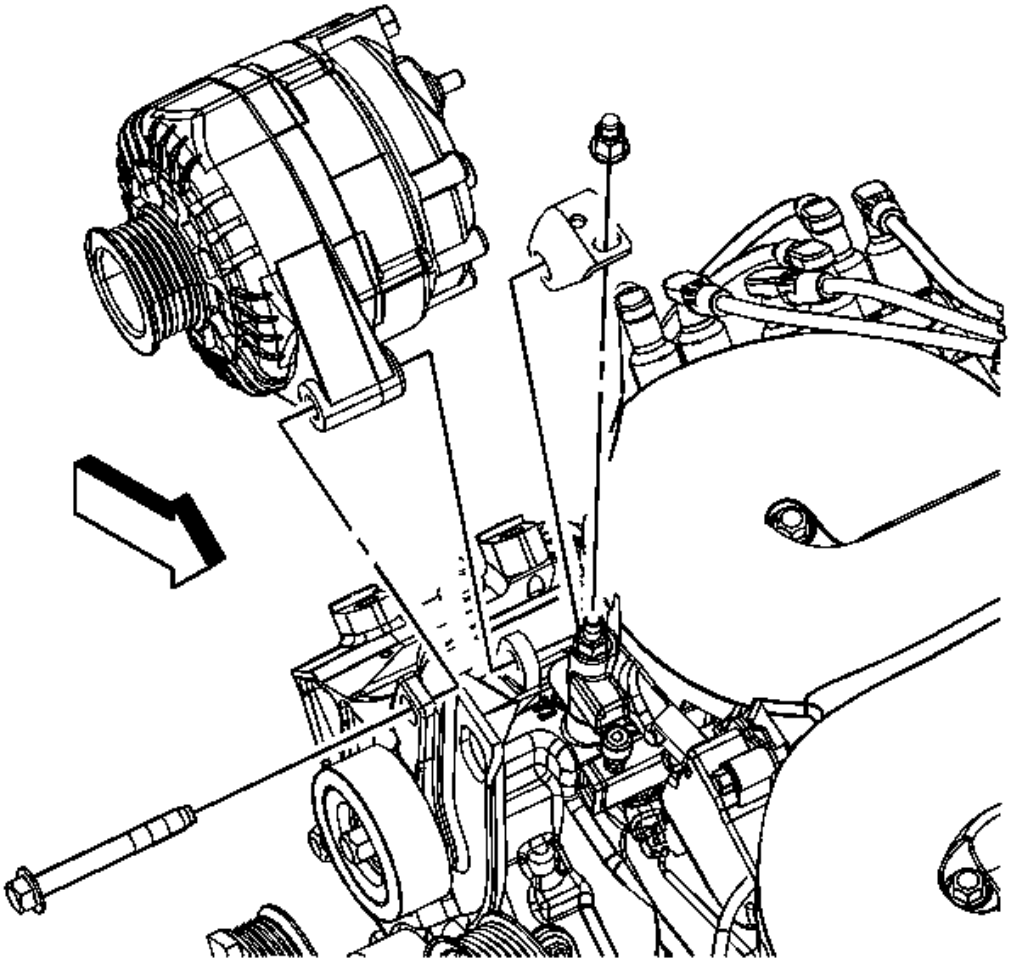

Fig. 72: Identifying Generator, Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

27. Remove the generator upper bolt.
28. Remove the generator ball stud.
29. Remove the generator rear brace.

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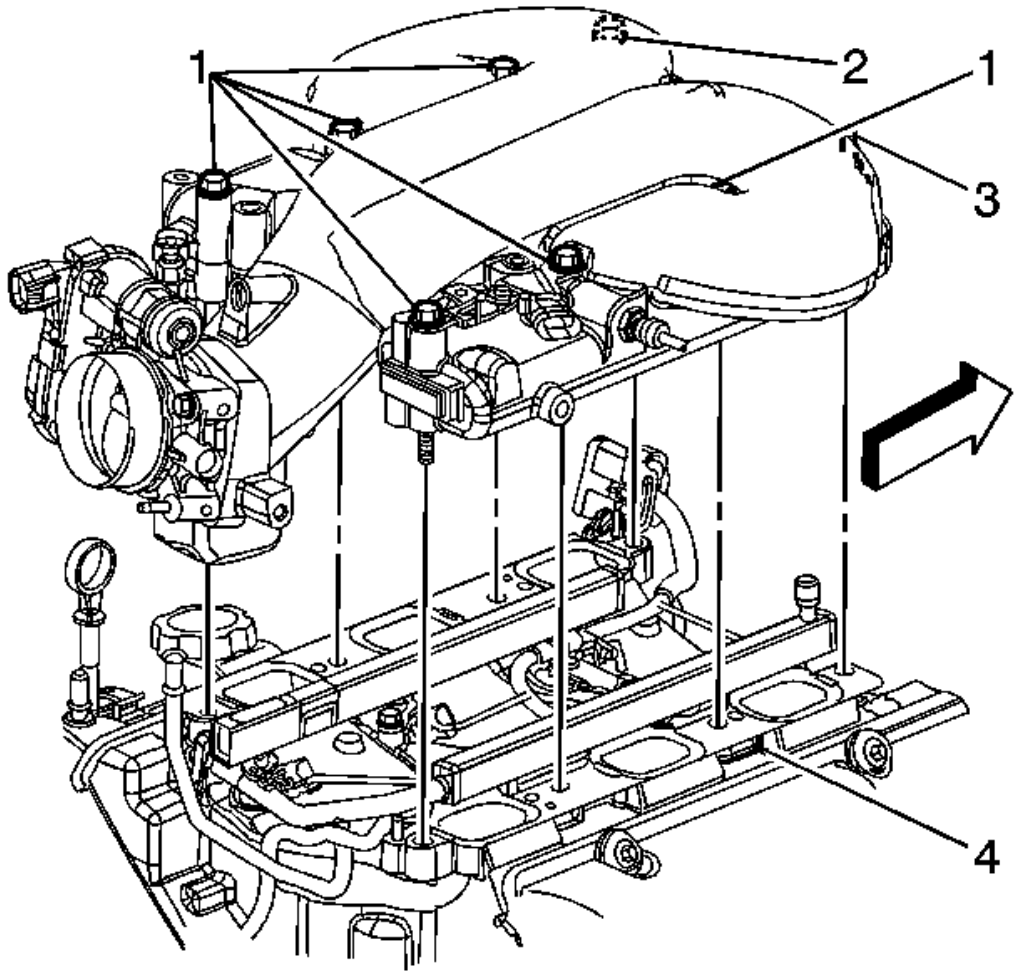

Fig. 73: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

30. Remove the upper intake manifold bolts (1, 2) and stud (3).
31. Separate and remove the upper intake manifold from the lower intake manifold.

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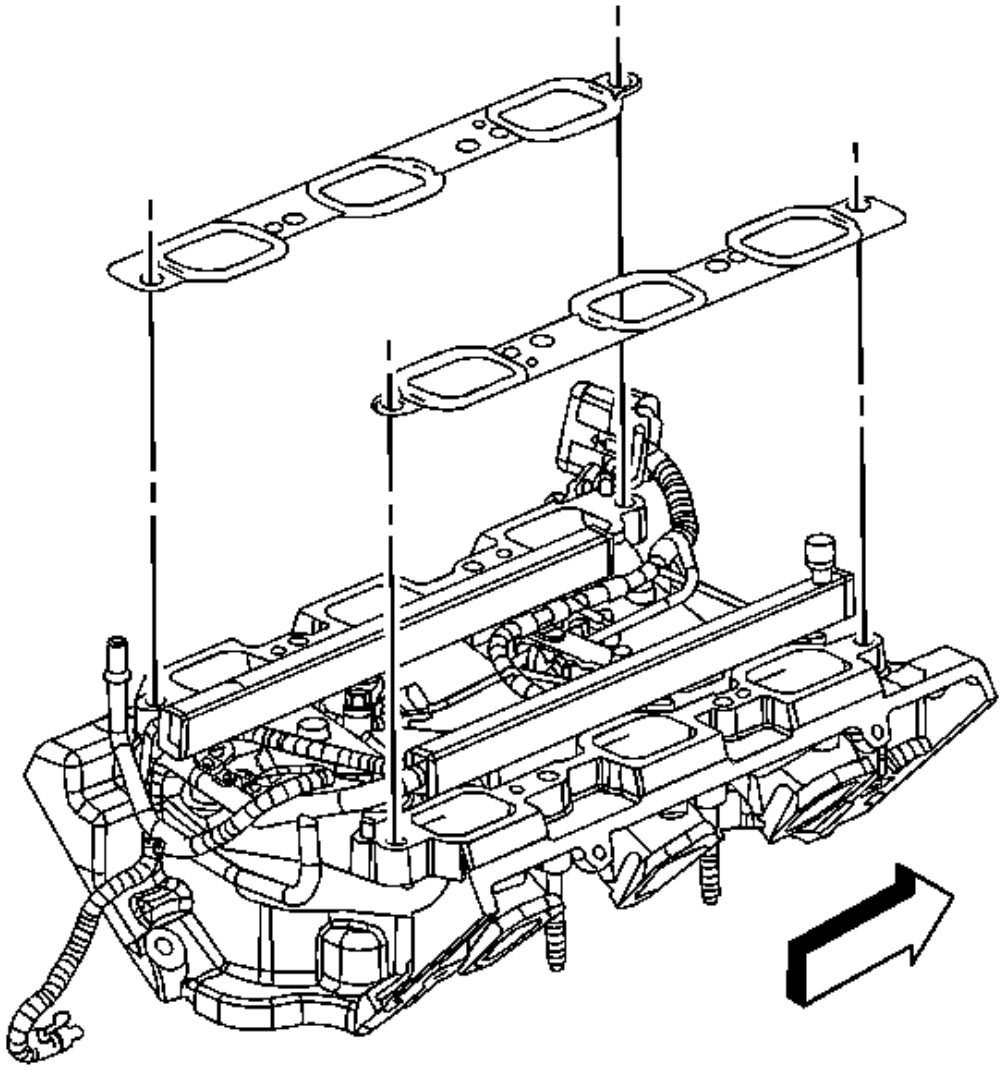

Fig. 74: Identifying Upper Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

32. Remove the upper to lower intake manifold gaskets.

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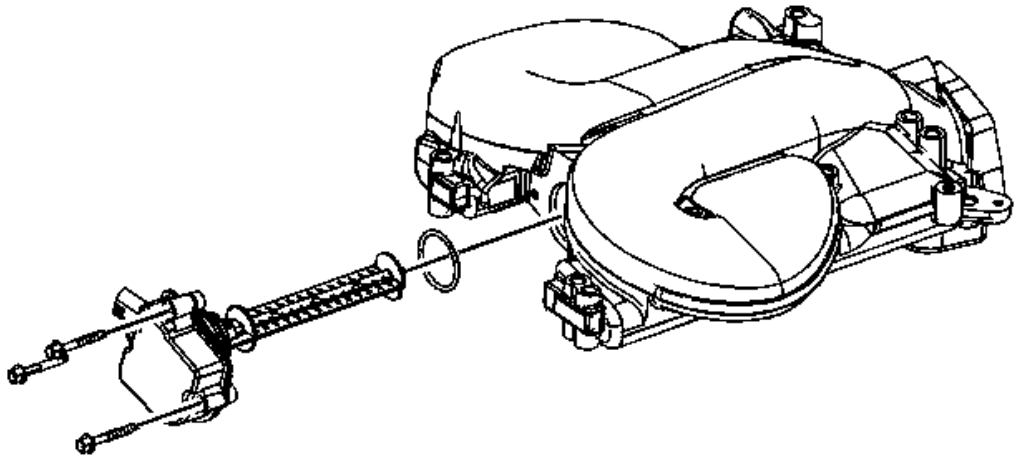

Fig. 75: View Of Intake Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

33. Remove the inlet manifold tuning valve bolts and valve.

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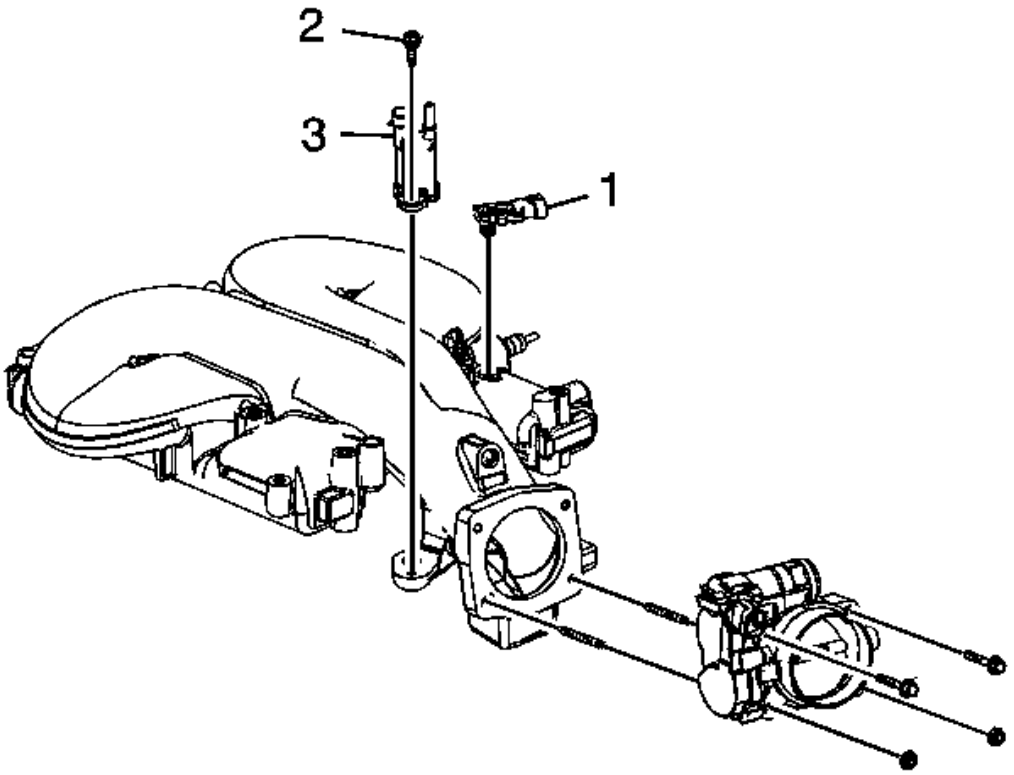

Fig. 76: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

34. Remove the throttle body bolts/studs and throttle body.
35. Remove the MAP sensor bracket and sensor (1).
36. Remove the EVAP canister purge solenoid valve bolt (2) and valve (3).
37. Clean the upper intake to lower intake gasket mating surfaces.

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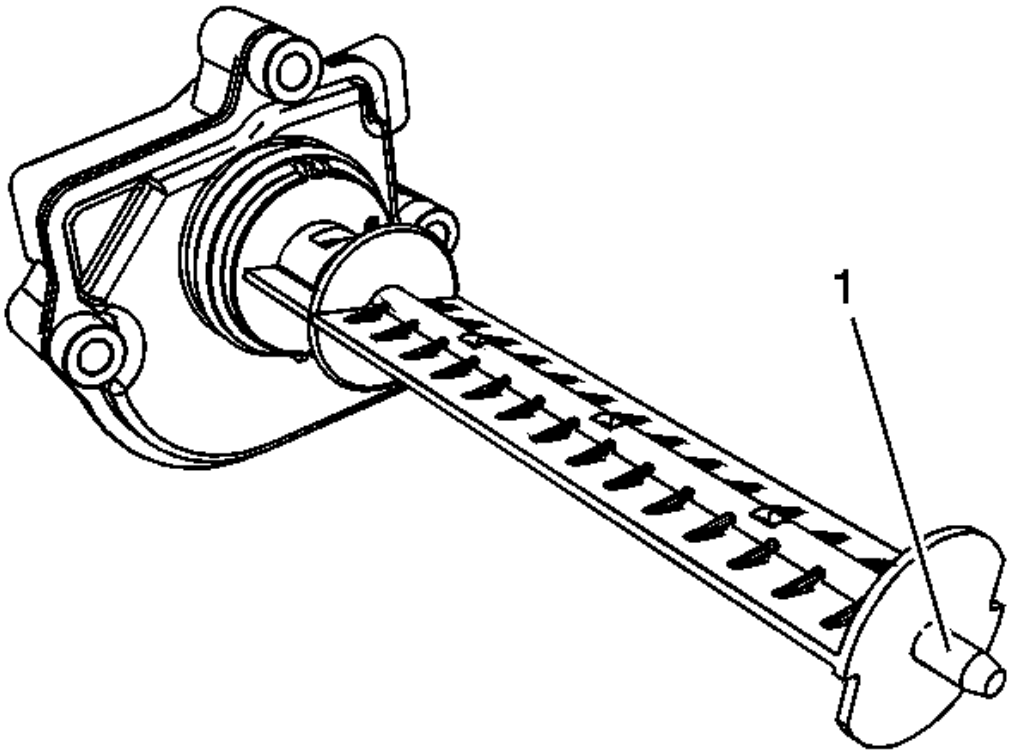

Fig. 77: Identifying Tuning Valve Blade
Courtesy of GENERAL MOTORS CORP.

38. Inspect the intake manifold tuning valve seal for damage. The tuning valve blade attachment to the motor should be tight, with no looseness or slack present, Replace as necessary.
39. Apply lubricant to the nose of the valve blade (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

Installation Procedure

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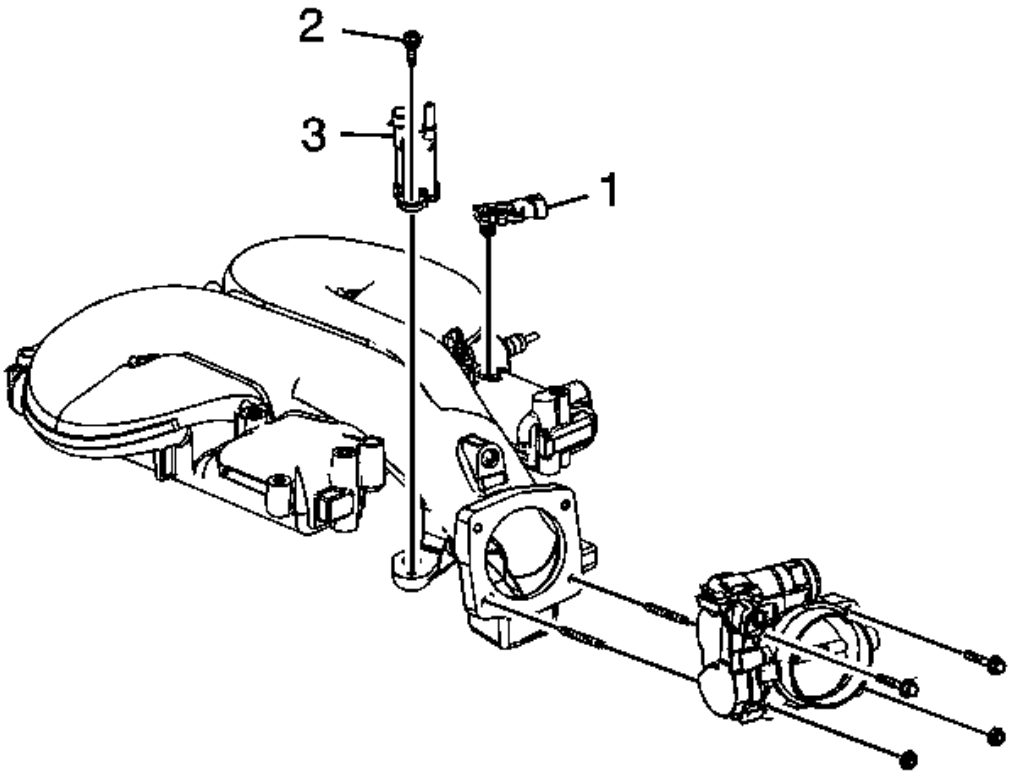

Fig. 78: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Inspect the EVAP canister purge solenoid valve seal for damage, replace as necessary.
2. Install the EVAP canister purge solenoid valve (3) and bolt (2).

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

3. Inspect the MAP sensor seal for damage, replace as necessary.
4. Install the MAP sensor and bracket.
5. Inspect the throttle body seal for damage, replace as necessary.
6. Apply threadlock to the throttle body bolts/studs threads. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
7. Install the throttle body and bolts/studs.

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

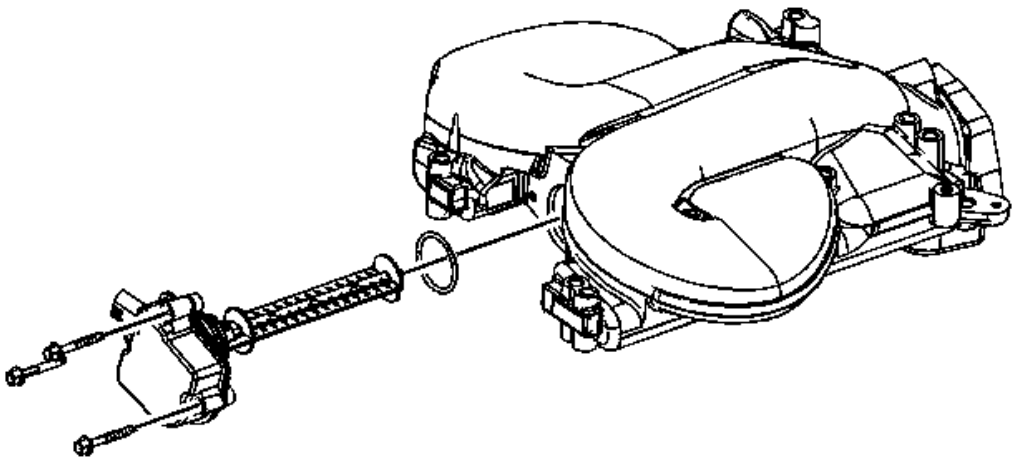

Fig. 79: View Of Intake Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

8. Install the inlet manifold tuning valve, and bolts.

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

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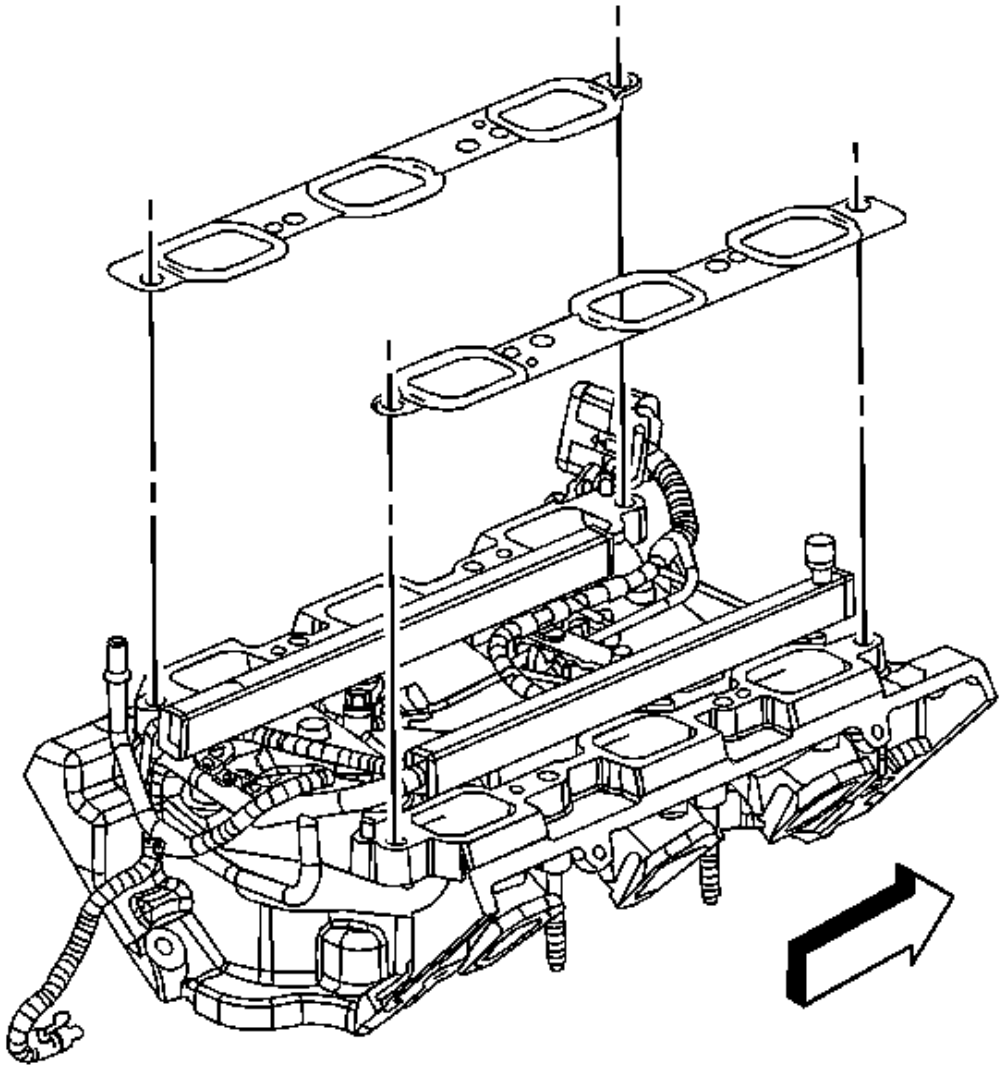

Fig. 80: Identifying Upper Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

9. Install the NEW upper to lower intake manifold gaskets.

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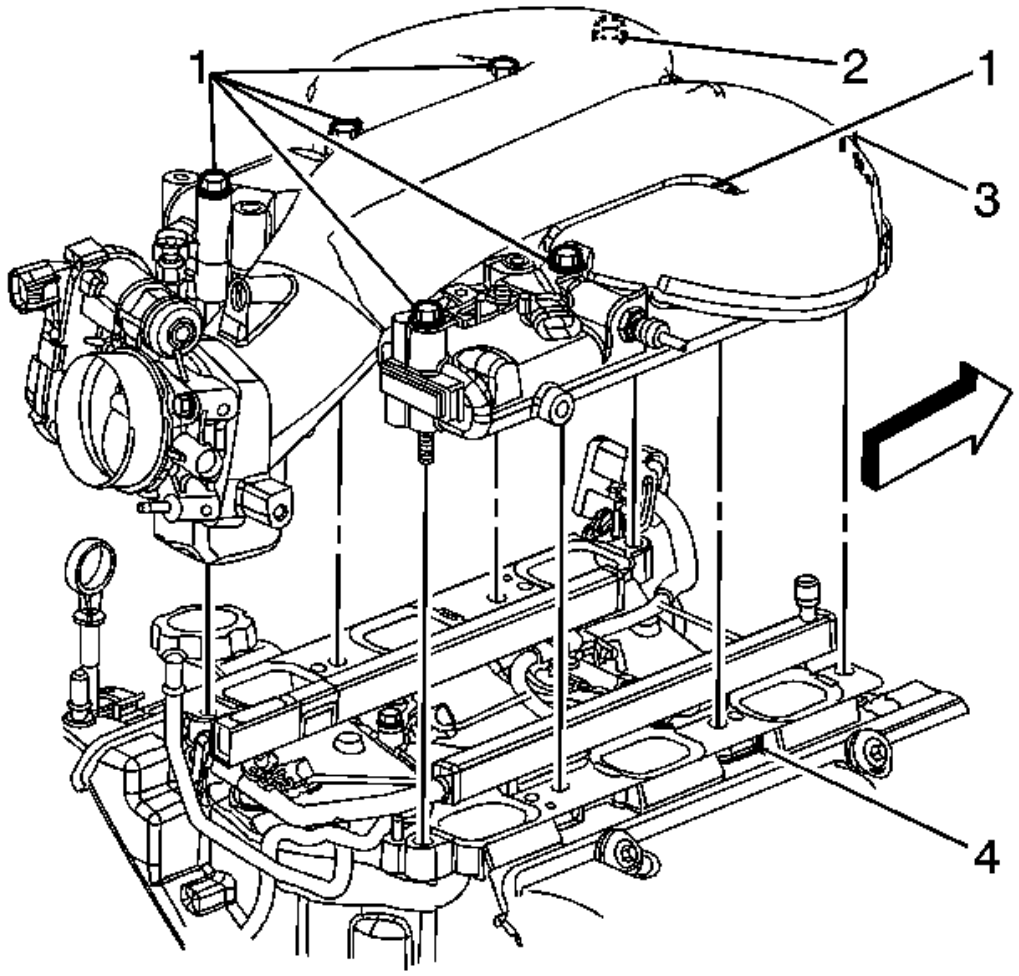

Fig. 81: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

10. Set the upper intake manifold onto the lower intake manifold.
11. Apply threadlock to the upper intake manifold bolts/stud threads. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
12. Install the upper intake manifold bolts (1, 2) and stud (3).

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

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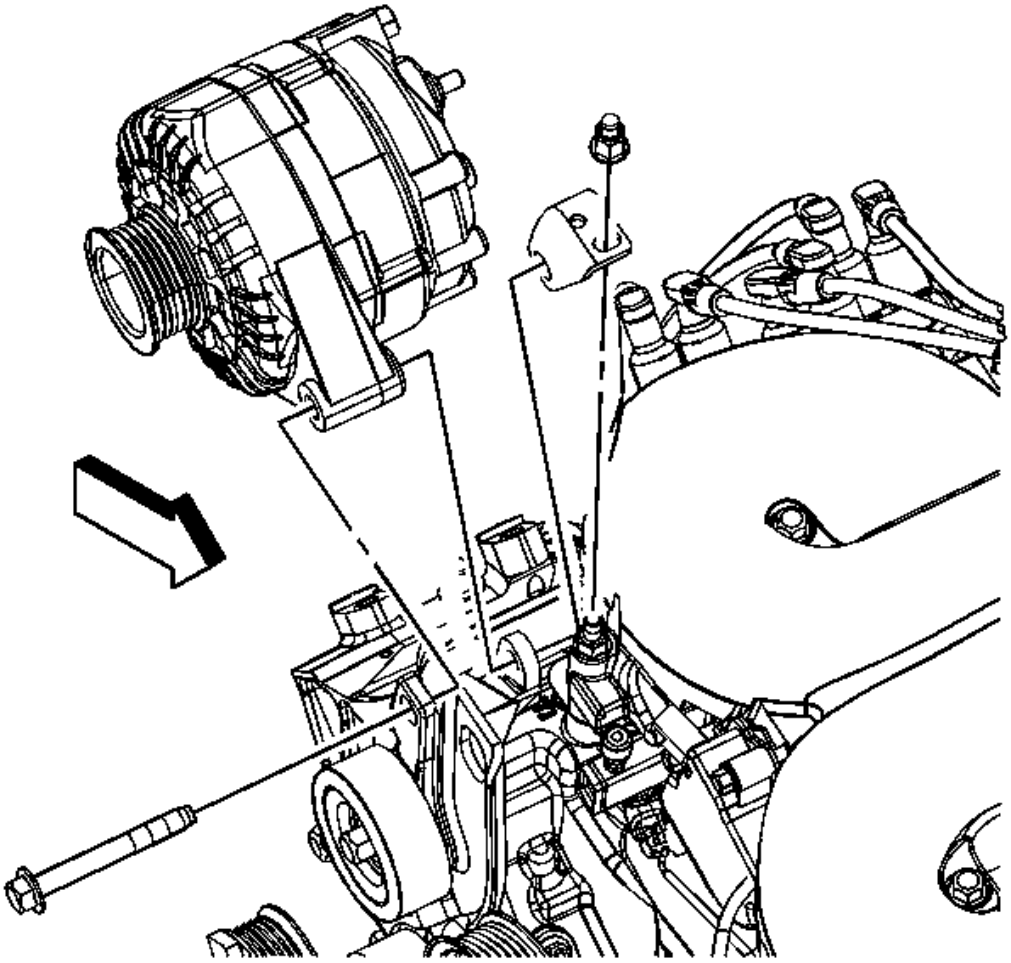

Fig. 82: Identifying Generator, Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the generator rear brace.
14. Install the generator ball stud.

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

15. Install the generator upper bolt.

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

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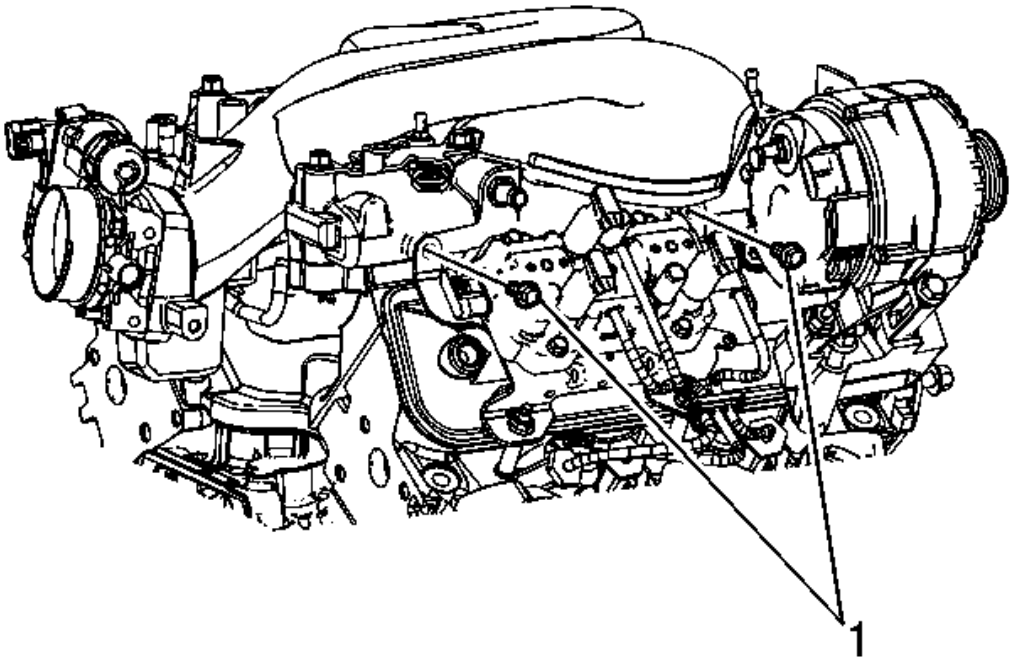

Fig. 83: Identifying Ignition Coil Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the 2 ignition coil bolts (1).

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

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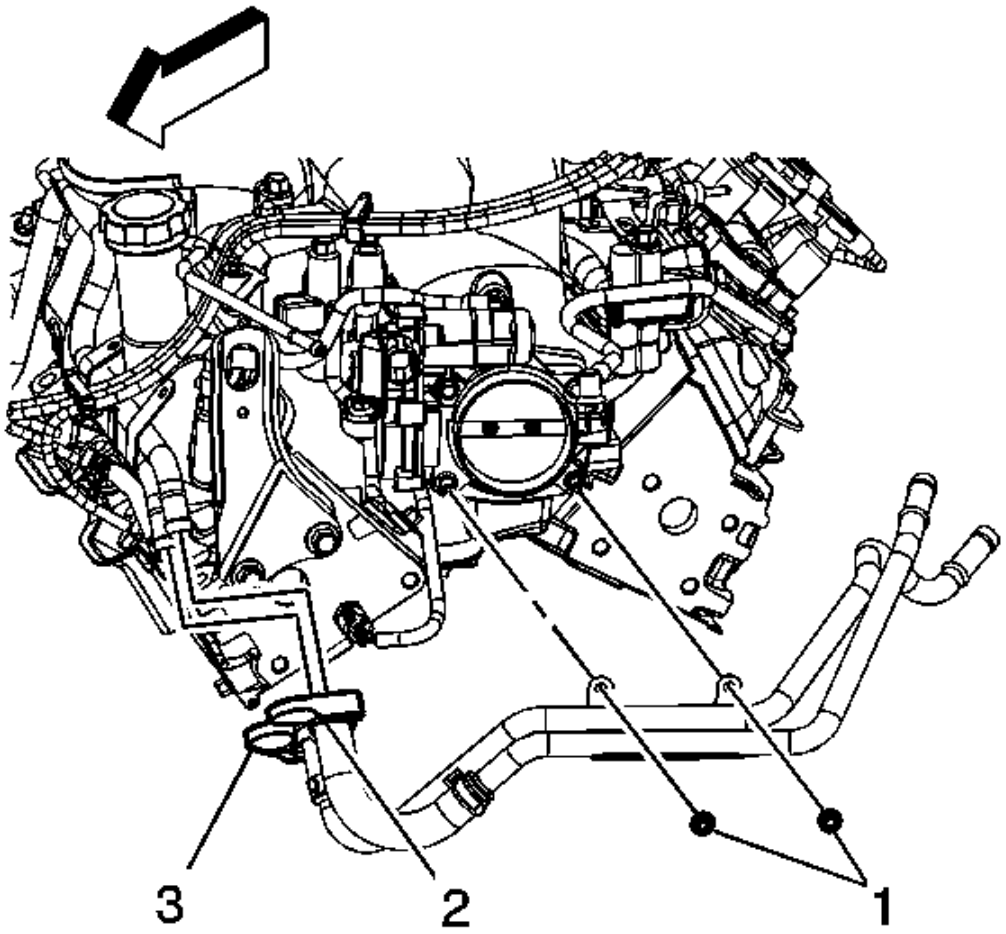

Fig. 84: View Of Inlet & Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

17. Install the inlet and outlet pipe (2, 3) to the studs.
18. Install the heater inlet and outlet pipe nuts (1) to the throttle body studs.

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

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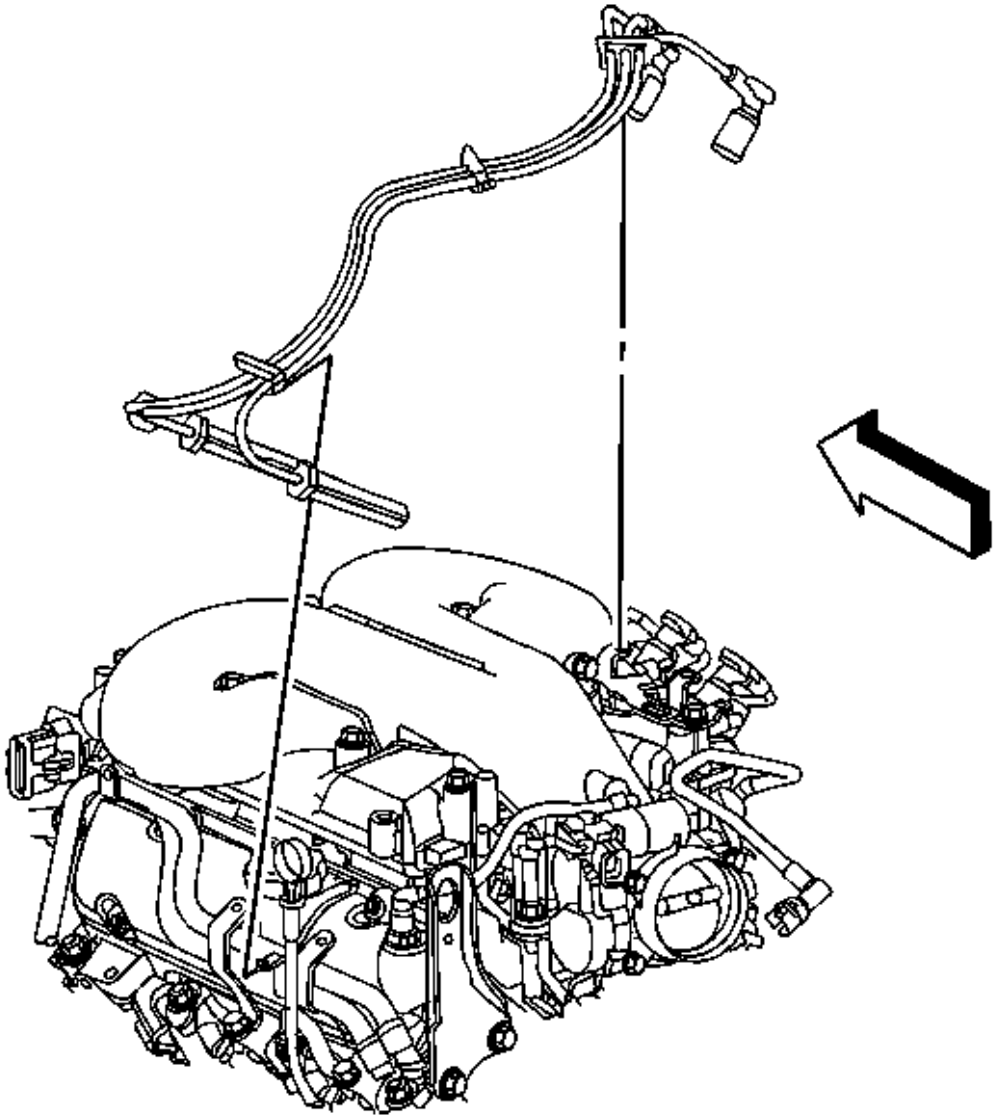

Fig. 85: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

19. Install the left side spark plug wires.
20. Connect the left side spark plug wires to the spark plugs.
21. Connect the left side spark plug wires to the ignition coil.
22. Engage the spark plug wire retainer clips to the intake manifold bracket and the heater inlet/outlet pipe.

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23. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

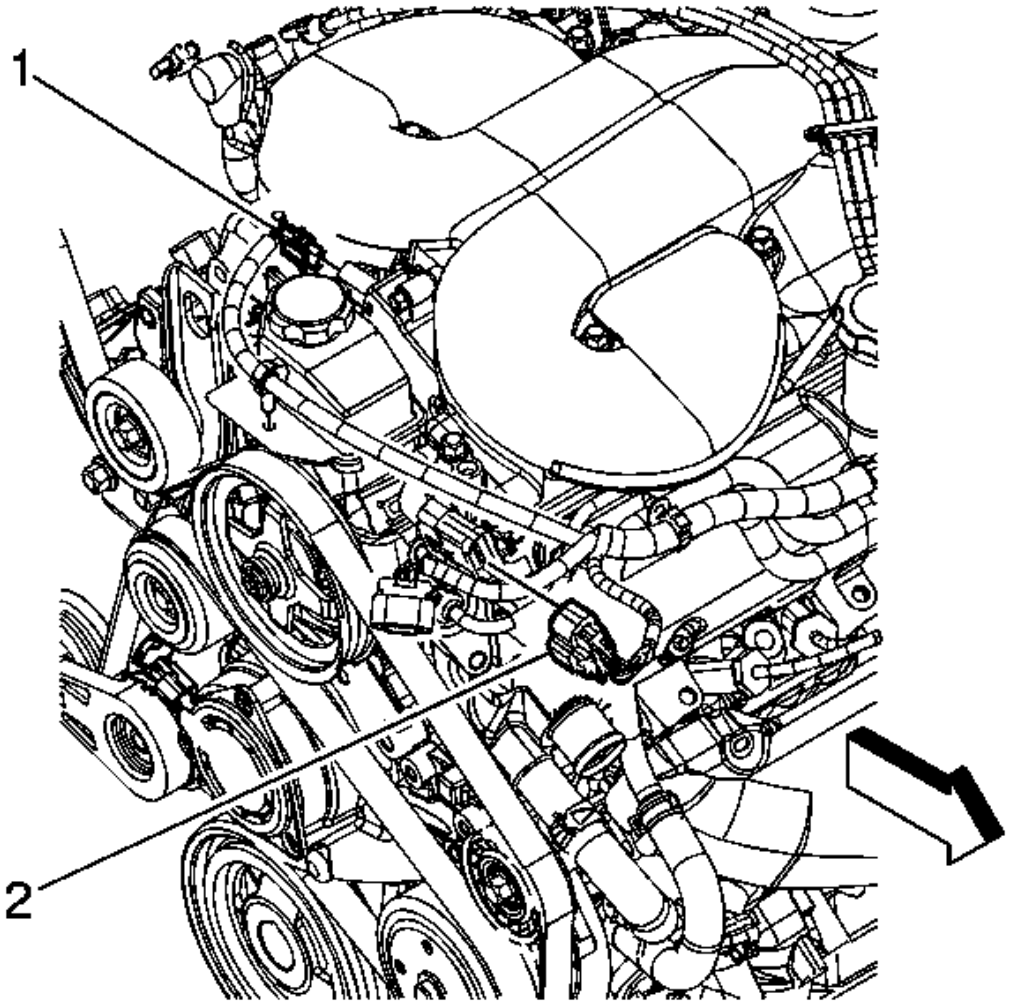

Fig. 86: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

24. Connect the inlet manifold valve electrical connector (1).

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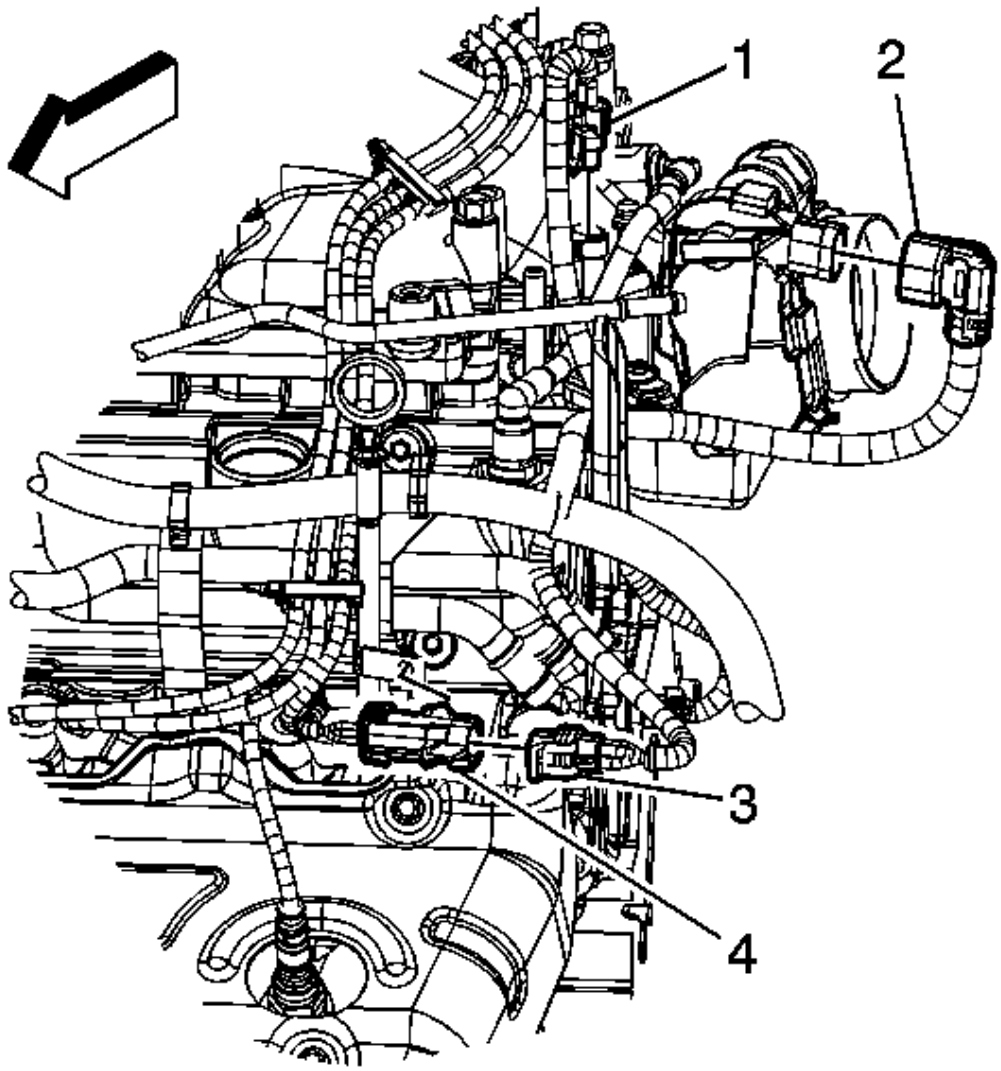

Fig. 87: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

25. Connect the EVAP canister purge solenoid electrical connector (1).
26. Connect the ETC electrical connector (2).

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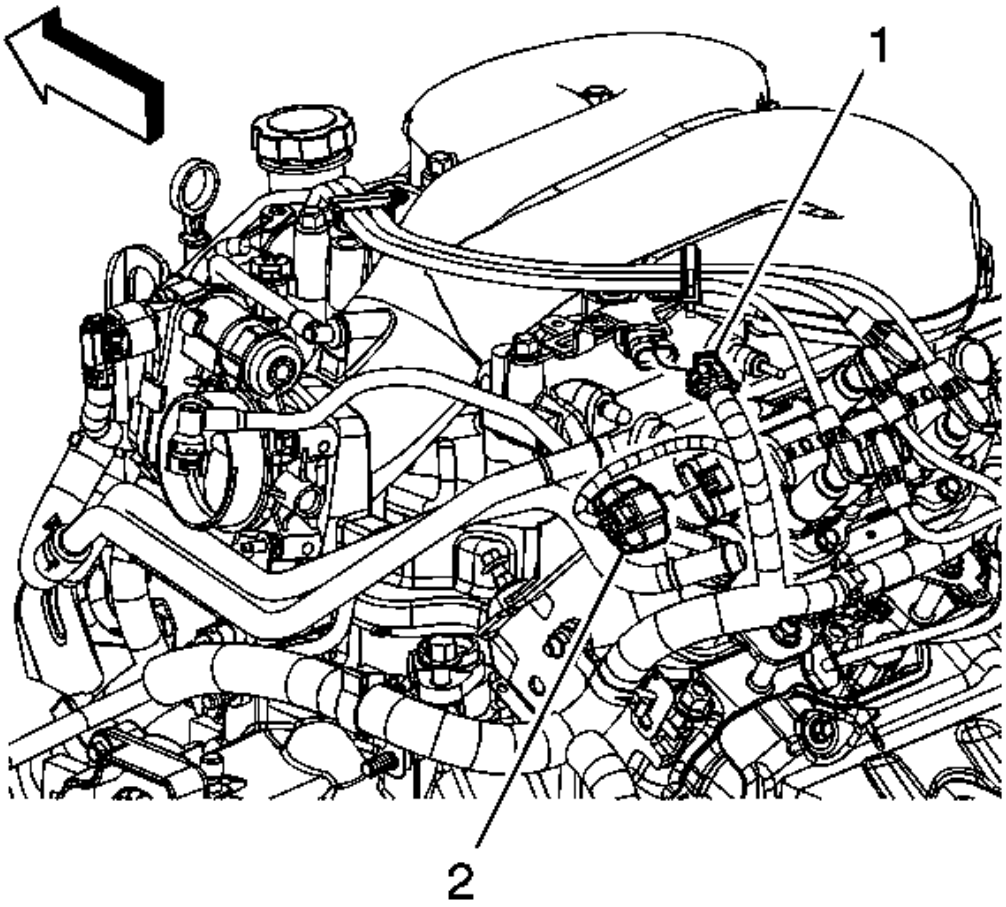

Fig. 88: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

27. Connect the MAP sensor electrical connector (1).

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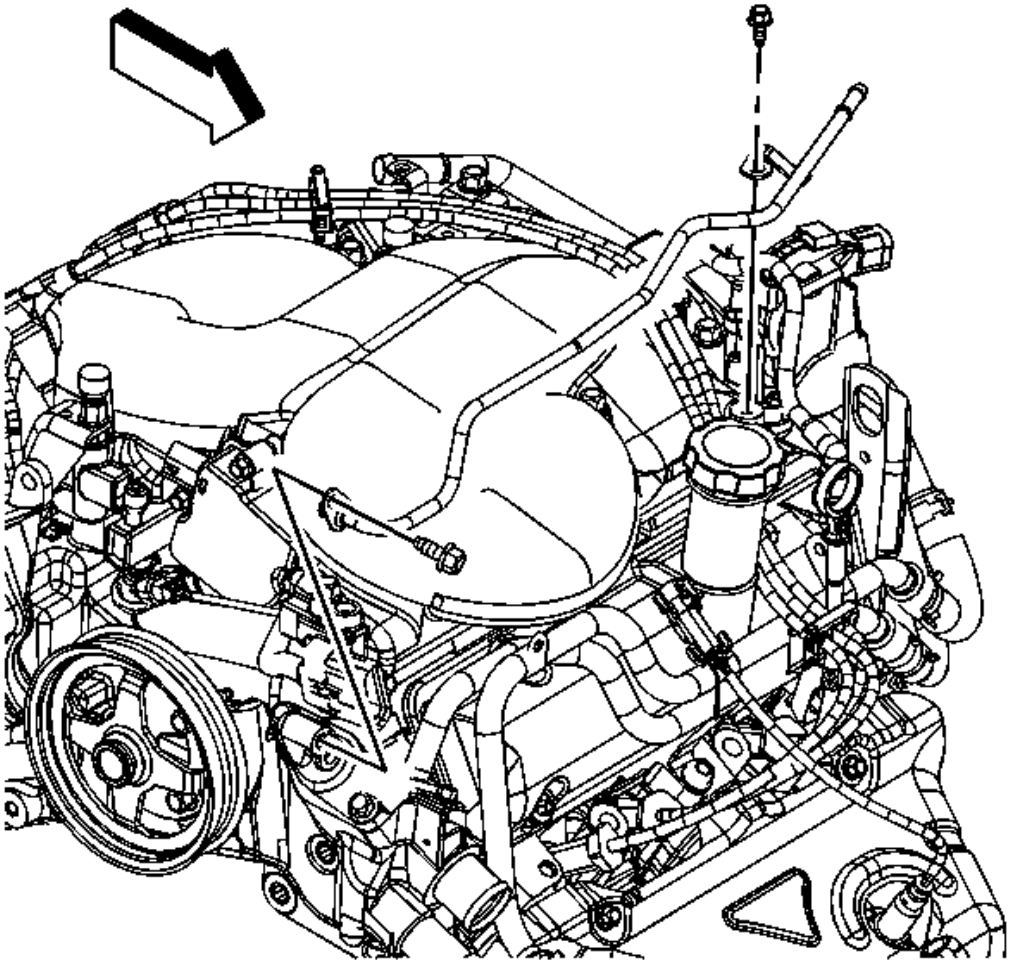

Fig. 89: Identifying Radiator Surge Tank Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

28. Install the radiator surge tank inlet pipe.
29. Install the radiator surge tank inlet pipe bolts.

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

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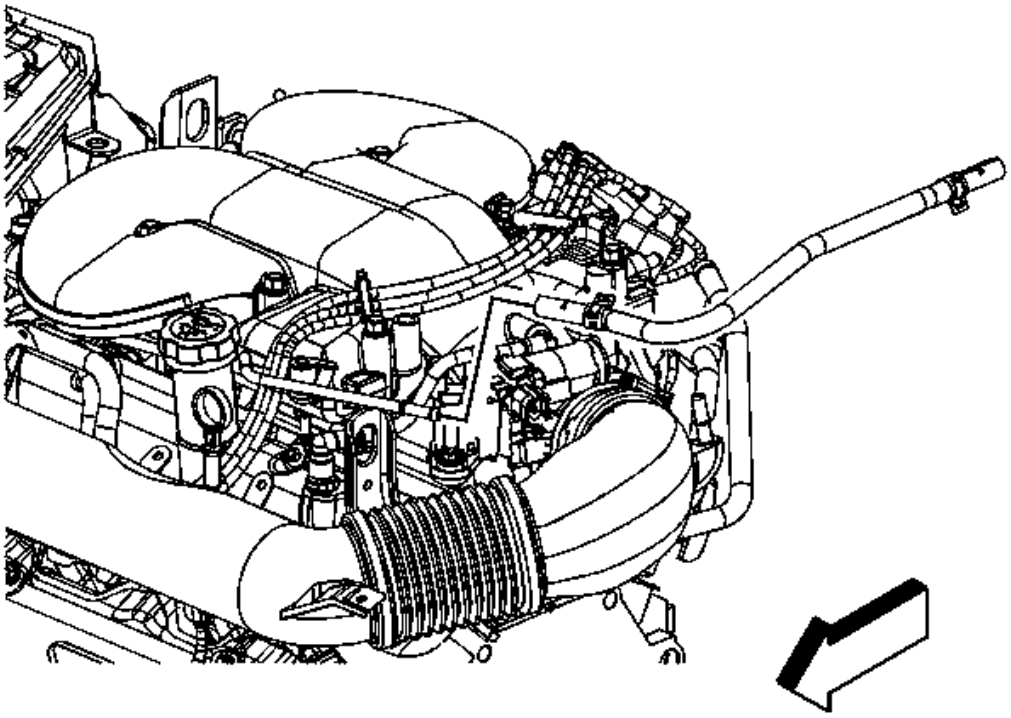

Fig. 90: View Of Radiator Surge Tank Inlet Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

30. Install the radiator surge tank inlet hose to the inlet pipe.
31. Position the radiator surge tank inlet hose clamp.

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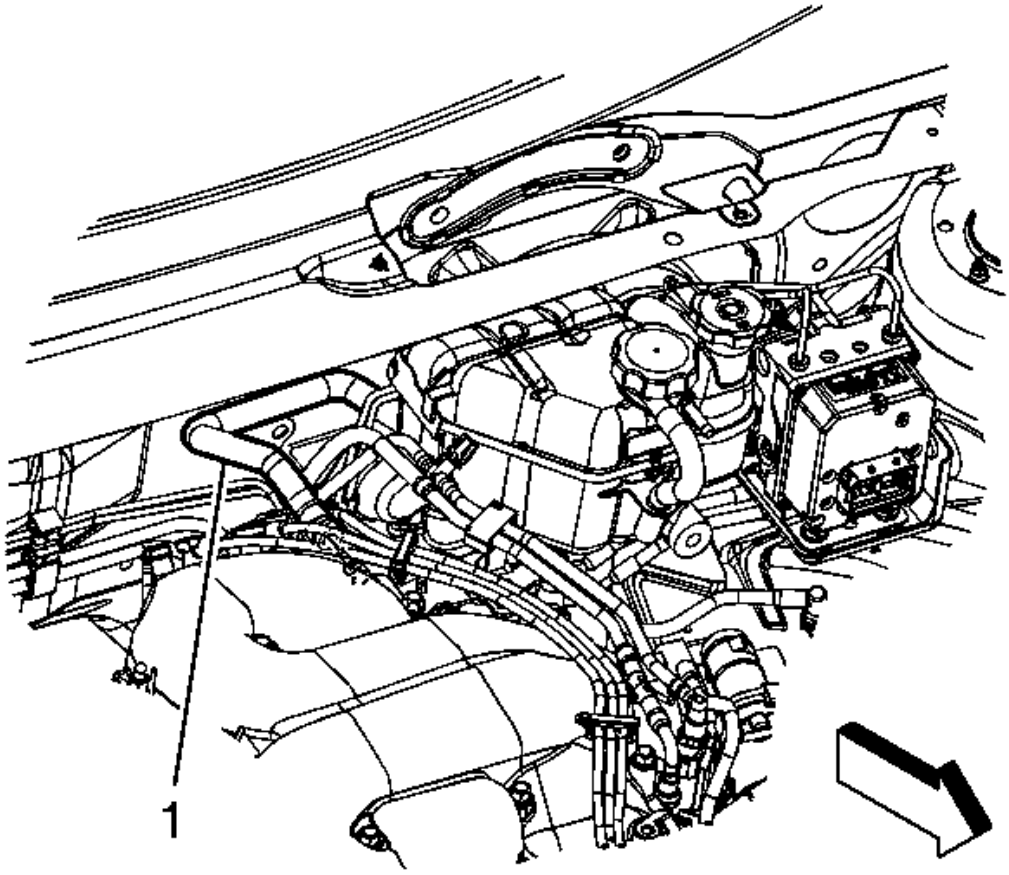

Fig. 91: Identifying Brake Booster Vacuum Hose To Intake Manifold
Courtesy of GENERAL MOTORS CORP.

32. Install the brake booster vacuum hose (1) to the intake manifold.
33. Position the vacuum hose clamp at the intake manifold.

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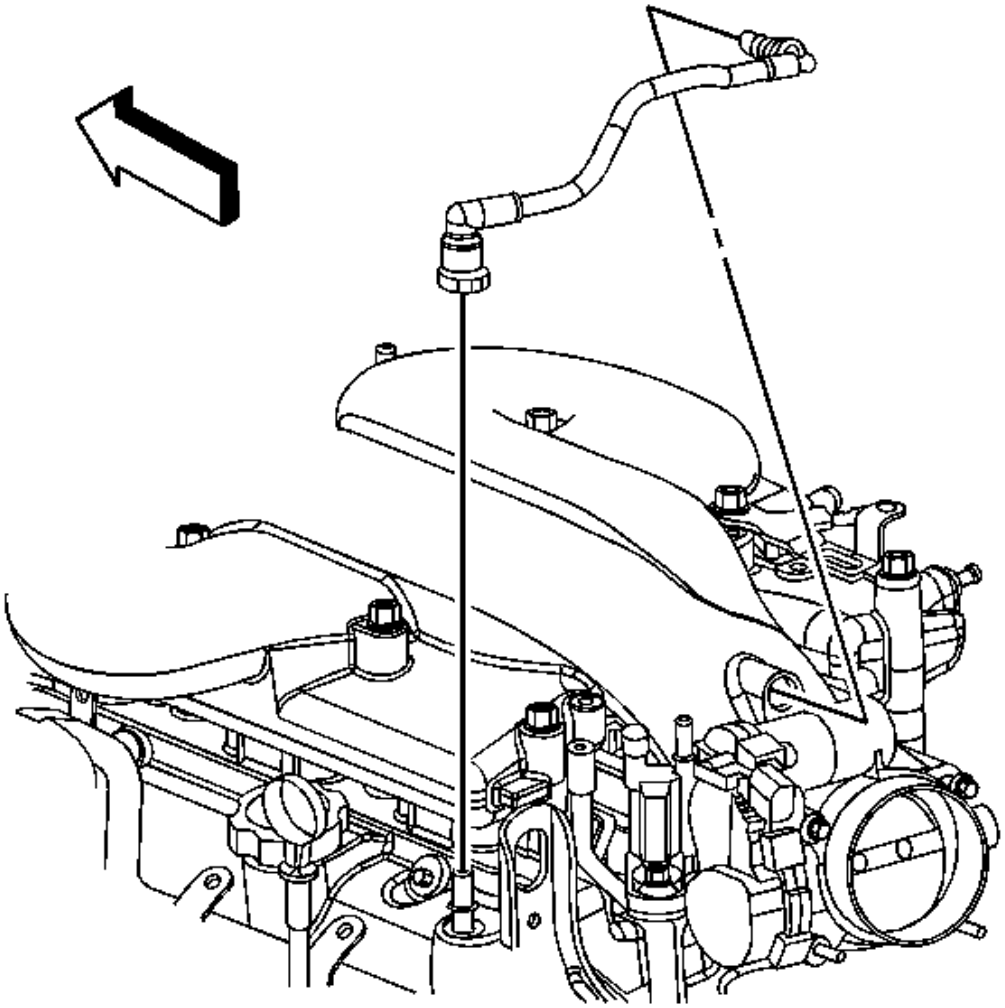

Fig. 92: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

34. Install the PCV foul air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

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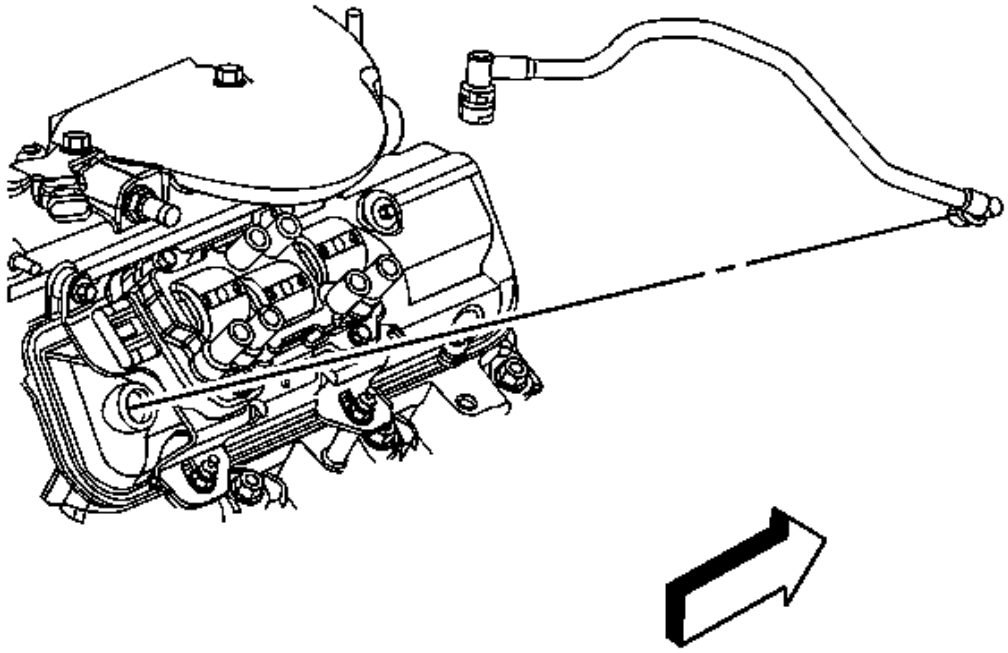

Fig. 93: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

35. Install the PCV fresh air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

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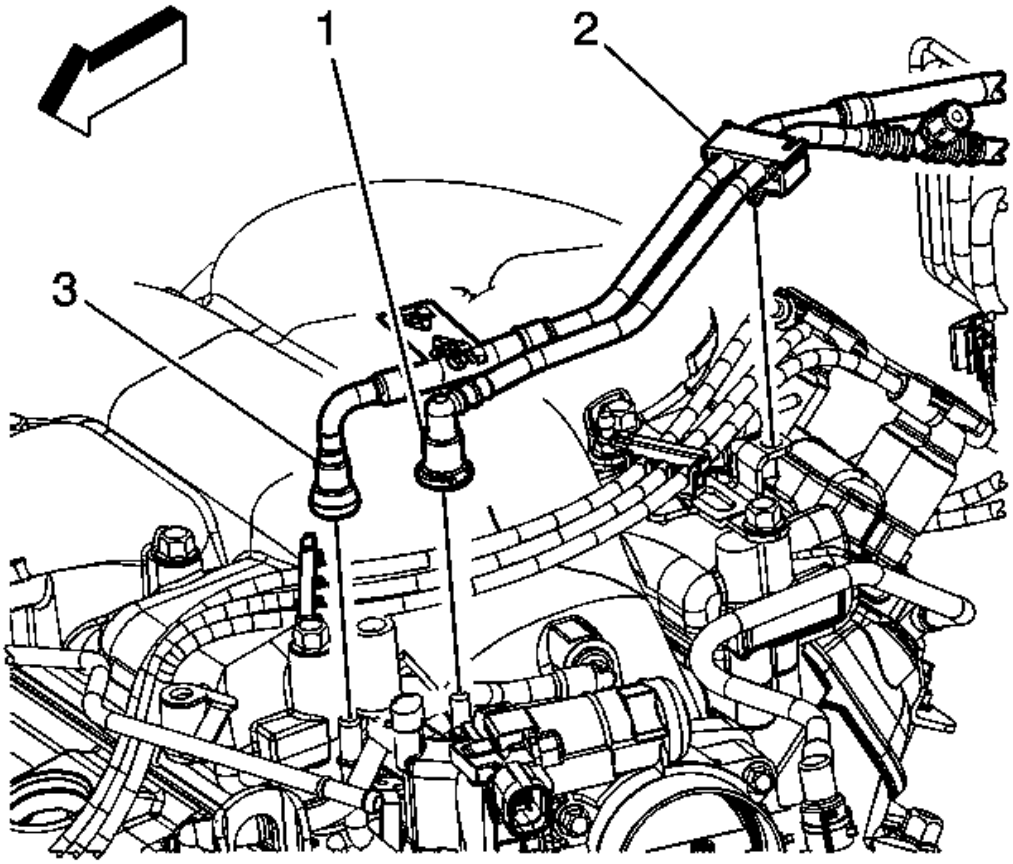

Fig. 94: View Of Fuel Feed/EVAP Pipes
Courtesy of GENERAL MOTORS CORP.

36. Install the fuel and EVAP pipes to the retainer clip (2) and close the clip.
37. Connect the fuel feed pipe (3) quick connect fitting to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
38. Connect the EVAP emission pipe (1) to the purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
39. Fill the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
40. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
41. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

LOWER INTAKE MANIFOLD REPLACEMENT

Removal Procedure

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NOTE: **This engine uses a sequential multiport fuel injection system. Injector wiring harness connectors must be connected to their appropriate fuel injector or exhaust emissions and engine performance may be seriously affected.**

1. Remove the coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement (LZ9)** .
2. Remove the upper intake manifold. Refer to **Upper Intake Manifold Replacement**.
3. Remove the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side**.
4. Remove the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right Side**.
5. Disconnect the engine coolant temperature (ECT) electrical connector.
6. Disconnect the fuel feed line from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .

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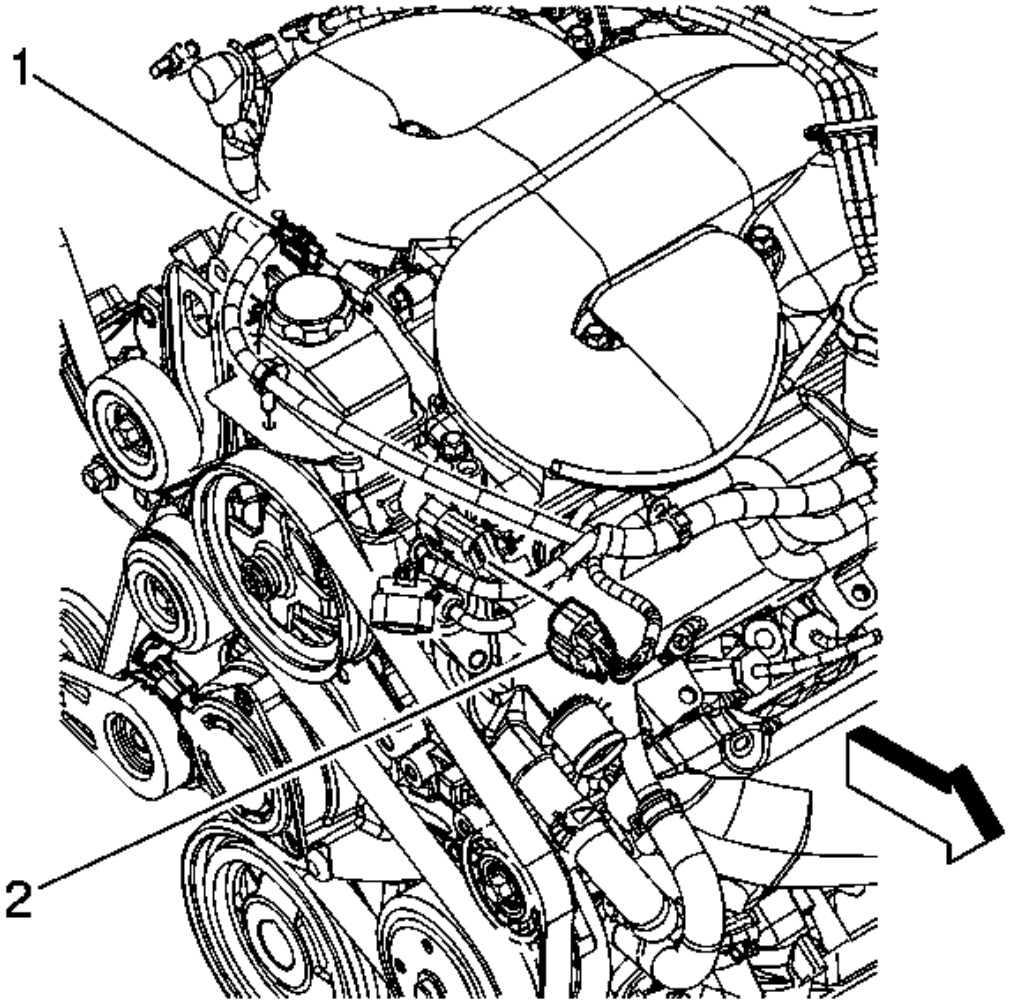

Fig. 95: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the fuel injector inline connector (2).

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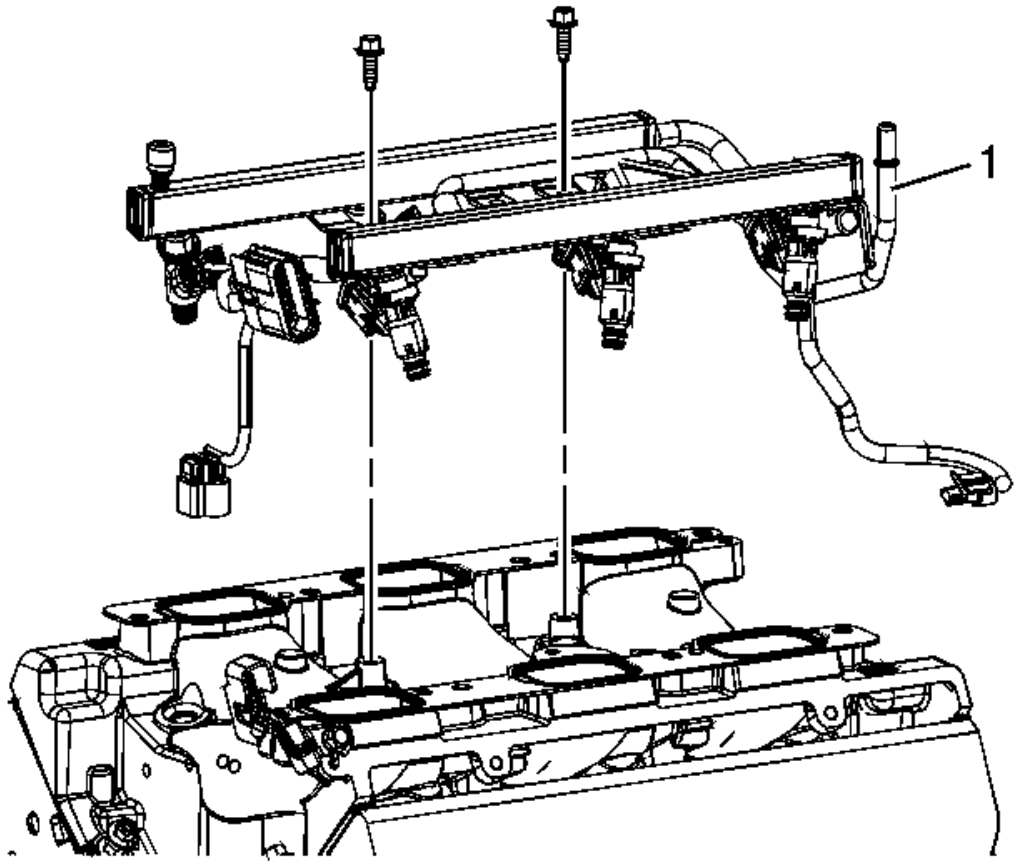

Fig. 96: Identifying Fuel Rail
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel injector harness connector bracket bolt from the intake manifold.
9. Disconnect the camshaft position (CMP) sensor electrical connector.
10. Remove the fuel injector rail bolts.
11. Remove the fuel rail (1).

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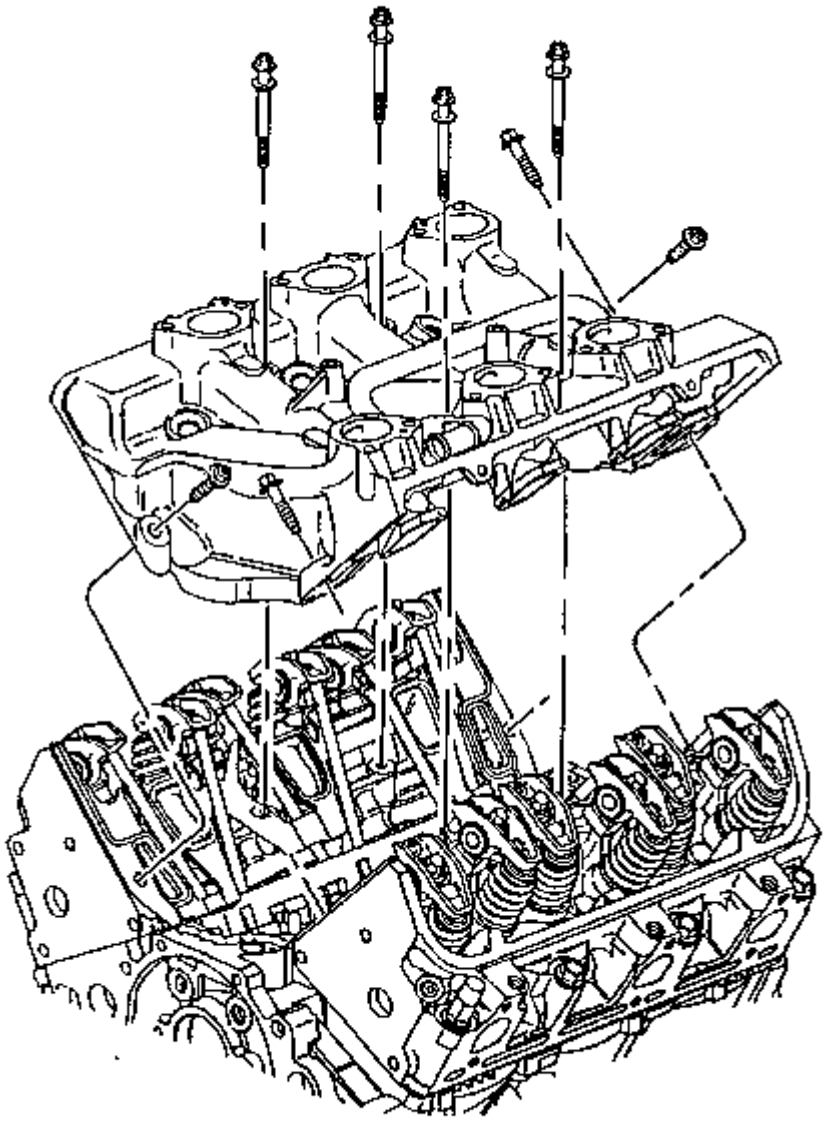

Fig. 97: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the lower intake manifold bolts.
13. Remove the lower intake manifold.

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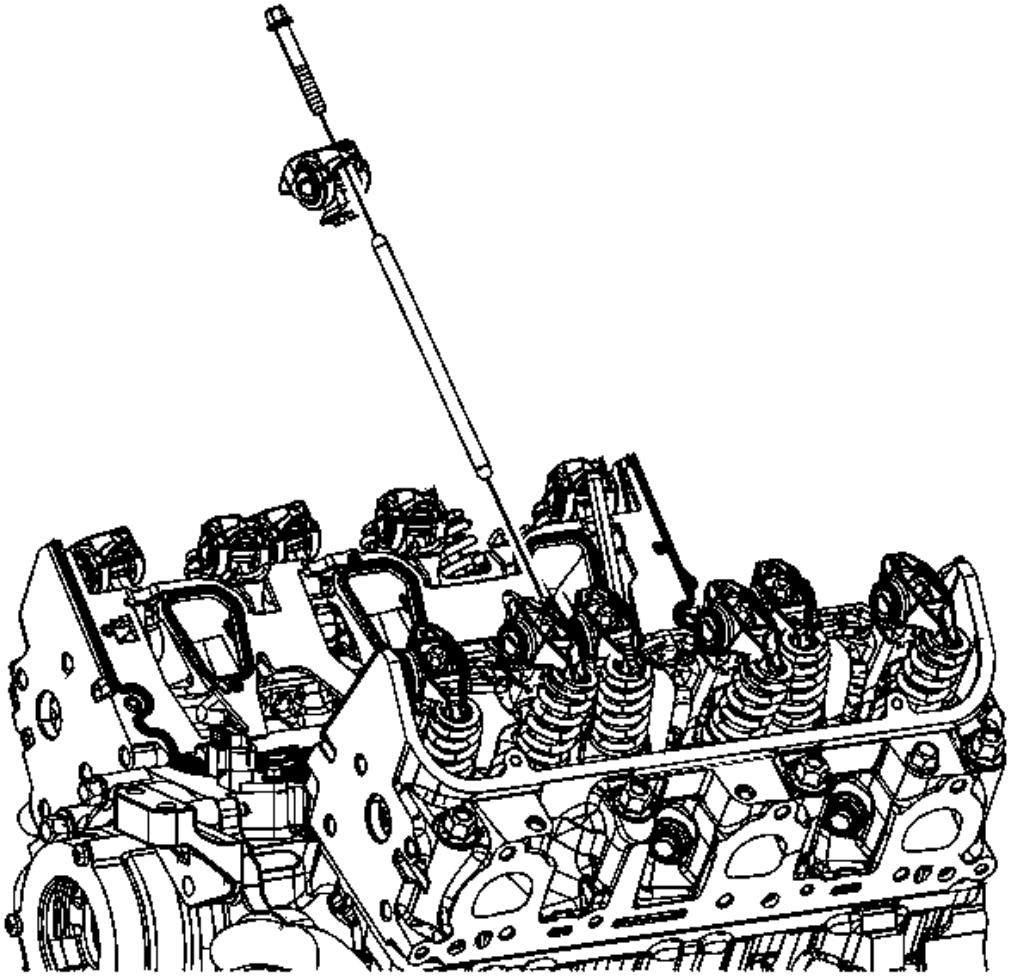

Fig. 98: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Loosen the valve rocker arm bolts.

NOTE: Place the valve train components in a rack in order to ensure that the components are installed in the same location from which they where removed.

15. Remove the valve rocker arms.
16. Remove the push rods.
    - The intake push rods measure 147.51 mm (5.81 in).

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- The exhaust push rods measure 154.87 mm (6.1 in).

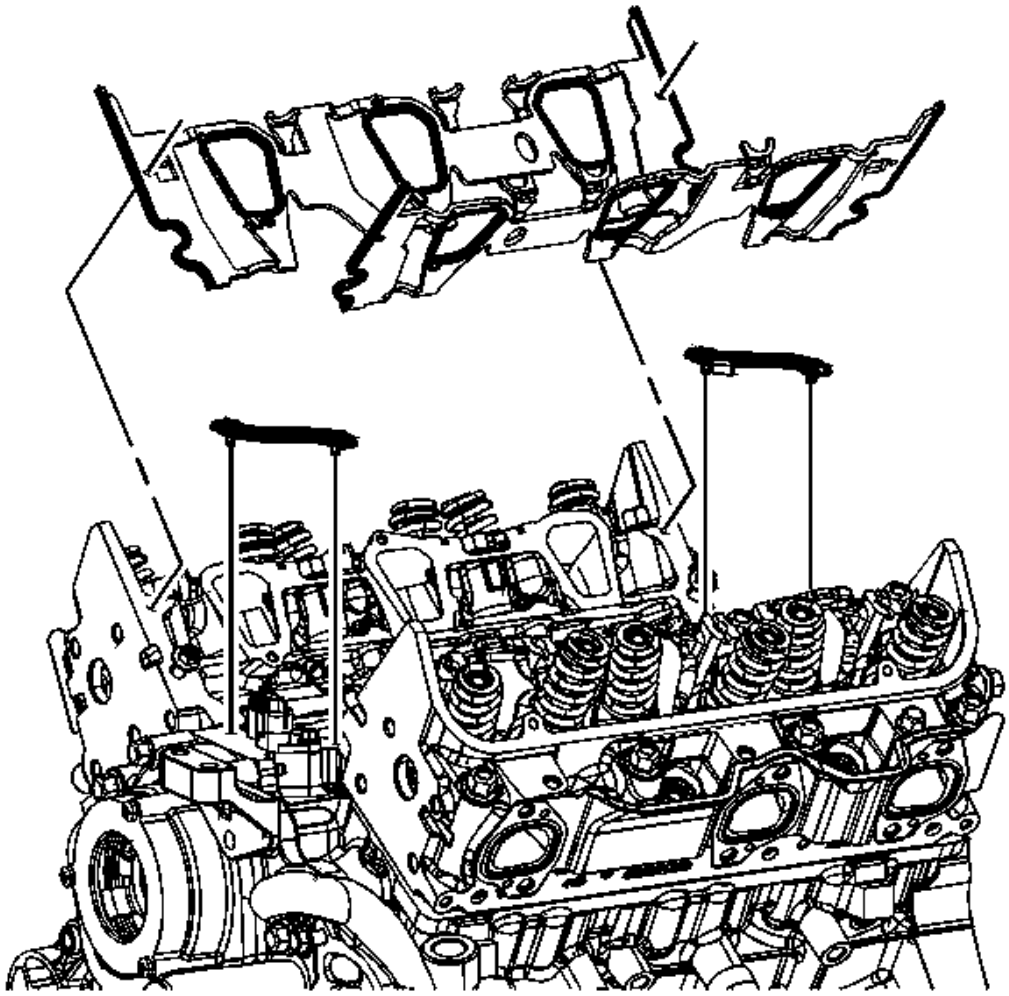

Fig. 99: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

17. Remove the lower intake manifold gaskets and seals.
18. Clean the lower intake manifold gasket and seal surfaces on the cylinder heads and the engine block.
19. Clean the gasket and seal surfaces on the lower intake manifold with degreaser.
20. Remove all the loose room temperature vulcanizing sealer (RTV).

Installation Procedure

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NOTE: **All gasket mating surfaces need to be free of oil and foreign material. Use lubricant to clean the surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers for the correct part number.**

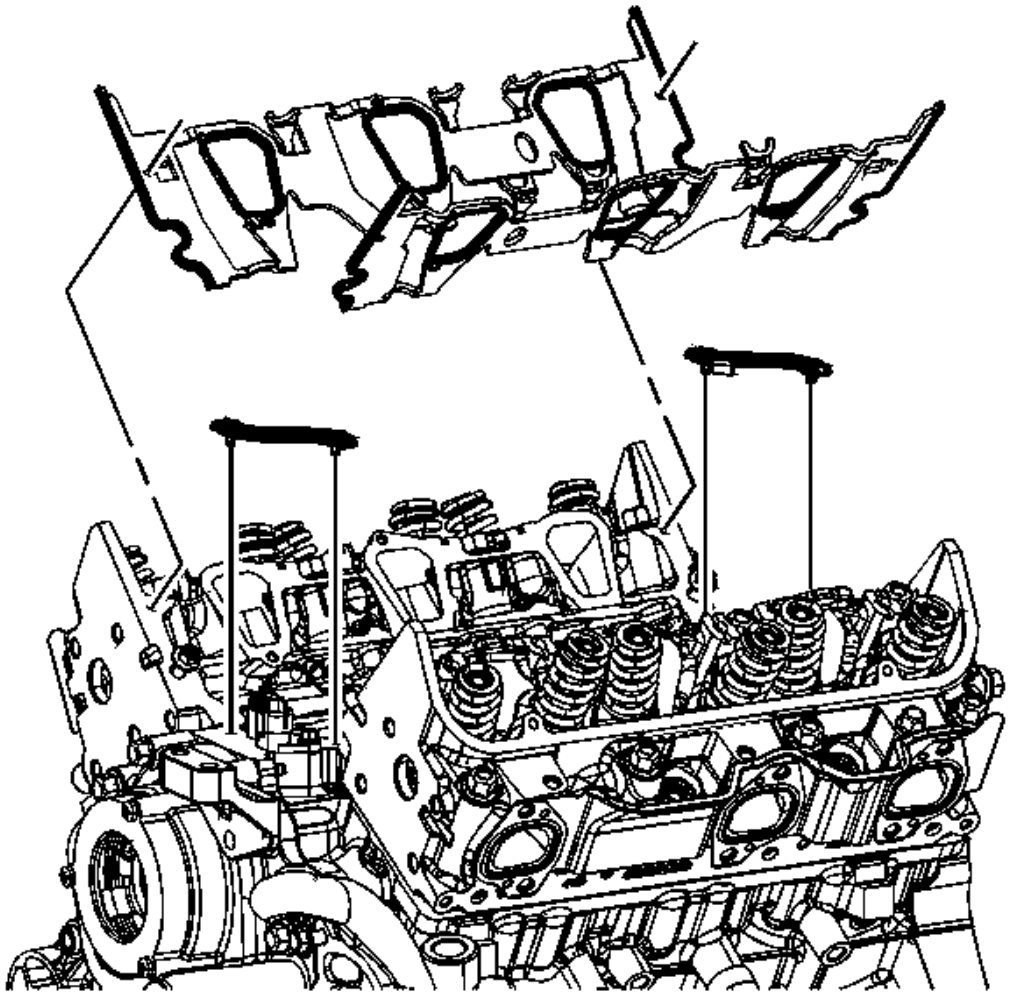

Fig. 100: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

NOTE: **RTV sealer is NOT to be placed under the lower intake manifold gaskets.**

1. Install the lower intake manifold gaskets and seals.

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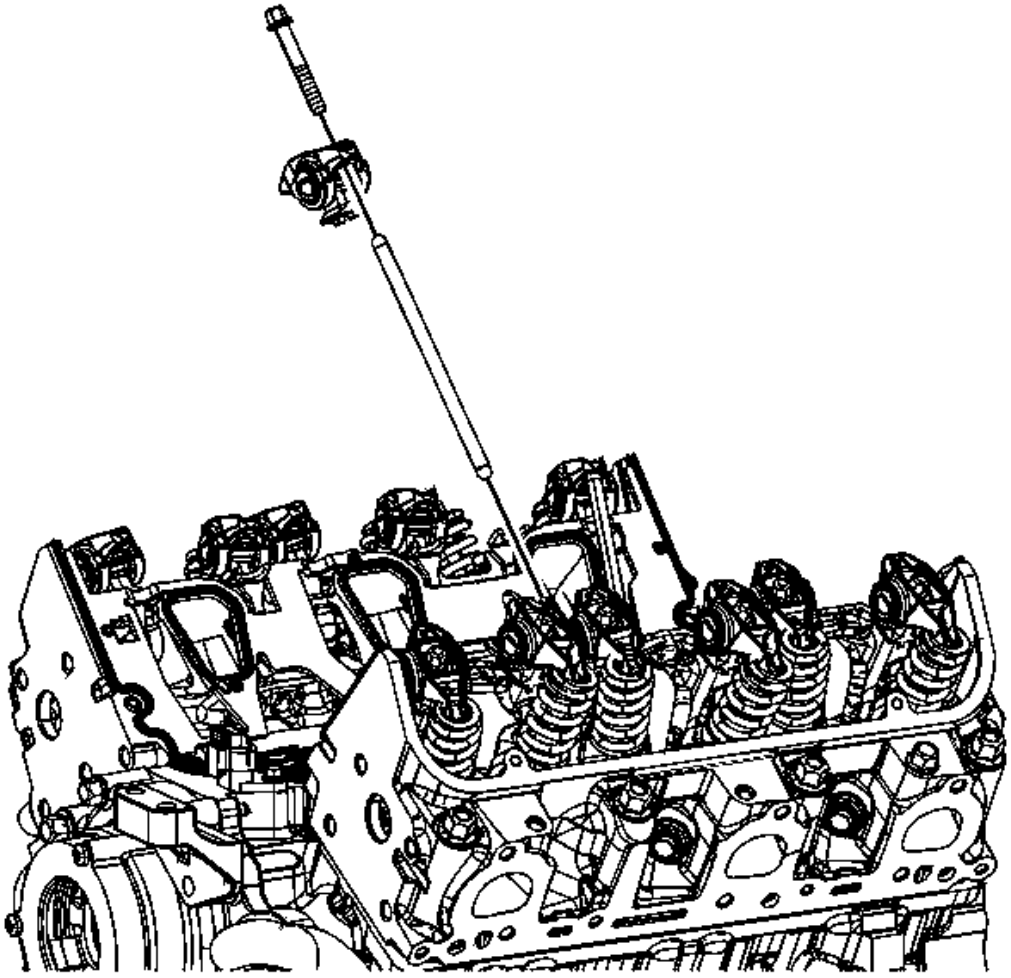

Fig. 101: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Coat the ends of the push rods using prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

NOTE: The intake valve push rods measure 146.0 mm (5.75 in) and the exhaust valve push rods measure 152.5 mm (6.0 in).

3. Install the push rods in their original location.
4. Coat the rocker arm friction surfaces using prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

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NOTE: **Shims (P/N 88894006) may be required under the valve rocker arm pedestals if reconditioning has been performed on the cylinder head or its components.**

CAUTION: Refer to Fastener Caution .

5. Install the valve rocker arms in their original positions.
6. Install the valve rocker arm bolts.

   Tighten: Tighten the bolts to 34 N.m (25 lb ft).

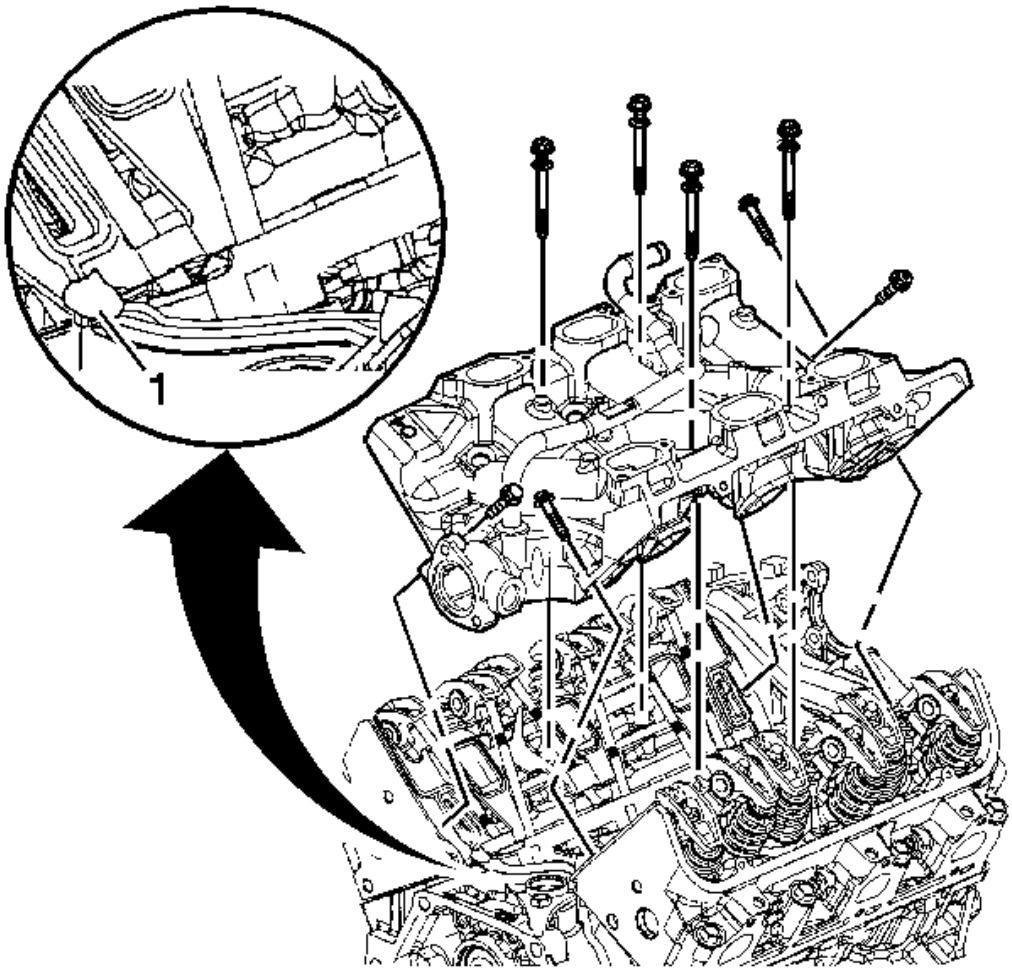

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Fig. 102: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. With the NEW gaskets and seals in place, apply a small drop, 8-10 mm (0.031-0.39 in) of RTV sealer to the 4 corners of the intake manifold to engine block joints (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
8. Install the lower intake manifold.

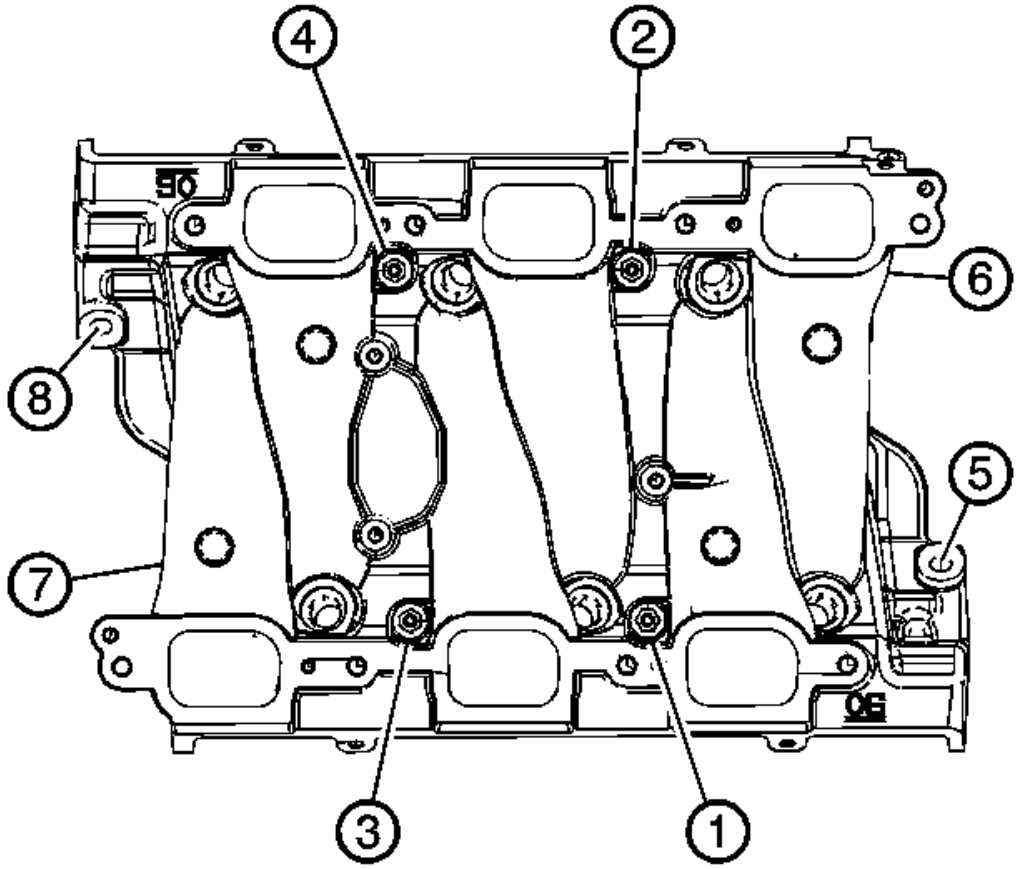

Fig. 103: Identifying Lower Intake Manifold Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

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CAUTION: Failure to tighten vertical bolts before the diagonal bolts may cause an oil leak.

9. Apply sealer to the lower intake manifold bolt threads. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
10. Install the lower intake manifold bolts.
11. Tighten the lower intake manifold bolts in the sequence shown.

Tighten:

1. Tighten the bolts (1, 2, 3, 4) in sequence to 16 N.m (12 lb ft).
2. Tighten the bolts (5, 6, 7, 8) in sequence to 25 N.m (18 lb ft).

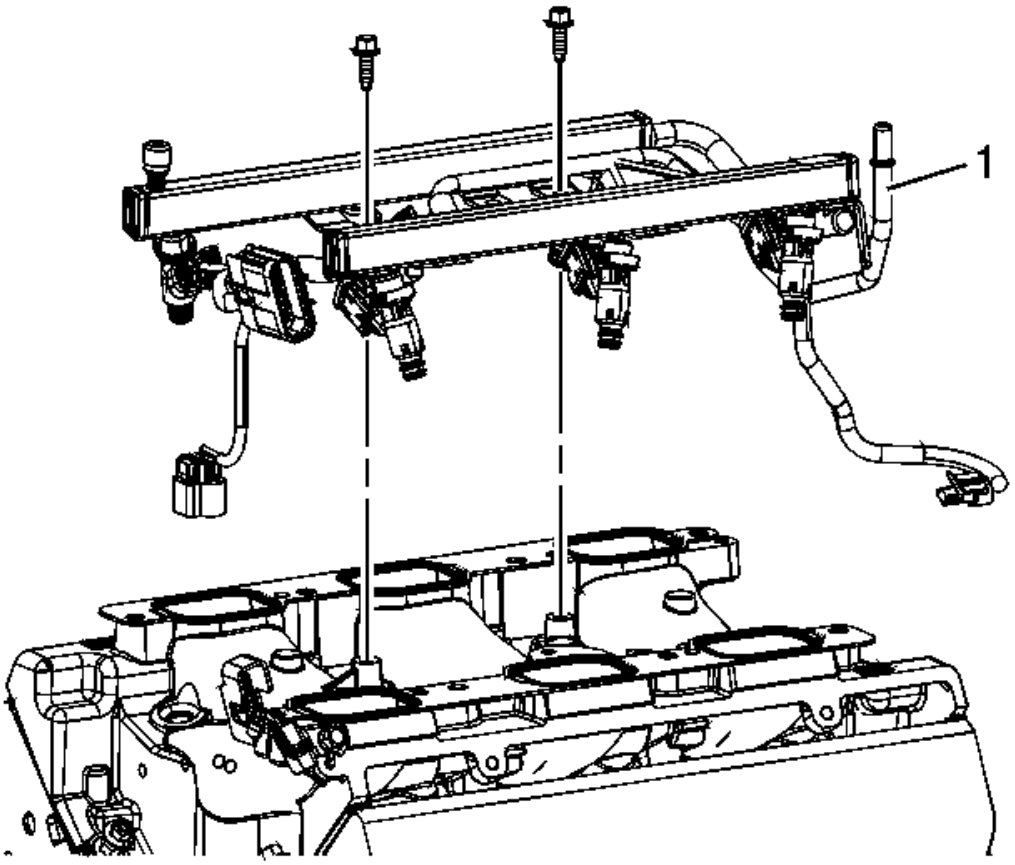

Fig. 104: Identifying Fuel Rail
Courtesy of GENERAL MOTORS CORP.

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12. Inspect the fuel rail, fuel injectors and fuel injector O-rings for damage and replace as necessary.
13. Lubricate the fuel injector O-rings using lubricant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
14. Install the injector nozzles into the lower intake manifold injector bores.
15. Press on the injector rail (1) using the palms of both hands until the injector is fully seated.
16. Install the fuel injector rail bolts.

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

17. Connect the CMP sensor electrical connector.
18. Position the fuel injector harness connector bracket to the intake manifold.
19. Install the fuel injector harness connector bracket bolt.

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

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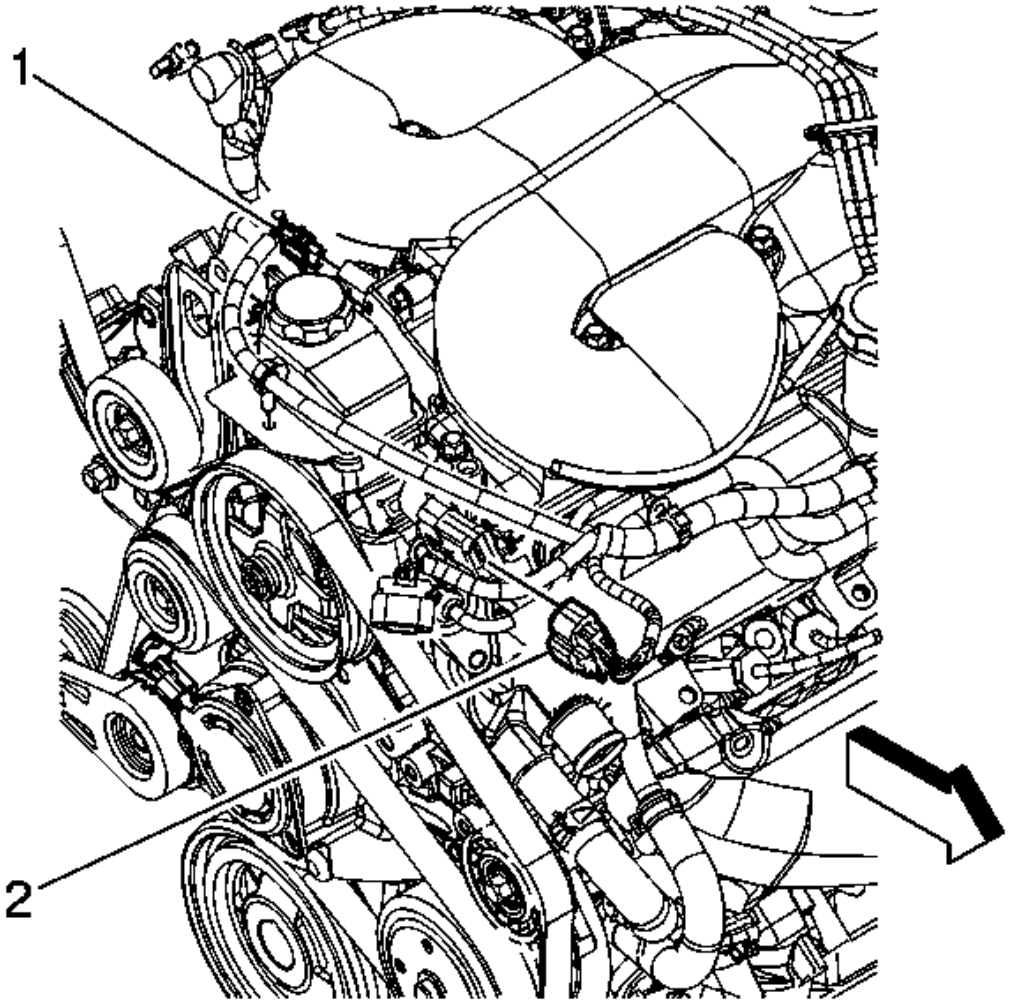

Fig. 105: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

20. Connect the fuel injector inline connector (2).
21. Connect the fuel feed line to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
22. Connect the ECT electrical connector.
23. Install the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right Side**.
24. Install the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side**.
25. Install the upper intake manifold. Refer to **Upper Intake Manifold Replacement**.
26. Install the coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement (LZ9)** .

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POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

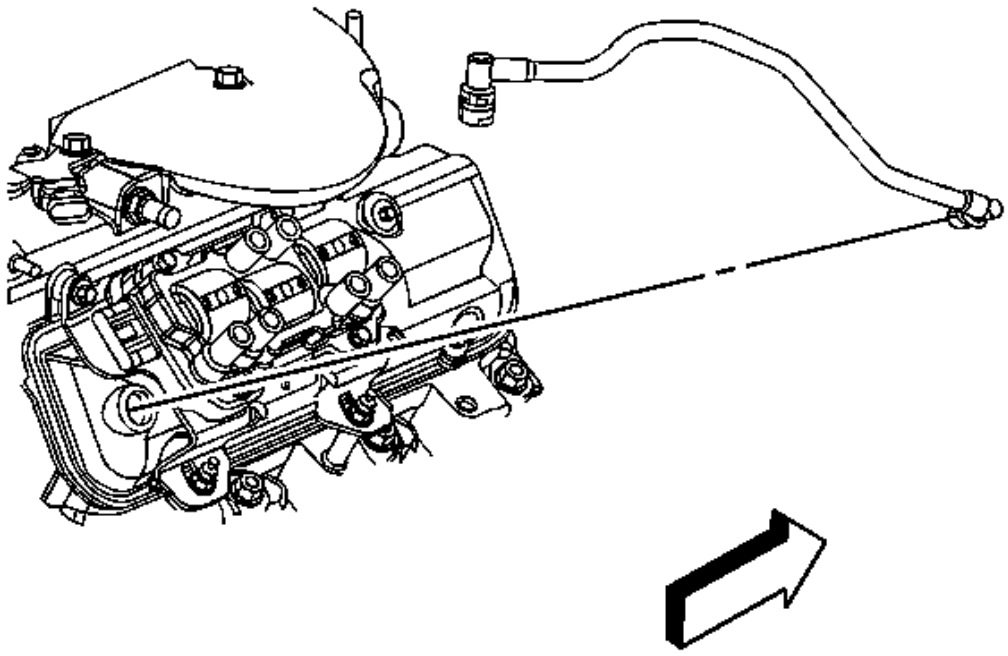

Fig. 106: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Disconnect the positive crankcase ventilation (PCV) fresh air tube from the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Remove the PCV fresh air tube from the rocker arm cover.
4. Remove the PCV fresh air tube from the vehicle.

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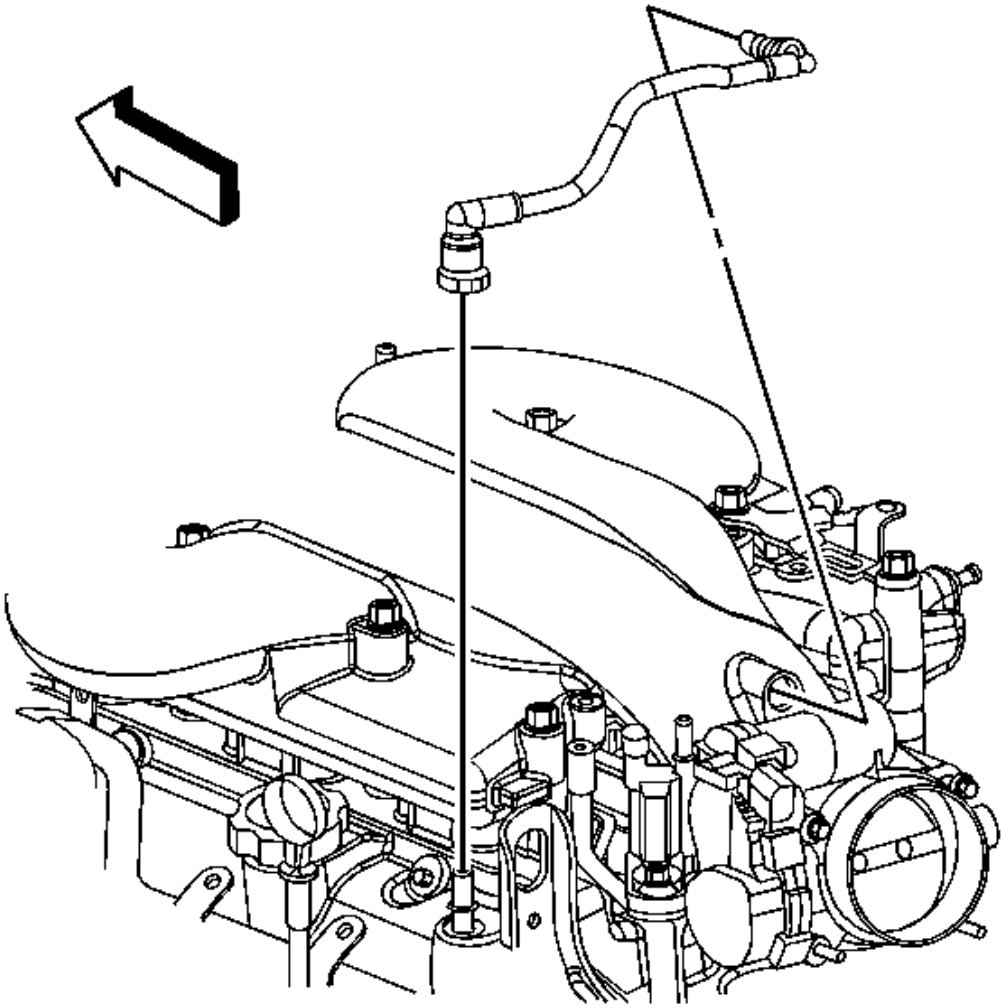

Fig. 107: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the PCV foul air tube from the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
6. Remove the PCV foul air tube from the intake manifold.
7. Remove the PCV foul air tube from the vehicle.

Installation Procedure

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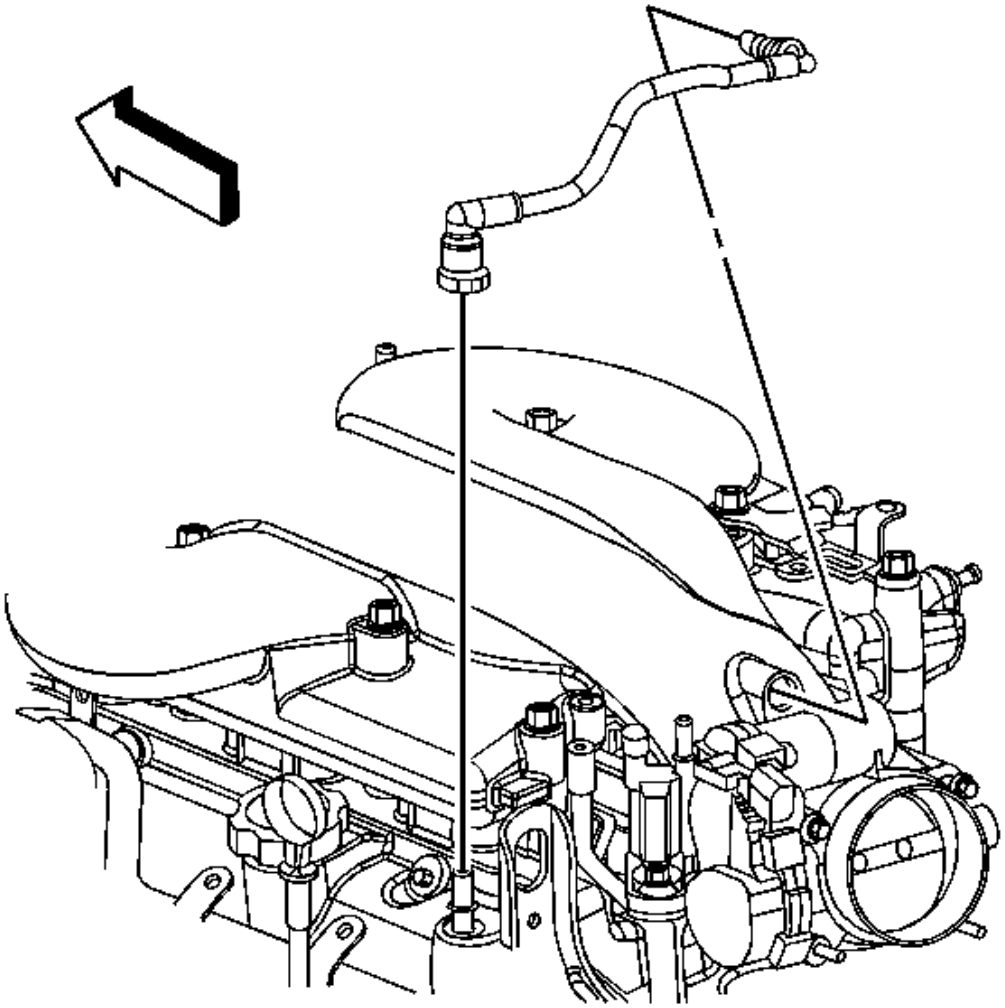

Fig. 108: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV foul air tube to the vehicle.
2. Install the PCV foul air tube to the intake manifold.
3. Connect the PCV foul air tube to the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

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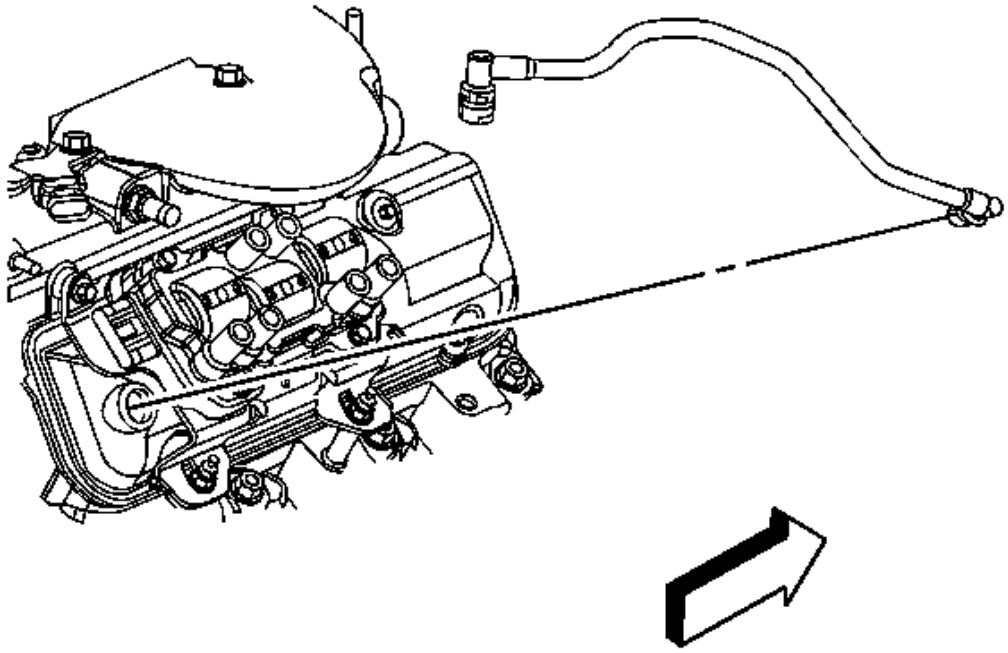

Fig. 109: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Install the PCV fresh air tube to the vehicle.
5. Install the PCV fresh air tube to the rocker arm cover.
6. Connect the PCV fresh air tube to the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

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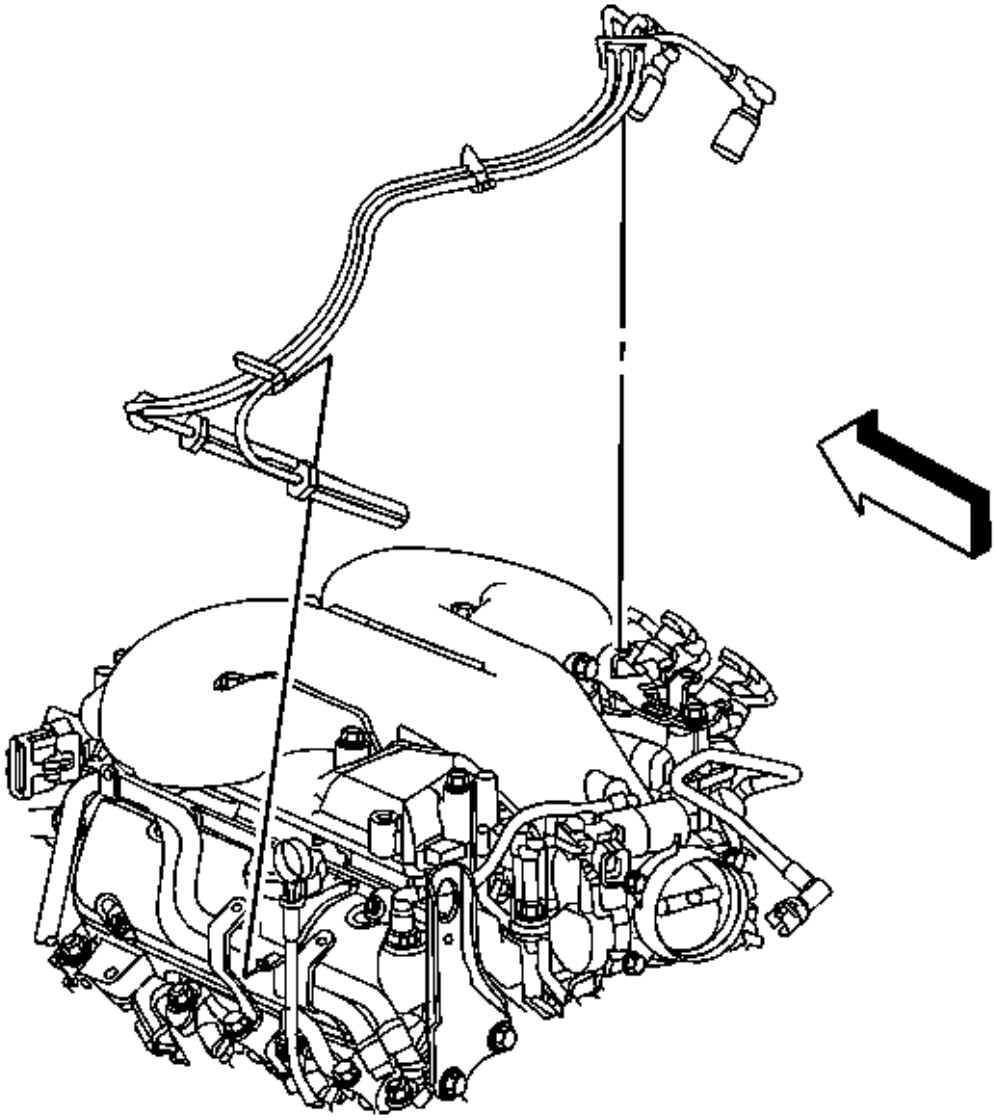

Fig. 110: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

1. Partially drain the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
3. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
4. Disconnect the left spark plug wires from the spark plugs.

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5. Remove the spark plug wire harness clip from the heater inlet and outlet front pipe bracket.
6. Remove the heater inlet and outer front pipe. Refer to **Heater Inlet Hose/Pipe and Heater Outlet Hose/Pipe Replacement (LZE, LZ4, LZ9)** .

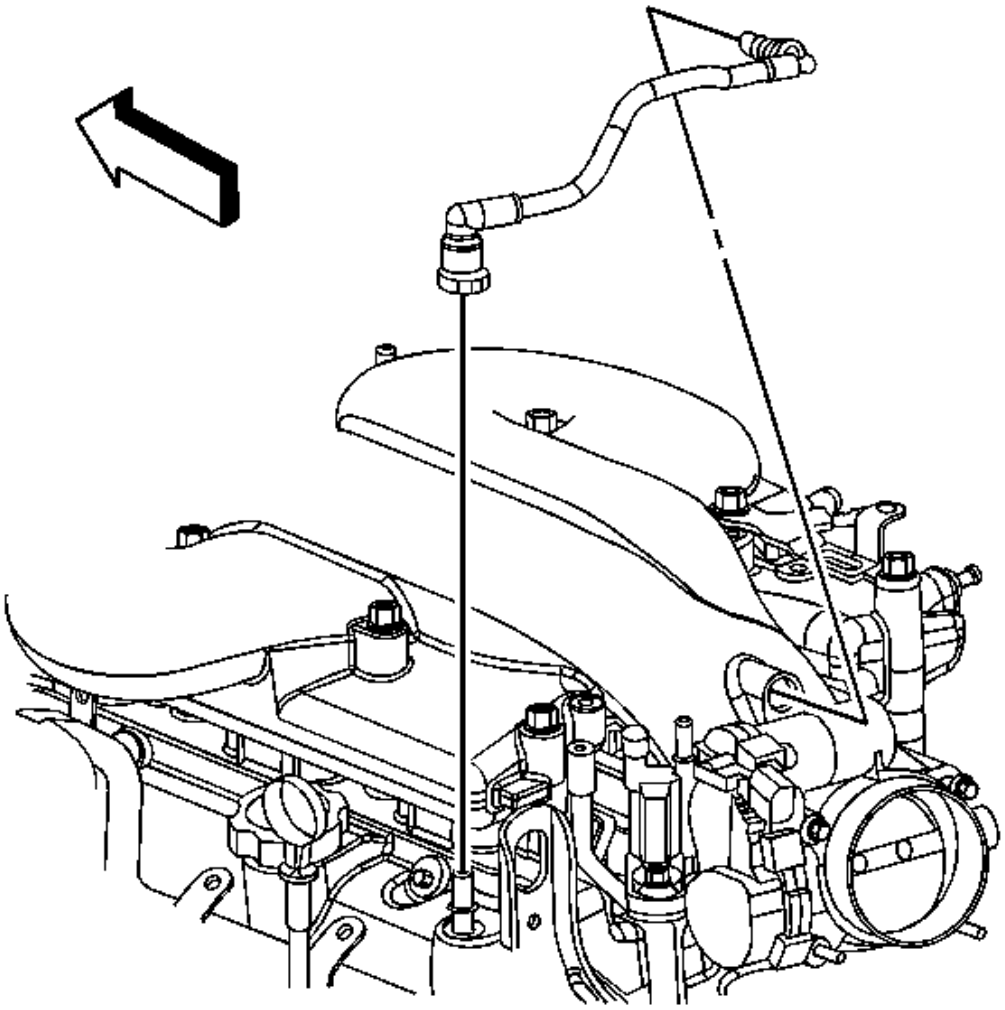

Fig. 111: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the positive crankcase ventilation (PCV) foul air tube from the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

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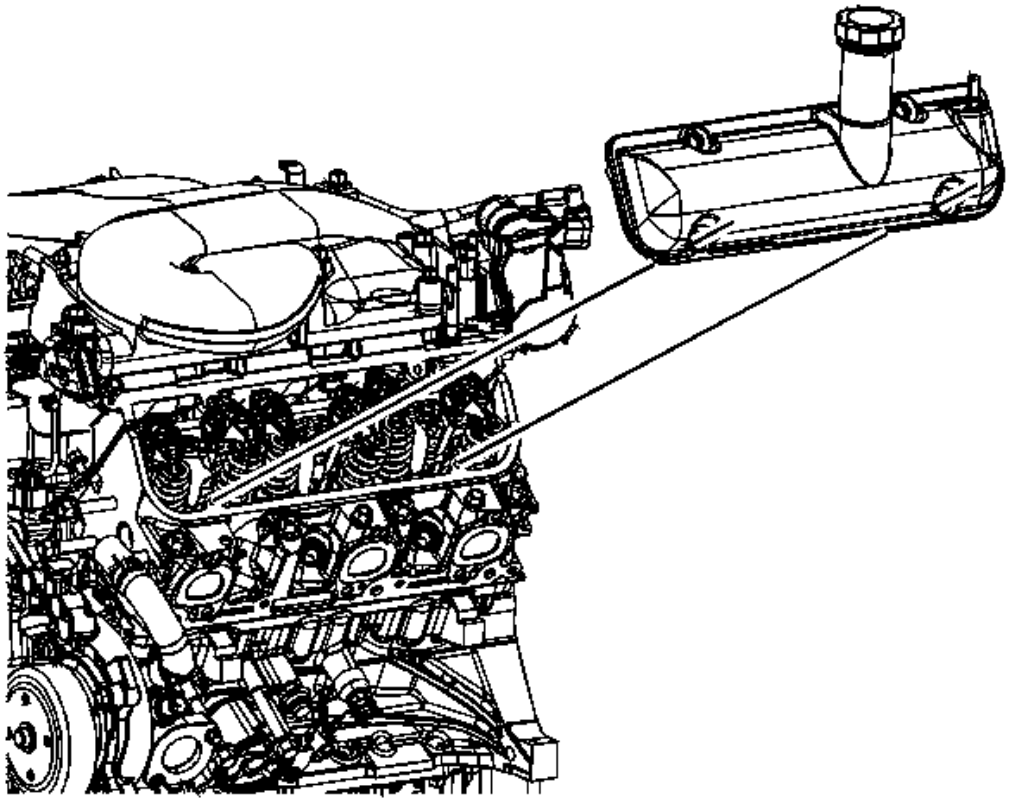

Fig. 112: Identifying Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve rocker arm cover bolts.

NOTE: When removing the valve rocker arm cover, ensure the gasket stays in place attached to the cylinder head.

9. Remove the valve rocker arm cover. If necessary, bump the end of the cover with the palm of your hand or a soft rubber mallet if the cover adheres to the cylinder head.
10. Cut the RTV in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
11. Remove the valve cover gasket.
12. Clean the sealing surface on the cylinder head with degreaser.

Installation Procedure

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NOTE: **All gasket mating surfaces need to be free of oil and foreign material. Use lubricant to clean the surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers for the correct part number.**

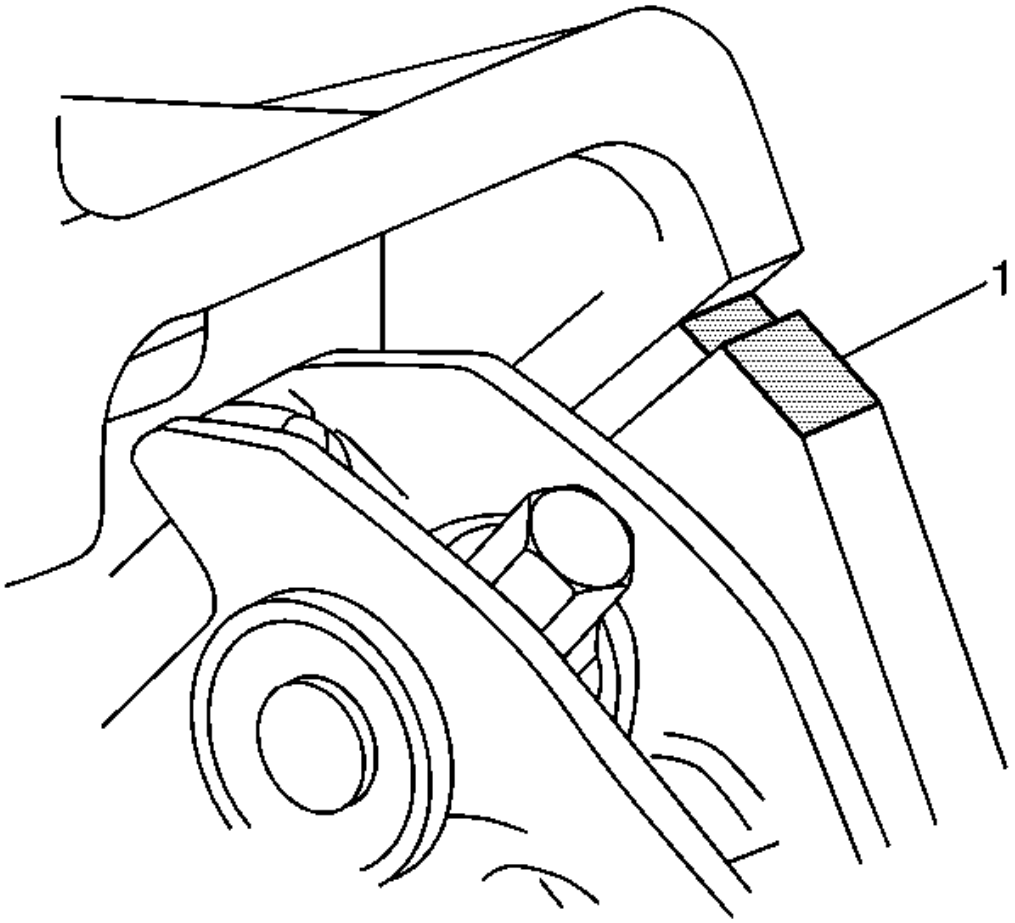

Fig. 113: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW valve rocker arm cover gasket into the groove in the valve rocker arm cover. Ensure that the gasket is properly seated in the groove of the valve rocker arm cover.
2. Apply sealant at the cylinder head to the surfaces where the cylinder head and intake manifold meet (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

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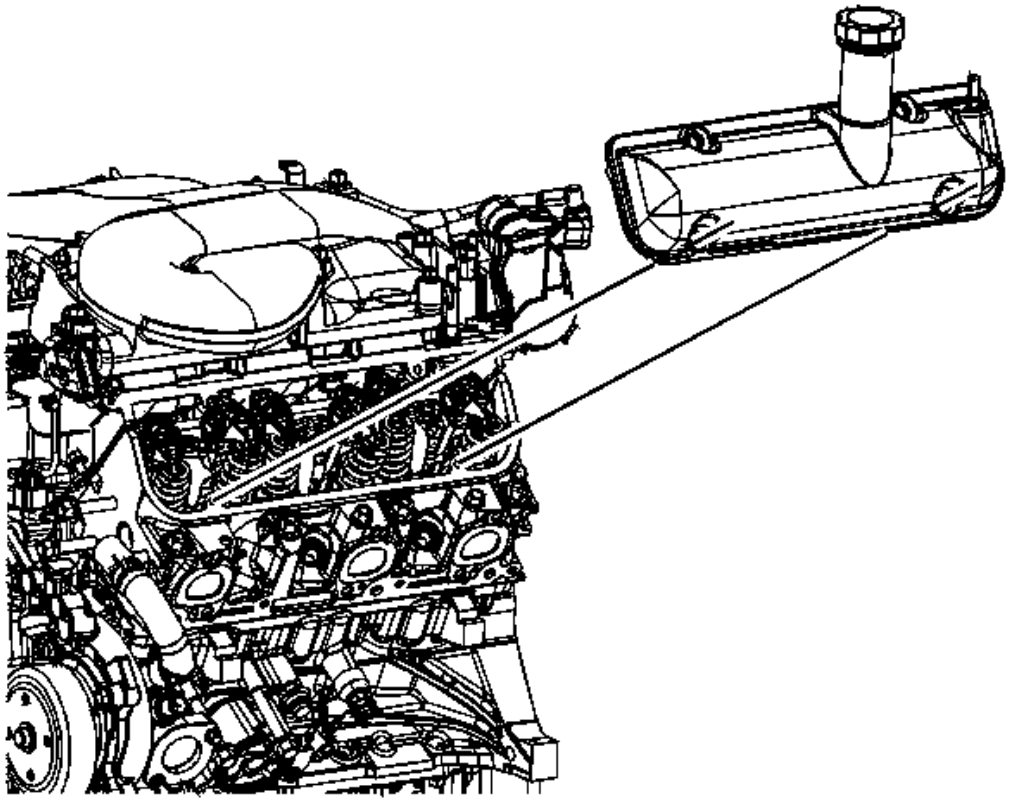

Fig. 114: Identifying Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover.

CAUTION: Refer to Fastener Caution .

NOTE: Use an alternating criss-cross pattern when tightening the valve rocker cover bolts. Failure to do so may result in oil leakage from the valve cover due to improper seating of the gasket.

4. Install the valve rocker arm cover bolts.

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

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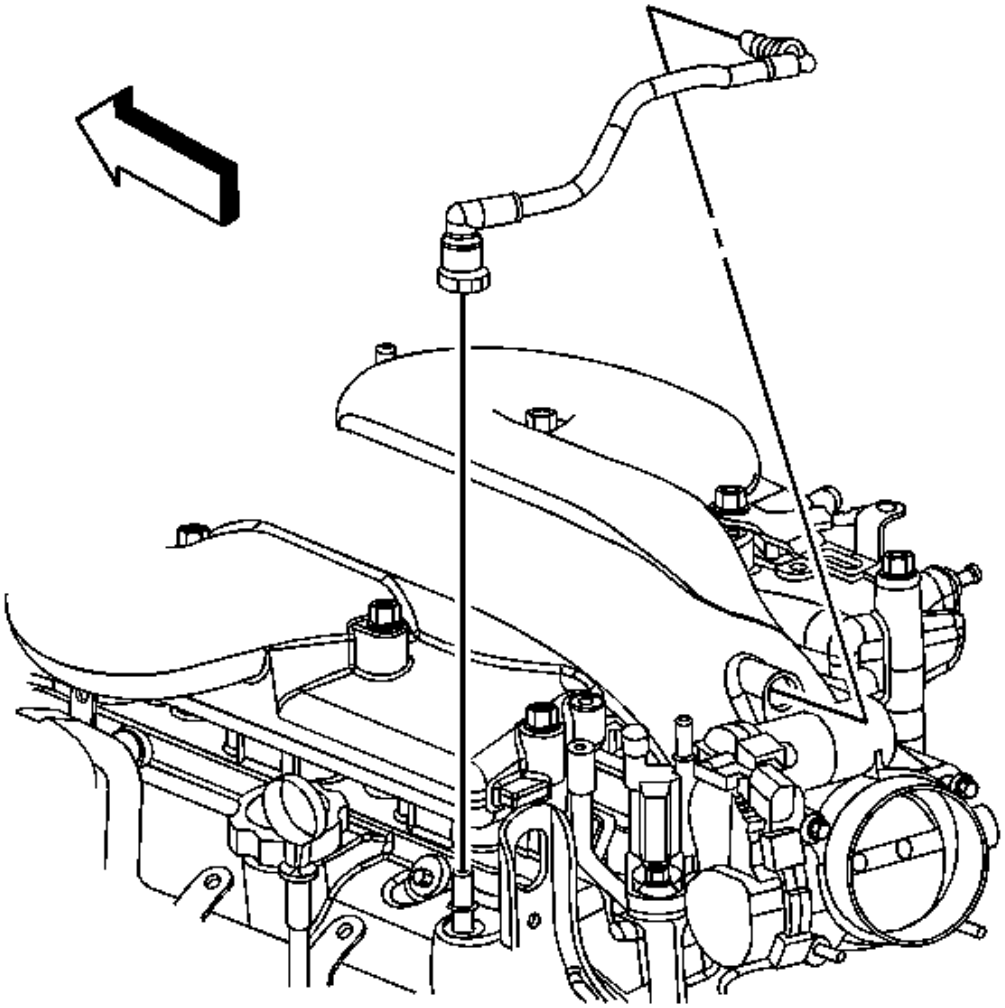

Fig. 115: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Connect the PCV foul air tube to the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

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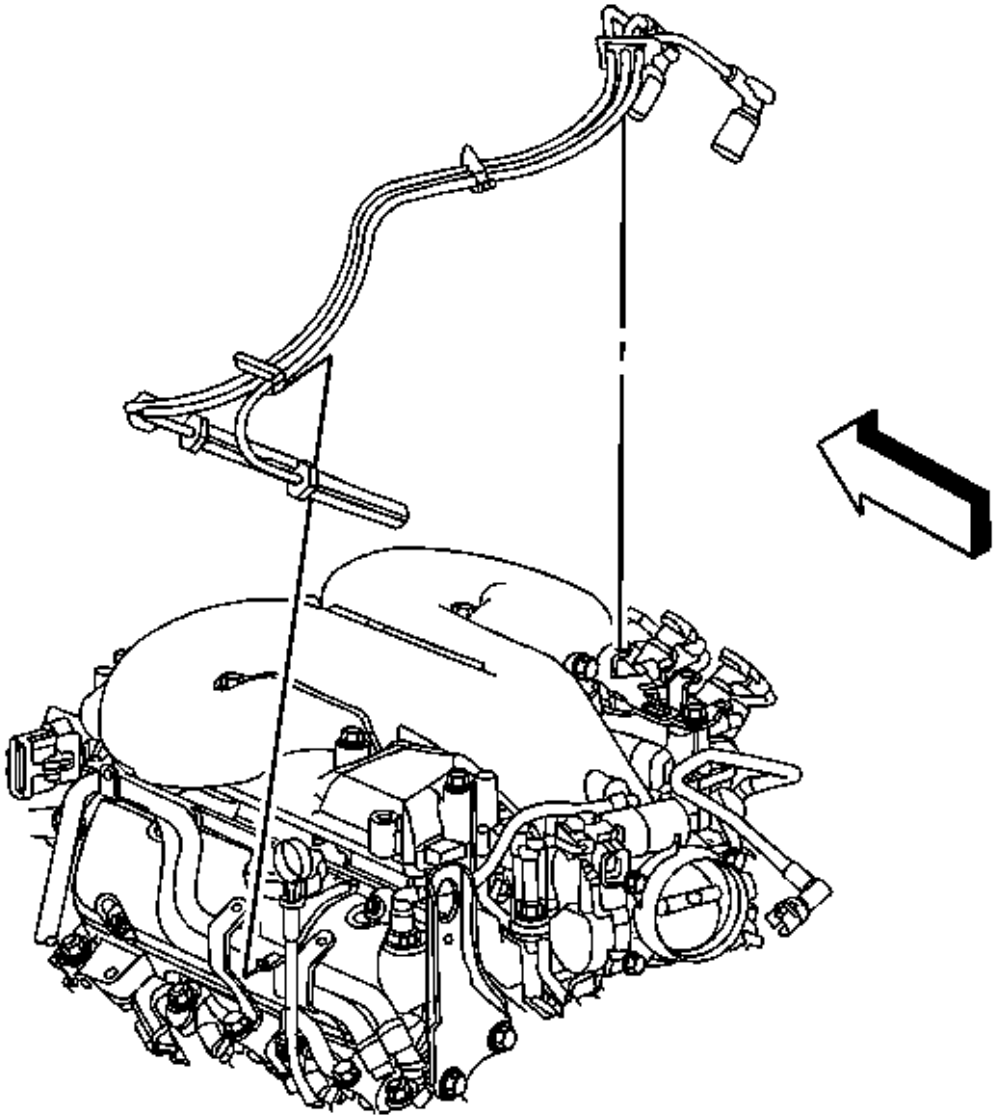

Fig. 116: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

6. Install the heater inlet and outer front pipe. Refer to **Heater Inlet Hose/Pipe and Heater Outlet Hose/Pipe Replacement (LZE, LZ4, LZ9)** .
7. Install the spark plug wire harness clip to the heater inlet and outlet front pipe bracket.
8. Connect the left spark plug wires to the spark plugs.
9. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

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10. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
11. Fill the cooling system, as necessary. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

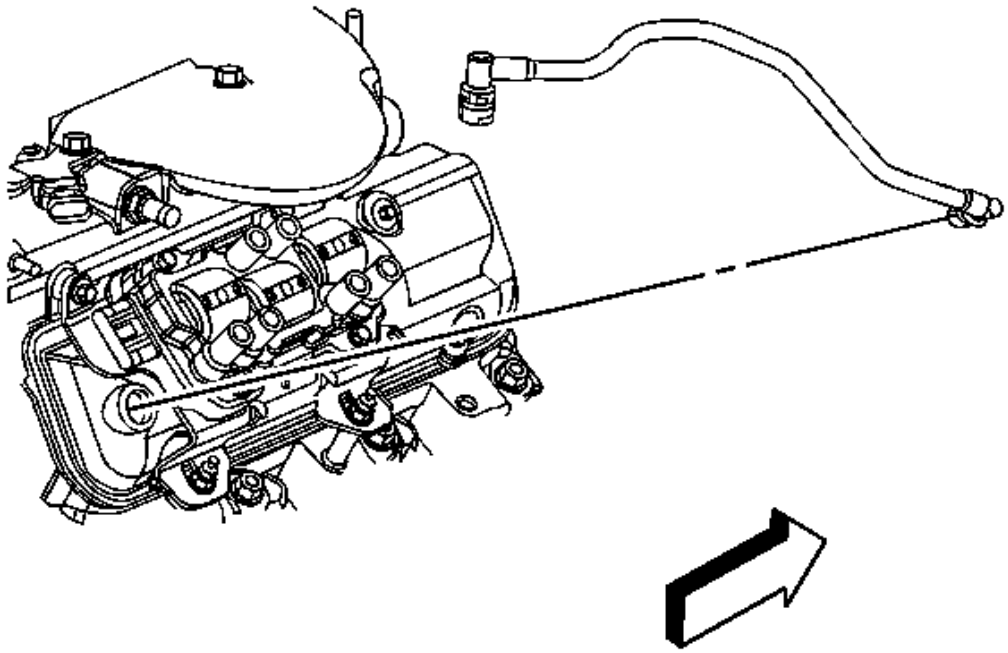

Fig. 117: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the generator. Refer to **Generator Replacement (LZ9)** .
2. Remove the engine coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement (LZ9)** .
3. Disconnect the positive crankcase ventilation (PCV) fresh air tube from the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
4. Remove the PCV fresh air tube from the right side valve rocker arm cover.

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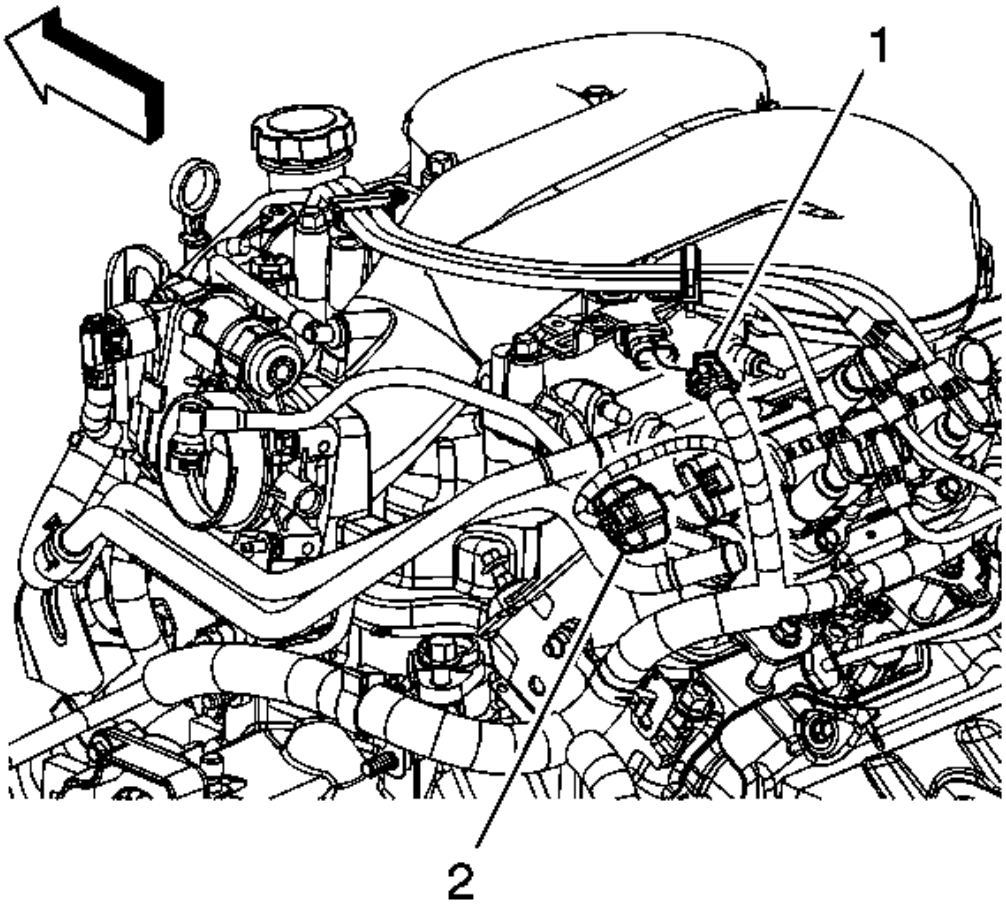

Fig. 118: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (1).
6. Disconnect the ignition coil electrical connector (2).
7. Remove the heated oxygen sensor (HO2S) electrical connector clip from the ignition coil bracket.

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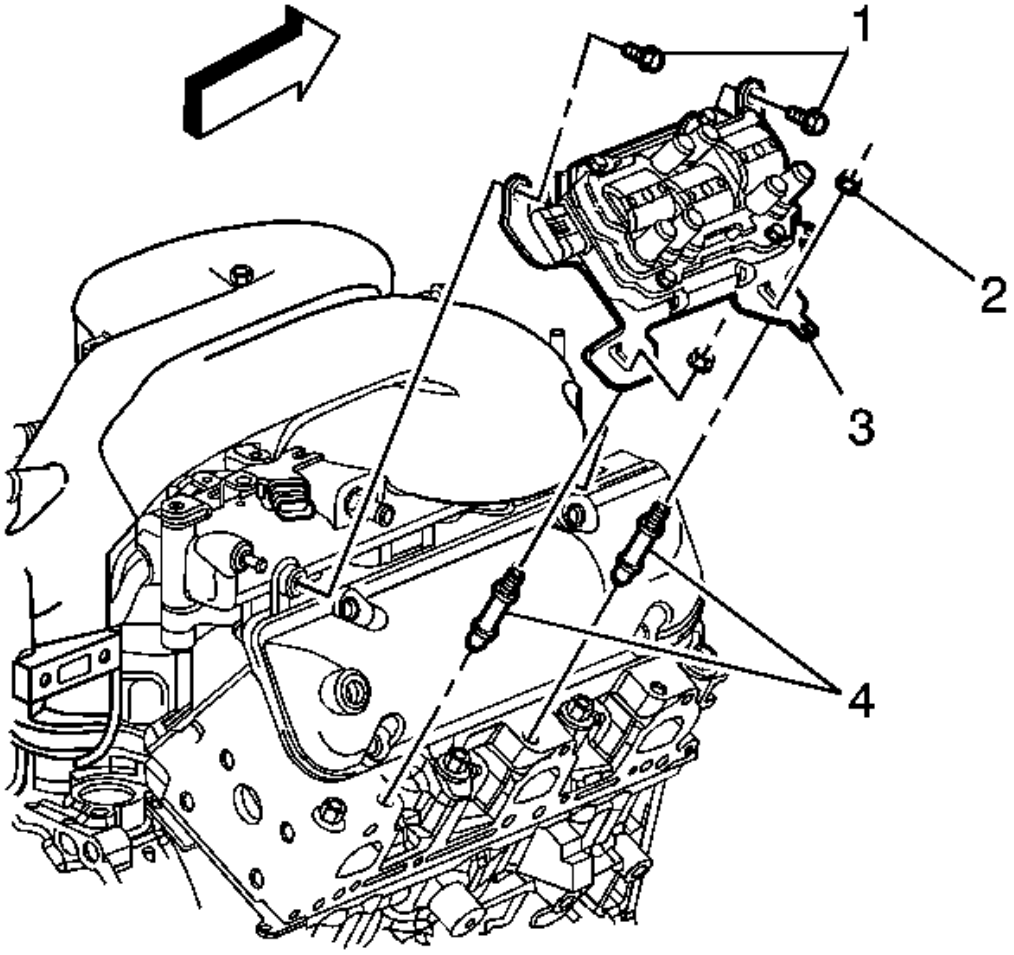

Fig. 119: Identifying Ignition Coil Bracket Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

8. Remove the spark plug wires from the ignition coil.
9. Remove the ignition coil bracket bolts (1) and nuts (2).
10. Remove the ignition coil with bracket (3) from the engine.

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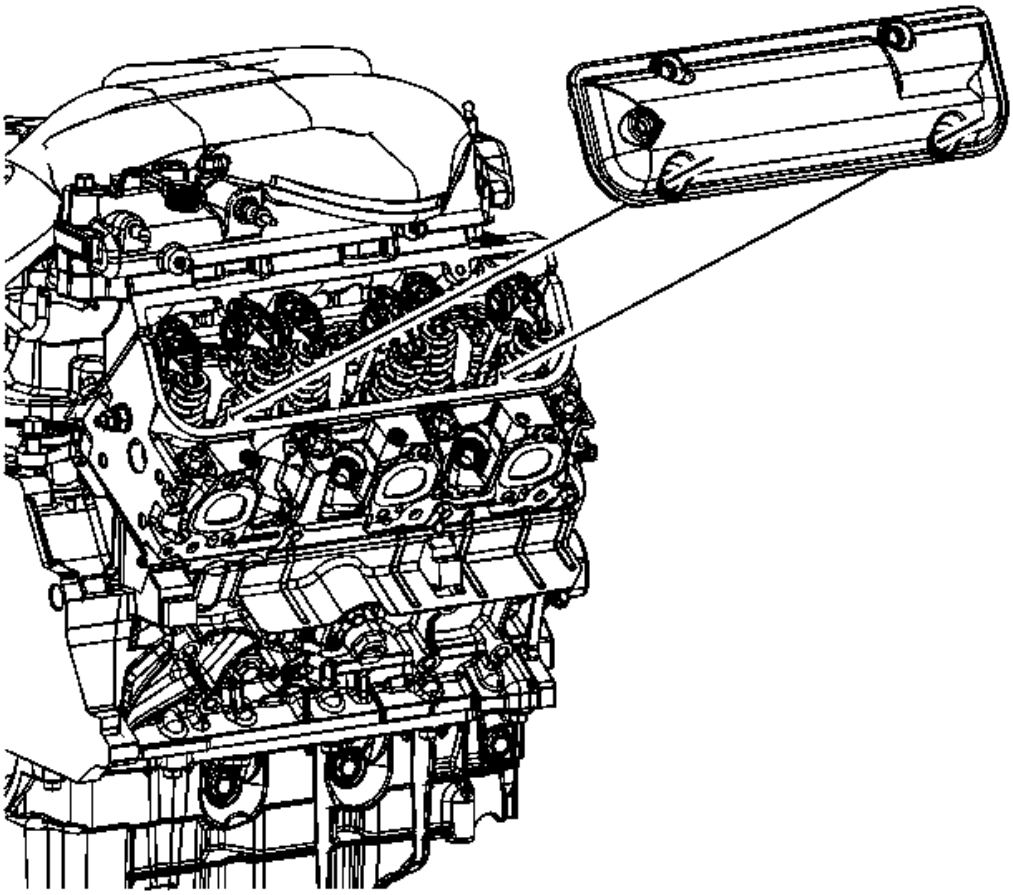

Fig. 120: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

11. Remove the valve rocker arm cover bolts.

NOTE: When removing the valve rocker arm cover, ensure the gasket stays in place attached to the cylinder head.

12. Remove the valve rocker arm cover. Bump the end of the cover with the palm of your hand or a soft rubber mallet if the cover adheres to the cylinder head.
13. Cut the room temperature vulcanizing (RTV) sealer in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
14. Remove the valve cover gasket.
15. Clean the sealing surface on the cylinder head with degreaser.

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Installation Procedure

NOTE: All gasket mating surfaces need to be free of oil and foreign material. Use lubricant to clean the surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers for the correct part number.

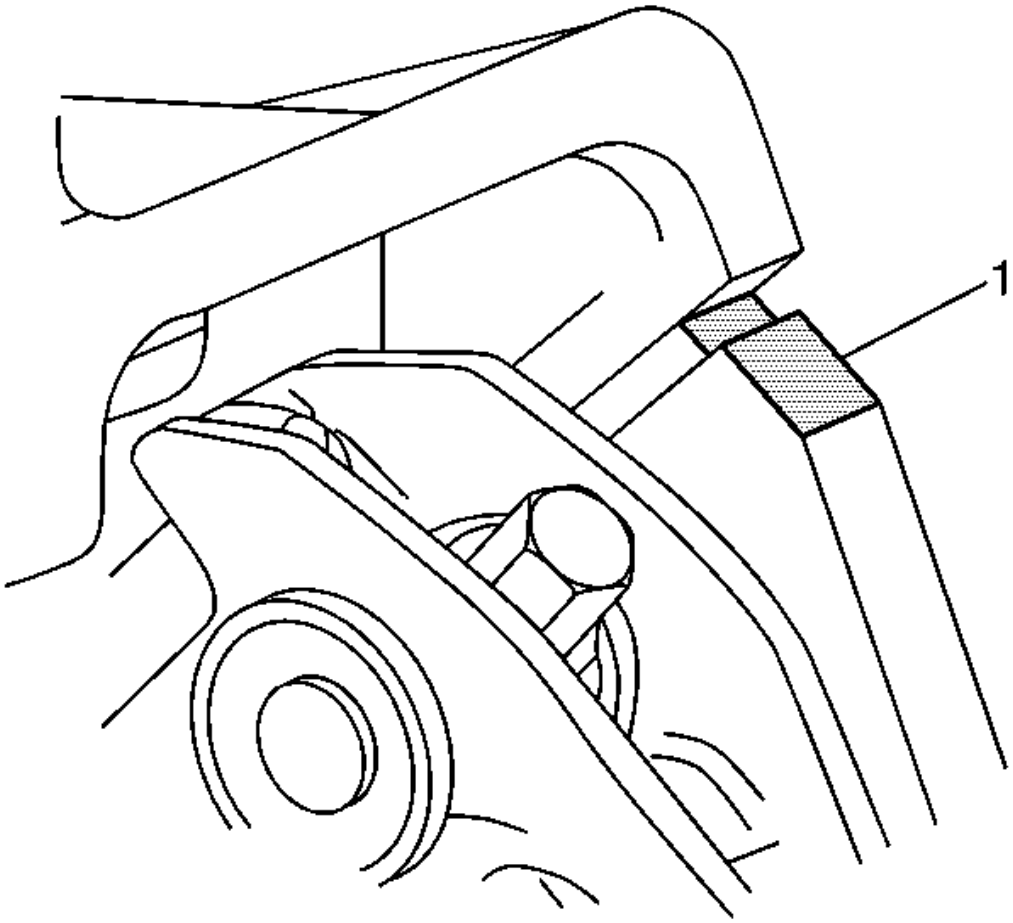

Fig. 121: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW valve rocker arm cover gasket into the groove in the valve rocker arm cover. Ensure that the gasket is properly seated in the groove of the valve rocker arm cover.
2. Apply sealant at the cylinder head to the surfaces where the cylinder head and intake manifold meet (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

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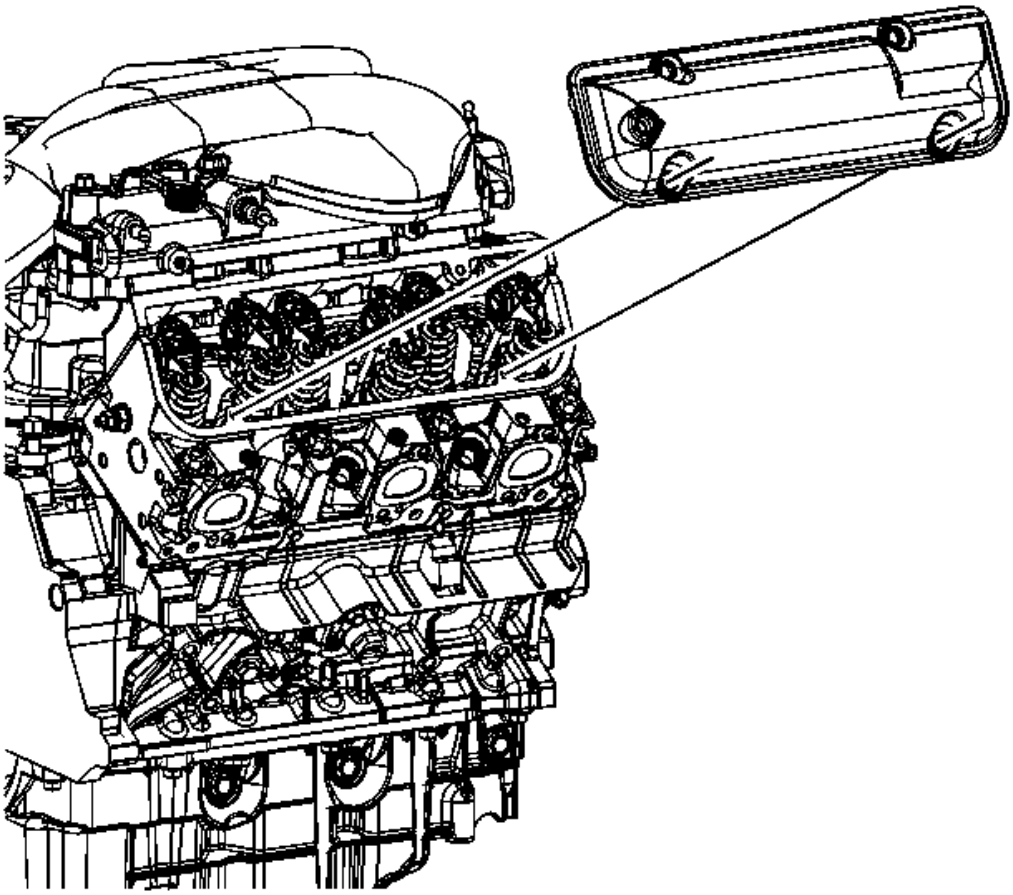

Fig. 122: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Install a new gasket to the valve rocker arm cover. Ensure that the gasket is properly seated in the groove of the valve rocker arm cover.
4. Install the right valve rocker arm cover.

CAUTION: Refer to Fastener Caution .

NOTE: Use an alternating criss-cross pattern when tightening the valve rocker cover bolts. Failure to do so may result in oil leakage from the valve cover due to improper seating of the gasket.

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5. Install the valve rocker arm cover bolts.

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

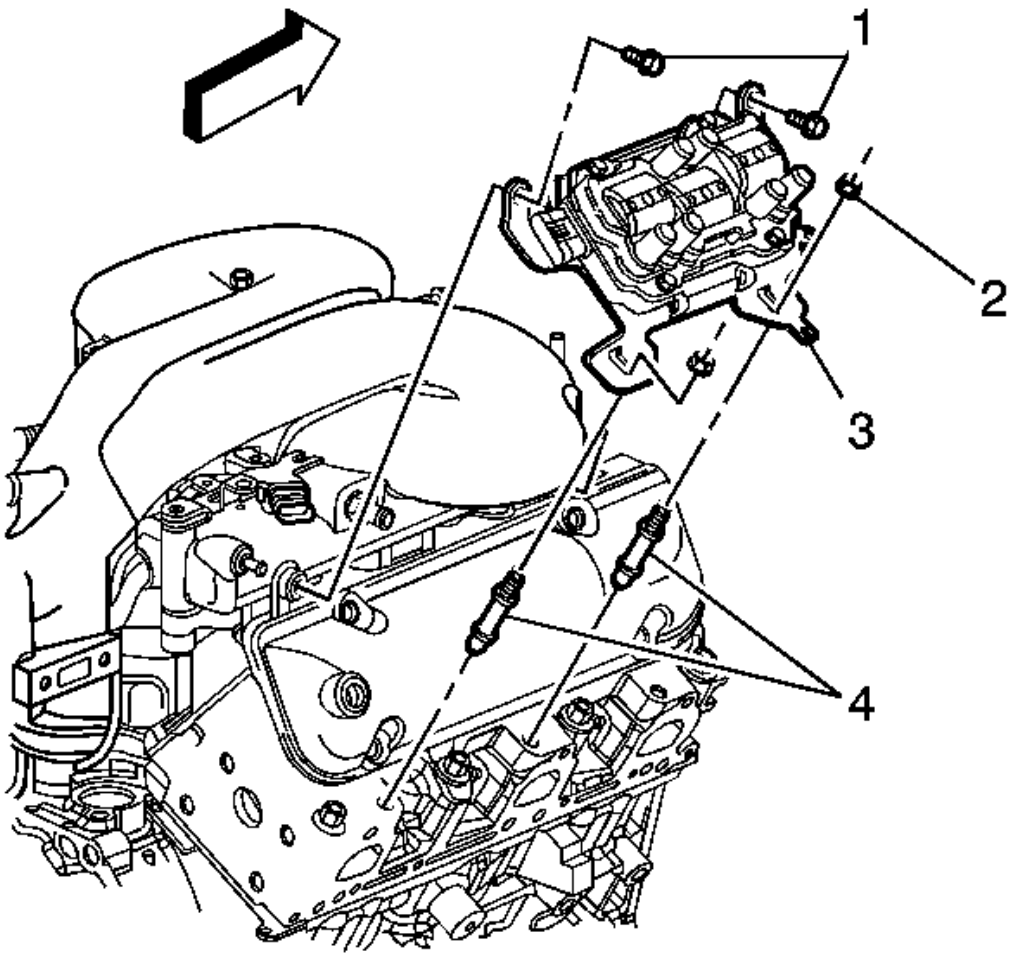

Fig. 123: Identifying Ignition Coil Bracket Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the ignition coil with bracket (3) to the engine.
7. Install the ignition coil bracket bolts (1) and nuts (2).

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

8. Install the spark plug wires to the ignition coil.

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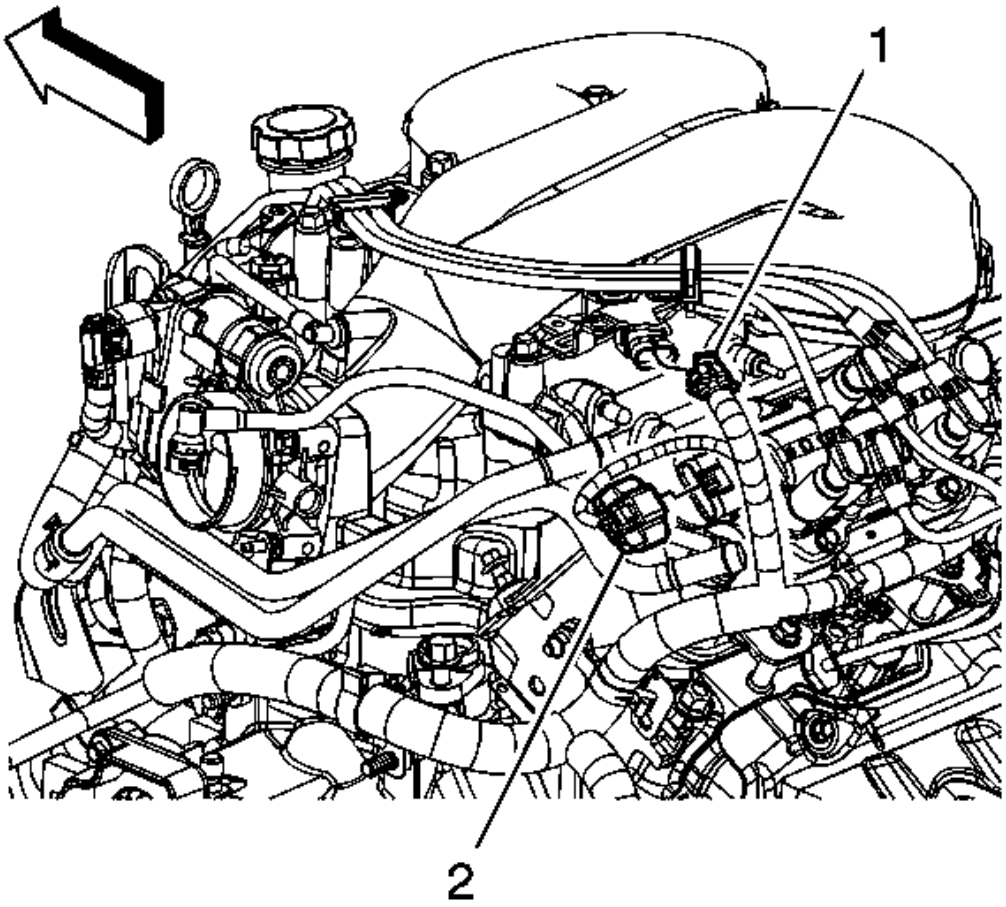

Fig. 124: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

9. Install the HO2S electrical connector clip to the ignition coil bracket.
10. Connect the ignition coil electrical connector (2).
11. Connect the MAP sensor electrical connector (1).

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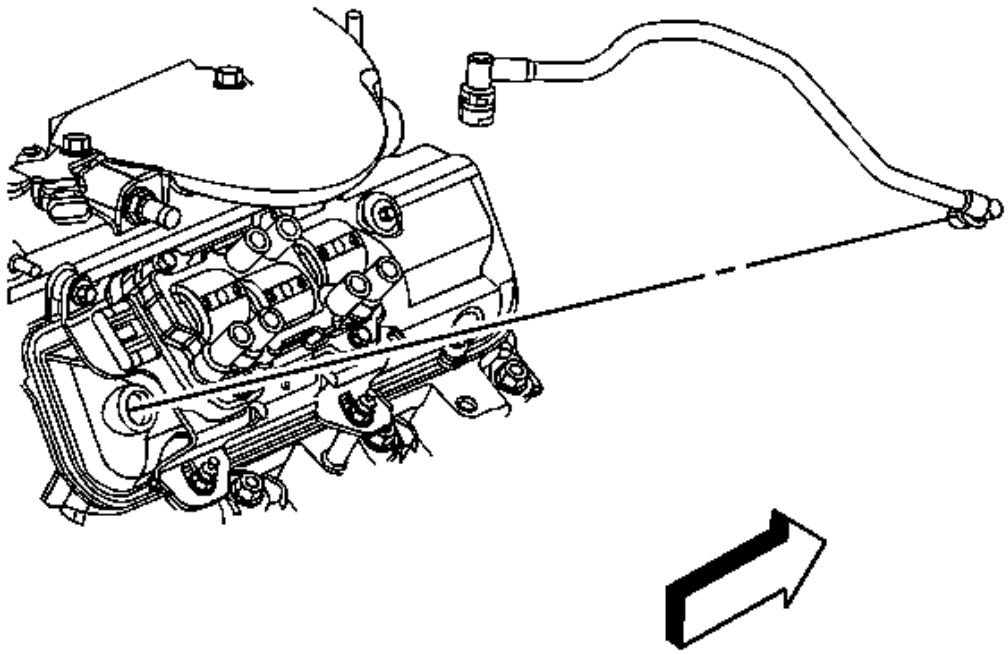

Fig. 125: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

12. Install the PCV fresh air tube to the right side valve rocker arm cover.
13. Connect the PCV fresh air tube to the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
14. Install the engine coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement (LZ9)** .
15. Install the generator. Refer to **Generator Replacement (LZ9)** .

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

NOTE: **Place the valve train components in a rack in order to ensure that the components are installed in the same location from which they were removed.**

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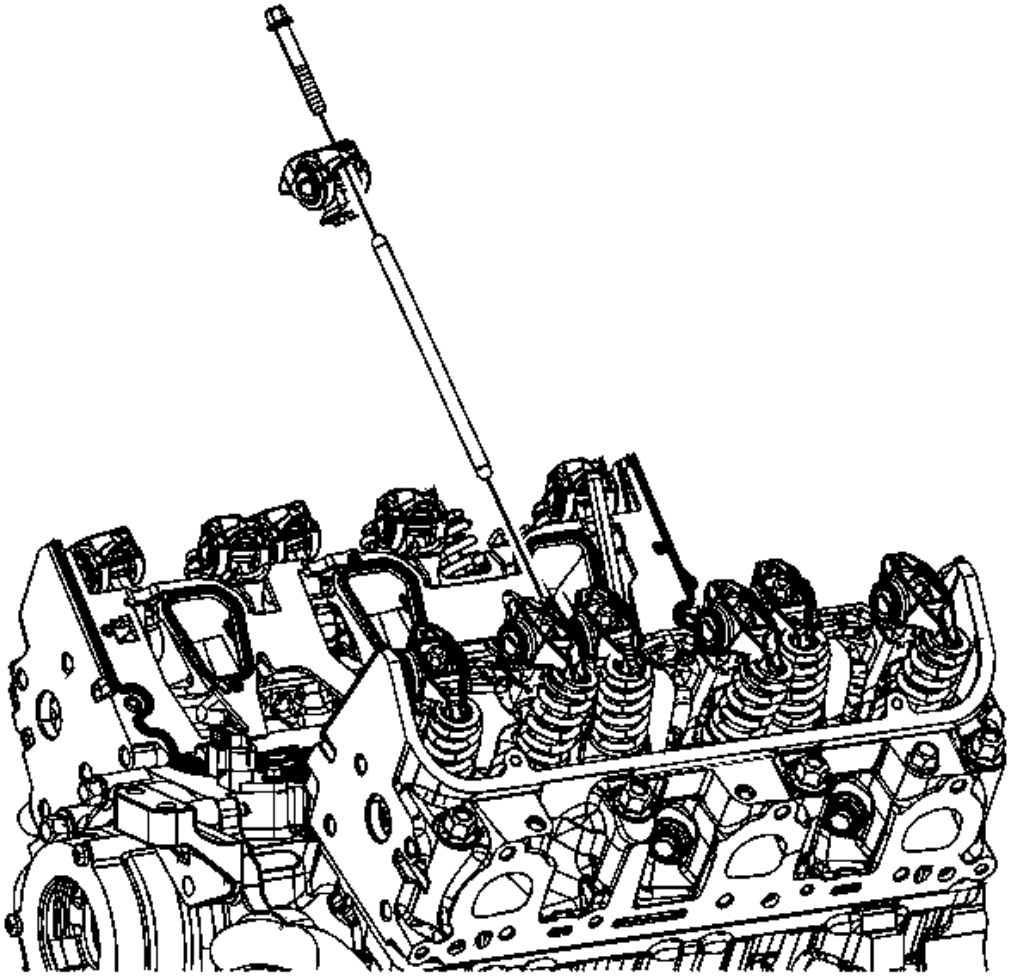

Fig. 126: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm covers. Refer to **Valve Rocker Arm Cover Replacement - Left Side** or **Valve Rocker Arm Cover Replacement - Right Side**.
2. Remove the valve rocker arm bolts.
3. Remove the rocker arms.
4. Remove the pushrods.
    - The intake push rods measure 147.51 mm (5.81 in).
    - The exhaust push rods measure 154.87 mm (6.1 in).

Installation Procedure

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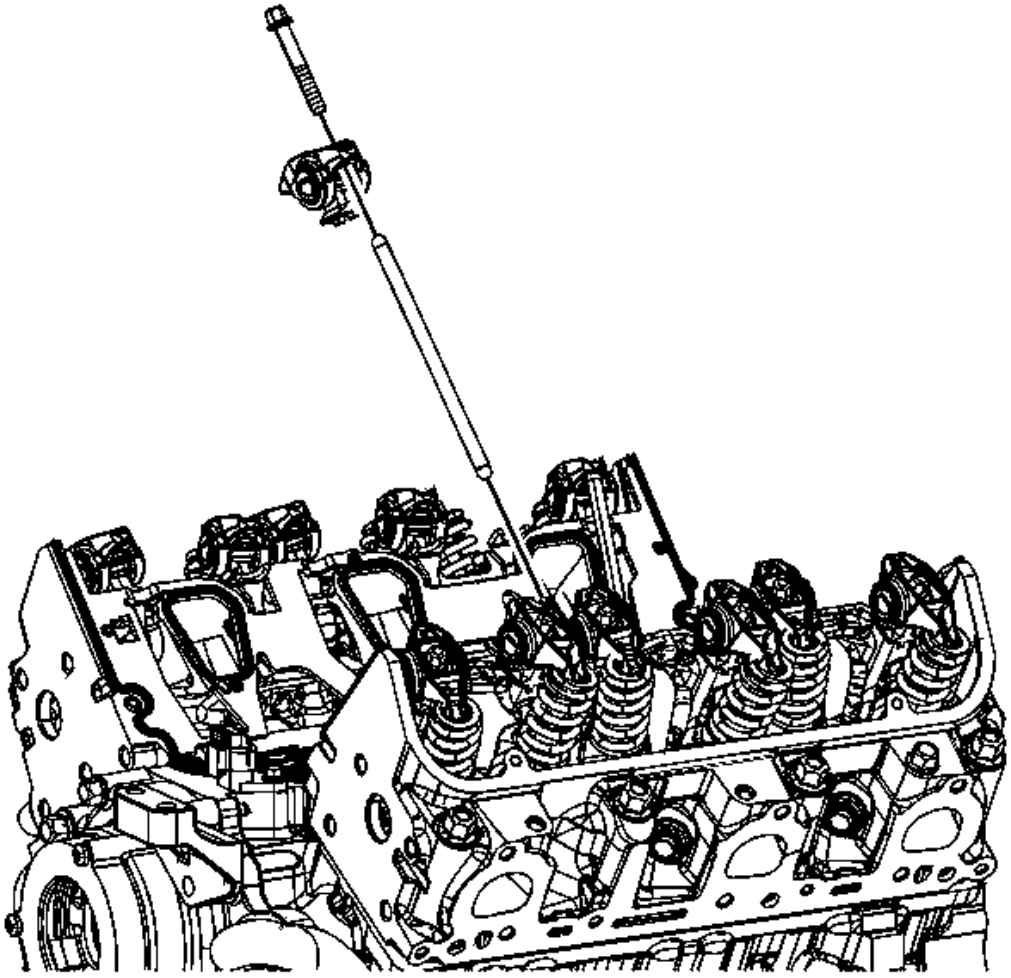

Fig. 127: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Coat the ends of the pushrods using prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Install the pushrods.
   - The intake pushrods are identified with blue stripes.
   - The exhaust pushrods are identified with yellow stripes.
3. Ensure that the pushrods seat in the lifter bore.
4. Coat the rocker arm friction surfaces using prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

NOTE: Shims (88894006) may be required under the valve rocker arm pedestals if

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reconditioning has been performed on the cylinder head or its components.

5. Install the rocker arms.

CAUTION: Refer to Fastener Caution .

6. Install the rocker arm bolts and tighten to 34 N.m (25 lb ft).
7. Install the valve rocker arm covers. 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

- **EN-47823** Valve Spring Compressor Adapter
- **J 22794** Spark Plug Port Adapter
- **J 5892-D** Valve Spring Compressor

Removal Procedure

IMPORTANT:

- **Before removing the valve locks, rotate the engine so that the piston in the cylinder you are working on is at top dead center (TDC). This will eliminate the possibility of the valve accidentally falling inside the cylinder.**
- **Loosen the spark plug, and clean any dirt and/or debris from the spark plug recess area before removing.**

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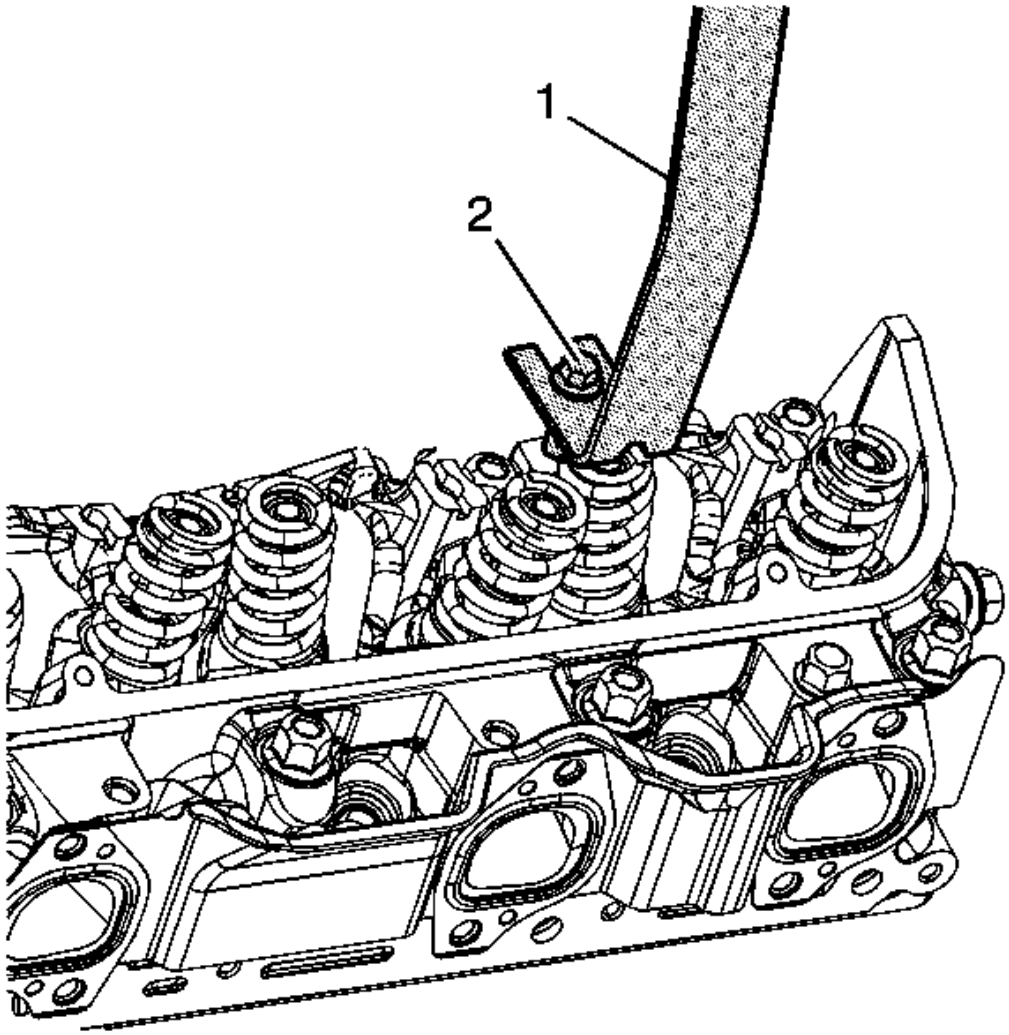

Fig. 128: Identifying Valve Spring Compressing Tools
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug. Refer to **Spark Plug Replacement** .
2. Remove the rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
3. Install the **J 22794** into the spark plug port. Apply compressed air in order to hold the valve in place.
4. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve spring using the **J 5892-D** (1) and the **EN-47823** (2).

