2007 ENGINE

Engine Mechanical - 3.9L - Montana SV6 (Canadian), Terraza & Uplander

SPECIFICATIONS

FASTENER TIGHTENING 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		
• First Pass	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	95 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
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

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Engine Lift Bracket Bolt	70 N.m	52 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
Oil Pan Side Bolt	50 N.m	37 lb ft
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
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
Upper Intake Manifold Bolt/Stud	25 N.m	18 lb ft
Valve Lifter Guide Bolt	10 N.m	89 lb in

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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

Engine Mechanical Specifications

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

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• 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
• Connecting Rod Journal Width	21.92-22.08 mm	0.863-0.869 in
• 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

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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	38.05-38.10 mm	1.498-1.500 in
• Gear Pocket - Depth	30.52-30.58 mm	1.202-1.204 in
• Gear Pocket - Diameter	38.176-38.226 mm	1.503-1.505 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
• 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		

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• 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	0.026-0.068 mm	0.0010-0.0027 in
Valve Lifters/Push Rods		
• Push Rod Length - Intake	146.0 mm	5.75 in
• Push Rod Length - Exhaust	152.5 mm	6.0 in
Valve Springs		
• Valve Spring Free Length	48.5 mm	1.89 in
• Valve Spring Installed Height	43.2 mm	1.701 in
• Valve Spring Load - Closed	320 N 43.2 mm	75 lb 1.701 in
• Valve Spring Load - Open	1036 N 32 mm	230 lb 1.260 in
• Valve Spring Total Number of Coils	6.55	

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

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

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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 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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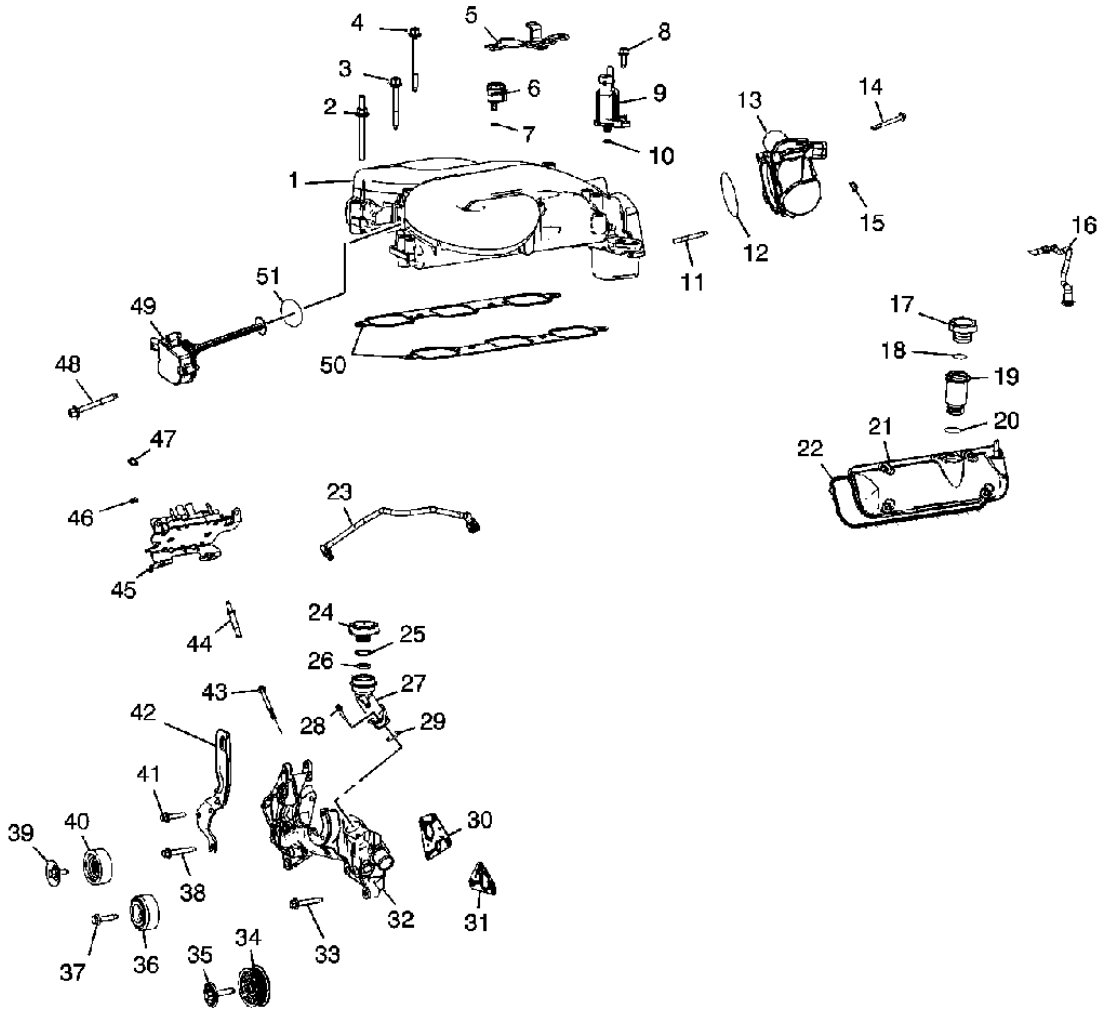

Fig. 1: Upper Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

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	Water Outlet Stud
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
48	Intake Manifold Tuning Valve Bolt
49	Intake Manifold Tuning Valve
50	Upper Intake Manifold Gasket
51	Intake Manifold Tuning Valve Seal

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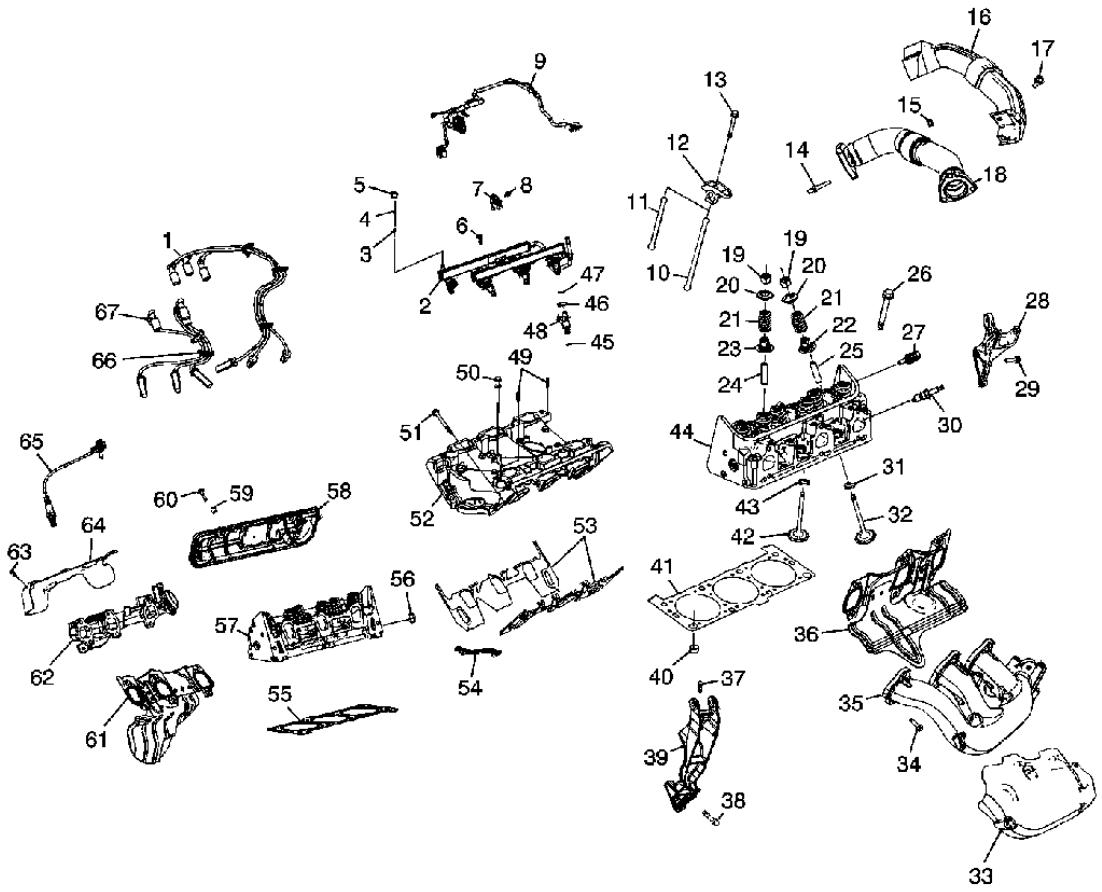

Fig. 2: Lower Intake Manifold, Cylinder Head, and Components
Courtesy of GENERAL MOTORS CORP.

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	Exhaust Crossover Pipe Stud

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15	Exhaust Crossover Pipe Nut
16	Exhaust Crossover Pipe Heat Shield
17	Exhaust Crossover Pipe Heat Shield Bolt
18	Exhaust Crossover Pipe
19	Valve Stem Key
19	Valve Stem Key
20	Valve Spring Cap
20	Valve Spring Cap
21	Valve Spring
21	Valve Spring
22	Valve Stem Oil Seal
23	Valve Stem Oil Seal
24	Valve Guide
25	Valve Guide
26	Cylinder Head Bolt
27	Engine Coolant Temperature Sensor
28	Engine Mount Strut and Engine Lift Bracket
29	Engine Mount Strut and Engine Lift Bracket Bolt
30	Spark Plug
31	Exhaust Valve Seat
32	Exhaust Valve
33	Exhaust Manifold Heat Shield
34	Exhaust Manifold Bolt
35	Exhaust Manifold
36	Exhaust Manifold Gasket
37	Engine Mount Strut Bracket Bolt
38	Engine Mount Strut Bracket Bolt
39	Engine Mount Strut Bracket
40	Cylinder Head Location Pin
41	Cylinder Head Gasket
42	Intake Valve
43	Intake Valve Seat
44	Cylinder Head
45	Fuel Injector Seal
46	Fuel Injector Retainer
47	Fuel Injector Seal
48	Sequential Multiport Fuel Injector
49	Lower Intake Manifold Location Pin
50	Lower Intake Manifold Bolt
51	Lower Intake Manifold Bolt
52	Lower Intake Manifold

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	Lower Intake Manifold Gasket
54	Lower Intake Manifold Seal
55	Cylinder Head Gasket
56	Cylinder Head Core Hole Plug
57	Cylinder Head
58	Valve Rocker Arm Cover
59	Valve Rocker Arm Cover Bolt Grommet
60	Valve Rocker Arm Cover Bolt
61	Exhaust Manifold Gasket
62	Exhaust Manifold
63	Exhaust Manifold Heat Shield Bolt
64	Exhaust Manifold Heat Shield
65	Oxygen Sensor
66	Spark Plug Wire Support
67	Spark Plug Wire Harness

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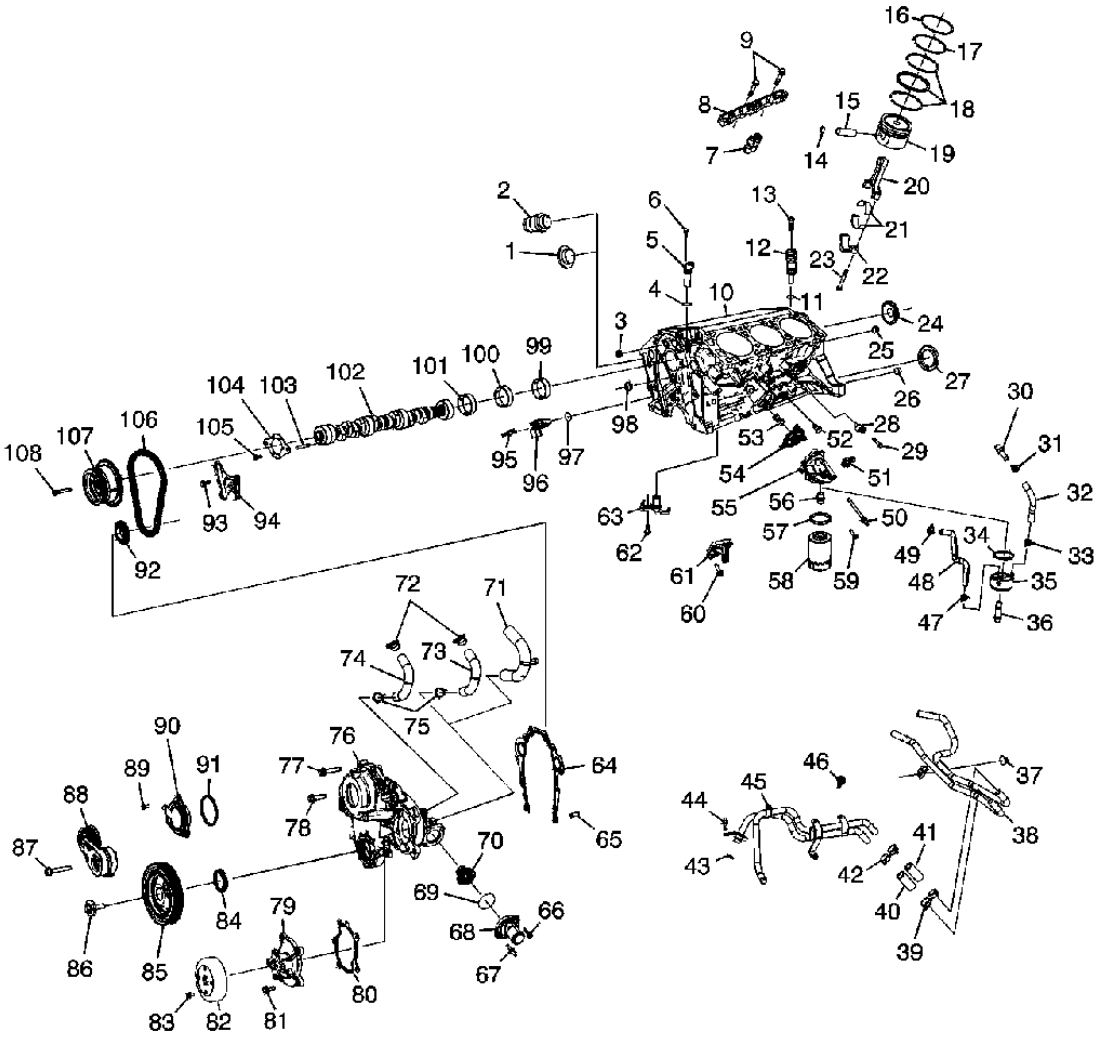

Fig. 3: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

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

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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
45	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

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	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	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 Dampener Bolt

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	Timing Chain Dampener
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

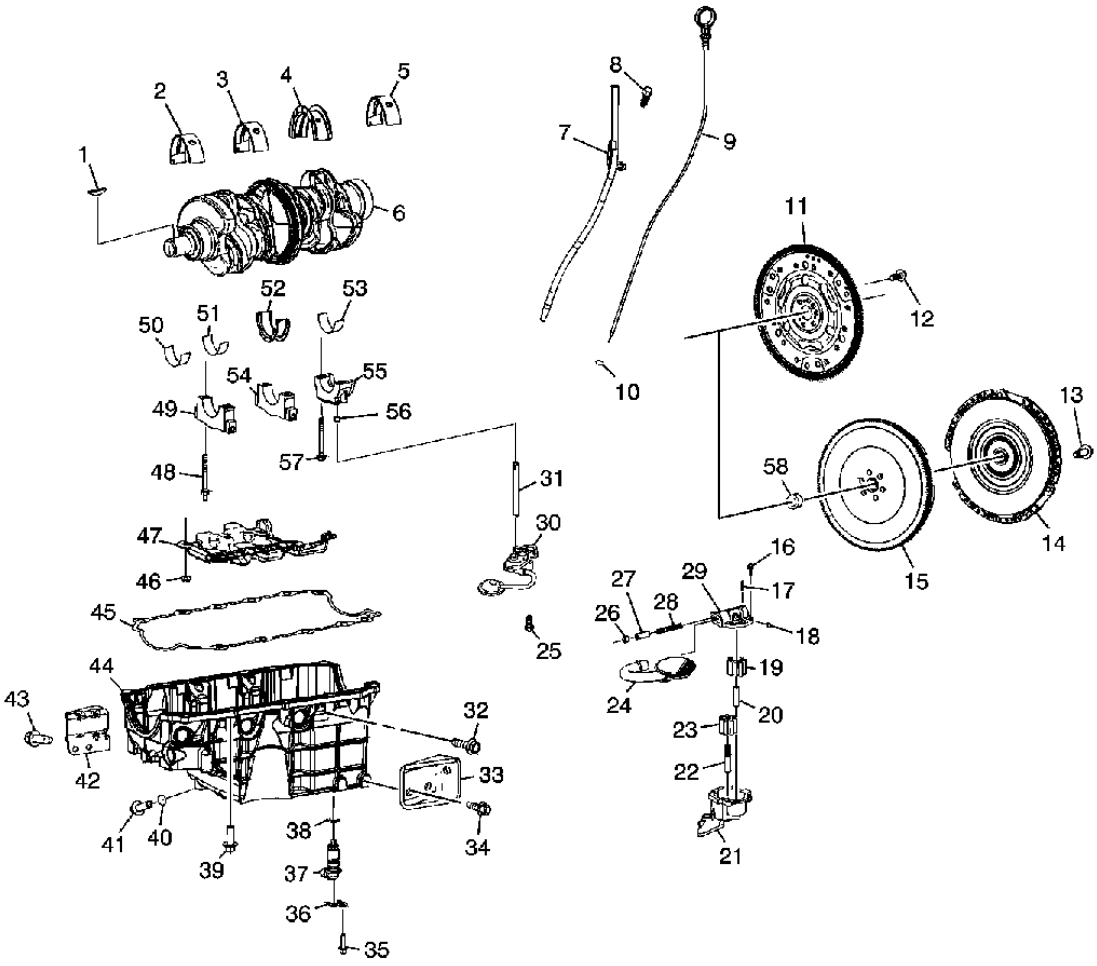

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Fig. 4: Crankshaft and Components
Courtesy of GENERAL MOTORS CORP.

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
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

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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	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

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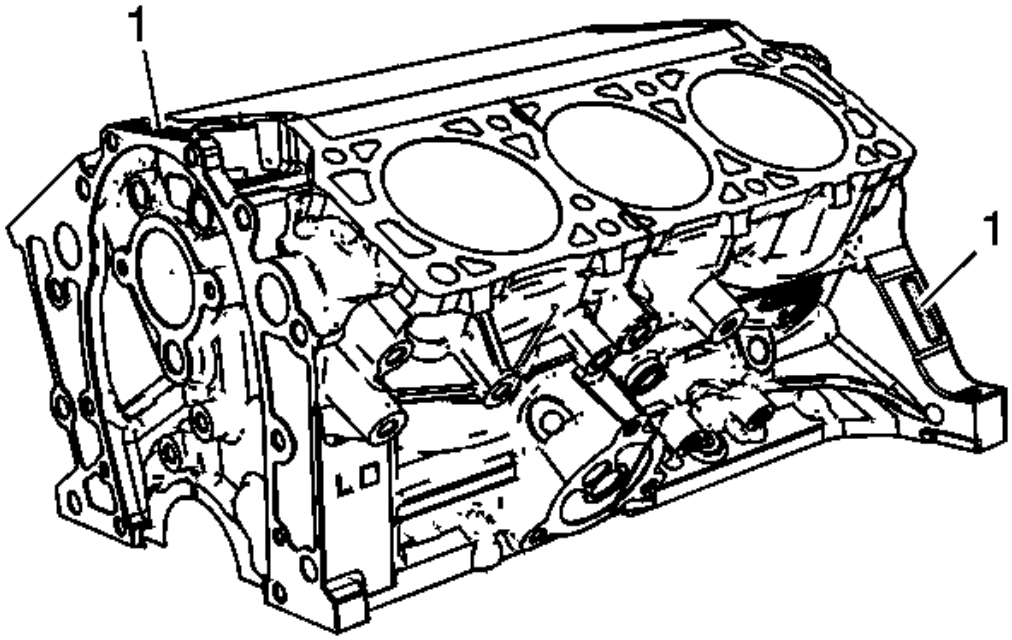

Fig. 5: Locating Engine Identification Tags
Courtesy of GENERAL MOTORS CORP.

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

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, **Drive Belt System Description** and **Lubrication Description** in Engine Mechanical. 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.

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SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **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**

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- **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

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.
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	Repair or replace as required.

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cause the valve not to close properly.	
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

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 without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** 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** in Engine Controls. 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**.

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	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

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.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction

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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

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

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

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 to **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 and/or damaged valve rotators	Replace the valve rotators as required.
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:

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	• The balance shaft gear • 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

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.

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Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to **Electronic Ignition (EI) System Diagnosis** .
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

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**	

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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**. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to **Electronic Ignition (EI) 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

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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.
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

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.	

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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.
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

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

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

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

IMPORTANT: Remove the powertrain control module (PCM) and the ignition fuses from 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. See **Special Tools**.
    - 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.

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CYLINDER LEAKAGE TEST

Tools Required

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

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

CAUTION: Refer to Battery Disconnect Caution .

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

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

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

IMPORTANT:

- **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 Bearings 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** .

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- Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .

11. Remove the **J 35667-A** . See **Special Tools**.
12. Install the spark plugs. Refer to **Spark Plug Replacement** .
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

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.

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- 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

Tools Required

- **J-21867-6** Oil Pressure Adapter Fitting. See **Special Tools**.
- **J 25087-C** Oil Pressure Tester and Pump Primer. See **Special Tools**.

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. See **Special Tools**. Insert the hose in the small hole of the **J 25087-C** base. See **Special Tools**. 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. See **Special Tools**.
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. The oil pressure should be approximately 414 kPa (60 psi) at 1,850 RPM using 5W-30 engine oil.
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.

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OIL LEAK DIAGNOSIS

Tools Required

J 28428-E High Intensity Black Light Kit. See **Special Tools**.

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.

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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.
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. See **Special Tools**. 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

Crankcase Ventilation System Inspection/Diagnosis

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked positive crankcase ventilation (PCV) hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions:

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	• Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or low idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

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.

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

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

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

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

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

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

Drive Belt Chirping, Squeal, and Whine Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**

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2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 19**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?		

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	If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids.	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement**. 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

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operating with the drive belts removed.

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

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

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

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

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

Drive Belt Rumbling and Vibration Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: 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
	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.		

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3	2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to **Symptoms - Engine Mechanical** or Go to **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement**. Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement** . 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

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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.

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 plys.

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a 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.

Drive Belt Falls Off and Excessive Wear Diagnosis

Step	Action	Yes	No

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NOTE:
Refer to Belt Dressing Notice .

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. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement**. 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	**NOTE:** **Refer to Fastener Notice .** 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**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**

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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**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

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 REPAIR INSTRUCTIONS

Intake Manifold Cover Replacement

Removal Procedure

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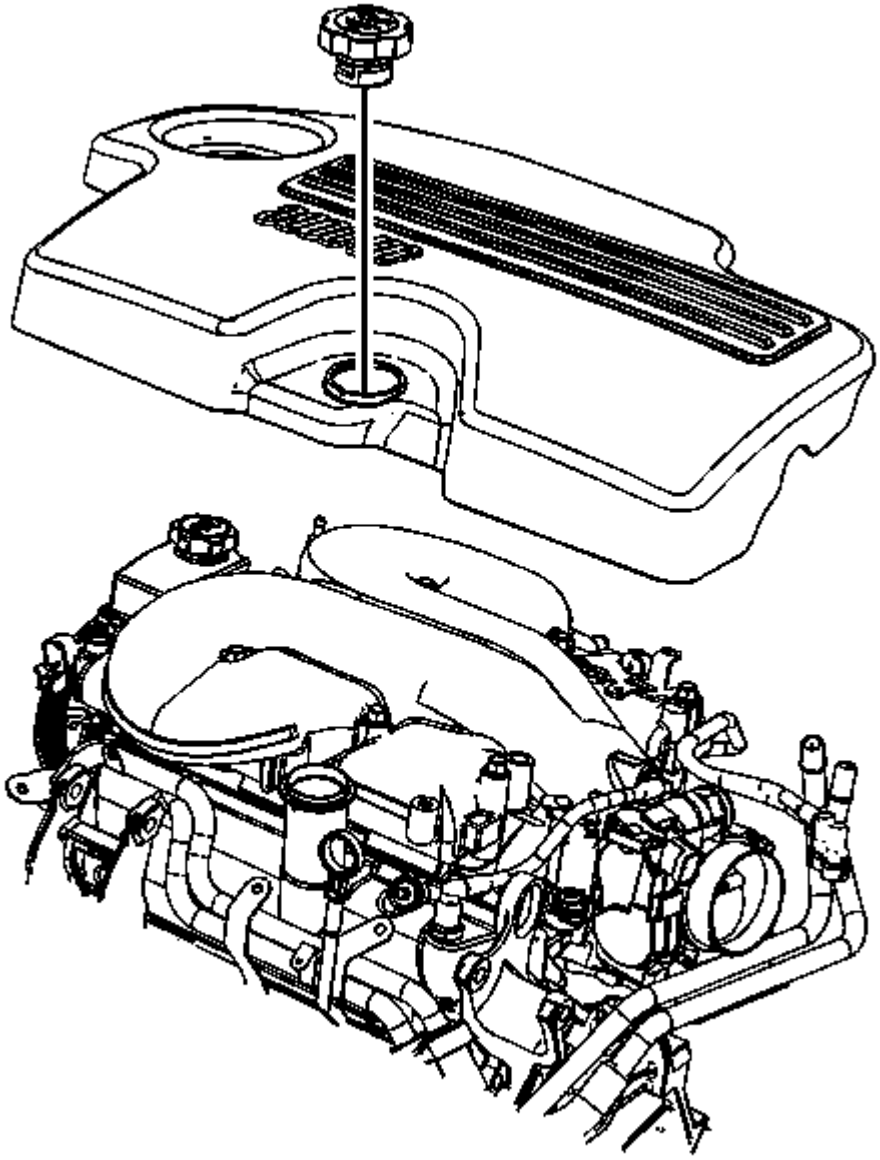

Fig. 6: Identifying Engine Manifold Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine oil fill cap.
2. Remove the oil fill pipe.
3. Pull up on the cover in order to disengage the cover from the studs.

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Installation Procedure

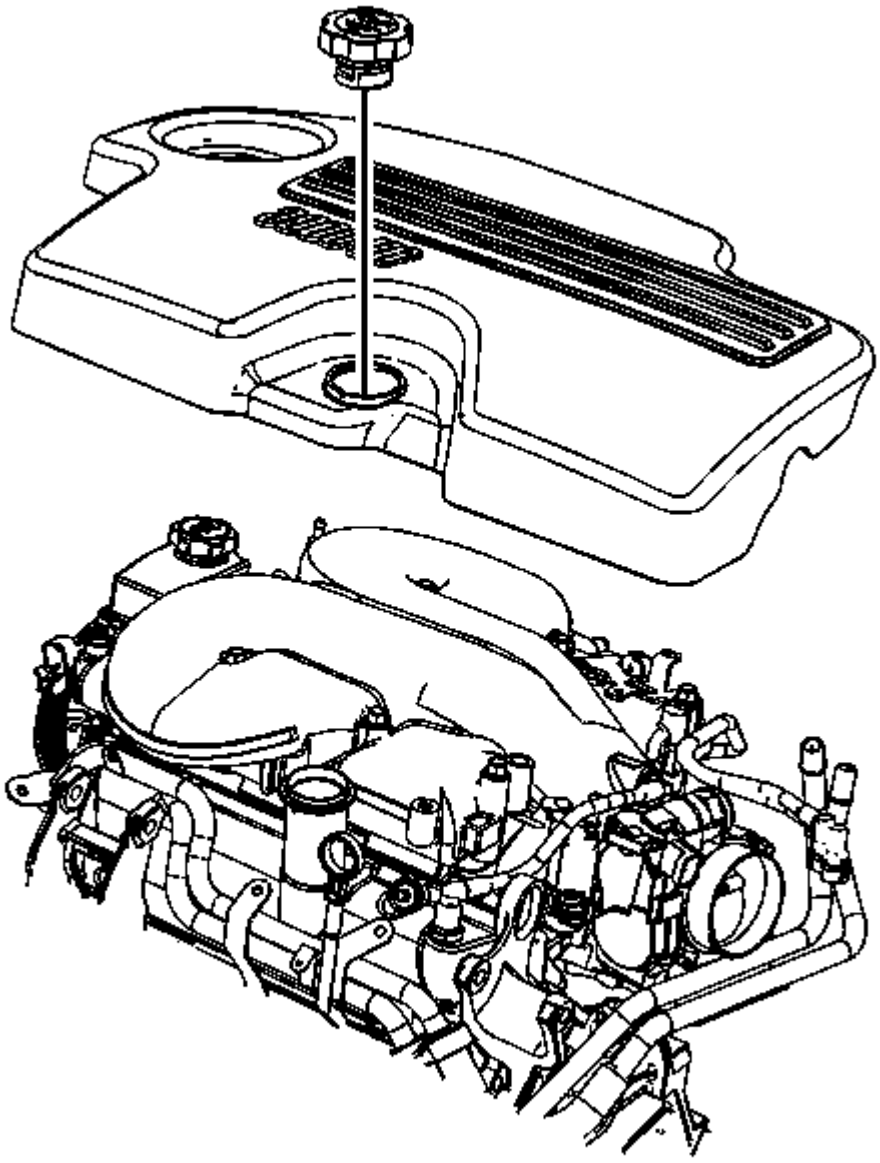

Fig. 7: Identifying Engine Manifold Cover
Courtesy of GENERAL MOTORS CORP.

1. Align the cover to the studs on the engine, push down on the cover above the studs in order to engage the cover to the studs.

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2. Install the oil fill pipe.
3. Install the engine oil fill cap.

Drive Belt Replacement

Removal Procedure

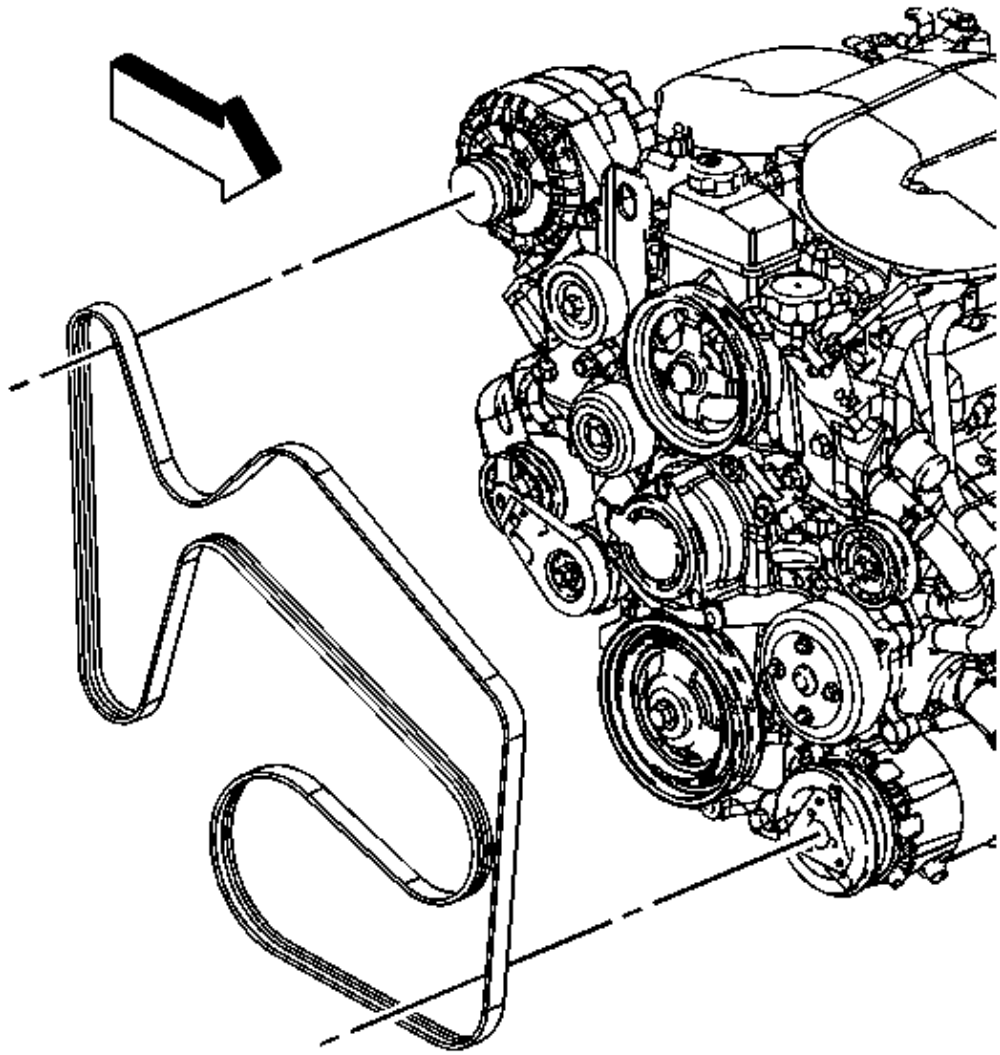

Fig. 8: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

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1. Rotate the drive belt tensioner clockwise in order to release the tensioner spring tension.
2. Remove the drive belt (1), if equipped with electric power steering.
3. Remove the drive belt (2), if equipped with hydraulic power steering.

Installation Procedure

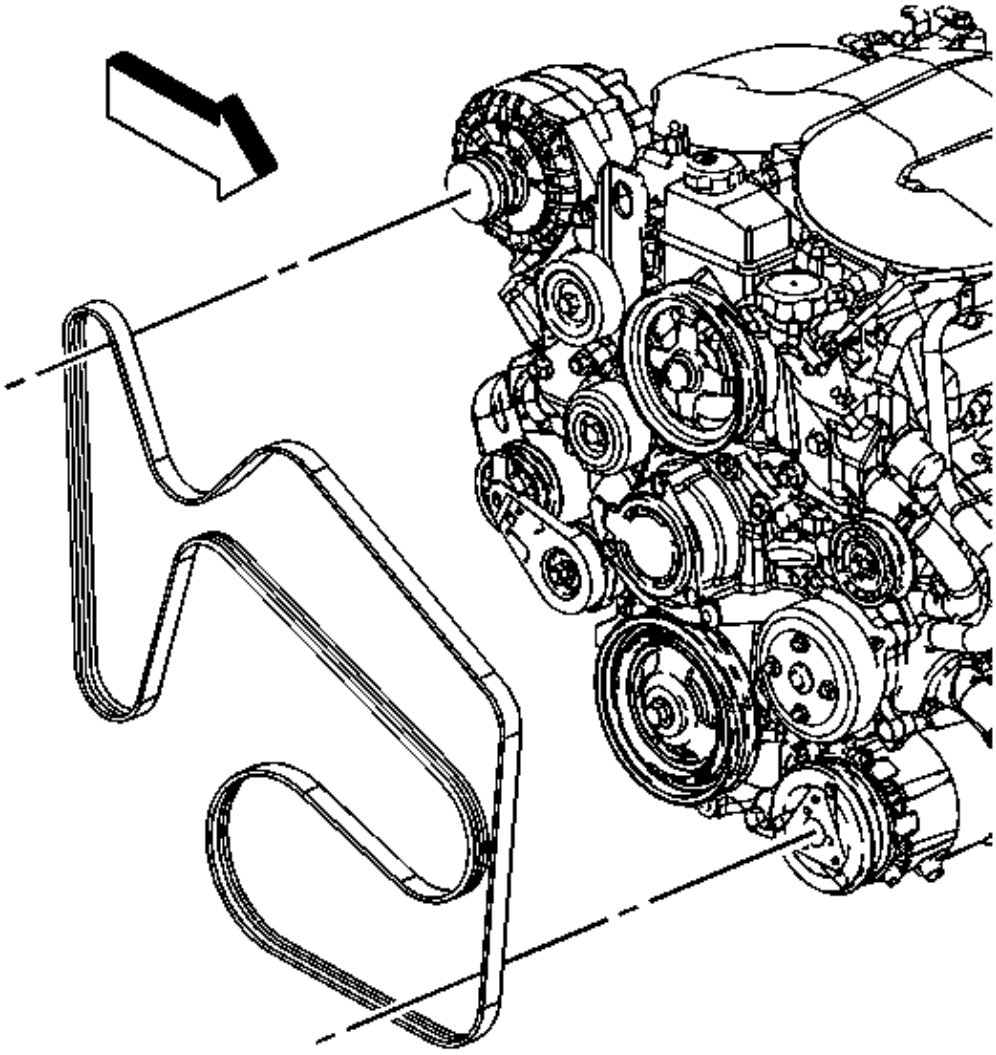

Fig. 9: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Rotate the drive belt tensioner clockwise in order to release the tensioner spring tension.

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2. Install the drive belt (1), if equipped with electric power steering.
3. Install the drive belt (2), if equipped with hydraulic power steering.

Drive Belt Idler Pulley Replacement

Removal Procedure

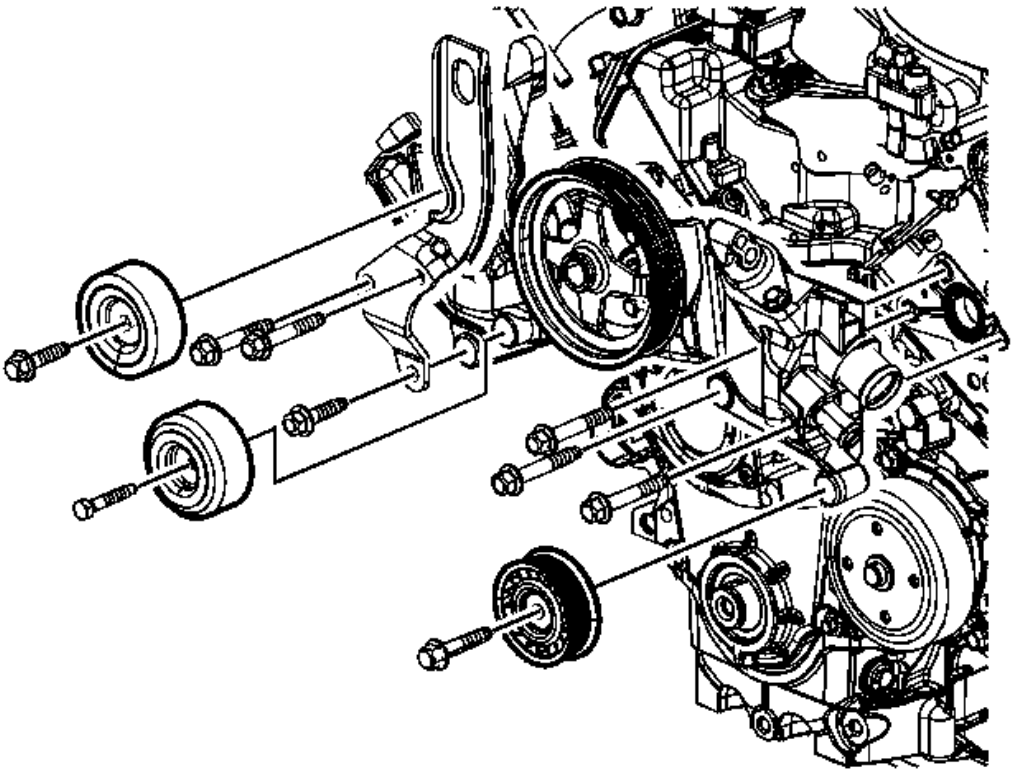

Fig. 10: View Of Drive Belt Idler Pulleys
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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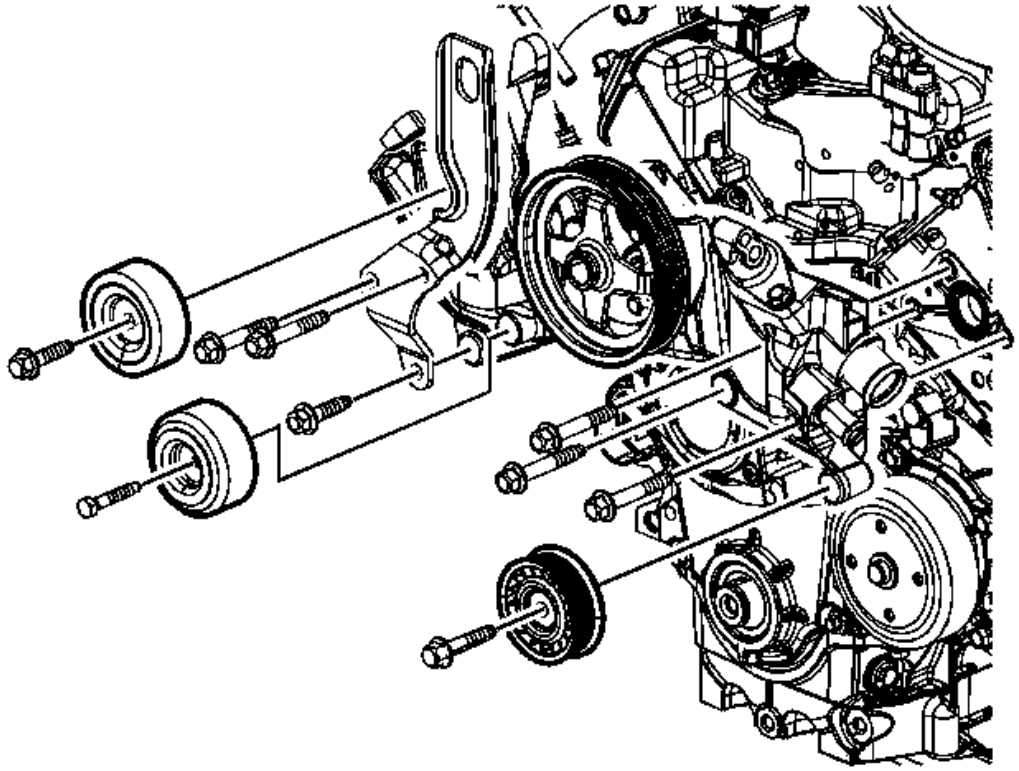

Fig. 11: View Of Drive Belt Idler Pulleys
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the drive belt idler pulley.
2. Install the required drive belt idler pulley bolt.

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

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

Drive Belt Tensioner Replacement

Removal Procedure

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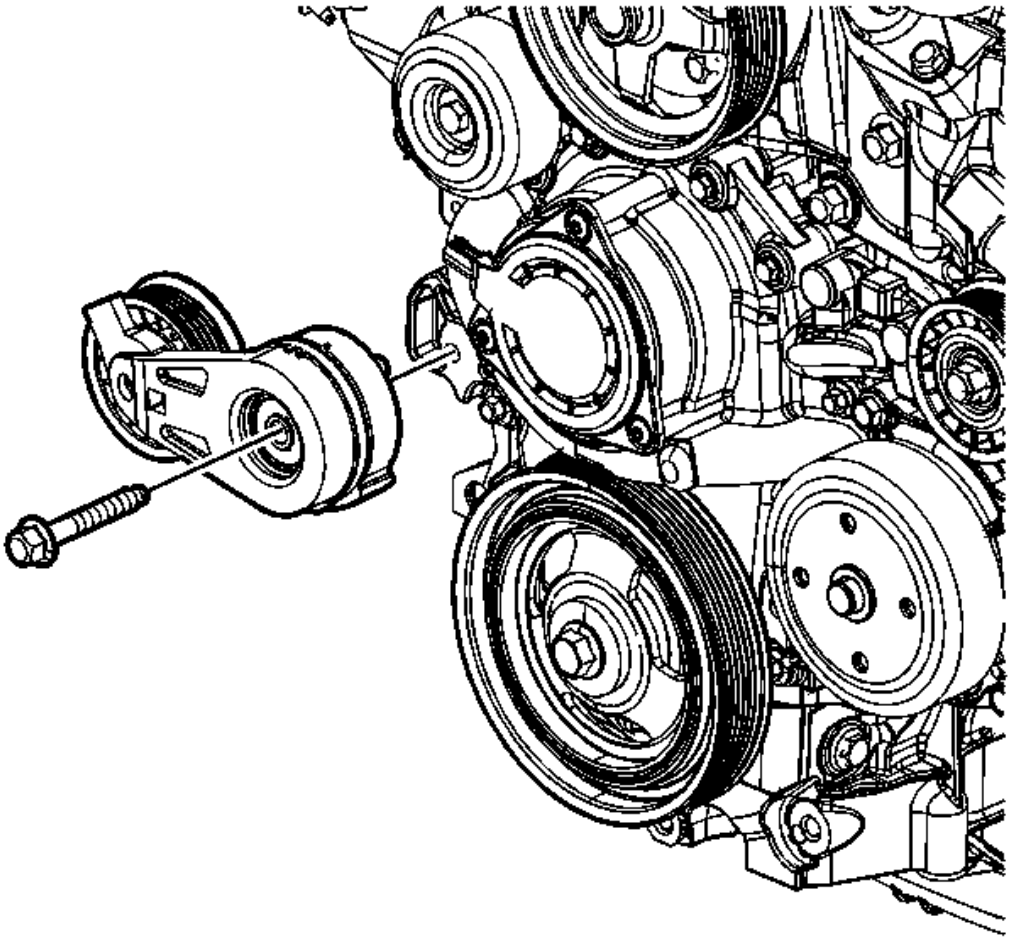

Fig. 12: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the drive belt tensioner bolt by accessing it through the wheelhouse opening.
4. Remove the drive belt tensioner by accessing it through the wheelhouse opening.

Installation Procedure

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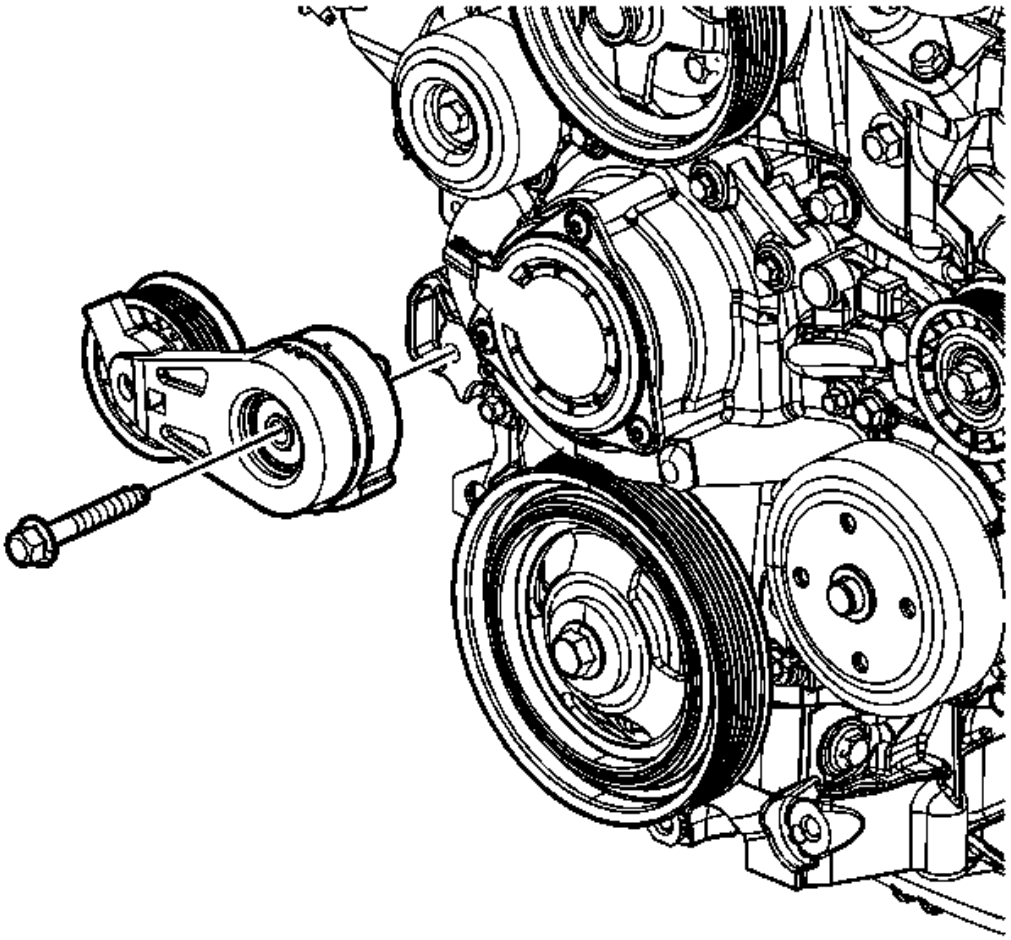

Fig. 13: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner by accessing it through the wheelhouse opening.

   NOTE: Refer to Fastener Notice .

2. Install the drive belt tensioner bolt by accessing it through the wheelhouse opening.

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

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

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Engine Support Fixture

Tools Required

- **J 28467-34** Lift Hook Wing Nut and Washer (2)
- **J 28467-6A** Bracket Assembly (2)
- **J 28467-7A** Bolt Hook (2)
- **J 28467-500** Engine Support Fixture
- **J 28467-B** Universal Engine Support Fixture
- **J 45057** Engine Support Bar Assembly

Installation Procedure

1. Remove the right engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.

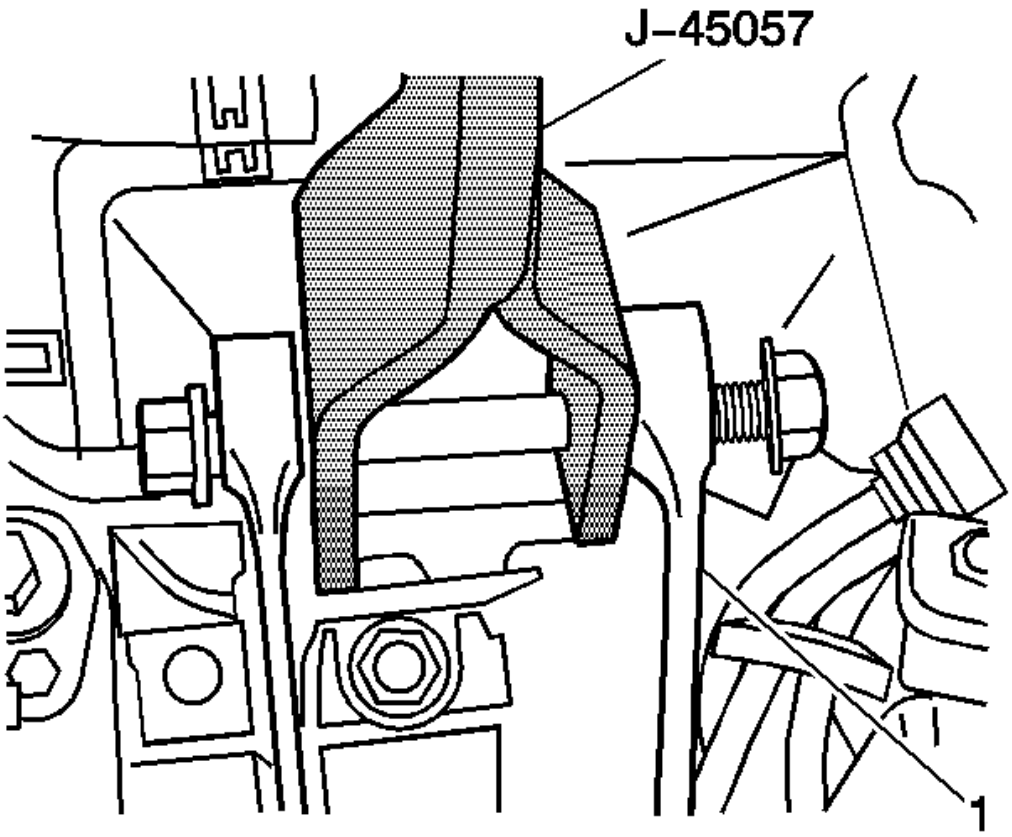

Fig. 14: View Of J 45057

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Courtesy of GENERAL MOTORS CORP.

2. Install the **J 45057** to the right engine mount strut bracket (1).

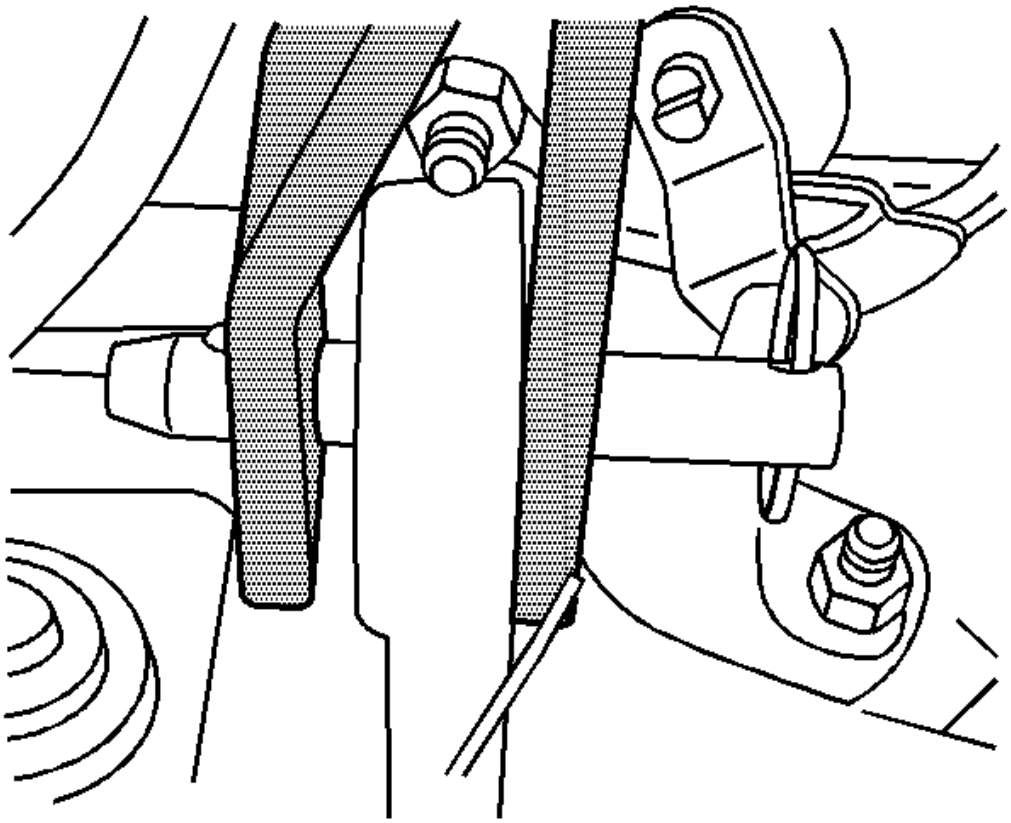

Fig. 15: Installing J 45057 To Left Side Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 45057** to the left side engine lift bracket.

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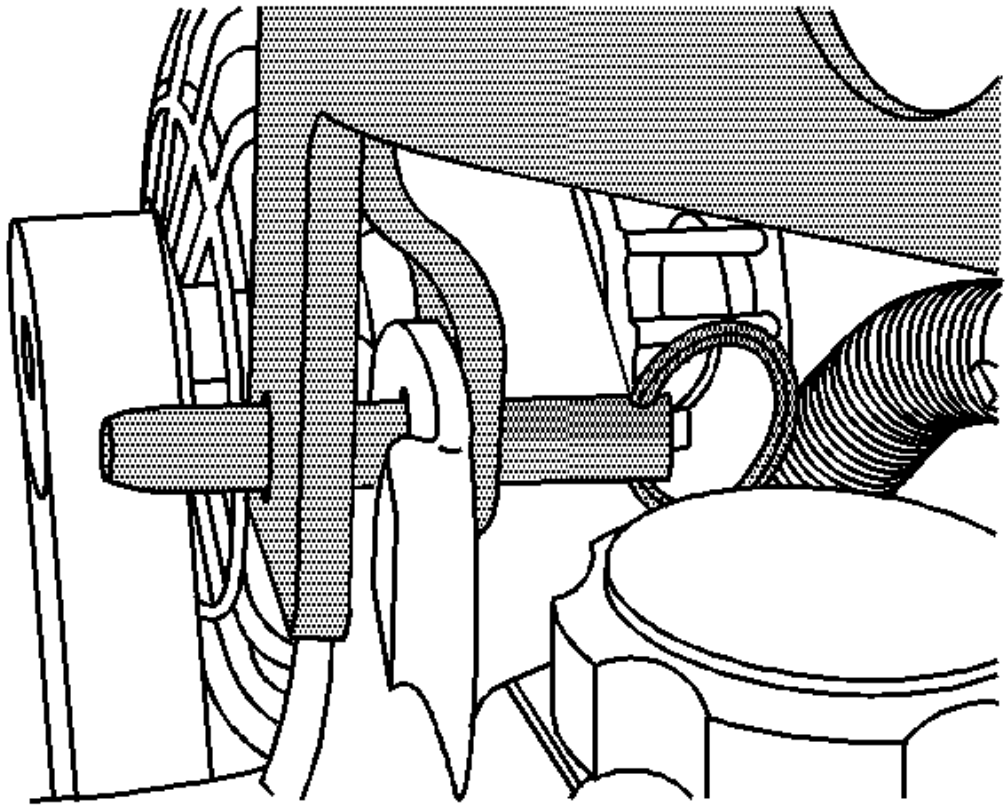

Fig. 16: View of J 45057 Installed To Right Side Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 45057** to the right rear engine lift bracket.
5. Open and secure the hood in a 90 degree position.

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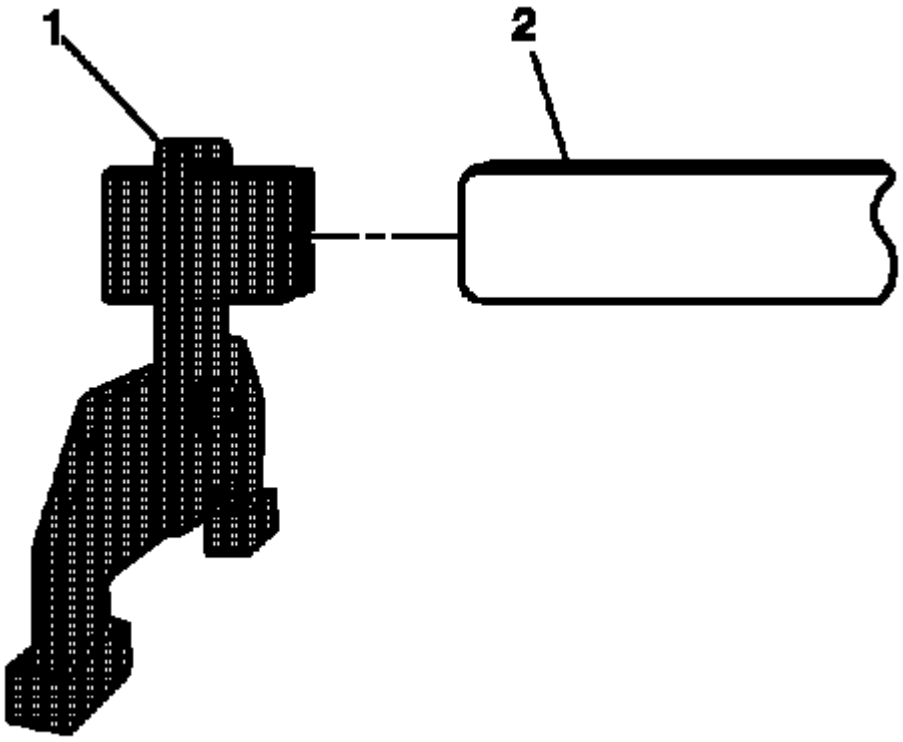

Fig. 17: Identifying J 28467-B & J 28467-3
Courtesy of GENERAL MOTORS CORP.

6. Install a **J 28467-B** and retention pin to each end of the **J 28467-500** beam (2).

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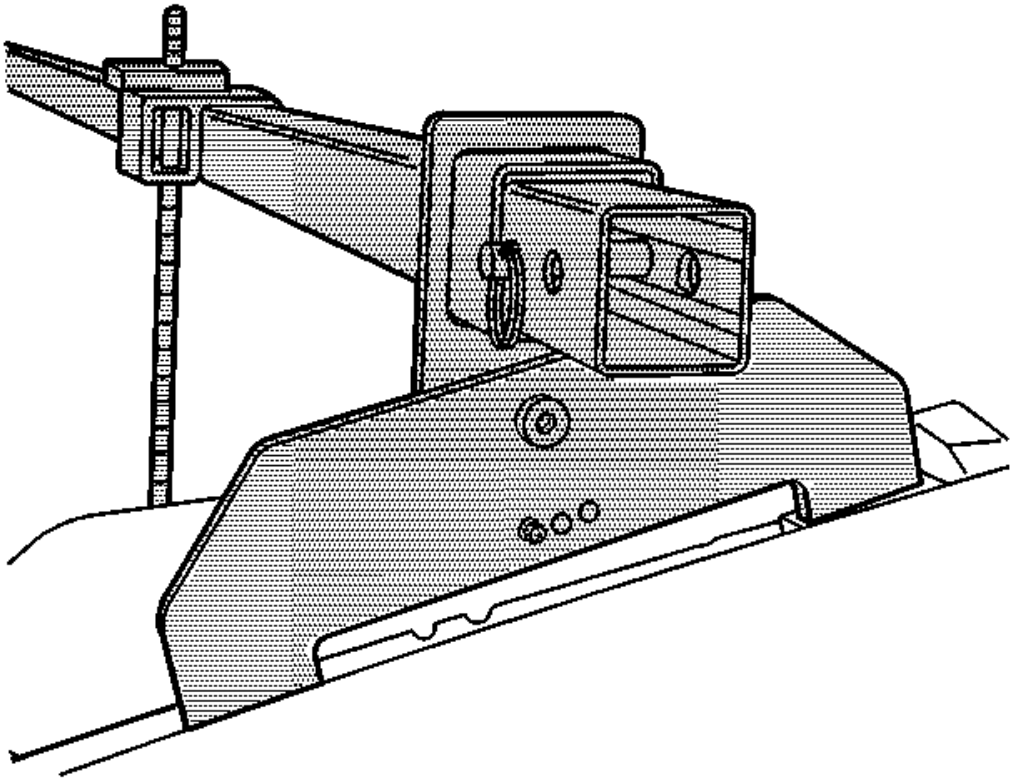

Fig. 18: View Of Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

7. Position the **J 28467-B** to the left and right side inner fender rails in order to install the **J 28467-500** .

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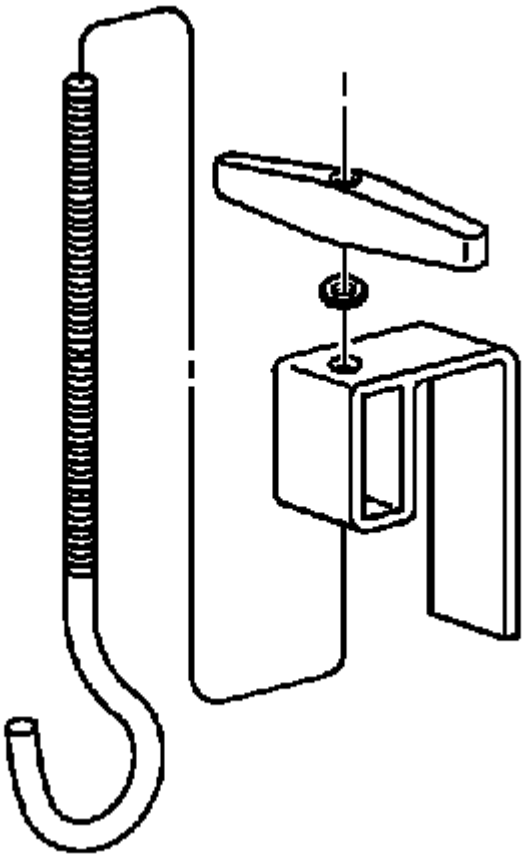

Fig. 19: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

8. Assemble the following to create 2 lift hook assemblies as shown:
   - **J 28467-34**
   - **J 28467-6A**
   - **J 28467-7A**

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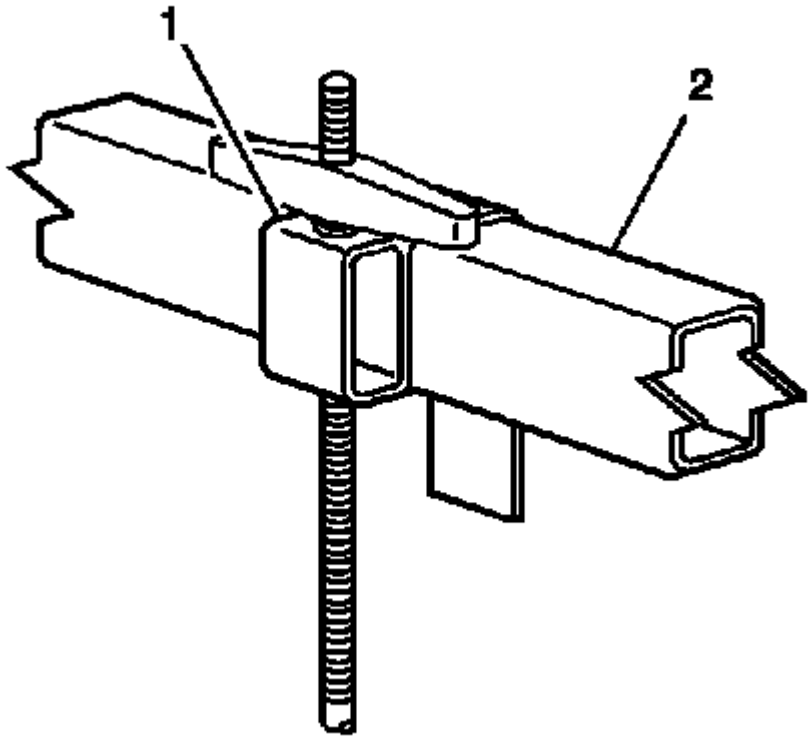

Fig. 20: View Of Lift Hook & Bracket Assembly At Longitudinal Mounted Cross Bar
Courtesy of GENERAL MOTORS CORP.

9. Install the 2 lift hook assemblies (1) to the **J 45057-2** (2).

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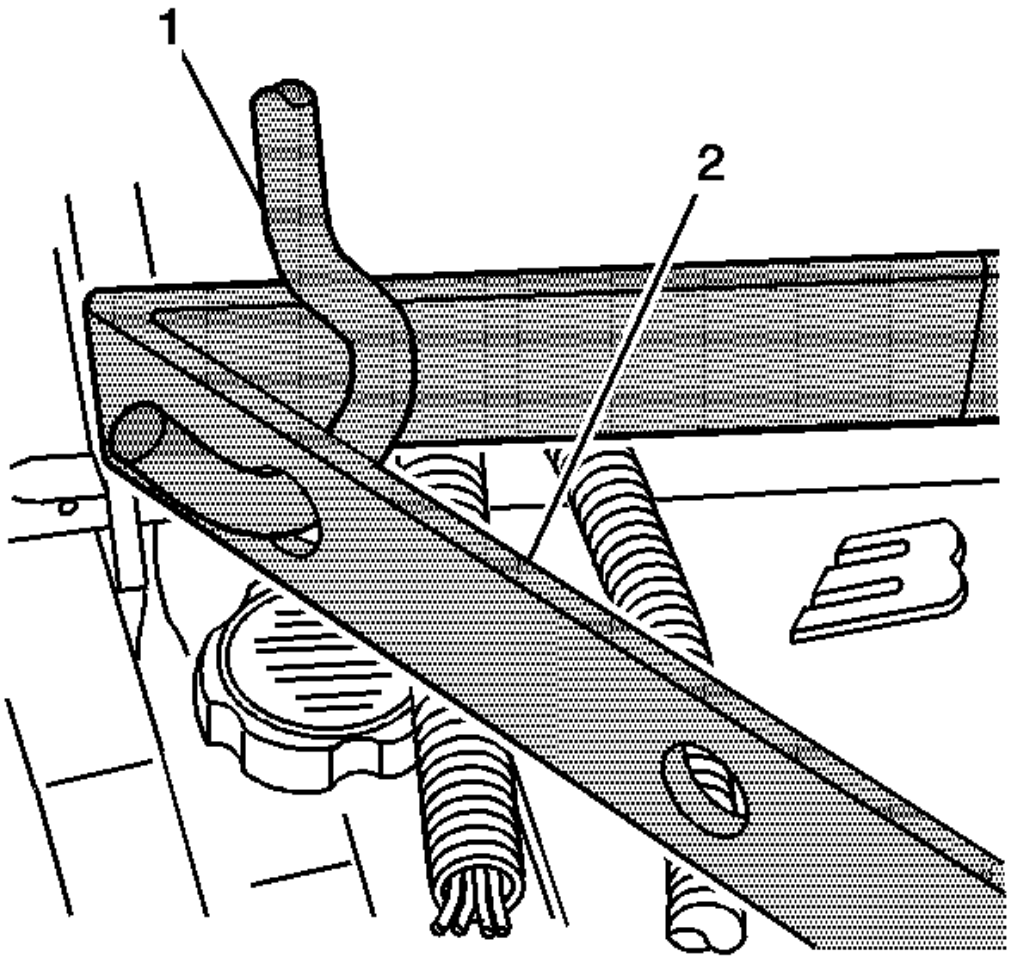

Fig. 21: View Of Right Side Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

10. Install the right side lift hook assembly to the right side hole in the **J 45057** (2).

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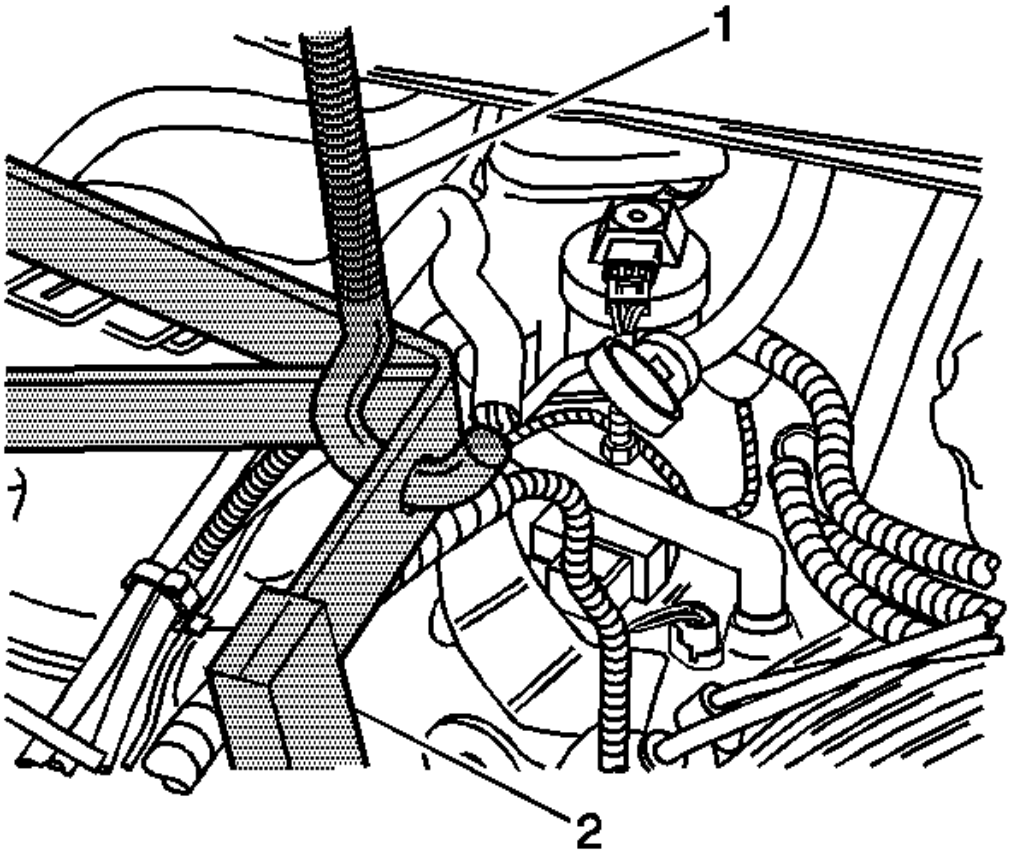

Fig. 22: View Of Left Side Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

11. Install the left side lift hook assembly to the left side hole in the **J 45057** (2).
12. Gently tighten the **J 28467-34** lift hook wing nuts.
13. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
14. Remove the lower air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
15. Install one end of a suitable utility strap to the transaxle.
    - If the vehicle is equipped with All Wheel Drive (AWD), carefully wrap the utility strap around the transfer case.
    - If the vehicle is equipped with Front Wheel Drive (FWD), carefully wrap the utility strap around the transaxle case extension housing.
16. Install the opposite end of the utility strap to a suitable underbody structure.
17. Tighten the utility strap in order to prevent movement of the powertrain.

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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, and 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 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.
4. For engine mount replacement, refer to **Engine Mount Replacement**.

Engine Mount Replacement

Removal Procedure

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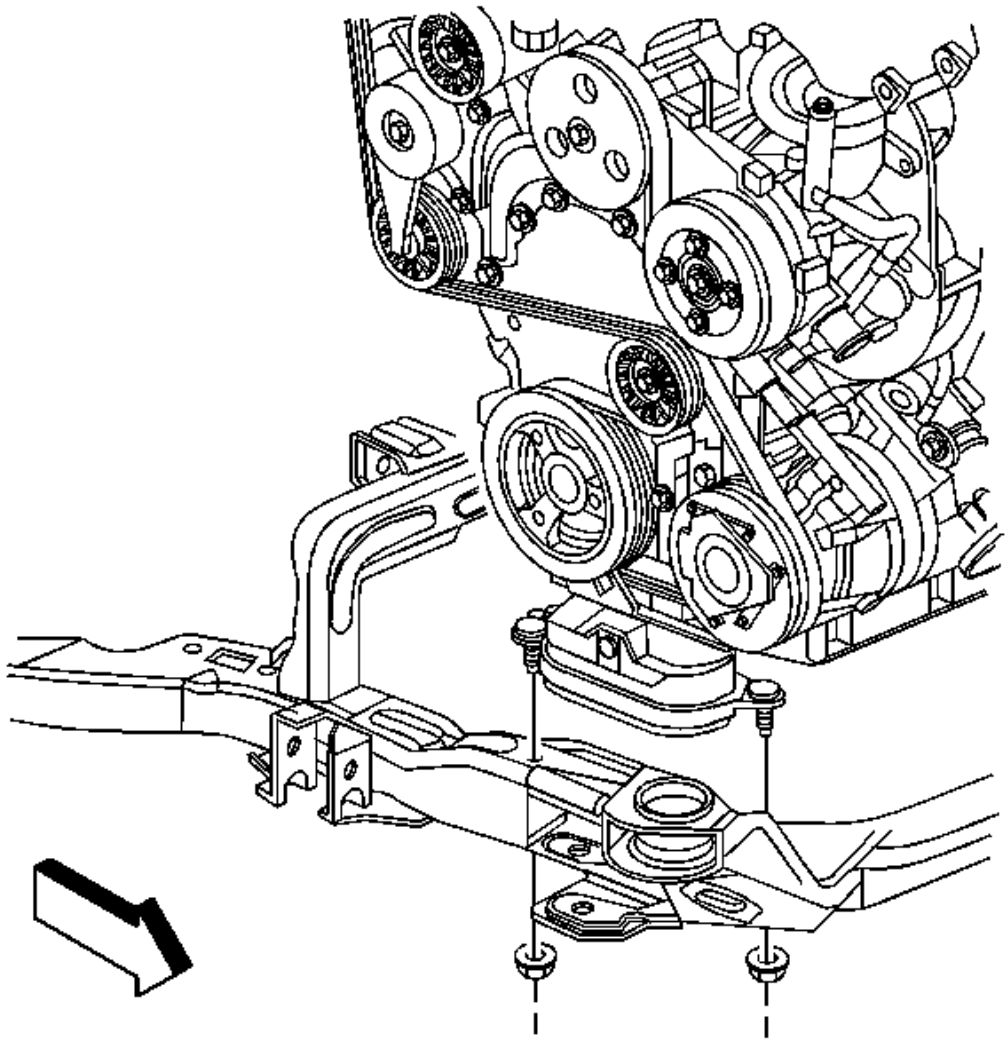

Fig. 23: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement - Left Side** and **Engine Mount Strut Replacement - Right Side**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the catalytic converter. Refer to **Catalytic Converter Replacement** .
5. Remove the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .
6. Remove the right engine splash shield. Refer to **Engine Splash Shield Replacement** .

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7. Remove the engine mount to frame nuts.

NOTE: In order to avoid oil pan damage and possible engine failure, insert a block of wood that spans the width of the oil pan bottom between the oil pan and the jack support.

8. Place a utility stand and a block of wood under the oil pan in order to raise the engine.

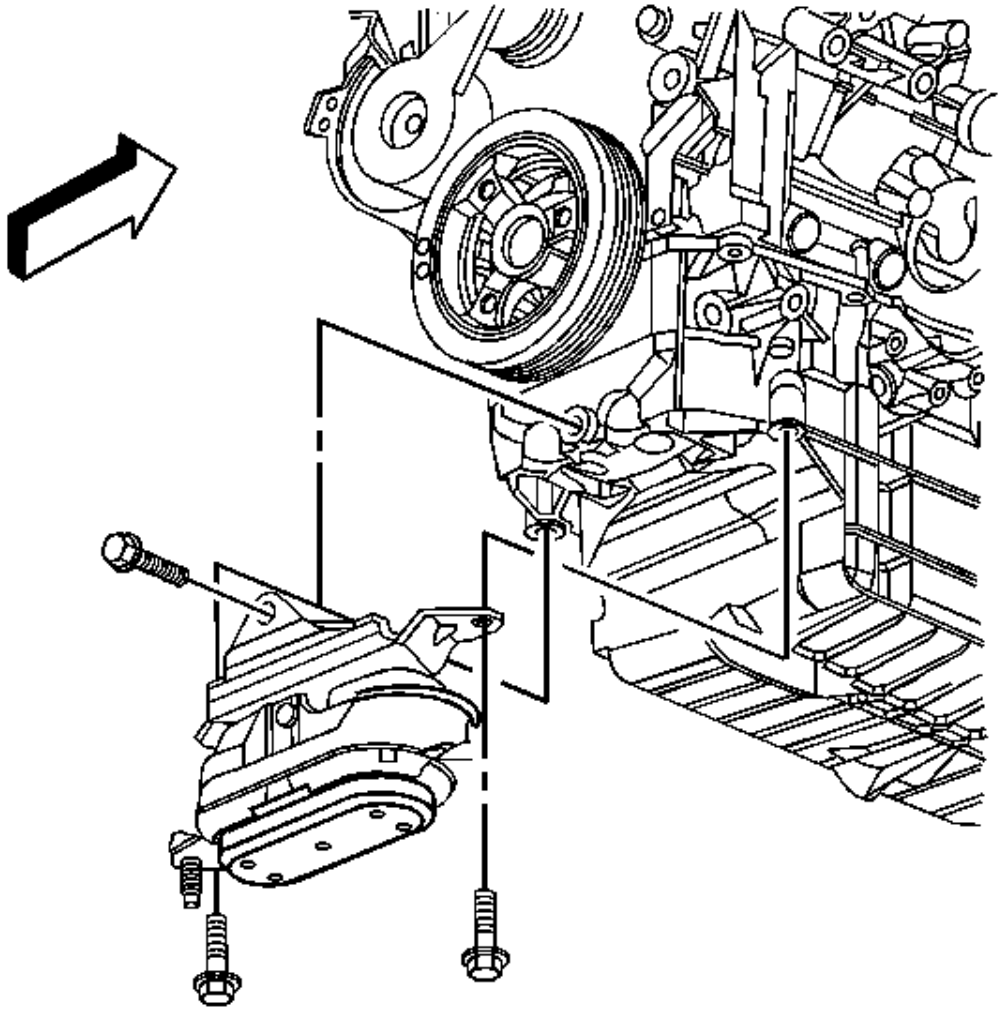

Fig. 24: Removing/Installing Engine Mount & Bracket To-Oil-Pan Bolts
Courtesy of GENERAL MOTORS CORP.

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9. Remove the engine mount bracket to oil pan bolts.
10. Remove the engine mount and bracket.

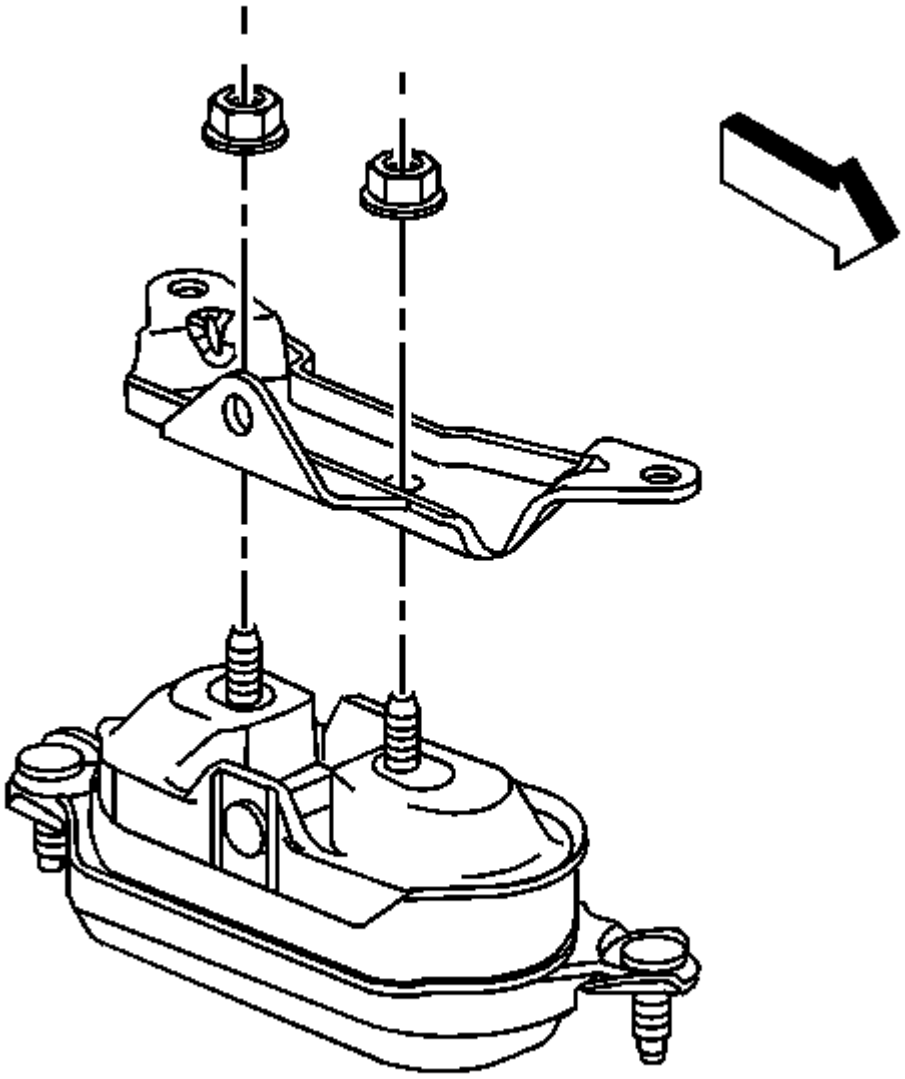

Fig. 25: Identifying Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine mount bracket to engine mount nuts.
12. Remove the engine mount from the bracket.

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Installation Procedure

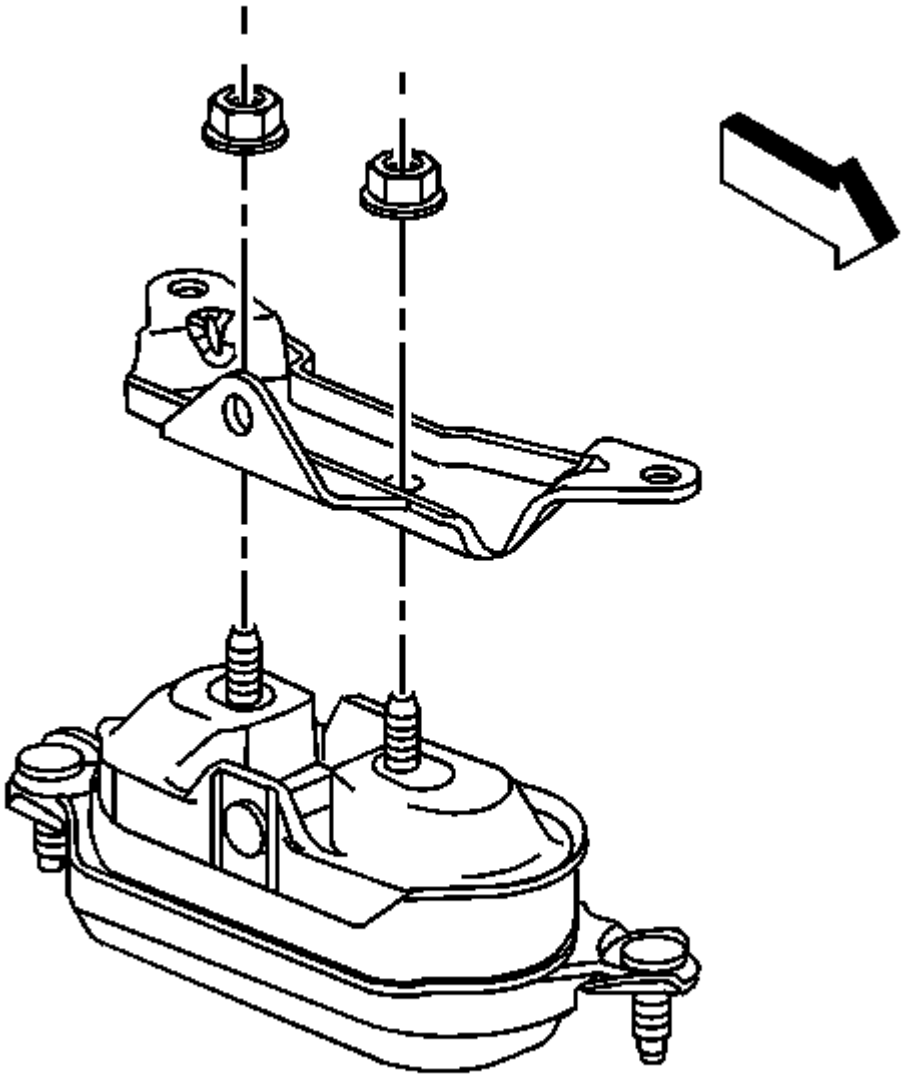

Fig. 26: Identifying Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount to the bracket.

NOTE: Refer to Fastener Notice .

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

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

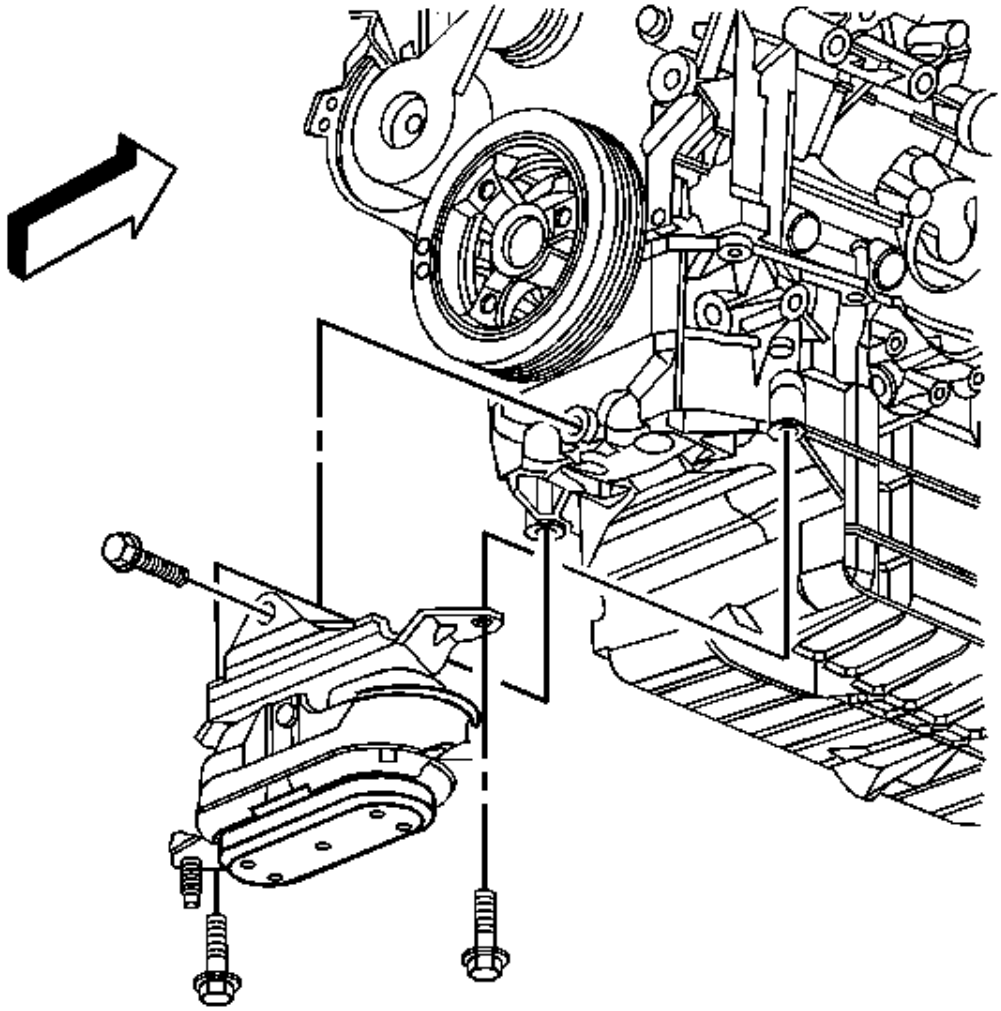

Fig. 27: Removing/Installing Engine Mount & Bracket To-Oil-Pan Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount and bracket to the oil pan.
4. Install the engine mount bracket to oil pan bolts.

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

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5. Using the utility stand, lower the engine.

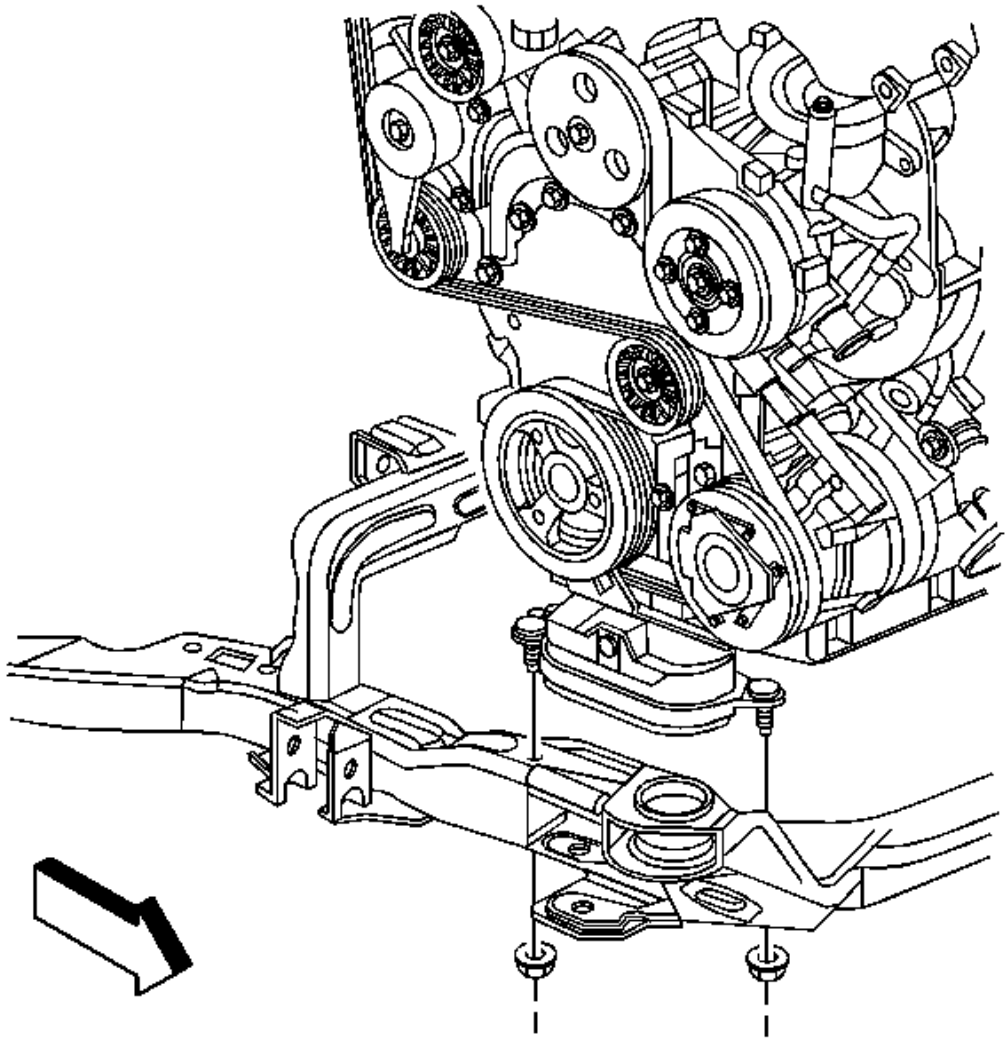

Fig. 28: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount to frame nuts.

   Tighten: Tighten the nuts to 47 N.m (35 lb ft).

7. Install the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
8. Install the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .

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9. Install the catalytic converter. Refer to **Catalytic Converter Replacement** .
10. Lower the vehicle.
11. Install the engine mount struts. Refer to **Engine Mount Strut Replacement - Left Side** and **Engine Mount Strut Replacement - Right Side**.
12. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

Engine Mount Bracket Replacement

Removal Procedure

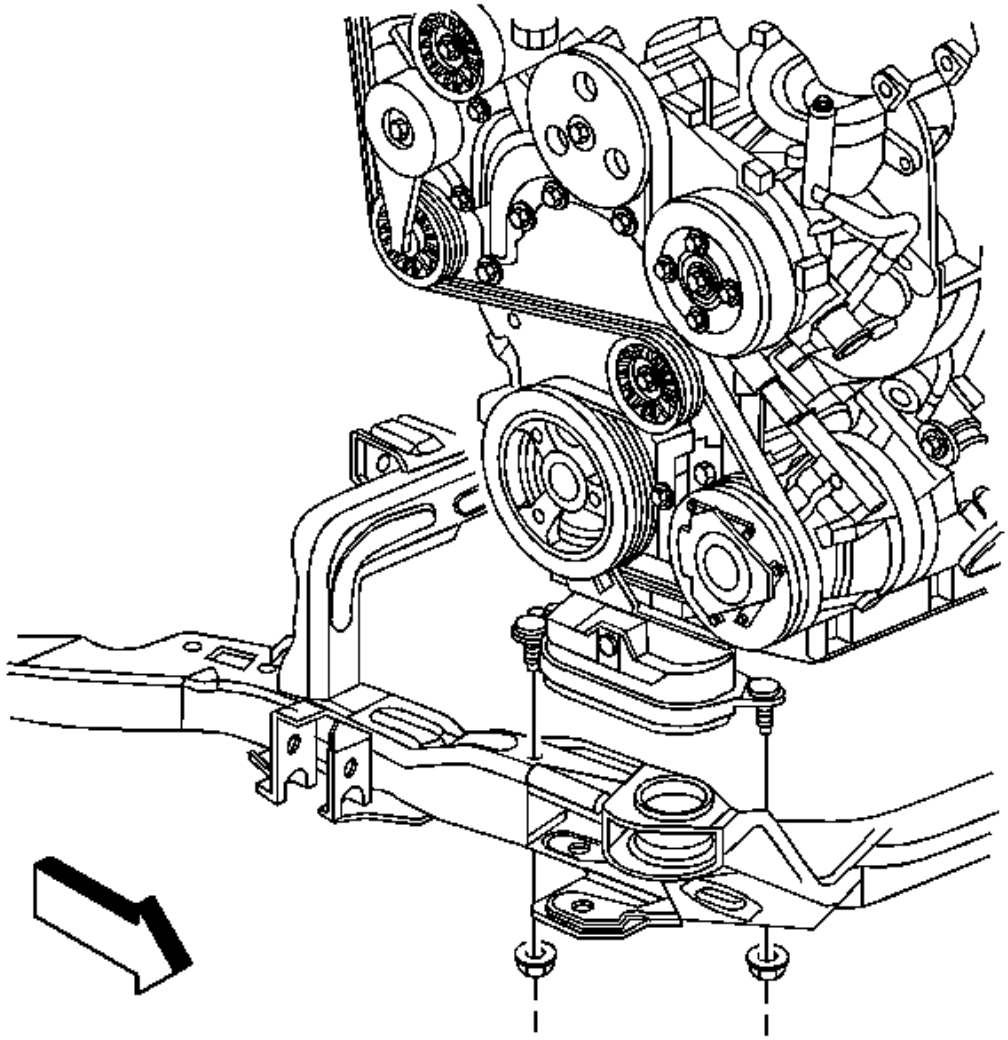

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Fig. 29: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement - Left Side** and **Engine Mount Strut Replacement - Right Side**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the catalytic converter. Refer to **Catalytic Converter Replacement** .
5. Remove the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .
6. Remove the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
7. Remove the engine mount to frame nuts.

NOTE: In order to avoid oil pan damage and possible engine failure, insert a block of wood that spans the width of the oil pan bottom between the oil pan and the jack support.

8. Place a utility stand and a block of wood under the oil pan in order to raise the engine.

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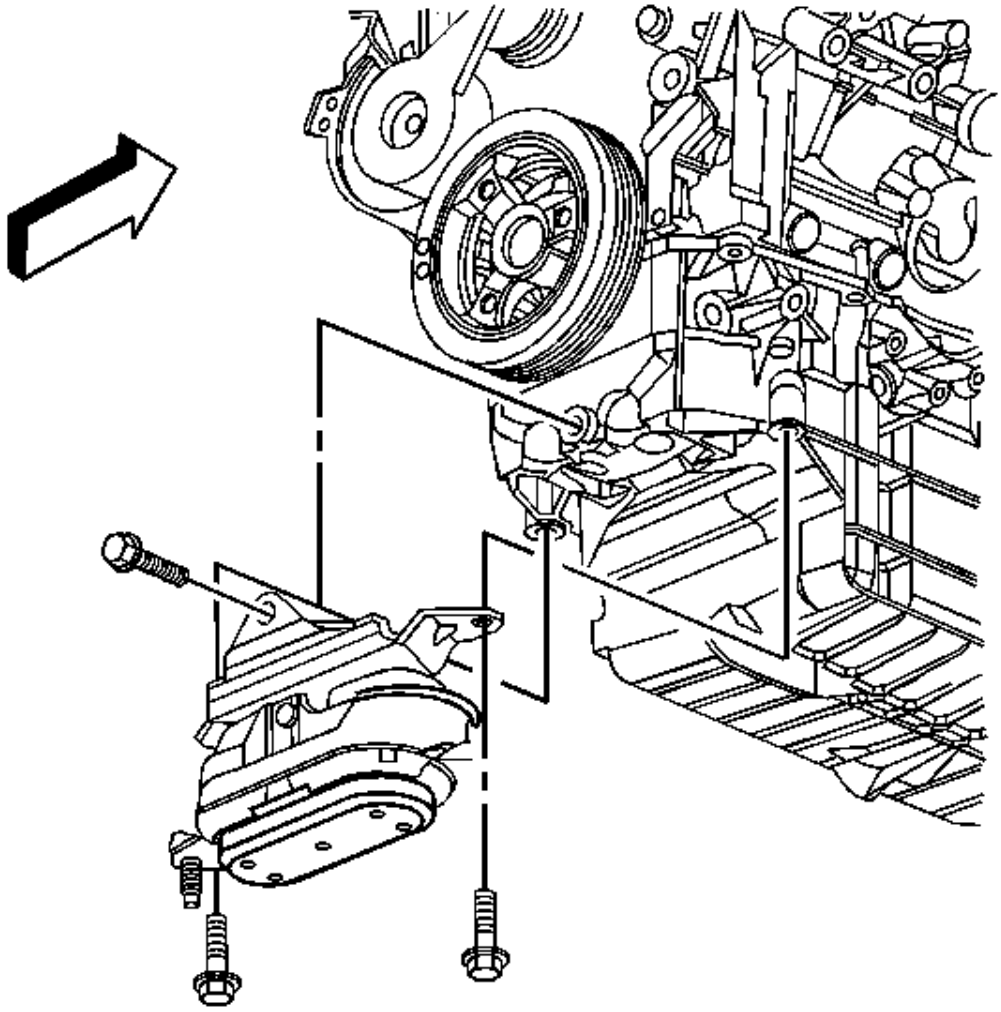

Fig. 30: Removing/Installing Engine Mount & Bracket To-Oil-Pan Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine mount bracket to oil pan bolts.
10. Remove the engine mount and bracket.

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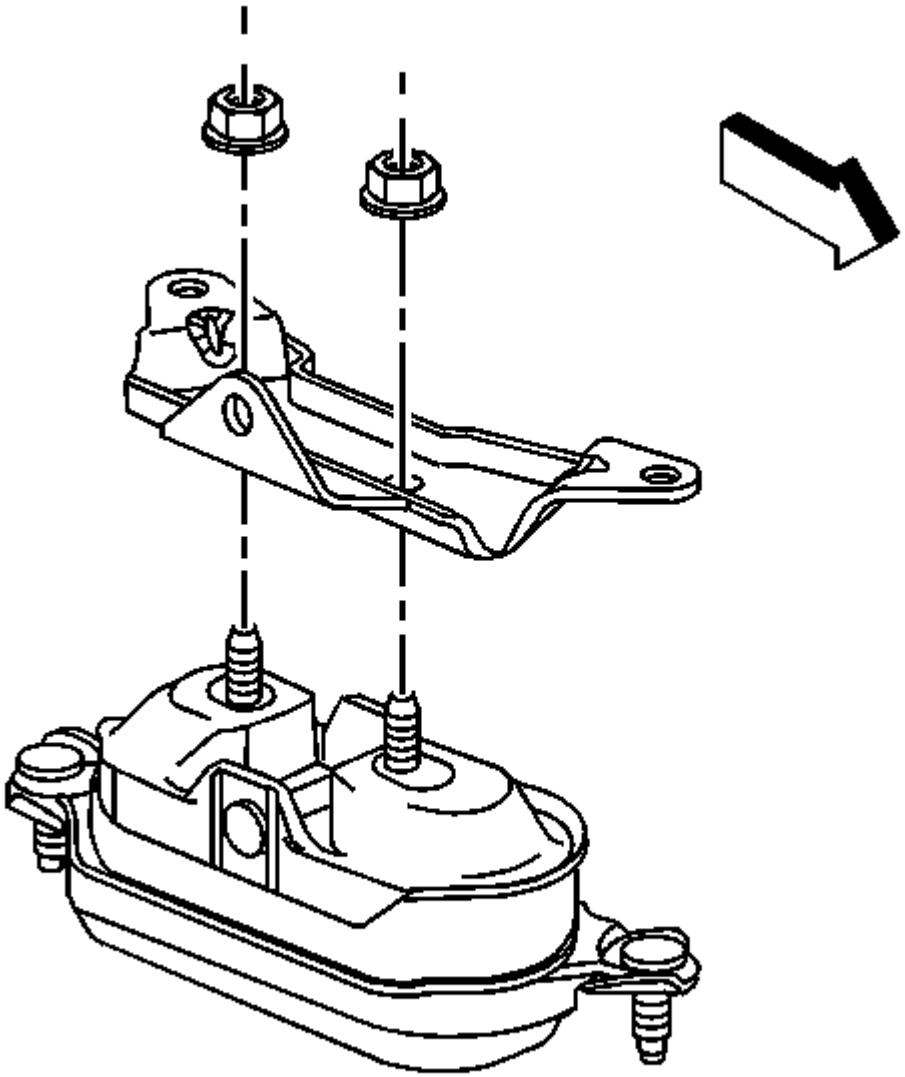

Fig. 31: Identifying Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine mount bracket to engine mount nuts.
12. Remove the engine bracket from the engine mount.

Installation Procedure

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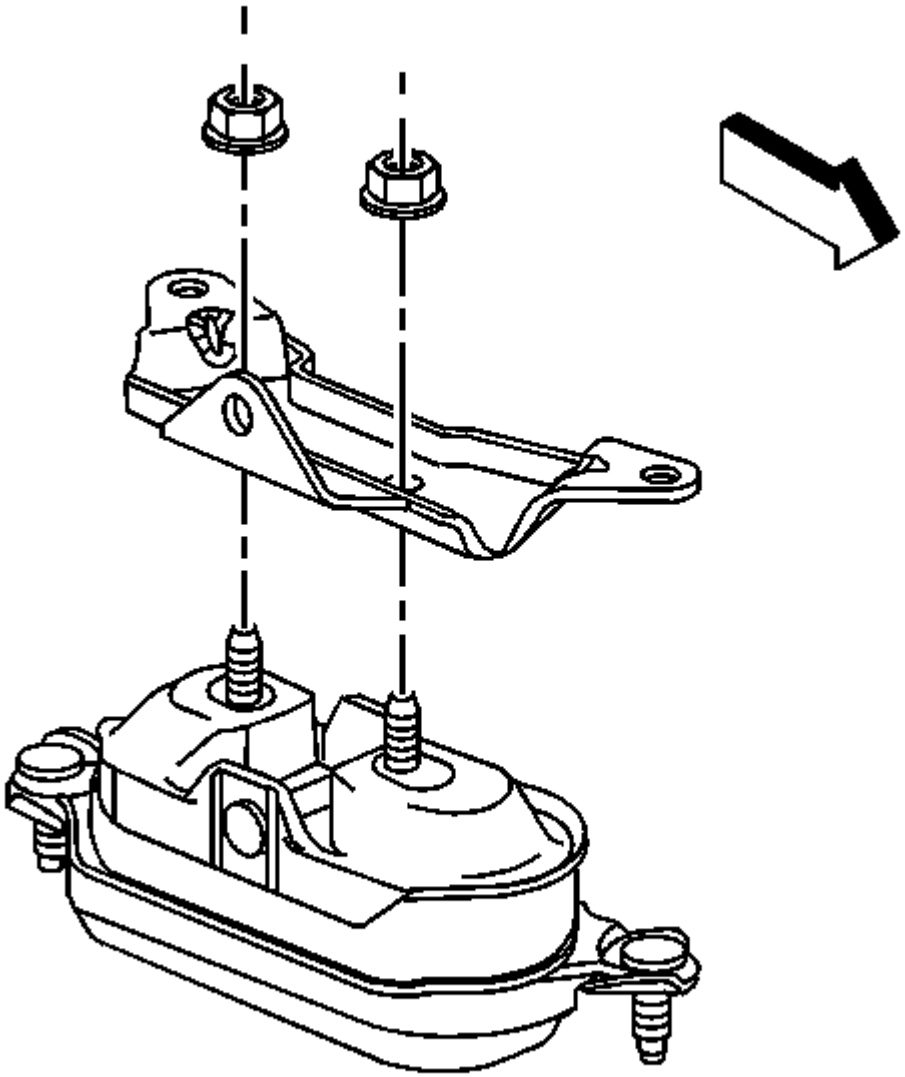

Fig. 32: Identifying Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket to the engine mount.

NOTE: Refer to Fastener Notice .

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

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

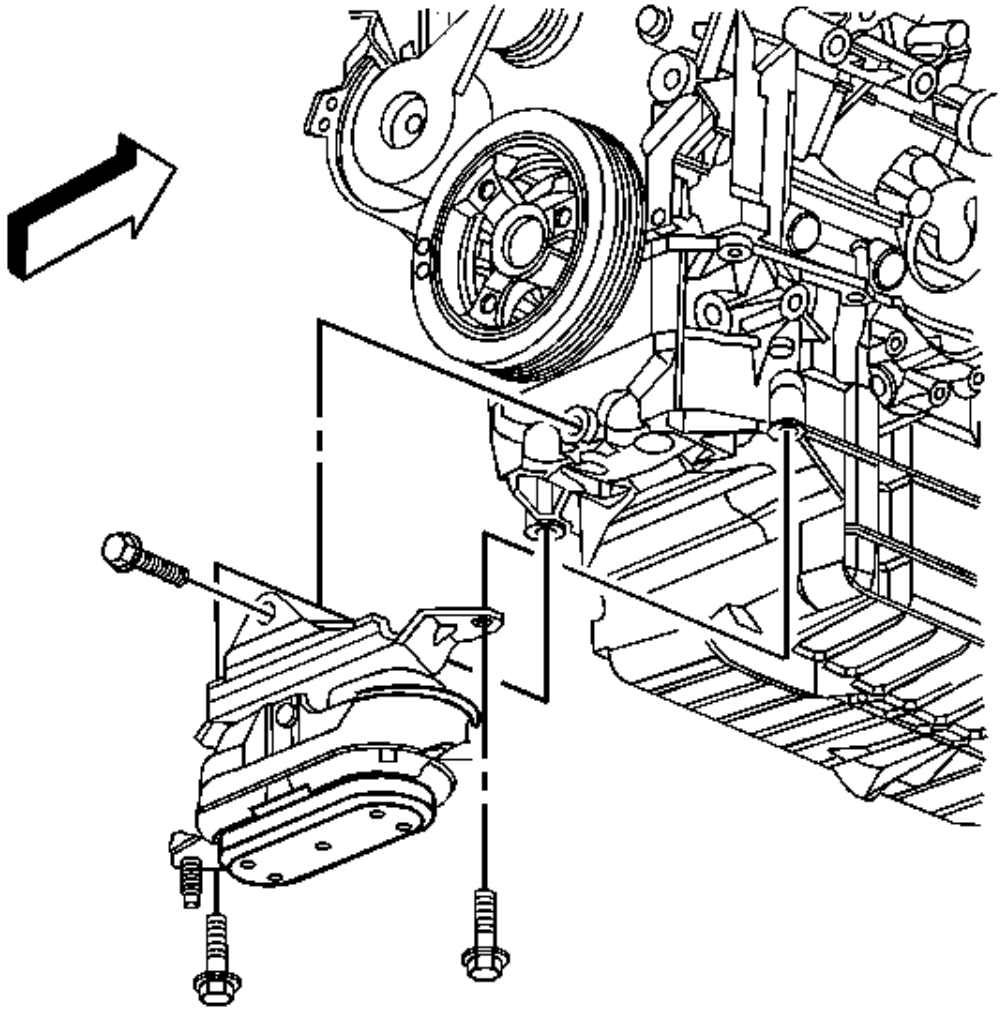

Fig. 33: Removing/Installing Engine Mount & Bracket To-Oil-Pan Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount and bracket to the oil pan.
4. Install the engine mount bracket to oil pan bolts.

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

5. Using the utility stand, lower the engine.

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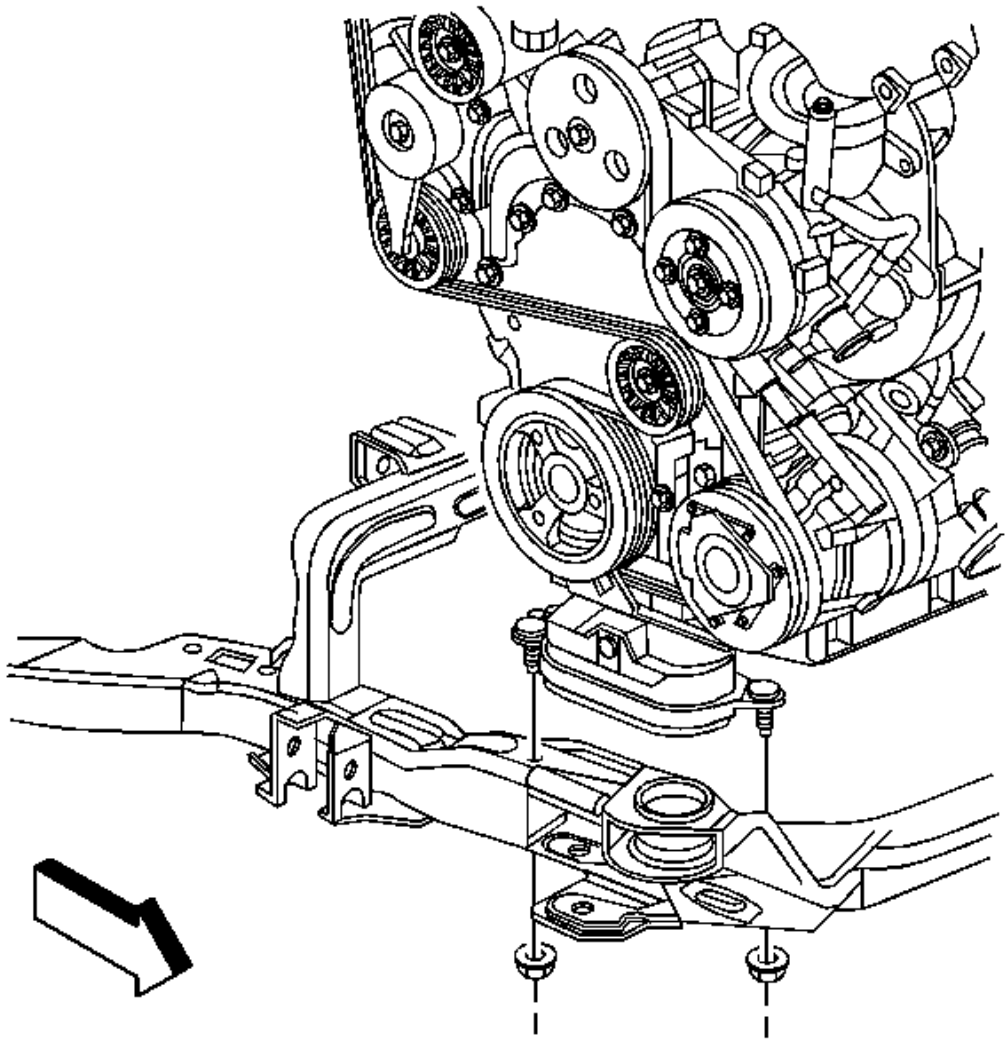

Fig. 34: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount to frame nuts.

   Tighten: Tighten the nuts to 47 N.m (35 lb ft).

7. Install the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
8. Install the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .
9. Install the catalytic converter. Refer to **Catalytic Converter Replacement** .

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10. Lower the vehicle.
11. Install the engine mount struts. Refer to **Engine Mount Strut Replacement - Left Side** and **Engine Mount Strut Replacement - Right Side**.
12. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

Engine Mount Strut Replacement - Left Side

Removal Procedure

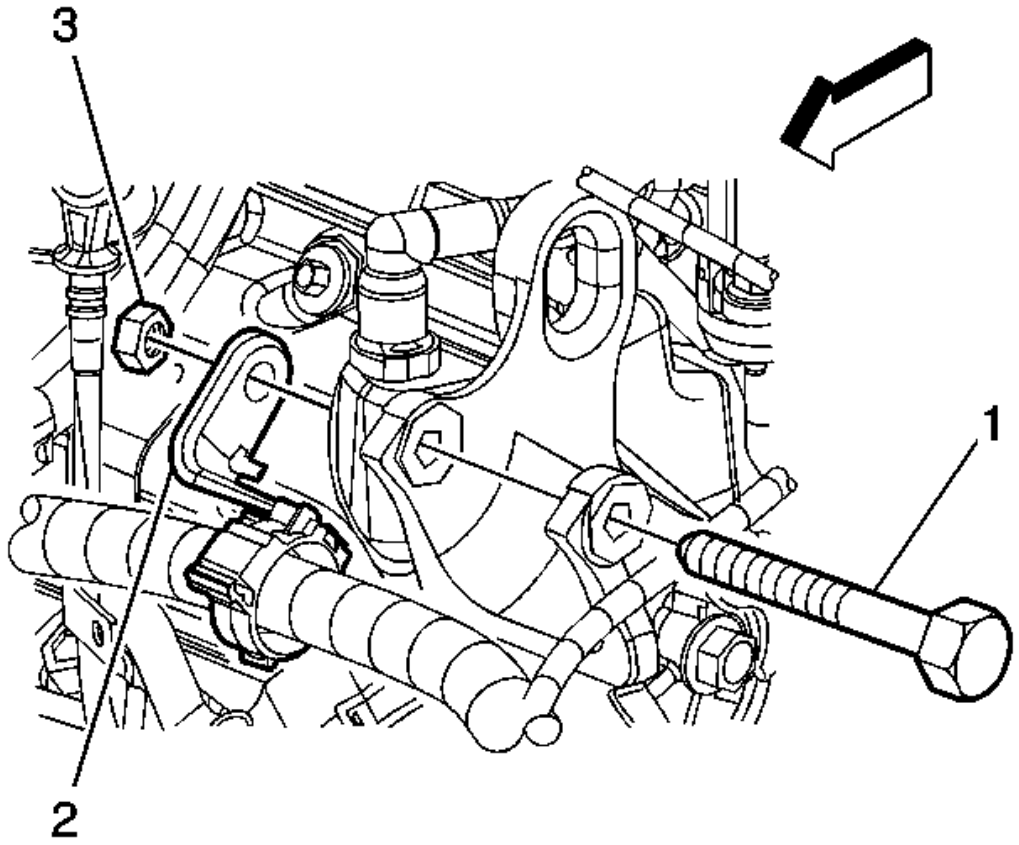

Fig. 35: Identifying Engine Mount Strut Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Loosen the engine mount strut to engine mount strut bracket through bolt (1) and nut (3).
3. Remove the engine mount strut bracket through bolt nut (3).
4. Remove the engine harness clip (2) from the through bolt.

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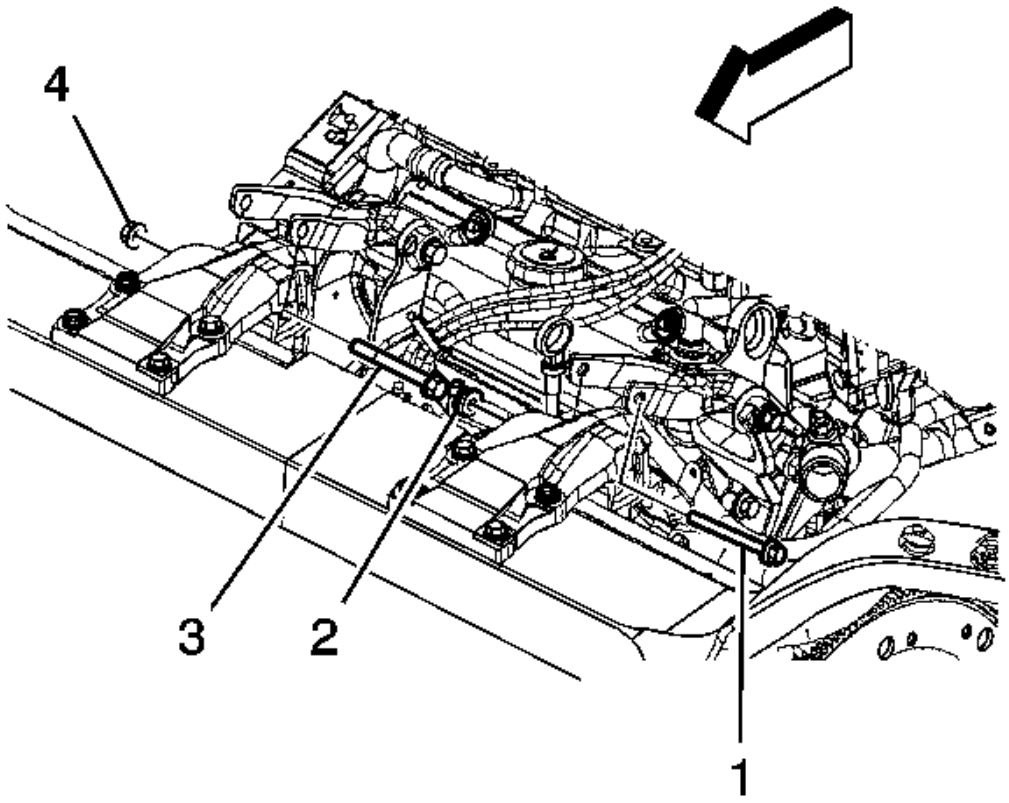

Fig. 36: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

5. Loosen and remove the engine mount strut to engine mount strut bracket through bolt (1) and nut (2).

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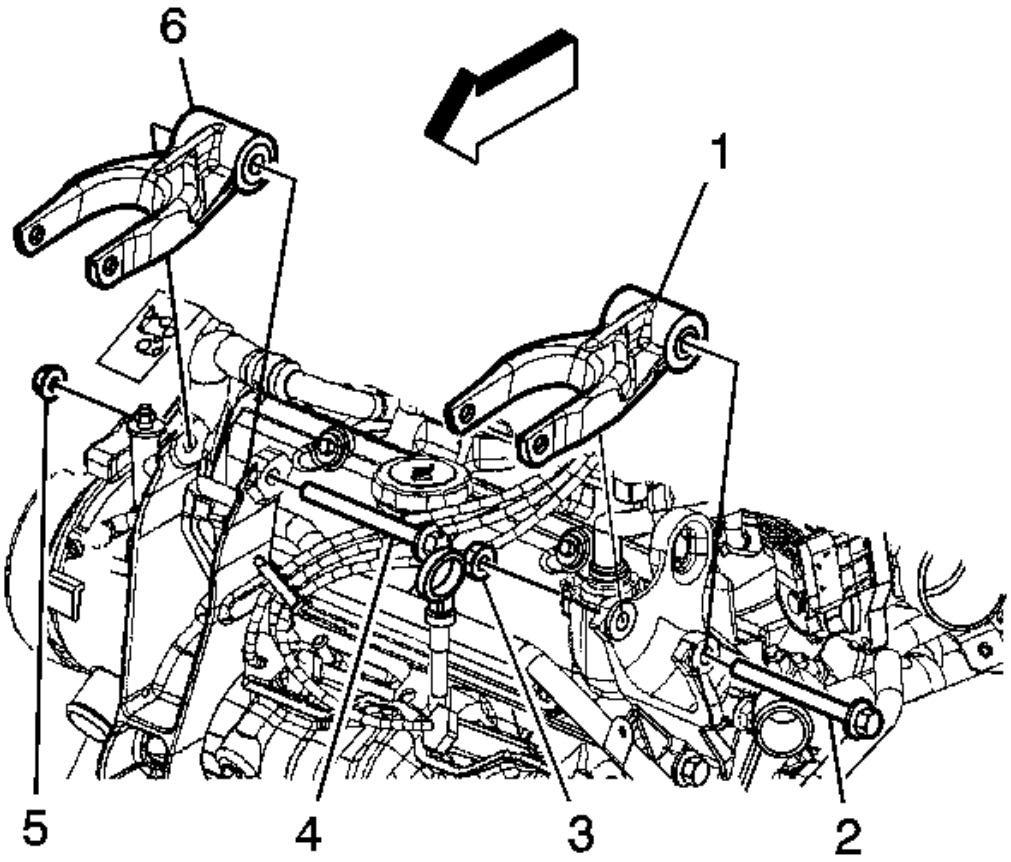

Fig. 37: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount strut to engine mount strut bracket through bolt (2).
7. Remove the engine mount strut (1).
8. Inspect the rubber in the engine mount strut for the following conditions:
    - Hardness
    - Splitting
    - Cracking

Installation Procedure

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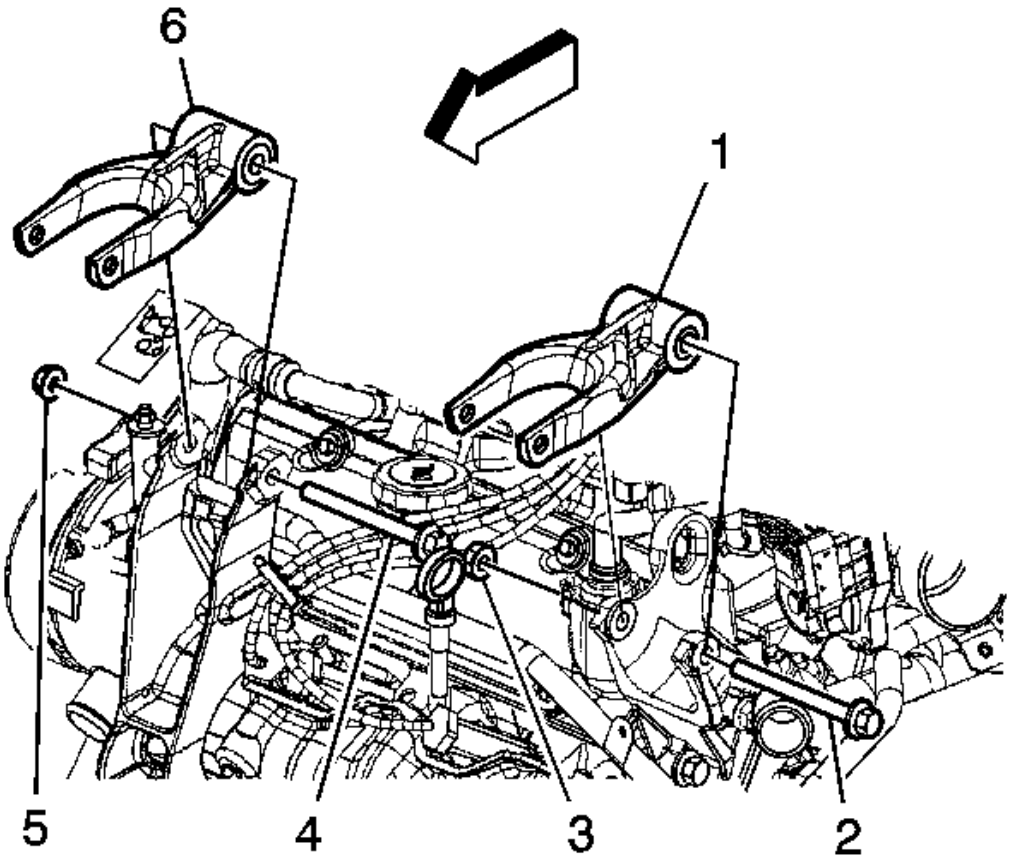

Fig. 38: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut (1).
2. Install the engine mount strut to engine mount strut bracket through bolt (2).

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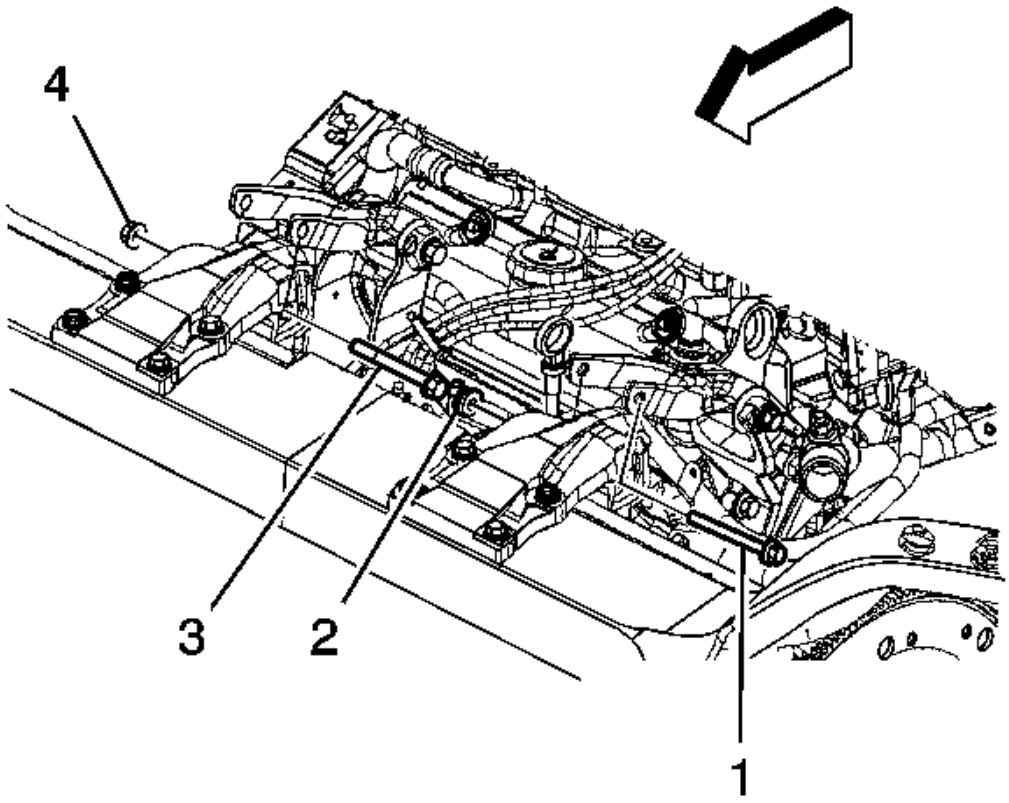

Fig. 39: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install and tighten the engine mount strut to engine mount strut bracket through bolt (1) and nut (2).

   Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

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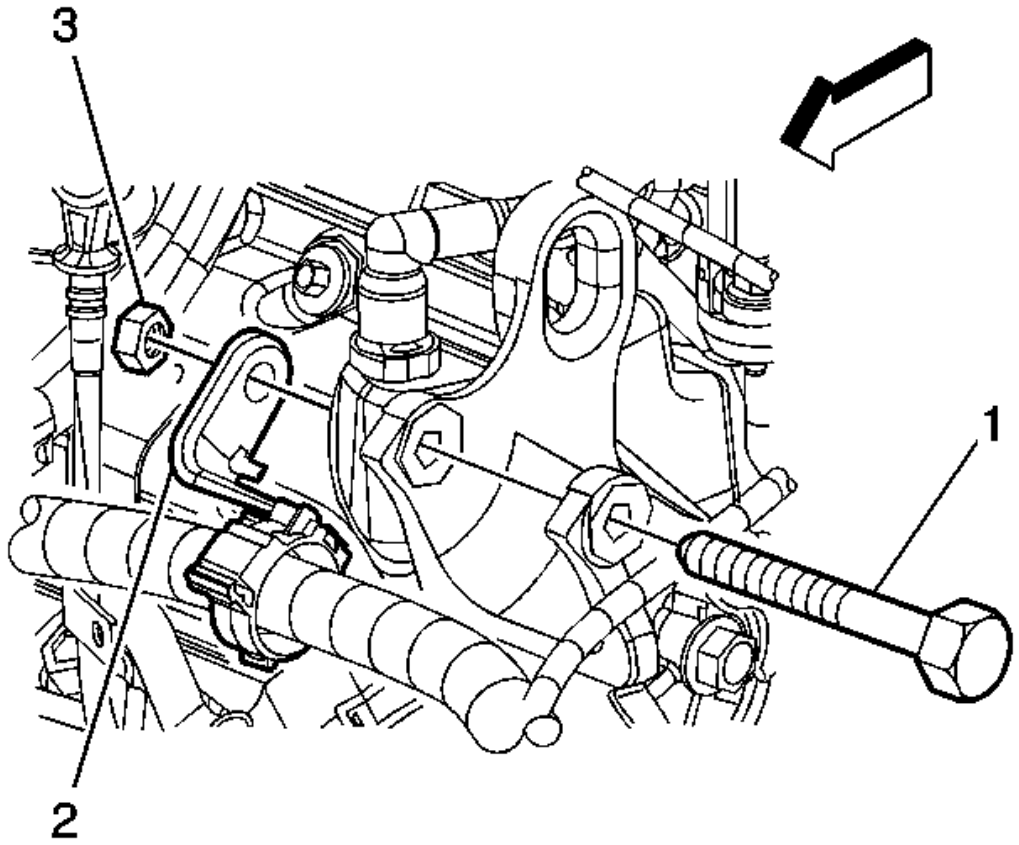

Fig. 40: Identifying Engine Mount Strut Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the engine harness clip (2) to the through bolt.
5. Install the engine mount strut bracket through bolt nut (3).
6. Tighten the engine mount strut to engine mount strut bracket through bolt (1) and nut (3).

   Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Engine Mount Strut Replacement - Right Side

Removal Procedure

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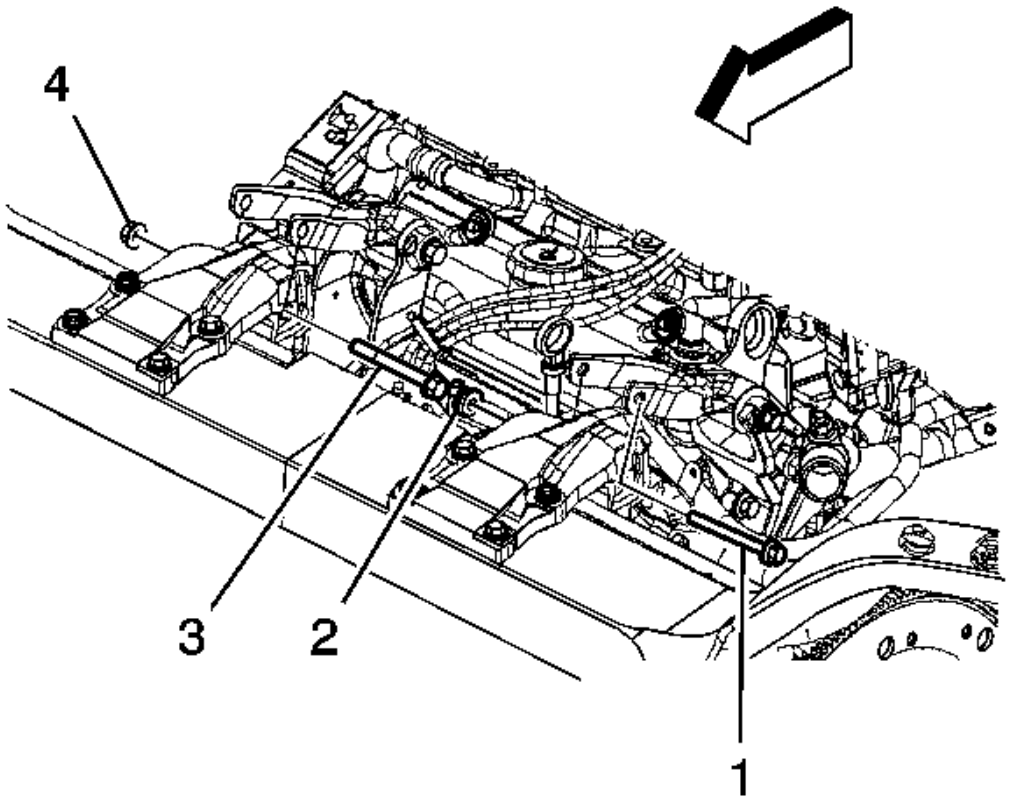

Fig. 41: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Loosen and remove the engine mount strut to engine mount strut bracket through bolt (3) and nut (4).

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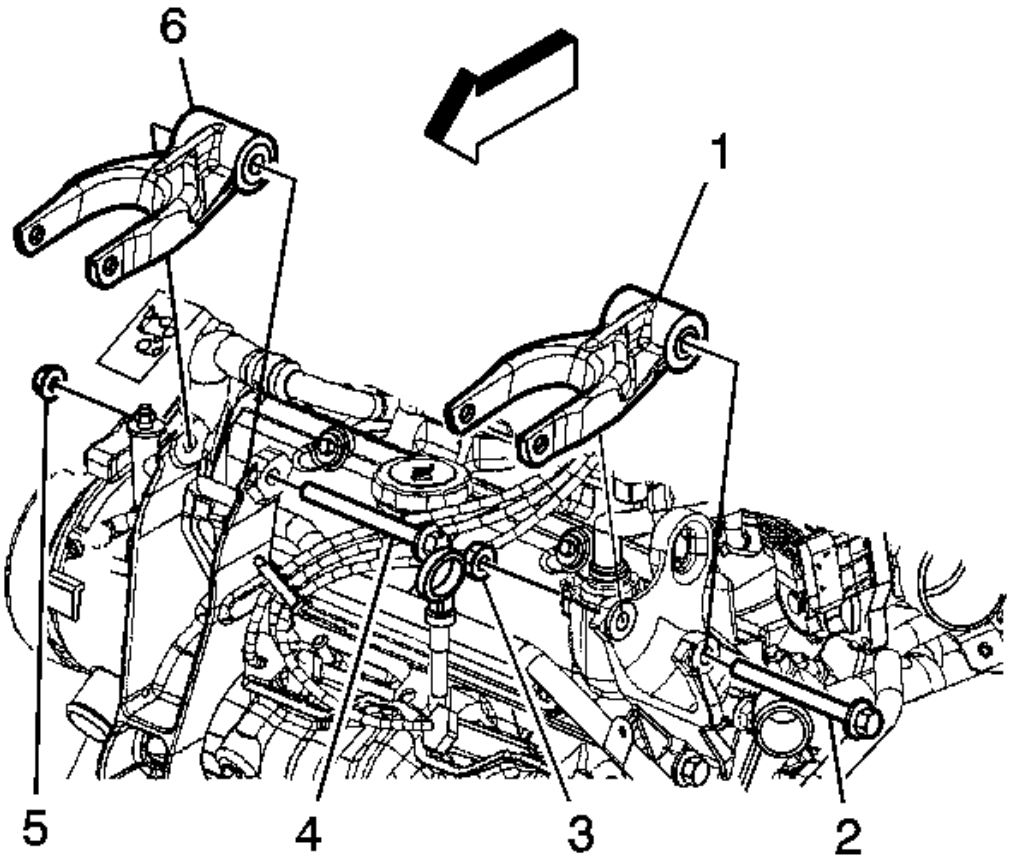

Fig. 42: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

3. Loosen and remove the engine mount strut to engine mount strut bracket through bolt (4) and nut (5).
4. Remove the engine mount strut (6).
5. Inspect the rubber in the engine mount strut for the following conditions:
    - Hardness
    - Splitting
    - Cracking

Installation Procedure

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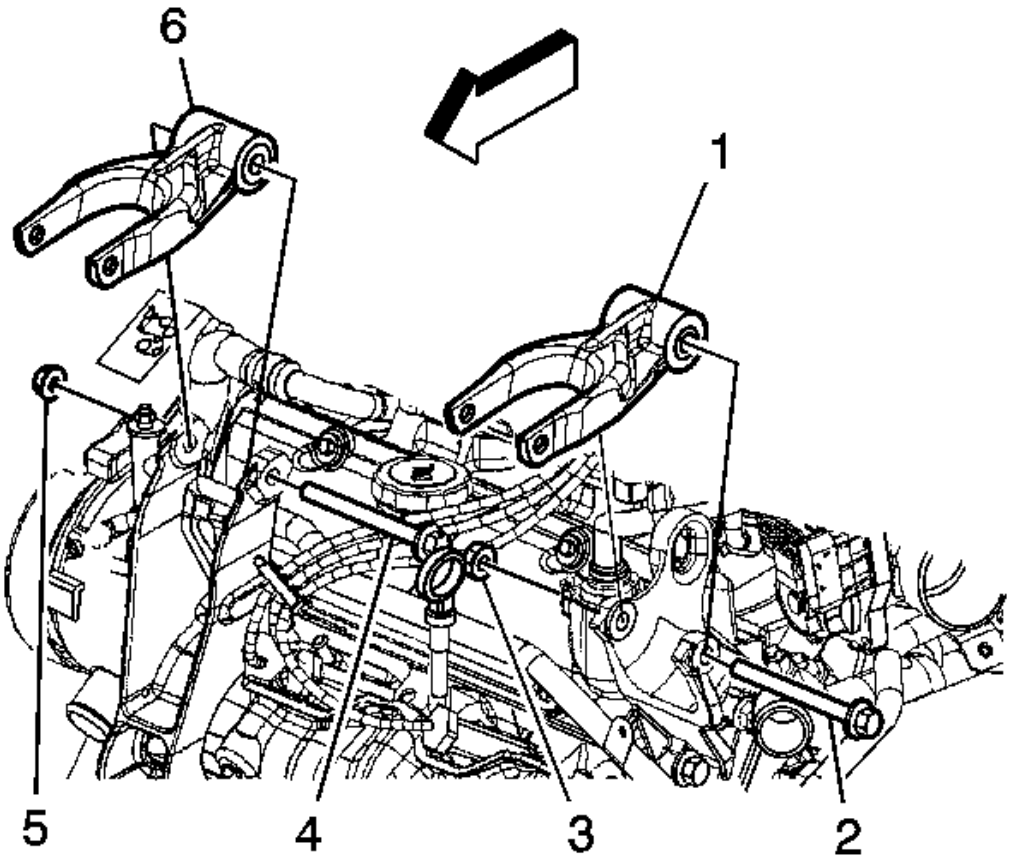

Fig. 43: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut (6).

NOTE: **Refer to Fastener Notice .**

2. Install and tighten the engine mount strut to engine mount strut bracket through bolt (4) and nut (5).

Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

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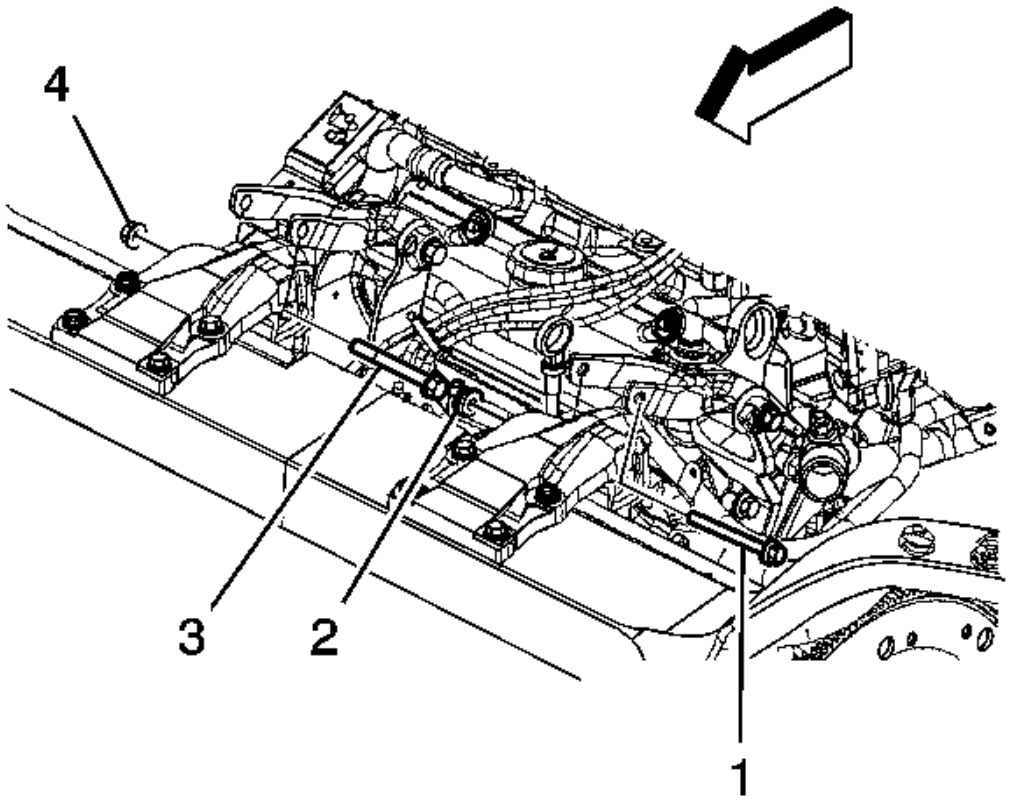

Fig. 44: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

3. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
4. Install and tighten the engine mount strut to engine mount strut bracket through bolt (3) and nut (4).

   Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

Engine Mount Strut Bracket Replacement - Left Side

Removal Procedure

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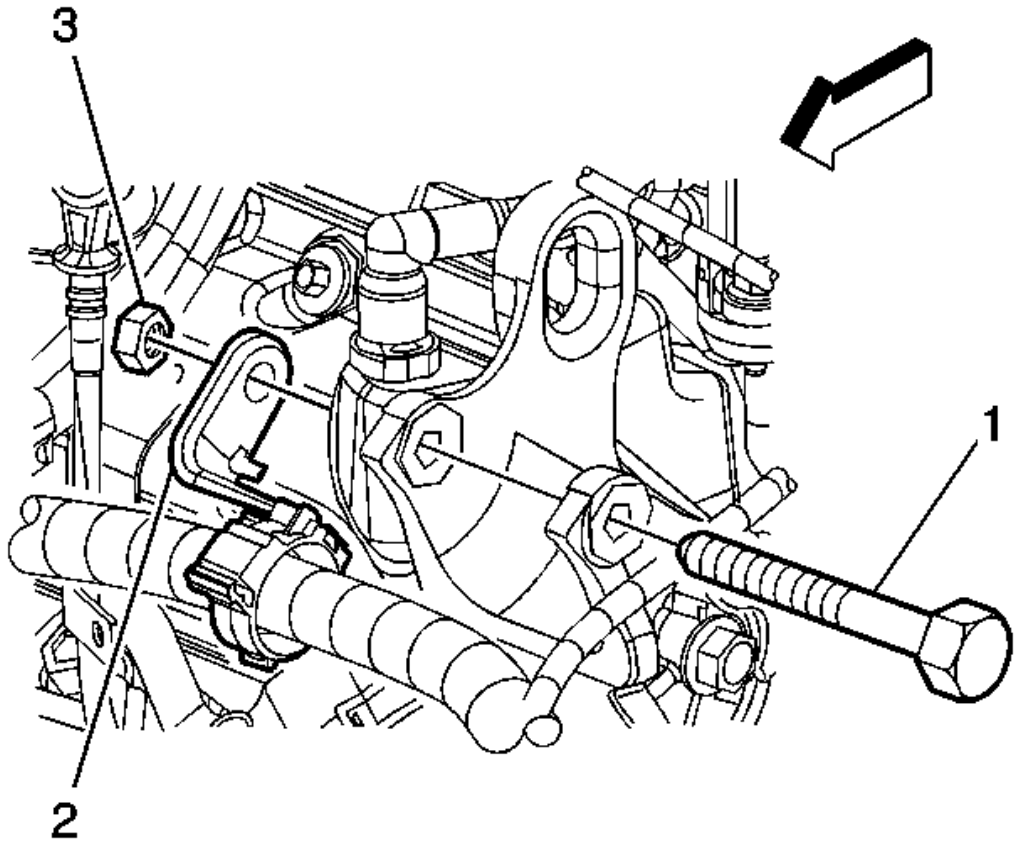

Fig. 45: Identifying Engine Mount Strut Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

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** .
3. Loosen the engine mount strut to engine mount strut bracket through bolt (1) and nut (3).
4. Remove the engine mount strut bracket through bolt nut (3).
5. Remove the engine harness clip (2) from the through bolt.

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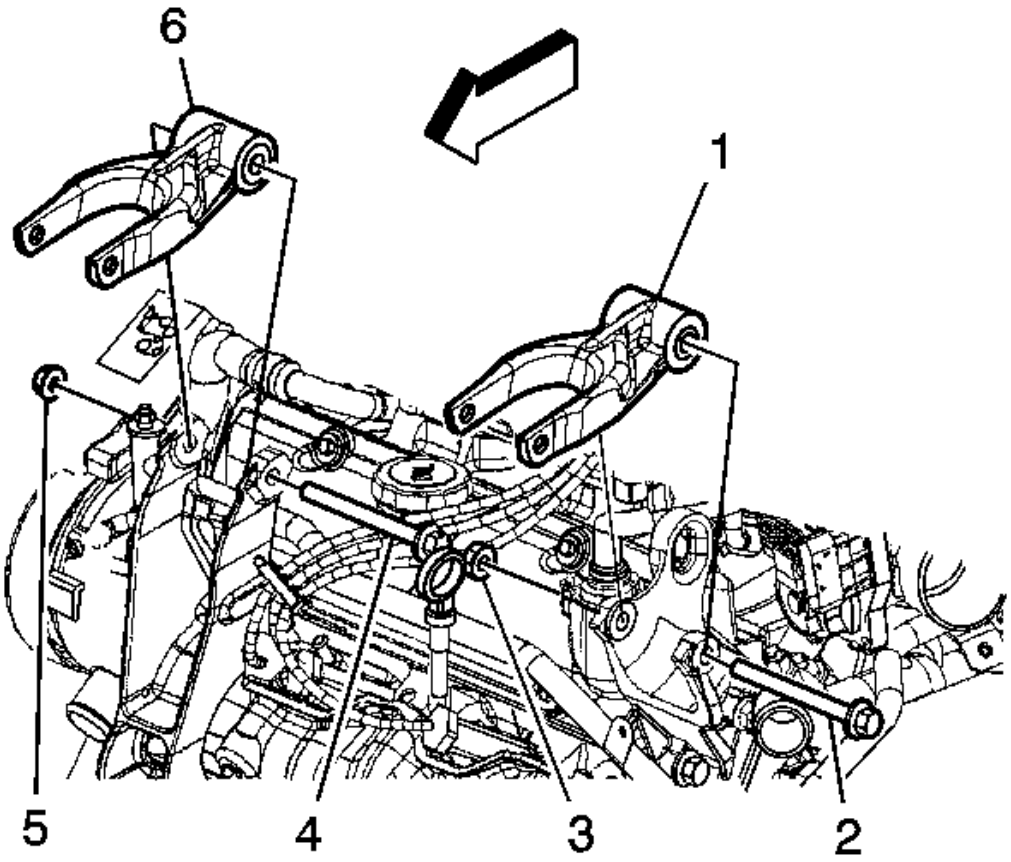

Fig. 46: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount strut to engine mount strut bracket through bolt (2).
7. Rotate the engine mount strut up out of the way.
8. Remove the 2 nuts holding the heater pipes onto the throttle body.
9. Position the heater pipes out of the way.

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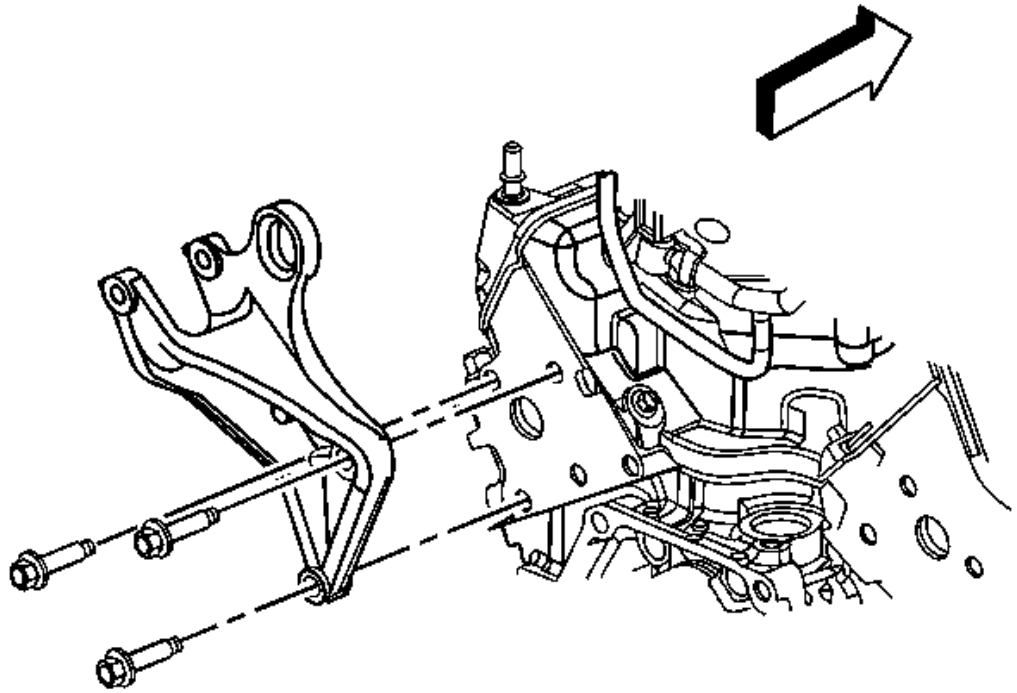

Fig. 47: Identifying Engine Mount Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine mount strut/engine lift bracket bolts.
11. Remove the engine mount strut/engine lift bracket.

Installation Procedure

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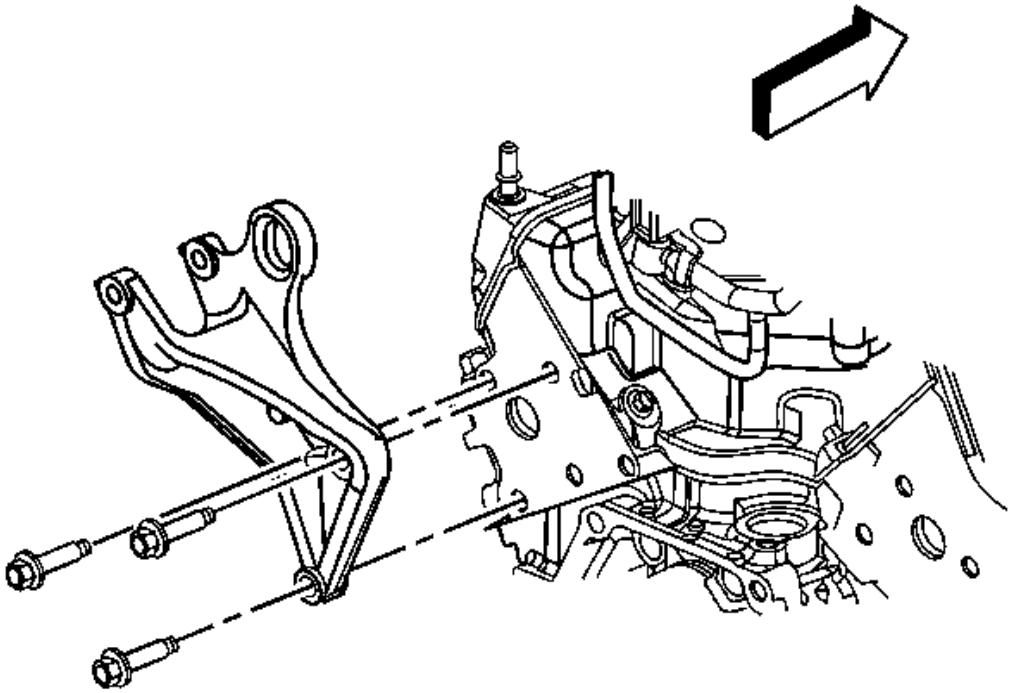

Fig. 48: Identifying Engine Mount Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount strut/engine lift bracket to the cylinder head.

NOTE: **Refer to Fastener Notice .**

2. Install the engine mount strut/engine lift bracket bolts

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

3. Position the back heater pipe to the throttle body.
4. Install the nuts holding the heater pipes to the throttle body.

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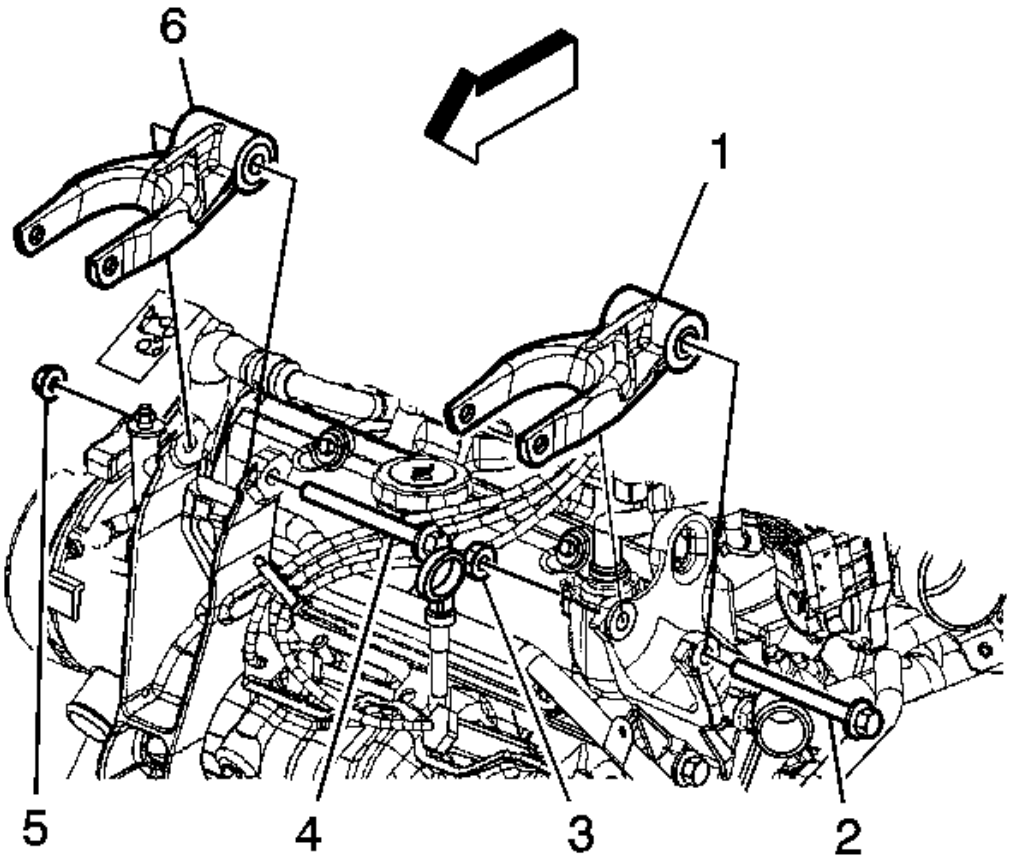

Fig. 49: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

5. Rotate the engine mount strut into position.
6. Install the engine mount strut to engine mount strut bracket through bolt (2).

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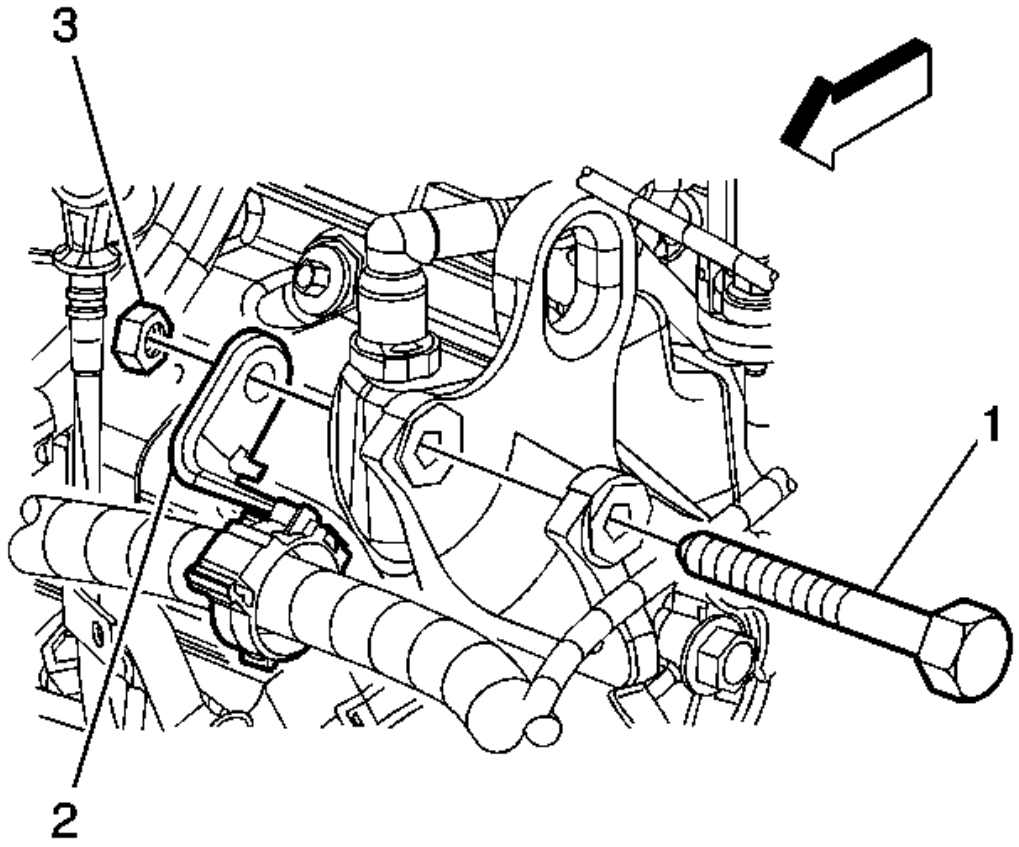

Fig. 50: Identifying Engine Mount Strut Bracket Through Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the engine harness clip (2) to the through bolt.
8. Install the engine mount strut bracket through bolt nut (3).
9. Tighten the engine mount strut to engine mount strut bracket through bolt (1) and nut (3).

   Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

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

Engine Mount Strut Bracket Replacement - Right Side

Removal Procedure

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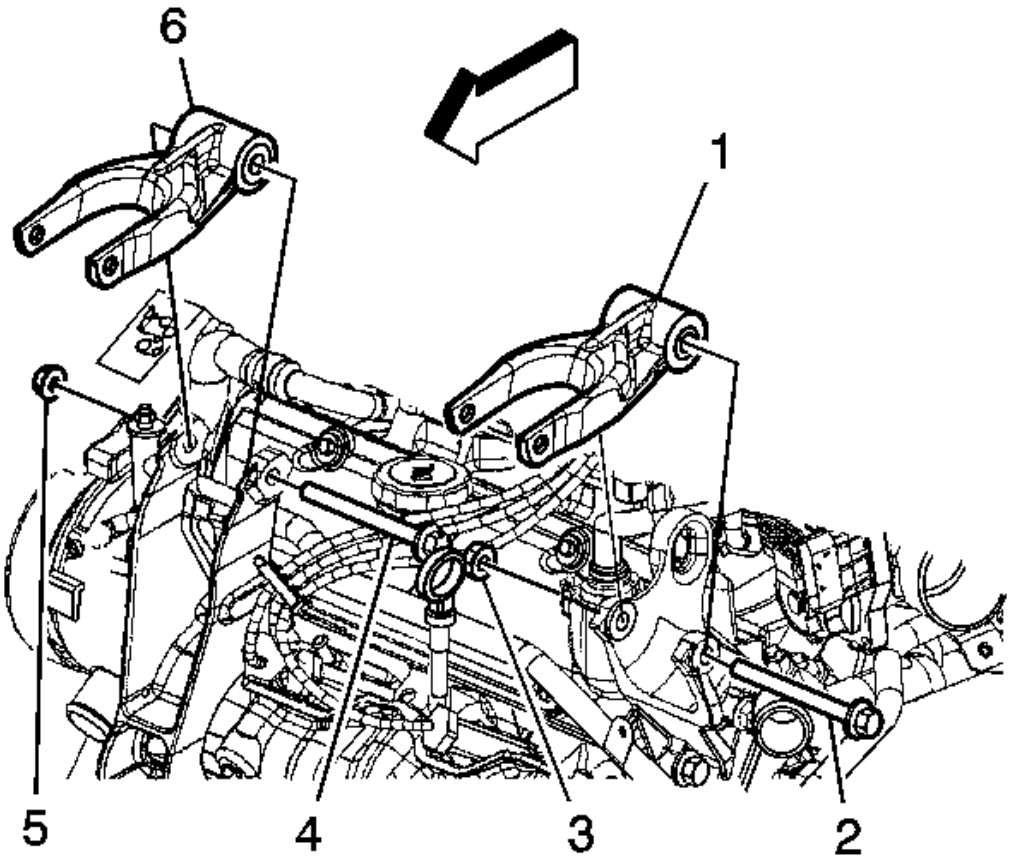

Fig. 51: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Loosen and remove the engine mount strut to engine mount strut bracket through bolt (4) and nut (5).
3. Rotate the engine mount strut up out of the way.

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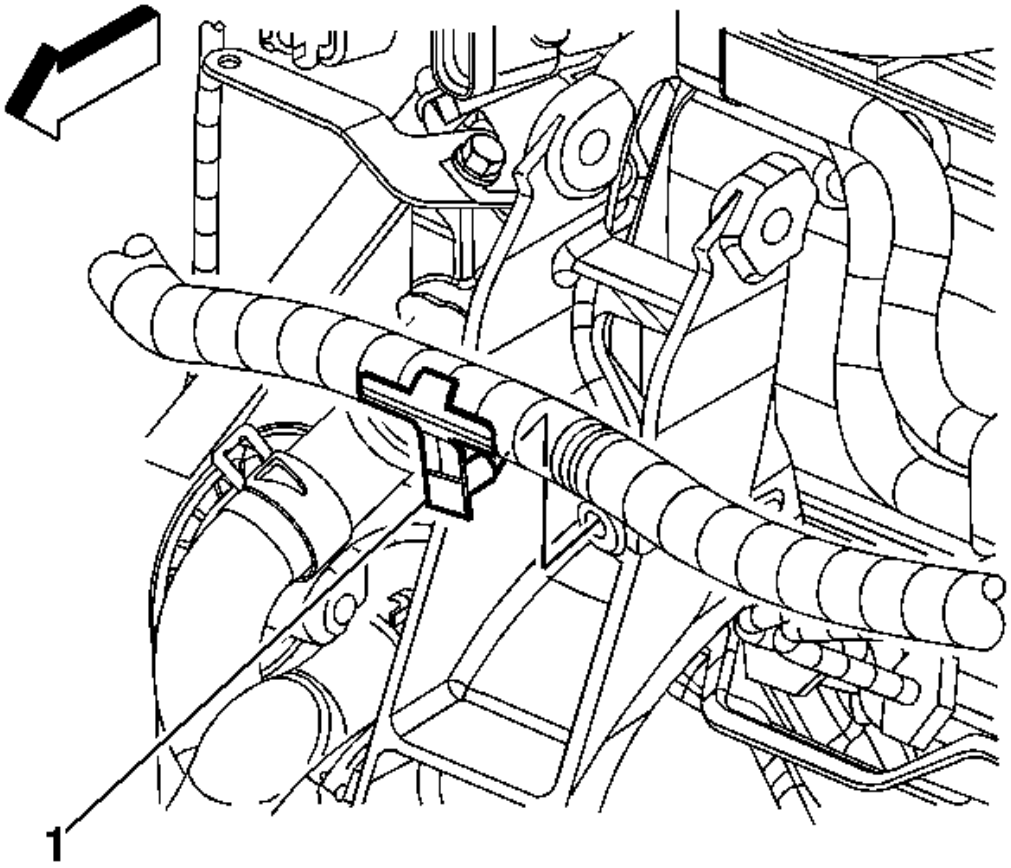

Fig. 52: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine harness clip (1) from the engine mount strut bracket.
5. Remove the drive belt. Refer to **Drive Belt Replacement**.
6. Remove the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
7. Remove the right front engine splash shield. Refer to **Engine Splash Shield Replacement** .

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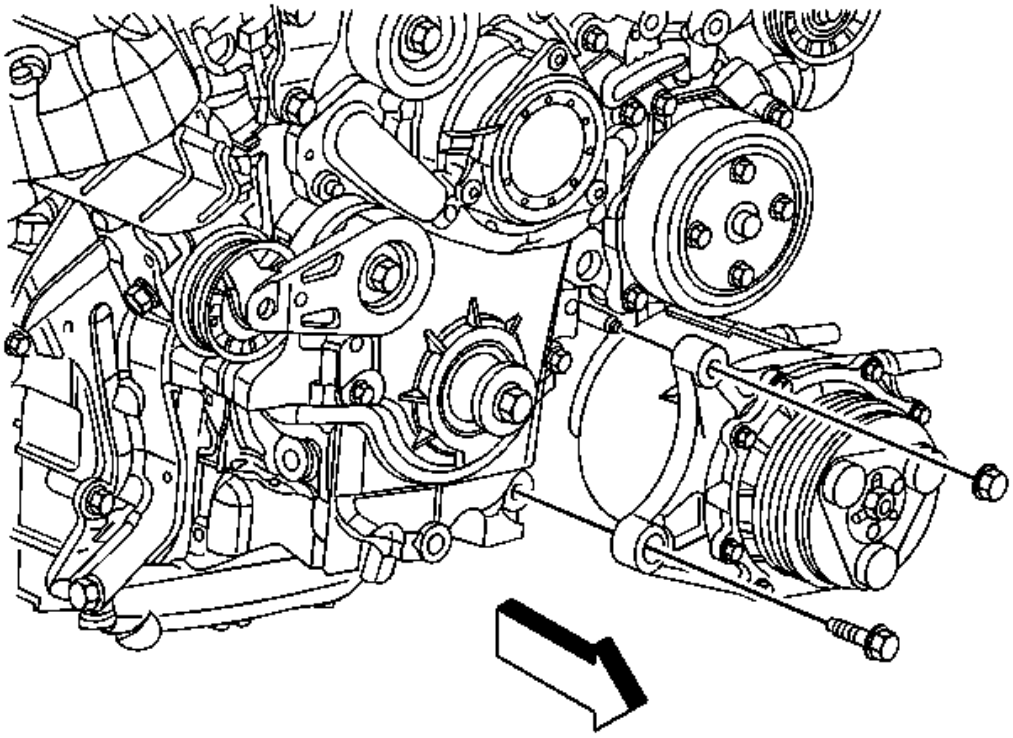

Fig. 53: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

8. Remove the A/C compressor front bolt and nut.

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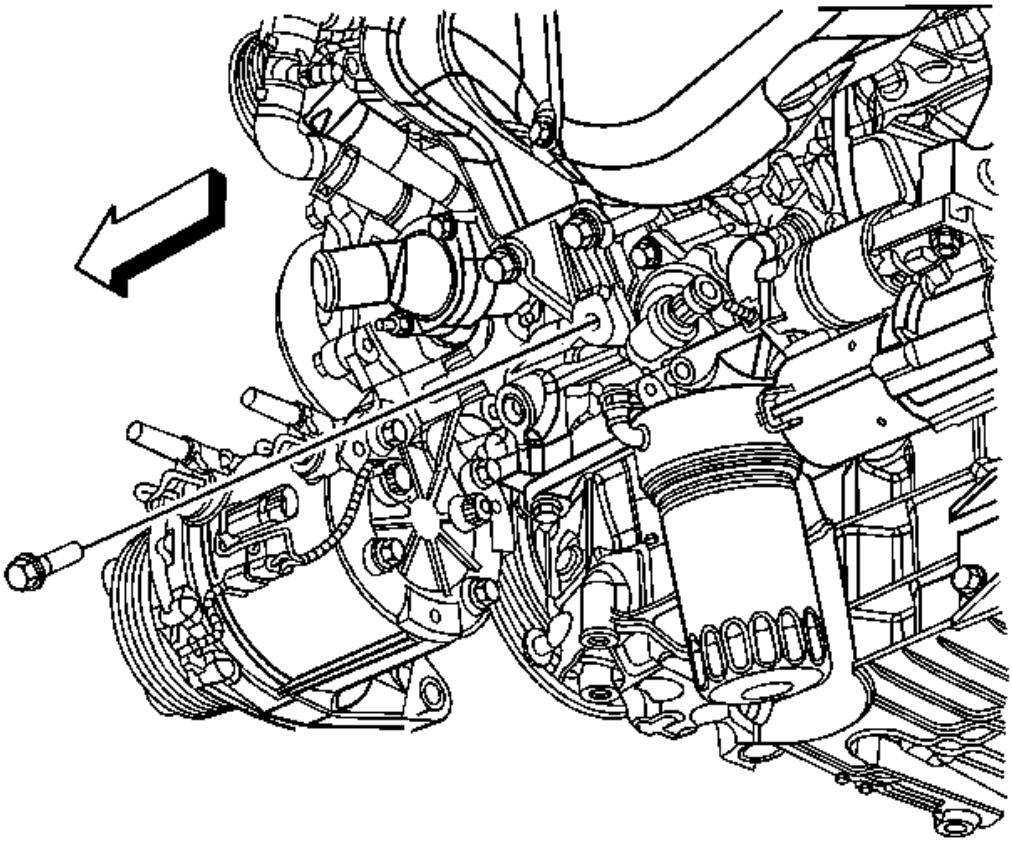

Fig. 54: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the A/C compressor rear bolt.

IMPORTANT: Do not evacuate the air conditioning (A/C) system.

10. Position the A/C compressor aside.

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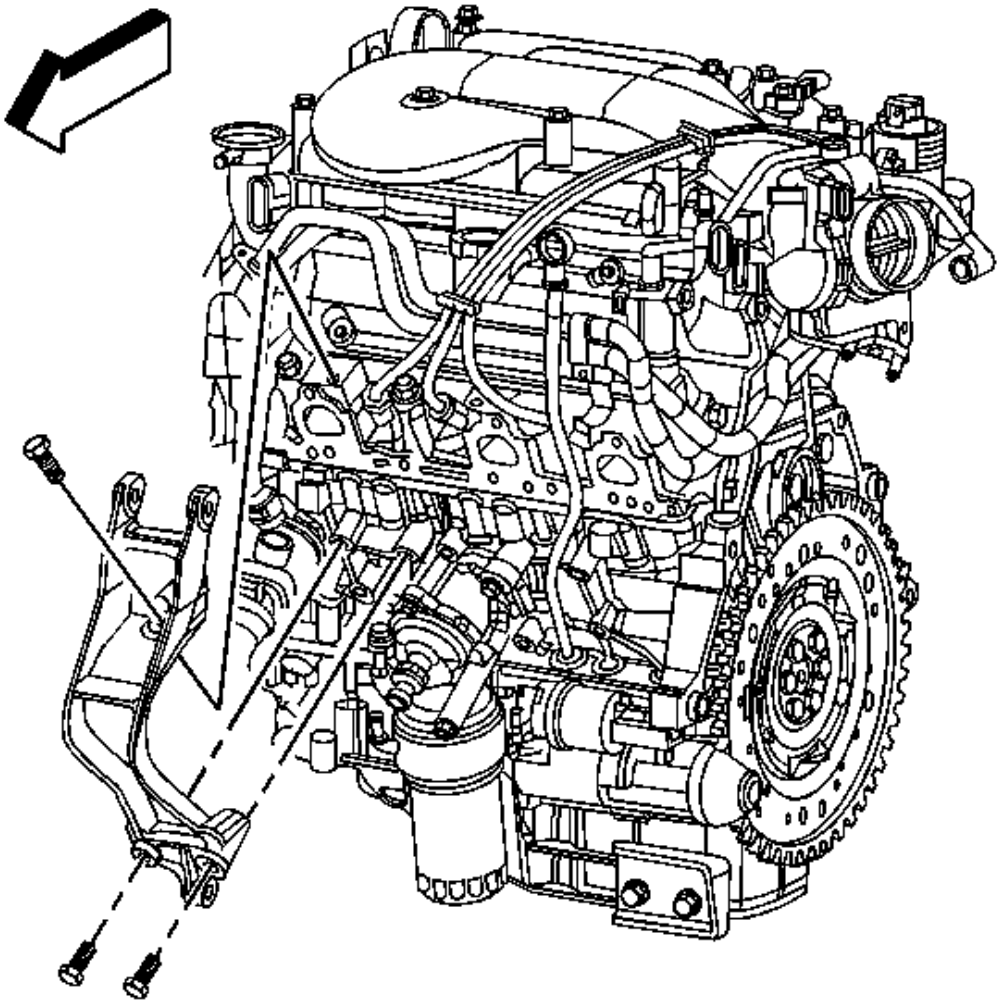

Fig. 55: Identifying Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

11. Remove the lower engine mount strut bracket bolts.
12. Lower the vehicle.
13. Remove the upper engine mount strut bracket bolts.
14. Remove the engine mount strut bracket.

Installation Procedure

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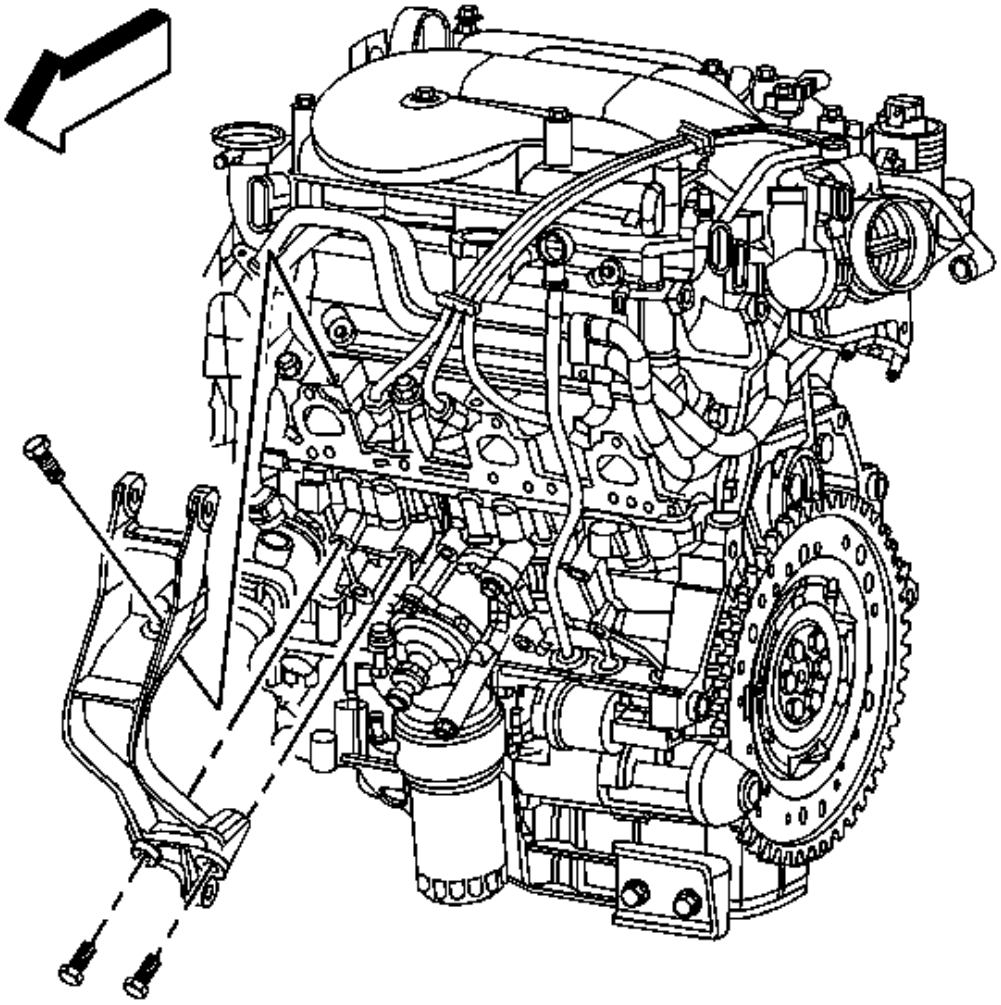

Fig. 56: Identifying Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount strut bracket to the engine.
2. Install the upper engine mount strut bracket bolt.
3. Raise the vehicle.

NOTE: Refer to Fastener Notice .

4. Install the lower engine mount strut bracket bolts.

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

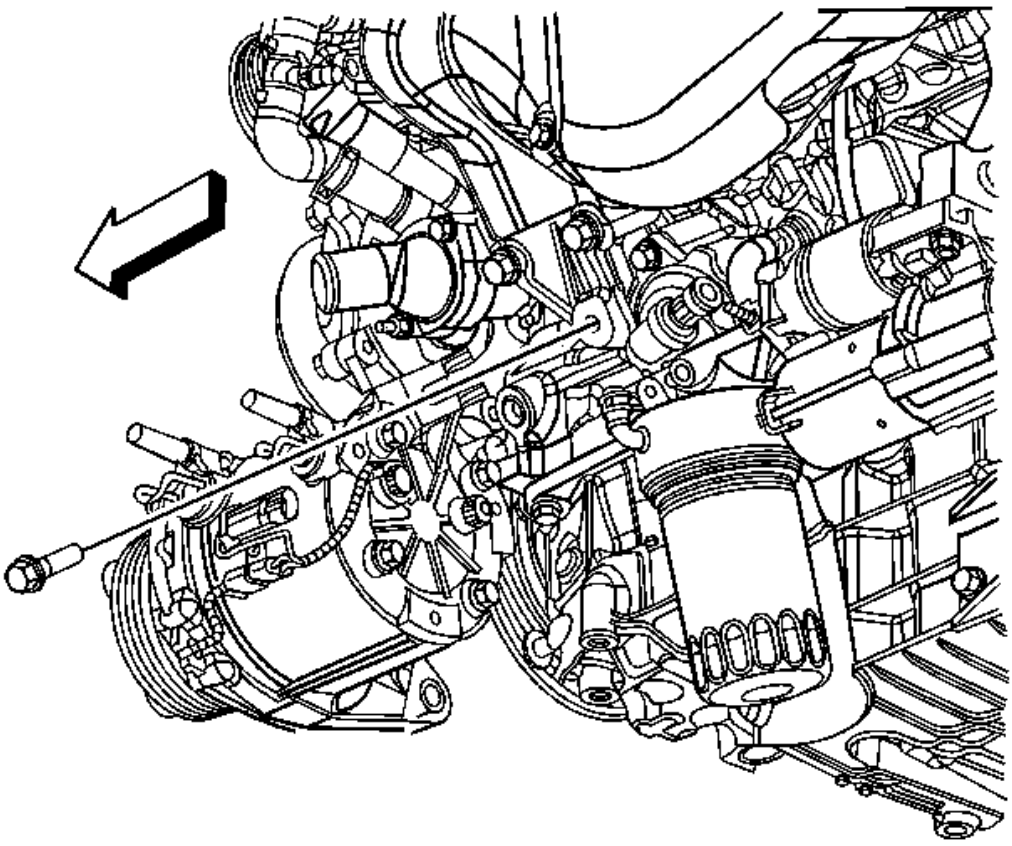

Fig. 57: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

5. Position and install the A/C compressor onto the stud.
6. Install the A/C compressor rear bolt.

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

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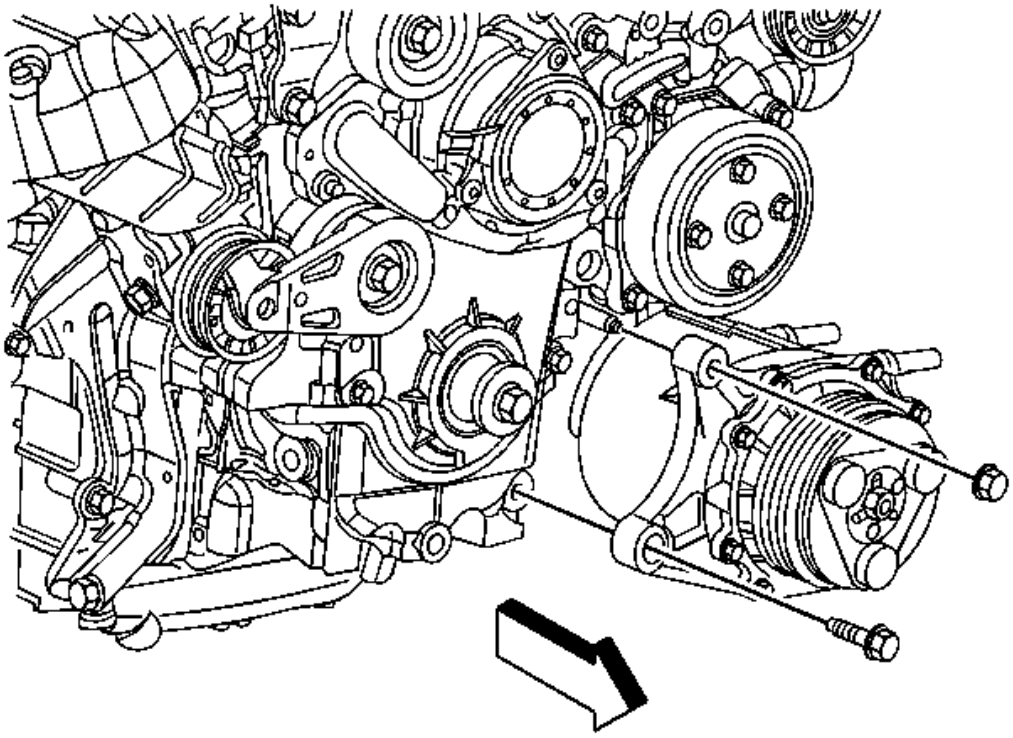

Fig. 58: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

7. Install the A/C compressor front bolt and nut.

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

8. Install the drive belt. Refer to **Drive Belt Replacement**.
9. Install the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
10. Install the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .

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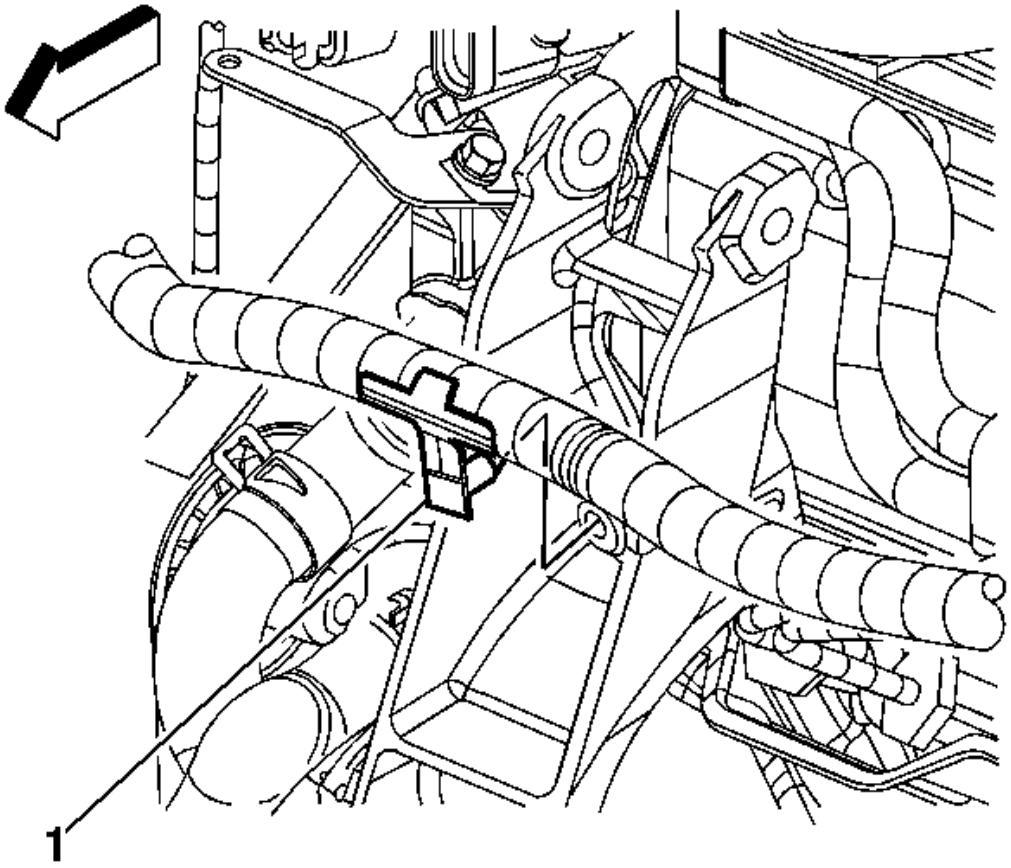

Fig. 59: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

11. Install the engine harness clip (1) to the engine mount strut bracket.

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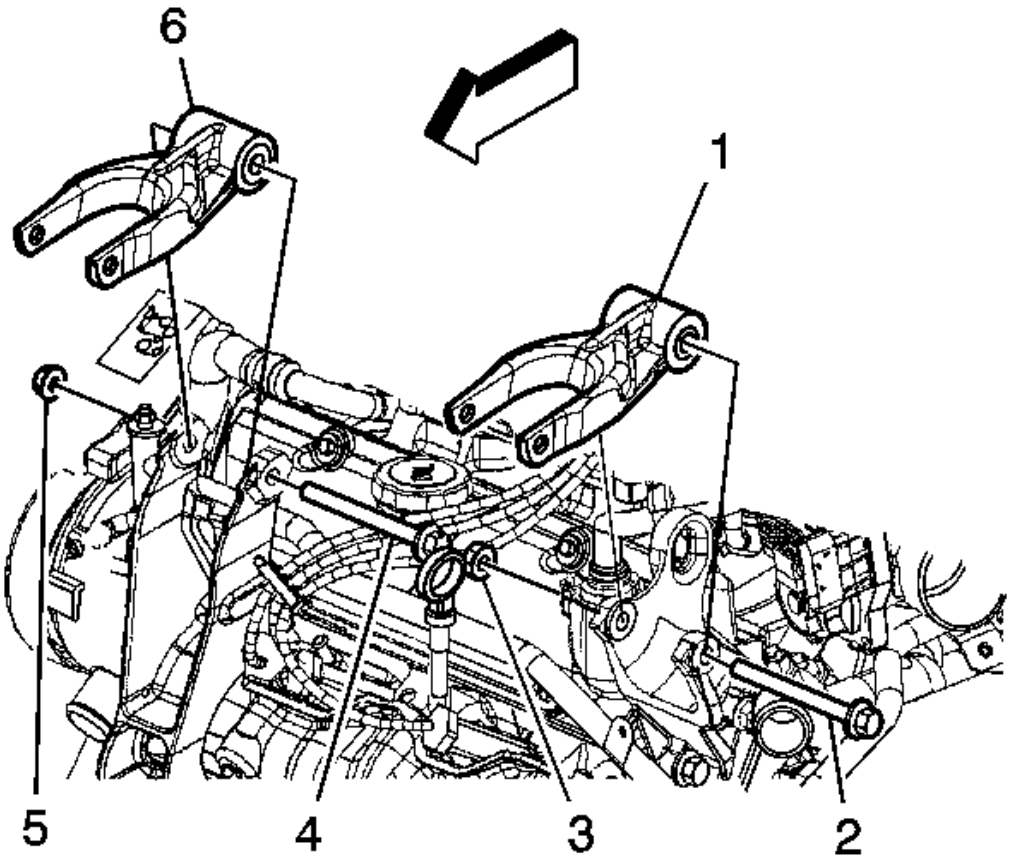

Fig. 60: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

12. Rotate the engine mount strut into position.
13. Install and tighten the engine mount strut to engine mount strut bracket through bolt (4) and nut (5).

    Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

14. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Engine Mount Strut Bracket Replacement - Upper Radiator Support

Removal Procedure

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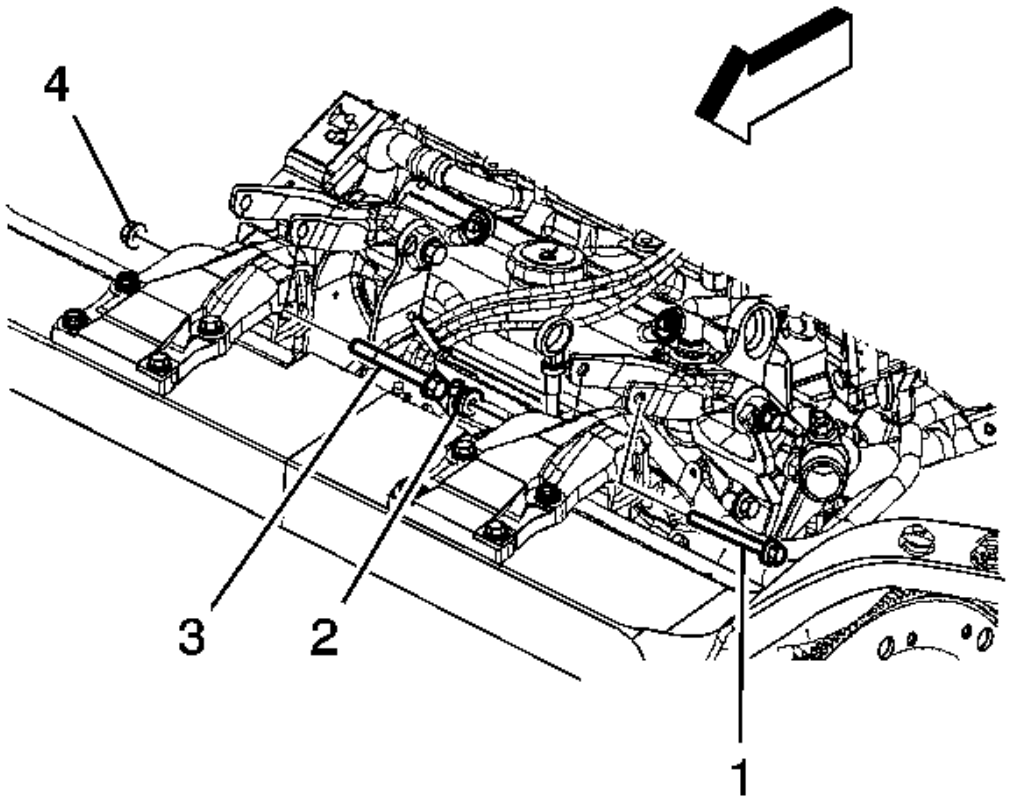

Fig. 61: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Loosen and remove the engine mount strut to engine mount strut bracket through bolts (1, 3) and nuts (2, 4).
3. Rotate the engine mount struts up out of the way.

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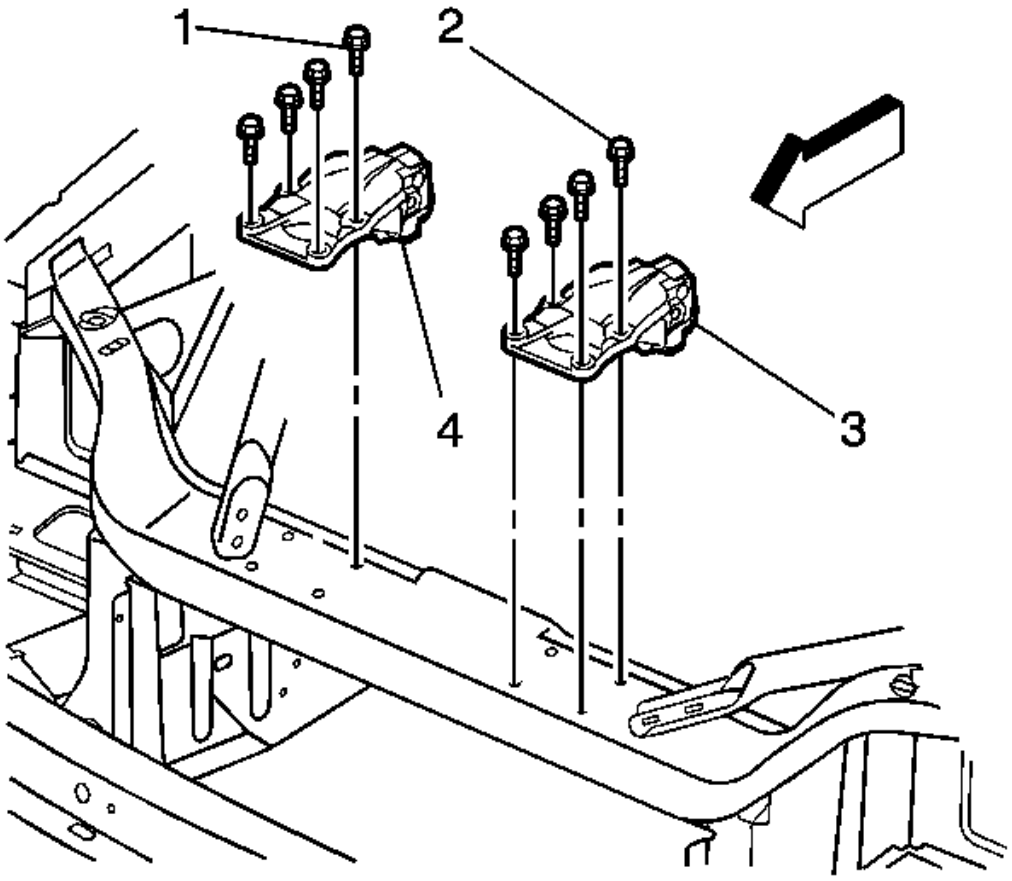

Fig. 62: View Of Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount strut bracket bolts (1, 2).
5. Remove the engine mount strut brackets (3, 4).

Installation Procedure

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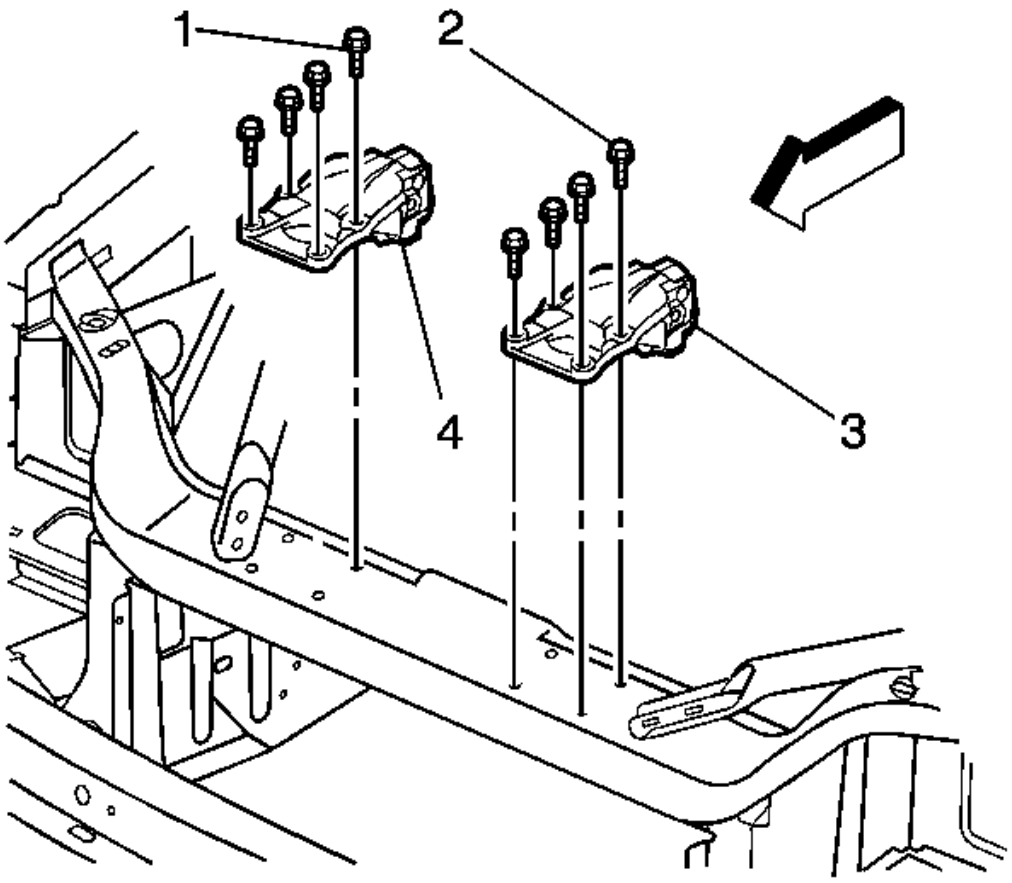

Fig. 63: View Of Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount strut brackets to the radiator support (3, 4).

   NOTE: Refer to Fastener Notice .

2. Install the engine mount strut bracket bolts (1, 2).

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

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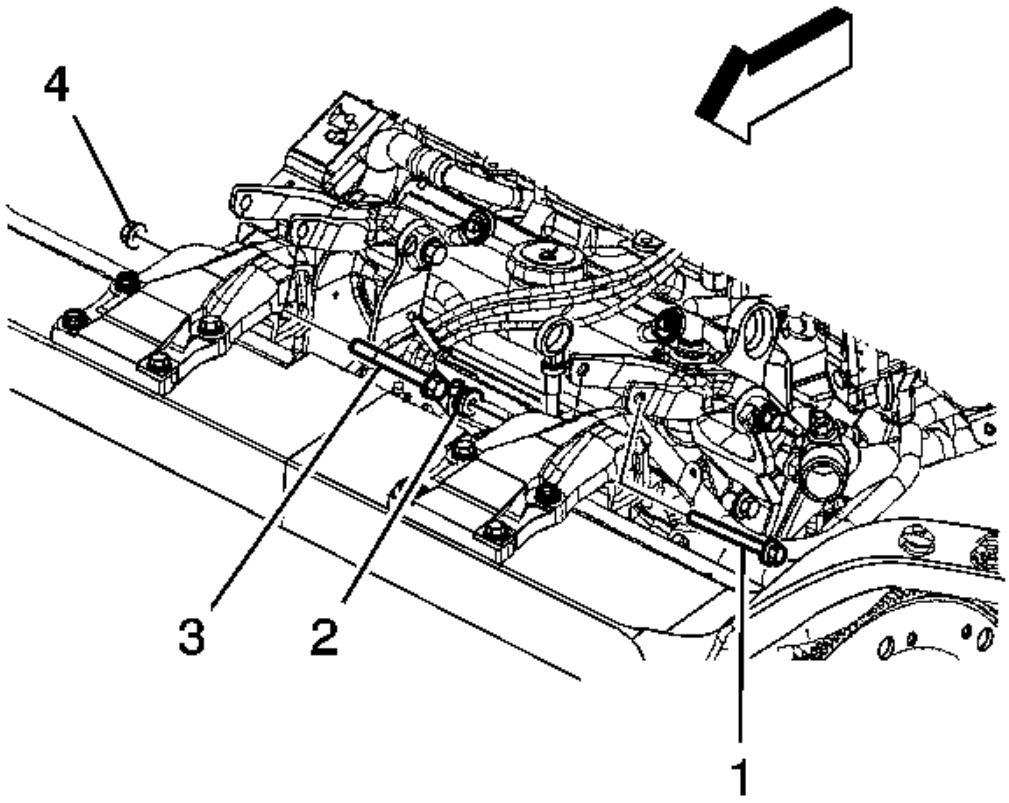

Fig. 64: Identifying Engine Mount Strut Bracket Through Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

3. Rotate the engine mount struts into position.
4. Install and tighten the engine mount strut to engine mount strut bracket through bolts (1, 3) and nuts (2, 4).

   Tighten: Tighten the bolt/nut to 48 N.m (36 lb ft).

5. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Rotating the Engine for Service Access

Tools Required

J 41131 Engine Tilt Strap

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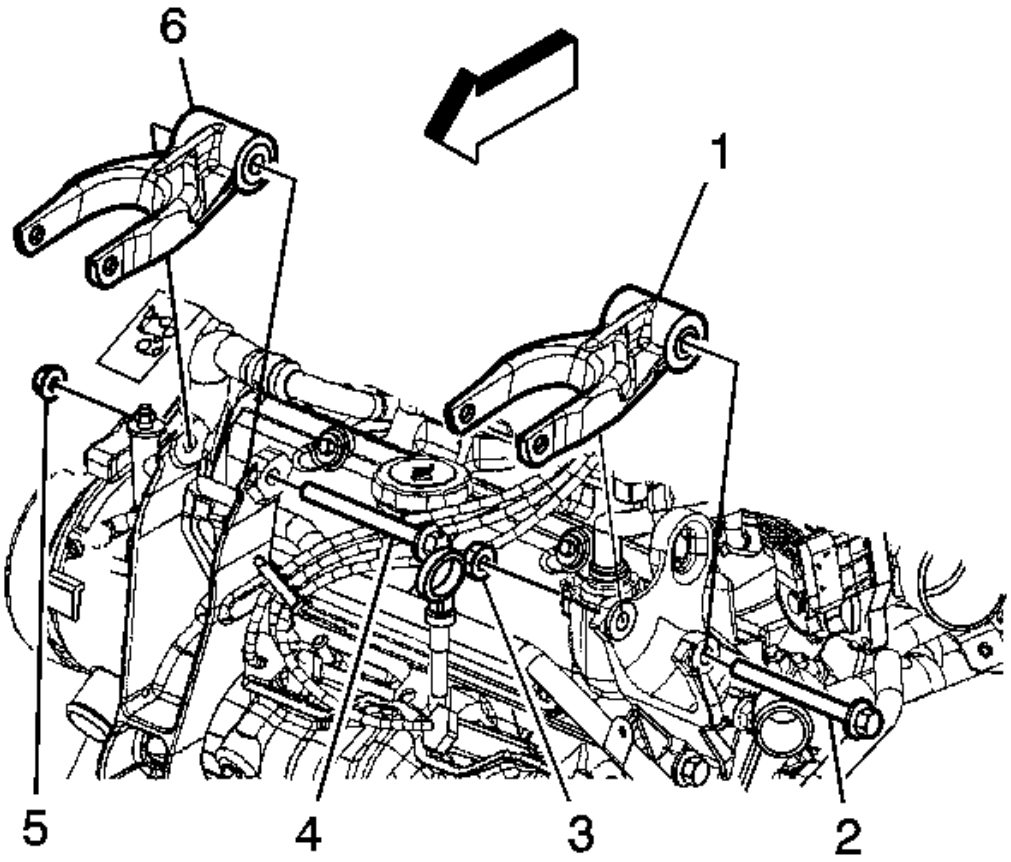

Fig. 65: Identifying Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Set the park brake.
3. Shift the transaxle into Neutral.
4. Loosen and remove the engine mount strut to engine mount strut bracket through bolts (2, 4) and nuts (3, 5).
5. Rotate the engine mount struts up out of the way.

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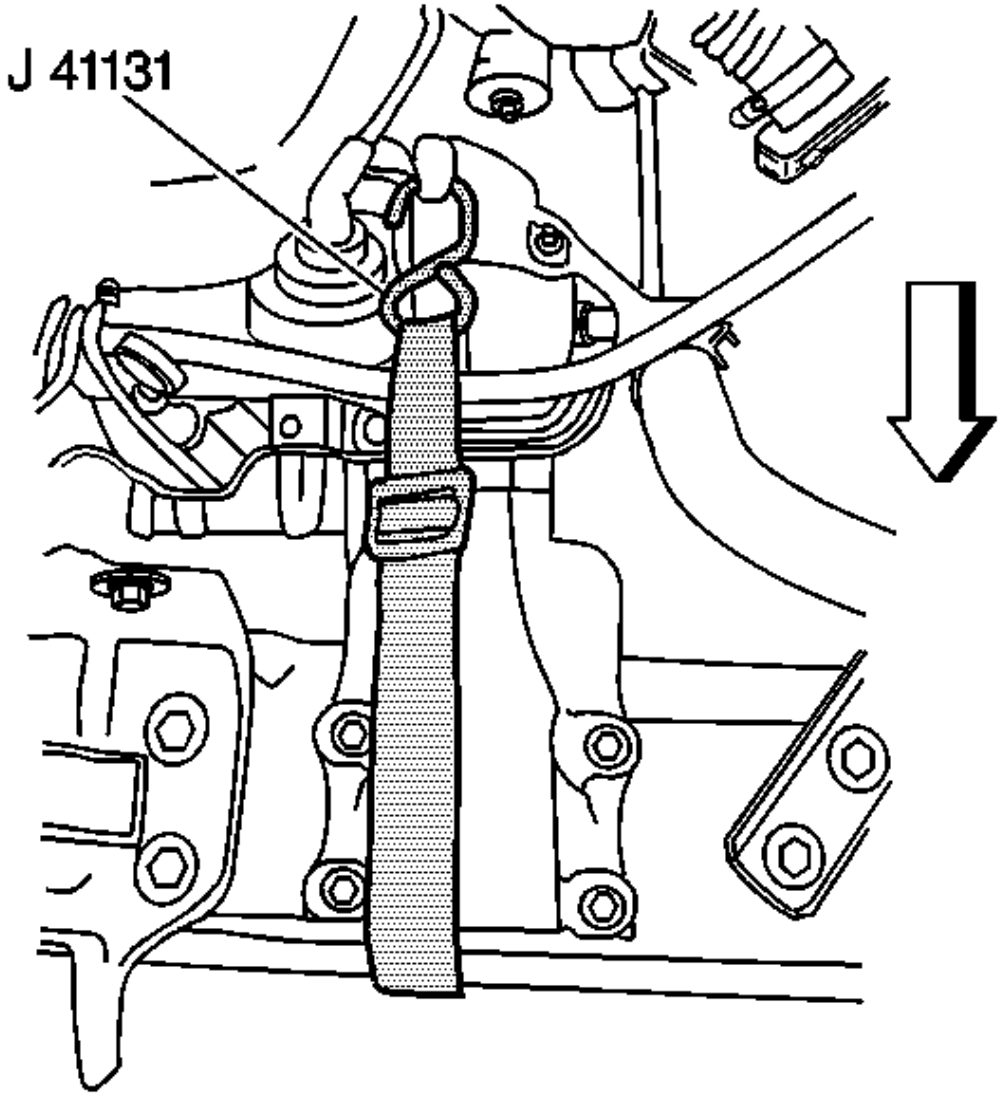

Fig. 66: View Of J 41131
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 41131** .
7. Pull on the engine in order to rotate the engine forward.
8. Tighten the **J 41131** .

Oil Filter Adapter and Bypass Valve Assembly Replacement

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Removal Procedure

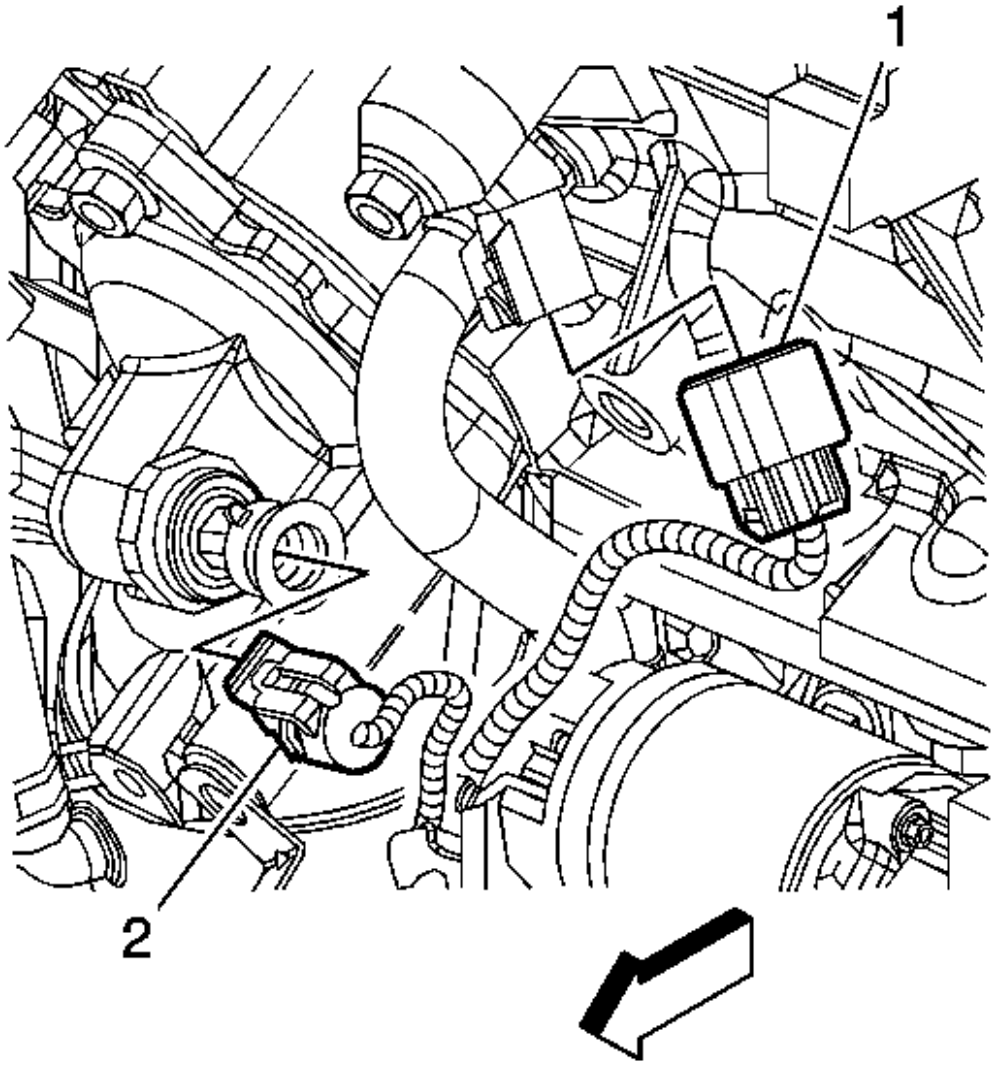

Fig. 67: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine oil cooler. Refer to **Engine Oil Cooler Replacement**.
2. Disconnect the oil pressure sensor electrical connector (2).

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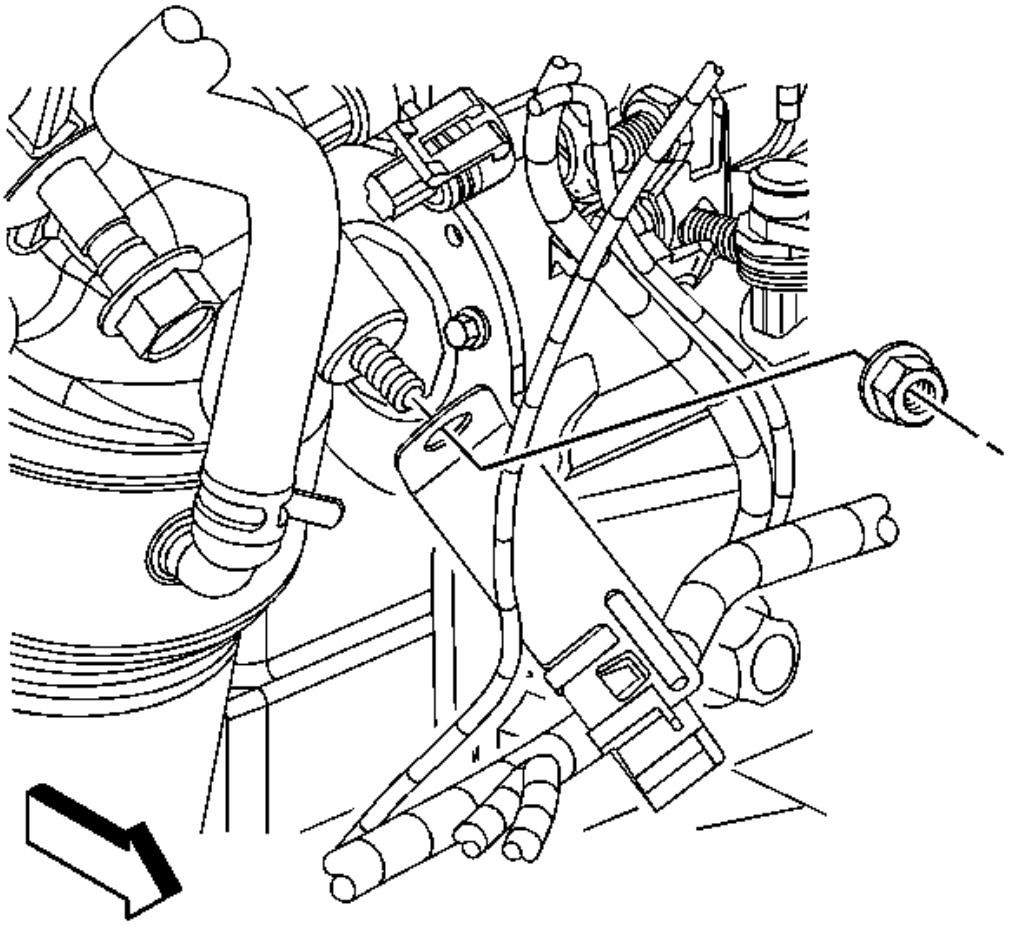

Fig. 68: Identifying Wiring Harness Retainer Nut
Courtesy of GENERAL MOTORS CORP.

3. Remove the nut securing the engine wiring harness clip to the oil filter adapter stud.
4. Reposition the engine wiring harness out of the way.

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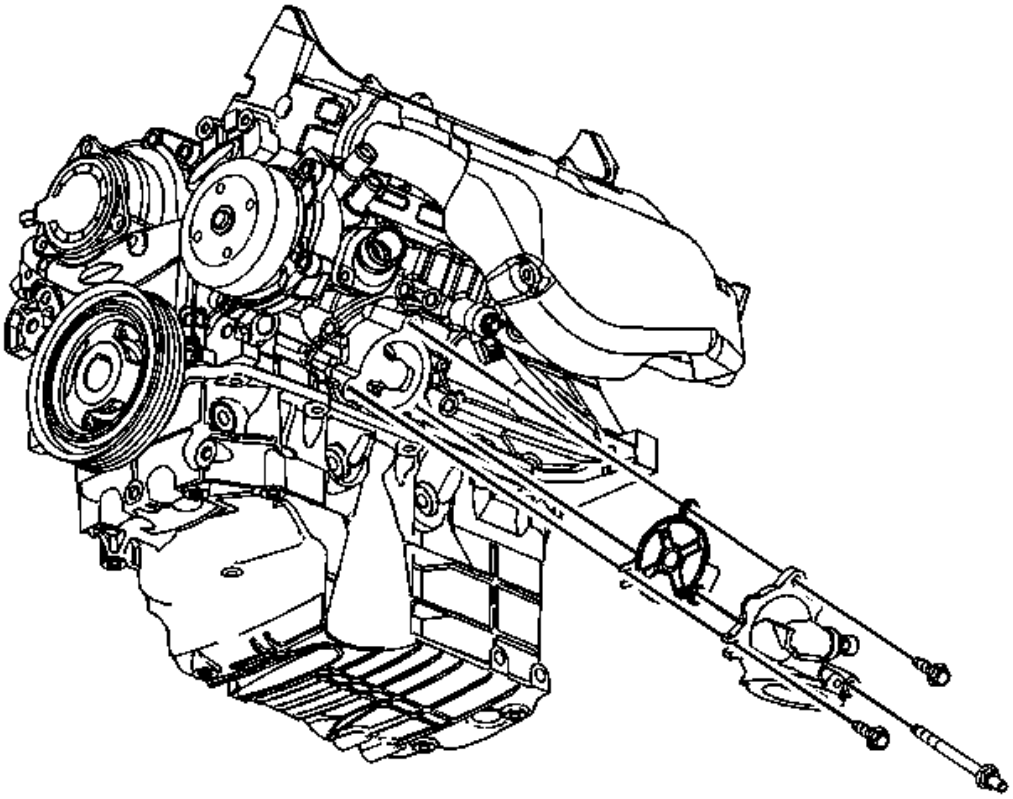

Fig. 69: Identifying Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil filter adapter bolts and stud.
6. Remove the oil filter adapter and gasket from the engine block.
7. Discard the oil filter gasket.

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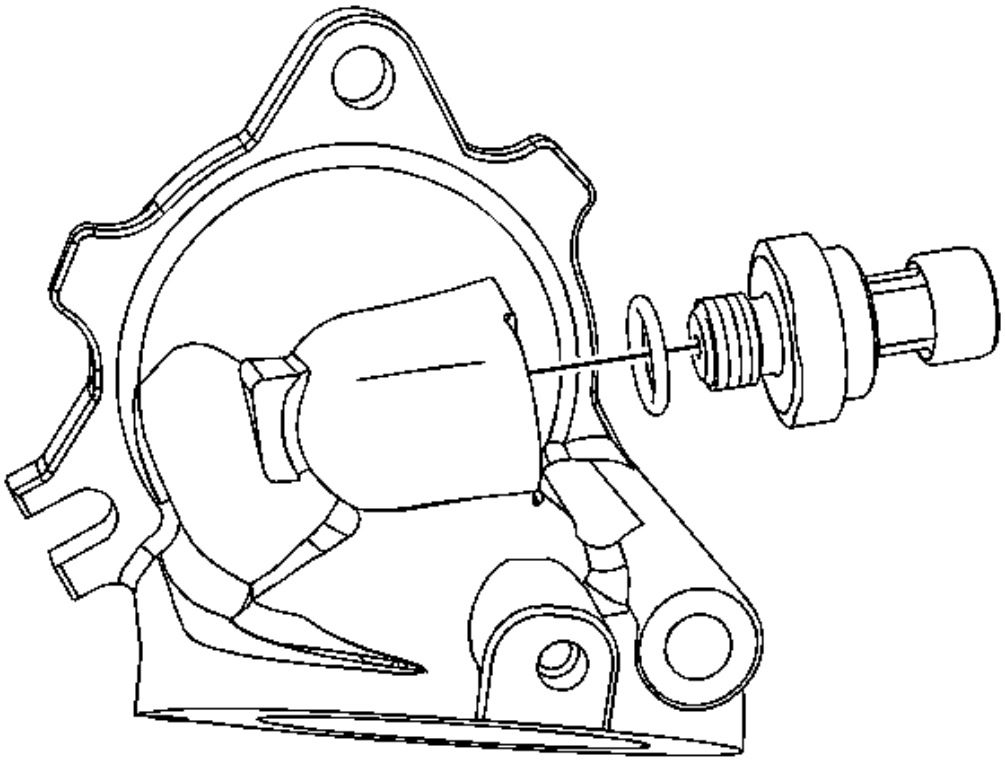

Fig. 70: Locating Oil Pressure Sensor Assembly
Courtesy of GENERAL MOTORS CORP.

8. If replacing the oil filter adapter, remove the oil pressure sensor.

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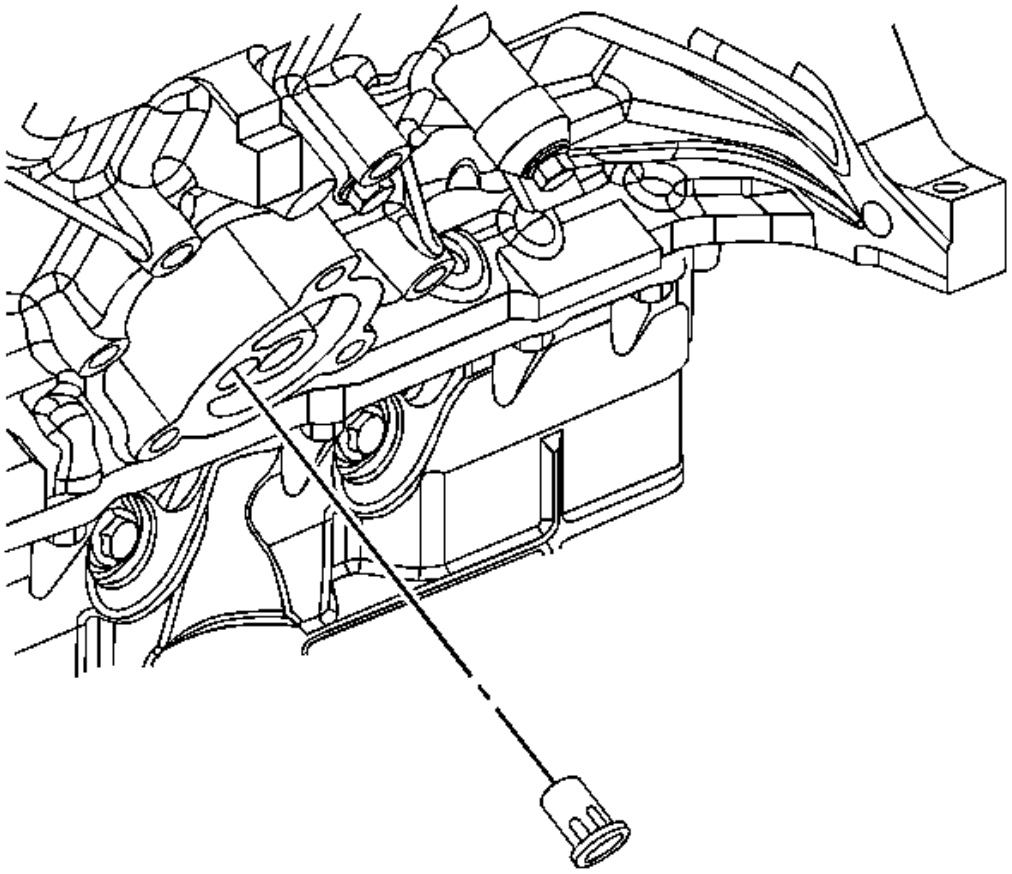

Fig. 71: Locating Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

9. If replacing the oil filter bypass valve, insert a flat bladed tool into the oil filter bypass hole and remove the valve.

Installation Procedure

NOTE: 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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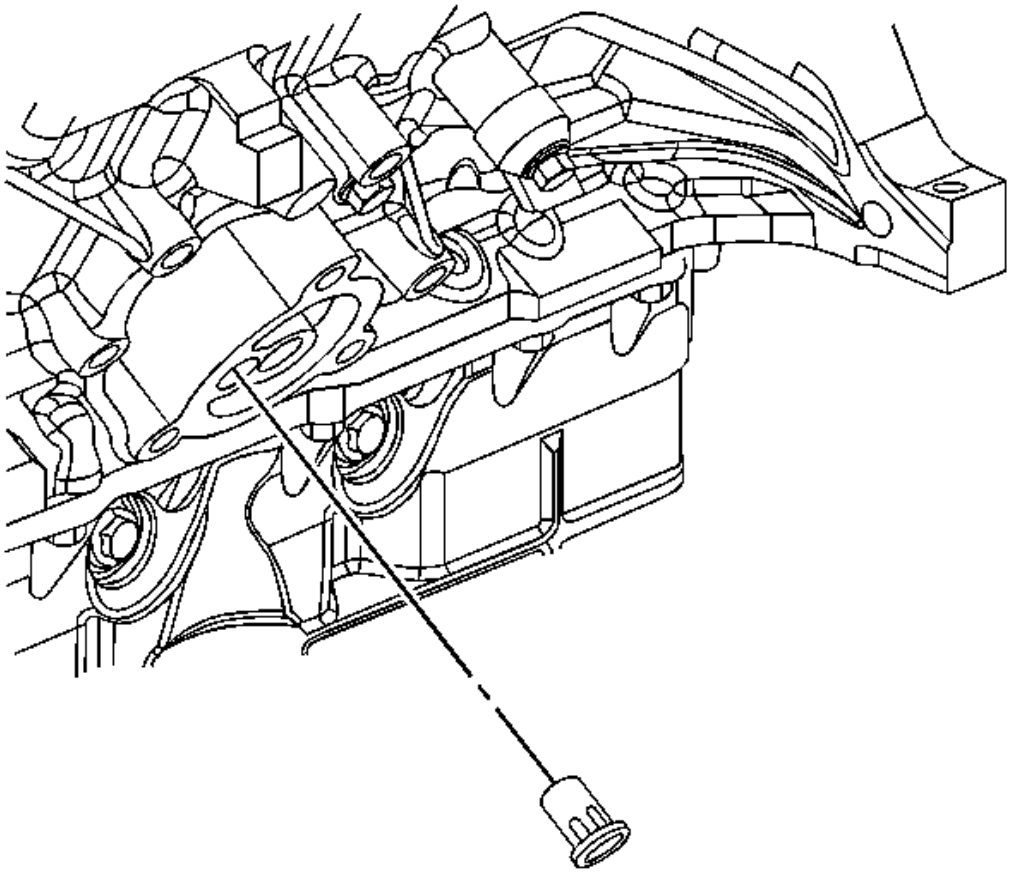

Fig. 72: Locating Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. If the oil filter bypass valve was replaced, seat the valve fully below the bypass valve hole chamfer.

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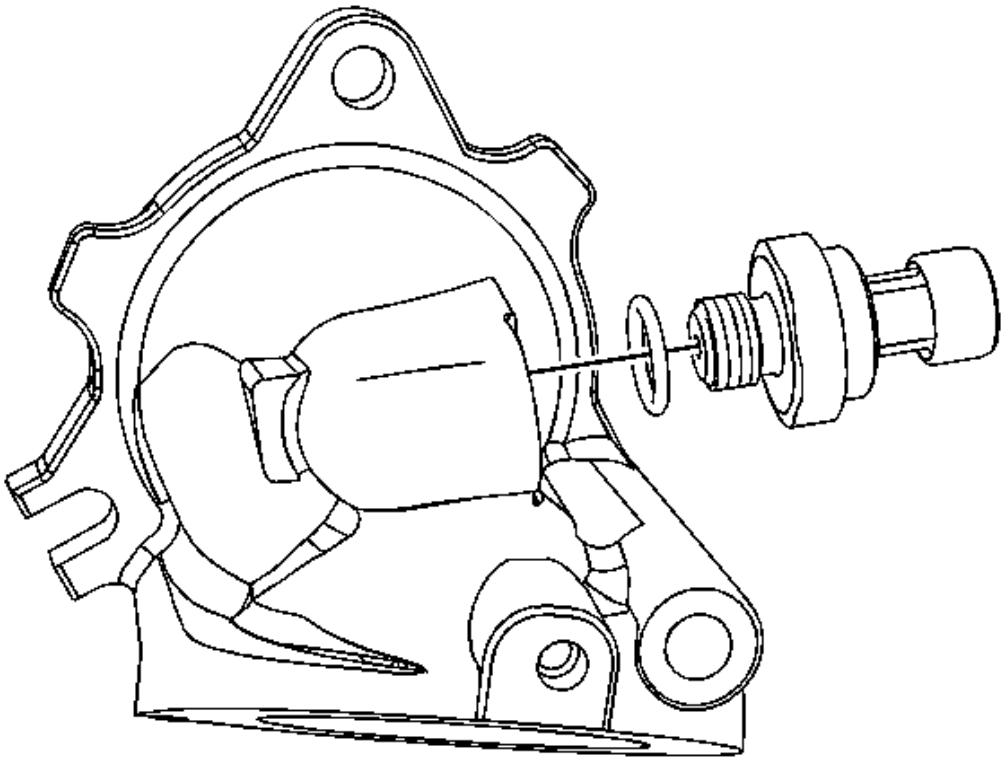

Fig. 73: Locating Oil Pressure Sensor Assembly
Courtesy of GENERAL MOTORS CORP.

2. If the oil filter adapter was replaced, lubricate the oil pressure sensor seal with clean engine oil.
3. Apply sealant to the threads of the oil pressure sensor. Refer to **Sealers, Adhesives, and Lubricants**.

NOTE: Refer to Fastener Notice .

4. Install the oil pressure sensor to the oil filter adapter.

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

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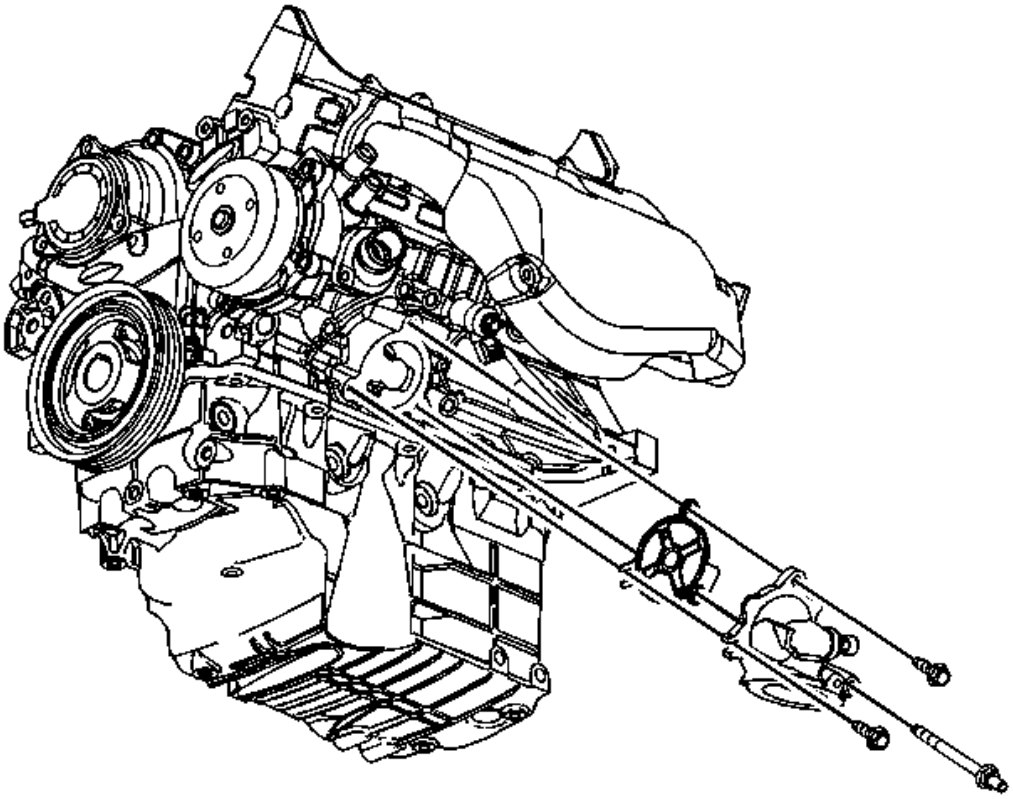

Fig. 74: Identifying Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant to the bolt/stud threads, if required. Refer to **Sealers, Adhesives, and Lubricants**.
6. Position the NEW oil filter gasket and the oil filter adapter to the engine block.
7. Install the oil filter adapter bolts and stud.

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

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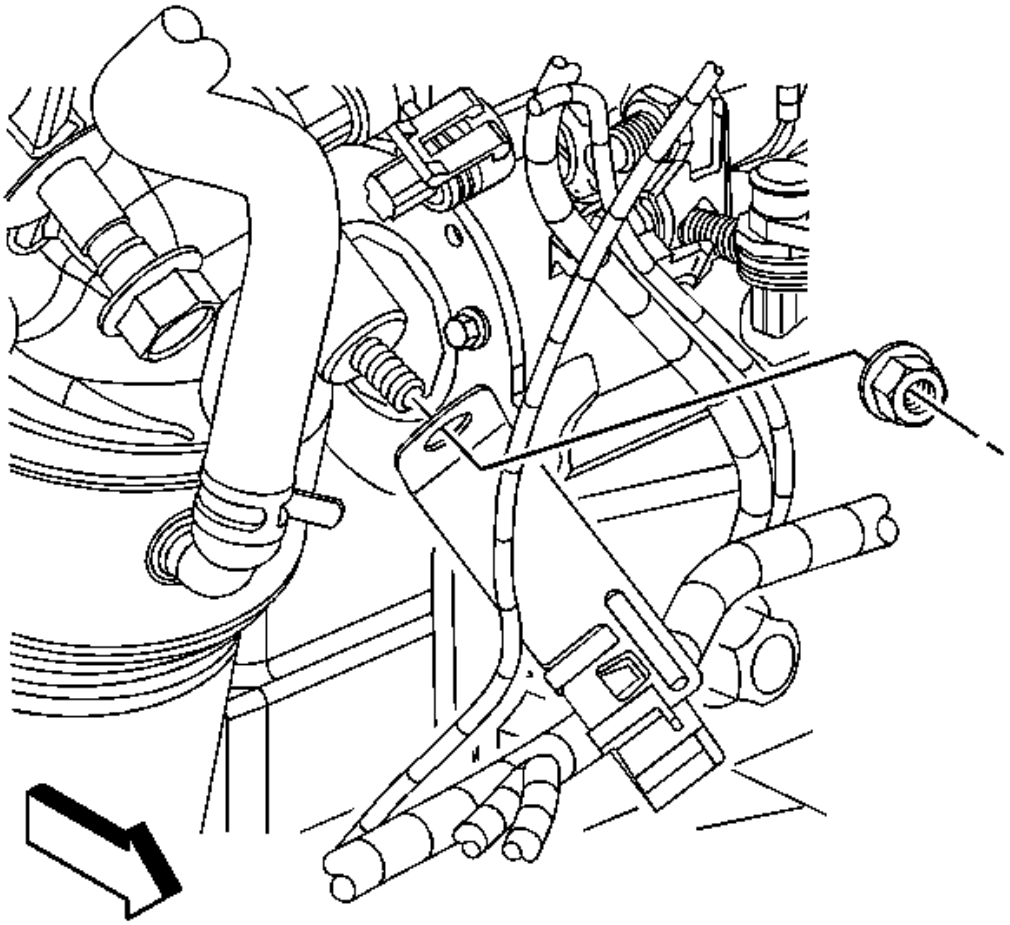

Fig. 75: Identifying Wiring Harness Retainer Nut
Courtesy of GENERAL MOTORS CORP.

8. Install the engine wiring harness clip to the oil filter adapter stud.
9. Install the engine wiring harness nut.

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

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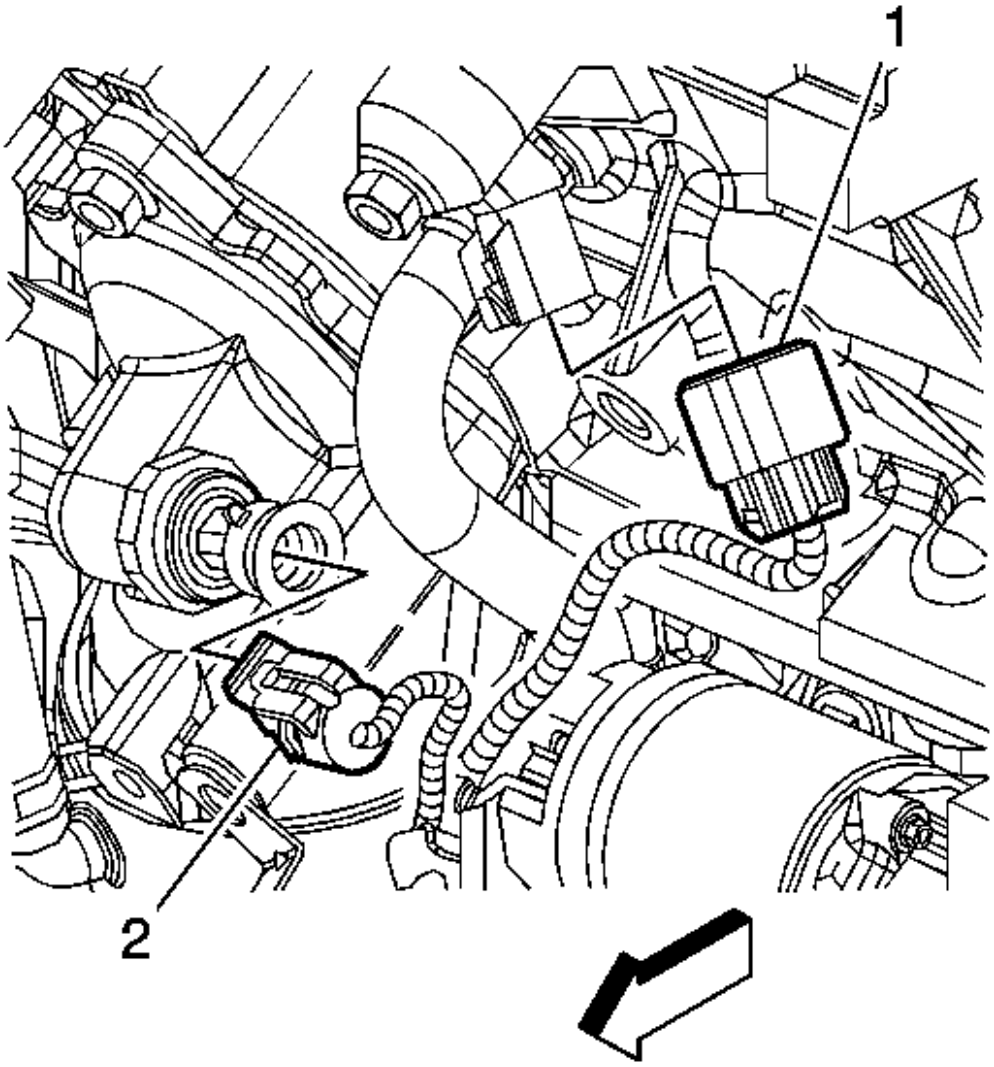

Fig. 76: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the oil pressure sensor electrical connector (2).
11. Install the engine oil cooler. Refer to **Engine Oil Cooler Replacement**.

Engine Oil Cooler Replacement

Removal Procedure

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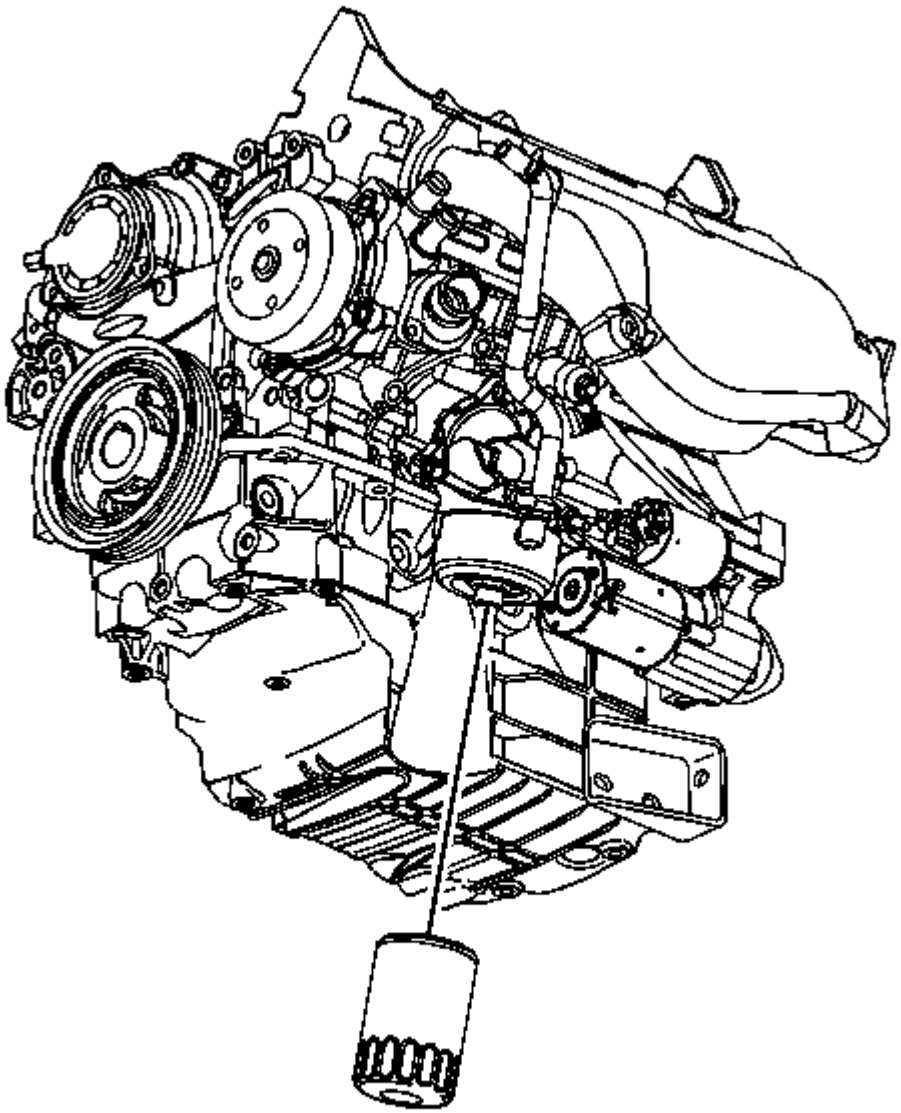

Fig. 77: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
2. Remove the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
3. Place a suitable drain pan under the oil filter.
4. Remove the oil filter.

