

2004 Buick Century

2004 ENGINE Engine Mechanical - 3.1L - Century & Regal

2004 ENGINE**Engine Mechanical - 3.1L - Century & Regal****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS****Fastener Tightening Specifications**

Application	Specification	
	Metric	English
Air Conditioning Compressor Bolts	50 N.m	37 lb ft
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Camshaft Sprocket Bolt	140 N.m	103 lb ft
Camshaft Thrust Plate Screw	10 N.m	89 lb in
Connecting Rod Bearing Cap Nut		
• First Pass	20 N.m	15 lb ft
• Final Pass	75 degrees	
Coolant Drain Plug	19 N.m	14 lb ft
Coolant Temperature Sensor	23 N.m	17 lb ft
Crankshaft Balancer Bolt		
• First Pass	70 N.m	52 lb ft
• Final Pass	72 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 Bolt - Front Cover	10 N.m	89 lb in
Crankshaft Position Sensor Stud - Side of Engine Block	11 N.m	98 lb in
Crankshaft Position Sensor Wiring Bracket Bolt	27 N.m	20 lb ft
Cylinder Head Bolt		
• First Pass	60 N.m	44 lb ft
• Final Pass	95 degrees	
Drive Belt Shield Bolt	10 N.m	89 lb in
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
EGR Valve Pipe to EGR Valve Bolt	25 N.m	18 lb ft
EGR Valve Pipe to Exhaust Manifold Nut	25 N.m	18 lb ft
EGR Valve to Upper Intake Manifold Bolt	30 N.m	22 lb ft
Engine Coolant Temperature Sensor	25 N.m	17 lb ft
Engine Front Cover Bolt - Large	55 N.m	41 lb ft

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Engine Front Cover Bolt - Medium	55 N.m	41 lb ft
Engine Front Cover Bolt - Small	27 N.m	20 lb ft
Engine Mount Bracket Bolt	58 N.m	43 lb ft
Engine Mount Lower Nut	47 N.m	35 lb ft
Engine Mount Strut Bolt - Horizontal/Vertical	26 N.m	19 lb ft
Engine Mount Strut Bolt/Nut	48 N.m	35 lb ft
Engine Mount Strut Bracket Bolt - Upper Radiator Support	28 N.m	21 lb ft
Engine Mount Strut Bracket Bolts	70 N.m	52 lb ft
Engine Mount Upper Nut	47 N.m	35 lb ft
Engine Oil Pressure Indicator Switch	16 N.m	12 lb ft
Engine to Transaxle Bolt/Stud	75 N.m	55 lb ft
Engine Wiring Harness Bracket Bolt	13 N.m	115 lb in
Engine Wiring Harness Ground Nut	35 N.m	26 lb ft
Exhaust Manifold Nut	16 N.m	12 lb ft
Exhaust Manifold Stud	18 N.m	13 lb ft
Flywheel Bolt	71 N.m	52 lb ft
Fuel Feed and Return Pipe Clip Nut	25 N.m	18 lb ft
Fuel Feed and Return Pipe Clip Stud	50 N.m	37 lb ft
Fuel Feed Pipe to Fuel Injector Rail Nut	17 N.m	13 lb ft
Fuel Injector Rail Bolt	10 N.m	89 lb in
Fuel Pipe Bracket Bolt/Stud	50 N.m	37 lb ft
Fuel Pipe Clip Bolt	8 N.m	71 lb in
Fuel Return Pipe to Fuel Injector Rail Nut	17 N.m	13 lb ft
Generator Bracket Bolt	50 N.m	37 lb ft
Heated Oxygen Sensor	42 N.m	31 lb ft
Heater Inlet Pipe Nut	25 N.m	18 lb ft
Heater Inlet Pipe Stud	50 N.m	37 lb ft
Ignition Coil Bracket Bolt/Nut/Stud	25 N.m	18 lb ft
Intake Manifold Coolant Pipe Bolt	10 N.m	89 lb in
Knock Sensor	19 N.m	14 lb ft
Left Engine Mount Bracket Bolts to Engine	102 N.m	75 lb ft
Lift Bracket Bolt - Engine Left Rear	70 N.m	52 lb ft
Lower Intake Manifold Bolts - Center		
• First Pass	7 N.m	62 lb in
• Final Pass	13 N.m	115 lb in
Lower Intake Manifold Bolts - Corner		
• First Pass	13 N.m	115 lb in
• Final Pass	25 N.m	18 lb ft
MAP Sensor Bolt	5 N.m	44 lb in
Oil Cooler Connector	50 N.m	37 lb ft

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Oil Cooler Hose Fitting	19 N.m	14 lb ft
Oil Cooler Pipe Bracket Bolt	25 N.m	18 lb ft
Oil Filter	13 N.m	115 lb in
Oil Filter Bypass Hole Plug	19 N.m	14 lb ft
Oil Filter Fitting	39 N.m	29 lb ft
Oil Gallery Plug - 1/4 inch	19 N.m	14 lb ft
Oil Gallery Plug - 3/8 inch	33 N.m	24 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Level Sensor Bolt - if equipped	10 N.m	89 lb in
Oil Level Sensor Harness Retainer Bolt	10 N.m	89 lb in
Oil Pan Bolt	25 N.m	18 lb ft
Oil Pan Drain Plug	30 N.m	22 lb ft
Oil Pan Side Bolt	50 N.m	37 lb ft
Oil Pump Cover Bolt	10 N.m	89 lb in
Oil Pump Drive Clamp Bolt	36 N.m	27 lb ft
Oil Pump Mounting Bolt	41 N.m	30 lb ft
PCV Valve Access Cover Bolts	10 N.m	89 lb in
Spark Plug - New Cylinder Head	20 N.m	15 lb ft
Spark Plug - After Initial Installation	15 N.m	13 lb ft
Thermostat Bypass Pipe to Engine Front Cover Bolt	12 N.m	106 lb in
Thermostat Bypass Pipe to Throttle Body Nut	25 N.m	18 lb ft
Throttle Body Bolt/Stud	25 N.m	18 lb ft
Timing Chain Dampener 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
Valve Rocker Arm Bolt	32 N.m	24 lb ft
Valve Rocker Arm Cover Bolt	10 N.m	89 lb in
Water Outlet Bolt	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° V-6	
• Displacement	3.1L	191 cu in
• RPO	LG8	
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• VIN		
• Bore	89 mm	3.50 in
• Stroke	84 mm	3.31 in
• Compression Ratio	9.6:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	1.52 mm	0.60 in
Block		
• Camshaft Bearing Bore Diameter - ID	47.516-47.541 mm	1.871-1.872 in
• Camshaft Bearing Bore Diameter - Front and Rear	51.03-51.08 mm	2.009-2.011 in
• Camshaft Bearing Bore Diameter - Middle #2, #3	50.77-50.82 mm	1.999-2.001 in
• Crankshaft Main Bearing Bore Diameter	72.1535-72.1695 mm	2.8407-2.8413 in
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.0003 in
• Cylinder Bore Diameter - Production	89.016-89.034 mm	3.5046-3.5053 in
• Cylinder Bore Diameter - Service	89.016-89.042 mm	3.5046-3.5056 in
• Cylinder Bore Out-of-Round - Diametral - Production	0.020 mm	0.0008 in
• Cylinder Bore Out-of-Round - Diametral - Service	0.025 mm	0.001 in
• Cylinder Bore Taper - Production	0.020 mm	0.0008 in
• Cylinder Bore Taper - Service	0.025 mm	0.001 in
• Cylinder Head Deck Height	224 mm	8.819 in
• Cylinder Head Deck Surface Flatness	0.05 mm per 152 mm	0.002 in per 6 in
• Valve Lifter Bore Diameter	21.417-21.455 mm	0.843-0.845 in
Camshaft		
• Camshaft Bearing Inside Diameter	47.516-47.541 mm	1.871-1.872 in
• Camshaft Journal Diameter	47.443-47.468 mm	1.868-1.869 in
• Camshaft Journal Out-of-Round	0.003 mm	0.00012 in
• Camshaft Journal to Bearing Clearance	0.048-0.098 mm	0.002-0.004 in
• Camshaft Lobe Lift - Exhaust	6.9263 mm	0.2727 in
• Camshaft Lobe Lift - Intake	6.9263 mm	0.2727 in
• Camshaft Runout	0.050 mm	0.002 in
Cooling System		
• Capacity @ Engine RPM	12.4 liters	13.1 quarts

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• Thermostat Full Open Temperature	195 degrees	
Connecting Rod		
• Connecting Rod Bearing Clearance	0.18-0.062 mm	0.0007-0.017 in
• Connecting Rod Bore Diameter	53.962-53.978 mm	2.124-2.125 in
• Connecting Rod Bore Out-of-Round	0.008 mm	0.00031 in
• Connecting Rod Length - Center to Center	144.75-144.81 mm	5.69-5.70 in
• Connecting Rod Side Clearance	0.25-0.37 mm	0.010-0.015 in
Crankshaft		
• Connecting Rod Journal Diameter	50.768-50.784 mm	1.9987-1.9994 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	8.62-8.69 in
• Crankshaft End Play	0.060-0.210 mm	0.0024-0.0083 in
• Crankshaft Main Bearing Journal Width - #1	29.5 mm	1.161 in
• Crankshaft Main Bearing Journal Width - #2	24.0 mm	0.945 in
• Crankshaft Main Bearing Journal Width - #3	24.04 mm	0.946 in
• Crankshaft Main Bearing Journal Width - #4	35.8 mm	1.409 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 Diameter	67.239-67.257 mm	2.6473-2.6483 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
• Crankshaft Reluctor Ring Runout - Max	0.34 mm	0.0134 in
• Crankshaft Runout	0.025 mm	0.0010 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