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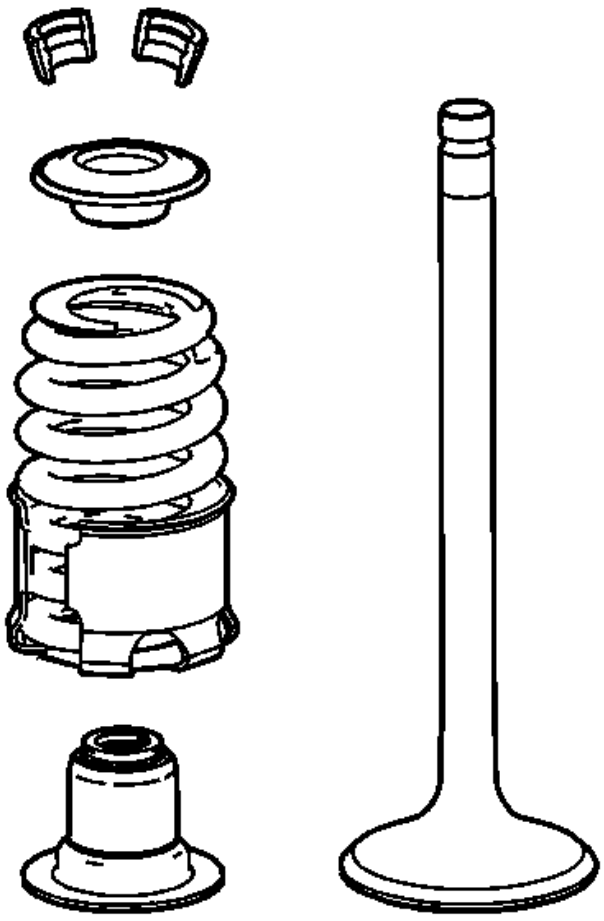

Fig. 129: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve spring cap keys.
6. Remove the valve cap.
7. Remove the valve spring.
8. Remove the valve stem oil seal.

Installation Procedure

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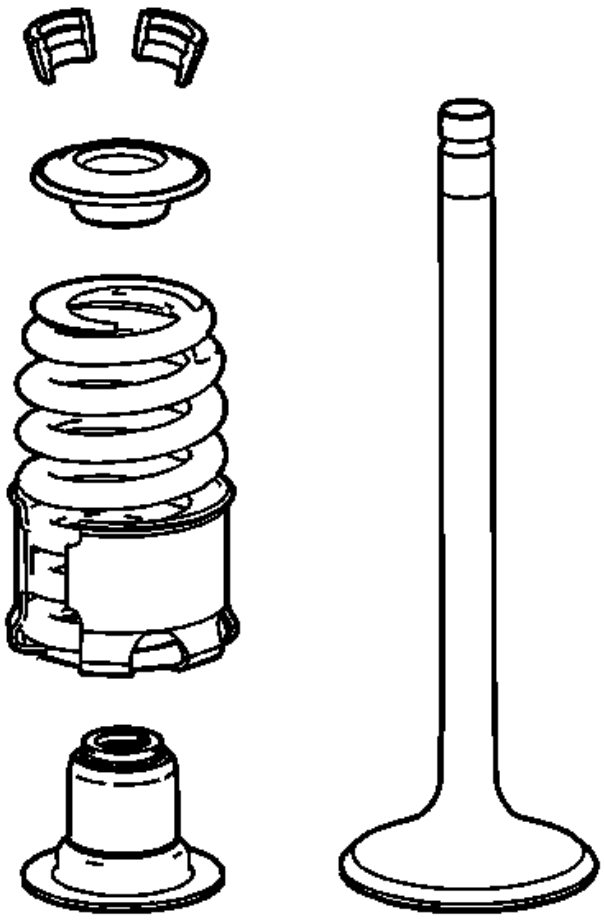

Fig. 130: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem with clean engine oil.
2. Install the valve stem oil seal, ensuring the proper seals (intake - black seal and exhaust - brown seal), are installed.
3. Install the valve spring.
4. Install the valve cap.

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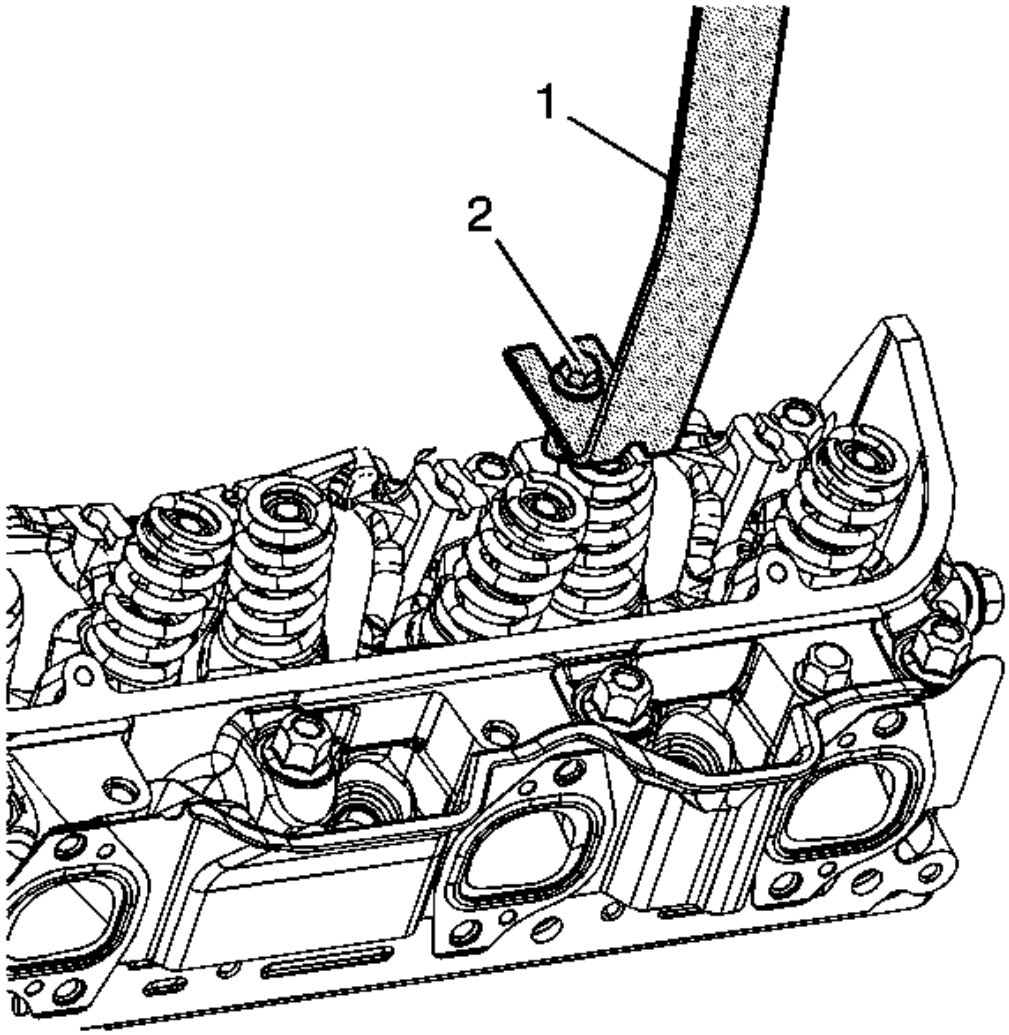

Fig. 131: Identifying Valve Spring Compressing Tools
Courtesy of GENERAL MOTORS CORP.

5. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve spring using the **J 5892-D** (1) and the **EN-47823** (2).
6. Install the valve cap keys. If necessary, use grease in order to hold the valve cap keys in place.
7. Ensure the valve cap keys are seated.
8. Remove the compressed air and remove the **J 22794** from the spark plug port.
9. Install the rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
10. Install the spark plug. Refer to **Spark Plug Replacement** .

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VALVE LIFTER REPLACEMENT

Removal Procedure

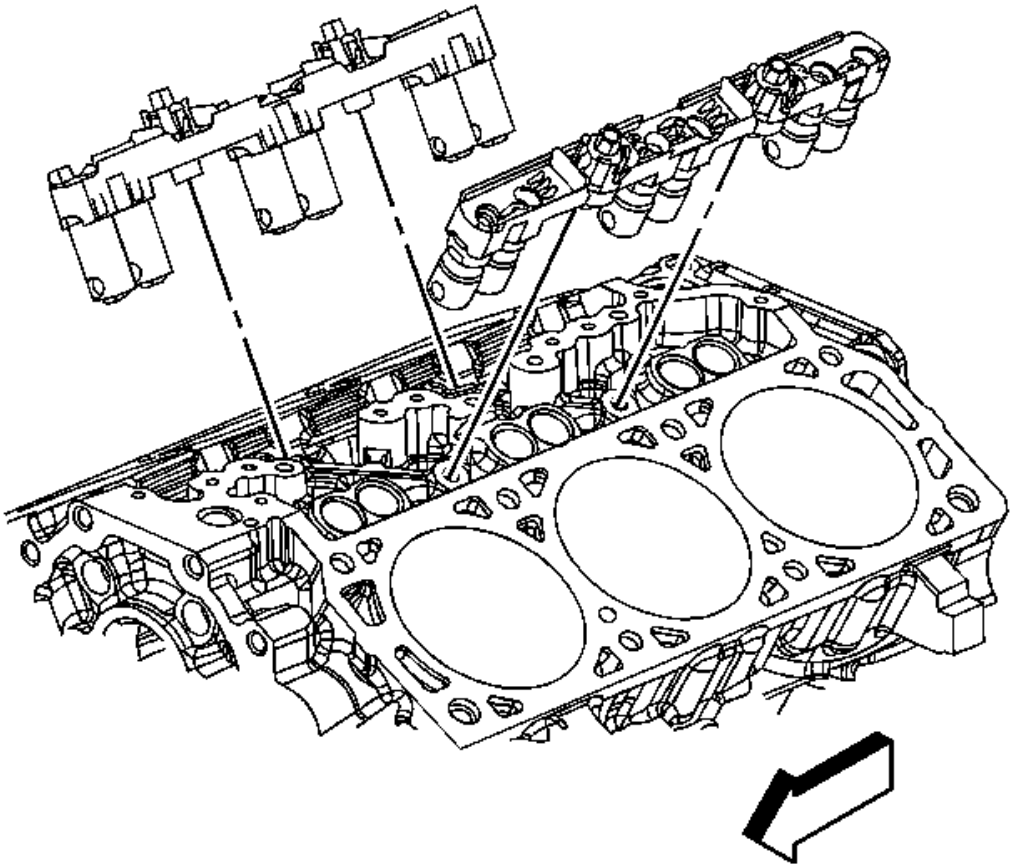

Fig. 132: Identifying Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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

NOTE: The valve lifter guide bolts are not removable.

3. Loosen the valve lifter guide bolts.
4. Remove the valve lifter guides.

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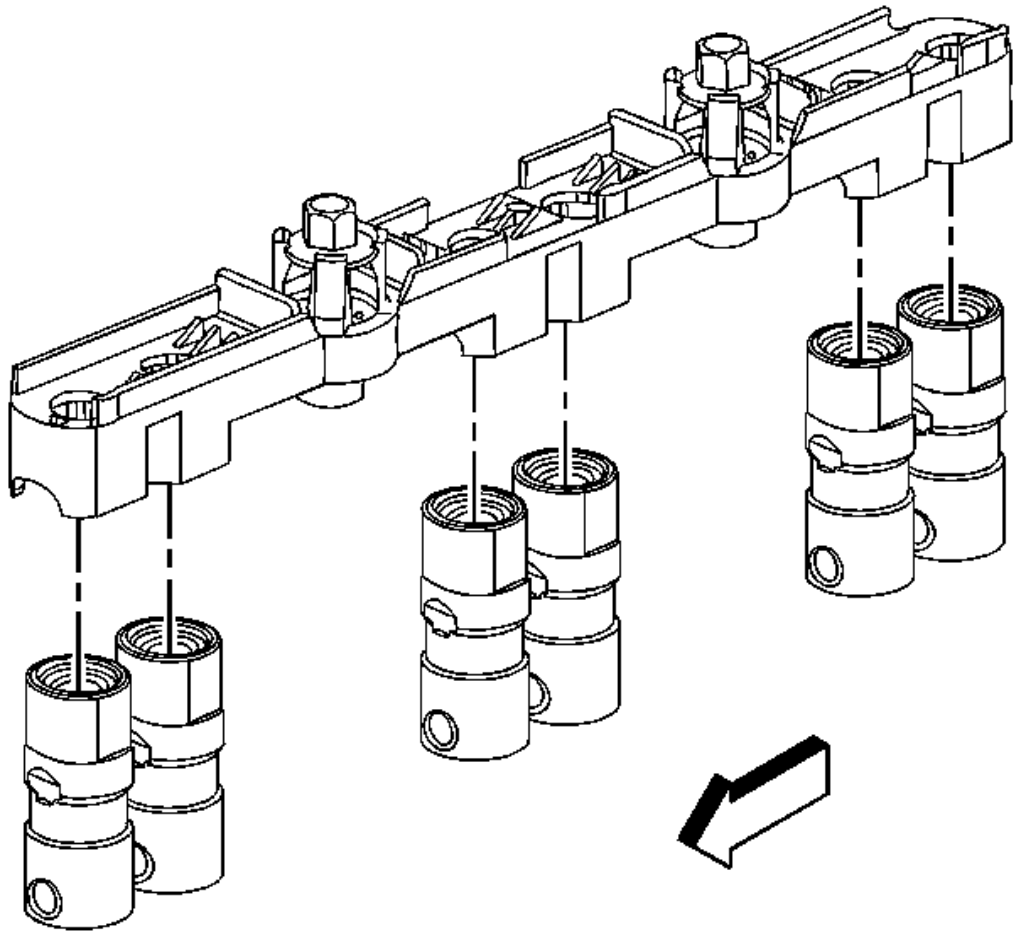

Fig. 133: Identifying Valve Lifters
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve lifters from the valve lifter guides.
6. Clean all gasket surfaces with degreaser.

Installation Procedure

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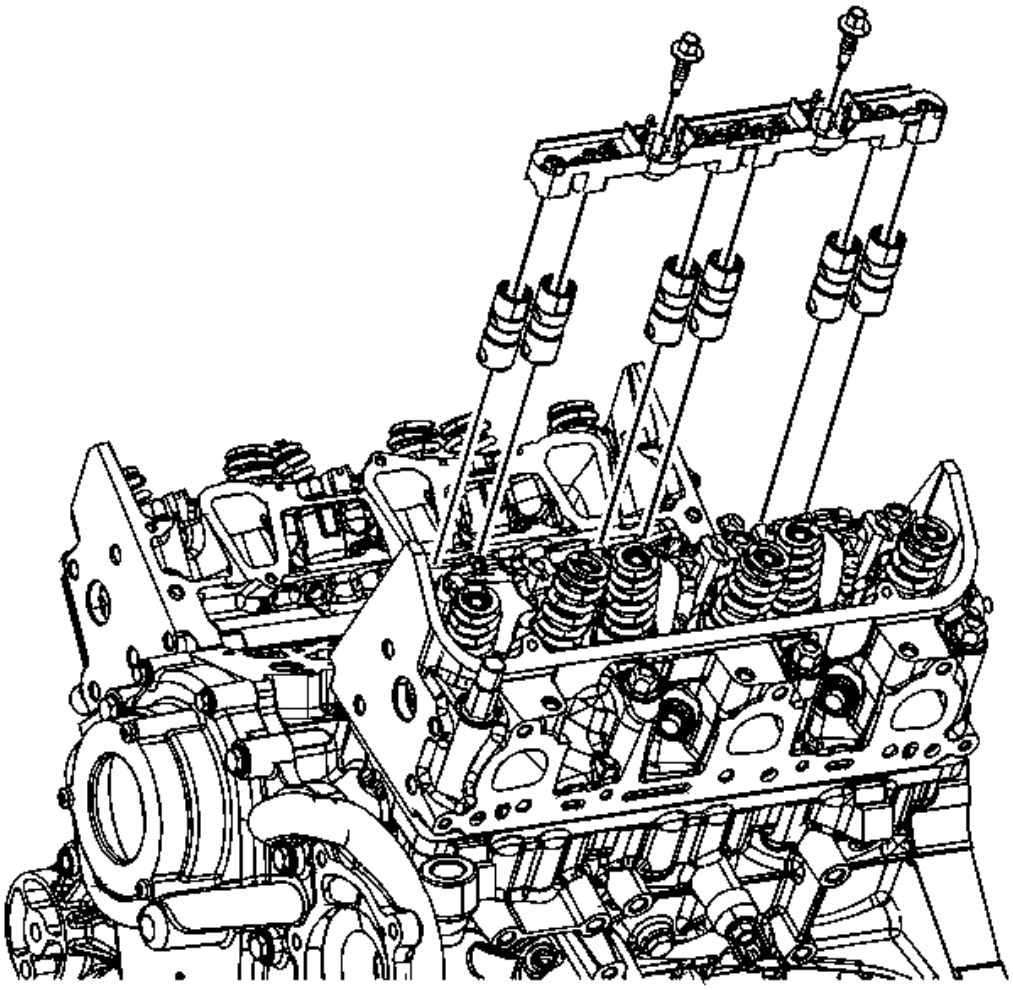

Fig. 134: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve lifters using prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Install the valve lifters to the cylinder bores.
3. Apply threadlock to the valve lifter guide bolt threads. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
4. Install the valve lifter guides.

CAUTION: Refer to Fastener Caution .

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5. Tighten the valve lifter guide bolts and tighten to 10 N.m (89 lb in).
6. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
7. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **EN 46359** Puller End Protector
- **J 29113** Balancer and Crank Sprocket Installer
- **J 37096** Flywheel Holder
- **J 41816** Harmonic Balancer Remover
- **J 45059** Angle Meter

Removal Procedure

CAUTION: 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.

1. Remove the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
4. Remove the right engine splash shield. Refer to **Radiator Air Side Baffle and Deflector Replacement** .
5. Install adjustable jack stands under the frame.
6. Loosen the left side frame bolts and remove the right side frame bolts.
7. Using the jack stands, lower the right side of the frame in order to access the crankshaft balancer.
8. Remove the torque converter covers.
9. Install the **J 37096** to the flywheel in order to prevent flywheel rotation.

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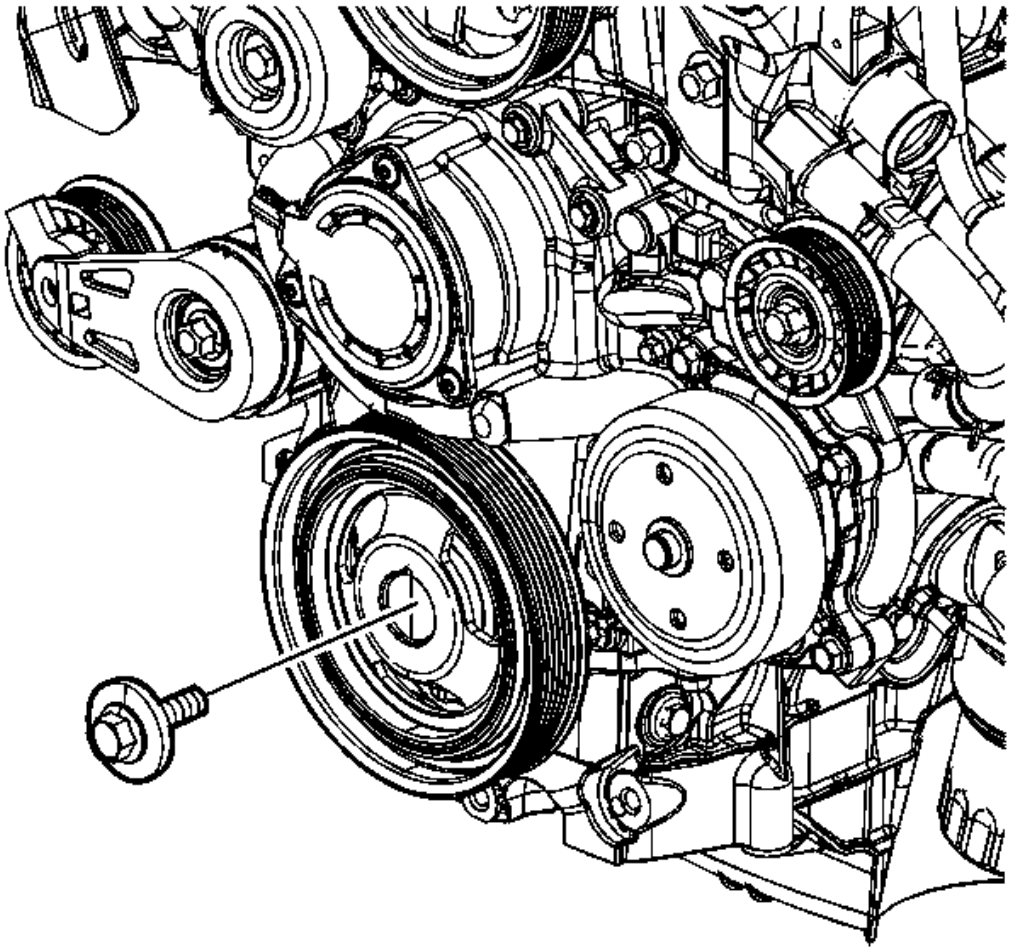

Fig. 135: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft balancer bolt and the washer.

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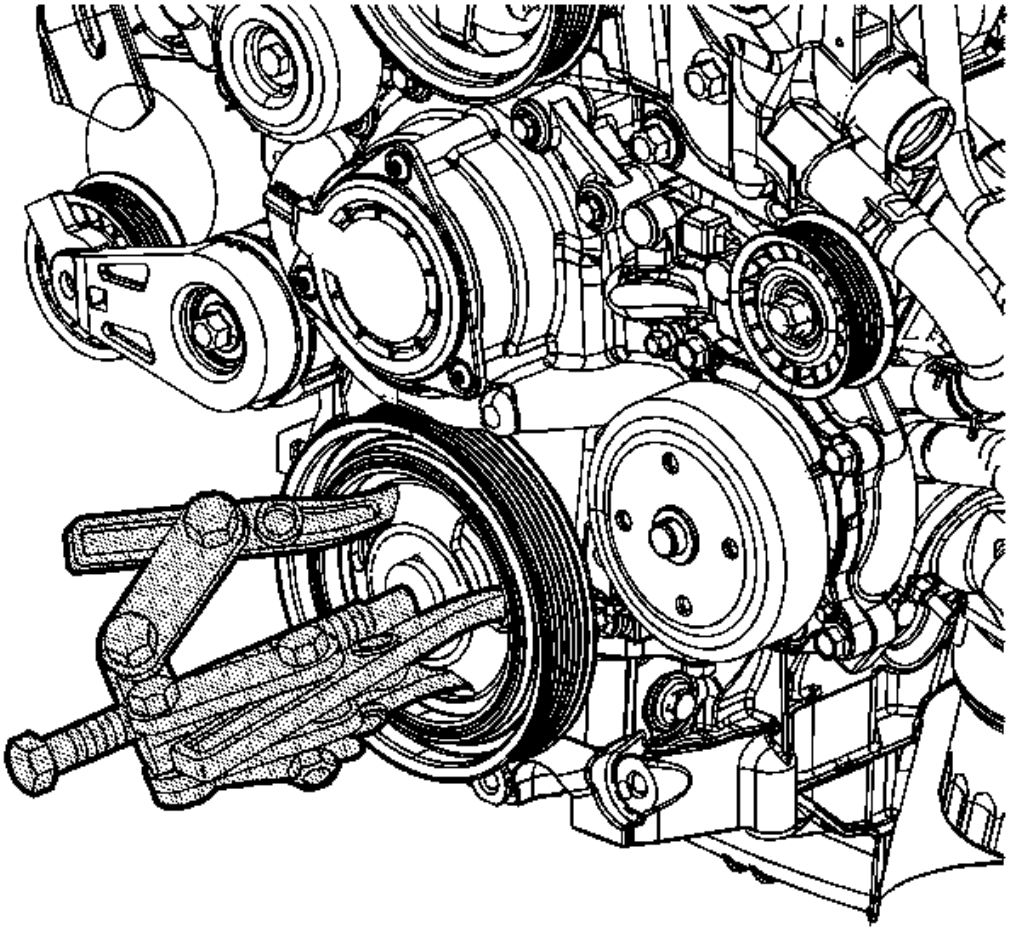

Fig. 136: Identifying Crankshaft Balancer Removing Tool J 41816
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do NOT use a power-assisted tool with the special tool in order to remove or install this component. You cannot properly control the alignment of this component using a power-assisted tool, and this can damage the component.

11. Remove the crankshaft balancer using the **J 41816** and **EN 46359** .

Installation Procedure

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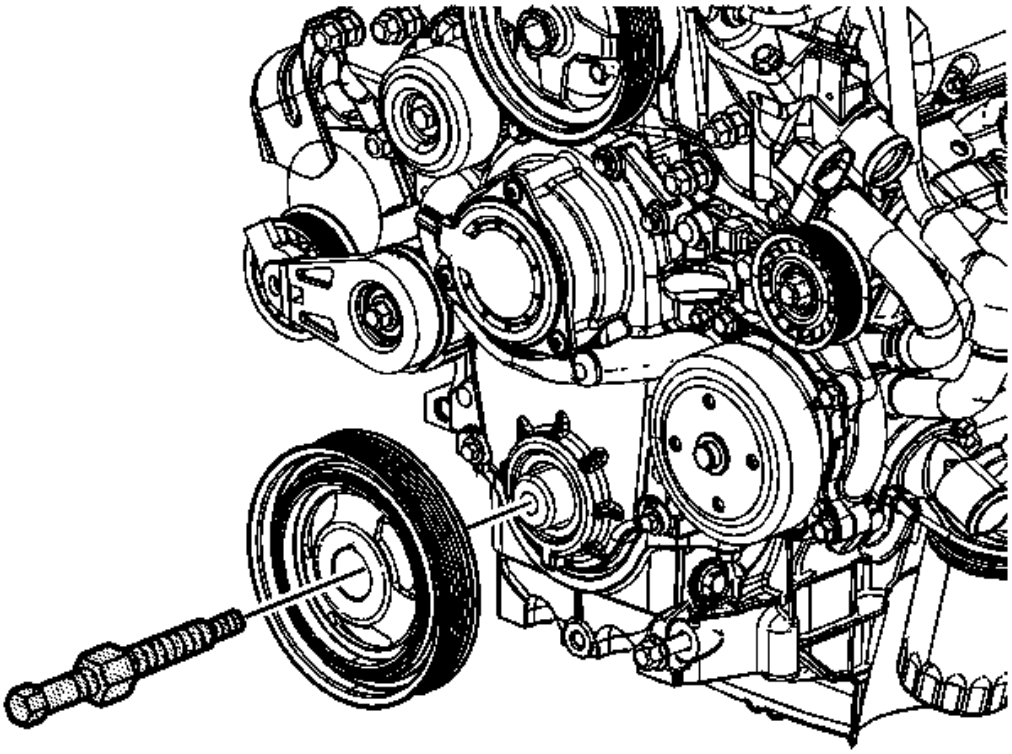

Fig. 137: View Of Balancer & Crank Sprocket Puller (J 29113)
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer to the keyway of the crankshaft balancer. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
2. Place the crankshaft balancer into position over the key in the crankshaft.

CAUTION: Do NOT use a power-assisted tool with the special tool in order to remove or install this component. You cannot properly control the alignment of this component using a power-assisted tool, and this can damage the component.

3. Thread the **J 29113** into the crankshaft.
4. Rotate the hex nut on the **J 29113** in order to install the crankshaft balancer onto the crankshaft.
5. Remove the **J 29113** from the crankshaft.

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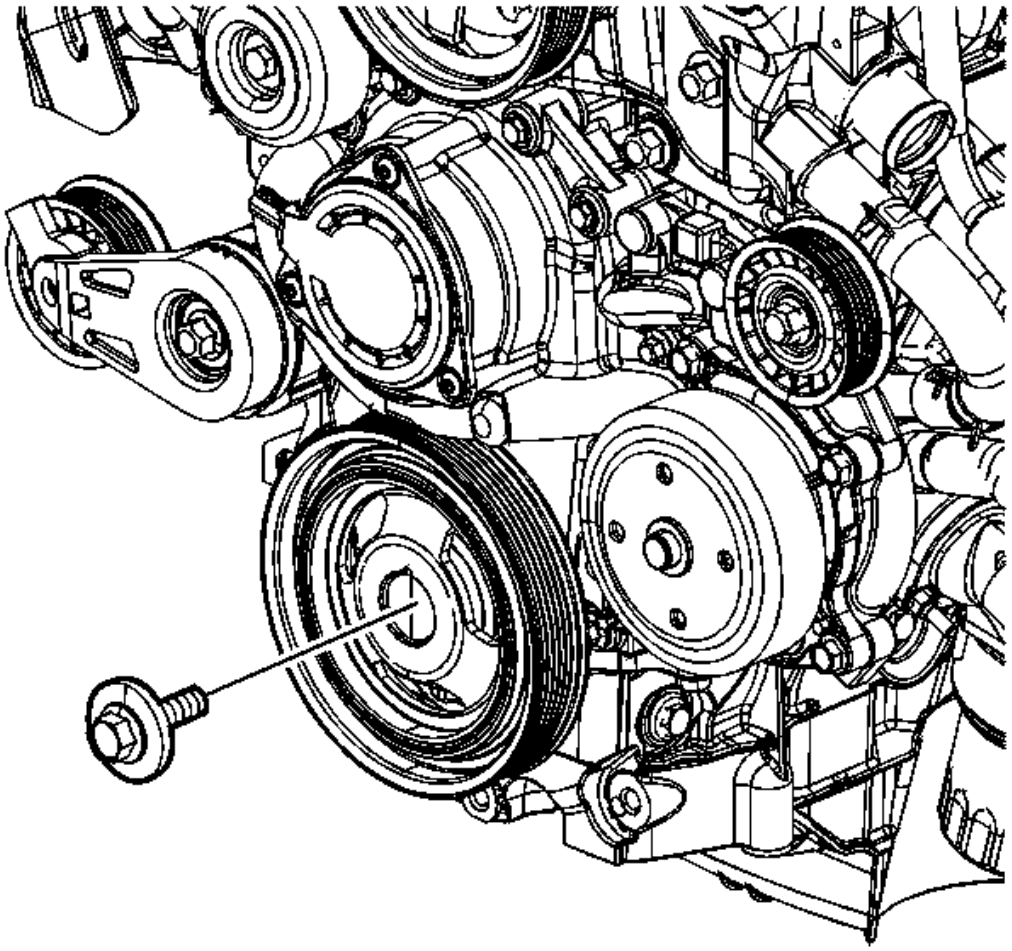

Fig. 138: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft balancer washer and the bolt.

CAUTION: Refer to Fastener Caution .

7. Install the used crankshaft balancer bolt.

Tighten: Tighten the used crankshaft balancer bolt to 125 N.m (92 lb ft).

8. Remove the used crankshaft balancer bolt.

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9. Install the NEW crankshaft balancer bolt.

   Tighten:
   1. Tighten the crankshaft balancer bolt a first pass to 125 N.m (92 lb ft).
   2. Tighten the crankshaft balancer bolt a final pass to 130 degrees using the **J 45059** .

10. Remove the **J 45059** from the flywheel.
11. Install the torque converter covers.
12. Raise the frame into the original position.
13. Install and tighten the right and left side frame bolts.

    Tighten: Tighten the bolts to 100 N.m (74 lb ft) plus an additional 90 degrees using the **J 45059** .

14. Install the right engine splash shield. Refer to **Radiator Air Side Baffle and Deflector Replacement** .
15. Install the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
16. Lower the vehicle.
17. Install the drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.

OIL PAN REPLACEMENT

Special Tools

J 45059 Angle Meter

Removal Procedure

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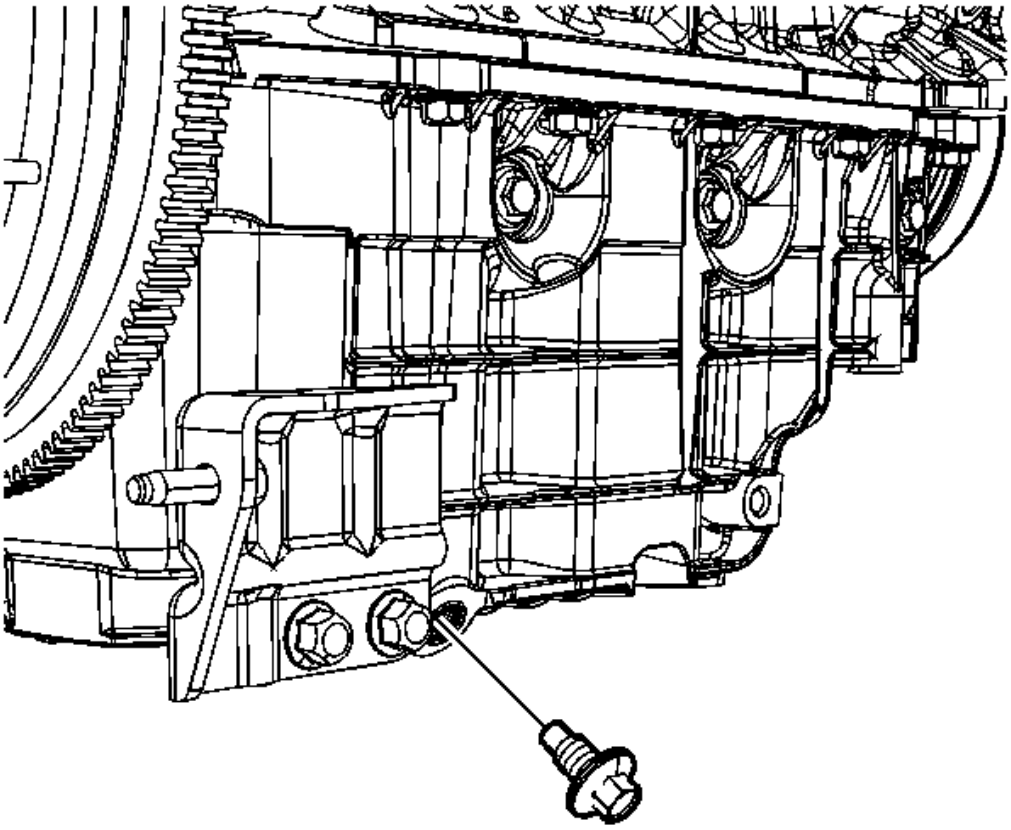

Fig. 139: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the engine mount snubber and drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
3. Remove the air cleaner inlet duct. Refer to **Air Cleaner Inlet Duct Replacement** .
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
6. Place a suitable drain pan under the oil pan drain plug.
7. Remove the oil pan drain plug and drain the engine oil from the crankcase.
8. Reinstall the oil pan drain plug until snug.
9. Remove the right front splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .
10. Remove the starter. Refer to **Starter Replacement (LZ9)** .

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11. Remove the engine oil cooler. Refer to **Engine Oil Cooler Replacement**.
12. Remove the oil filter adapter. Refer to **Oil Filter Adapter and Bypass Valve Assembly Replacement**.

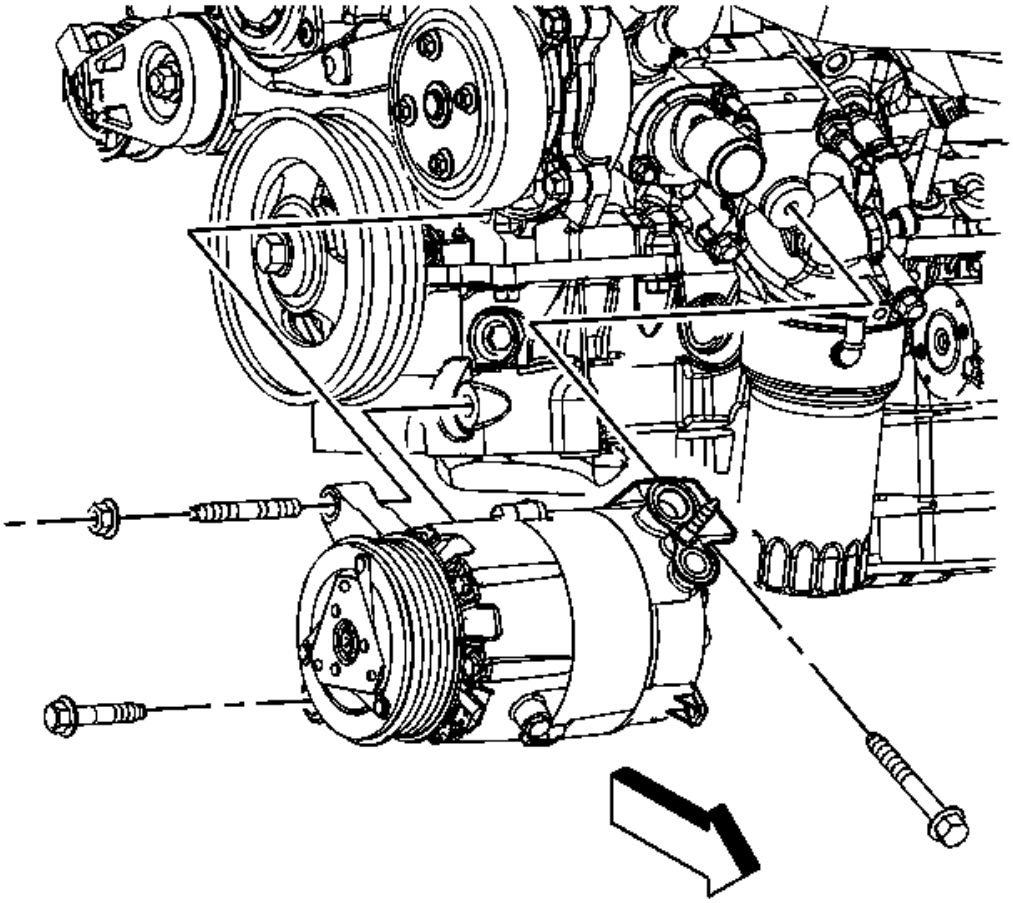

Fig. 140: View Of A/C compressor & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the air conditioning (A/C) compressor bolts and position the compressor aside.

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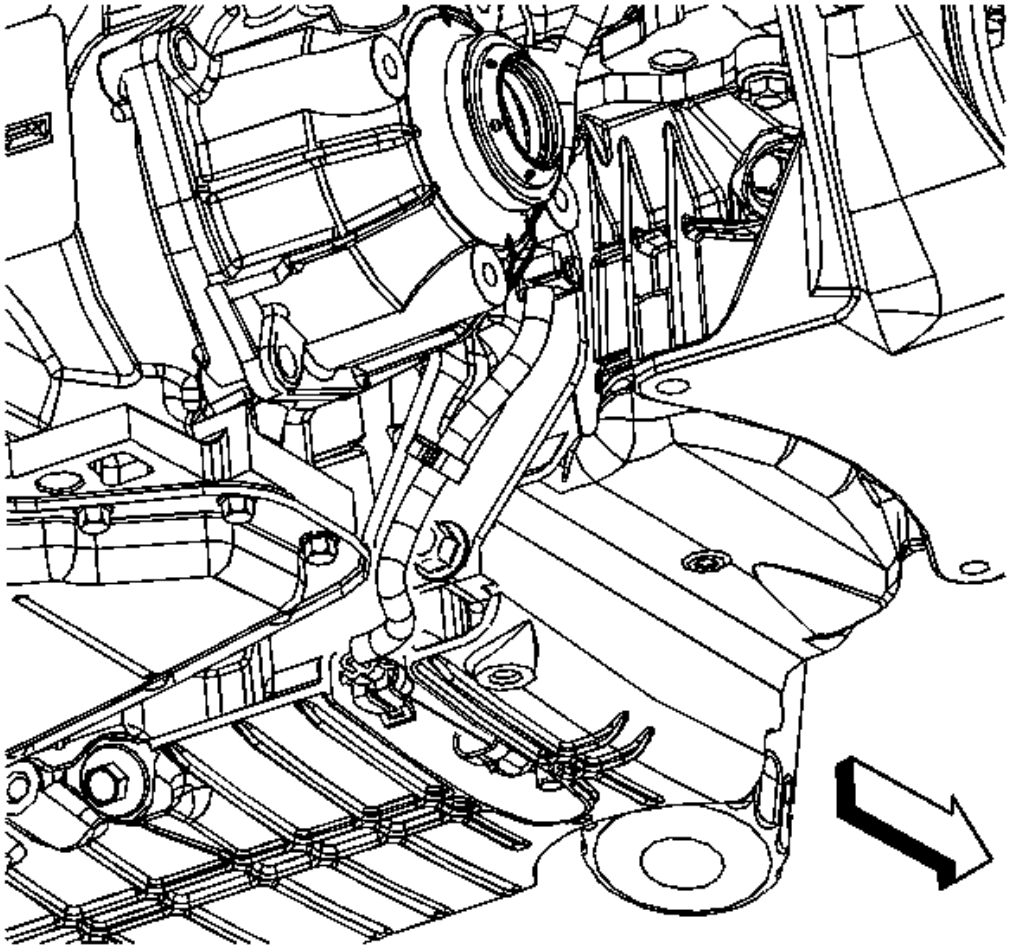

Fig. 141: Identifying Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the oil level sensor electrical connector.
15. Remove the catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LZ9)** and **Catalytic Converter Replacement - Right Side (LZ9 w/RPO M15)** or **Catalytic Converter Replacement - Right Side (LZ9 w/RPO MT2)** .

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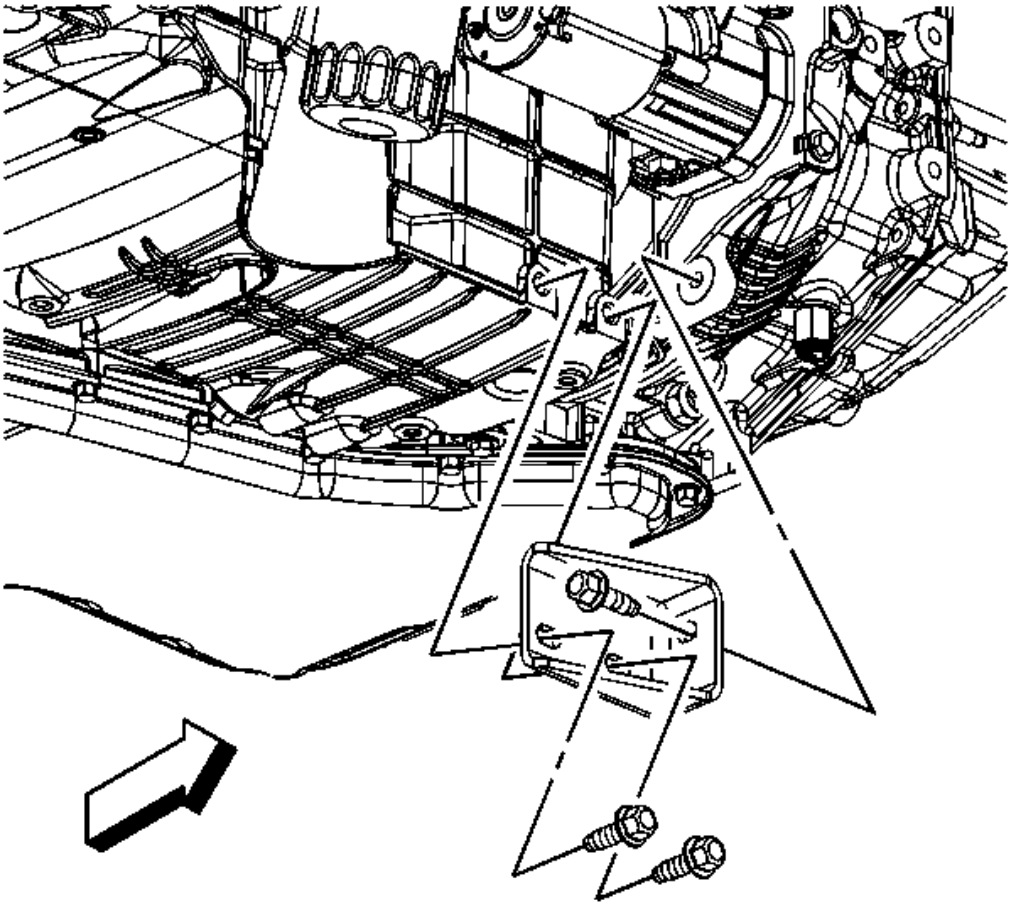

Fig. 142: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the transaxle brace to oil pan bolts.
17. Remove the transaxle brace to transaxle bolt and remove the brace.

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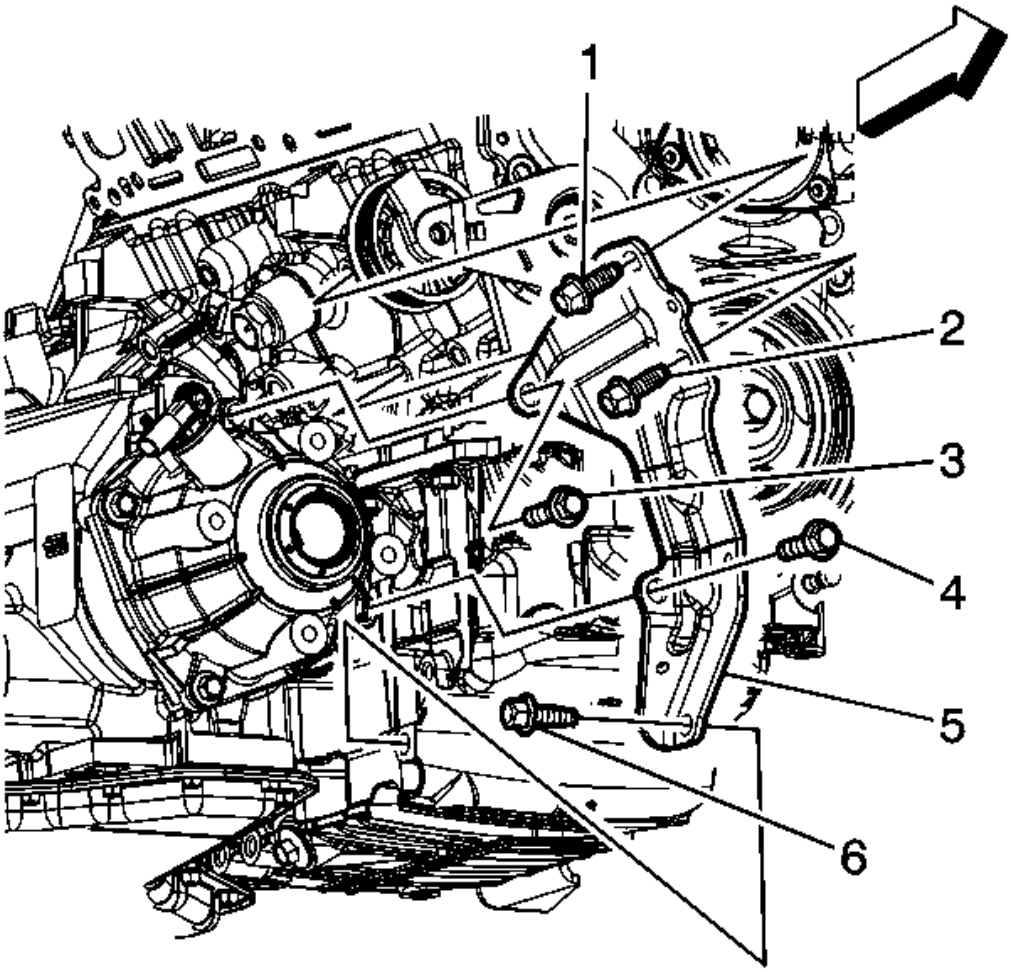

Fig. 143: Identifying Transaxle Brace-To-Oil Pan Lower Bolt
Courtesy of GENERAL MOTORS CORP.

18. Remove the transaxle brace to oil pan lower bolt (6), if equipped with regular production option (RPO) M15.

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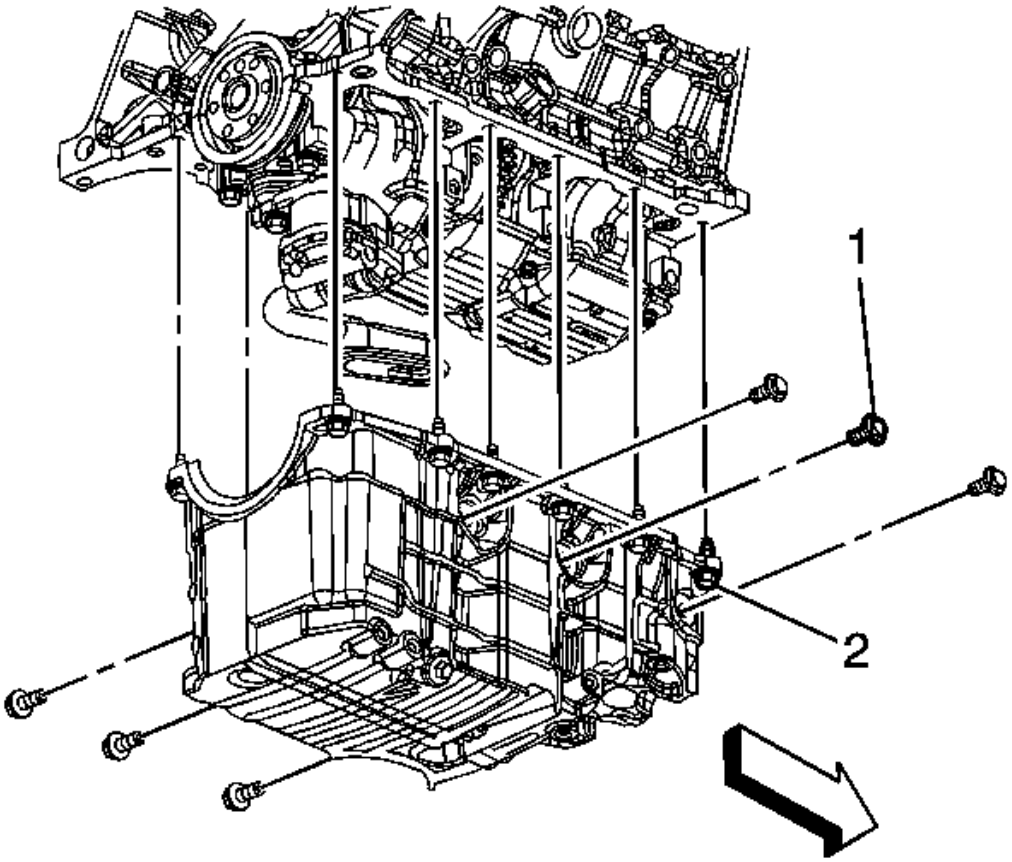

Fig. 144: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

19. Remove the oil pan bolts (1, 2).
20. Remove the oil pan.
21. Remove and discard the oil pan gasket.
22. Clean the oil pan sealing surfaces.

Installation Procedure

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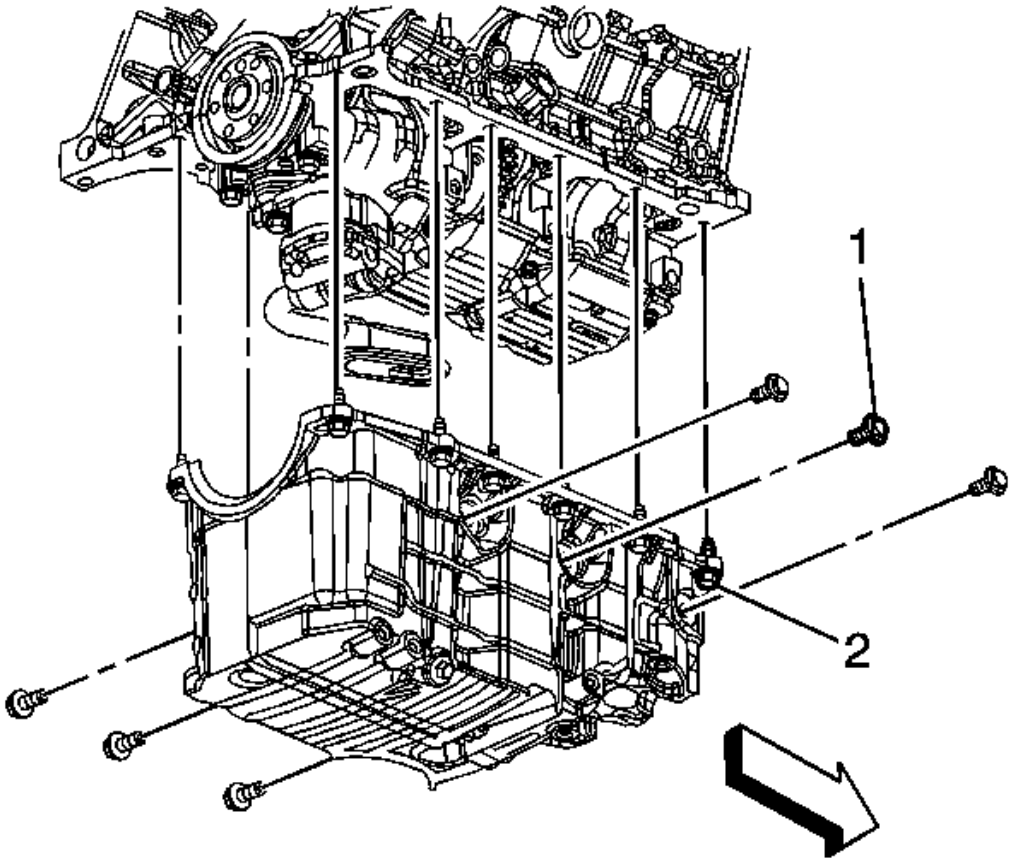

Fig. 145: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer to both sides of the crankshaft rear main bearing cap. Press the sealer into the gap using a putty knife. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Apply sealer to both sides of the front cover/block mating area. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
3. Install a NEW oil pan gasket.
4. Position the oil pan to the engine.

CAUTION: Refer to Fastener Caution .

5. Install the oil pan bolts (1, 2).
   - Tighten the bolts (1) to 50 N.m (37 lb ft).

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- Tighten the bolts (2) to 25 N.m (18 lb ft).

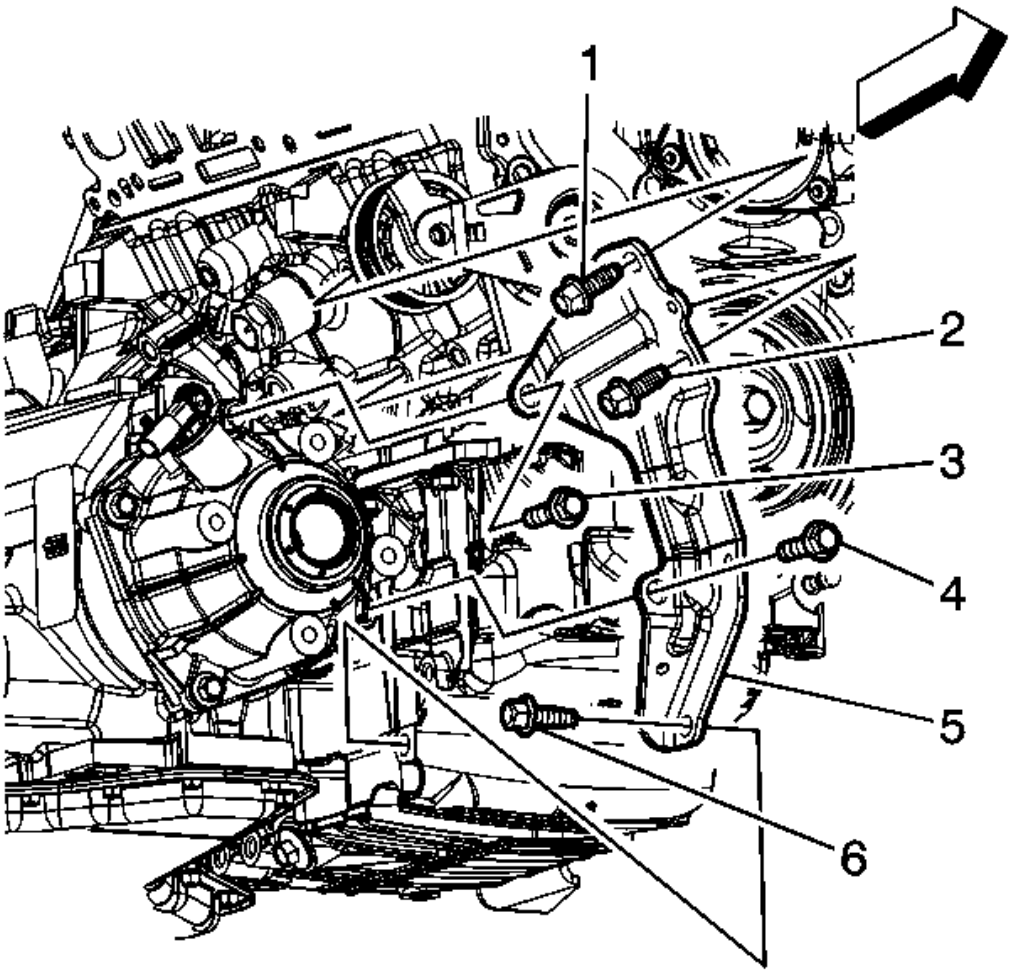

Fig. 146: Identifying Transaxle Brace-To-Oil Pan Lower Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the transaxle brace to oil pan lower bolt (6), if equipped with (RPO) M15 and tighten to 50 N.m (37 lb ft).

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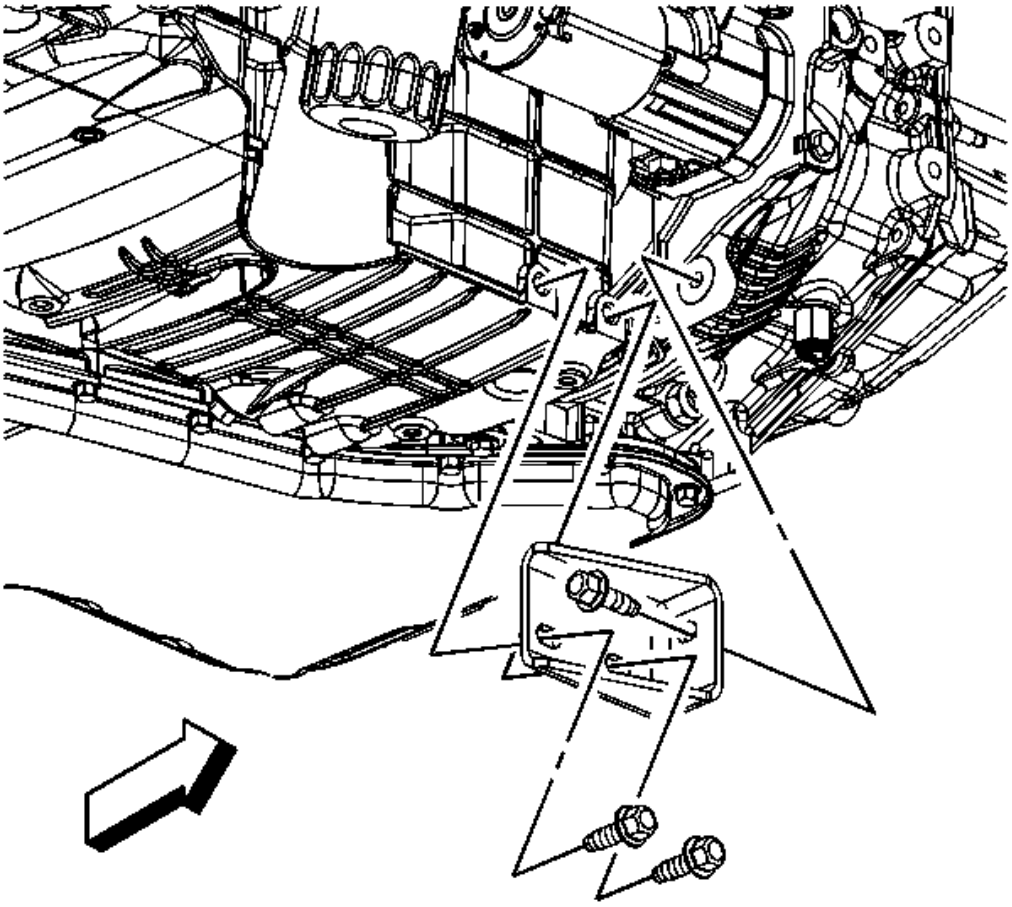

Fig. 147: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

7. Position the transaxle brace and install the transaxle brace to transaxle bolt until snug.
8. Install the transaxle brace to oil pan bolts and tighten to 50 N.m (37 lb ft).

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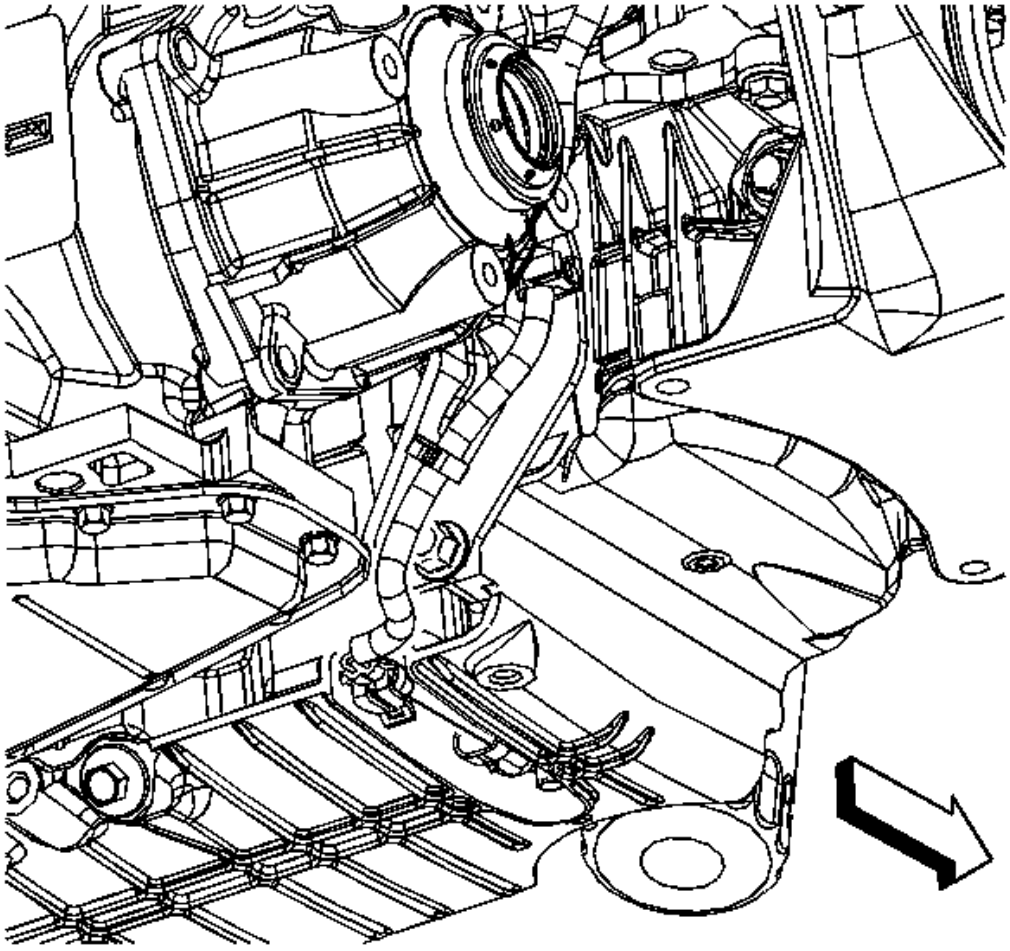

Fig. 148: Identifying Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Connect the oil level sensor electrical connector.
10. Install the catalytic converter. Refer to **Catalytic Converter Replacement - Left Side (LZ9)** and **Catalytic Converter Replacement - Right Side (LZ9 w/RPO M15)** or **Catalytic Converter Replacement - Right Side (LZ9 w/RPO MT2)** .

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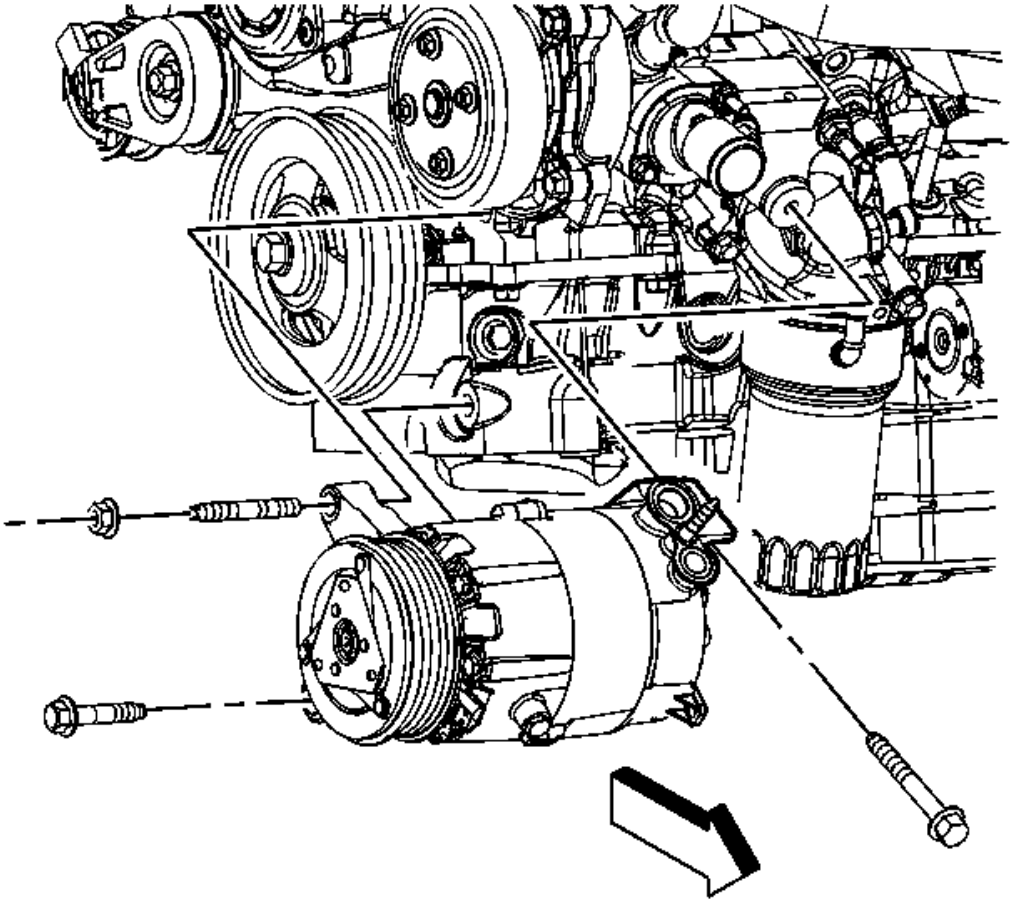

Fig. 149: View Of A/C compressor & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Position the A/C compressor and install the bolts. Tighten the bolts to 50 N.m (37 lb ft)
12. Install the right front splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .
13. Install the starter. Refer to **Starter Replacement (LZ9)** .
14. Install the oil filter adapter. Refer to **Oil Filter Adapter and Bypass Valve Assembly Replacement**.
15. Install the oil cooler. Refer to **Engine Oil Cooler Replacement**.
16. Ensure that the oil pan drain plug is tighten.

    Tighten the drain plug to 26 N.m (19 lb ft).

17. Lower the vehicle.
18. Remove the engine support fixture.

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19. Install the air cleaner inlet duct. Refer to **Air Cleaner Inlet Duct Replacement** .
20. Install the engine mount snubber and drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
21. Fill the crankcase.
22. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

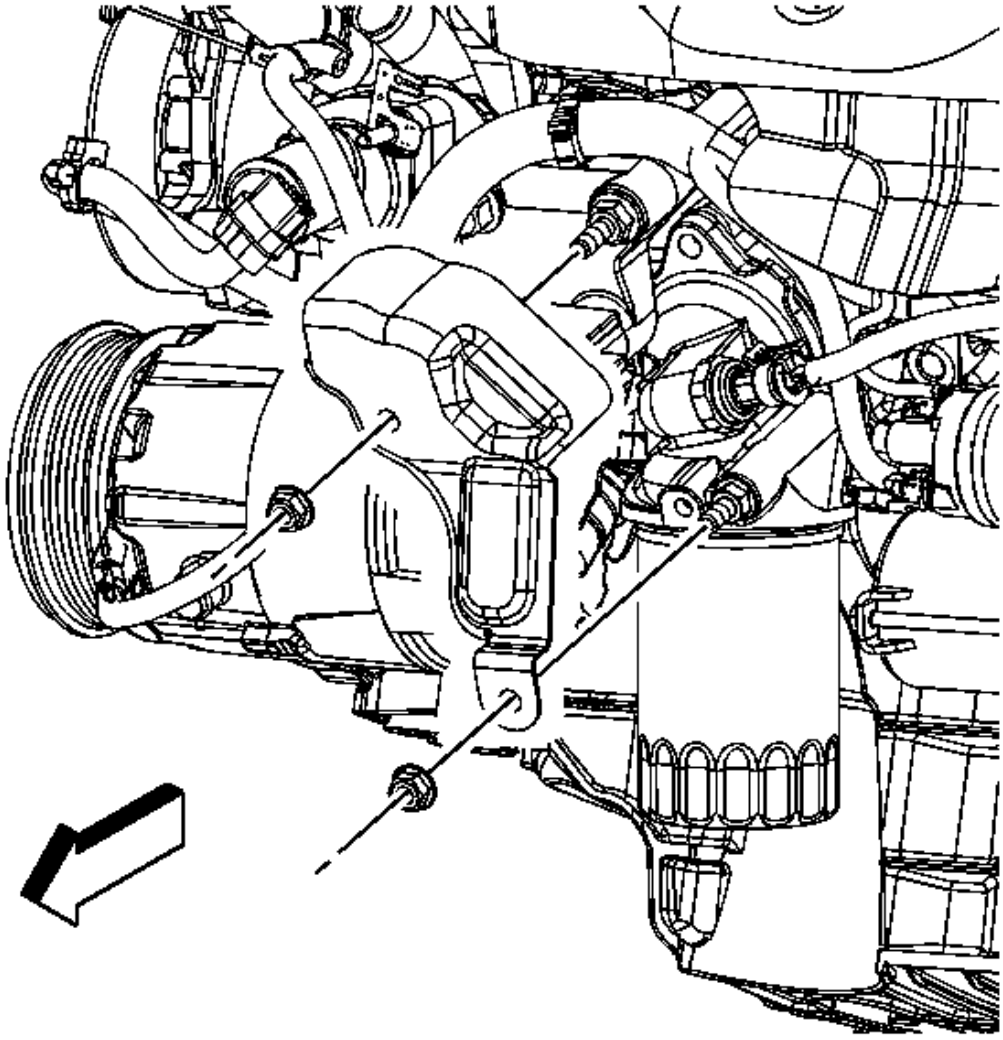

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Fig. 150: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the oil pressure heat shield bolts and shield.

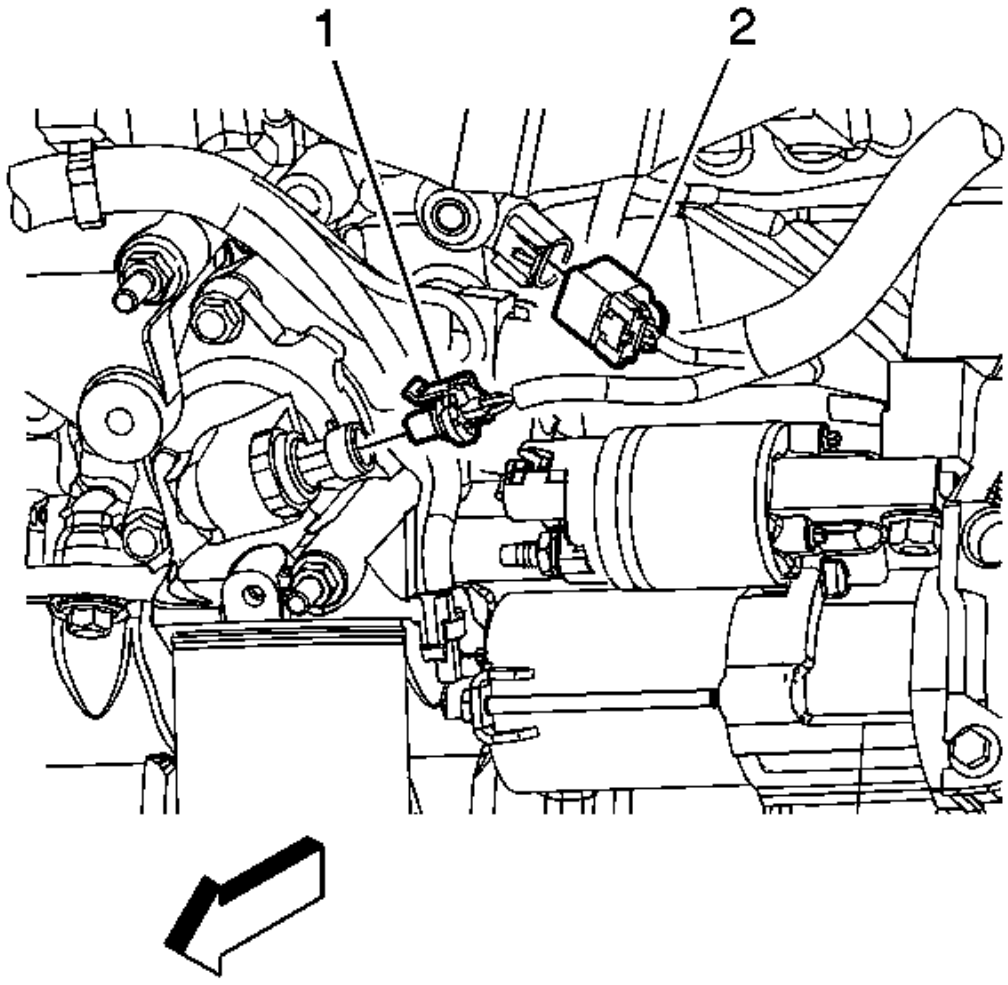

Fig. 151: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Disconnect engine oil pressure sensor electrical connector (1).

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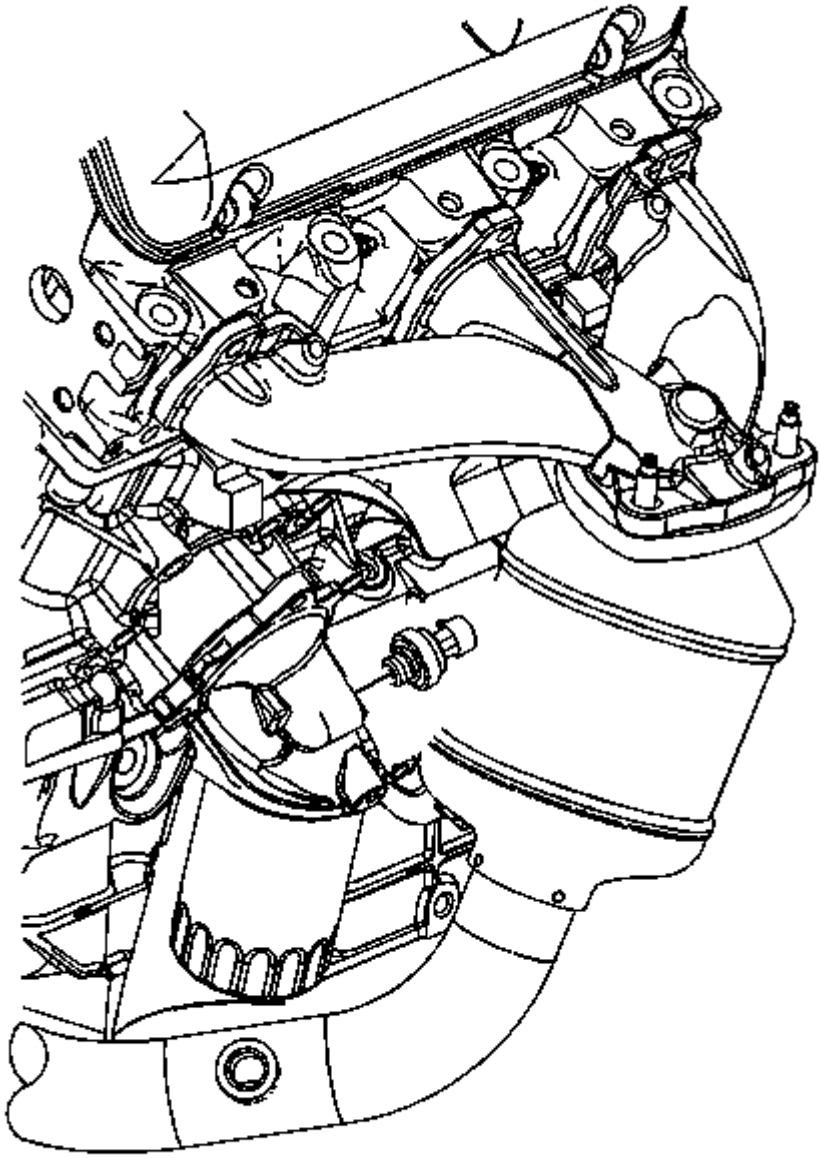

Fig. 152: Identifying Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine oil pressure sensor.

Installation Procedure

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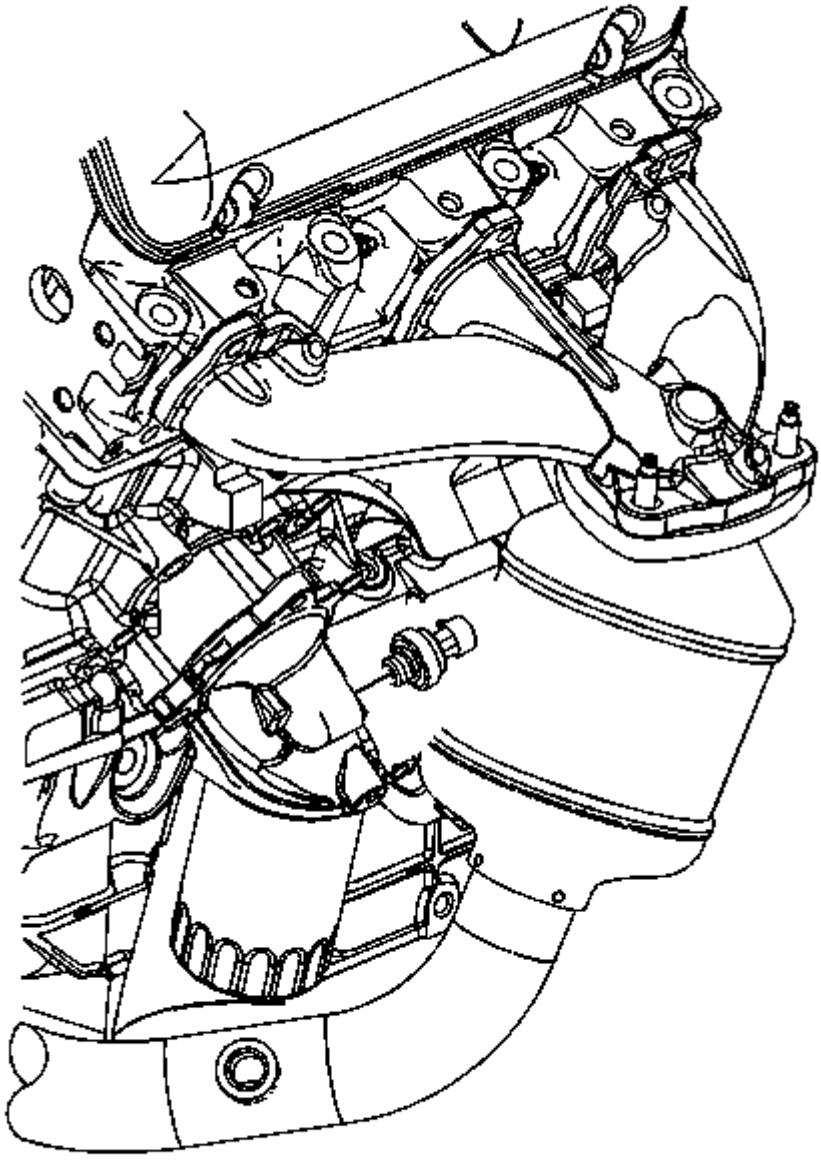

Fig. 153: Identifying Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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1. Install the engine oil pressure sensor.

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

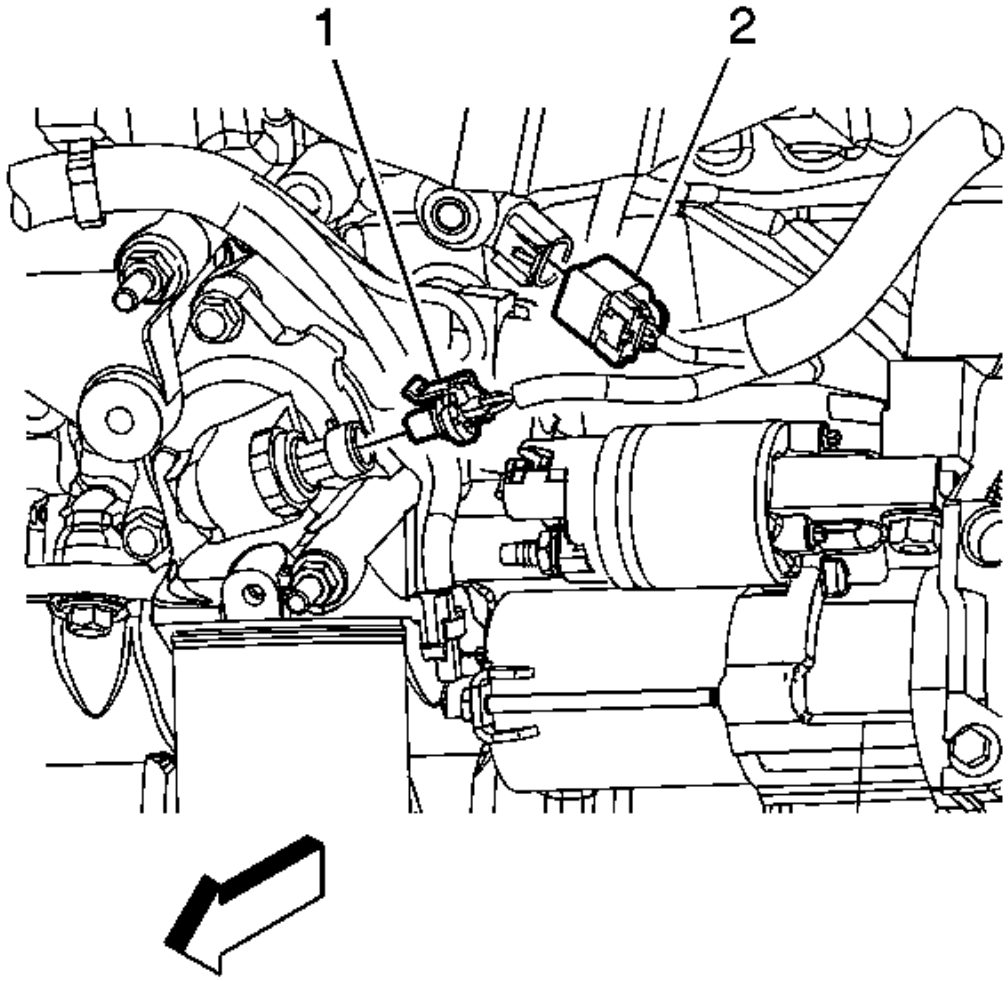

Fig. 154: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect engine oil pressure sensor electrical connector (1).

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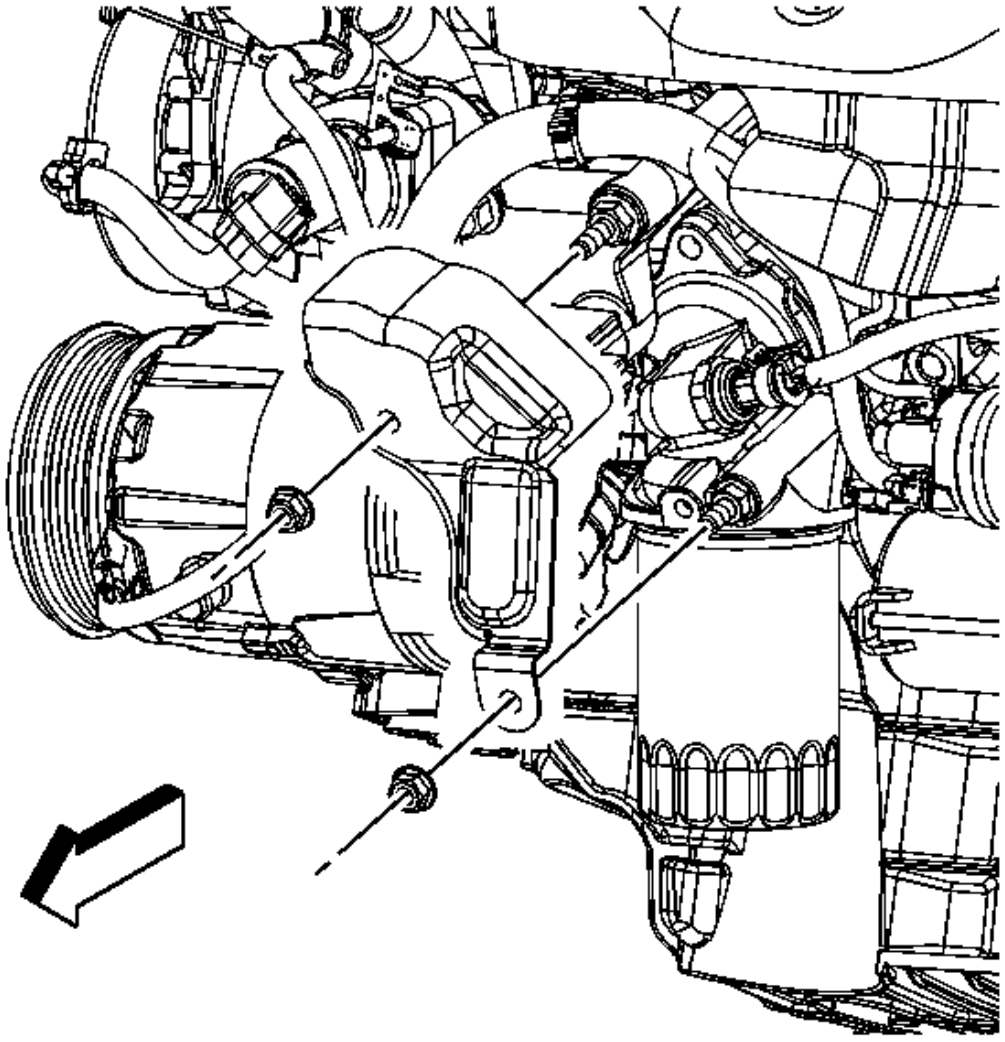

Fig. 155: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pressure heat shield and bolts.

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

4. Lower the vehicle.

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

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Removal Procedure

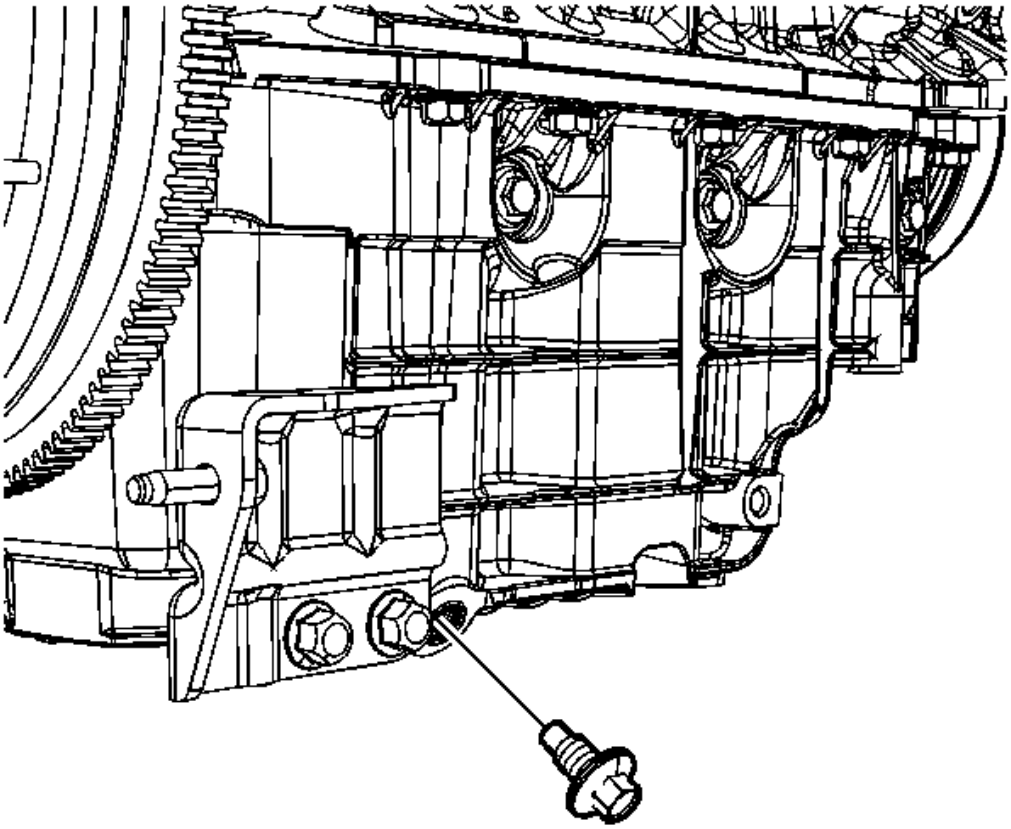

Fig. 156: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the oil pan drain plug.
3. Drain the crankcase.
4. Reinstall the oil pan drain plug.

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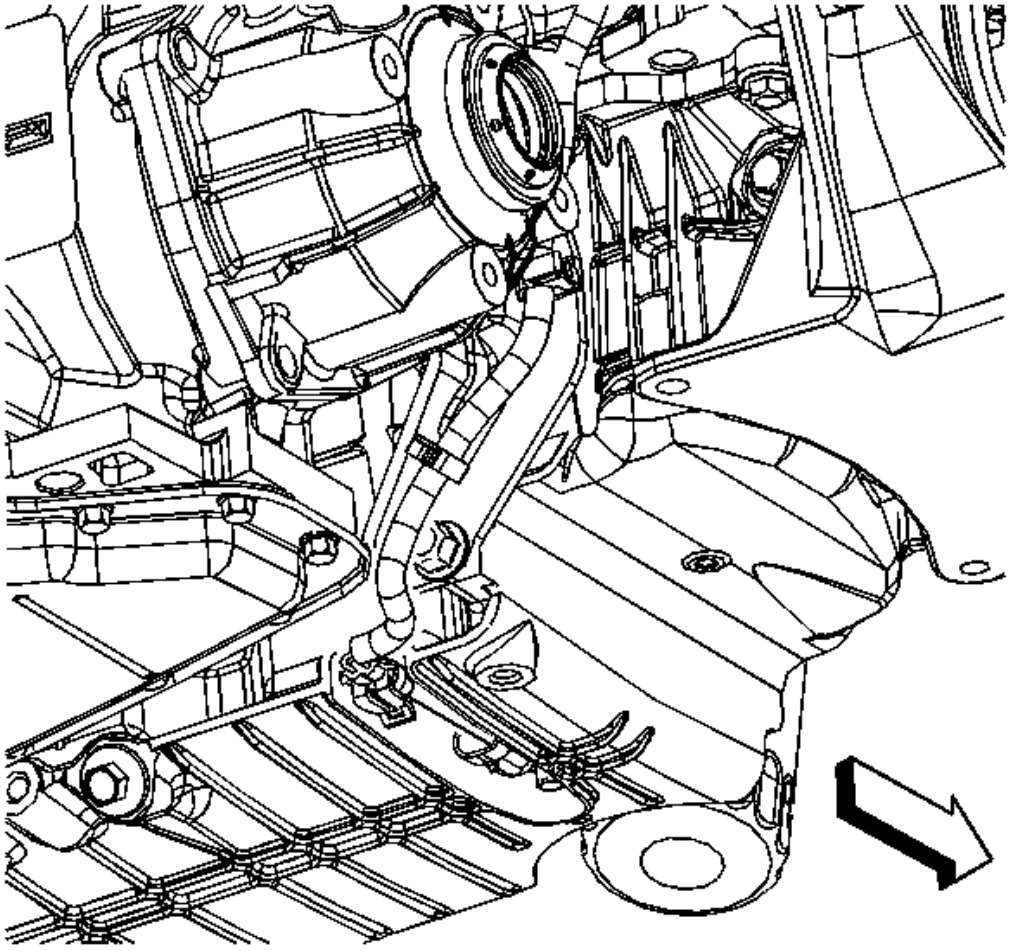

Fig. 157: Identifying Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine oil level sensor electrical connector.

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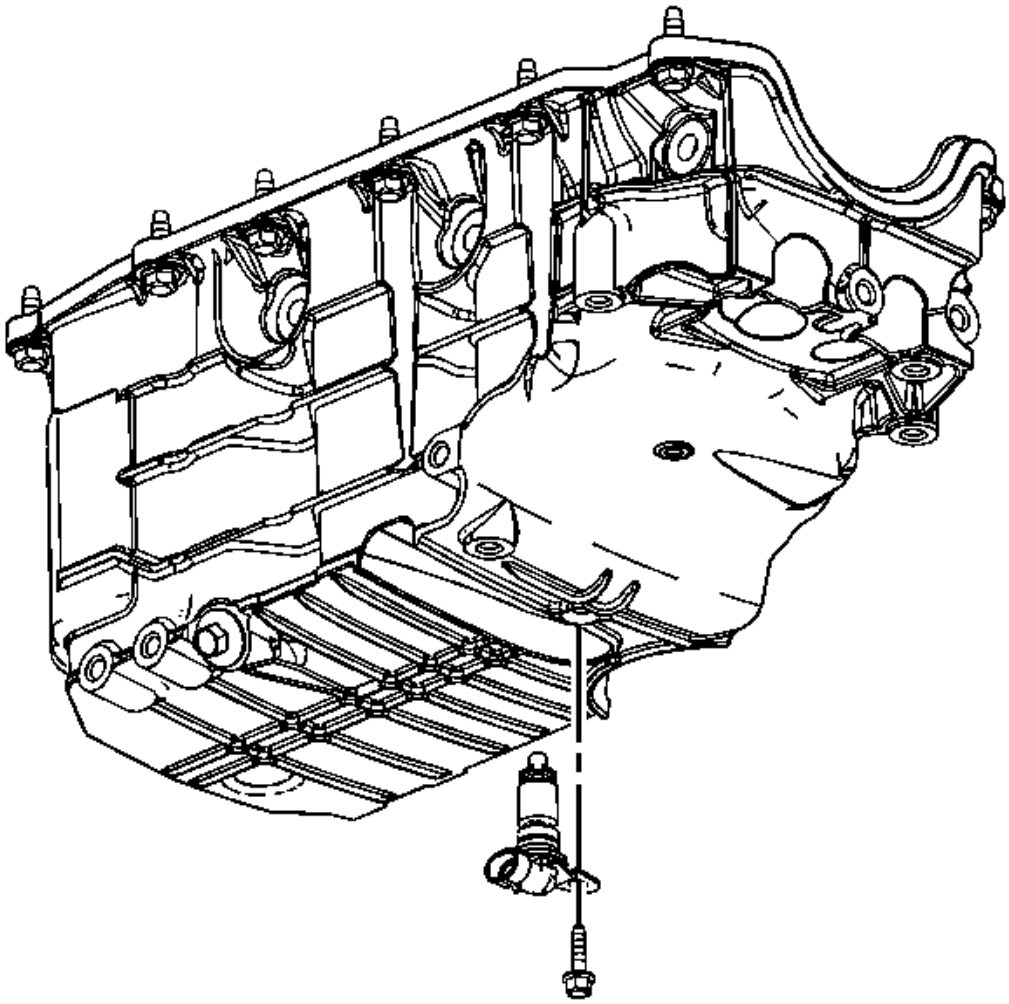

Fig. 158: Identifying Engine Oil Level Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil level sensor bolt and sensor.

Installation Procedure

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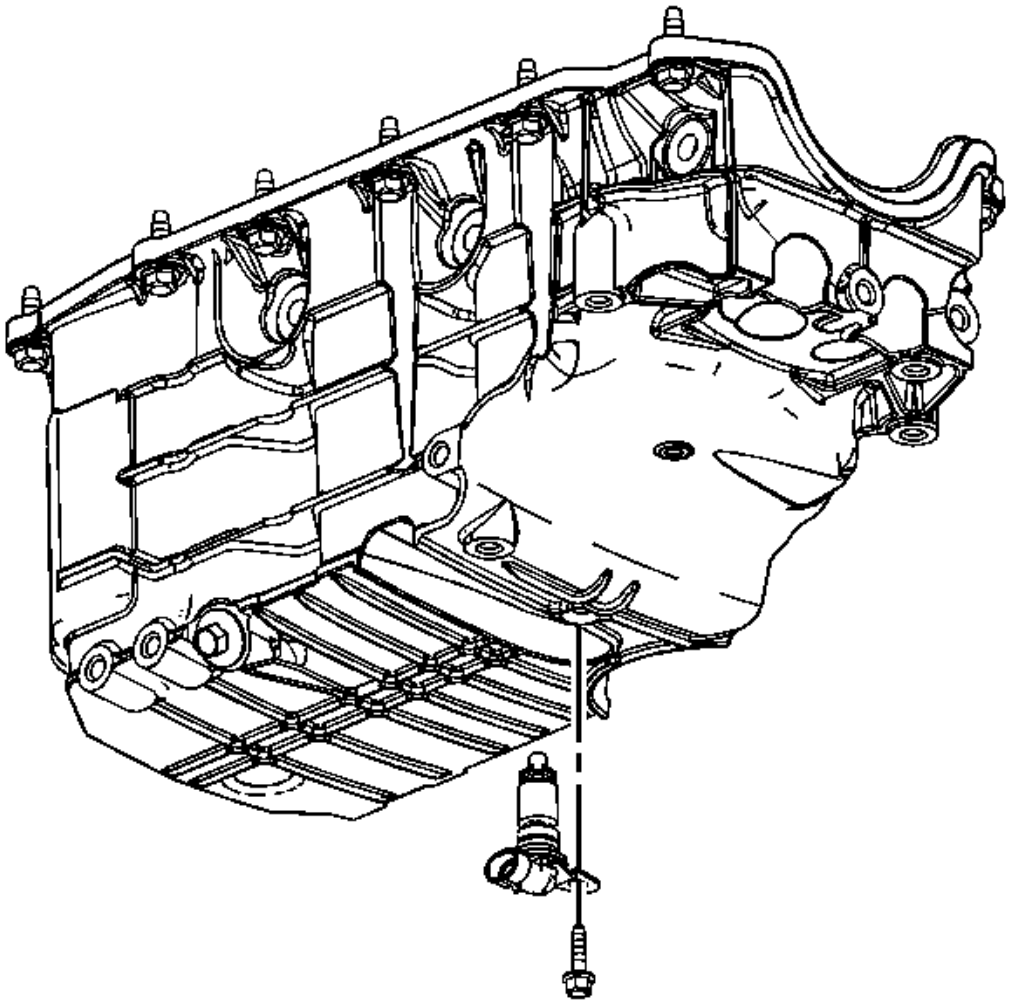

Fig. 159: Identifying Engine Oil Level Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil level sensor and bolt.

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

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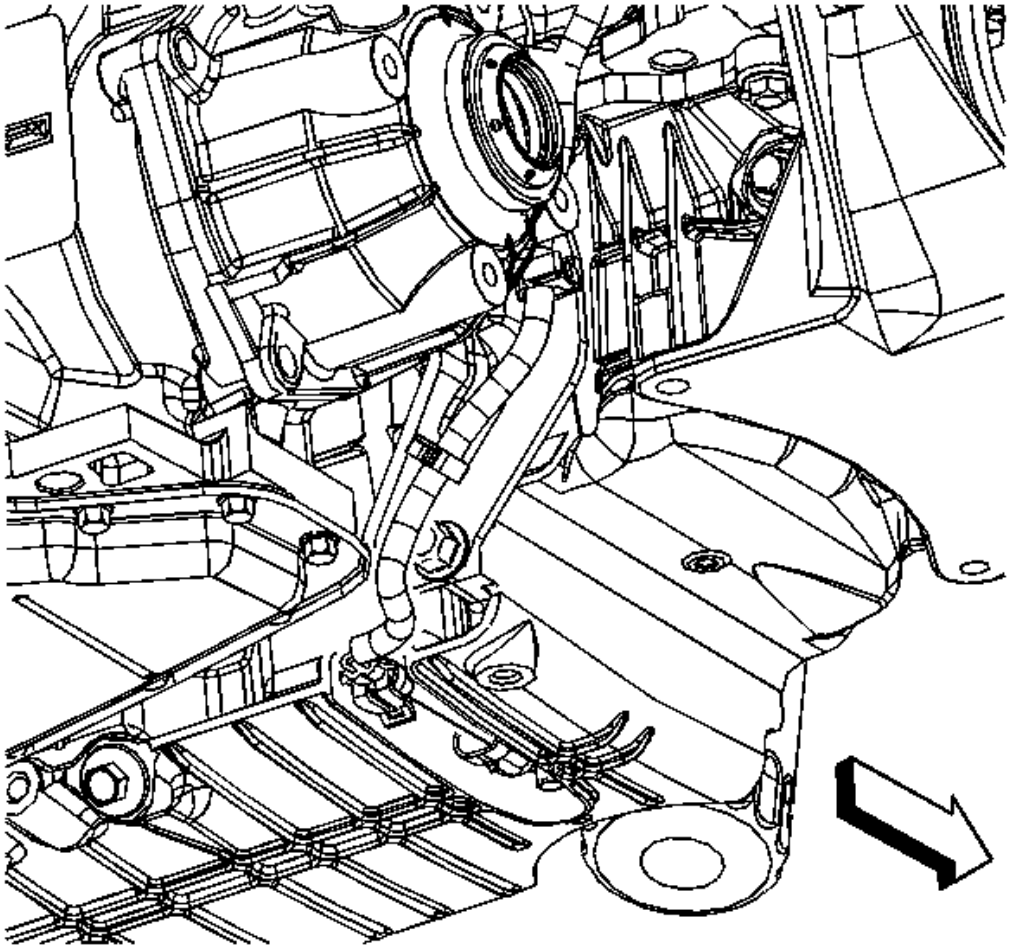

Fig. 160: Identifying Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine oil level sensor electrical connector.
3. Lower the vehicle.
4. Refill the crankcase with new engine oil.

OIL PUMP REPLACEMENT

Removal Procedure

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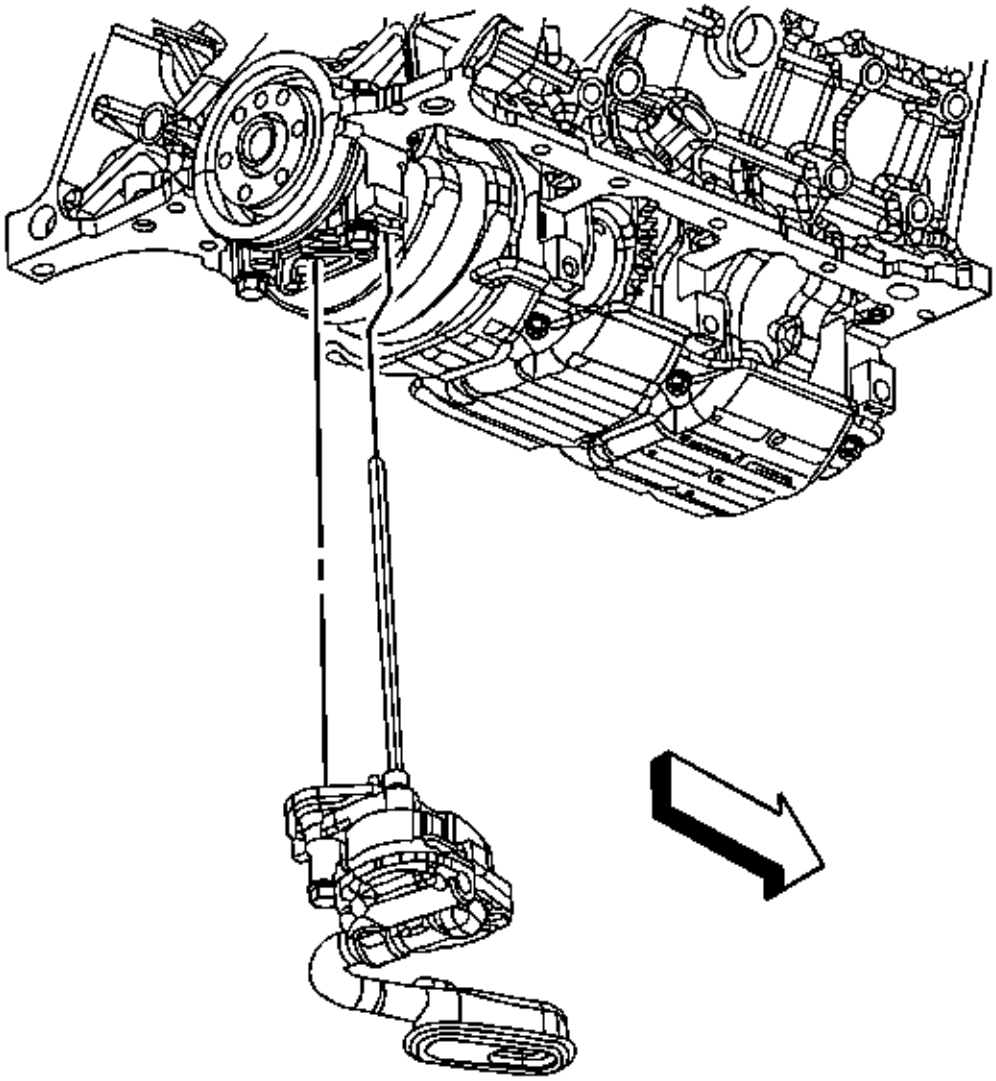

Fig. 161: Identifying Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the oil pump bolt.
3. Remove the oil pump and the oil pump drive shaft.

Installation Procedure

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NOTE: **Rotate the oil pump drive shaft as necessary in order to obtain the engagement with the oil pump drive unit.**

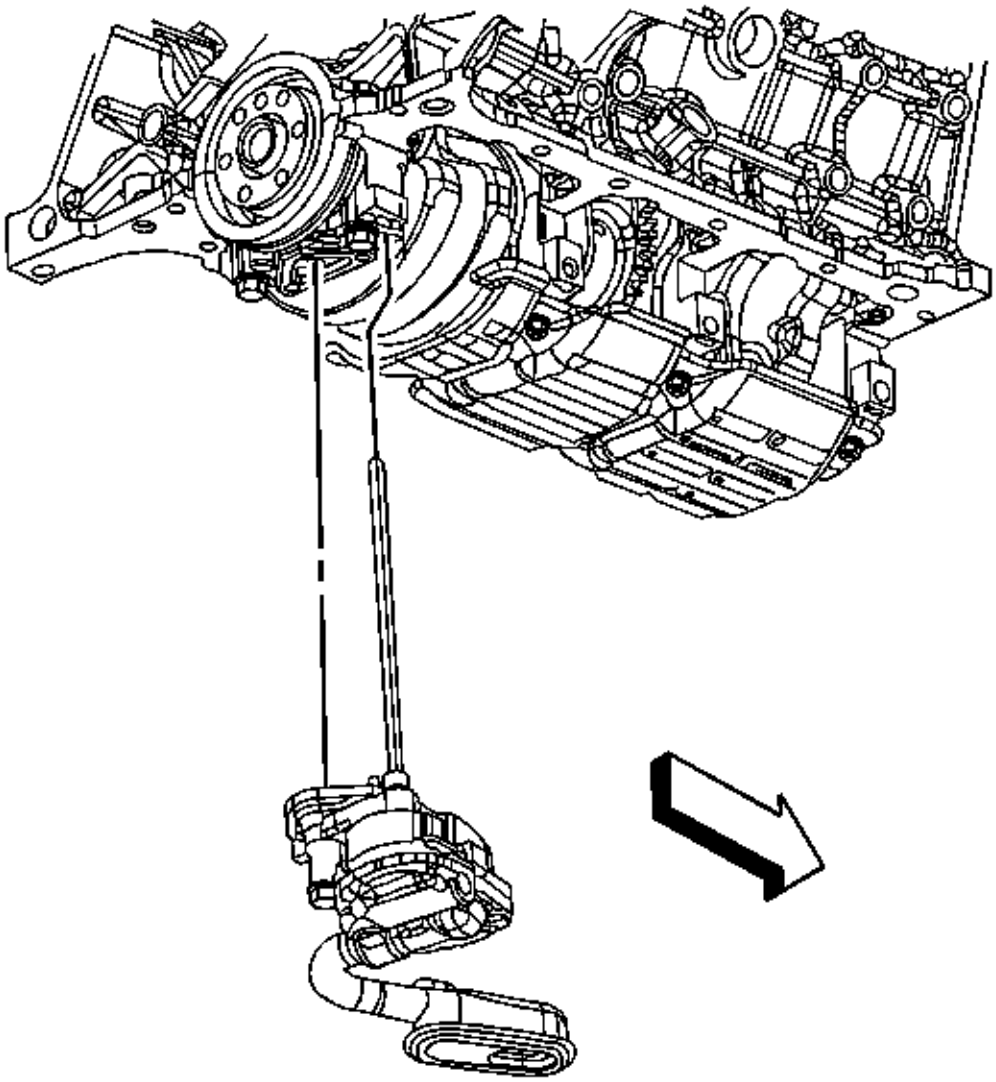

Fig. 162: Identifying Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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1. Install the oil pump drive shaft and the oil pump.
2. Install the oil pump bolt and tighten to 41 N.m (30 lb ft).
3. Install the oil pan. Refer to **Oil Pan Replacement**.

OIL PUMP DRIVE REPLACEMENT

Removal Procedure

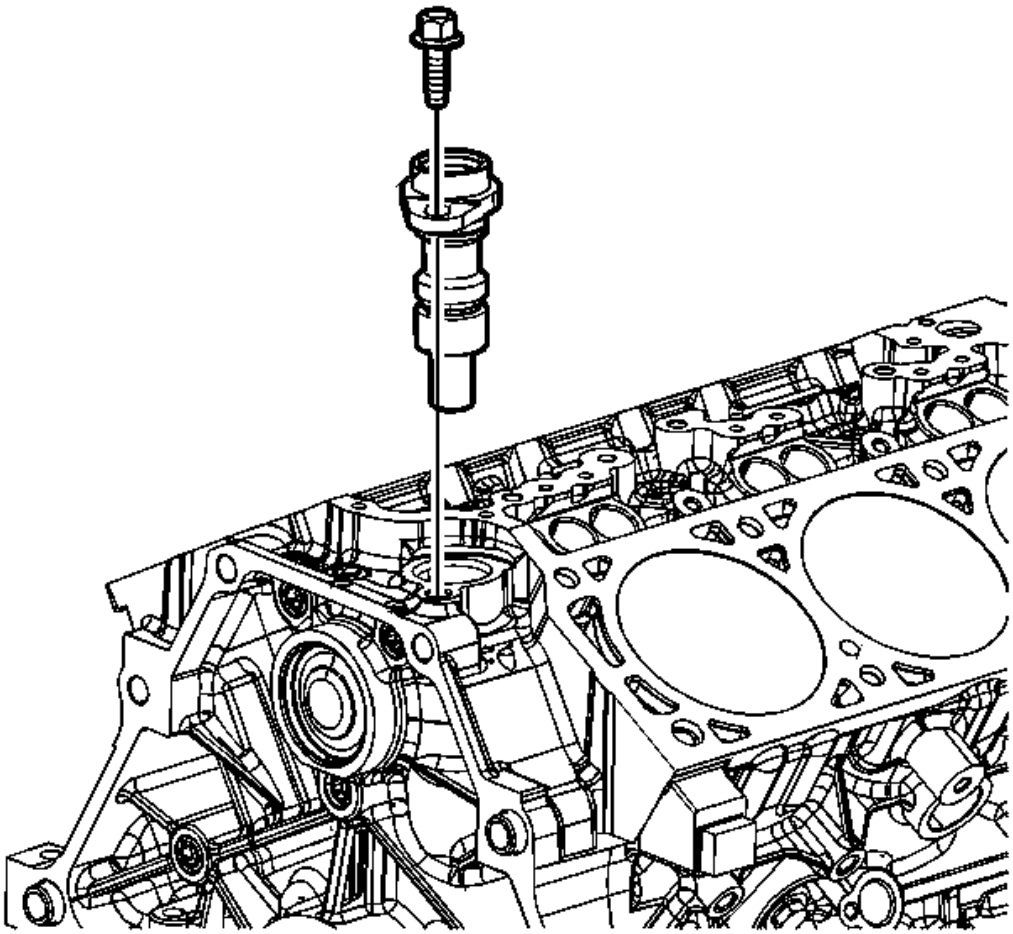

Fig. 163: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

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3. Remove the oil pump drive bolt.
4. Remove the oil pump drive.

Installation Procedure

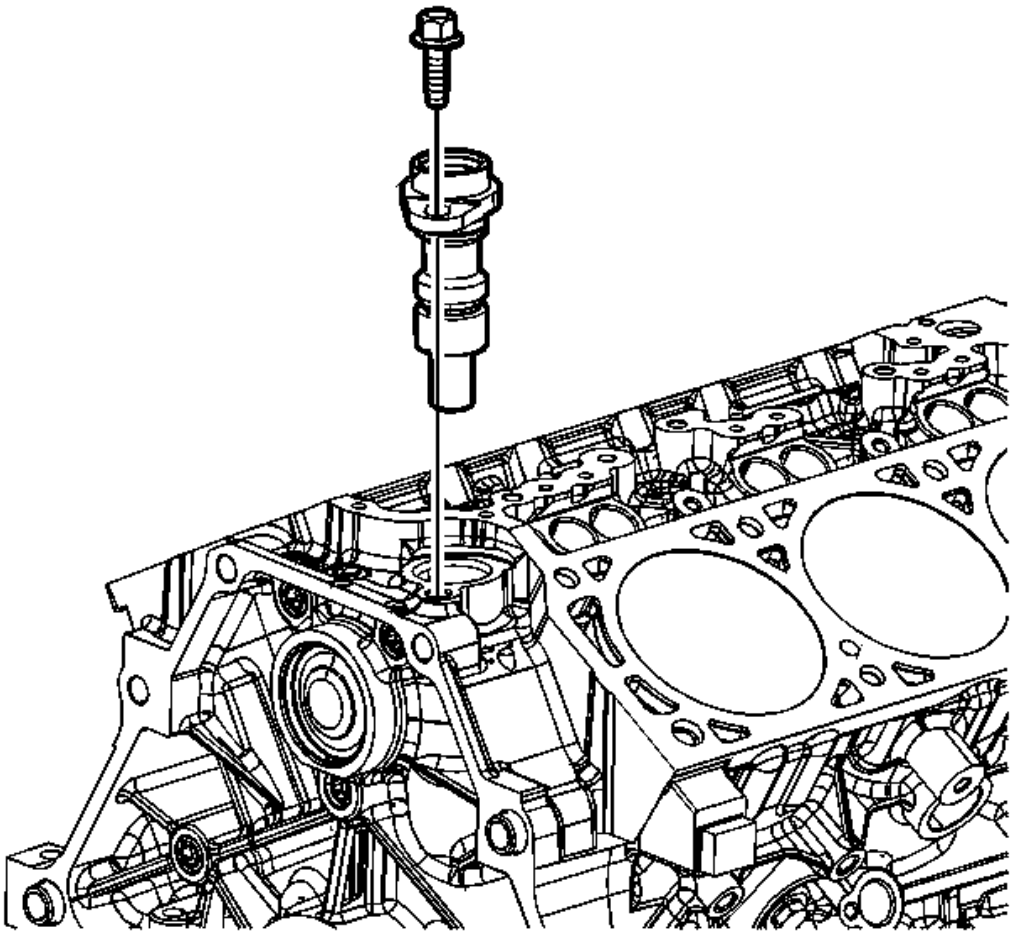

Fig. 164: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Coat the seal or bore in the engine block with prelube. Refer to **Adhesives, Fluids, Lubricants, and Sealers**
2. Install the oil pump drive.

CAUTION: Refer to Fastener Caution .

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3. Install the oil pump drive bolt.

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

4. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
5. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

EN-48869 Front Crankshaft Seal Installer

Removal Procedure

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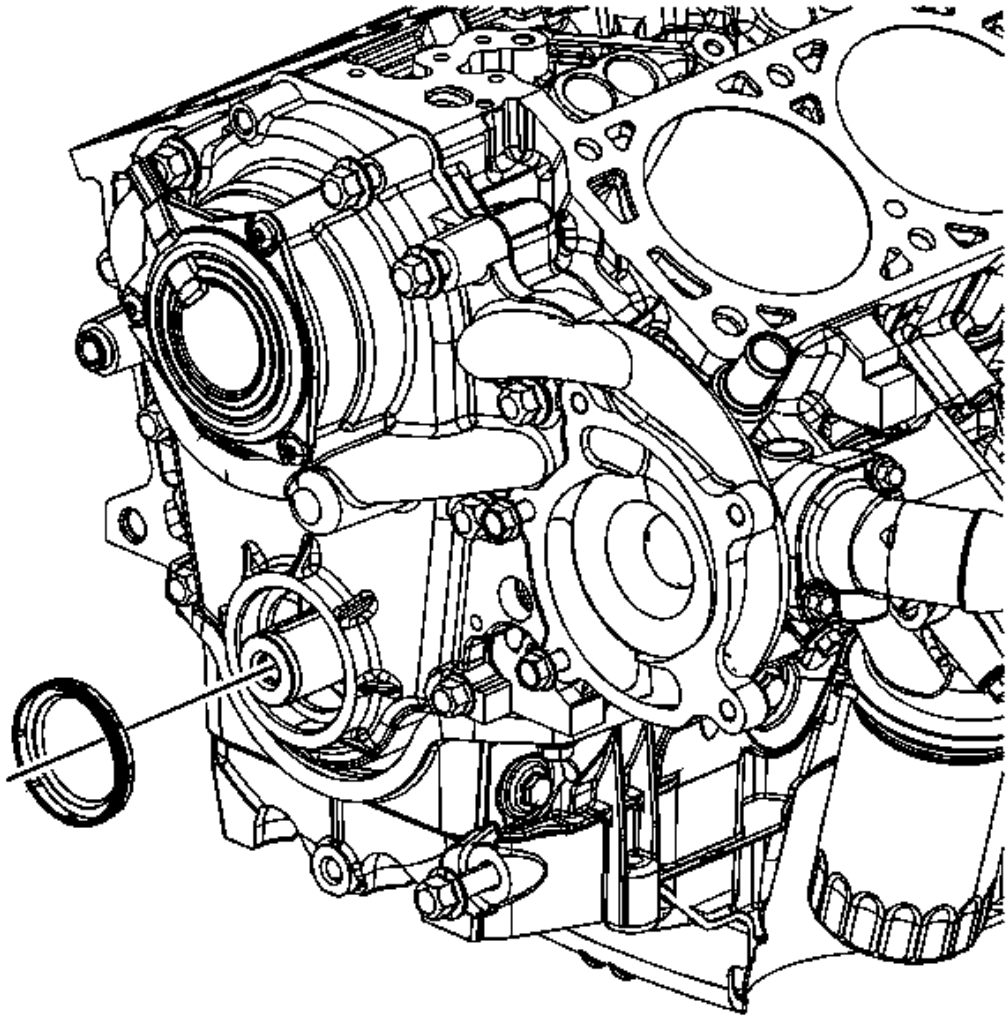

Fig. 165: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Pry out the crankshaft front oil seal using a suitable tool. Use care not to damage the engine front cover or the crankshaft.

Installation Procedure

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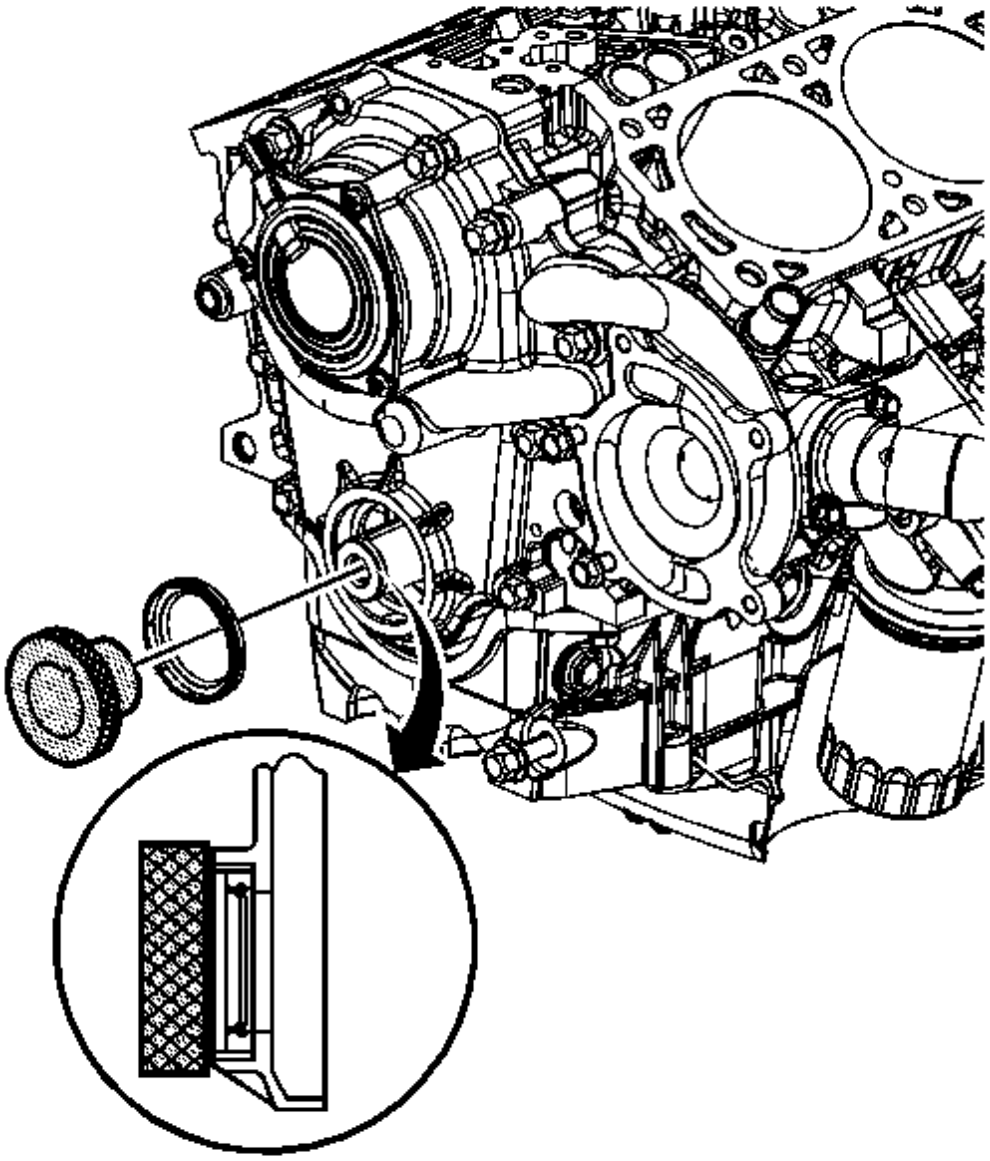

Fig. 166: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the NEW oil seal with clean engine oil.
2. Align the **EN-48869** and the crankshaft front oil seal with the engine front cover and crankshaft.
3. Install the crankshaft front oil seal using **EN-48869** and a suitable tool.

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

CAMSHAFT POSITION ACTUATOR MAGNET REPLACEMENT

Removal Procedure

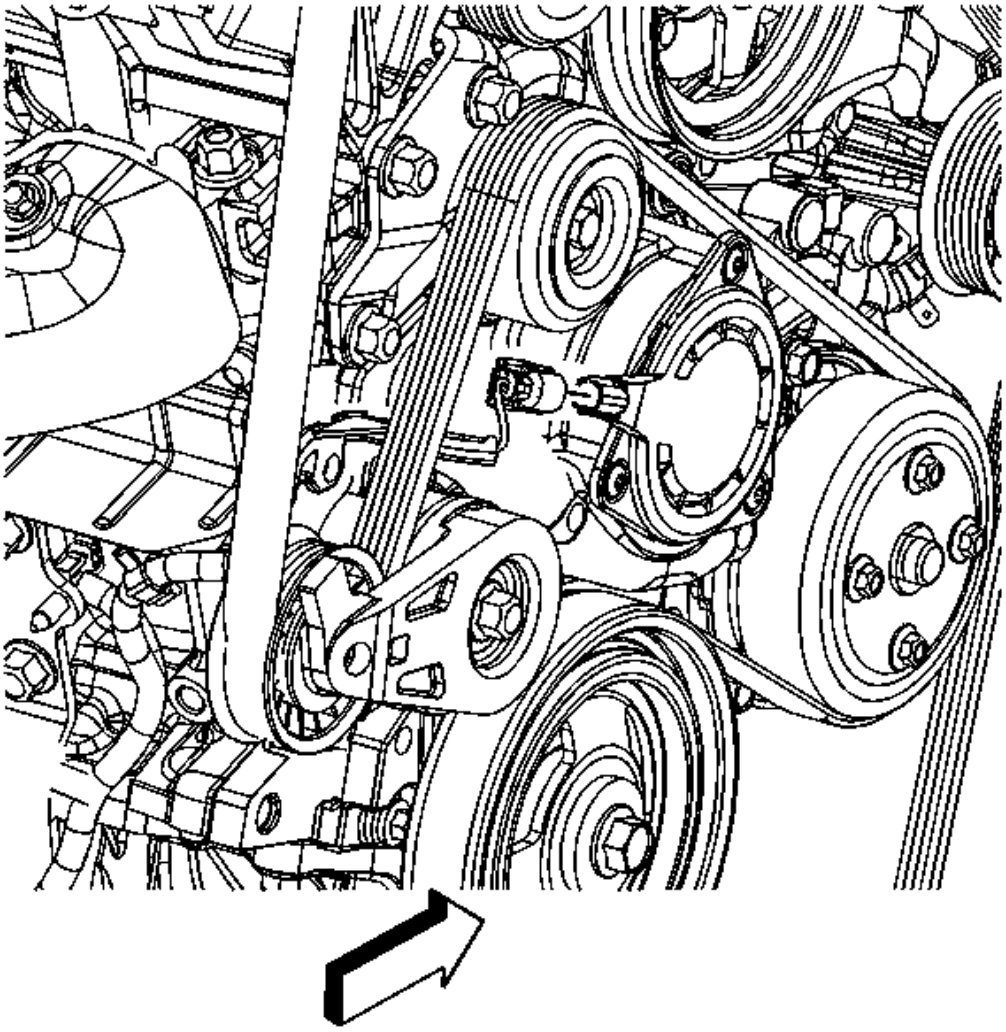

Fig. 167: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

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3. Remove the engine mount snubber bracket. Refer to **Engine Mount Snubber Bracket Replacement**.
4. Remove the engine mount bracket, if equipped with a convertible top. Refer to **Engine Mount Bracket Replacement (Convertible)** or **Engine Mount Bracket Replacement (Coupe)**.
5. Disconnect the camshaft position actuator magnet electrical connector.

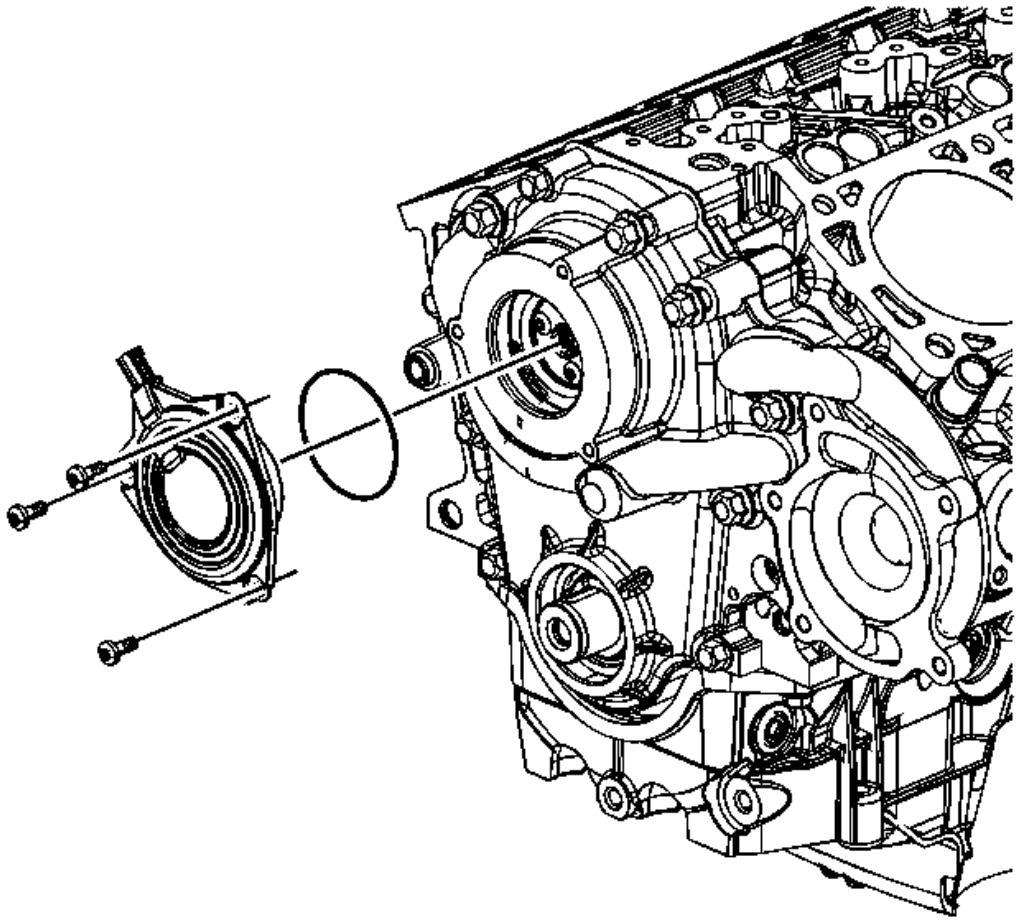

Fig. 168: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft position actuator magnet bolts.
7. Remove the camshaft position actuator magnet and O-ring seal.

Installation Procedure

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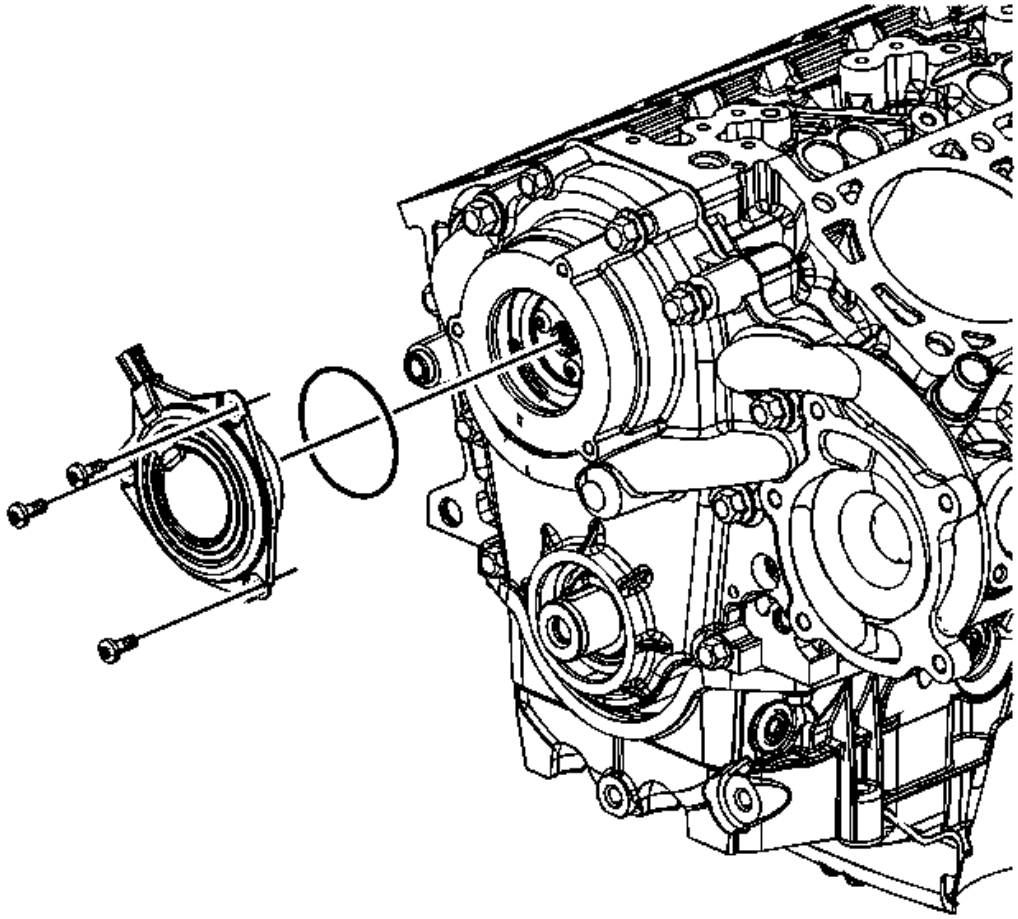

Fig. 169: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the camshaft position actuator magnet O-ring seal and magnet.

CAUTION: Refer to Fastener Caution .

2. Install the camshaft position actuator magnet bolts and tighten to 10 N.m (89 lb in).

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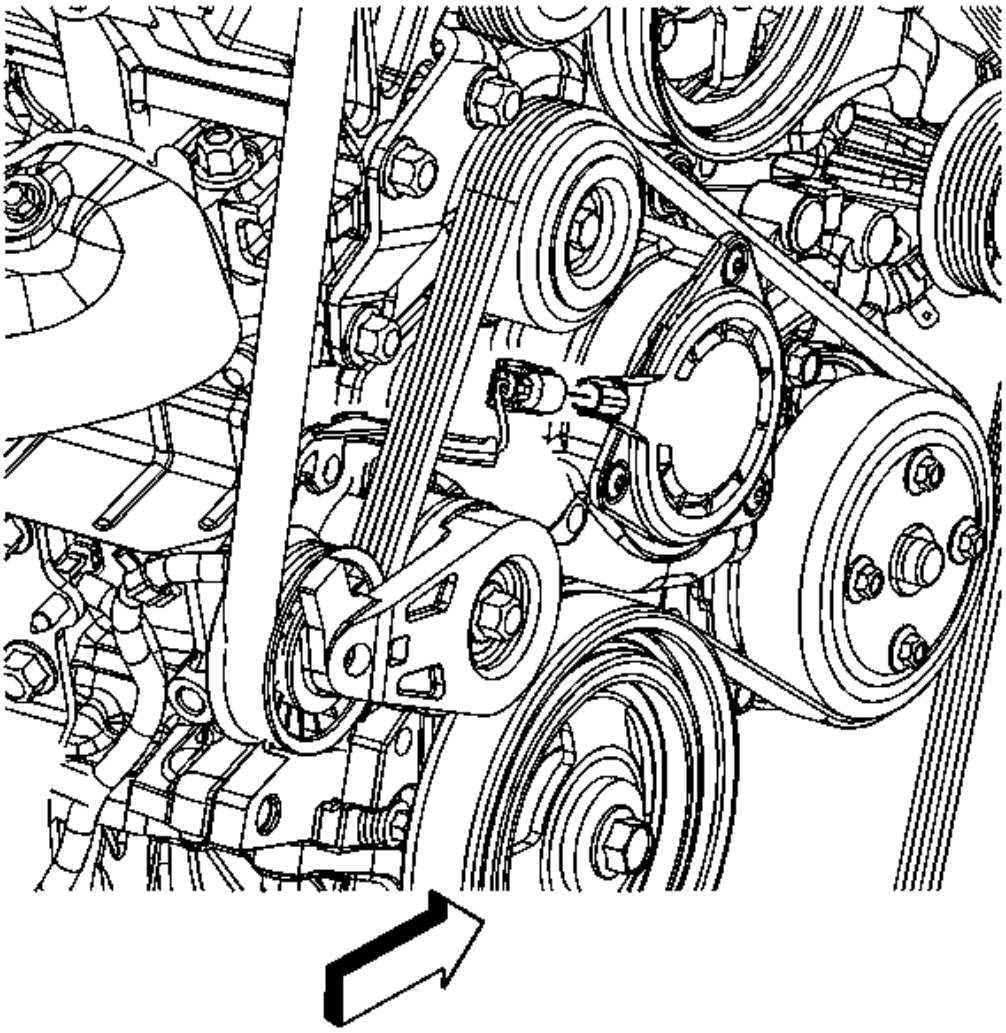

Fig. 170: View Of Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect the camshaft position actuator magnet electrical connector.
4. Install the engine mount bracket, if equipped with a convertible top. Refer to **Engine Mount Bracket Replacement (Convertible)** or **Engine Mount Bracket Replacement (Coupe)**.
5. Install the engine mount snubber bracket. Refer to **Engine Mount Snubber Bracket Replacement**.
6. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

ENGINE FRONT COVER REPLACEMENT

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Removal Procedure

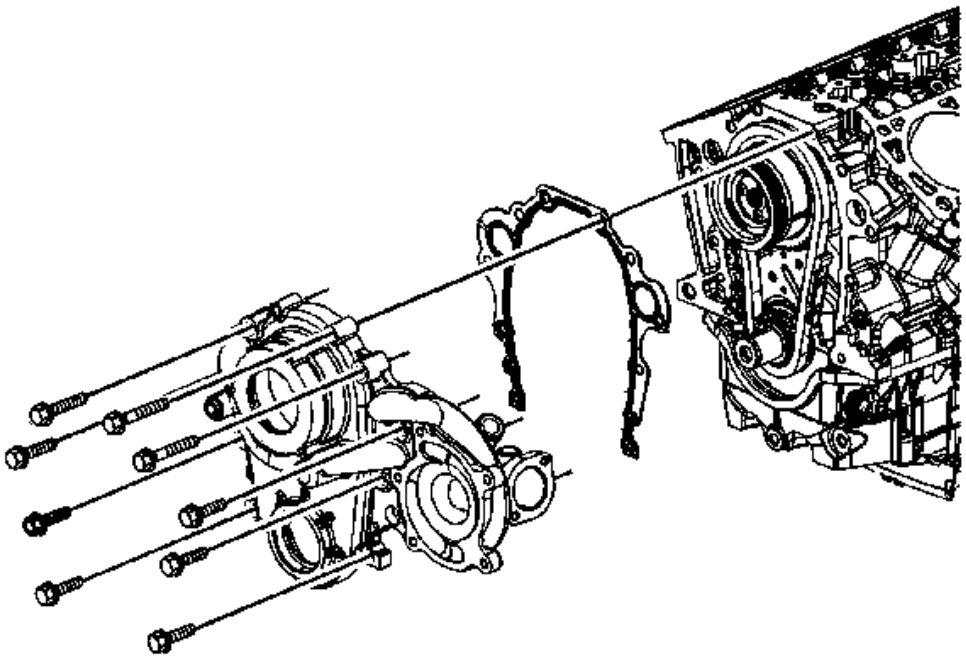

Fig. 171: Identifying Engine Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
2. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
3. Remove the oil pan. Refer to **Oil Pan Replacement**.
4. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
5. Remove the crankshaft position actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.
6. Remove the thermostat housing. Refer to **Engine Coolant Thermostat Housing Replacement (LZ4/LZ9)** .
7. Remove the water pump. Refer to **Water Pump Replacement (LZ4/LZ9)** .
8. Remove the engine front cover bolts.

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9. Remove the engine front cover.
10. Remove the engine front cover gasket.

Installation Procedure

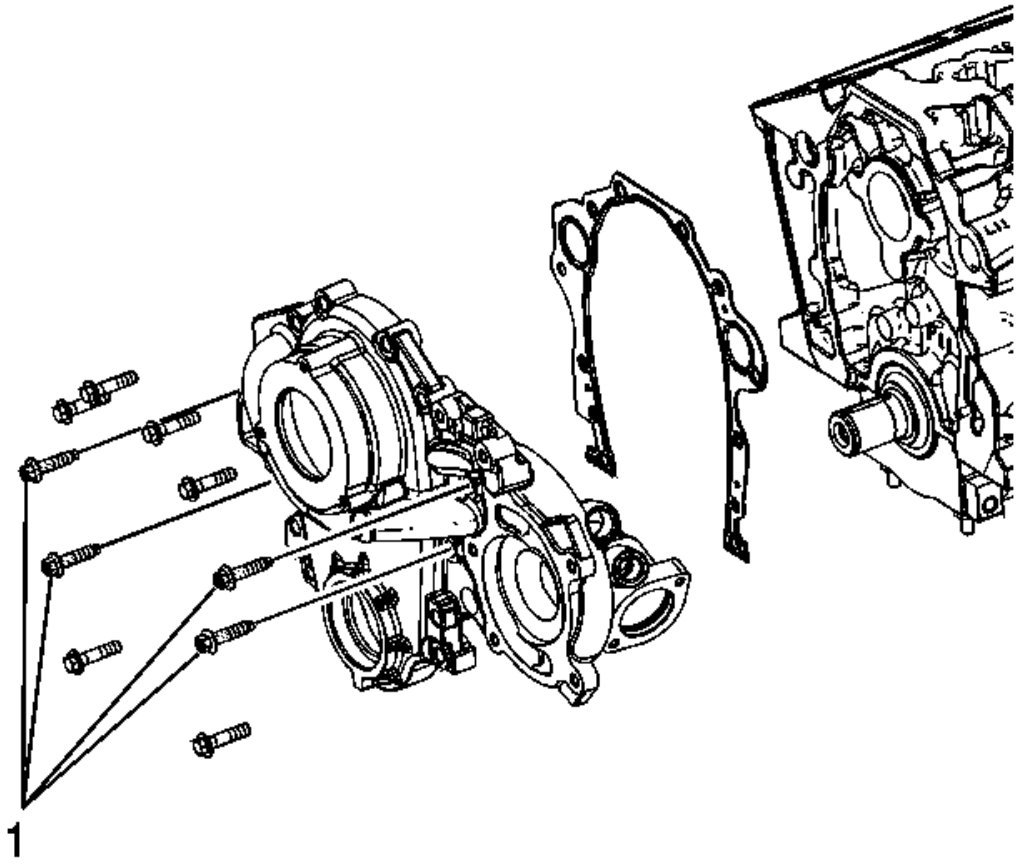

Fig. 172: Identifying Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover gasket.
2. Install the engine front cover.

CAUTION: Refer to Fastener Caution .

3. Add sealant to the bolts in the locations pointed out in the graphic. Refer to **Adhesives, Fluids,**

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Lubricants, and Sealers for the correct part number.

4. Install the engine front cover bolts (1).

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

5. Install the water pump. Refer to **Water Pump Replacement (LZ4/LZ9)** .
6. Install the thermostat housing. Refer to **Engine Coolant Thermostat Housing Replacement (LZ4/LZ9)** .
7. Install the crankshaft position actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.
8. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
9. Install the oil pan. Refer to **Oil Pan Replacement**.
10. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
11. Fill the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .

CAMSHAFT TIMING CHAIN AND SPROCKET REPLACEMENT

Special Tools

EN-47719: Tensioner Compressor

Removal Procedure

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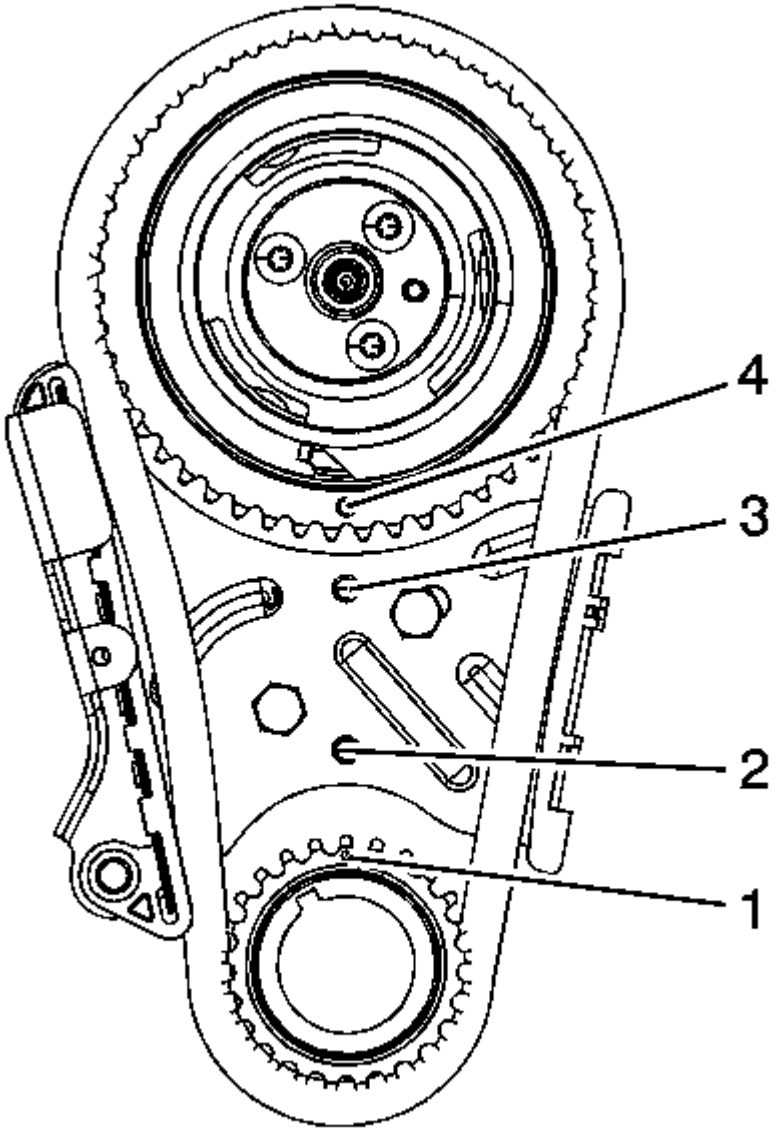

Fig. 173: Identifying Timing Marks & Chain Tensioners
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Align the crankshaft timing mark (1) to the timing mark on the bottom of the timing chain tensioner (2).
3. Align the timing mark on the camshaft gear (3) with the timing mark on top of the timing chain tensioner (4).

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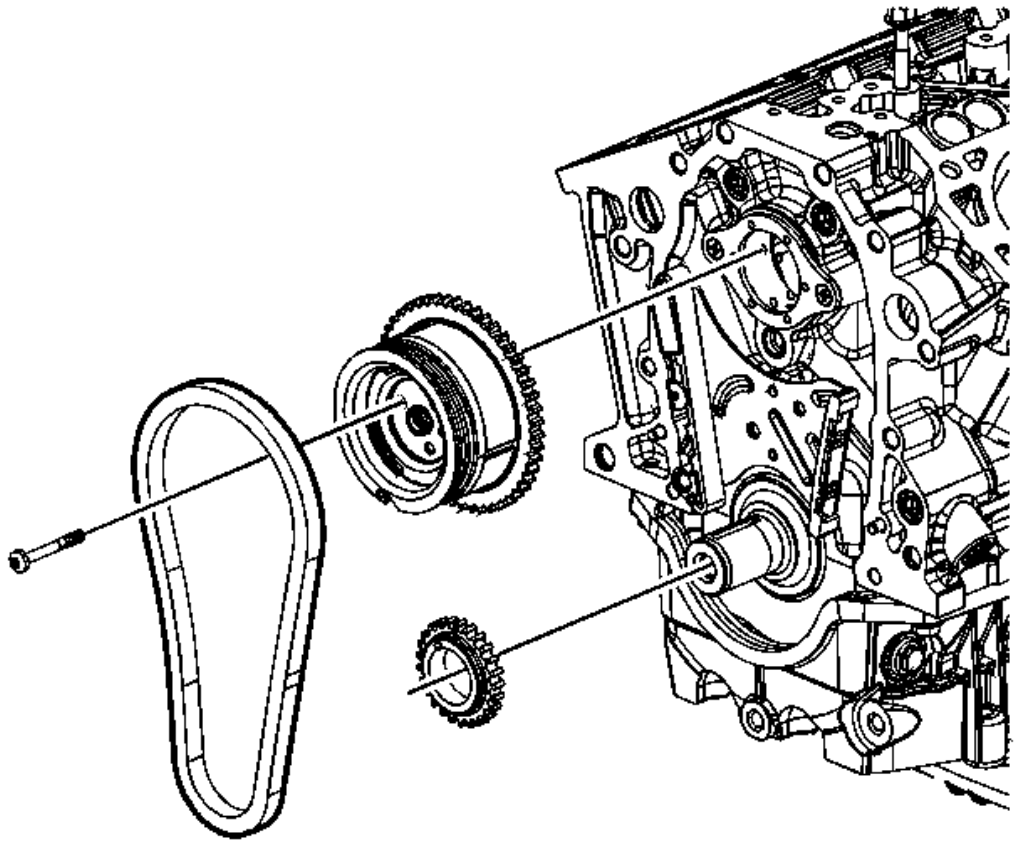

Fig. 174: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft sprocket bolts.
5. Remove the timing chain, camshaft, and crankshaft sprockets.

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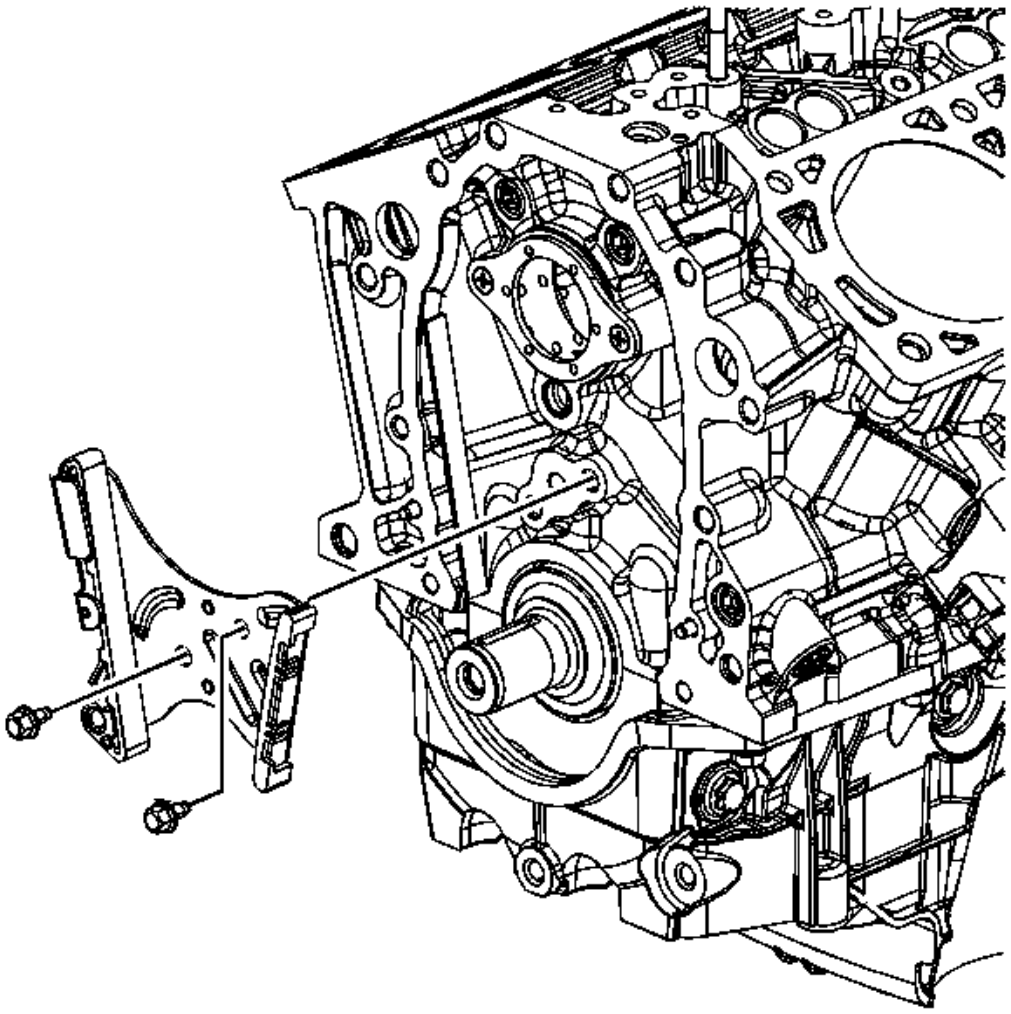

Fig. 175: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing chain tensioner bolts.
7. Remove the timing chain tensioner.

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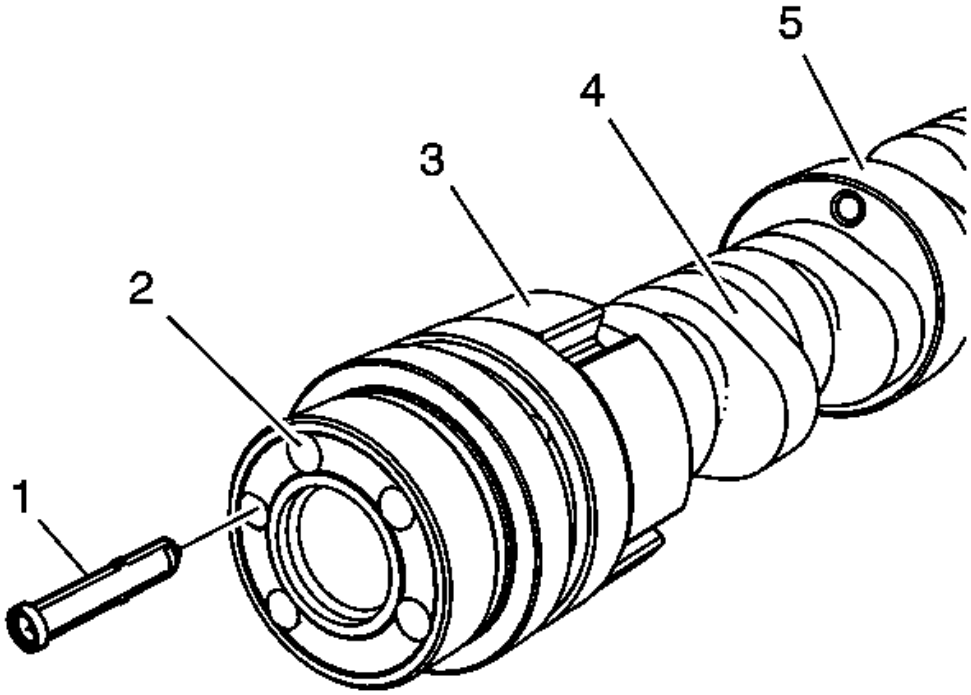

Fig. 176: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the camshaft position actuator filter (1) from the end of the camshaft.

Installation Procedure

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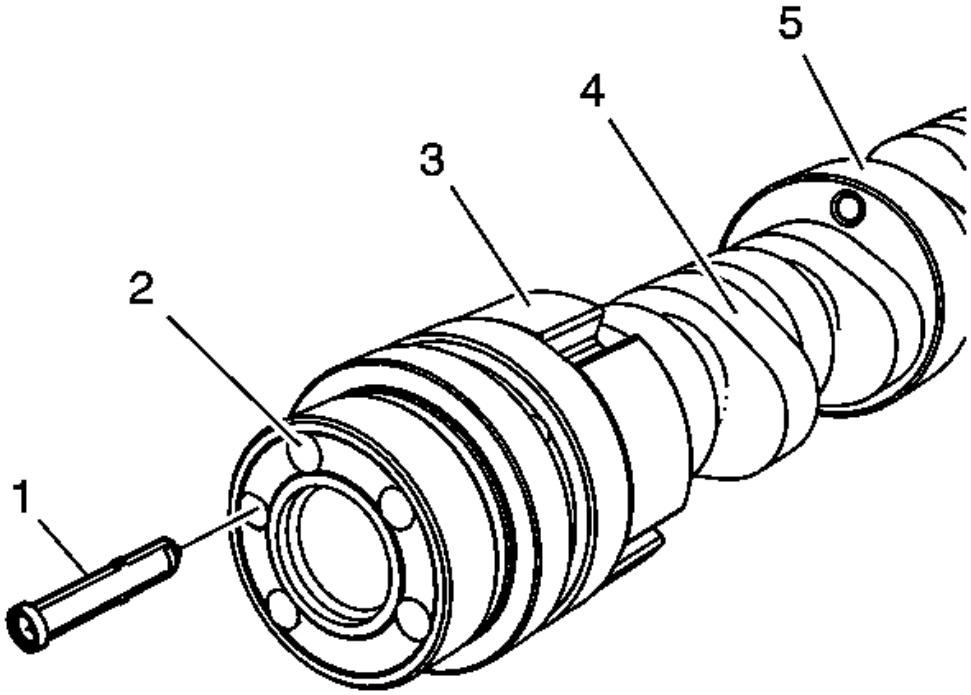

Fig. 177: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install a NEW camshaft position actuator filter anytime the camshaft position actuator is removed.

1. Install a NEW camshaft position actuator filter (1) to the end of the camshaft.

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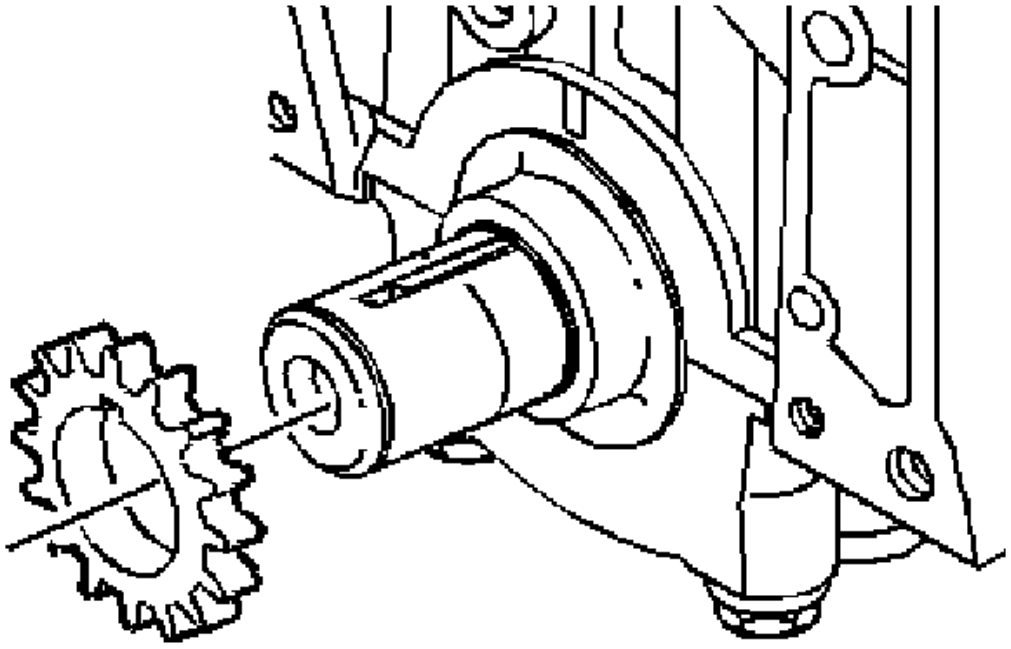

Fig. 178: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft sprocket.
3. Apply prelube to the crankshaft sprocket thrust surface. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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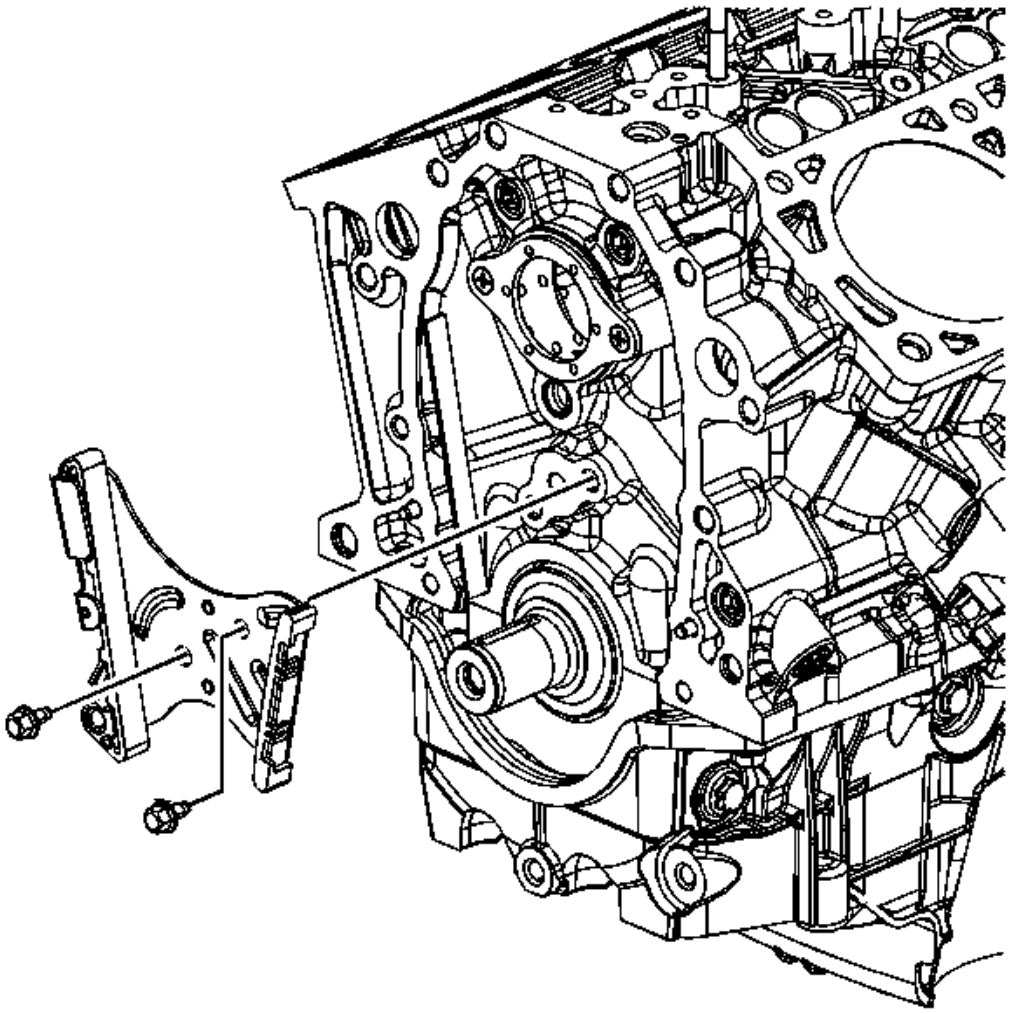

Fig. 179: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the timing chain tensioner.
5. Install the timing chain tensioner bolts and tighten to 21 N.m (15 lb ft).

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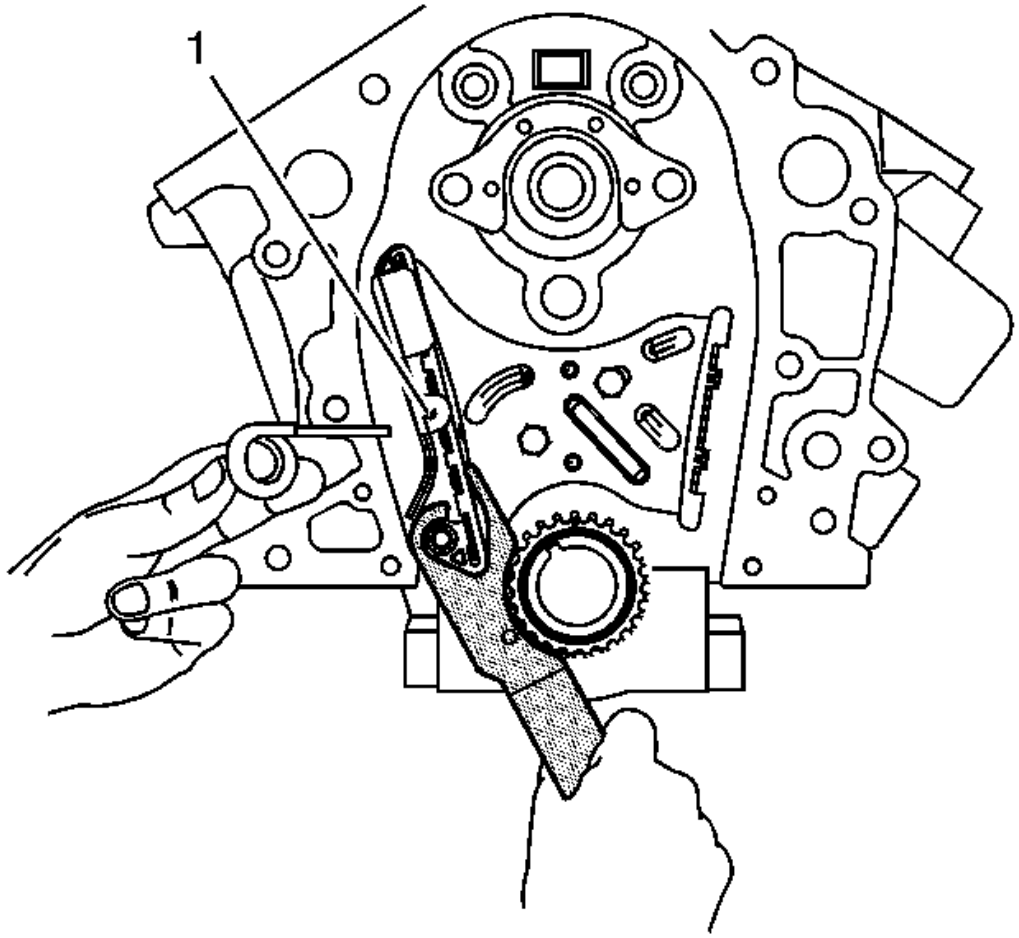

Fig. 180: Identifying Tensioner Collapsing Procedure
Courtesy of GENERAL MOTORS CORP.

6. Using the **EN-47719:** Tensioner Compressor, fully collapse the tensioner, and place the tensioner retaining pin into the retaining hole (1).

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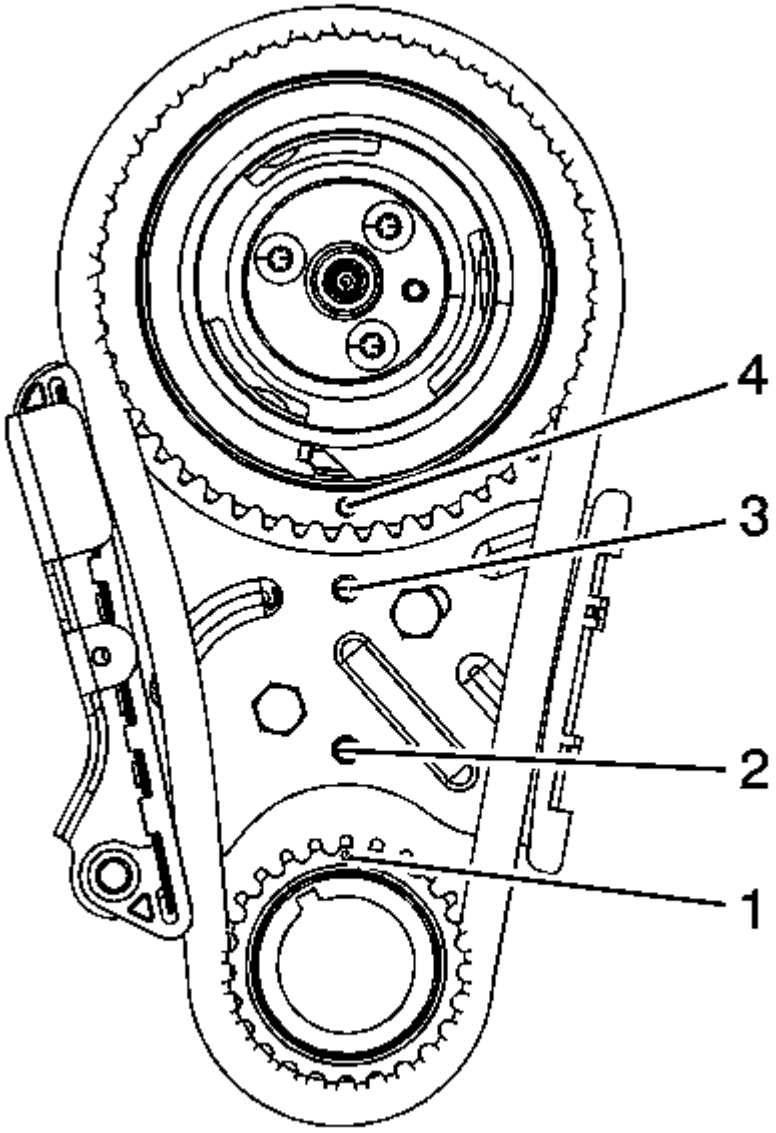

Fig. 181: Identifying Timing Marks & Chain Tensioners
Courtesy of GENERAL MOTORS CORP.

7. Align the crankshaft timing mark (1) to the timing mark on the bottom of the timing chain tensioner (2).
8. Hold the camshaft sprocket with the timing chain hanging down and install the timing chain to the crankshaft gear.
9. Align the timing mark on the camshaft gear (3) with the timing mark on top of the timing chain tensioner

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(4).

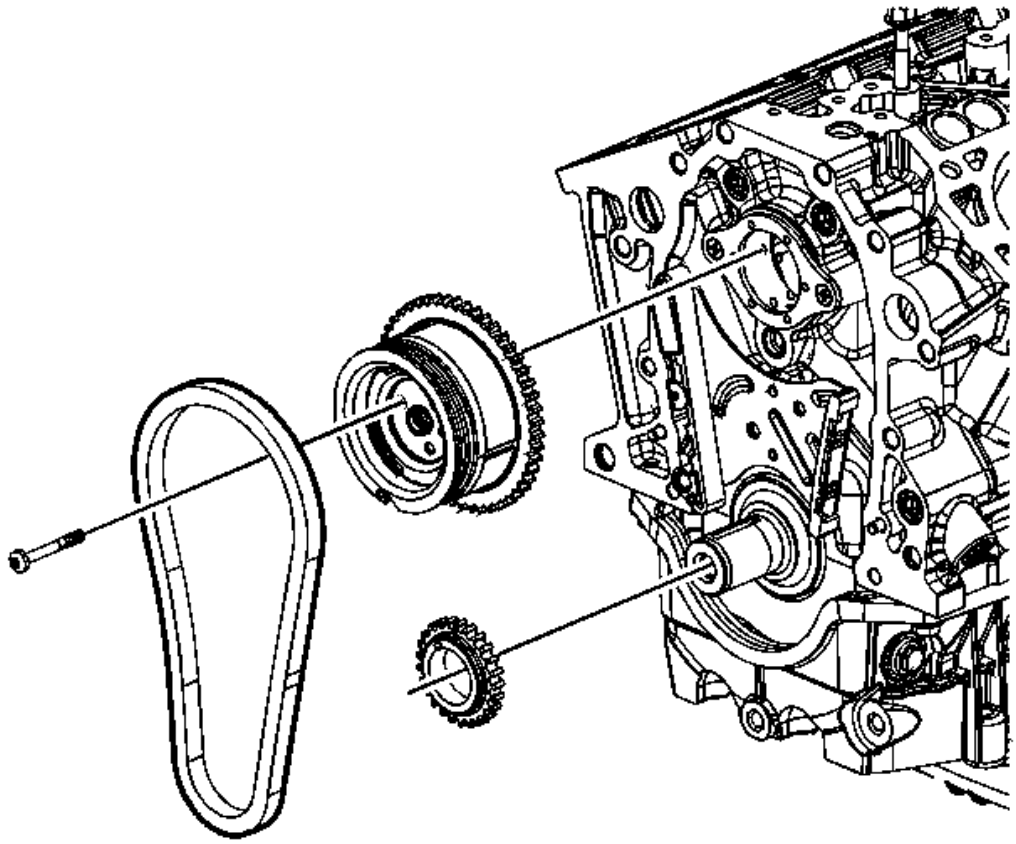

Fig. 182: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

10. Align the dowel in the camshaft sprocket with the dowel hole in the camshaft.
11. Draw the camshaft sprocket onto the camshaft using the mounting bolts. Tighten the bolts to 16 N.m (12 lb ft).
12. Remove the retaining pin from the timing chain tensioner in order to make the tensioner active.
13. Coat the crankshaft and camshaft sprockets with clean engine oil.
14. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Special Tools

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J 45059 Angle Meter

Removal Procedure

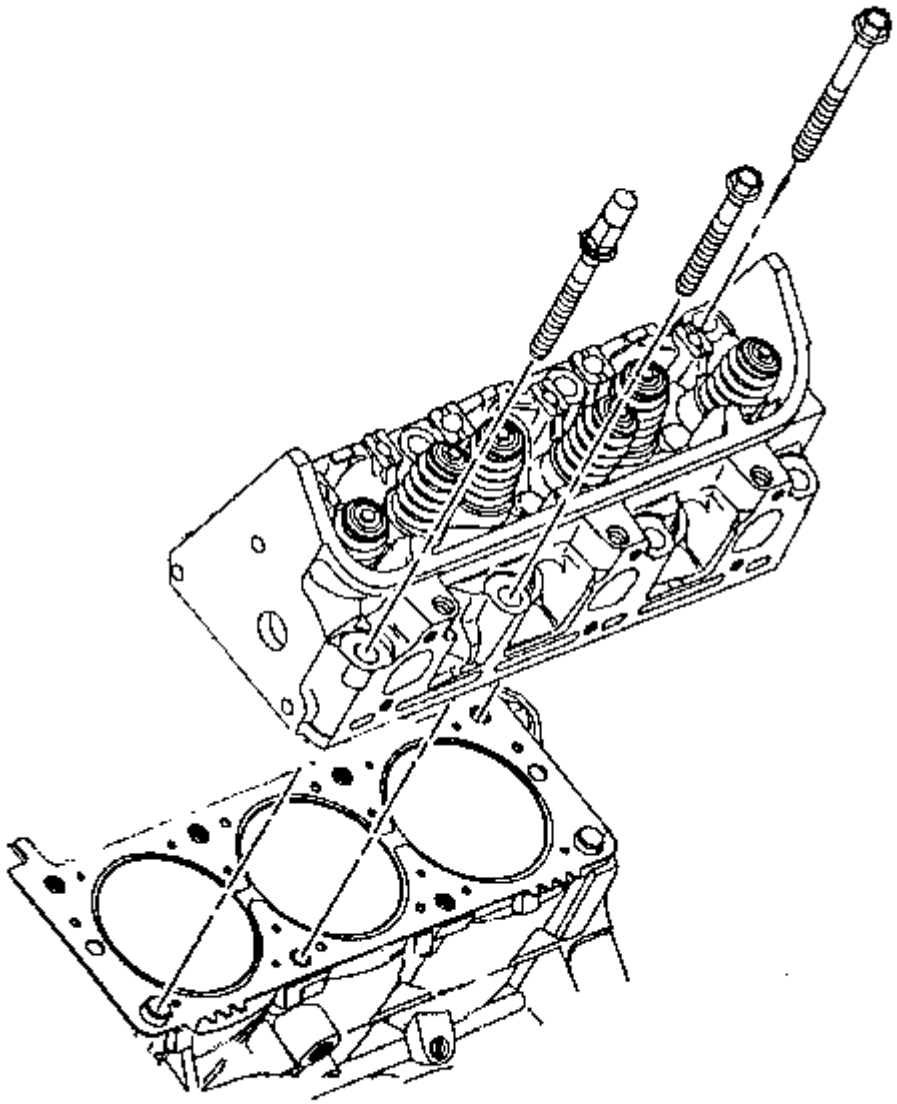

Fig. 183: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

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2. Lower the vehicle.
3. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
4. Remove the valve rocker arms and the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LZ9)** .
6. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
7. Remove the left spark plugs. Refer to **Spark Plug Replacement** .
8. Remove and discard the cylinder head bolts.
9. Remove the cylinder head.

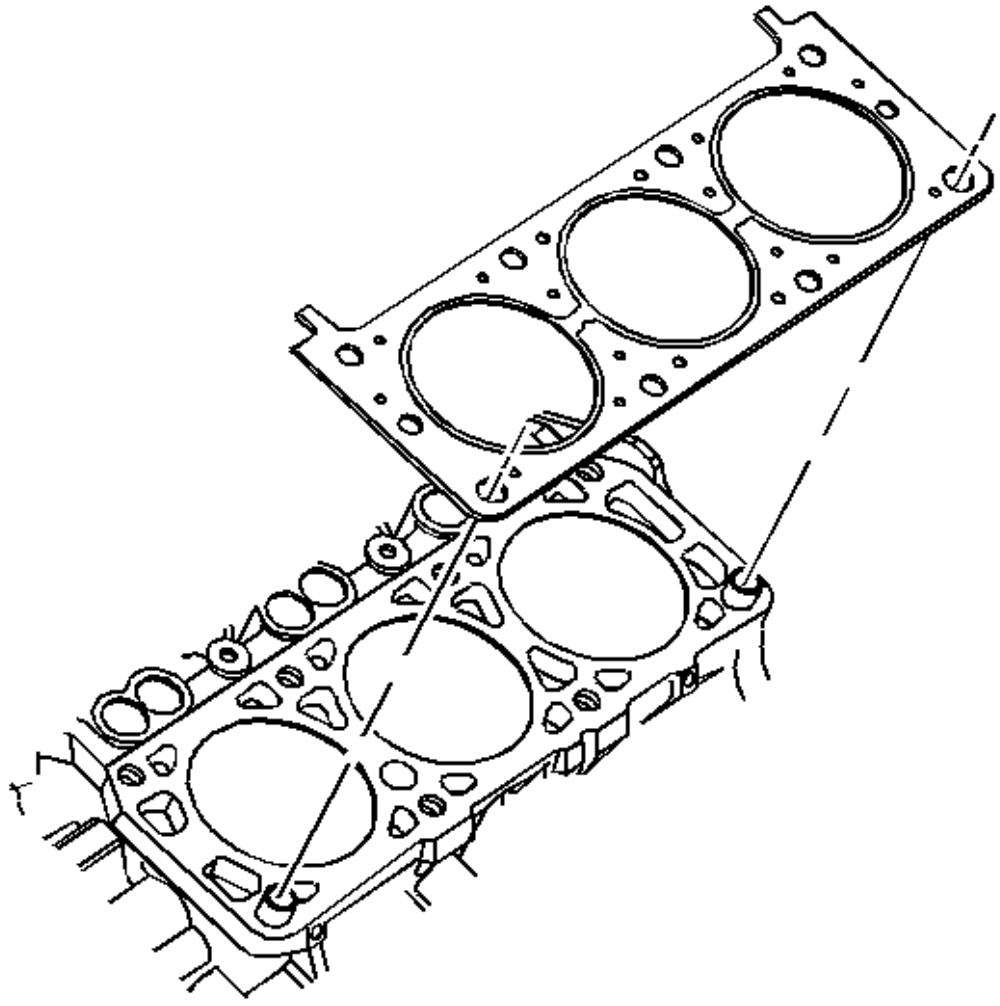

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Fig. 184: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the cylinder head gasket.
11. Remove the cylinder head locator dowel pins, if necessary.
12. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

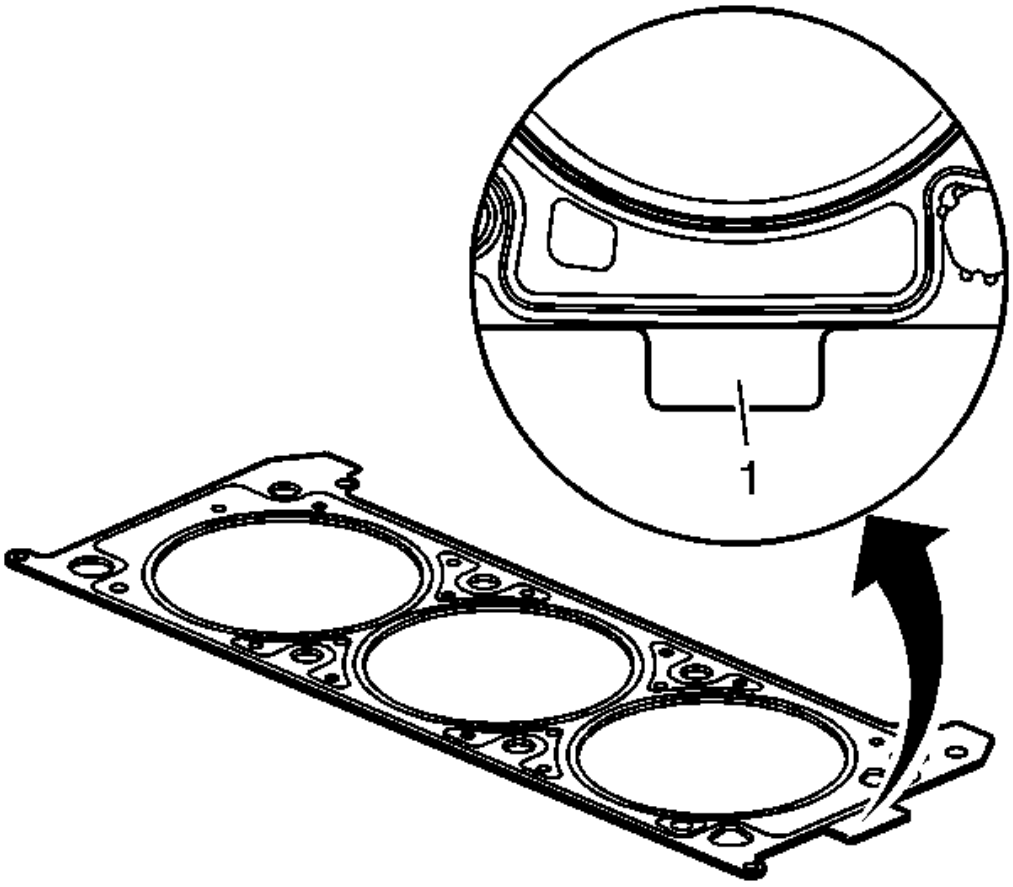

Fig. 185: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Head gaskets are specific for right hand and left hand applications, and also must be installed with the correct side facing up. Note the markings (1) on the head gaskets for proper installation. Failure to do

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so may lead to engine damage.