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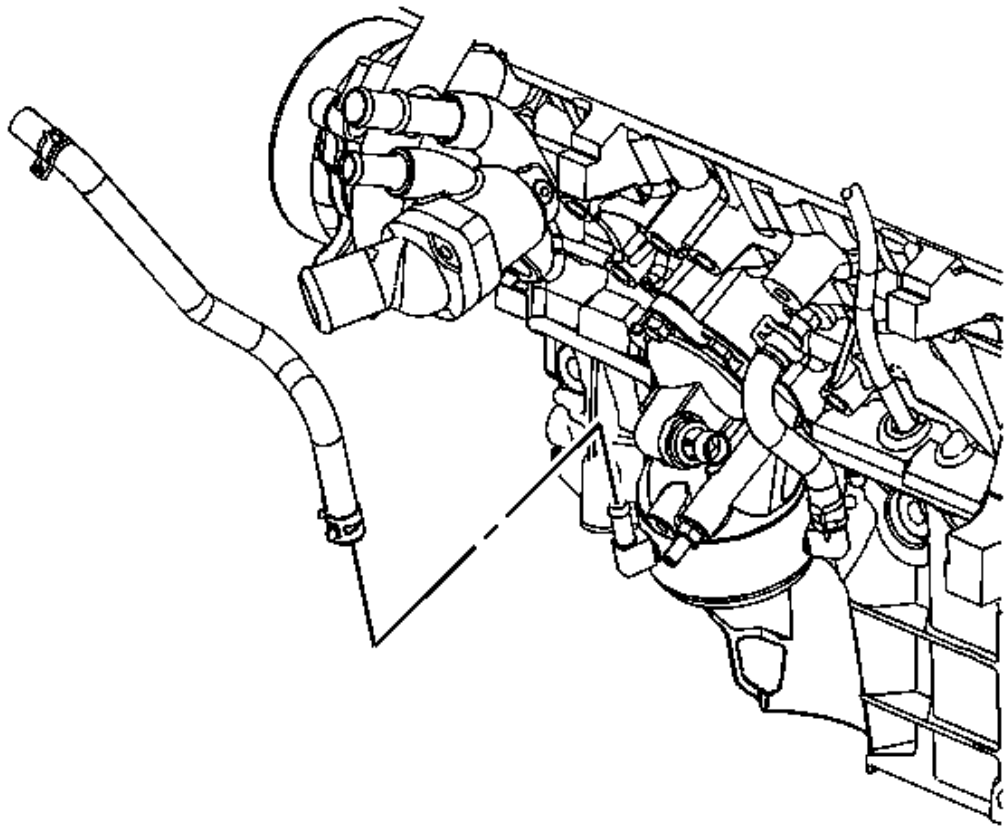

Fig. 78: Identifying Oil Cooler Outlet Hose
Courtesy of GENERAL MOTORS CORP.

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

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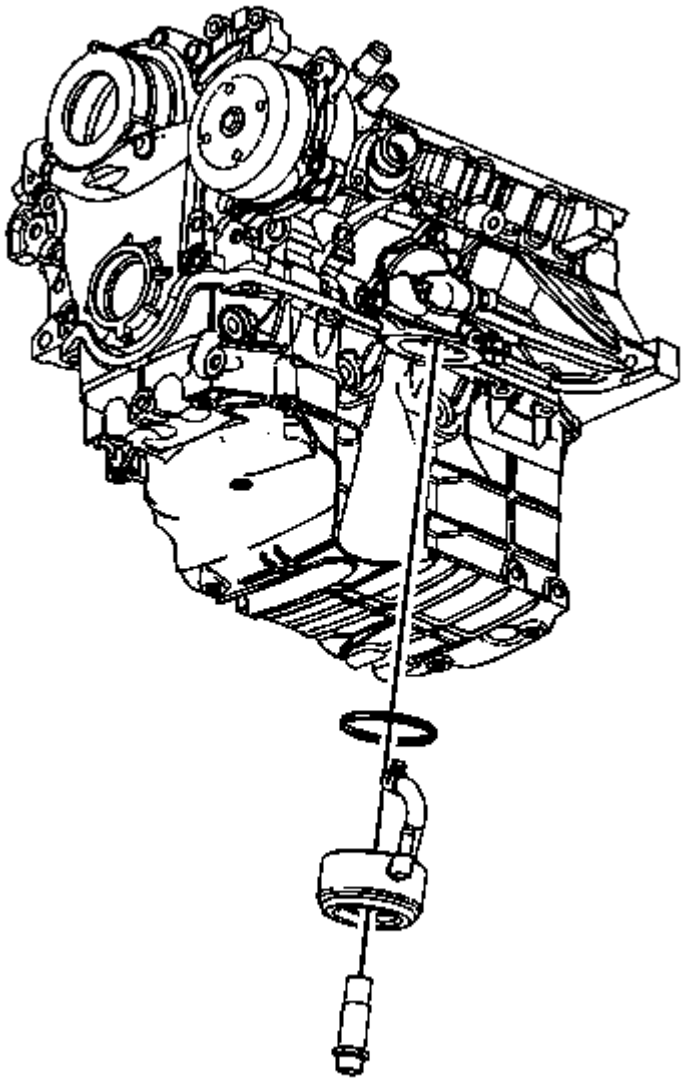

Fig. 79: View Of Oil Cooler Assembly
Courtesy of GENERAL MOTORS CORP.

7. Reposition the oil cooler inlet hose clamp at the engine.
8. Remove the oil cooler inlet hose from the engine fitting.
9. Remove the oil cooler connector.
10. Remove the oil cooler and gasket from the oil filter adapter.

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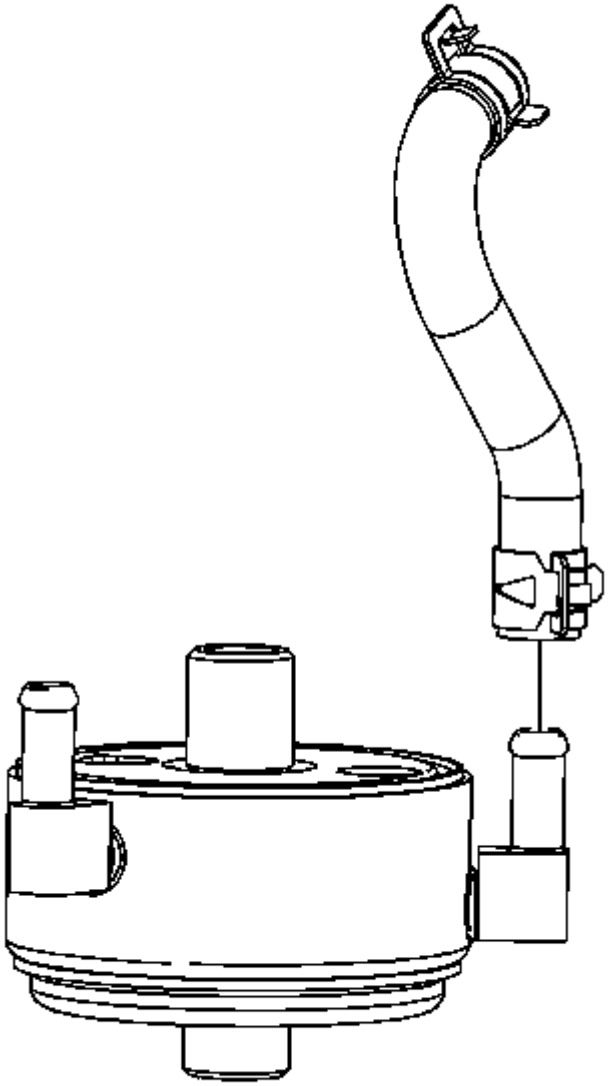

Fig. 80: View Of Oil Cooler Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

11. If replacing the oil cooler, reposition the oil cooler inlet hose clamp at the oil cooler.
12. Remove the oil cooler inlet hose from the oil cooler.

Installation Procedure

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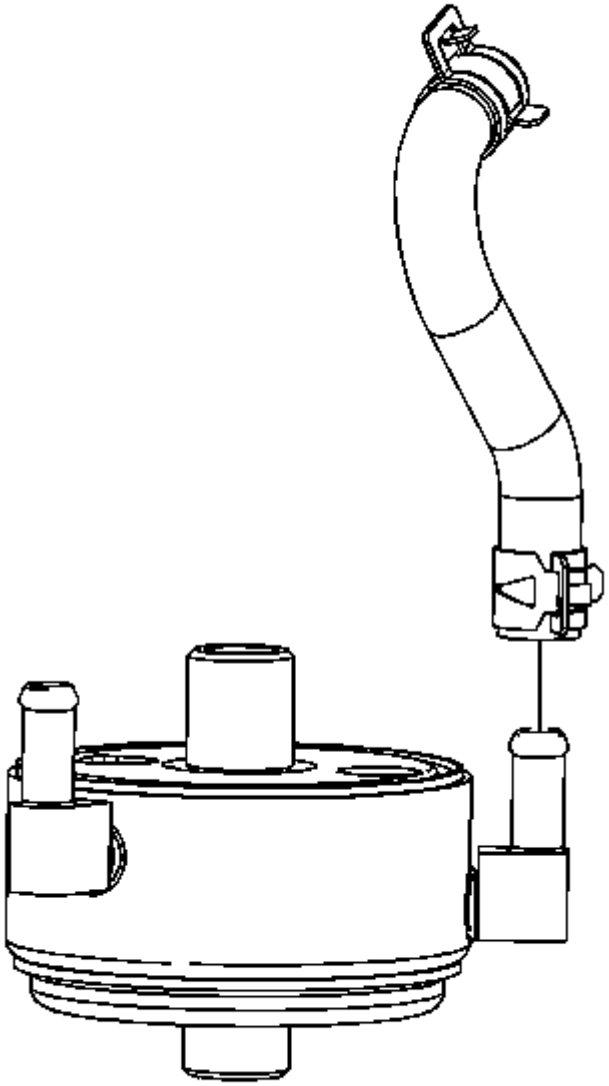

Fig. 81: View Of Oil Cooler Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. If the oil cooler was replaced, install the oil cooler inlet hose to the oil cooler.
2. Position the oil cooler inlet hose clamp at the oil cooler.

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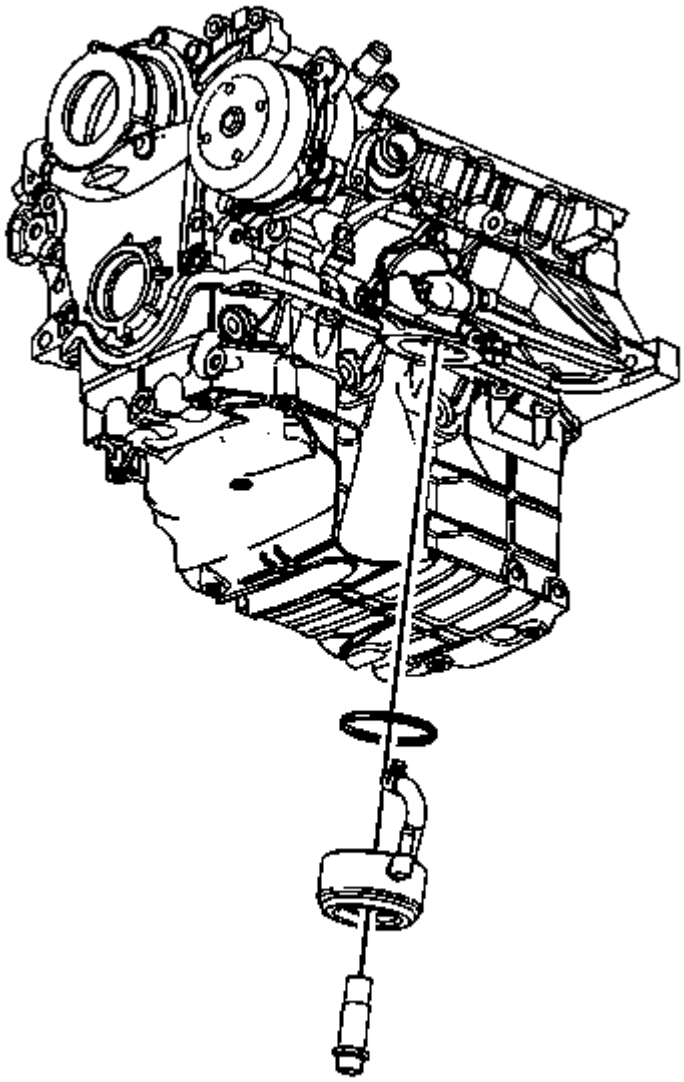

Fig. 82: View Of Oil Cooler Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW oil cooler gasket onto the oil cooler.
4. Install the oil cooler and gasket to the oil filter adapter.

NOTE: Refer to Fastener Notice .

5. Install the oil cooler connector.

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

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

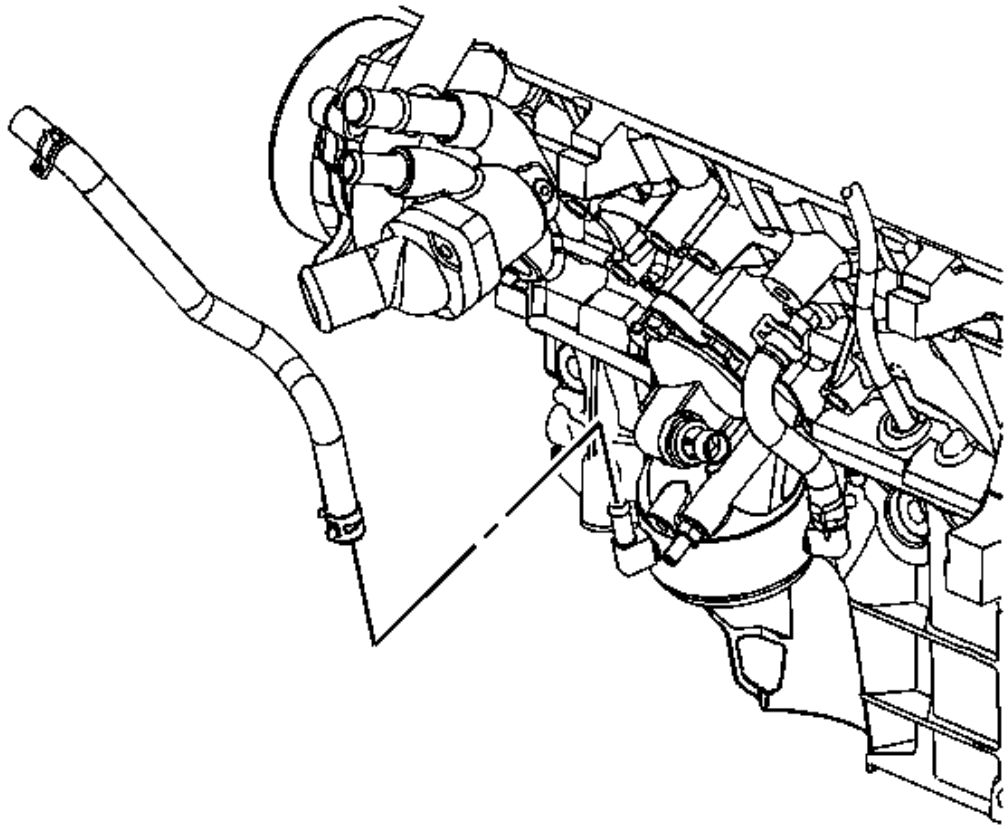

Fig. 83: Identifying Oil Cooler Outlet Hose
Courtesy of GENERAL MOTORS CORP.

8. Install the oil cooler outlet hose to the oil cooler fitting.
9. Position the oil cooler outlet hose clamp at the oil cooler.

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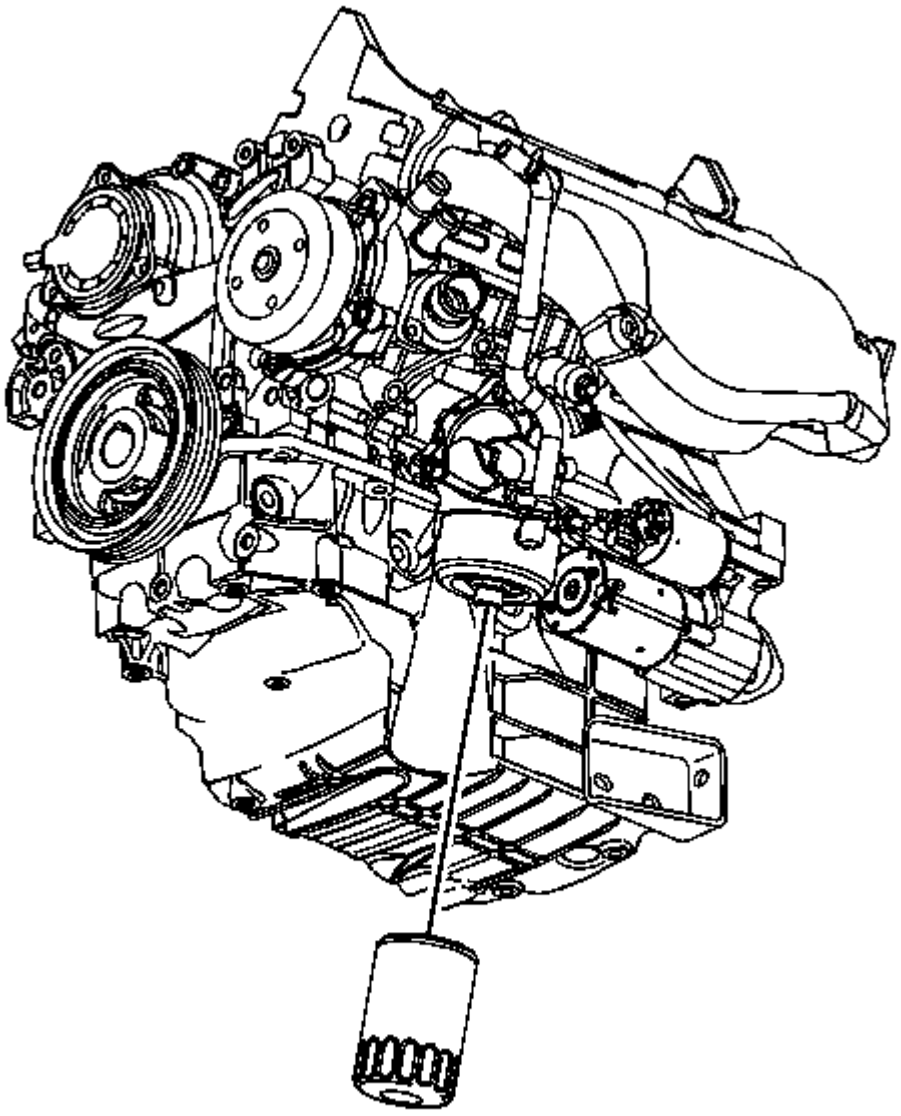

Fig. 84: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

10. Install the oil filter.

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

11. Remove the drain pan from under the oil filter.

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12. Install the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
13. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
14. Check and fill the crankcase, if necessary.

Oil Level Indicator and Tube Replacement

Removal Procedure

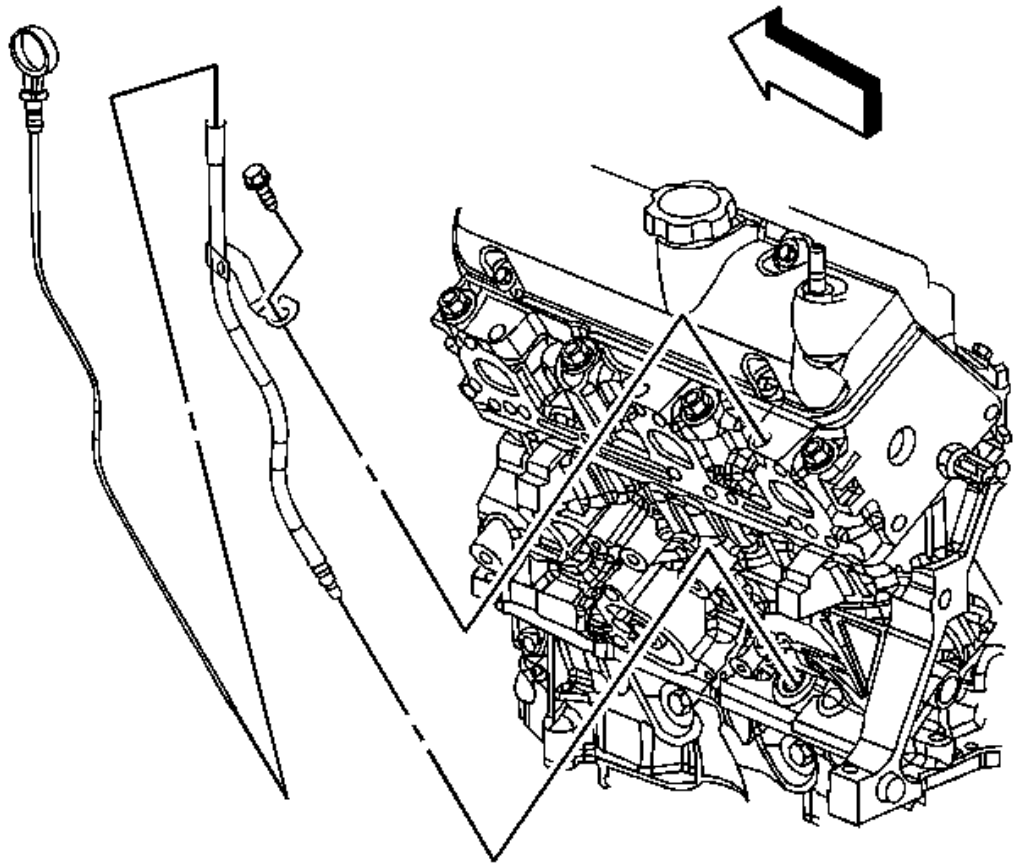

Fig. 85: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wire from the number 6 cylinder spark plug.
2. Remove the oil level indicator.
3. Remove the oil level indicator tube bracket bolt.

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

Installation Procedure

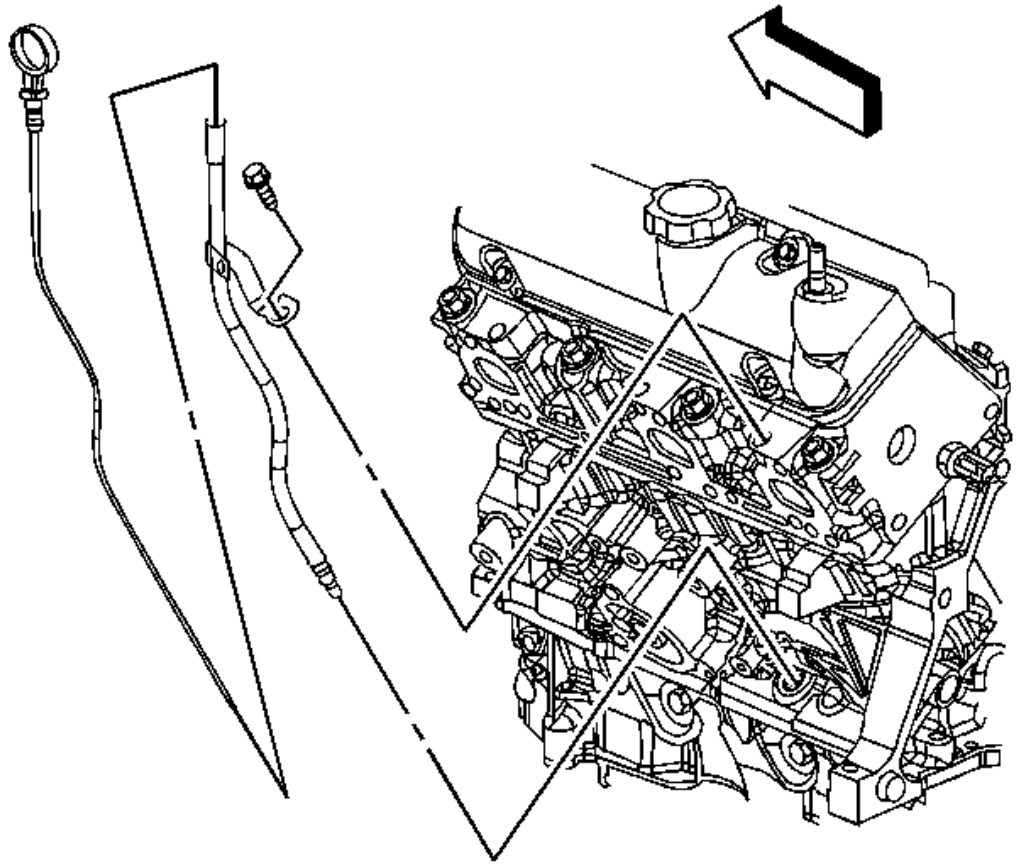

Fig. 86: Identifying Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice .

3. Install the oil level indicator tube bracket bolt.

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

4. Install the oil level indicator.
5. Install the spark plug wire to the number 6 cylinder spark plug.

Upper Intake Manifold Replacement

Removal Procedure

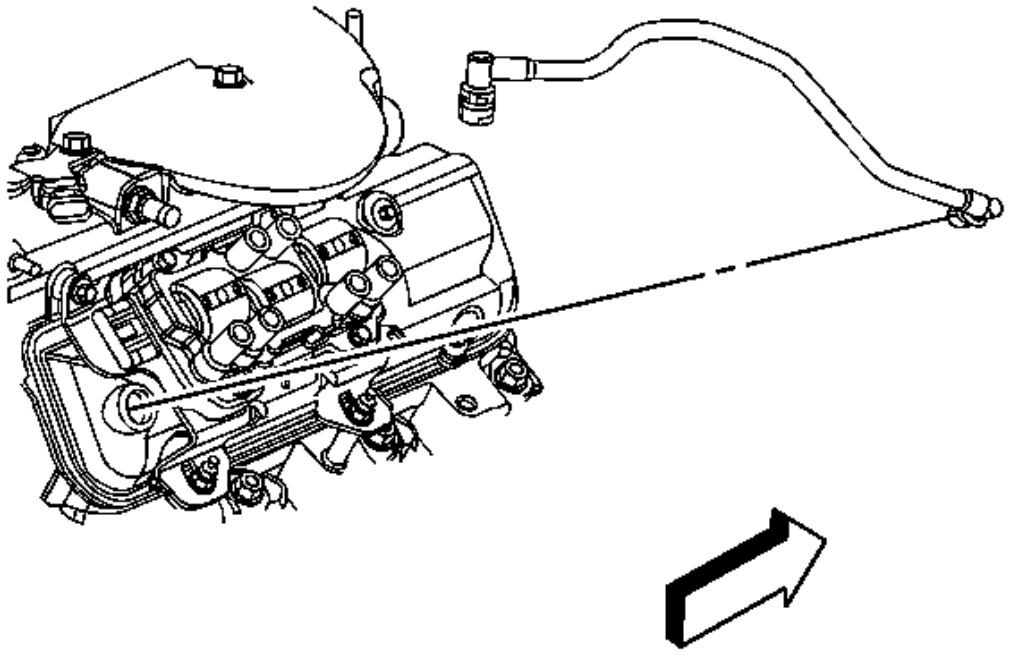

Fig. 87: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
3. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
4. Remove the positive crankcase ventilation (PCV) fresh air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

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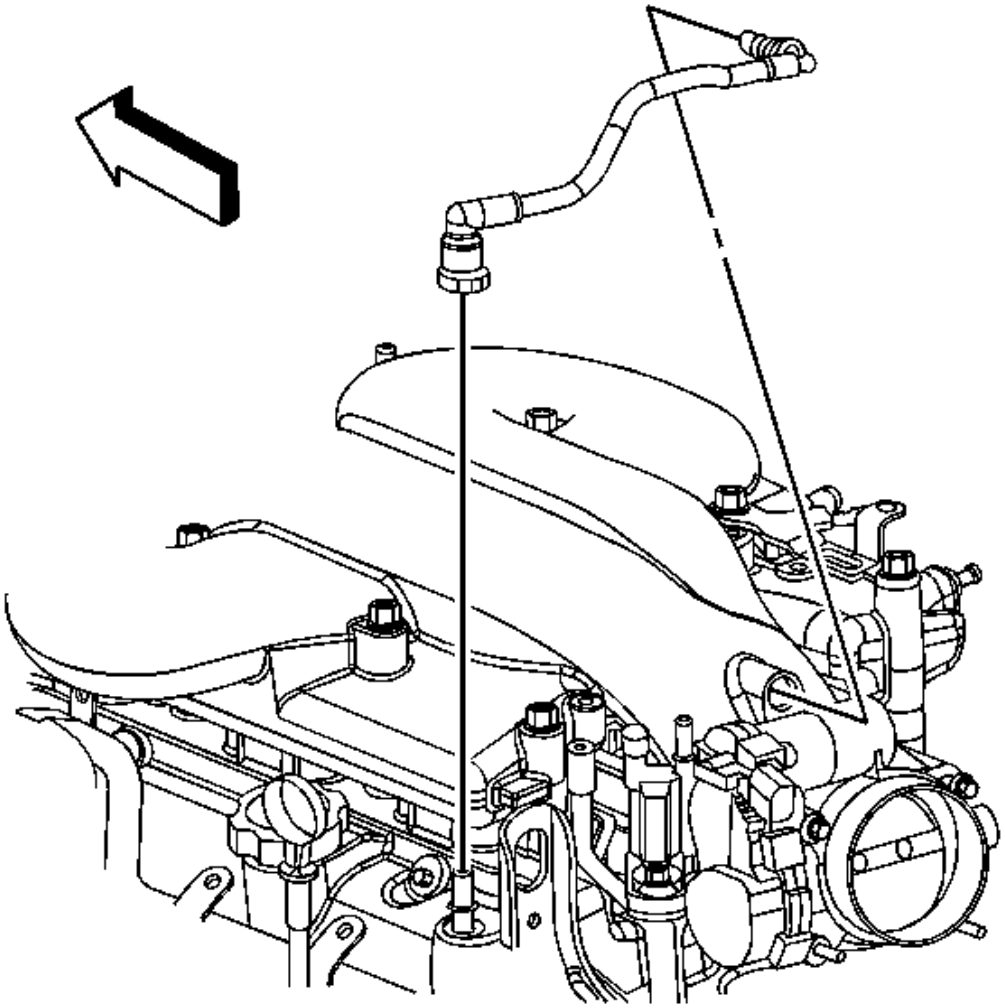

Fig. 88: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Remove the PCV foul air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .
6. Reposition the brake booster vacuum hose clamp at the intake manifold.
7. Remove the vacuum hose from the intake manifold.

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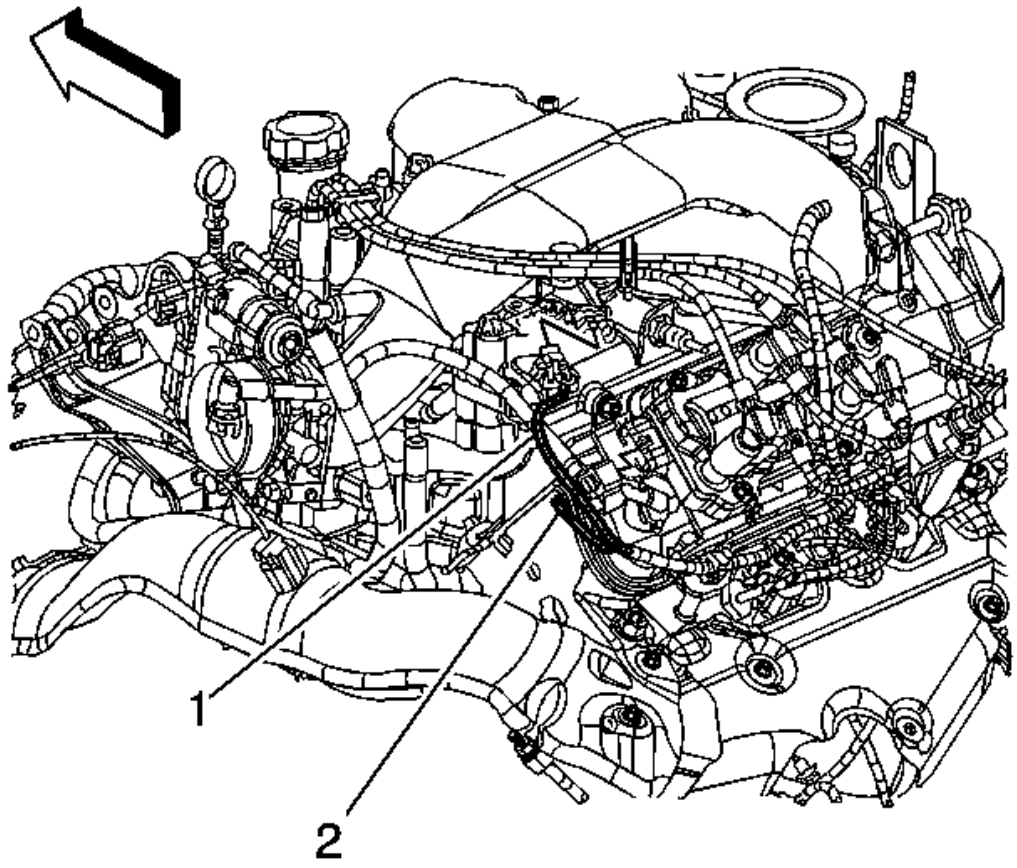

Fig. 89: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the engine harness electrical connector (1) from the manifold absolute pressure (MAP) sensor.

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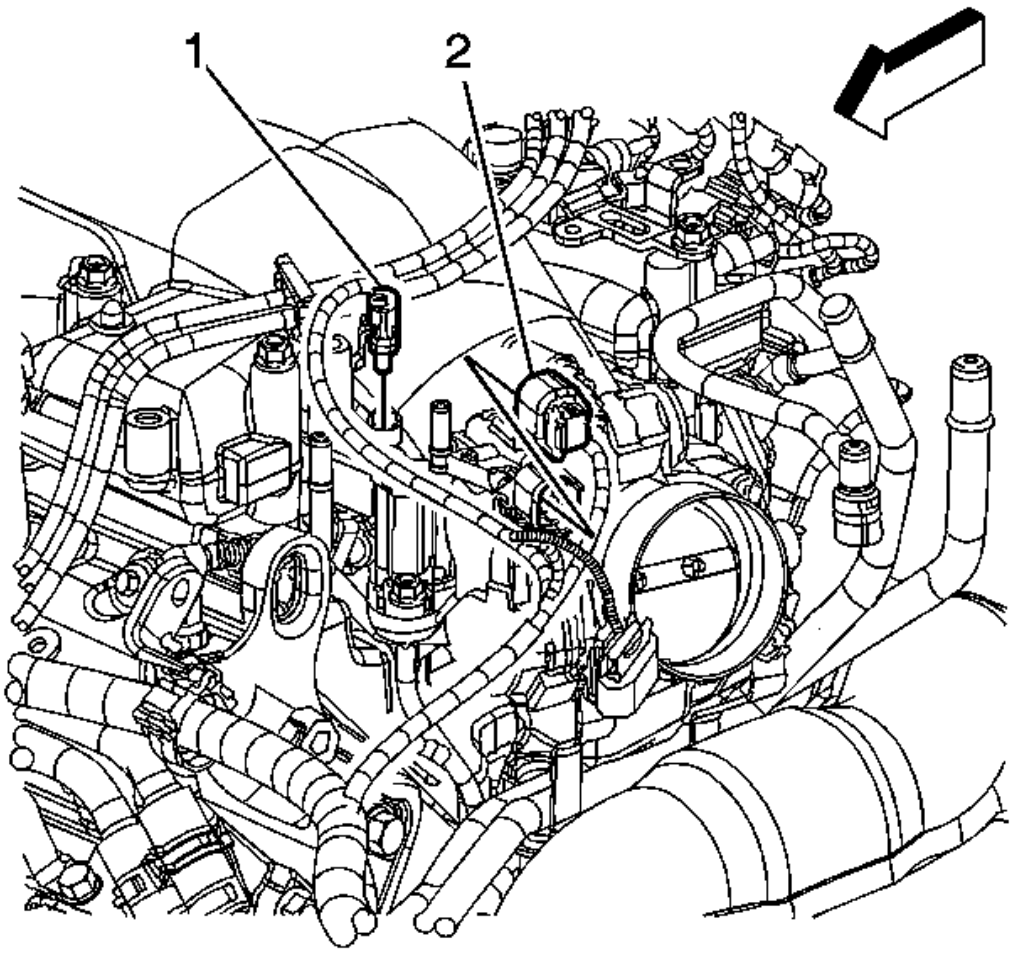

Fig. 90: Locating EVAP & ETC Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine harness electrical connectors (1, 2) from the following: electrical connector (1).
    - The evaporative emission (EVAP) canister purge solenoid
    - The electronic throttle control (ETC)

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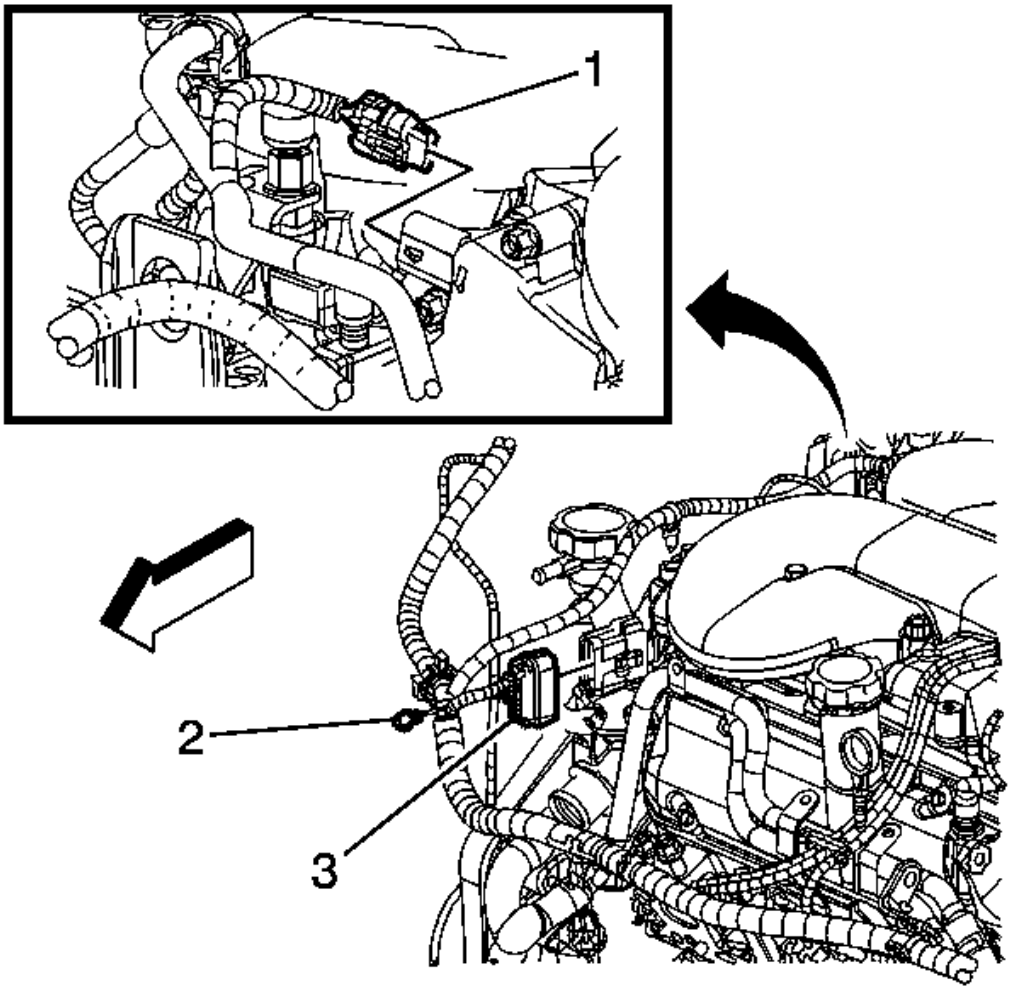

Fig. 91: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the engine harness electrical connector (1) from the intake manifold tuning valve.

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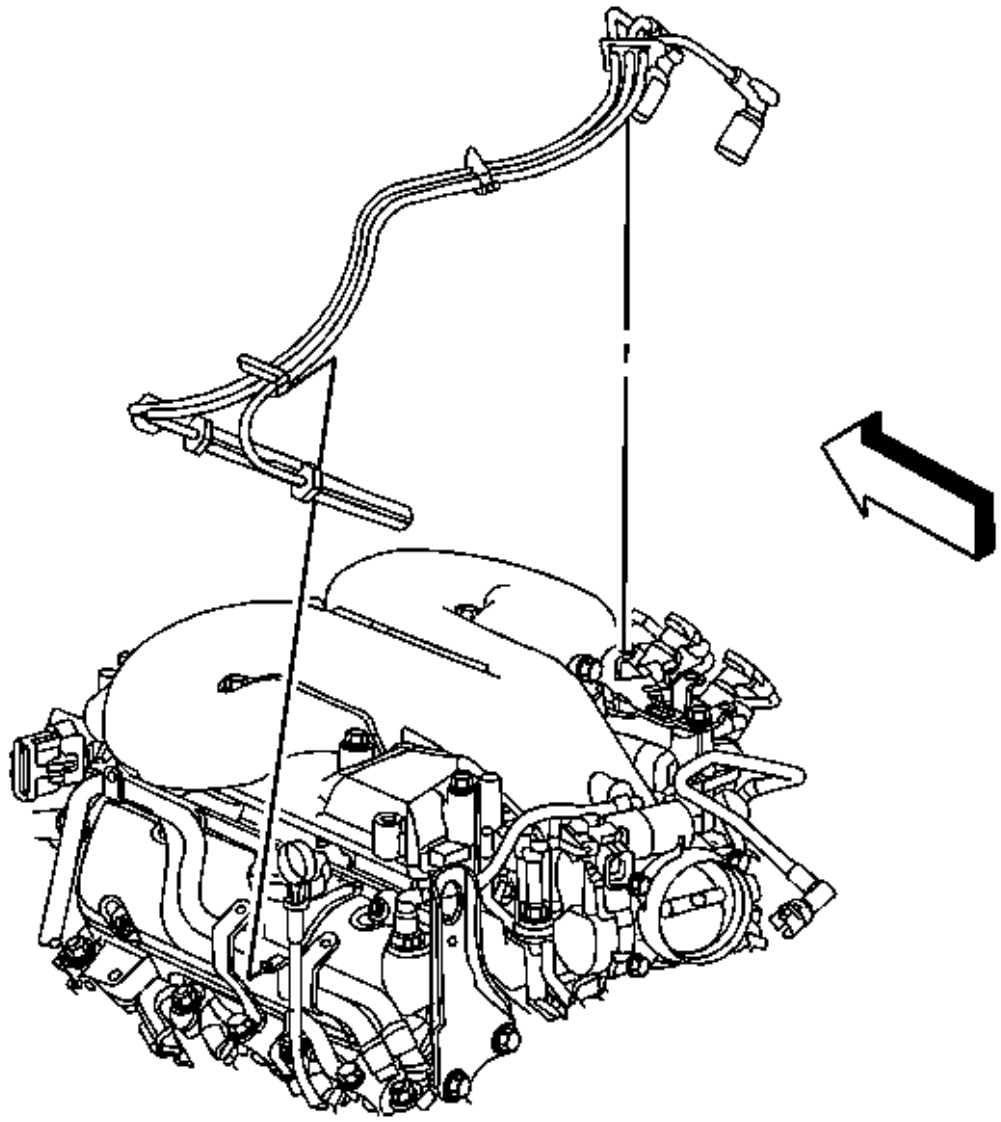

Fig. 92: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

11. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
12. Disconnect the left side spark plug wires from the spark plugs.
13. Disconnect the left side spark plug wires from the ignition control module.
14. Disengage the spark plug wire retainer clips from the intake manifold bracket and the heater inlet/outlet pipe.

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15. Remove the left side spark plug wires.

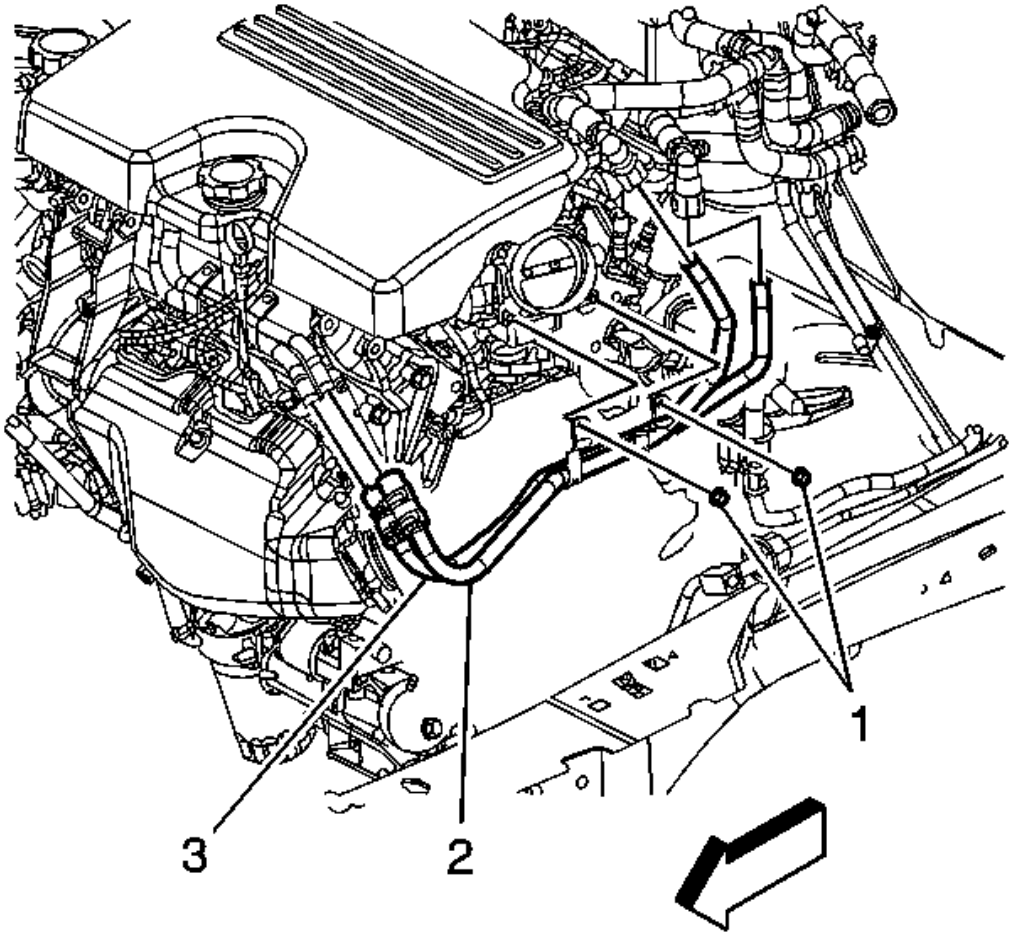

Fig. 93: Identifying Heater Inlet & Outlet Hose/Pipes
Courtesy of GENERAL MOTORS CORP.

16. Remove the heater inlet and outlet pipe nuts (1) from the throttle body studs.
17. Remove the inlet and outlet pipe from the studs.

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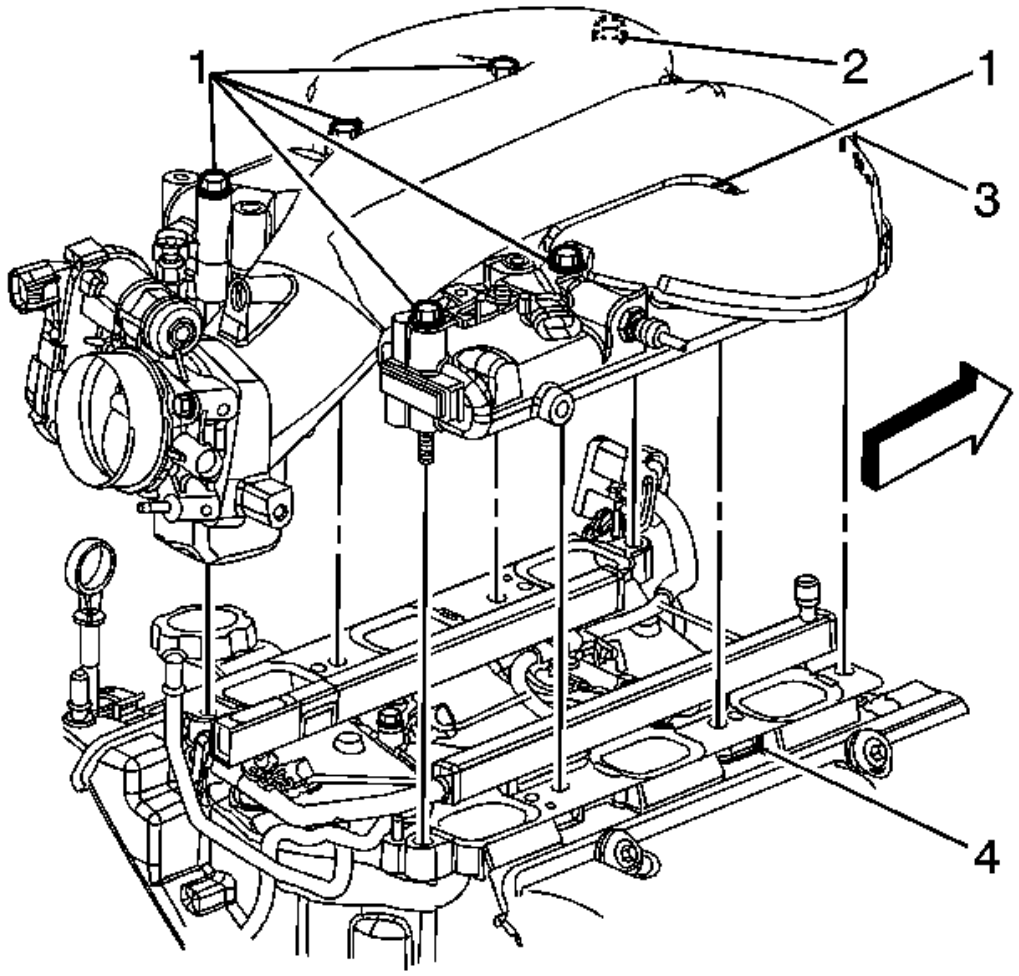

Fig. 94: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

18. Remove the nut from the generator bracket to the intake manifold.
19. Remove the bolt connecting the generator to the bracket and the generator to the intake manifold.
20. Remove the bracket.
21. Remove the bolt holding the transmission dipstick tube to the upper intake manifold.
22. Remove the ignition coils. Refer to **Ignition Coil Replacement** .
23. Remove the upper intake manifold bolts (1, 2) and stud (3).
24. Separate and remove the upper intake manifold from the lower intake manifold.

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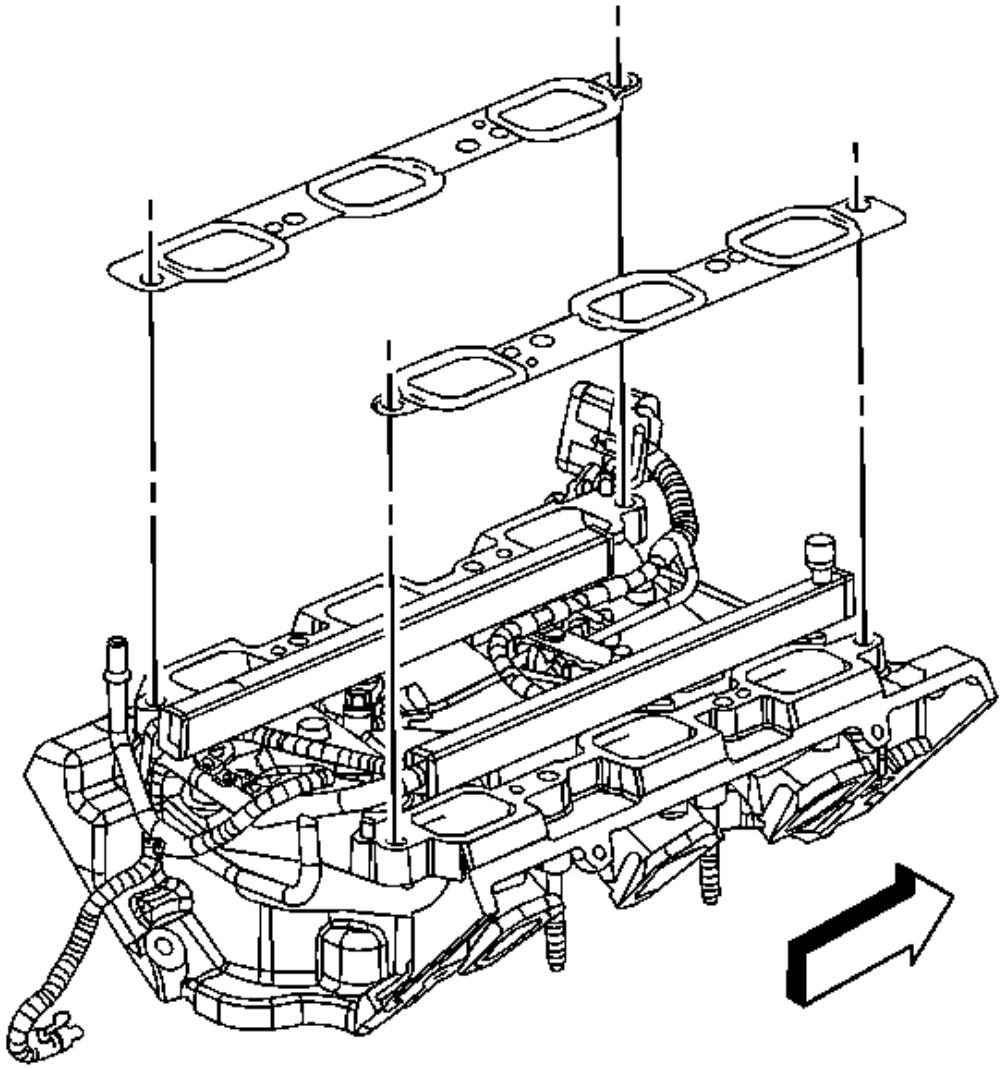

Fig. 95: Identifying Upper Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

25. Remove the upper to lower intake manifold gaskets.

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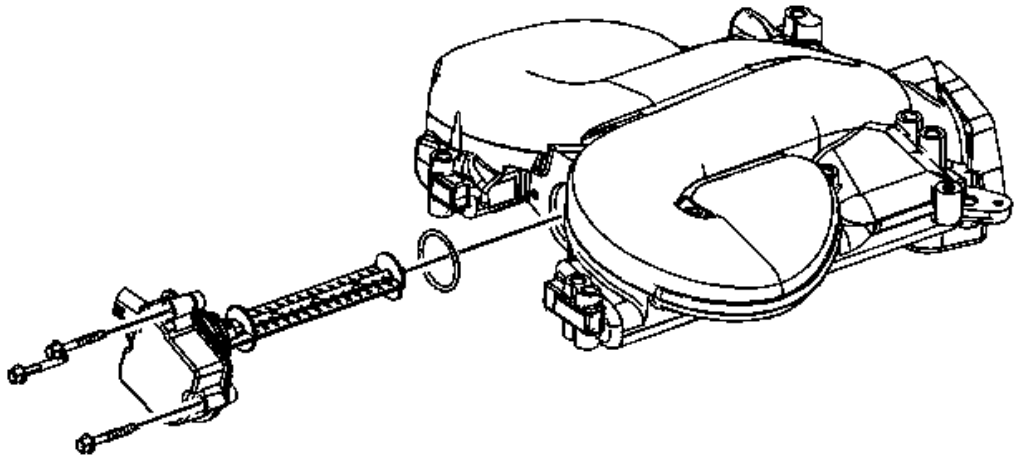

Fig. 96: Identifying Inlet Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

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

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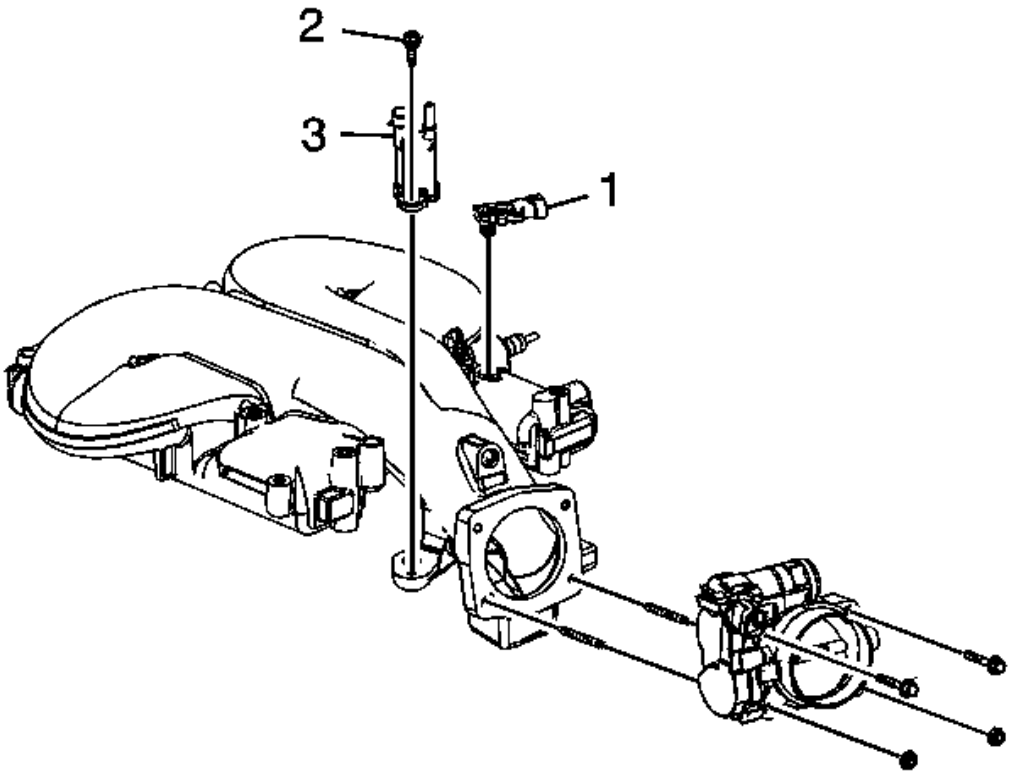

Fig. 97: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

27. Remove the EVAP canister purge solenoid valve bolt (2) and valve (3).
28. Remove the MAP sensor bracket bolts, bracket and sensor (1).
29. Remove the throttle body bolts/studs and throttle body.
30. Clean the upper intake to lower intake gasket mating surfaces.

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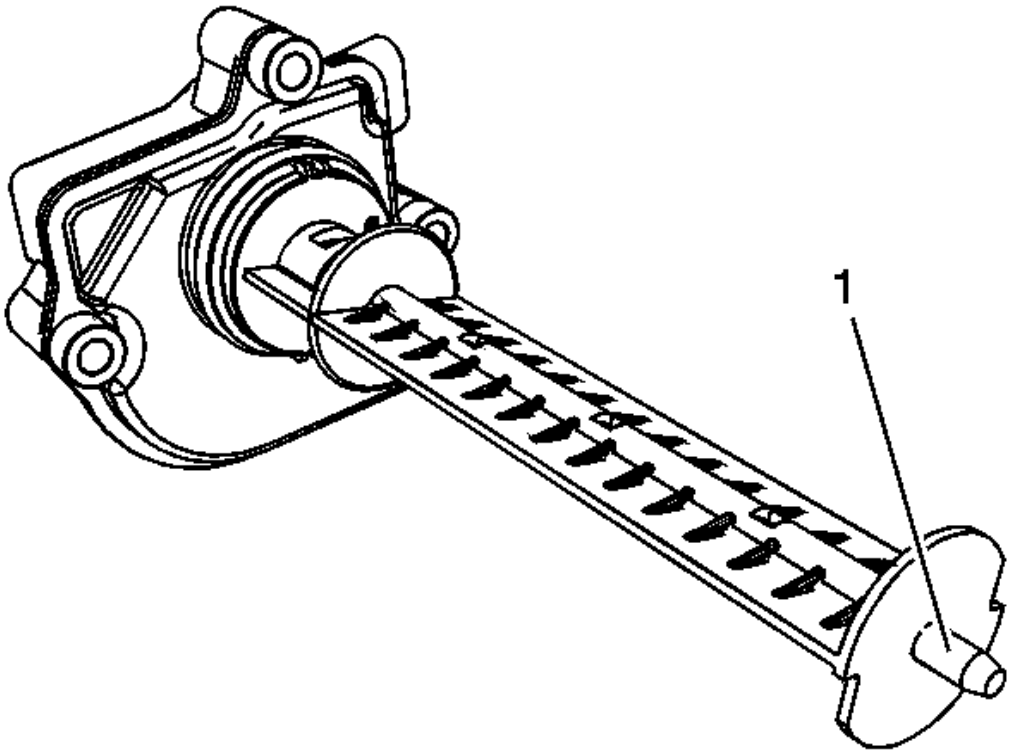

Fig. 98: View Of Tuning Valve Blade
Courtesy of GENERAL MOTORS CORP.

31. 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.
32. Apply lubricant to the nose of the valve blade (1). Refer to **Sealers, Adhesives, and Lubricants**.

Installation Procedure

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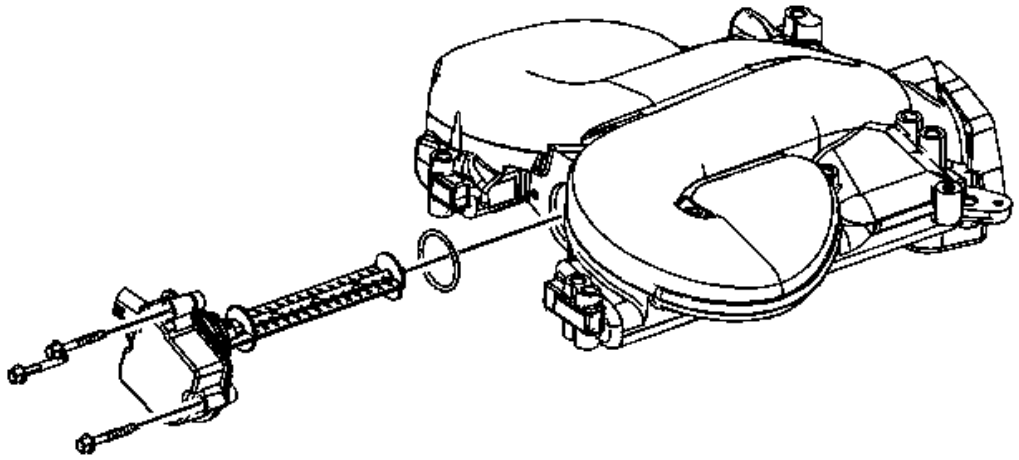

Fig. 99: Identifying Inlet Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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

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

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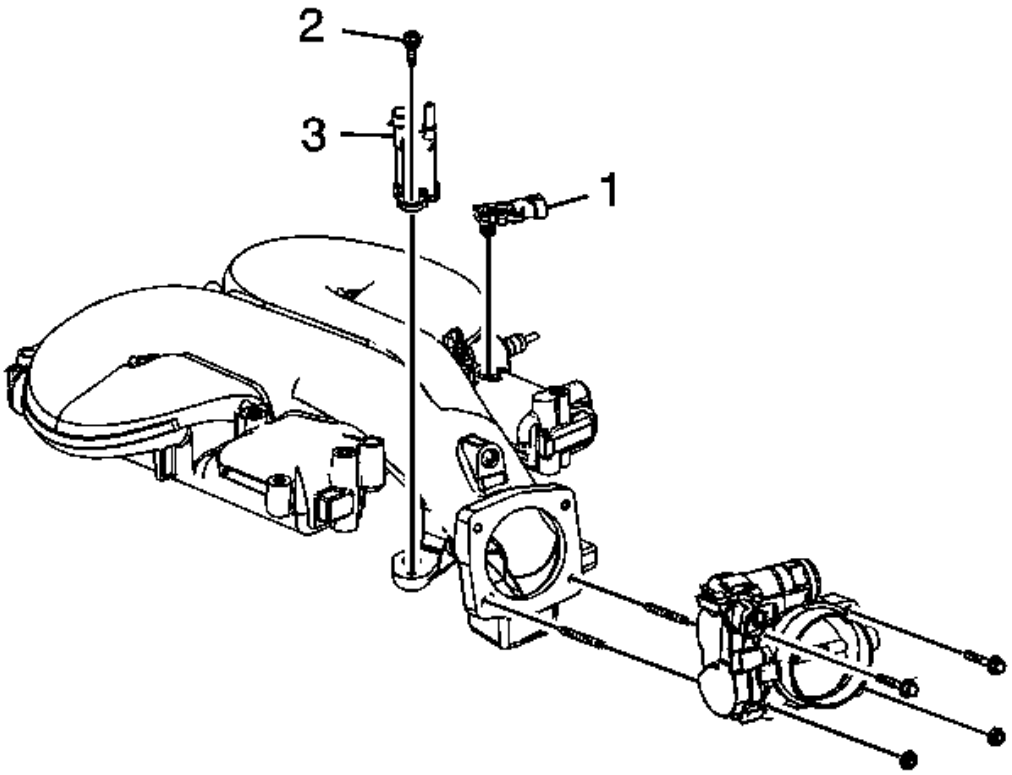

Fig. 100: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

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

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

4. Inspect the MAP sensor seal for damage, replace as necessary.
5. Install the MAP sensor (1), bracket, and bolts.
6. Inspect the throttle body seal for damage. Replace as necessary.
7. Apply threadlocker to the throttle body bolts/studs threads. Refer to **Sealers, Adhesives, and Lubricants**.
8. Install the throttle body and bolts/studs.

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

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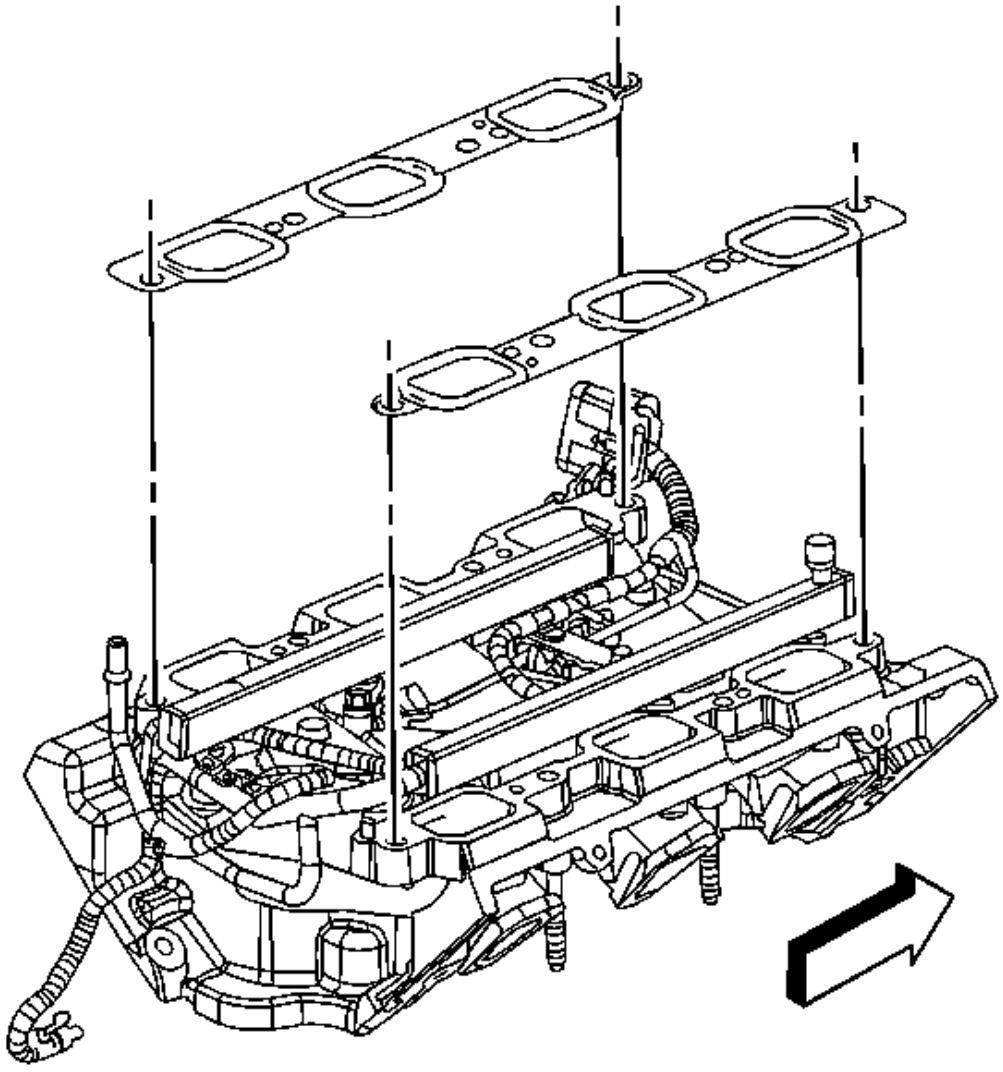

Fig. 101: Identifying Upper Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

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

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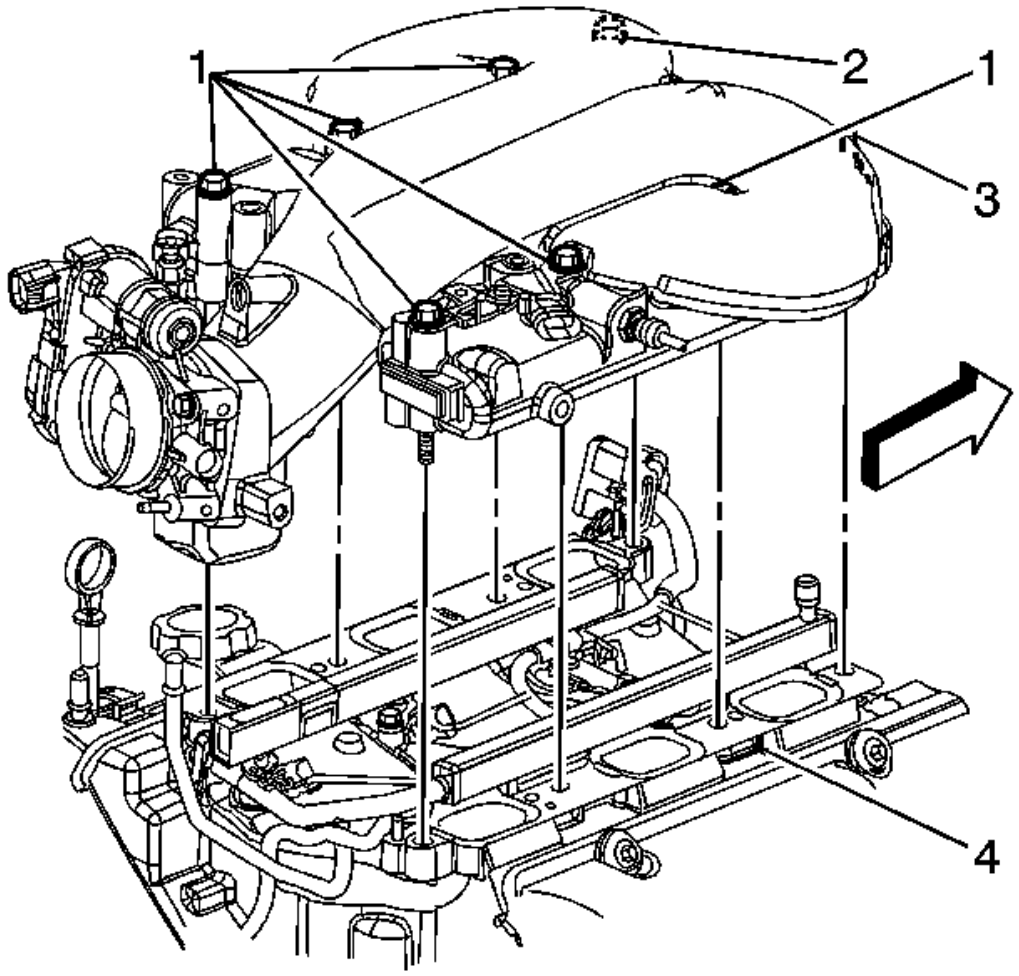

Fig. 102: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

10. Set the upper intake manifold onto the lower intake manifold.
11. Apply threadlocker to the upper intake manifold bolts/stud threads. Refer to **Sealers, Adhesives, and Lubricants**.
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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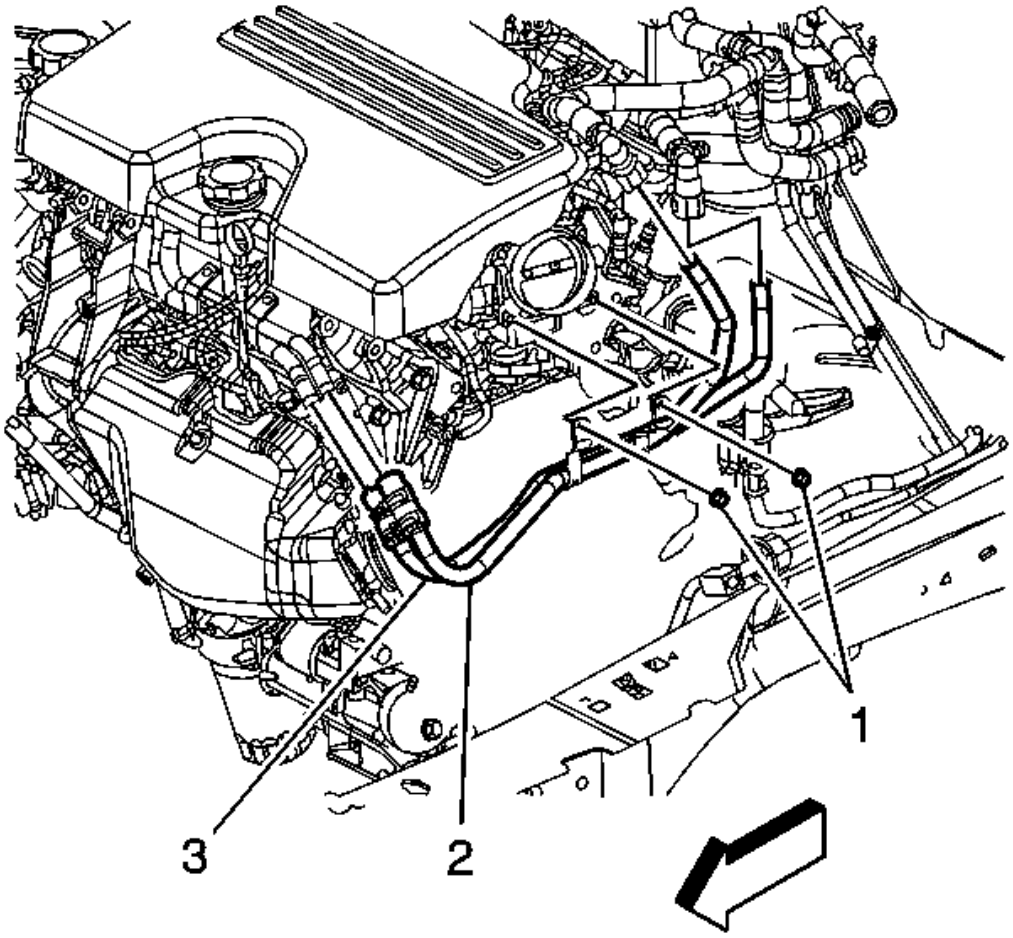

Fig. 103: Identifying Heater Inlet & Outlet Hose/Pipes
Courtesy of GENERAL MOTORS CORP.

13. Install the ignition coil. Refer to **Ignition Coil Replacement** .
14. Reposition the transmission tube and install the bolt at the intake manifold.
15. Install the bracket from the generator to the intake manifold.
16. Install the bolt connecting the generator, bracket and the intake manifold.
17. Install the nut connecting the generator bracket to the upper intake manifold.
18. Install the inlet and outlet pipe to the studs.
19. 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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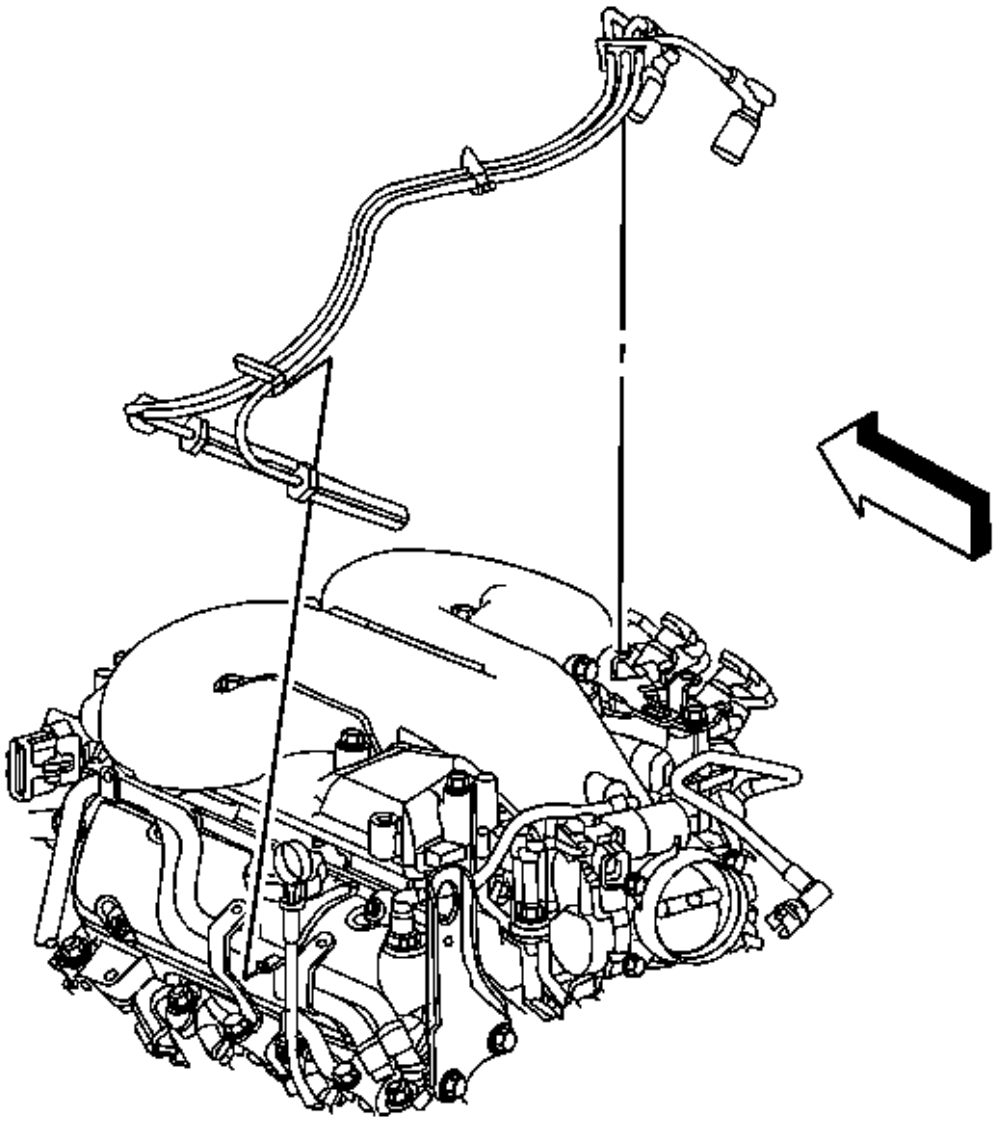

Fig. 104: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

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

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

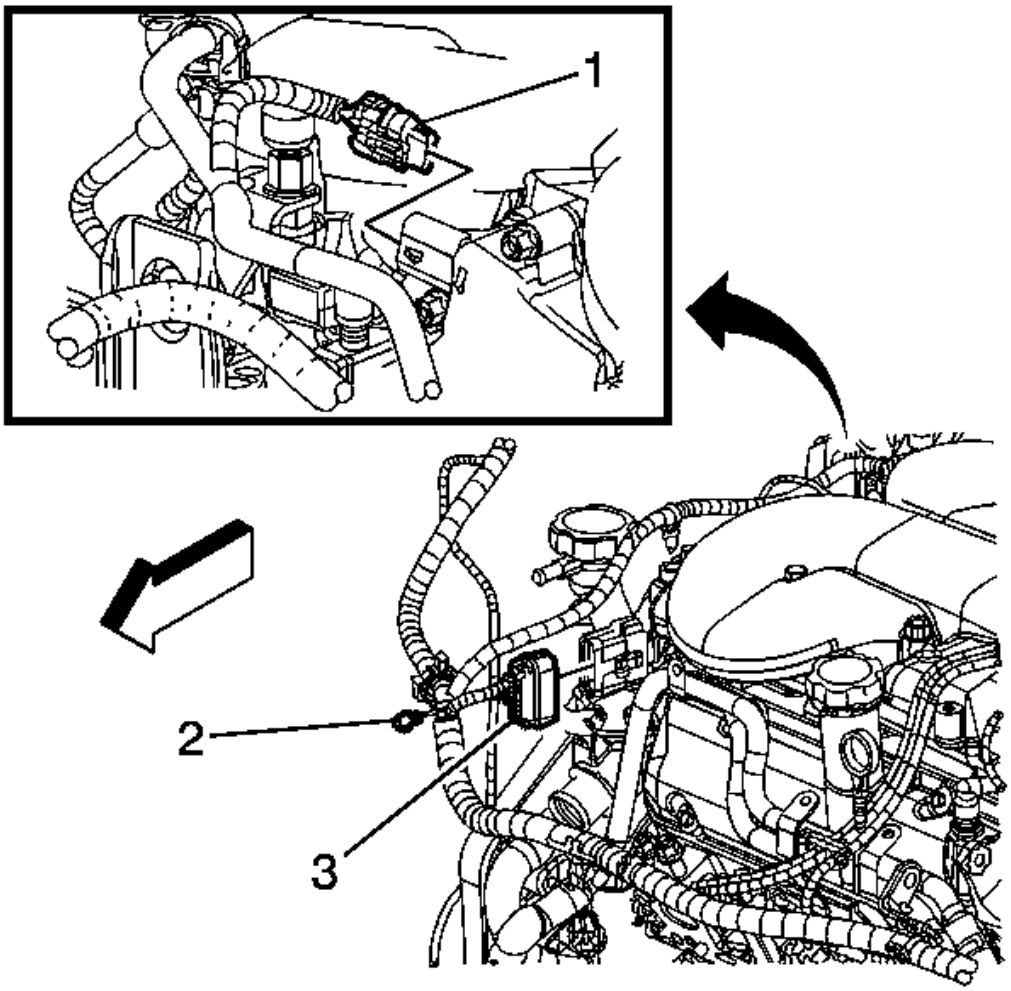

Fig. 105: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

25. Connect the engine harness electrical connector (1) to the intake manifold tuning valve.

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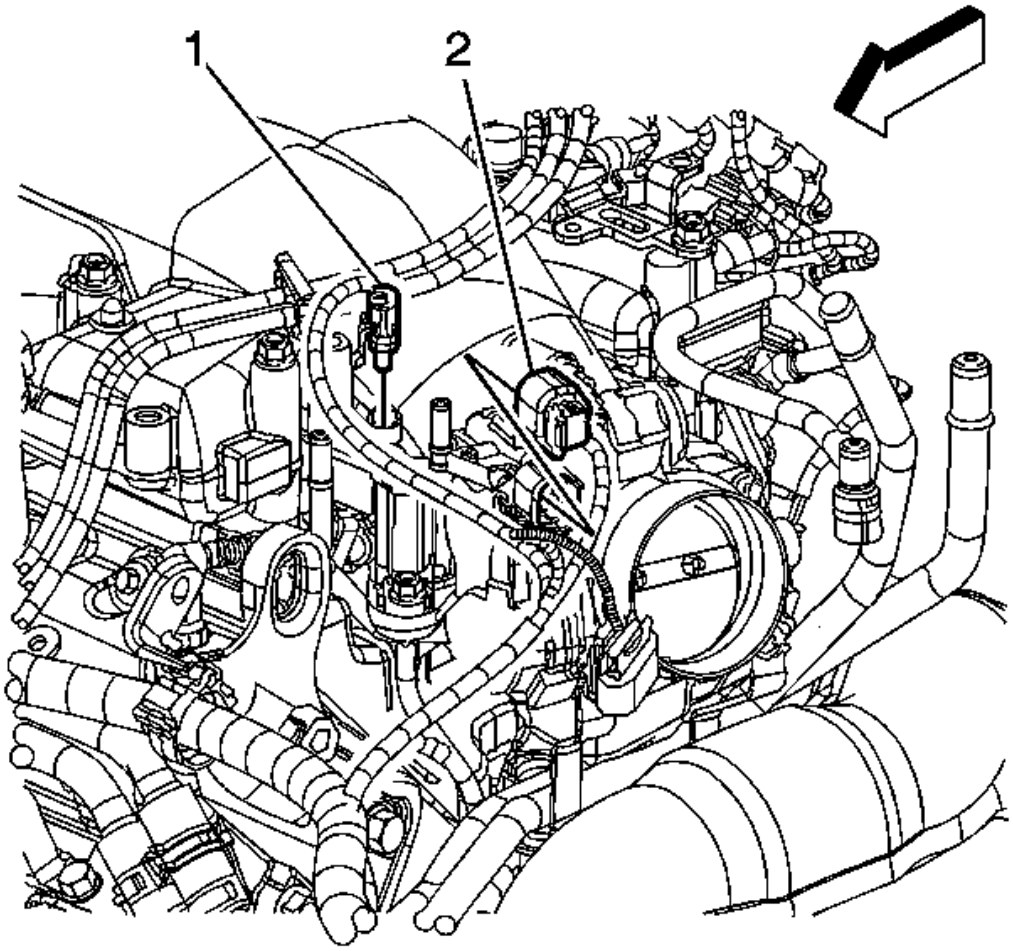

Fig. 106: Locating EVAP & ETC Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

26. Connect the engine harness electrical connectors (1, 2) to the following:
    - The EVAP canister purge solenoid
    - The ETC

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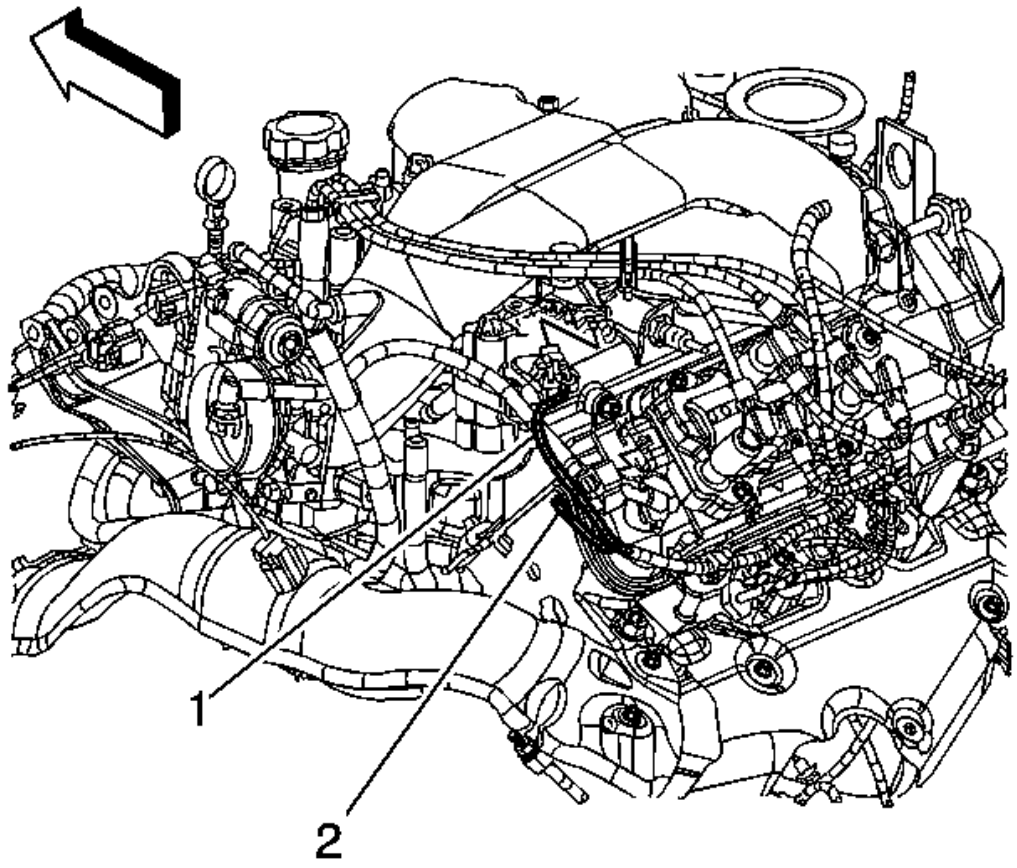

Fig. 107: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

27. Connect the MAP sensor electrical connector (1).
28. Install the brake booster vacuum hose to the intake manifold.
29. Position the vacuum hose clamp at the intake manifold.

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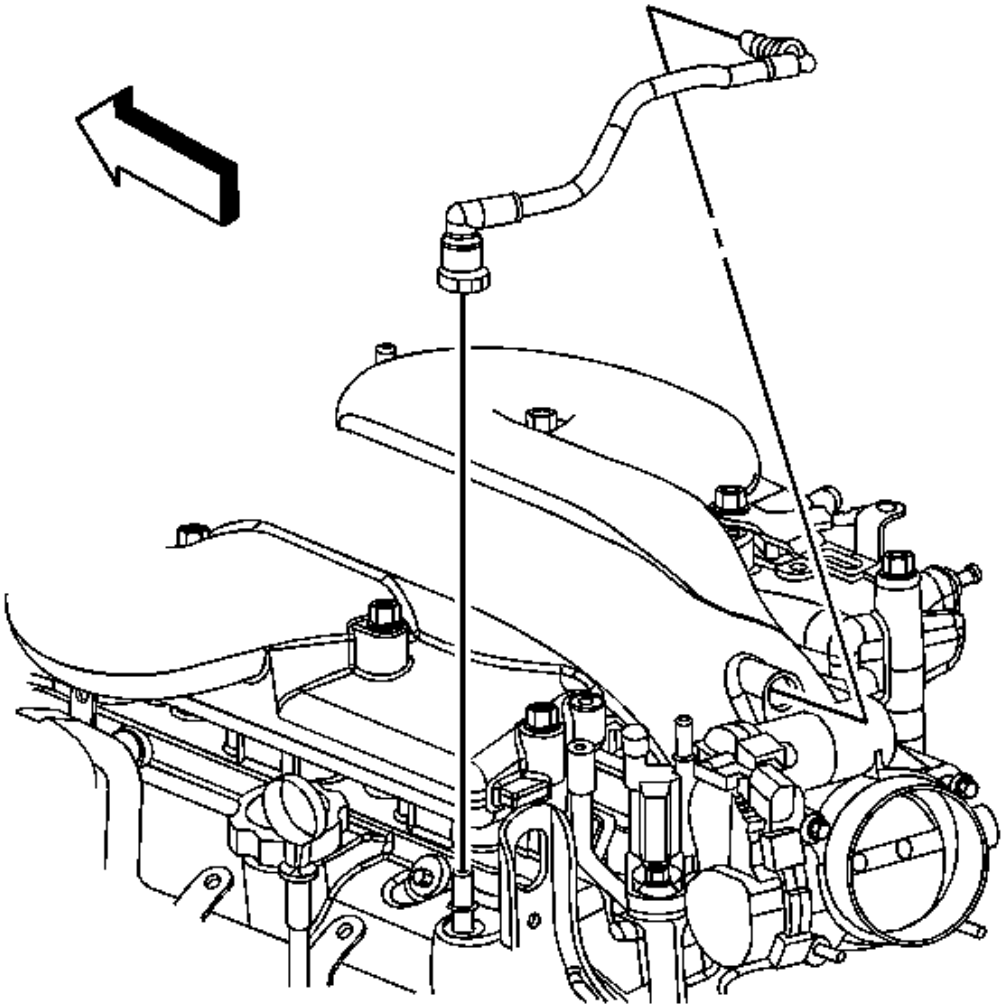

Fig. 108: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

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

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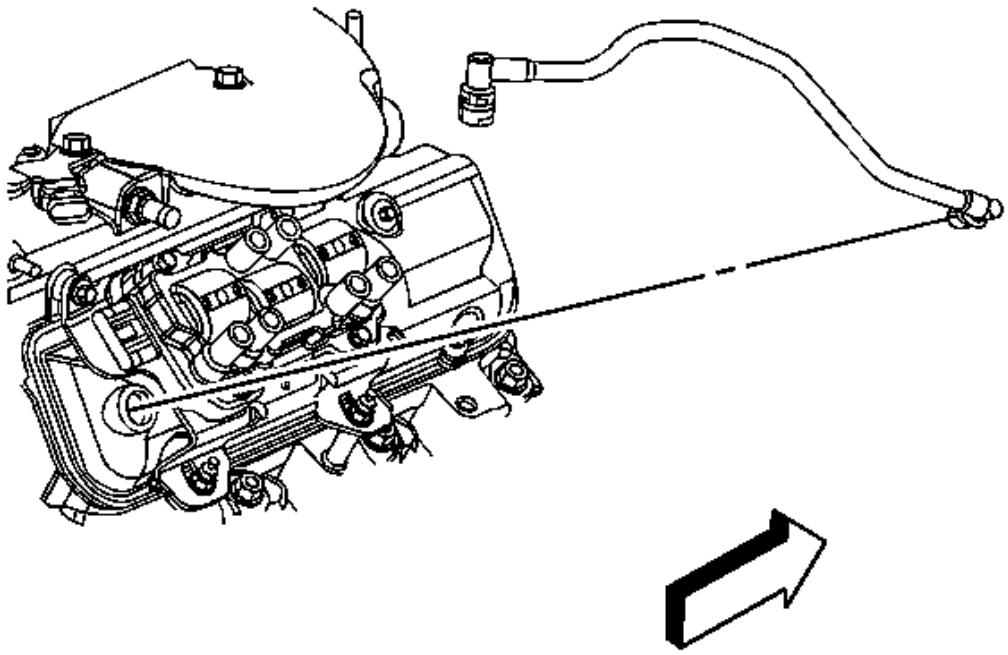

Fig. 109: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

31. Install the PCV fresh air tube. Refer to **Plastic Collar Quick Connect Fitting Service** .
32. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
33. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
34. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

Lower Intake Manifold Replacement

Removal Procedure

IMPORTANT: 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** .
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**.

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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** .

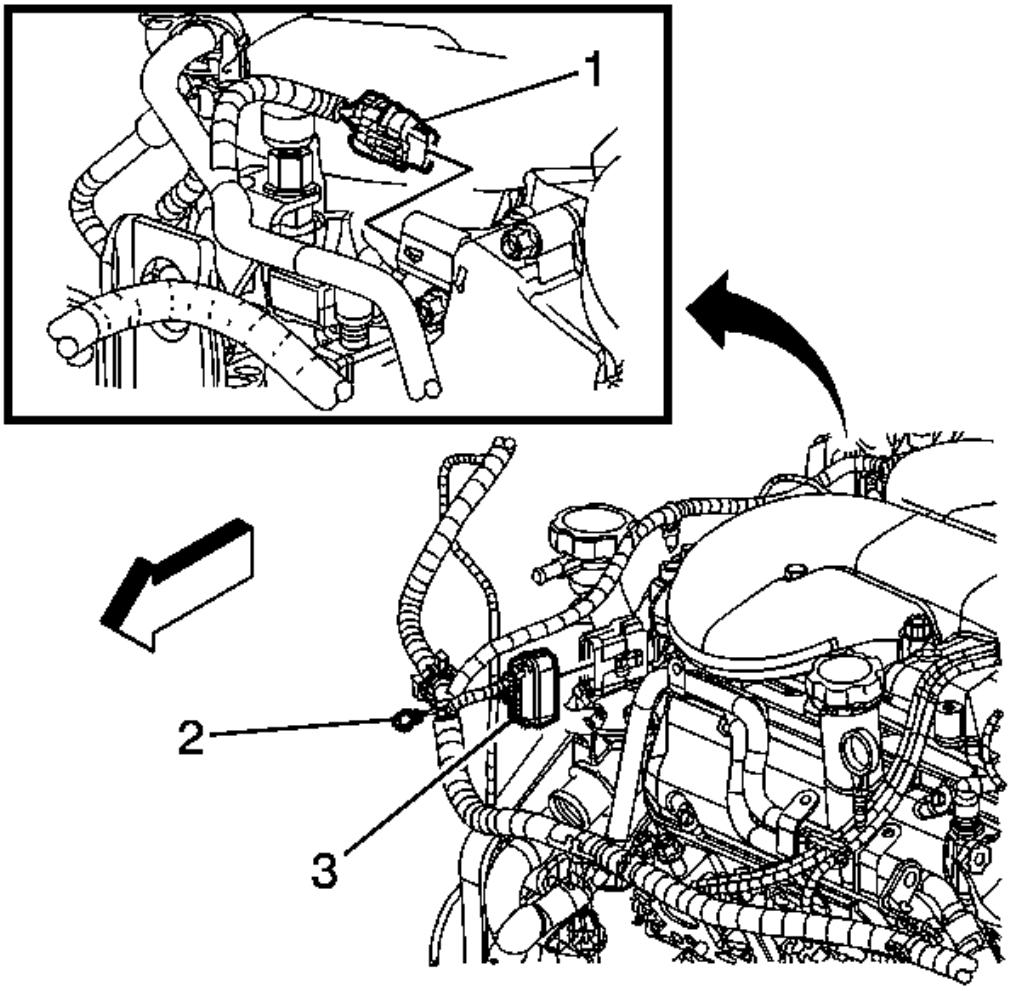

Fig. 110: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Remove the connector position assurance (CPA) retainer (2).
8. Disconnect the engine harness electrical connector (3) from the fuel injector harness electrical connector.

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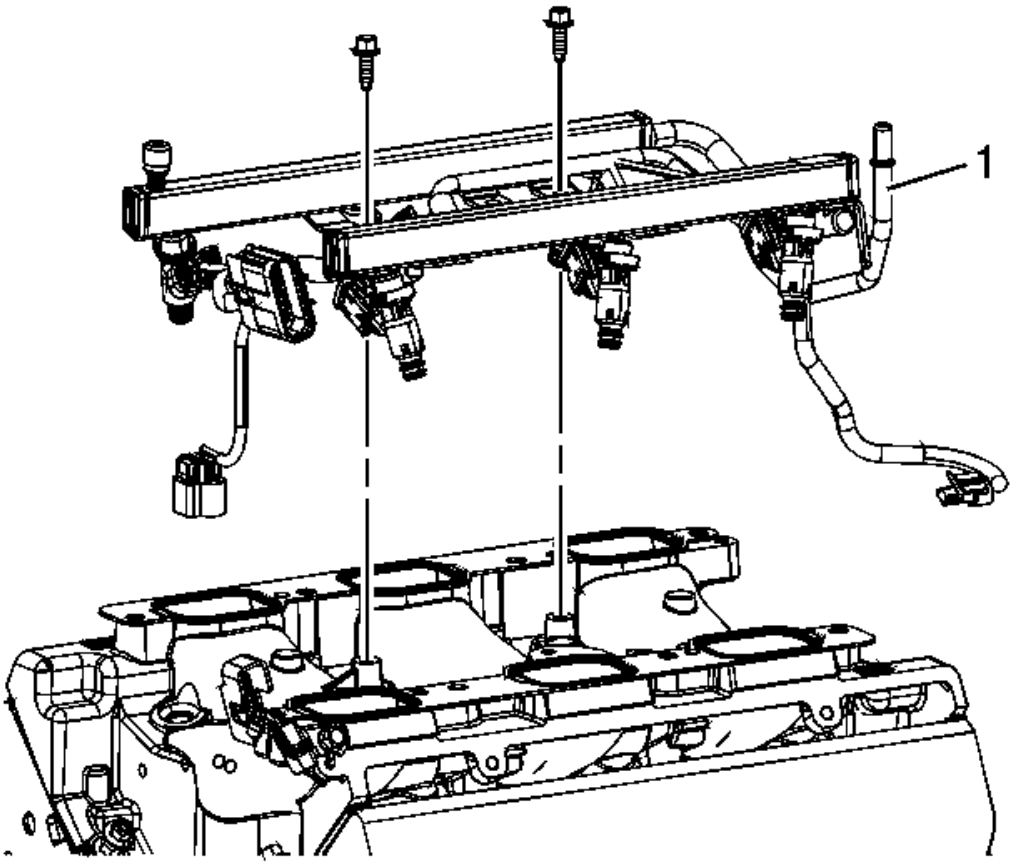

Fig. 111: Identifying Fuel Rail
Courtesy of GENERAL MOTORS CORP.

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

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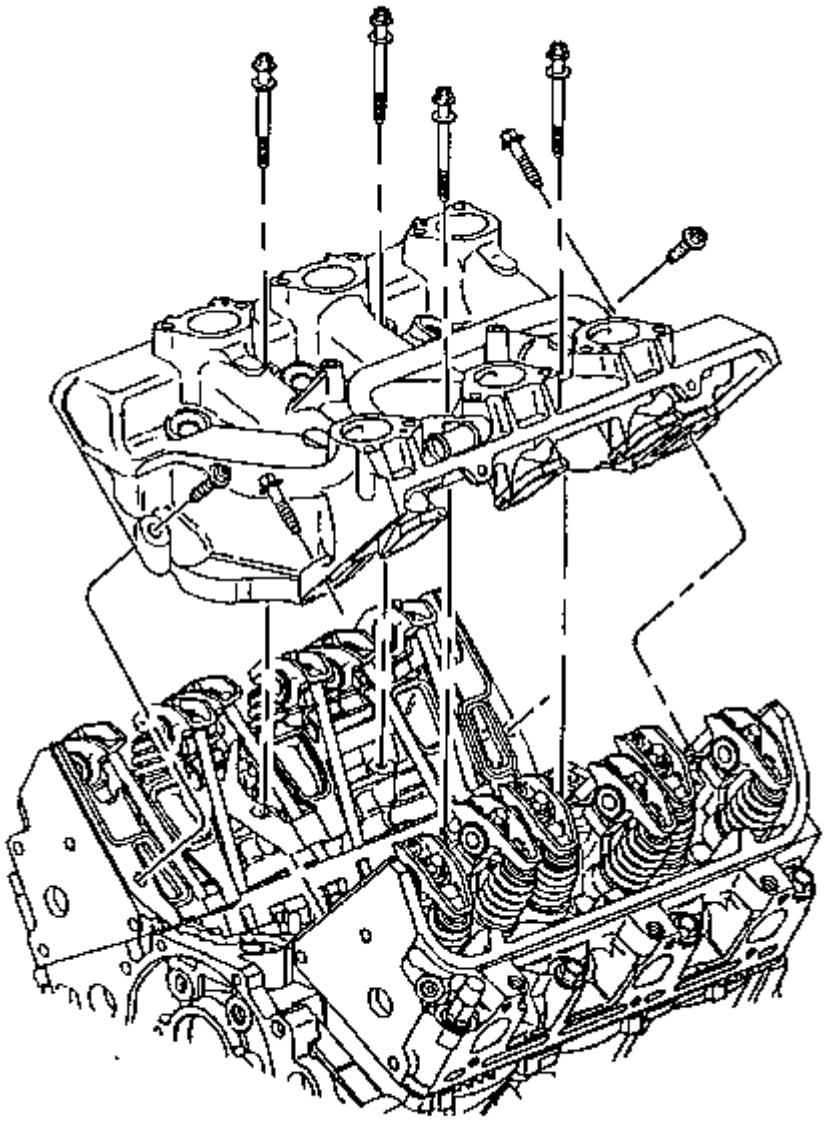

Fig. 112: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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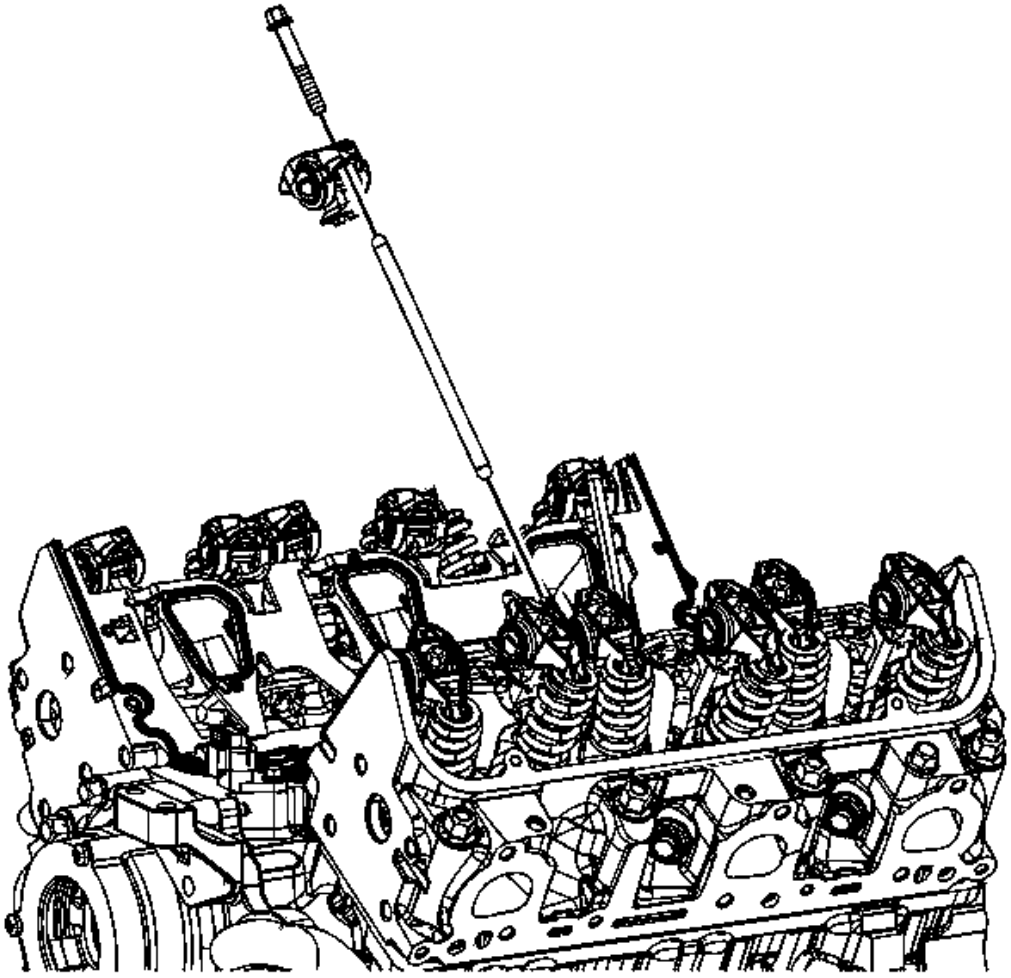

Fig. 113: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

15. 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.

16. Remove the valve rocker arms.
17. 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).

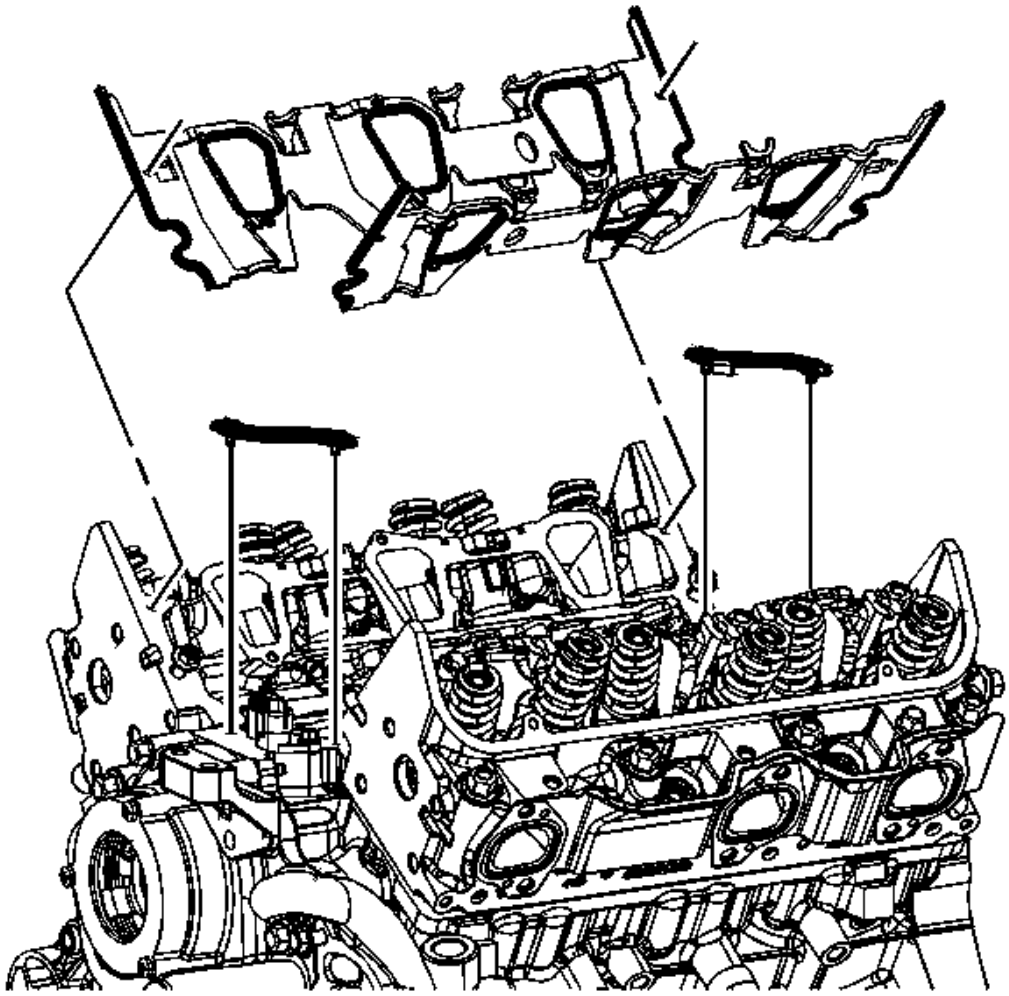

Fig. 114: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

18. Remove the lower intake manifold gaskets and seals.
19. Clean the lower intake manifold gasket and seal surfaces on the cylinder heads and the engine block.
20. Clean the gasket and seal surfaces on the lower intake manifold with degreaser.
21. Remove all the loose room temperature vulcanizing sealer (RTV) (1).

Installation Procedure

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IMPORTANT: All gasket mating surfaces need to be free of oil and foreign material. Use cleaner to clean the surfaces. Refer to Sealers, Adhesives, and Lubricants.

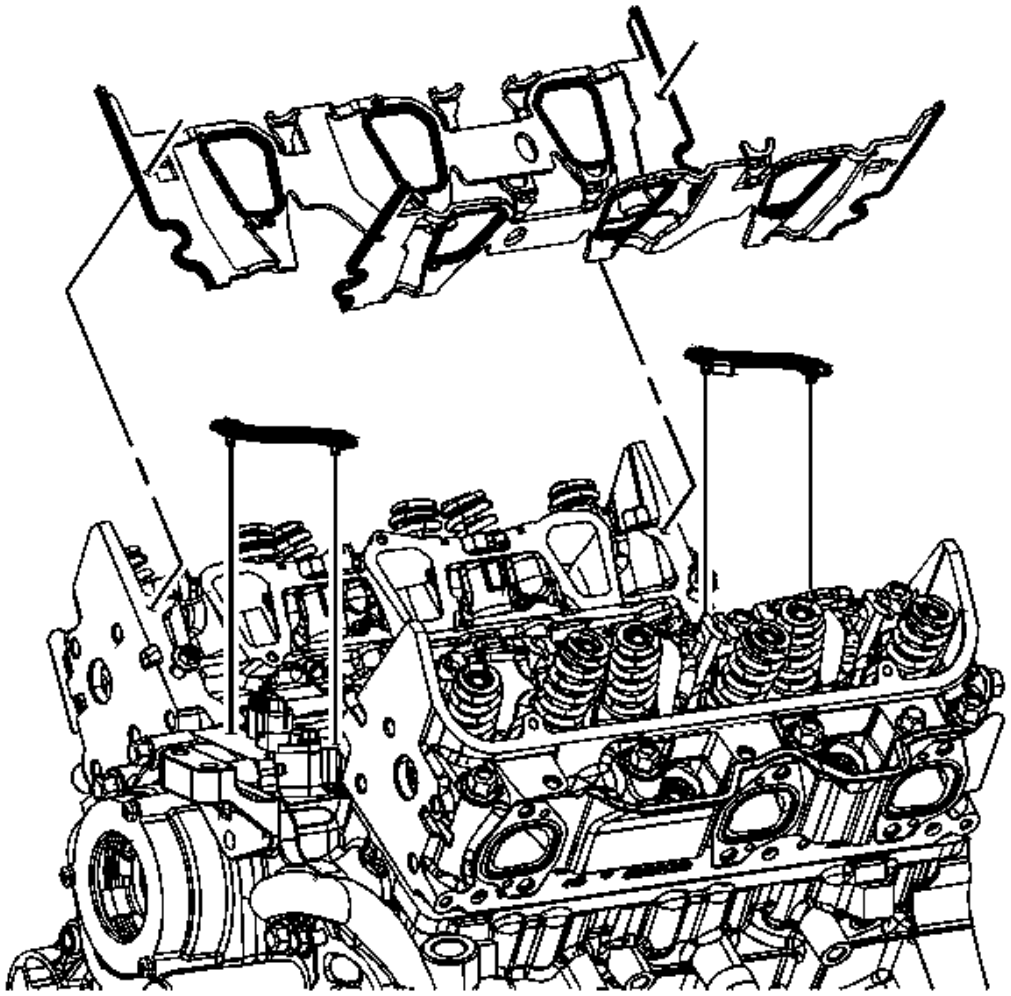

Fig. 115: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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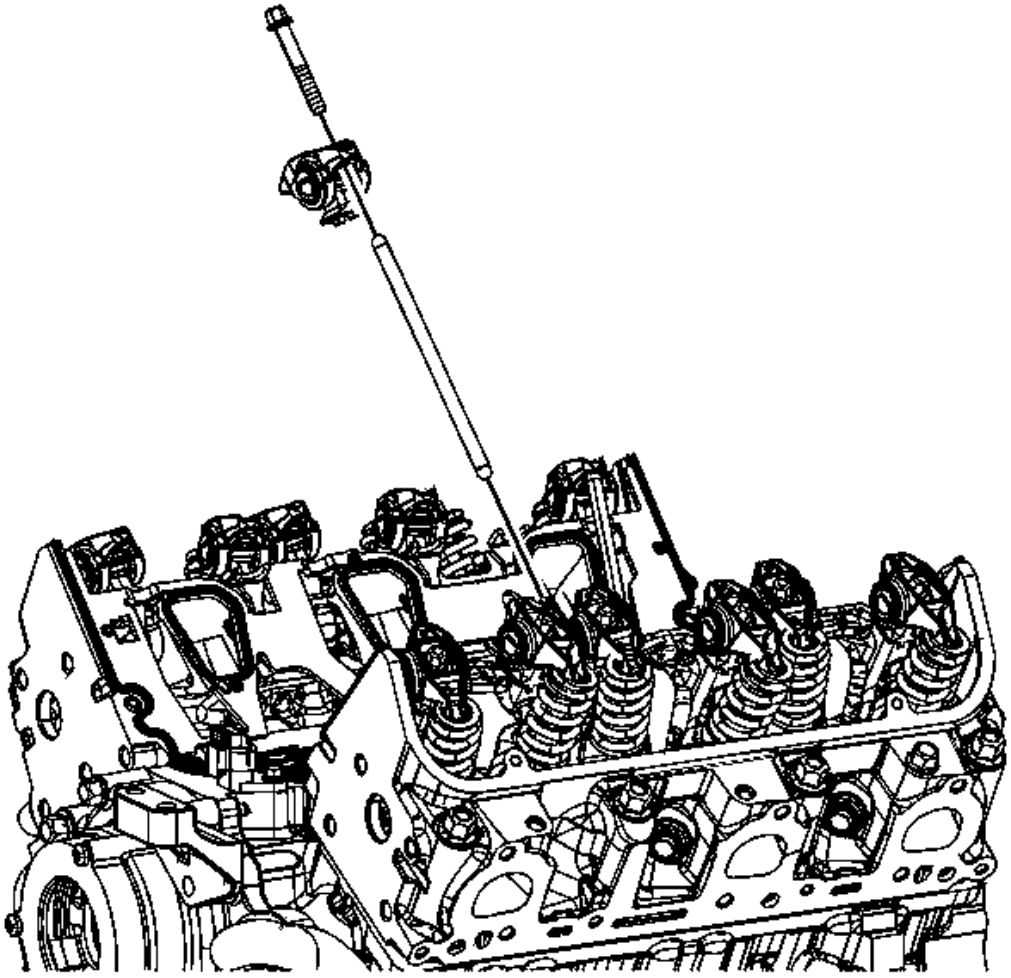

Fig. 116: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Coat the ends of the push rods using prelube. Refer to **Sealers, Adhesives, and Lubricants**.

IMPORTANT: 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 **Sealers, Adhesives, and Lubricants**.

IMPORTANT: Shims (P/N 88894006) may be required under the valve rocker arm

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

NOTE: Refer to Fastener Notice .

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).

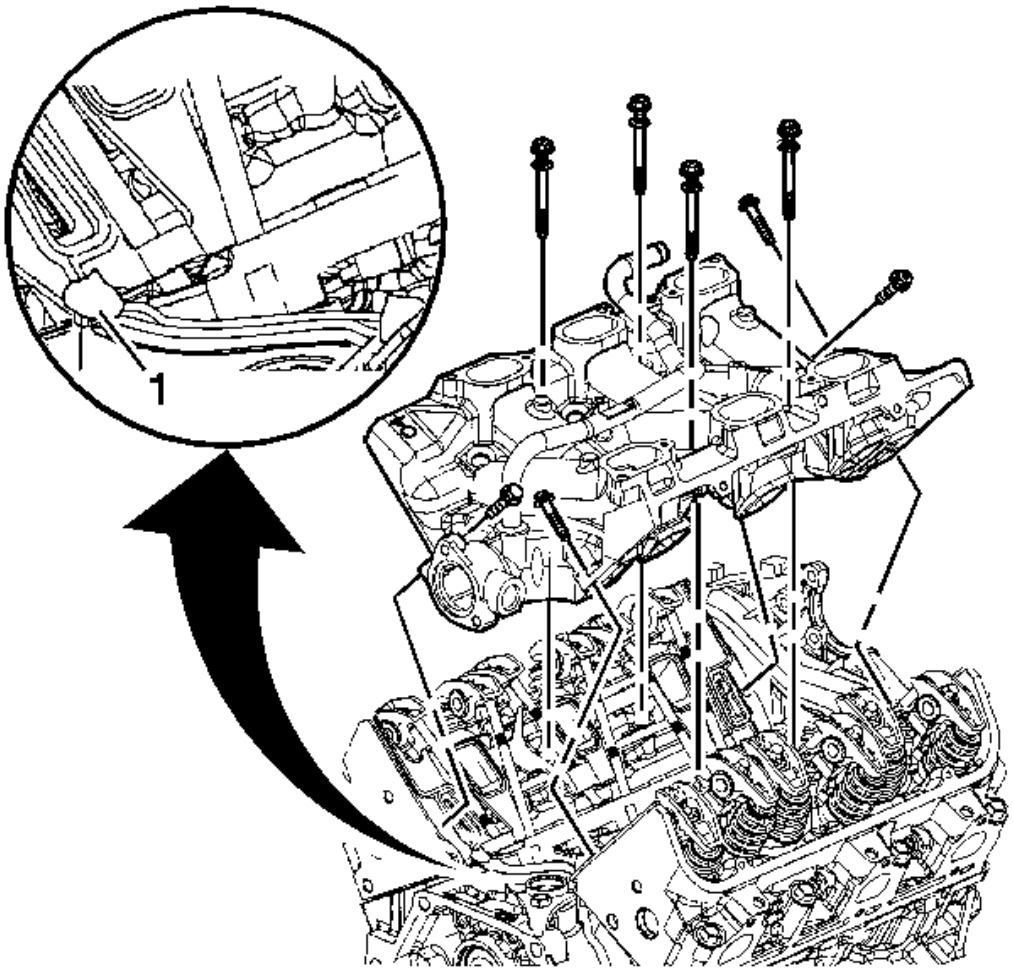

Fig. 117: Installing Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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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 **Sealers, Adhesives, and Lubricants**.
8. Install the lower intake manifold.

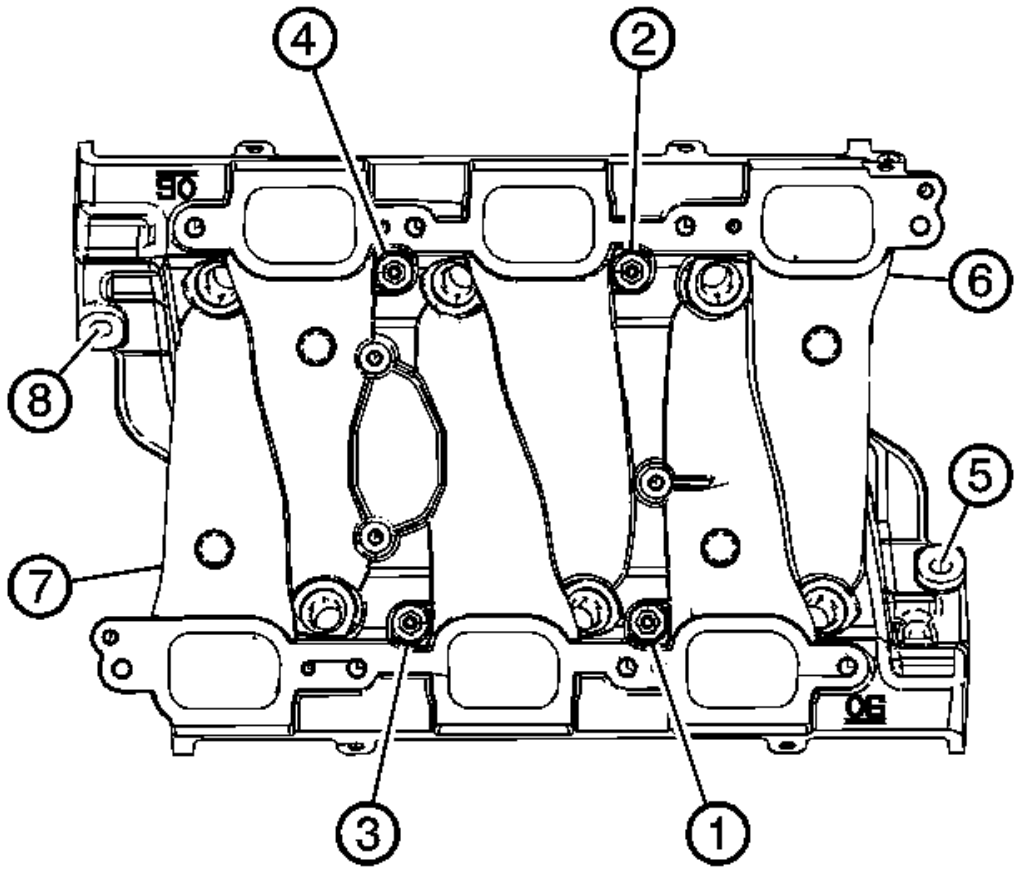

Fig. 118: Identifying Lower Intake Manifold Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

NOTE: Failure to tighten vertical bolts before the diagonal bolts may cause an oil

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leak.

9. Apply sealer to the lower intake manifold bolt threads. Refer to **Sealers, Adhesives, and Lubricants**.
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).

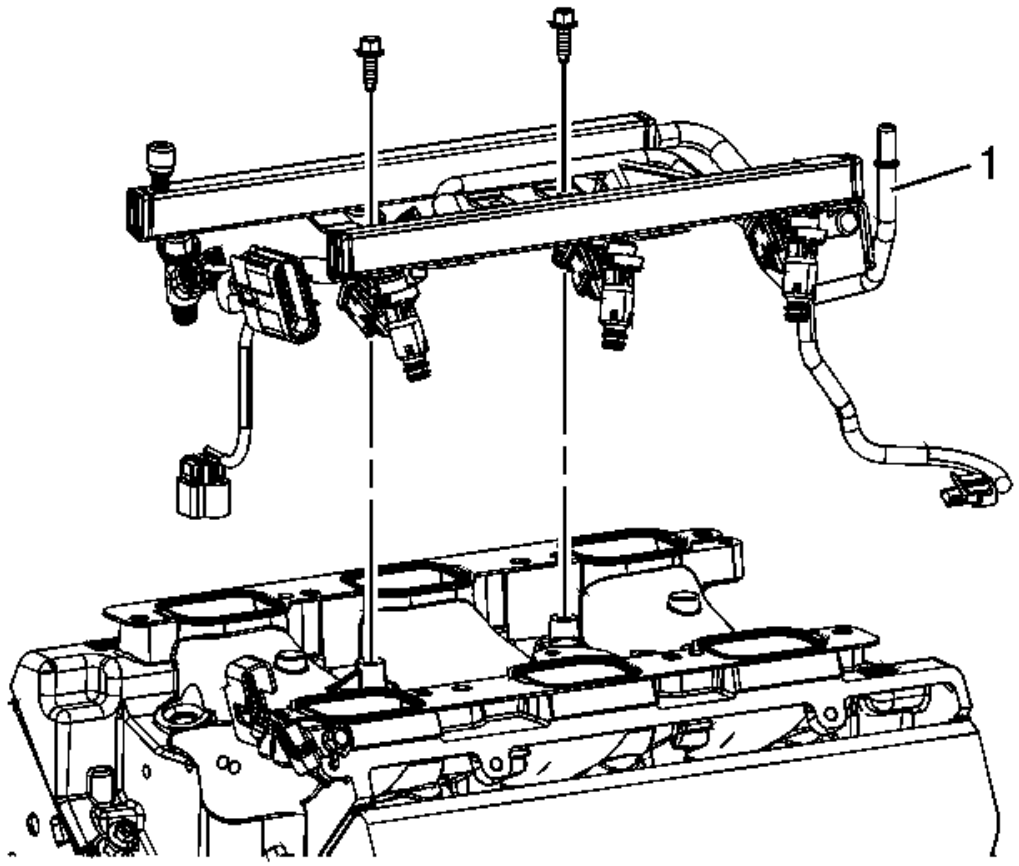

Fig. 119: Identifying Fuel Rail
Courtesy of GENERAL MOTORS CORP.

12. Inspect the fuel rail (1), fuel injectors and fuel injector O-rings for damage and replace as necessary.
13. Lubricate the fuel injector O-rings using the engine oil. Refer to **Sealers, Adhesives, and Lubricants**.

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14. Install the injector nozzles into the lower intake manifold injector bores.
15. Press on the injector rail using the palms of both hands until the injector are 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).

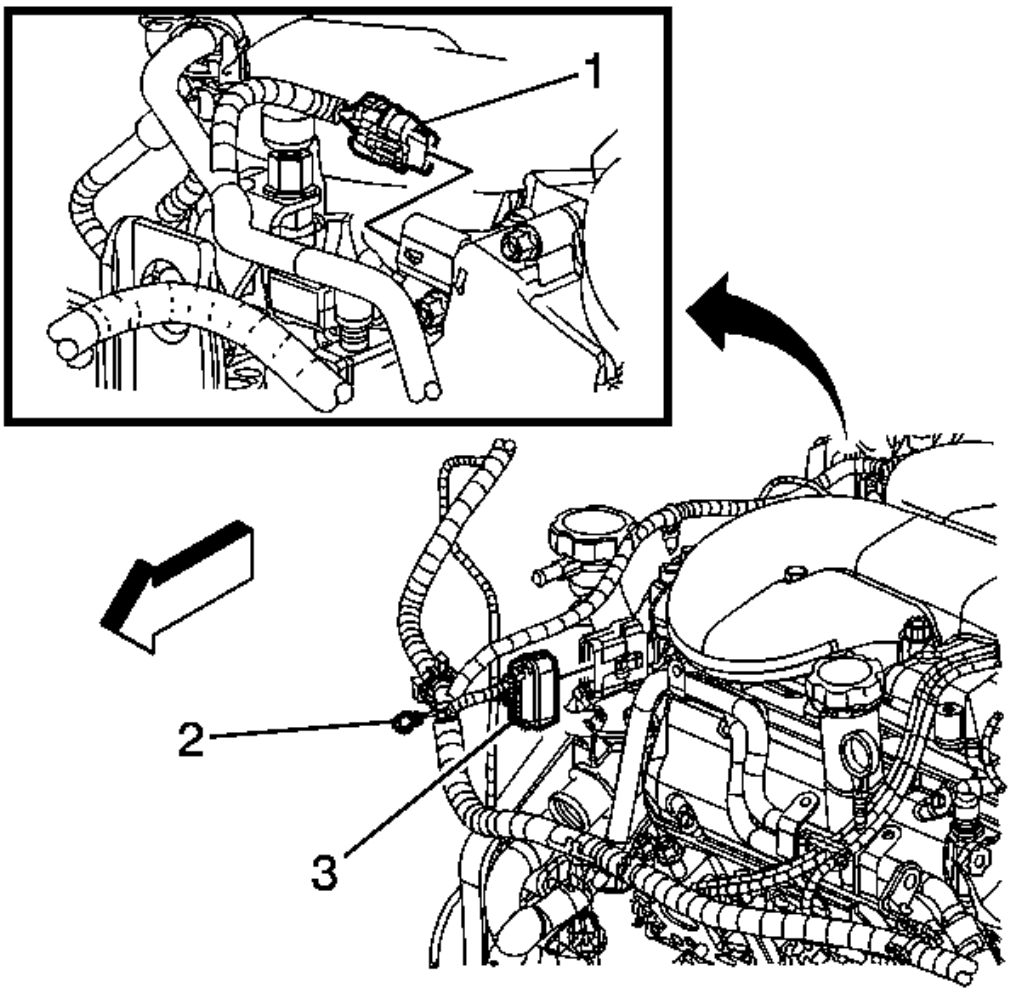

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Fig. 120: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

20. Connect the engine harness electrical connector (3) to the fuel injector wiring harness electrical connector.
21. Install the CPA retainer (2).
22. Connect the fuel feed line to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
23. Connect the ECT electrical connector.
24. Install the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right Side**.
25. Install the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side**.
26. Install the upper intake manifold. Refer to **Upper Intake Manifold Replacement**.
27. Install the coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement** .

Crankcase Ventilation Hoses/Pipes Replacement

Removal Procedure

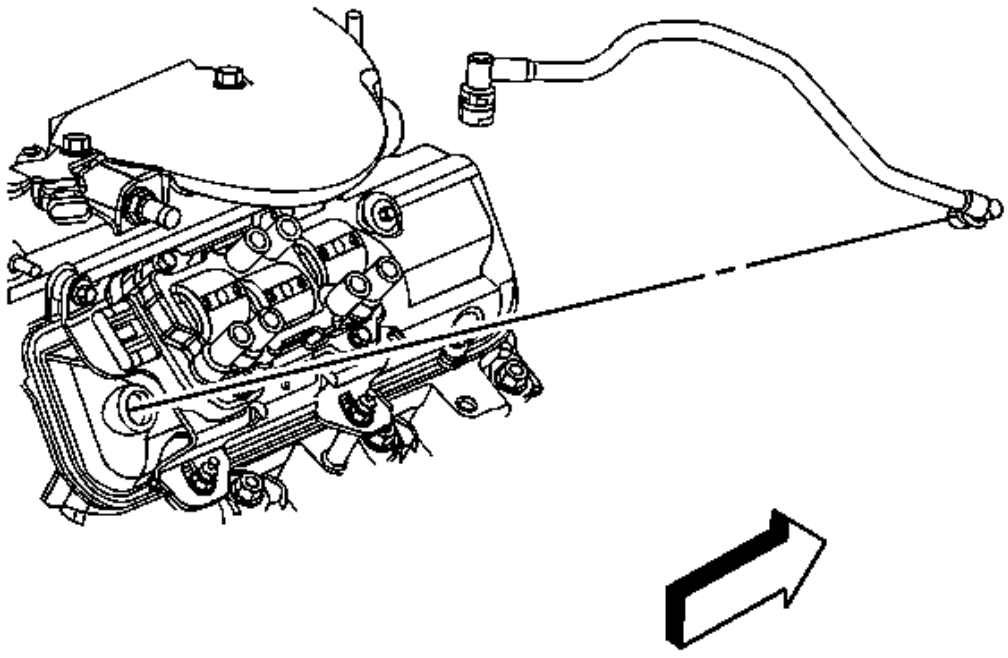

Fig. 121: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

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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.

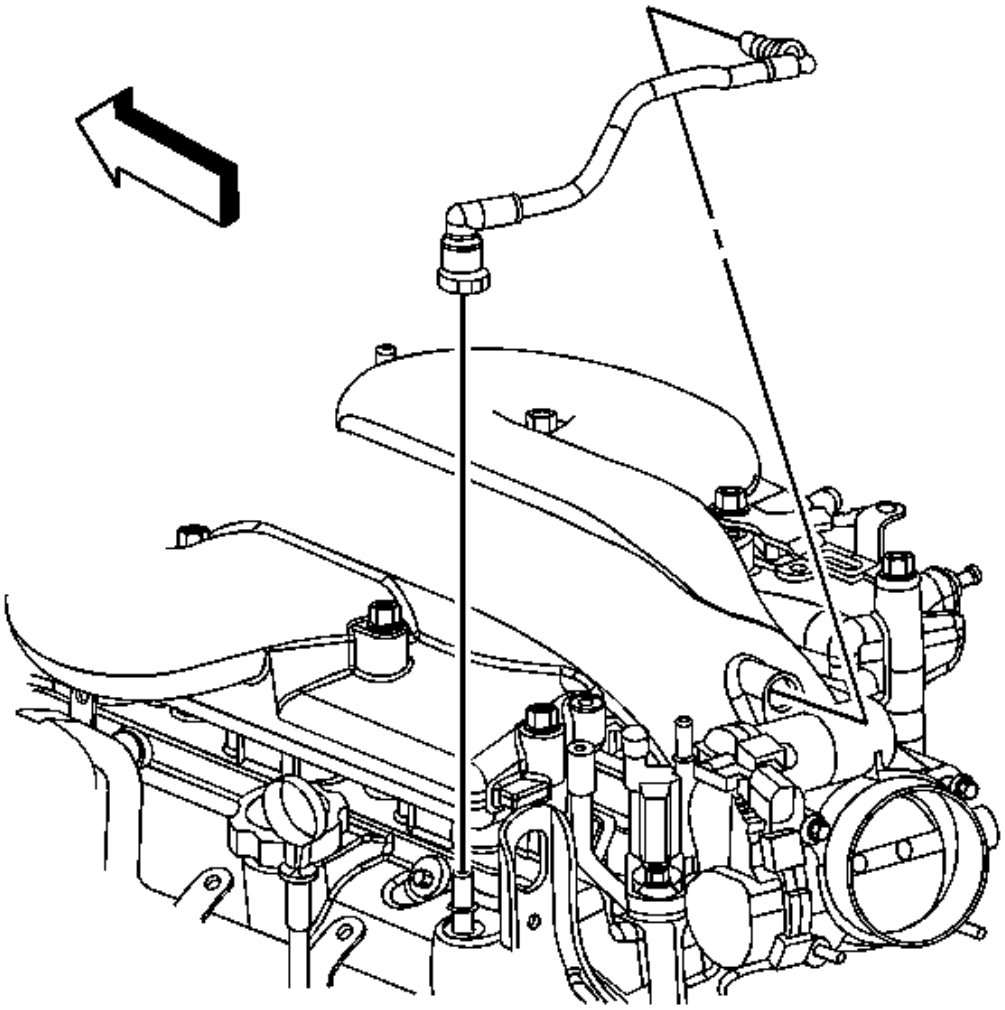

Fig. 122: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

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

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6. Remove the PCV foul air tube from the intake manifold.
7. Remove the PCV foul air tube from the vehicle.

Installation Procedure

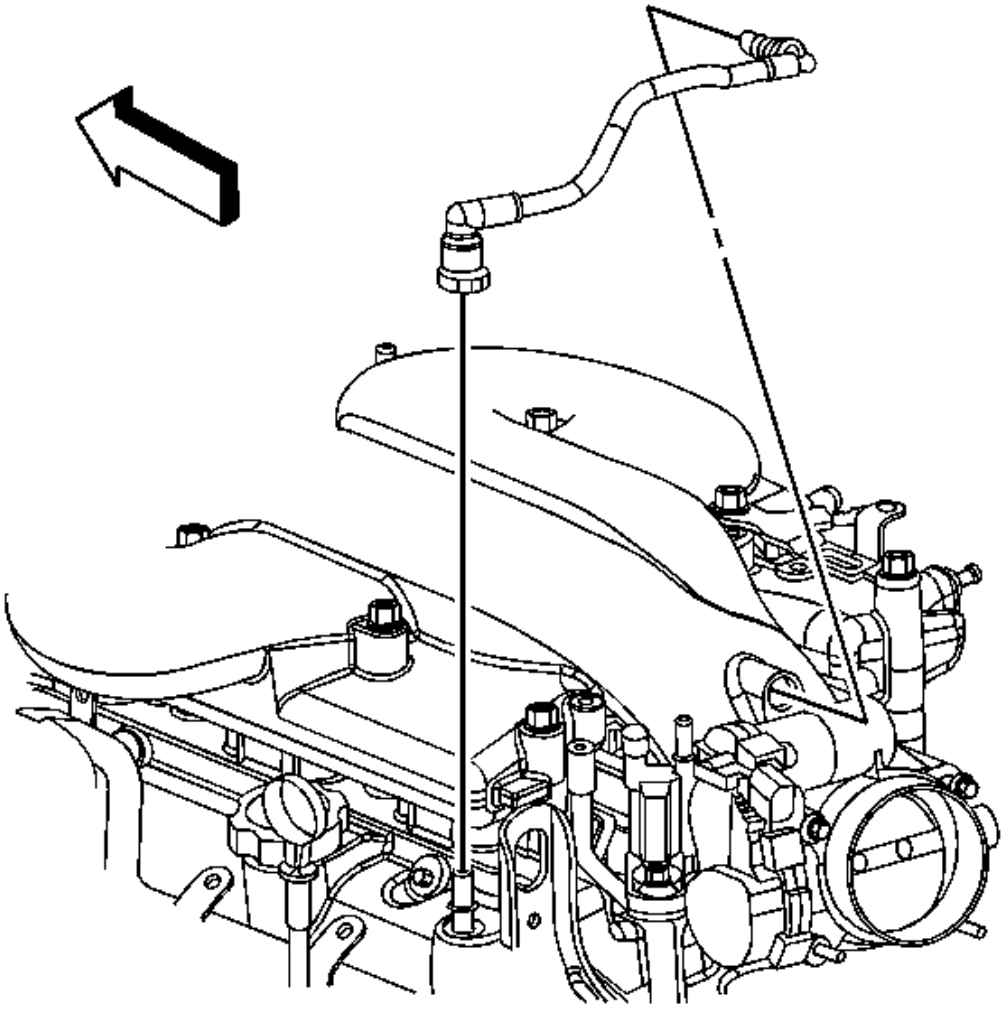

Fig. 123: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

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**

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Service .

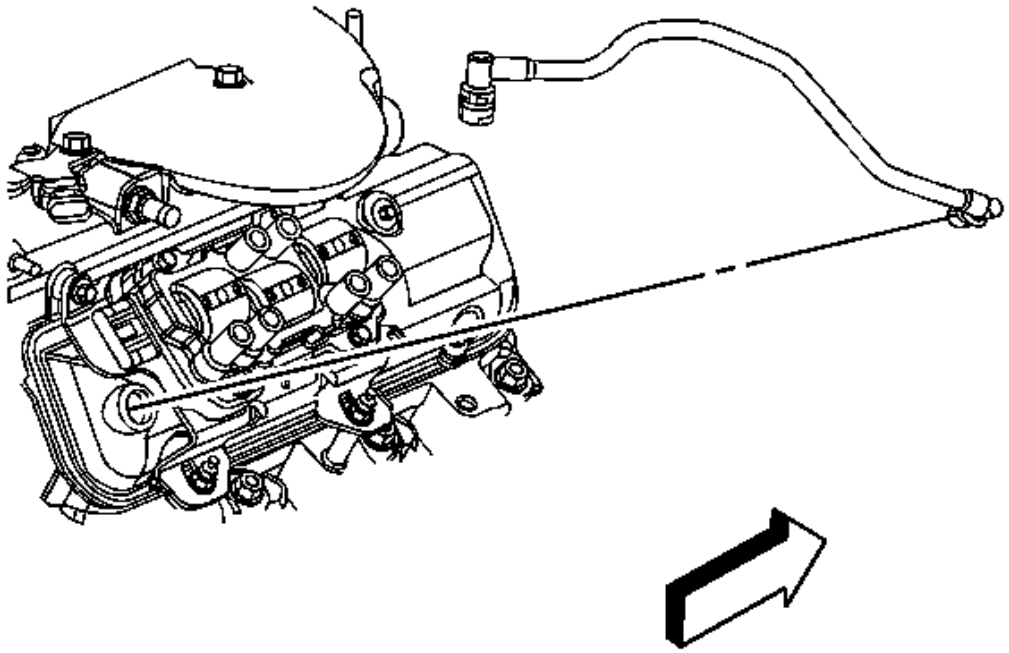

Fig. 124: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

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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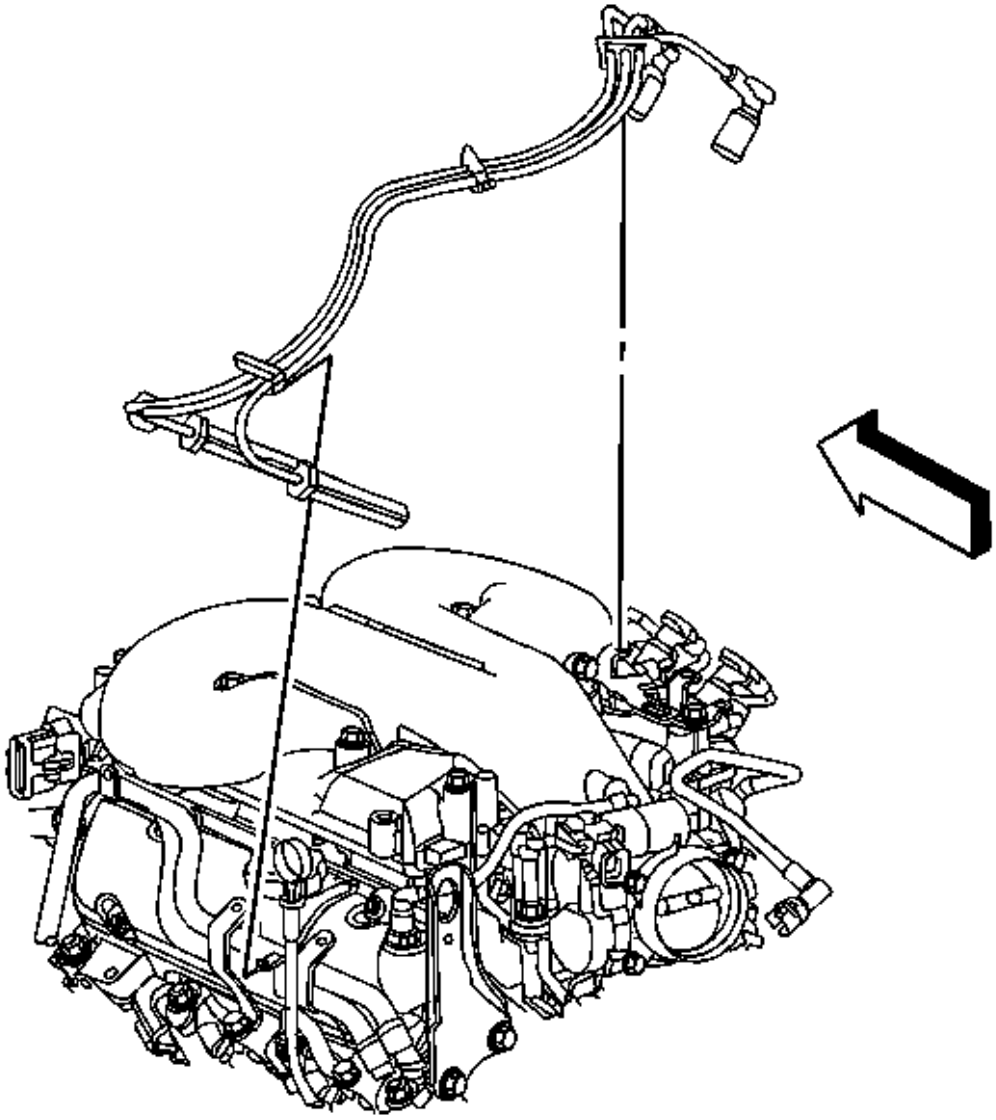

Fig. 125: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the heater inlet and outer front pipe. Refer to **Heater Inlet Hose/Pipe and Heater Outlet Hose/Pipe Replacement** .

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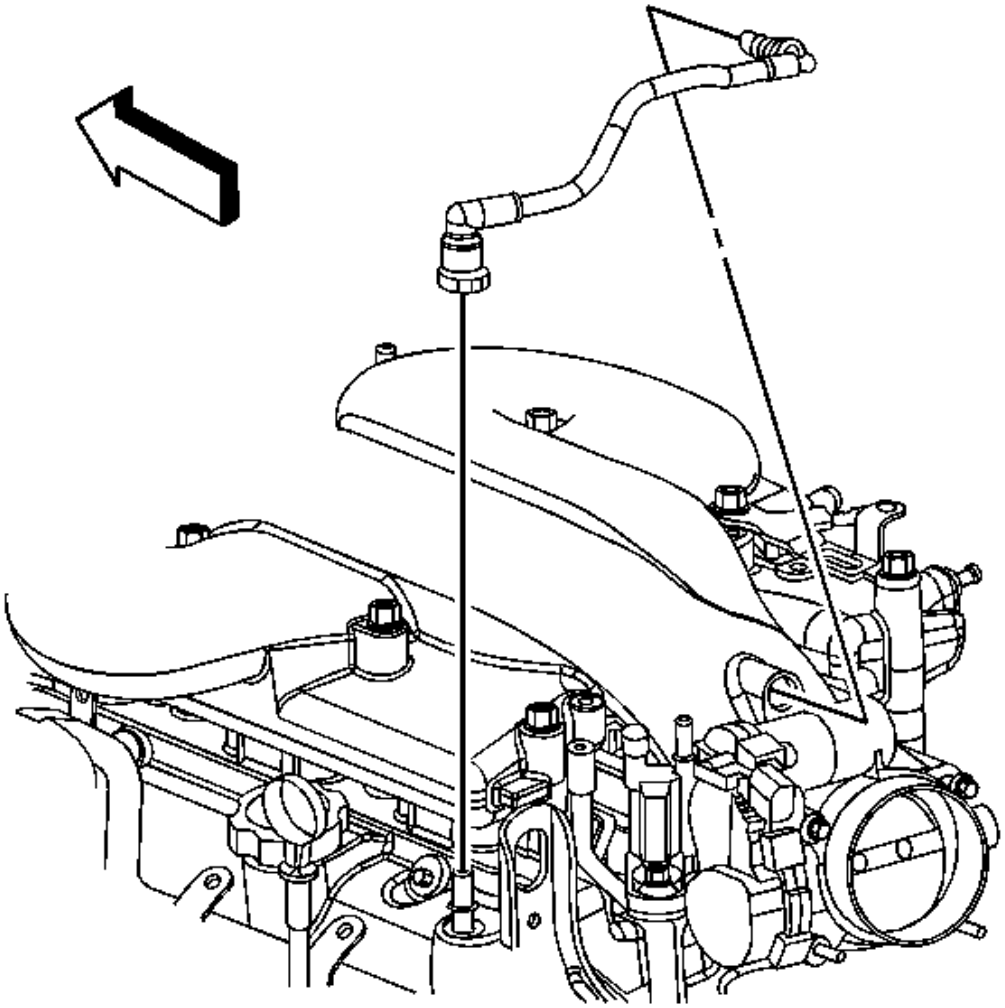

Fig. 126: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the positive crankcase ventilation (PCV) foul air tube from the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
4. Remove the right engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.

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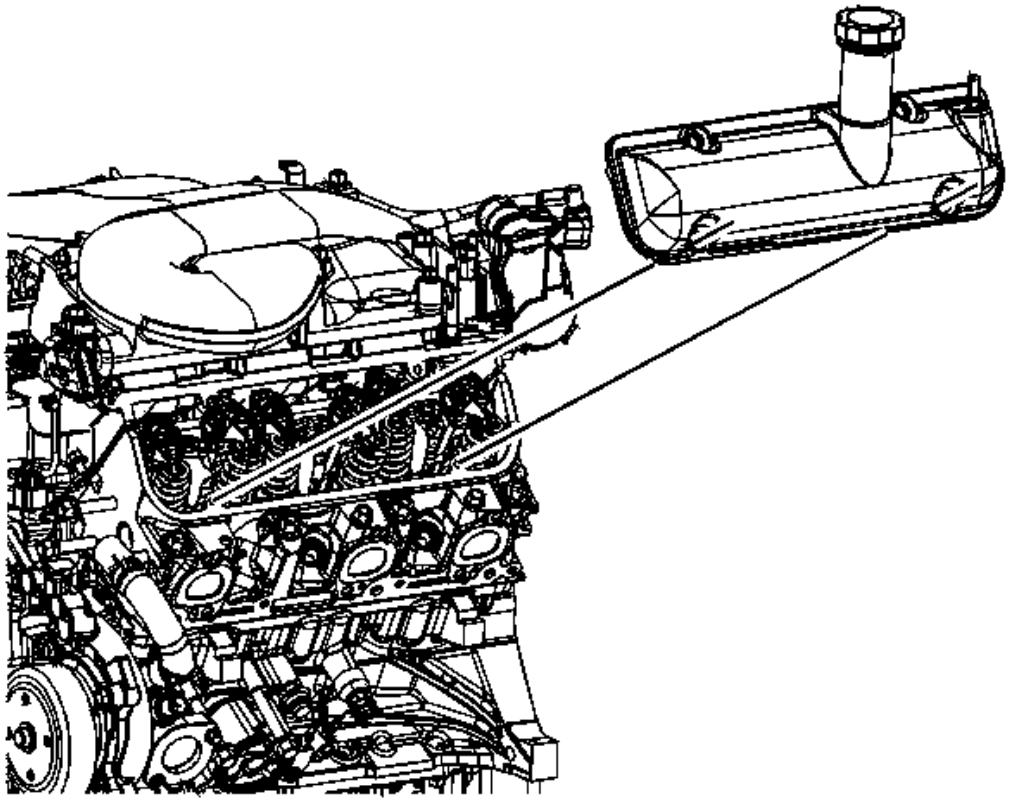

Fig. 127: Identifying Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover bolts.

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

6. 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.
7. Cut the RTV in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
8. Remove the valve cover gasket.
9. Clean the sealing surface on the cylinder head with degreaser.

Installation Procedure

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IMPORTANT: All gasket mating surfaces need to be free of oil and foreign material. Use cleaner to clean the surfaces. Refer to Sealers, Adhesives, and Lubricants.

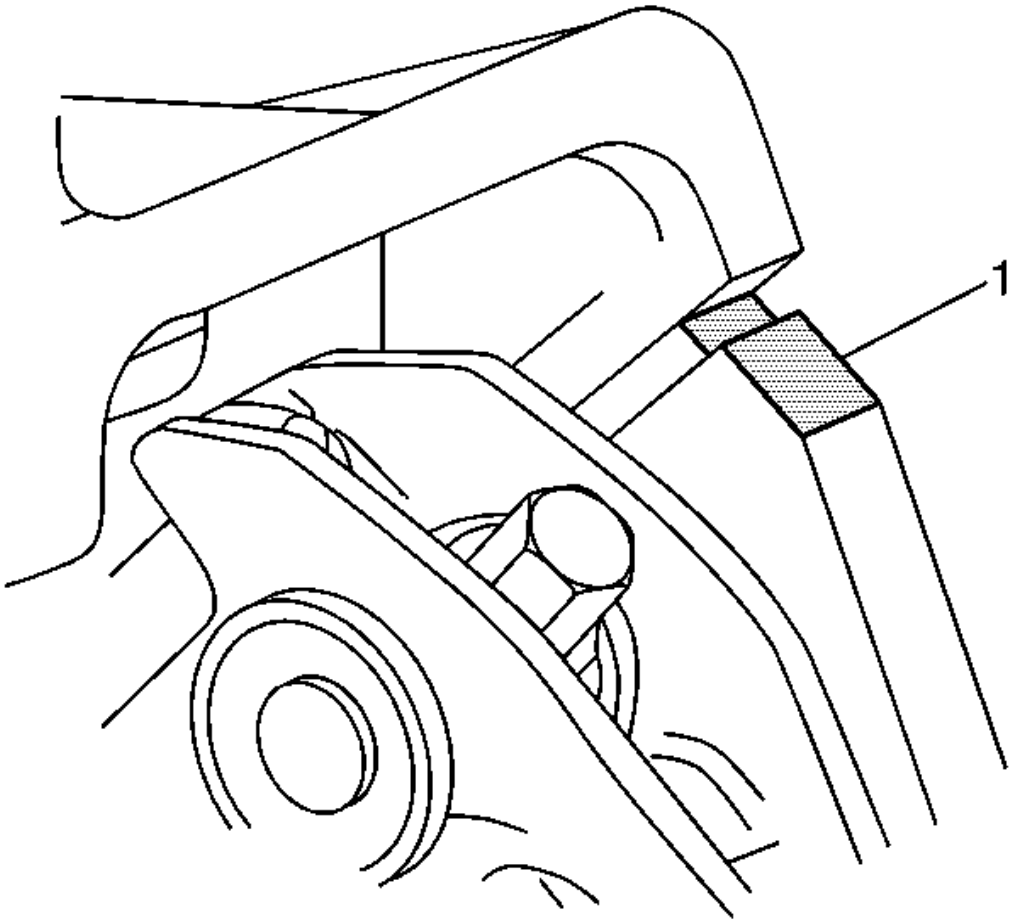

Fig. 128: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

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 **Sealers, Adhesives, and Lubricants**.

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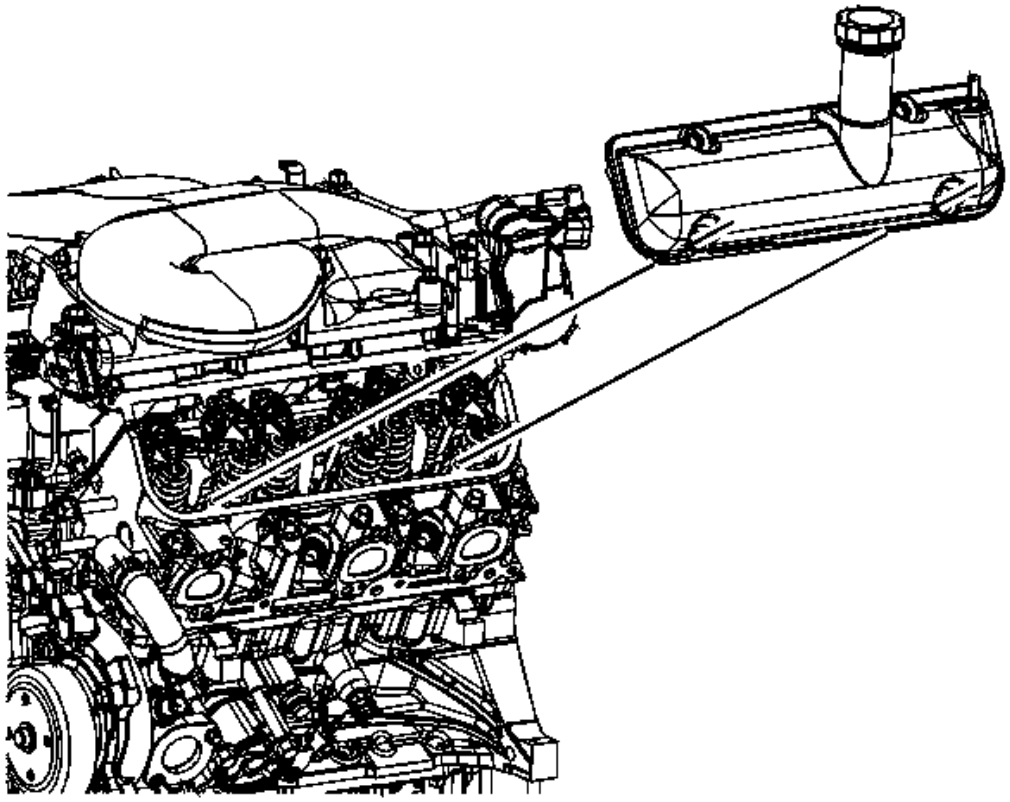

Fig. 129: Identifying Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover.

NOTE: **Refer to Fastener Notice .**

IMPORTANT: 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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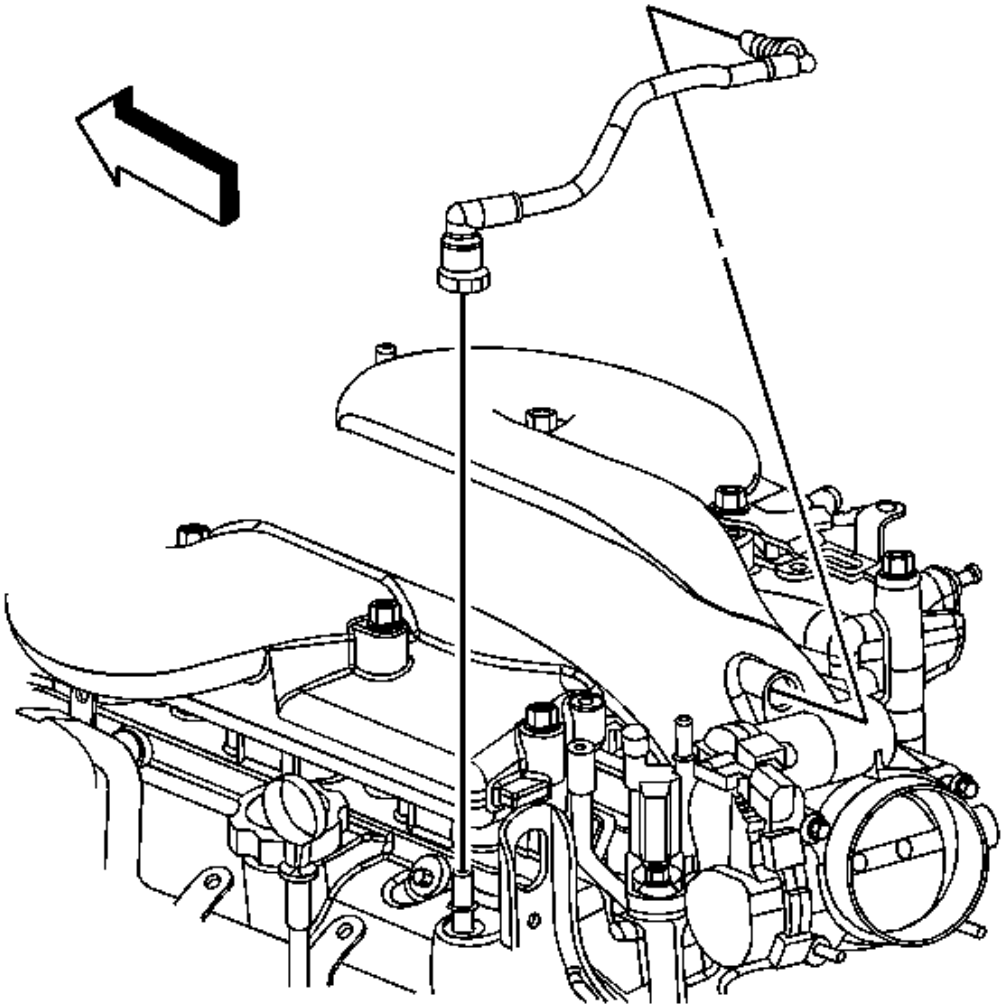

Fig. 130: Identifying Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the right engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.
6. Connect the PCV foul air tube to the PCV valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

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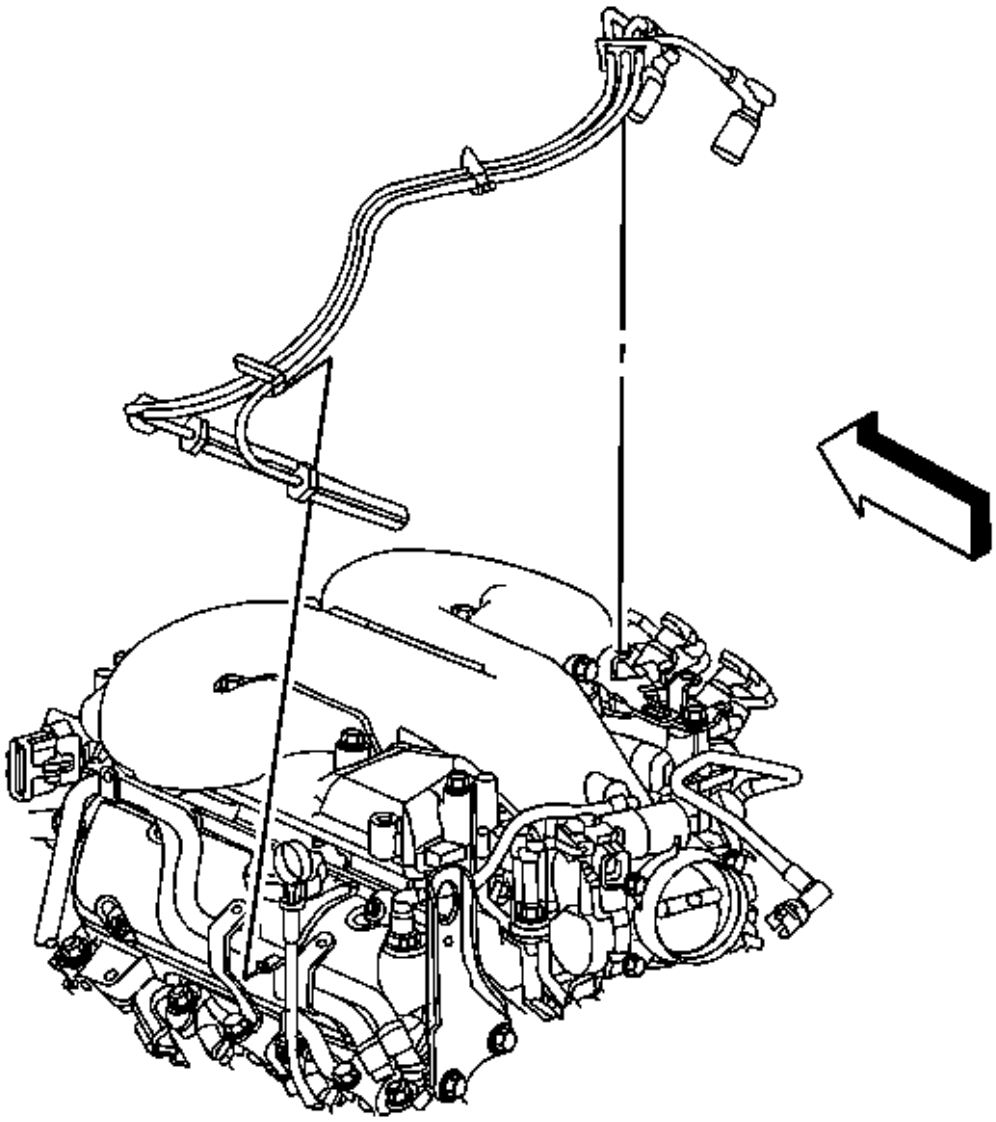

Fig. 131: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

7. Install the heater inlet and outer front pipe. Refer to **Heater Inlet Hose/Pipe and Heater Outlet Hose/Pipe Replacement** .
8. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Valve Rocker Arm Cover Replacement - Right Side

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Removal Procedure

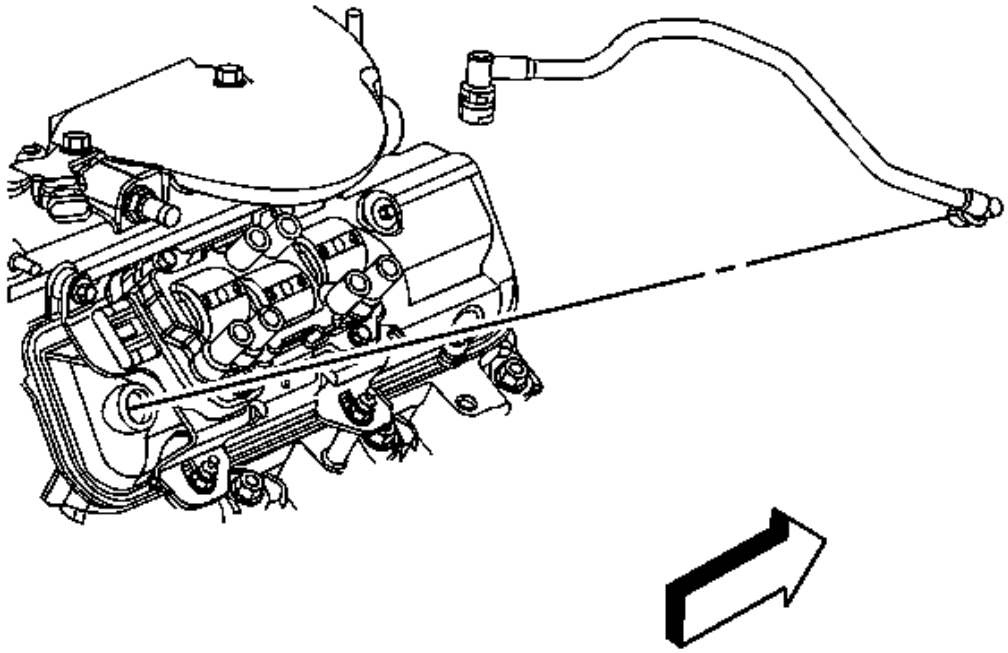

Fig. 132: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the generator. Refer to **Generator Replacement** .
2. Drain the cooling system, Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
3. Remove the coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement** .
4. Disconnect the positive crankcase ventilation (PCV) fresh air tube from the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Remove the PCV fresh air tube from the right side valve rocker arm cover.

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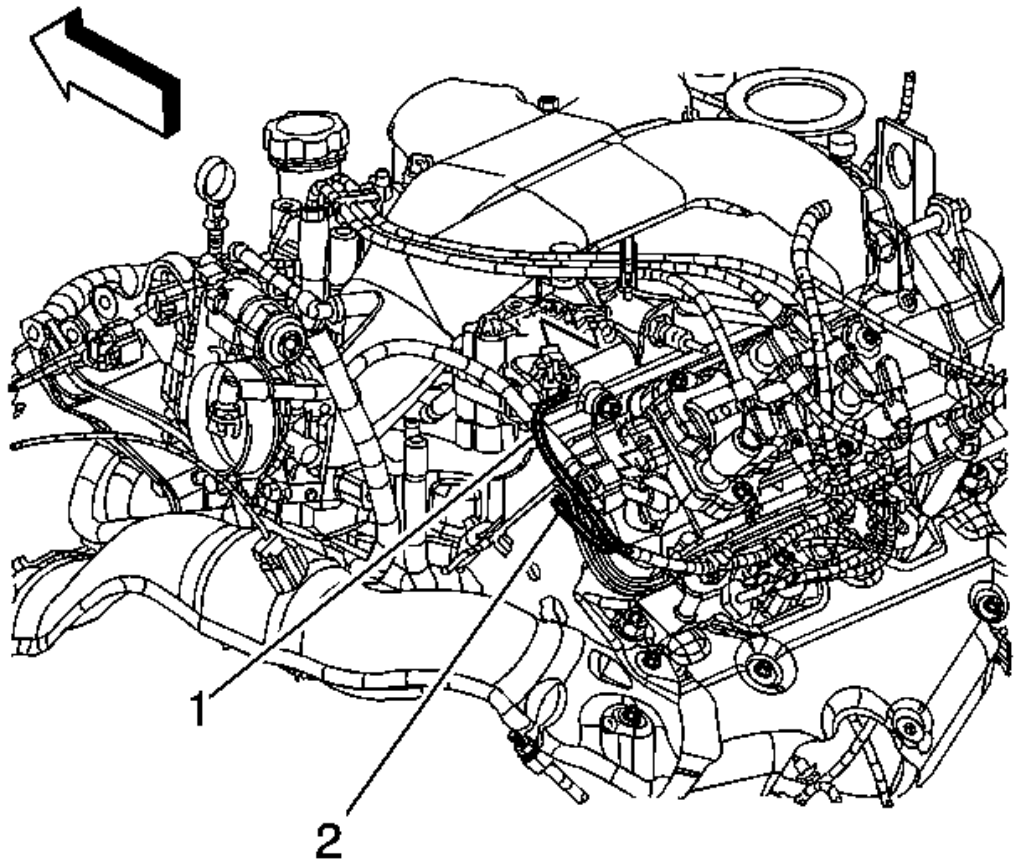

Fig. 133: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

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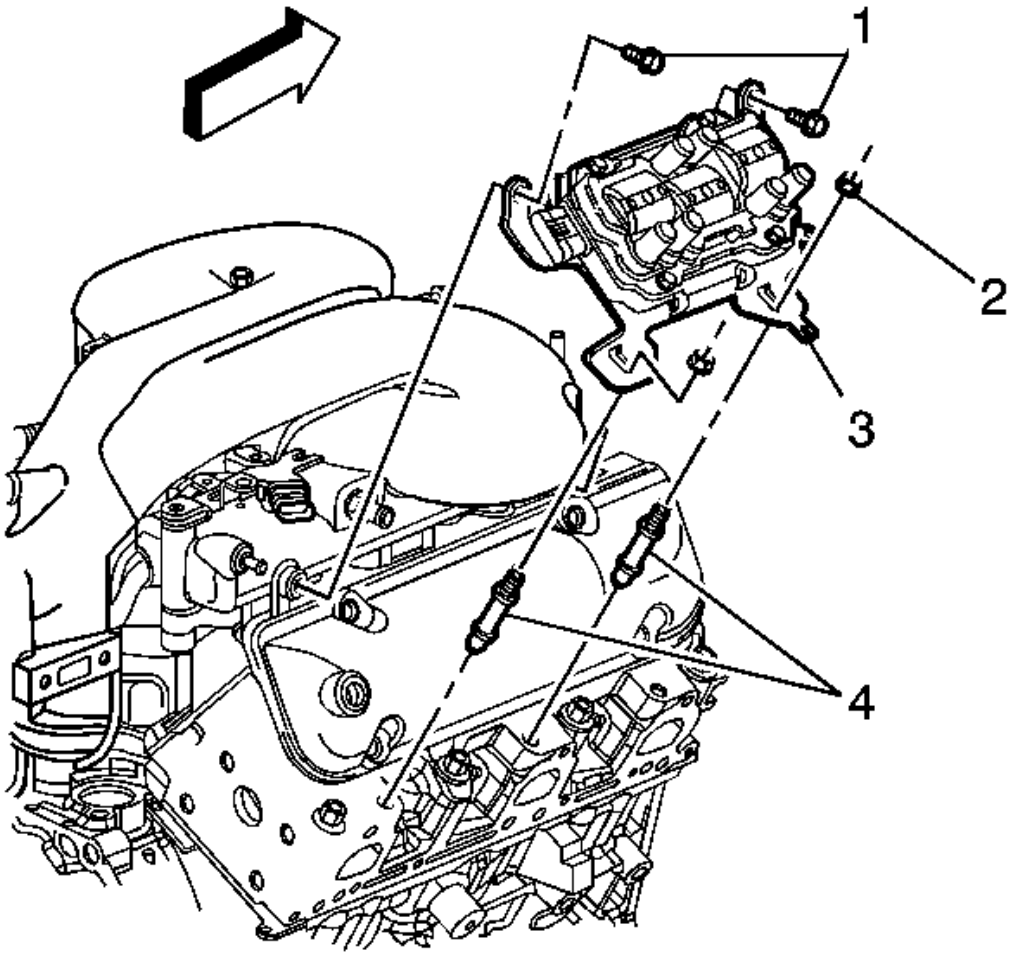

Fig. 134: Removing/Installing Ignition Coil Bracket Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

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

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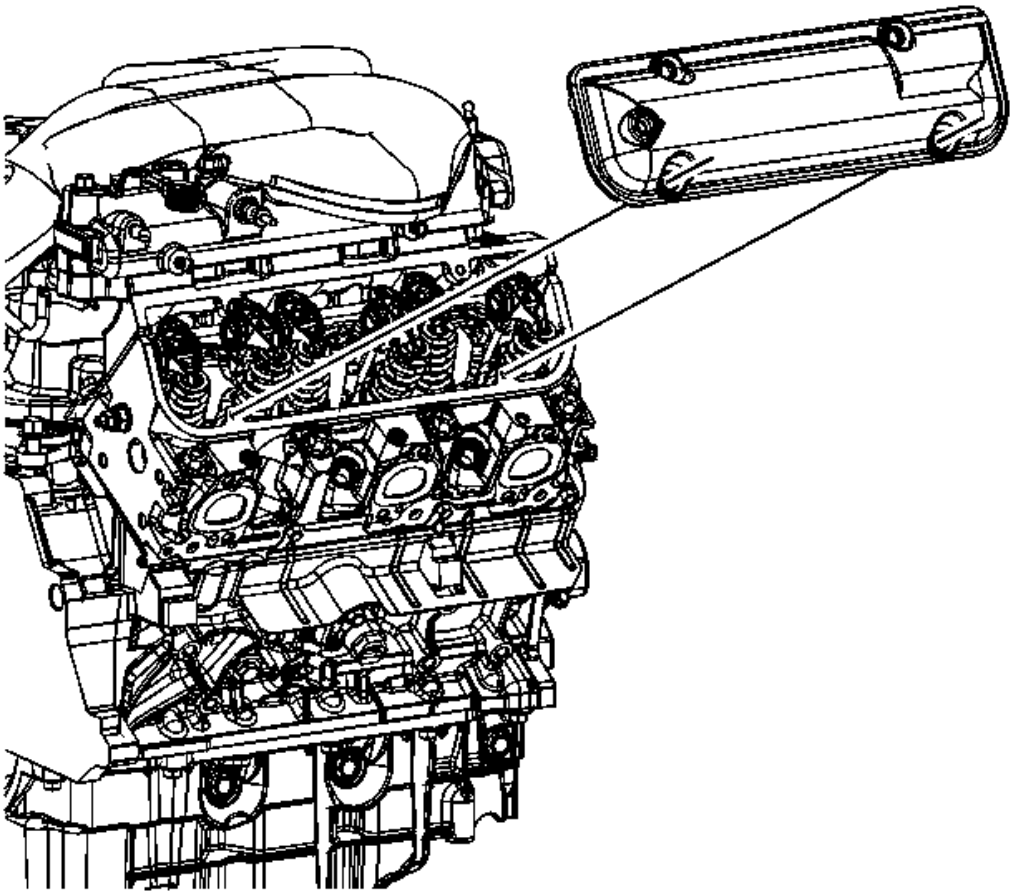

Fig. 135: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve rocker arm cover bolts.

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

13. 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.
14. 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.
15. Remove the valve cover gasket.
16. Clean the sealing surface on the cylinder head with degreaser.

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Installation Procedure

IMPORTANT: All gasket mating surfaces need to be free of oil and foreign material. Use cleaner to clean the surfaces. Refer to Sealers, Adhesives, and Lubricants.

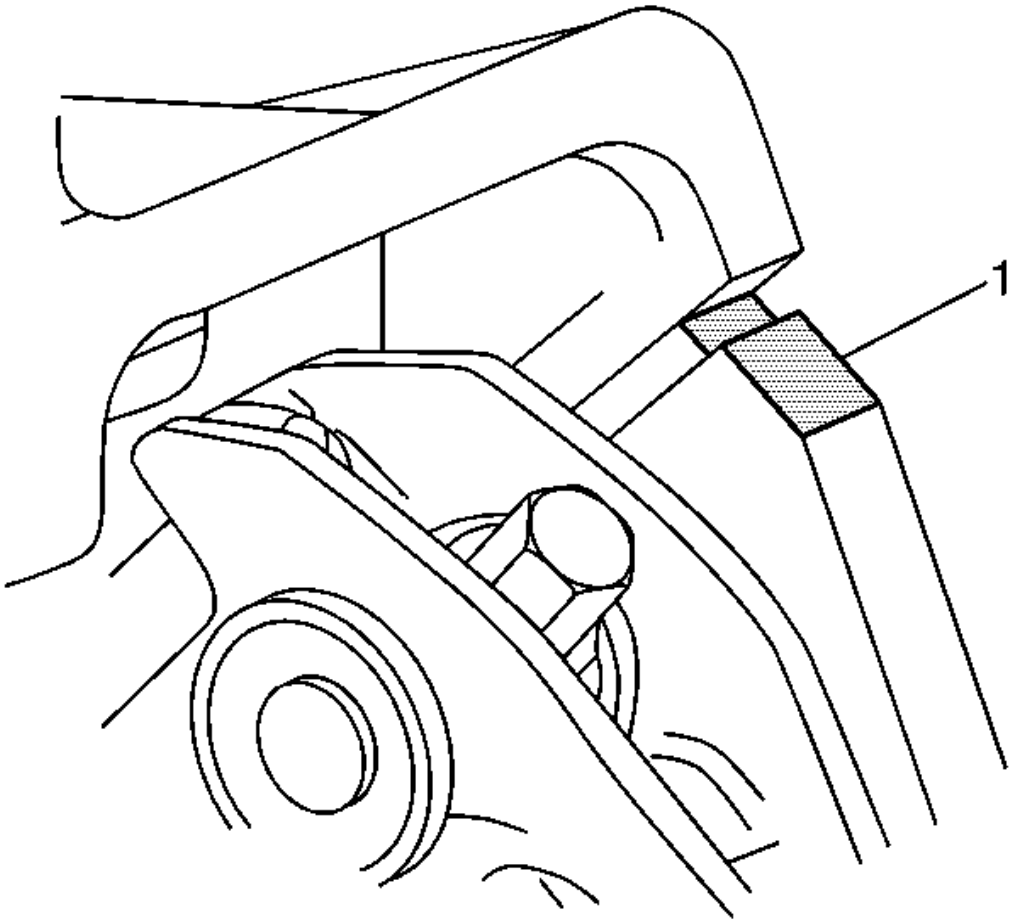

Fig. 136: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

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 **Sealers, Adhesives, and Lubricants**.

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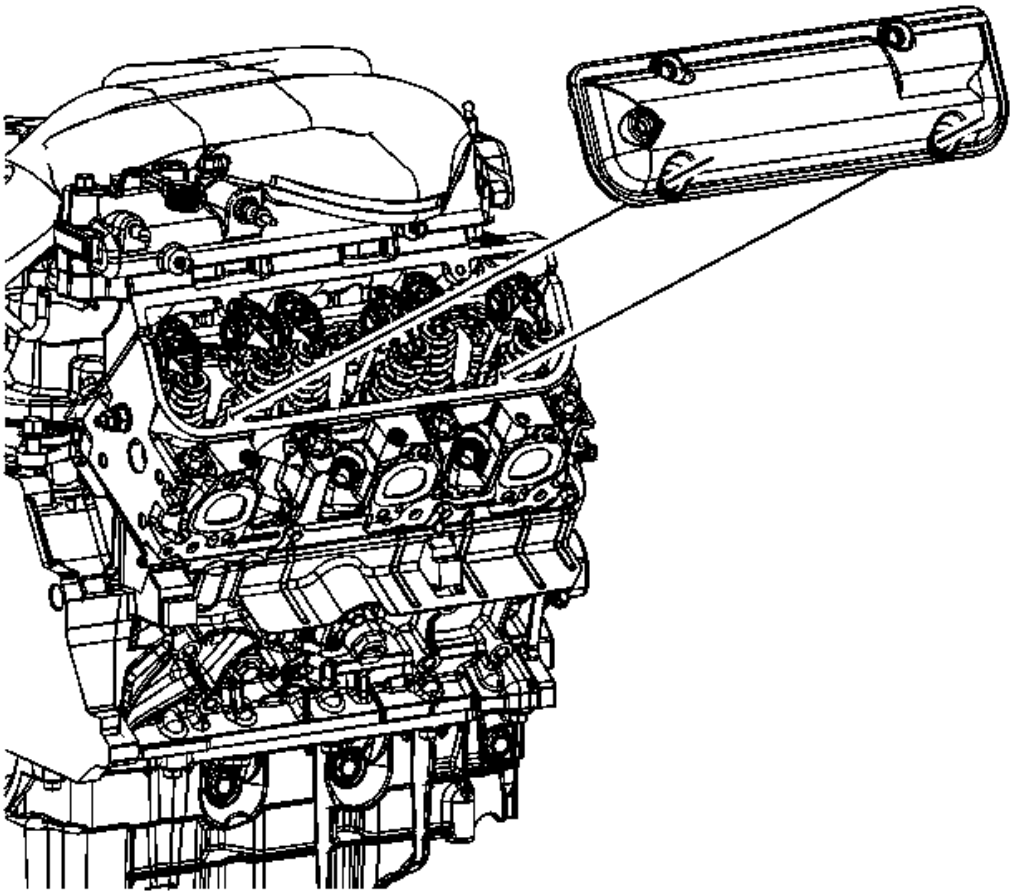

Fig. 137: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the right valve rocker arm cover.

NOTE: **Refer to Fastener Notice .**

IMPORTANT: 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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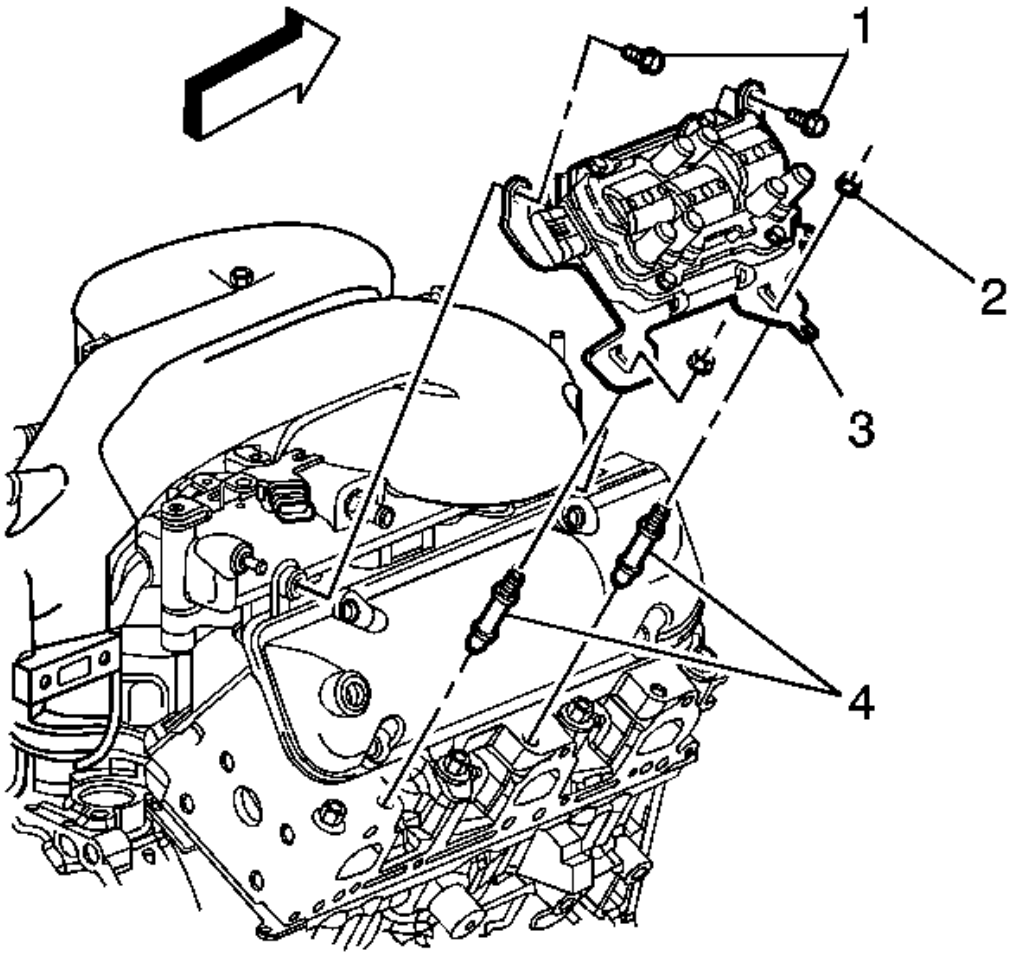

Fig. 138: Removing/Installing Ignition Coil Bracket Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

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

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

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

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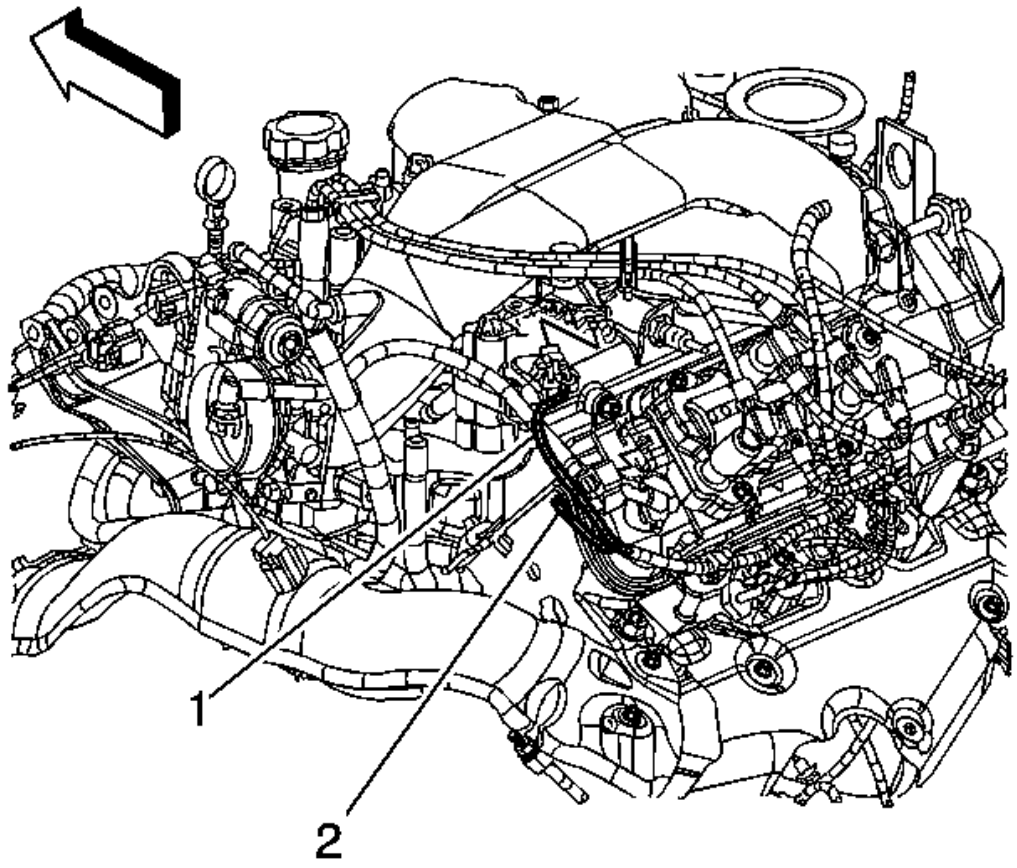

Fig. 139: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

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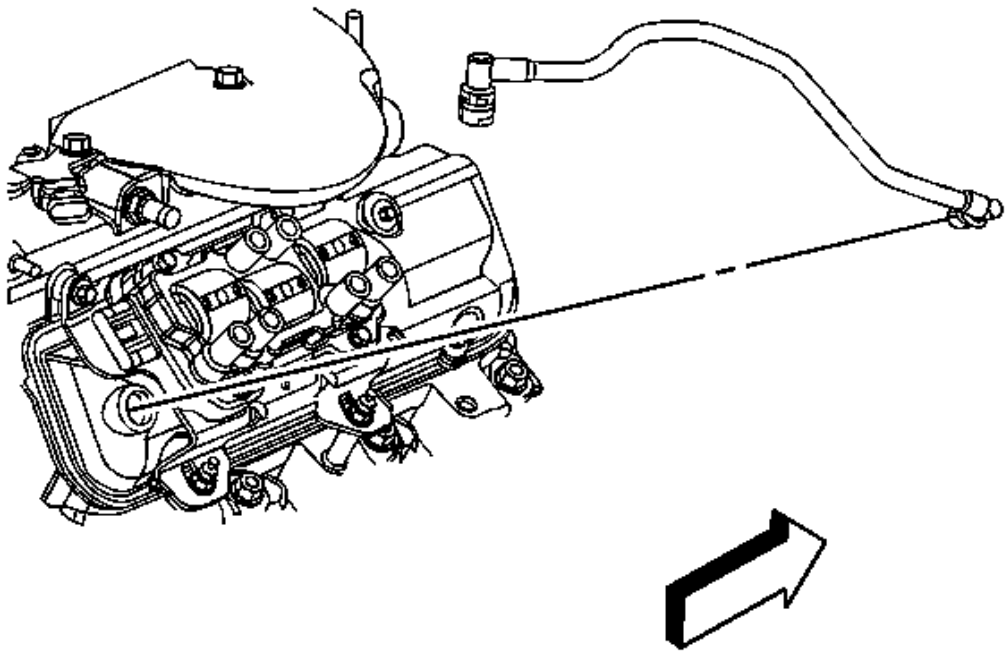

Fig. 140: Identifying Positive Crankcase Ventilation (PCV) Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

11. Install the coolant crossover pipe. Refer to **Engine Coolant Crossover Pipe Replacement** .
12. Fill the coolant. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
13. Install the PCV fresh air tube to the right side valve rocker arm cover.
14. Connect the PCV fresh air tube to the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
15. Install the generator. Refer to **Generator Replacement** .

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

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 were removed.

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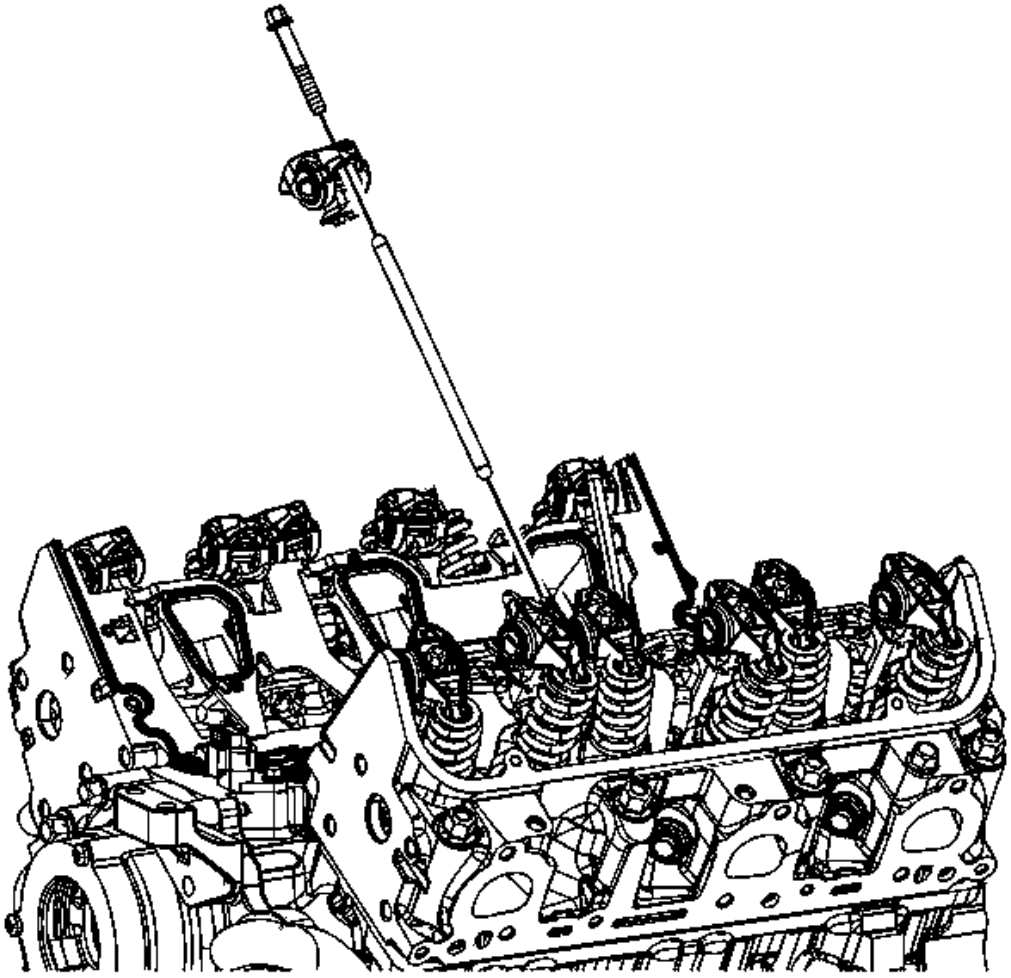

Fig. 141: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

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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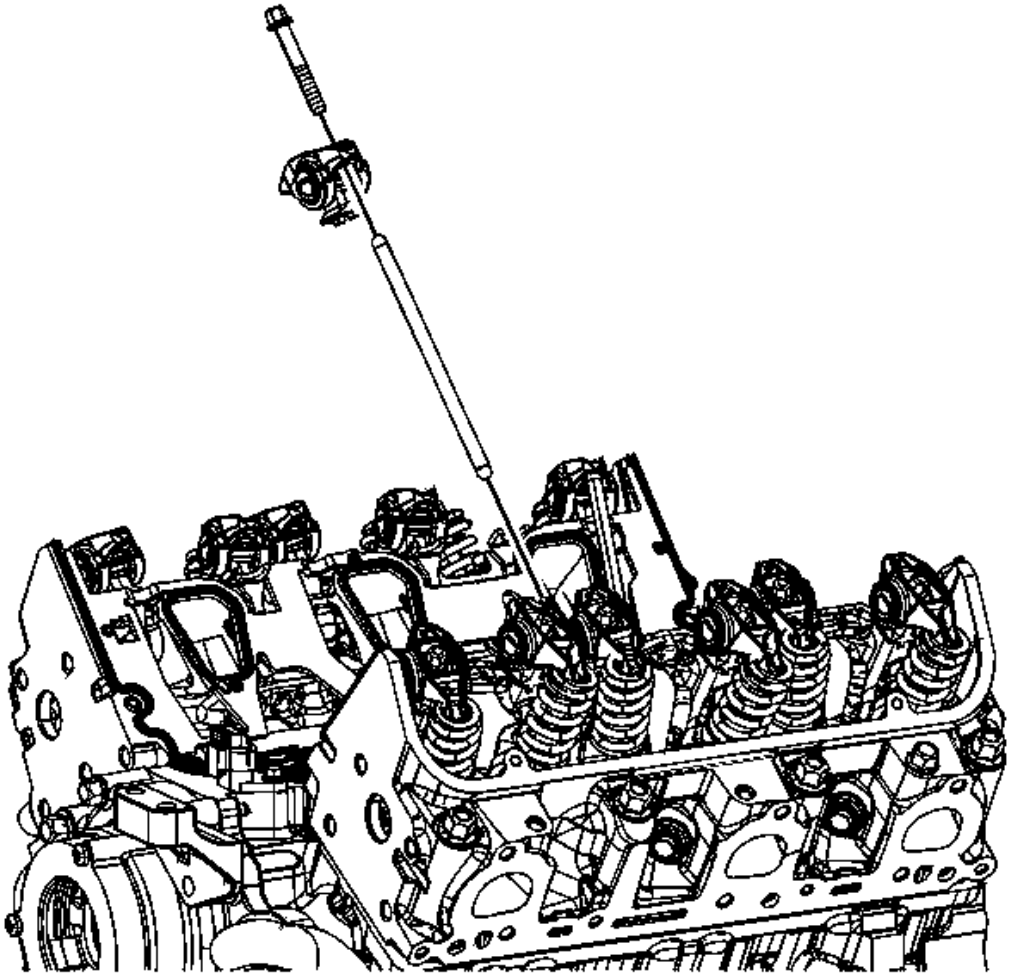

Fig. 142: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Shims (88894006) may be required under the valve rocker arm pedestals if reconditioning has been performed on the cylinder head or its

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components.

NOTE: Refer to Fastener Notice .

5. Install the rocker arms.
6. Install the rocker arm bolts.

   Tighten: Tighten the bolts 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. See **Special Tools**.
- **J 22794** Spark Plug Port Adapter
- **J 5892-D** Valve Spring Compressor. See **Special Tools**.

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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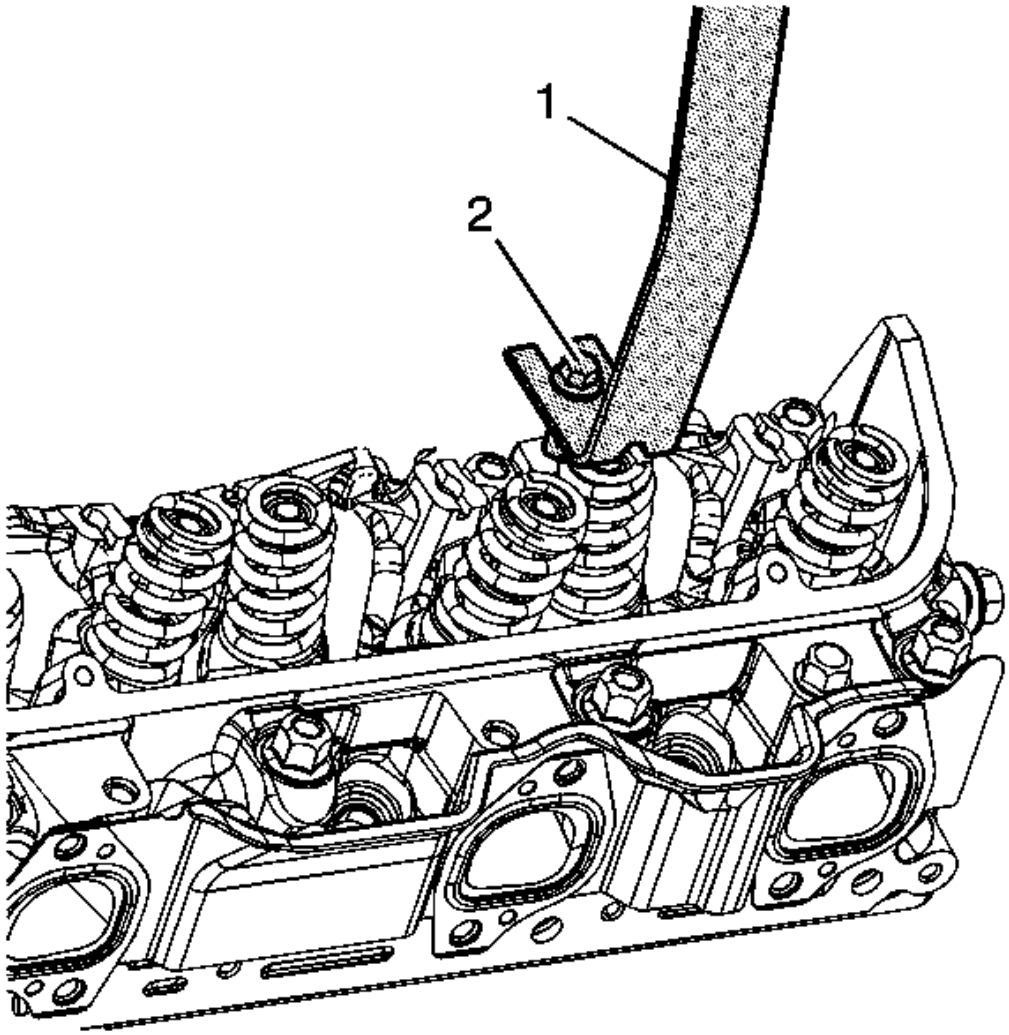

Fig. 143: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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). See **Special Tools**.

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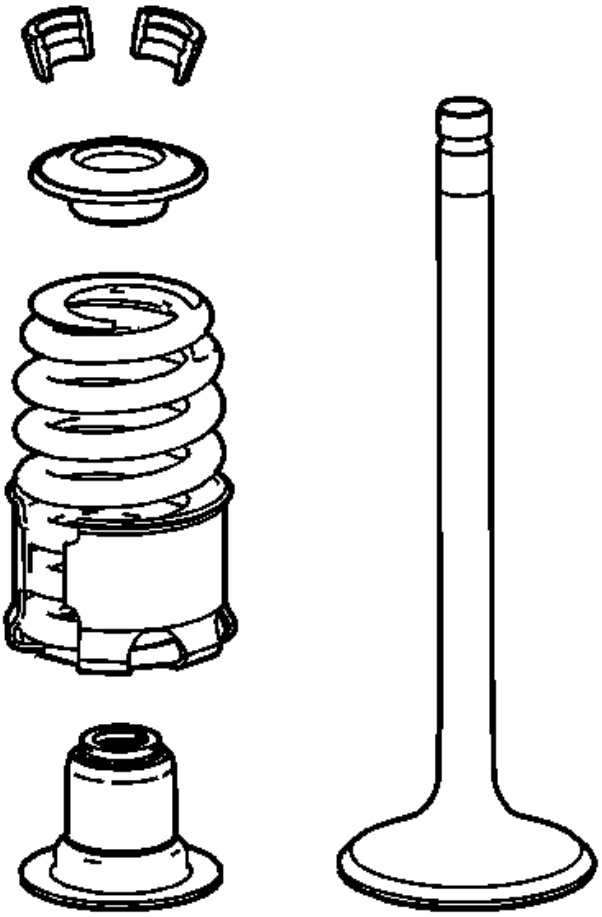

Fig. 144: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

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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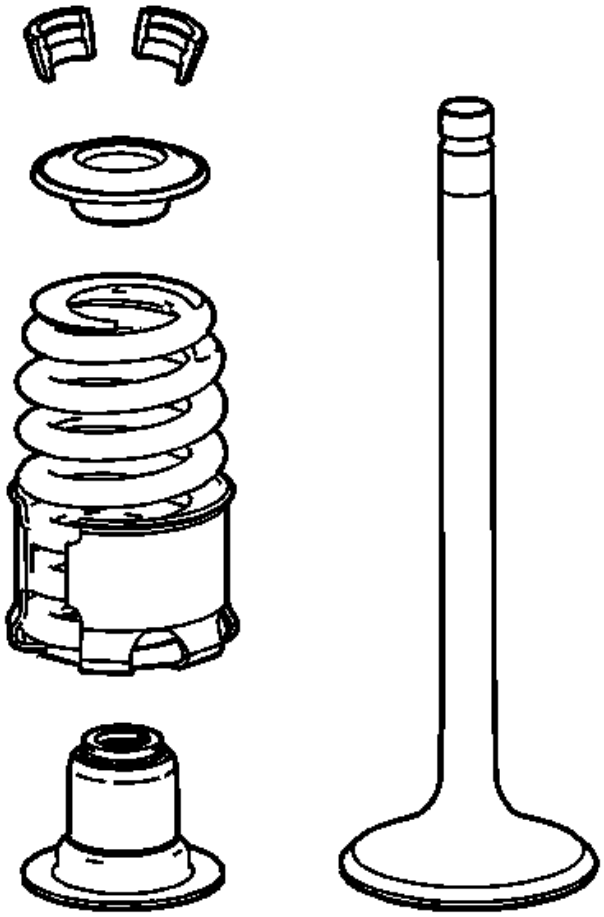

Fig. 145: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

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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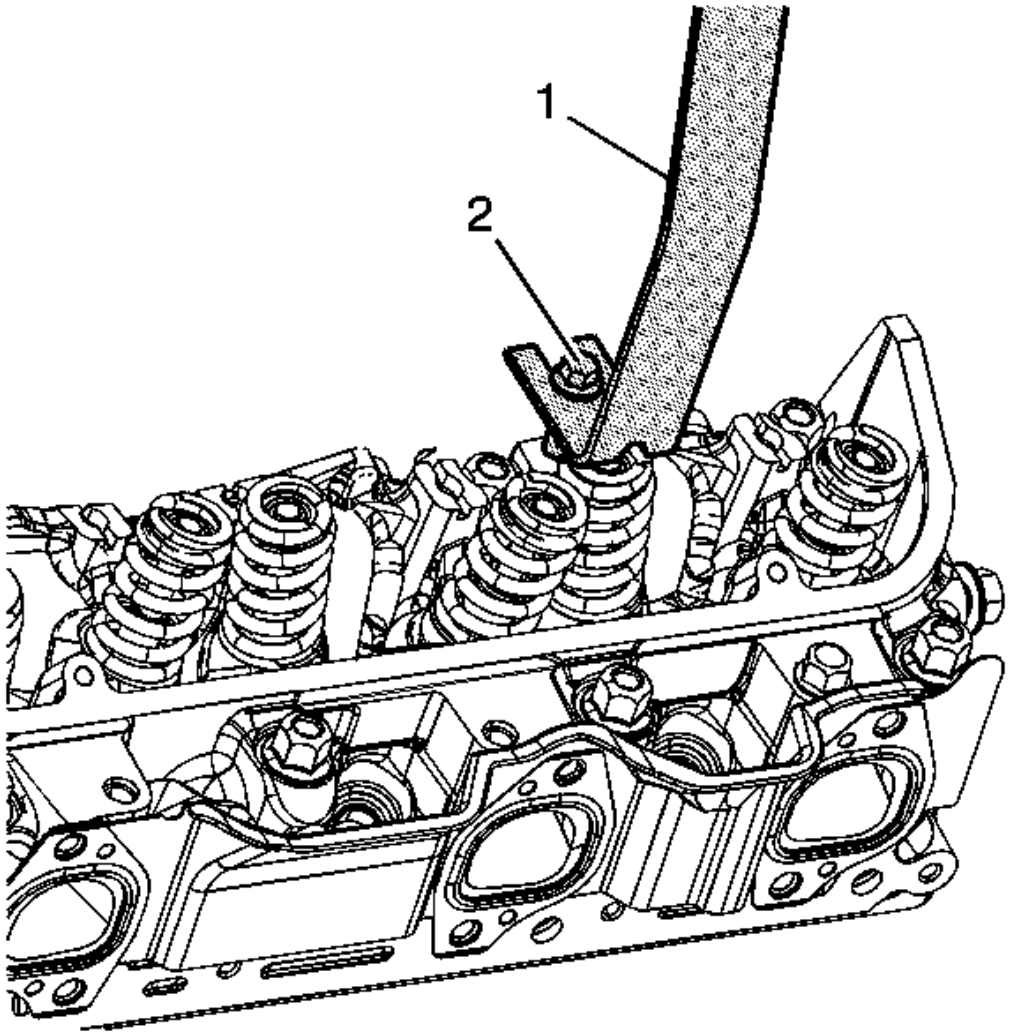

Fig. 146: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

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). See **Special Tools**.
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

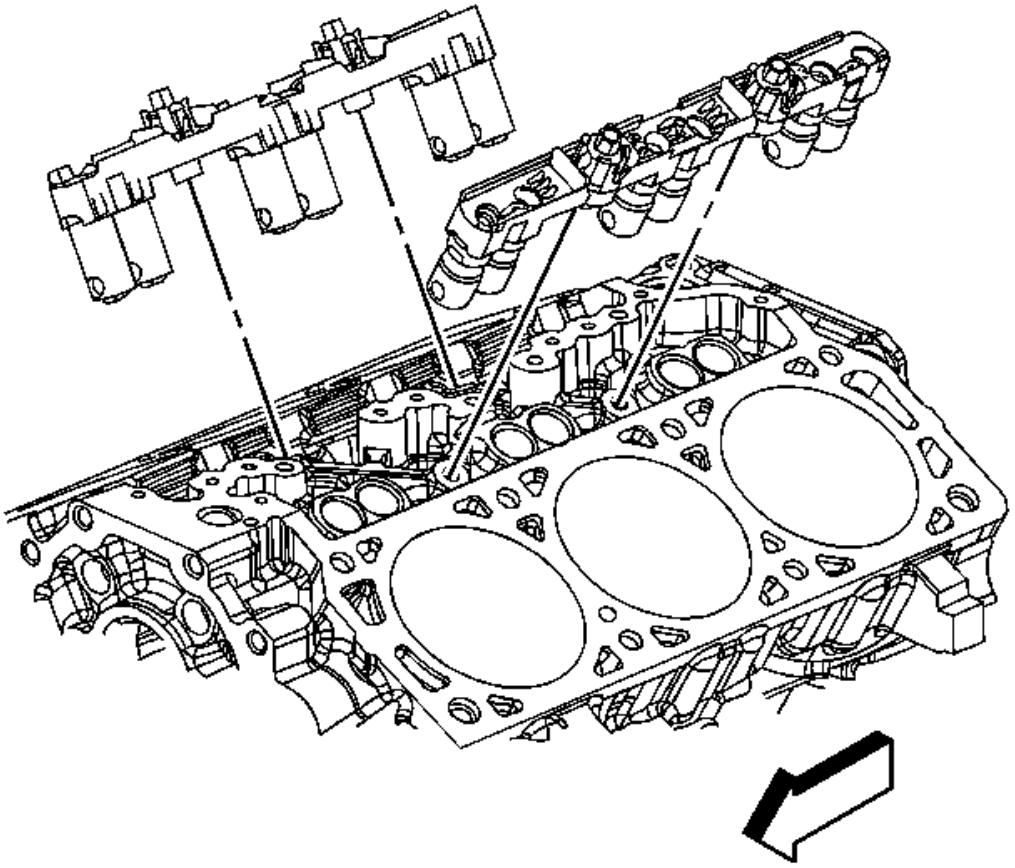

Fig. 147: Identifying Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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**.

IMPORTANT: 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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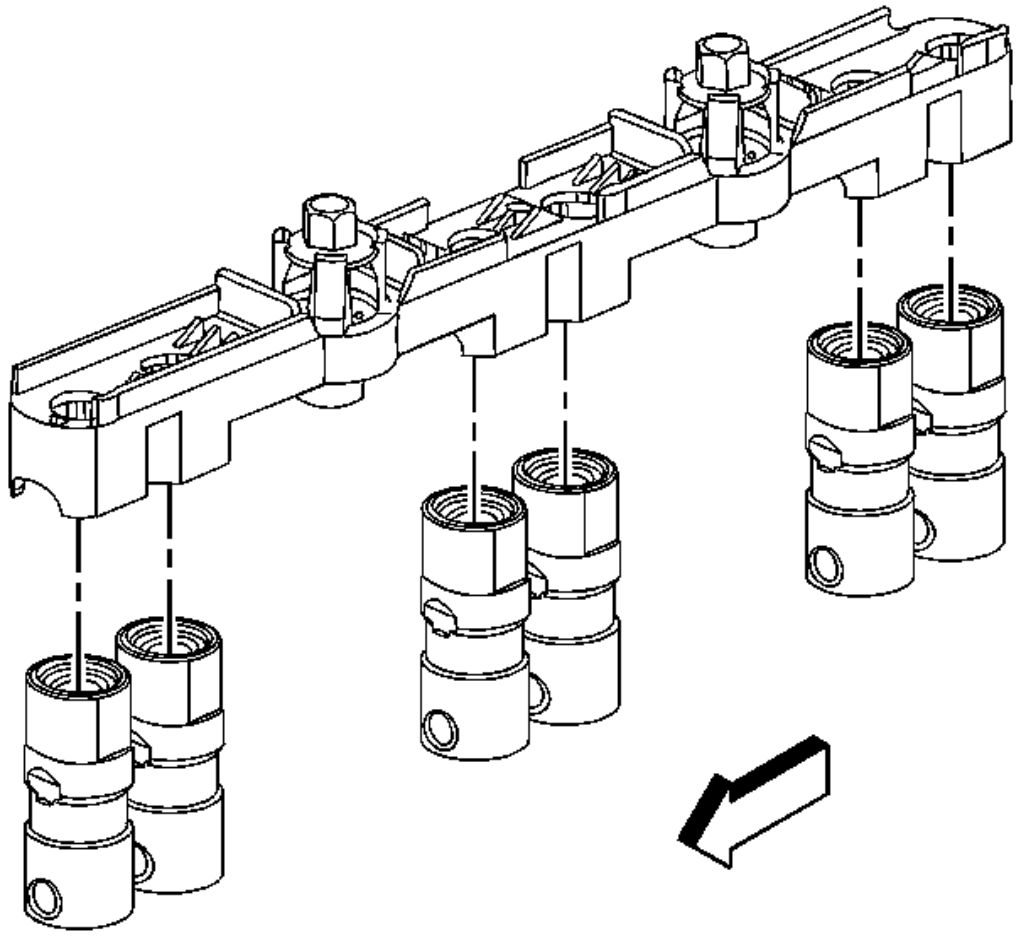

Fig. 148: Identifying Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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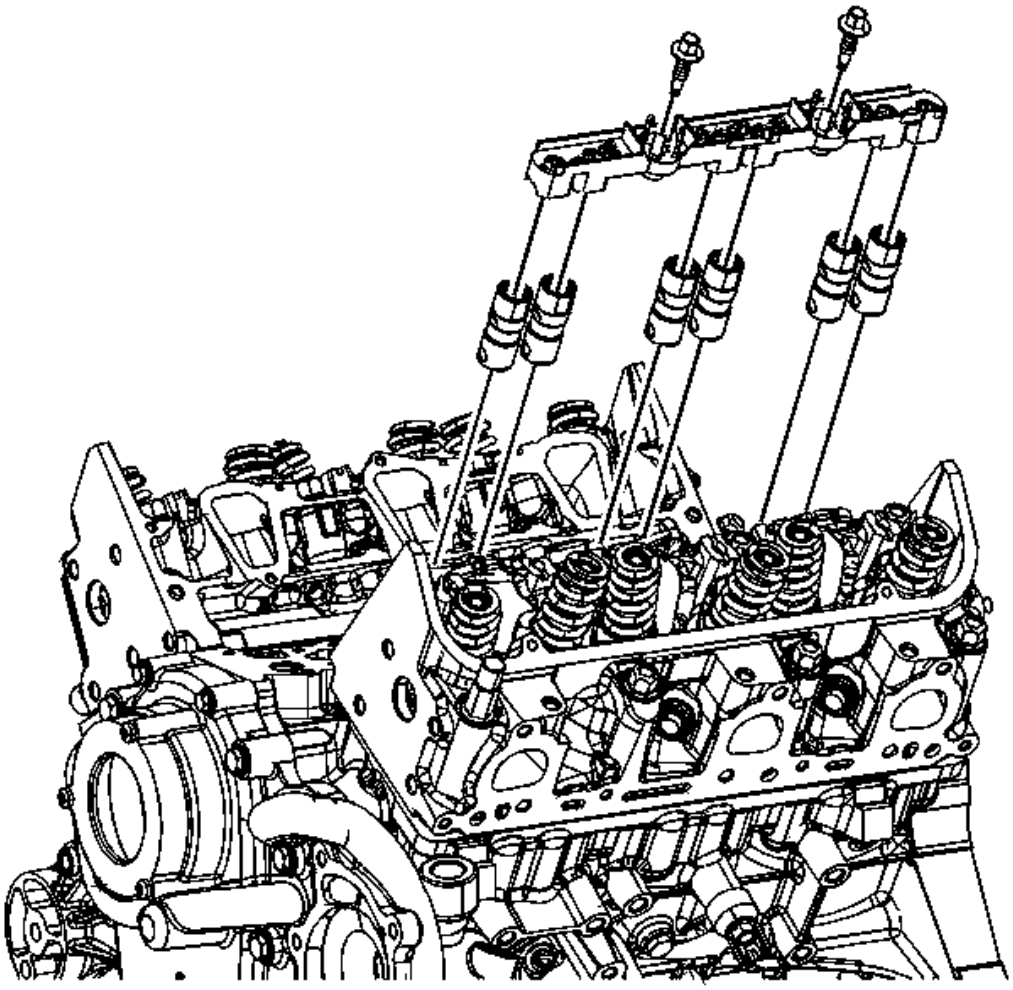

Fig. 149: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice .

5. Tighten the valve lifter guide bolts.

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Tighten: Tighten the bolts 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

Tools Required

- **J 29113** Balancer and Crank Sprocket Installer. See **Special Tools**.
- **J 37096** Flywheel Holder
- **J 41816** Crankshaft Balancer Remover. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

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

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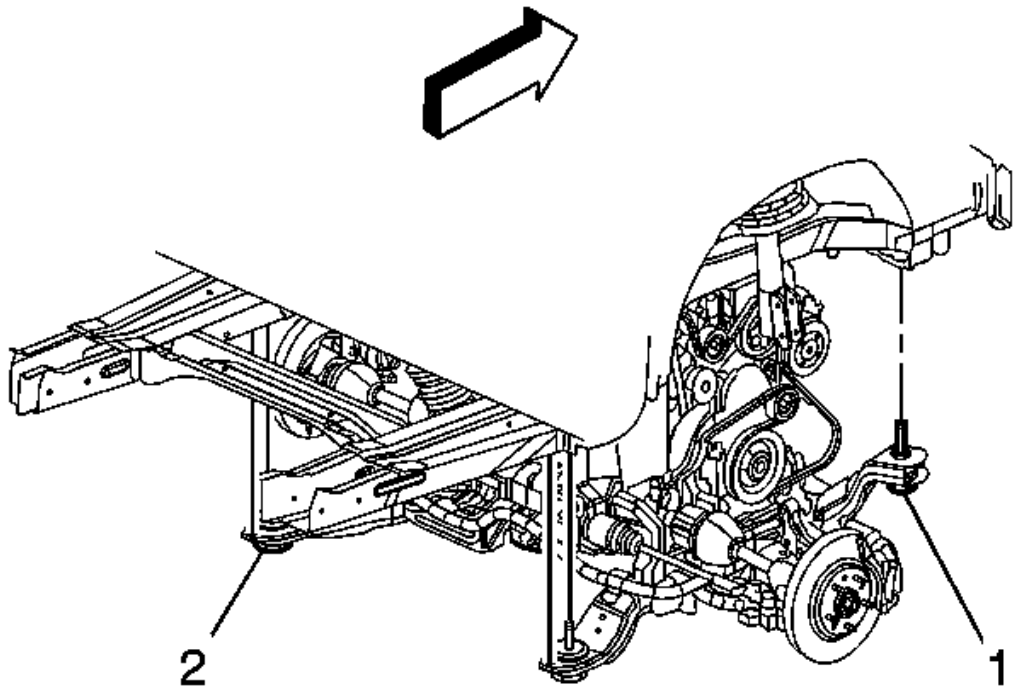

Fig. 150: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
3. Remove the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
4. Place adjustable jack stands under the frame.
5. Loosen the left side frame bolts (2) and remove the right side frame bolts (1).
6. Using the jack stands, lower the right side of the frame enough to access the crankshaft balancer.
7. Remove the engine to transmission bracket bolts at the rear lower left side of the engine and transaxle assembly.
8. Remove the engine to transmission bracket from the rear lower left side of the engine and transaxle assembly.

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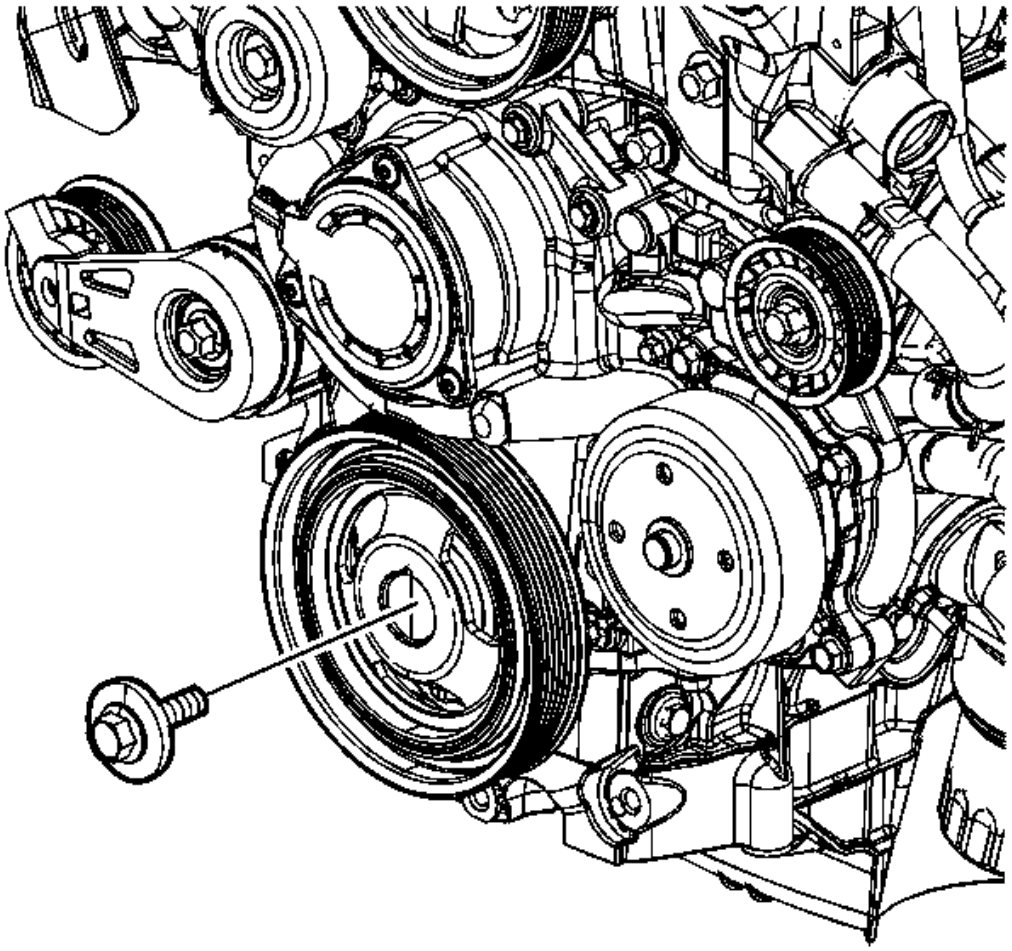

Fig. 151: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

9. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** .
10. Install the **J 37096** to the flywheel in order to prevent flywheel rotation.
11. Remove the crankshaft balancer bolt and the washer.

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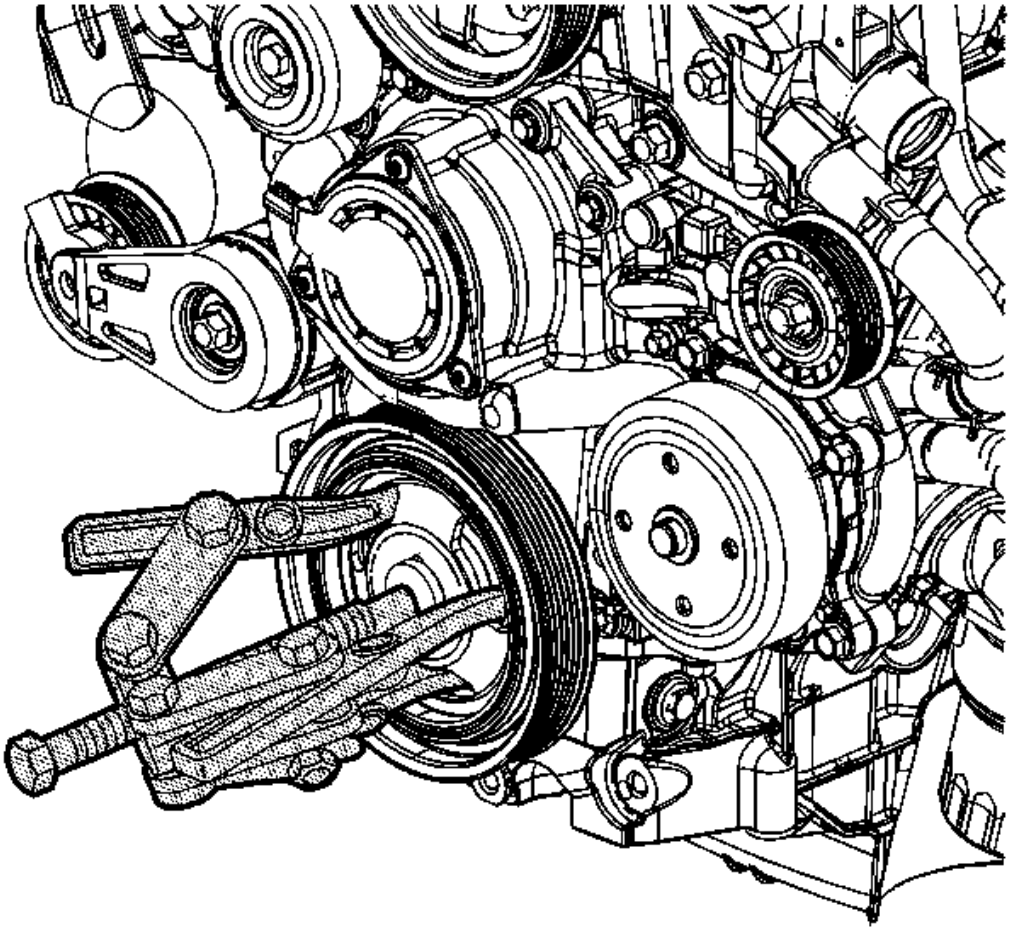

Fig. 152: Identifying Crankshaft Balancer Removing Tool J 41816
Courtesy of GENERAL MOTORS CORP.

12. Remove the crankshaft balancer using the **J 41816** . See **Special Tools**.

Installation Procedure

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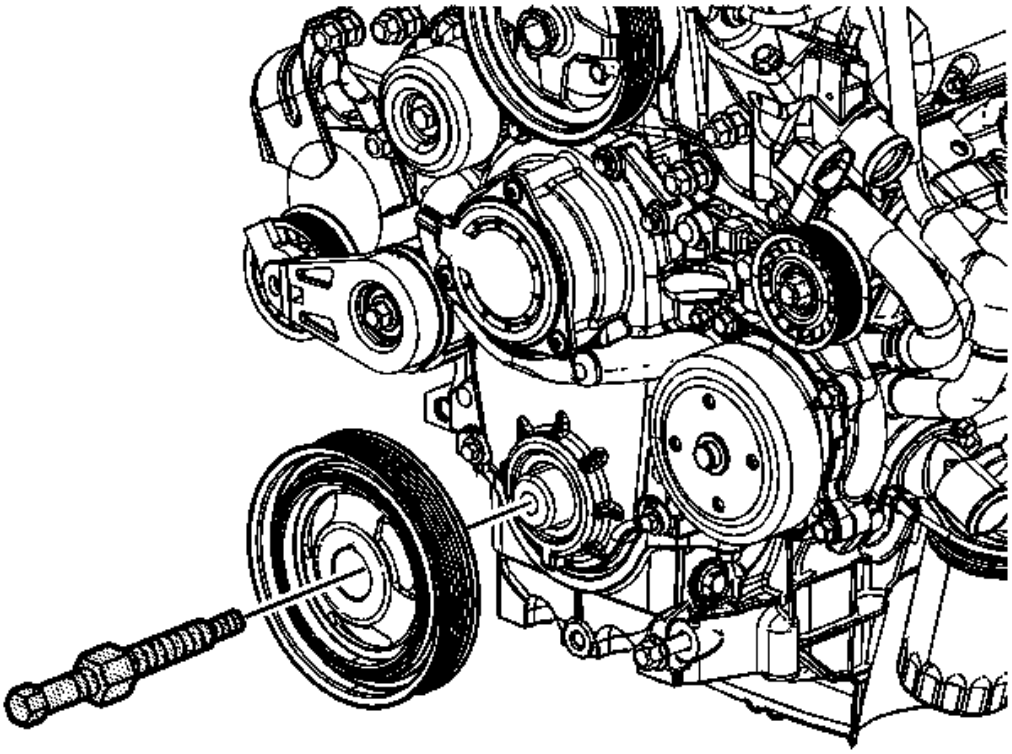

Fig. 153: View Of Balancer & Crank Sprocket Puller (J 29113)
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer to the keyway of the crankshaft balancer. Refer to **Sealers, Adhesives, and Lubricants**.
2. Place the crankshaft balancer into position over the key in the crankshaft.
3. Install the **J 29113** onto the crankshaft. See **Special Tools**.
4. Rotate the hex nut on the **J 29113** in order to install the crankshaft balancer onto the crankshaft. See **Special Tools**.
5. Remove the **J 29113** from the crankshaft. See **Special Tools**.

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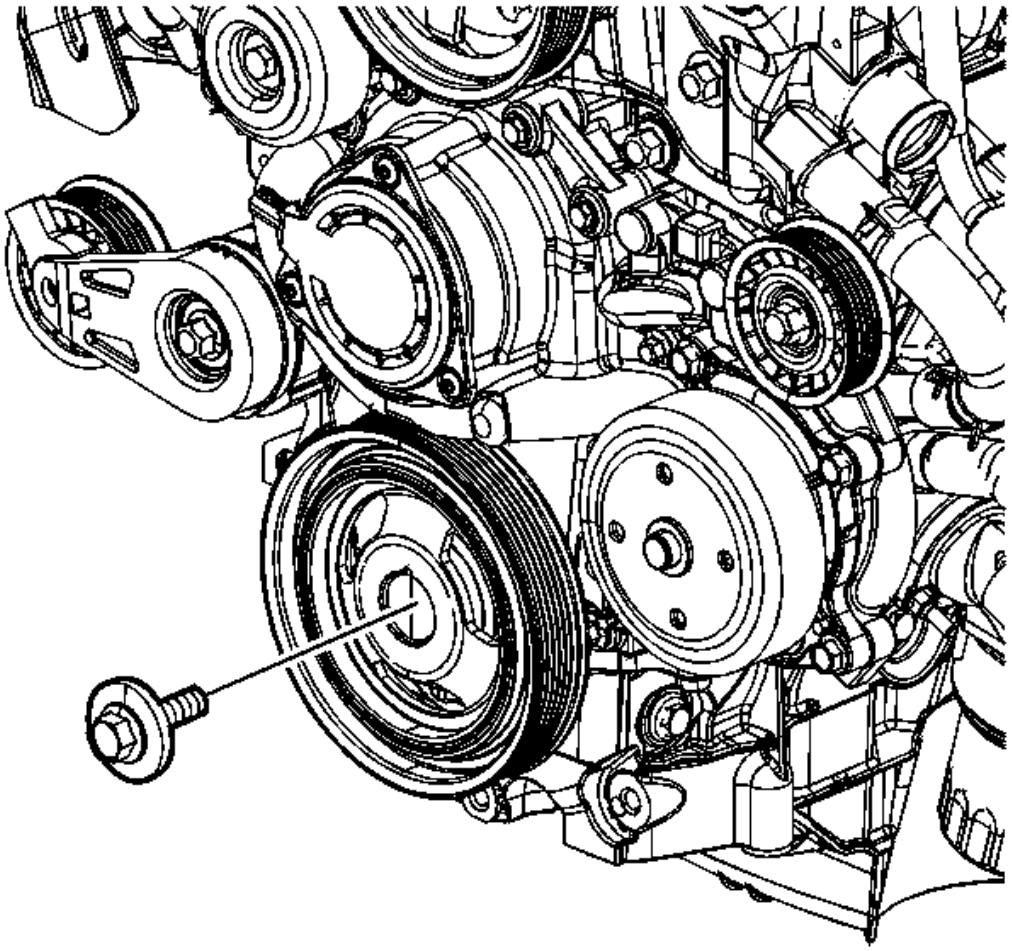

Fig. 154: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the crankshaft balancer washer and bolt.

   Tighten:
   - Tighten the bolt a first pass to 70 N.m (52 lb ft).
   - Tighten the bolt a final pass to 70 degrees using the **J 45059** . See **Special Tools**.

7. Remove the **J 37096** from the flywheel.
8. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** .

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9. Install the engine to transaxle bracket at the rear lower left side of the engine.
10. Install the engine to transaxle bracket bolts at the rear lower left side of the engine.

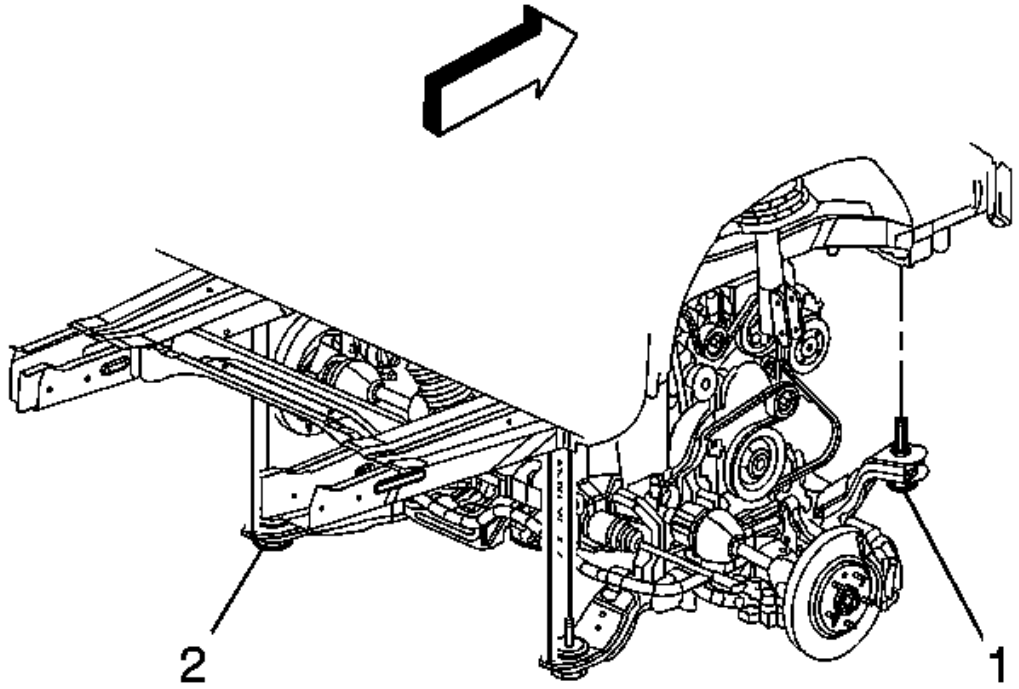

Fig. 155: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

11. Raise the frame to the original position using the adjustable jacks.
12. Install and tighten the right side frame bolts and tighten the left side frame bolts.

Tighten:

- Tighten the front frame bolts to 130 N.m (96 lb ft).
- Tighten the rear frame bolts to 240 N.m (177 lb ft).

13. Remove the jack stands supporting the frame.
14. Install the right engine splash shield. Refer to **Engine Splash Shield Replacement** .
15. Install the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
16. Install the drive belt. Refer to **Drive Belt Replacement**.

Oil Pan Replacement

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Tools Required

J 41820 Ball Joint Separator

Removal Procedure

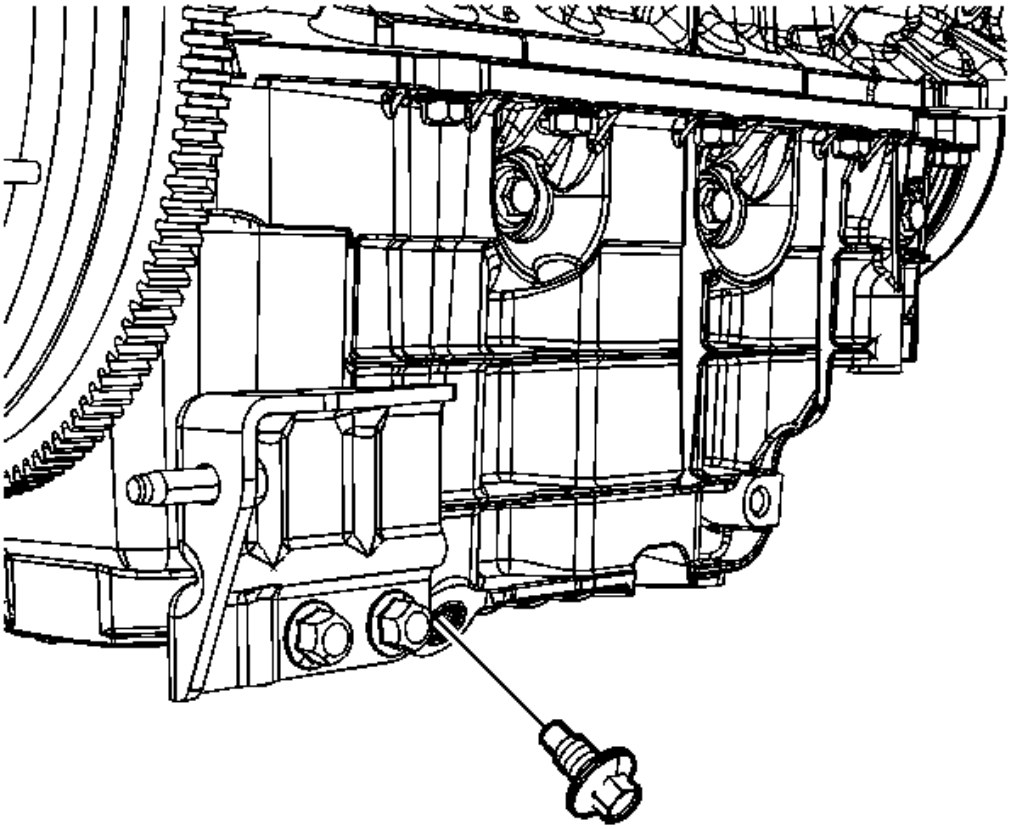

Fig. 156: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
3. Remove the right front splash shield. Refer to **Engine Splash Shield Replacement** .
4. Remove the oil pan drain plug.
5. Drain the crankcase.
6. Reinstall the oil pan drain plug until snug.

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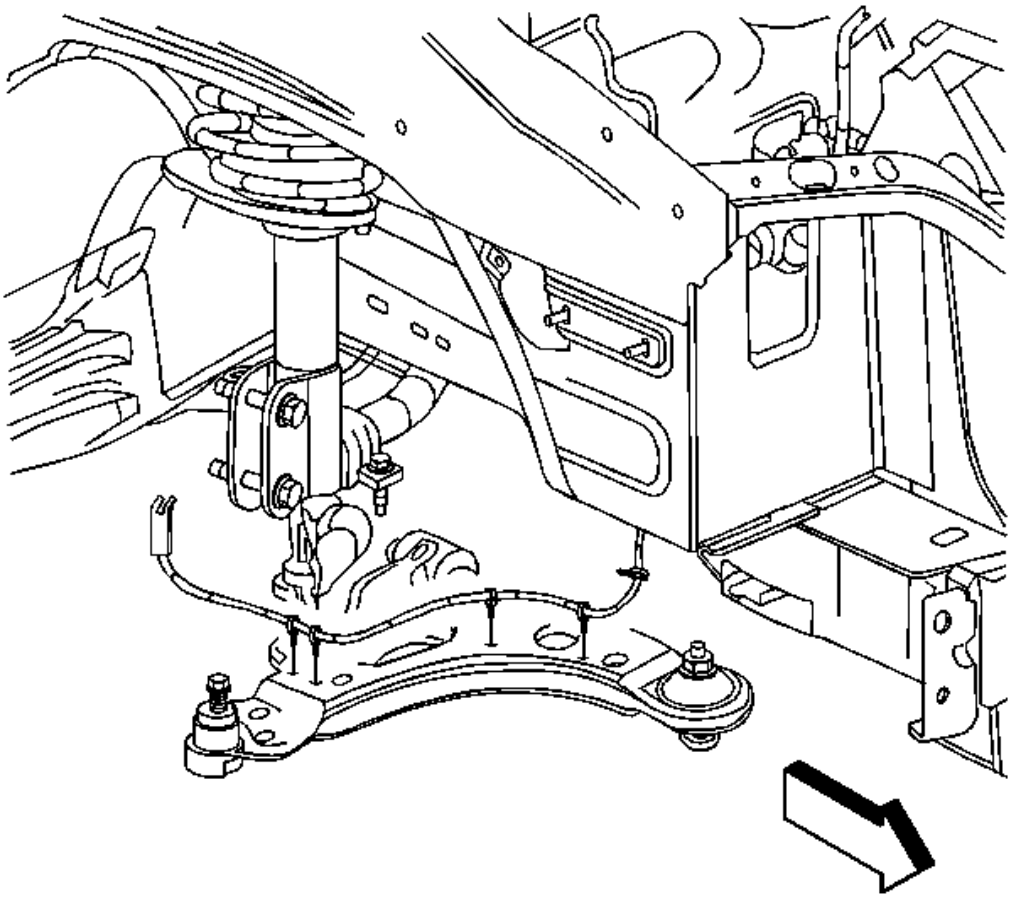

Fig. 157: Identifying Right Lower Control Arm
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine harness clips from the right lower control arm.

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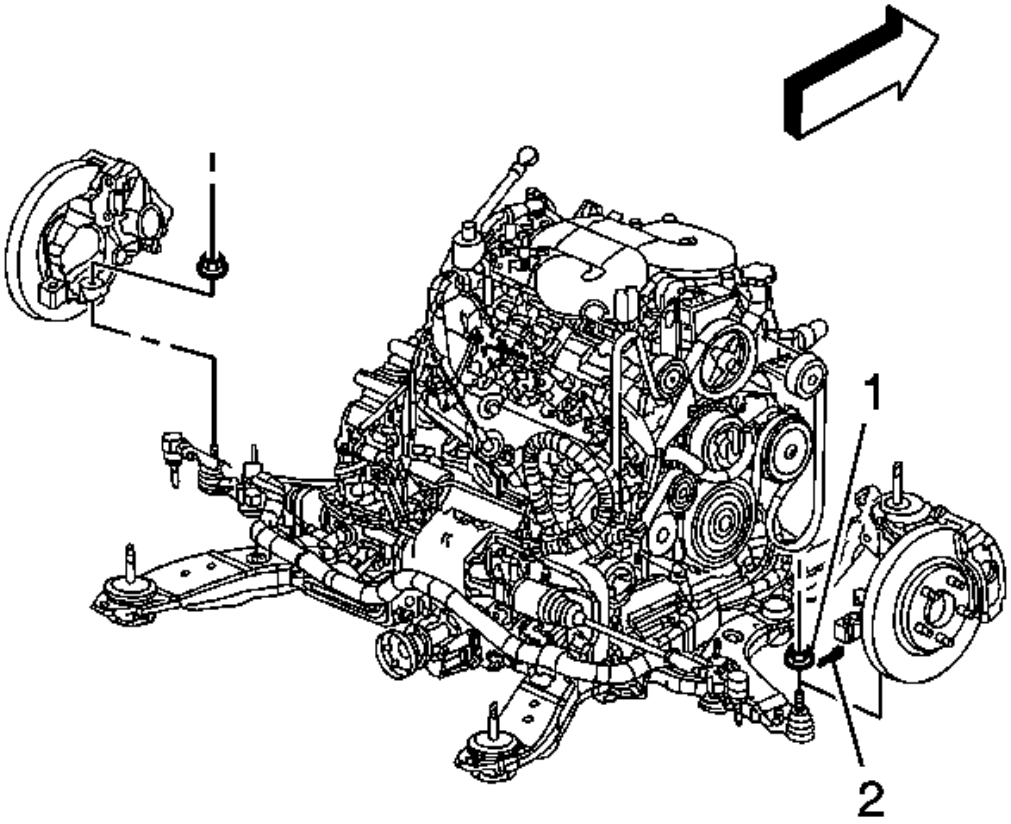

Fig. 158: View Of Outer Tie Rod Ends & Steering Knuckles
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the lower ball joint castle nut cotter pin (1).
9. Remove the lower ball joint castle nut (1).