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• Valve Guide Bore - Intake	8.01 mm	0.315 in
• Valve Guide Installed Height	16.6 mm	0.654 in
Lubrication System		
• Oil Capacity - with Filter	4.3 liters	4.5 quarts
• Oil Capacity - without Filter	3.8 liters	4.0 quarts
• Oil Pressure - @ 1850 RPM	414 kPa	60 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
Piston Ring End Gap		
• First Compression Ring	0.15-0.36 mm	0.006-0.014 in
• Second Compression Ring	0.5-0.71 mm	0.0197-0.0280 in
• Oil Control Ring	0.25-1.02 mm	0.009-0.040 in
Piston Ring to Groove Clearance		
• First Compression Ring	0.04-0.086 mm	0.002-0.0033 in
• Second Compression Ring	0.04-0.08 mm	0.002-0.0035 in
• Oil Control Ring	0.07-0.095 mm	0.0028-0.0037 in
Piston Ring Thickness		
• First Compression Ring	1.164-1.190 mm	0.046-0.047 in
• Second Compression Ring	1.470-1.490 mm	0.057-0.058 in
• Oil Control Ring - Maximum	2.960 mm	0.116 in
Pistons		
• Piston Diameter - New	88.986-89.024 mm	3.503-3.504 in
• Piston Ring Groove Width - Top	1.23-1.25 mm	0.048-0.049 in
• Piston Ring Groove Width - Second	1.53-1.55 mm	0.060-0.061 in
• Piston Ring Groove Width - Third	3.03-3.05 mm	0.119-0.120 in
• Piston to Bore Clearance	-0.008--0.048 mm	-0.0003--0.0018 in
Rocker Arms		
• Valve Rocker Arm Ratio	1.6:1	
Valves		
• Valve Face Angle	45 degrees	
• Valve Face Runout	0.050 mm	0.002 in

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• Valve Seat Angle	46 degrees	
• Valve Seat Depth - Intake	7.9-8.1 mm	0.311-0.318 in
• Valve Seat Depth - Exhaust	8.9-9.1 mm	0.350-0.358 in
• Valve Seat Runout	0.037 mm	0.0015 in
• Valve Seat Width - Intake	1.55-1.80 mm	0.061-0.071 in
• Valve Seat Width - Exhaust	1.70-2.0 mm	0.067-0.079 in
• Valve Stem-to-Guide Clearance	0.026-0.068 mm	0.0010-0.0027 in
• Valve Stem Diameter - Intake	7.967-7.980 mm	0.3137-0.3142 in
• Valve Stem Diameter	7.944-7.965 mm	0.3128-0.3136 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 Lifter Diameter	21.387-21.405 mm	0.8420-0.3136 in
• Valve Lifter-to-Bore Clearance	0.012-0.068 mm	0.0005-0.0027 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
Accelerator Control Cable Bracket Bolt Threads	Threadlock	12345382	10953489
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	12346141	10953433
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 Front Cover Gasket Lower Tabs	Sealant	12346004	10953480
Engine Oil	10W-30 Oil	12345616	993182

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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	12346141	10953433
Oil Filter Bypass Hole Plug Threads	Sealant	12346004	10953480
Oil Pan Surface at Rear Crankshaft Main Bearing Cap	Sealant	12346141	10953433
Oil Pressure Switch Threads	Sealant	12346004	10953480
Oil Pump Suction Pipe	Sealant	12346004	10953480
Piston and Piston Pin	10W-30 Oil	12345616	993182
Rear Crankshaft Main Bearing Cap	Sealant	1052942	10953466
Throttle Body Bolt and Stud	Threadlock	12345382	10953489
Valve Lifter Guide Bolt Threads	Threadlock	12345382	10953489
Valve Rocker Arm Cover Notch at Cylinder Head and Lower Intake Manifold	Sealant	12346141	10953433
Valve Lifter and Camshaft Prelube	Lubricant	12345501	992704

COMPONENT LOCATOR**DISASSEMBLED VIEWS**

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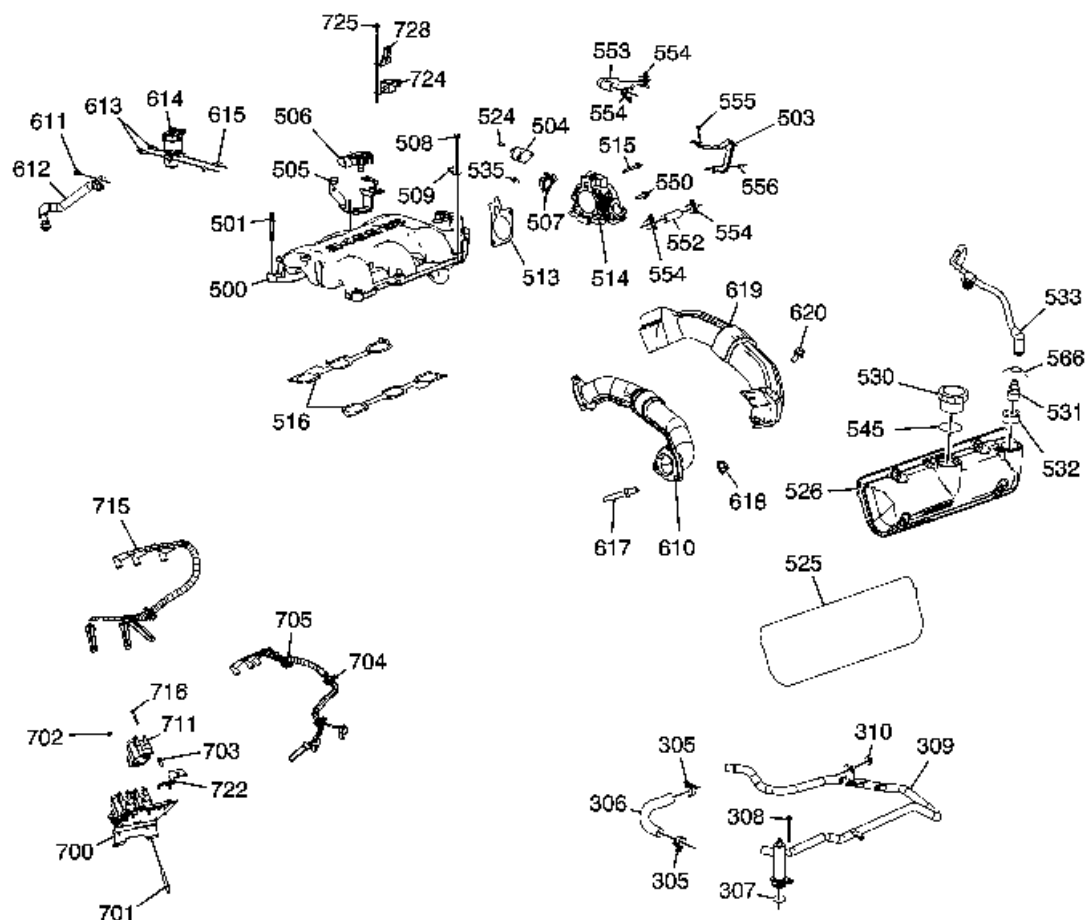


Fig. 1: Upper Intake Manifold And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
305	Thermostat Bypass Hose Clamp
305	Thermostat Bypass Hose Clamp
306	Thermostat Bypass Hose
307	Thermostat Bypass Pipe Seal
308	Thermostat Bypass Pipe Bolt - To Front Cover
309	Thermostat Bypass Pipe
310	Thermostat Bypass Pipe Nut
500	Upper Intake Manifold
501	Upper Intake Manifold Stud
503	Accelerator Control Cable Bracket
504	Idle Air Control Valve
505	MAP Sensor Bracket

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506	MAP Sensor
507	Throttle Position Sensor
508	Upper Intake Manifold Bolt
509	Spark Plug Wire Support Bracket
513	Throttle Body Gasket
514	Throttle Body
515	Throttle Body Bolt
516	Upper Intake Manifold Gasket
524	Idle Air Control Valve Bolt
525	Valve Rocker Cover Seal
526	Valve Rocker Cover
530	Oil Fill Cap
531	PCV Valve
532	PCV Valve Grommet
533	PCV Tube - Foul Air
535	Throttle Position Sensor Bolt
545	Oil Fill Cap Seal
550	Throttle Body Stud
552	Throttle Body Heater Hose - Outlet
553	Throttle Body Heater Hose - Inlet
554	Throttle Body Heater Hose Clamp
554	Throttle Body Heater Hose Clamp
554	Throttle Body Heater Hose Clamp
554	Throttle Body Heater Hose Clamp
555	Accelerator Control Cable Bracket Bolt
556	Accelerator Control Cable Bracket Nut
566	PCV Valve Retainer
610	Exhaust Crossover Pipe
611	EGR Pipe Bolt - To EGR
612	EGR Pipe
613	EGR Valve Bolt
614	EGR Valve
615	EGR Valve Gasket - To Intake Manifold
617	Exhaust Crossover Pipe Stud
618	Exhaust Crossover Pipe Nut
619	Exhaust Crossover Pipe Heat Shield
620	Exhaust Crossover Pipe Heat Shield Bolt
700	Ignition Coil Assembly
701	Ignition Coil Assembly Stud
702	Ignition Coil Assembly Nut
703	Ignition Coil Assembly Bolt

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	Spark Plug Wire Harness - Front
705	Spark Plug Wire Support
711	Ignition Coil
715	Spark Plug Wire Harness - Rear
716	Ignition Coil Bolt
722	Wire Support Bracket
724	EVAP Purge Valve
725	EVAP Purge Valve Bolt
728	EVAP Purge Valve Bracket