1. Install the cylinder head locator dowel pins, if necessary.
2. Inspect the cylinder head locator dowel pins for proper installation.

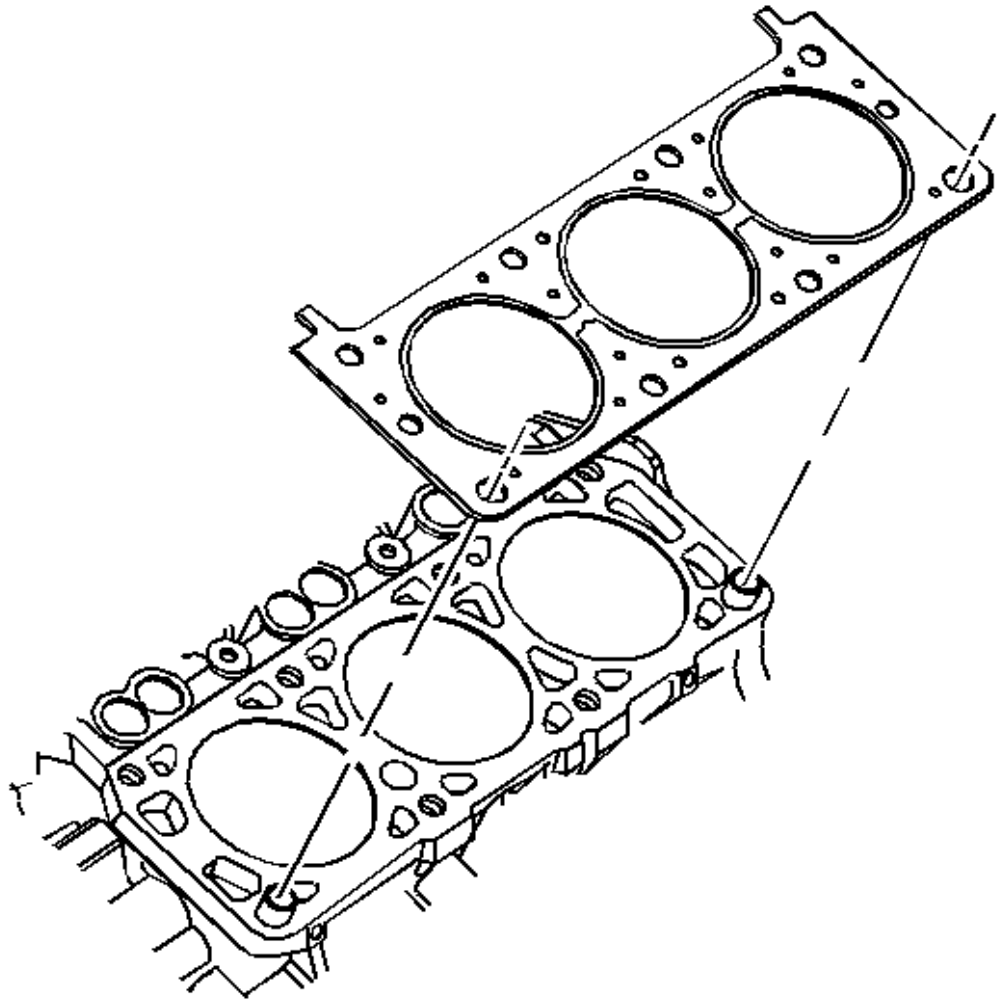

Fig. 186: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW cylinder head gasket.

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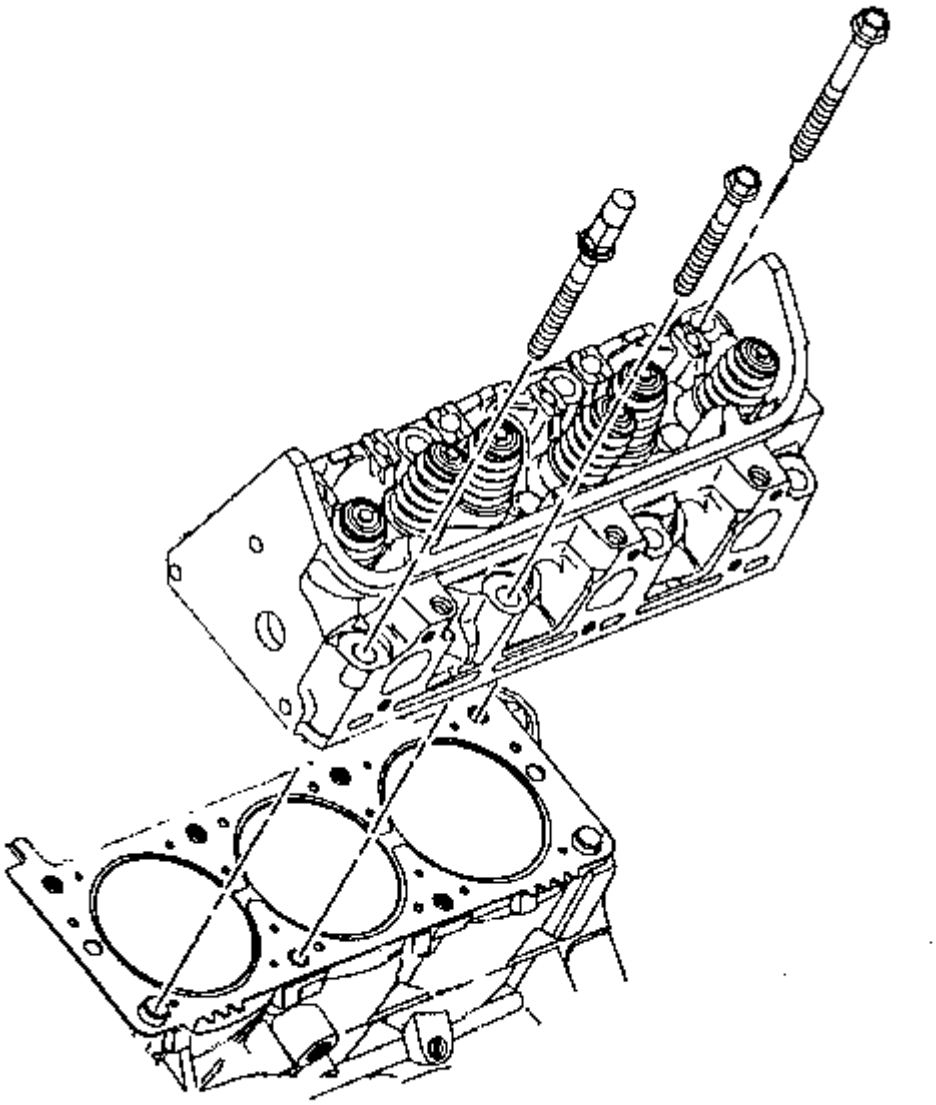

Fig. 187: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

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4. Install the cylinder head onto the locator pins and the engine.
5. Install NEW cylinder head bolts finger tight.

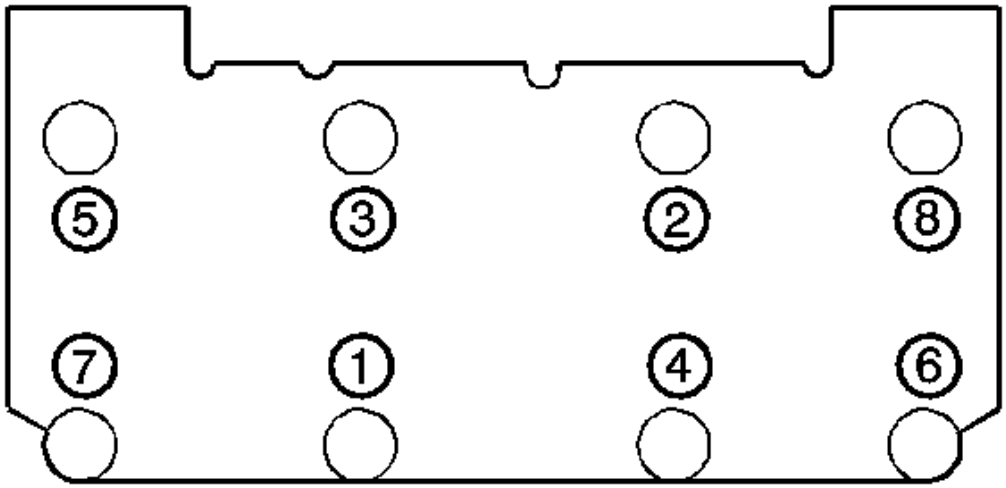

Fig. 188: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the NEW small hex cylinder head bolts (5 and 8).
7. Install the NEW large hex cylinder head bolts (1, 2, 3, 4, 6 and 7).

Tighten:

1. Tighten the cylinder head bolts a first pass in sequence to 60 N.m (44 lb ft).
2. Tighten the cylinder head bolts a final pass in sequence to 140 degrees using the.

8. Install the left spark plugs. Refer to **Spark Plug Replacement** .
9. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
10. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LZ9)** .
11. Install the valve rocker arms and the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
12. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
13. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.

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14. Inspect for leaks.

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Special Tools

J 45059 Angle Meter

Removal Procedure

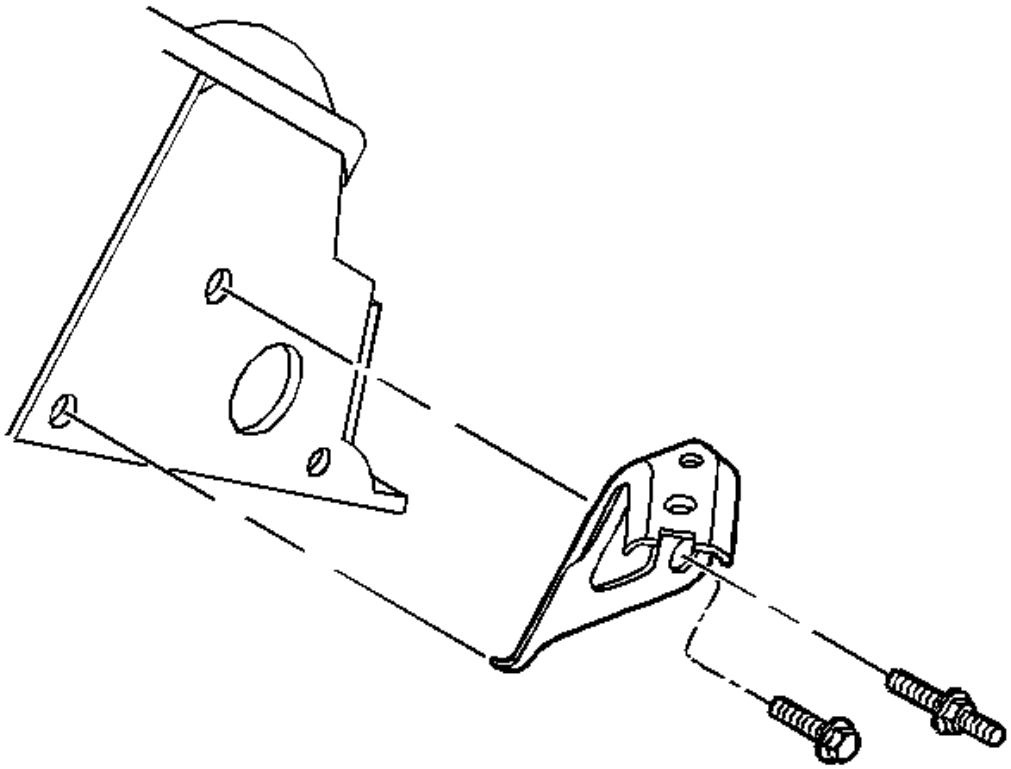

Fig. 189: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
2. Lower the vehicle.
3. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
4. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LZ9 w/RPO**

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MT2) or **Exhaust Manifold Replacement - Right Side (LZ9 w/RPO M15)** .

6. Remove the right spark plugs. Refer to **Spark Plug Replacement** .
7. Remove the fuel line bracket bolt and stud.
8. Remove the fuel line bracket.
9. Remove the generator. Refer to **Generator Replacement (LZ9)** .

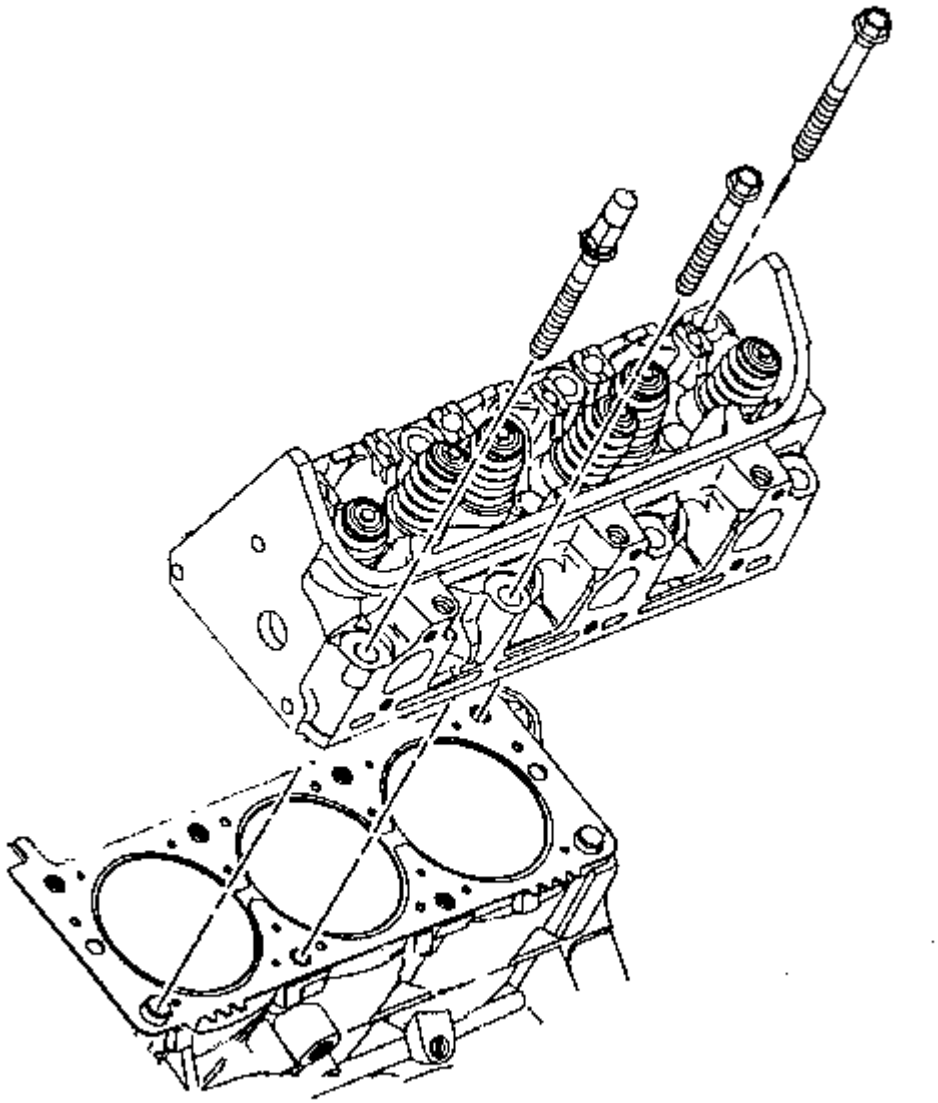

Fig. 190: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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10. Remove and discard the cylinder head bolts.
11. Remove the cylinder head.

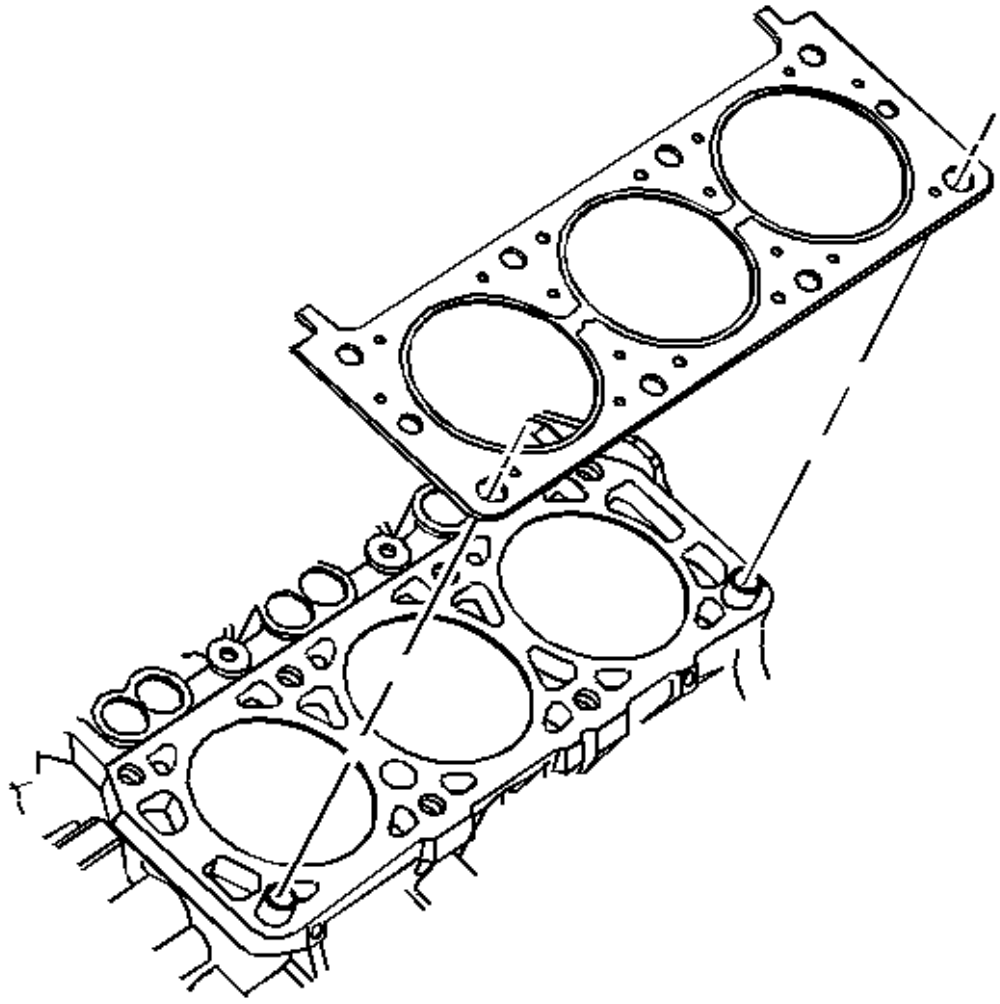

Fig. 191: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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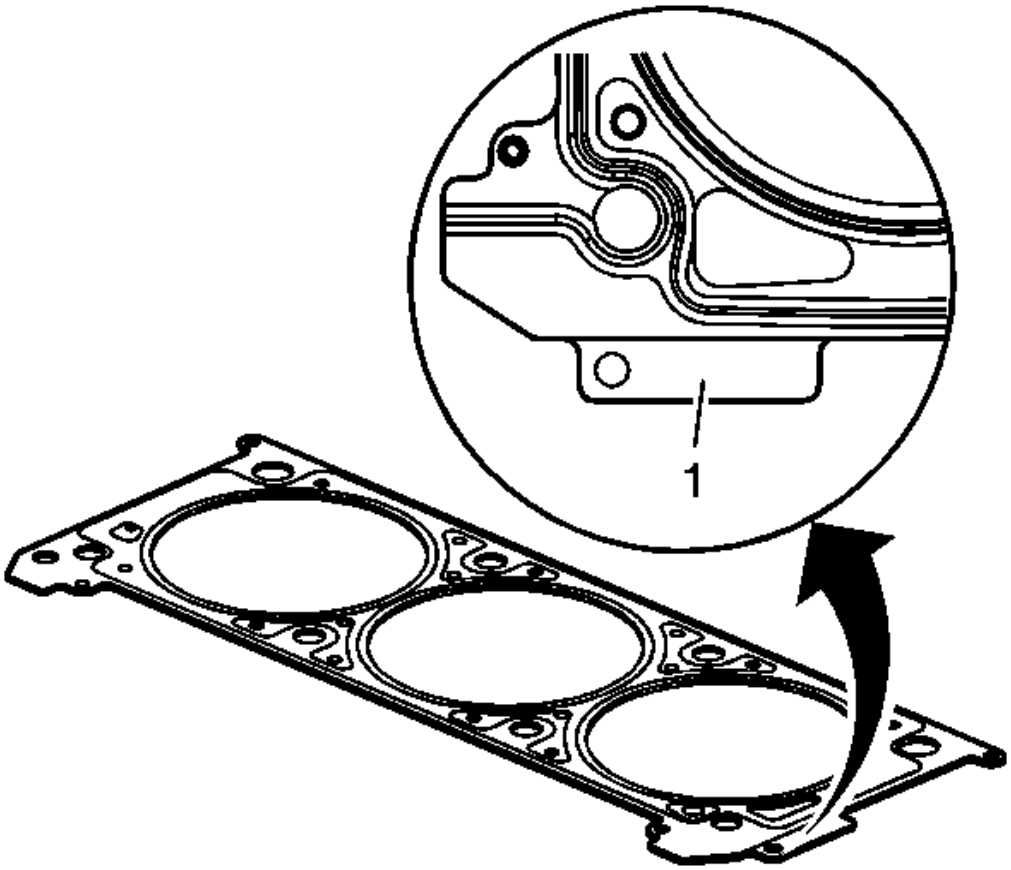

Fig. 192: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Head gaskets are specific for right hand and left hand applications, and also must be installed with the correct side facing up. Note the markings (1) on the head gaskets for proper installation. Failure to do so may lead to engine damage.

1. Install the cylinder head locator dowel pins, if necessary.
2. Inspect the cylinder head locator dowel pins for proper installation.

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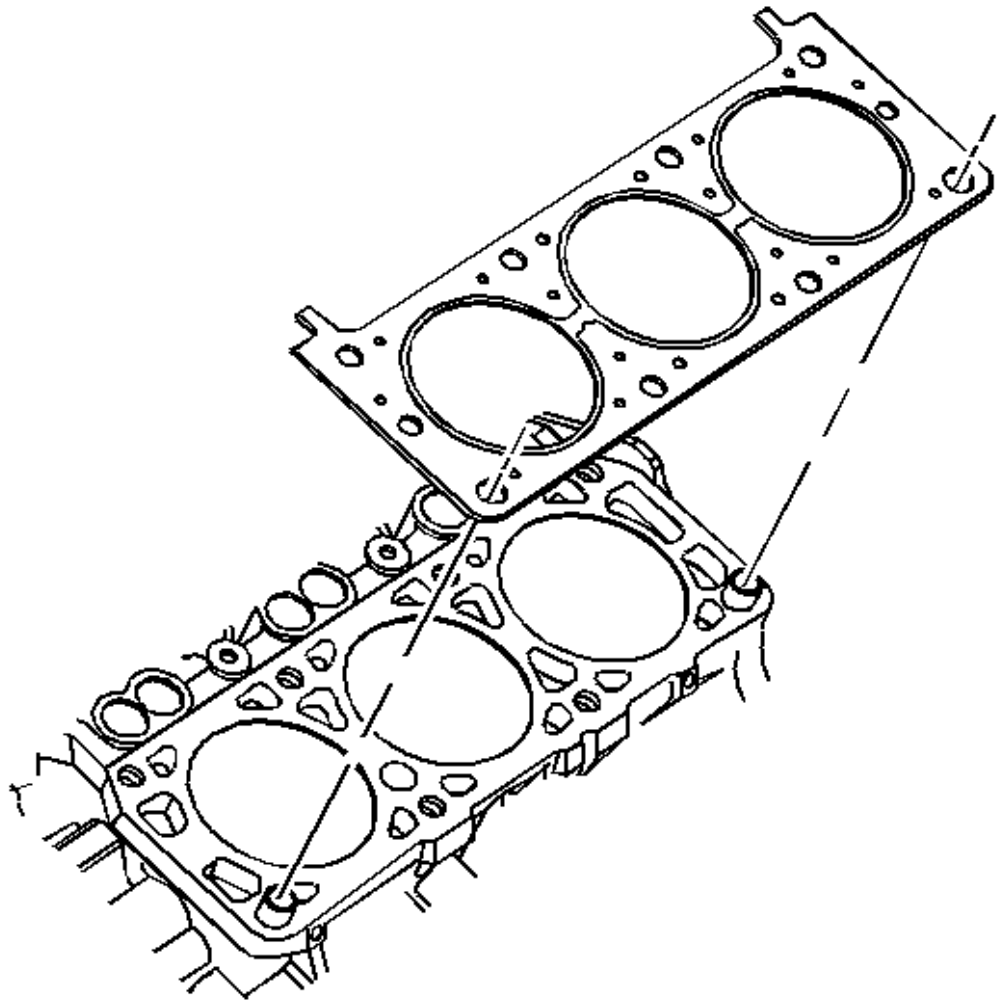

Fig. 193: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW cylinder head gasket.

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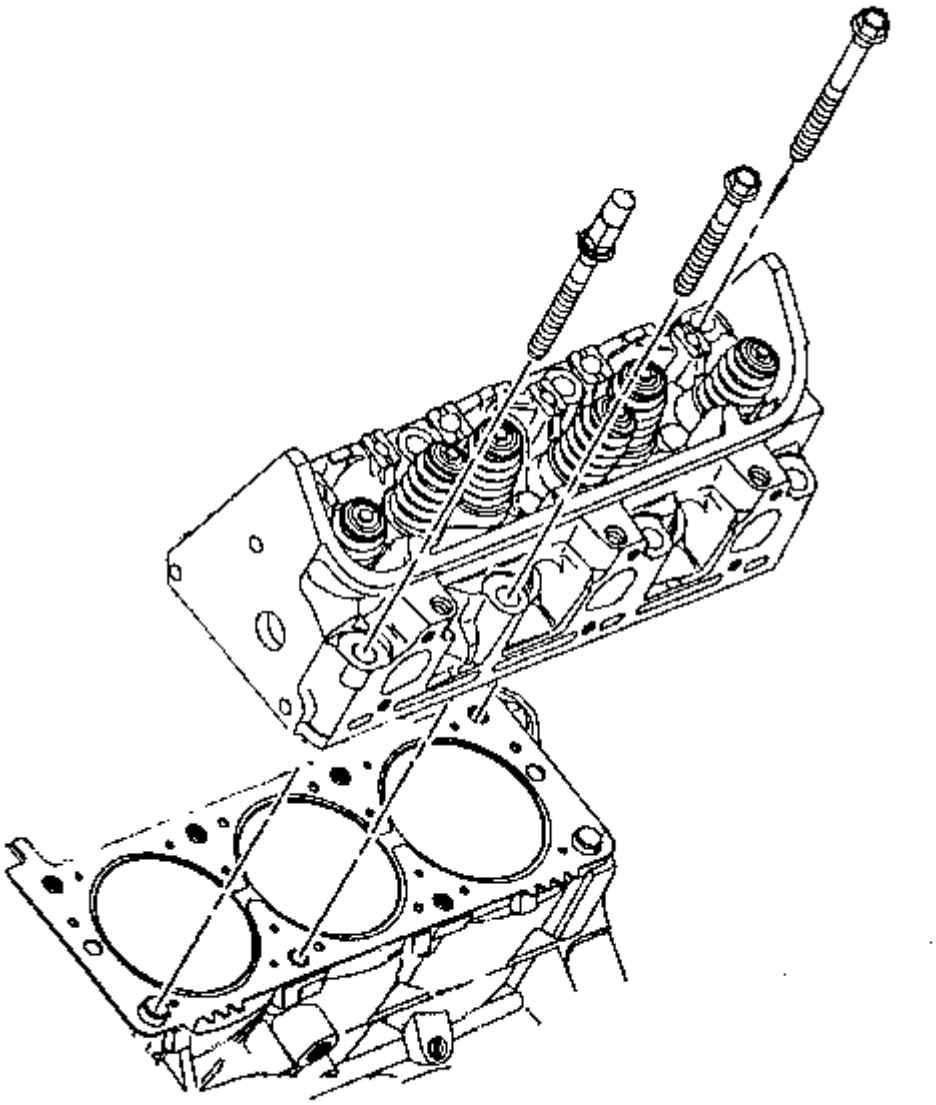

Fig. 194: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

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4. Install the cylinder head onto the locator pins and the engine.
5. Install NEW cylinder head bolts finger tight.

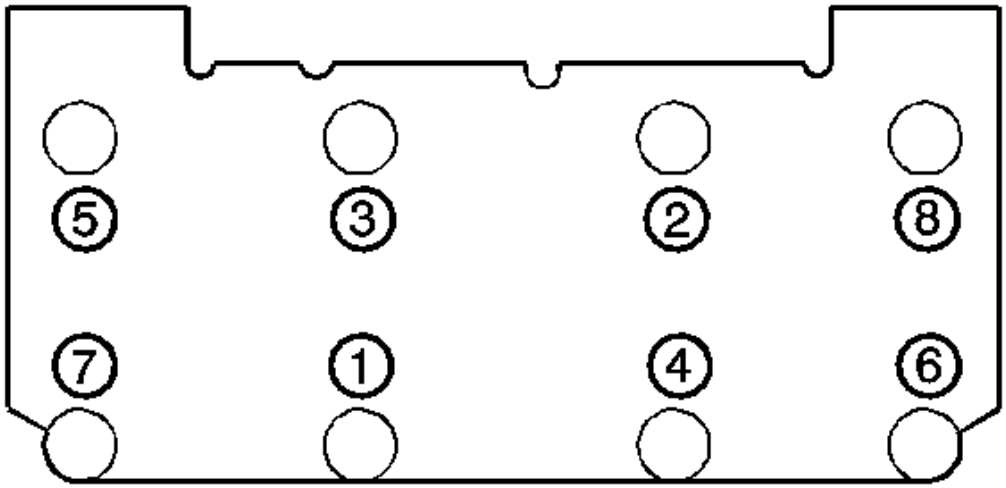

Fig. 195: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the NEW small hex cylinder head bolts (5 and 8).
7. Install the NEW large hex cylinder head bolts (1, 2, 3, 4, 6 and 7).

Tighten:

1. Tighten the cylinder head bolts a first pass in sequence to 60 N.m (44 lb ft).
2. Tighten the cylinder head bolts a final pass in sequence to 140 degrees using the **J 45059** .

8. Install the generator. Refer to **Generator Replacement (LZ9)** .

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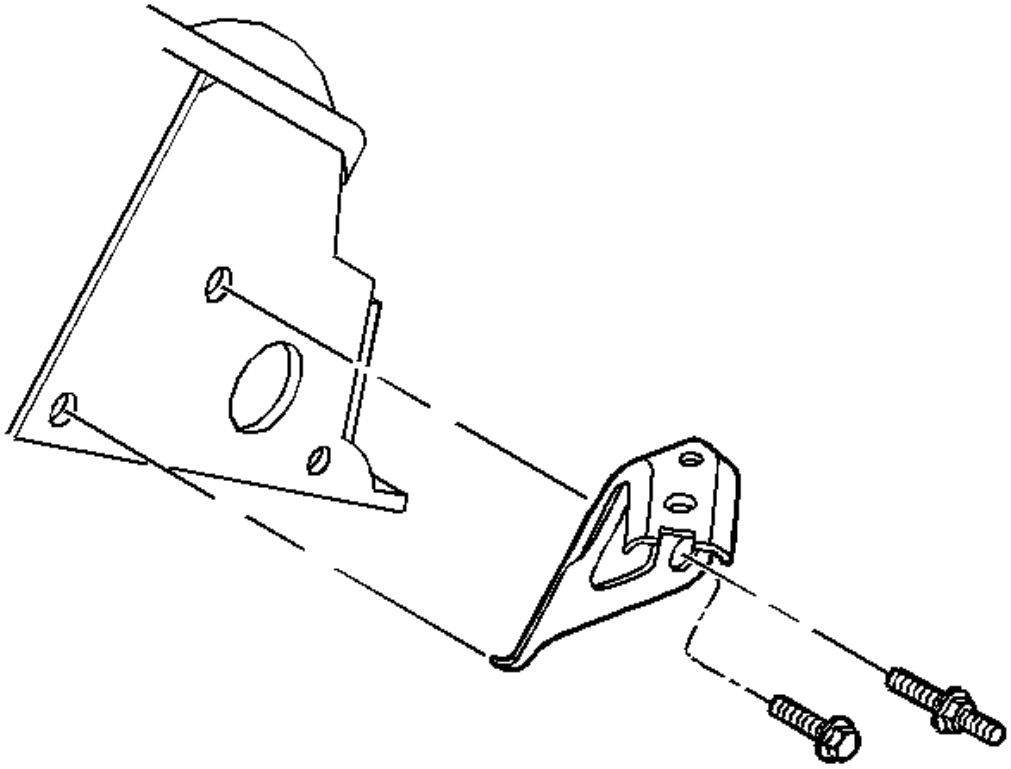

Fig. 196: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

9. Position the fuel line bracket to the cylinder head.
10. Install the fuel line bracket bolt and stud.

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

11. Install the right spark plugs. Refer to **Spark Plug Replacement** .
12. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LZ9 w/RPO MT2)** or **Exhaust Manifold Replacement - Right Side (LZ9 w/RPO M15)** .
13. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
14. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
15. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement** .
16. Inspect for leaks.

ENGINE FLYWHEEL REPLACEMENT

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Special Tools

J 37096 Flywheel Holder

Removal Procedure

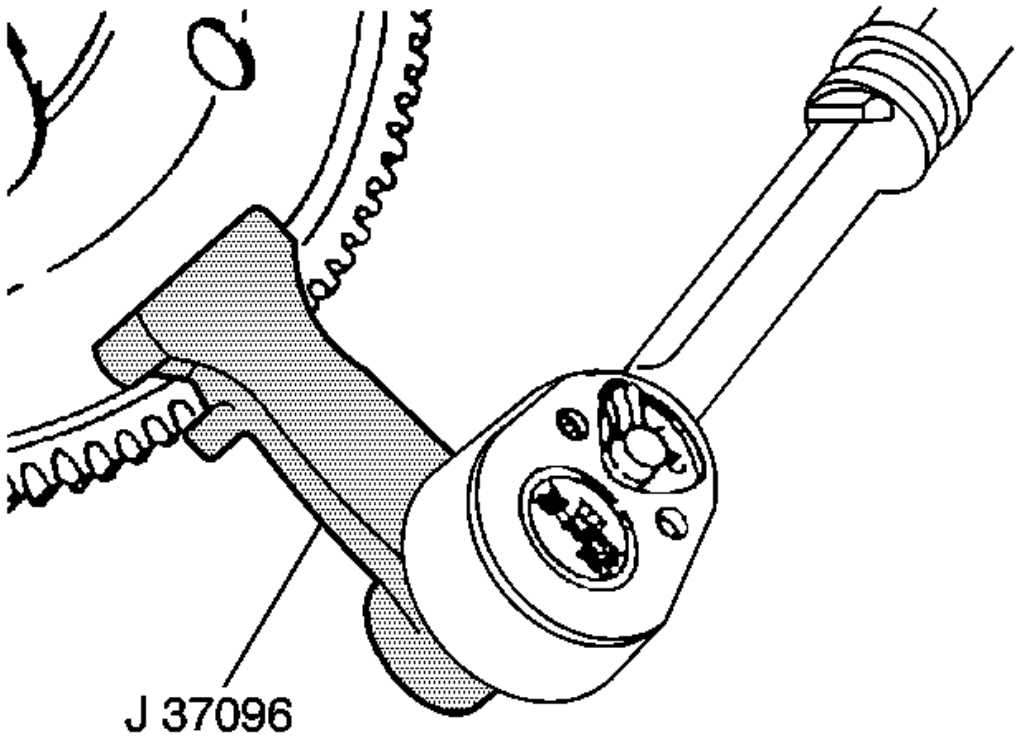

Fig. 197: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transaxle. Refer to **Transmission Replacement** .
2. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating.

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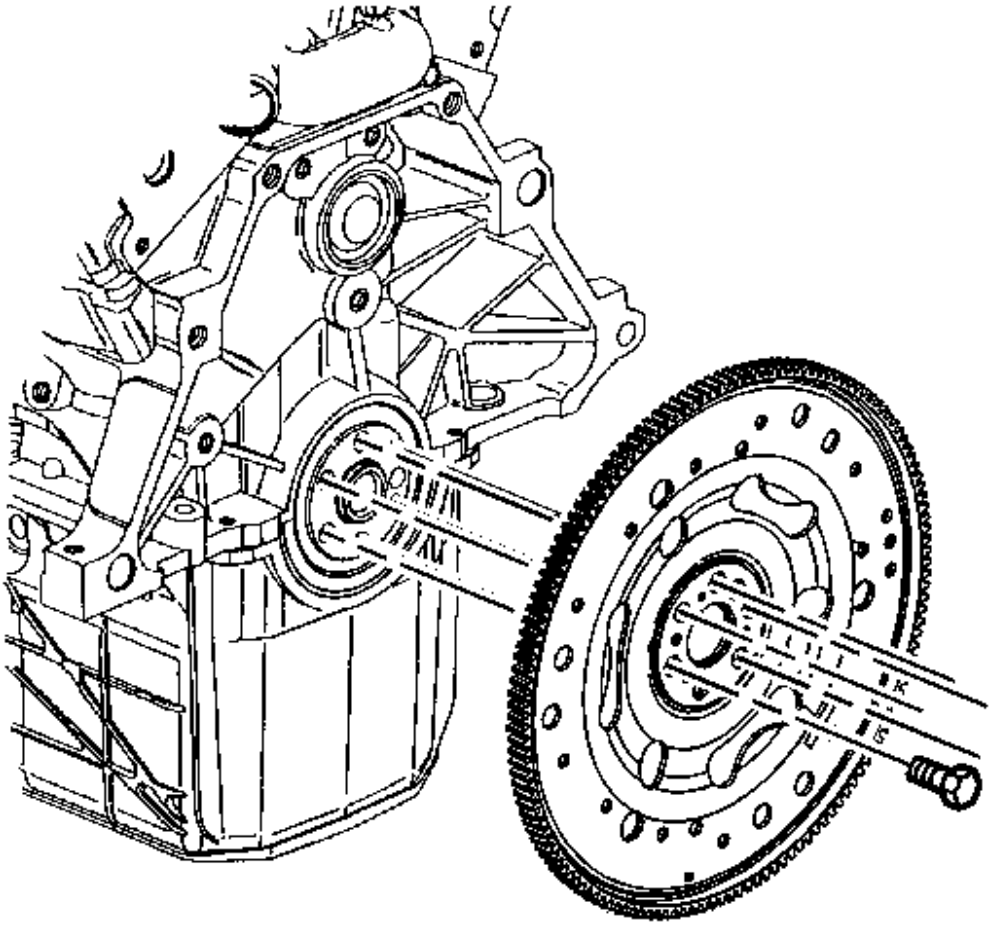

Fig. 198: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

3. Loosen the flywheel bolts.
4. Remove 5 of the 6 flywheel bolts leaving one bolt at the top of the crankshaft.
5. Grip the flywheel and remove the remaining bolt. Do not drop the flywheel when removing the final bolt.
6. Remove the engine flywheel.
7. Clean the engine flywheel bolt threads and bolt holes.

Installation Procedure

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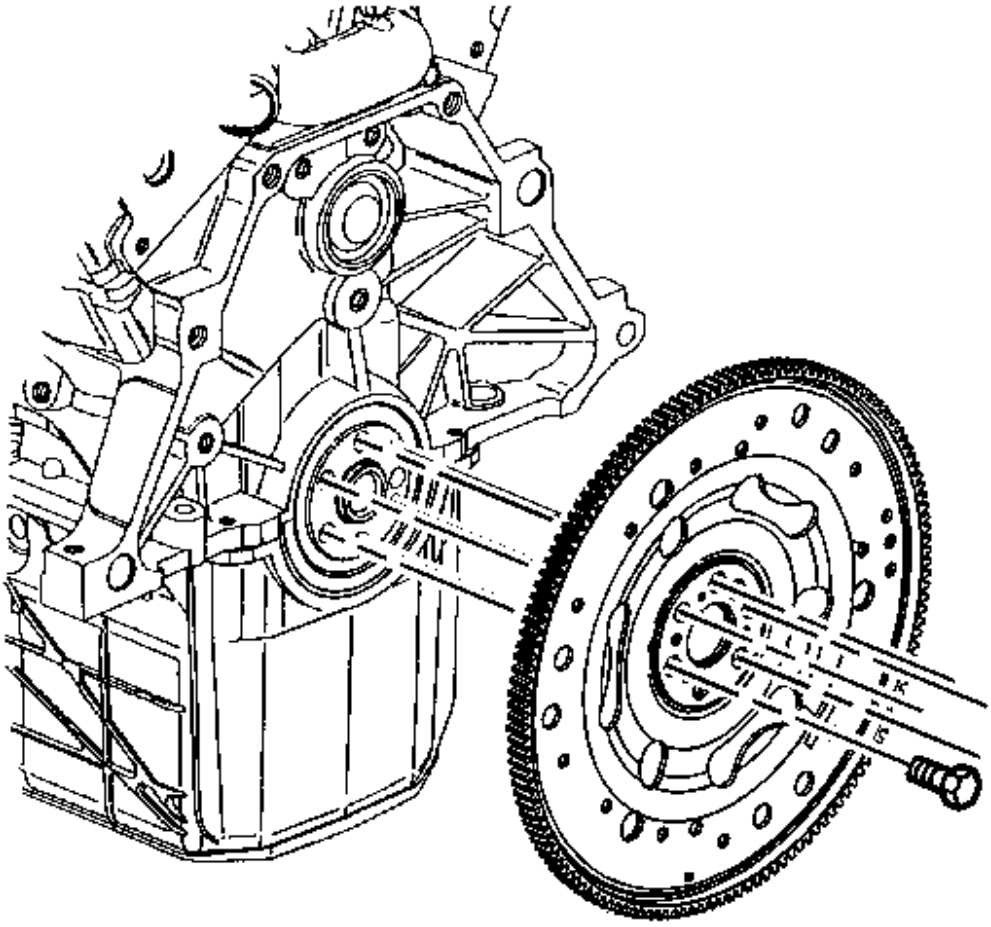

Fig. 199: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel to the crankshaft.
2. Install the flywheel bolts finger tight.
3. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating.

CAUTION: Refer to Fastener Caution .

4. Tighten the engine flywheel bolts.

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Tighten: Tighten the bolts to 70 N.m (52 lb ft).

5. Install the automatic transaxle. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Removal Procedure

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the crankshaft rear main oil seal. Refer to **Crankshaft Rear Oil Seal Removal**.

Installation Procedure

1. Install the crankshaft rear main seal. Refer to **Crankshaft Rear Oil Seal Installation**.
2. Install the flywheel. Refer to **Engine Flywheel Replacement**.

CAMSHAFT REAR BEARING HOLE PLUG REPLACEMENT

Removal Procedure

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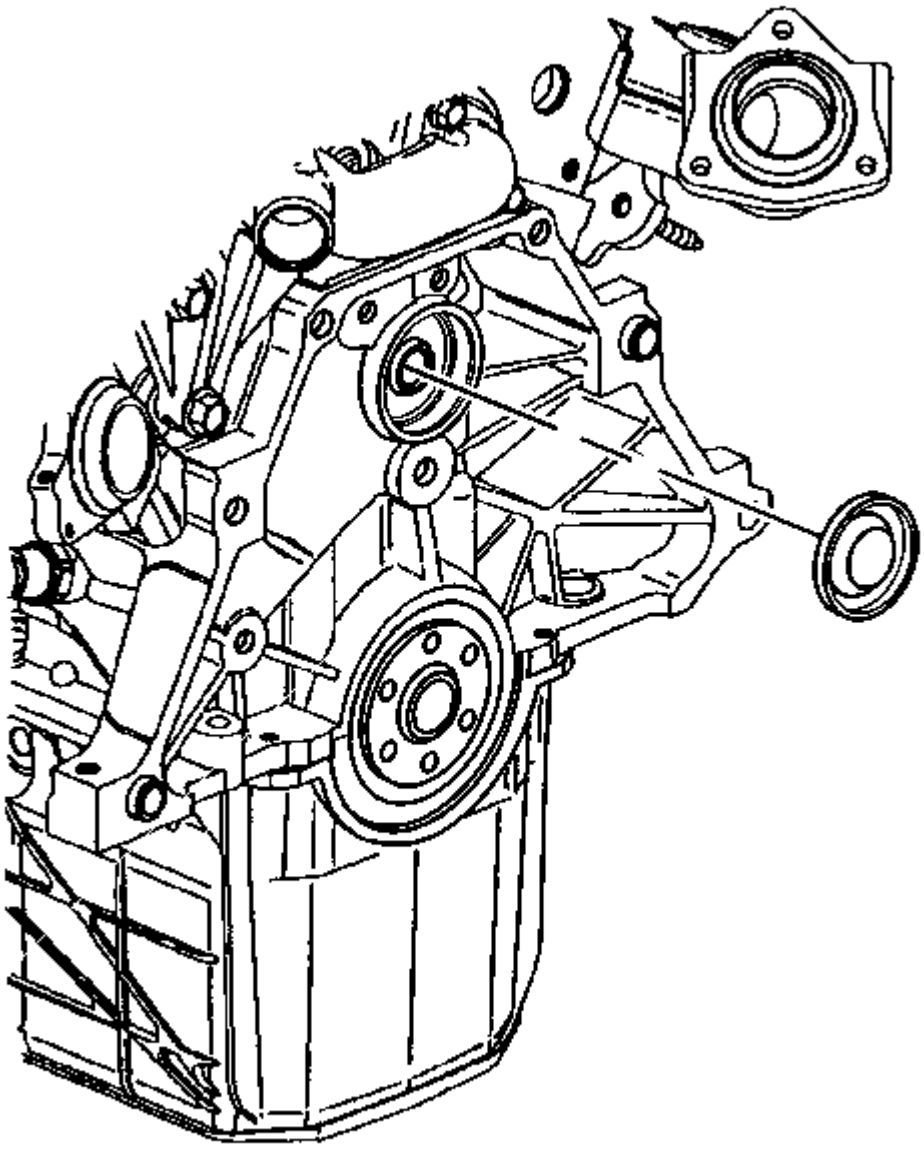

Fig. 200: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the camshaft rear bearing hole plug.

Installation Procedure

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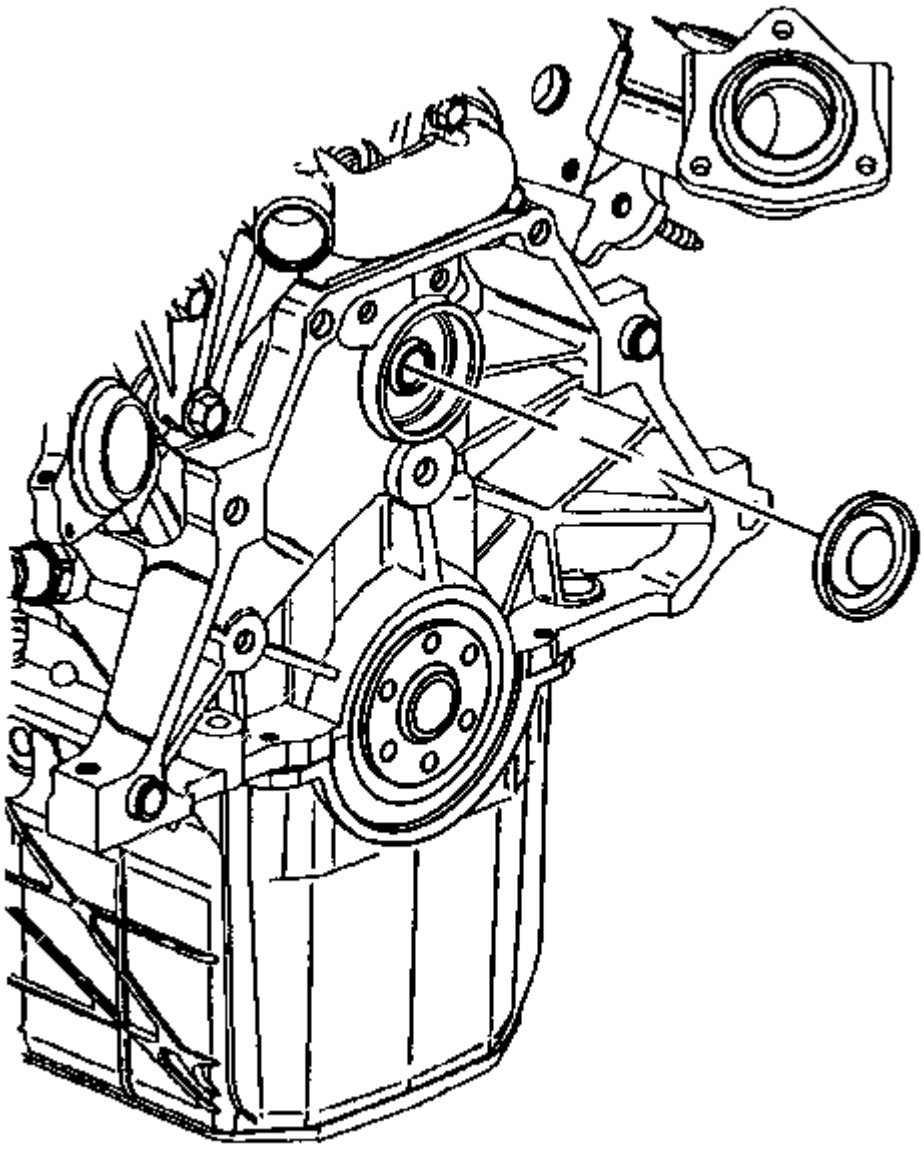

Fig. 201: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

1. Coat the camshaft rear bearing hole plug with sealer. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Install the camshaft rear bearing hole plug.

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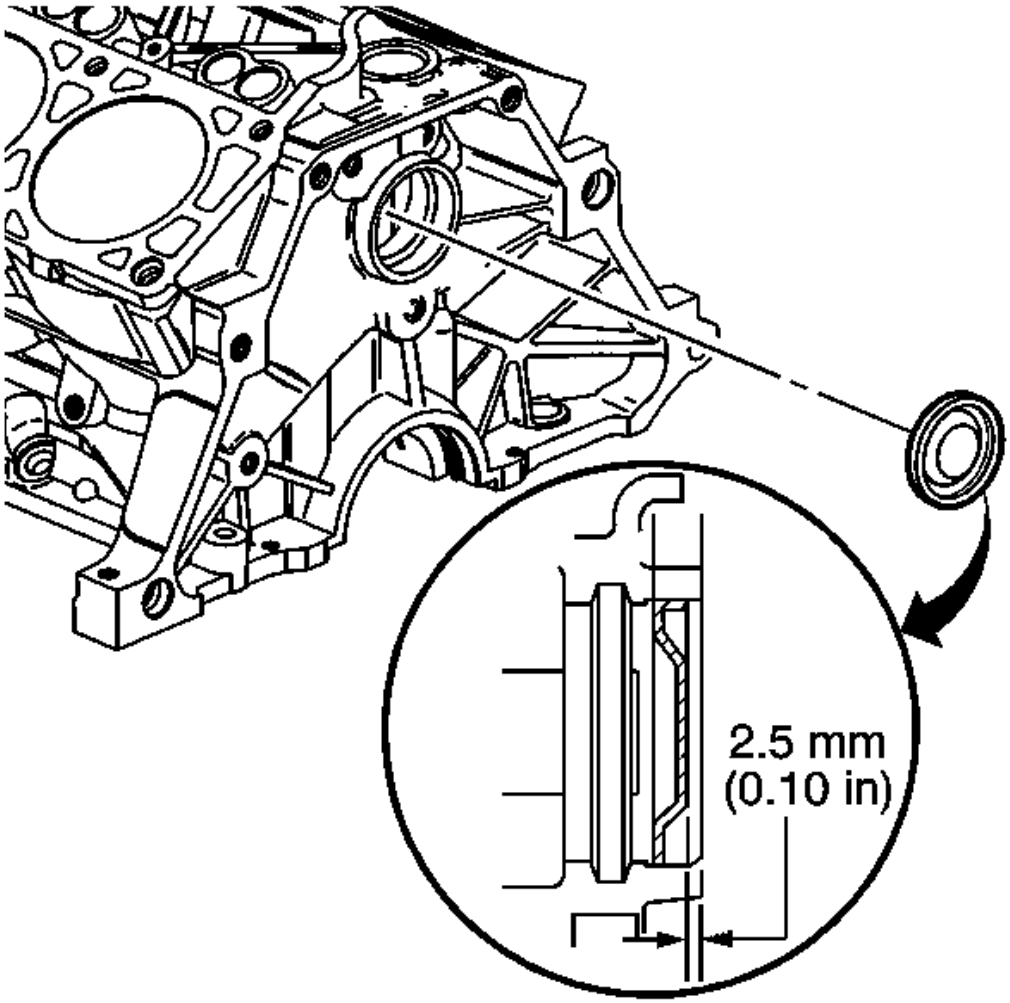

Fig. 202: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

3. Ensure that the camshaft rear bearing plug is installed to specifications.
4. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

ENGINE REPLACEMENT

Removal Procedure

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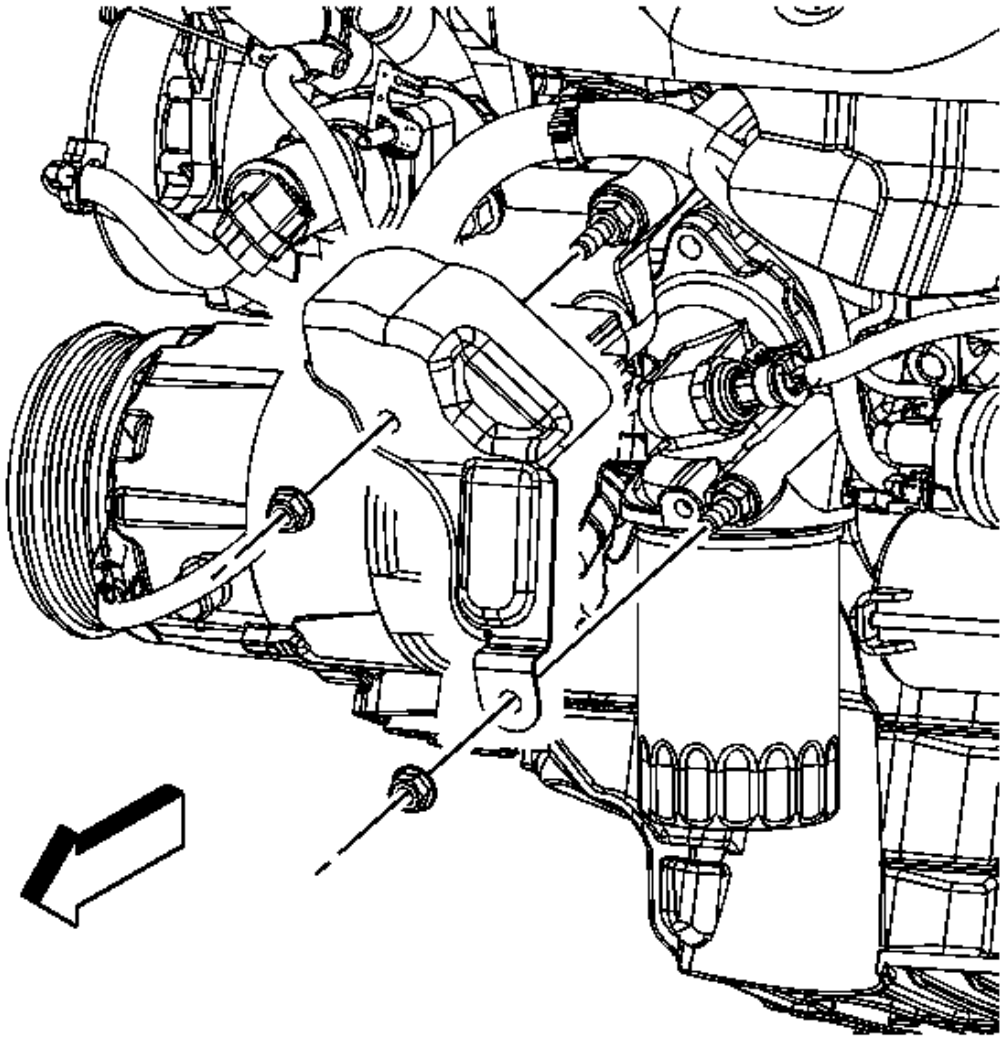

Fig. 203: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the hood. Refer to **Hood Replacement** .
4. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
5. Remove the engine mount snubber and drive belt. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.

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6. Remove the power steering pump and disconnect the power steering lines, if equipped. Refer to **Power Steering Pump Replacement (LZ4, LZ9)** .
7. Drain the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
8. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
9. Remove the oil pressure sensor heat shield nuts and shield.

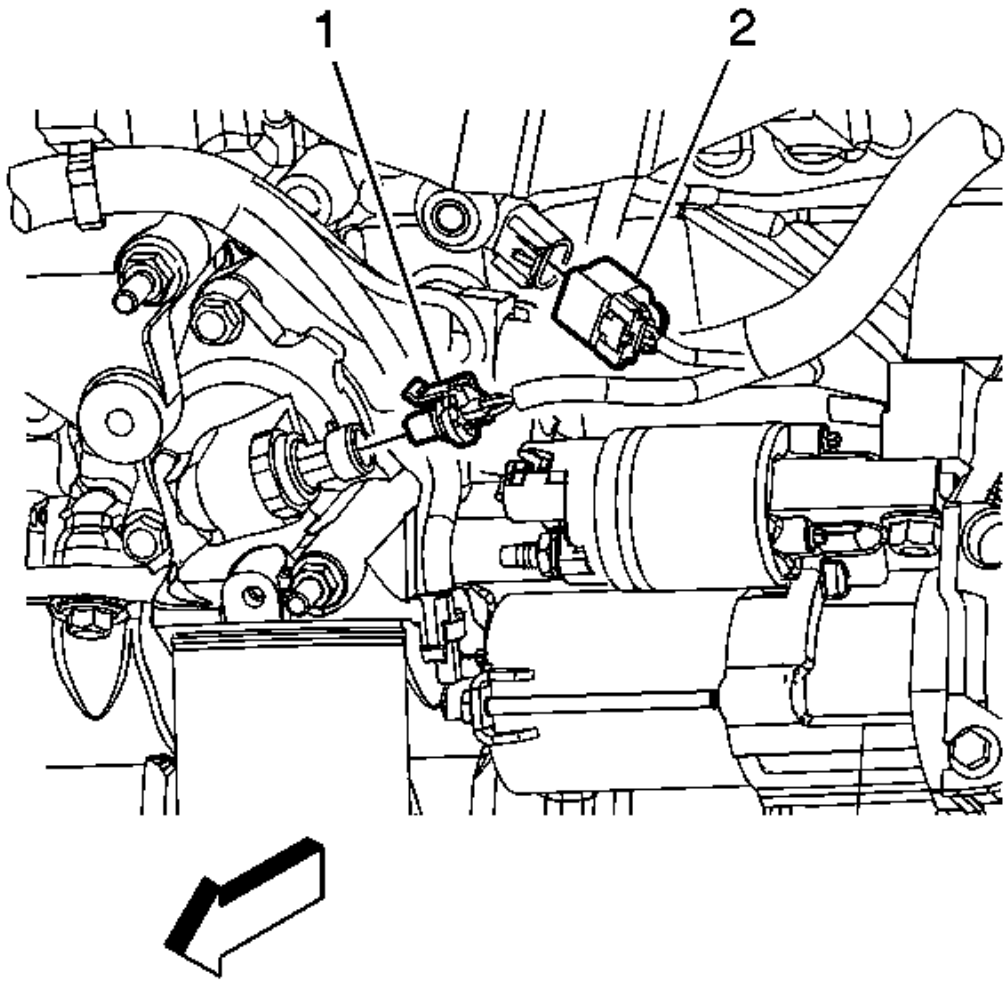

Fig. 204: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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

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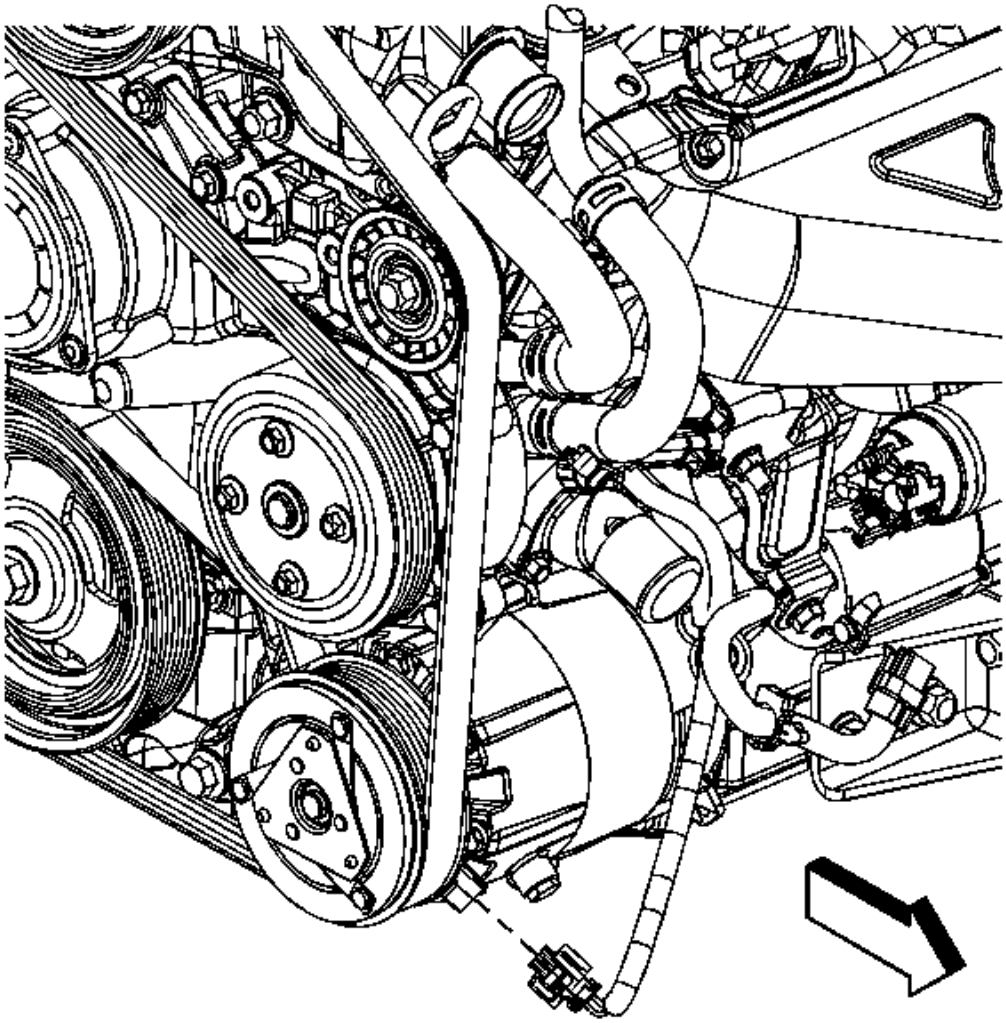

Fig. 205: Identifying Engine Wiring Harness Electrical Connector & A/C Compressor
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the air conditioning (A/C) compressor electrical connector.
13. Lower the vehicle.

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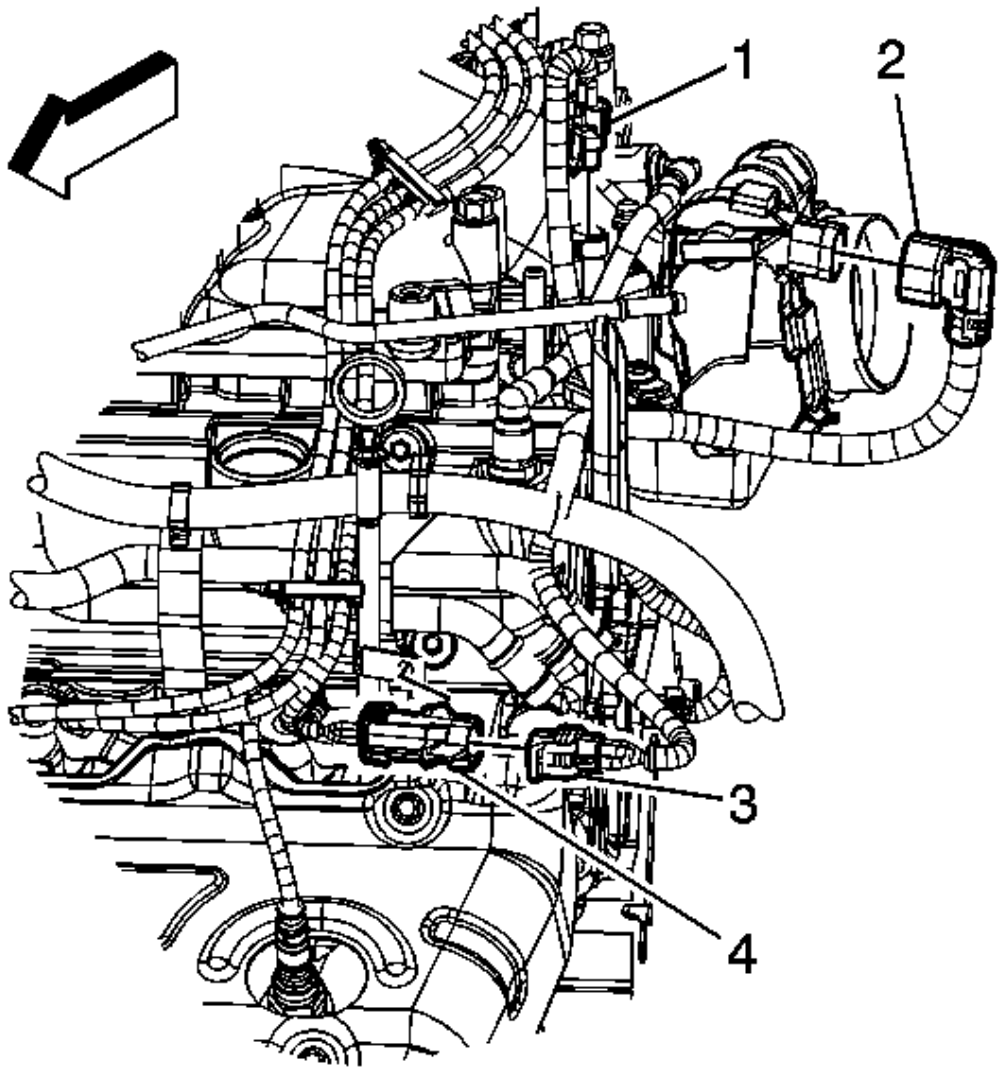

Fig. 206: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the evaporative emission (EVAP) canister purge solenoid (1) electrical connector.
15. Disconnect the electronic throttle control (ETC) (2) electrical connector.
16. Remove the connector position assurance (CPA) retainer (5).
17. Disconnect the heated oxygen sensor (HO2S) (3) electrical connector.

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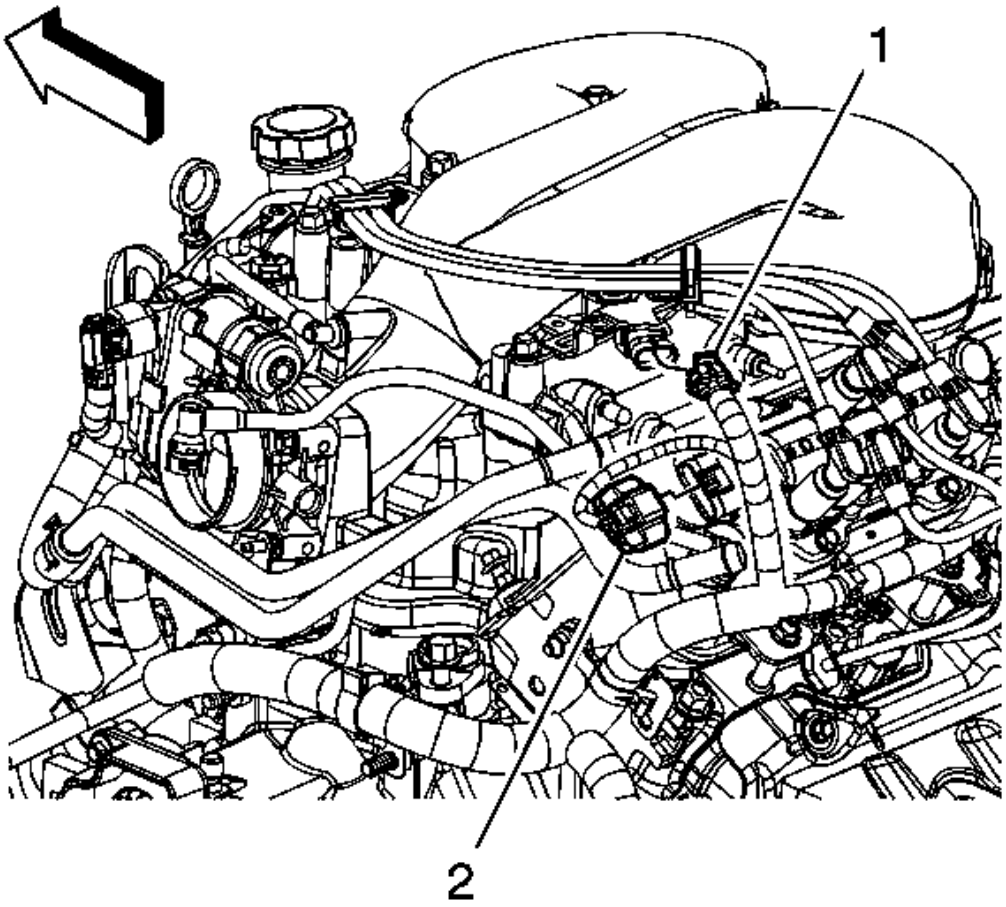

Fig. 207: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the manifold absolute pressure (MAP) sensor (1) electrical connector.
19. Disconnect the ignition control module (2) electrical connector.

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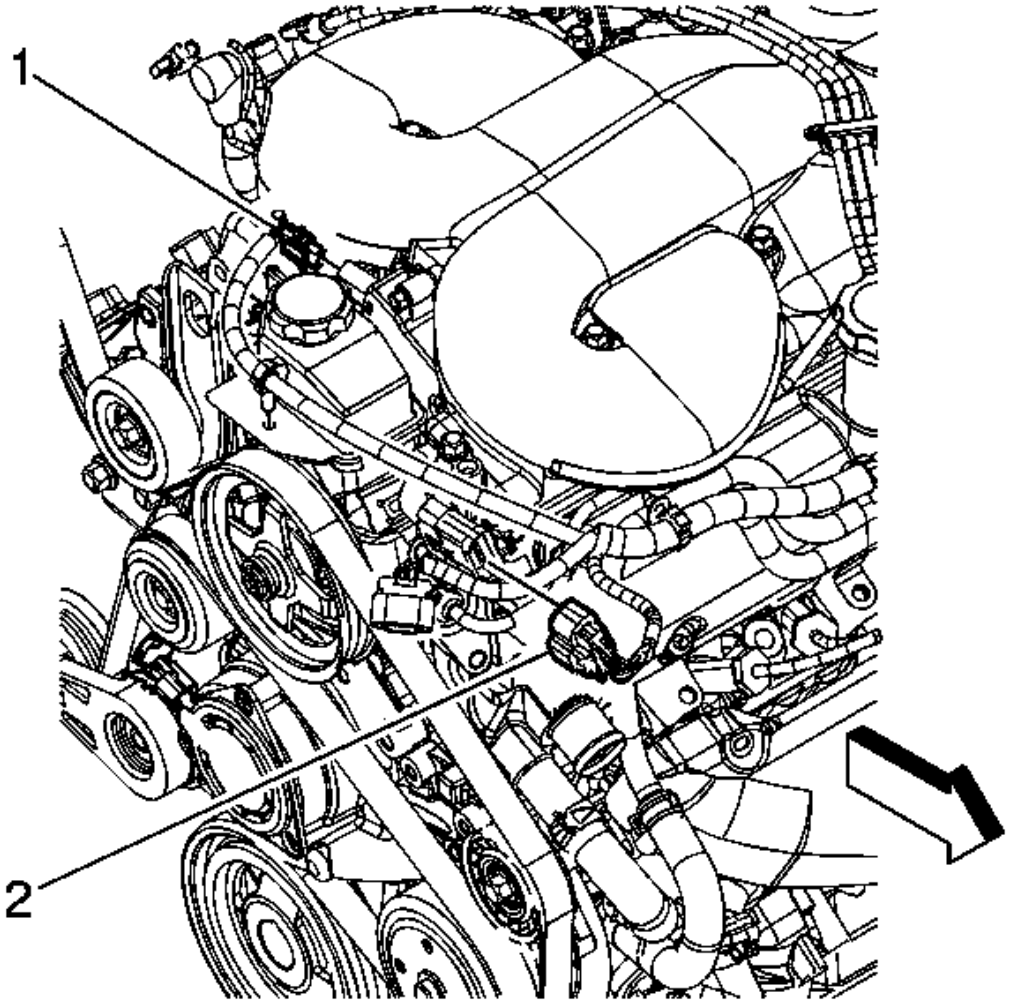

Fig. 208: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

20. Disconnect the inlet manifold valve (1) electrical connector.
21. Disconnect the fuel injector inline (2) electrical connector.

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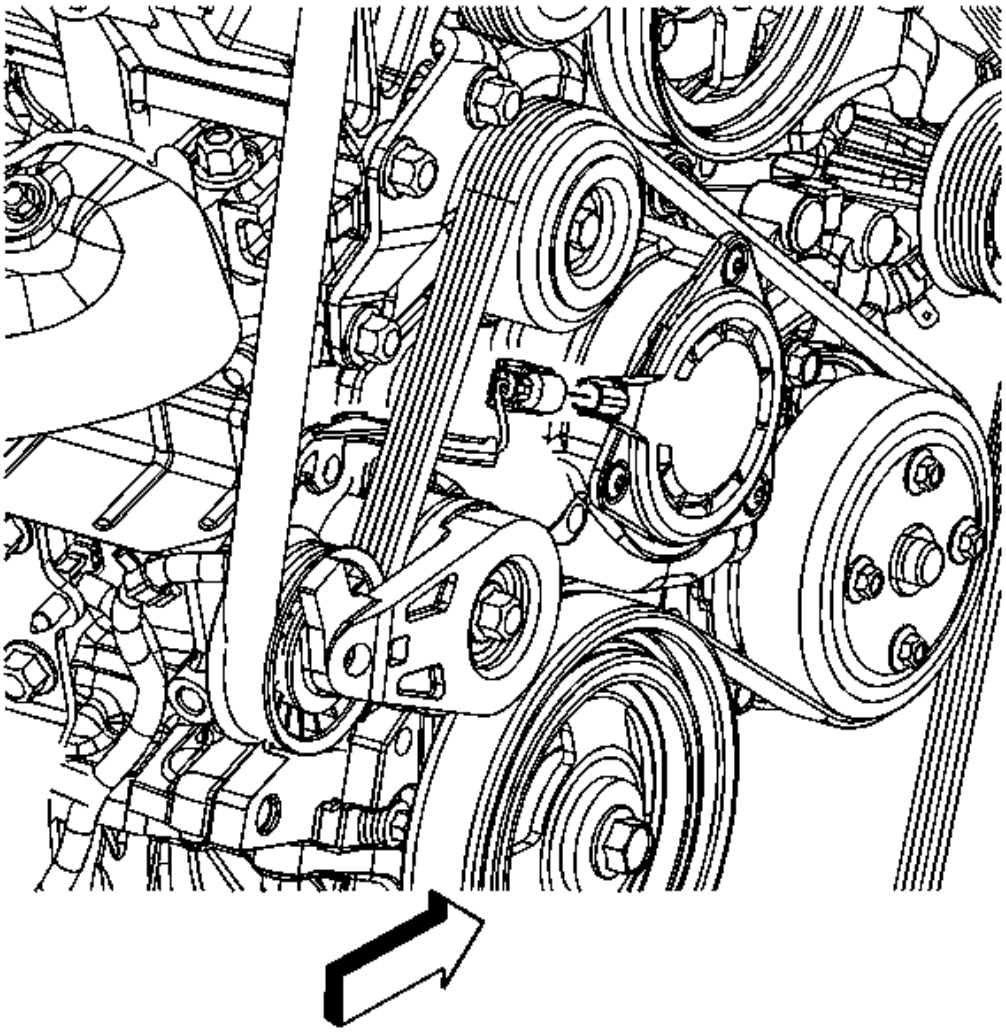

Fig. 209: View Of Engine Wiring Harness (Camshaft Phasor) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

22. Disconnect the camshaft phasor sensor electrical connector.

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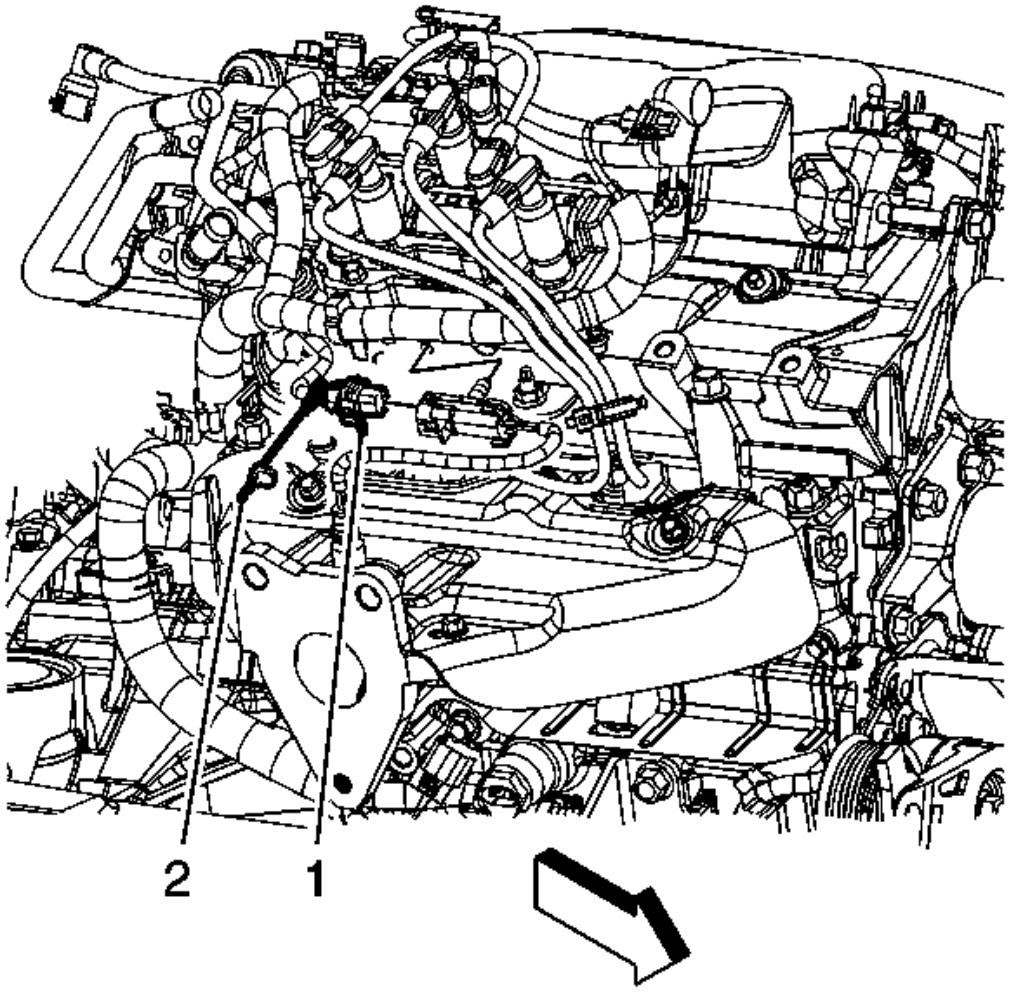

Fig. 210: Identifying HO2S & CPA Connectors
Courtesy of GENERAL MOTORS CORP.

23. Remove the CPA retainer.
24. Disconnect the rear upper HO2S electrical connector (1).

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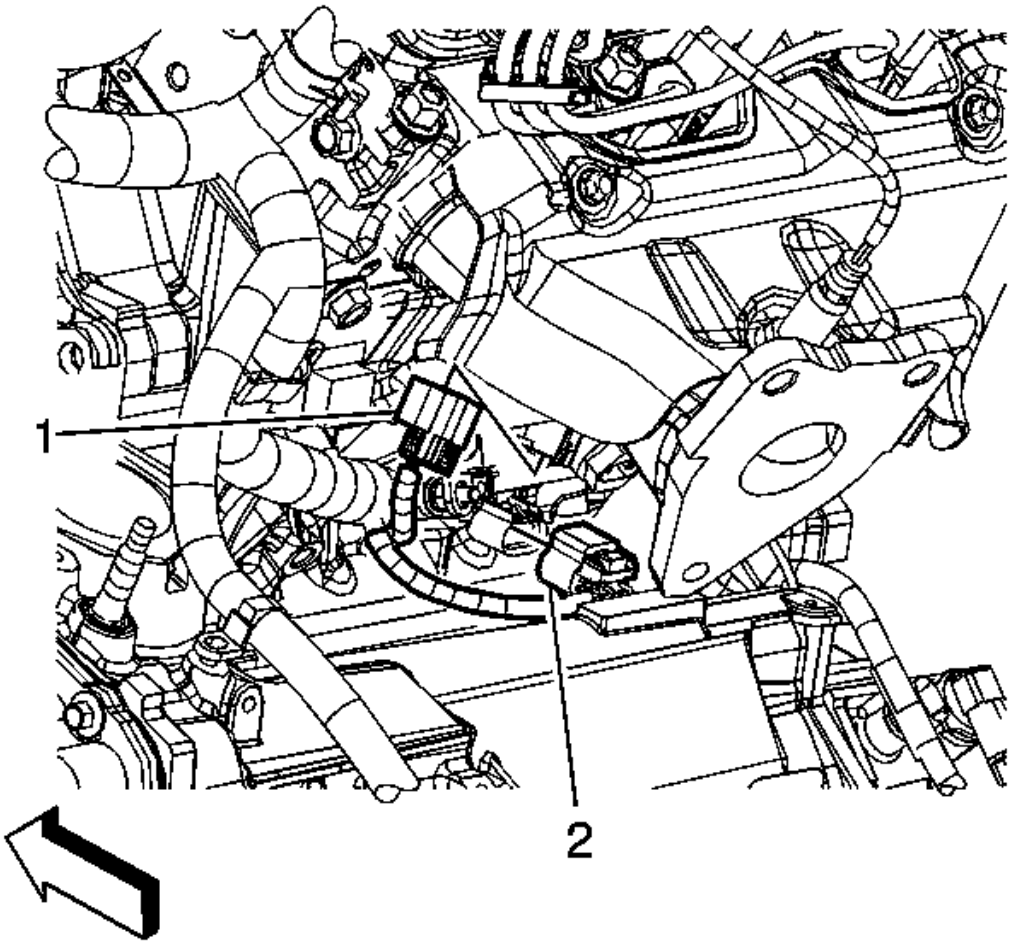

Fig. 211: View Of KS & CKP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

25. Disconnect the knock sensor electrical connector (1).
26. Disconnect the crankshaft position (CKP) sensor electrical connector (2).

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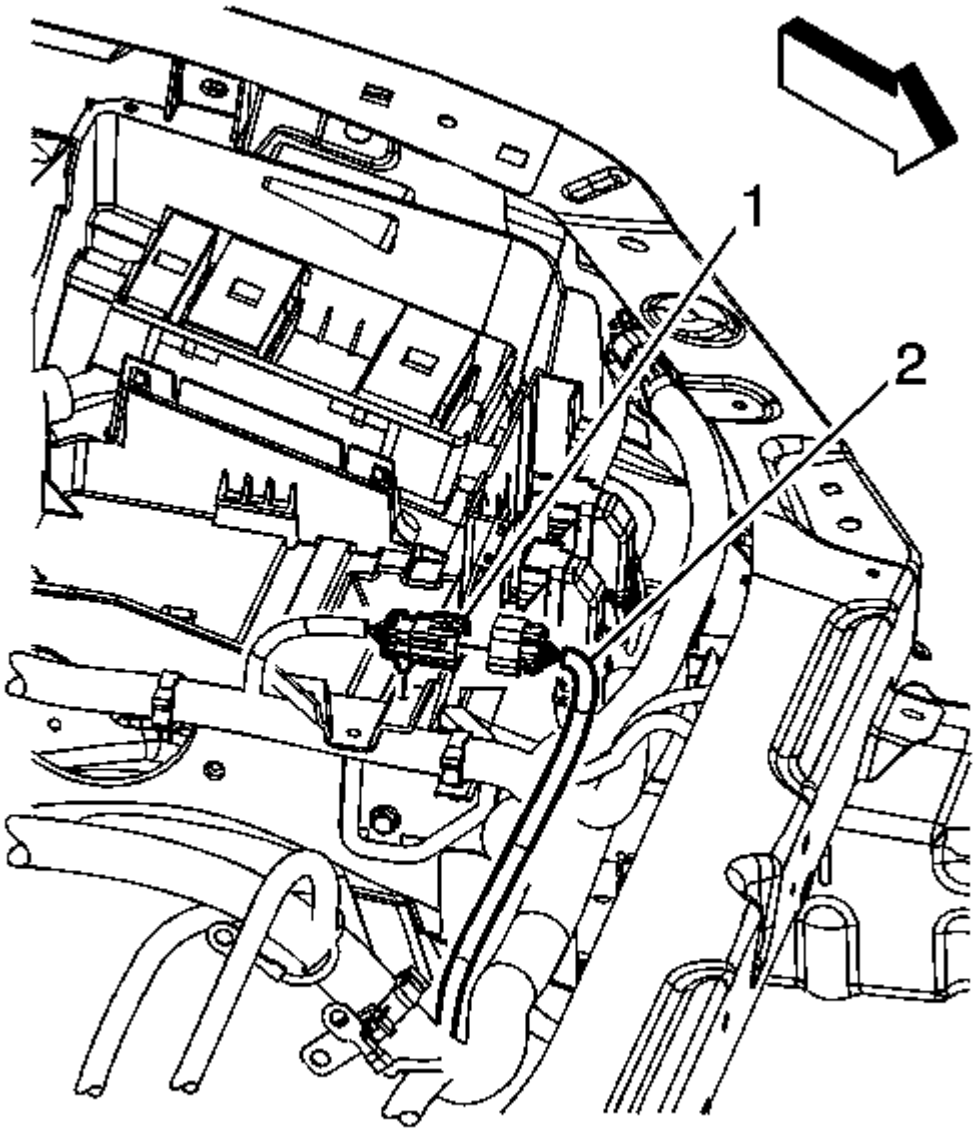

Fig. 212: Locating Engine/Body Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

27. Disconnect the engine harness connector (1) from the body harness connector (2).

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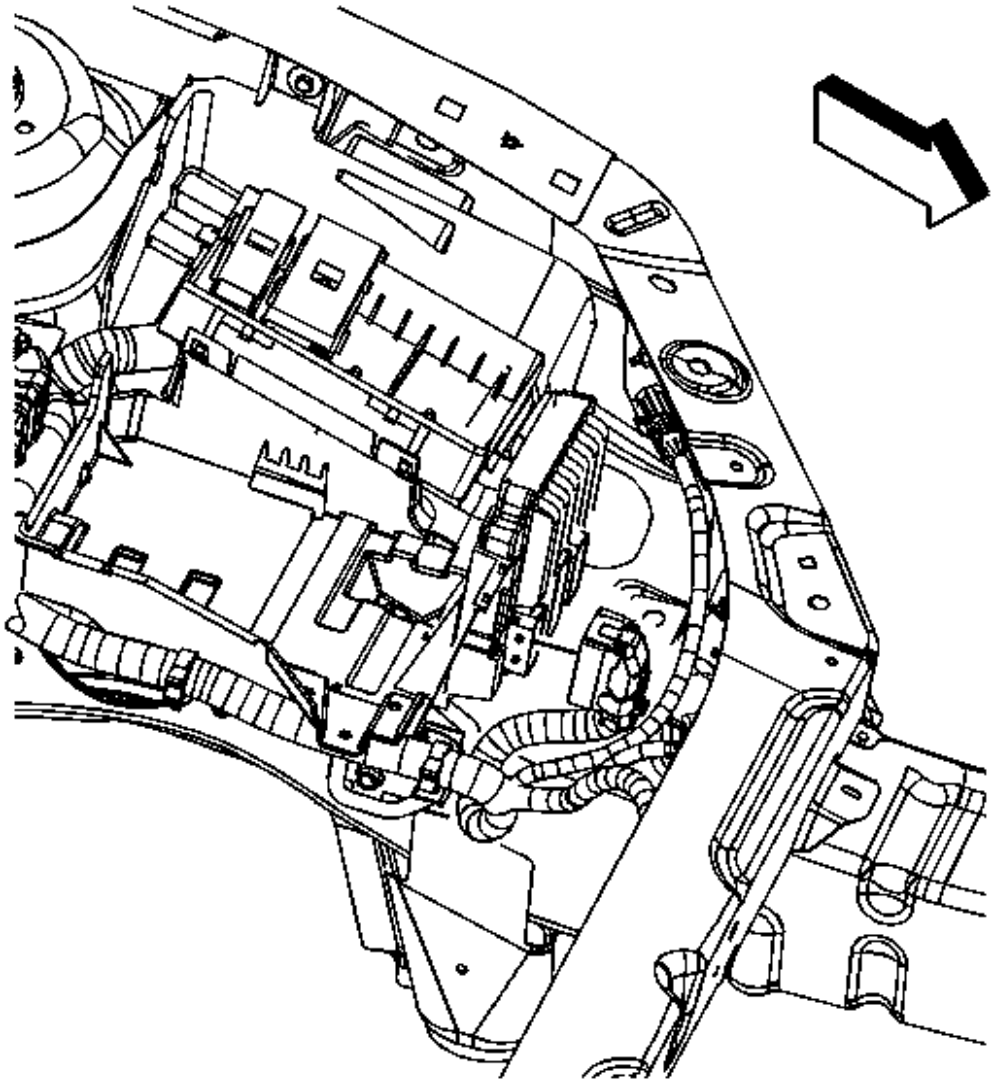

Fig. 213: View Of Body Harness ECM/PCM Connectors
Courtesy of GENERAL MOTORS CORP.

28. Disconnect the body harness electrical connector from the powertrain control module (PCM).

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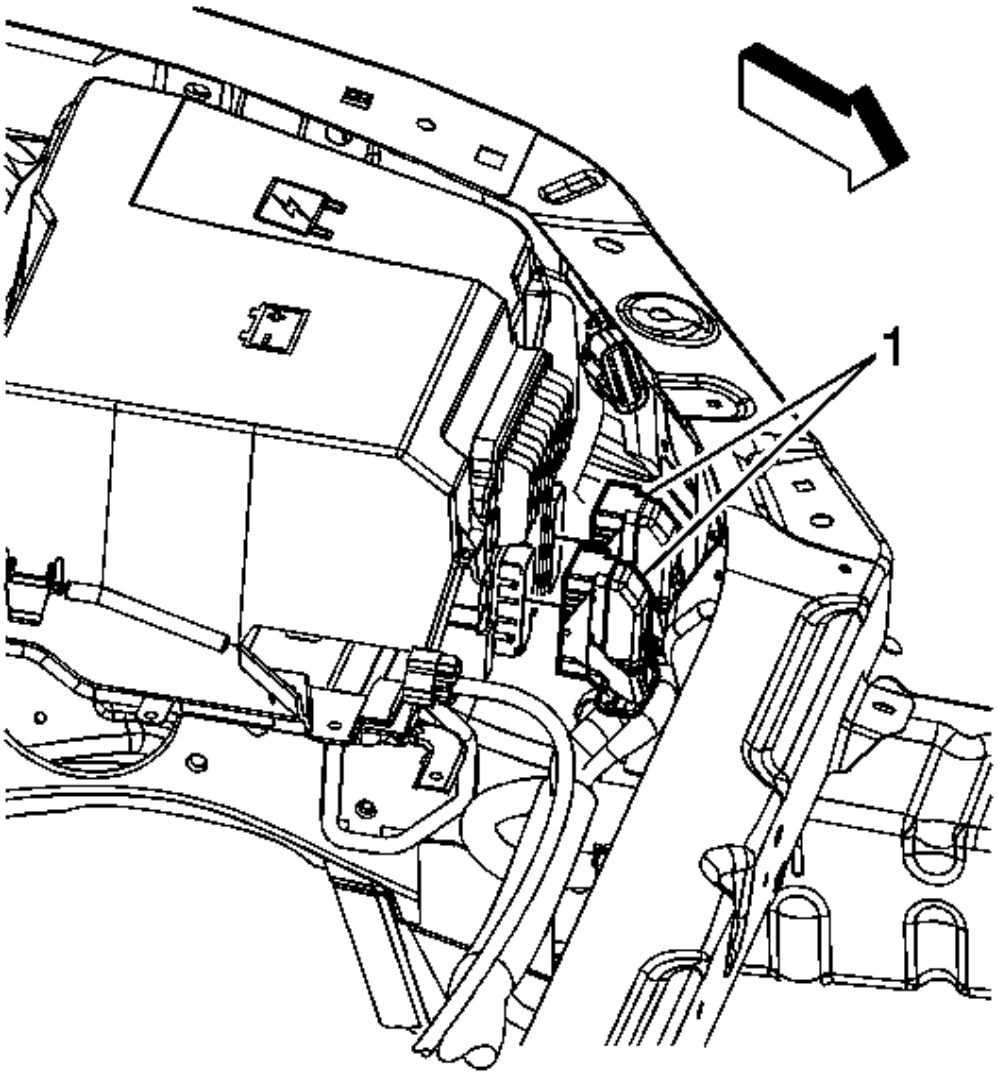

Fig. 214: View Of Engine Harness ECM/PCM Connectors
Courtesy of GENERAL MOTORS CORP.

29. Disconnect the engine harness electrical connectors (1) from the PCM.

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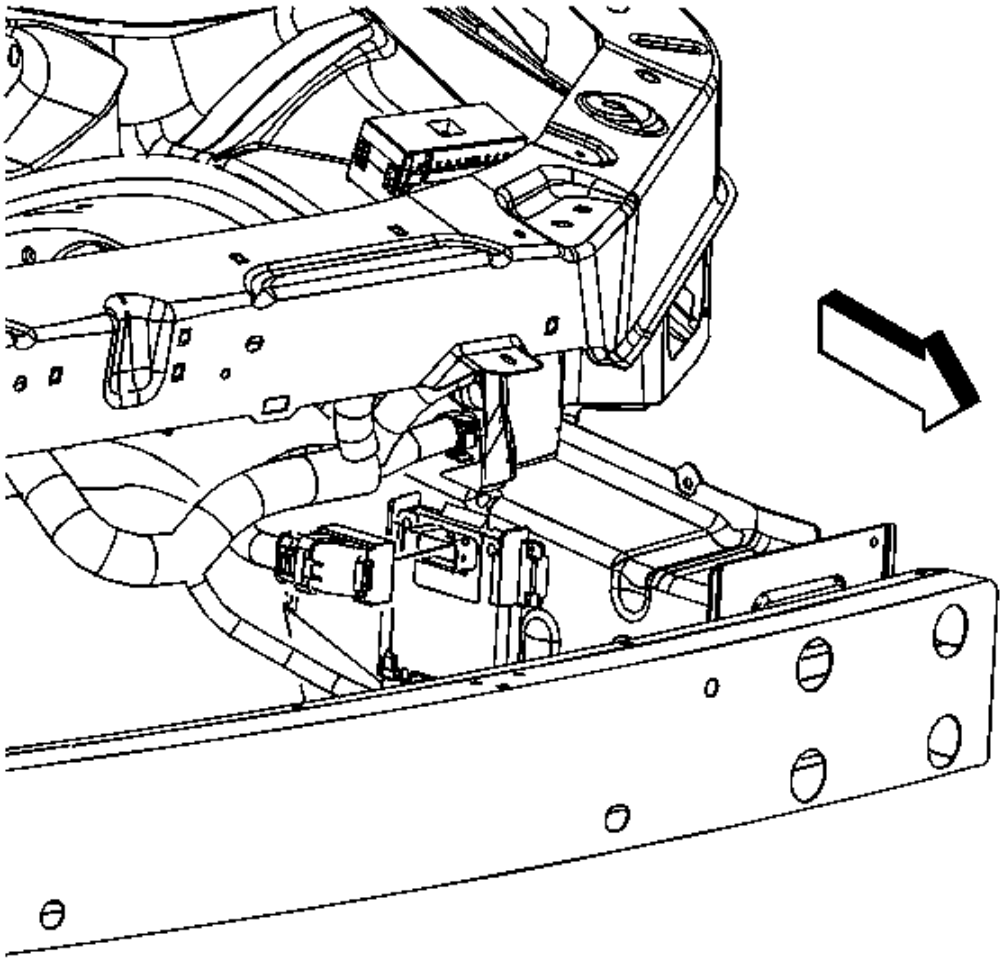

Fig. 215: Identifying Engine Harness Electrical Connector & Transmission Control Module (TCM)
Courtesy of GENERAL MOTORS CORP.

30. Disconnect the engine harness electrical connector from the transmission control module (TCM).

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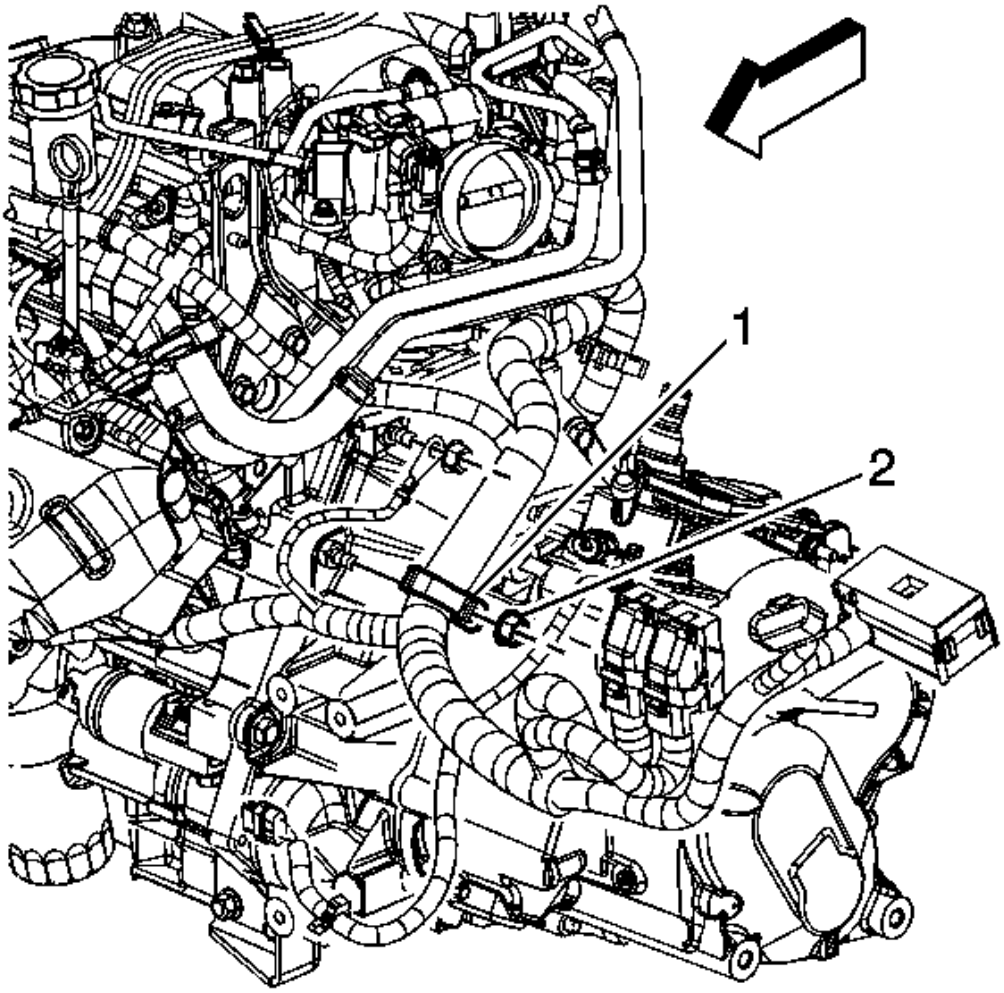

Fig. 216: Identifying Engine Harness Clip & Nut
Courtesy of GENERAL MOTORS CORP.

31. Remove the engine harness clip nut (2).
32. Remove the engine harness clip (1) from the transmission stud.

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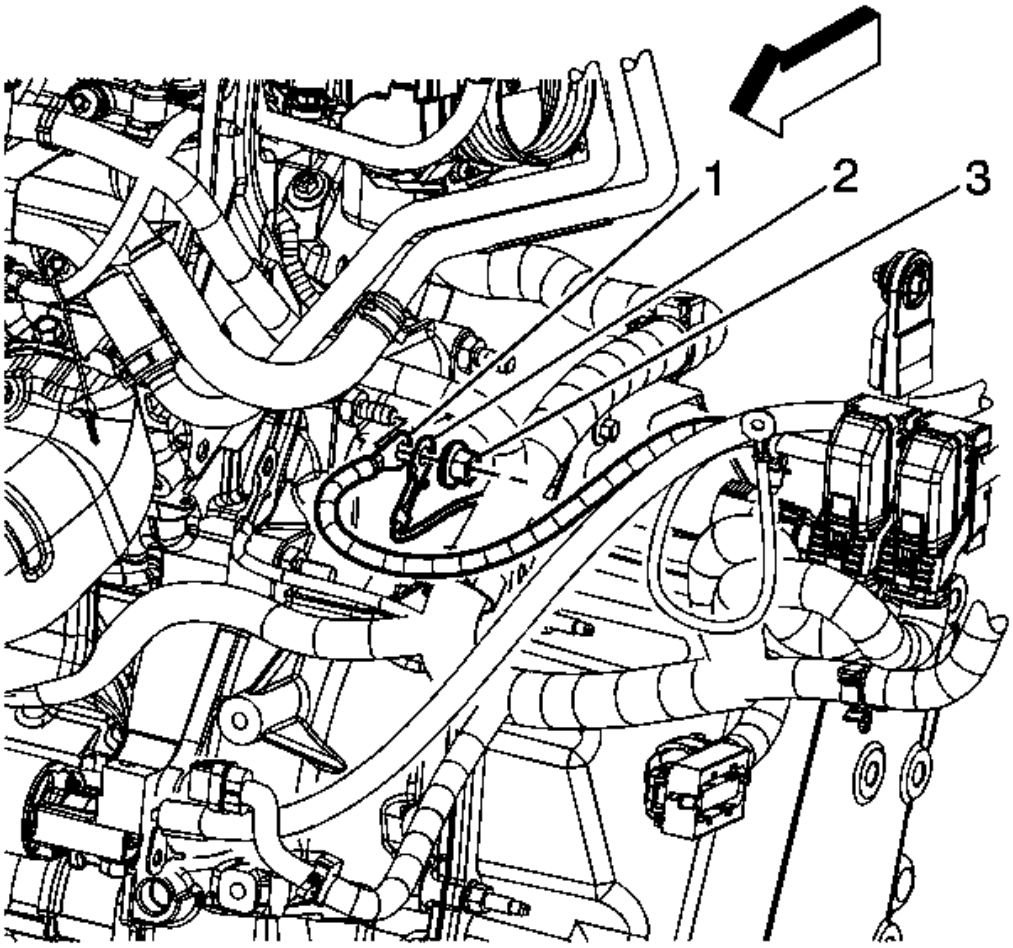

Fig. 217: View Of Engine Wiring Harness Ground Bolt, Terminal & Battery Cable Ground Terminal
Courtesy of GENERAL MOTORS CORP.

33. Remove the engine harness ground nut (2).
34. Remove the engine harness ground terminal (1) from the transmission stud.

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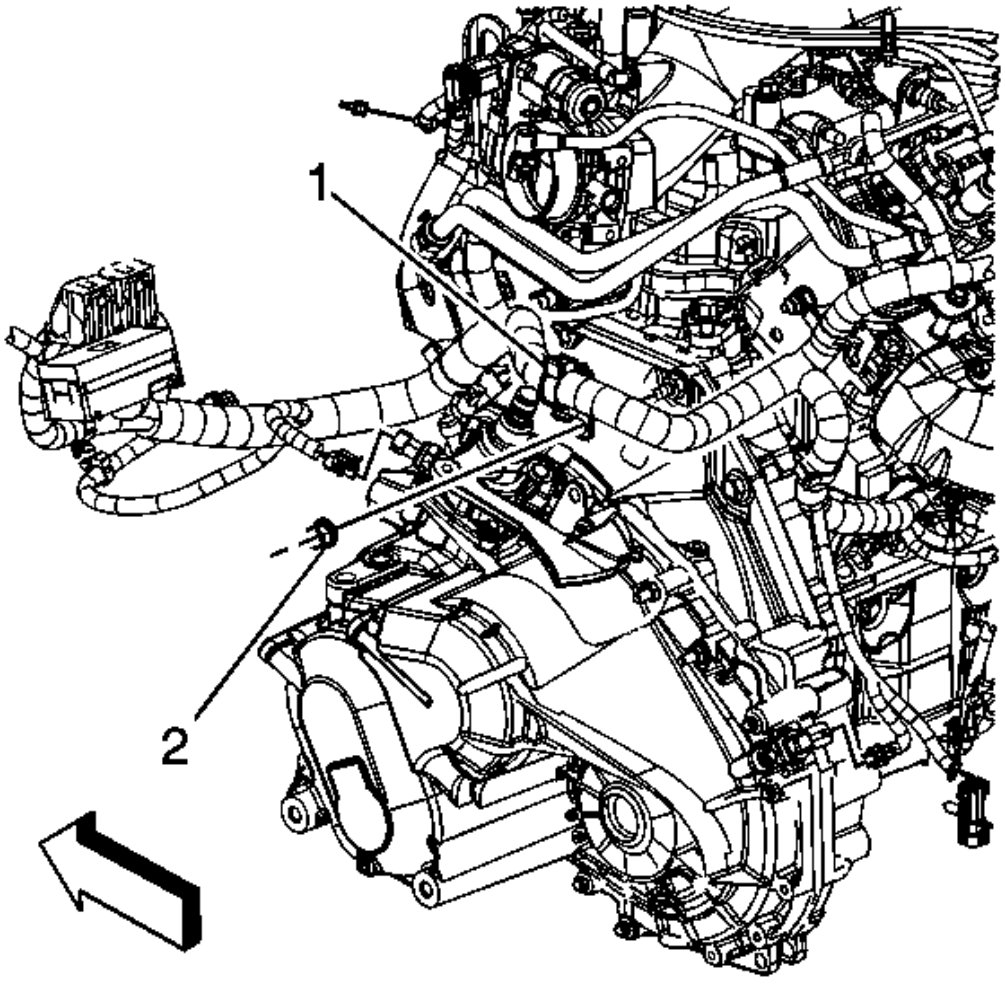

Fig. 218: View Of Engine Harness Clip & Nut
Courtesy of GENERAL MOTORS CORP.

35. Remove the engine harness rear clip nut (2).
36. Remove the engine harness rear clip (1) from the transmission stud.
37. Remove the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side (LZ9)** and **Catalytic Converter Replacement - Right Side (LZ9 w/RPO M15)** or **Catalytic Converter Replacement - Right Side (LZ9 w/RPO MT2)** .
38. Remove the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.
39. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** .
40. Remove the starter motor. Refer to **Starter Replacement (LZ9)** .

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41. Remove the torque converter bolts. Refer to **Flywheel to Torque Converter Bolt Replacement** .
42. Unbolt and reposition the A/C compressor to the side. DO NOT discharge the A/C system.

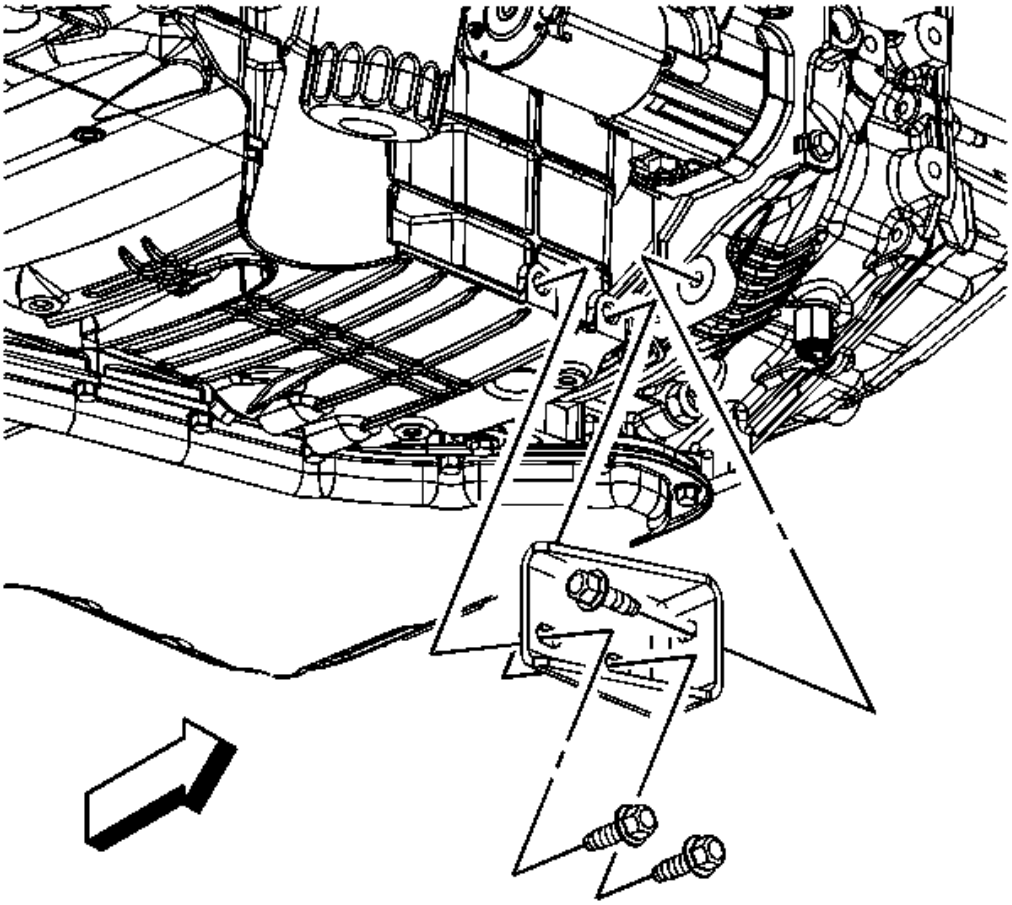

Fig. 219: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

43. Remove the transaxle brace to oil pan bolts.
44. Remove the transaxle brace to transaxle bolt and remove the brace.

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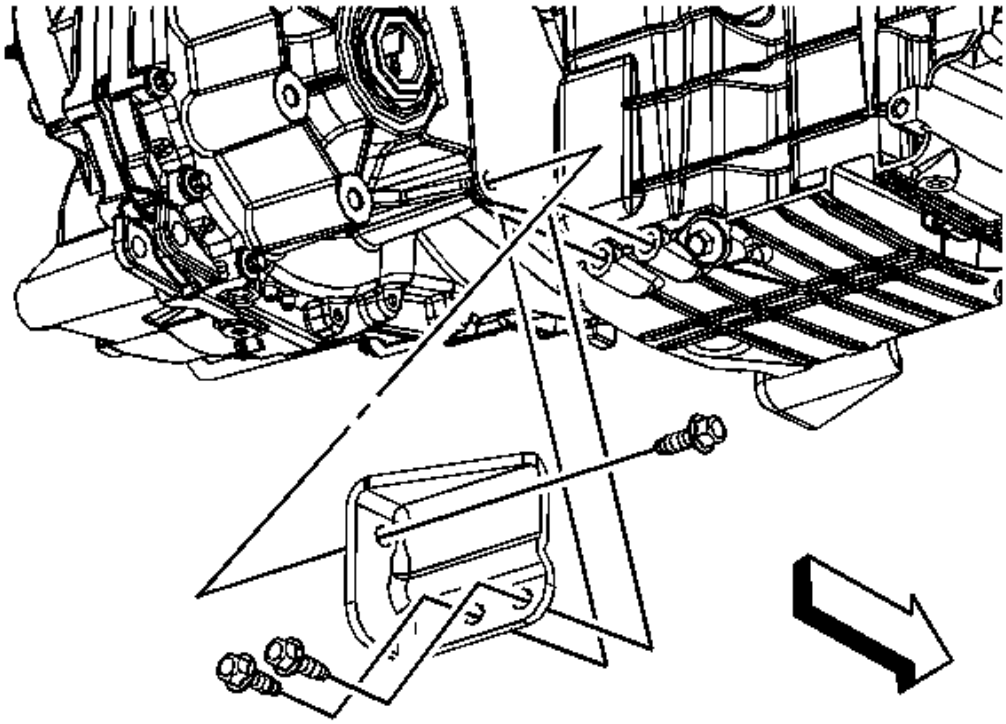

Fig. 220: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

45. Remove the transaxle brace to oil pan bolts, if equipped with regular production option (RPO) MT2.
46. Remove the transaxle brace to transaxle bolt and remove the brace, if equipped with RPO MT2.

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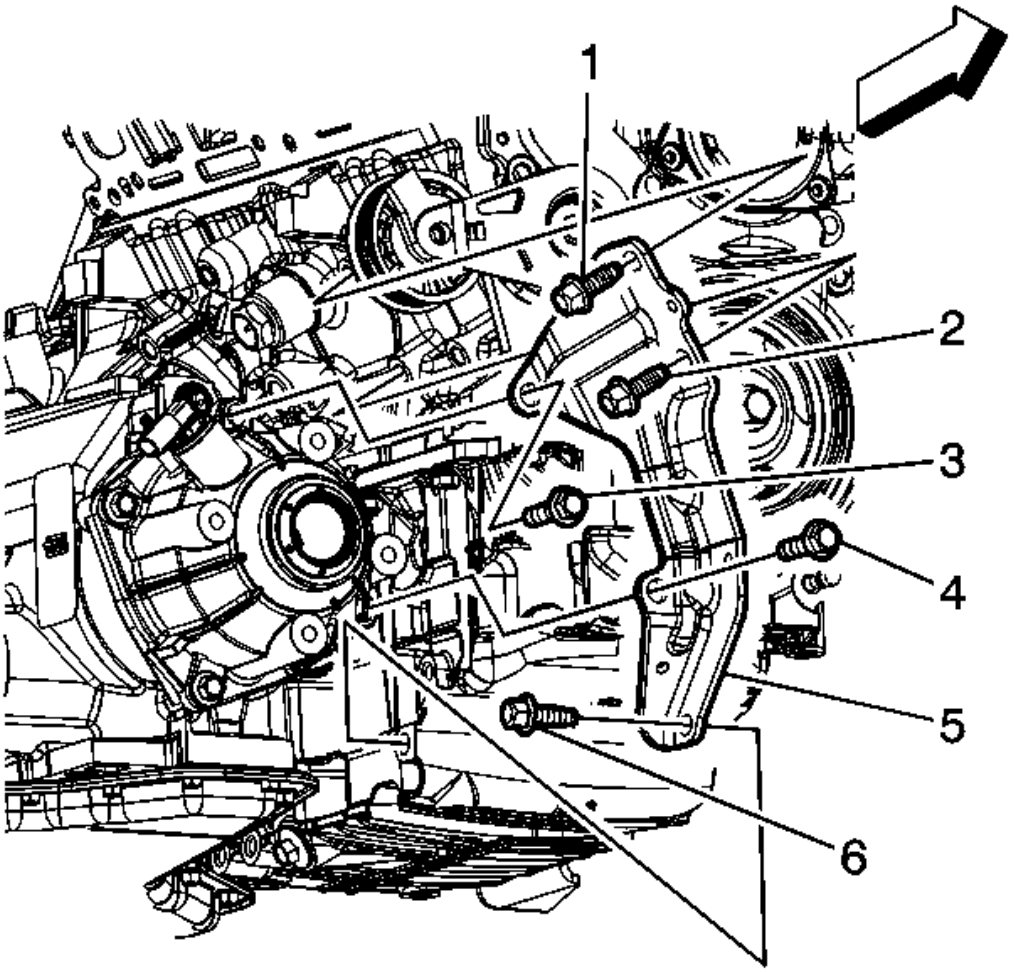

Fig. 221: Identifying Transaxle Brace-To-Oil Pan Lower Bolt
Courtesy of GENERAL MOTORS CORP.

47. Remove the transaxle brace to oil pan lower bolt (6), if equipped with RPO M15.
48. Remove the lower transaxle-to-engine bolt and stud.

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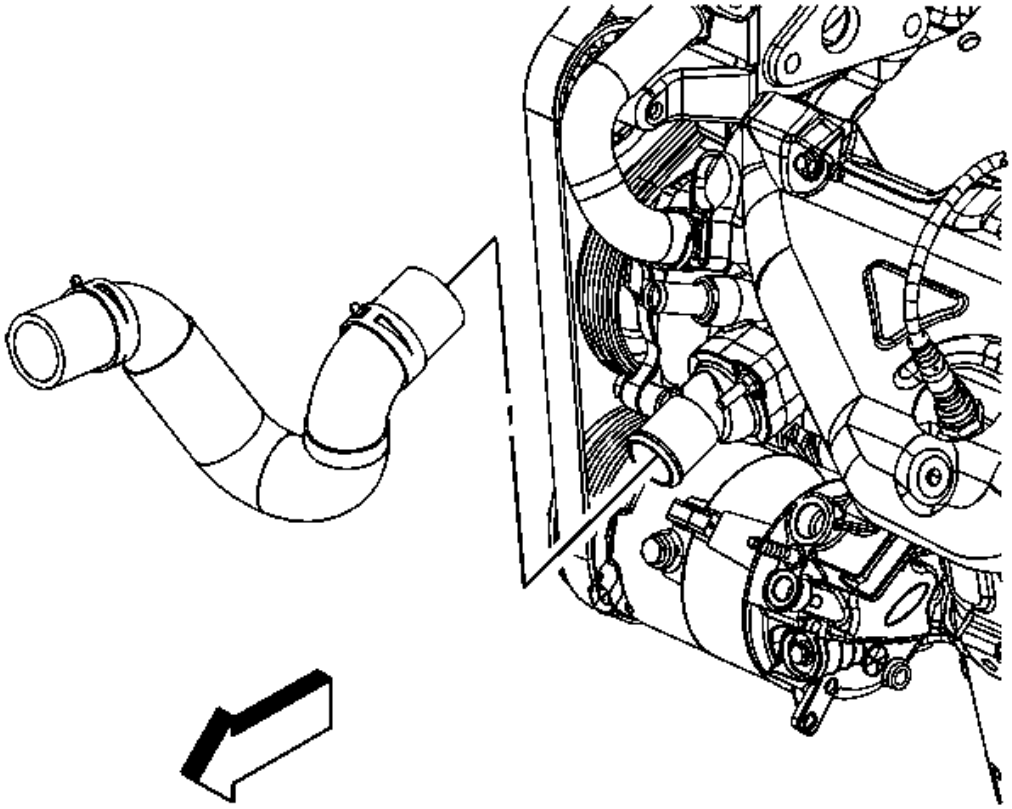

Fig. 222: Identifying Radiator Outlet Hose & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

49. Reposition the radiator outlet hose clamp at the thermostat housing.
50. Remove the radiator outlet hose from the thermostat housing.
51. Lower the vehicle and support the transaxle.

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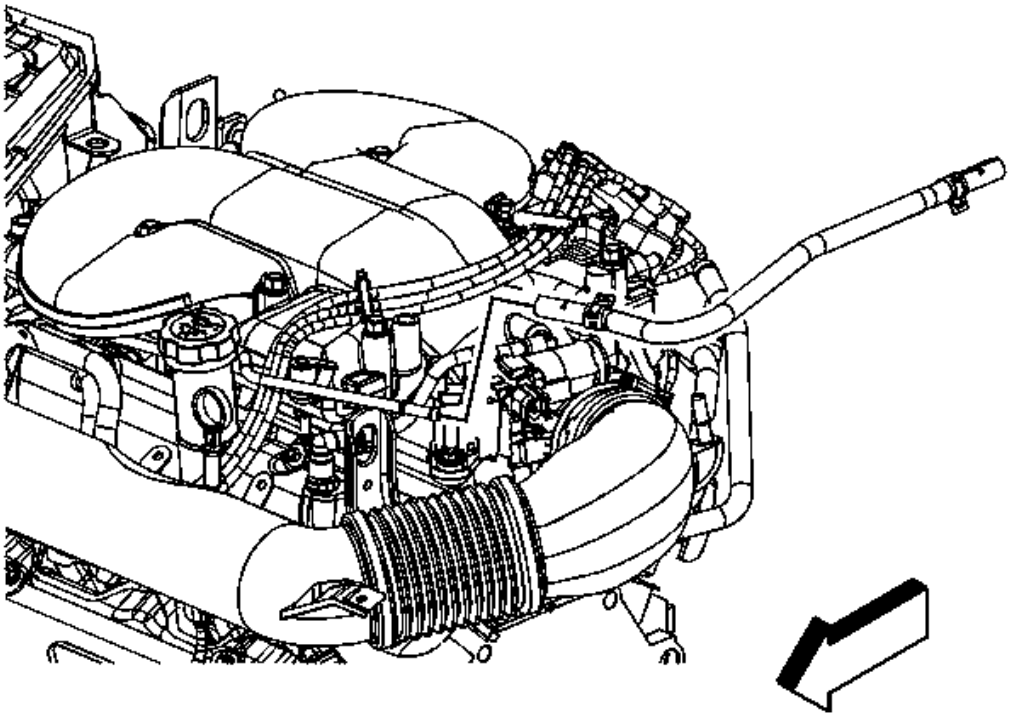

Fig. 223: View Of Radiator Surge Tank Inlet Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

52. Reposition the radiator surge tank hose clamp at the surge tank pipe.
53. Remove the radiator surge tank hose from the surge tank pipe.

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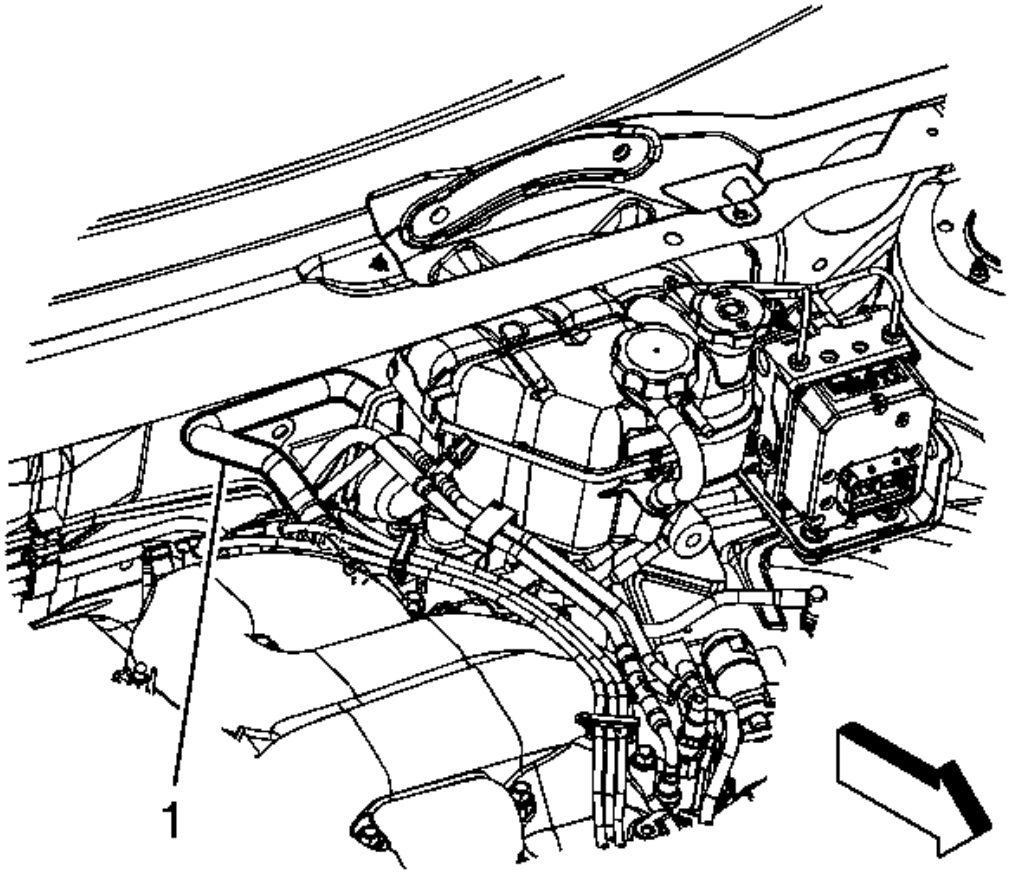

Fig. 224: Identifying Brake Booster Vacuum Hose To Intake Manifold
Courtesy of GENERAL MOTORS CORP.

54. Reposition the brake booster vacuum hose clamp at the intake manifold.
55. Remove the brake booster vacuum hose (1) from the intake manifold.
56. Reposition the heater inlet and outlet hose clamps at the engine.
57. Remove the heater outlet and inlet hoses from the engine.
58. Disconnect the fuel feed line from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
59. Disconnect the EVAP purge line from the canister purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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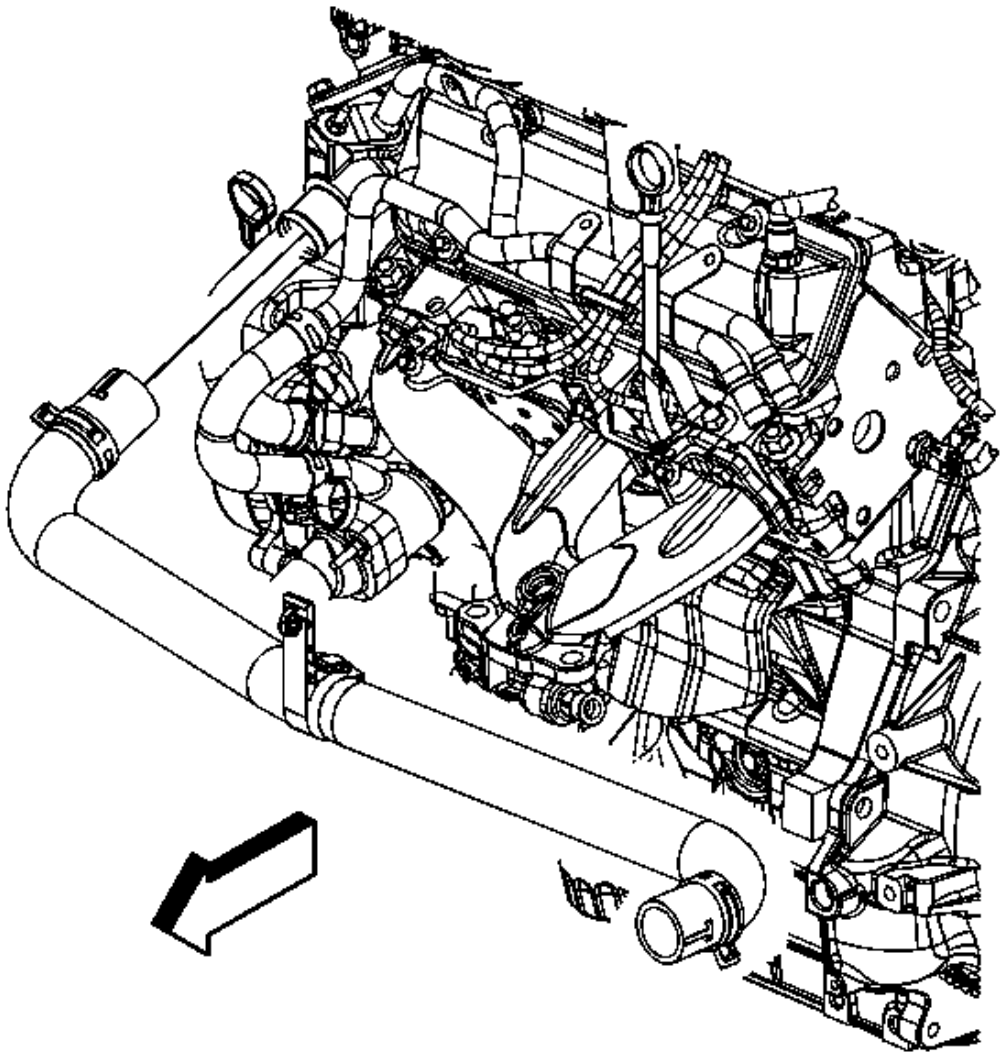

Fig. 225: Identifying Radiator Inlet Hose & Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

60. Reposition the radiator inlet hose clamp at the engine.
61. Remove the radiator inlet hose from the engine.
62. Install a engine lifting device to the engine.

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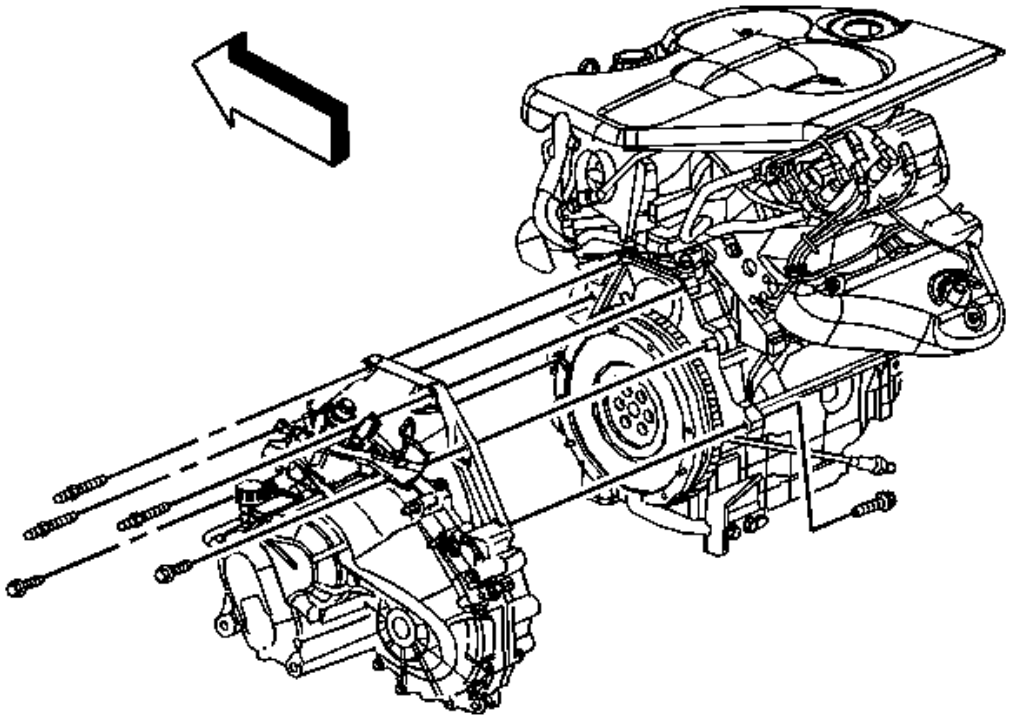

Fig. 226: View Of Transaxle-To-Engine Bolts/Studs (M/T)
Courtesy of GENERAL MOTORS CORP.

63. Remove the remaining transaxle-to-engine bolts/studs if equipped with a manual transmission.

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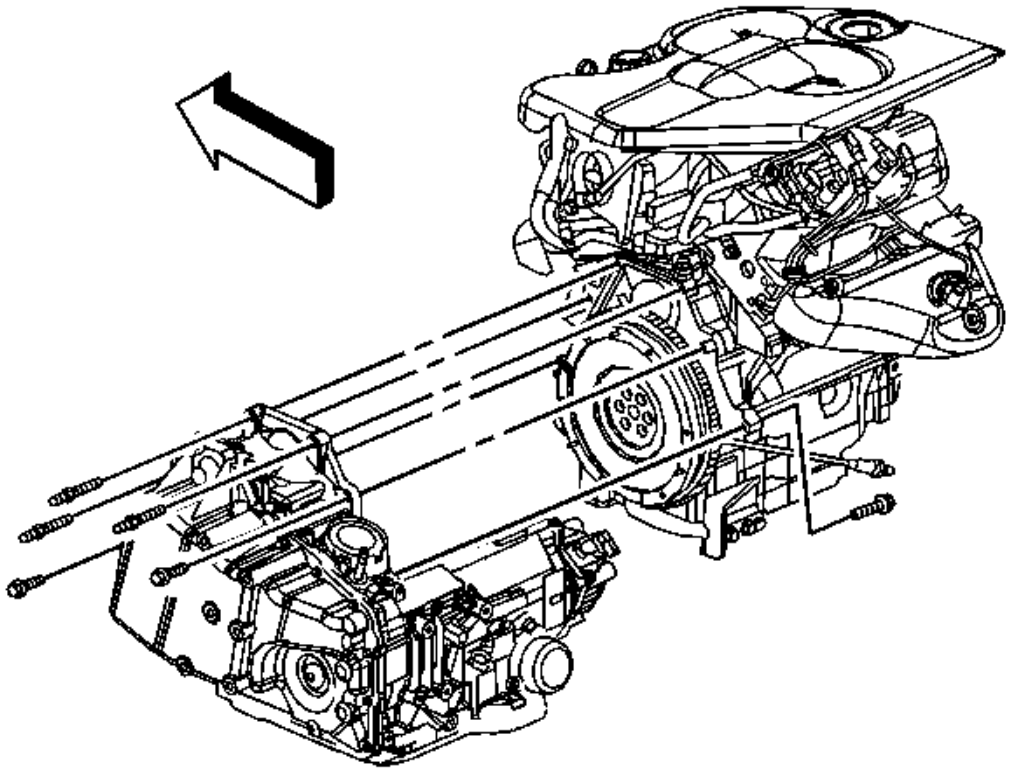

Fig. 227: View Of Transaxle-To-Engine Bolts/Studs (A/T)
Courtesy of GENERAL MOTORS CORP.

64. Remove the remaining transaxle-to-engine bolts/studs if equipped with a automatic transmission.
65. Remove the engine from the vehicle.
66. Remove the flywheel. Refer to **Engine Flywheel Replacement**.
67. Install the engine to the engine stand.

Installation Procedure

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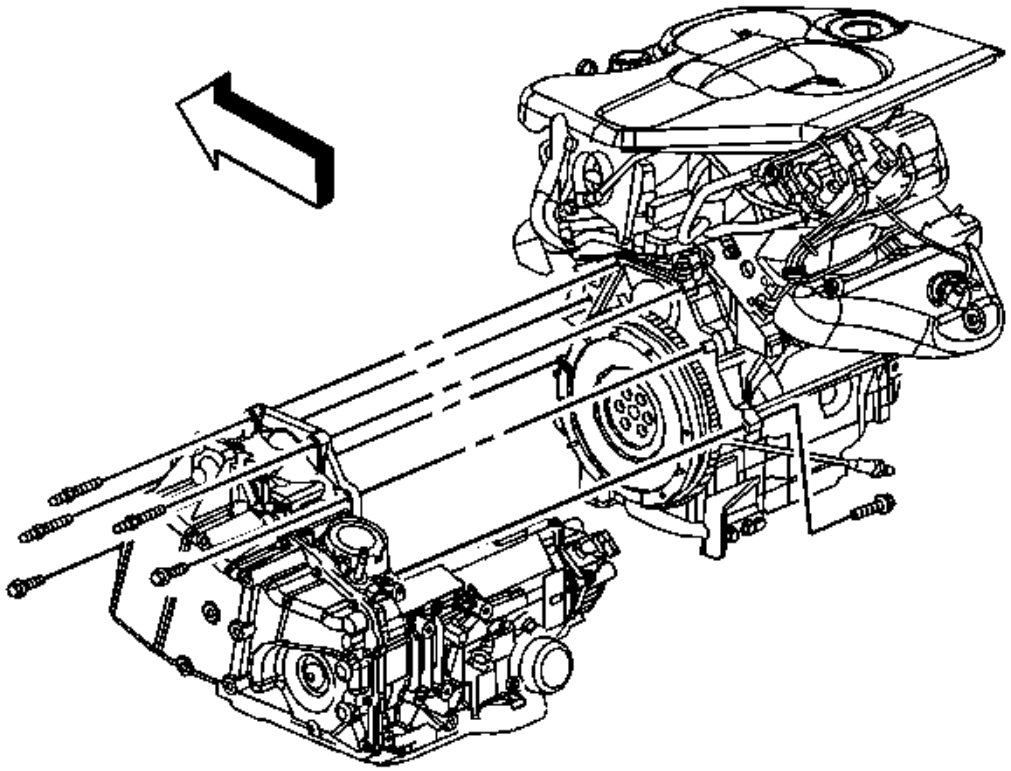

Fig. 228: View Of Transaxle-To-Engine Bolts/Studs (A/T)
Courtesy of GENERAL MOTORS CORP.

1. Install an engine lifting device to the engine.
2. Remove the engine from the engine stand.
3. Install the flywheel. Refer to **Engine Flywheel Replacement**.
4. Install the engine to the vehicle.

CAUTION: Refer to Fastener Caution .

5. Install the transaxle-to-engine bolts/studs if equipped with a automatic transmission and tighten to 75 N.m (55 lb ft).

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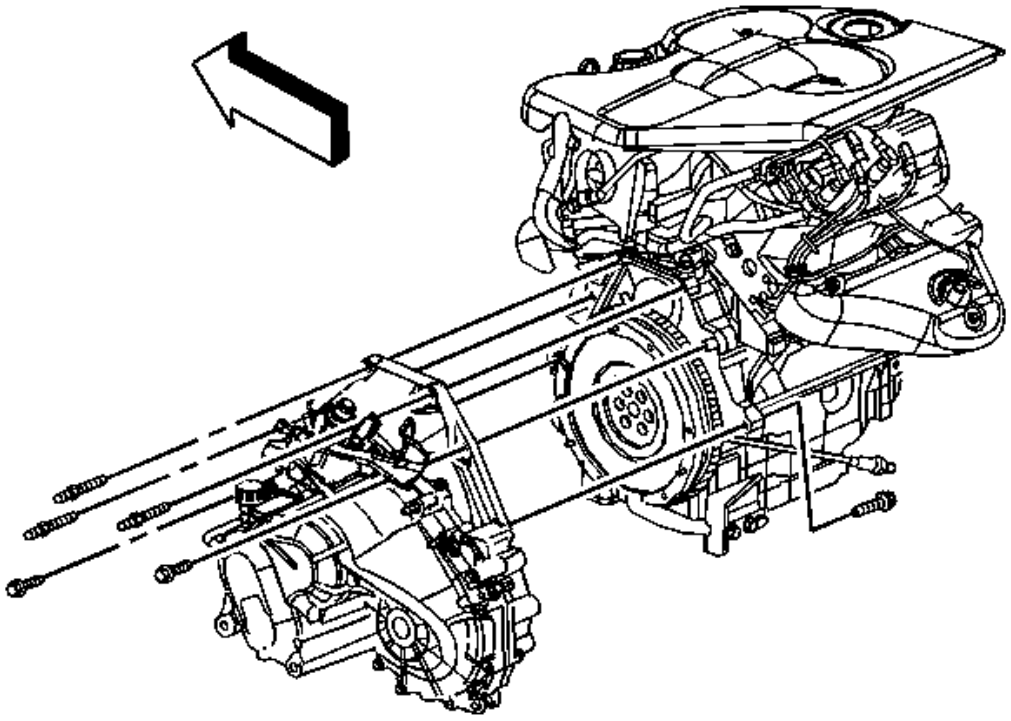

Fig. 229: View Of Transaxle-To-Engine Bolts/Studs (M/T)
Courtesy of GENERAL MOTORS CORP.

6. Install the transaxle-to-engine bolts/studs if equipped with a manual transmission and tighten to 75 N.m (55 lb ft).

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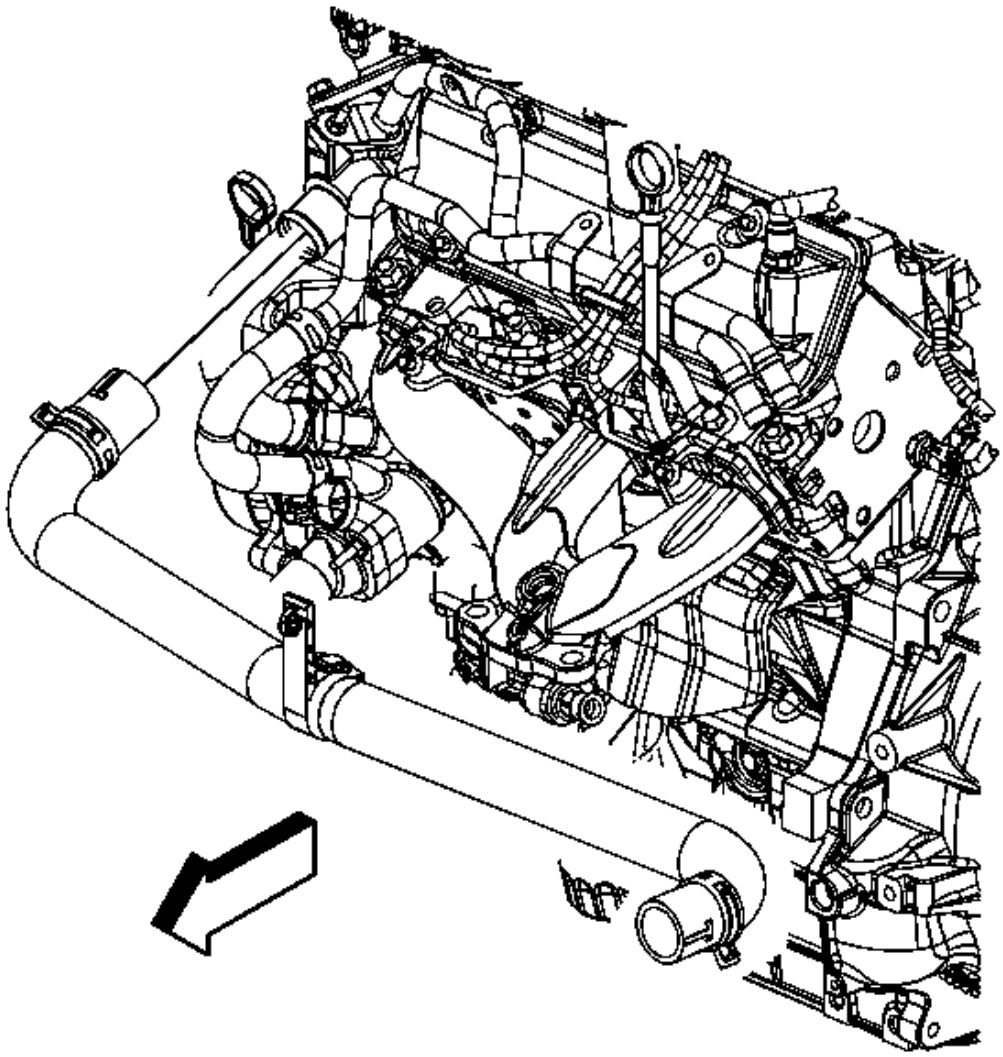

Fig. 230: Identifying Radiator Inlet Hose & Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine lifting device from the engine.
8. Install the radiator inlet hose to the engine.
9. Position the radiator inlet hose clamp at the engine.

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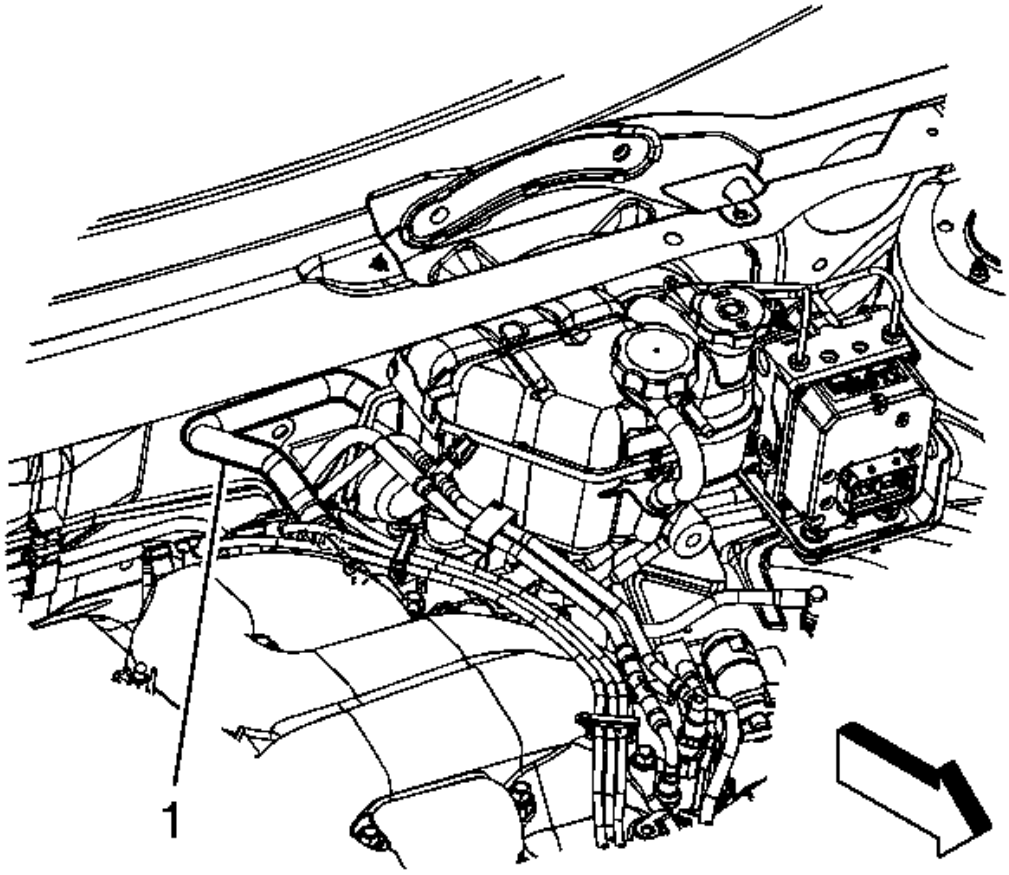

Fig. 231: Identifying Brake Booster Vacuum Hose To Intake Manifold
Courtesy of GENERAL MOTORS CORP.

10. Connect the EVAP purge line to the canister purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
11. Connect the fuel feed line to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
12. Install the heater outlet and inlet hoses to the engine.
13. Position the heater inlet and outlet hose clamps at the engine.
14. Install the brake booster vacuum hose (1) to the intake manifold.
15. Position the brake booster vacuum hose clamp at the intake manifold.

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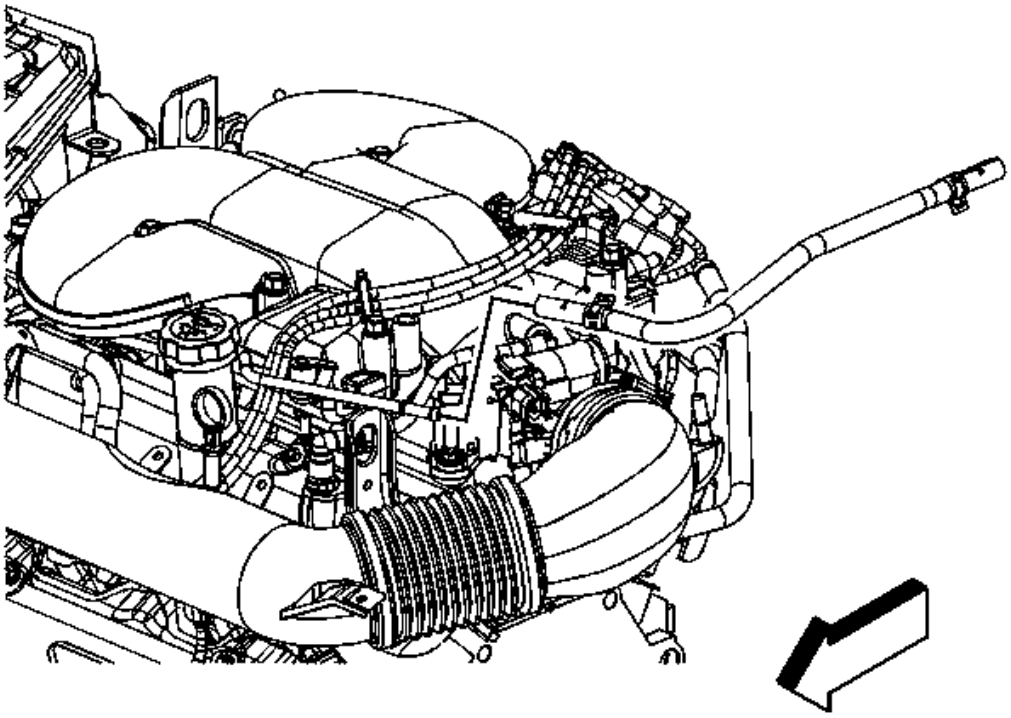

Fig. 232: View Of Radiator Surge Tank Inlet Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

16. Install the radiator surge tank hose to the surge tank pipe.
17. Position the radiator surge tank hose clamp at the surge tank pipe.

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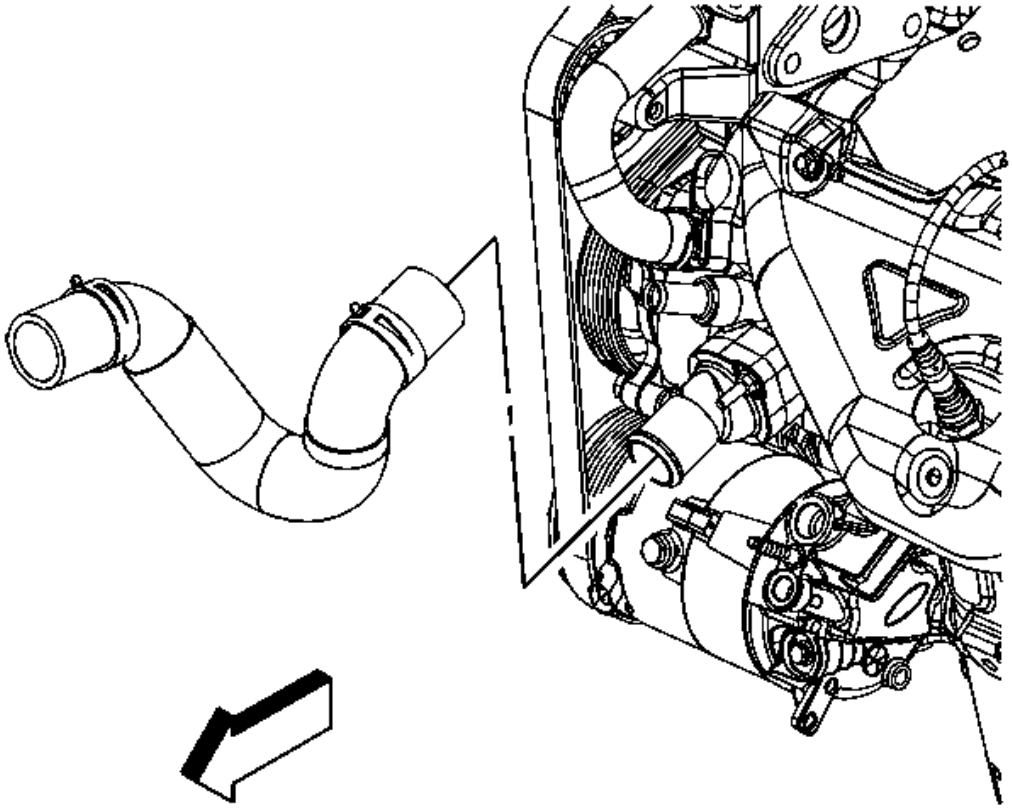

Fig. 233: Identifying Radiator Outlet Hose & Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

18. Raise and support the vehicle.
19. Install the radiator outlet hose to the thermostat housing.
20. Position the radiator outlet hose clamp at the thermostat housing.
21. Install the lower transaxle-to-engine bolt and stud and tighten to 75 N.m (55 lb ft).

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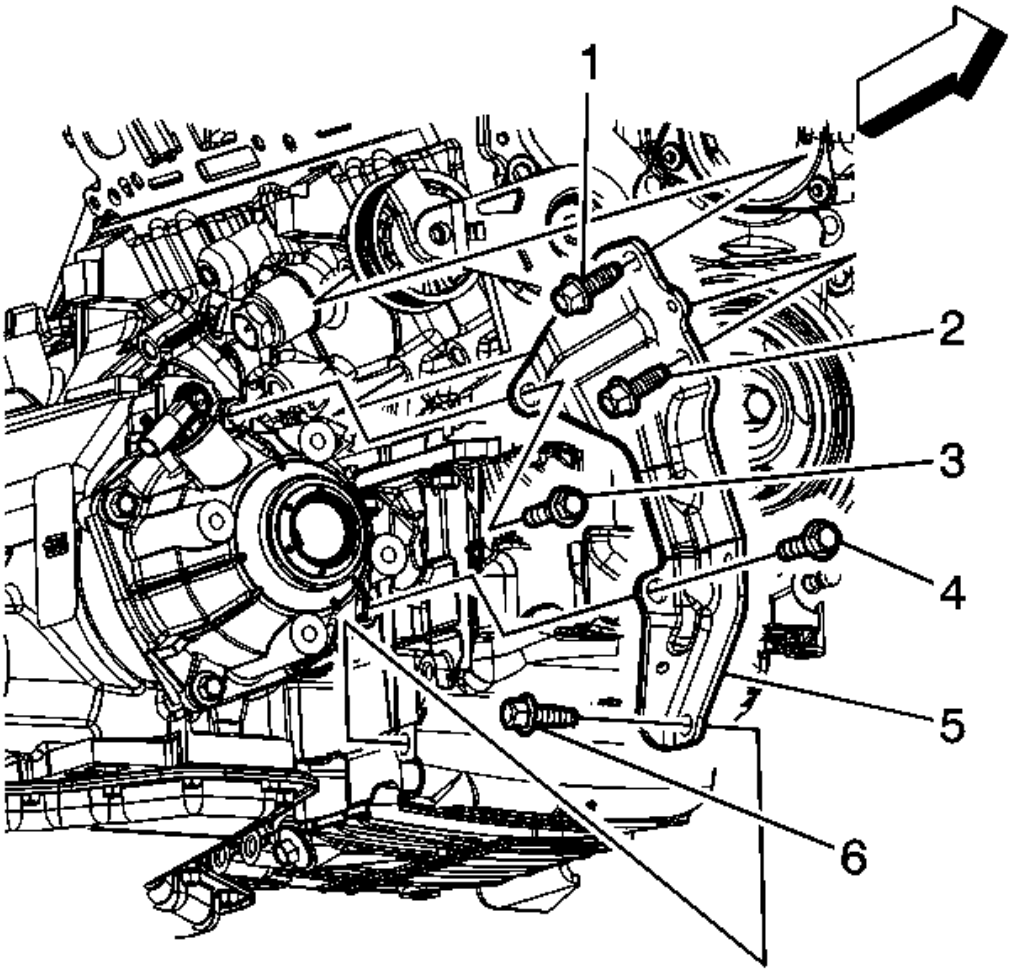

Fig. 234: Identifying Transaxle Brace-To-Oil Pan Lower Bolt
Courtesy of GENERAL MOTORS CORP.

22. Install the transaxle brace to oil pan lower bolt (6), if equipped with RPO M15 and tighten to 50 N.m (37 lb ft).

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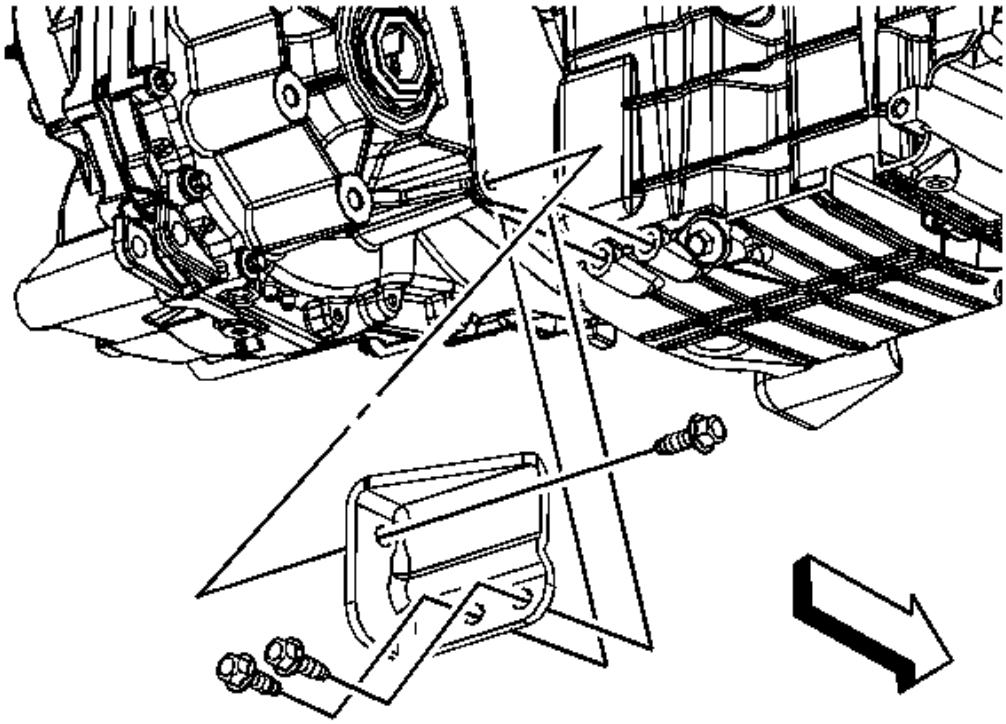

Fig. 235: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

23. Position the transaxle brace and install the transaxle brace to transaxle bolt until snug, if equipped with RPO MT2.
24. Install the transaxle brace to oil pan bolts, if equipped with RPO MT2 and tighten to 50 N.m (37 lb ft.

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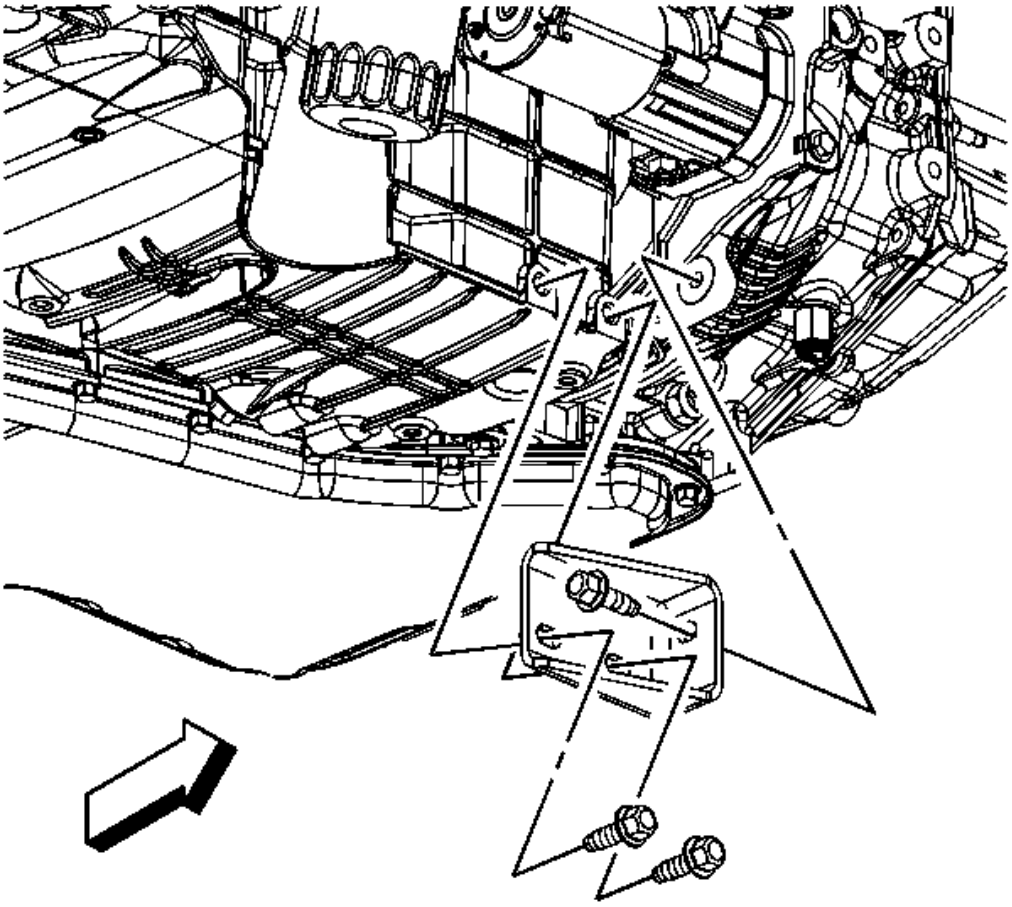

Fig. 236: Identifying Transaxle Brace-To-Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

25. Position the transaxle brace and install the transaxle brace to transaxle bolt until snug.
26. Install the transaxle brace to oil pan bolts and tighten to 50 N.m (37 lb ft).
27. Position and bolt up the A/C compressor and tighten the bolt to 50 N.m (37 lb ft).
28. Install the torque converter bolts. Refer to **Flywheel to Torque Converter Bolt Replacement** .
29. Install the starter motor. Refer to **Starter Replacement (LZ9)** .
30. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** .
31. Install the engine mount. Refer to **Engine Mount Replacement (Coupe)** or **Engine Mount Replacement (Convertible)**.

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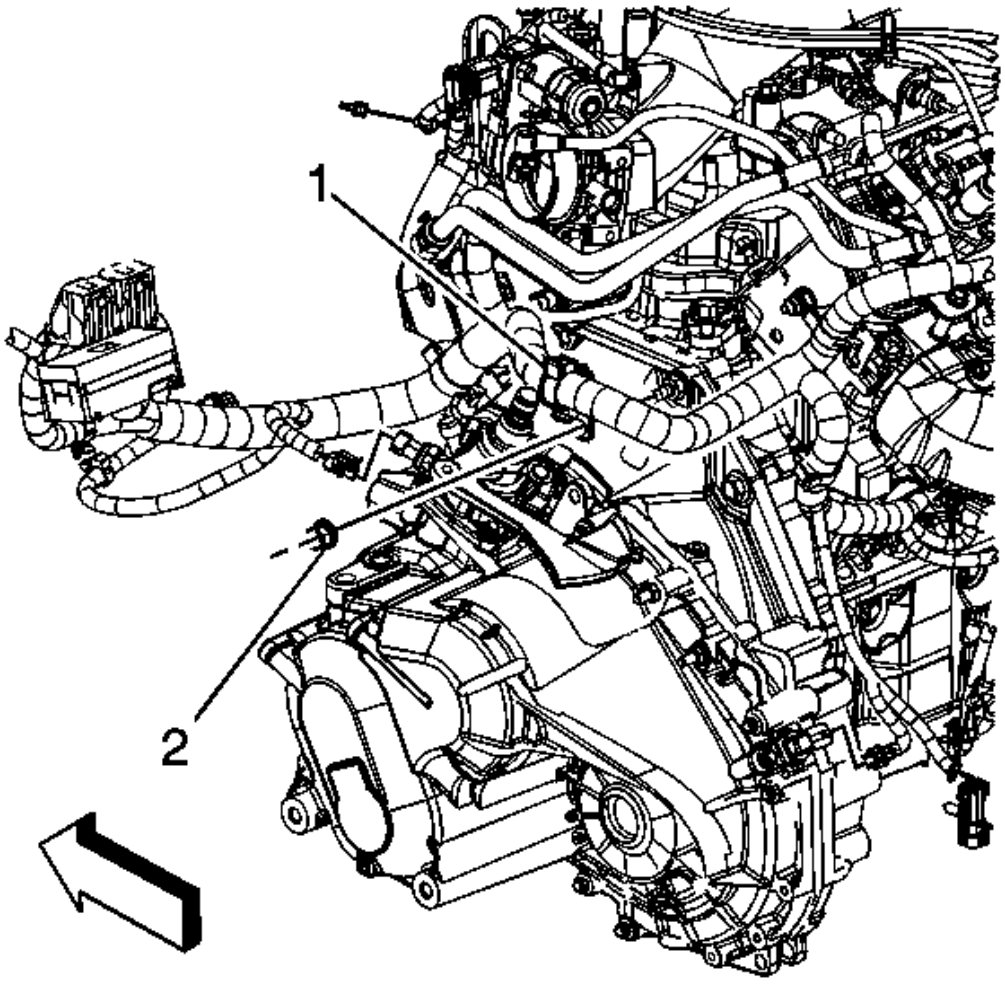

Fig. 237: View Of Engine Harness Clip & Nut
Courtesy of GENERAL MOTORS CORP.

32. Install the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side (LZ9)** and **Catalytic Converter Replacement - Right Side (LZ9 w/RPO M15)** or **Catalytic Converter Replacement - Right Side (LZ9 w/RPO MT2)** .
33. Install the engine harness rear clip (1) to the transmission stud.
34. Install the engine harness rear clip nut (2) and tighten to 25 N.m (18 lb ft).

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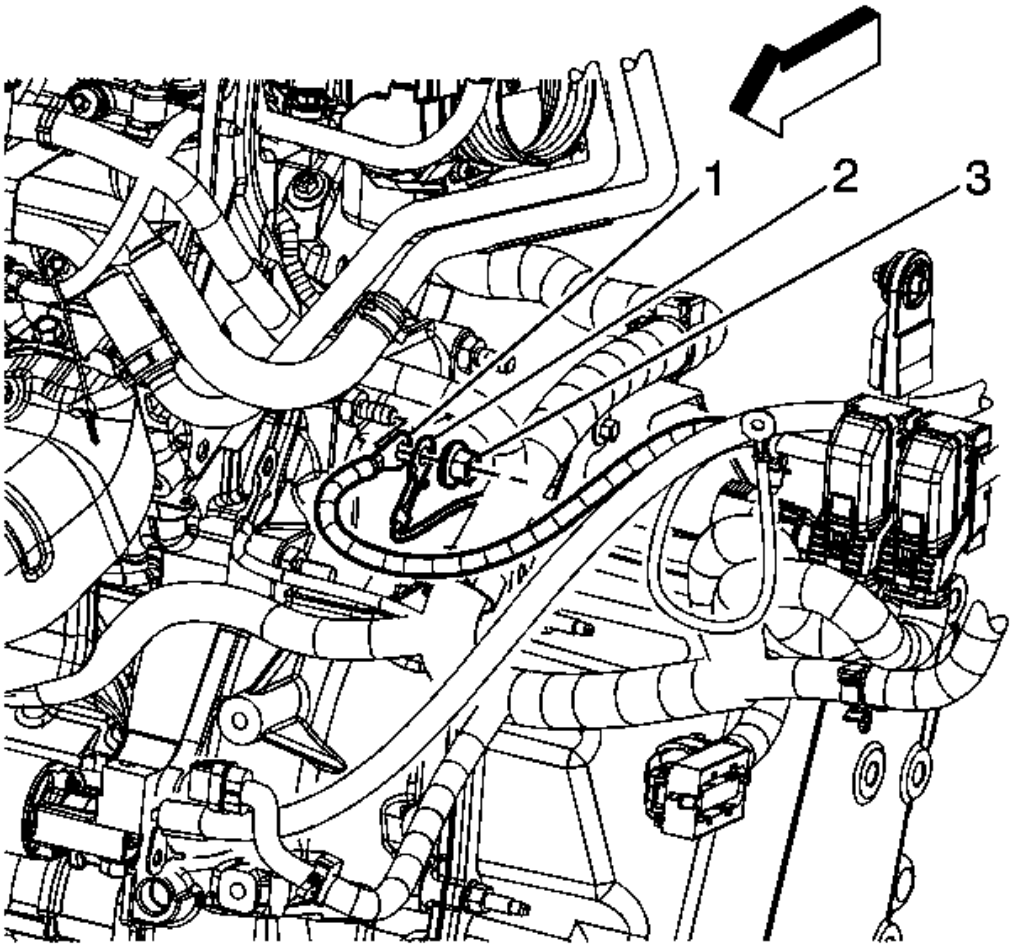

Fig. 238: View Of Engine Wiring Harness Ground Bolt, Terminal & Battery Cable Ground Terminal
Courtesy of GENERAL MOTORS CORP.

35. Install the engine harness ground terminal (1) to the transmission stud.
36. Install the engine harness ground nut (2) and tighten to 25 N.m (18 lb ft).

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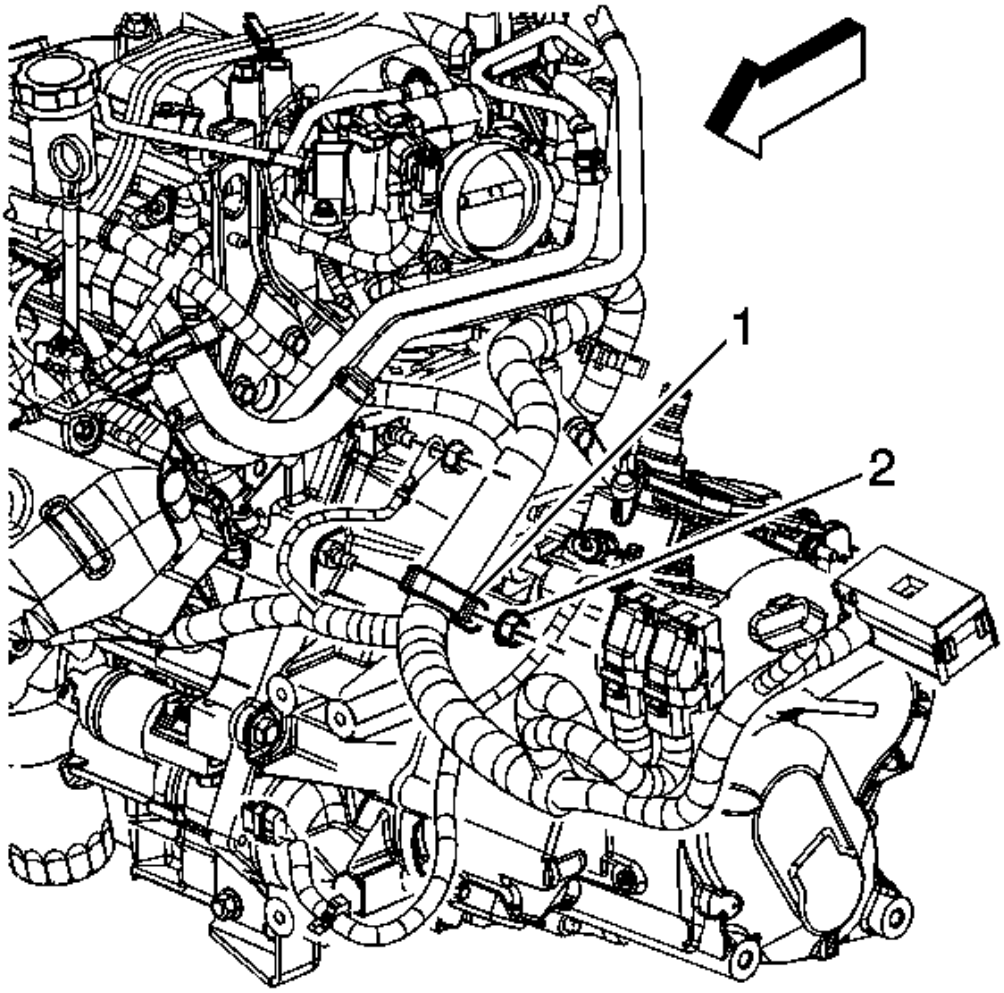

Fig. 239: Identifying Engine Harness Clip & Nut
Courtesy of GENERAL MOTORS CORP.

37. Install the engine harness clip (1) to the transmission stud.
38. Install the engine harness clip nut (2) and tighten to 25 N.m (18 lb ft).

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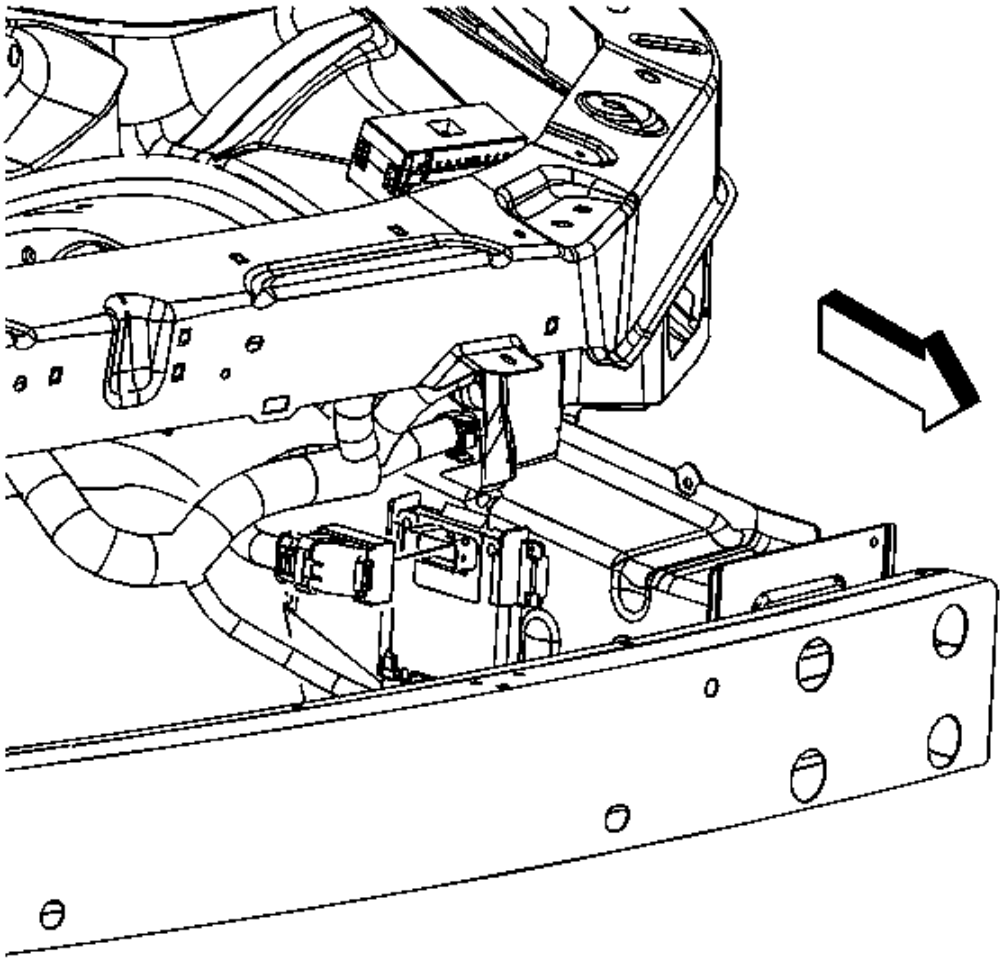

Fig. 240: Identifying Engine Harness Electrical Connector & Transmission Control Module (TCM)
Courtesy of GENERAL MOTORS CORP.

39. Connect the engine harness electrical connector to the TCM.

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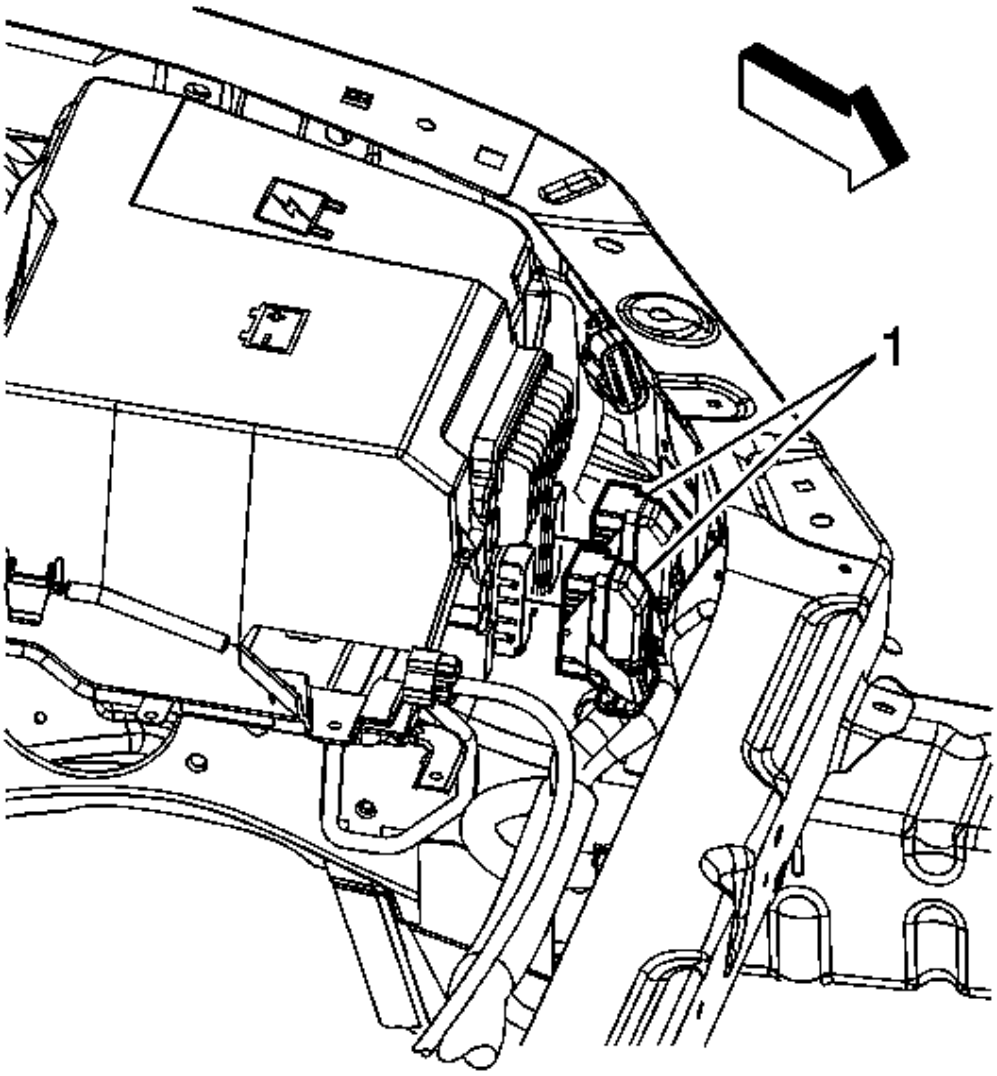

Fig. 241: View Of Engine Harness ECM/PCM Connectors
Courtesy of GENERAL MOTORS CORP.