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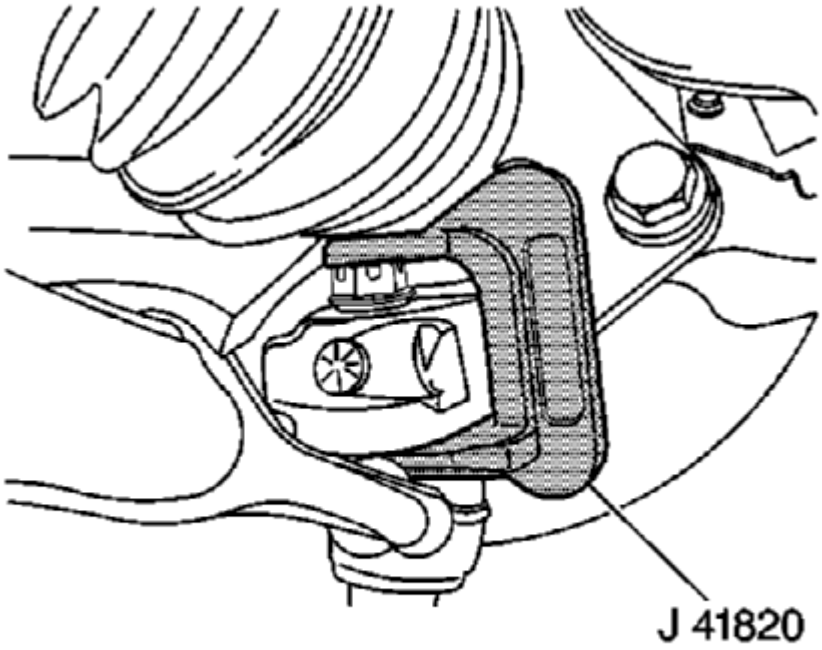

Fig. 159: Separating Ball Stud From Steering Knuckle
Courtesy of GENERAL MOTORS CORP.

10. Install the over **J 41820** the ball stud and lower control arm as shown.
11. Rotate the ball stud nut counterclockwise in order to separate the ball stud from the steering knuckle

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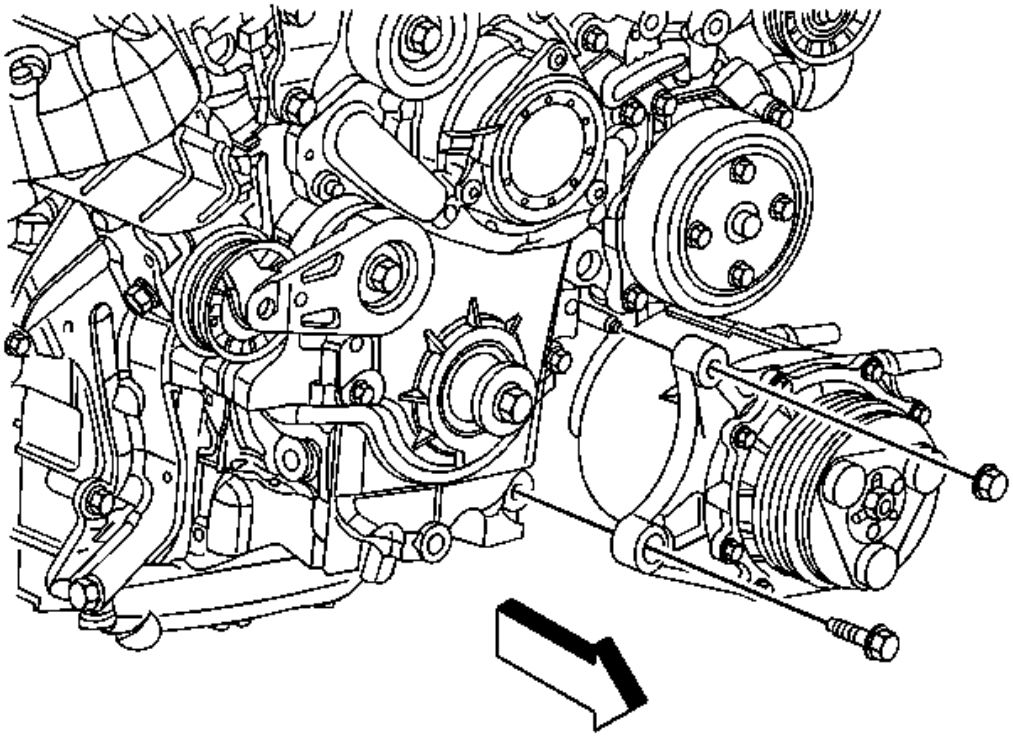

Fig. 160: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

12. Remove the air conditioning (A/C) compressor front bolt and nut.

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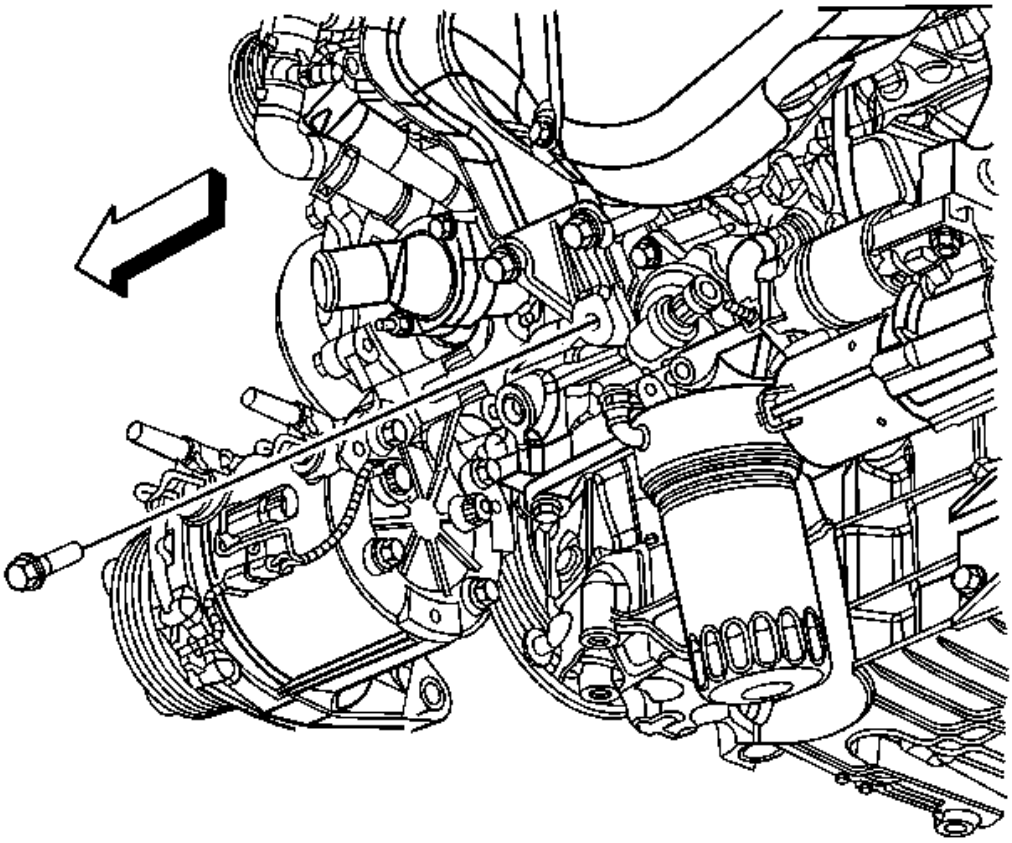

Fig. 161: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

13. Remove the A/C compressor rear bolt and position the compressor aside.

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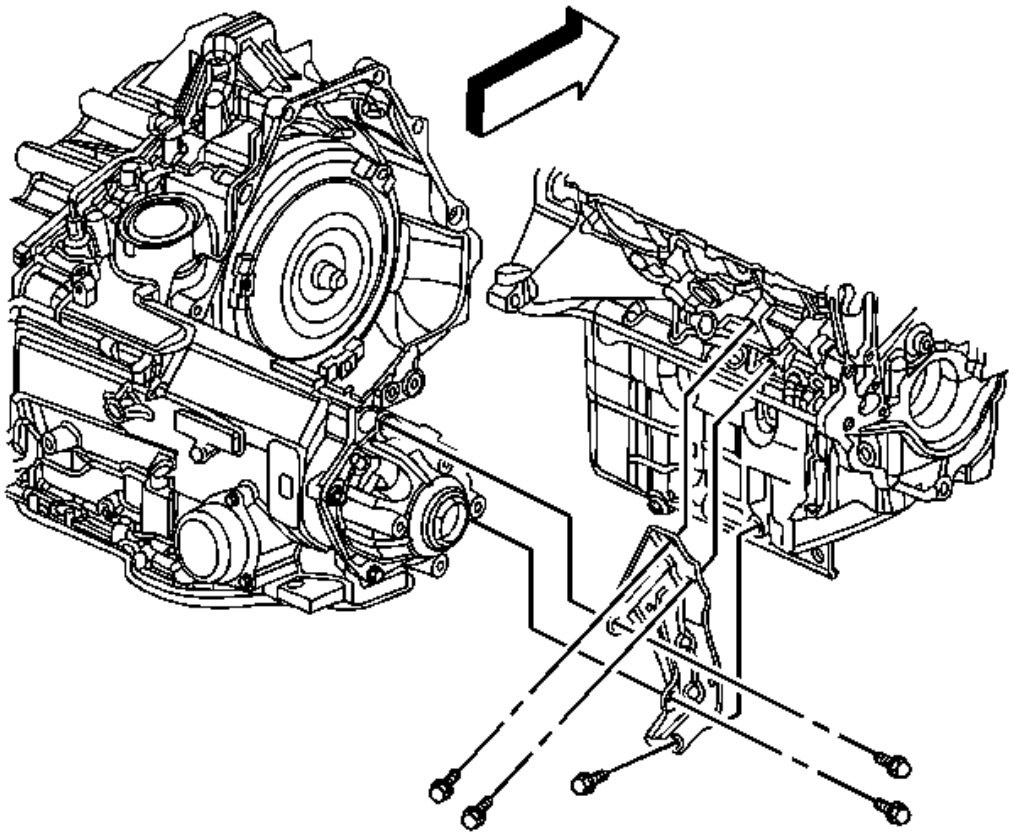

Fig. 162: Removing/Installing Transaxle Brace To Engine Block
Courtesy of GENERAL MOTORS CORP.

14. Remove the transaxle brace to engine block/oil pan bolts.
15. Remove the transaxle brace to transaxle bolts.
16. Remove the transaxle brace.

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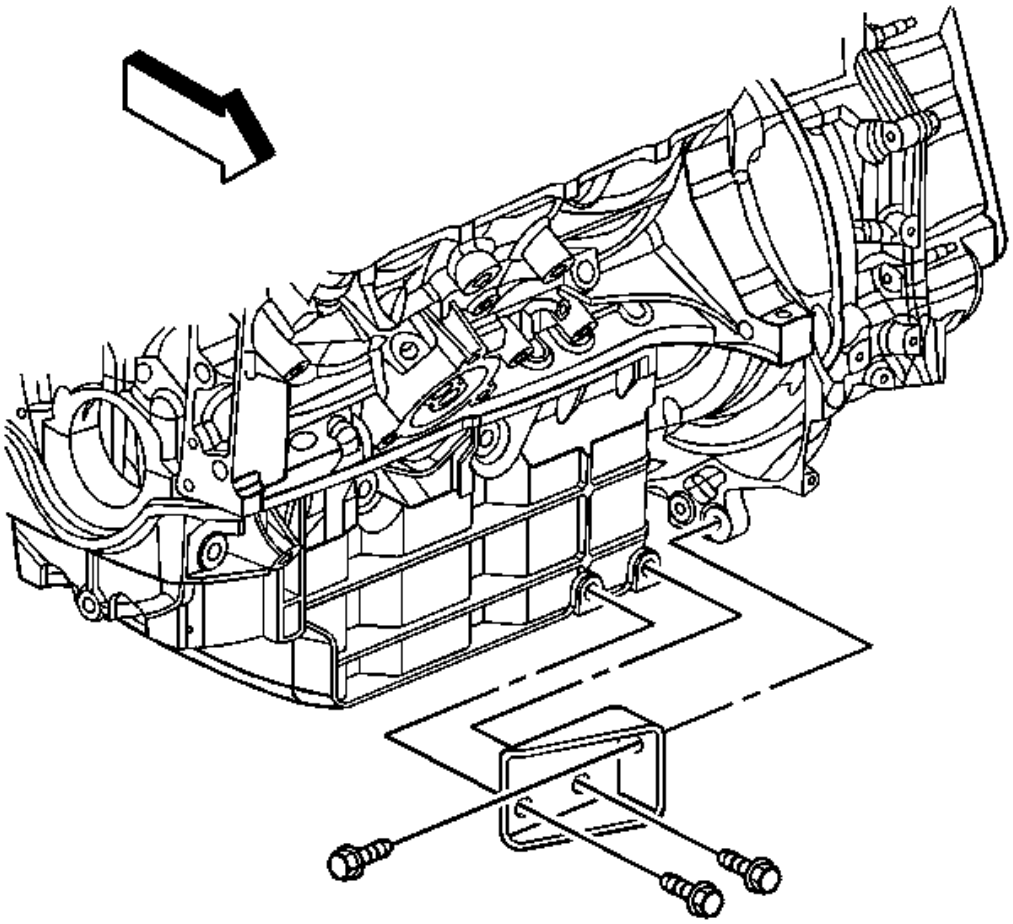

Fig. 163: Identifying Engine Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

17. Remove the transaxle brace to oil pan bolts.
18. Remove the transaxle brace to transaxle bolt.
19. Remove the transaxle brace.
20. Remove the starter. Refer to **Starter Motor Replacement** .

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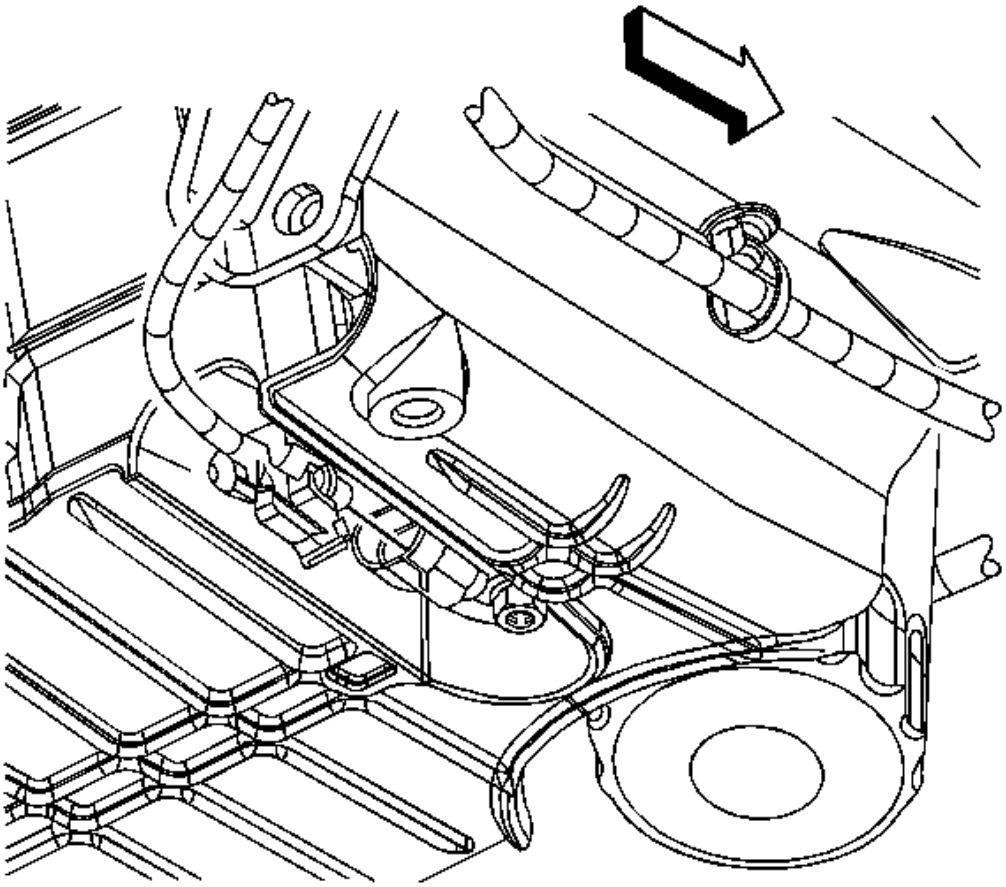

Fig. 164: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

21. Disconnect the engine harness electrical connector from the oil level sensor.

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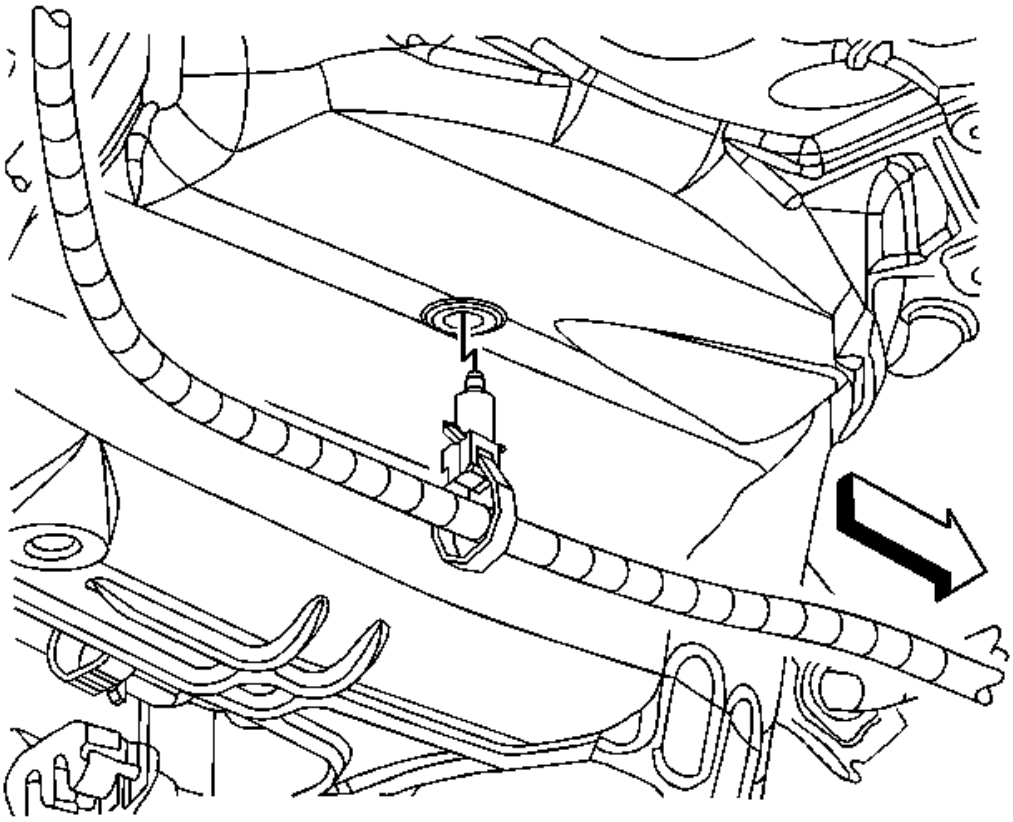

Fig. 165: Locating Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

22. Remove the engine harness clip from the oil pan.
23. Remove the engine mount. Refer to **Engine Mount Replacement**.

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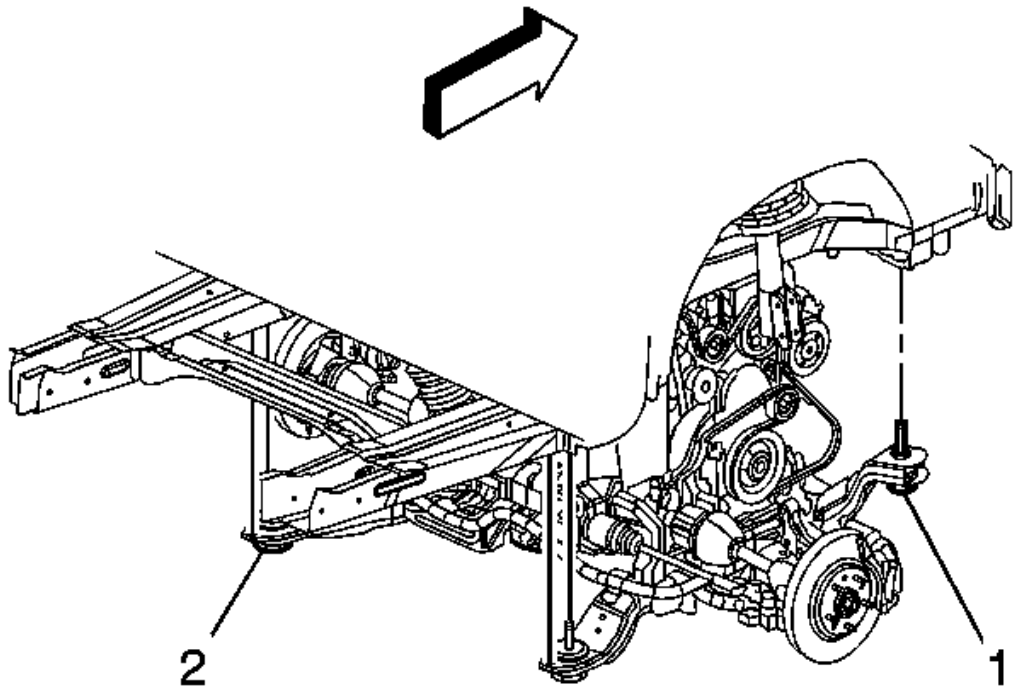

Fig. 166: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

24. Place adjustable jack stands under the frame.
25. Loosen the left side frame bolts (2) and remove the right side frame bolts (1).
26. Using the jack stands, lower the right side of the frame enough to remove the oil pan.

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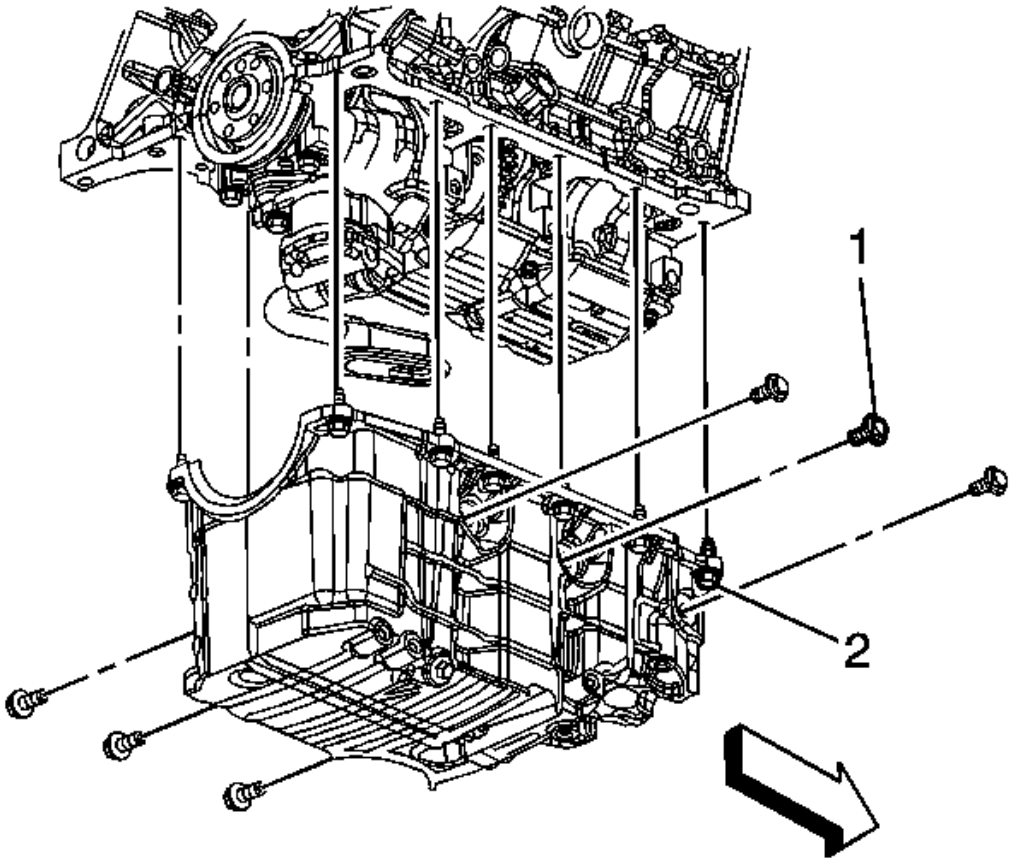

Fig. 167: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

27. Remove the oil pan side bolts (1).
28. Remove the oil pan bolts (2).
29. Remove the oil pan.
30. Remove the oil pan gasket.
31. Clean the following items:
    - The oil pan flanges
    - The oil pan rail
    - The front cover
    - The rear main bearing cap
    - The threaded holes

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Installation Procedure

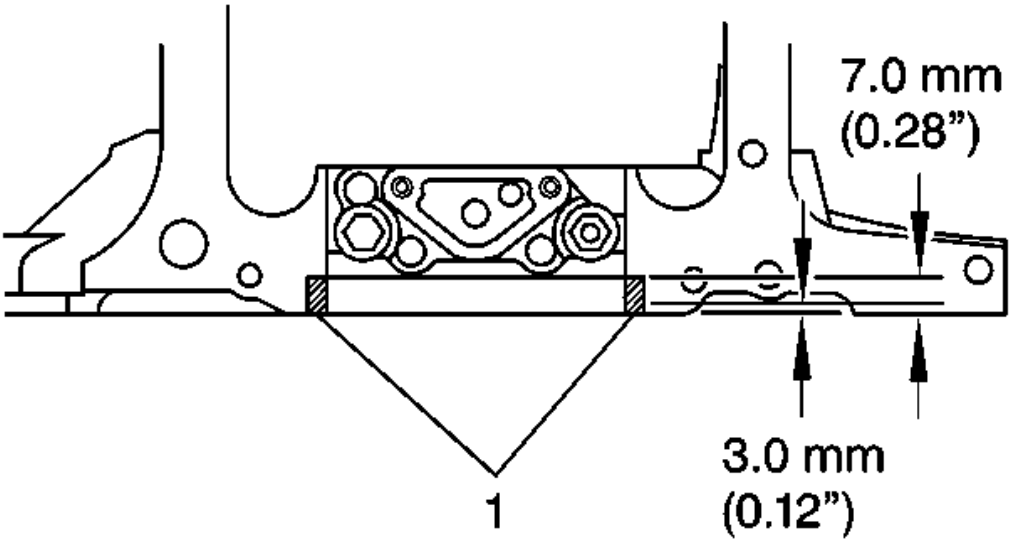

Fig. 168: Illustrating Proper Sealer Application
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer to both sides of the crankshaft rear main bearing cap (1). Refer to **Sealers, Adhesives, and Lubricants**. Press sealer into the gaps using a putty knife.

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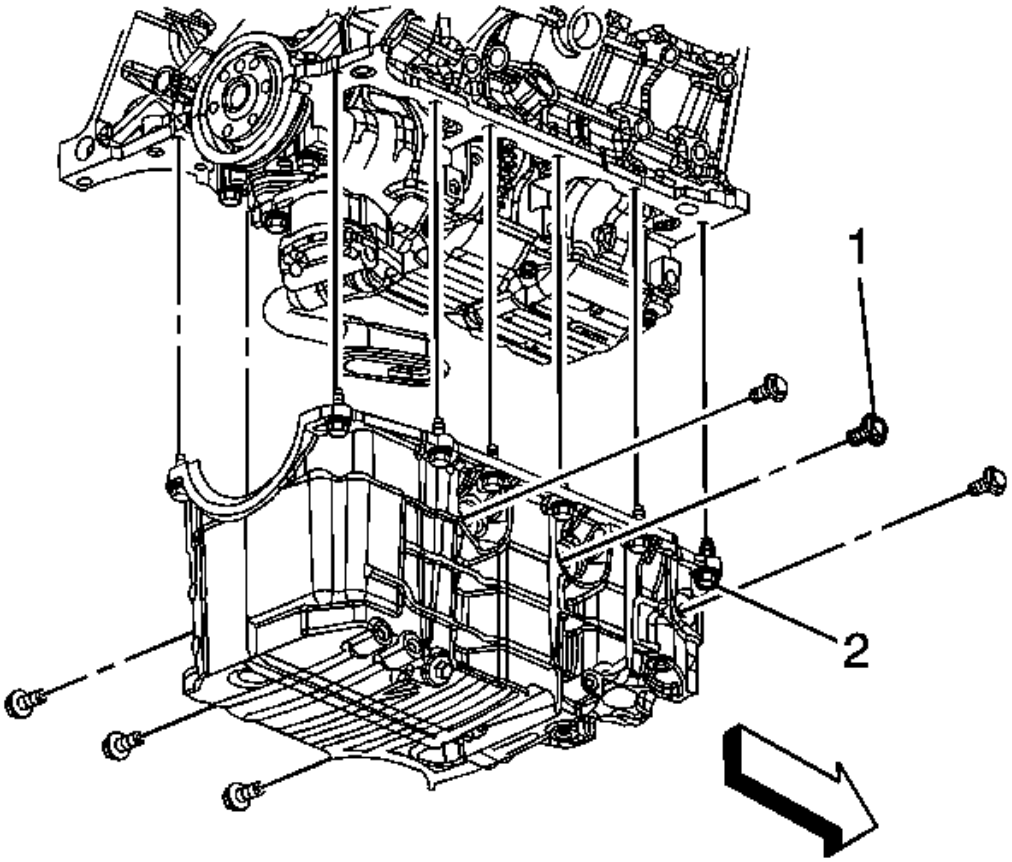

Fig. 169: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pan gasket.
3. Install the oil pan.

NOTE: Refer to Fastener Notice .

4. Install the oil pan bolts (2).

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

5. Install the oil pan side bolts (1).

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

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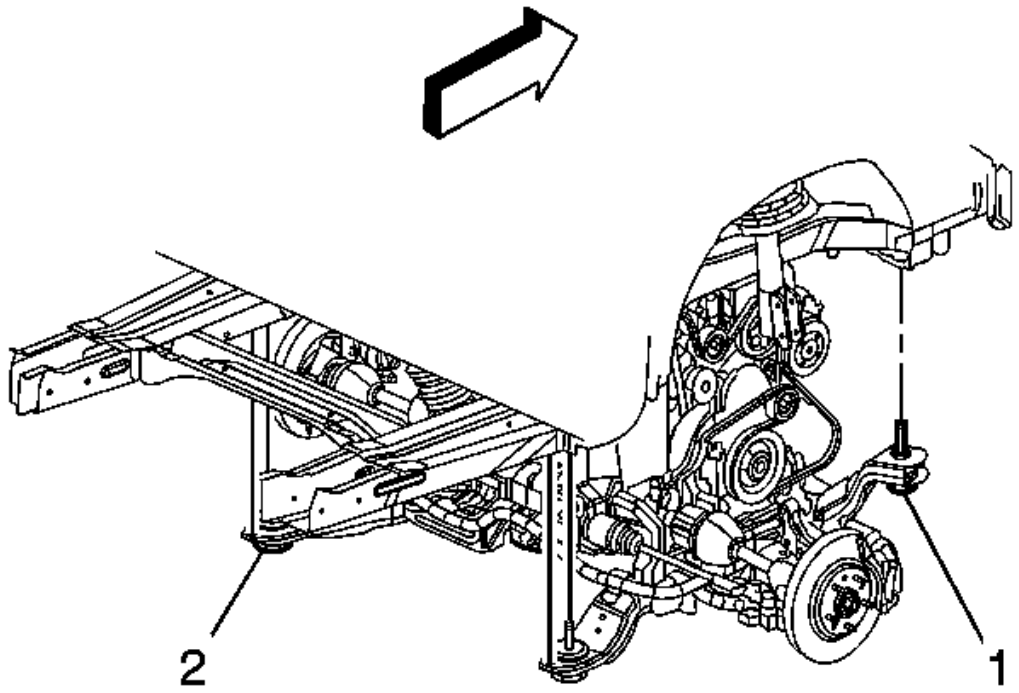

Fig. 170: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

6. Using the jack stands, raise the right side of the frame.
7. Install and tighten the right side frame bolts (1) and tighten the left side frame bolts (2).

   Tighten:
   - Tighten the front frame bolts to 130N.m (96 lb ft).
   - Tighten the rear frame bolts to 240 N.m (177 lb ft).

8. Remove the adjustable jack stands from under the frame.

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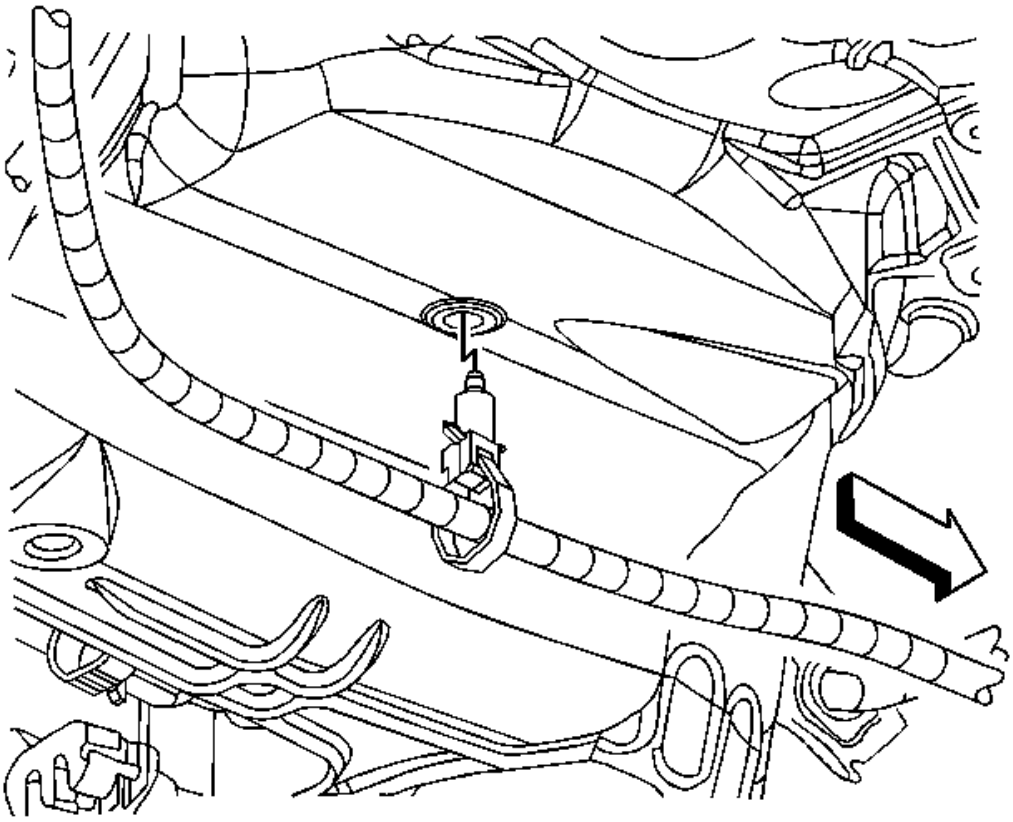

Fig. 171: Locating Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

9. Install the engine mount. Refer to **Engine Mount Replacement**.
10. Install the engine harness clip to the oil pan.

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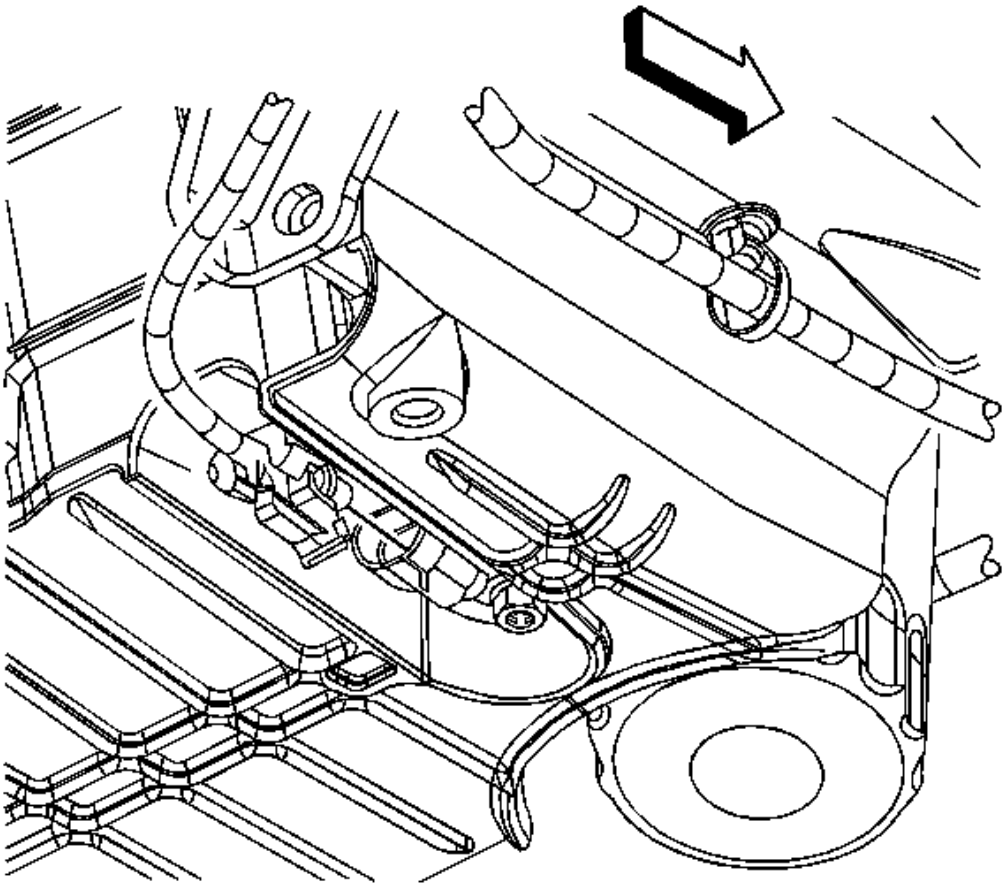

Fig. 172: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

11. Connect the engine harness electrical connector to the oil level sensor.

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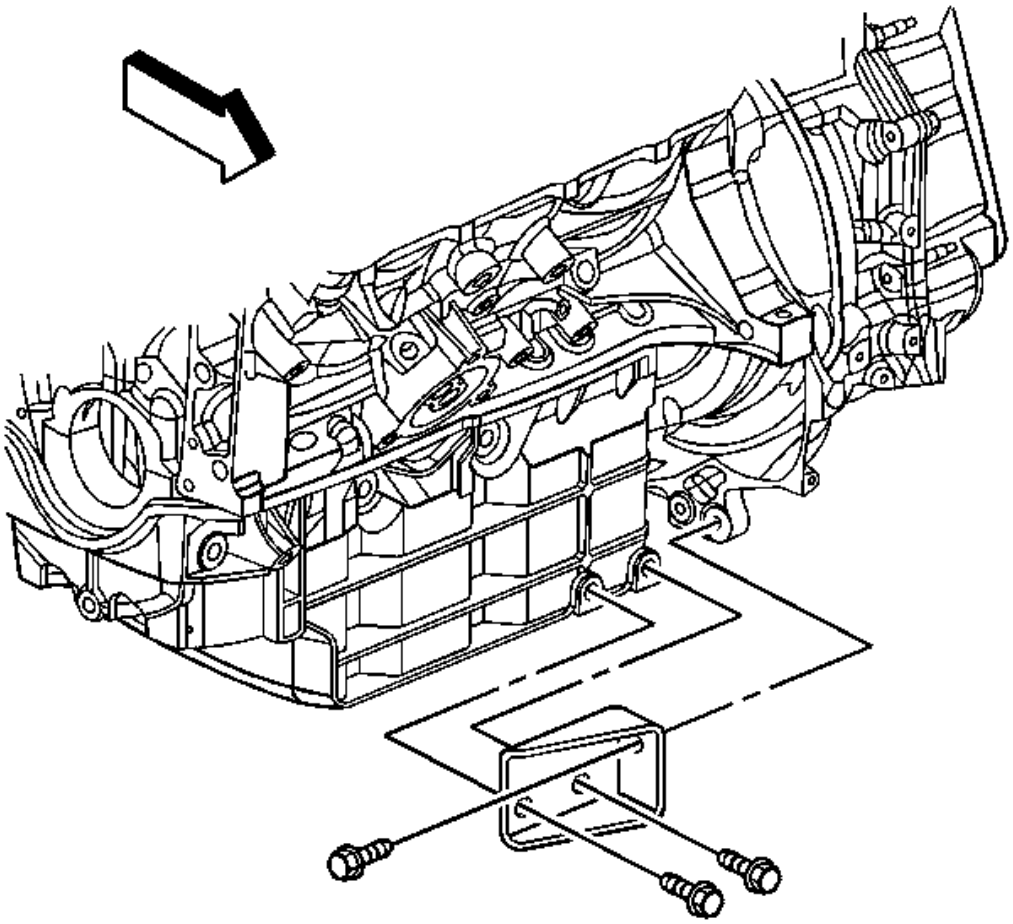

Fig. 173: Identifying Engine Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

12. Install the starter. Refer to **Starter Motor Replacement** .
13. Position the transaxle brace to the transaxle and oil pan.
14. Install the transaxle brace to transaxle bolt.
15. Install the transaxle brace to oil pan bolts.

Tighten: Tighten the bolts to 43 N.m (32 lb ft).

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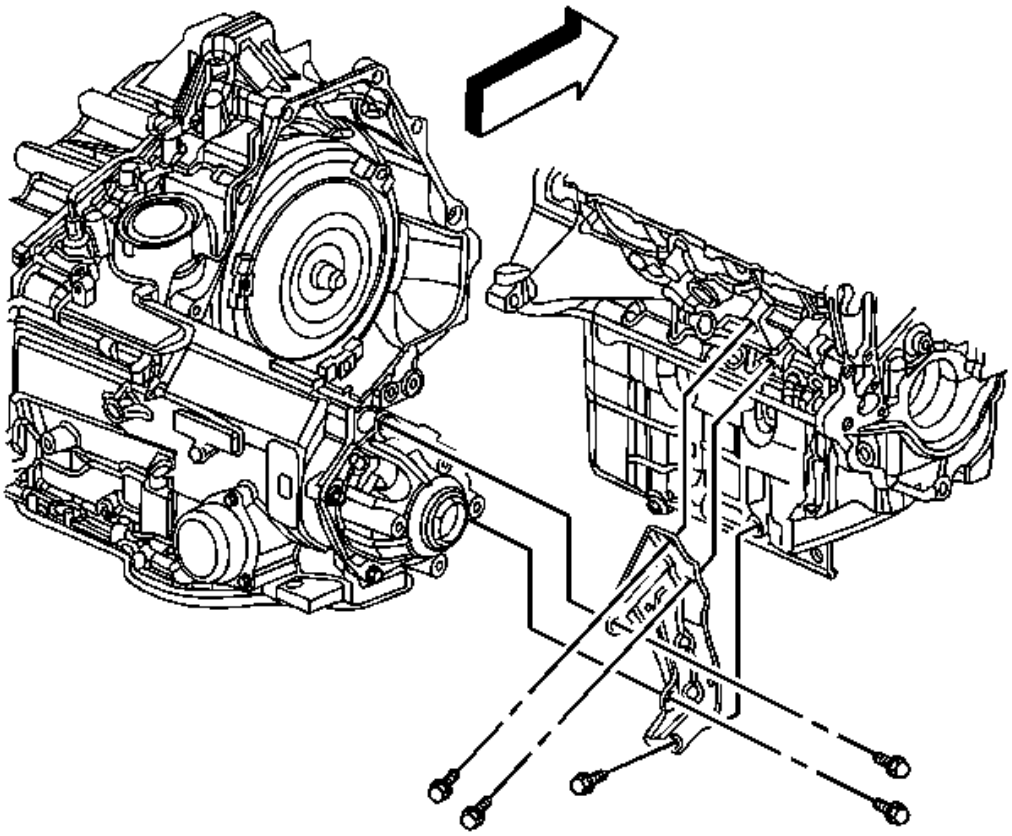

Fig. 174: Removing/Installing Transaxle Brace To Engine Block
Courtesy of GENERAL MOTORS CORP.

16. Position the transaxle brace to the transaxle and the engine block/oil pan.
17. Install the transaxle brace to transaxle bolts.
18. Install the transaxle brace to engine block/oil pan bolts.

Tighten: Tighten the bolts to 43 N.m (32 lb ft).

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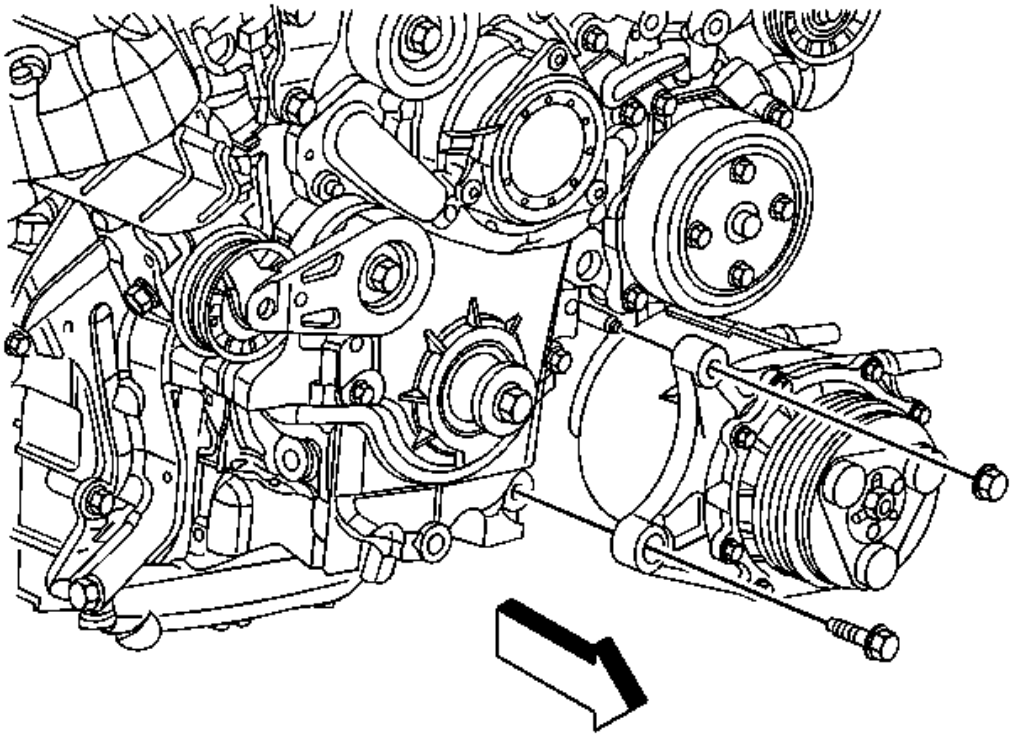

Fig. 175: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

19. Position the A/C compressor over the front stud and install the A/C compressor front bolt and nut.

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

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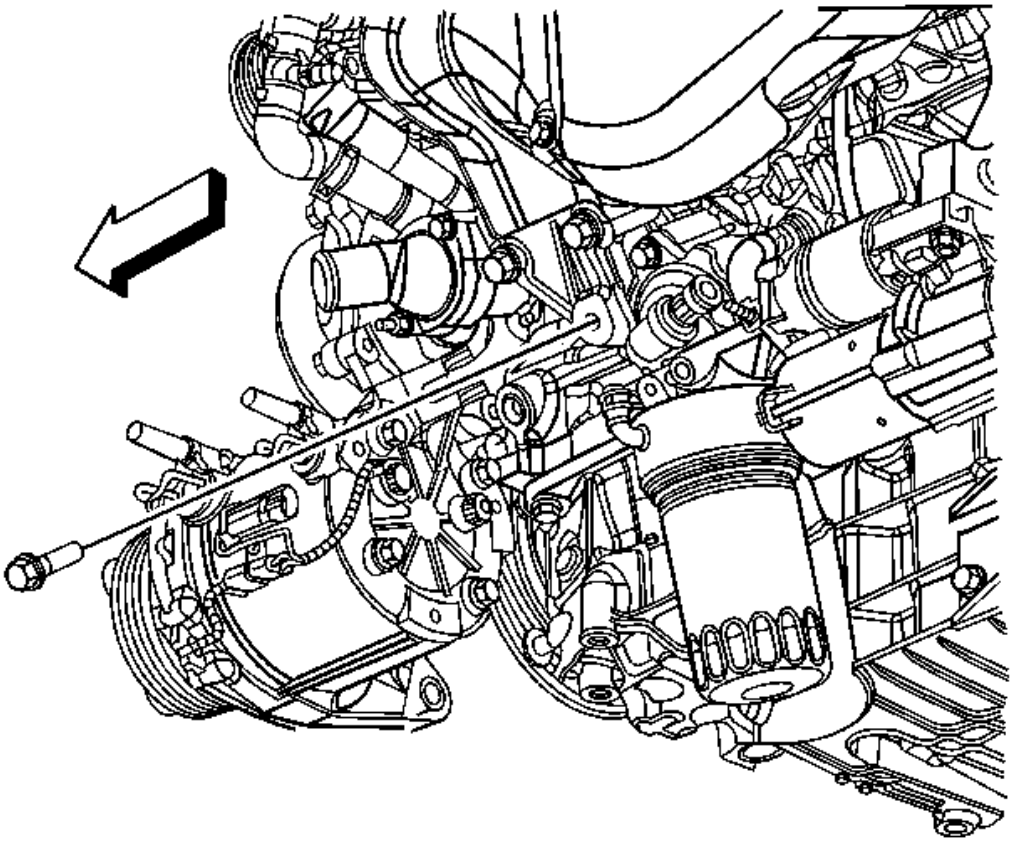

Fig. 176: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

20. Install the A/C compressor rear bolt.

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

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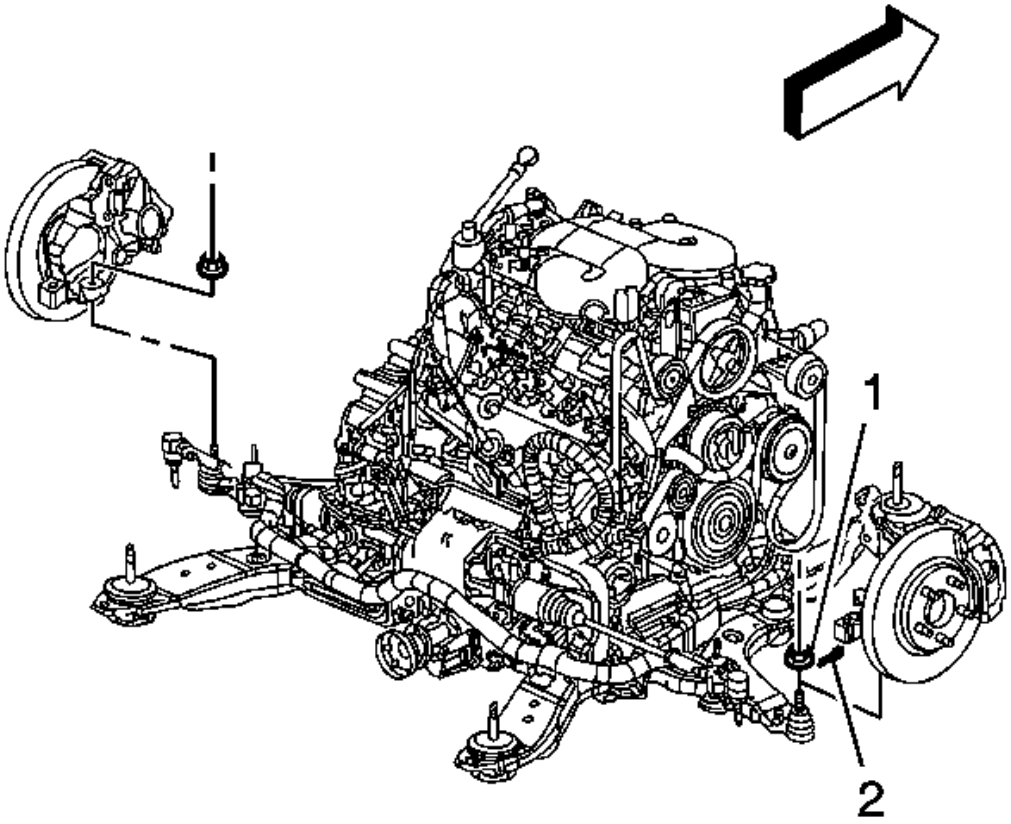

Fig. 177: View Of Outer Tie Rod Ends & Steering Knuckles
Courtesy of GENERAL MOTORS CORP.

21. Install the lower ball joint to the steering knuckle.
22. Install the lower ball joint castle nut (1).

Tighten: Tighten the nut to 55 N.m (40 lb ft).

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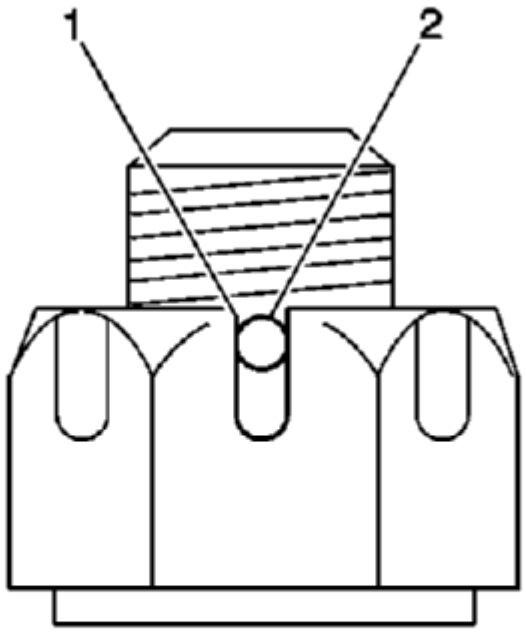

Fig. 178: Aligning Ball Stud Castle Nut Slot To The Ball Stud Cotter Pin Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not loosen the castle nut in order to align the slots to the ball joint stud pin hole.

23. If necessary, tighten the castle nut in order to align one of the slots (1) to the ball joint stud pin hole (2) as shown.

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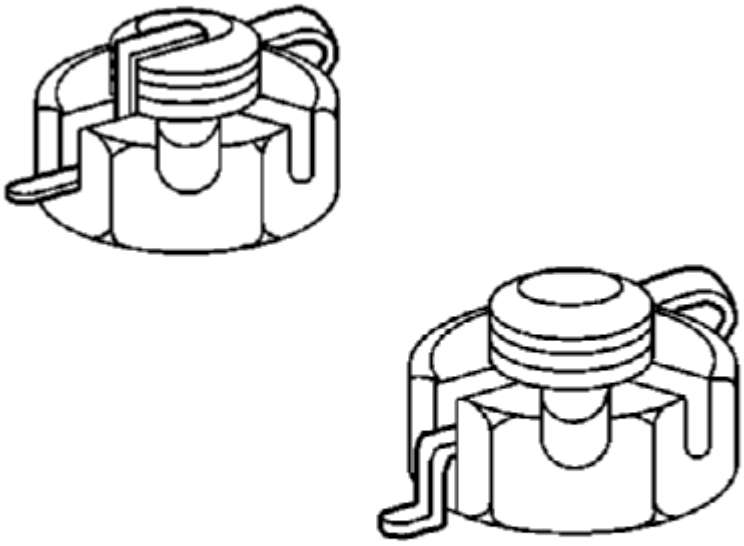

Fig. 179: Securing Cotter Pin In Ball Joint Castle Nut
Courtesy of GENERAL MOTORS CORP.

24. Install a NEW cotter pin to the castle nut and ball joint stud.
25. Bend the NEW cotter pin ends as shown in either example.

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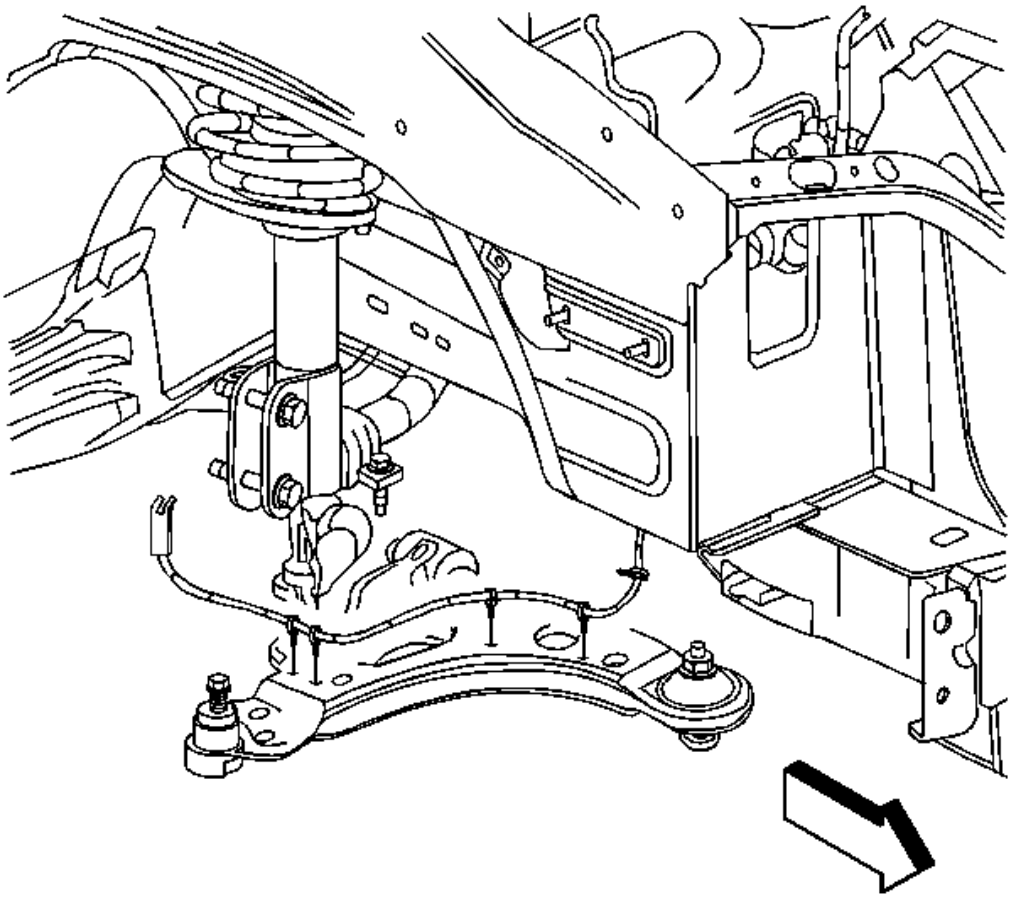

Fig. 180: Identifying Right Lower Control Arm
Courtesy of GENERAL MOTORS CORP.

26. Install the engine harness clips to the right lower control arm.

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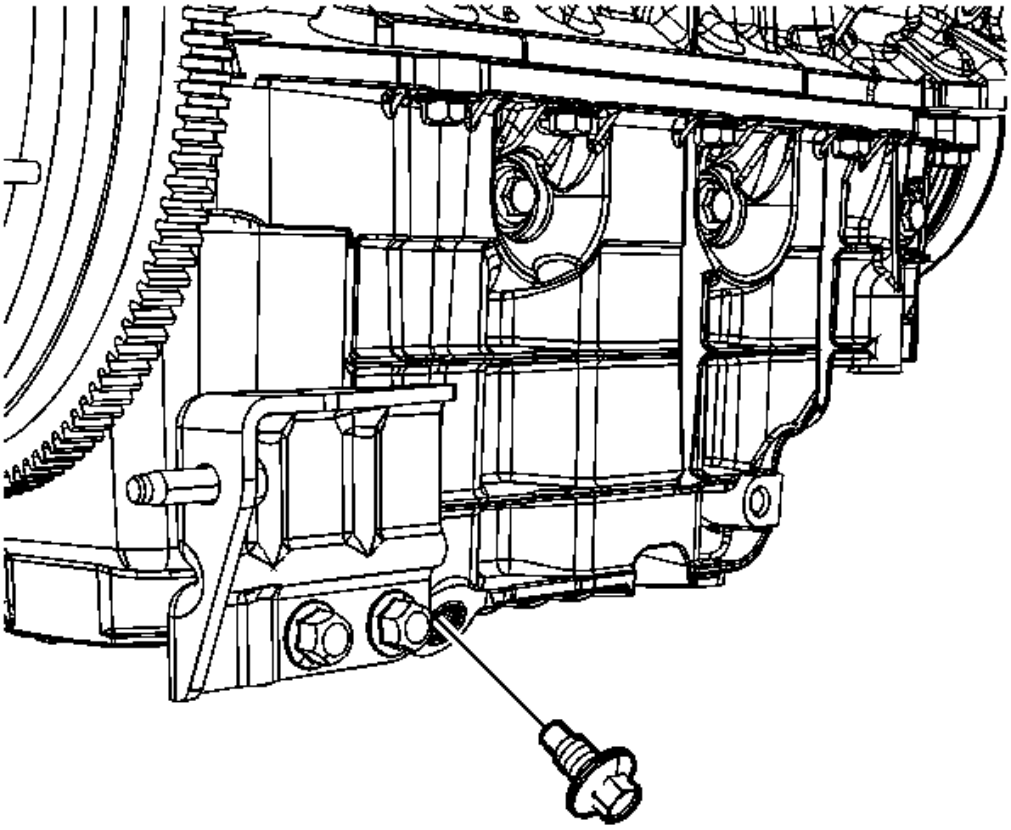

Fig. 181: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

27. Install the right front splash shield. Refer to **Engine Splash Shield Replacement** .
28. Install the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
29. Remove the engine support fixture. Refer to **Engine Support Fixture**.
30. Fill the crankcase with NEW oil.

Engine Oil Pressure Sensor and/or Switch Replacement

Removal Procedure

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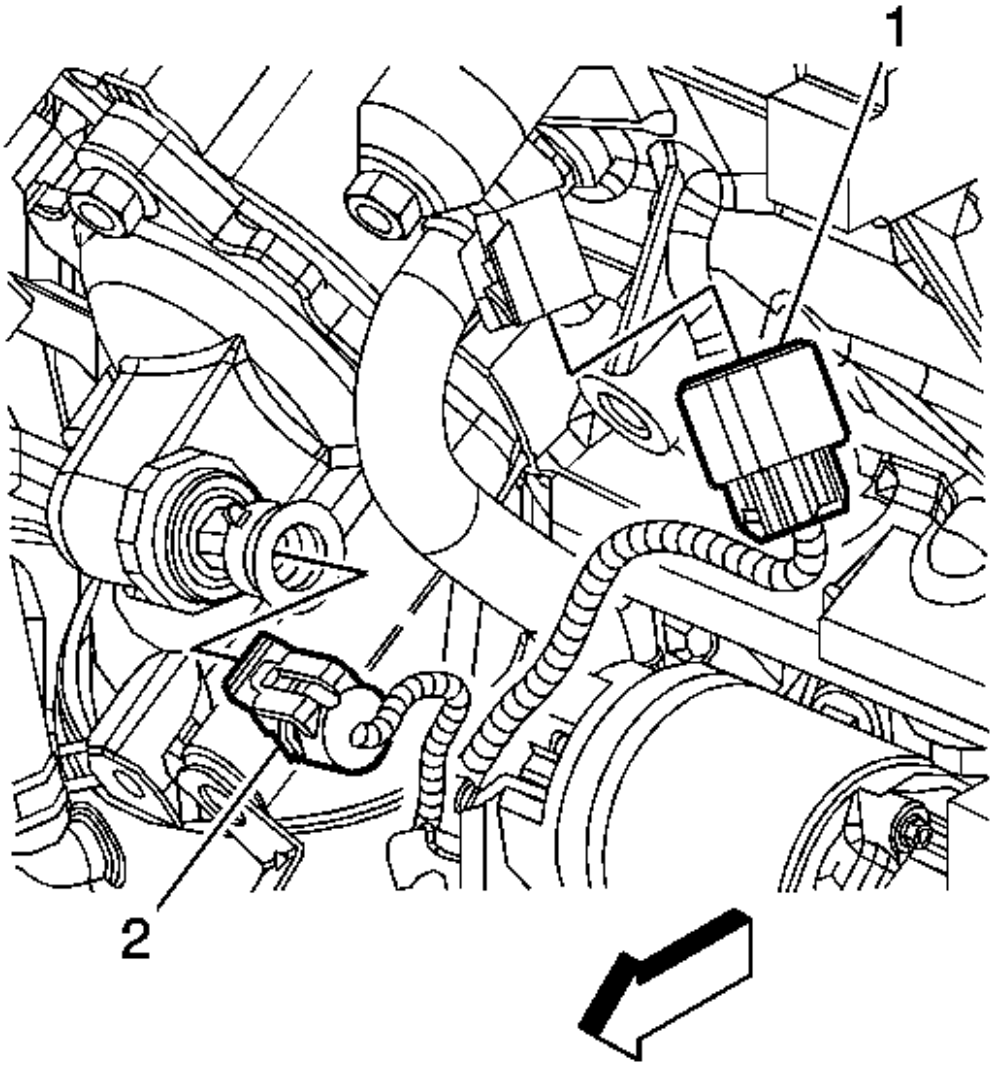

Fig. 182: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
4. Disconnect the engine harness electrical connector (2) from the engine oil pressure sensor.

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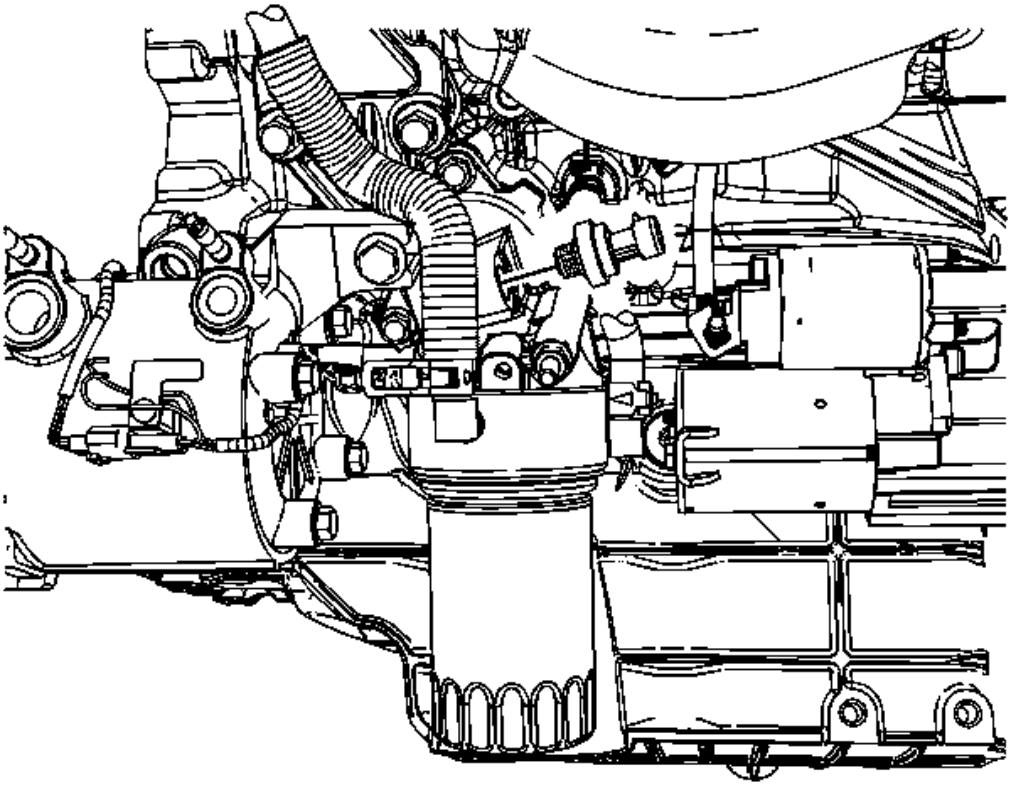

Fig. 183: Identifying Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine oil pressure sensor.

Installation Procedure

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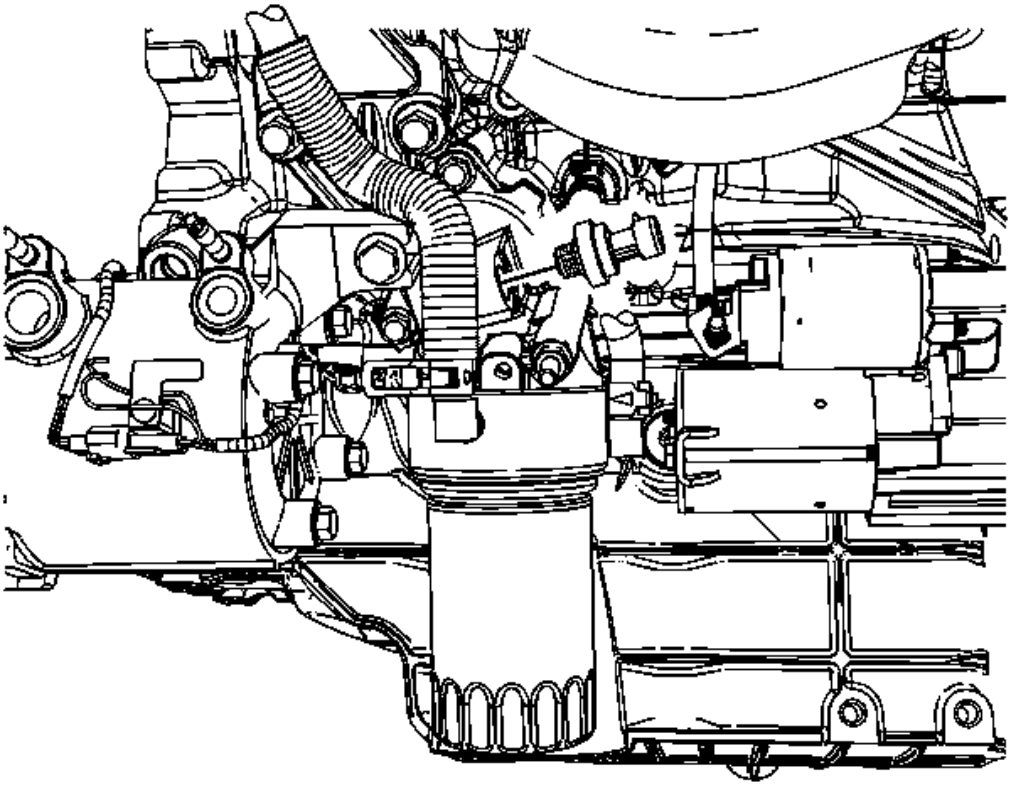

Fig. 184: Identifying Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the engine oil pressure sensor.

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

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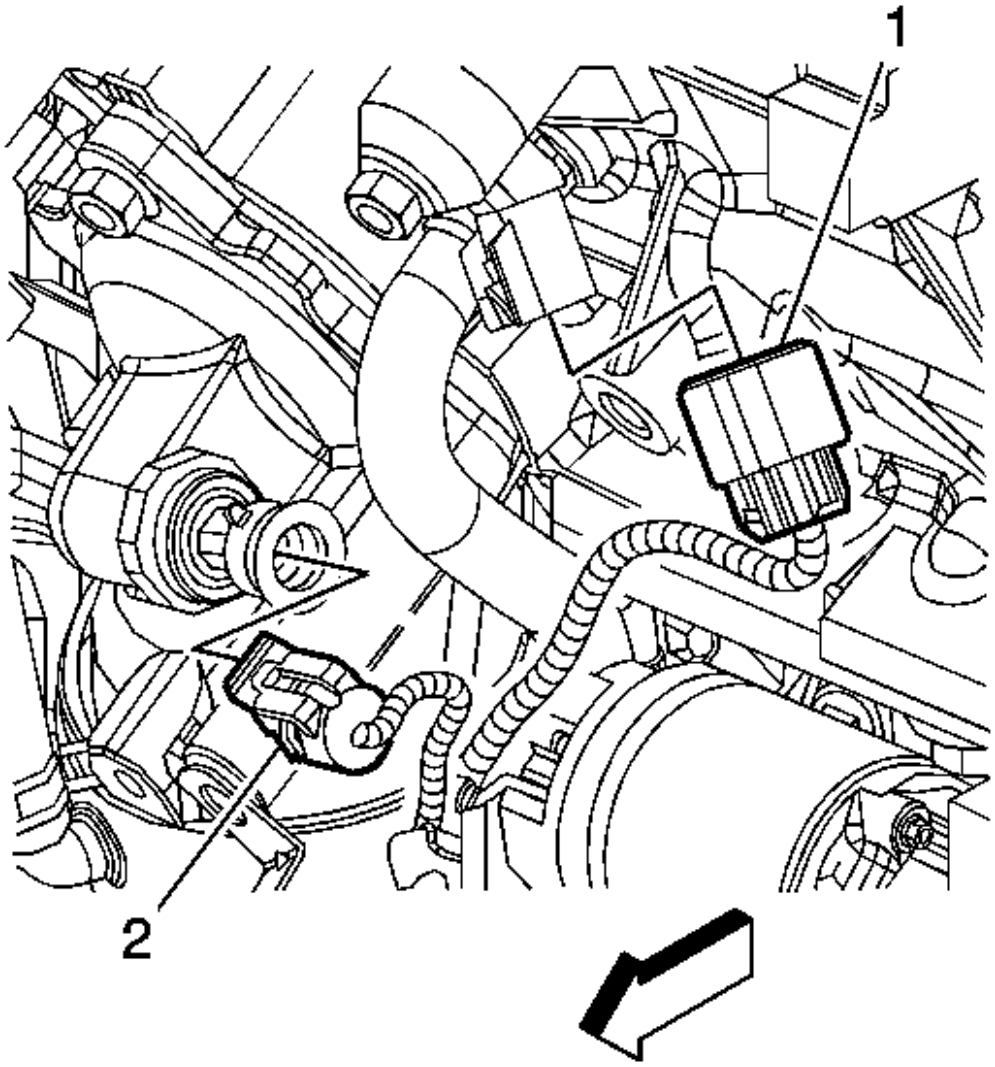

Fig. 185: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine harness electrical connector (2) to the engine oil pressure sensor.
3. Install the radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
4. Lower the vehicle.
5. Connect the negative cable. Refer to **Battery Negative Cable Disconnection and Connection** .

Engine Oil Level Sensor and/or Switch Replacement

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Removal Procedure

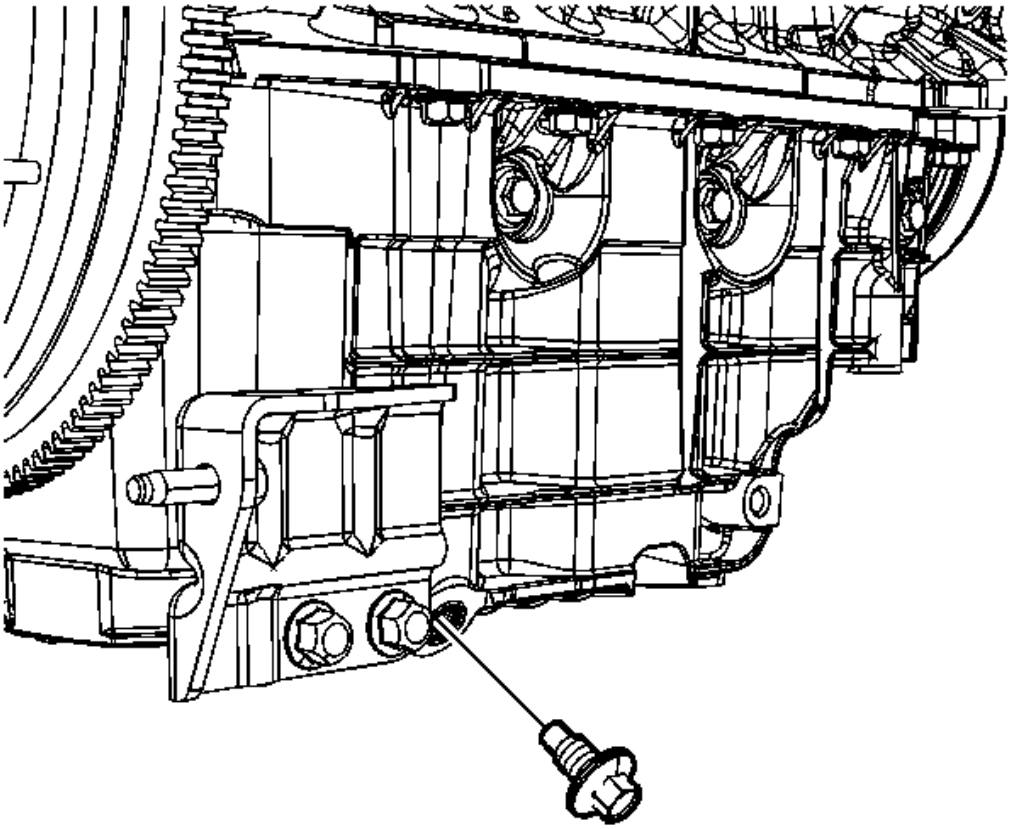

Fig. 186: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

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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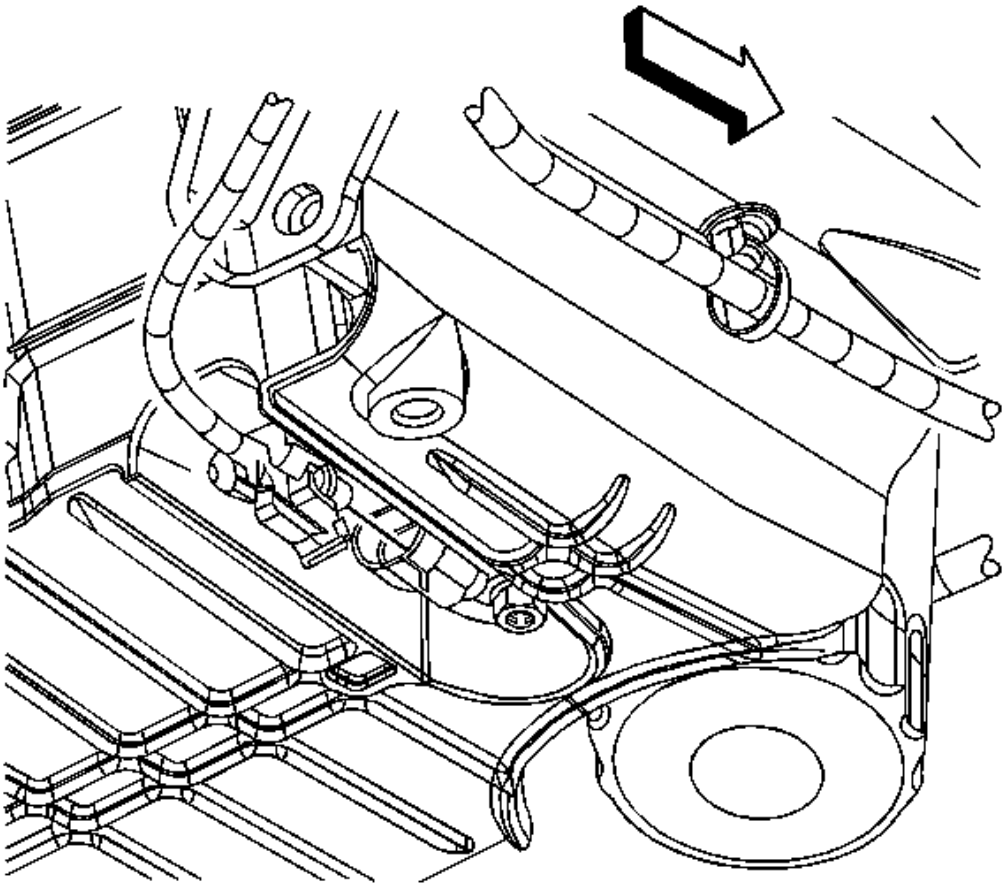

Fig. 187: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine oil level sensor electrical connector.

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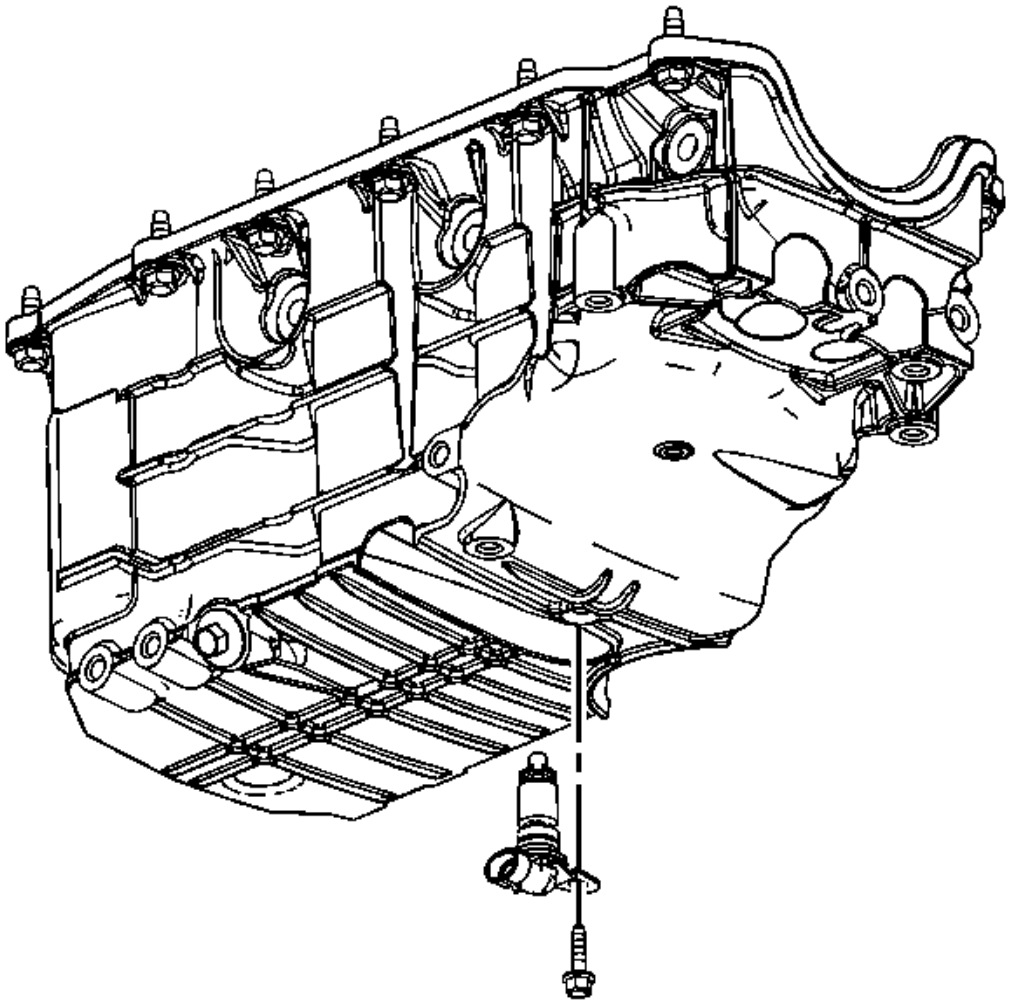

Fig. 188: Identifying Engine Oil Level Sensor Bolt & Sensor
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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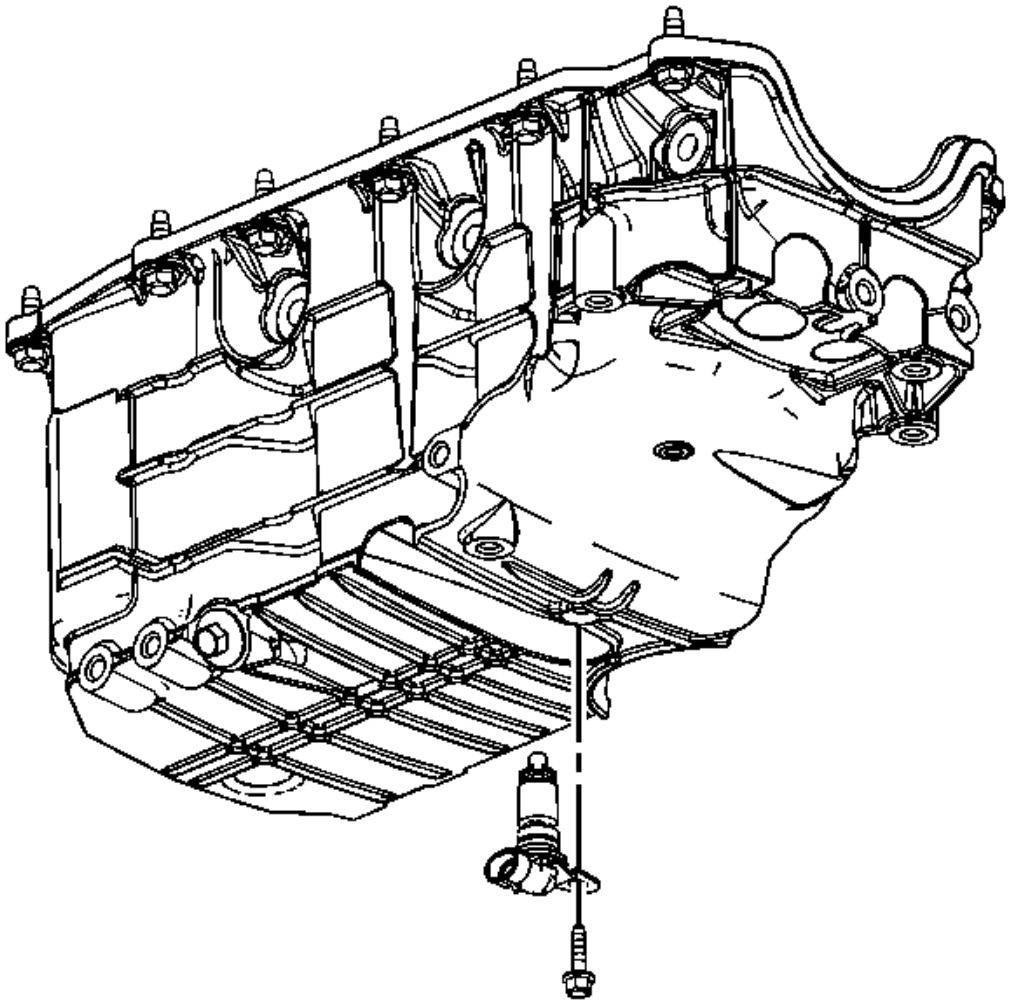

Fig. 189: Identifying Engine Oil Level Sensor Bolt & Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the engine oil level sensor and bolt.

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

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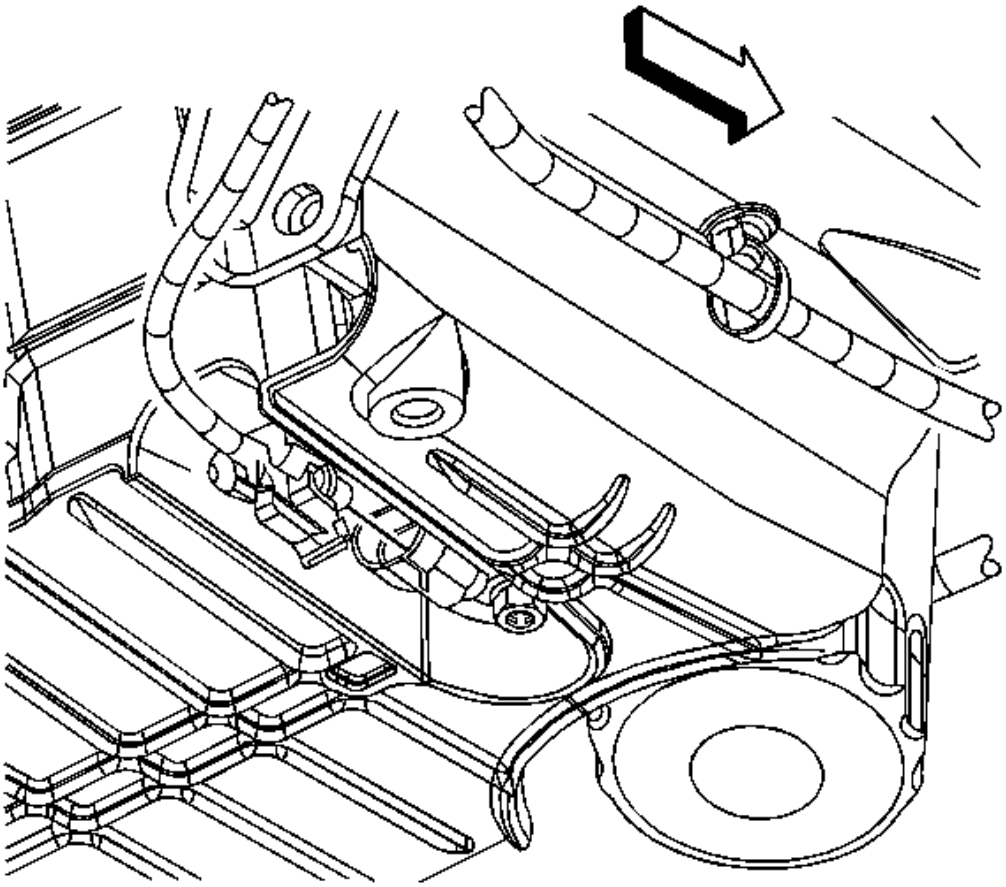

Fig. 190: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

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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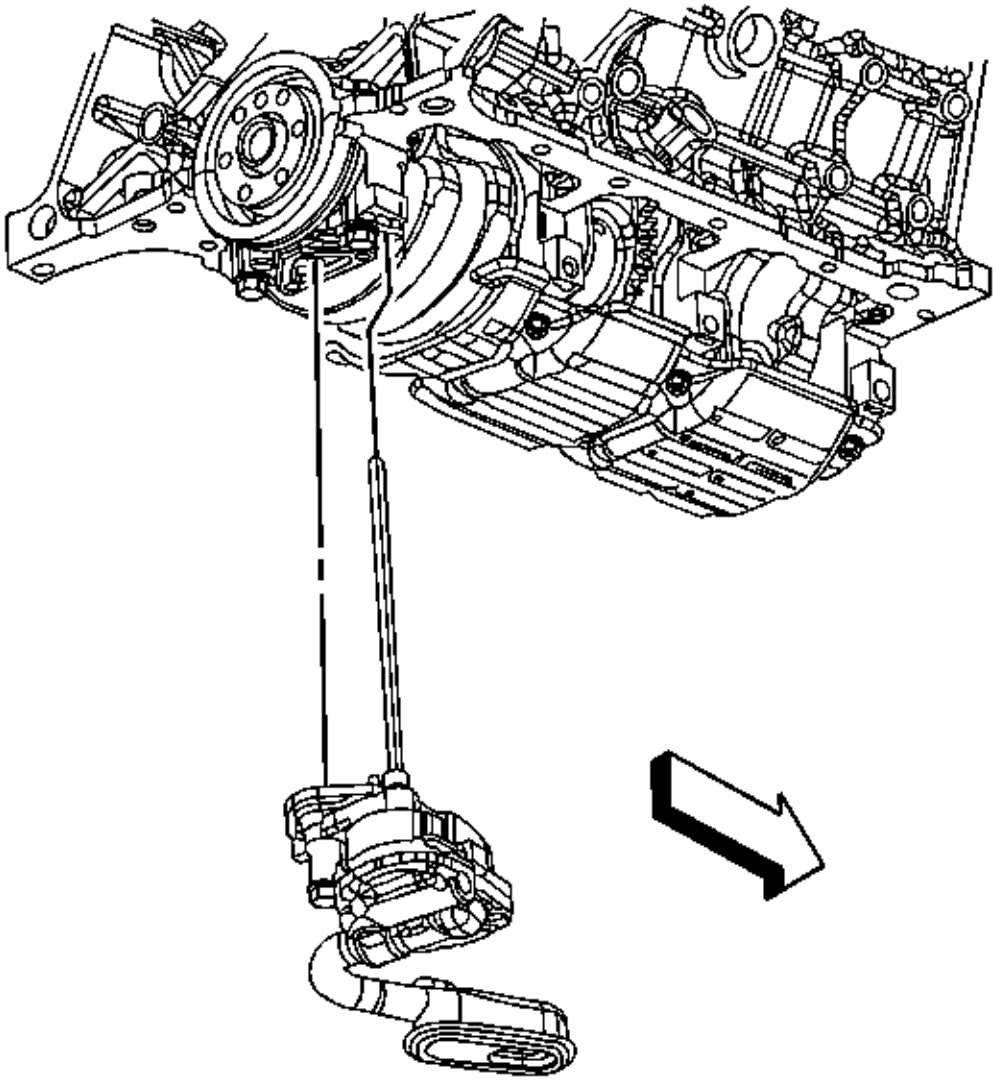

Fig. 191: Identifying Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

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

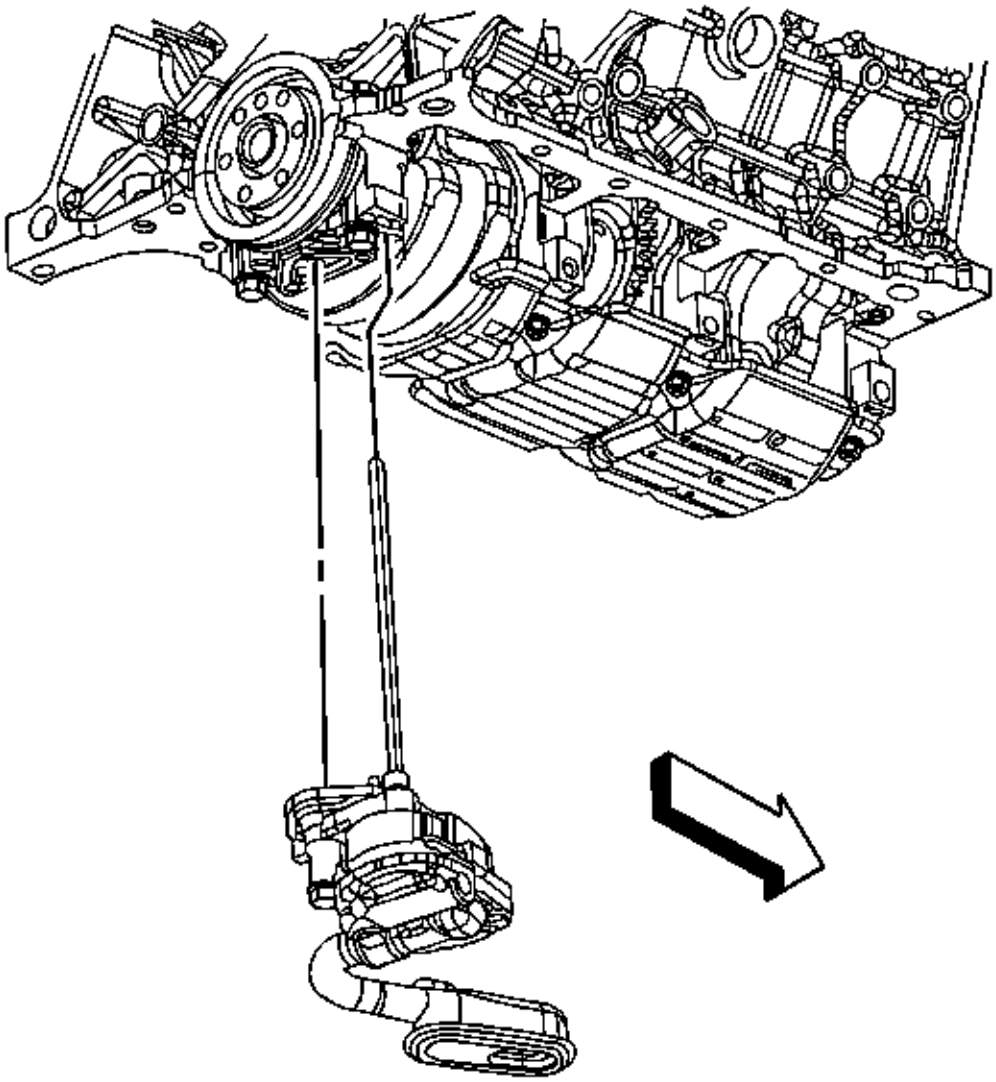

Fig. 192: Identifying Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil pump drive shaft and the oil pump.

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2. Install the oil pump bolt.

   Tighten: Tighten the bolt to 41 N.m (30 lb ft).

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

Oil Pump Drive Replacement

Removal Procedure

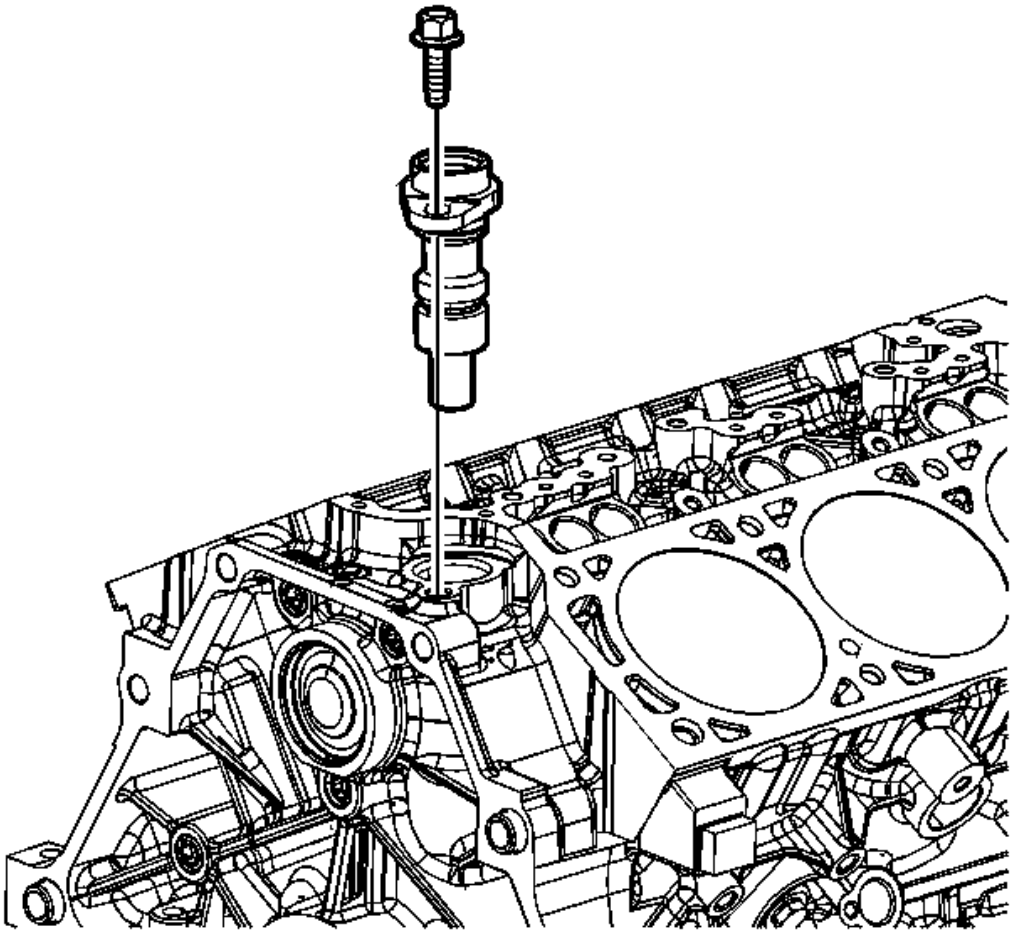

Fig. 193: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.

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2. Remove the oil pump drive bolt. (cylinder heads shown removed for clarity).
3. Remove the oil pump drive.

Installation Procedure

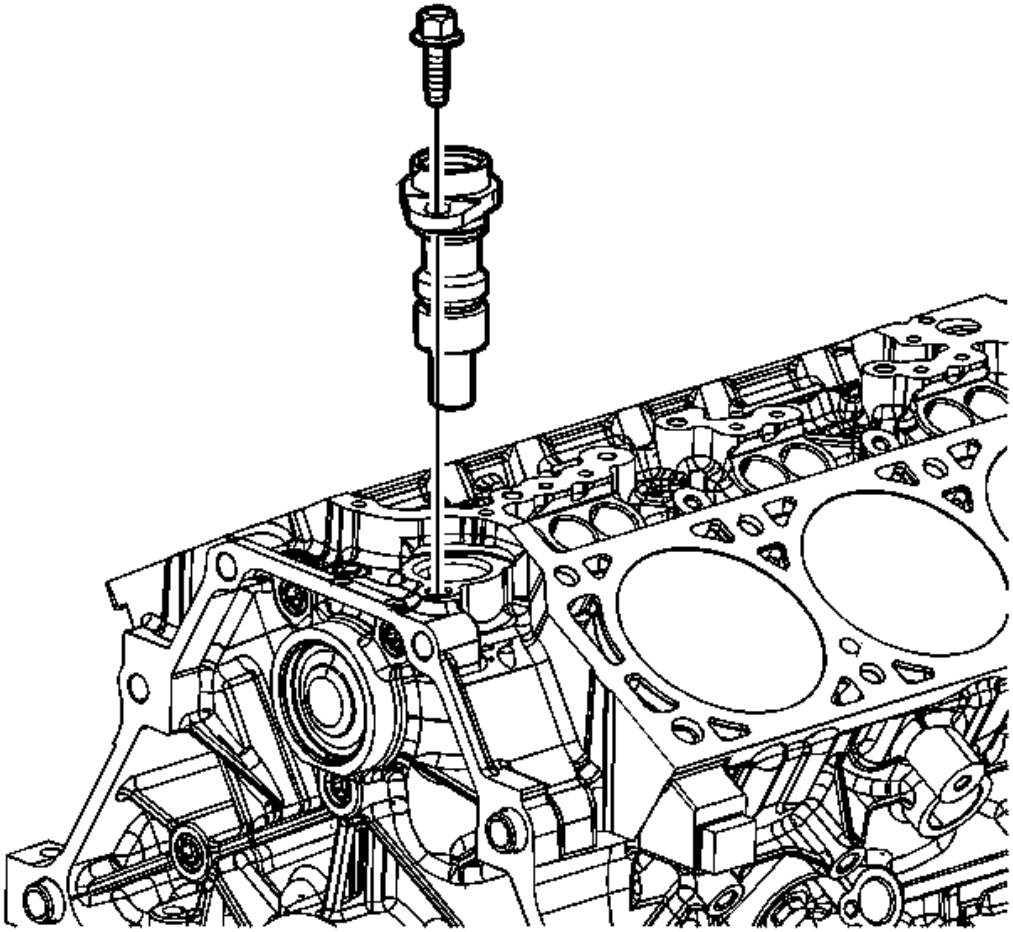

Fig. 194: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Apply prelube to the oil pump drive gear. Refer to **Sealers, Adhesives, and Lubricants**.
2. Install the oil pump drive.

NOTE: Refer to Fastener Notice .

3. Install the oil pump drive bolt.

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Tighten: Tighten the bolt to 36 N.m (27 lb ft).

4. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.

Crankshaft Front Oil Seal Replacement

Tools Required

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

Removal Procedure

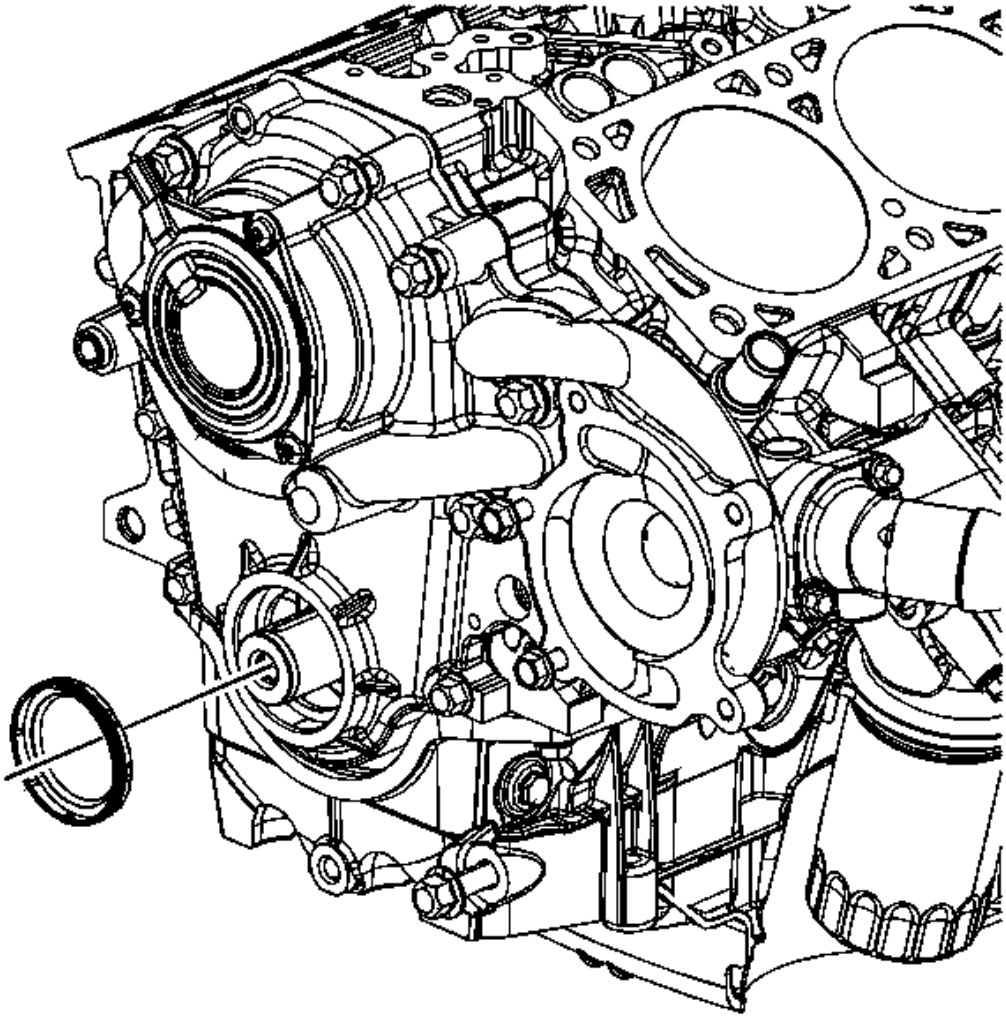

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Fig. 195: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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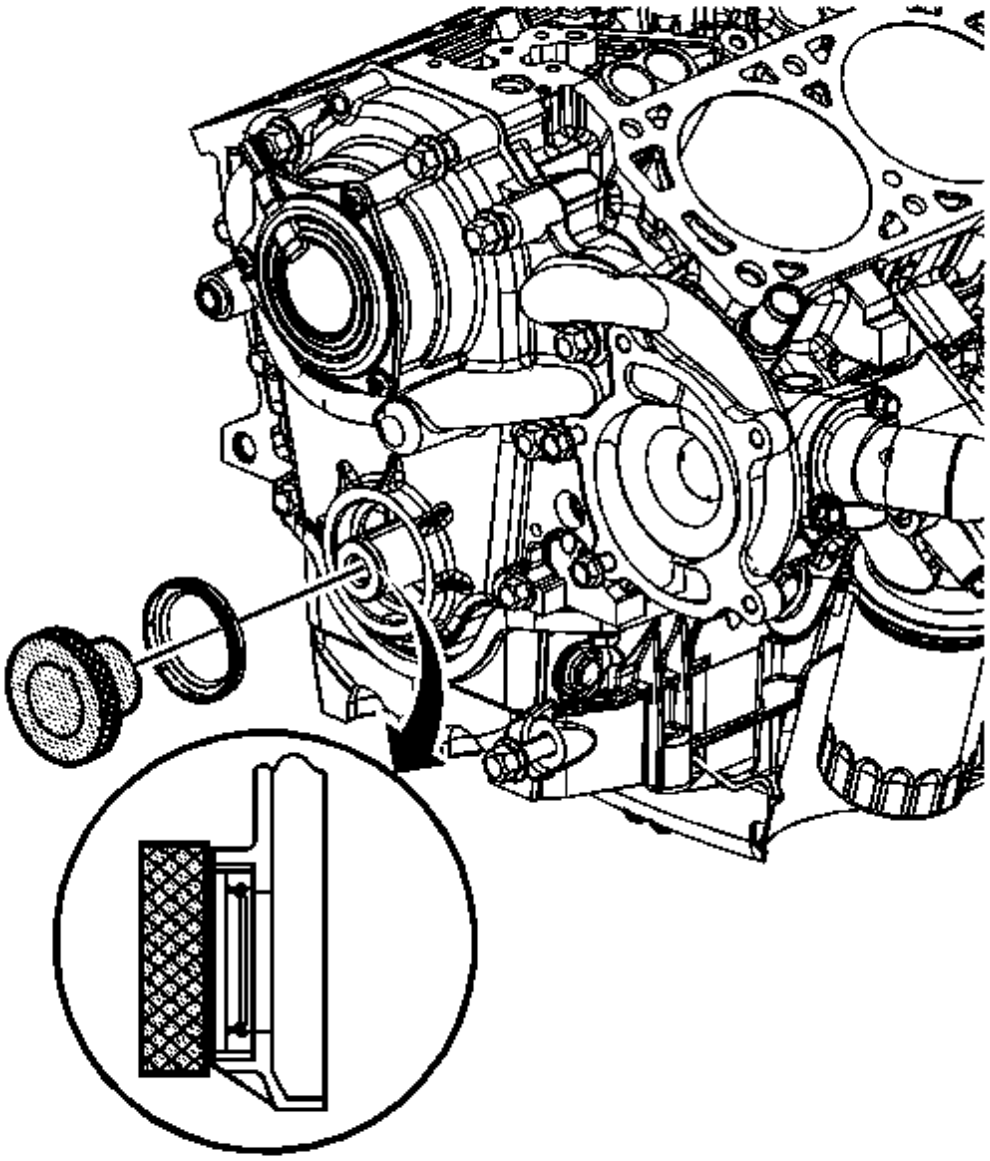

Fig. 196: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the NEW oil seal with clean engine oil.
2. Align the **J 35468** and the crankshaft front oil seal with the engine front cover and crankshaft. See **Special Tools**.
3. Install the crankshaft front oil seal using **J 35468** and a suitable tool. See **Special Tools**.

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

Camshaft Position Actuator Magnet Replacement

Removal Procedure

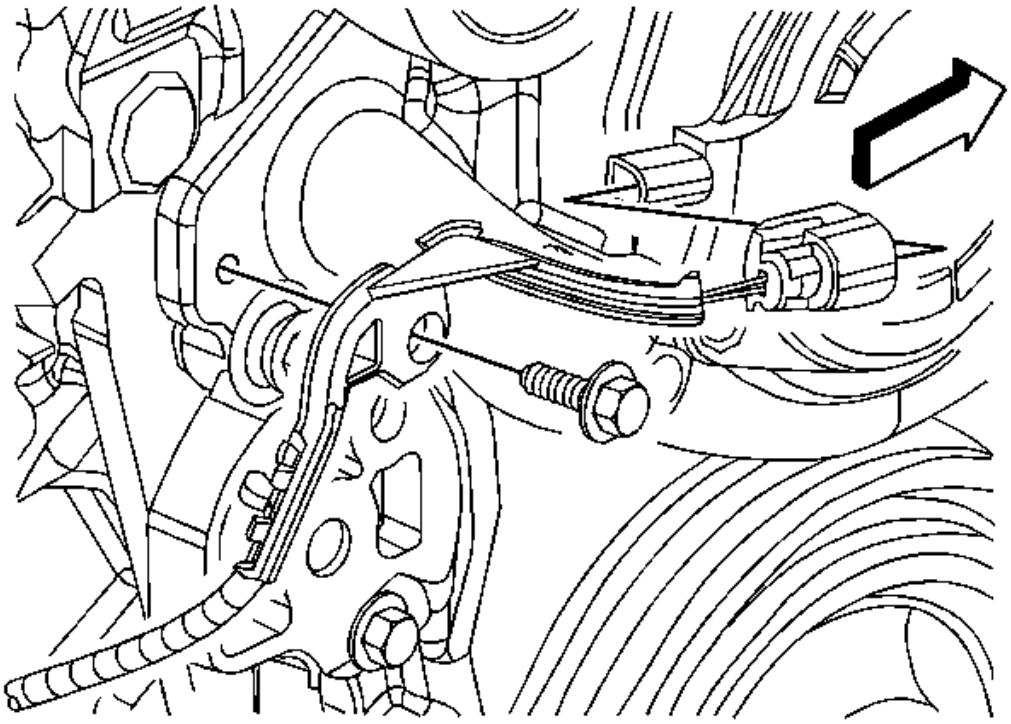

Fig. 197: Locating Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the washer solvent container. Refer to **Washer Solvent Container Replacement** .
3. Disconnect the engine harness electrical connector from the camshaft position actuator magnet.

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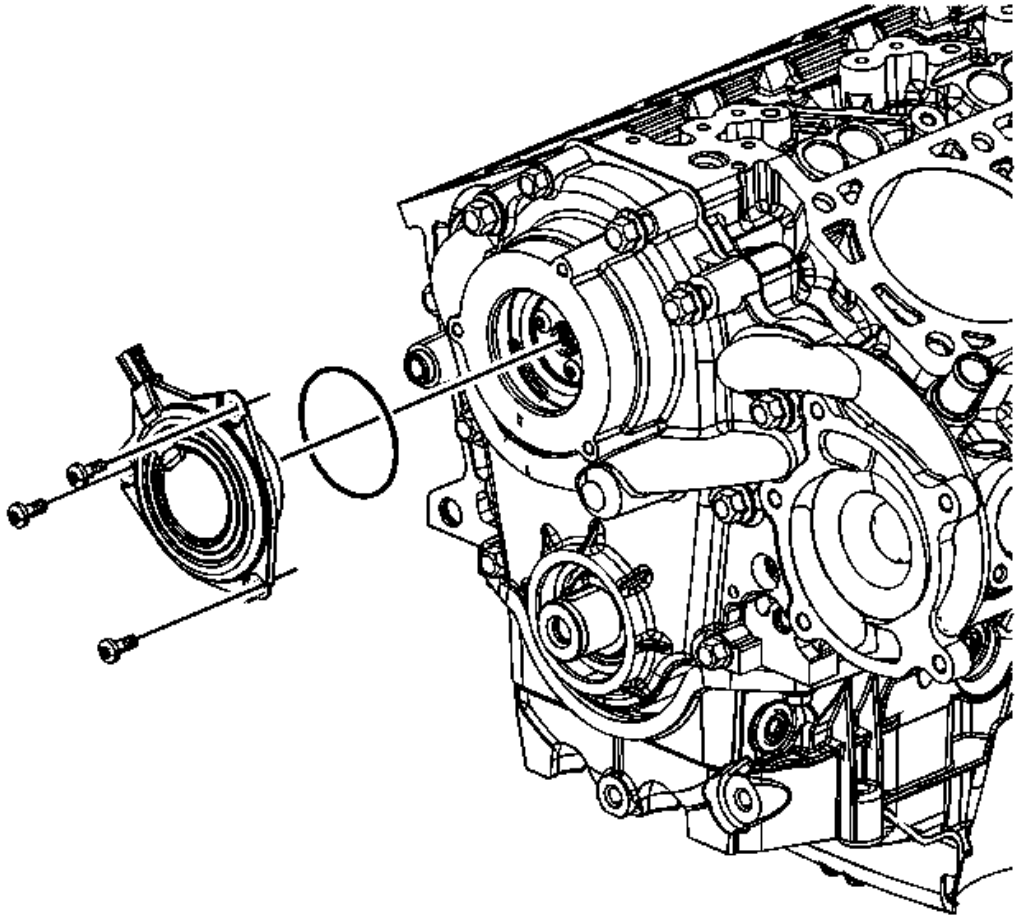

Fig. 198: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft position actuator magnet bolts.
5. Remove the camshaft position actuator magnet and O-ring seal.

Installation Procedure

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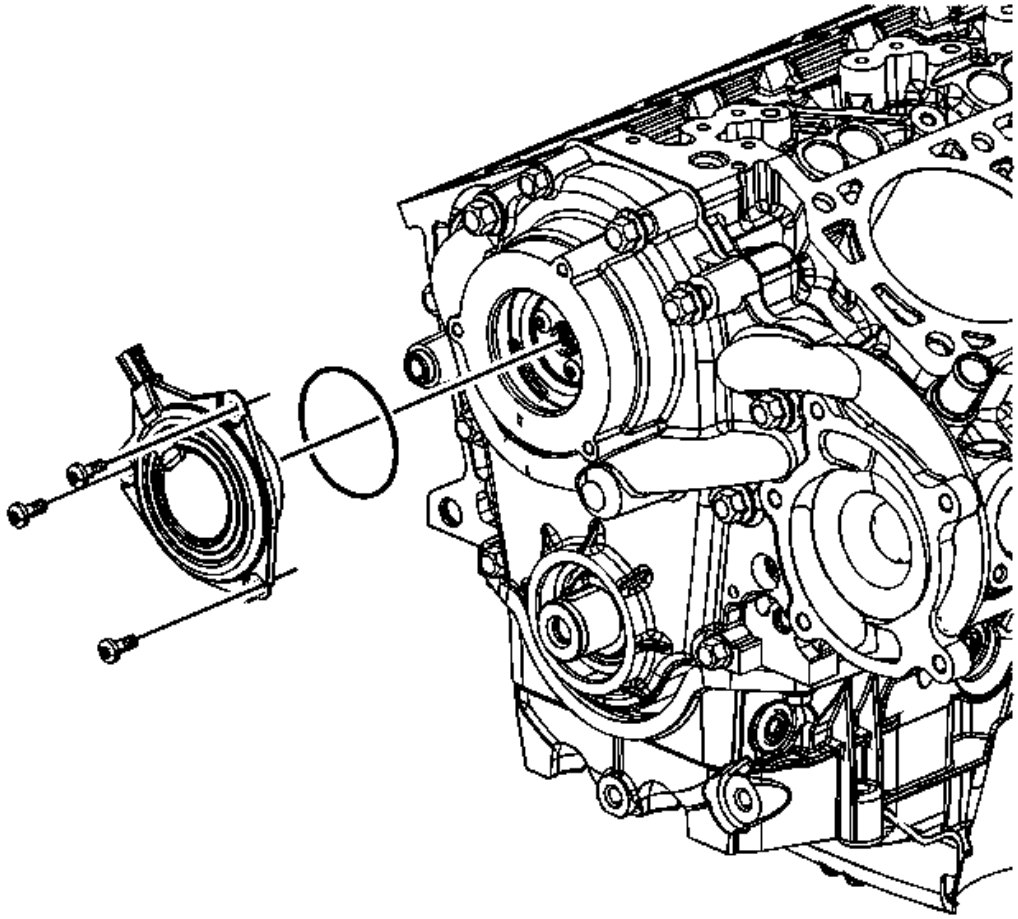

Fig. 199: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

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

   NOTE: Refer to Fastener Notice .

2. Install the camshaft position actuator magnet bolts.

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

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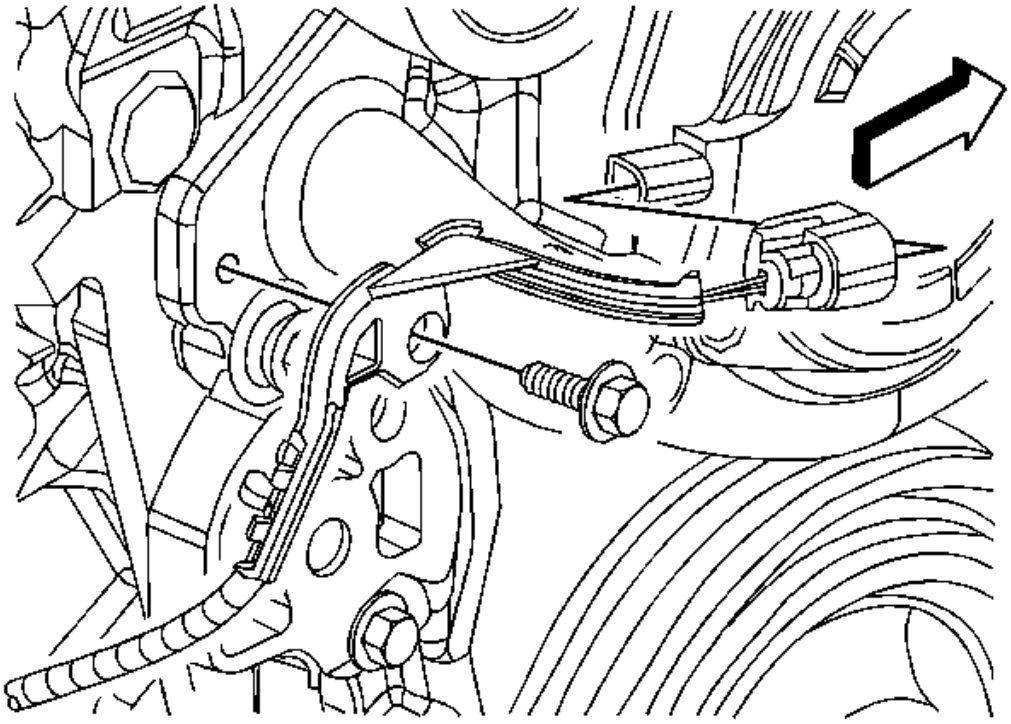

Fig. 200: Locating Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect the engine harness electrical connector to the camshaft position actuator magnet.
4. Install the washer solvent container. Refer to **Washer Solvent Container Replacement** .
5. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Engine Front Cover Replacement

Removal Procedure

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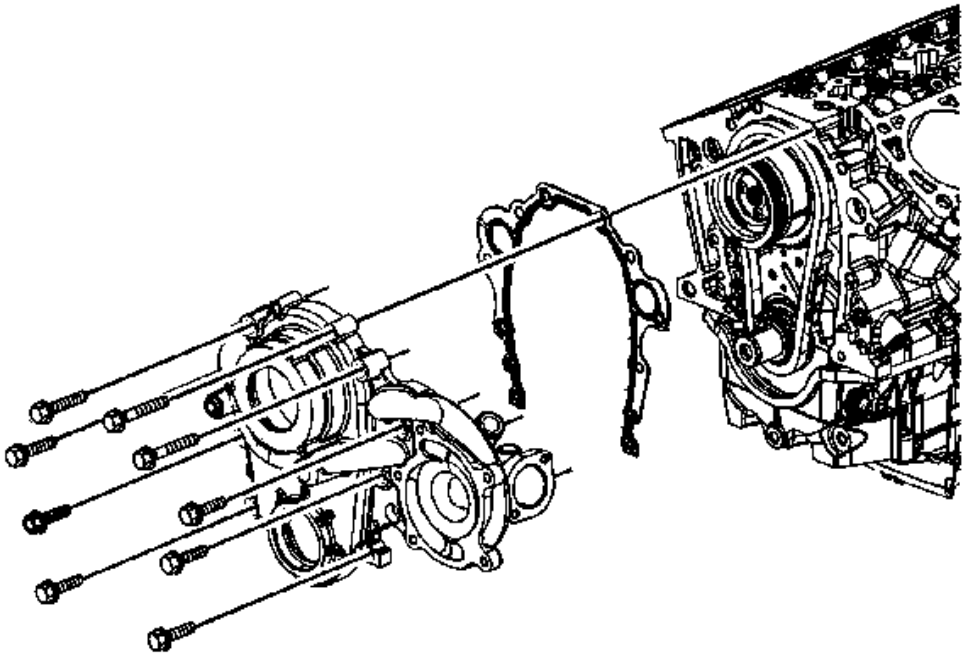

Fig. 201: Identifying Engine Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)**
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 camshaft position actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.
6. Remove the thermostat housing. Refer to **Engine Coolant Thermostat Housing Replacement** .
7. Remove the water pump. Refer to **Water Pump Replacement** .
8. Remove the engine front cover bolts.
9. Remove the engine front cover.
10. Remove the engine front cover gasket.

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Installation Procedure

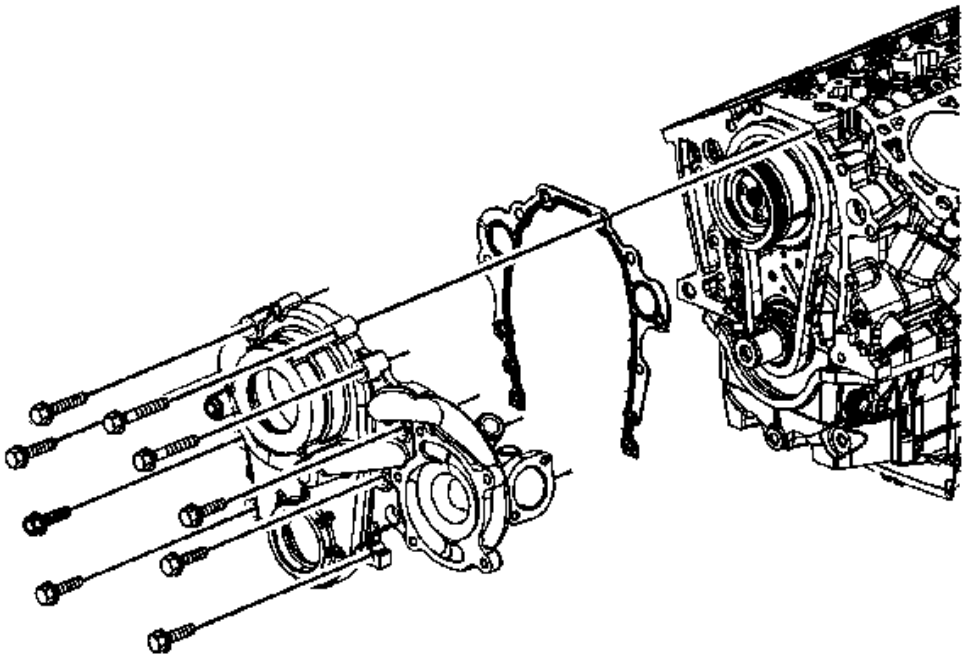

Fig. 202: Identifying Engine Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Position the engine front cover gasket to the engine block.
2. Install the engine front cover.

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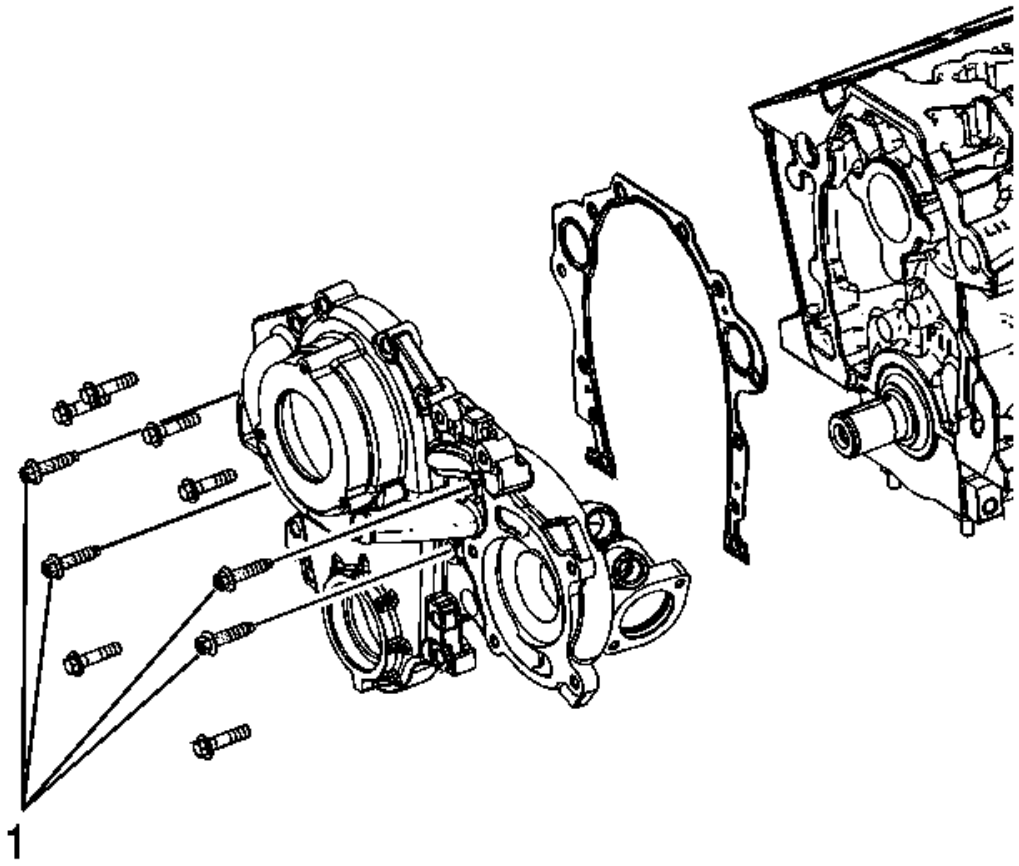

Fig. 203: Identifying Bolts Requiring Sealer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply sealer 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.

3. Install the engine front cover bolts.

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

4. Install the water pump. Refer to **Water Pump Replacement** .
5. Install the thermostat housing. Refer to **Engine Coolant Thermostat Housing Replacement** .
6. Install the camshaft position actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.
7. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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8. Install the oil pan. Refer to **Oil Pan Replacement**.
9. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
10. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .

Timing Chain and Sprockets Replacement

Tools Required

EN-47719 Tensioner Compressor. See **Special Tools**.

Removal Procedure

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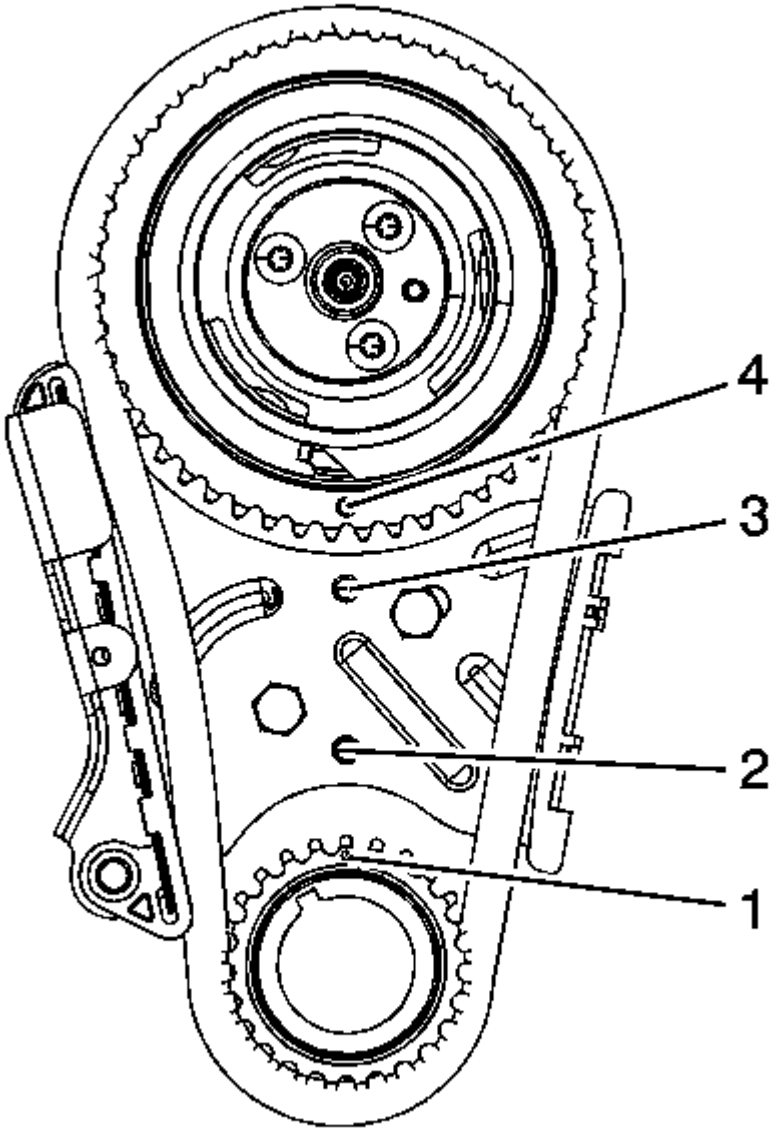

Fig. 204: Identifying Timing Marks & Tensioner
Courtesy of GENERAL MOTORS CORP.

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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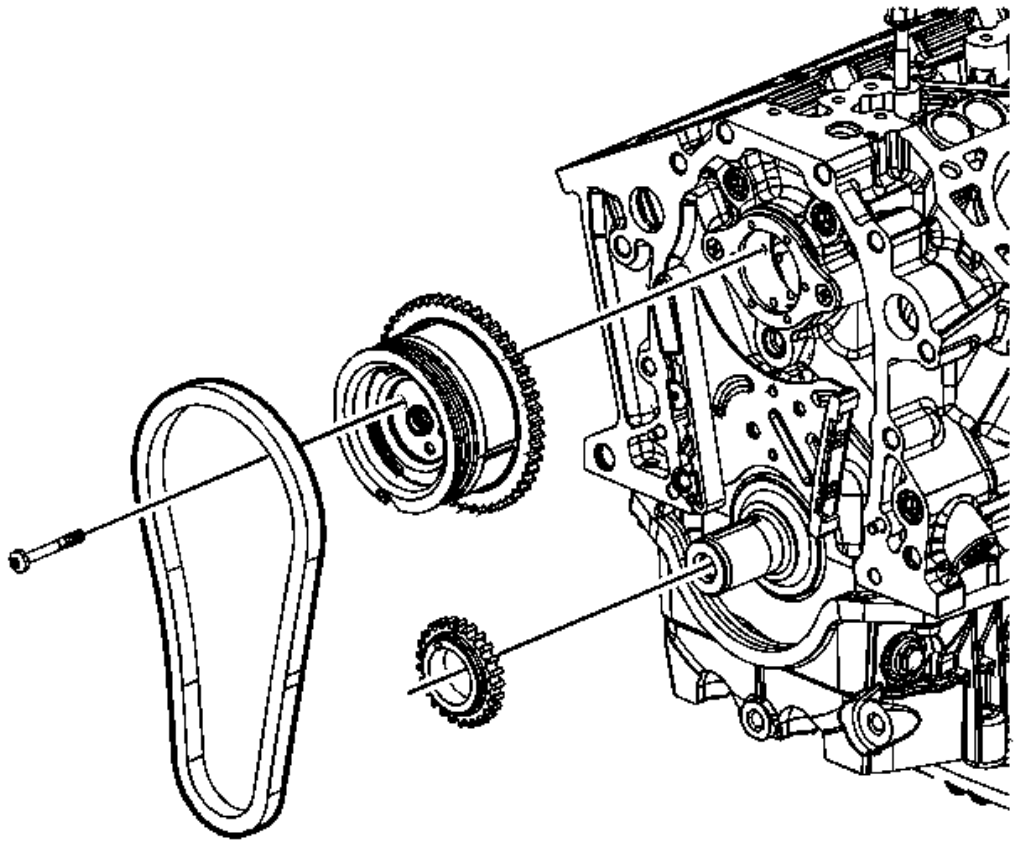

Fig. 205: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

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

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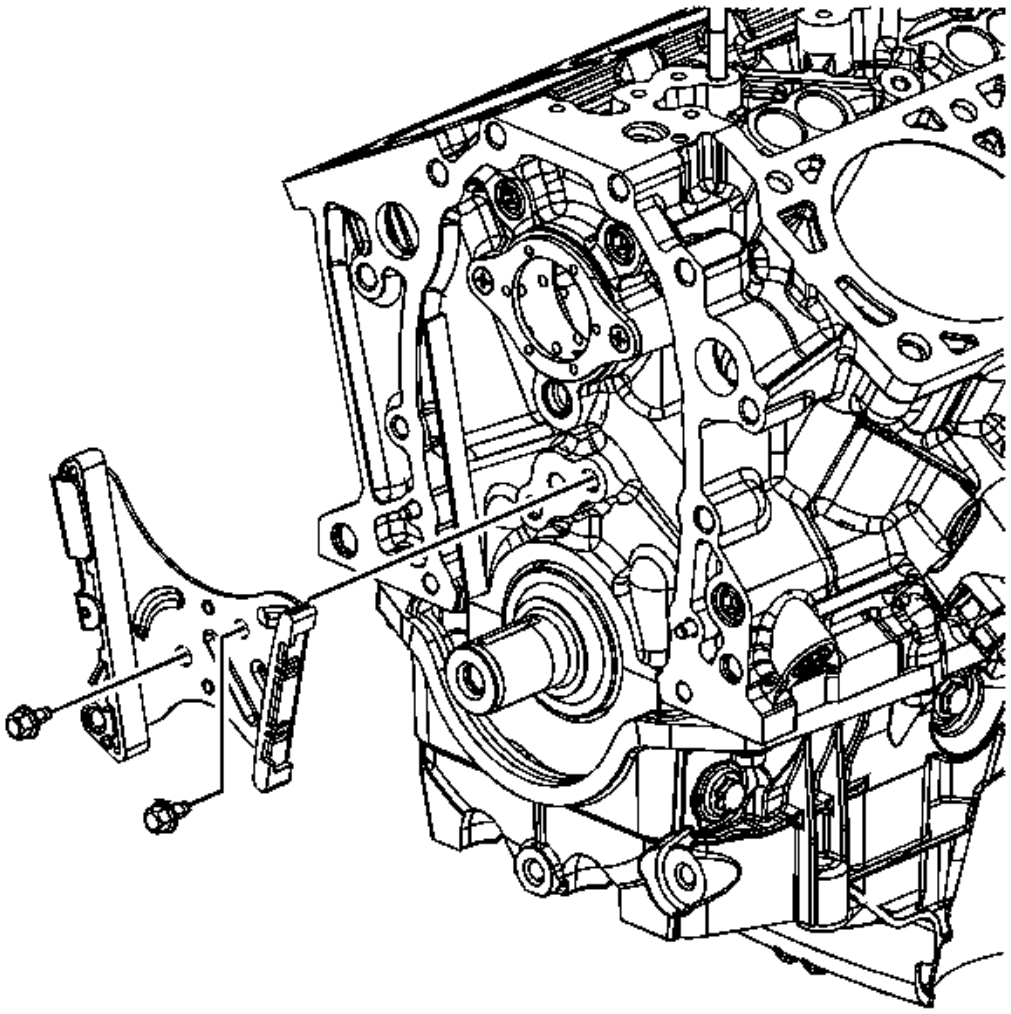

Fig. 206: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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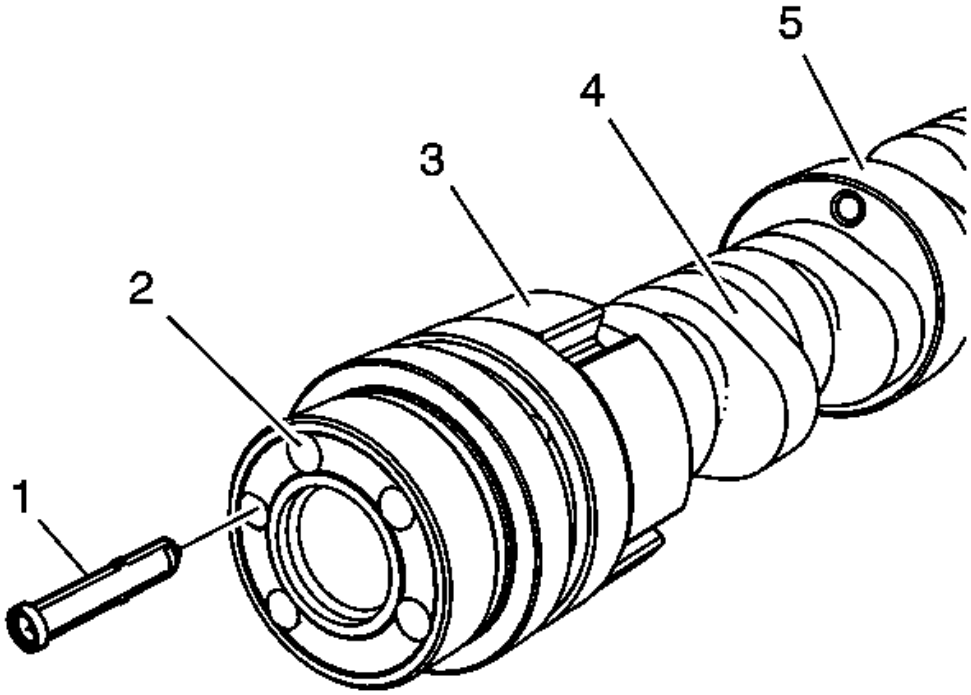

Fig. 207: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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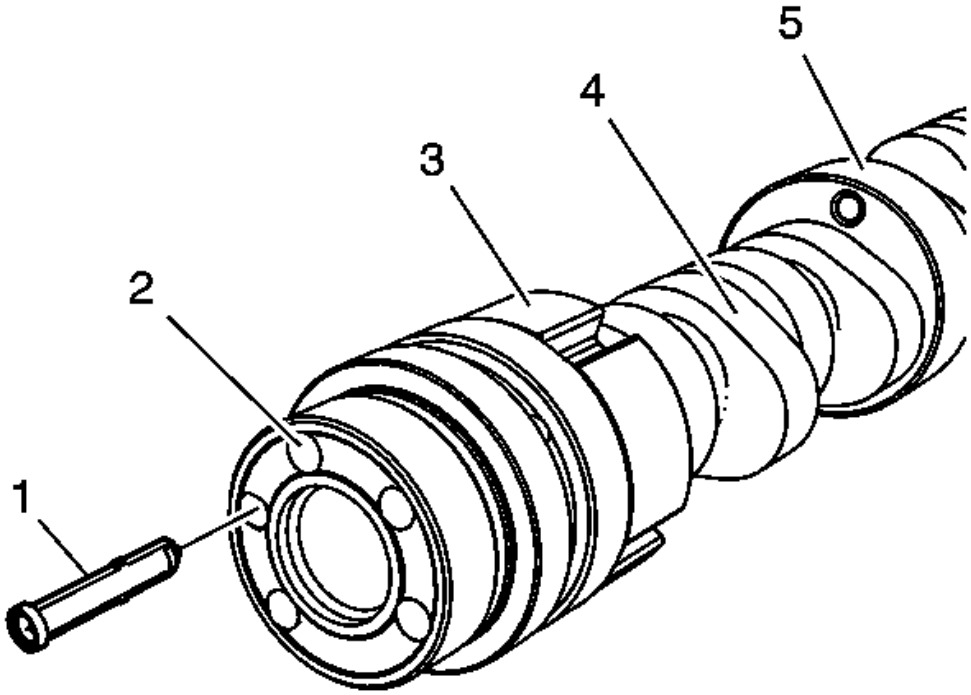

Fig. 208: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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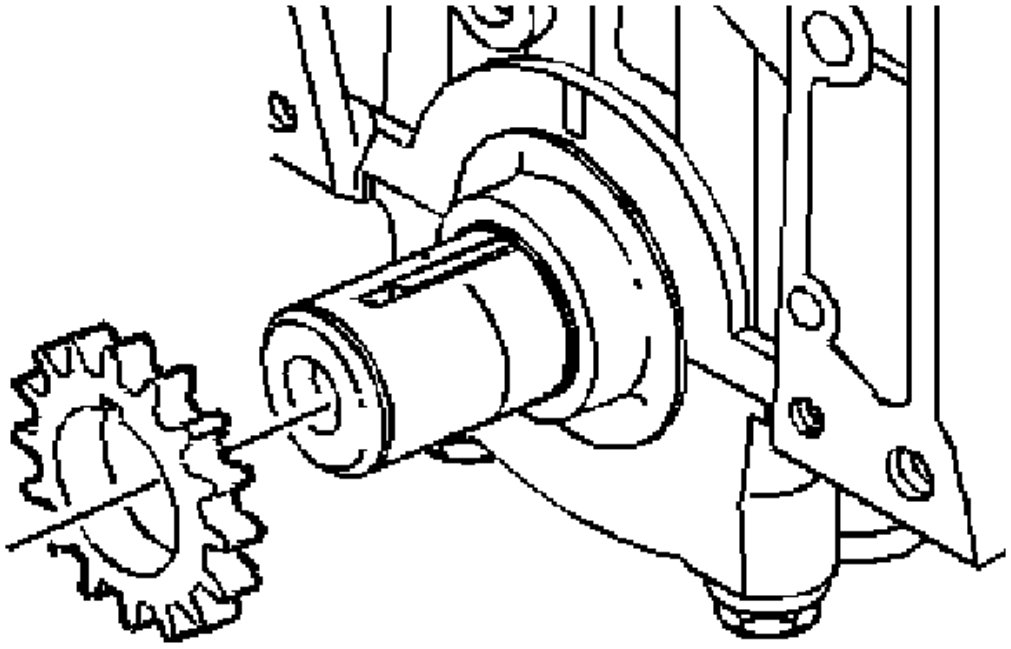

Fig. 209: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

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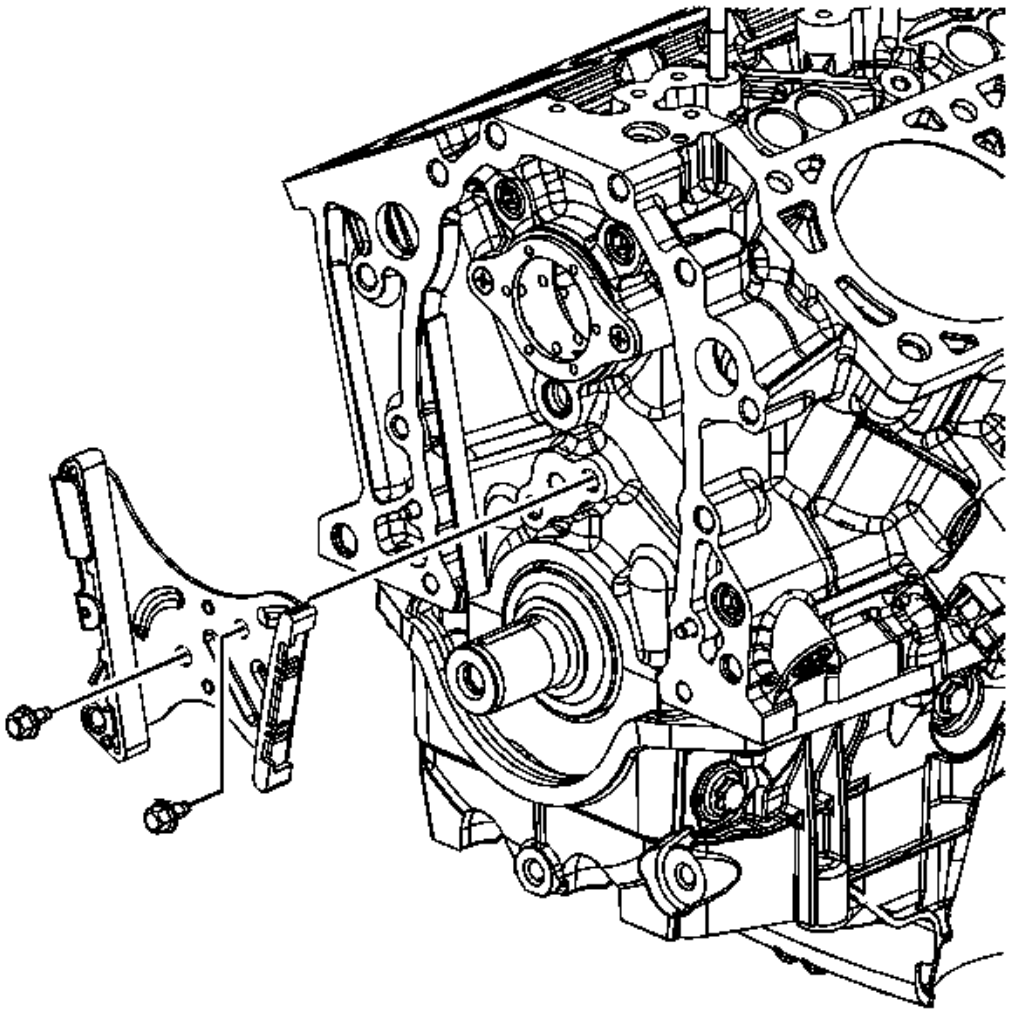

Fig. 210: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the timing chain tensioner.
5. Install the timing chain tensioner bolts.

Tighten: Tighten the bolts 21 N.m (15 lb ft).

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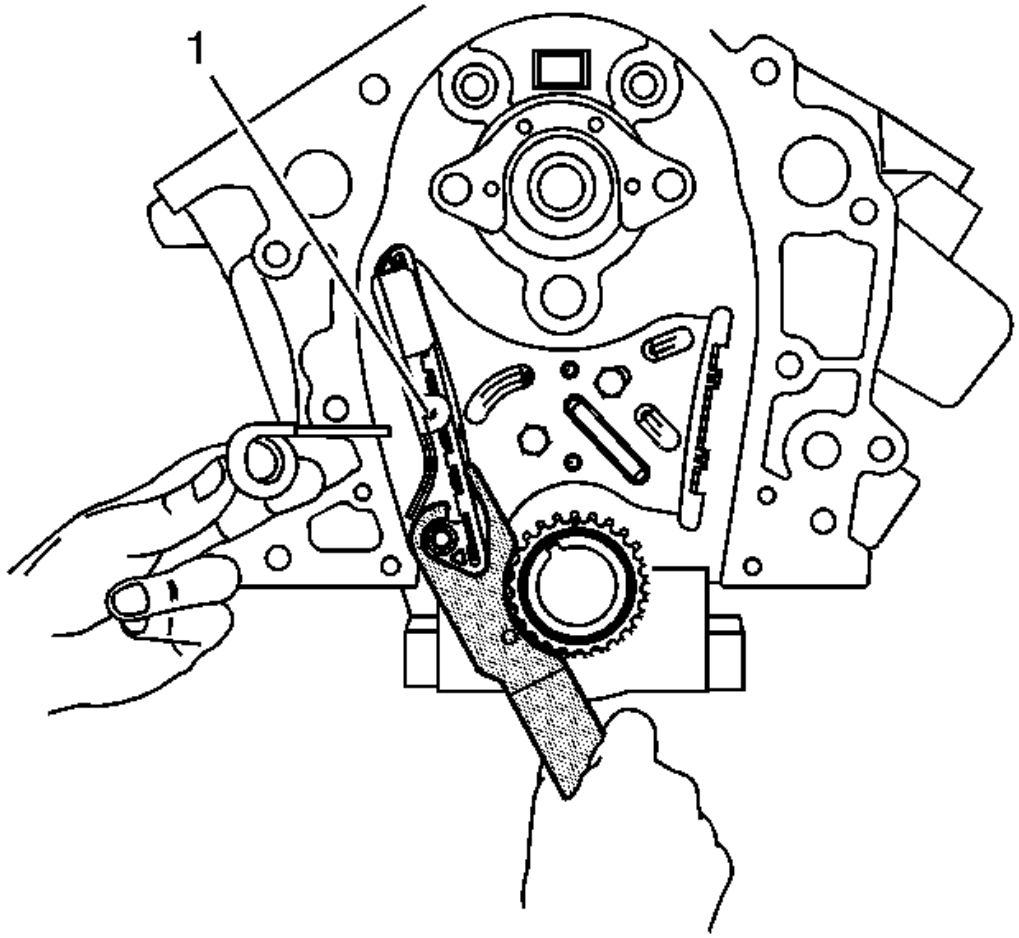

Fig. 211: Collapsing Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Using the **EN-47719** , fully collapse the tensioner, and place the tensioner retaining pin into the retaining hole (1). See **Special Tools**.

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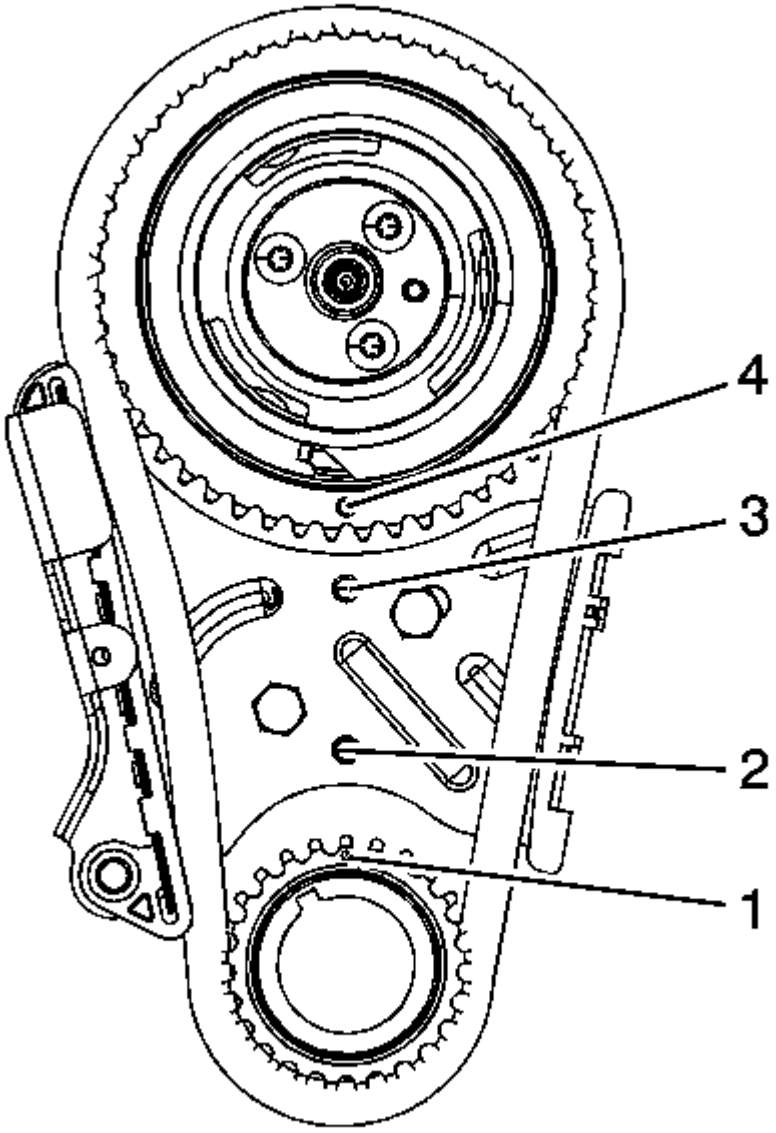

Fig. 212: Identifying Timing Marks & Tensioner
Courtesy of GENERAL MOTORS CORP.

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).

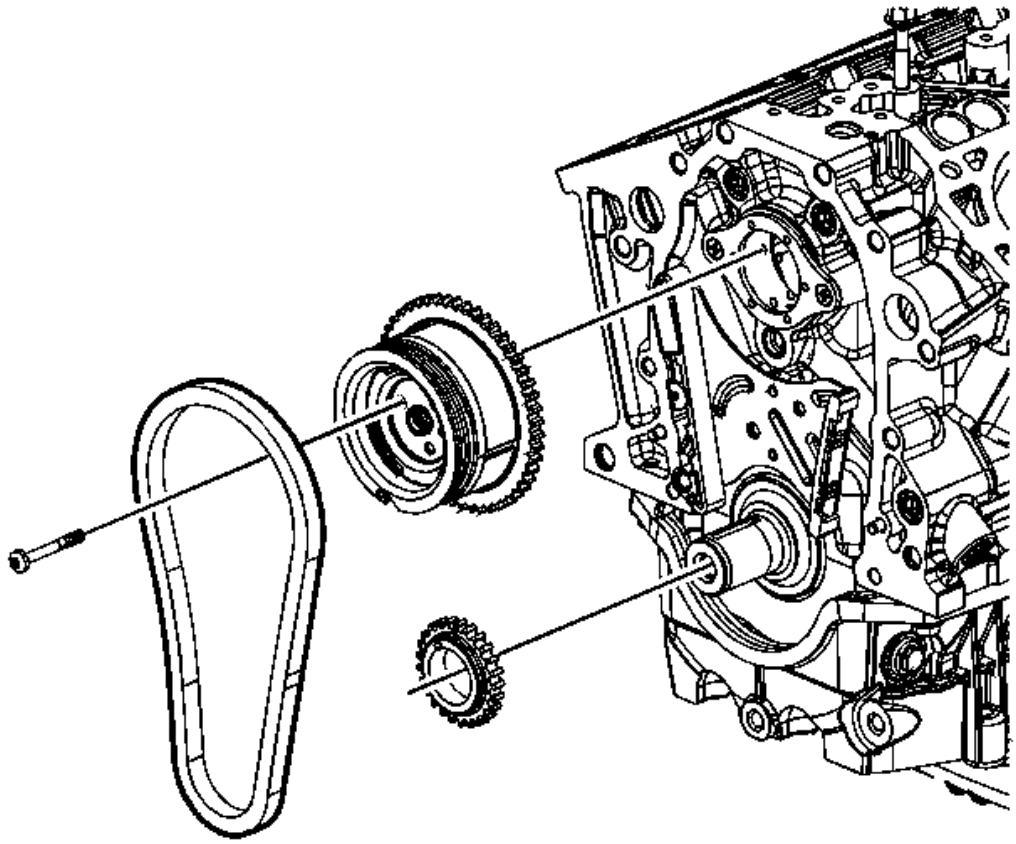

Fig. 213: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

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: Tighten the bolts 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

Tools Required

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

Removal Procedure

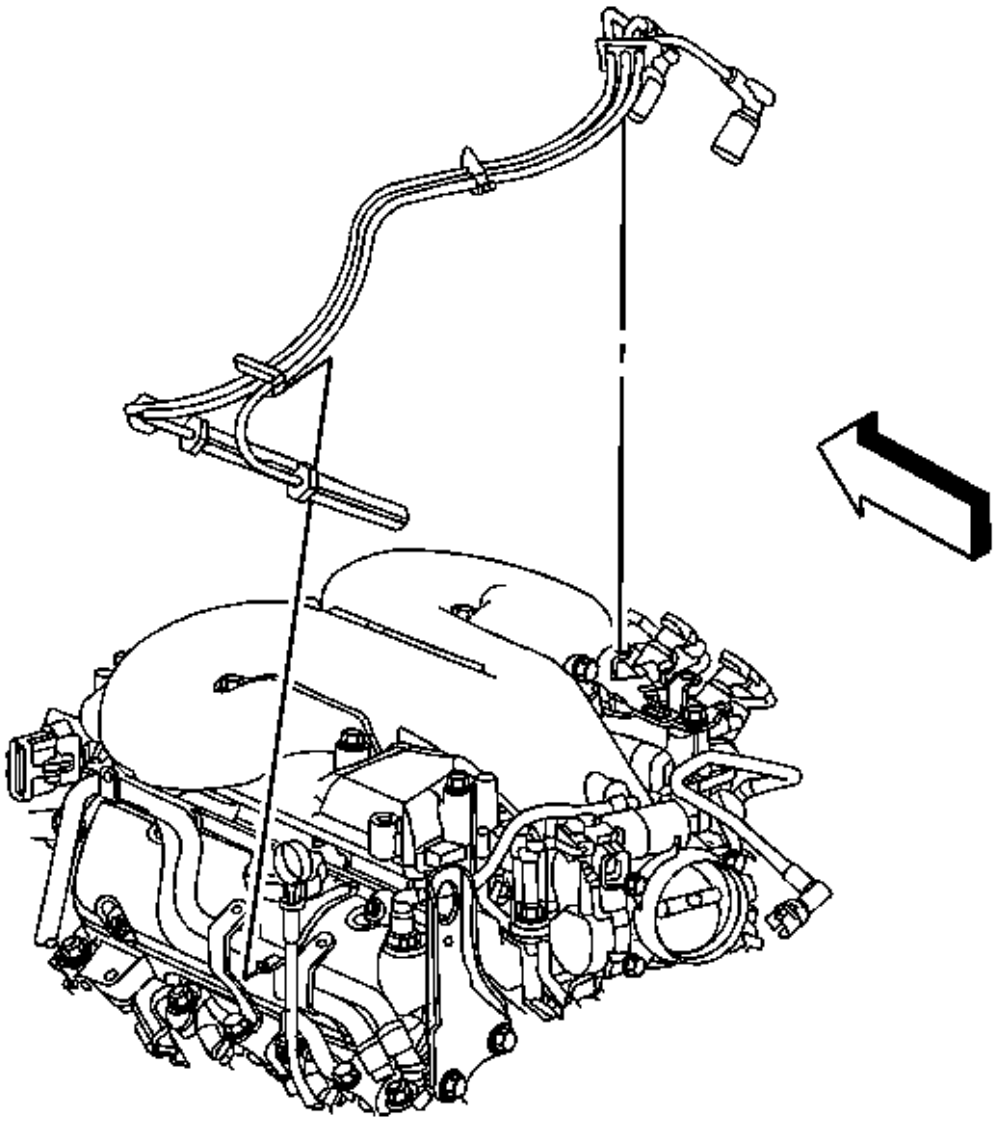

Fig. 214: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

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

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2. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
3. Lower the vehicle.
4. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
5. Remove the exhaust crossover pipe. Refer to **Exhaust Crossover Pipe Replacement** .
6. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.

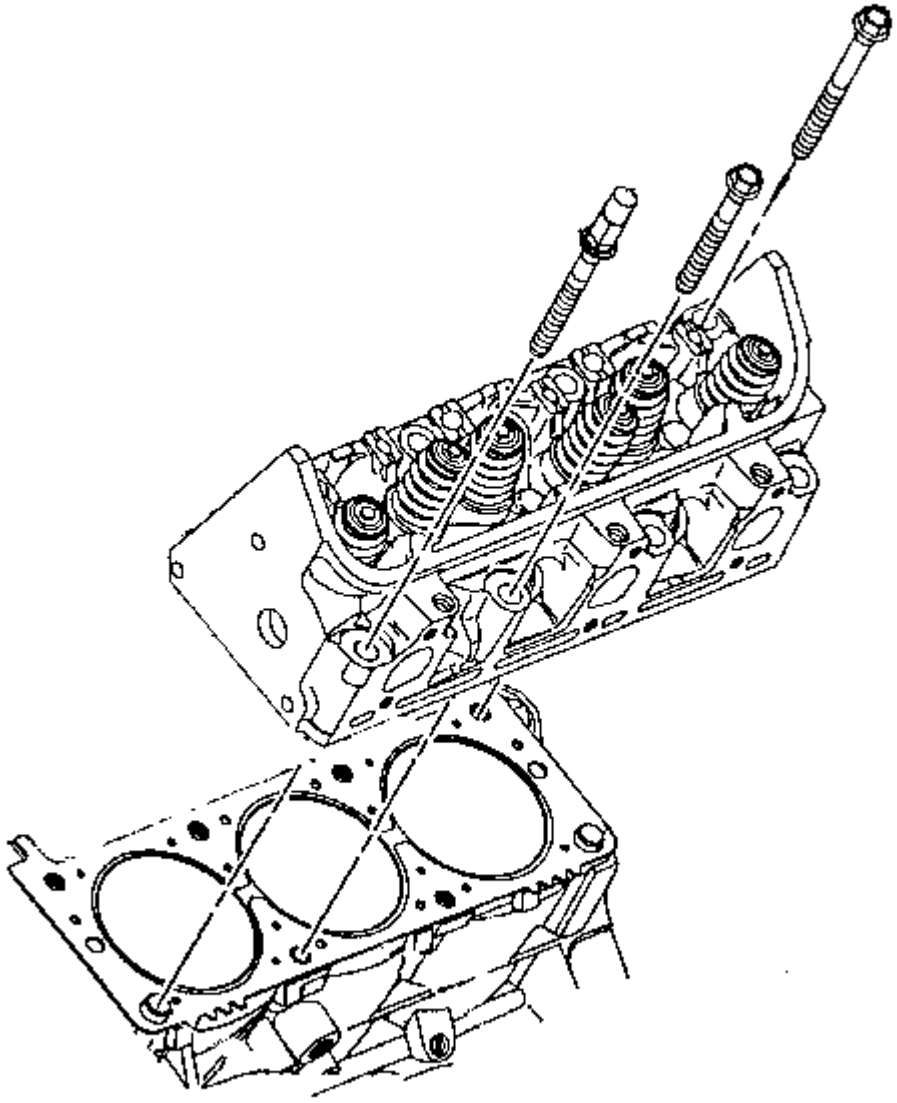

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Fig. 215: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Remove the left spark plugs. Refer to **Spark Plug Replacement** .
8. Remove and discard the cylinder head bolts.
9. Remove the cylinder head.

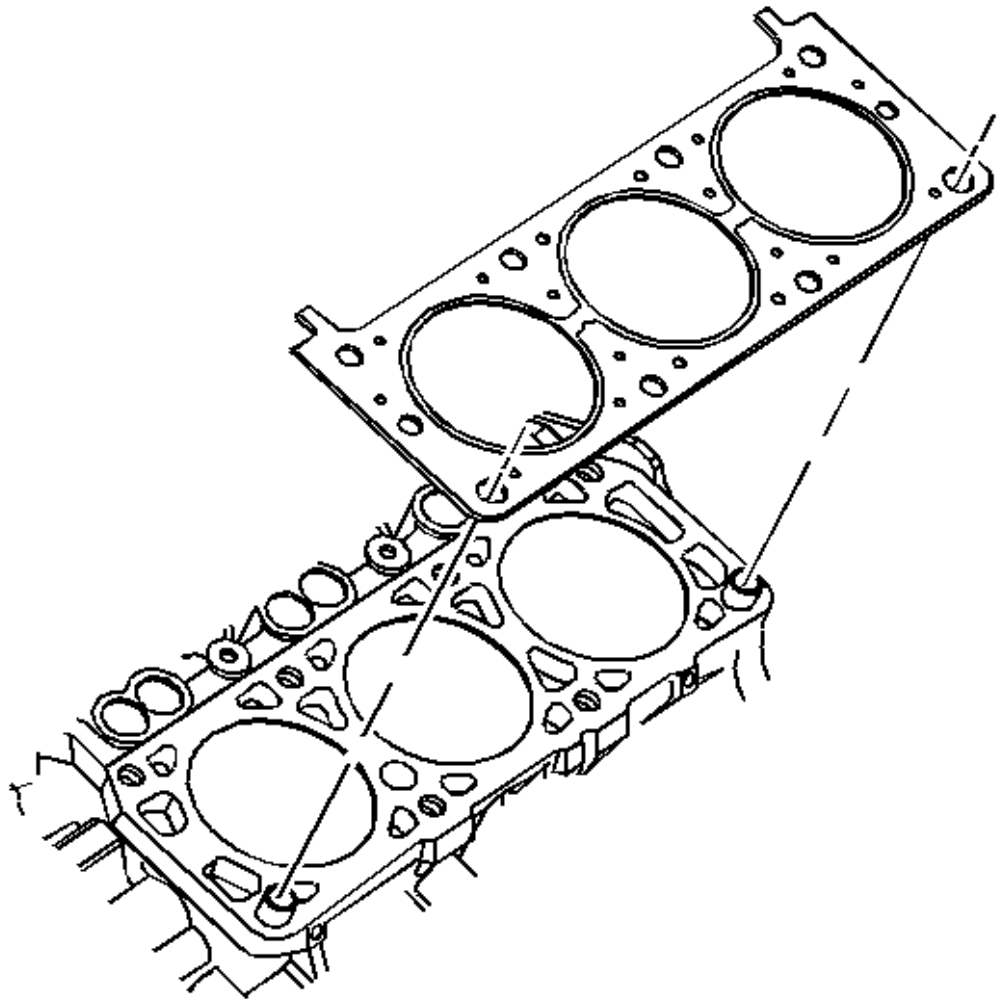

Fig. 216: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the cylinder head gasket.

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11. Remove the cylinder head dowel pins, if necessary.

Installation Procedure

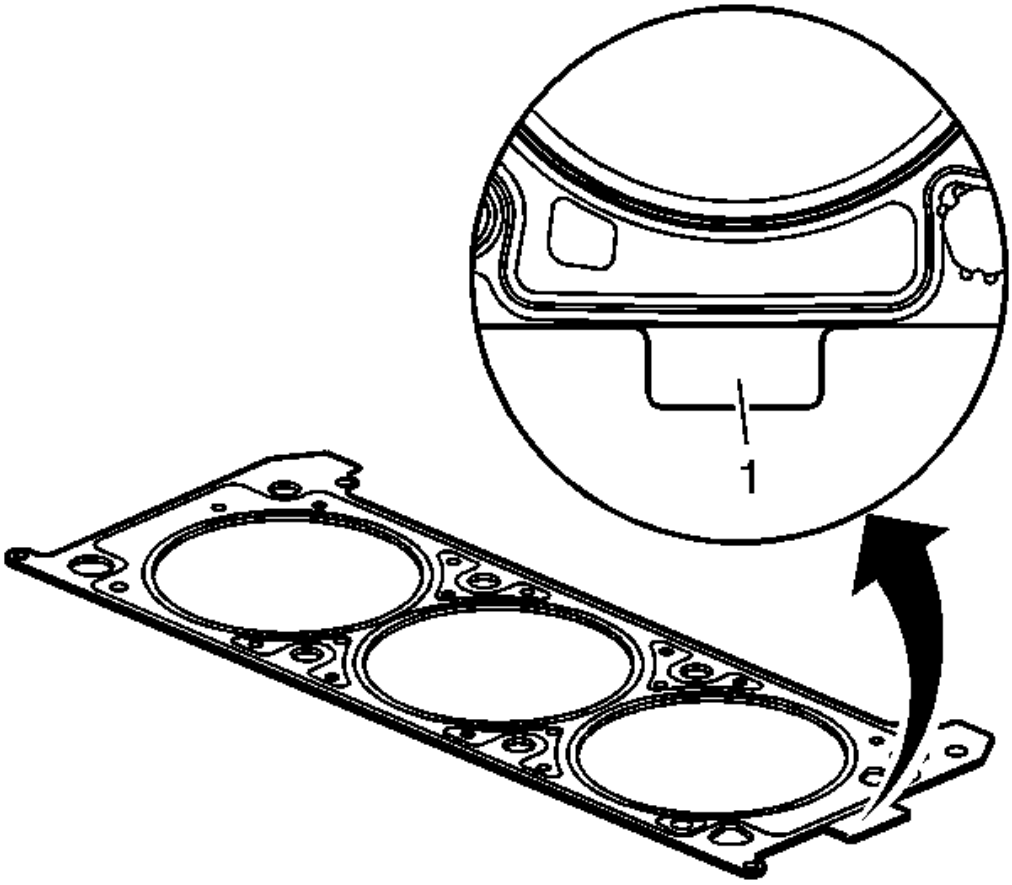

Fig. 217: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Clean the gasket mating surfaces.
2. Install the spark plugs to the cylinder head.
3. Install the cylinder head locator dowel pins, if necessary.

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4. Inspect the cylinder head locator dowel pins for proper installation.

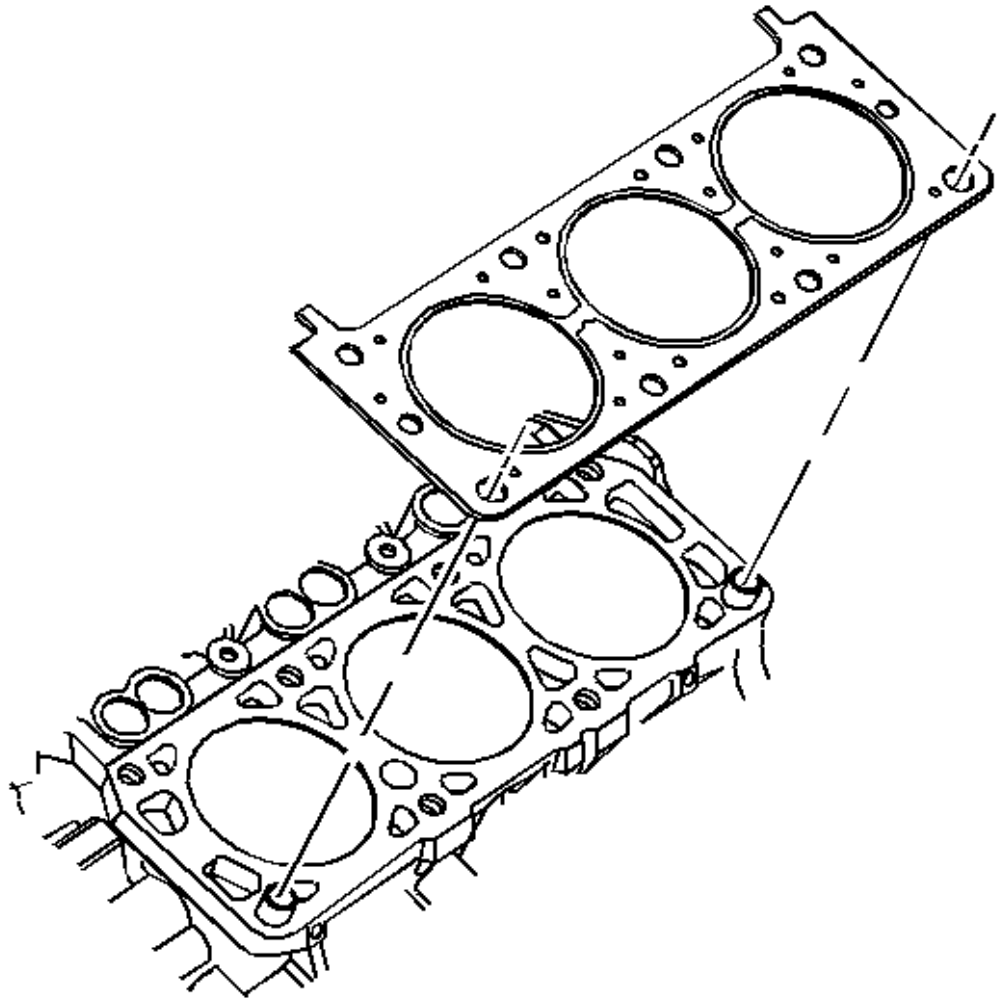

Fig. 218: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

5. Install a NEW cylinder head gasket.

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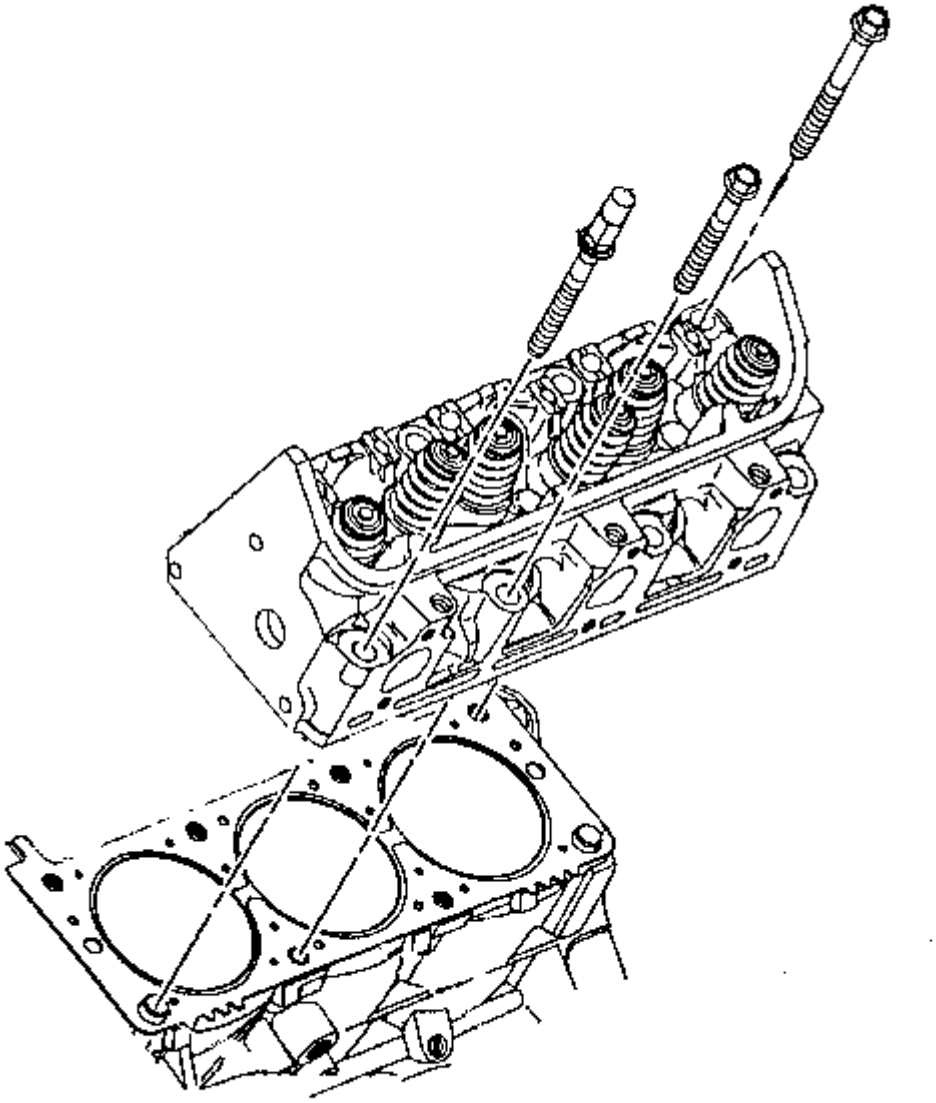

Fig. 219: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Install the cylinder head onto the locator pins and the engine.

NOTE: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt

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torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

7. Install the NEW cylinder head bolts finger tight.

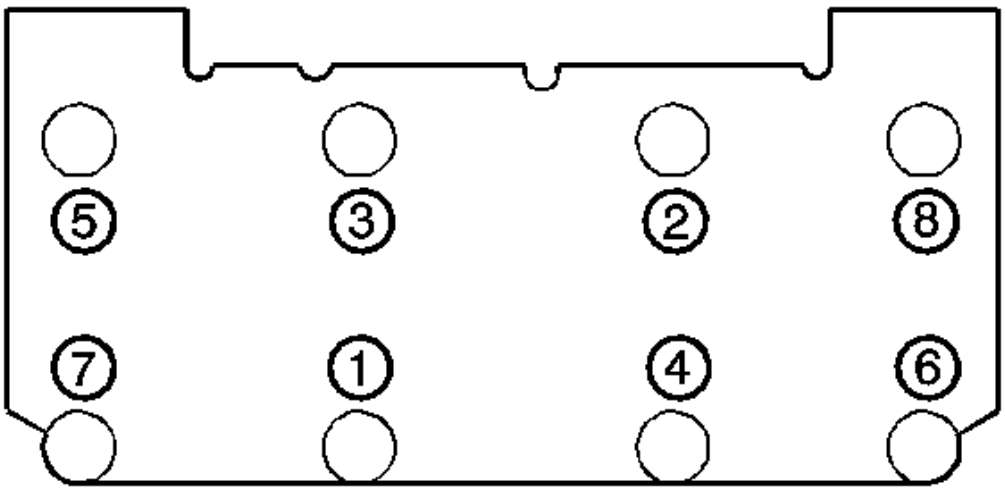

Fig. 220: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the cylinder head bolts.

   Tighten: Tighten the bolts in sequence to 60 N.m (44 lb ft) plus an additional 95 degrees using the **J 45059** . See **Special Tools**.

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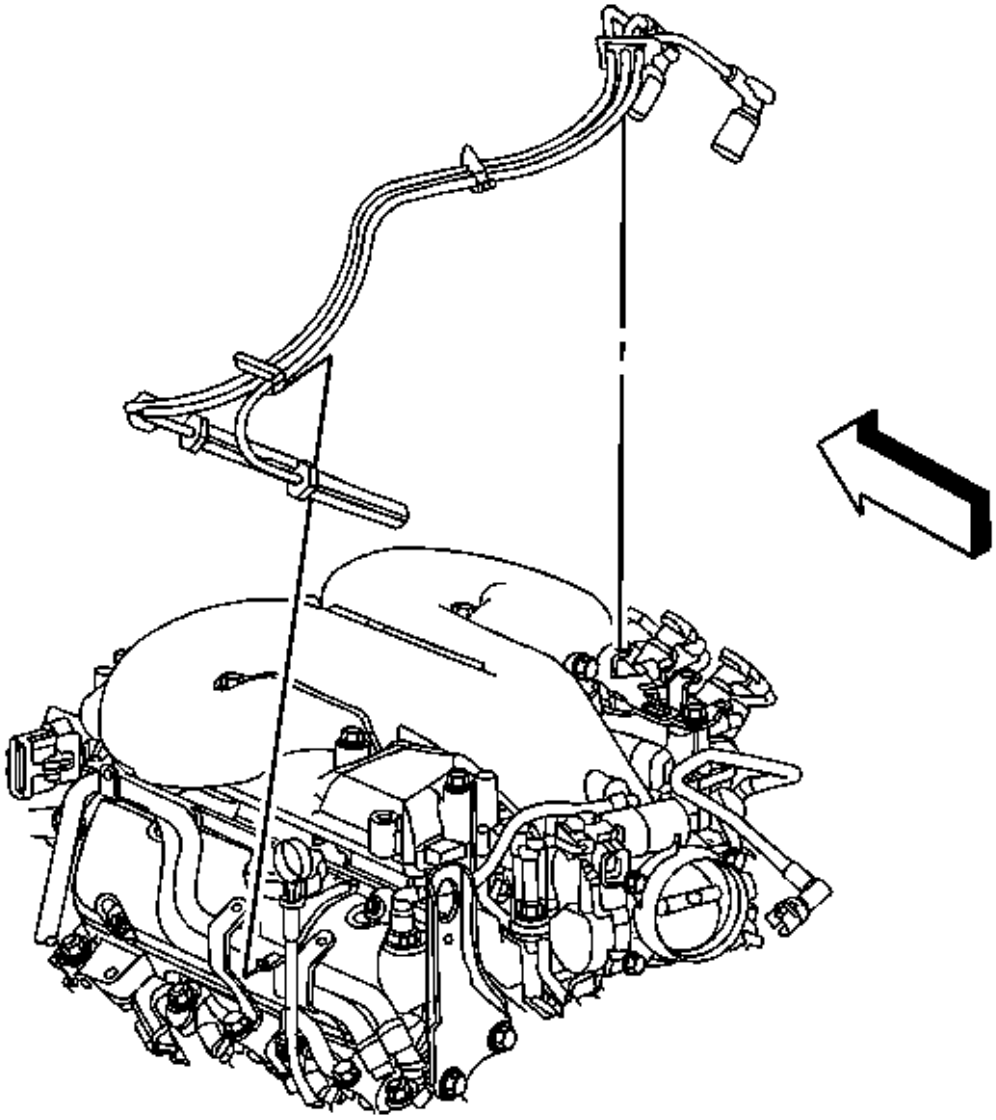

Fig. 221: View Of Left Spark Plug/Coil Harness
Courtesy of GENERAL MOTORS CORP.

9. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
10. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side** .
11. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
12. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.

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13. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
14. Inspect for leaks.

Cylinder Head Replacement - Right Side

Tools Required

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

Removal Procedure

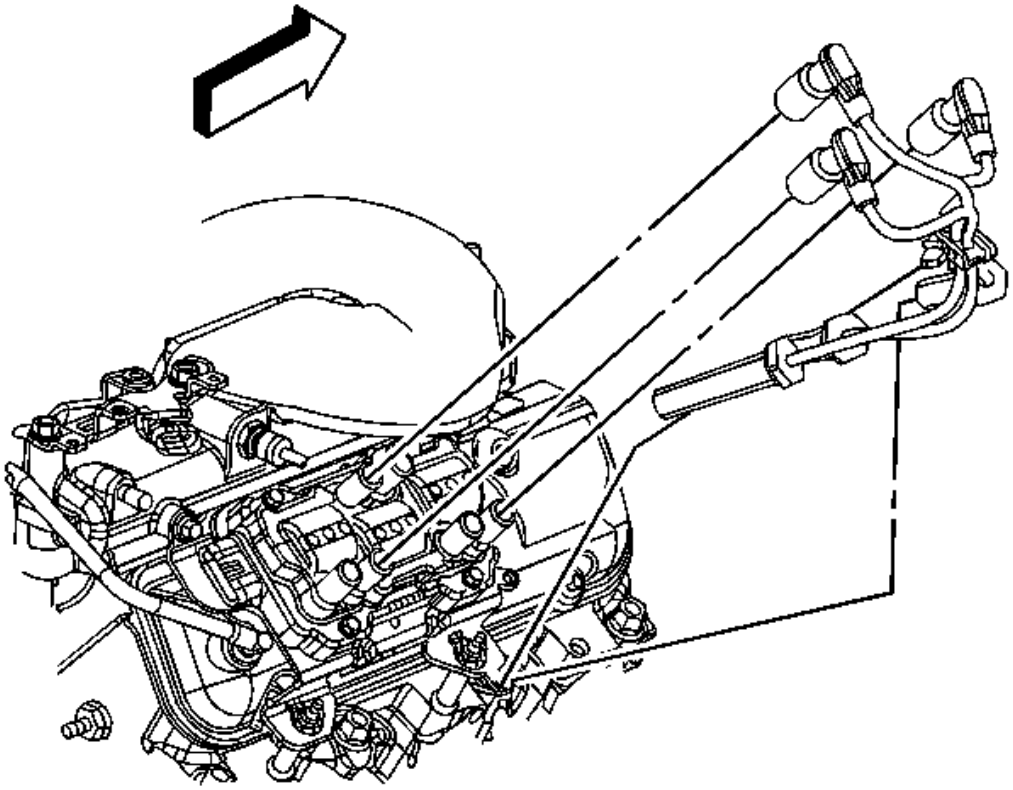

Fig. 222: View Of Spark Plug Wire Assembly
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

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3. Lower the vehicle.
4. Remove the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
5. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .

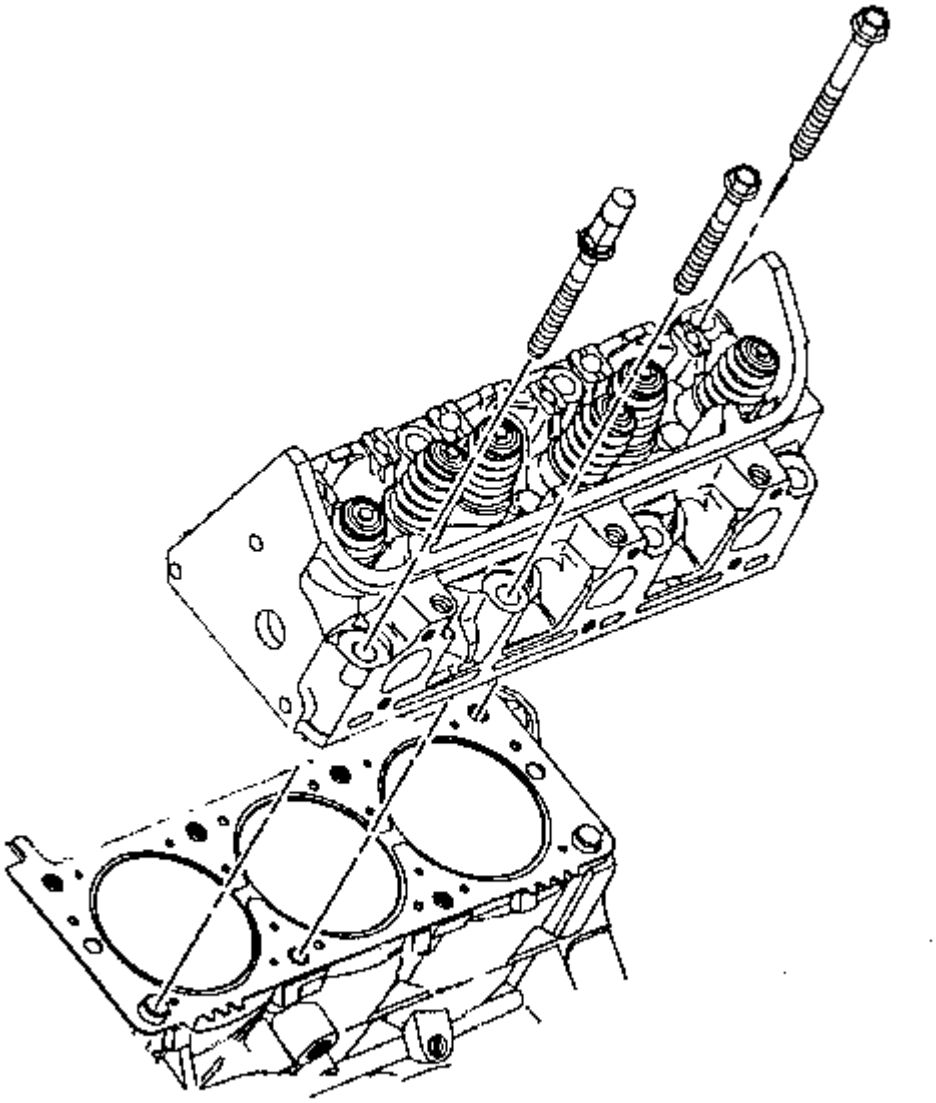

Fig. 223: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Remove the right spark plugs. Refer to **Spark Plug Replacement** .

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7. Remove and discard cylinder head bolts.
8. Remove the cylinder head.

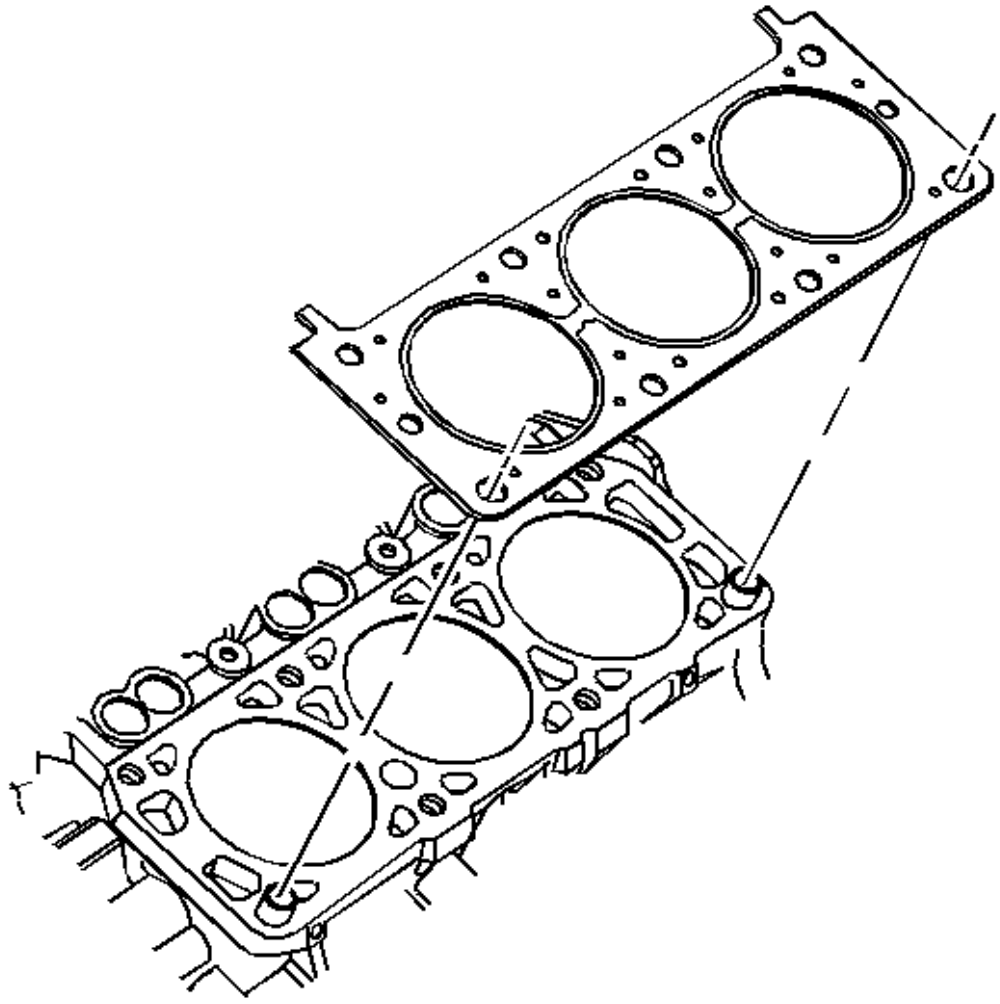

Fig. 224: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the cylinder head gasket.
10. Remove the cylinder head locator dowel pins, if necessary.

Installation Procedure

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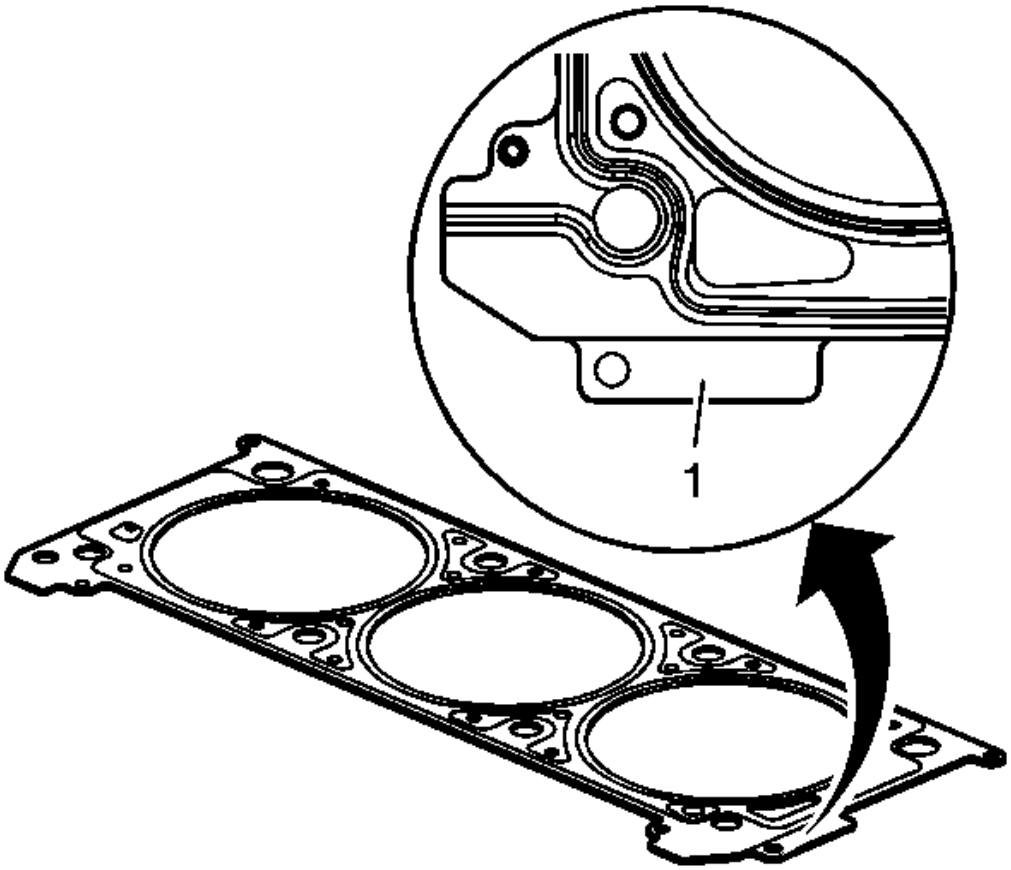

Fig. 225: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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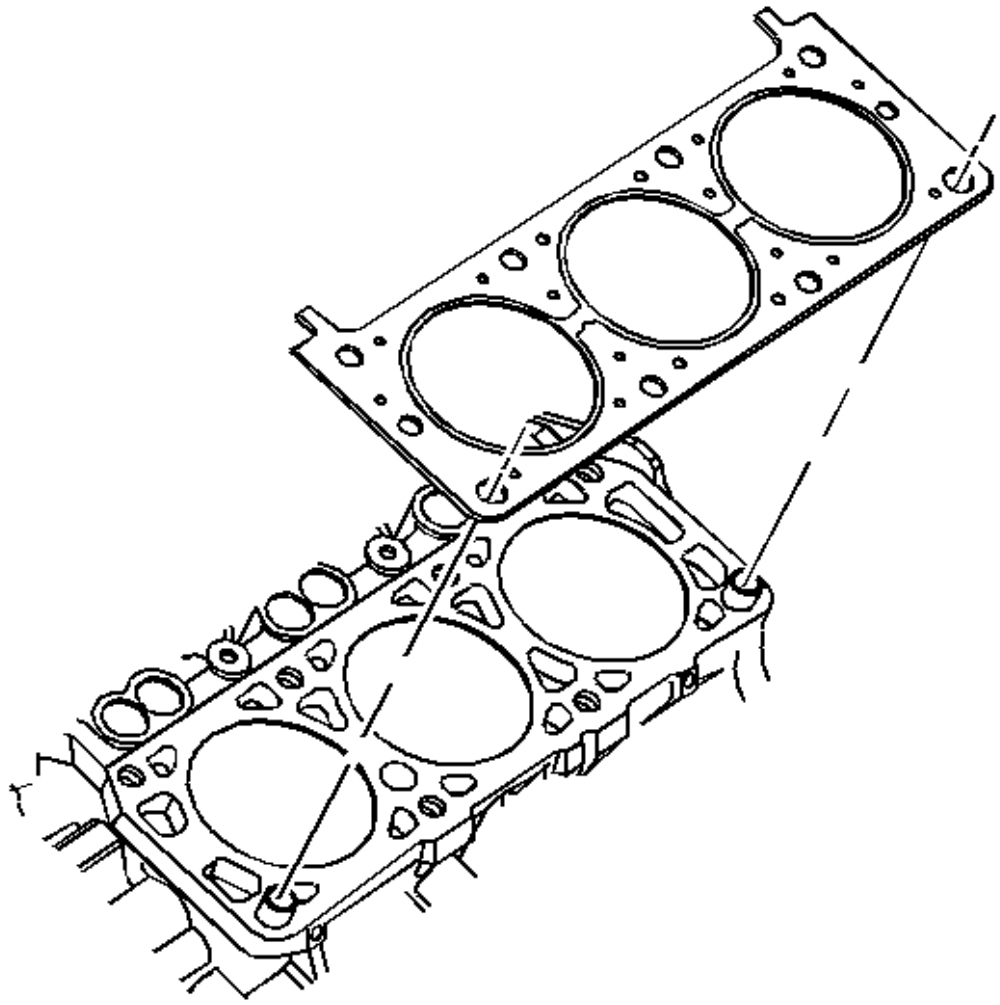

Fig. 226: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW cylinder head gasket.

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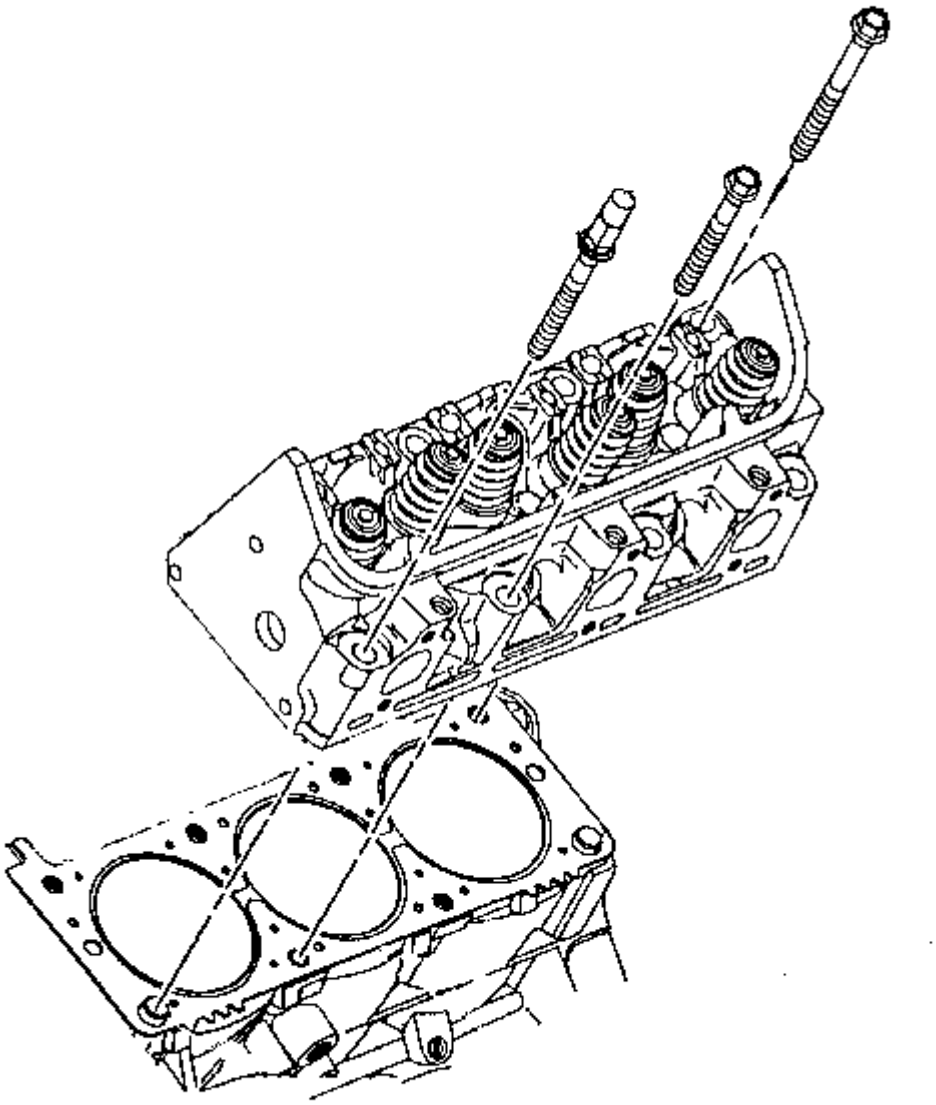

Fig. 227: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the spark plugs. Refer to **Spark Plug Replacement** .
5. Install the cylinder head onto the locator pins and the engine.

NOTE: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be

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installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

6. Install NEW cylinder head bolts finger tight.

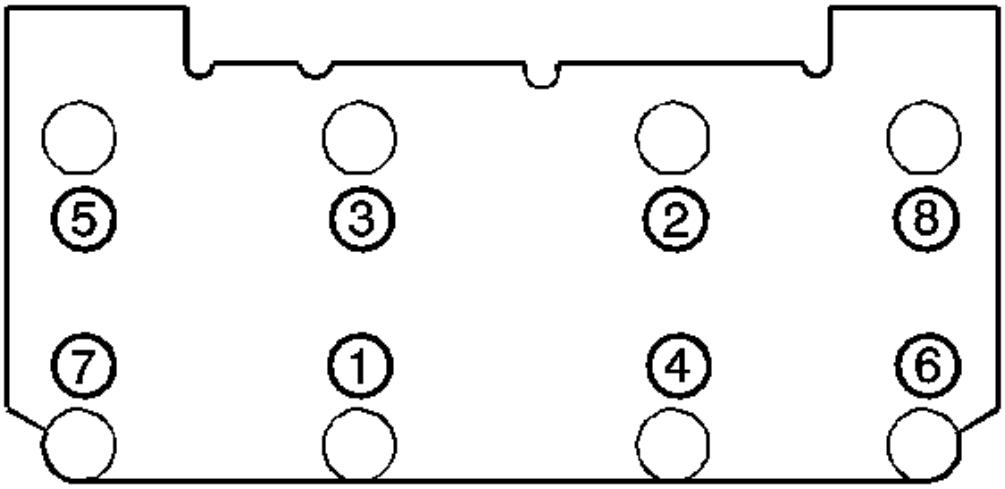

Fig. 228: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Tighten the cylinder head bolts.

Tighten: Tighten the bolts in sequence to 60 N.m (44 lb ft) plus an additional 95 degrees using the **J 45059** . See **Special Tools**.

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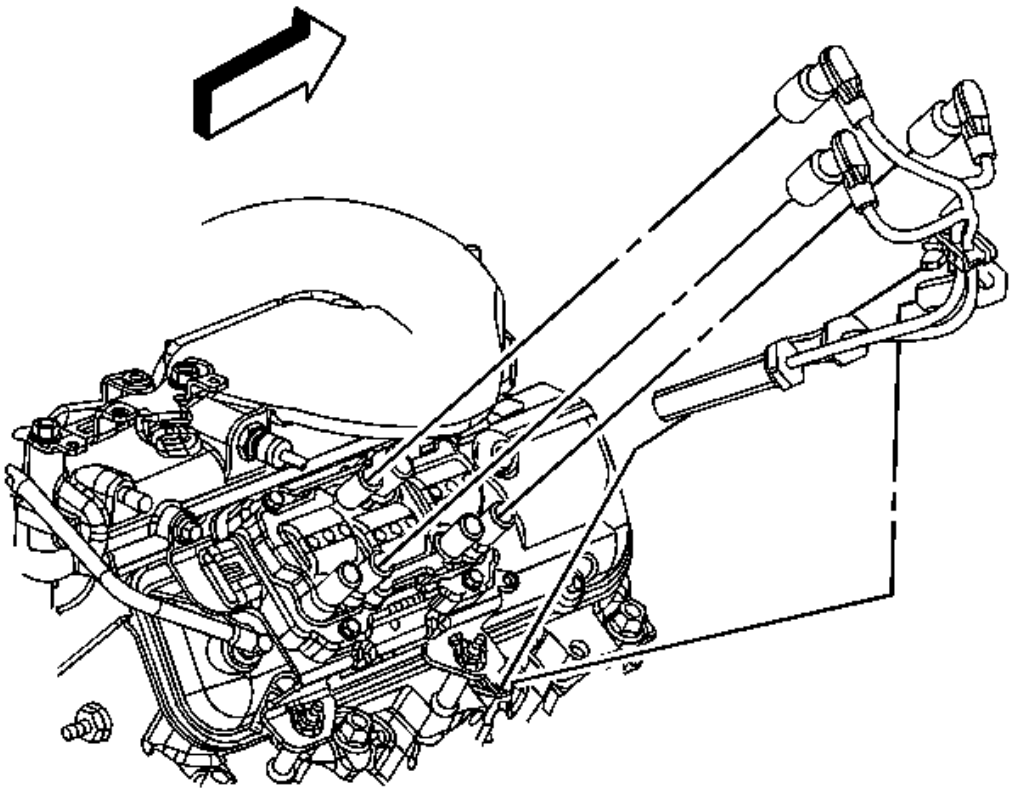

Fig. 229: View Of Spark Plug Wire Assembly
Courtesy of GENERAL MOTORS CORP.

8. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .
9. Install the lower intake manifold. Refer to **Lower Intake Manifold Replacement**.
10. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
11. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
12. Inspect for leaks.

Engine Flywheel Replacement

Tools Required

J 37096 Flywheel Holder

Removal Procedure

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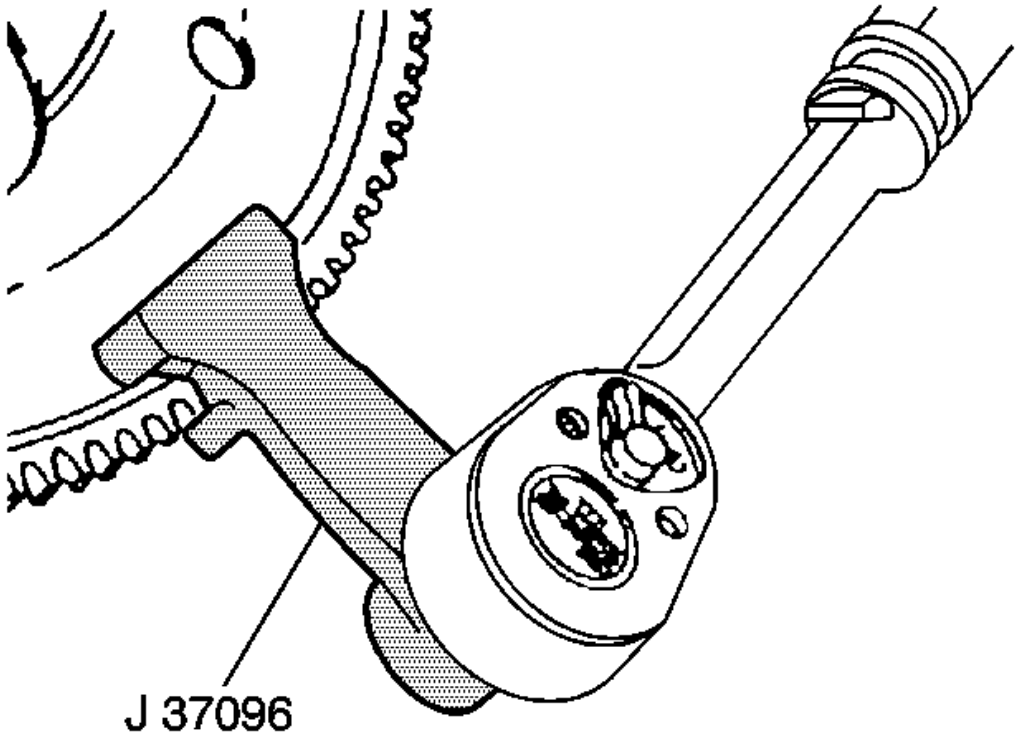

Fig. 230: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transaxle. Refer to **Transmission Replacement (M15)** .
2. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating.

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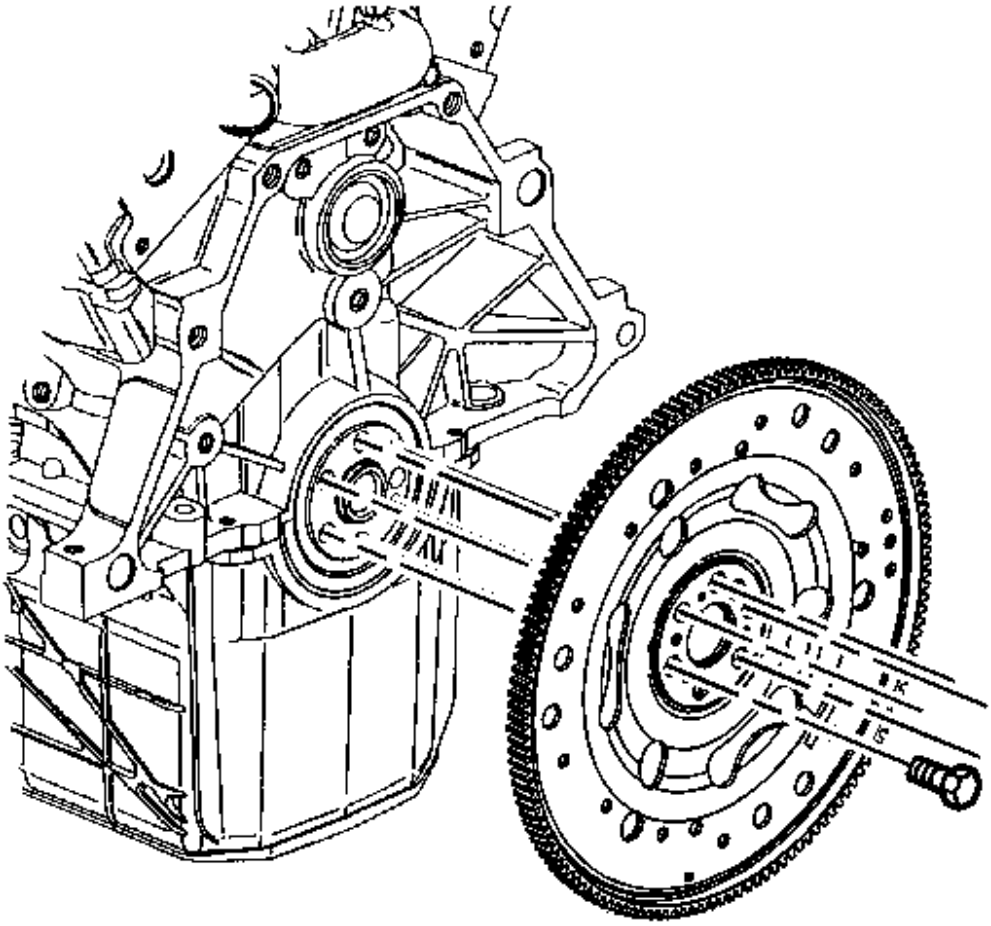

Fig. 231: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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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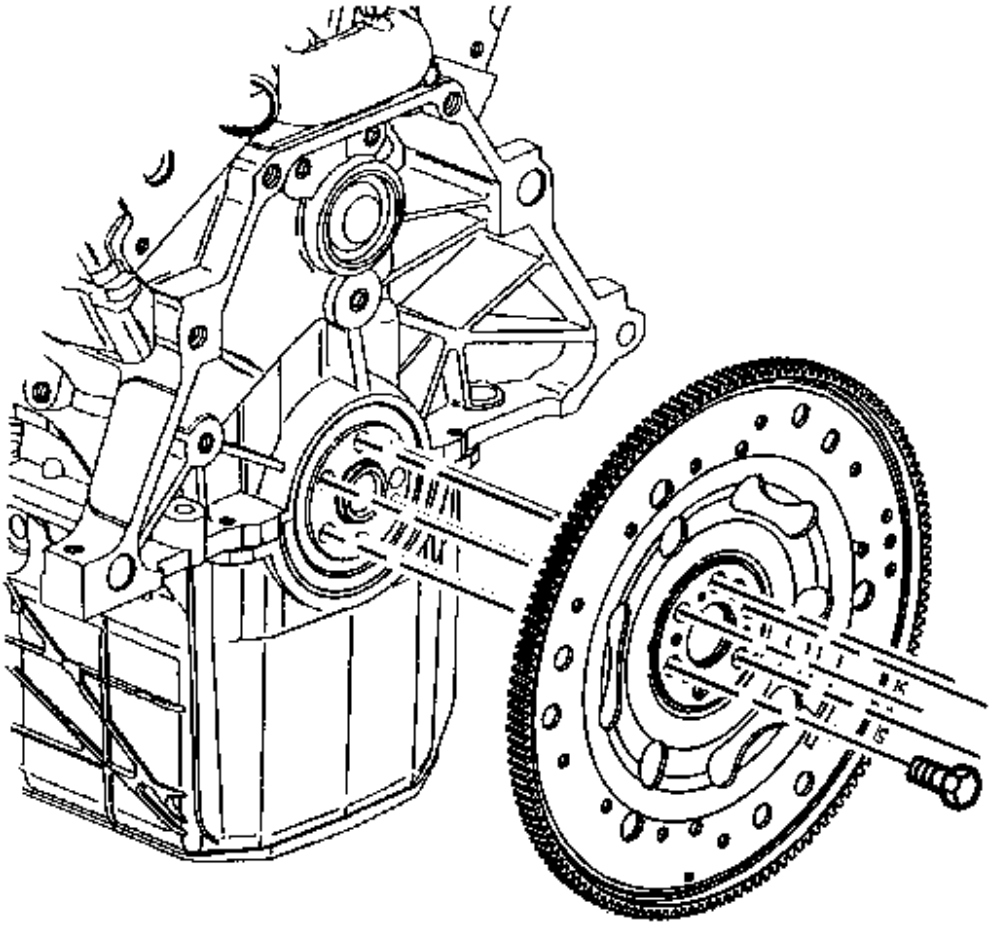

Fig. 232: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: **Refer to Fastener Notice .**

4. Tighten the flywheel bolts.

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

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5. Install the automatic transaxle. Refer to **Transmission Replacement (M15)** .

Crankshaft Rear Oil Seal Replacement

Tools Required

EN-48108 Rear Main Oil Seal Installer

Removal Procedure

IMPORTANT: Do not nick the crankshaft sealing surface when removing the seal.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the crankshaft rear main oil seal using one of the following techniques:

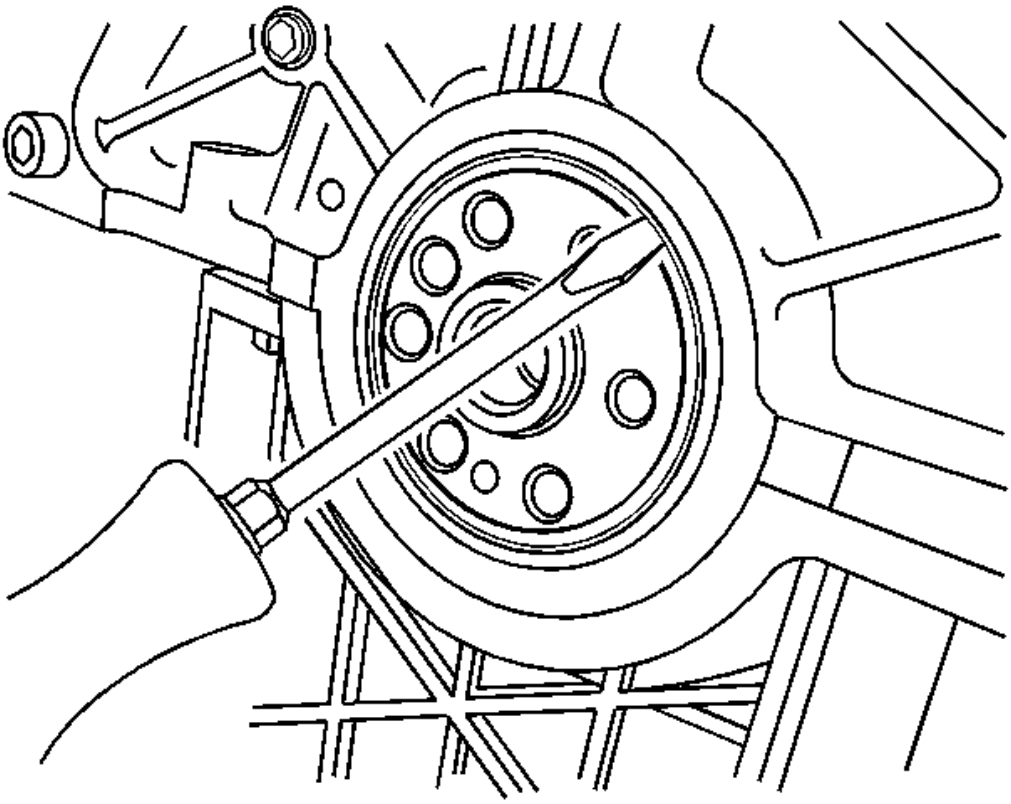

Fig. 233: View Of NEW Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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3. If removing the new style seal - seal lip facing outward, insert a flat-bladed or similar tool between the sealing lip and the outer casing of the seal at an angle, and gently pry the seal out be moving the tool towards the center of the crankshaft.

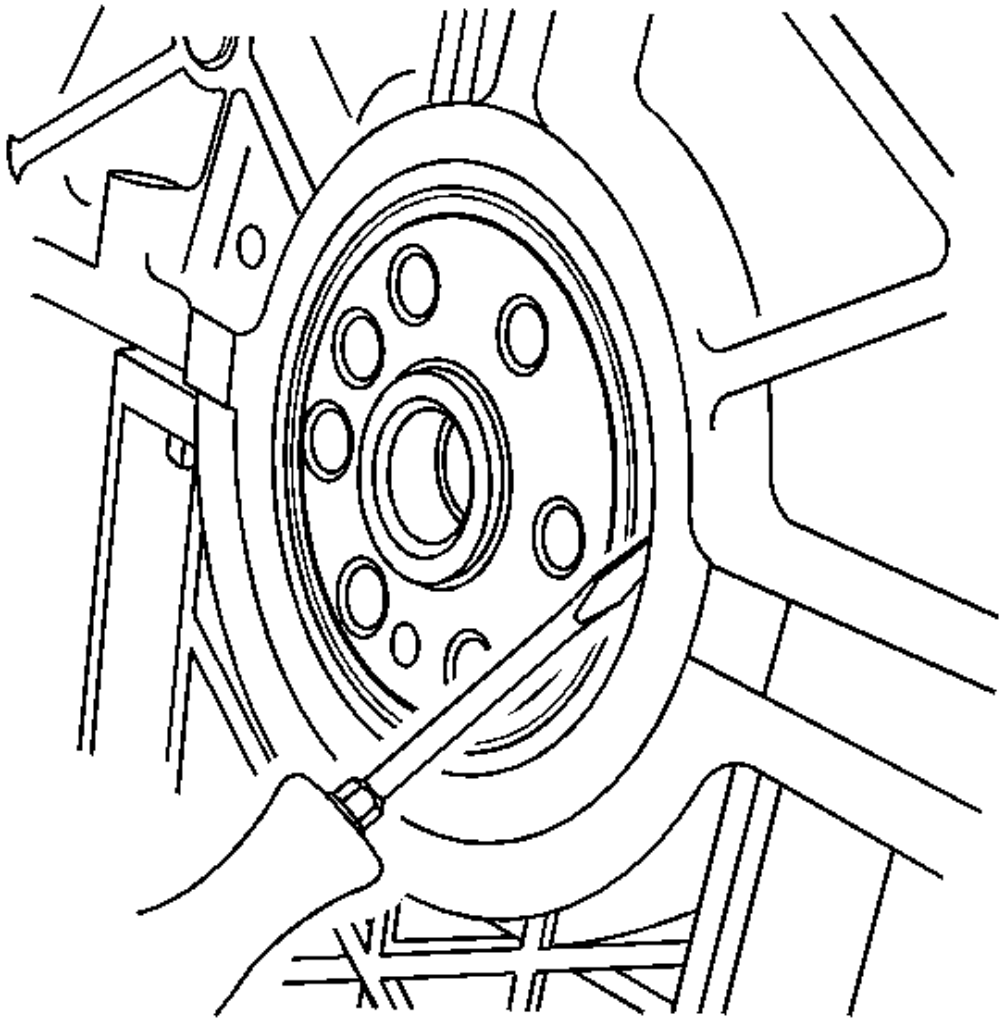

Fig. 234: View Of OLD Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

4. If removing an old style seal - seal lip faces inward, insert a flat-bladed or similar tool between the outer seal casing and the engine block casting and gently pry the seal out.
5. Repeat the above steps as necessary around the crankshaft rear oil seal, until the seal is removed.

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Installation Procedure

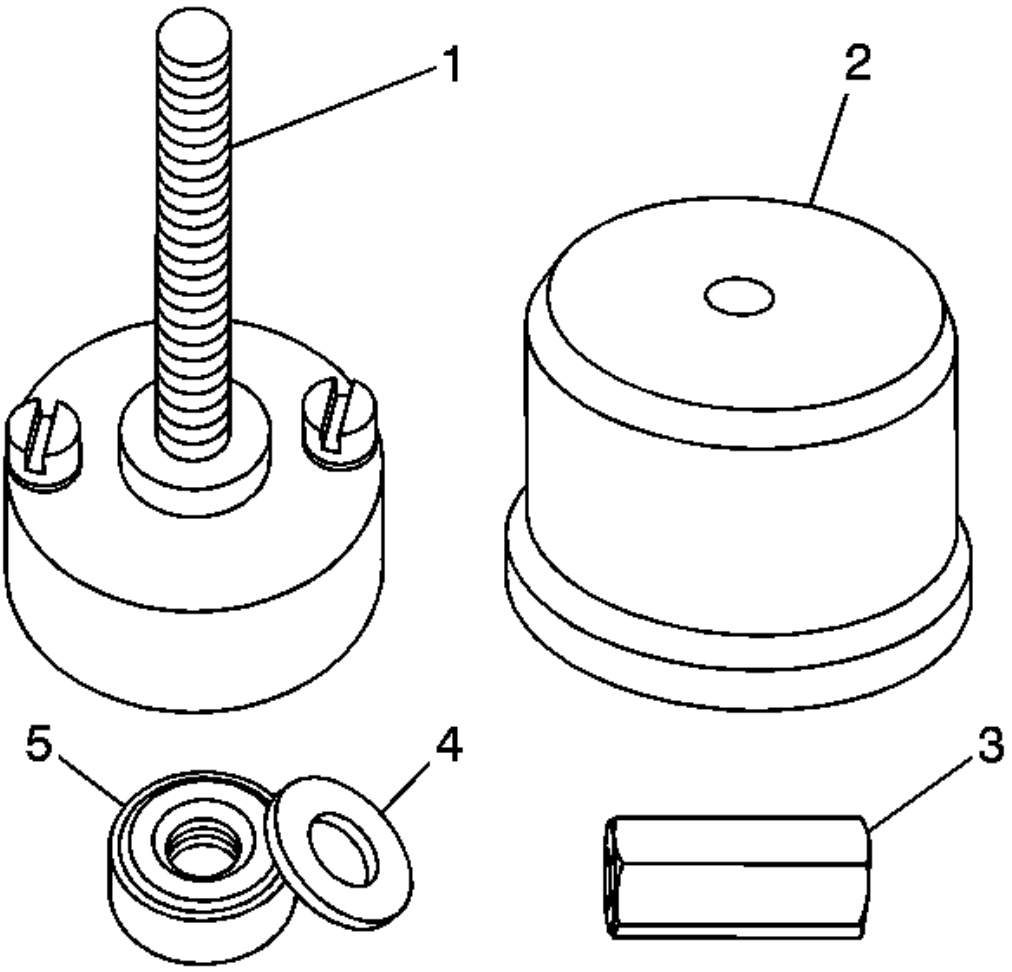

Fig. 235: Identifying Crankshaft Rear Oil Seal Installation Tools (EN-48108)
Courtesy of GENERAL MOTORS CORP.

1. The **EN-48108** tool 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 the installation, review the above illustration to become familiar with the following components:
    - Mandrel (1)
    - Drive Drum (2)
    - Drive Nut (3)
    - Washer (4)

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- Bearing (5)

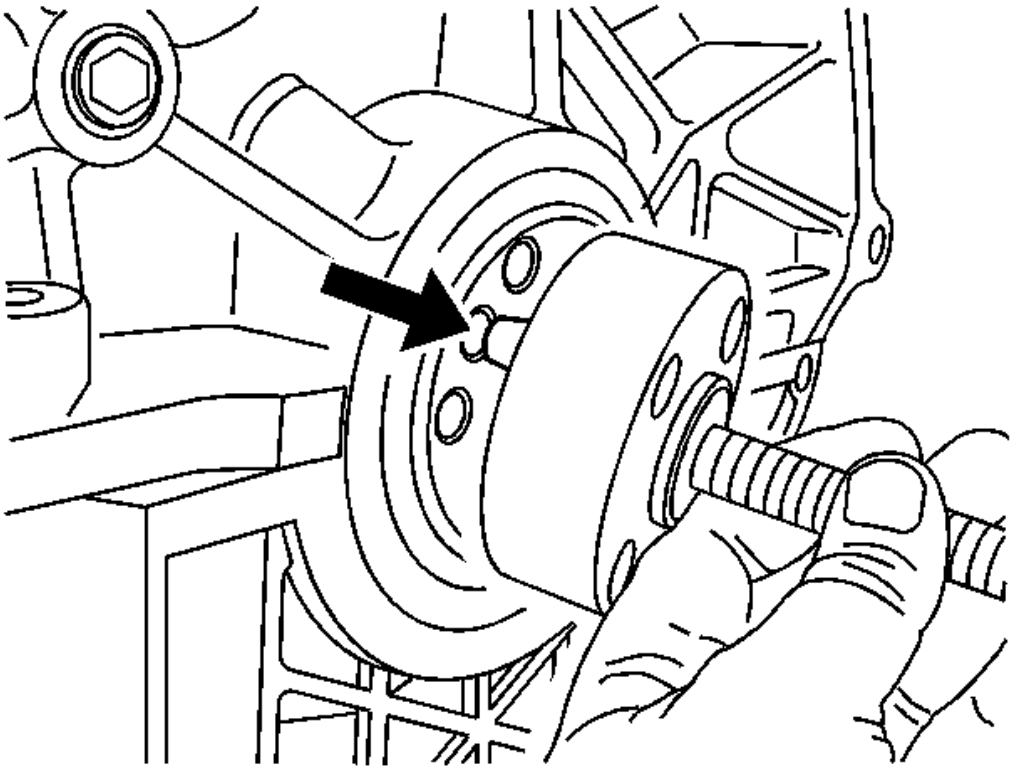

Fig. 236: Aligning Mandrel Dowel Pin
Courtesy of GENERAL MOTORS CORP.

2. Align the mandrel dowel pin to the dowel pin hole in the crankshaft.

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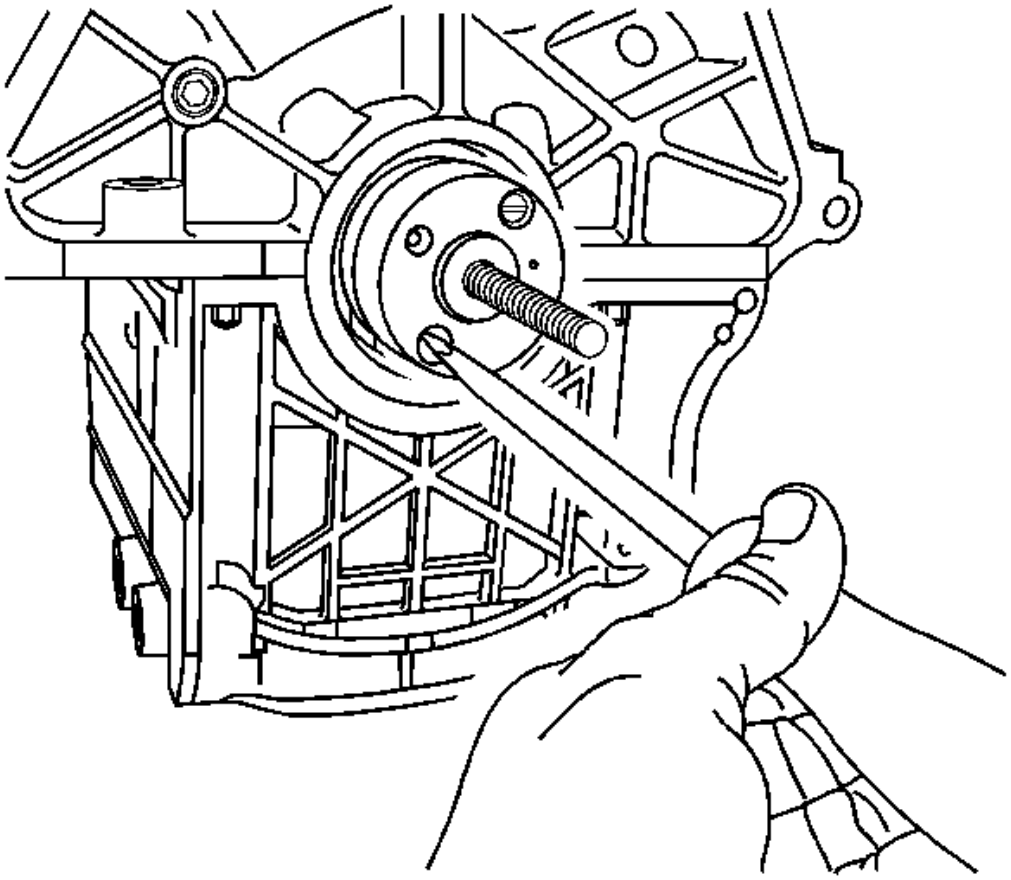

Fig. 237: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

3. Using a large flat-bladed screwdriver, tighten the 2 mandrel screws to the crankshaft, ensuring the mandrel is snug to the crankshaft hub.

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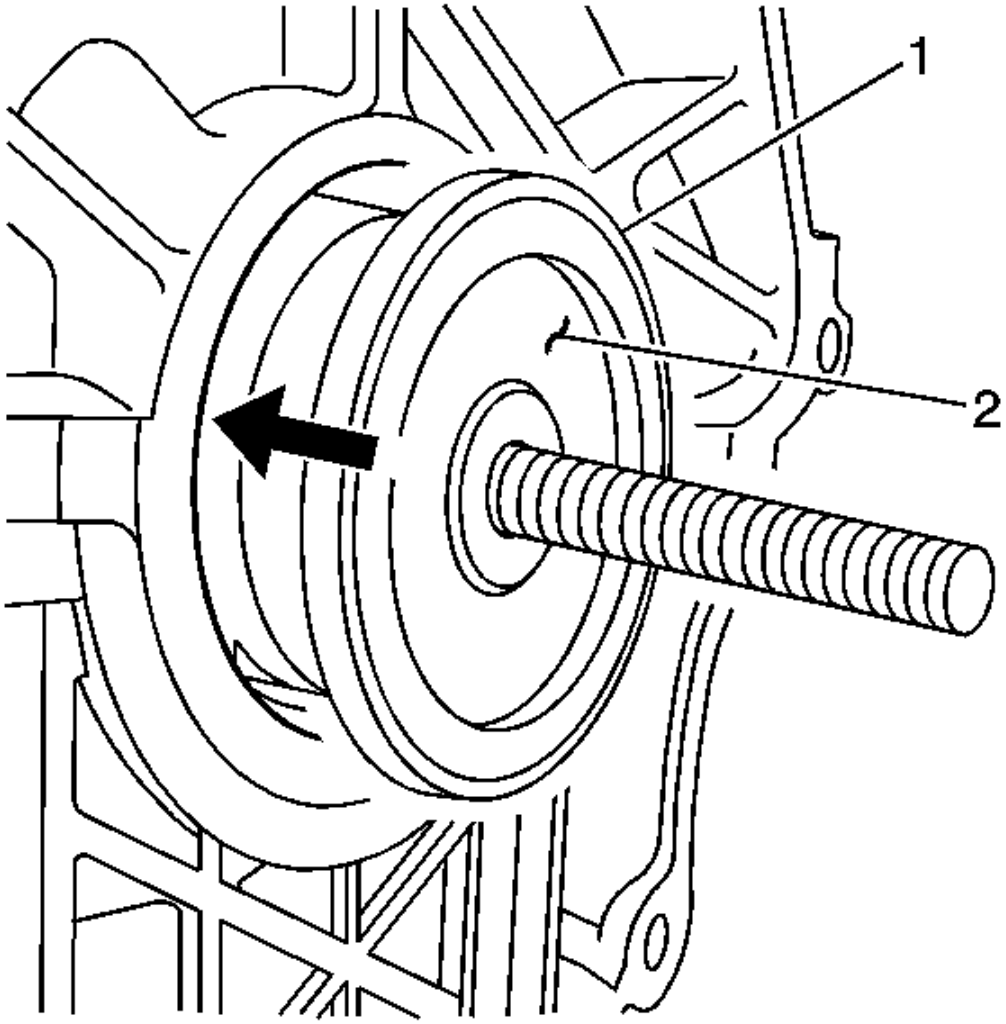

Fig. 238: View Of Rear Main Seal Mandrel
Courtesy of GENERAL MOTORS CORP.

4. Install the rear main seal, with the protective nylon sleeve attached, onto the mandrel.

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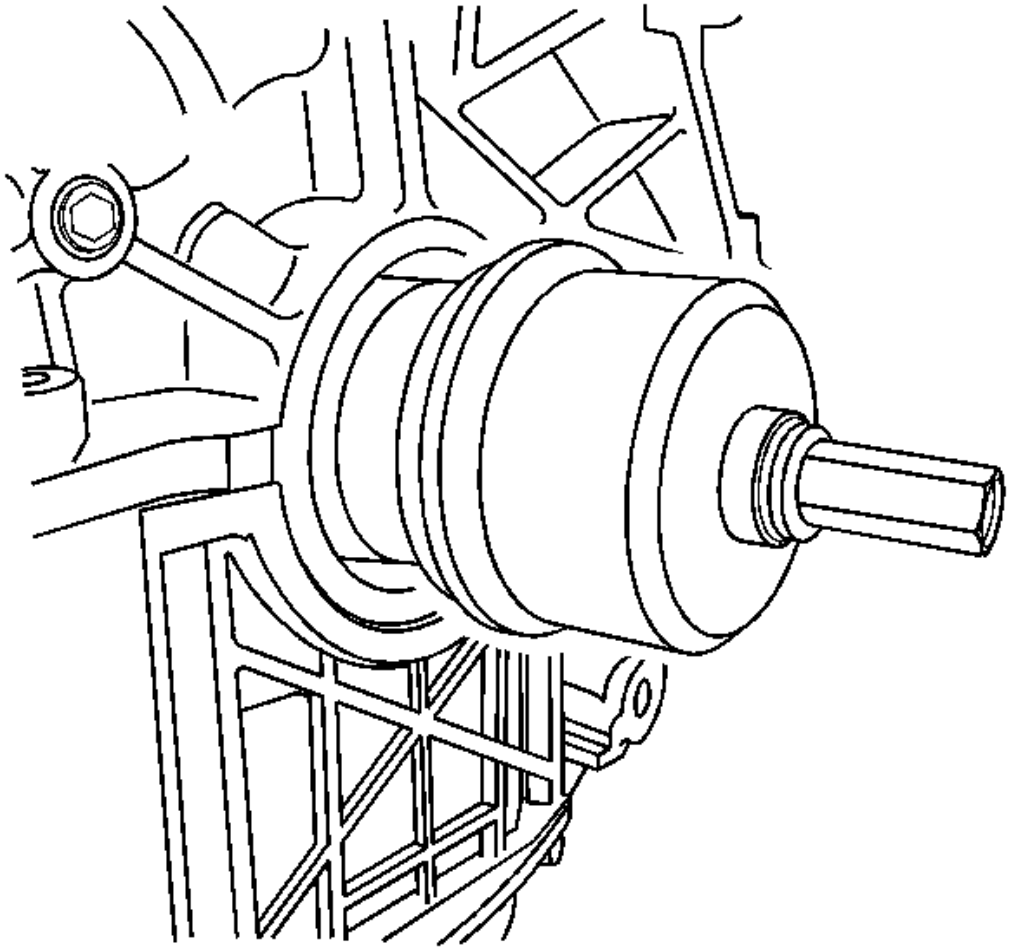

Fig. 239: Identifying Outer Drive Drum
Courtesy of GENERAL MOTORS CORP.

5. Install the outer drive drum onto the mandrel.
6. Install the bearing, washer, and the drive nut onto the threaded shaft.

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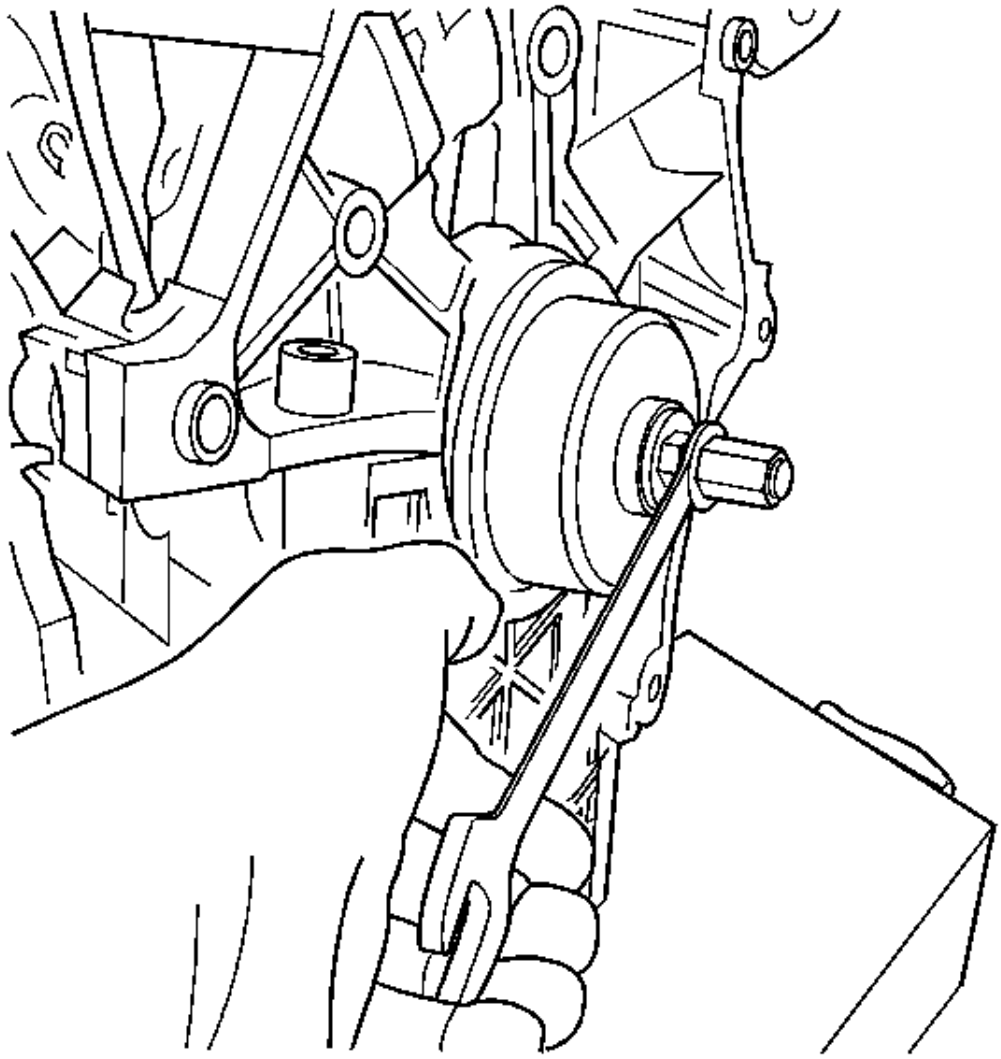

Fig. 240: Pressing Seal Into Bore
Courtesy of GENERAL MOTORS CORP.

7. Using a wrench, turn the drive nut on the mandrel, which will push the seal into the engine block bore.
8. Turn the wrench until the drive drum is snug and flush against the engine block.
9. Loosen and remove the drive nut, washer, bearing and drive drum. Discard the nylon plastic seal protector.
10. Verify that the seal has seated properly.

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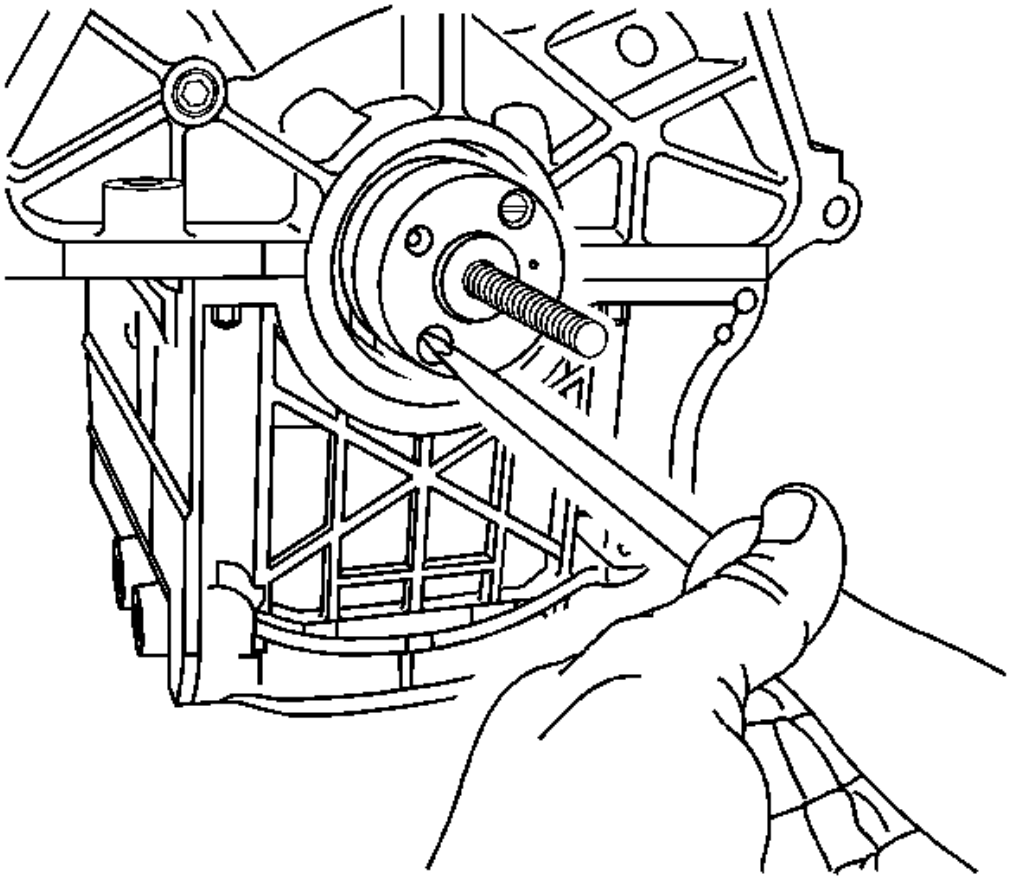

Fig. 241: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

11. Use a flat-bladed screwdriver to remove the 2 attachment screws from the mandrel and remove the mandrel from the crankshaft hub.