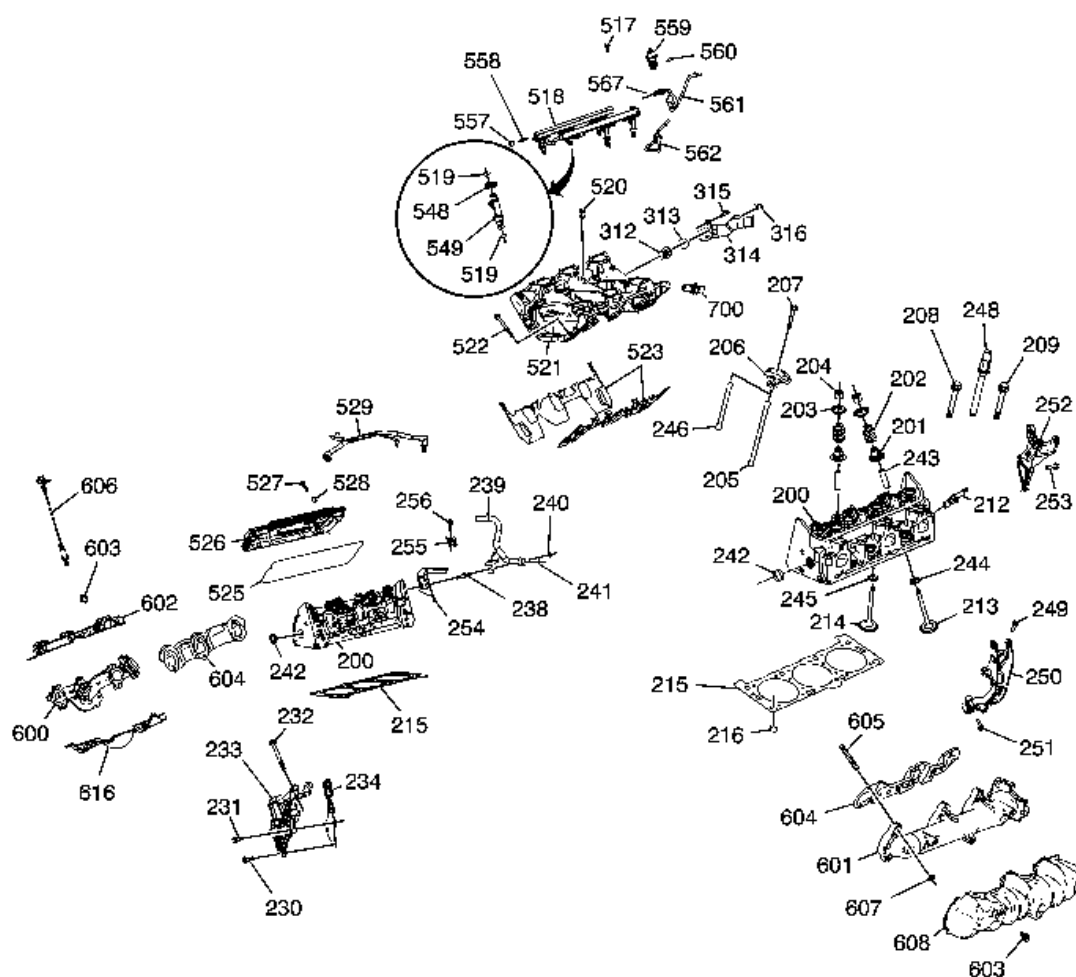


Fig. 2: Lower Intake Manifold, Cylinder Head And Components
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Cylinder Head

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200	Cylinder Head
201	Valve Seal
202	Valve Spring
203	Valve Spring Cap
204	Valve Stem Key
205	Valve Pushrod - Exhaust
206	Valve Rocker Arm
207	Valve Rocker Arm Bolt
208	Cylinder Head Bolt - Medium
209	Cylinder Head Bolt - Short
212	Spark Plug
213	Exhaust Valve
214	Intake Valve
215	Cylinder Head Gasket
215	Cylinder Head Gasket
216	Cylinder Head Locating Pin
230	Generator Bracket Bolt - Short
231	Generator Bracket Bolt - Medium
232	Generator Bracket Bolt - Long
233	Generator Bracket
234	Engine Lift Bracket - Front
238	Heater Inlet Pipe Stud
239	Heater Inlet Pipe
240	Heater Inlet Pipe Nut
241	Heater Inlet Pipe Seal
242	Cylinder Head Expansion Plug
242	Cylinder Head Expansion Plug
243	Valve Guide
244	Valve Seat - Exhaust
245	Valve Seat - Intake
246	Valve Pushrod - Intake
248	Cylinder Head Bolt - Long
249	Engine Mount Strut and A/C Compressor Bracket Bolt - Short
250	Engine Mount Strut and A/C Compressor Bracket
251	Engine Mount Strut and A/C Compressor Bracket Bolt - Long
252	Engine Mount Strut and Engine Lift Bracket
253	Engine Mount Strut and Engine Lift Bracket Bolt
254	Fuel Feed and Return Pipe Bracket
255	Fuel Feed and Return Pipe Clip
256	Fuel Feed and Return Pipe Clip Bolt
312	Thermostat

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	Thermostat Seal
314	Water Outlet Housing
315	Water Outlet Housing Bolt
316	Water Outlet Housing Fitting
517	Fuel Rail Bolt
518	Fuel Rail
519	Fuel Injector Seal
519	Fuel Injector Seal
520	Lower Intake Manifold Bolt - Long
521	Lower Intake Manifold
522	Lower Intake Manifold Bolt - Short
523	Lower Intake Manifold Gasket
525	Valve Rocker Cover Seal
526	Valve Rocker Cover
527	Valve Rocker Cover Bolt
528	Valve Rocker Cover Bolt Grommet
529	Vacuum Harness
548	Fuel Injector Retaining Clip
549	Fuel Injector
557	Fuel Rail Service Port Cap
558	Fuel Rail Service Port Schrader Valve
559	Fuel Pressure Regulator
560	Fuel Pressure Regulator Bolt
561	Fuel Feed Pipe
562	Fuel Return Pipe
567	Fuel Feed Pipe Seal
600	Exhaust Manifold - Left
601	Exhaust Manifold - Right
602	Exhaust Manifold Heat Shield - Right - Upper
603	Exhaust Manifold Heat Shield Bolt
603	Exhaust Manifold Heat Shield Bolt
604	Exhaust Manifold Gasket
604	Exhaust Manifold Gasket
605	Exhaust Manifold Stud
606	Heated Oxygen Sensor
607	Exhaust Manifold Nut
608	Exhaust Manifold Heat Shield - Left
616	Exhaust Manifold Heat Shield - Right - Lower
700	Ignition Coil Assembly

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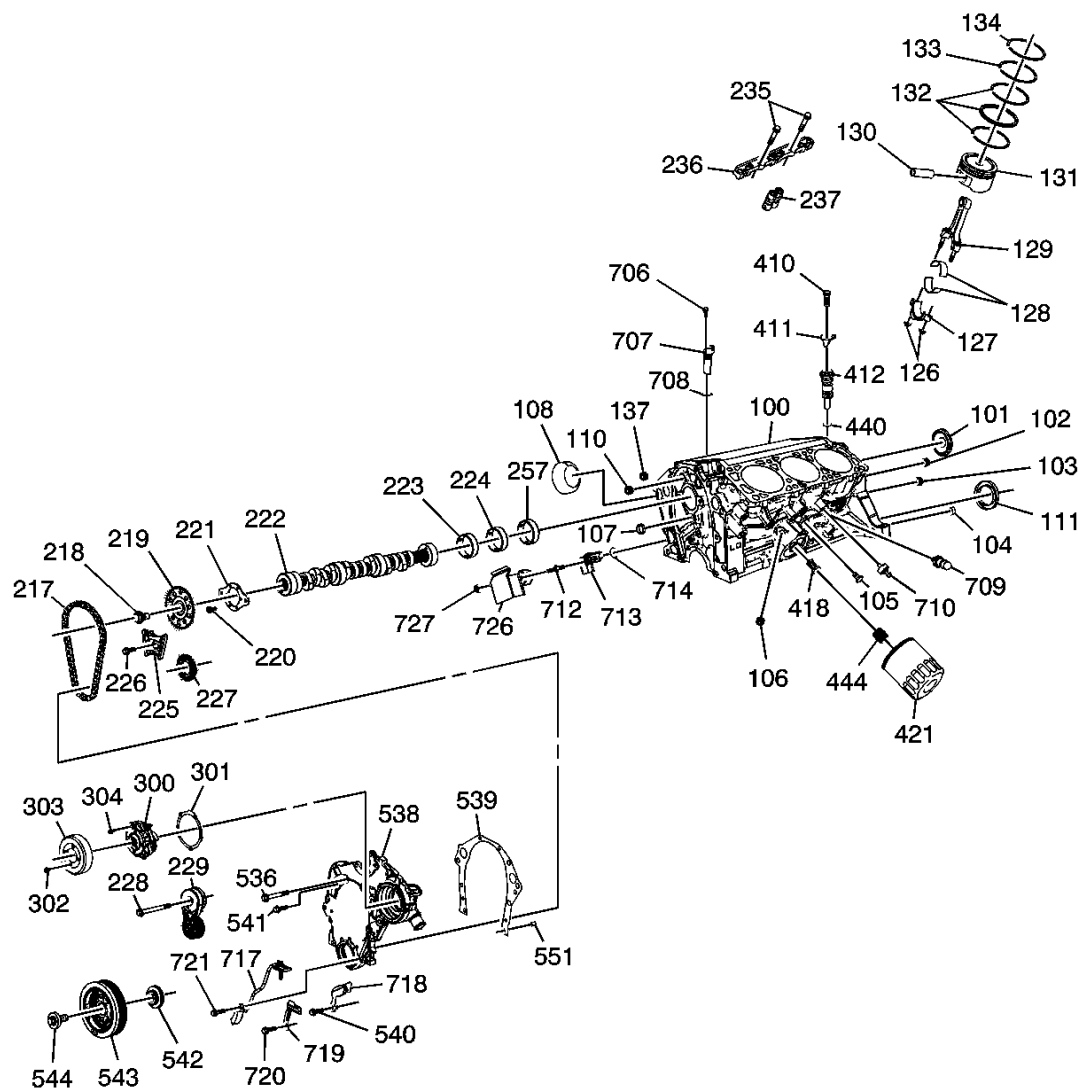


Fig. 3: Engine Block And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Camshaft Rear Bearing Hole Plug
102	Engine Block Oil Gallery Plug - Rear - Large
103	Engine Block Oil Gallery Plug - Rear - Small
104	Transmission Locating Pin
105	Engine Block Coolant Drain Hole Plug
106	Oil Filter Bypass Hole Plug
107	Engine Block Oil Gallery Plug - Front - Press Fit