40. Connect the engine harness electrical connectors (1) to the PCM.

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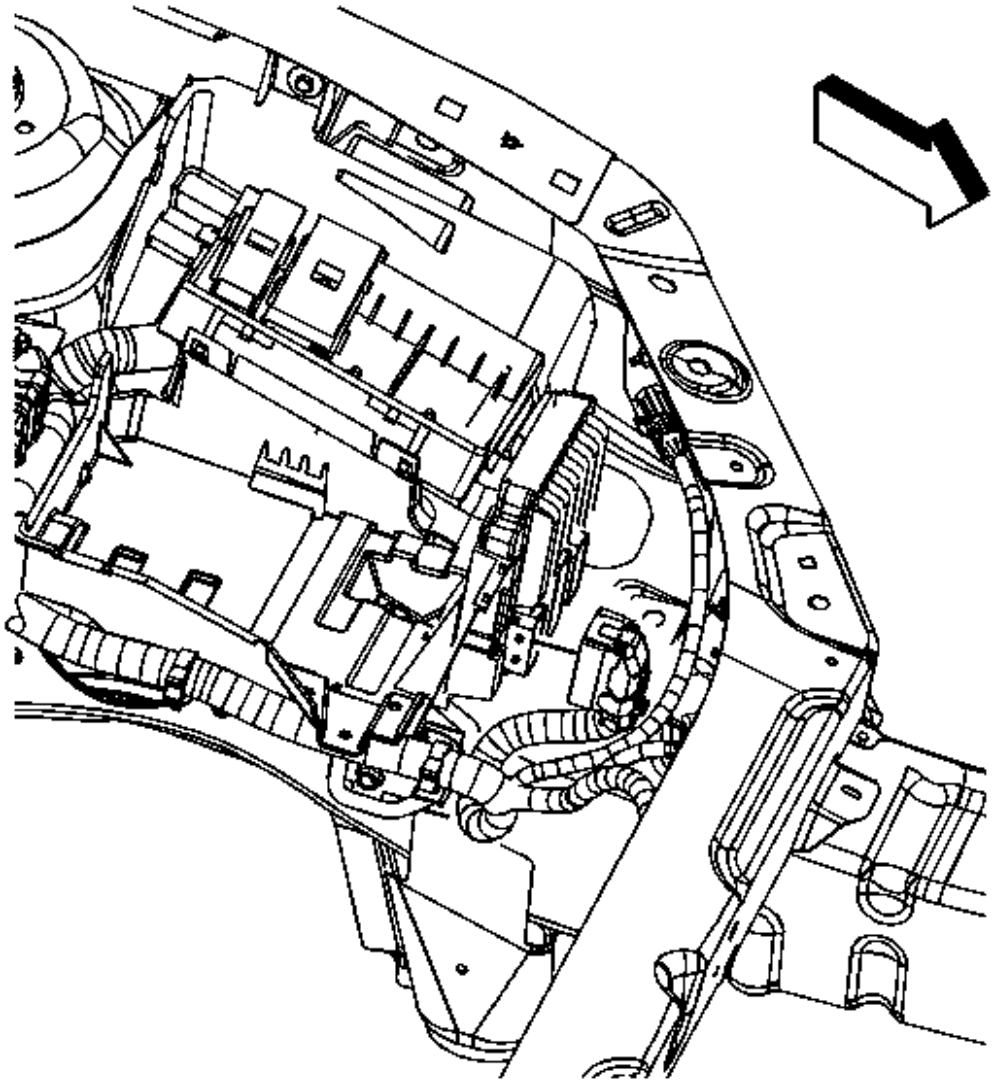

Fig. 242: View Of Body Harness ECM/PCM Connectors
Courtesy of GENERAL MOTORS CORP.

41. Connect the body harness electrical connector to the PCM.

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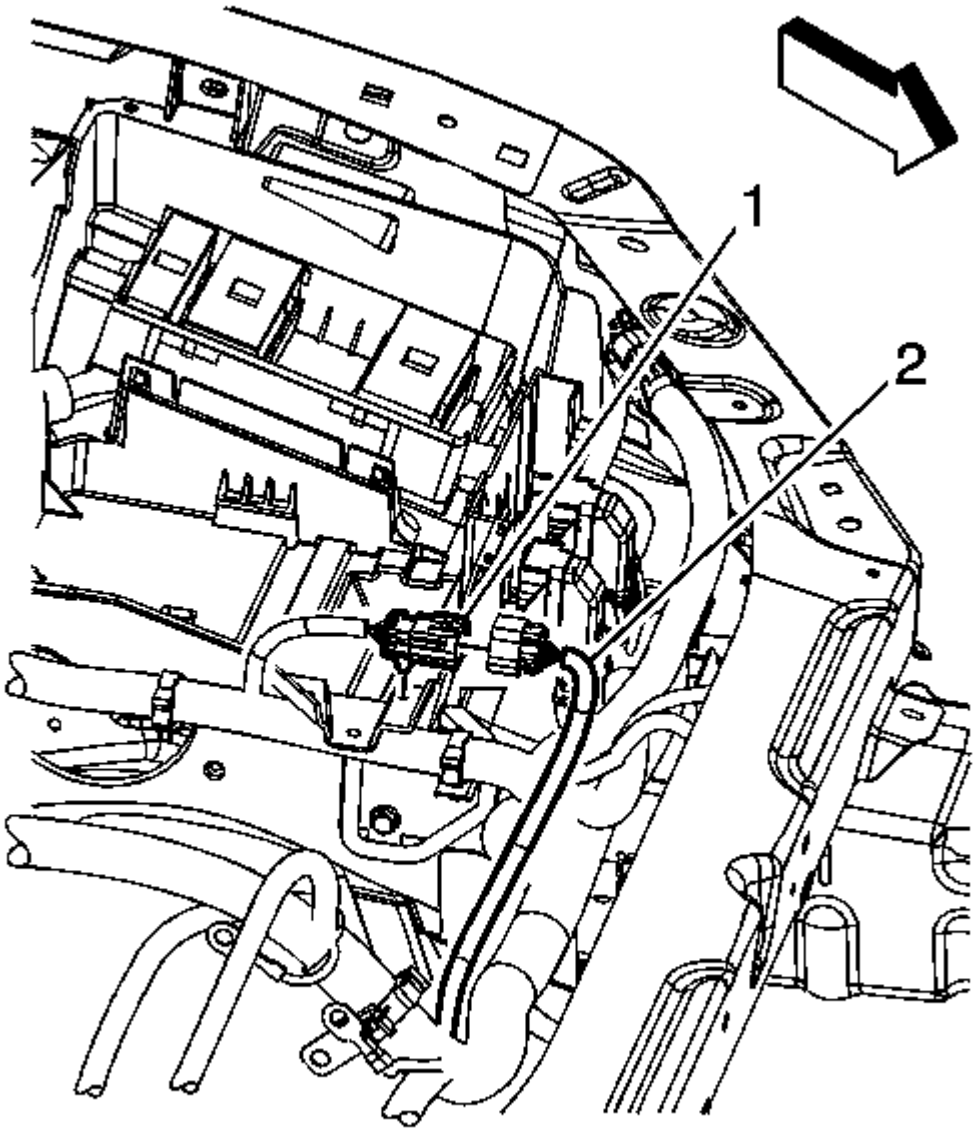

Fig. 243: Locating Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

42. Connect the engine harness connector (1) to the body harness connector (2).

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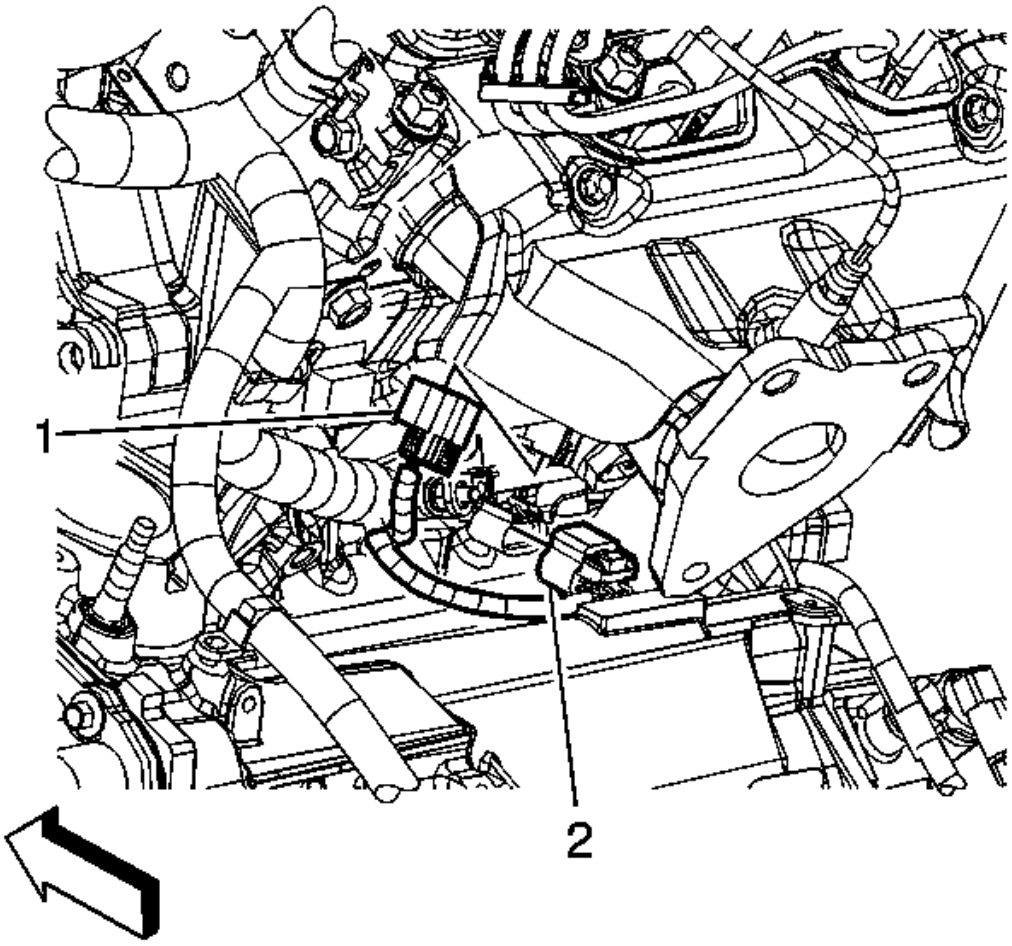

Fig. 244: View Of KS & CKP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

43. Connect the CKP sensor electrical connector (2).
44. Connect the knock sensor electrical connector (1).

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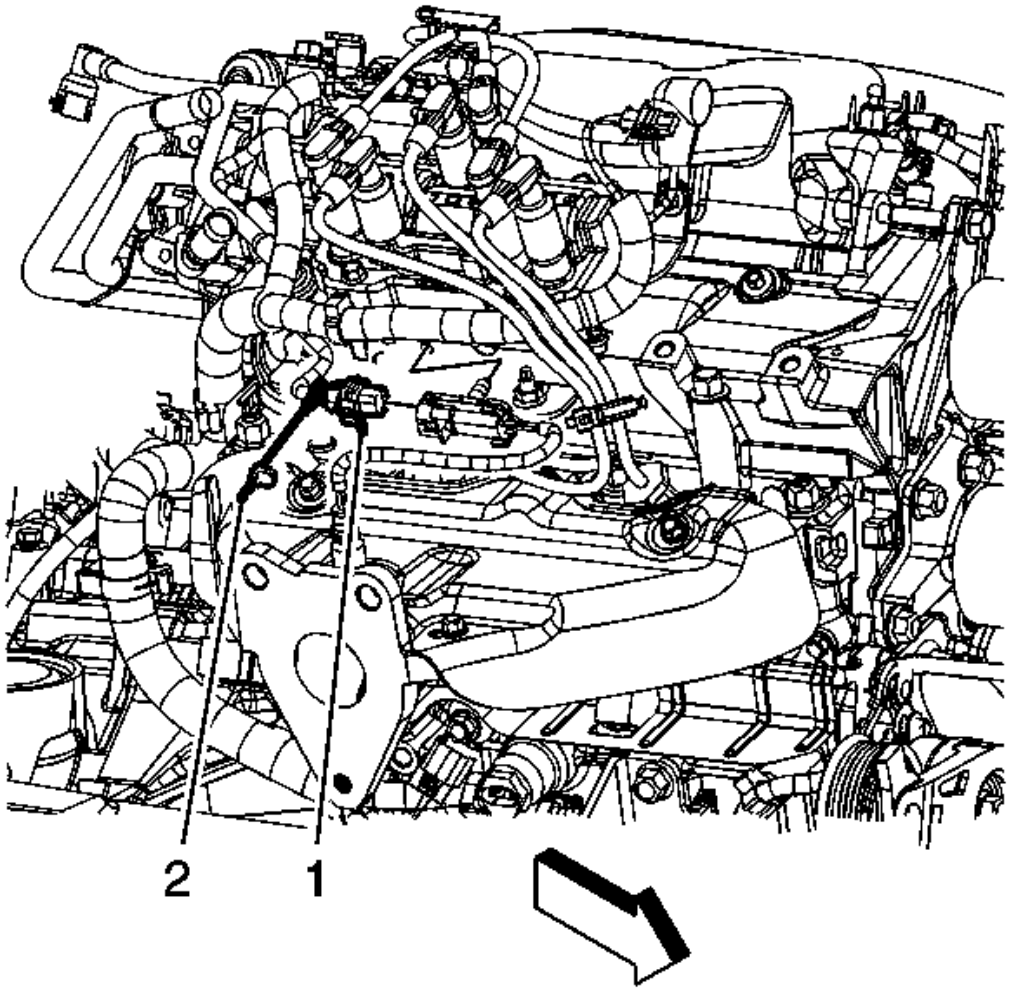

Fig. 245: Identifying HO2S & CPA Connectors
Courtesy of GENERAL MOTORS CORP.

45. Connect the rear upper HO2S electrical connector (1).
46. Install the CPA retainer.

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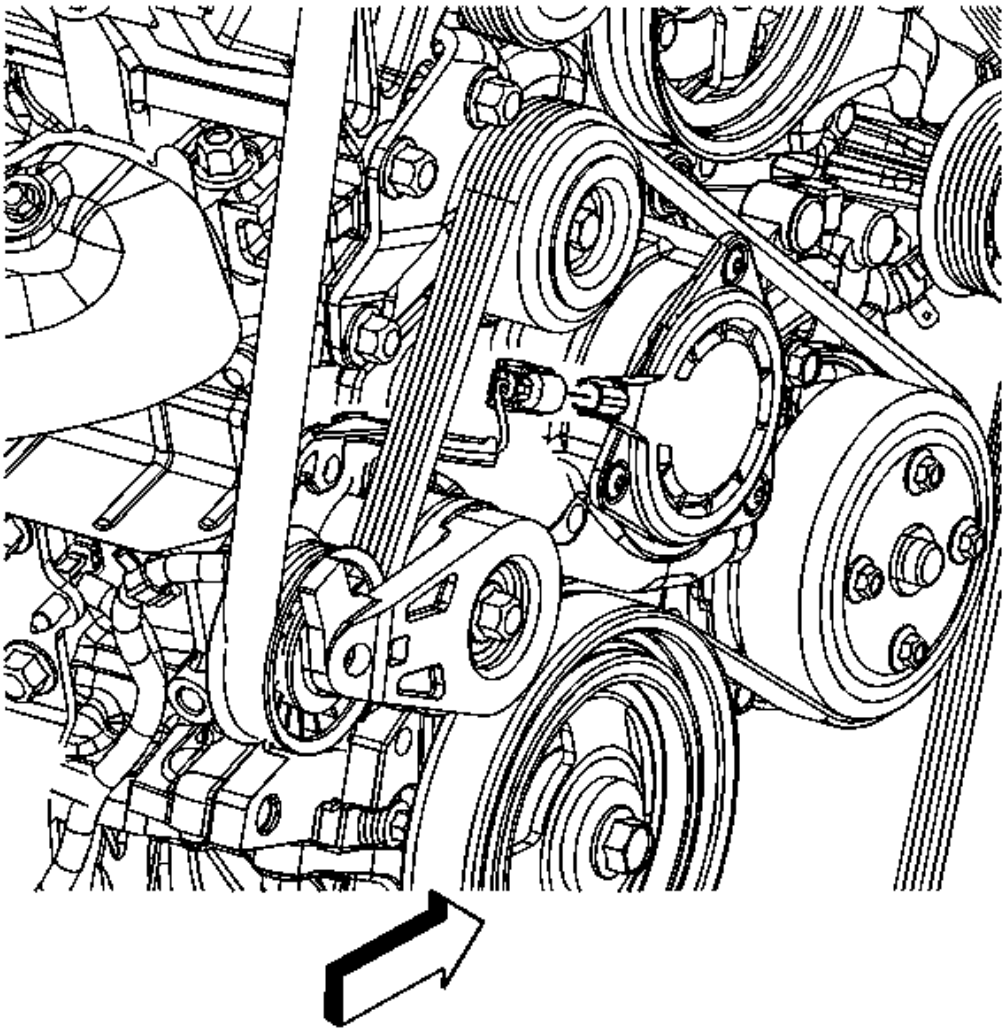

Fig. 246: View Of Engine Wiring Harness (Camshaft Phasor) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

47. Connect the camshaft phasor sensor electrical connector.

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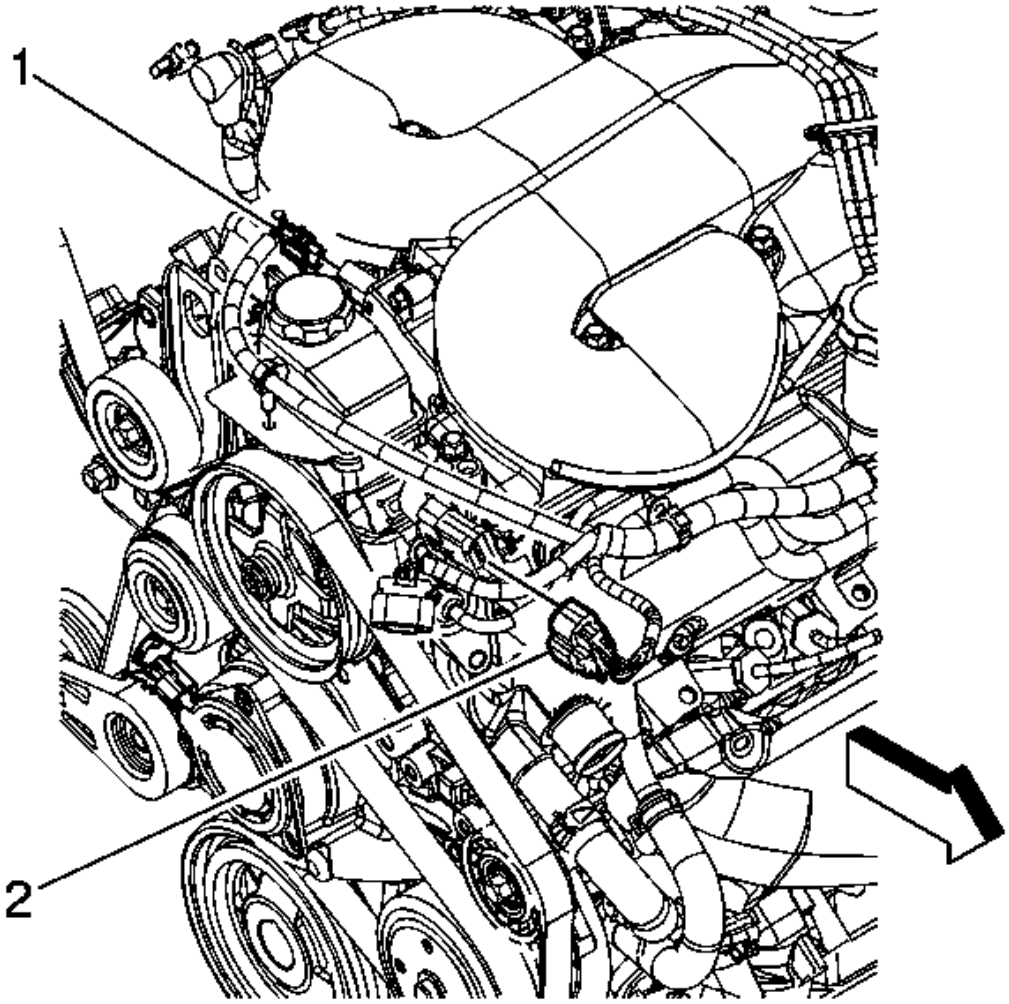

Fig. 247: Identifying Intake Manifold Tuning Valve & Injector Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

48. Connect the fuel injector inline (2) electrical connector.
49. Connect the inlet manifold valve (1) electrical connector.

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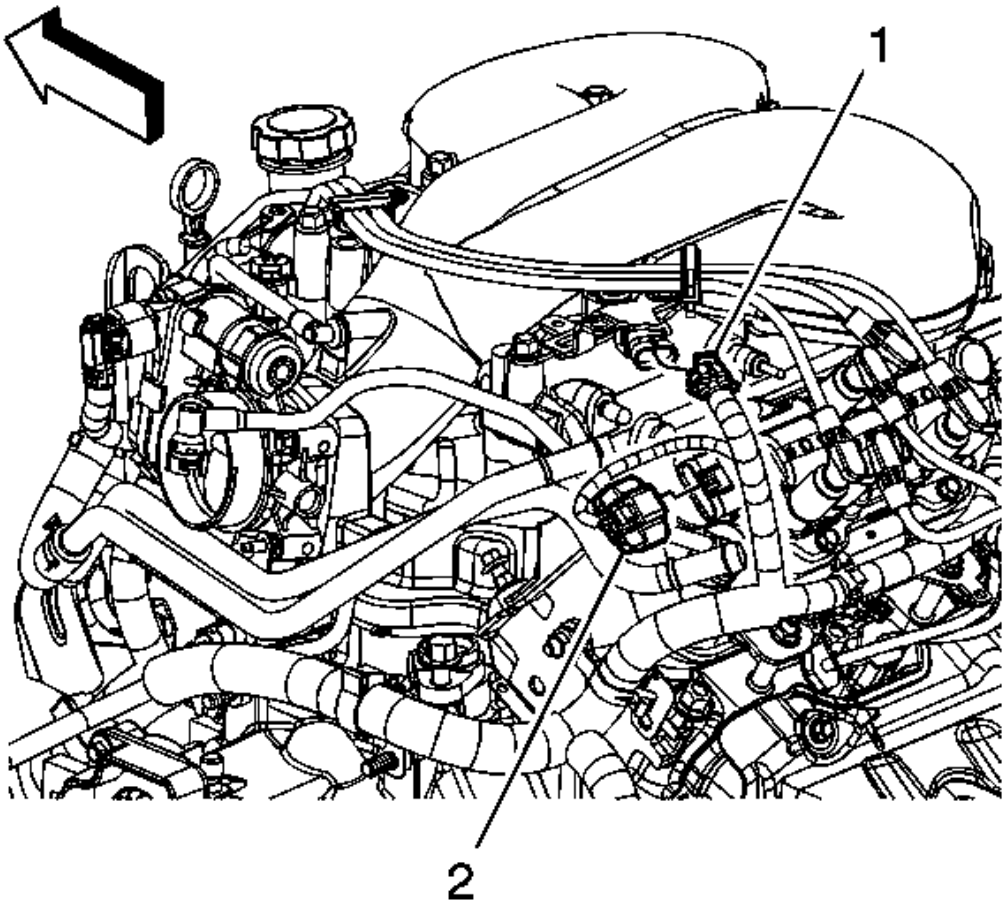

Fig. 248: Locating ECM & MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

50. Connect the ignition control module (2) electrical connector.
51. Connect the MAP sensor (1) electrical connector.

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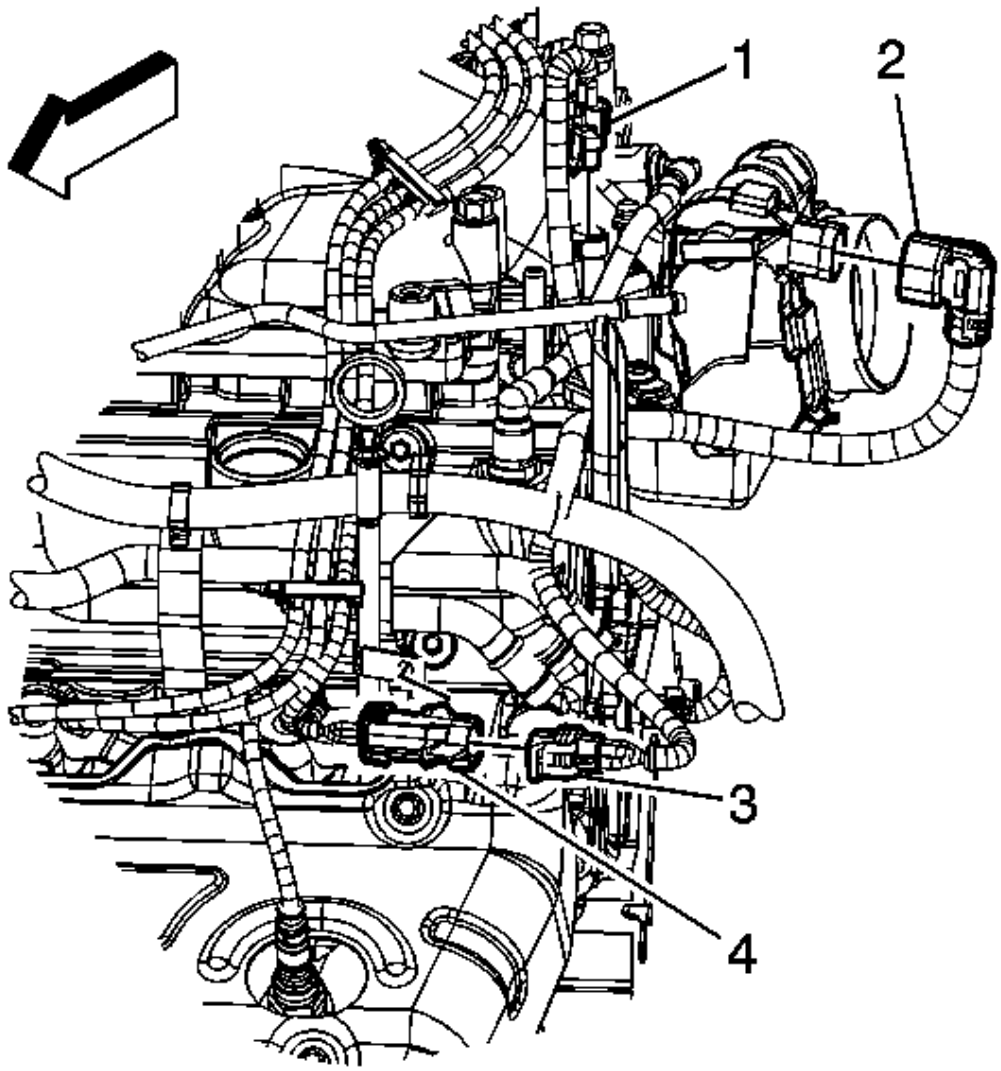

Fig. 249: Identifying HO2S Connectors
Courtesy of GENERAL MOTORS CORP.

52. Connect the HO2S (3) electrical connector.
53. Install the CPA retainer.
54. Connect the ETC (2) electrical connector.
55. Connect the EVAP canister purge solenoid (1) electrical connector.
56. Raise and support the vehicle.

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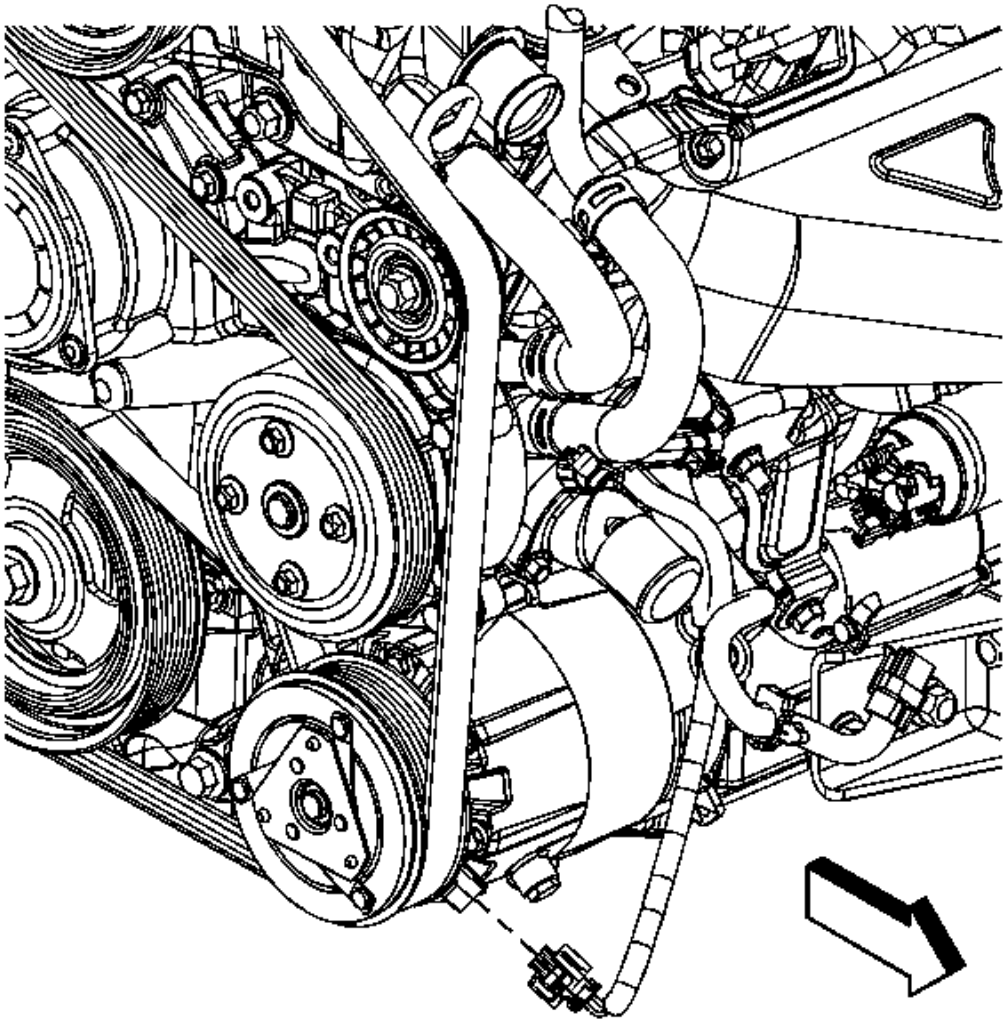

Fig. 250: Identifying Engine Wiring Harness Electrical Connector & A/C Compressor
Courtesy of GENERAL MOTORS CORP.

57. Connect the A/C compressor electrical connector.

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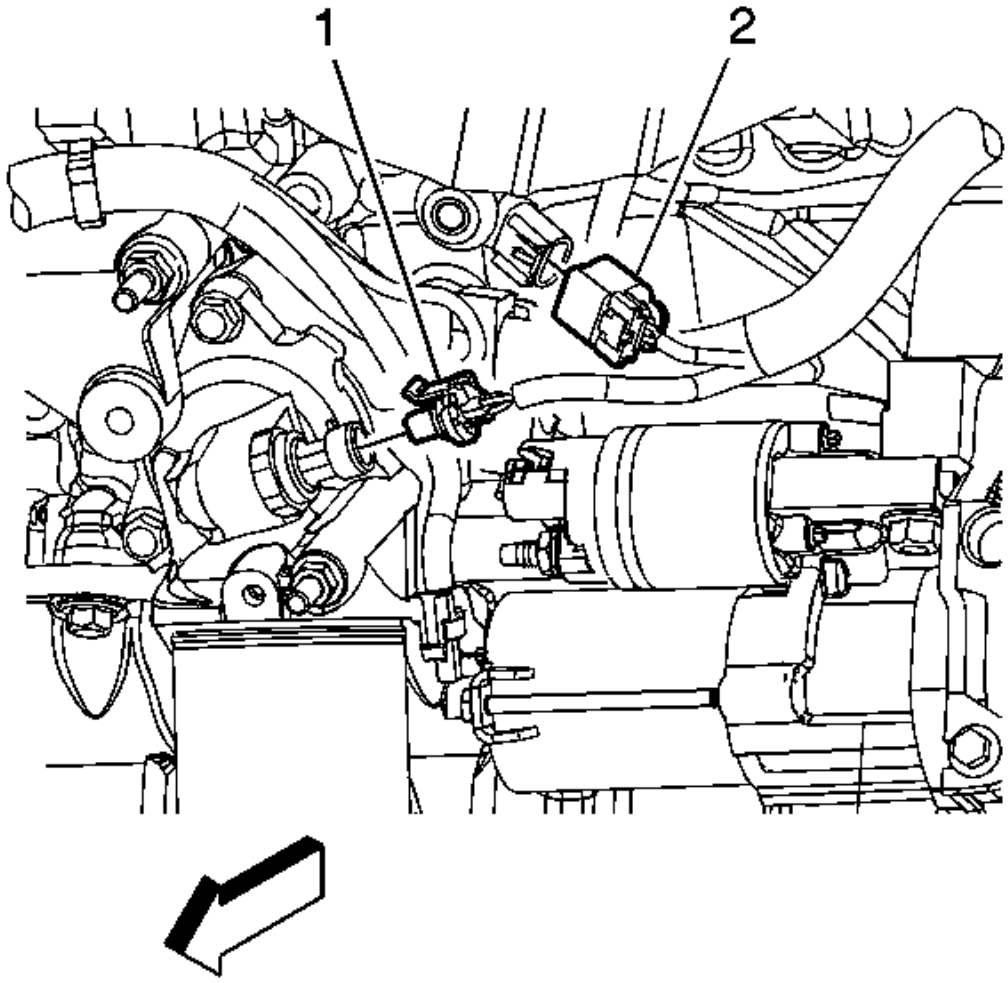

Fig. 251: View Of Knock Sensor & Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

58. Connect the knock sensor (2) electrical connector.
59. Connect the oil pressure sensor (1) electrical connector.

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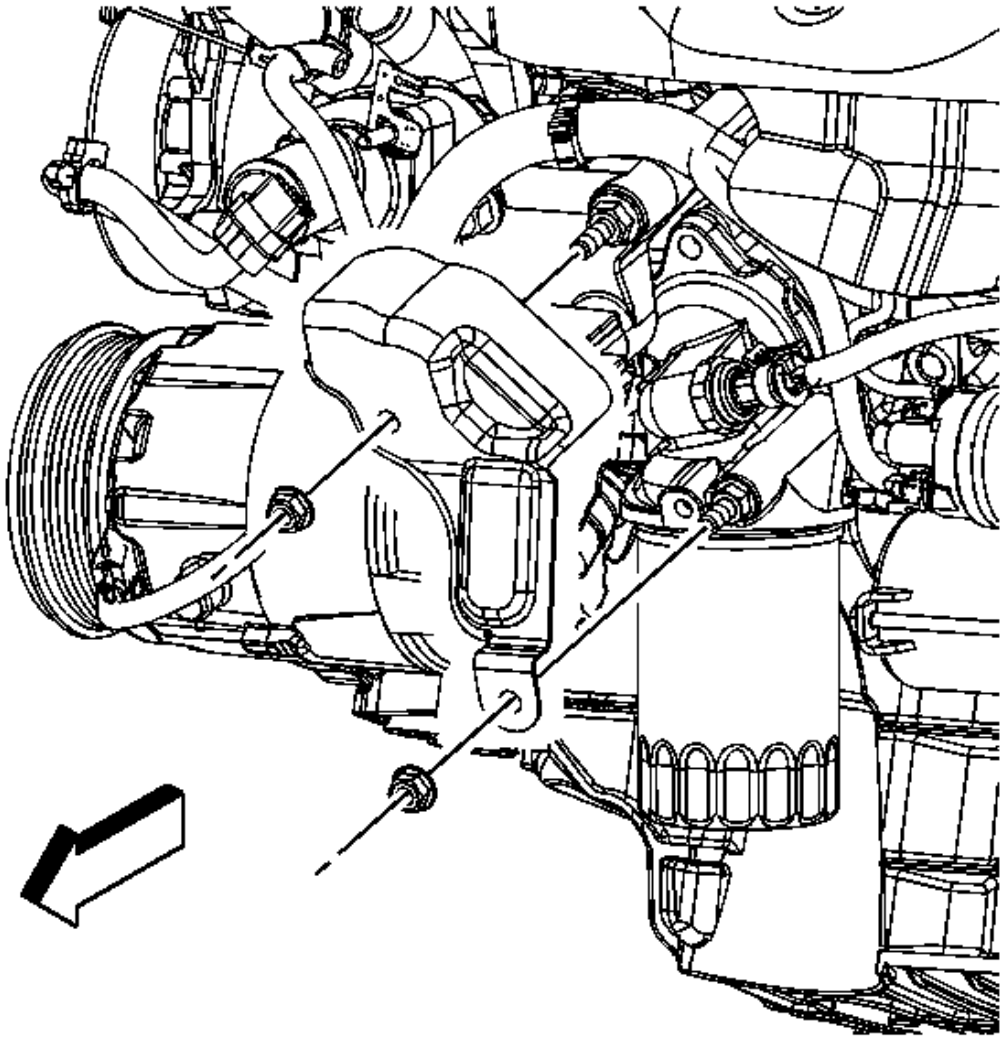

Fig. 252: Identifying Oil Pressure Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

60. Install the oil pressure sensor heat shield and nuts and tighten the nuts to 25 N.m (18 lb ft).
61. Lower the vehicle.
62. Connect the power steering lines and install the power steering pump, if equipped. Refer to **Power Steering Pump Replacement (LZ4, LZ9)** .
63. Install the drive belt and engine mount snubber. Refer to **Drive Belt Replacement (Coupe)** or **Drive Belt Replacement (Convertible)**.
64. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

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65. Install the hood. Refer to **Hood Replacement** .
66. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
67. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement** .
68. Fill the cooling system. Refer to **Cooling System Draining and Filling (LY7, LZE, LZ4, LZ9)** .
69. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
70. Inspect for leaks.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

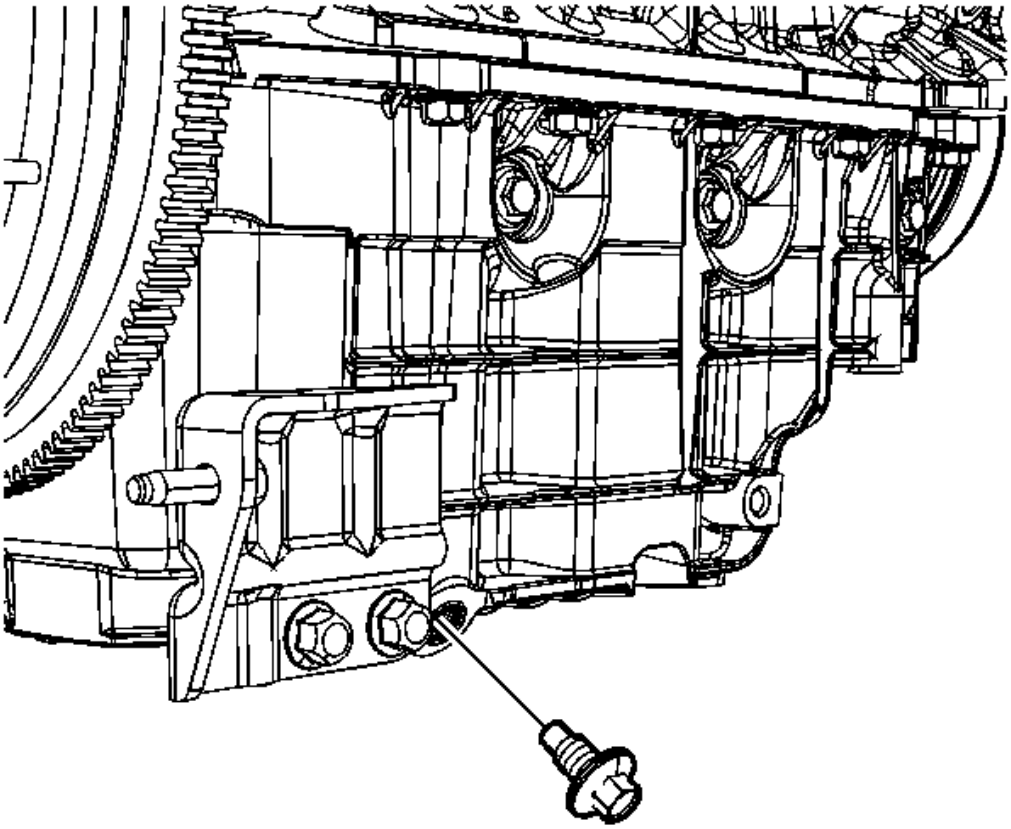

Fig. 253: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Position a suitable drain pan under the oil pan drain plug.

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3. Remove the oil pan drain plug.
4. Allow the engine oil to drain completely.
5. Clean and inspect the oil pan drain plug sealing surface, replace the oil pan if necessary.
6. Wipe any remaining oil from the drain plug hole and reinstall the oil pan drain plug until snug.

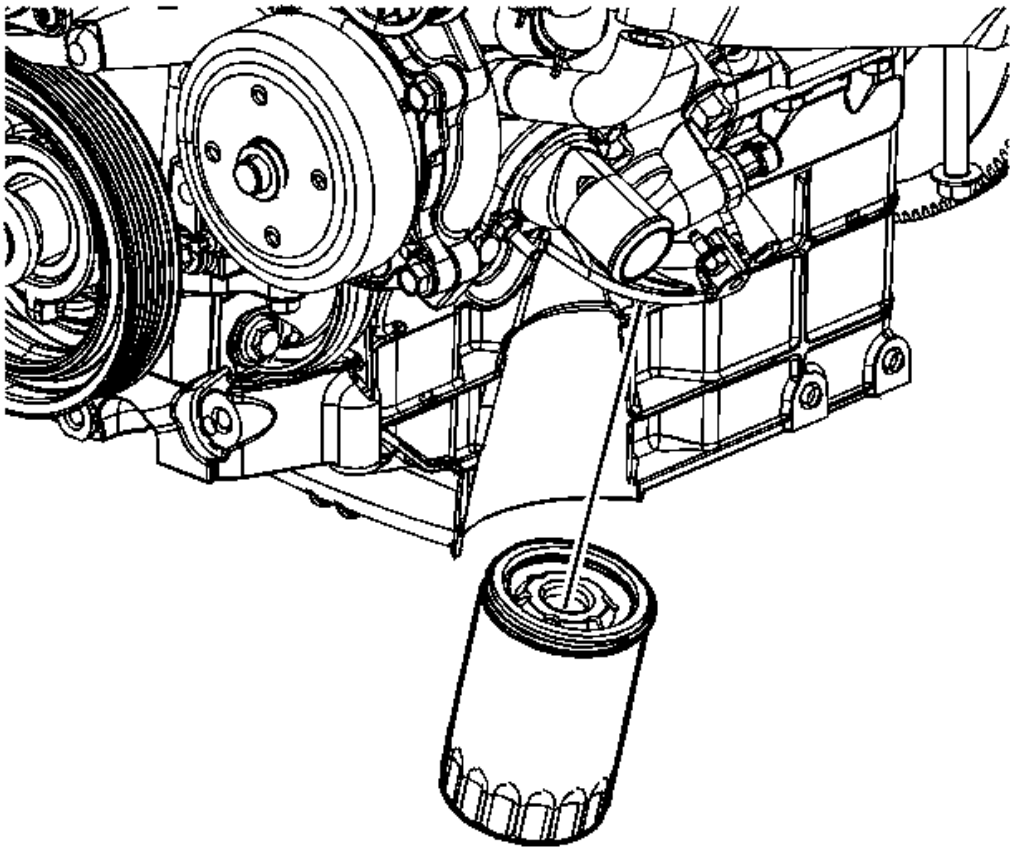

Fig. 254: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

7. Position a suitable drain pan under the oil filter.
8. Remove the oil filter.
9. Ensure that the oil filter gasket is still on the old filter. If not remove the oil filter gasket from the adapter.

Installation Procedure

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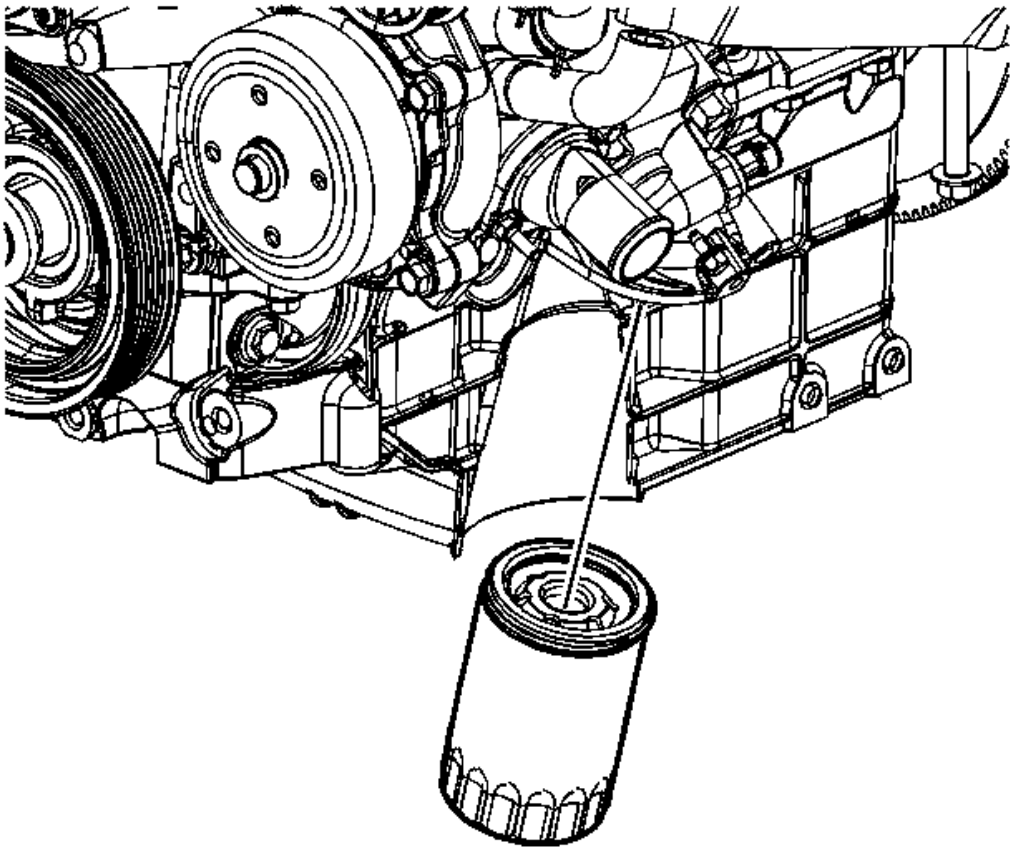

Fig. 255: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the NEW oil filter gasket.
2. Install the NEW oil filter and tighten 3/4 to 1 full turn, after the oil filter gasket contacts the adapter.

CAUTION: Refer to Fastener Caution .

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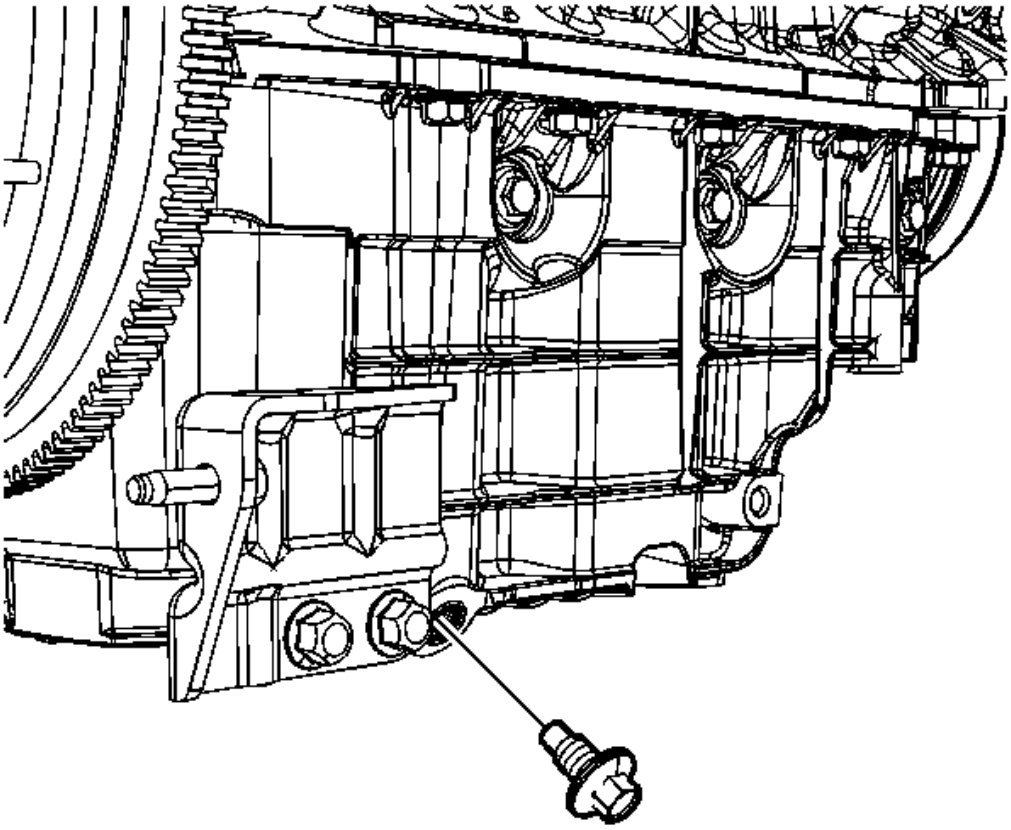

Fig. 256: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Tighten the oil pan drain plug to 26 N.m (19 lb ft).
4. Remove the oil drain pan from under the vehicle.
5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations** .
7. Start the engine.
8. Inspect the for oil leaks after engine start up.
9. Turn OFF the engine and allow the oil a few minutes to drain back into the oil pan.
10. Remove the oil level indicator from the oil level indicator tube.
11. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
12. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.

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13. Again, remove the oil level indicator from the oil level indicator tube keeping the tip of the oil level indicator down.
14. Check the level if the engine oil on the oil level indicator.
15. If necessary, adjust the oil level by adding or draining oil.
16. Check for oil leaks.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

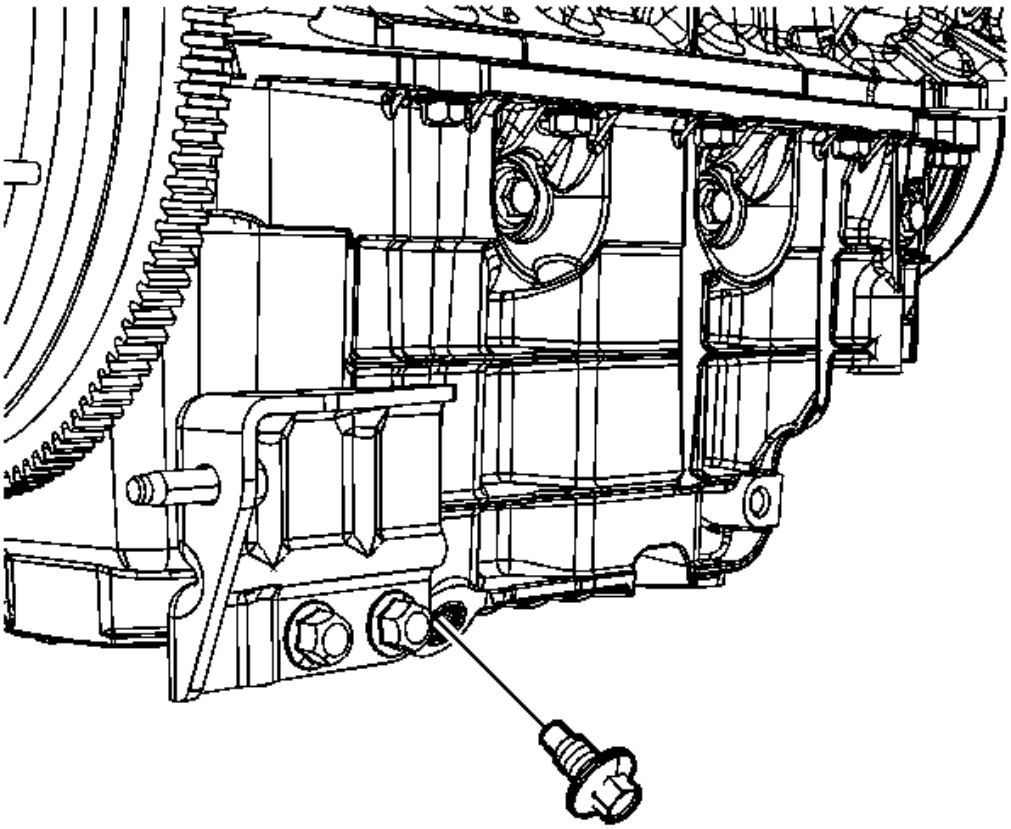

Fig. 257: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug.
2. Drain the engine oil.

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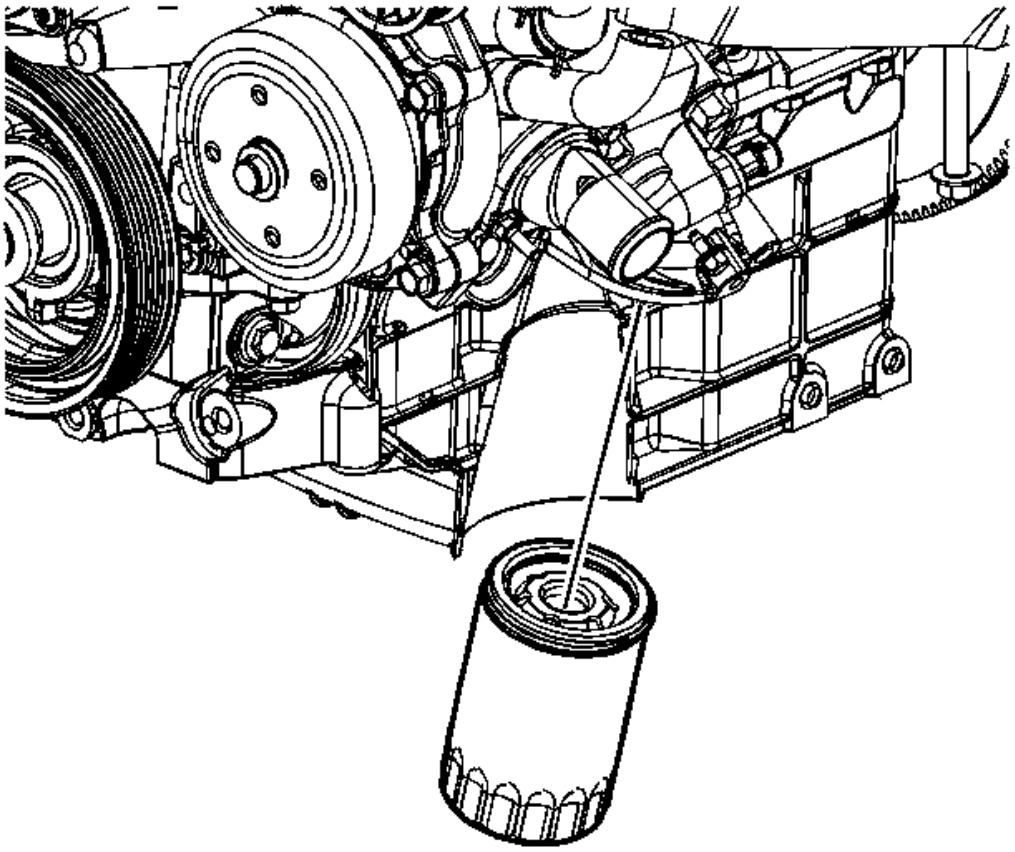

Fig. 258: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

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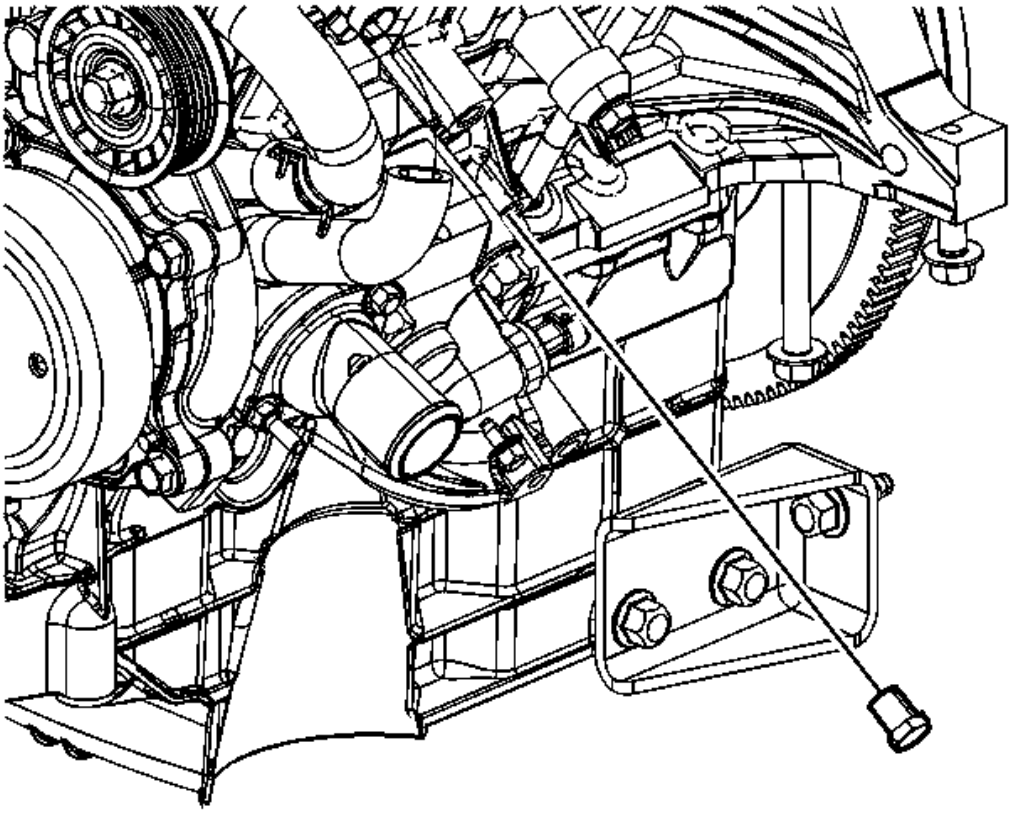

Fig. 259: Identifying Left Side Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the coolant drain plug from the left side.

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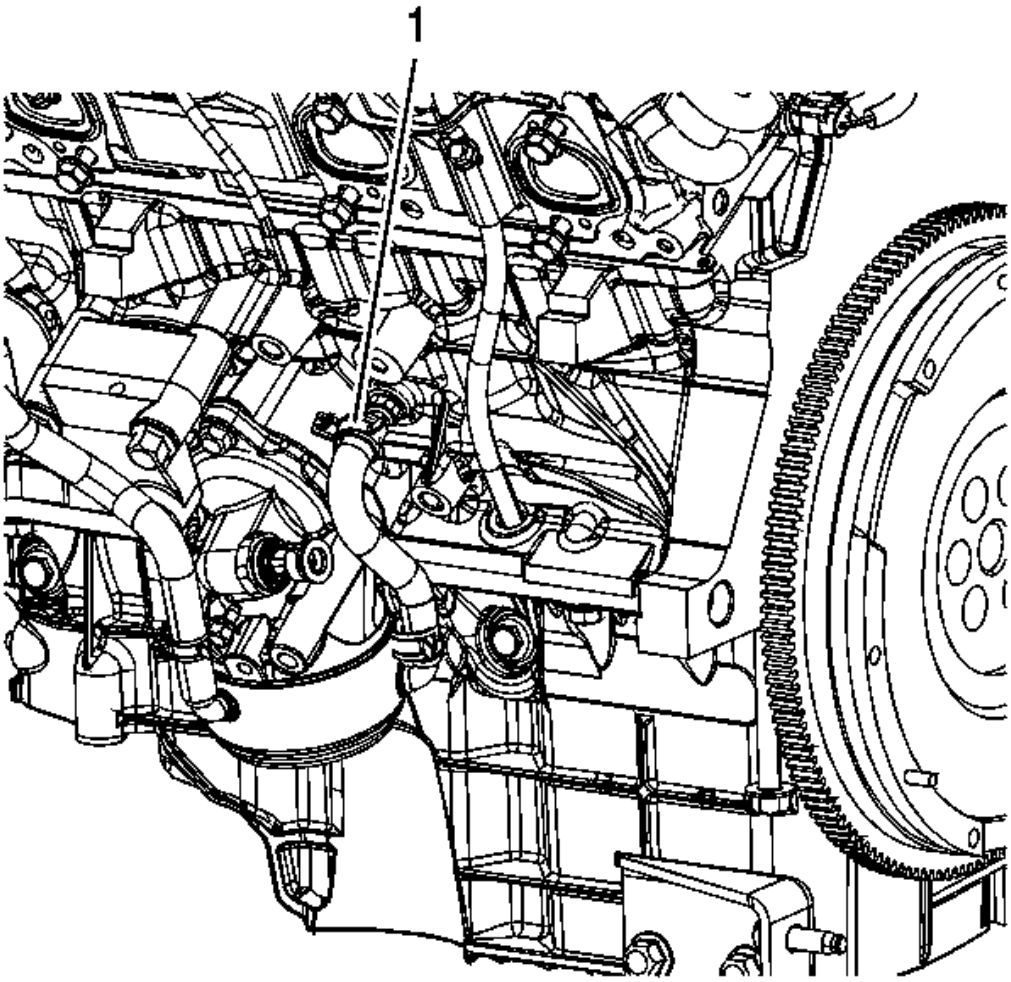

Fig. 260: Identifying Oil Cooler Inlet Hose
Courtesy of GENERAL MOTORS CORP.

5. If equipped with an oil cooler (RPO-KC4), reposition the upper inlet hose clamp (1).
6. Remove the oil cooler inlet hose from the block outlet.

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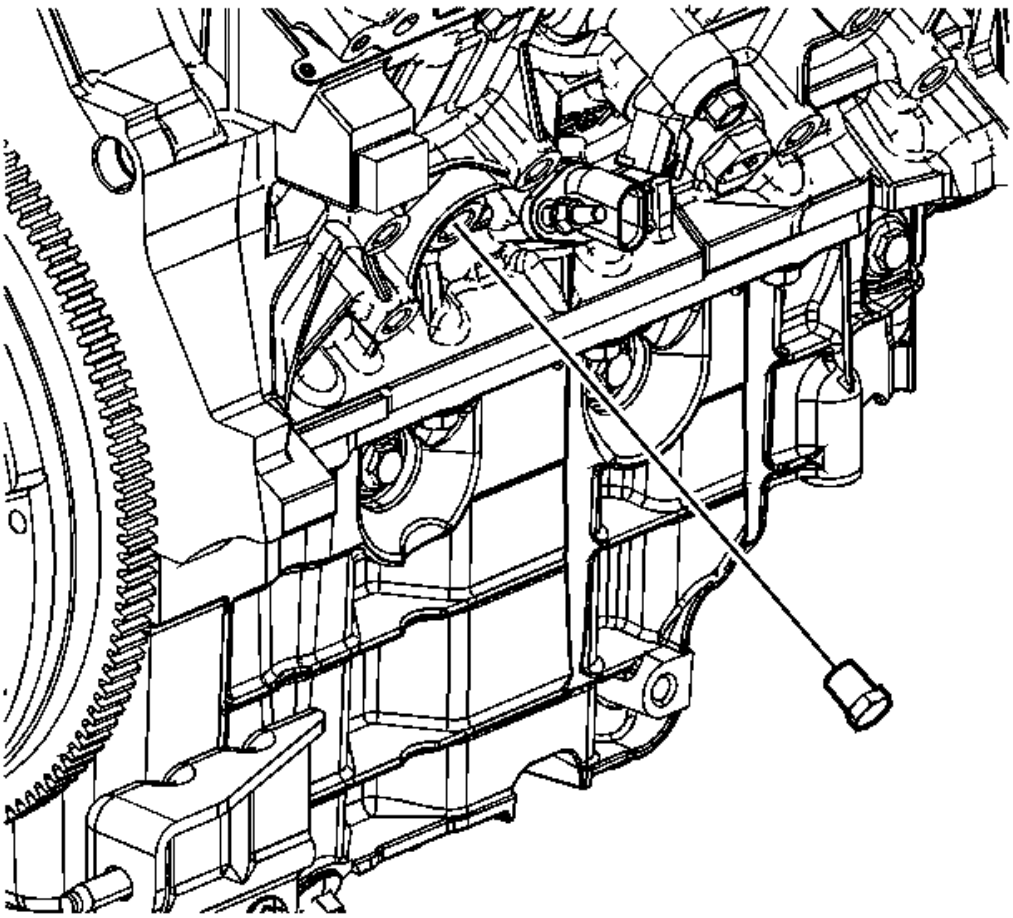

Fig. 261: Identifying Right Side Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

7. If not equipped with an oil cooler (RPO-KC4), remove the coolant drain plug from the right side.
8. Drain the coolant.

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **EN-46539:** Puller End Protector
- **J-41816:** Crankshaft Balancer Remover

Removal

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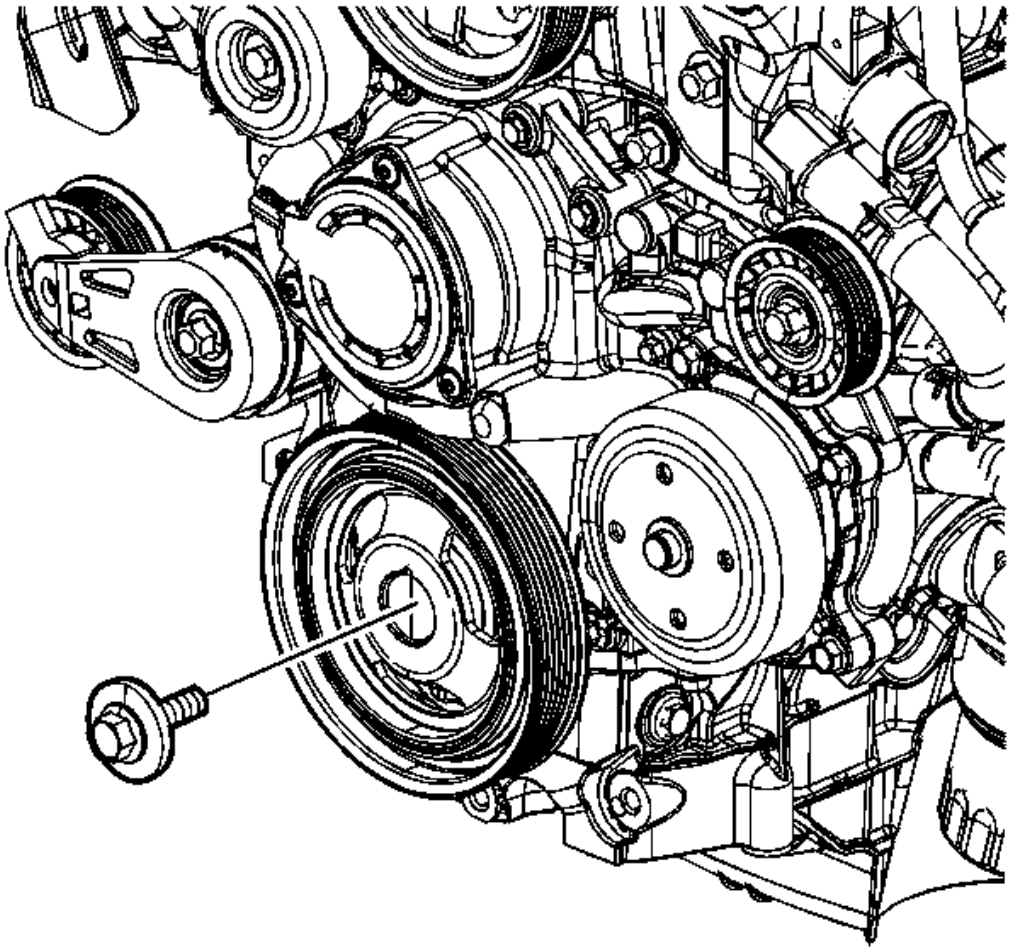

Fig. 262: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt and washer.

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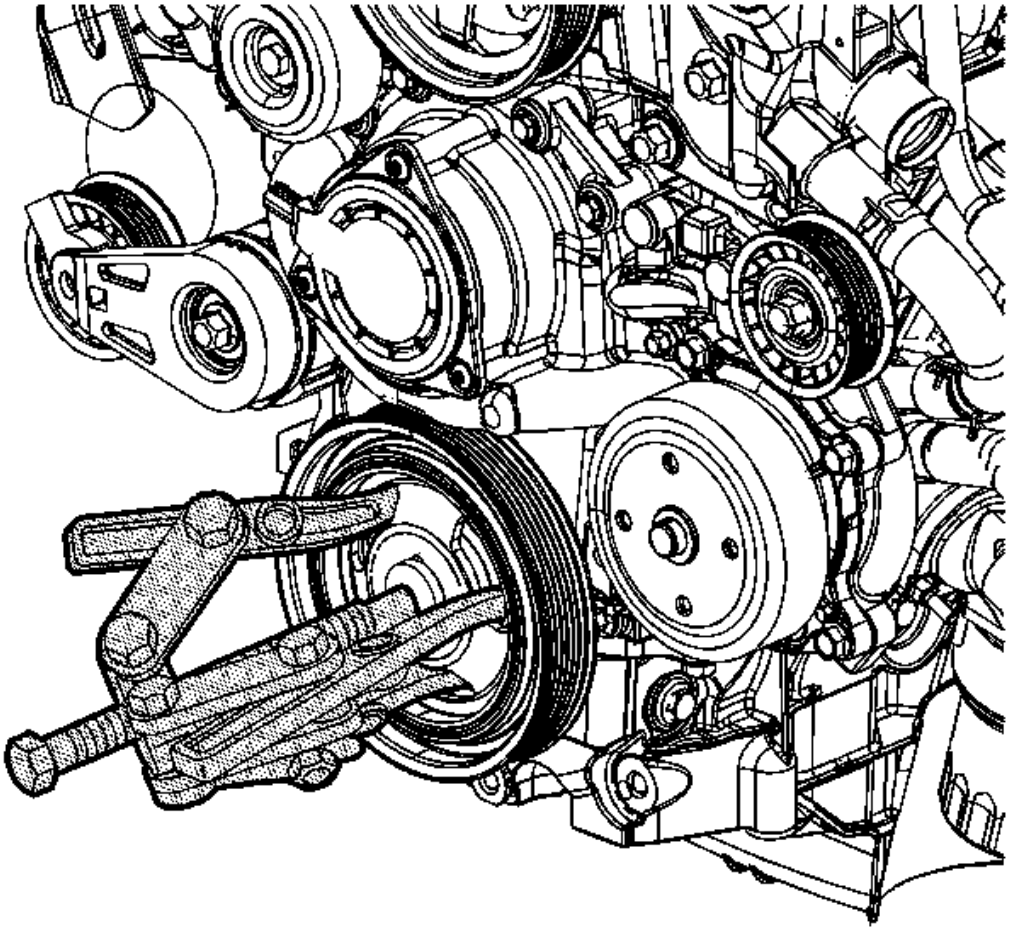

Fig. 263: Identifying Crankshaft Balancer Removing Tool J 41816
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do NOT use a power-assisted tool with the special tool in order to remove or install this component. You cannot properly control the alignment of this component using a power-assisted tool, and this can damage the component.

2. Remove the crankshaft balancer using the **J-41816:** Crankshaft Balancer Remover along with **EN-46539:** Puller End Protector.

ENGINE FLYWHEEL REMOVAL (AUTOMATIC TRANSMISSION)

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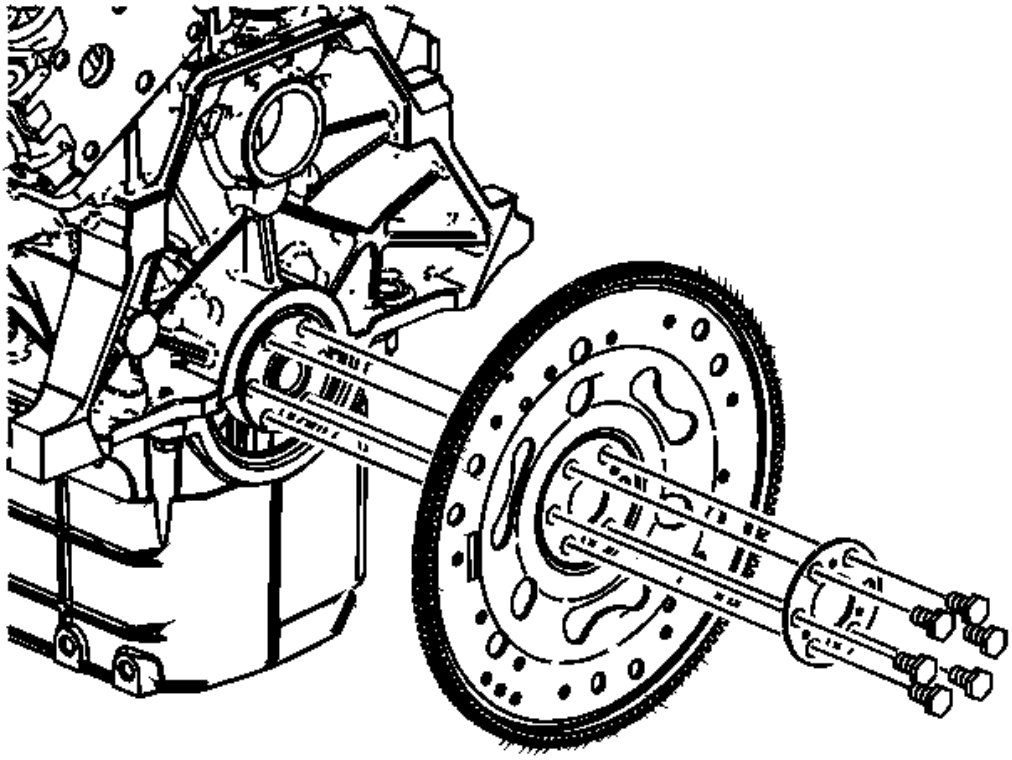

Fig. 264: Identifying Flywheel & Bolts (A/T)
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel bolts.
2. Remove the flywheel.

ENGINE FLYWHEEL REMOVAL (MANUAL TRANSMISSION)

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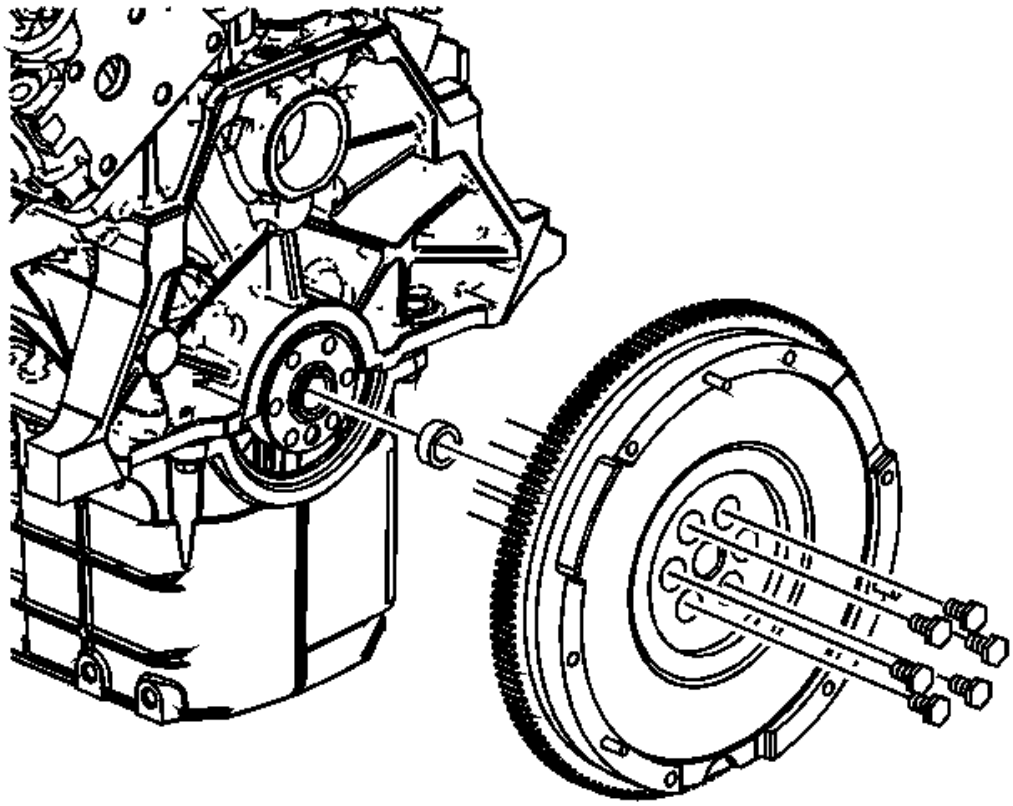

Fig. 265: Identifying Flywheel & Bolts (M/T)
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel/pressure plate bolts.
2. Remove the flywheel/pressure plate.
3. Remove the clutch pilot bearing.

DRIVE BELT TENSIONER REMOVAL

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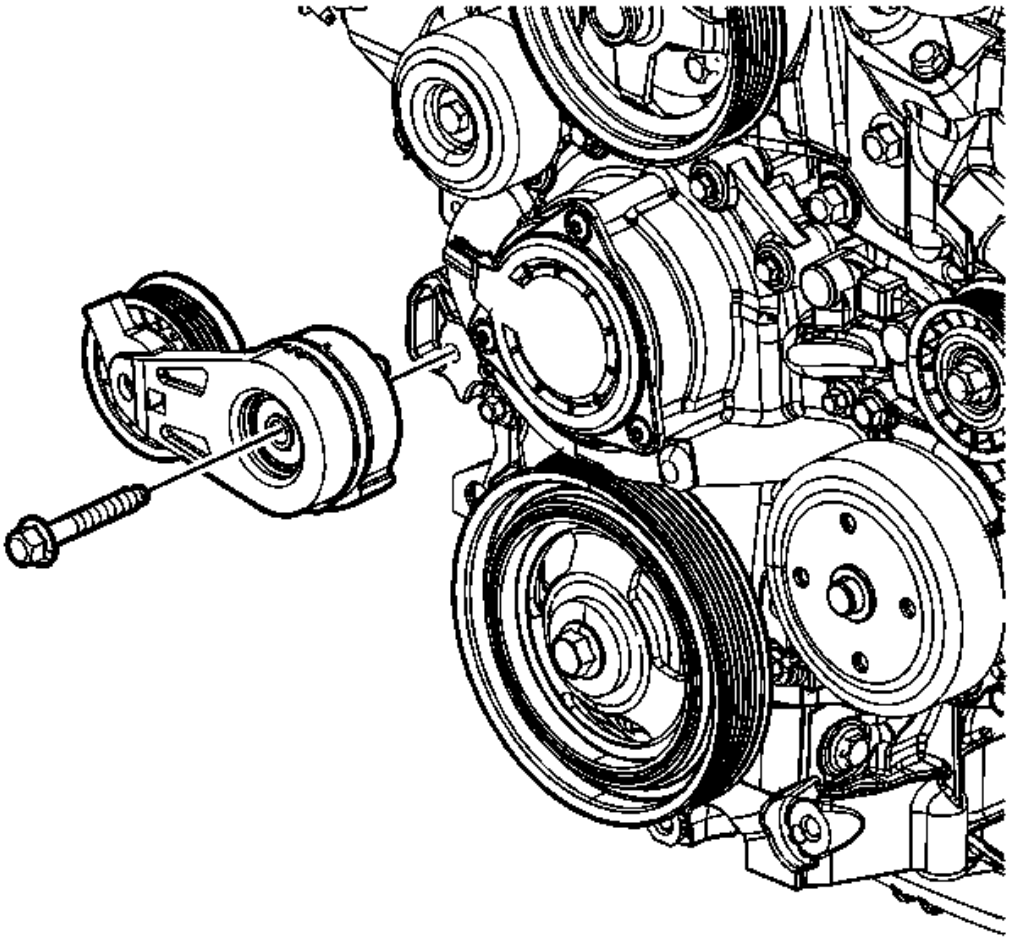

Fig. 266: Identifying Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

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

ENGINE COOLANT CROSSOVER PIPE REMOVAL

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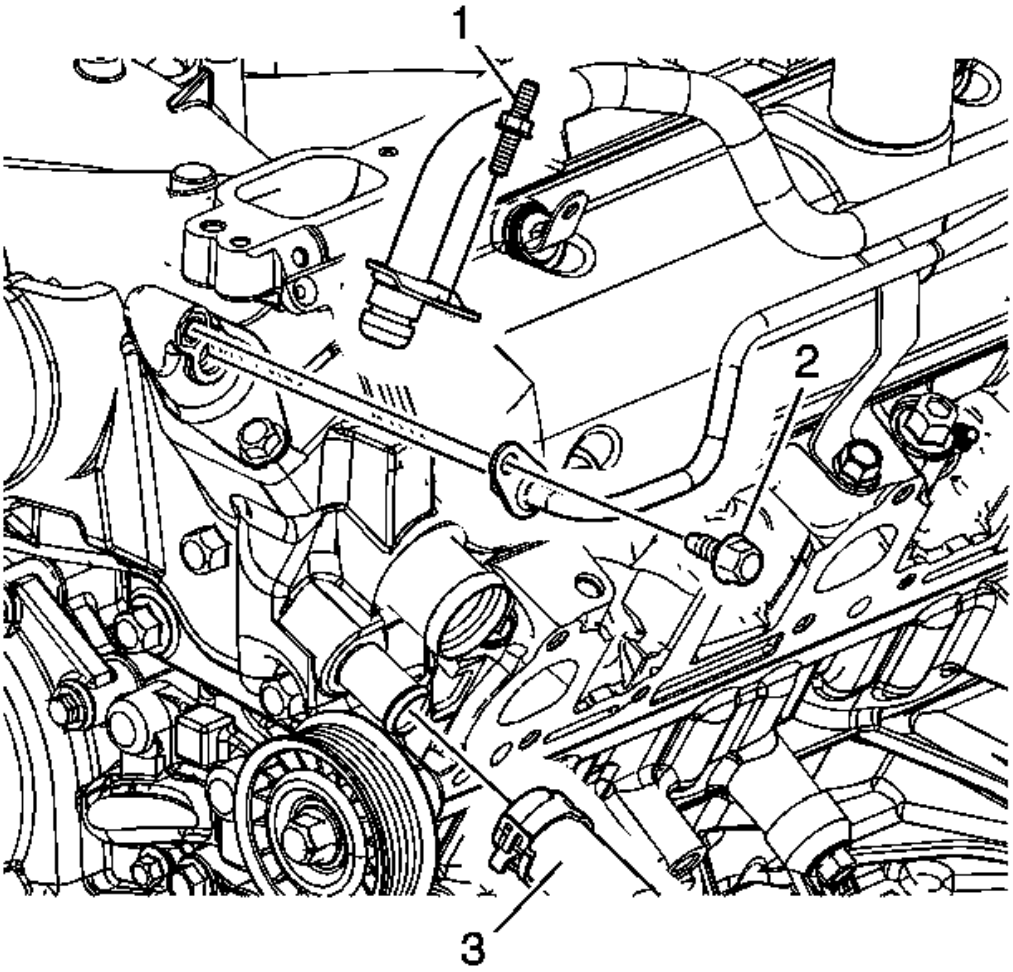

Fig. 267: Identifying Thermal Bypass Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Loosen thermal bypass hose clamp (3) and remove hose from the coolant crossover pipe.
2. Remove the heater inlet/outlet pipe bolt (1) and remove the heater inlet/outlet pipe.
3. Remove the coolant vent pipe bolt (2) and the coolant vent pipe.

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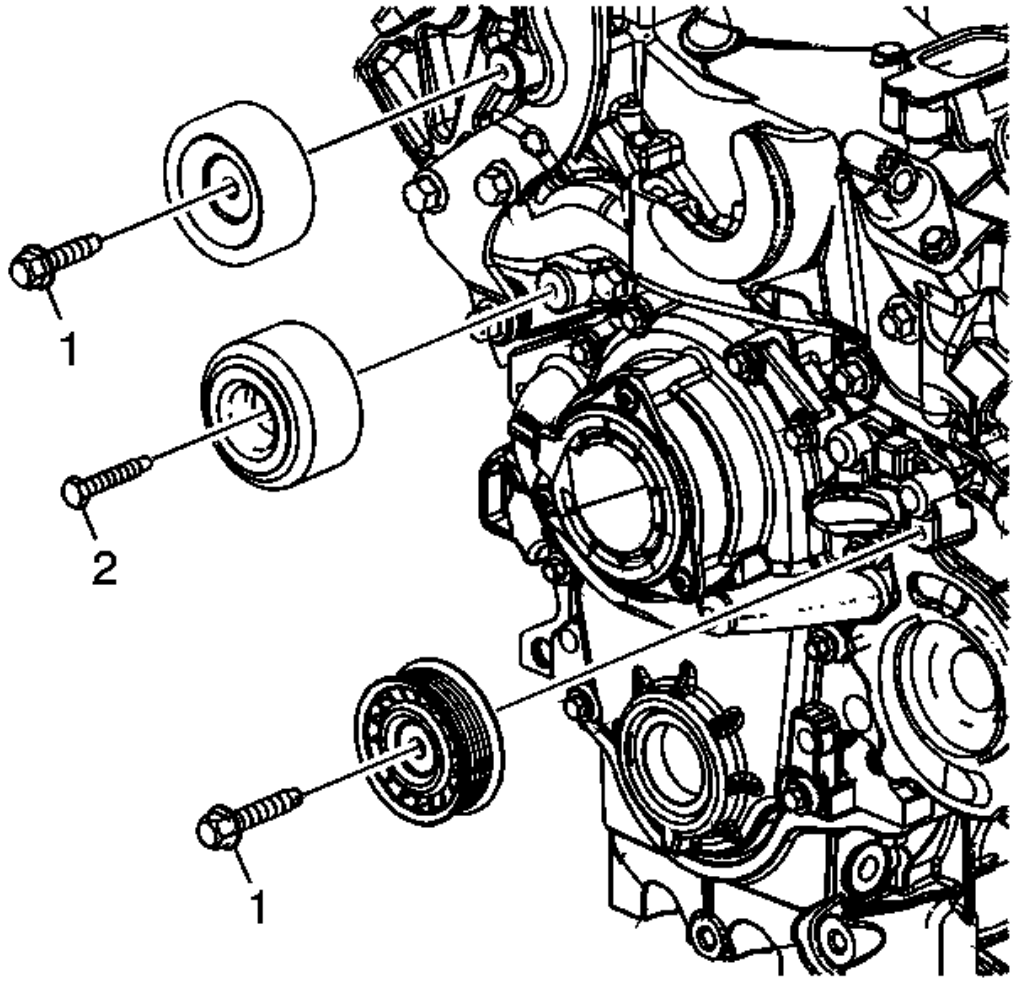

Fig. 268: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

4. Remove the idler pulley bolts and pulleys (1, 2).

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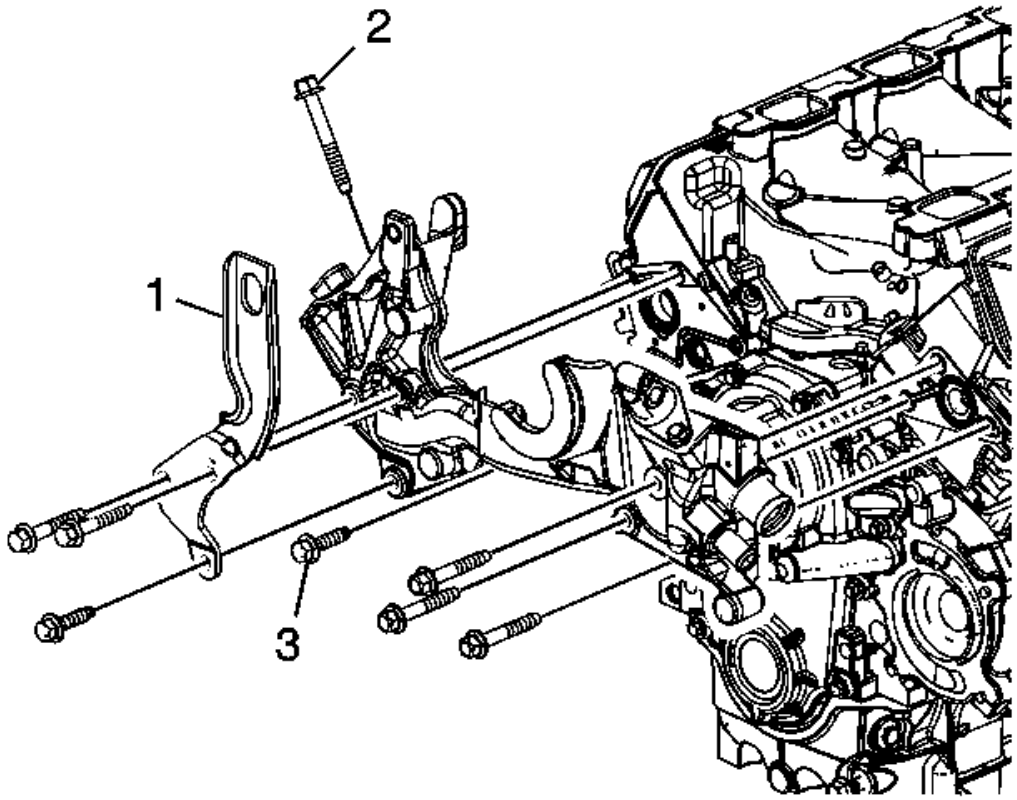

Fig. 269: Identifying Coolant Crossover Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the coolant crossover pipe bolts (2, 3), engine lift bracket (1), and the coolant crossover pipe assembly.

ENGINE LIFT REAR BRACKET REMOVAL

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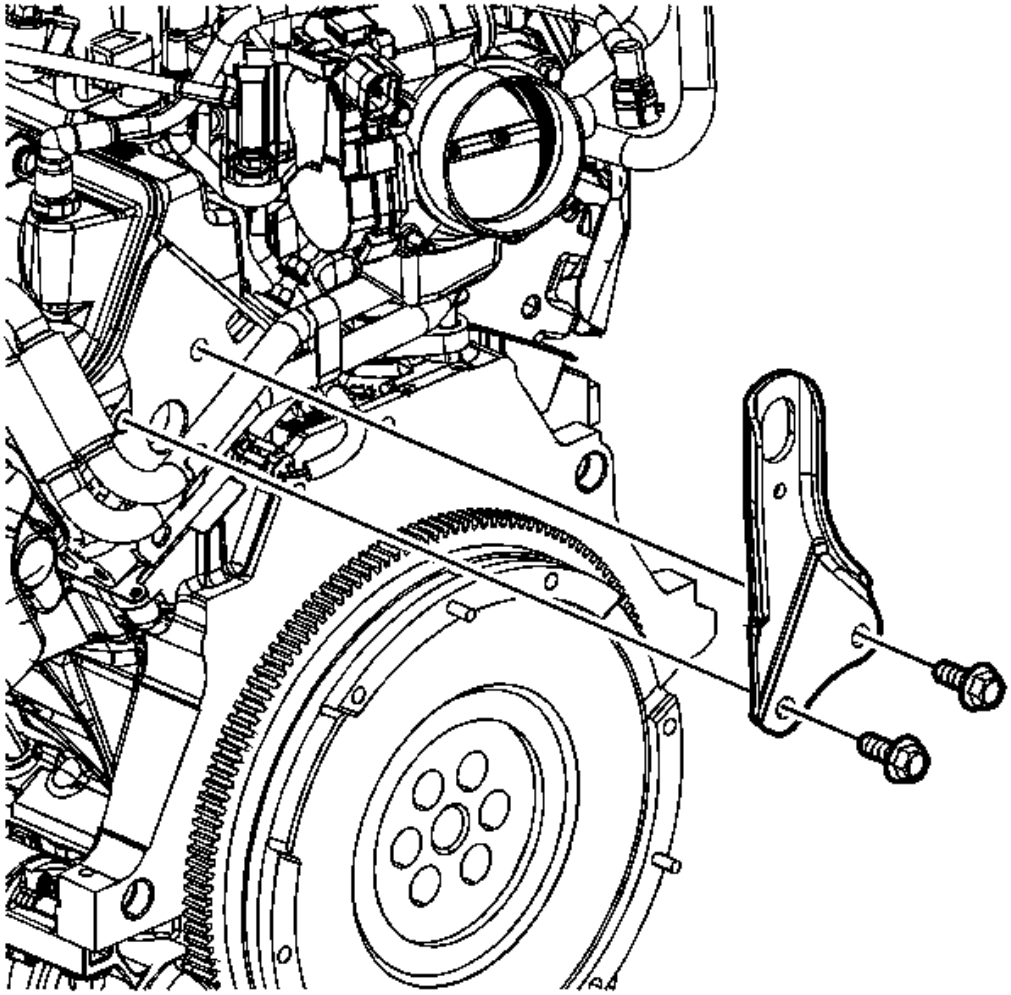

Fig. 270: Identifying Rear Engine Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the rear engine lift bracket bolts.
2. Remove the rear engine lift bracket.

OIL LEVEL INDICATOR AND TUBE REMOVAL

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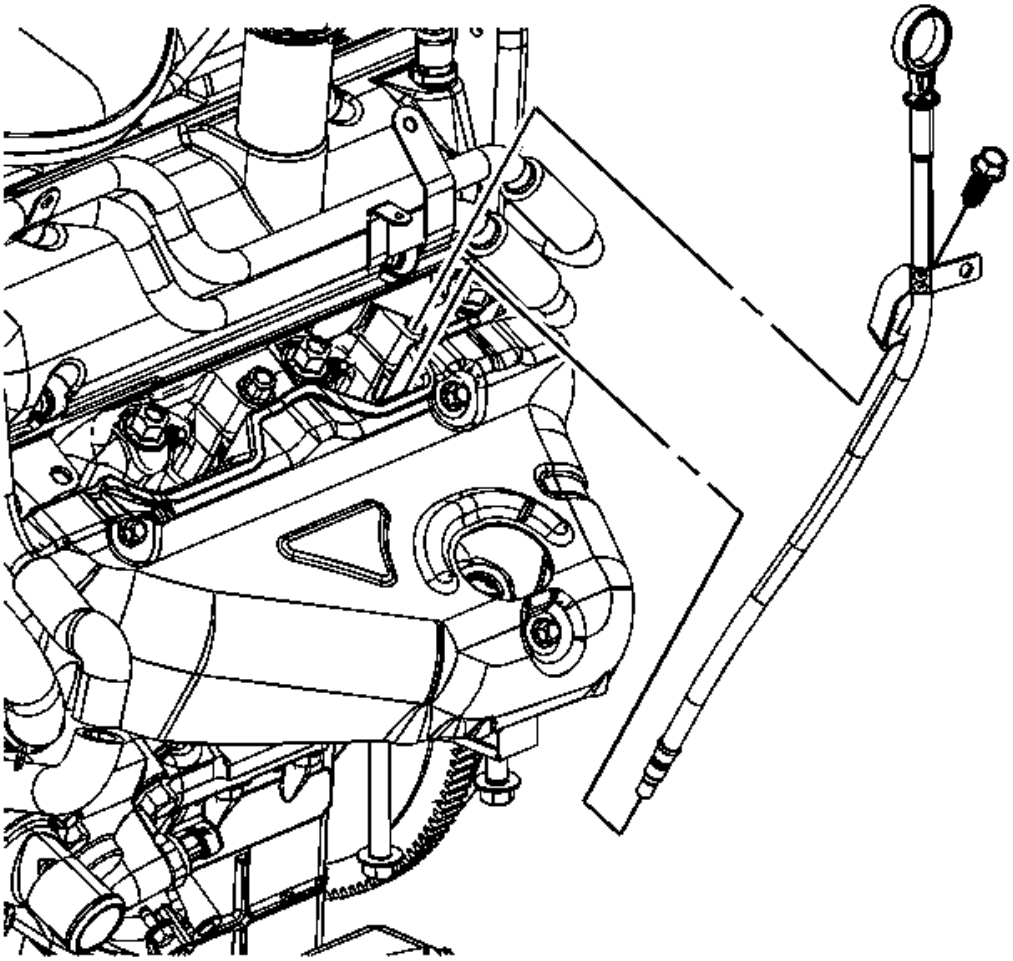

Fig. 271: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator tube bolt.
2. Remove the oil level indicator and oil level indicator tube.

OIL FILTER ADAPTER REMOVAL

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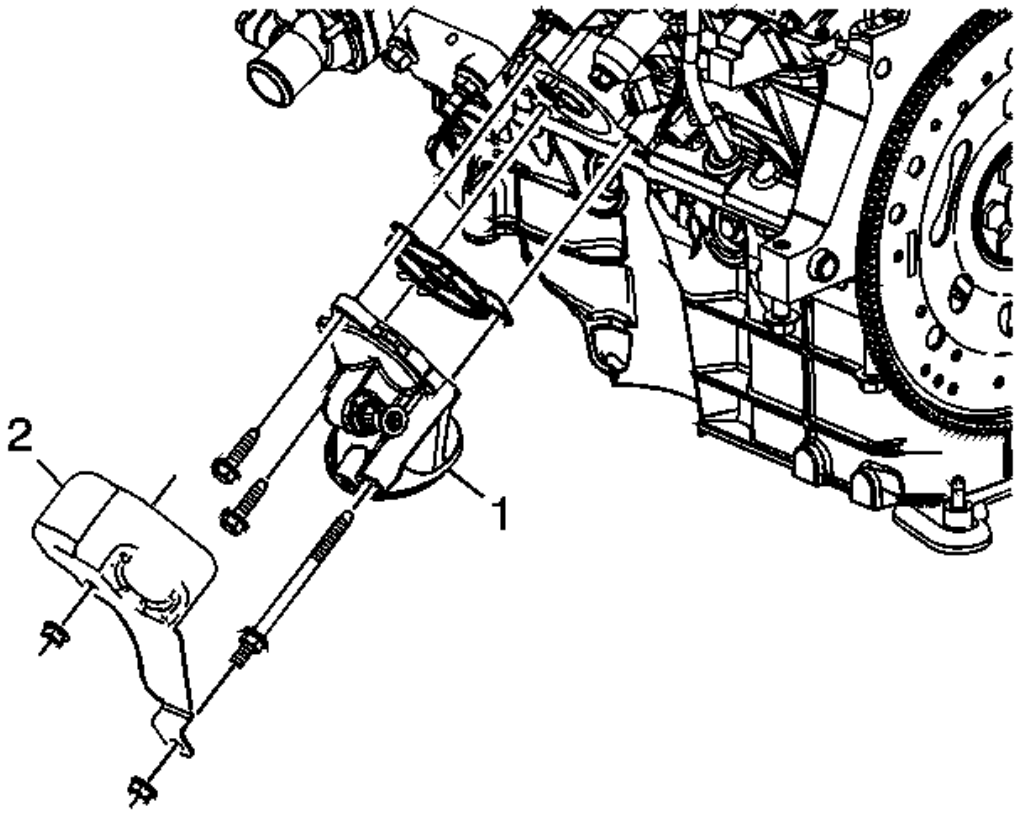

Fig. 272: Identifying Oil Filter Adapter & Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter heat shield nuts.
2. Remove the oil filter adapter heat shield (2).
3. Remove the oil filter adapter bolts.
4. Remove the oil filter adapter (1) and gasket.

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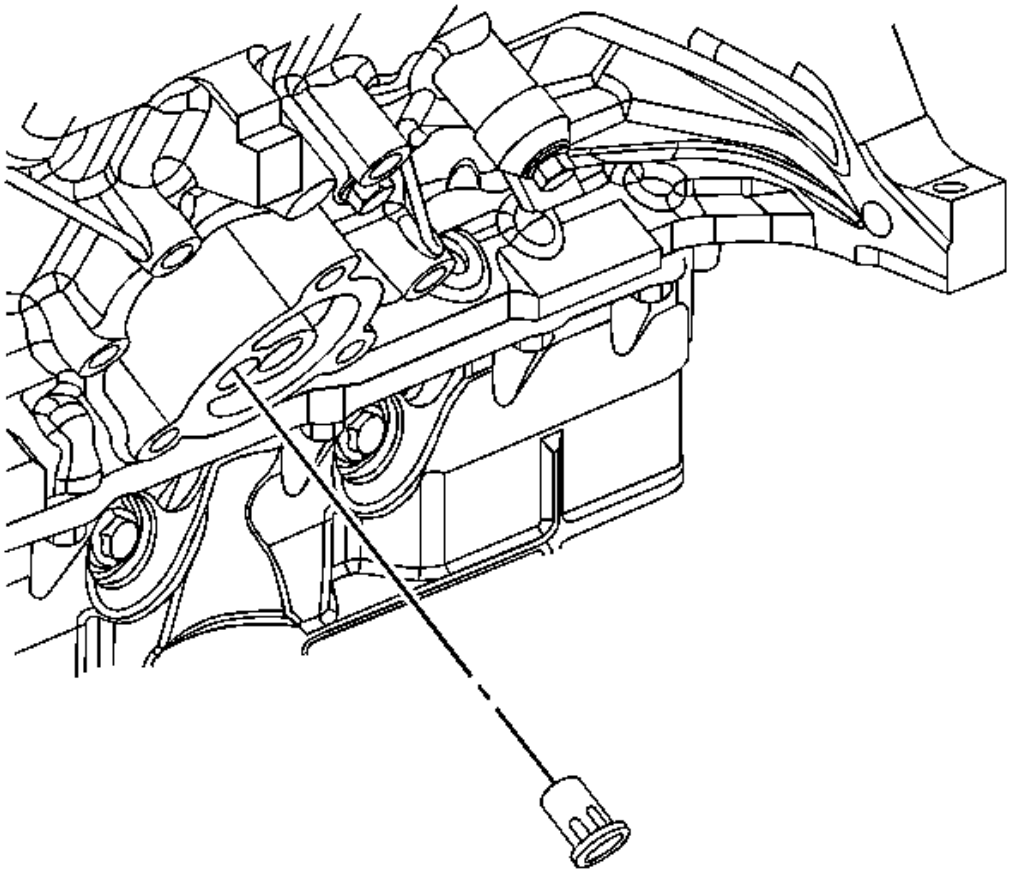

Fig. 273: Locating Oil Filter Bypass Hole & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

5. Insert a flat-bladed tool into the oil filter bypass hole and remove the oil filter bypass valve.

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

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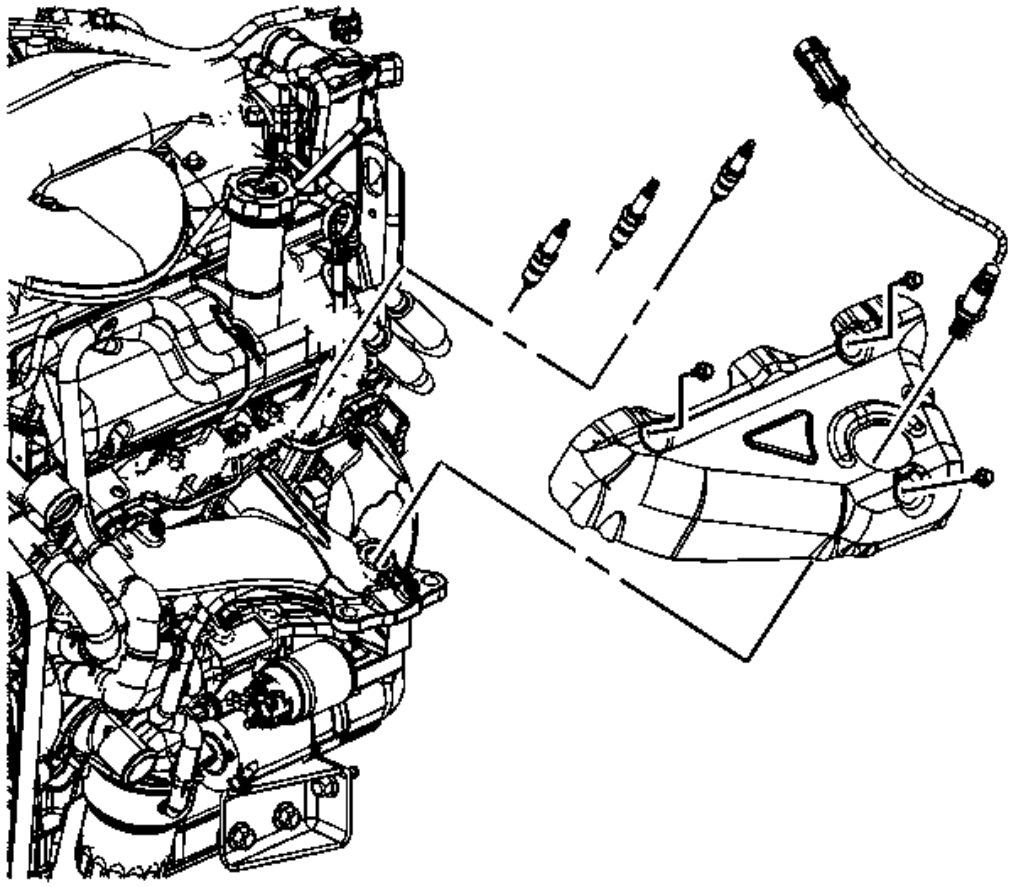

Fig. 274: Identifying Left Exhaust Manifold Heat Shield, Spark Plugs & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the heated oxygen sensor.
2. Remove the spark plug wires from the spark plugs and set aside.
3. Remove the spark plugs.
4. Remove the exhaust manifold heat shield bolts.
5. Remove the exhaust manifold heat shield.

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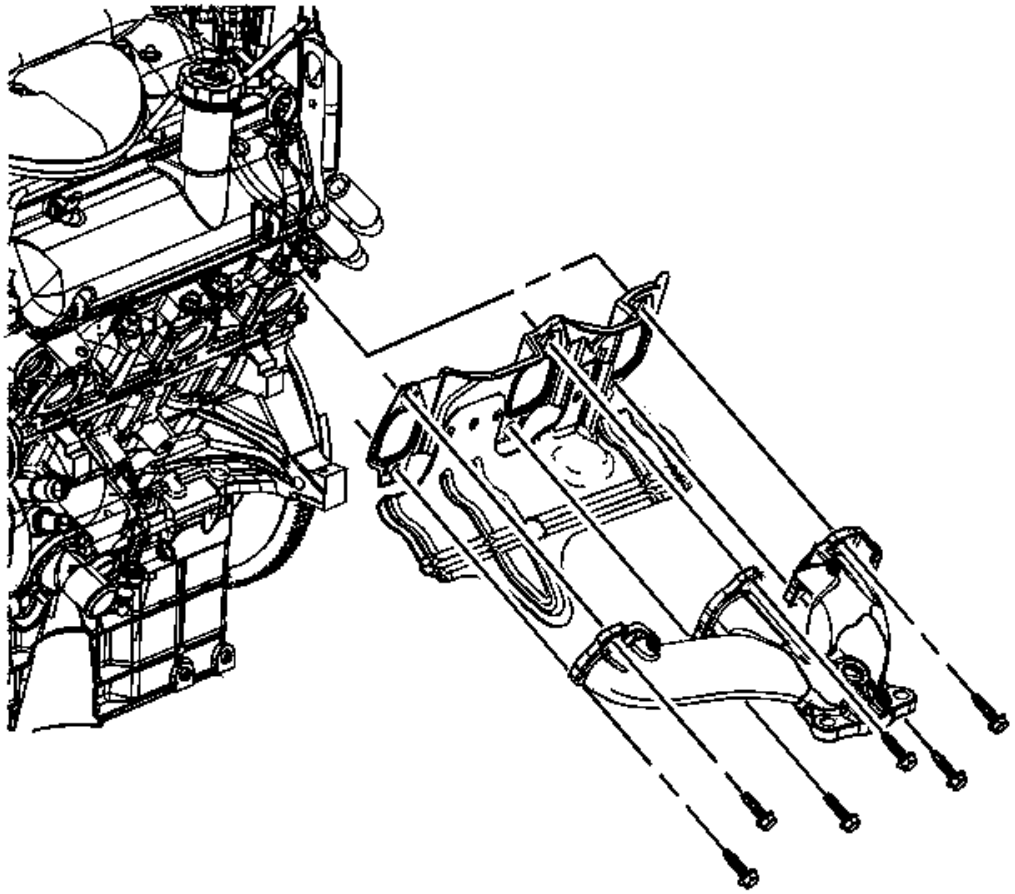

Fig. 275: Identifying Left Exhaust Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the exhaust manifold bolts.
7. Remove the exhaust manifold.
8. Remove the exhaust manifold gasket.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

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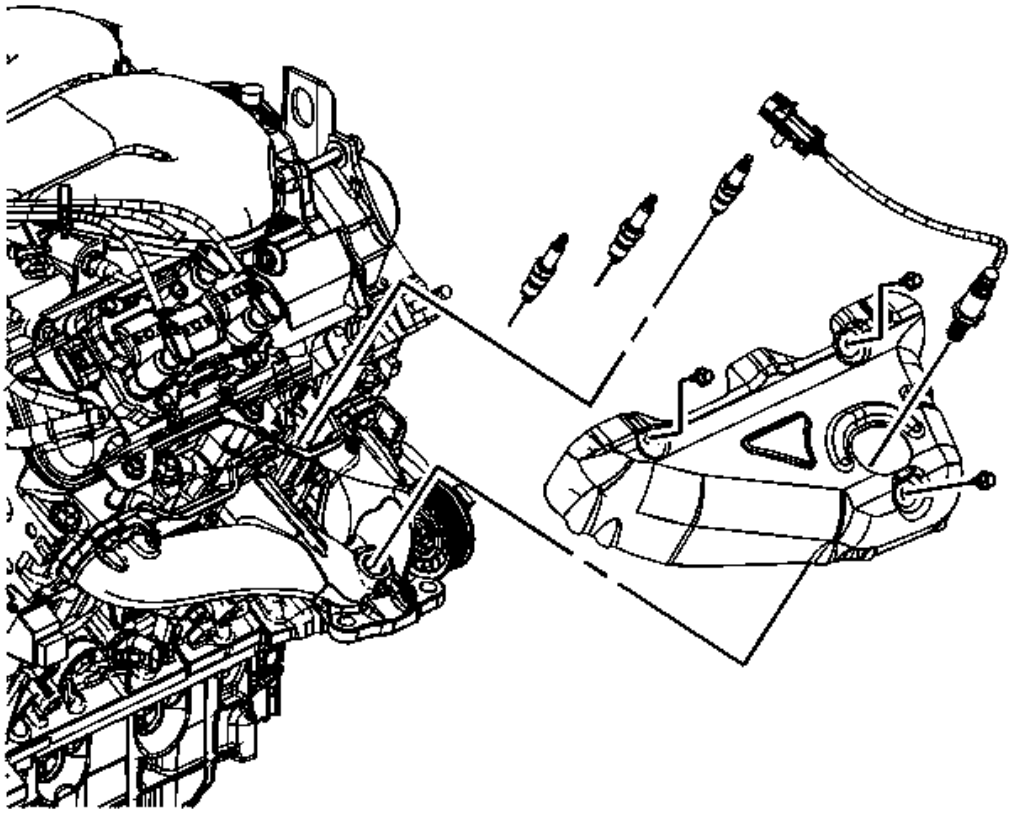

Fig. 276: Identifying Right Side Spark Plugs, HO2S & Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the heated oxygen sensor.
2. Remove the spark plug wires.
3. Remove the spark plugs.
4. Remove the exhaust manifold heat shield bolts.
5. Remove the exhaust manifold heat shields.

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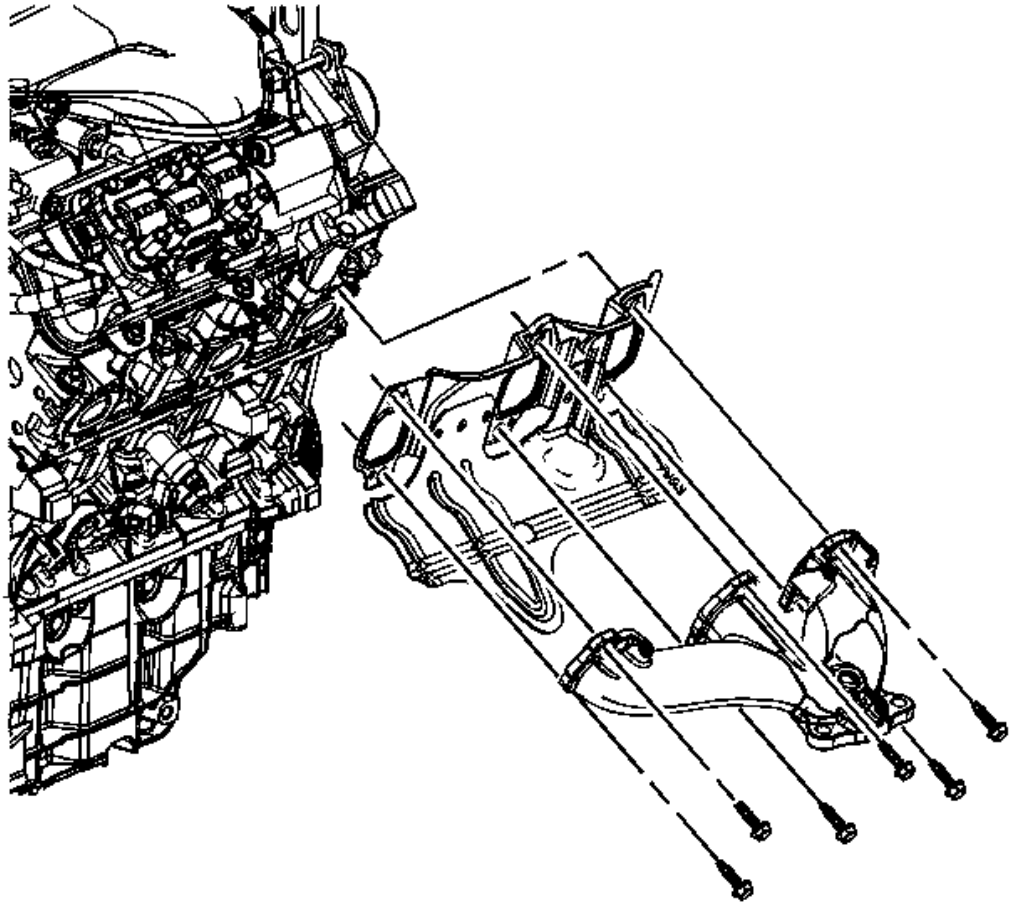

Fig. 277: View Of Right Exhaust manifold, bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the exhaust manifold bolts.
7. Remove the exhaust manifold.
8. Remove the exhaust manifold gasket.

WATER INLET AND ENGINE COOLANT THERMOSTAT REMOVAL

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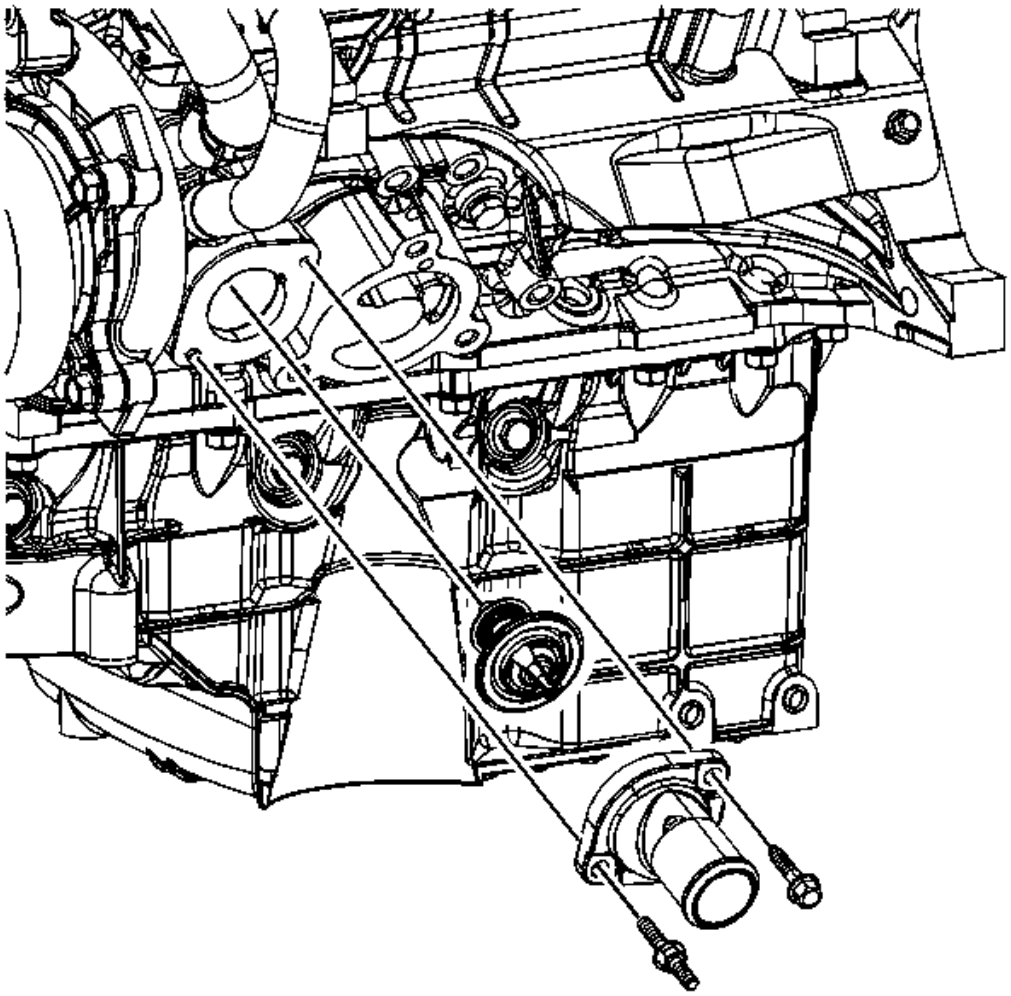

Fig. 278: Identifying Thermostat Housing & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

1. Remove the water inlet bolts.
2. Remove the water inlet.
3. Remove the thermostat.

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

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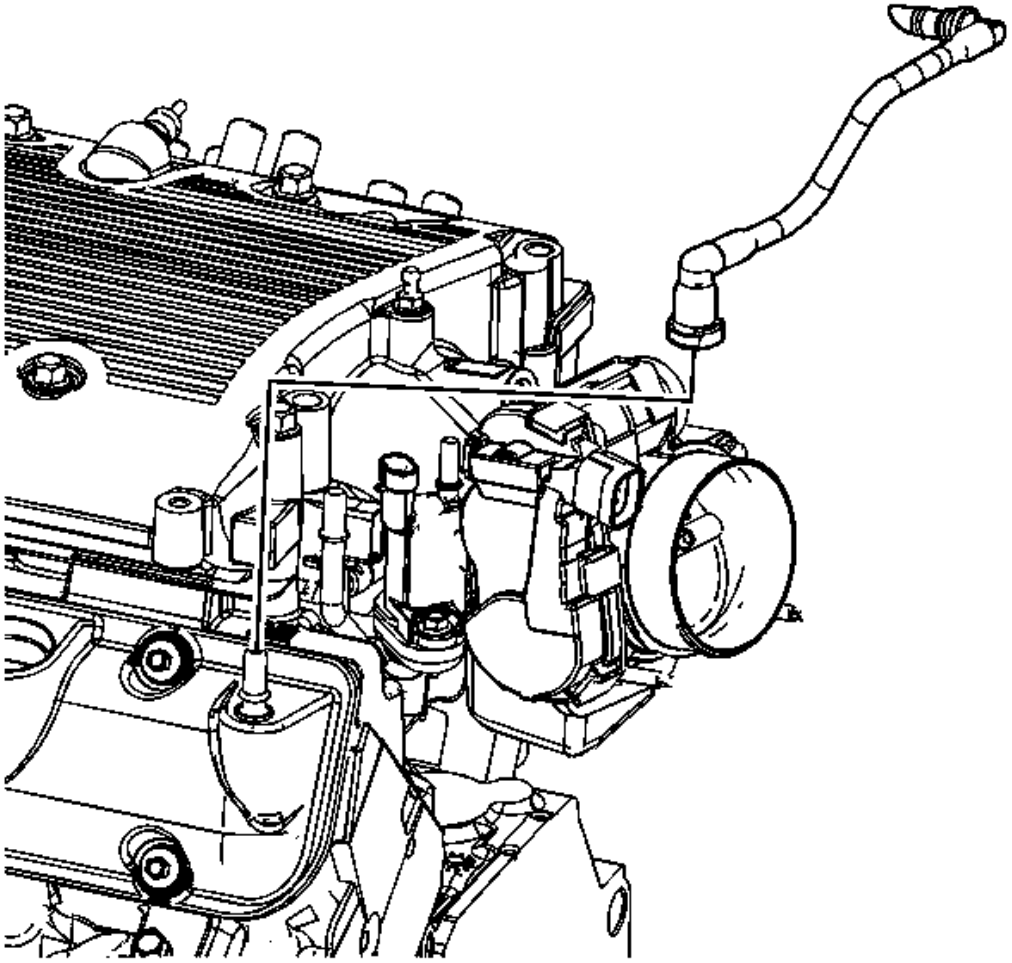

Fig. 279: Positive Crankcase Ventilation (PCV) Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the positive crankcase ventilation (PCV) tube.

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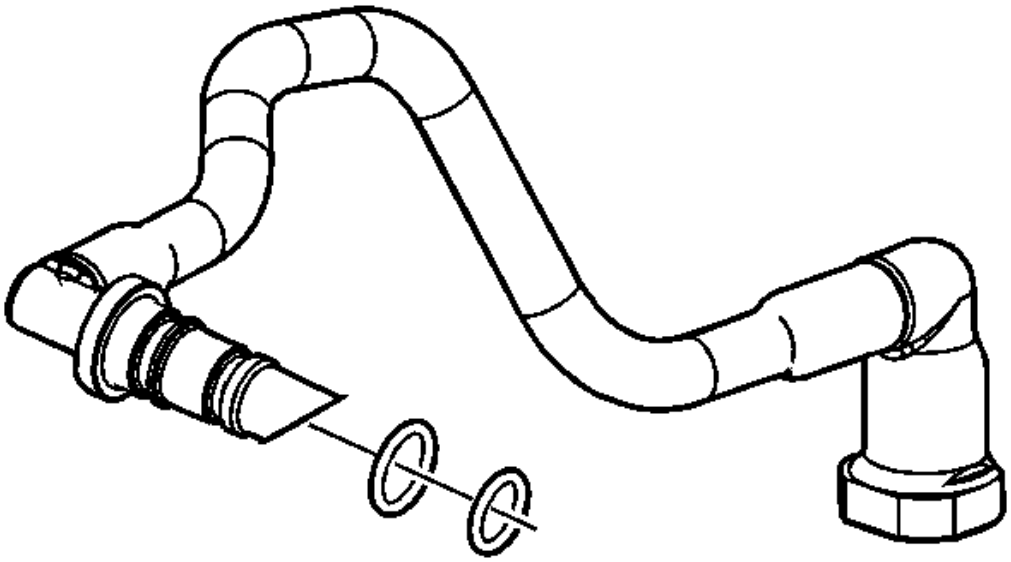

Fig. 280: Identifying PCV Tube O-Rings
Courtesy of GENERAL MOTORS CORP.

2. Remove and discard both PCV tube O-rings.

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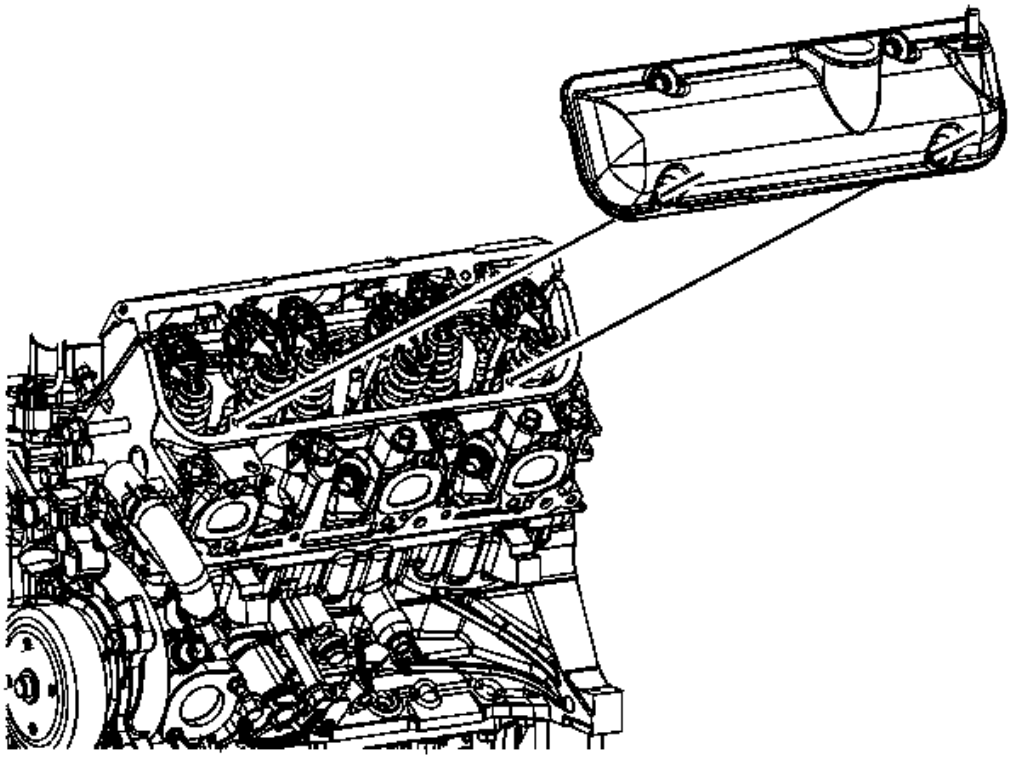

Fig. 281: Identifying Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm cover bolts.

IMPORTANT: When removing the valve rocker arm cover make sure the gasket stays in place attached to the cylinder head.

4. Remove the valve rocker arm cover.
5. Cut the room temperature vulcanizing (RTV) in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
6. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

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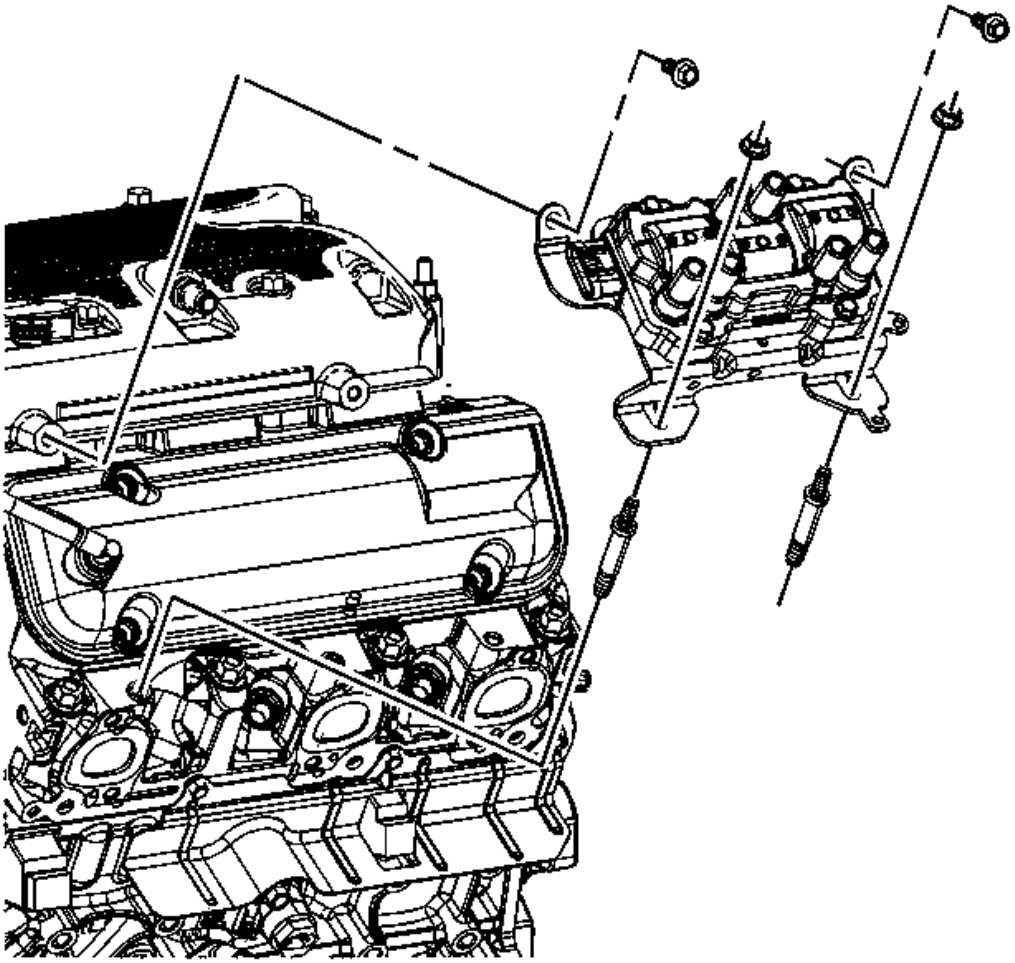

Fig. 282: Identifying Ignition Coil Assembly Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove any remaining spark plug wires from their retainers.
2. Remove the ignition coil assembly bolts and nuts.
3. Remove the ignition coil assembly.
4. Remove the ignition coil assembly studs, if necessary.

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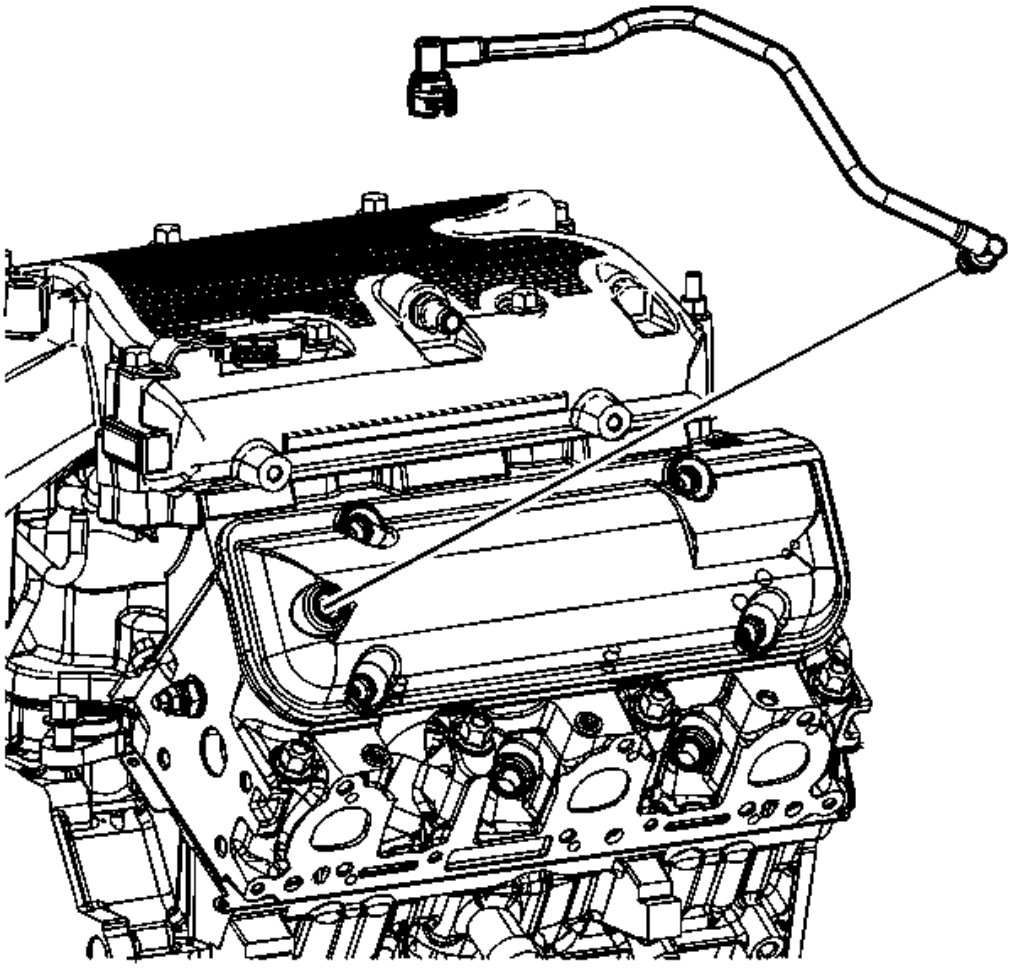

Fig. 283: Identifying Fresh Air Tube & Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

5. Remove the fresh air tube from the valve rocker arm cover.

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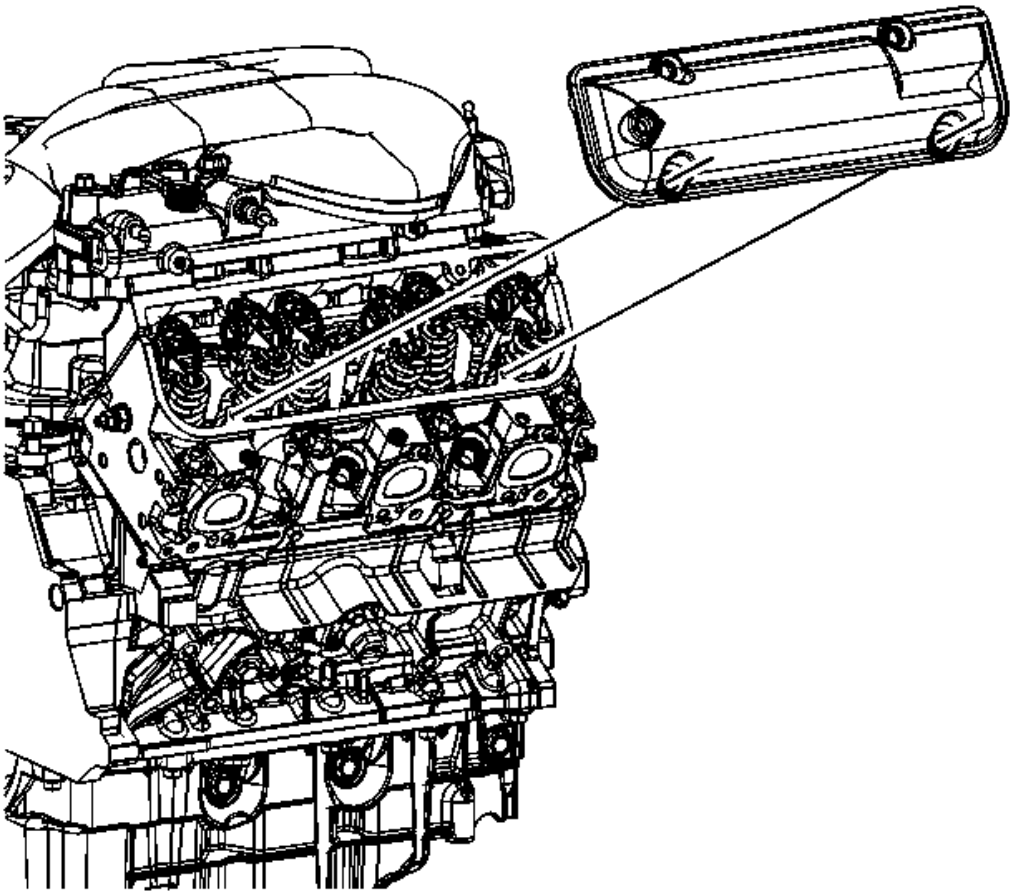

Fig. 284: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts.

IMPORTANT: When removing the valve rocker arm cover make sure the gasket stays in place attached to the cylinder head.

7. Remove the valve rocker arm cover.
8. Cut the room temperature vulcanizing (RTV) in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
9. Remove and discard the valve rocker arm cover gasket, valve rocker arm cover grommets and valve rocker arm cover bolts if they are serviced with the grommet.

UPPER INTAKE MANIFOLD REMOVAL

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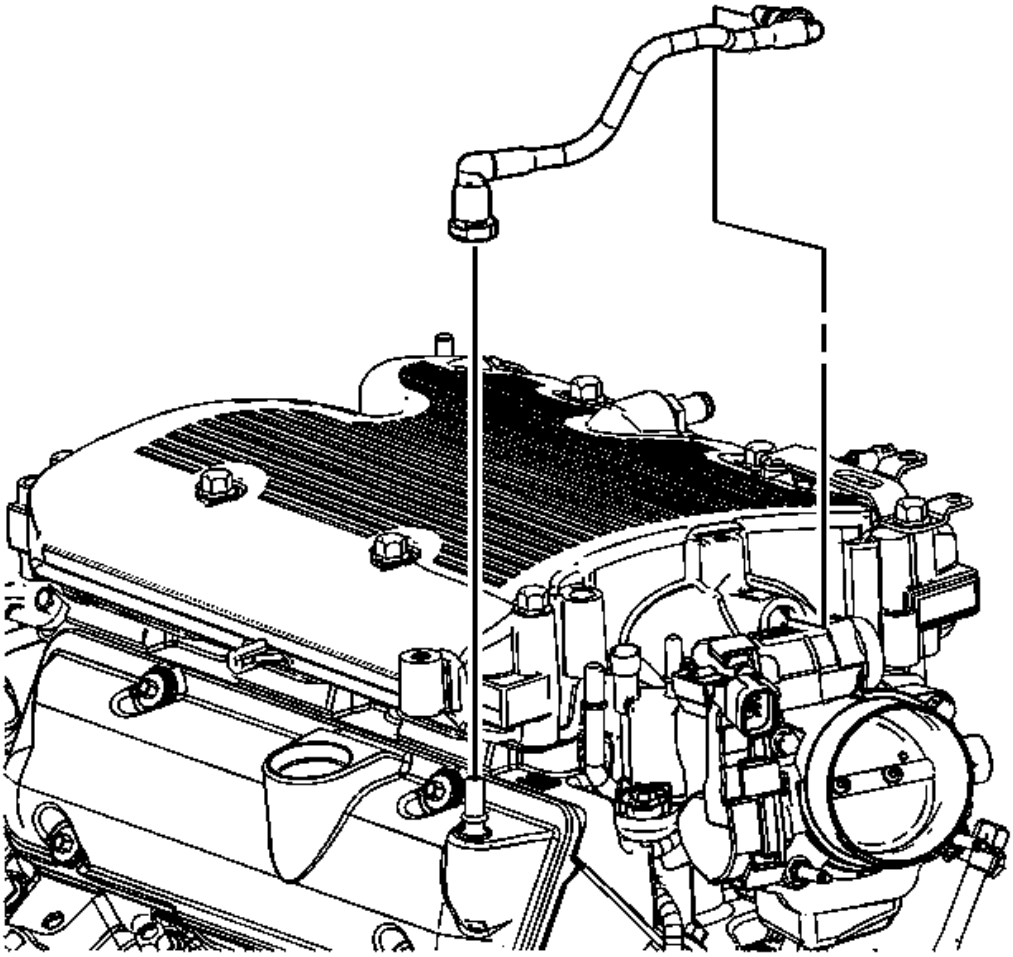

Fig. 285: Identifying Crankcase Ventilation (PCV) Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the foul air positive crankcase ventilation (PCV) tube.

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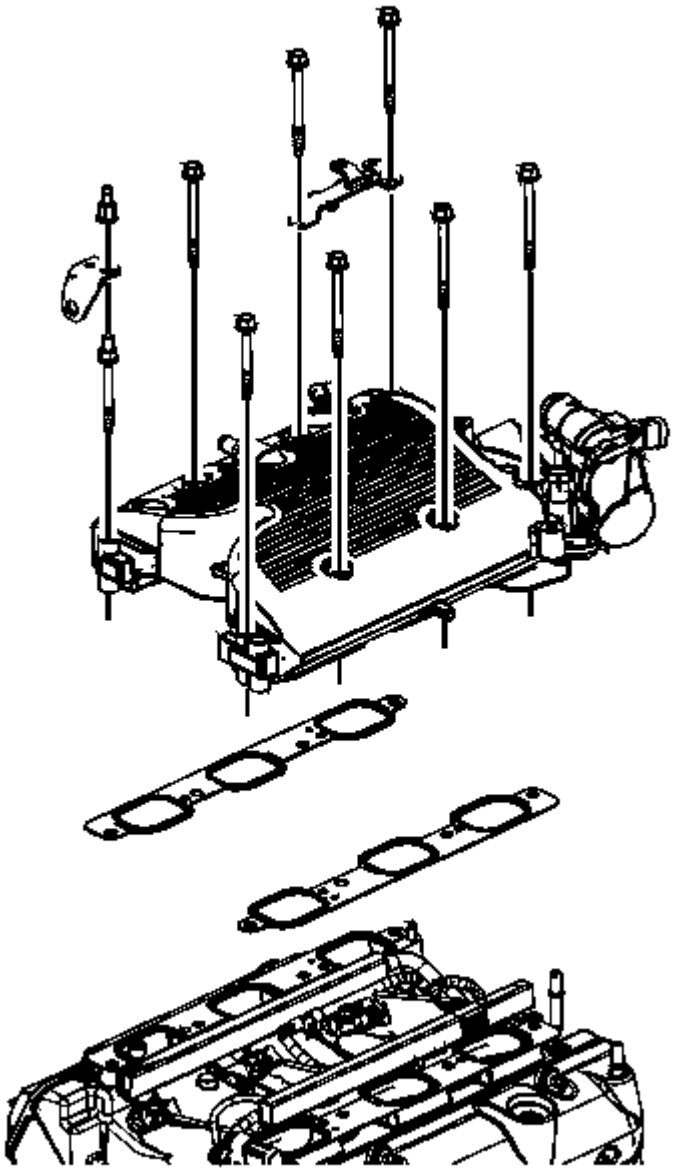

Fig. 286: View Of Upper Intake Manifold, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper intake manifold bolts, stud, and manifold absolute pressure (MAP) sensor bracket.
3. Remove the upper intake manifold and gaskets.

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LOWER INTAKE MANIFOLD REMOVAL

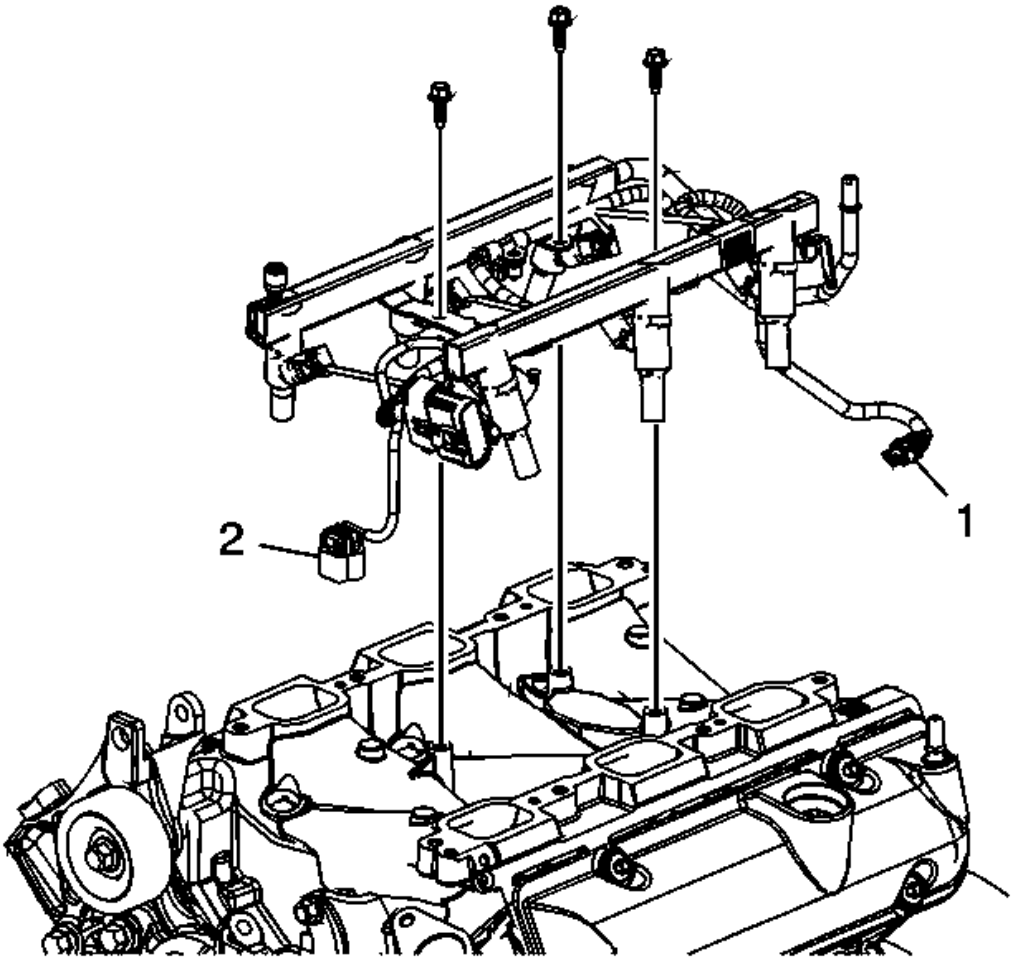

Fig. 287: Identifying Lower Intake Manifold Attachments
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the coolant temperature sensor (1).
2. Disconnect the camshaft position (CMP) sensor (2).
3. Remove the fuel injector rail bolts.
4. Remove the fuel rail assembly.

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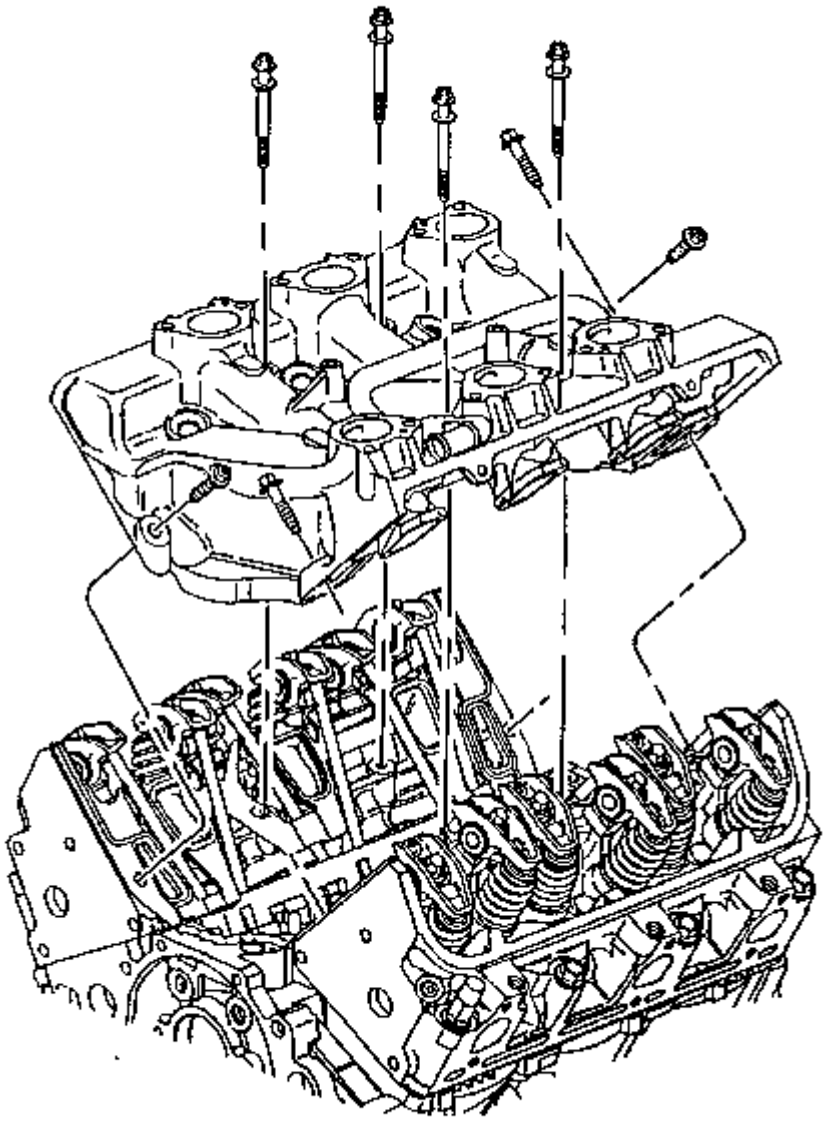

Fig. 288: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the lower intake manifold bolts and discard.
6. Remove the lower intake manifold.

VALVE ROCKER ARM AND PUSH ROD REMOVAL

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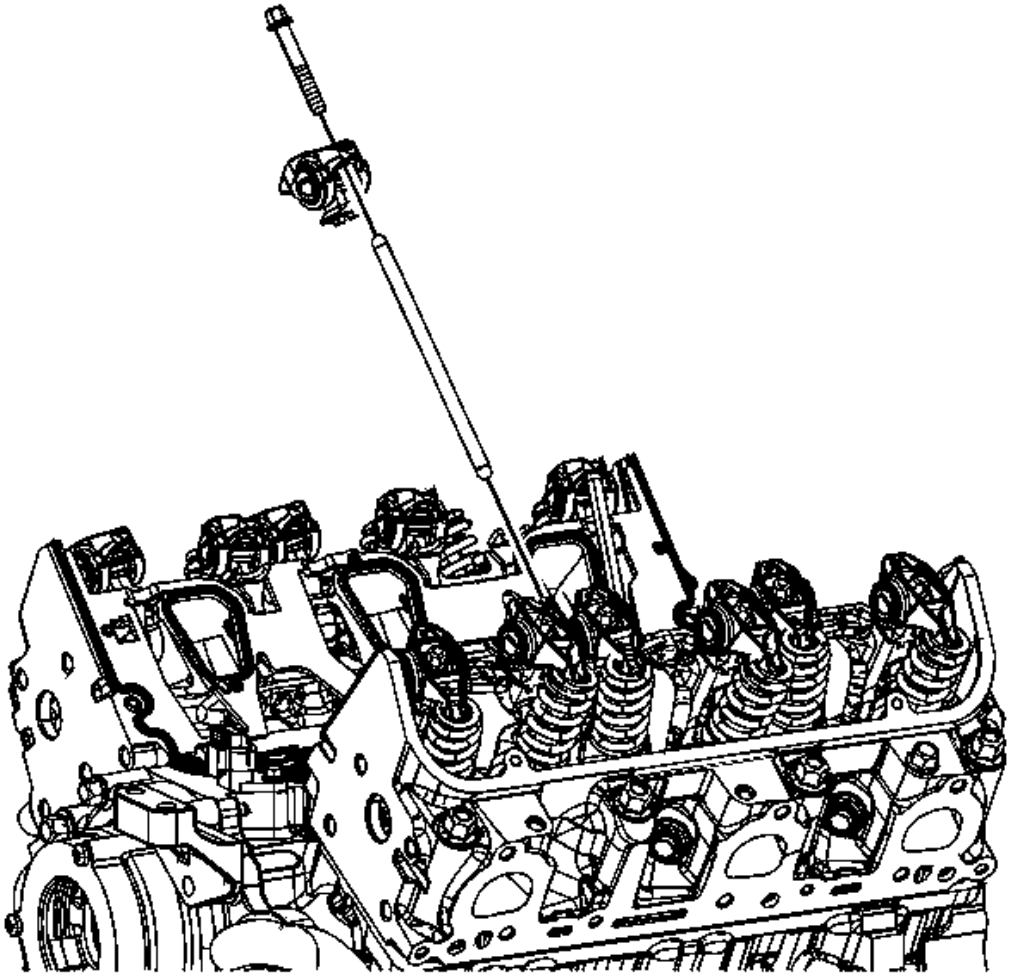

Fig. 289: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Loosen the valve rocker arm bolts.

IMPORTANT: Place the valve train components in a rack in order to ensure that the components are installed in the same location from which they where removed.

2. Remove the valve rocker arms.
3. Remove the push rods.
   - The intake push rods measure 147.51 mm (5.81 in).

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- The exhaust push rods measure 154.87 mm (6.1 in).

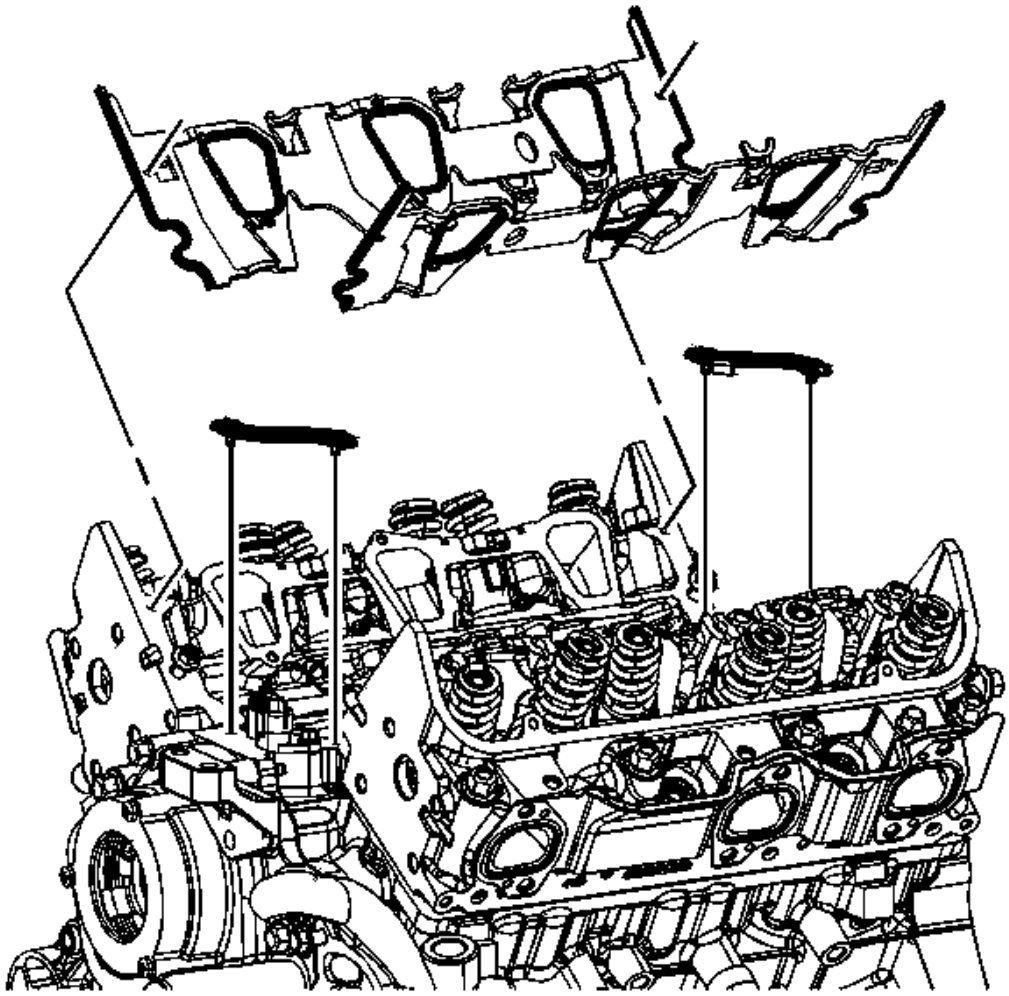

Fig. 290: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold gaskets.

VALVE LIFTER REMOVAL

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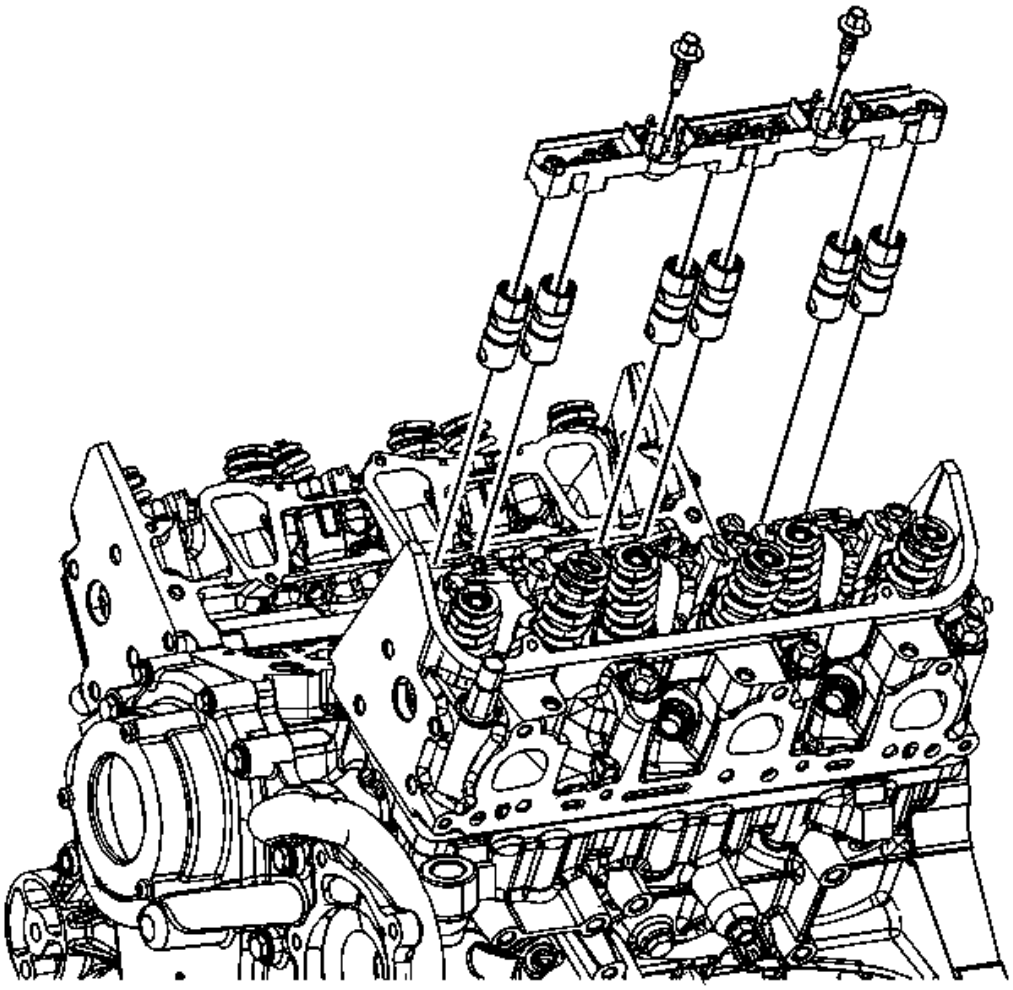

Fig. 291: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve lifter guide bolts.
2. Remove the valve lifter guides.

IMPORTANT: Once removed, place the valve lifters in an organized order so the valve lifters can be installed into the original locations.

3. Remove the valve lifters.

WATER PUMP REMOVAL

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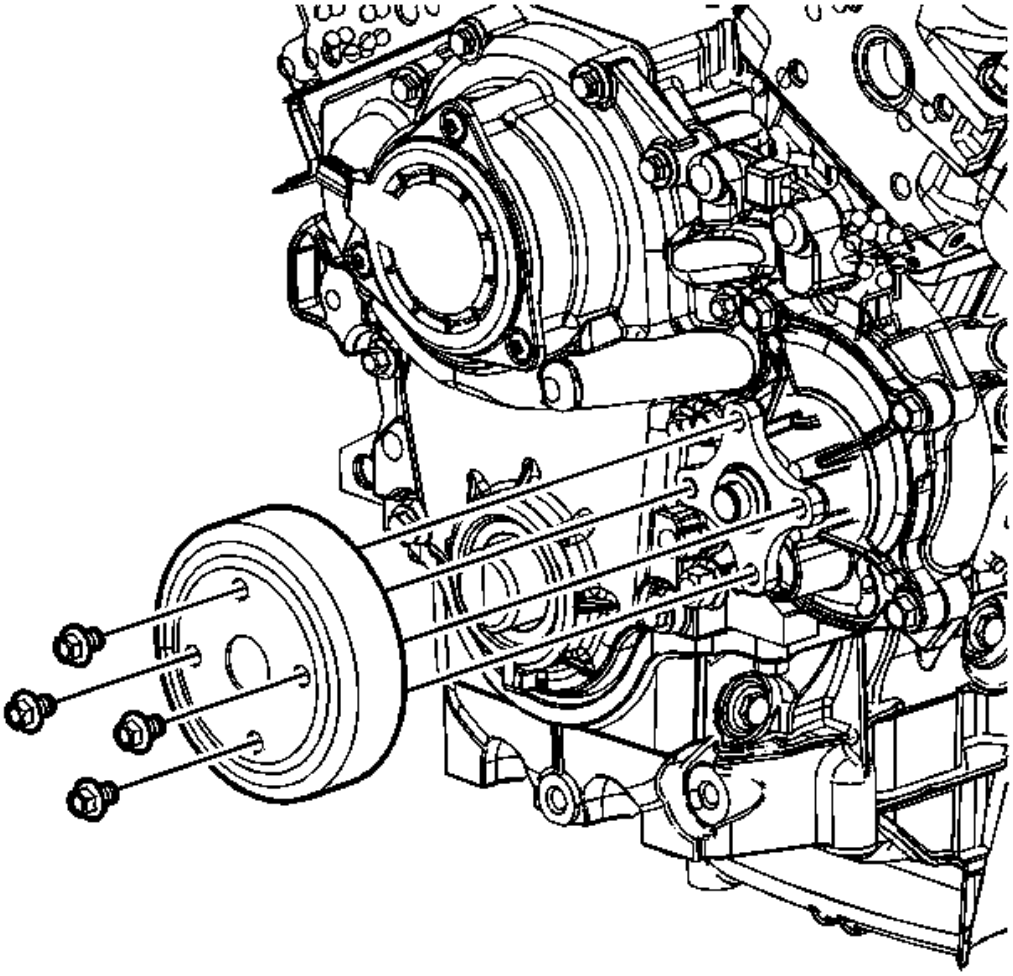

Fig. 292: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump pulley bolts.
2. Remove the water pump pulley.

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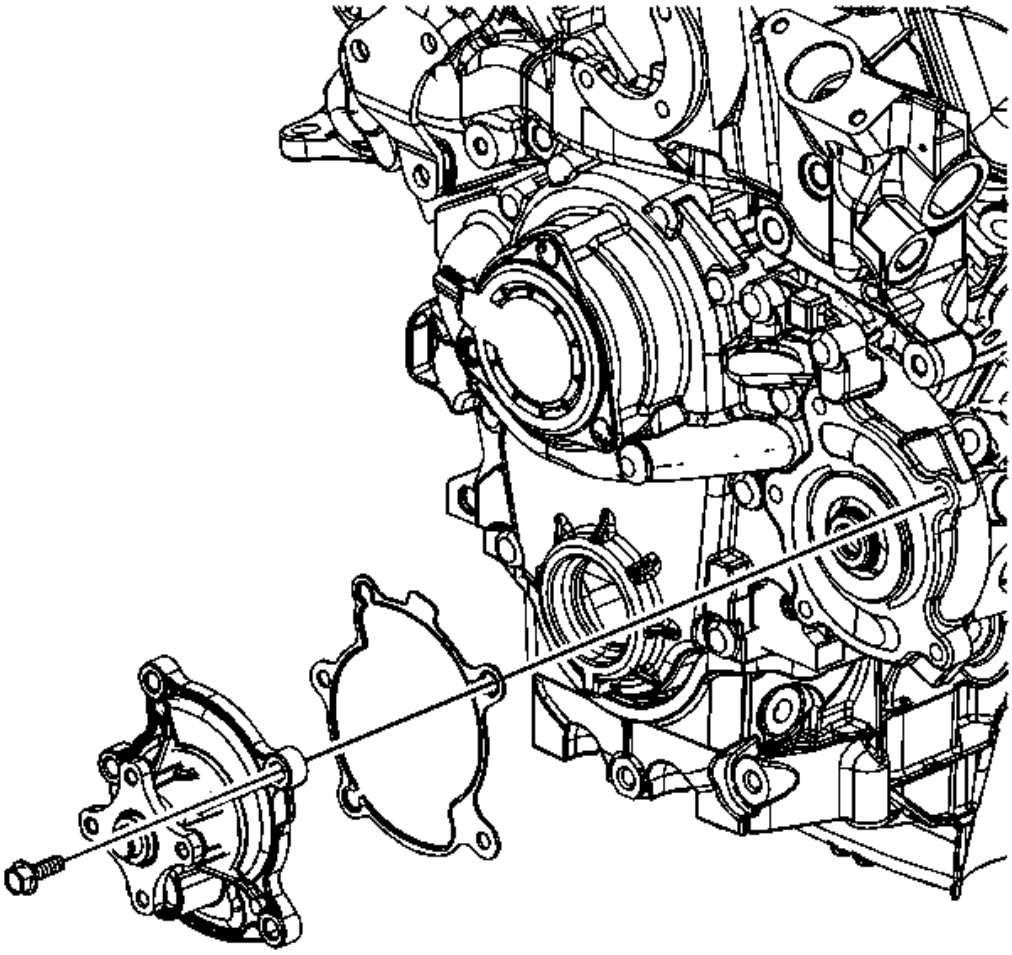

Fig. 293: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gasket.

CYLINDER HEAD REMOVAL - LEFT SIDE

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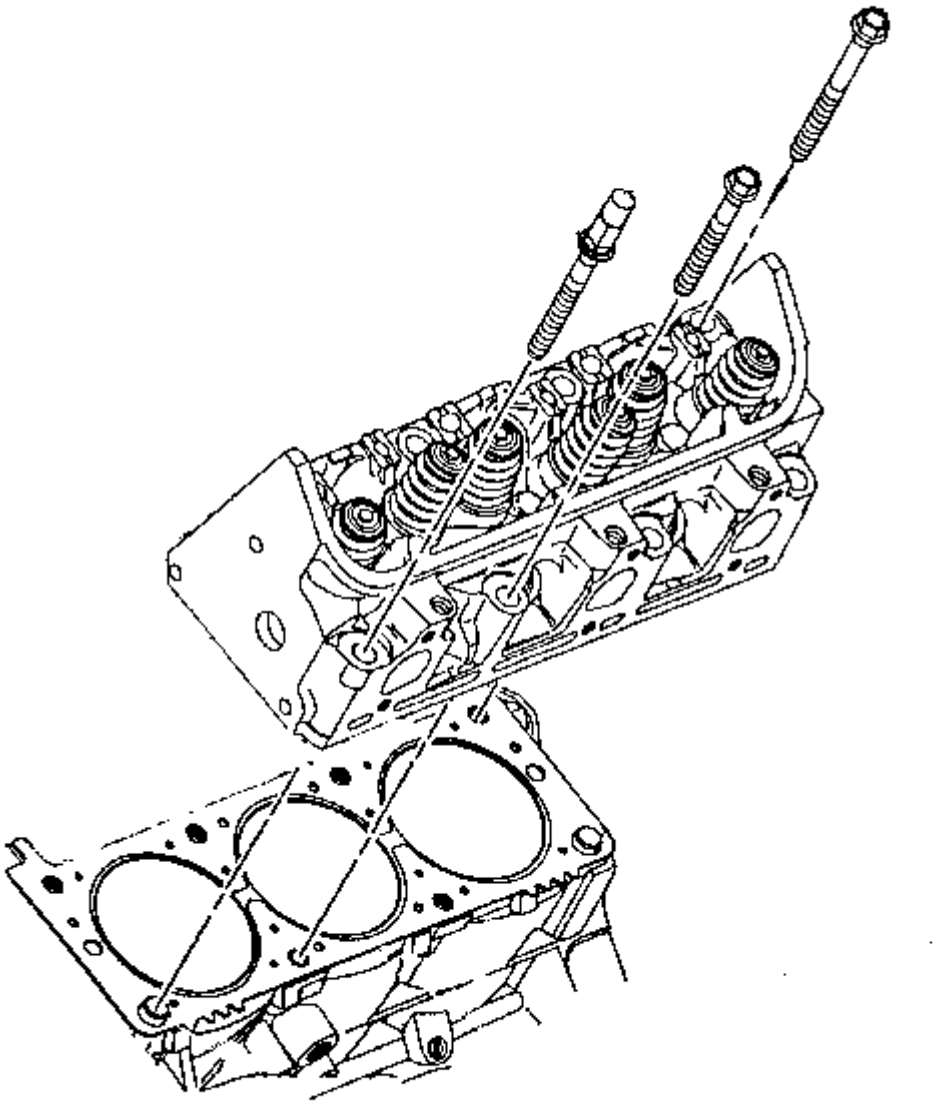

Fig. 294: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolt and discards.
2. Remove the cylinder head.

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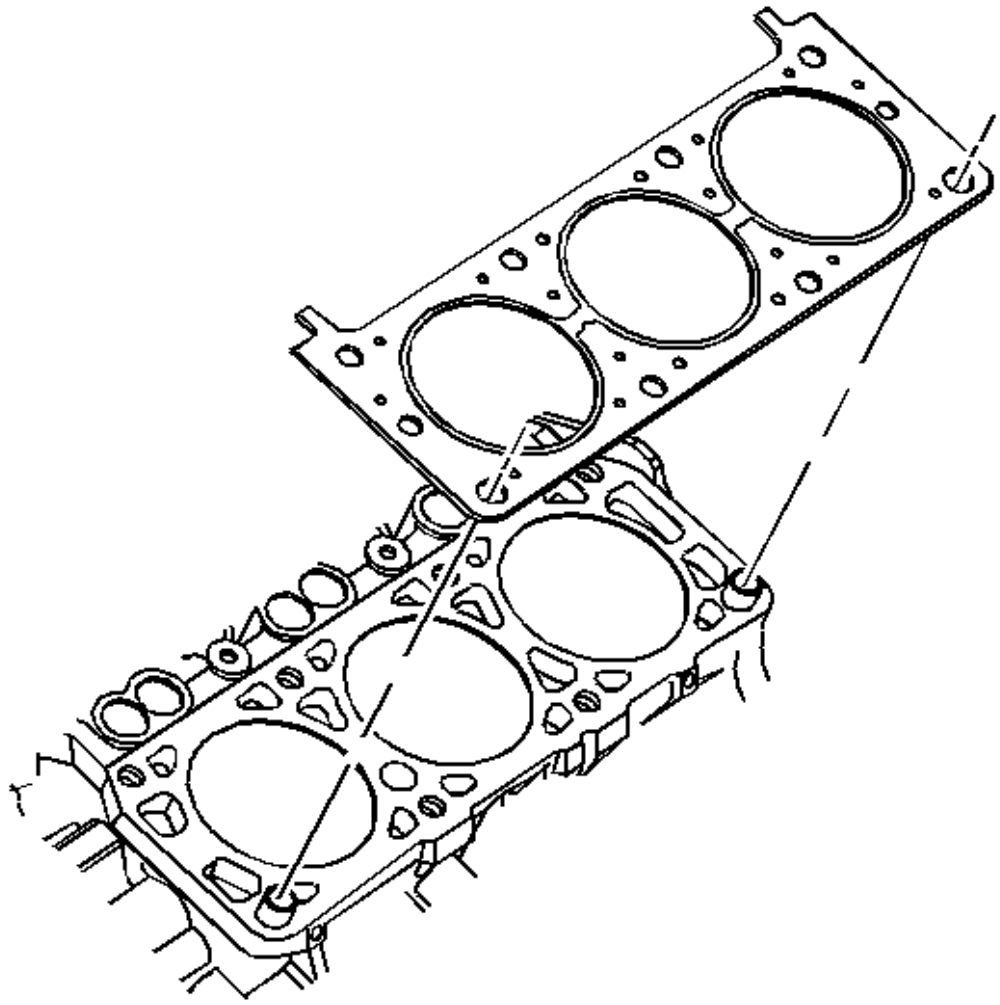

Fig. 295: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Remove the cylinder head locator dowel pins, if required.

CYLINDER HEAD REMOVAL - RIGHT SIDE

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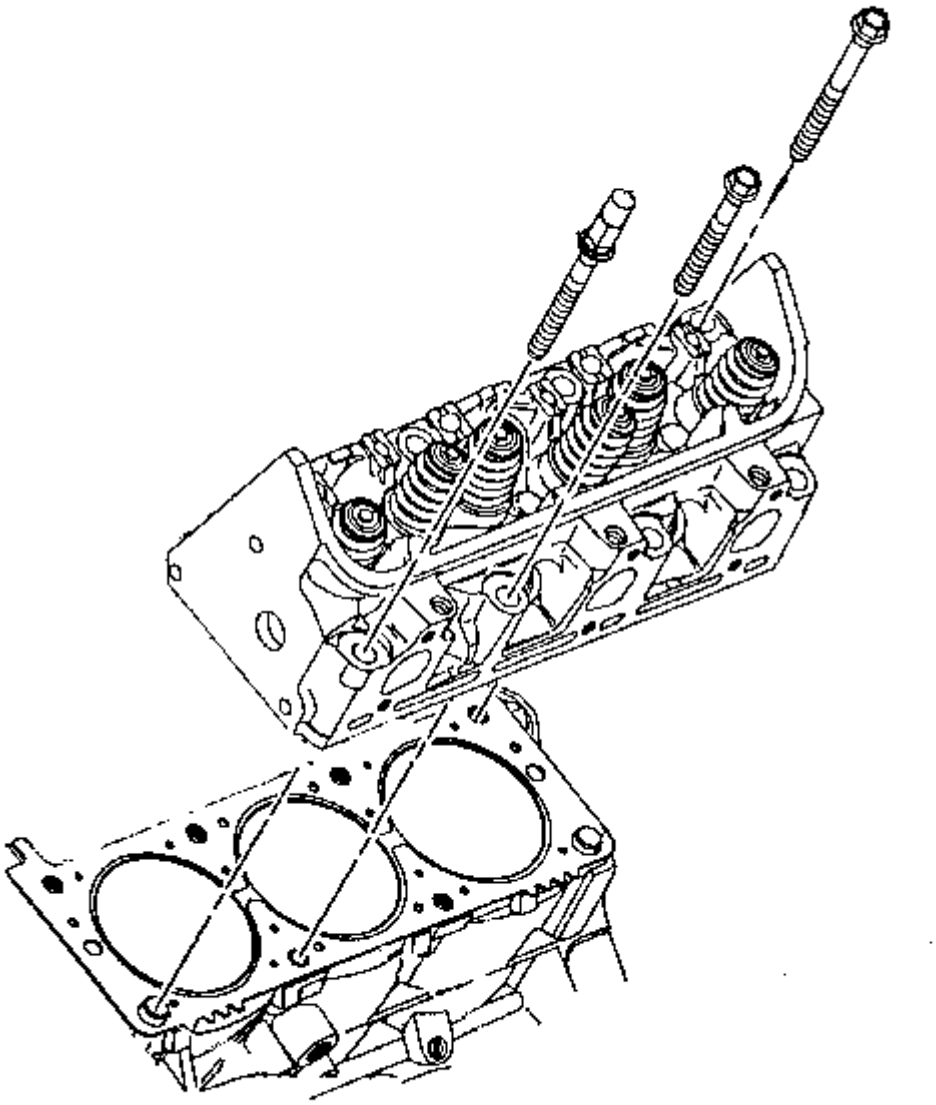

Fig. 296: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts and discard.
2. Remove the cylinder head.

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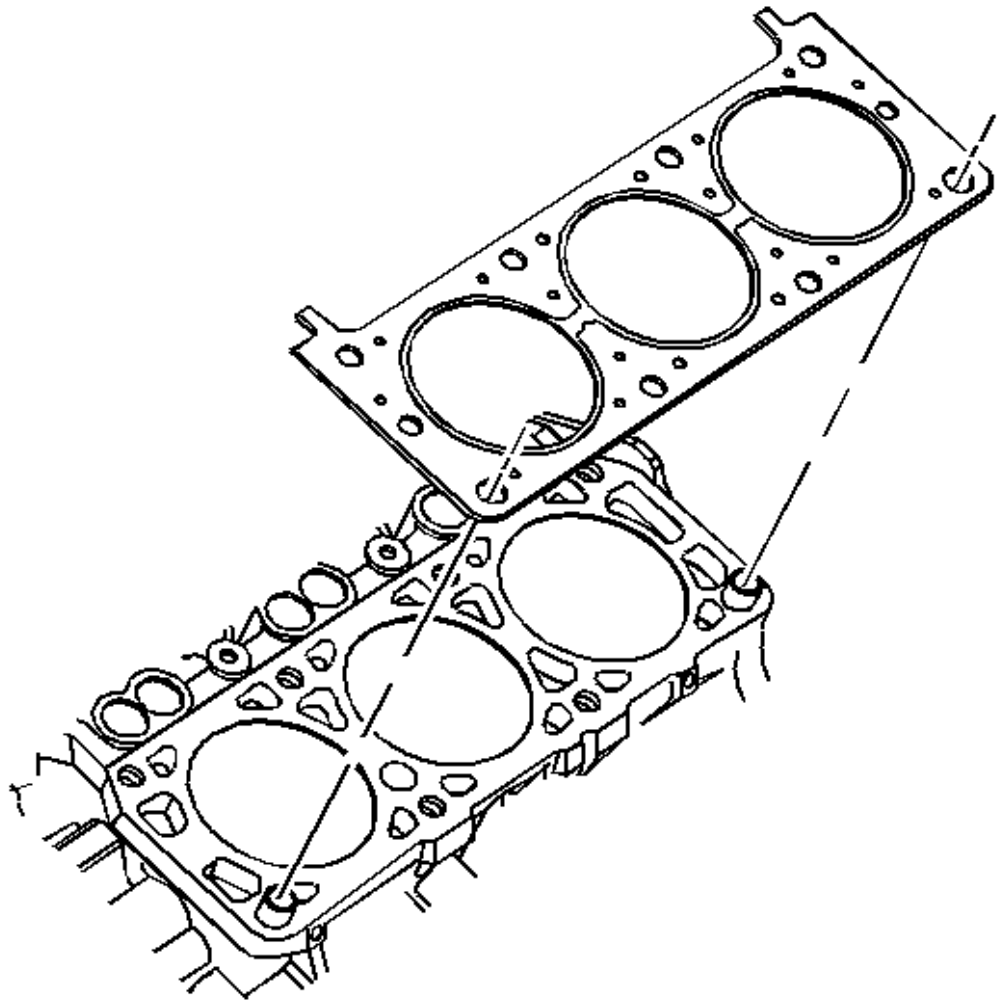

Fig. 297: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Remove the cylinder head locator dowel pins, if required.

OIL PAN REMOVAL

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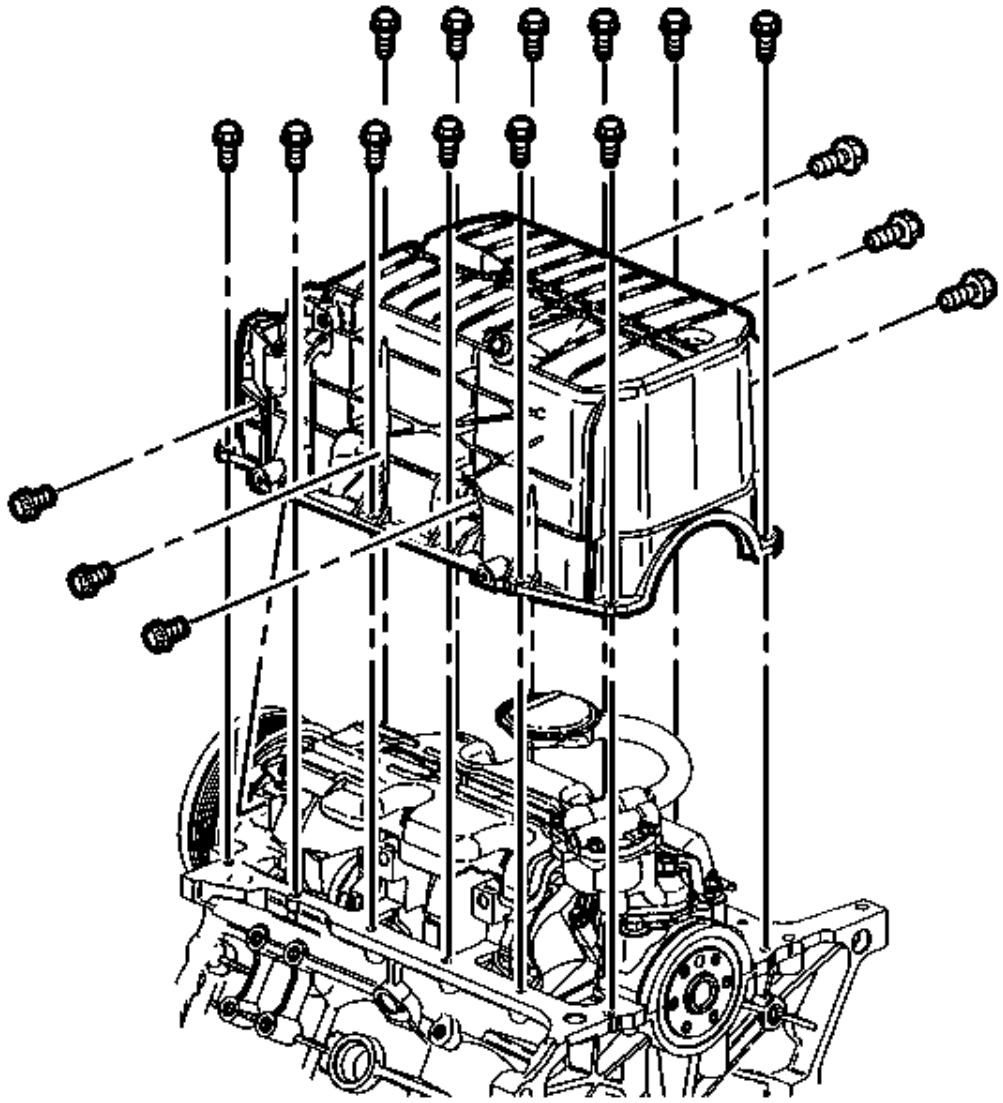

Fig. 298: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan support bracket bolts and brackets as needed
2. Remove the oil pan side bolts.
3. Remove the oil pan bolts.
4. Remove the oil pan.
5. Remove the oil pan gasket.