Camshaft Rear Bearing Hole Plug Replacement

Removal Procedure

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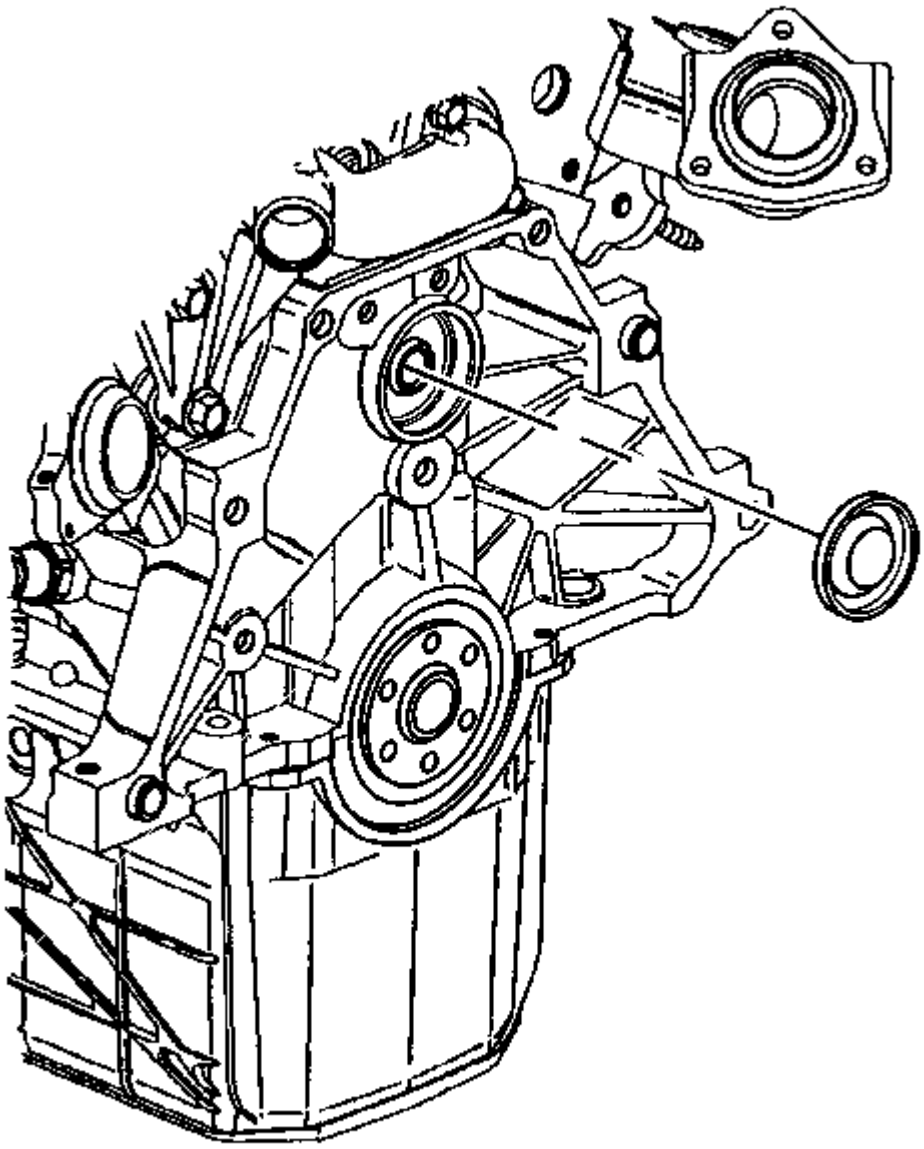

Fig. 242: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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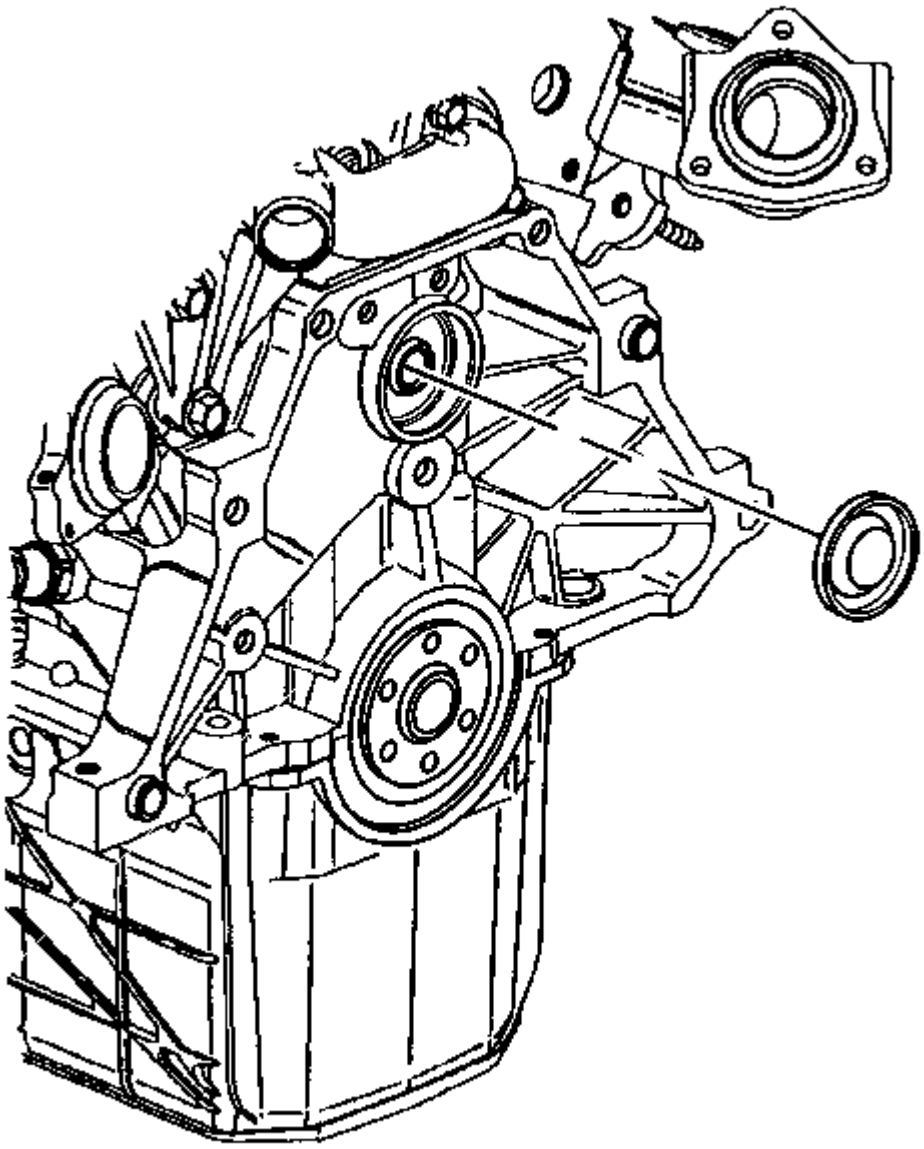

Fig. 243: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

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

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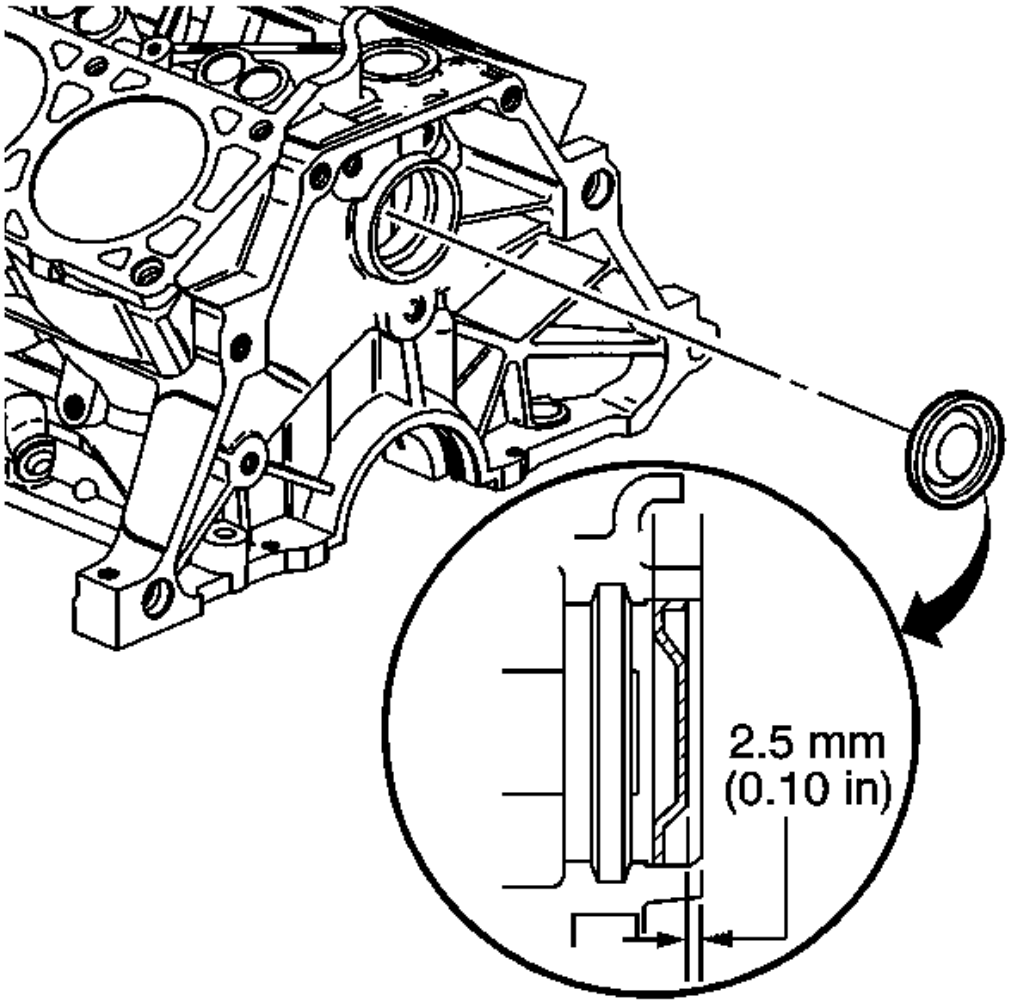

Fig. 244: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

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

Engine Replacement

Tools Required

- **J 38185** (SA9111E) Hose Clamp Pliers
- **J 24319-B** Steering Linkage and Tie Rod Puller

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- **J 41820** Ball Joint Separator
- **J 2619-O1** Slide Hammer
- **J 29794** Axle Shaft Remover Extension
- **J 33008-A** Axle Shaft Puller
- **J 42640** Steering Column Anti-Rotation Pin
- **J 39580** Engine Support Table
- **J 37096** Flywheel Holder
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

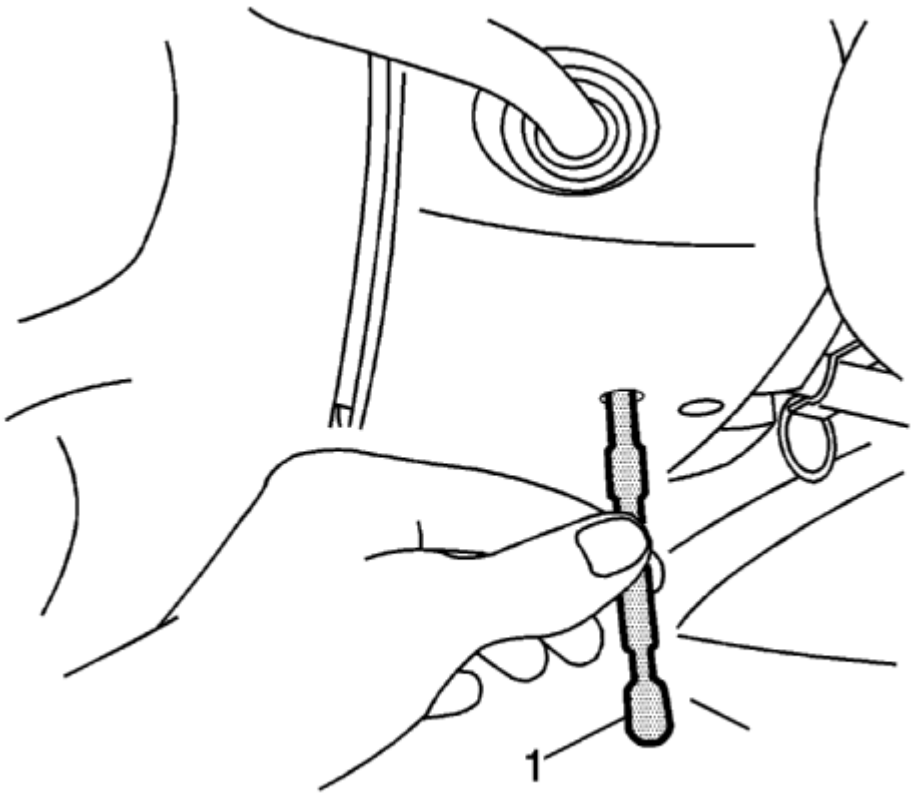

Fig. 245: Identifying J 42640
Courtesy of GENERAL MOTORS CORP.

NOTE: The front wheels of the vehicle must be maintained in the straight ahead position and the steering column must be in the LOCK position before disconnecting the steering column or intermediate shaft. Failure to follow these procedures will cause improper alignment of some components during installation and result in damage to the SIR coil assembly.

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1. Lock the steering column by installing the **J 42640** into the underside of the steering column.

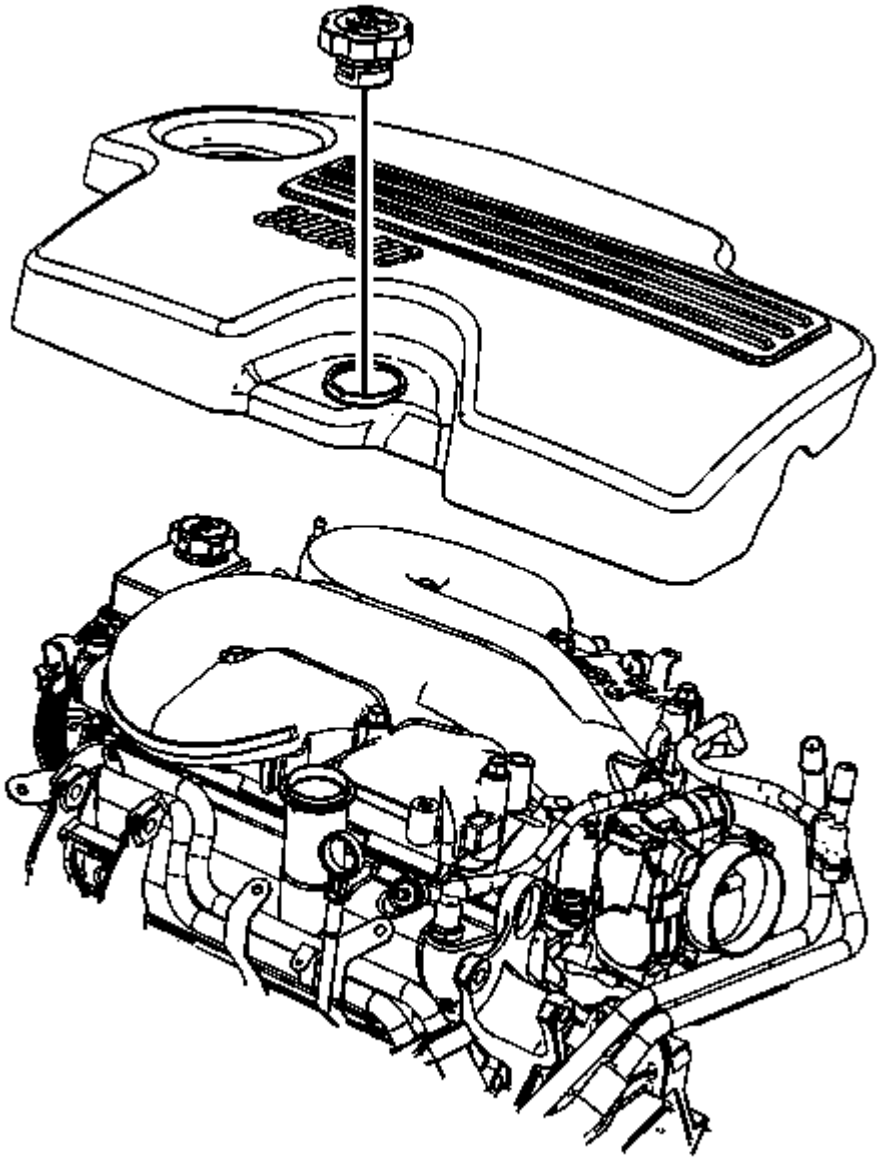

Fig. 246: Identifying Engine Manifold Cover
Courtesy of GENERAL MOTORS CORP.

2. Open the hood.

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3. Remove the engine oil fill cap.
4. Pull up on the intake manifold cover in order to disengage the cover from the studs.
5. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
6. Disconnect the positive battery cable.
7. Disconnect the battery current sensor. Refer to **Battery Current Sensor Replacement** .
8. Disconnect the auxiliary ground cable on the inner fender.
9. Disconnect the positive battery feed at the junction box.
10. Remove the lower radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
11. Drain the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
12. Lower the vehicle.

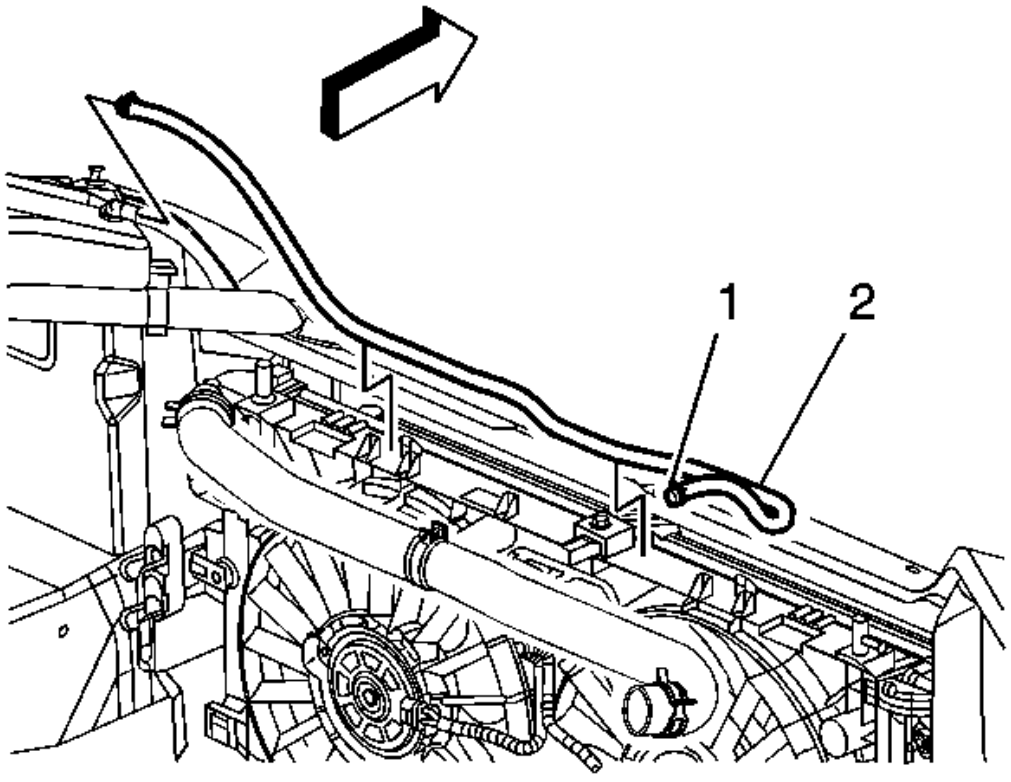

Fig. 247: View Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

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13. Reposition the coolant recovery reservoir hose clamp (1) at the coolant crossover.
14. Remove the coolant recovery reservoir hose (2) from the crossover.
15. Remove the coolant reservoir. Refer to **Coolant Recovery Reservoir Replacement** .
16. Remove the left side diagonal brace. Refer to **Front End Sheet Metal Diagonal Brace Replacement (Pontiac)** or **Front End Sheet Metal Diagonal Brace Replacement (Chevrolet)** or **Front End Sheet Metal Diagonal Brace Replacement (Buick)** .

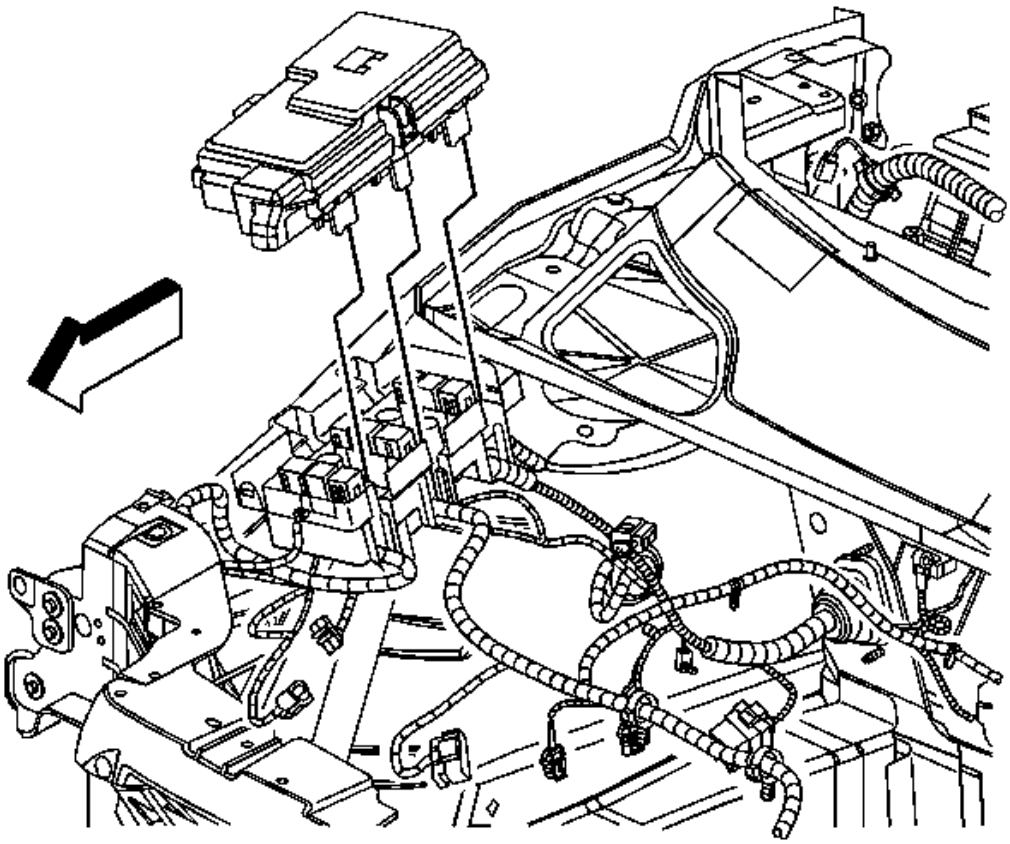

Fig. 248: View Of Junction Block Cover
Courtesy of GENERAL MOTORS CORP.

17. Unsnap and remove the junction block cover.

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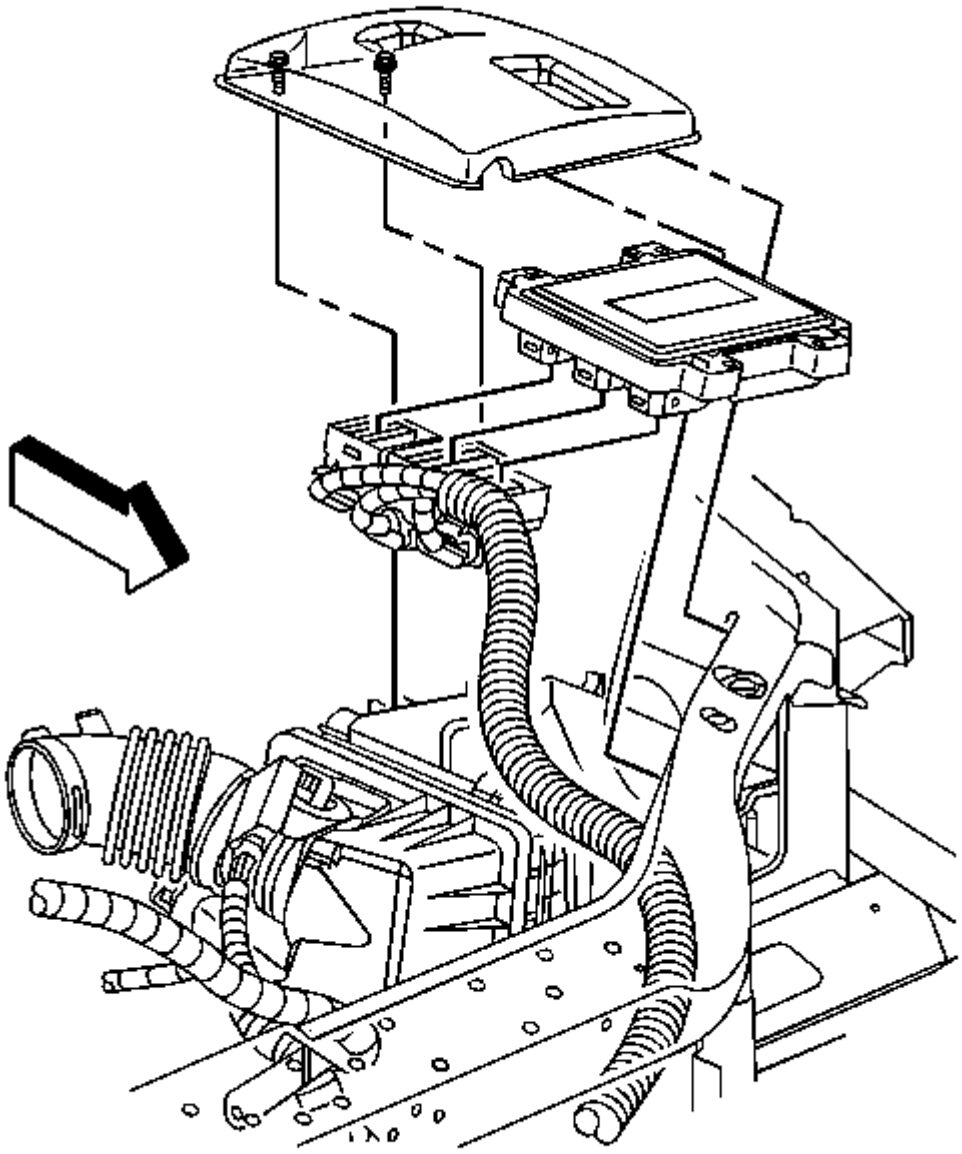

Fig. 249: View Of Air Cleaner Cover
Courtesy of GENERAL MOTORS CORP.

18. Loosen the air cleaner cover bolts.
19. Remove the air cleaner cover.
20. Remove the engine control module (ECM) from the air cleaner cover.

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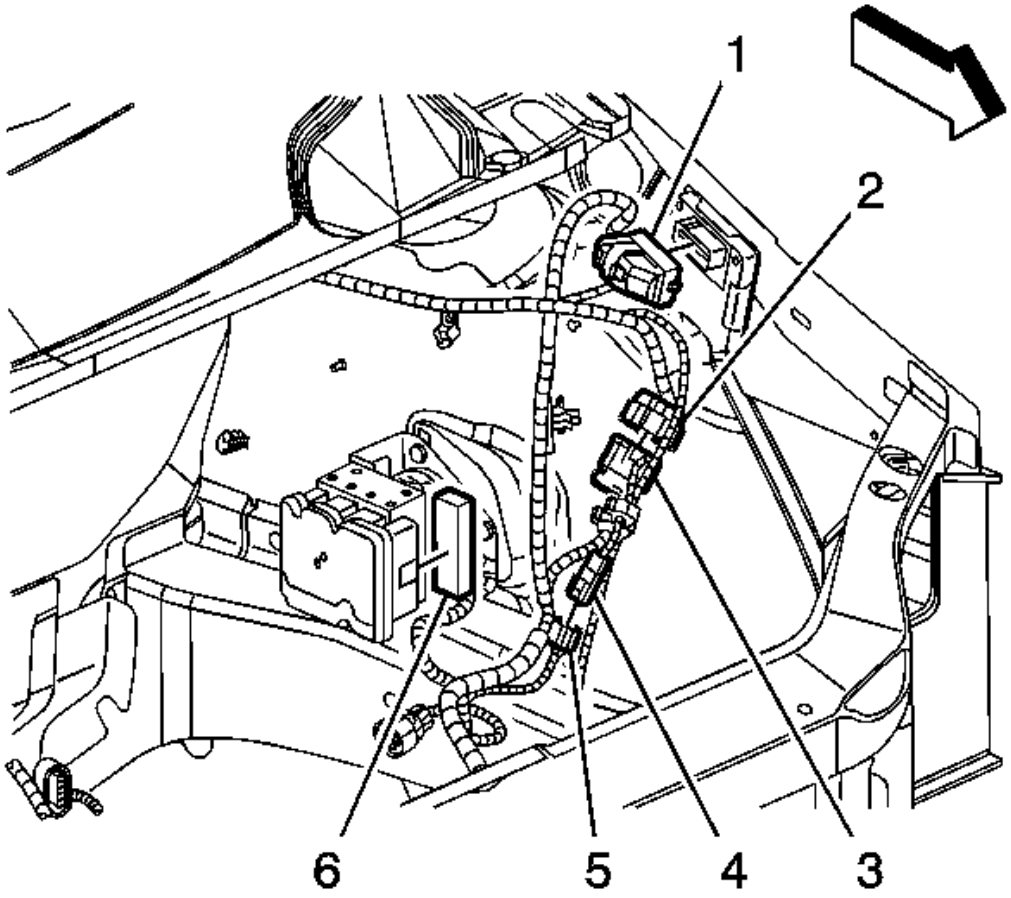

Fig. 250: View Of Engine Control Module (ECM) & Air Cleaner Cover
Courtesy of GENERAL MOTORS CORP.

21. Disconnect the engine harness electrical connector (1) from the transaxle control module (TCM).
22. Disconnect the engine harness electrical connector (3) from the instrument panel (I/P) harness electrical connector (2).
23. Disconnect the engine harness electrical connector (5) from the I/P harness electrical connector (4).
24. Disconnect the engine harness electrical connector (6) from the ABS module.

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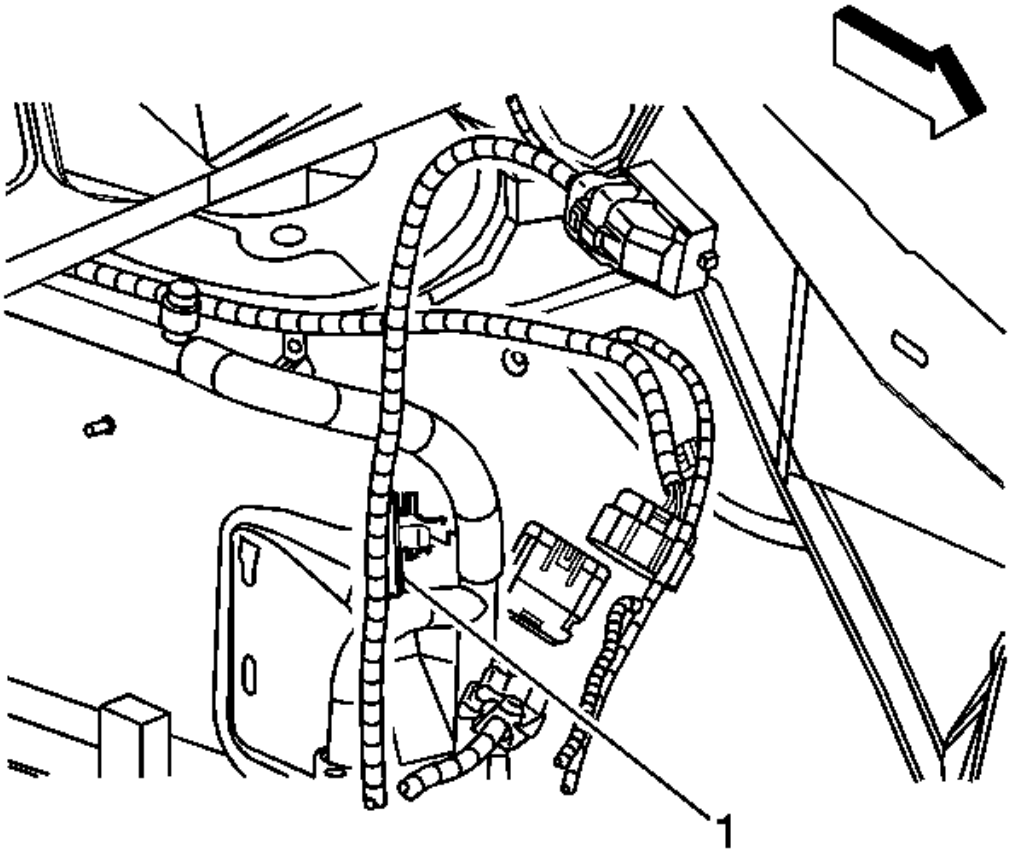

Fig. 251: Identifying Engine Harness Clip At A/C Line
Courtesy of GENERAL MOTORS CORP.

25. Remove the engine harness clip (1) from the air conditioning (A/C) line.

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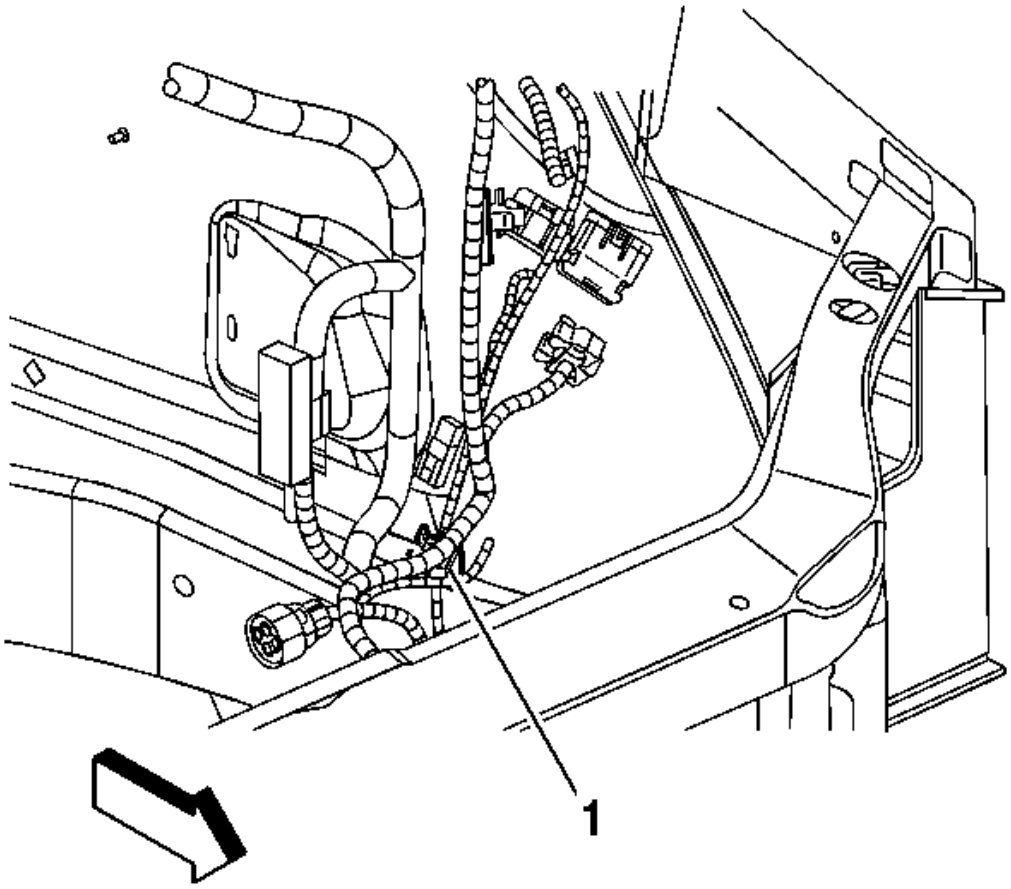

Fig. 252: View Of Engine Harness Clip At A/C Line
Courtesy of GENERAL MOTORS CORP.

26. Remove the engine harness clip (1) from the A/C line.
27. Remove the underhood junction. Refer to **Underhood Electrical Center or Junction Block Replacement** .

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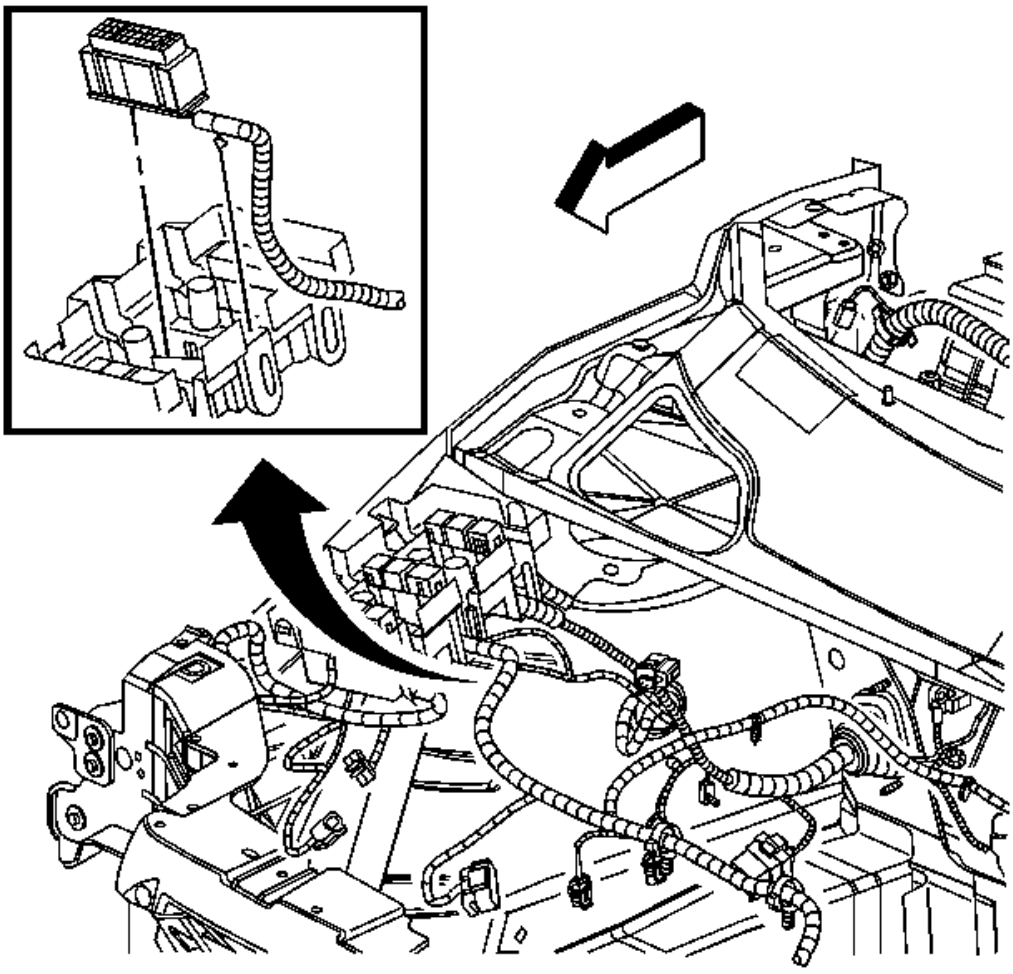

Fig. 253: Identifying Engine Harness connector At junction block.
Courtesy of GENERAL MOTORS CORP.

28. Unsnap and remove the engine harness connector from the junction block retainer.

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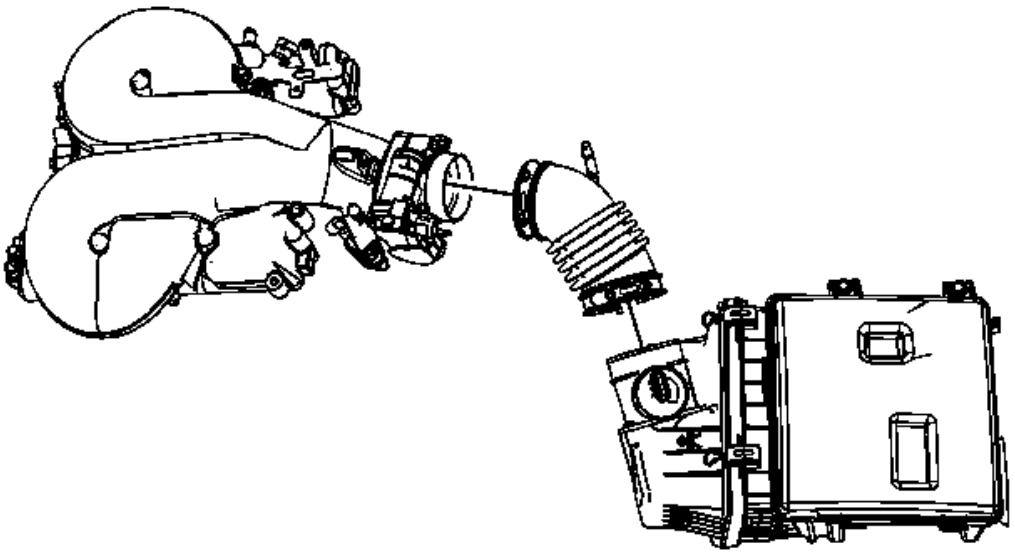

Fig. 254: Identifying Engine Harness connector At Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor
Courtesy of GENERAL MOTORS CORP.

29. Disconnect the engine harness electrical connector from the mass air flow (MAF)/intake air temperature (IAT) sensor.
30. Disconnect the positive crankcase ventilation (PCV) fresh air tube quick connect fitting from the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
31. Loosen the air cleaner outlet duct clamps at the throttle body and the MAF/IAT sensor.
32. Remove the air cleaner outlet duct from the throttle body and MAF/IAT sensor.
33. Gather the outer branches of the engine harness and lay them on top of the engine.

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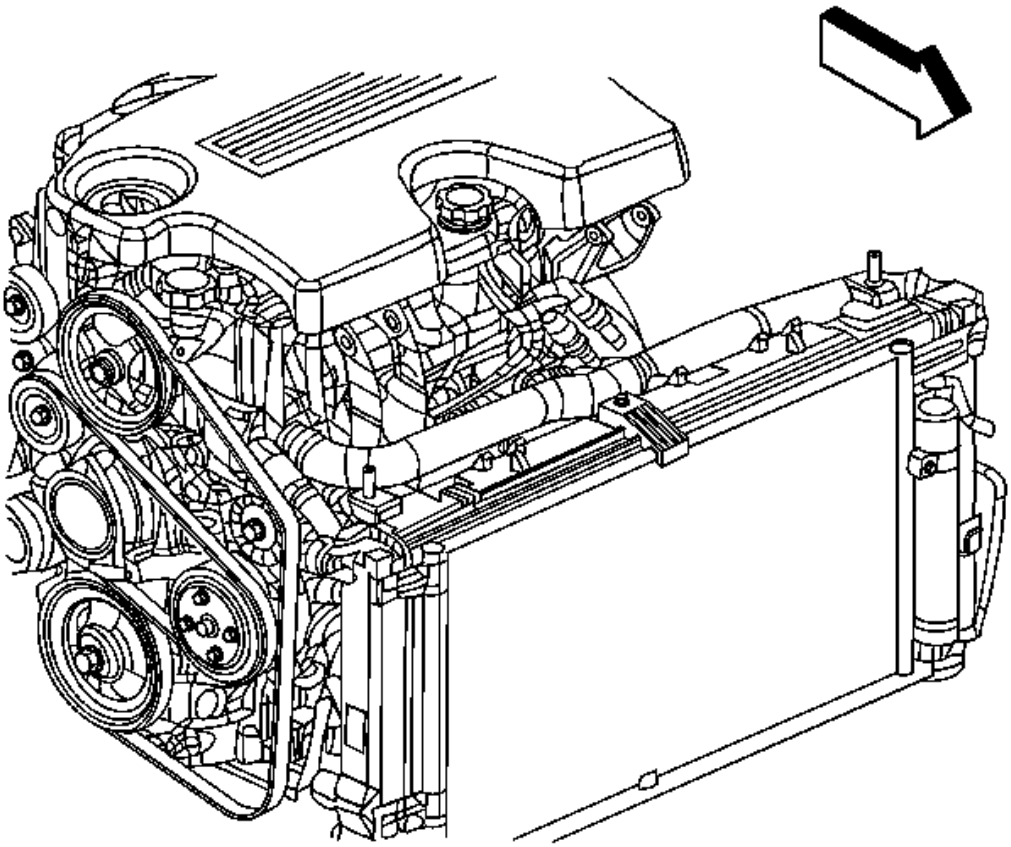

Fig. 255: View Of Radiator, Inlet Hose & Coolant Recovery Reservoir Inlet Hose
Courtesy of GENERAL MOTORS CORP.

34. Using the **J 38185** , release the tension on the radiator inlet hose clamp and reposition the clamp.
35. Remove the radiator inlet hose from the coolant crossover.

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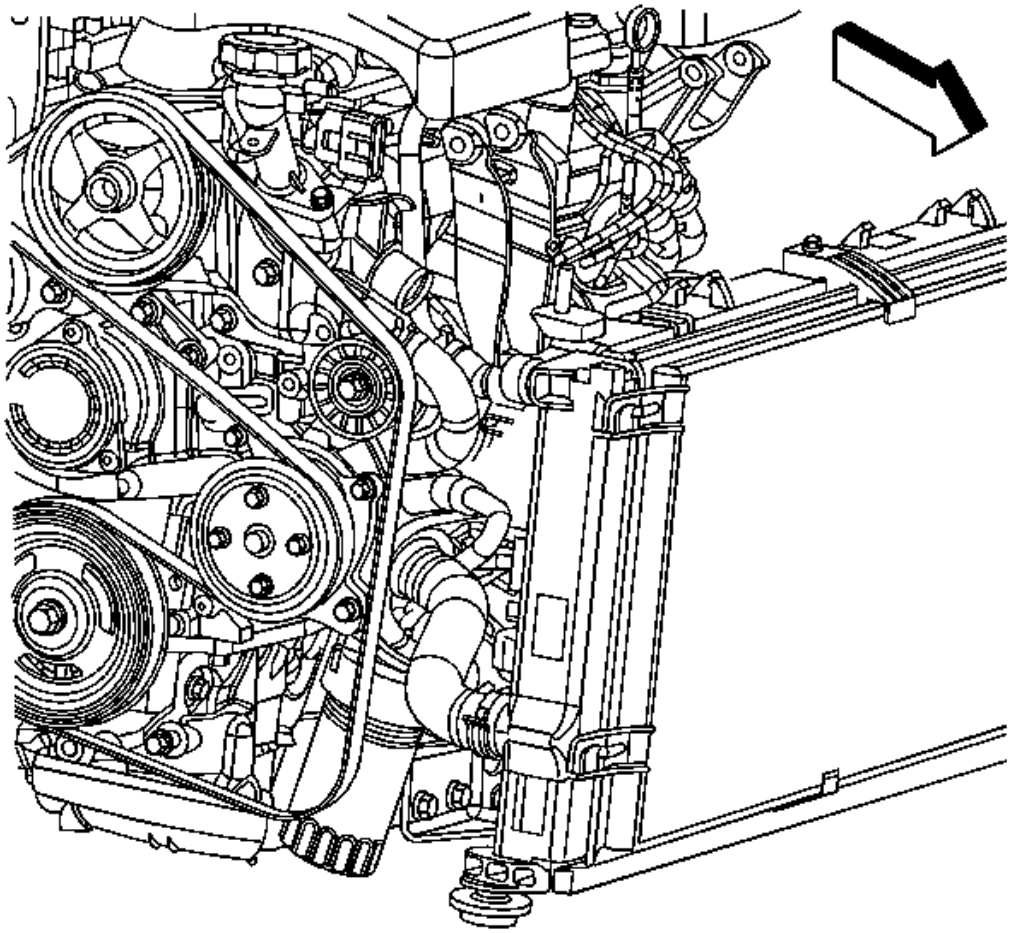

Fig. 256: View Of Radiator Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

36. Using the **J 38185** , release the tension on the radiator outlet hose clamp and reposition the clamp.
37. Remove the radiator outlet hose from the thermostat housing.

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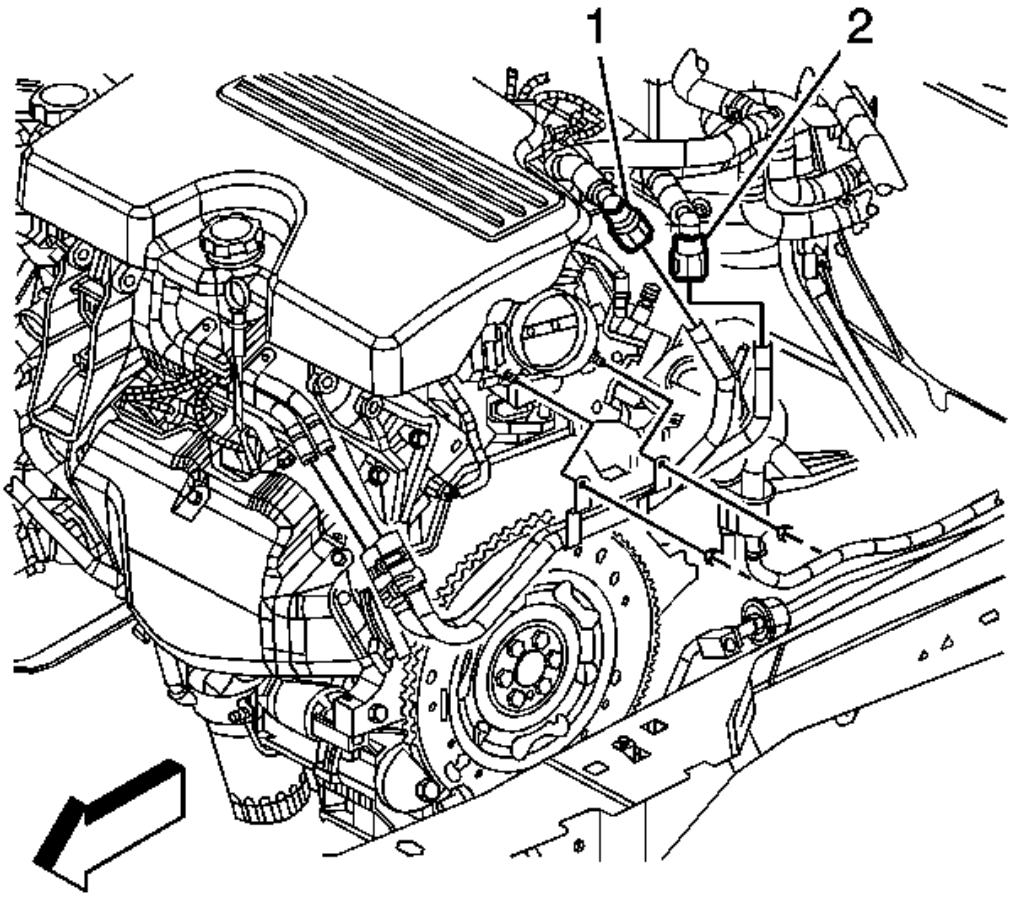

Fig. 257: View Of Heater Hoses
Courtesy of GENERAL MOTORS CORP.

38. Disconnect the heater inlet (2) and outlet (1) hose quick connect fittings from the inlet and outlet pipes.

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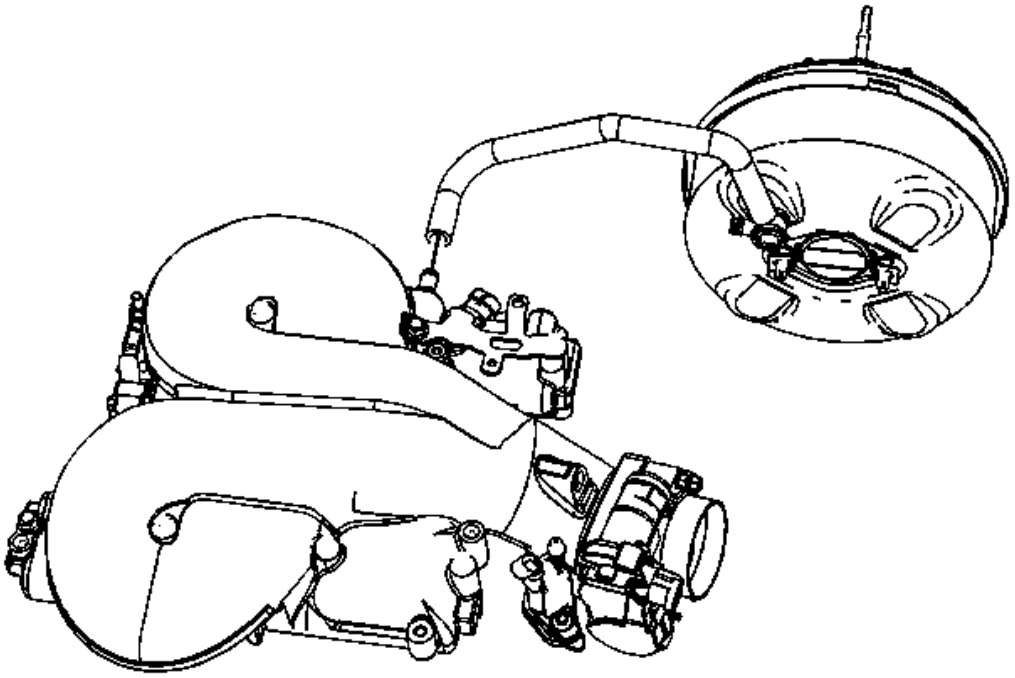

Fig. 258: View Of Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

39. Remove the brake booster vacuum hose from the upper intake manifold fitting.

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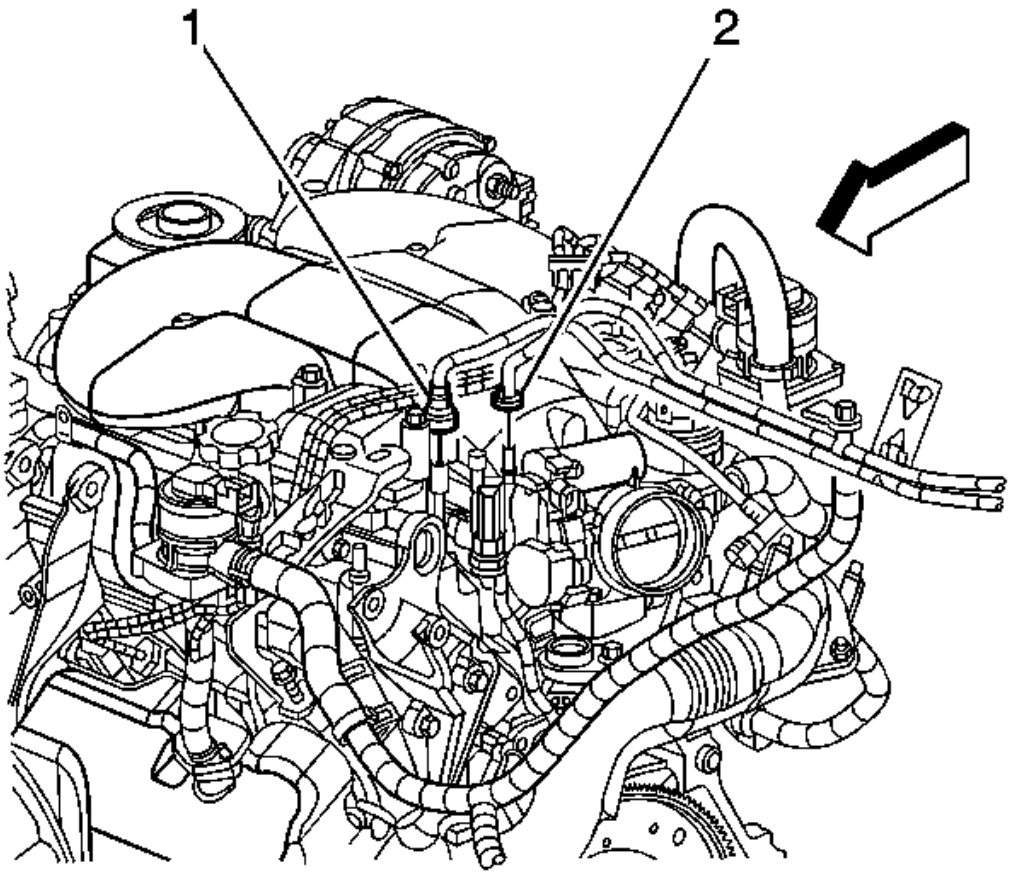

Fig. 259: Identifying Fuel Feed & Evaporative Emission (EVAP) Line Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

40. Disconnect the fuel feed (1) and evaporative emission (EVAP) (2) line quick connect fittings. Refer to **Metal Collar Quick Connect Fitting Service** and **Plastic Collar Quick Connect Fitting Service** .
41. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement - Right Side** and **Engine Mount Strut Bracket Replacement - Left Side**.
42. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
43. Remove the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .

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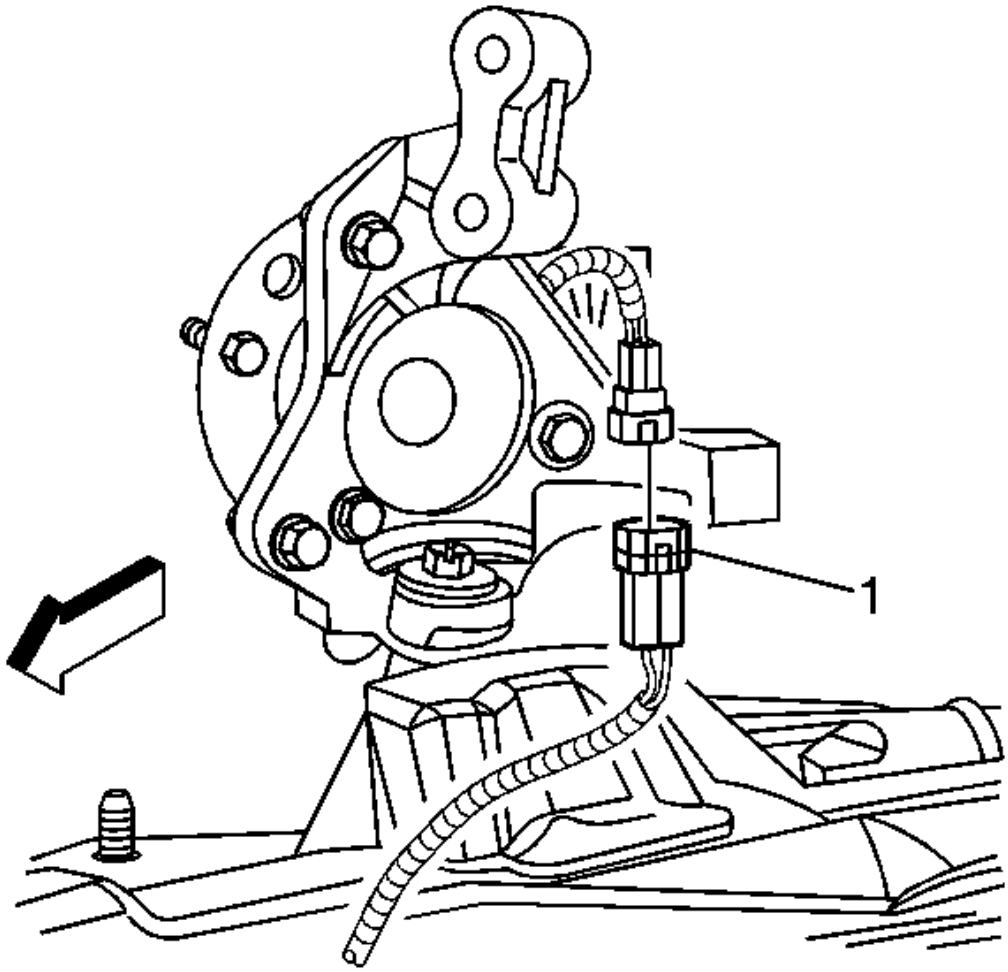

Fig. 260: Identifying Engine Harness Electrical Connectors Located At Left & Right Wheel Speed Sensors
Courtesy of GENERAL MOTORS CORP.

44. Disconnect the engine harness electrical connectors (1) from the left and right wheel speed sensors. (right side shown, left side similar).
45. Remove the drive belt. Refer to **Drive Belt Replacement**.

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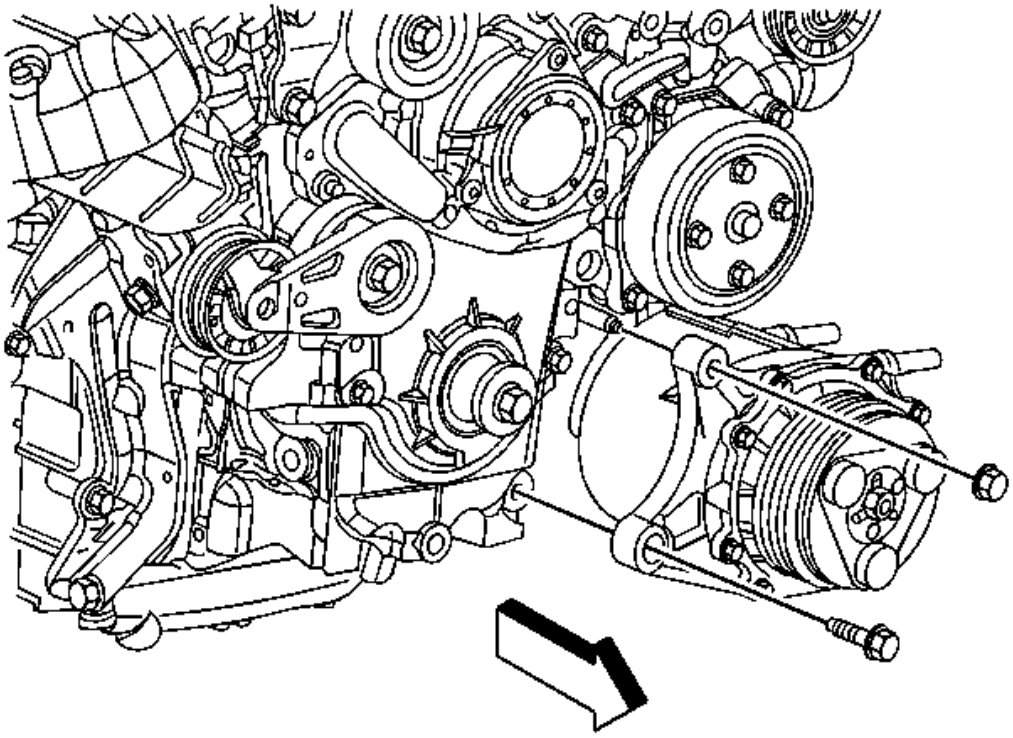

Fig. 261: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

46. Disconnect the engine harness electrical connectors from the A/C compressor.

IMPORTANT: It is not necessary to evacuate the A/C system prior to repositioning the A/C compressor.

47. Remove the A/C compressor front bolt and nut.

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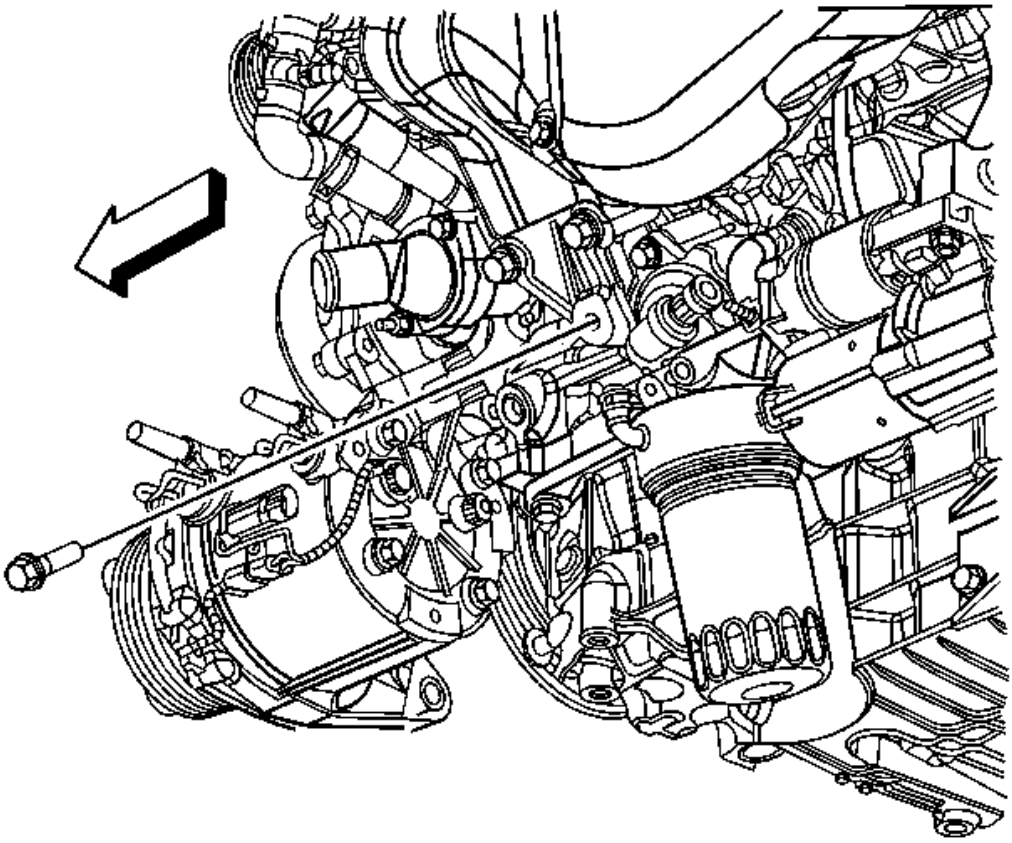

Fig. 262: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

48. Remove the A/C compressor rear bolt. Reposition and support the A/C compressor out of the way.
49. Remove the catalytic converter. Refer to **Catalytic Converter Replacement** .
50. Remove the engine splash shield. Refer to **Engine Splash Shield Replacement** .
51. Disconnect the battery cable retainers at the core support.

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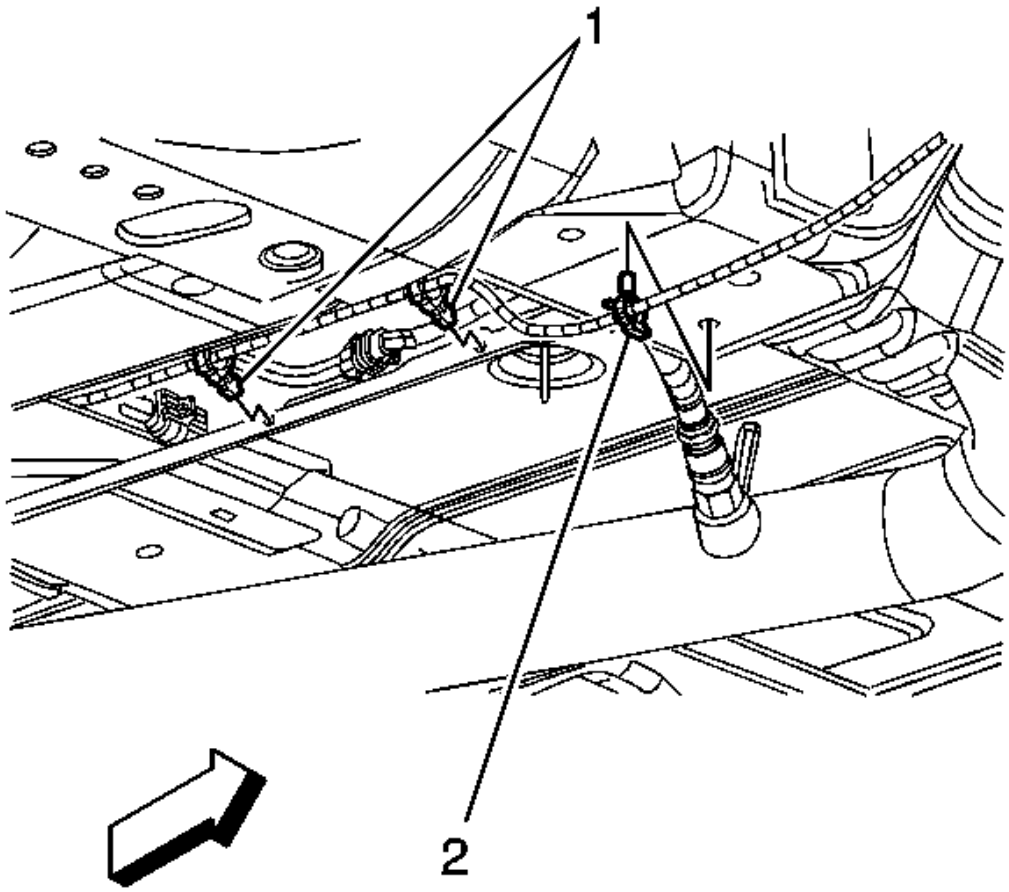

Fig. 263: Identifying Engine Harness Clips At Heat Shield
Courtesy of GENERAL MOTORS CORP.

52. Remove the engine harness clips (1, 2) from the heat shield.

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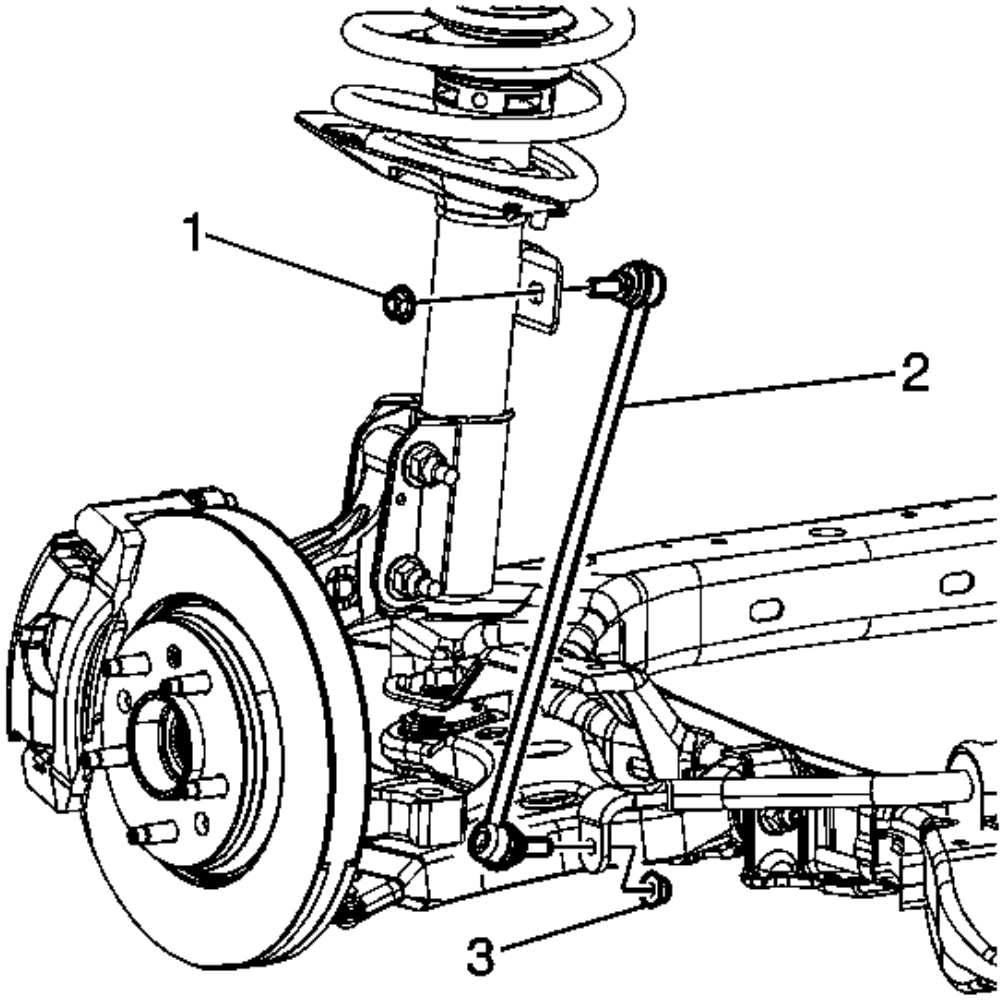

Fig. 264: Identifying Stabilizer Shaft Components
Courtesy of GENERAL MOTORS CORP.

53. Remove the stabilizer shaft link lower nuts (3). (left side shown, right side similar).
54. Remove the stabilizer shaft links (2) from the stabilizer shaft.

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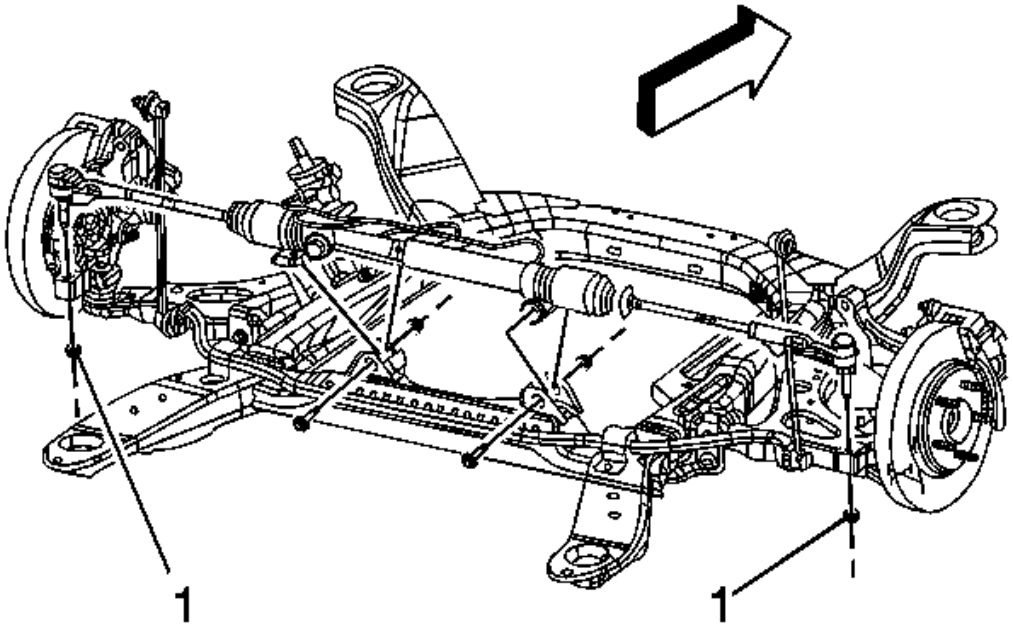

Fig. 265: Identifying Tie Rod End Nuts
Courtesy of GENERAL MOTORS CORP.

55. Remove the tie rod end nuts (1) at the steering knuckles.

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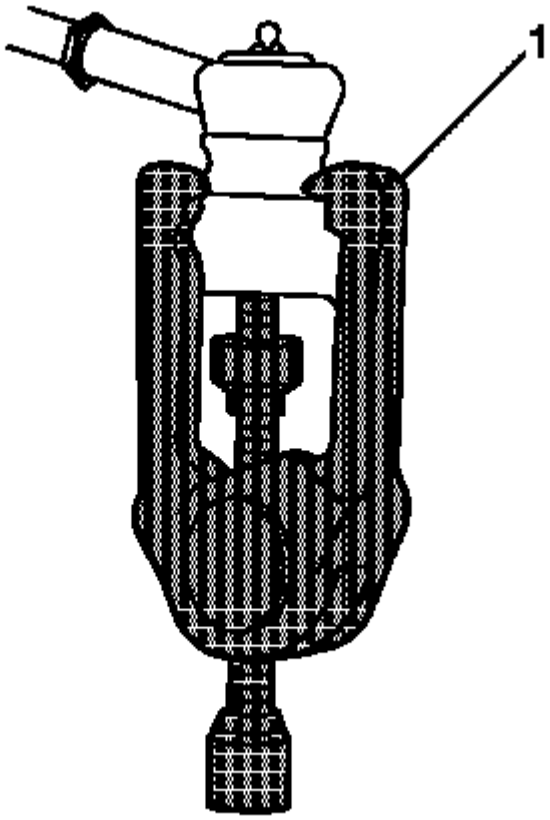

Fig. 266: Removing Outer Tie Rod Assembly From Steering Knuckle
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not attempt to free the ball stud by using a pickle fork or wedge type tool, because seal or bushing damage could result. Use the proper tool to separate all ball joints.

56. Using the **J 24319-B** , separate the outer tie rod ends from the steering knuckle.

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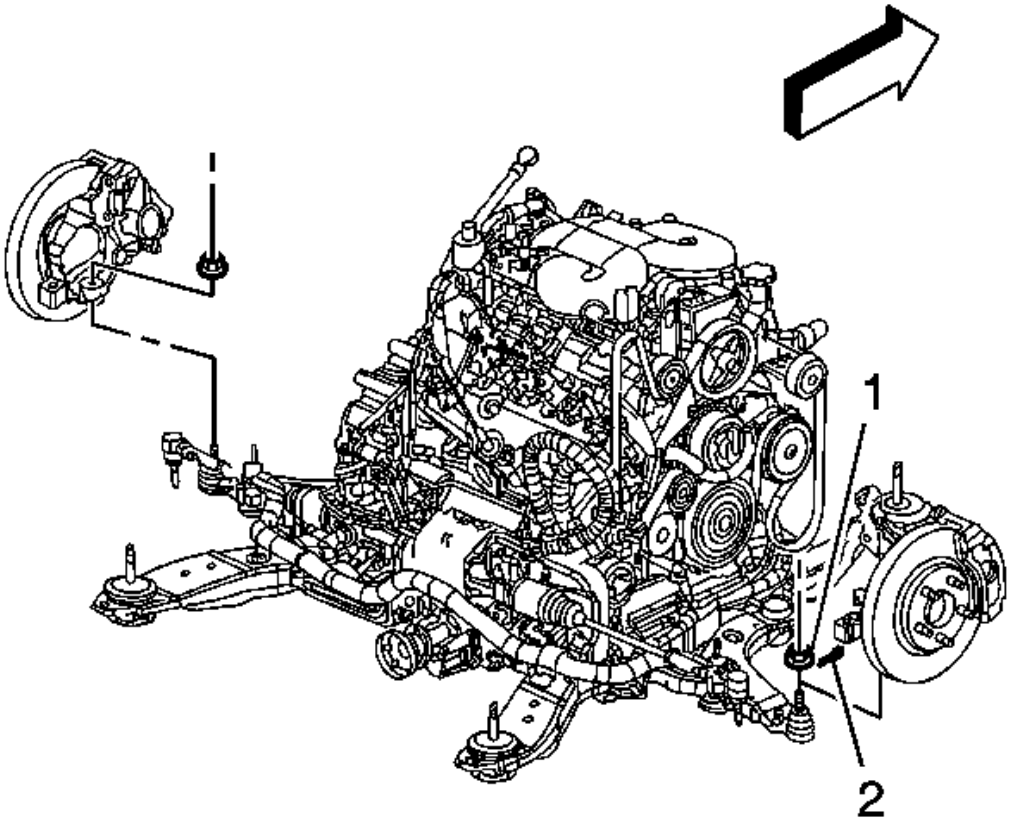

Fig. 267: View Of Outer Tie Rod Ends & Steering Knuckles
Courtesy of GENERAL MOTORS CORP.

57. Remove the lower ball joint cotter pins (2) from the ball joints.
58. Loosen the lower ball joint castle nuts (1).

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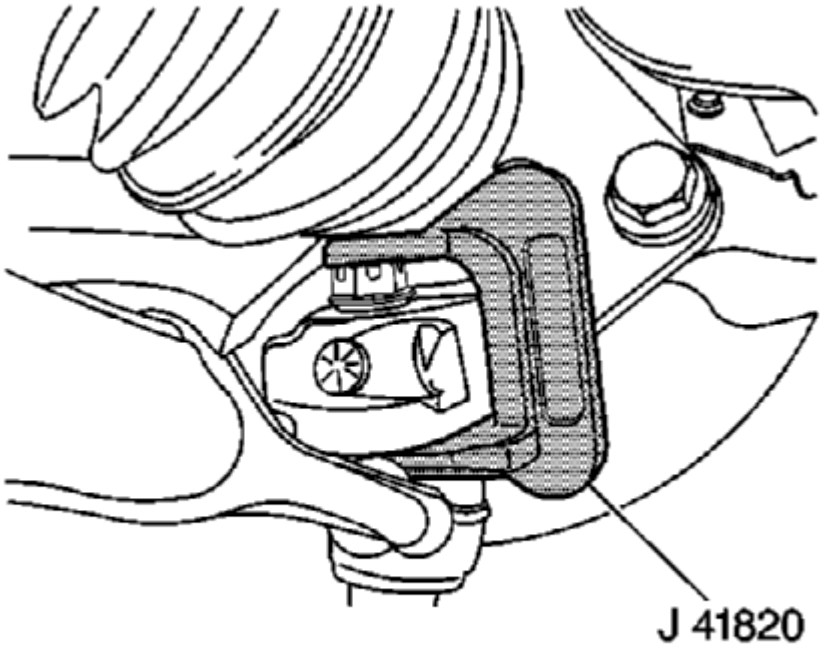

Fig. 268: Separating Ball Stud From Steering Knuckle
Courtesy of GENERAL MOTORS CORP.

NOTE: Use only the recommended tools for separating the ball joint from the knuckle. Do NOT hammer or pry the ball joint from the knuckle. Failure to use the recommended tools may cause damage to the ball joint and seal.

59. Install the **J 41820** over the ball joint and lower control arm as shown.
60. Rotate the castle nut counterclockwise in order to separate the ball joint from the steering knuckle.

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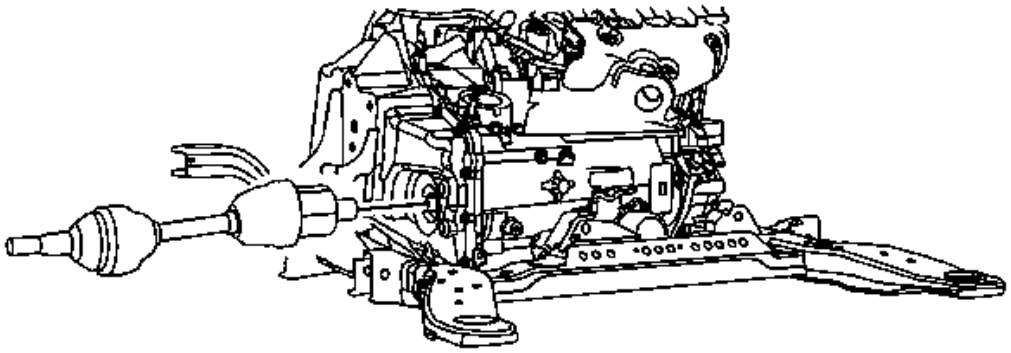

Fig. 269: Identifying Wheel Drive Shafts
Courtesy of GENERAL MOTORS CORP.

61. Assemble the **J 33008-A** , **J 29794** , and the **J 2619-O1** .
62. Using the **J 33008-A** , **J 29794** , and the **J 2619-O1** disengage the wheel drive shafts from the transaxle. (left side shown, right side similar).
63. Secure the wheel drive shafts to the steering knuckle/struts.

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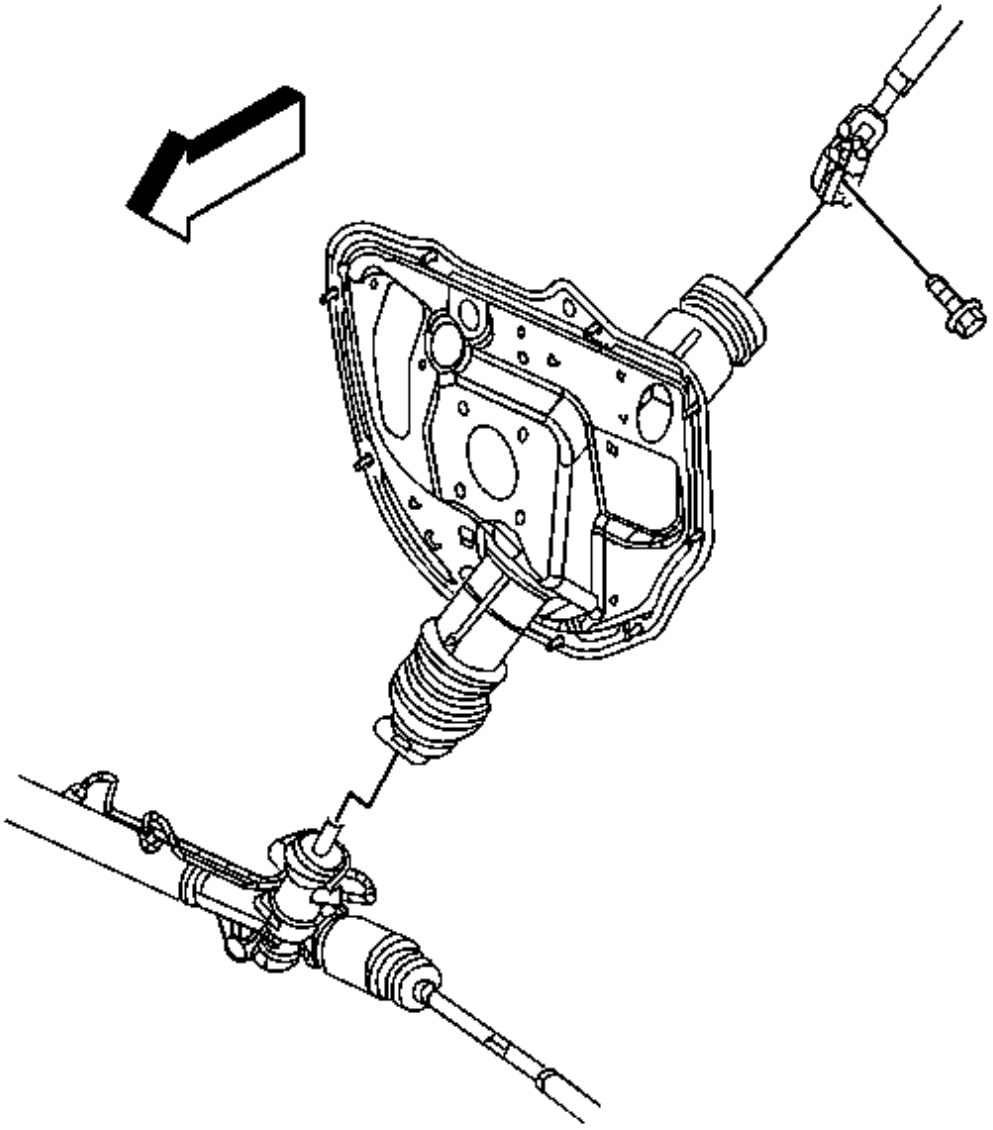

Fig. 270: Identifying Wheel Intermediate Steering Shaft & Pinch Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Failure to disconnect the intermediate shaft from the rack and pinion steering gear stub shaft can result in damage to the steering gear and/or intermediate shaft. This damage may cause loss of steering control which could result in an accident and possible personal injury

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64. Reposition the intermediate steering shaft seal in order to provide access to the intermediate steering shaft pinch bolt.
65. Remove the intermediate steering shaft pinch bolt.
66. Disconnect the intermediate steering shaft from the power steering gear.

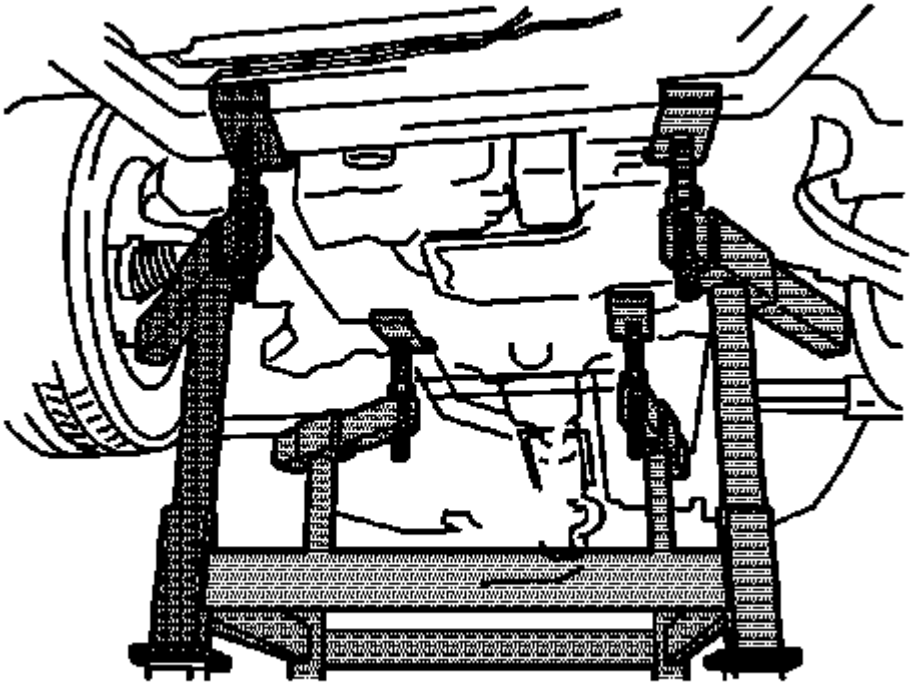

Fig. 271: Identifying Utility Stand
Courtesy of GENERAL MOTORS CORP.

67. Place the **J 39580** under the frame.
68. Lower the vehicle until the frame contacts the **J 39580** .

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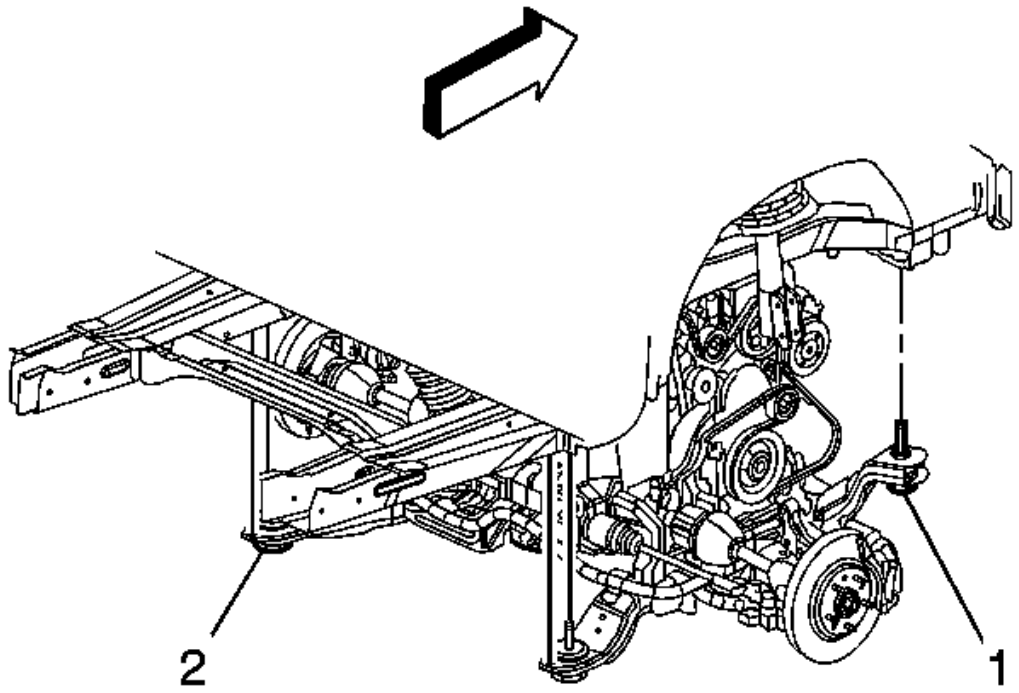

Fig. 272: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

69. Remove the front and rear frame bolts (1, 2).

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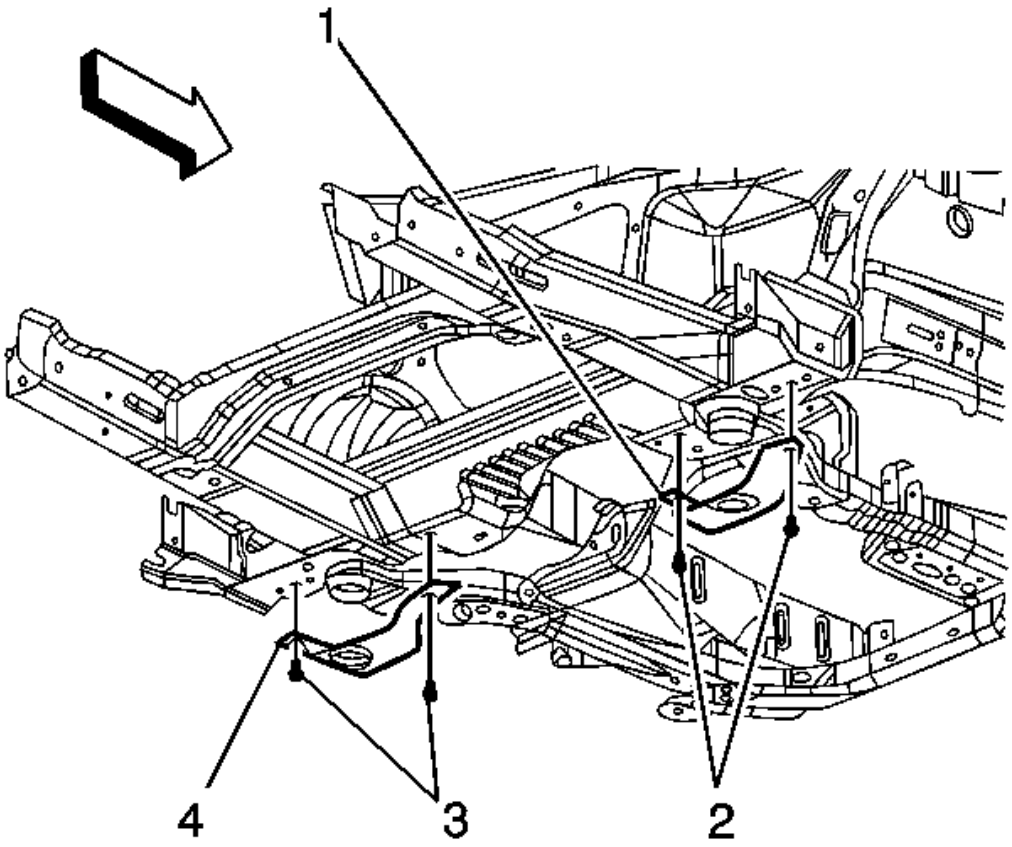

Fig. 273: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

70. Remove the frame rear strap bolts (2, 3).
71. Remove the frame rear straps (1, 4).
72. Raise the vehicle in order to separate the powertrain/frame assembly from the vehicle.

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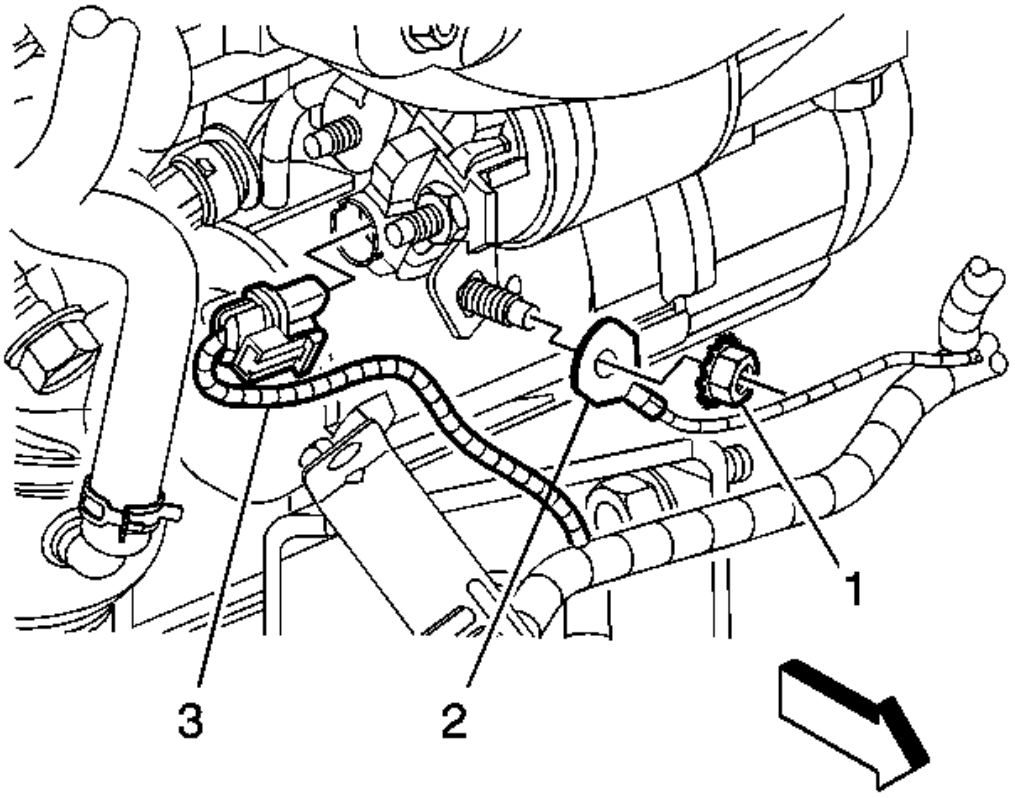

Fig. 274: Identifying Engine Harness Ground Wire Nut
Courtesy of GENERAL MOTORS CORP.

73. If necessary perform the following steps, remove the engine harness ground wire nut (1).
74. Remove the engine harness positive battery cable (2) from the stud.
75. Disconnect the engine harness electrical connector (3) from the starter.

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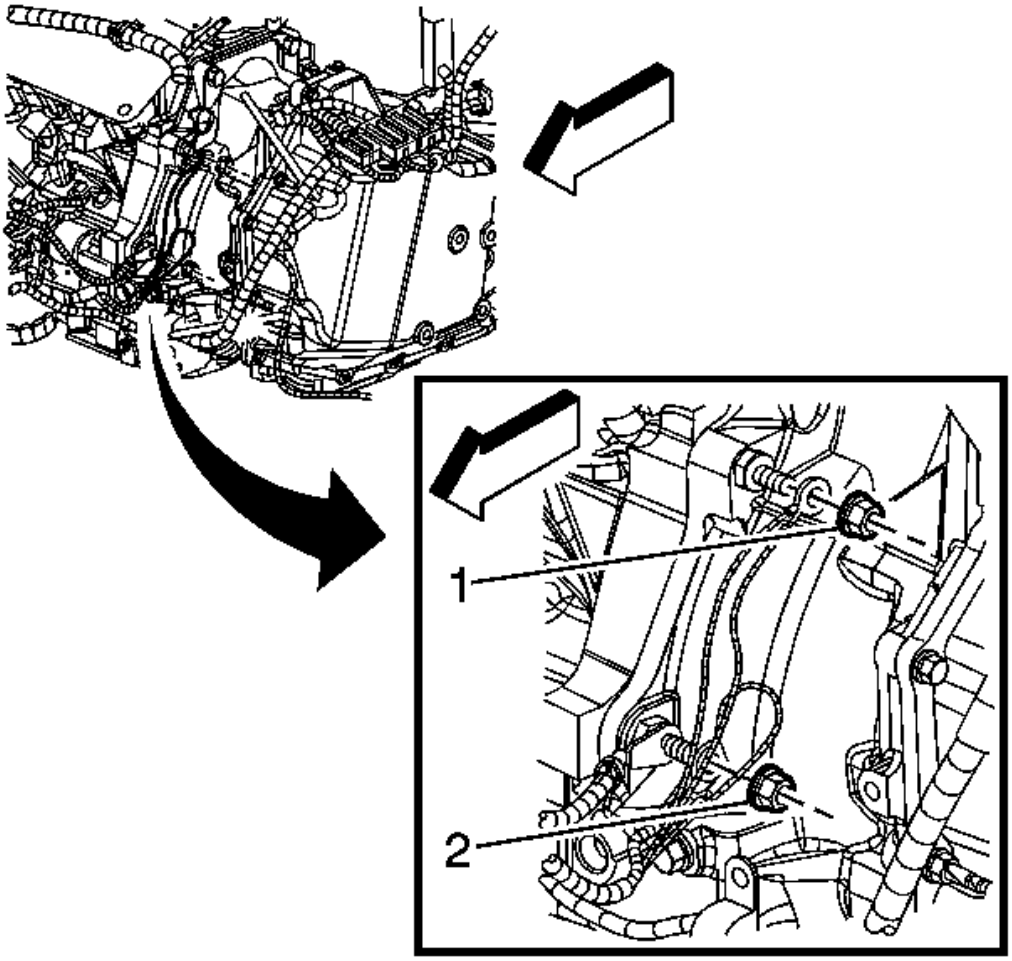

Fig. 275: Locating Engine Harness Grounds
Courtesy of GENERAL MOTORS CORP.

76. Remove the engine harness ground nuts (1, 2) from the transaxle studs.
77. Remove the engine harness grounds from the studs.
78. Remove the negative battery cable from the transaxle stud.

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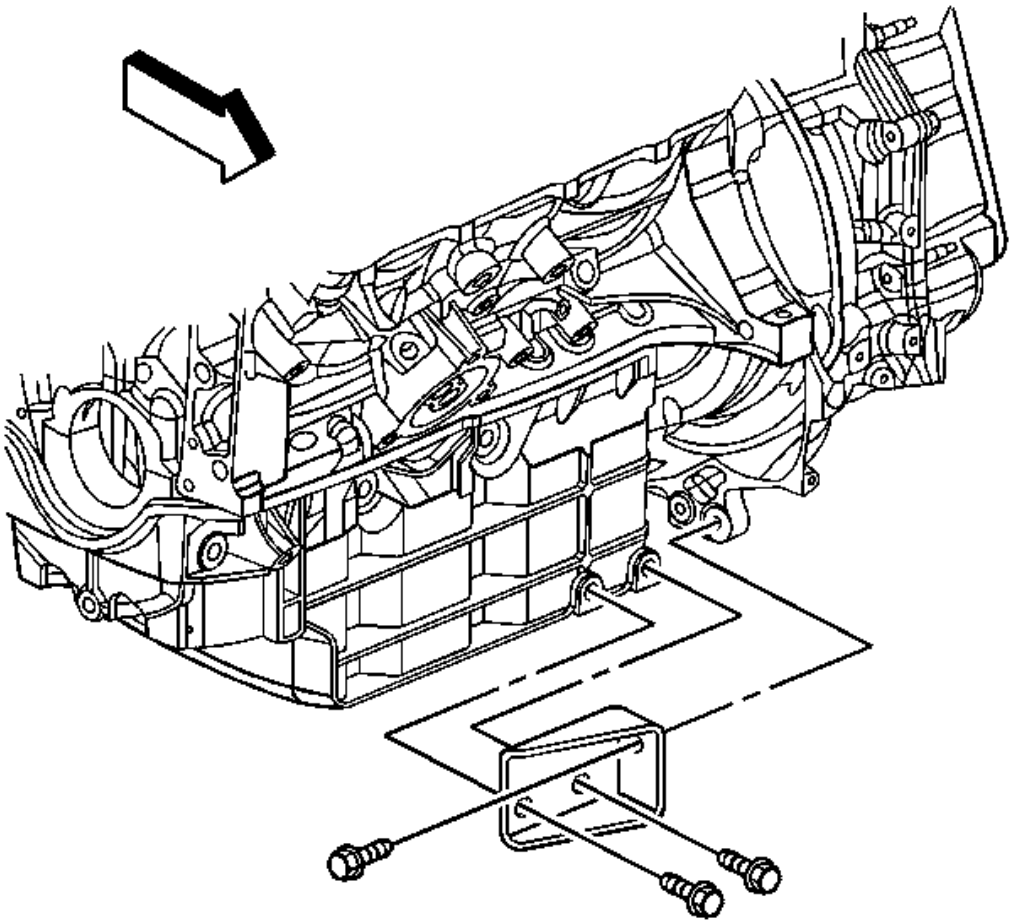

Fig. 276: Identifying Engine Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

79. Remove the engine to transaxle brace.

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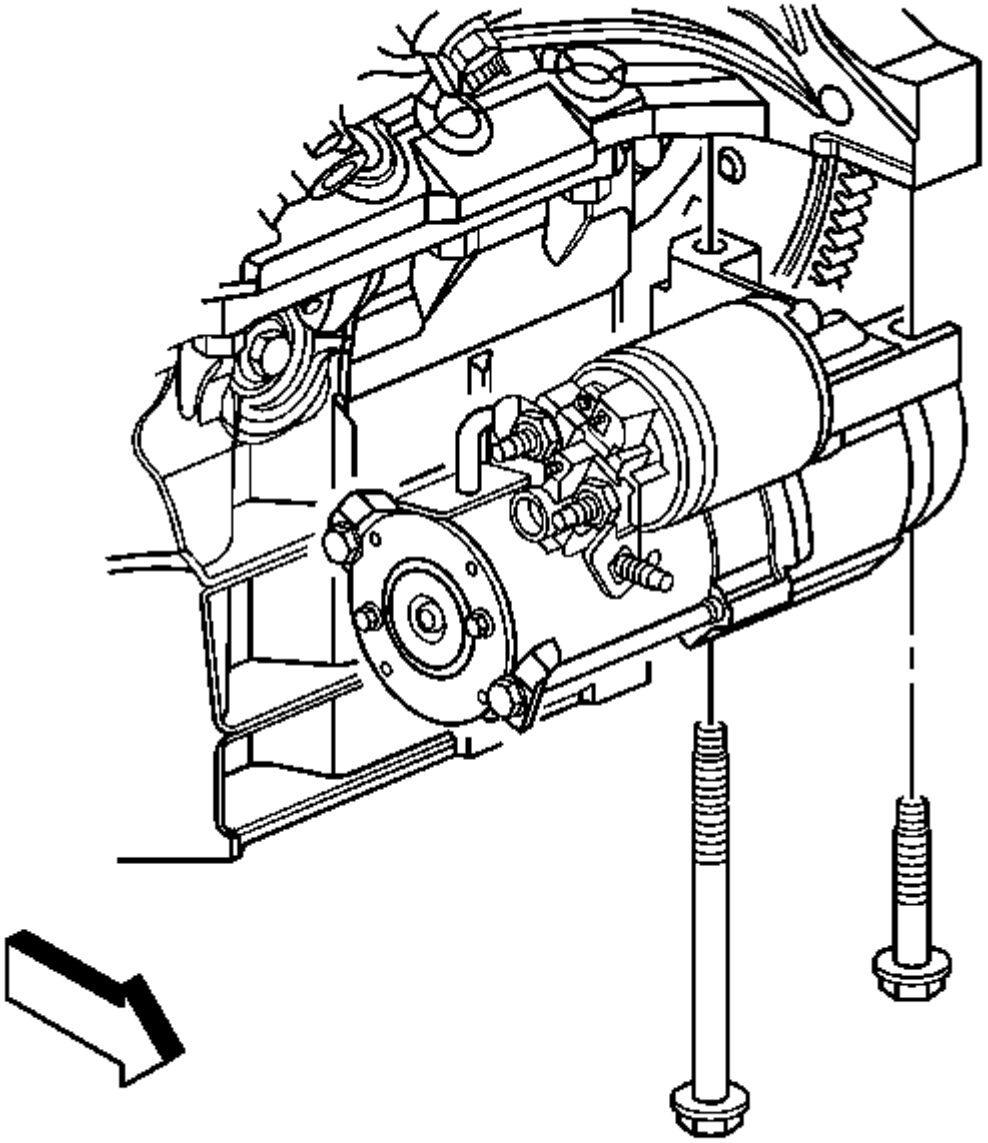

Fig. 277: Identifying Starter Motor & Bolts
Courtesy of GENERAL MOTORS CORP.

80. Remove the starter motor bolts and starter.

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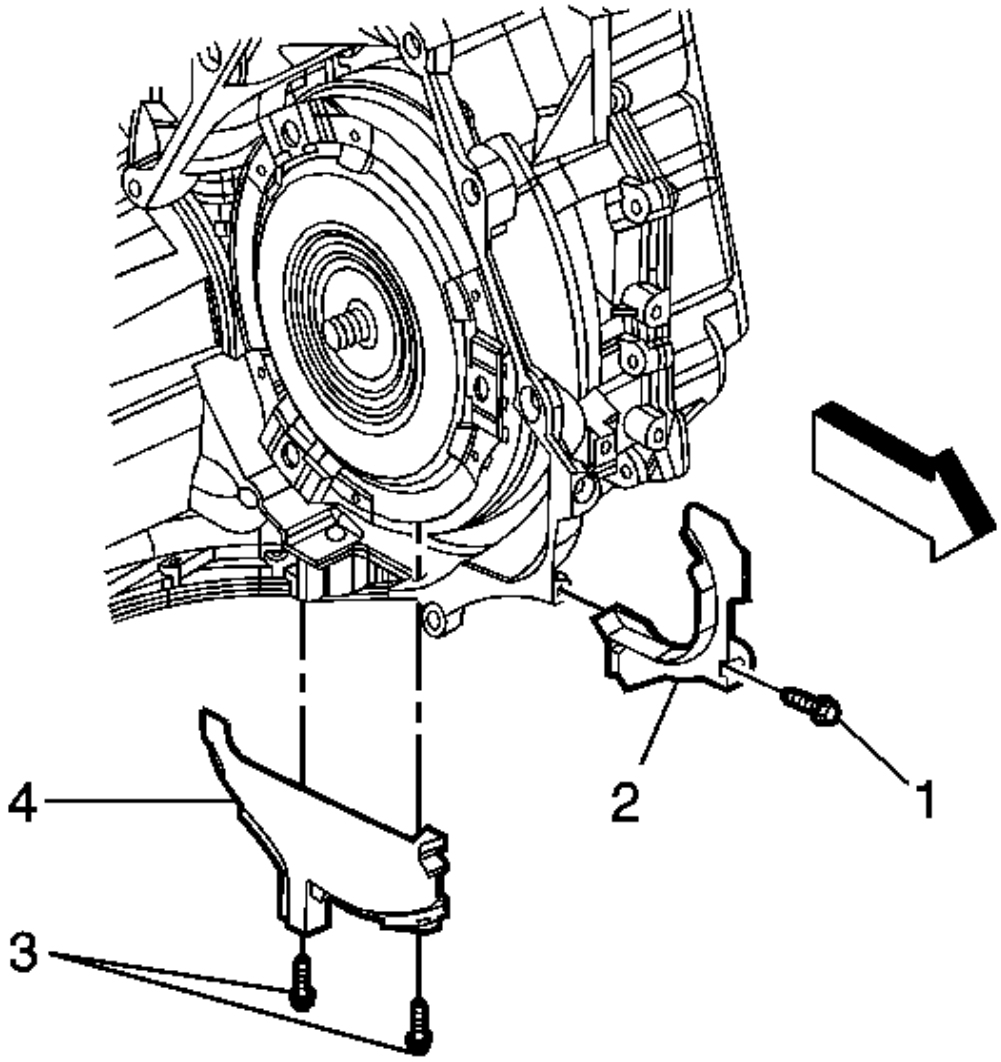

Fig. 278: Identifying Torque Converter Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

81. Remove the torque converter cover bolts (1, 3).
82. Remove the torque converter covers (2, 4).

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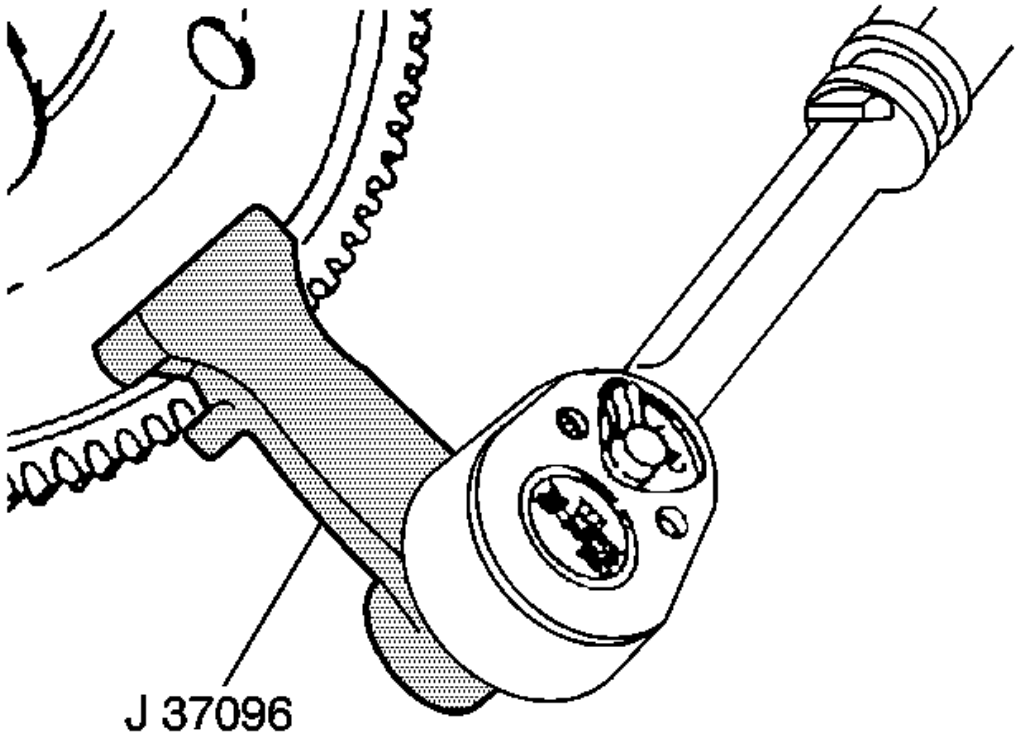

Fig. 279: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

83. Use the **J 37096** in order to hold the flywheel, and also rotate the flywheel to access the torque converter bolts.

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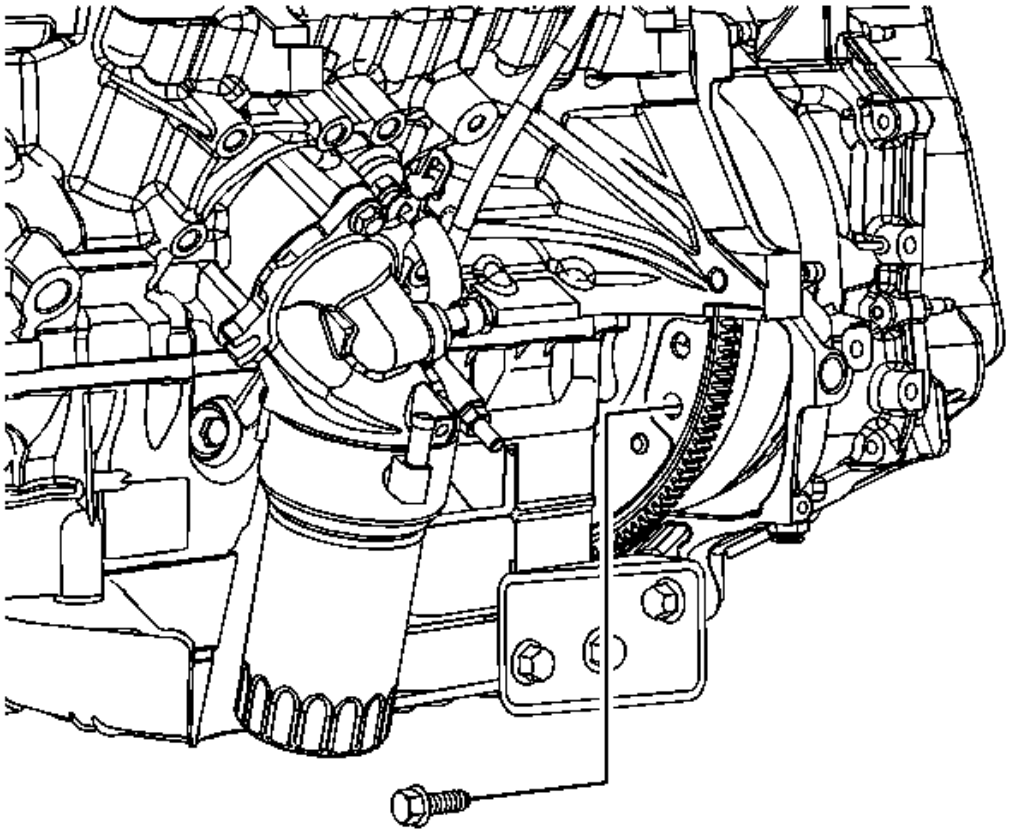

Fig. 280: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

84. Remove the torque converter bolts.

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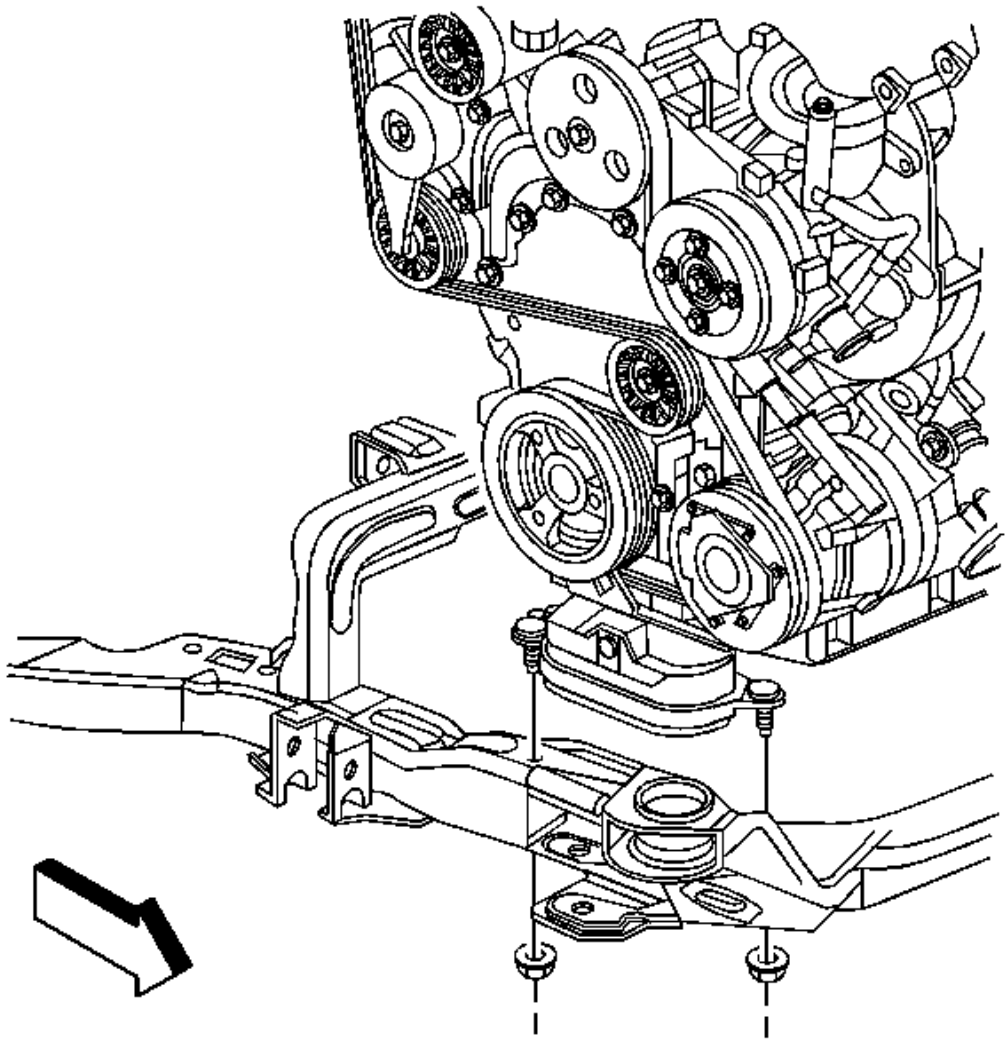

Fig. 281: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

85. Remove the engine mount to frame nuts.

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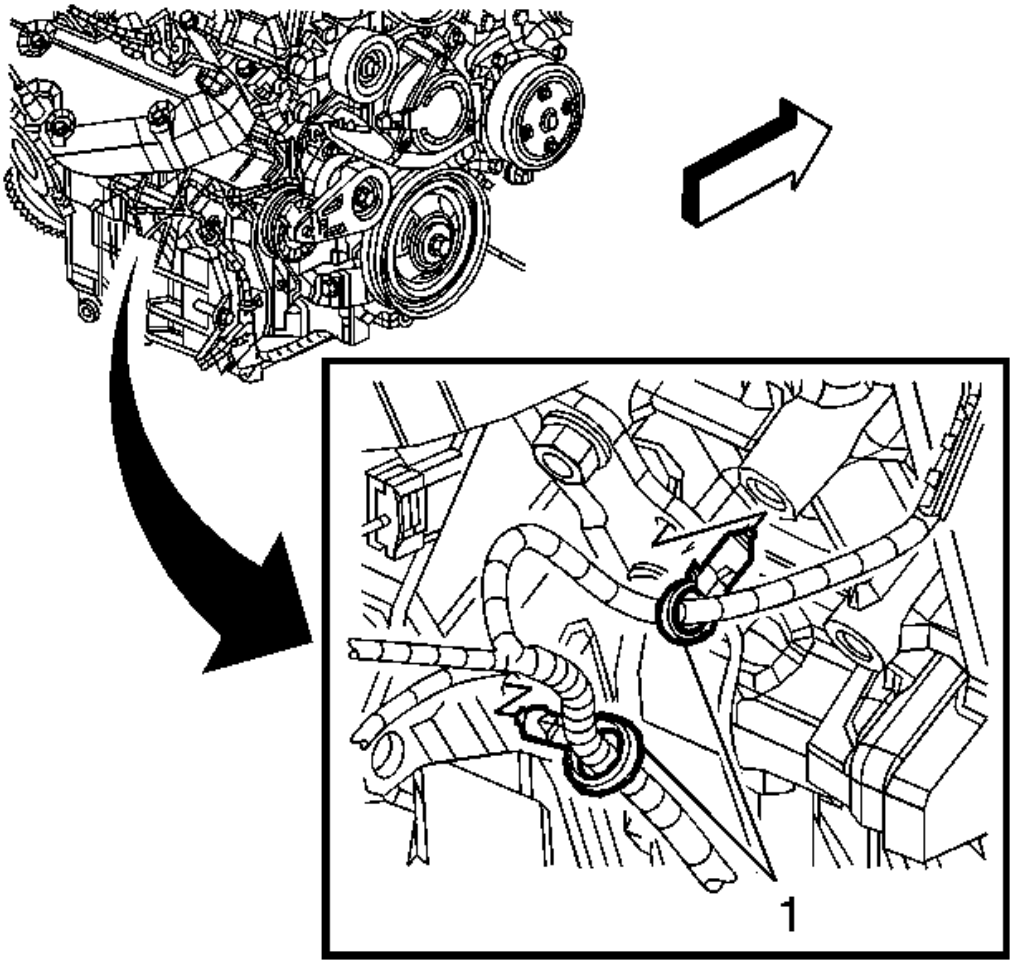

Fig. 282: Removing/Installing Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

86. Remove the engine harness clips (1) from the transaxle brace.

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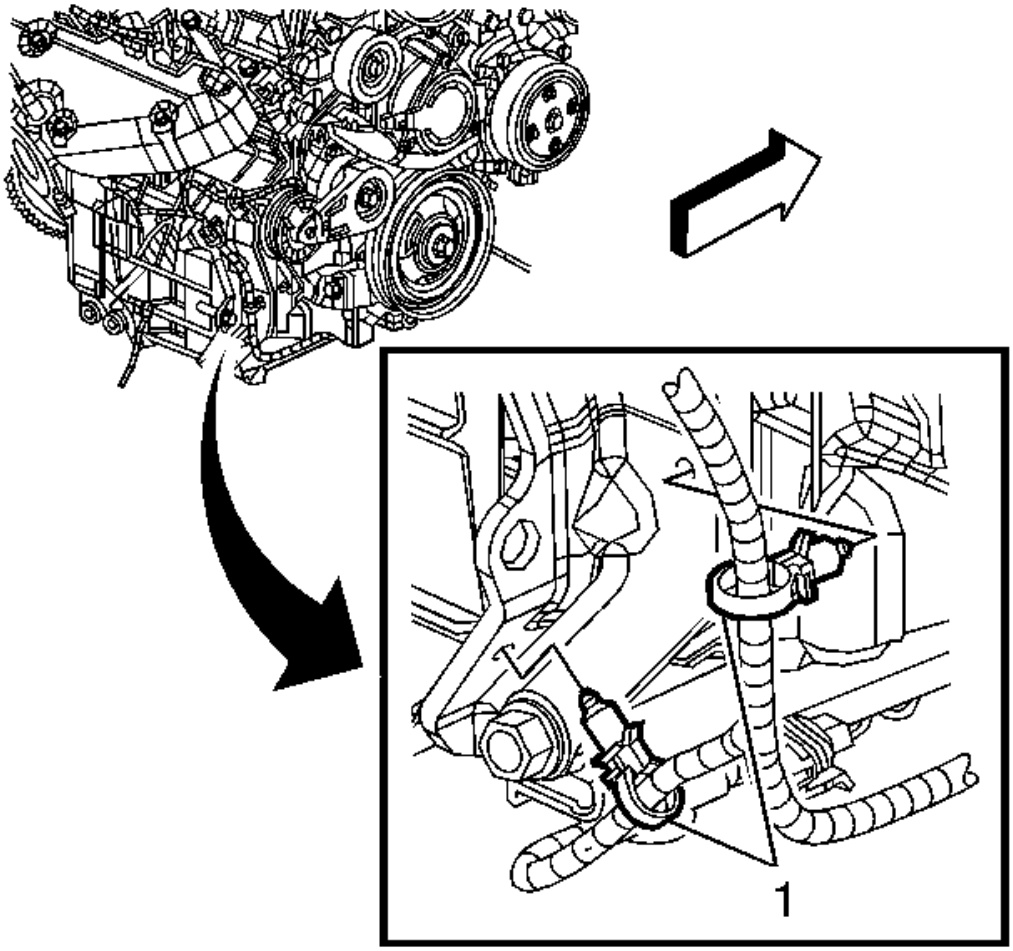

Fig. 283: Identifying Engine Harness Clips At Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

87. Remove the engine harness clips (1) from the transaxle brace.

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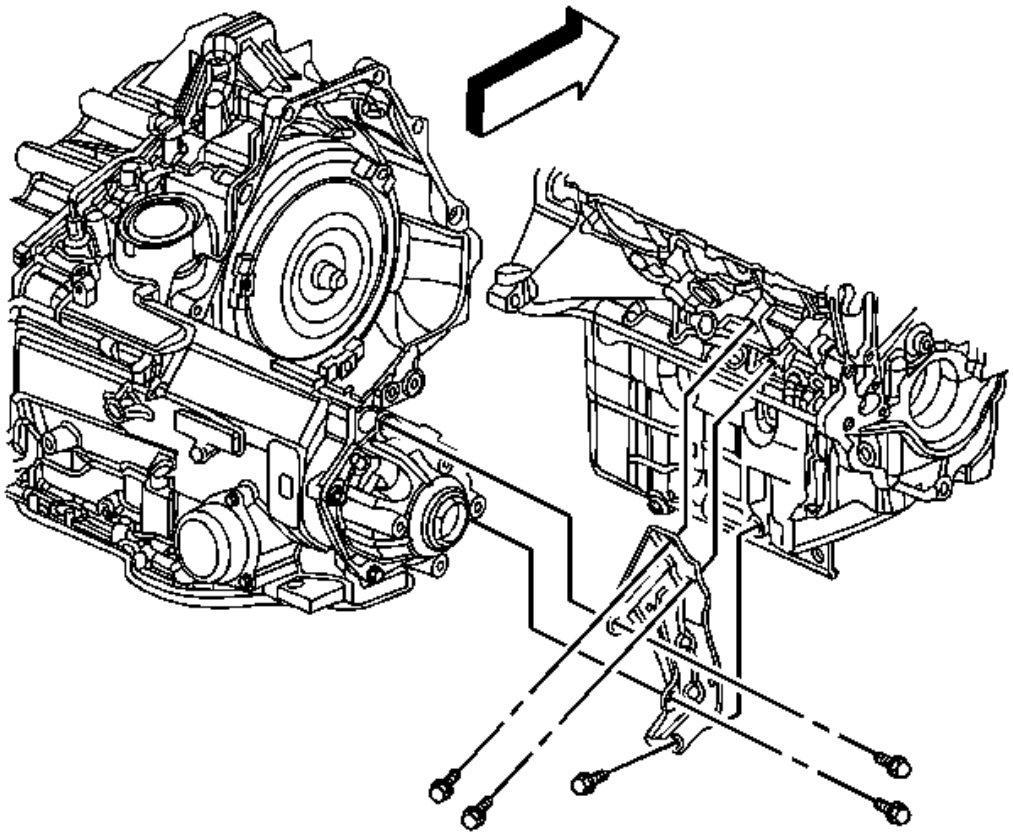

Fig. 284: Removing/Installing Transaxle Brace To Engine Block
Courtesy of GENERAL MOTORS CORP.

88. Remove the transaxle brace bolts and brace.

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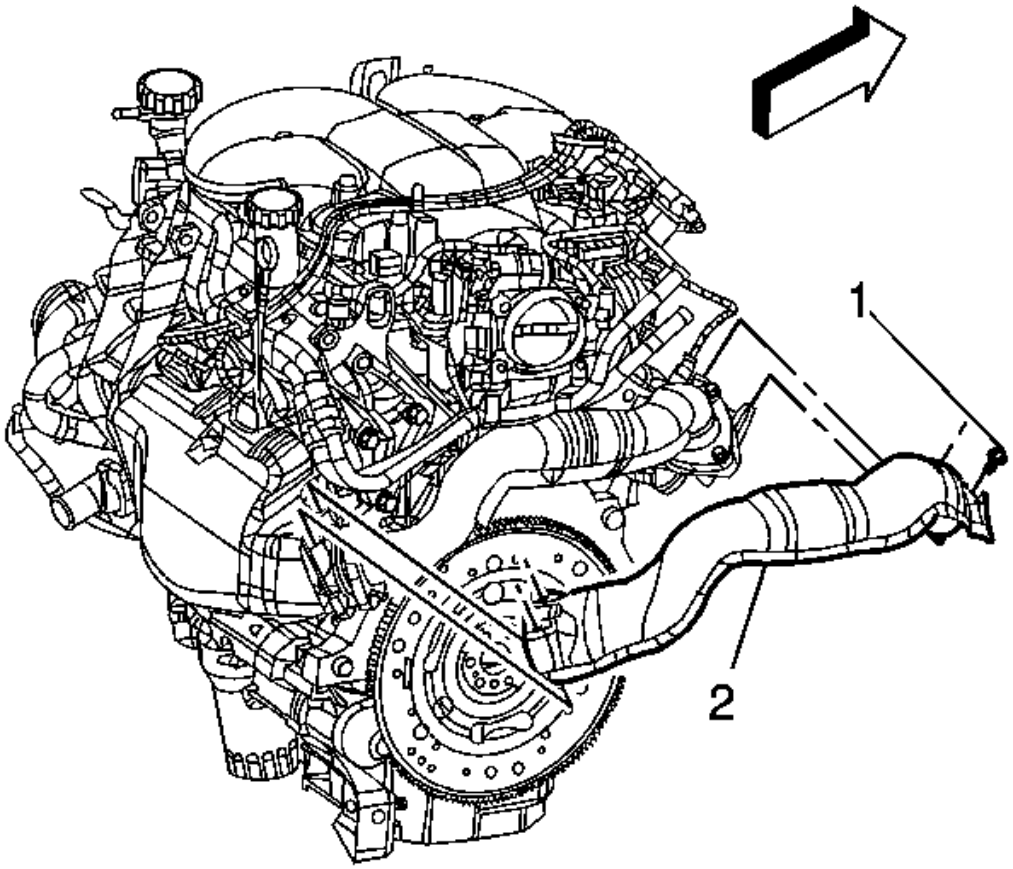

Fig. 285: Removing/Installing Exhaust Crossover Pipe Shield Bolts & Shield
Courtesy of GENERAL MOTORS CORP.

89. Remove the exhaust crossover pipe shield bolts (1) and shield (2).

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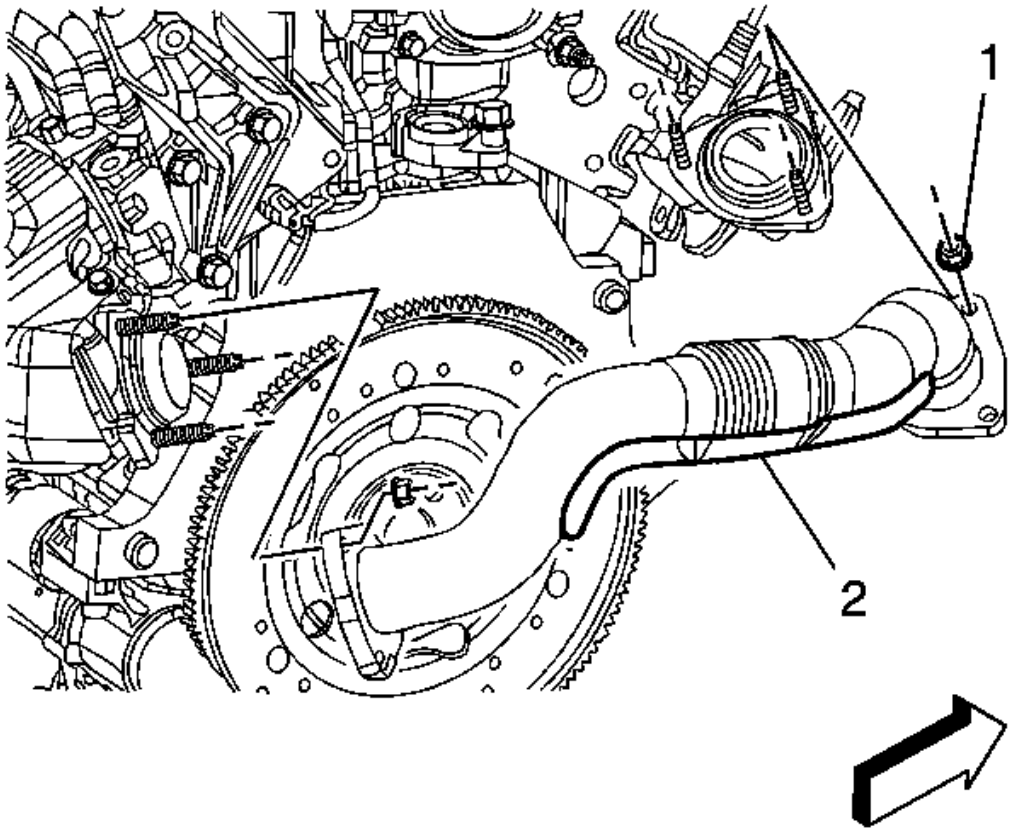

Fig. 286: Identifying Exhaust Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

90. Remove the exhaust crossover pipe nuts (1) and pipe (2).

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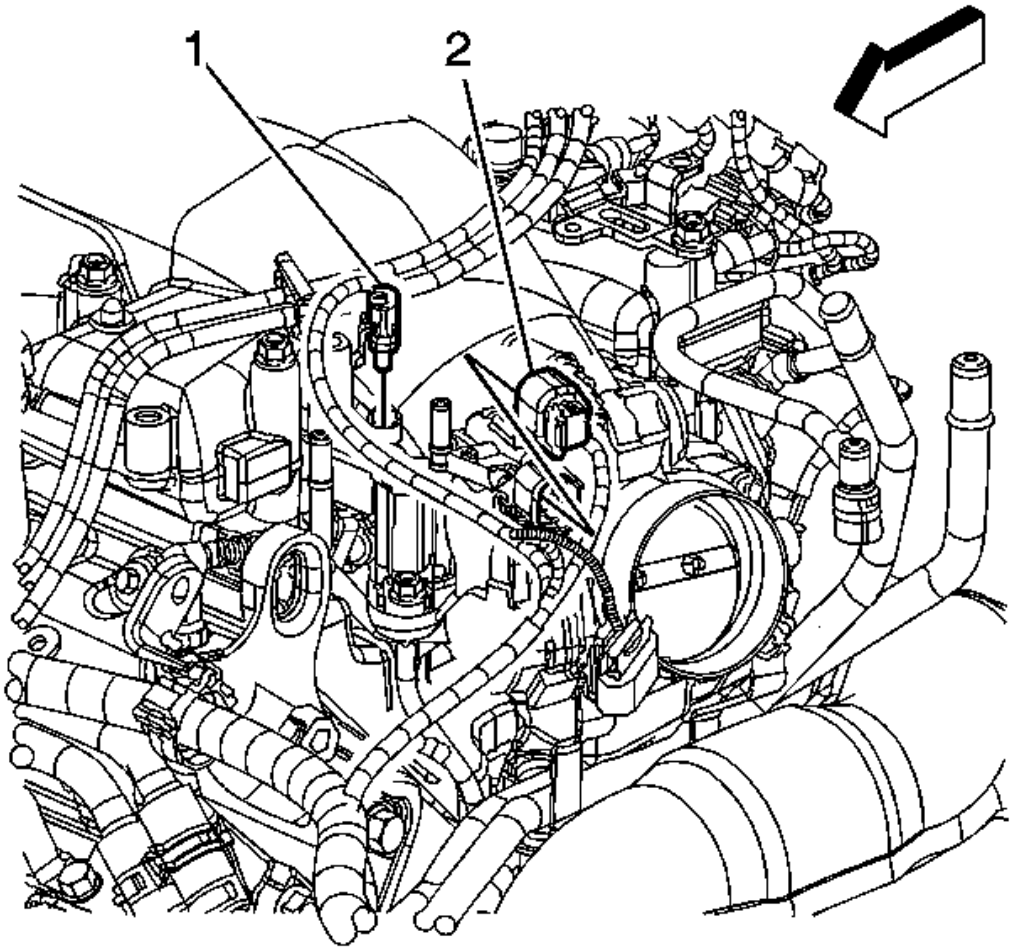

Fig. 287: Locating EVAP & ETC Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

91. Disconnect the engine harness electrical connector (1) from the EVAP purge solenoid.
92. Disconnect the engine harness electrical connector (2) from the throttle actuator.

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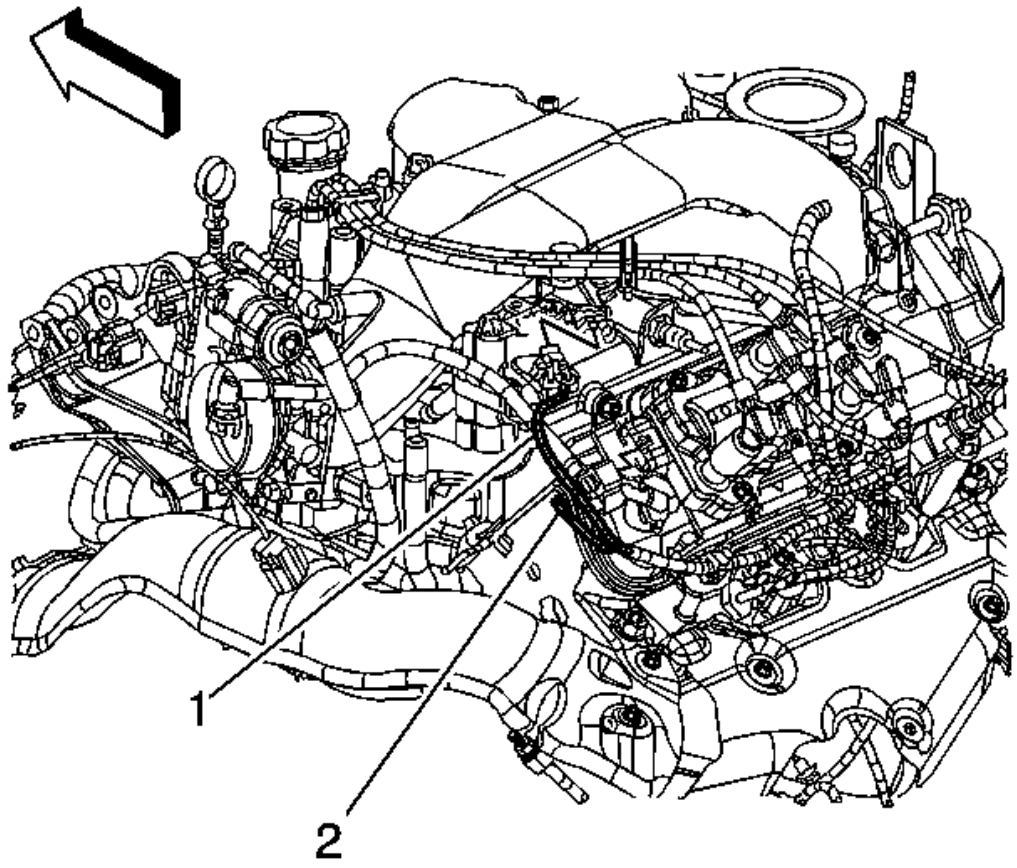

Fig. 288: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

93. Disconnect the engine harness electrical connector (1) from the manifold absolute pressure (MAP) sensor.
94. Disconnect the engine harness electrical connector (2) from the ignition coil.

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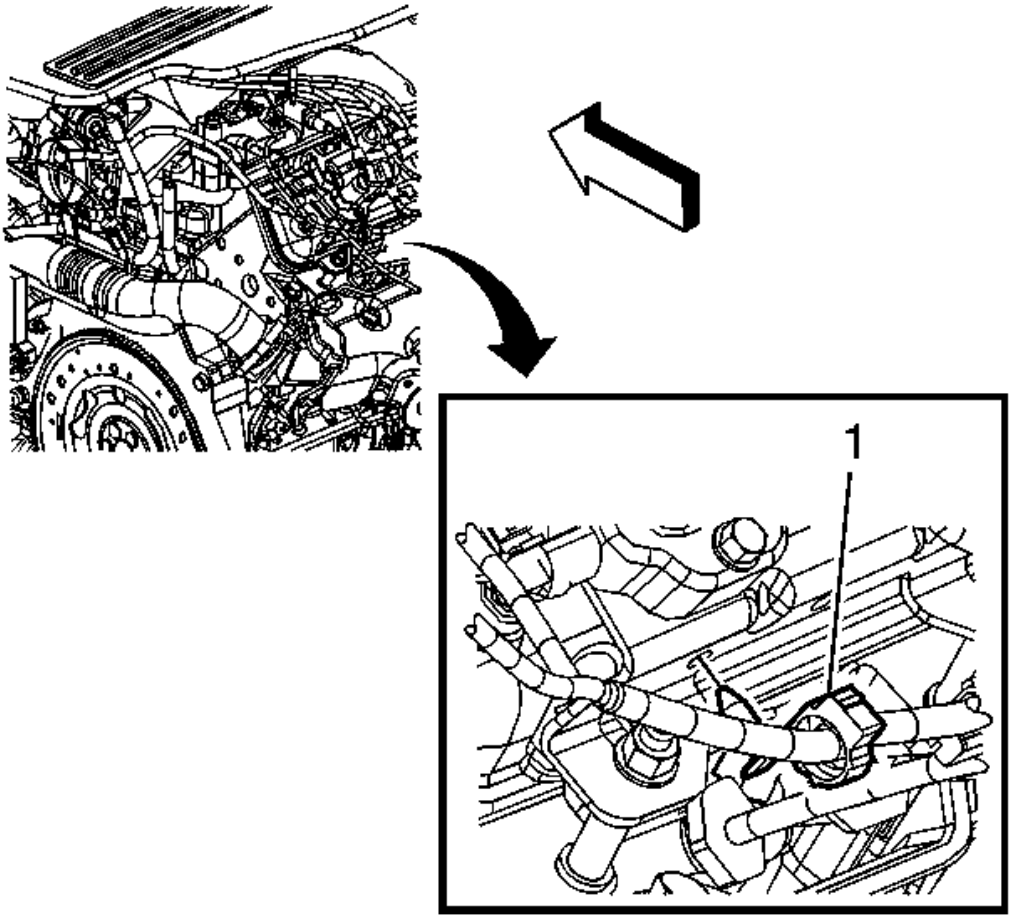

Fig. 289: View Of Engine Harness At Ignition Coil Bracket
Courtesy of GENERAL MOTORS CORP.

95. Remove the engine harness clip (1) from the ignition coil bracket.

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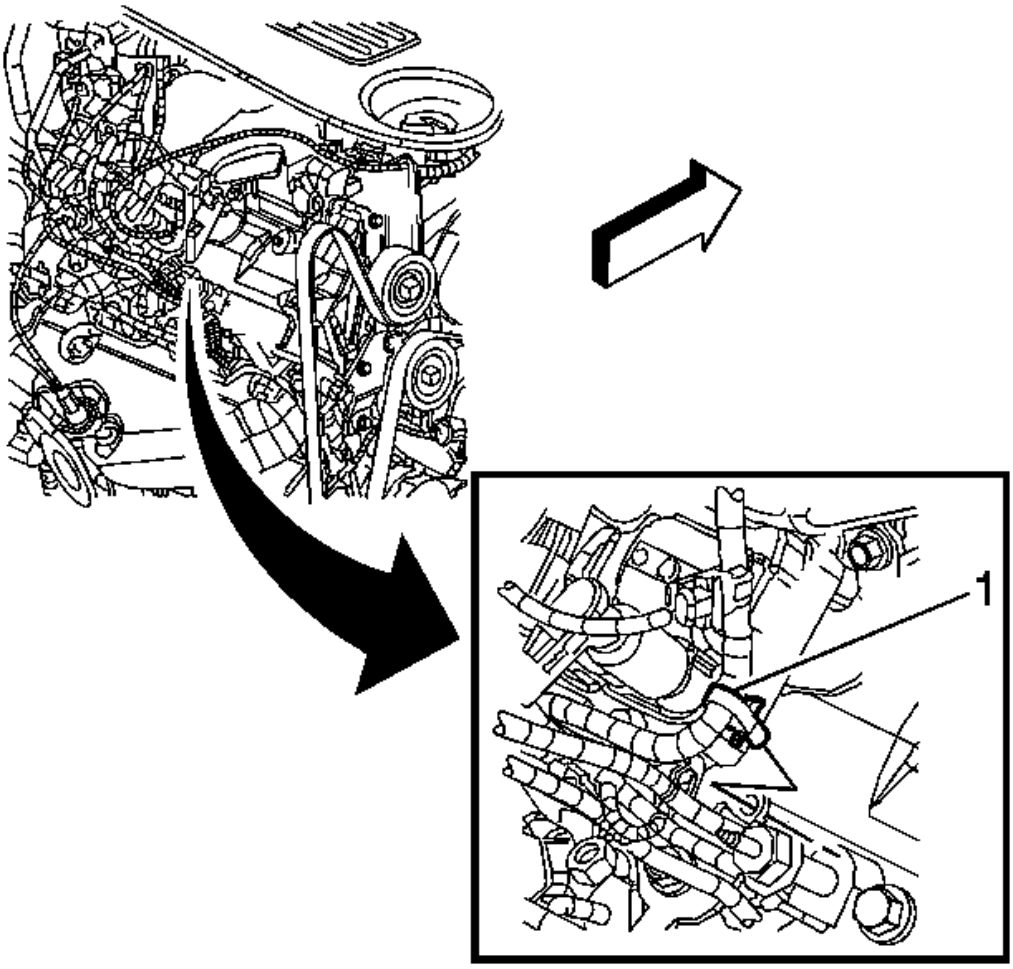

Fig. 290: Identifying Engine Harness At Ignition Coil Bracket
Courtesy of GENERAL MOTORS CORP.

96. Remove the engine harness clip (1) from he ignition coil bracket.

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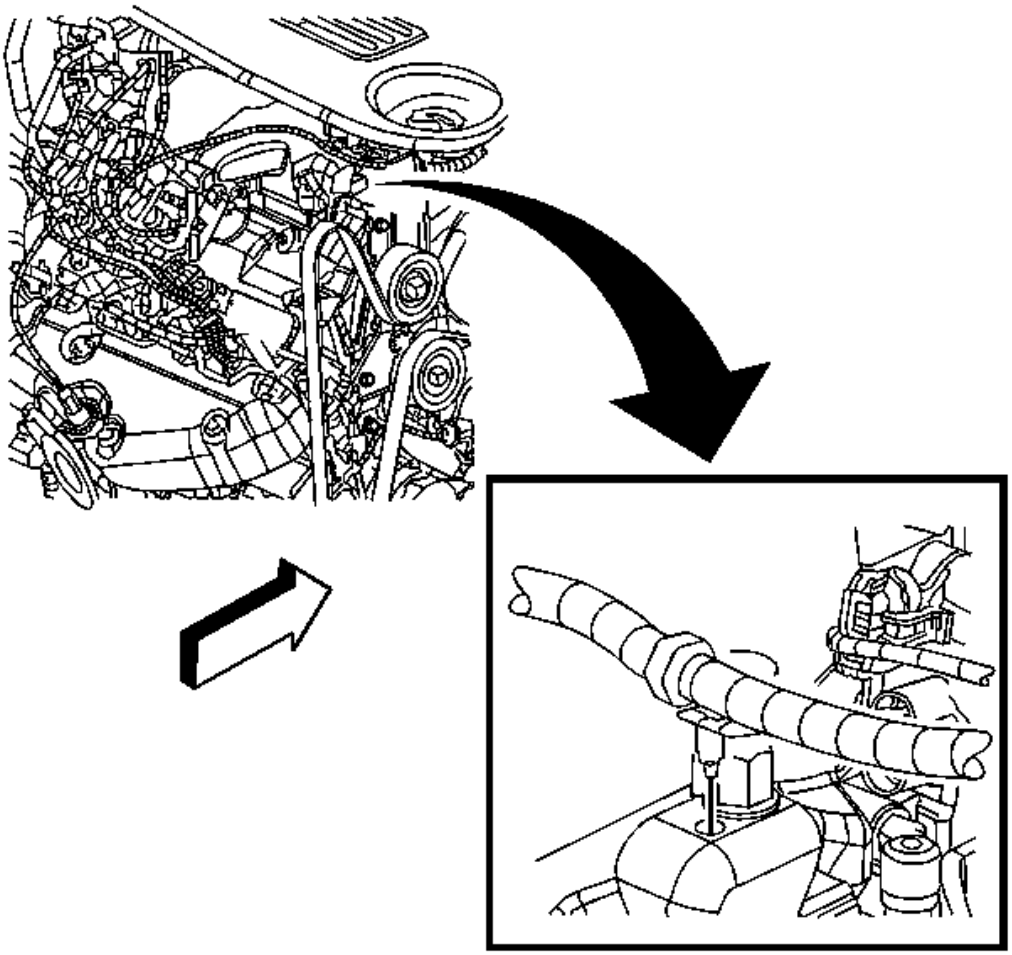

Fig. 291: Removing/Installing Engine Harness To Engine
Courtesy of GENERAL MOTORS CORP.

97. Remove the engine harness clip from the engine.

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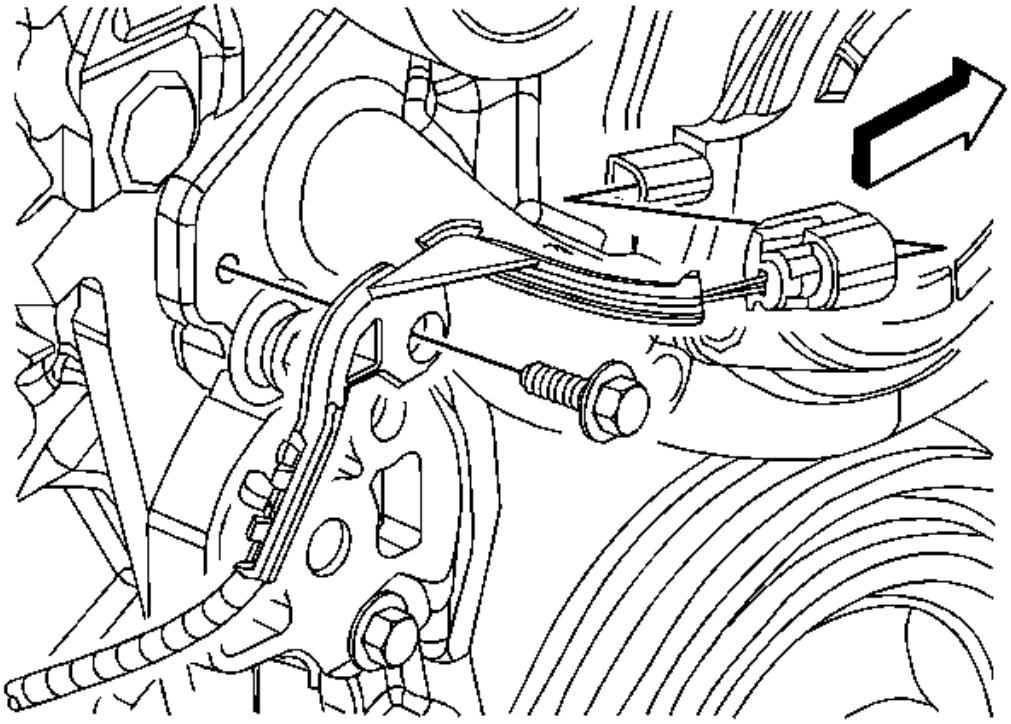

Fig. 292: Locating Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

98. Remove the engine harness bolt.
99. Disconnect the engine harness electrical connector from the camshaft actuator magnet.

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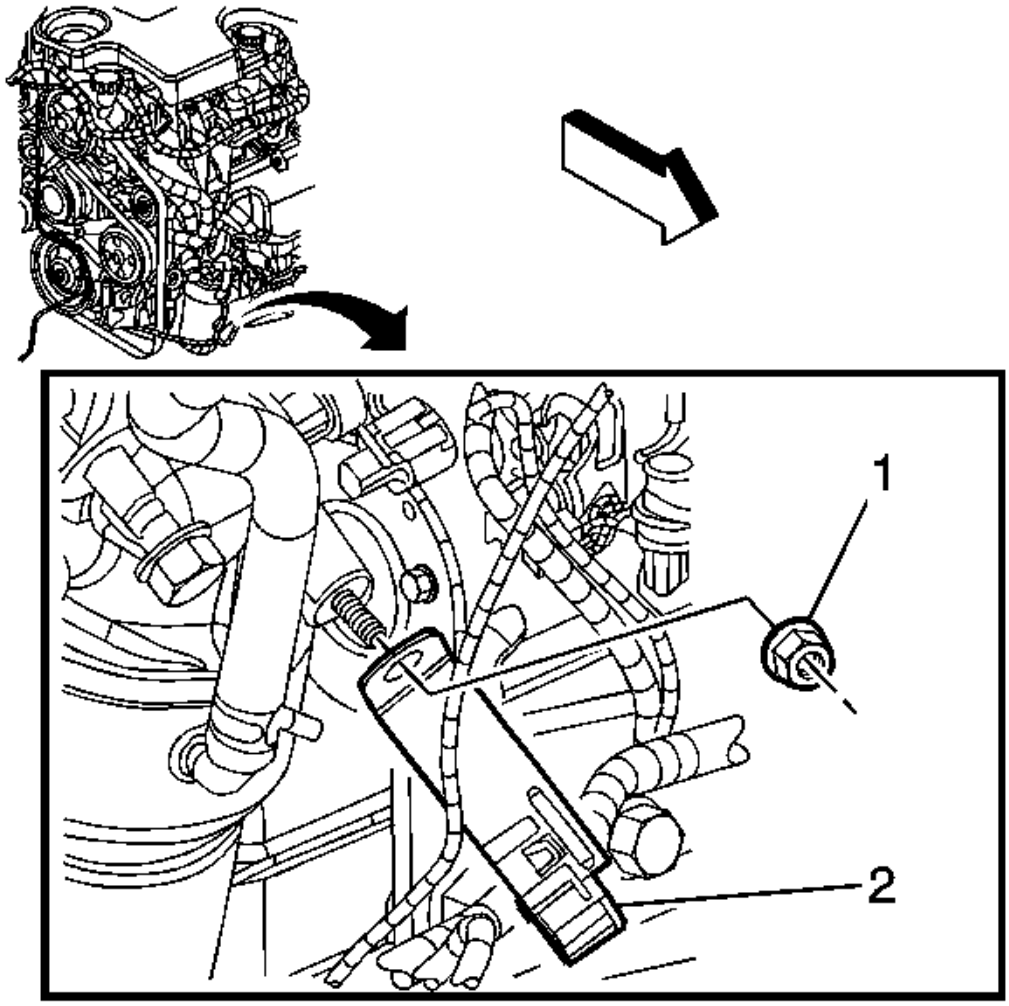

Fig. 293: Locating Engine Harness Bracket Nut
Courtesy of GENERAL MOTORS CORP.

100. Remove the engine harness bracket nut (1).
101. Remove the engine harness bracket (2) from the stud.

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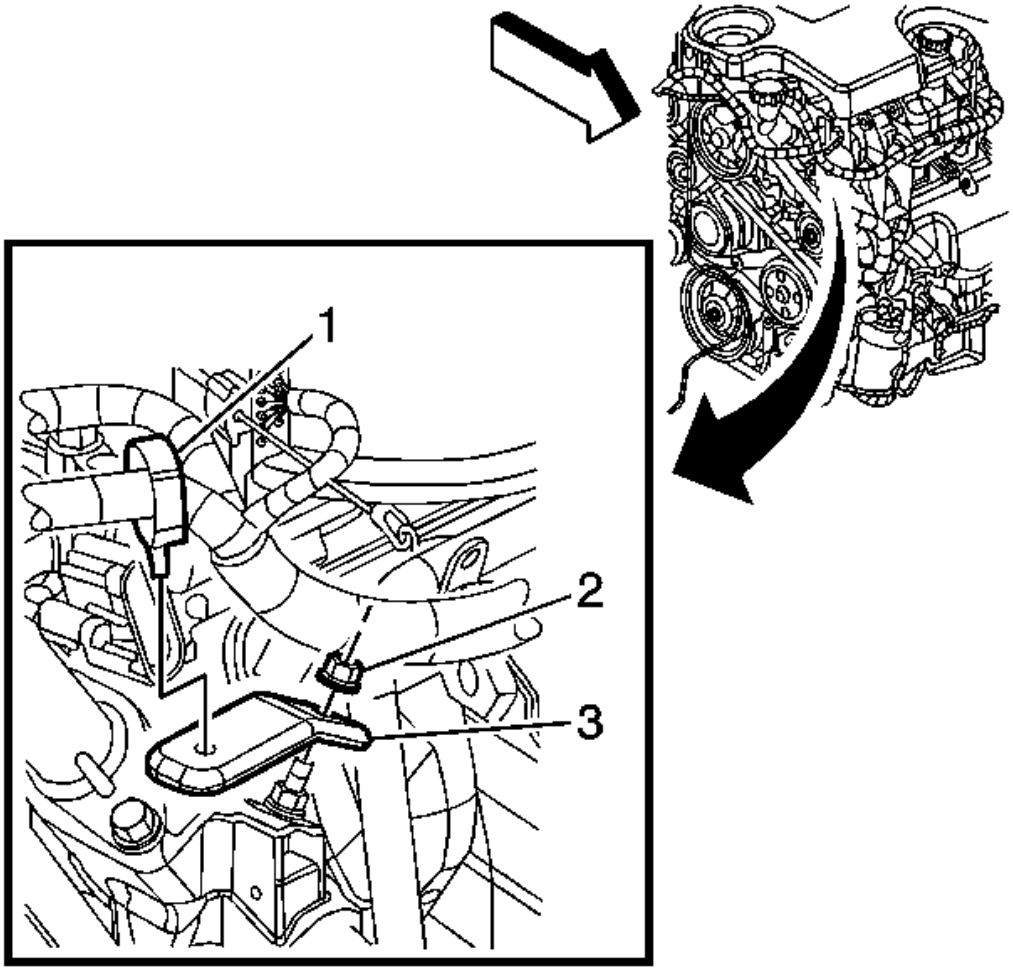

Fig. 294: View Of Engine Harness Clip At Bracket
Courtesy of GENERAL MOTORS CORP.

102. Remove the engine harness clip (1) from the bracket.

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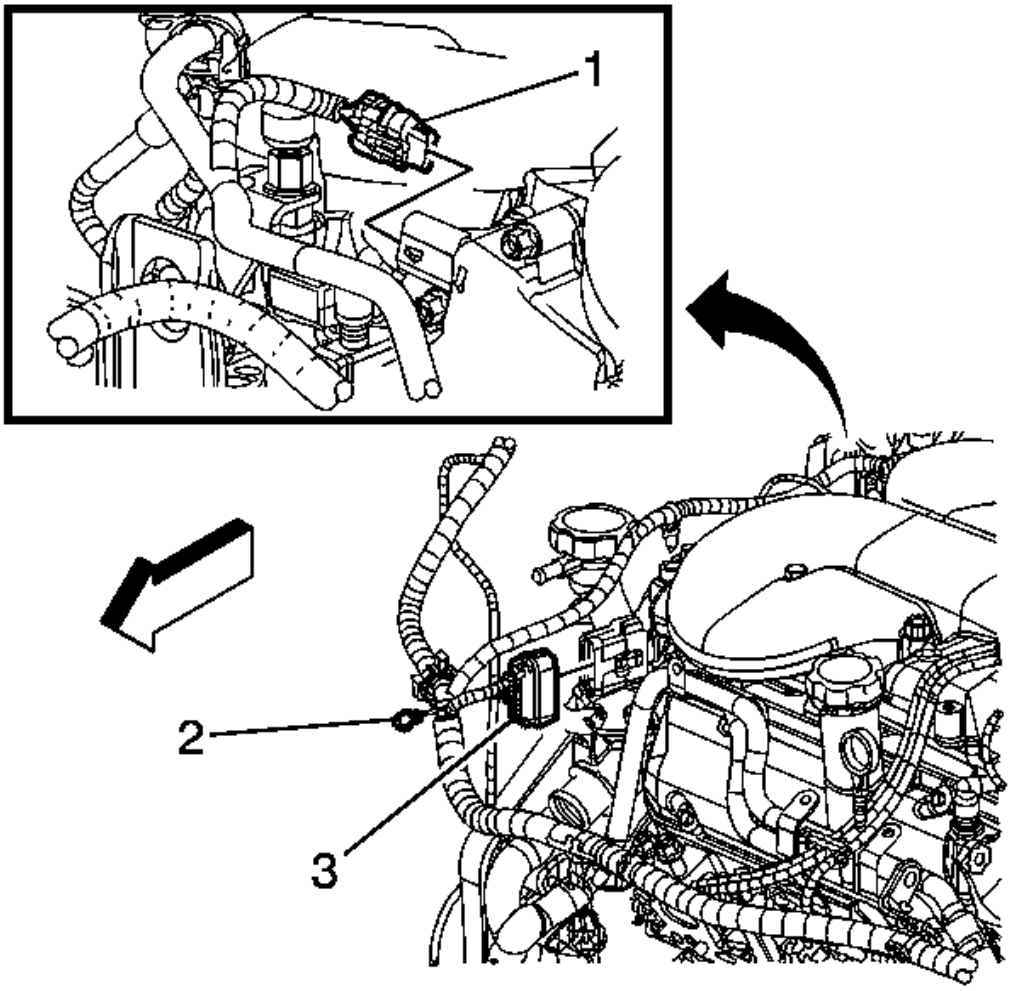

Fig. 295: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

103. Disconnect the engine harness electrical connector (1) from the intake manifold tuning valve.
104. Remove the connector position assurance (CPA) retainer (2).
105. Disconnect the engine harness electrical connector (3) from the fuel injector harness electrical connector.

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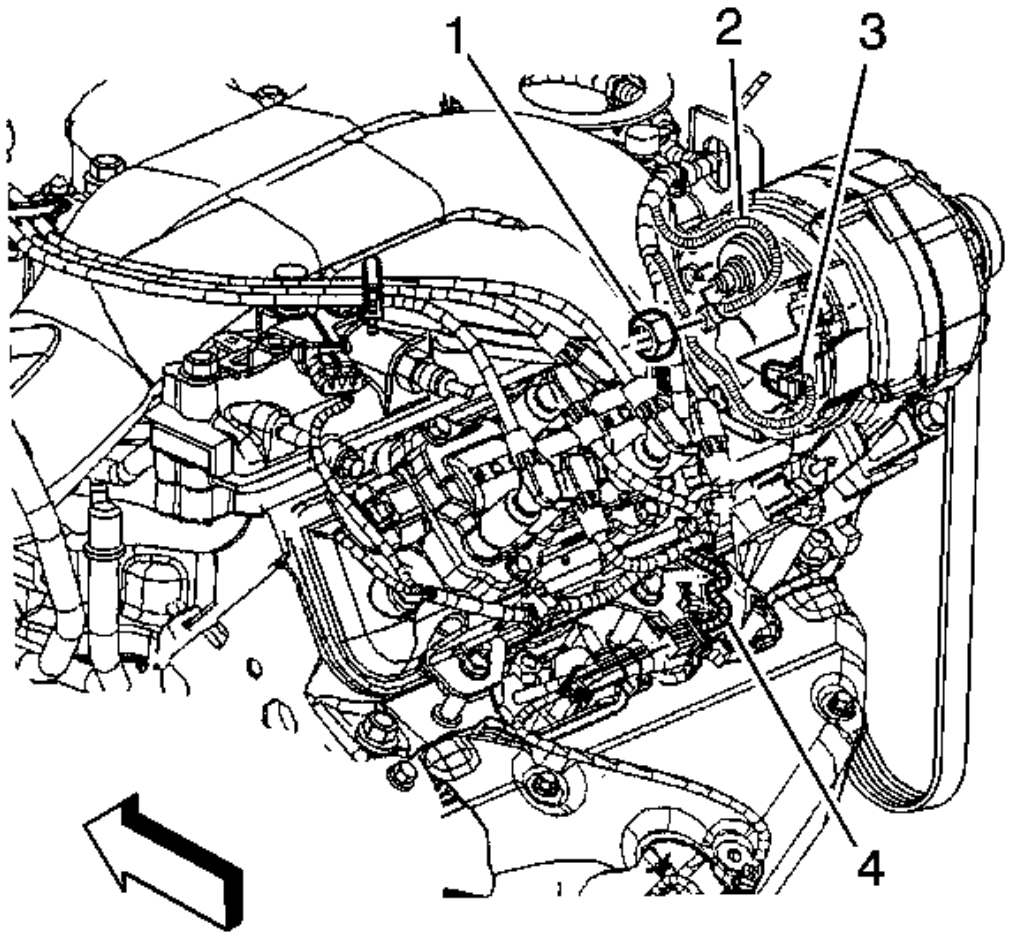

Fig. 296: View Of Generator And Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

106. Remove the generator terminal nut (1).
107. Remove the engine harness lead (2) from the generator.
108. Disconnect the engine harness electrical connector (3) from the generator.
109. Disconnect the engine harness electrical connector (4) from the heated oxygen sensor (HO2S).

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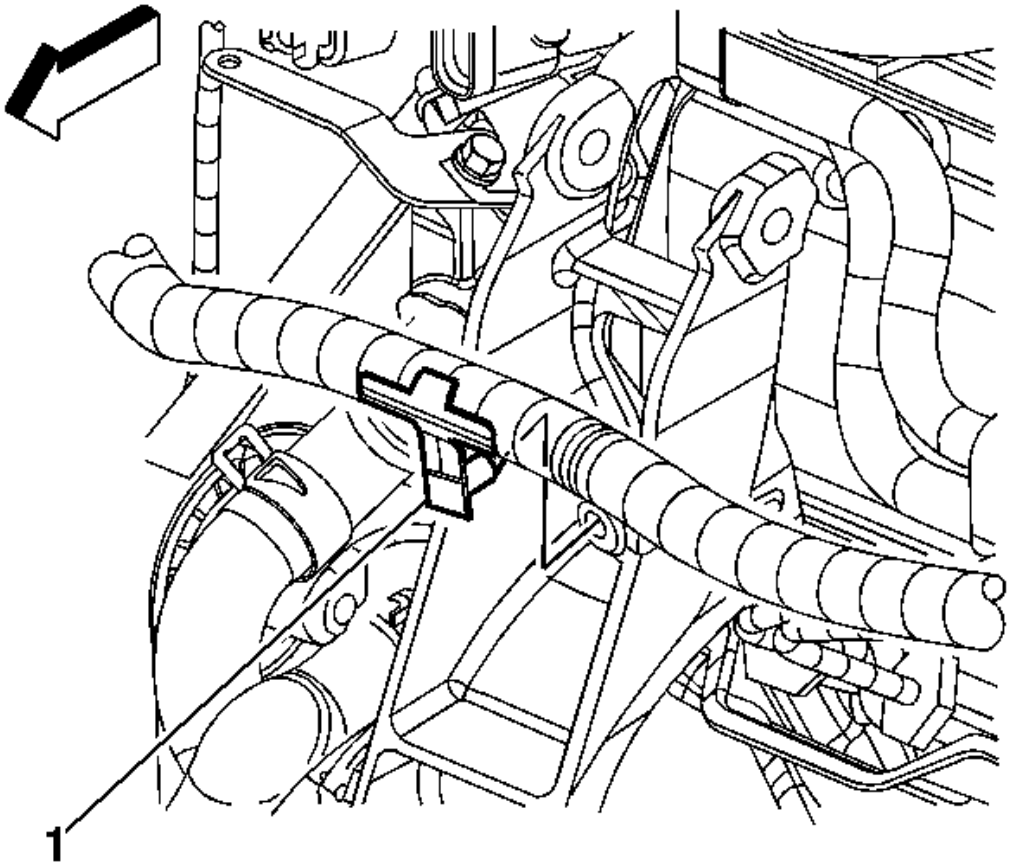

Fig. 297: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

110. Remove the engine harness clip (1) from the strut bracket.

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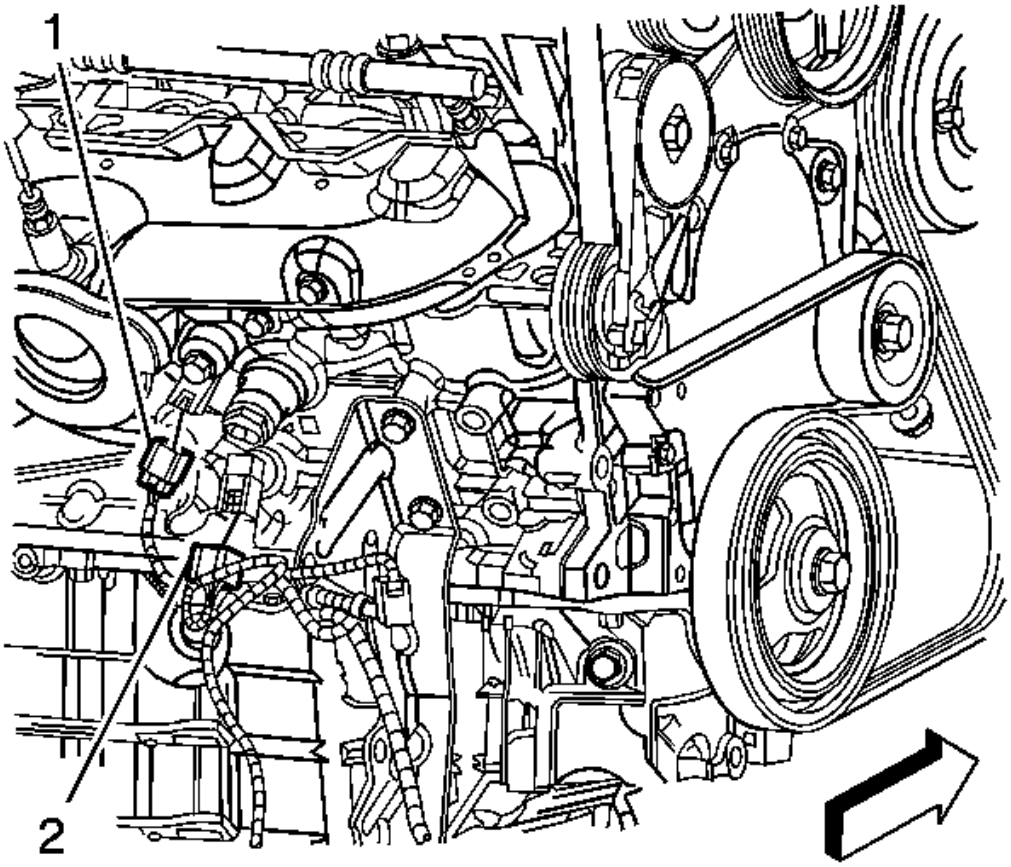

Fig. 298: Identifying Knock Sensor (KS) & Crankshaft Position (CKP) Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

111. Disconnect the engine harness electrical connector (1) from the crankshaft position (CKP) sensor.

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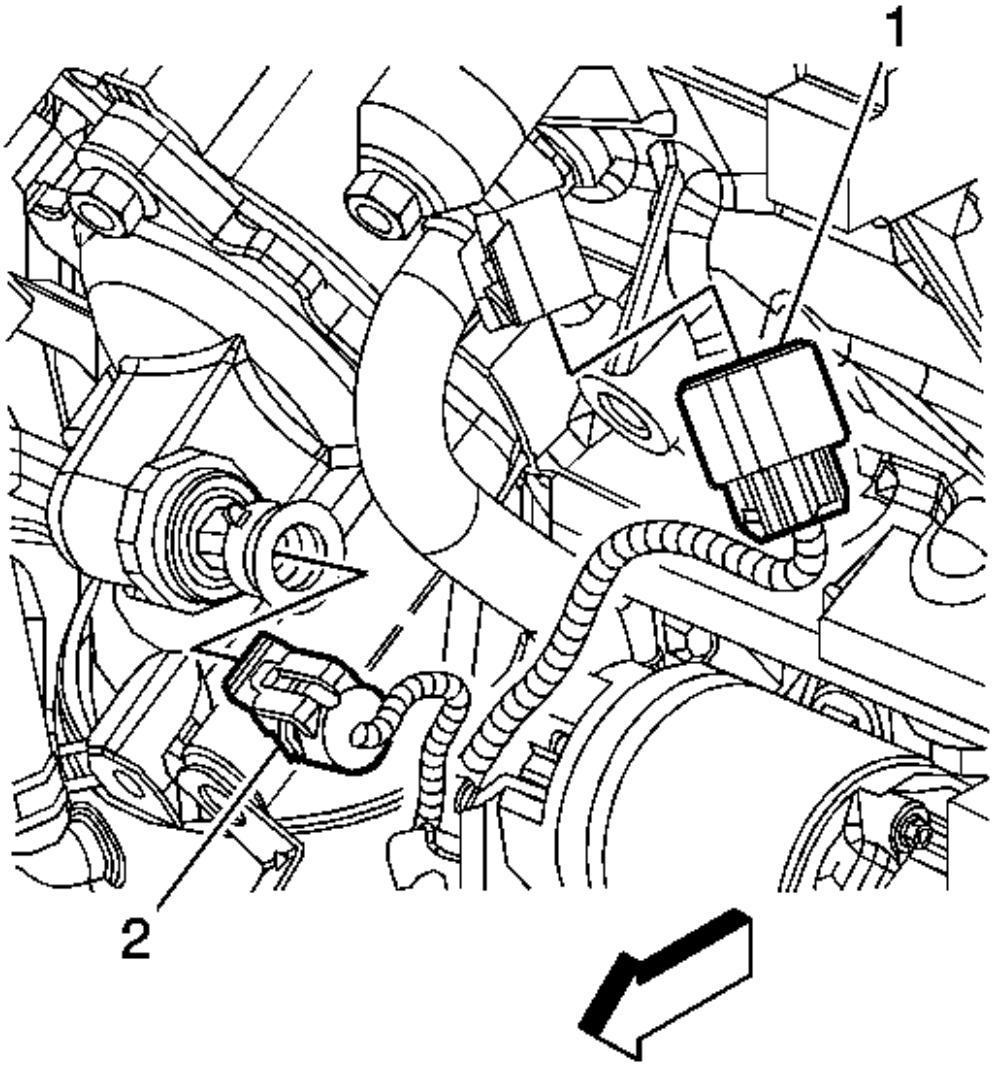

Fig. 299: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

112. Disconnect the engine harness electrical connector (1) from the knock sensor.
113. Disconnect the engine harness electrical connector (2) from the oil pressure sensor.

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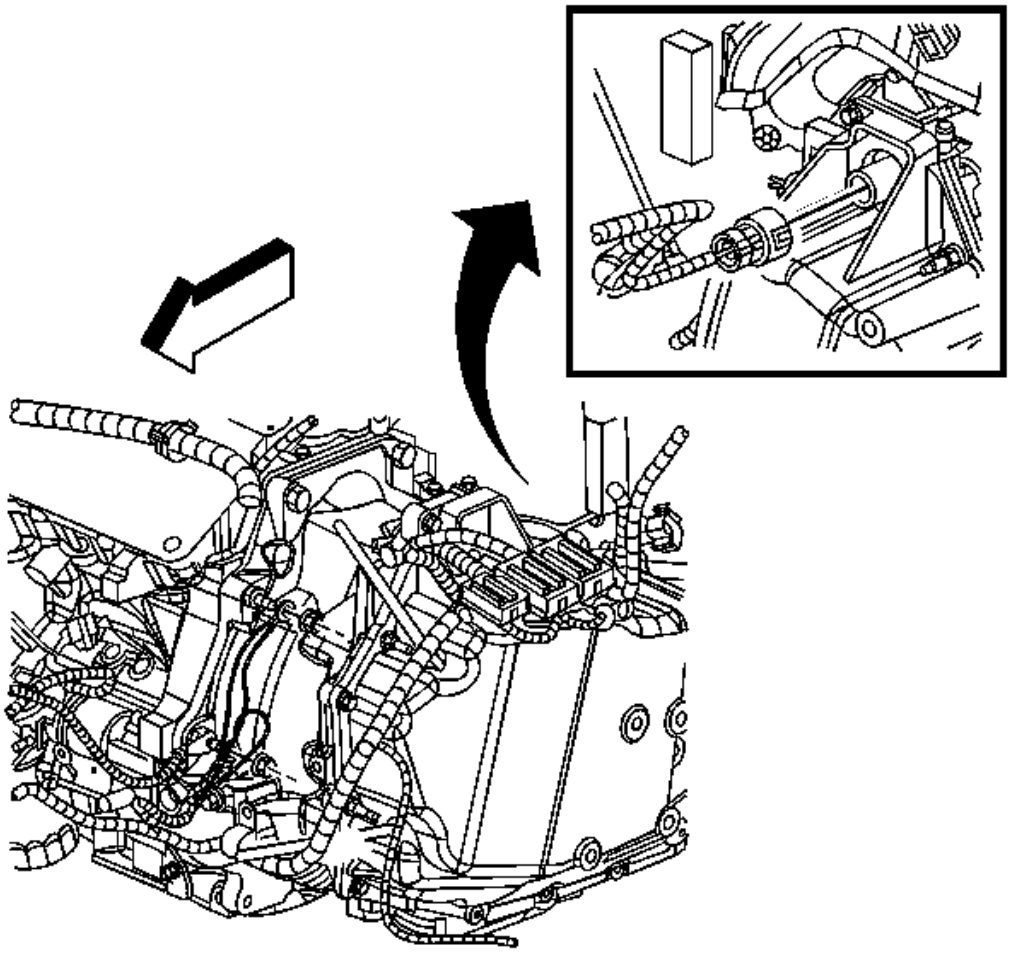

Fig. 300: Identifying Engine Harness Connector At Transaxle
Courtesy of GENERAL MOTORS CORP.

114. Disconnect the engine harness electrical connector from the transaxle.

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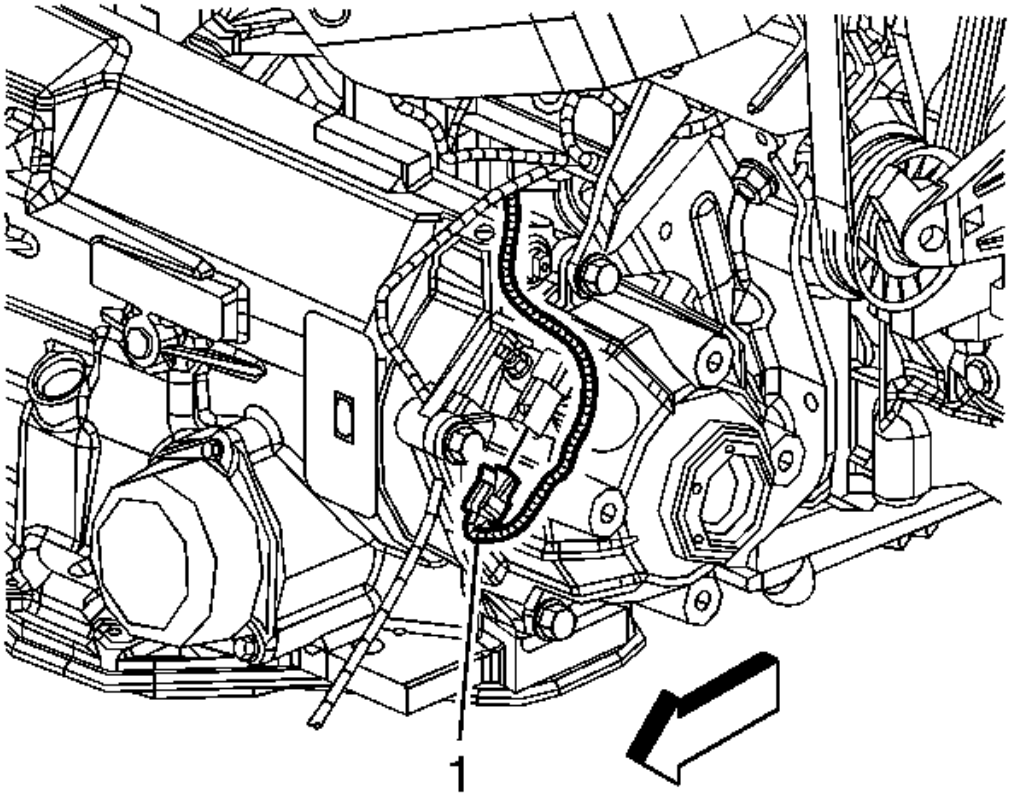

Fig. 301: Identifying Engine Harness connector At Vehicle Speed Sensor (VSS)
Courtesy of GENERAL MOTORS CORP.

115. Disconnect the engine harness electrical connector from the vehicle speed sensor (VSS).

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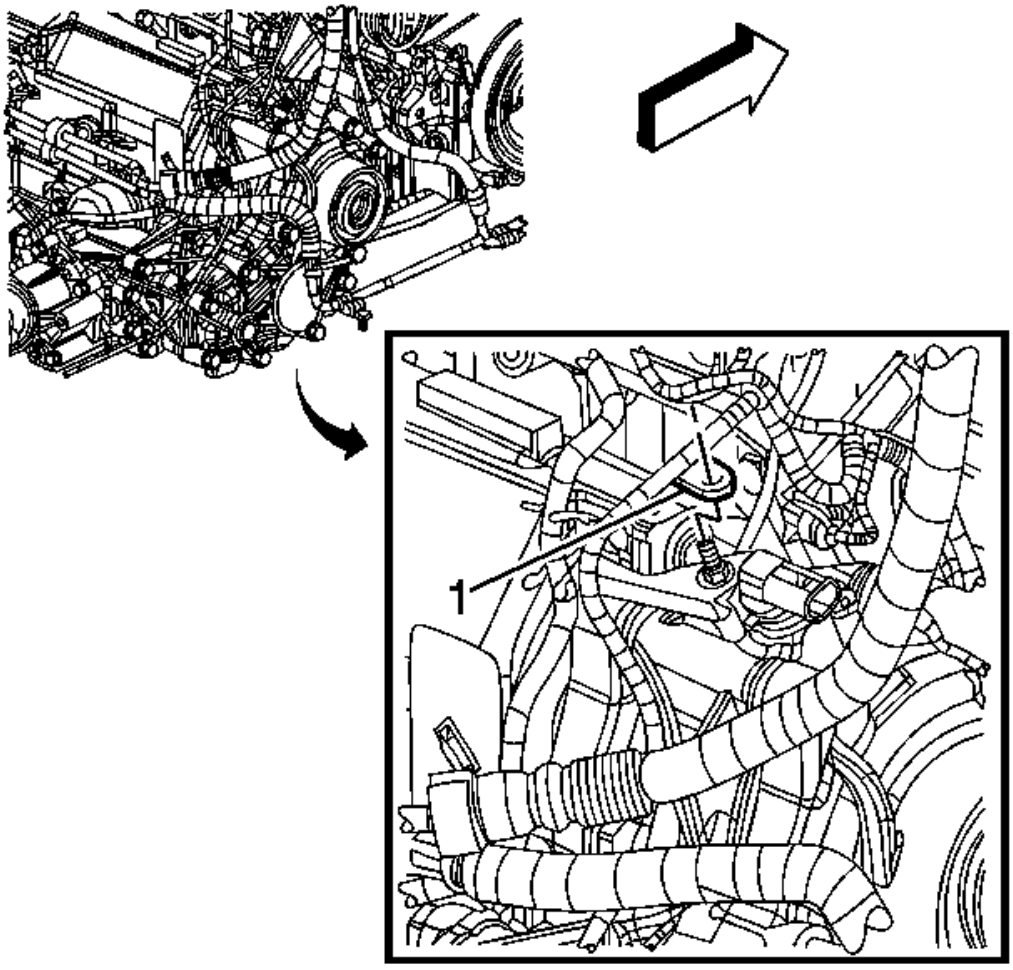

Fig. 302: Identifying Engine Harness Clip Studs
Courtesy of GENERAL MOTORS CORP.

116. Remove the engine harness clip (1) from the stud on the transaxle.

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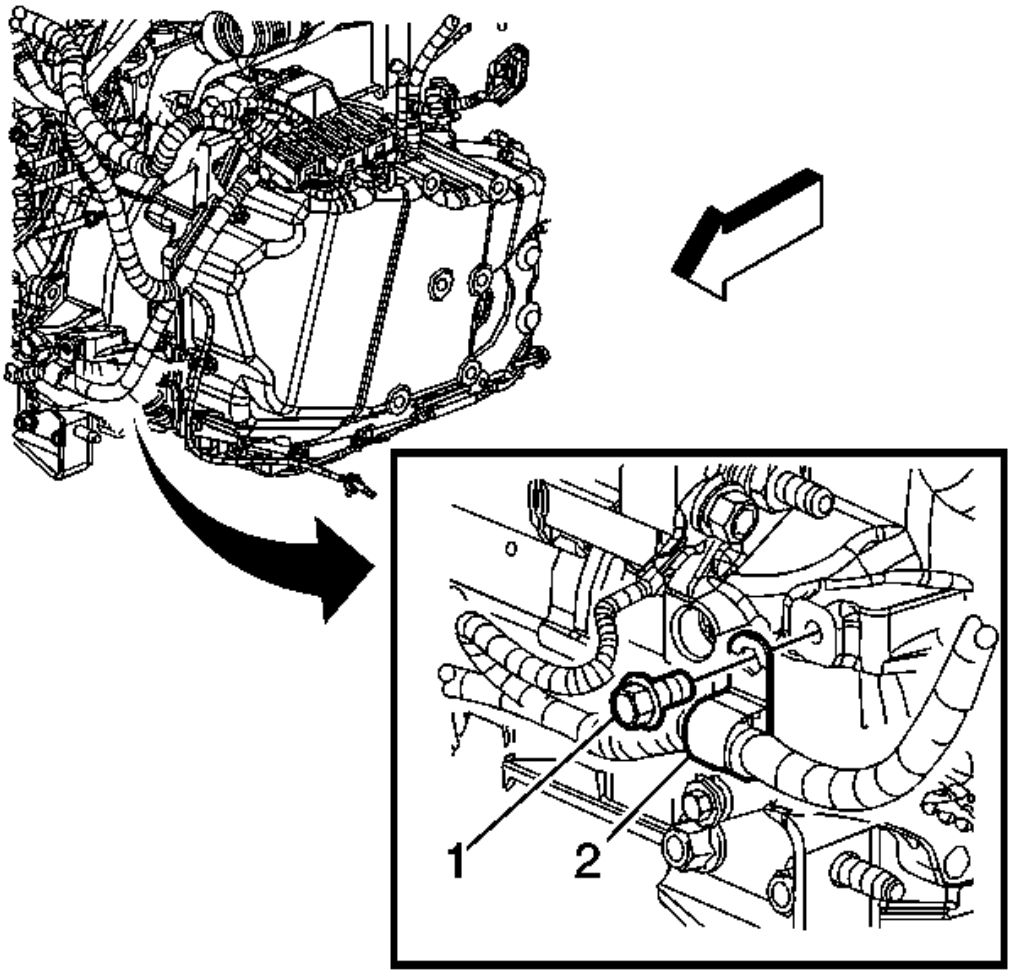

Fig. 303: Identifying Engine Harness Clamp Bolts
Courtesy of GENERAL MOTORS CORP.

117. Remove the engine harness clamp bolt from the transaxle.

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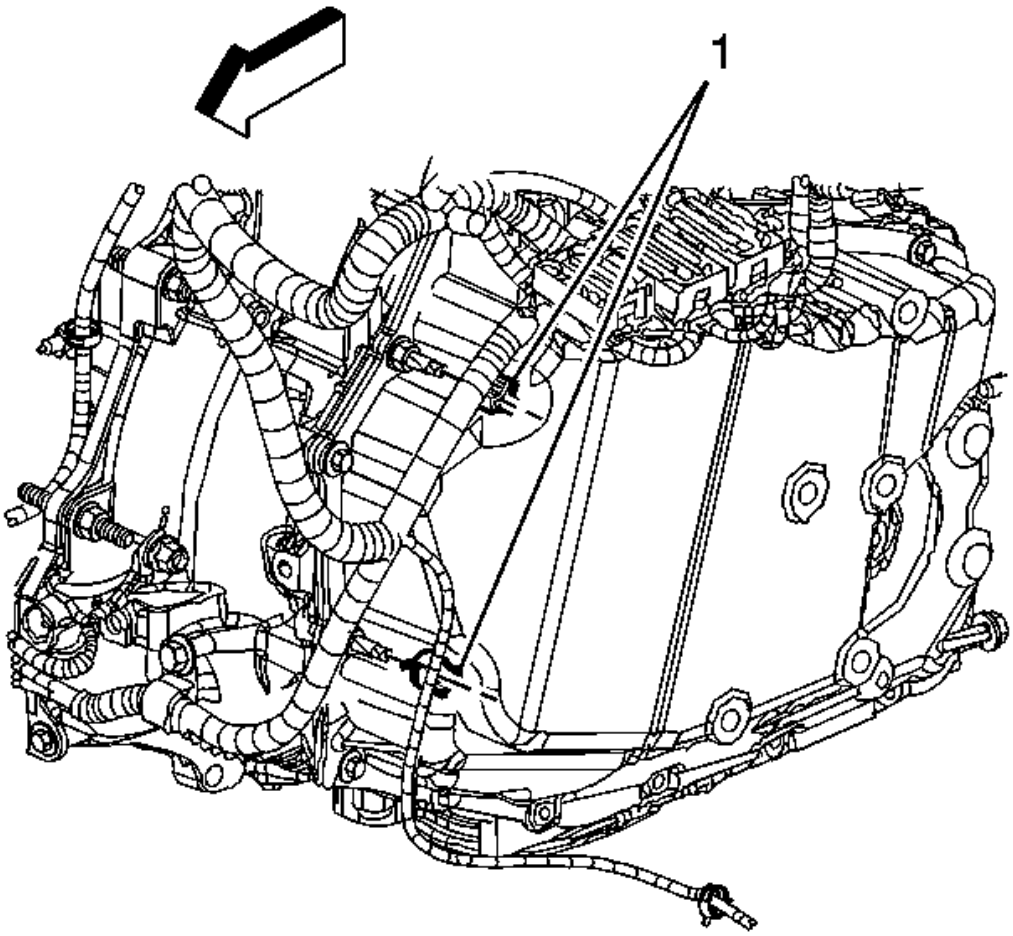

Fig. 304: Identifying Engine Harness, Clips & Transaxle Studs
Courtesy of GENERAL MOTORS CORP.

118. Remove the engine harness clips (1) from the transaxle studs.

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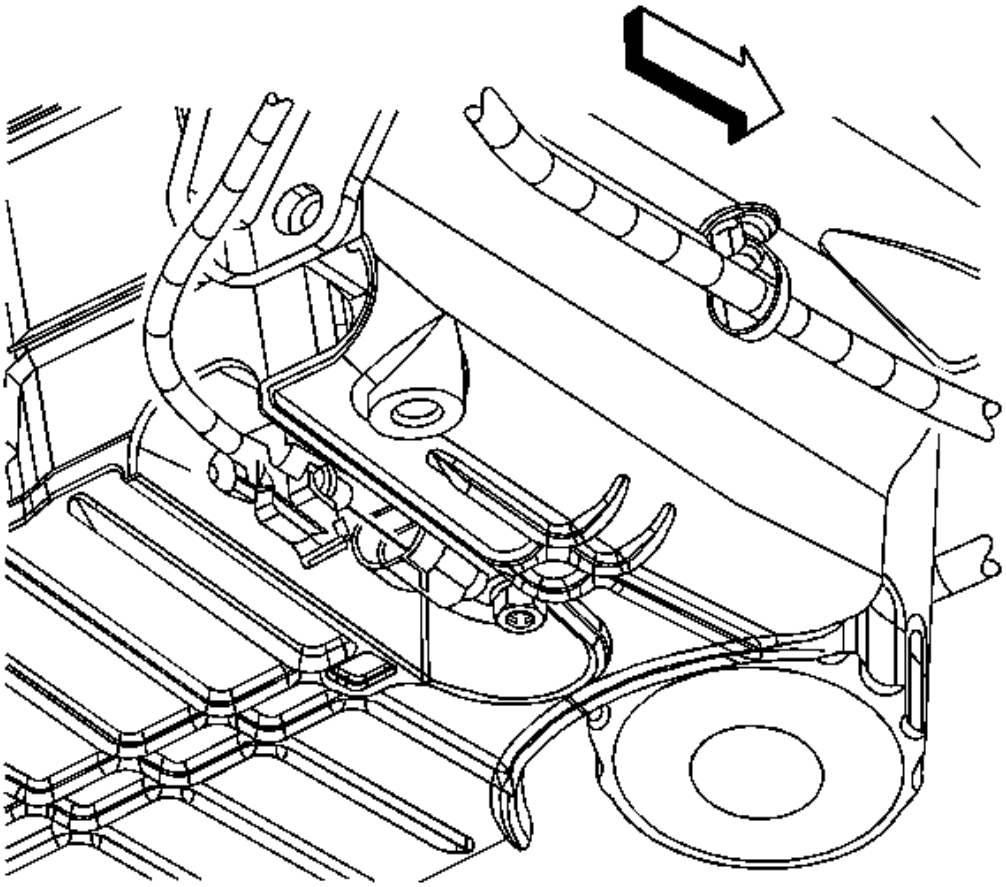

Fig. 305: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

119. Disconnect the engine harness electrical connector from the oil level sensor.

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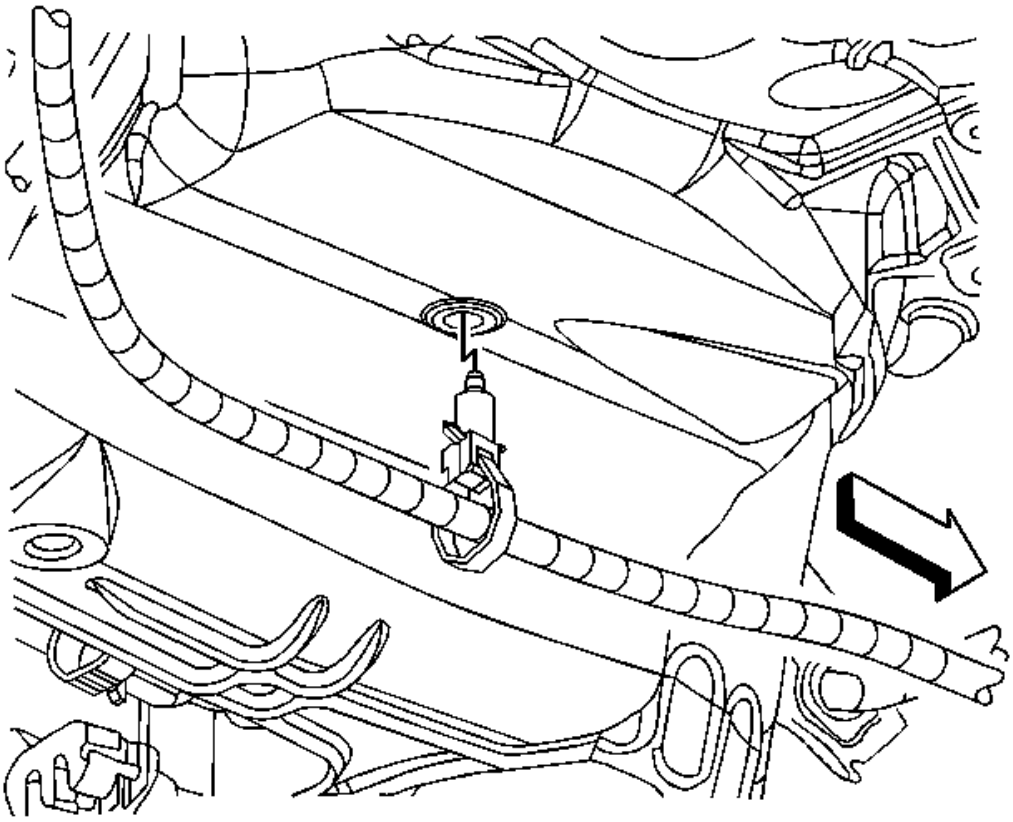

Fig. 306: Locating Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

120. Remove the engine harness clip from the oil pan.
121. Gather all branches of the engine harness together and remove the engine harness from the engine.
122. Disconnect the power steering line retainer from the generator bracket.
123. Remove the power steering pressure pipe and return line from the power steering pump and position out of the way. Refer to **Power Steering Gear Inlet Pipe/Hose Replacement** .

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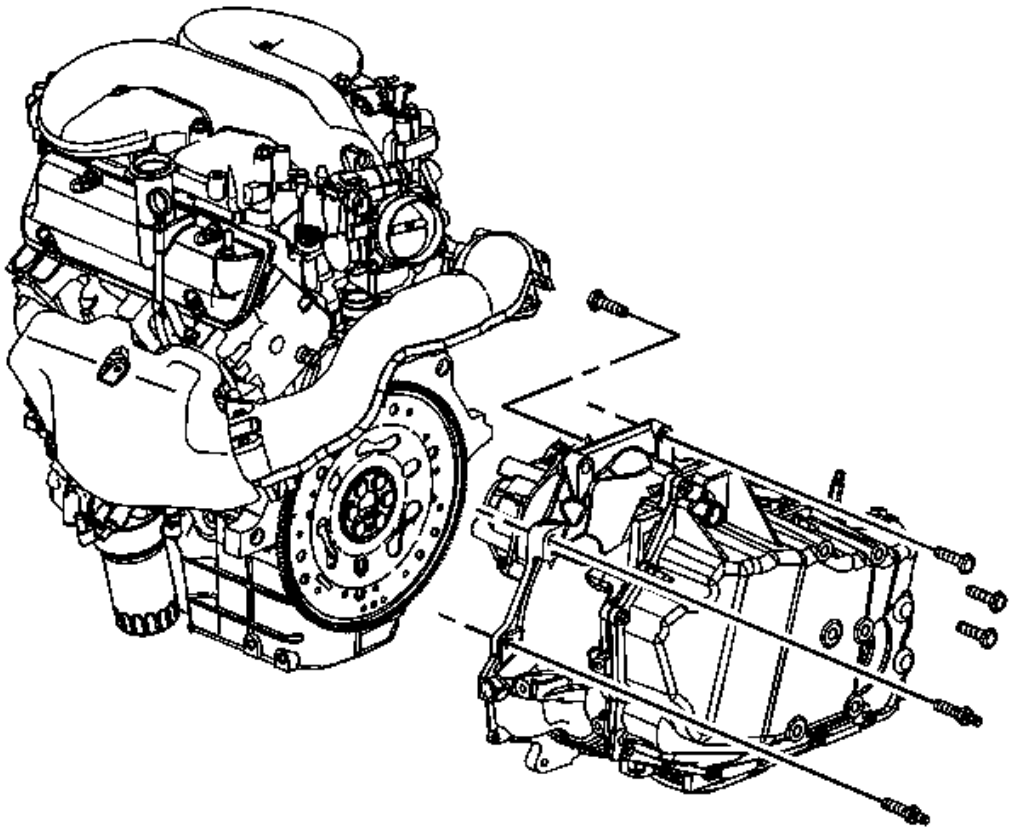

Fig. 307: Removing/Installing Engine To Transaxle
Courtesy of GENERAL MOTORS CORP.

124. Install an engine hoist to the engine.
125. Remove the transaxle bolts and studs.
126. Support the transaxle.
127. Separate and remove the engine from the transaxle and the frame.

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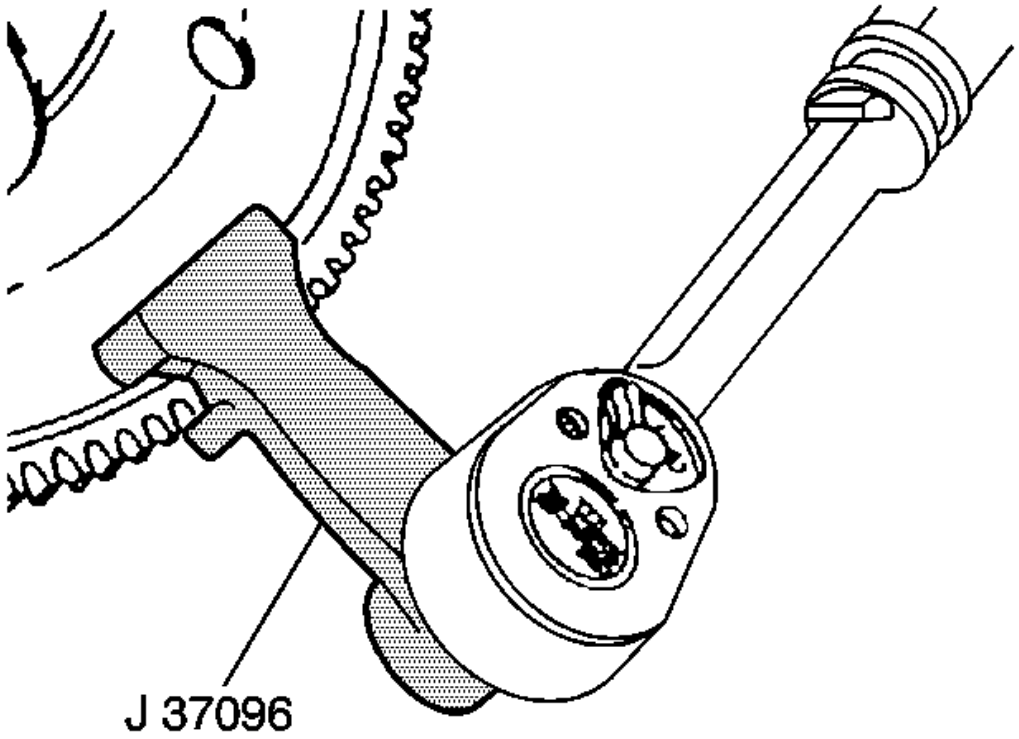

Fig. 308: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

128. Use the **J 37096** in order to hold the flywheel.

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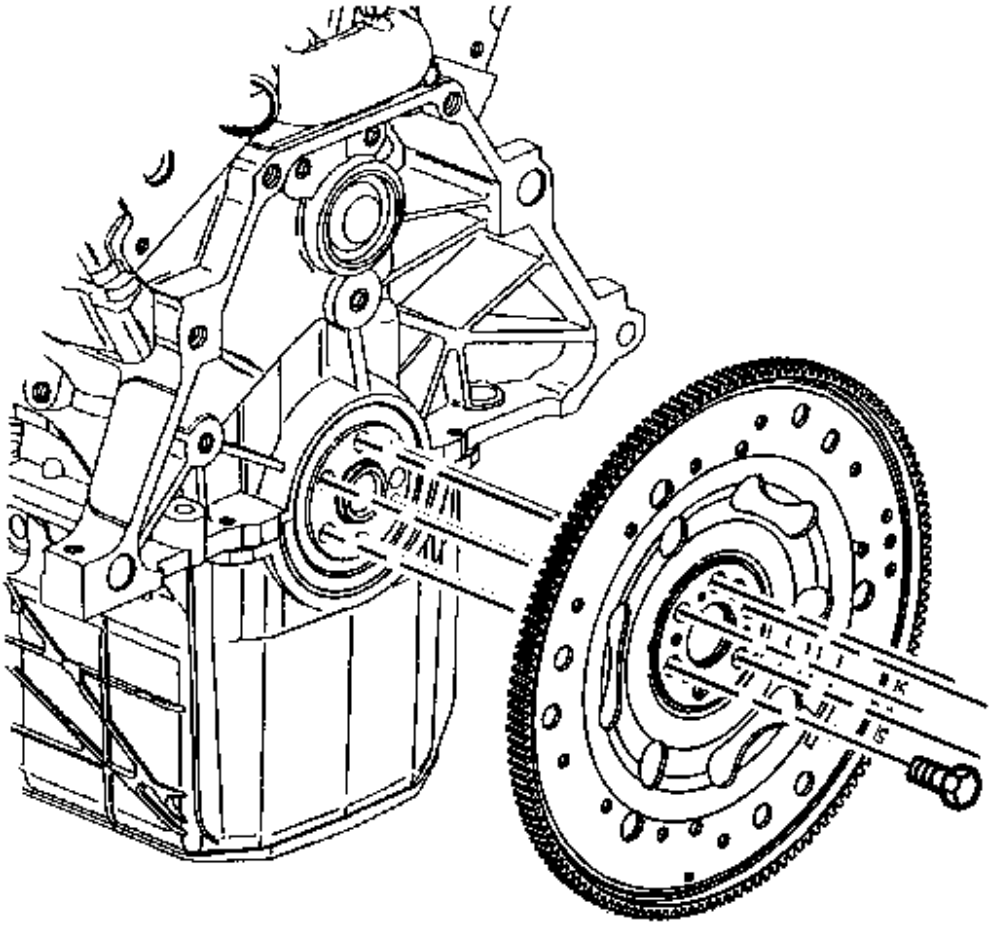

Fig. 309: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

129. Loosen the flywheel bolts.
130. Remove 5 of the 6 flywheel bolts leaving one bolt at the top of the crankshaft.
131. Grip the flywheel and remove the remaining bolt. Do not drop the flywheel when removing the final bolt.
132. Remove the engine flywheel.
133. Install the engine to the engine stand.
134. Remove the engine hoist from the engine.

Installation Procedure

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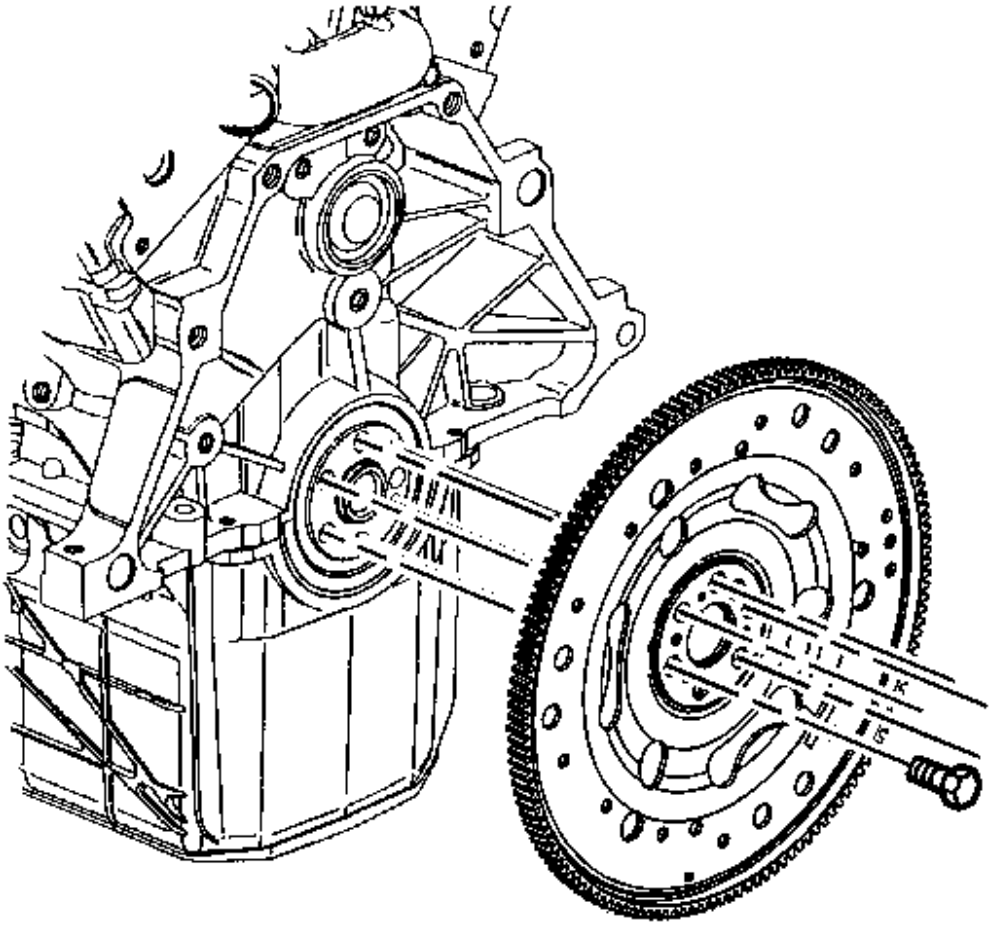

Fig. 310: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install an engine hoist to the engine.
2. Remove the engine from the engine stand.
3. Position the flywheel to the crankshaft.
4. Install the flywheel bolts finger tight.
5. Use the **J 37096** in order to hold the flywheel.

NOTE: Refer to Fastener Notice .

6. Tighten the flywheel bolts.

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

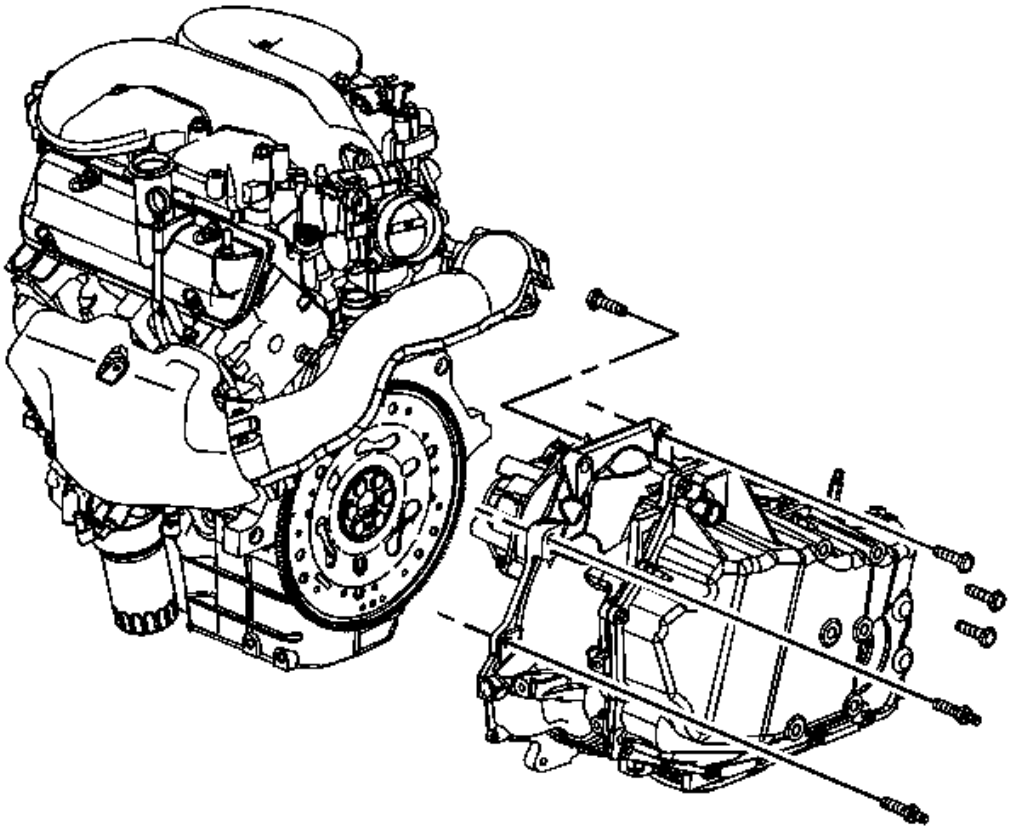

Fig. 311: Removing/Installing Engine To Transaxle
Courtesy of GENERAL MOTORS CORP.

7. Install the engine to the transaxle and the frame.
8. Install the transaxle bolts and studs.

   Tighten: Tighten the bolts/studs to 75 N.m (55 lb ft).

9. Remove the support from the transaxle.
10. Remove the engine hoist from the engine.
11. Install the power steering pressure and return lines to the power steering pump. Refer to **Power Steering Gear Inlet Pipe/Hose Replacement** .
12. Connect the power steering line retainer at the generator bracket.

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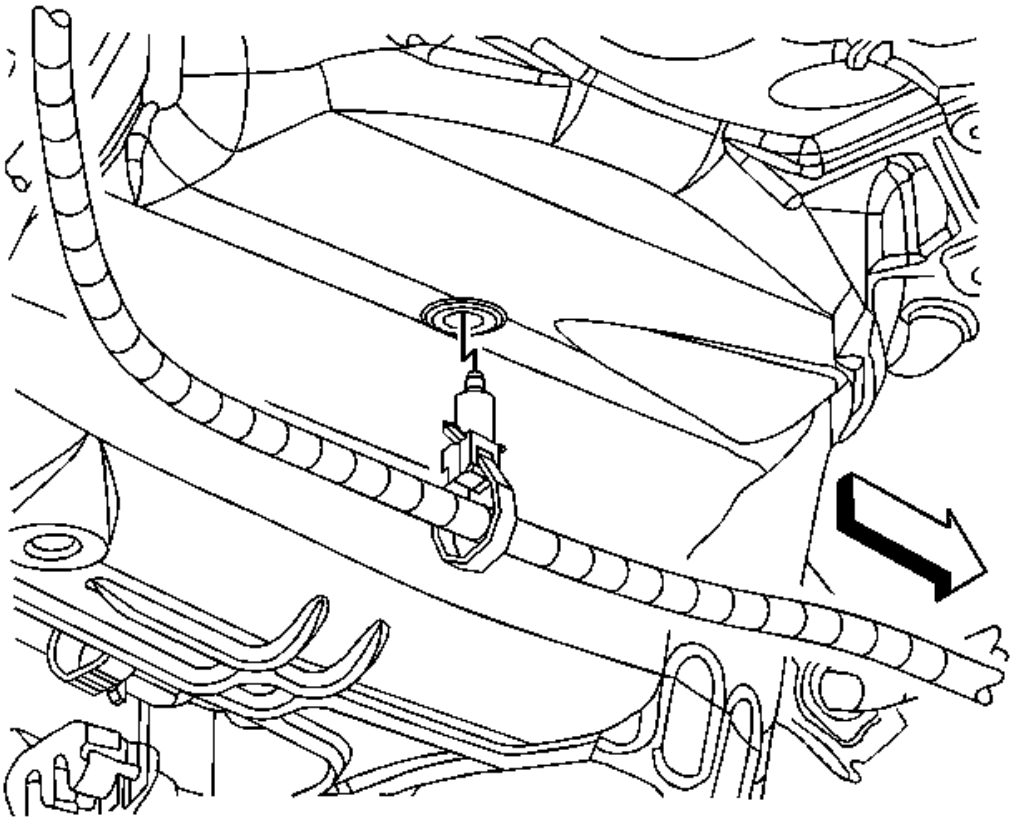

Fig. 312: Locating Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

13. Place the engine wiring harness on top of the engine and position the harness branches.
14. Install the engine harness clip to the oil pan.

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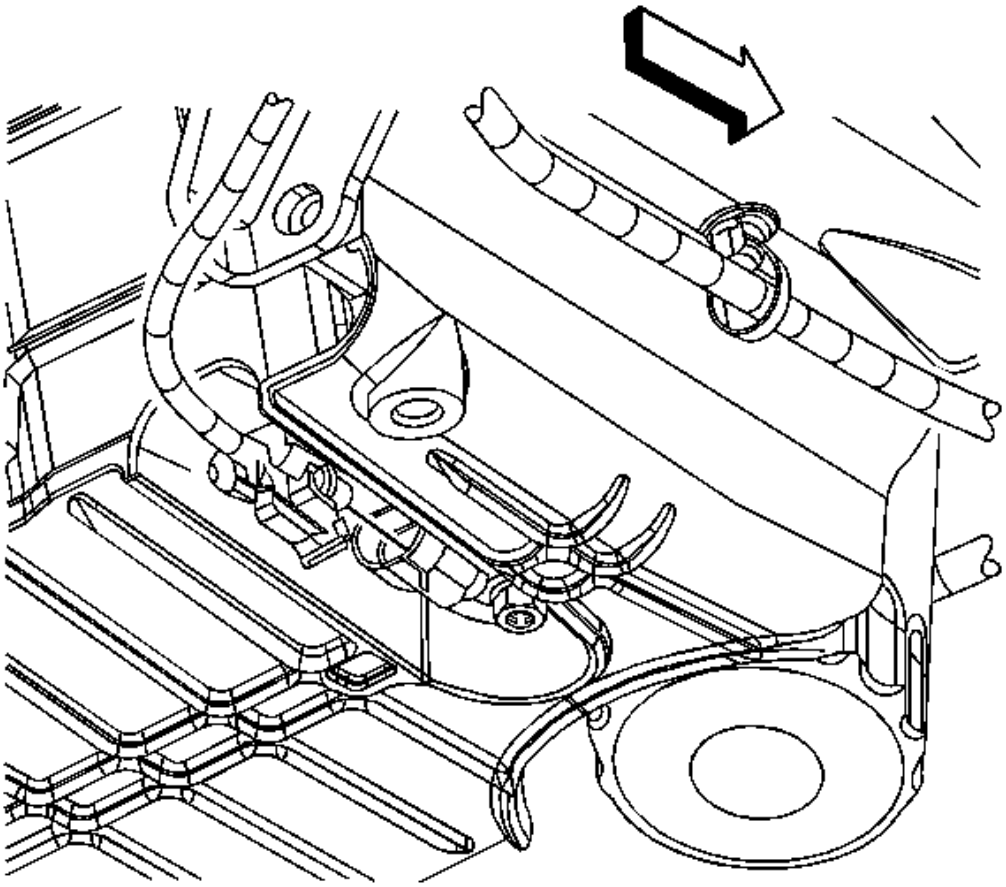

Fig. 313: Identifying Engine Harness & Clips
Courtesy of GENERAL MOTORS CORP.

15. Connect the engine harness electrical connector to the oil level sensor.

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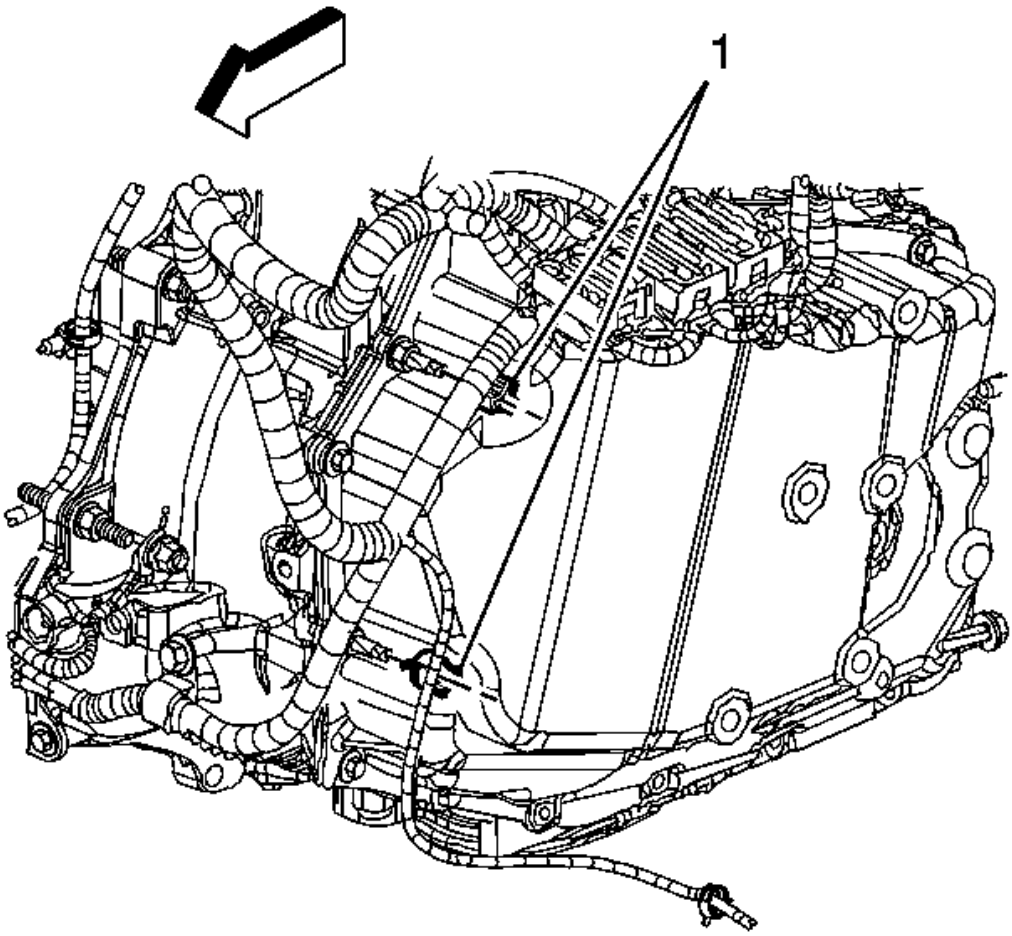

Fig. 314: Identifying Engine Harness, Clips & Transaxle Studs
Courtesy of GENERAL MOTORS CORP.

16. Install the engine harness clips (1) to the transaxle studs.

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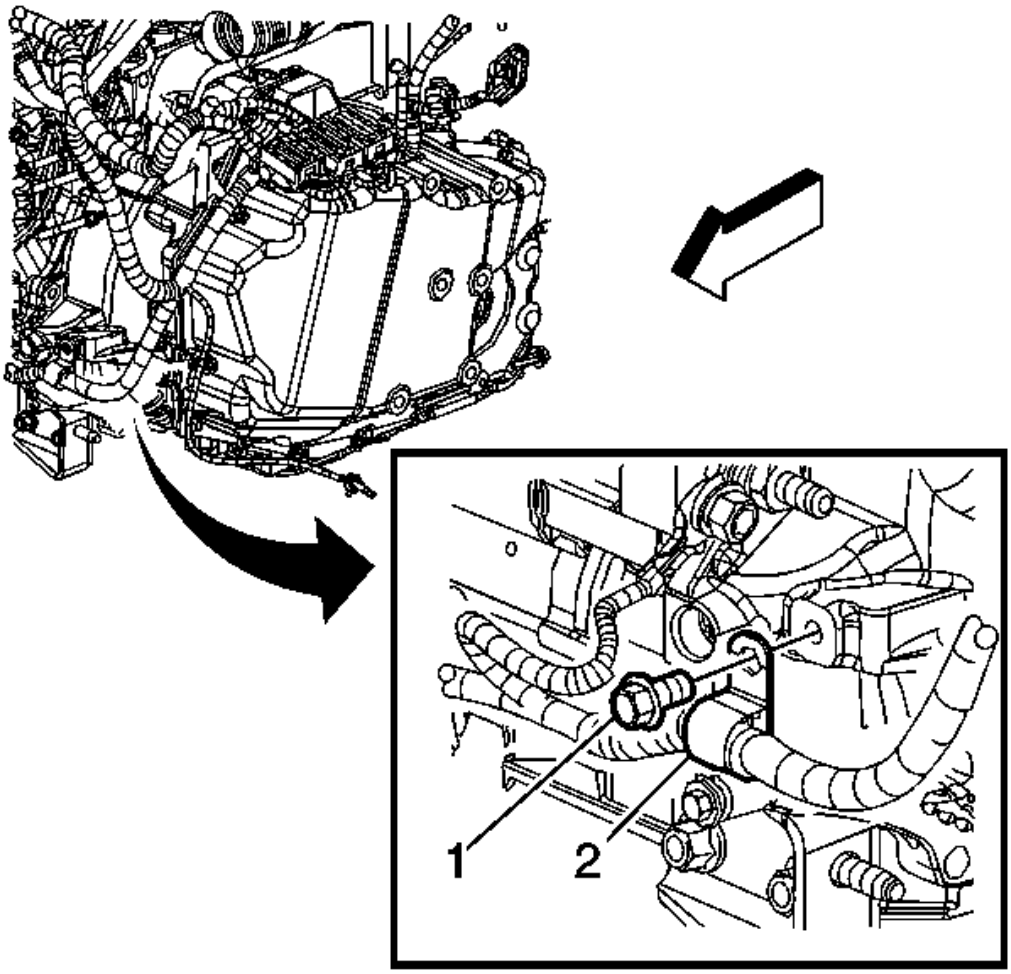

Fig. 315: Identifying Engine Harness Clamp Bolts
Courtesy of GENERAL MOTORS CORP.

17. Install the engine harness clamp bolt to the transaxle.

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

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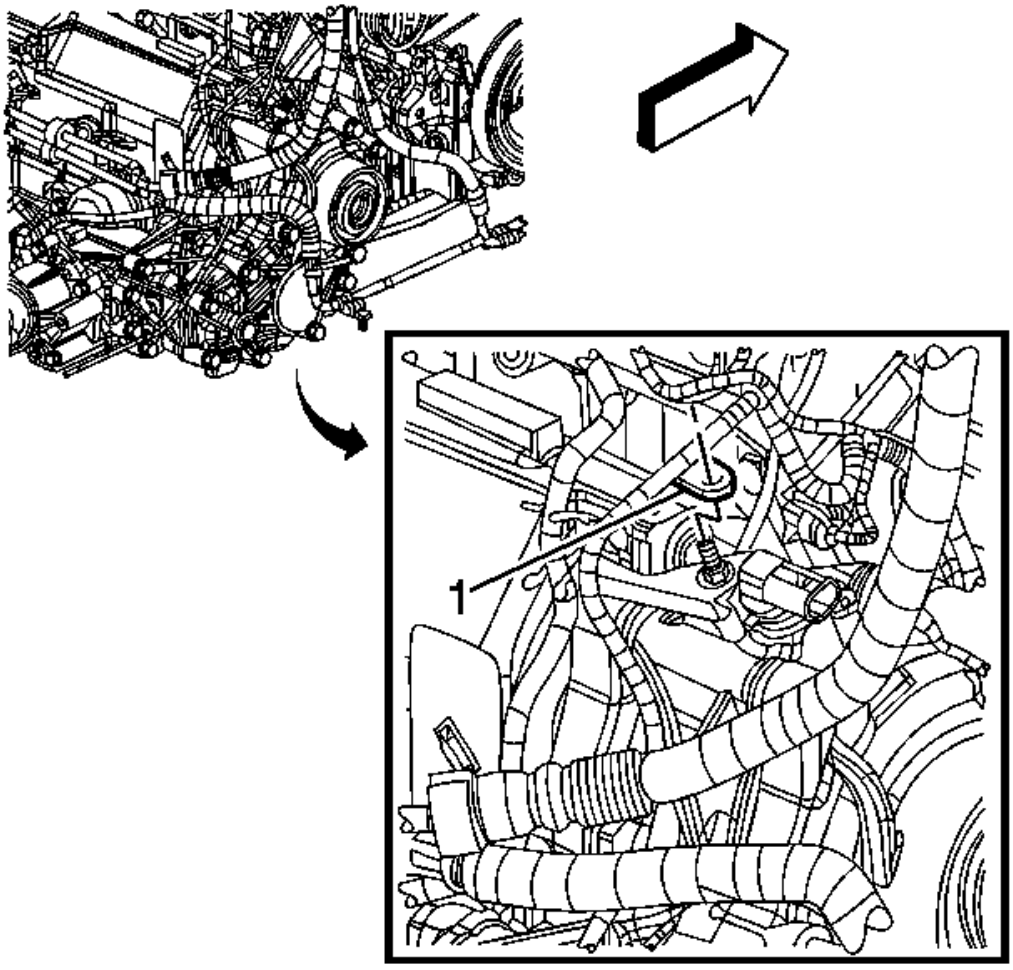

Fig. 316: Identifying Engine Harness Clip Studs
Courtesy of GENERAL MOTORS CORP.

18. Install the engine harness clip (1) to the stud on the transaxle.

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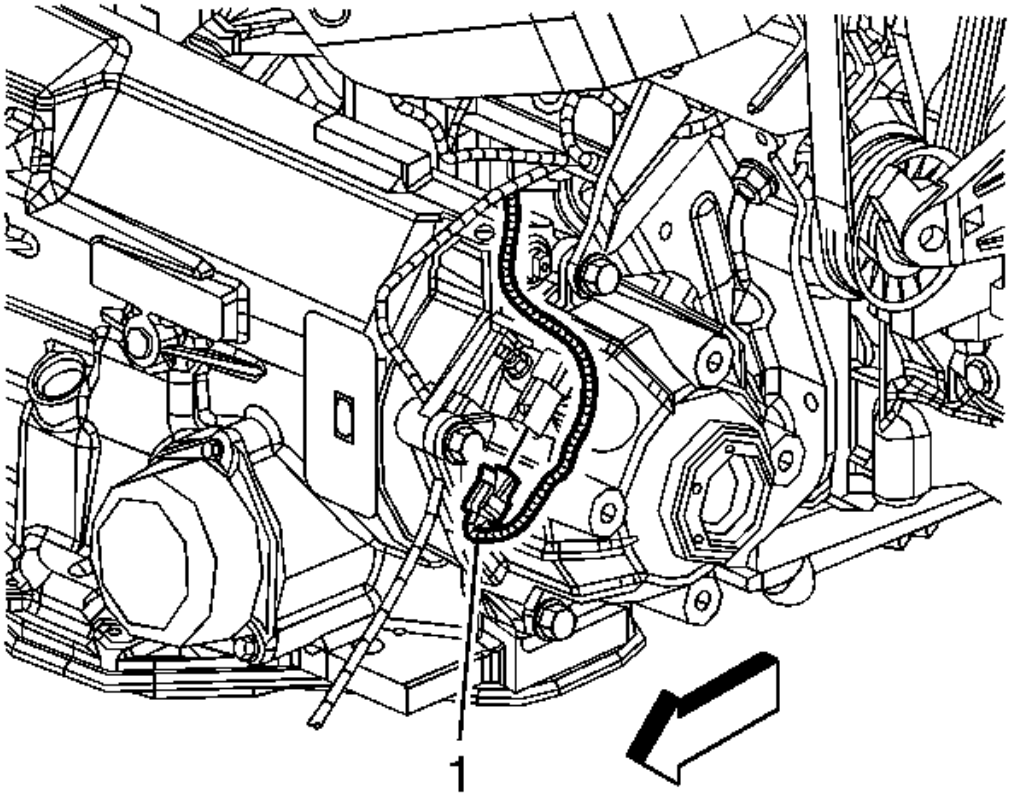

Fig. 317: Identifying Engine Harness connector At Vehicle Speed Sensor (VSS)
Courtesy of GENERAL MOTORS CORP.

19. Connect the engine harness electrical connector to the VSS.

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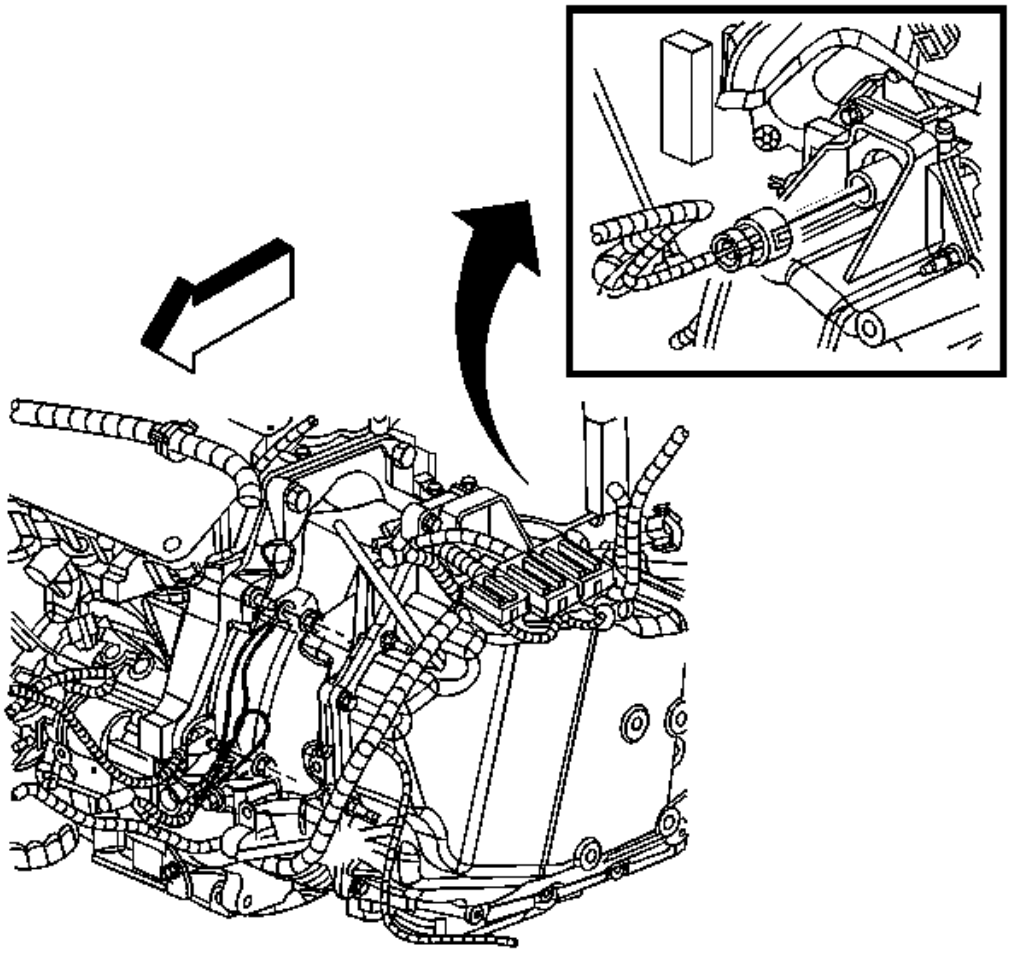

Fig. 318: Identifying Engine Harness Connector At Transaxle
Courtesy of GENERAL MOTORS CORP.

20. Connect the engine harness electrical connector to the transaxle.

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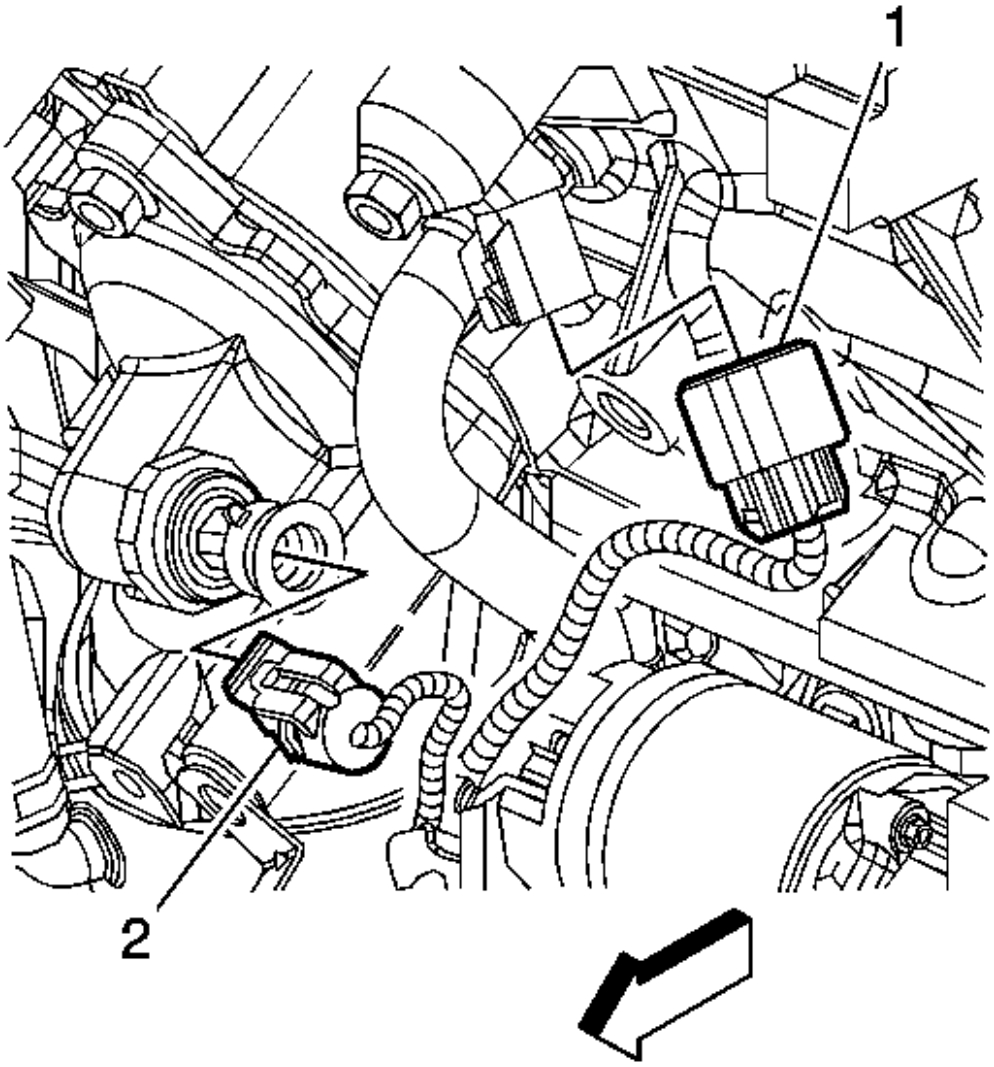

Fig. 319: Identifying Oil Pressure Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

21. Connect the engine harness electrical connector (1) to the knock sensor.
22. Connect the engine harness electrical connector (2) to the oil pressure sensor.