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108	Engine Block Plug
110	Engine Block Oil Gallery Plug - Front - Small
111	Crankshaft Rear Oil Seal
126	Connecting Rod Bearing Cap Nut
127	Connecting Rod Bearing Cap
128	Connecting Rod Bearing
129	Connecting Rod
130	Piston Pin
131	Piston
132	Piston Ring - Oil Control
133	Piston Ring - Compression - Lower
134	Piston Ring - Compression - Upper
137	Engine Block Oil Gallery Plug - Front - Large
217	Timing Chain
218	Camshaft Sprocket Bolt
219	Camshaft Sprocket
220	Camshaft Thrust Plate Bolt
221	Camshaft Thrust Plate
222	Camshaft
223	Camshaft Bearing - 1
224	Camshaft Bearing - 2 and 3
225	Timing Chain Dampener
226	Timing Chain Dampener Bolt
227	Crankshaft Sprocket
228	Drive Belt Tensioner Bolt
229	Drive Belt Tensioner
235	Valve Lifter Guide Bolt
236	Valve Lifter Guide
237	Valve Lifter
257	Camshaft Bearing - 4
300	Water Pump
301	Water Pump Gasket
302	Water Pump Pulley Bolt
303	Water Pump Pulley
304	Water Pump Bolt
410	Oil Pump Drive Bolt
411	Oil Pump Drive Clamp
412	Oil Pump Drive
418	Oil Filter Bypass Valve
421	Oil Filter
440	Oil Pump Drive Seal
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	Oil Filter Fitting
536	Engine Front Cover Bolt - Large
538	Engine Front Cover
539	Engine Front Cover Gasket
540	Engine Front Cover Bolt - Small
541	Engine Front Cover Bolt - Medium
542	Crankshaft Front Oil Seal
543	Crankshaft Balancer
544	Crankshaft Balancer Bolt
551	Front Cover Locating Pins
706	Camshaft Position Sensor Bolt
707	Camshaft Position Sensor
708	Camshaft Position Sensor Seal
709	Engine Oil Pressure Sensor
710	Knock Sensor
712	Crankshaft Position Sensor Stud
713	Crankshaft Position Sensor - Engine Block
714	Crankshaft Position Sensor Seal
717	Crankshaft Position Sensor - Front Cover
718	Crankshaft Position Sensor Wire Harness Bracket - Small
719	Crankshaft Position Sensor Wire Harness Bracket - Large
720	Crankshaft Position Sensor Wire Harness Bracket Bolt
721	Crankshaft Position Sensor Bolt - Front Cover
726	Crankshaft Position Sensor Heat Shield
727	Crankshaft Position Sensor Heat Shield Nut

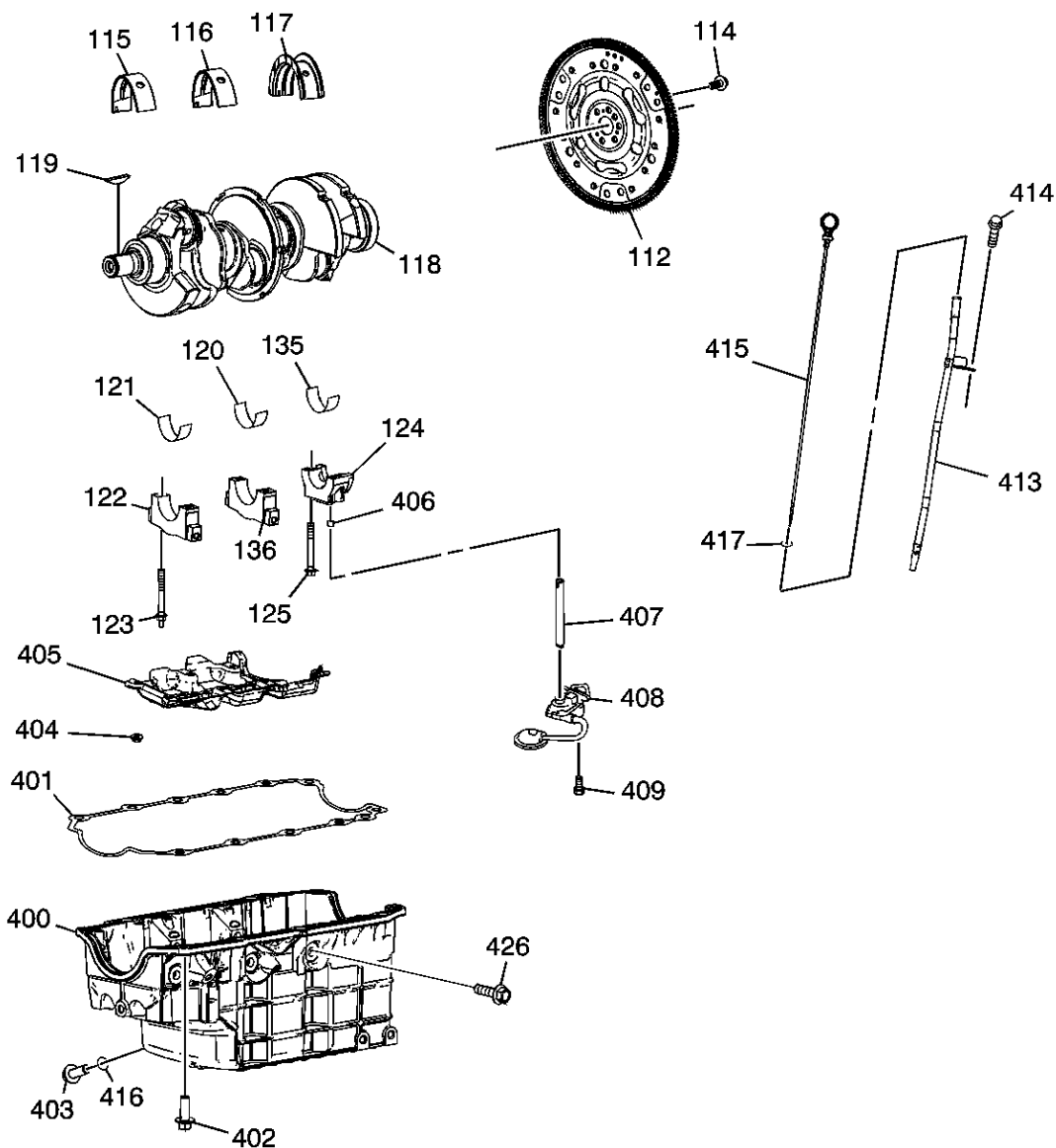


Fig. 4: Crankshaft And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
112	Flywheel
114	Flywheel Bolt
115	Crankshaft Upper Bearing - 1 and 4
116	Crankshaft Upper Bearing - 2
117	Crankshaft Upper Bearing - 3
118	Crankshaft

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119	Crankshaft Balancer Key
120	Crankshaft Lower Bearing - 2
121	Crankshaft Lower Bearing - 1 and 4
122	Crankshaft Bearing Cap - 1
123	Crankshaft Bearing Cap Stud
124	Crankshaft Bearing Cap - 4
125	Crankshaft Bearing
135	Crankshaft Lower Bearing - 3
136	Crankshaft Bearing Cap - 2 and 3
400	Oil Pan
401	Oil Pan Gasket
402	Oil Pan Bolt - to Engine Block
403	Oil Pan Drain Plug
404	Crankshaft Oil Deflector Nut
405	Crankshaft Oil Deflector
406	Oil Pump Locating Pin
407	Oil Pump Shaft
408	Oil Pump
409	Oil Pump Bolt
413	Oil Level Indicator Tube
414	Oil Level Indicator Tube Bolt
415	Oil Level Indicator
416	Oil Pan Drain Plug Seal
417	Oil Level Indicator Seal
426	Oil Pan Bolt - Side of Pan

ENGINE IDENTIFICATION

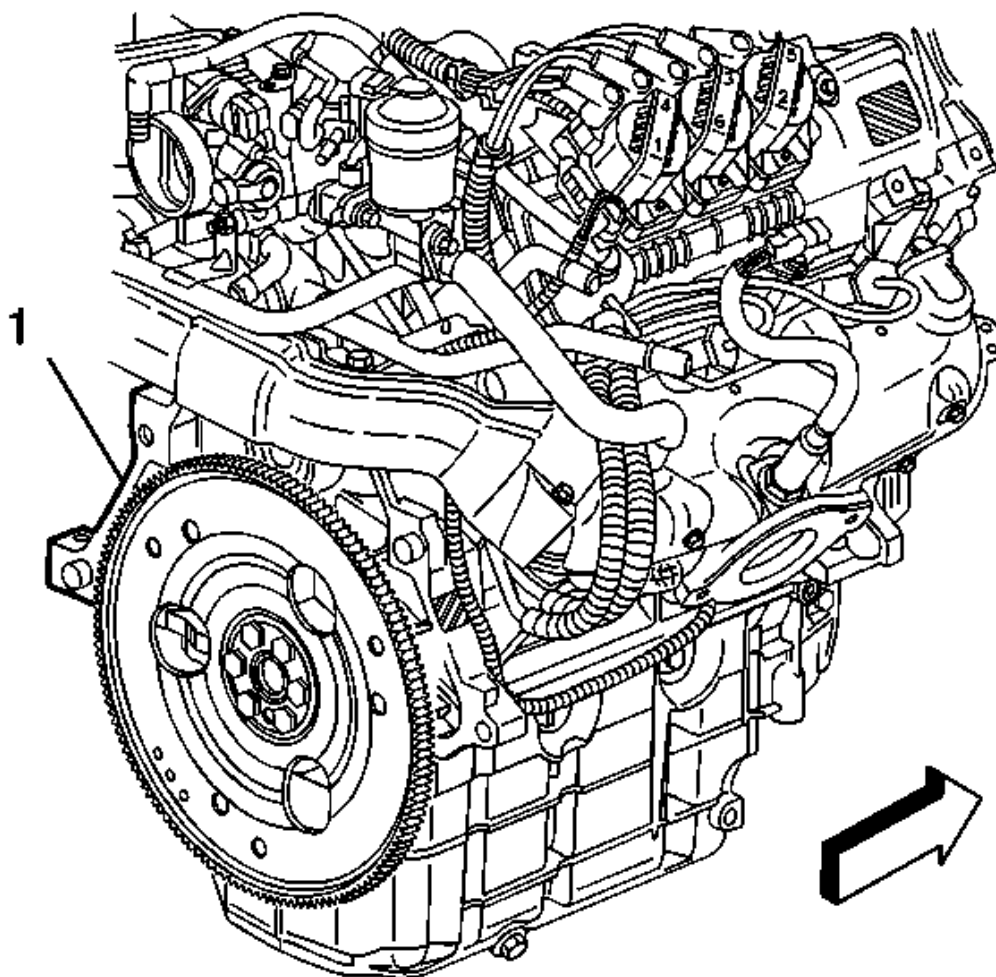


Fig. 5: Engine Identification Location

Courtesy of GENERAL MOTORS CORP.