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OIL PUMP REMOVAL

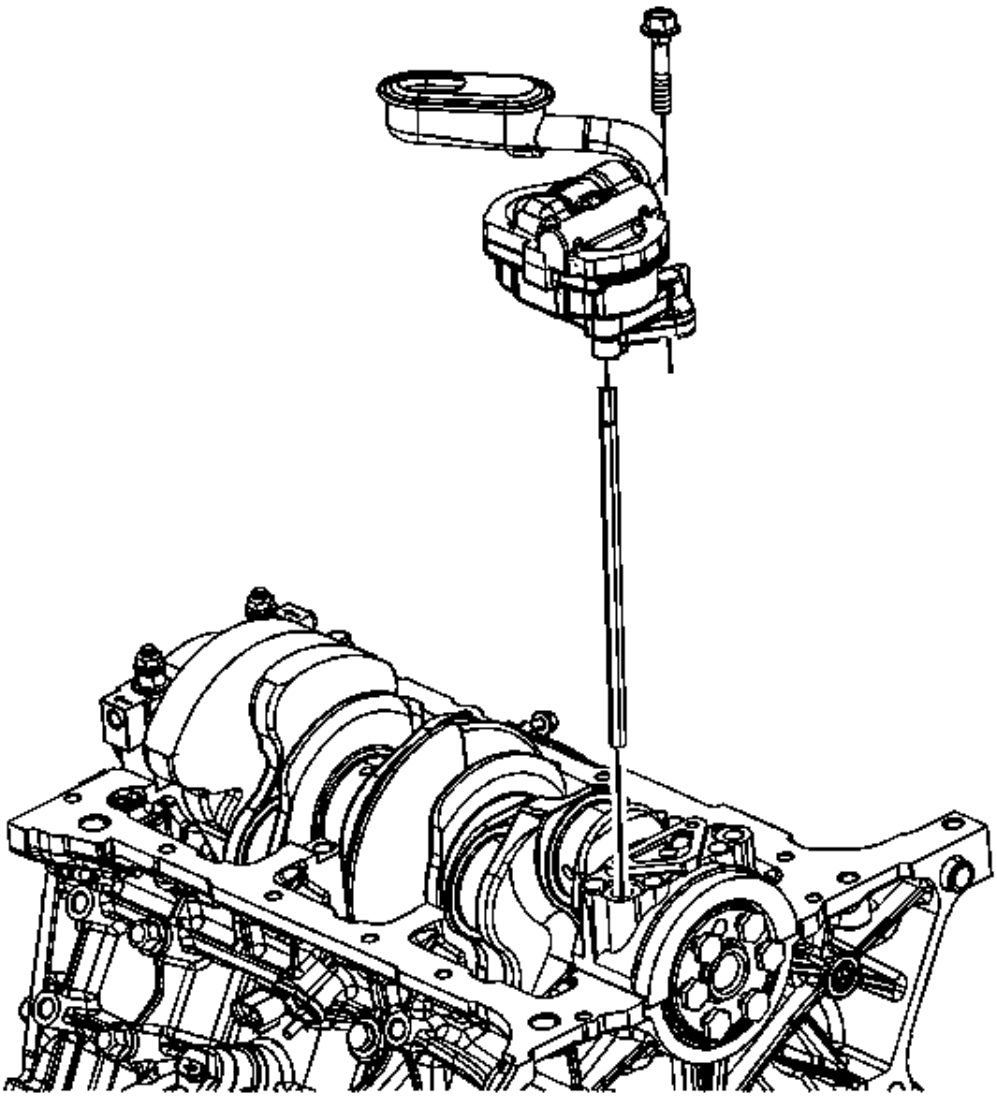

Fig. 299: View Of Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolt.
2. Remove the oil pump and oil pump drive shaft.

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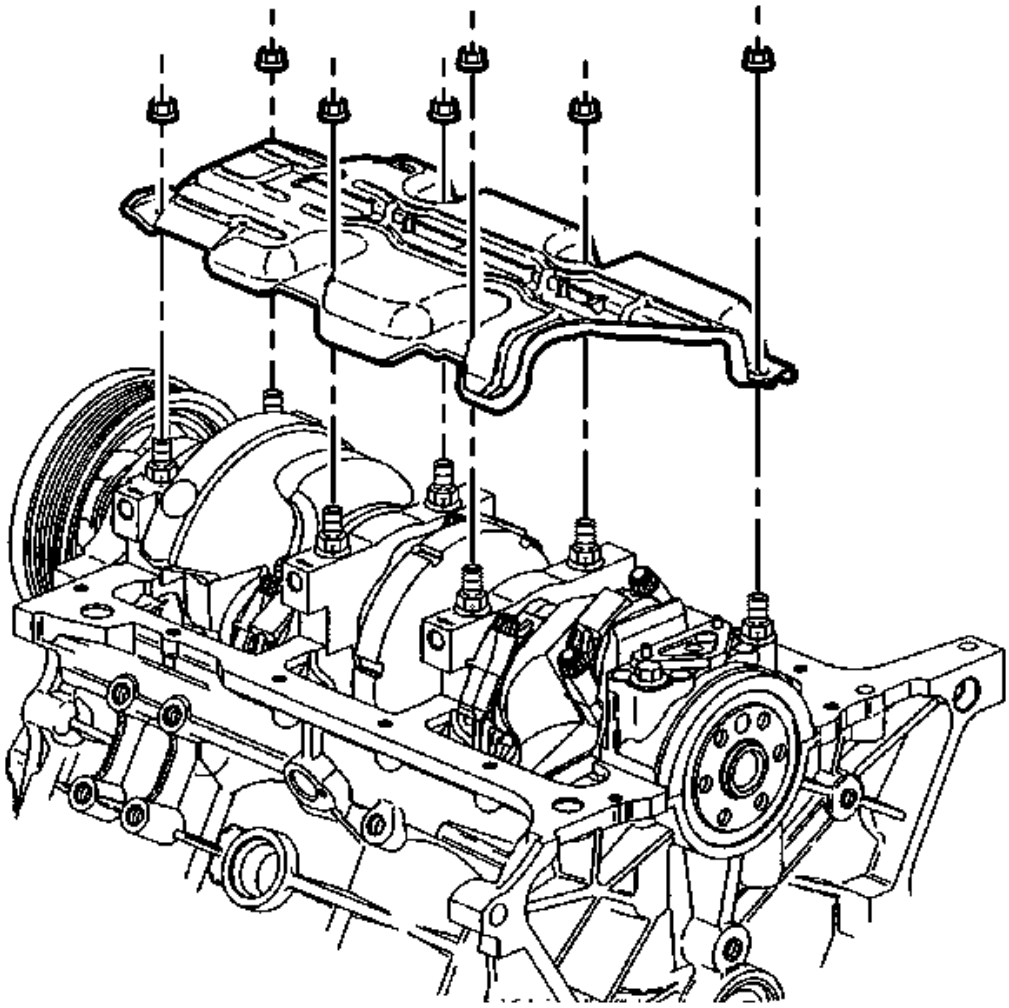

Fig. 300: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft oil deflector nuts.
4. Remove the crankshaft oil deflector.

CAMSHAFT POSITION ACTUATOR MAGNET REMOVAL

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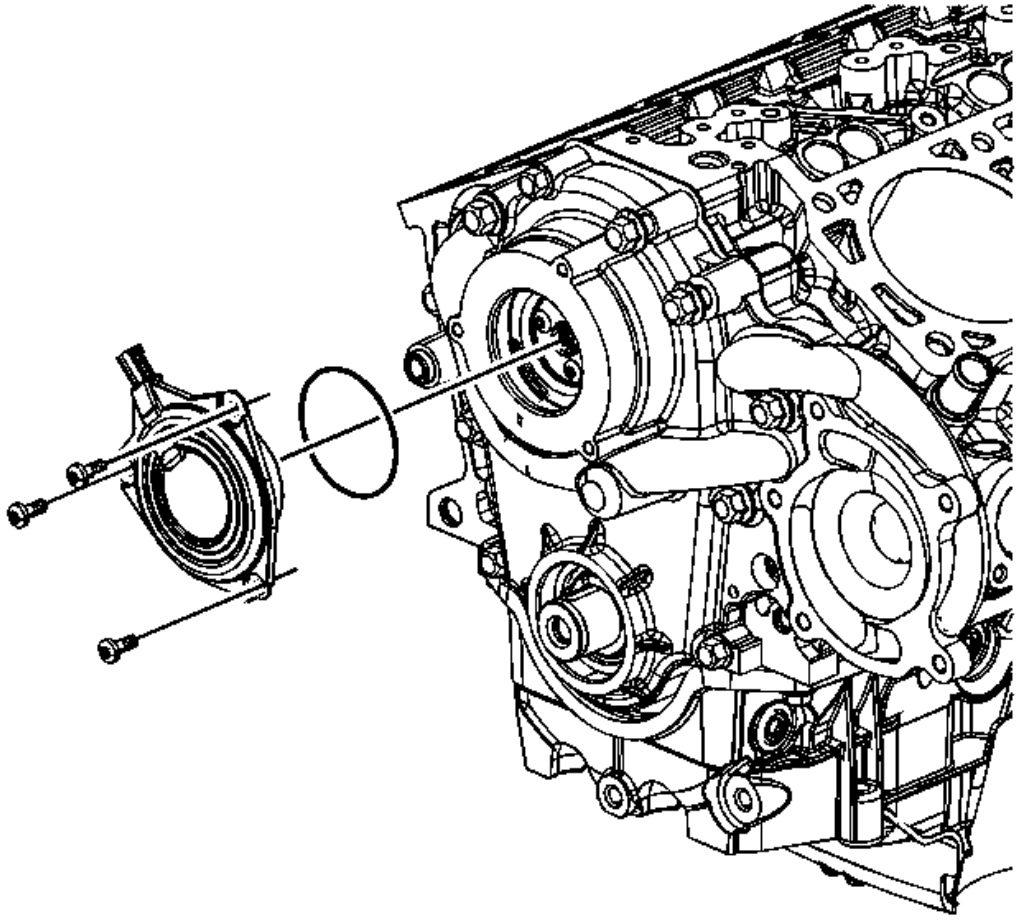

Fig. 301: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position actuator magnet bolts.
2. Remove the camshaft position actuator magnet and O-ring seal.

OIL PUMP DRIVE REMOVAL

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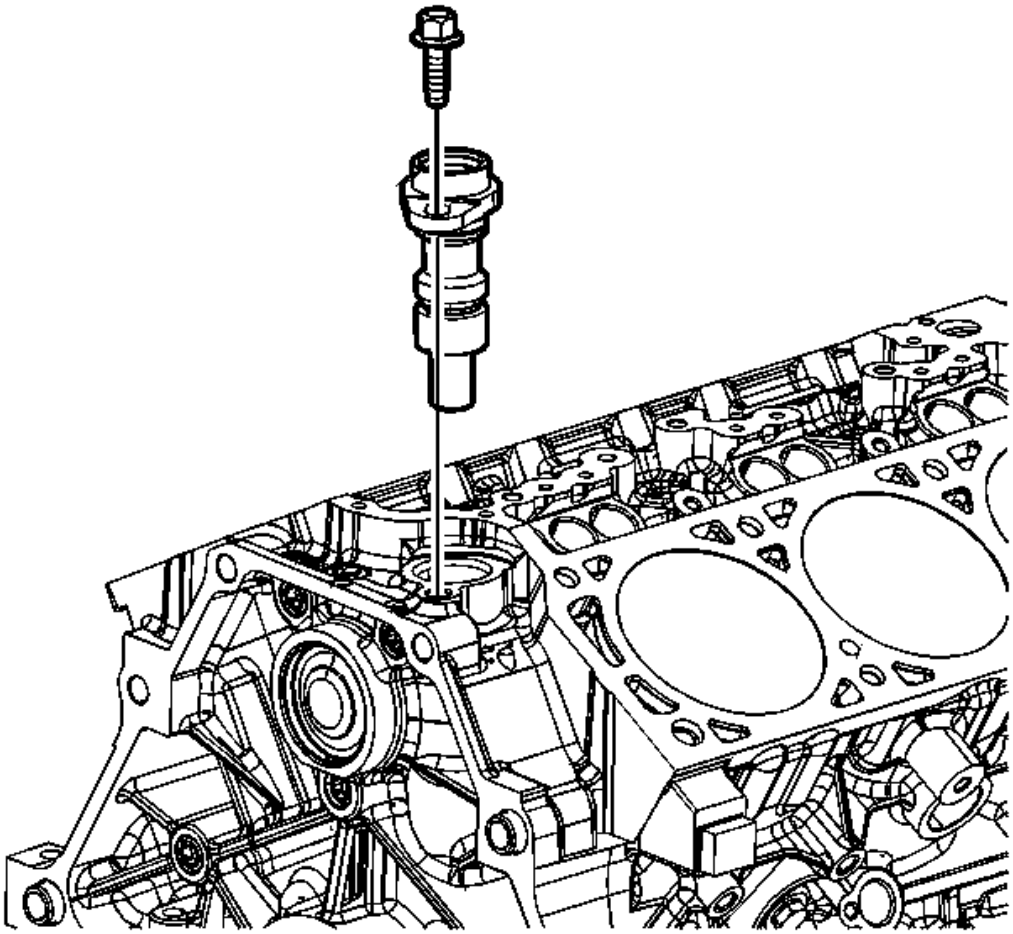

Fig. 302: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump drive clamp bolt.
2. Remove the oil pump drive clamp.
3. Remove the oil pump drive.

CRANKSHAFT FRONT OIL SEAL REMOVAL

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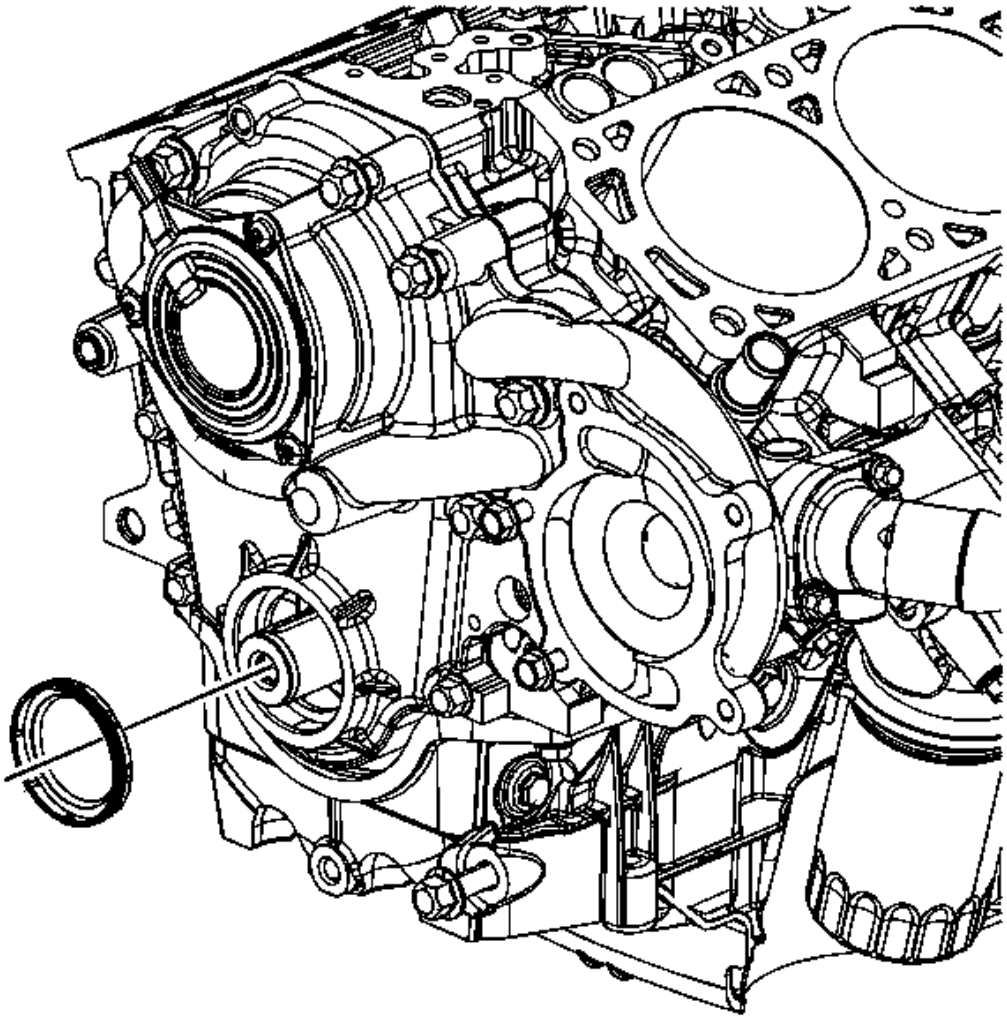

Fig. 303: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Pry out the crankshaft front oil seal using a suitable tool. Use care not to damage the engine front cover or the crankshaft.

ENGINE FRONT COVER REMOVAL

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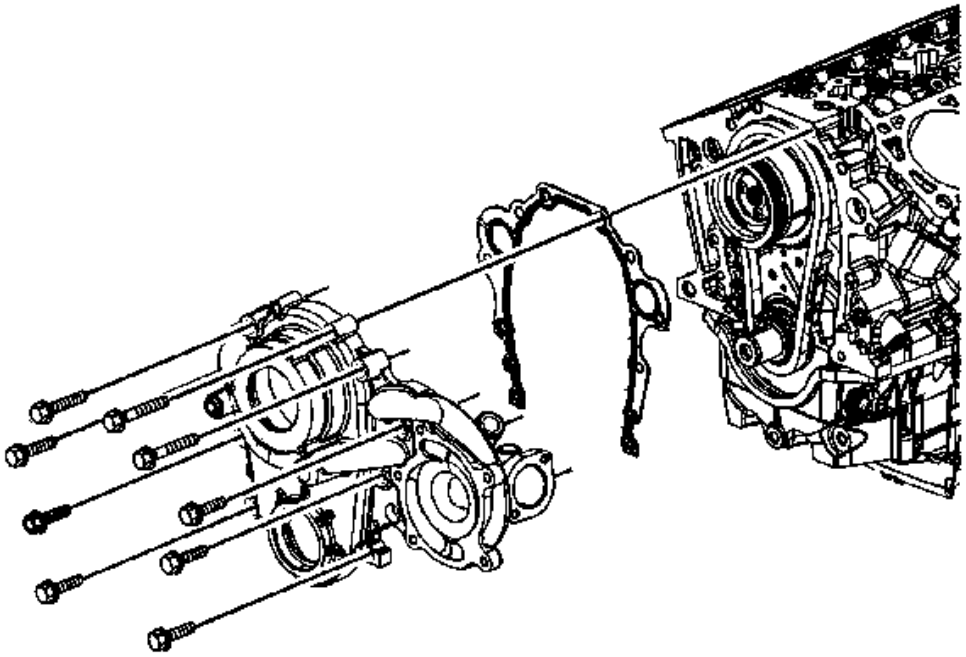

Fig. 304: Identifying Engine Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover bolts.
2. Remove the engine front cover.
3. Remove the engine front cover gasket.

TIMING CHAIN AND SPROCKET REMOVAL

Tools Required

EN-47719 Tensioner Compressor

Removal

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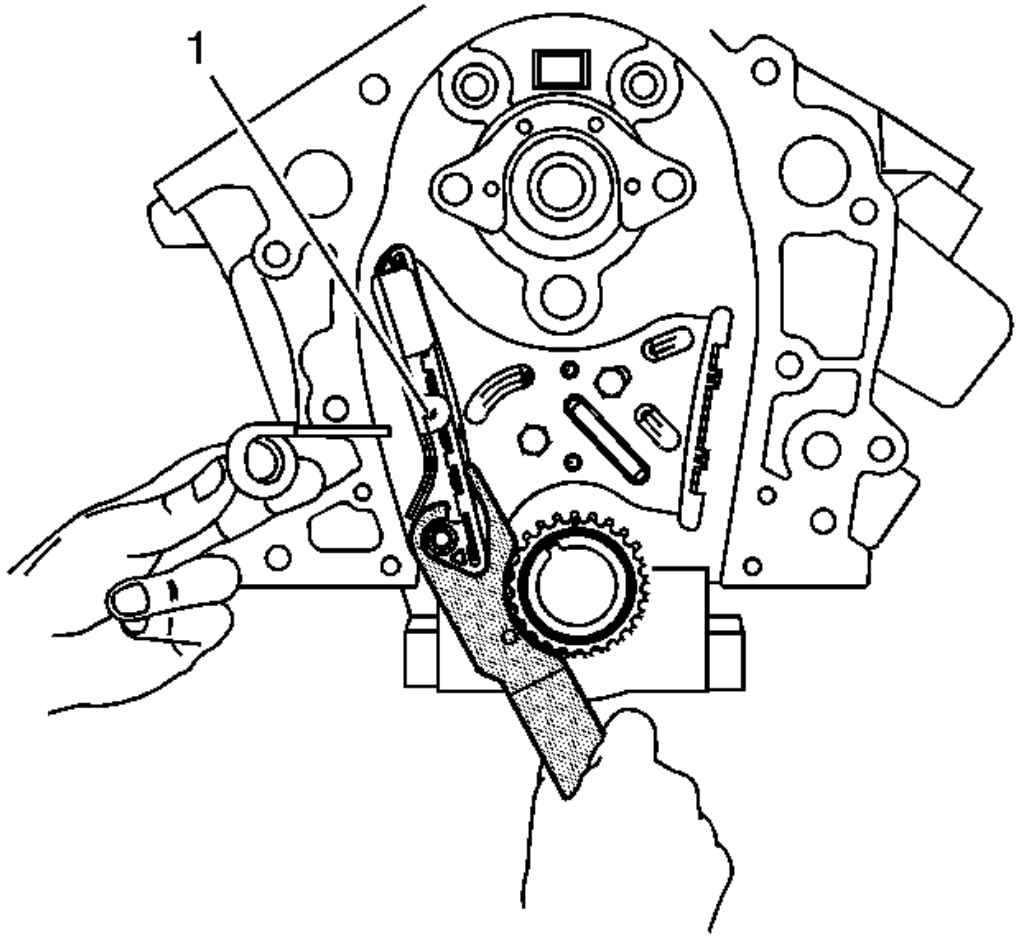

Fig. 305: Identifying Tensioner Collapsing Procedure
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-47719** fully collapse the tensioner and place the tensioner retaining pin into the retaining hole (1).

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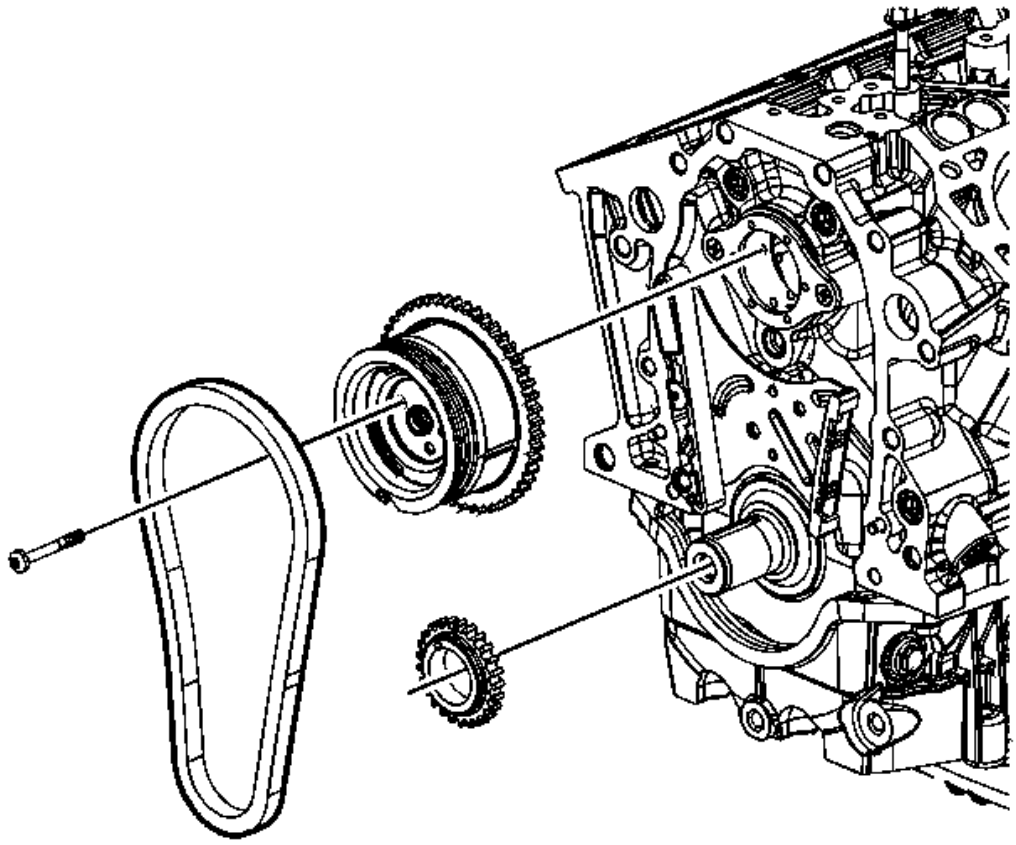

Fig. 306: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft sprocket bolts.
3. Remove the timing chain and sprockets.

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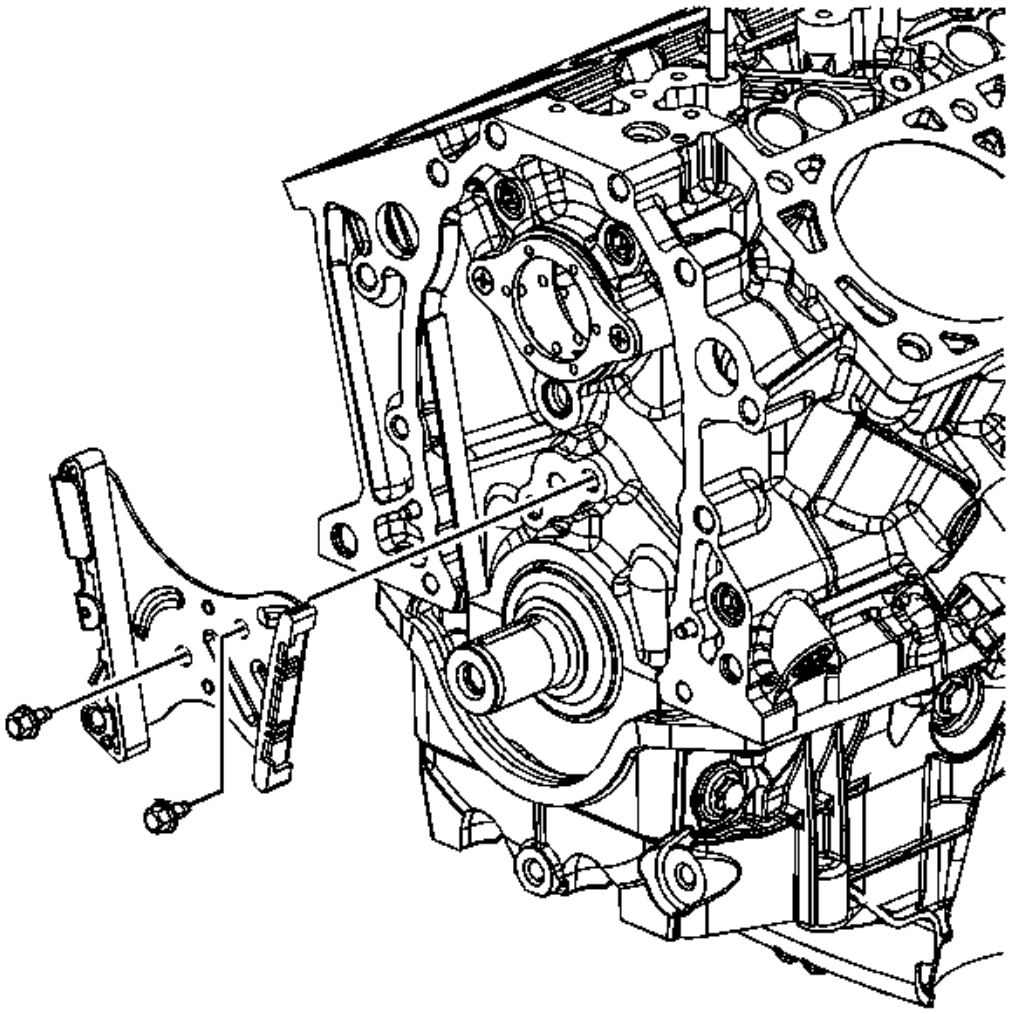

Fig. 307: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain tensioner bolts.
5. Remove the timing chain tensioner.

CAMSHAFT REMOVAL

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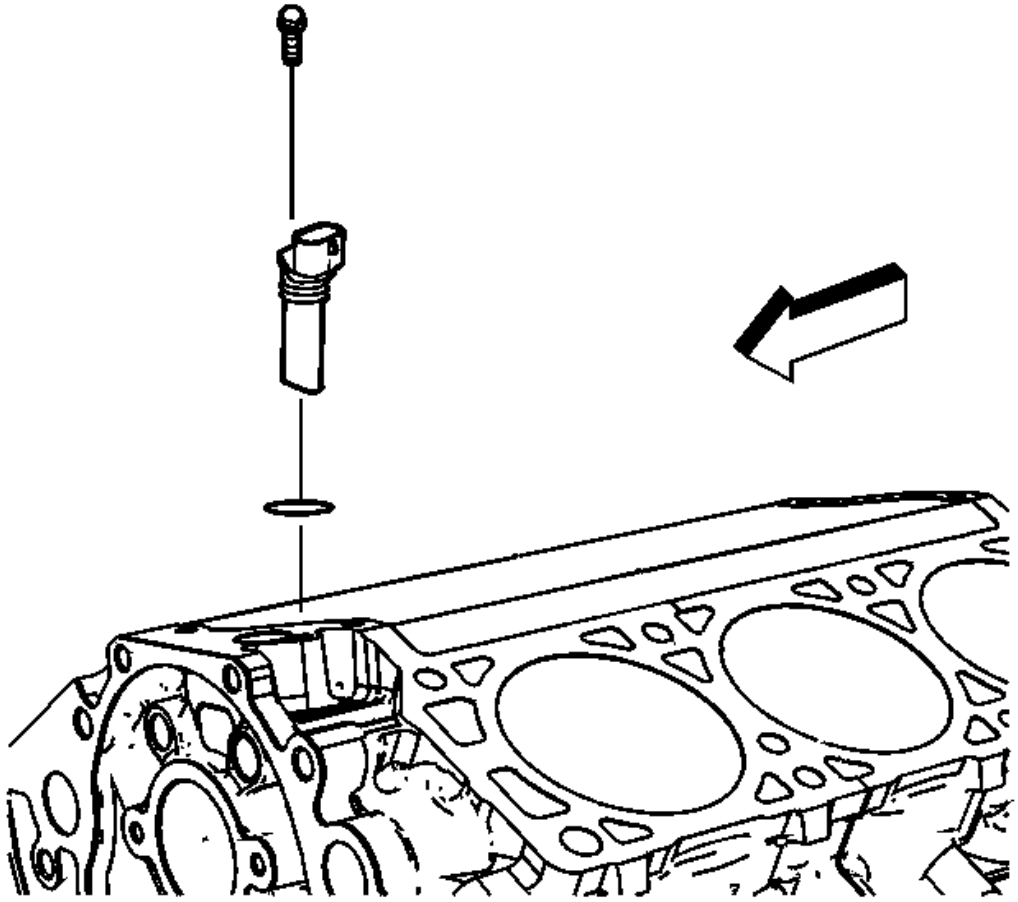

Fig. 308: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position sensor bolt.
2. Remove the camshaft position sensor.

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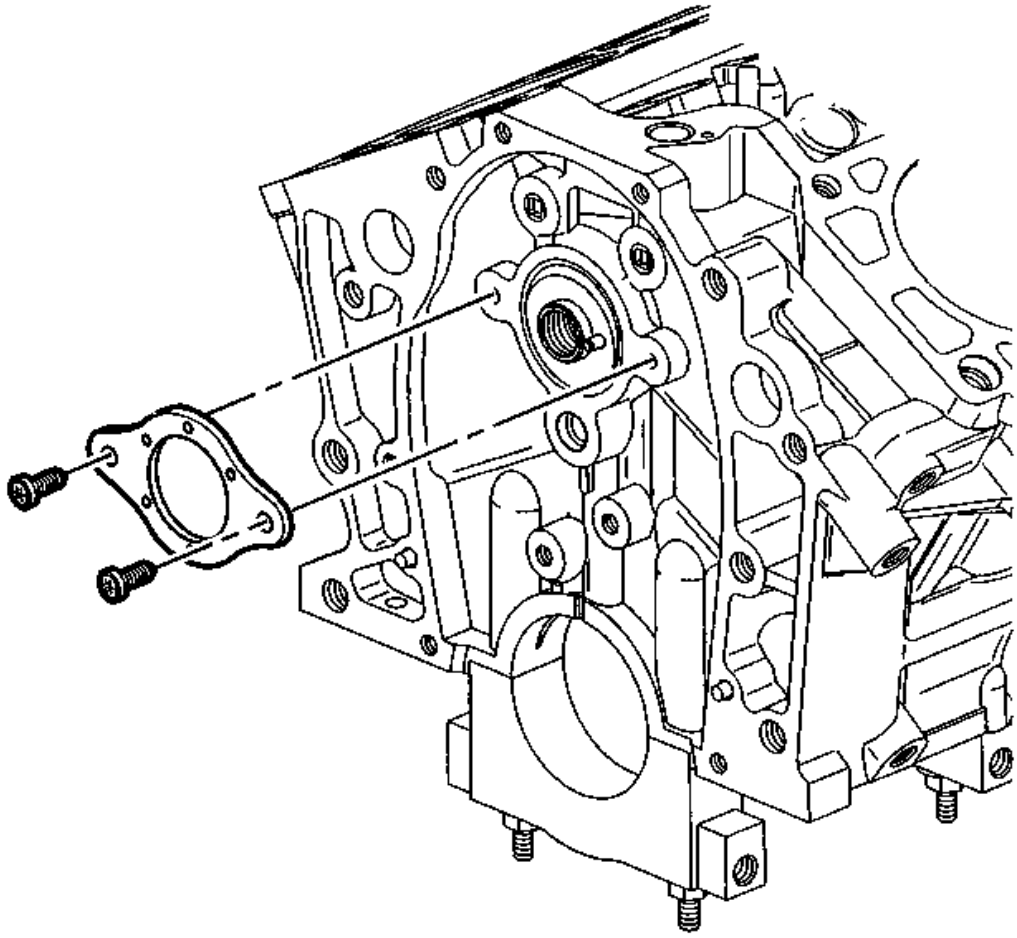

Fig. 309: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft thrust plate screws.
4. Remove the camshaft thrust plate.

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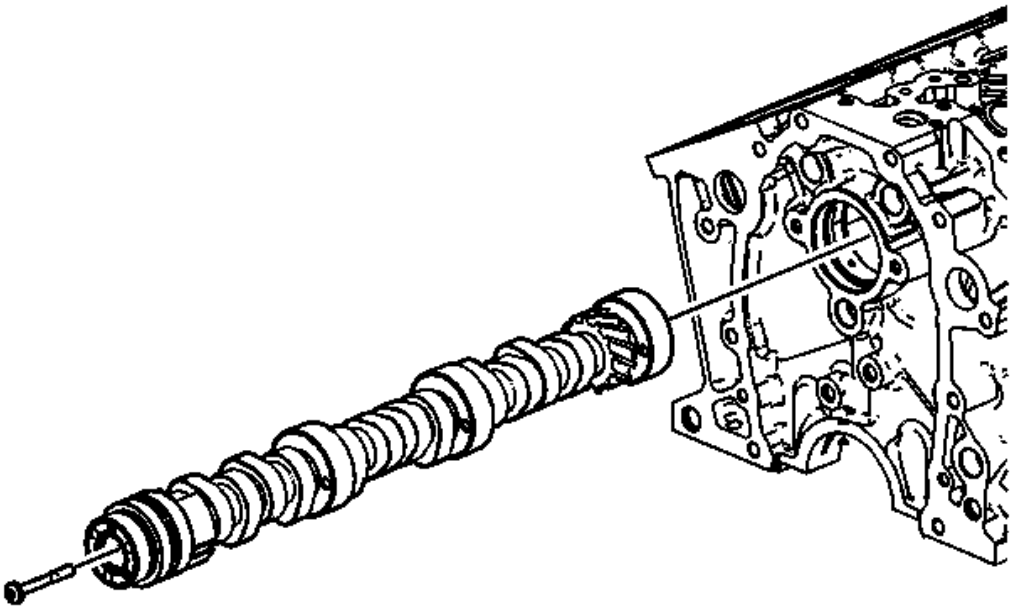

Fig. 310: Identifying Camshaft & Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

5. Complete the following steps in order to remove the camshaft.
    1. Install a camshaft sprocket bolt into the camshaft. Tighten finger tight only.
    2. Carefully rotate and remove the camshaft from the engine block.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

- **J-24270:** Cylinder Bore Ridge Reamer
- **J-41556:** Connecting Rod Guide

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

Removal

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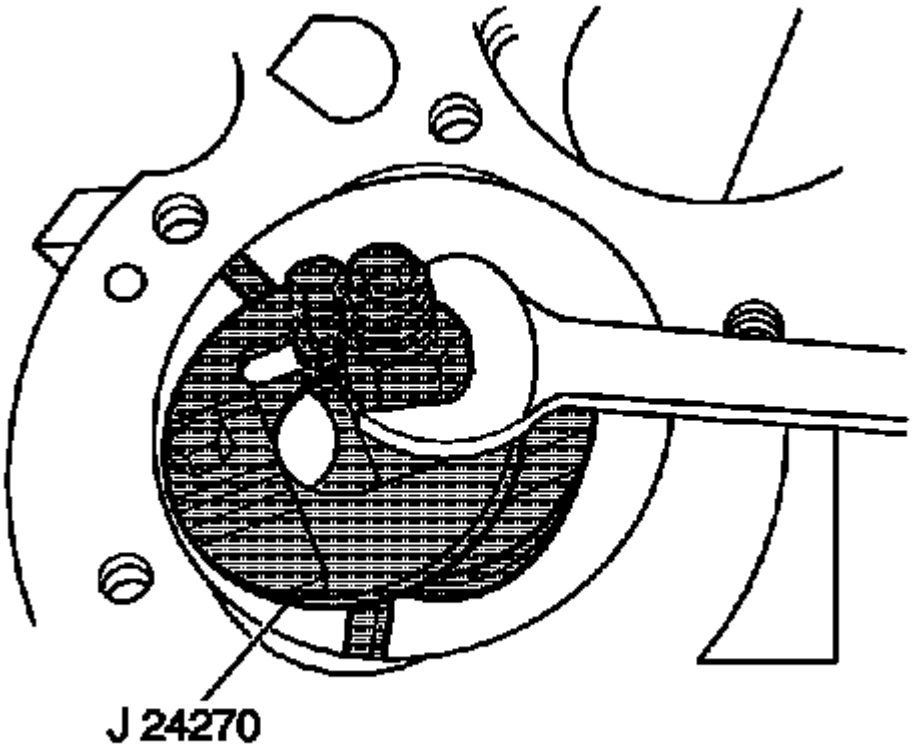

Fig. 311: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Mark the piston with the number of the cylinder from which the piston is being removed.
2. Mark the connecting rod and the connecting rod cap in order to ensure correct assembly.

CAUTION: If there is a pronounced ridge at the top of the piston travel, the ridge must be removed with a ridge reamer before the piston and connecting rod assembly are removed. Applying force may break the piston rings or damage the piston.

3. Use the **J-24270:** Cylinder Bore Ridge Reamer in order to remove the cylinder bore ring ridge. Complete the following steps:
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Cover the piston with a cloth.
    3. Remove the cylinder ring ridge.
    4. Turn the crankshaft until the piston is at the top of the stroke.
    5. Remove the cloth.
    6. Remove the metal shavings from the cylinder and piston.

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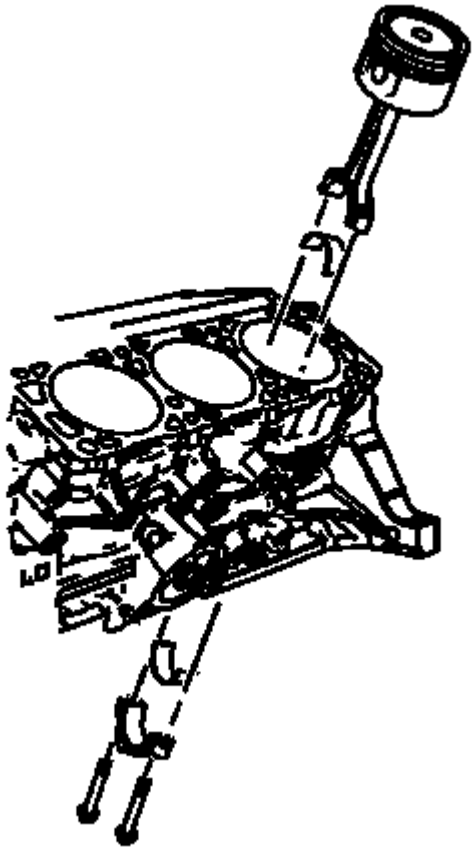

Fig. 312: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.
6. Remove the connecting rod bearing half.
7. Install **J-41556:** Connecting Rod Guide into the connecting rod.
8. Remove the connecting rod and piston assembly from the engine with a suitable tool.

CRANKSHAFT REAR OIL SEAL REMOVAL

Special Tools

- **EN-48672** Rear Main Oil Seal Remover
- **J 23444-A** Extreme Press Lubricant - 1/4 Ounce Tube

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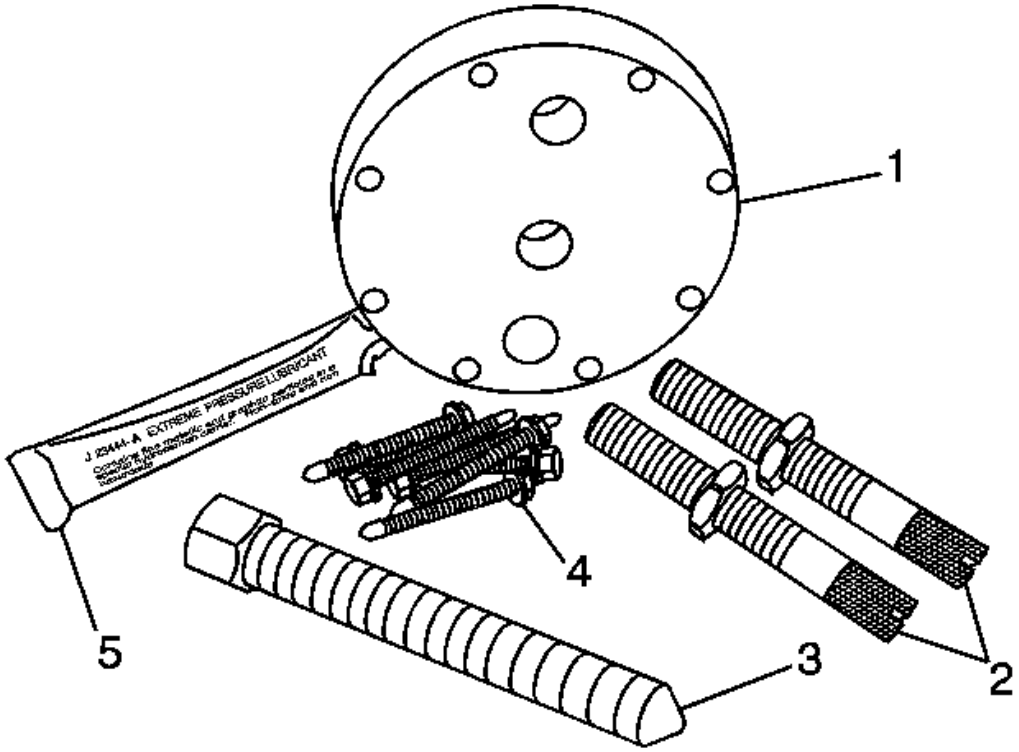

Fig. 313: Identifying Rear Main Oil Seal Remover (EN-48672)
Courtesy of GENERAL MOTORS CORP.

The **EN-48672** has a unique design to allow the technician to easily remove the rear main seal without nicking the crankshaft sealing surface when removing the seal. Before proceeding with removal, review the illustration to become familiar with the following components:

- Removal Plate (1)
- Threaded Adjustment Pins and Jam Nuts (2)
- Force Screw (3)
- #2 Self Drill Screws 38 mm (1.5 in) long - 8 needed (4)
- Extreme Pressure Lubricant (5)

Removal

1. Remove the transmission. Refer to **Transmission Replacement** .
2. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

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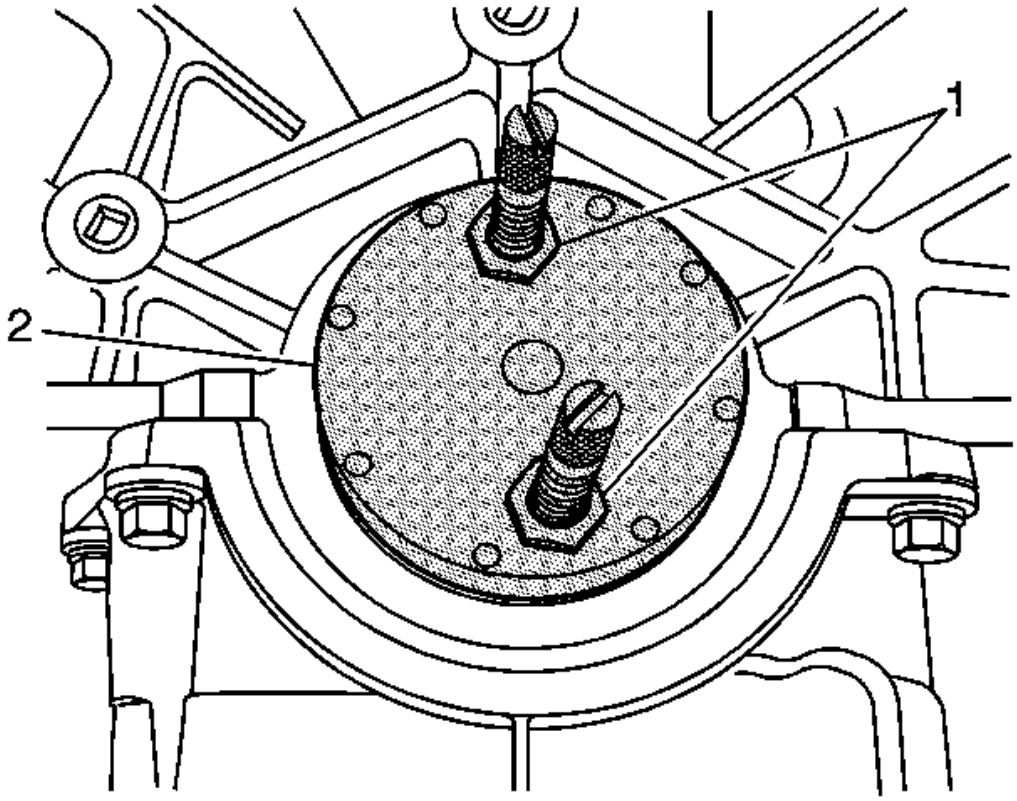

Fig. 314: View Of Installed EN-48672 Removal Plate
Courtesy of GENERAL MOTORS CORP.

3. Install the removal plate (2) and both threaded adjustment pins and jam nuts (1) into the back of the crankshaft flange and secure the plate with adjustment pins and jam nuts.

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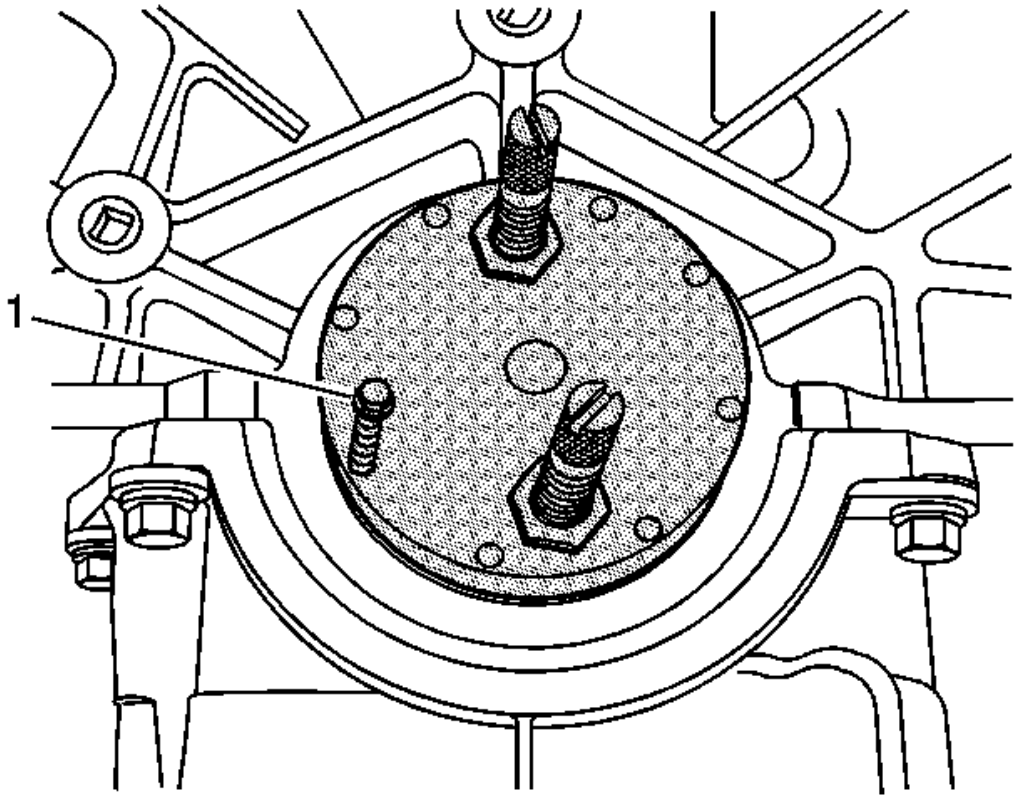

Fig. 315: View Of 8 Installed EN-48672 #2 Self Drill Screws
Courtesy of GENERAL MOTORS CORP.

4. Install the #2 self drill screws 38 mm (1.5 in) long, 8 needed (1) and tighten the screws down flush to the plate.

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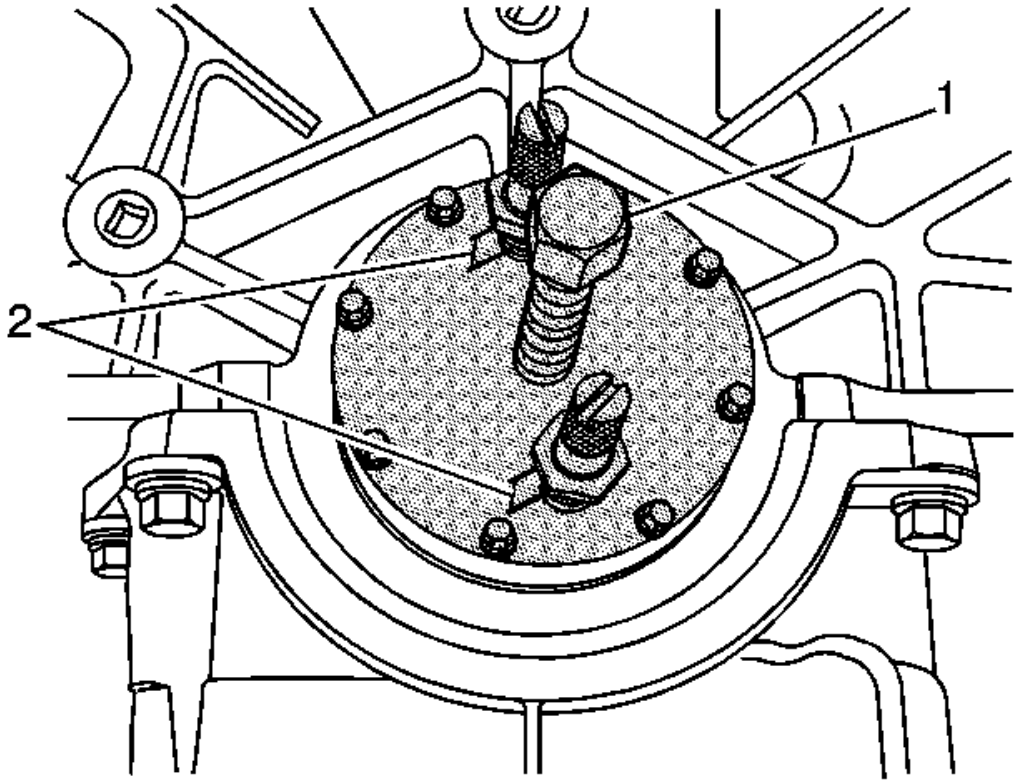

Fig. 316: View Of Installed EN-48672 Force Screw & Jam Nuts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Before installing the force screw, apply a small amount of the extreme pressure lubricant J 23444-A , provided in the tool kit.

5. Install the force screw (1) and back off both jam nuts (2). Continue to turn the force screw (1) into the removal plate in order to remove the seal from the crankshaft.

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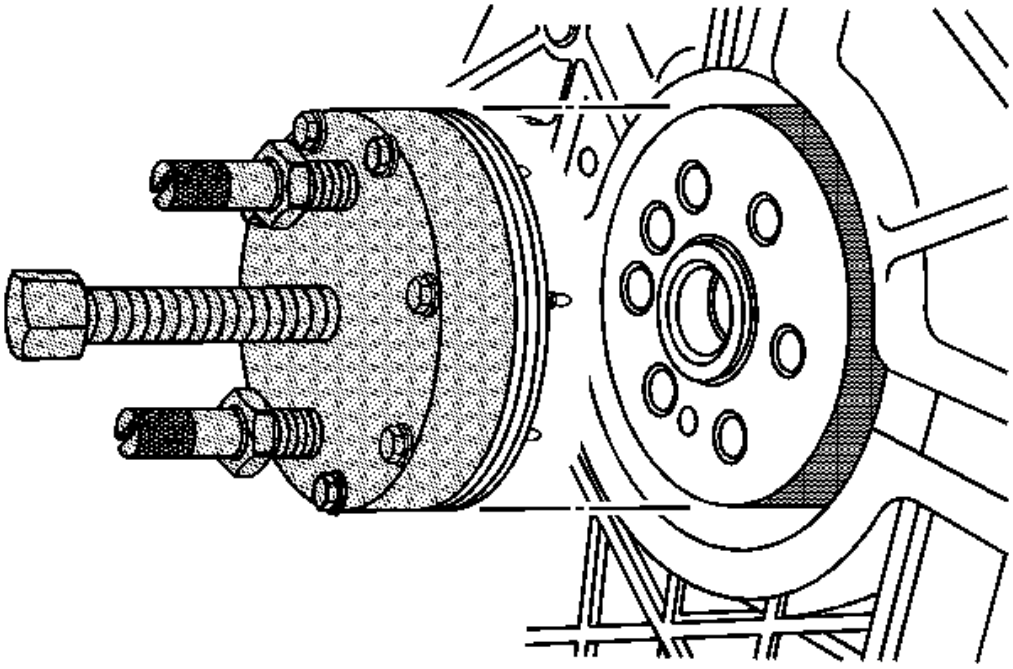

Fig. 317: Oil Seal Removed Using EN-48672
Courtesy of GENERAL MOTORS CORP.

6. Once the seal is removed from the crankshaft, remove and save all 8 screws. Discard the old seal.

CRANKSHAFT AND BEARING REMOVAL

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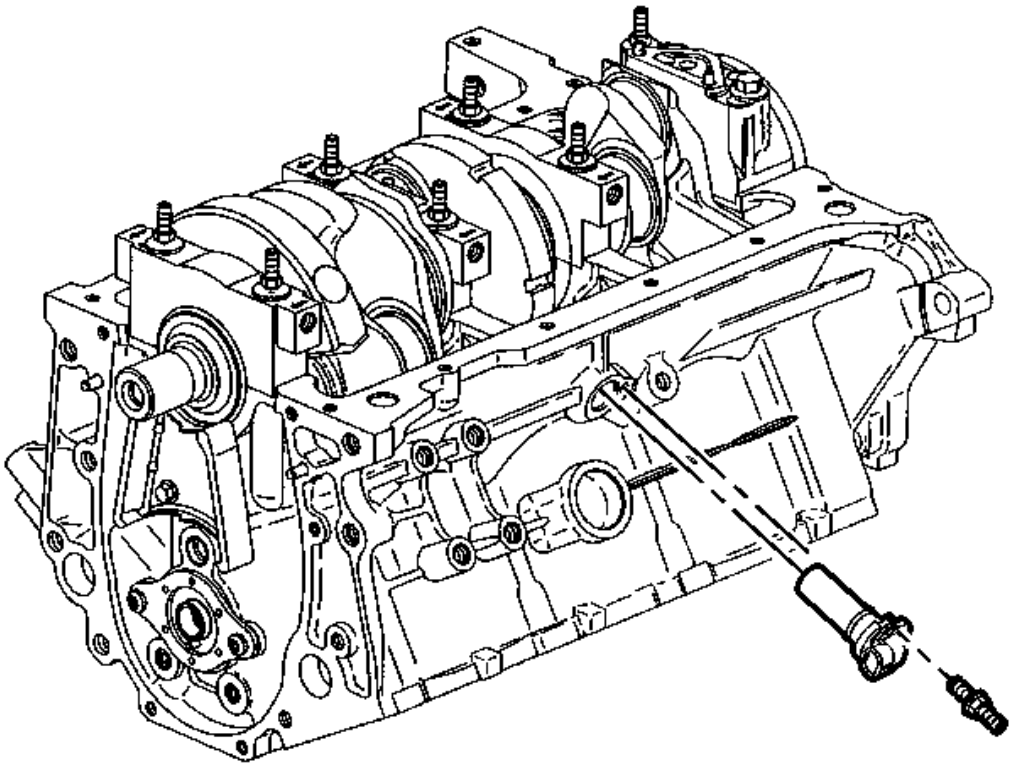

Fig. 318: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor heat shield nut and heat shield.
2. Remove the crankshaft position sensor stud.
3. Remove the crankshaft position sensor from the side of the block.

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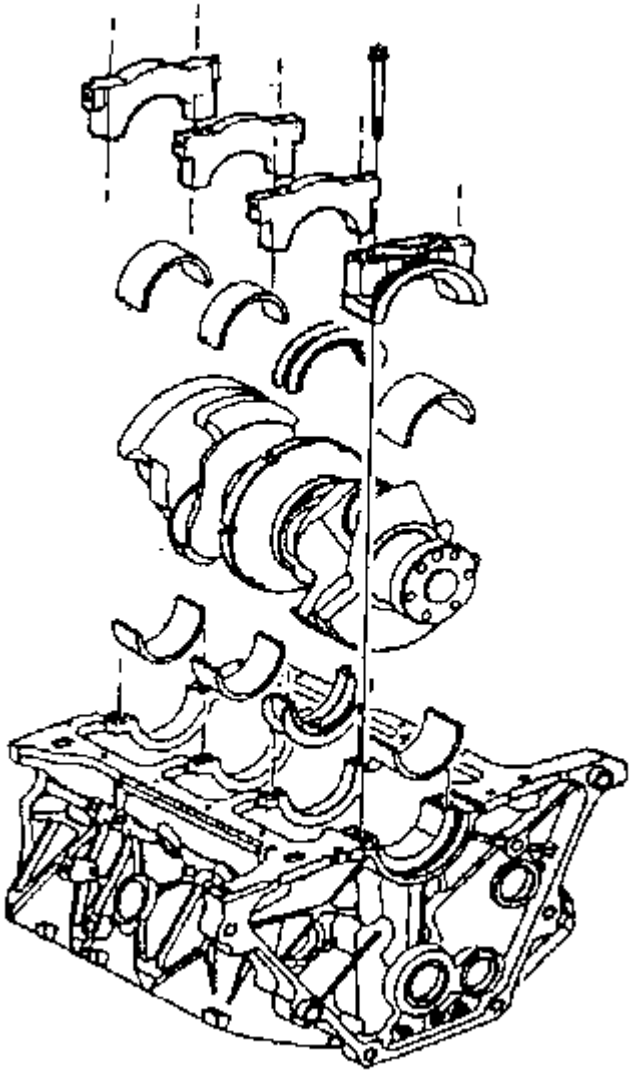

Fig. 319: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft main bearing cap bolt and studs.
5. Remove the crankshaft main bearing caps and lower crankshaft main bearing halves.

IMPORTANT: Use Care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor wheel teeth. Nicks, burrs or other damage to the teeth may effect On-board Diagnostics (OBD) II system performance.

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6. Remove the crankshaft.
7. Remove the upper crankshaft main bearing halves.

PISTON OIL NOZZLE REMOVAL

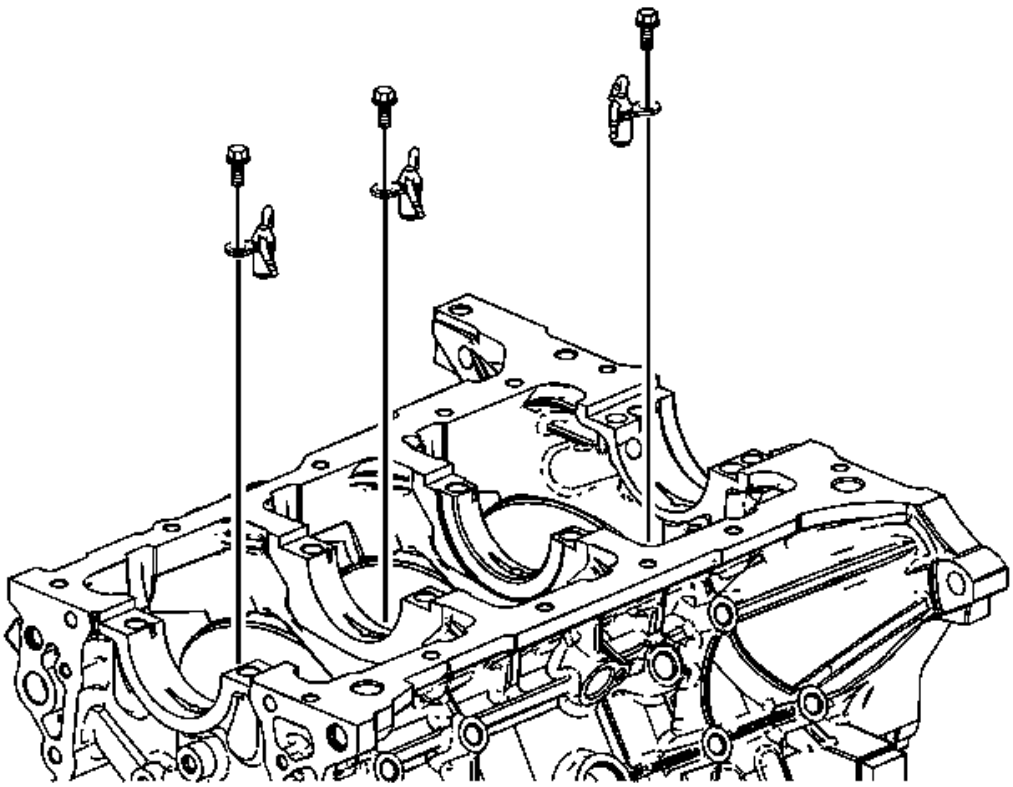

Fig. 320: Identifying Piston Oil Nozzles & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts retaining the piston oil nozzles to the engine block.
2. Remove the piston oil nozzles.

CAMSHAFT BEARING REMOVAL

Special Tools

J 33049 Camshaft Bearing Service Set

Removal

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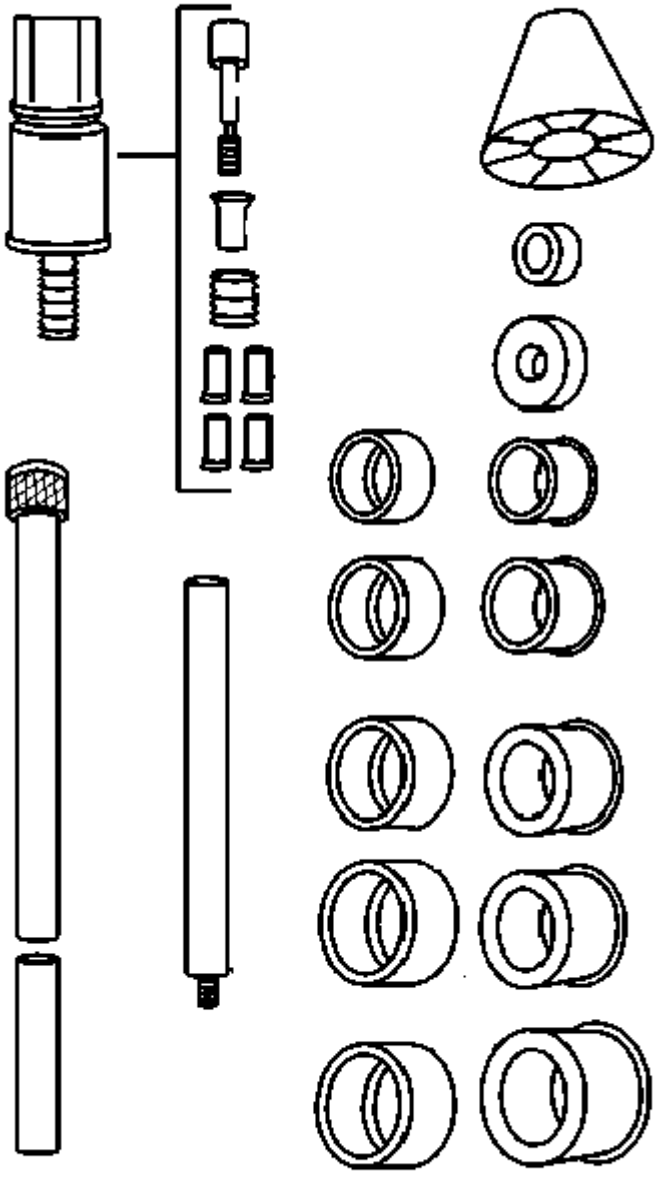

Fig. 321: View Of Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

1. Select the expander assembly and driving washer.
2. Assemble the **J 33049** .

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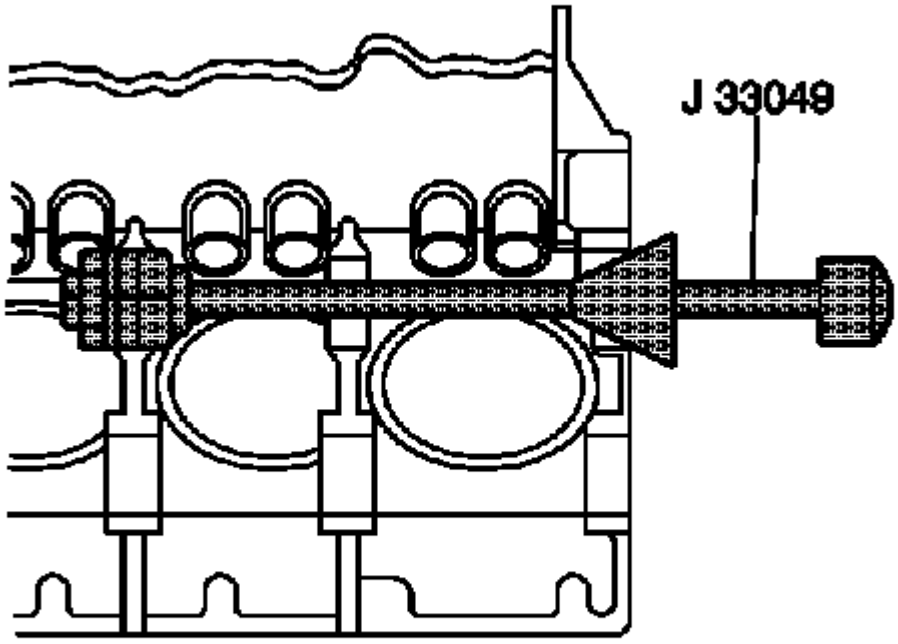

Fig. 322: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

3. Drive out the camshaft bearings. Use the **J 33049** .

ENGINE BLOCK DISASSEMBLE

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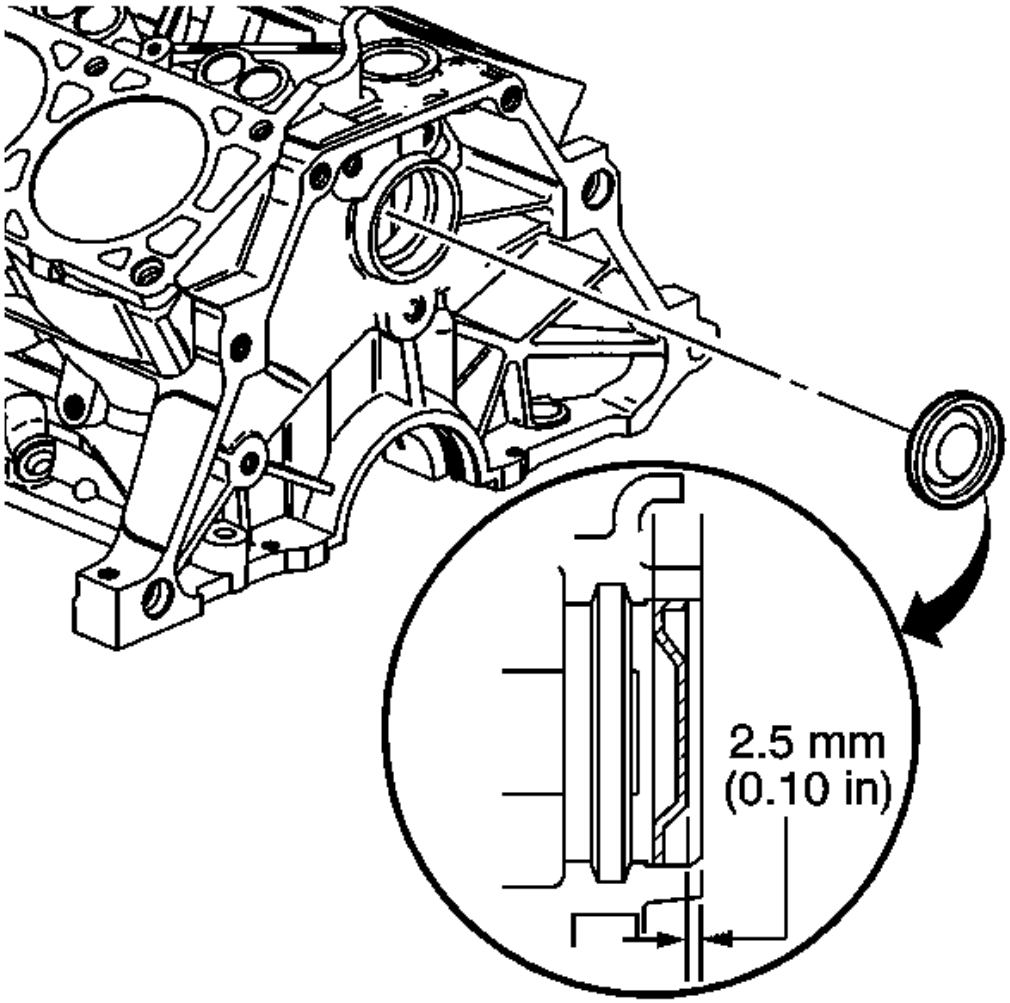

Fig. 323: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

1. Remove the camshaft rear bearing hole plug.

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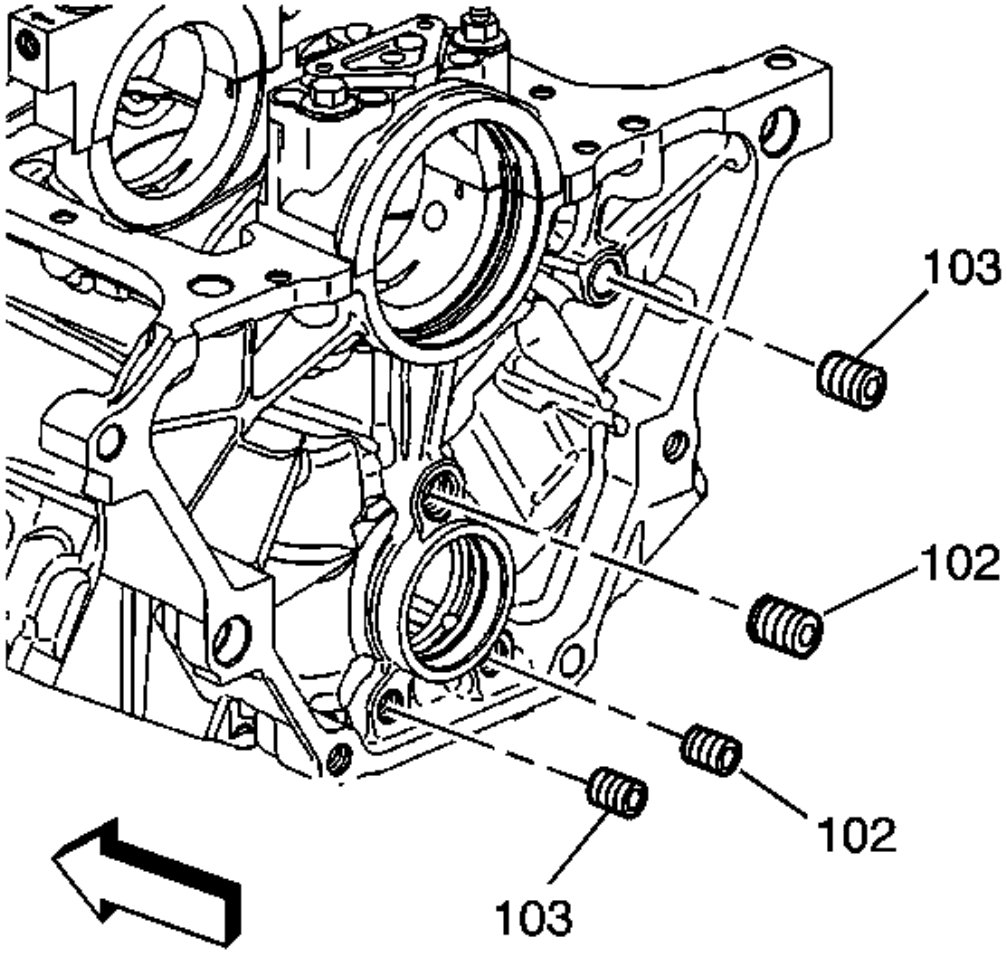

Fig. 324: View Of Rear Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear oil gallery plugs (102, 103).

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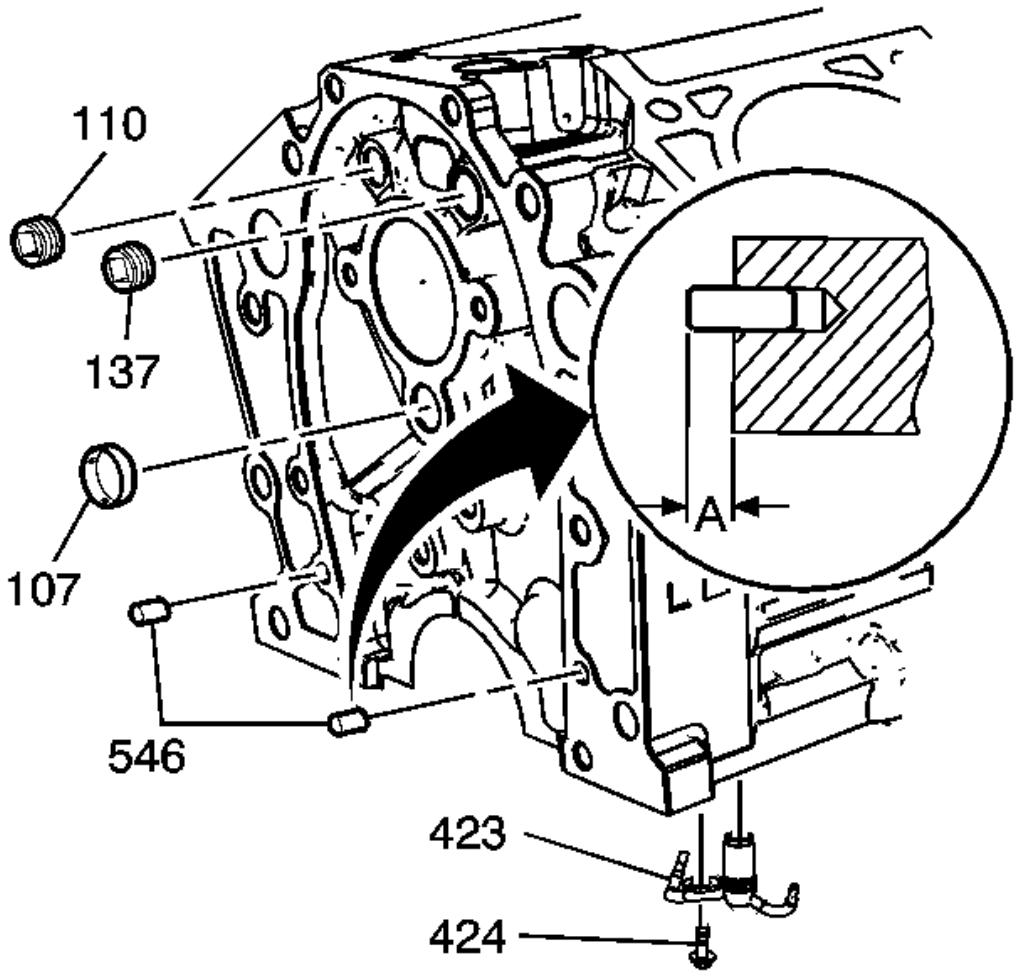

Fig. 325: View Of Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

3. Remove the front oil gallery plugs (107, 110, 137).
4. Remove the engine front cover locating pins (546).

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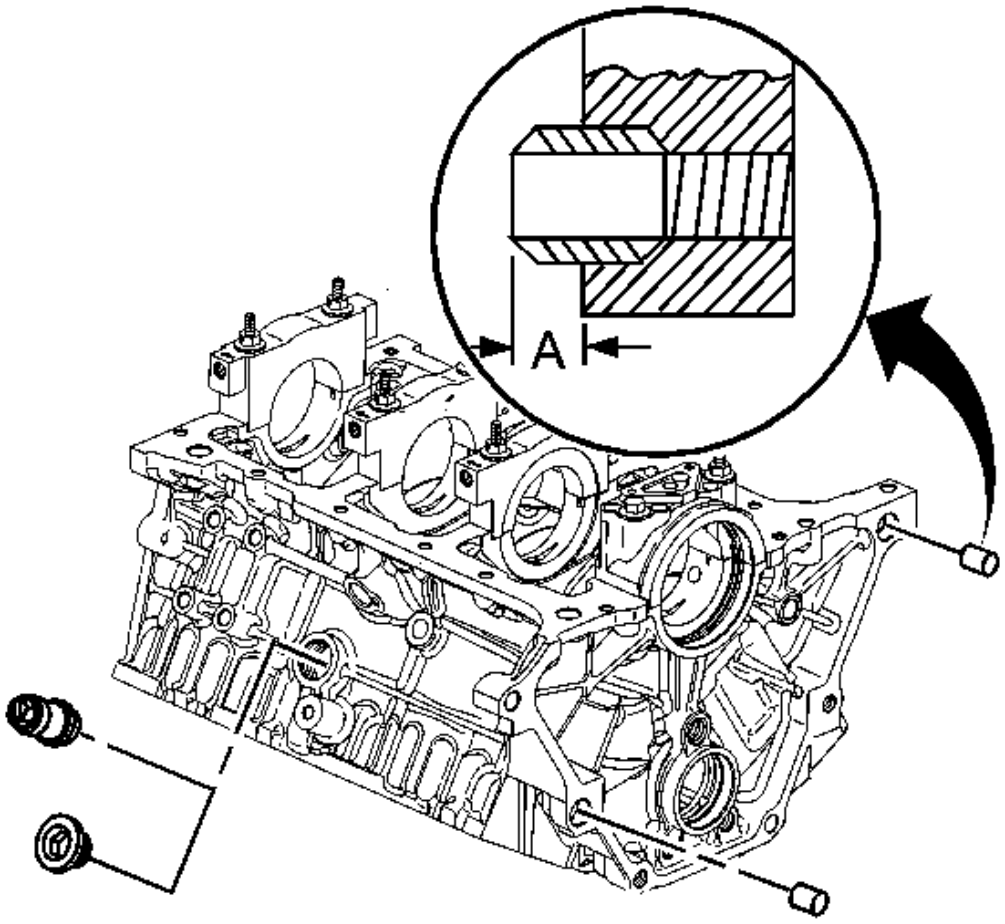

Fig. 326: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block plug.
6. Remove the transmission locating pins (A).

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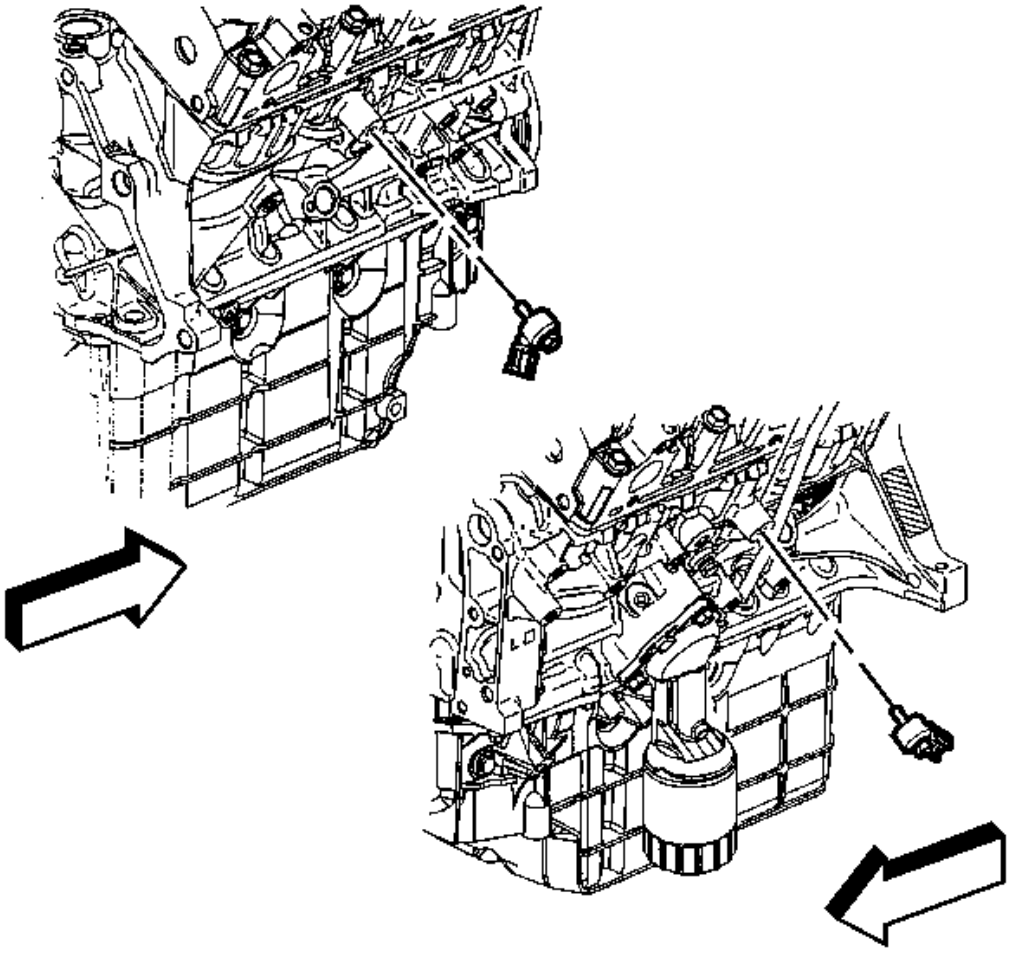

Fig. 327: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

7. Remove the knock sensors.

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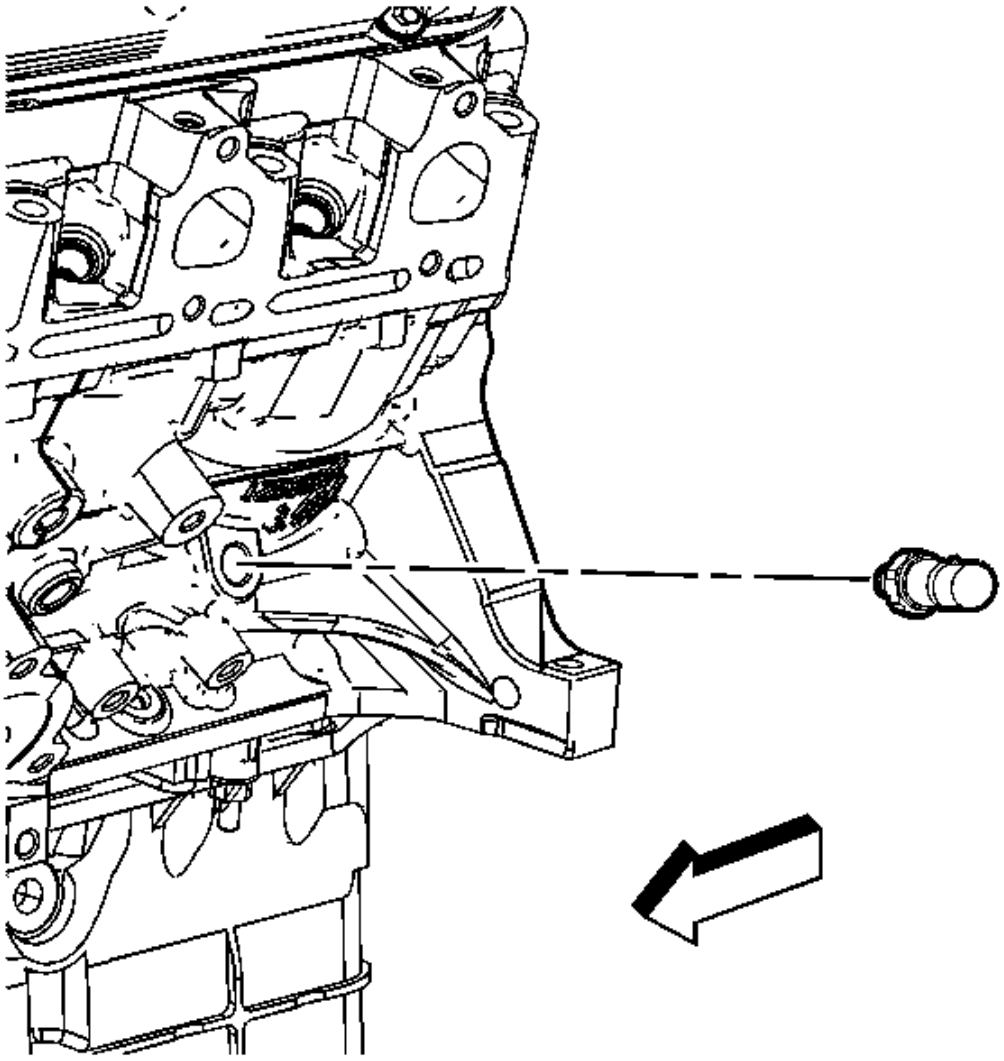

Fig. 328: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine oil pressure indicator switch.

ENGINE BLOCK HEATER REMOVAL

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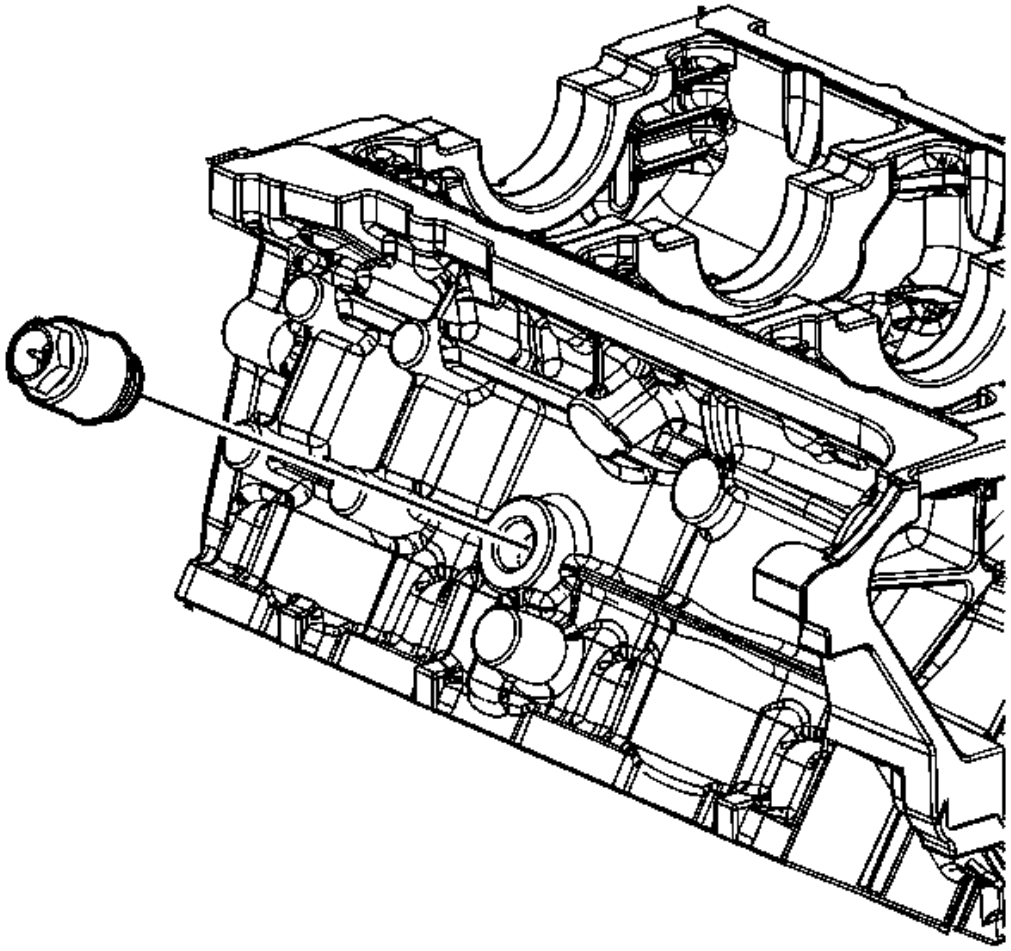

Fig. 329: View Of Engine Block Heater
Courtesy of GENERAL MOTORS CORP.

Remove the engine block heater from engine block.

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **J-8001:** Dial Indicator Set
- **J-8087:** Cylinder Bore Gage

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

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Cleaning and Inspection

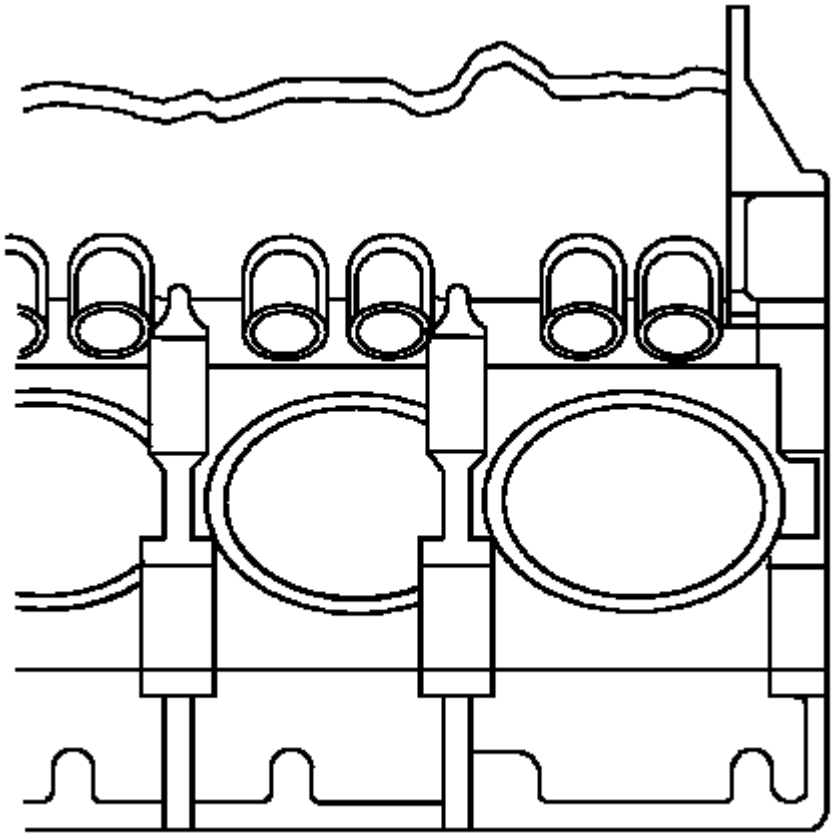

Fig. 330: View Of Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
2. Boil the engine block in caustic solution.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes.
8. Clean the holes with a tap. Drill out the holes and install thread inserts, as needed.

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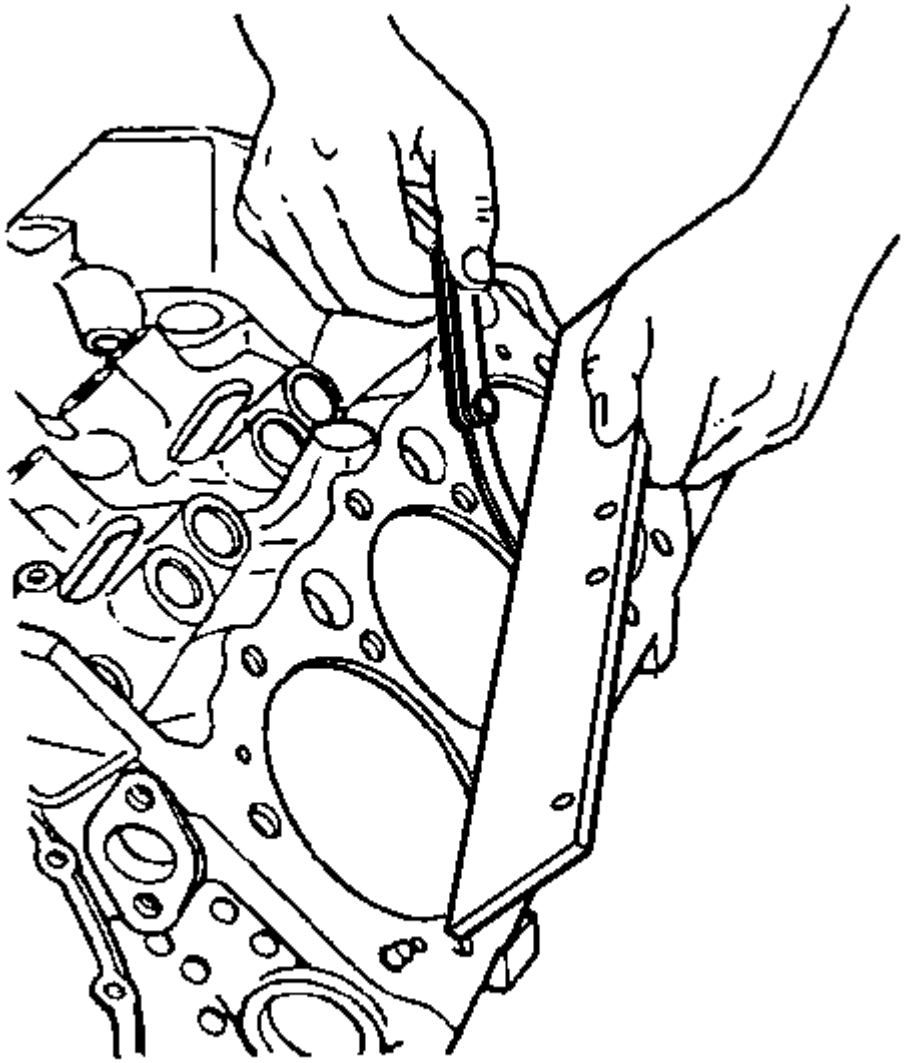

Fig. 331: Testing Block Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

9. Use a straight edge and a feeler gauge in order to test the deck surface for flatness. Replace the block if it is outside of the specification limit.
10. Inspect the oil pan rail for nicks.
11. Inspect the front cover attaching area for nicks. Use a flat mill file in order to remove any nicks.

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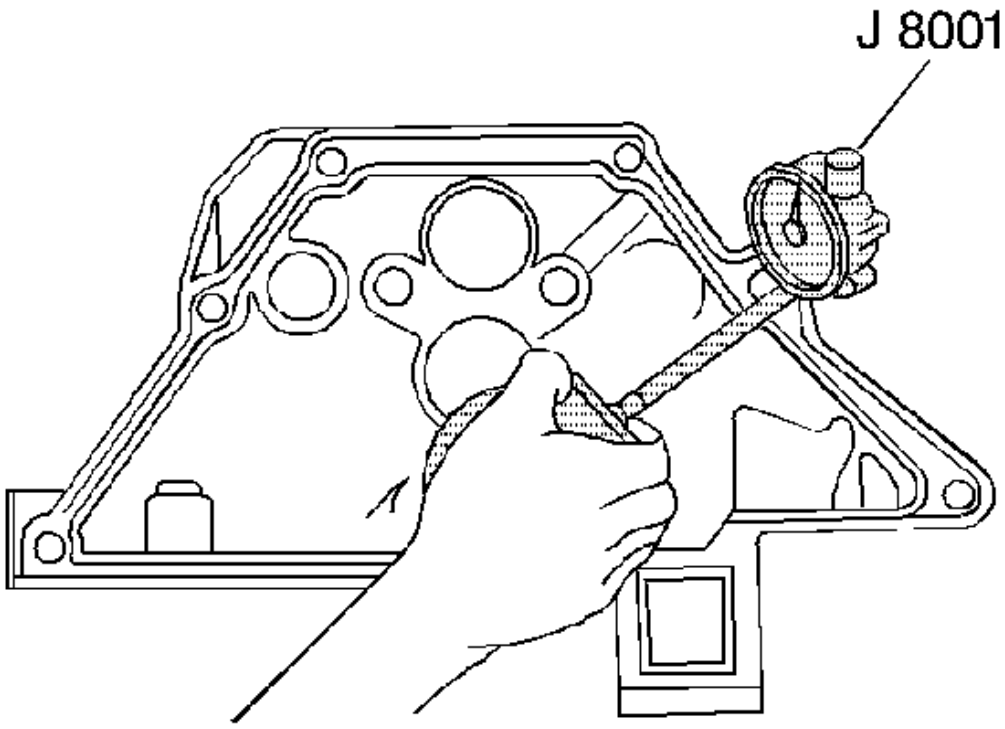

Fig. 332: Inspecting Mating Surfaces Of Transmission Case
Courtesy of GENERAL MOTORS CORP.

12. Inspect the mating surfaces of the transmission case.

CAUTION: A broken flywheel may result if the transmission case mating surface is not flat.

13. Use the following procedure in order to measure the engine block flange runout at the 6 mounting bolt hole bosses:
    1. Temporarily install the crankshaft. Measure the crankshaft flange runout.
    2. Hold the **J-8001:** Dial Indicator Set gage plate flat against the crankshaft flange.
    3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
    4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.25 mm (0.010 in).
    5. Retest the crankshaft flange runout if the readings vary more than 0.25 mm (0.010 in). If the crankshaft flange runout is not within the specification, replace the engine block.

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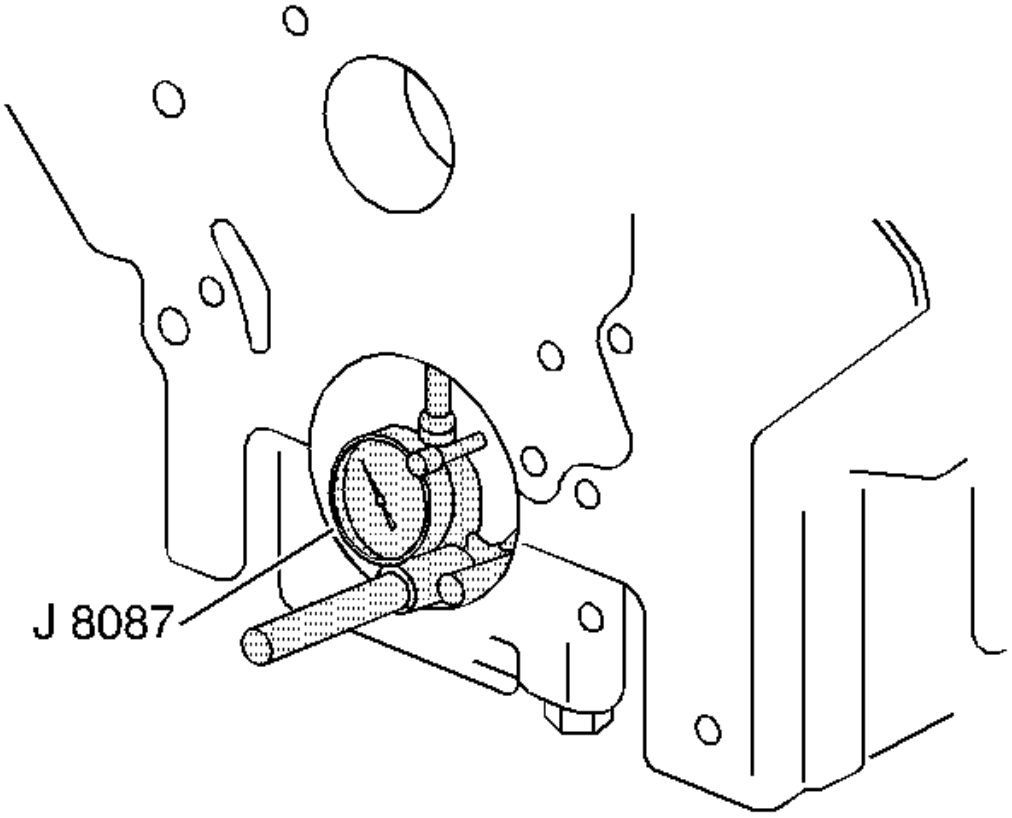

Fig. 333: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

NOTE: Perform the following inspections, and reconditioning if necessary, with the crankshaft main bearing caps installed and tightened to specification.

14. Inspect the crankshaft main bearing bores. Use the **J-8087:** Cylinder Bore Gage in order to measure the bearing bore concentricity and alignment at the following locations:
    - The camshaft
    - The crankshaft
15. Replace the engine block if the bores are out of specification.

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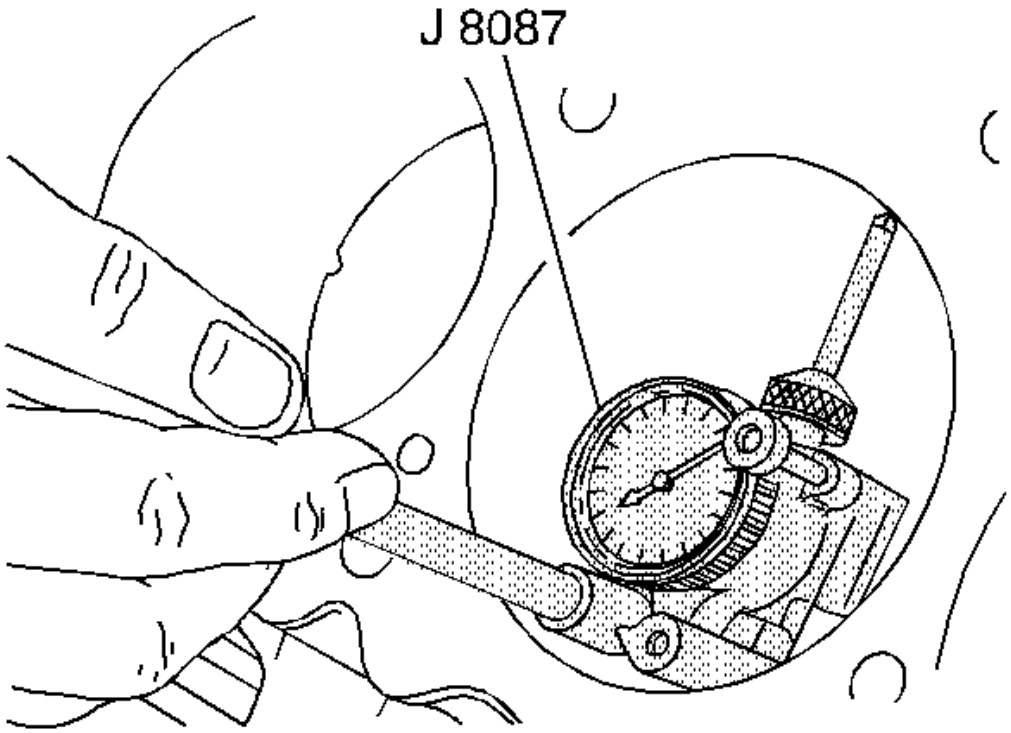

Fig. 334: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

16. Use the **J-8087:** Gage in order to inspect the cylinder bores. Inspect the bores for the following conditions:
    - Wear
    - Taper
    - Runout
    - Ridging

NOTE: If the bore is worn beyond the limits, refit the bore with 0.5 mm (0.02 in) oversized pistons.

17. Leave sufficient material in order to allow honing when fitting the piston.

CYLINDER BORING AND HONING

Boring Procedure

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1. Before honing or boring, measure all of the new pistons. Select the smallest piston for the piston fitting. Slightly varied pistons in a set may provide correction, if the first piston is too loosely fitted.
2. Before using any type of boring bar, file the top of the engine block to remove any dirt or burrs. If the cylinder block is not straight, the boring bar may be tilted, causing the bored cylinder wall to have incorrect right angles to the crankshaft.
3. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
4. Install all crankshaft main bearing caps to specification when boring cylinders. Cover or tape the crankshaft bearings and other internal parts to protect these parts during the boring or honing operation.
5. Leave 0.03 mm (0.001 in) on the diameter for finish honing when performing the final cut with a boring bar. Carefully perform the honing and boring operation to maintain the specified clearances between pistons, rings, and cylinder bores.

Honing Procedure

1. Follow the manufacturer's recommendations for use, cleaning, and lubrication when honing the cylinders. 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. When using coarse or medium-grade stones, leave sufficient metal so all stone marks may be removed with the fine stones used for finishing to provide the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Check for the correct piston fit.

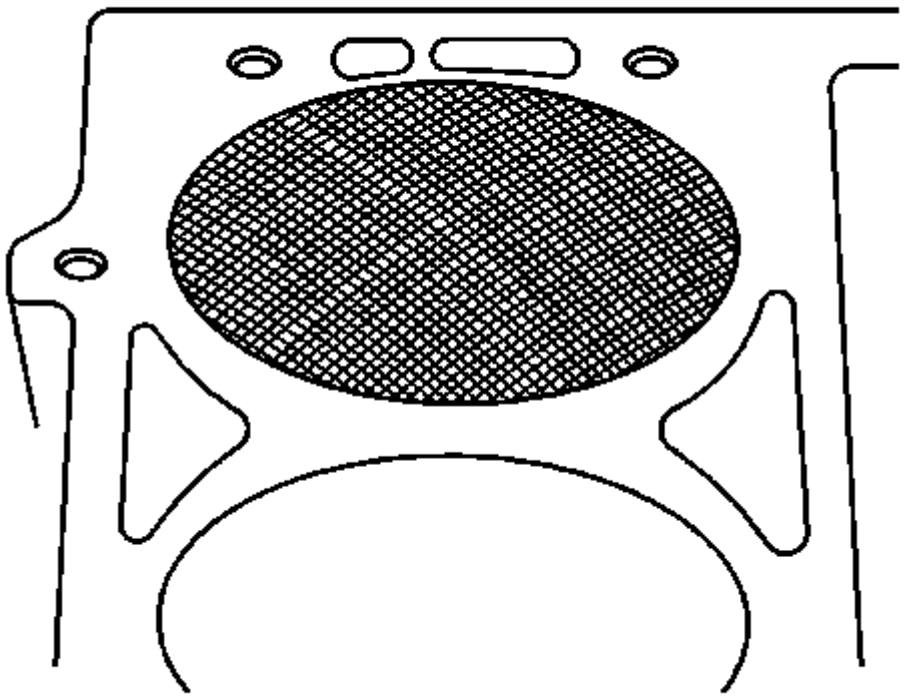

Fig. 335: Identifying Cylinder Bore Cross Hatch Pattern

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Courtesy of GENERAL MOTORS CORP.

3. Make full strokes in the cylinder to eliminate taper. Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

CAUTION: Handle the pistons with care. Do not force the pistons through the cylinder until you hone the cylinder to the correct size. The piston can be distorted through careless handling.

4. When finish honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed to obtain a fine and uniform surface finish in a cross hatch pattern.
5. The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.
6. Determine the finish hone cylinder measurement by measuring the piston to be installed, and by adding the average of the clearance specification. Measure the block and the piston at normal room temperature.
7. True up the refinished cylinder bores. Final hone each cylinder bore to remove all stone or cutter marks.
8. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material will wear the new rings, the cylinder bores, and the bearings lubricated by the contaminated oil. After washing dry the bore.
9. Permanently mark the piston for the cylinder to which the piston has been fitted.
10. Apply clean engine oil to each bore to prevent rusting.

ENGINE BLOCK ASSEMBLE

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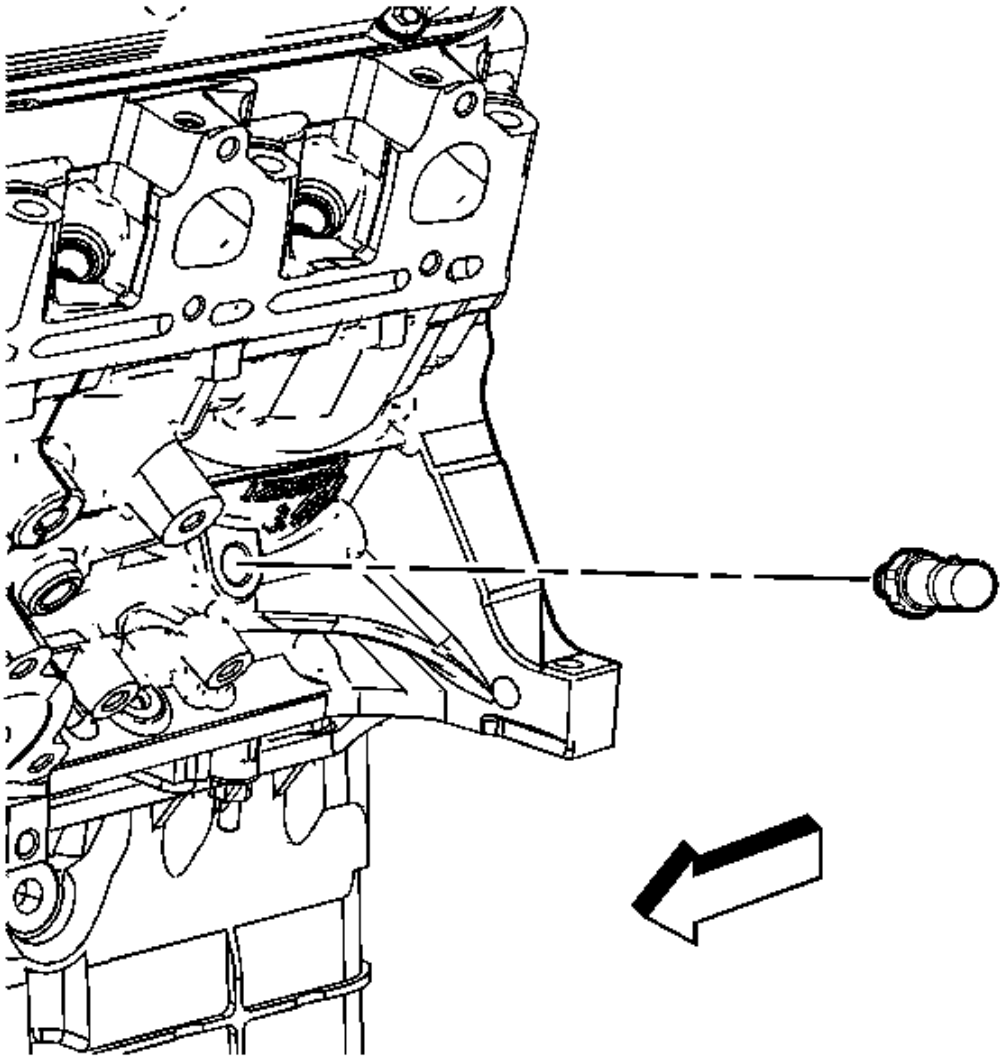

Fig. 336: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the oil pressure switch threads.

CAUTION: Refer to Fastener Caution .

2. Install the engine oil pressure switch and tighten to 16 N.m (12 lb ft).

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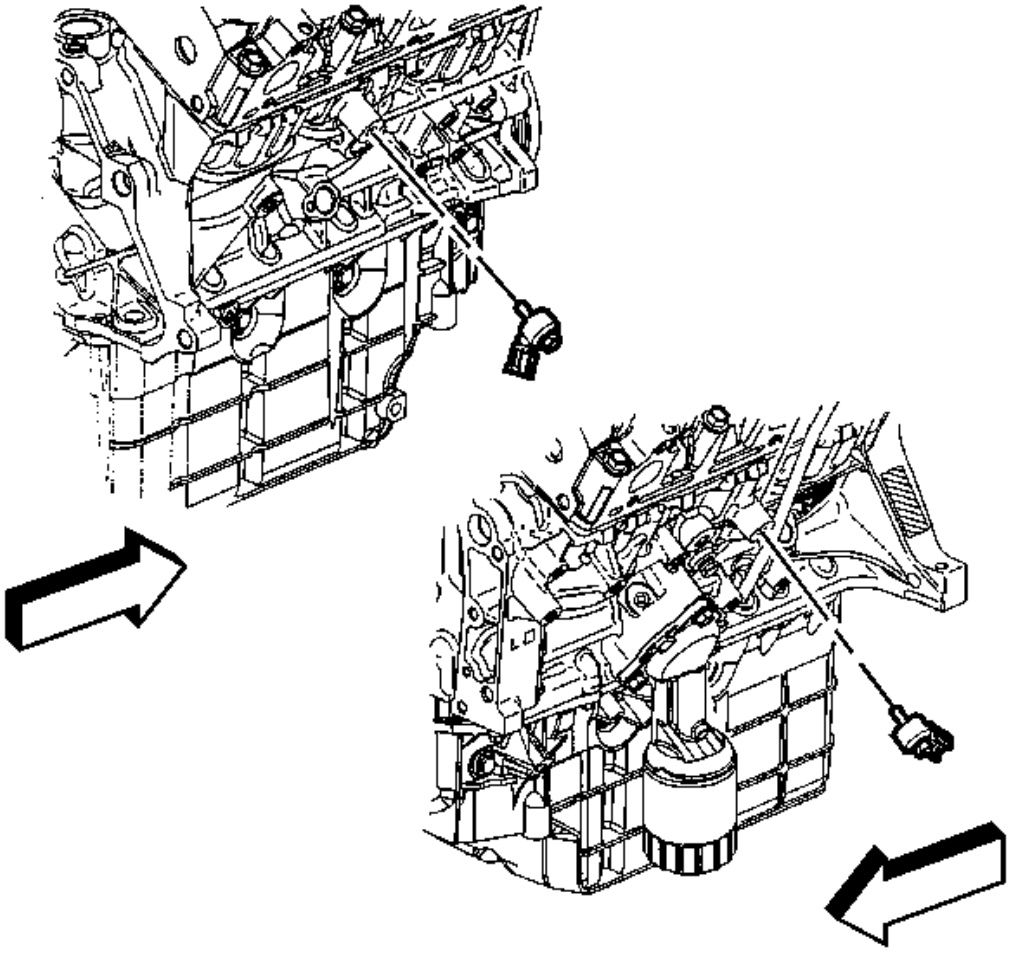

Fig. 337: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

3. Install the knock sensors and tighten to 25 N.m (18 lb ft).

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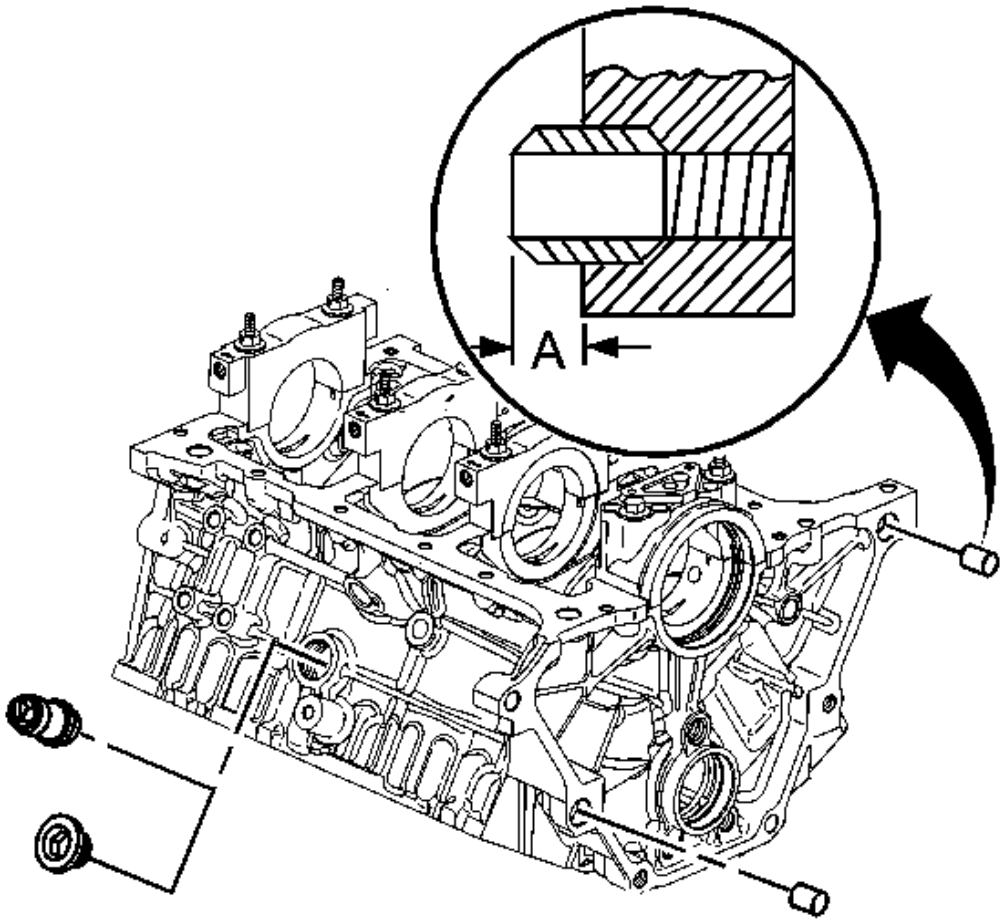

Fig. 338: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the engine block plug.
5. Install a NEW engine block plug and tighten to 60 N.m (44 lb ft).
6. Install the transmission locating pins. The installation height should be 8.3-9.3 mm (0.327-0.366 in) (A).

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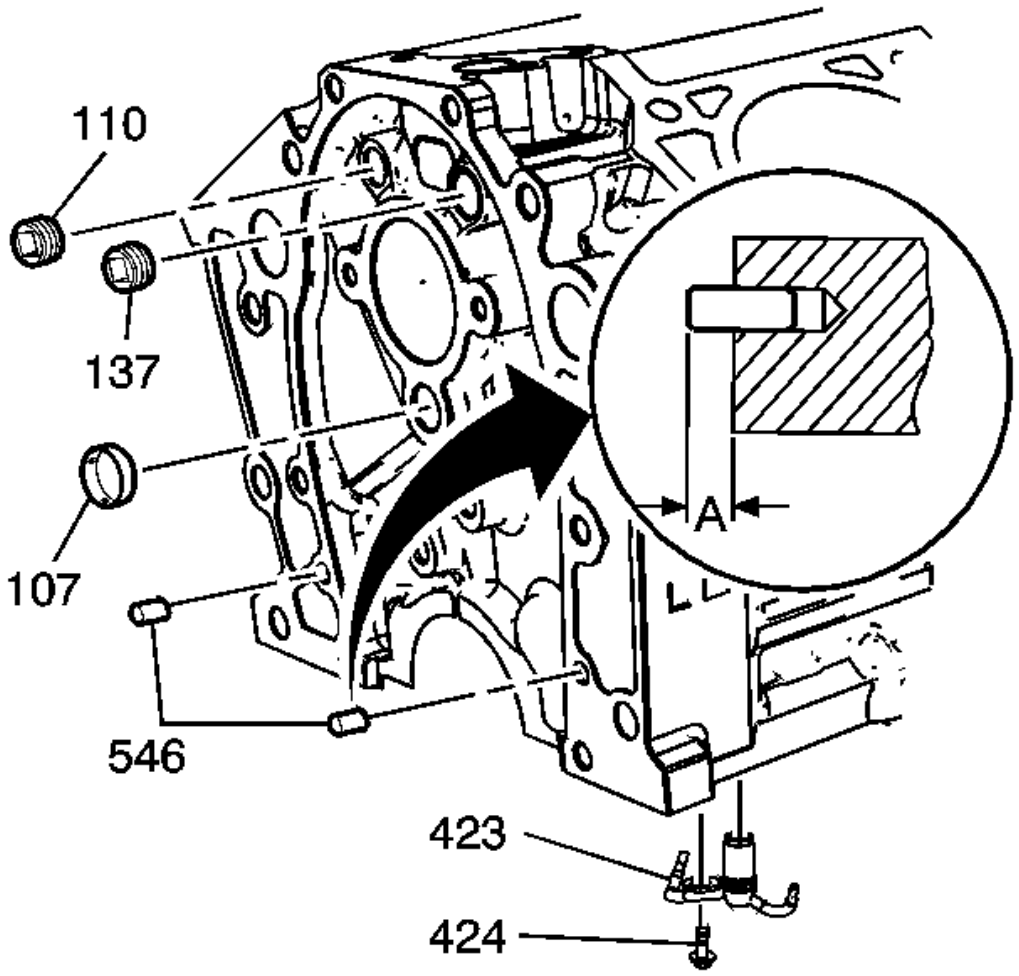

Fig. 339: View Of Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

7. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the front oil gallery plug threads (110, 137).
8. Install the front oil gallery plug (110) and tighten to 19 N.m (14 lb ft).
9. Install the front oil gallery plug (137) and tighten to 33 N.m (24 lb ft).
10. Apply sealer GM P/N 12377901 (Canadian P/N 10953504), or equivalent to the front oil gallery plug (107).
11. Install the front oil gallery plug (107) so that it is 1.5 mm (0.06 in) below flush of the engine block.
12. Install the engine front cover locating pins (546). The installation height should be 5.8-8.2 mm (0.228-0.323 in) (A).

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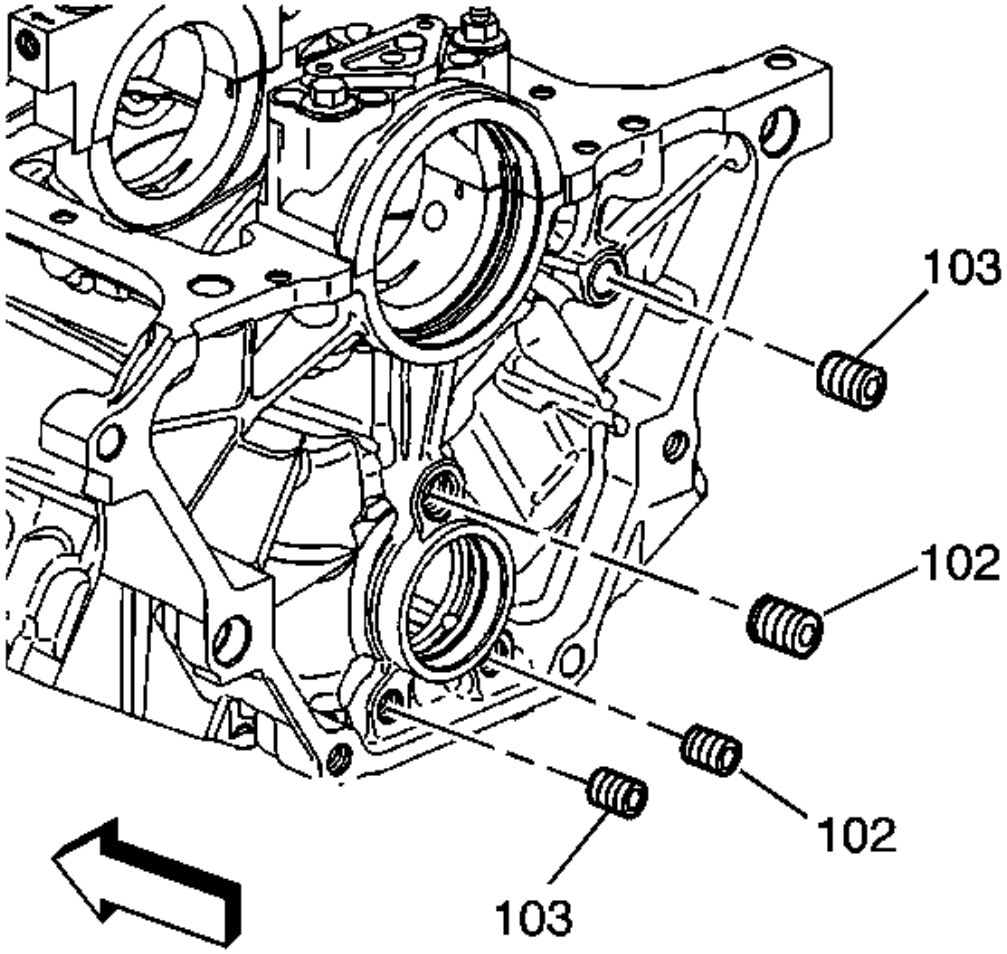

Fig. 340: View Of Rear Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

13. Apply Sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the rear oil gallery plugs.
14. Install the rear oil gallery plugs (103) and tighten to 19 N.m (14 lb ft).
15. Install the rear oil gallery plugs (102) and tighten to 33 N.m (24 lb ft).

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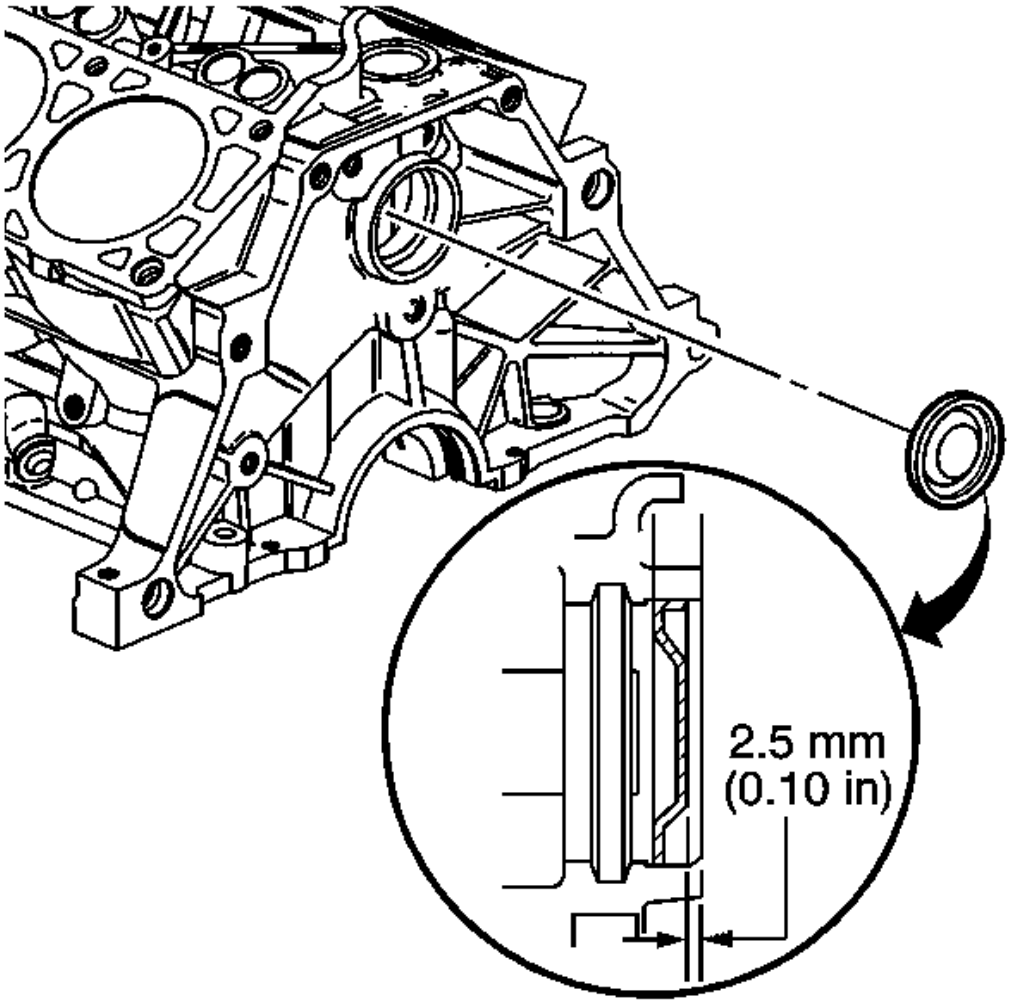

Fig. 341: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

16. Apply sealer GM P/N 12377901 (Canadian P/N 10953504), or equivalent to the camshaft rear bearing hole plug.
17. Install the camshaft rear bearing hole plug.

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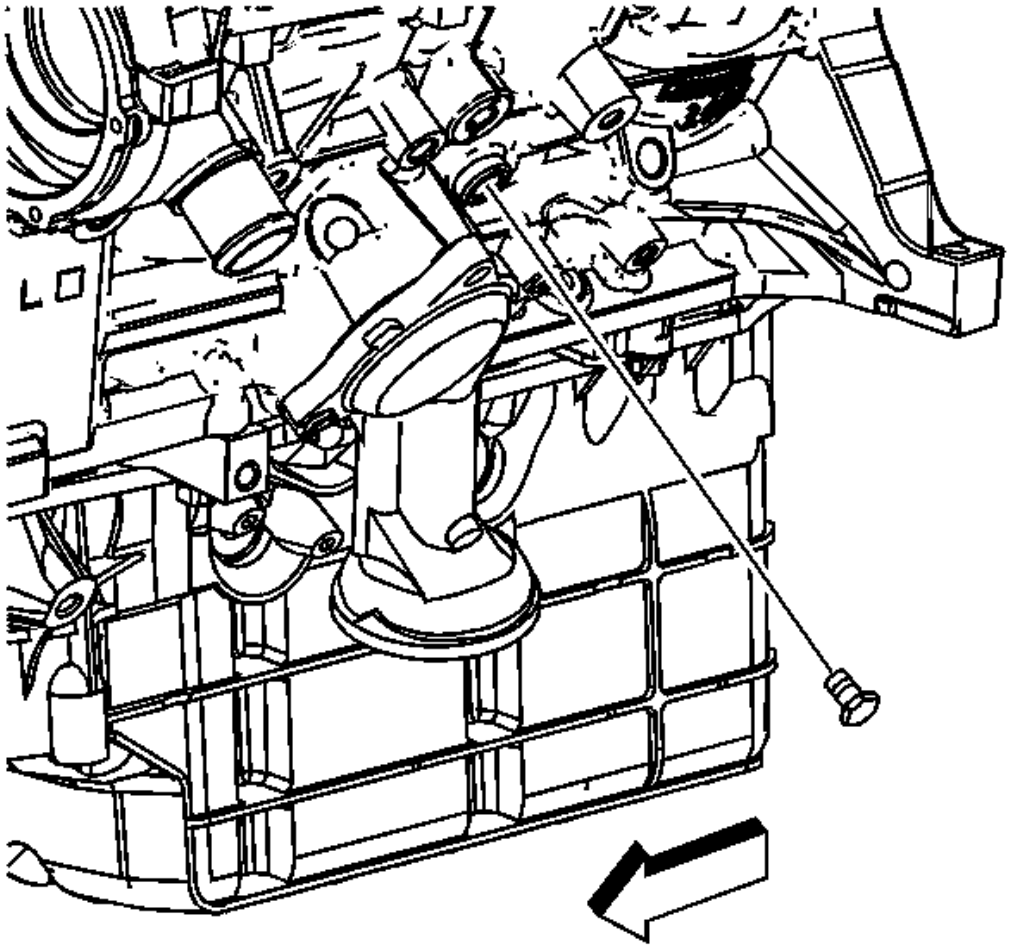

Fig. 342: View Of Left Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

18. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the left and right coolant drain plug threads.
19. Install the left coolant drain plug and tighten to 19 N.m (14 lb ft).

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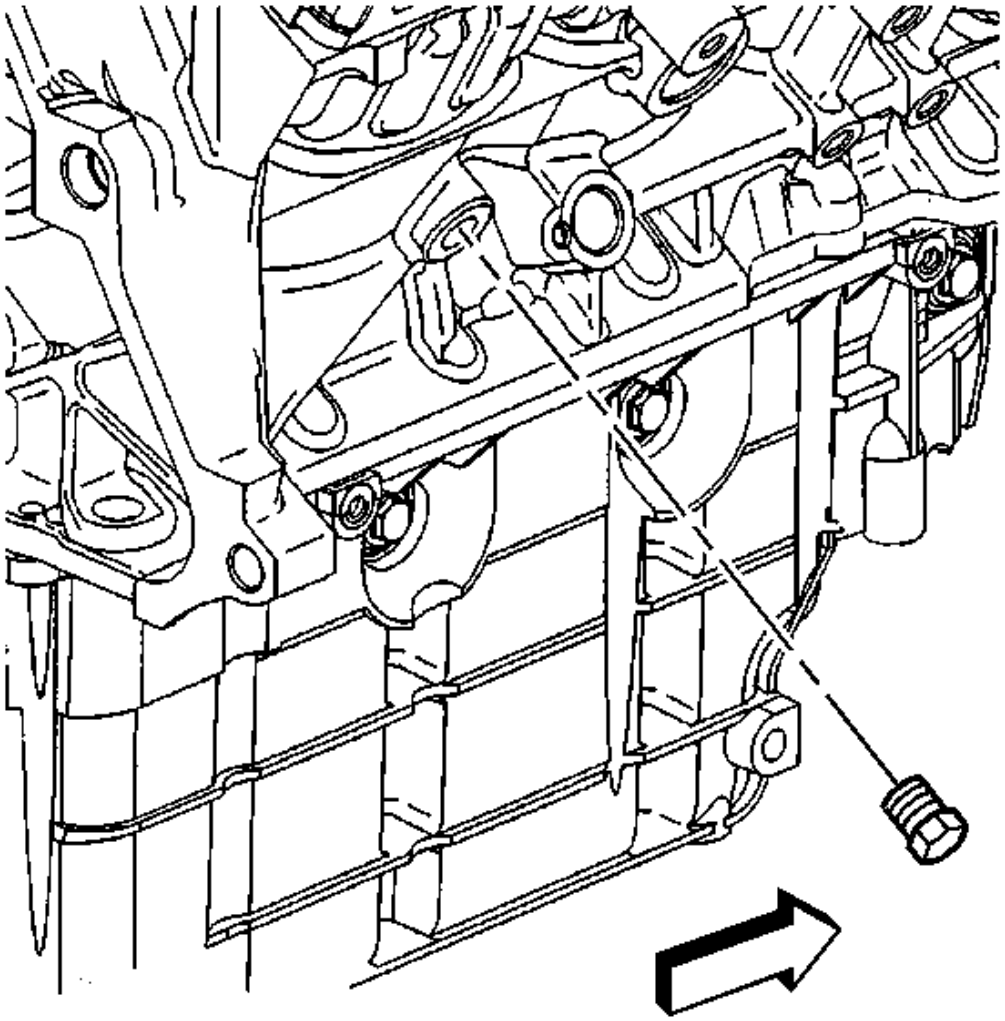

Fig. 343: View Of Right Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

20. Install the right coolant drain plug and tighten to 19 N.m (14 lb ft).

ENGINE BLOCK HEATER INSTALLATION

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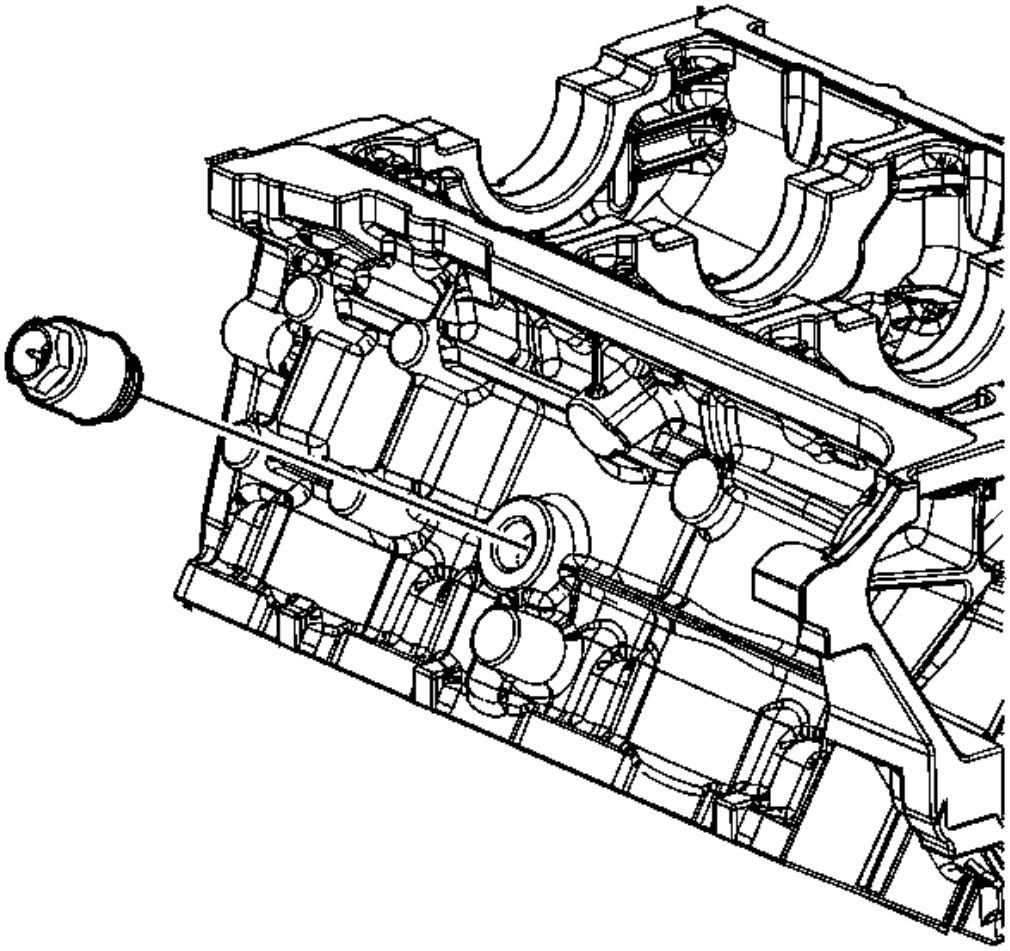

Fig. 344: View Of Engine Block Heater
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004 (Canadian P/N 1095380), or equivalent to the engine block heater.

CAUTION: Refer to Fastener Caution .

2. Install the engine block heater into the engine block and tighten to 50 N.m (37 lb ft).

PISTON OIL NOZZLE CLEANING AND INSPECTION

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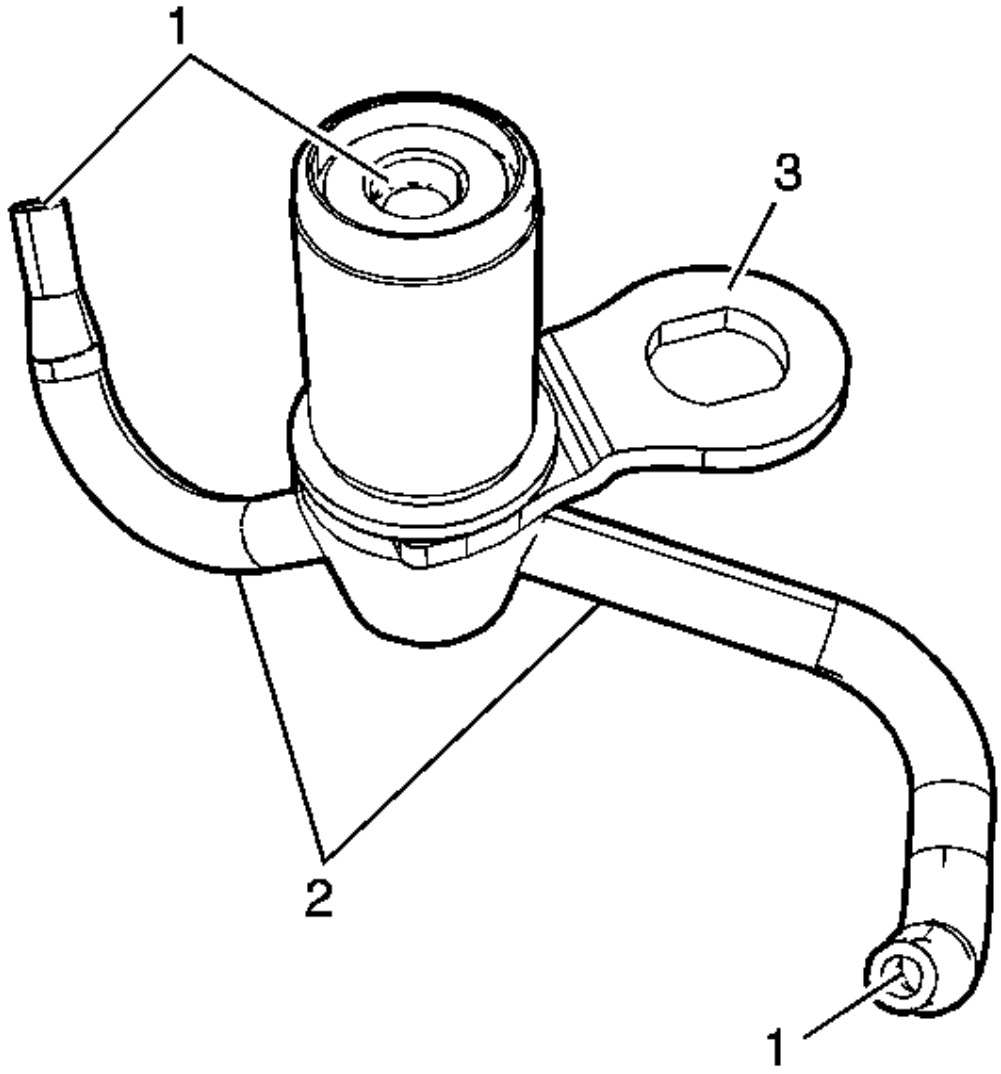

Fig. 345: View Of Piston Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Cleaning Solvent Warning .

1. Clean the piston oil nozzle in cleaning solvent using GM P/N 10953463 (Canadian P/N 88901148) or equivalent.

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WARNING: Wear safety glasses in order to avoid eye damage.

2. Dry the nozzle with compressed air.
3. Inspect the piston oil nozzle for the following:
    - For cracks or damage
    - Plugged oil passages (1)
    - Bent, misaligned, or cracked oil nozzle tubes (2)
    - Bent or broken clip (3)

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

- **J-8087:** Cylinder Bore Gage
- **J-45059:** Angle Meter

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

Cleaning and Inspection

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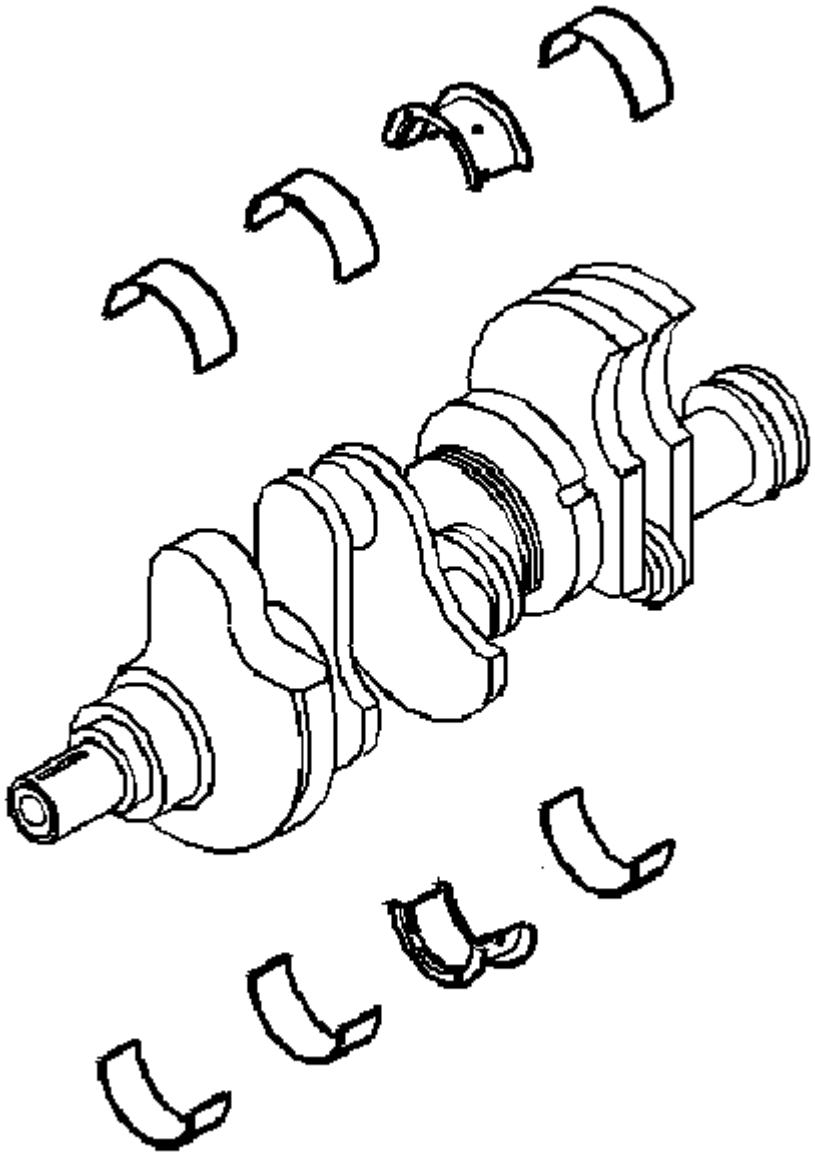

Fig. 346: View Of Crankshaft & Bearings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor wheel teeth. Nicks, burrs or other damage to the teeth may effect on-board diagnostics (OBD) 2 system performance.

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1. Clean the crankshaft of the following elements:
   - Oil
   - Sludge
   - Carbon
2. Inspect the crankshaft oil passages for obstructions.

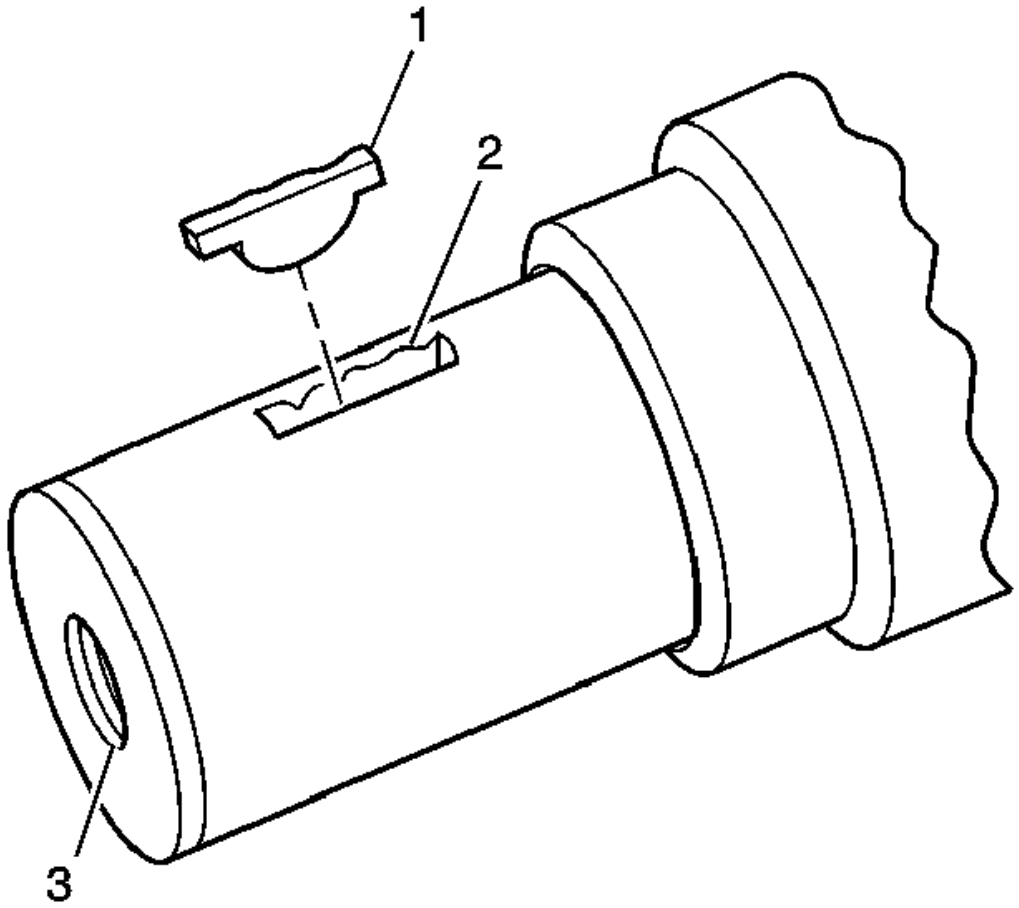

Fig. 347: Inspecting Crankshaft Keyway
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft keyway for the following conditions:
   - A worn crankshaft key (1)
   - A worn crankshaft keyway (2)
4. Inspect the crankshaft threads (3) for damage.

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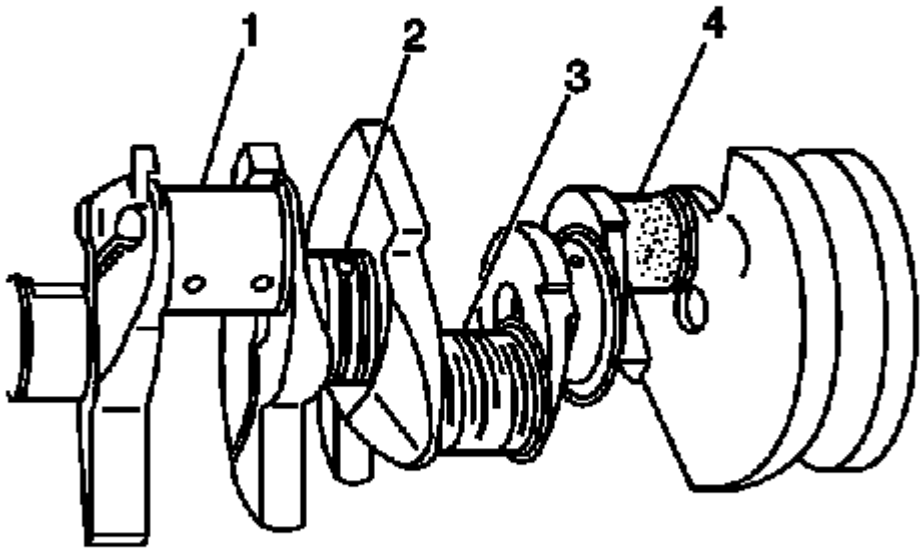

Fig. 348: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

NOTE: If cracks, severe gouges or burned spots are found, replace the crankshaft. Remove slight roughness using a fine polishing cloth soaked in clean engine oil. Remove any burrs using a fine oil stone.

5. Inspect the crankshaft bearing journals and the crankshaft thrust surfaces for the following conditions:
   - Wear without any grooves or scratches (1)
   - Grooves or scoring (2)
   - Scratches or excessive wear (3)
   - Pitting or embedded bearing material (4)-Inspect the corresponding crankshaft bearing inserts for embedded material and determine the source of the material.
   - Overheating or discoloration

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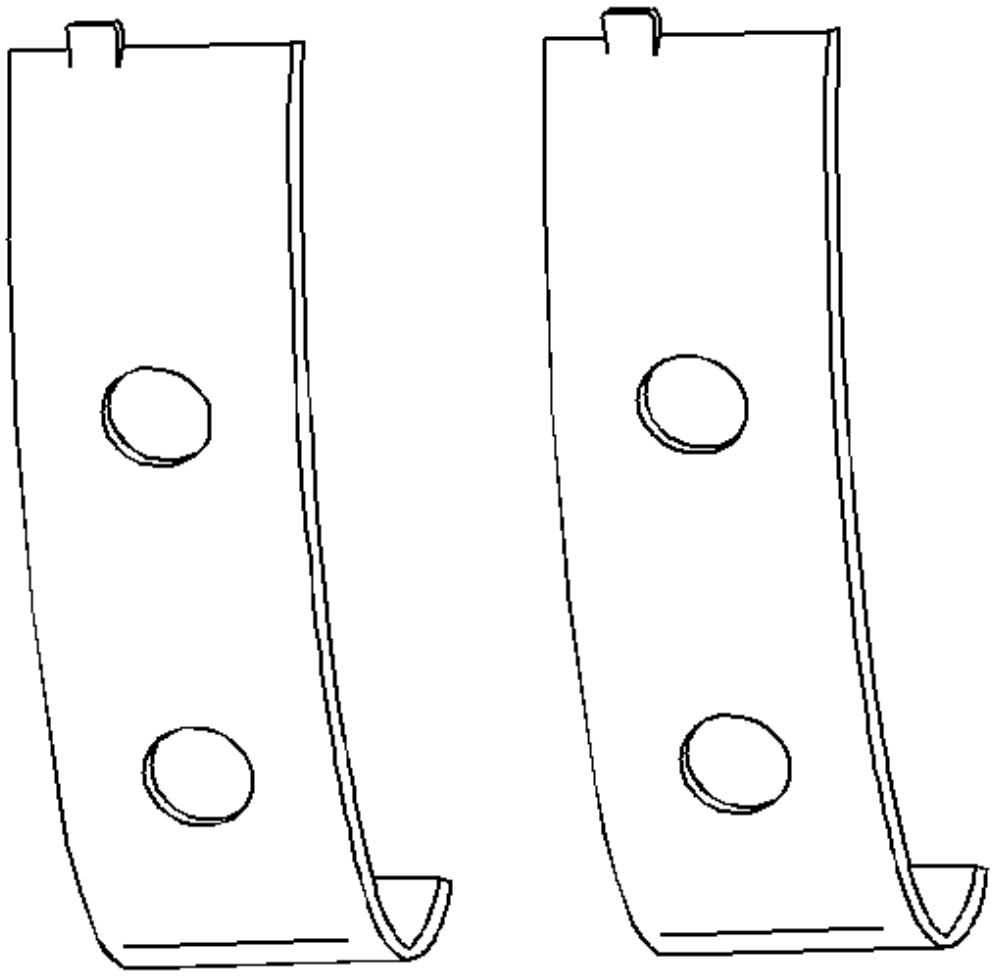

Fig. 349: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

6. The crankshaft bearings are the precision insert type.
7. Inspect the outer surfaces of the crankshaft bearings for the following conditions:
    - Wear-surface wear indicates either movement of the insert, or high spots in the surrounding material - spot wear.
    - Overheating or discoloration
    - Looseness or rotation indicated by flattened tangs and wear grooves

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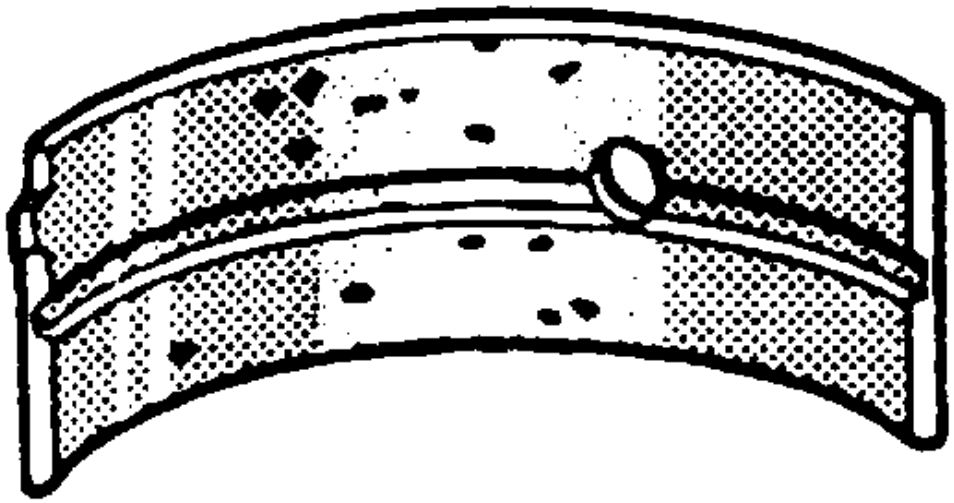

Fig. 350: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

NOTE: Note the location of the crankshaft main bearing high spots. If the spots are not in line, the crankshaft is bent. Replace the crankshaft.

8. Inspect the crankshaft main bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.
9. Inspect the thrust surfaces of the main thrust bearing for the following conditions:
    - Wear
    - Grooving-Grooves are caused by irregularities of the crankshaft thrust surface.

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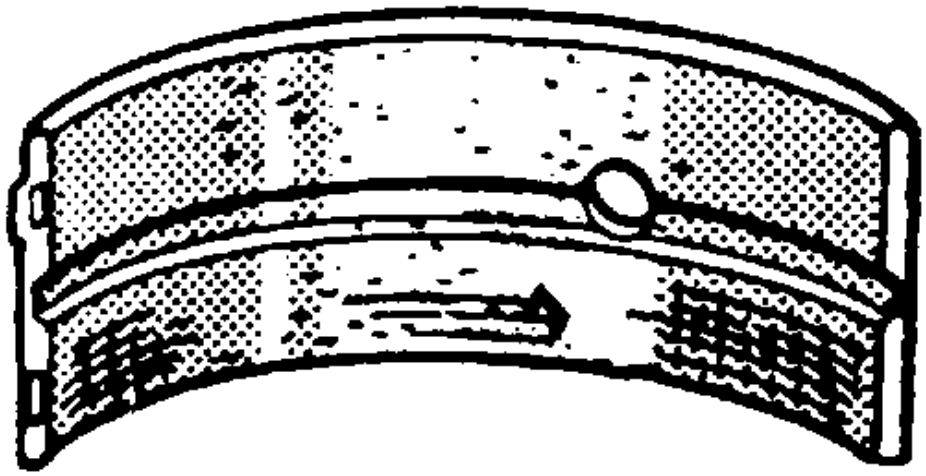

Fig. 351: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

10. Inspect the crankshaft bearings for excessive scoring or discoloration.
11. Inspect the crankshaft main bearings for dirt or imbedded debris.

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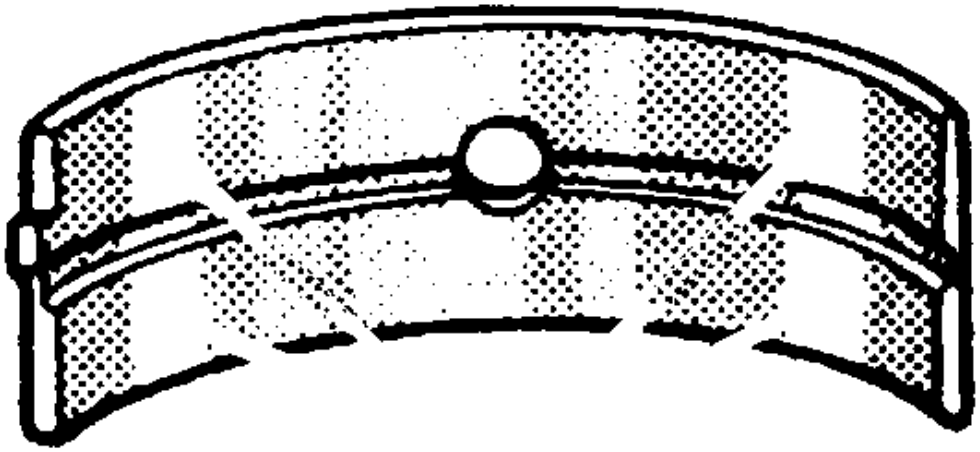

Fig. 352: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

12. Inspect the crankshaft main bearings for improper seating indicated by bright, polished sections.
13. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

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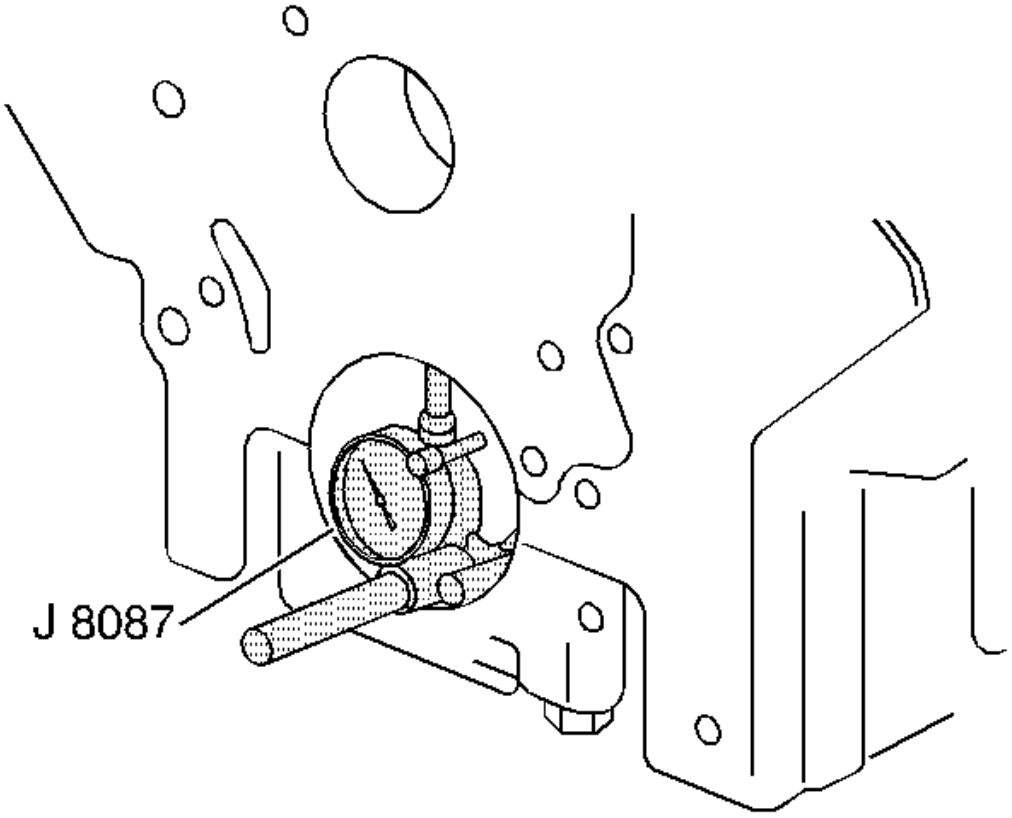

Fig. 353: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

NOTE: If crankshaft bearing failure is due to conditions other than normal wear, investigate the cause of the condition. Inspect the crankshaft or connecting rod bearing bores.

14. Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:
    1. Tighten the bearing cap to specification.
    2. Use the **J-8087:** gage in order to measure the bearing bore for taper and out-of-round. Record the readings for bearing selection.
    3. No taper or out-of-round should exist.

Bearing Selection

Measure the bearing clearance to determine the correct replacement bearing insert size. There are two methods to measure bearing clearance. Method A gives more reliable results and is preferred.

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- Method A yields measurement from which the bearing clearance can be computed.
- Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

Method A

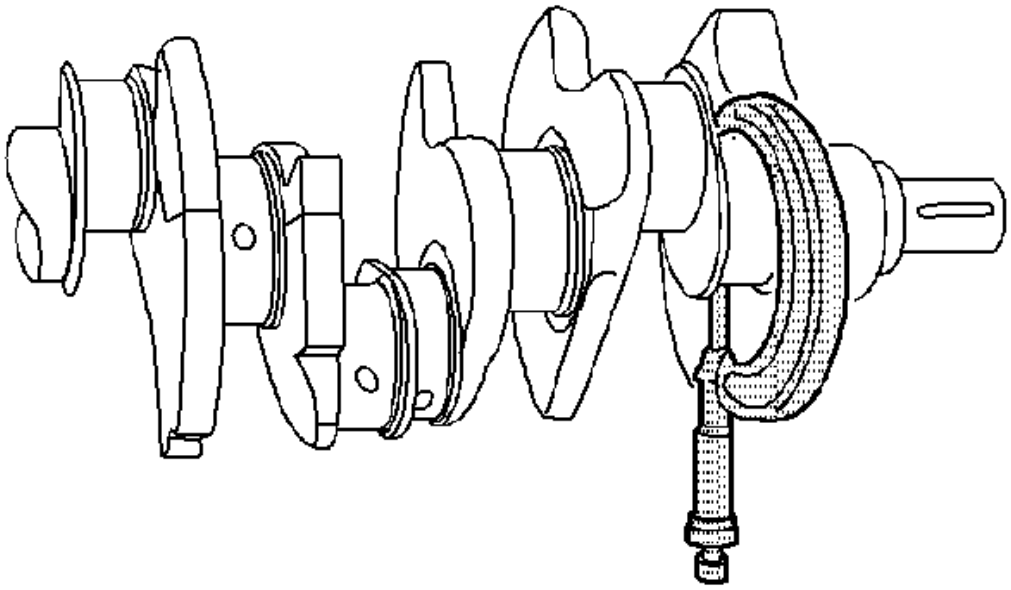

Fig. 354: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not mix inserts of different nominal size in the same bearing bore.

1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
2. Measure the crankshaft bearing journal taper and runout.
3. Install the crankshaft bearing inserts. Tighten the bearing cap bolts to specification using **J-45059:** meter.
4. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
5. Measure the crankshaft main bearing inside diameter with an inside micrometer.
6. Select a set of bearing inserts that will produce the desired clearance.
7. If the specified clearances cannot be met, the crankshaft journals must be reconditioned and undersized bearing inserts installed.

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Method B

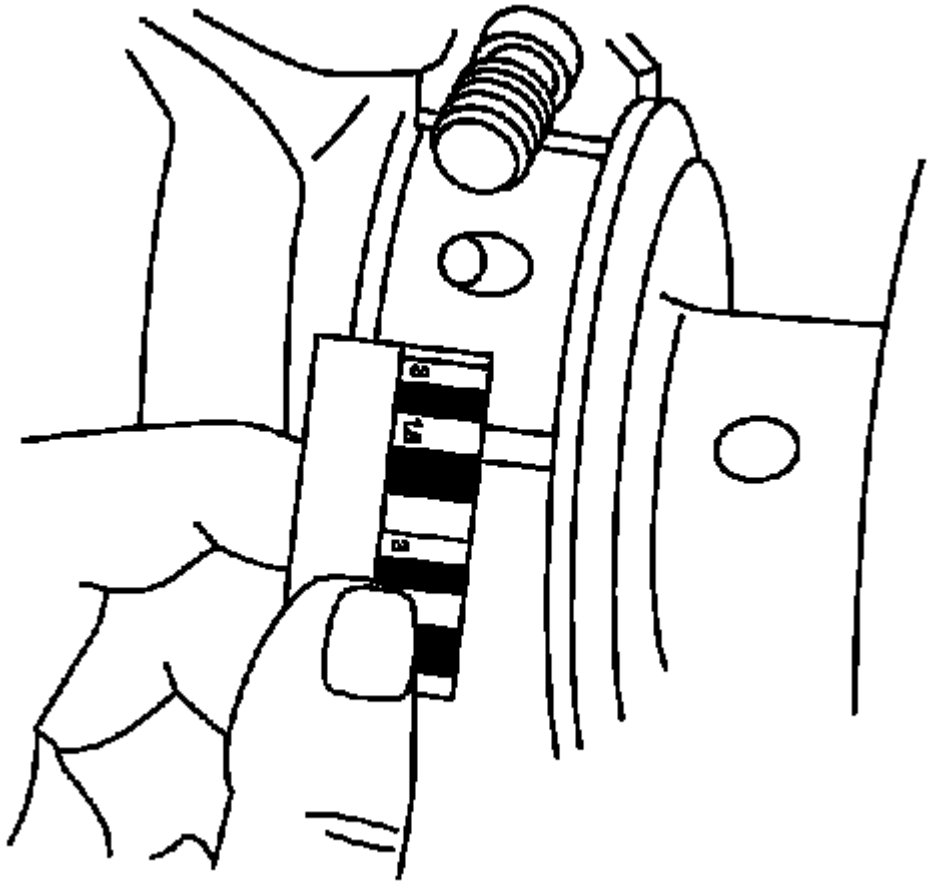

Fig. 355: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not mix inserts of different nominal size in the same bearing bore.

1. Clean the used bearing inserts.
2. Install the used bearing inserts.
3. Place a piece of gaging plastic across the entire bearing width.
4. Install the bearing caps.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

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5. Install the bearing cap bolts to specification using **J-45059:** meter.

NOTE: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale printed on the gaging plastic package.
8. Remove the gaging plastic.
9. Select a set of bearing inserts that will produce the desired clearance.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

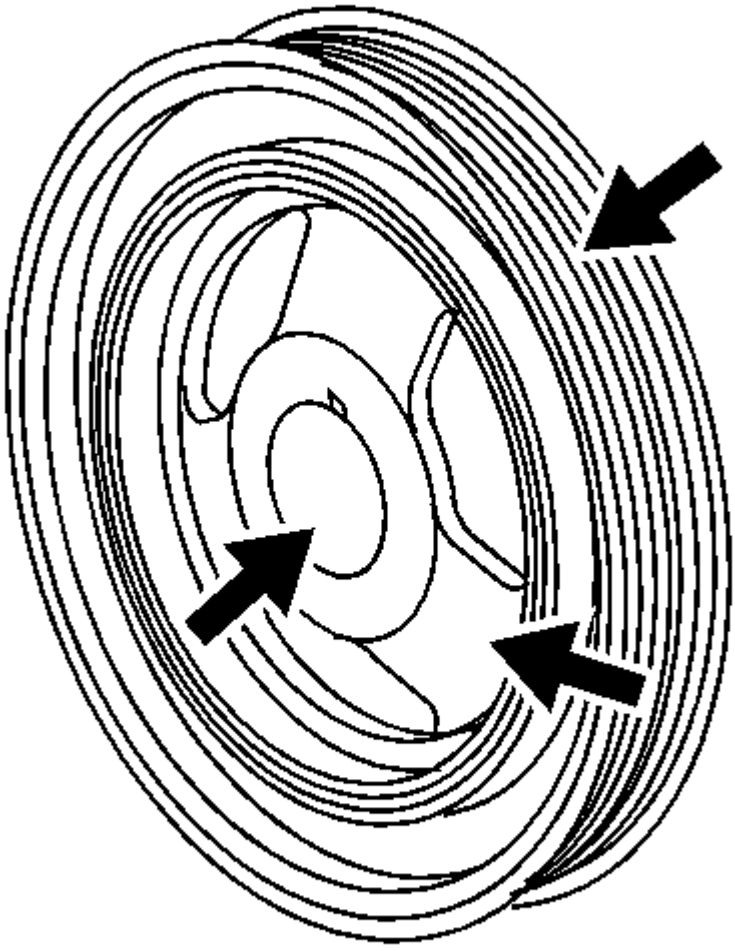

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Fig. 356: Cleaning Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Inspect the crankshaft balancer for the following:

NOTE: A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced. Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

- Worn, grooved, or damaged hub seal surface

NOTE: In order for the belt to track properly, the belt grooves should be free of all dirt, debris, nicks, gouges or other damage. Minor imperfections may be removed with a fine file.

- Dirty or damaged belt grooves.
- Worn, chunking or deteriorated rubber between the hub and pulley

ENGINE FLYWHEEL CLEANING AND INSPECTION

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

NOTE: In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.

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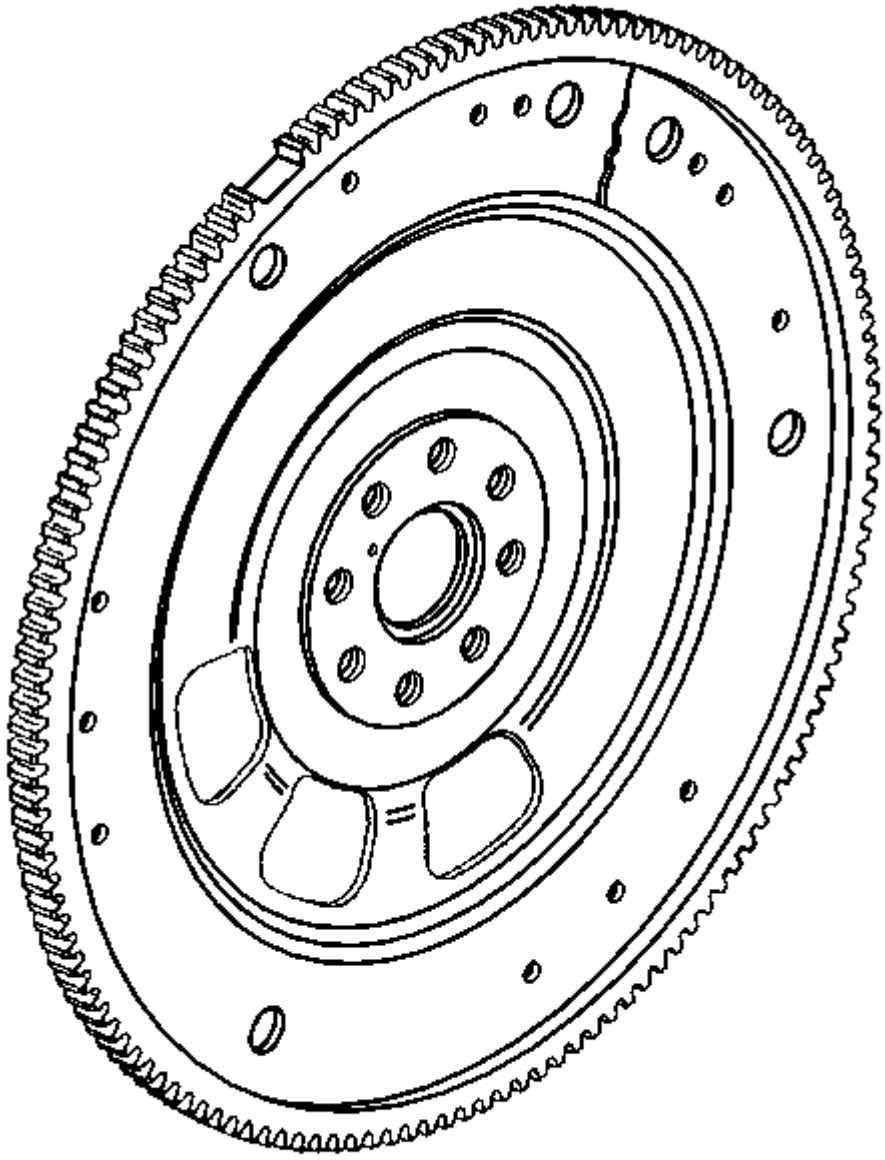

Fig. 357: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine flywheel with solvent.
2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel for the following:

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- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Special Tools

- **EN-46745:** Piston Pin Retainer Remover and Installer
- **J-8087:** Cylinder Bore Gage

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

Cleaning and Inspection

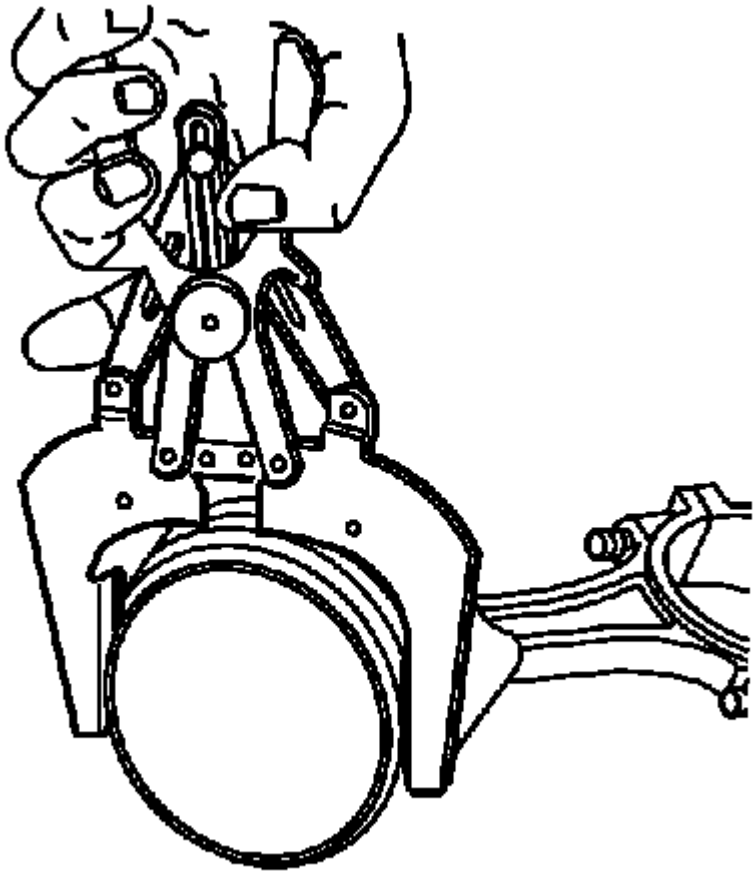

Fig. 358: Cleaning Piston Ring Grooves
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

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NOTE: **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 or connecting rod assembly.**

NOTE: **Some steps in this procedure may reflect on a disassembled oversized piston. Others will only apply to the standard size pistons that are NOT to be disassembled.**

1. Clean the piston and connecting rod in solvent.
2. Dry off the piston and connecting rod with compressed air.
3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.

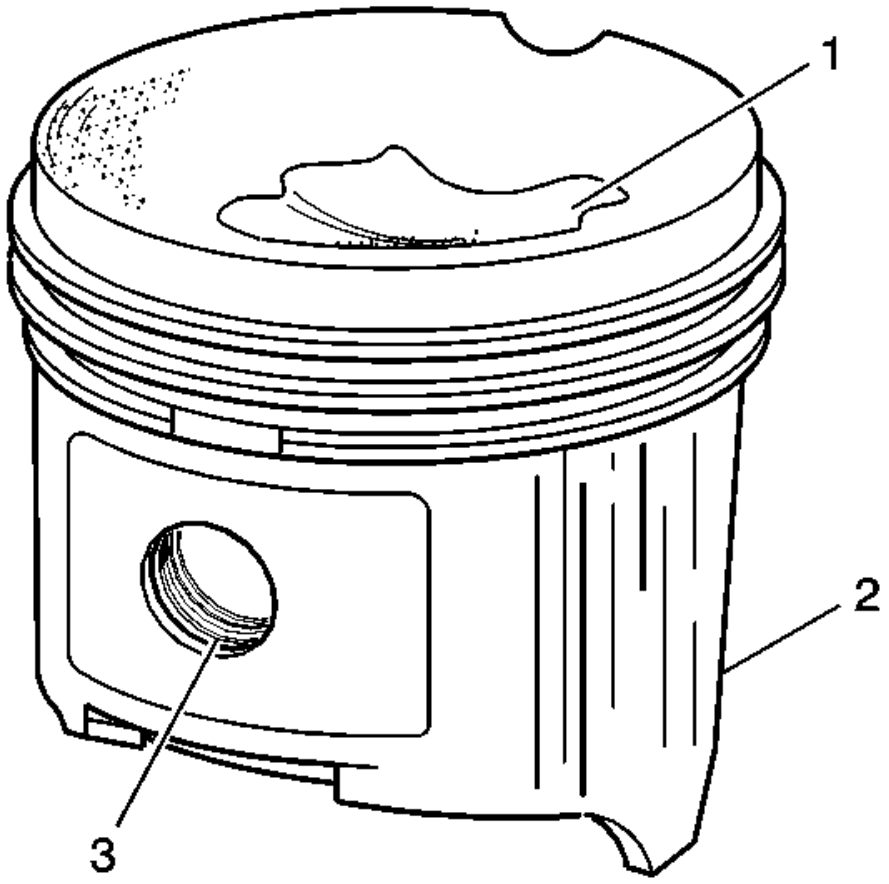

Fig. 359: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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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.