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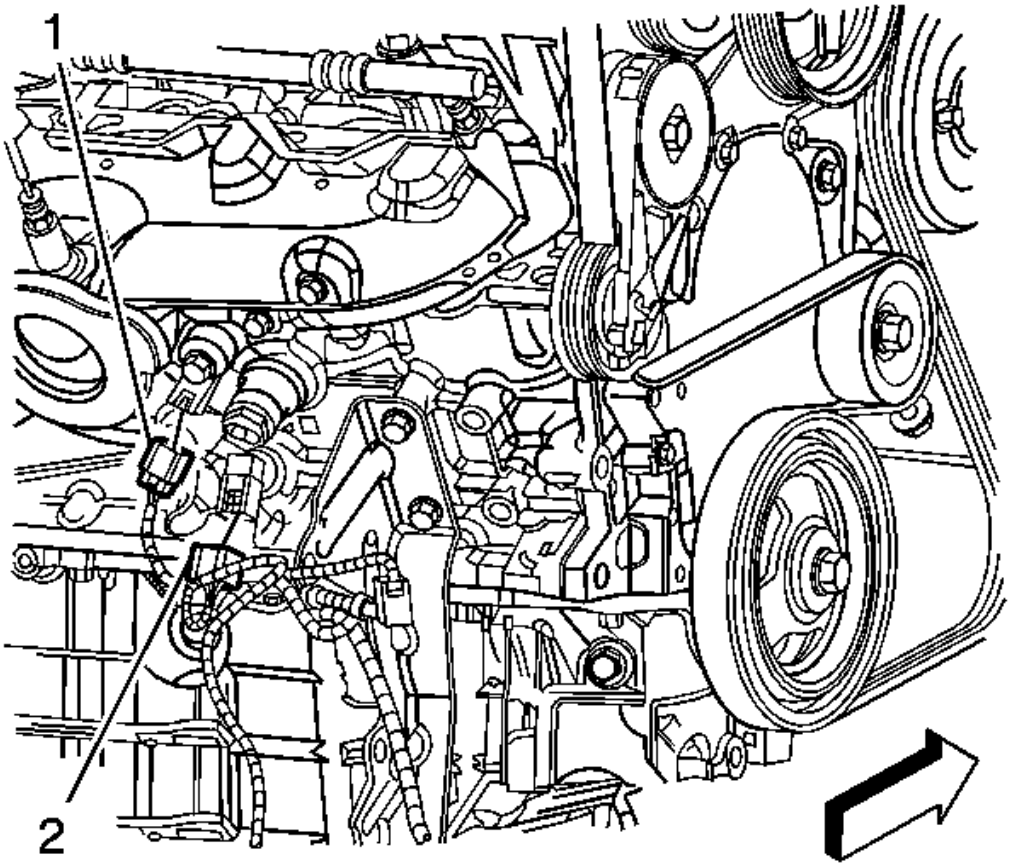

Fig. 320: Identifying Knock Sensor (KS) & Crankshaft Position (CKP) Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

23. Connect the engine harness electrical connector (1) to the CKP sensor.

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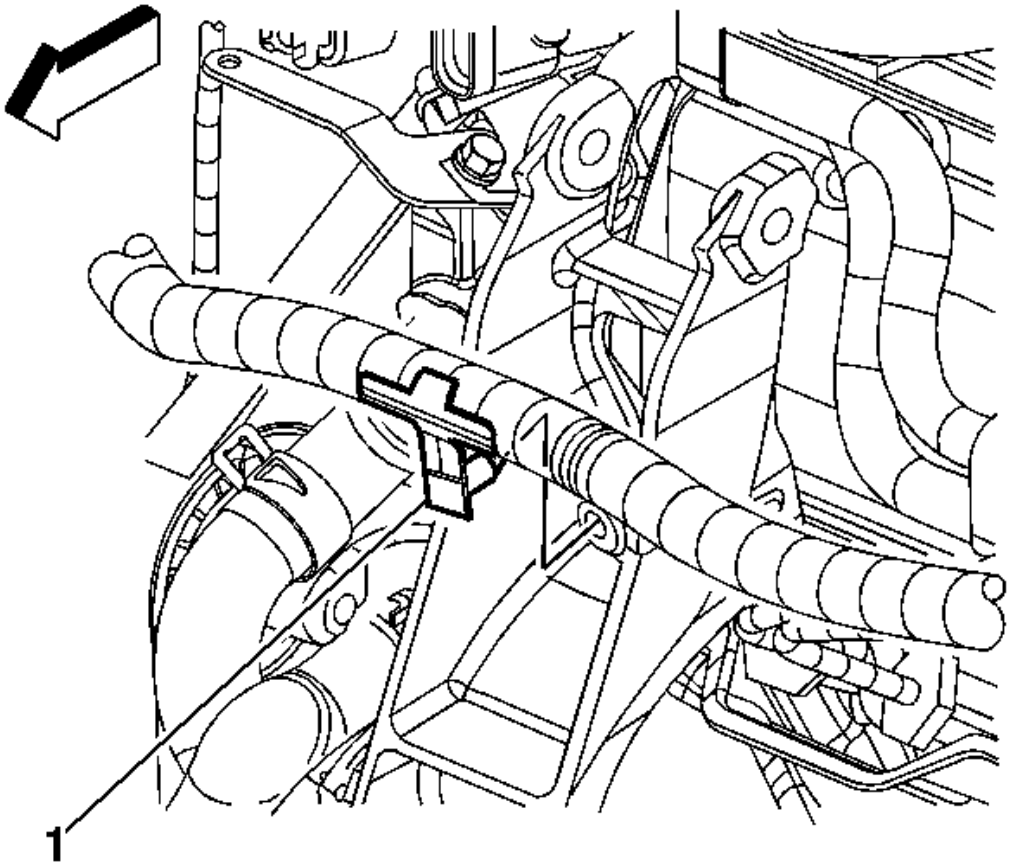

Fig. 321: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

24. Install the engine harness clip (1) to the strut bracket.

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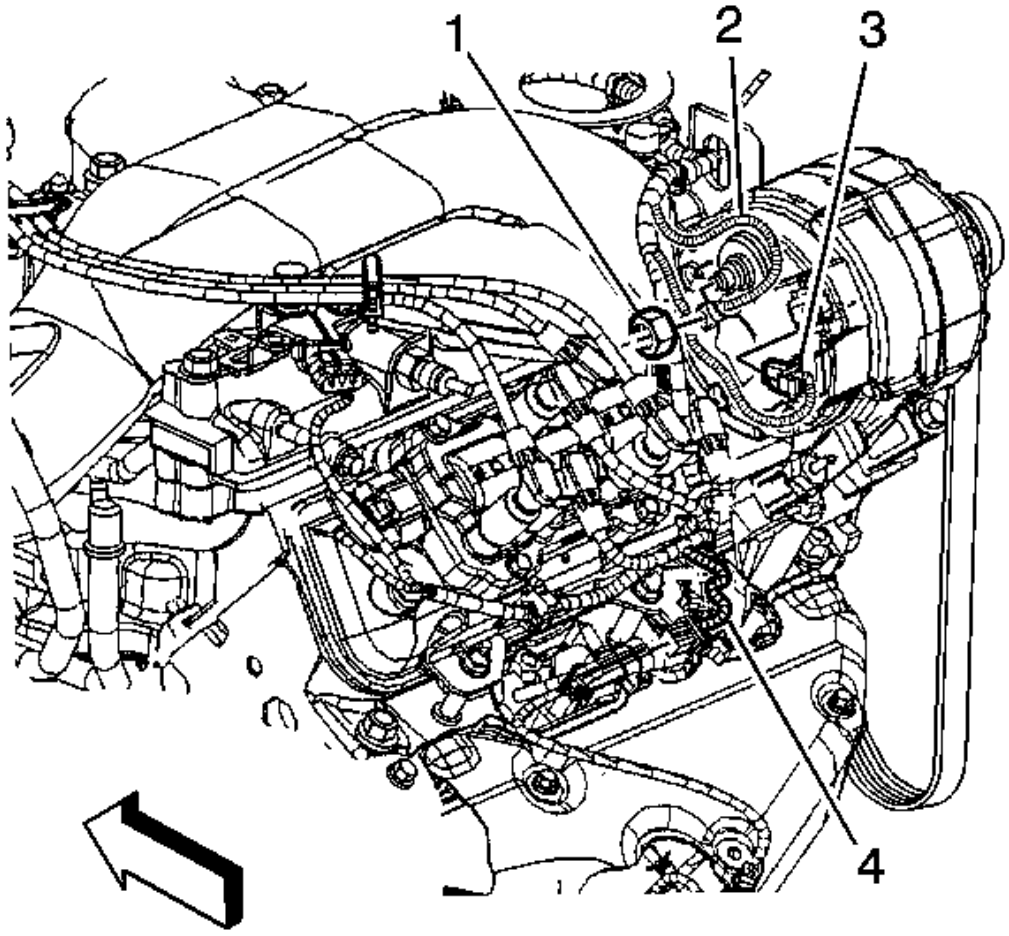

Fig. 322: View Of Generator And Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

25. Connect the engine harness electrical connector (4) to the HO2S.
26. Connect the engine harness electrical connector (3) to the generator.
27. Install the engine harness lead (2) to the generator.
28. Install the generator terminal nut (1).

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

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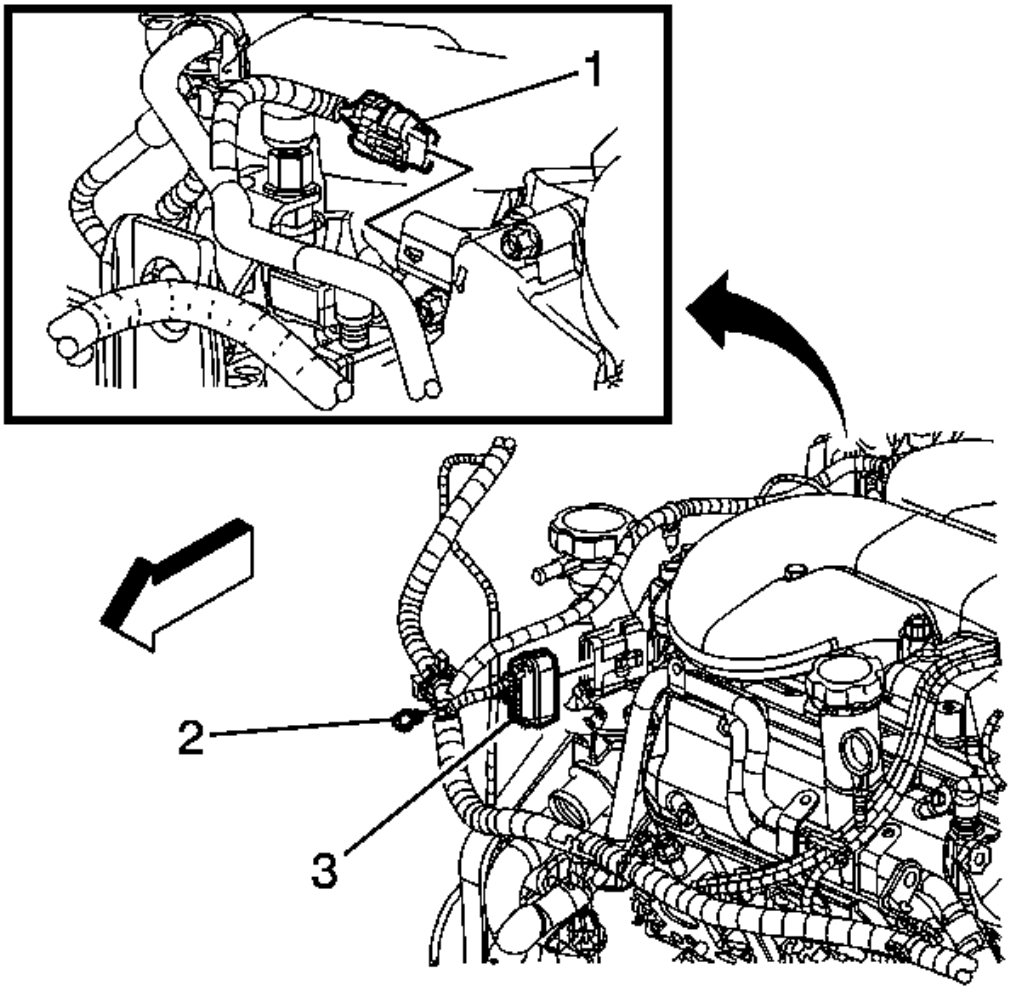

Fig. 323: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

29. Connect the engine harness electrical connector (3) to the fuel injector harness electrical connector.
30. Install the CPA retainer (2).
31. Connect the engine harness electrical connector (1) to the intake manifold tuning valve.

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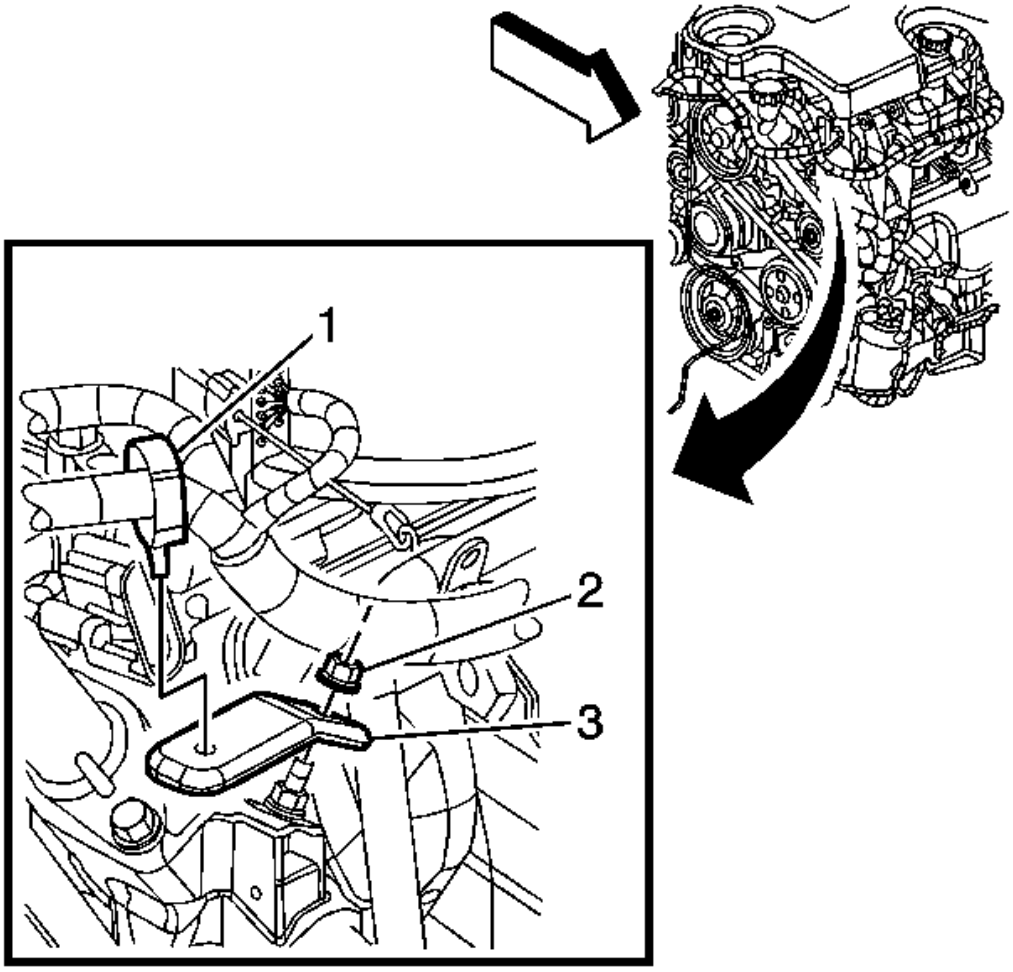

Fig. 324: View Of Engine Harness Clip At Bracket
Courtesy of GENERAL MOTORS CORP.

32. Install the engine harness clip (1) to the bracket.

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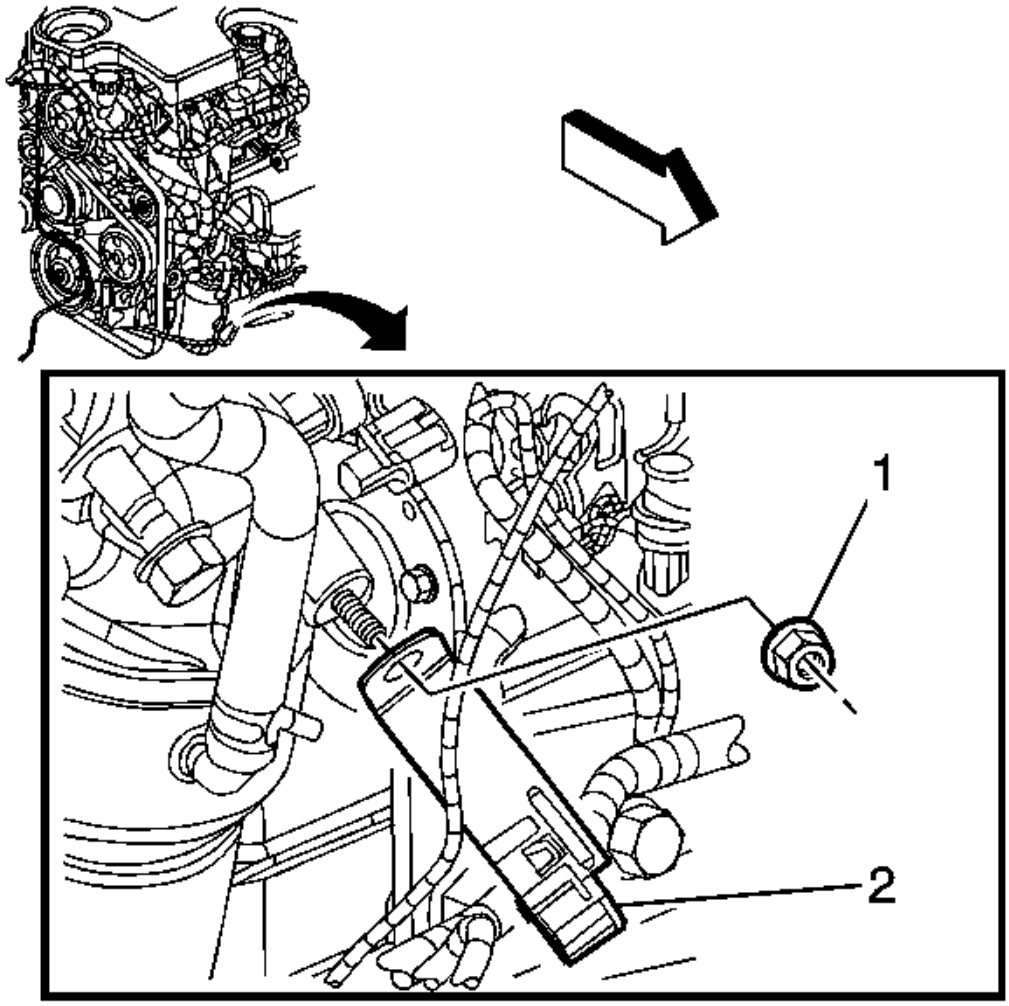

Fig. 325: Locating Engine Harness Bracket Nut
Courtesy of GENERAL MOTORS CORP.

33. Install the engine harness bracket (2) to the stud.
34. Install the engine harness bracket nut (1).

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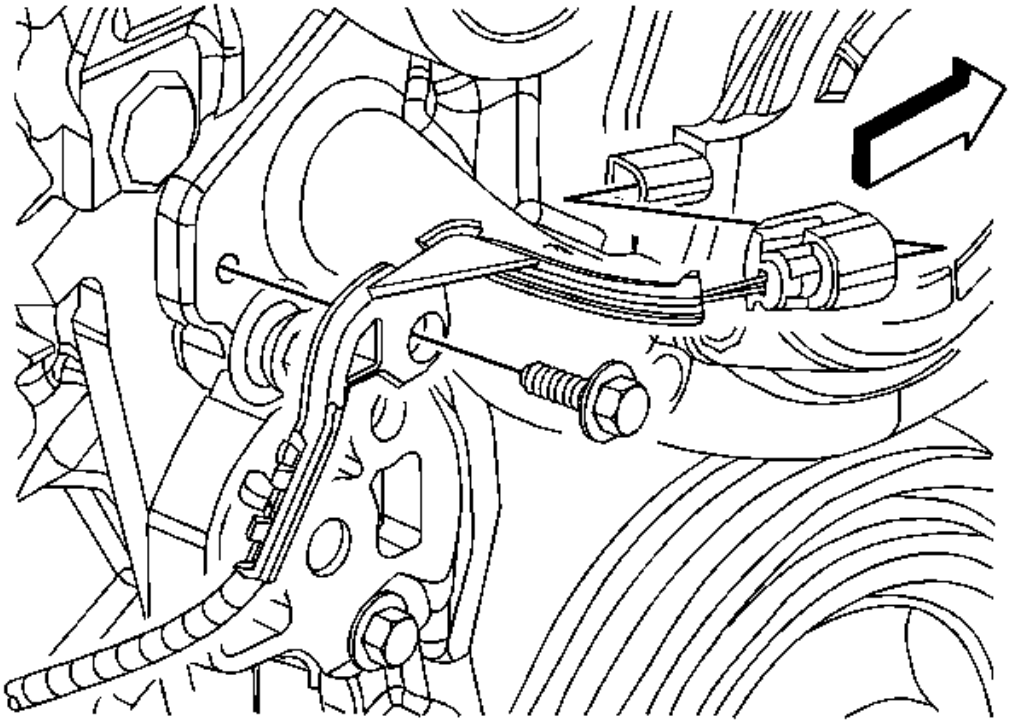

Fig. 326: Locating Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

35. Connect the engine harness electrical connector to the camshaft actuator magnet.
36. Install the engine harness bolt.

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

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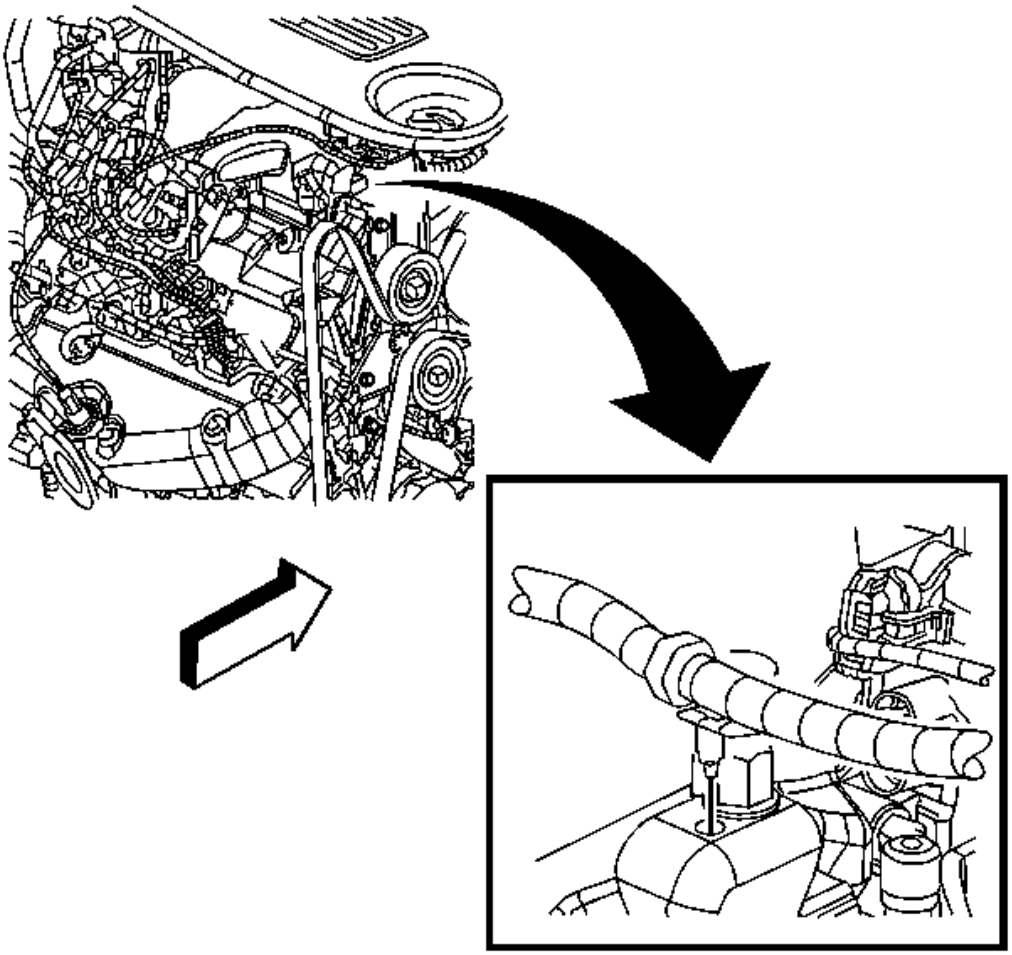

Fig. 327: Removing/Installing Engine Harness To Engine
Courtesy of GENERAL MOTORS CORP.

37. Install the engine harness clip to the engine.

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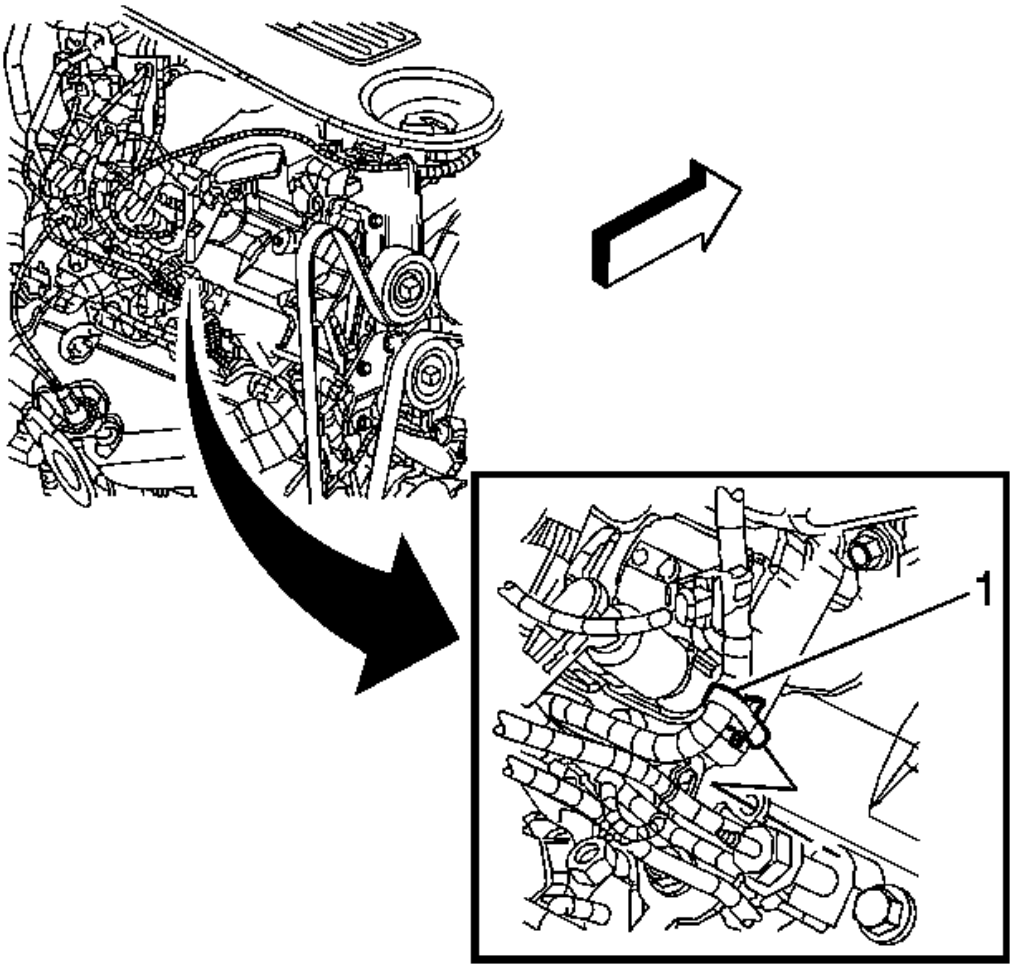

Fig. 328: Identifying Engine Harness At Ignition Coil Bracket
Courtesy of GENERAL MOTORS CORP.

38. Install the engine harness clip (1) to the ignition coil bracket.

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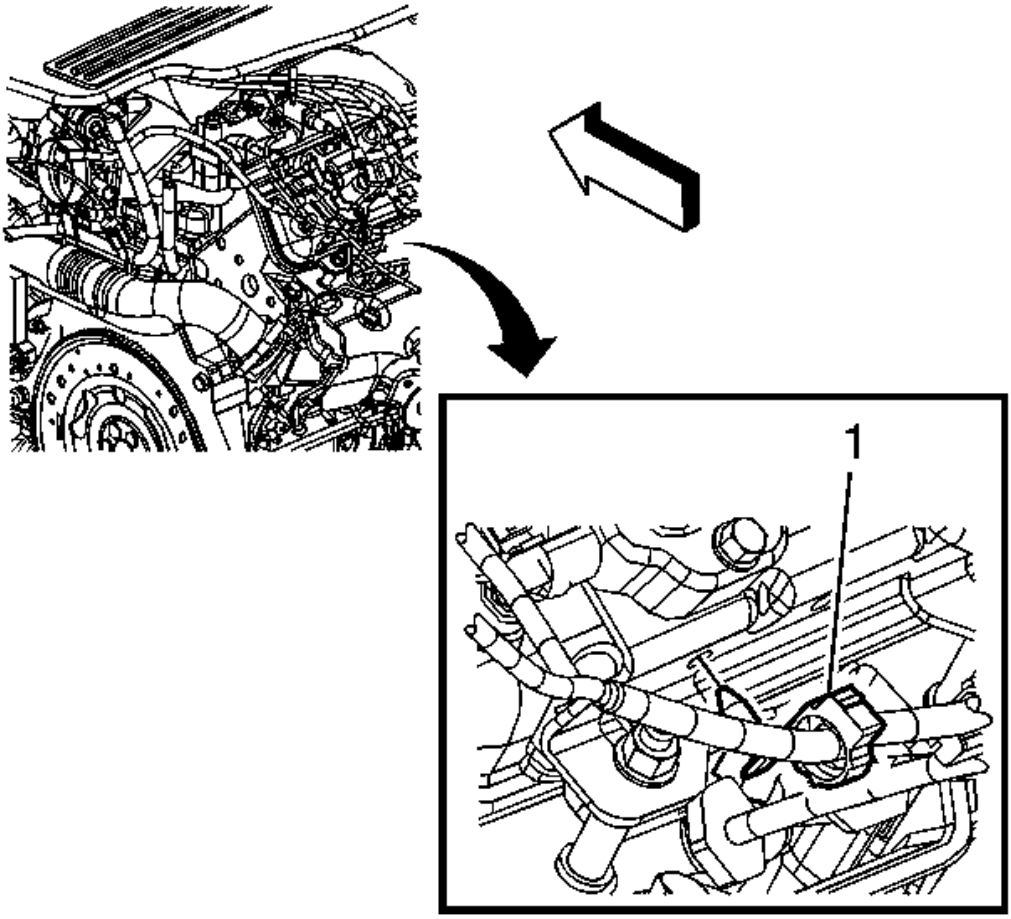

Fig. 329: View Of Engine Harness At Ignition Coil Bracket
Courtesy of GENERAL MOTORS CORP.

39. Install the engine harness clip (1) to the ignition coil bracket.

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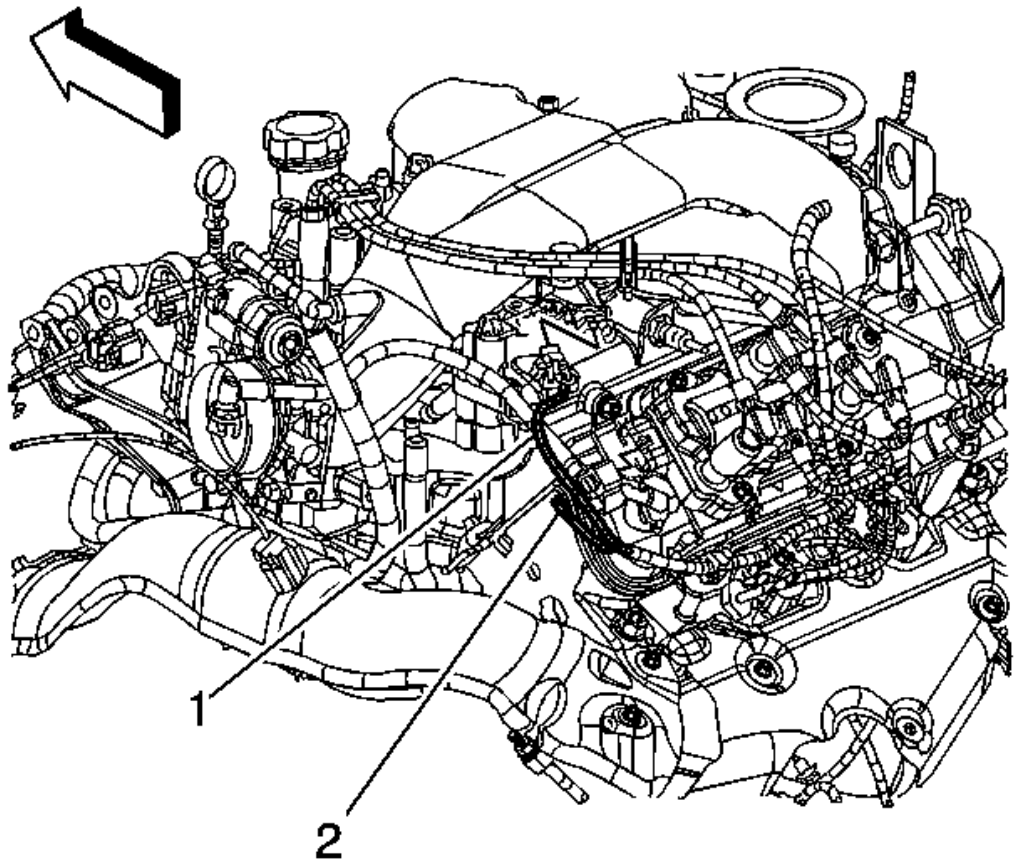

Fig. 330: Locating MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

40. Connect the engine harness electrical connector (2) to the ignition coil.
41. Connect the engine harness electrical connector (1) to the MAP sensor.

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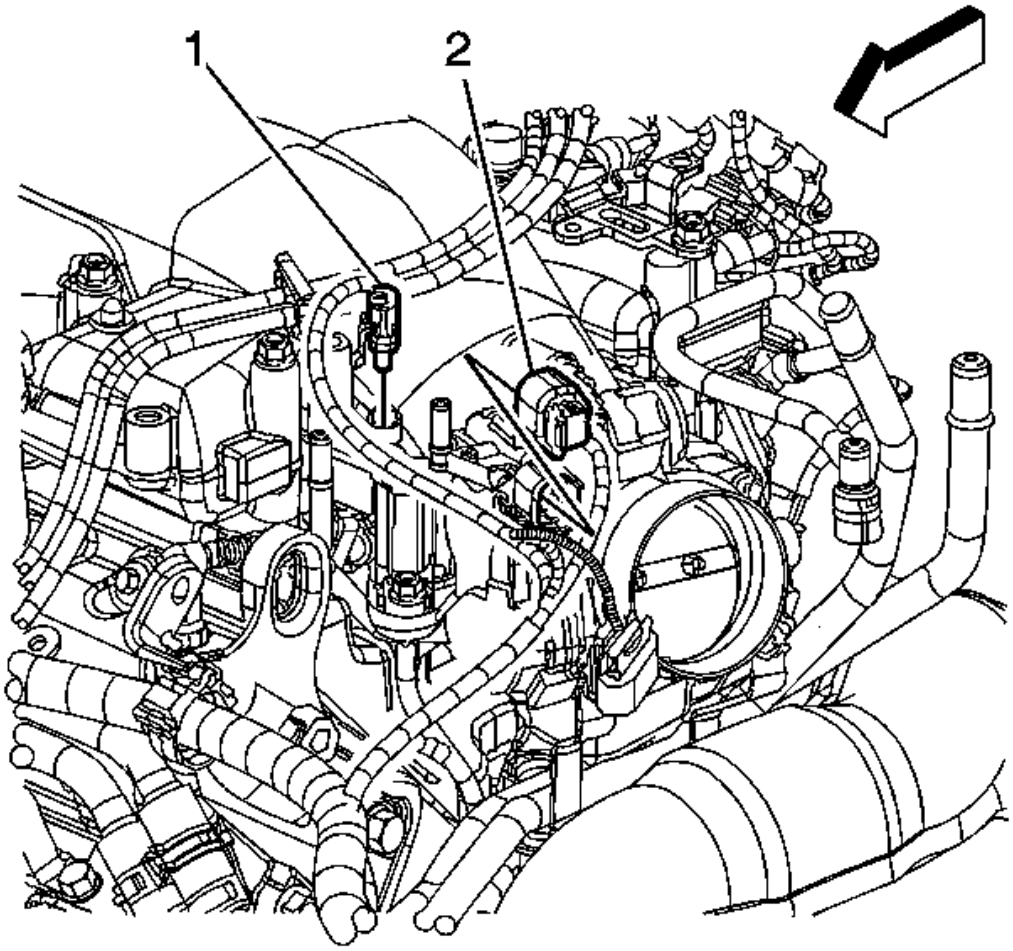

Fig. 331: Locating EVAP & ETC Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

42. Connect the engine harness electrical connector (2) to the throttle actuator.
43. Connect the engine harness electrical connector (1) to the EVAP purge solenoid.

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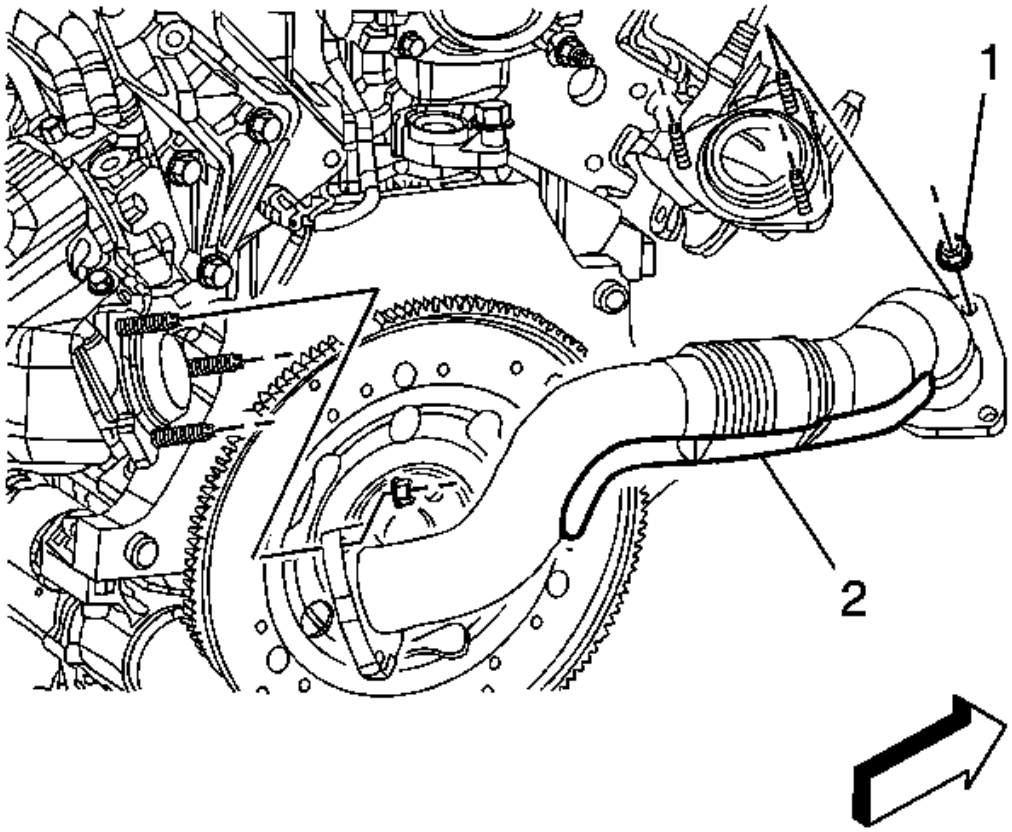

Fig. 332: Identifying Exhaust Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

44. Install the exhaust crossover pipe (2) and nuts (1).

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

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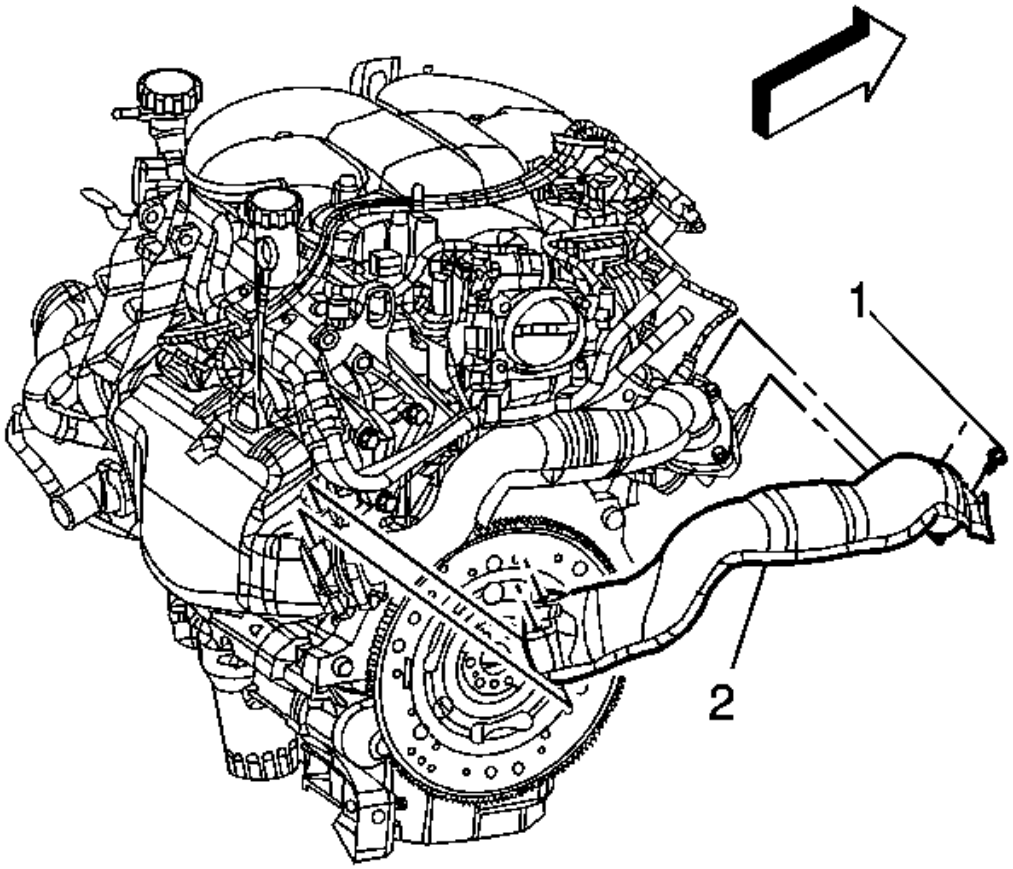

Fig. 333: Removing/Installing Exhaust Crossover Pipe Shield Bolts & Shield
Courtesy of GENERAL MOTORS CORP.

45. Install the exhaust crossover pipe shield (2) and bolts (1).

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

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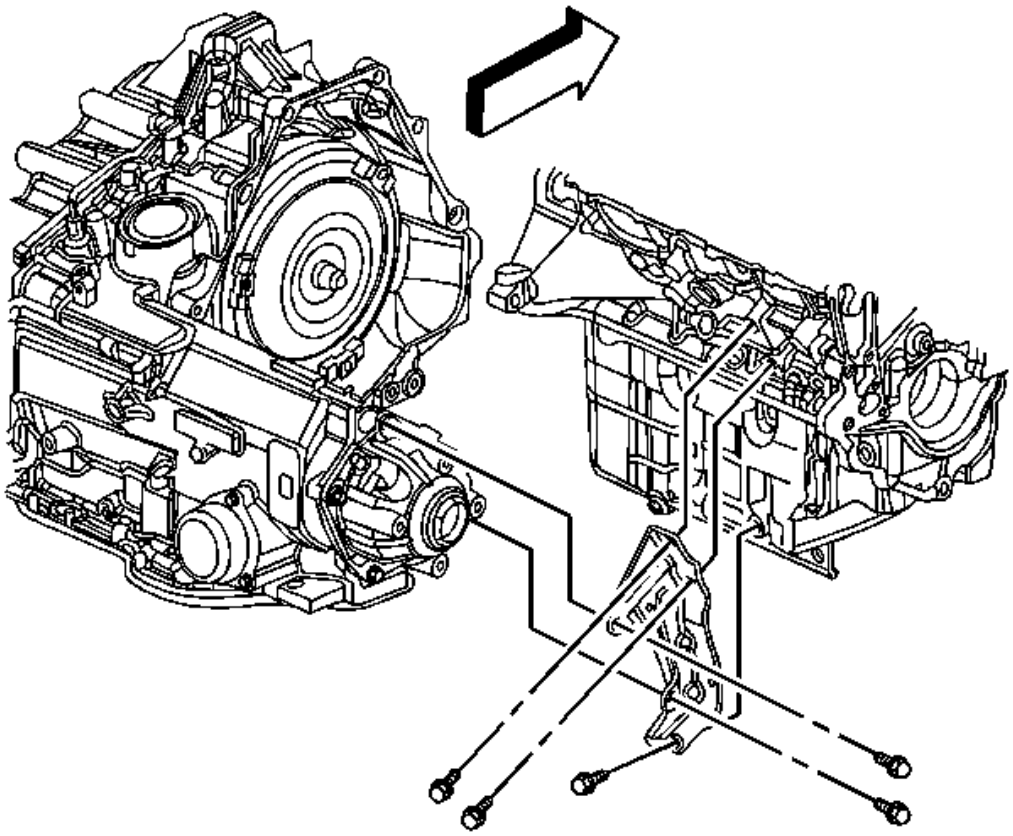

Fig. 334: Removing/Installing Transaxle Brace To Engine Block
Courtesy of GENERAL MOTORS CORP.

46. Install the transaxle brace and bolts.

    Tighten: Tighten the bolts to 43 N.m (32 lb ft).

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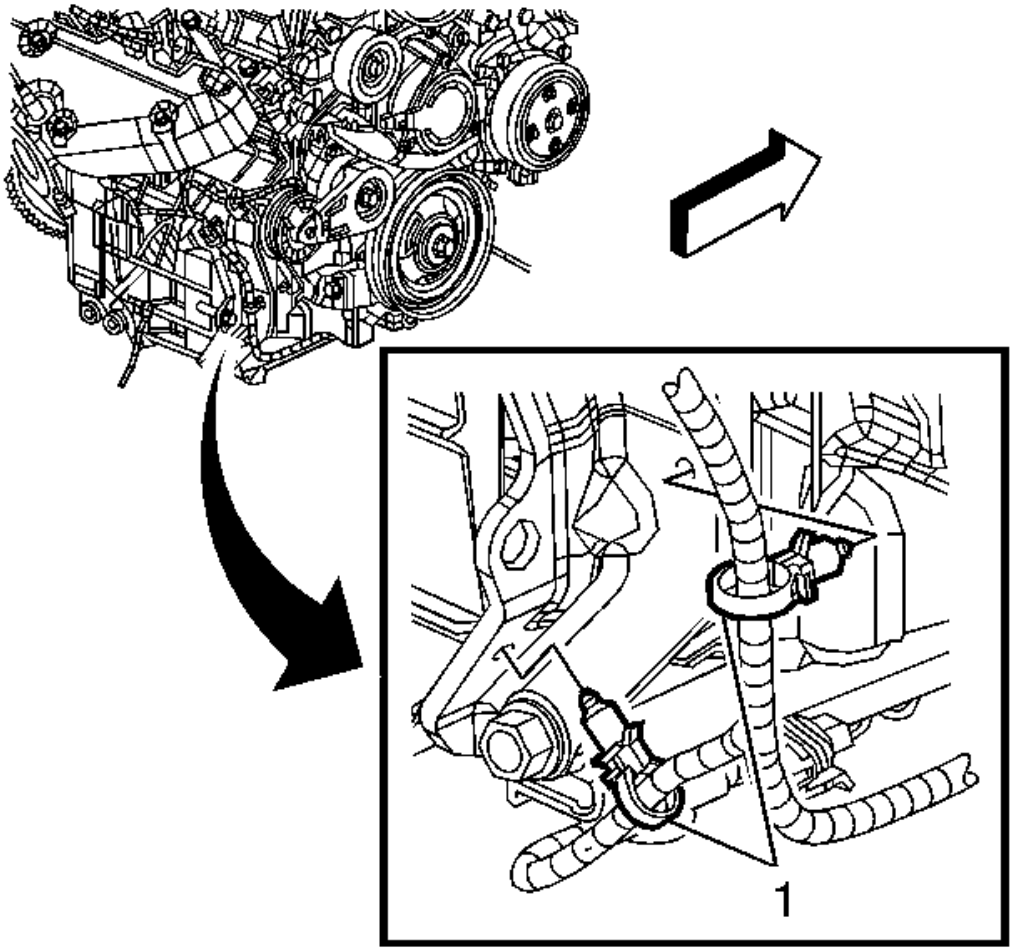

Fig. 335: Identifying Engine Harness Clips At Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

47. Install the engine harness clips (1) to the transaxle brace.

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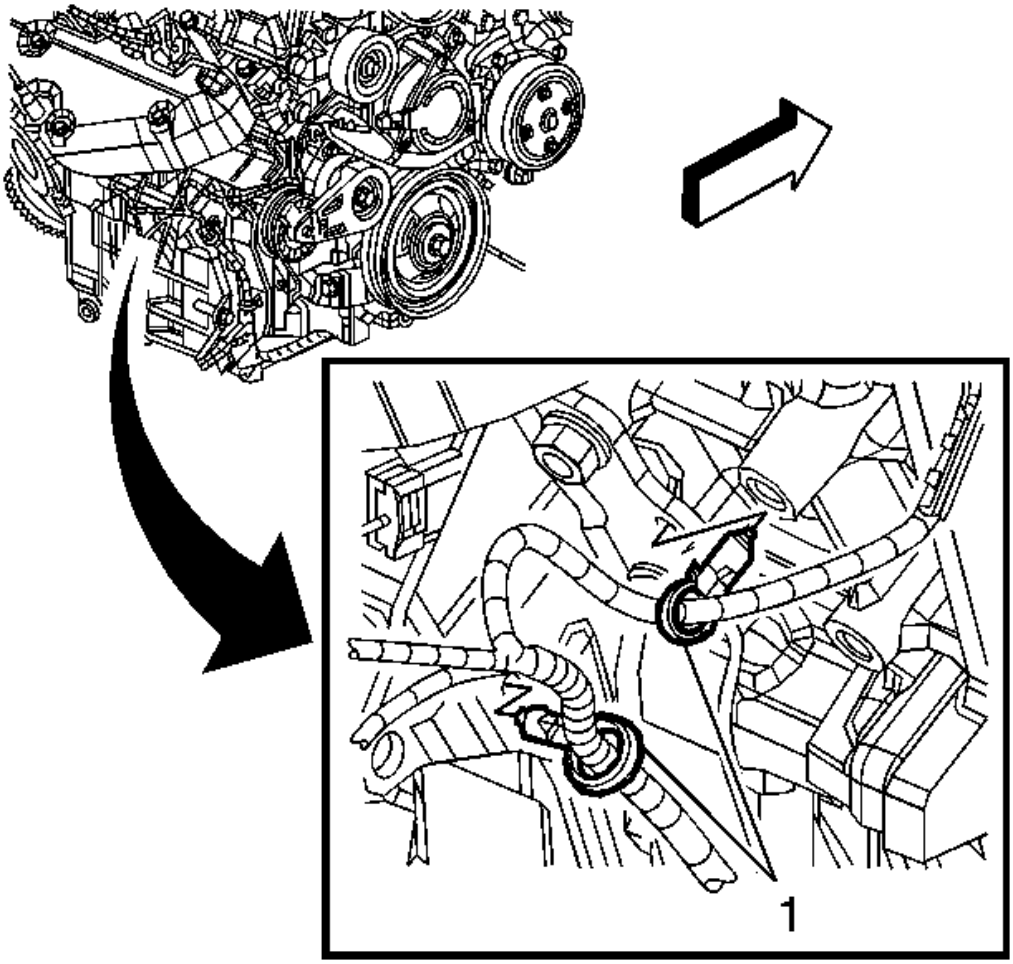

Fig. 336: Removing/Installing Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

48. Install the engine harness clips (1) to the transaxle brace.

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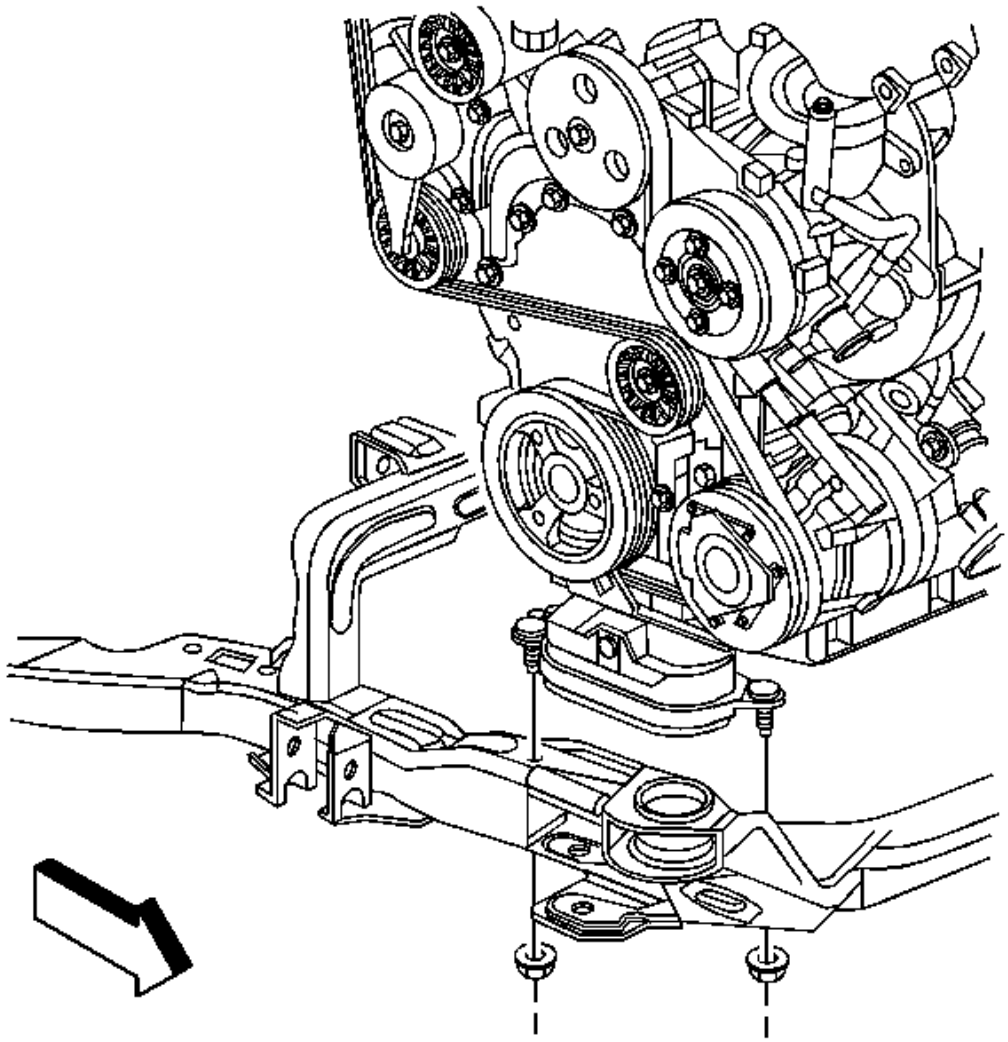

Fig. 337: View Of Engine Mount-To-Support Frame Bolts
Courtesy of GENERAL MOTORS CORP.

49. Install the engine mount to frame nuts.

    Tighten: Tighten the nuts to 47 N.m (35 lb ft).

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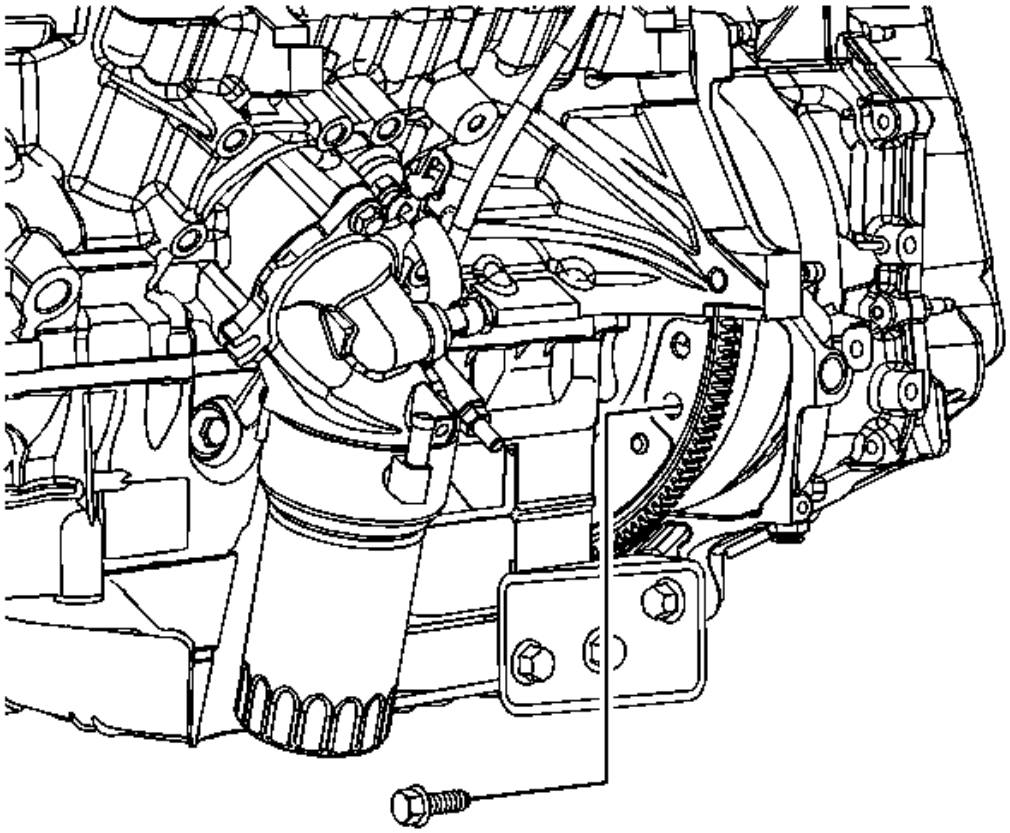

Fig. 338: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

50. Install the torque converter bolts.
51. Use the **J 37096** in order to hold the flywheel.
52. Tighten the torque converter bolts.

Tighten: Tighten the bolts to 63 N.m (47 lb ft).

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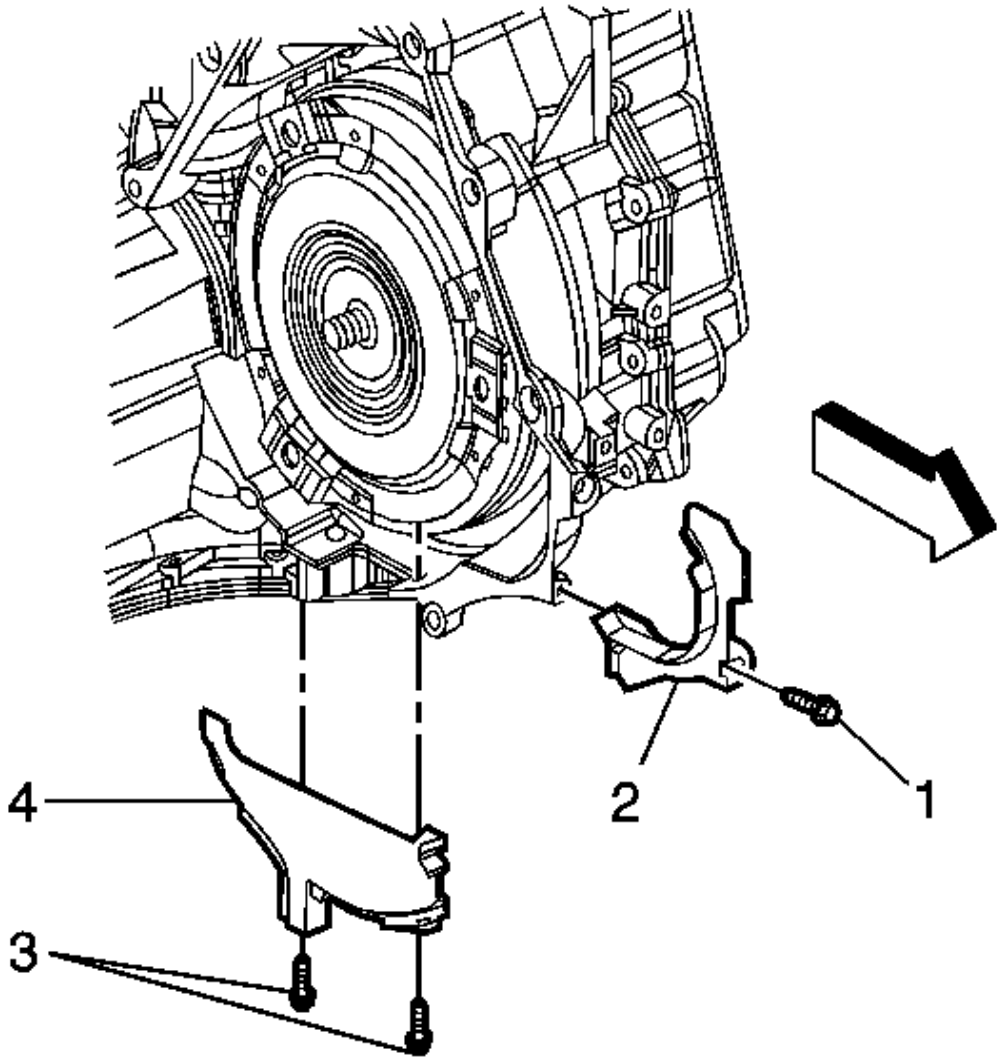

Fig. 339: Identifying Torque Converter Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

53. Install the torque converter covers (2, 4).
54. Install the torque converter cover bolts (1, 3).

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

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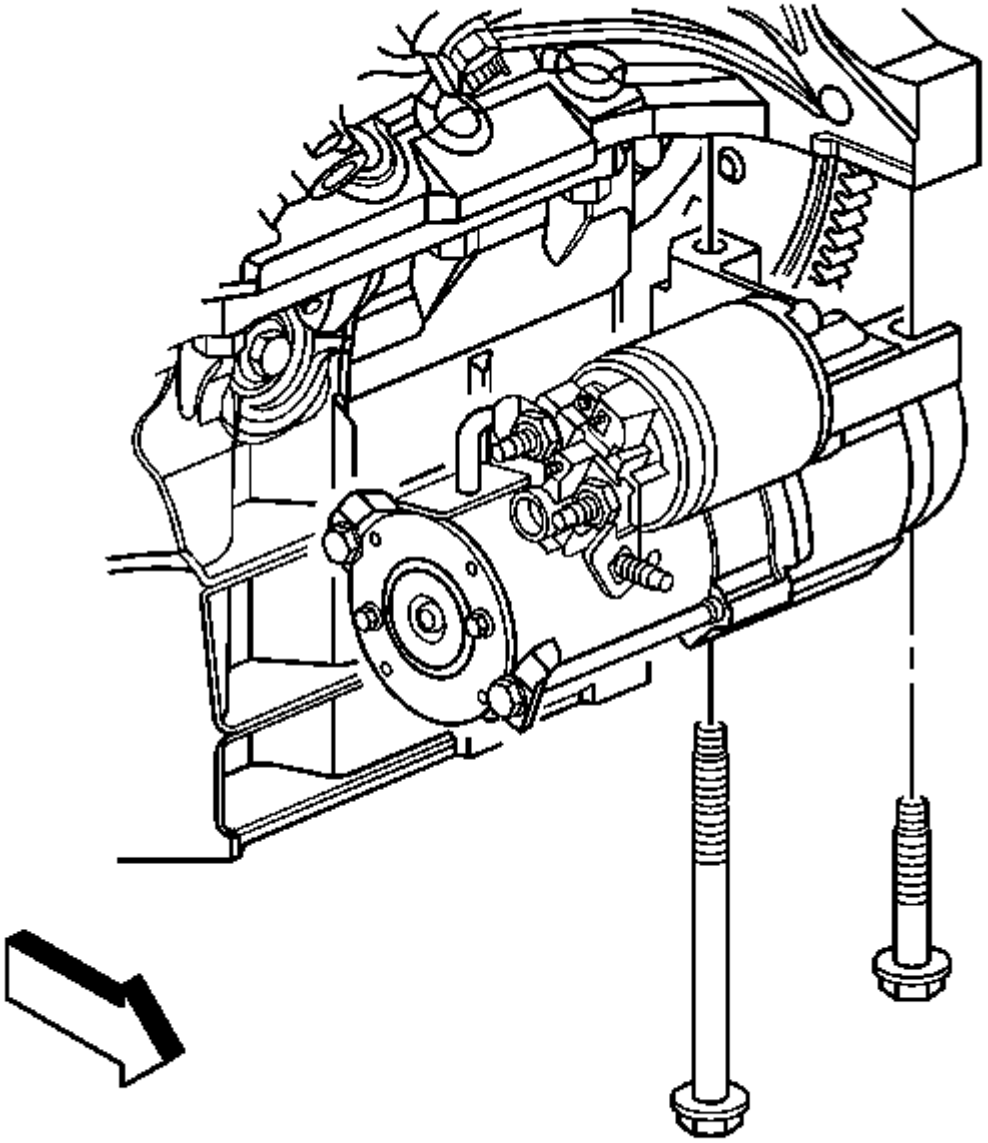

Fig. 340: Identifying Starter Motor & Bolts
Courtesy of GENERAL MOTORS CORP.

55. Install the starter motor and bolts.

    Tighten: Tighten the bolts to 40 N.m (30 lb ft).

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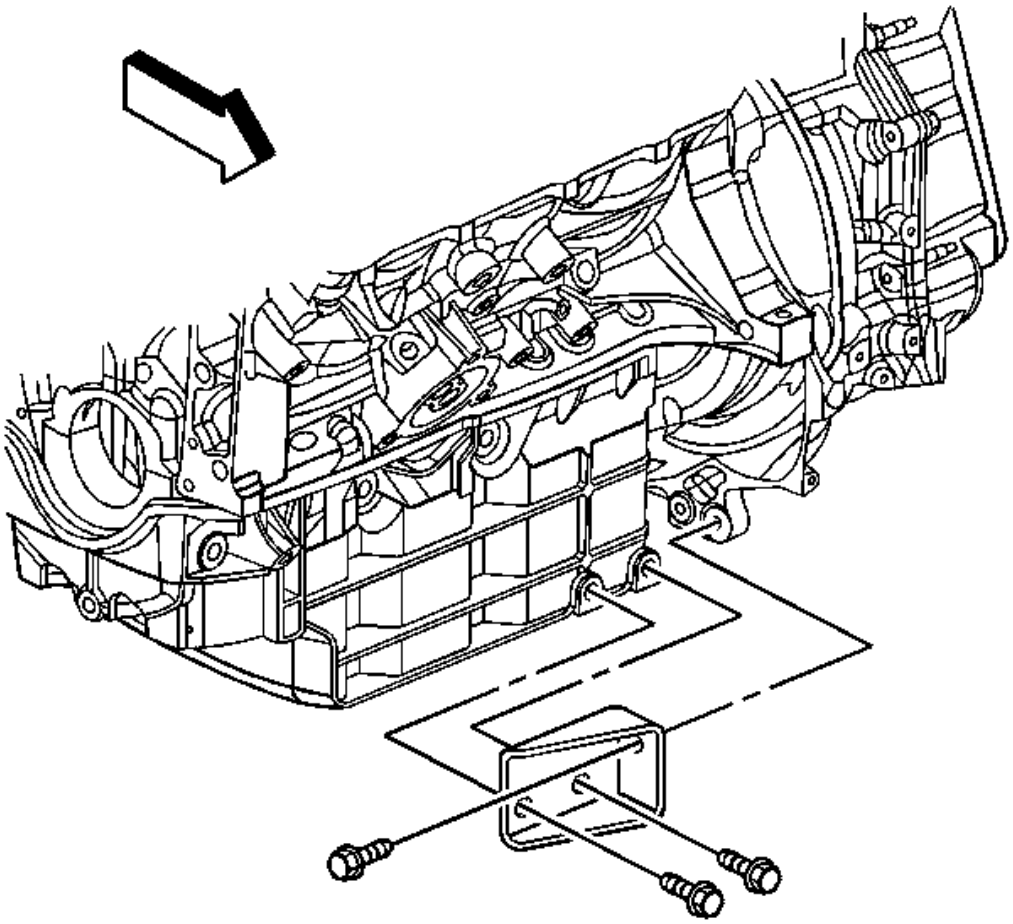

Fig. 341: Identifying Engine Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

56. Install the transaxle brace and bolts.

    Tighten: Tighten the bolts to 43 N.m (32 lb ft).

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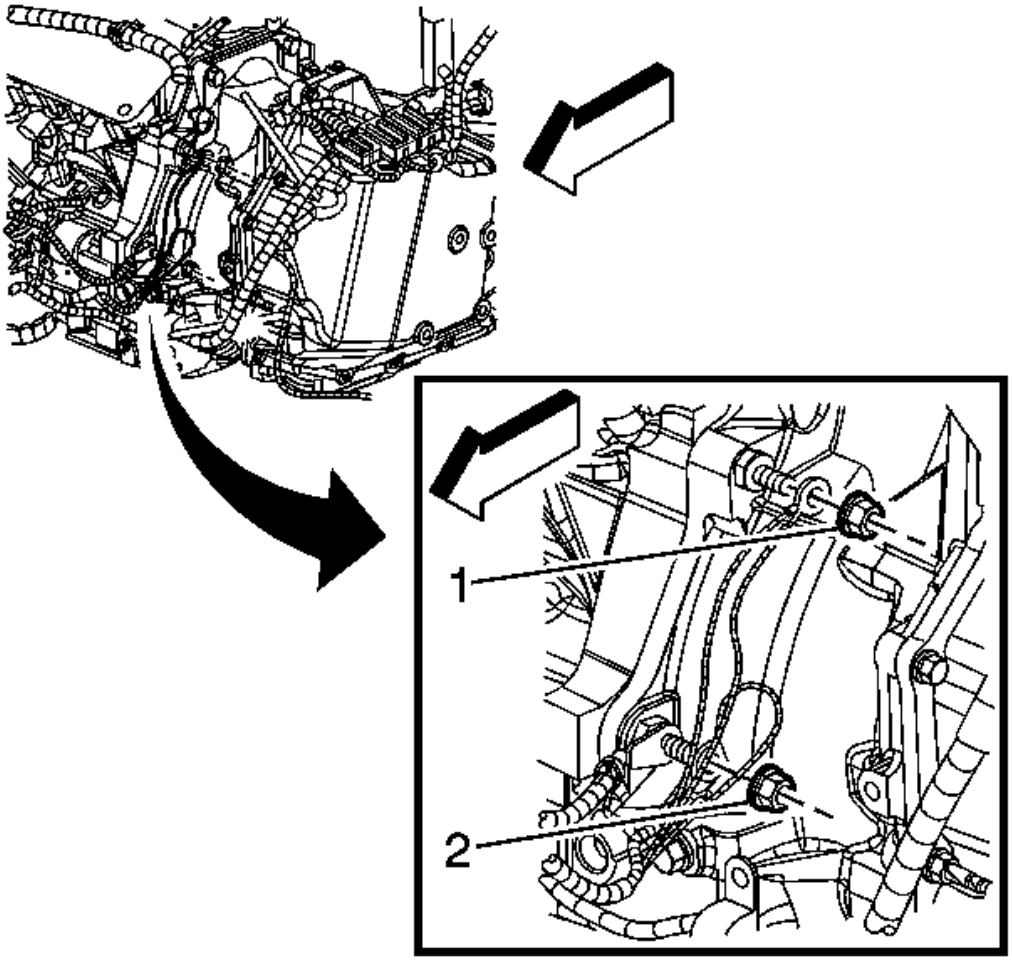

Fig. 342: Locating Engine Harness Grounds
Courtesy of GENERAL MOTORS CORP.

57. Install the negative battery cable to the transaxle stud.
58. Install the engine harness grounds to the studs.
59. Install the engine harness ground nuts (1, 2) to the transaxle studs.

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

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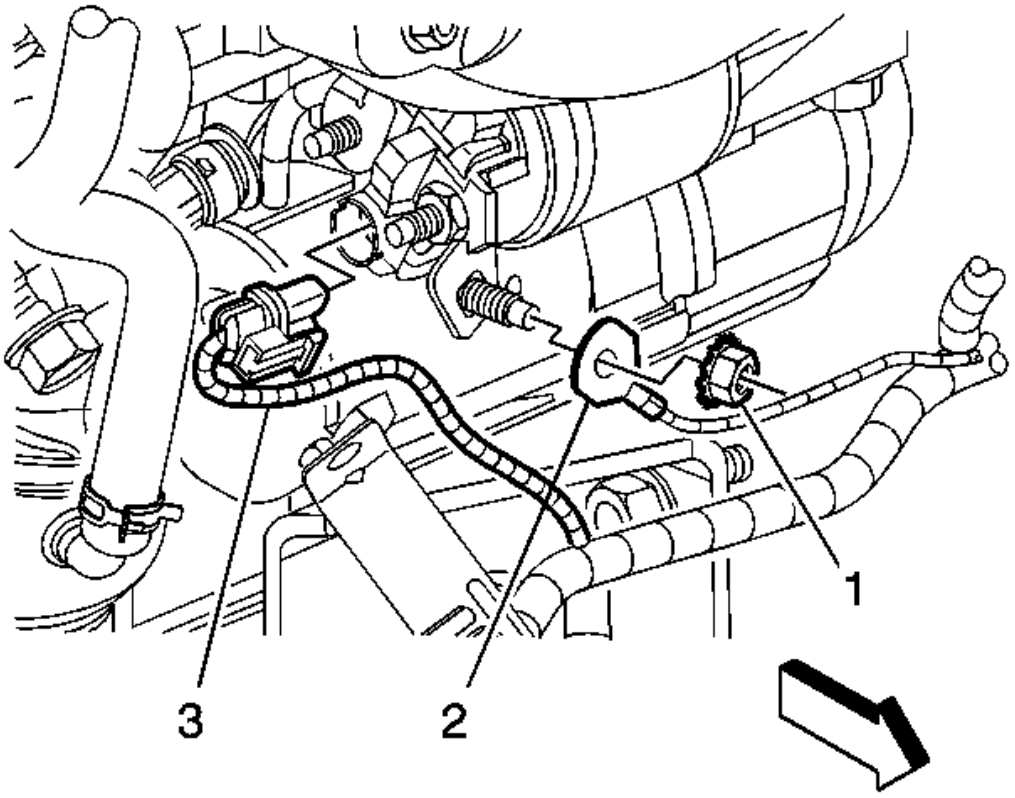

Fig. 343: Identifying Engine Harness Ground Wire Nut
Courtesy of GENERAL MOTORS CORP.

60. If necessary perform the following steps, connect the engine harness electrical connector (3) to the starter.
61. Install the engine battery positive wire terminal (2) to the stud.
62. Install the engine battery positive wire nut (1).

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

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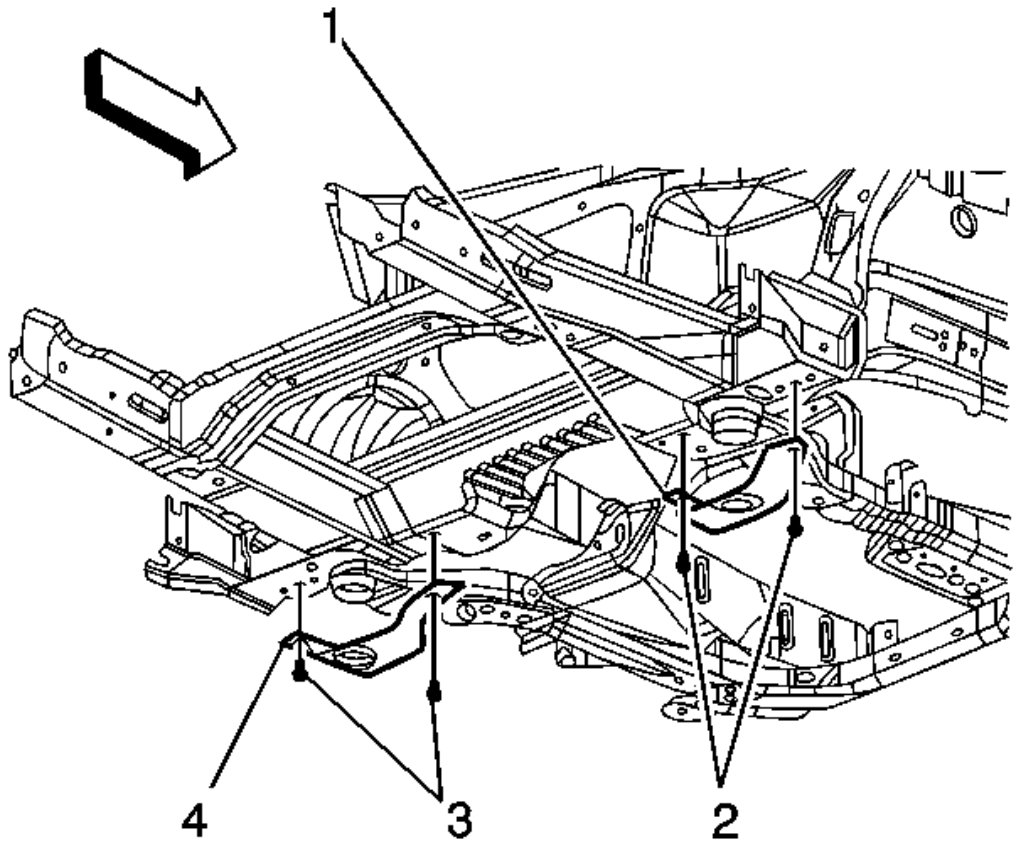

Fig. 344: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

63. Lower the vehicle over the powertrain/frame assembly.
64. Position the frame rear straps (1, 4).
65. Install the frame rear strap bolts (2, 3).

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

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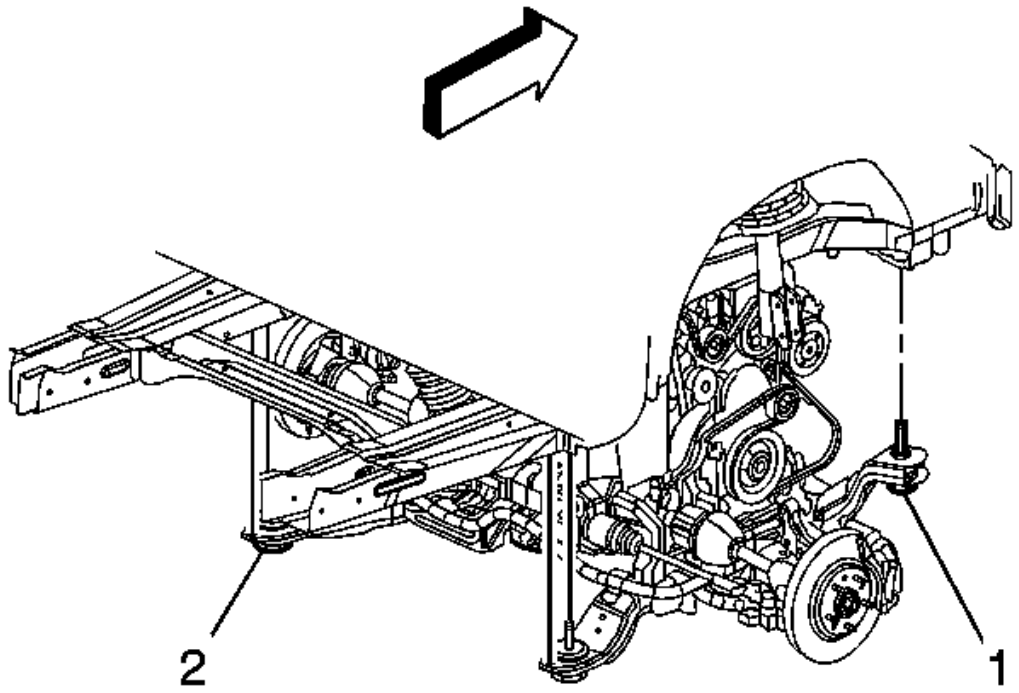

Fig. 345: Identifying Frame Bolts
Courtesy of GENERAL MOTORS CORP.

66. Install the front and rear frame bolts (1, 2).

Tighten:

- Tighten the front bolts to 130 N.m (96 lb ft).
- Tighten the rear bolts to 240 N.m (177 lb ft).

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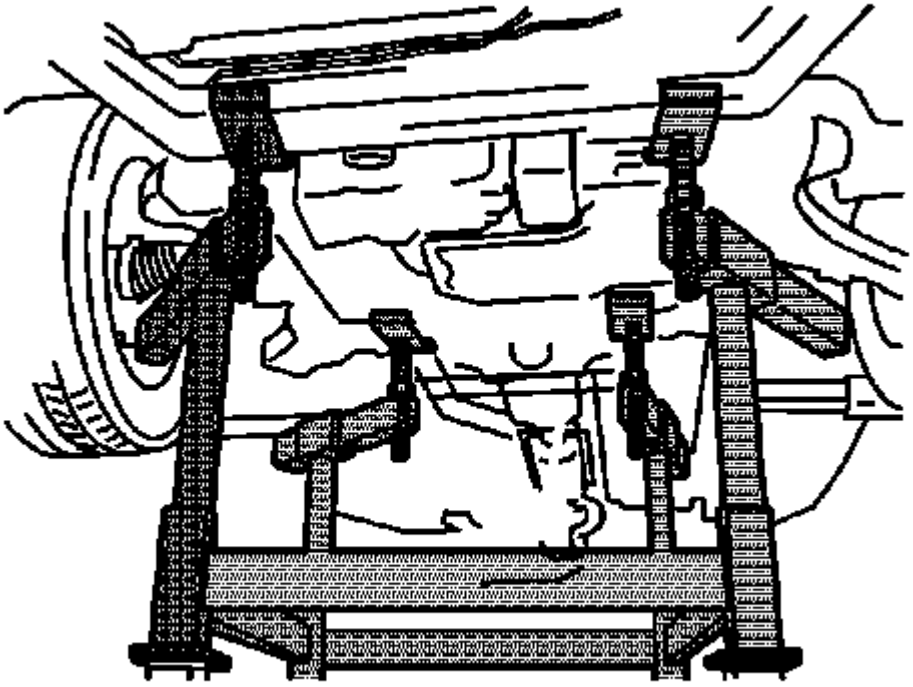

Fig. 346: Identifying Utility Stand
Courtesy of GENERAL MOTORS CORP.

67. Raise the vehicle off of the **J 39580** .
68. Remove the **J 39580** from under the frame.

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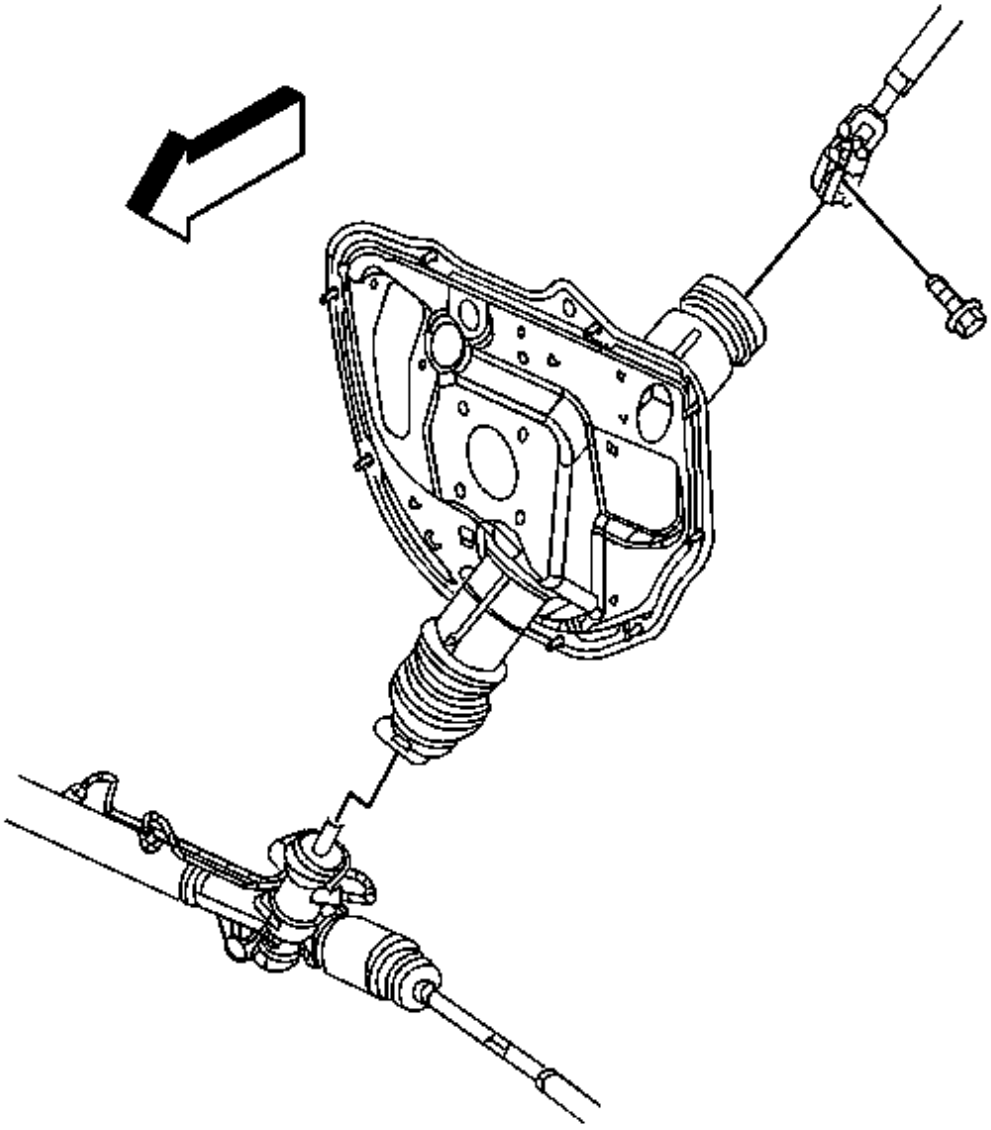

Fig. 347: Identifying Wheel Intermediate Steering Shaft & Pinch Bolt
Courtesy of GENERAL MOTORS CORP.

69. Connect the intermediate steering shaft to the power steering gear.
70. Install the intermediate steering shaft pinch bolt.

Tighten: Tighten the bolt to 48 N.m (35 lb ft).

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71. Position the intermediate steering shaft seal onto the steering gear.

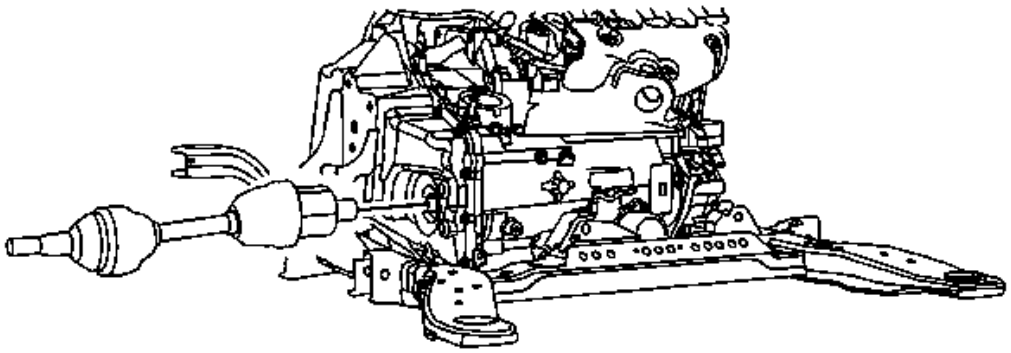

Fig. 348: Identifying Wheel Drive Shafts
Courtesy of GENERAL MOTORS CORP.

72. Unsecure the wheel drive shafts from the steering knuckle/struts.
73. Install the wheel drive shafts to the transaxle.
74. Verify that the wheel drive shaft is properly engaged to the transaxle by grasping the inner tripot housing and pulling outward. Do not pull on the wheel drive shaft bar. The wheel drive shaft will remain firmly in place when properly engaged.

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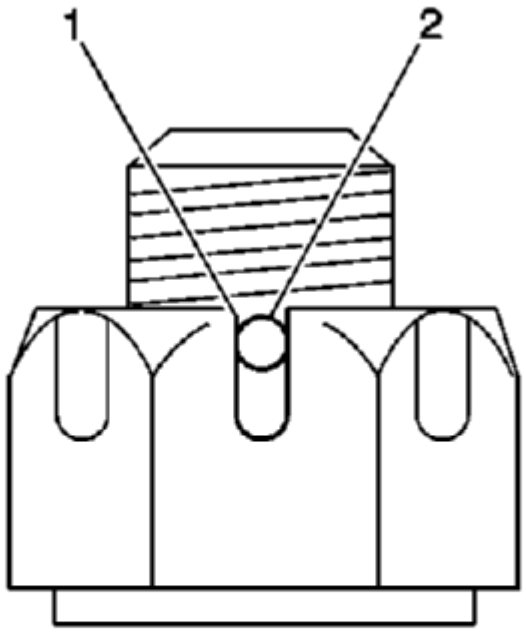

Fig. 349: Aligning Ball Stud Castle Nut Slot To The Ball Stud Cotter Pin Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the ball joint cotter pin hole parallel to the knuckle in order to ease the cotter pin installation.

75. Install the ball joints to the knuckles.
76. Install the ball joint castle nuts.

IMPORTANT: DO NOT loosen the castle nut in order to align the nut to the cotter pin hole.

77. If necessary, tighten the castle nut in order to align the nut slot (1) to the cotter pin hole (2) as shown.

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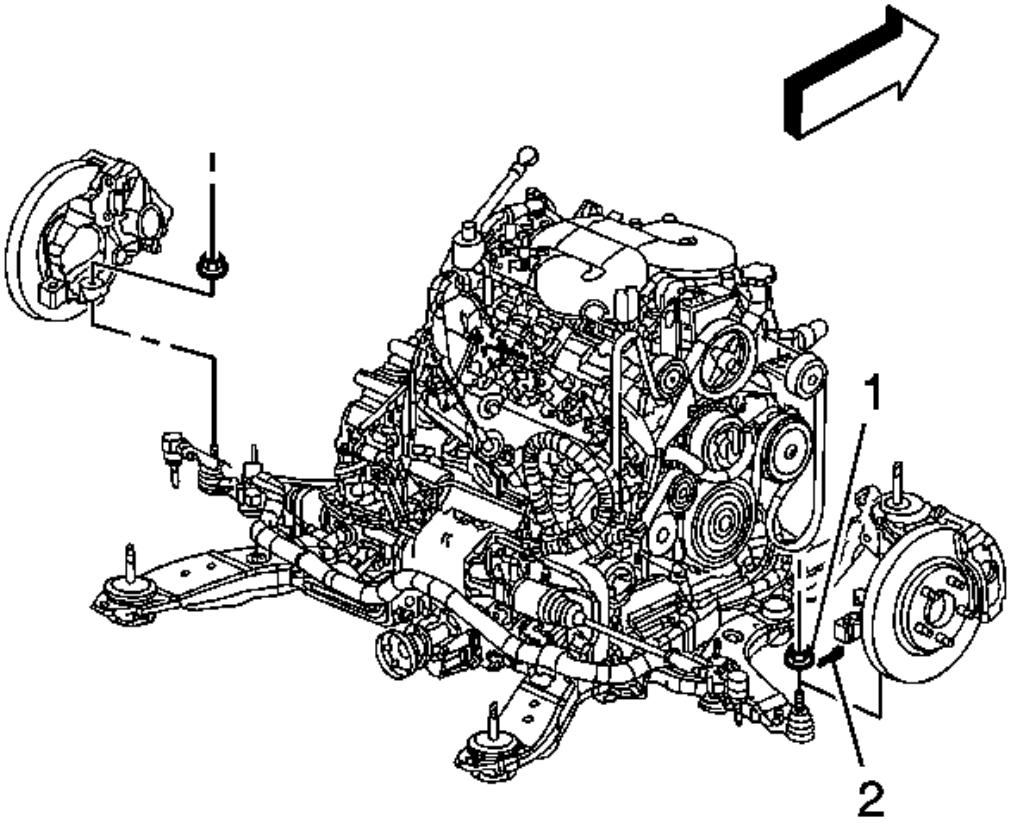

Fig. 350: View Of Outer Tie Rod Ends & Steering Knuckles
Courtesy of GENERAL MOTORS CORP.

78. Tighten the lower ball joint castle nuts (1).

    Tighten: Tighten the nuts to 55 N.m (40 lb ft).

79. Install NEW lower ball joint cotter pins (2) to the ball joints.

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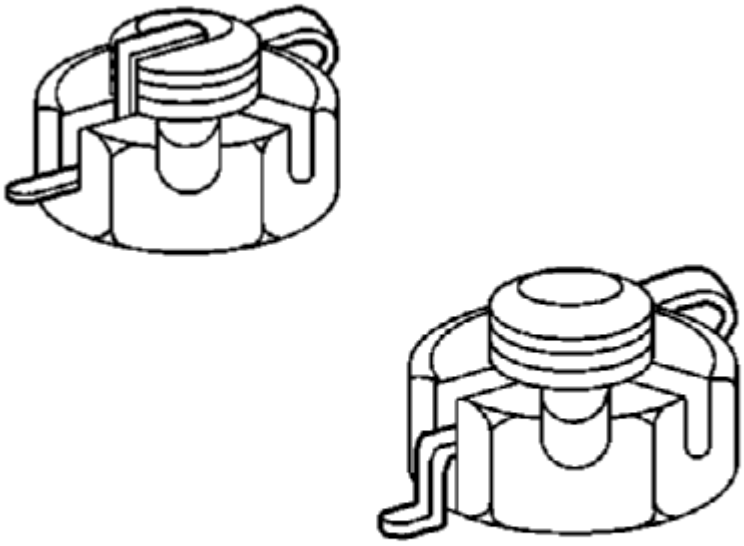

Fig. 351: Securing Cotter Pin In Ball Joint Castle Nut
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the cotter pin ends do NOT contact the ABS wheel speed sensor, the ABS sensor connector, or the drive axle.

80. Bend the ends of the cotter pin as shown in either example.

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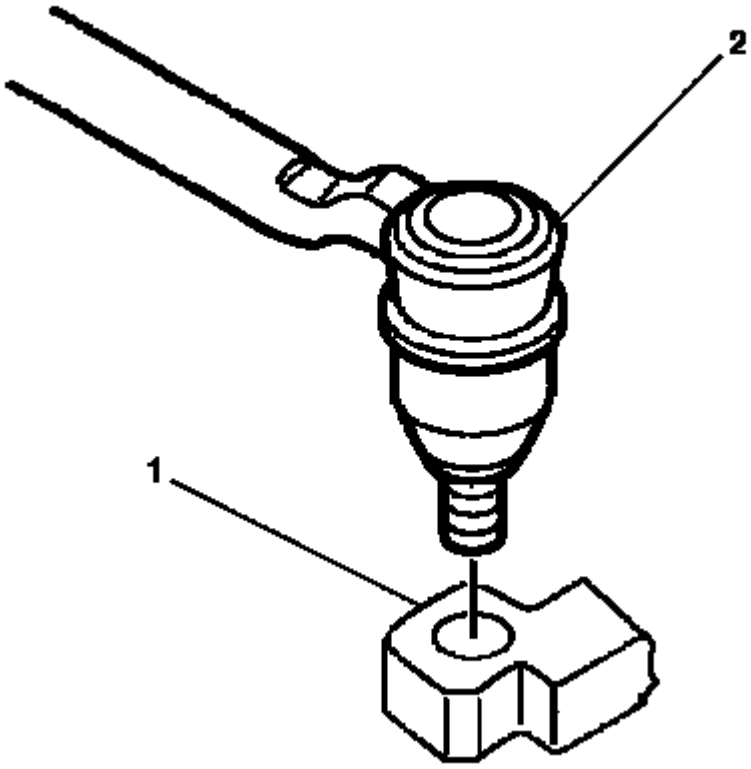

Fig. 352: View Of Outer Tie Rod & Steering Knuckle
Courtesy of GENERAL MOTORS CORP.

81. Install the outer tie rod (2) to the steering knuckle (1).

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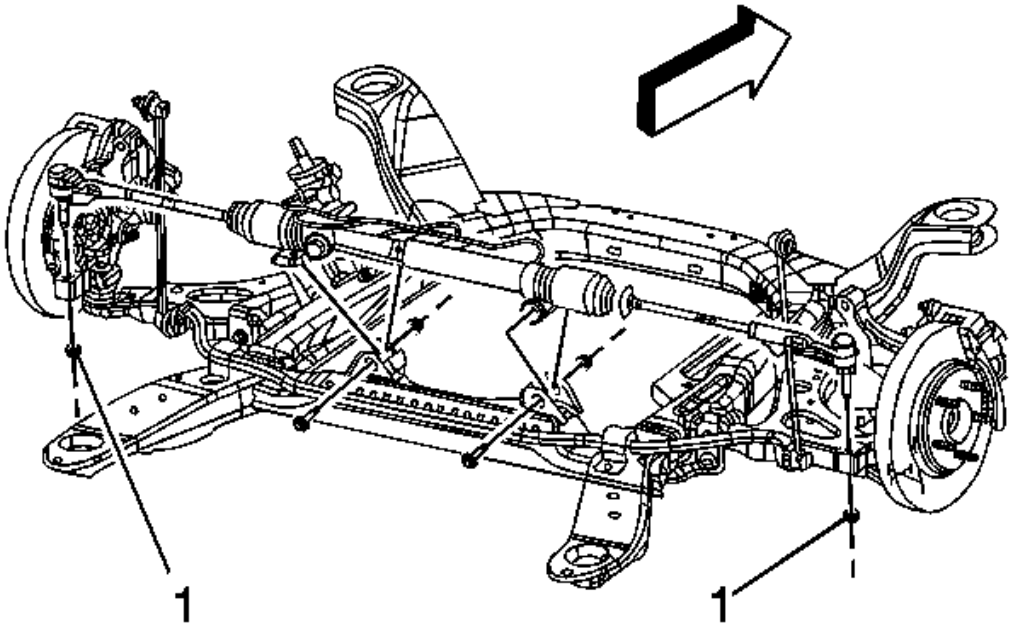

Fig. 353: Identifying Tie Rod End Nuts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This is a prevailing torque type fastener. You may reuse this fastener ONLY under the following conditions:

- **The fastener and its counterpart are clean and free from rust.**
- **The fastener develops 2 N.m (18 lb in) of torque/drag against its counterpart prior to fastener seating.**

If the fastener does not meet these criteria, REPLACE the fastener.

82. Install the tie rod end nuts (1) at the steering knuckles.

Tighten: Tighten the nuts to 30 N.m (22 lb ft) plus an additional 120 degrees using the **J 45059** . See **Special Tools**.

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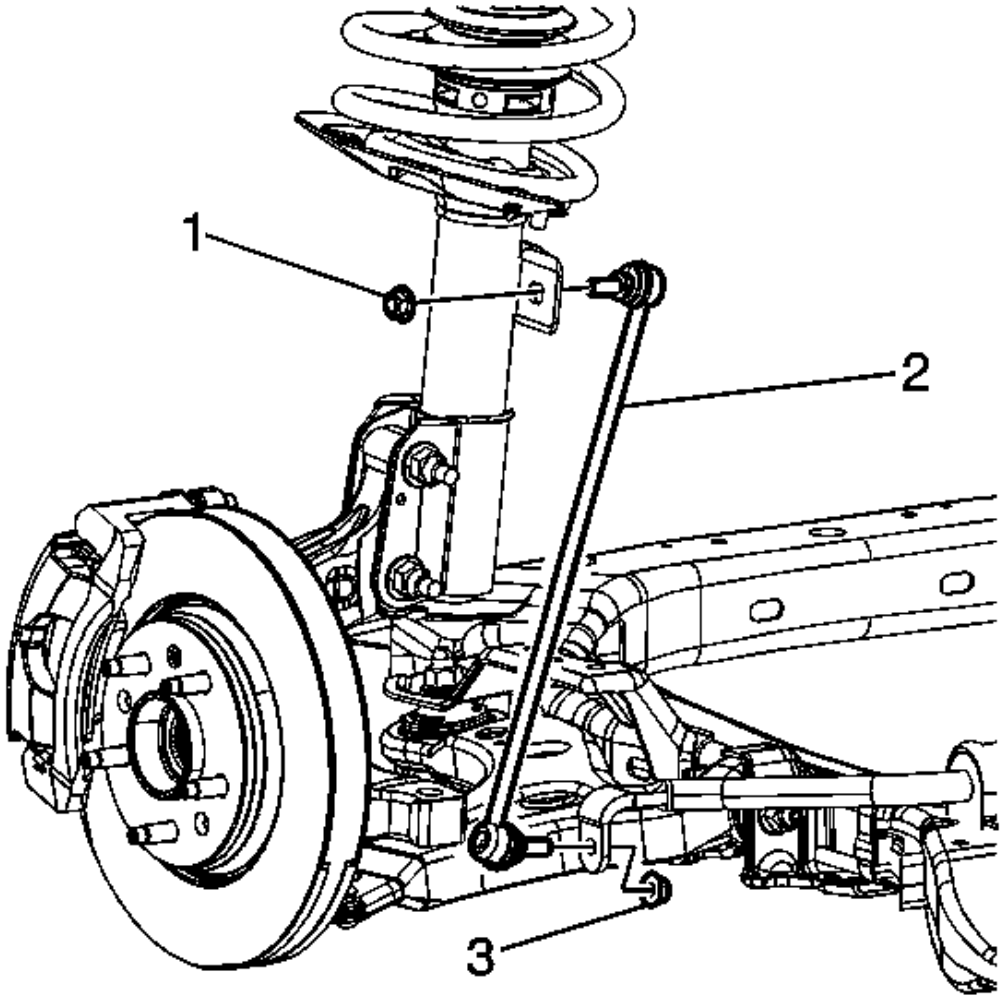

Fig. 354: Identifying Stabilizer Shaft Components
Courtesy of GENERAL MOTORS CORP.

83. Install the stabilizer shaft links (2) to the stabilizer shaft. (left side shown, right side similar).
84. Install the stabilizer shaft link lower nuts (3).

Tighten: Tighten the nuts to 23 N.m (17 lb ft).

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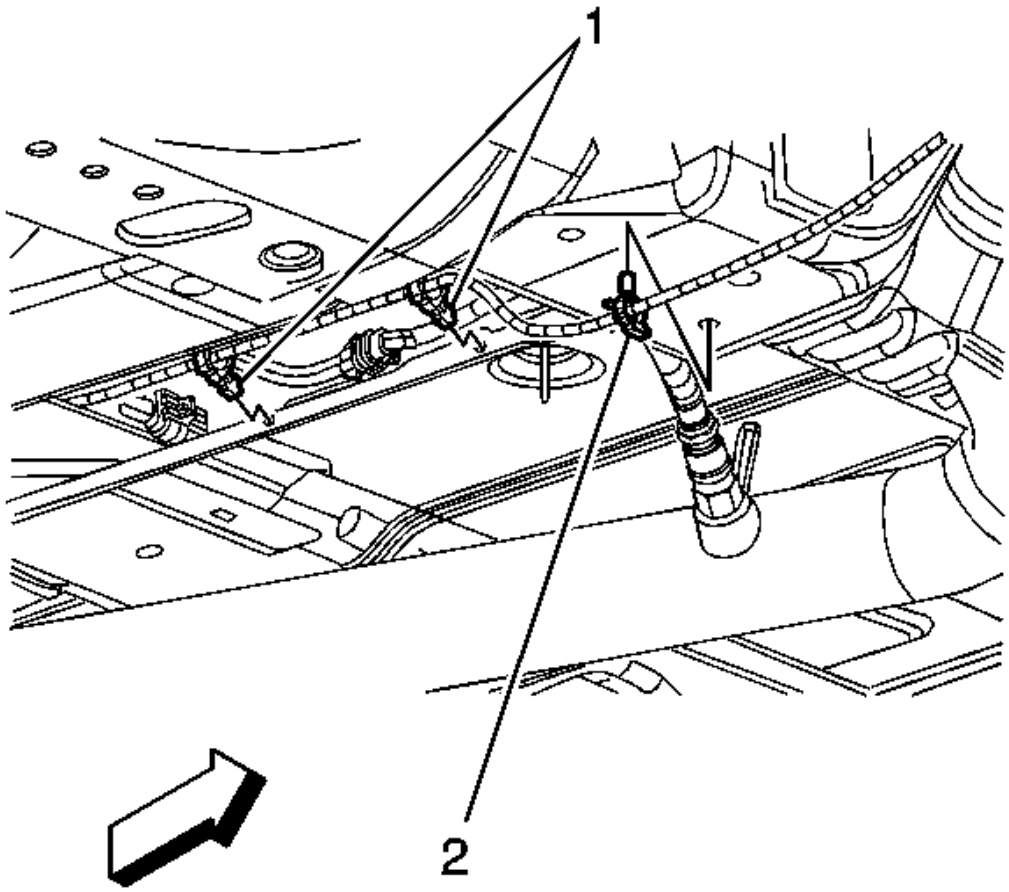

Fig. 355: Identifying Engine Harness Clips At Heat Shield
Courtesy of GENERAL MOTORS CORP.

85. Install the engine harness clips (1, 2) to the heat shield.
86. Connect the battery cable retainers at the core support.
87. Install the engine splash shield. Refer to **Engine Splash Shield Replacement** .
88. Install the catalytic converter. Refer to **Catalytic Converter Replacement** .

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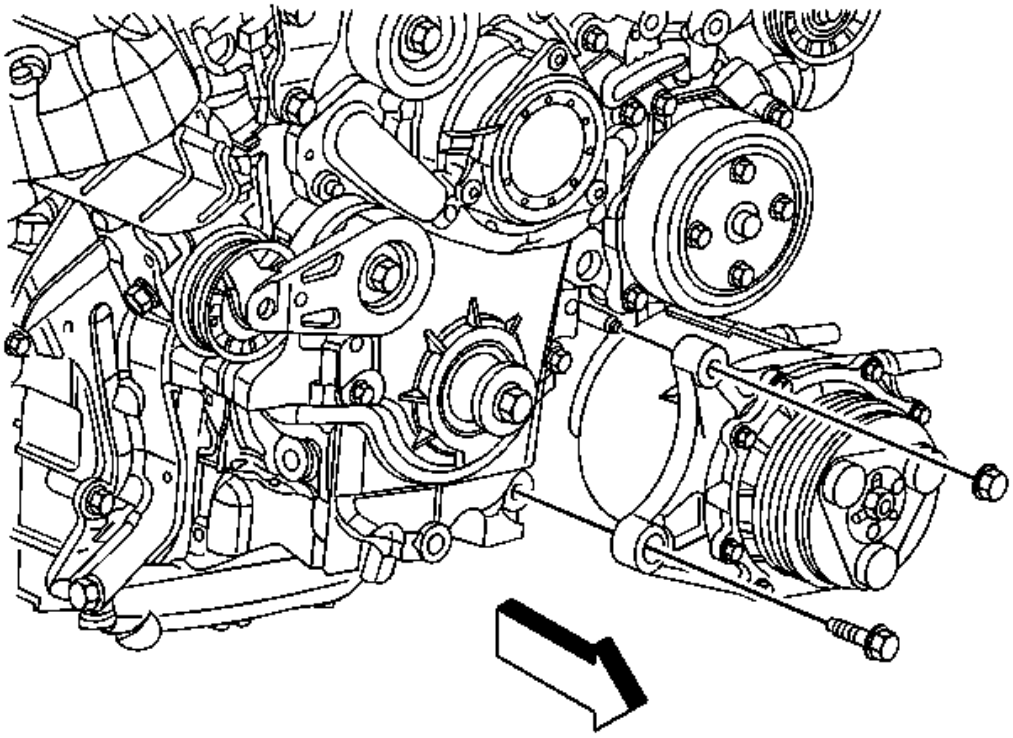

Fig. 356: Identifying A/C Compressor Front Bolt & Nut
Courtesy of GENERAL MOTORS CORP.

89. Position and install the A/C compressor onto the stud.
90. Install the A/C compressor front bolt and nut.

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

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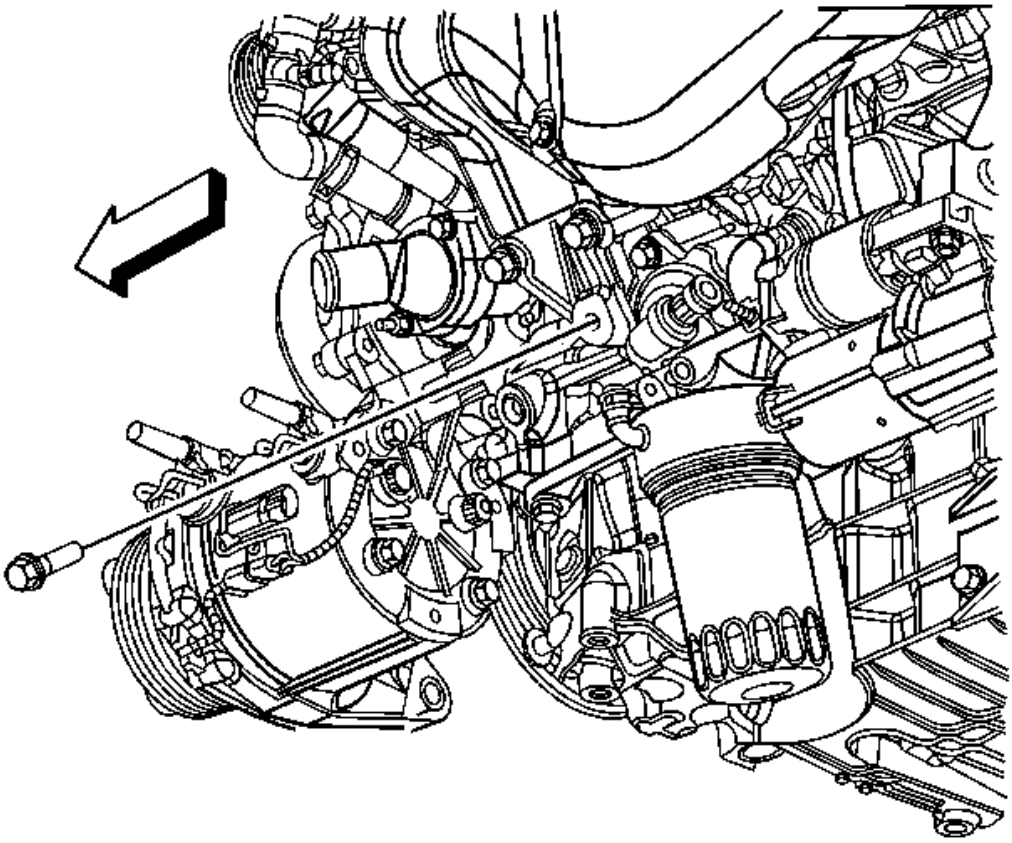

Fig. 357: Identifying A/C Compressor Rear Bolt
Courtesy of GENERAL MOTORS CORP.

91. Install the A/C compressor rear bolt.

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

92. Connect the engine harness electrical connectors to the A/C compressor.
93. Install the drive belt. Refer to **Drive Belt Replacement**.

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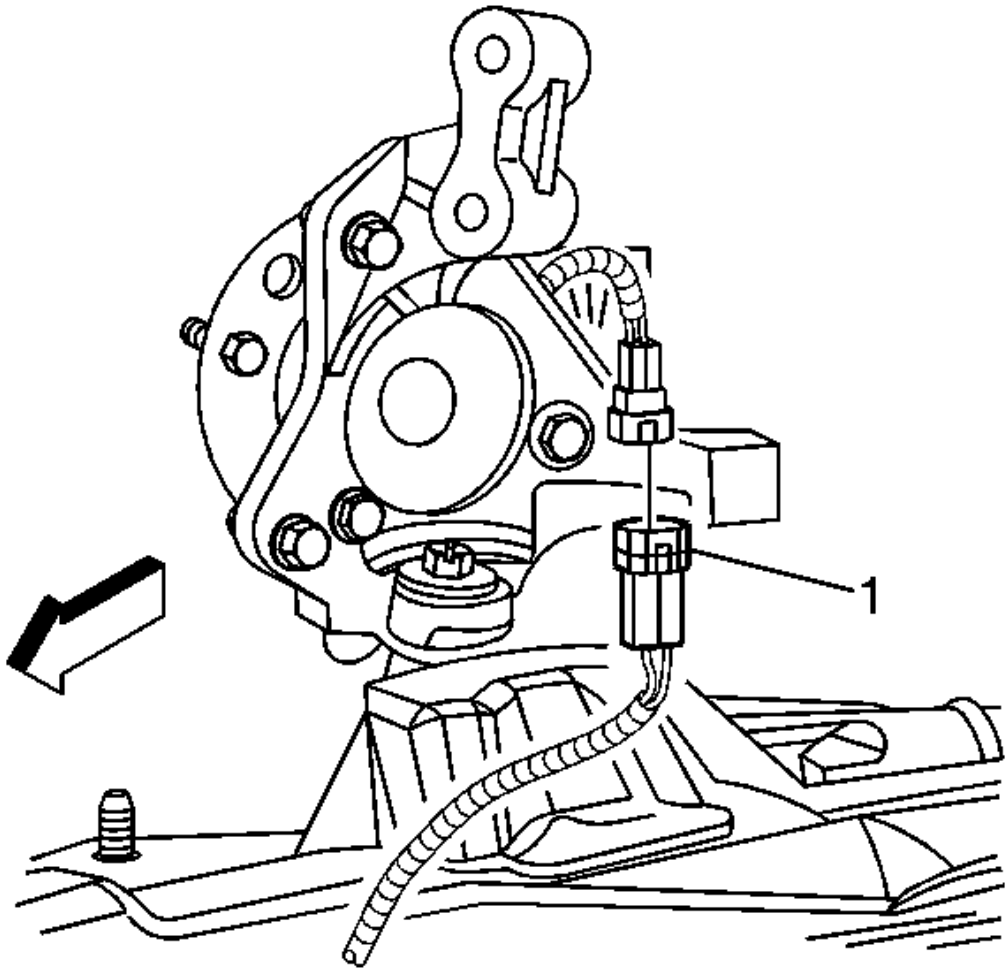

Fig. 358: Identifying Engine Harness Electrical Connectors Located At Left & Right Wheel Speed Sensors
Courtesy of GENERAL MOTORS CORP.

94. Connect the engine harness electrical connectors (1) to the left and right wheel speed sensors. (right side shown, left side similar).

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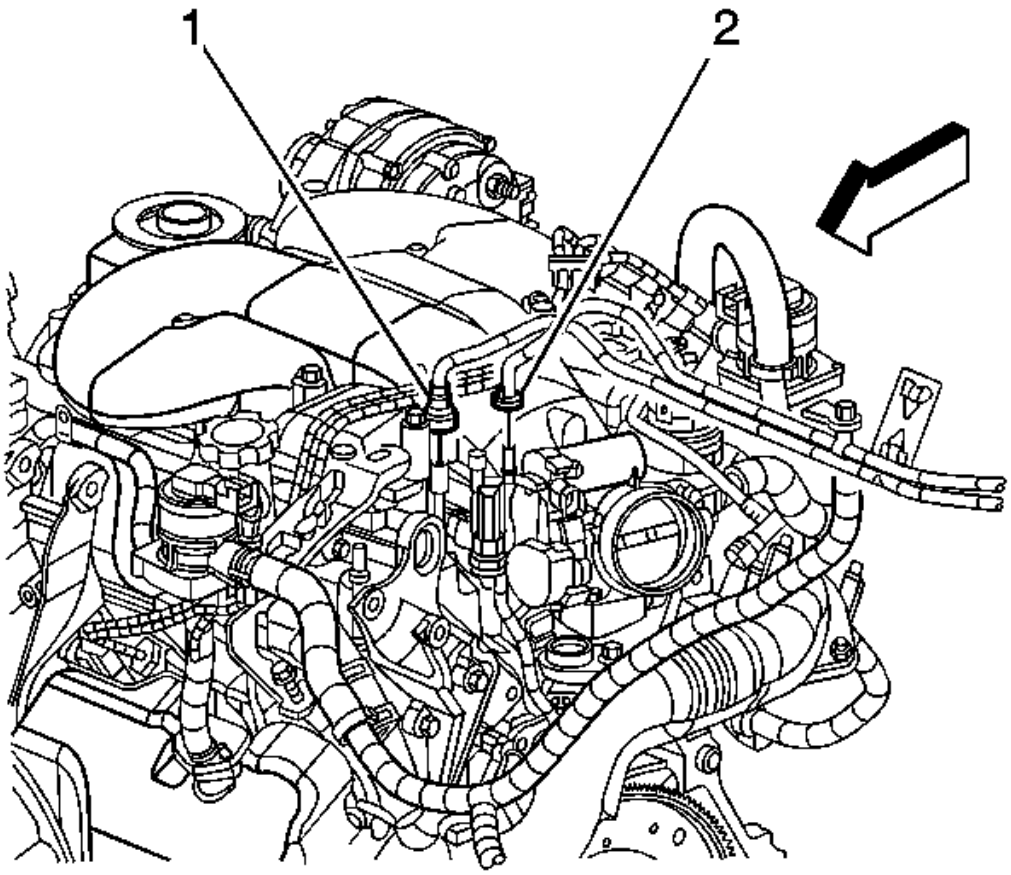

Fig. 359: Identifying Fuel Feed & Evaporative Emission (EVAP) Line Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

95. Install the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
96. Install the engine mount struts. Refer to **Engine Mount Strut Replacement - Right Side** and **Engine Mount Strut Bracket Replacement - Left Side**.
97. Connect the fuel feed (1) and EVAP (2) line quick connect fittings. Refer to **Metal Collar Quick Connect Fitting Service** and **Plastic Collar Quick Connect Fitting Service** .

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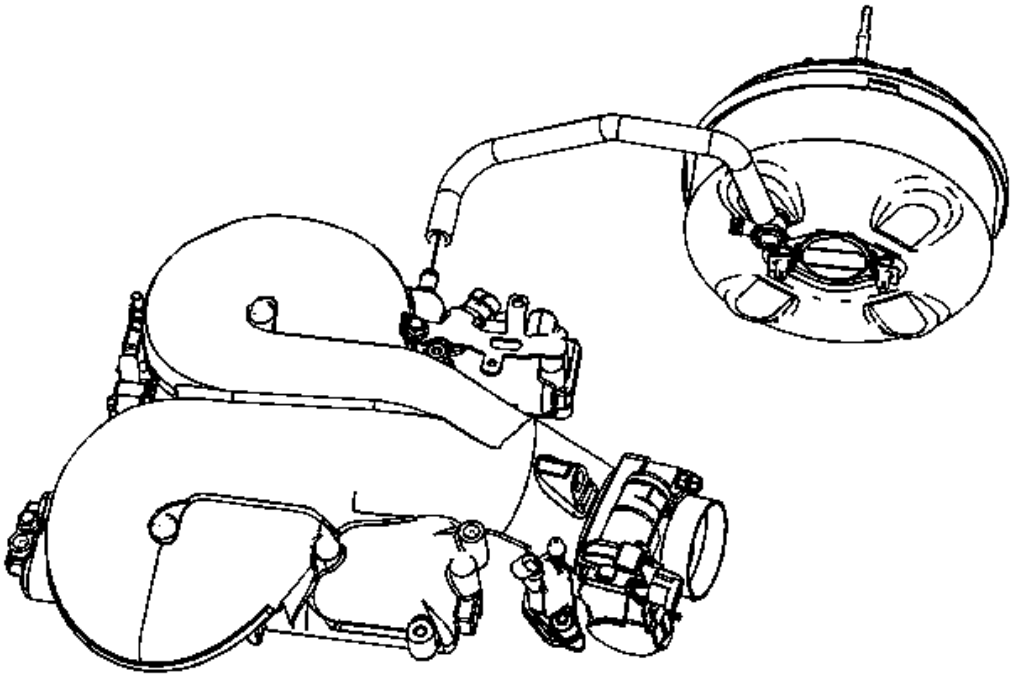

Fig. 360: View Of Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

98. Install the brake booster vacuum hose to the upper intake manifold fitting.

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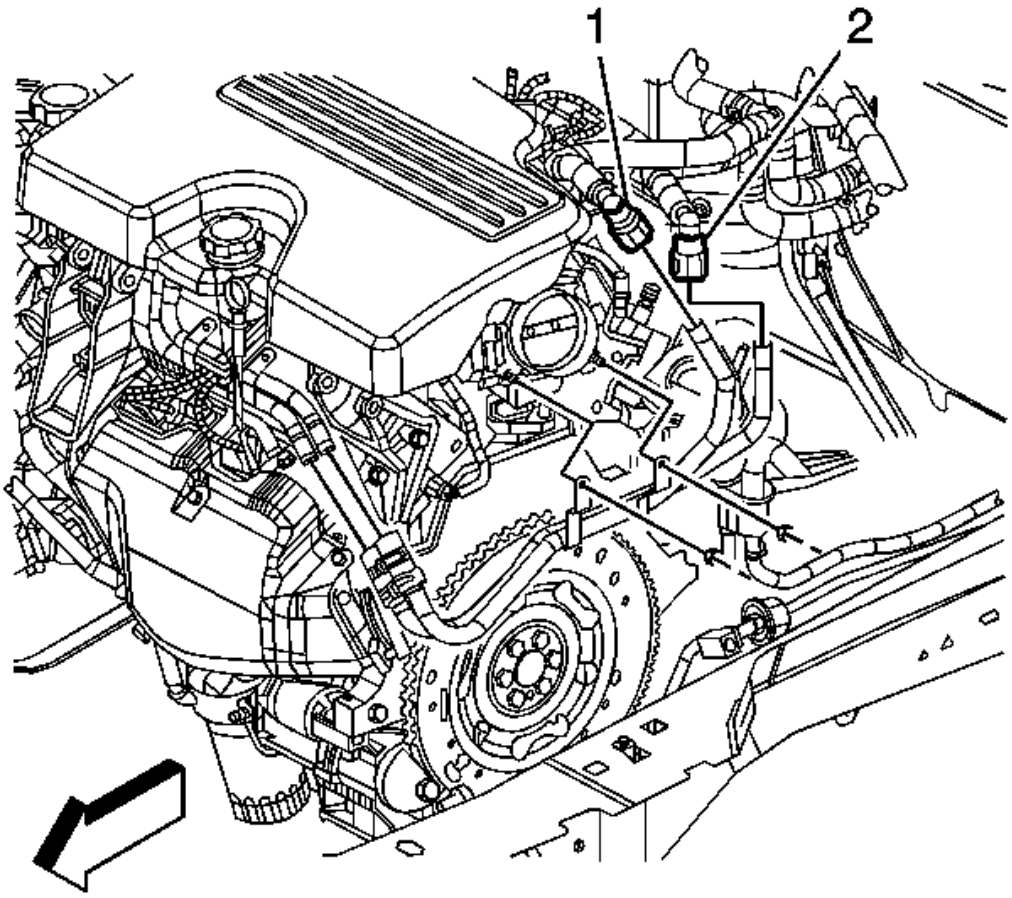

Fig. 361: View Of Heater Hoses
Courtesy of GENERAL MOTORS CORP.

99. Connect the heater inlet (2) and outlet (1) hose quick connect fittings to the inlet and outlet pipes.

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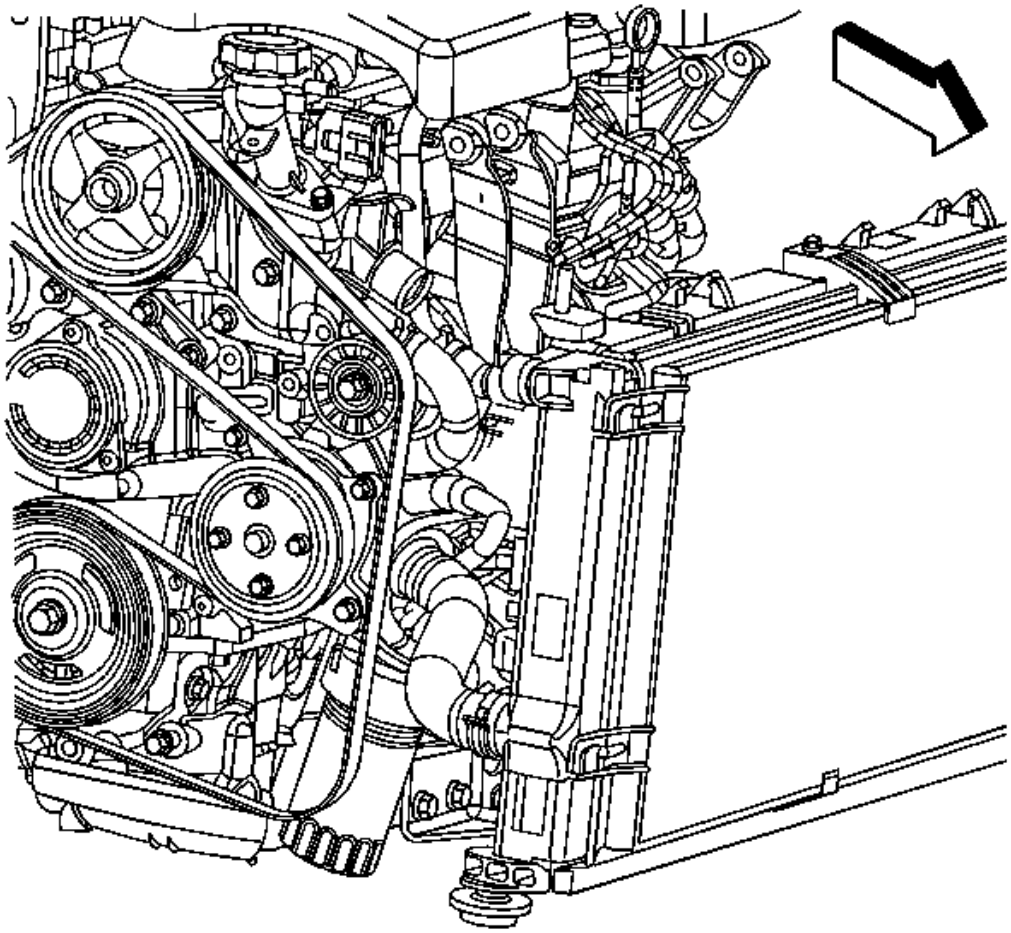

Fig. 362: View Of Radiator Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

100. Install the radiator outlet hose to the thermostat housing.
101. Using the **J 38185** , release the radiator outlet hose clamp.

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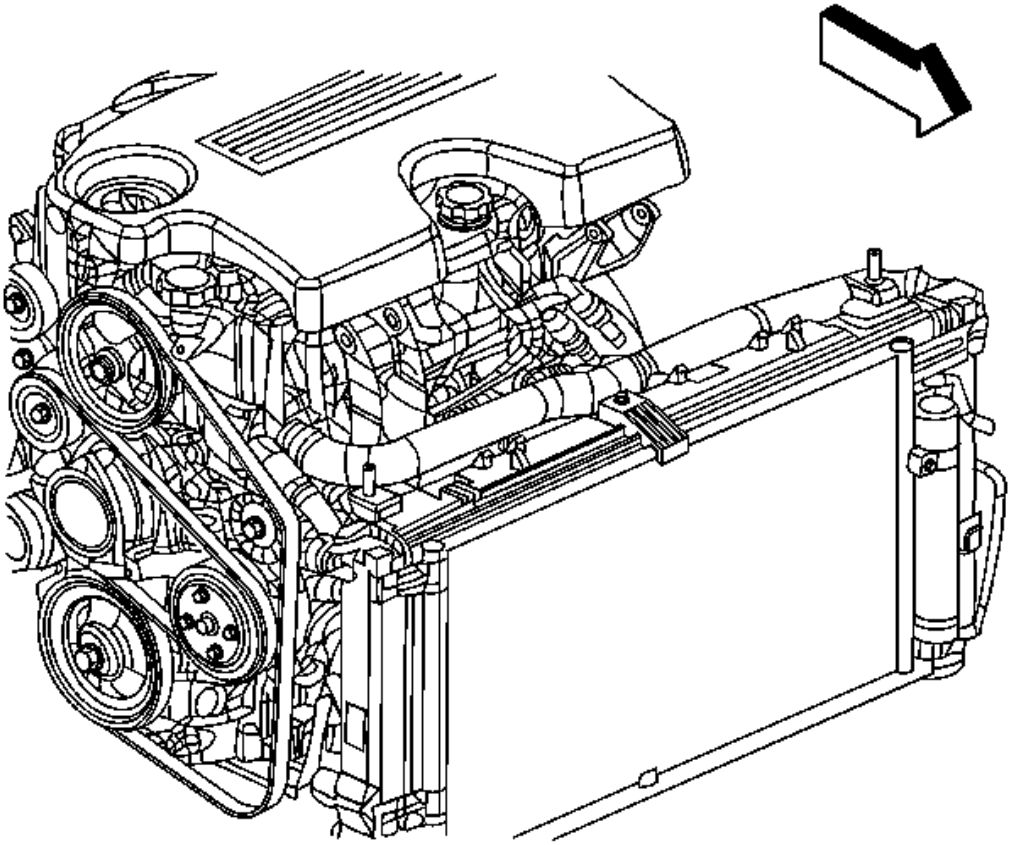

Fig. 363: View Of Radiator, Inlet Hose & Coolant Recovery Reservoir Inlet Hose
Courtesy of GENERAL MOTORS CORP.

102. Install the radiator inlet hose to the coolant crossover.
103. Using the **J 38185** , release the radiator inlet hose clamp.

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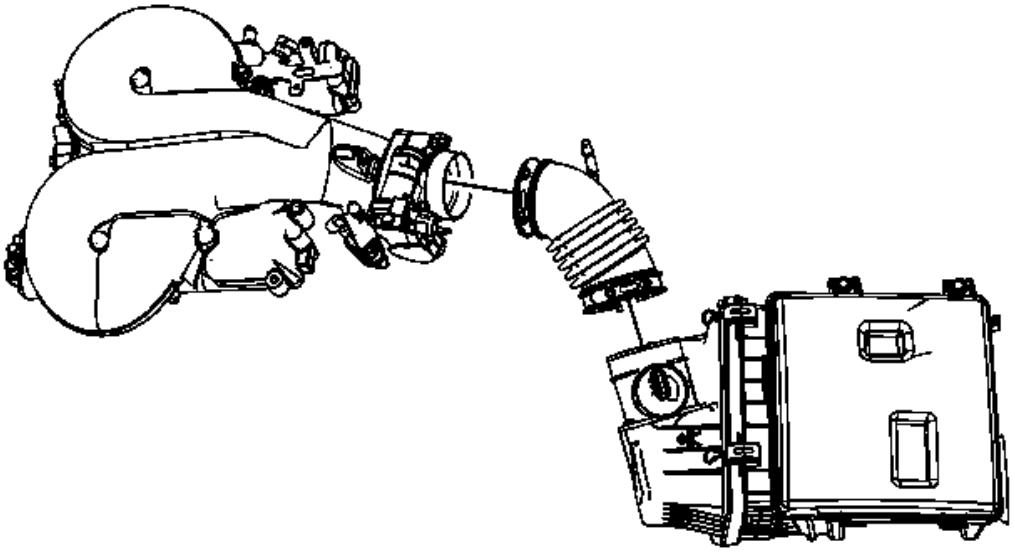

Fig. 364: Identifying Engine Harness connector At Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor
Courtesy of GENERAL MOTORS CORP.

104. Remove the engine harness wiring branch from on top of the engine.
105. Install the air cleaner outlet duct to the throttle body and MAF/IAT sensor.
106. Tighten the air cleaner outlet duct clamps at the throttle body and the MAF/IAT sensor.

    Tighten: Tighten the clamps to 2 N.m (18 lb in).

107. Connect the PCV fresh air tube quick connect fitting to the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
108. Connect the engine harness electrical connector to the MAF/IAT sensor.

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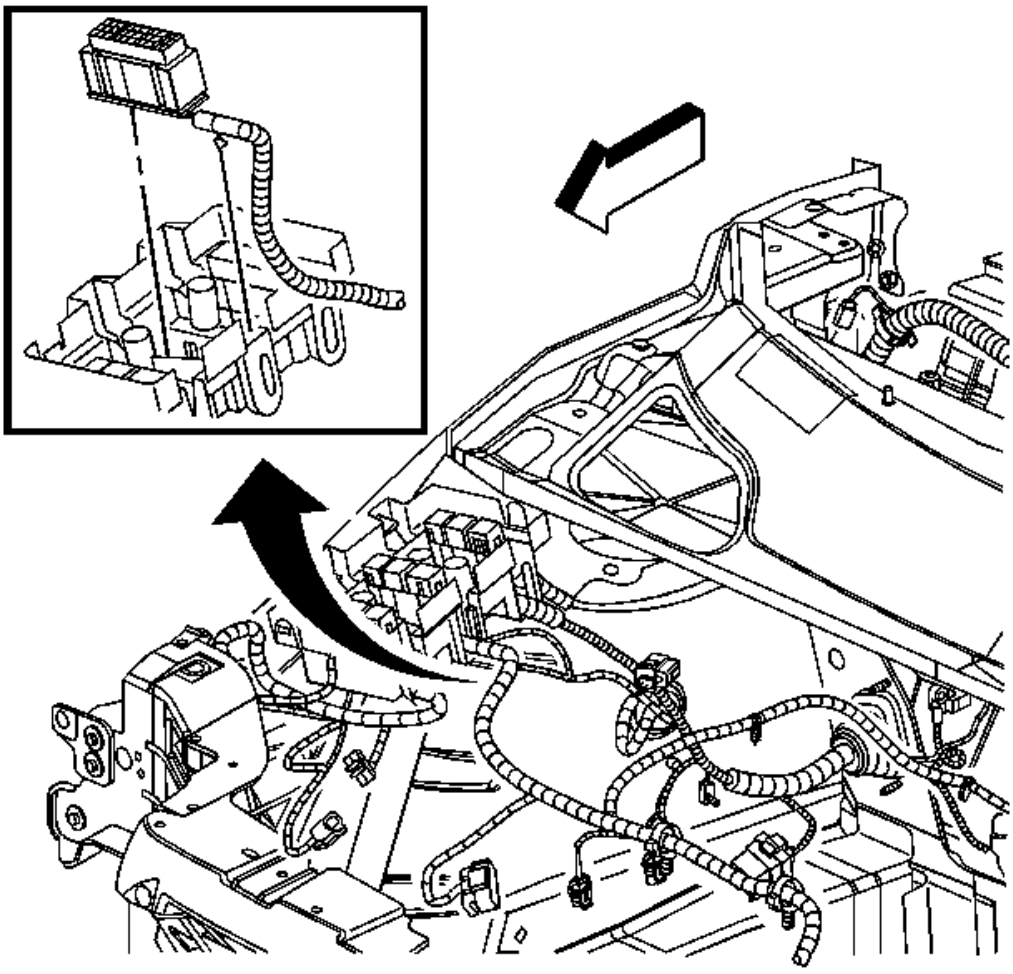

Fig. 365: Identifying Engine Harness connector At junction block.
Courtesy of GENERAL MOTORS CORP.

109. Install the engine harness connector to the junction block retainer.
110. Install the underhood junction block. Refer to **Underhood Electrical Center or Junction Block Replacement** .

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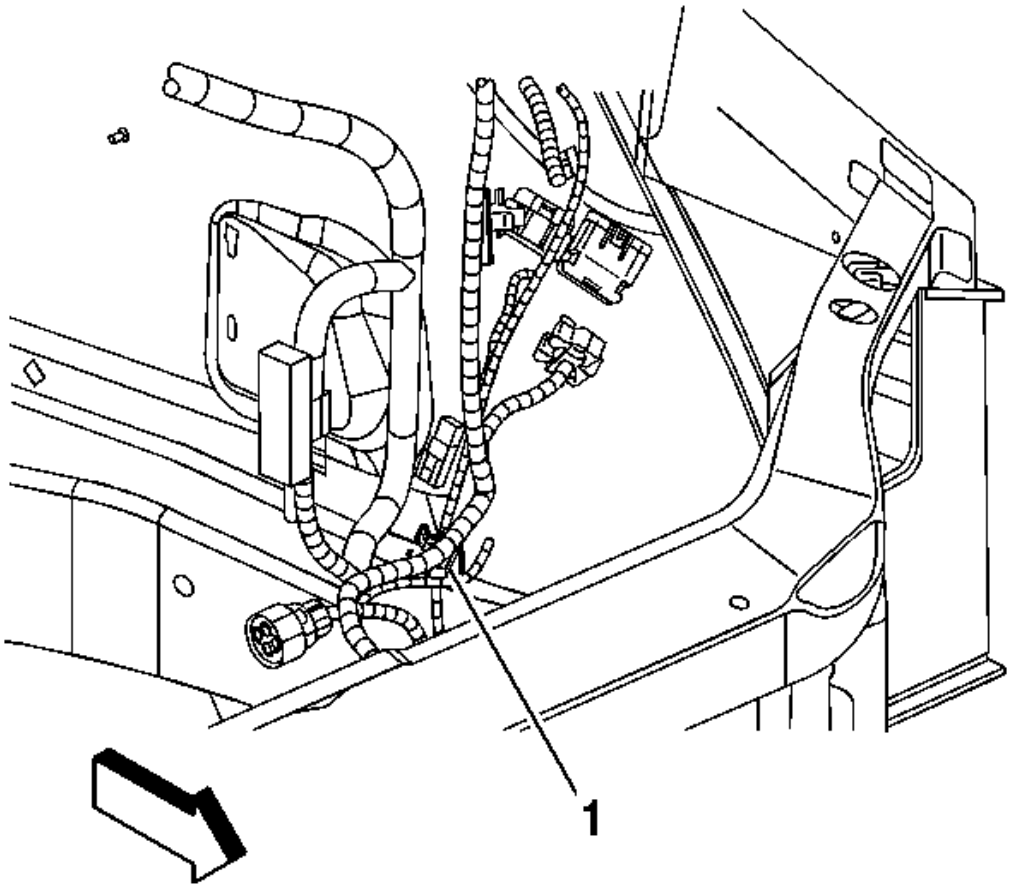

Fig. 366: View Of Engine Harness Clip At A/C Line
Courtesy of GENERAL MOTORS CORP.

111. Install the engine harness clip (1) to the A/C line.

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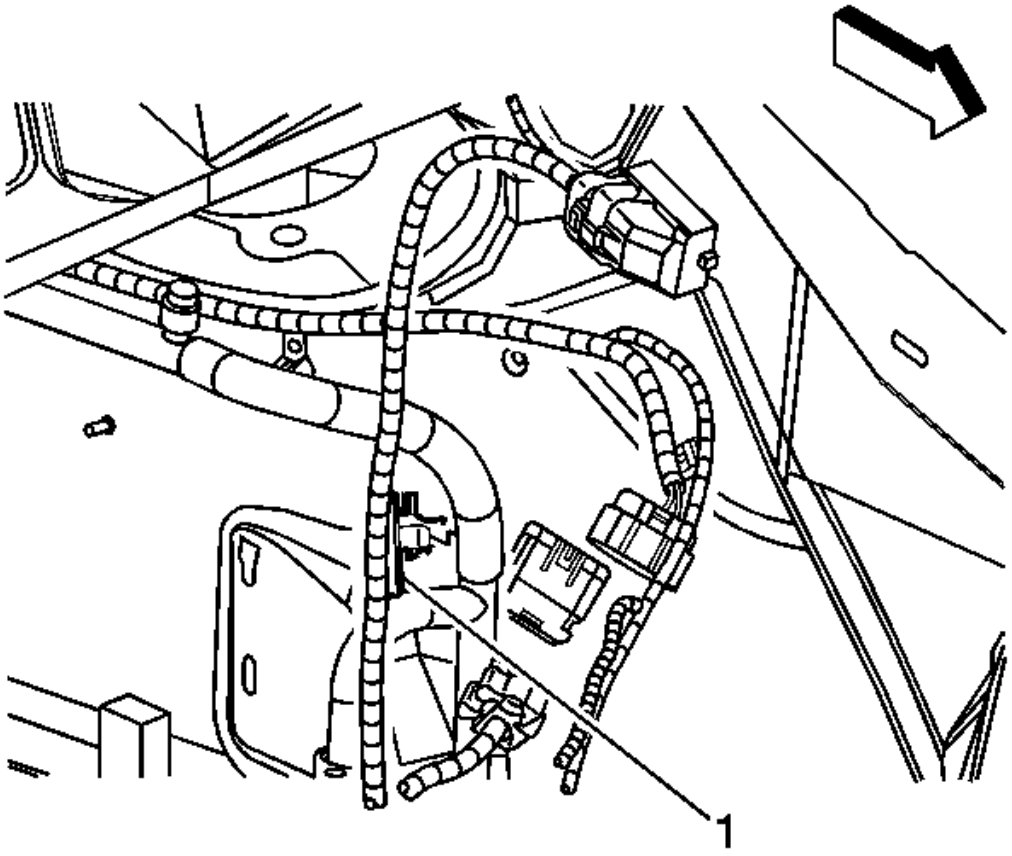

Fig. 367: Identifying Engine Harness Clip At A/C Line
Courtesy of GENERAL MOTORS CORP.

112. Install the engine harness clip (1) to the A/C line.

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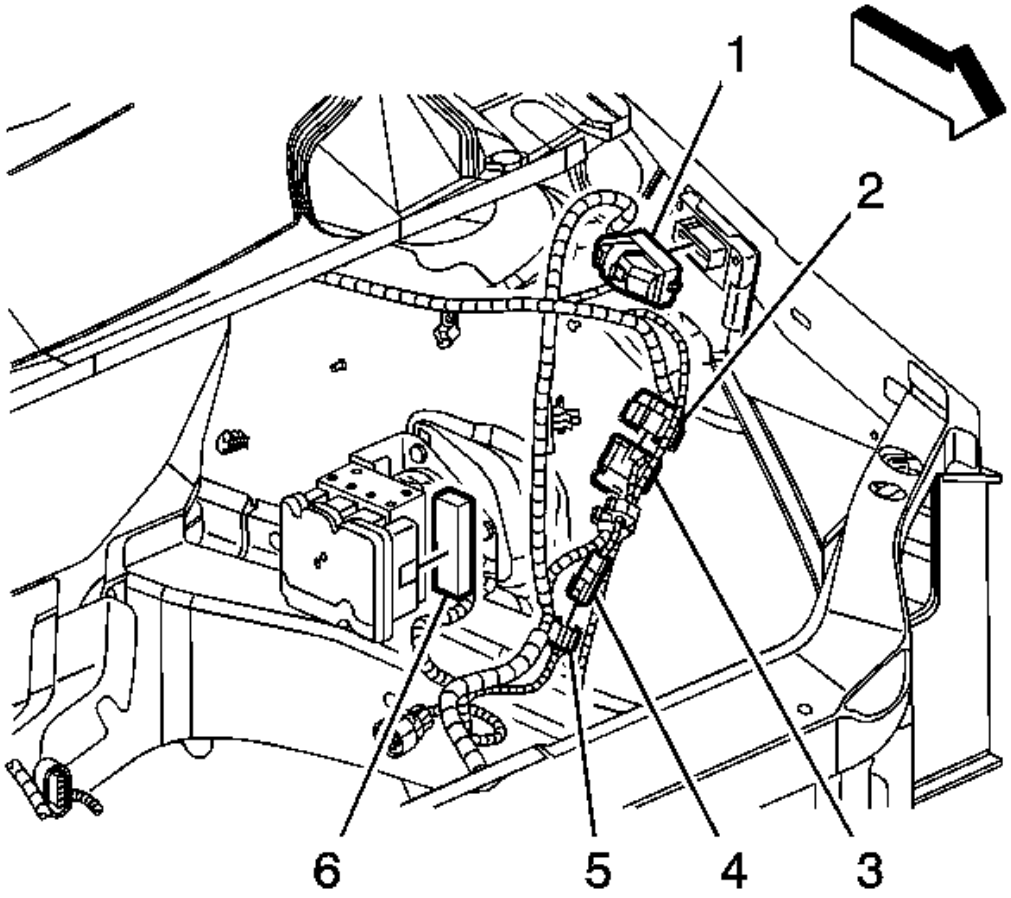

Fig. 368: View Of Engine Control Module (ECM) & Air Cleaner Cover
Courtesy of GENERAL MOTORS CORP.

113. Connect the engine harness electrical connector (6) to the ABS module.
114. Connect the engine harness electrical connector (5) to the I/P harness electrical connector (4).
115. Connect the engine harness electrical connector (3) to the I/P harness electrical connector (2).
116. Connect the engine harness electrical connector (1) to the TCM.

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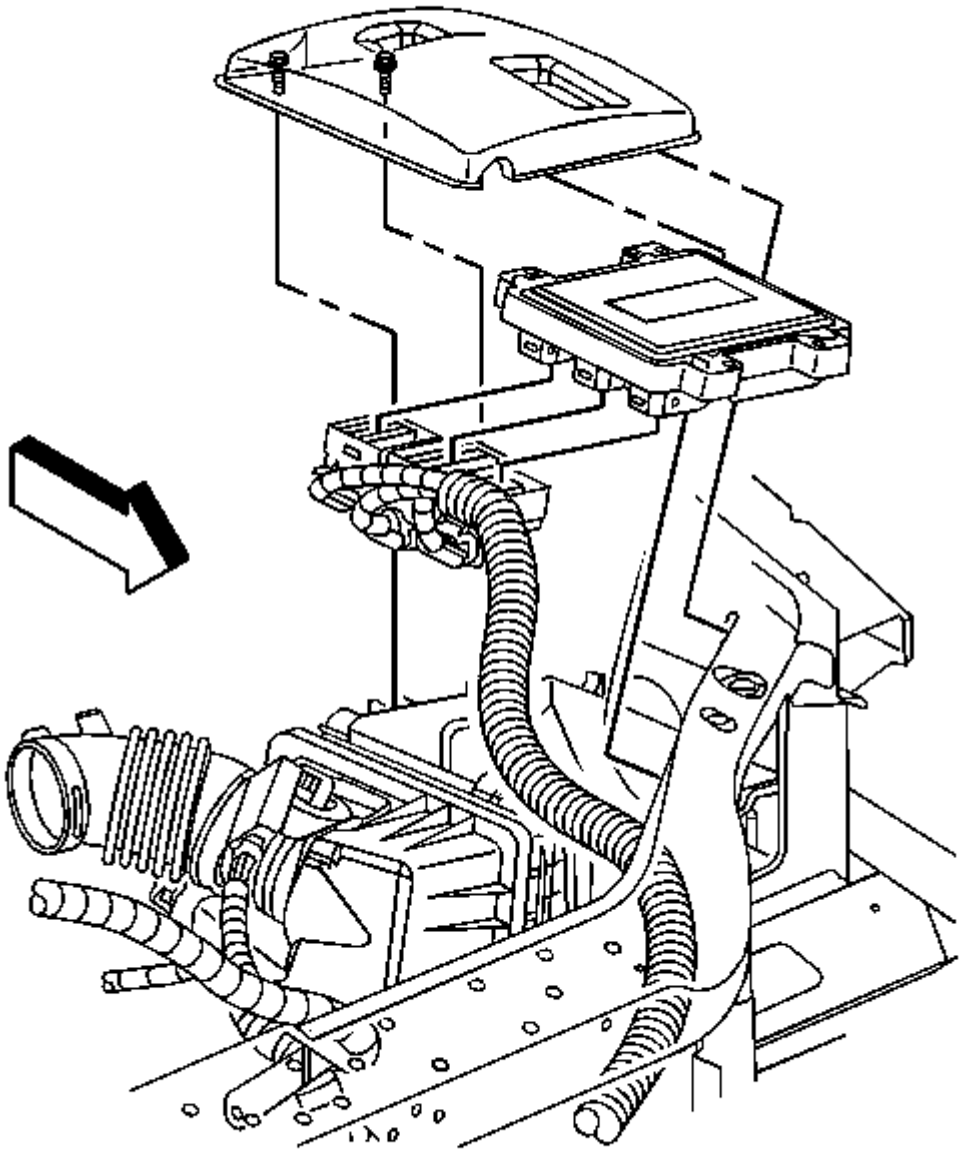

Fig. 369: View Of Air Cleaner Cover
Courtesy of GENERAL MOTORS CORP.

117. Install the ECM to the air cleaner cover.
118. Install the air cleaner cover.
119. Tighten the air cleaner cover bolts.

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

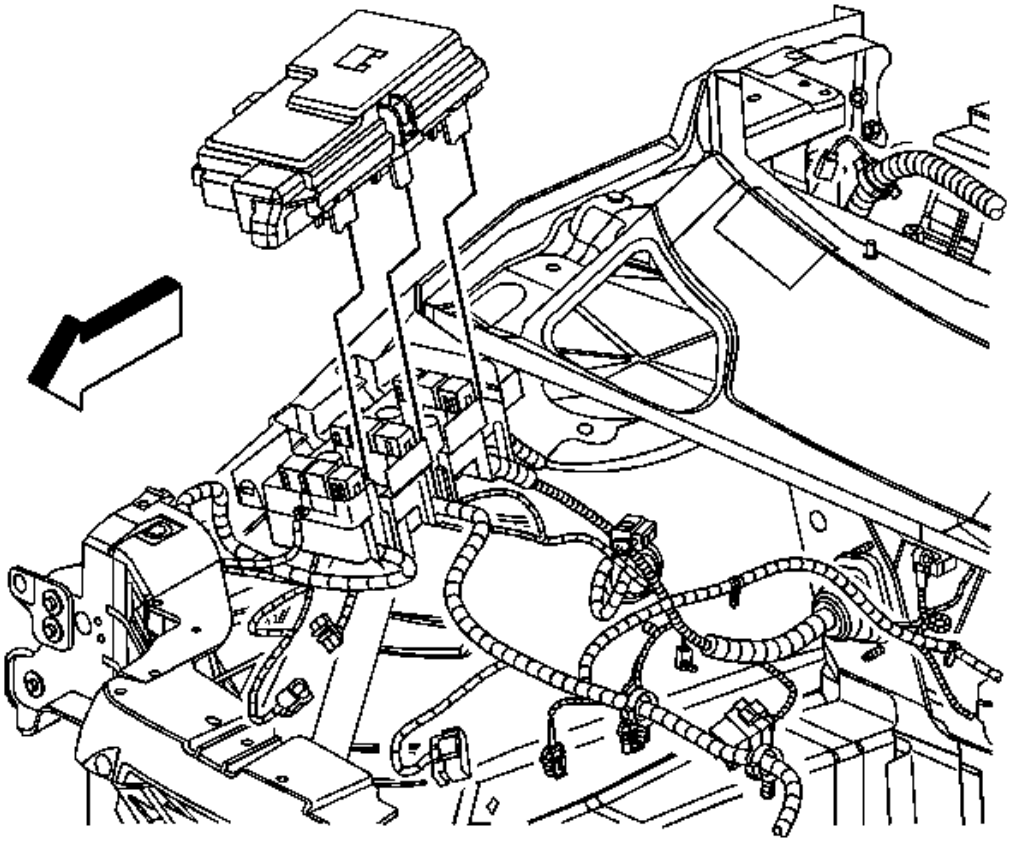

Fig. 370: View Of Junction Block Cover
Courtesy of GENERAL MOTORS CORP.

120. Install the junction block cover.
121. Install the left side diagonal brace. Refer to **Front End Sheet Metal Diagonal Brace Replacement (Pontiac)** or **Front End Sheet Metal Diagonal Brace Replacement (Chevrolet)** or **Front End Sheet Metal Diagonal Brace Replacement (Buick)** .
122. Install the coolant reservoir. Refer to **Coolant Recovery Reservoir Replacement** .

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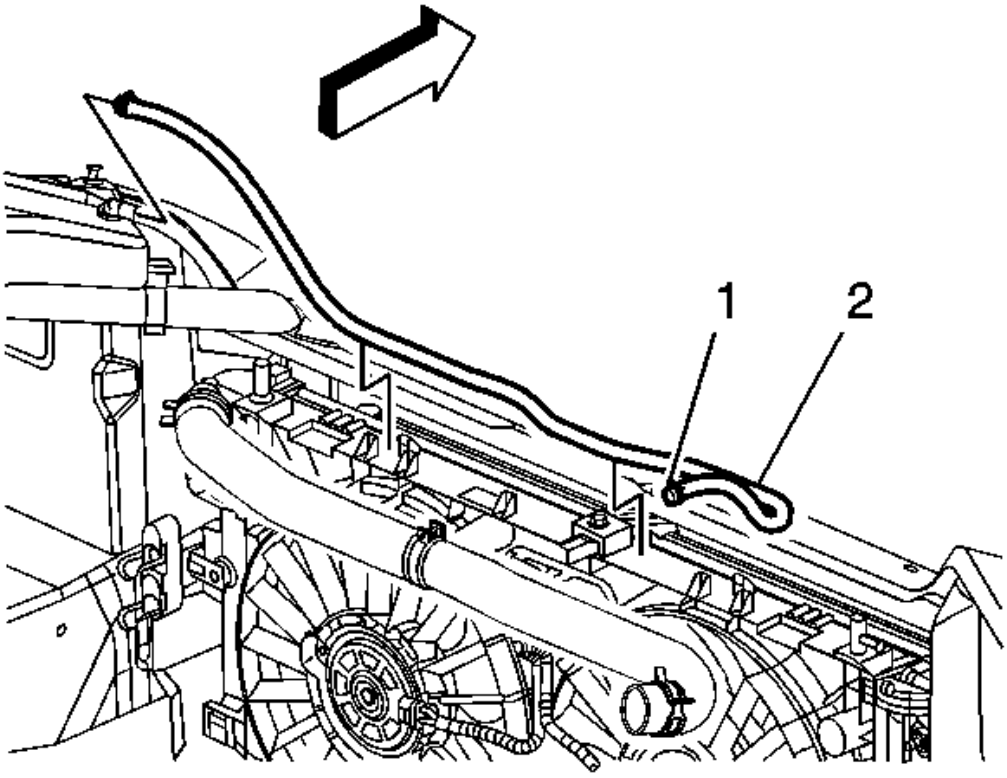

Fig. 371: View Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

123. Install the coolant recovery reservoir hose (2) to the crossover.
124. Position the coolant recovery reservoir hose clamp (1) at the coolant crossover.

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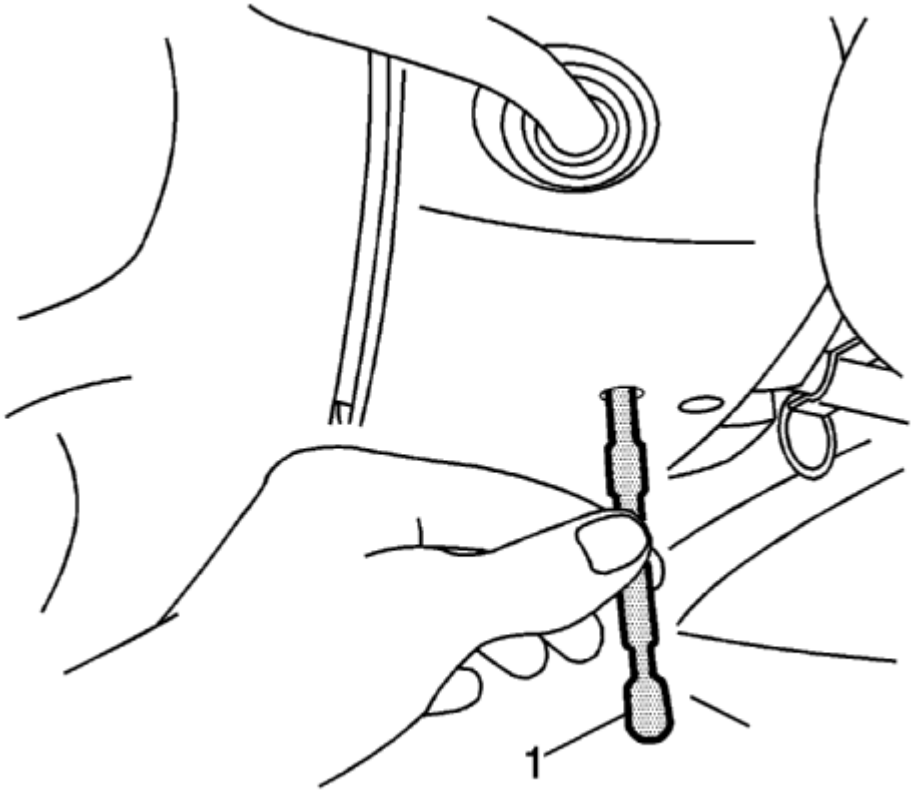

Fig. 372: Identifying J 42640
Courtesy of GENERAL MOTORS CORP.

125. Remove the **J 42640** from the underside of the steering column.
126. Install the lower radiator air baffle. Refer to **Radiator Air Baffle Assemblies and Deflectors** .
127. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
128. Connect the positive battery cable.
129. Connect the positive battery cable at the junction box.
130. Connect the auxiliary ground cable on the inner fender.
131. Connect the electrical connector to the sensor on the negative battery cable.
132. Fill the cooling system. Refer to **Draining and Filling Cooling System (Static Fill LZ9)** or **Draining and Filling Cooling System (Vac-N-Fill)** .
133. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
134. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

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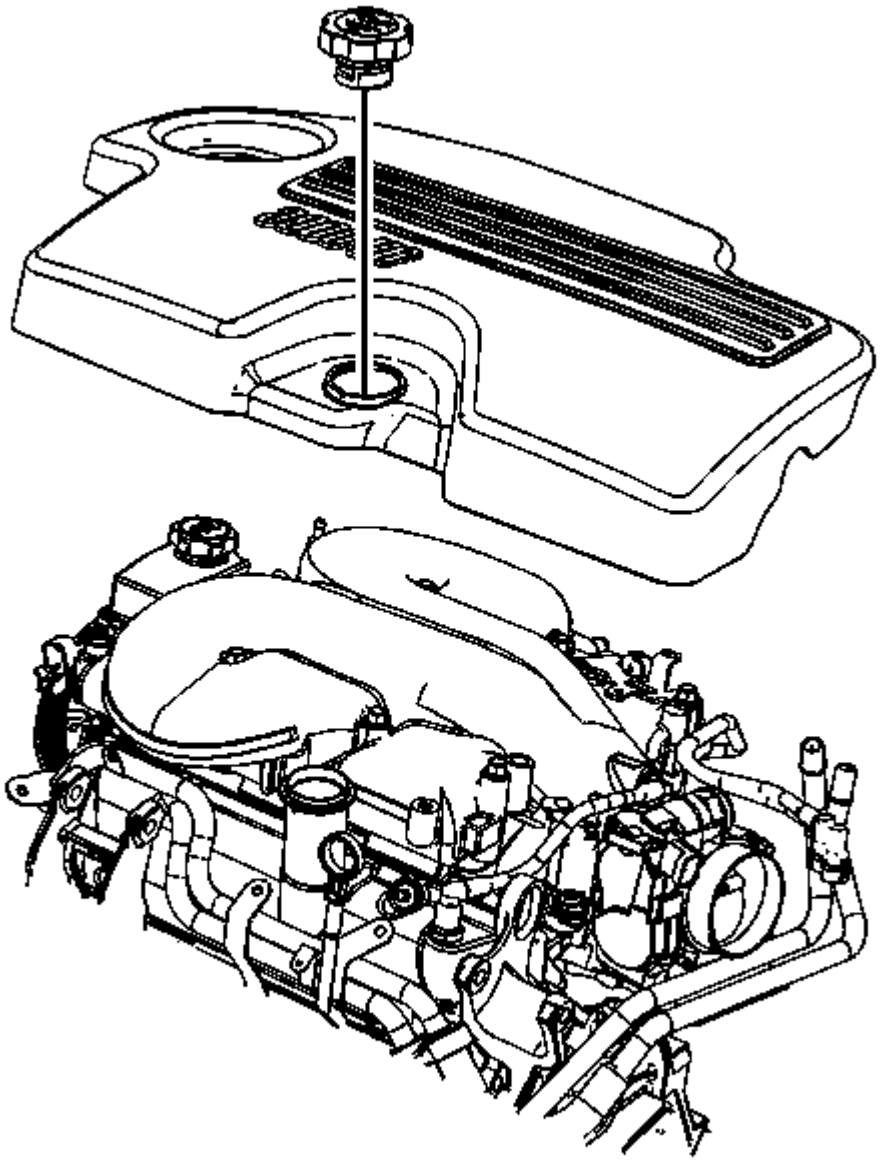

Fig. 373: Identifying Engine Manifold Cover
Courtesy of GENERAL MOTORS CORP.

135. Align the cover to the studs on the engine, push down on the cover above the stud in order to engage the cover to the studs.
136. Install the engine oil fill cap.
137. Start the engine listen for unusual noises.

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138. Inspect the engine for leaks.

Engine Oil and Oil Filter Replacement

Removal Procedure

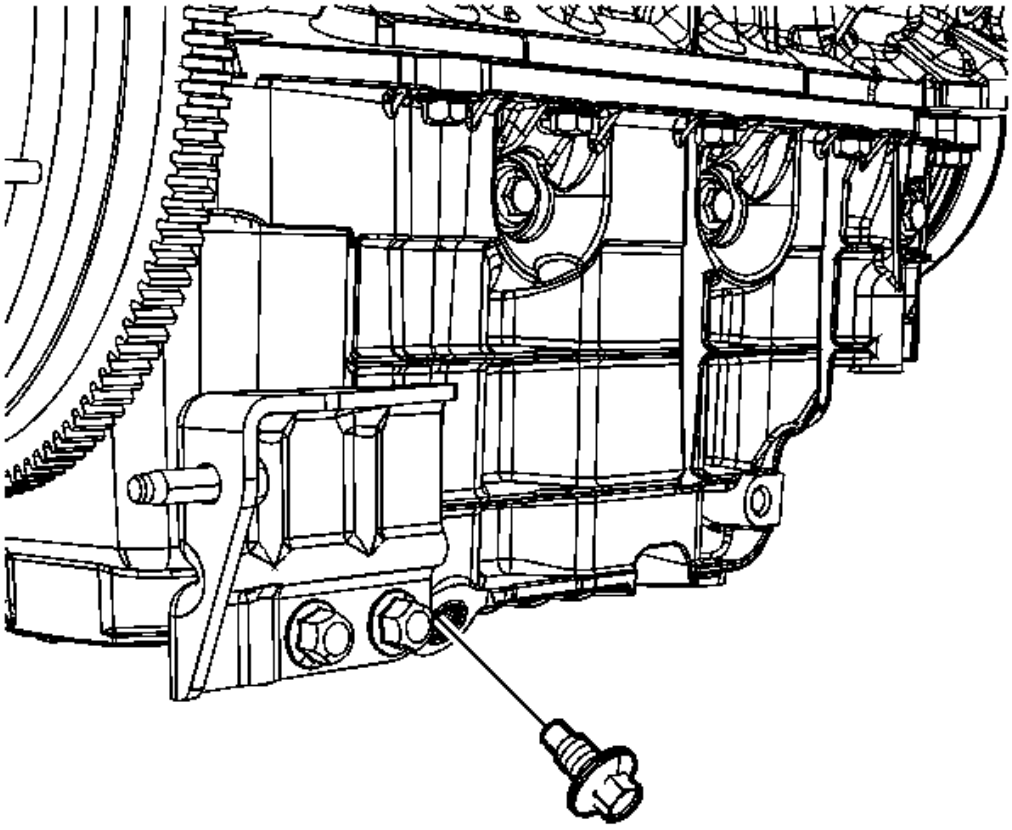

Fig. 374: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

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.
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.

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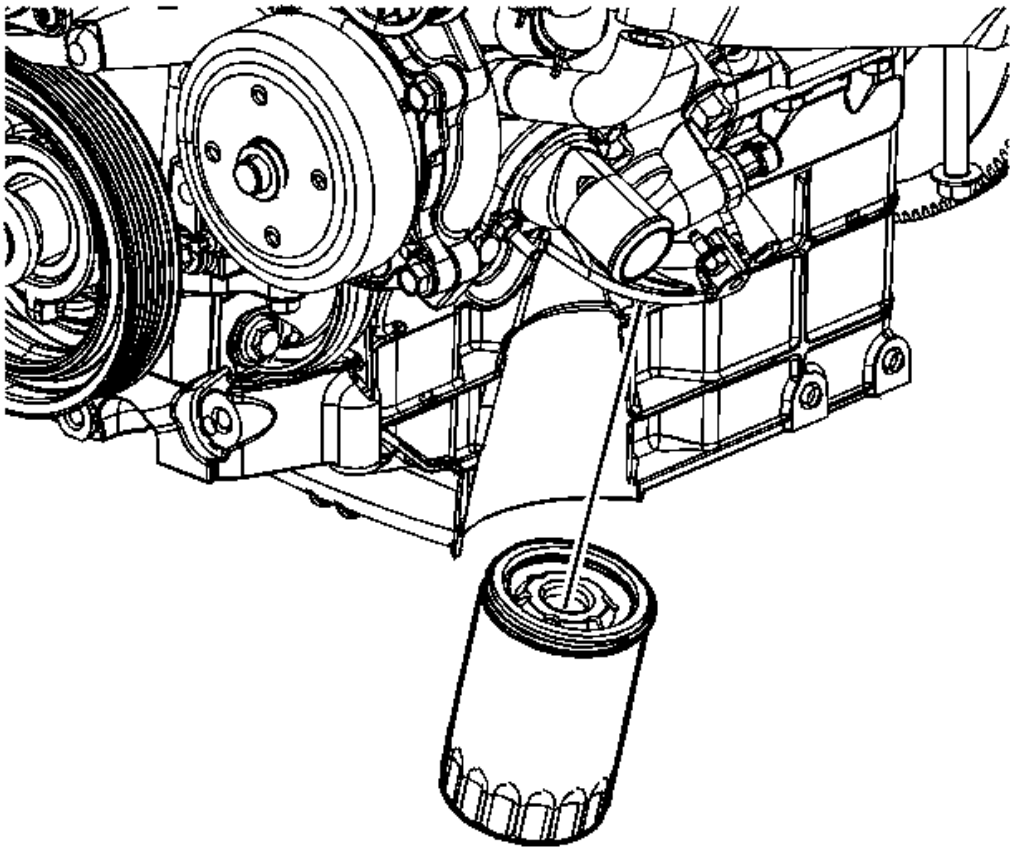

Fig. 375: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

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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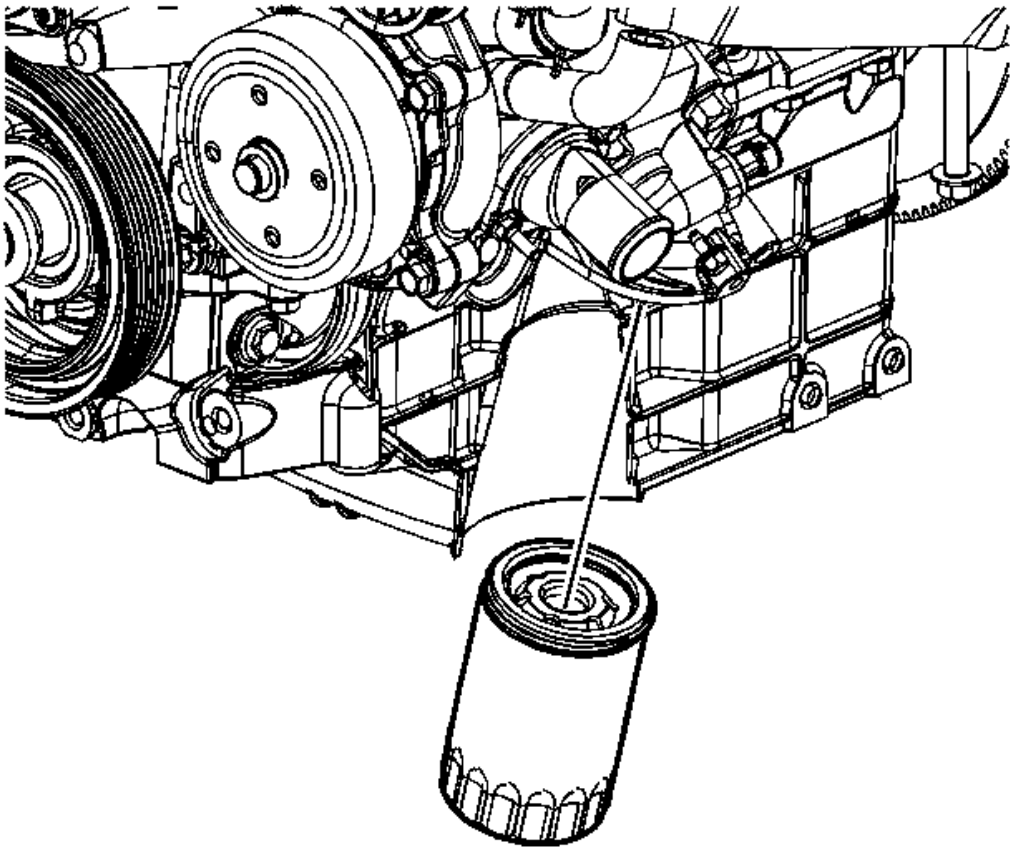

Fig. 376: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the NEW oil filter gasket.
2. Install the NEW oil filter.

Tighten: Tighten the new filter to 3/4 to 1 full turn, after the oil filter gasket contacts the adapter.

NOTE: Refer to Fastener Notice .

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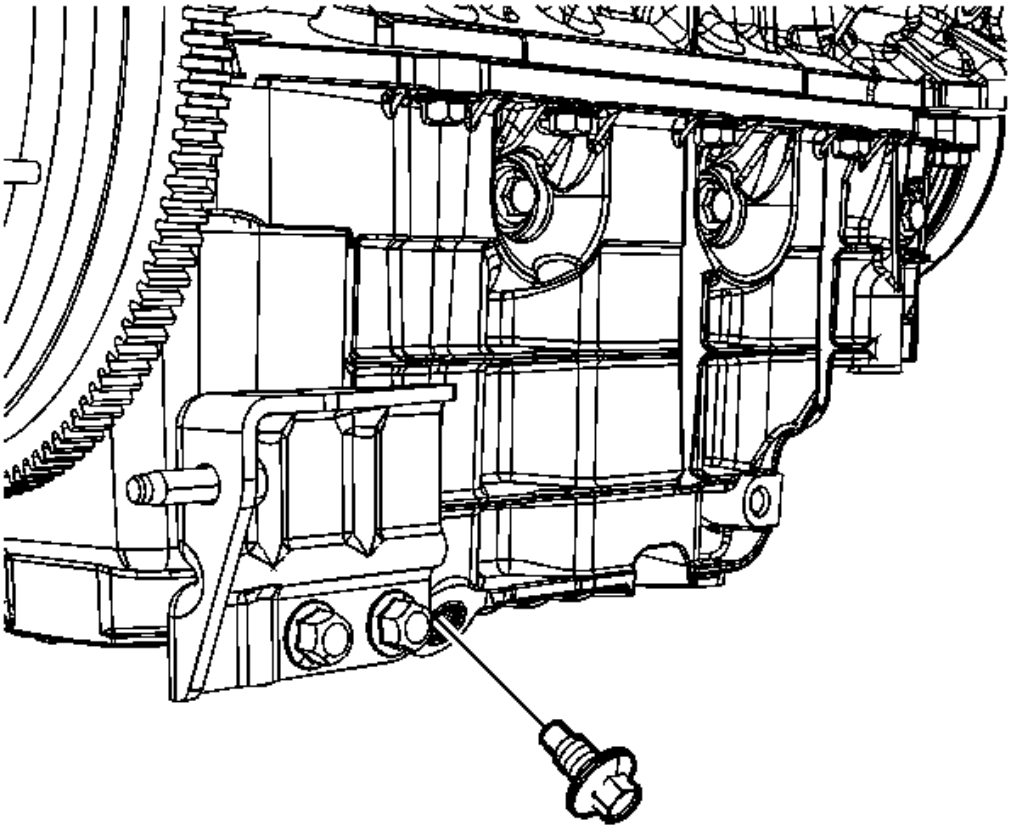

Fig. 377: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Tighten the oil pan drain plug.

   Tighten: Tighten the 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.

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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.
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.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

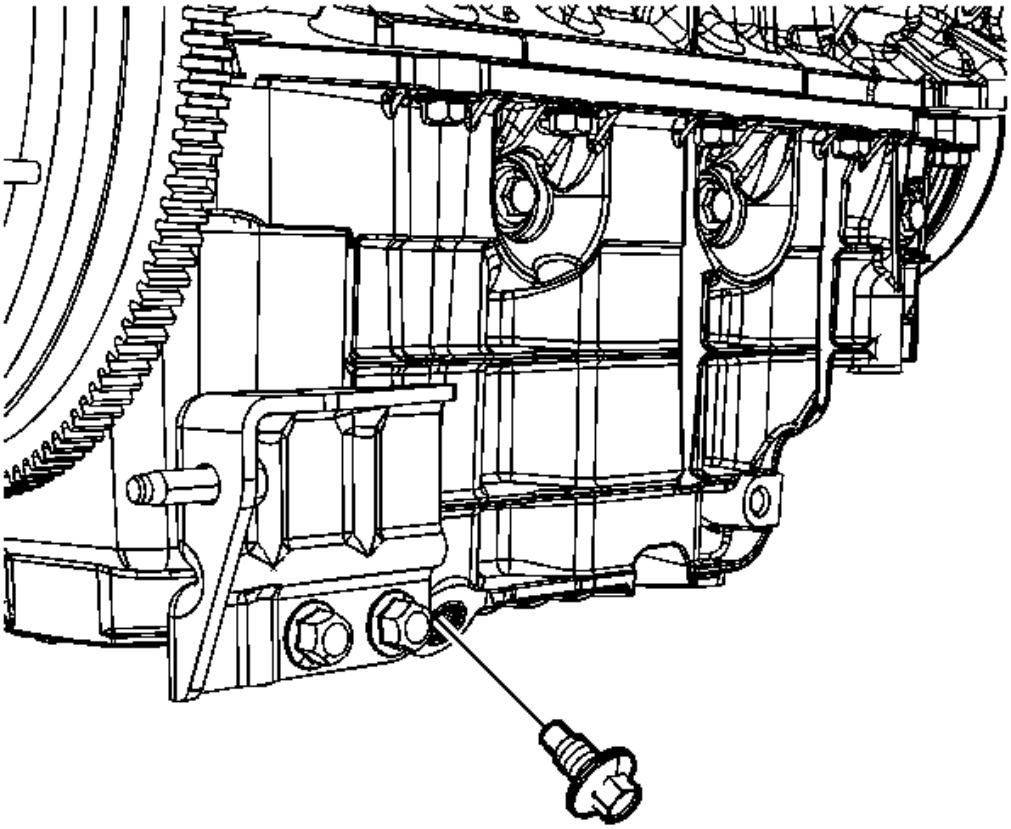

Fig. 378: View Of Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug.

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2. Drain the engine oil.

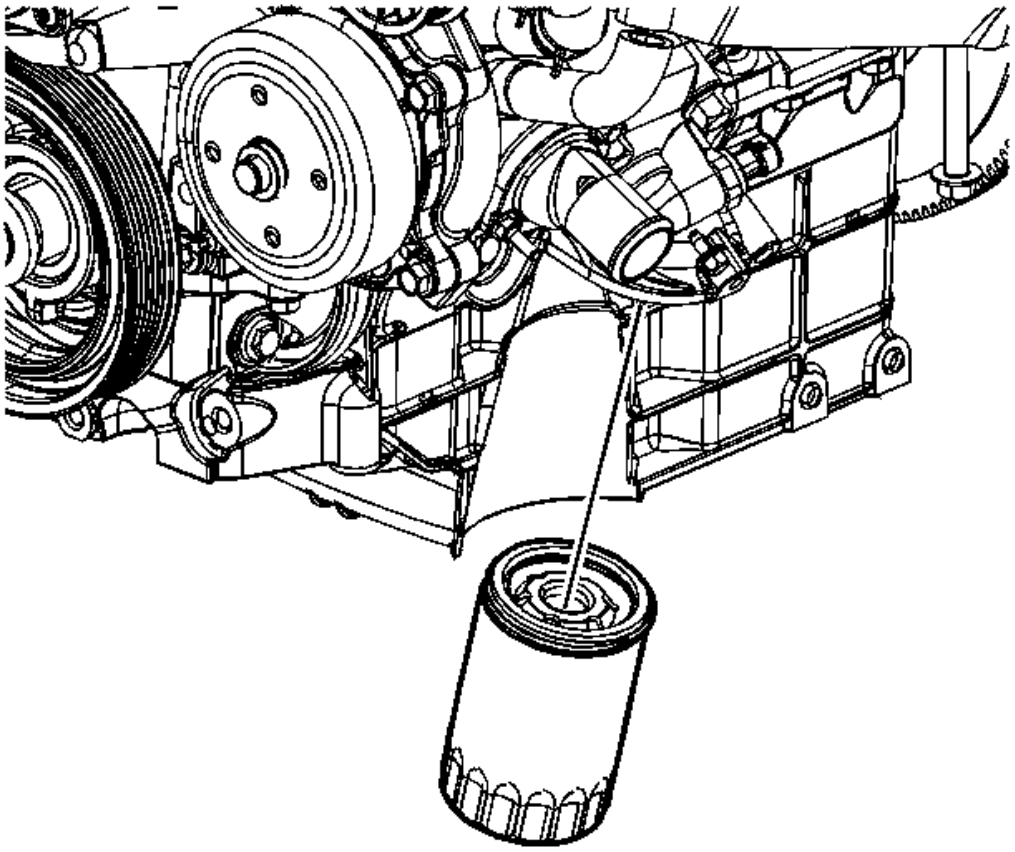

Fig. 379: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

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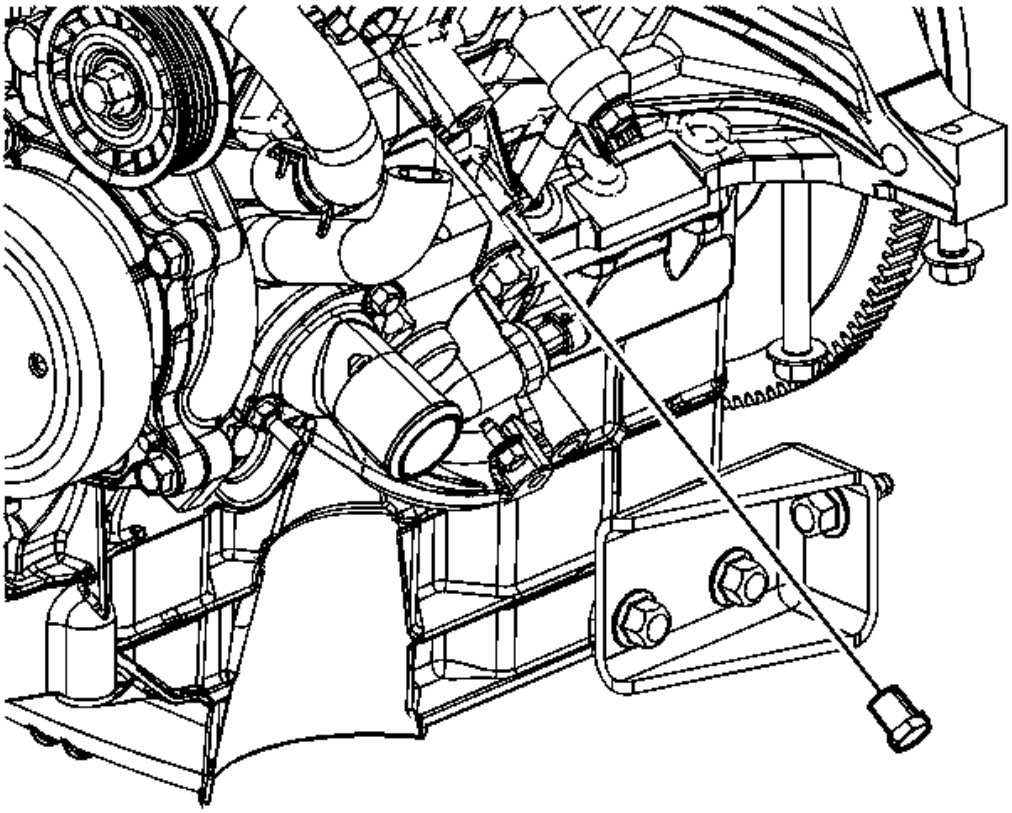

Fig. 380: Identifying Left Side Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

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

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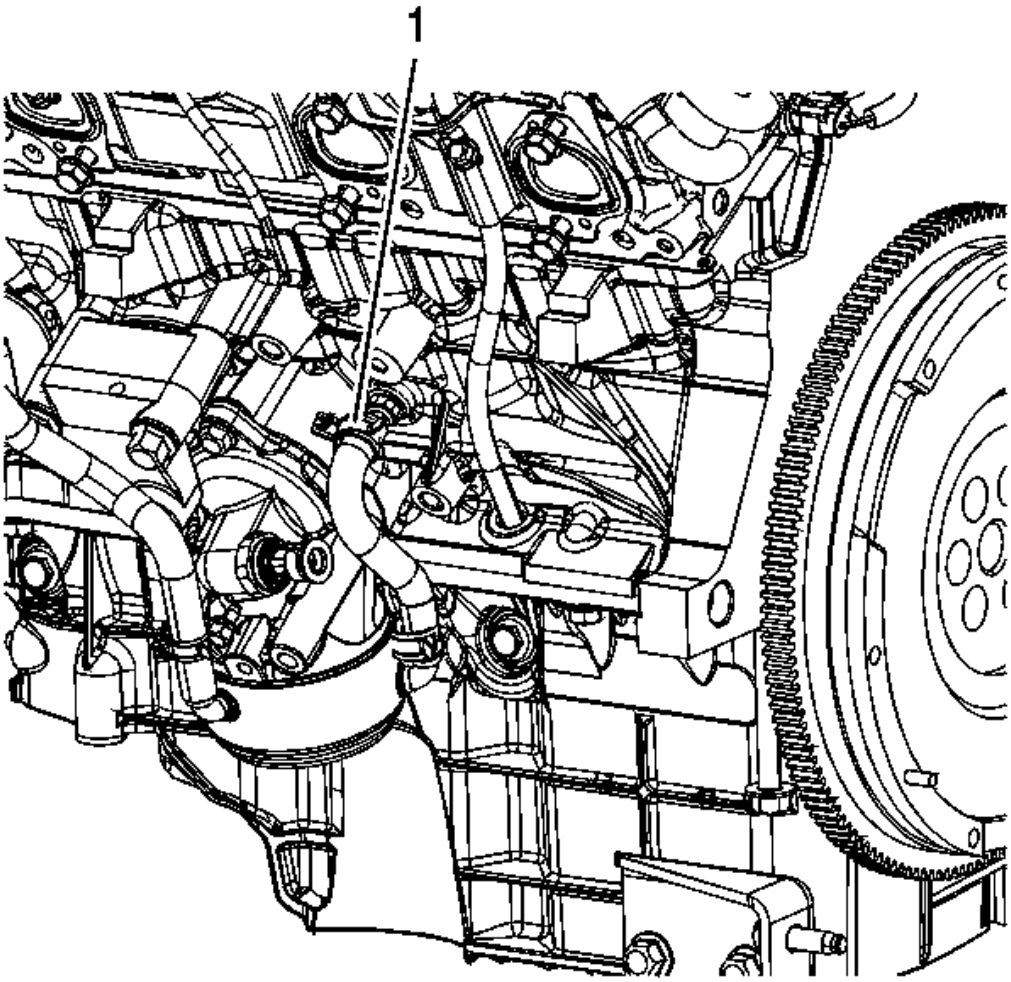

Fig. 381: Identifying Oil Cooler Inlet Hose
Courtesy of GENERAL MOTORS CORP.

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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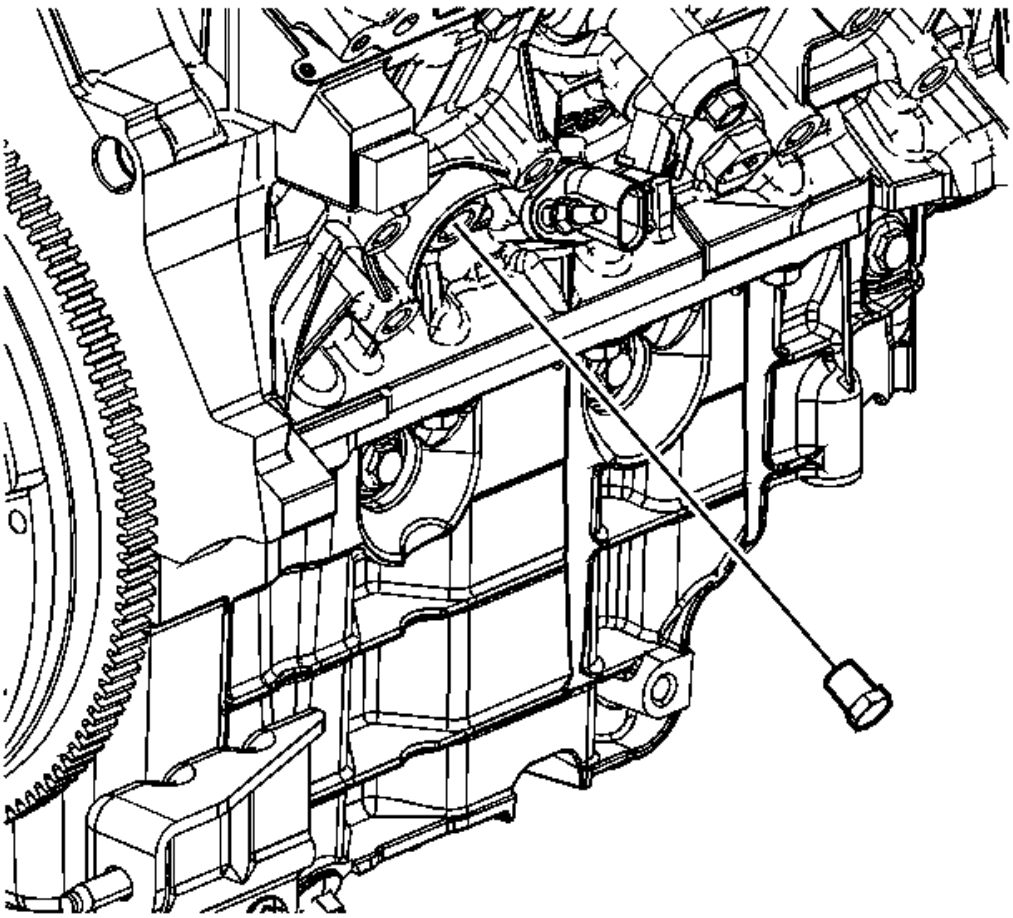

Fig. 382: Identifying Right Side Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

- **J 41816** Crankshaft Balancer Remover. See **Special Tools**.
- **EN 46359** Puller End Protector. See **Special Tools**.

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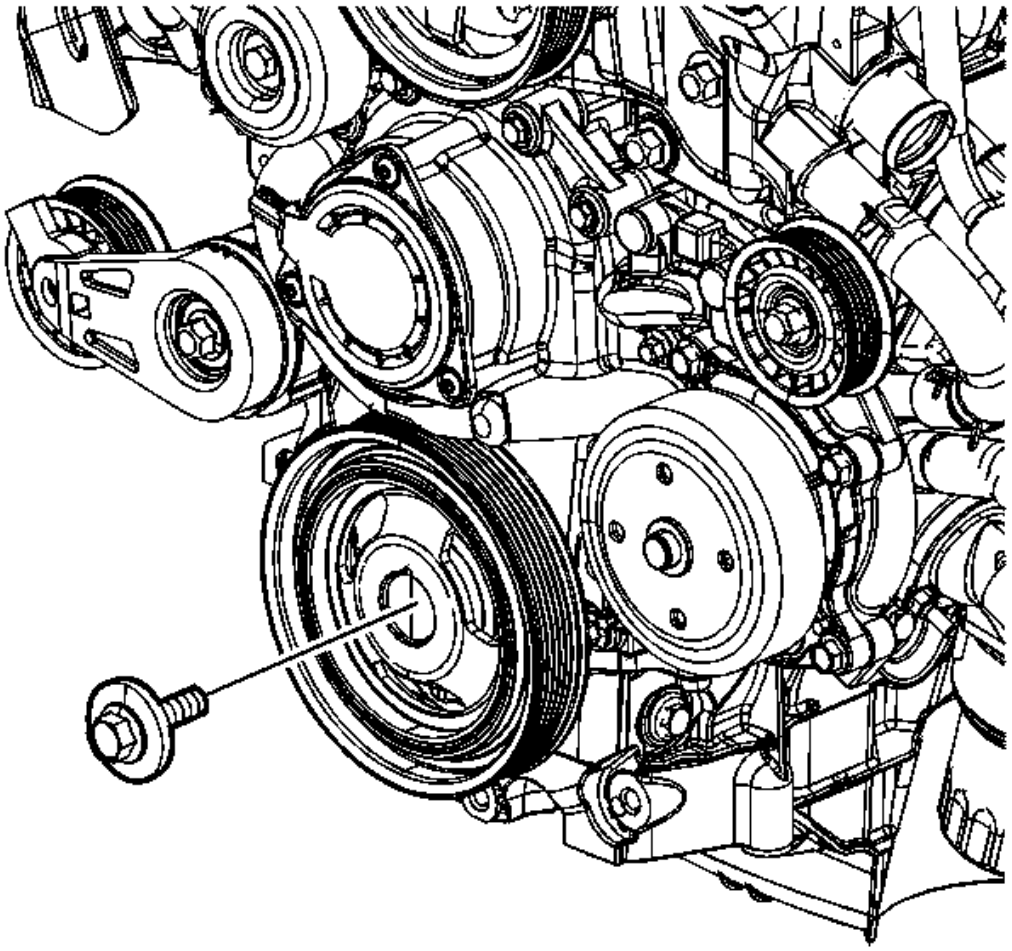

Fig. 383: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt and washer.

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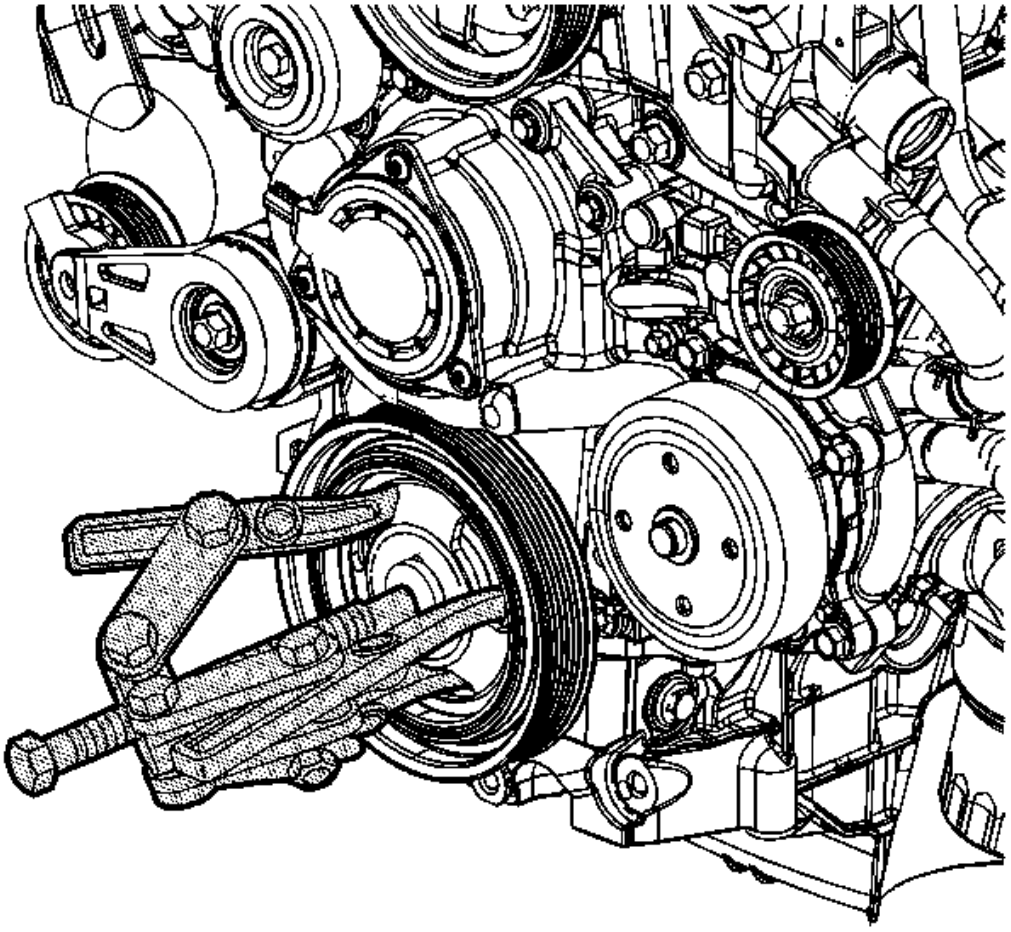

Fig. 384: Identifying Crankshaft Balancer Removing Tool J 41816
Courtesy of GENERAL MOTORS CORP.

NOTE: 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** along with **EN 46359** . See **Special Tools**.

Engine Flywheel Removal (Automatic Transmission)

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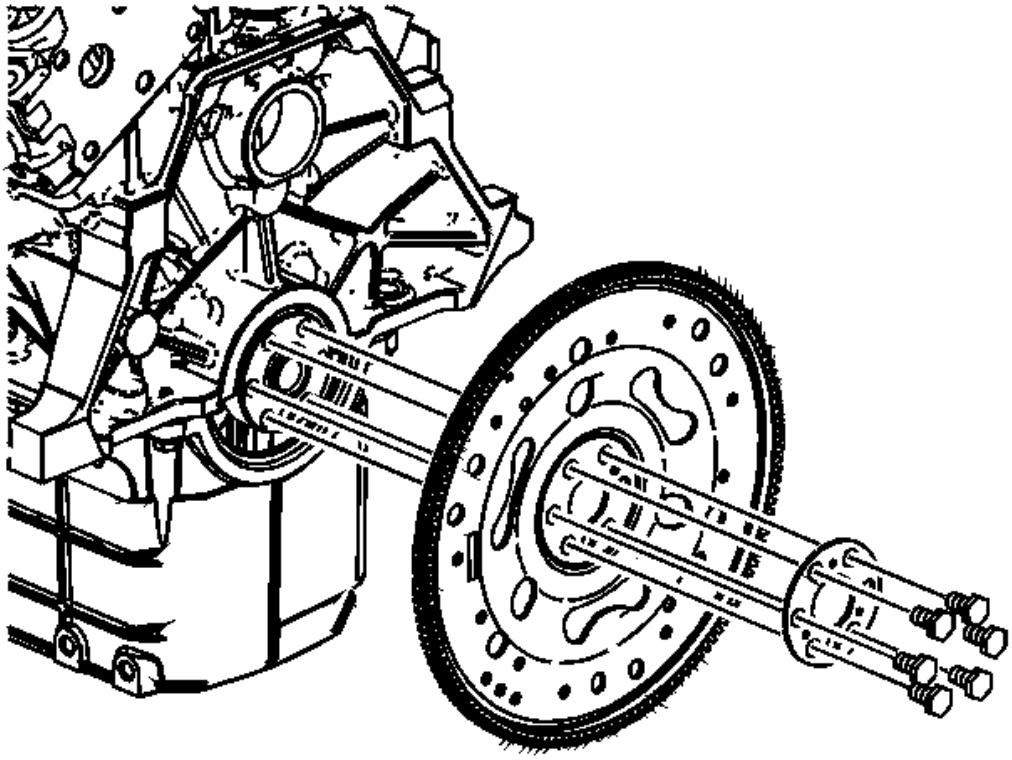

Fig. 385: Identifying Flywheel & Bolts (A/T)
Courtesy of GENERAL MOTORS CORP.

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

Drive Belt Tensioner Removal

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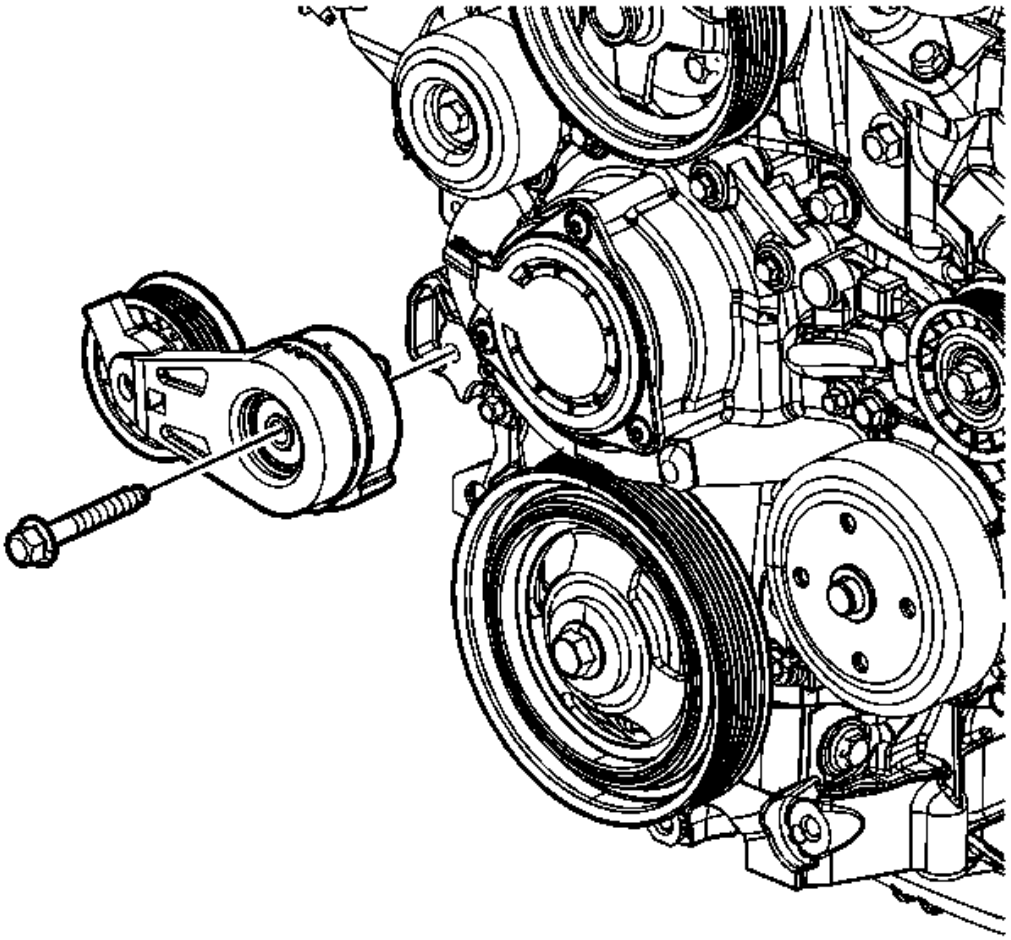

Fig. 386: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Engine Mount Strut and Engine Lift Bracket Removal

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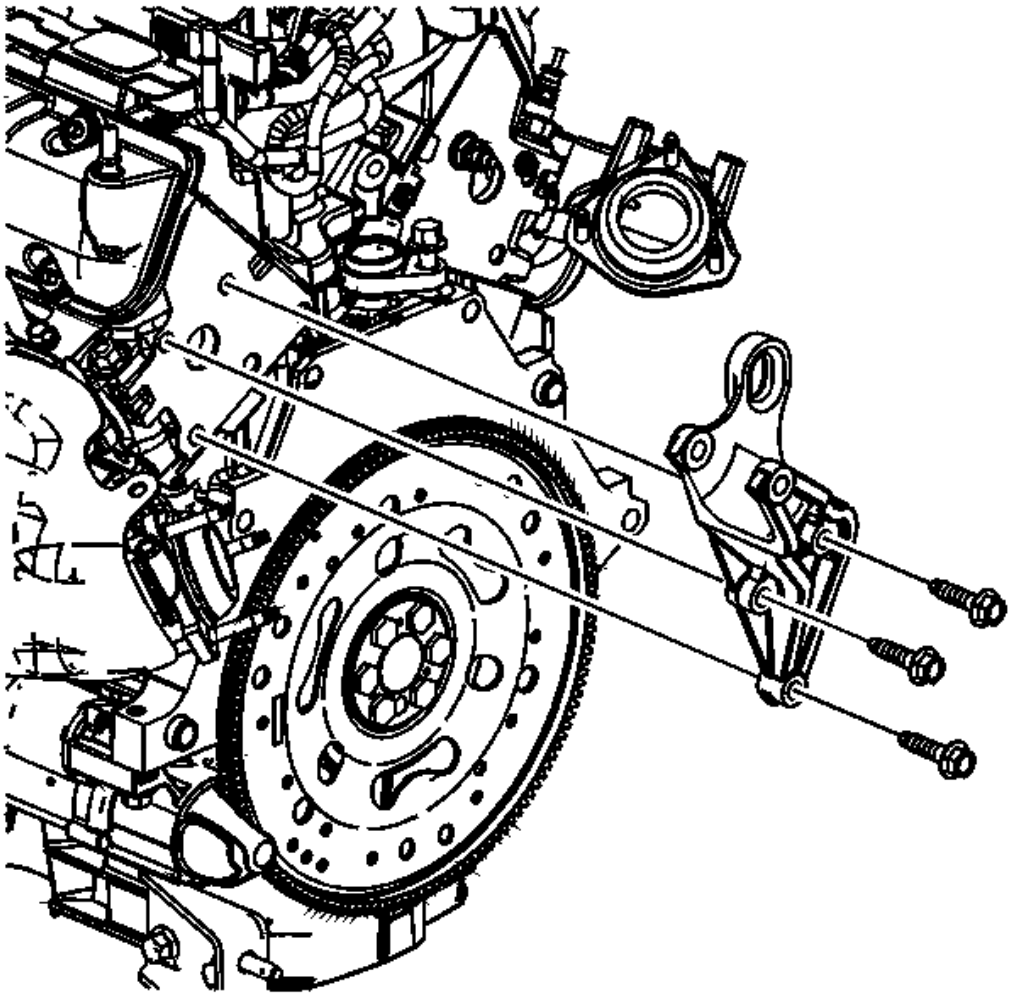

Fig. 387: Identifying Engine Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut and engine lift bracket bolts.
2. Remove the engine mount strut and engine lift bracket.

Engine Mount Support and Strut Bracket Removal

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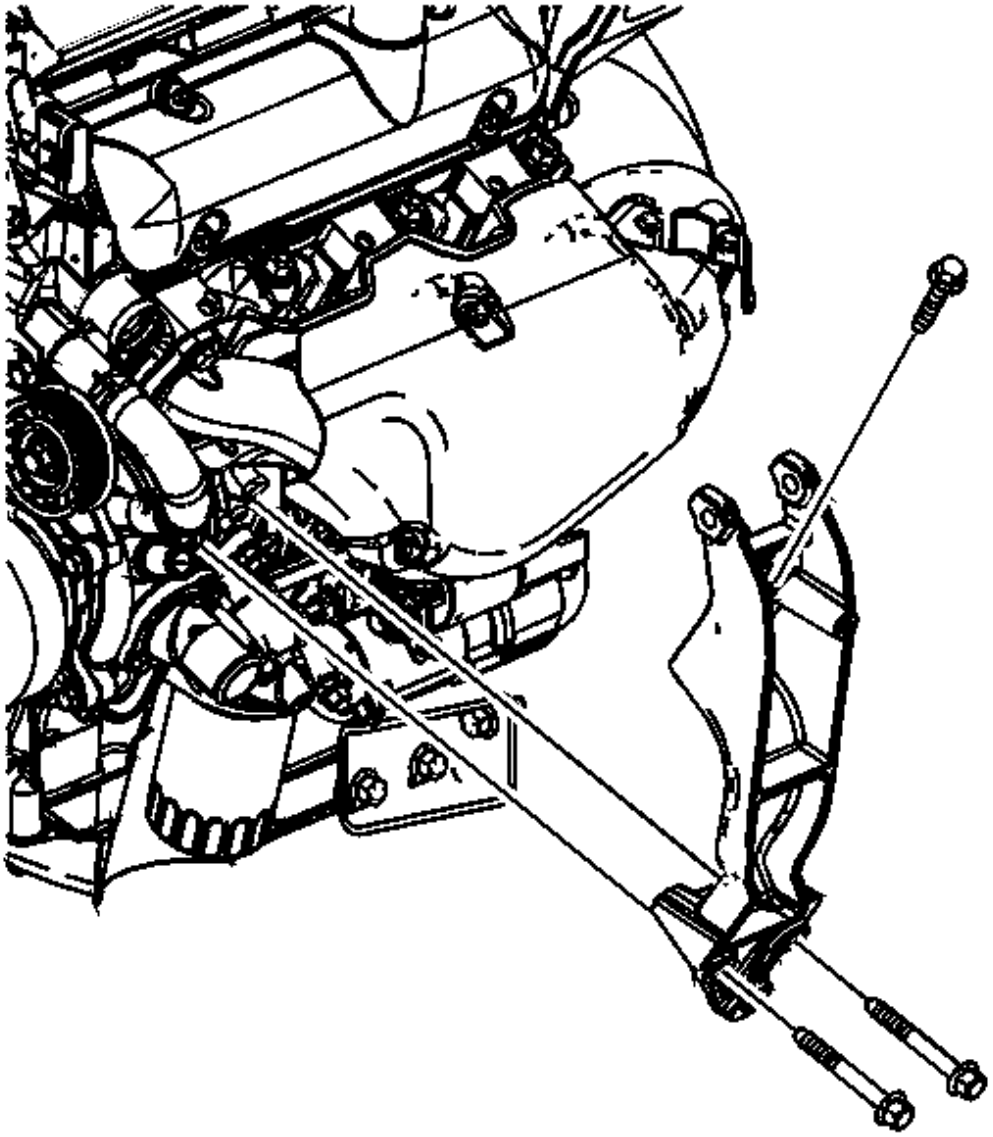

Fig. 388: View Of Engine Mount Support & Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount support and strut bracket bolts.
2. Remove the engine mount support and strut bracket.

Coolant Crossover Pipe Removal

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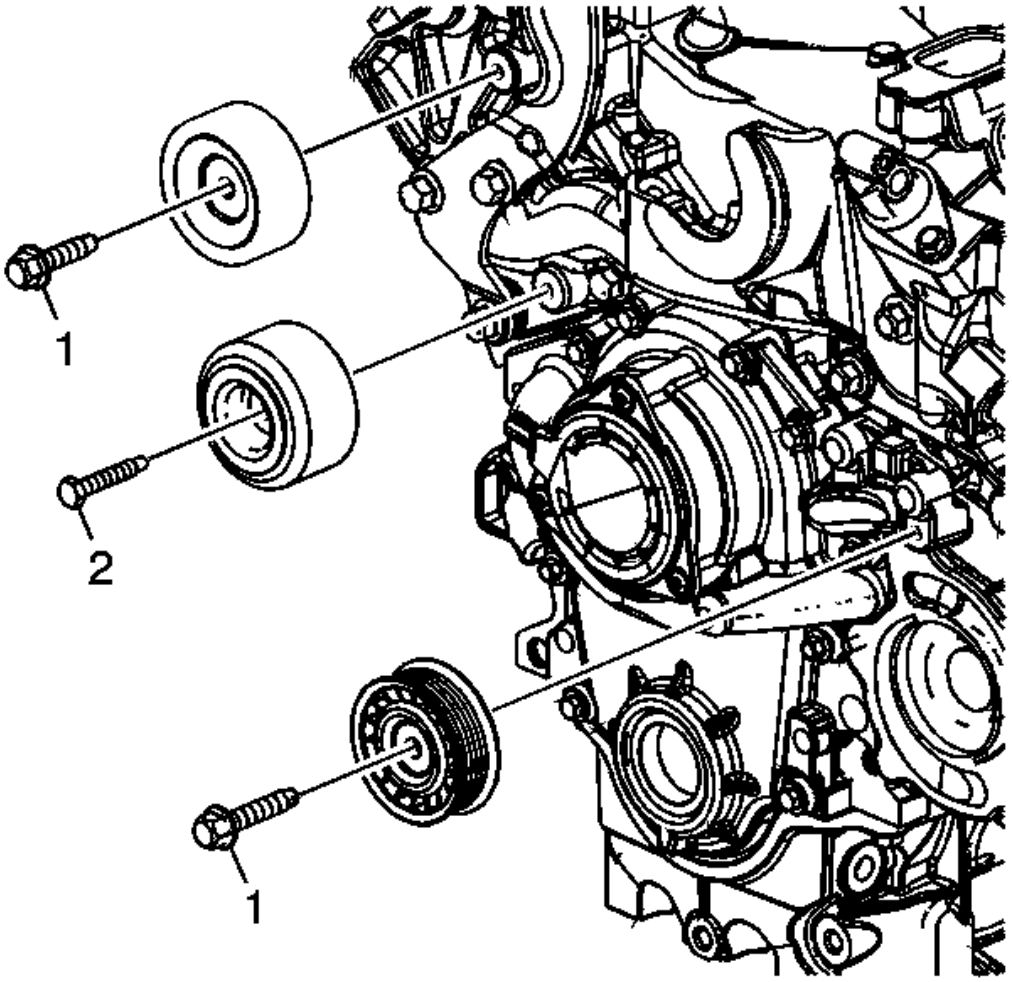

Fig. 389: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

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

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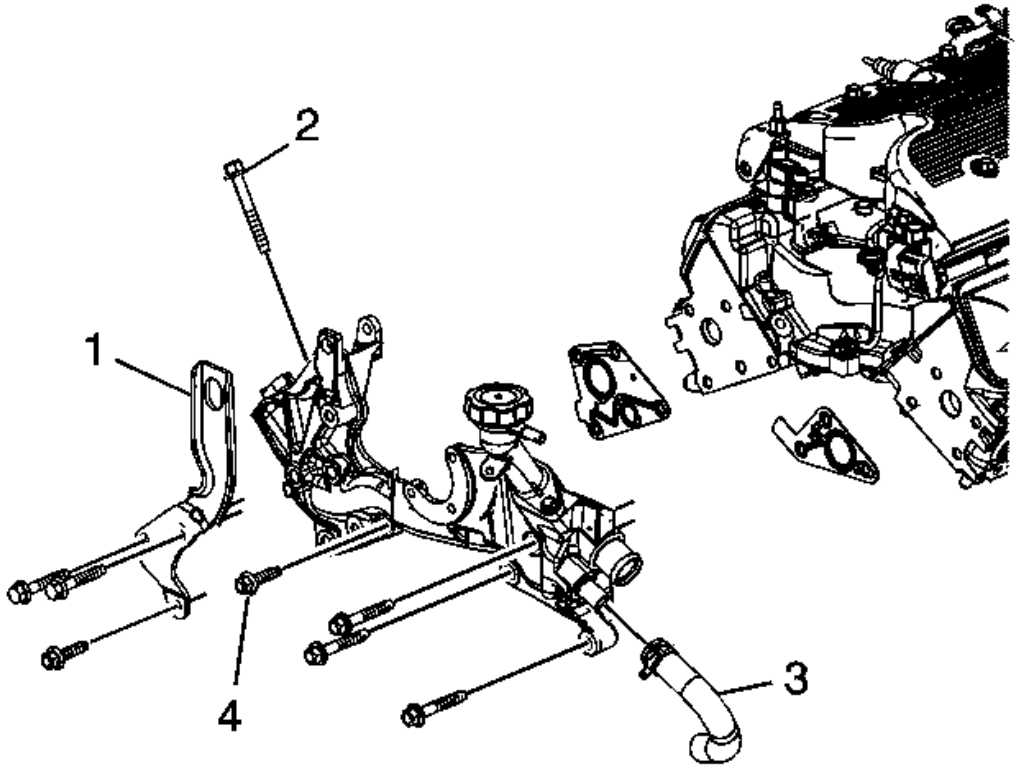

Fig. 390: View Of Coolant Crossover Pipe Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Loosen the thermal bypass hose clamp and remove the hose (3) from the coolant crossover pipe.
3. Remove the coolant crossover pipe bolts (2, 4), engine lift bracket (1), and the coolant crossover pipe assembly.
4. Remove the coolant crossover pipe gaskets.

Oil Level Indicator and Tube Removal

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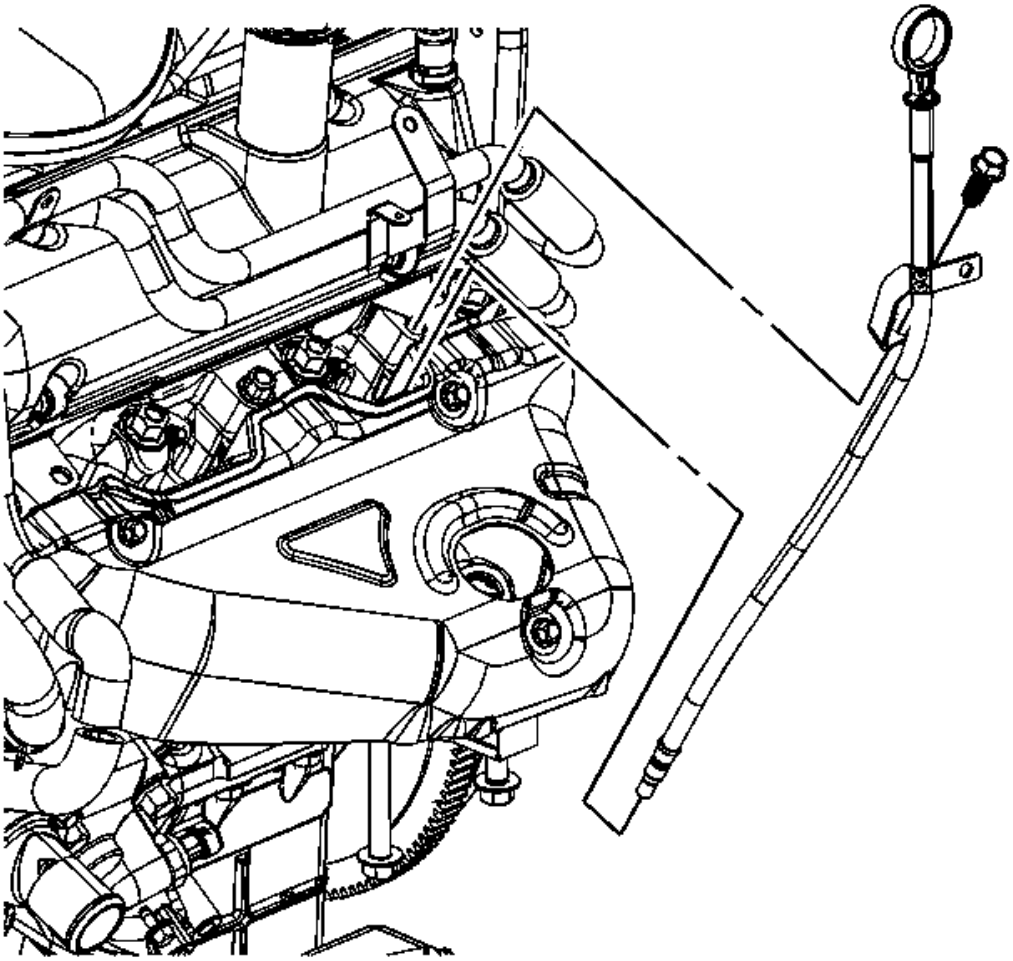

Fig. 391: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

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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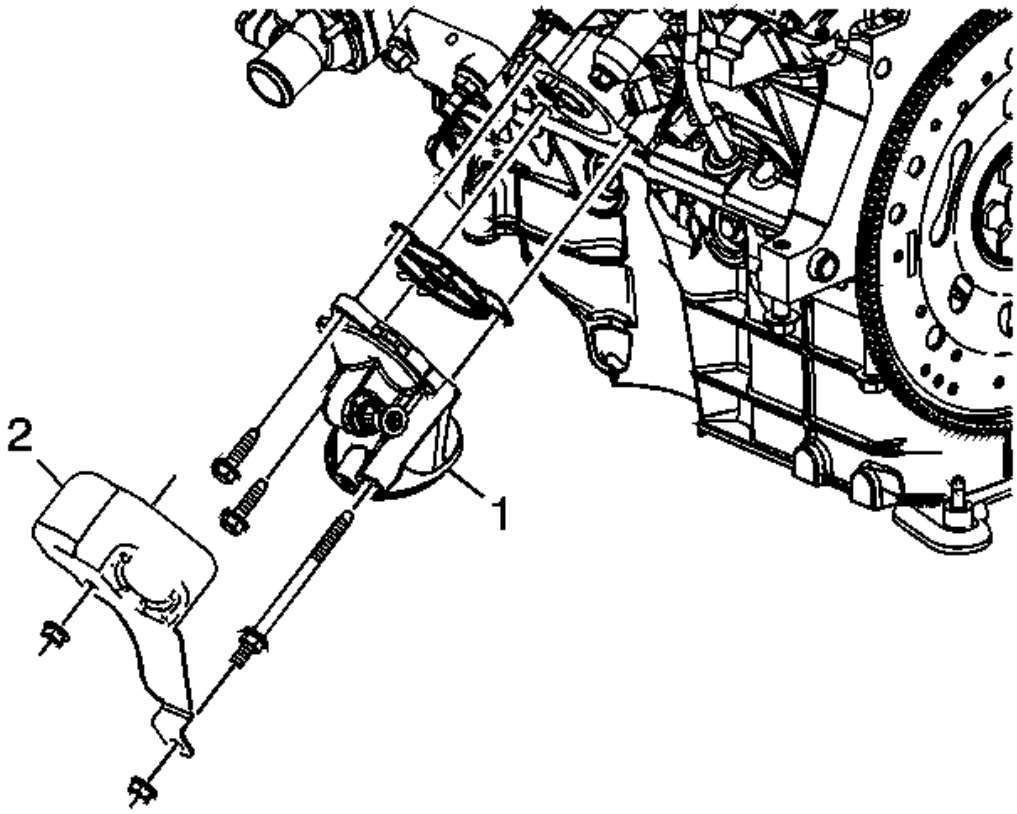

Fig. 392: Identifying Oil Filter Adapter & Heat Shield
Courtesy of GENERAL MOTORS CORP.

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.

Exhaust Crossover Pipe Removal

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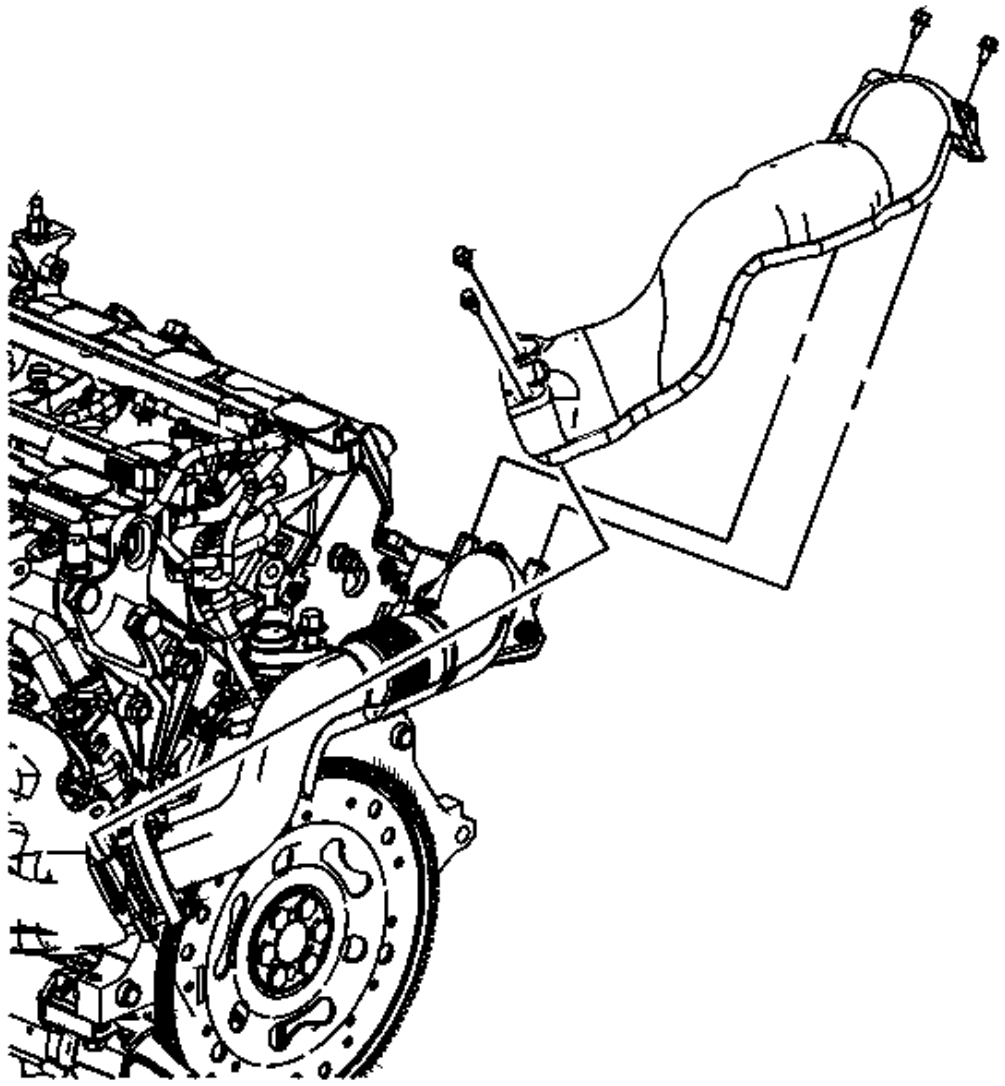

Fig. 393: Identifying Exhaust Crossover Pipe Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust crossover heat shield pipe bolts.
2. Remove the exhaust crossover heat shield.

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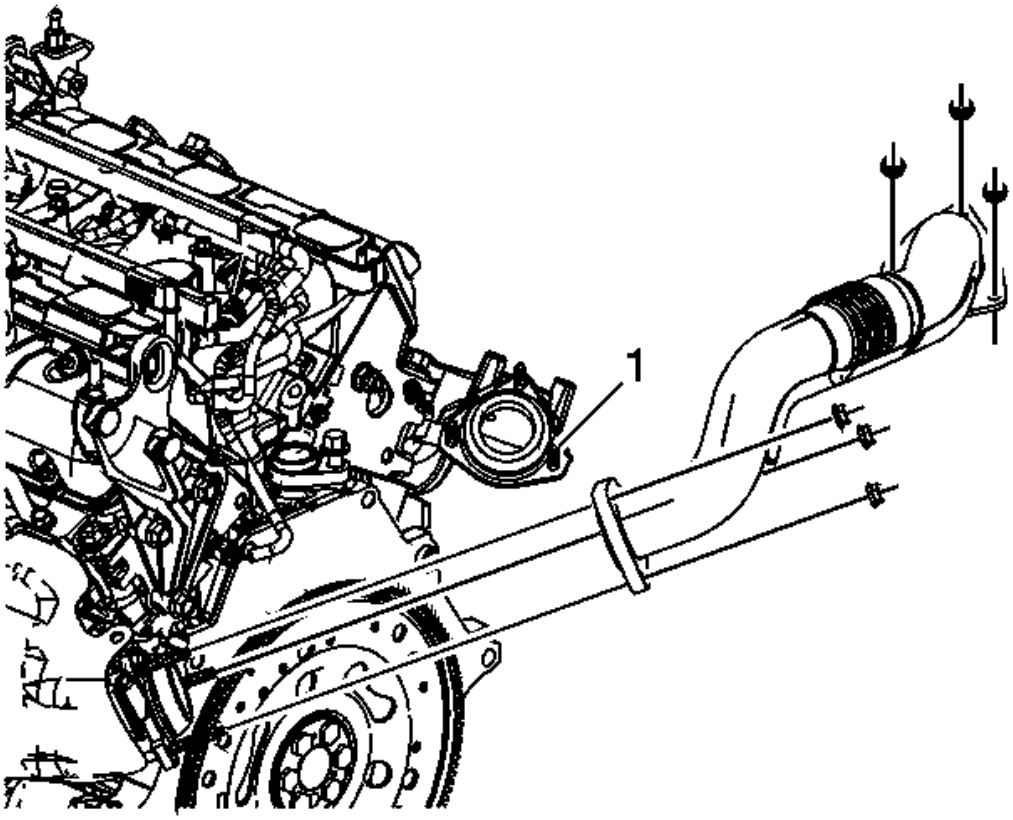

Fig. 394: Identifying Exhaust Crossover Pipe & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the exhaust crossover pipe nuts.
4. Remove the exhaust crossover pipe studs (1) if necessary.
5. Remove the exhaust crossover pipe.

Exhaust Manifold Removal - Left Side

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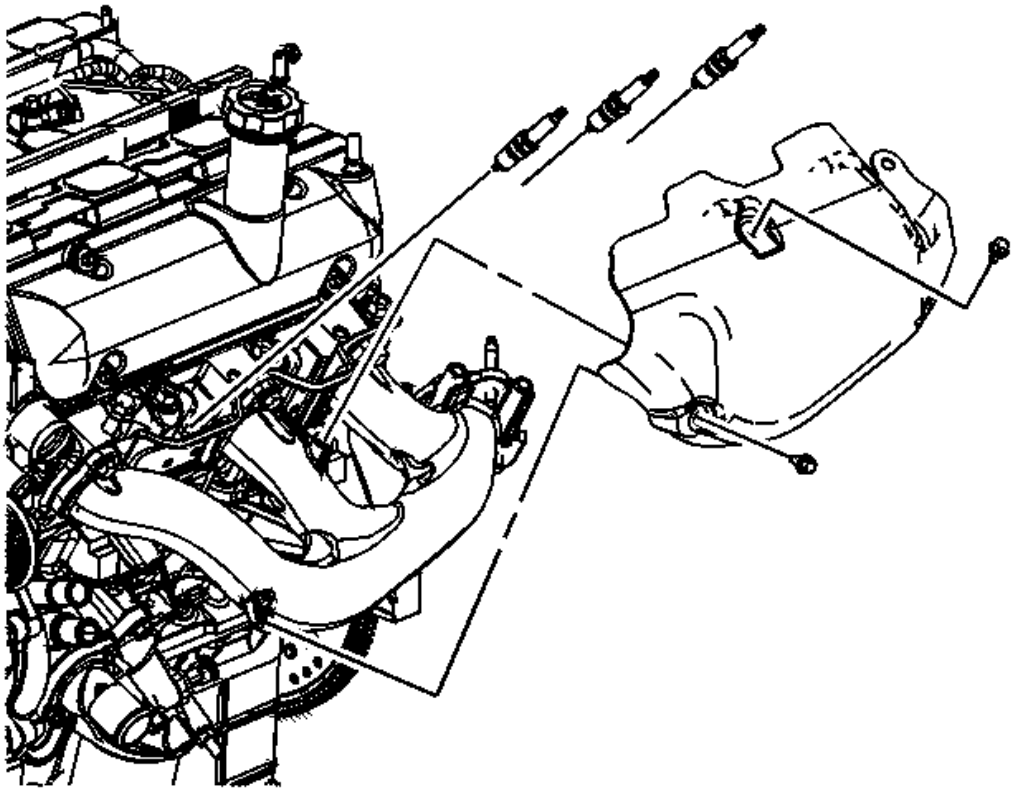

Fig. 395: View Of Spark Plugs & Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires and spark plugs.
2. Remove the exhaust manifold heat shield bolts.
3. Remove the exhaust manifold heat shield.

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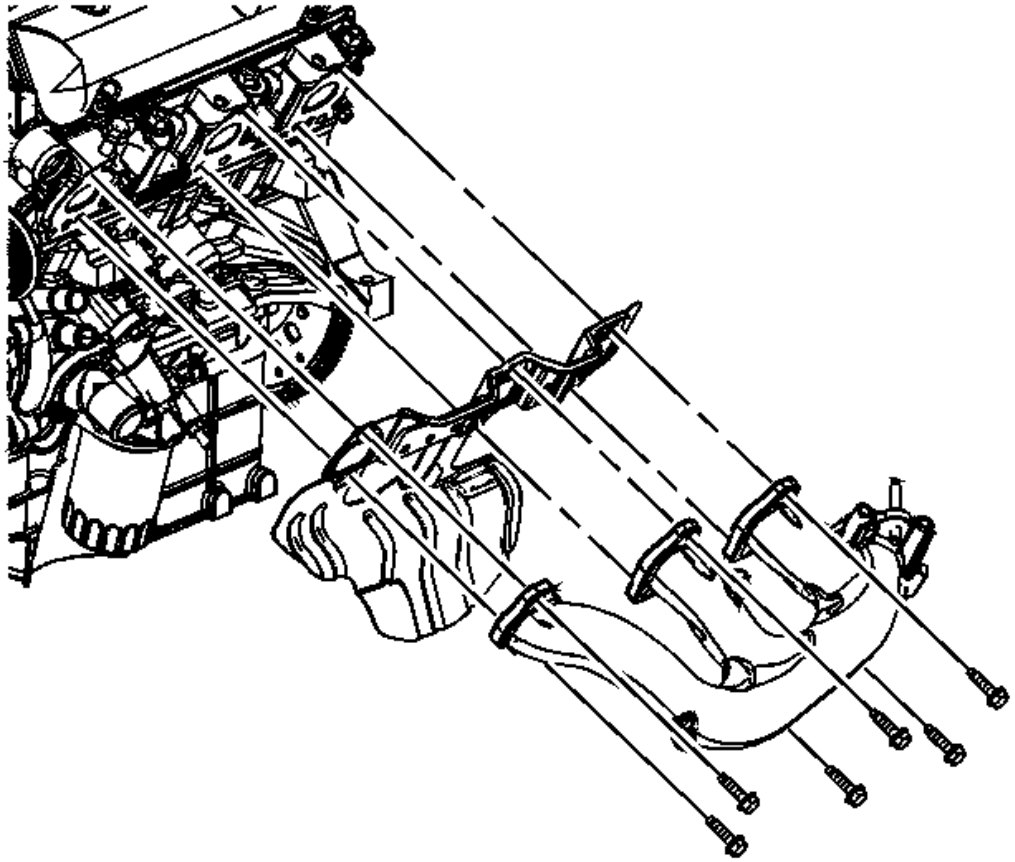

Fig. 396: View Of Left Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold bolts.
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket.

Exhaust Manifold Removal - Right Side

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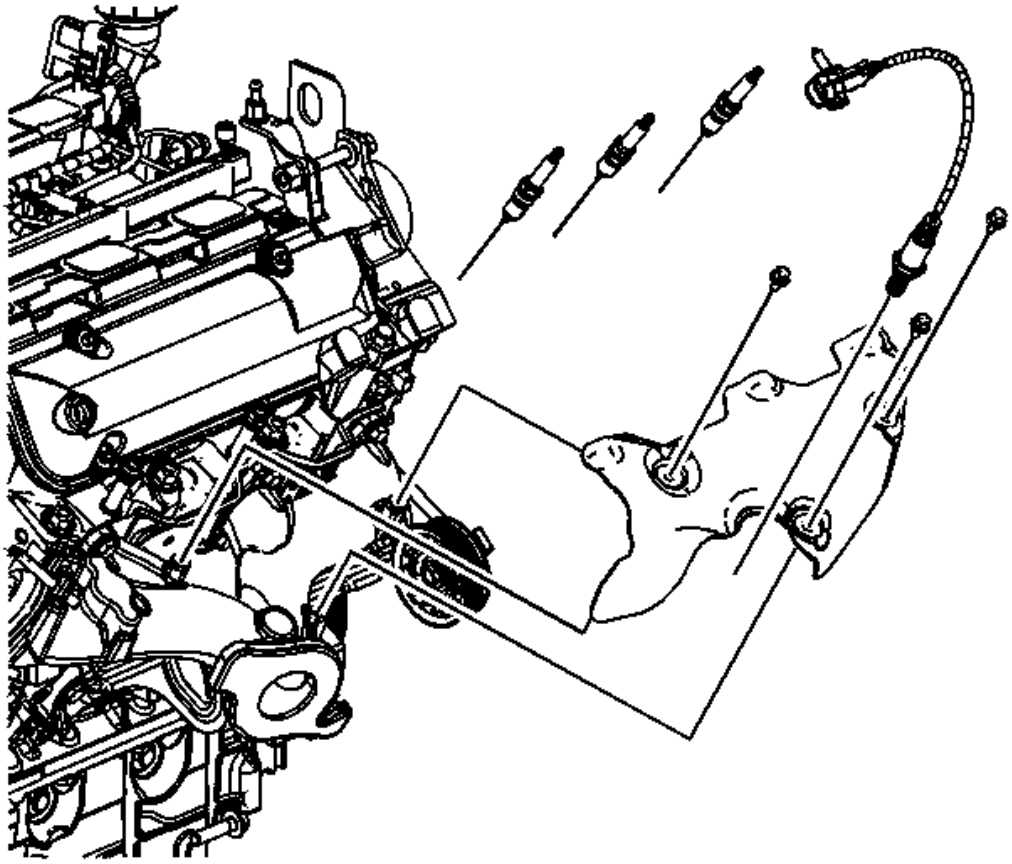

Fig. 397: Identifying Right Side Spark Plugs, HO2S & Heat Shield
Courtesy of GENERAL MOTORS CORP.

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

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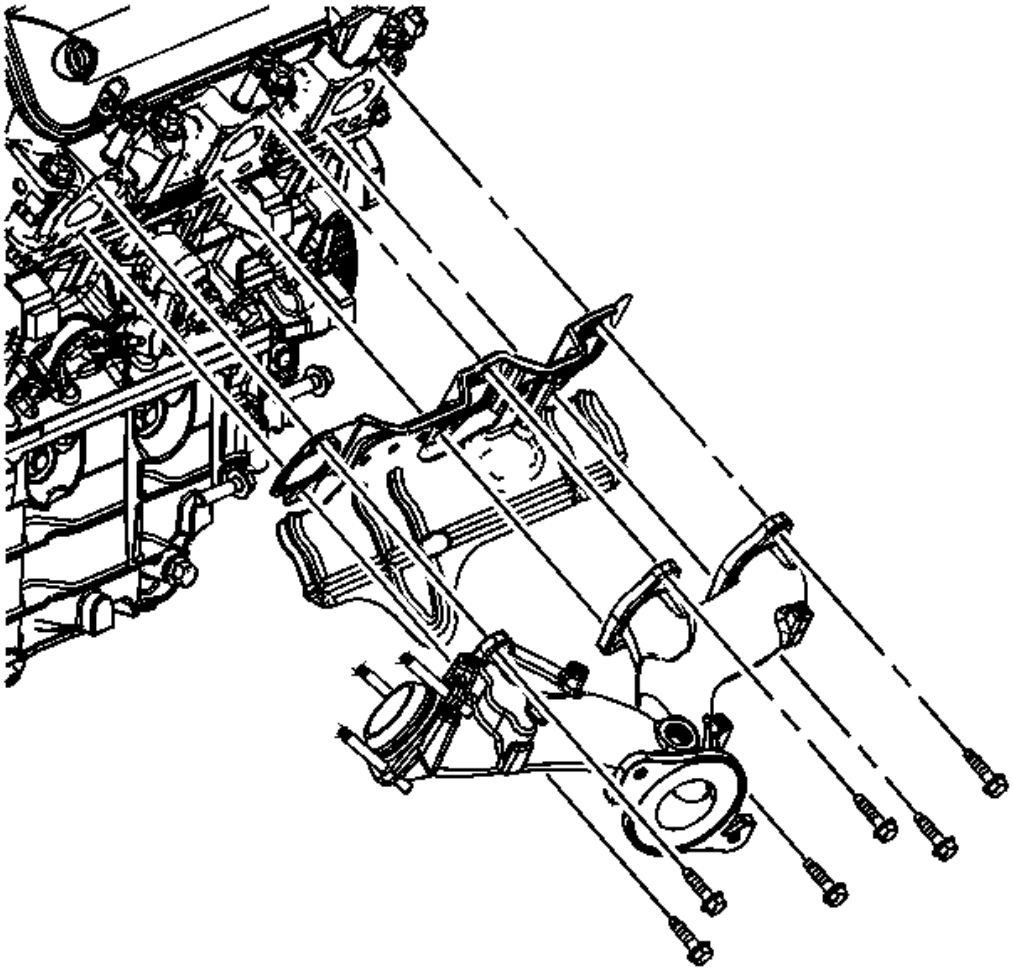

Fig. 398: View Of Right Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

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

Water Outlet and Thermostat Removal

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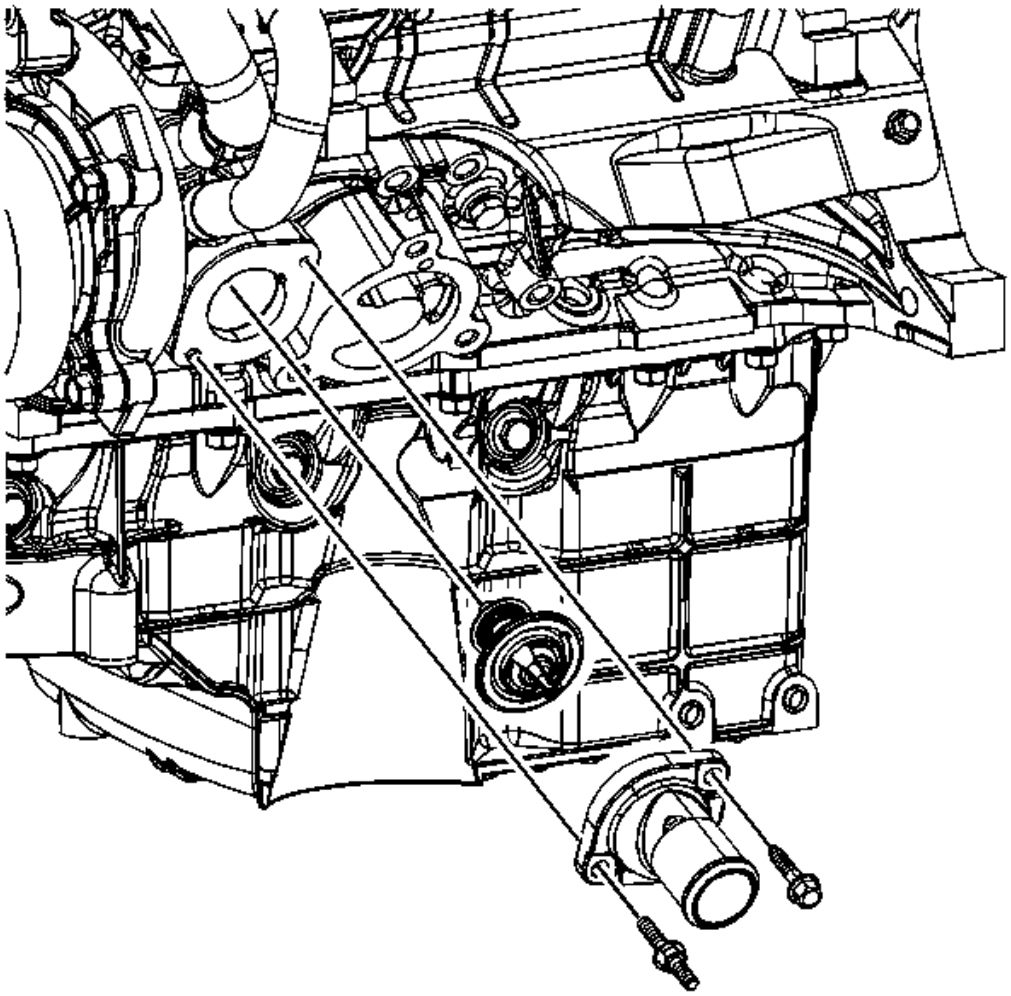

Fig. 399: Identifying Thermostat Housing & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

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

Valve Rocker Arm Cover Removal - Left Side

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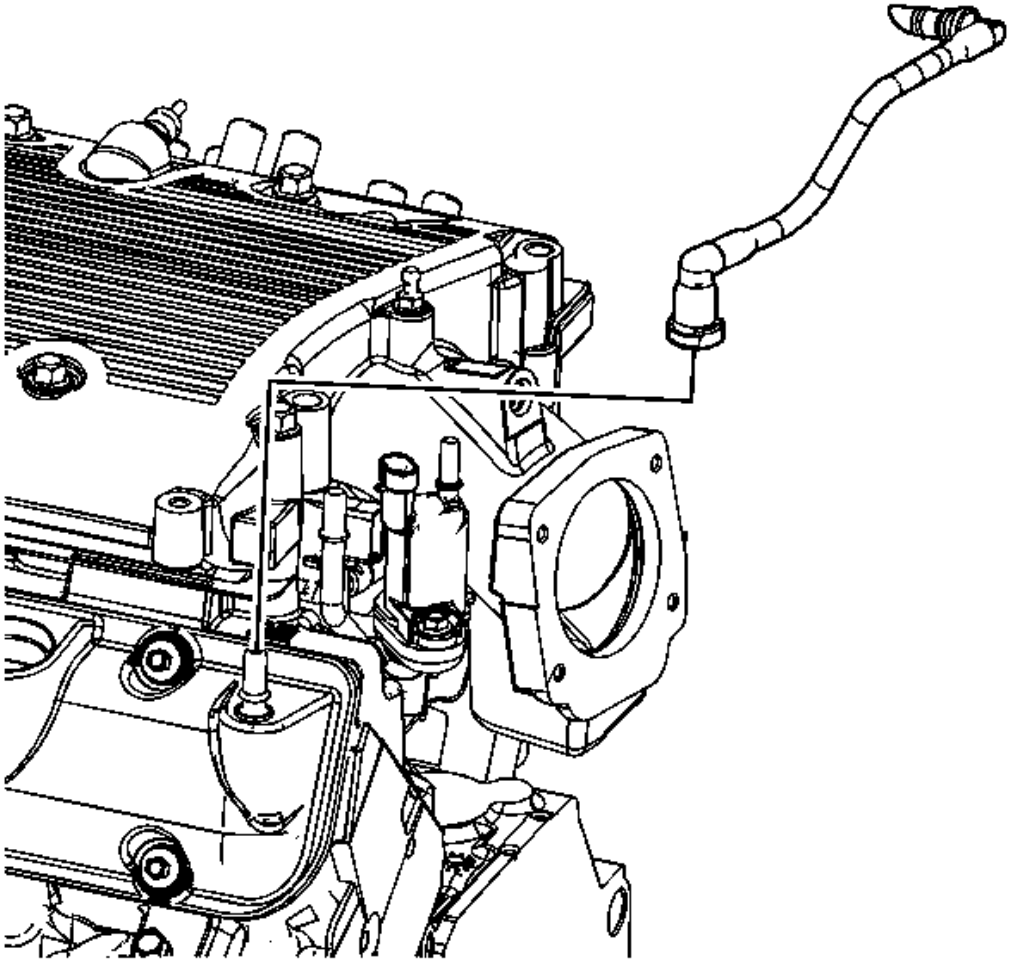

Fig. 400: Locating Positive Crankcase Ventilation (PCV) Valve & Tube
Courtesy of GENERAL MOTORS CORP.

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

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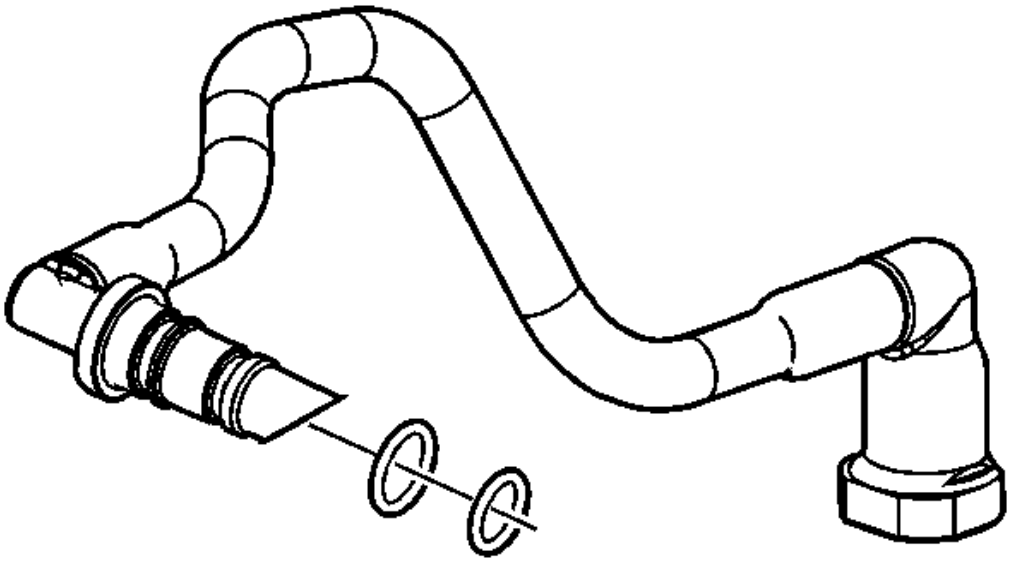

Fig. 401: Identifying PCV Tube O-Rings
Courtesy of GENERAL MOTORS CORP.