The Vehicle Identification Number - VIN derivative (1) for 3100 LG8 and 3400 LA1 is stamped or laser etched on the left side rear 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, Lubrication Description, and New Product Information 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.

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform A Diagnostic System Check in Engine Controls before using the symptom tables - if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to Disassembled Views, Engine Component Description, Drive Belt System Description, Lubrication Description, and New Product Information 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
- Engine Compression Test
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Drive Belt Chirping Diagnosis
- Drive Belt Squeal Diagnosis
- Drive Belt Whine Diagnosis
- Drive Belt Rumbling Diagnosis
- Drive Belt Vibration Diagnosis
- Drive Belt Falls Off Diagnosis
- Valve Rocker Arm Cover Replacement - Right
- Drive Belt Tensioner Diagnosis

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal 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 and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to <u>Drive Belt Tensioner Replacement</u> .
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	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .

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misfire condition.	
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 cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • 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 A Diagnostic Starting Point - Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to identify the cause. • 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	Replace the drive belt. Refer to <u>Drive Belt</u>

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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.	<u>Tensioner Replacement.</u>
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 <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement.</u>
Worn Piston Rings - Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test.</u> • Perform cylinder leak down and compression testing to determine the cause. • 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
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.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to <u>Diagnostic Starting Point - Engine Cooling</u> in Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	- Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> in Engine Controls. - Perform a cylinder leak down test. - Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. - 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	- Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. - Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	- Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. - Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. - Perform cylinder leak down and compression testing to determine the cause. - 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
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	- Drain the oil. - Install the correct viscosity oil.
Worn crankshaft thrust bearing	- Inspect the thrust bearing and crankshaft. - Repair or replace as required.
High valve lifter leak down rate	Replace the lifters as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

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Cause	Correction
Low oil pressure	- Perform an oil pressure test. Refer <u>Oil Pressure Diagnosis and Testing</u>. - Repair or replace as required.
Loose and/or worn valve rocker arm attachments	- Inspect the valve rocker arm stud, nut, or bolt. - Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Bent or damaged push rod	Inspect the following components, and replace as required: - The valve rocker arm - The valve push rod - The valve lifter
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: - The valve rocker arm - The valve push rod - The valve lifter - The oil filter bypass valve - The oil pump and pump screen - The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn timing chain tensioner - if applicable	Replace the timing chain tensioners as required.
Worn engine camshaft lobes	- Inspect the engine camshaft lobes. - Replace the camshaft and valve lifters as required.
Damaged, broken, or dirty, balance shaft sprocket teeth - if applicable	Inspect the following components, and repair as required: - The balance shaft gear - 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

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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

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • 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.	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to <u>Knock Sensor (KS) System Description</u> in Engine Controls.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • 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.	• Inspect the oil pan. • Inspect the oil pump screen • Repair or replace as required.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings

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	• 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.	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the knock sensor system. Refer to <u>Knock Sensor (KS) System Description</u> in Engine Controls.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel - automatic transmission	• Inspect the flywheel bolts and flywheel. • 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

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

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.
Seized balance shaft bearing if equipped	1. Inspect balance shaft bearings. 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.	

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

Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket/Faulty lower intake manifold gasket	Replace the head gasket, faulty lower intake manifold gasket and components as required. Refer to <u>Cylinder Head Assemble</u> and <u>Cylinder Head Replacement - Left</u> or <u>Cylinder Head Replacement - Right</u> .
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to <u>Cylinder Head Replacement - Left</u> or <u>Cylinder Head Replacement - Right</u> .
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 <u>Lower Engine Noise, Regardless of Engine Speed</u>. 2. Inspect by performing a <u>Cylinder Leakage Test</u>. 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 <u>Engine Compression Test</u>.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket/faulty lower intake manifold gasket	Replace the head gasket, lower intake manifold gasket and components as required. Refer to <u>Cylinder Head Assemble</u> and <u>Cylinder Head</u>

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

ENGINE COMPRESSION TEST

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 I/P fuse block. Refer to Electrical Center Identification Views in Wiring Systems.

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. Record the compression readings from all of the cylinders.
 - The lowest reading should not be less than 70 percent of the highest reading.
 - No cylinder reading should be less than 689 kPa (100 psi).
8. The following list contains examples of the possible measurements:
 - When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
 - When the compression is low on the first stroke and tends to build up on the following strokes, but does not reach the normal compression, the piston rings may be the cause.
 - If the compression improves considerably with the addition of three squirts of oil, the piston rings may be the cause.
 - When the compression is low on the first stroke and does not build up in the following strokes, 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 two adjacent cylinders, or coolant is present in the crankcase, the head gasket may be the cause.
9. Remove the block from the throttle plate.
 10. Install the air duct to the throttle body.
 11. Install the spark plugs.
 12. Install the powertrain control module (PCM) fuse.
 13. Install the ignition fuse to the I/P fuse block.

CYLINDER LEAKAGE TEST

Testing Procedure

Tools Required

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

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 in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
3. Install the **J 35667-A**. See **Special Tools and Equipment**.
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 and Equipment**. Refer to the manufacturer's instructions.
6. Record the cylinder leakage readings for each cylinder.

IMPORTANT:

- Normal cylinder leakage is from 12 to 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**.
 - Inspect the engine block. Refer to **Engine Block Cleaning and Inspection**.
11. Remove the **J 35667-A**. See **Special Tools and Equipment**.
12. Install the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

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.

- 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 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 25087-C Oil Pressure Tester

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** in General Information.
3. Remove the oil filter.
4. Assemble the plunger valve in the large hole of the **J 25087-C** base. Insert the hose in the small hole of the **J 25087-C** base. Connect the gauge 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** on the filter mounting pad.
7. Start the engine.
8. Inspect the overall oil pressure, the oil pressure switch, and for noisy lifters. Ensure that the engine is at operating temperature before inspecting the oil pressure. 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.

OIL LEAK DIAGNOSIS

Tools Required

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

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
- Engine coolant
- Fuel

Visual Inspection Method

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

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

Powder Method

1. Completely clean the entire engine and surrounding components.
2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area.

3. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.
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 and Equipment**. 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

Concern	Action
External oil leak	Inspect for any of the following conditions: • Plugged positive crankcase ventilation (PCV) valve. • Plugged or kinked PCV hoses. • Damaged or incorrectly installed PCV valve or hoses. • Excessive crankcase pressure.
Rough Idle	Inspect for any of the following conditions:

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	• Plugged PCV valve. • Plugged or kinked PCV hoses. • Leaking or damaged PCV valve or hoses.
Stalling or slow idle speed	Inspect for any of the following conditions: • Plugged PCV valve. • Plugged or kinked PCV hoses. • Leaking or damaged PCV valve or hoses.
High idle speed	Inspect for a leaking or damaged PCV valve or hoses.
Sludge in the engine	Inspect for any of the following conditions: • Plugged PCV valve. • Plugged or kinked PCV hoses.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt 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.

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

Test Description

The 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 belt 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 belt 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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
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. • It usually occurs on cold damp mornings.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to <u>Engine Noise on Start-Up, but Only Lasting a Few Seconds</u> or <u>Upper Engine Noise, Regardless of Engine Speed</u> or <u>Lower Engine Noise, Regardless of Engine Speed</u>	Go to Step 4
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does 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 15	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 15	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 15	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
	Tighten any loose fasteners.		

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11	Replace any improper or missing fasteners. Refer to <u>Fastener Tightening Specifications</u> . Did you complete the repair?	Go to Step 15	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 13	Go to Step 14
13	Replace the bent pulley. Did you complete the repair?	Go to Step 15	Go to Step 14
14	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the repair?	Go to Step 15	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

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

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

Test Description

The numbers below refer to the step 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 belt and operating the engine for a brief period will verify the squeal noise is the drive belt or an accessory drive component. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.
- 4:** This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.
- 5:** This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
- 6:** This test is to verify that the drive 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.
- 7:** Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or

outward from a previous repair. Test for a misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt (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.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to <u>Engine Noise on Start-Up, but Only Lasting a Few Seconds</u>	Go to Step 4
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to Step 9	Go to Step 5
5	Test the drive belt tensioner for proper operation. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Did you find and correct the condition?	Go to Step 9	Go to Step 6
6	Inspect for the correct drive belt length. Refer to <u>Drive Belt Replacement</u> . Did you find and correct the condition?	Go to Step 9	Go to Step 7
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 9	Go to Step 8
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 9	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT WHINE DIAGNOSIS

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Diagnostic Aids

The drive belt will not cause the whine noise.

If the whine noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. Such items but not limited to may be an A/C system overcharged, the power steering system restricted or the wrong fluid, or the generator failing.

Test Description

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

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

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belt may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper inspection and replacement procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u> . 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to <u>Engine Noise on Start-Up, but Only Lasting a Few Seconds</u>	Go to Step 4
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to Step 5	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

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

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

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 the drive belt is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

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

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

Drive Belt Rumbling Diagnosis

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

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3	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u>. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to <u>Engine Noise on Start-Up, but Only Lasting a Few Seconds</u>	Go to Step 4
4	Inspect the drive belt for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to <u>Drive Belt Replacement</u>. Did you complete the repair?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <u>Drive Belt Replacement</u>. Did you complete the replacement?	Go to Step 8	-
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

DRIVE BELT VIBRATION DIAGNOSIS**Diagnostic Aids**

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

Test Description

The 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 such as the exhaust system, or the drivetrain.