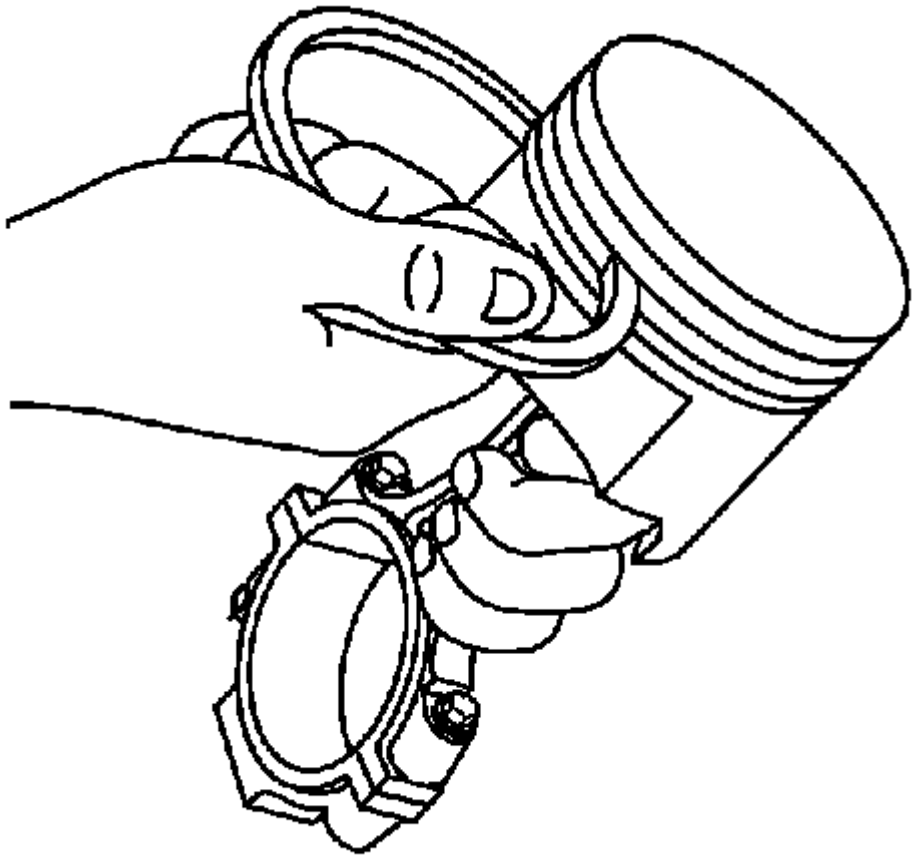

Fig. 360: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

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 ring groove.
        - If binding is caused by distorted piston ring groove, replace the piston.
        - If binding is caused by a distorted piston ring, replace the piston ring.

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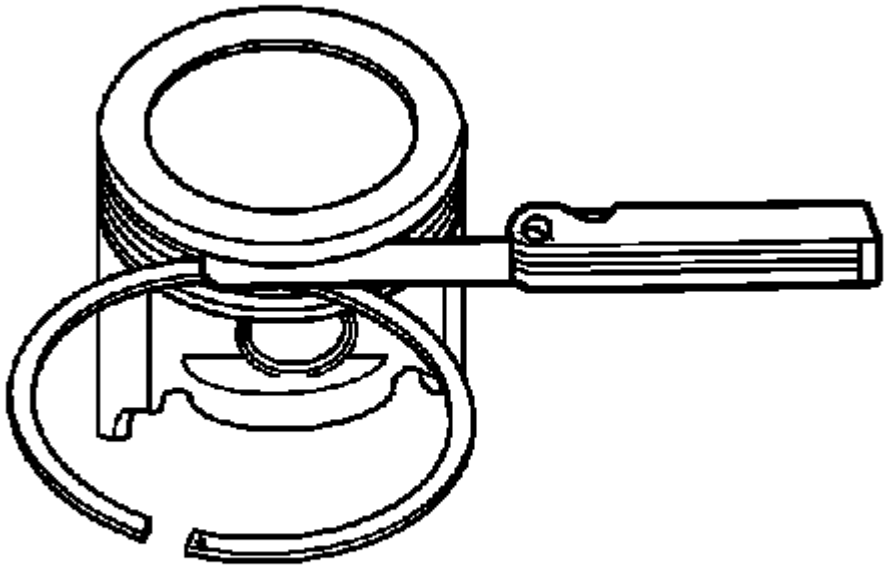

Fig. 361: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gage.
9. If the side clearance is too small try another ring set.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
    - Proper ring-to-piston ring groove clearance for the top ring is 0.03-0.065 mm (0.001-0.002 in).
    - Proper ring-to-piston ring groove clearance for the second ring is 0.04-0.078 mm (0.002-0.003 in).

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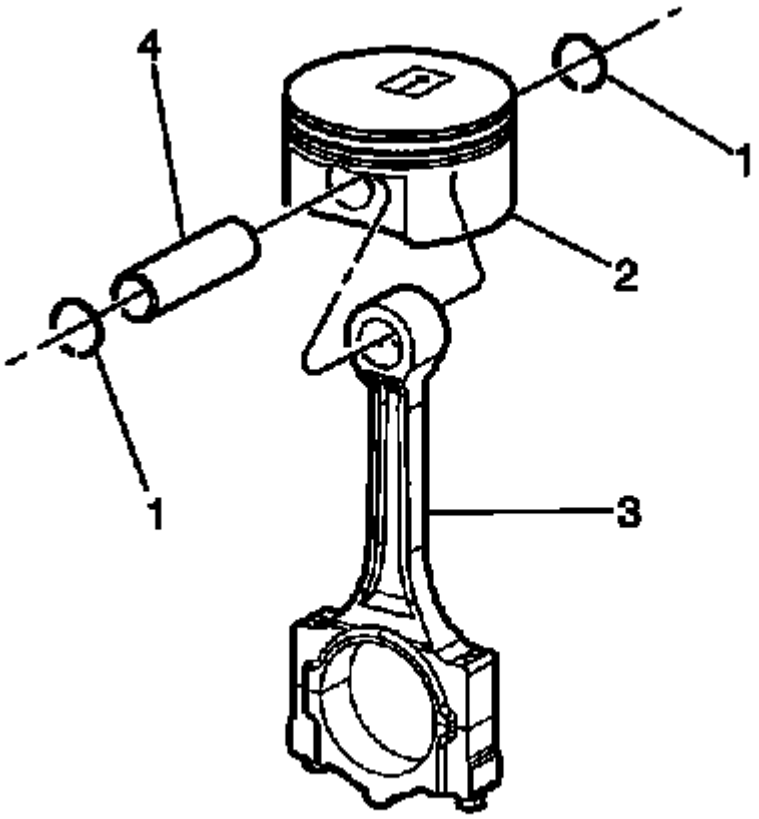

Fig. 362: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

11. Using the **EN-46745:** installer, remove the piston pin retainers (1).
12. Discard the oil piston pin retainers.
13. Slide the piston pin (4) out of the piston (2), disconnecting the piston from the connecting rod (3).

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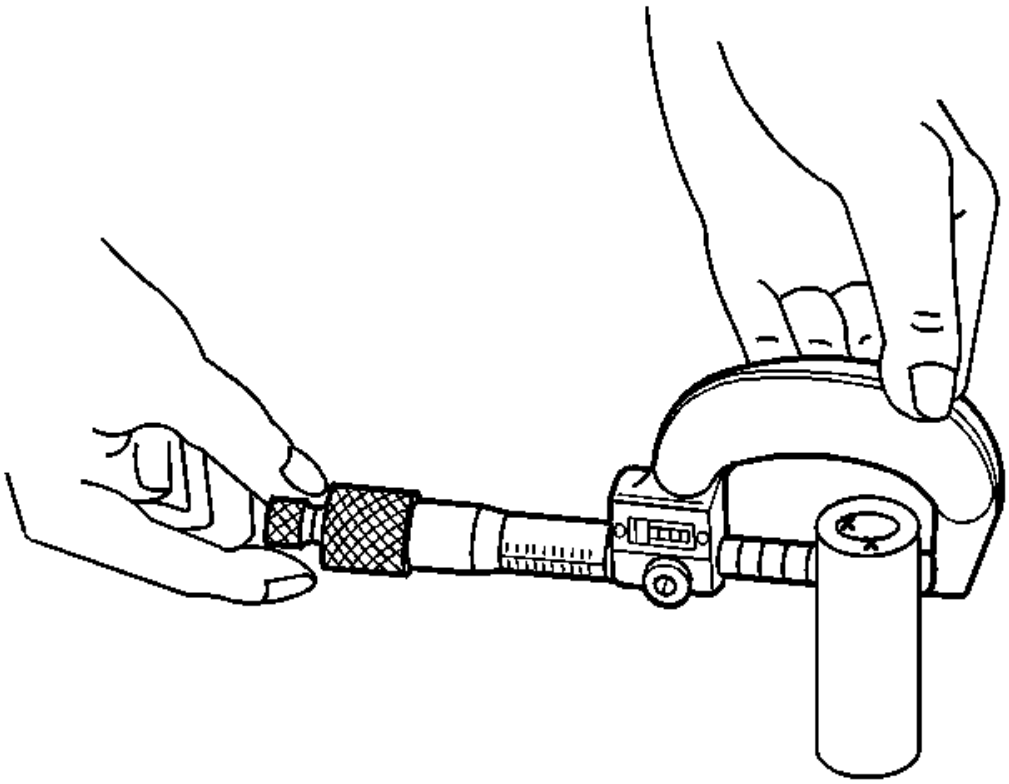

Fig. 363: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

14. Measure the piston pin diameter using and outside micrometer.

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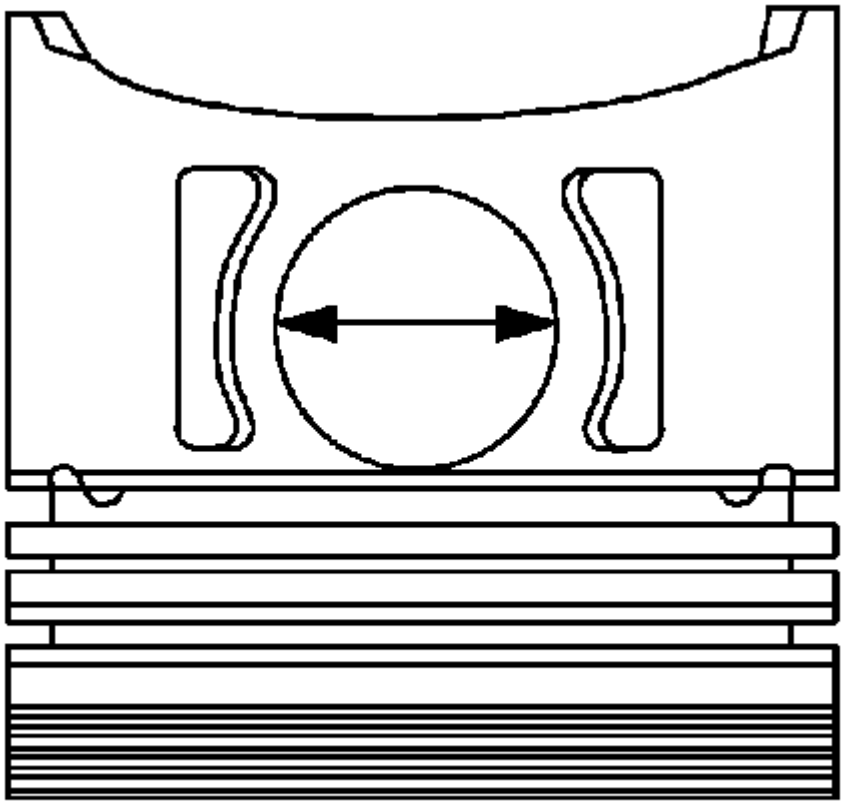

Fig. 364: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

NOTE: When fitting pistons, consider both the pistons and the cylinder bore conditions together. Production and service pistons have the same nominal weight and may be intermixed without affecting engine balance. If necessary, used pistons may be fitted selectively to any cylinder of the engine, providing the pistons are in good condition and the same weight. Do not cut oversize pistons down or the engine balance may be affected. Finish hone when selecting the pistons.

15. Measure the piston pin bore using an inside micrometer.
16. Subtract the piston pin diameter from the piston pin bore diameter in order to determine the piston pin-to-piston pin bore clearance.
17. Piston-to-piston pin bore clearance must measure 0.002-0.010 mm (0.00008-0.0004 in). Replace the piston and the piston pin if the piston and the piston pin are not within specifications.

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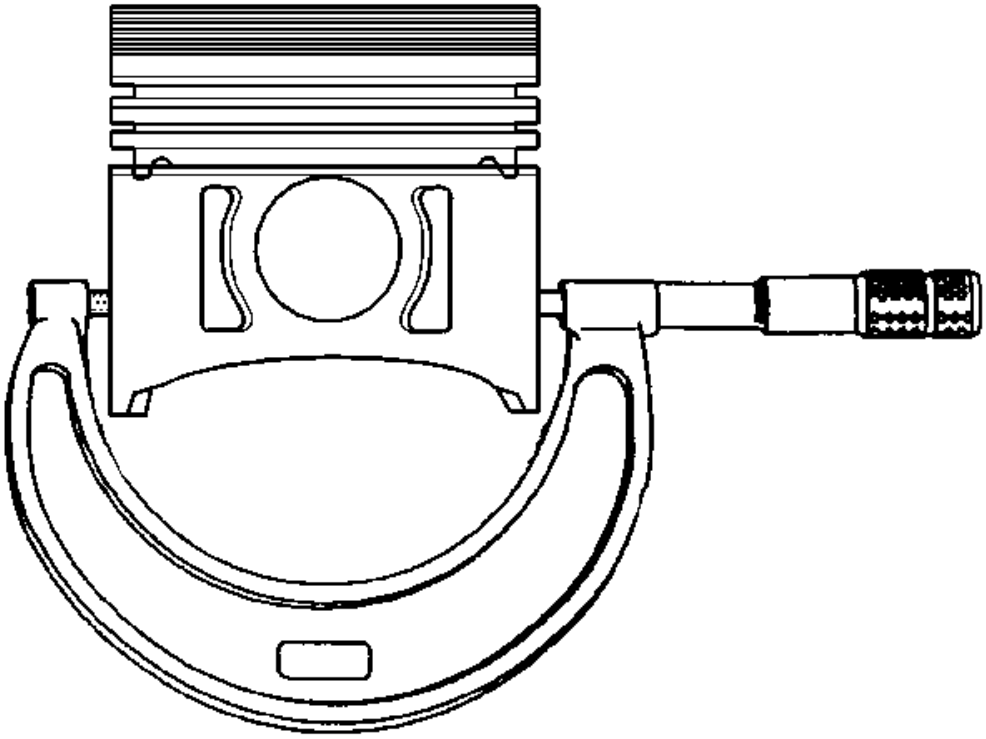

Fig. 365: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

18. Measure the piston diameter with a micrometer at a right angle to the piston bore with the piston pin removed, and record the measurement. Measure the piston at 43 mm (1.692 in) from dome of piston. Piston diameter must measure no less than 98.950 mm (3.895 in). Replace the piston and the pin as an assembly if the piston is not within specifications.

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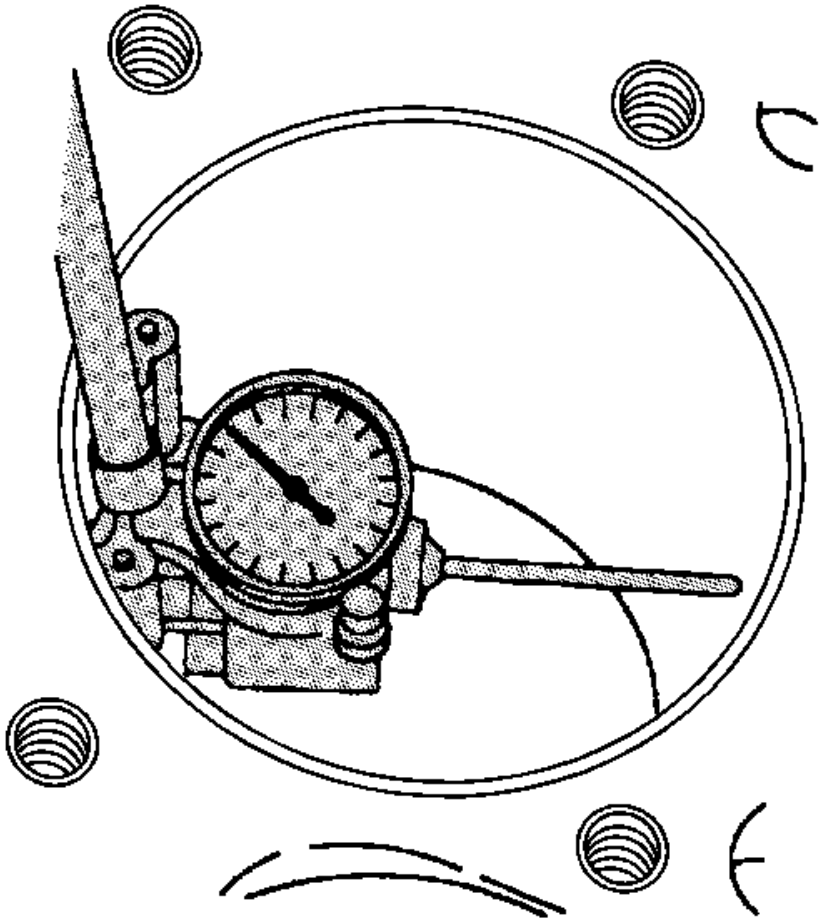

Fig. 366: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

19. Measure the cylinder bore, using **J-8087:** gage.

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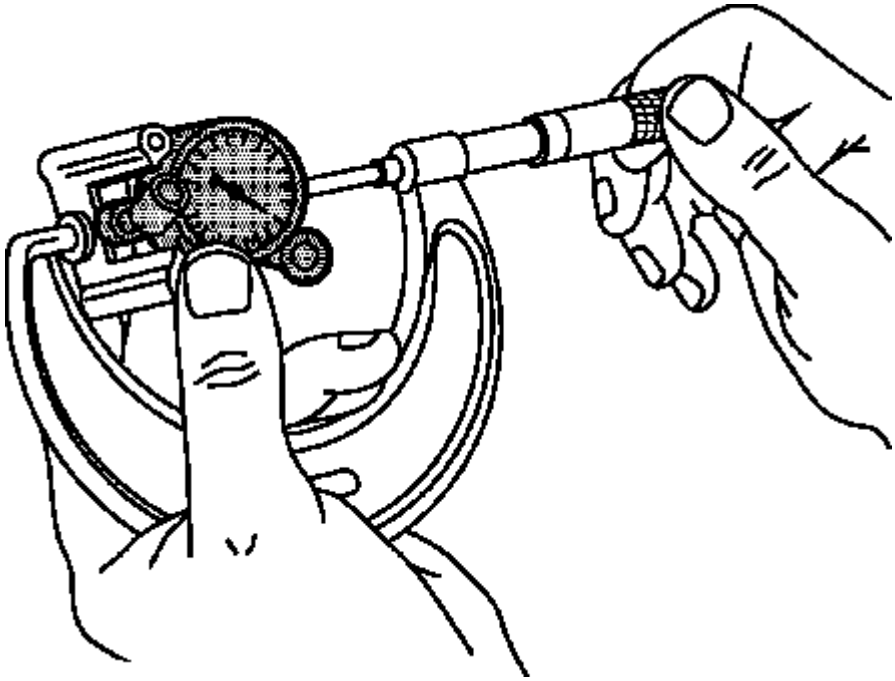

Fig. 367: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

20. Measure the **J-8087:** gage. Record this reading.
21. Subtract the diameter of the piston from the diameter of the cylinder bore to determine the piston-to-bore clearance. The cylinder bore clearance must be no more than 0.080 mm (0.003 in).
22. If a used piston is not acceptable, inspect the service piston size and determine if a new piston may be selected. Service pistons are available in standard and 0.5 mm (0.012 in) oversize.
23. When a piston has been selected, mark the piston in order to identify the cylinder for which the piston was fitted.

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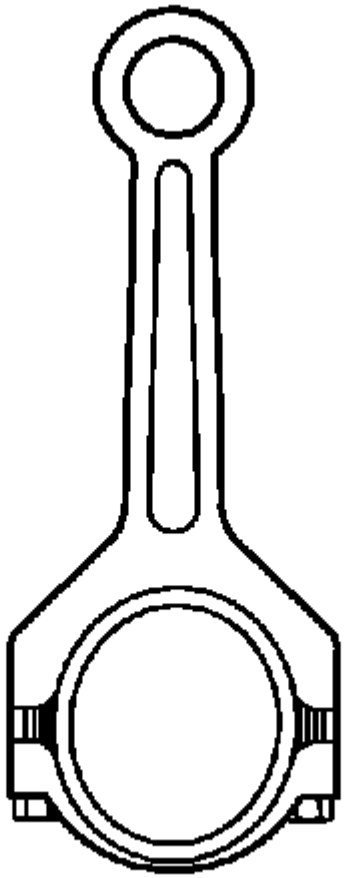

Fig. 368: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

24. Inspect the connecting rod for an out-of-round bearing bore. If the out-of-round measurement exceeds 0.005 mm (0.0002 in) the connecting rod must be replaced.

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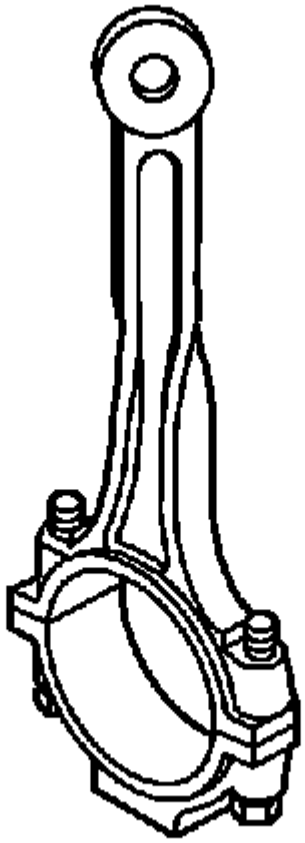

Fig. 369: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

25. Inspect the connecting rod for twisting.
    1. Install the connecting rod cap.
    2. Place the connecting rod assembly on a checking fixture. Inspect the assembly for bending or twisting.
    3. Do not attempt to straighten the connecting rod. Ensure that the connecting rod meets the following conditions:
        - The connecting rods are not bent more than 0.18 mm (0.007 in).
        - The connecting rods are not twisted more than 0.38 mm (0.015 in).
    4. Replace any bent or twisted connecting rods.
    5. Inspect the new connecting rods before using the new rods.
26. Inspect the connecting rod for damage to the bearing cap and bolt threads.

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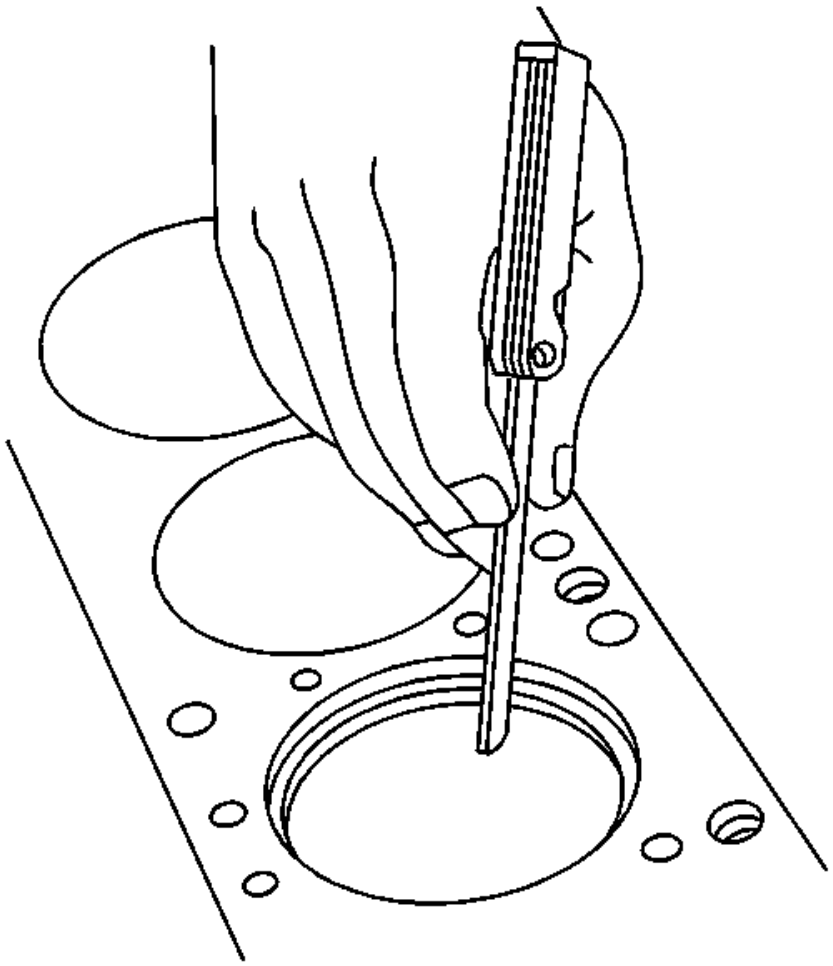

Fig. 370: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

27. Measure the piston compression ring end gap.

NOTE: 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 bottom of the cylinder bore to approximately 6.5 mm (0.25 in) above ring travel. The ring must be square to the cylinder wall.
3. Use a feeler gage in order to measure the end gap. The first compression ring end gap must measure 0.15-0.30 mm (0.006-0.011 in), the second compression ring must measure 0.25-0.45 mm (0.009-0.017 in).
4. Select another size ring set if the end gap exceeds specifications. If ring gap clearance is below specifications, increase the gap by carefully filing off excess material.

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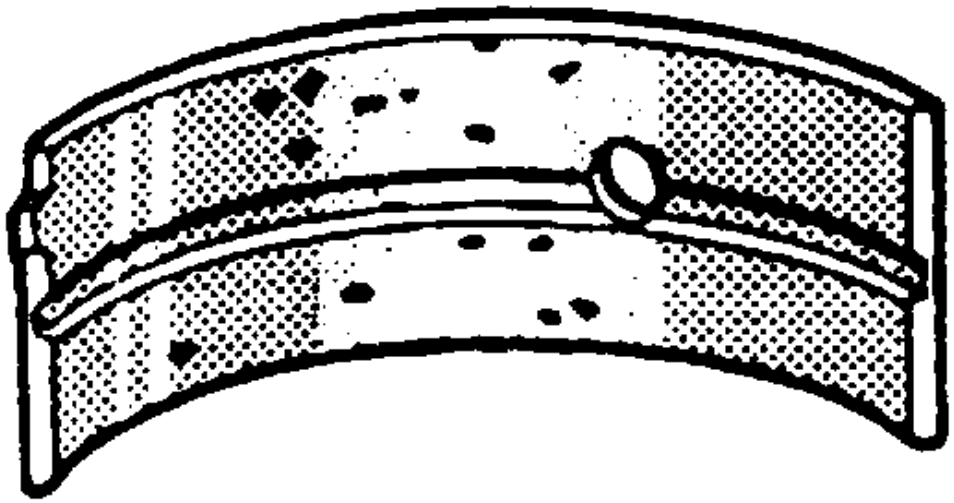

Fig. 371: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

28. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the connecting rod bearing halves may indicate fatigue.

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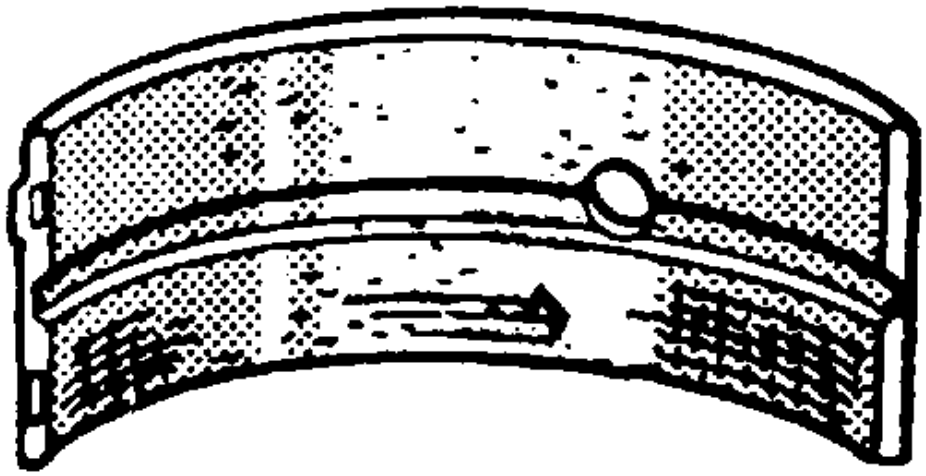

Fig. 372: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

29. Inspect the connecting rod bearings for excess scoring or discoloration.
30. Inspect the connecting rod bearings for dirt or debris imbedded into the connecting rod bearing halves.

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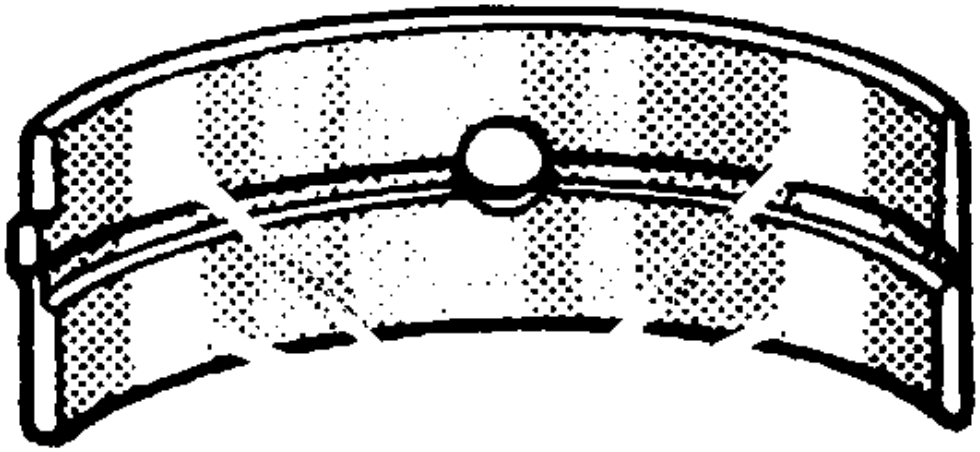

Fig. 373: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

31. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearings.
32. Inspect the inside of the connecting rod bearing and the outside diameter of the connecting rod bearing journal for wear. This indicates high spots.

CAMSHAFT AND BEARINGS CLEANING AND INSPECTION

Special Tools

J-7872: Magnetic Base Dial Indicator

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

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Cleaning and Inspection

1. Remove and discard the camshaft position actuator filter (1).
2. Clean the camshaft with cleaning solvent.

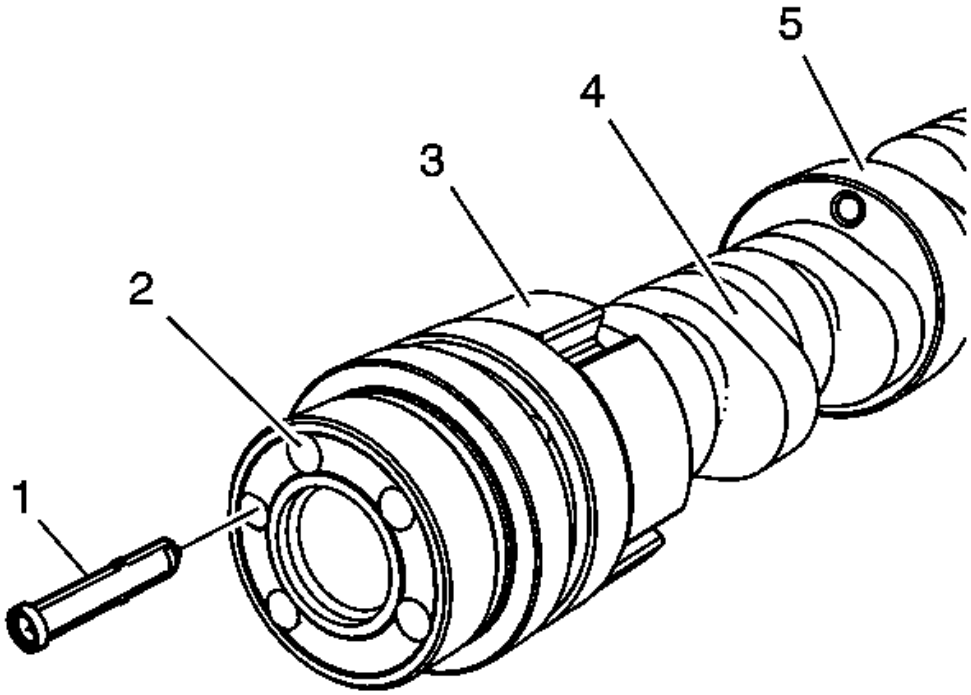

Fig. 374: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Cleaning Solvent Warning .

3. Inspect the camshaft for the following conditions:
   - Scored camshaft bearing journals (5)
   - Damaged camshaft lobes (4)
   - Damaged camshaft position sensor reluctor area (3)
   - Damaged threads (2)

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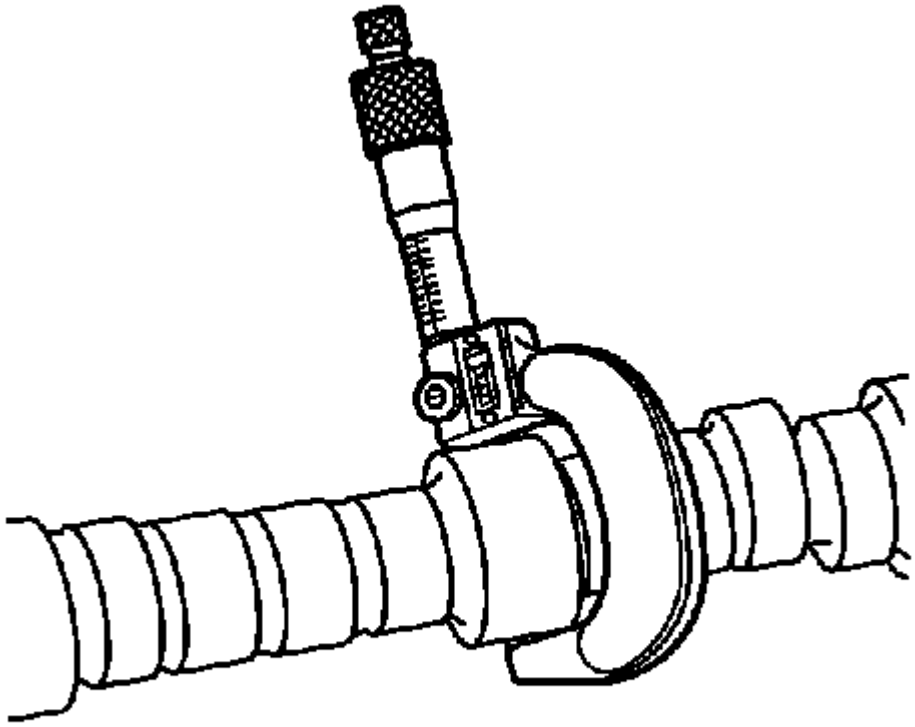

Fig. 375: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft journals using a micrometer.

   If the camshaft journals are not within specifications, replace the camshaft.

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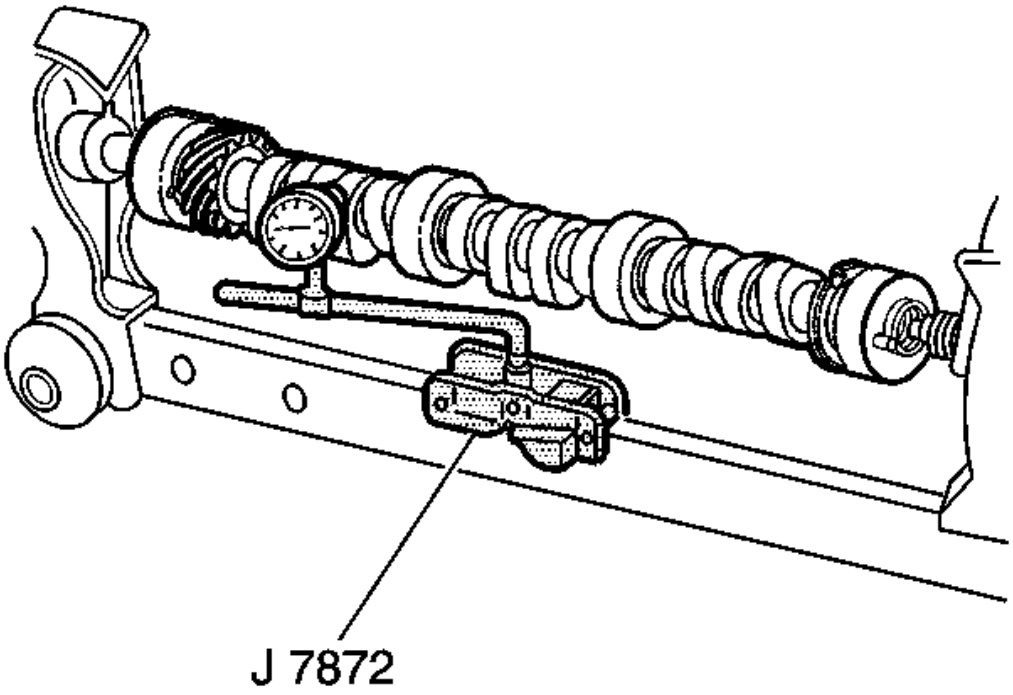

Fig. 376: Measuring Camshaft With J 7872
Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft runout using the **J-7872:** Magnetic Base Dial Indicator.
    1. Mount the camshaft in V-blocks between the centers.
    2. Use the **J-7872:** Indicator in order to measure the intermediate camshaft journal.
6. Measure the camshaft lobe lift using the **J-7872:** Indicator.
    1. Lubricate the camshaft using GM P/N 12345501 (Canadian P/N 992704) or the equivalent.
    2. Set the camshaft on V-blocks.
    3. Use the **J-7872:** Indicator in order to measure the lobe lift.
7. If the runout or lobe lift is not within specifications, replace the camshaft.

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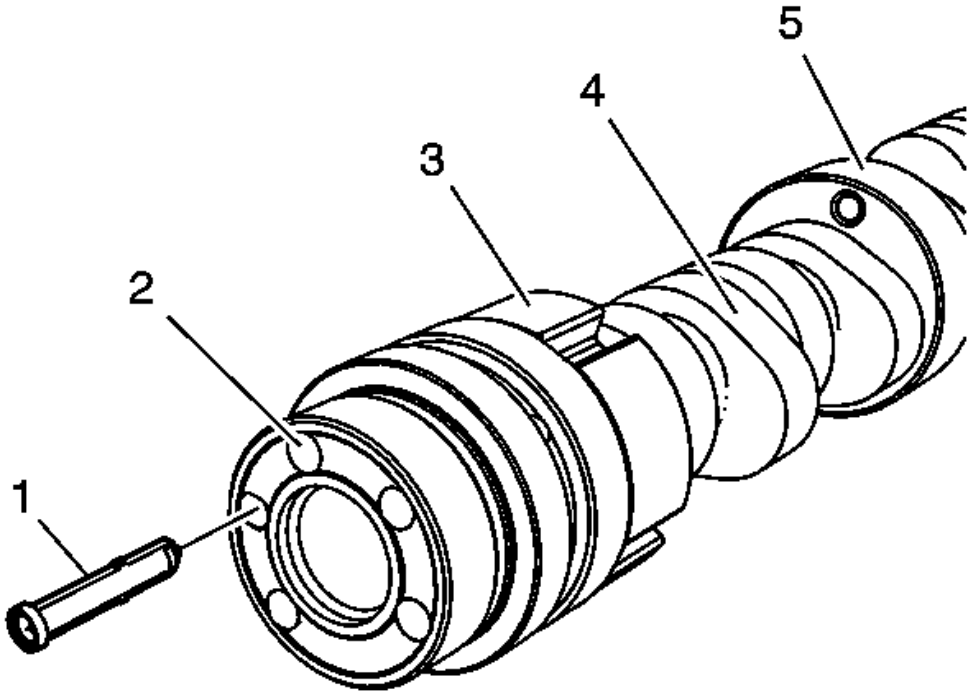

Fig. 377: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install a NEW camshaft position actuator filter anytime the camshaft position actuator is removed or installed.

8. Install a NEW camshaft position actuator filter (1).

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

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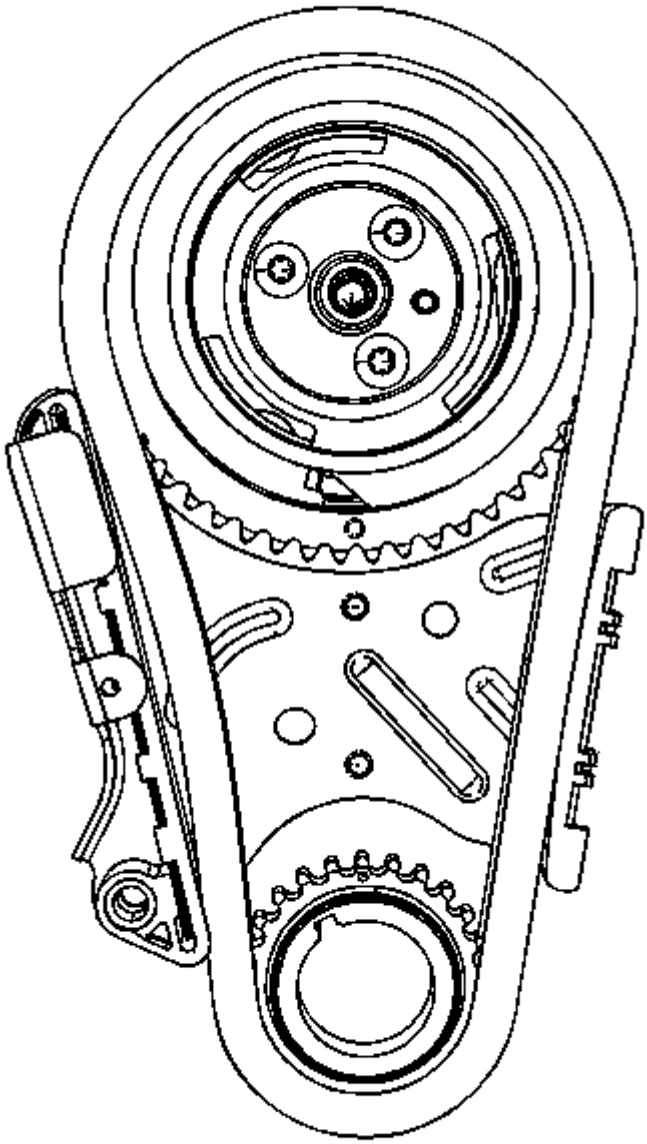

Fig. 378: View Of Timing Chain, Sprockets & Tensioners
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

1. Clean all components with cleaning solvent.

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2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.

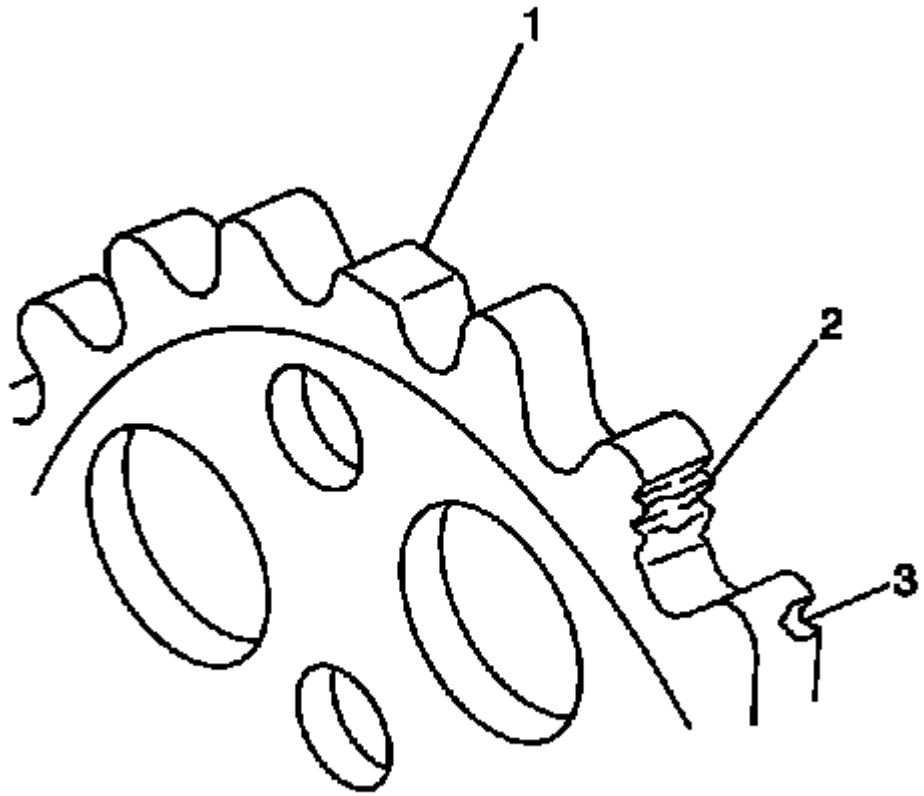

Fig. 379: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft and crankshaft sprockets for:
    - Worn teeth (1)
    - Broken teeth (2)
    - Chipped teeth (3)

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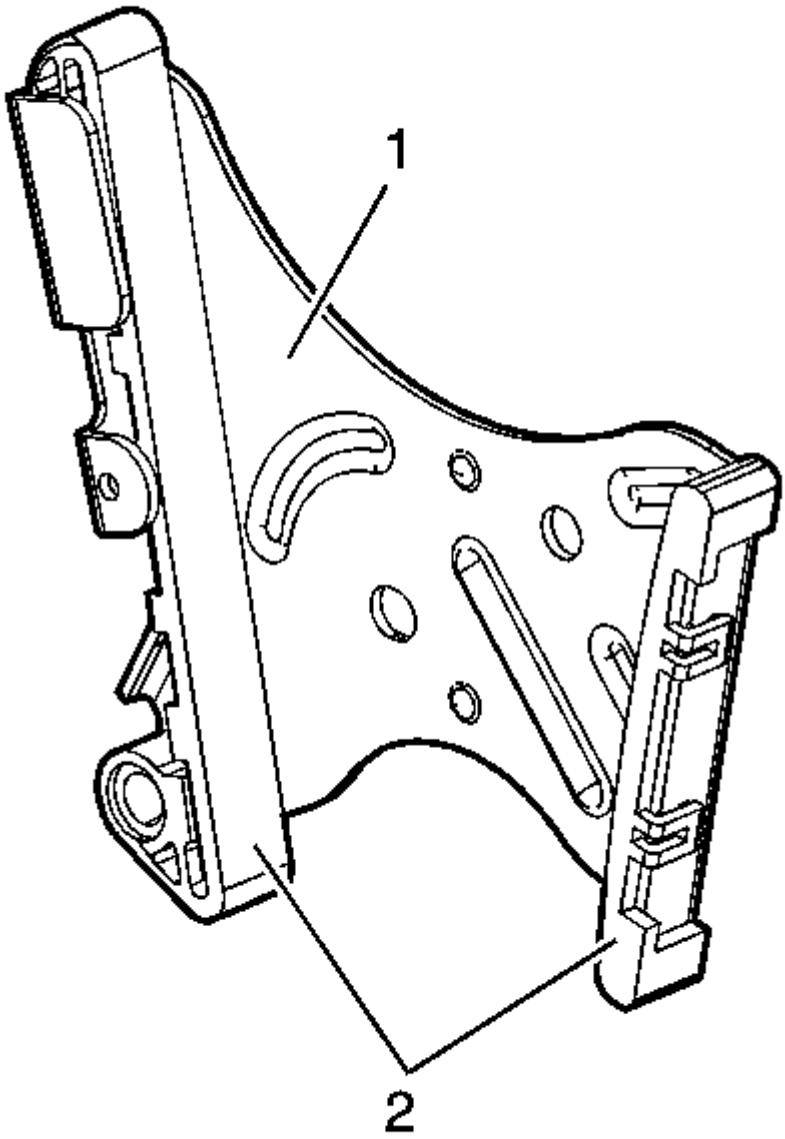

Fig. 380: Identifying Damaged Timing Chain Tensioner & Chain Tensioner Slides
Courtesy of GENERAL MOTORS CORP.

5. Inspect the timing chain tensioner (1) and timing chain tensioner slides (2) for excessive wear or cracks. Repair or replace as required.

CAMSHAFT POSITION ACTUATOR MAGNET CLEANING AND INSPECTION

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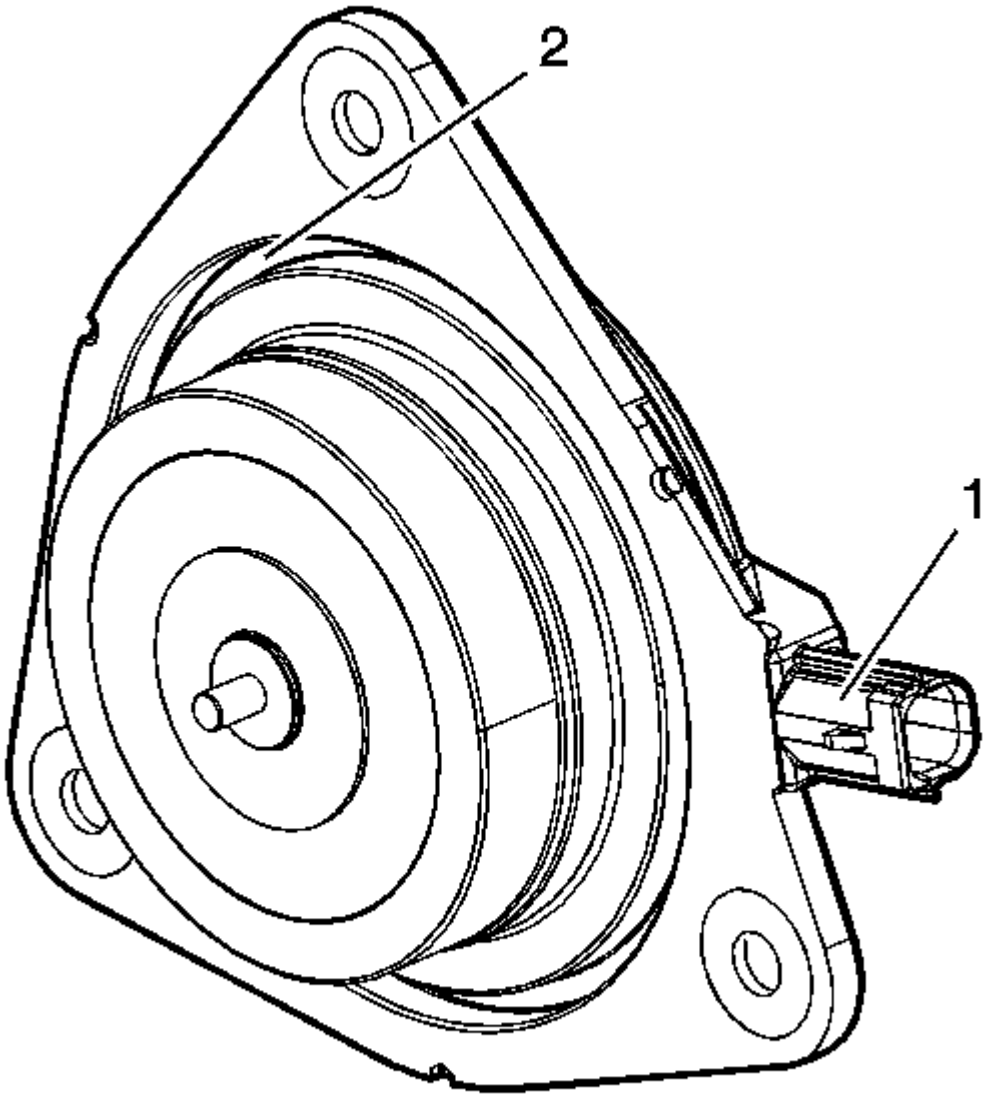

Fig. 381: Identifying Sealing Area & Magnet
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft position actuator magnet for the following conditions:
   - The camshaft position actuator magnet wiring connector (1) for damage.
   - The camshaft position actuator magnet O-ring seal and sealing area (2) for damage.
2. Repair or replace the camshaft position actuator housing and/or components as necessary.

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CAMSHAFT POSITION ACTUATOR CLEANING AND INSPECTION

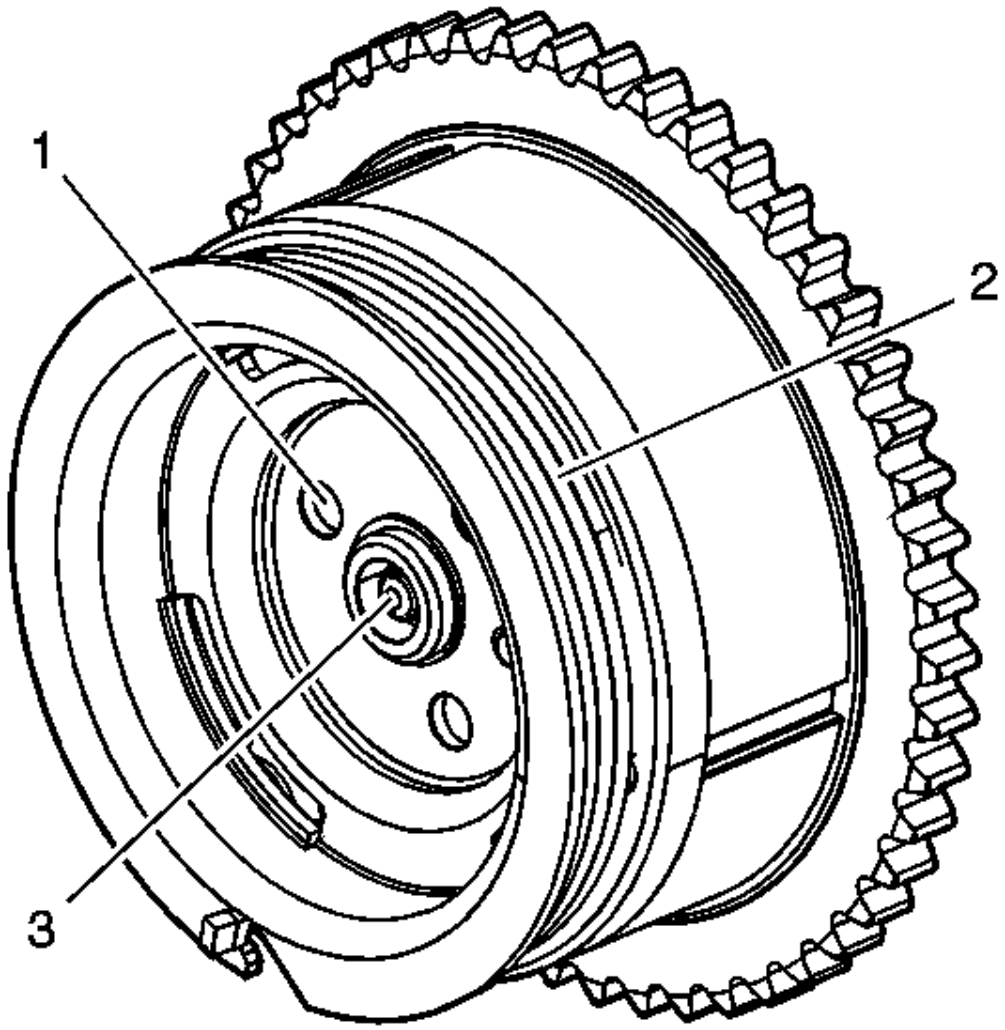

Fig. 382: Identifying Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Cleaning Solvent Warning .

1. Clean the camshaft position actuator components with solvent.

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

2. Dry the camshaft position actuator components with compressed air.
3. Inspect the camshaft position actuator for the following conditions:
   - The camshaft position actuator mounting bores (1) for damage
   - The camshaft position actuator return spring (2) for nicks or damage
   - The camshaft position actuator valve surface for pitting or damage (3)
4. Replace the camshaft position actuator as necessary.

VALVE LIFTERS CLEANING AND INSPECTION

1. Clean the valve lifters in cleaning solvent.

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

2. Dry the valve lifters with compressed air.

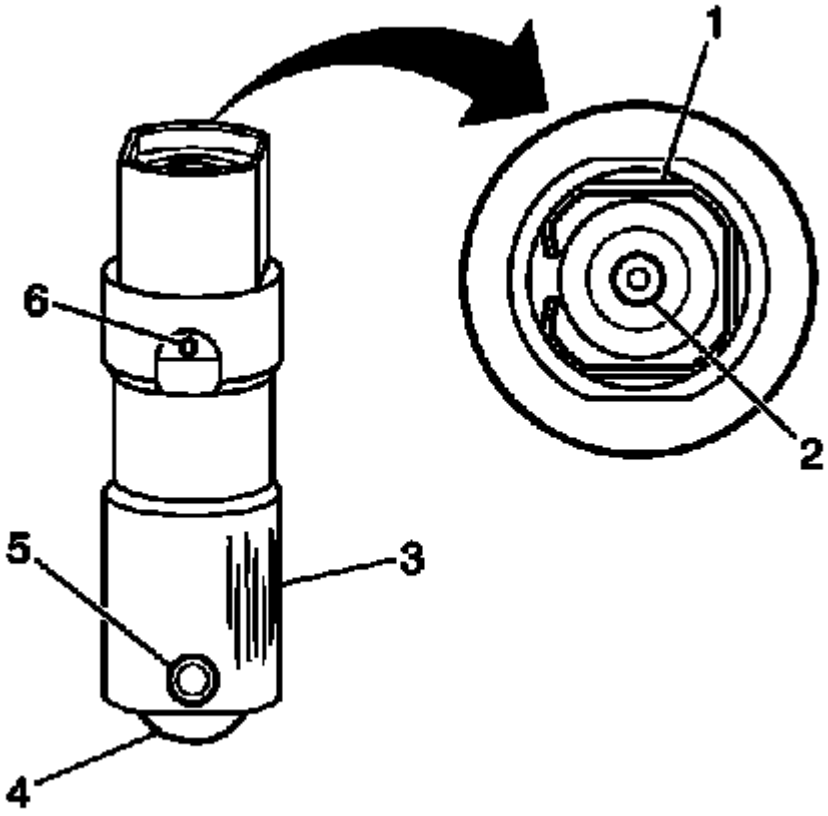

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Fig. 383: Identifying Valve Lifter Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve lifters for the following:
   - Bent or broken clip (1)
   - Worn push rod socket (2)
   - Scuffed or worn sides (3)

     If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

   - Flat spots on the roller (4)
   - Loose or damaged pin (5)
   - Plugged oil hole (6)
   - Worn or damaged roller bearing

     The roller should rotate freely with no binding or roughness.

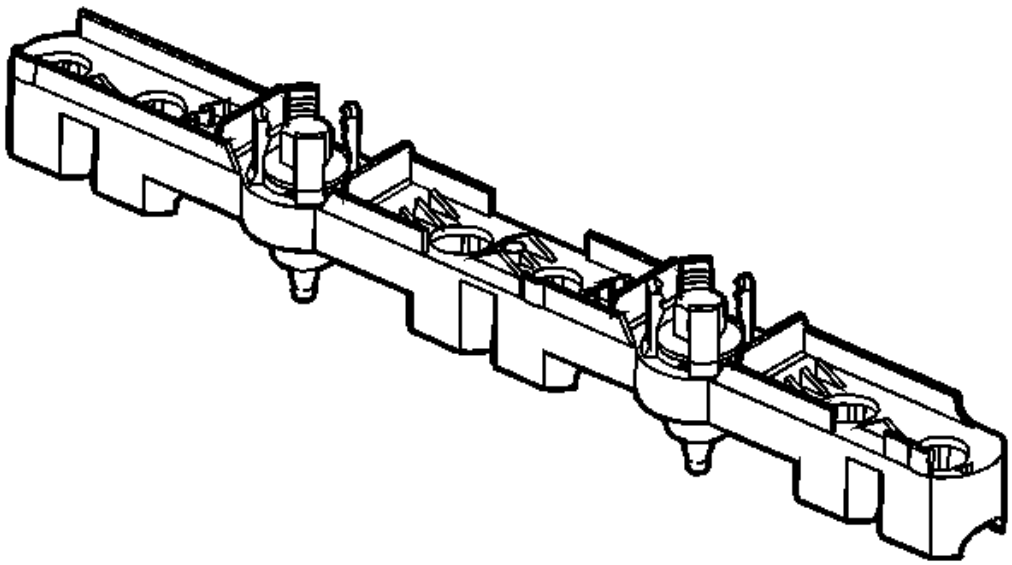

Fig. 384: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter guides for the following:
   - For cracks or damage
   - Excessive wear in the lifter mounting bores

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VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

WARNING: Refer to Cleaning Solvent Warning .

1. Clean the valve rocker arms and push rods in cleaning solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the valve rocker arms and push rods with compressed air.

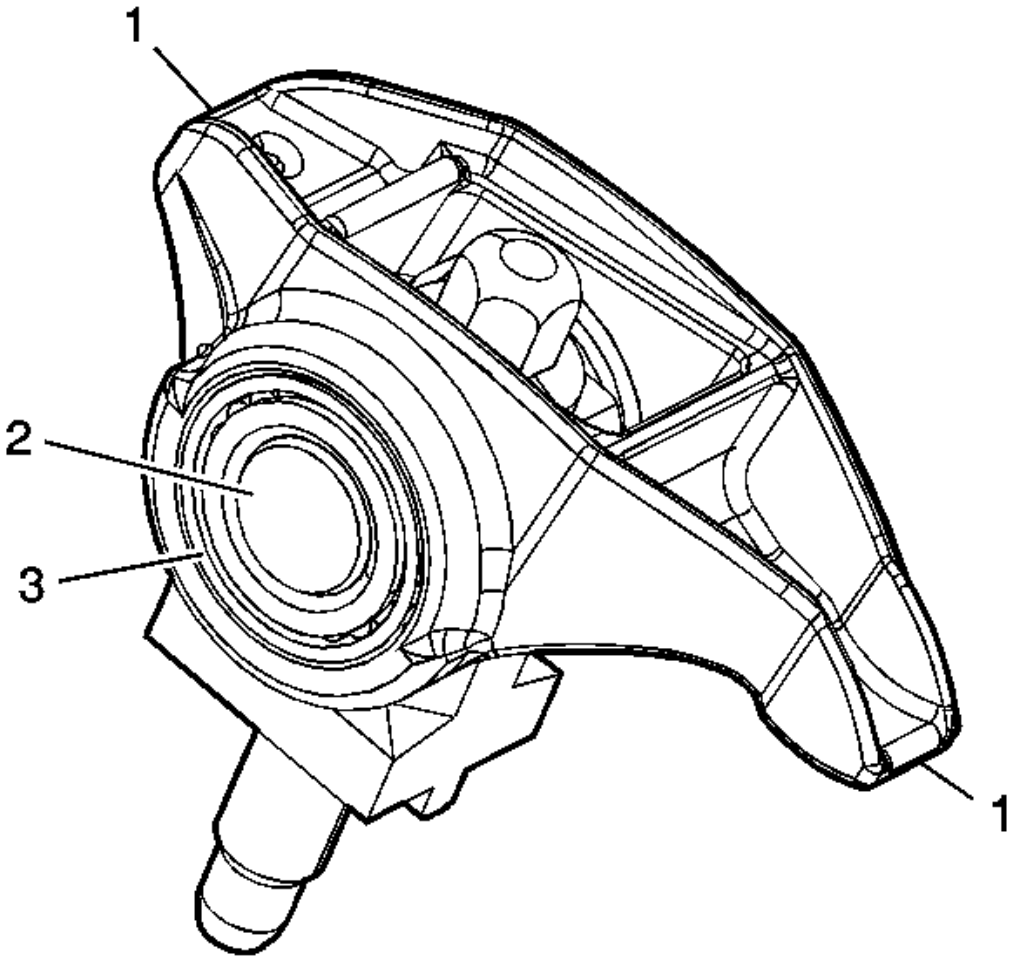

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Fig. 385: Identifying Valve Rocker Arm Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve rocker arms for the following conditions:
   - Excessive wear at the valve contact or push rod socket area (1)
   - A loose or damaged pin (2)
   - A worn or damaged roller bearing (3)-The roller should rotate freely with no binding or roughness.
   - The bolt threads for damage

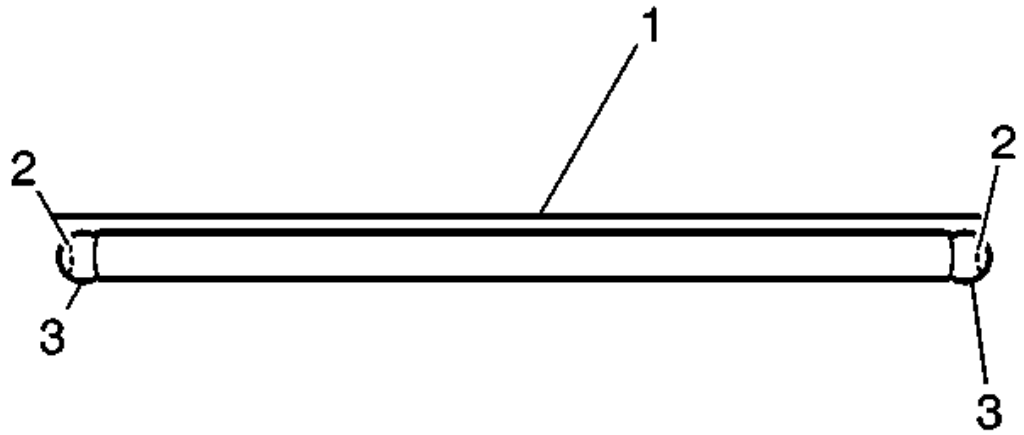

Fig. 386: Inspecting Push Rods
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep the push rods in order. The intake and exhaust are different lengths.

4. Inspect the push rods for the following conditions:
   - Straightness using a straight edge (1)
   - Excessive wear on the push rod ends (3)
   - Clogging of the oil passage (2)

CYLINDER HEAD DISASSEMBLE

Special Tools

- **EN-47823:** Valve Spring Compressor Adapter
- **J 5892-D:** Valve Spring Compressor

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

Disassemble

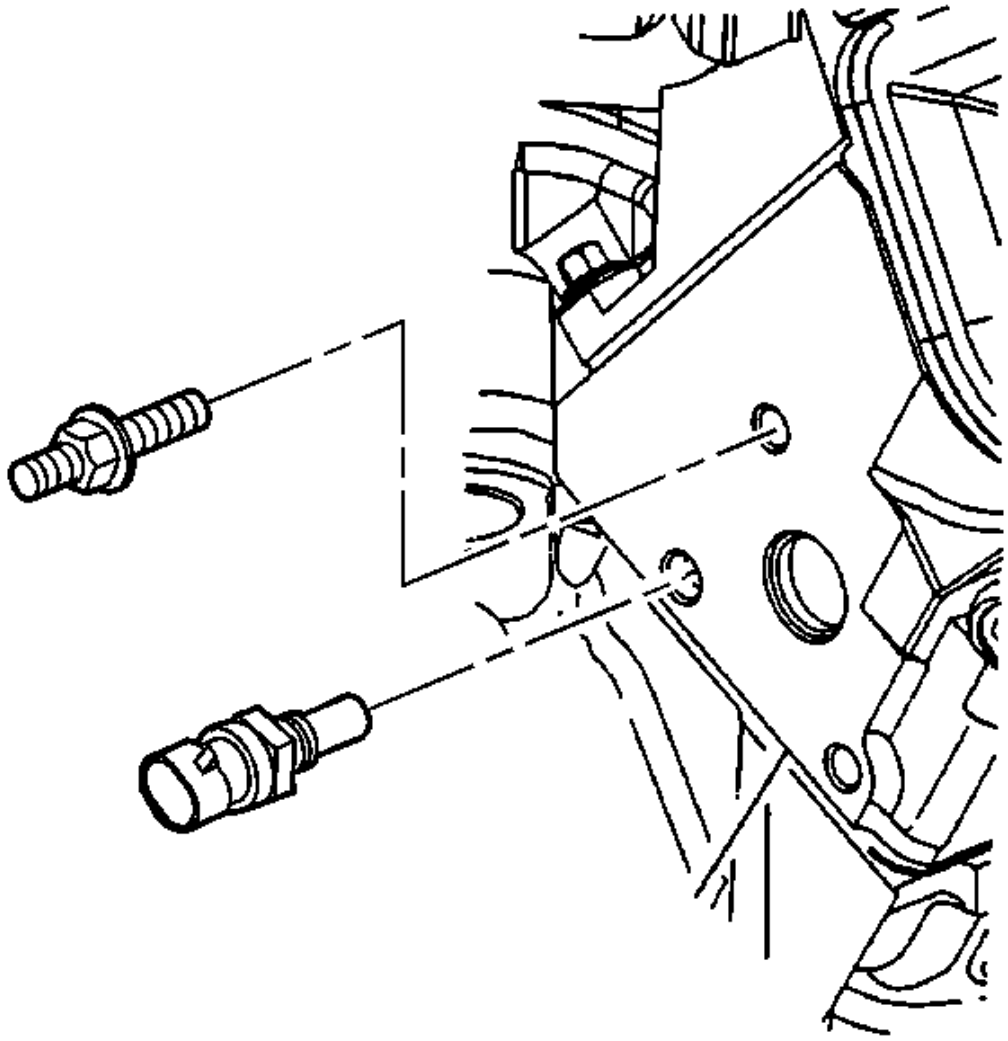

Fig. 387: View Of Heater Inlet Pipe Stud & Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater inlet pipe stud from the right cylinder head, if required.
2. Remove the coolant temperature sensor from the right cylinder head, if required.

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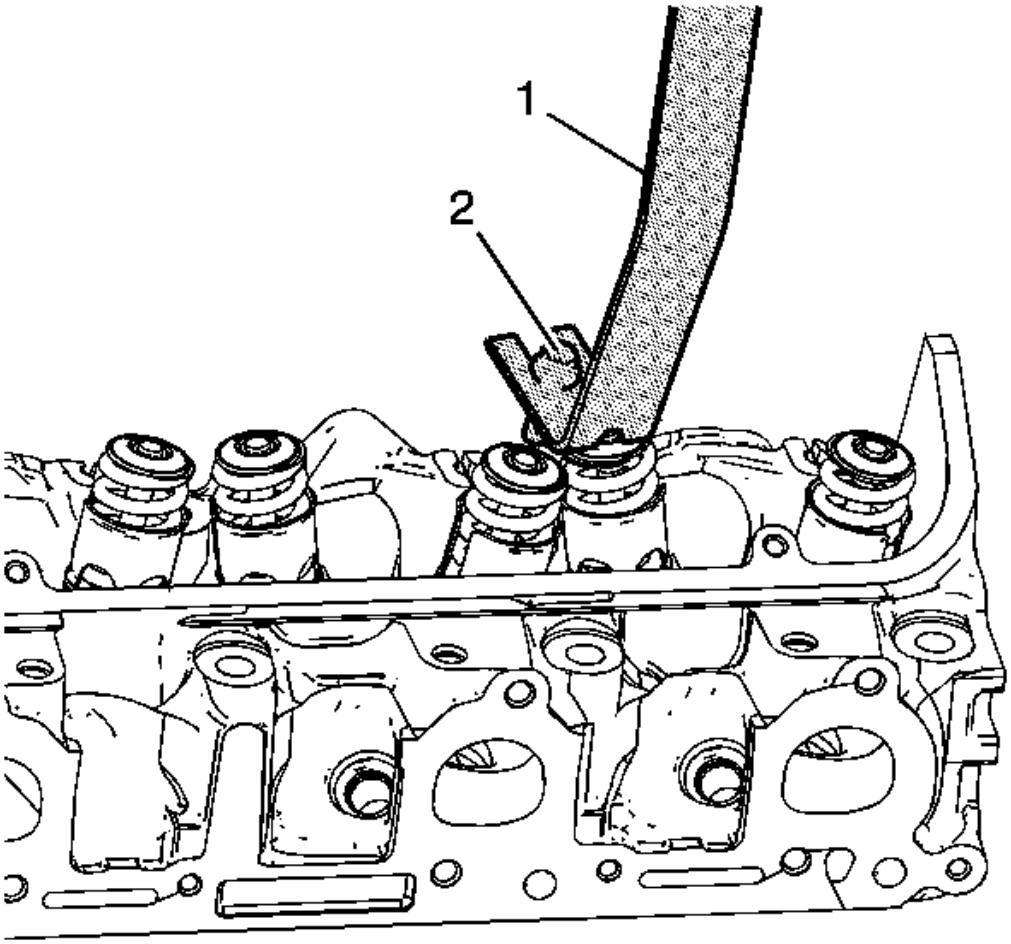

Fig. 388: Identifying Special Tools J 5892-D & EN 47823
Courtesy of GENERAL MOTORS CORP.

3. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve springs using the **EN-47823:** adapter (1) and the **EN-47823:** adapter (2).

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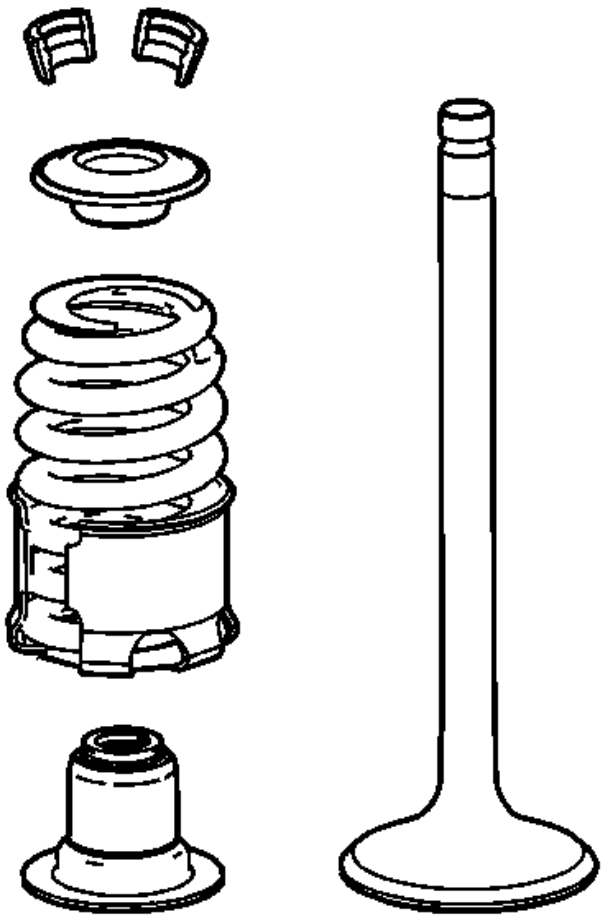

Fig. 389: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

NOTE: Ensure that the valve train components are marked, organized or sorted when disassembling the cylinder head. Install the valve train components in the original location from which the component were removed.

4. Remove the valve spring cap keys.
5. Remove the valve spring caps.
6. Remove the valve spring assembly.
7. Remove the valves.
8. Remove the valve stem oil seals and spring seats as an assembly.
9. Inspect all valve components for any damage or excess wear. Repair or replace as necessary.

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CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **J-8089:** Carbon Removing Brush
- **J-9666:** Valve Spring Tester

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

Cleaning and Inspection

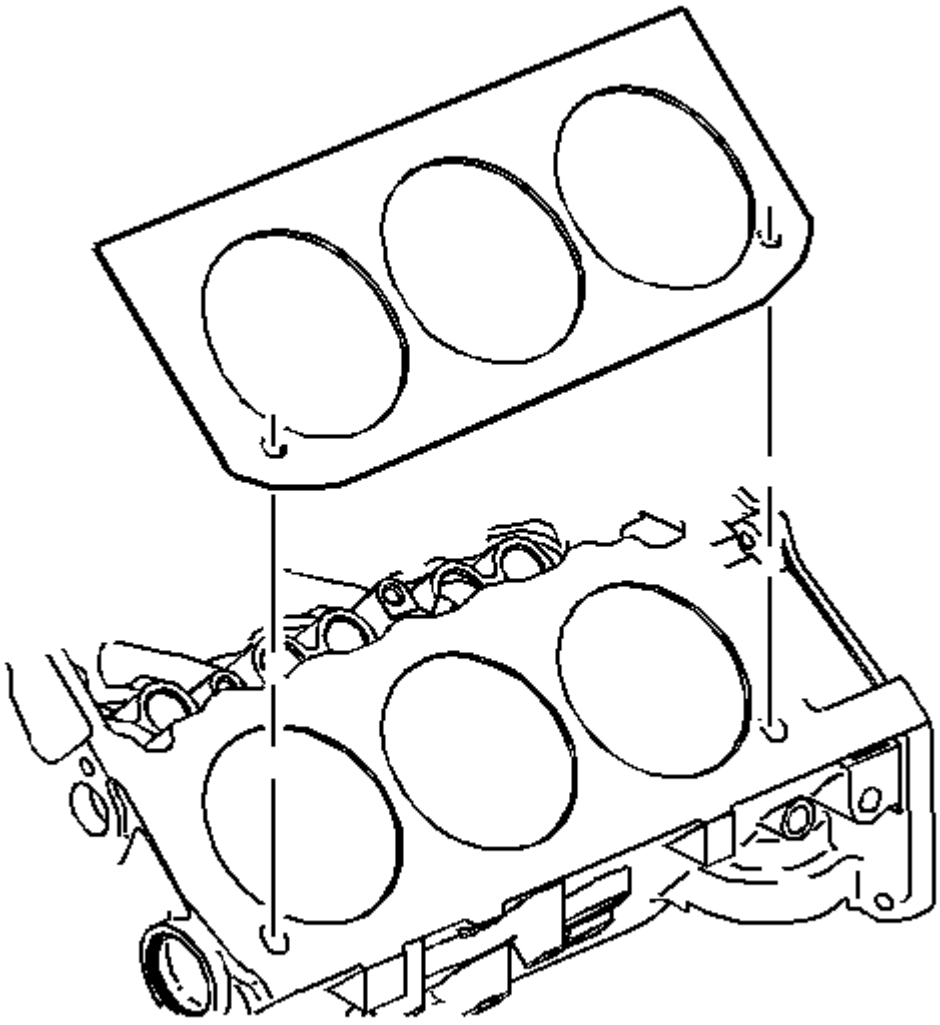

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Fig. 390: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surfaces. Inspect for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. The following conditions may cause gasket failure:
    - Improper installation
    - A loose or warped cylinder head
    - Missing, off location, or not fully seated dowel pins
    - Low torque on the cylinder head bolts
    - Cylinder head bolts with the incorrect length
    - A warped engine block surface
    - Scratched surfaces
    - Excessive intake manifold torque
    - Cracked engine block threaded holes
    - Porosity

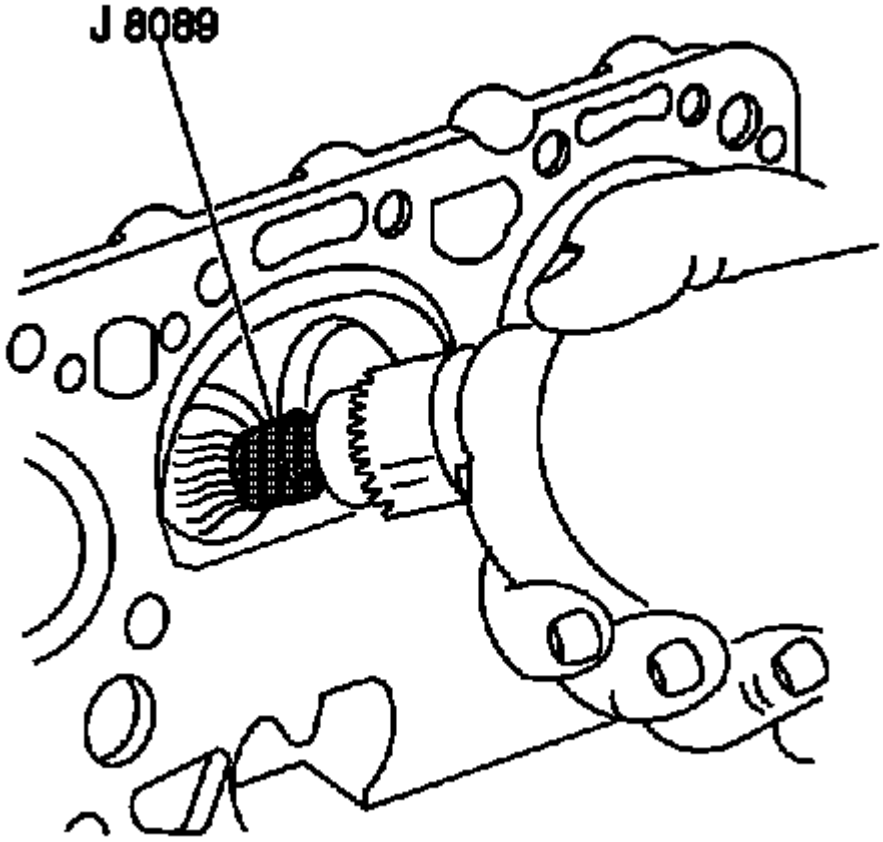

Fig. 391: Cleaning Carbon Using J 8089
Courtesy of GENERAL MOTORS CORP.

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

NOTE: **Do not scuff the chamber.**

3. Use the **J-8089:** brush in order to remove the carbon from the combustion chambers.
4. Clean the following components:
   - The gasket surfaces

     Do not use a motorized brush on any gasket sealing surface.

   - Valve stems and heads on a buffing wheel
   - The bolt hole threads

     Remove all dirt, debris, or threadlocking material from the bolt holes.

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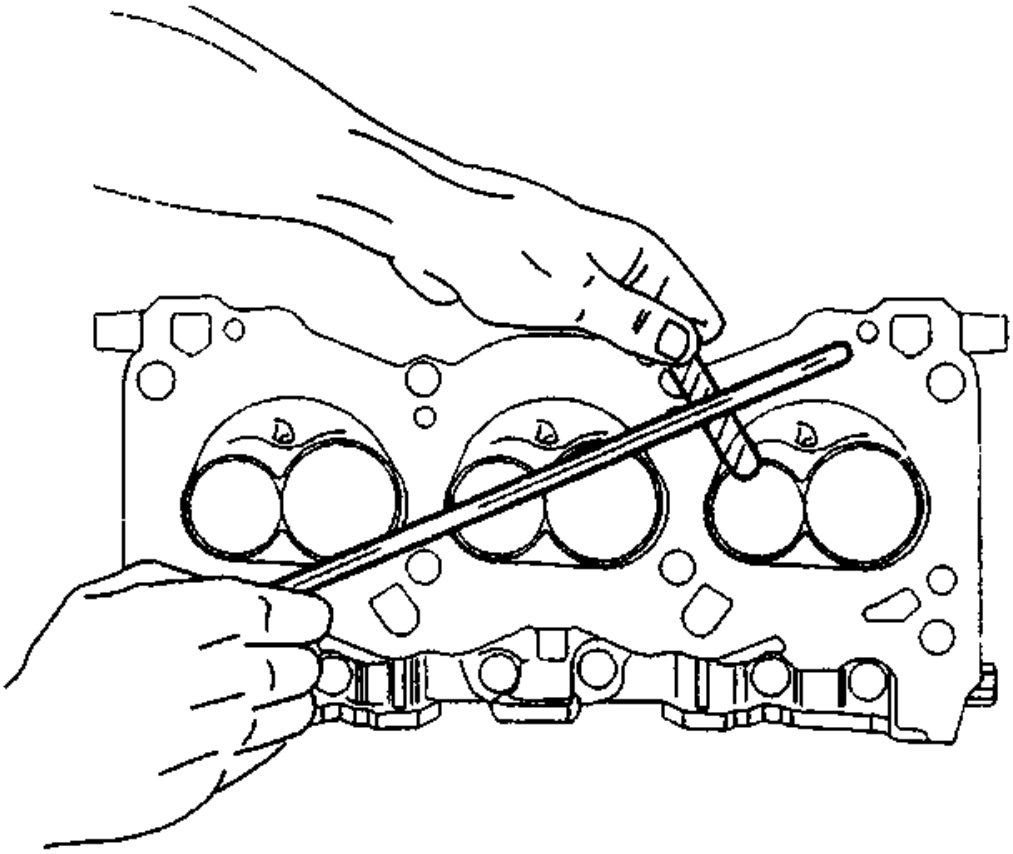

Fig. 392: Inspecting Cylinder Head Mating Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

5. Inspect the cylinder head mating surfaces for flatness. Replace the cylinder head if it is outside of the specification limit.
6. Inspect the cylinder head for cracks.
7. Inspect the cylinder head deck for corrosion. Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head.

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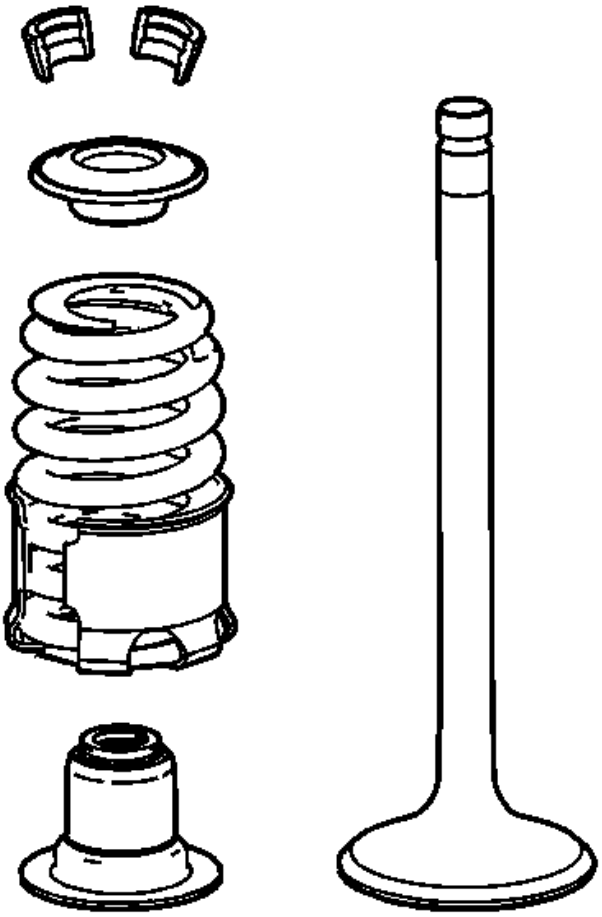

Fig. 393: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve spring dampener.

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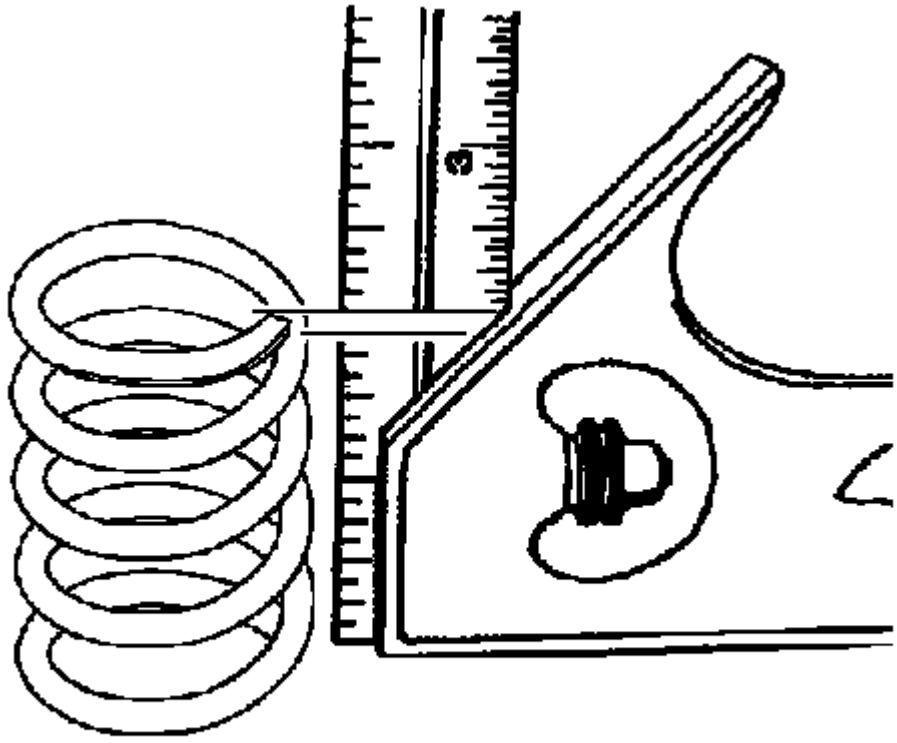

Fig. 394: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

9. Inspect the valve springs for squareness.

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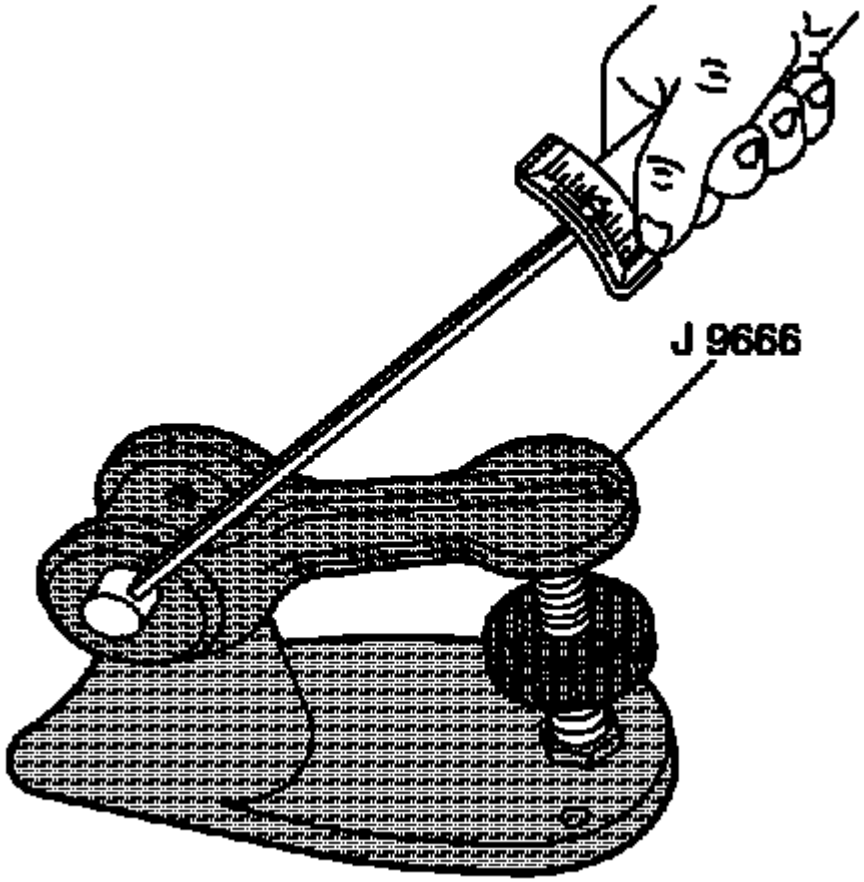

Fig. 395: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

10. Use the **J-9666:** tester in order to measure the valve spring tension.

    Replace the spring if the spring tension is not within specification.

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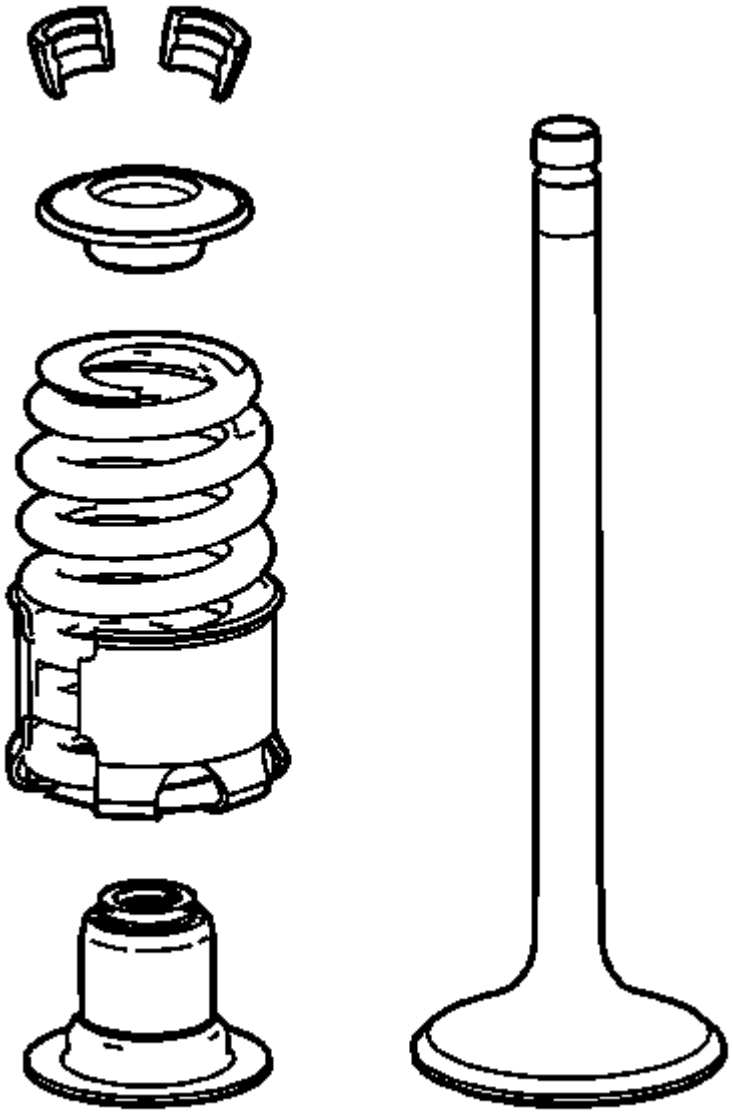

Fig. 396: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

11. Install the valve spring dampener.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Special Tools

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J-8520: Cam Lobe Lift Indicator

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

Procedure

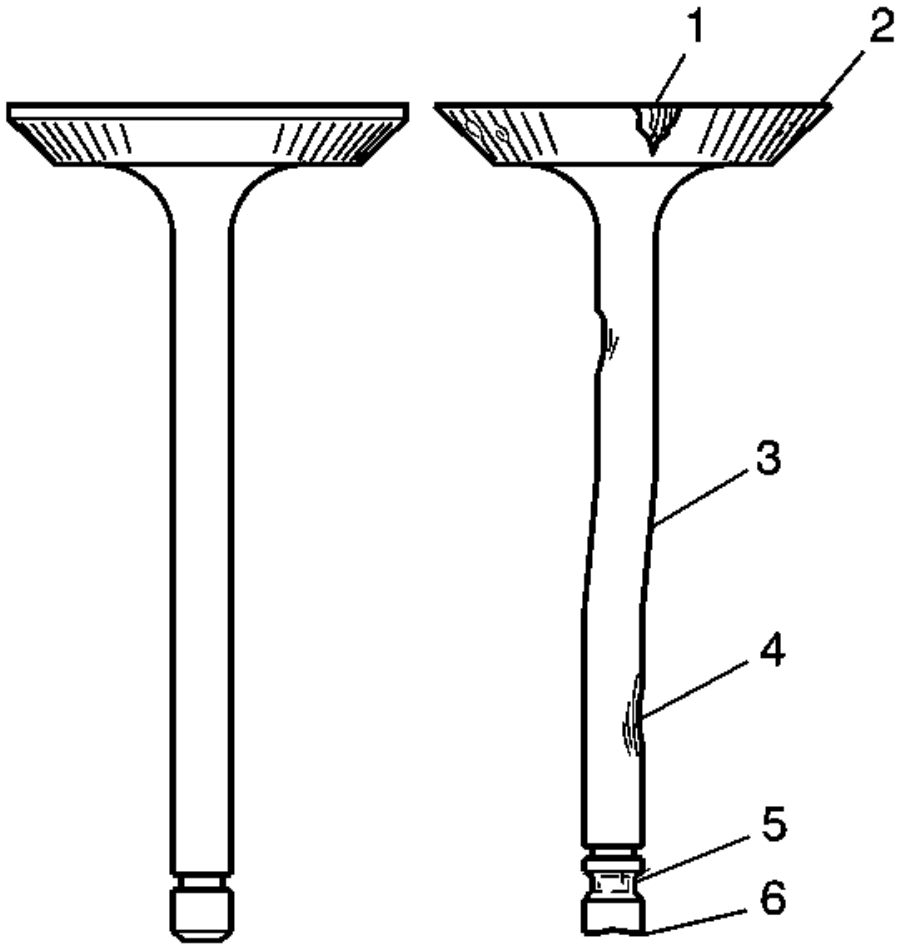

Fig. 397: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valves for the following conditions:
   - Burnt or eroded areas (1)
   - A worn margin (2)
   - A bent stem (3)
   - A worn or scored stem (4)
   - A worn key groove (5)
   - A worn stem tip (6)

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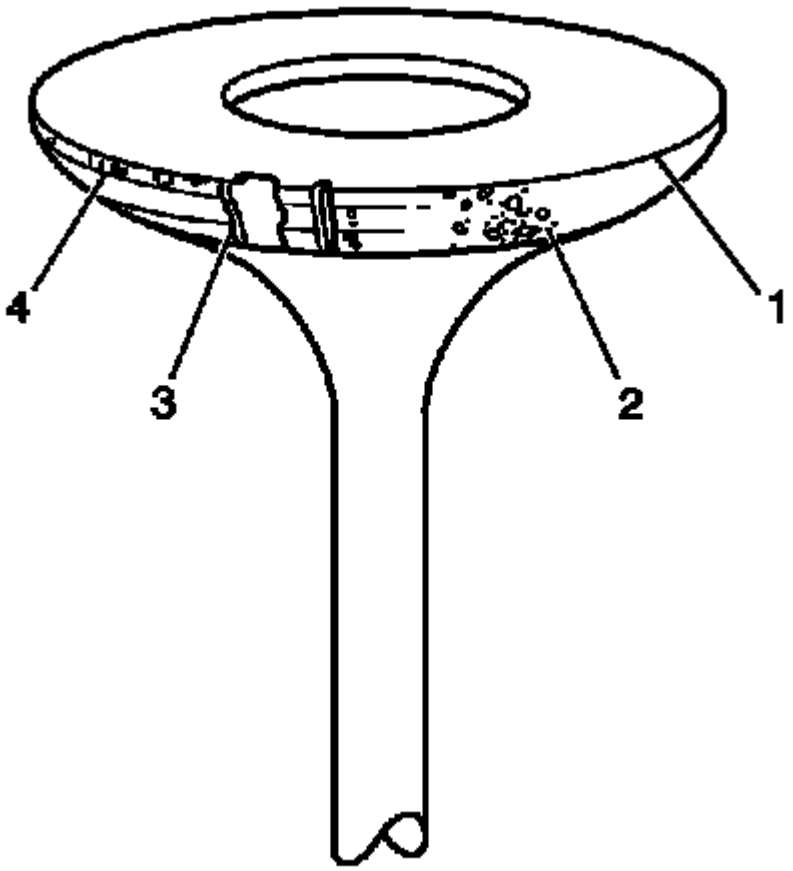

Fig. 398: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
   - Worn margin (4)
   - No margin (1)
   - Pitted surfaces (2)
   - Burnt or eroded areas (3)
3. Inspect the valve seats for a loose fit in the cylinder head.

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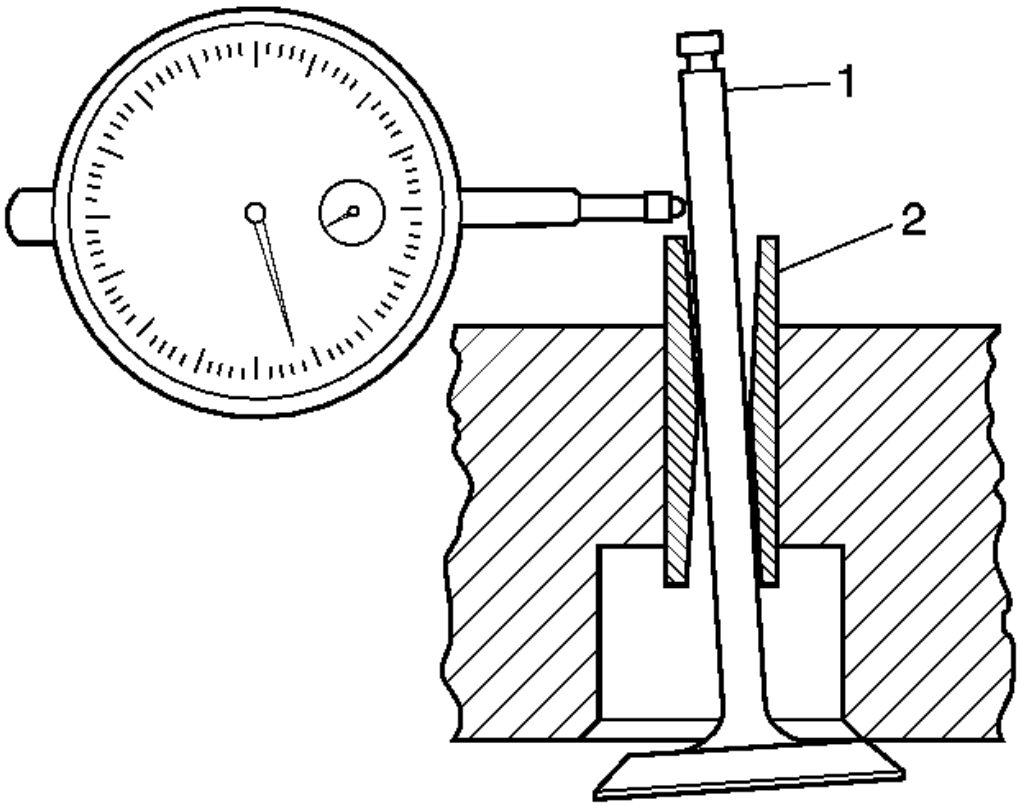

Fig. 399: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

CAUTION: Proper valve stem-to-valve guide clearance is necessary for proper engine operation and component life. Excessive clearance may cause a noisy valve train, premature valve stem oil seal failure, excessive oil consumption and related component damage. Insufficient clearance may cause a noisy valve train, rough engine operation or sticking valves that may lead to related component damage. Failure to inspect valve stem-to-valve guide clearance and repair or replace necessary components may lead to extensive engine damage.

NOTE: Excessive valve stem-to-guide clearance may cause the following conditions:

- **A noisy valve train**
- **Premature valve stem oil seal wear**

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- **Component damage**
- **Excessive engine oil consumption**

4. Inspect for excessive valve stem (1) to guide (2) clearance.

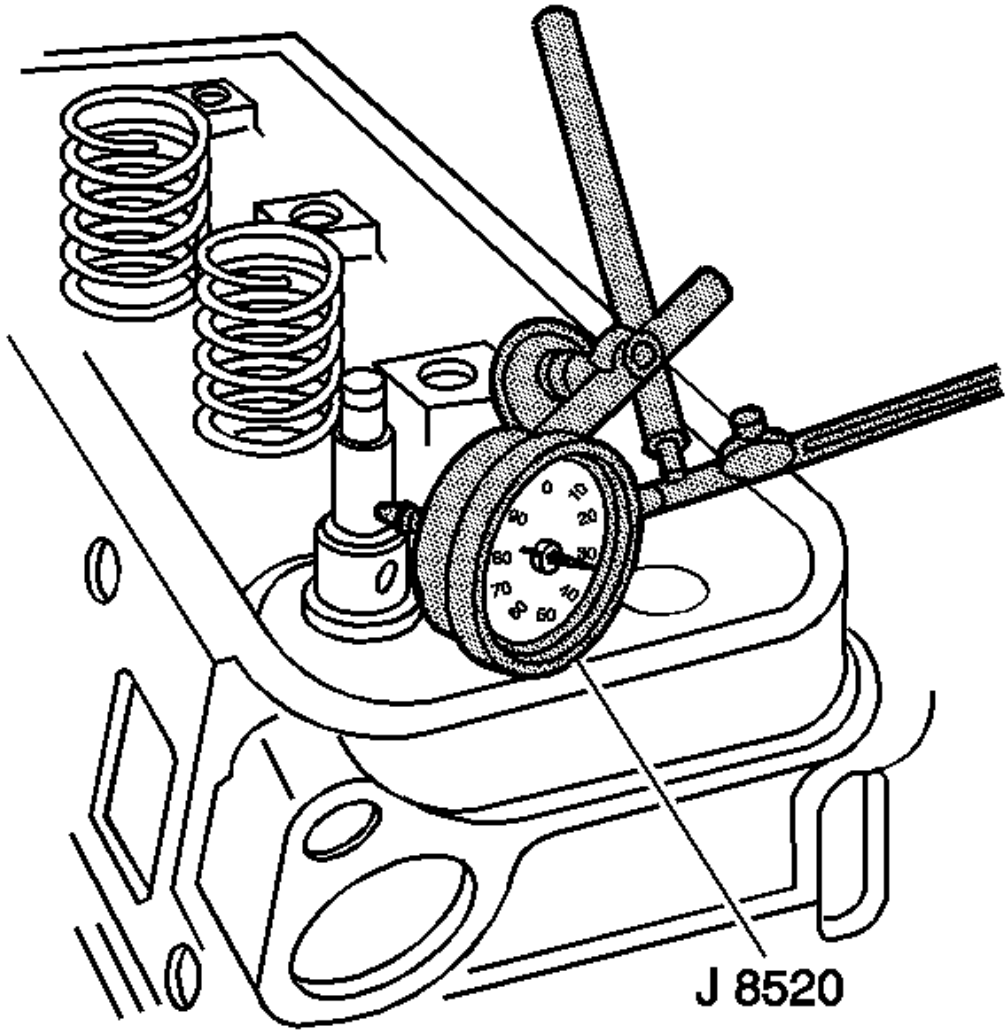

Fig. 400: Identifying J 8520
Courtesy of GENERAL MOTORS CORP.

5. Use a dial indicator in order to measure the valve stem-to-guide clearance. Complete the following steps:
    1. Install the valve into the guide.

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2. Install the **J-8520:** indicator onto the cylinder head.
3. Locate 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 on the indicator stem.
4. Ensure that the indicator stem contacts the side of the valve stem just above the valve guide.
5. Drop the valve head about 2 mm (1/8 in) off the valve seat.
6. Use light pressure and move the valve stem side to side in order to obtain a clearance reading.
7. If the valve stem to guide clearance is not within specification, replace the valve and/or repair the guide in order to obtain the proper clearances.

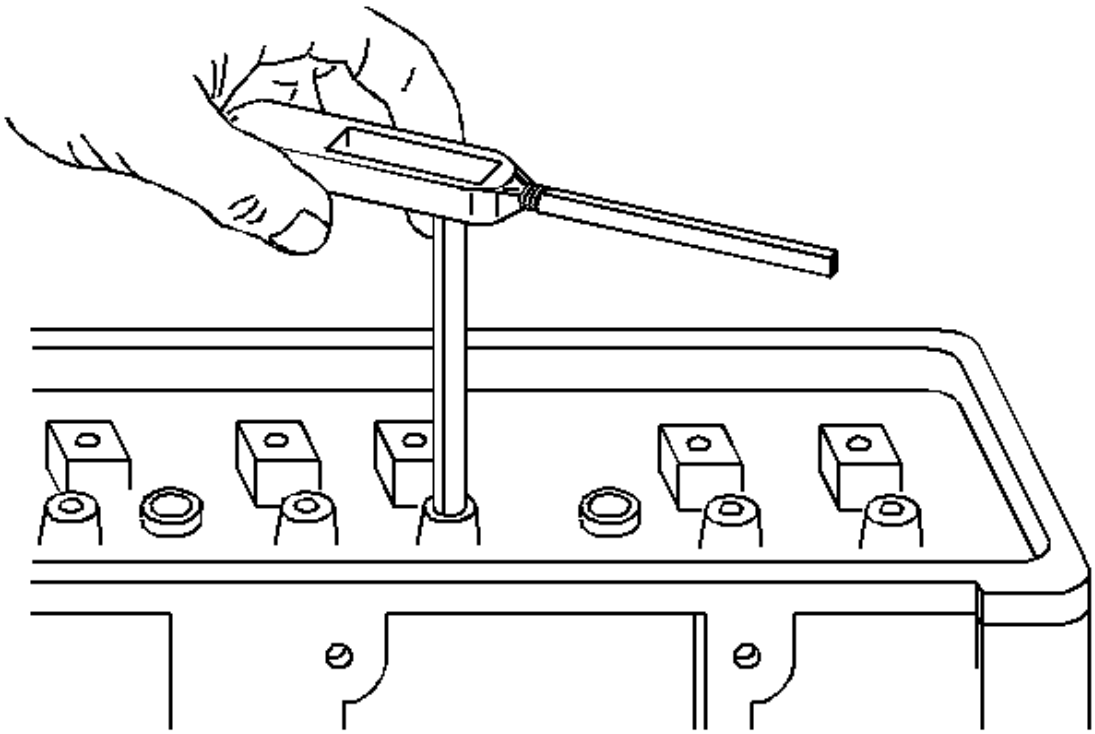

Fig. 401: Reaming Valve Guides For Oversize Valves
Courtesy of GENERAL MOTORS CORP.

NOTE: **Replace a valve stem that has excessive scoring or wear. A valve guide that is worn and has excessive stem-to-guide clearance may need to be**

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sleeved.

6. Ream the valve guides for oversize valves if the clearance exceeds the specifications.

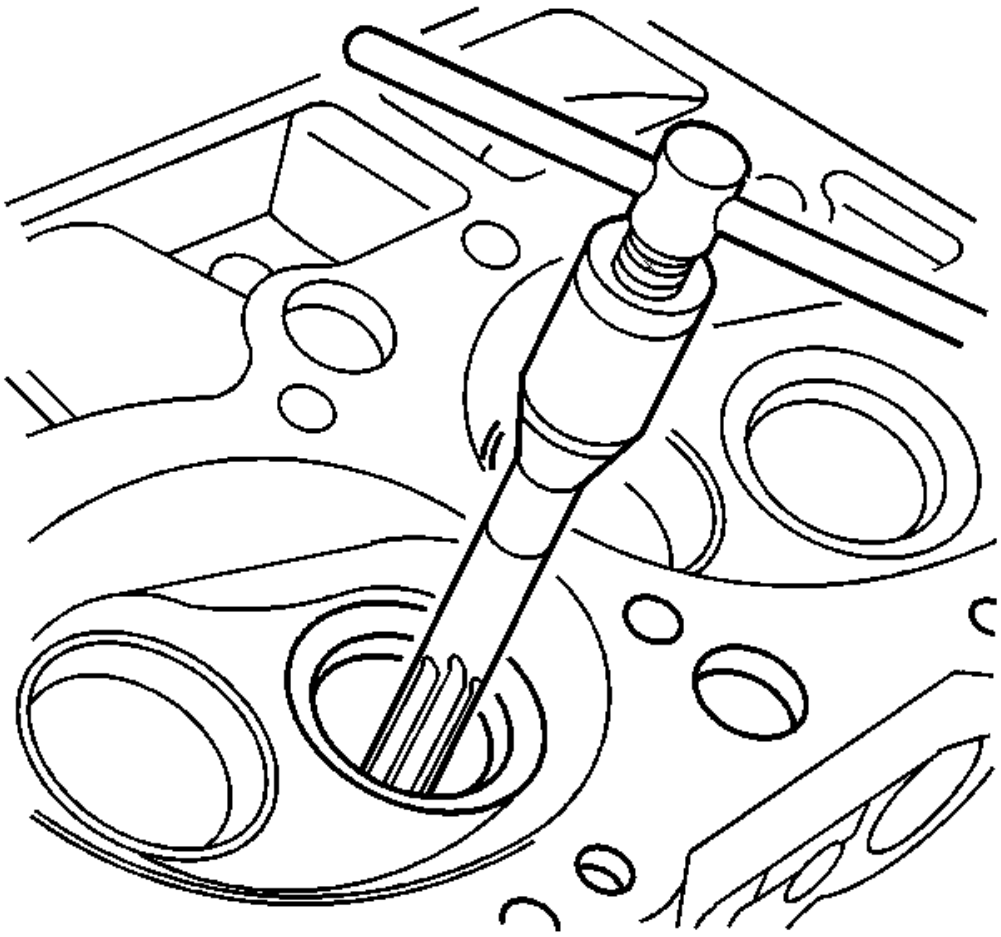

Fig. 402: Reaming Valve Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Follow the manufacturers instructions when using valve guide reamers, sleeves, and installers.

7. Ream the valve guide in order to obtain the proper specification.

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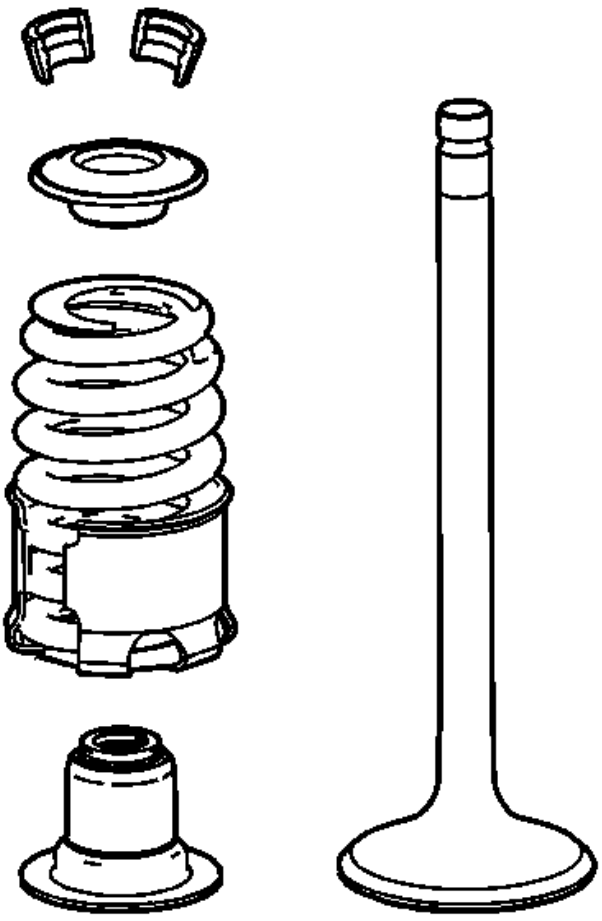

Fig. 403: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

NOTE: Valves that are pitted must be refaced to the proper angle. Replace valve stems that show excessive wear, or replace valves that are warped. Several different types of equipment are available for refacing valves and valve seats. Follow the manufacturers recommendations when performing these procedures.

8. Inspect the valves for excessive scoring.

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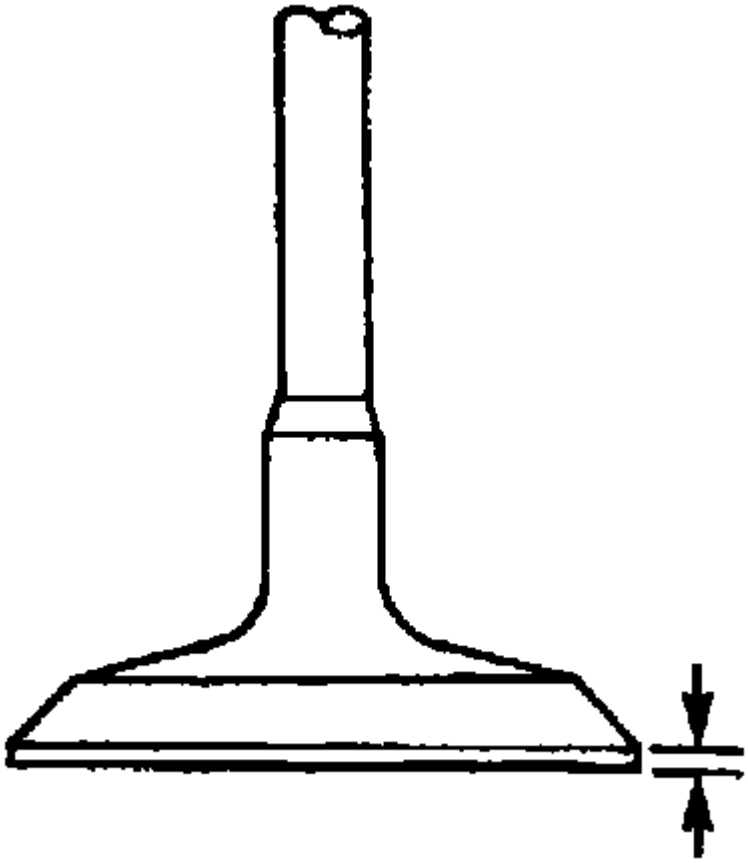

Fig. 404: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

9. Inspect the valve face.

   Replace the valve if the valve margin is not within specifications after grinding.

10. Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem.

NOTE: Reconditioning the valve seats is very important. Ensure perfect seating of the valves in the engine in order to deliver optimum power and performance. Clean the valve guides of all debris and dirt before grinding the valve seat.

11. Recondition the valve seats after reaming the valve guide bores or installing the new valve guides.
12. The valve seats should be concentric to within 0.05 mm (0.031 in) total indicator reading.

CYLINDER HEAD ASSEMBLE

Special Tools

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- **EN-47823:** Valve Spring Compressor Adapter
- **J 5892-D:** Valve Spring Compressor

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

Assemble

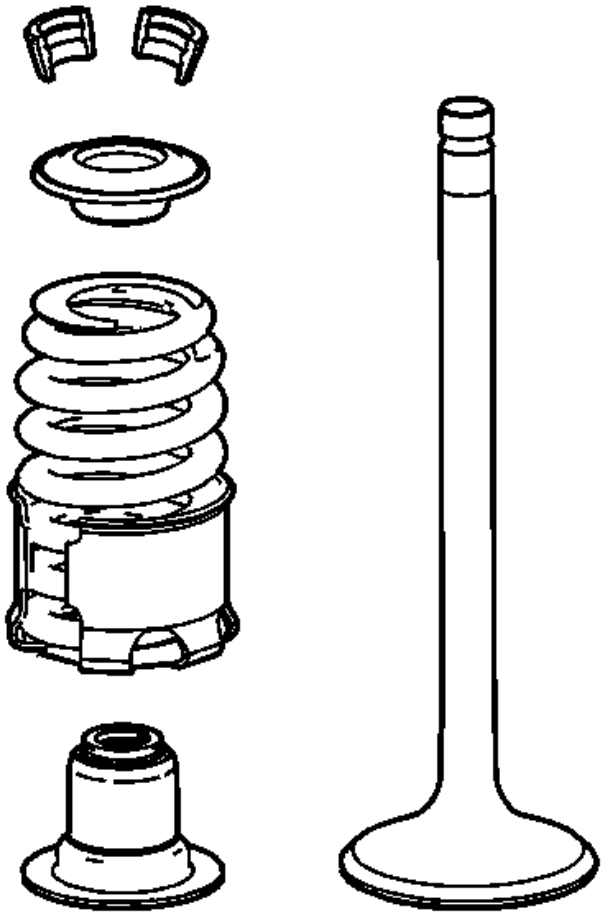

Fig. 405: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

NOTE: Use oversize valve stem seals if you install oversize valves.

1. Lubricate the valve stem with clean engine oil.
2. Install the valves.
3. Lightly tap the new or reconditioned valves into the valve seat.
4. Install the valve stem oil seals, ensuring proper intake - black seal and exhaust - brown seal, seals are installed.

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5. Install the valve springs.
6. Install the valve spring caps.

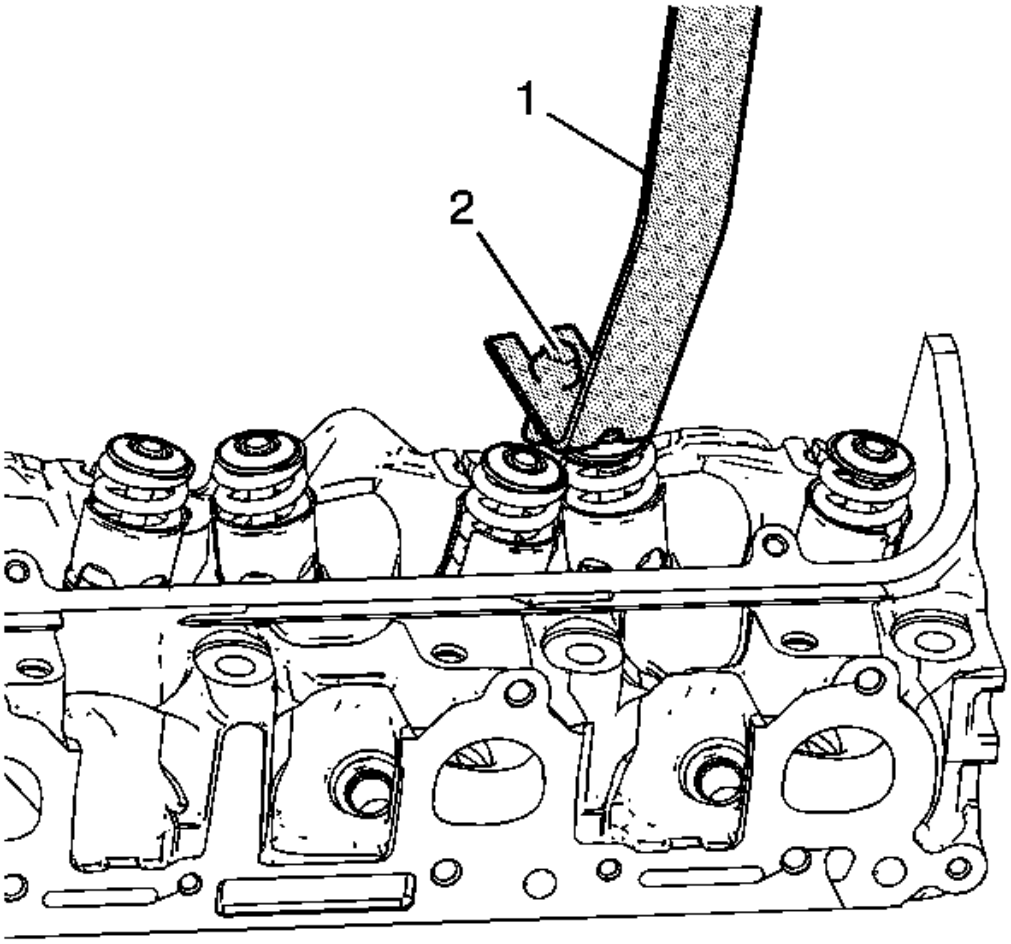

Fig. 406: Identifying Special Tools J 5892-D & EN 47823
Courtesy of GENERAL MOTORS CORP.

7. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve springs using the **J 5892-D:** compressor (1) and the **EN-47823:** adapter (2).
8. Install the valve spring cap keys. Hold the valves in place with grease, if necessary.
9. Release the valve springs.
10. Ensure that the valve locks are seated.

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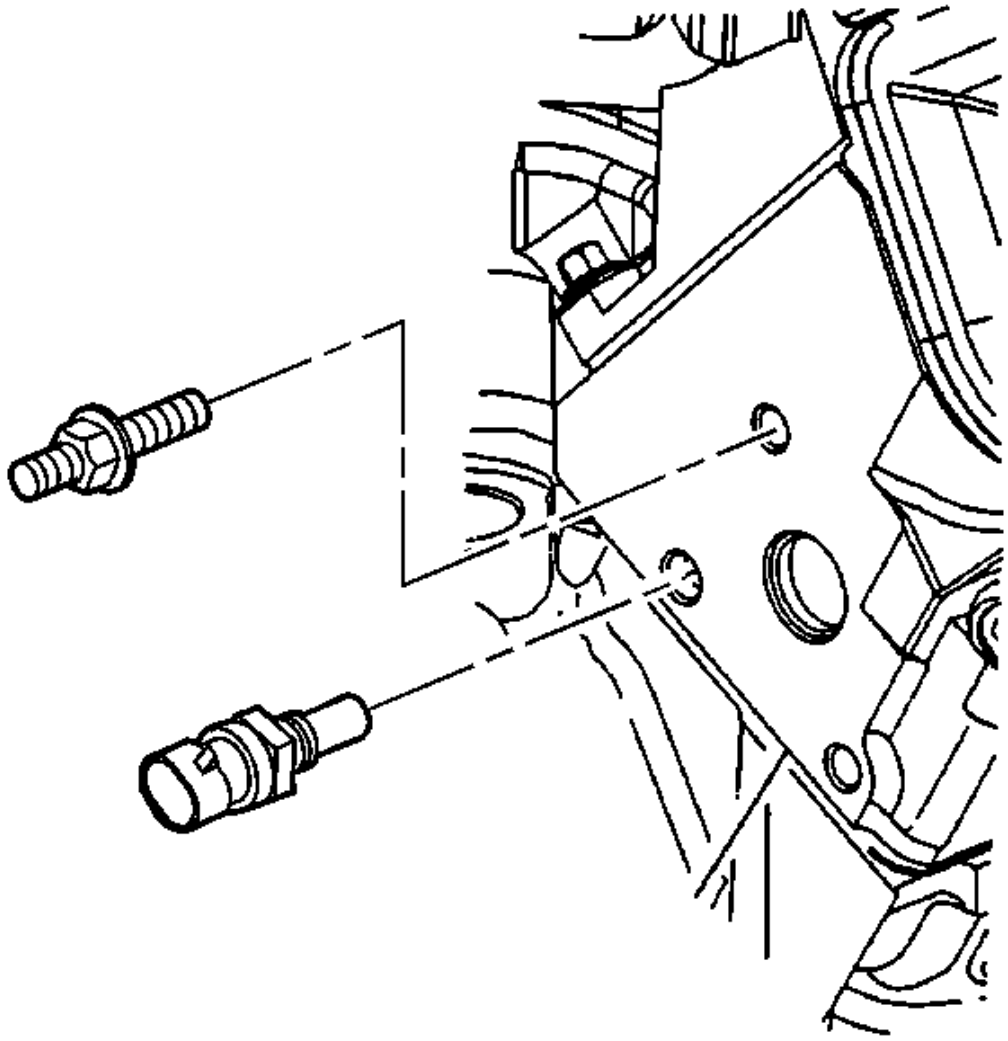

Fig. 407: View Of Heater Inlet Pipe Stud & Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

11. Apply sealer P/N 21485278 to the coolant temperature sensor.

CAUTION: Refer to Fastener Caution .

12. Install the coolant temperature sensor, if required. Tighten the coolant temperature sensor to 23 N.m (17 lb ft).

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13. Install the heater inlet pipe stud, if required. Tighten the heater inlet pipe stud to 35 N.m (26 lb ft).

OIL PUMP DISASSEMBLE

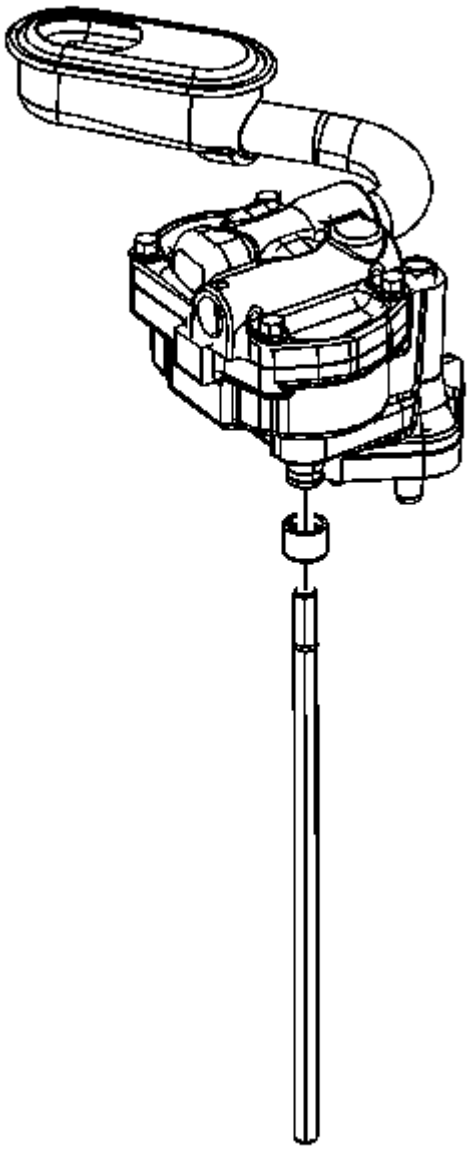

Fig. 408: Identifying Oil Pump Drive Components
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

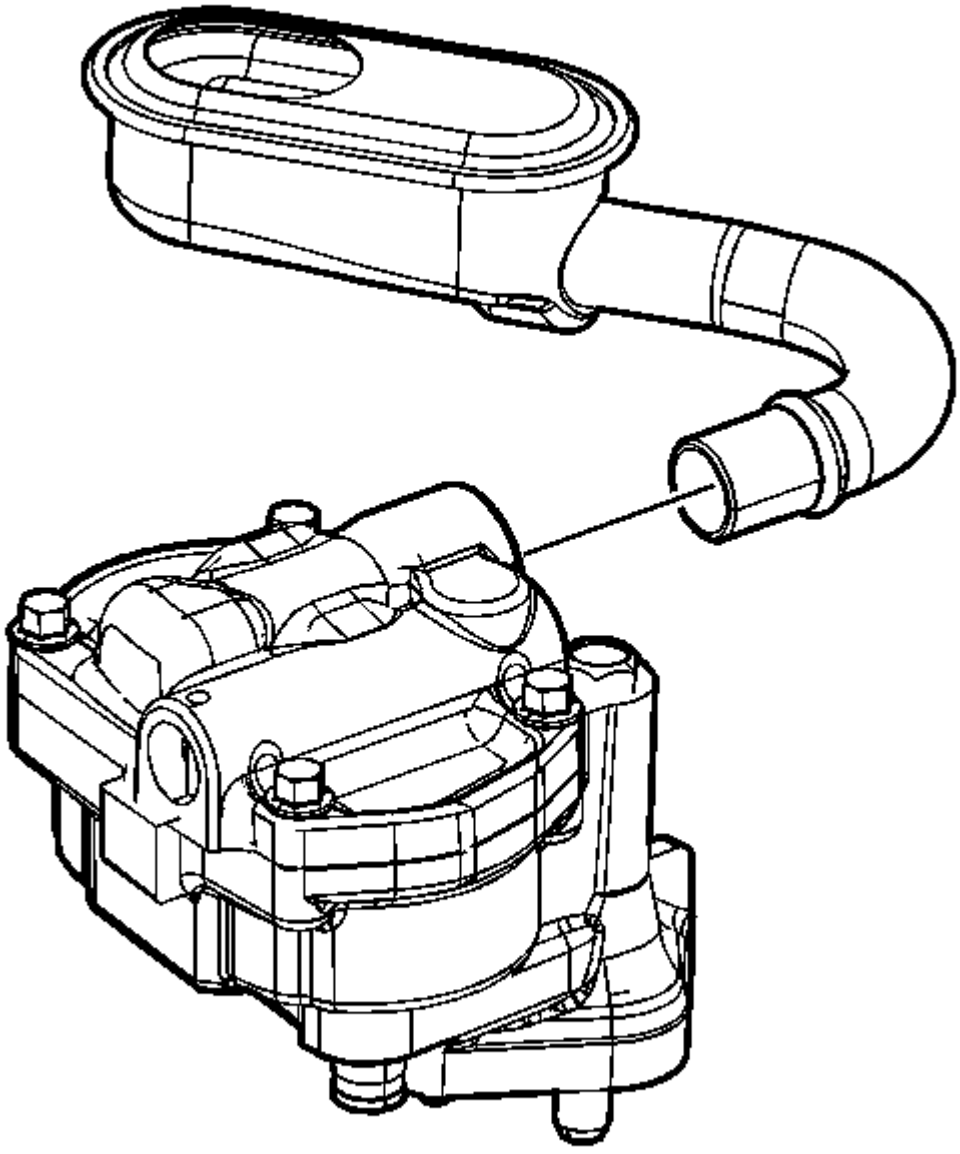

Fig. 409: Identifying Oil Pump & Screen
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

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2. Remove the oil pump screen, if necessary.

   The oil pump screen has a press fit into the oil pump cover.

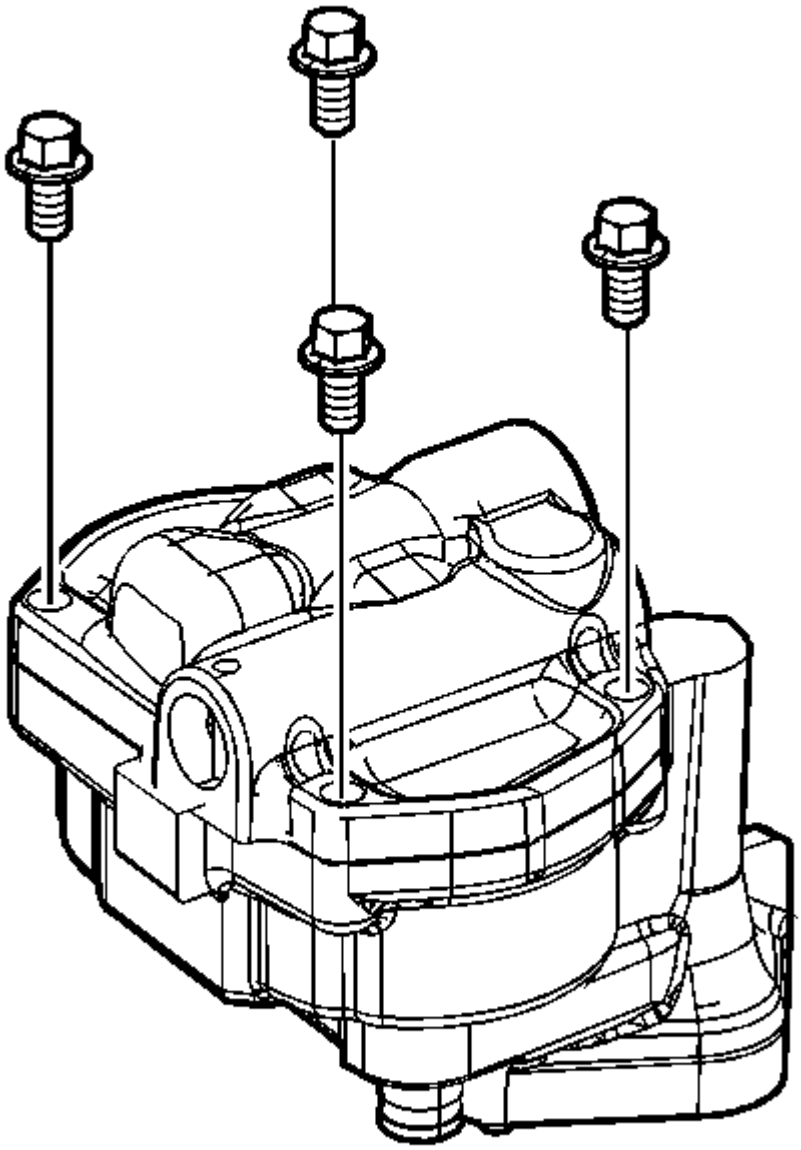

Fig. 410: Identifying Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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3. Remove the oil pump cover bolts.

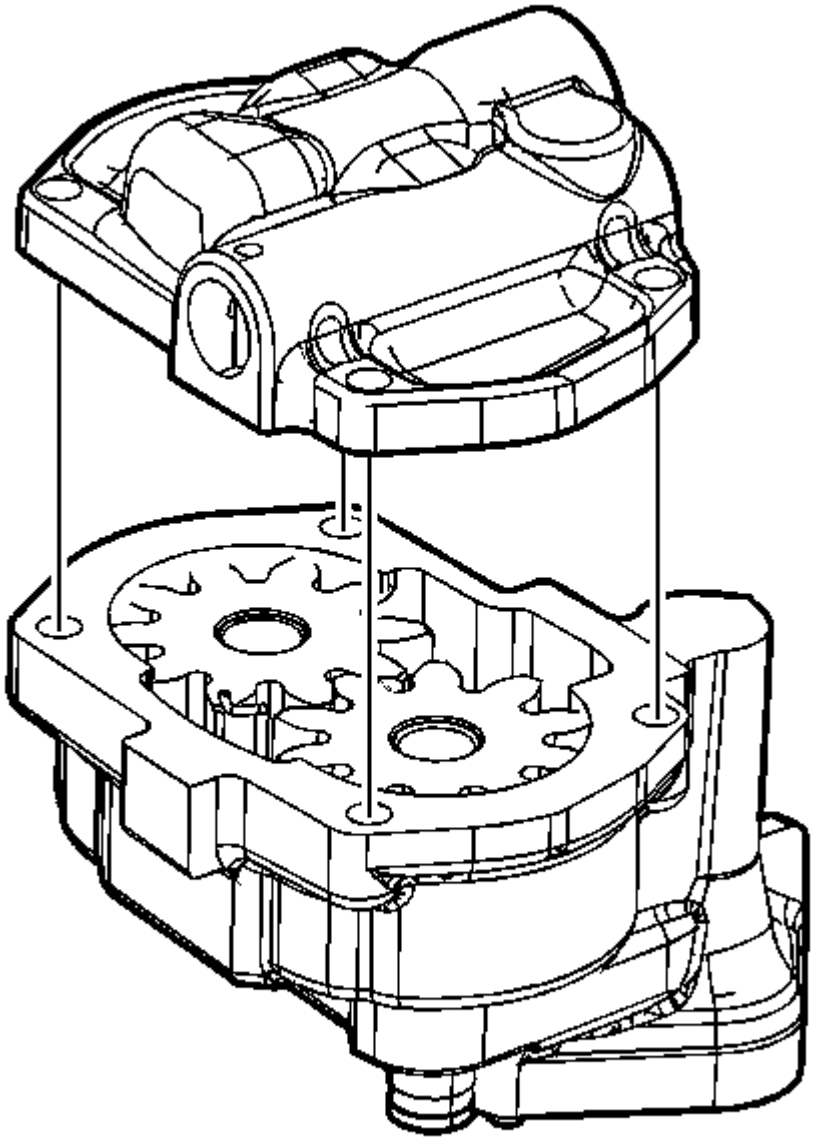

Fig. 411: Identifying Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover.

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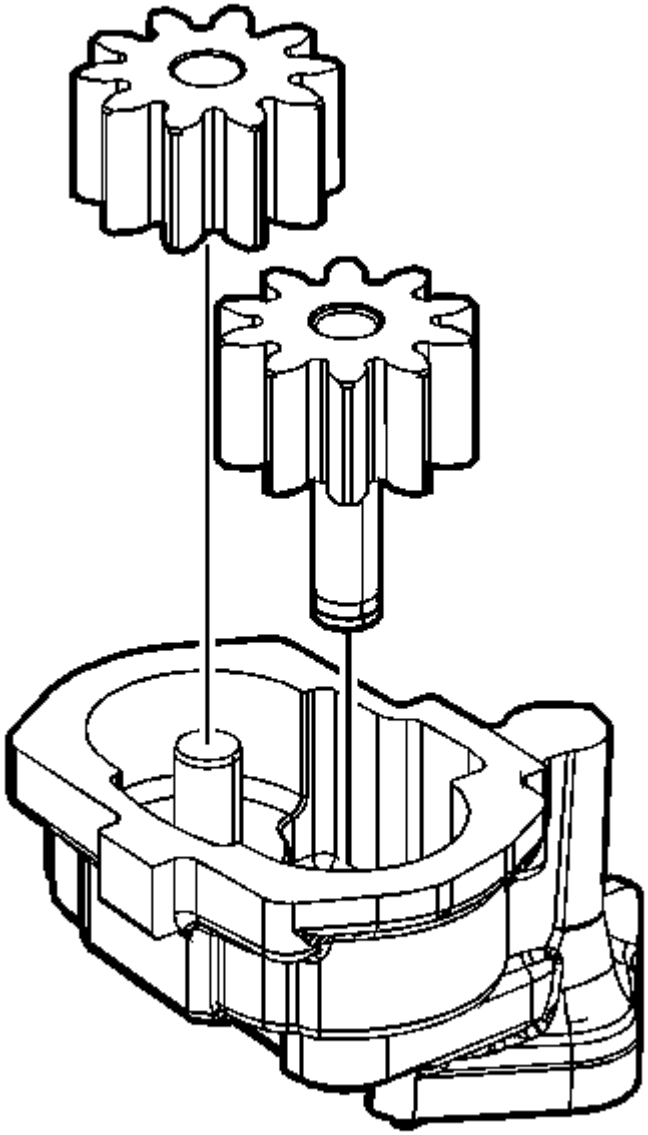

Fig. 412: Identifying Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

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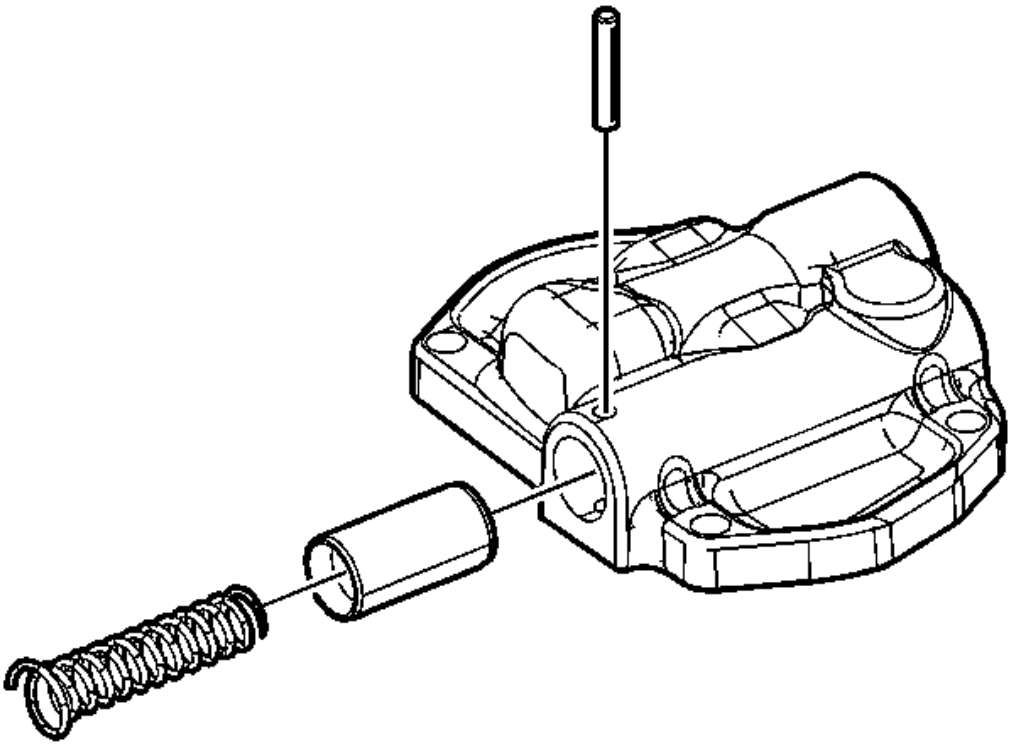

Fig. 413: Identifying Pressure Regulator Valve Spring
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

WARNING: In some models, the pressure regulator valve spring is under pressure. Remove the retaining pin carefully in order to avoid bodily injury.

7. Remove the following items:
    1. The oil pump pressure relief valve spring straight pin
    2. The oil pump pressure relief spring

WARNING: Refer to Cleaning Solvent Warning .

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3. The oil pump pressure relief valve-If the valve is stuck, soak the pump housing in cleaning solvent.

OIL PUMP CLEANING AND INSPECTION

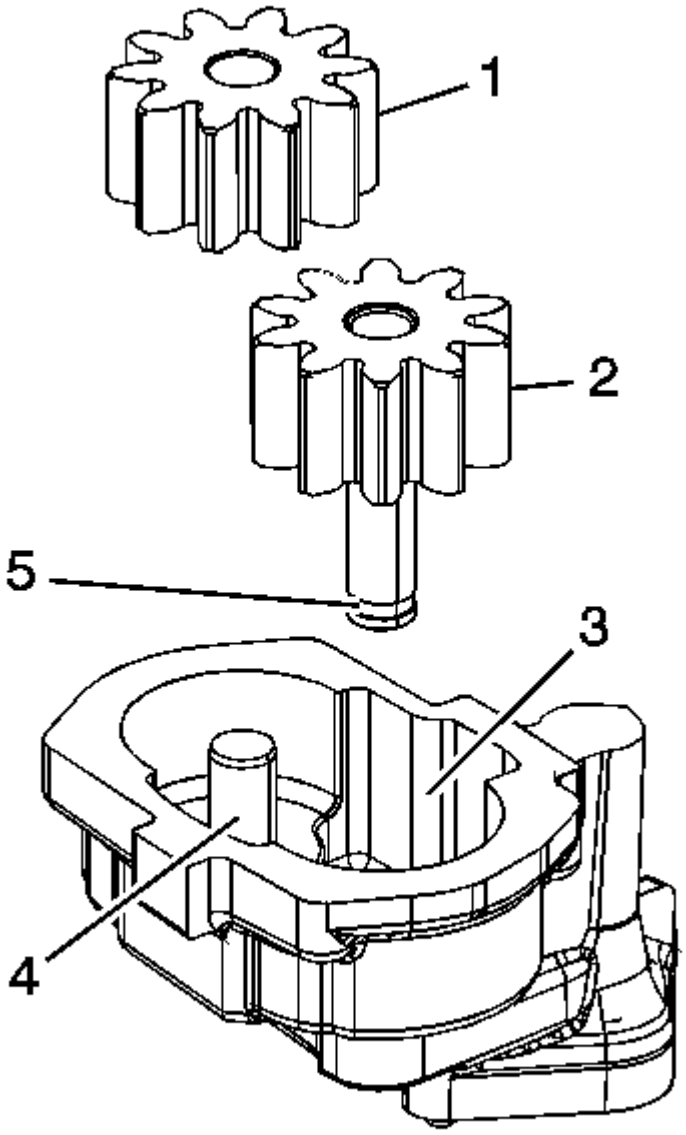

Fig. 414: Identifying Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

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WARNING: **Refer to Cleaning Solvent Warning .**

1. Clean all parts of sludge, oil, and varnish by soaking in cleaning solvent.
2. Inspect for foreign material and determine the source of the foreign material.
3. Inspect the pump housing and cover for the following conditions:
   - Cracks or casting imperfections
   - Scoring (3)
   - Damaged threads
4. Do not attempt to repair the pump housing.

   Replace the pump housing.

5. Inspect the oil pump gears for the following conditions:
   - Scoring (1)
   - Excessive wear (2)
6. Inspect the idler shaft for looseness or scoring (4).

   If loose or damaged, replace the oil pump.

7. Inspect the drive gear shaft for looseness or scoring (5).

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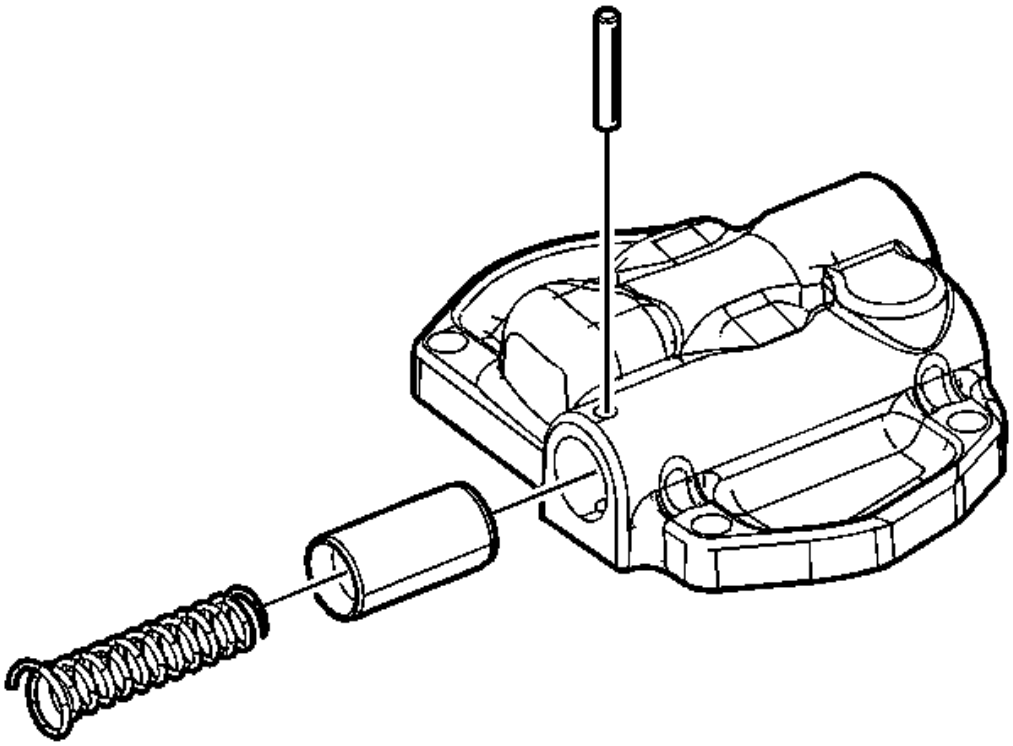

Fig. 415: Identifying Oil Pump Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

8. Inspect the pressure regulator valve for the following conditions:
   - Scoring
   - Sticking

   Burrs may be removed using a fine oil stone.

9. Inspect the pressure regulator valve spring for the following conditions:
   - Loss of tension
   - Bending
10. Inspect the suction pipe and screen assembly for the following conditions:
   - Looseness-If the suction pipe is loose, bent or has been removed, replace the pump body cover and suction pipe.
   - Broken wire mesh or screen

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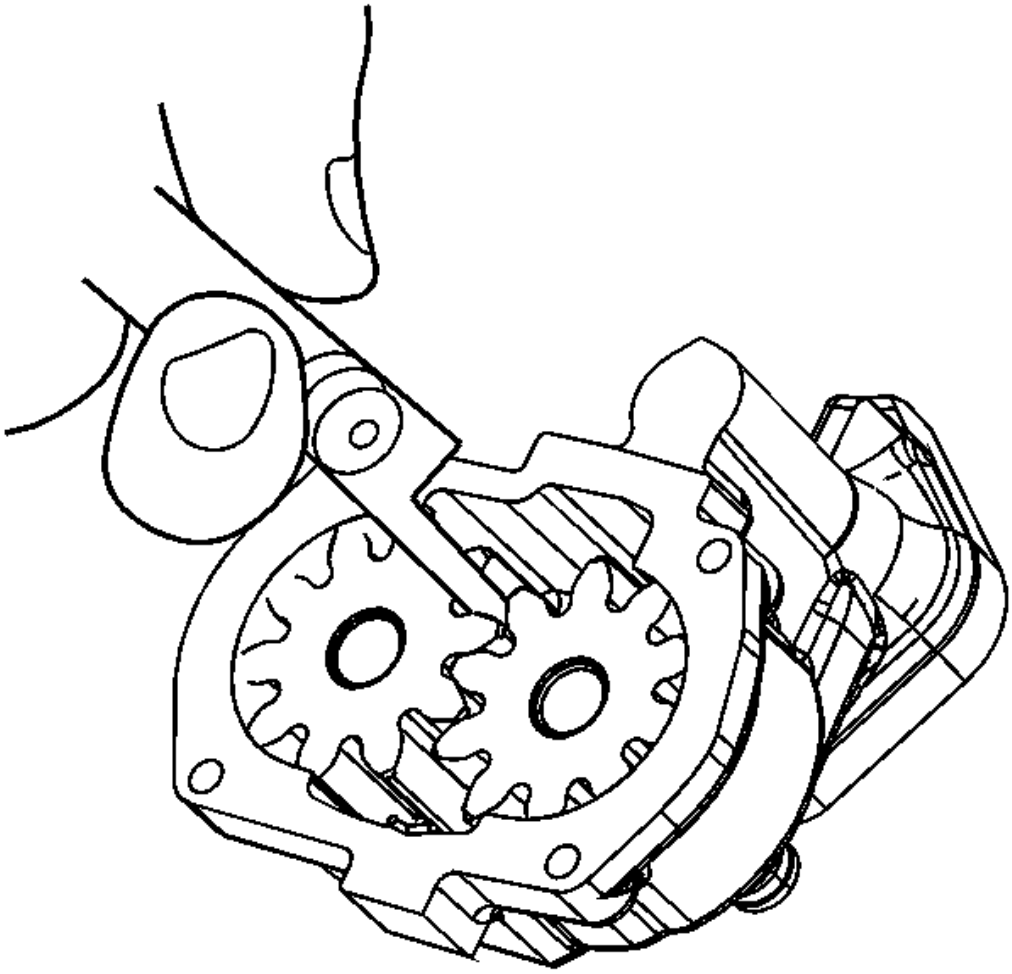

Fig. 416: Measuring Oil Pump Gear Lash
Courtesy of GENERAL MOTORS CORP.

11. Measure the oil pump gear lash. Install the gears, and measure in several places.

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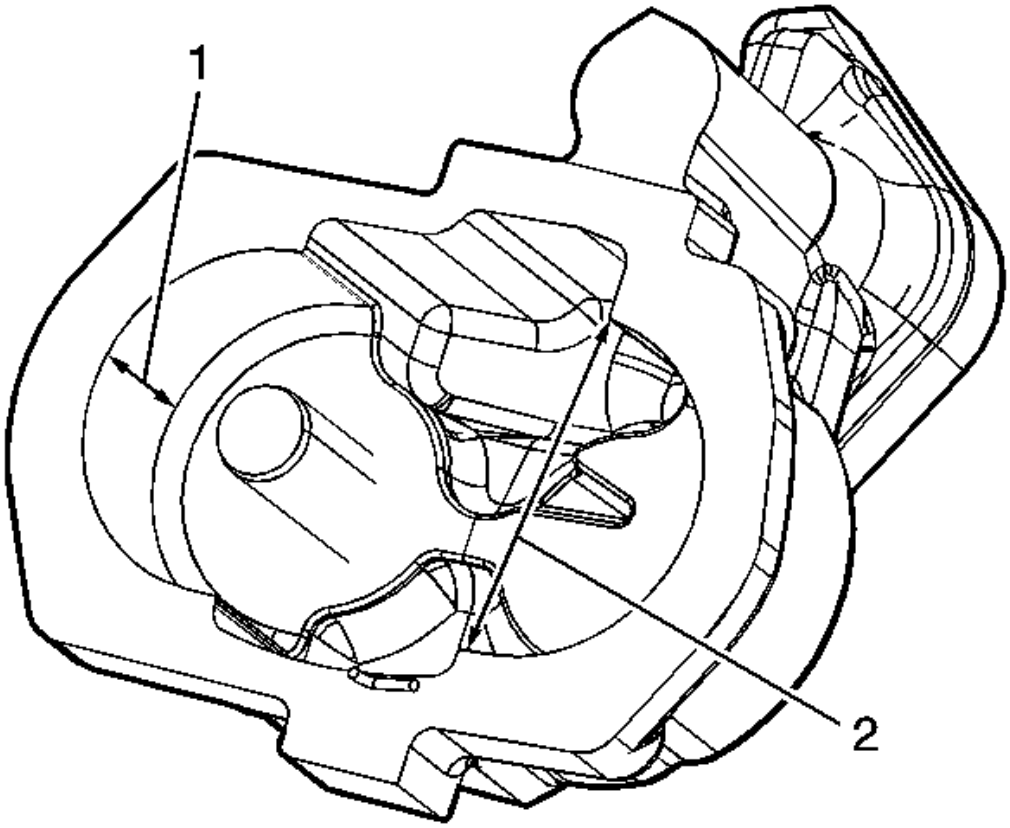

Fig. 417: Measuring Oil Pump Housing Gear Pocket
Courtesy of GENERAL MOTORS CORP.

12. Measure the oil pump housing gear pocket (1, 2).

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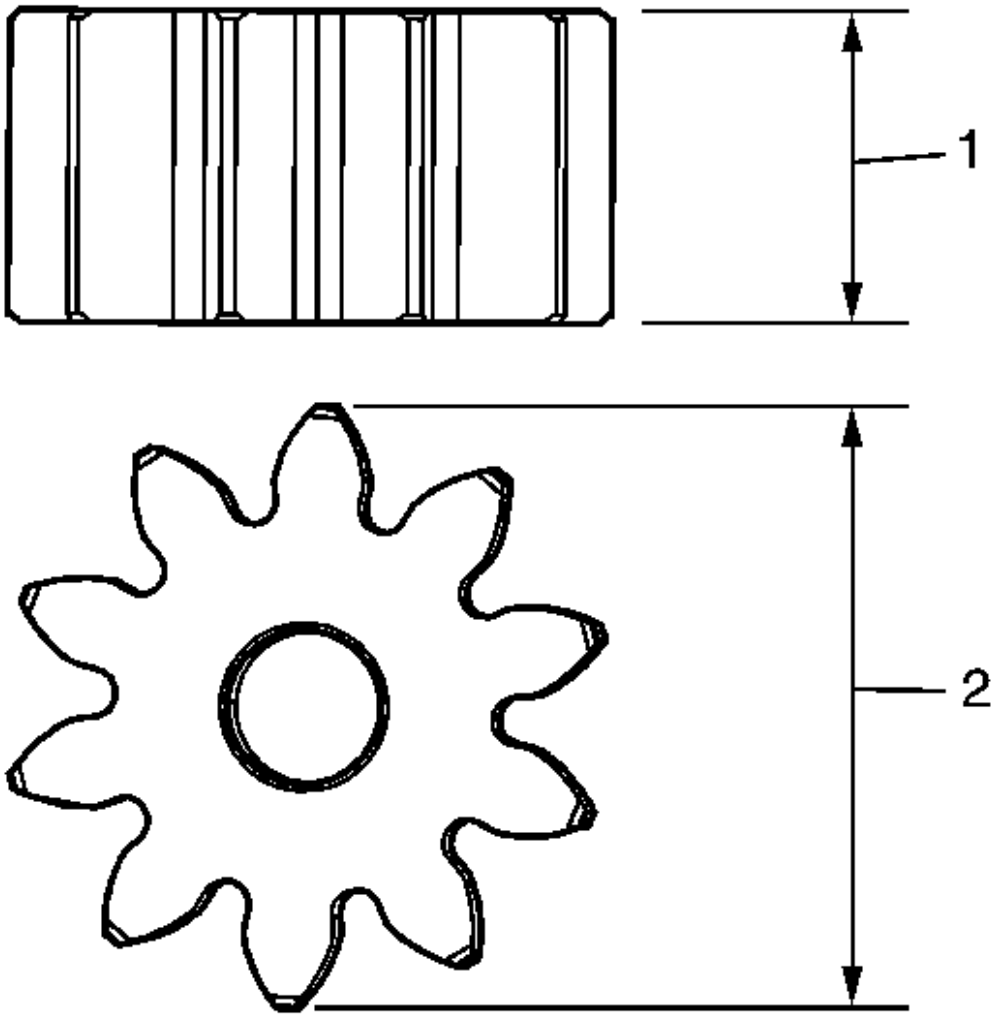

Fig. 418: Measuring Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

13. Measure the oil pump gears (1, 2).

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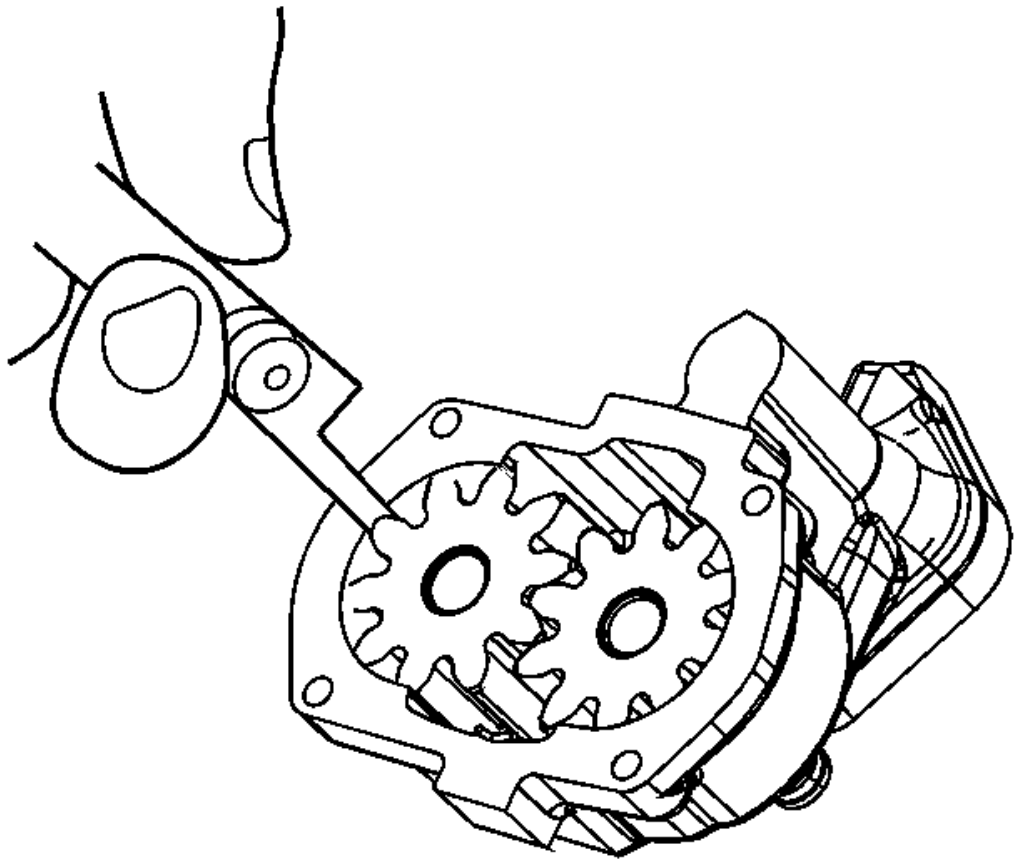

Fig. 419: Measuring Oil Pump Gear Side Clearance
Courtesy of GENERAL MOTORS CORP.

NOTE: When deciding pump serviceability based on end clearance, consider depth of the wear pattern in the pump cover.

14. Measure the oil pump gear side clearance.

OIL PUMP ASSEMBLE

Special Tools

J-22144: Oil Suction Pipe Installer

Assemble

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1. Lubricate all the internal oil pump parts using engine oil during assembly.

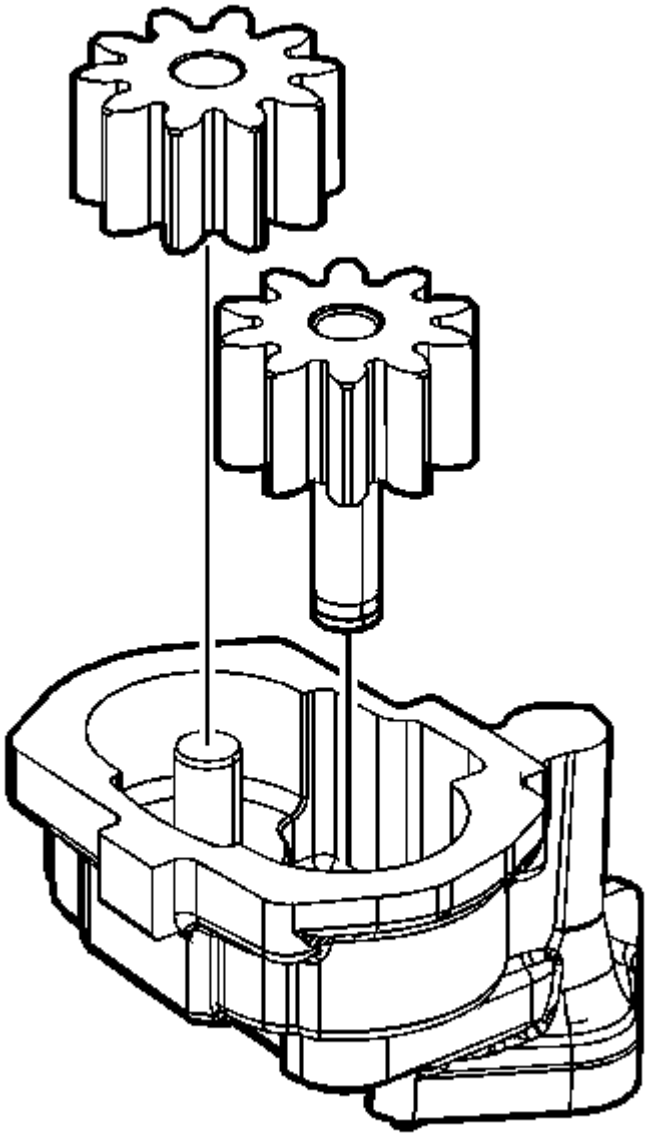

Fig. 420: Identifying Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump gears.

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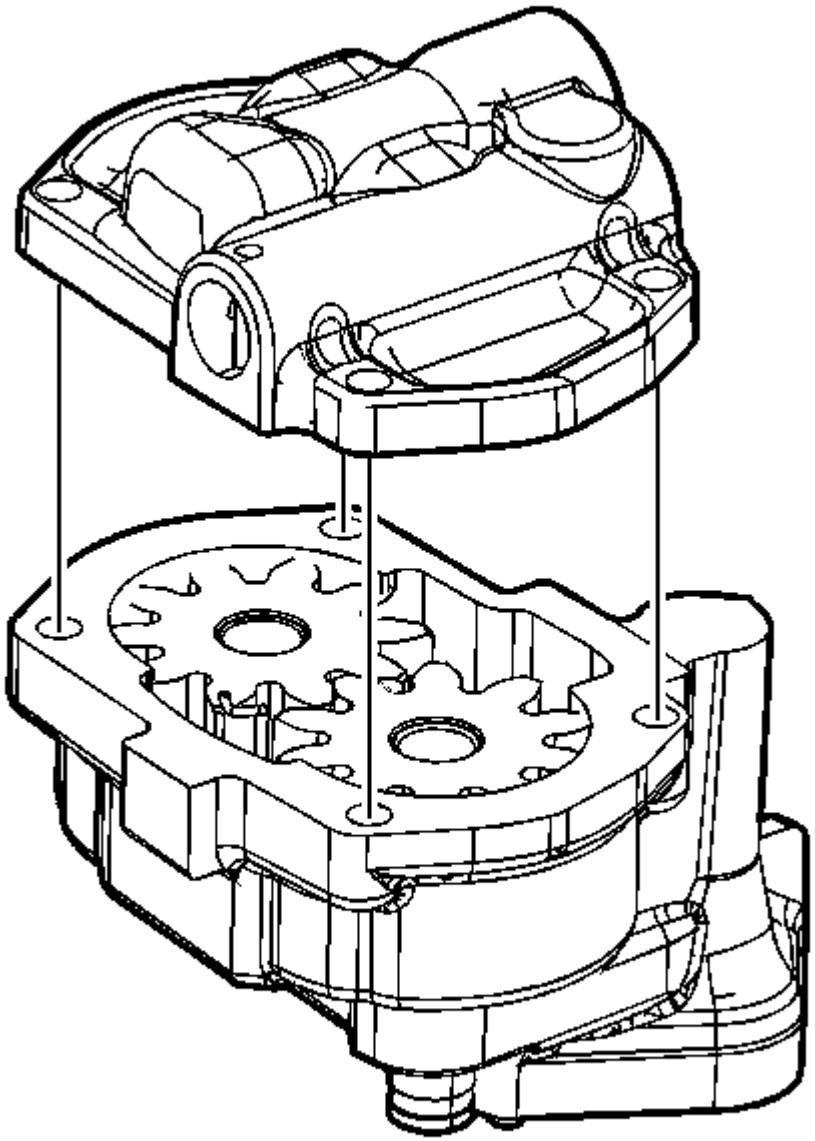

Fig. 421: Identifying Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump cover.

CAUTION: Refer to Fastener Caution .

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4. Install the oil pump cover bolts and tighten to 10 N.m (89 lb in).

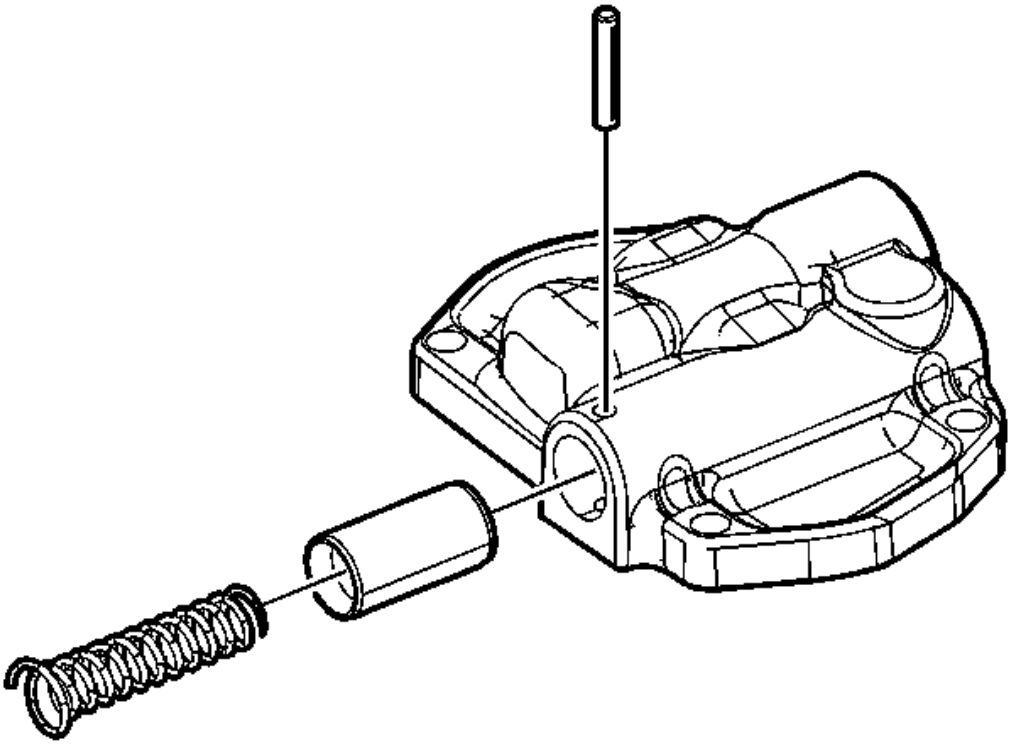

Fig. 422: Identifying Oil Pump Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure regulator valve.
6. Install the pressure regulator spring.
7. Install the cotter pin.

NOTE: Make sure the cotter pin is properly secured.

8. Apply sealer GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the new suction pipe.
9. Tap the new suction pipe into place using a plastic hammer and **J-22144:** Oil Suction Pipe Installer.

ENGINE FRONT COVER CLEANING AND INSPECTION

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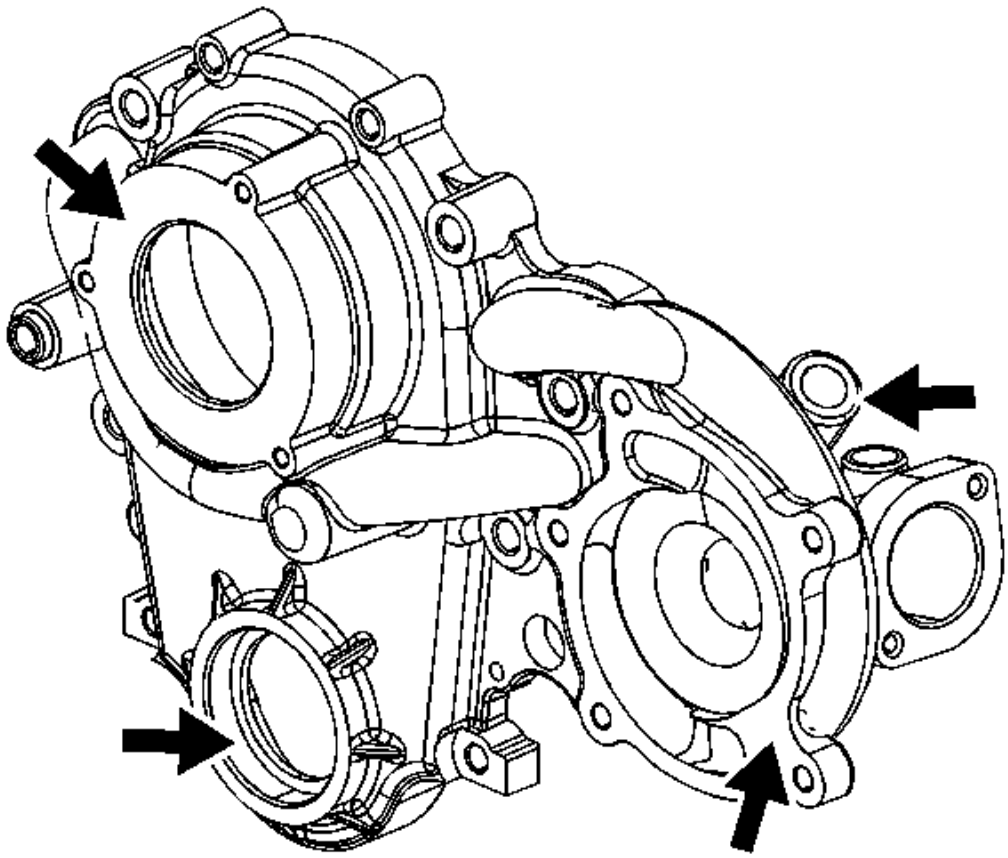

Fig. 423: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

1. Clean the engine front cover with solvent.
2. Dry the engine front cover with compressed air.
3. Inspect the engine front cover sealing surfaces for damage.
4. Inspect the engine front cover threaded holes.
5. Repair or replace the engine front cover as needed.

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

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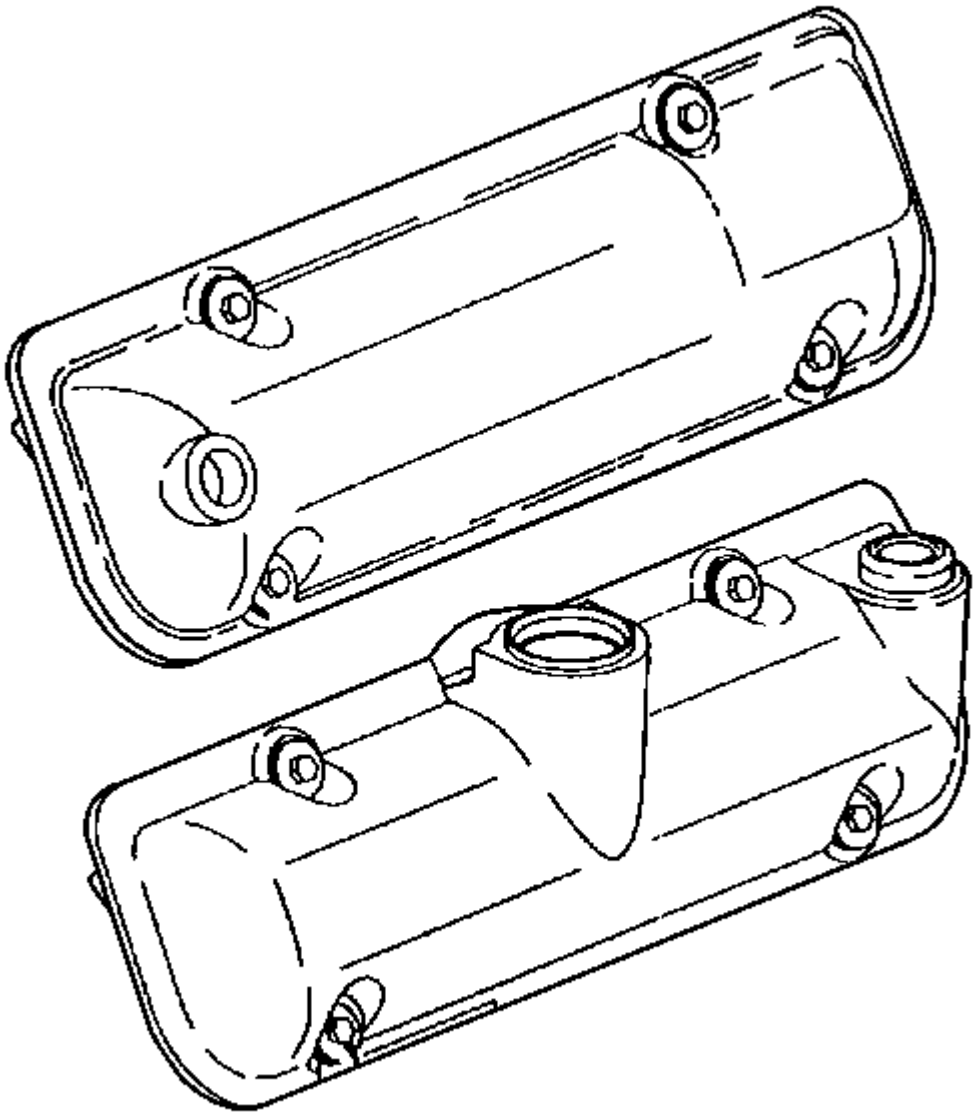

Fig. 424: View Of Valve Rocker Arm Covers
Courtesy of GENERAL MOTORS CORP.

1. Remove all rubber grommets from the valve rocker arm covers.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

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2. Clean the valve rocker arm covers with solvent.
3. Dry the valve rocker arm covers with compressed air.
4. Inspect the valve rocker arm covers for damage and replace if necessary.

POSITIVE CRANKCASE VENTILATION (PCV) VALVE CLEANING AND INSPECTION

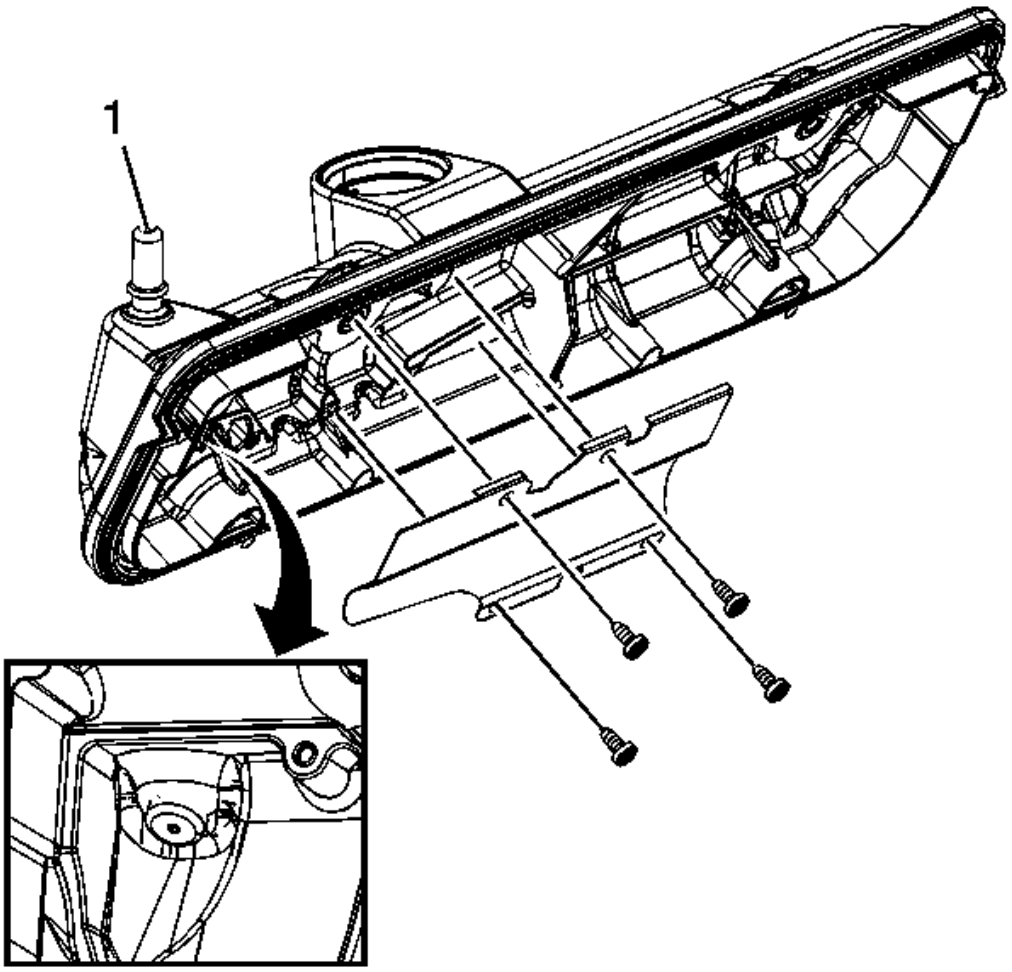

Fig. 425: Identifying Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not attempt to remove the valve from the valve rocker arm cover, as damage may occur to the rocker arm valve cover. The positive crankcase ventilation (PCV) valve is a fixed orifice system.