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

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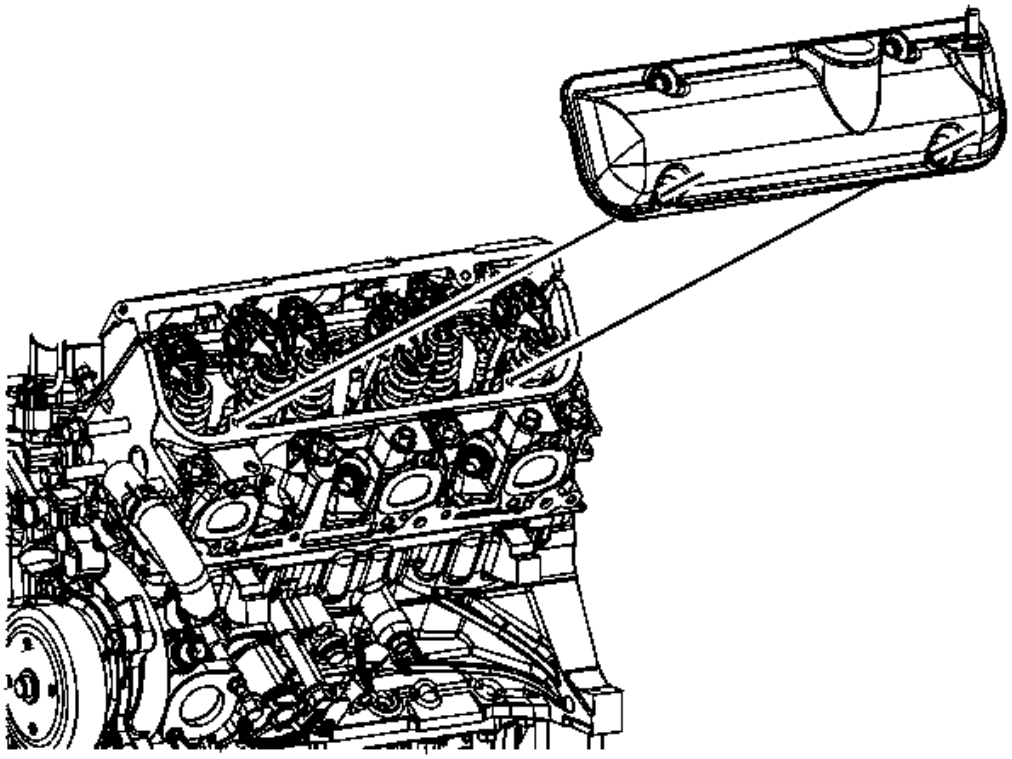

Fig. 402: Removing/Installing Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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 the valve rocker arm cover gasket.

Valve Rocker Arm Cover Removal - Right Side

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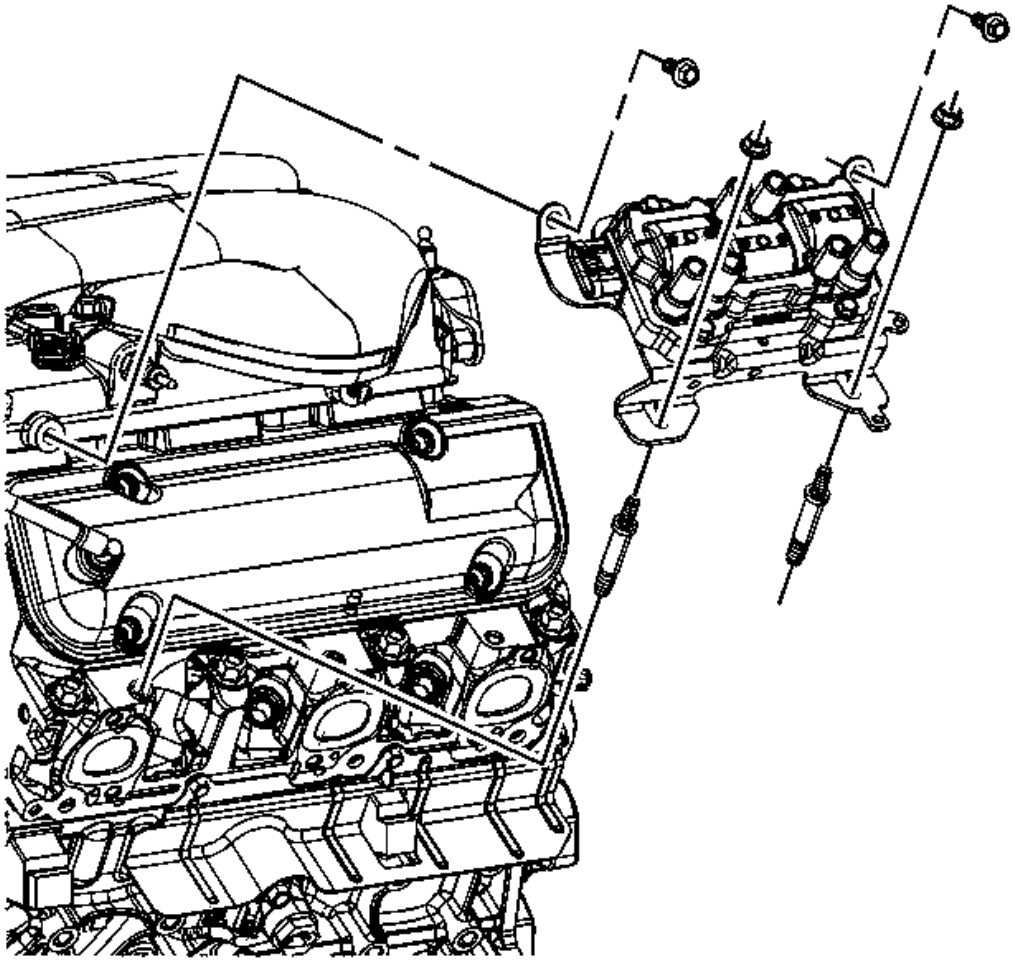

Fig. 403: Identifying Ignition Coil Assembly, Studs & Nuts
Courtesy of GENERAL MOTORS CORP.

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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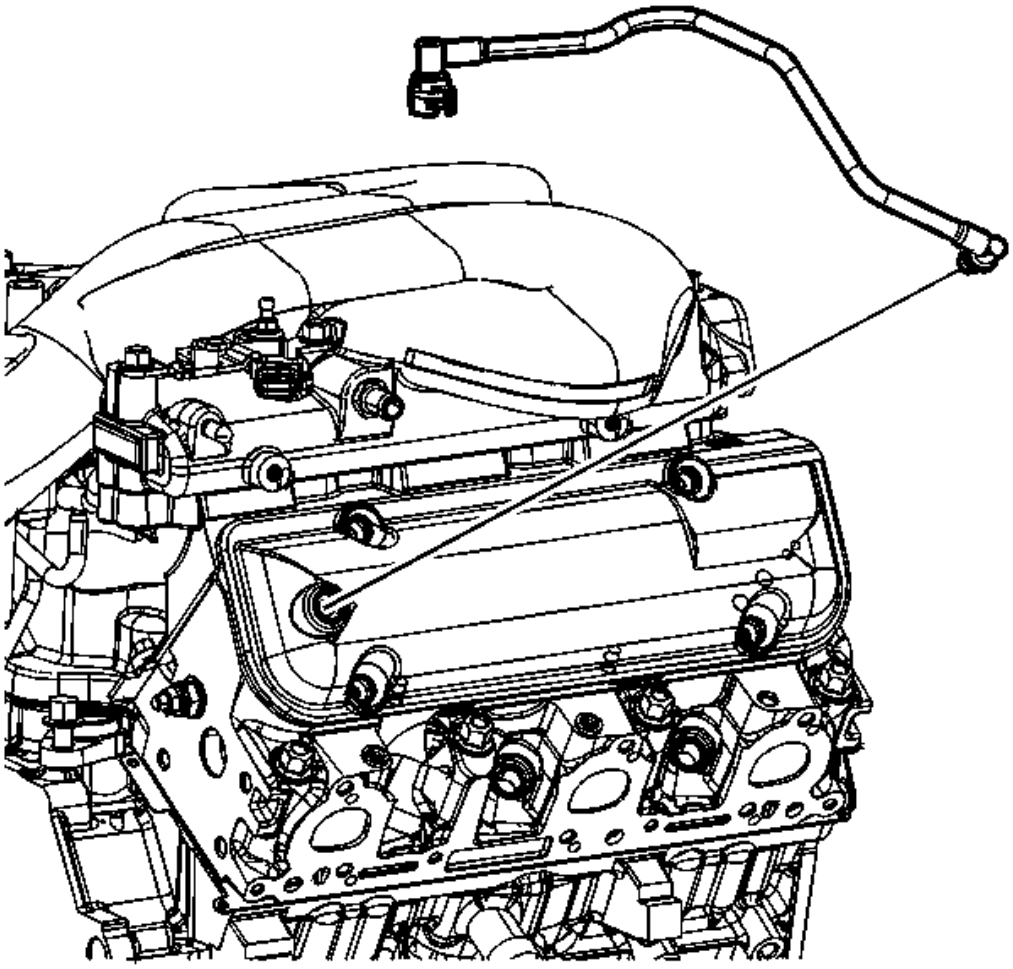

Fig. 404: Identifying Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

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

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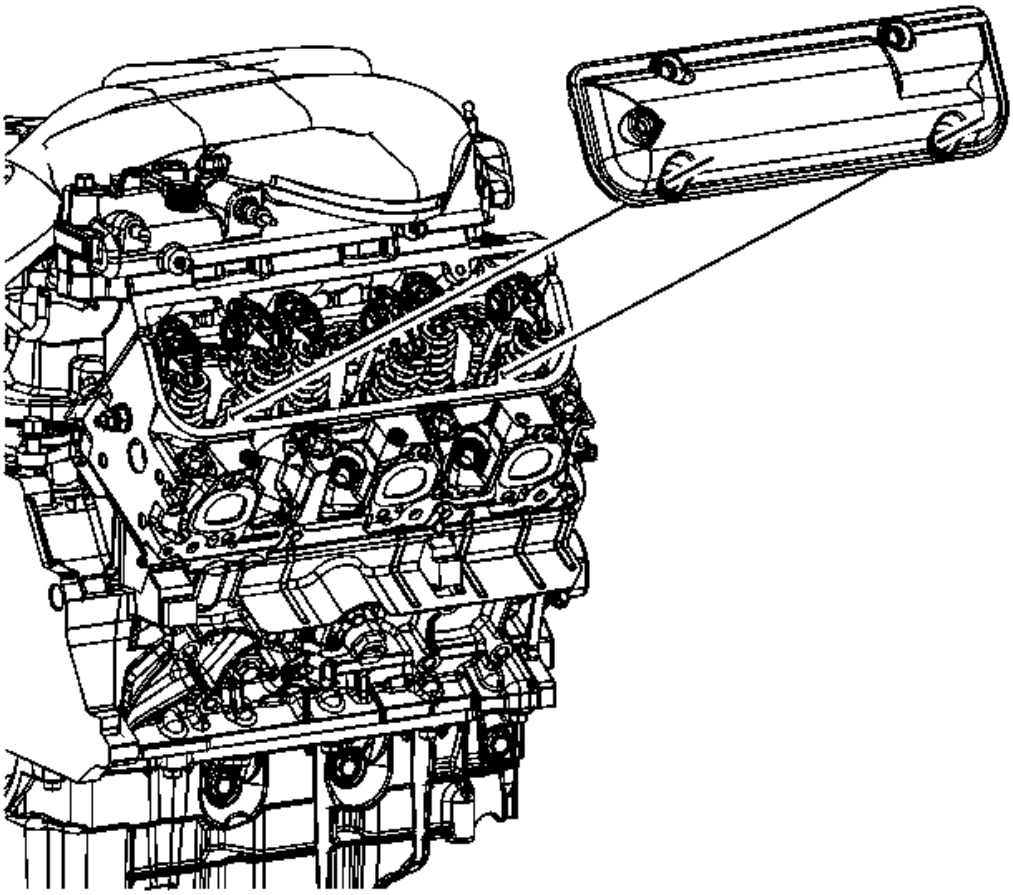

Fig. 405: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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 the valve rocker arm cover gasket.

Upper Intake Manifold Removal

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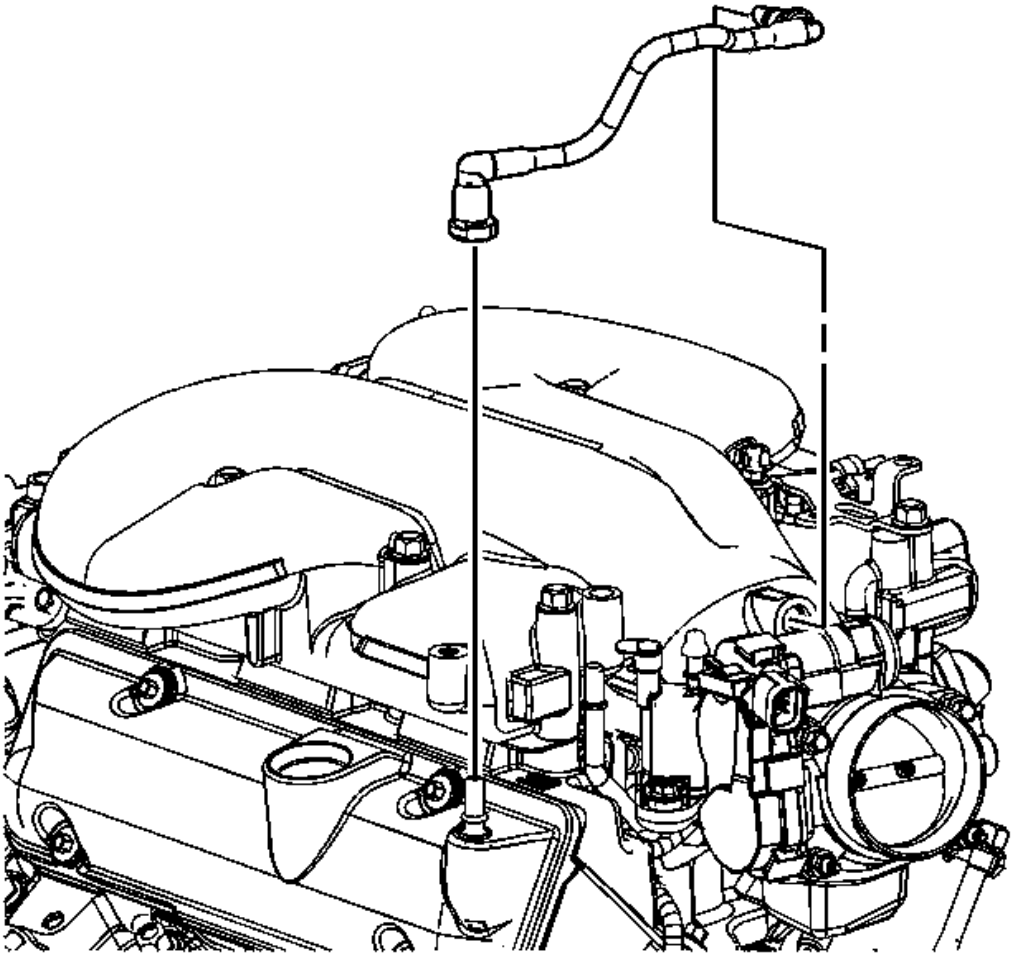

Fig. 406: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

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

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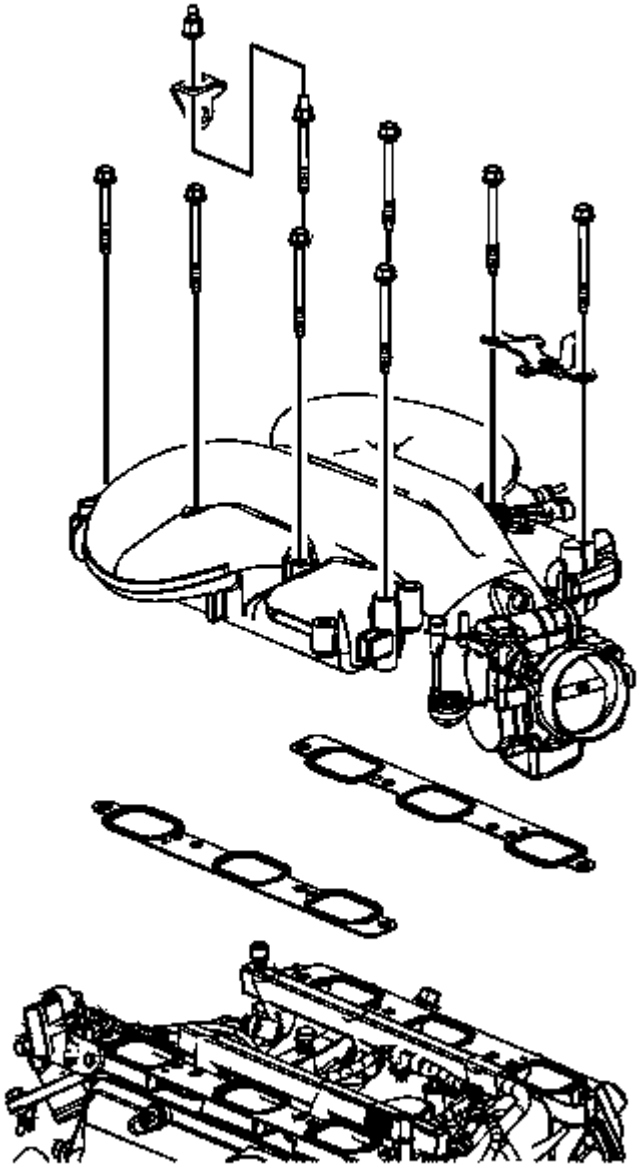

Fig. 407: View Of Upper Intake Manifold Bolts, Studs & Gaskets
Courtesy of GENERAL MOTORS CORP.

2. Remove the upper intake manifold bolts, stud, and manifold absolute pressure (MAP) sensor bracket.
3. Remove the upper intake manifold and gaskets.

Lower Intake Manifold Removal

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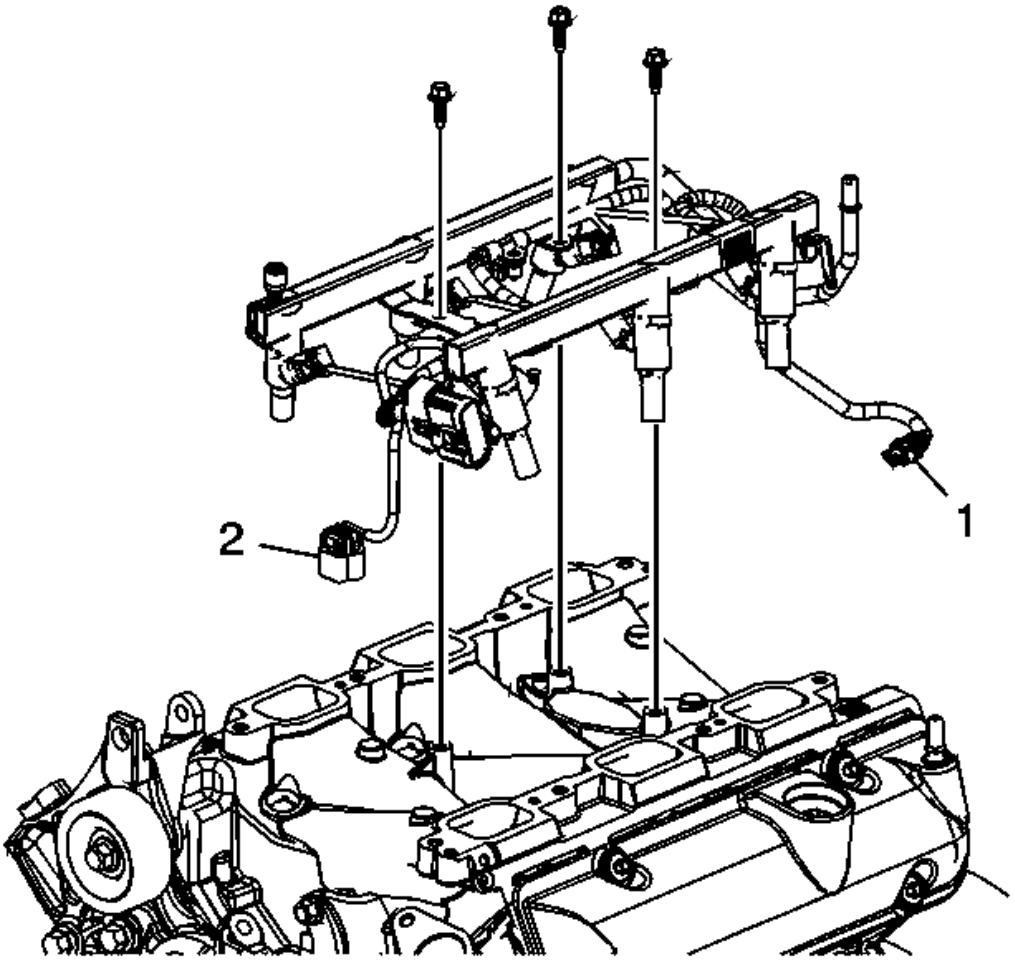

Fig. 408: Identifying Lower Intake Manifold Attachments
Courtesy of GENERAL MOTORS CORP.

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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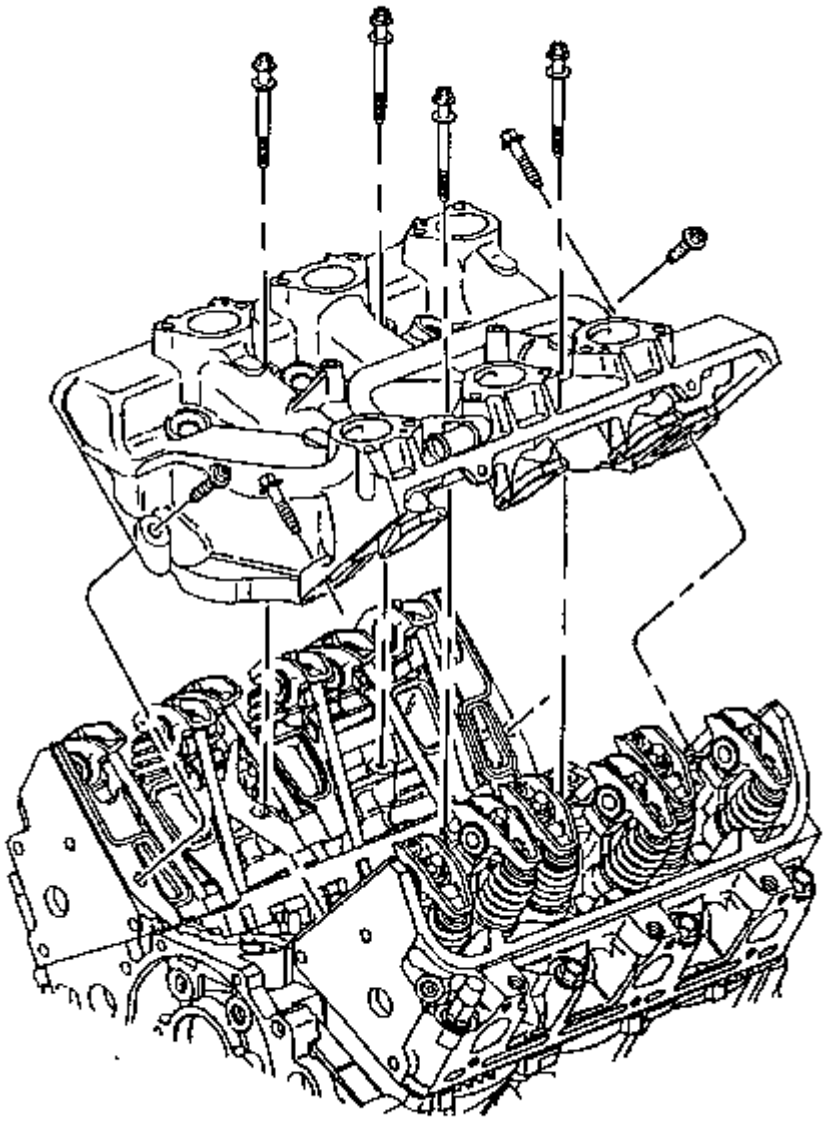

Fig. 409: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

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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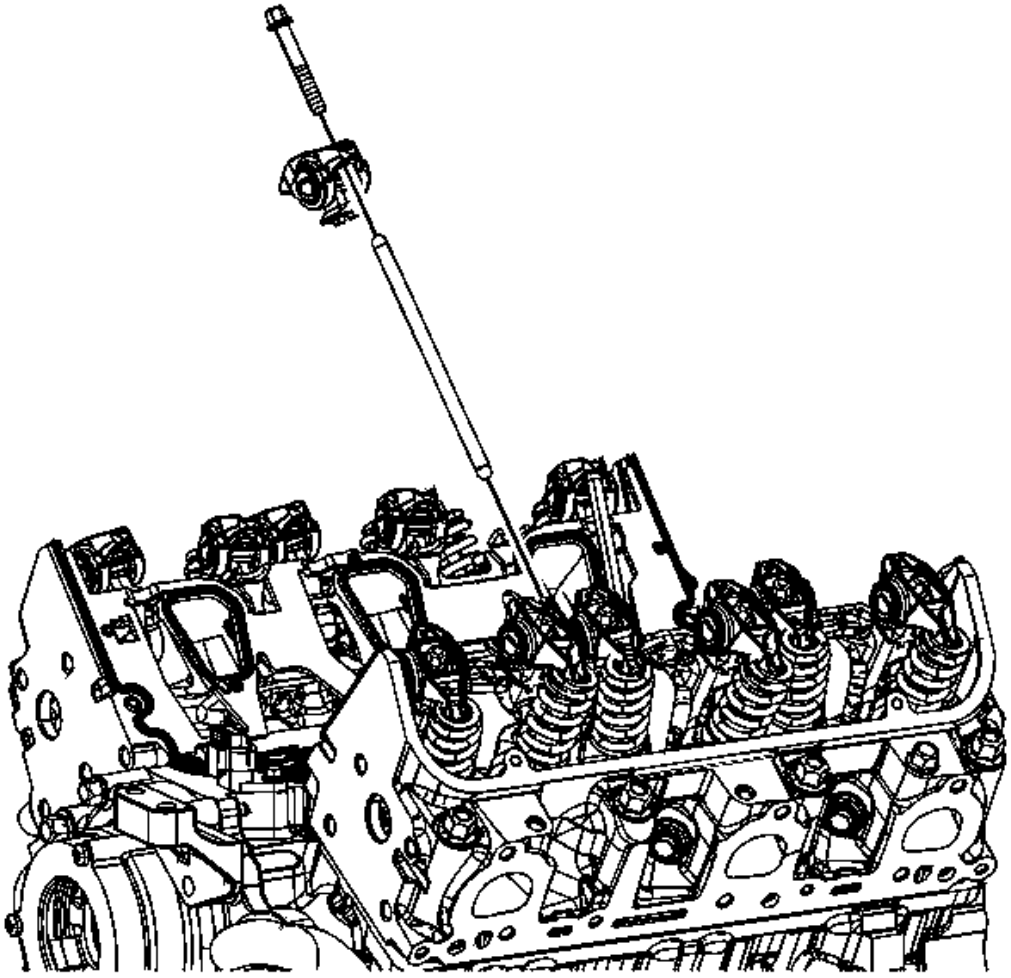

Fig. 410: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

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).

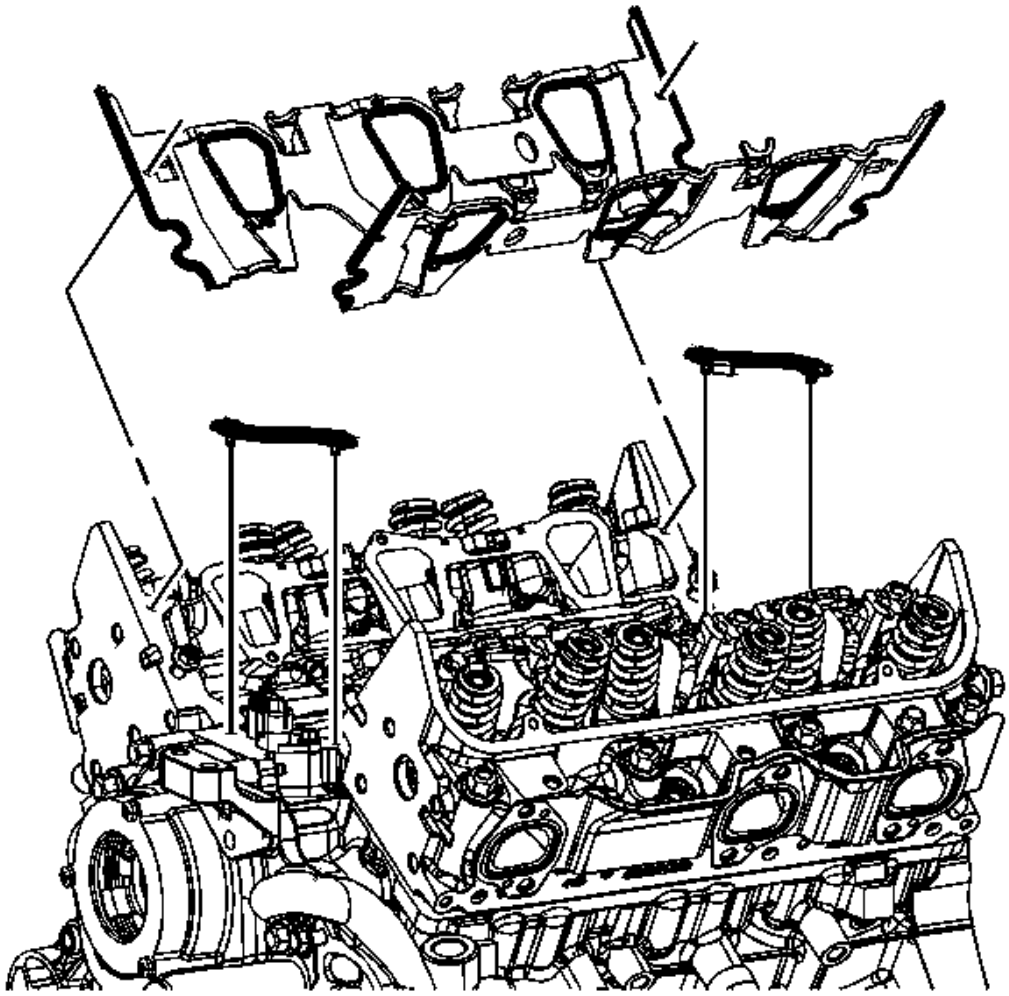

Fig. 411: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold gaskets.

Valve Lifter Removal

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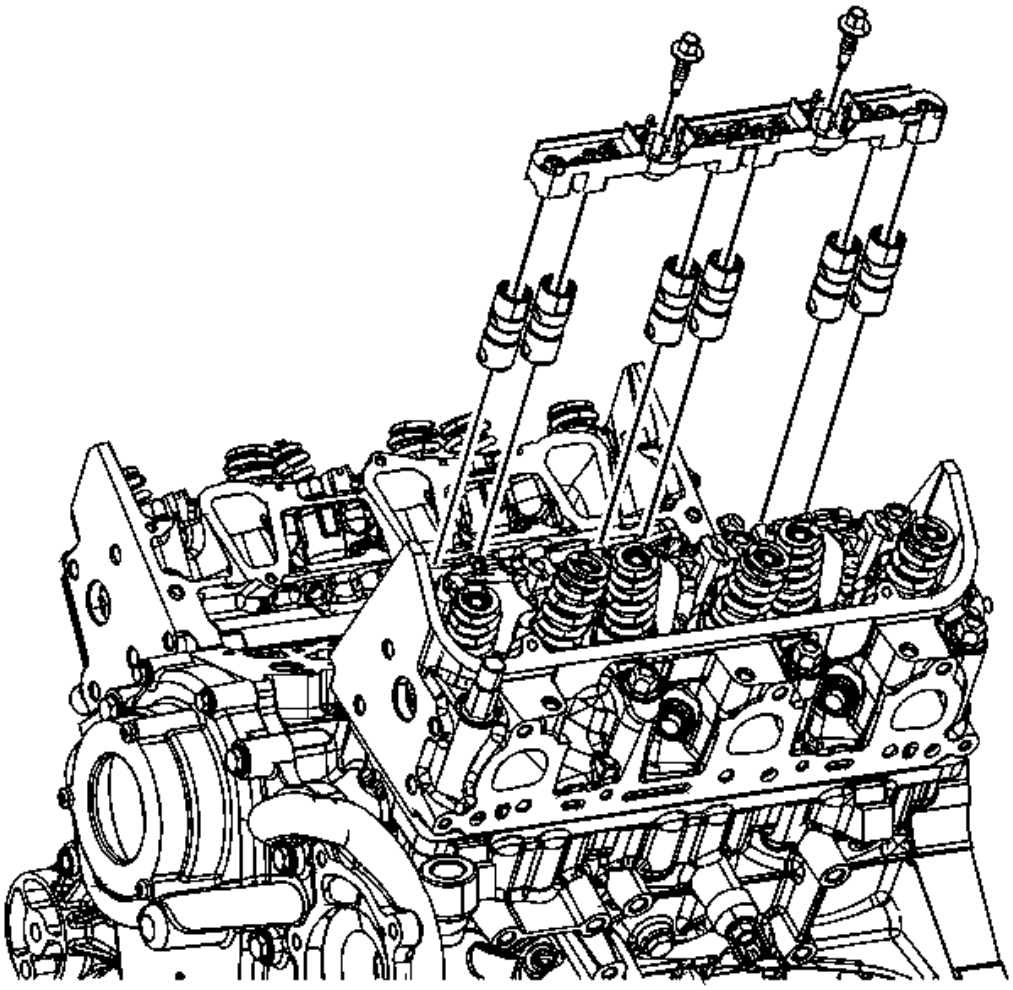

Fig. 412: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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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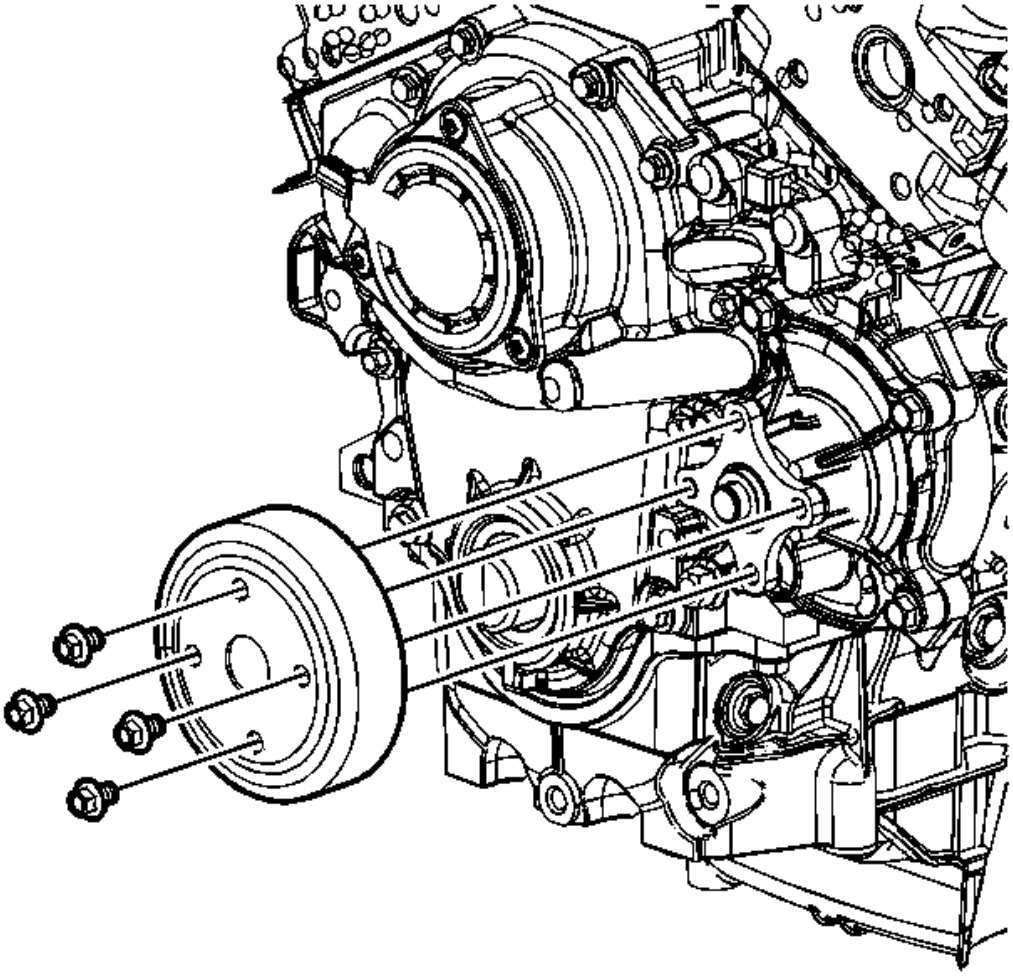

Fig. 413: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump pulley bolts.
2. Remove the water pump pulley.

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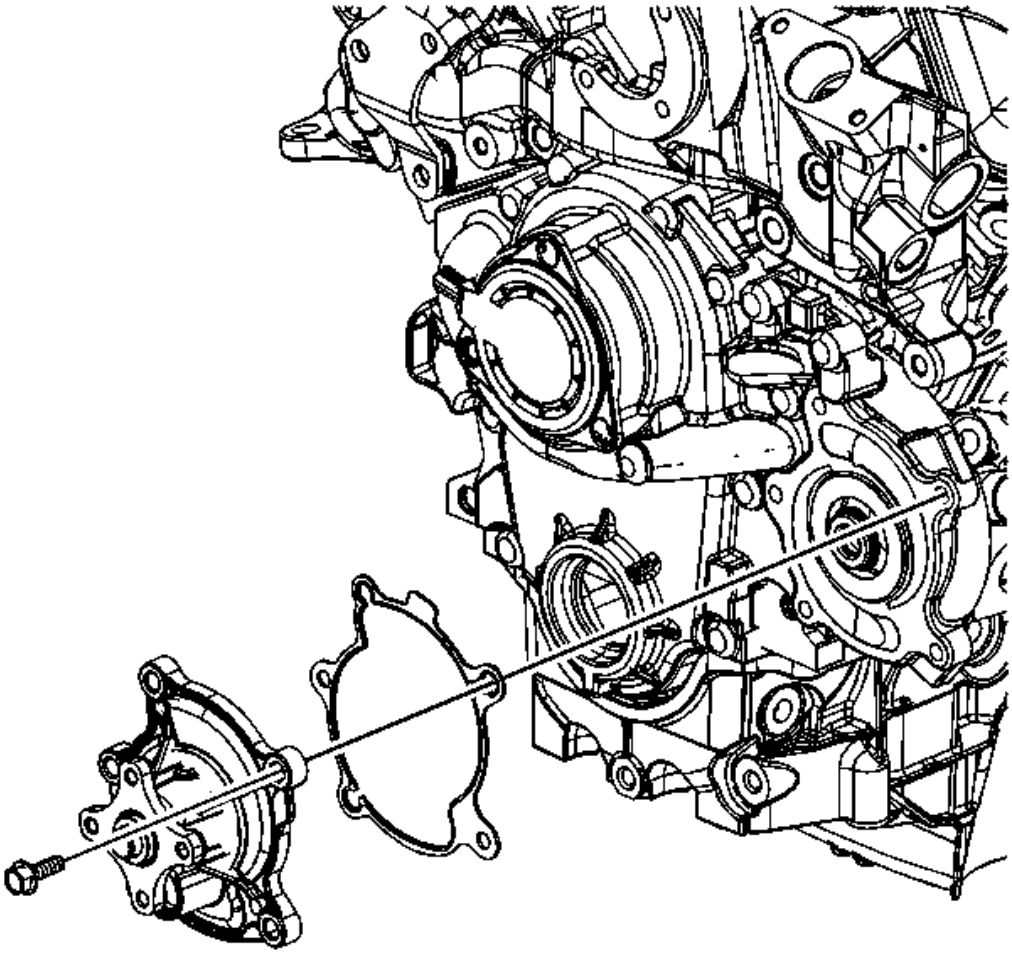

Fig. 414: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

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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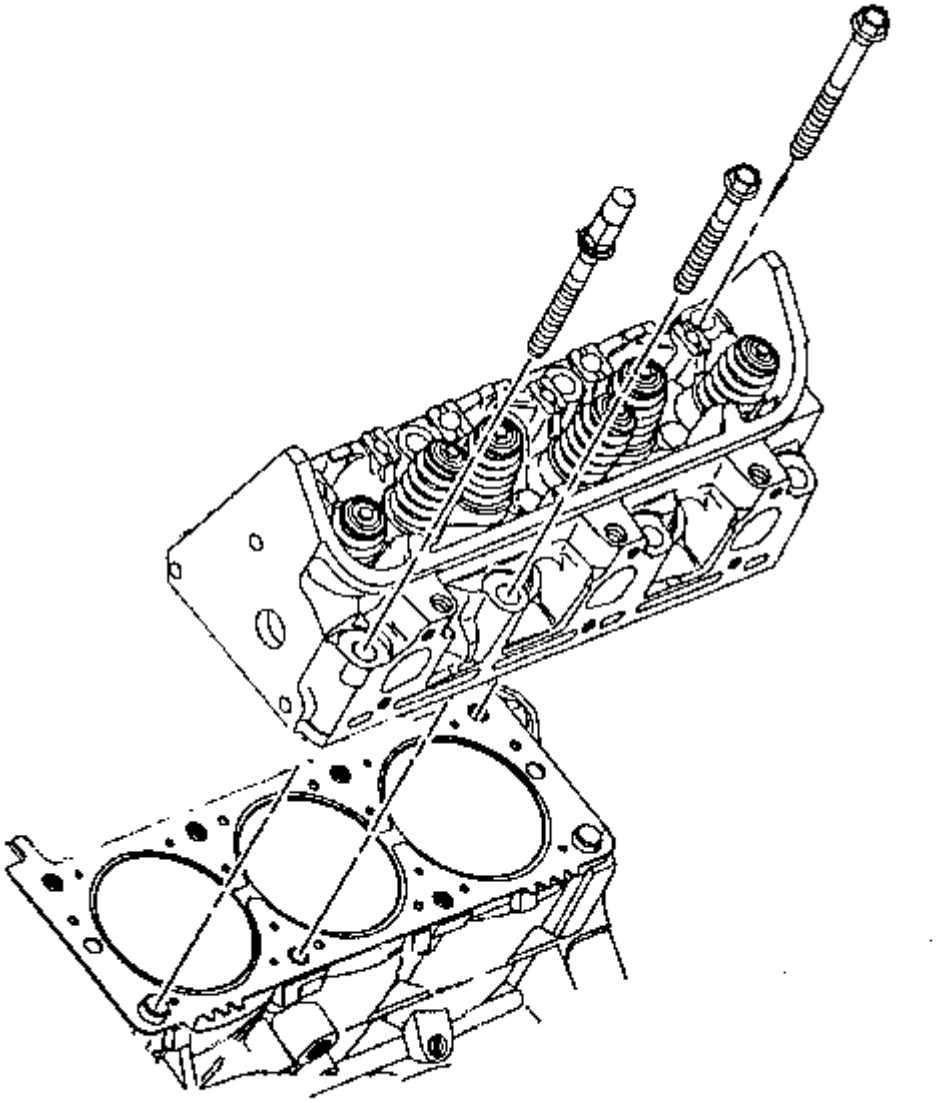

Fig. 415: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolt and discards.
2. Remove the cylinder head.

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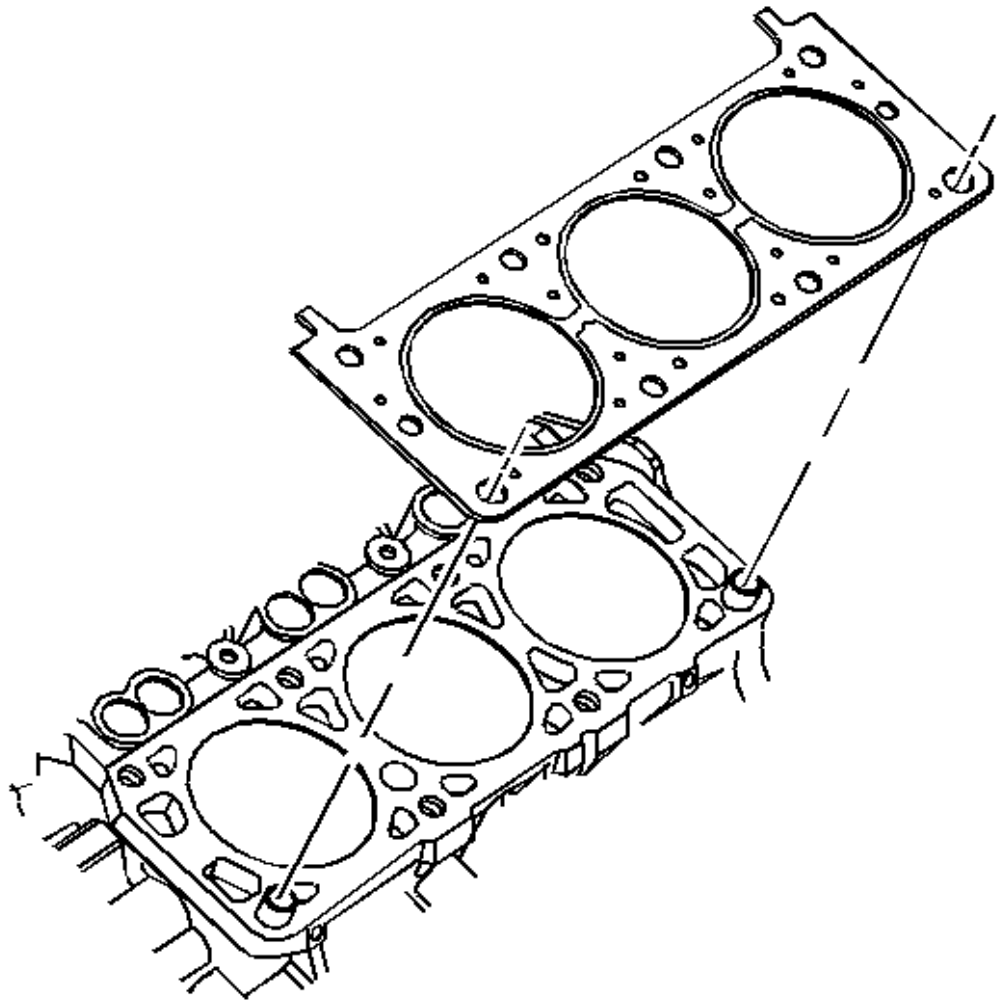

Fig. 416: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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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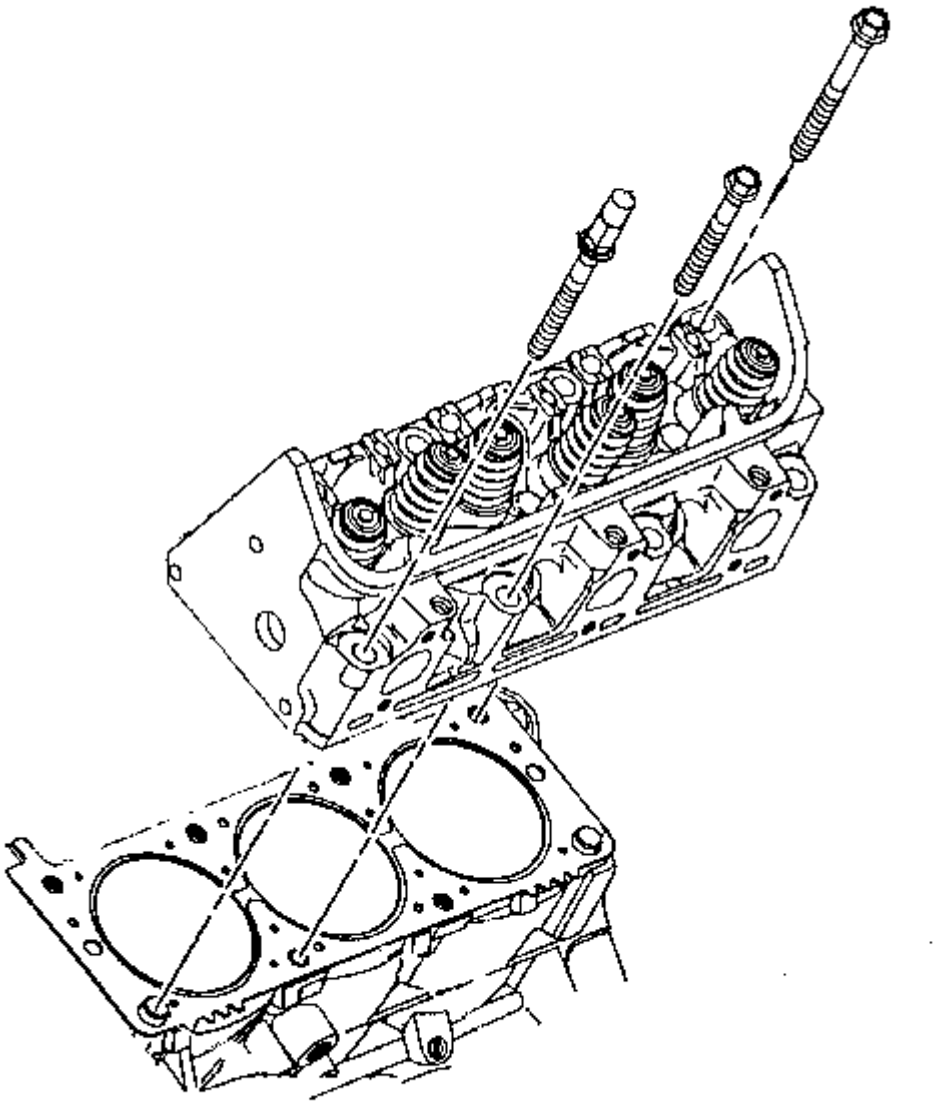

Fig. 417: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts and discard.
2. Remove the cylinder head.

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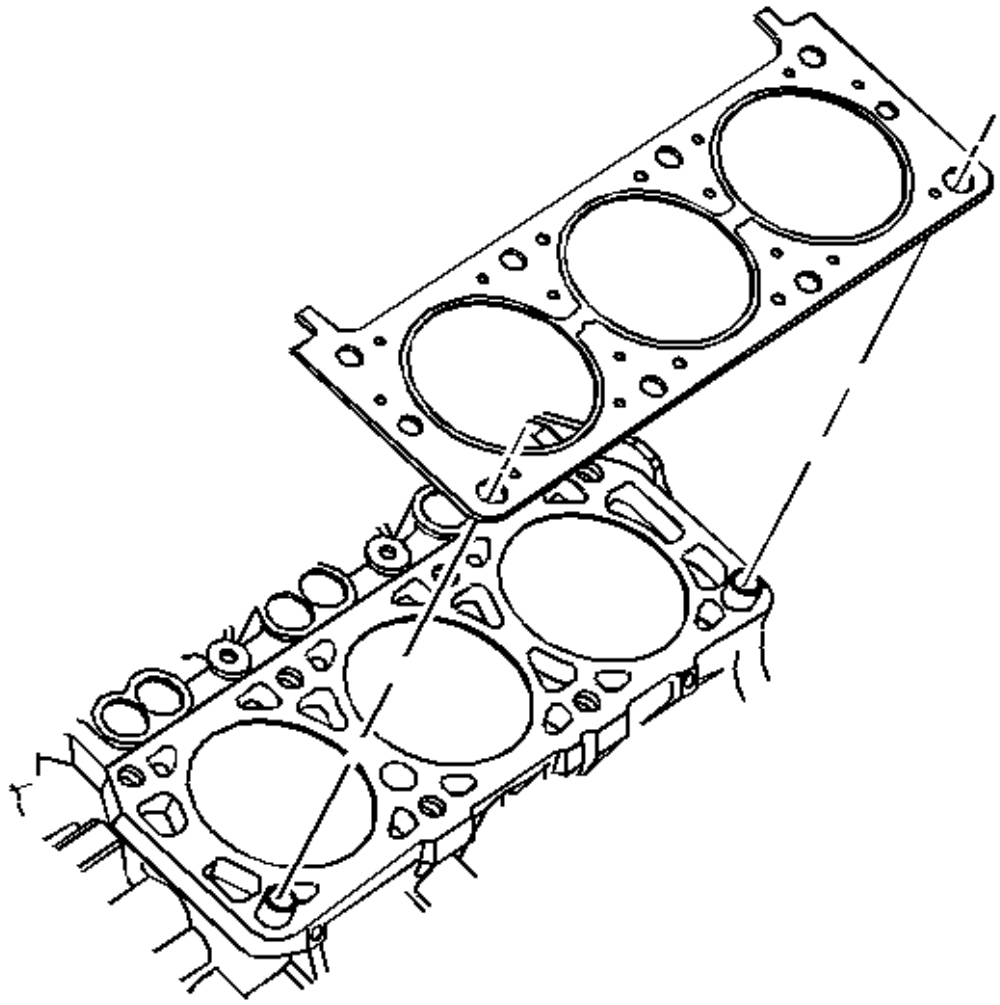

Fig. 418: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Remove the cylinder head locator dowel pins, if required.

Oil Pan Removal

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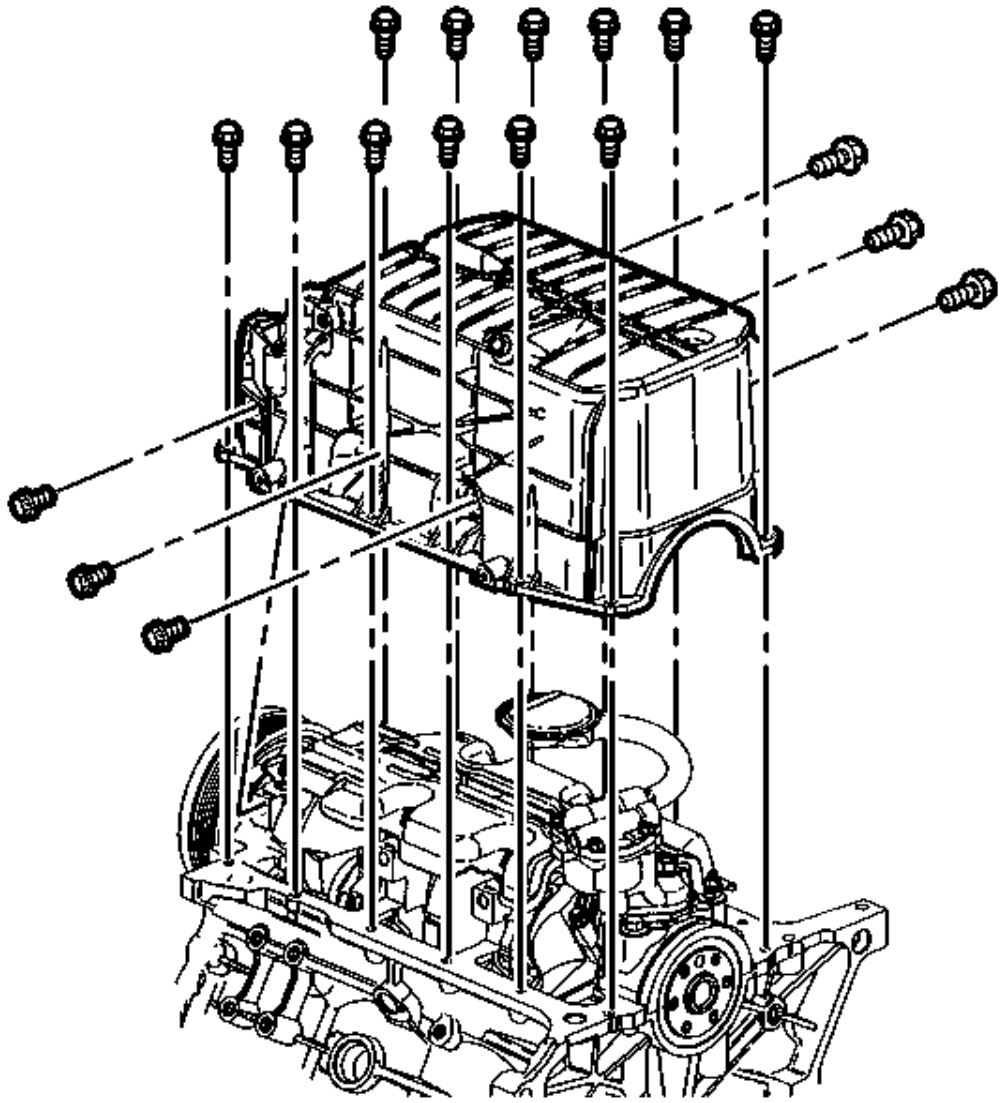

Fig. 419: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

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

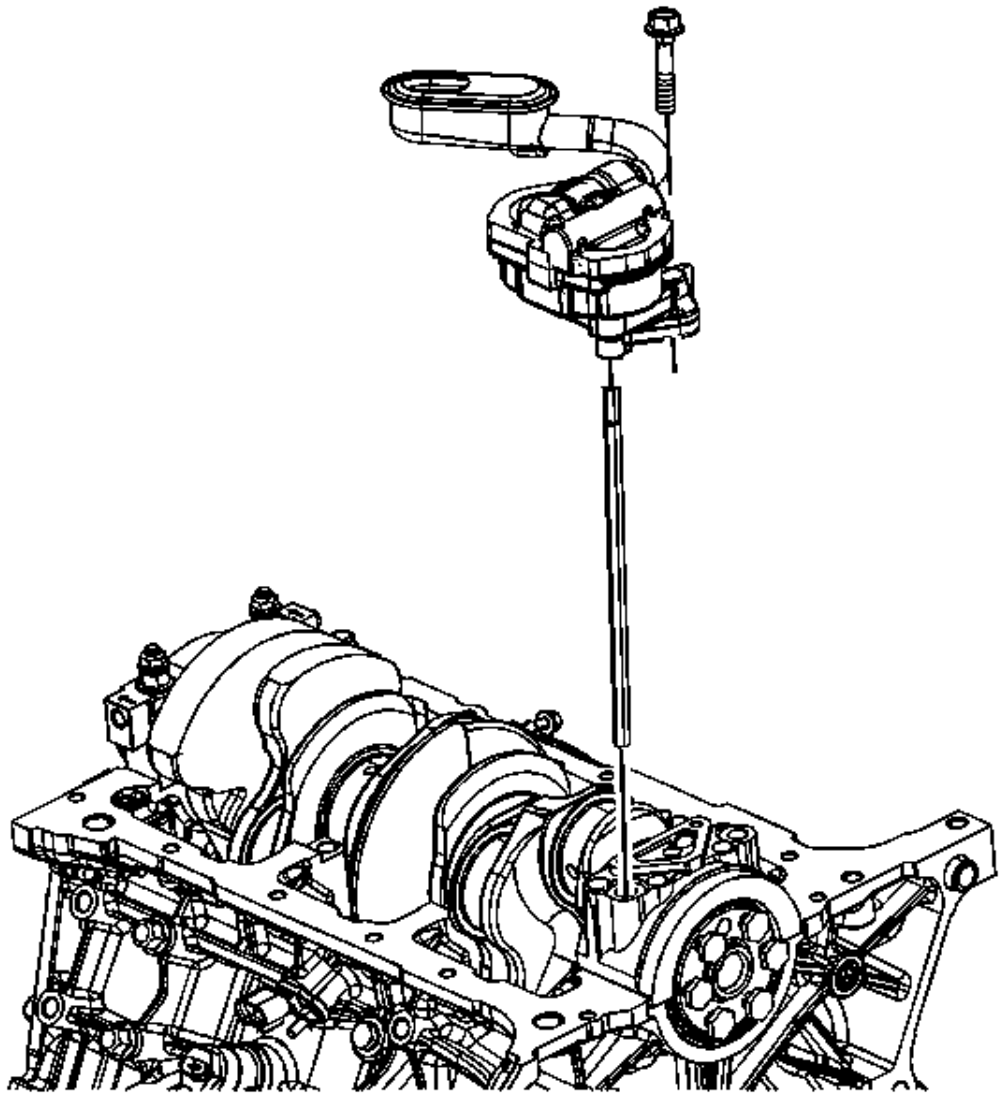

Fig. 420: View Of Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolt.
2. Remove the oil pump and oil pump drive shaft.

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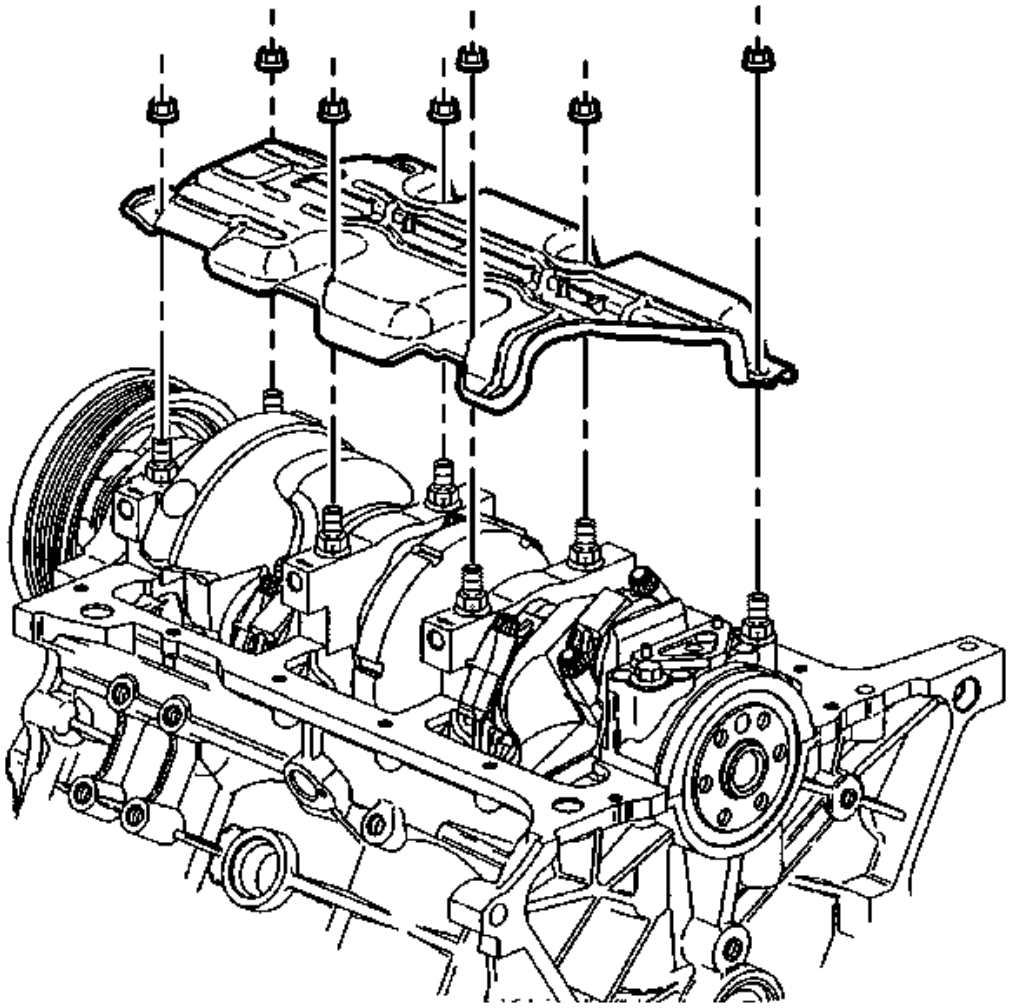

Fig. 421: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft oil deflector nuts.
4. Remove the crankshaft oil deflector.

Camshaft Position Actuator Magnet Removal

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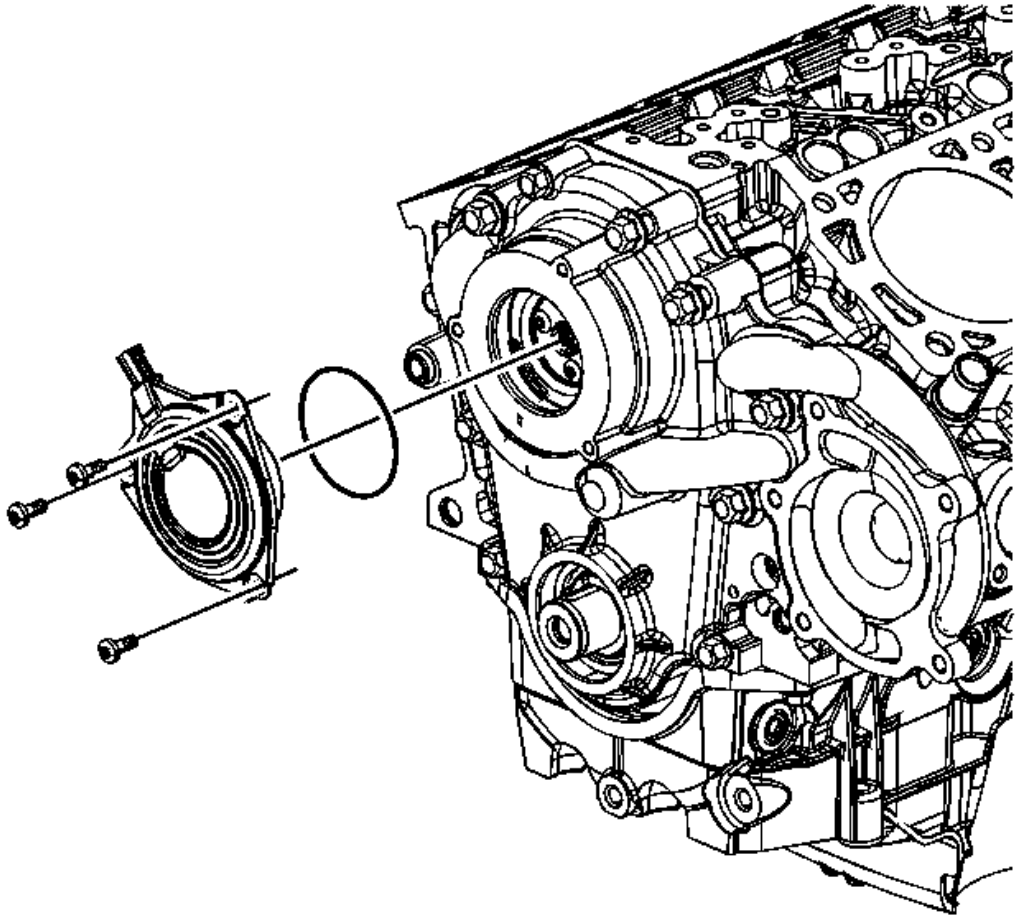

Fig. 422: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

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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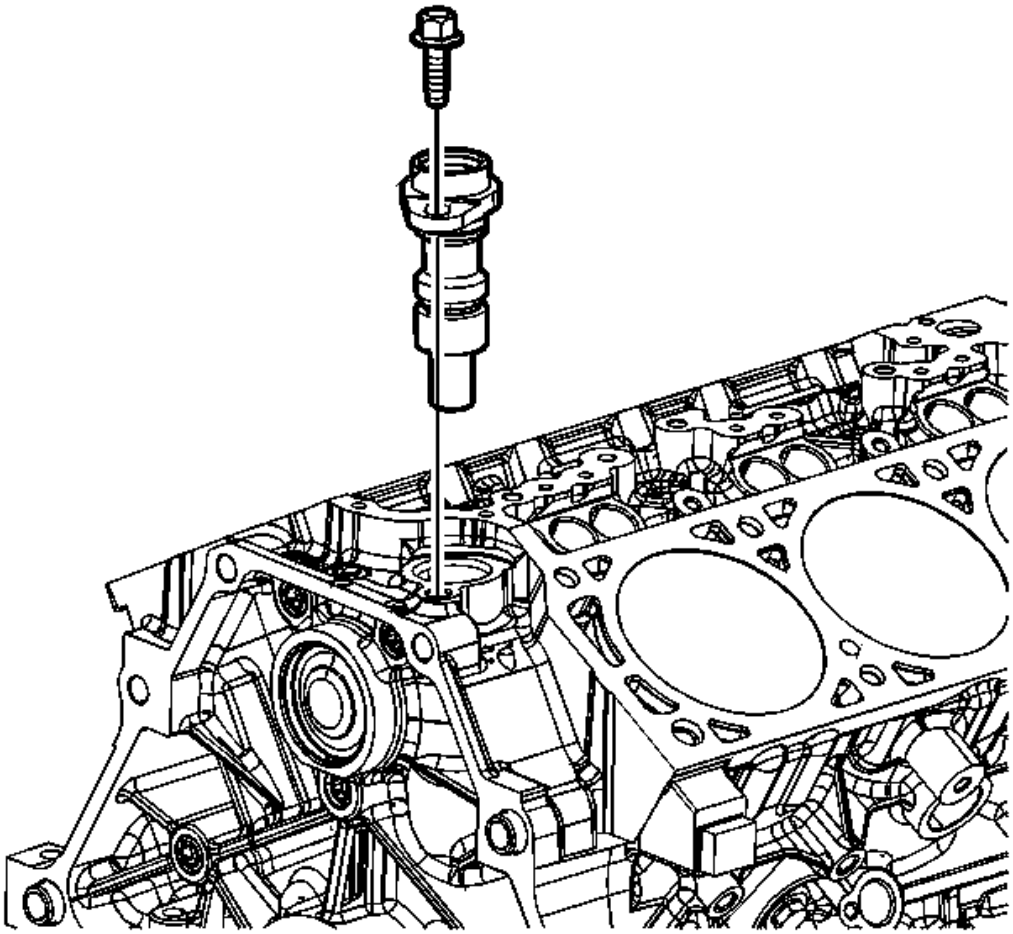

Fig. 423: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

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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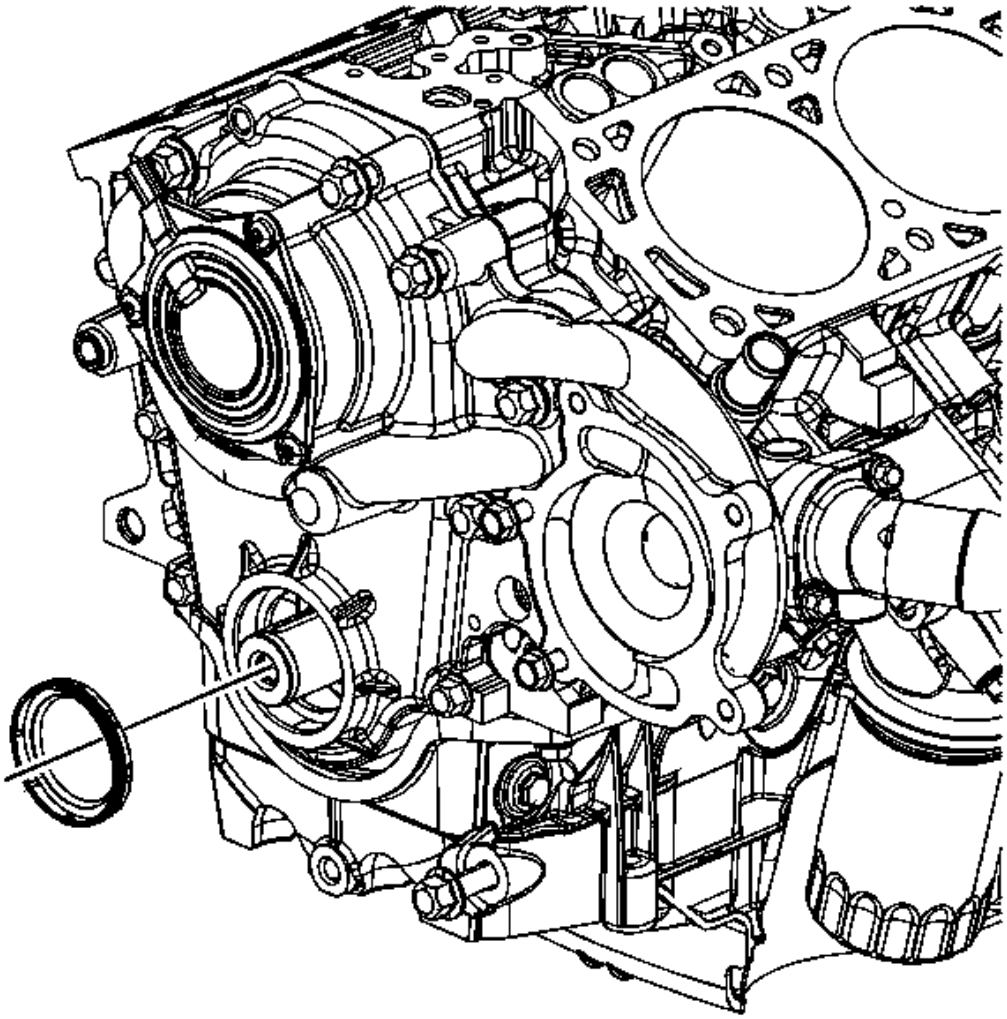

Fig. 424: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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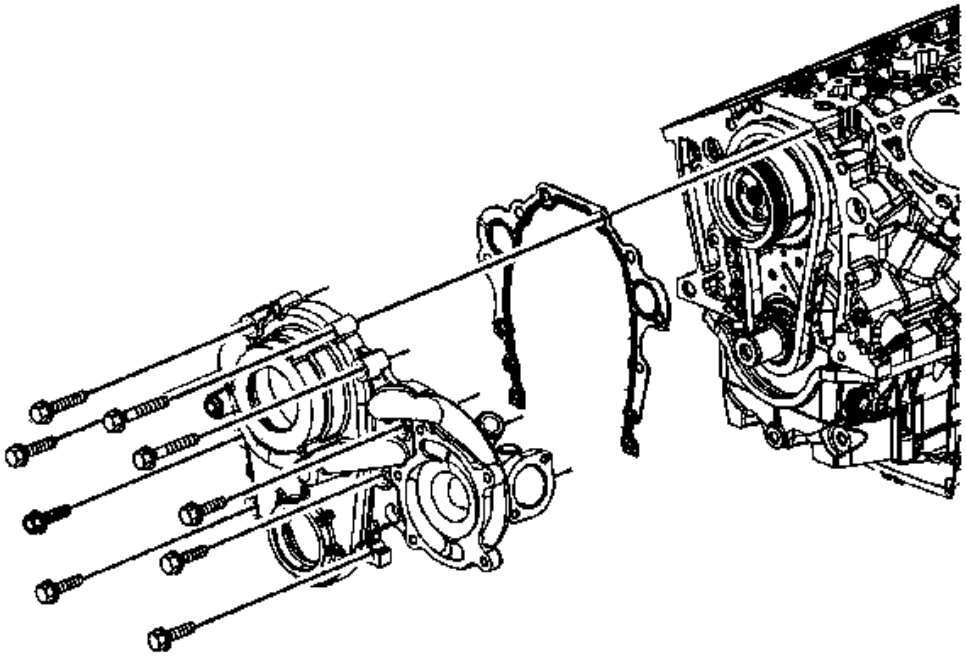

Fig. 425: Identifying Engine Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover bolts.
2. Remove the engine front cover.
3. Remove the engine front cover gasket.

Timing Chain and Sprockets Removal

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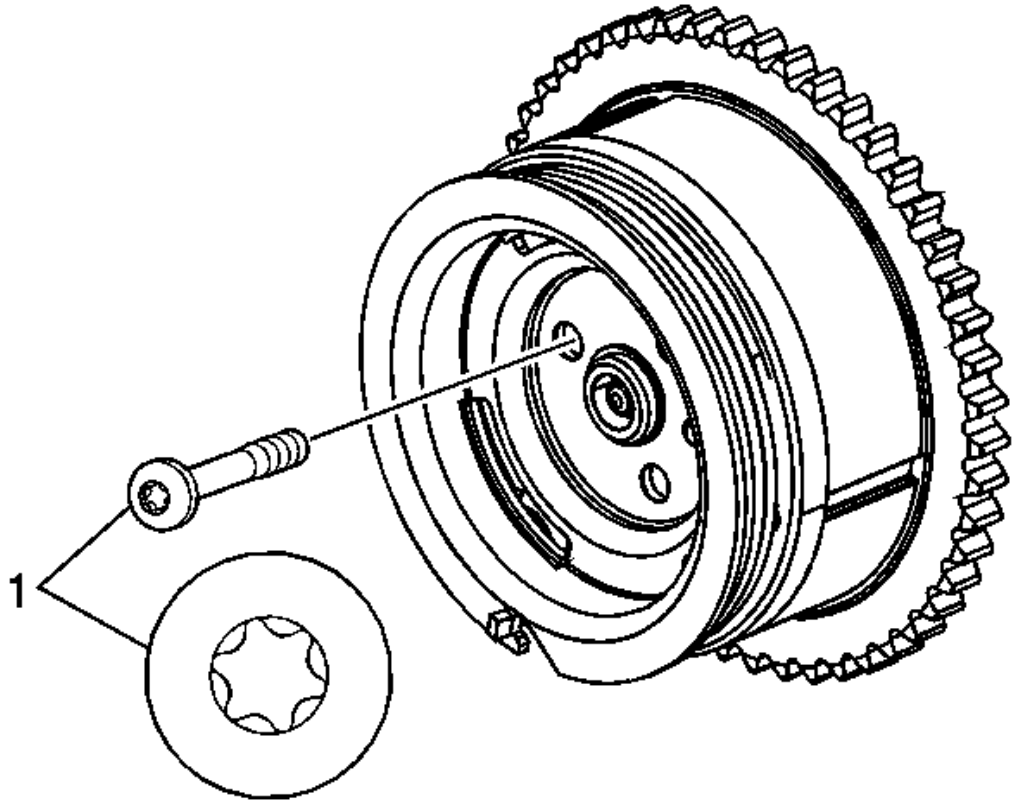

Fig. 426: Identifying Camshaft Position Actuator & Fasteners
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

1. Install the camshaft position actuator fastener (1).

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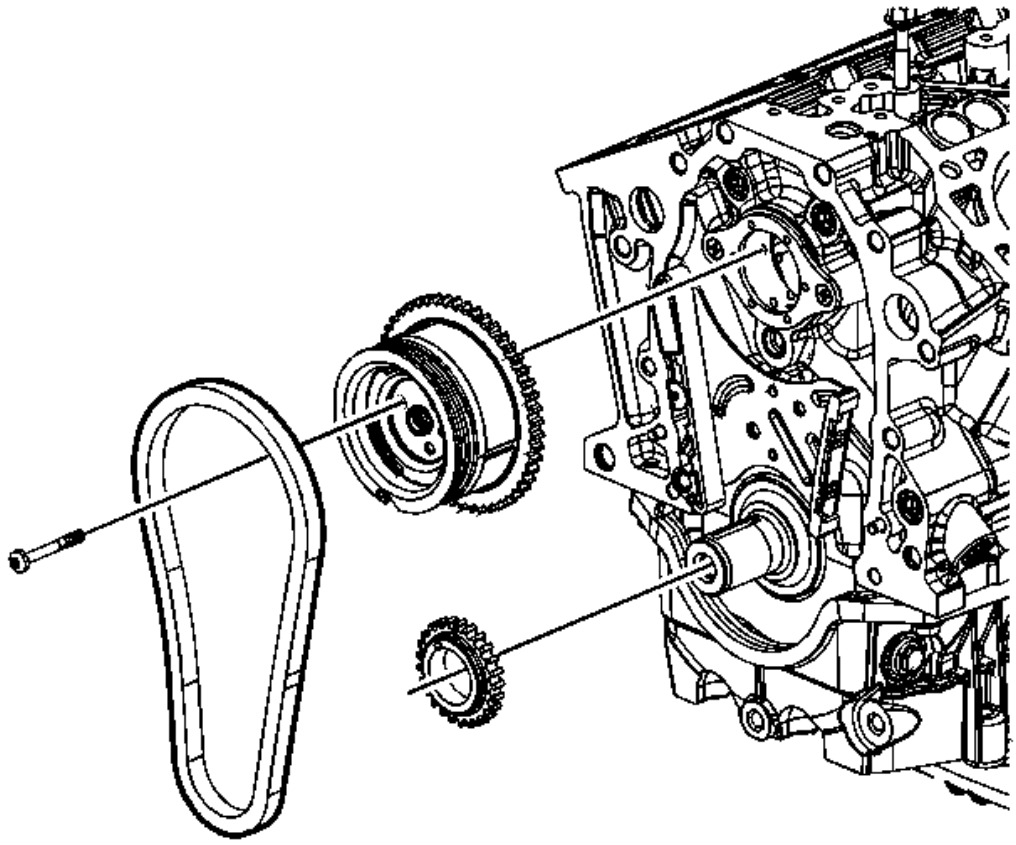

Fig. 427: View Of Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft sprocket bolts.
3. Remove the timing chain and sprockets.

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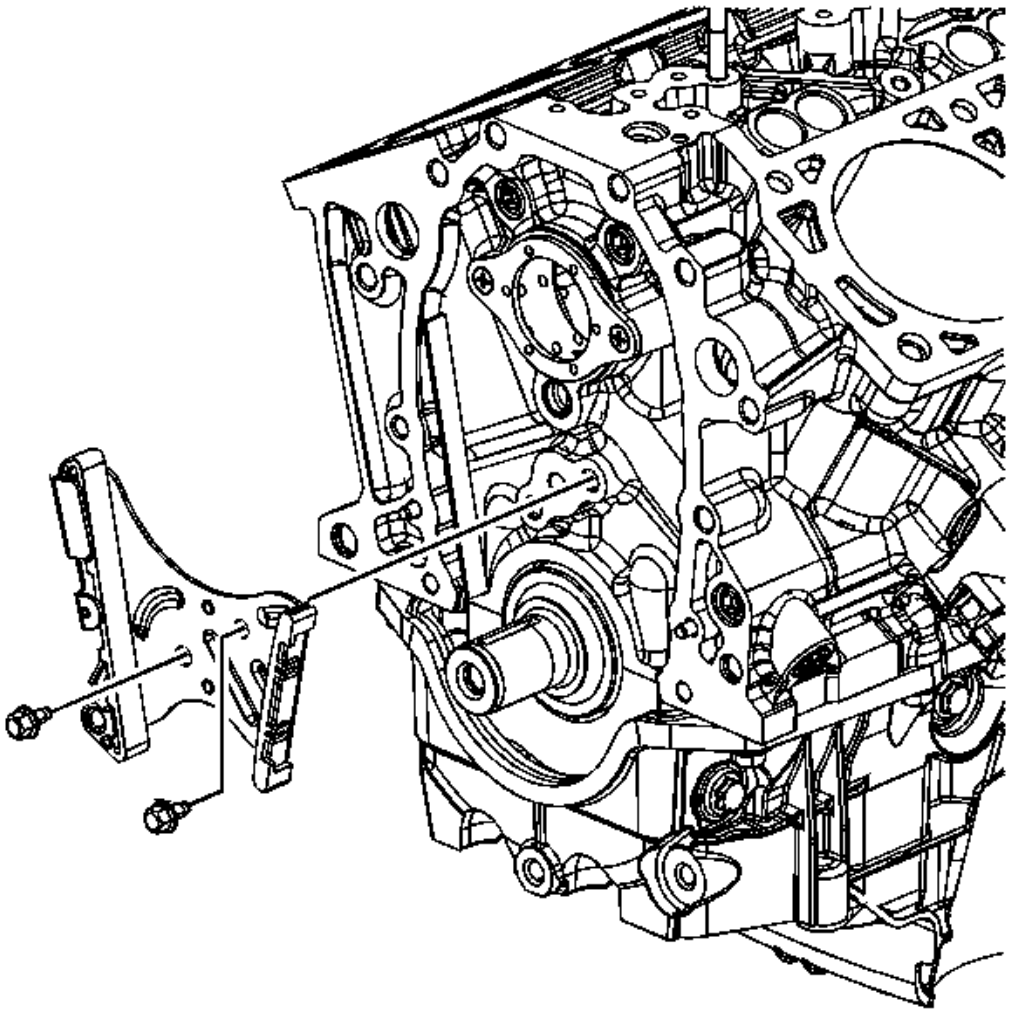

Fig. 428: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain tensioner bolts.
5. Remove the timing chain tensioner.

Camshaft Removal

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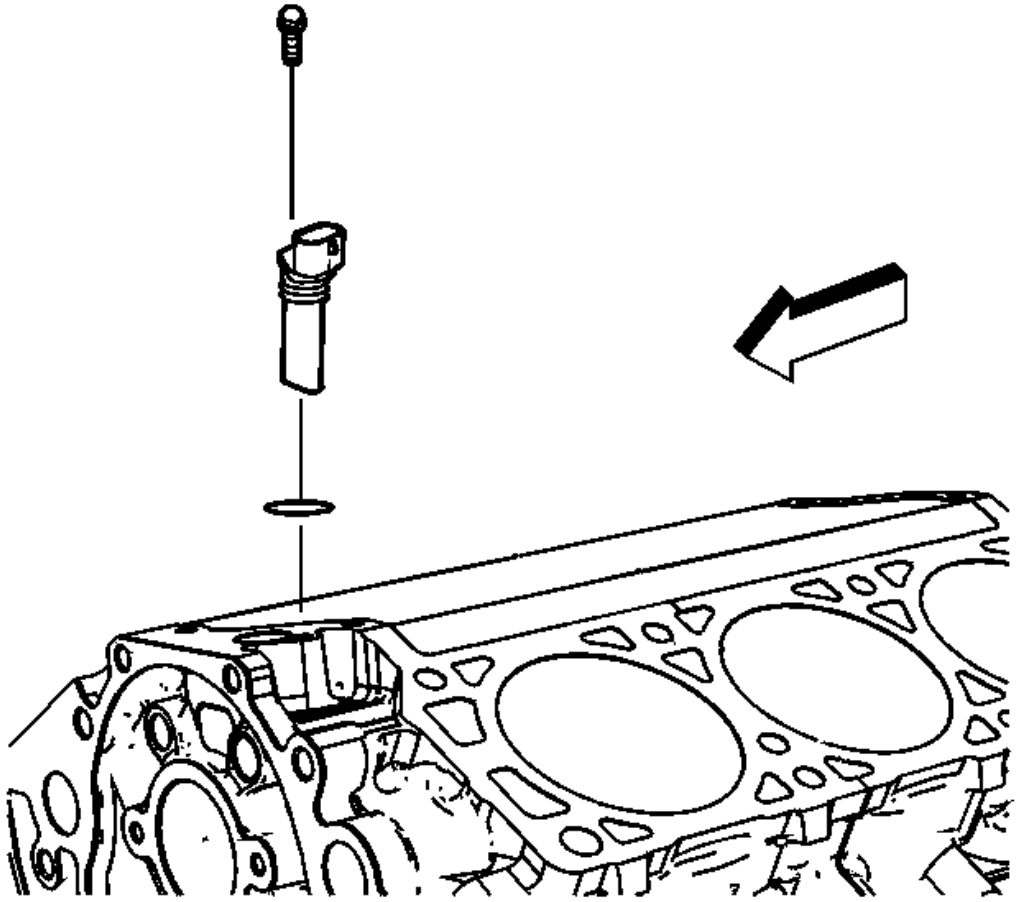

Fig. 429: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position sensor bolt.
2. Remove the camshaft position sensor.

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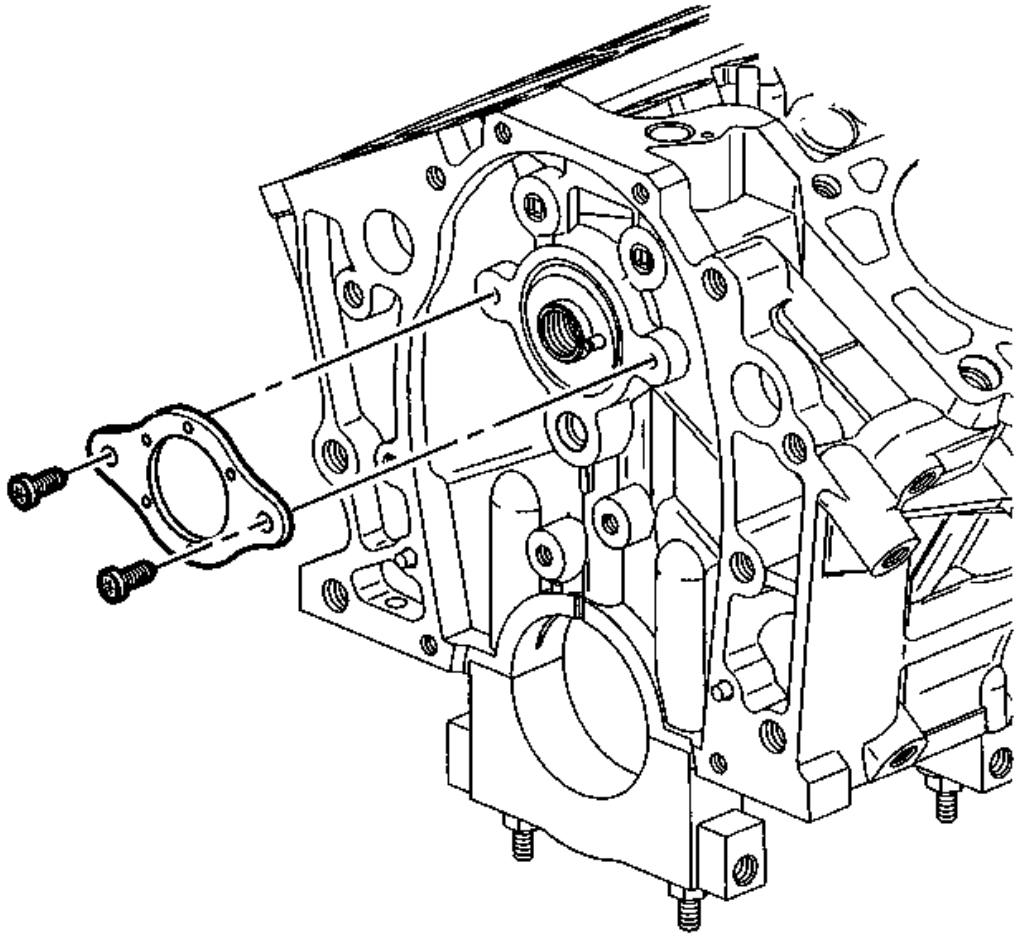

Fig. 430: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft thrust plate screws.
4. Remove the camshaft thrust plate.

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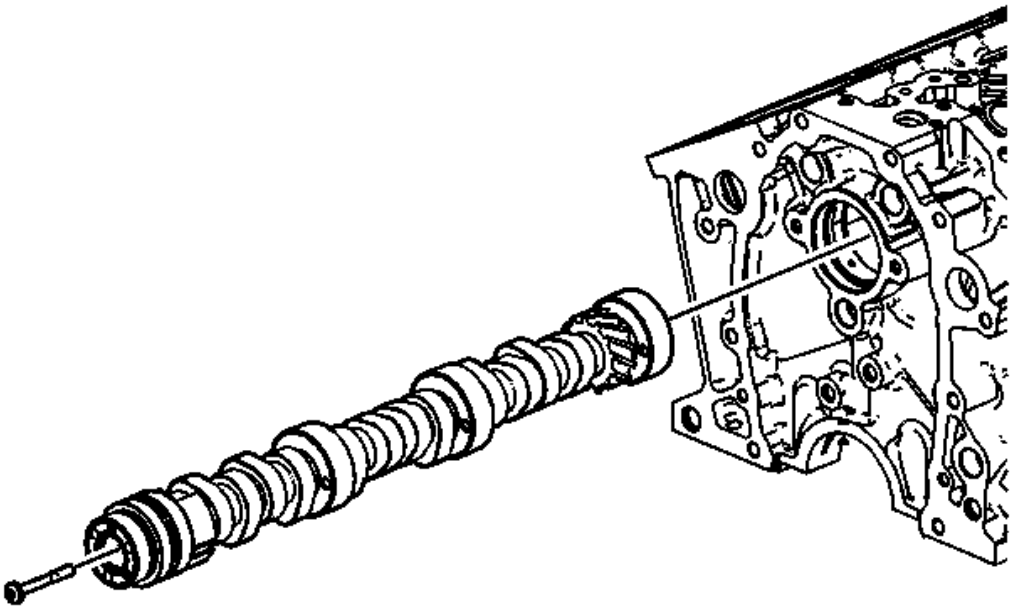

Fig. 431: Identifying Camshaft & Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

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

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

Tools Required

- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.

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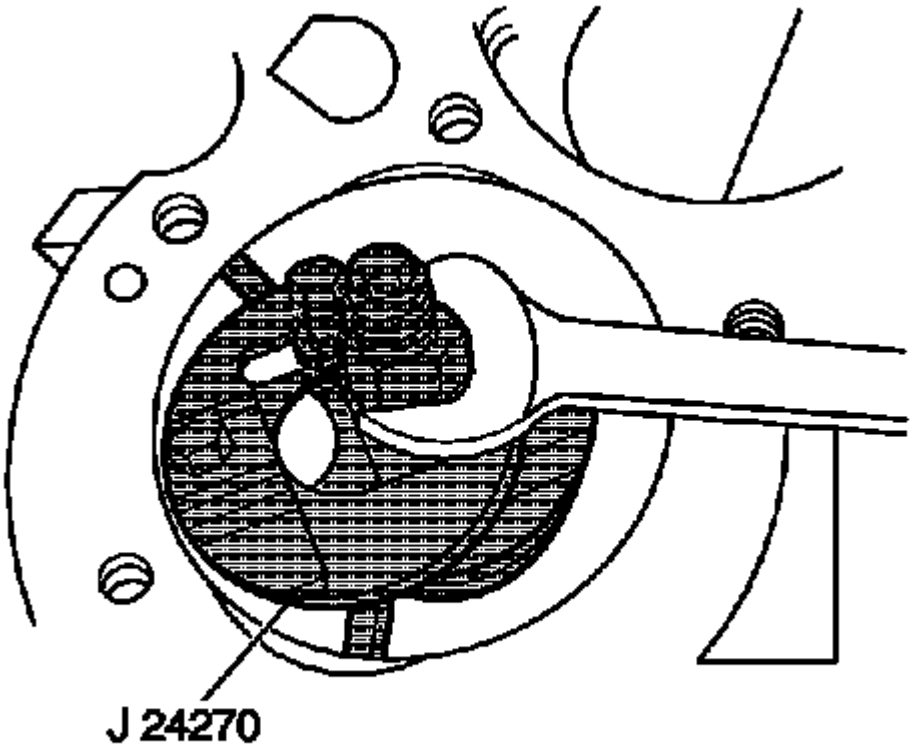

Fig. 432: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: 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** in order to remove the cylinder bore ring ridge. See **Special Tools**. 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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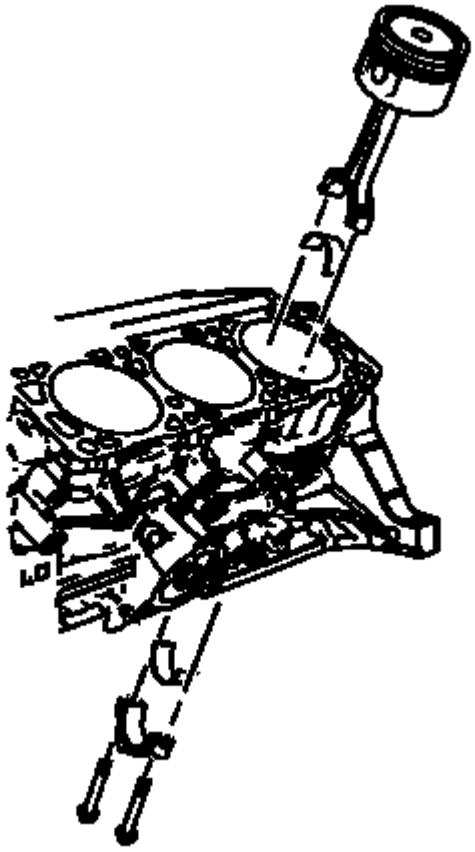

Fig. 433: Removing Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.
6. Remove the connecting rod bearing half.
7. Install **J 41556** into the connecting rod. See **Special Tools**.
8. Remove the connecting rod and piston assembly from the engine with a suitable tool.

Crankshaft Rear Oil Seal Removal

IMPORTANT: Do not nick the crankshaft sealing surface when removing the seal.

1. Remove crankshaft rear main oil seal using one of the following techniques:
   - Refer to step #2 for the removal of new style crankshaft rear main oil seal.
   - Refer to step #3 for the removal of old style crankshaft rear main oil seal.

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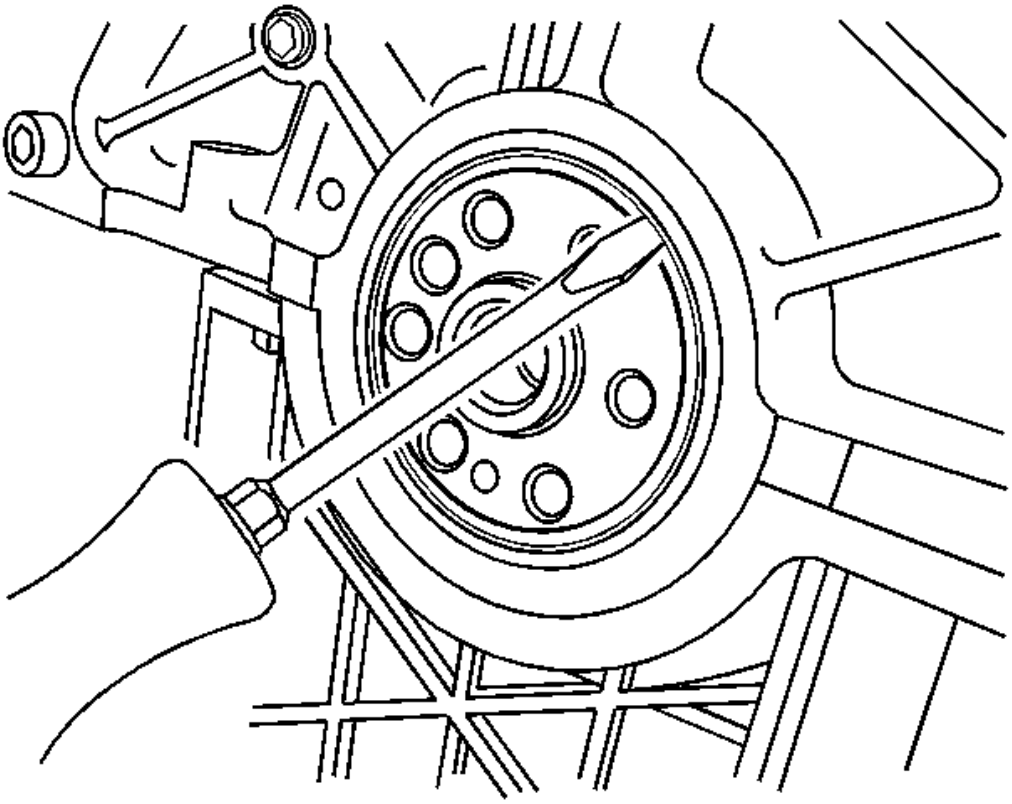

Fig. 434: View Of NEW Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

2. If removing a new style seal-seal lip is facing outward, insert a flat-bladed or similar tool between the sealing lip and the outer casing of the seal at an angle, and gently pry seal out by moving tool towards the center of the crankshaft.

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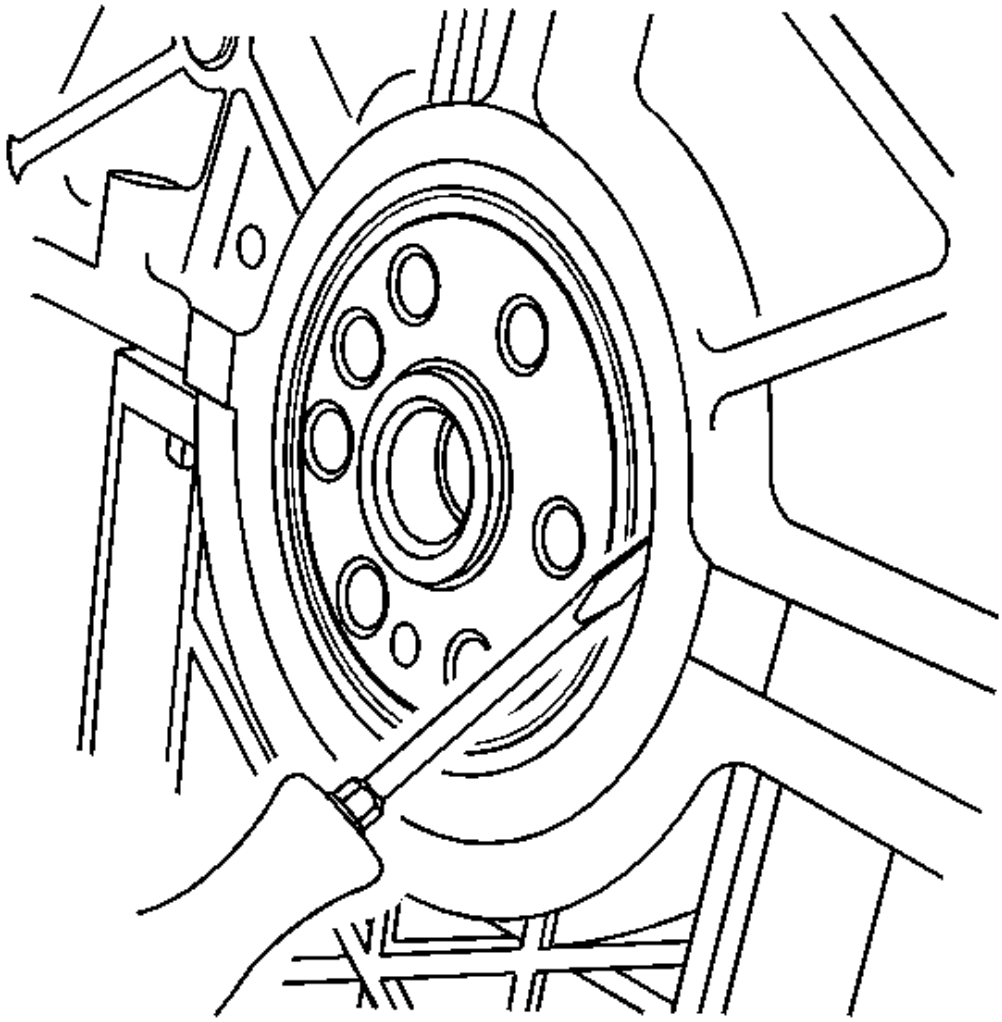

Fig. 435: View Of OLD Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. If removing an old style-seal lip faces inward, insert a flat-bladed or similar tool between the outer seal casing and the engine block casting and gently pry seal out.
4. Repeat above steps as necessary around the crankshaft rear oil seal, until the seal is removed.

Crankshaft and Bearings Removal

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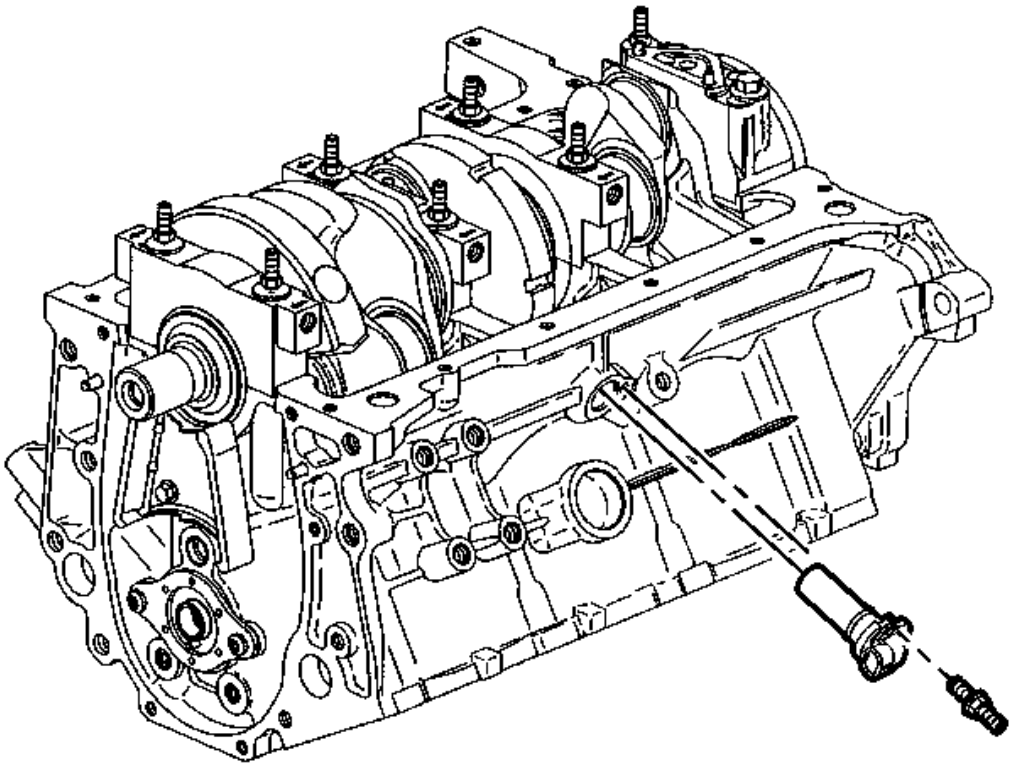

Fig. 436: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

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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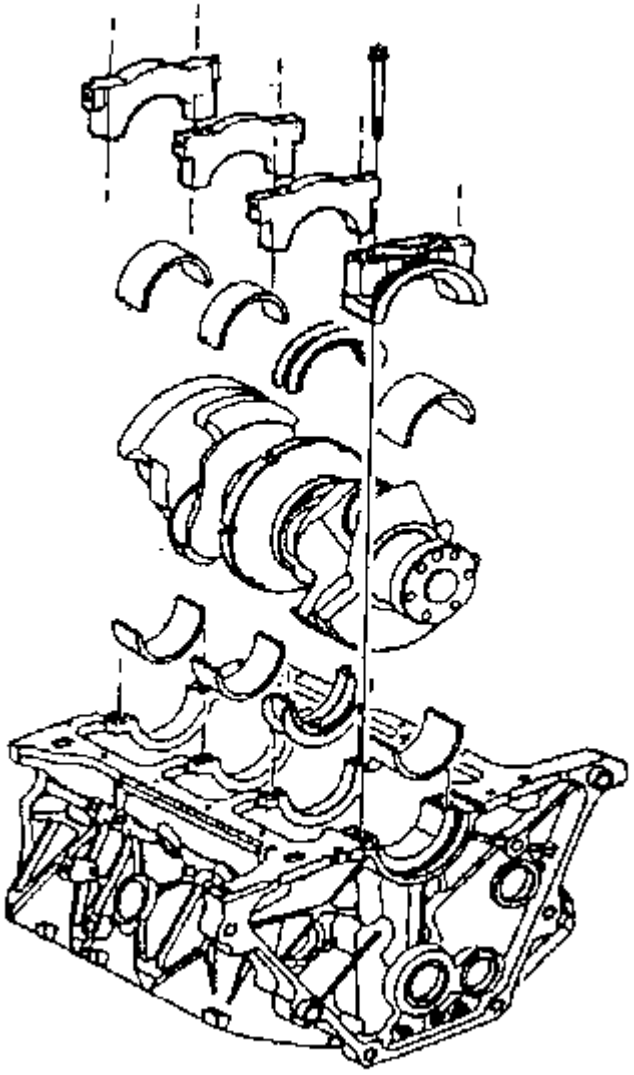

Fig. 437: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

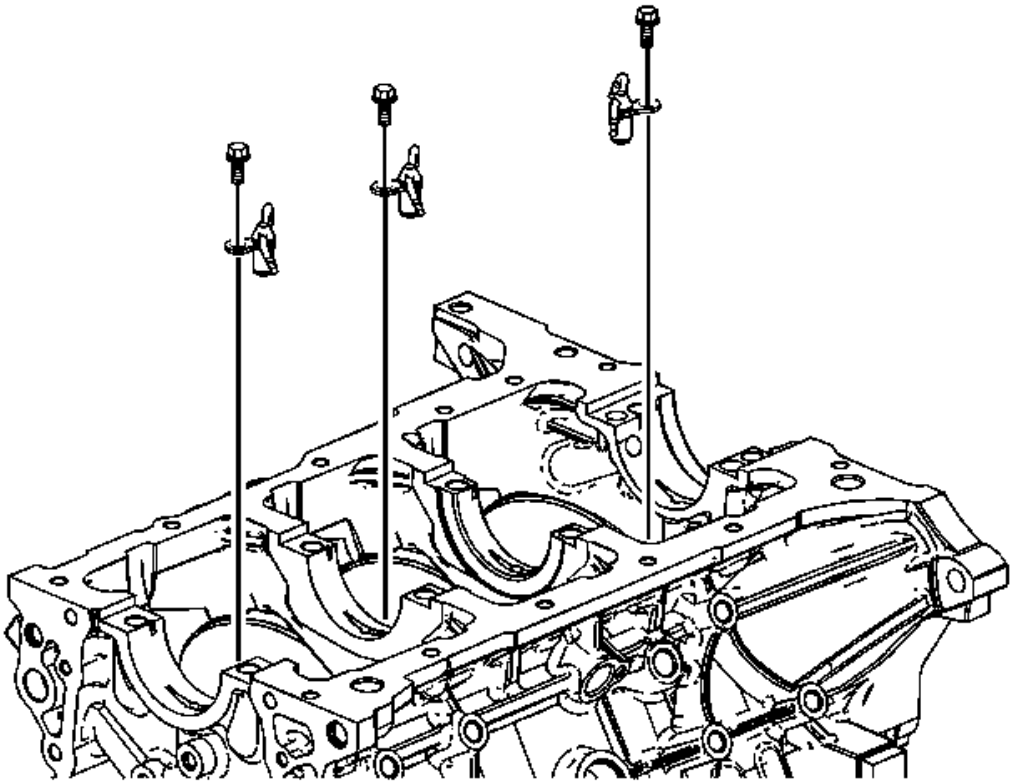

Fig. 438: Identifying Piston Oil Nozzles & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts retaining the piston oil nozzles to the engine block.
2. Remove the piston oil nozzles.

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**

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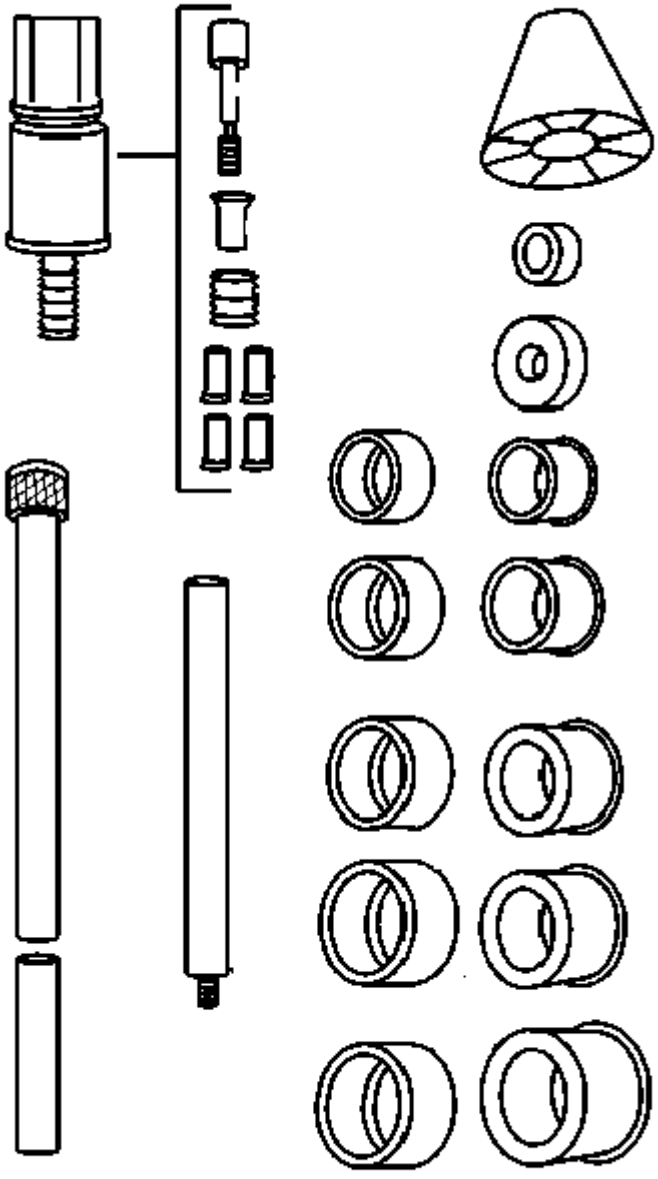

Fig. 439: Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

1. Select the expander assembly and driving washer.
2. Assemble the **J 33049** . See **Special Tools**.

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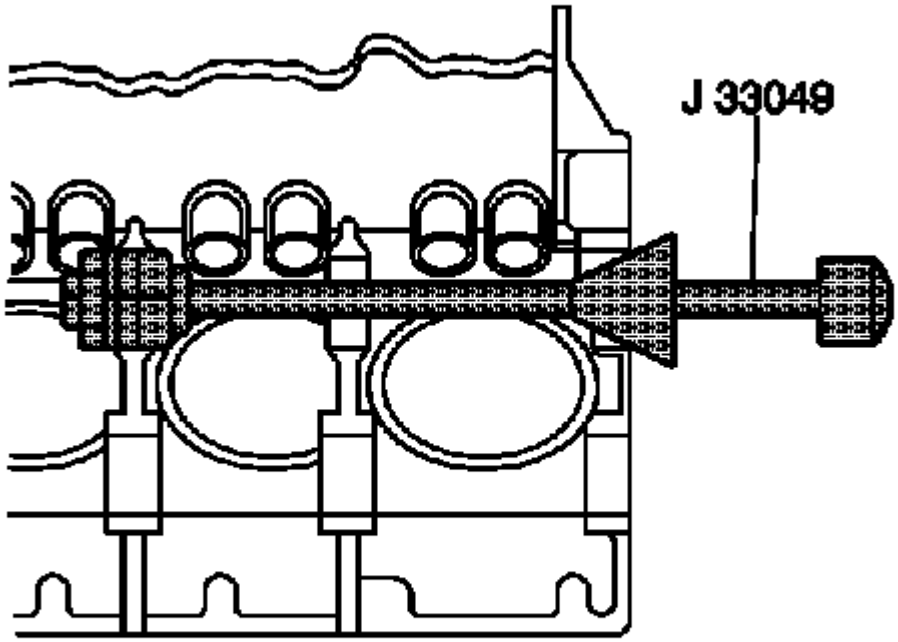

Fig. 440: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

3. Drive out the camshaft bearings. Use the **J 33049** . See **Special Tools**.

Engine Block Disassemble

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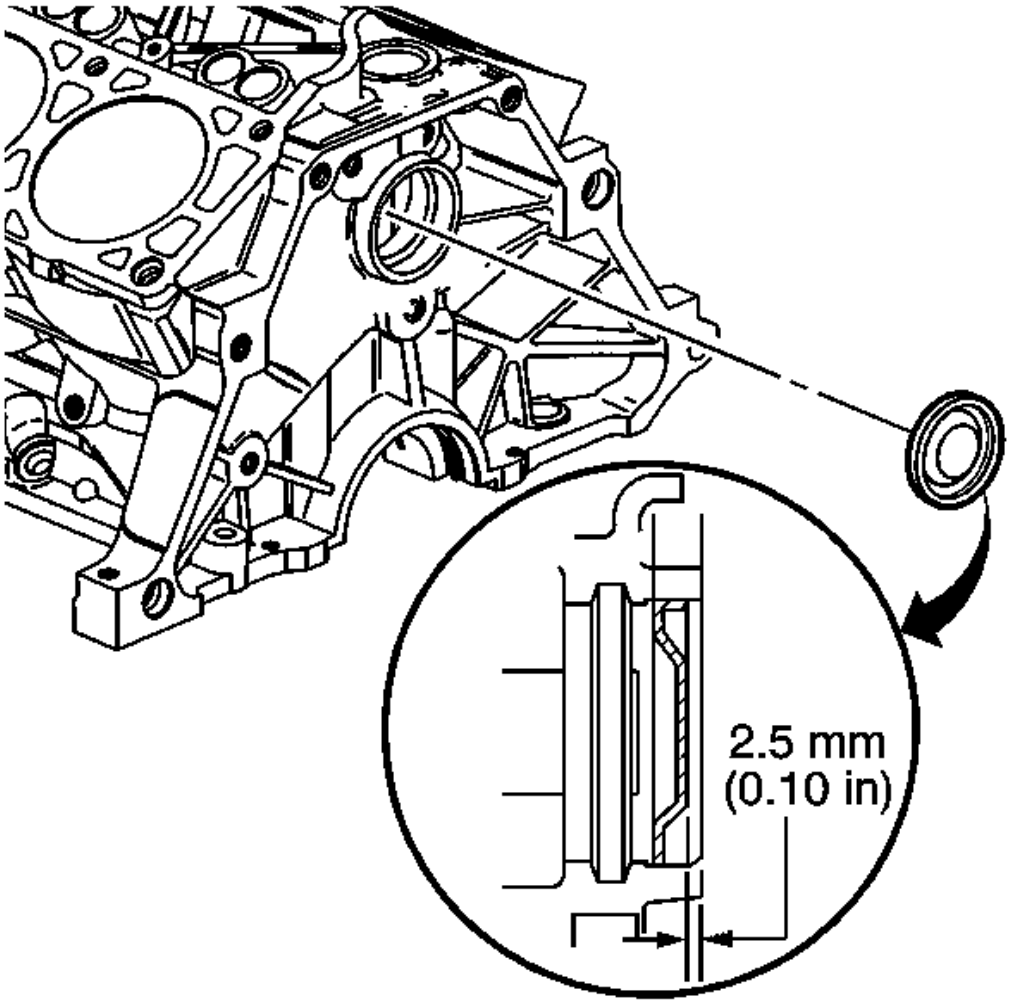

Fig. 441: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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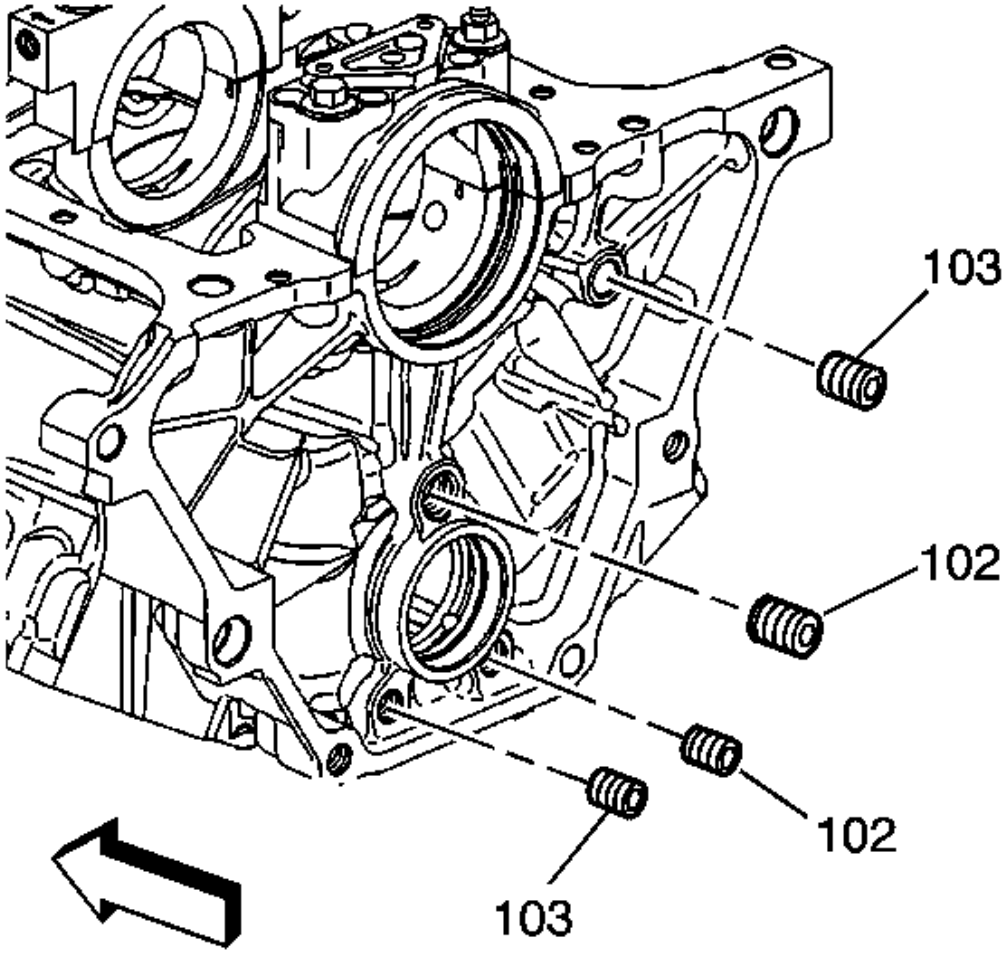

Fig. 442: Removing Rear Oil Gallery Plugs (102, 103)
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear oil gallery plugs (102, 103).

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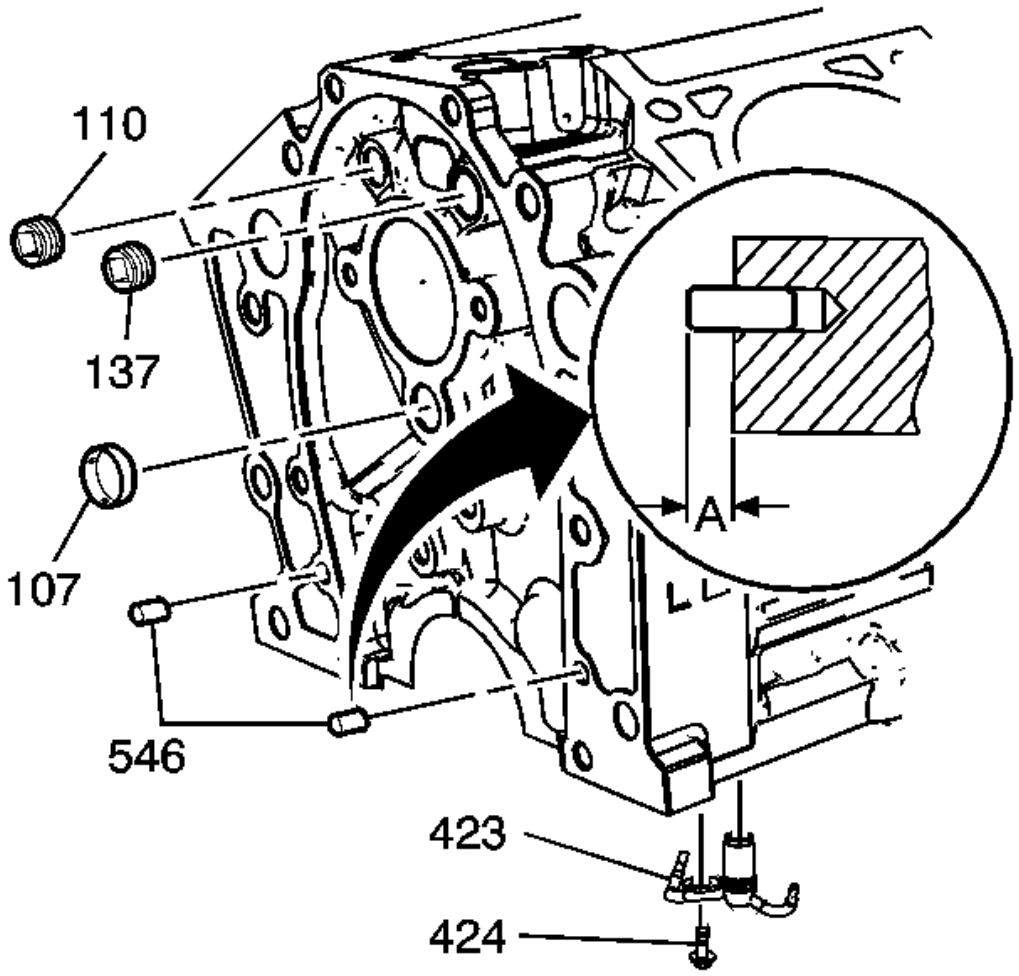

Fig. 443: Removing Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

3. Remove the front oil gallery plugs (107, 110, 137).
4. Remove the engine front cover locating pins (546).

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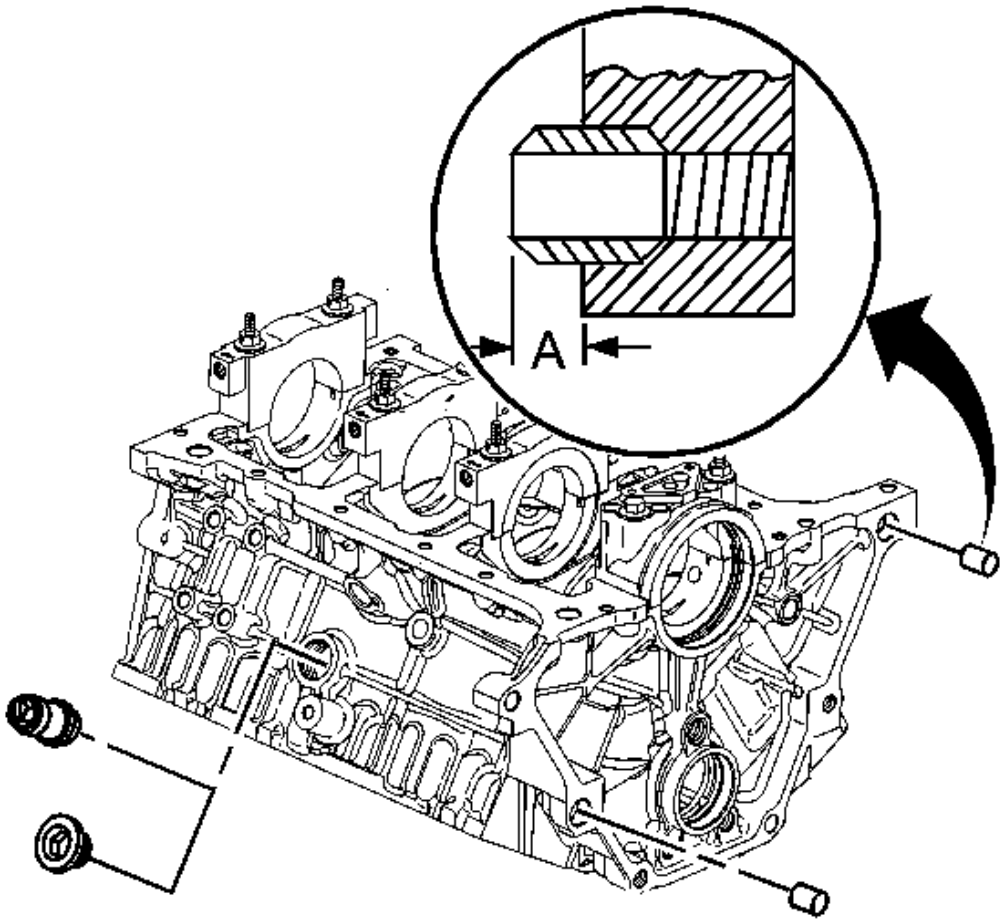

Fig. 444: Removing Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block plug.
6. Remove the transmission locating pins (A).

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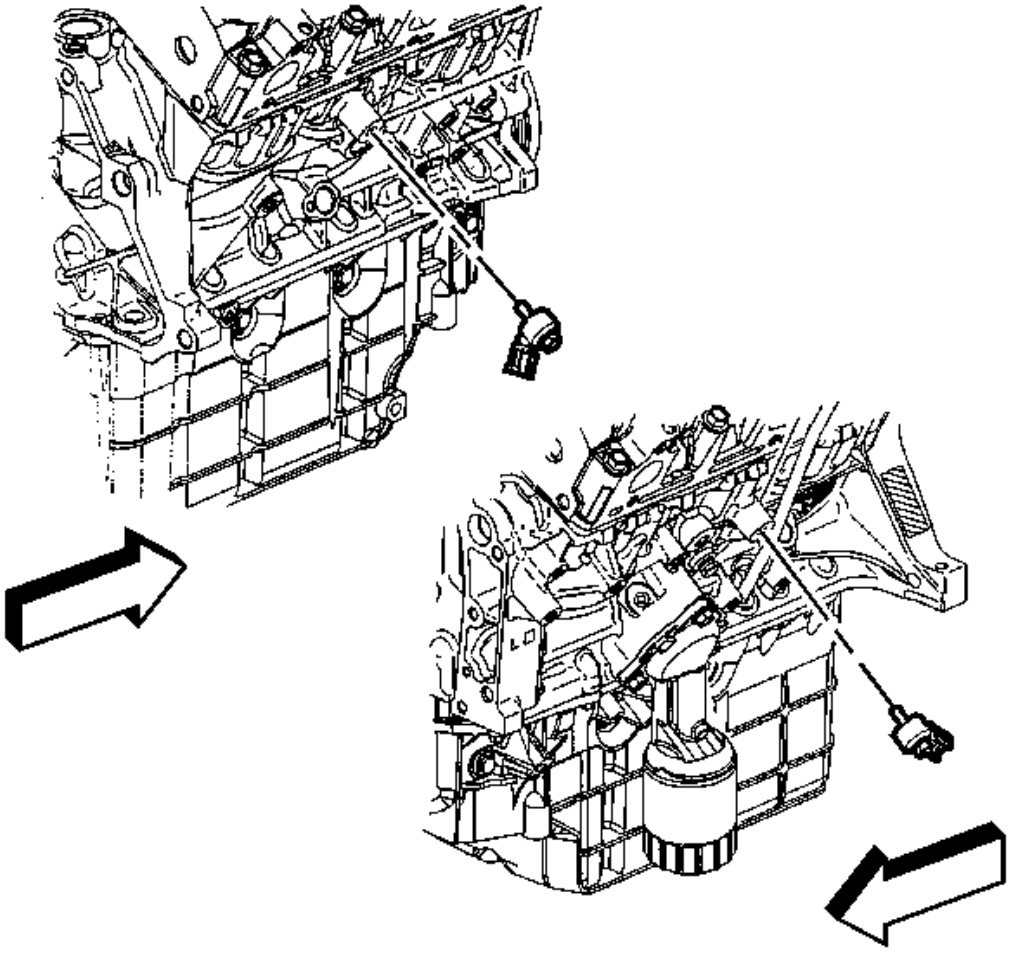

Fig. 445: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

7. Remove the knock sensors.

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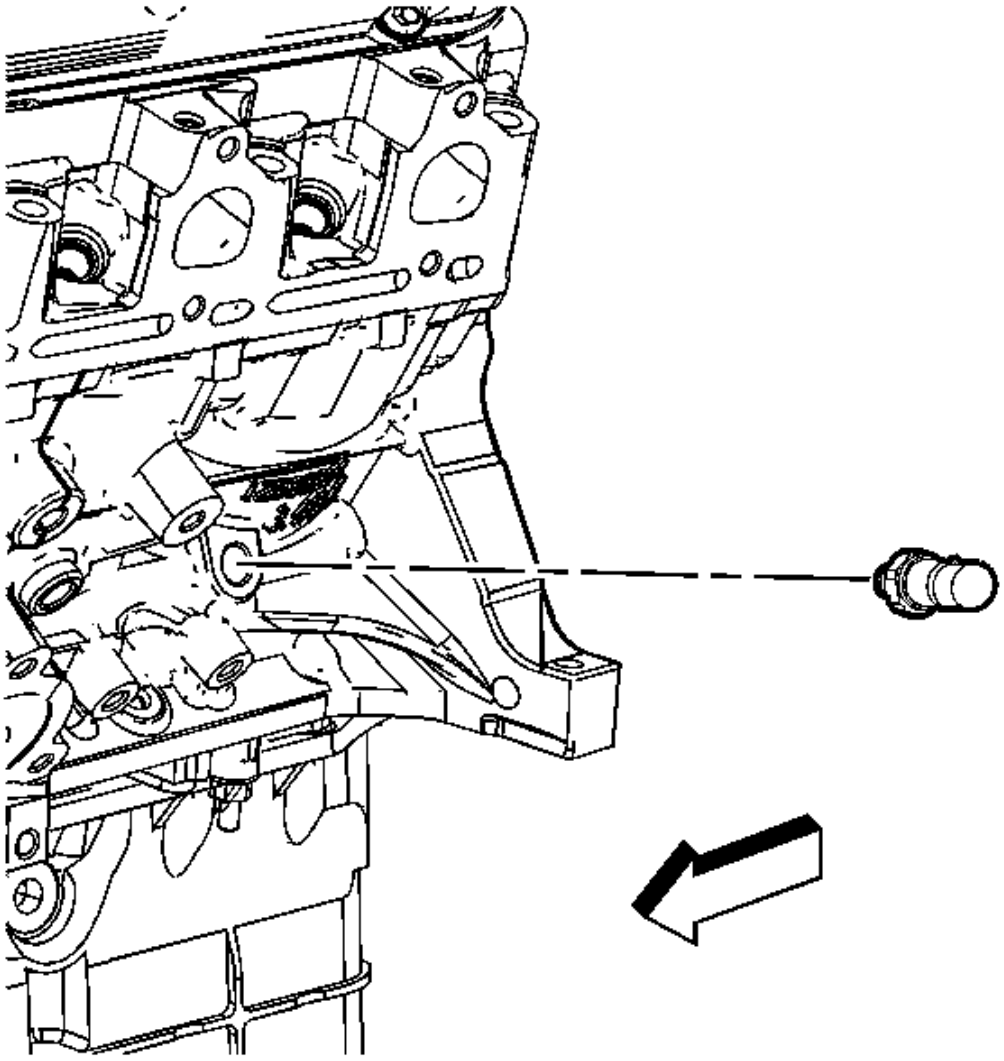

Fig. 446: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine oil pressure indicator switch.

Engine Block Heater Removal

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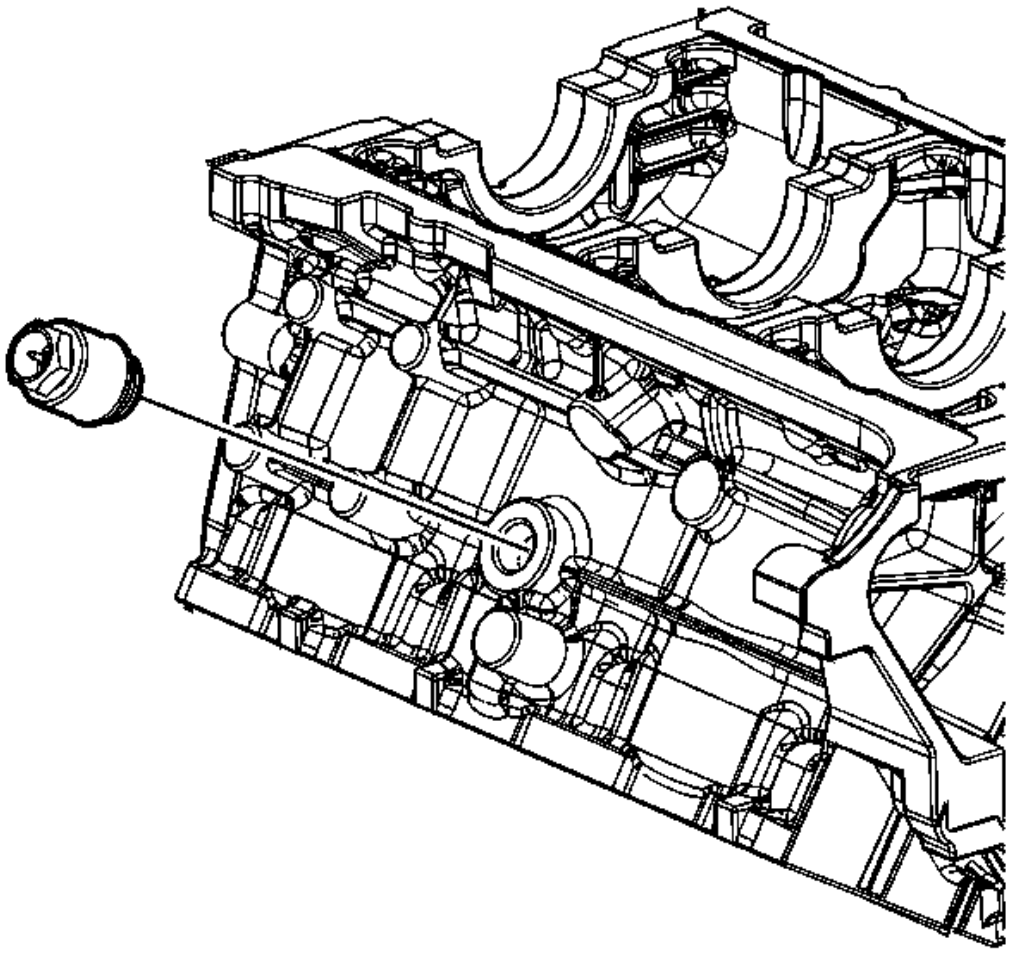

Fig. 447: View Of Engine Block Heater
Courtesy of GENERAL MOTORS CORP.

Remove the engine block heater from engine block.

Engine Block Cleaning and Inspection

Tools Required

- **J 8001** Dial Indicator Set. See **Special Tools**.
- **J 8087** Cylinder Bore Gage

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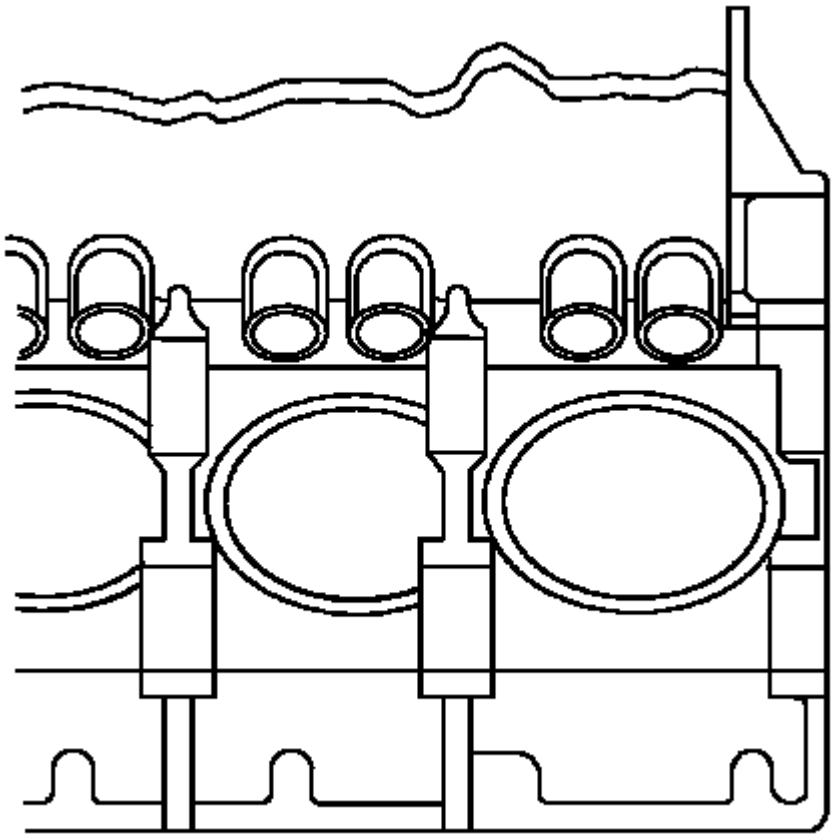

Fig. 448: View Of Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

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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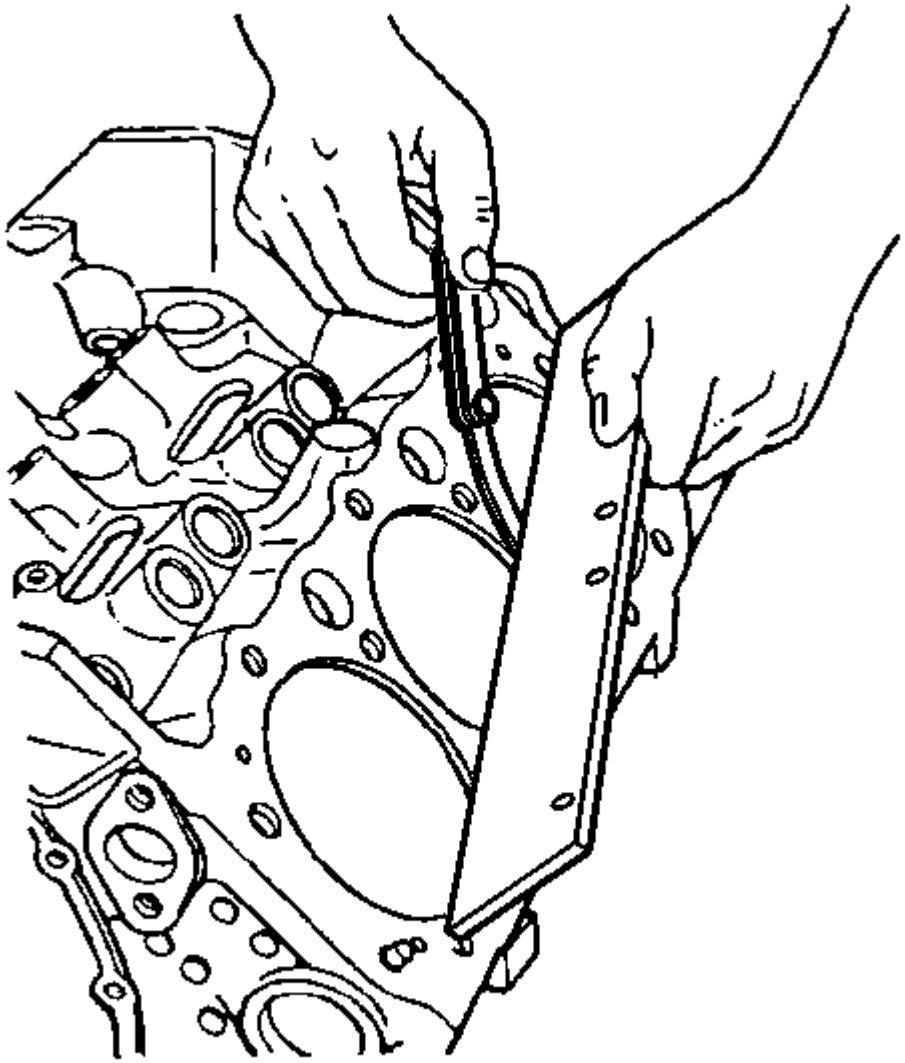

Fig. 449: Testing Block Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

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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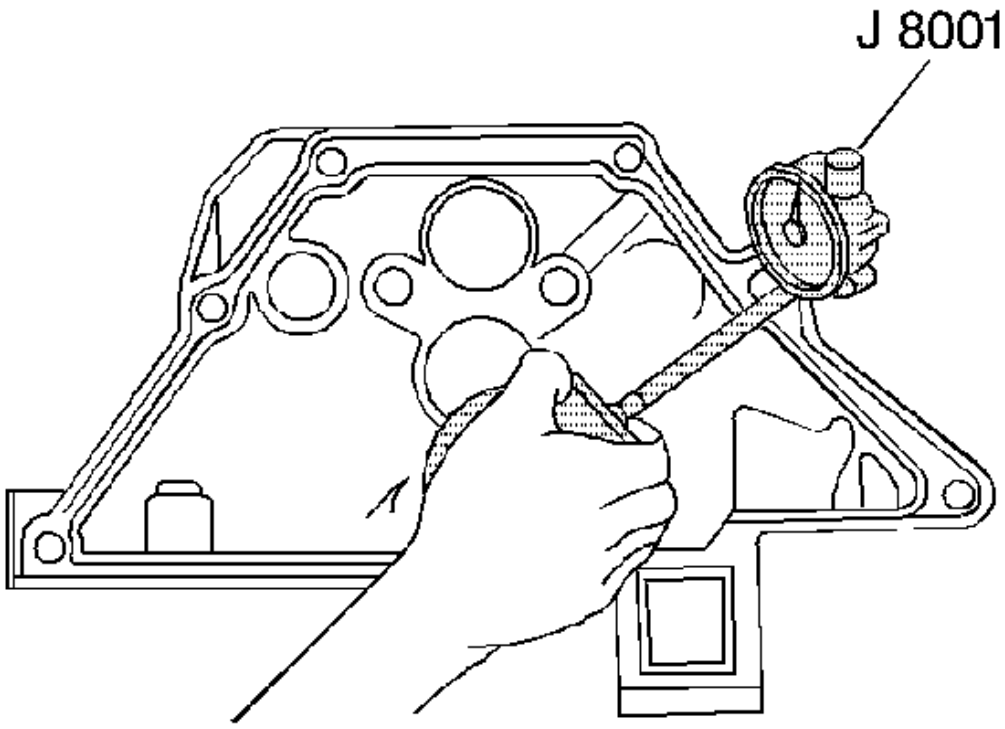

Fig. 450: Inspect Mating Surfaces Of Transmission Case
Courtesy of GENERAL MOTORS CORP.

12. Inspect the mating surfaces of the transmission case.

NOTE: 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** gage plate flat against the crankshaft flange. See **Special Tools**.
    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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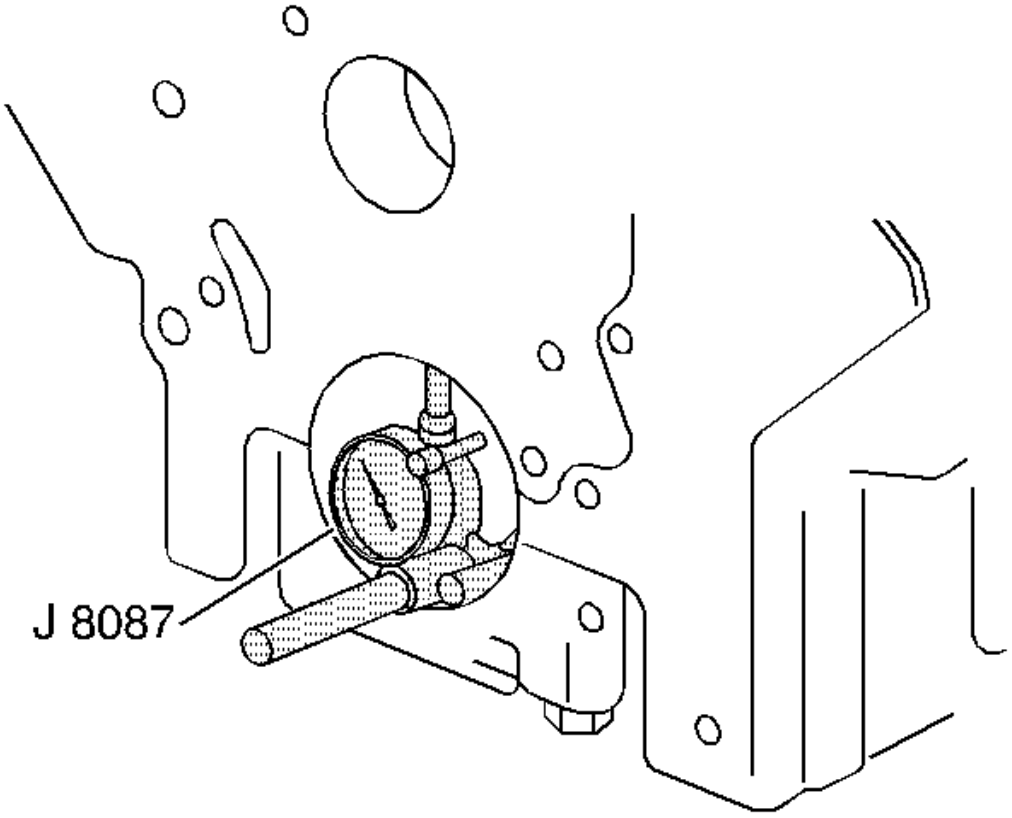

Fig. 451: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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** 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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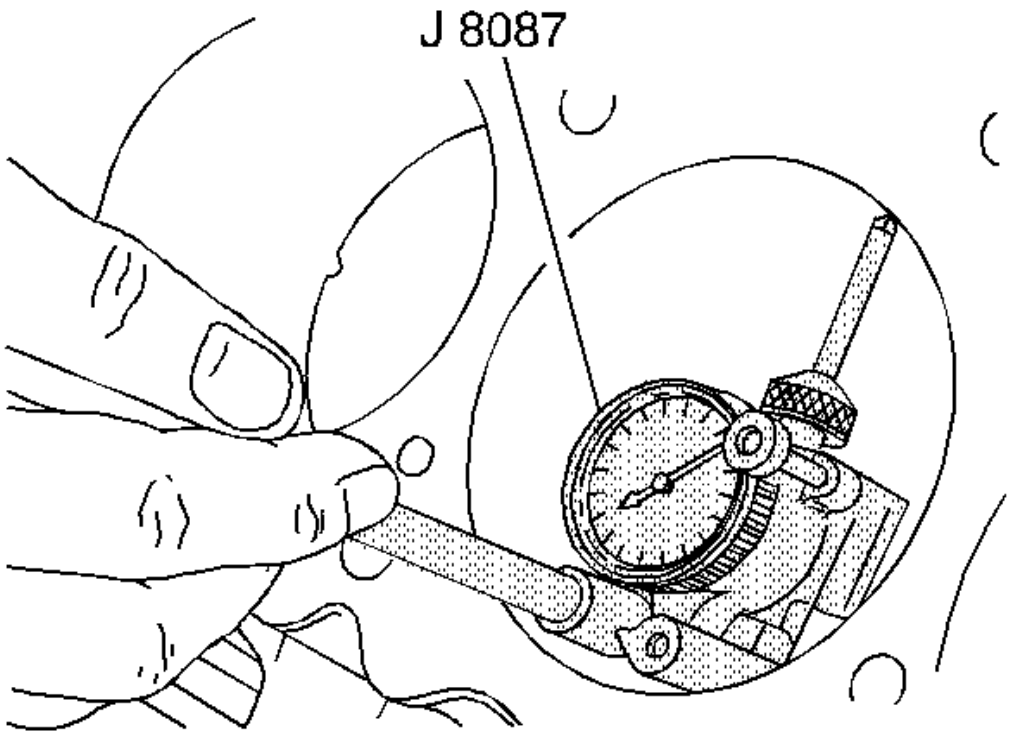

Fig. 452: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

16. Use the **J 8087** in order to inspect the cylinder bores. Inspect the bores for the following conditions:
    - Wear
    - Taper
    - Runout
    - Ridging

IMPORTANT: 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

1. Before honing or boring, measure all of the new pistons. Select the smallest piston for the piston fitting.

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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.

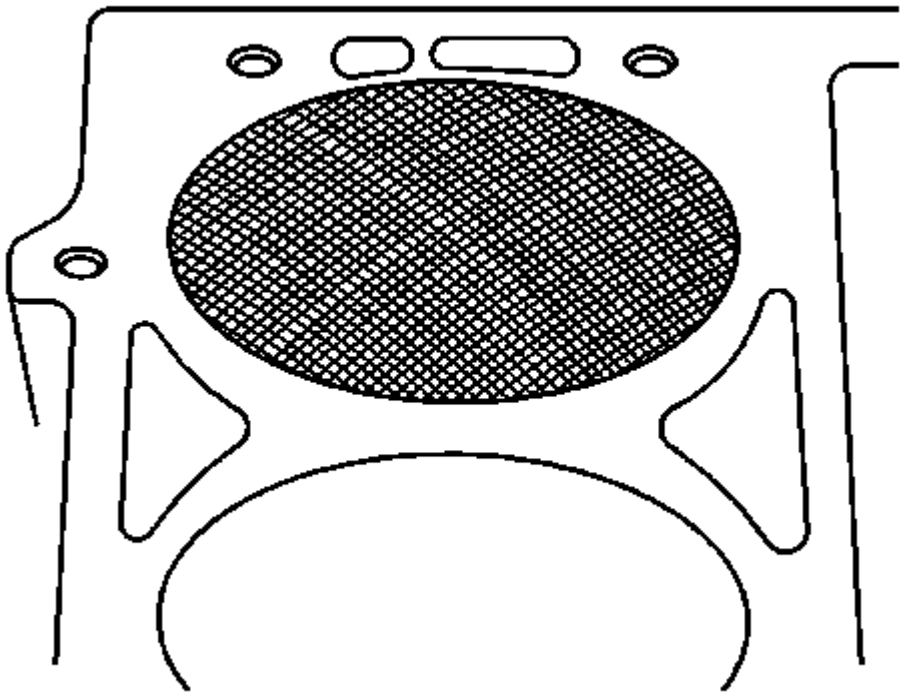

Fig. 453: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

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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.

NOTE: 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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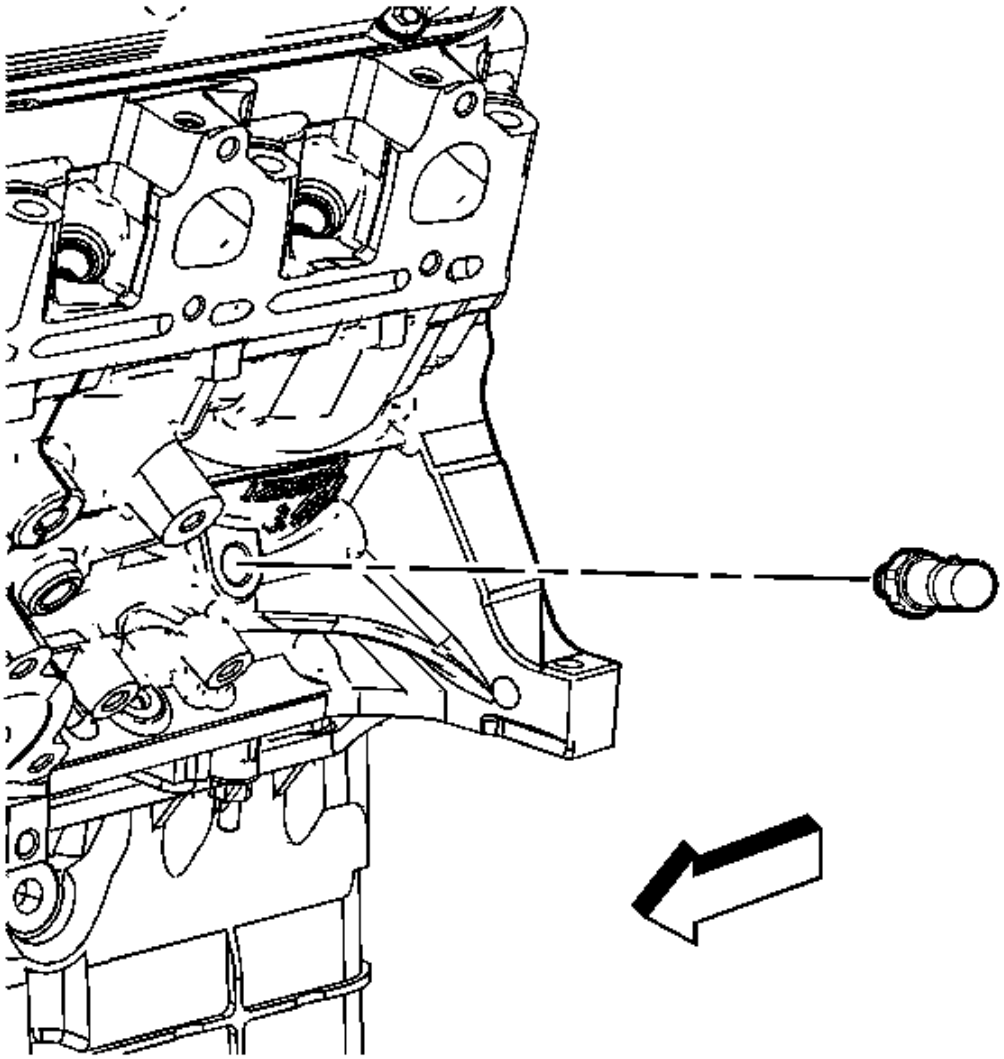

Fig. 454: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the oil pressure switch threads.

NOTE: Refer to Fastener Notice .

2. Install the engine oil pressure switch.

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Tighten: Tighten the engine oil pressure switch to 16 N.m (12 lb ft).

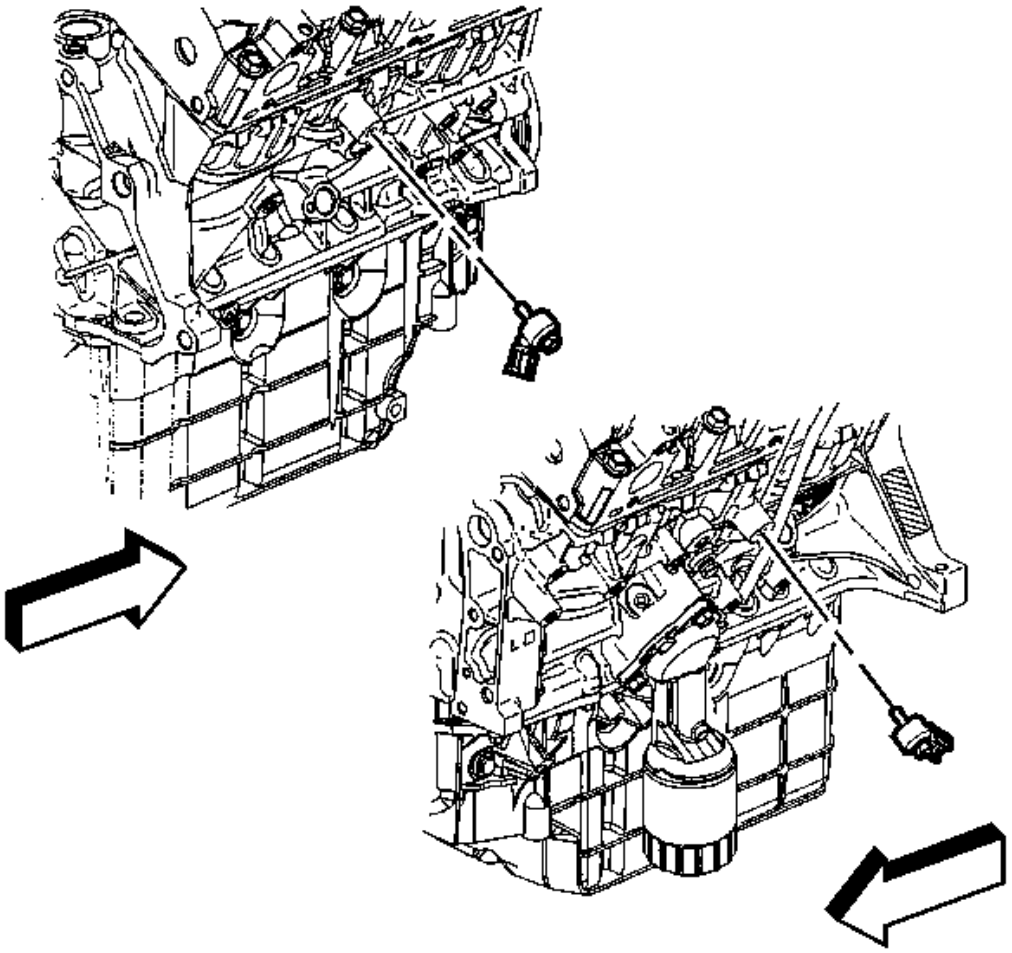

Fig. 455: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

3. Install the knock sensors.

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

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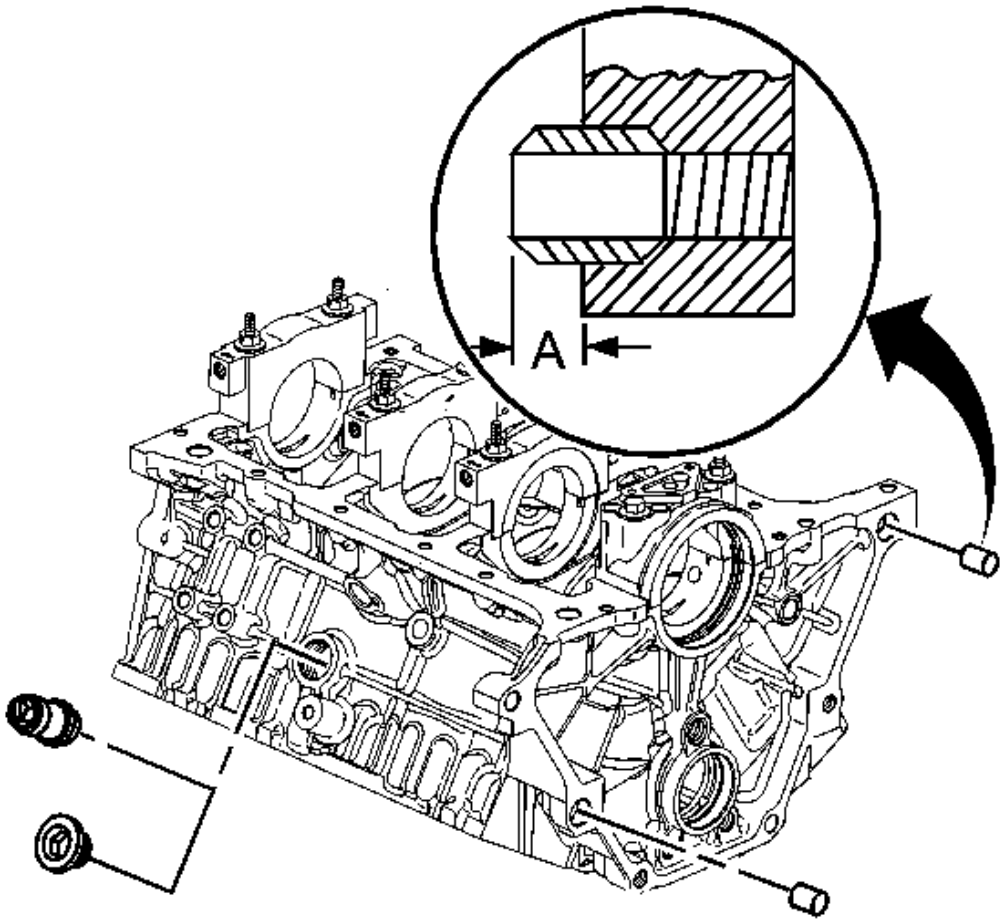

Fig. 456: Removing Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

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.

   Tighten: Tighten the engine block plug 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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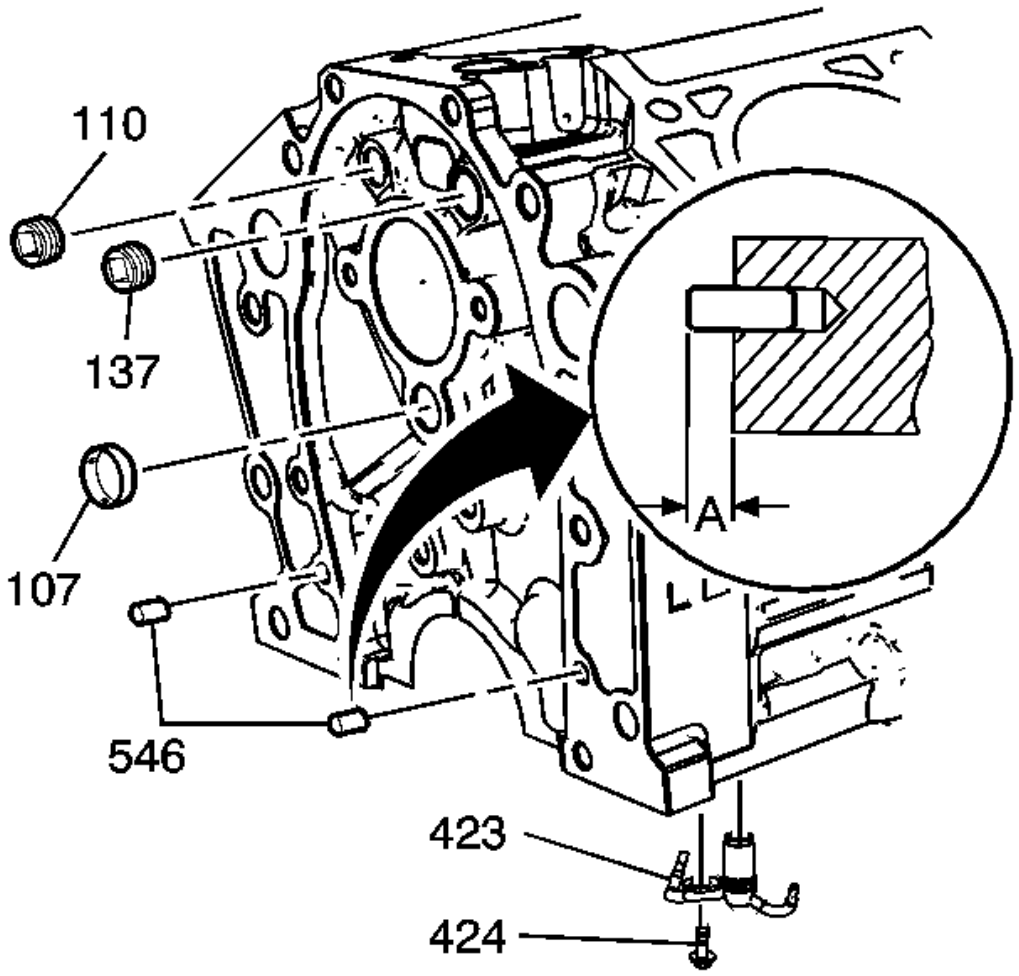

Fig. 457: Removing Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

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).

   Tighten: Tighten the front oil gallery plug to 19 N.m (14 lb ft).

9. Install the front oil gallery plug (137).

   Tighten: Tighten the front oil gallery plug to 33 N.m (24 lb ft).

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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).

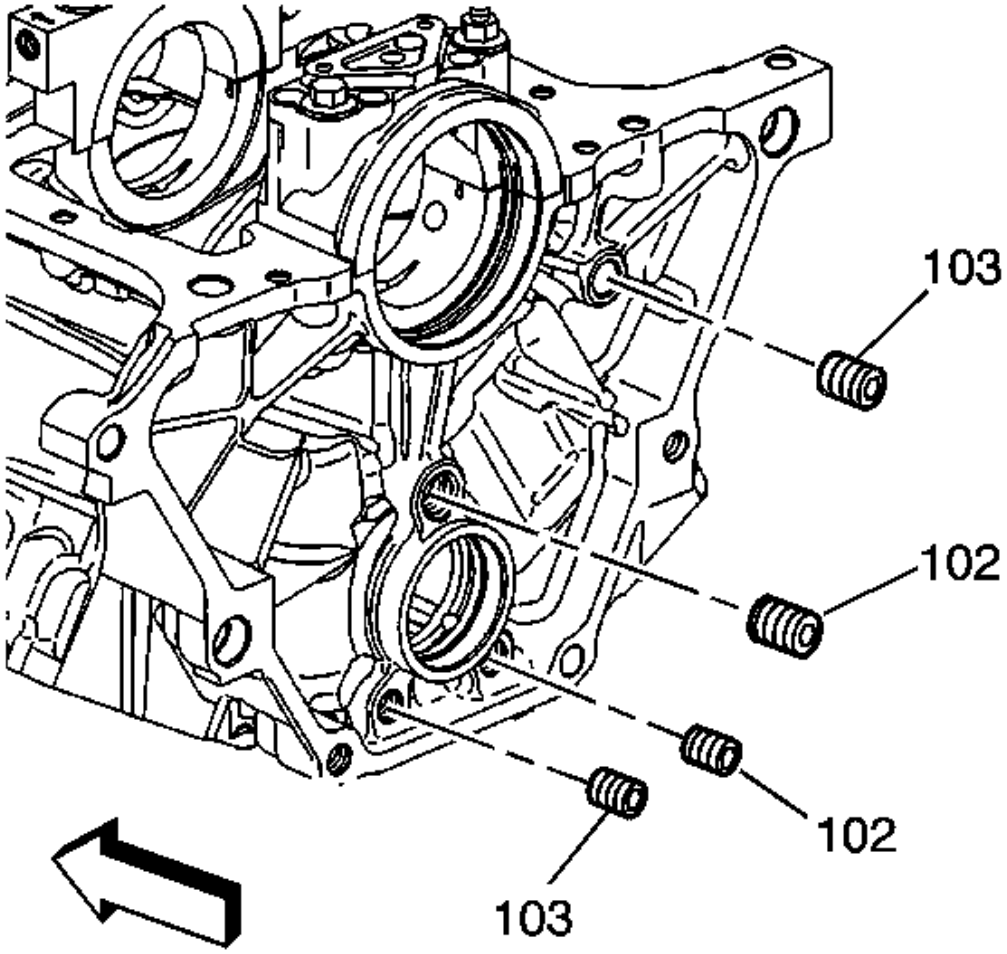

Fig. 458: Removing Rear Oil Gallery Plugs (102, 103)
Courtesy of GENERAL MOTORS CORP.

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).

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Tighten: Tighten the rear oil gallery plugs to 19 N.m (14 lb ft).

15. Install the rear oil gallery plugs (102).

    Tighten: Tighten the rear oil gallery plugs to 33 N.m (24 lb ft).

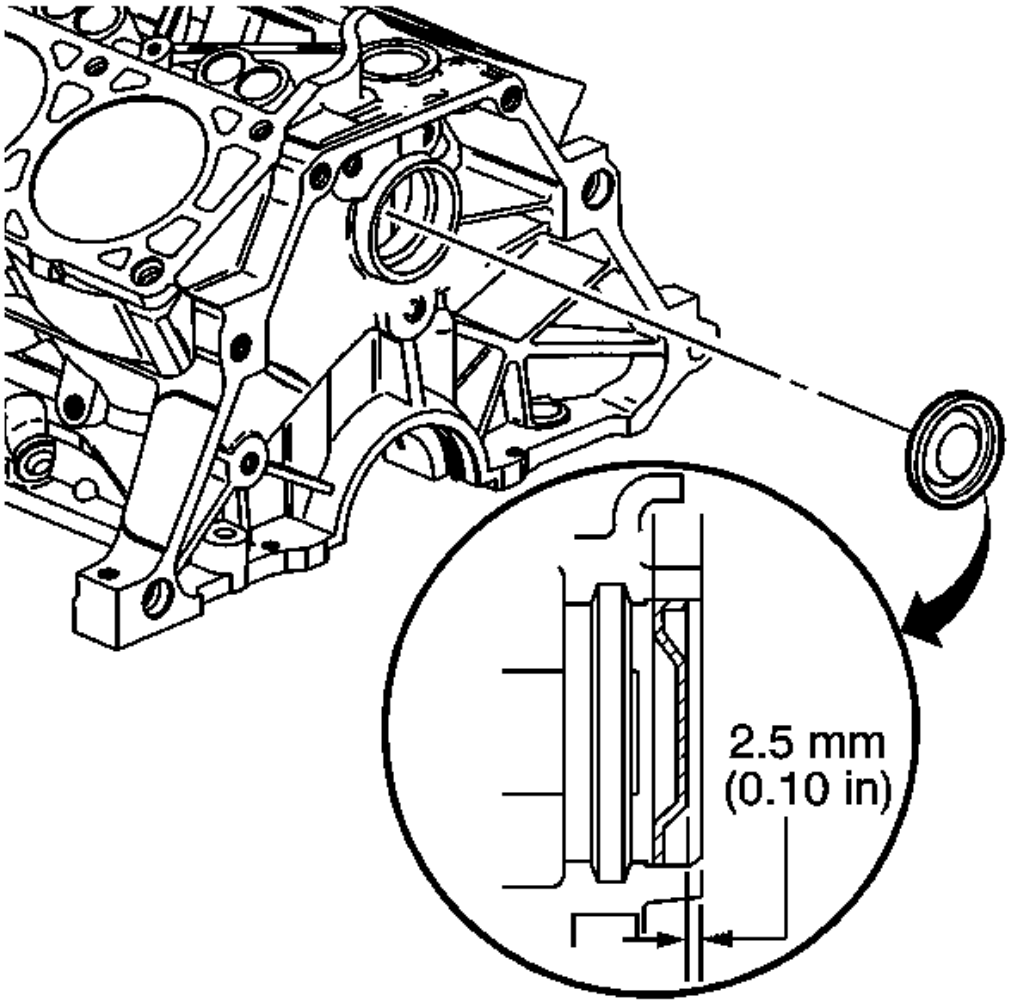

Fig. 459: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

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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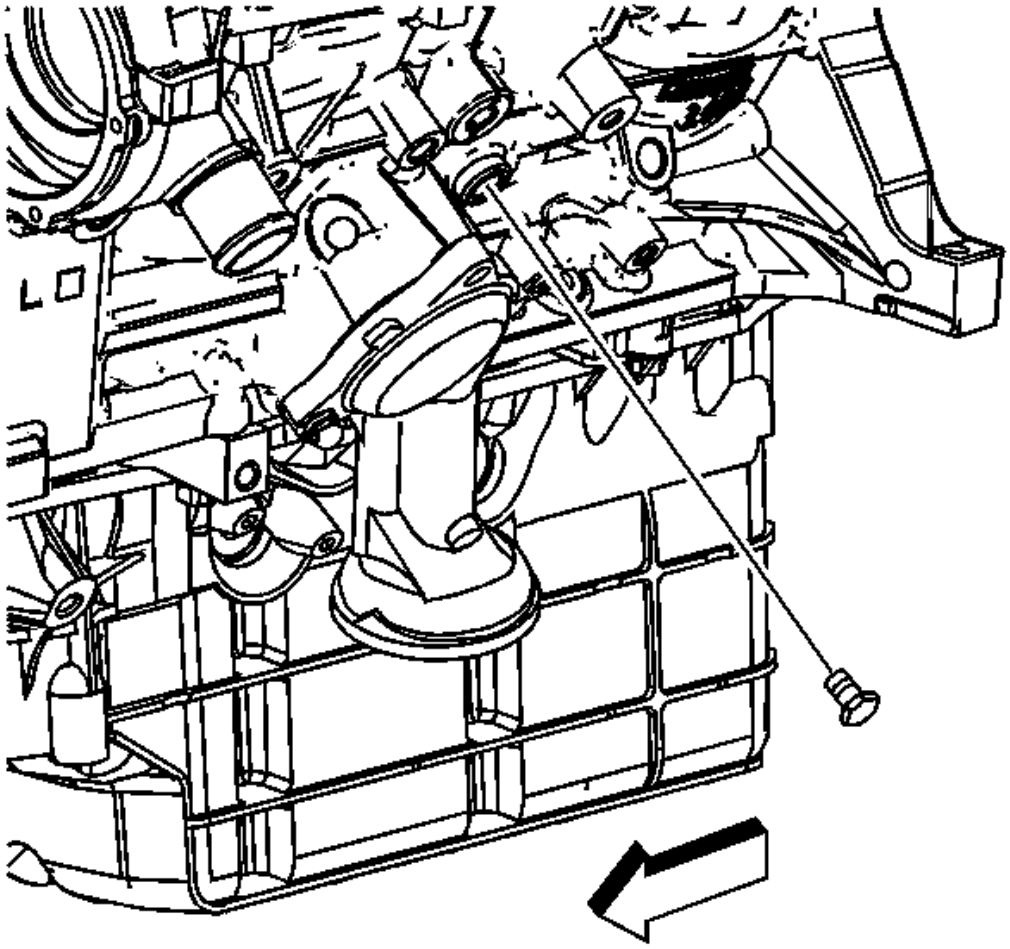

Fig. 460: Removing Coolant Drain Plug From Left Side
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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Tighten: Tighten the left coolant drain plug to 19 N.m (14 lb ft).

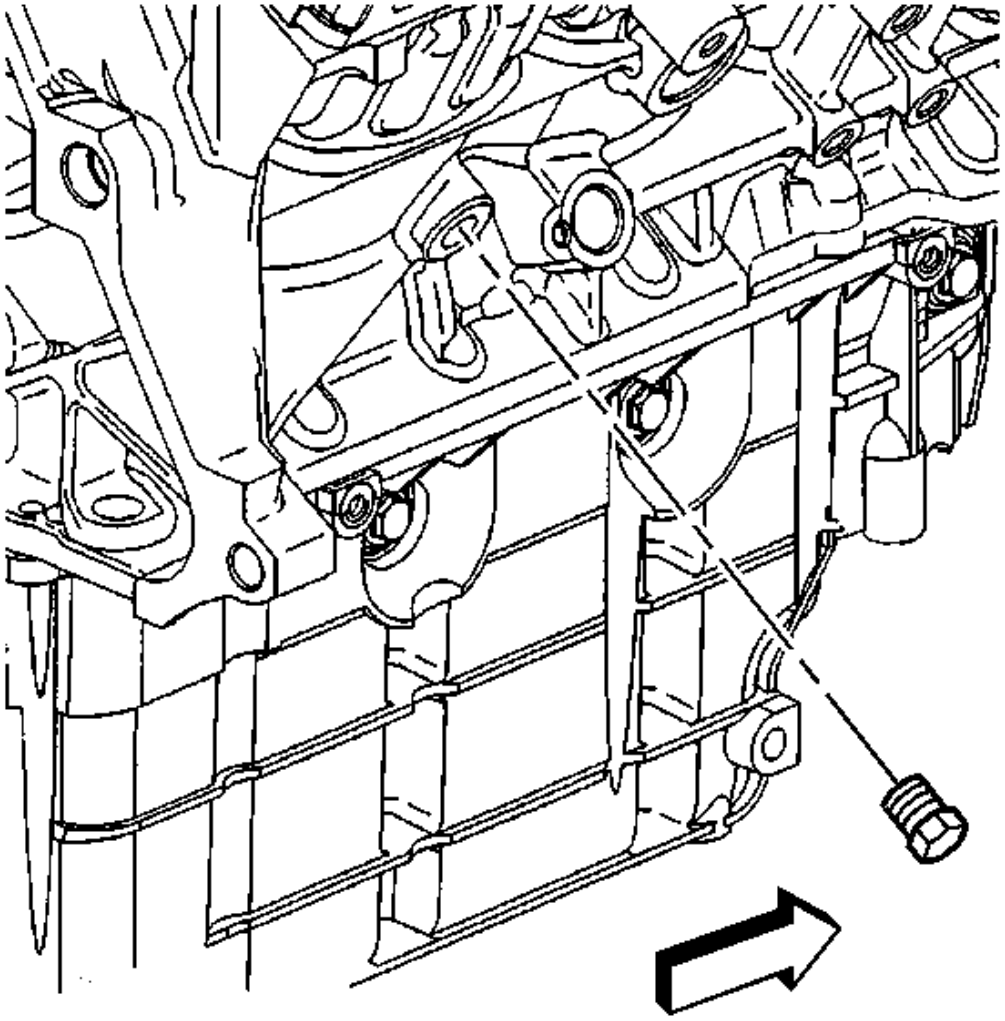

Fig. 461: Removing Coolant Drain Plug From Right Side
Courtesy of GENERAL MOTORS CORP.

20. Install the right coolant drain plug.

    Tighten: Tighten the right coolant drain plug to 19 N.m (14 lb ft).

Engine Block Heater Installation

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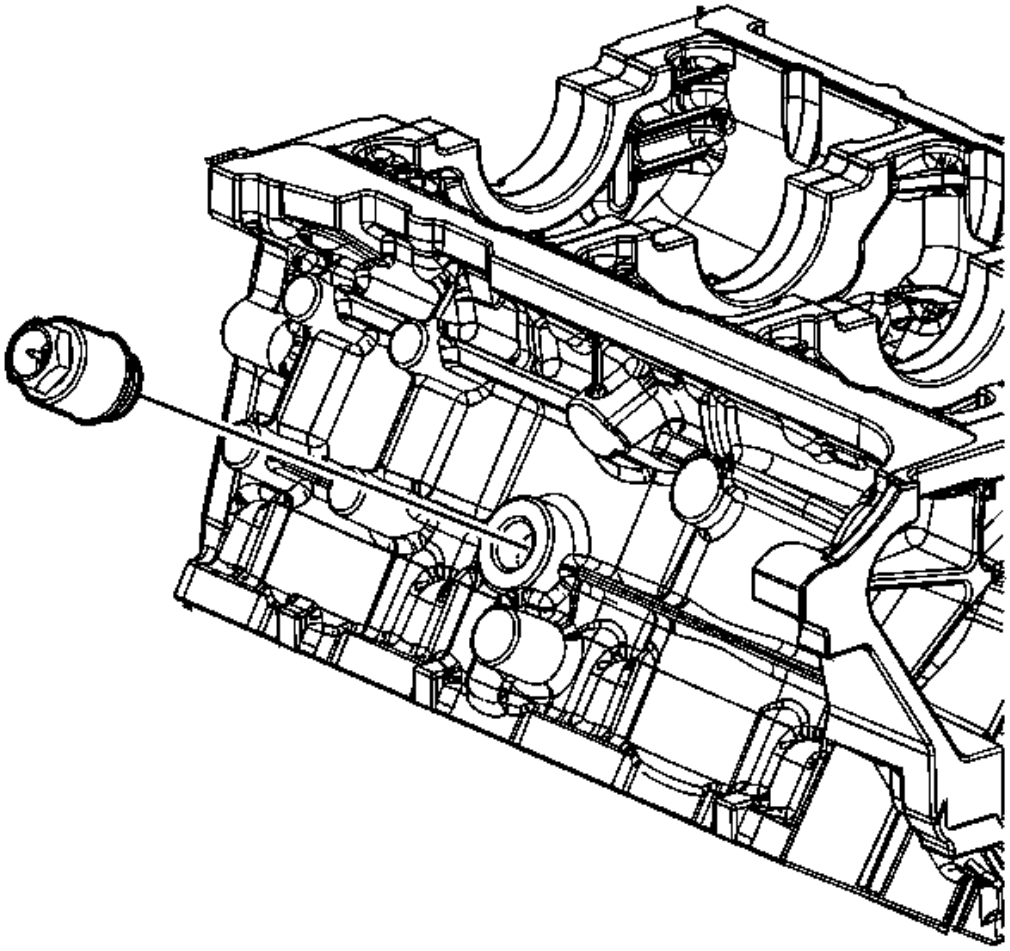

Fig. 462: View Of Engine Block Heater
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004 (Canadian P/N 1095380), or equivalent to the engine block heater.

NOTE: **Refer to Fastener Notice .**

2. Install the engine block heater into the engine block.

Tighten: Tighten engine block heater to 50 N.m (37 lb ft).

Piston Oil Nozzle Cleaning and Inspection

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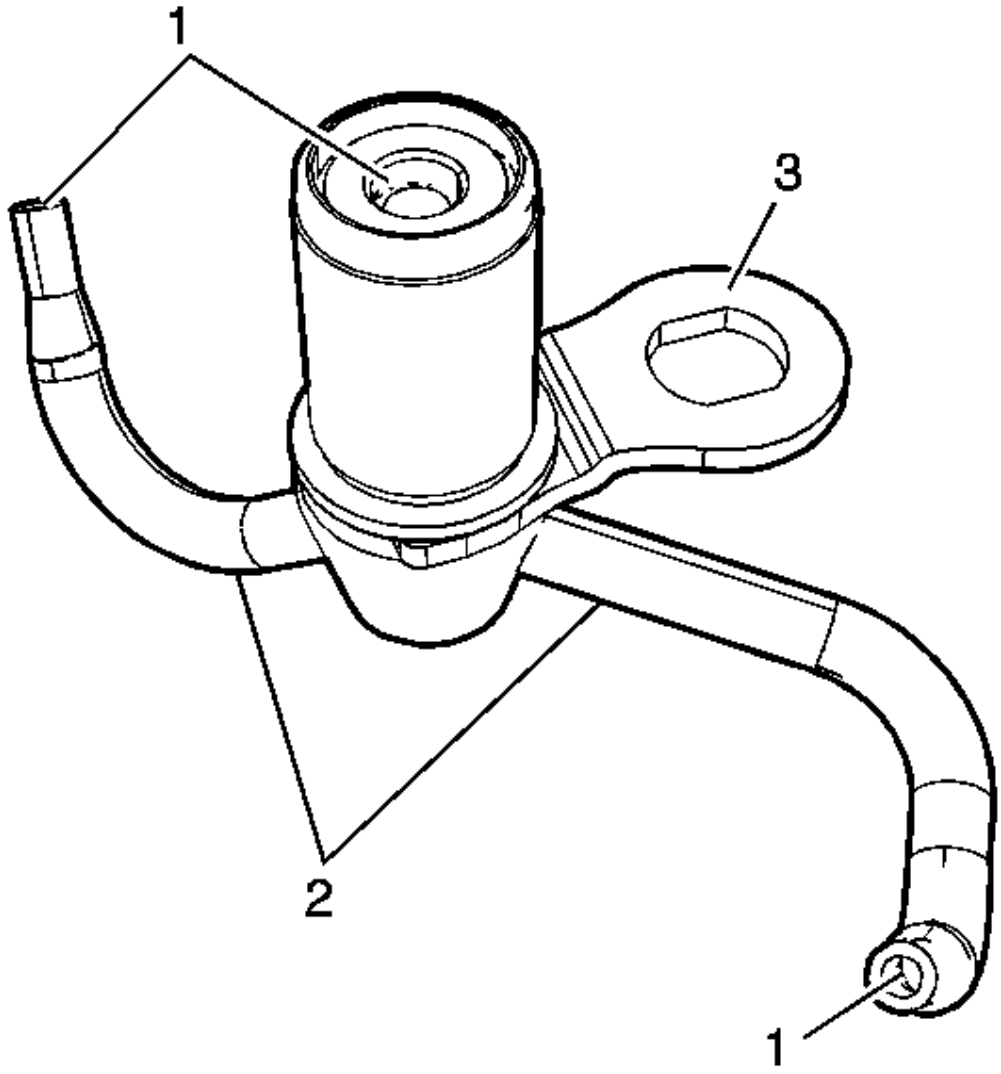

Fig. 463: Inspecting Piston Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution .

1. Clean the piston oil nozzle in cleaning solvent using GM P/N 10953463 (Canadian P/N 88901148) or equivalent.

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CAUTION: 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 Bearings Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

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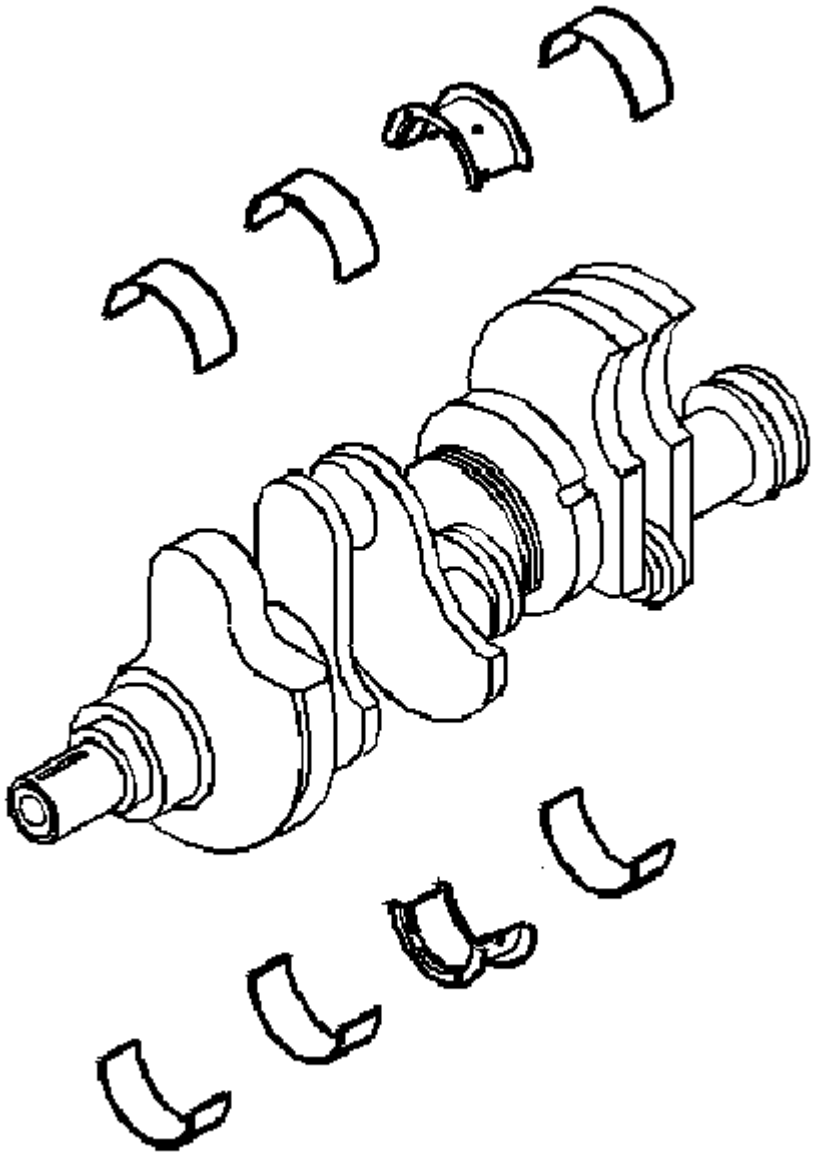

Fig. 464: View Of Crankshaft & Bearings
Courtesy of GENERAL MOTORS CORP.

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) 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.

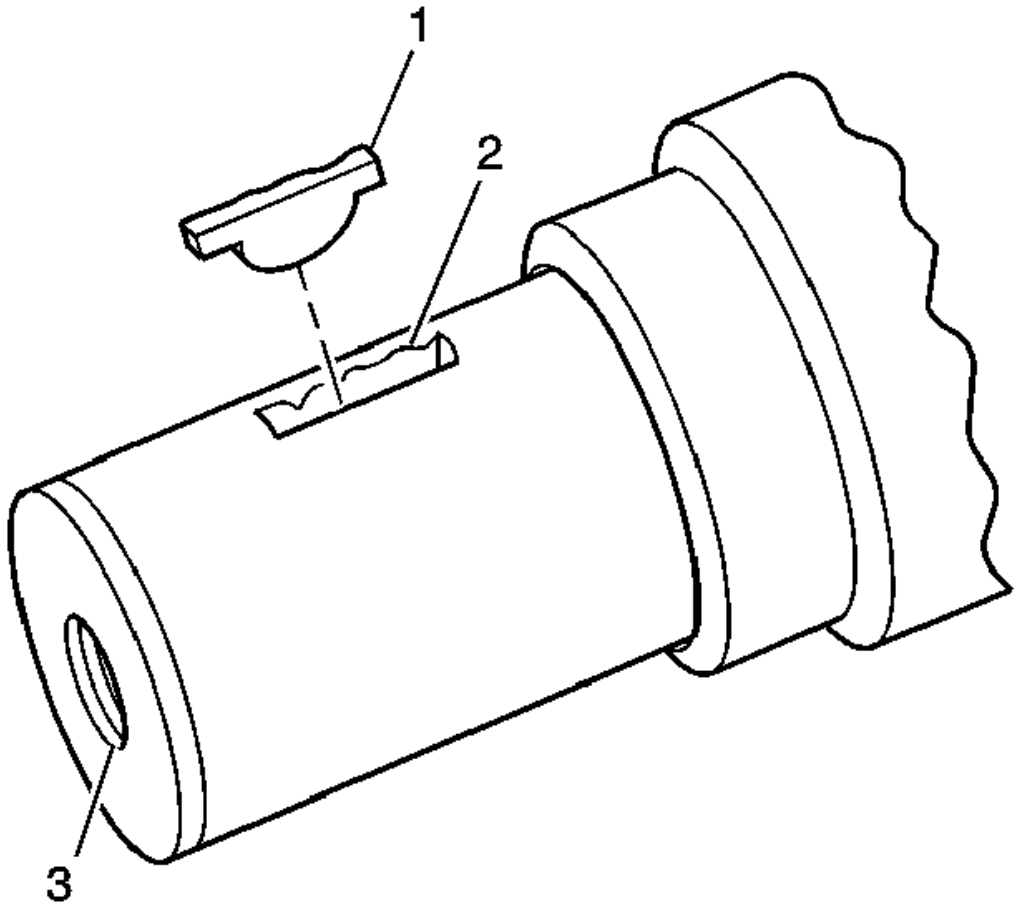

Fig. 465: Inspecting Crankshaft Keyway
Courtesy of GENERAL MOTORS CORP.

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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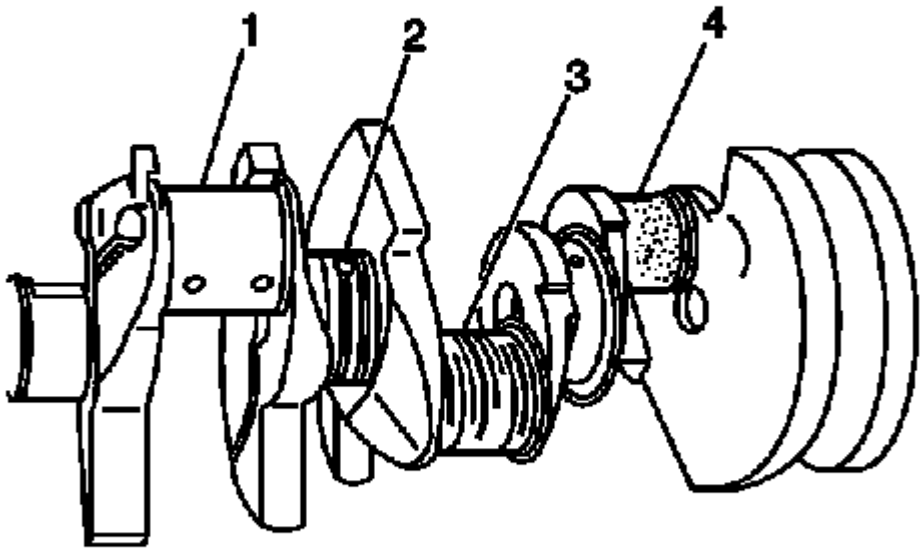

Fig. 466: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If cracks, severe gouges or burned spots are found, replace the crankshaft. Remove slight roughness using a fine polishing cloth soaked in clean engine oil. Remove any burrs using a fine oil stone.

5. Inspect the 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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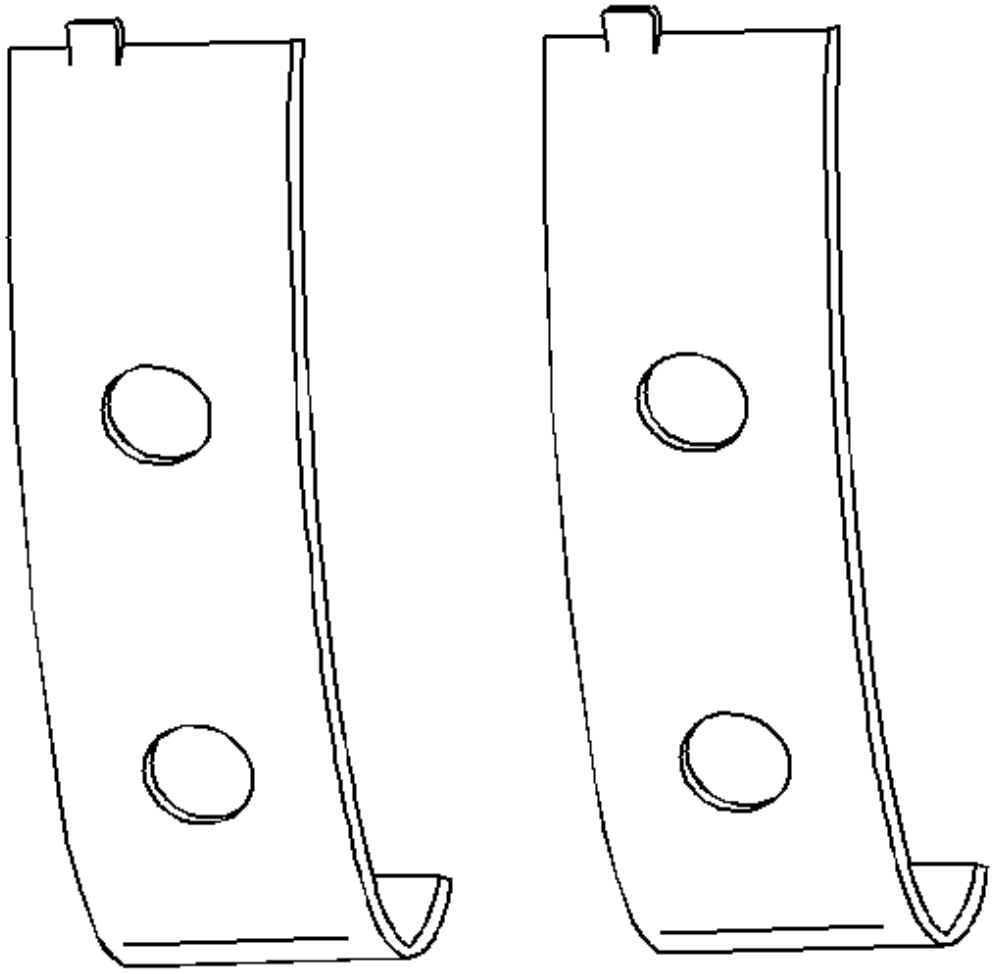

Fig. 467: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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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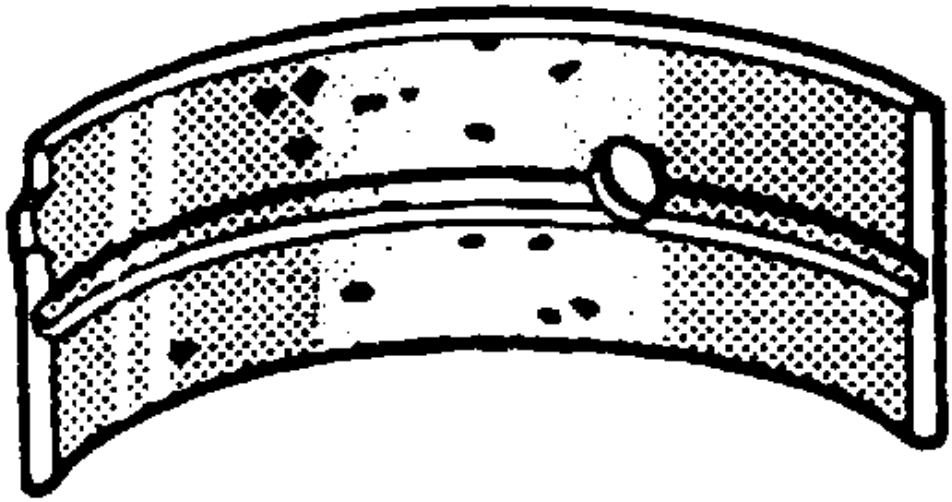

Fig. 468: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the location of the crankshaft main bearing high spots. If the spots are not in line, the crankshaft is bent. Replace the crankshaft.

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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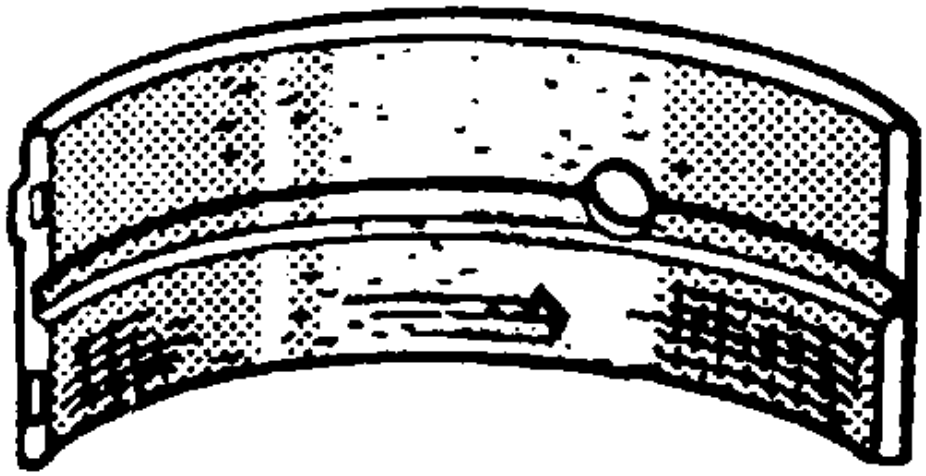

Fig. 469: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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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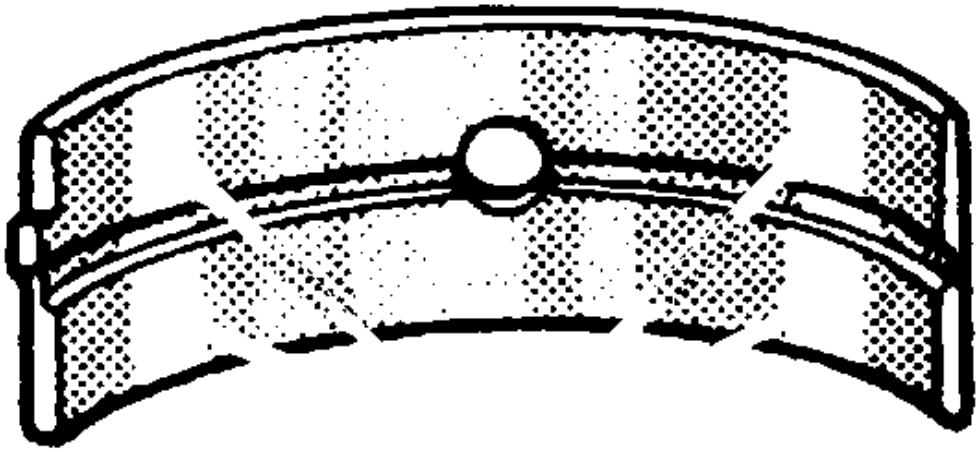

Fig. 470: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

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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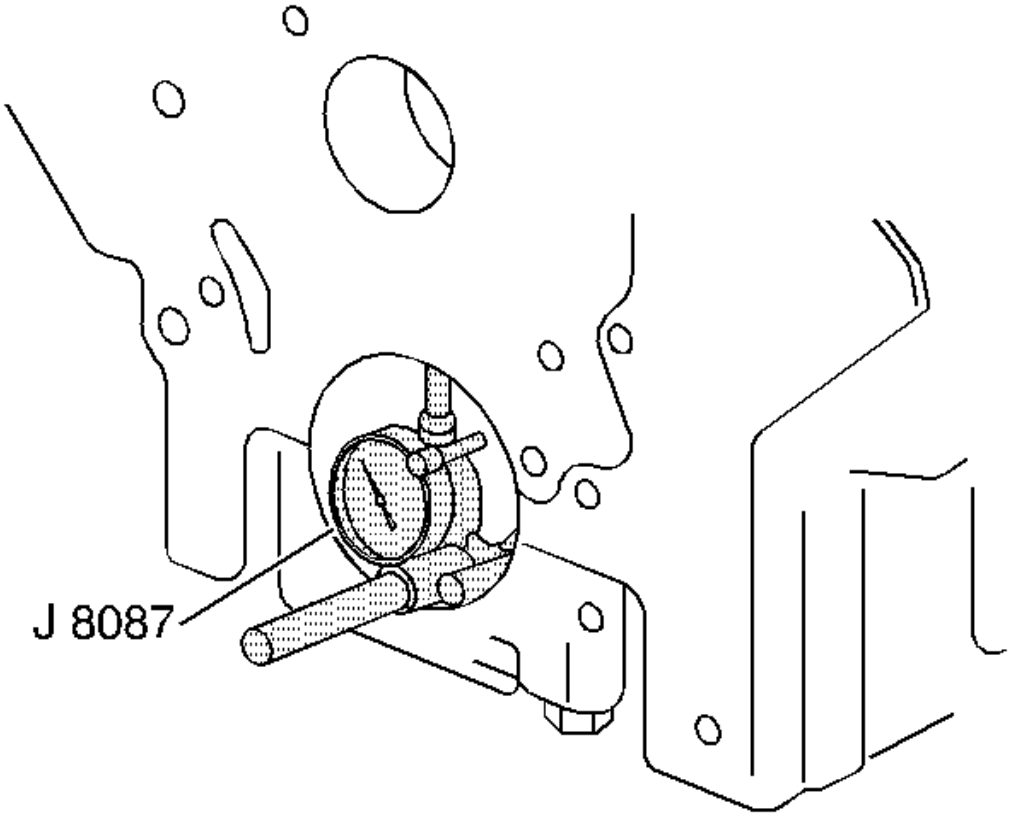

Fig. 471: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If crankshaft bearing failure is due to conditions other than normal wear, investigate the cause of the condition. Inspect the crankshaft or connecting rod bearing bores.

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** in order to measure the bearing bore for taper and out-of-round. See **Special Tools**. 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

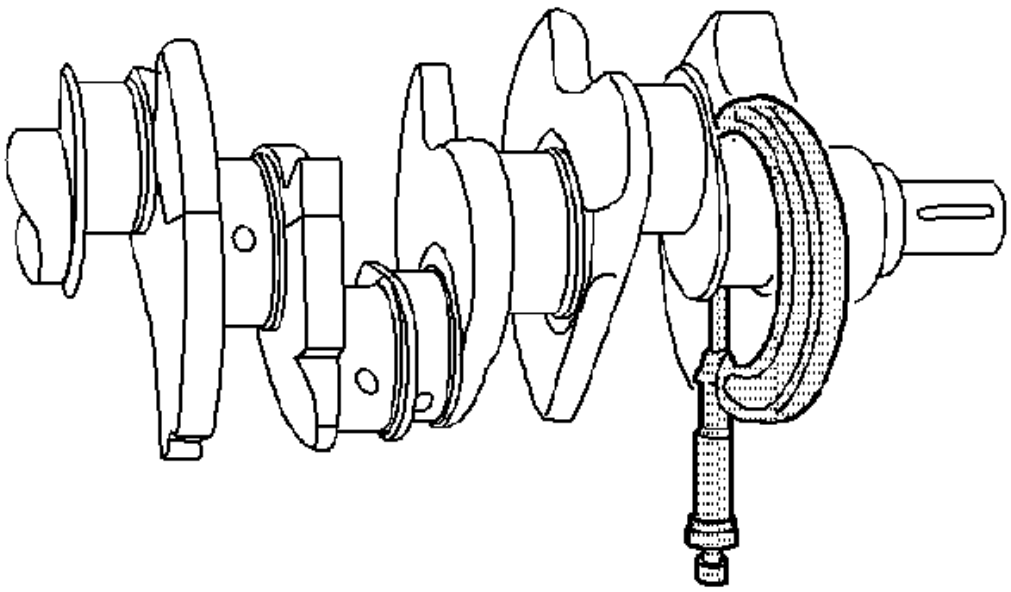

Fig. 472: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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** . See **Special Tools**.
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

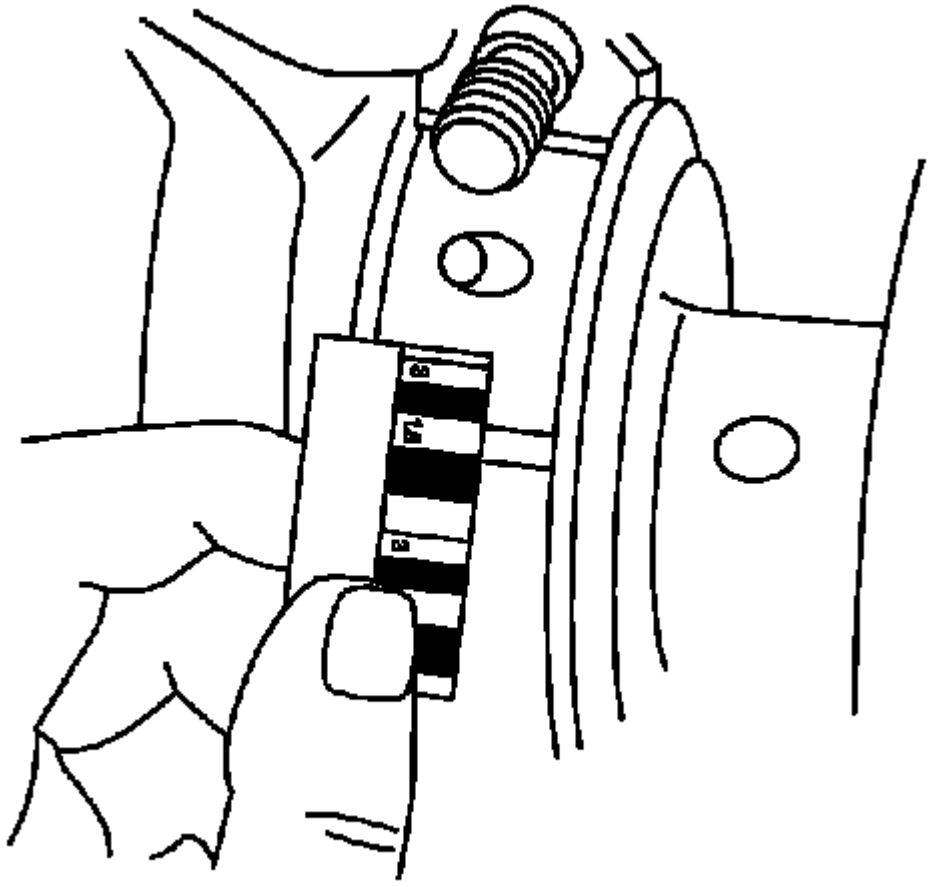

Fig. 473: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

NOTE: 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** . See **Special Tools**.

IMPORTANT: 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

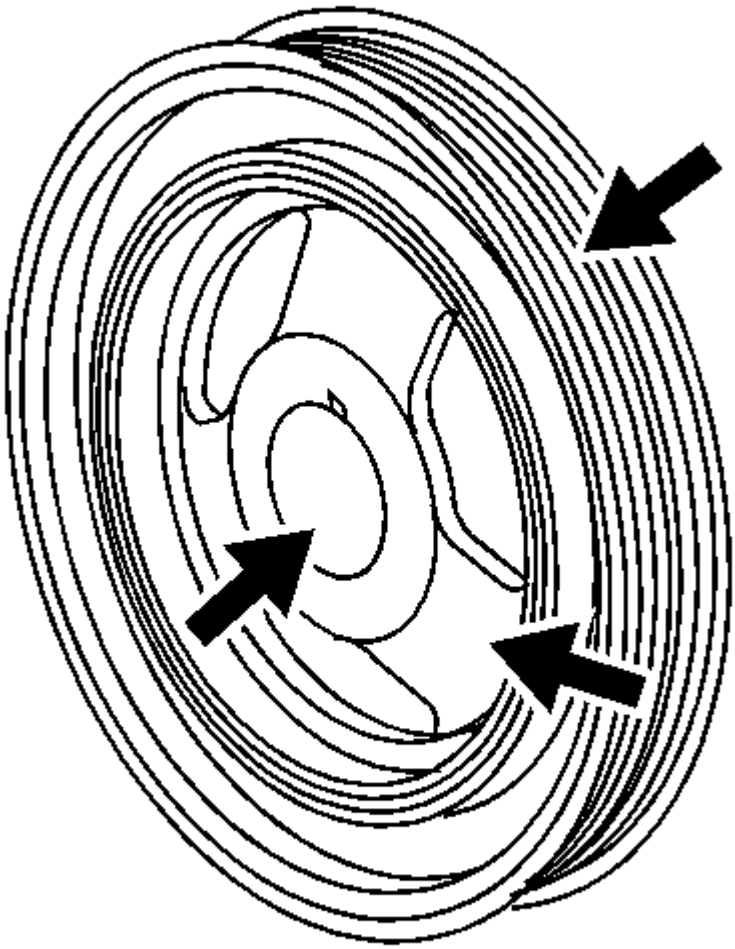

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Fig. 474: Cleaning Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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:

IMPORTANT: 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

IMPORTANT: 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

IMPORTANT: 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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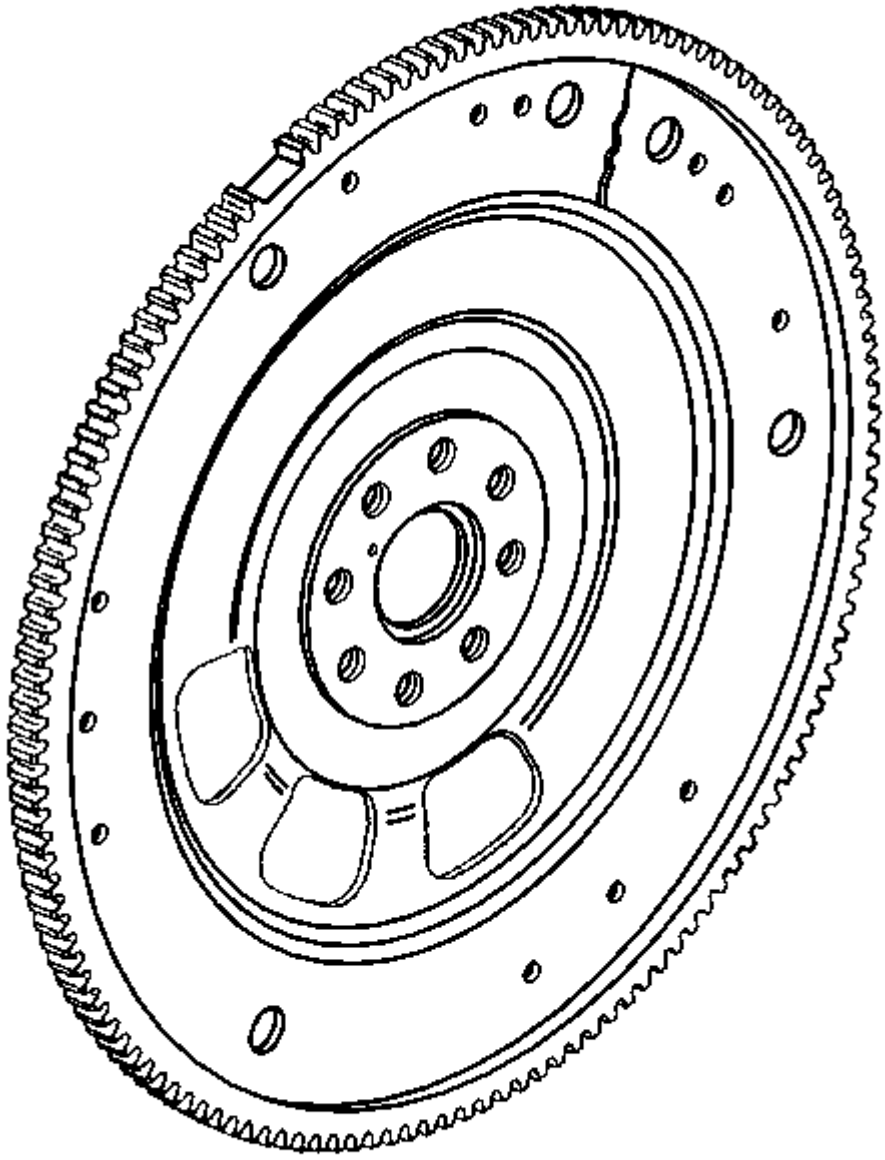

Fig. 475: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

CAUTION: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

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1. Clean the engine flywheel with solvent.
2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel for the following:
   - Damaged ring gear teeth
   - Stress cracks around the flywheel-to-crankshaft bolt hole locations

Piston, Connecting Rod, and Bearings Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage. See **Special Tools**.
- **EN-46745** Piston Pin Retainer Remover and Installer

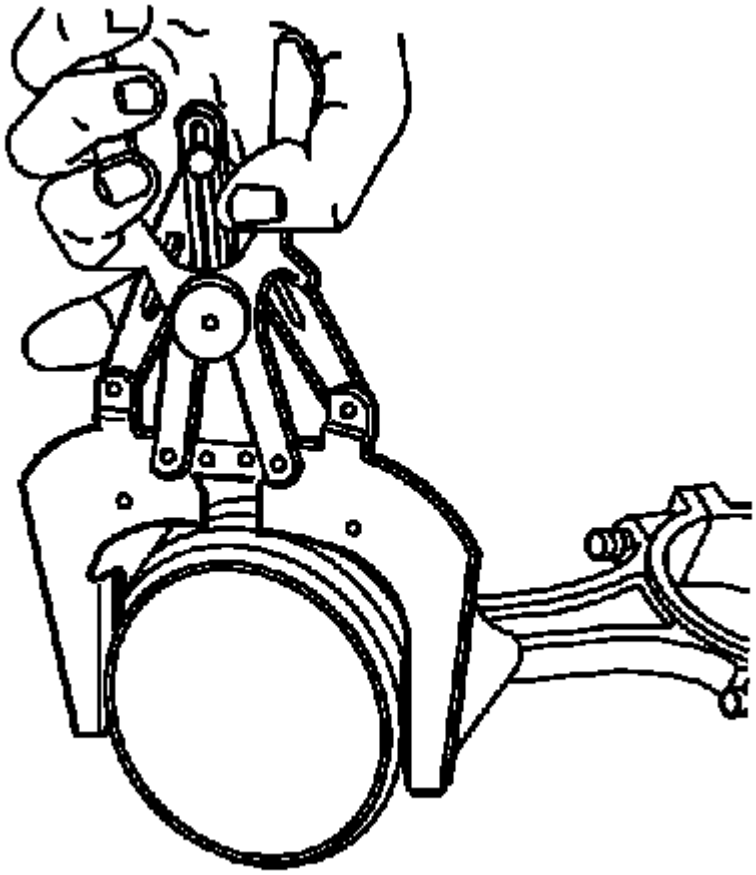

Fig. 476: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

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IMPORTANT: Measurement of all components should be taken with the components at room temperature. Do not use a wire brush in order to clean any part of the piston or connecting rod assembly.

IMPORTANT: 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.

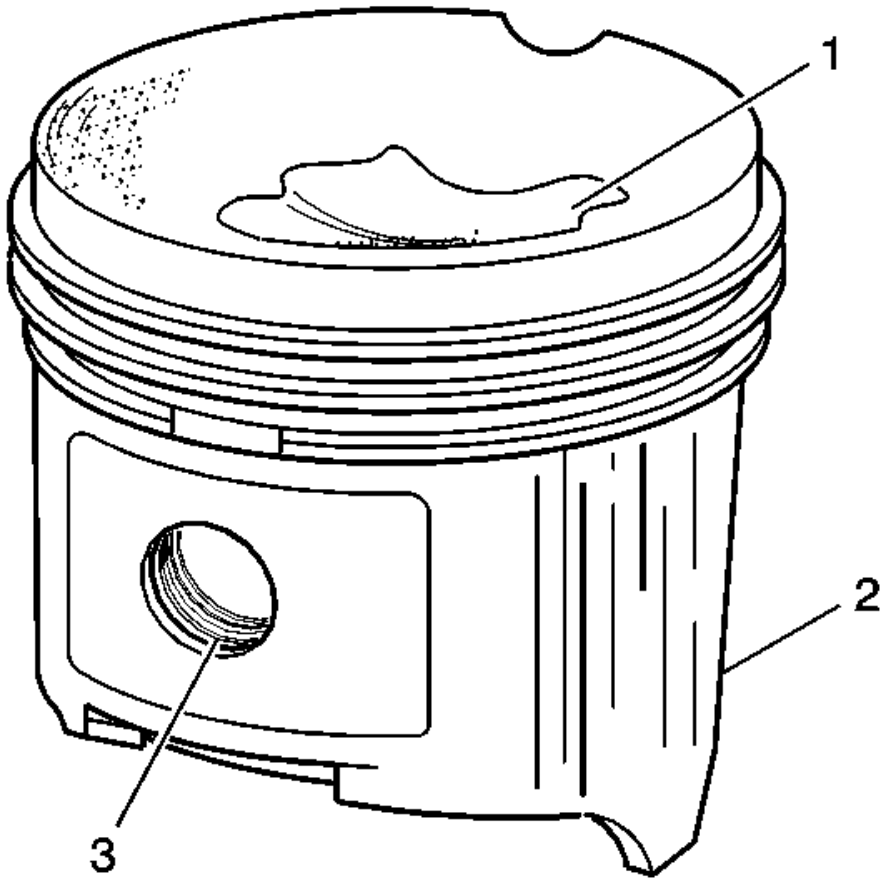

Fig. 477: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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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.

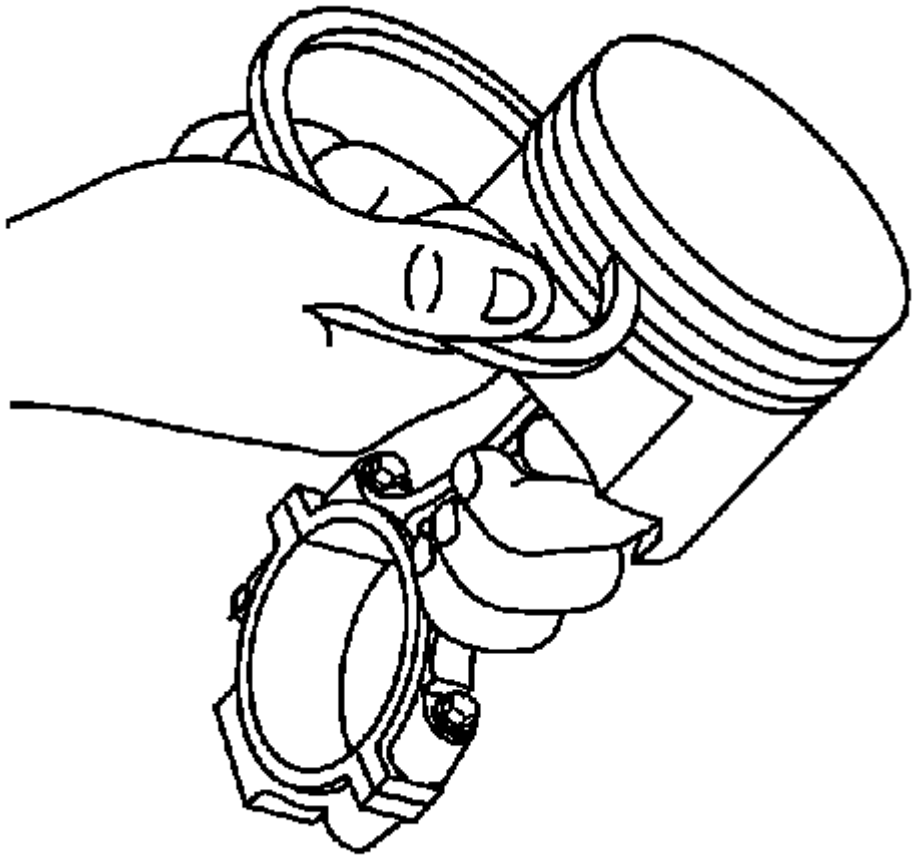

Fig. 478: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

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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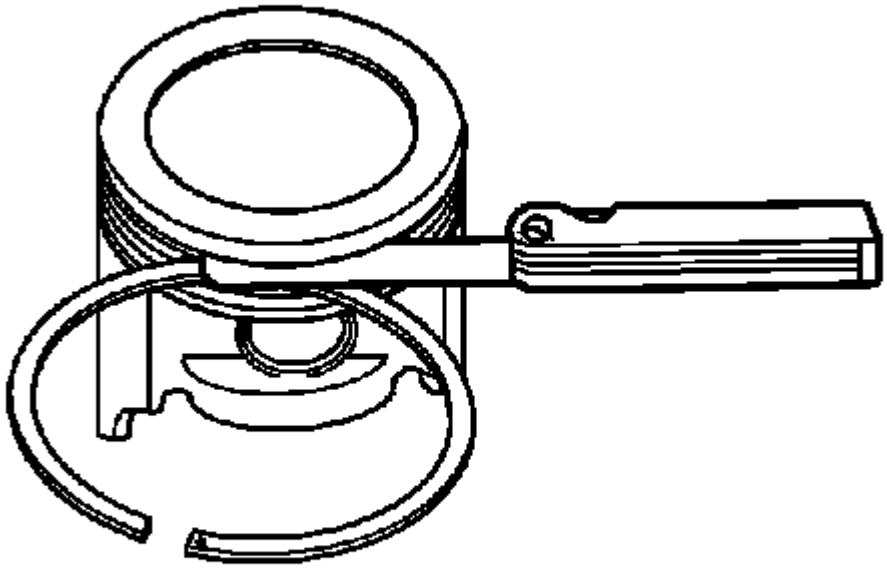

Fig. 479: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

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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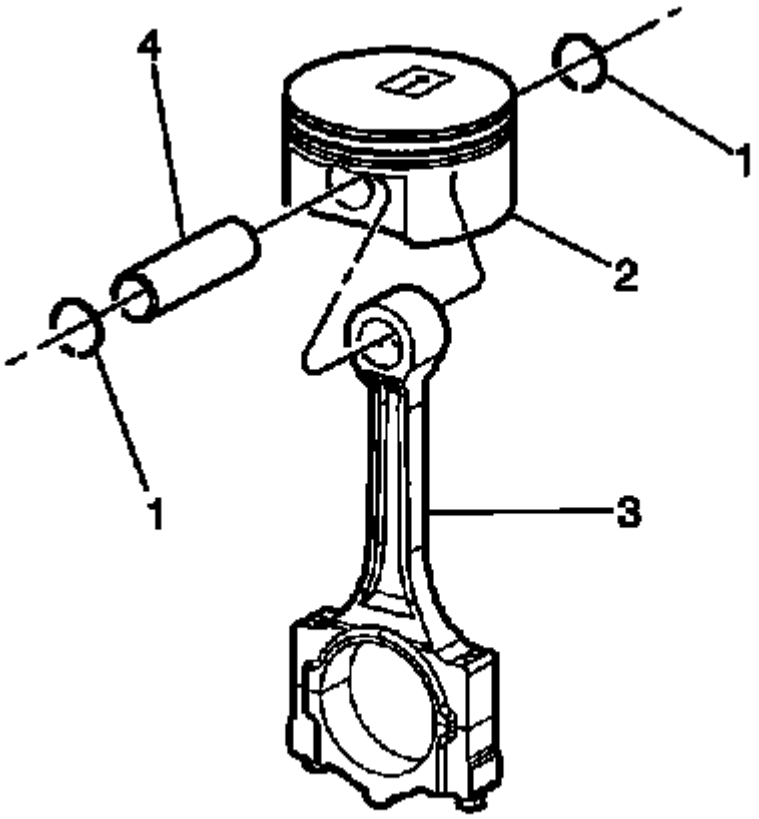

Fig. 480: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

11. Using the **EN-46745** , 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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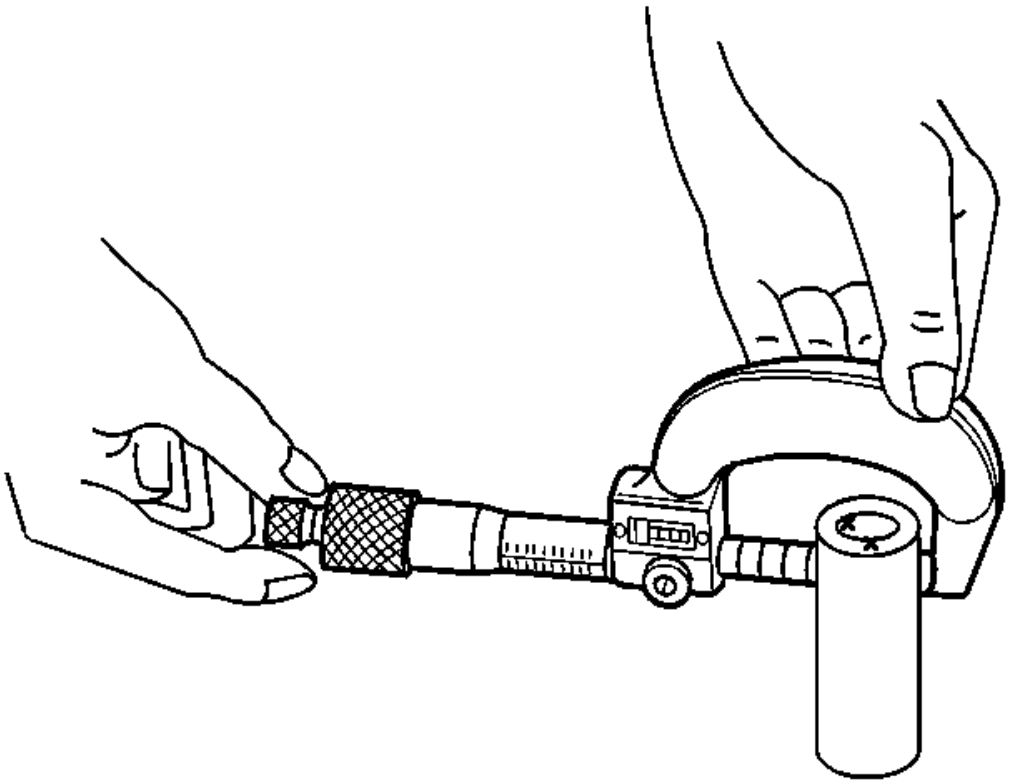

Fig. 481: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

14. Measure the piston pin diameter using an outside micrometer.

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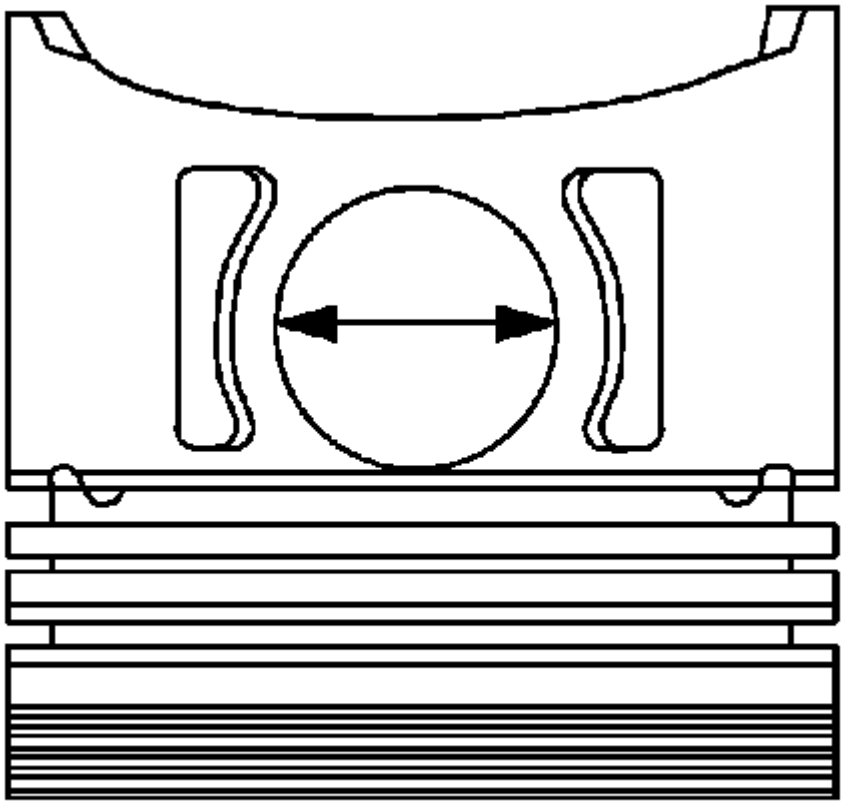

Fig. 482: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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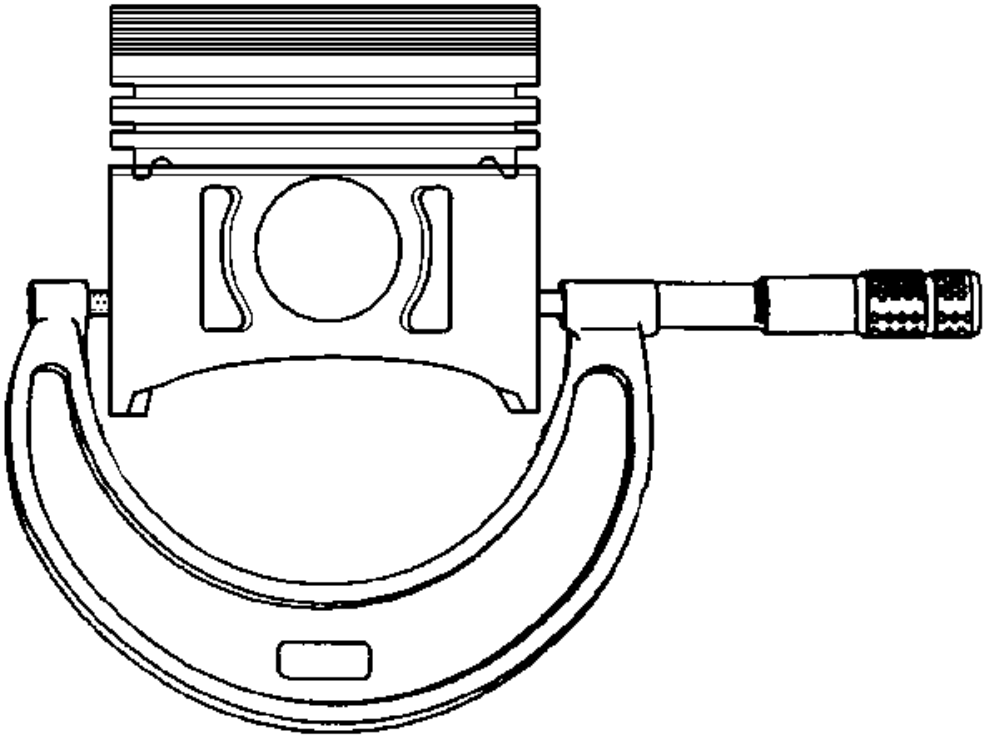

Fig. 483: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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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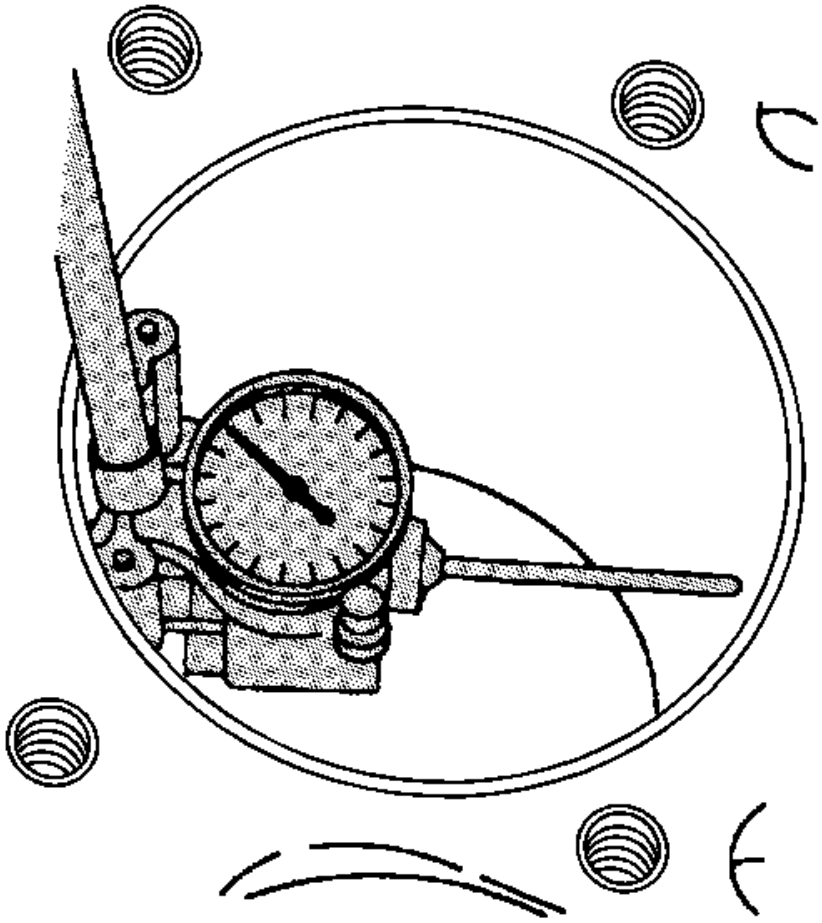

Fig. 484: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

19. Measure the cylinder bore, using **J 8087** . See **Special Tools**.

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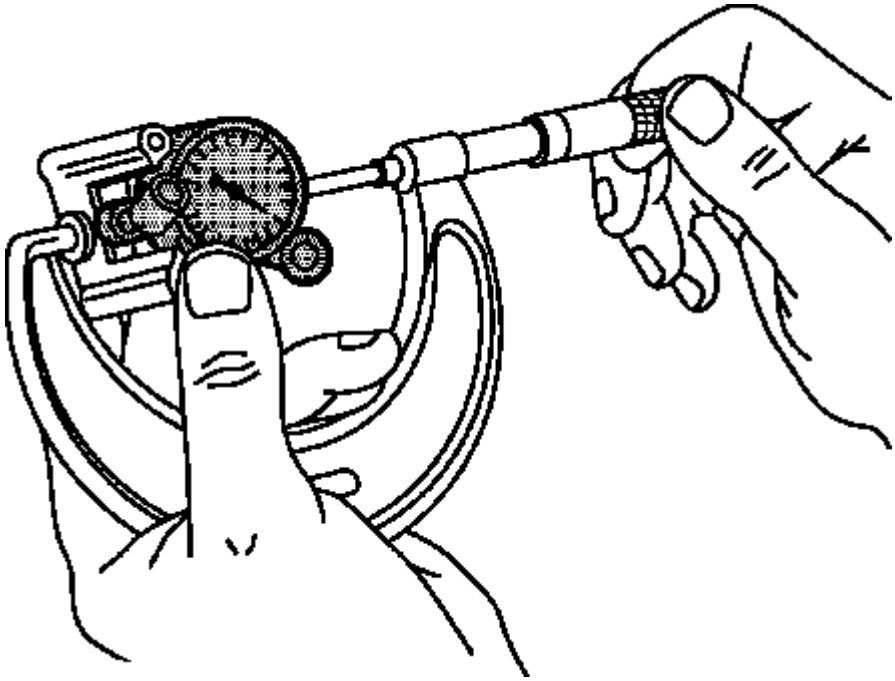

Fig. 485: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

20. Measure the **J 8087** . See **Special Tools**. 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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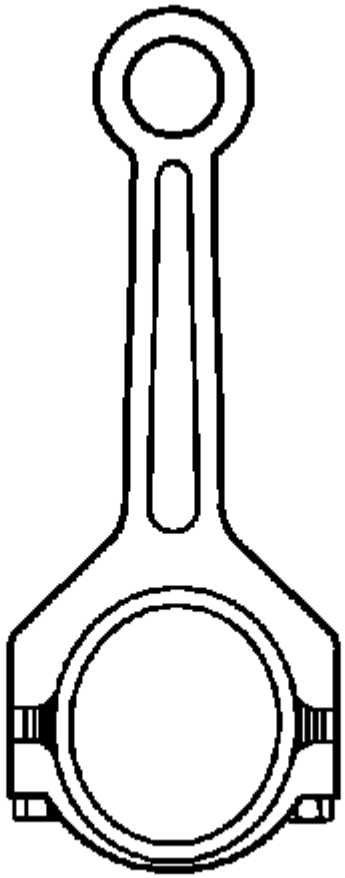

Fig. 486: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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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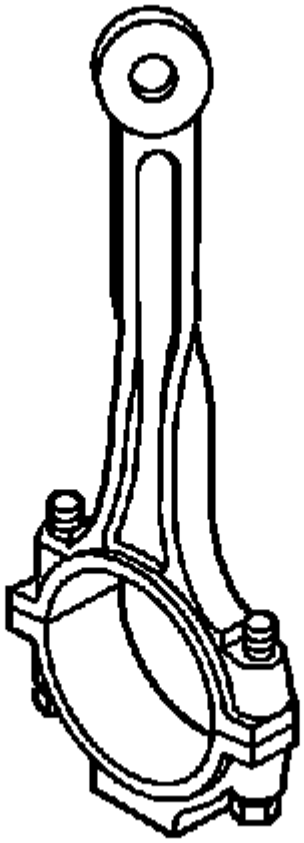

Fig. 487: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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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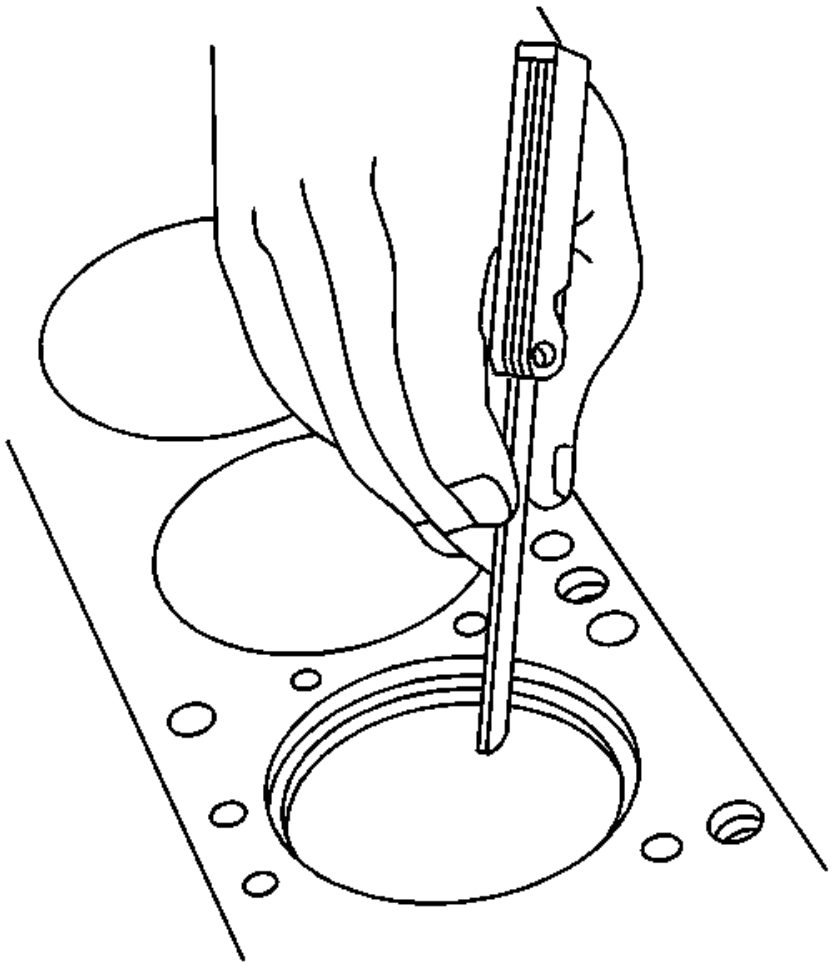

Fig. 488: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

27. Measure the piston compression ring end gap.

IMPORTANT: Fit each compression ring to the cylinder in which it will be used.