3: This test is to verify that the drive belt or accessory drive components may be causing the vibration. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4: The drive belt may cause a vibration. While the drive belt is removed this is the best time to inspect the condition of the belt.

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

installed.

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

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
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 Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u> . 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to Step 6	Go to Step 4
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to Step 5	Go to Step 6
5	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the replacement?	Go to Step 10	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 7	Go to Step 8
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to <u>Fastener Tightening Specifications</u> . Did you complete the repair?	Go to Step 10	-
8	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to <u>Water Pump Replacement (3.1L)</u> or <u>Water Pump Replacement (3.8L)</u> in Engine Cooling. Did you find and correct the condition?	Go to Step 10	Go to Step 9
9	Inspect for bent or cracked brackets.		Go to Diagnostic

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	Did you find and correct the condition?	Go to Step 10	Aids
10	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

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

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

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

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 misalign pulley using a straight edge in the pulley grooves across two or three pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

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

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

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

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Inspect for a damaged drive belt.		

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	Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . 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	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to <u>Fastener Tightening Specifications</u> . 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 <u>Drive Belt Tensioner Diagnosis</u> . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . 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

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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: 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.

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

4: This inspection is to verify the drive belt 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 Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</u> in Cautions and Notices.			
DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Symptoms - Engine Mechanical operation and perform the necessary inspections?	Go to Step 2	Go to <u>Symptoms - Engine Mechanical</u>
2	Inspect the drive belt for the proper installation. Refer to <u>Drive Belt Replacement</u> . Did you find this condition?	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the replacement?	Go to Step 6	-
6	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	1. Remove the drive belt. Refer to <u>Drive Belt Replacement</u> . 2. 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
	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop.		

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3	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% of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement

Removal Procedure

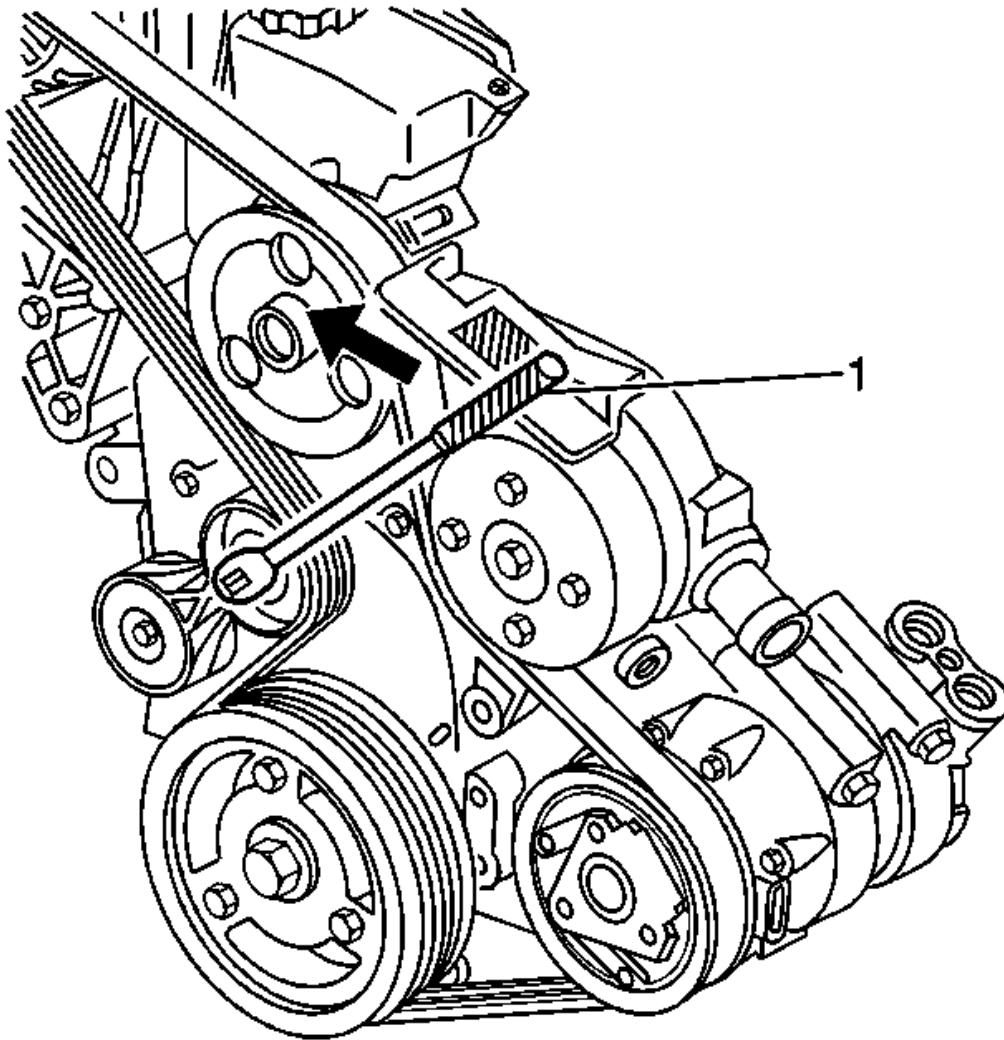


Fig. 6: Removing/Installing Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner by lifting or rotating the drive belt tensioner off of the drive belt, using a 3/8 inch breaker bar (1).

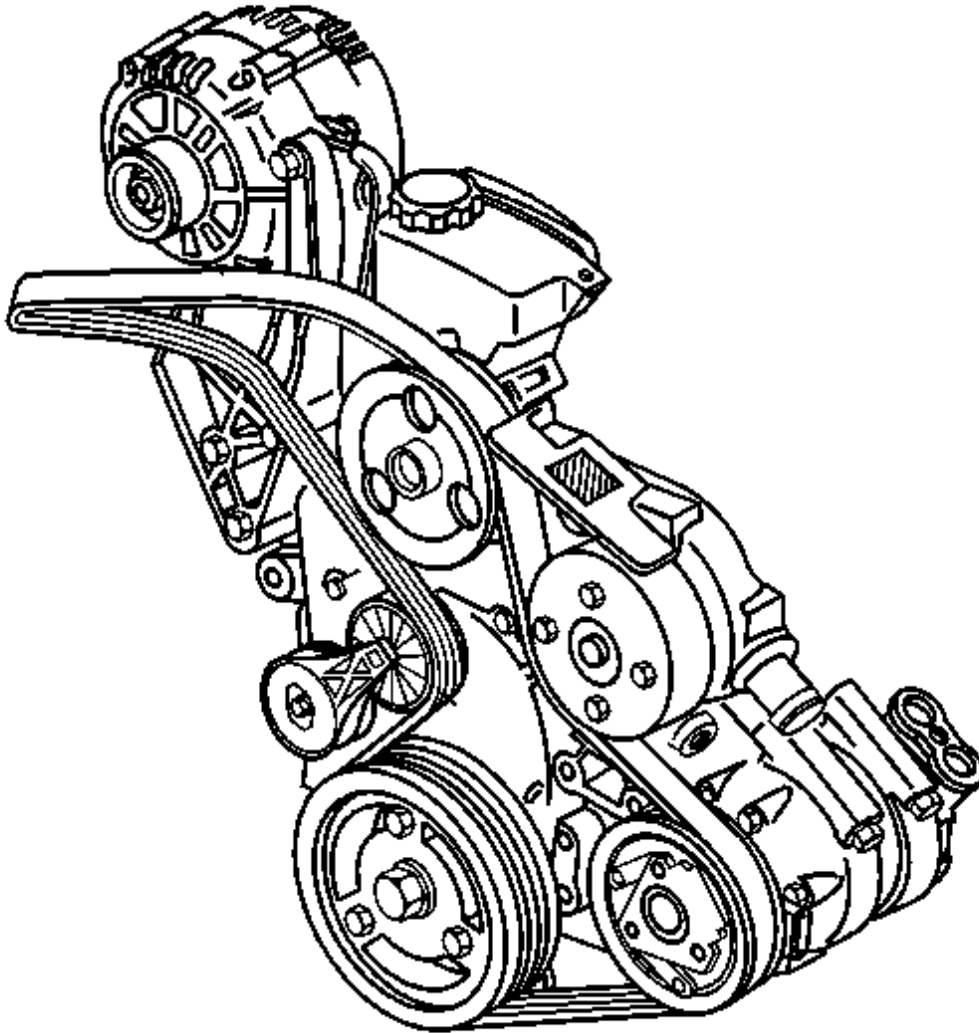


Fig. 7: Drive Belt Routing

Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt.