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1. Flush the carbon from the PCV valve orifices (1) using solvent.
2. Dry the PCV valve orifices using compressed air.

OIL PAN CLEANING AND INSPECTION

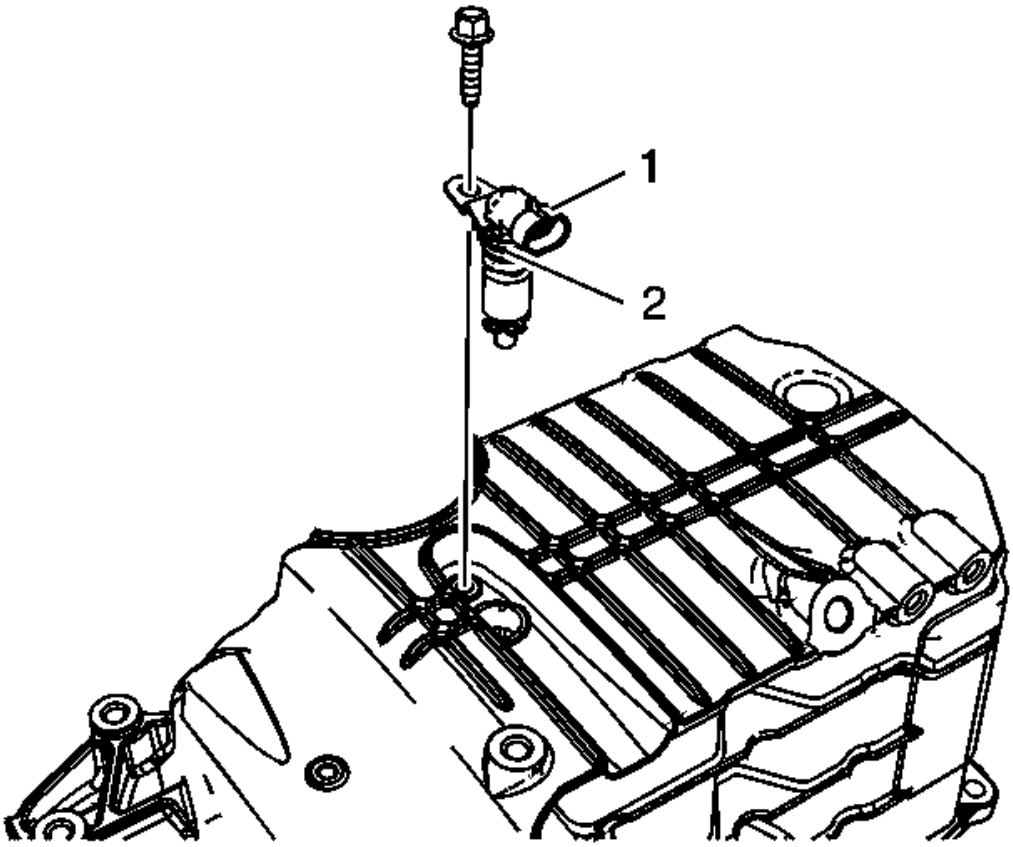

Fig. 426: Identifying Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level sensor.
2. Inspect the O-ring seal (2) and the electrical connector (1) for wear or damage. Repair or replace as necessary.

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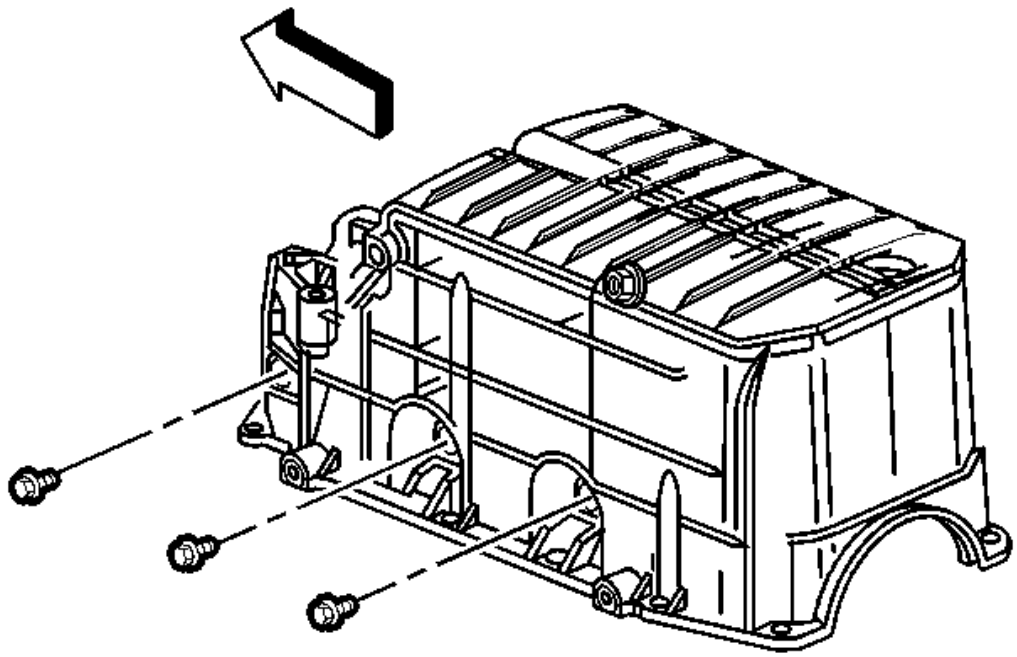

Fig. 427: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

3. Clean the oil pan with solvent. Remove all sludge and debris from the oil pan.
4. Dry the oil pan with compressed air.
5. Inspect the oil pan sealing surface for damage and replace if necessary.

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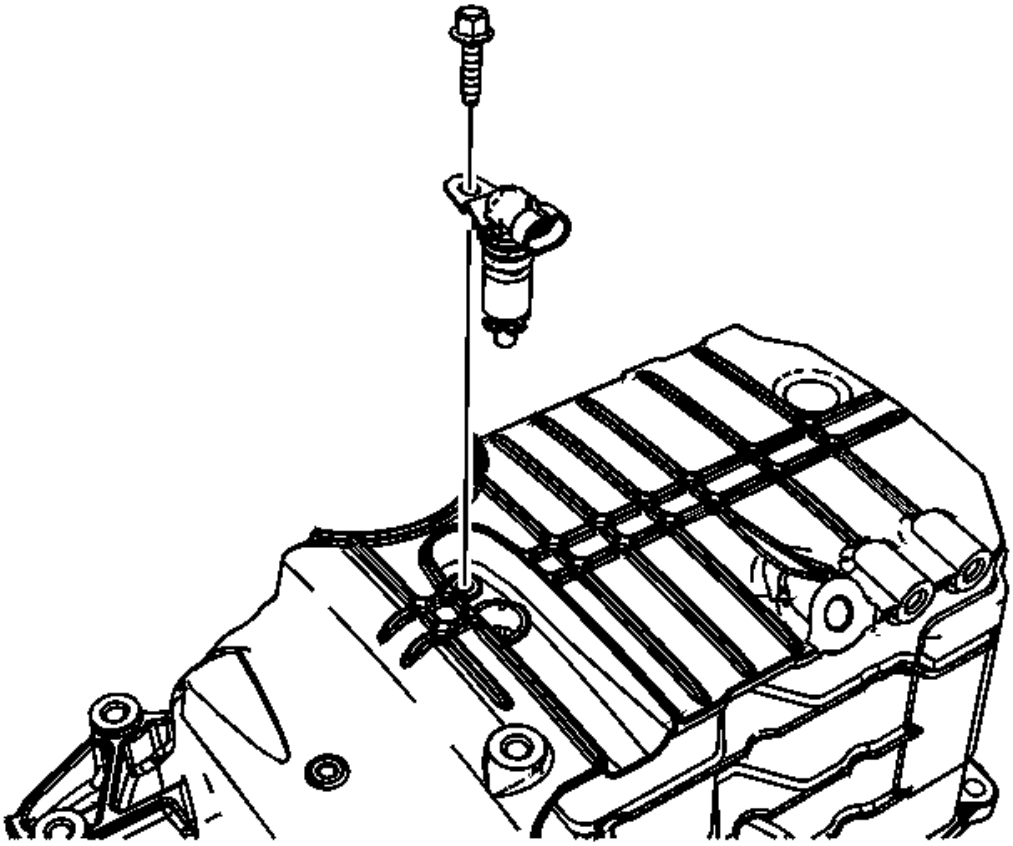

Fig. 428: View Of Oil Level Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the oil level sensor and bolt and tighten to 10 N.m (89 lb in).

LOWER INTAKE MANIFOLD CLEANING AND INSPECTION

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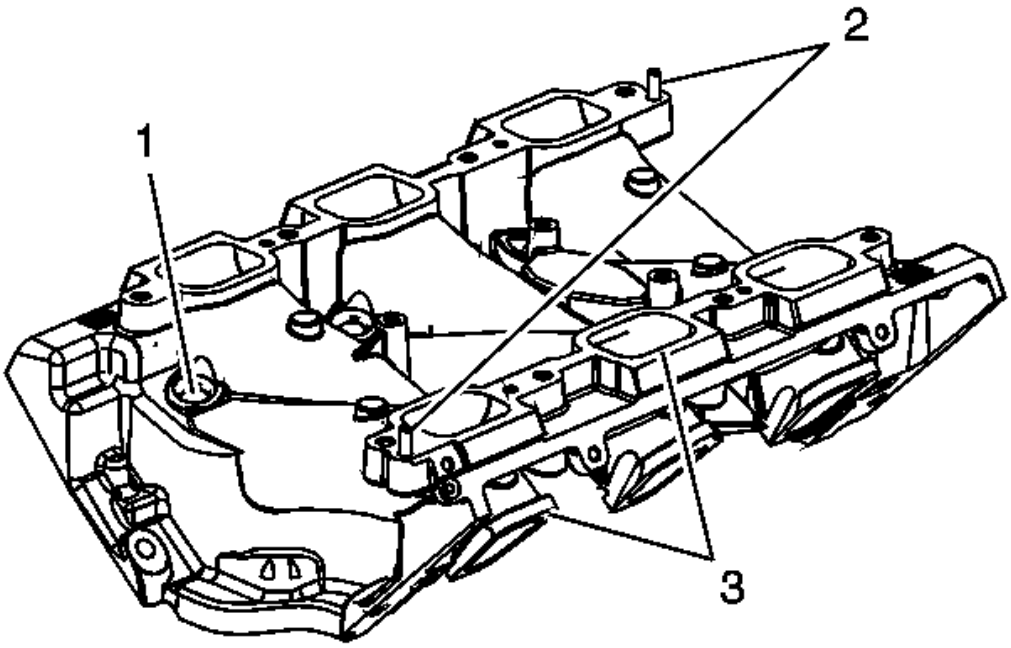

Fig. 429: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the intake manifold gasket mating surfaces (3) using GM P/N 12346139 (Canadian P/N 10953463) or equivalent.
2. Clean the fuel injector bores (1).
3. Inspect the lower intake manifold locating pins (2) for damage. Replace as necessary.
4. Inspect the intake manifold for damage.

IMPORTANT: If replacing the lower intake manifold, make sure to transfer or replace the locating pins as necessary.

5. Repair or replace the intake manifold as necessary.

COOLANT CROSSOVER PIPE CLEANING AND INSPECTION

WARNING: Refer to Cleaning Solvent Warning .

1. Clean the coolant crossover pipe with solvent.

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WARNING: Refer to Safety Glasses Warning .

2. Dry the coolant crossover pipe with compressed air.

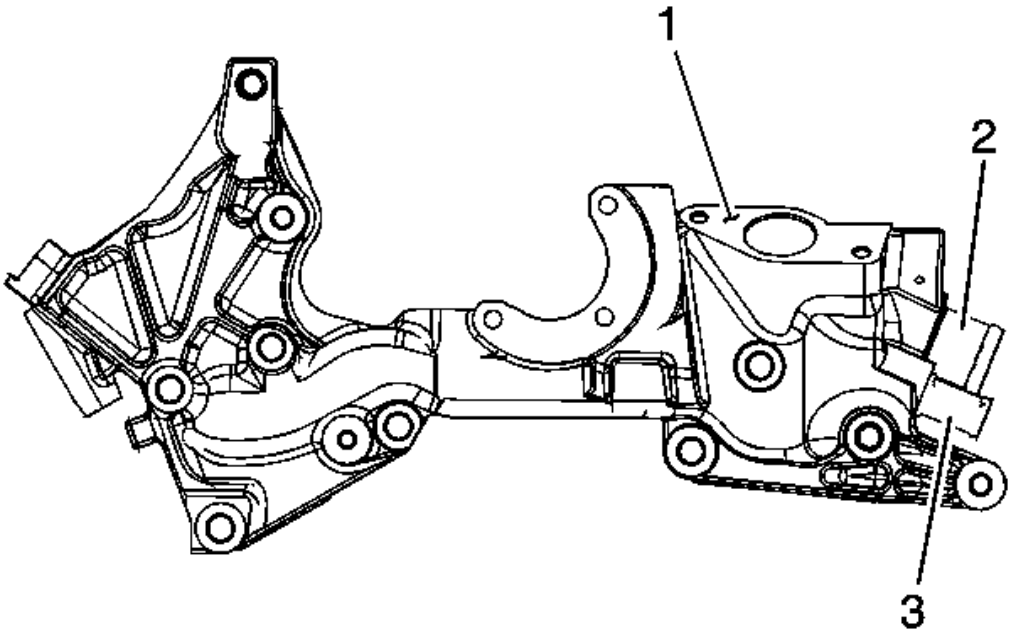

Fig. 430: View Of Front Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the coolant crossover pipe for the following:
   - Damage to the coolant fill adapter sealing surface (1)
   - Damage or restrictions to the radiator hose connection (2)
   - Damage or restrictions to the thermal bypass hose connection (3)
   - Damage, blockage, or excessive corrosion to the engine coolant passages
   - Damage or restrictions to any fastener threads
   - Damage or restrictions to any mounting holes

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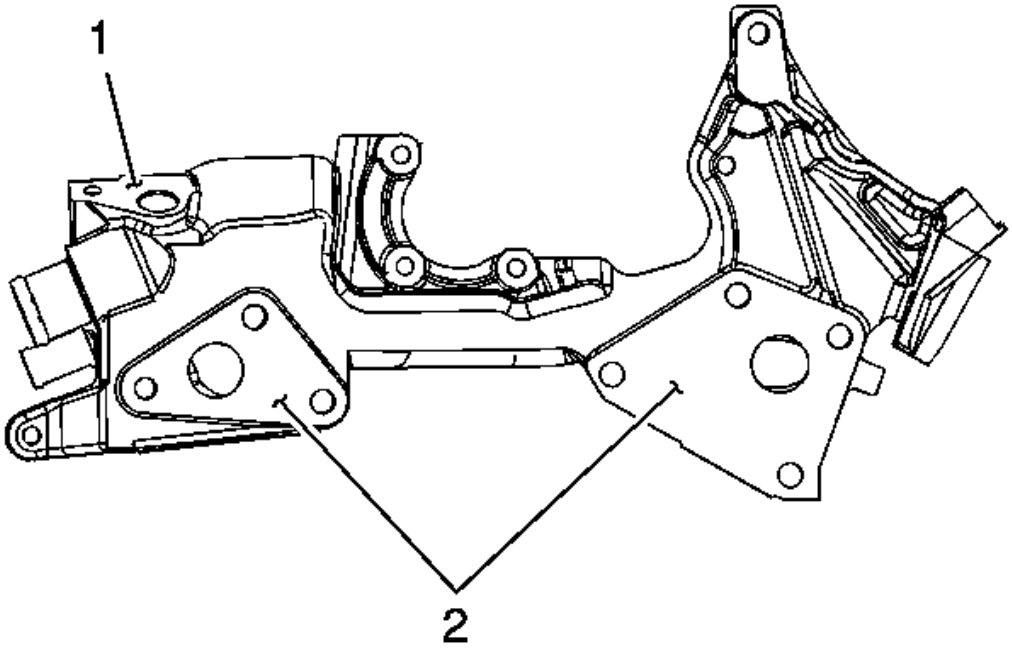

Fig. 431: View Of Rear Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

4. Inspect the rear of the coolant crossover pipe for the following:
    - Damage to the heater inlet/outlet sealing surface (1)
    - Damage to the coolant crossover pipe-to-cylinder head sealing surfaces (2)
    - Damage, blockage, or excessive corrosion to the engine coolant passages
    - Damage or restrictions to any fastener threads
    - Damage or restrictions to any mounting holes
5. Repair or replace the coolant crossover pipe as necessary.

UPPER INTAKE MANIFOLD CLEANING AND INSPECTION

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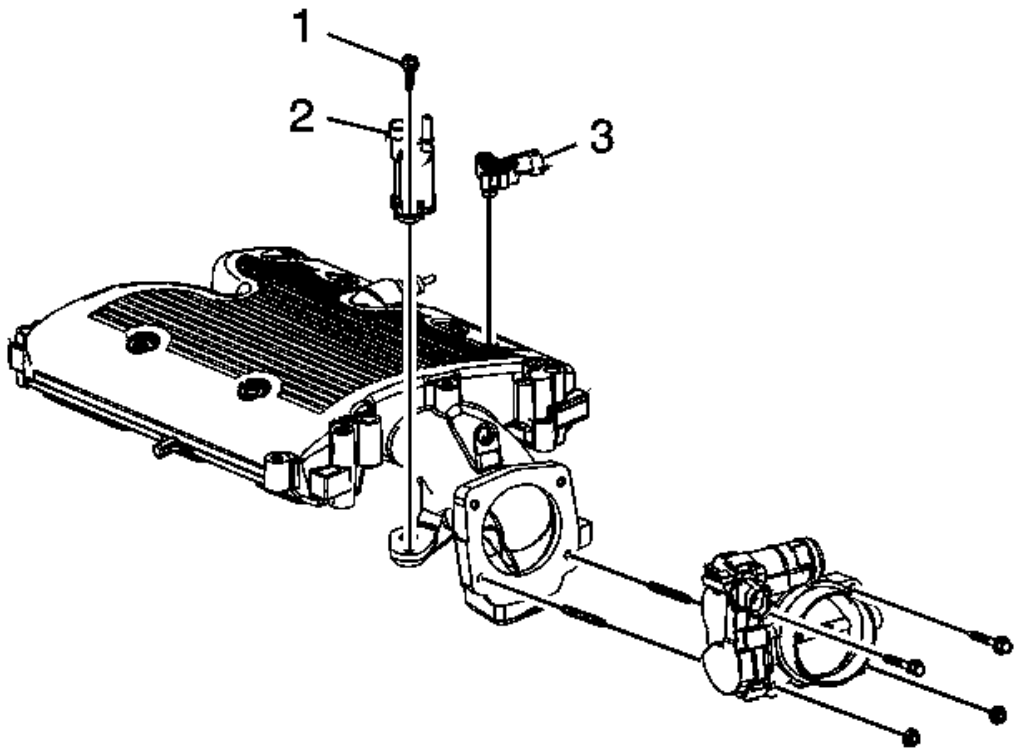

Fig. 432: View Of Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body bolts and nuts.
2. Remove the throttle body.
3. Remove the throttle body studs, if required.
4. Remove the manifold absolute pressure (MAP) sensor (1).
5. Remove the evaporative emission (EVAP) purge valve bolt (2).
6. Remove the EVAP purge valve (3).

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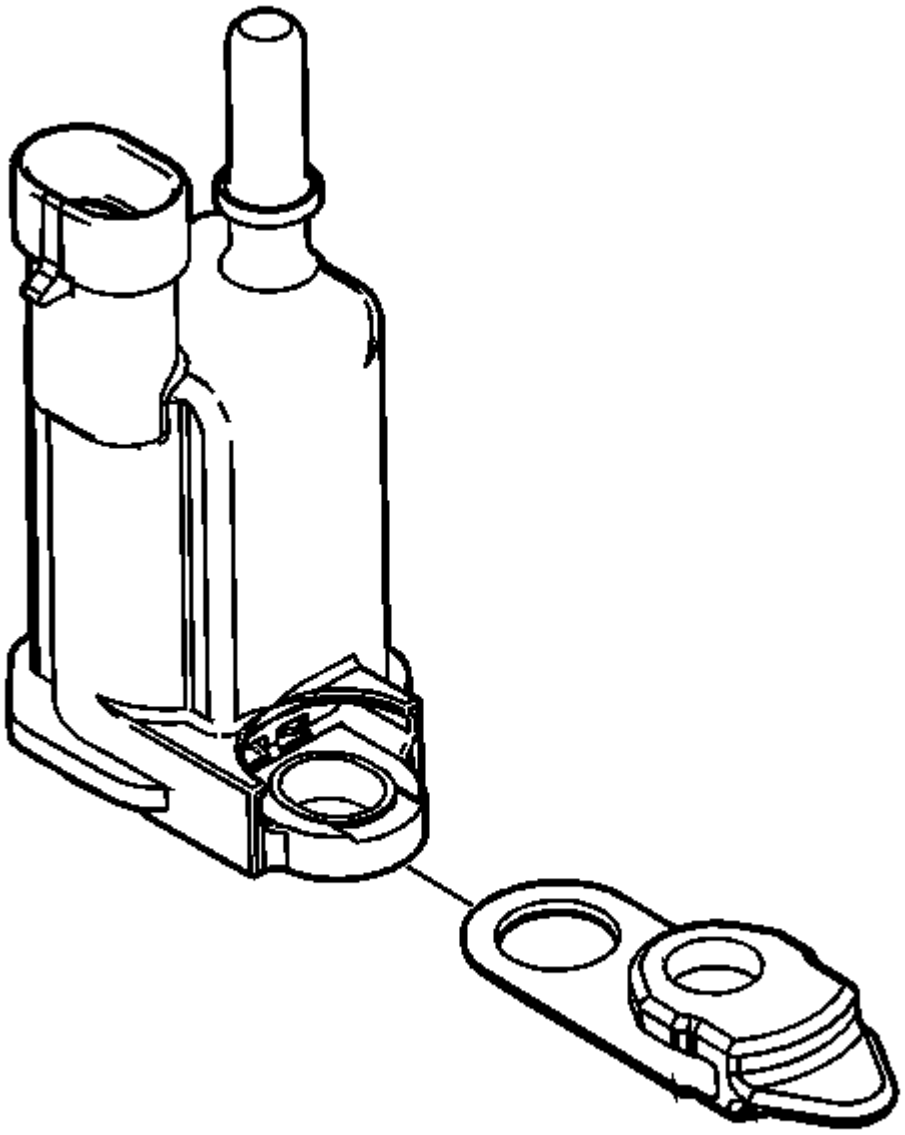

Fig. 433: Identifying EVAP Purge Valve Isolator
Courtesy of GENERAL MOTORS CORP.

7. Remove the EVAP purge valve isolator, if equipped.

WARNING: Refer to Cleaning Solvent Warning .

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WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

8. Clean the intake manifold with solvent.
9. Dry the intake manifold with compressed air.
10. Inspect all gasket mating surfaces for nicks or cracks and replace if necessary.

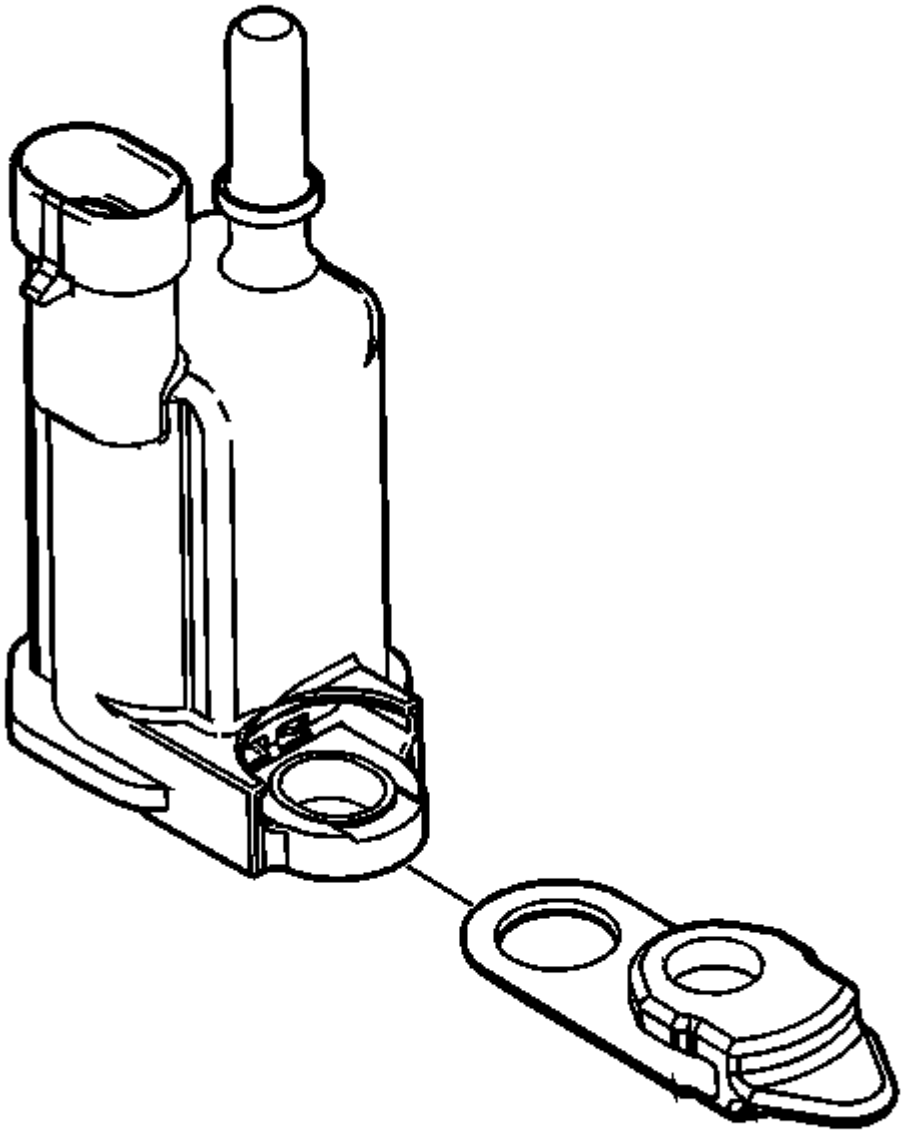

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Fig. 434: Identifying EVAP Purge Valve Isolator
Courtesy of GENERAL MOTORS CORP.

11. Install the EVAP purge valve isolator, if equipped.

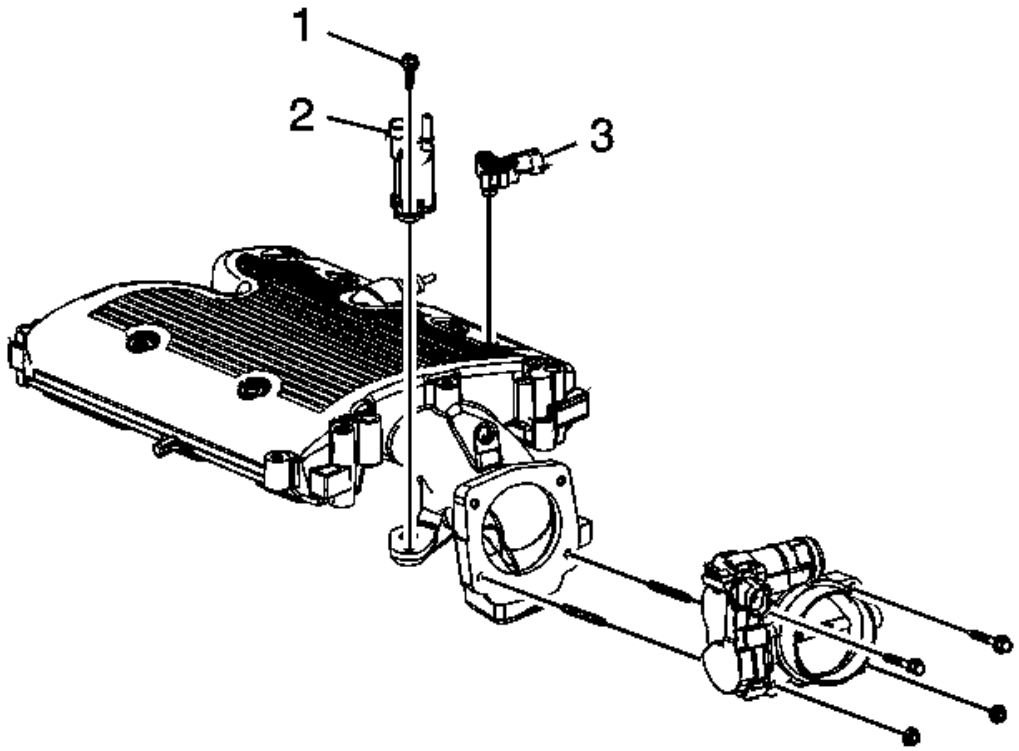

Fig. 435: View Of Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

12. Inspect the EVAP purge valve seal for damage and replace if necessary.
13. Install the EVAP purge valve (3).

CAUTION: Refer to Fastener Caution .

14. Install the EVAP purge valve bolt (2) and tighten to 16 N.m (12 lb ft).

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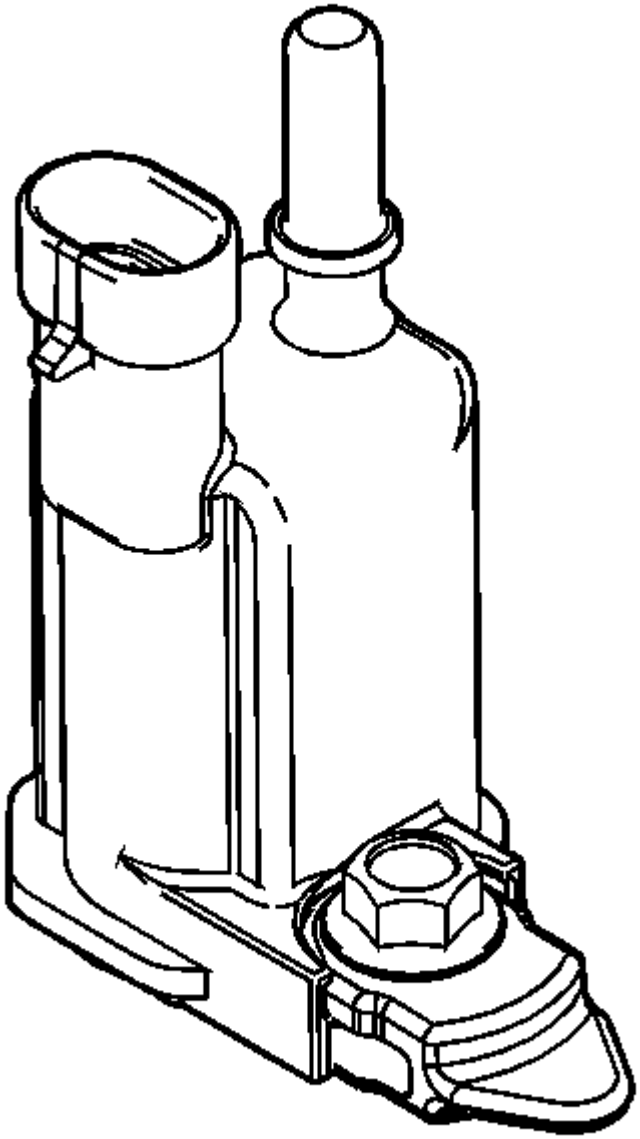

Fig. 436: Identifying Correct EVAP Purge Valve Isolator Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the EVAP purge valve isolator is installed properly as shown, with the isolator covering the top and bottom of the purge valve bolt hole flange. Failure to do so may cause improper EVAP purge valve operation.

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15. Inspect the MAP sensor seal for damage and replace if necessary.
16. Install the MAP sensor.
17. Install the throttle body studs, if required. Tighten the throttle body studs to 6 N.m (53 lb in).
18. Inspect the throttle body seal for damage and replace if necessary.
19. Install the throttle body.
20. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the throttle body bolt and nut threads.
21. Install the throttle body bolts and nuts and tighten to 10 N.m (89 lb in).

EXHAUST MANIFOLD CLEANING AND INSPECTION

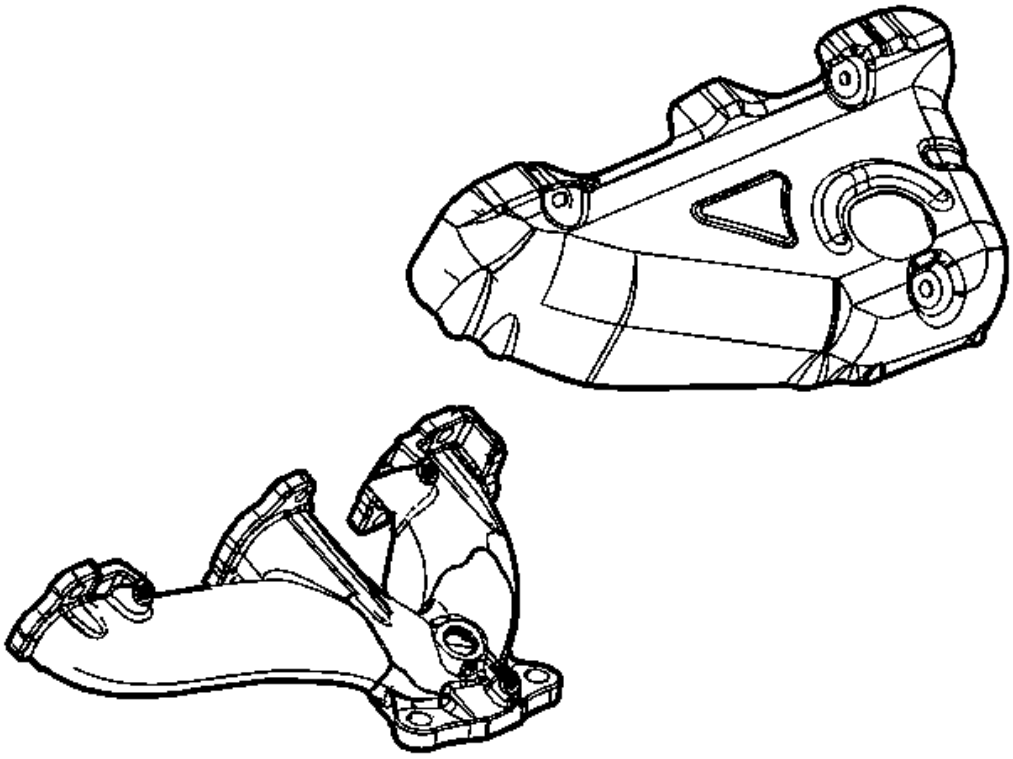

Fig. 437: Cleaning Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

WARNING: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

1. Clean the exhaust manifold and heat shield in solvent.

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2. Dry the exhaust manifold and heat shield with compressed air.
3. Inspect the exhaust manifold for cracks or damage.

WATER PUMP CLEANING AND INSPECTION

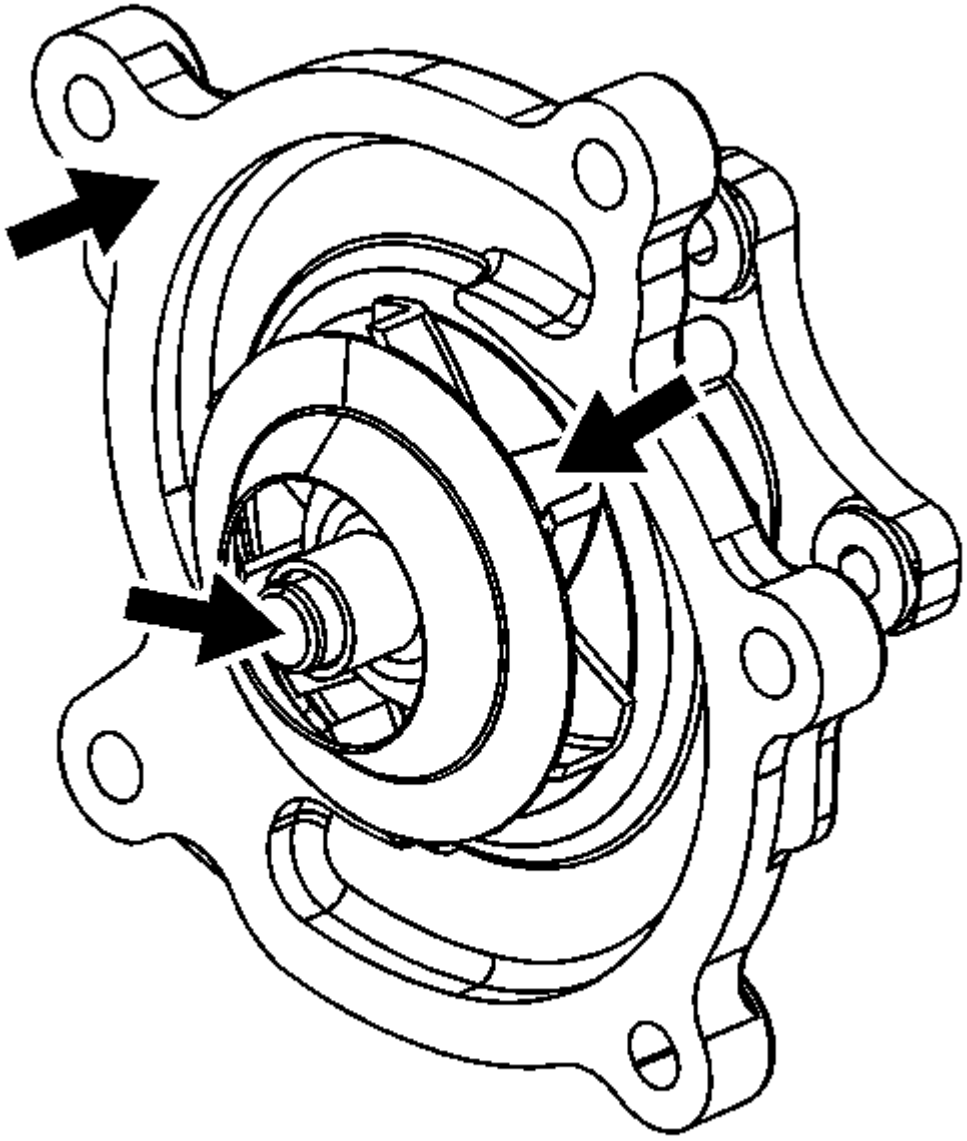

Fig. 438: Rear View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

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1. Remove all gasket material from the sealing surface.
2. Inspect the water pump impeller for damage.
3. Inspect the water pump shaft for looseness.
4. Replace the water pump if necessary.

THREAD REPAIR

General purpose thread repair kits are available commercially.

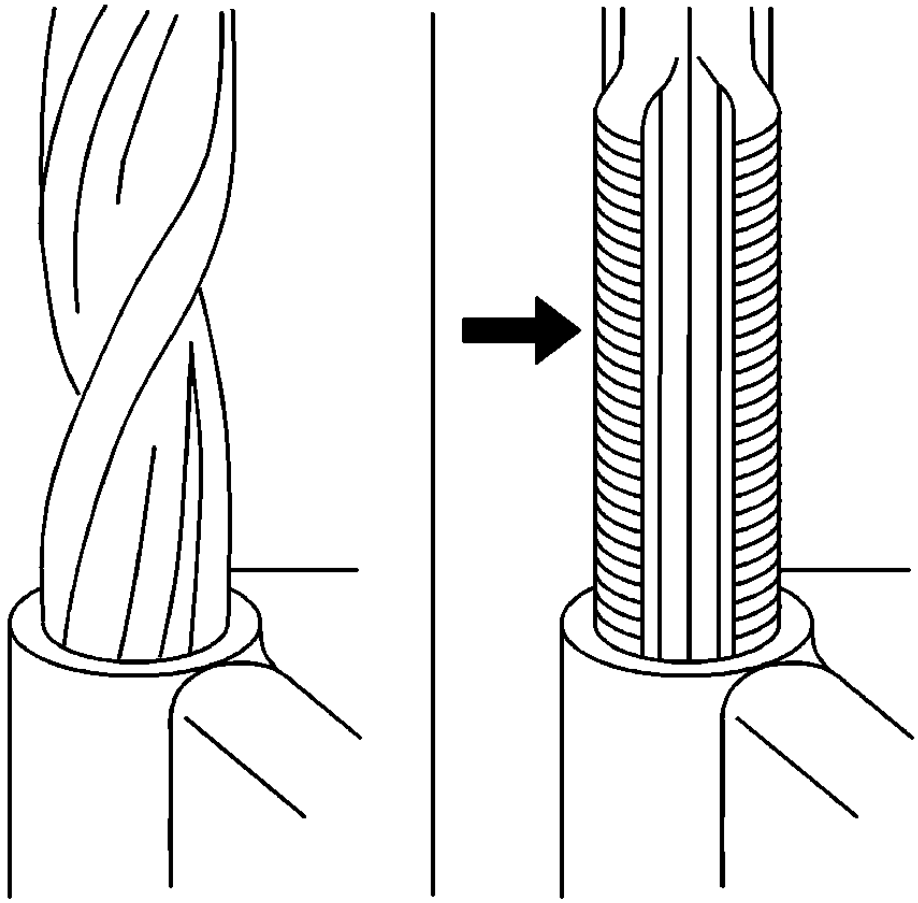

Fig. 439: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

NOTE: Refer to the thread repair kit manufacturer's instructions regarding the

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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.

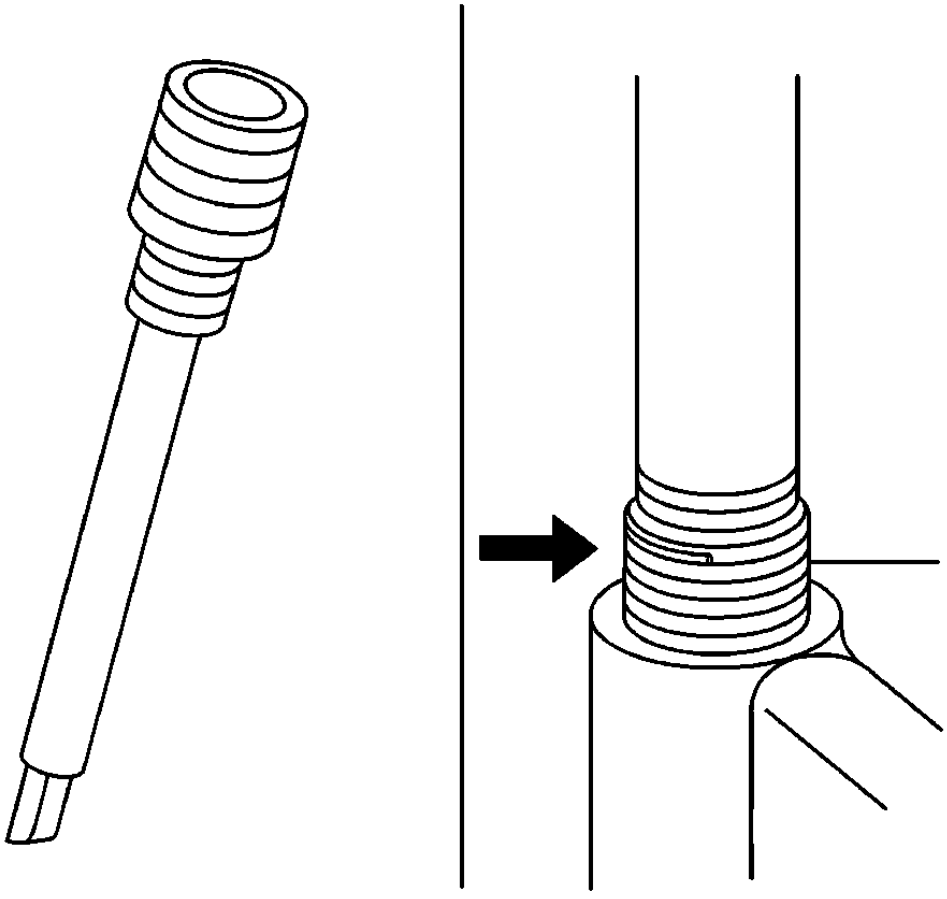

Fig. 440: View Of Thread Insert
Courtesy of GENERAL MOTORS CORP.

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert

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onto the end of the mandrel.

NOTE: 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 of the components. Use the proper tools in order to measure components when inspecting for excessive wear. Repair or replace the components that are not within the manufacturers specification. When components are reinstalled into an engine, return the components to their original location, position, and direction. During assembly, lubricate all of the moving parts with clean engine oil or engine assembly lubricant unless otherwise specified. This will provide initial lubrication when the engine is first started.

CAMSHAFT BEARING INSTALLATION

Special Tools

J-33049: Camshaft Bearing Service Set

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

Installation

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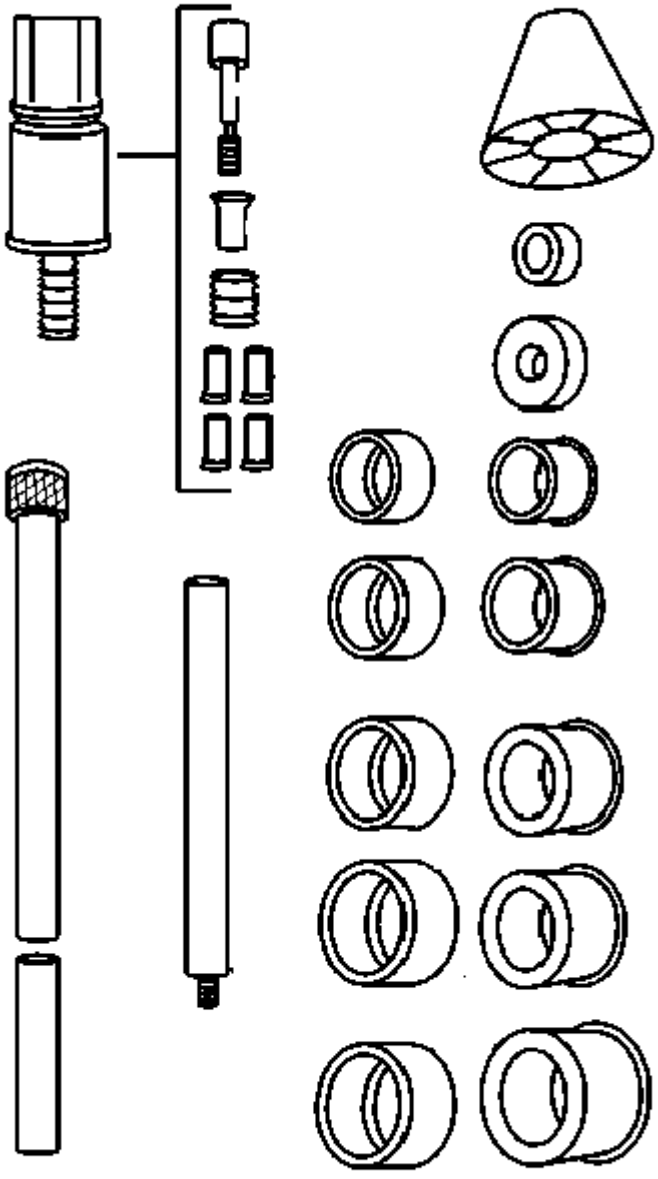

Fig. 441: View Of Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

1. Assemble the **J-33049:** Camshaft Bearing Service Set according to the manufacturer's instructions.

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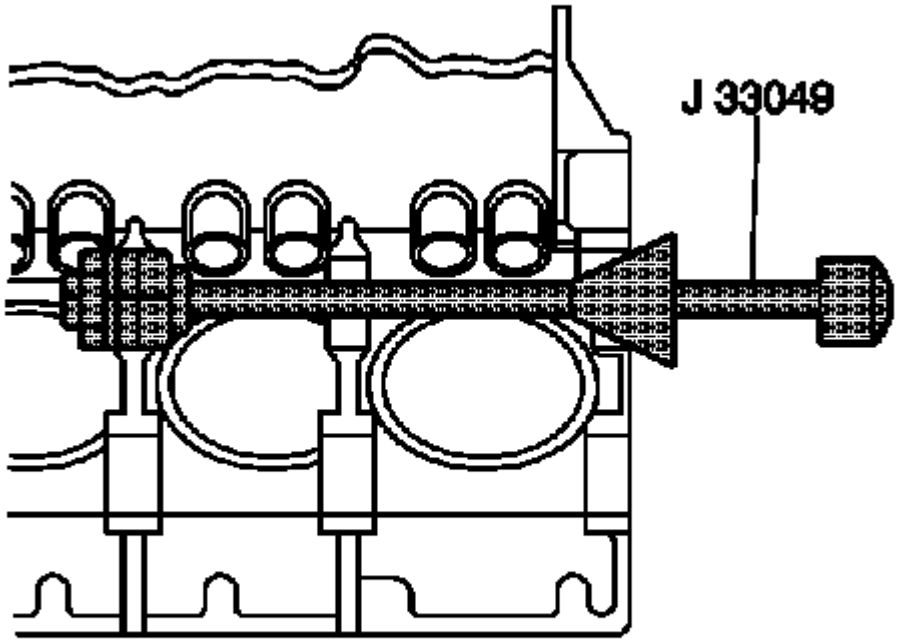

Fig. 442: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

CAUTION: Severe engine damage may result if the oil holes are not correctly aligned.

2. Install the camshaft bearings in the following order:
    1. Index the camshaft bearing oil holes with the engine block oil passages.
    2. Place the bearing on the **J-33049:** Service Set .
    3. Install the third camshaft bearing.
    4. Install the second camshaft bearing.
    5. Install the outer camshaft bearings.

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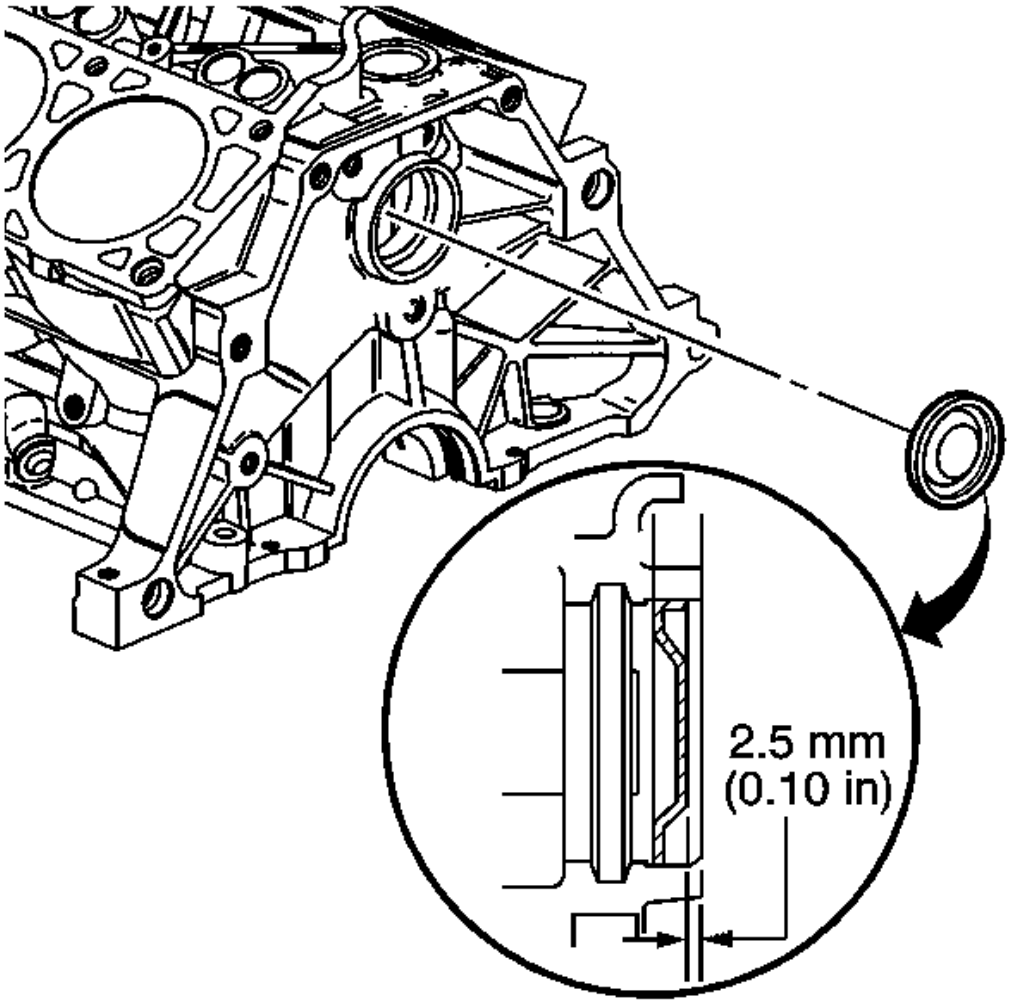

Fig. 443: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

3. Apply sealer GM P/N 12377901 (Canadian P/N 10953504) or the equivalent to the camshaft rear bearing hole plug.
4. Install the camshaft rear bearing hole plug.

PISTON OIL NOZZLE INSTALLATION

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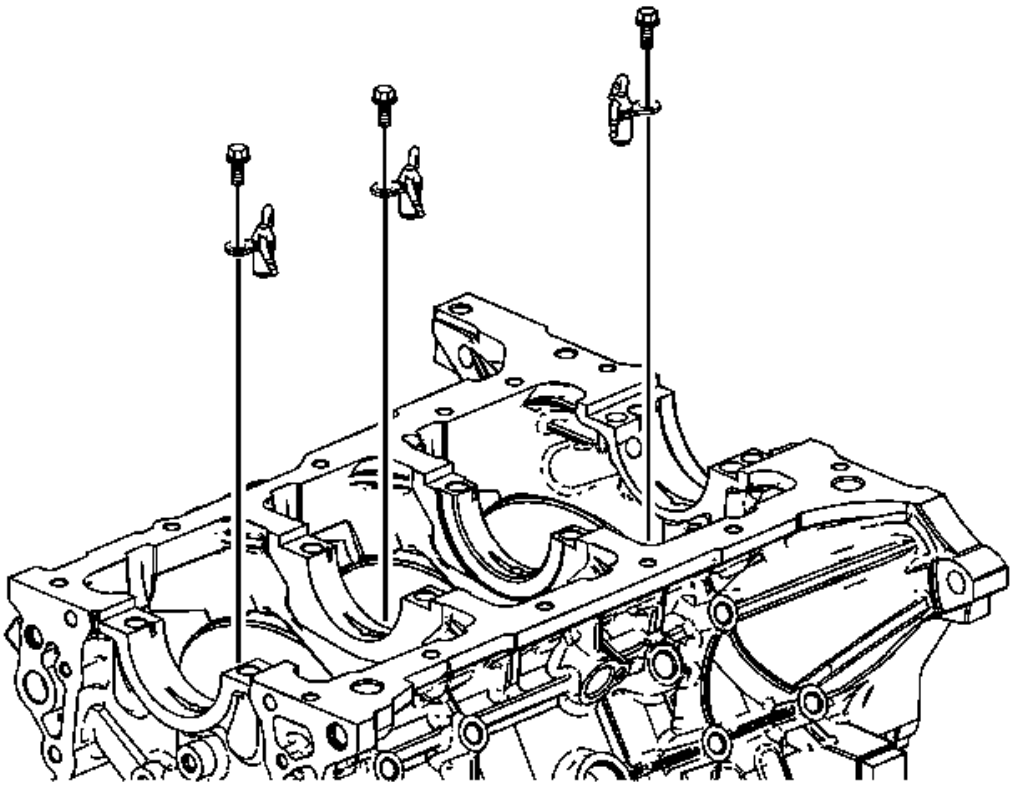

Fig. 444: Identifying Piston Oil Nozzles & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the piston oil nozzles in the engine block.

CAUTION: Refer to Fastener Caution .

2. Install the bolts retaining the piston oil nozzles to the engine block, and tighten to 10 N.m (89 lb in).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

J-45059: Angle Meter

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

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Installation

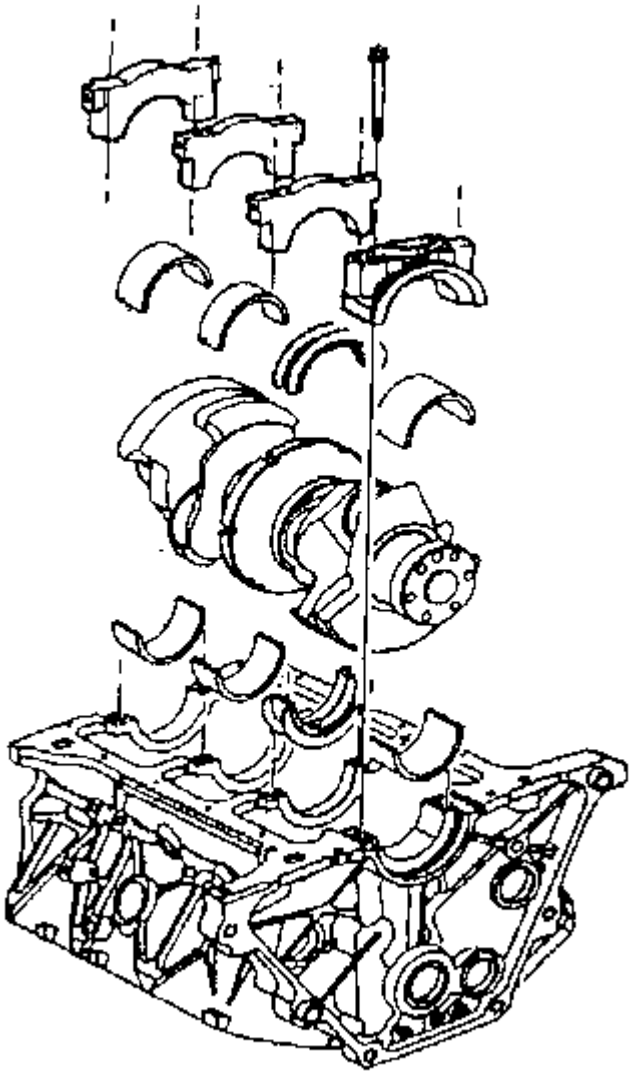

Fig. 445: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the crankshaft bearing cap bolt holes and the crankshaft bearing cap mating surfaces are clean and dry.

1. Dip the crankshaft bearing cap bolts in clean engine oil.

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CAUTION: Upper and lower inserts may be different. Do not obstruct any oil passages.

2. Place the crankshaft bearing inserts into the crankshaft bearing cap and into the engine block.

NOTE: The crankshaft bearing inserts will project slightly when put into place. Ensure that the bearing inserts project an equal distance on both sides. Ensure that the insert tangs are engaged.

3. Lubricate the crankshaft main bearing surface with clean engine oil.
4. Install the crankshaft.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

5. Install the crankshaft main bearing caps. Apply a small amount of sealer GM P/N 1052942 (Canadian P/N 10953466) to the rear of the #4 crankshaft main bearing cap sealing surface.

CAUTION: Refer to Fastener Caution .

6. Install the crankshaft main bearing cap bolts. Use the **J-45059:** meter in order to tighten the crankshaft main bearing cap bolts to 50 N.m (37 lb ft) plus 77 degrees.

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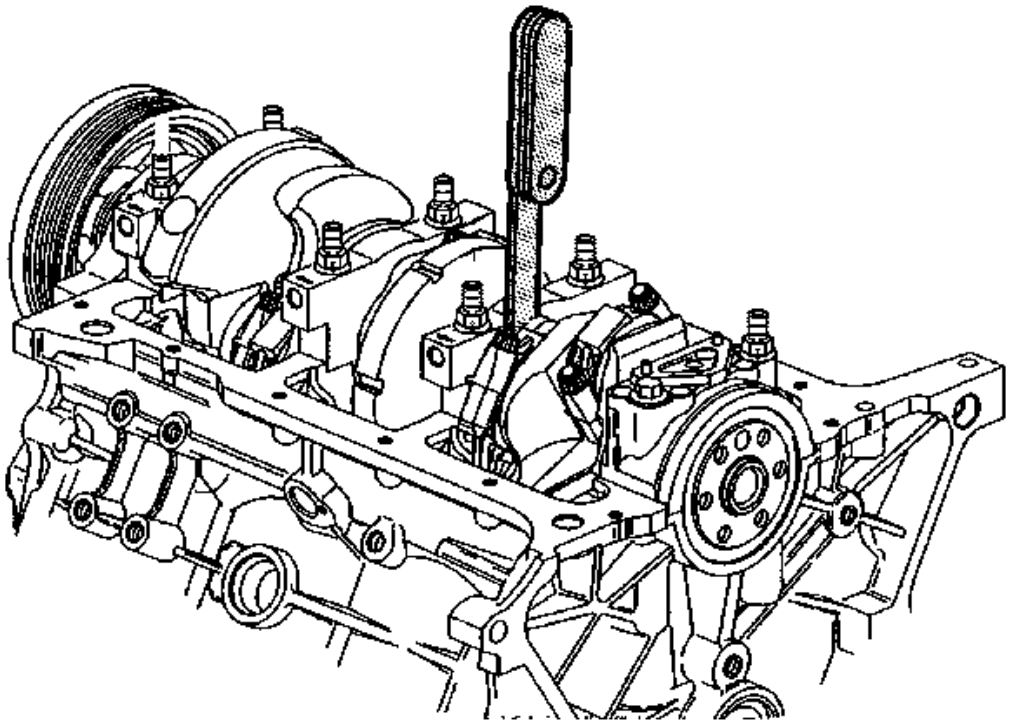

Fig. 446: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

7. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gage between the number 3 crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance. The proper crankshaft end play clearance is 0.06-0.21 mm (0.002-0.008 in).
    3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

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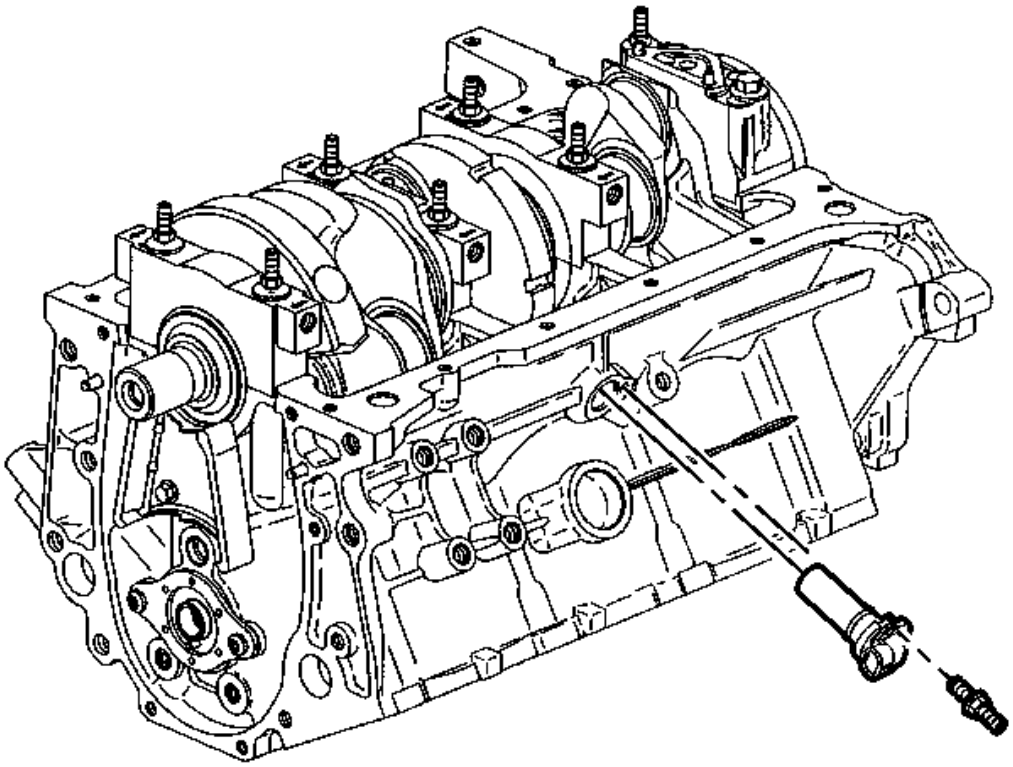

Fig. 447: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

8. Install the crankshaft position sensor into the side of the engine block.
9. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or the equivalent to the crankshaft position sensor stud threads.
10. Install the crankshaft position sensor stud and tighten to 11 N.m (98 lb in).
11. Install the crankshaft position sensor shield and nut and tighten to 11 N.m (98 lb in).

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

- **EN-48108:** Rear Main Oil Seal Installer
- **J-23444-A:** Extreme Press Lubricant - 1/4 Ounce Tube

CAUTION: Do not remove the protective sleeve from the seal. The sleeve assures the seal is installed correctly and protects the seal from damage. If removed,

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the EN-48108 installation tool will not work.

CAUTION: Clean the crankshaft sealing surface with a clean, lint-free towel. Inspect lead-in edge of crankshaft for burrs/sharp edges that could damage the rear main oil seal. Remove burrs/sharp edges with crocus cloth before proceeding.

CAUTION: Do not remove protective nylon sleeve prior to installation. The rear main oil seal installation tool is designed to install the rear main seal with the protective sleeve in place. Never apply or use any oil, lubricants or sealing compounds on the crankshaft rear main oil seal.

NOTE: Before replacement of the new design crankshaft rear main oil seal, ensure the positive crankcase ventilation (PCV) system is operating correctly.

A new design crankshaft rear main oil seal and installation tool, **EN-48108:** Rear Main Oil Seal Installer, has been released. This seal incorporates features that improve high mileage durability. Replace the crankshaft rear main oil seal with the new design rear main oil seal, GM P/N 12592195 (Canadian P/N 12592195).

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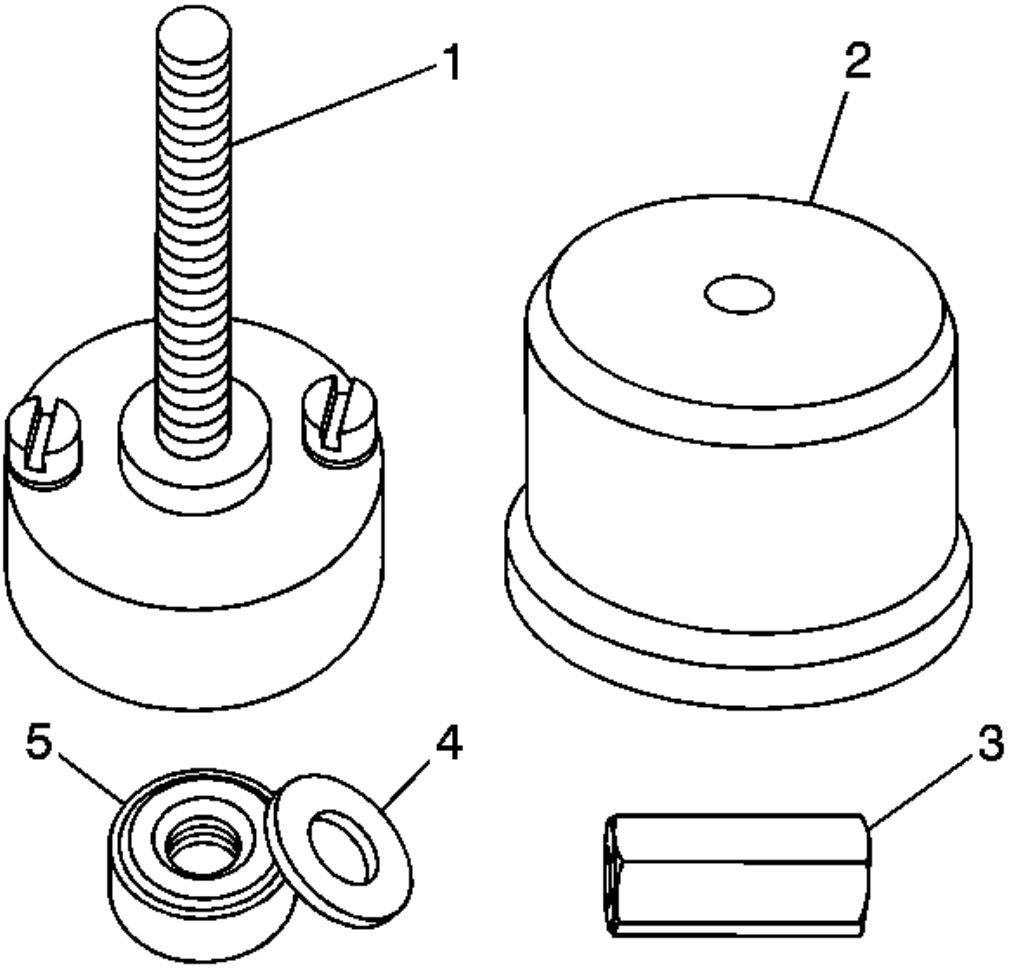

Fig. 448: Identifying Crankshaft Rear Oil Seal Installation Tools (EN-48108)
Courtesy of GENERAL MOTORS CORP.

The **EN-48108:** Installer has a unique design to allow the technician to easily install the rear main seal squarely to the correct depth and direction. Before proceeding with installation, review the illustration to become familiar with the following components:

- Mandrel (1)
- Drive Drum (2)
- Drive Nut (3)
- Washer (4)
- Bearing (5)

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Installation

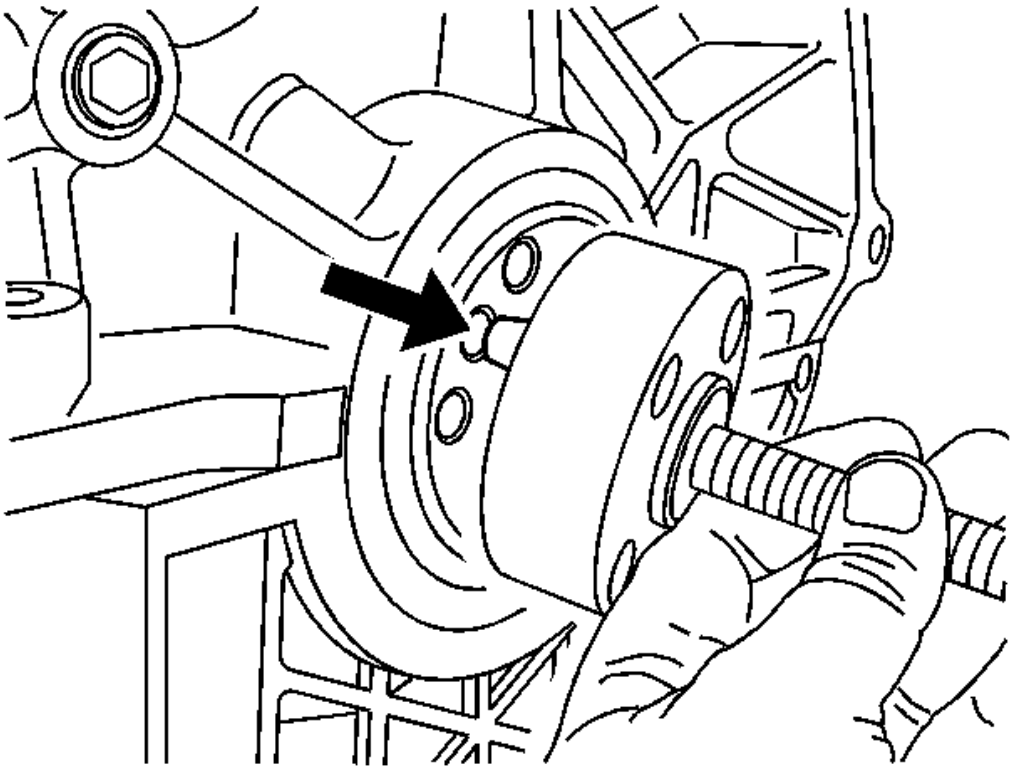

Fig. 449: Locating Mandrel Dowel Pin
Courtesy of GENERAL MOTORS CORP.

1. Align the mandrel dowel pin to the dowel pin hole in the crankshaft.

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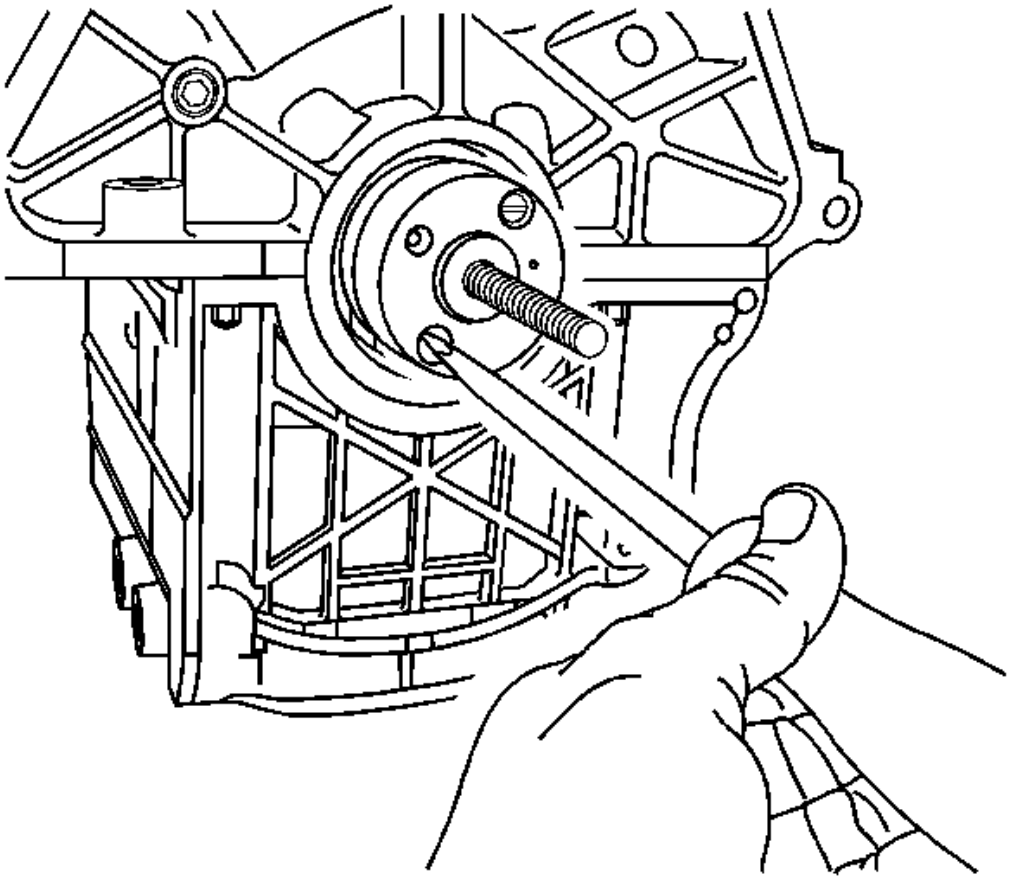

Fig. 450: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

2. Using a large flat-blade screwdriver, tighten the 2 mandrel screws to the crankshaft. Ensure the mandrel is snug to the crankshaft hub.

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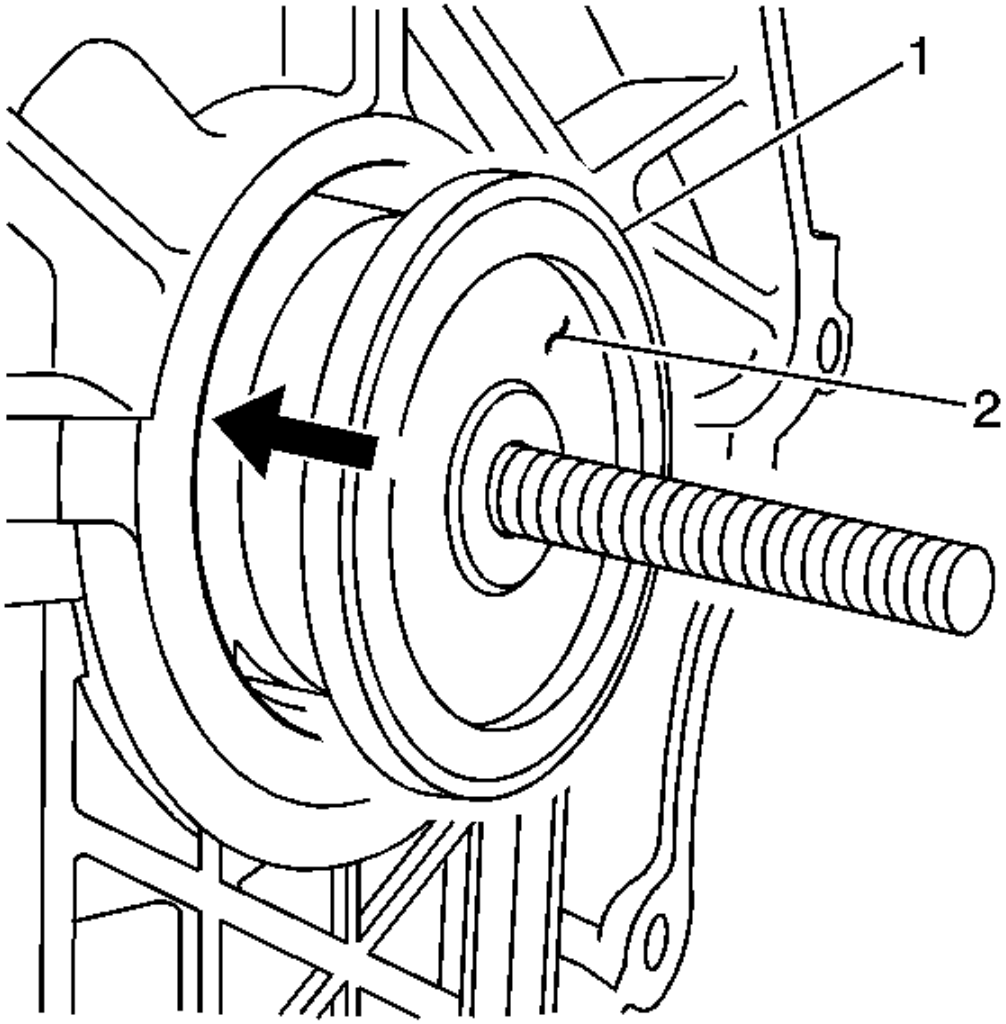

Fig. 451: View Of Rear Main Seal Mandrel
Courtesy of GENERAL MOTORS CORP.

3. Install the rear main seal (1), with the protective nylon sleeve attached (2), onto the mandrel. The seal, if properly installed, will center on a step that protrudes from the center of the mandrel. As an error proof, the seal will fit only 1 way onto the mandrel.

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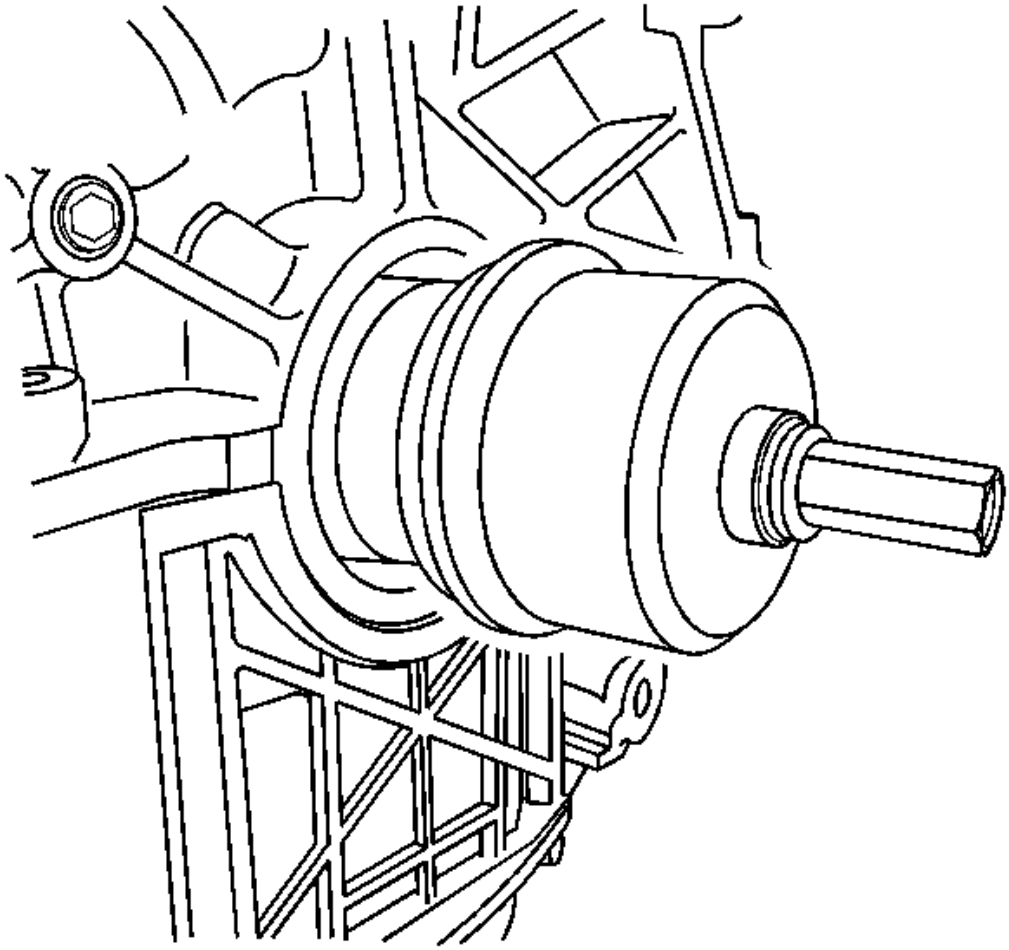

Fig. 452: Identifying Outer Drive Drum
Courtesy of GENERAL MOTORS CORP.

NOTE: Before installing the outer drive drum, bearing, washer, and drive nut onto the threaded shaft, apply a small amount of the extreme pressure lubricant J-23444-A: Extreme Press Lubricant - 1/4 Ounce Tube, provided in the tool kit.

4. Install the outer drive drum onto the mandrel.
5. Install the bearing, washer, and drive nut onto the threaded shaft.

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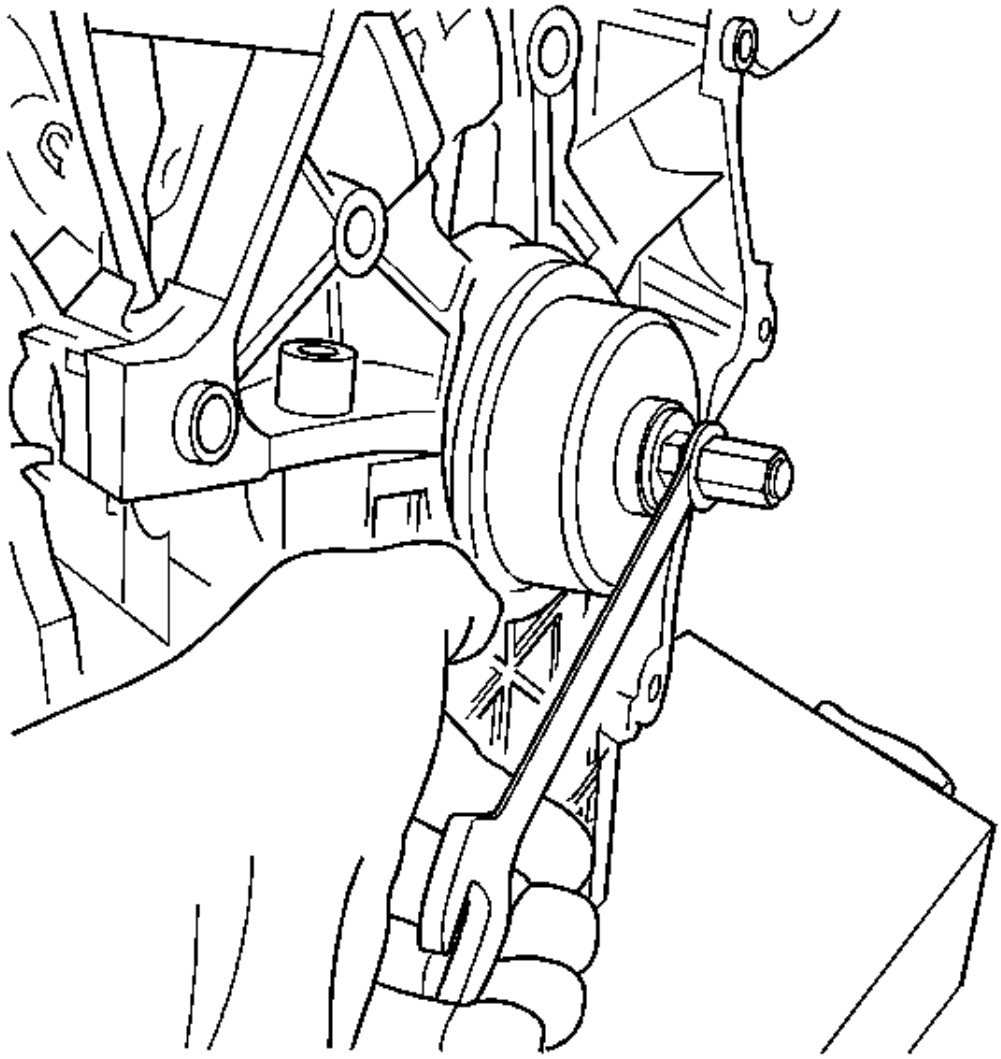

Fig. 453: Identifying Drive Nut
Courtesy of GENERAL MOTORS CORP.

6. Using a wrench, turn the drive nut on the mandrel, which will push the seal into the engine block bore. Turn the wrench until the drive drum is snug and flush against the engine block.
7. Loosen and remove the drive nut, washer, bearing, and drive drum. Discard the protective nylon sleeve.
8. Verify that the seal has seated properly.

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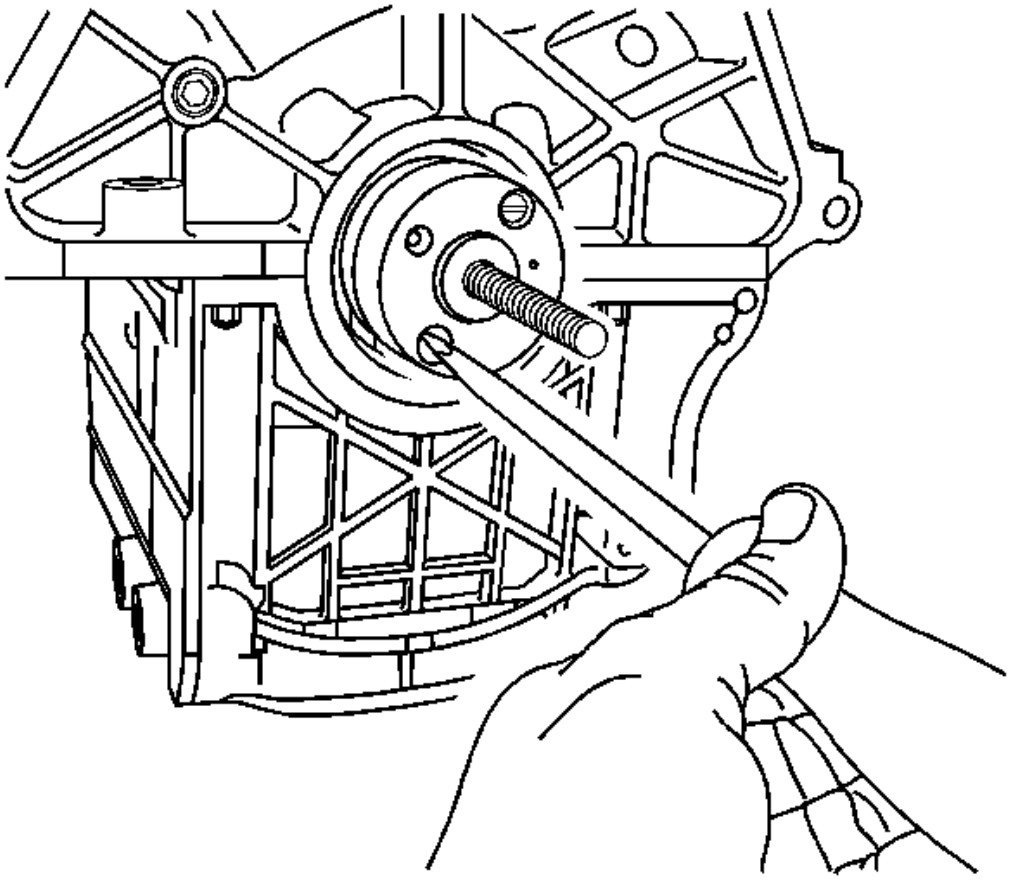

Fig. 454: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

9. Use a flat-blade screwdriver in order to remove the 2 attachment screws from the mandrel and remove the mandrel from the crankshaft hub.
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.
11. Install the transmission. Refer to **Transmission Replacement** .
12. Inspect for proper fluid levels.
13. Inspect for leaks.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

- **J 8037:** Ring Compressor

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- **J 41556:** Connecting Rod Guide
- **J 43654:** Piston Pin Clip Remover and Installer
- **J 43690:** Rod Bearing Clearance Checking Tool
- **J 43690-100:** Rod Bearing Clearance Checking Tool-Adapter Kit
- **J 45059:** Angle Meter

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

Installation

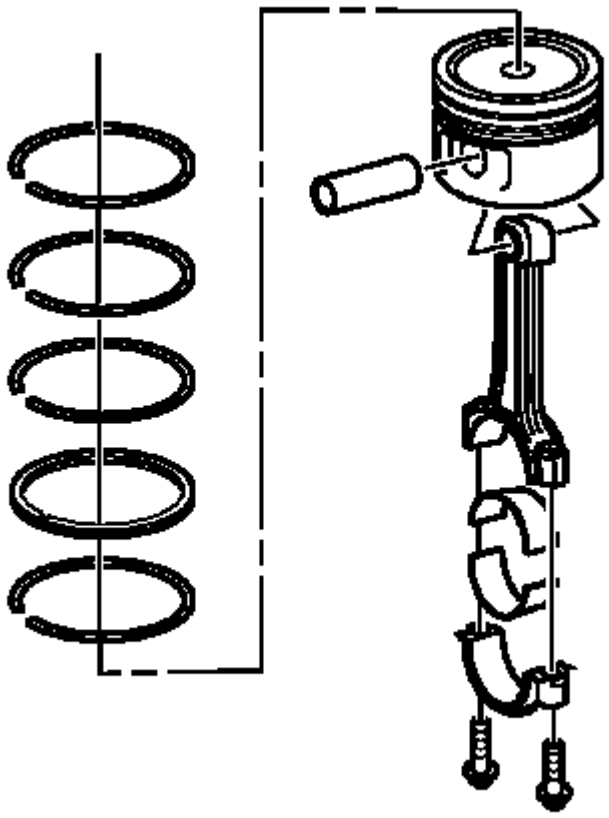

Fig. 455: Identifying Piston Components Requiring Lubrication
Courtesy of GENERAL MOTORS CORP.

1. Lightly lubricate the following components with clean engine oil:
    - The piston
    - The piston pin
    - The piston rings
    - The cylinder bore
    - The bearing surfaces

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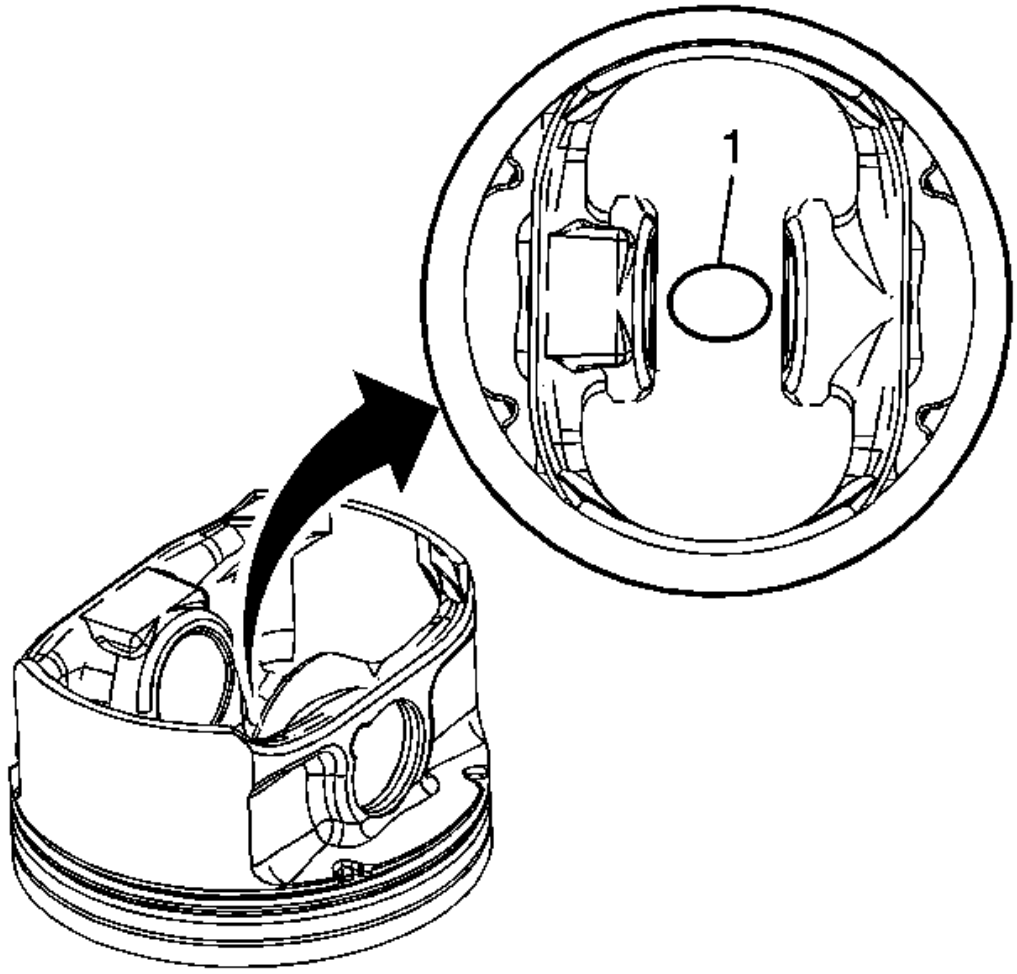

Fig. 456: Locating Piston Identification Mark
Courtesy of GENERAL MOTORS CORP.

2. There are two styles of pistons in use in the LZ engine, and each piston must use the appropriate matching piston ring set. To identify which make you have, look on the bottom of the piston, in between the piston pin bores (1).
    - If there is an "FM" marking, it is a Federal Mogul piston and must use the Federal Mogul piston rings.
    - If there is no marking, it is a Mahle piston and must use Mahle piston rings. Failure to do so may result in engine damage.

NOTE: The tops of the first and second piston rings are marked with light green stripes to insure proper orientation on the piston. The top ring has a light

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green stripe 180 degrees from the gap, and the second ring has a light green stripe 90 degrees from the gap. These stripes must be facing up and in this orientation prior to installing the pistons. This is necessary for proper operation.

3. Stagger the oil control ring end gaps a minimum of 90 degrees.
4. Stagger the compression ring end gaps a minimum of 25 mm (1 in).
5. Install the **J 8037:** compressor onto the piston and compress the piston rings.

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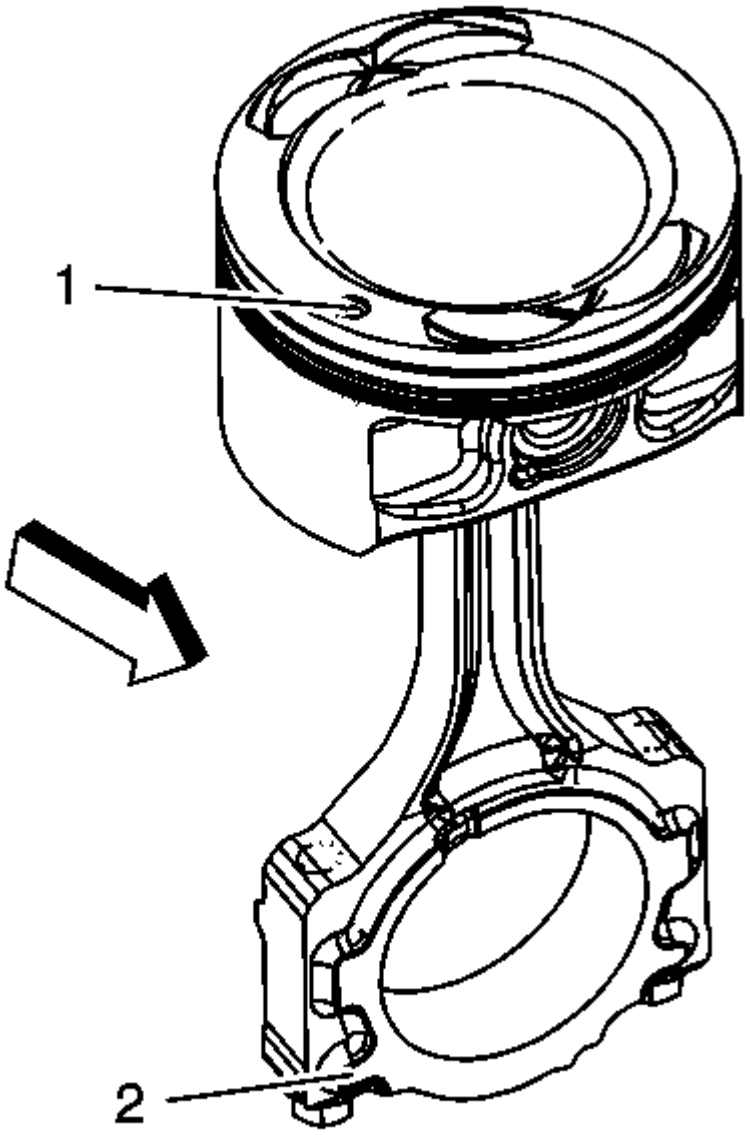

Fig. 457: Identifying Correct Piston Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: When assembling the connecting rod to the piston, make sure the connecting rod reference mark (2) is facing towards front of engine, and is in proper correlation with the front of engine piston reference mark (1).

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6. Align the piston pin bore with the connecting rod pin bore.

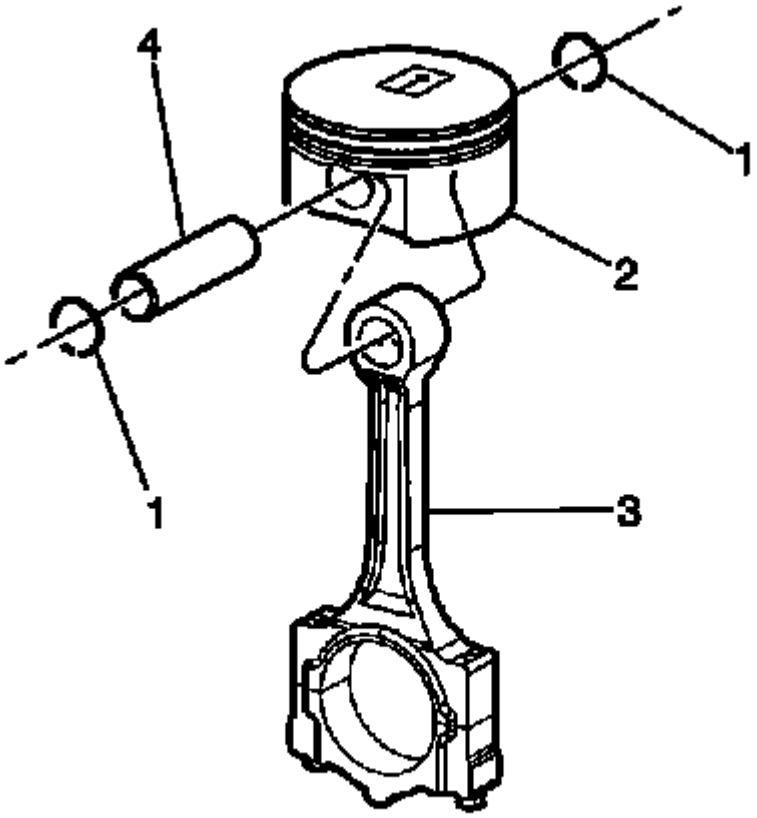

Fig. 458: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

7. Slide the piston pin (4) into the piston and the connecting rod (3).

NOTE: NEW piston pin retainers must be used. Never reuse the piston pin retainers.

8. Install NEW piston pin retainers (1) using the **J 43654:** installer.
9. Ensure that the piston pin retainers are fully seated in their grooves.
10. Repeat these procedures for the remaining pistons.
11. Install the **J 41556:** guide into the connecting rod.

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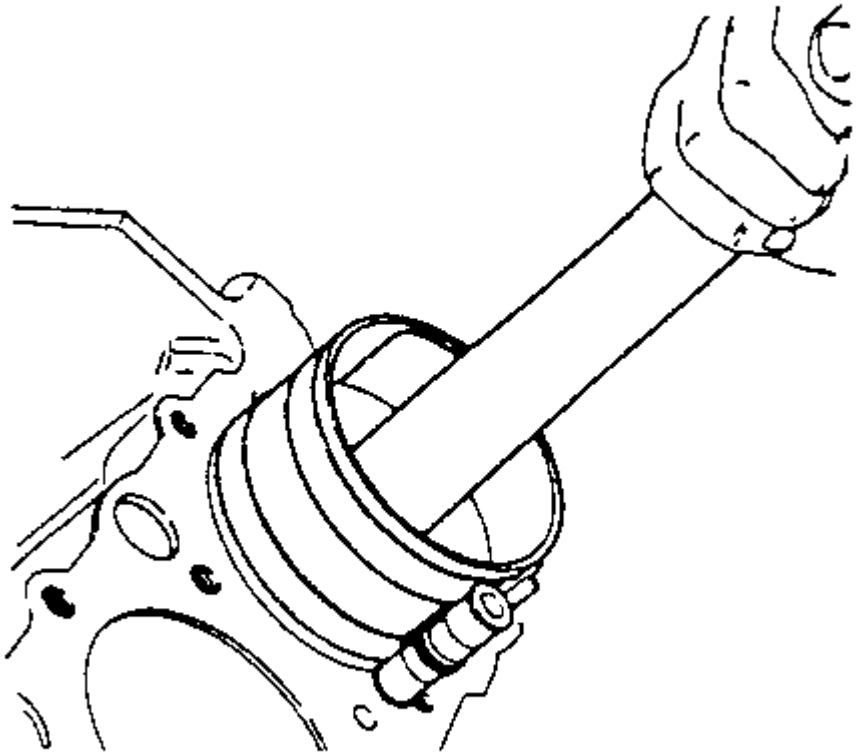

Fig. 459: Installing Piston & Connecting Rod Assembly Into Cylinder
Courtesy of GENERAL MOTORS CORP.

12. Install the piston and connecting rod assembly into the proper cylinder bore.
13. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all of the piston rings enter the cylinder bore.

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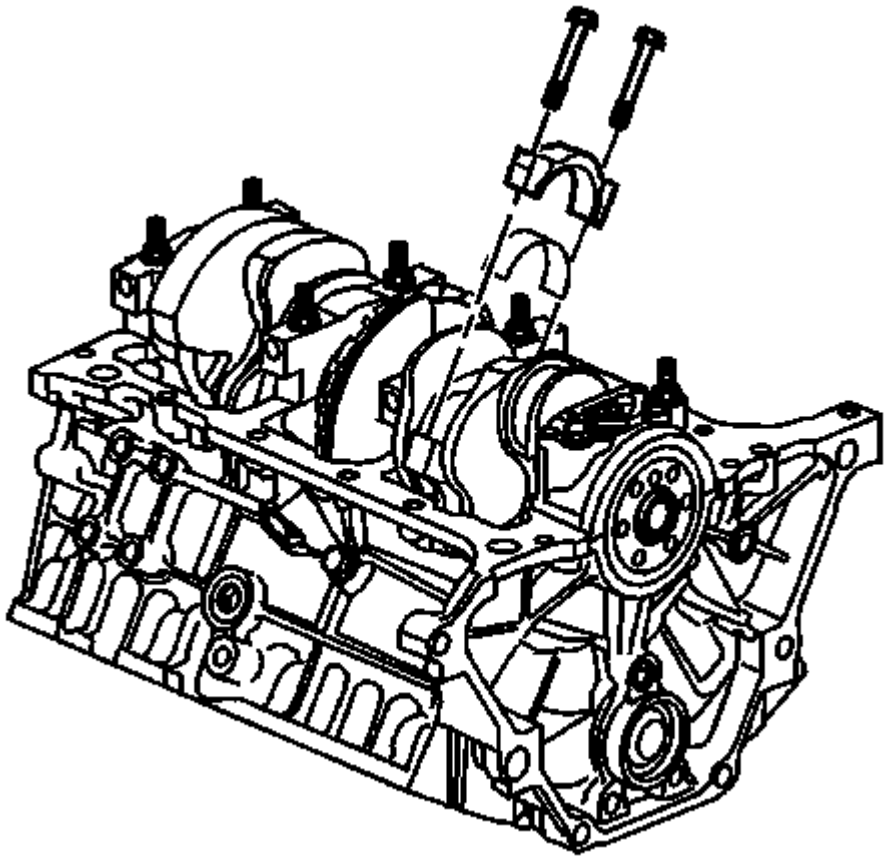

Fig. 460: View Of Bearing, Bearing Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: When installing the pistons into the cylinder bore, make sure not to contact the piston oil nozzle with the connecting rod. Failure to do so may damage the piston oil nozzle, resulting in potential engine damage.

14. Using **J 41556:** guide, guide the connecting rod end onto the crankshaft journal.

CAUTION: Refer to Fastener Caution .

15. Install the bearing, bearing cap and bolts.
    - Tighten the connecting rod bearing cap bolts a first pass to 25 N.m (18 lb ft) .
    - Tighten the connecting rod bearing cap bolts a final pass to 110 degrees using the **J 45059:** meter .

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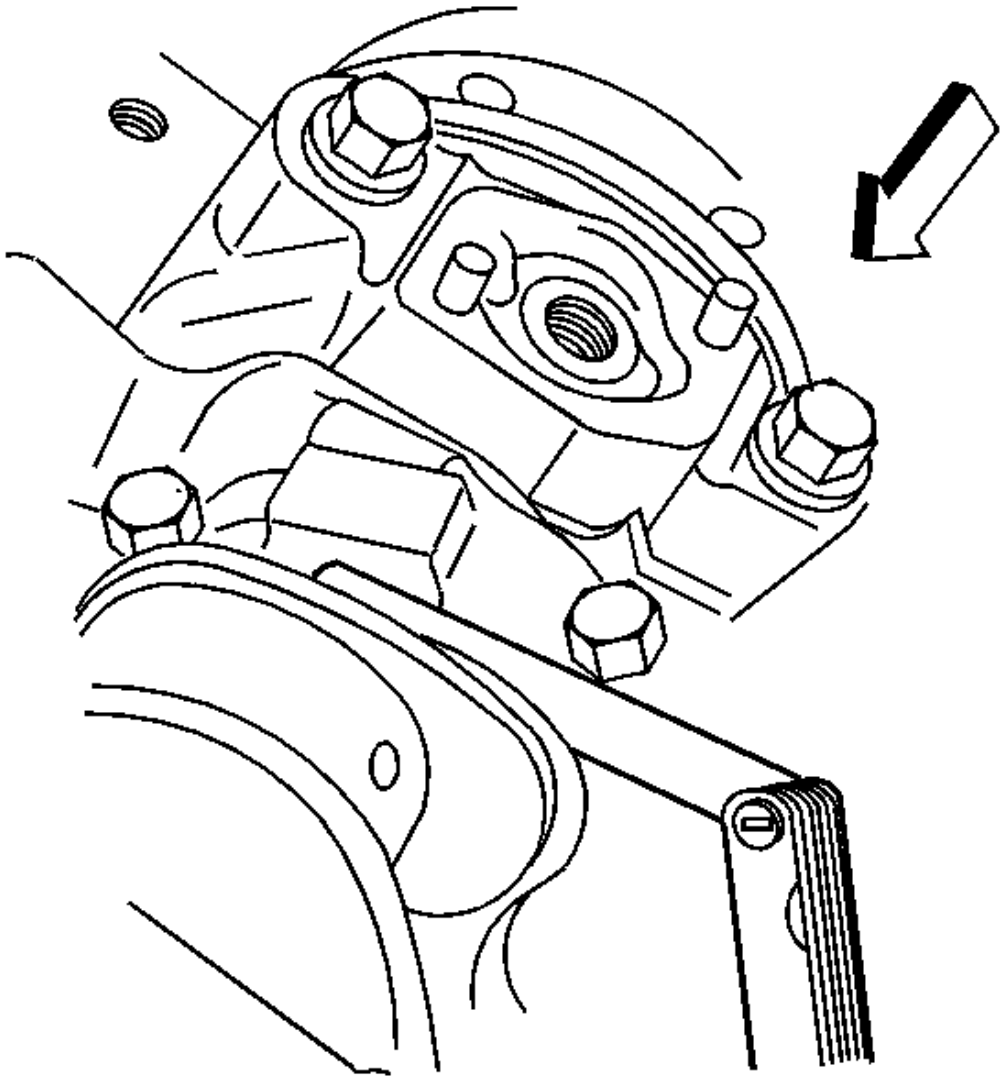

Fig. 461: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

16. With the pistons and connecting rods installed, use a soft faced mallet and lightly tap each connecting rod assembly parallel to the crankpin to make sure that the rods have side clearance.
17. Measure the connecting rod side clearance using a feeler gage or dial indicator. Connecting rod side clearance should be within 0.18-0.44 mm (0.007-0.017 in).

Measuring Connecting Rod Bearing Clearance Using J 43690 and J 43690-100

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J 43690: tool and **J 43690-100:** kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

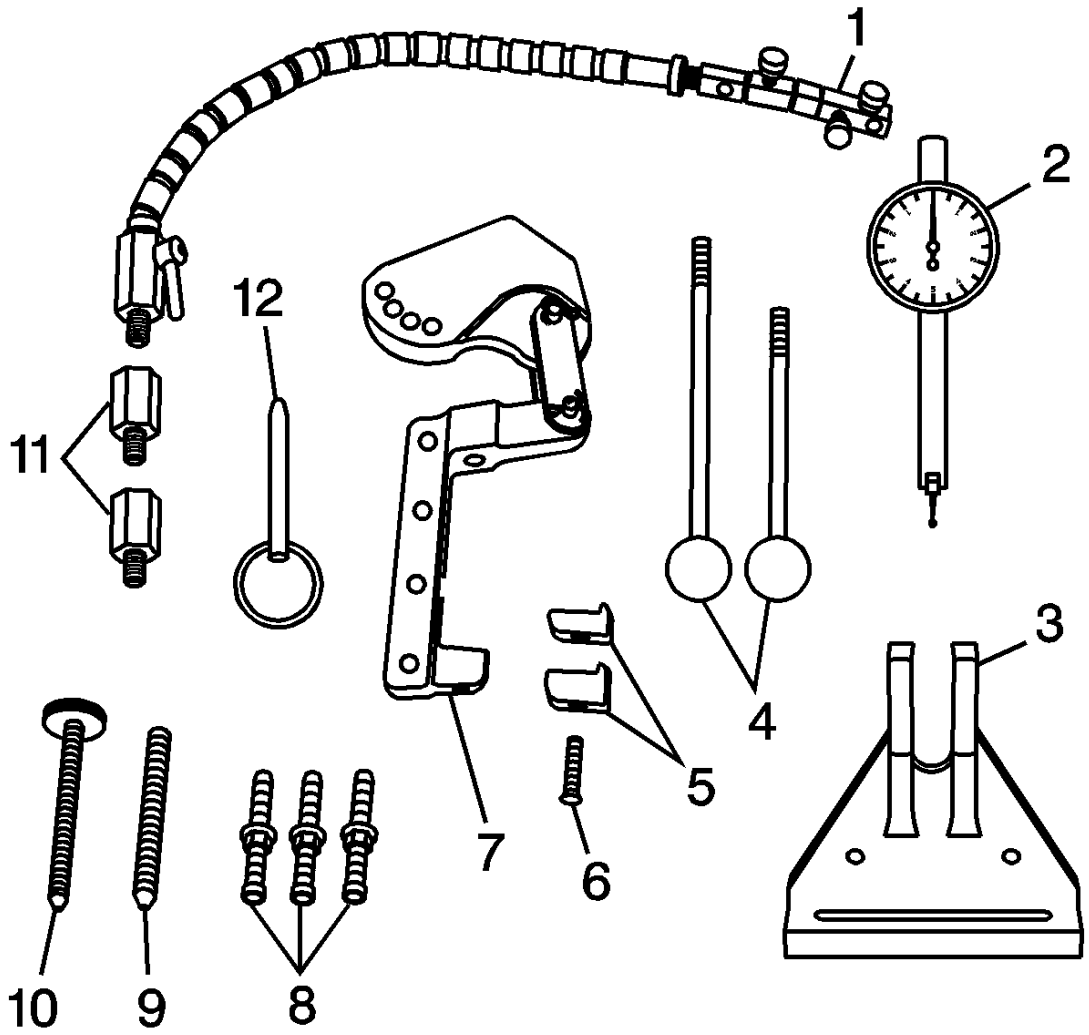

Fig. 462: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

1. **J 43690:** tool includes:
   - J 43690-20 Swivel Base (1)
   - J 43690-19 Dial Indicator (2)
   - J 43690-2 Base (3)
   - J 43690-5,-6 Handle (4)
   - J 43690-10,-11 Foot (5)
   - 280307 Screw (6)

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- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3,-7,-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17,-18 Adapter (11)
- 280310 Pin (12)

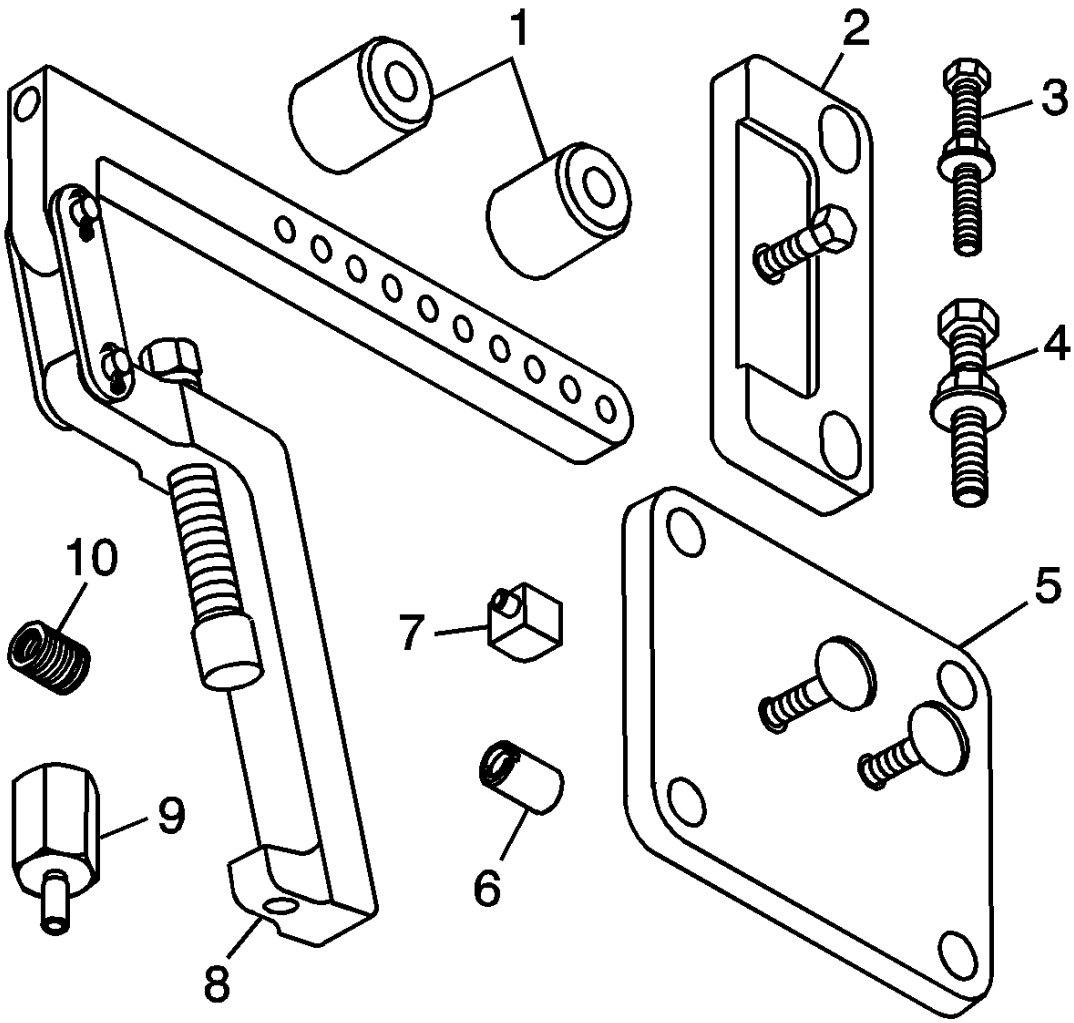

Fig. 463: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

2. **J 43690-100:** kit includes:
   - J 43690-104 Spacer (1)
   - J 43690-105 Retainer Plate (2)
   - 505478 Bolt (3)
   - 511341 Bolt (4)

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- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

NOTE: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

3. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
4. Remove the crankshaft main bearing cap bolts.
5. Remove the crankshaft main lower bearing cap.
6. Insert a piece of paper stock onto the crankshaft journal.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

CAUTION: This bolt is designed to permanently stretch when tightened, and therefore MUST be replaced anytime it is removed. The correct part number fastener must be used to replace this type of fastener. Do not use a bolt that is stronger in this application. If the correct bolt is not used, the parts will not be tightened correctly. The system or the components may be damaged.

7. Install the crankshaft main bearing cap and bolts. Start the crankshaft main bearing cap bolts by hand. Ensure the bottom of the crankshaft main bearing cap is parallel to the bottom of the channel.
    1. Tighten the crankshaft main bearing cap bolts in equal increments. Do not completely tighten one bolt at a time to prevent the cap from being cocked.
    2. Tighten the bolts to 50 N.m (37 lb ft) to fully seat the crankshaft main bearing caps. Loosen the bolts 360 degrees counterclockwise.
    3. Tighten the bolts to 20 N.m (15 lb ft), then 50 N.m (37 lb ft).
    4. Use **J 45059:** meter to tighten the bolts to 77 degrees.
8. Install the following:
    - J 43690-101 (8)
    - J 43690-5 (4)
    - J 43690-2 (3)
    - J 43690-7 (8)

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- 280310 (12)
- J 43690-17 (11)

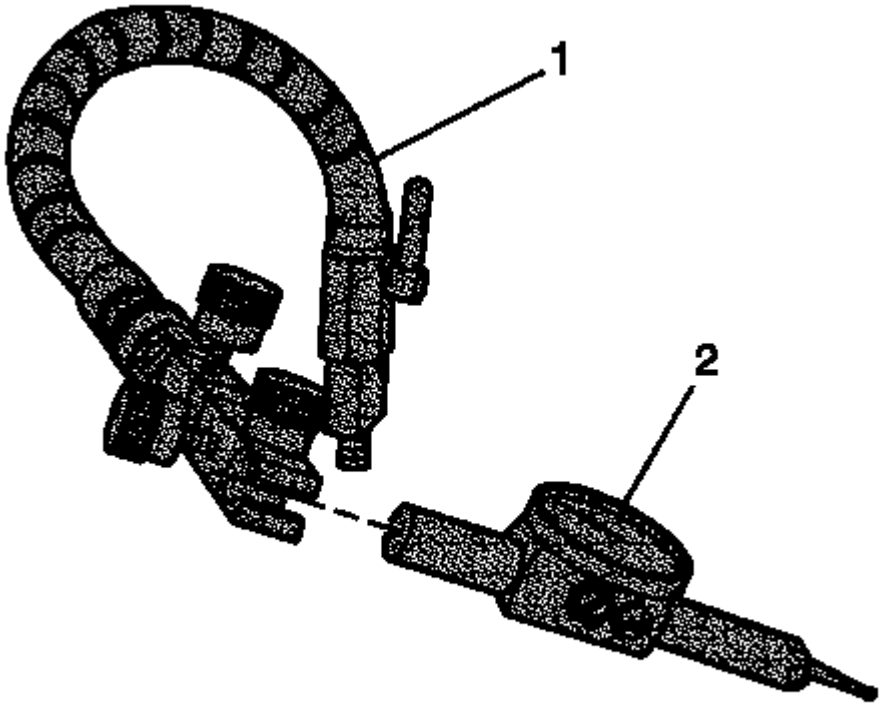

Fig. 464: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

9. Install the swivel base (1) and dial indicator (2).
10. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance. The connecting rod bearing clearance should be between 0.0127-0.0660 mm (0.0005-0.0026 in).

CAMSHAFT INSTALLATION

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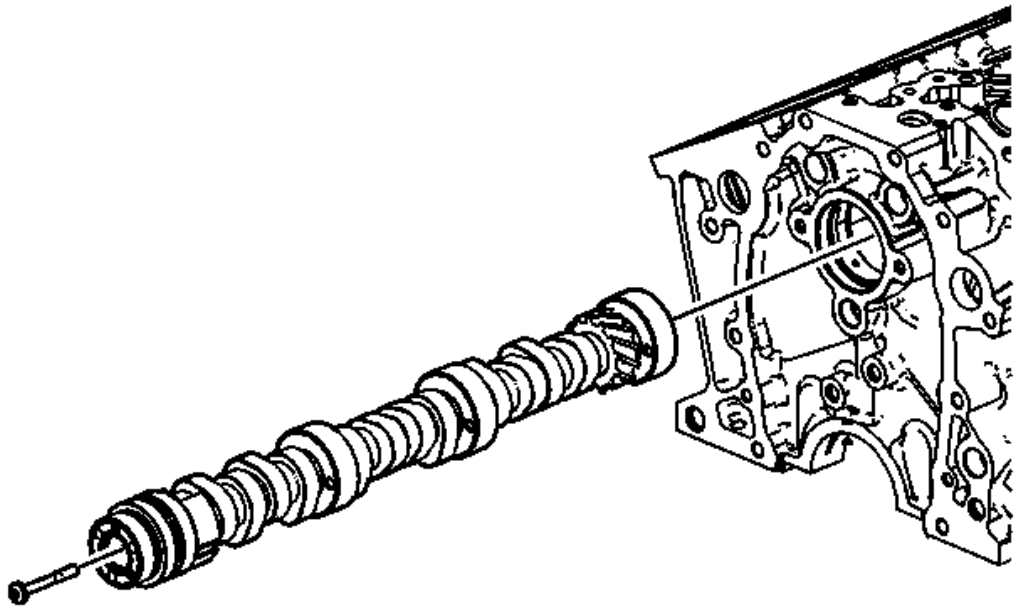

Fig. 465: Identifying Camshaft & Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

1. Coat the camshaft journals with clean engine oil.
2. Coat the camshaft lobes with prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.
3. Install the camshaft using the following procedure:
    1. Install a camshaft sprocket bolt into the camshaft. Tighten finger tight only.
    2. Carefully rotate the camshaft while installing the camshaft into the camshaft bearings.

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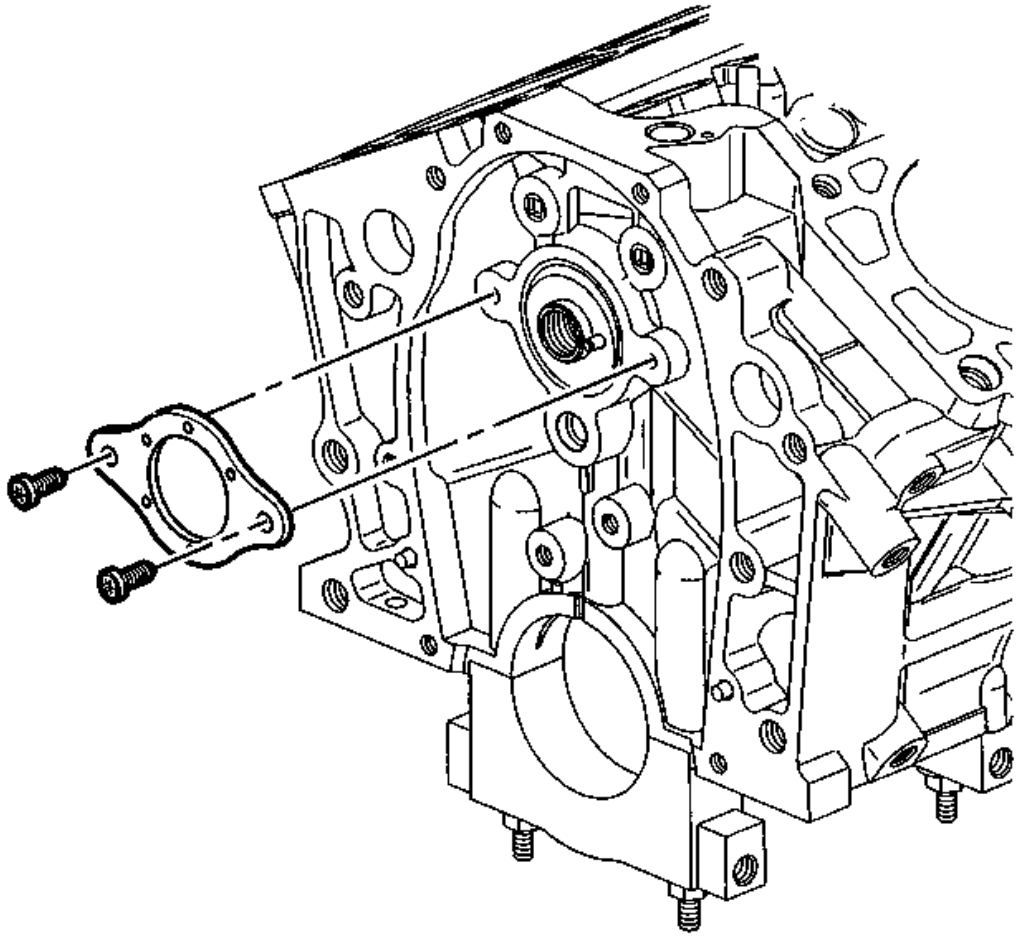

Fig. 466: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

4. Install the camshaft thrust plate.

CAUTION: Refer to Fastener Caution .

5. Install the camshaft thrust plate screws and tighten to 10 N.m (89 lb in).

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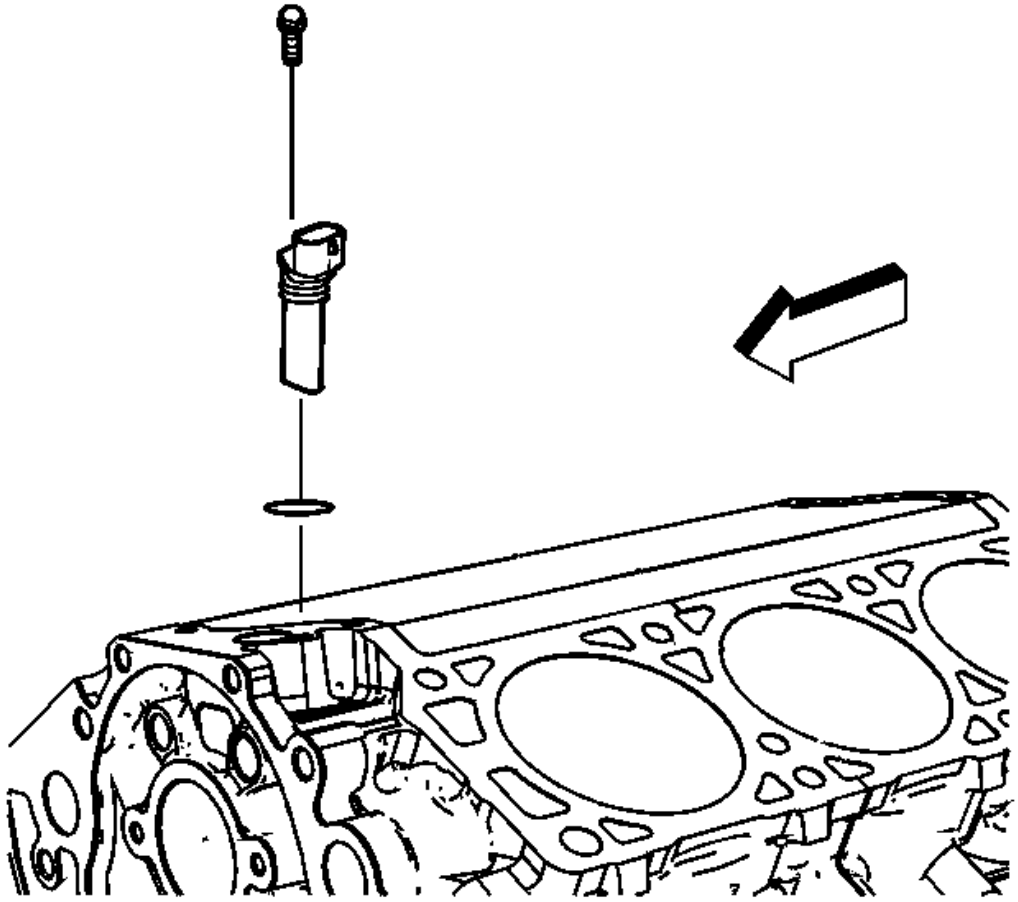

Fig. 467: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft position sensor.
7. Install the camshaft position sensor bolt and tighten to 10 N.m (89 lb in).

TIMING CHAIN AND SPROCKET INSTALLATION

Special Tools

EN-47719: Tensioner Compressor

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

Installation

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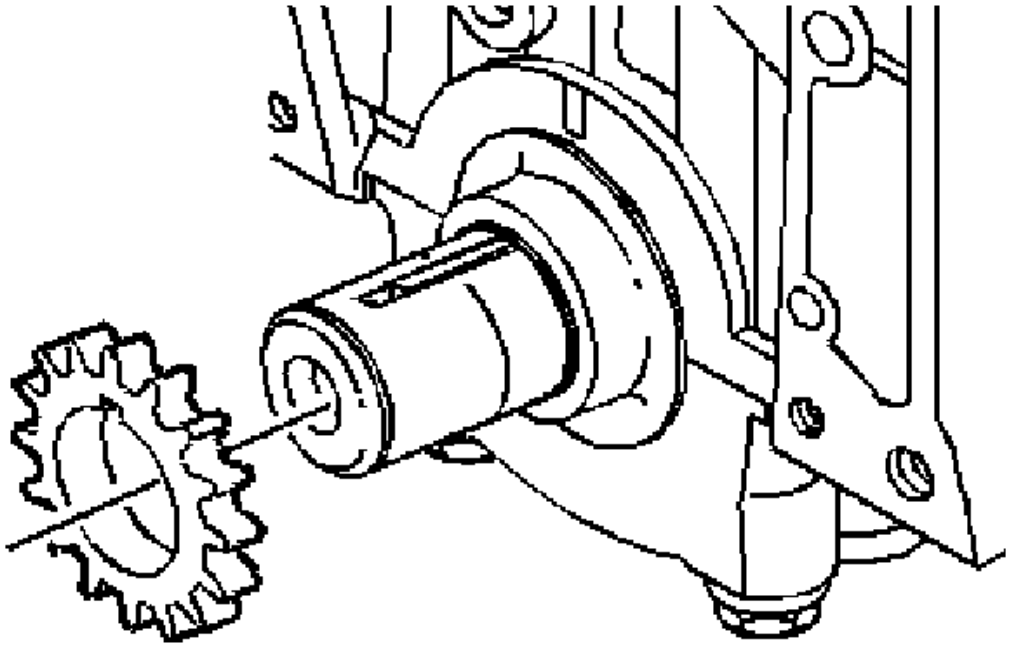

Fig. 468: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft sprocket.
2. Apply prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent to the crankshaft sprocket thrust surface.

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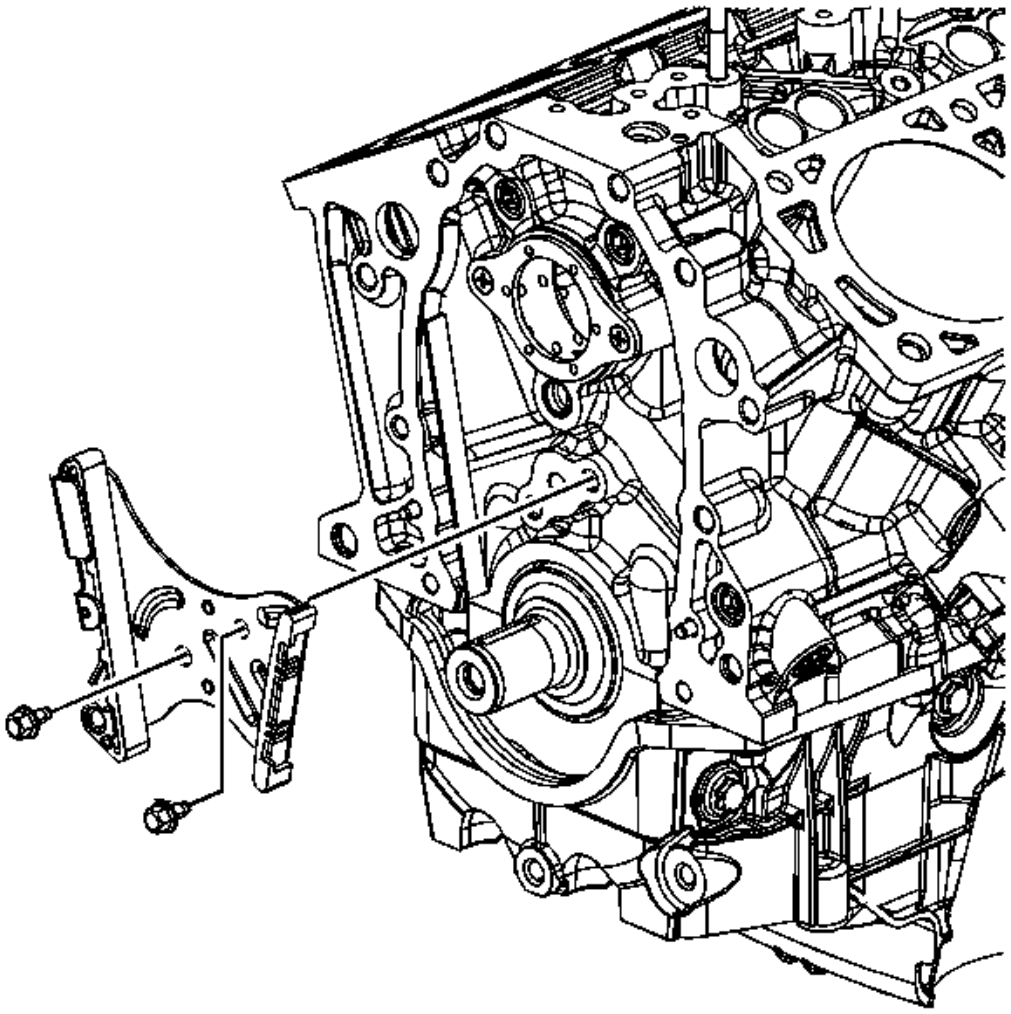

Fig. 469: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain tensioner.

CAUTION: Refer to Fastener Caution .

4. Install the timing chain tensioner bolts and tighten to 21 N.m (15 lb ft).

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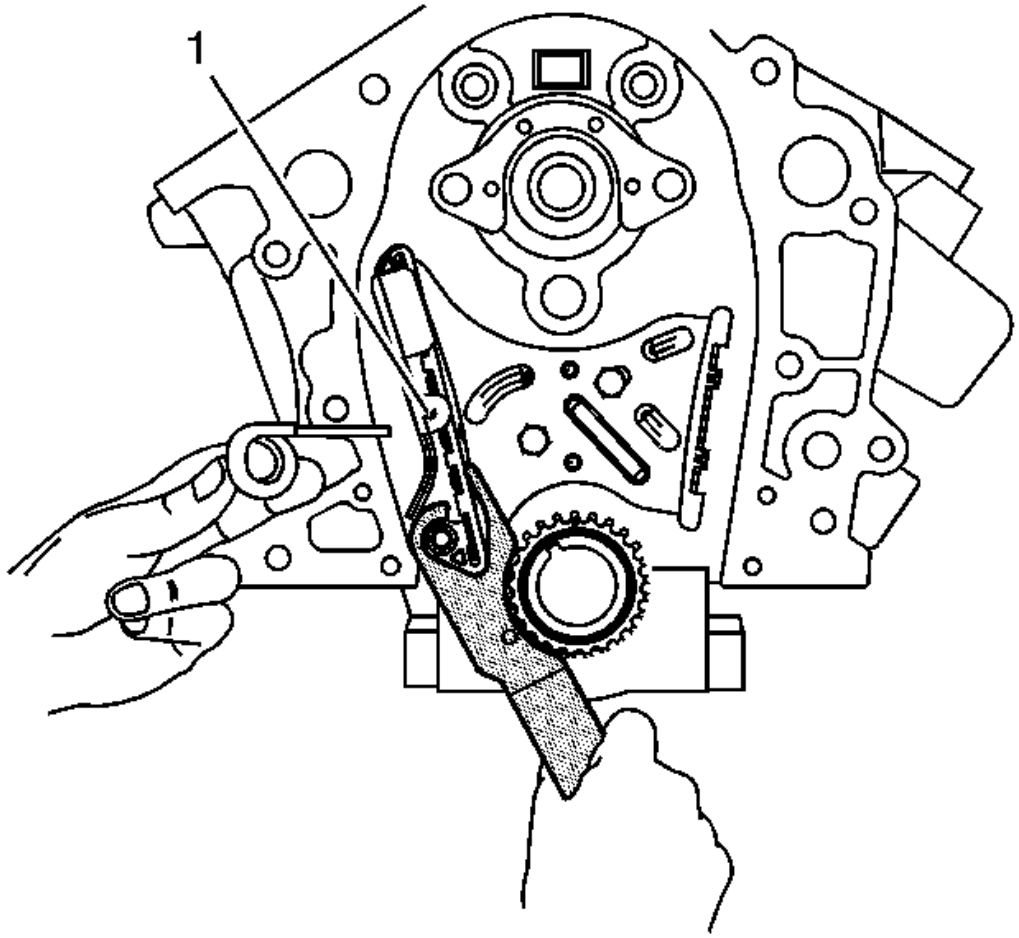

Fig. 470: Identifying Tensioner Collapsing Procedure
Courtesy of GENERAL MOTORS CORP.

5. Using the **EN-47719:** compressor, fully collapse the tensioner, and place the tensioner retaining pin into the retaining hole (1).

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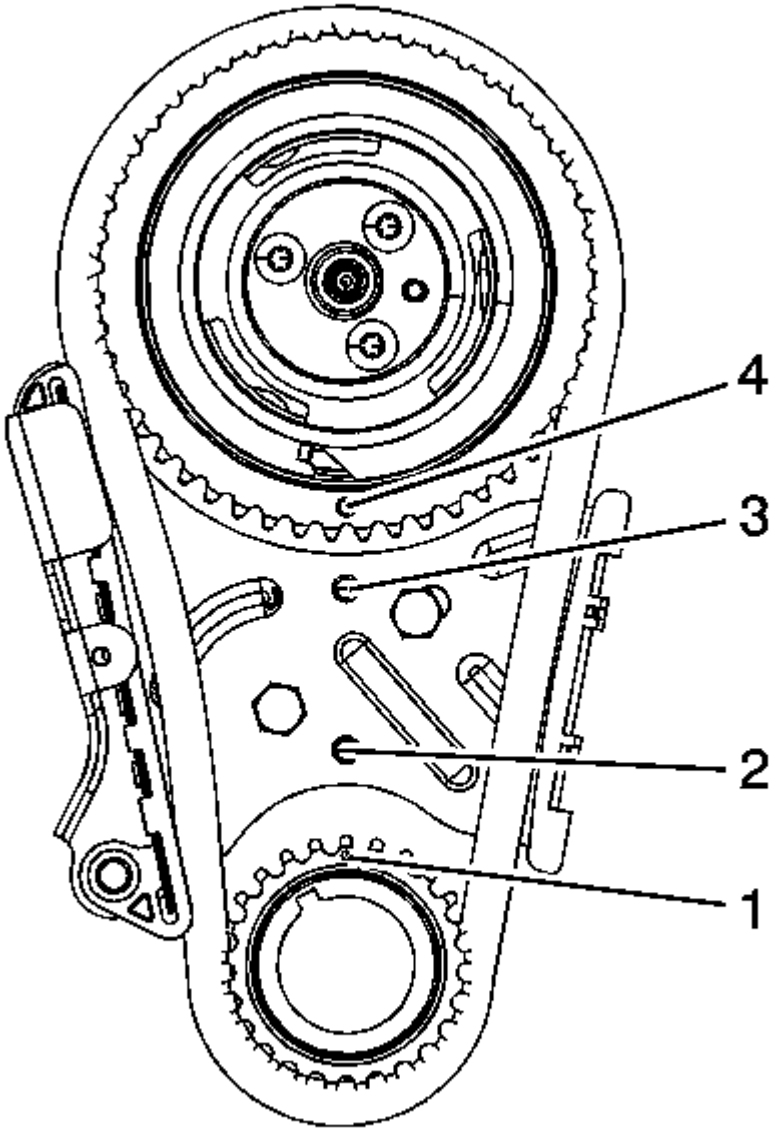

Fig. 471: Identifying Timing Marks & Chain Tensioners
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install a NEW camshaft position actuator filter, located in pilot nose of camshaft, anytime the camshaft position actuator is removed or installed. Refer to Camshaft and Bearings Cleaning and Inspection for filter changing instructions.

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6. Align the crankshaft timing mark (1) to the timing mark on the bottom of the timing chain tensioner (2).
7. Hold the camshaft sprocket with the timing chain hanging down and install the timing chain to the crankshaft gear.
8. Align the timing mark on the camshaft gear (4) with the timing mark on top of the timing chain tensioner (3).

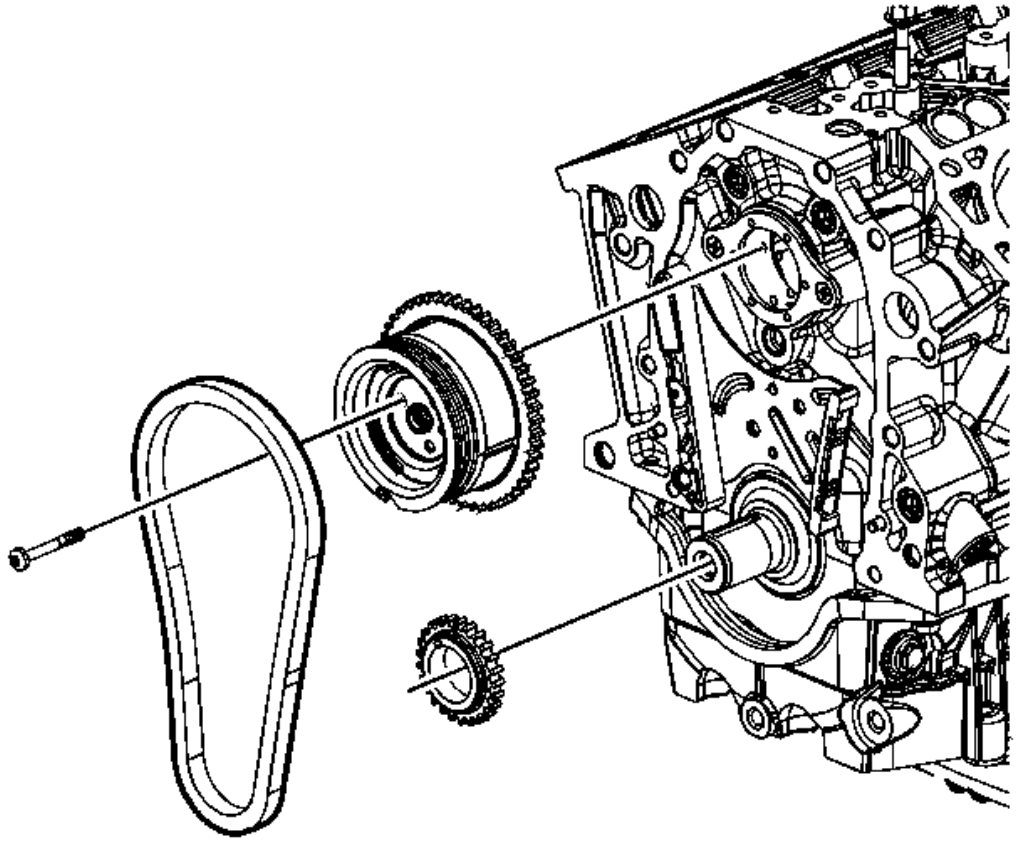

Fig. 472: Identifying Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

9. Align the dowel in the camshaft position actuator with the dowel hole in the camshaft.

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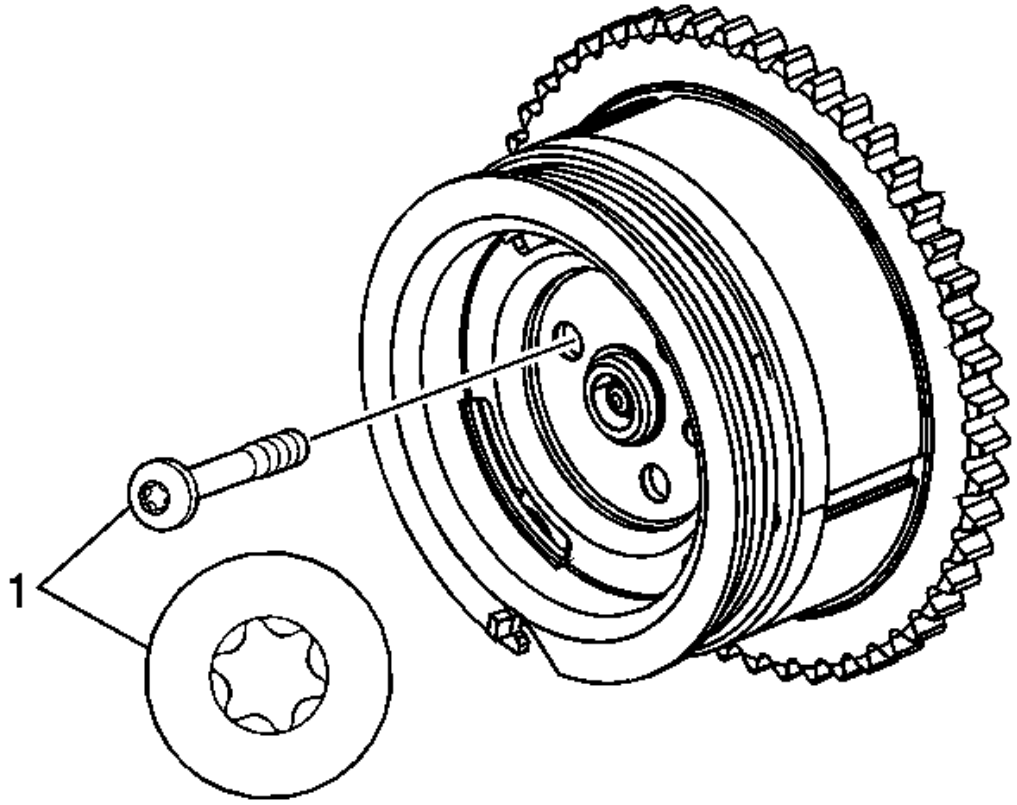

Fig. 473: Identifying Camshaft Position Actuator & Fasteners
Courtesy of GENERAL MOTORS CORP.

CAUTION: Use only a Torx Plus® Bit when removing or installing the camshaft position actuator fasteners (1). The Torx Plus® design differs from typical Torx® fastener. Use of a standard Torx® bit on Torx Plus® fasteners may result in a rounded out fastener head or incorrect faster torque.

NOTE: DO NOT use any type of threadlocking compound on the camshaft position actuator mounting bolts. Usage of a threadlocking compound on the threads could lead to contamination of the camshaft position actuator, possibly resulting in potential damage to the actuator.

10. Draw the camshaft sprocket onto the camshaft using the mounting bolts, and tighten to 16 N.m (12 lb ft).
11. Remove the tensioner retaining pin.
12. Coat the crankshaft and camshaft sprocket with engine oil.

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ENGINE FRONT COVER INSTALLATION

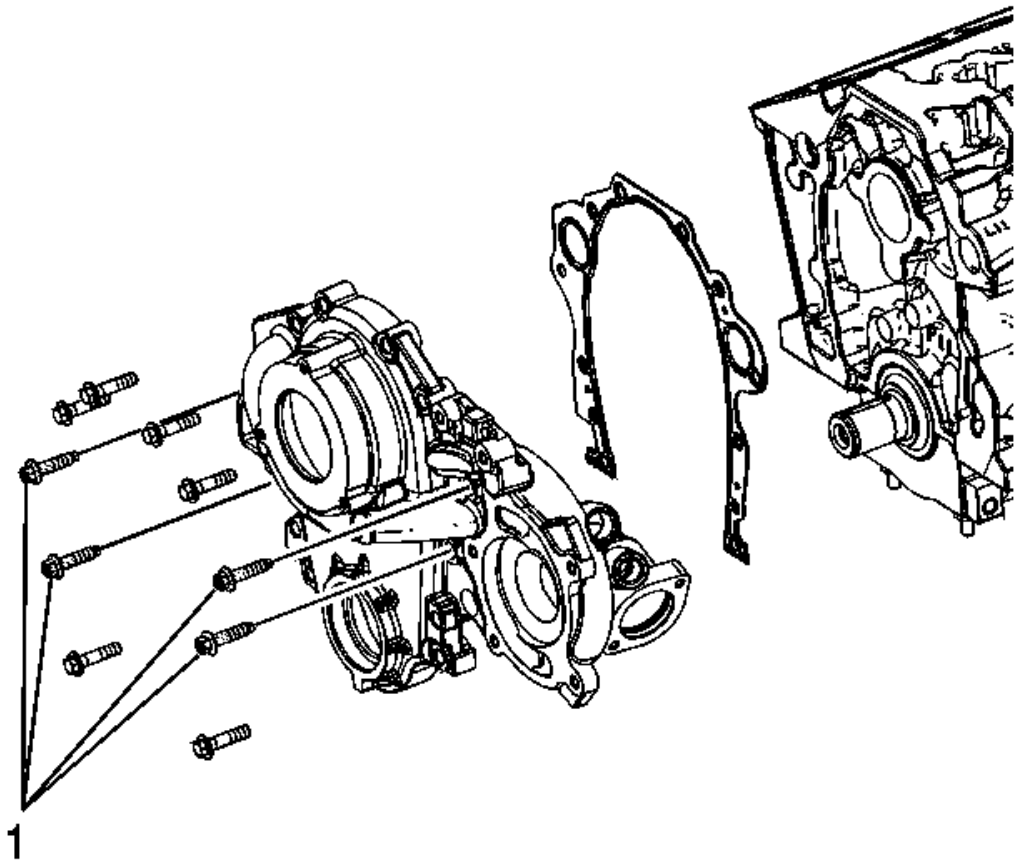

Fig. 474: Identifying Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the front cover and the front cover gasket.

CAUTION: Refer to Fastener Caution .

NOTE: Apply sealer GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the shaded bolts (1) in the graphic. Failure to do so may result in engine coolant leakage from the bolt holes passing through the water jacket.

2. Install the front cover bolts and tighten to 25 N.m (18 lb ft).

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CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

EN-48869 Front Crankshaft Oil Seal Installer

Installation

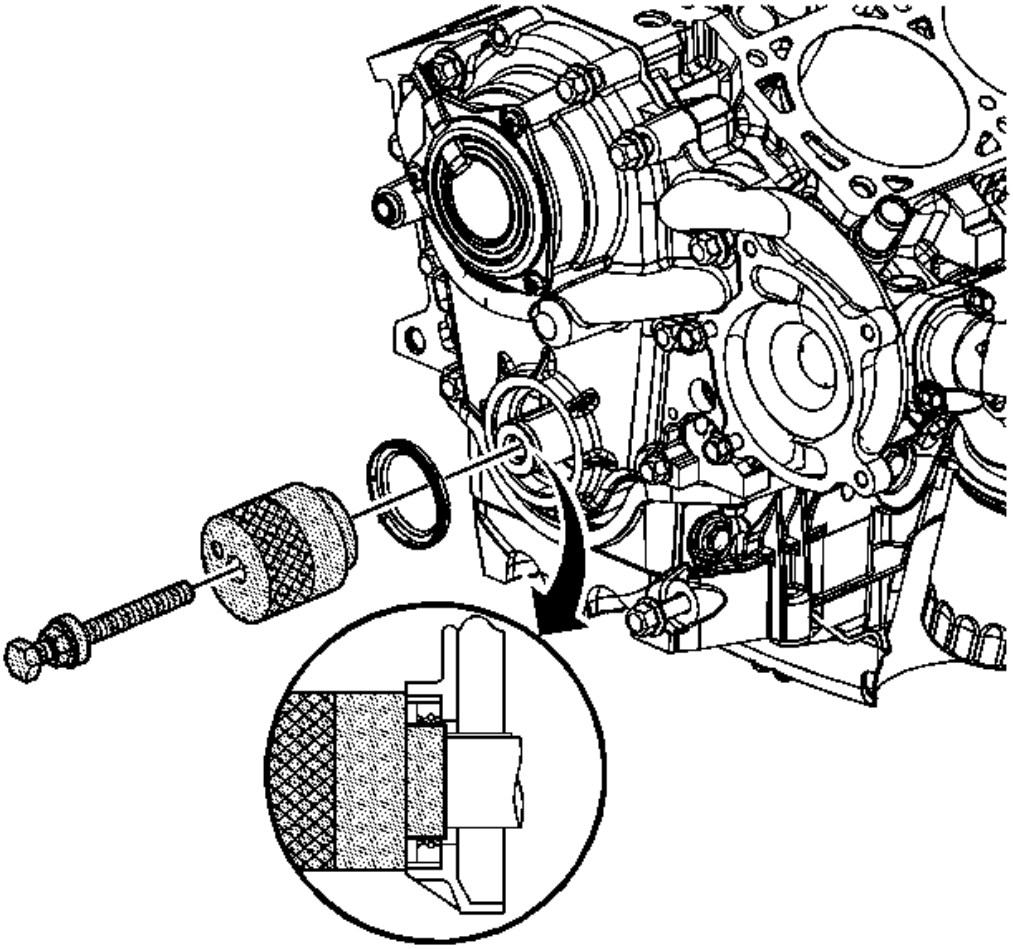

Fig. 475: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Place the crankshaft front oil seal on the **EN-48869** with lip facing inward, aligning crankshaft keyway to the groove in the installer.
2. Thread the forcing bolt with bearing, washer and nut as shown.

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3. Tighten the nut until seal bottoms, then remove the **EN-48869** .

OIL PUMP DRIVE INSTALLATION

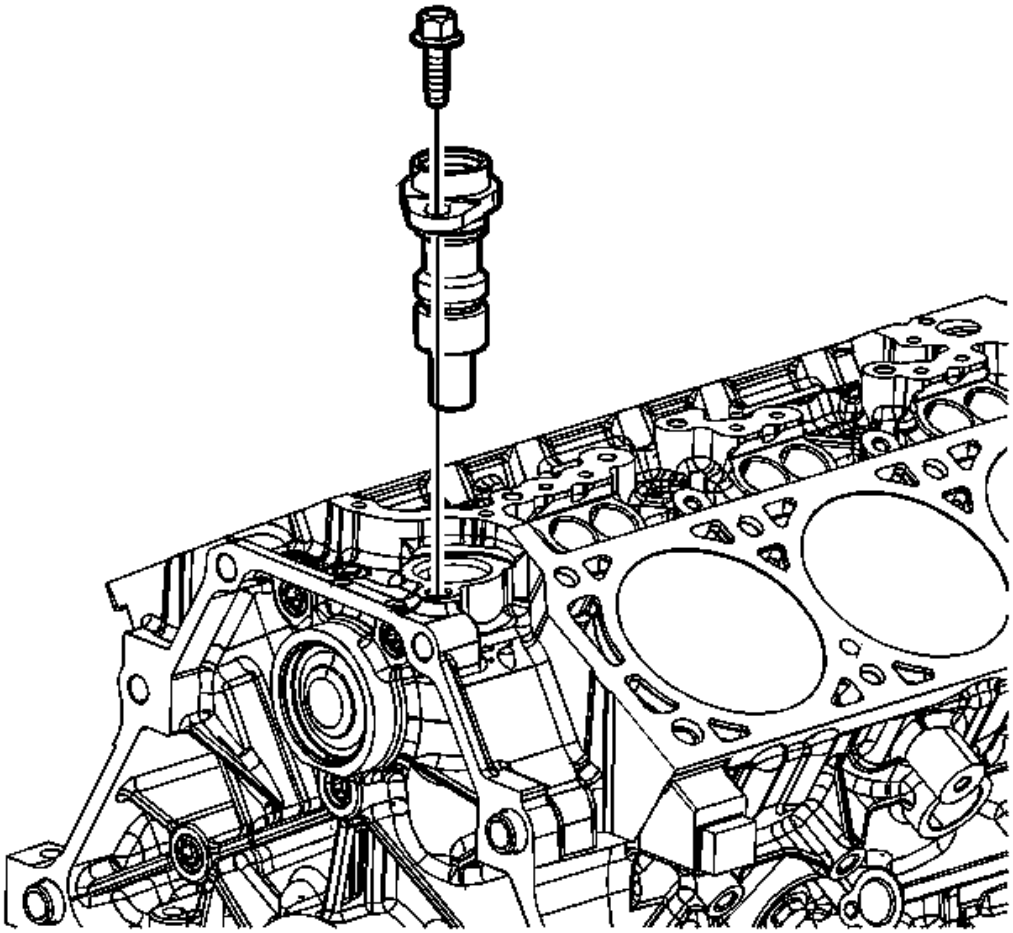

Fig. 476: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Apply prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent to the oil pump drive gear.
2. Apply engine oil to the oil pump drive gear assembly for ease of assembly.
3. Install the oil pump drive gear assembly.
4. Install the oil pump drive gear clamp.

CAUTION: Refer to Fastener Caution .

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5. Install the oil pump drive gear clamp bolt and tighten to 36 N.m (27 lb ft).

CAMSHAFT POSITION ACTUATOR MAGNET INSTALLATION

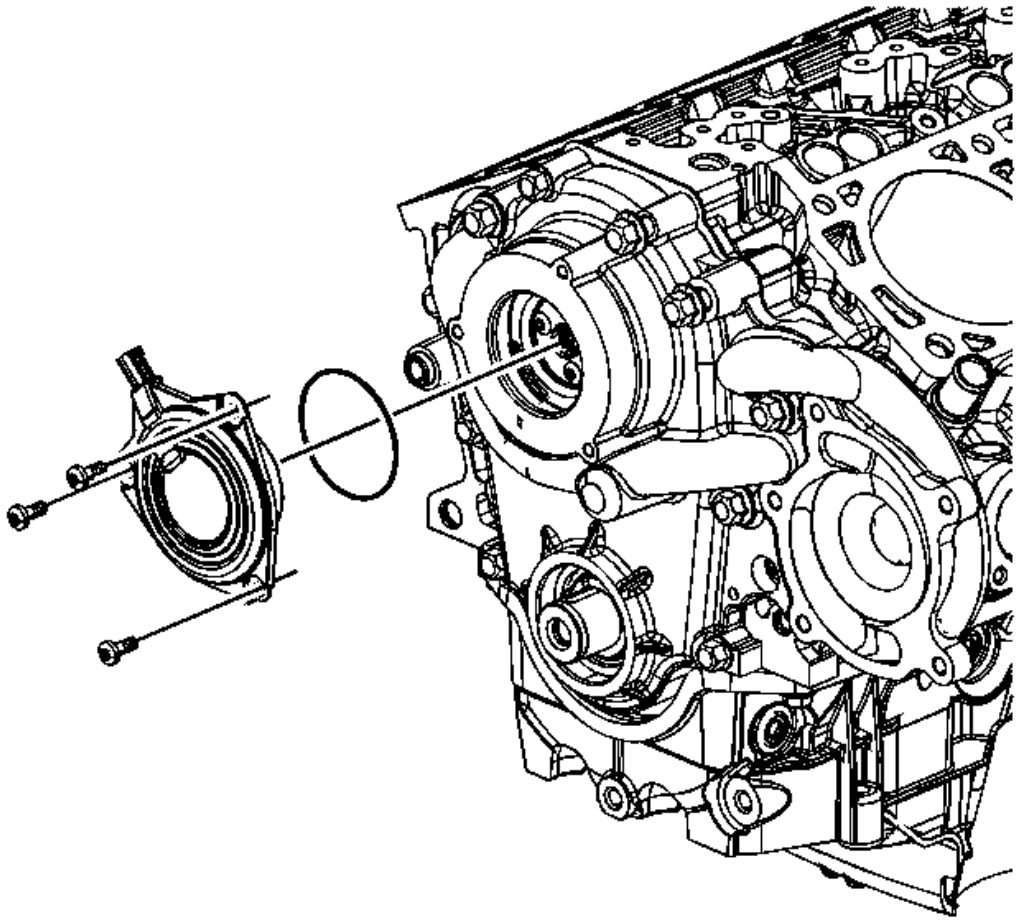

Fig. 477: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the camshaft position actuator magnet and O-ring seal into the front cover.

CAUTION: Refer to Fastener Caution .

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2. Install the camshaft position actuator magnet bolts.
    - Starting with the uppermost bolt, tighten the camshaft position actuator magnet bolts a first pass in a clockwise sequence to 10 N.m (89 lb in) .
    - Starting with the uppermost bolt, tighten the camshaft position actuator magnet bolts a final pass in a clockwise sequence to 10 N.m (89 lb in) .

OIL PUMP INSTALLATION

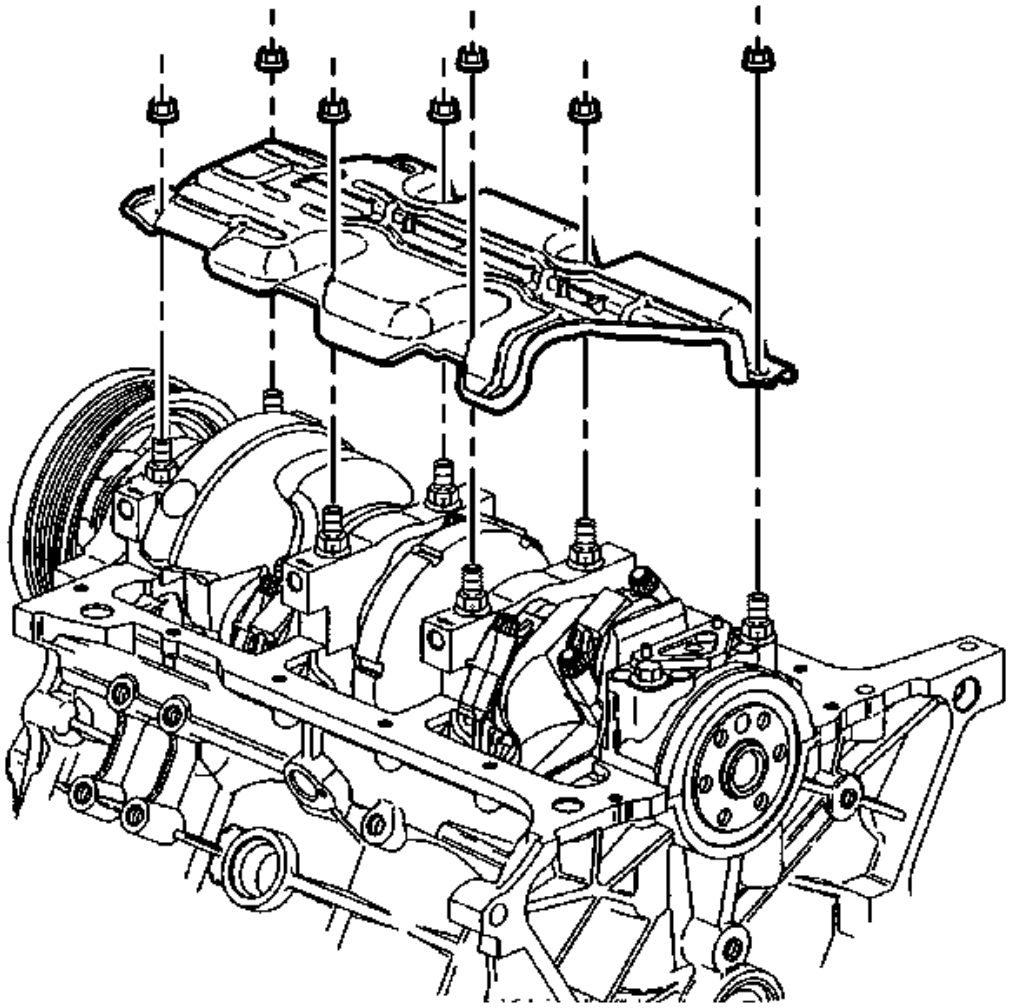

Fig. 478: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft oil deflector.

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CAUTION: Refer to Fastener Caution .

2. Install the crankshaft oil deflector nuts and tighten to 25 N.m (18 lb ft).

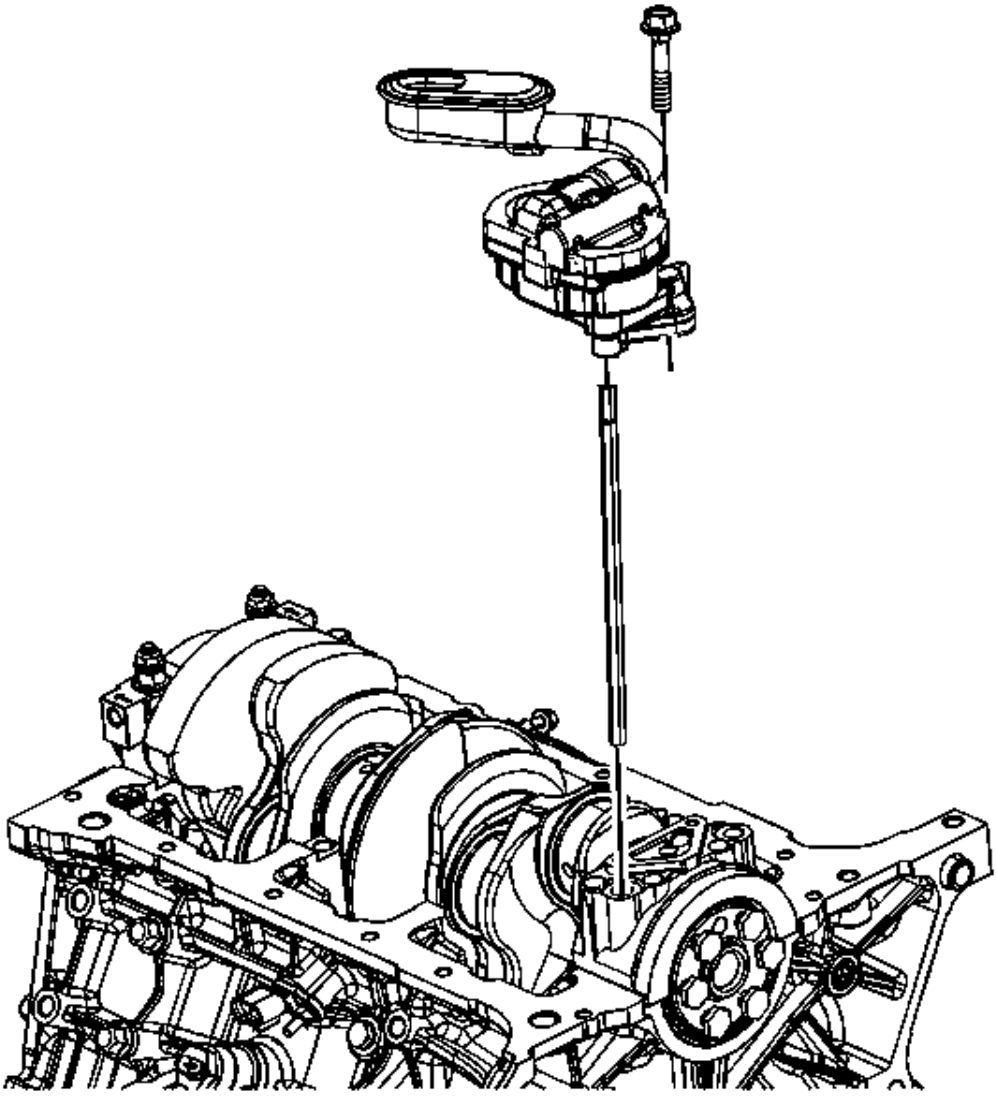

Fig. 479: Identifying Oil Pump, Screen & Driveshaft
Courtesy of GENERAL MOTORS CORP.

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NOTE: Do not reuse the oil pump driveshaft retainer. During assembly, install a NEW oil pump driveshaft retainer.

3. Install the oil pump.
4. Position the oil pump onto the pins.
5. Install the oil pump bolt attaching the oil pump to the rear crankshaft bearing cap, and tighten to 41 N.m (30 lb ft).

OIL PAN INSTALLATION

Special Tools

J 45059: Angle Meter

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

Installation

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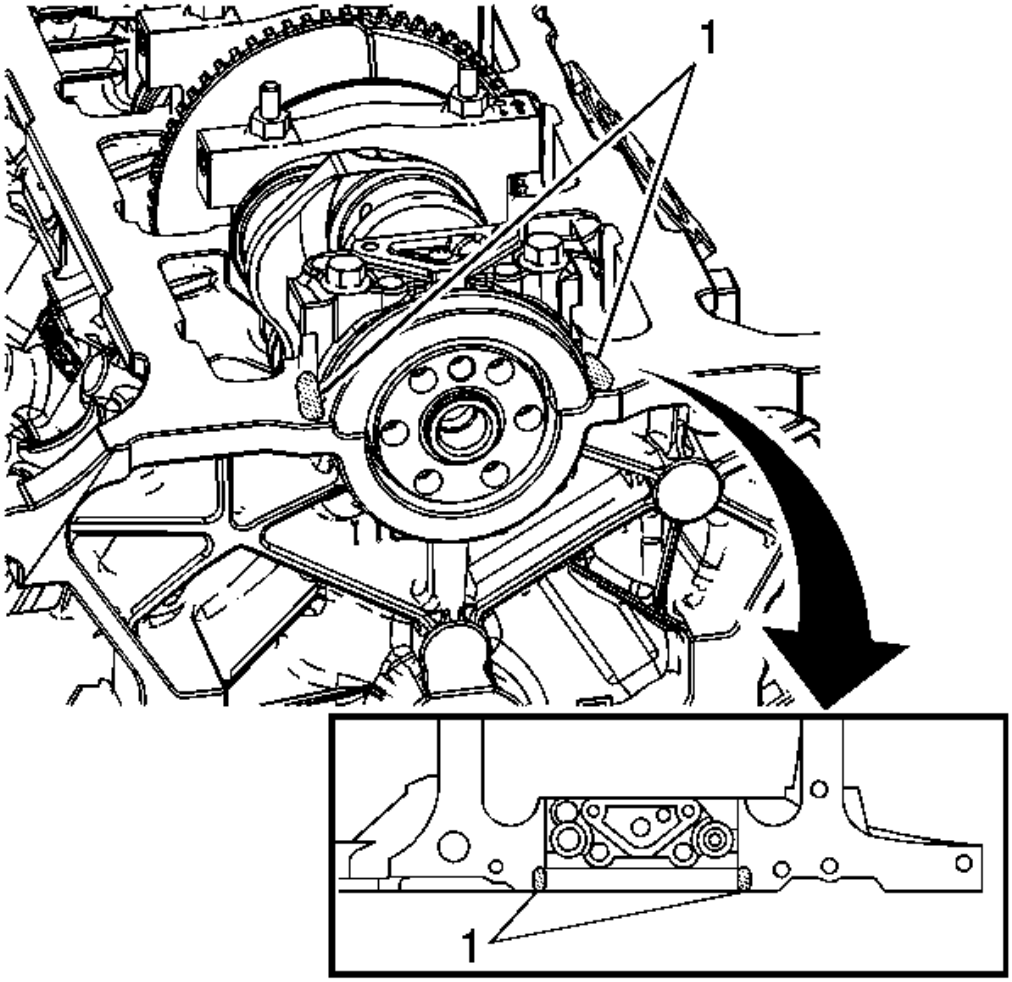

Fig. 480: Identifying Crankshaft Rear Main Bearing Cap
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12378521, (Canadian P/N 88901148) or the equivalent to both sides of the crankshaft rear main bearing cap (1). Press sealer into gap using a putty knife.

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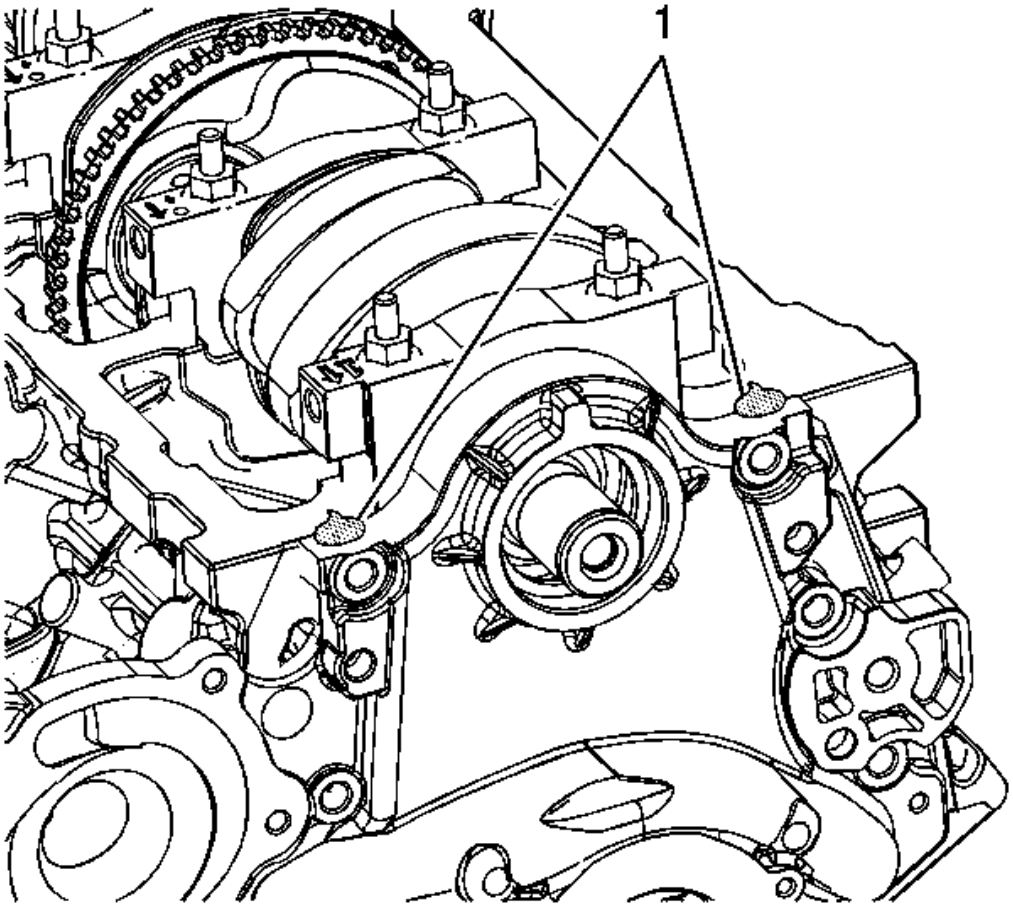

Fig. 481: View Of Oil Pan Sealing Points
Courtesy of GENERAL MOTORS CORP.

2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to both sides of the front cover/block mating area (1).

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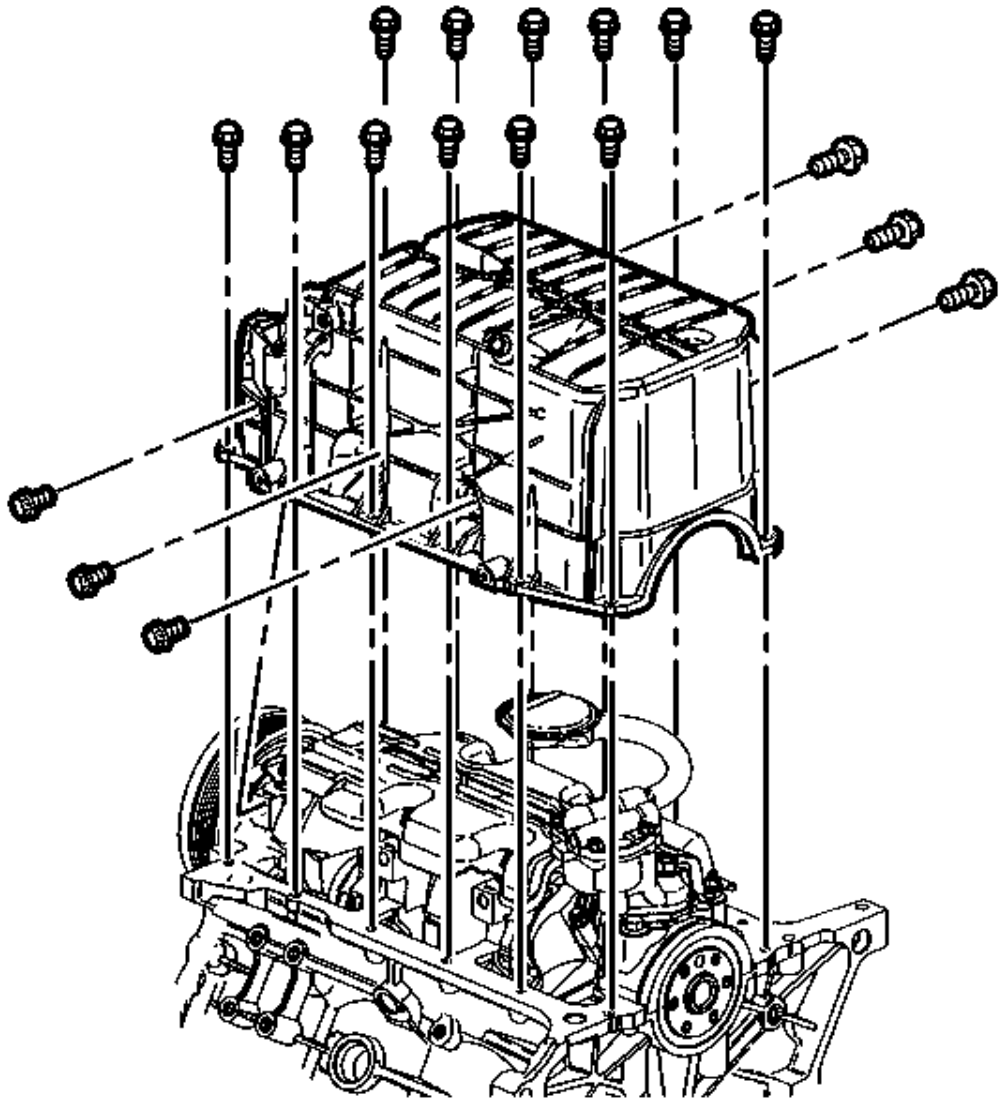

Fig. 482: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan gasket.
4. Install the oil pan.

CAUTION: Refer to Fastener Caution .