1. Place the compression ring into the cylinder bore.
2. Push the compression ring into the 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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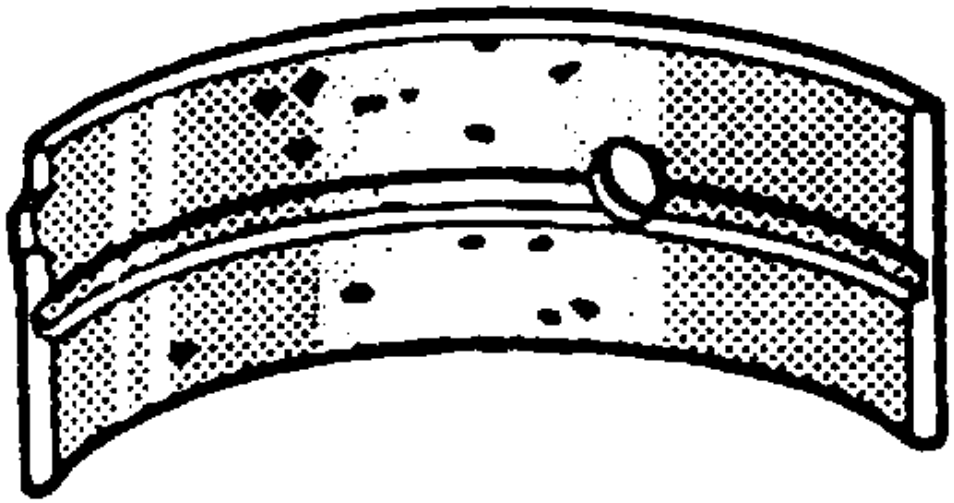

Fig. 489: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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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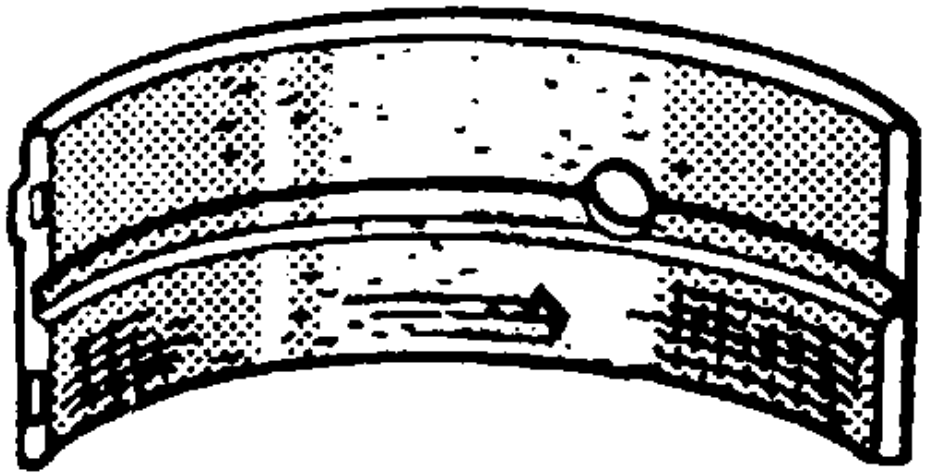

Fig. 490: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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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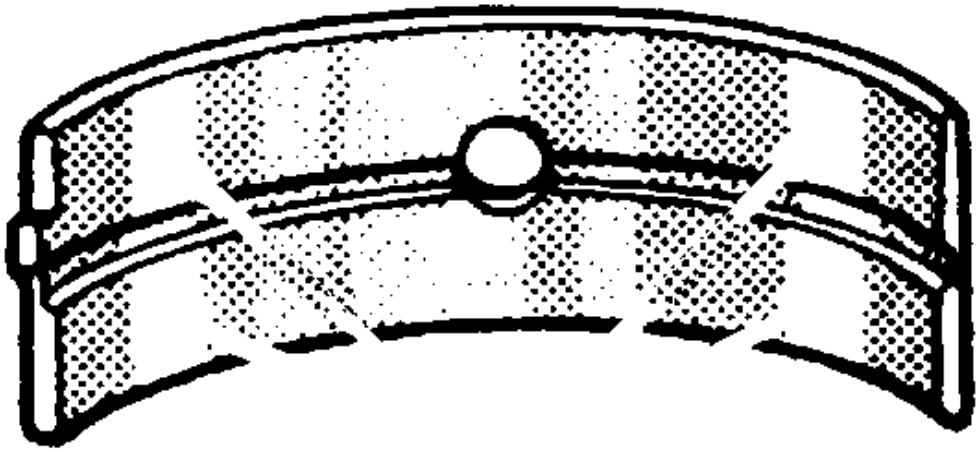

Fig. 491: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

J 7872 Magnetic Base Dial Indicator. See **Special Tools**

1. Remove and discard the camshaft position actuator filter (1).
2. Clean the camshaft with cleaning solvent.

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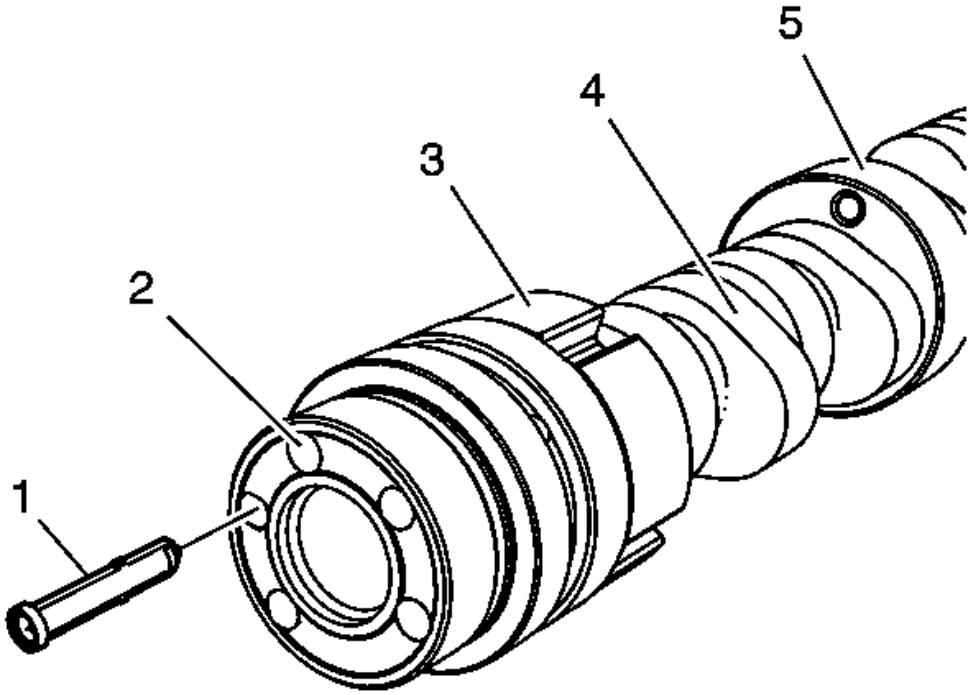

Fig. 492: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution .

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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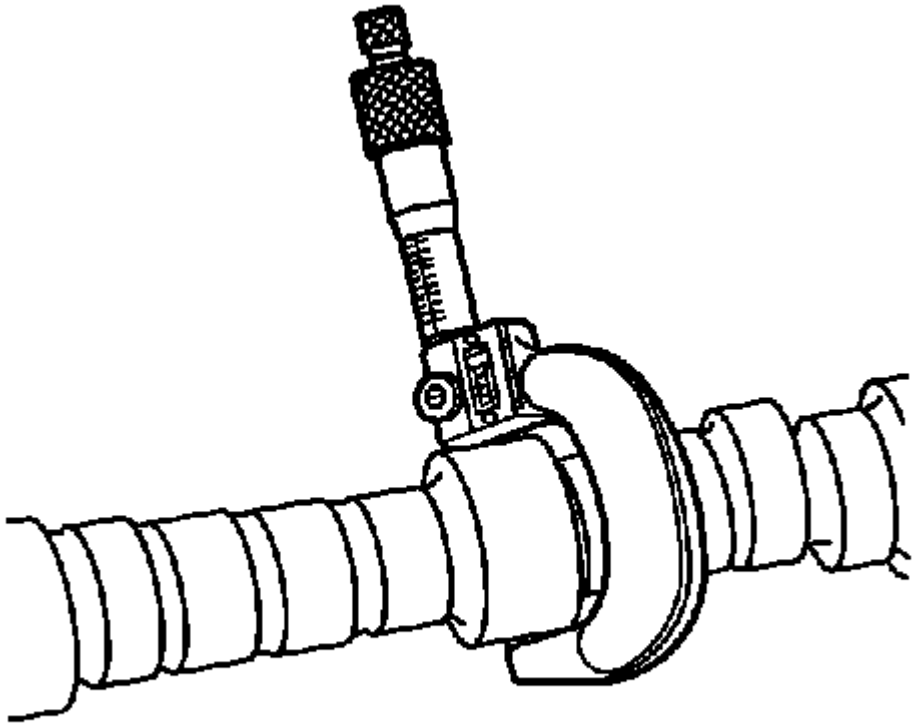

Fig. 493: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft journals using a micrometer.

   If the camshaft journals are not within specifications, replace the camshaft.

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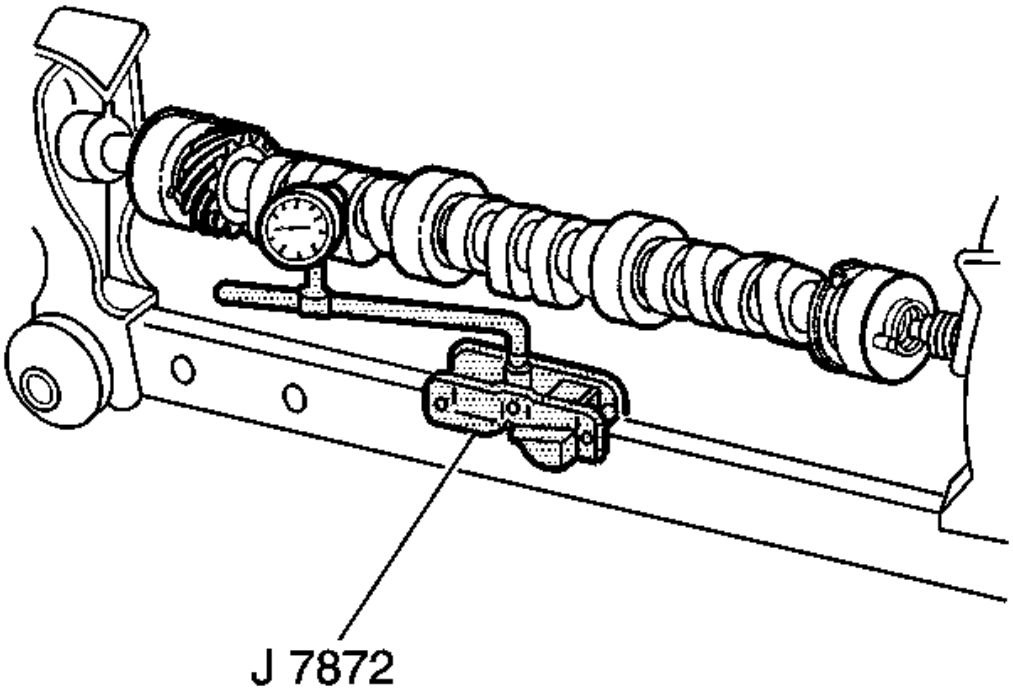

Fig. 494: Measuring Camshaft With J 7872
Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft runout using the **J 7872** . See **Special Tools**.
    1. Mount the camshaft in V-blocks between the centers.
    2. Use the **J 7872** in order to measure the intermediate camshaft journal. See **Special Tools**.
6. Measure the camshaft lobe lift using the **J 7872** . See **Special Tools**.
    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** in order to measure the lobe lift. See **Special Tools**.
7. If the runout or lobe lift is not within specifications, replace the camshaft.

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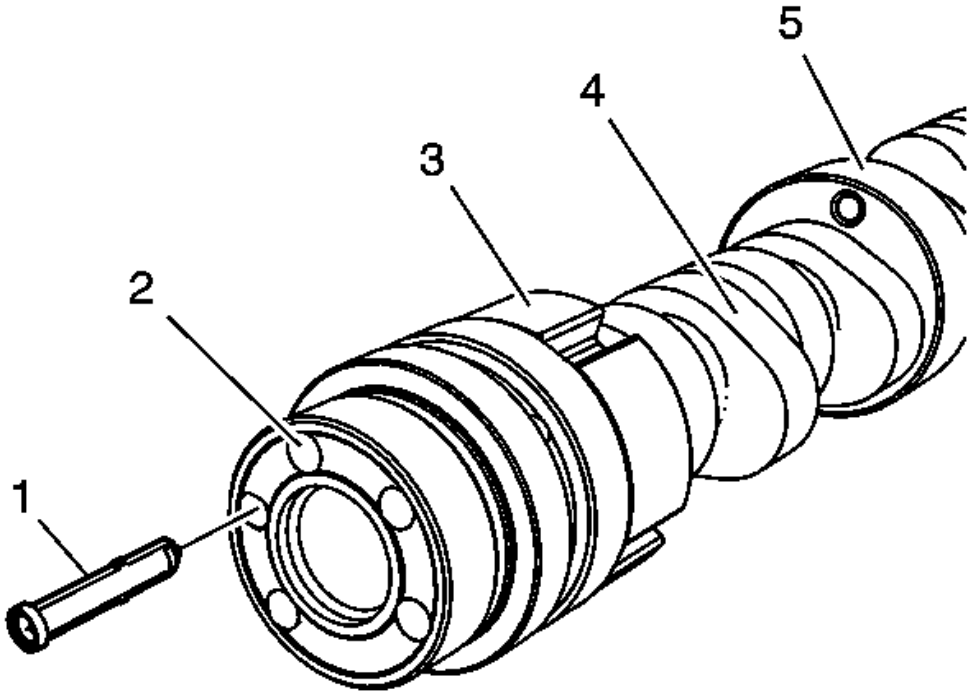

Fig. 495: View Of Camshaft & Actuator Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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).

Timing Chain and Sprockets Cleaning and Inspection

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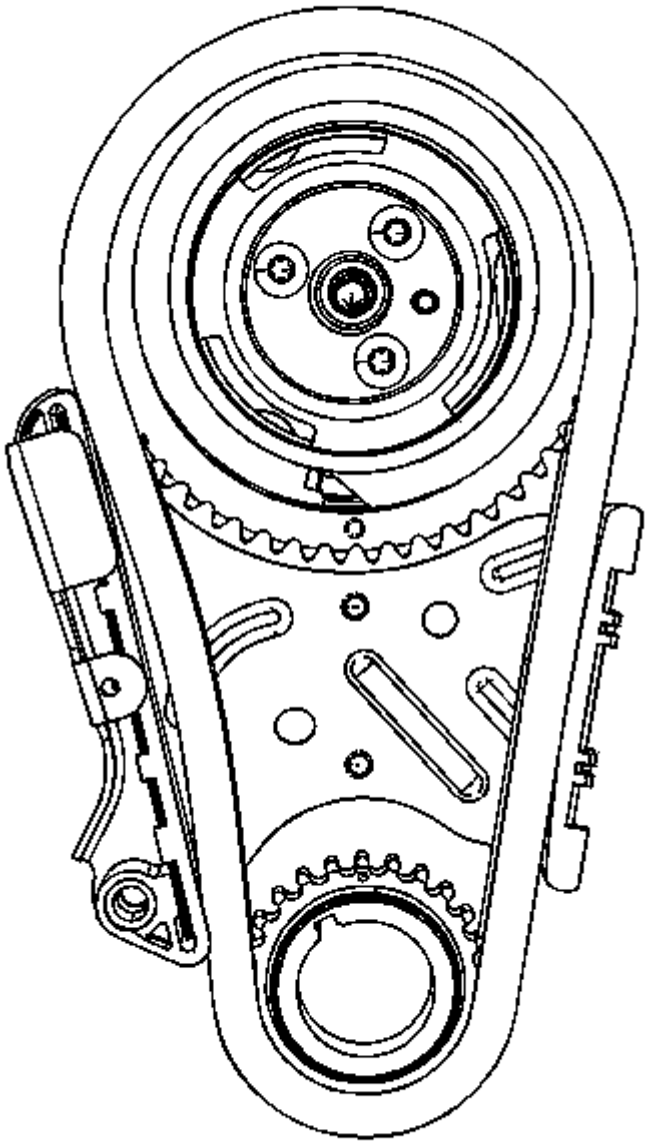

Fig. 496: View Of Timing Chain, Sprockets & Tensioners
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

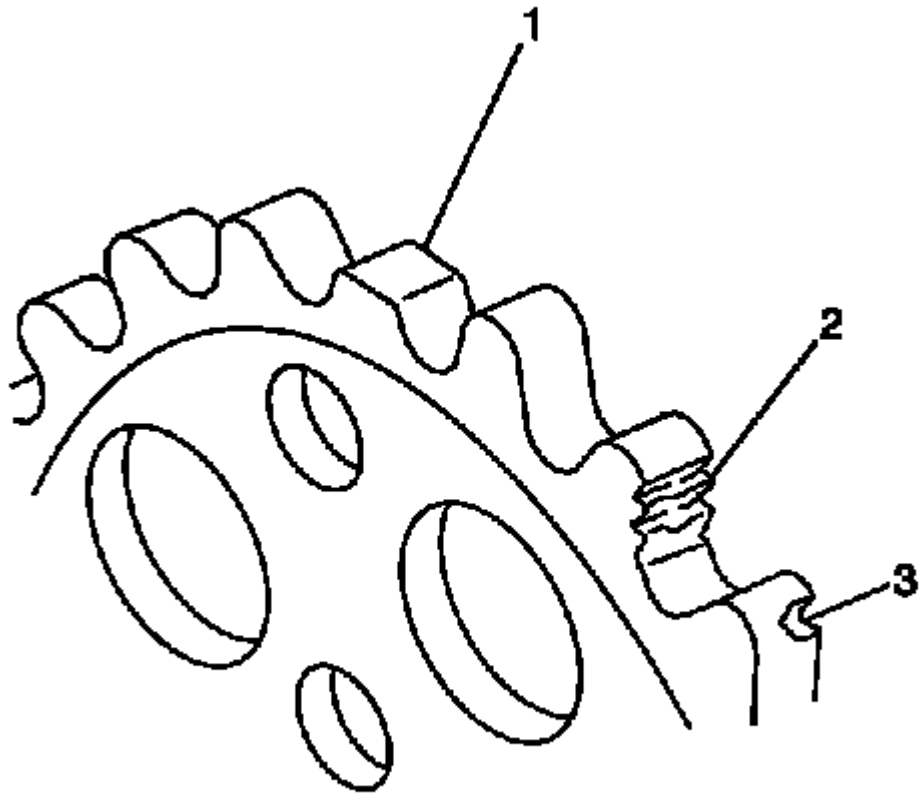

Fig. 497: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft and crankshaft sprockets for:
    - Worn teeth (1)
    - Broken teeth (2)
    - Chipped teeth (3)

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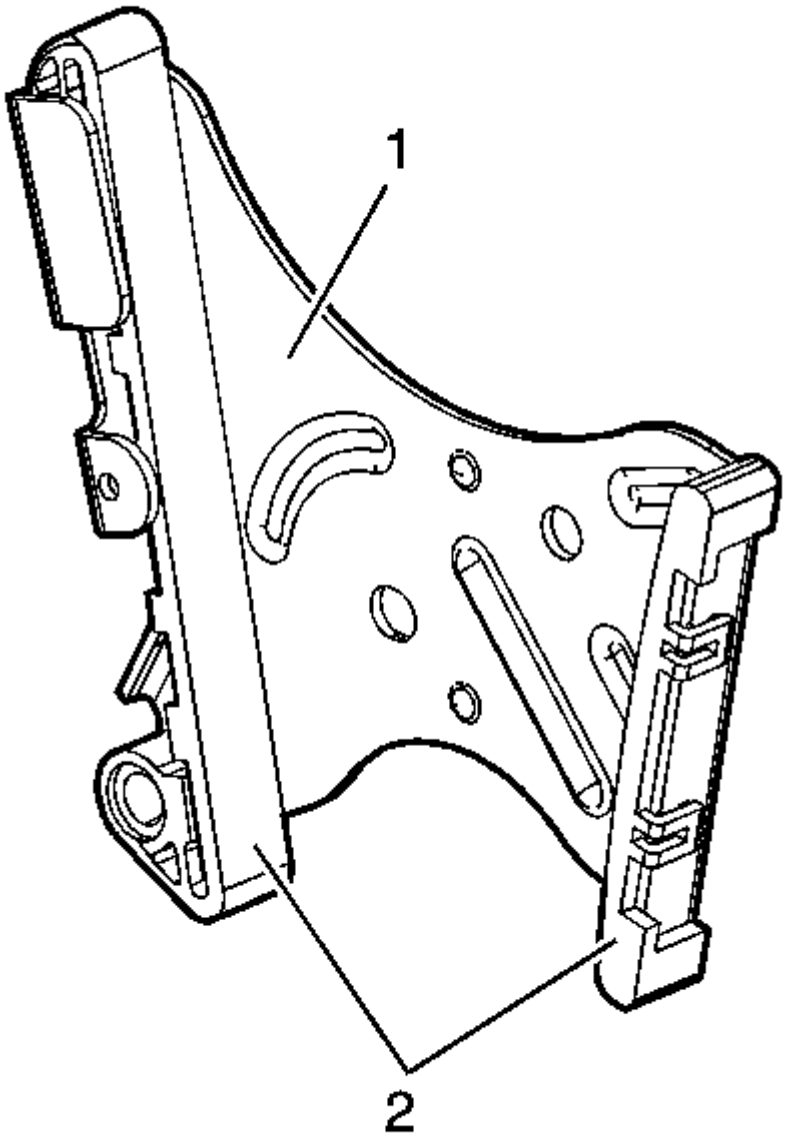

Fig. 498: Identifying Damaged Timing Chain Tensioner & Chain Tensioner Slides
Courtesy of GENERAL MOTORS CORP.

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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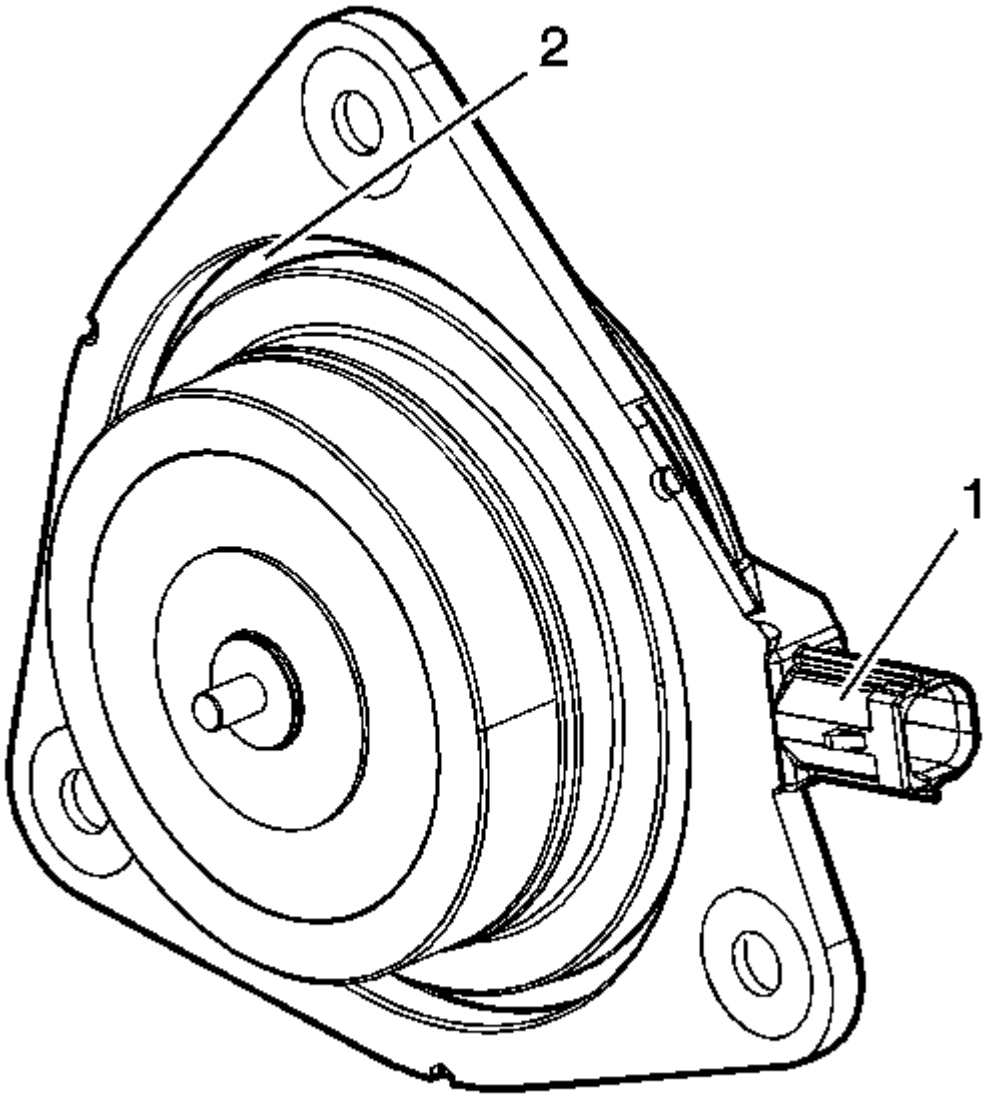

Fig. 499: Identifying Sealing Area & Magnet
Courtesy of GENERAL MOTORS CORP.

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

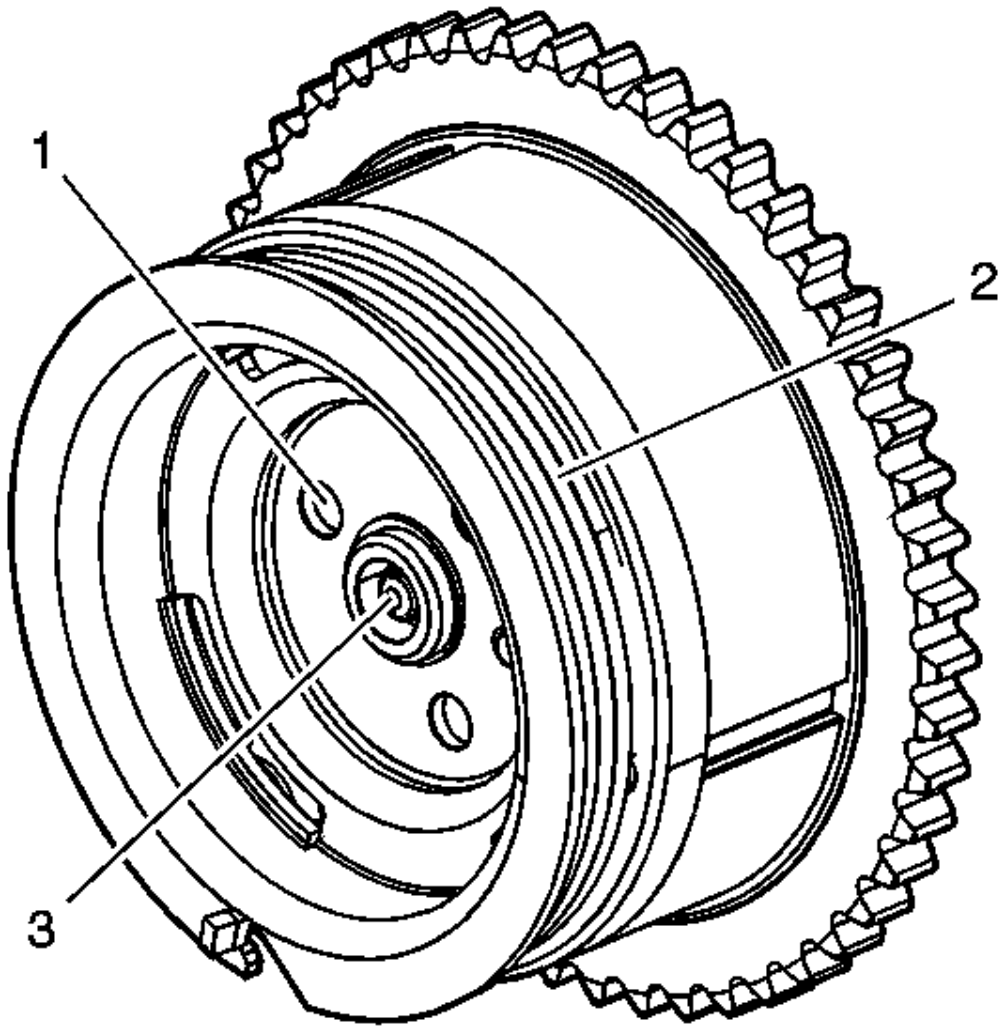

Fig. 500: Identifying Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution .

1. Clean the camshaft position actuator components with solvent.

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CAUTION: Refer to Safety Glasses Caution .

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.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the valve lifters with compressed air.

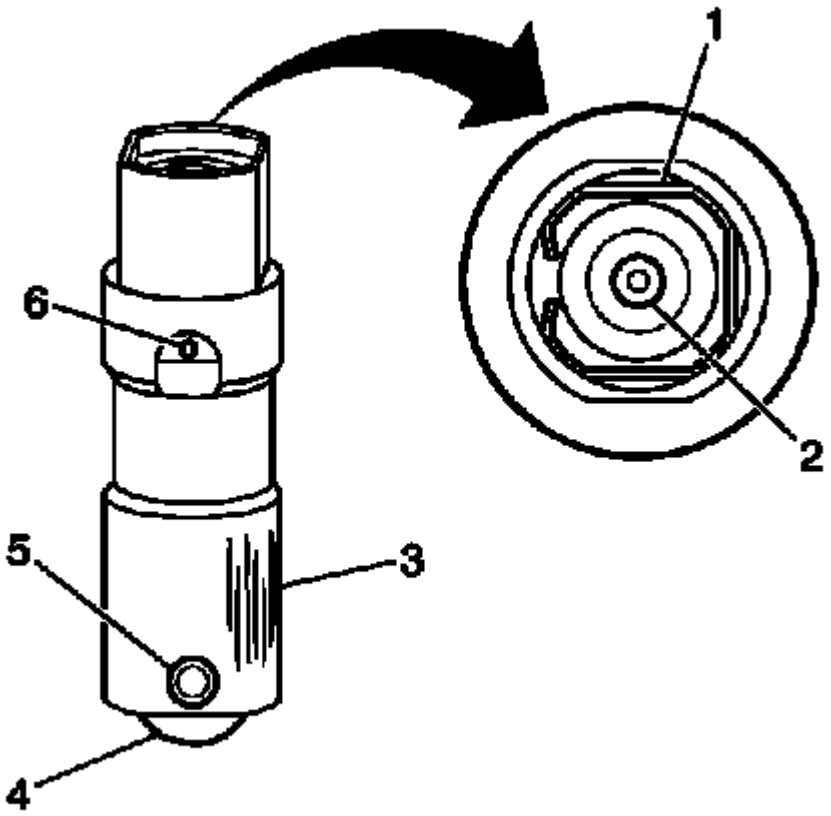

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Fig. 501: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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.

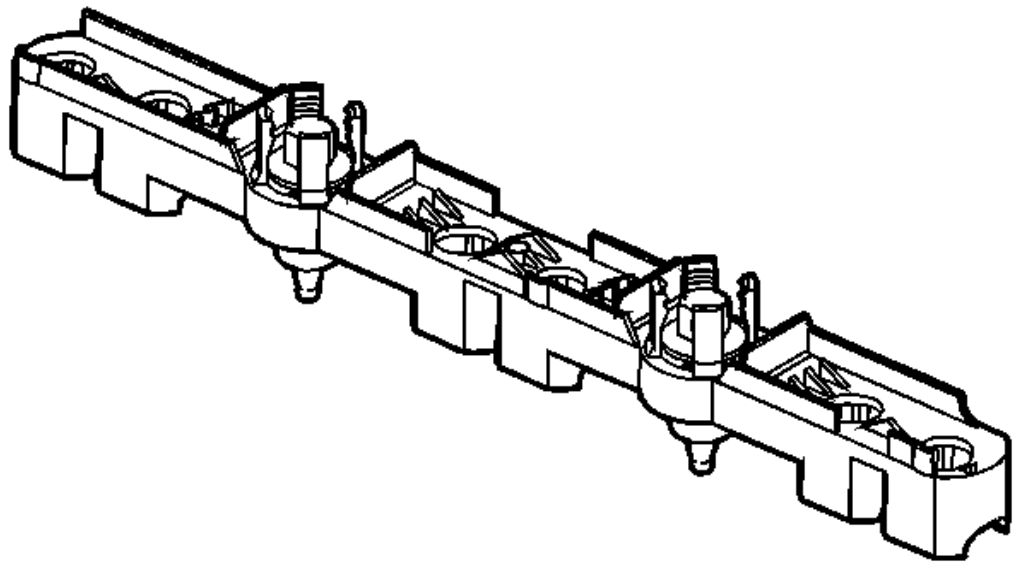

Fig. 502: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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 Rods Cleaning and Inspection

CAUTION: Refer to Cleaning Solvent Caution .

1. Clean the valve rocker arms and push rods in cleaning solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the valve rocker arms and push rods with compressed air.

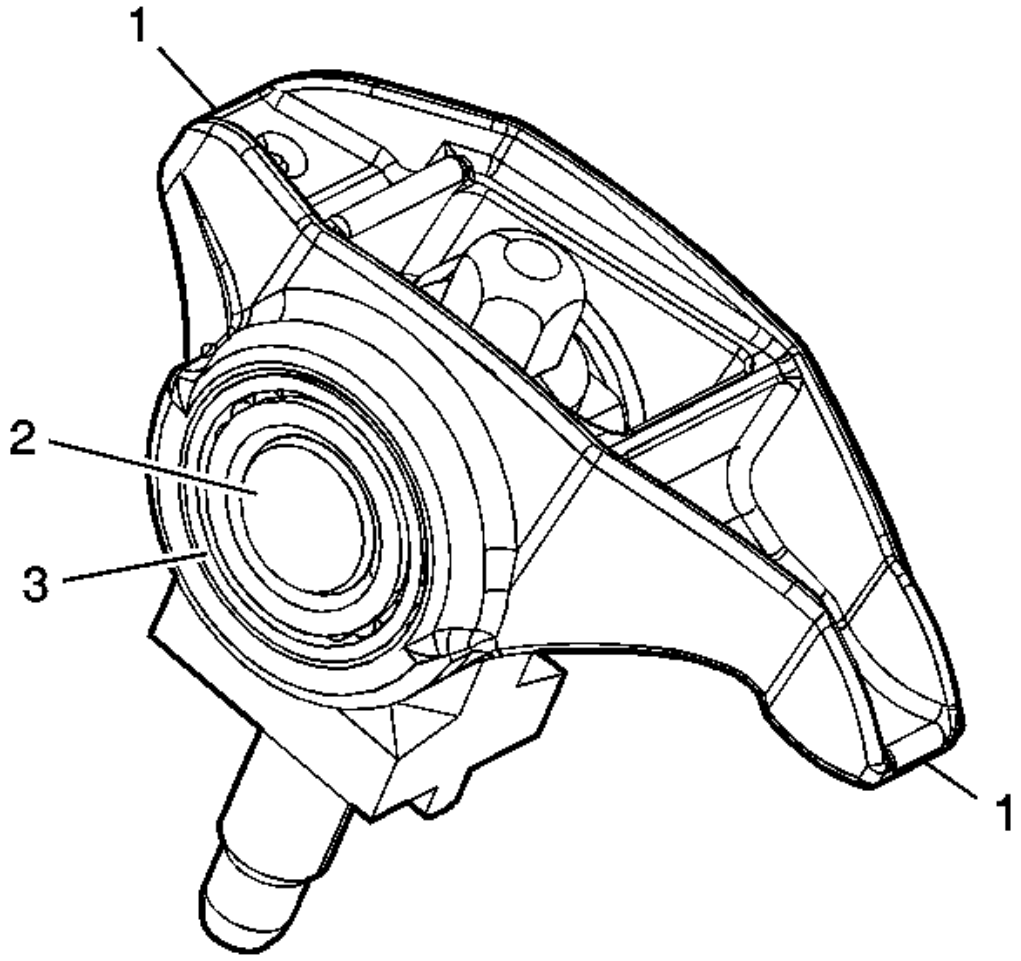

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Fig. 503: Inspecting Rocker Arm Assemblies
Courtesy of GENERAL MOTORS CORP.

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 (2)

     The roller should rotate freely with no binding or roughness.

   - The bolt threads for damage

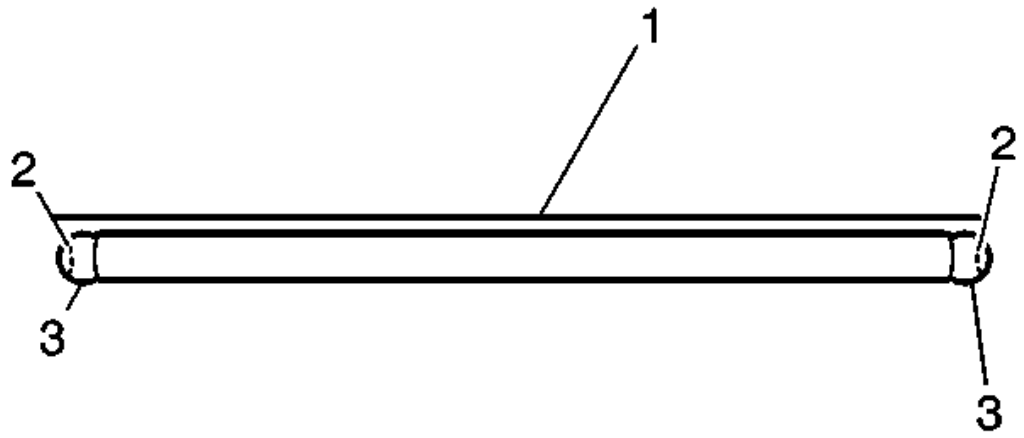

Fig. 504: Inspecting Push Rods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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

Tools Required

- **EN-47823** Valve Spring Compressor Adapter. See **Special Tools**.

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- **J 5892-D** Valve Spring Compressor. See **Special Tools**.

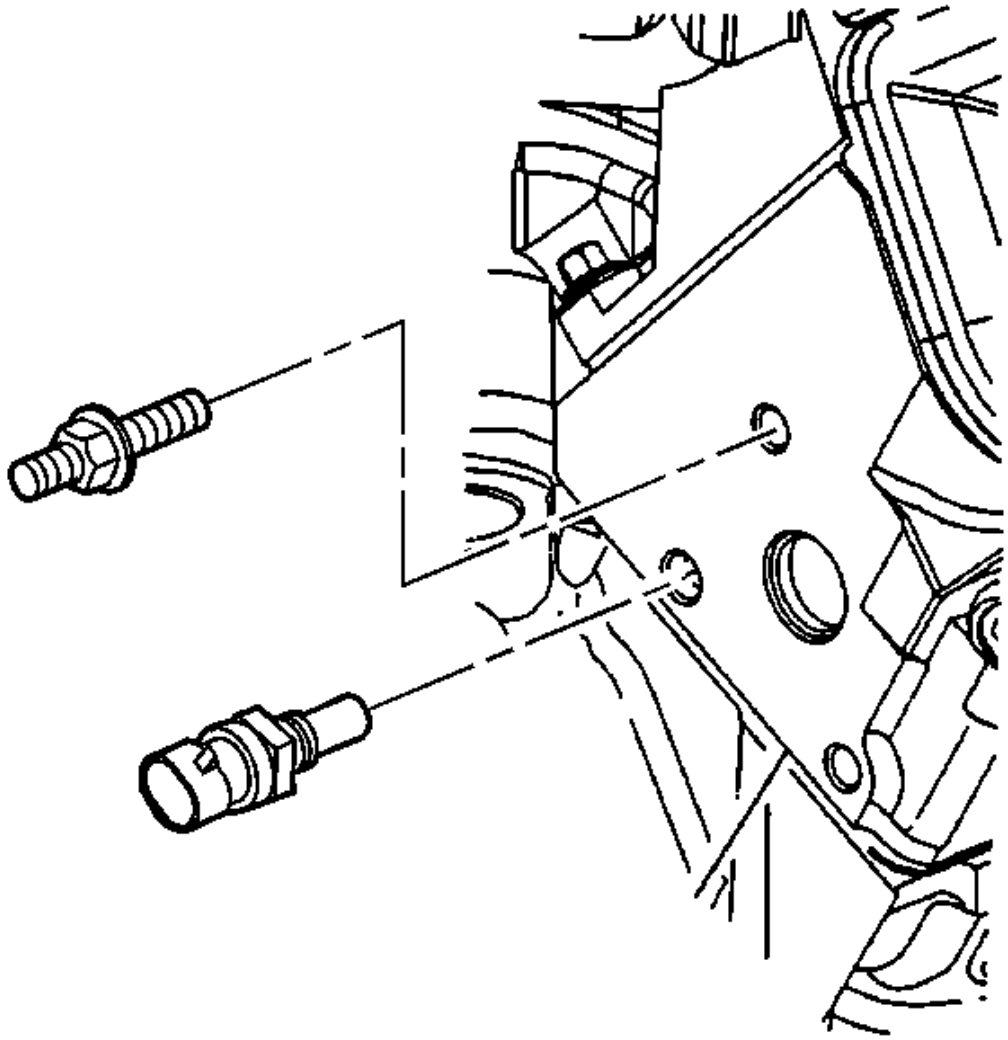

Fig. 505: Removing Heater Inlet Pipe Stud From Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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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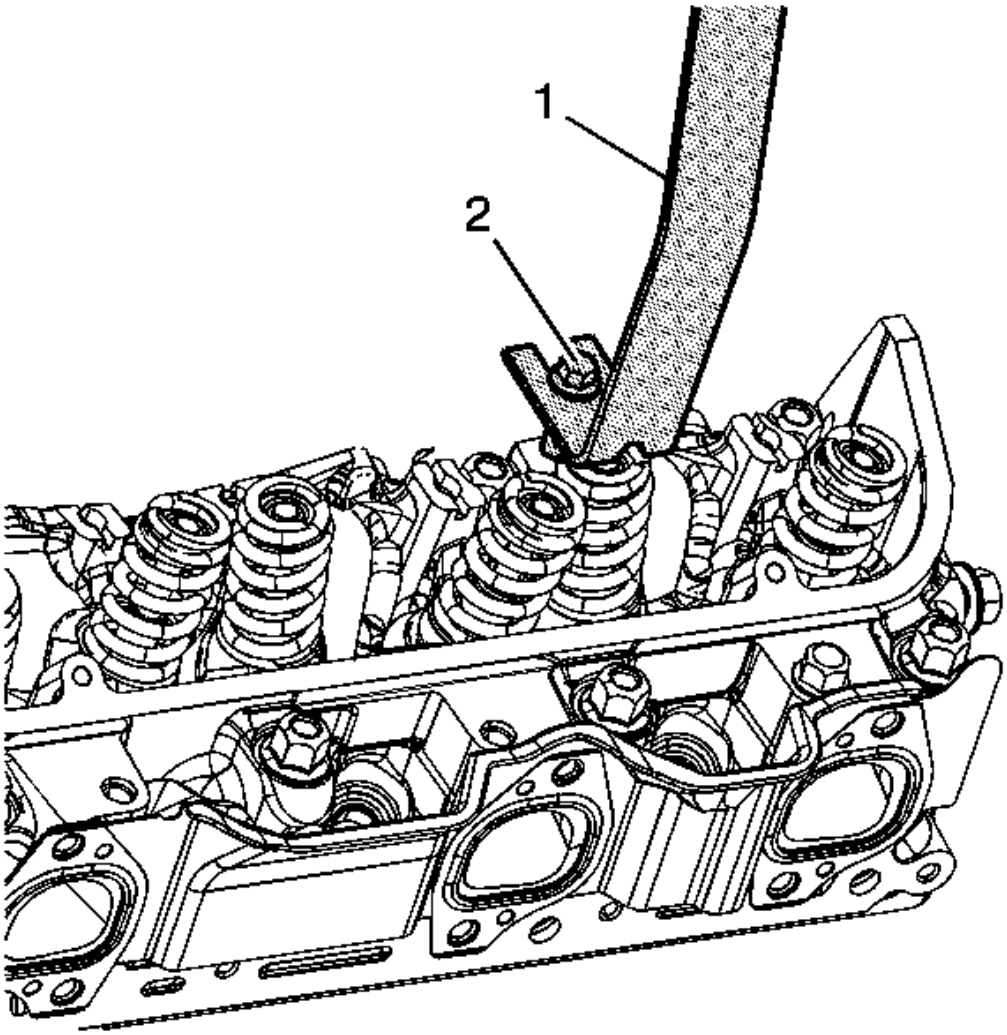

Fig. 506: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

3. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve springs using the **J 5892-D** (1) and the **EN-47823** (2). See **Special Tools**.

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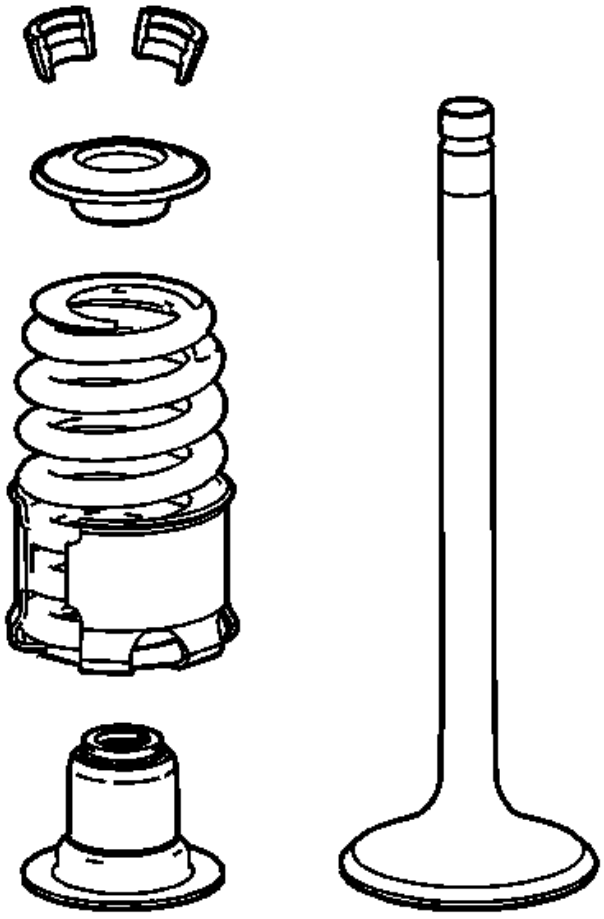

Fig. 507: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

IMPORTANT: 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

Tools Required

- **J 8089** Carbon Removing Brush. See **Special Tools**.
- **J 9666** Valve Spring Tester

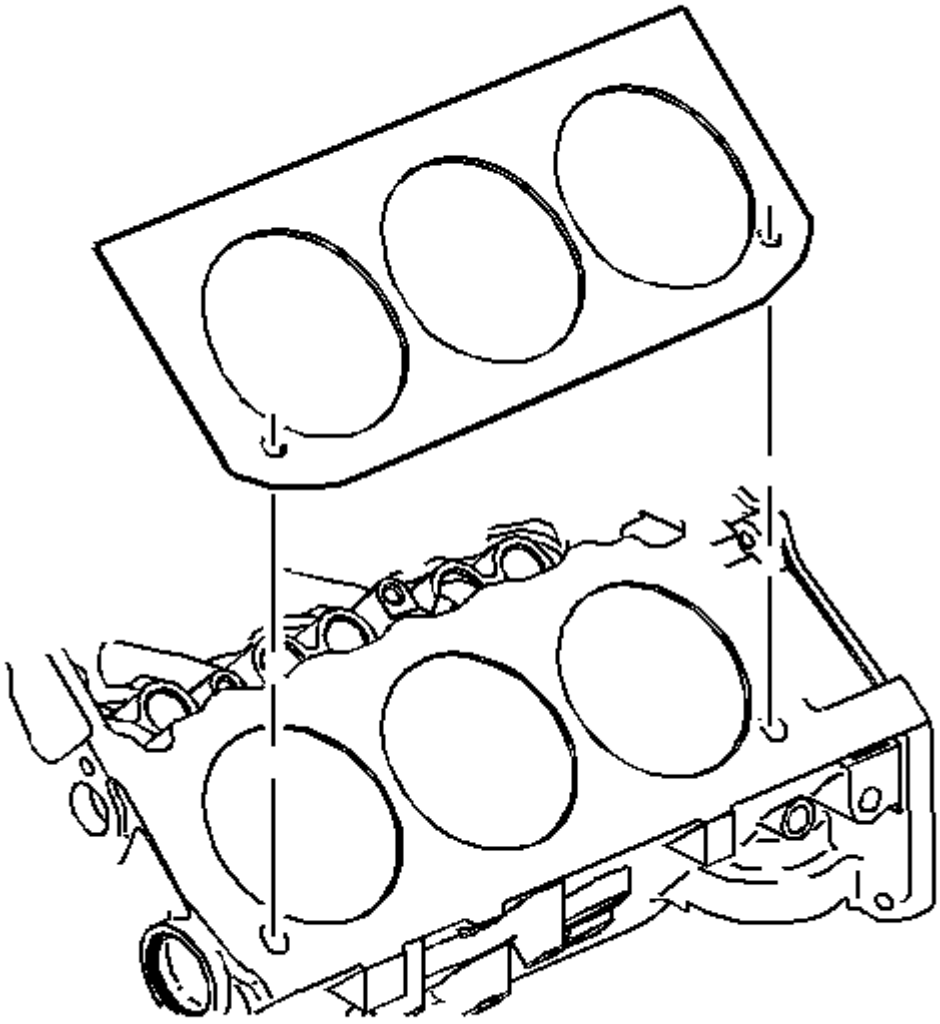

Fig. 508: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surfaces. Inspect for leaks, corrosion, and blowby.

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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

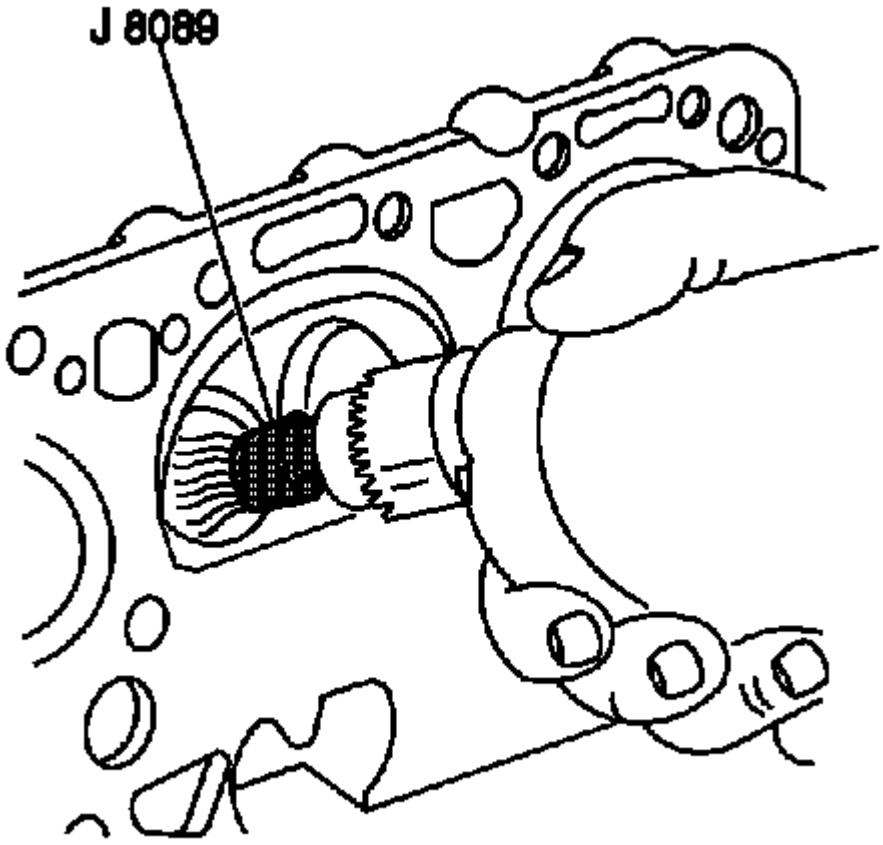

Fig. 509: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

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IMPORTANT: Do not scuff the chamber.

3. Use the **J 8089** in order to remove the carbon from the combustion chambers. See **Special Tools**.
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.

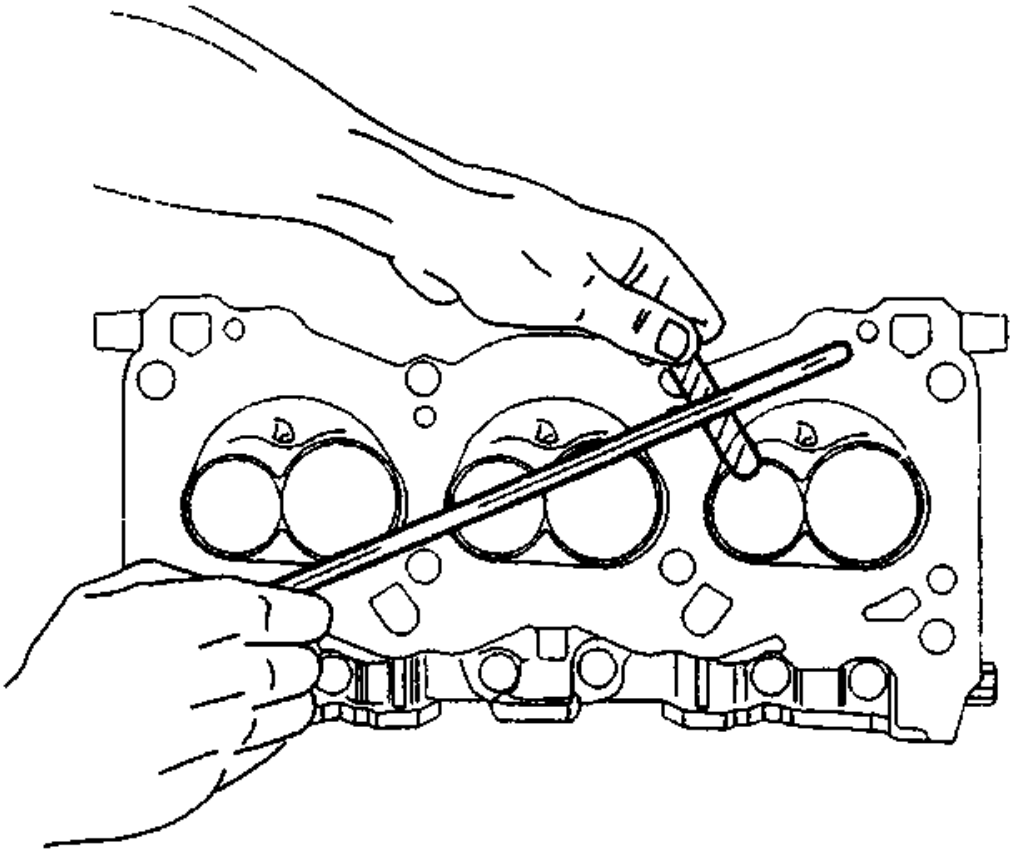

Fig. 510: Inspecting Cylinder Head Mating Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

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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.

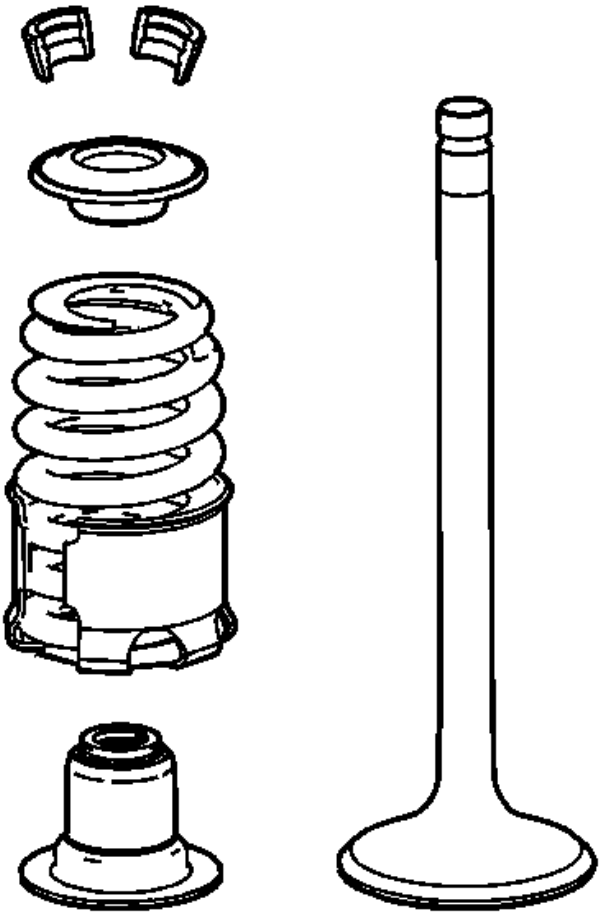

Fig. 511: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve spring dampener.

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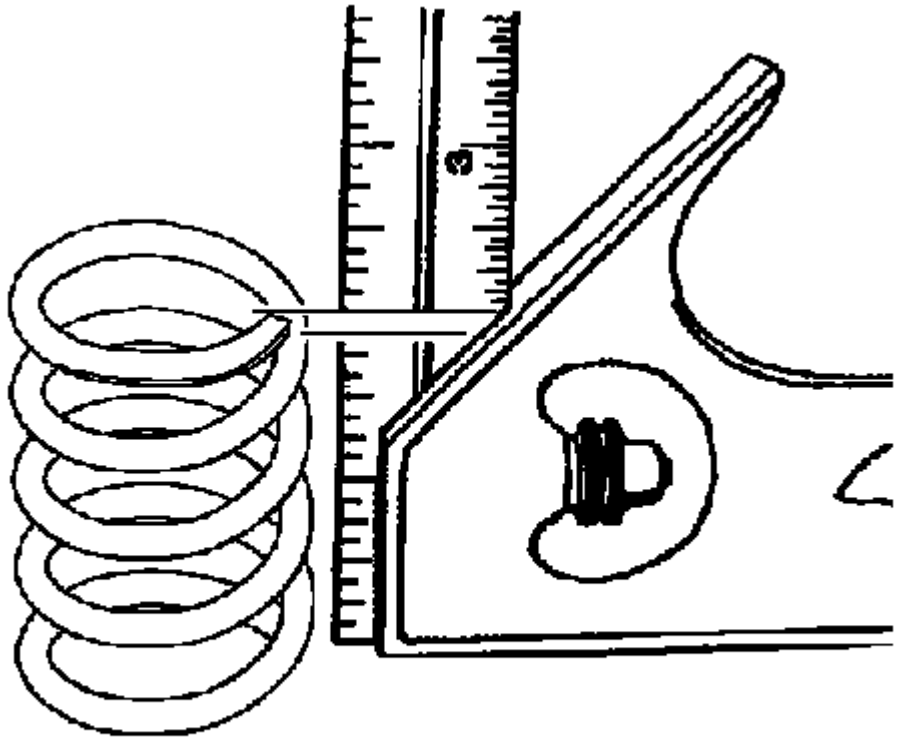

Fig. 512: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

9. Inspect the valve springs for squareness.

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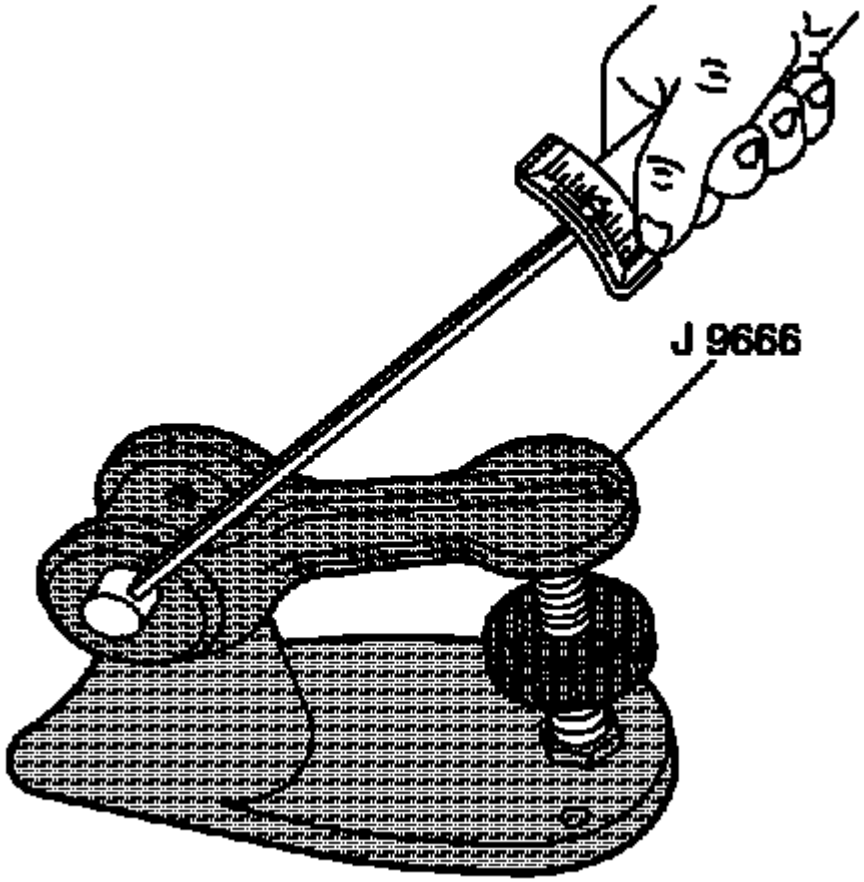

Fig. 513: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

10. Use the **J 9666** in order to measure the valve spring tension.

    Replace the spring if the spring tension is not within specification.

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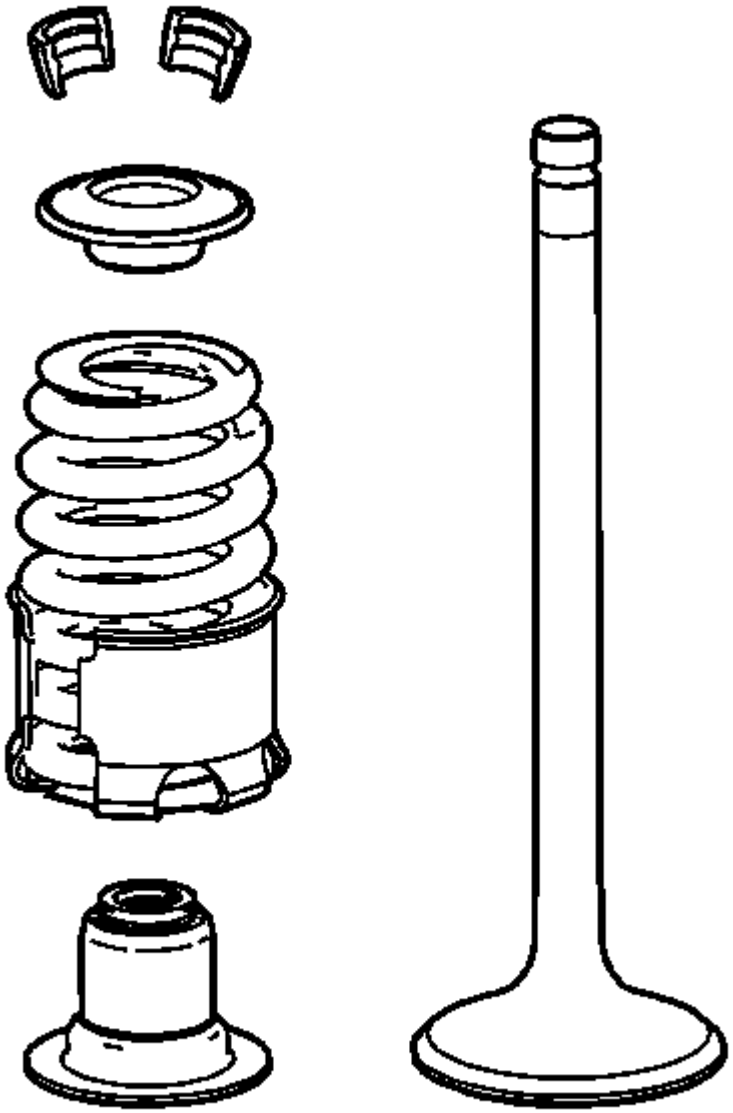

Fig. 514: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

11. Install the valve spring dampener.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

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J 8520 Cam Lobe Lift Indicator. See **Special Tools**

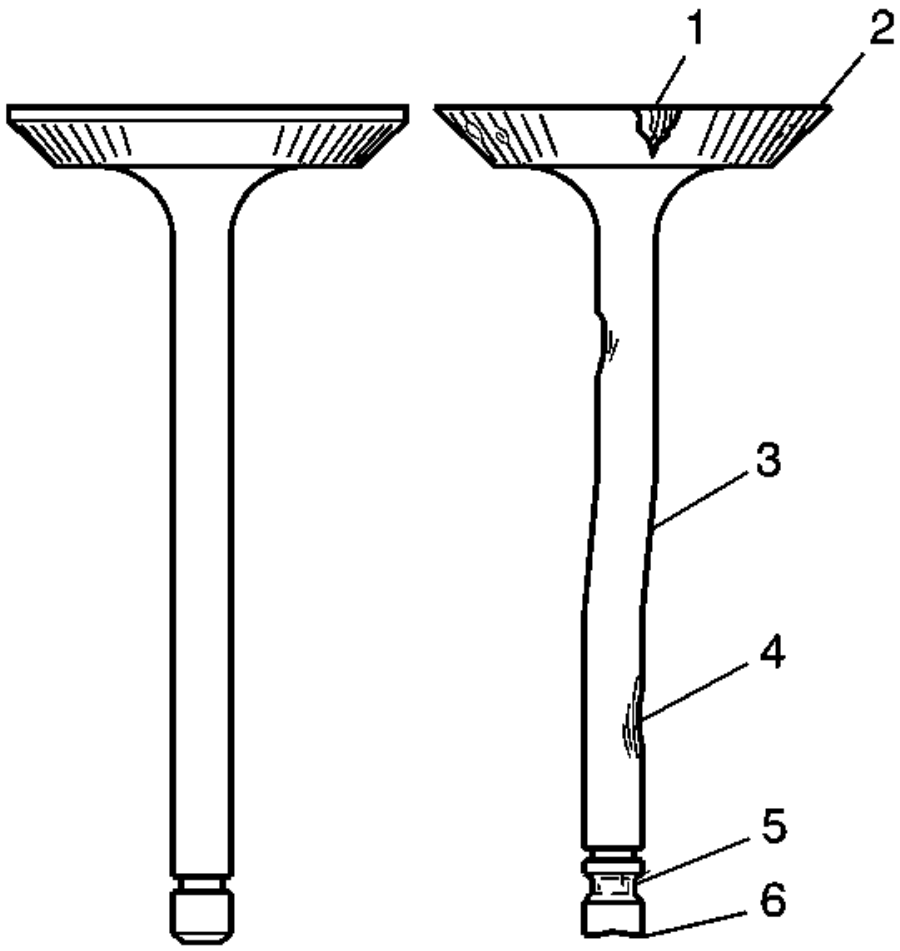

Fig. 515: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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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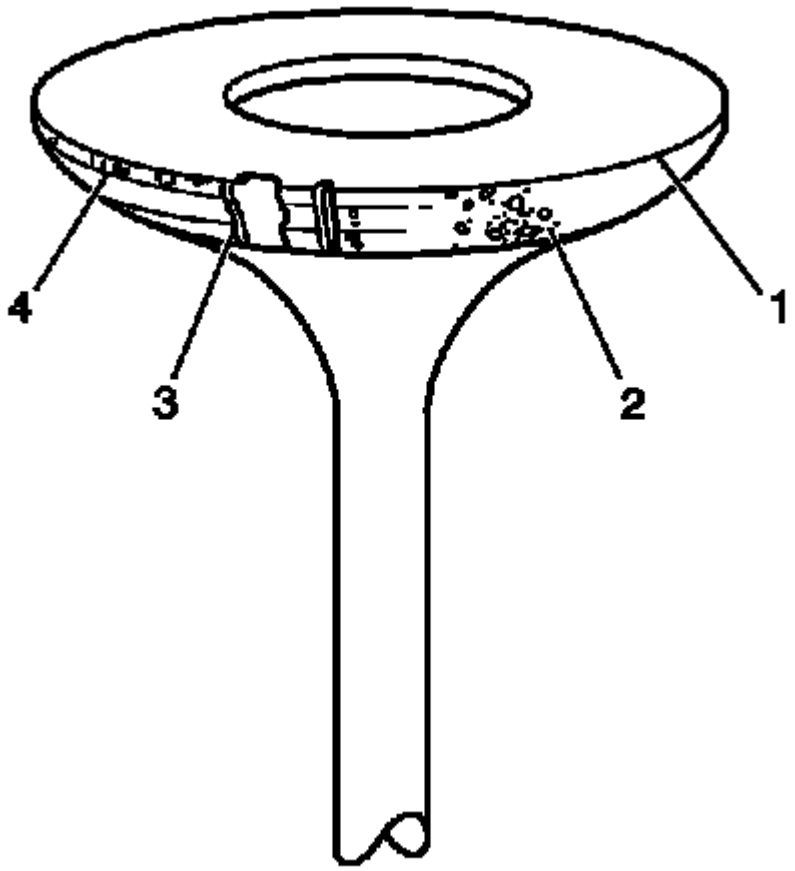

Fig. 516: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

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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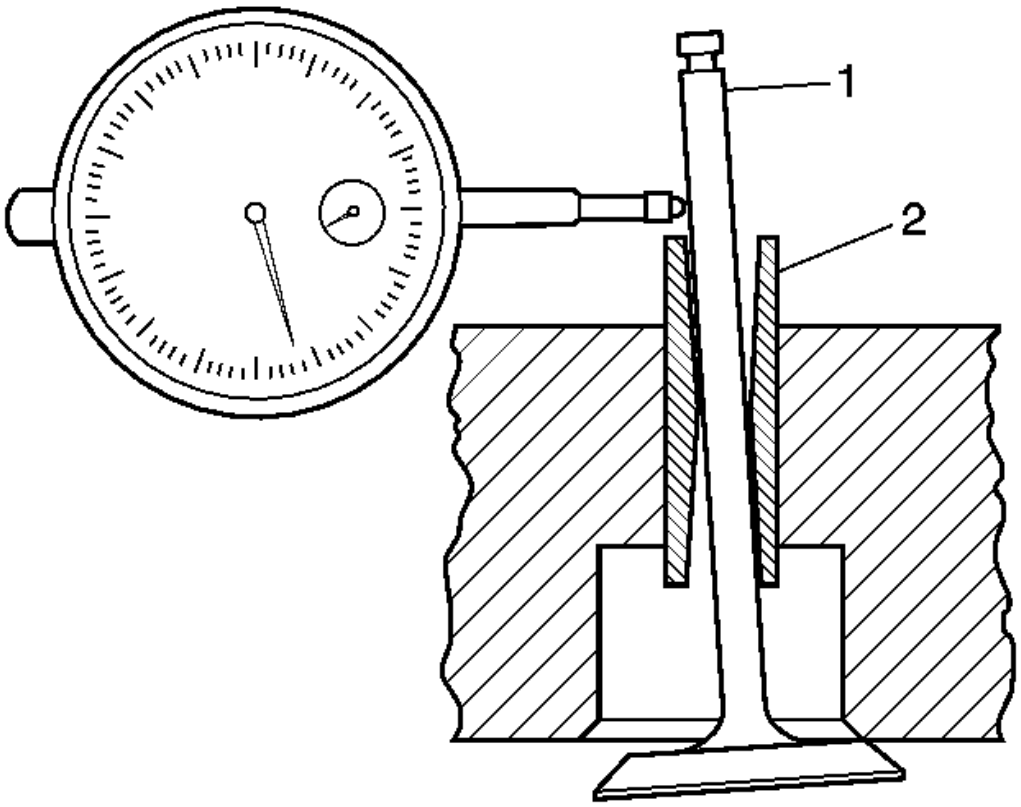

Fig. 517: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

IMPORTANT: Excessive valve stem-to-guide clearance may cause the following conditions:

- **A noisy valve train**
- **Premature valve stem oil seal wear**
- **Component damage**

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- **Excessive engine oil consumption**

4. Inspect for excessive valve stem (1) to guide (2) clearance.

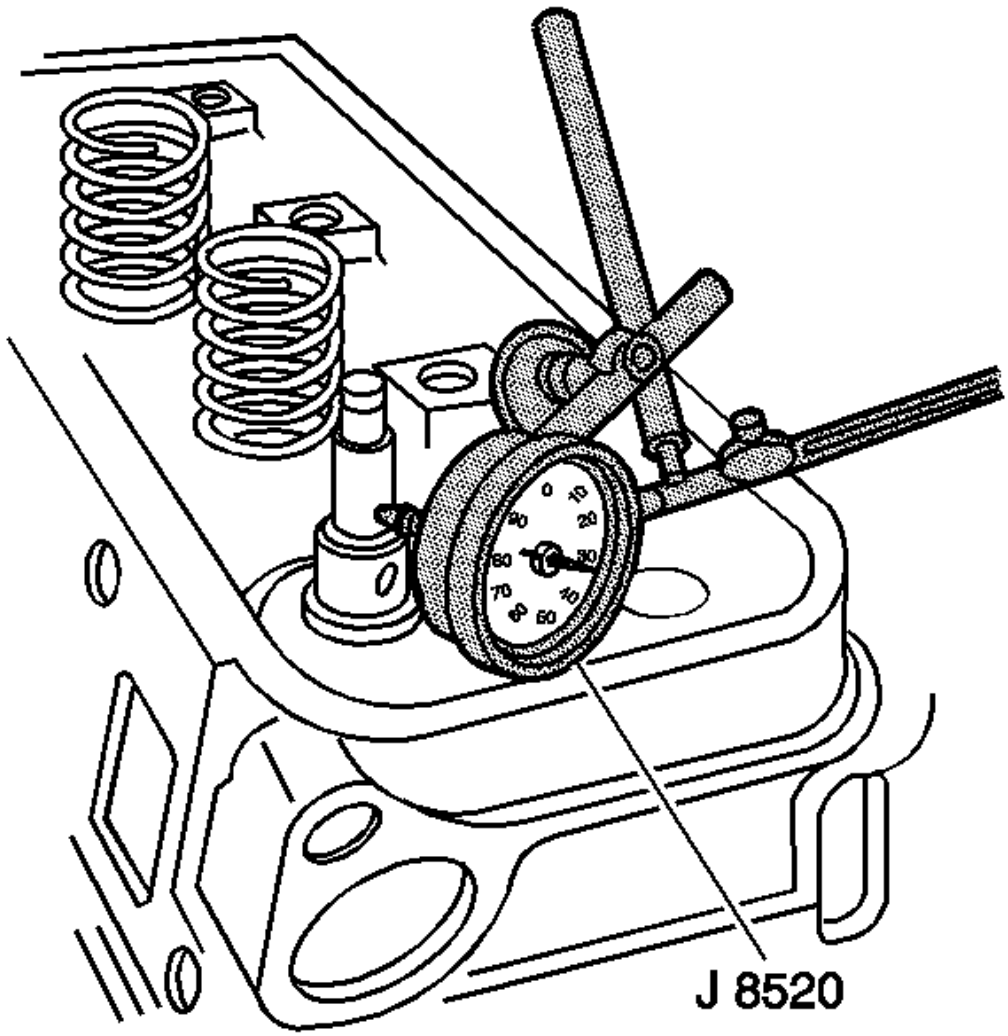

Fig. 518: Identifying J 8520
Courtesy of GENERAL MOTORS CORP.

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.
    2. Install the **J 8520** onto the cylinder head. See **Special Tools**.

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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.

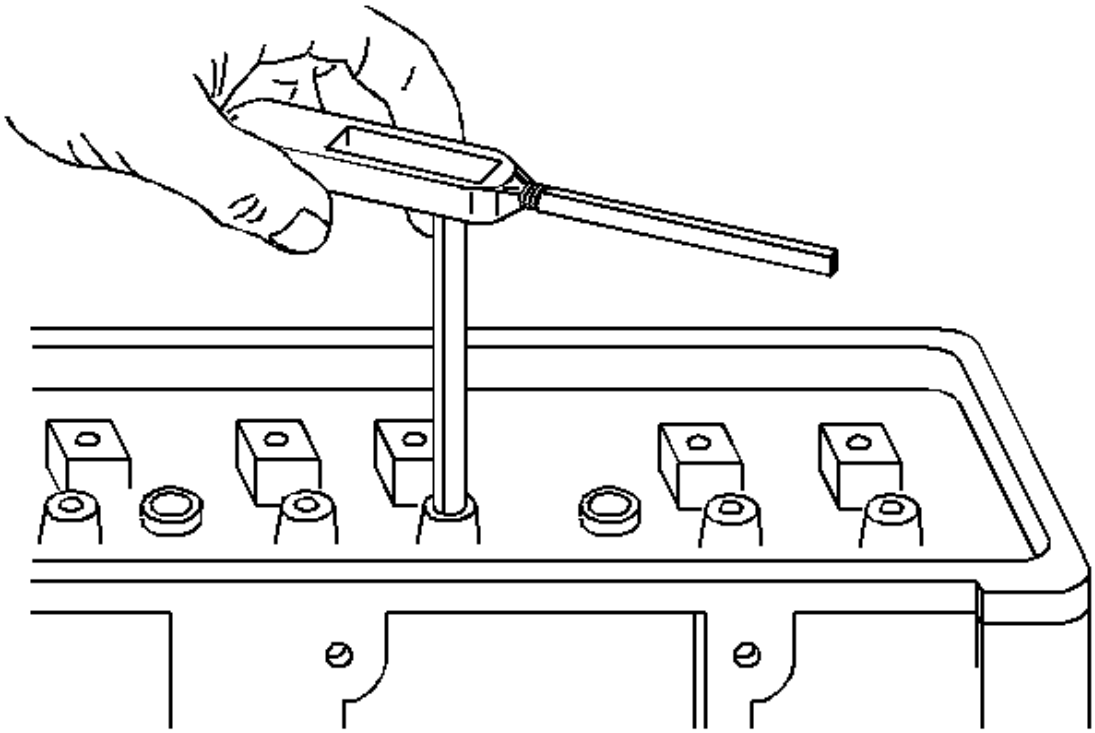

Fig. 519: Reaming Valve Guides For Oversize Valves
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 sleeved.

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6. Ream the valve guides for oversize valves if the clearance exceeds the specifications.

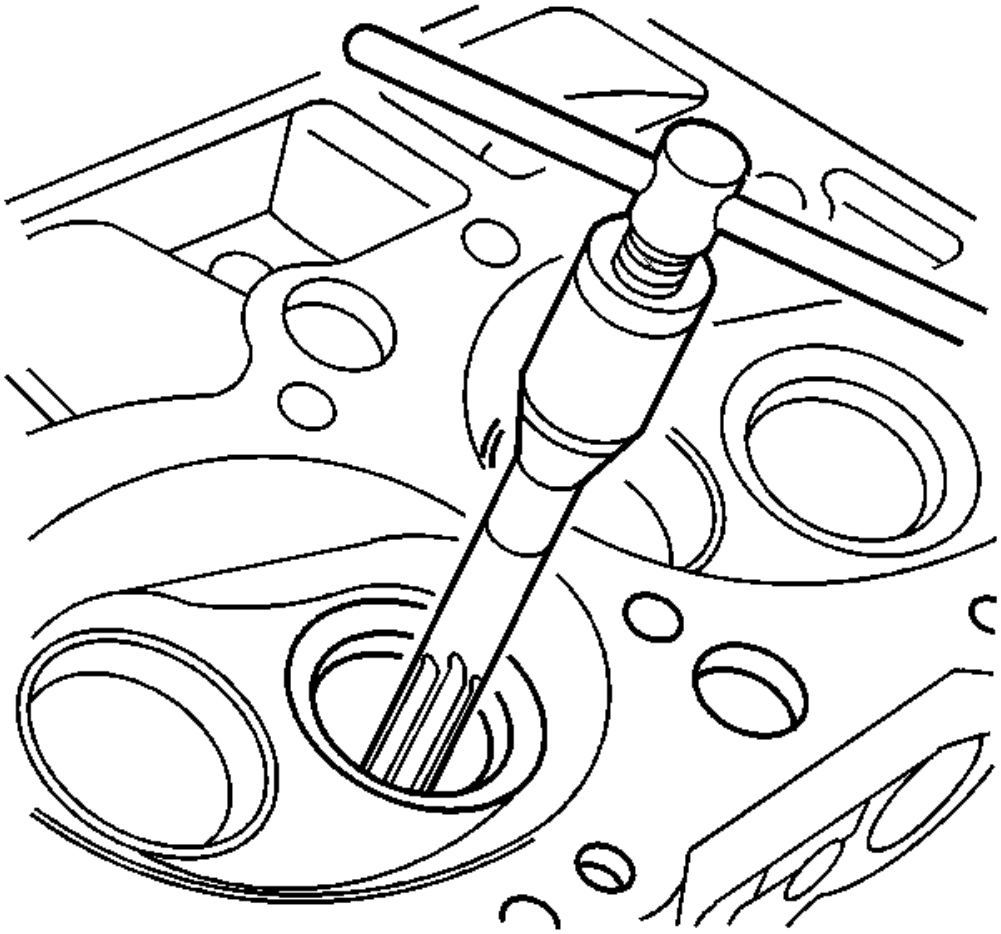

Fig. 520: Reaming Valve Guide
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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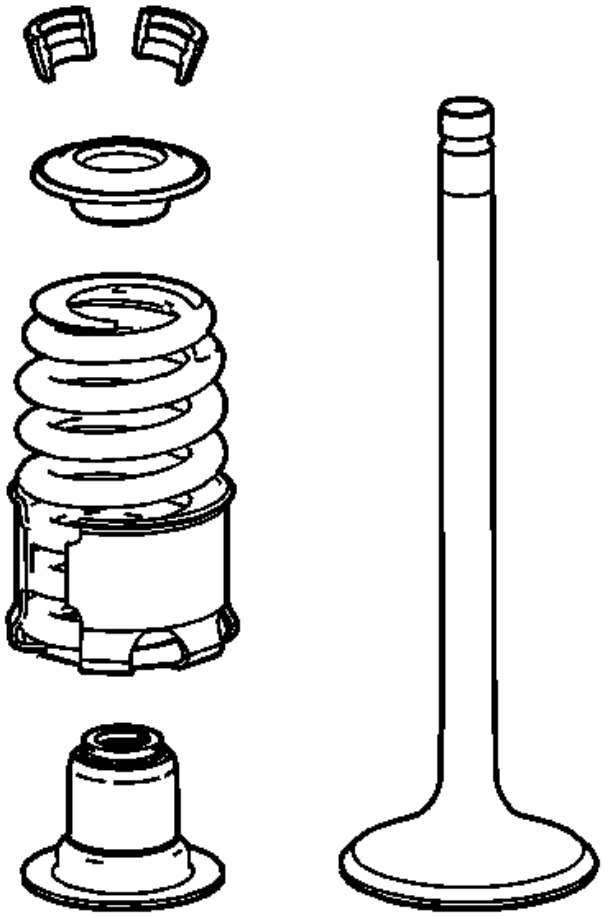

Fig. 521: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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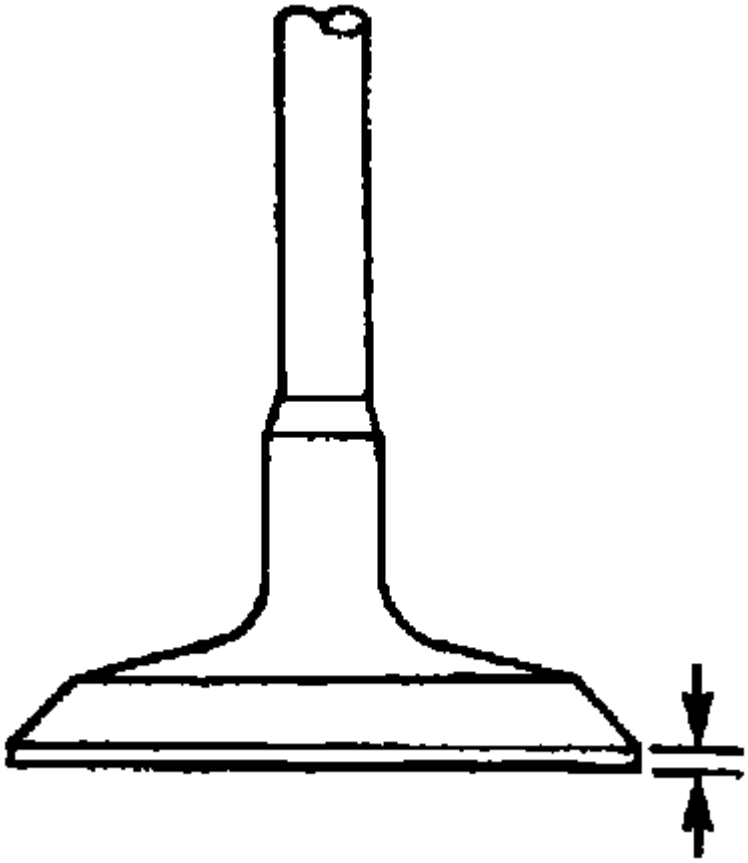

Fig. 522: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: 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

Tools Required

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- **EN-47823** Valve Spring Compressor Adapter. See **Special Tools**.
- **J 5892-D** Valve Spring Compressor. See **Special Tools**.

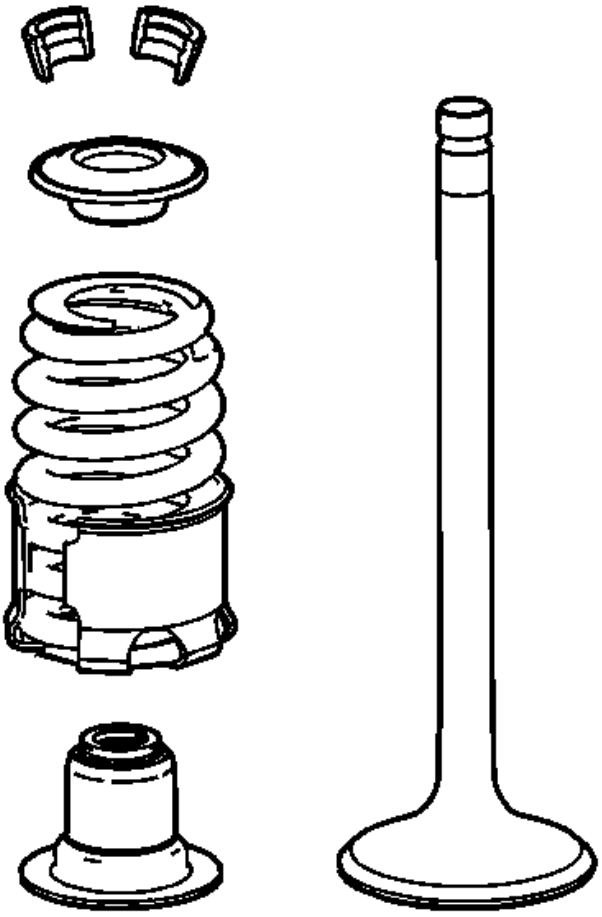

Fig. 523: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.
5. Install the valve springs.
6. Install the valve spring caps.

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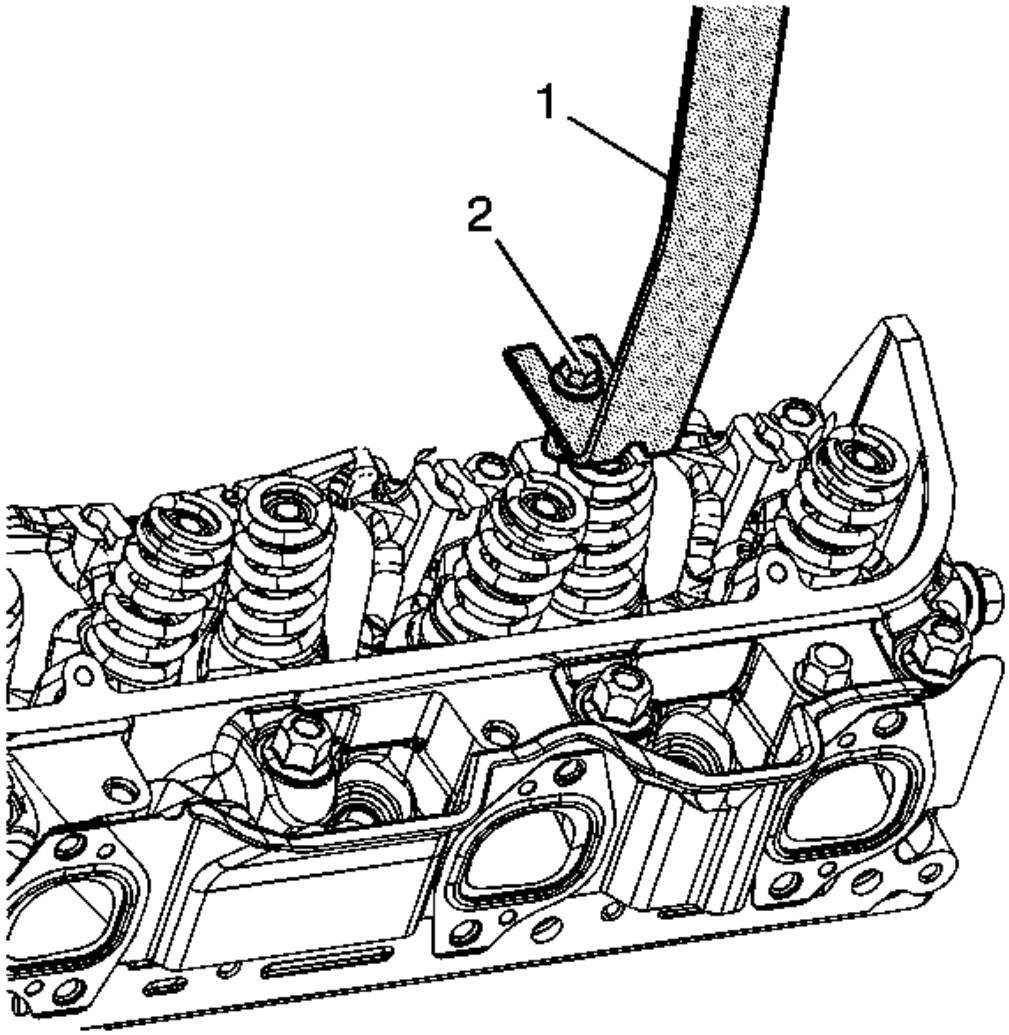

Fig. 524: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

7. Using caution so as not to damage the valve spring or valve spring dampener, compress the valve springs using the **J 5892-D** (1) and the **EN-47823** (2). See **Special Tools**.
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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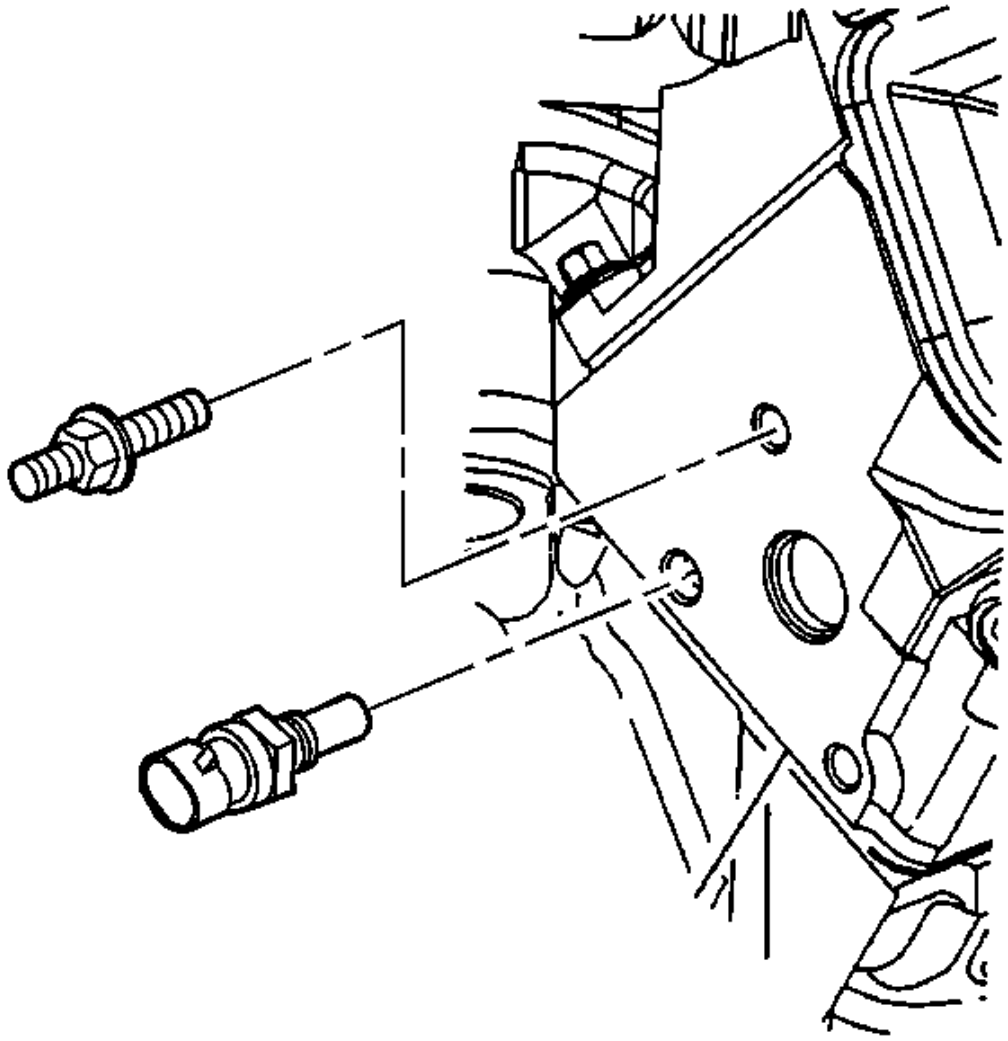

Fig. 525: Removing Heater Inlet Pipe Stud From Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

11. Apply sealer P/N 21485278 to the coolant temperature sensor.

NOTE: **Refer to Fastener Notice .**

12. Install the coolant temperature sensor, if required.

Tighten: 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: Tighten the heater inlet pipe stud to 35 N.m (26 lb ft).

Oil Pump Disassemble

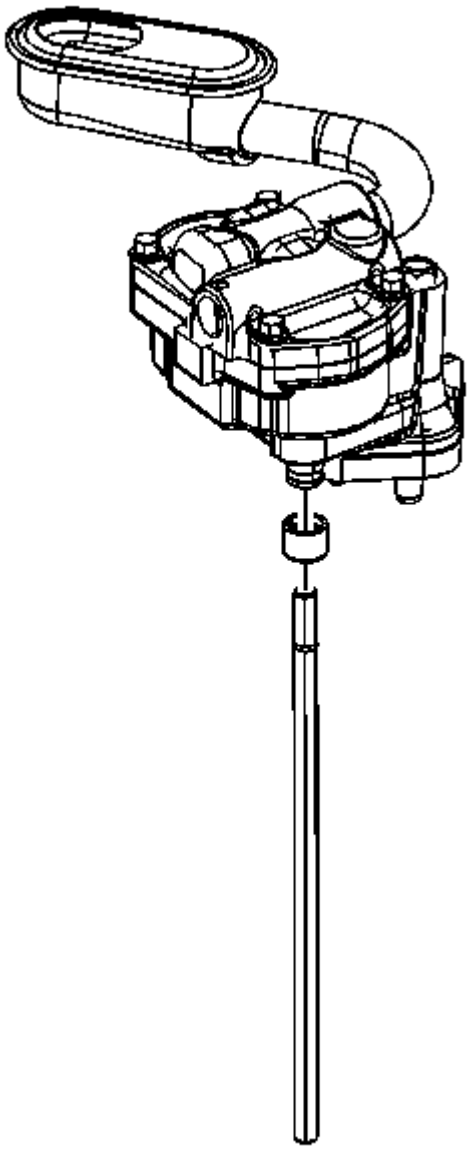

Fig. 526: Identifying Oil Pump Drive Components

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Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

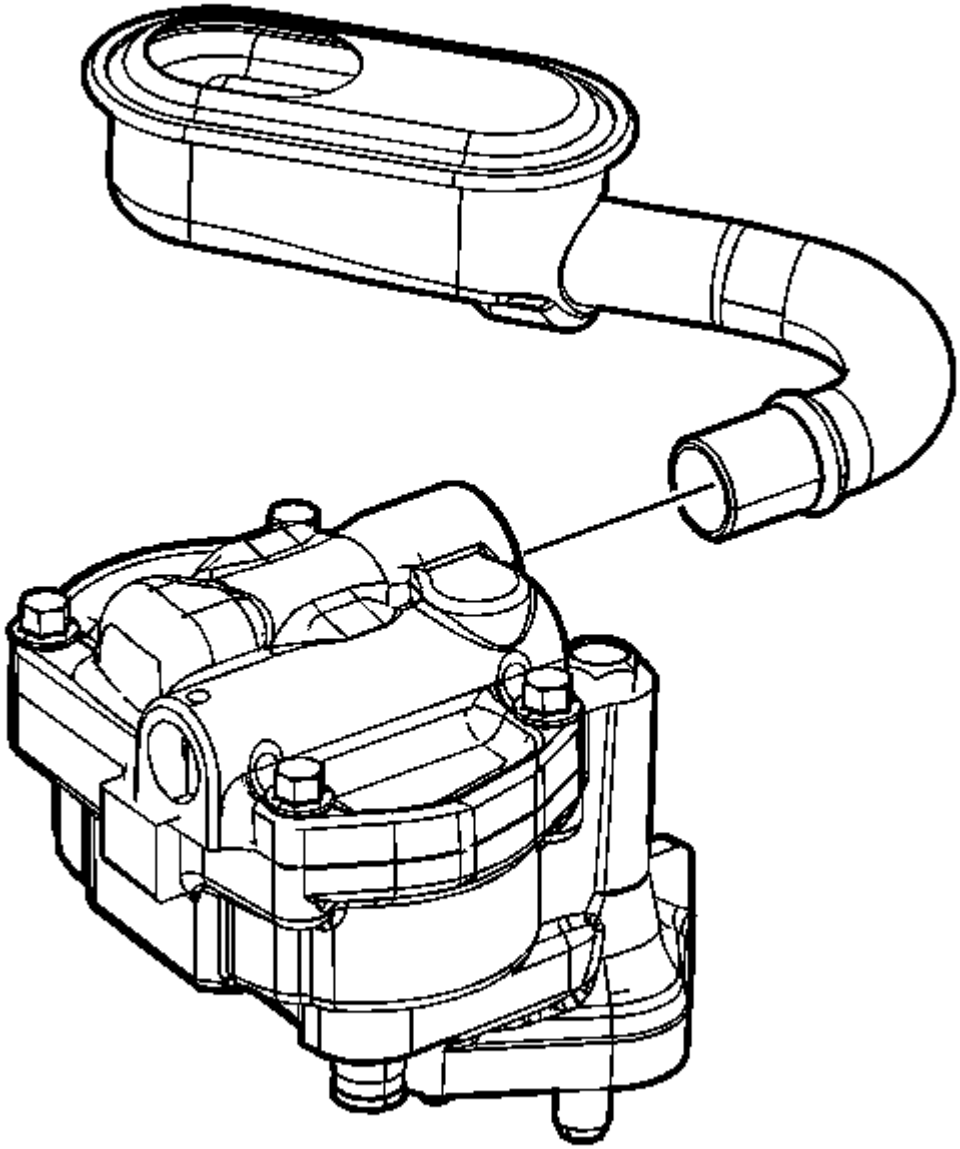

Fig. 527: Identifying Oil Pump & Screen
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

2. Remove the oil pump screen, if necessary.

   The oil pump screen has a press fit into the oil pump cover.

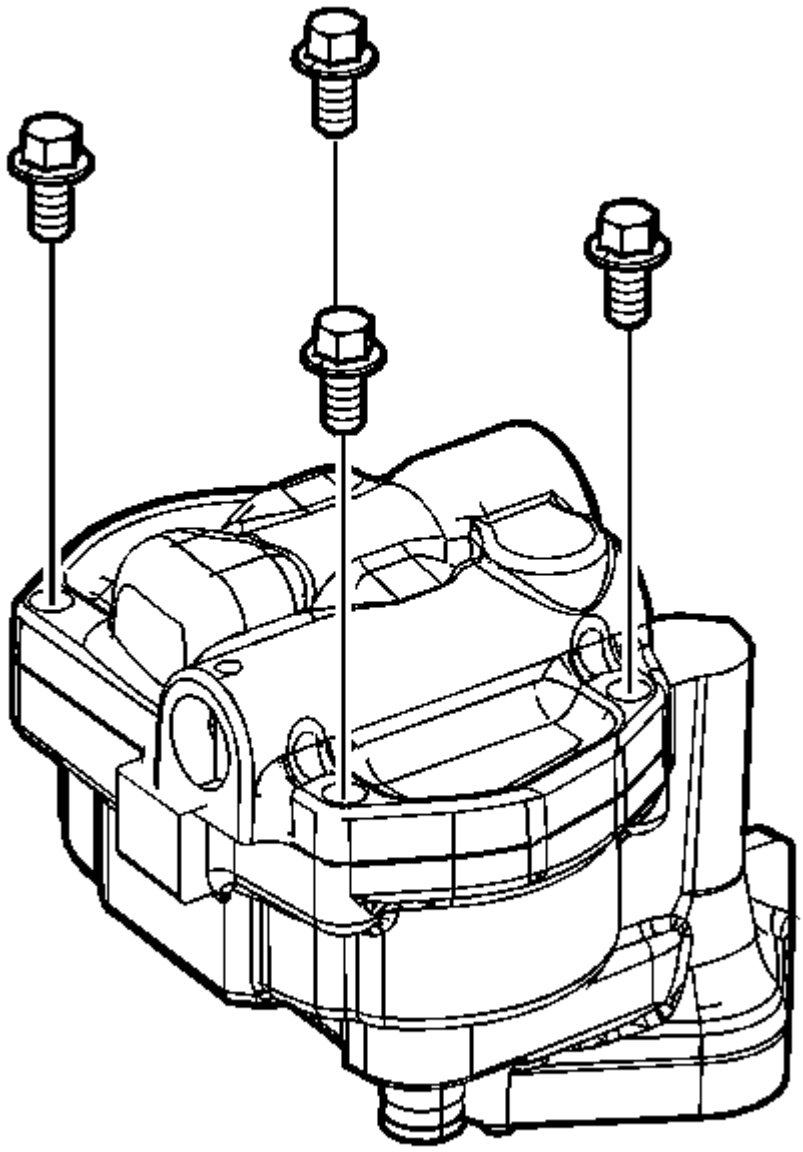

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Fig. 528: Identifying Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover bolts.

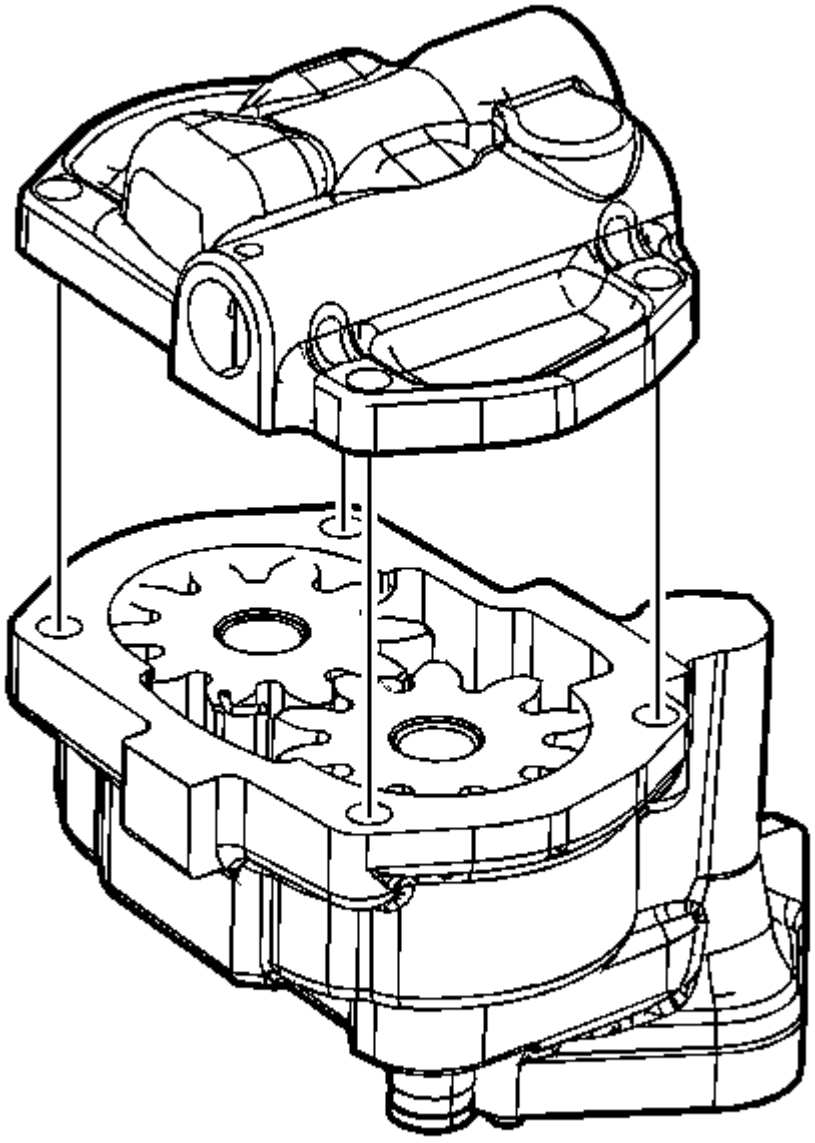

Fig. 529: Identifying Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

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4. Remove the oil pump cover.

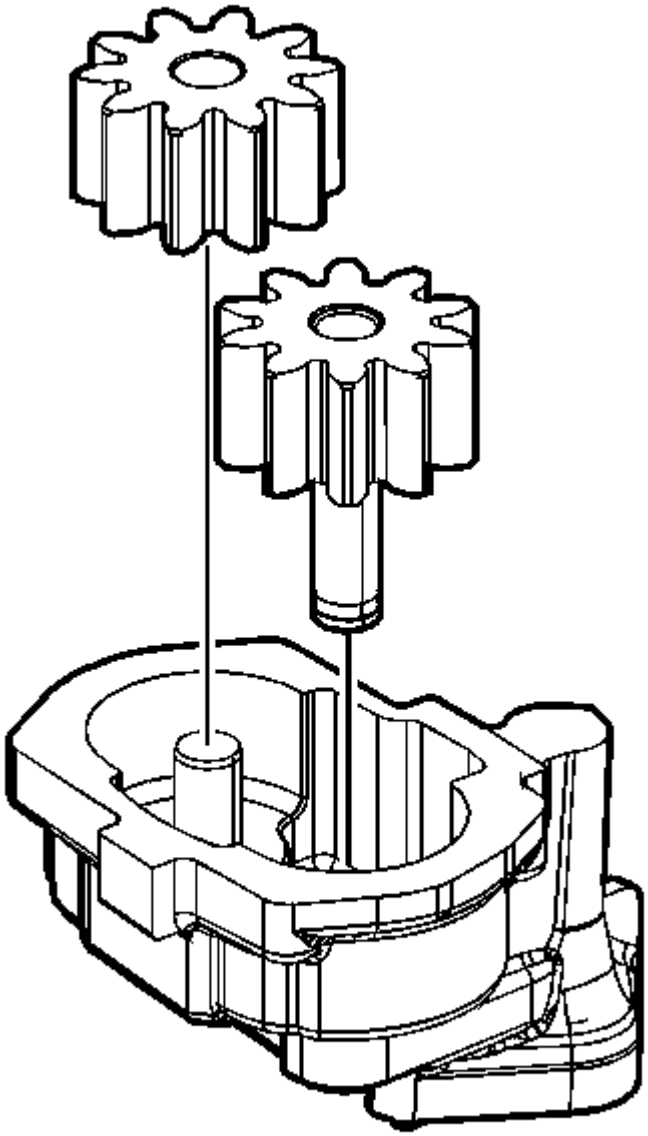

Fig. 530: Identifying Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

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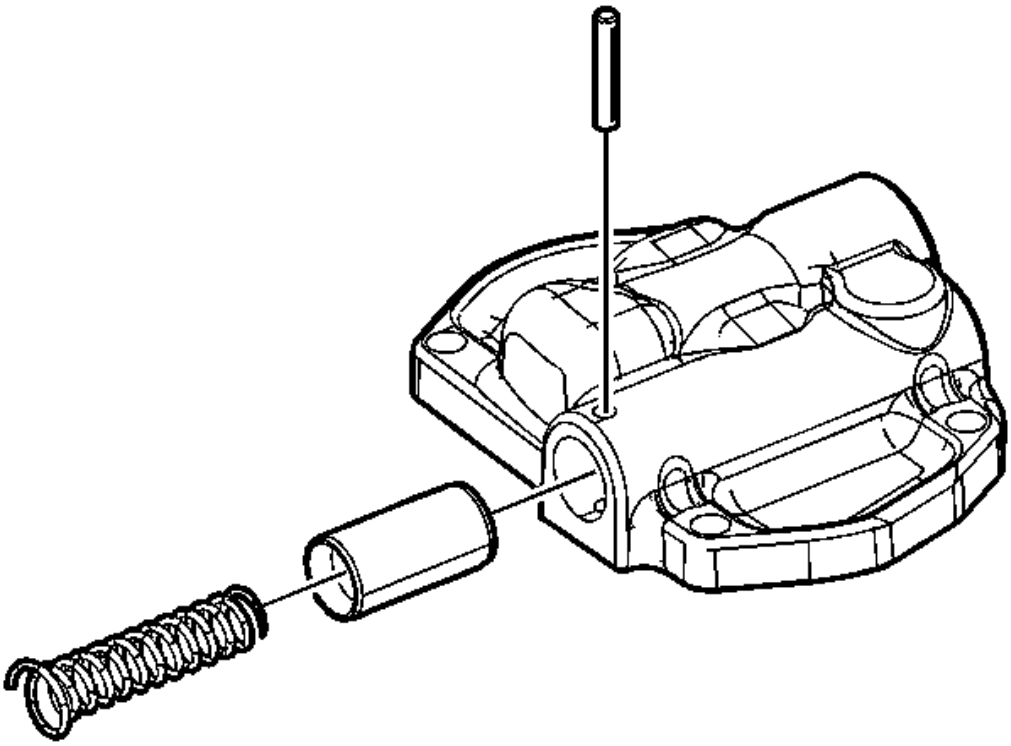

Fig. 531: Identifying Pressure Regulator Valve Spring
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

CAUTION: 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.

CAUTION: Refer to Cleaning Solvent Caution .

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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

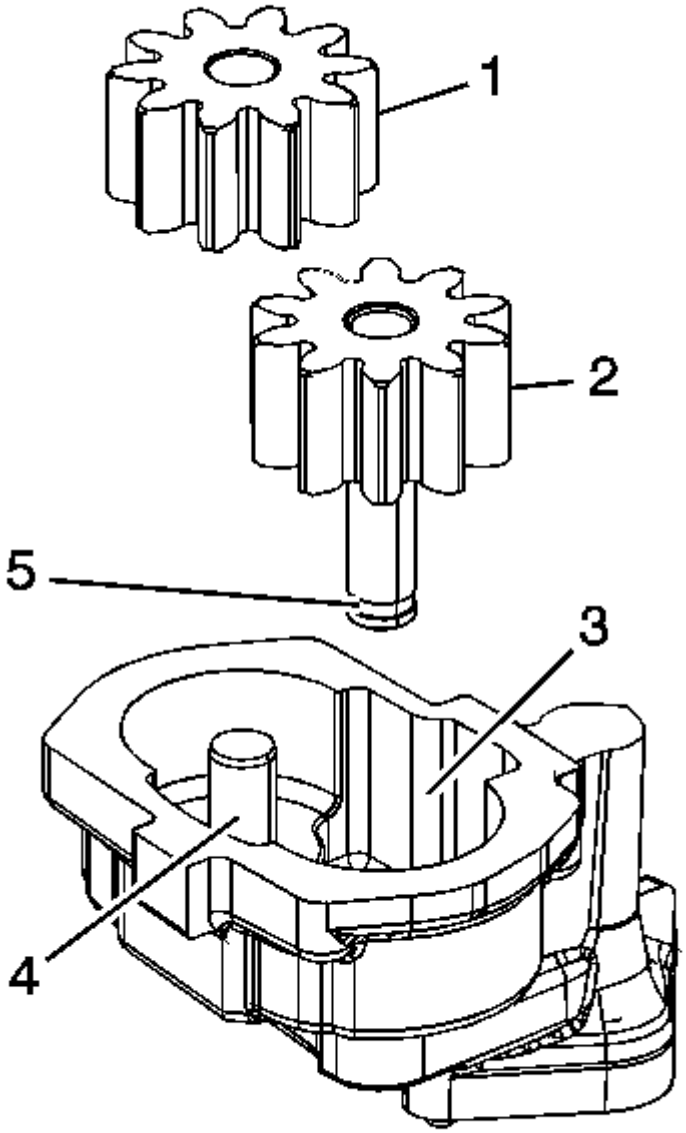

Fig. 532: Identifying Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

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CAUTION: Refer to Cleaning Solvent Caution .

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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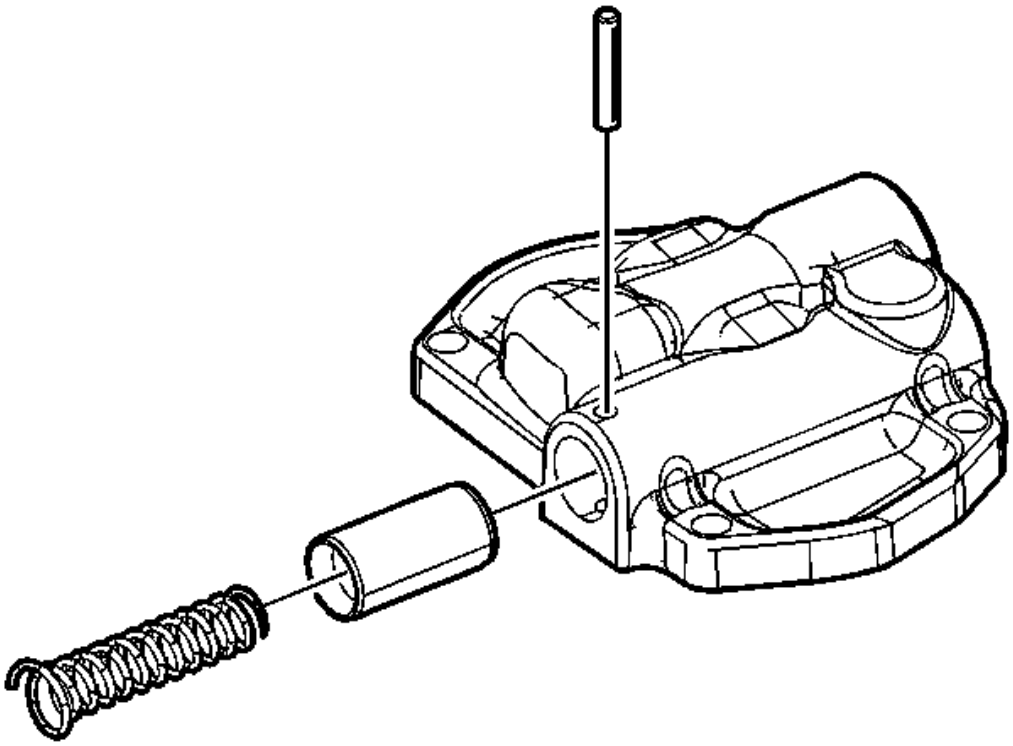

Fig. 533: Identifying Oil Pump Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

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.

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- Broken wire mesh or screen

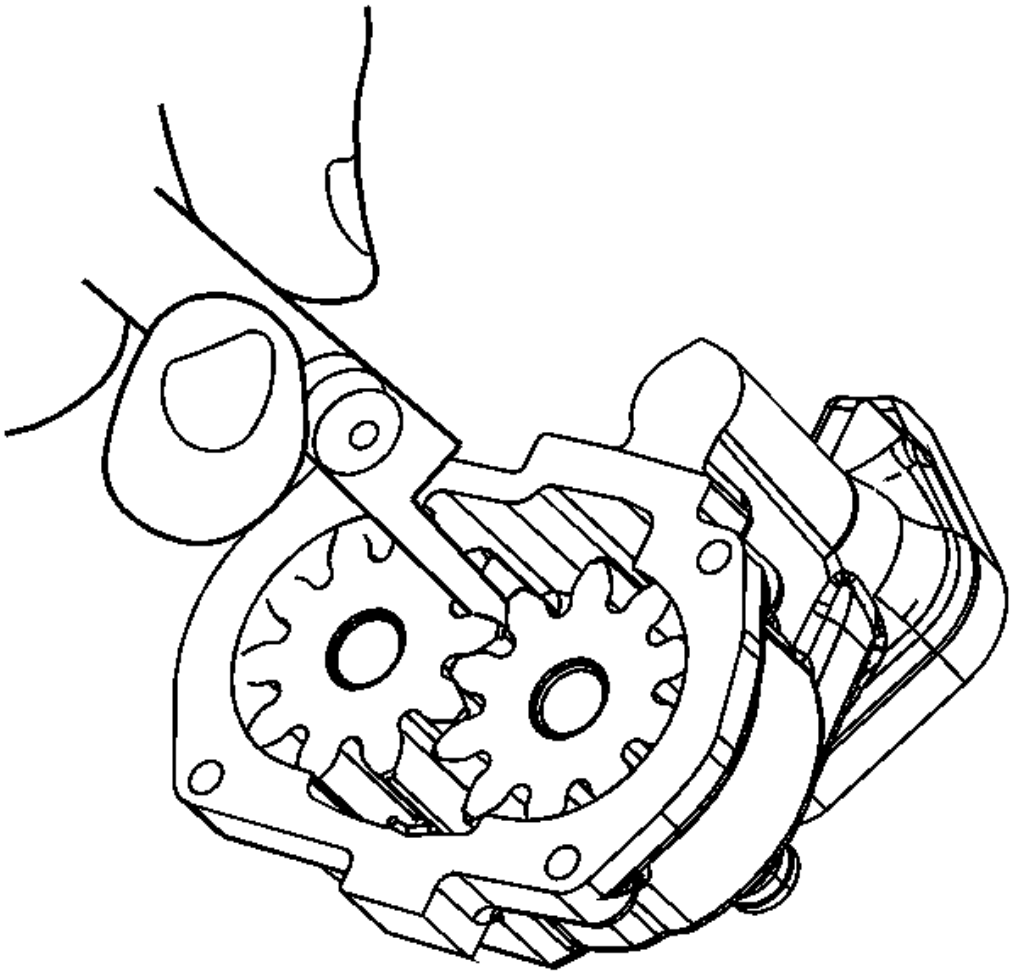

Fig. 534: Measuring Oil Pump Gear Lash
Courtesy of GENERAL MOTORS CORP.

11. Measure the oil pump gear lash. Install the gears, and measure in several places.

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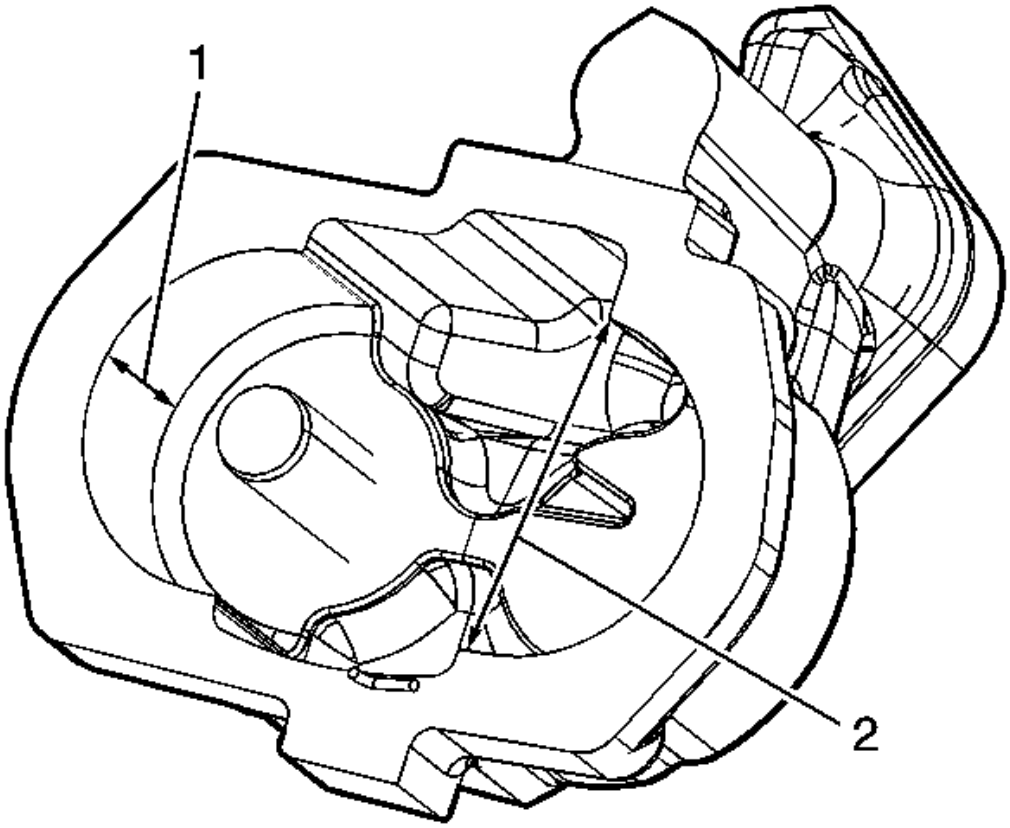

Fig. 535: Measuring Oil Pump Housing Gear Pocket
Courtesy of GENERAL MOTORS CORP.

12. Measure the oil pump housing gear pocket (1, 2).

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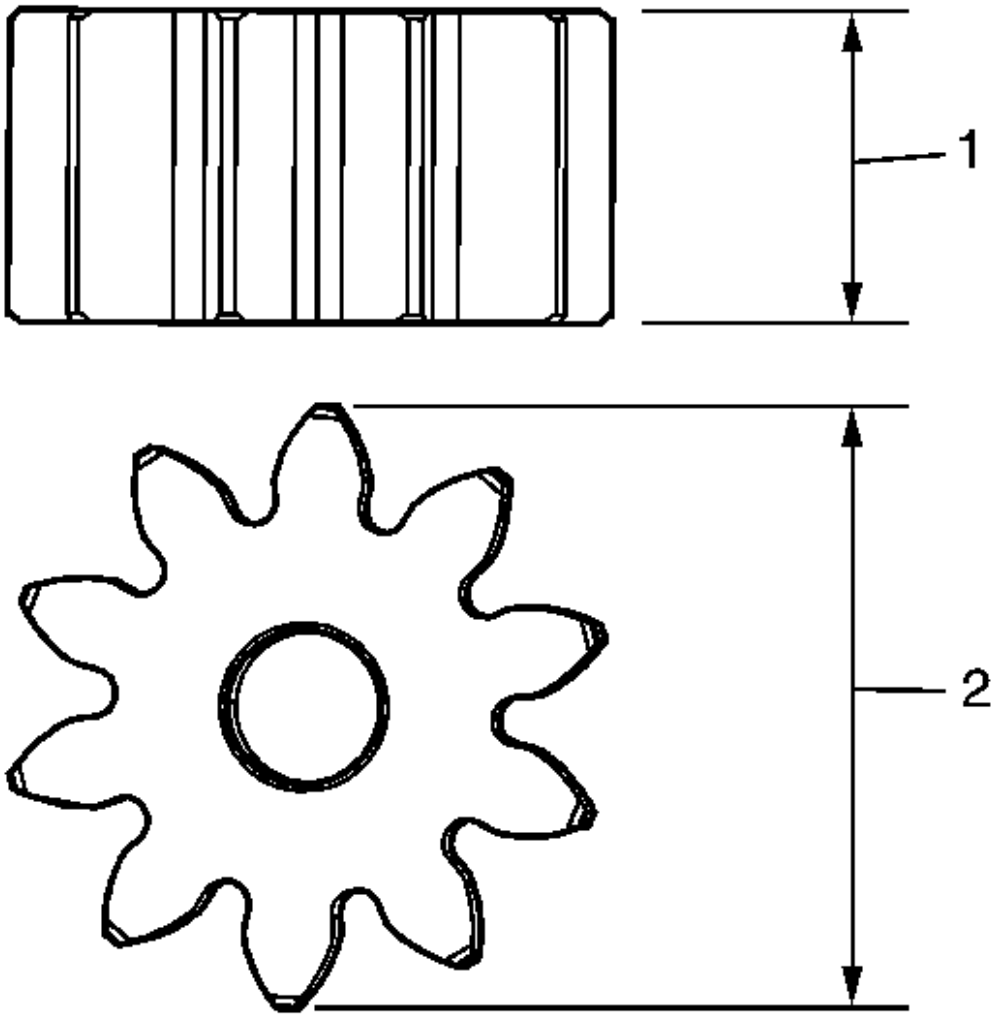

Fig. 536: Measuring Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

13. Measure the oil pump gears (1, 2).

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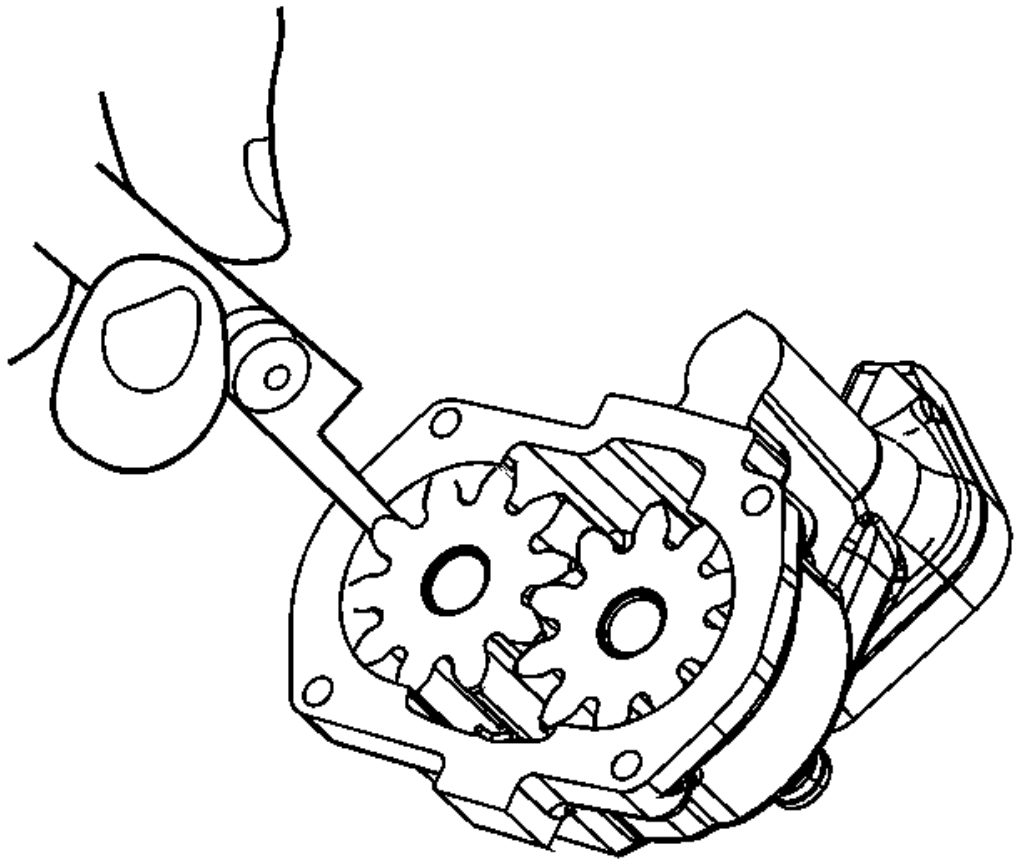

Fig. 537: Measuring Oil Pump Gear Side Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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

Tools Required

J 22144 Oil Suction Pipe Installer. See **Special Tools**

1. Lubricate all the internal oil pump parts using engine oil during assembly.

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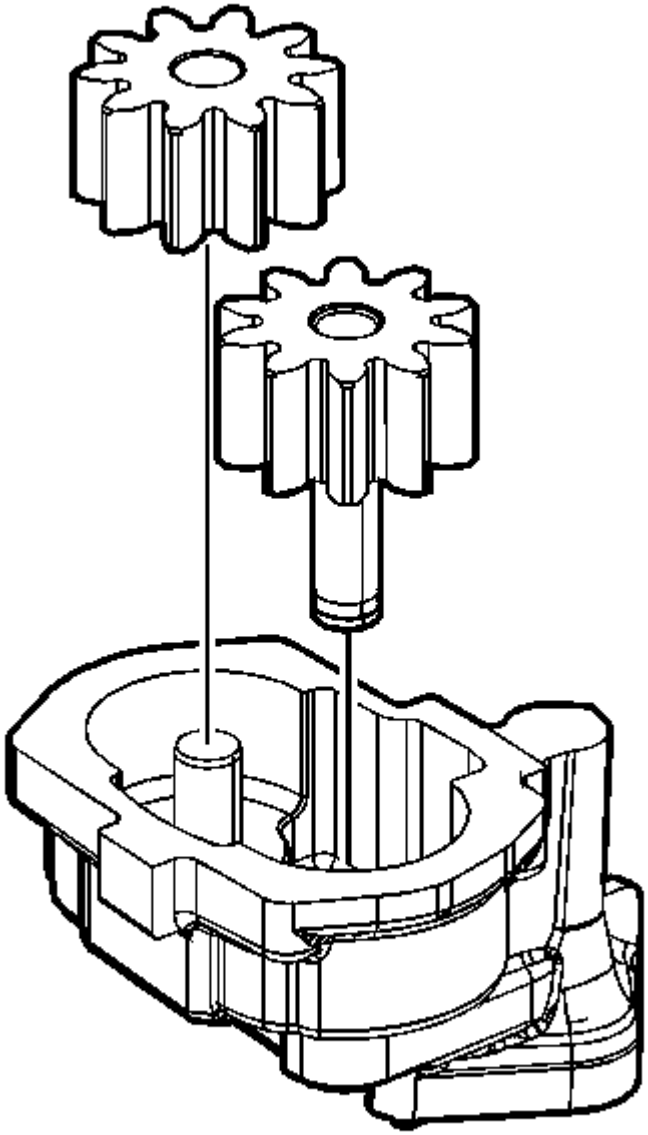

Fig. 538: Identifying Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump gears.

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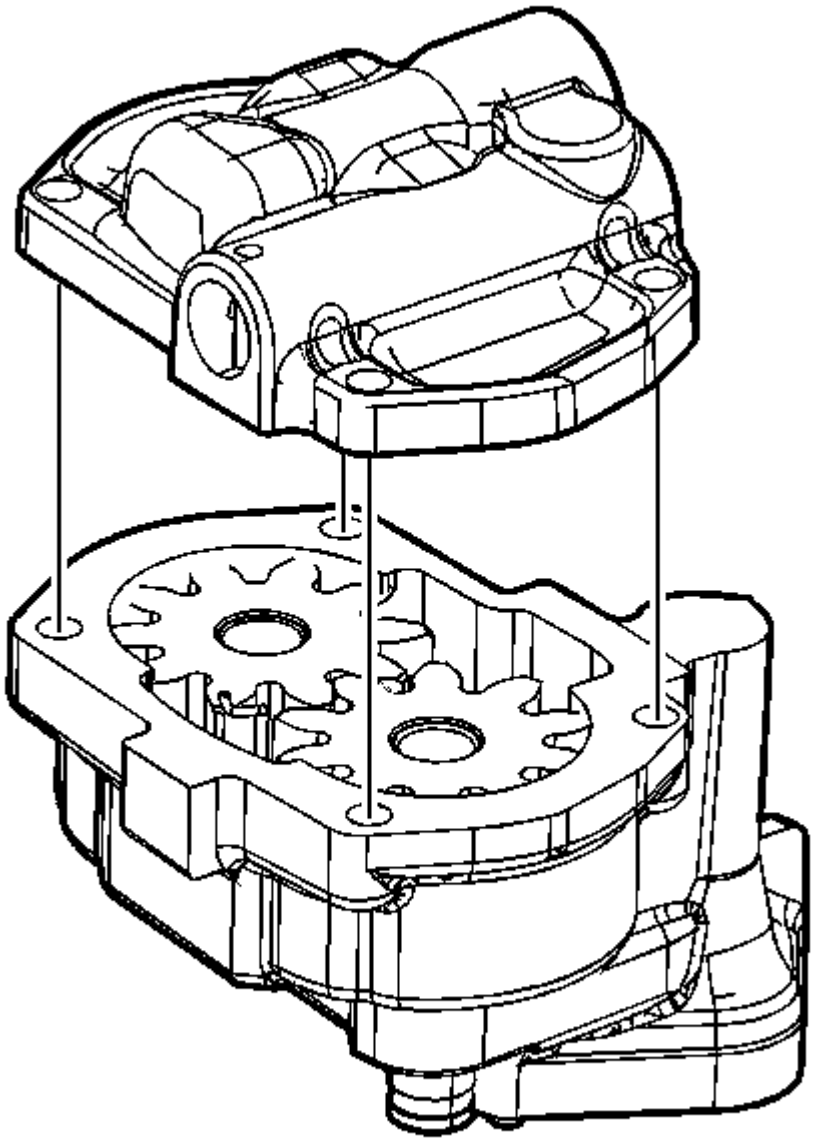

Fig. 539: Identifying Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump cover.

NOTE: Refer to Fastener Notice .

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4. Install the oil pump cover bolts.

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

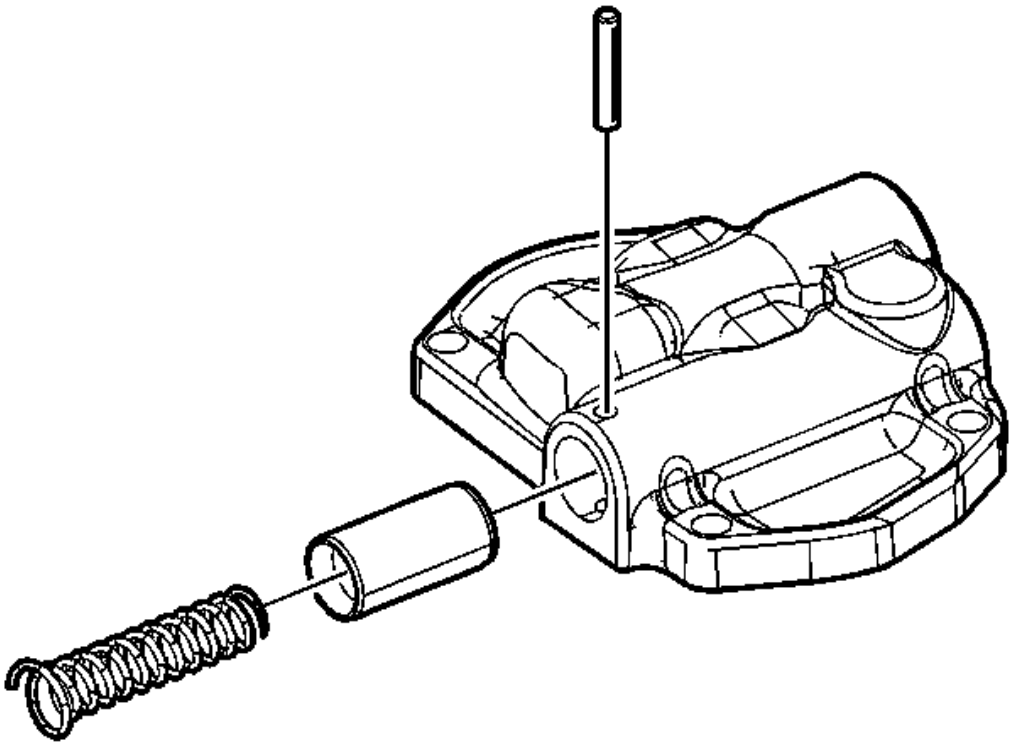

Fig. 540: Identifying Oil Pump Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure regulator valve.
6. Install the pressure regulator spring.
7. Install the cotter pin.

IMPORTANT: 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** . See **Special Tools**.

Engine Front Cover Cleaning and Inspection

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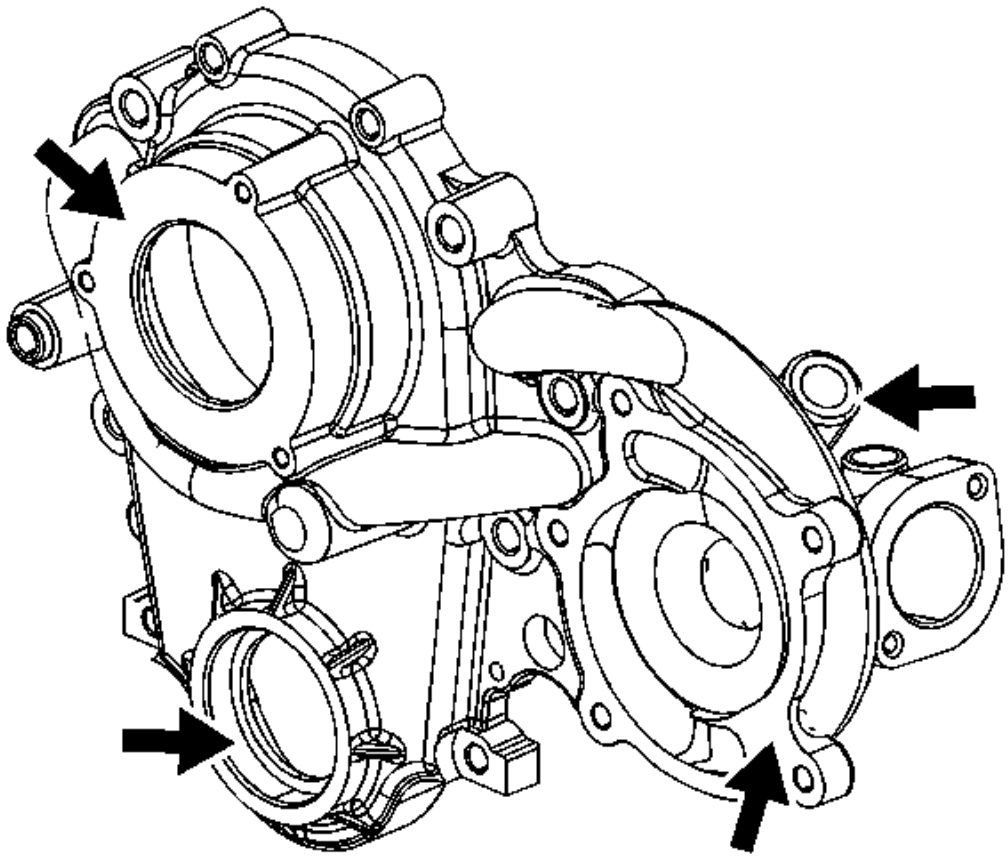

Fig. 541: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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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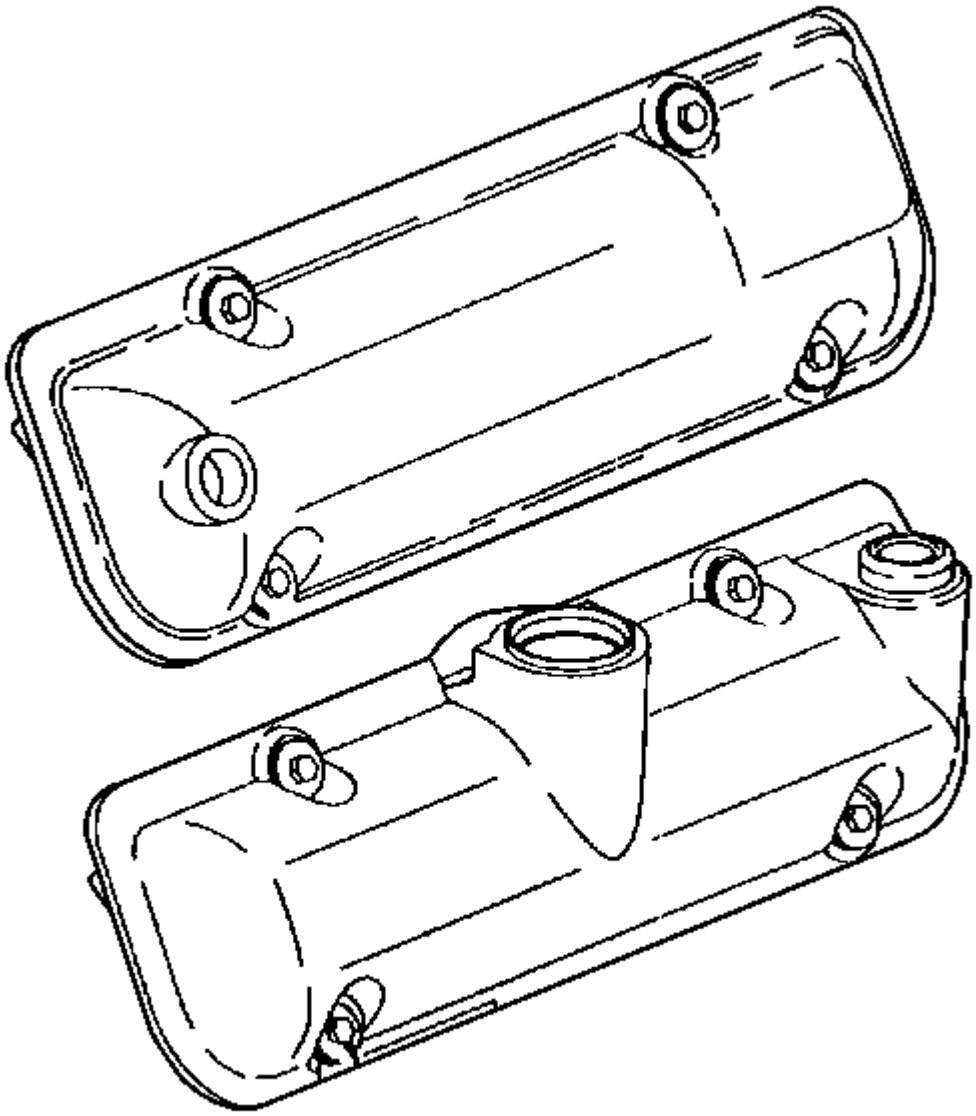

Fig. 542: Cleaning Valve Rocker Arm Covers
Courtesy of GENERAL MOTORS CORP.

1. Remove all rubber grommets from the valve rocker arm covers.

CAUTION: 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

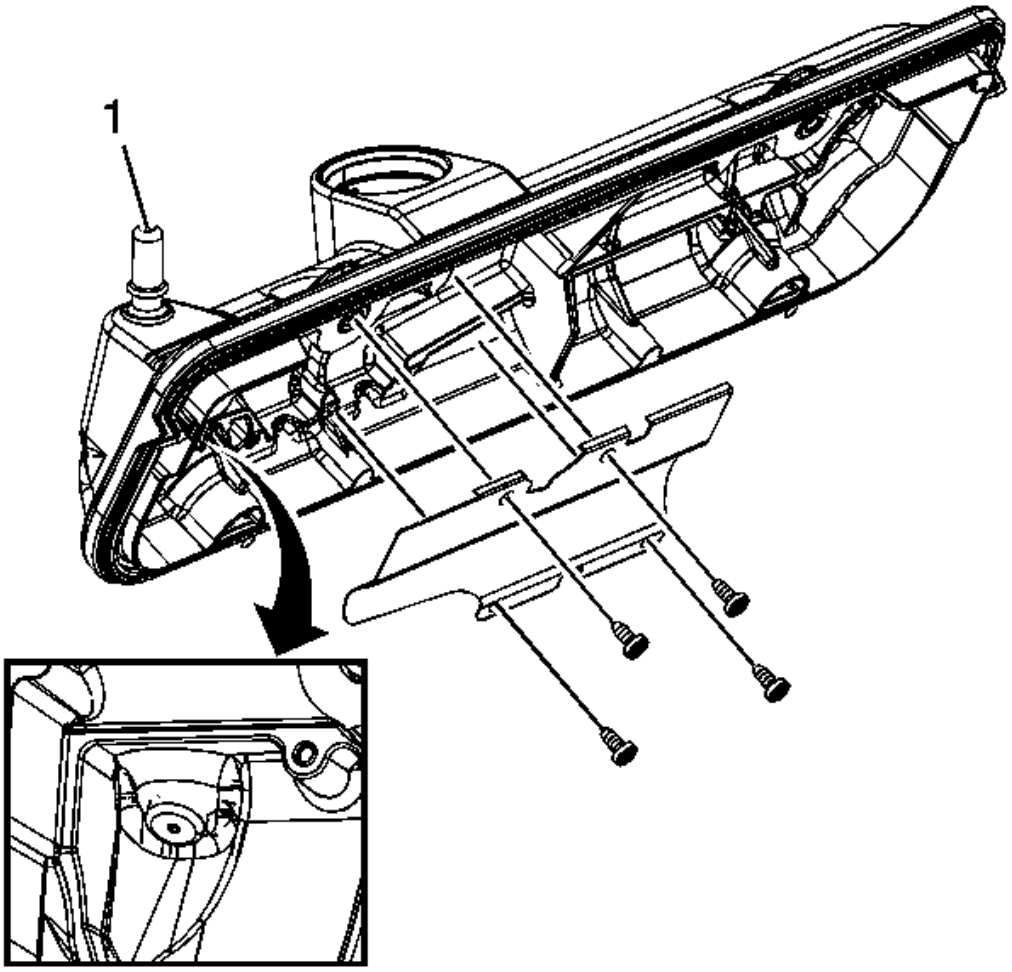

Fig. 543: Identifying Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: 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

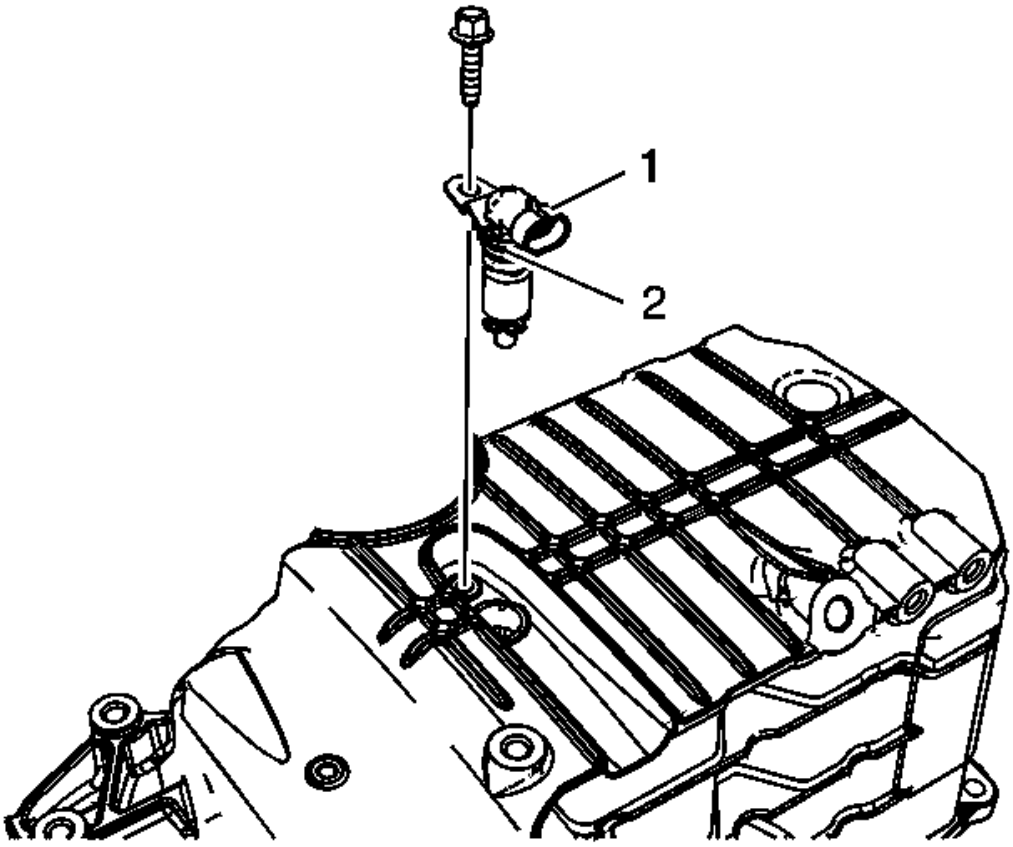

Fig. 544: Identifying Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

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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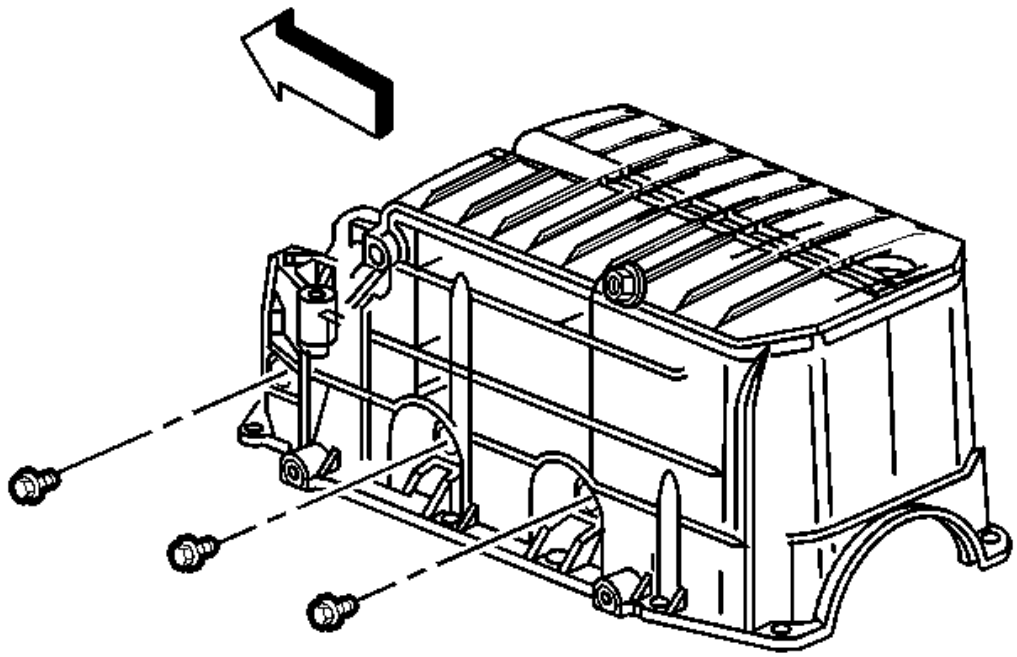

Fig. 545: Oil Pan
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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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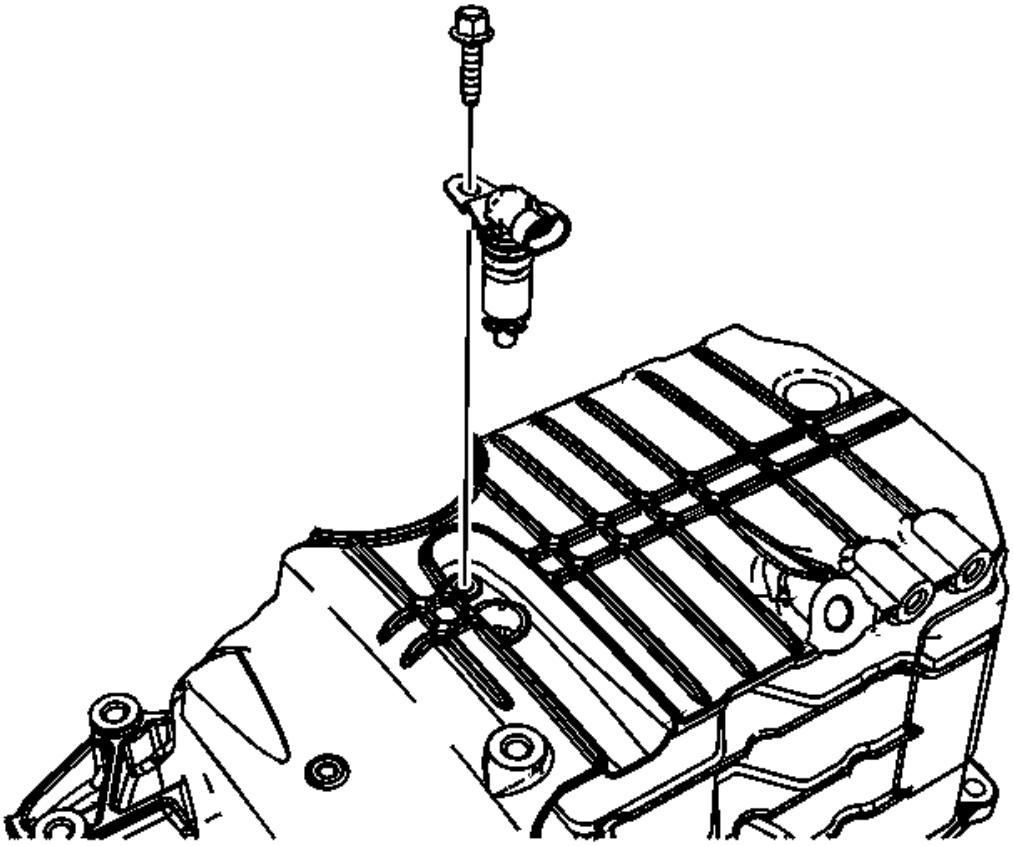

Fig. 546: View Of Oil Level Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the oil level sensor and bolt.

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

Lower Intake Manifold Cleaning and Inspection

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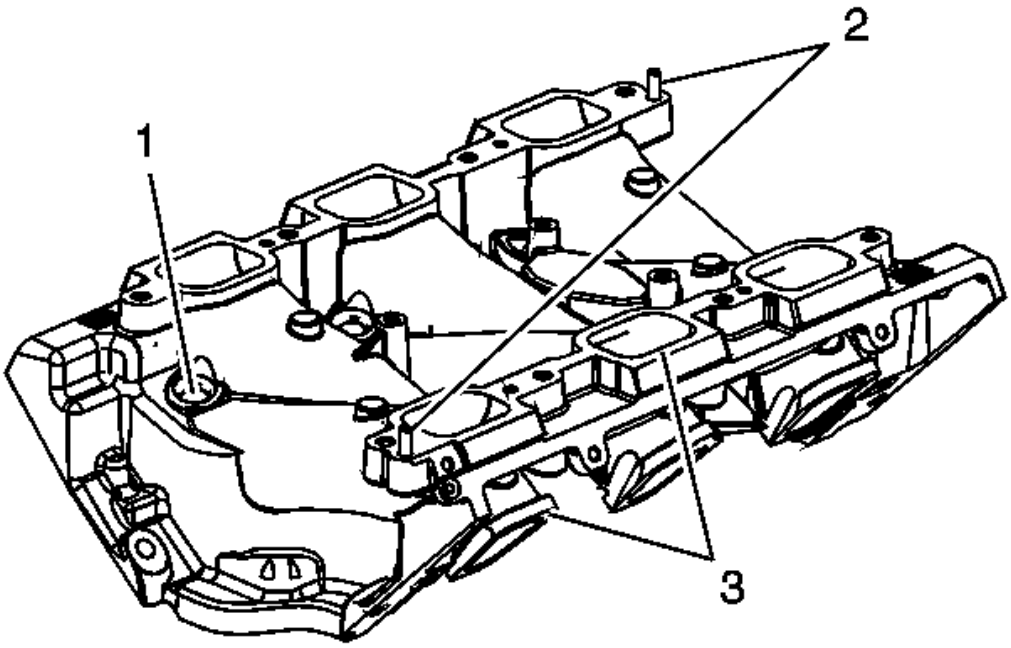

Fig. 547: View Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Cleaning Solvent Caution .

1. Clean the coolant crossover pipe with solvent.

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CAUTION: Refer to Safety Glasses Caution .

2. Dry the coolant crossover pipe with compressed air.

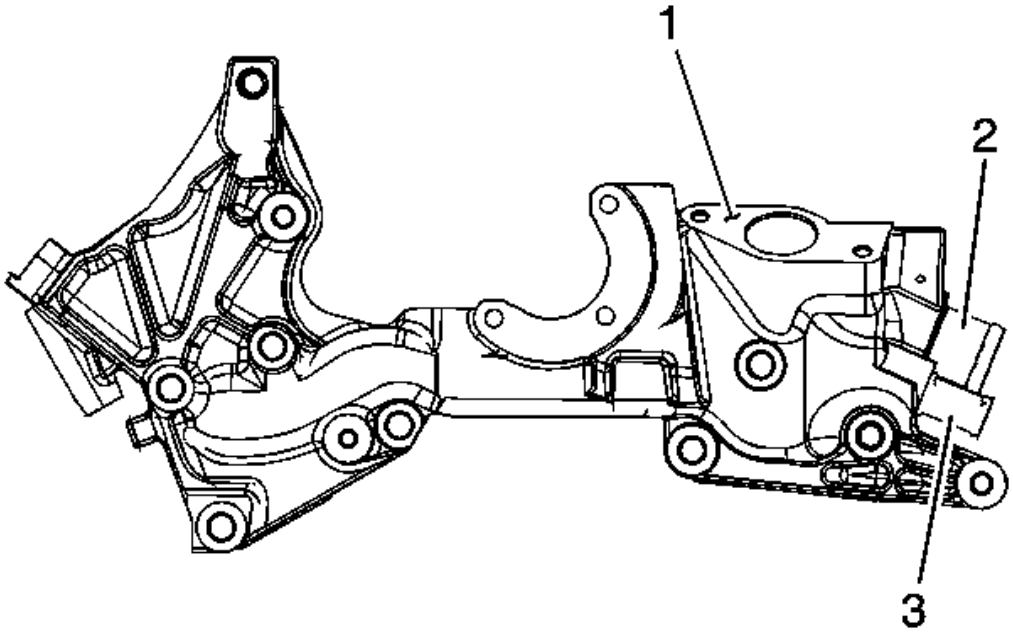

Fig. 548: View Of Front Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

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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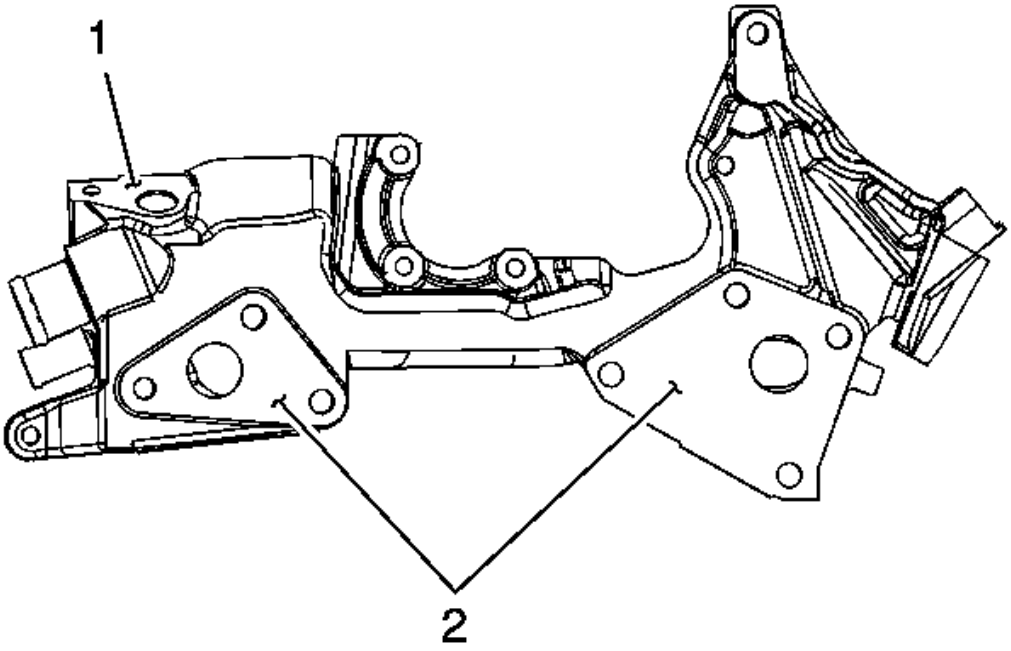

Fig. 549: View Of Rear Of Coolant Crossover Pipe
Courtesy of GENERAL MOTORS CORP.

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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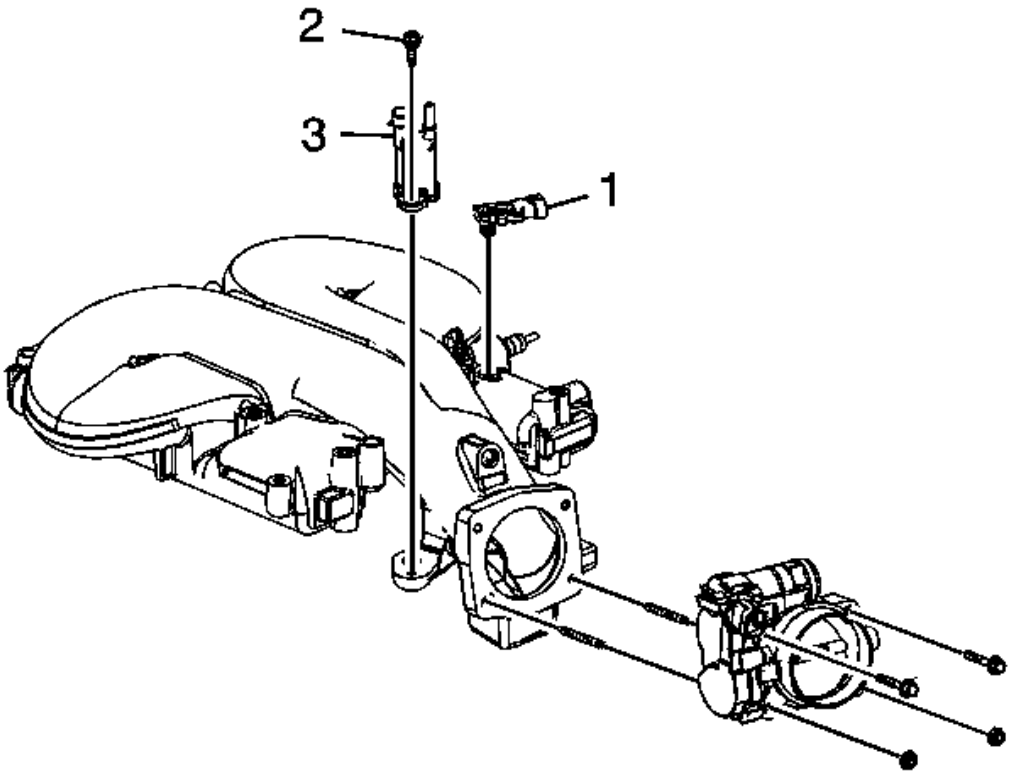

Fig. 550: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

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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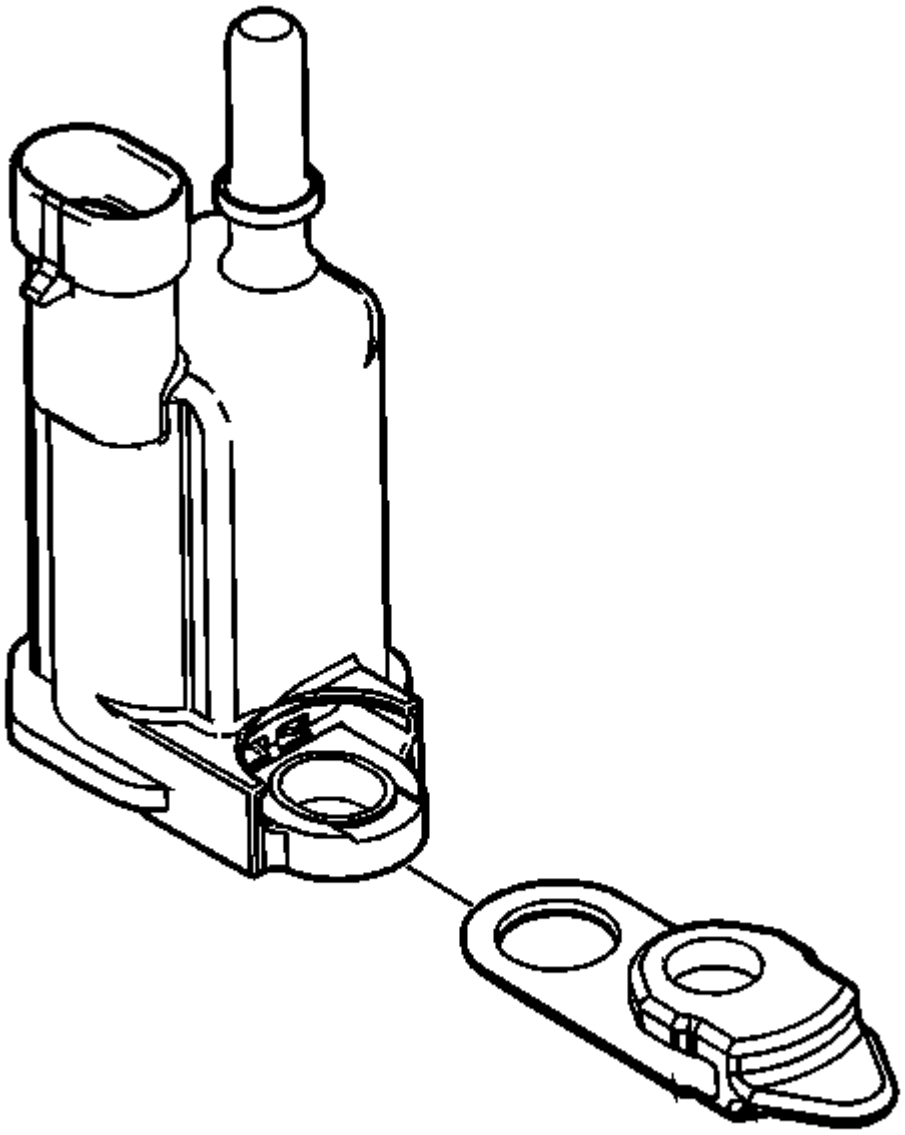

Fig. 551: Identifying EVAP Purge Valve Isolator
Courtesy of GENERAL MOTORS CORP.

7. Remove the EVAP purge valve isolator, if equipped.

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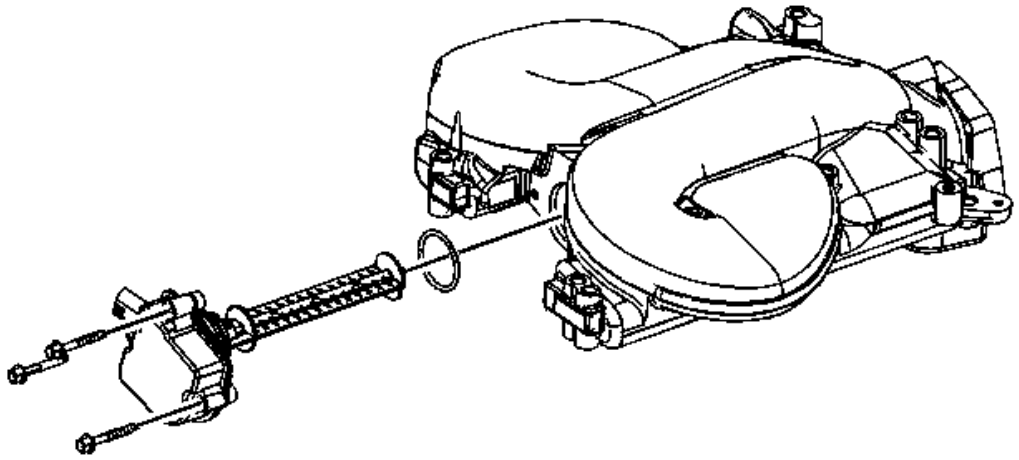

Fig. 552: Identifying Inlet Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If at any time the intake manifold tuning valve blade becomes separated from the actuator, DO NOT cycle the actuator. Cycling the actuator without the blade attached will offset the calibration, and the entire intake manifold tuning valve assembly will need to be replaced.

8. Remove the intake manifold tuning valve bolts.
9. Remove the intake manifold tuning valve.

CAUTION: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

10. Clean the intake manifold with solvent.
11. Dry the intake manifold with compressed air.
12. Inspect all gasket mating surfaces for nicks or cracks and replace if necessary.
13. Inspect the intake manifold tuning valve seal for damage. Inspect the intake manifold tuning valve blade for cracks, missing material, or looseness. The tuning valve blade attachment to the motor should be tight, with no slack present. Replace if necessary.

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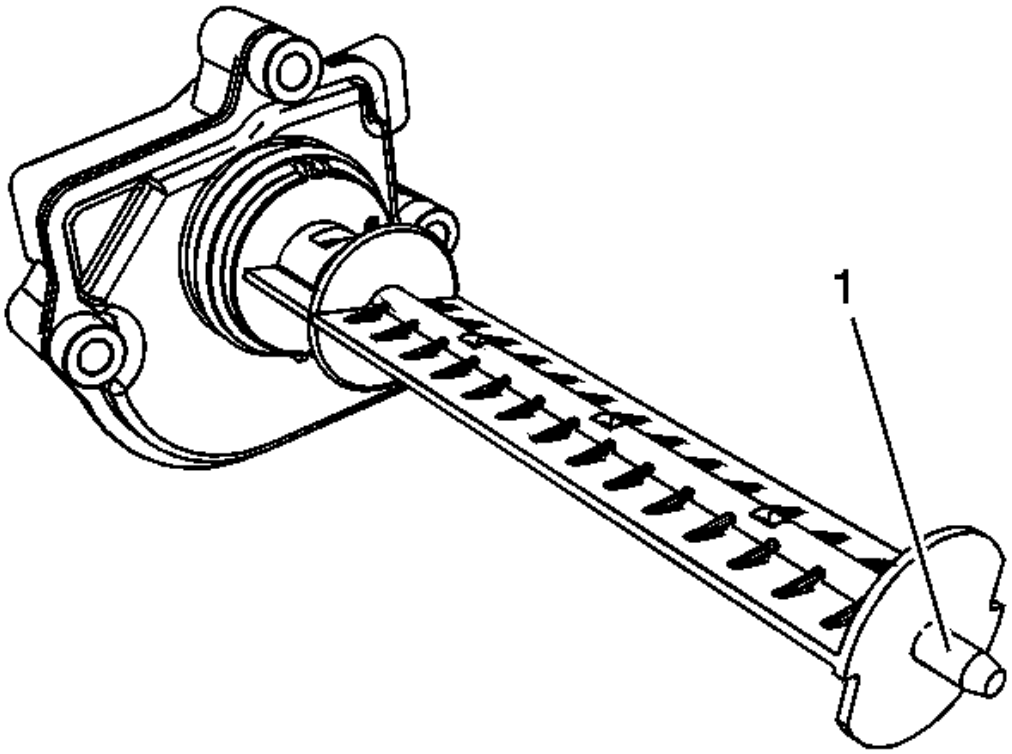

Fig. 553: View Of Tuning Valve Blade
Courtesy of GENERAL MOTORS CORP.

14. Apply lubricant GM P/N 1051344 (Canadian P/N 993037) to the valve shaft (1).

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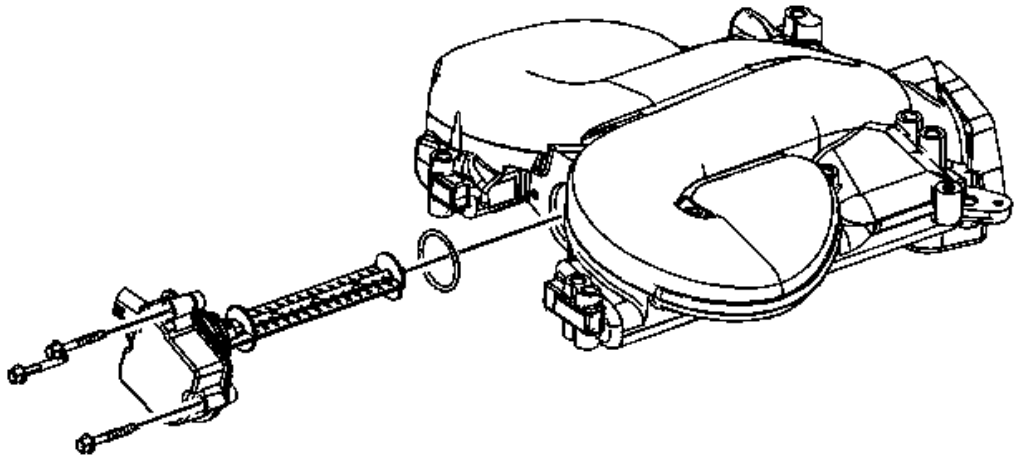

Fig. 554: Identifying Inlet Manifold Tuning Valve
Courtesy of GENERAL MOTORS CORP.

15. Install the intake manifold tuning valve, ensuring proper alignment is achieved. Failure to do so may result in the valve getting jammed or stuck in the intake manifold.

NOTE: Refer to Fastener Notice .

16. Install the intake manifold tuning valve bolts.

Tighten: Tighten the intake manifold tuning valve bolts to 10 N.m (89 lb in).

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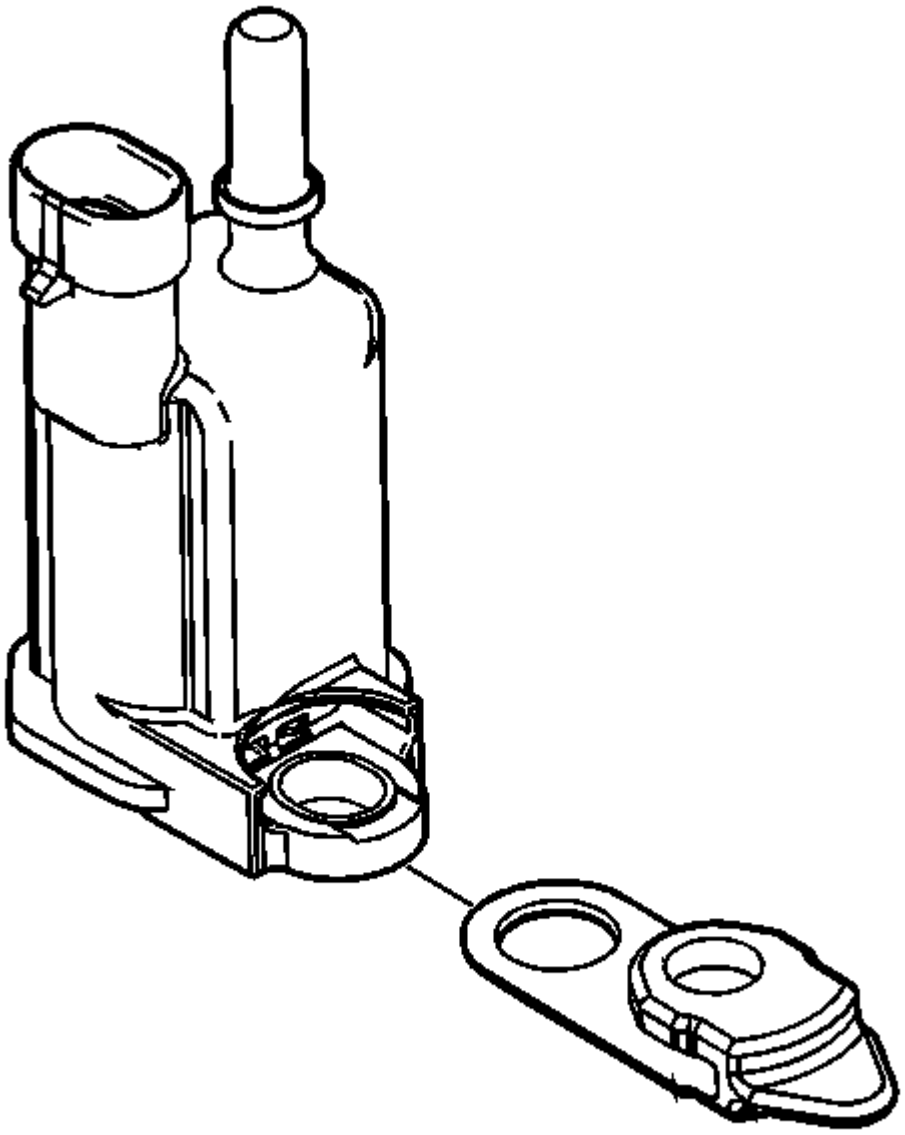

Fig. 555: Identifying EVAP Purge Valve Isolator
Courtesy of GENERAL MOTORS CORP.

17. Install the EVAP purge valve isolator, if equipped.

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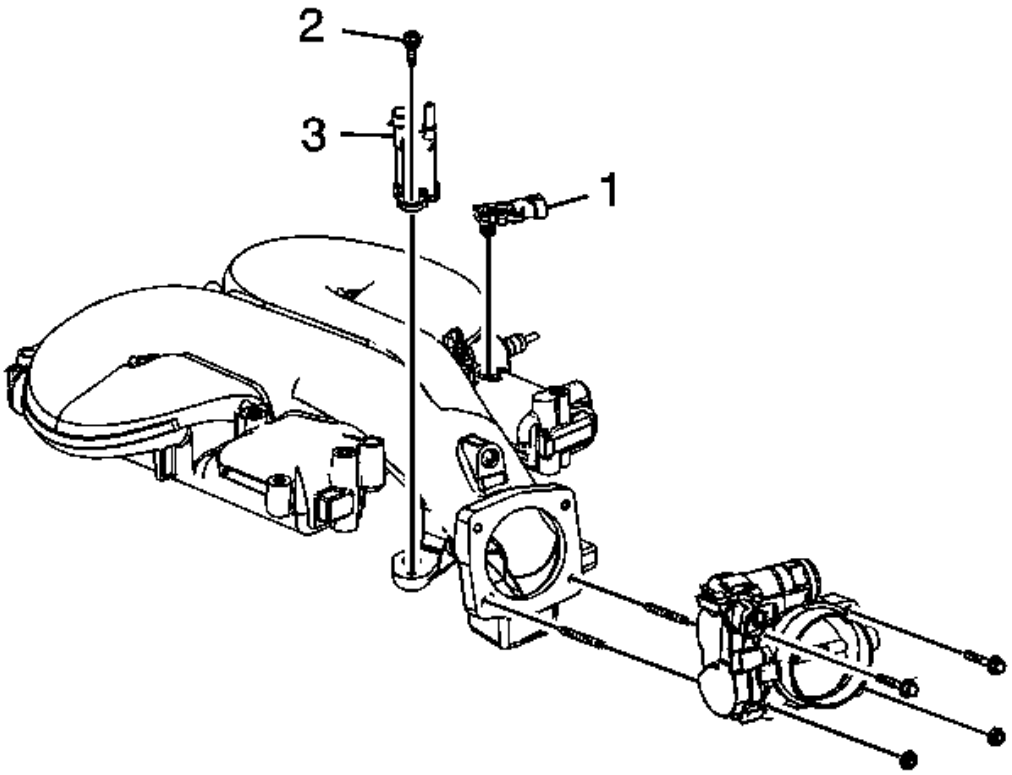

Fig. 556: Identifying Upper Intake Manifold Components
Courtesy of GENERAL MOTORS CORP.

18. Inspect the EVAP purge valve seal for damage and replace if necessary.
19. Install the EVAP purge valve (3).
20. Install the EVAP purge valve bolt (2).

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

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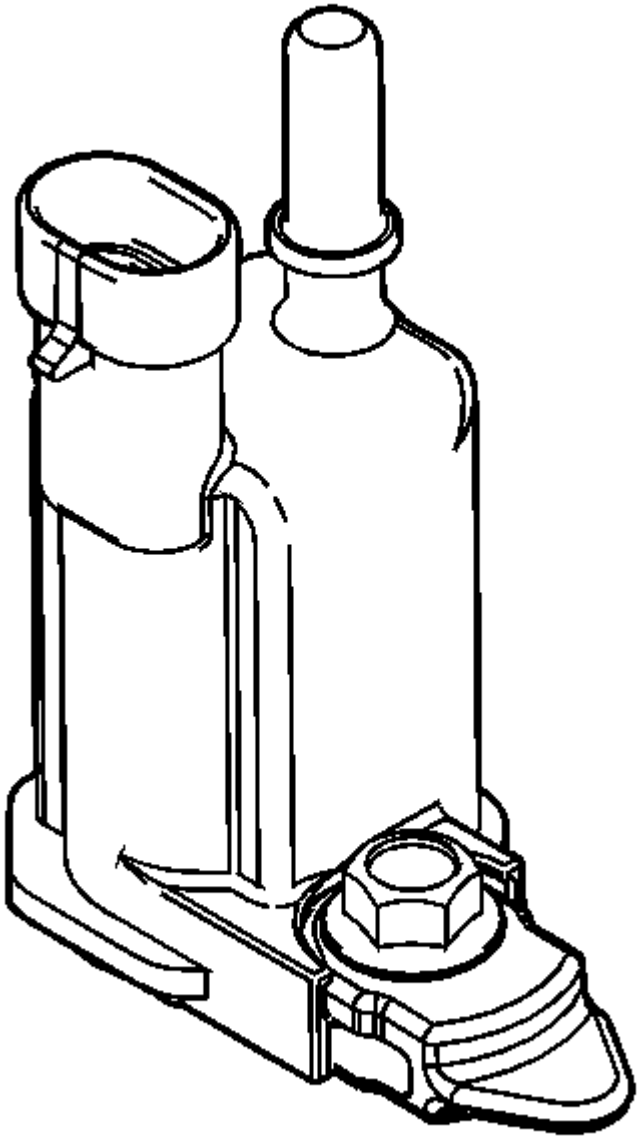

Fig. 557: Correct EVAP Purge Valve Isolator Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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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21. Inspect the MAP sensor seal for damage and replace if necessary.
22. Install the MAP sensor.
23. Install the throttle body studs, if required.

    Tighten: Tighten the throttle body studs to 6 N.m (53 lb in).

24. Inspect the throttle body seal for damage and replace if necessary.
25. Install the throttle body.
26. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the throttle body bolt and nut threads.
27. Install the throttle body bolts and nuts.

    Tighten: Tighten the throttle body bolts and nuts to 10 N.m (89 lb in).

Exhaust Manifold Cleaning and Inspection

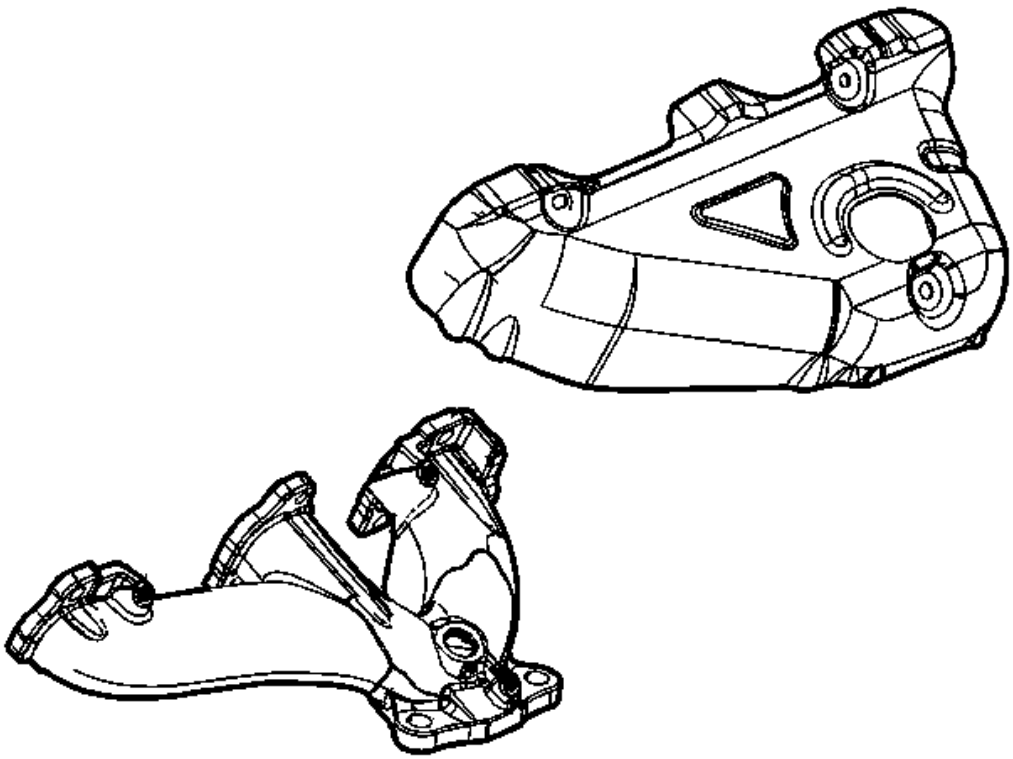

Fig. 558: Cleaning Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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CAUTION: 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.
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

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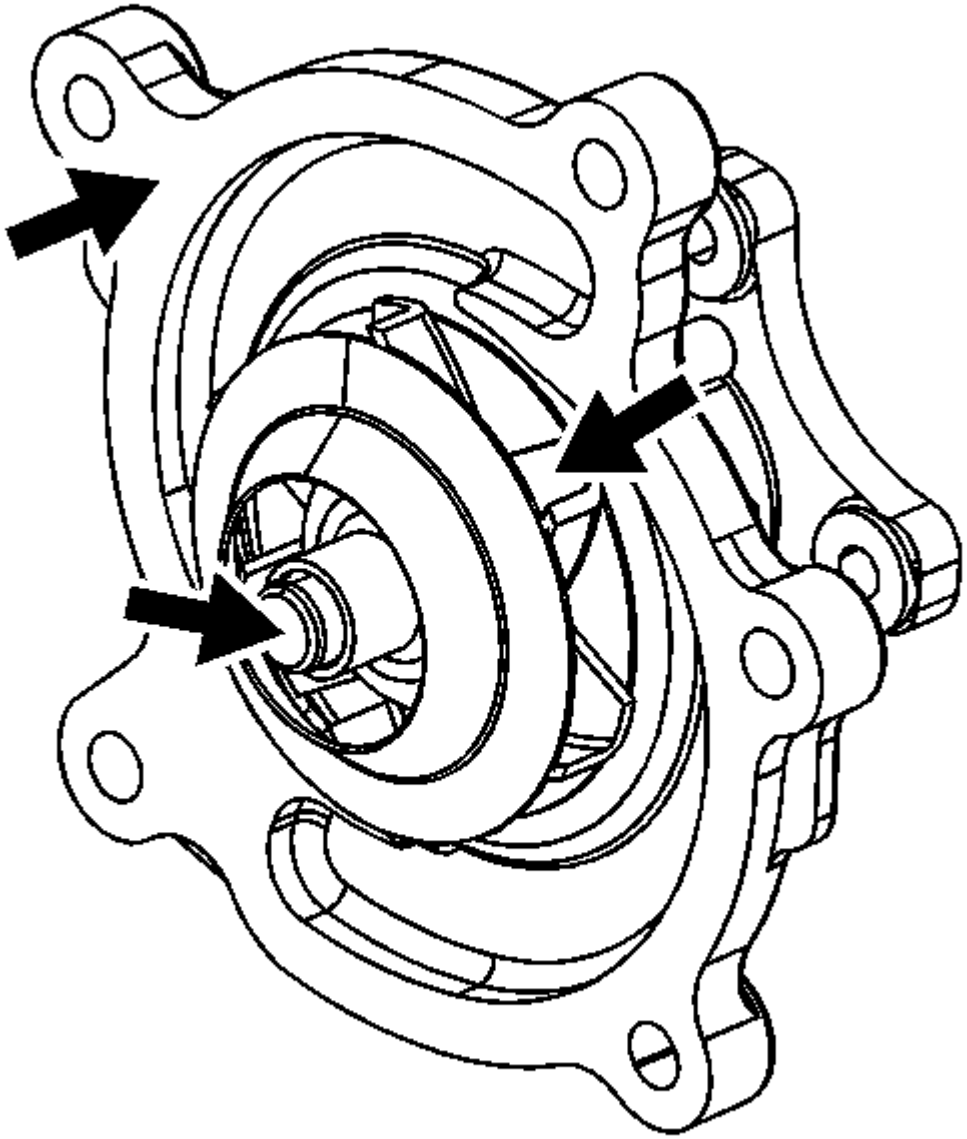

Fig. 559: Rear View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

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.

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Thread Repair

General purpose thread repair kits are available commercially.

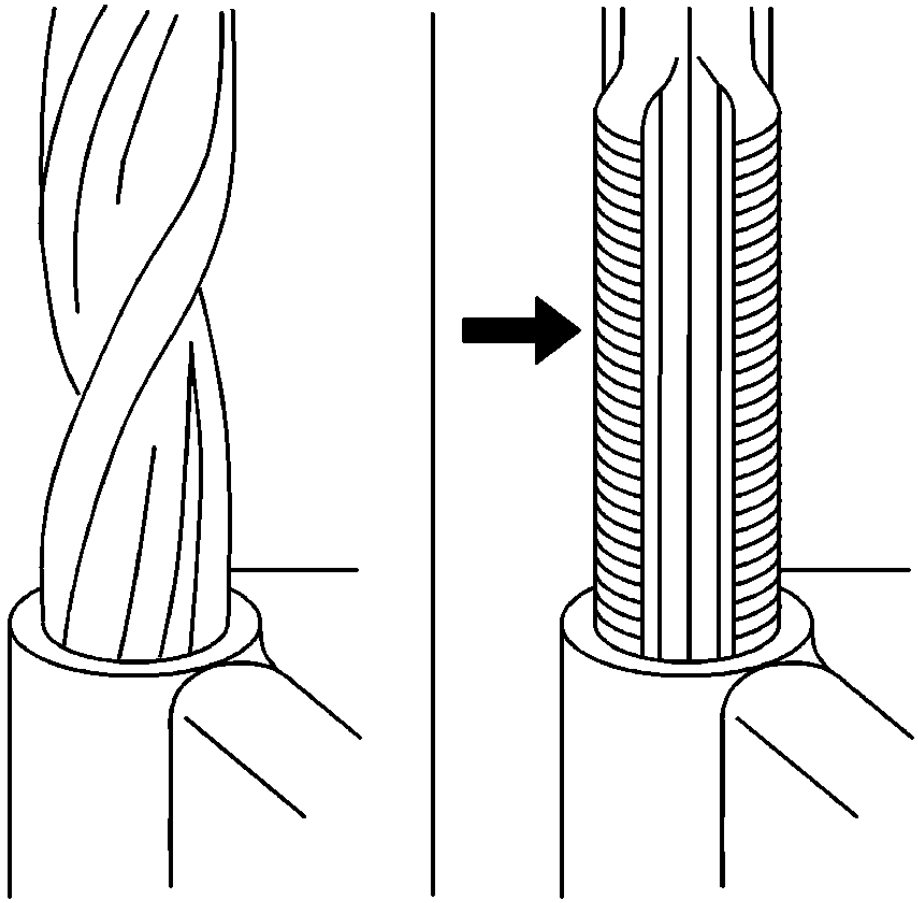

Fig. 560: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use.
Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread.
2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.

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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.

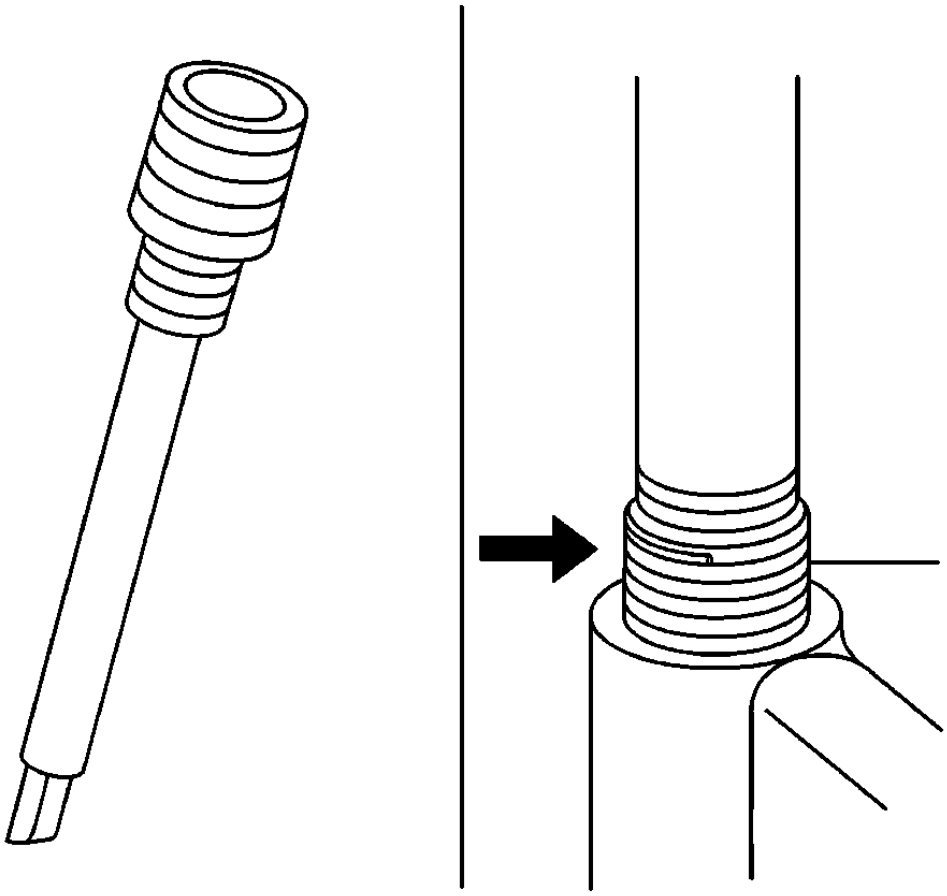

Fig. 561: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

IMPORTANT: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.

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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

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**

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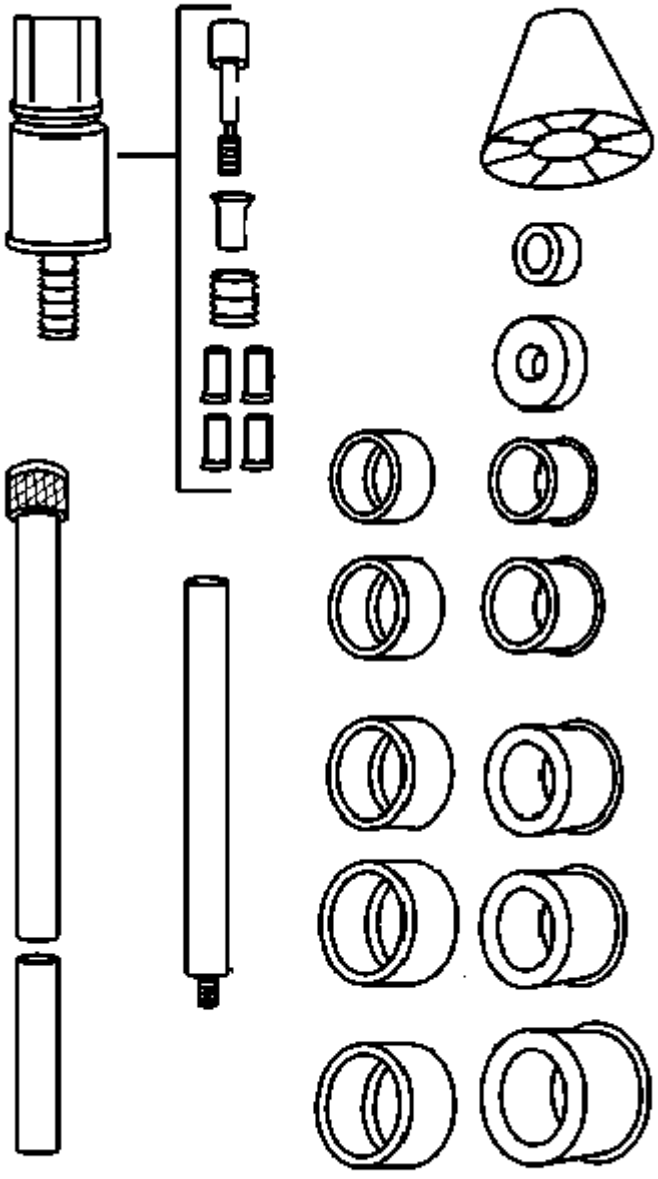

Fig. 562: Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

1. Assemble the **J 33049** according to the manufacturer's instructions. See **Special Tools**.

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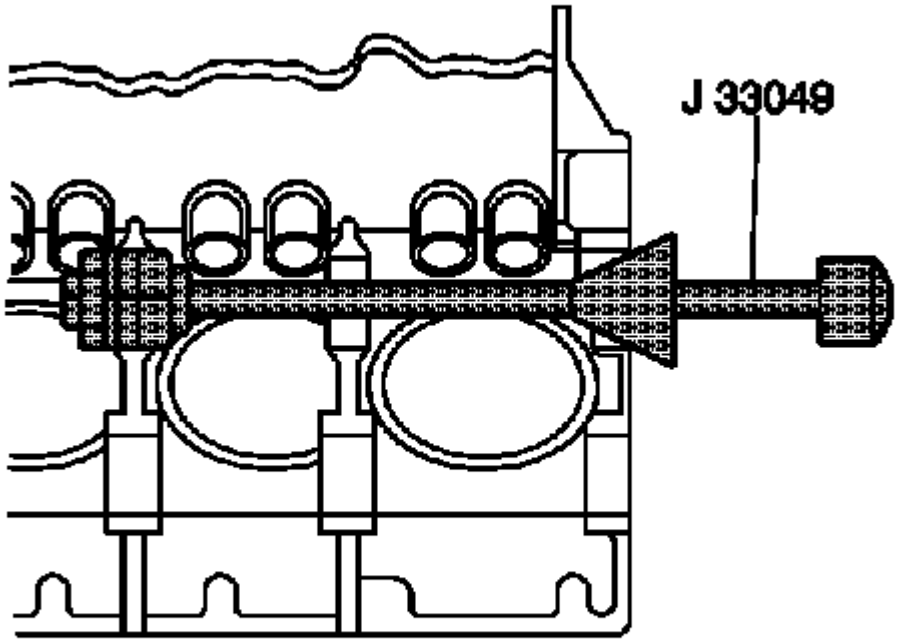

Fig. 563: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

NOTE: 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** . See **Special Tools**.
    3. Install the third camshaft bearing.
    4. Install the second camshaft bearing.
    5. Install the outer camshaft bearings.

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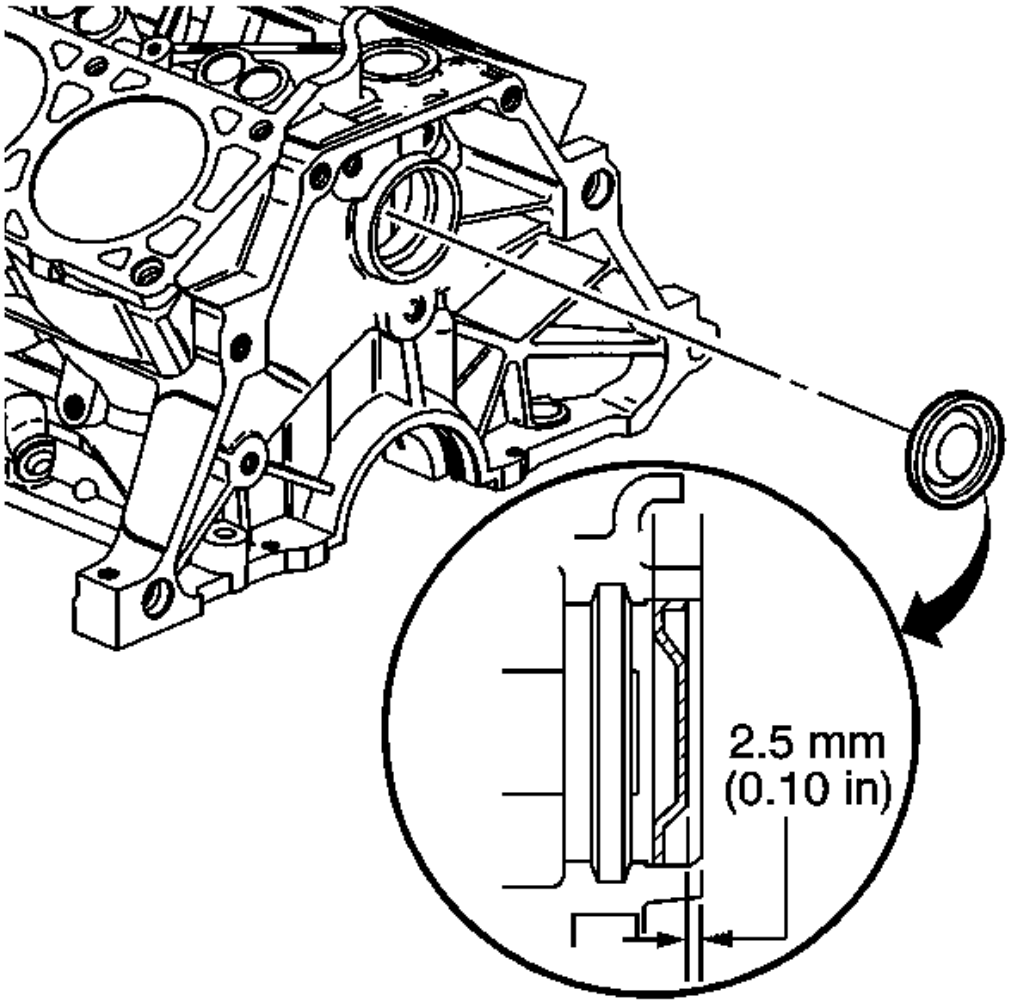

Fig. 564: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

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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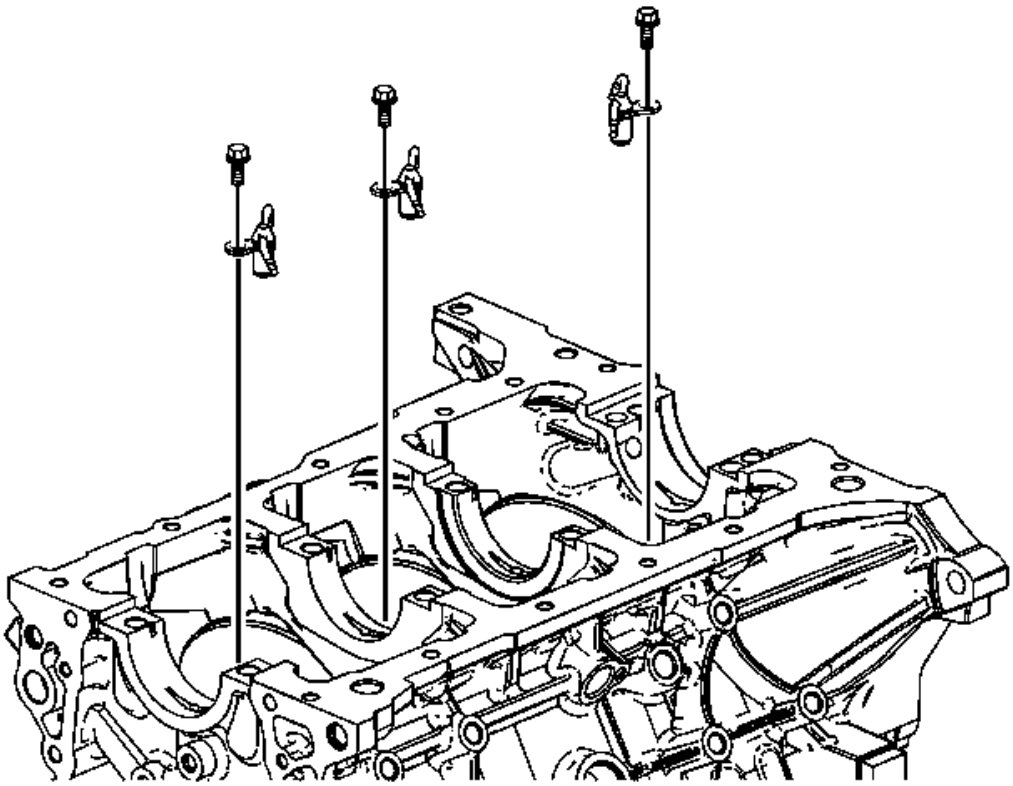

Fig. 565: Identifying Piston Oil Nozzles & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the piston oil nozzles in the engine block.

NOTE: **Refer to Fastener Notice .**

2. Install the bolts retaining the piston oil nozzles to the engine block.

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

Crankshaft and Bearings Installation

Tools Required

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

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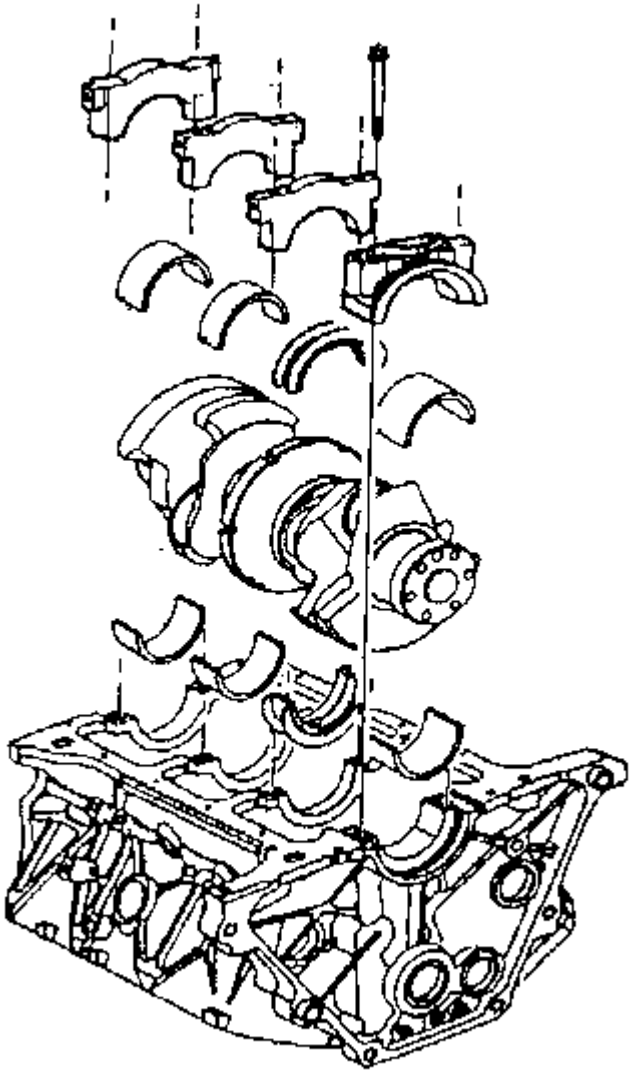

Fig. 566: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

NOTE: Upper and lower inserts may be different. Do not obstruct any oil

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passages.

2. Place the crankshaft bearing inserts into the crankshaft bearing cap and into the engine block.

IMPORTANT: 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.

NOTE: 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.

NOTE: Refer to Fastener Notice .

6. Install the crankshaft main bearing cap bolts.

Tighten: Use the **J 45059** in order to tighten the crankshaft main bearing cap bolts to 50 N.m (37 lb ft) plus 77 degrees.

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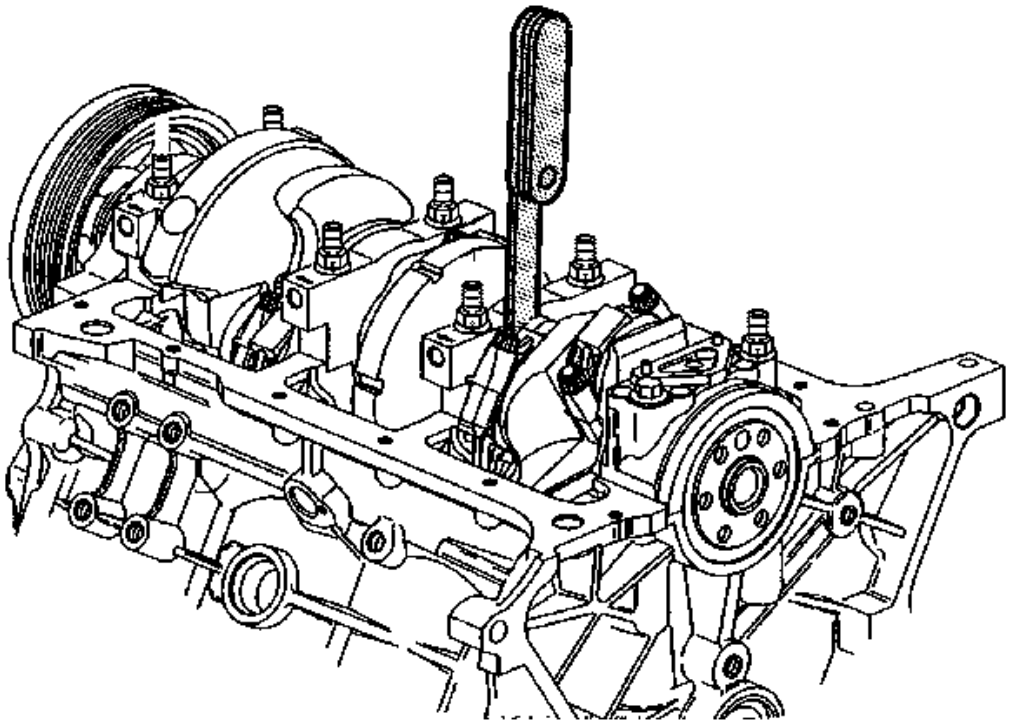

Fig. 567: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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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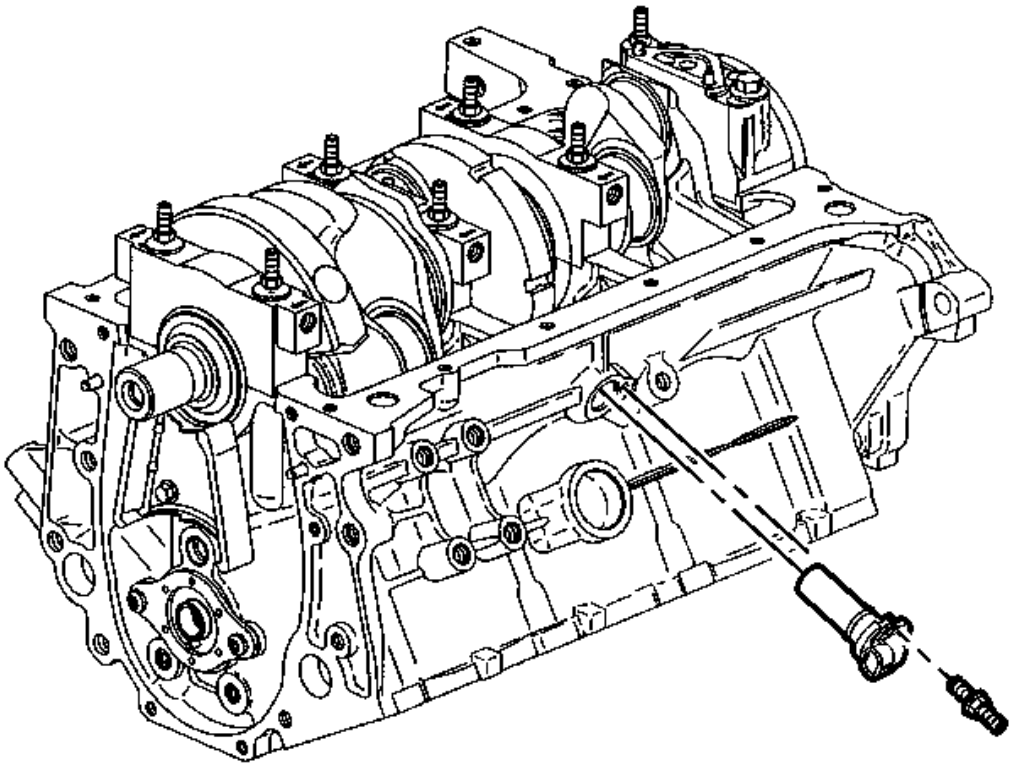

Fig. 568: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

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.

    Tighten: Tighten the crankshaft position sensor stud to 11 N.m (98 lb in).

11. Install the crankshaft position sensor shield and nut.

    Tighten: Tighten the crankshaft position sensor shield nut to 11 N.m (98 lb in).

Crankshaft Rear Oil Seal Installation

Tools Required

EN-48108 Rear Main Oil Seal Installer

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Installation Procedure

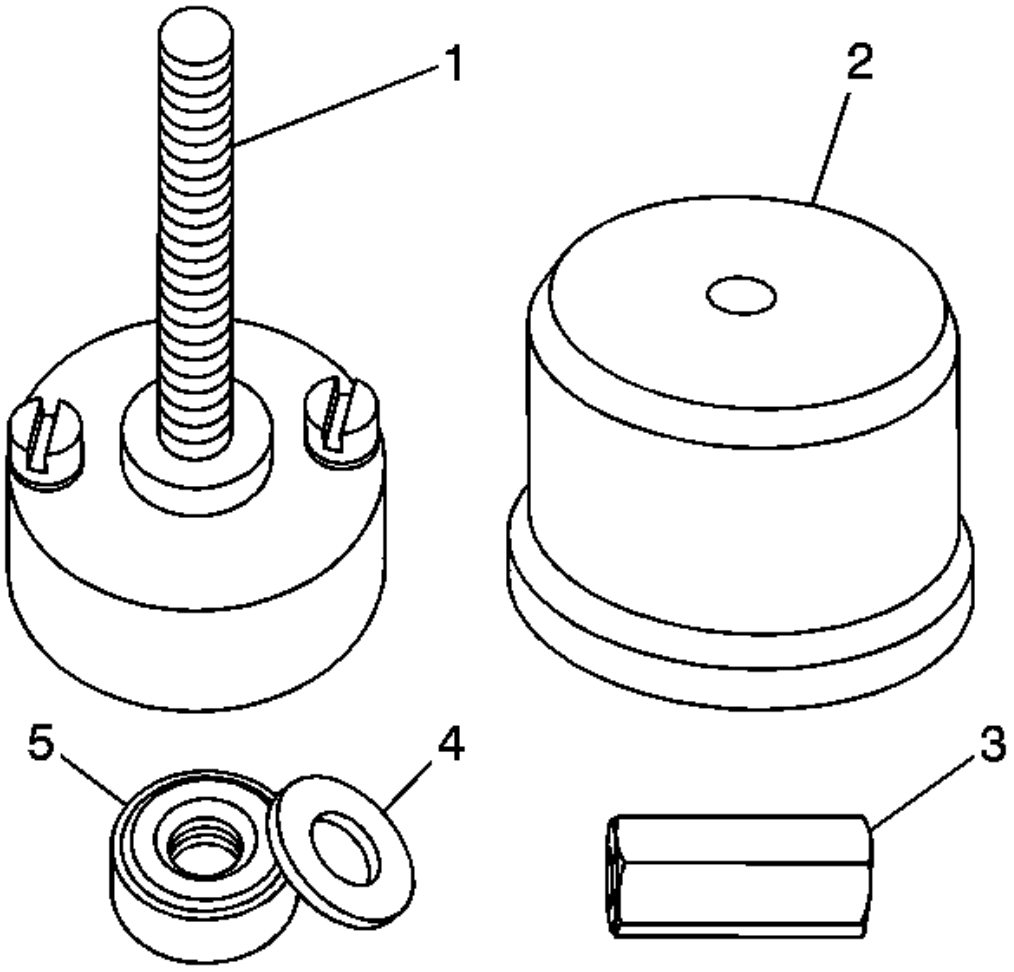

Fig. 569: Identifying Crankshaft Rear Oil Seal Installation Tools (EN-48108)
Courtesy of GENERAL MOTORS CORP.

NOTE: **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: **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**

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proceeding.

1. The **EN-48108** tool 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 above illustration to become familiar with the following components:
   - Mandrel (1)
   - Drive Drum (2)
   - Drive Nut (3)
   - Washer (4)
   - Bearing (5)

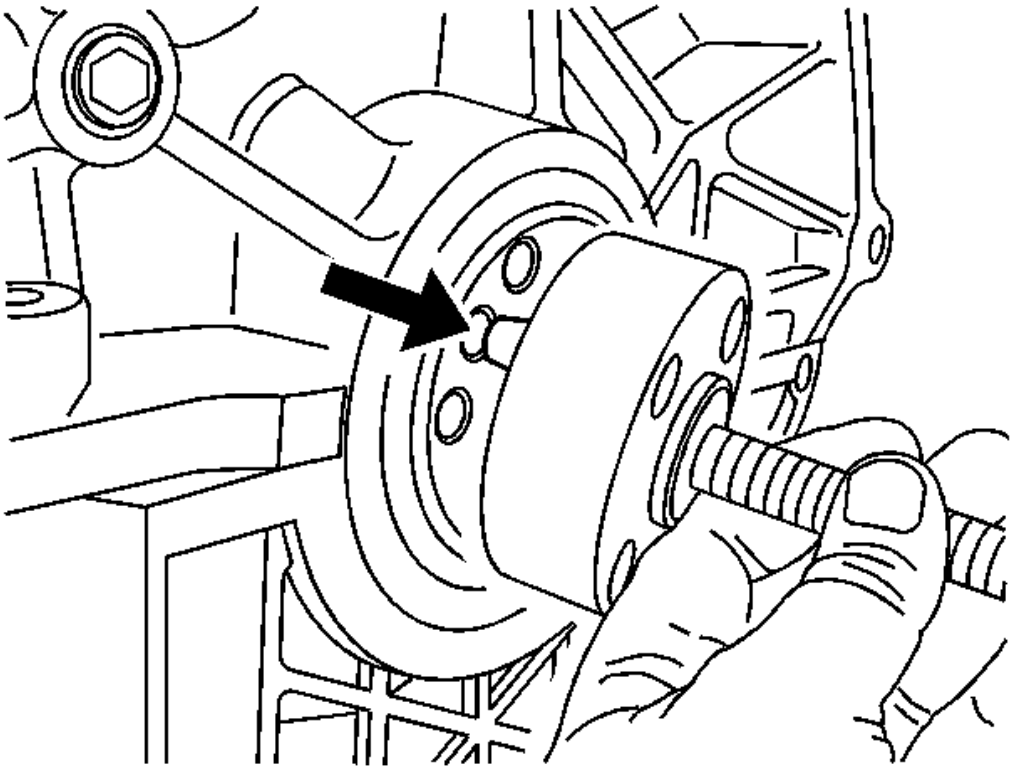

Fig. 570: Aligning Mandrel Dowel Pin
Courtesy of GENERAL MOTORS CORP.

2. Align the mandrel dowel pin to the dowel pin hole in the crankshaft.

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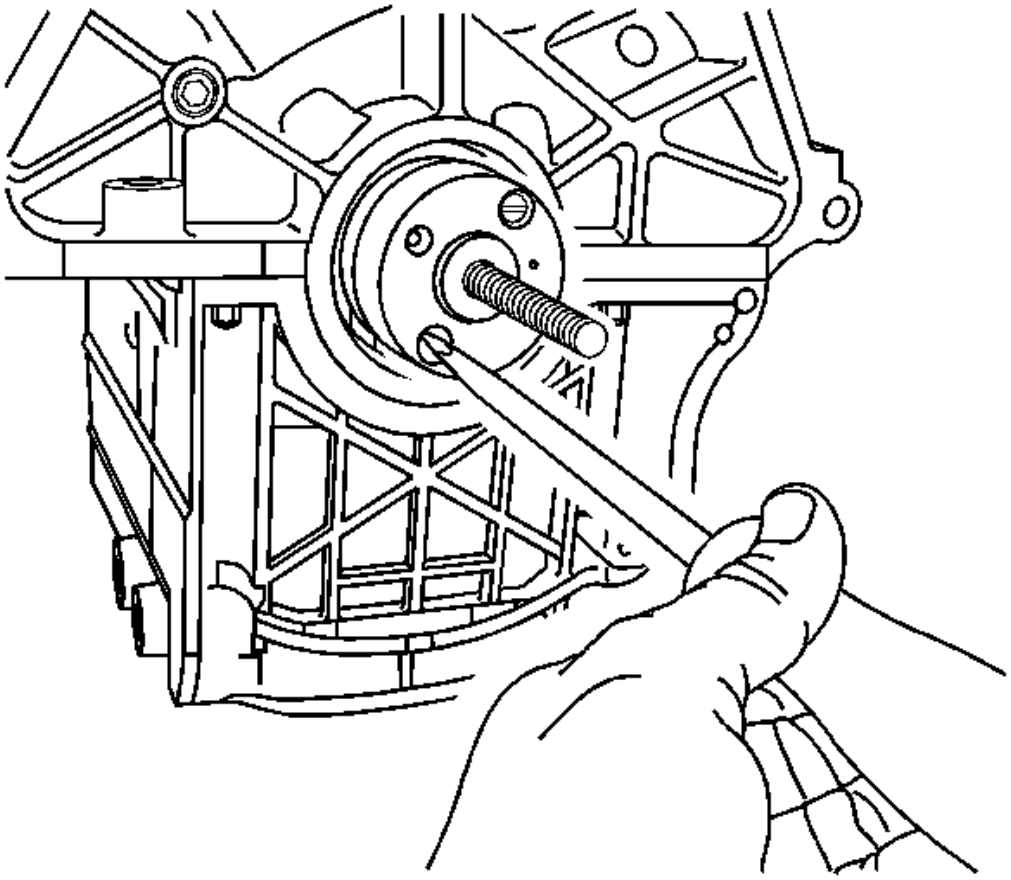

Fig. 571: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

3. Using a large flat blade screwdriver, tighten the two mandrel screws to the crankshaft, ensuring the mandrel is snug to the crankshaft hub.

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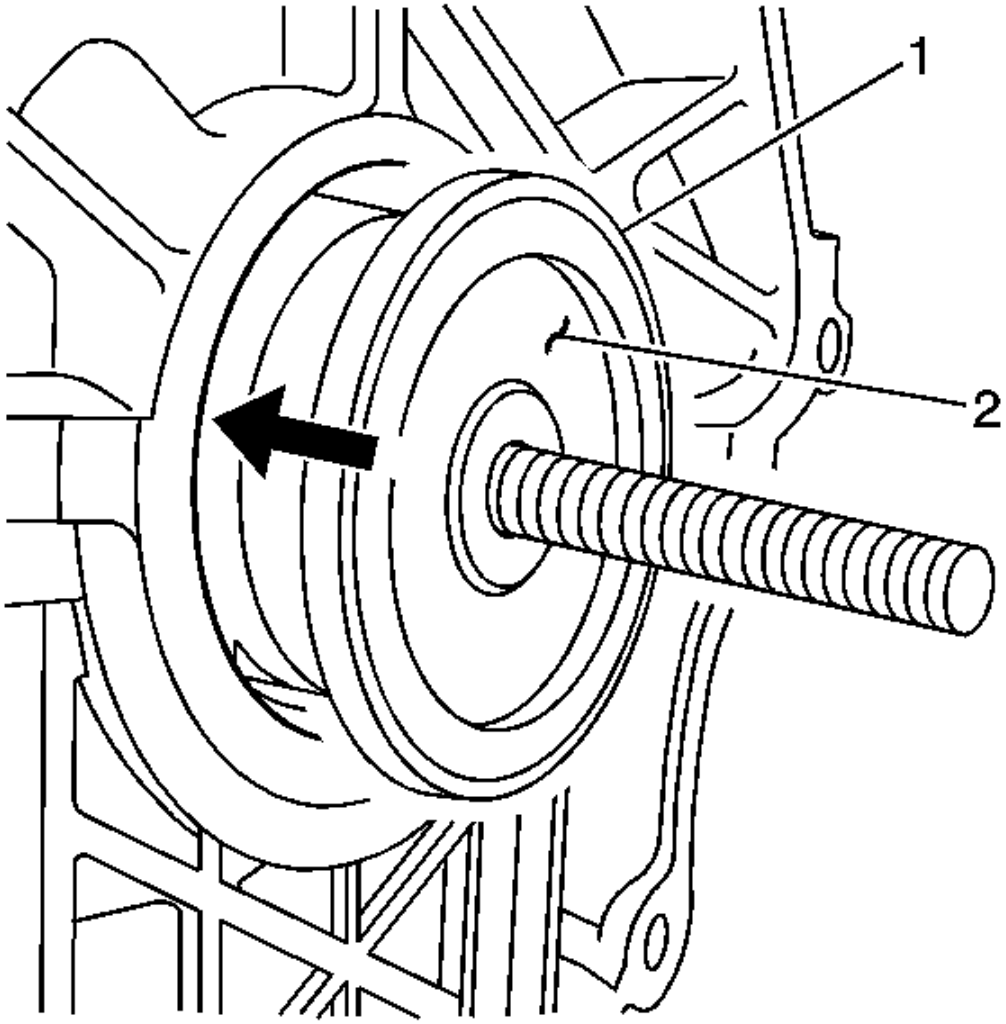

Fig. 572: View Of Rear Main Seal Mandrel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The seal will only fit one way onto the mandrel, and if properly installed, will center on a step that protrudes from the center of the mandrel.

4. Install the rear main seal, with the protective nylon sleeve attached, onto the mandrel.

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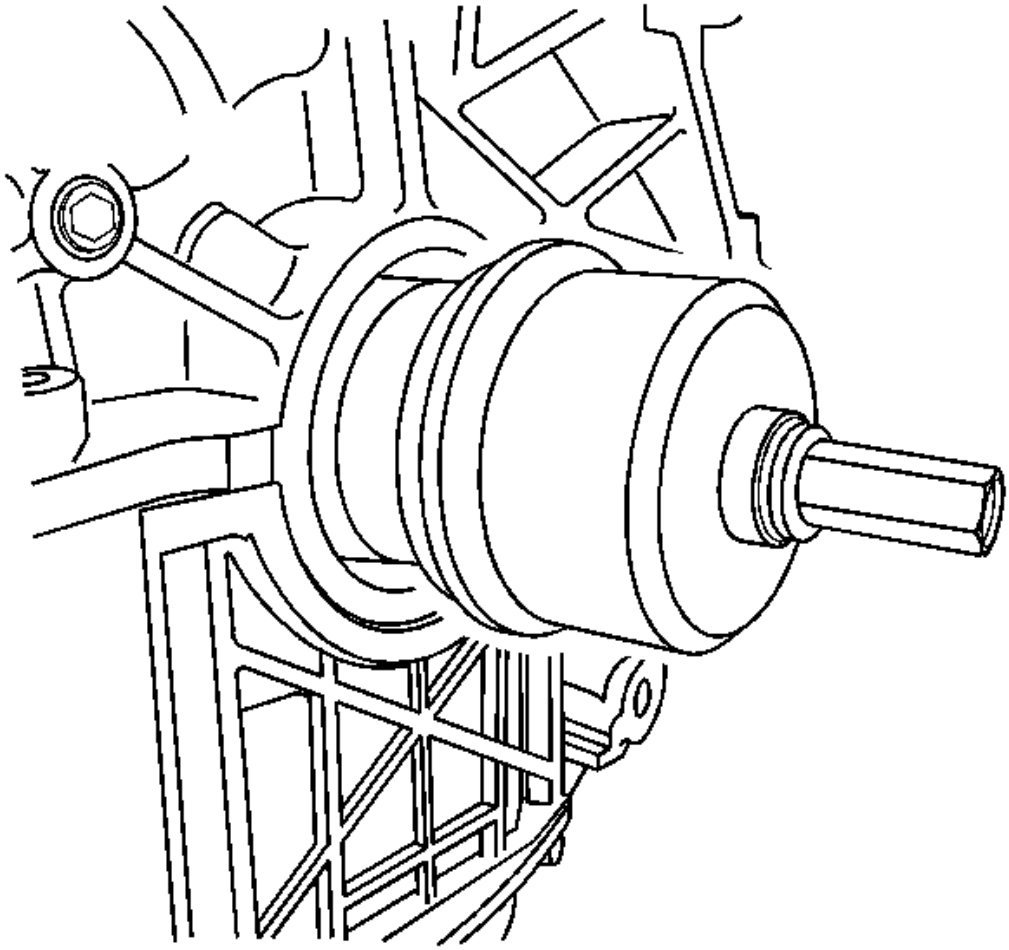

Fig. 573: Identifying Outer Drive Drum
Courtesy of GENERAL MOTORS CORP.

5. Install the outer drive drum onto the mandrel.
6. Install the bearing, washer, and the drive nut onto the threaded shaft.

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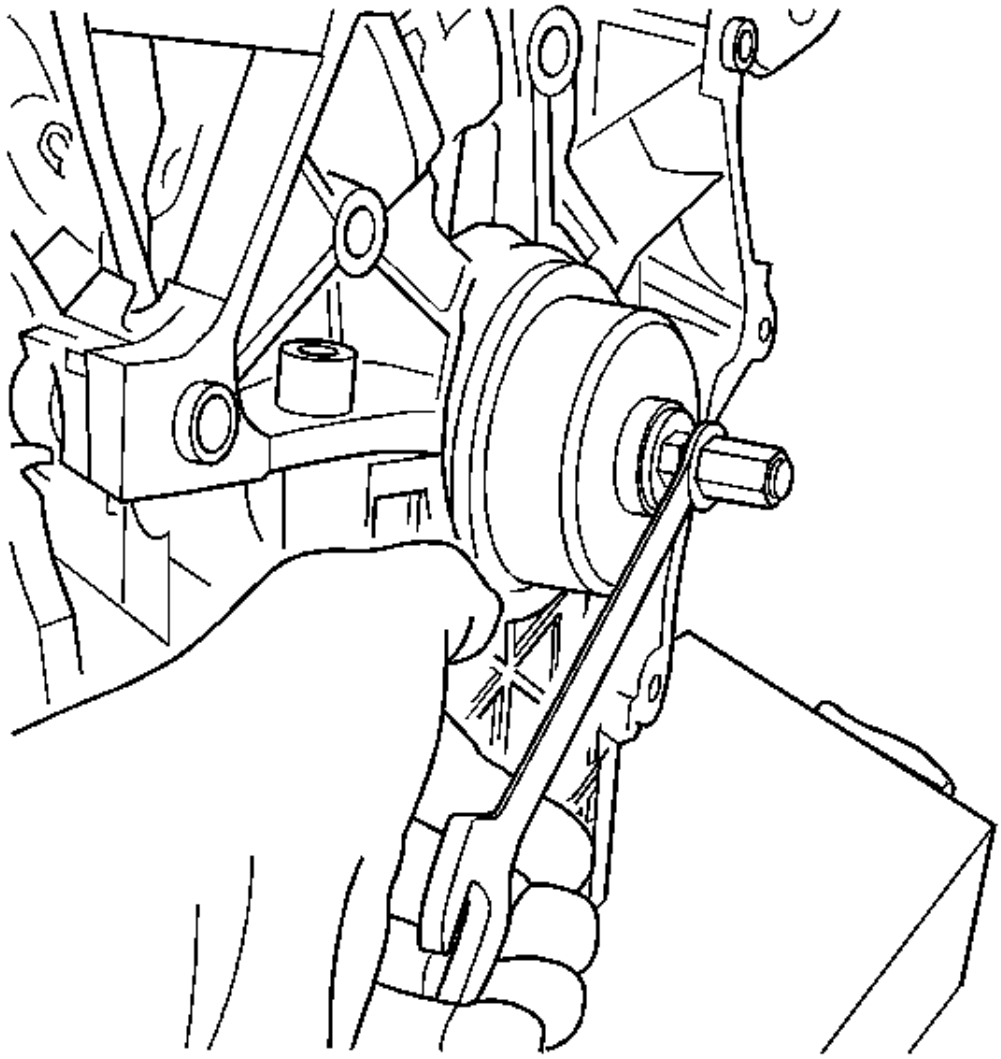

Fig. 574: Pressing Seal Into Bore
Courtesy of GENERAL MOTORS CORP.

7. Using a wrench, turn the drive nut on the mandrel, which will push the seal into the engine block bore.
8. Turn the wrench until the drive drum is snug and flush against the engine block.
9. Loosen and remove the drive nut, washer, bearing and drive drum. Discard the nylon plastic seal protector.
10. Verify that the seal has seated properly.

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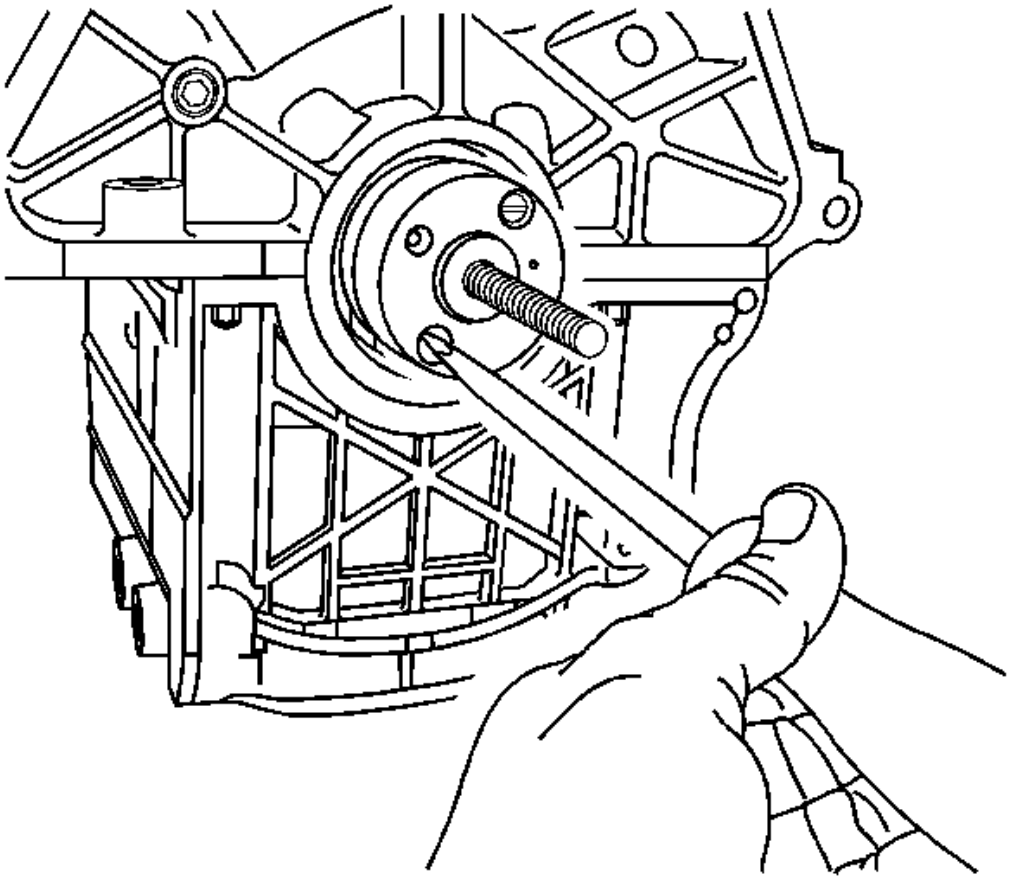

Fig. 575: Identifying Mandrel Screws
Courtesy of GENERAL MOTORS CORP.

11. Use a flat blade screwdriver to remove the two attachment screws from the mandrel and remove the mandrel from the crankshaft hub.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 8037** Ring Compressor. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.
- **J 43654** Piston Pin Clip Remover and Installer. See **Special Tools**.
- **J 43690** Rod Bearing Clearance Checking Tool. See **Special Tools**.
- **J 43690-100** Rod Bearing Clearance Checking Tool-Adapter Kit. See **Special Tools**.

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

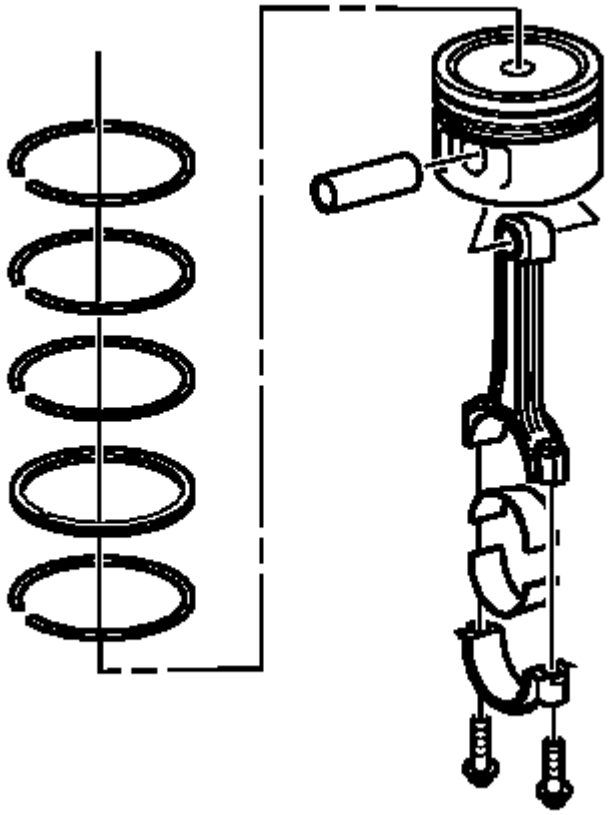

Fig. 576: Lubricating Piston Components
Courtesy of GENERAL MOTORS CORP.

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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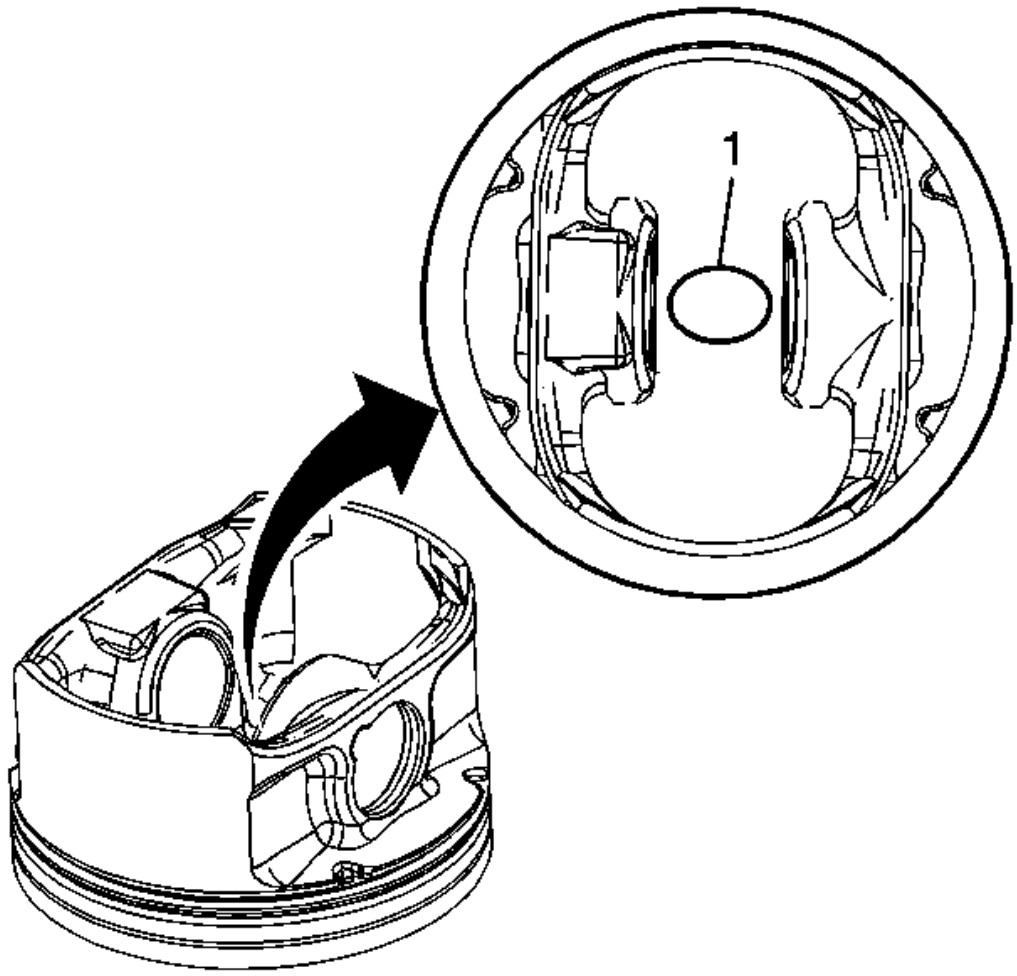

Fig. 577: Locating Piston Identification Mark
Courtesy of GENERAL MOTORS CORP.

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.
    - 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.

IMPORTANT: 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** onto the piston and compress the piston rings. See **Special Tools**.

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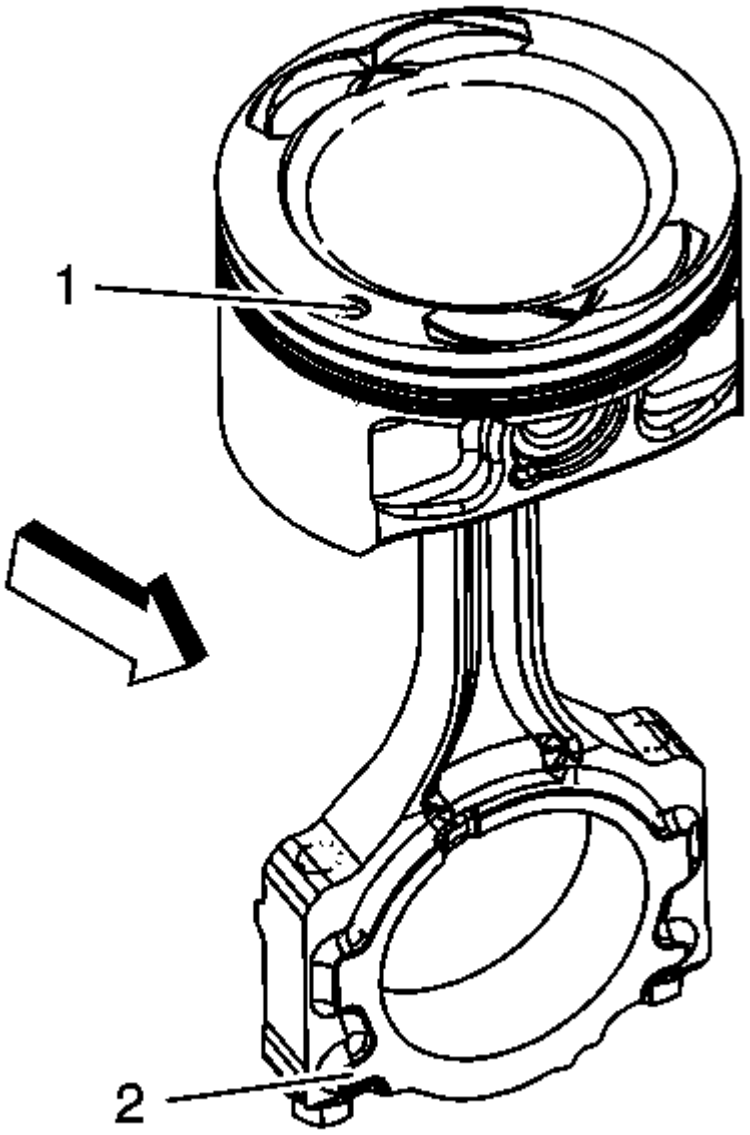

Fig. 578: Identifying Correct Piston Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

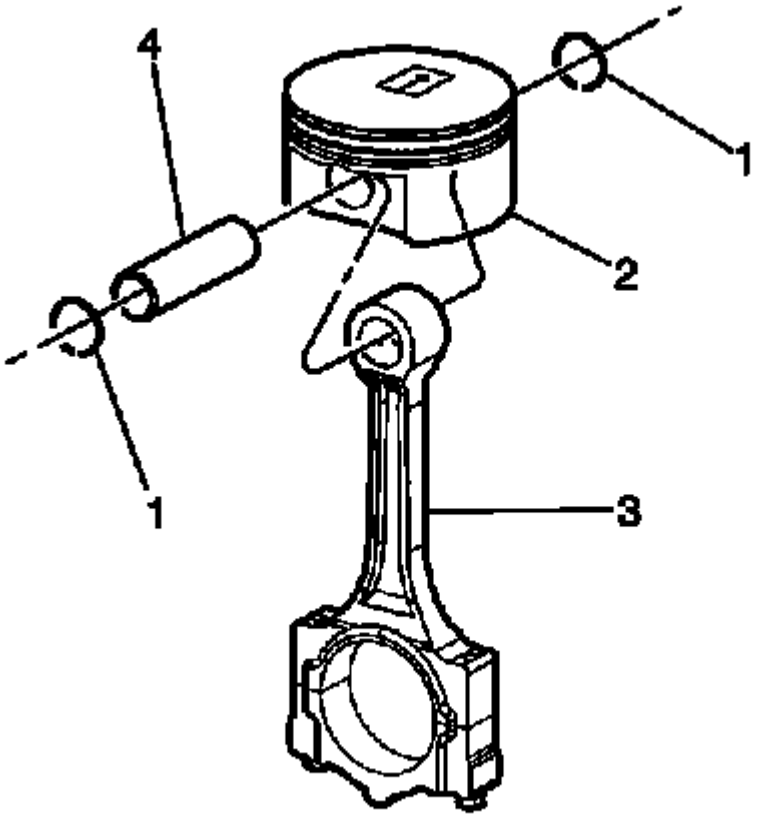

Fig. 579: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

7. Slide the piston pin (4) into the piston and the connecting rod (3).

IMPORTANT: NEW piston pin retainers must be used. Never reuse the piston pin retainers.