Installation Procedure

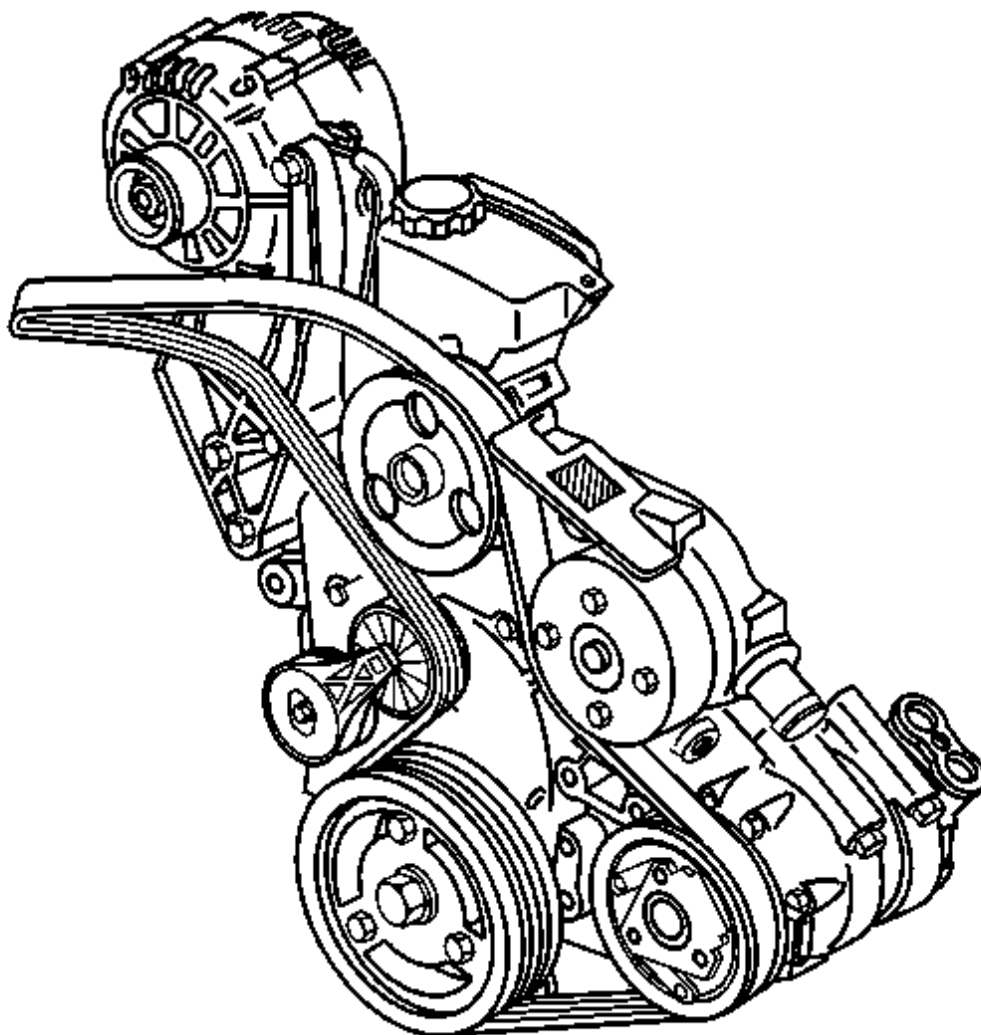


Fig. 8: Drive Belt Routing

Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt.
2. Inspect the drive belt and the drive belt system. Refer to **Drive Belt Excessive Wear Diagnosis**.

IMPORTANT: Make sure that the drive belt is aligned into the proper grooves of the accessory drive belt pulleys.

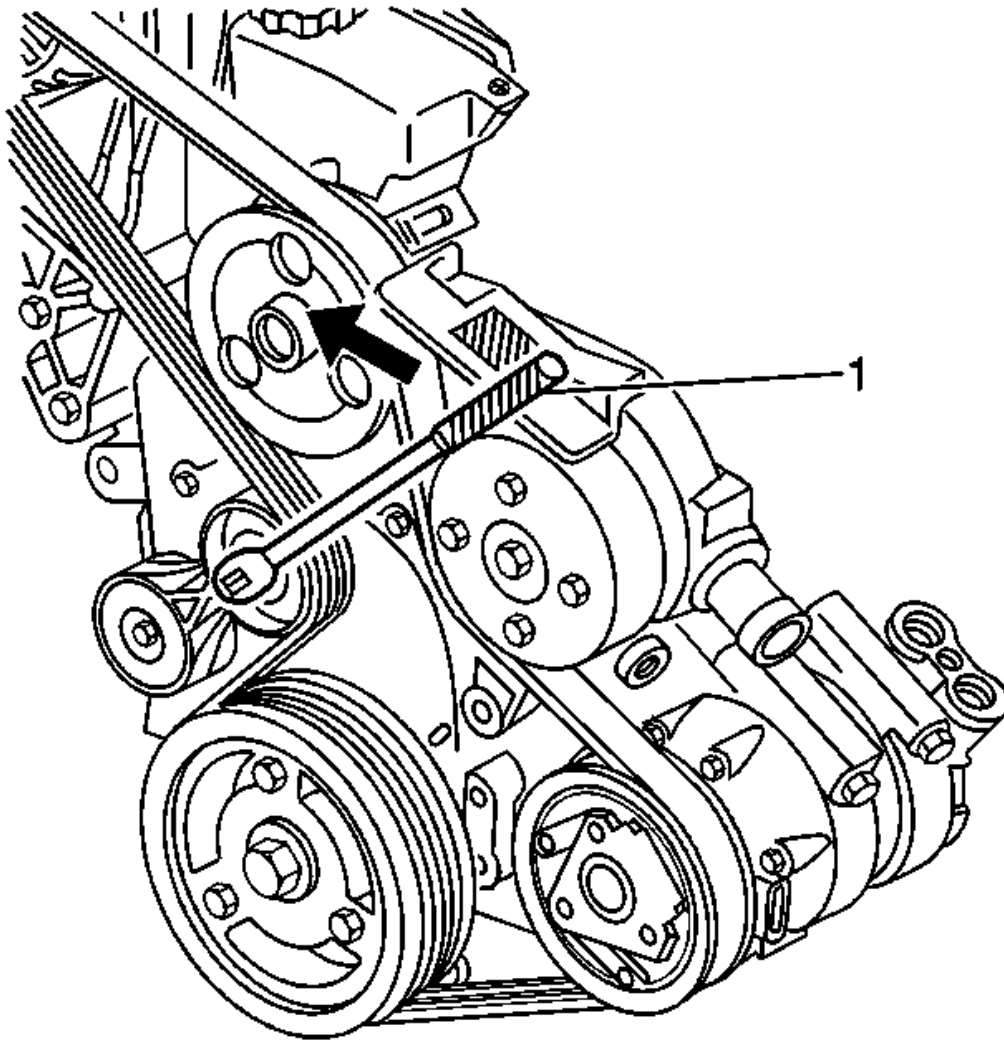


Fig. 9: Removing/Installing Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Install the drive belt under the drive belt tensioner pulley by lifting or rotating the drive belt tensioner, using a 3/8 inch breaker bar (1).

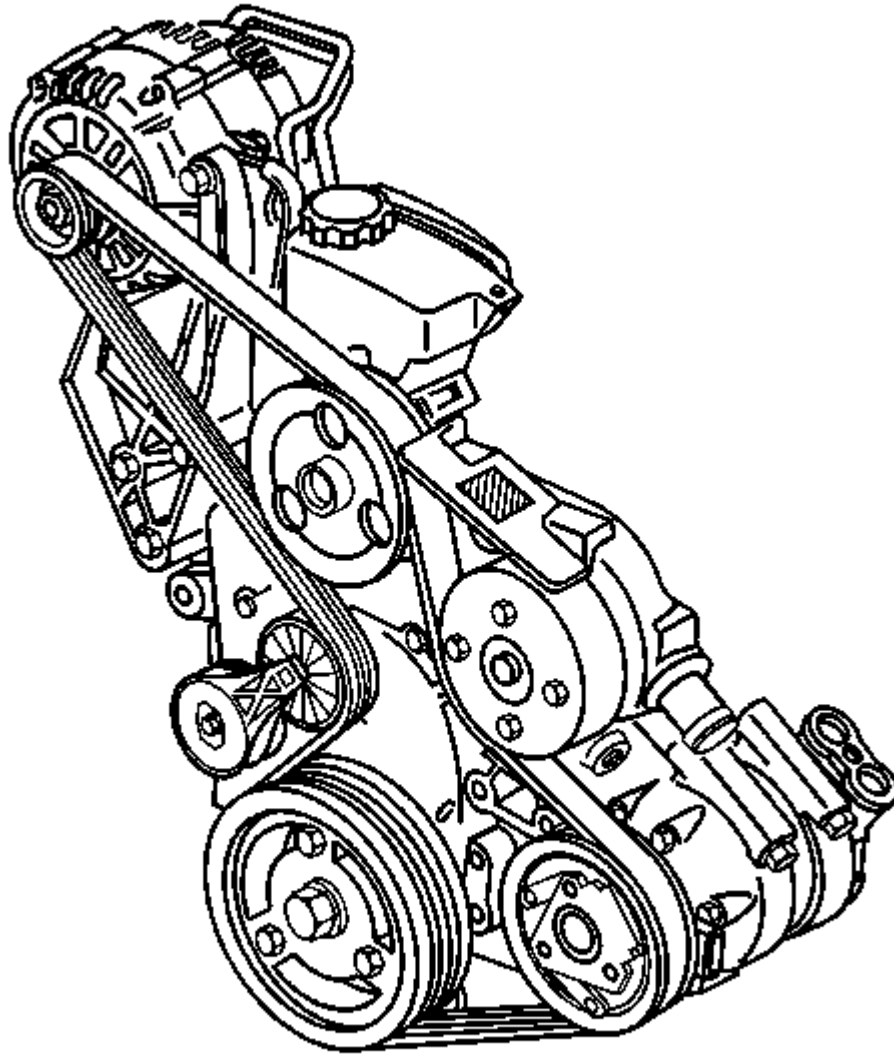


Fig. 10: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

4. Ensure that the drive belt is properly routed.
5. Inspect the drive belt length scale on the drive belt tensioner for the proper installed length.