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5. Install the oil pan bolts and tighten to 25 N.m (18 lb ft).
6. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the oil pan side bolt threads.
7. Install the oil pan side bolts.
8. Tighten the oil pan side bolts a first pass to 50 N.m (37 lb ft).
9. Tighten the oil pan side bolts a second pass to 50 degrees using the **J 45059:** meter.

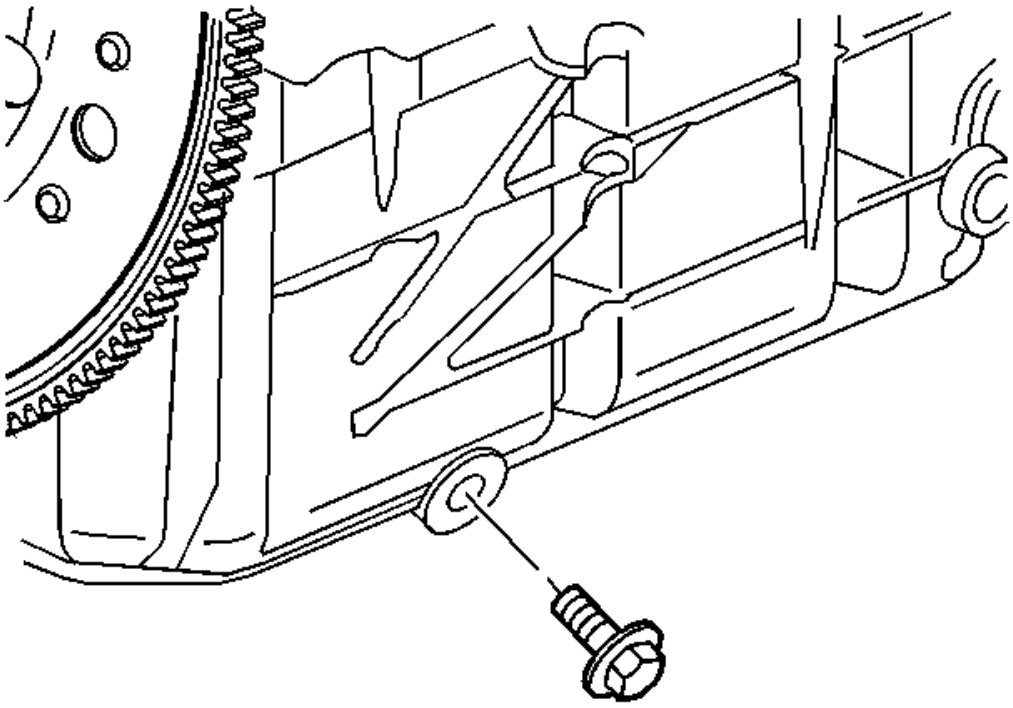

Fig. 483: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).

CYLINDER HEAD INSTALLATION - LEFT SIDE

Special Tools

J 45059: Angle Meter

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

Installation

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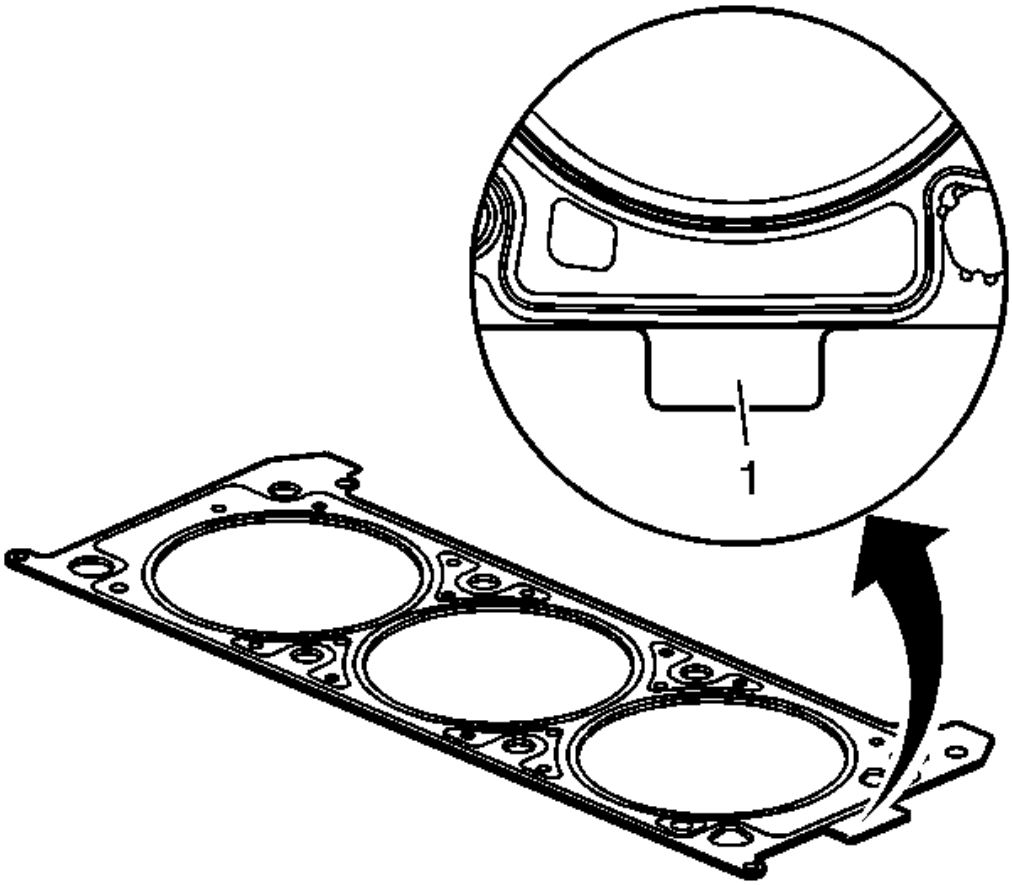

Fig. 484: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Head gaskets are specific for right hand and left hand applications, and also must be installed with the correct side facing up. Note the markings (1) on the head gaskets for proper installation. Failure to do so may lead to engine damage.

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

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

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2. Inspect the cylinder head locator dowel pins for proper installation.

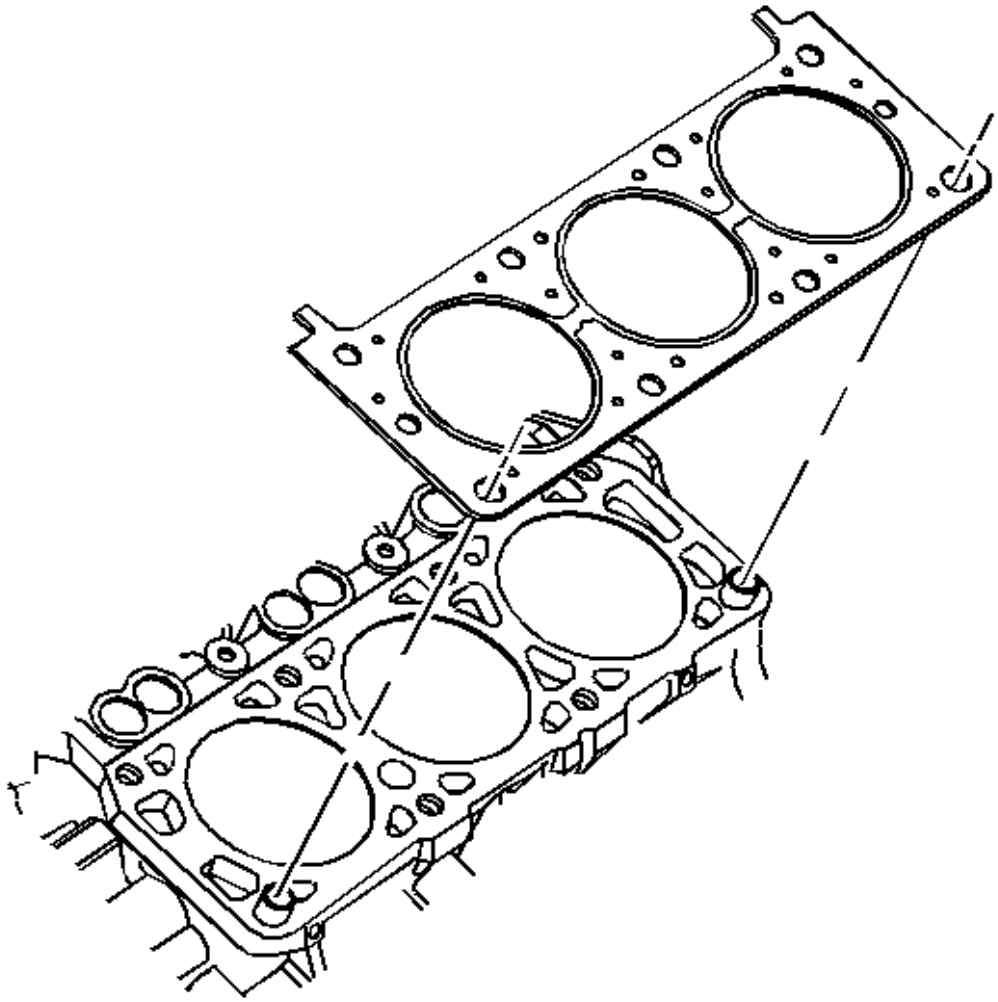

Fig. 485: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head gasket.

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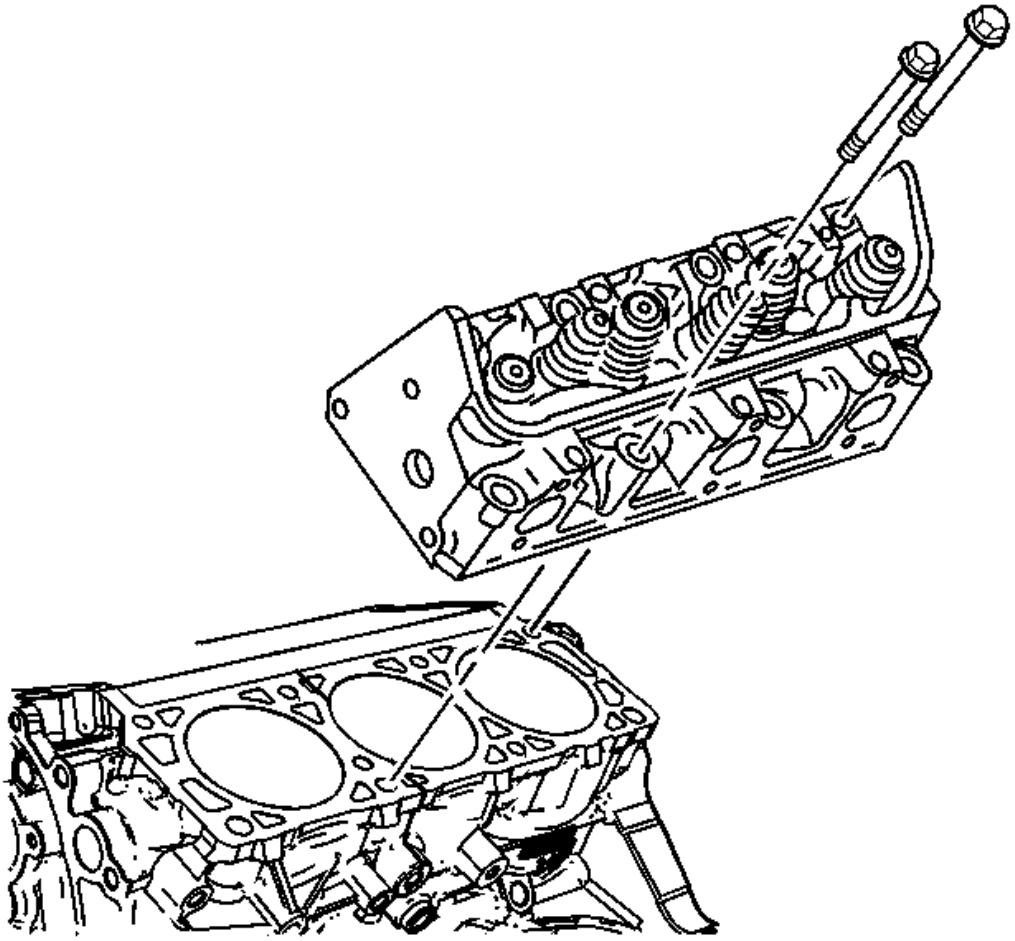

Fig. 486: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

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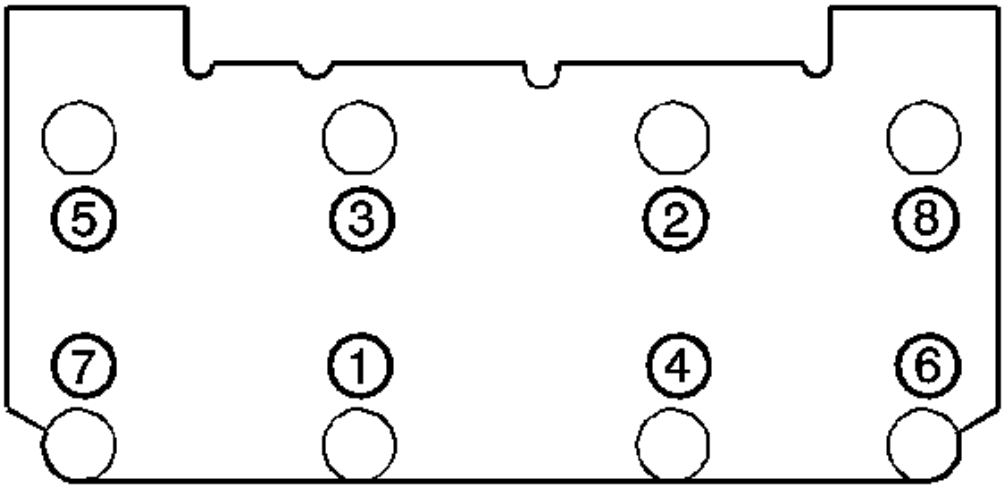

Fig. 487: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

5. Install the NEW small hex cylinder head bolts (5 and 8).
6. Install the NEW large hex cylinder head bolts (1, 2, 3, 4, 6 and 7).
    1. Tighten the cylinder head bolts a first pass in sequence to 60 N.m (44 lb ft) .
    2. Tighten the cylinder head bolts a final pass in sequence to 140 degrees using the **J 45059:** meter .

CYLINDER HEAD INSTALLATION - RIGHT SIDE

Special Tools

J 45059: Angle Meter

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

Installation

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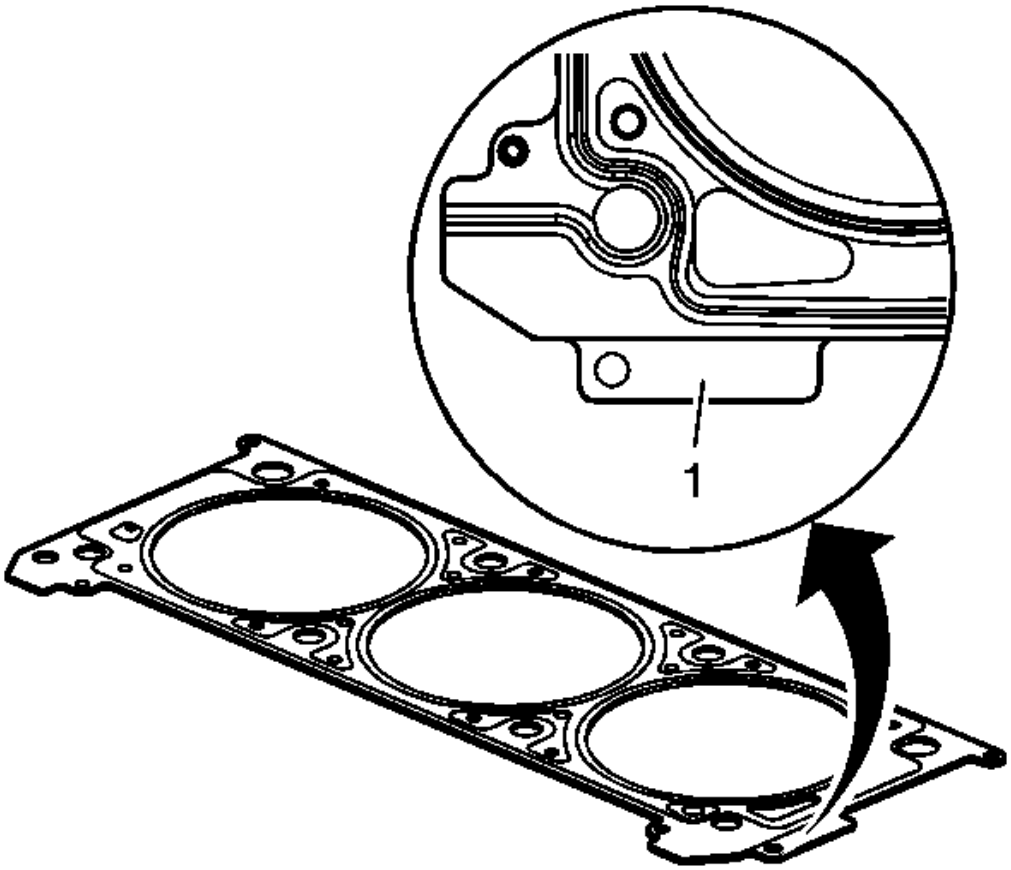

Fig. 488: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Head gaskets are specific for right hand and left hand applications, and also must be installed with the correct side facing up. Note the markings (1) on the head gaskets for proper installation. Failure to do so may lead to engine damage.

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

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

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2. Inspect the cylinder head locator dowel pins for proper installation.

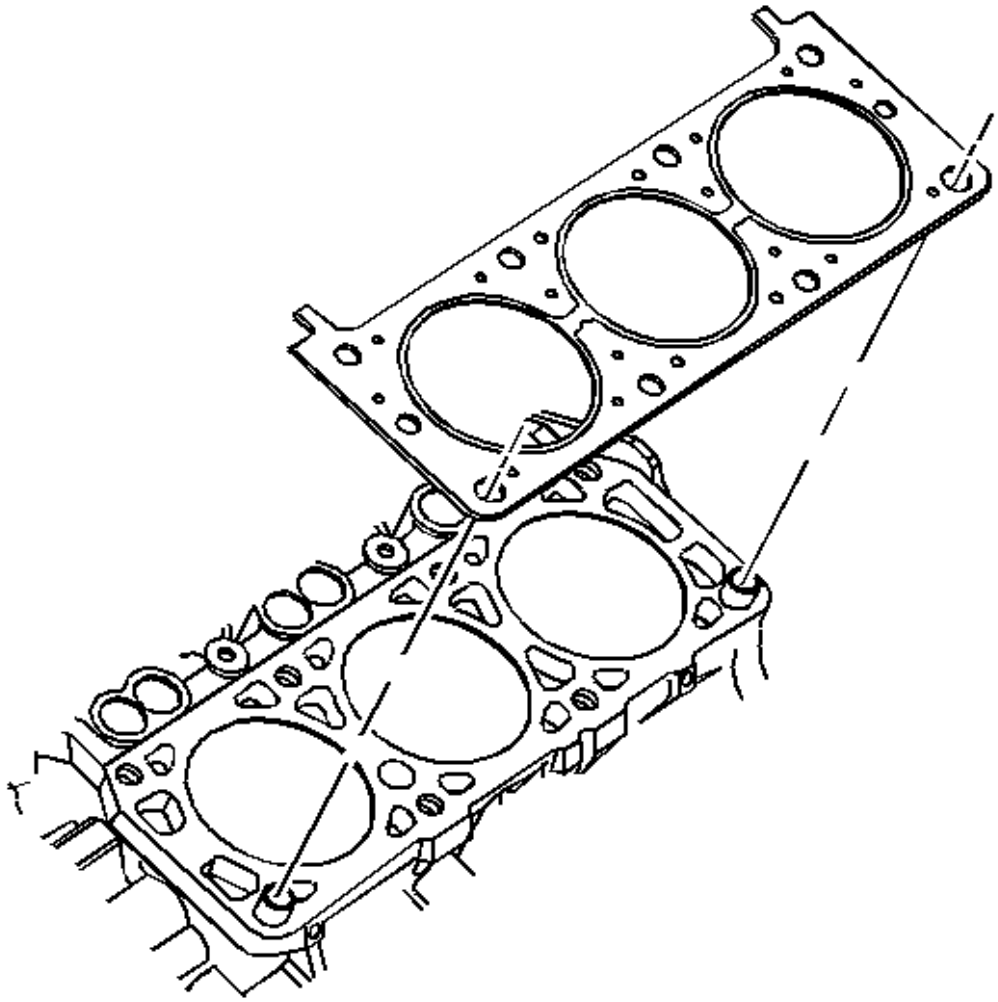

Fig. 489: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head gasket.

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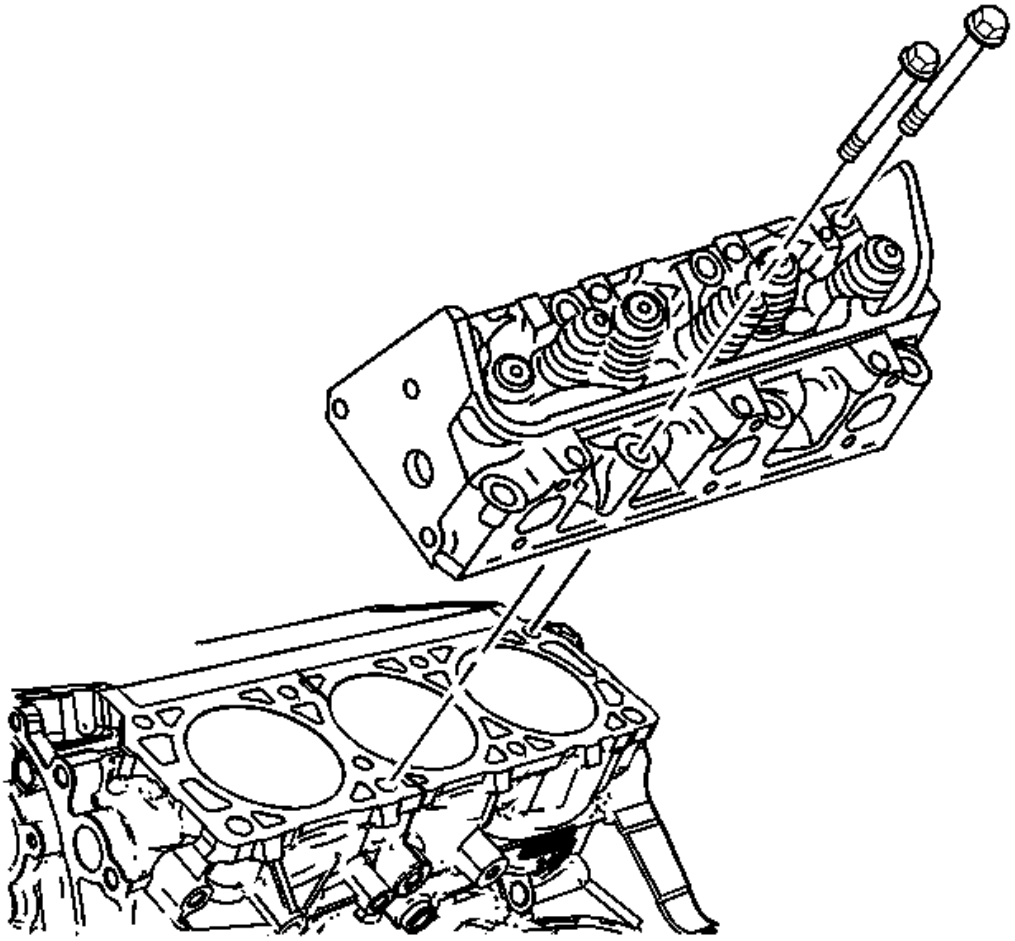

Fig. 490: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

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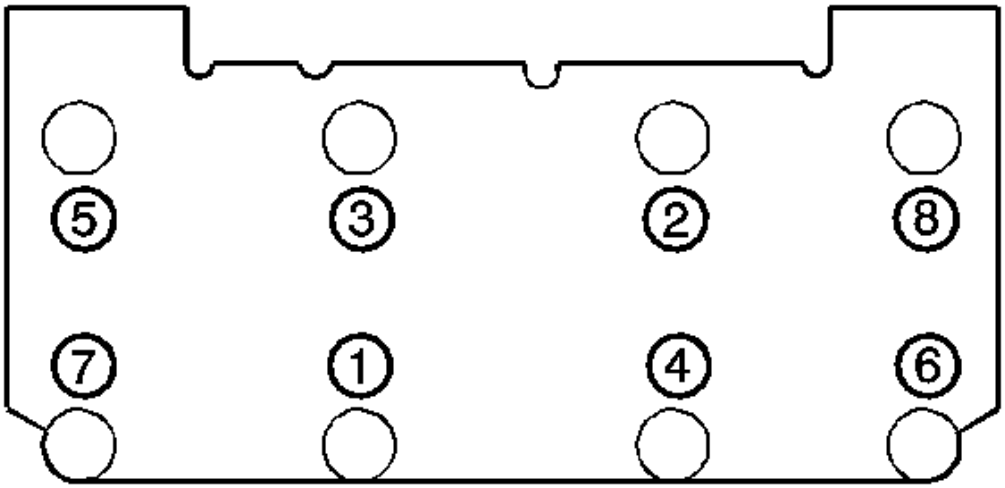

Fig. 491: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

5. Install the NEW small hex cylinder head bolts (5 and 8).
6. Install the NEW large hex cylinder head bolts (1, 2, 3, 4, 6 and 7).
    1. Tighten the cylinder head bolts a first pass in sequence to 60 N.m (44 lb ft) .
    2. Tighten the cylinder head bolts a final pass in sequence to 140 degrees using the **J 45059:** meter .

WATER PUMP INSTALLATION

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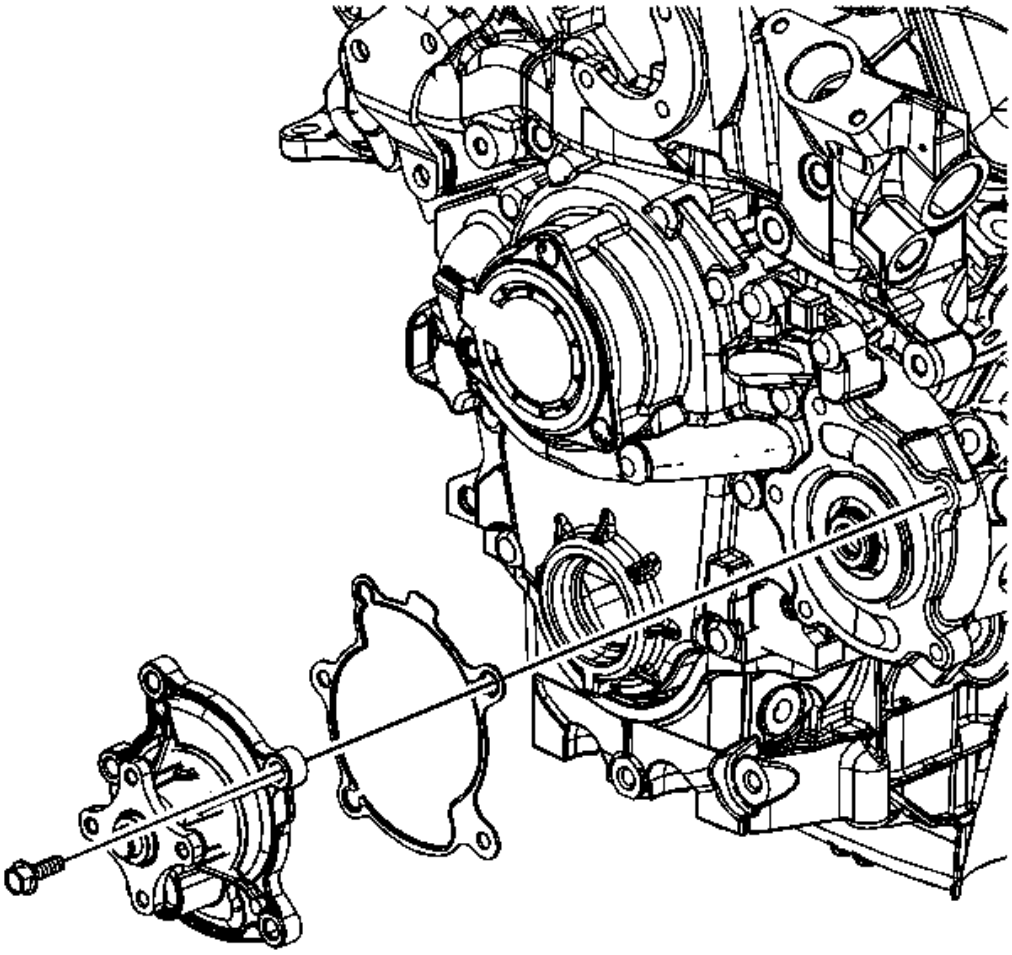

Fig. 492: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump gasket.
2. Install the water pump.

CAUTION: Refer to Fastener Caution .

3. Install the water pump bolts and tighten to 25 N.m (18 lb ft).

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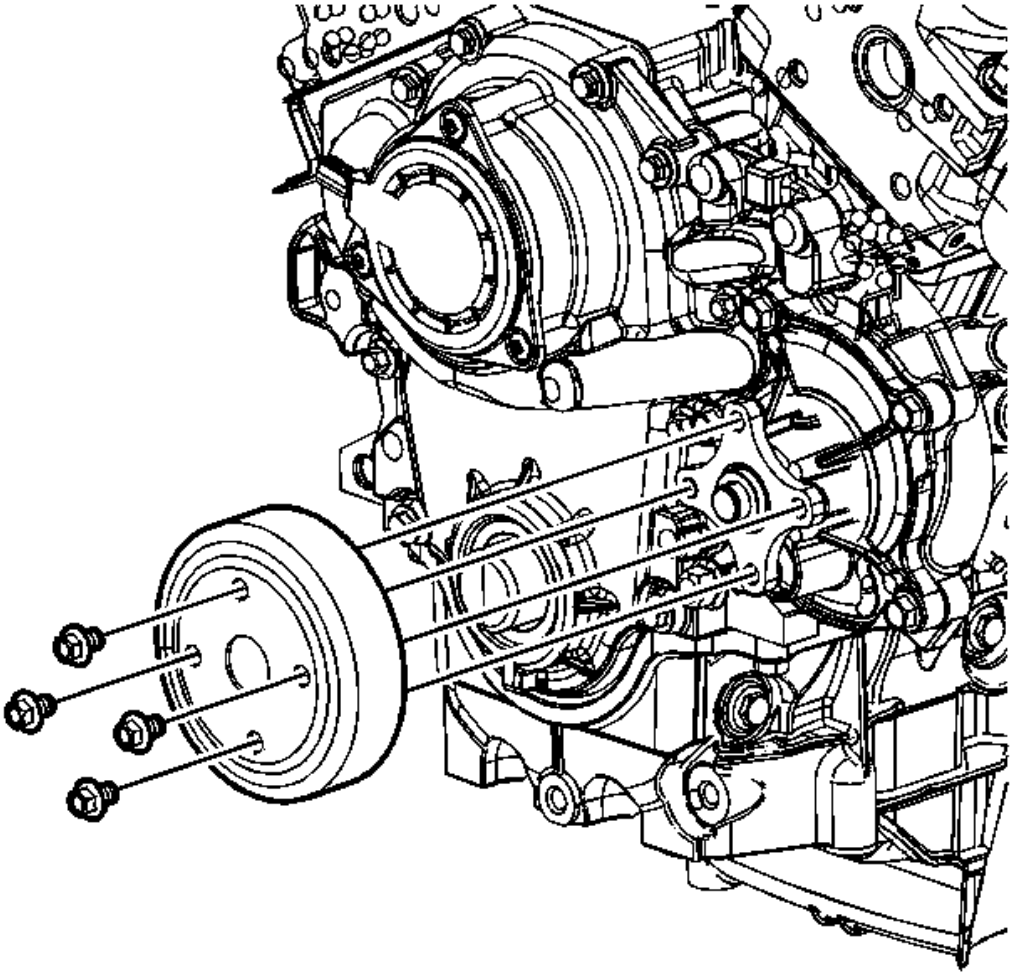

Fig. 493: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the water pump pulley.
5. Install the water pump pulley bolts and tighten to 25 N.m (18 lb ft).

VALVE LIFTER INSTALLATION

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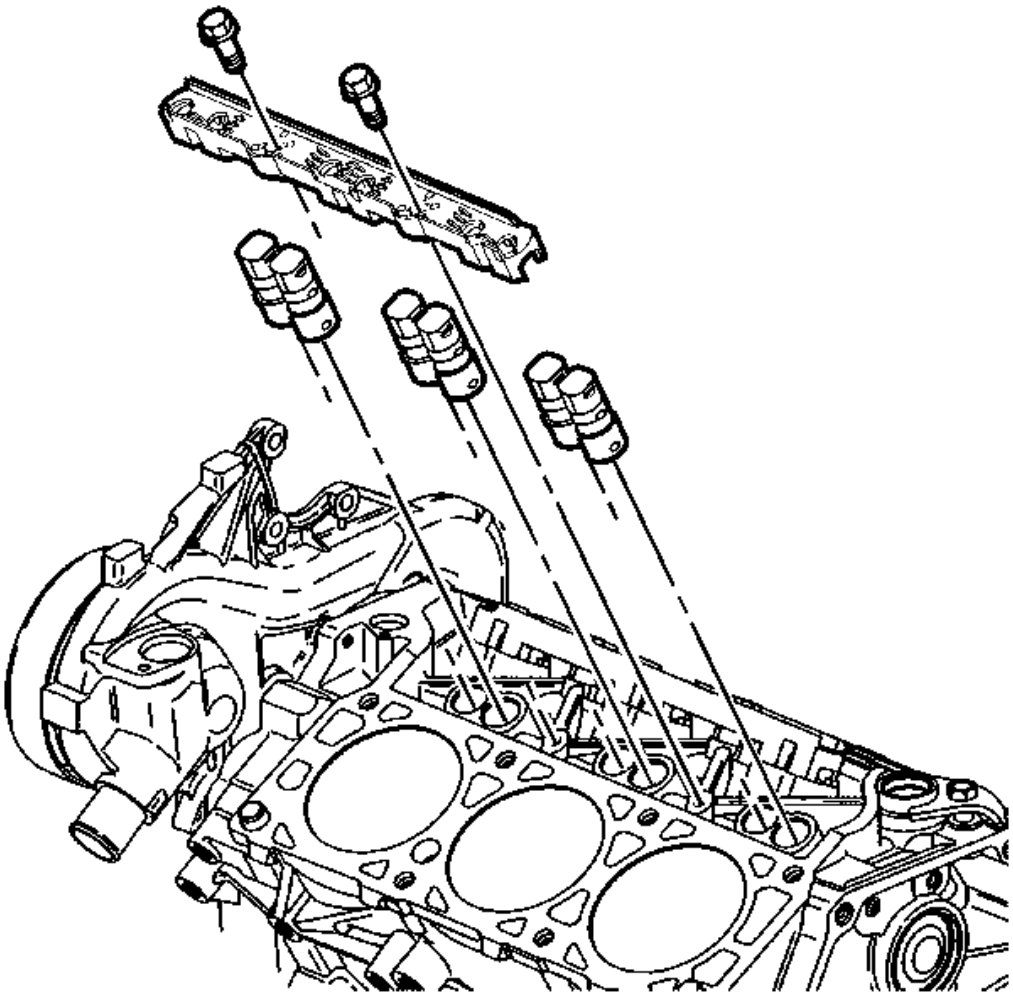

Fig. 494: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve lifters using prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.
2. Install the valve lifters in their original locations.
3. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or the equivalent to the threads.

CAUTION: Refer to Fastener Caution .

4. Install the valve lifter guides and guide bolts, and tighten to 10 N.m (89 lb in).

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VALVE ROCKER ARM AND PUSH ROD INSTALLATION

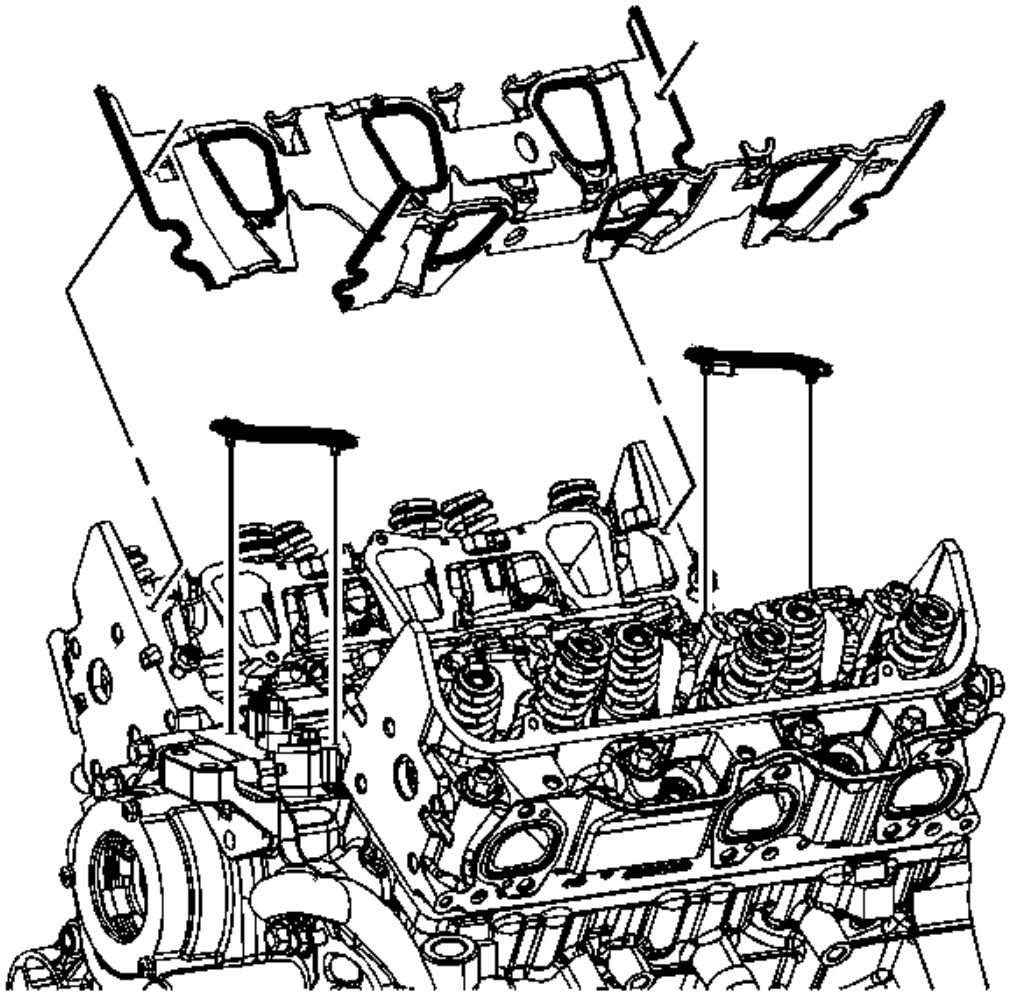

Fig. 495: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

NOTE: All gasket mating surfaces must be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

NOTE: Room temperature vulcanizing (RTV) sealer is not to be placed under the lower intake manifold gaskets.

1. Install the lower intake manifold gaskets.

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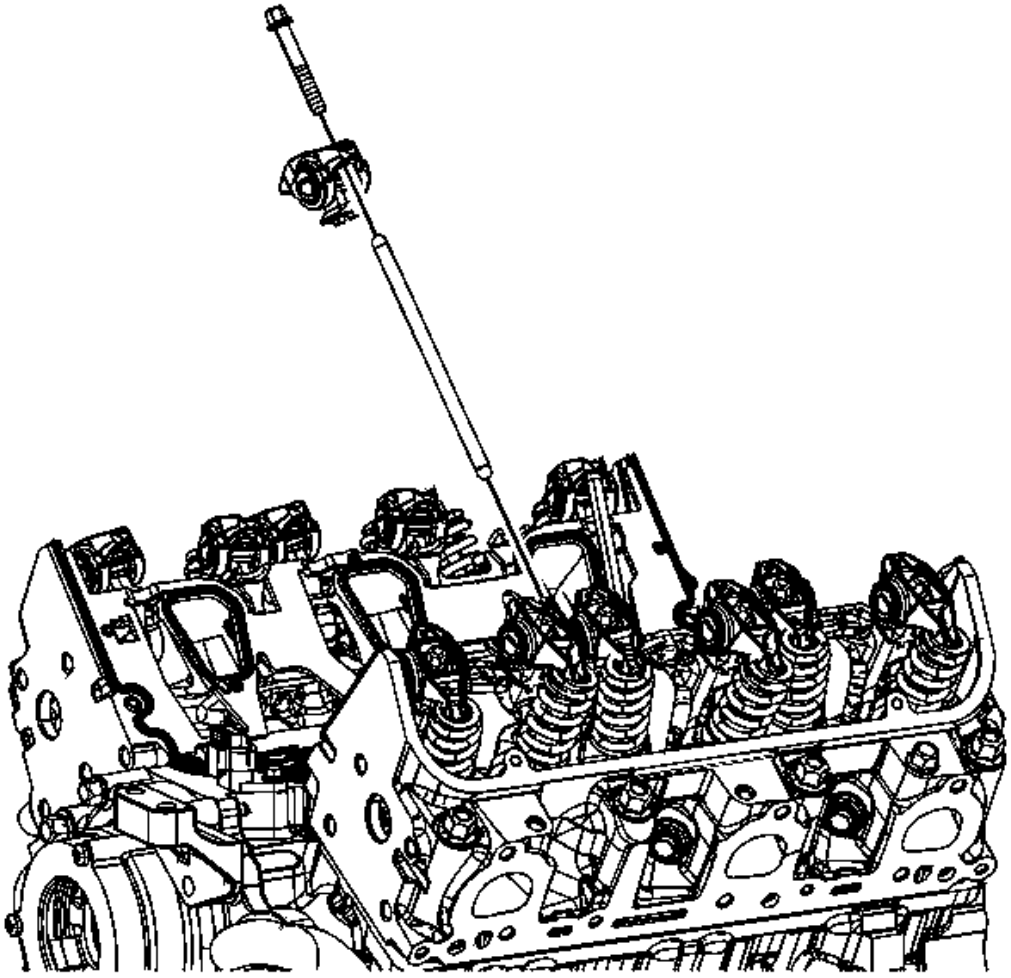

Fig. 496: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Coat the ends of the push rods using prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

NOTE: The intake valve push rods measure 147.51 mm (5.81 in) and the exhaust valve push rods measure 154.87 mm (6.1 in) in length.

3. Install the push rods in their original location.
4. Coat the rocker arm friction surfaces using prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

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NOTE: Shims (P/N 88894006) may be required under the valve rocker arm pedestals if reconditioning has been performed on the cylinder head or its components.

5. Install the valve rocker arms in their original positions.

CAUTION: Refer to Fastener Caution .

6. Install the valve rocker arm bolts and tighten to 34 N.m (25 lb ft).

LOWER INTAKE MANIFOLD INSTALLATION

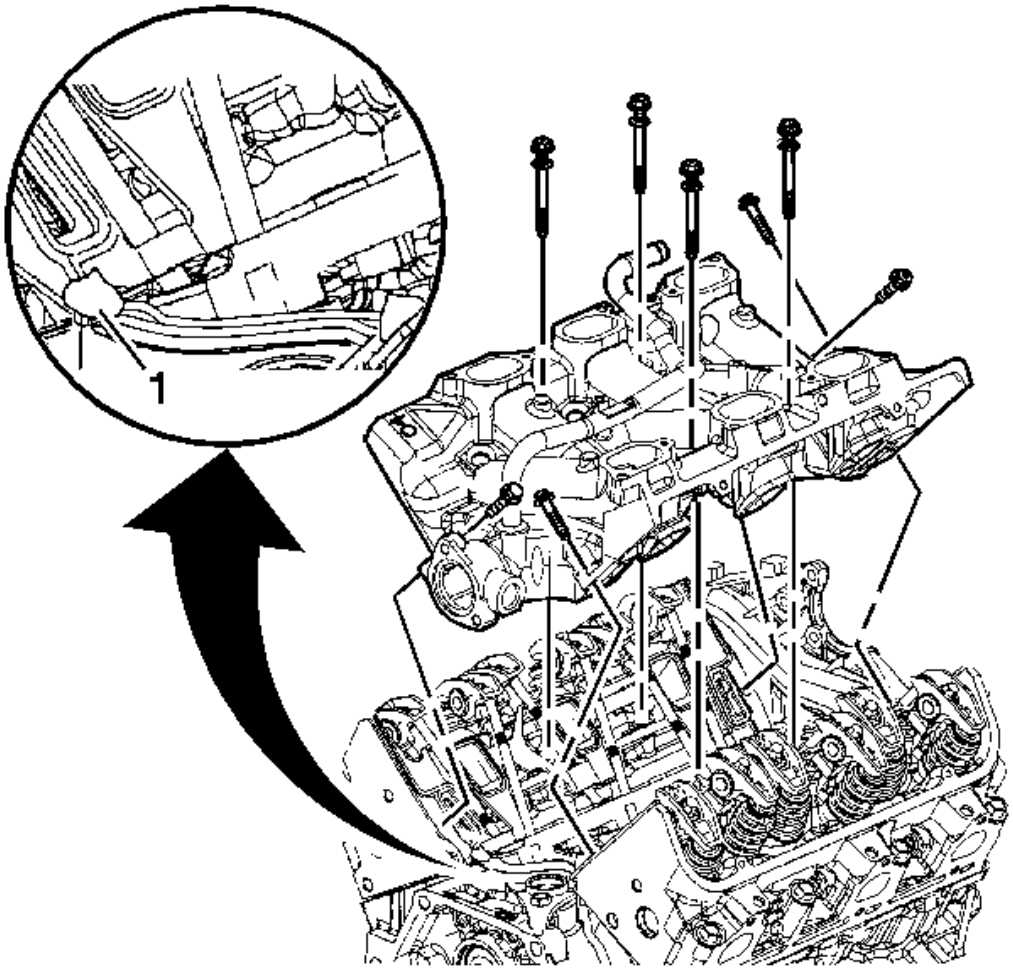

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Fig. 497: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

NOTE: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

1. With gaskets and seals in place apply a small drop 8-10 mm (0.31-0.39 in) of room temperature vulcanizing (RTV) sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the 4 corners of the intake manifold to block joints (1).

NOTE: To ensure proper lower intake manifold orientation during installation, make sure the intake port marked 1 faces the front of the engine.

2. Install the lower intake manifold.

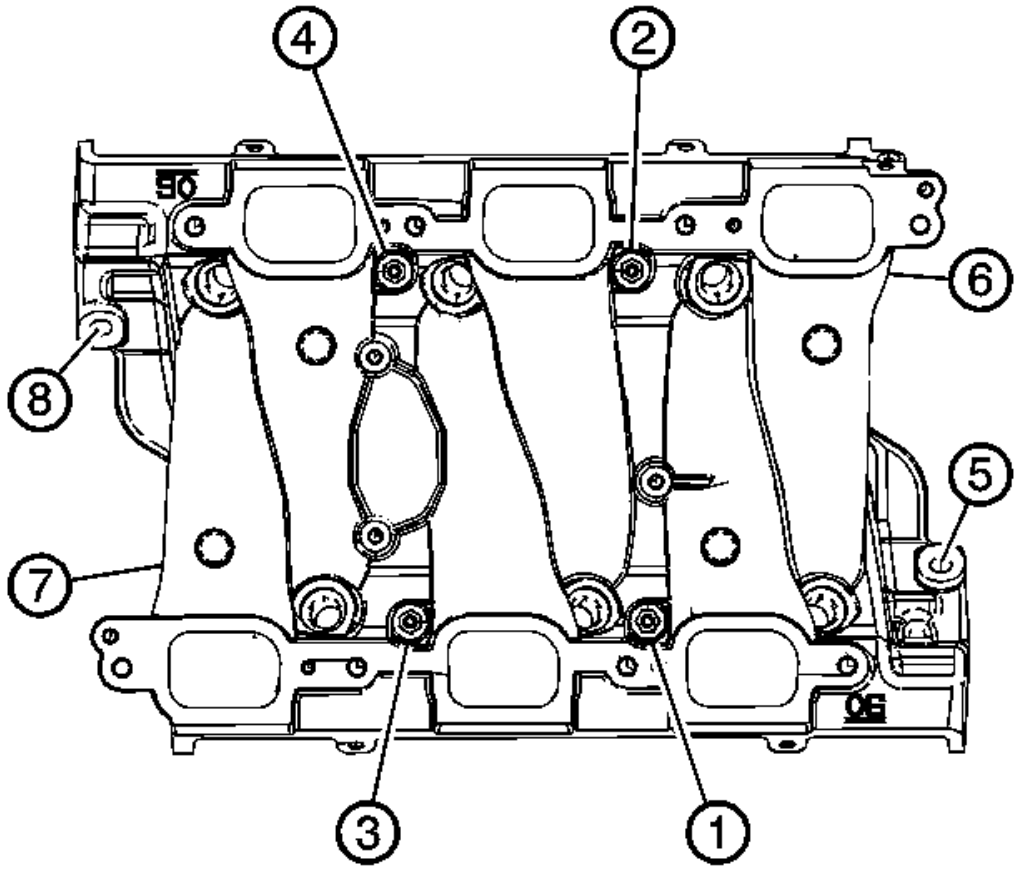

Fig. 498: Identifying Lower Intake Manifold Tightening Sequence

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Courtesy of GENERAL MOTORS CORP.

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

CAUTION: Failure to tighten vertical bolts before the diagonal bolts may cause an oil leak.

3. Apply sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the lower intake manifold bolt threads.

CAUTION: Refer to Fastener Caution .

4. Install the new lower intake manifold bolts if applicable, in sequence.
    1. Tighten the lower intake manifold bolts in sequence to 7 N.m (62 lb in) on the first pass.
    2. Tighten the lower intake manifold bolts (1, 2, 3, 4) in sequence to 13 N.m (115 lb in) on the final pass.
    3. Tighten the lower intake manifold bolts (5, 6, 7, 8) in sequence to 25 N.m (18 lb ft) on the final pass.

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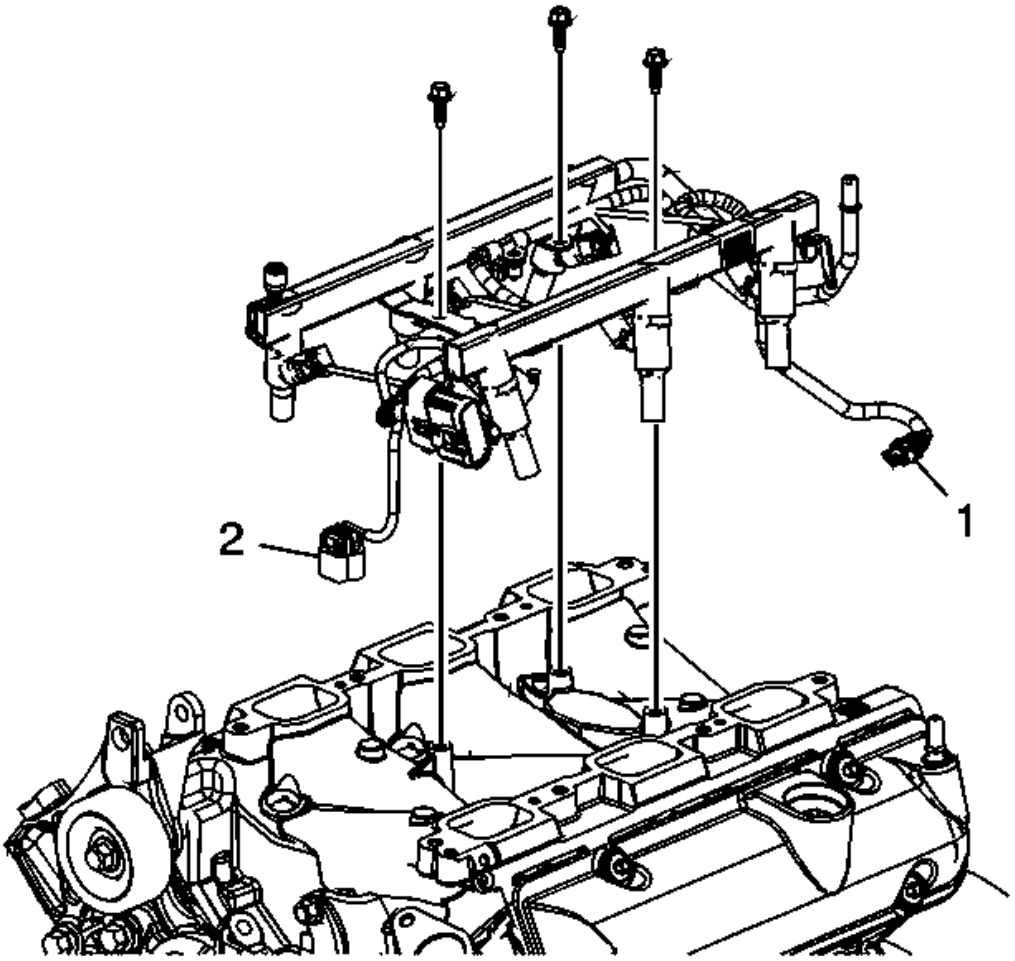

Fig. 499: Identifying Lower Intake Manifold Attachments
Courtesy of GENERAL MOTORS CORP.

5. Inspect the fuel rail, and fuel injectors for damage and replace if necessary.
6. Install NEW lower fuel injector O-rings.
7. Lubricate the fuel injector O-rings using GM P/N 12345616 (Canadian P/N 993182) or equivalent.

NOTE: To ensure proper fuel rail orientation during installation, make sure the fuel feed pipe faces the rear of the engine.

8. Install the injector nozzles into the lower intake manifold injector bores.
9. Press on the injector rail using the palms of both hands until the injectors are fully seated.
10. Install the fuel injector rail bolts and tighten to 10 N.m (89 lb in).

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11. Connect the coolant temperature sensor (1).
12. Connect the camshaft position (CMP) sensor (2).

UPPER INTAKE MANIFOLD INSTALLATION

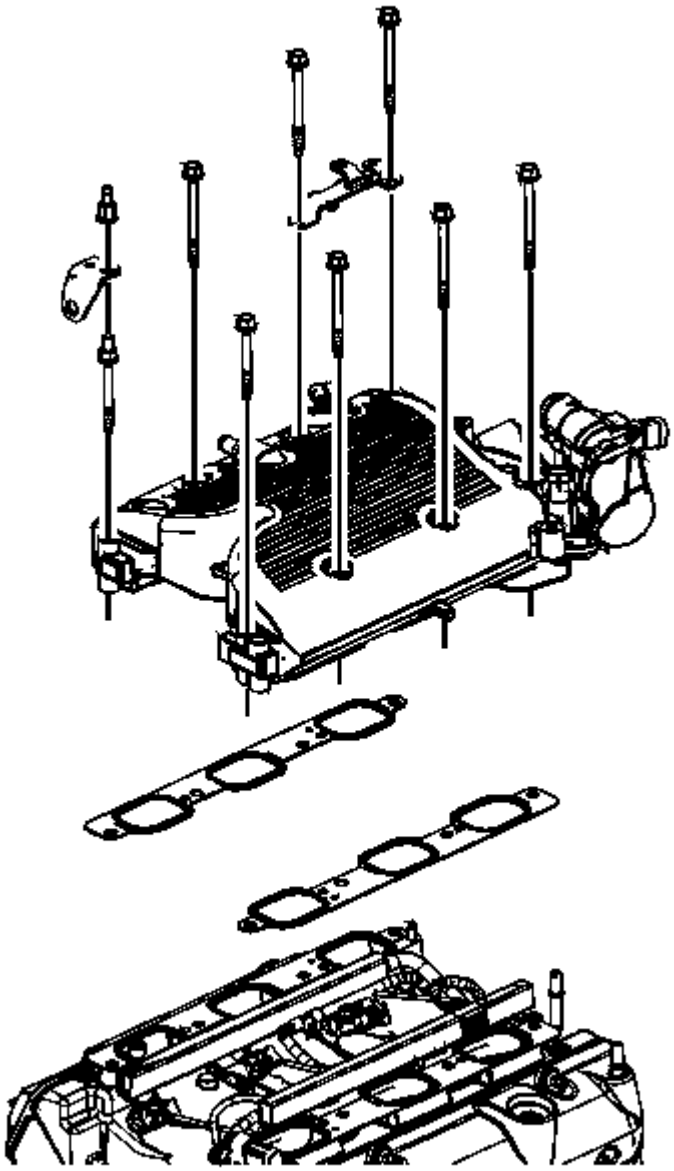

Fig. 500: View Of Upper Intake Manifold, Bolts & Gasket

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Courtesy of GENERAL MOTORS CORP.

1. Install the upper intake manifold gaskets and manifold.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the upper intake manifold bolt threads.

CAUTION: Refer to Fastener Caution .

3. Install the upper intake manifold bolts, stud, and manifold absolute pressure (MAP) sensor bracket. Tighten the upper intake manifold bolts and stud to 25 N.m (18 lb ft).

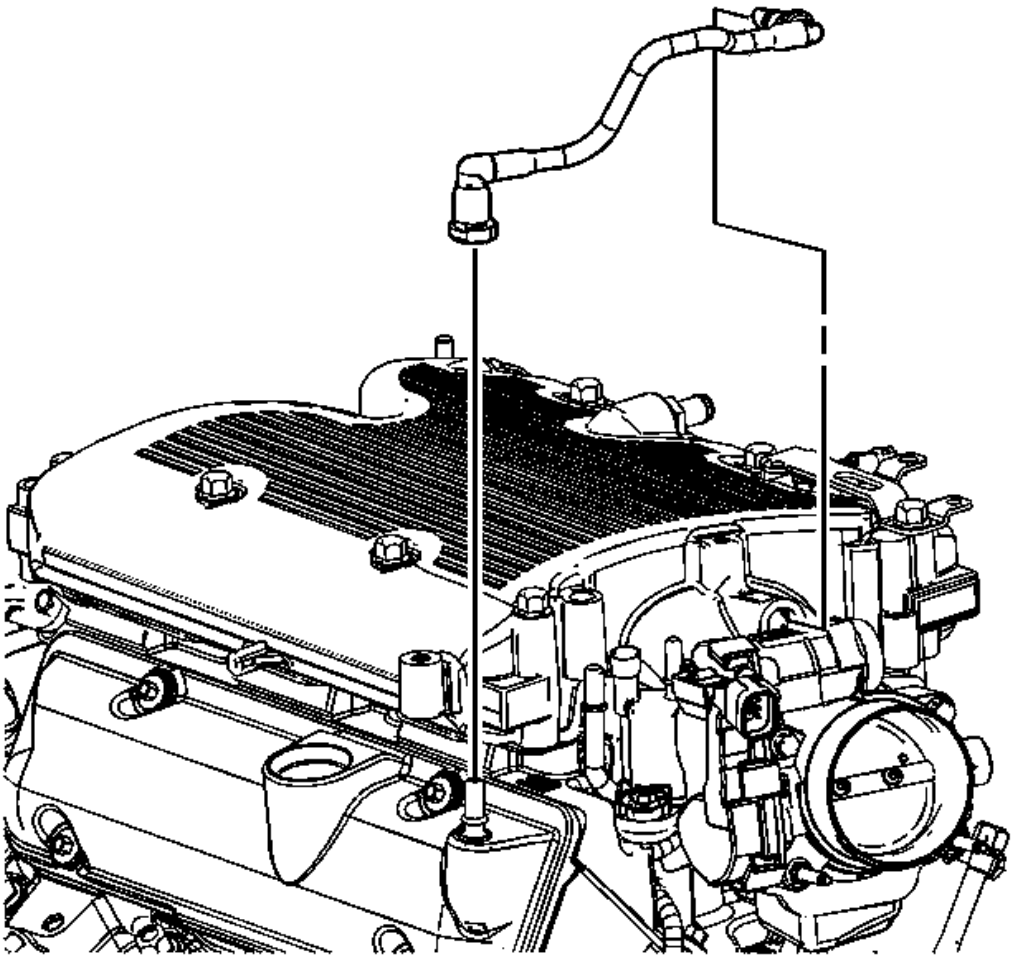

Fig. 501: Identifying Crankcase Ventilation (PCV) Tube

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Courtesy of GENERAL MOTORS CORP.

4. Install the foul air positive crankcase ventilation (PCV) tube.

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

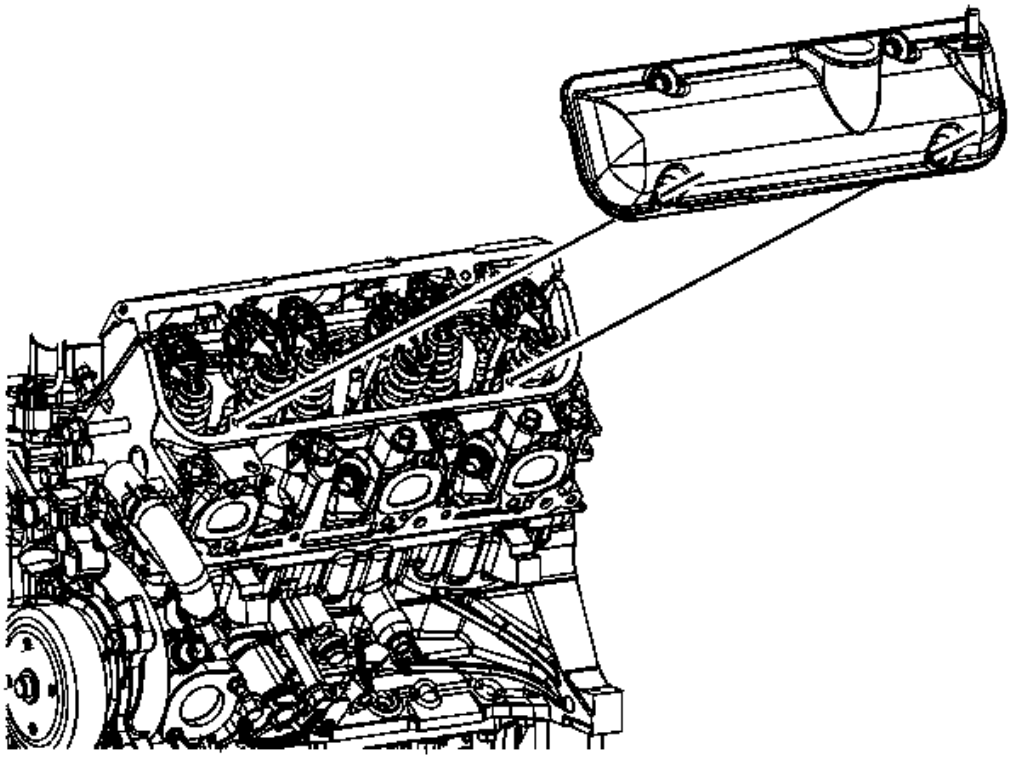

Fig. 502: Identifying Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

NOTE: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

2. Install the valve rocker arm cover gasket into the valve rocker arm cover.

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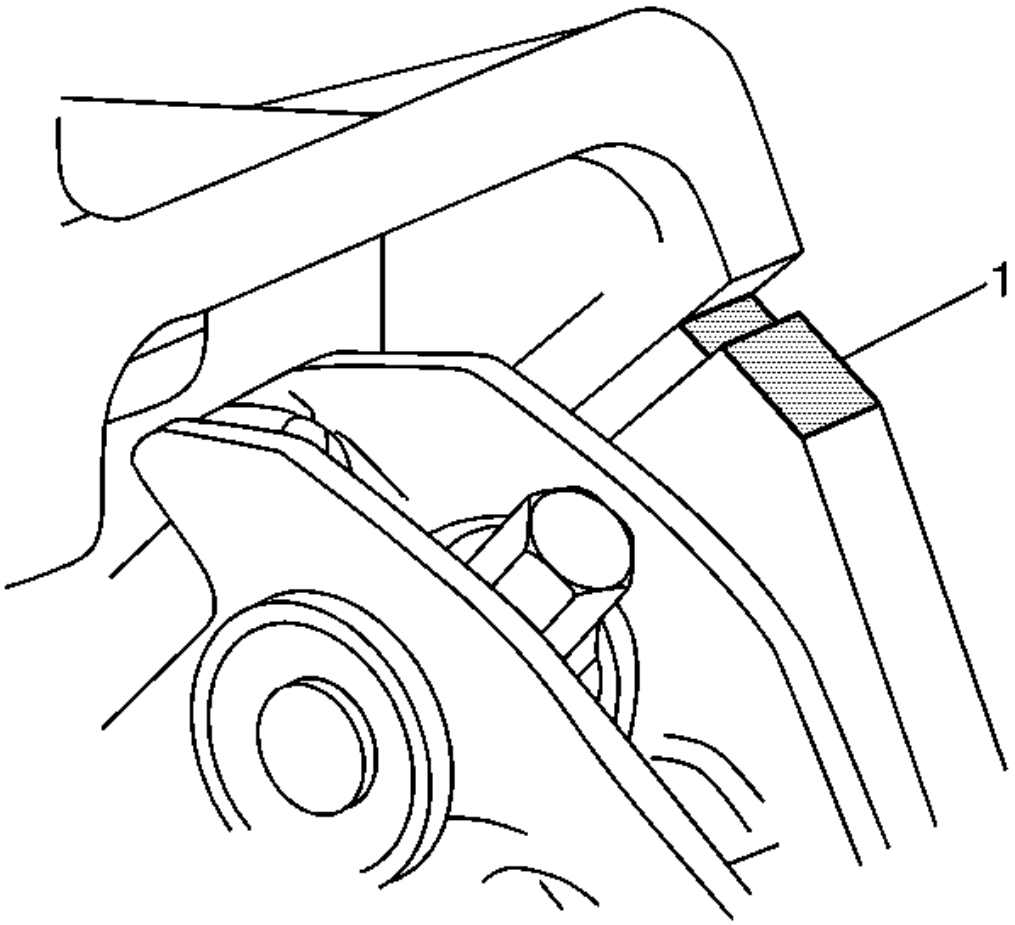

Fig. 503: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

3. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
4. Install the valve rocker arm cover.

CAUTION: Refer to Fastener Caution .

5. Install the valve rocker arm cover bolts, if necessary. Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

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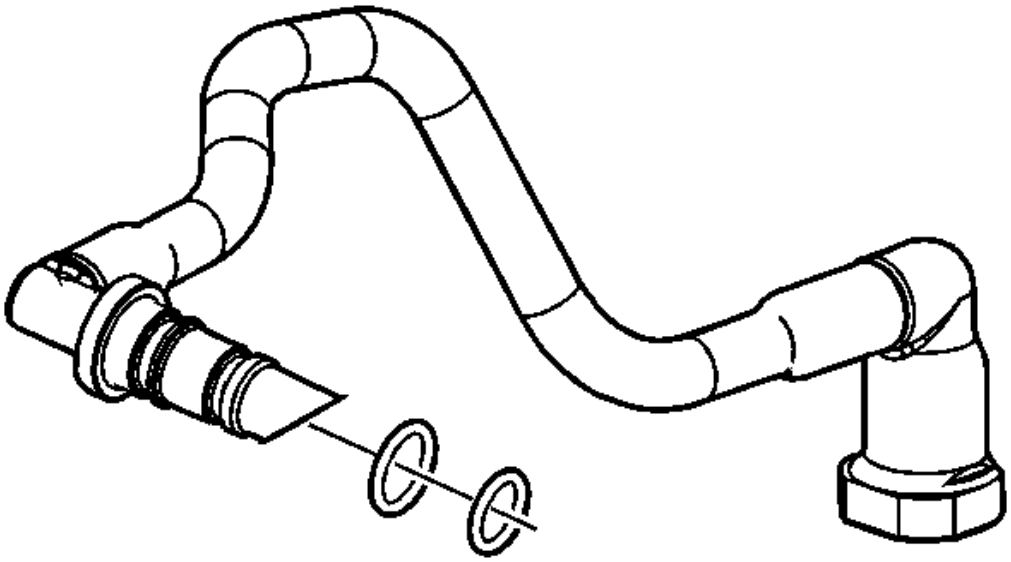

Fig. 504: Identifying PCV Tube O-Rings
Courtesy of GENERAL MOTORS CORP.

6. Install two NEW positive crankcase ventilation (PCV) tube O-rings.

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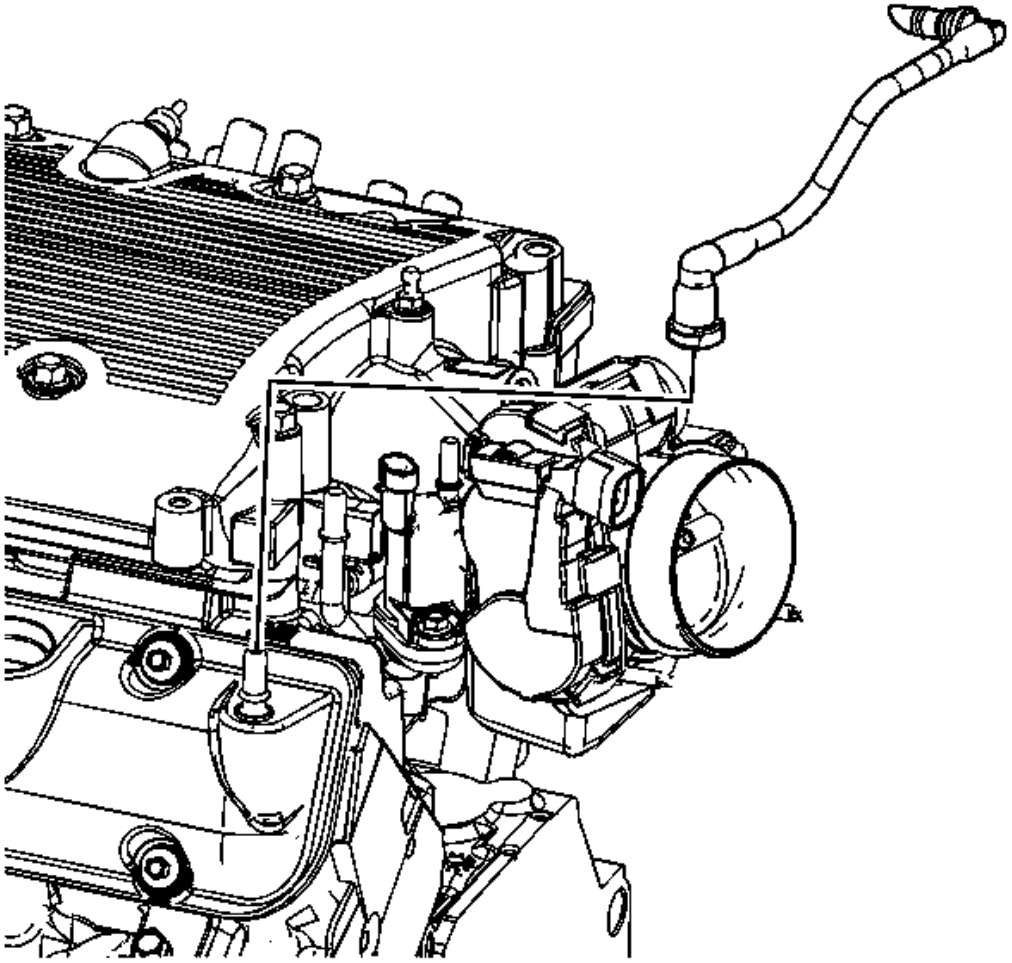

Fig. 505: Positive Crankcase Ventilation (PCV) Tube
Courtesy of GENERAL MOTORS CORP.

7. Install the fresh air tube.

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

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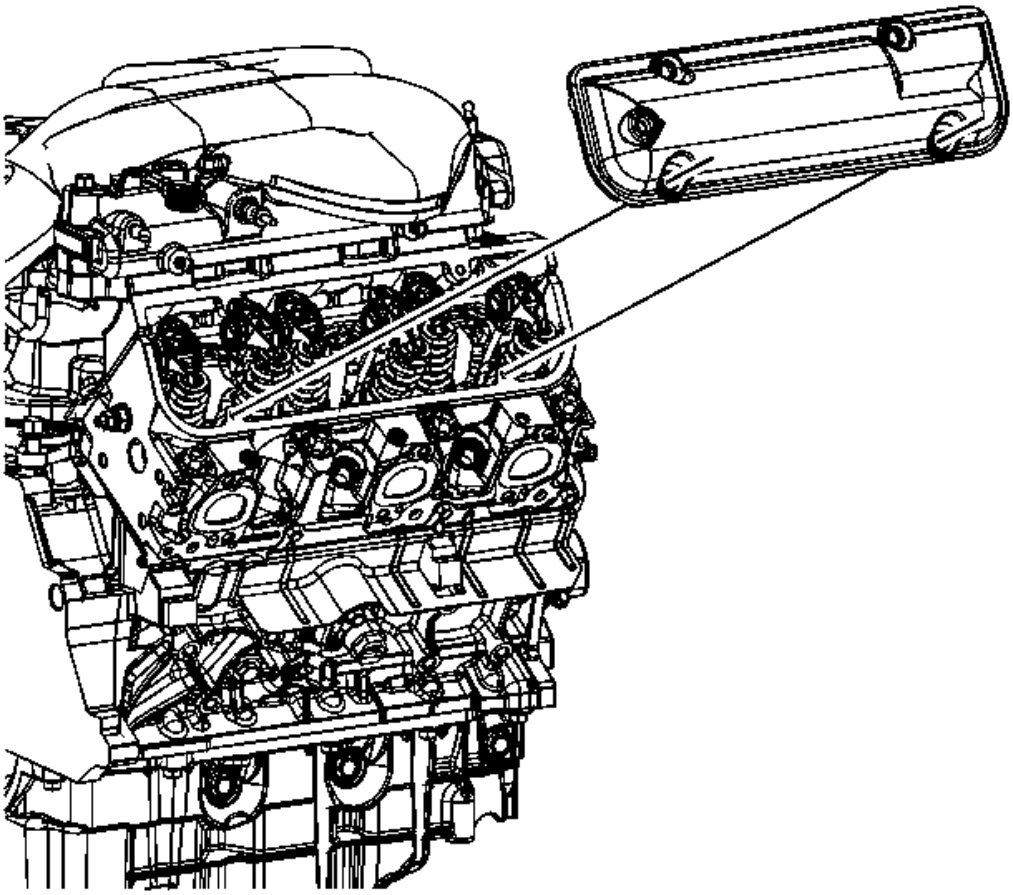

Fig. 506: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.

NOTE: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

2. Install the valve rocker arm cover gasket into the valve rocker arm cover.

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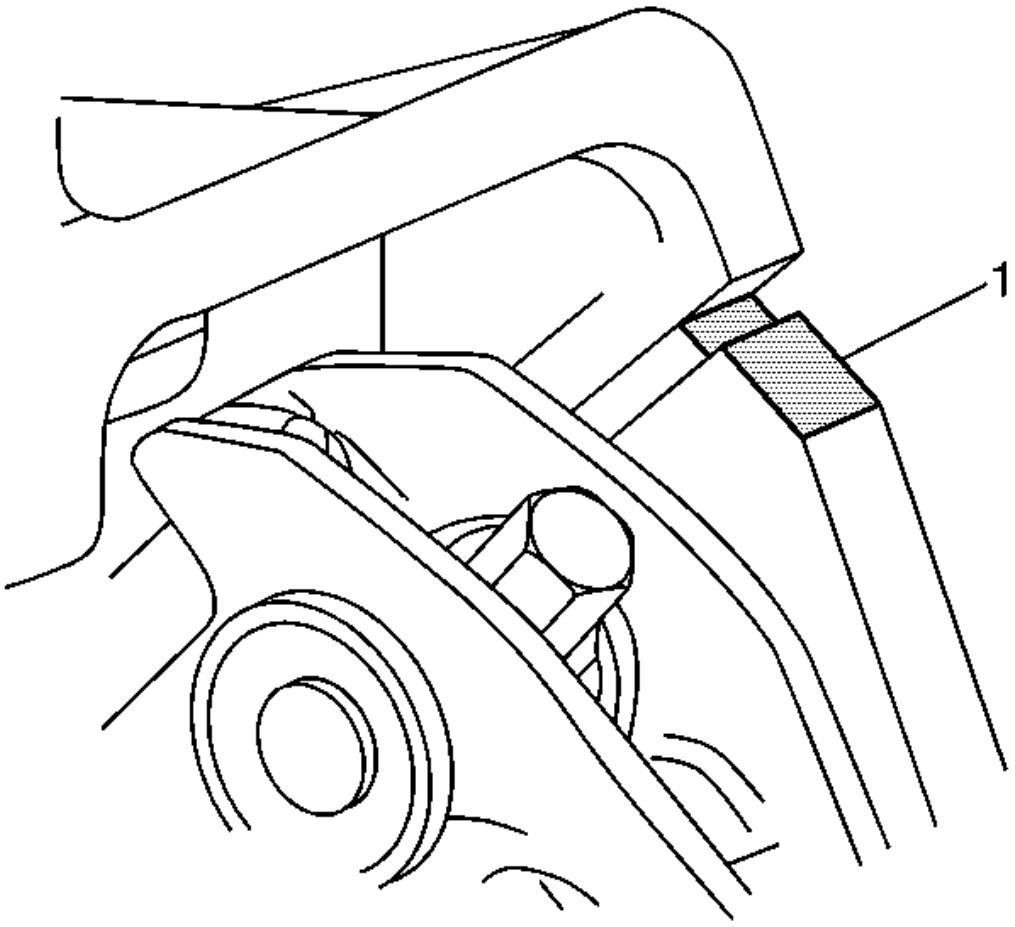

Fig. 507: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

3. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
4. Install the valve rocker arm cover.

CAUTION: Refer to Fastener Caution .

5. Install the valve rocker arm cover bolts, if necessary. Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

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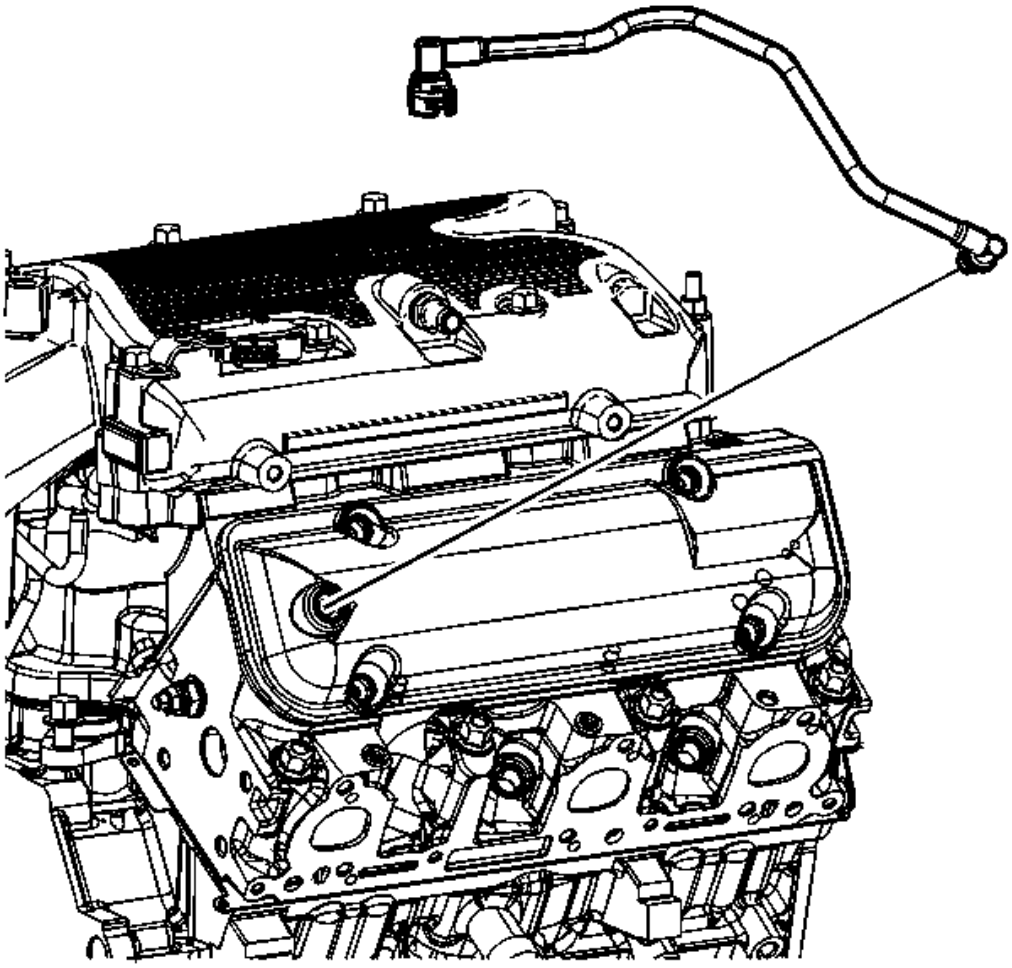

Fig. 508: Identifying Fresh Air Tube & Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Install the fresh air tube into the valve rocker arm cover.

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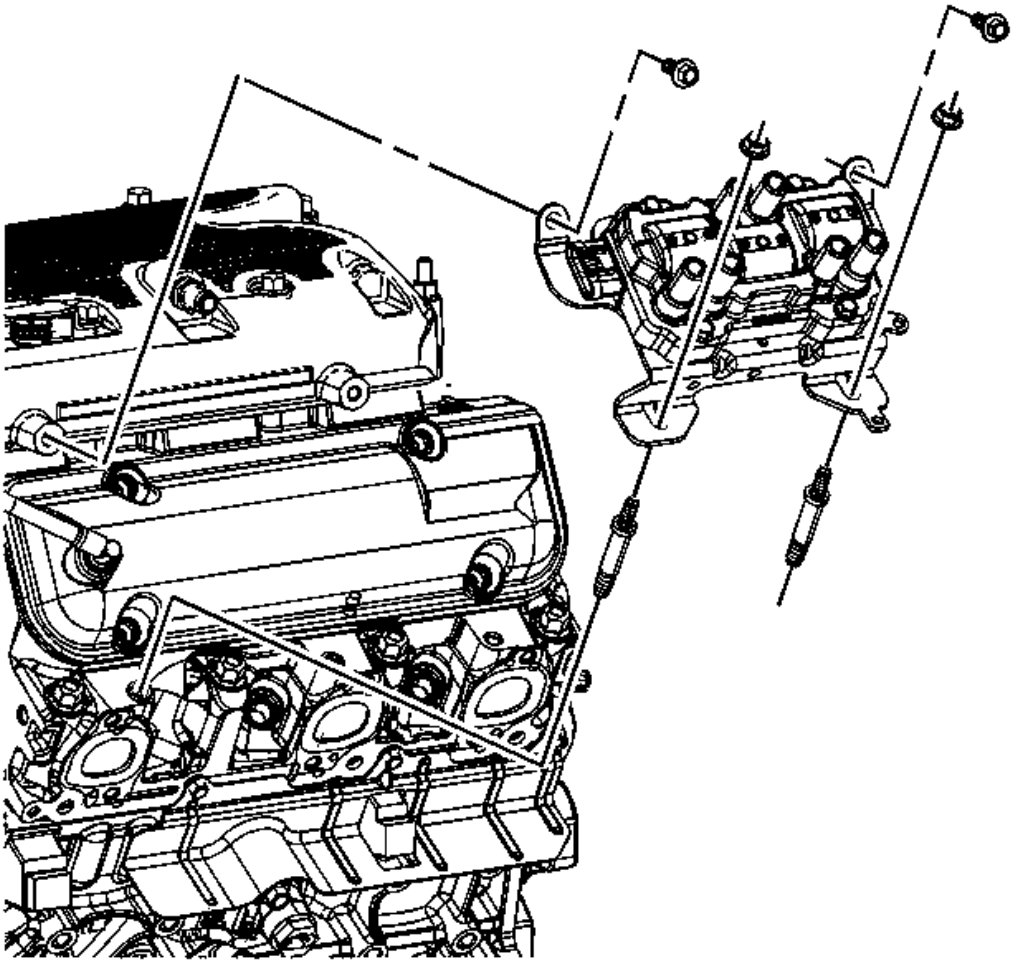

Fig. 509: Identifying Ignition Coil Assembly Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install the ignition coil assembly studs, if necessary. Tighten the ignition coil assembly studs to 25 N.m (18 lb ft).
8. Install the ignition coil assembly.
9. Install the ignition coil assembly bolts and nuts. Tighten the ignition coil assembly bolts and nuts to 25 N.m (18 lb ft).

WATER INLET AND ENGINE COOLANT THERMOSTAT INSTALLATION

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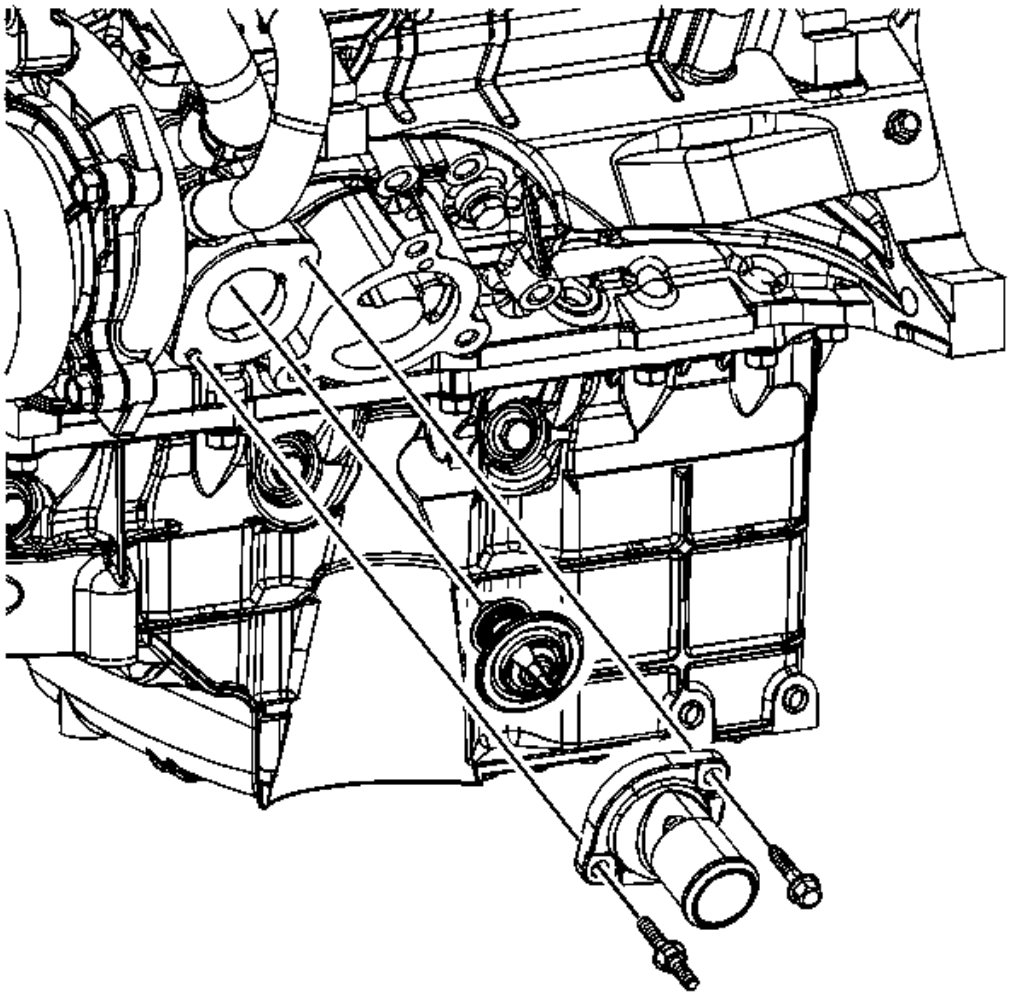

Fig. 510: Identifying Thermostat Housing & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat.
2. Install the water inlet.

CAUTION: Refer to Fastener Caution .

3. Install the water inlet bolts and tighten to 10 N.m (89 lb in).

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

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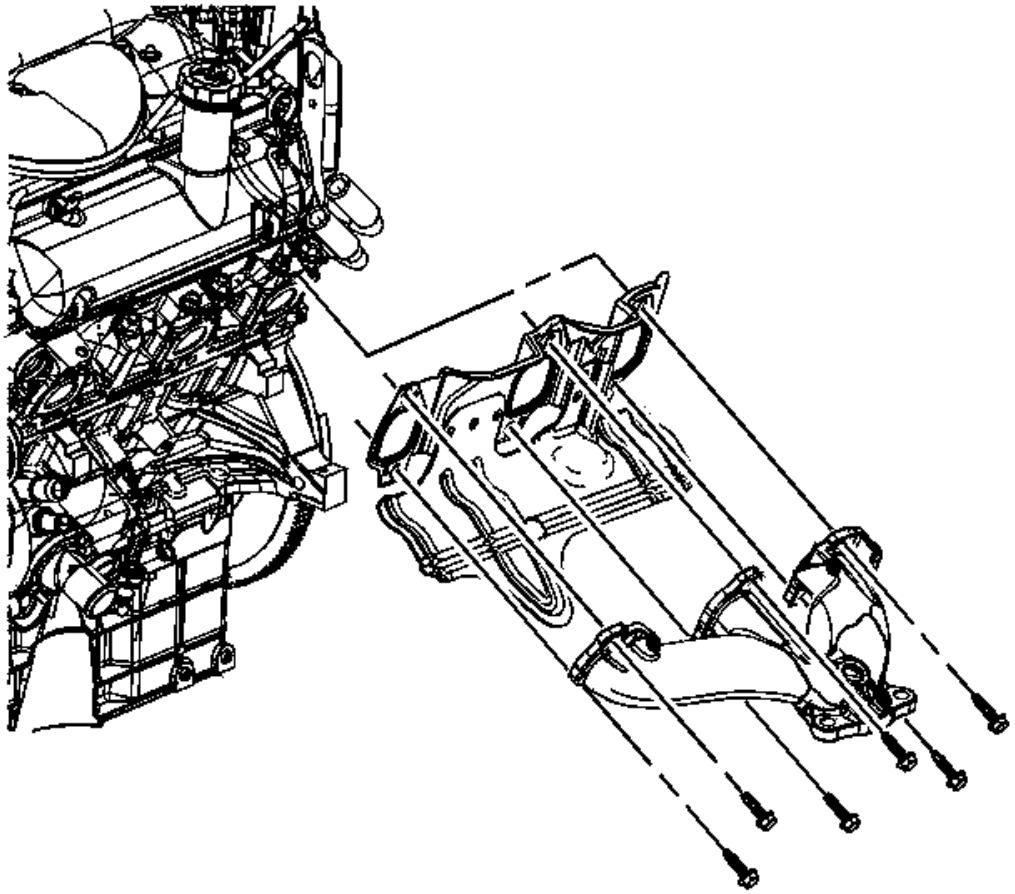

Fig. 511: Identifying Left Exhaust Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

CAUTION: Refer to Fastener Caution .

3. Install the exhaust manifold bolts and tighten to 20 N.m (15 lb ft).

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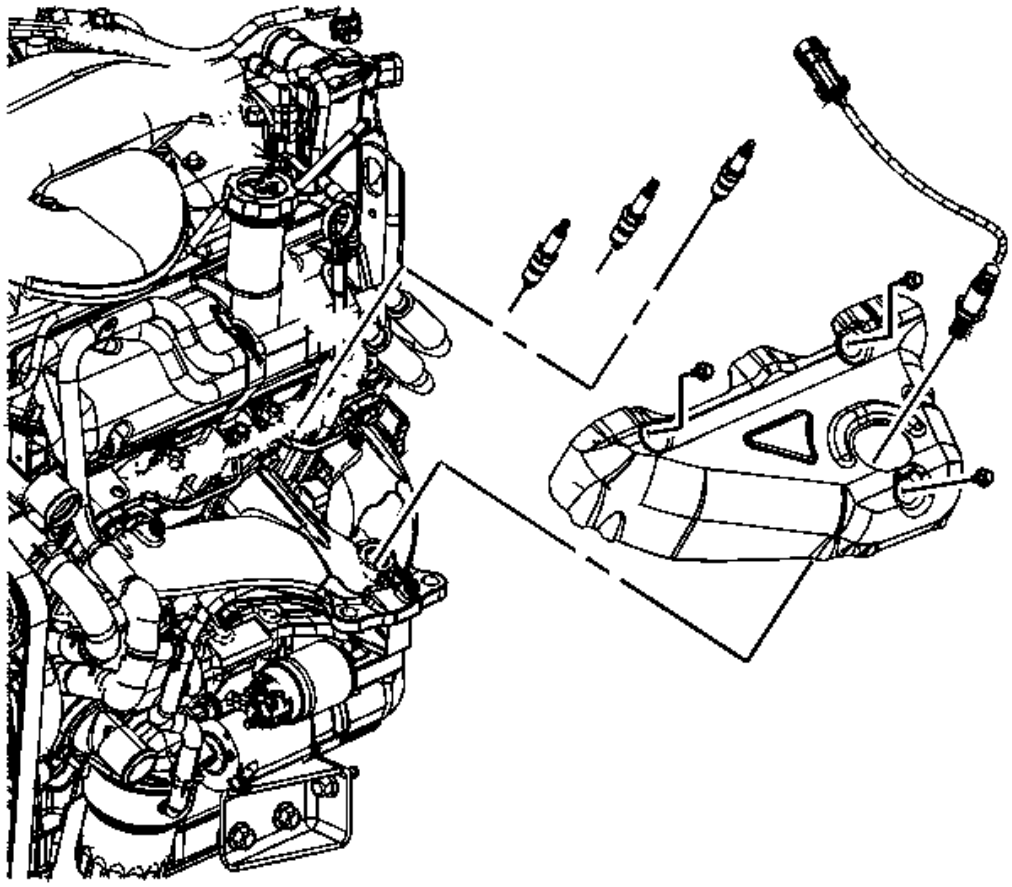

Fig. 512: Identifying Left Exhaust Manifold Heat Shield, Spark Plugs & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts and tighten to 10 N.m (89 lb in).
6. Install the spark plugs and tighten to 15 N.m (11 lb ft).
7. Install the spark plug wires.
8. Install the heated oxygen sensor and tighten to 42 N.m (31 lb ft).

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

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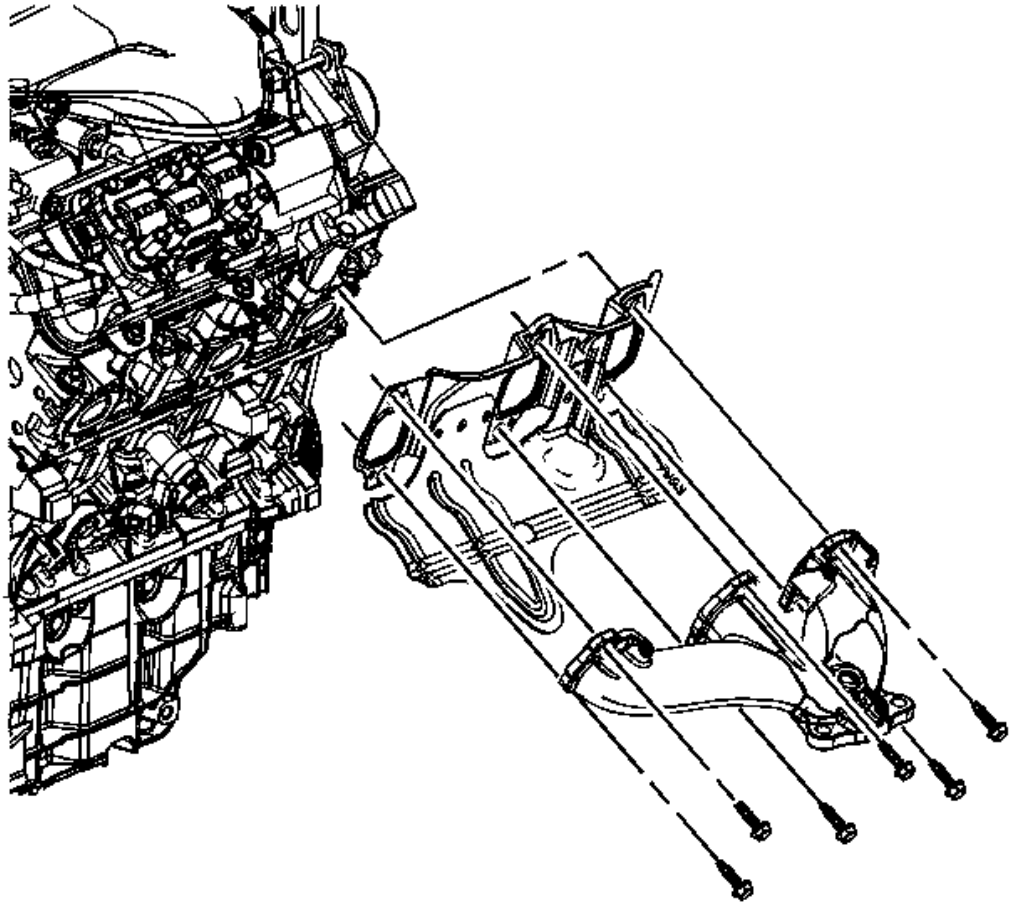

Fig. 513: View Of Right Exhaust manifold, bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

CAUTION: Refer to Fastener Caution .

3. Install the exhaust manifold bolts and tighten to 20 N.m (15 lb ft).

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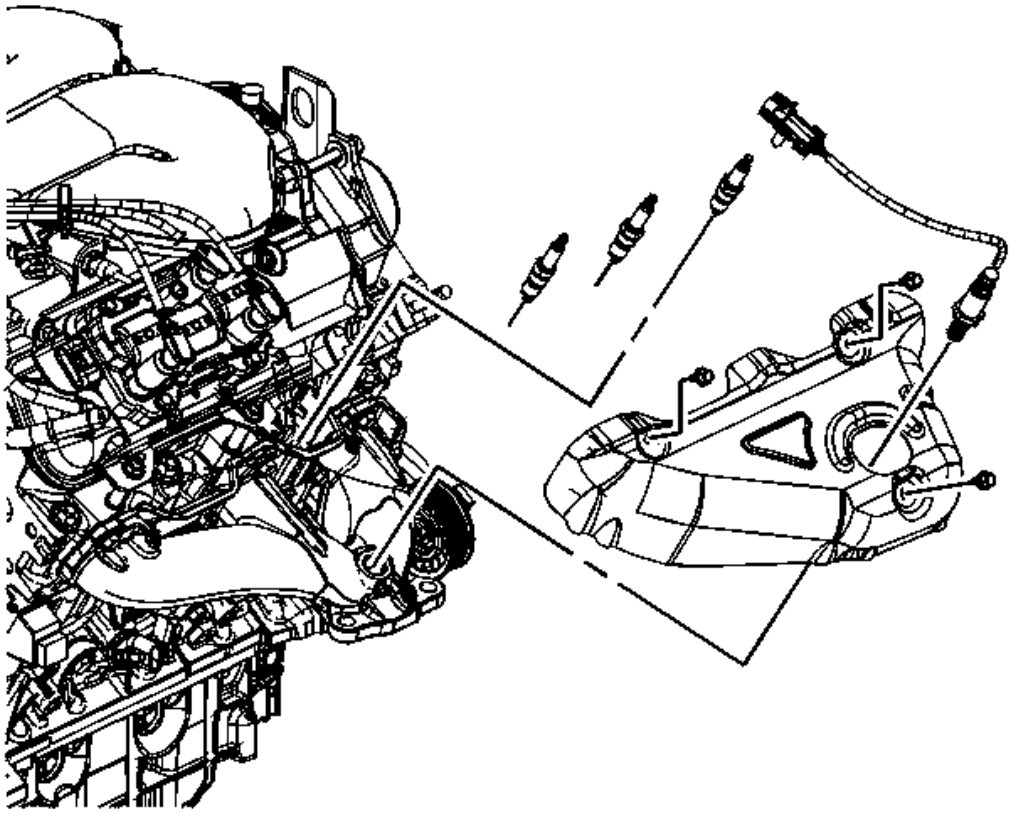

Fig. 514: Identifying Right Side Spark Plugs, HO2S & Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts and tighten to 10 N.m (89 lb in).
6. Install the spark plugs and tighten to 15 N.m (11 lb ft).
7. Install the spark plug wires.
8. Install the heated oxygen sensor and tighten to 42 N.m (31 lb ft).

OIL FILTER ADAPTER INSTALLATION

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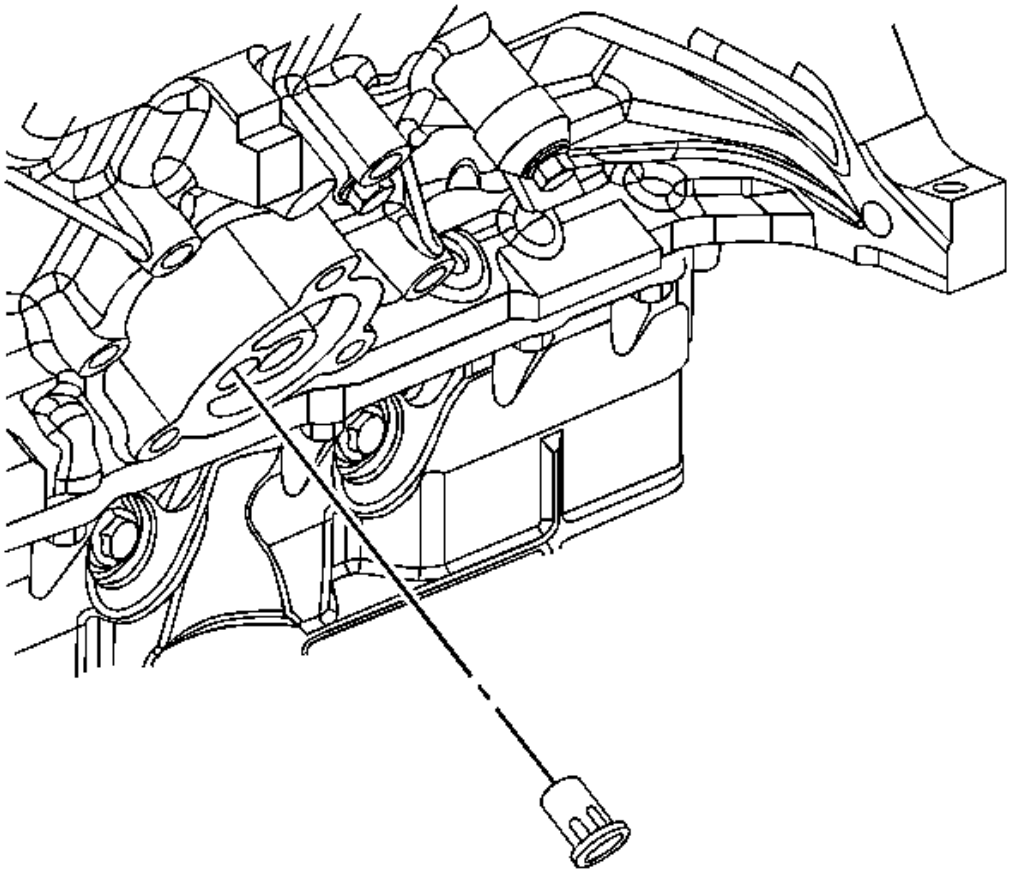

Fig. 515: Locating Oil Filter Bypass Hole & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter bypass valve. Seat the valve fully below the bypass valve hole chamfer.

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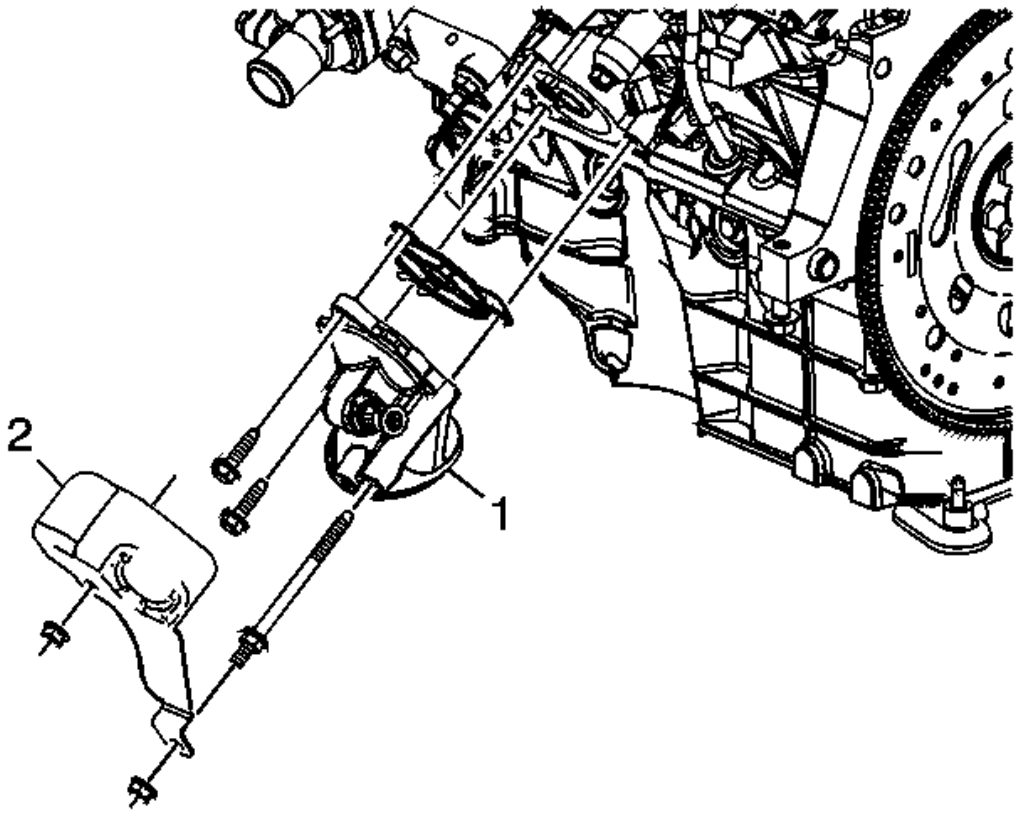

Fig. 516: Identifying Oil Filter Adapter & Heat Shield
Courtesy of GENERAL MOTORS CORP.

CAUTION: Maximum gasket performance is achieved when using new fasteners, which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

2. Install the oil filter adapter (1) and gasket.
3. Apply threadlocker P/N 21485277 to the bolt threads if required.

CAUTION: Refer to Fastener Caution .

4. Install the oil filter adapter bolts and tighten to 25 N.m (18 lb ft).

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5. Install the oil filter adapter heat shield (2).
6. Install the oil filter adapter heat shield nuts and tighten to 25 N.m (18 lb ft).

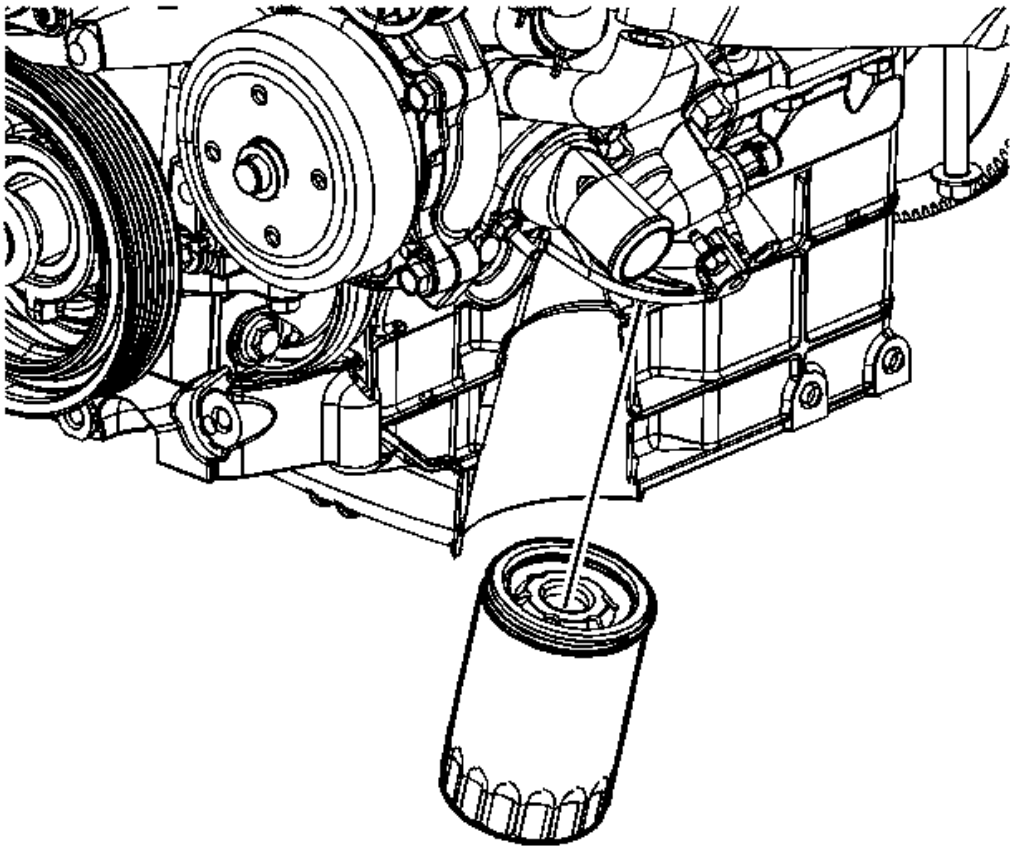

Fig. 517: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

7. Install the oil filter and tighten to 30 N.m (22 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

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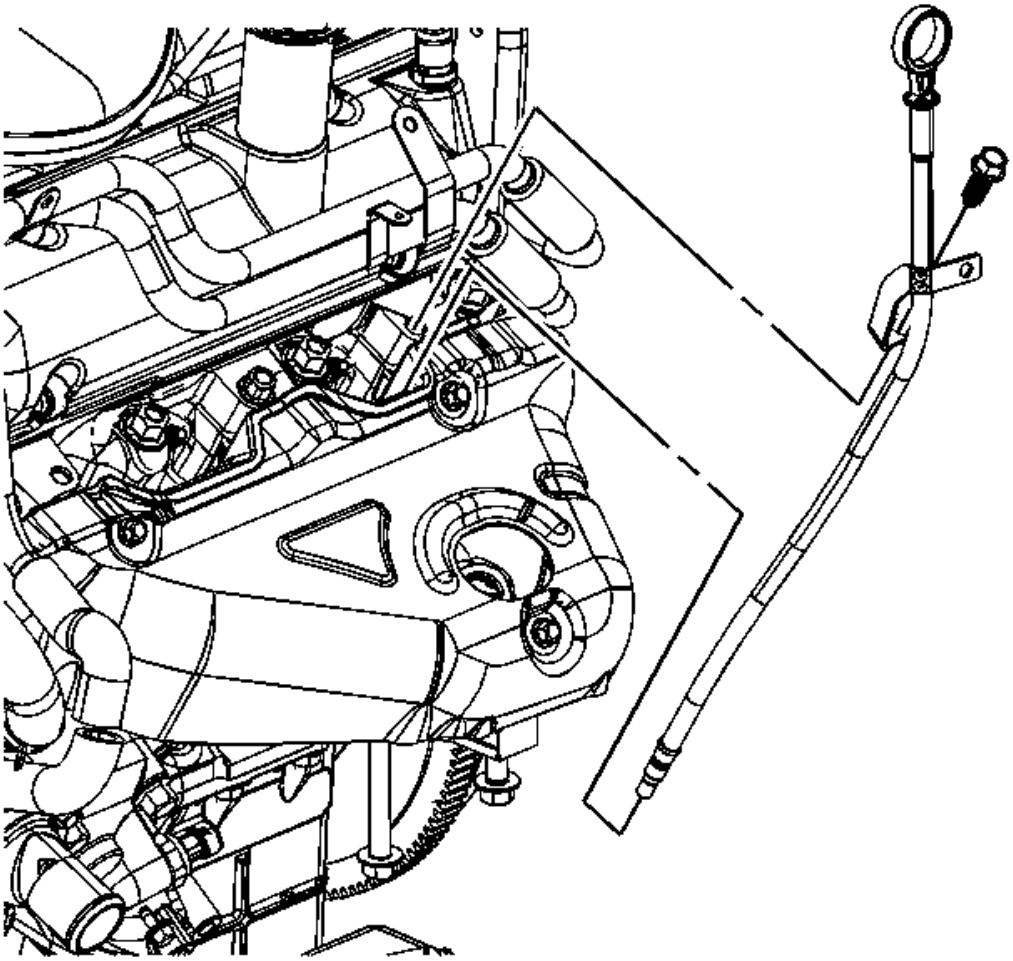

Fig. 518: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube and oil level indicator.

CAUTION: Refer to Fastener Caution .

2. Install the oil level indicator tube bolt and tighten to 25 N.m (18 lb ft).

ENGINE LIFT REAR BRACKET INSTALLATION

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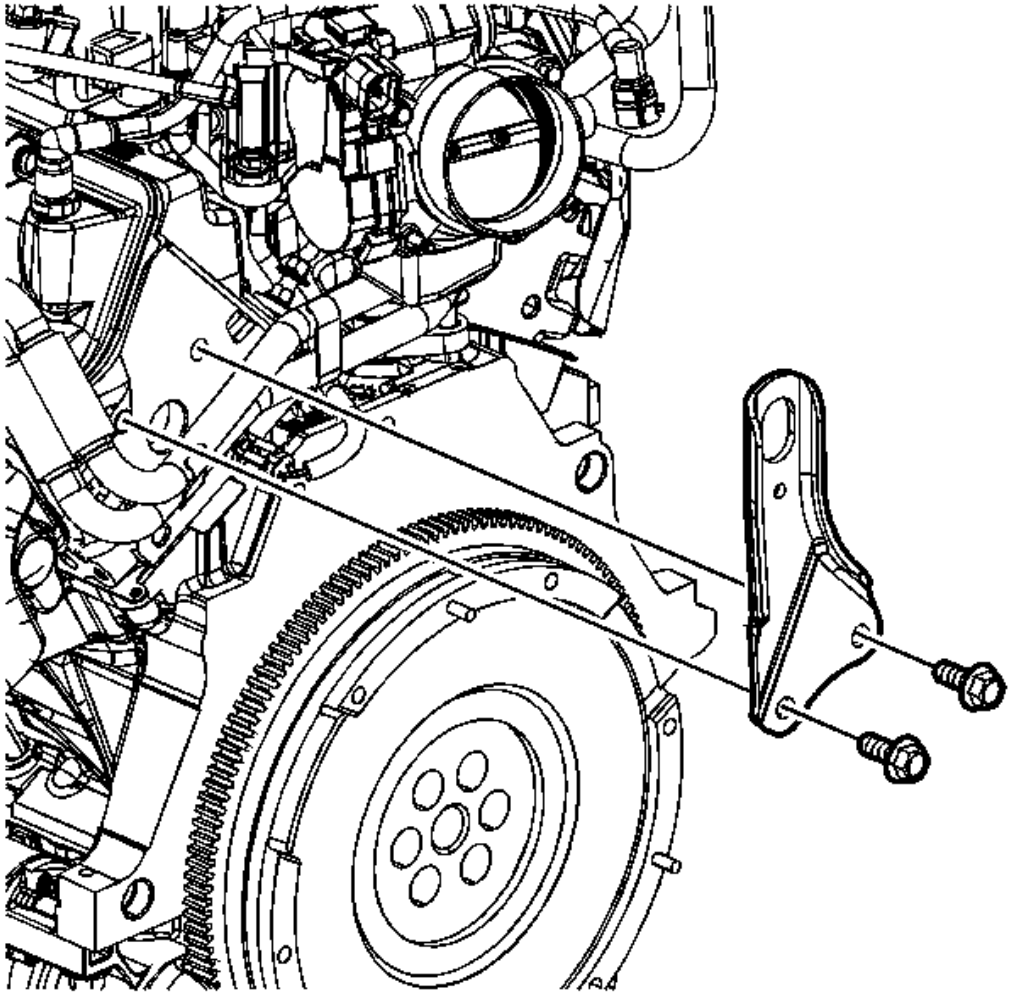

Fig. 519: Identifying Rear Engine Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the rear engine lift bracket.

CAUTION: Refer to Fastener Caution .

2. Install the rear engine lift bracket bolts and tighten to 50 N.m (37 lb ft).

ENGINE COOLANT CROSSOVER PIPE INSTALLATION

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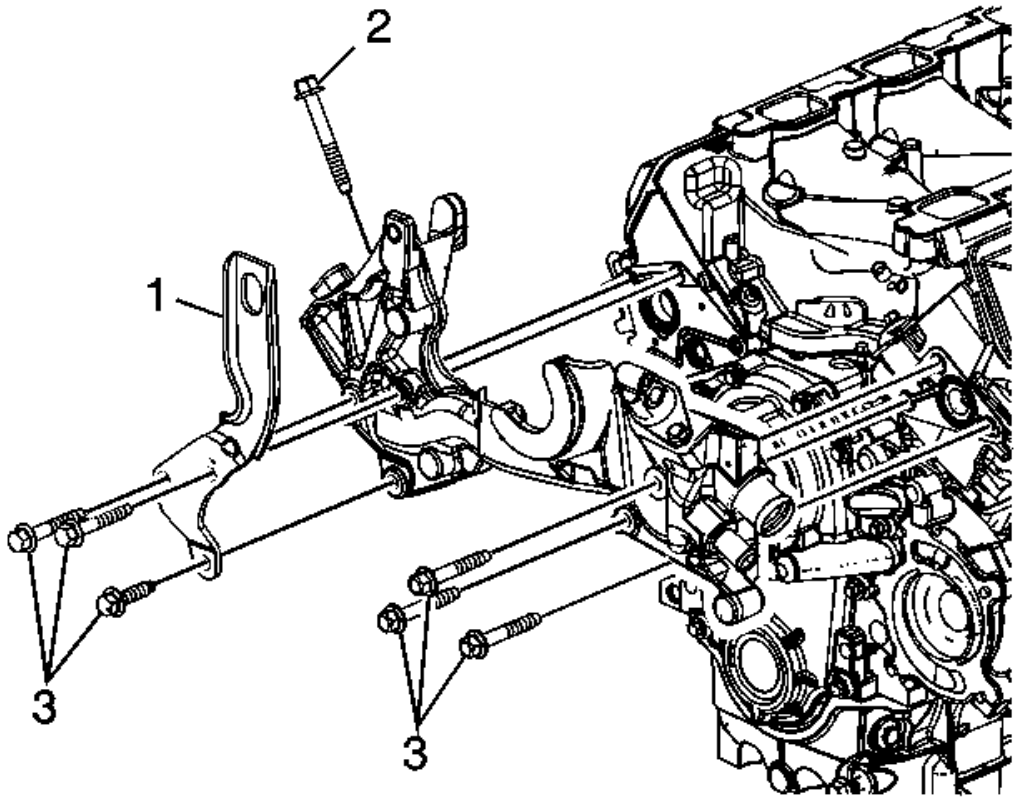

Fig. 520: Identifying Engine Lift Bracket And Front Coolant Crossover Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the coolant crossover pipe assembly onto the engine.

CAUTION: Refer to Fastener Caution .

2. Install the engine lift bracket (1) and the front coolant crossover pipe bolts (3) and tighten to 50 N.m (37 lb ft).
3. Install the side coolant crossover pipe bolt (2) and tighten to 10 N.m (89 lb in).

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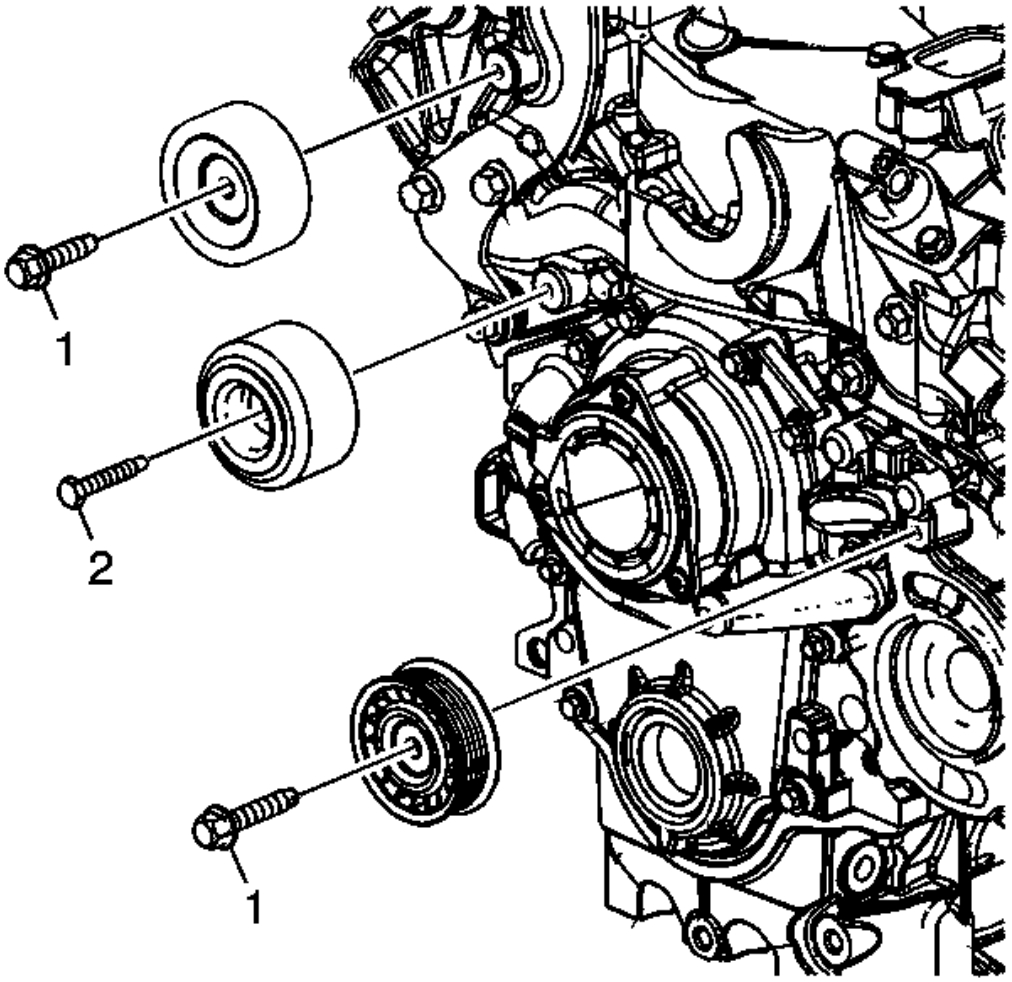

Fig. 521: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

4. Install the idler pulleys and bolts and tighten:
    - Tighten the bolts (1) to 50 N.m (37 lb ft) .
    - Tighten the bolt (2) to 30 N.m (22 lb ft) .

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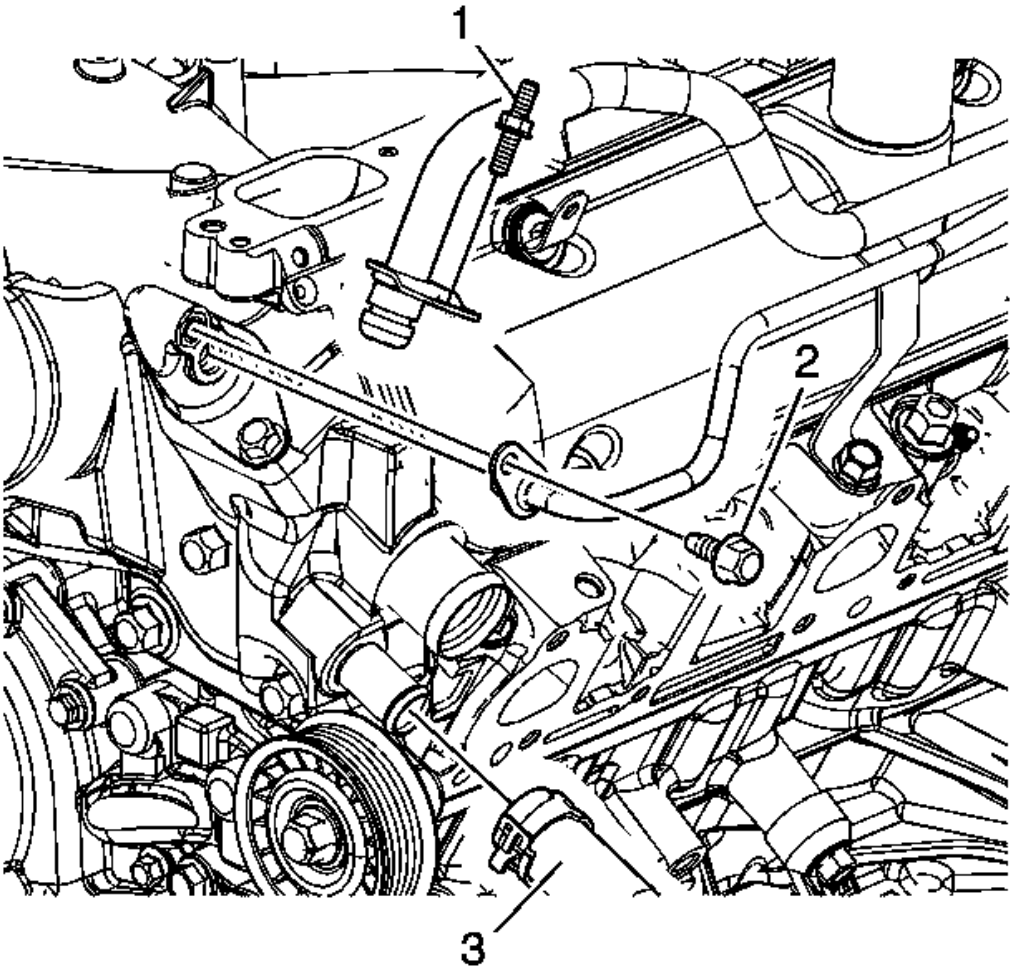

Fig. 522: Identifying Thermal Bypass Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

5. Install the coolant vent pipe and bolt (2) and tighten to 10 N.m (89 lb in).
6. Install the heater inlet/outlet pipe and bolt (1) and tighten to 10 N.m (89 lb in).
7. Install the thermal bypass hose and securely fasten the clamp (3).

DRIVE BELT TENSIONER INSTALLATION

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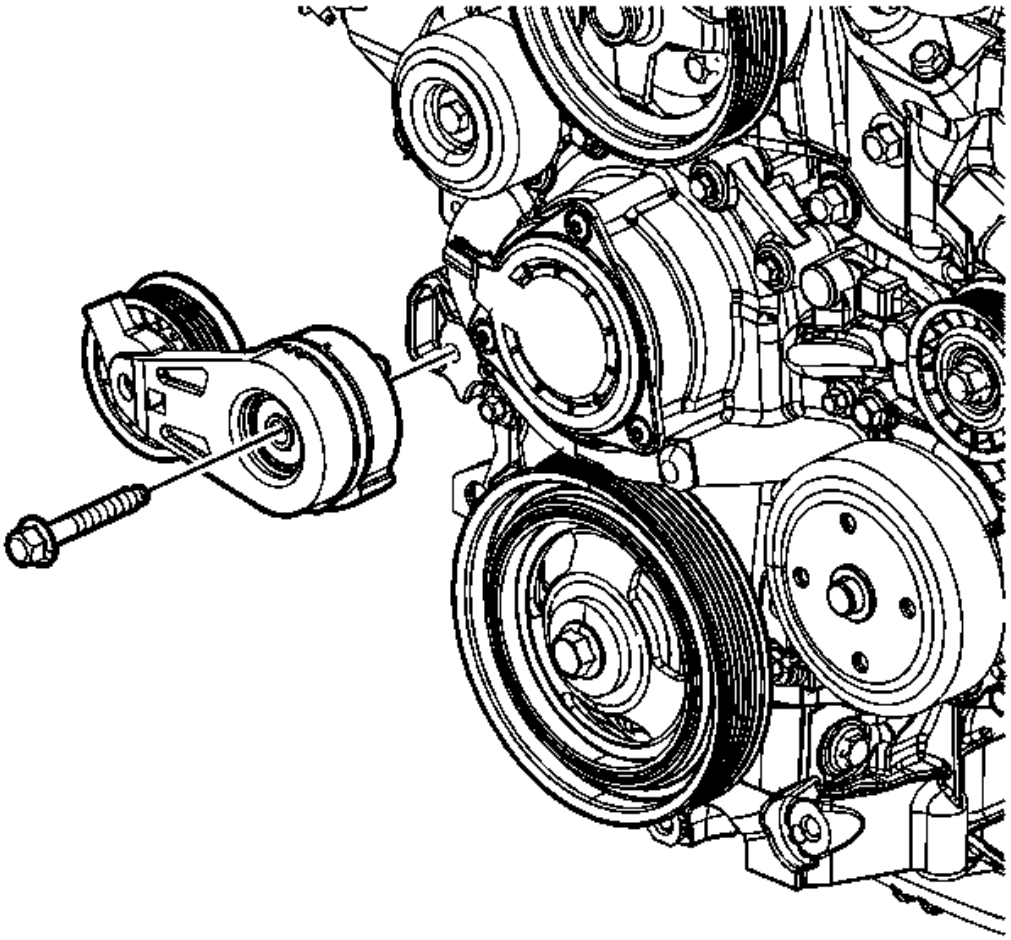

Fig. 523: Identifying Drive Belt Tensioner & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt and tighten to 50 N.m (37 lb ft).

ENGINE FLYWHEEL INSTALLATION (AUTOMATIC TRANSMISSION)

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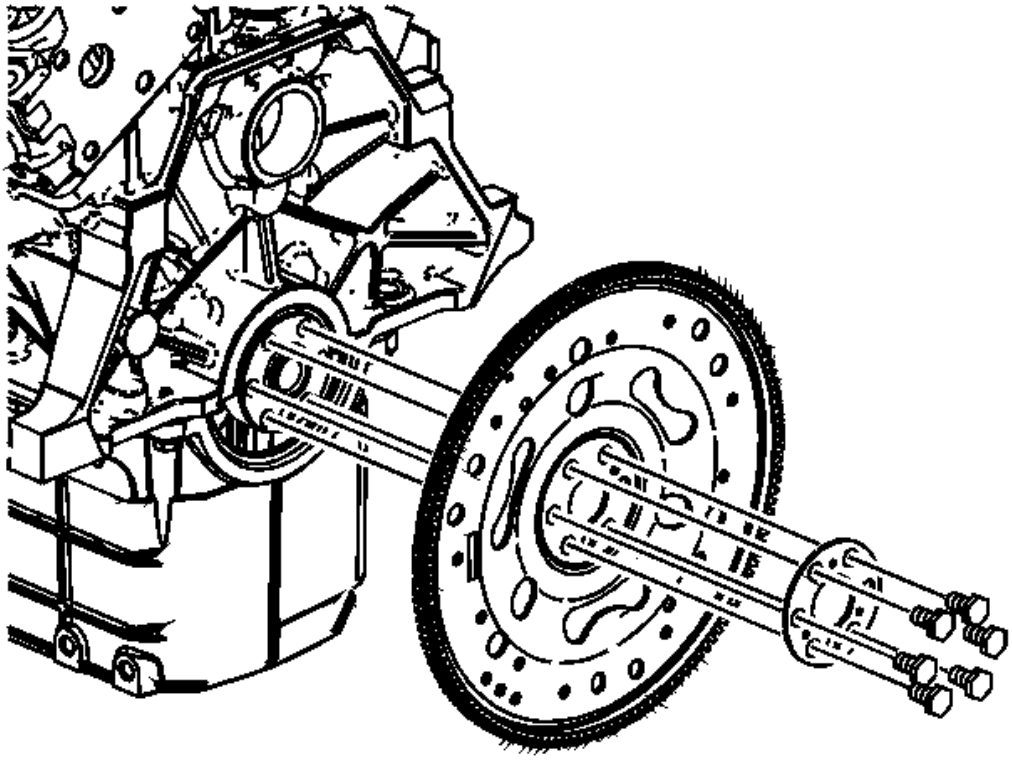

Fig. 524: Identifying Flywheel & Bolts (A/T)
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

CAUTION: Refer to Fastener Caution .

2. Install the flywheel bolts and tighten to 70 N.m (52 lb ft).

ENGINE FLYWHEEL INSTALLATION (MANUAL TRANSMISSION)

Special Tools

J 45059: Angle Meter

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

Installation

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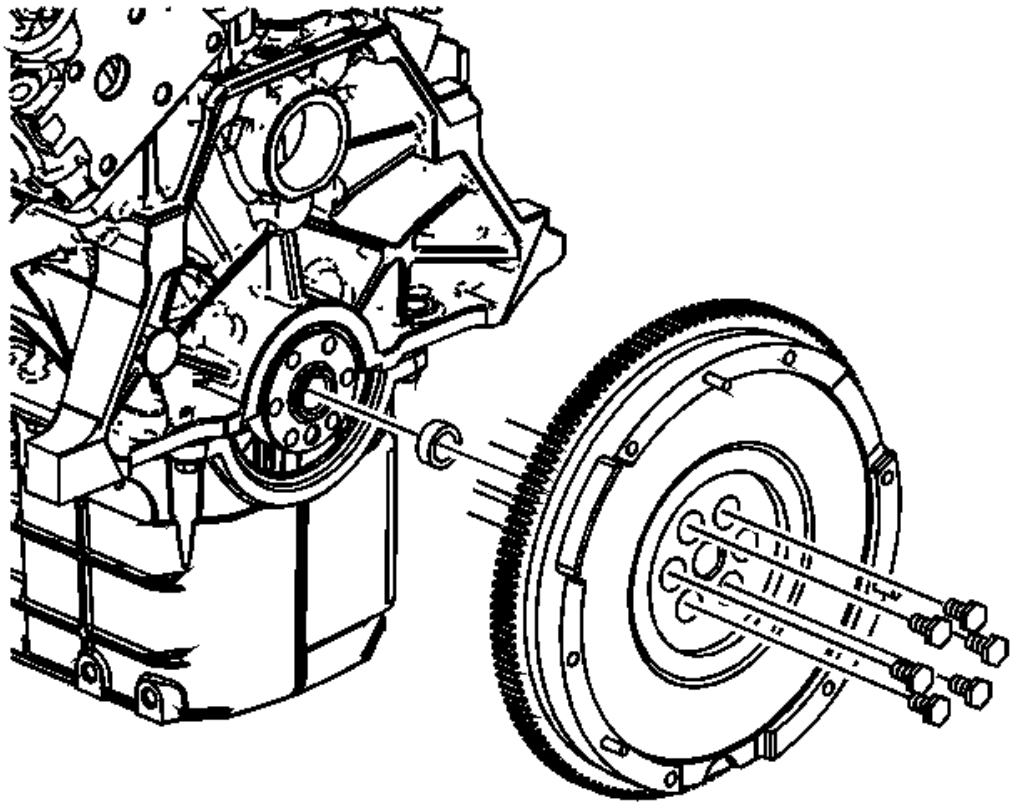

Fig. 525: Identifying Flywheel & Bolts (M/T)
Courtesy of GENERAL MOTORS CORP.

1. Install the clutch pilot bearing.
2. Install the flywheel/pressure plate.

CAUTION: Refer to Fastener Caution .

3. Install the flywheel/pressure plate bolts and tighten to 50 N.m (37 lb ft) plus an additional 70 degrees using the **J 45059:** meter.

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **J 29113:** Balancer and Crank Sprocket Puller

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- **J 45059:** Angle Meter

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

Installation

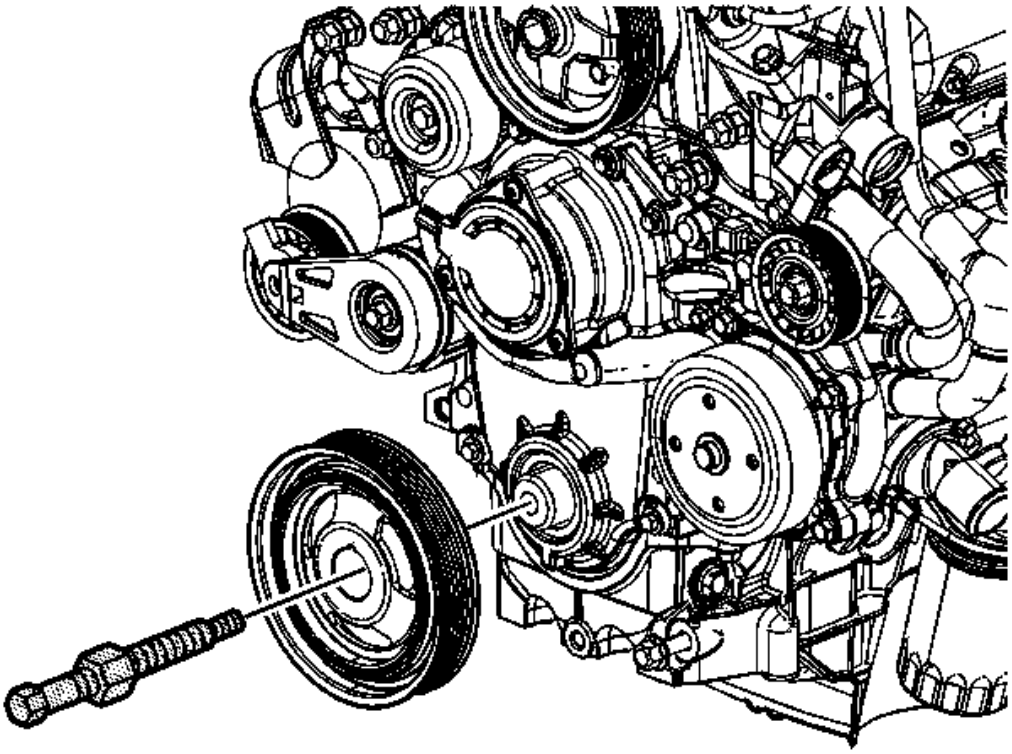

Fig. 526: View Of Balancer & Crank Sprocket Puller (J 29113)
Courtesy of GENERAL MOTORS CORP.

1. Place the crankshaft balancer into position over the key in the crankshaft.

CAUTION: Do NOT use a power-assisted tool with the special tool in order to remove or install this component. You cannot properly control the alignment of this component using a power-assisted tool, and this can damage the component.

2. Install the **J 29113:** puller onto the crankshaft.
3. Rotate the hex nut on the **J 29113:** puller to install the crankshaft balancer onto the crankshaft.
4. Remove the **J 29113:** puller from the crankshaft.

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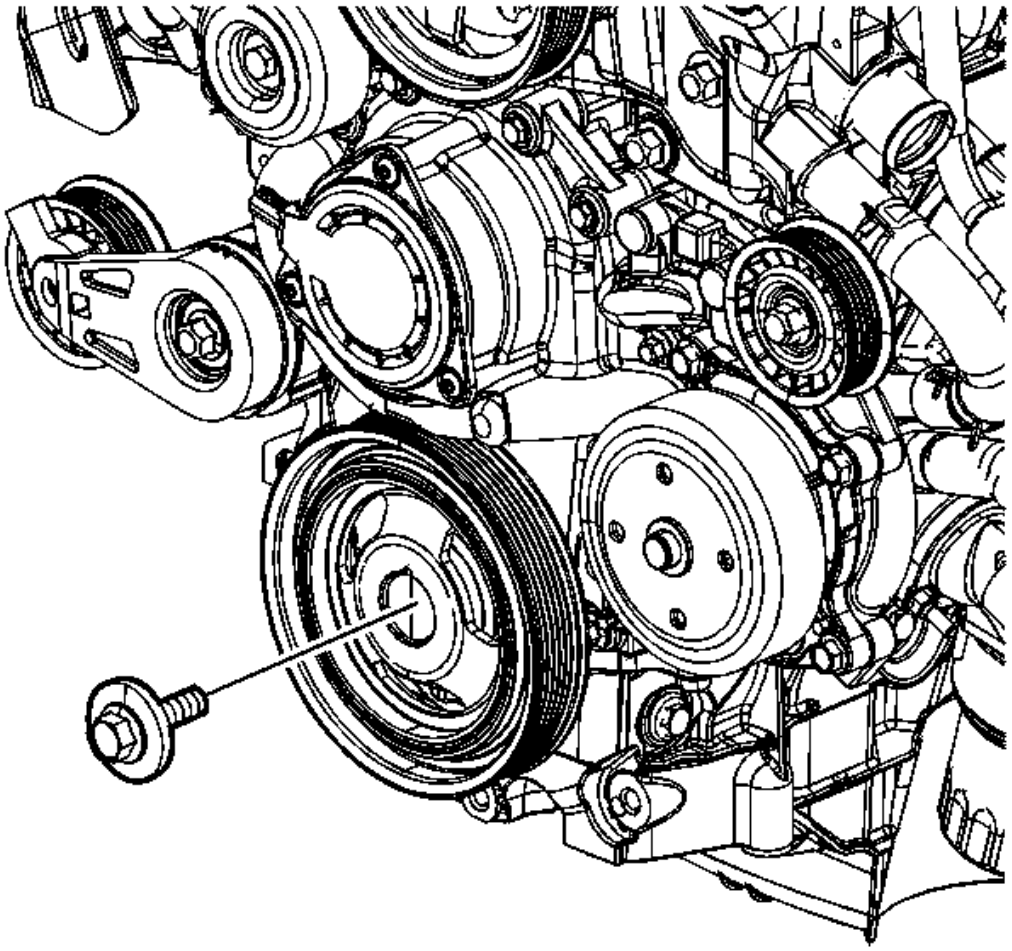

Fig. 527: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

5. Install the used crankshaft balancer bolt and tighten to 125 N.m (92 lb ft).
6. Remove the used crankshaft balancer bolt.
7. Install the NEW crankshaft balancer bolt.
    1. Tighten the crankshaft balancer bolt a first pass to 125 N.m (92 lb ft) .
    2. Tighten the crankshaft balancer bolt a final pass to 130 degrees using the **J 45059:** meter .

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ENGINE PRELUBING

Special Tools

- **J 21867-6:** Oil Pressure Adapter Fitting
- **J 45299:** Engine Preluber

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

Procedure

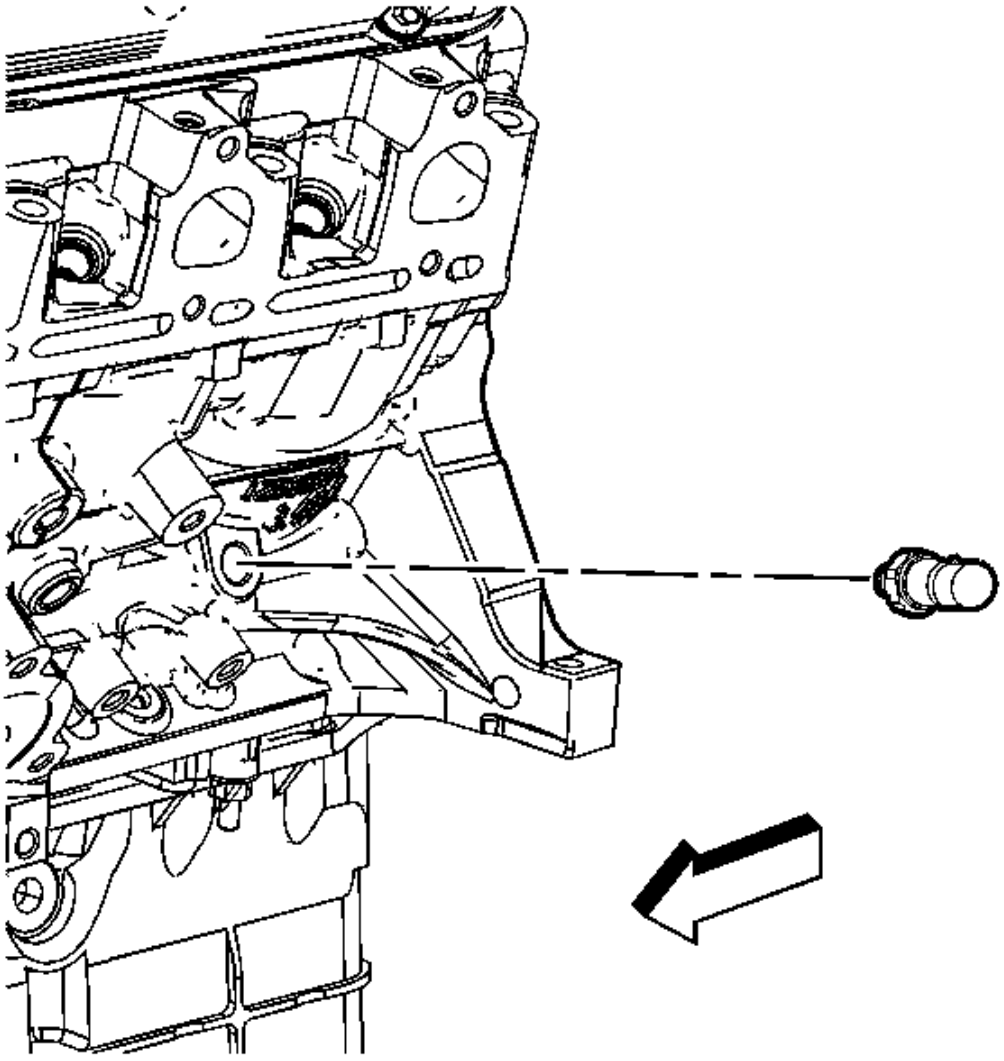

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Fig. 528: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: A constant/continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter, fill with clean engine oil, and reinstall. Tighten the oil filter to 30 N.m (22 lb ft).
2. Locate the engine oil pressure indicator switch on the left side of the engine and remove.
3. Install the 1/4 inch adapter P/N 509373 and the **J 21867-6:** fitting.

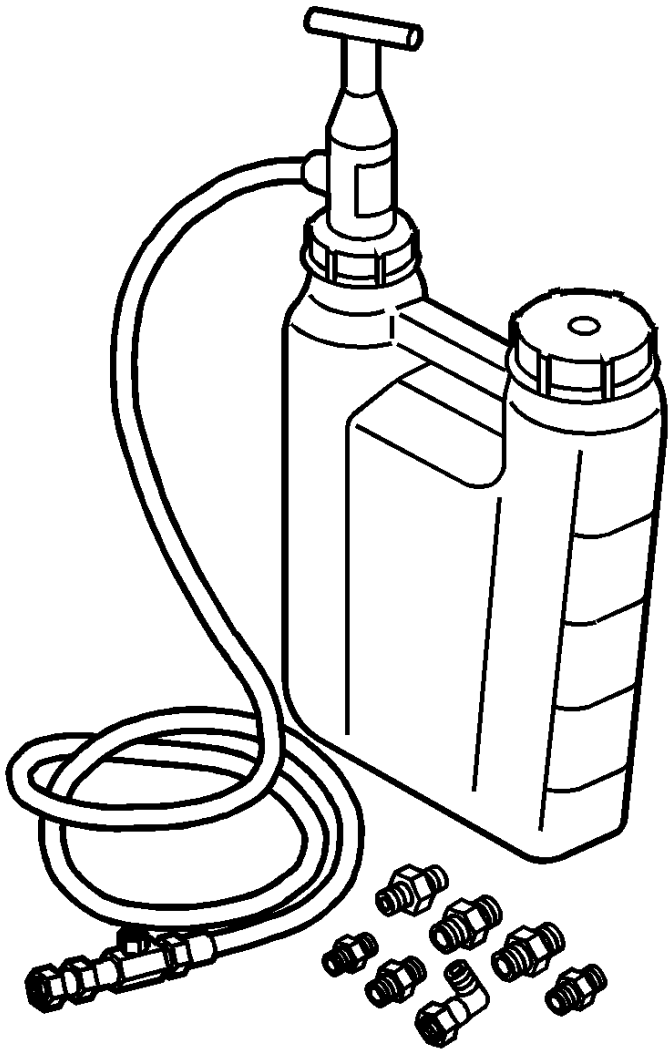

Fig. 529: Identifying Engine Preluber J 45299

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Courtesy of GENERAL MOTORS CORP.

4. Install the flexible hose to the adapter and open the valve.
5. Pump the handle on **J 45299:** preluber to flow a minimum of 1-2 quarts of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
6. Close the valve and remove the flexible hose and adapter from the engine.
7. Install the engine oil pressure indictor switch and tighten to 16 N.m (12 lb ft).
8. Top off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

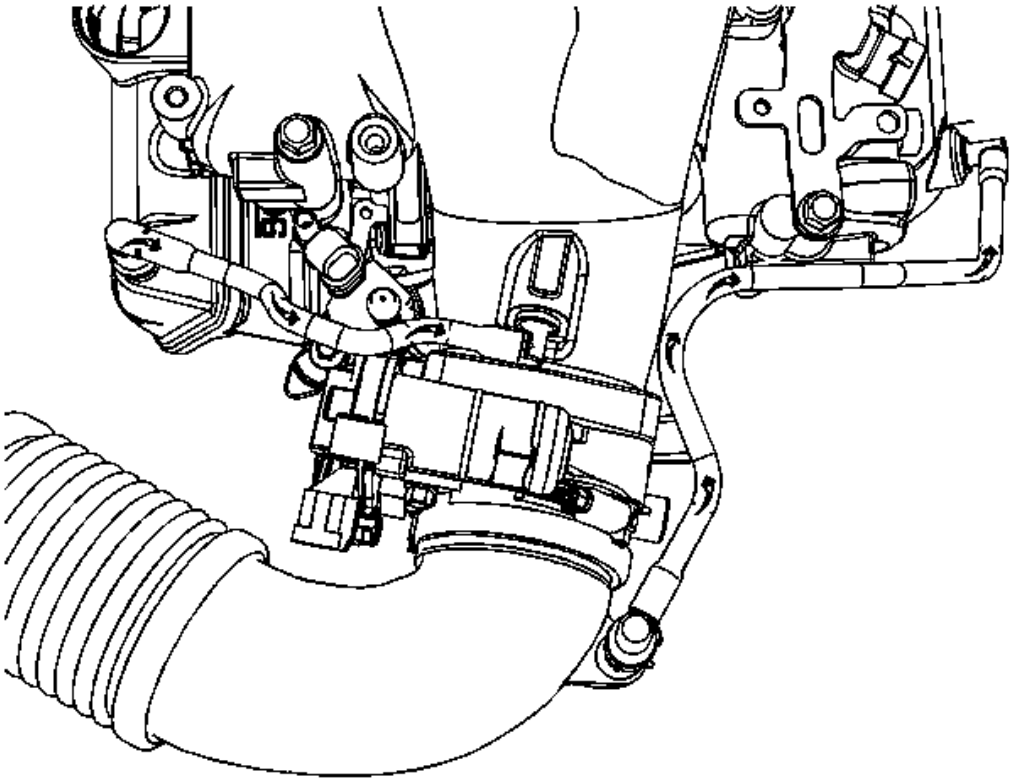

Fig. 530: View Of Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

A close crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase

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vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from upstream of the throttle blade to the front of the right rocker arm cover via a formed nylon tube. To reduce the potential of oil pullover into the throttle bore area due the back flow of the ventilation system, the fitting in the right rocker arm cover is shielded from the rocker arms. From there, fresh air and gases are routed through the crankcase and up to the opposite rocker arm cover where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a formed nylon tube to the intake manifold.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The crankshaft balancer pulley
- The accessory drive components
    - The generator
    - The A/C compressor
    - The power steering

The drive belt system uses one belt. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belt is 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.

ENGINE COMPONENT DESCRIPTION

The cylinder block is made of cast alloy iron. The cylinder block has 6 cylinders that are arranged in a V shape. There are 3 cylinders in each bank. The cylinder banks are set at a 60 degree angle from each other.

The left - front bank cylinders are 2, 4, 6. The right - rear bank cylinders are 1, 3, 5. Firing order is 1-2-3-4-5-6.

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Four main bearings support the crankshaft. The crankshaft is retained by the bearing caps. The bearing caps are machined with the block for proper alignment and clearances. The main bearing caps are drilled and tapped for the structural oil pan side bolts.

The aluminum cylinder heads have individual intake and exhaust ports for each cylinder. The valve guides are pressed in. The roller rocker arms are located on a pedestal in a slot in the cylinder head. The roller rocker arms are retained on individual threaded bolts.

The crankshaft is forged steel with deep rolled fillets on all 6 crankpins and all 4 main journals. Four steel-backed aluminum bearings are used. The #3 bearing is the end-thrust bearing.

The camshaft is made from a new metal composite design. The camshaft profile is a hydraulic roller design. The camshaft is supported by 4 journals. The camshaft includes an oil pump drive gear.

The pistons are cast aluminum using 2 compression rings and 1 oil control ring. The pistons also have 2 polymer coated patches on the skirt for noise reduction. The piston pin is offset 0.8 mm (0.031 in) towards the major thrust side. This placement allows for a gradual change in thrust pressure against the cylinder wall as the piston travels its path. The pins are made of chromium steel and have a floating fit in the pistons. The pins are retained in the connecting rods by piston pin retainer clips.

The connecting rods are made of forged steel. Full pressure lubrication is directed to the connecting rods by drilled oil passages from the adjacent main bearing journal.

A roller rocker type valve train is used. Motion is transmitted from the camshaft through the hydraulic roller lifter and from the pushrod to the roller rocker arm. The rocker arm pivots on the needle roller bearings. The rocker arm transmits the camshaft motion to the valve. The rocker arm pedestal is located in a slot in the cylinder head. The rocker arm is retained in the cylinder head by a bolt. The pushrod is located by the rocker arm.

The intake manifold is a 2-piece cast aluminum unit. The intake manifold centrally supports a fuel rail with 6 fuel injectors.

The exhaust manifolds are cast nodular iron.

LUBRICATION DESCRIPTION

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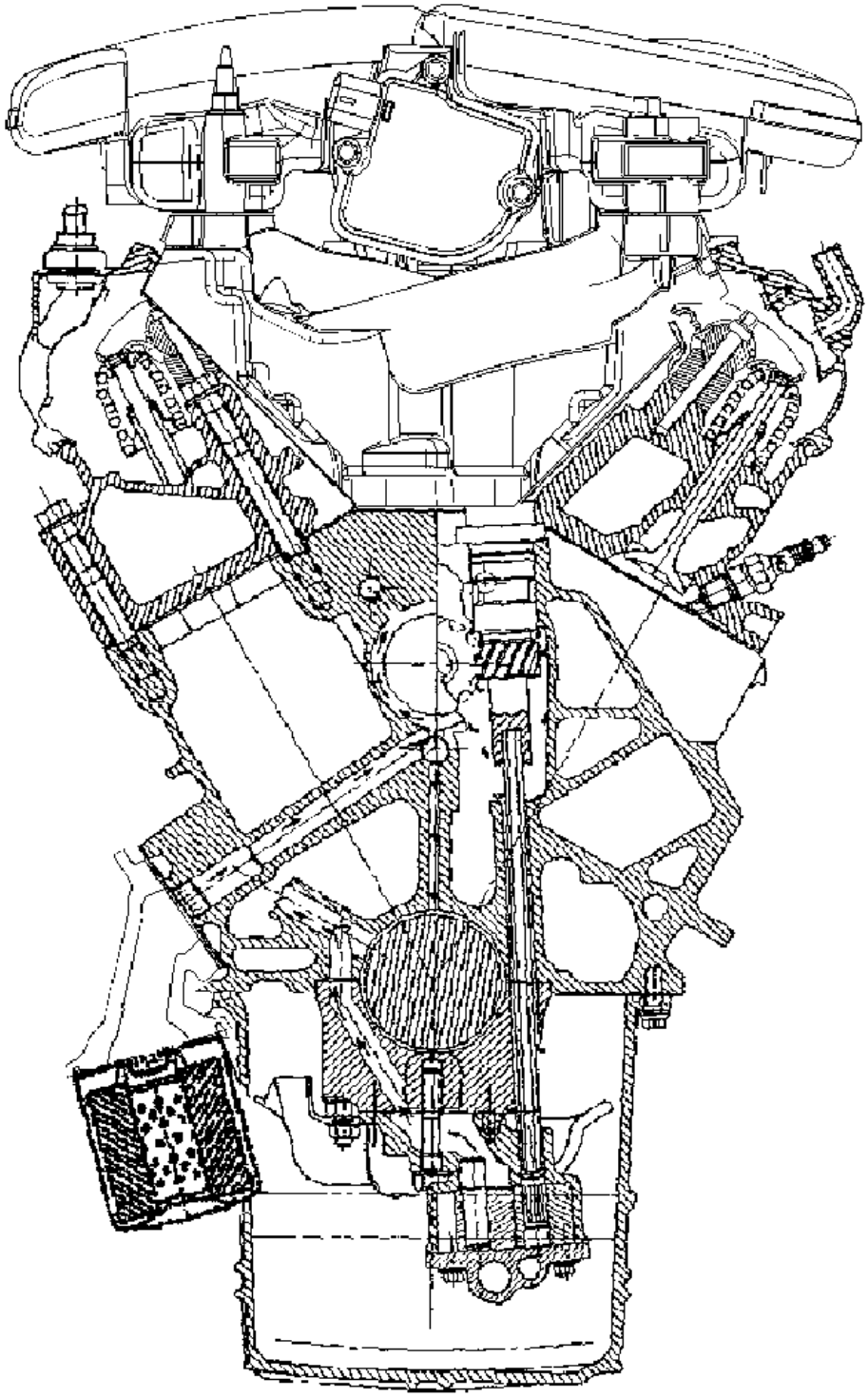

Fig. 531: Engine Lubrication Front View
Courtesy of GENERAL MOTORS CORP.

Full pressure lubrication, through a full flow oil filter, is furnished by a gear type oil pump. The oil is drawn up through the pickup screen and the tube. The oil passes through the pump to the oil filter.

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The oil filter is a full flow paper element unit. An oil filter bypass is used in order to ensure oil supply during the following conditions:

- On a cold start
- If the filter is plugged
- If the filter develops excessive pressure drop

The bypass is designed to open at 69-83 kPa (10-12 psi).

A priority oil delivery system supplies oil first to the crankshaft journals. The oil from the crankshaft main bearings is supplied to the connecting rod bearings by intersecting the passages drilled in the crankshaft. The passages supply the oil to the crankshaft main bearings and the camshaft bearings through the intersecting vertical drilled holes. The oil passages from the camshaft journals supply oil to the hydraulic lifters, and the piston oil nozzles. The camshaft phaser is fed oil from the number 1 camshaft bearing journal.

The piston oil nozzles lubricate the pistons and cylinder walls. A not-serviceable check valve integrated into the nozzle prevents oil bleed down from the nozzle when the engine is not running.

The hydraulic lifters pump oil up through the pushrods to the rocker arms. The cast dams in the crankcase casting direct the oil that drains back from the rocker arms onto the camshaft lobes. The camshaft chain drive is lubricated by indirect oil splash.

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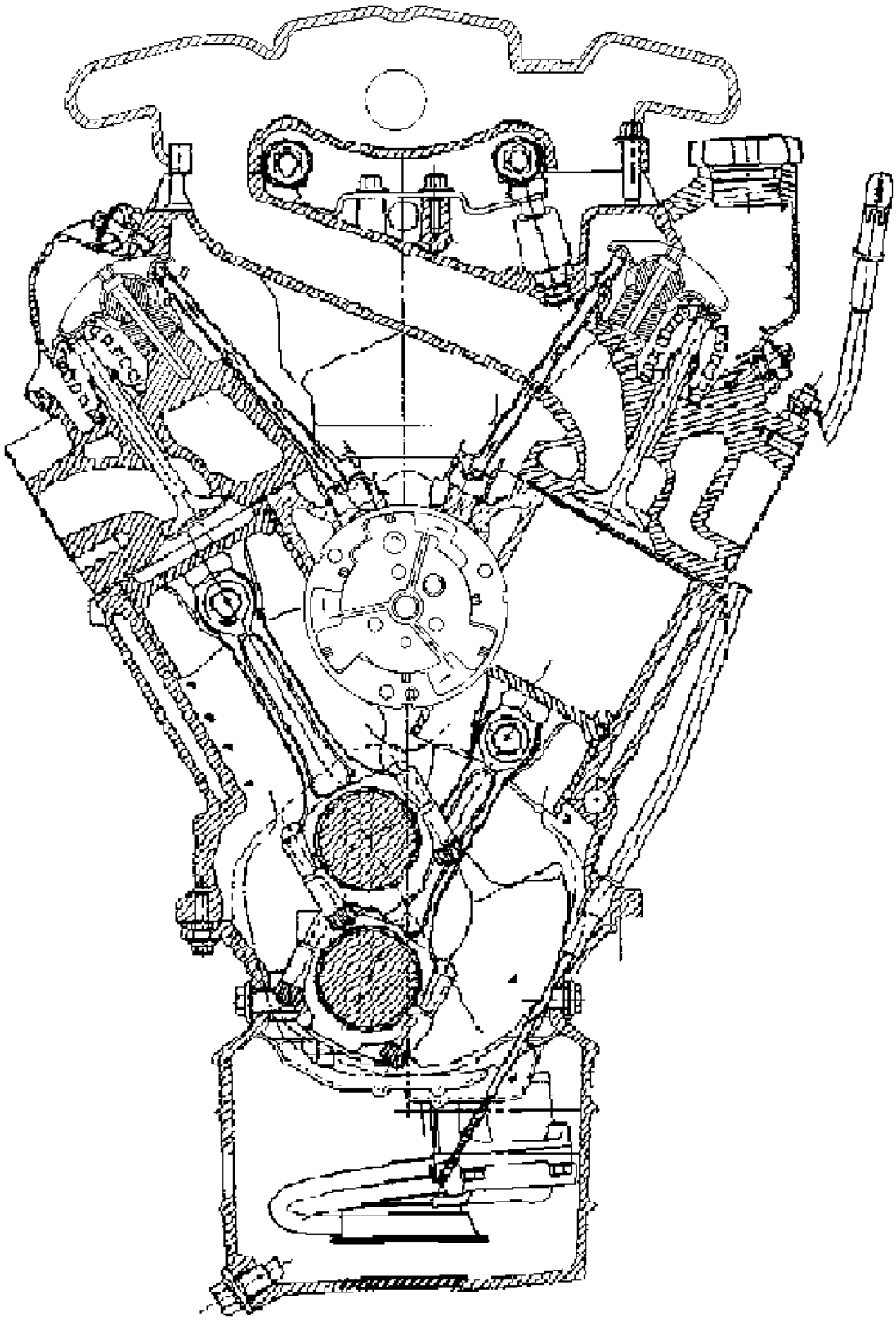

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Fig. 532: Engine Lubrication Rear View
Courtesy of GENERAL MOTORS CORP.

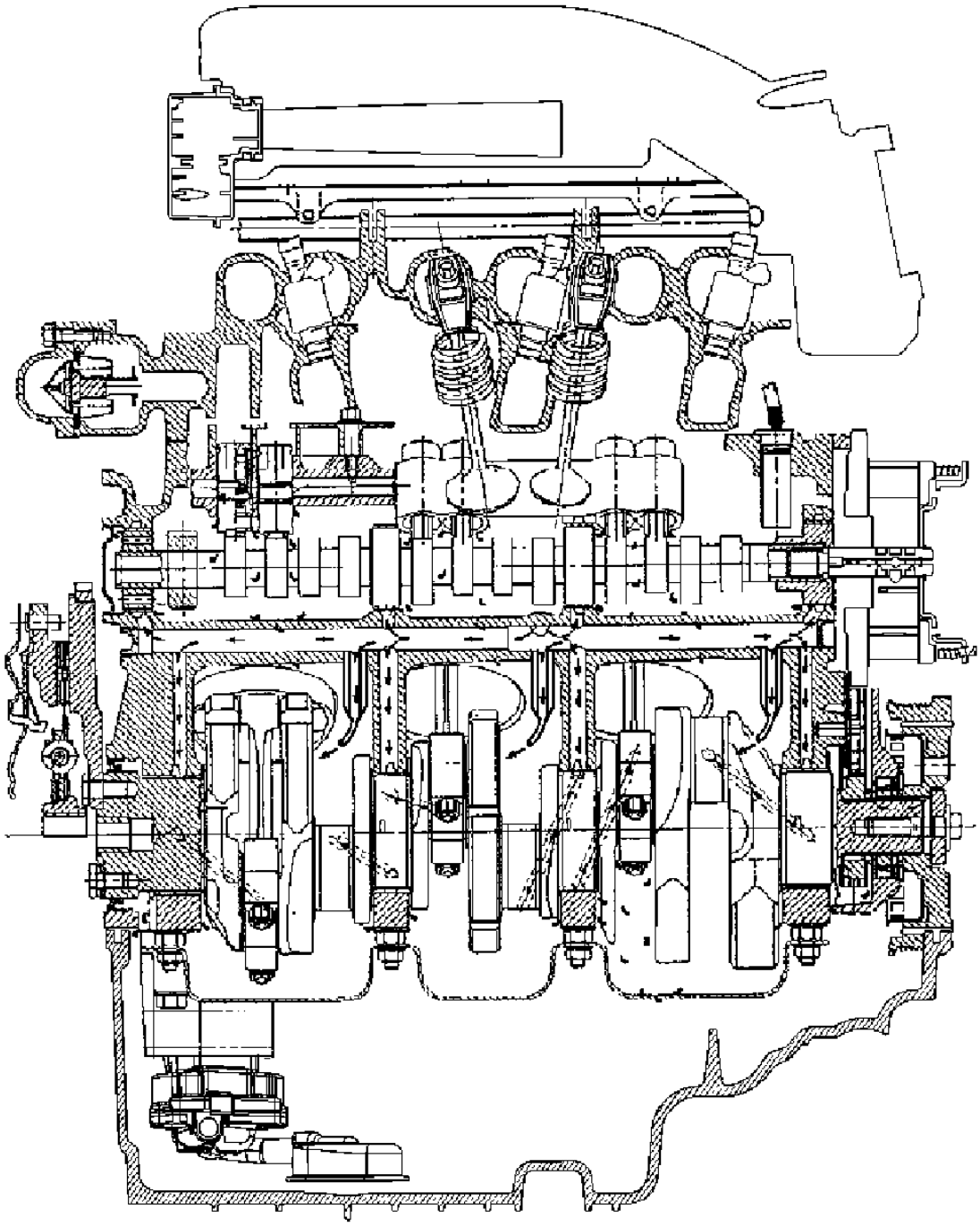

Fig. 533: Engine Lubrication Right View
Courtesy of GENERAL MOTORS CORP.

CLEANLINESS AND CARE

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

- Machined
- Honed
- Polished
- Lapped

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

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

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

WARNING: Refer to Battery Disconnect Warning .

Disconnect the negative battery cables before you perform any major work on the engine.

SEPARATING PARTS

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

REPLACING ENGINE GASKETS

1. Do not reuse any gasket unless otherwise specified. Reusable gaskets will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service procedure.
2. Use a rubber mallet in order to separate components. Bump the part sideways in order to loosen the components. Perform the bumping at the bends or at the reinforced areas in order to prevent the distortion of components.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a components.
Do not use the following items in order to clean the gasket surfaces:

- **Abrasive pads**

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- **Sand paper**
- **Power tools**

These methods of cleaning may damage the component. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

3. Remove all of the gasket and the sealing material from the component using a plastic or a wood scraper. Do not gouge or scrape the sealing surfaces.

IMPORTANT: Do not allow the sealant to enter any blind threaded holes. The sealant may cause the following conditions:

- **Prevent you from properly seating the bolt**
- **Cause damage when you tighten the bolt**

4. When assembling components, use only the sealant specified in the service procedure. Ensure that the sealing surfaces are clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure.
5. Tighten the bolts to the specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

The following 2 types of sealer are commonly used in engines:

- The RTV sealer
- The anaerobic gasket eliminator sealer

Follow the service procedure instructions. Use the correct sealer in the proper place in order to prevent oil leaks. Do not interchange the 2 types of sealers. Use the sealer recommended in the service procedure.

Applying RTV Sealer

- Do not use the room temperature vulcanizing (RTV) sealant in areas where extreme temperatures are expected. These areas include the following locations:
  - The exhaust manifold
  - The head gasket
  - The other surfaces where gasket eliminator is specified
- Use a rubber mallet in order to separate the components sealed with RTV sealant. Bump the part sideways in order to shear the RTV sealer. Perform the bumping at the bends or the reinforced areas in order to prevent distortion of the components. The RTV sealant is weaker in shear (lateral) strength than in tensile (vertical) strength.

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IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a component.

- Do not use the following items in order to clean the gasket surfaces:
  - Abrasive pads
  - Sand Paper
  - Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.

IMPORTANT: Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:

  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt
- Apply the RTV sealant to a clean surface. Use a bead size as specified in the procedure. Apply the bead to the inside of any bolt holes.
- Assemble the components while the RTV sealant is still wet (within 3 minutes). Do not wait for the RTV sealant to skin over.

IMPORTANT: Do not overtighten the bolts.

- Tighten the bolts to specifications.

Applying Anaerobic Sealer

The anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a component.

Do not use the following items in order to clean the gasket surfaces:

- Abrasive pads
- Sand paper

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- Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.
- Apply a continuous bead of the gasket eliminator to 1 flange. Clean and dry any surfaces that you will reseal.

IMPORTANT: Anaerobic sealed joints that are partially torqued and allowed to cure more than 5 minutes may result in incorrect shimming and sealing of the joint.

- Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:
  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt
- Spread the sealer evenly in order to get a uniform coating on the sealing surface.
- Tighten the bolts to the specifications.
- Remove the excess sealer from the outside of the joint.

TOOLS AND EQUIPMENT

Work in a clean and well-lit area. Have the following components available before you begin to work:

- A suitable parts cleaning tank
- A compressed air supply
- Trays, in order to keep the parts and the fasteners organized
- An adequate set of hand tools

An approved engine repair stand will prevent personal injury or damage to the engine components. The special tools are designed in order to quickly and safely accomplish the operations for which the tools are intended. Using the tools will minimize possible damage to the engine components. Precision measuring tools are required for the inspection of certain critical components. Torque wrenches are needed for the correct assembly of various parts.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description

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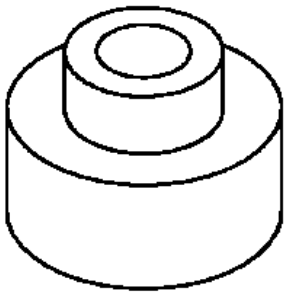
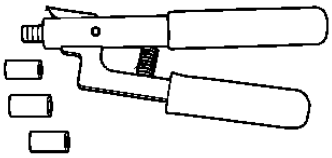
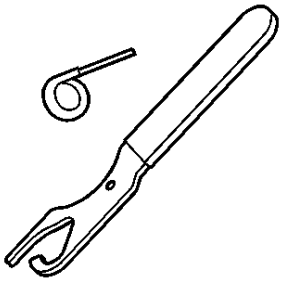
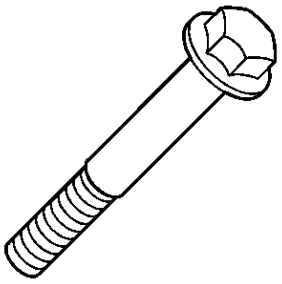
	EN 46359 Puller End Protector
	EN 46745 Piston Pin Retainer Remover and Installer
	EN 47719 Tensioner Compressor
	EN 47823 Valve Spring Compressor Adapter

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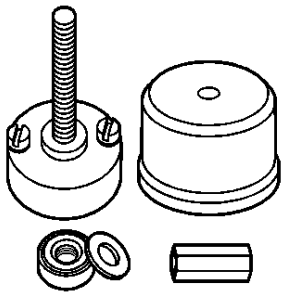
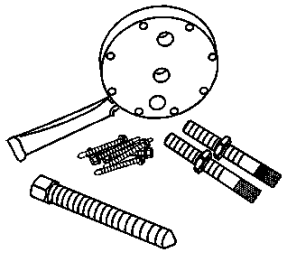
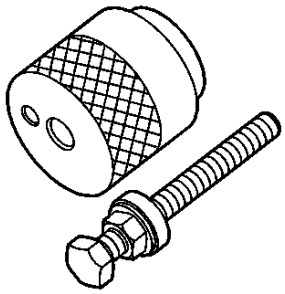
	EN 48108 Rear Main Oil Seal Installer
	EN 48672 Rear Main Oil Seal Remover
	EN 48869 Front Crankshaft Oil Seal Installer
	J 5892-D Valve Spring Compressor

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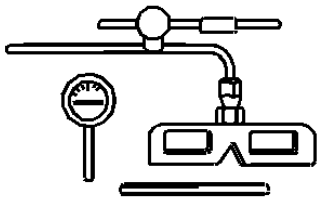
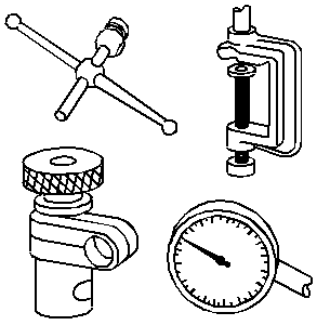
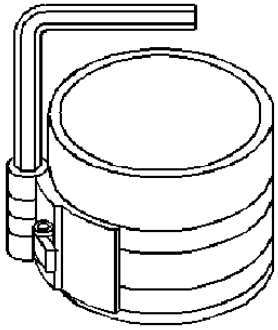
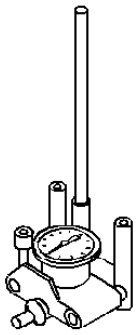
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set
	J 8037 Ring Compressor
	J 8087 Cylinder Bore Gage
	J 8089

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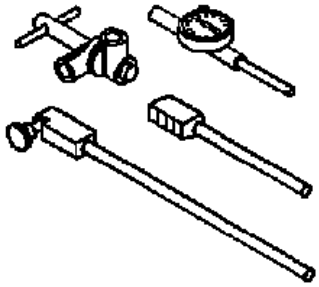
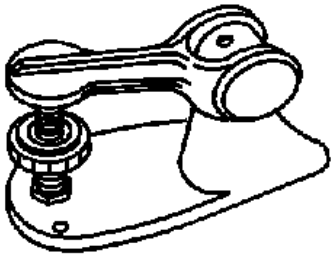
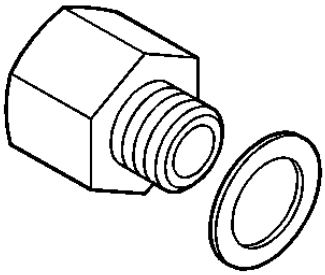
	Carbon Removal Brush
	J 8520 Cam Lobe Lift Indicator
	J 9666 Valve Spring Tester
	J 21867-6 Oil Pressure Adapter Fitting
	J 22144 Oil Suction Pipe Installer

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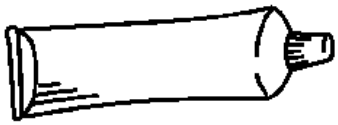
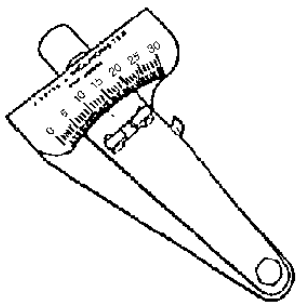
	J 22794 Spark Plug Port Adapter
	J 23444-A Extreme Press Lubricant - 1/4 Ounce Tube
	J 23498-A Drive Shaft Inclinometer
	J 24270 Cylinder Bore Ridge Reamer

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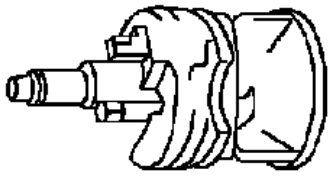
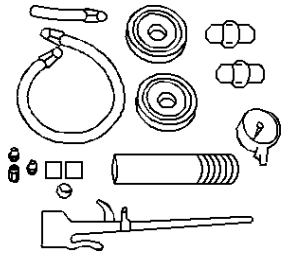
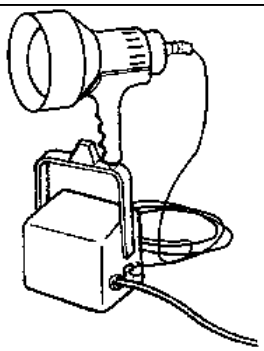
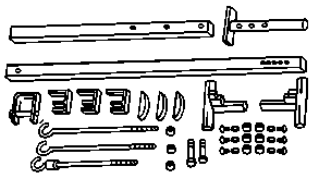
	
	J 25087-C Oil Pressure Tester
	J 28428-E High Intensity Black Light Kit
	J 28467-B Universal Engine Support Fixture
	J 29113 Balancer and Crank Sprocket Installer

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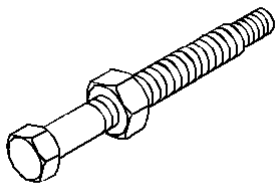
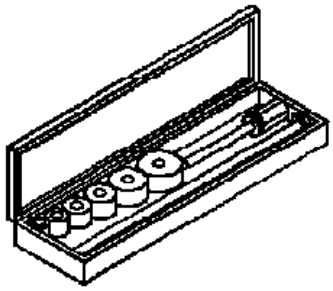
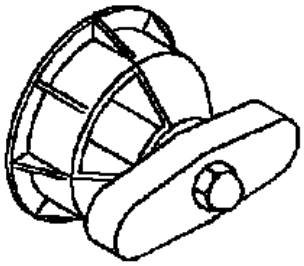
	
	J 33049 Camshaft Bearing Service Set
	J 34686 Rear Main Seal Installer
	J 35667-A Cylinder Leakdown Tester
	J 36462 Engine Support Adapter Leg

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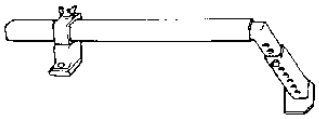
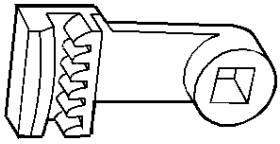
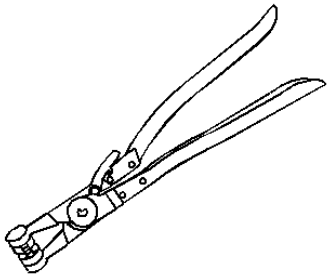
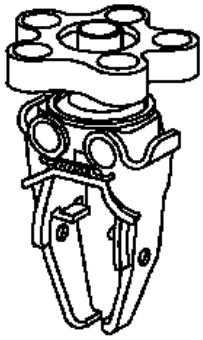
	
	J 37096 Flywheel Holder
	J 38185 Hose Clamp Pliers
	J 38606 Valve Spring Compressor
	J 38722 Compression Tester

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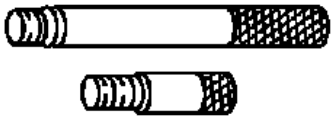
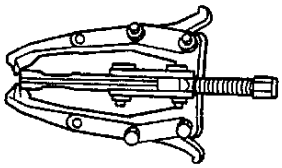
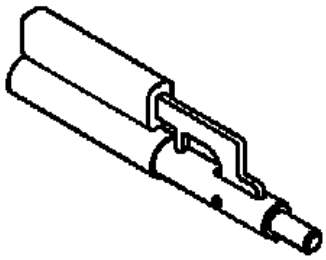
	J 41556 Connecting Rod Guide
	J 41816 Crankshaft Balancer Remover
	J 43654 Piston Pin Clip Remover and Installer
	J 43690 Rod Bearing Clearance Checking Tool

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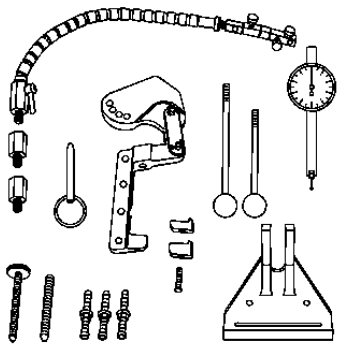
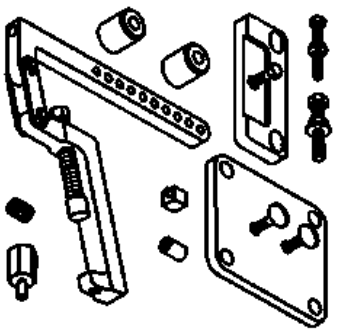
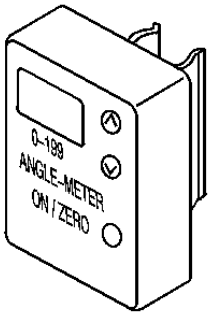
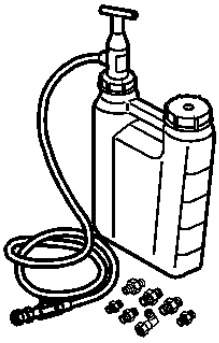
	
	J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit
	J 45059 Angle Meter
	J 45299 Engine Preluber

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