8. Install NEW piston pin retainers (1) using the **J 43654** . See **Special Tools**.
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** into the connecting rod. See **Special Tools**.

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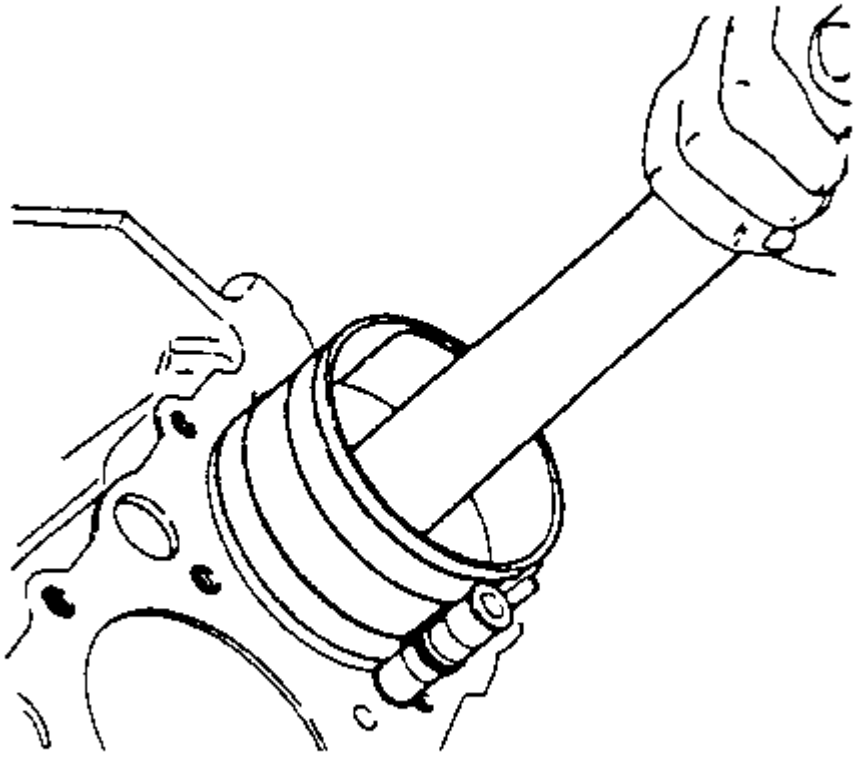

Fig. 580: Installing Piston & Connecting Rod Assembly Into Cylinder
Courtesy of GENERAL MOTORS CORP.

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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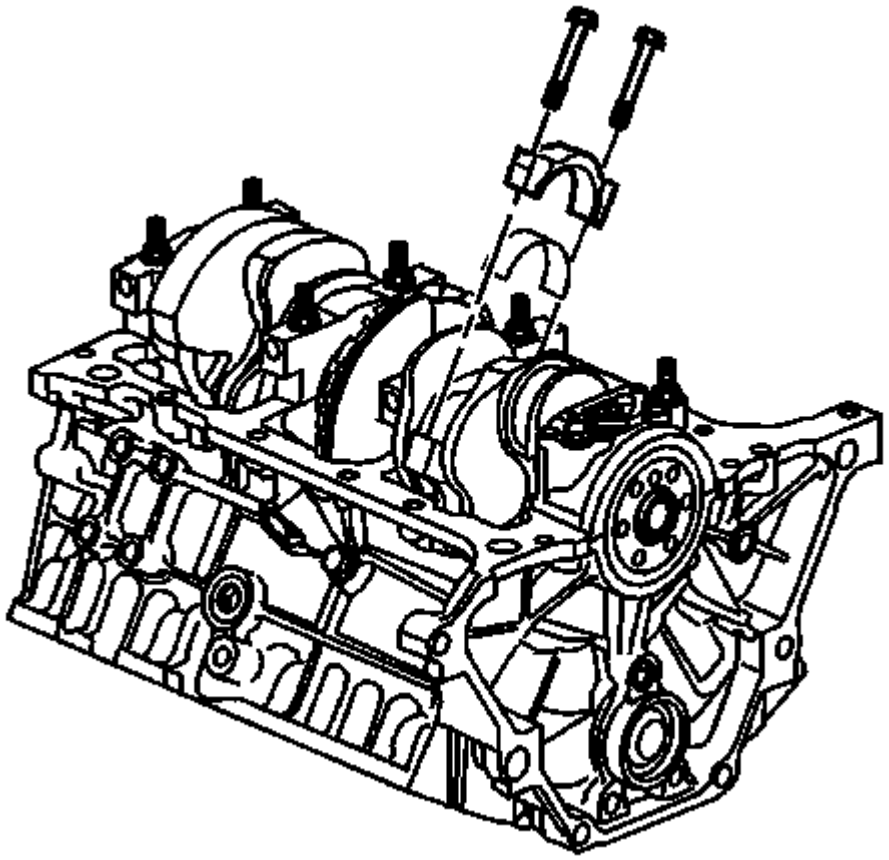

Fig. 581: Installing Bearing, Bearing Cap And Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 the connecting rod end onto the crankshaft journal. See **Special Tools**.

NOTE: Refer to Fastener Notice .

15. Install the bearing, bearing cap and bolts.

Tighten:

1. Tighten the connecting rod bearing cap bolts a first pass to 25 N.m (18 lb ft).
2. Tighten the connecting rod bearing cap bolts a final pass to 110 degrees using the **J 45059** . See **Special Tools**.

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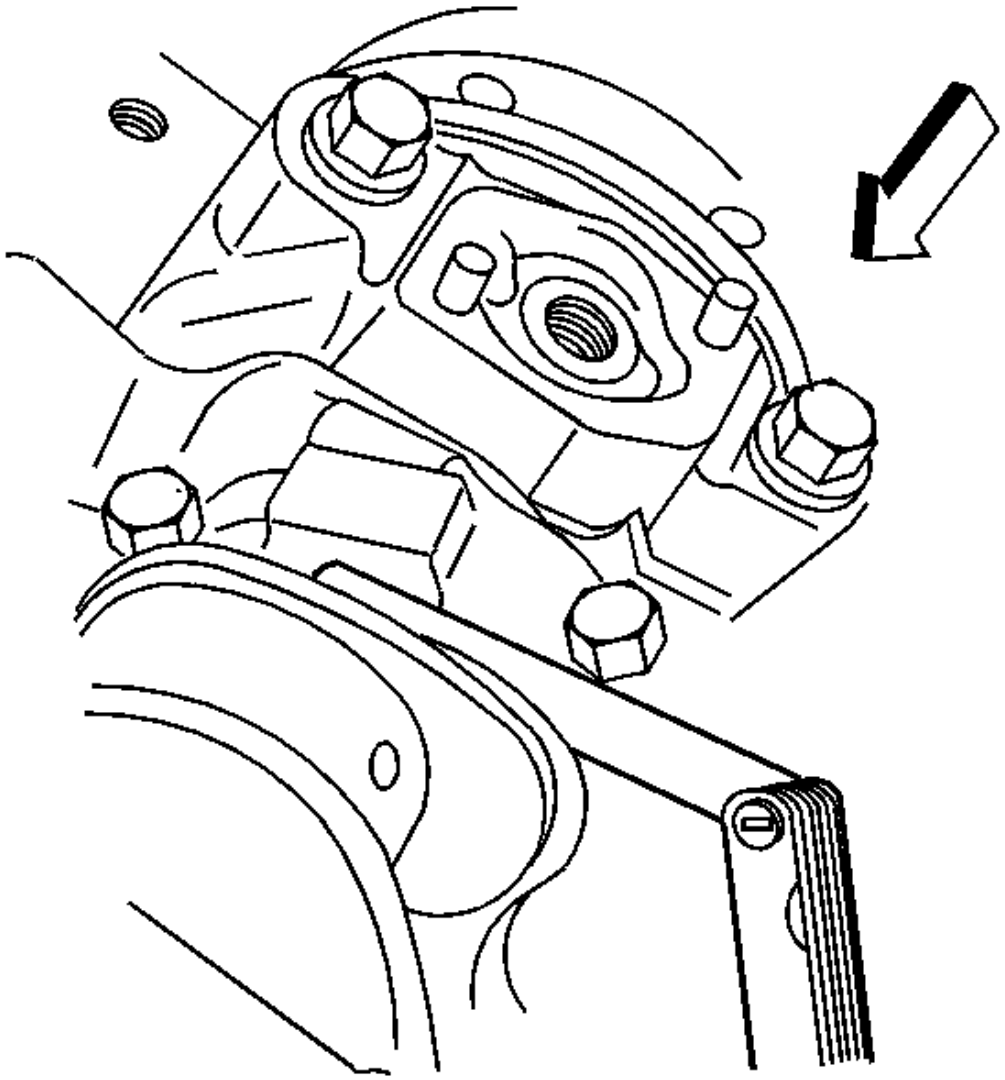

Fig. 582: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

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 and **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. See **Special Tools**. 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.

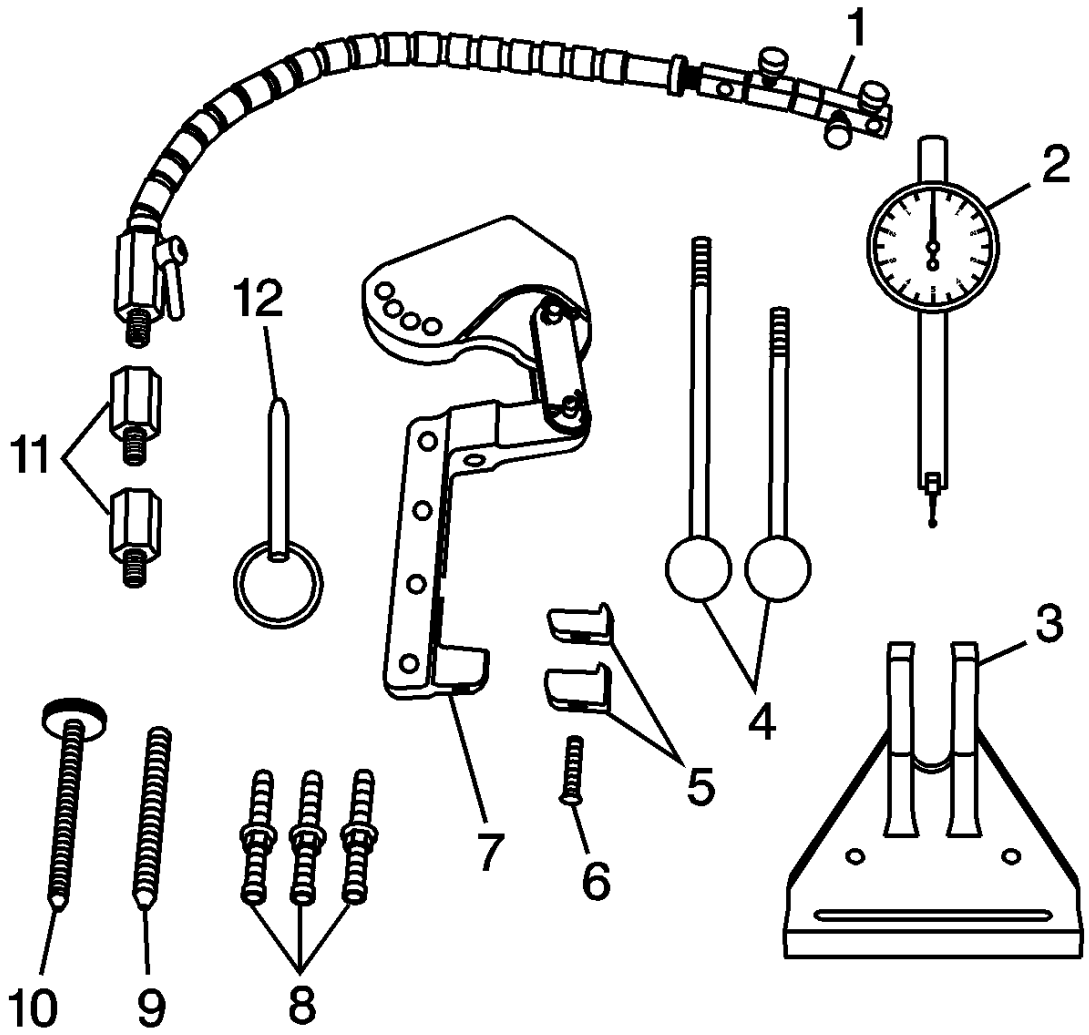

Fig. 583: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

1. **J 43690** Rod Bearing Checking 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)

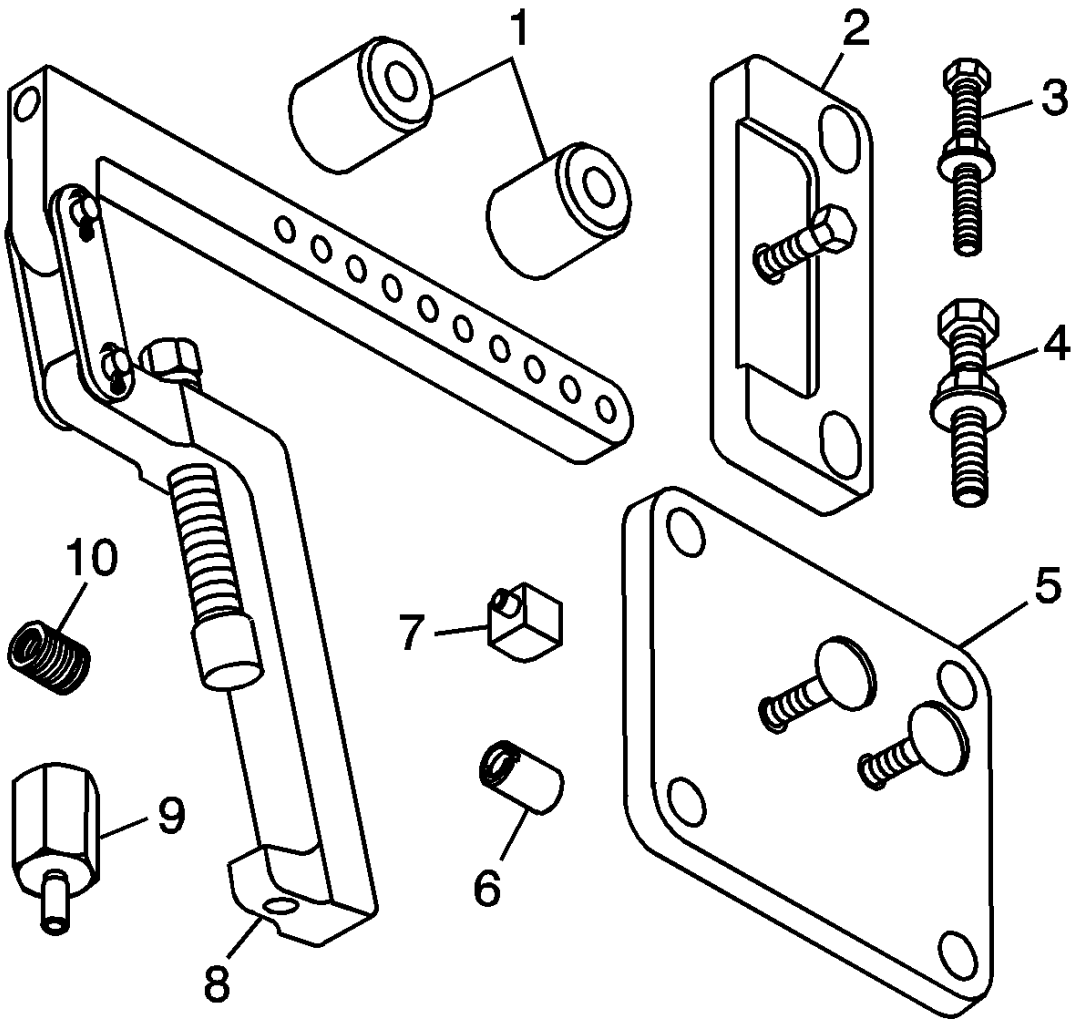

Fig. 584: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

2. **J 43690-100** Rod Bearing Checking Tool - Adapter 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)

IMPORTANT: 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.

NOTE: 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.

NOTE: 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.

Tighten:

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** to tighten the bolts to 77 degrees. See **Special Tools**.

8. Install the following:
   - J 43690-101 (8)
   - J 43690-5 (4)

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- J 43690-2 (3)
- J 43690-7 (8)
- 280310 (12)
- J 43690-17 (11)

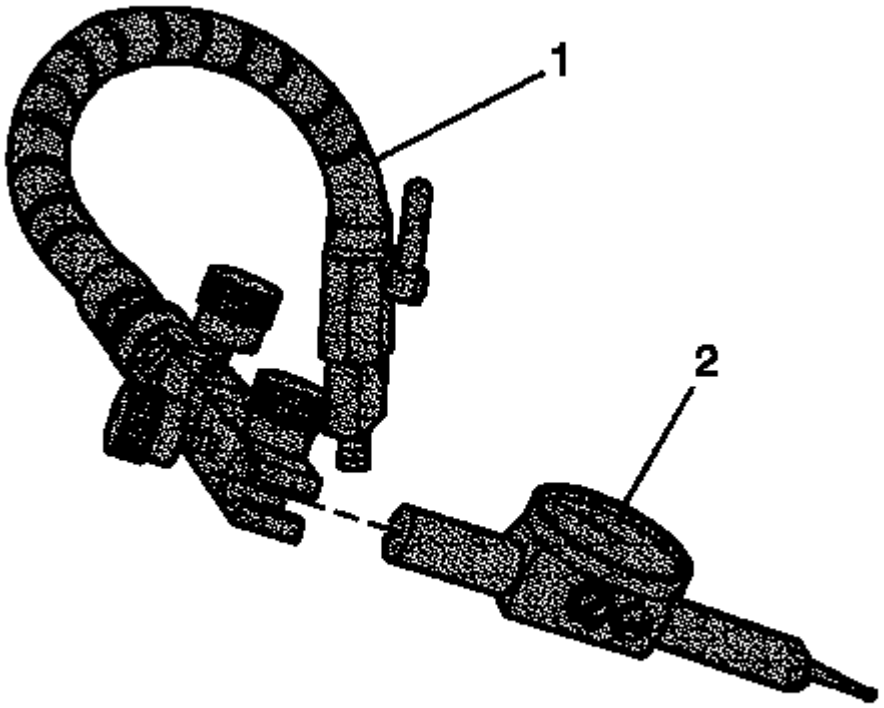

Fig. 585: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

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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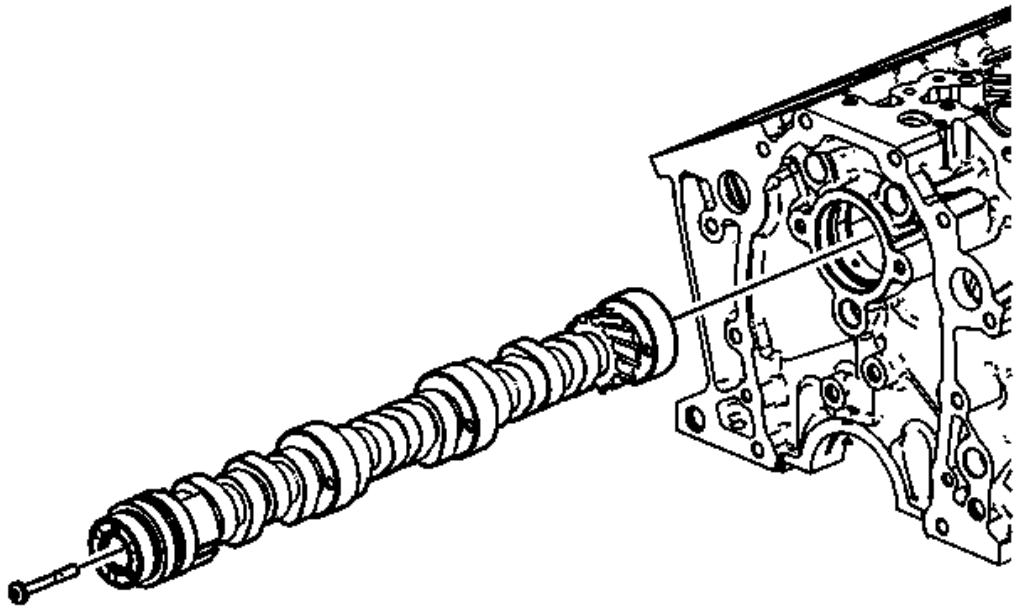

Fig. 586: Identifying Camshaft & Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

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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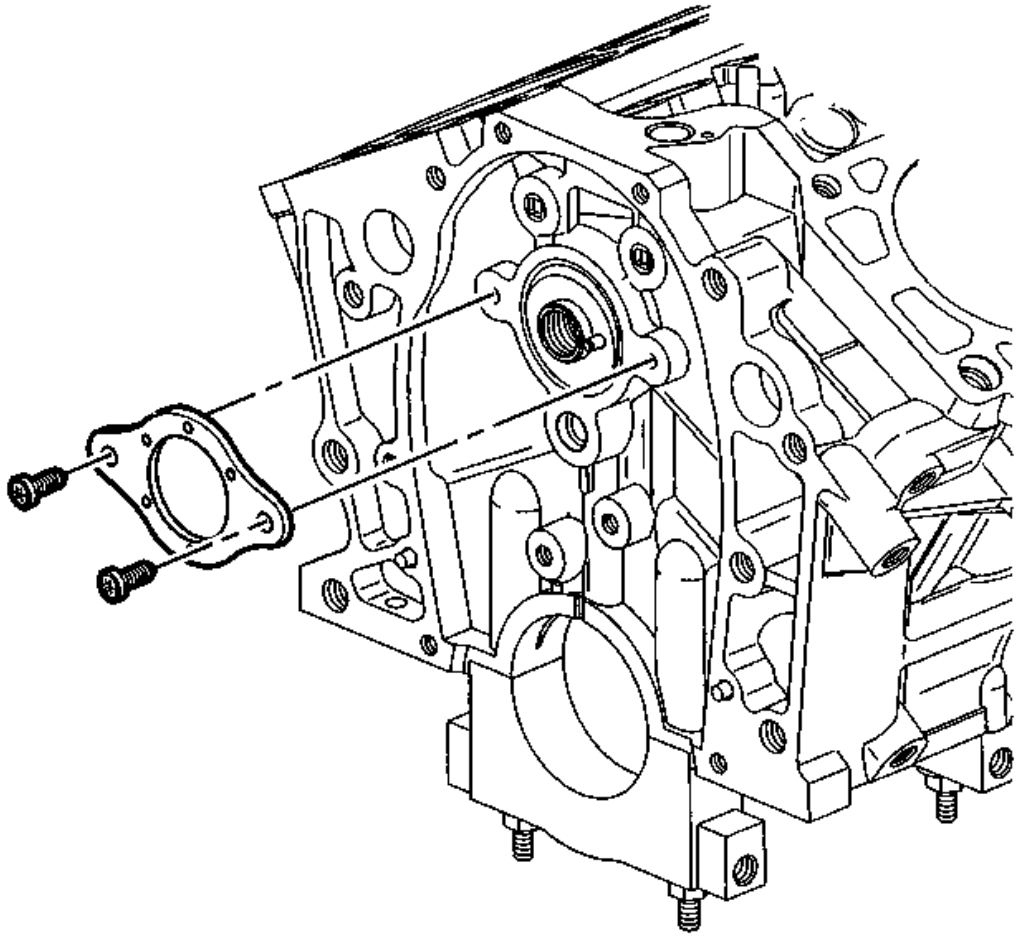

Fig. 587: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

4. Install the camshaft thrust plate.

NOTE: **Refer to Fastener Notice .**

5. Install the camshaft thrust plate screws.

Tighten: Tighten the camshaft thrust plate screws to 10 N.m (89 lb in).

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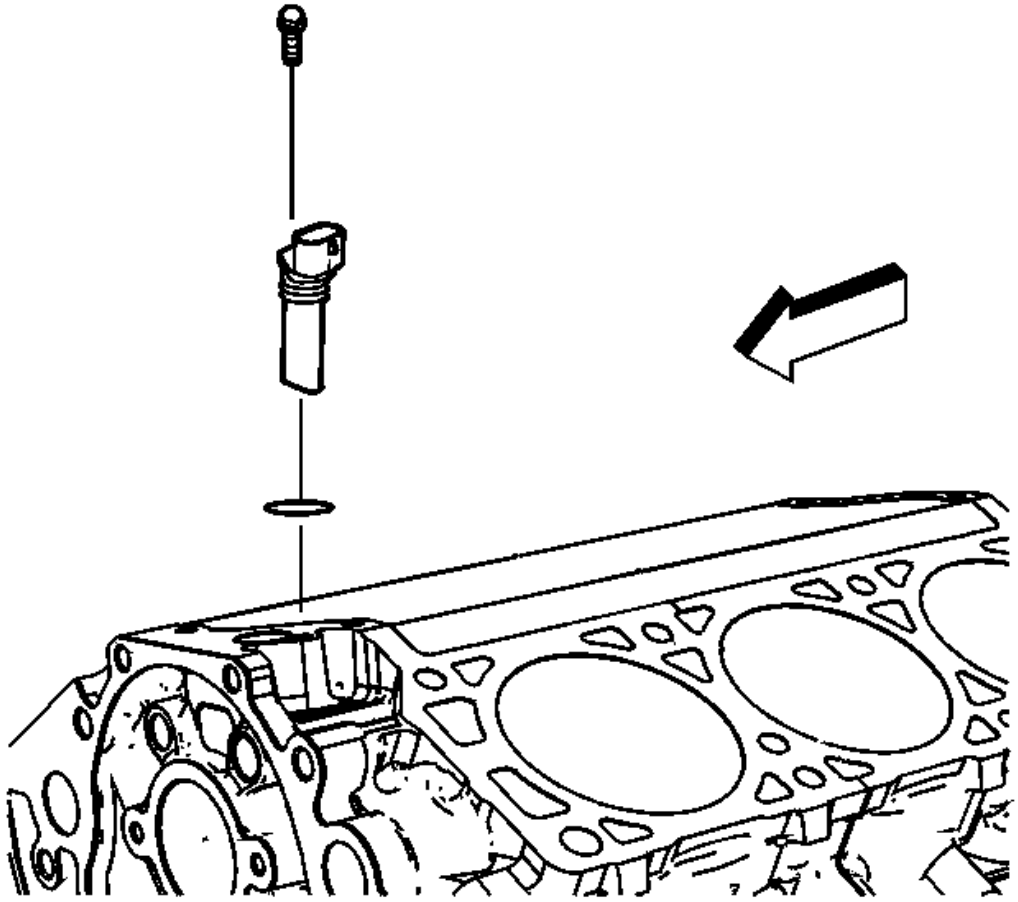

Fig. 588: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft position sensor.
7. Install the camshaft position sensor bolt.

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

Timing Chain and Sprockets Installation

Tools Required

EN-47719 Tensioner Compressor. See **Special Tools**

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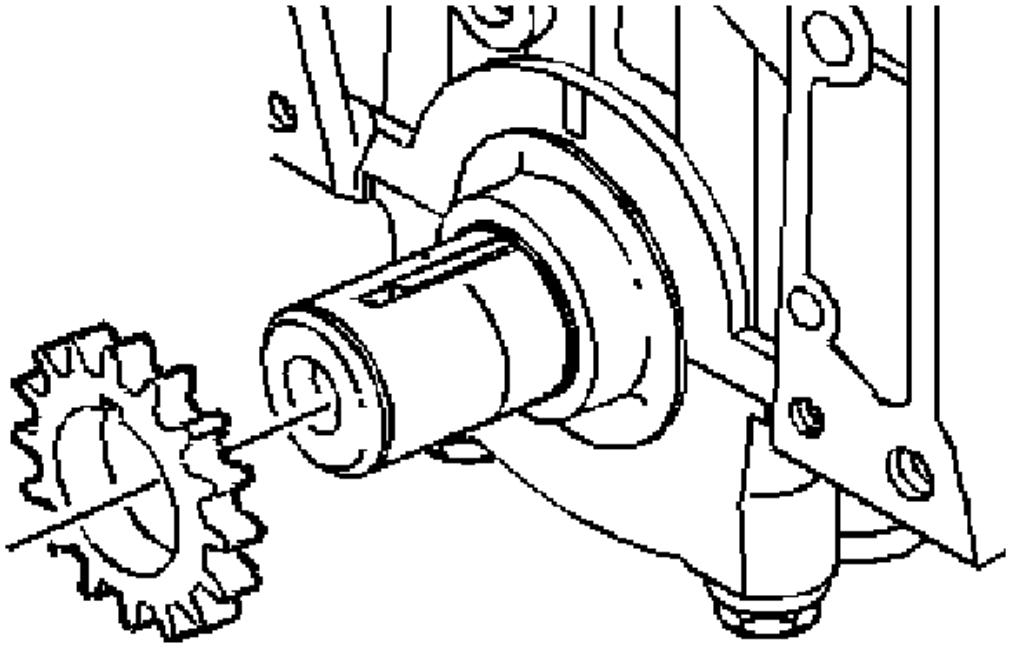

Fig. 589: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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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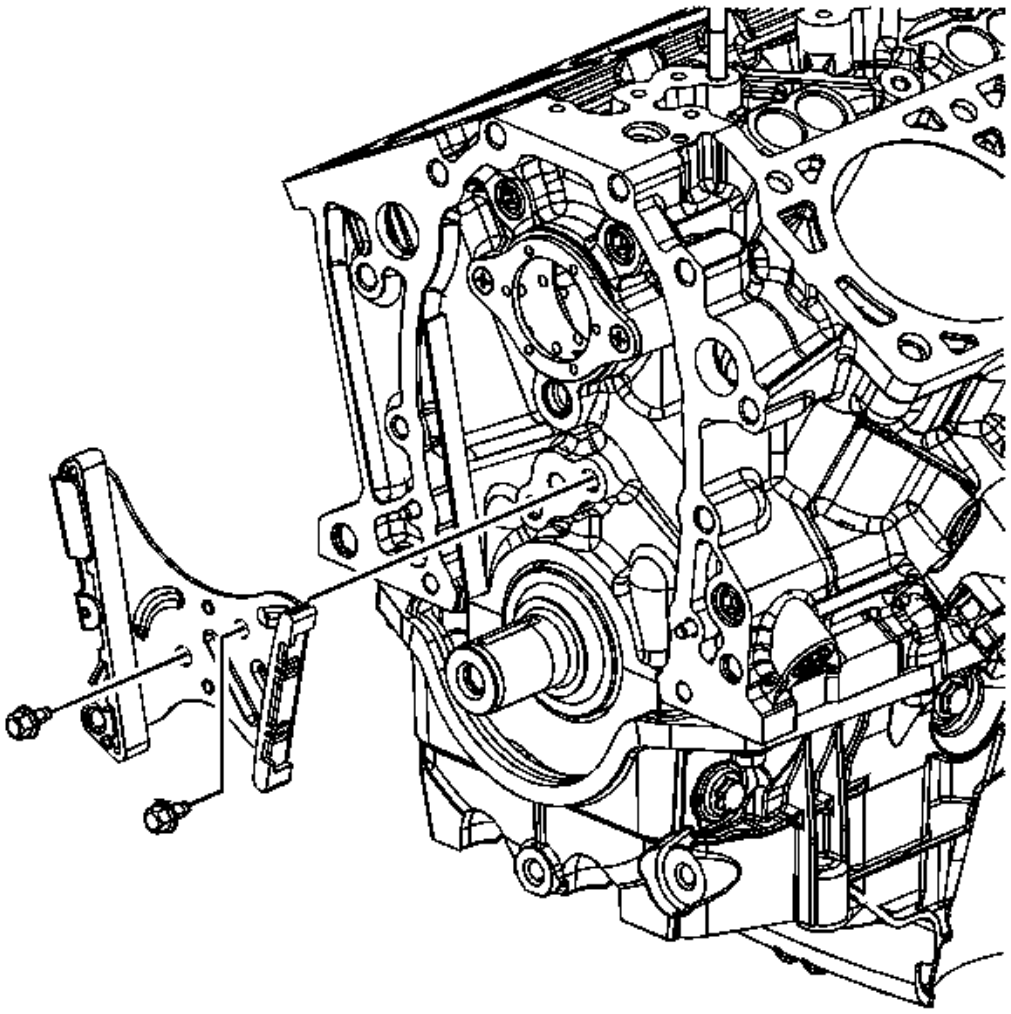

Fig. 590: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain tensioner.

NOTE: Refer to Fastener Notice .

4. Install the timing chain tensioner bolts.

Tighten: Tighten the timing chain tensioner bolts to 21 N.m (15 lb ft).

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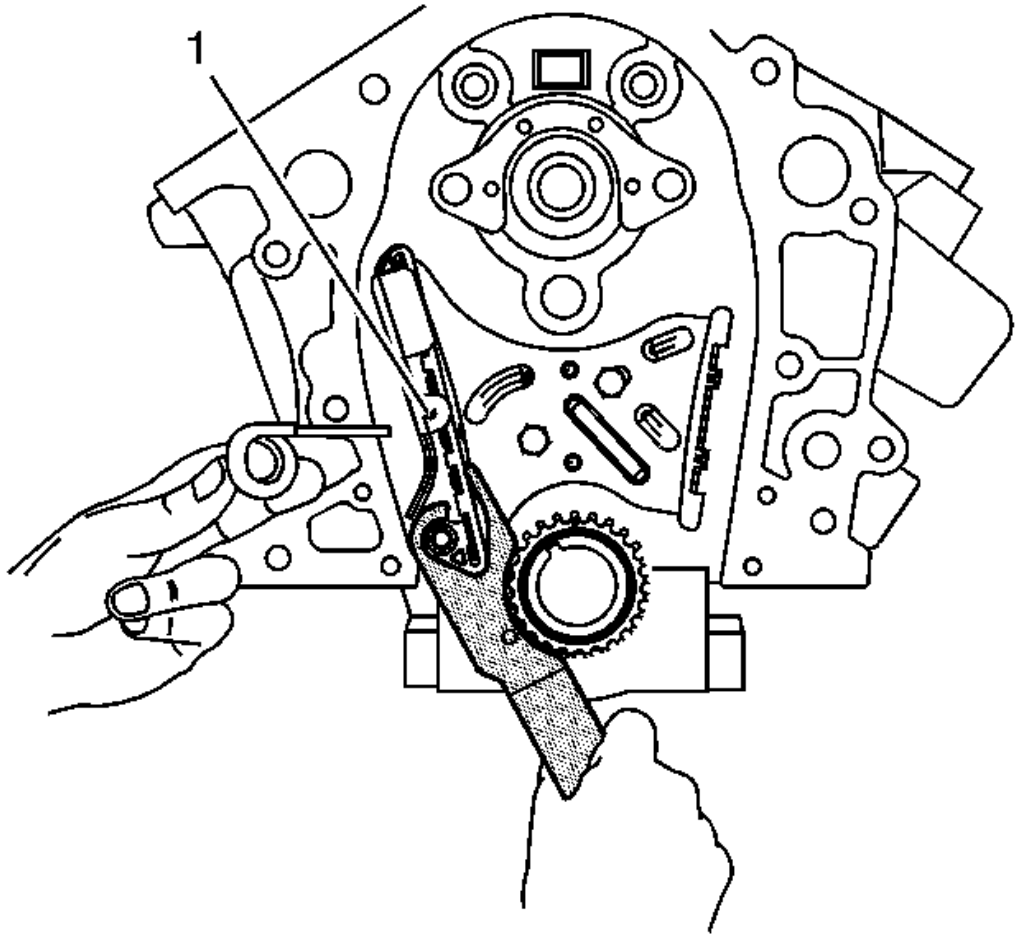

Fig. 591: Collapsing Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Using the **EN-47719** , fully collapse the tensioner, and place the tensioner retaining pin into the retaining hole (1). See **Special Tools**.

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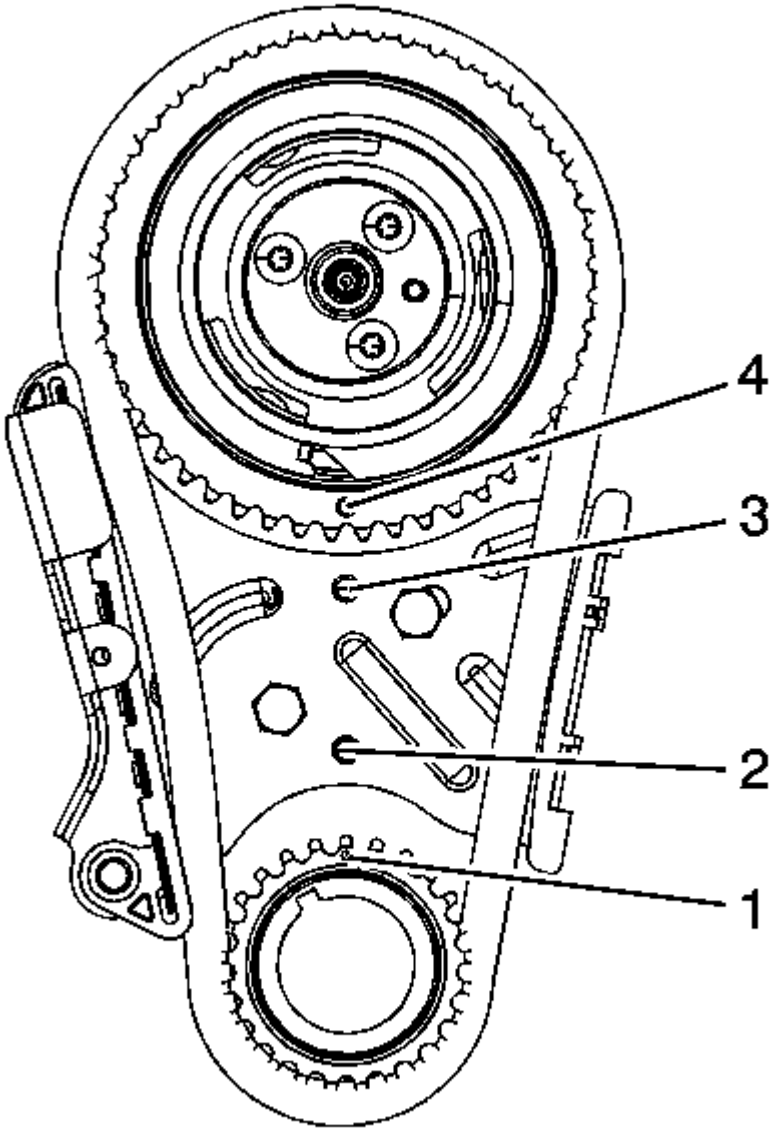

Fig. 592: Identifying Timing Marks & Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install a NEW camshaft position actuator filter 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).

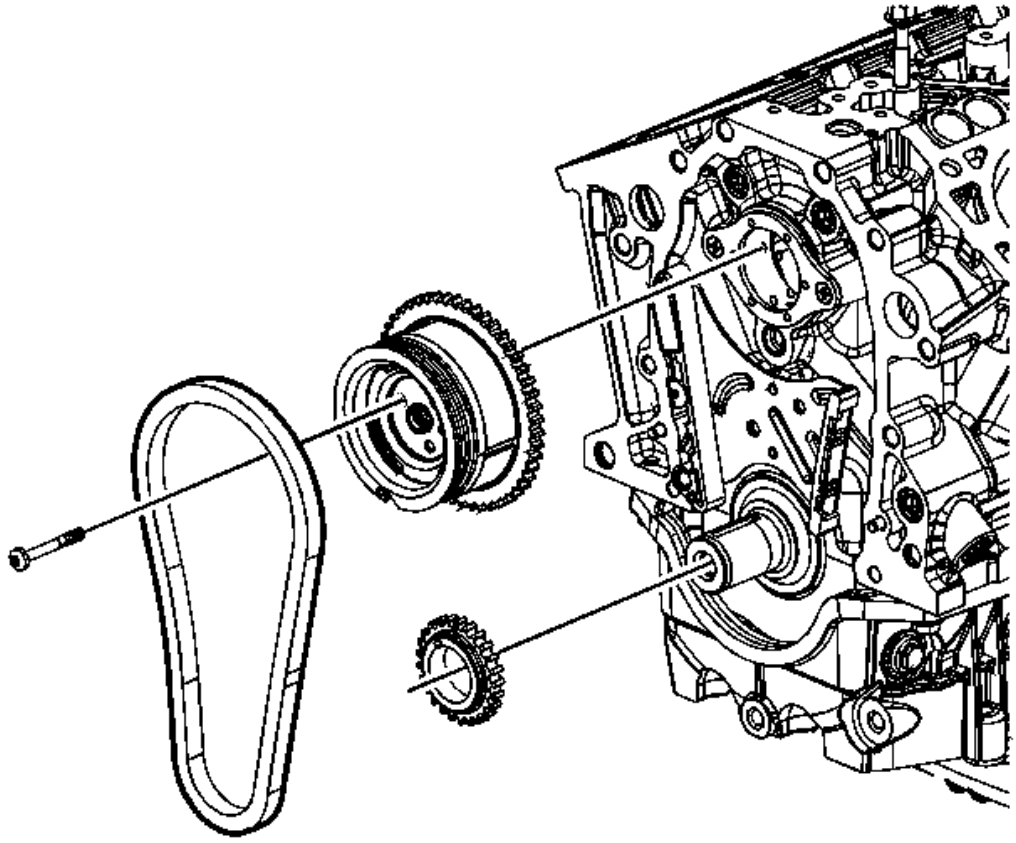

Fig. 593: Identifying Timing Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

9. Align the dowel in the camshaft position actuator with the dowel hole in the camshaft.

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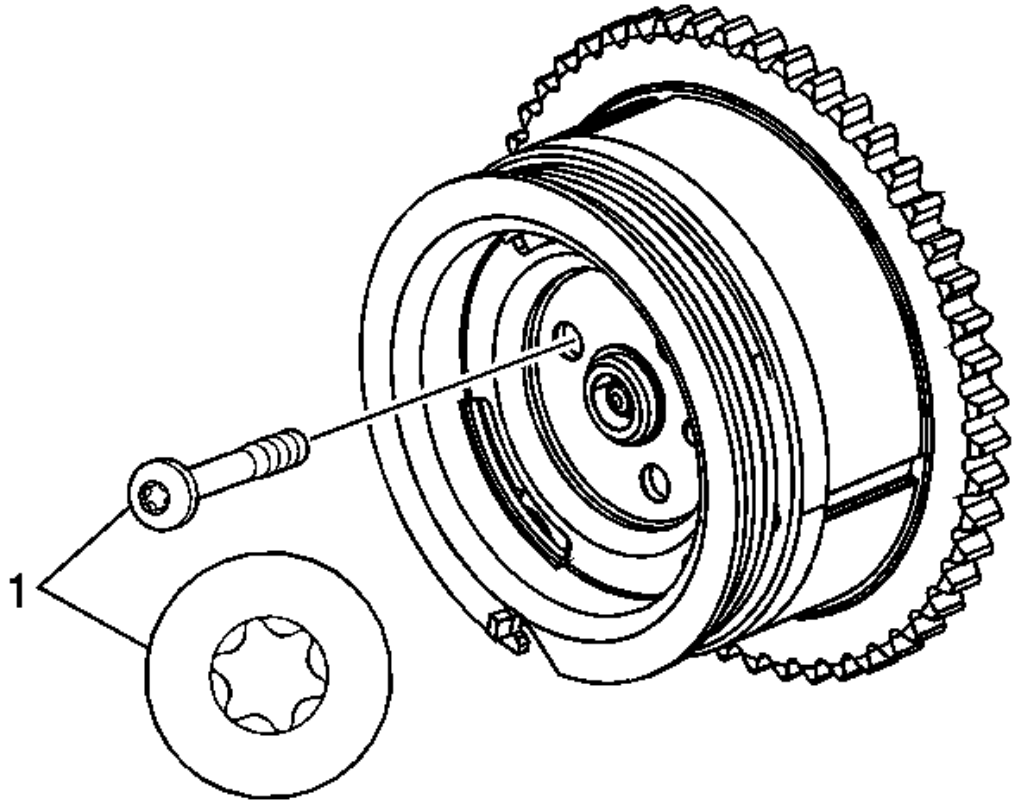

Fig. 594: Identifying Camshaft Position Actuator & Fasteners
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

IMPORTANT: 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.

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

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11. Remove the tensioner retaining pin.
12. Coat the crankshaft and camshaft sprocket with engine oil.

Engine Front Cover Installation

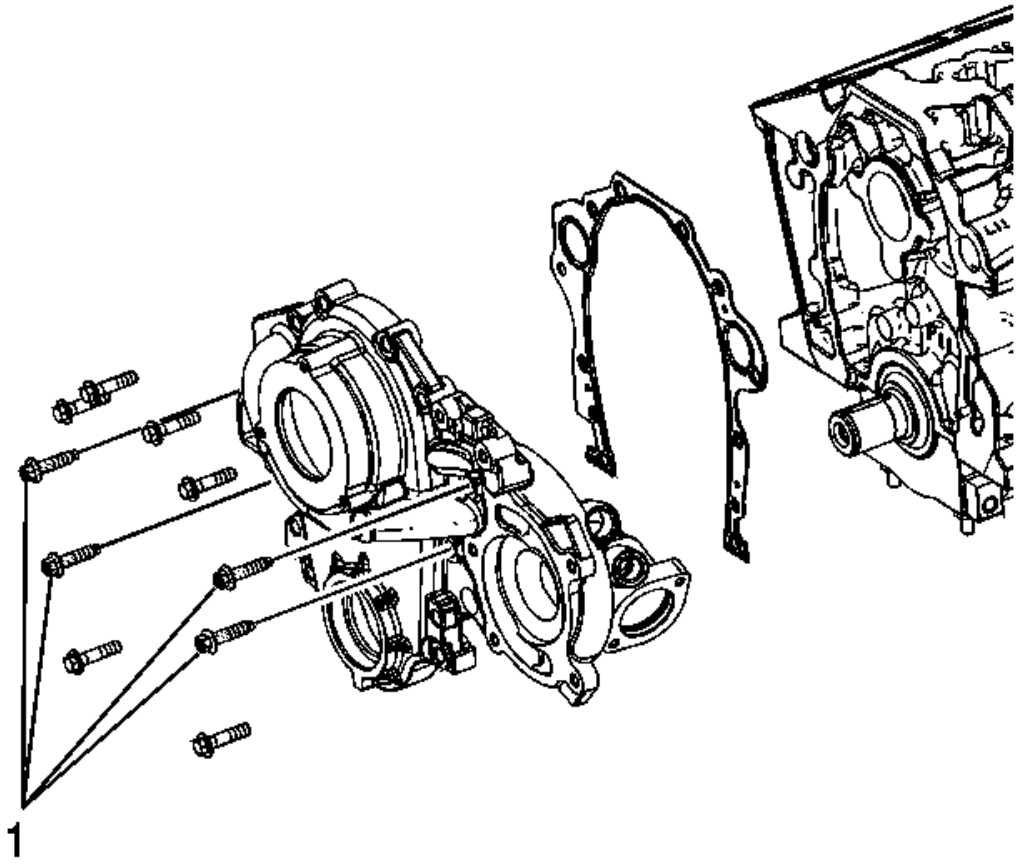

Fig. 595: Identifying Bolts Requiring Sealer
Courtesy of GENERAL MOTORS CORP.

1. Install the front cover and the front cover gasket.

NOTE: Refer to Fastener Notice .

IMPORTANT: 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.

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2. Install the front cover bolts.

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

Crankshaft Front Oil Seal Installation

Tools Required

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

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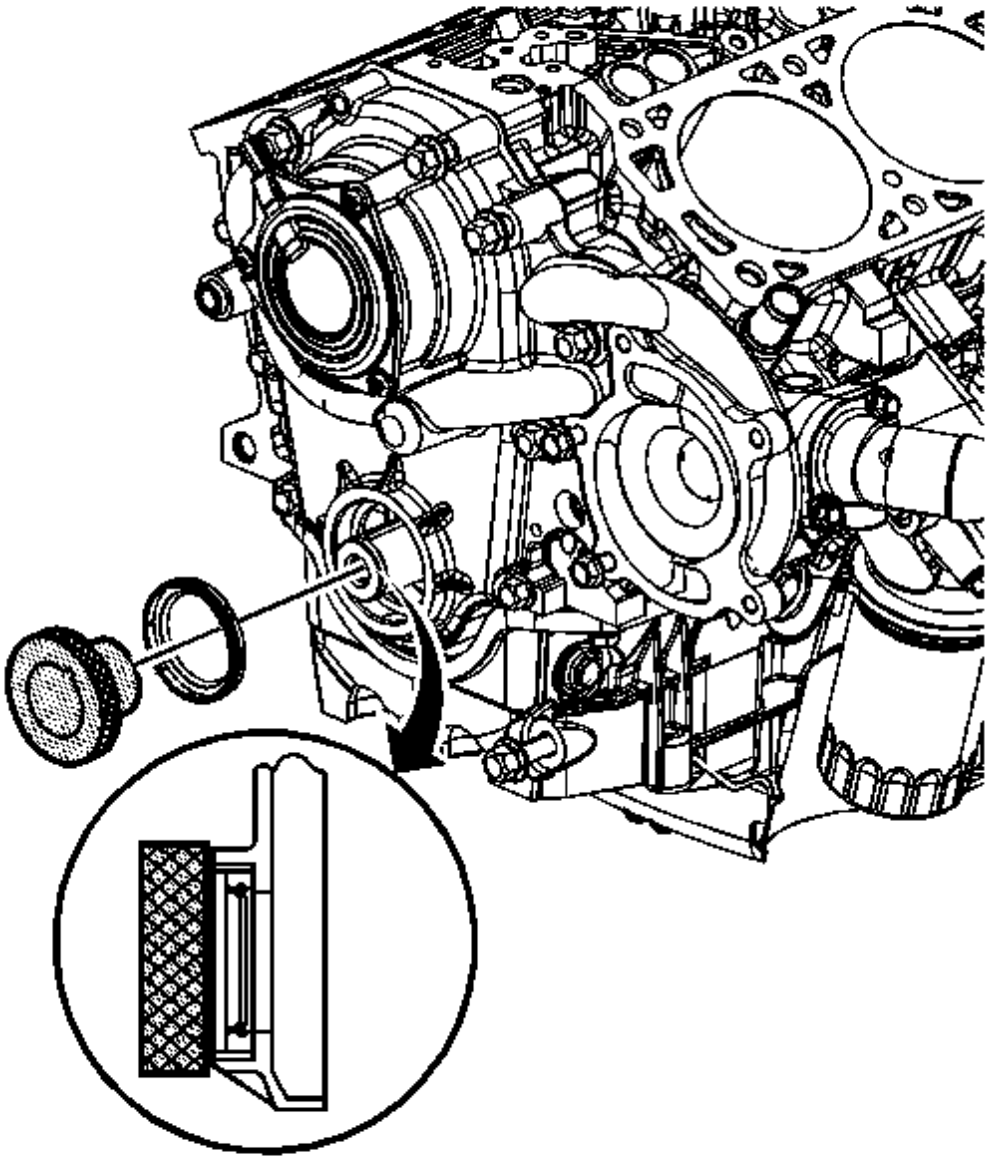

Fig. 596: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Align the **J 35468** and the crankshaft front oil seal with the engine front cover and crankshaft. See **Special Tools**.
2. Install the crankshaft front oil seal using the **J 35468** and a suitable tool. See **Special Tools**.

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Oil Pump Drive Installation

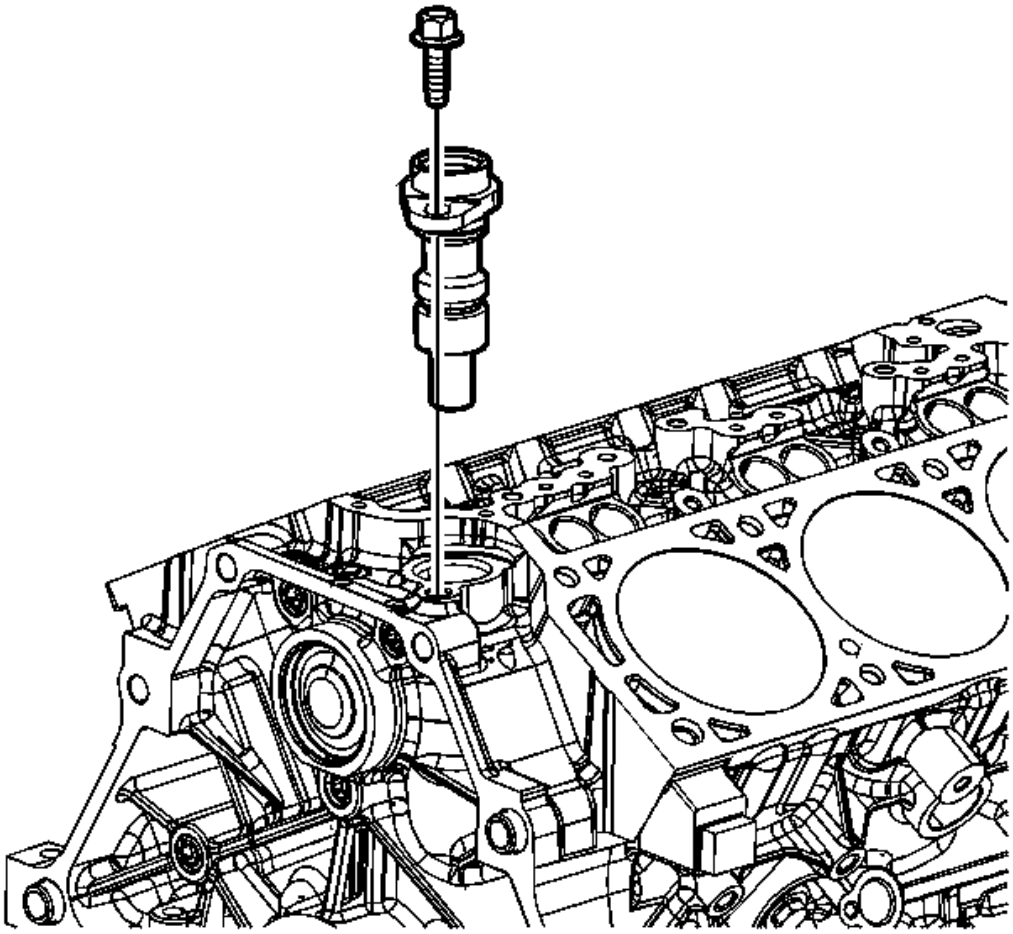

Fig. 597: Identifying Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice .

5. Install the oil pump drive gear clamp bolt.

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Tighten: Tighten the oil pump drive gear clamp bolt to 36 N.m (27 lb ft).

Camshaft Position Actuator Magnet Installation

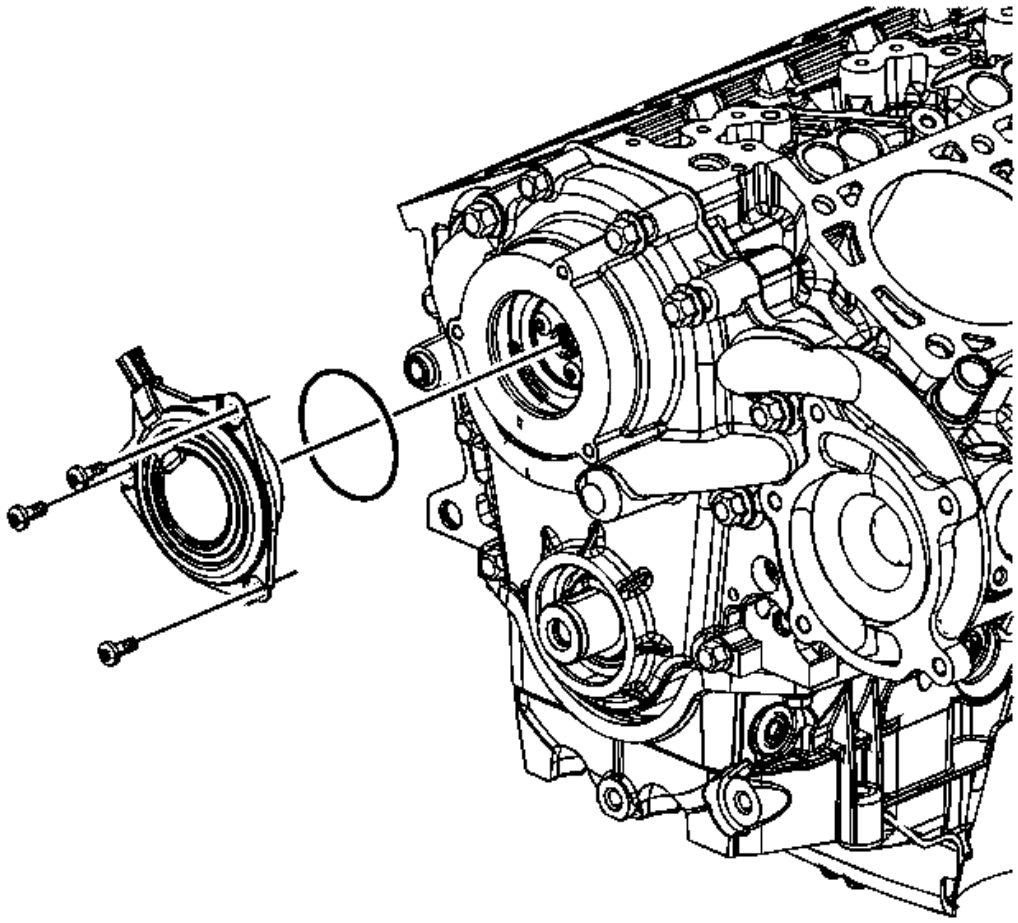

Fig. 598: Identifying Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: **Refer to Fastener Notice .**

2. Install the camshaft position actuator magnet bolts.

Tighten: Tighten the camshaft position actuator magnet bolts to 10 N.m (89 lb in).

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Oil Pump Installation

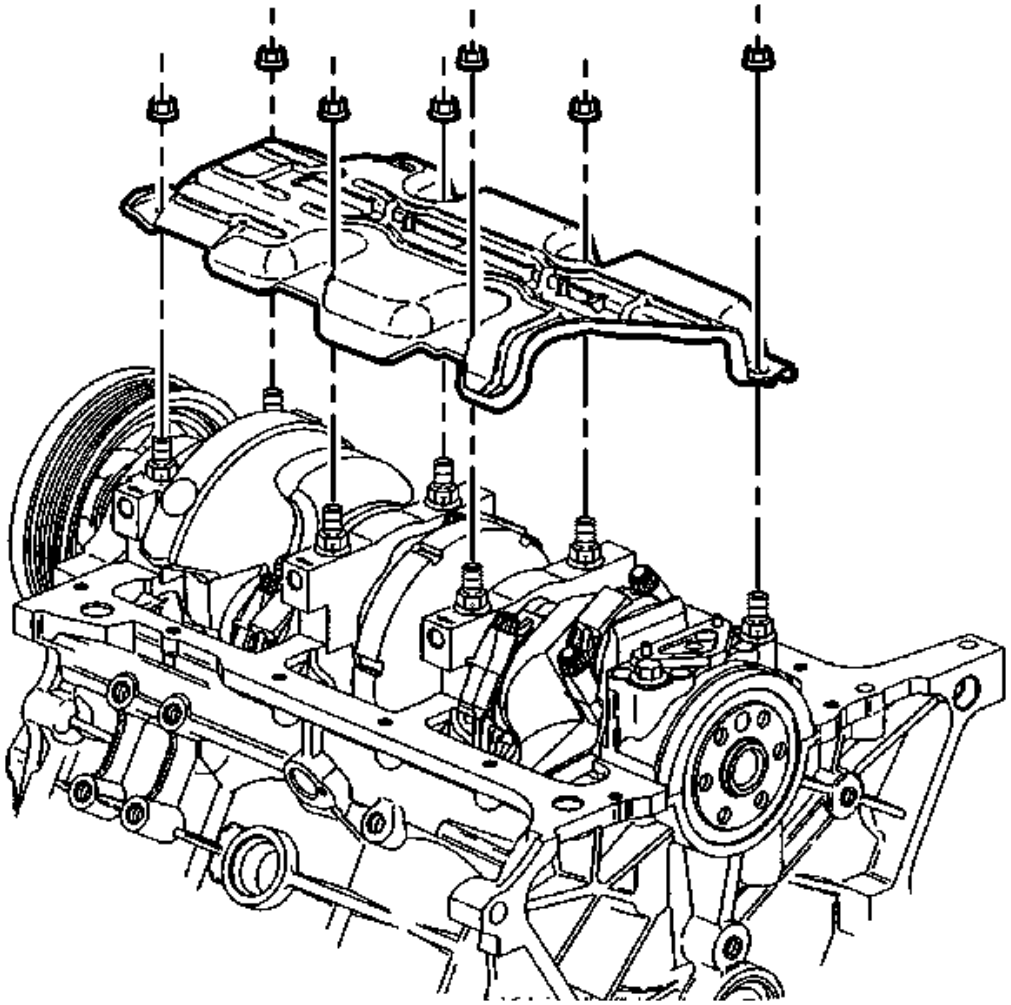

Fig. 599: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft oil deflector.

   NOTE: Refer to Fastener Notice .

2. Install the crankshaft oil deflector nuts.

   Tighten: Tighten the crankshaft oil deflector nuts to 25 N.m (18 lb ft).

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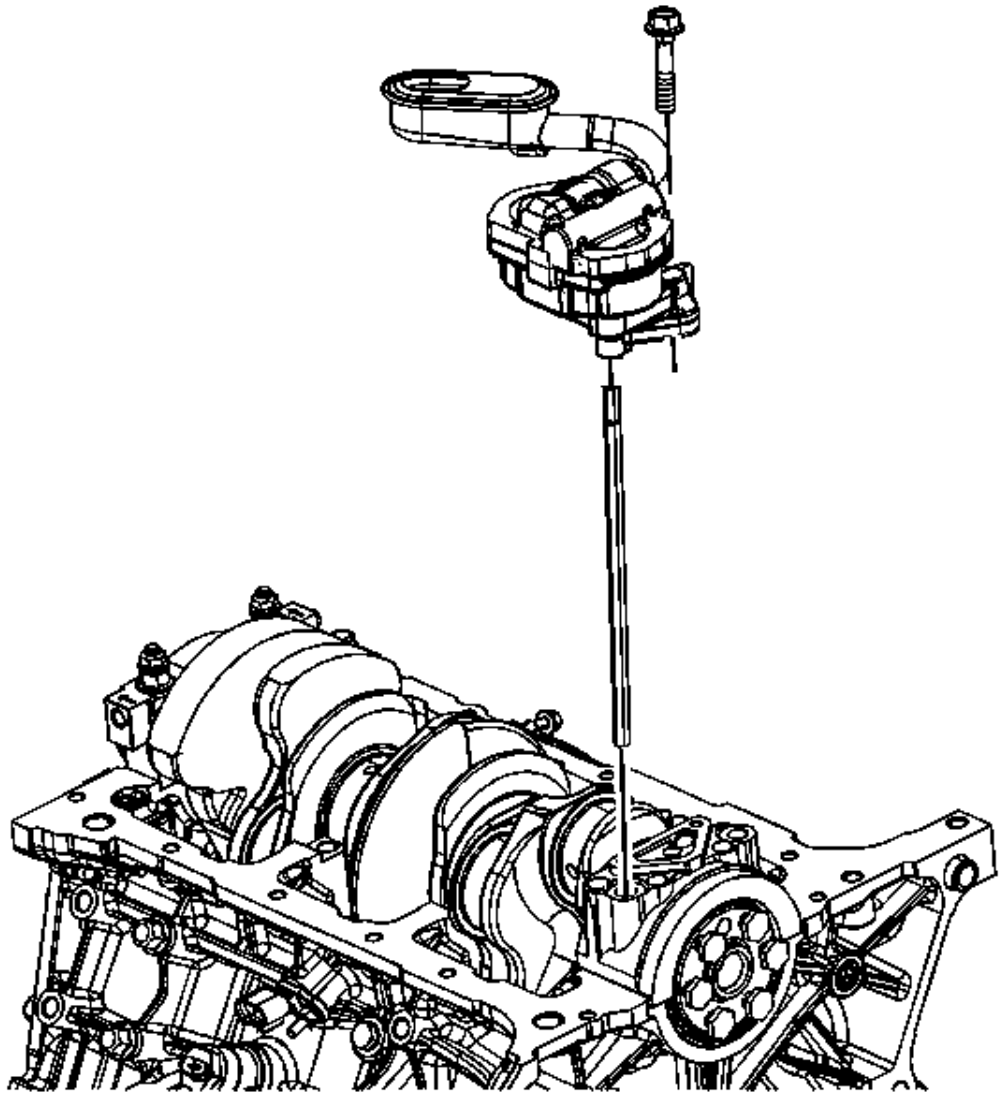

Fig. 600: Identifying Oil Pump, Screen & Driveshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

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5. Install the oil pump bolt attaching the oil pump to the rear crankshaft bearing cap.

   Tighten: Tighten the oil pump bolt to 41 N.m (30 lb ft).

Oil Pan Installation

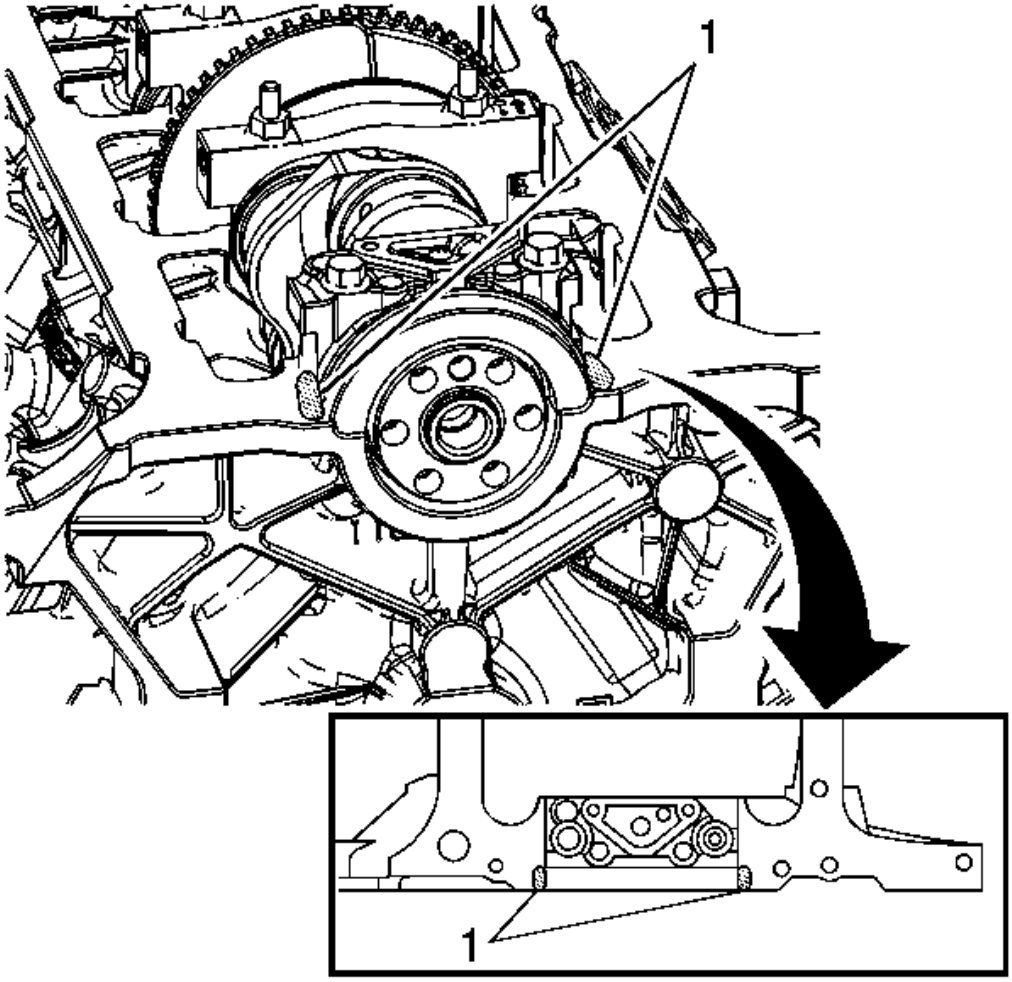

Fig. 601: Illustrating Proper Sealer Application
Courtesy of GENERAL MOTORS CORP.

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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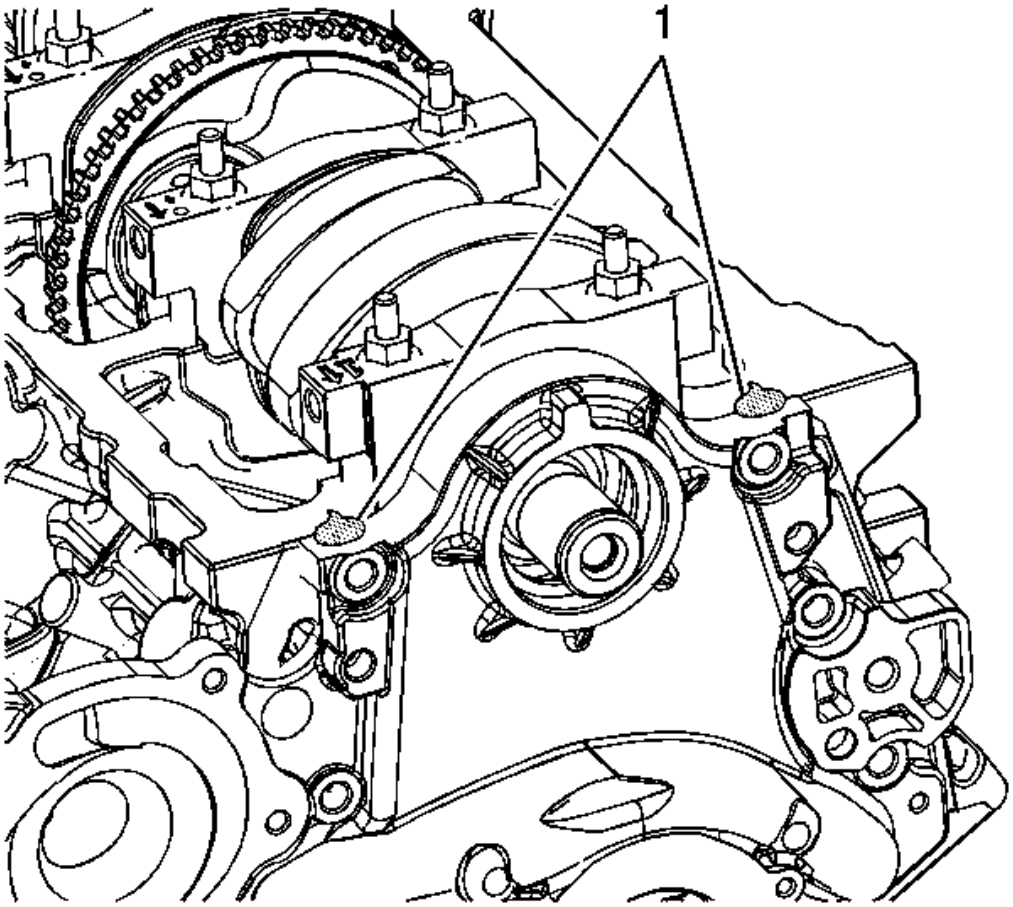

Fig. 602: View Of Oil Pan Sealing Points
Courtesy of GENERAL MOTORS CORP.

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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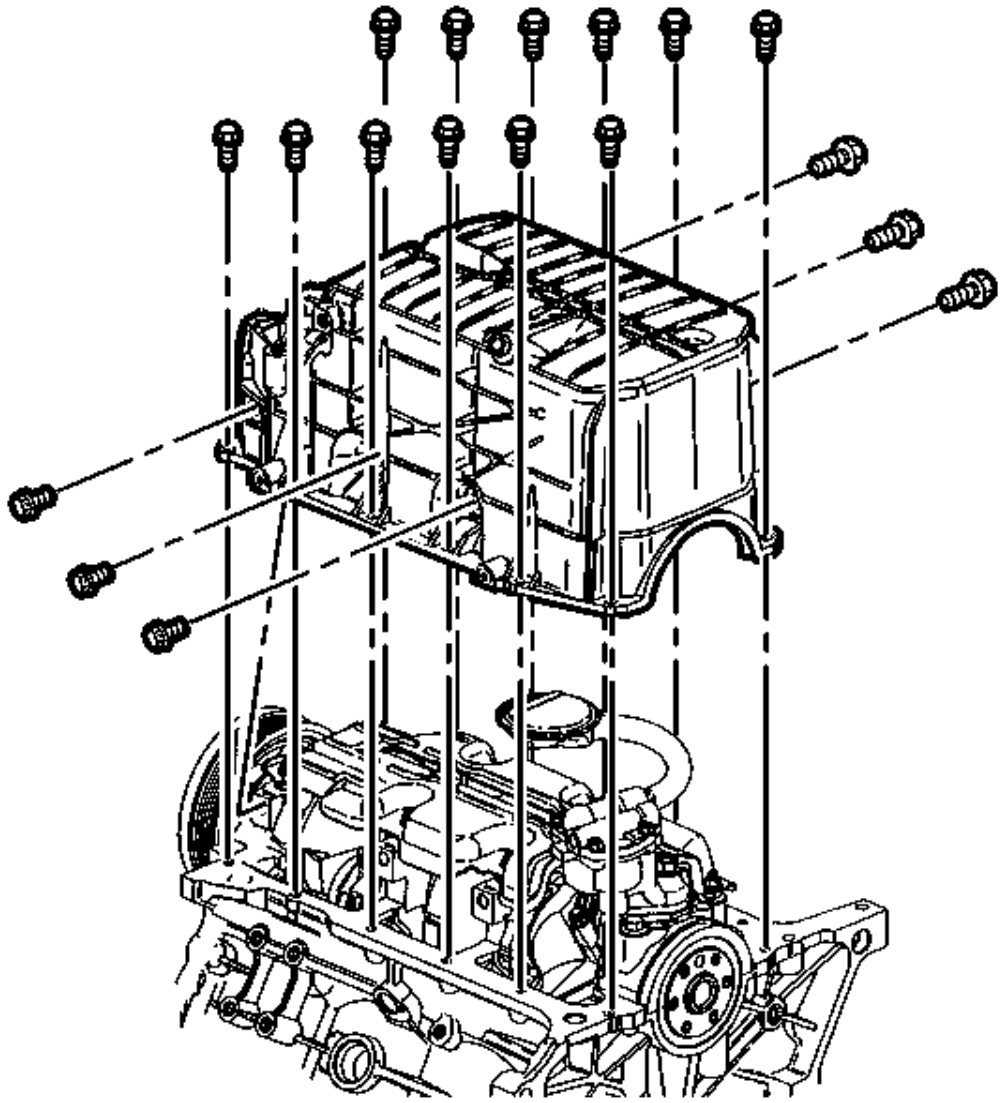

Fig. 603: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan gasket.
4. Install the oil pan.

NOTE: Refer to Fastener Notice .

5. Install the oil pan bolts.

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

6. Install the oil pan side bolts.

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

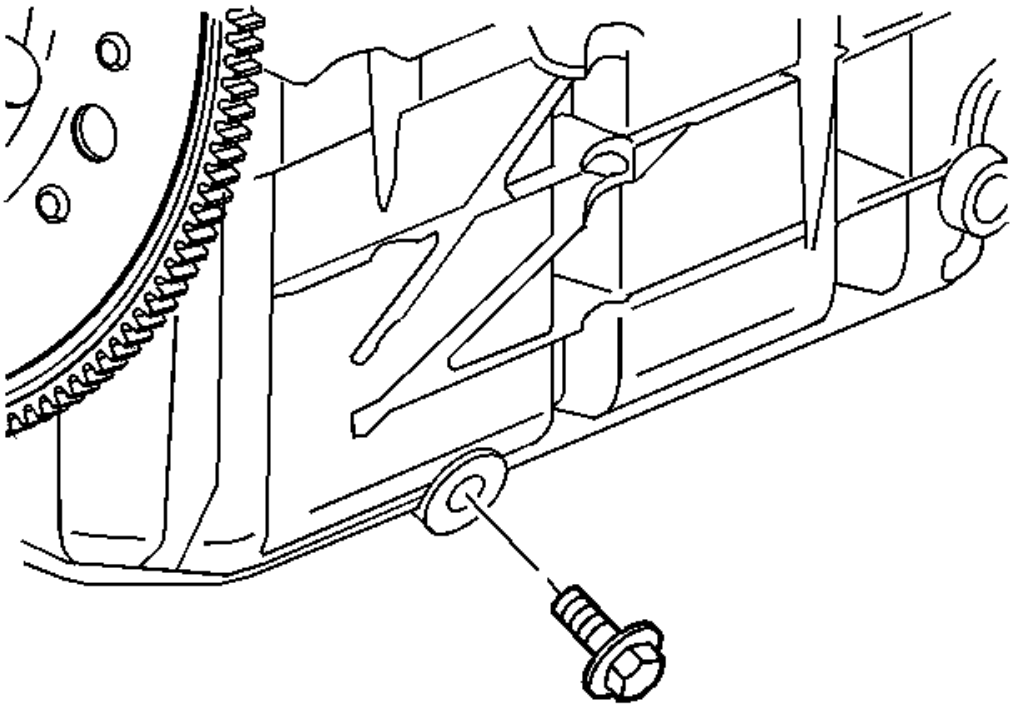

Fig. 604: Removing Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

7. Install the oil pan drain plug.

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

Cylinder Head Installation - Left Side

Tools Required

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

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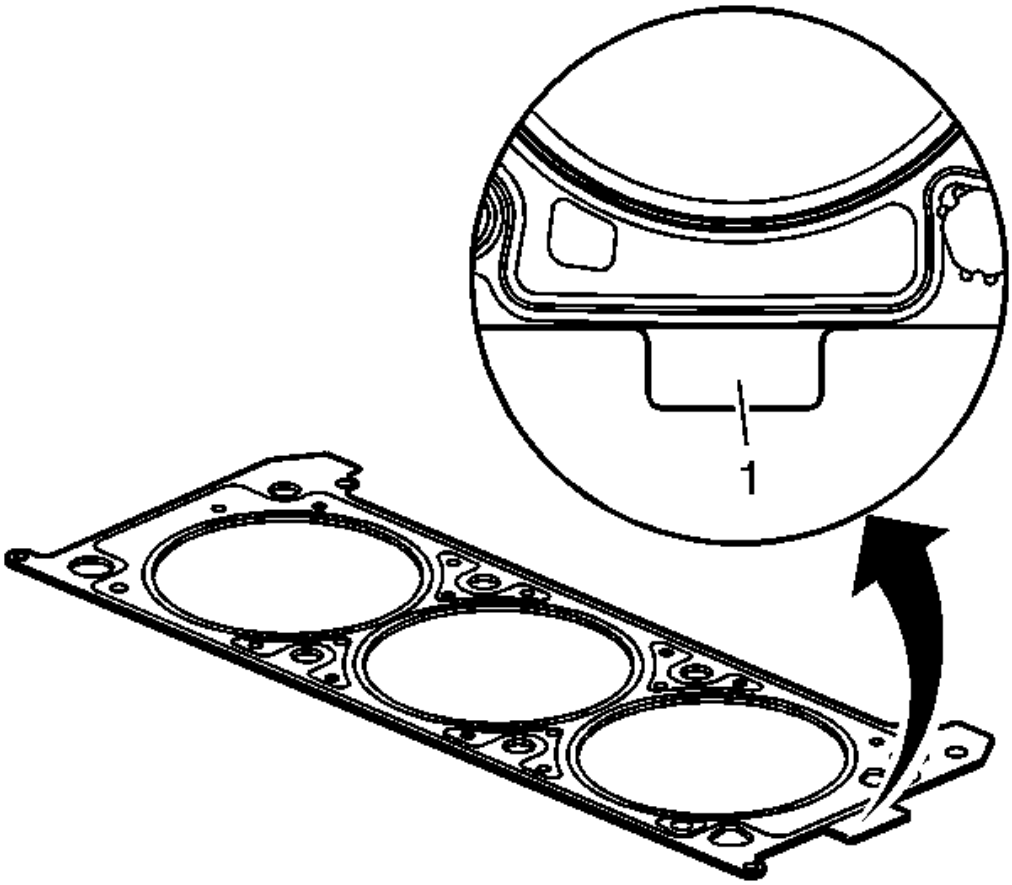

Fig. 605: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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

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.

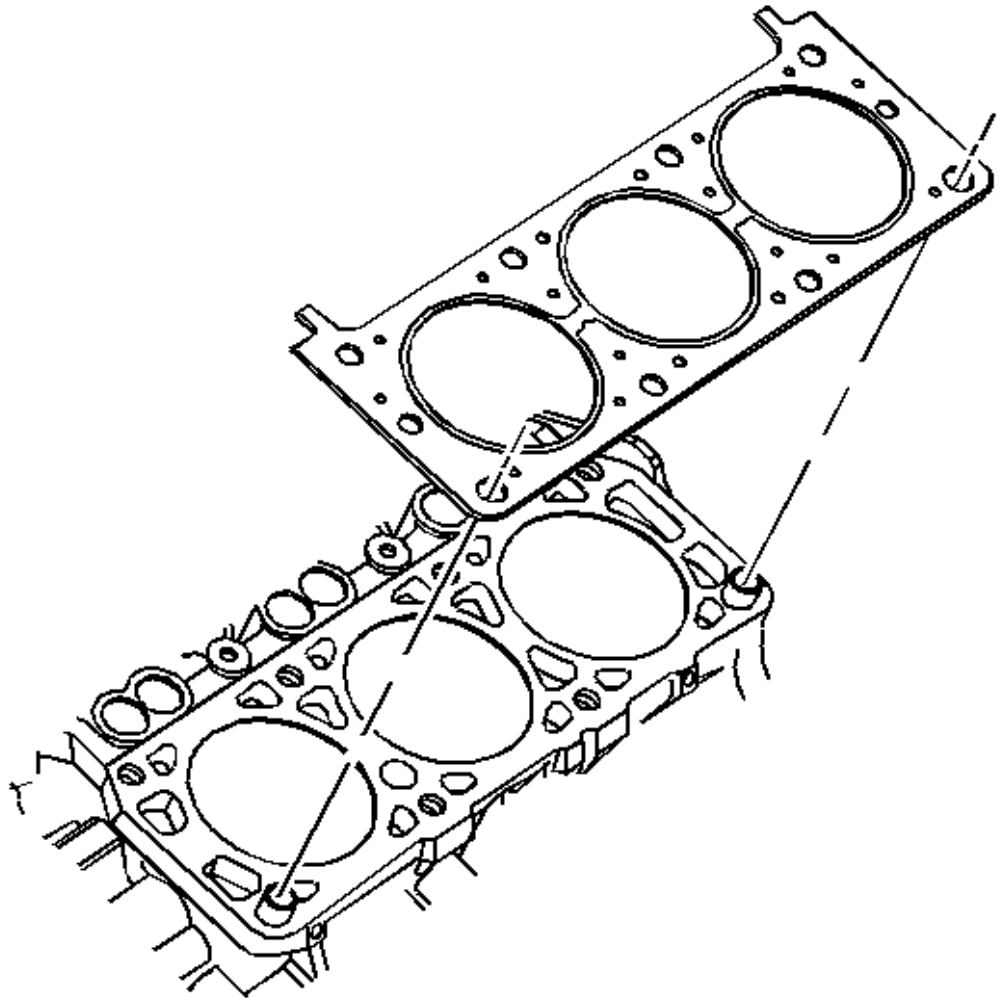

Fig. 606: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head gasket.

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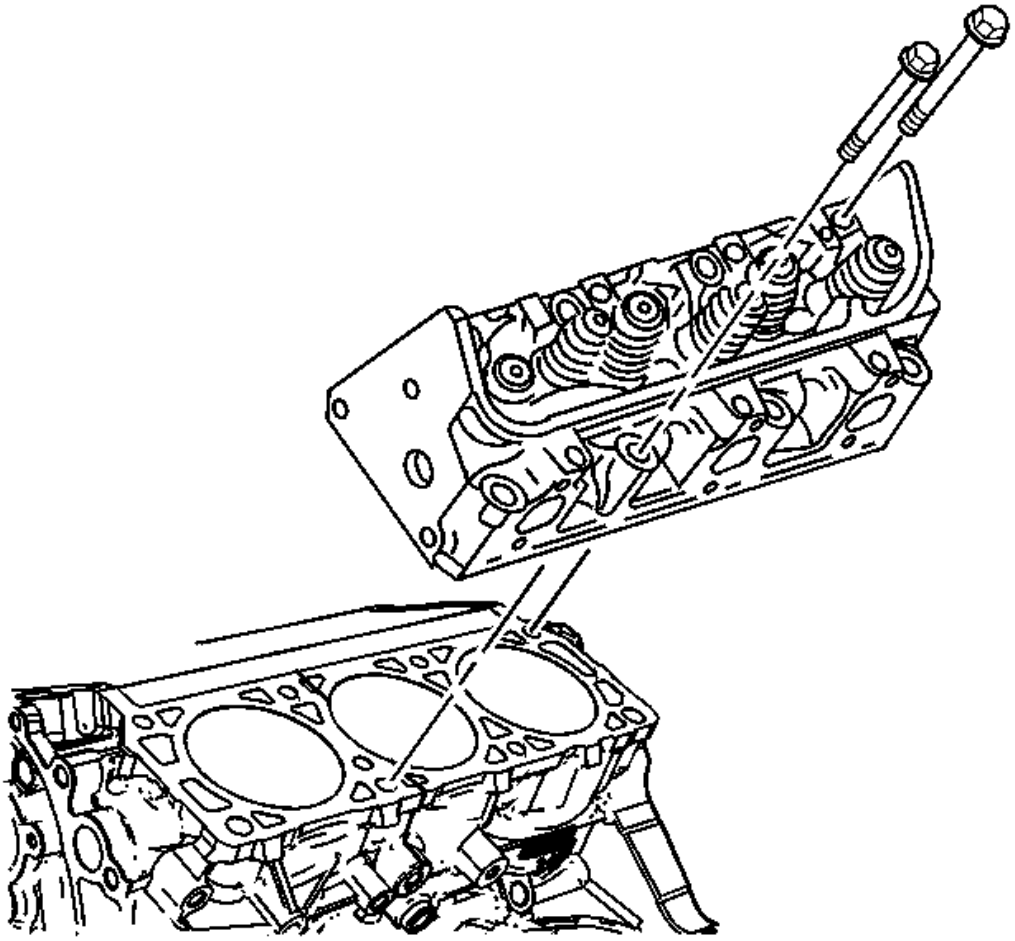

Fig. 607: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

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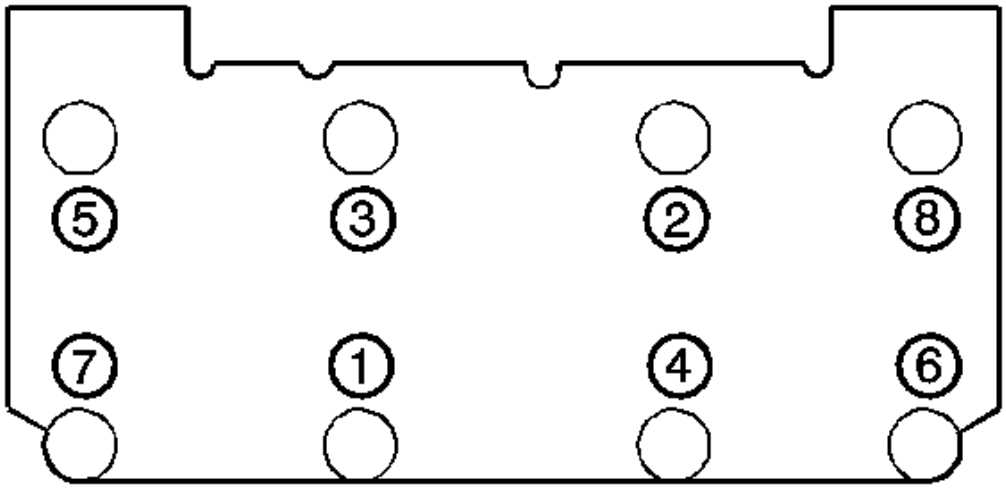

Fig. 608: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Install the new cylinder head bolts.

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 95 degrees using the **J 45059** . See **Special Tools**.

Cylinder Head Installation - Right Side

Tools Required

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

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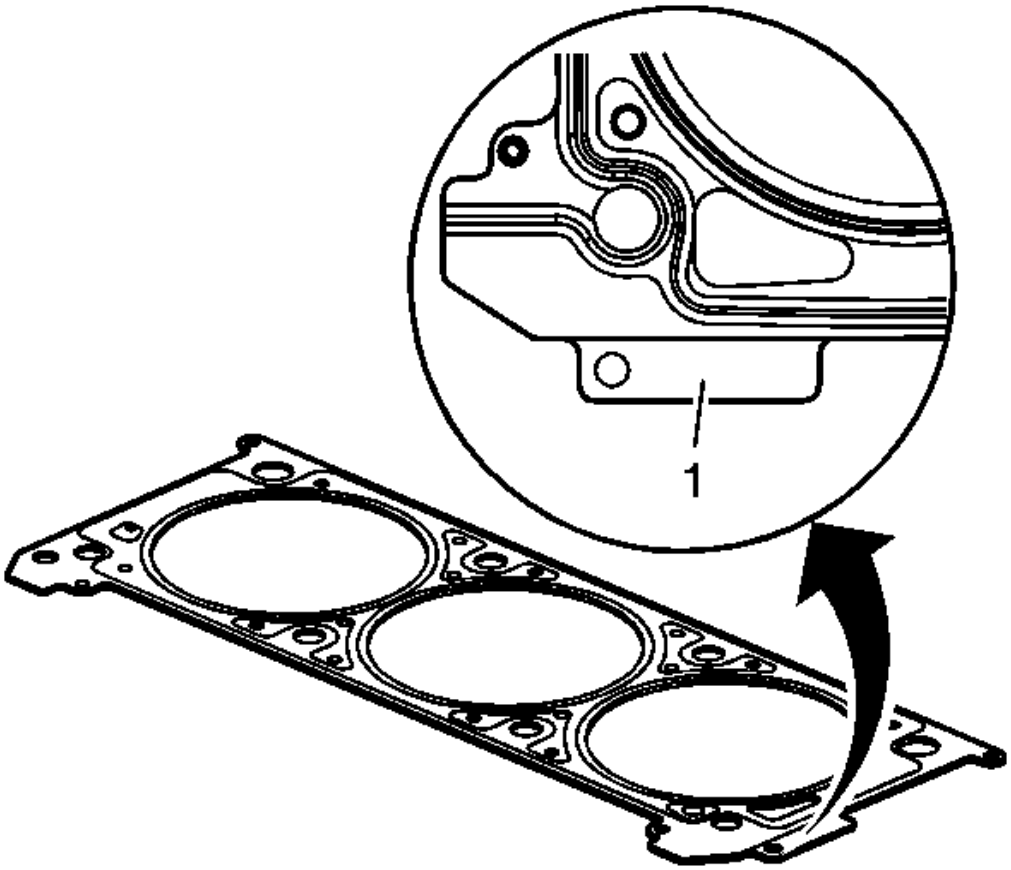

Fig. 609: Identifying Proper Cylinder Head Gasket Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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

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.

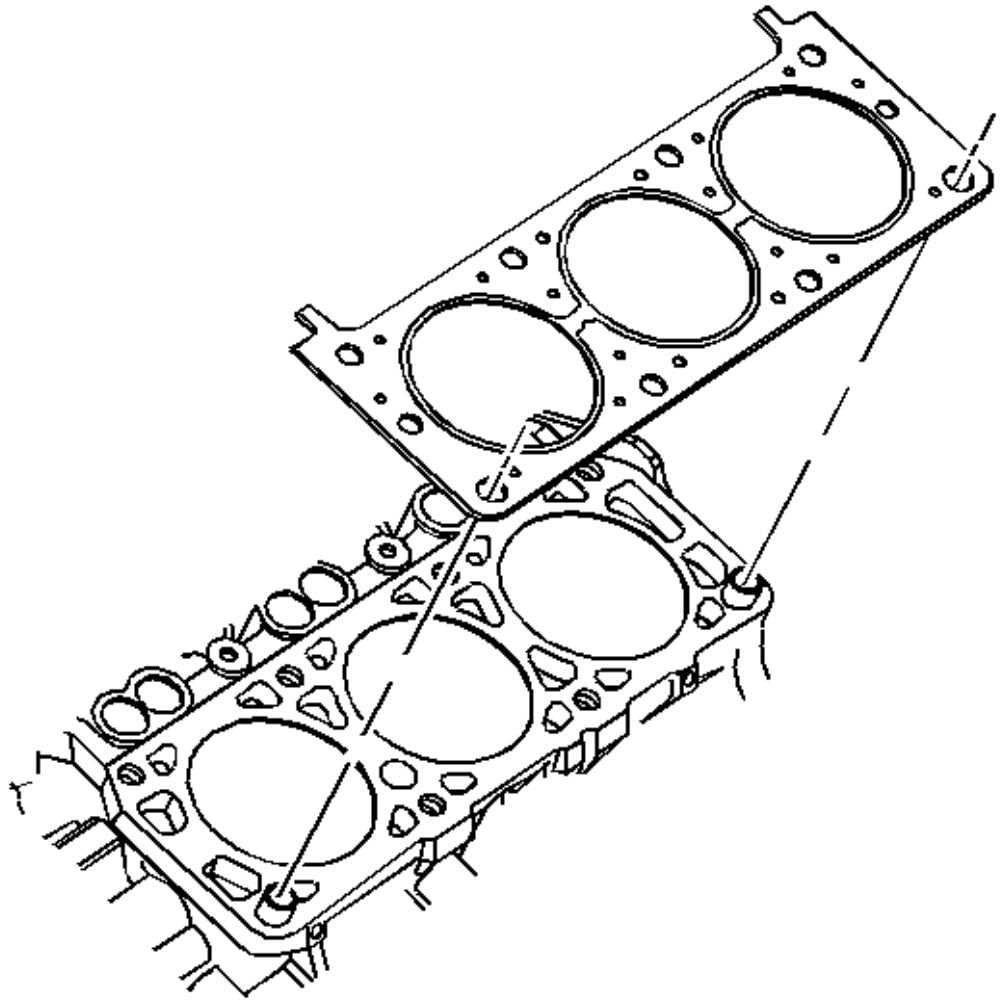

Fig. 610: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head gasket.

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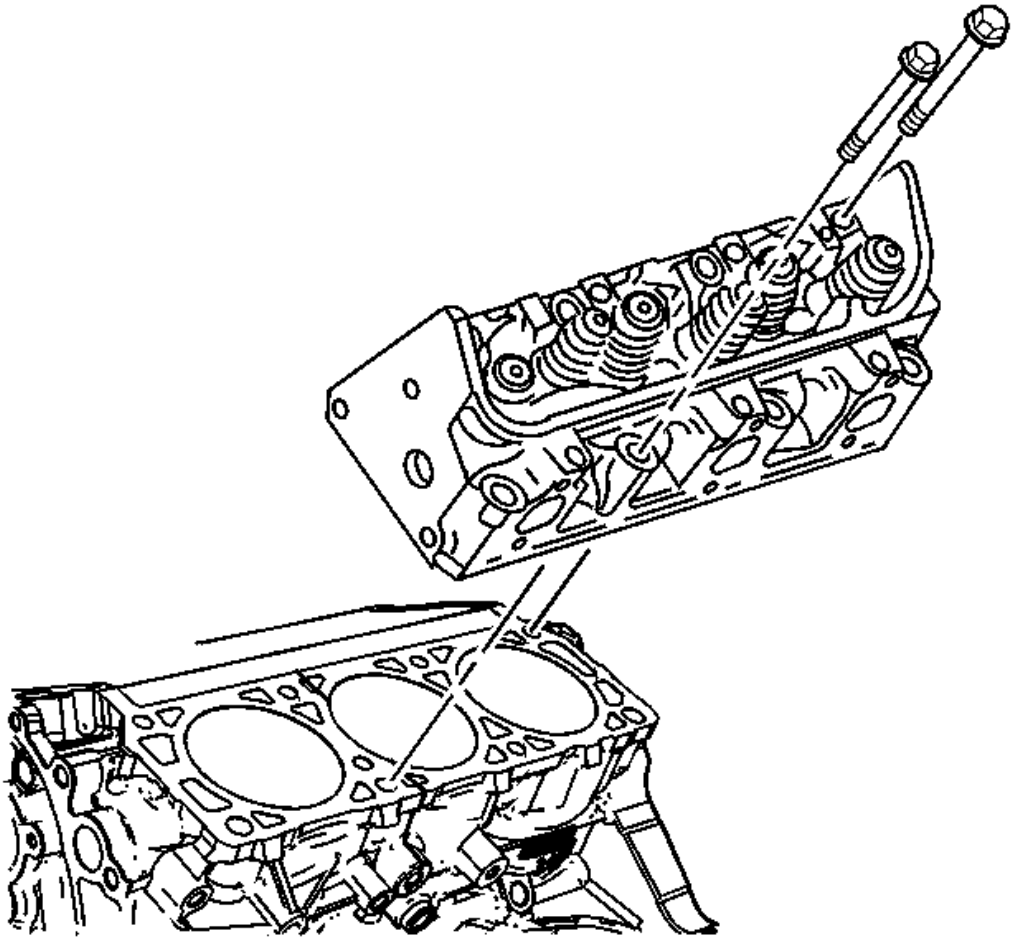

Fig. 611: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

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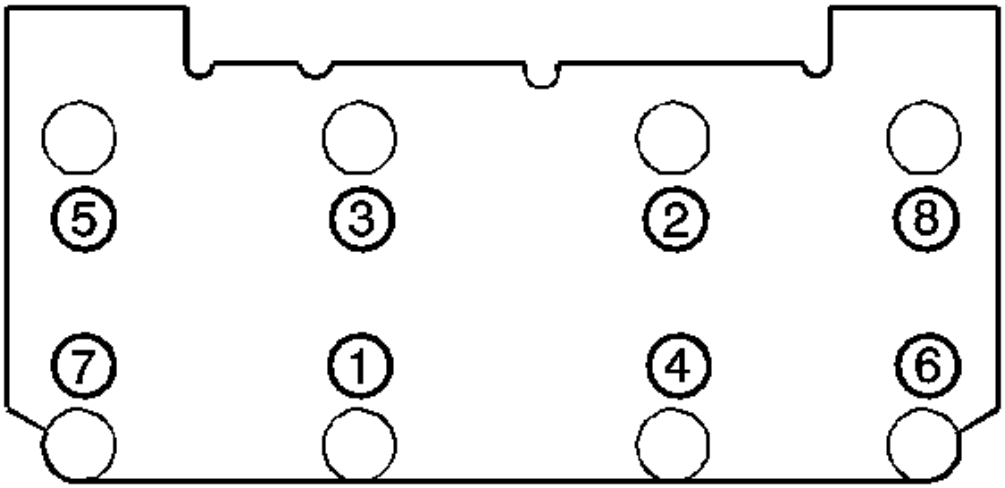

Fig. 612: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Install the new cylinder head bolts.

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 95 degrees using the **J 45059** . See **Special Tools**.

Water Pump Installation

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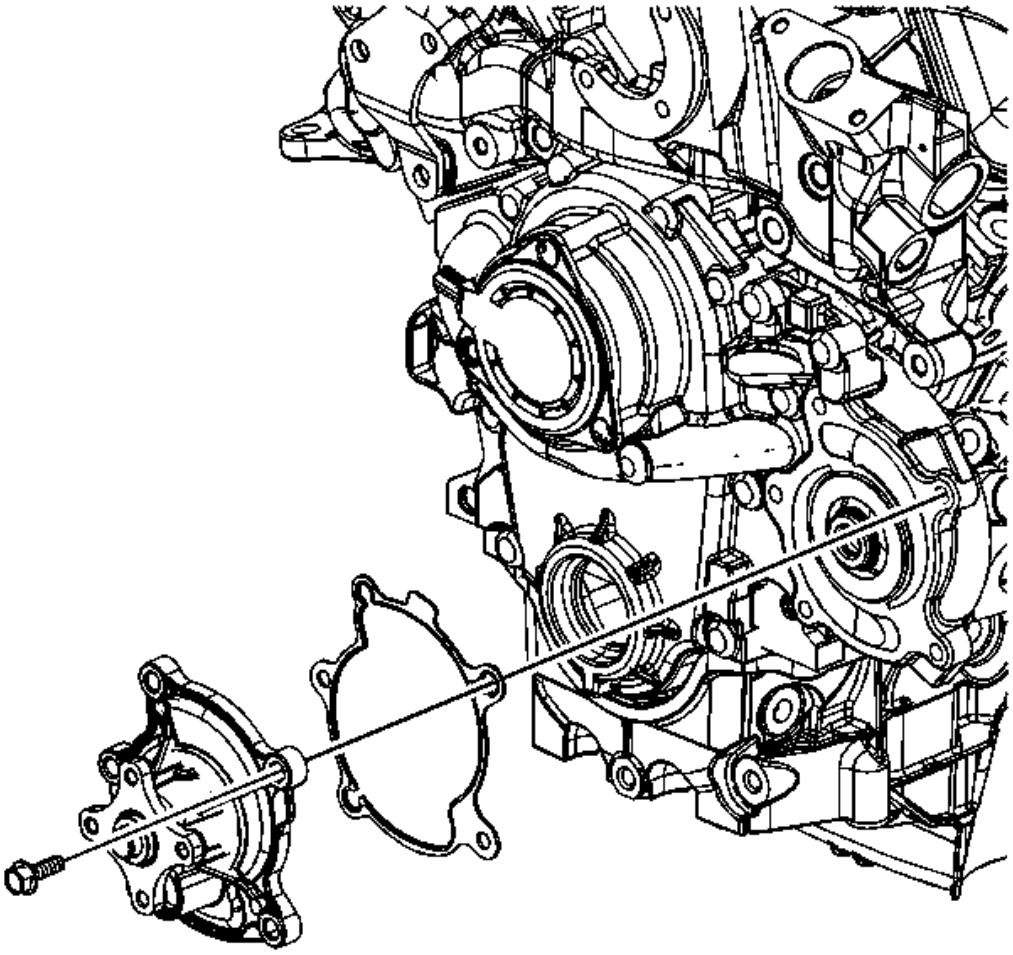

Fig. 613: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump gasket.
2. Install the water pump.

NOTE: Refer to Fastener Notice .

3. Install the water pump bolts.

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

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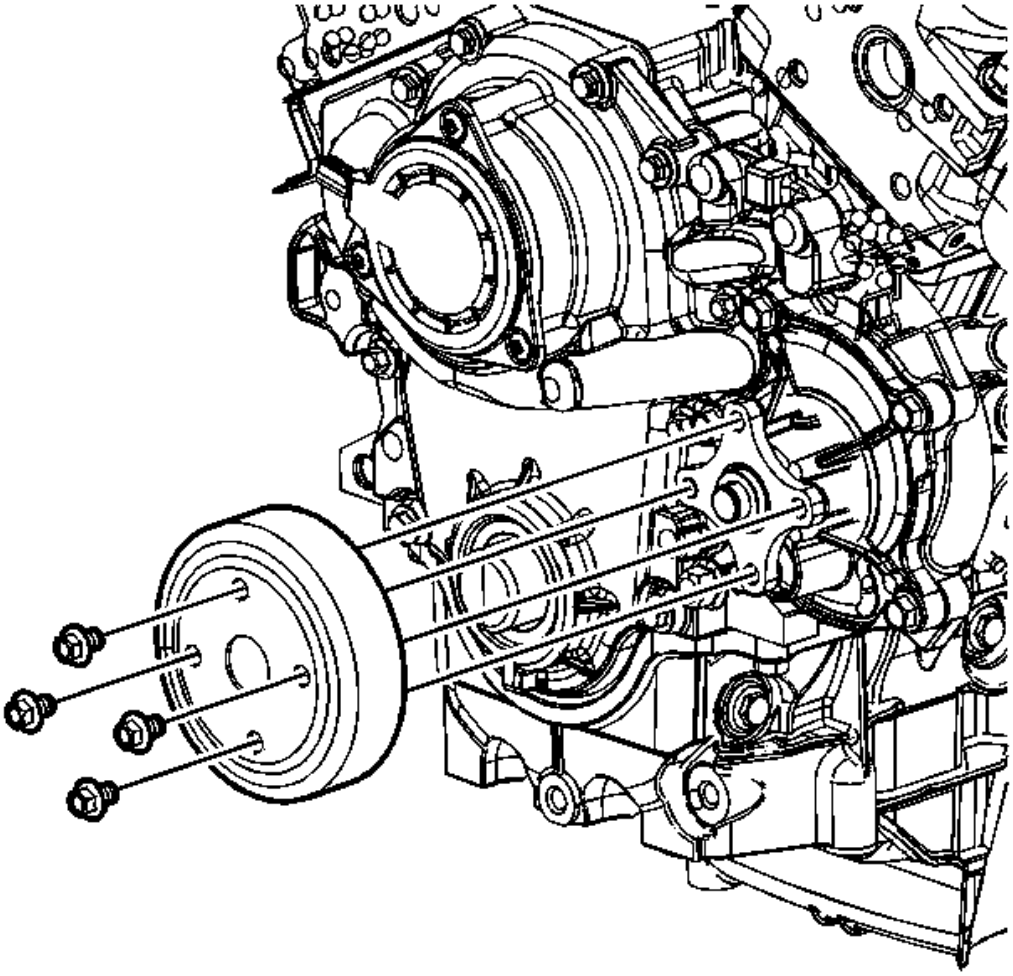

Fig. 614: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the water pump pulley.
5. Install the water pump pulley bolts.

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

Valve Lifter Installation

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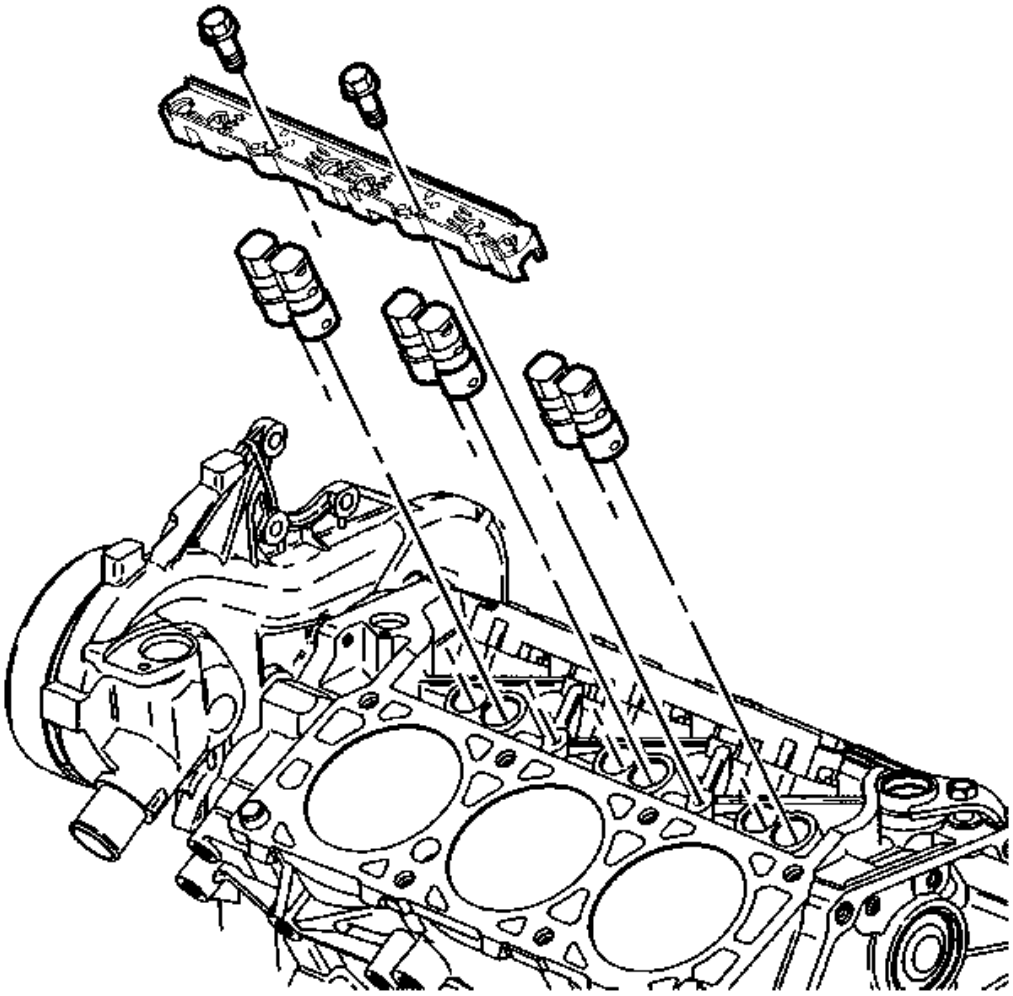

Fig. 615: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice .

4. Install the valve lifter guides and guide bolts.

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

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Valve Rocker Arm and Push Rod Installation

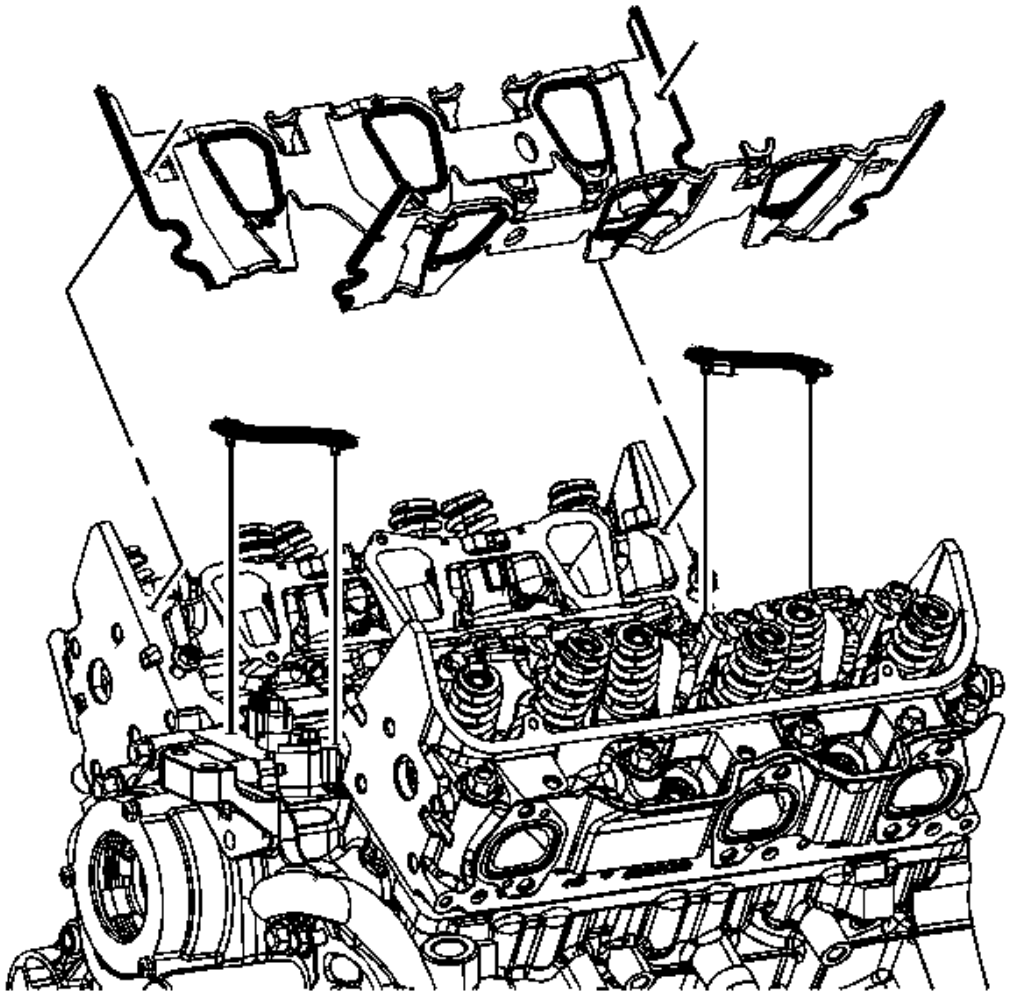

Fig. 616: Identifying Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

IMPORTANT: Room temperature vulcanizing (RTV) sealer is not to be placed under the lower intake manifold gaskets.

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1. Install the lower intake manifold gaskets.

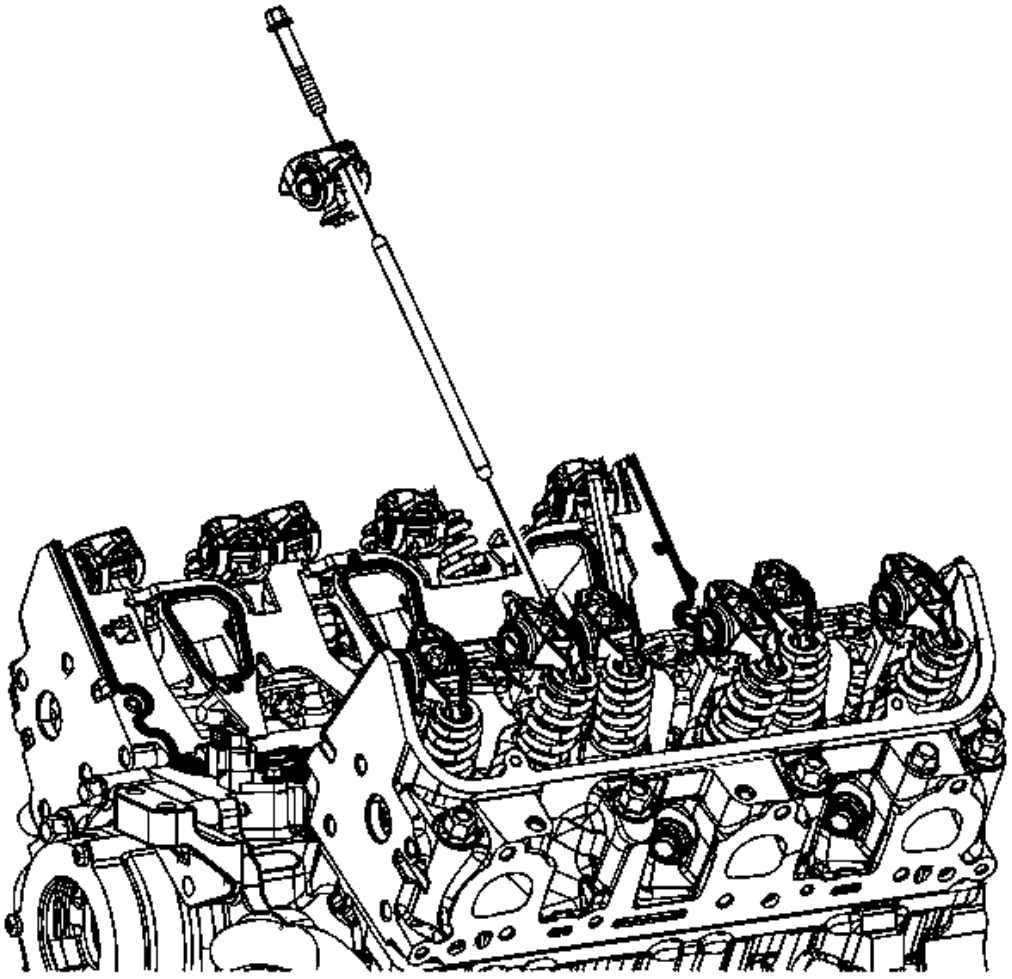

Fig. 617: Identifying Valve Rocker Arm & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Coat the ends of the push rods using prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

IMPORTANT: 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.

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4. Coat the rocker arm friction surfaces using prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

IMPORTANT: 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.

NOTE: Refer to Fastener Notice .

6. Install the valve rocker arm bolts.

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

Lower Intake Manifold Installation

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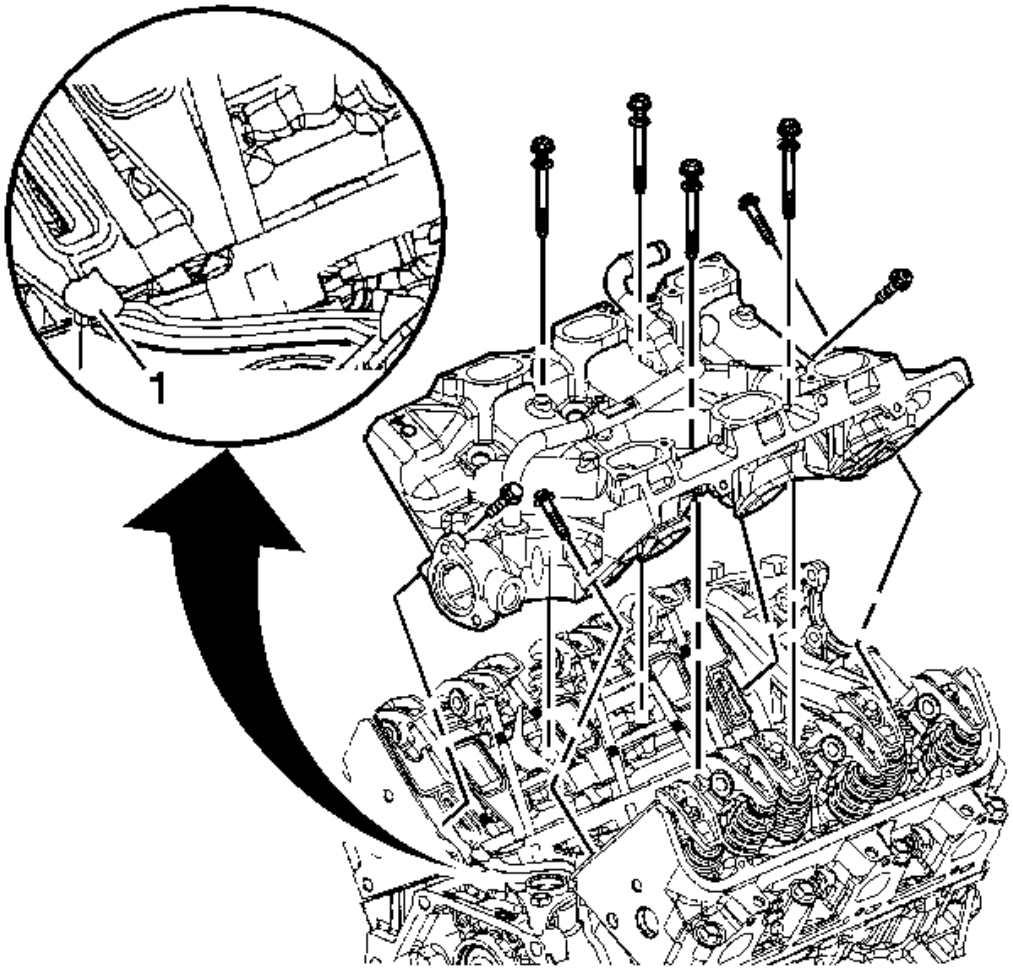

Fig. 618: Installing Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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).

IMPORTANT: To ensure proper lower intake manifold orientation during installation, make sure the intake port marked 1 faces the front of the engine.

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2. Install the lower intake manifold.

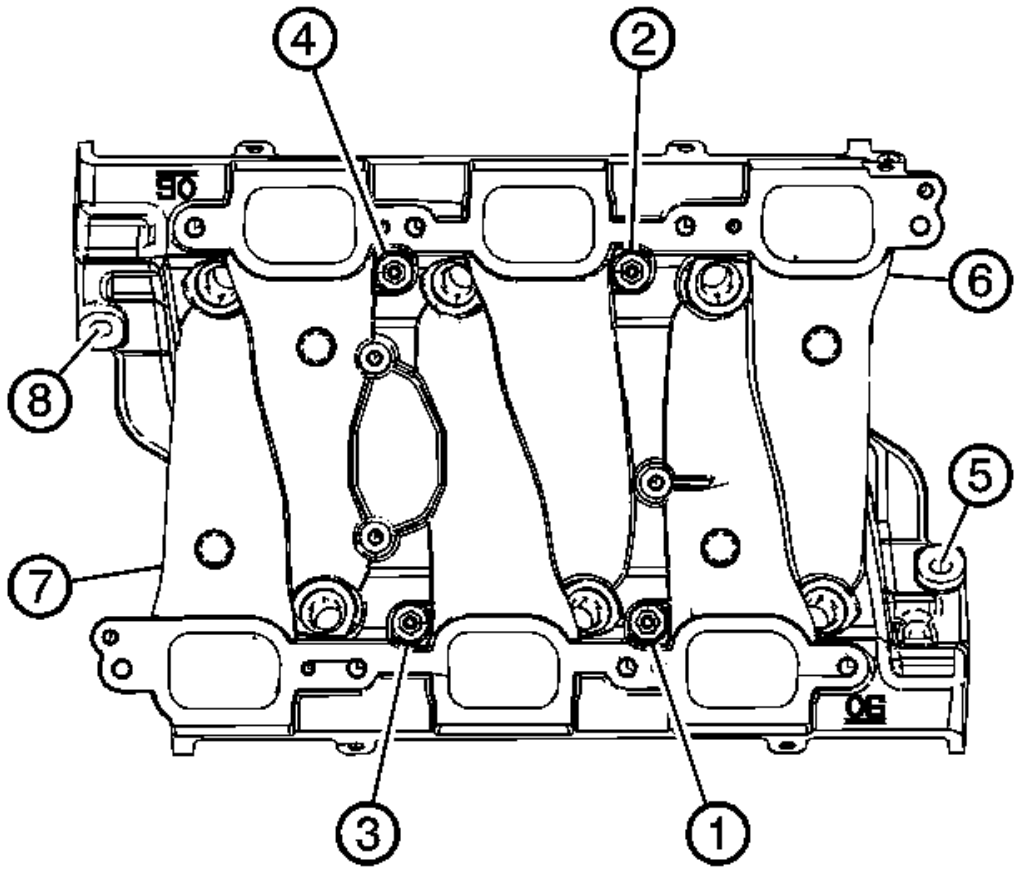

Fig. 619: Identifying Lower Intake Manifold Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

NOTE: 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.

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NOTE: **Refer to Fastener Notice .**

4. Install the new lower intake manifold bolts if applicable, in sequence.

Tighten:

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.

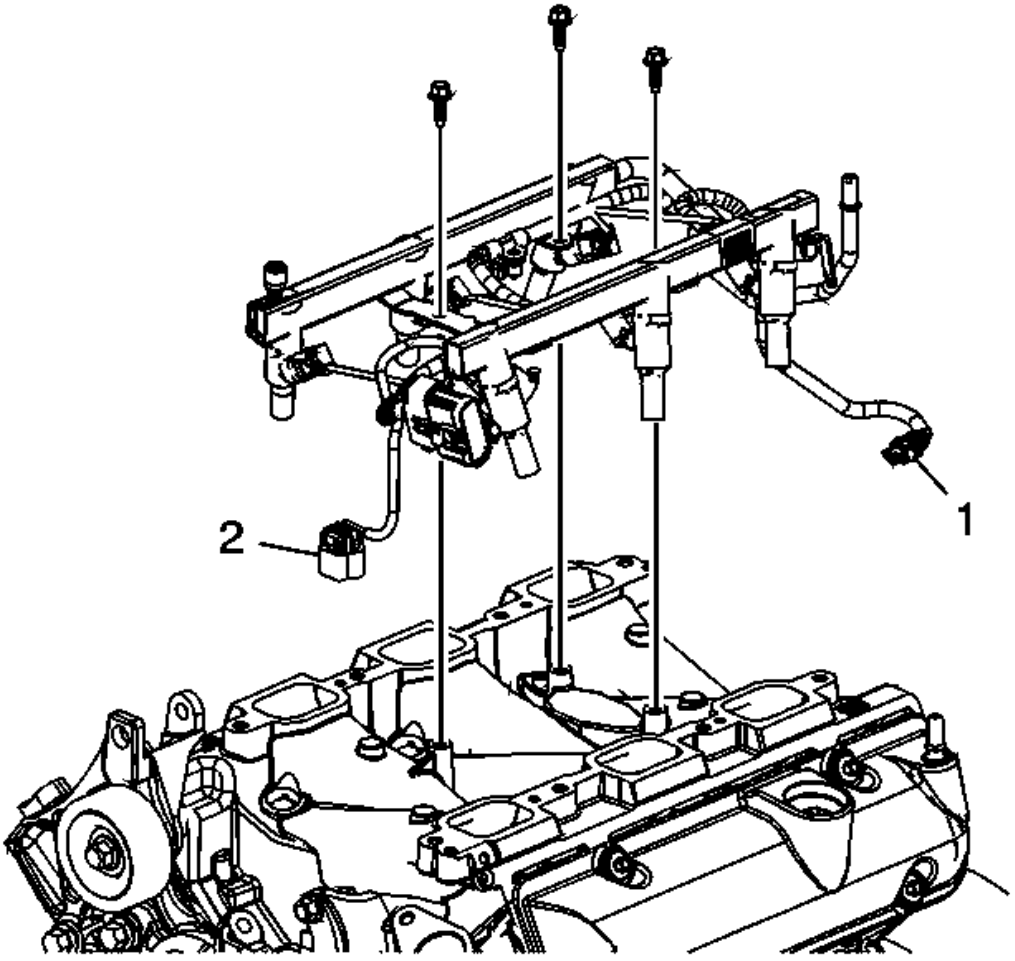

Fig. 620: Identifying Lower Intake Manifold Attachments
Courtesy of GENERAL MOTORS CORP.

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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.

IMPORTANT: 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.

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

11. Connect the coolant temperature sensor (1).
12. Connect the camshaft position (CMP) sensor (2).

Upper Intake Manifold Installation

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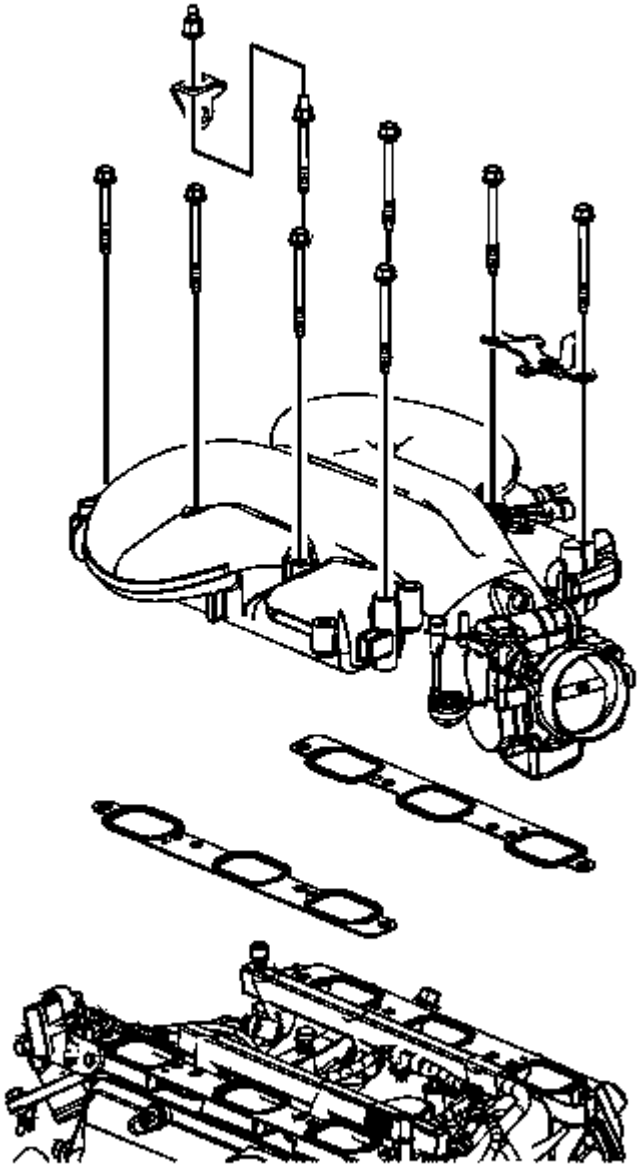

Fig. 621: View Of Upper Intake Manifold Bolts, Studs & Gaskets
Courtesy of GENERAL MOTORS CORP.

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.

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NOTE: Refer to Fastener Notice .

3. Install the upper intake manifold bolts, stud, and manifold absolute pressure (MAP) sensor bracket.

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

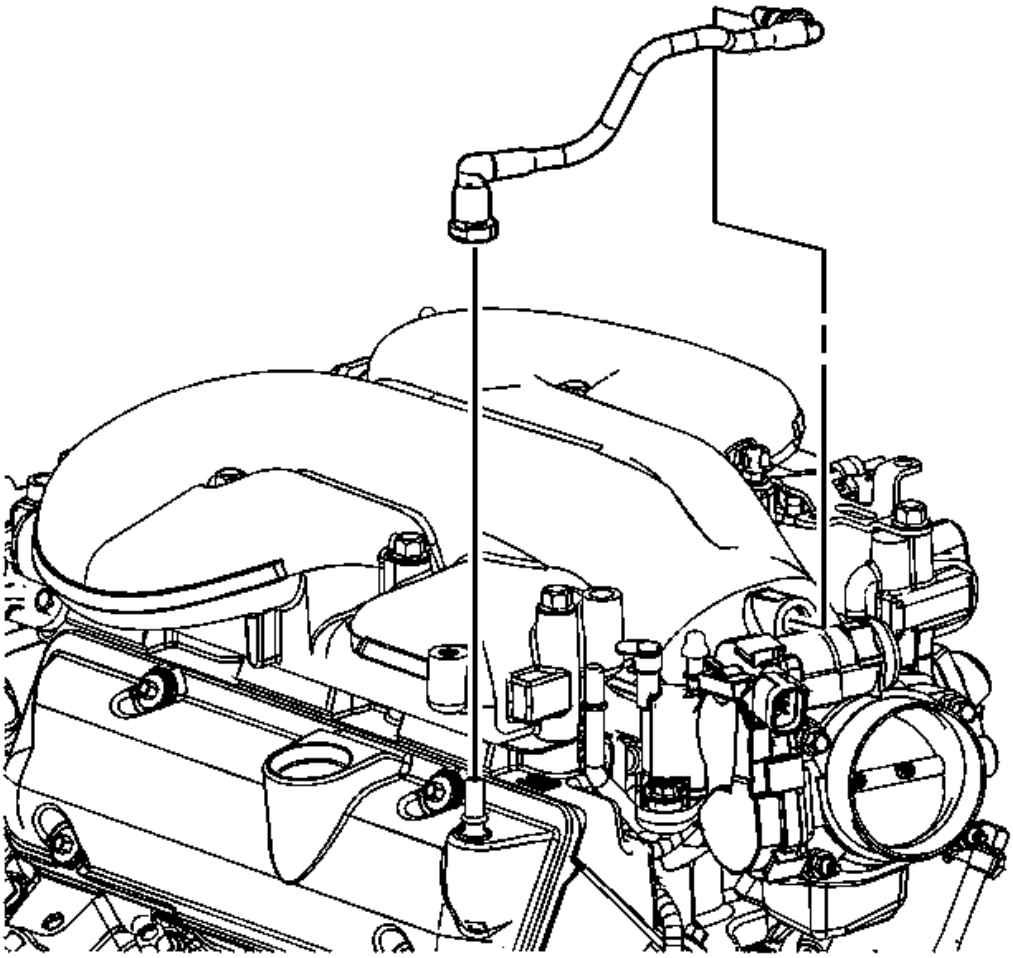

Fig. 622: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Install the foul air positive crankcase ventilation (PCV) tube.

Valve Rocker Arm Cover Installation - Left Side

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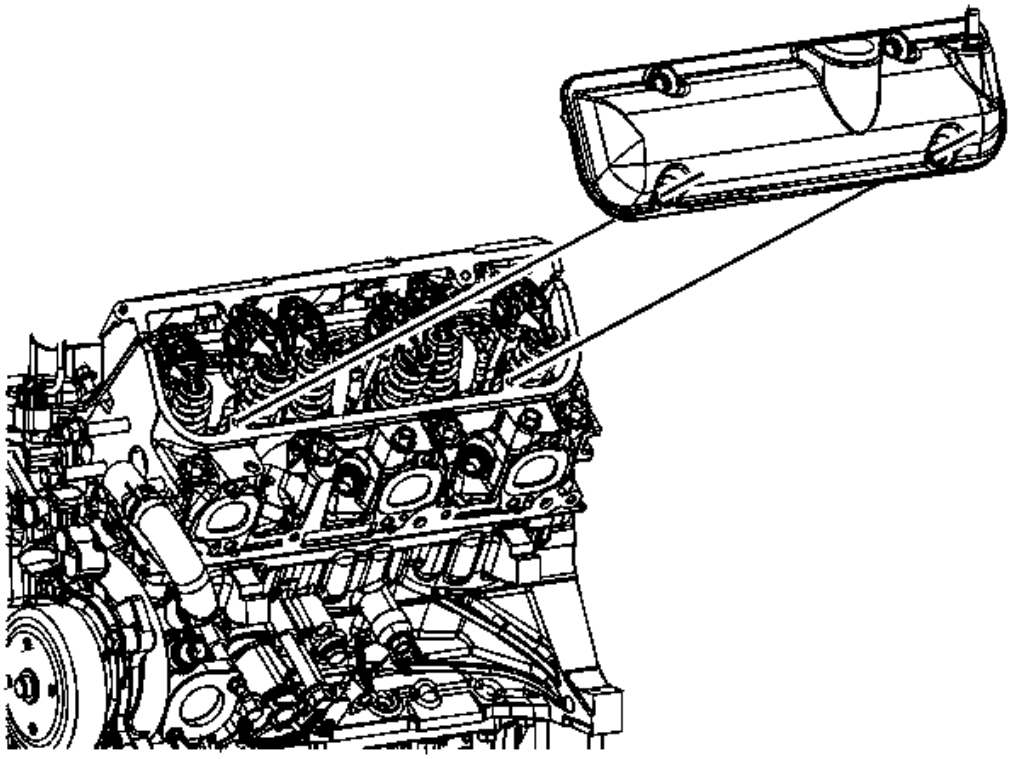

Fig. 623: Removing/Installing Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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. Install the valve rocker arm cover gasket into the valve rocker arm cover.

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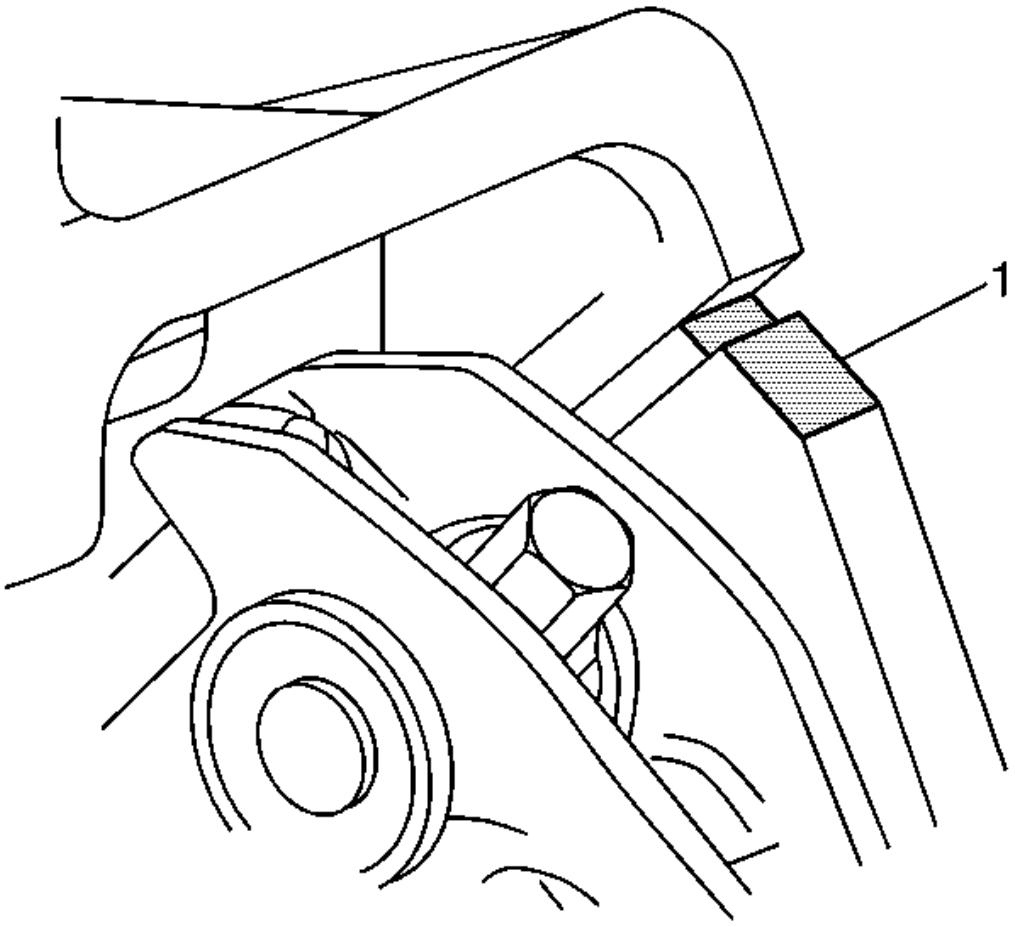

Fig. 624: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice .

4. Install the valve rocker arm cover bolts, if necessary.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

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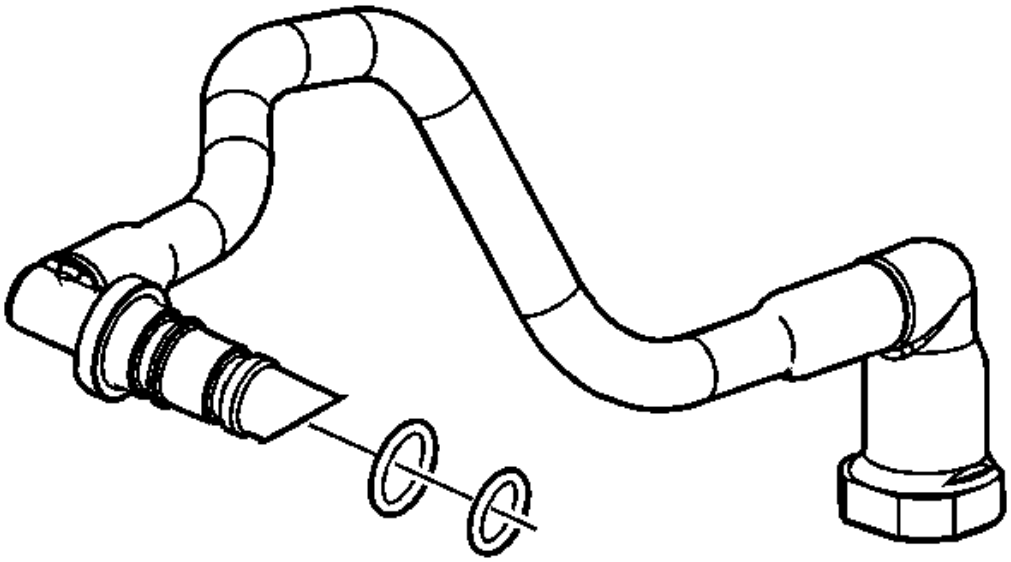

Fig. 625: Identifying PCV Tube O-Rings
Courtesy of GENERAL MOTORS CORP.

5. Install two NEW positive crankcase ventilation (PCV) tube O-rings.

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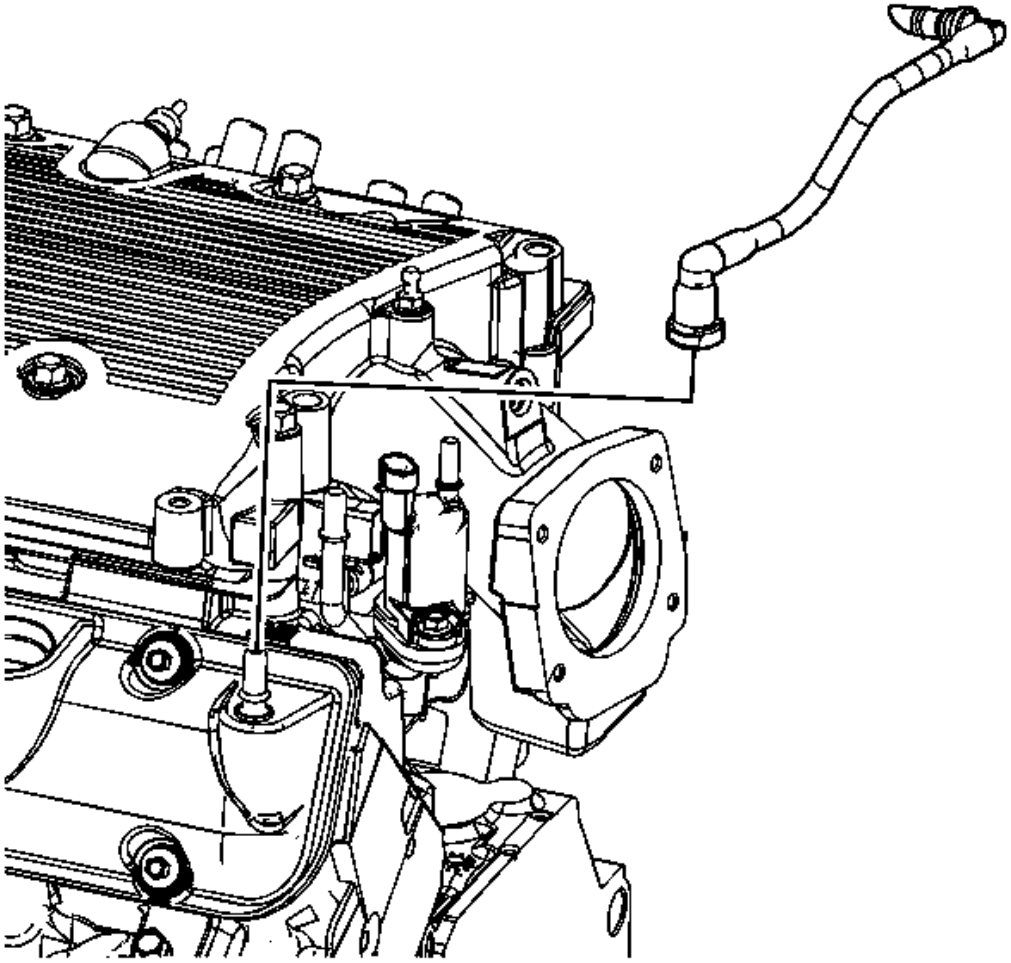

Fig. 626: Locating Positive Crankcase Ventilation (PCV) Valve & Tube
Courtesy of GENERAL MOTORS CORP.

6. Install the fresh air tube.

Valve Rocker Arm Cover Installation - Right Side

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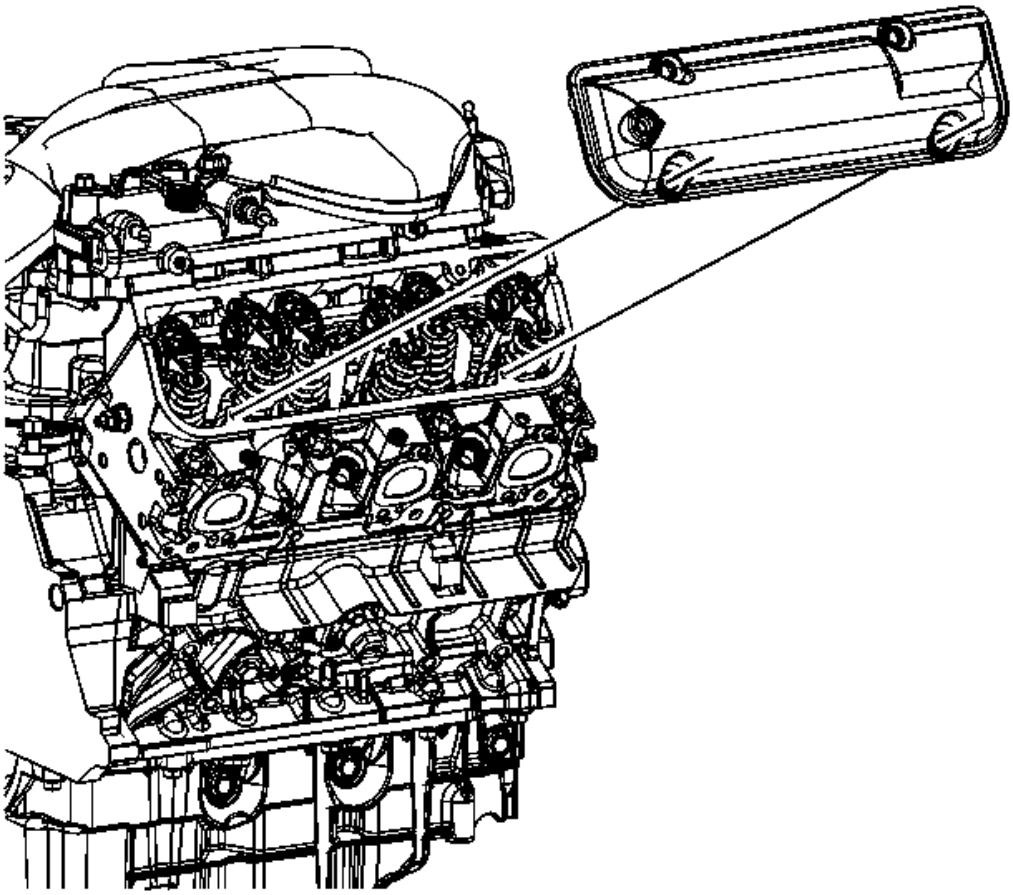

Fig. 627: View Of Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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. Install the valve rocker arm cover gasket into the valve rocker arm cover.

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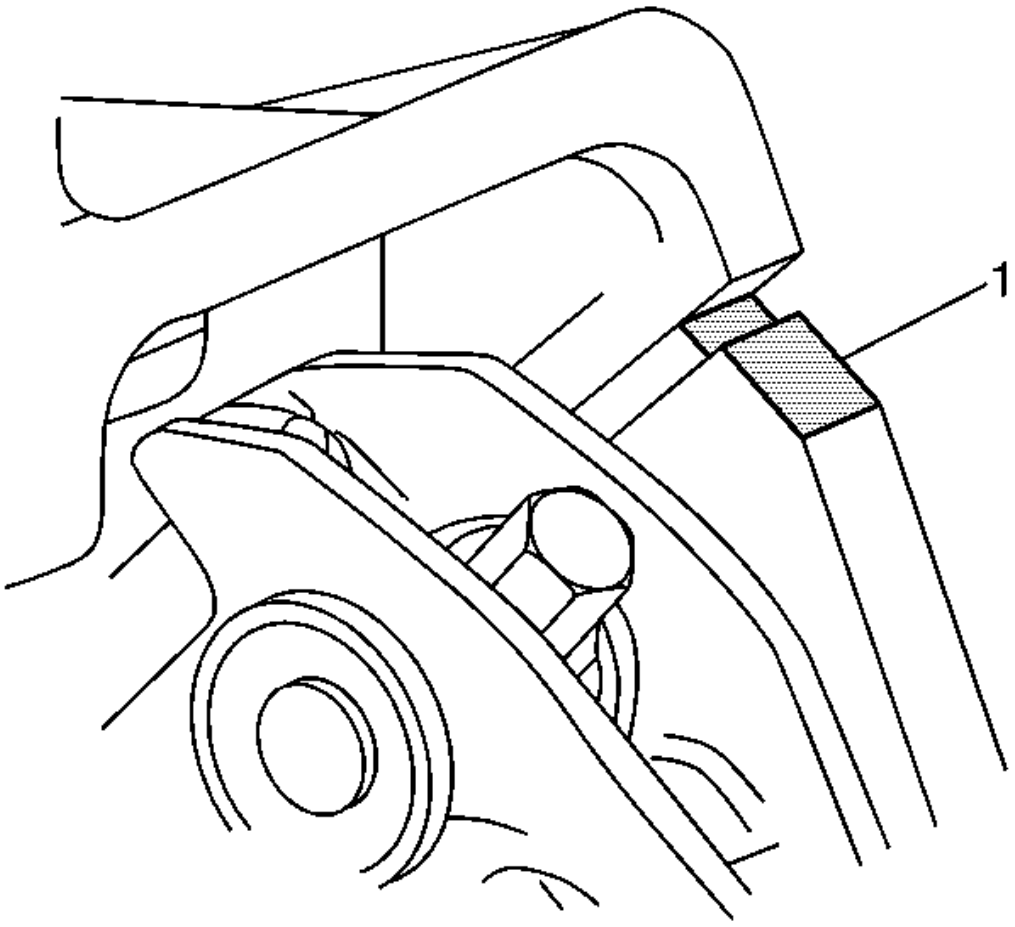

Fig. 628: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice .

4. Install the valve rocker arm cover bolts, if necessary.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

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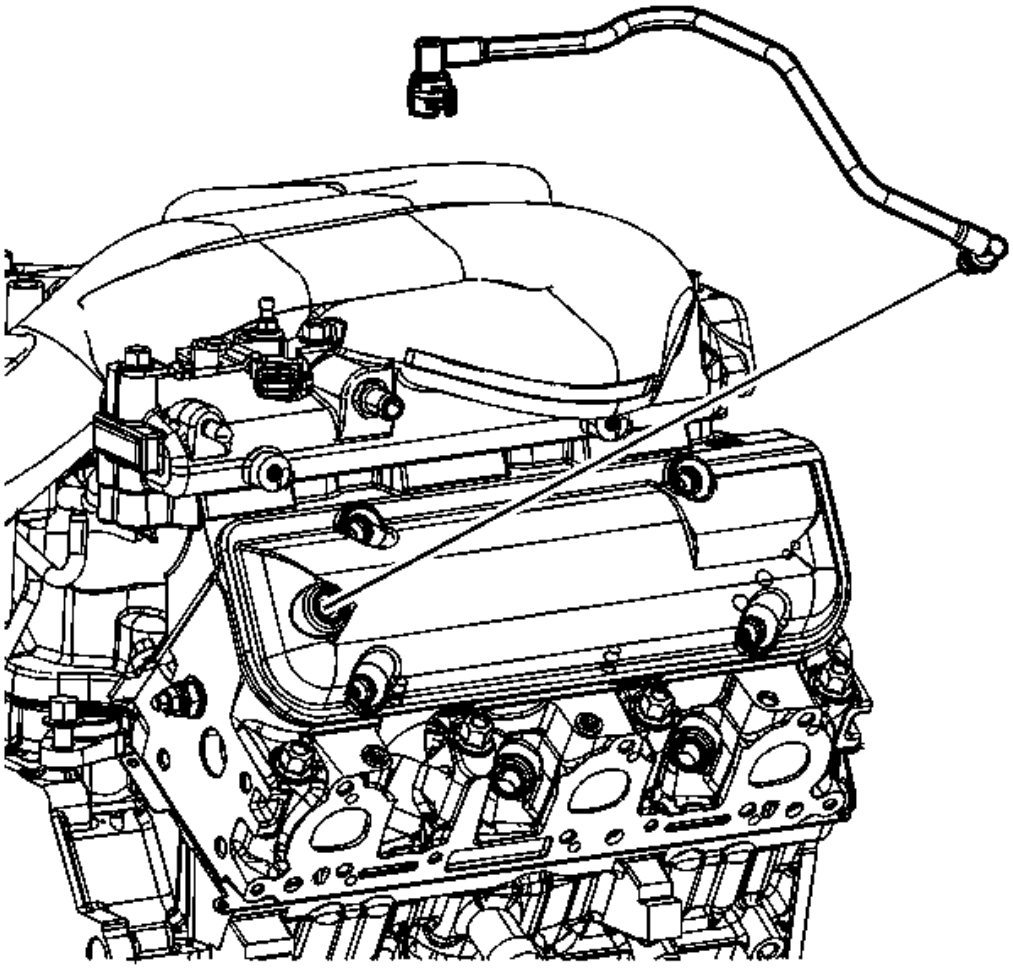

Fig. 629: Identifying Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the fresh air tube into the valve rocker arm cover.

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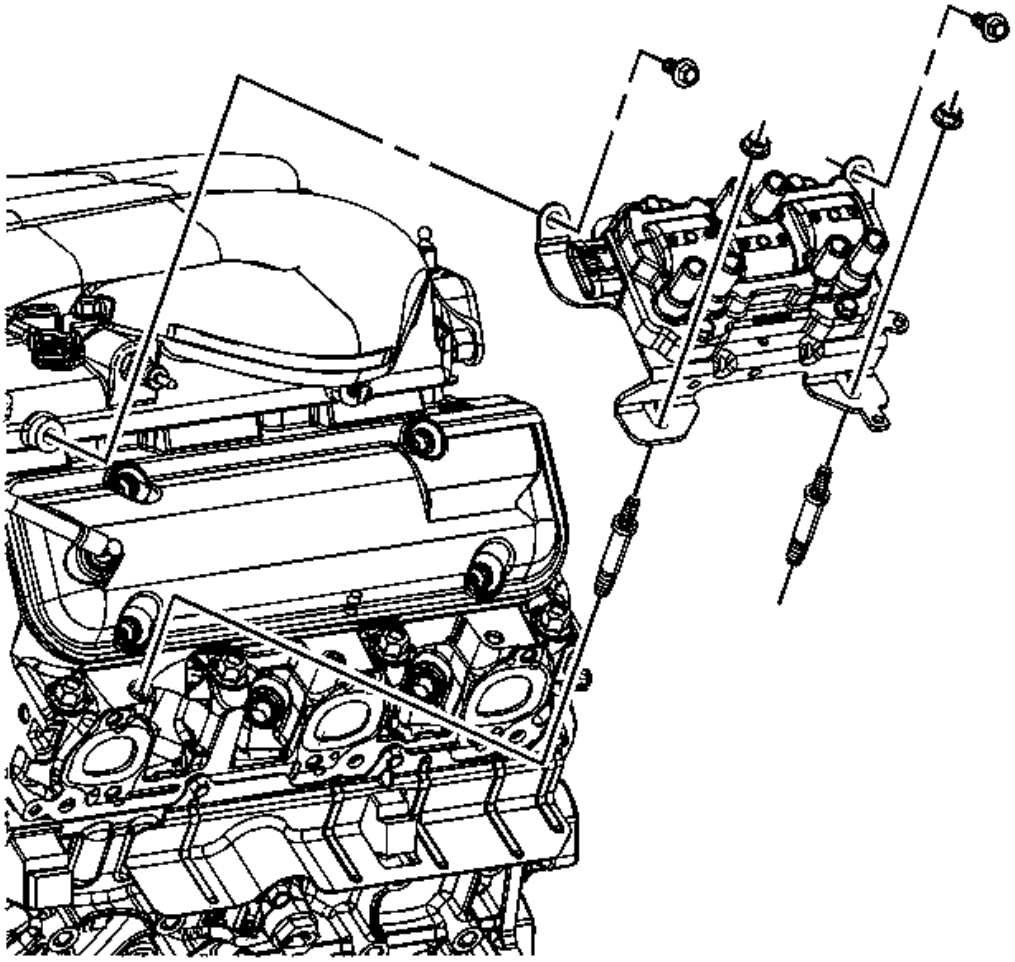

Fig. 630: Identifying Ignition Coil Assembly, Studs & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the ignition coil assembly studs, if necessary.

   Tighten: Tighten the ignition coil assembly studs to 25 N.m (18 lb ft).

7. Install the ignition coil assembly.
8. Install the ignition coil assembly bolts and nuts.

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

Water Outlet and Thermostat Installation

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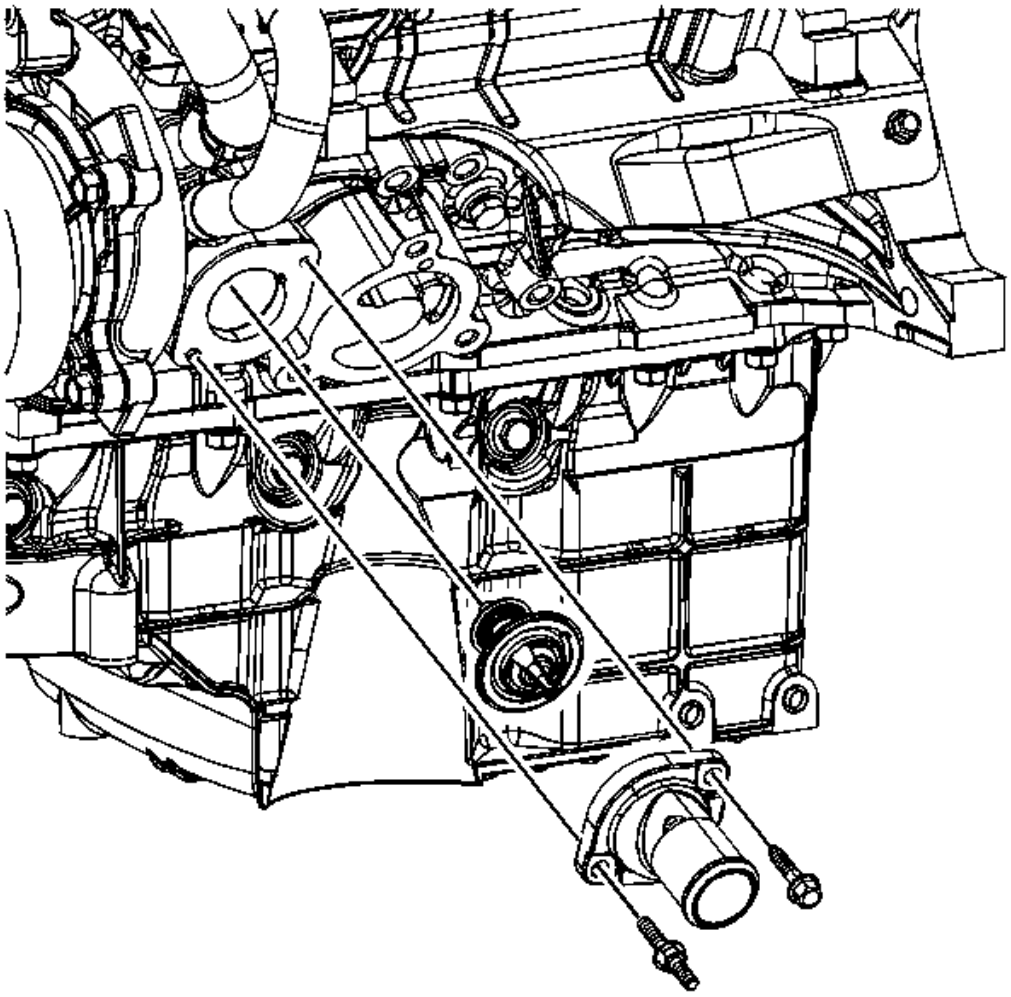

Fig. 631: Identifying Thermostat Housing & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat.
2. Install the water outlet.

NOTE: Refer to Fastener Notice .

3. Install the water outlet bolts.

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

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Exhaust Manifold Installation - Left Side

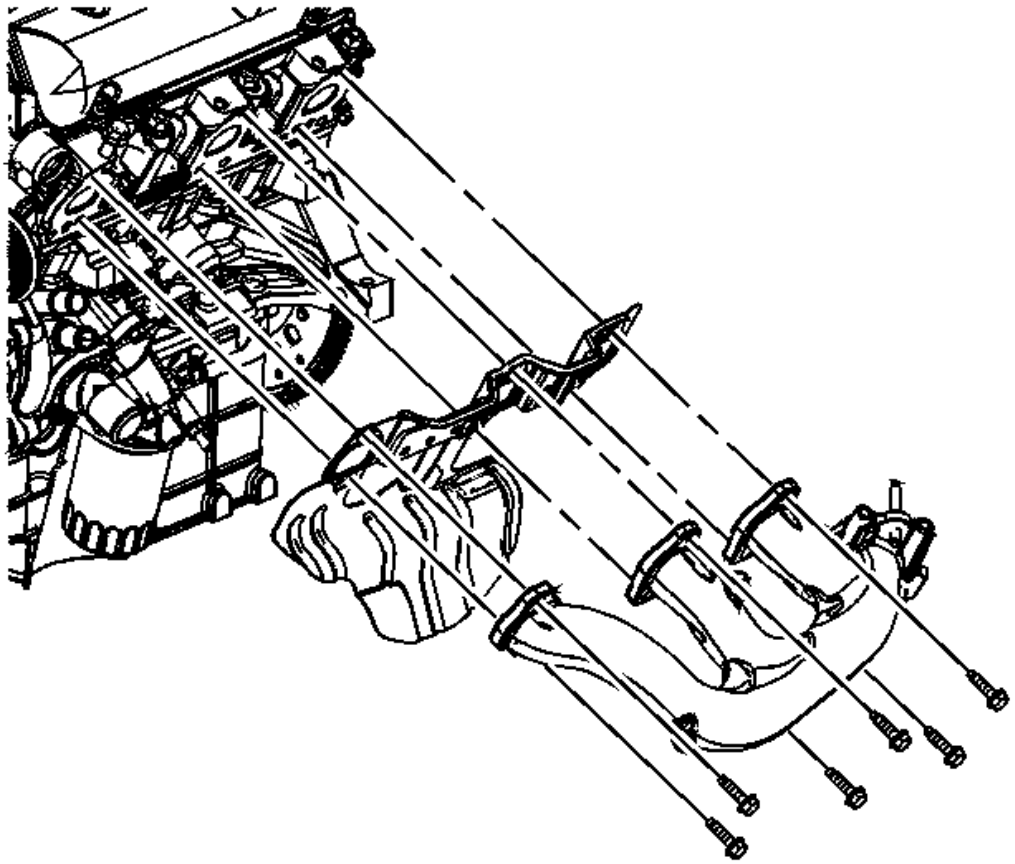

Fig. 632: View Of Left Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

NOTE: **Refer to Fastener Notice .**

3. Install the exhaust manifold bolts.

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

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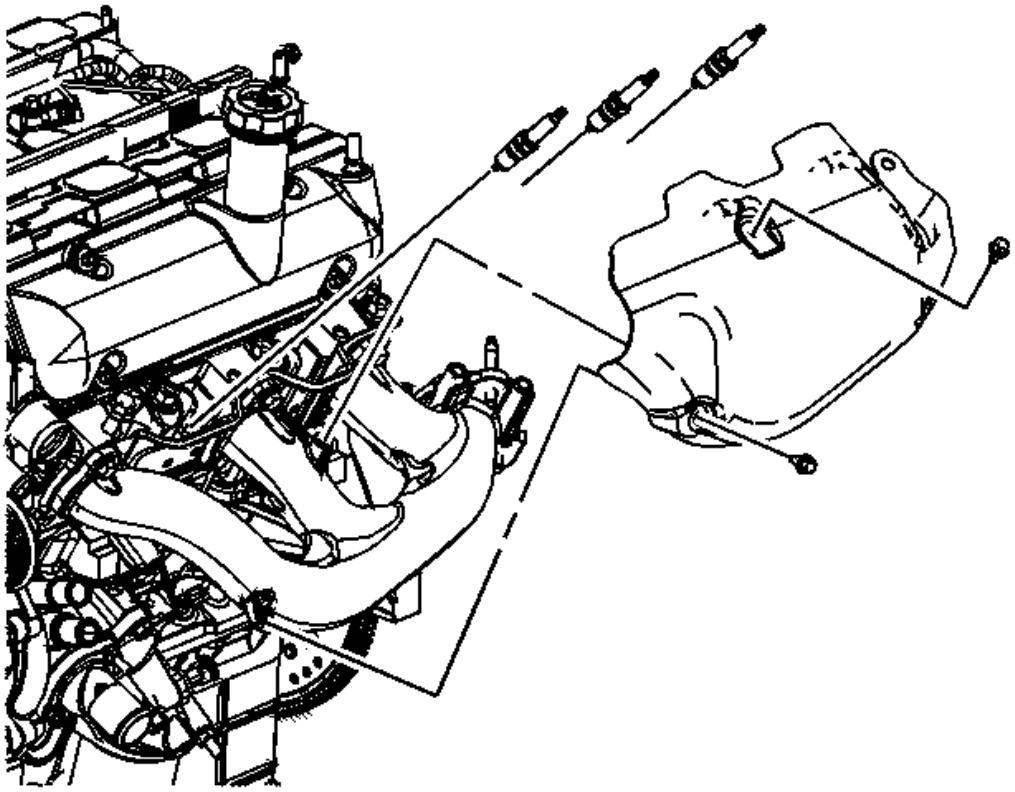

Fig. 633: View Of Spark Plugs & Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts.

   Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

6. Install the spark plugs.

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

7. Install the spark plug wires.

Exhaust Manifold Installation - Right Side

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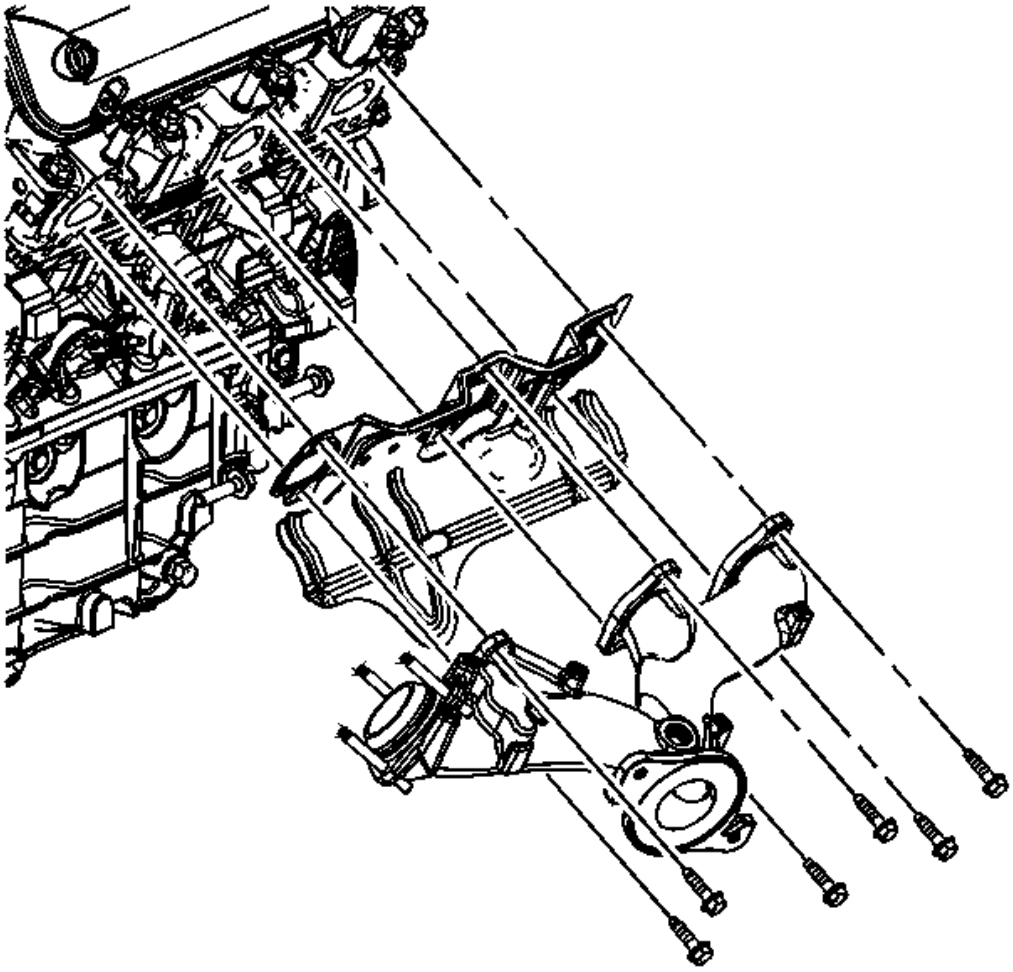

Fig. 634: View Of Right Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

NOTE: Refer to Fastener Notice .

3. Install the exhaust manifold bolts.

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

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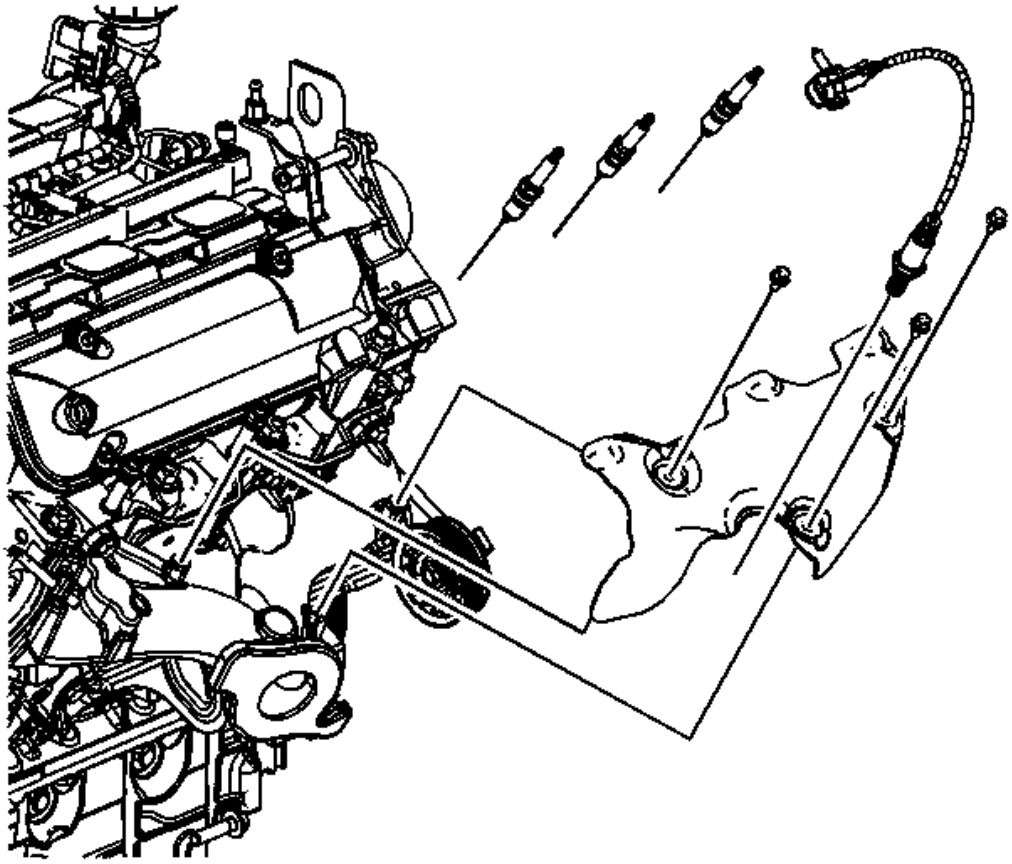

Fig. 635: Identifying Right Side Spark Plugs, HO2S & Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold heat shield.
5. Install the exhaust manifold heat shield bolts.

   Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

6. Install the spark plugs.

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

7. Install the spark plug wires.
8. Install the heated oxygen sensor.

   Tighten: Tighten the heated oxygen sensor to 42 N.m (31 lb ft).

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Exhaust Crossover Pipe Installation

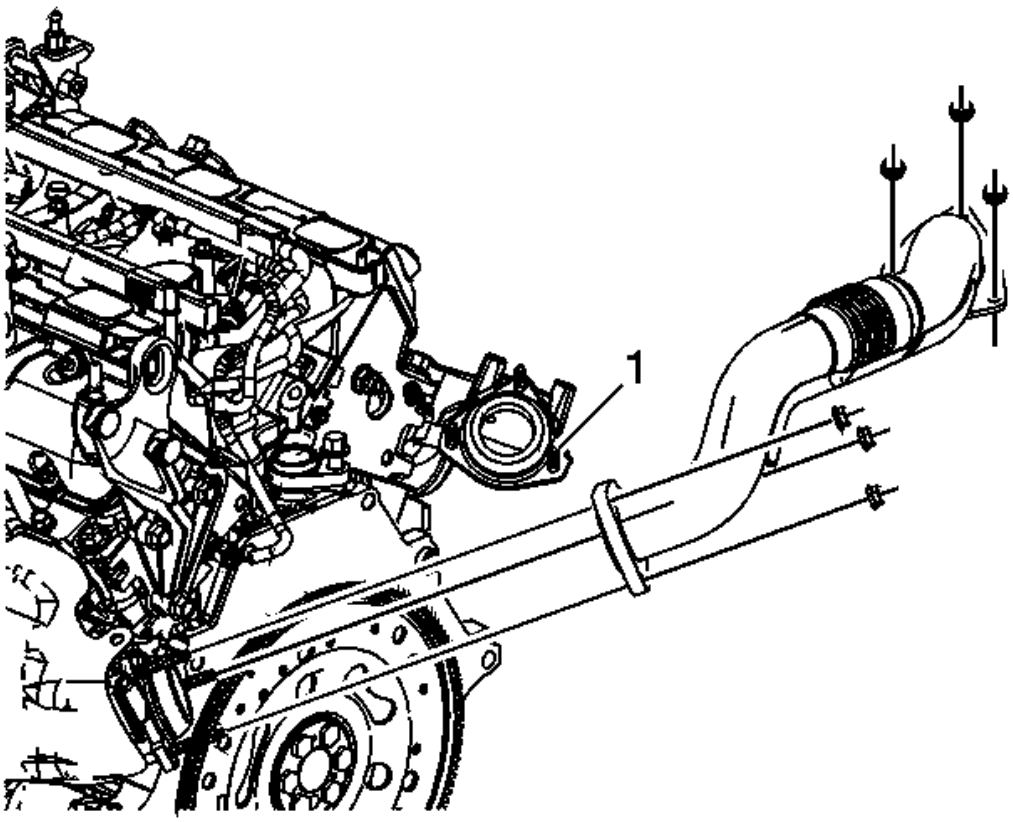

Fig. 636: Identifying Exhaust Crossover Pipe & Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the exhaust crossover pipe studs (1) if necessary.

   Tighten: Tighten the exhaust crossover pipe studs to 25 N.m (18 lb ft).

2. Install the exhaust crossover pipe.
3. Install the exhaust crossover pipe nuts.

   Tighten: Tighten the exhaust crossover pipe nuts to 25 N.m (18 lb ft).

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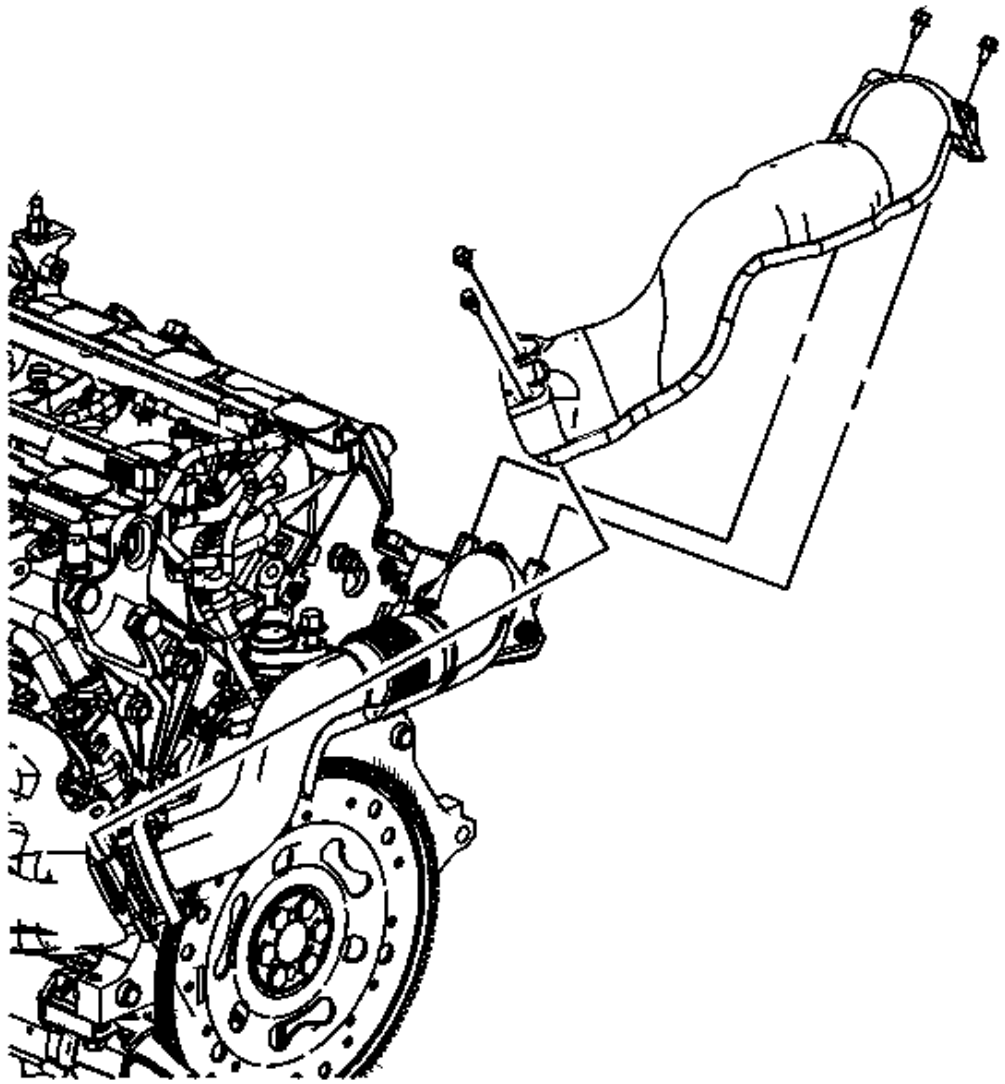

Fig. 637: Identifying Exhaust Crossover Pipe Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust crossover heat shield.
5. Install the exhaust crossover heat shield bolts.

Tighten: Tighten the exhaust crossover heat shield bolts to 10 N.m (89 lb in).

Oil Filter Adapter Installation

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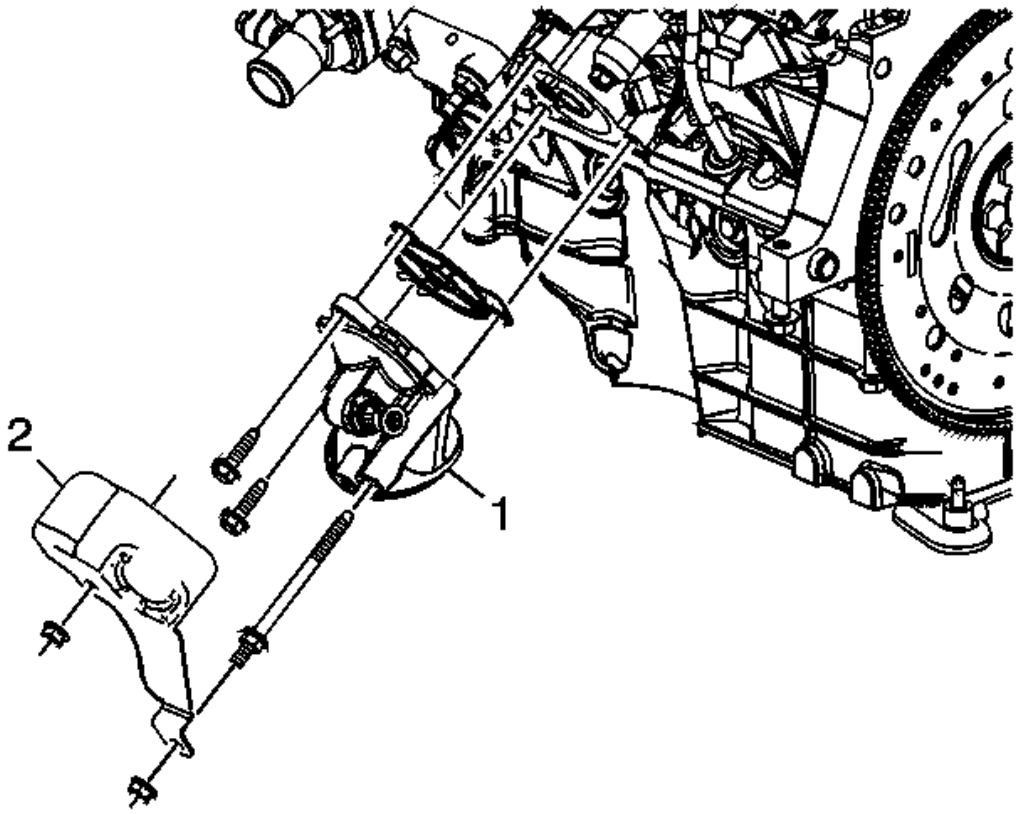

Fig. 638: Identifying Oil Filter Adapter & Heat Shield
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Install the oil filter adapter (1) and gasket.
2. Apply threadlocker P/N 21485277 to the bolt threads if required.

NOTE: Refer to Fastener Notice .

3. Install the oil filter adapter bolts.

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

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4. Install the oil filter adapter heat shield (2).
5. Install the oil filter adapter heat shield nuts.

   Tighten: Tighten the oil filter adapter heat shield nuts to 25 N.m (18 lb ft).

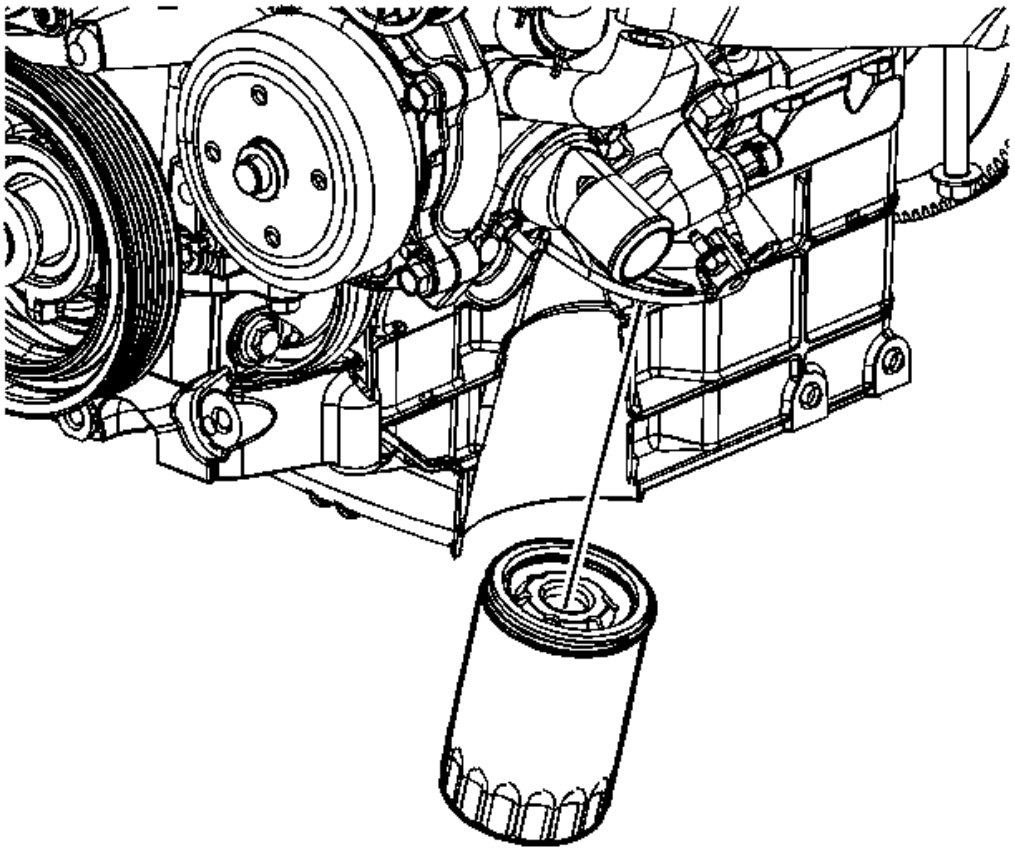

Fig. 639: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Install the oil filter.

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

Oil Level Indicator and Tube Installation

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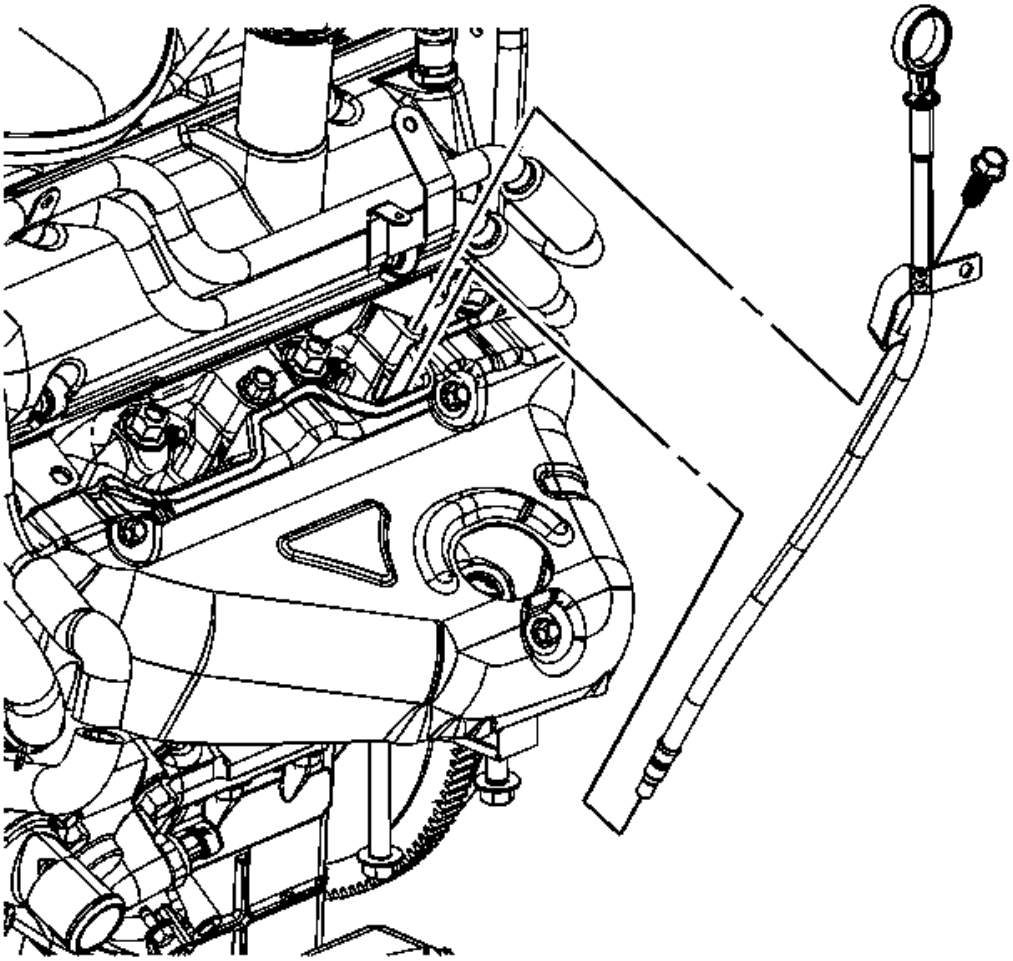

Fig. 640: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube and oil level indicator.

NOTE: **Refer to Fastener Notice .**

2. Install the oil level indicator tube bolt.

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

Coolant Crossover Pipe Installation

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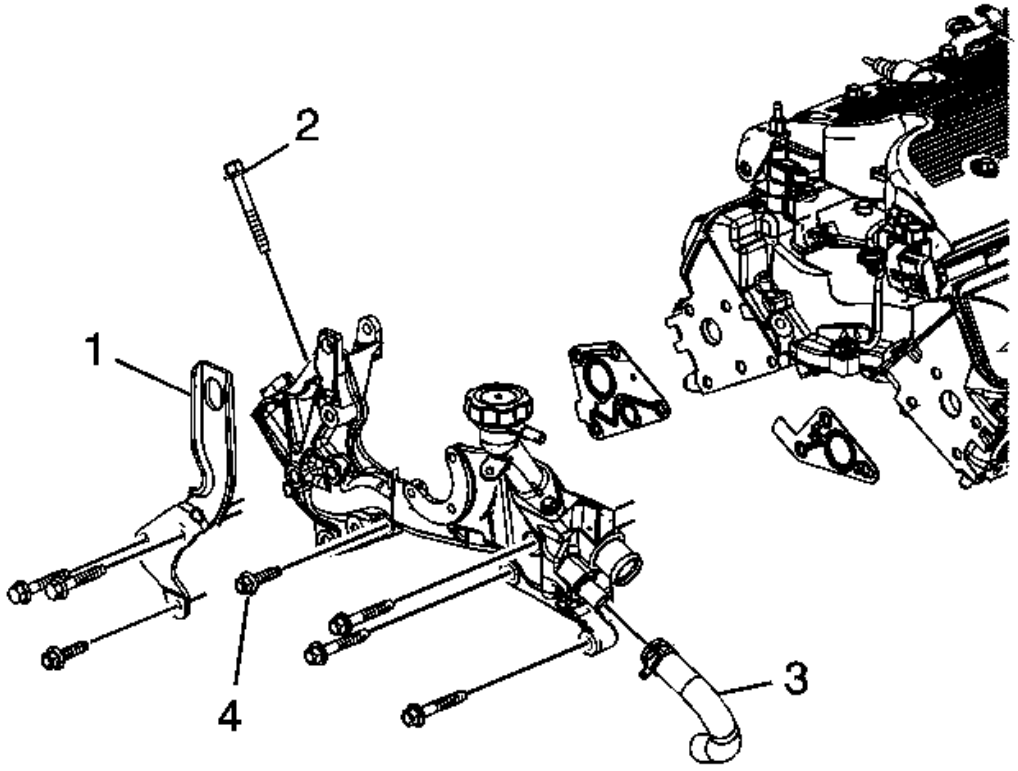

Fig. 641: View Of Coolant Crossover Pipe Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the coolant crossover pipe gaskets and the coolant crossover pipe assembly onto the engine.

NOTE: **Refer to Fastener Notice .**

2. Install the engine lift bracket (1) and the front coolant crossover pipe bolts (4).

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

3. Install the side coolant crossover pipe bolt (2).

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

4. Install the thermal bypass hose (3) and securely fasten the hose clamp.

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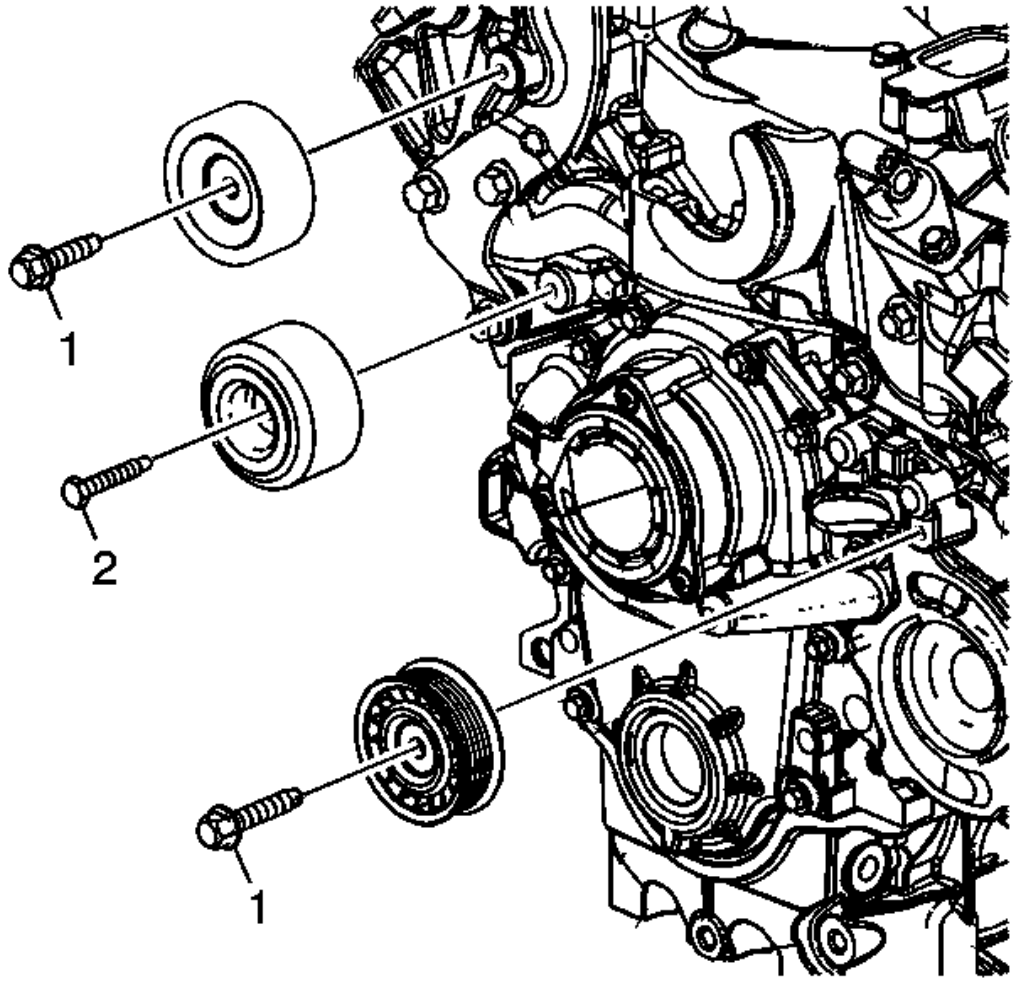

Fig. 642: Identifying Idler Pulley Bolts & Pulleys
Courtesy of GENERAL MOTORS CORP.

5. Install the idler pulleys and bolts.

Tighten:

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

Engine Mount Support and Strut Bracket Installation

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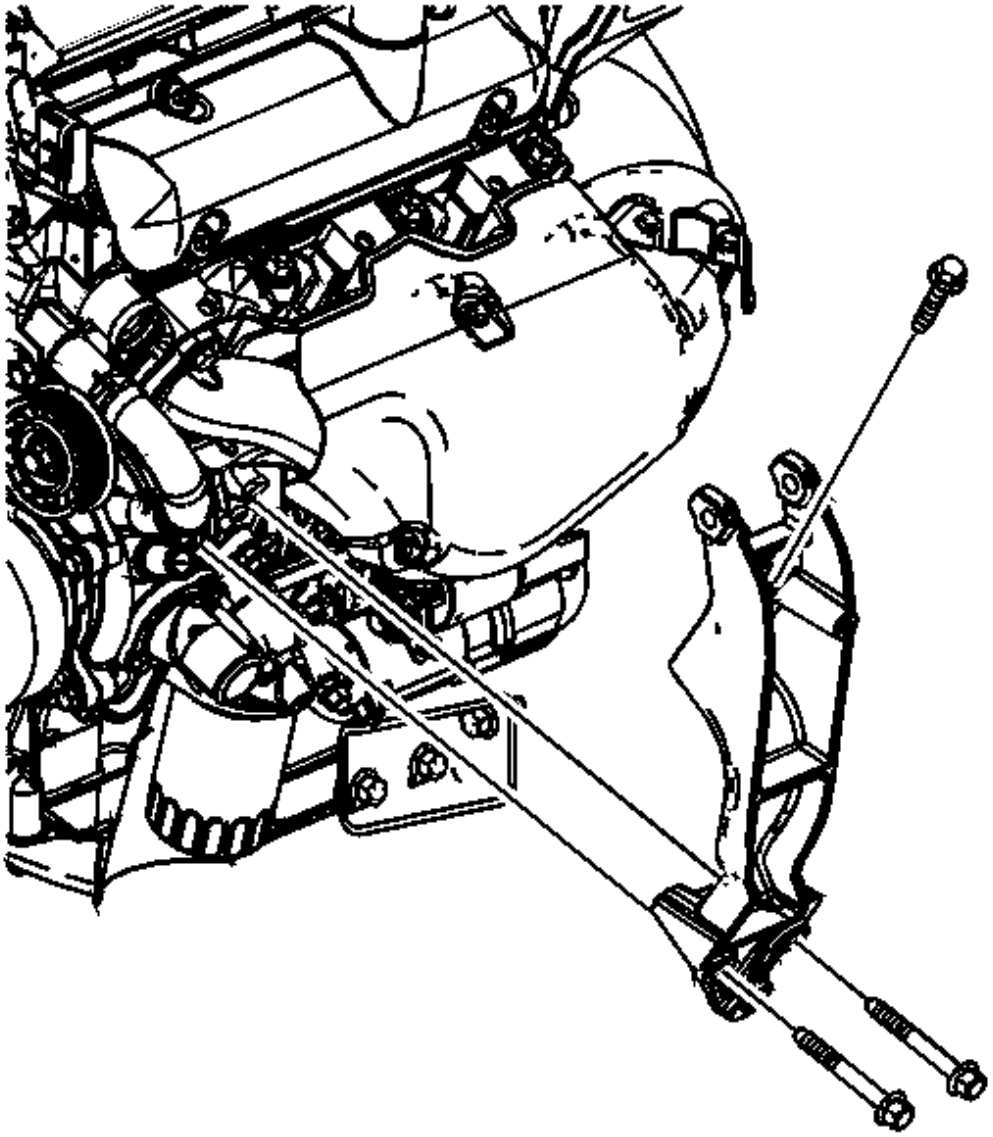

Fig. 643: View Of Engine Mount Support & Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount support and strut bracket and bracket bolts.

NOTE: **Refer to Fastener Notice .**

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2. Tighten the bolts.

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

Engine Mount Strut and Engine Lift Bracket Installation

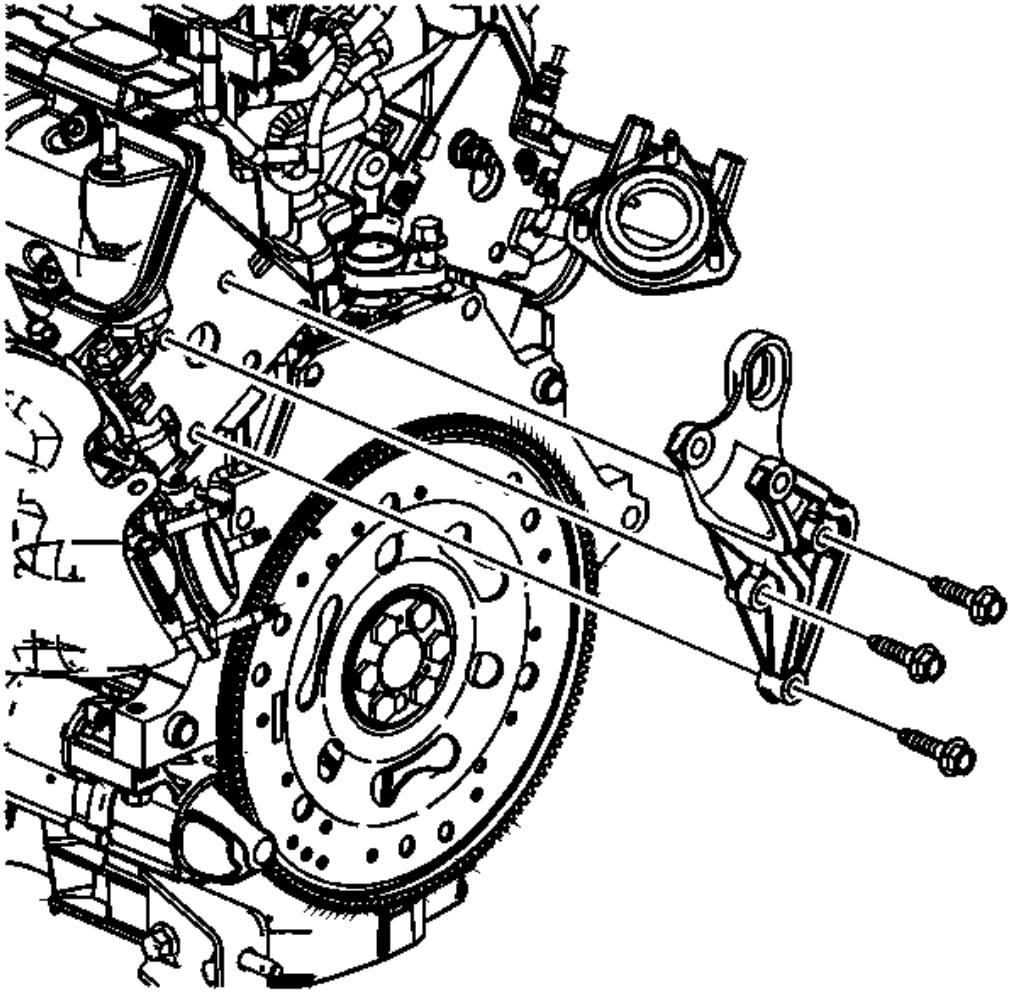

Fig. 644: Identifying Engine Lift Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut and engine lift bracket and bracket bolts.

   NOTE: Refer to Fastener Notice .

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2. Install the bolts.

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

Drive Belt Tensioner Installation

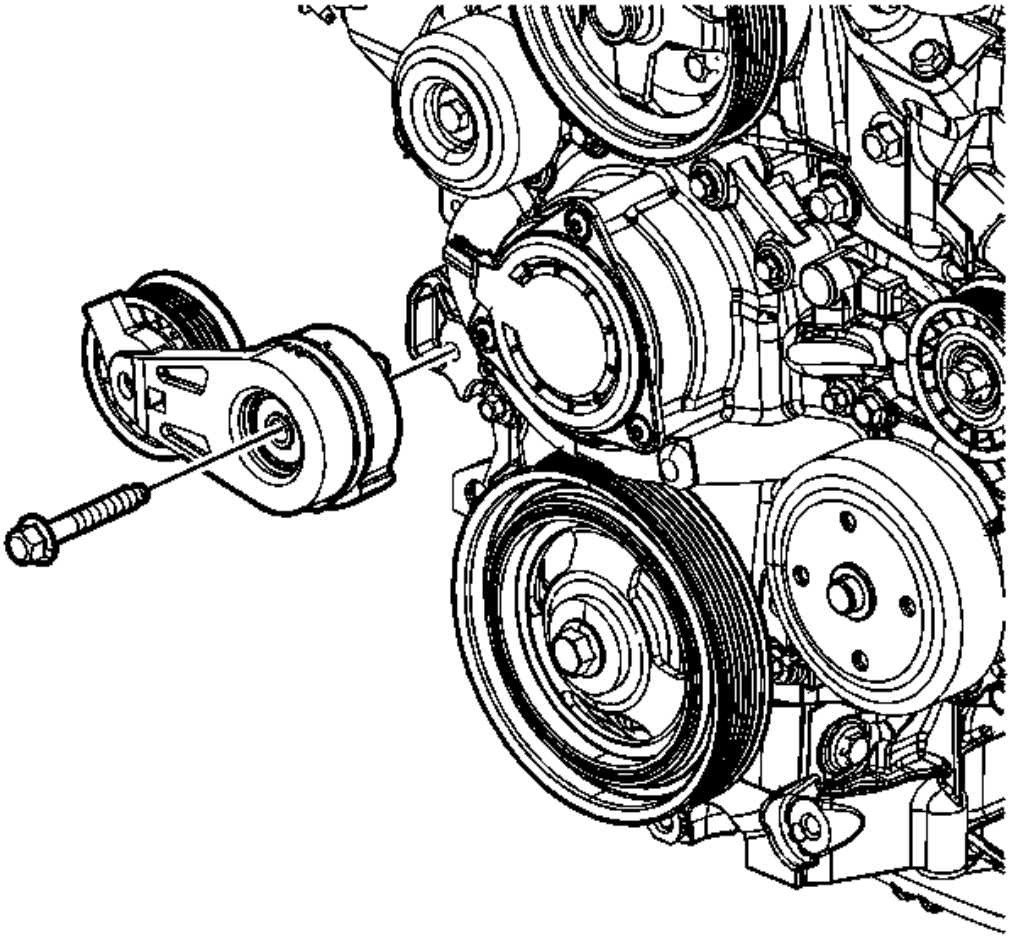

Fig. 645: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

   NOTE: Refer to Fastener Notice .

2. Install the drive belt tensioner bolt.

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

Engine Flywheel Installation (Automatic Transmission)

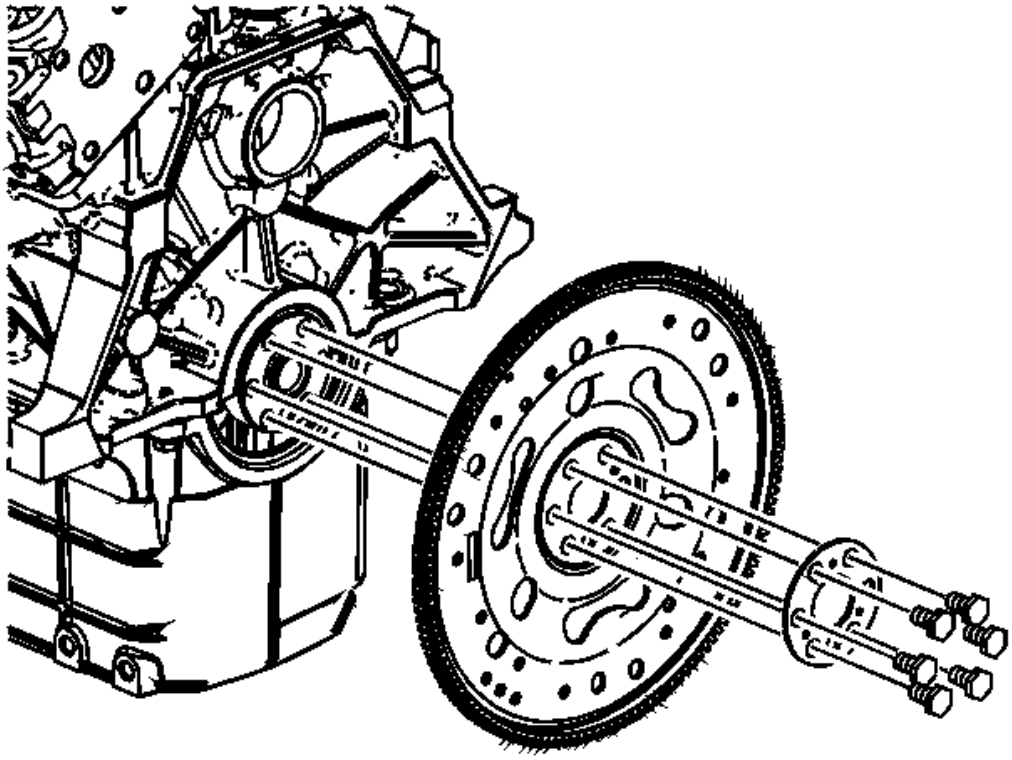

Fig. 646: Identifying Flywheel & Bolts (A/T)
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

NOTE: **Refer to Fastener Notice .**

2. Install the flywheel bolts.

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

Crankshaft Balancer Installation

Tools Required

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- **J 29113** Balancer and Crank Sprocket Puller. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

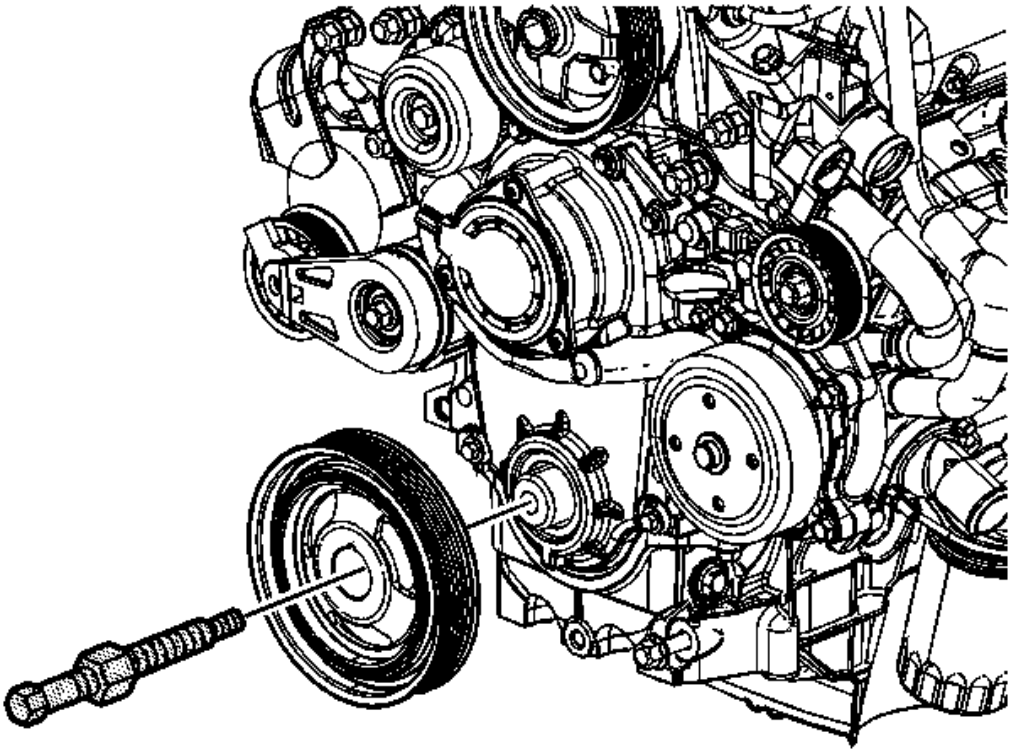

Fig. 647: View Of Balancer & Crank Sprocket Puller (J 29113)
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or the equivalent to the keyway of the crankshaft balancer.
2. Place the crankshaft balancer into position over the key in the crankshaft.

NOTE: 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. Install the **J 29113** onto the crankshaft. See **Special Tools**.
4. Rotate the hex nut on the **J 29113** to install the crankshaft balancer onto the crankshaft. See **Special Tools**.

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5. Remove the **J 29113** from the crankshaft. See **Special Tools**.

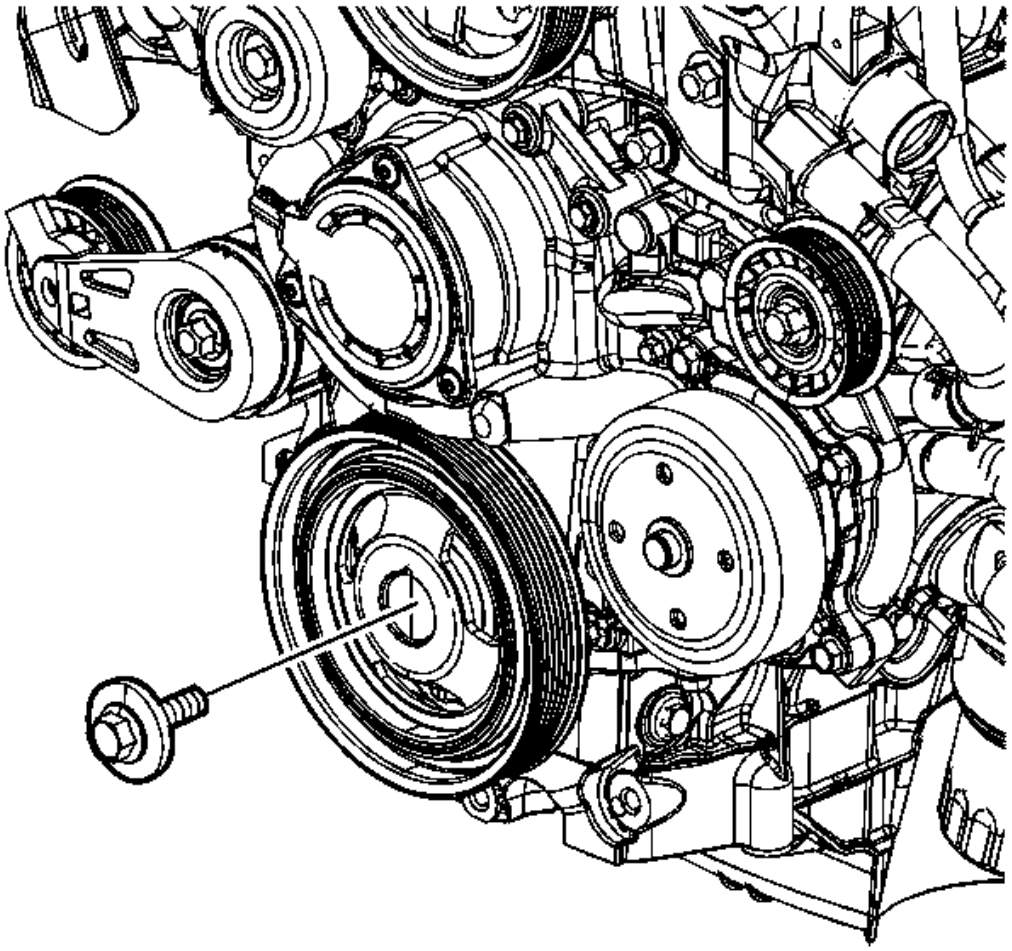

Fig. 648: Identifying Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the crankshaft balancer washer and bolt.

Tighten:

- Tighten the crankshaft balancer bolt a first pass to 125 N.m (92 lb ft).
- Tighten the crankshaft balancer bolt a final pass to 130 degrees using the **J 45059** . See **Special Tools**.

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Engine Prelubing

Tools Required

- **J-21867-6** Oil Pressure Adapter Fitting. See **Special Tools**.
- **J 45299** Engine Preluber. See **Special Tools**.

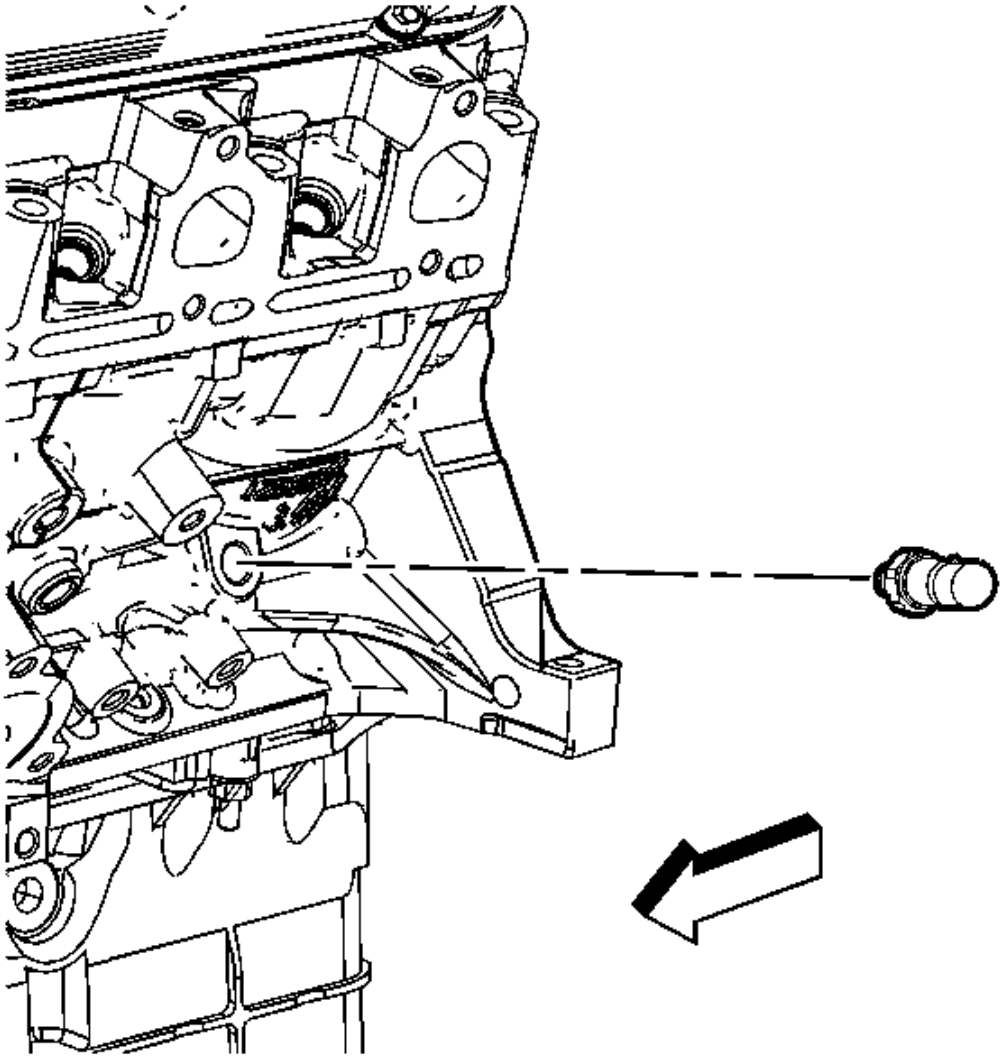

Fig. 649: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

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NOTE: **Refer to Fastener Notice .**

IMPORTANT: 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: 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** . See **Special Tools**.

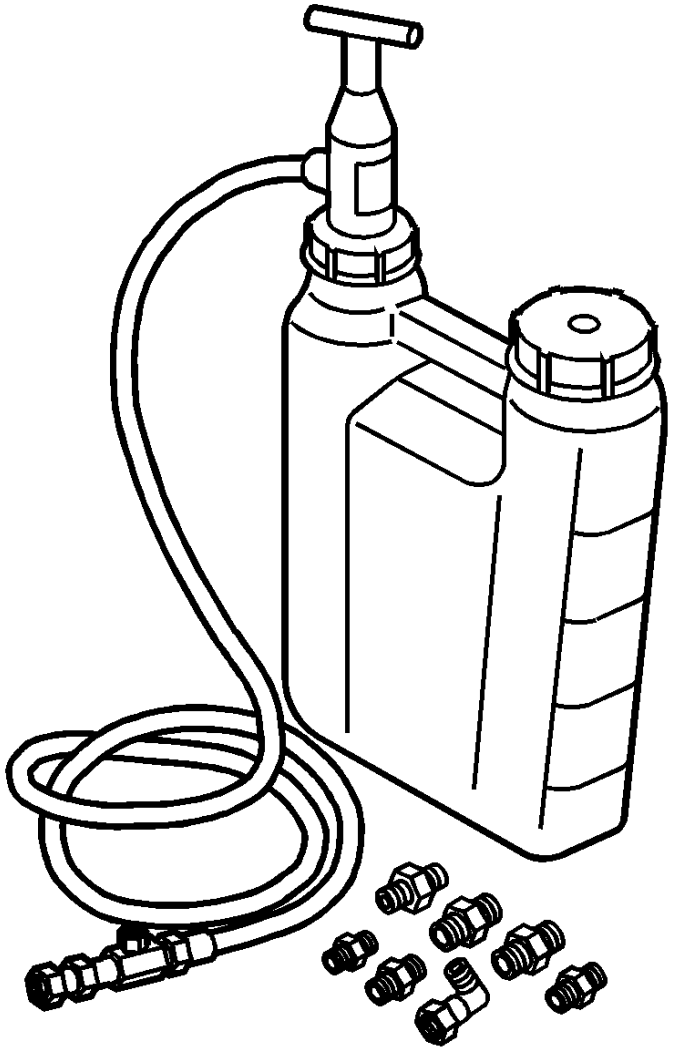

Fig. 650: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

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4. Install the flexible hose to the adapter and open the valve.
5. Pump the handle on **J 45299** to flow a minimum of 1-2 quarts of engine oil. See **Special Tools**. Observe the flow of engine oil through the flexible hose and into the engine assembly.
6. Close the valve and remove the flexible hose and adapter from the engine.
7. Install the engine oil pressure indictor switch.

   Tighten: Tighten the engine oil pressure indictor switch to 16 N.m (12 lb ft).

8. Top off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

A close crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from 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)

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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.

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.

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The exhaust manifolds are cast nodular iron.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important product changes from the previous model year.

Changes may include one or more of the following items:

- A component comparison from the previous year
- Fastener changes
- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required

Component Comparison

New rubber isolator on the EVAP purge solenoid.

Fastener Changes

No fastener changes for 2007.

Torque Values and/or Fastener Tightening Strategies

Updated crankshaft balancer torque.

Changed Engine Specifications

No specification changes for 2007.

New Sealants and/or Adhesives

No new sealants and or adhesives for 2007.

Disassembly and Assembly Procedure Revisions

Updated identification steps in the piston, connecting rod, and bearing installation procedure.

New rear crankshaft oil seal removal and installation procedures.

Engine Mechanical Diagnostic Procedure Revisions

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No revisions for 2007.

New Special Tools Required

New rear crankshaft oil seal installer.

LUBRICATION DESCRIPTION

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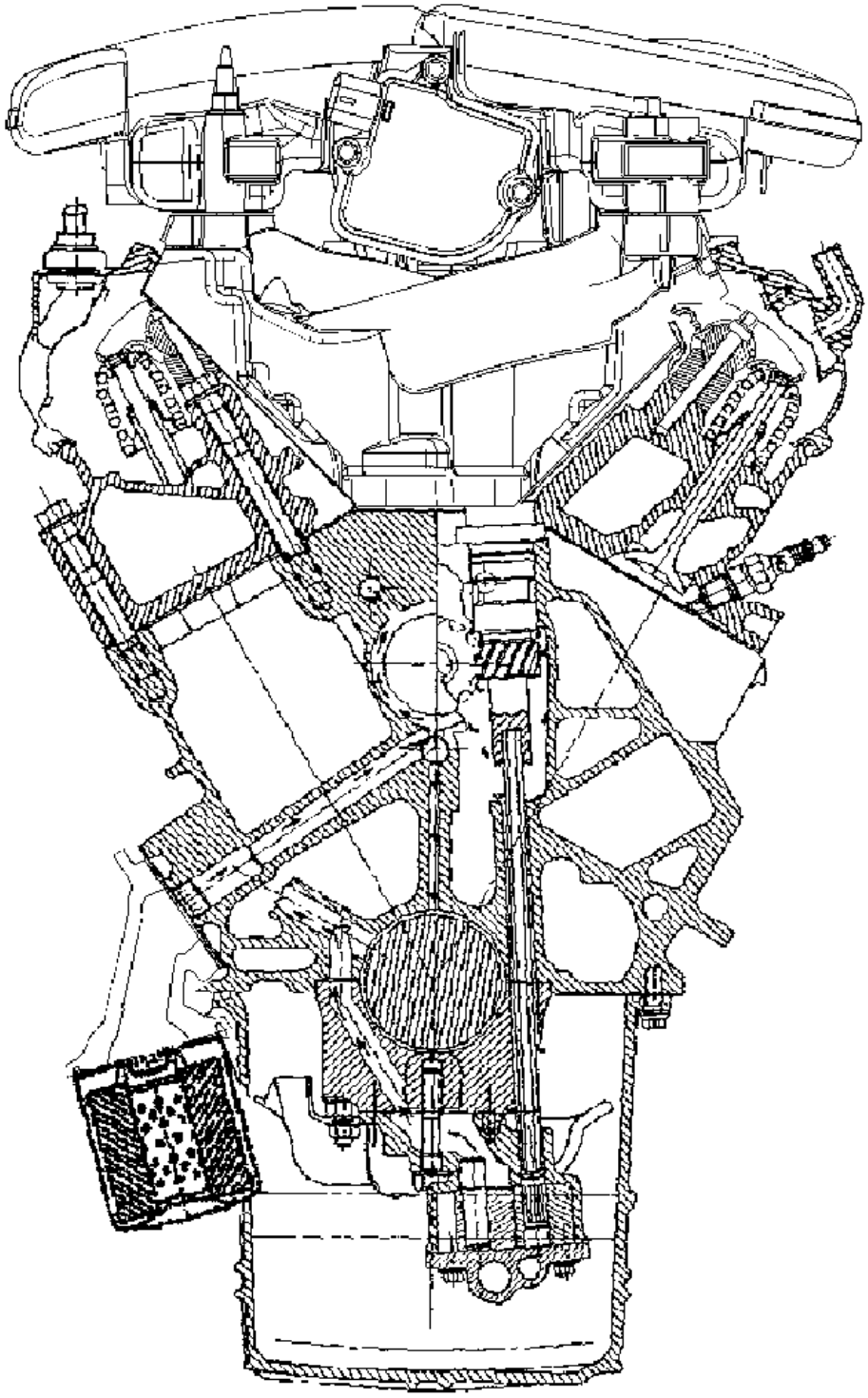

Fig. 651: Front View
Courtesy of GENERAL MOTORS CORP.

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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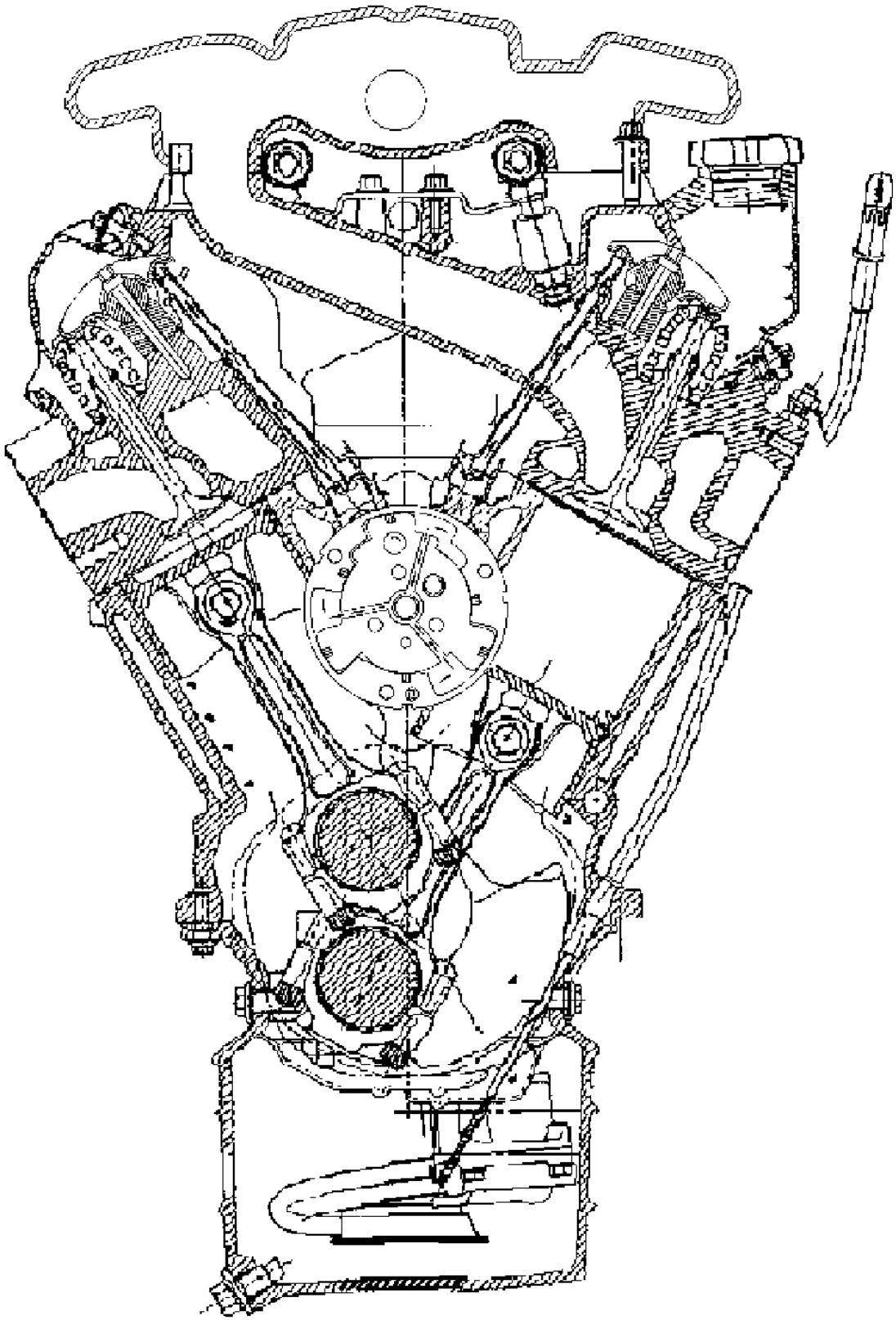

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Fig. 652: Rear View
Courtesy of GENERAL MOTORS CORP.

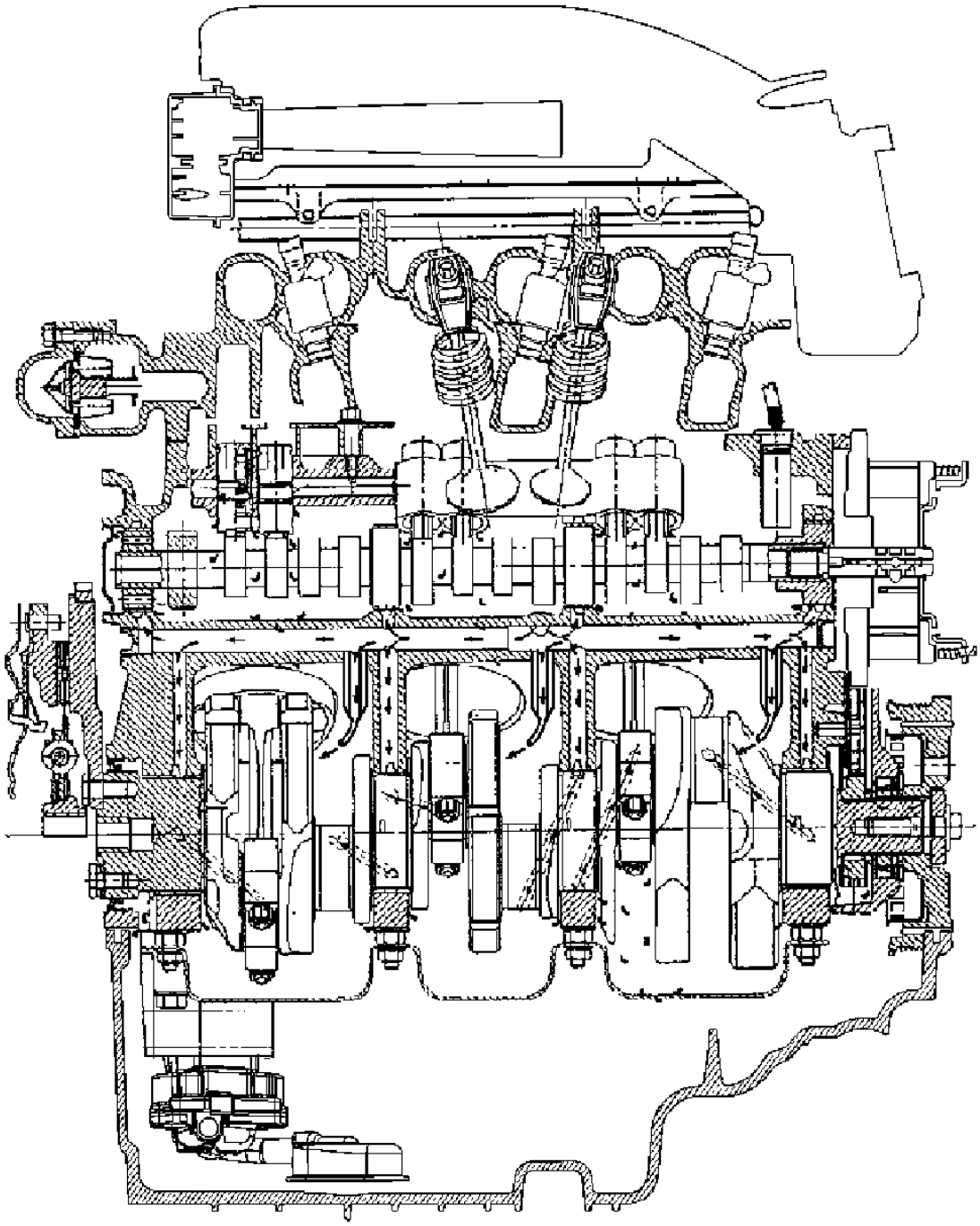

Fig. 653: Right View
Courtesy of GENERAL MOTORS CORP.

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.

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

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

CAUTION: Refer to Battery Disconnect Caution .

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to Engine Electrical.

SEPARATING PARTS

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:

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- **Abrasive pads**
- **Sand paper**
- **Power tools**

These methods of cleaning may damage the component. Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

3. Remove all of the gasket and the sealing material from the component using a plastic or a wood scraper. Do not gouge or scrape the sealing surfaces.

IMPORTANT: Do not allow the sealant to enter any blind threaded holes. The sealant may cause the following conditions:

- **Prevent you from properly seating the bolt**
- **Cause damage when you tighten the bolt**

4. When assembling components, use only the sealant specified in the service procedure. Ensure that the sealing surfaces are clean and free of debris or oil. When applying sealant to a component, apply a bead size as specified in the service procedure.
5. Tighten the bolts to the specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

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

Special Tools

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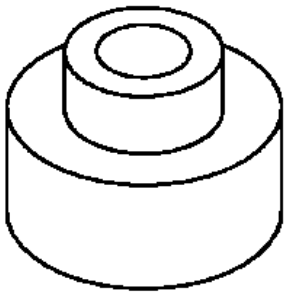
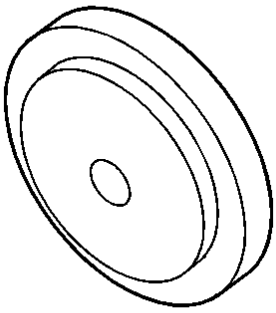
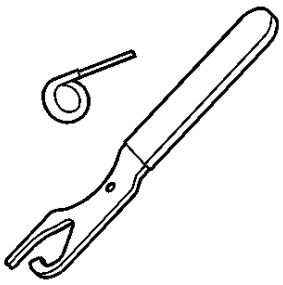
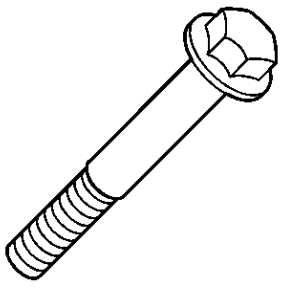
Illustration	Tool Number/Description
	EN 46359 Puller End Protector
	EN 47623 Anchor Bolt Socket
	EN 47719 Tensioner Compressor
	EN 47823 Valve Spring Compressor Adapter

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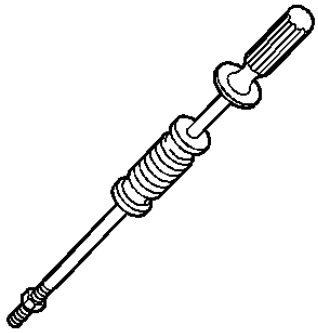
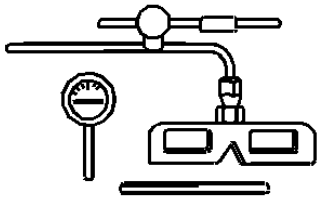
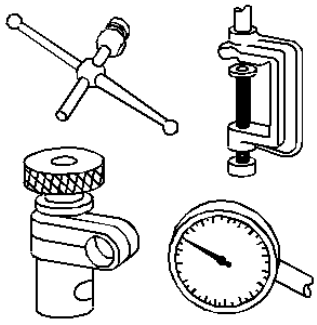
	J 5892-D Valve Spring Compressor
	J 6125-1B Slide Hammer with Adapter
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set
	J 8037 Ring Compressor

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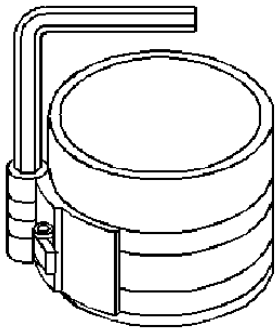
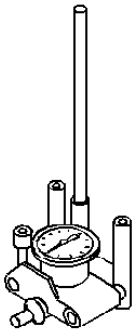
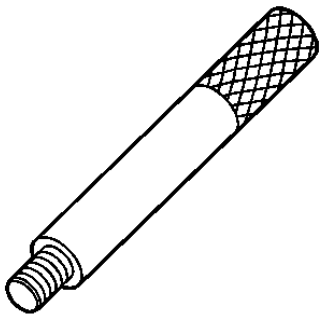
	
	J 8087 Cylinder Bore Gage
	J 8089 Carbon Removal Brush
	J 8092 Driver Handle
	J 8520 Cam Lobe Lift Indicator

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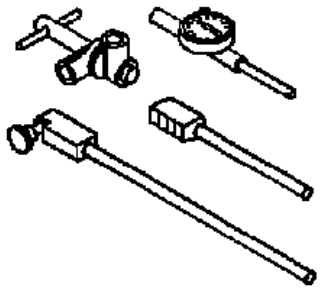
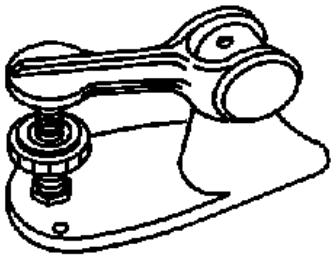
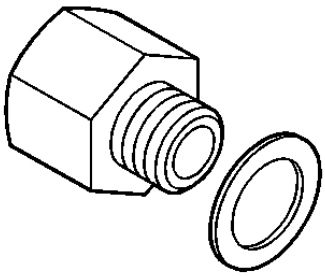
	
	J 9666 Valve Spring Tester
	J 21867-6 Oil Pressure Adapter Fitting
	J 22144 Oil Suction Pipe Installer
	J 24270 Cylinder Bore Ridge Reamer

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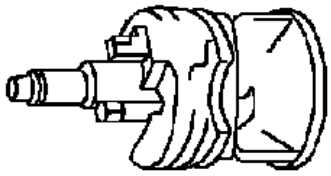
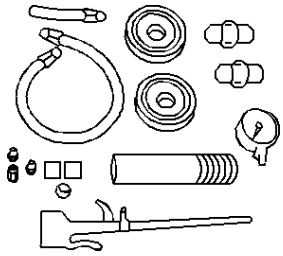
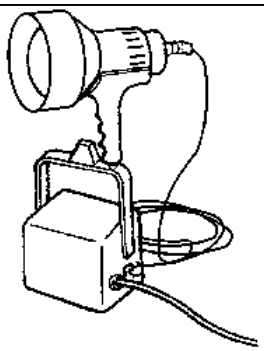
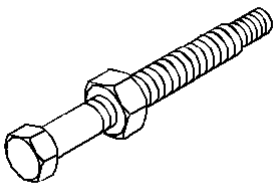
	
	J 25087-C Oil Pressure Tester and Pump Primer
	J 28428-E High Intensity Black Light Kit
	J 29113 Balancer and Crank Sprocket Puller
	J 33049 Camshaft Bearing Service Set

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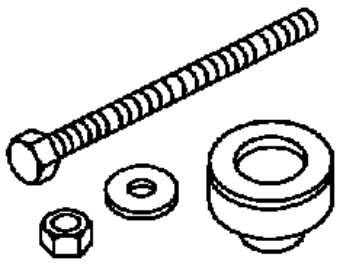	
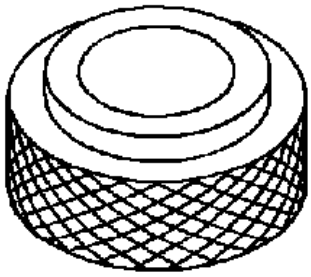	J 35468 Cover Aligner and Seal Installer
	J 35667-A Cylinder Head Leakdown Tester
	J 38722 Compression Tester
	J 39505 Torque Wrench Adapter

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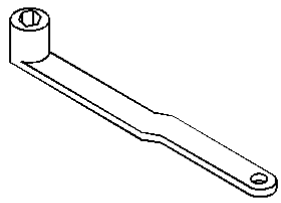
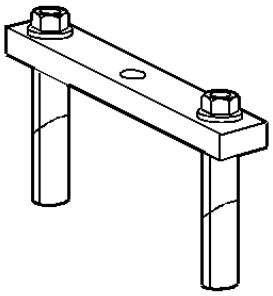
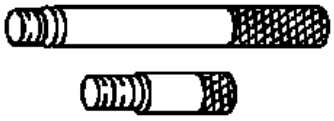
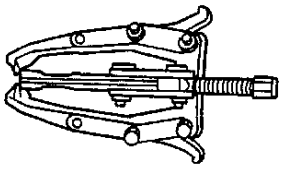
	
	J 41348 Bearing Cap Puller
	J 41556 Connecting Rod Guide
	J 41816 Crankshaft Balancer Remover
	J 43654 Piston Pin Clip Remover and Installer

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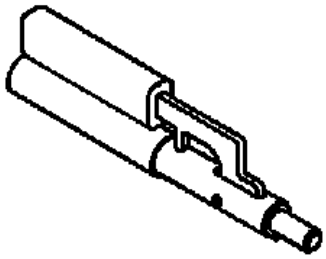
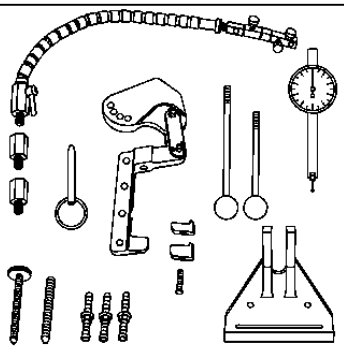
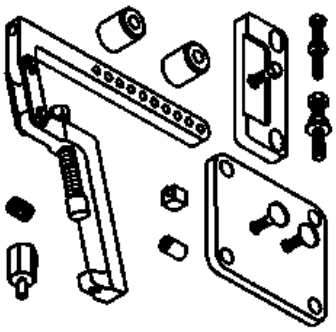
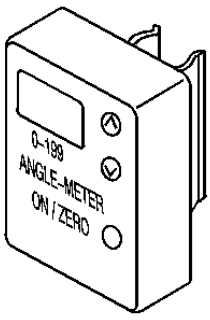
	
	J 43690 Rod Bearing Clearance Checking Tool - Adapter Kit
	J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit
	J 45059 Angle Meter
	J 45299 Engine Preluber

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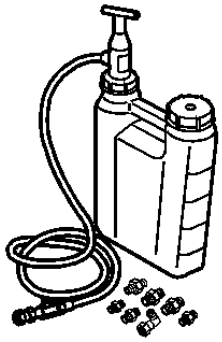	

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