Drive Belt Tensioner Replacement

Removal Procedure

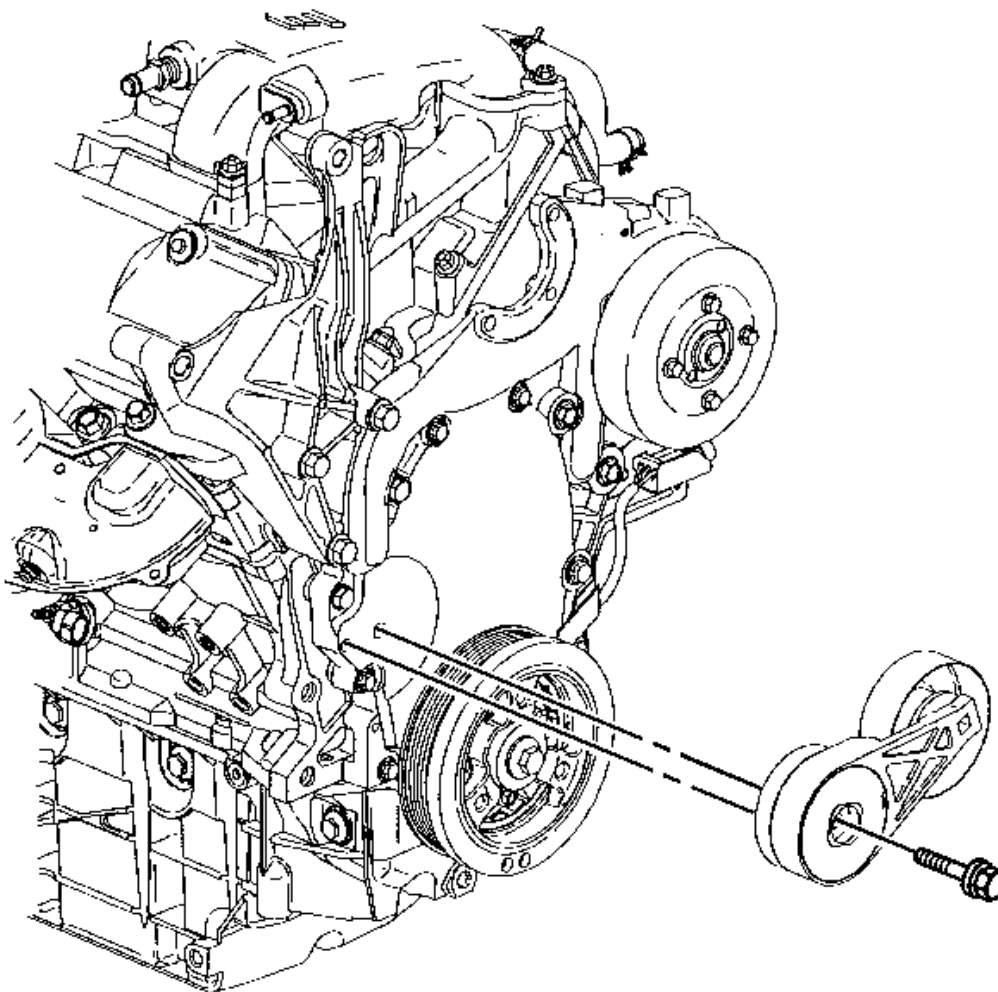


Fig. 11: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant recovery reservoir. Refer to **Coolant Recovery Reservoir Replacement** in Engine Cooling.
2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Remove the drive belt tensioner bolt.
4. Remove the drive belt tensioner.

Installation Procedure

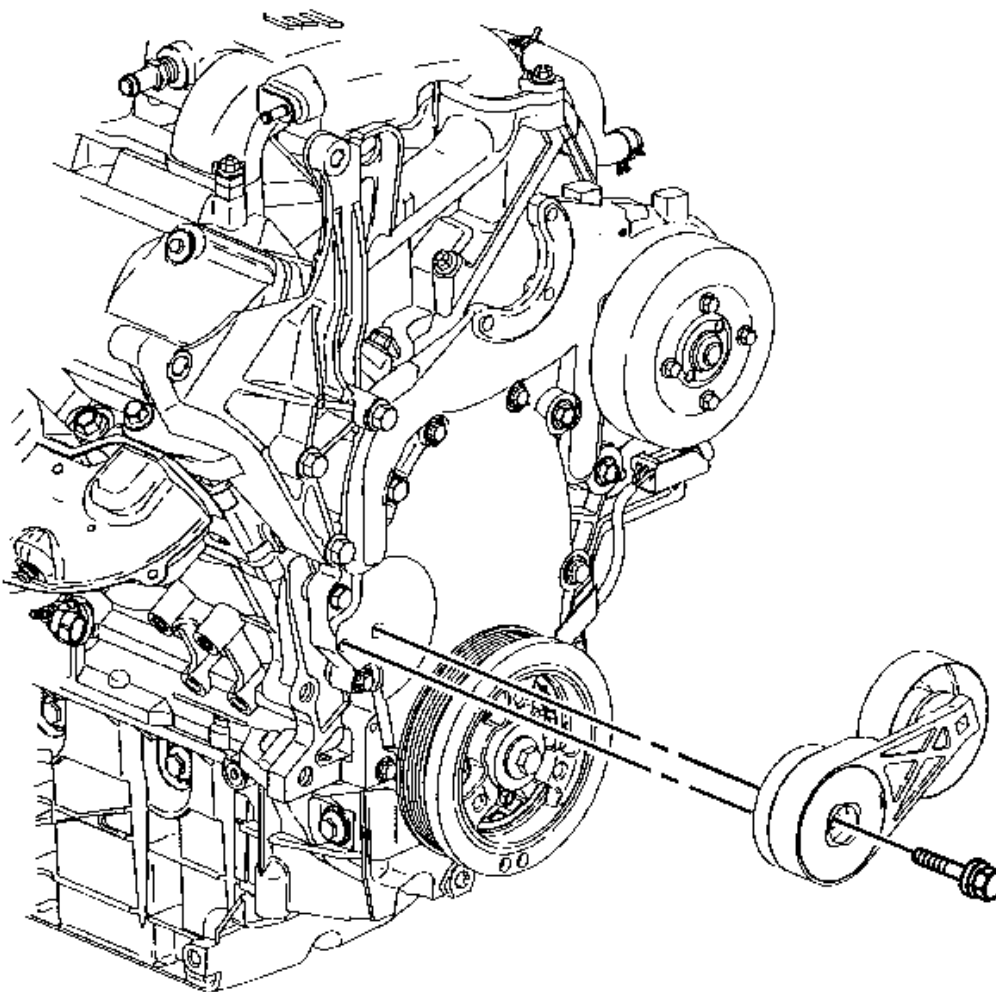


Fig. 12: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolt.

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

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

4. Install the coolant recovery reservoir. Refer to **Coolant Recovery Reservoir Replacement** in Engine Cooling.

Engine Mount Inspection

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

1. Raise the engine in order to remove the weight from the engine mount and create slight tension in the rubber.
2. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber surface 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.
3. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket. Refer to **Engine Mount Replacement**.
4. For information on the transaxle mount, refer to **Automatic Transmission Mount Replacement** in Automatic Transaxle - 4T65-E.

Engine Support Fixture**Tools Required**

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools and Equipment**.
 - **J 36462-A** Engine Support Adapter Leg Set. See **Special Tools and Equipment**.
 - **J-28467-501** Engine Support Fixture Adapters. See **Special Tools and Equipment**.
1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

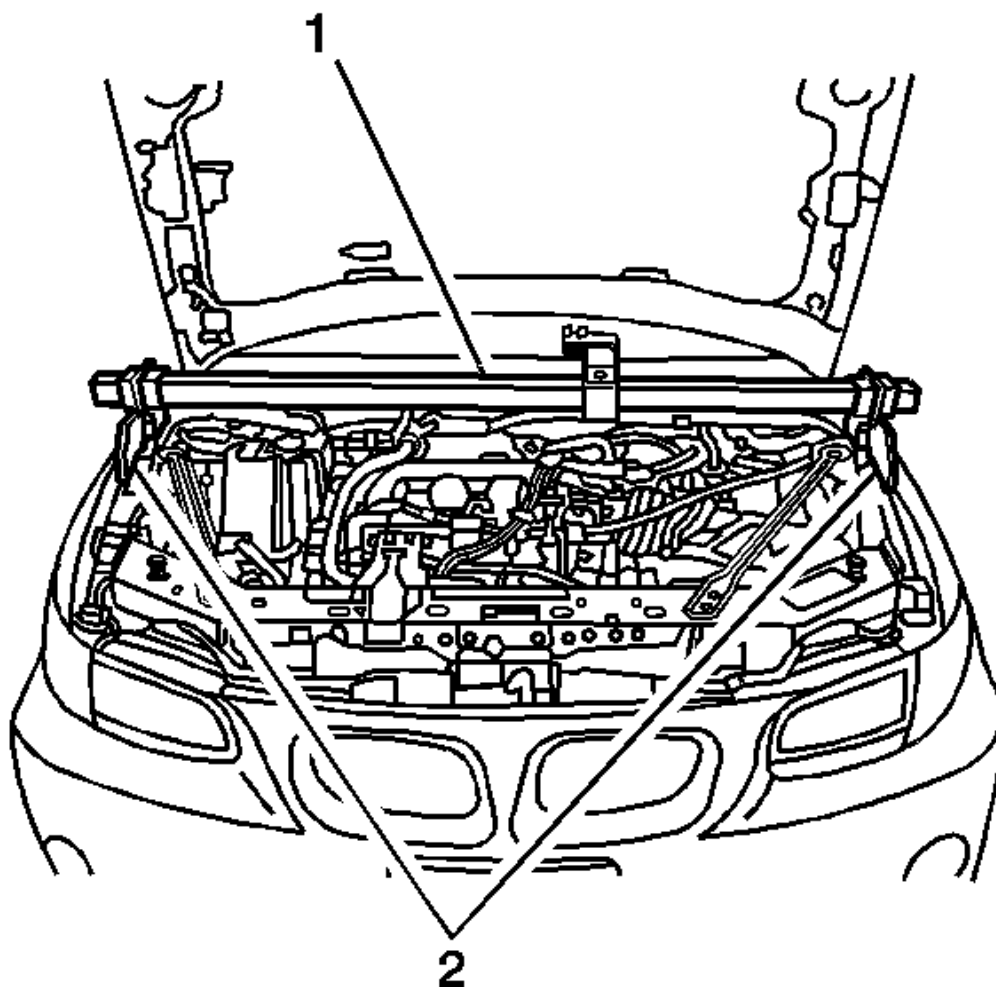


Fig. 13: J 28467-B & J-28467-501
Courtesy of GENERAL MOTORS CORP.

2. Remove the left engine mount strut and the bracket from the upper radiator support. Refer to **Engine Mount Strut Bracket Replacement - Upper Radiator Support**.
3. Assemble the **J-28467-501** (2) to the **J 28467-B** cross bar (1). See **Special Tools and Equipment**.
4. Install the **J 28467-B** (1) and the **J-28467-501** (2) to the fender rails.

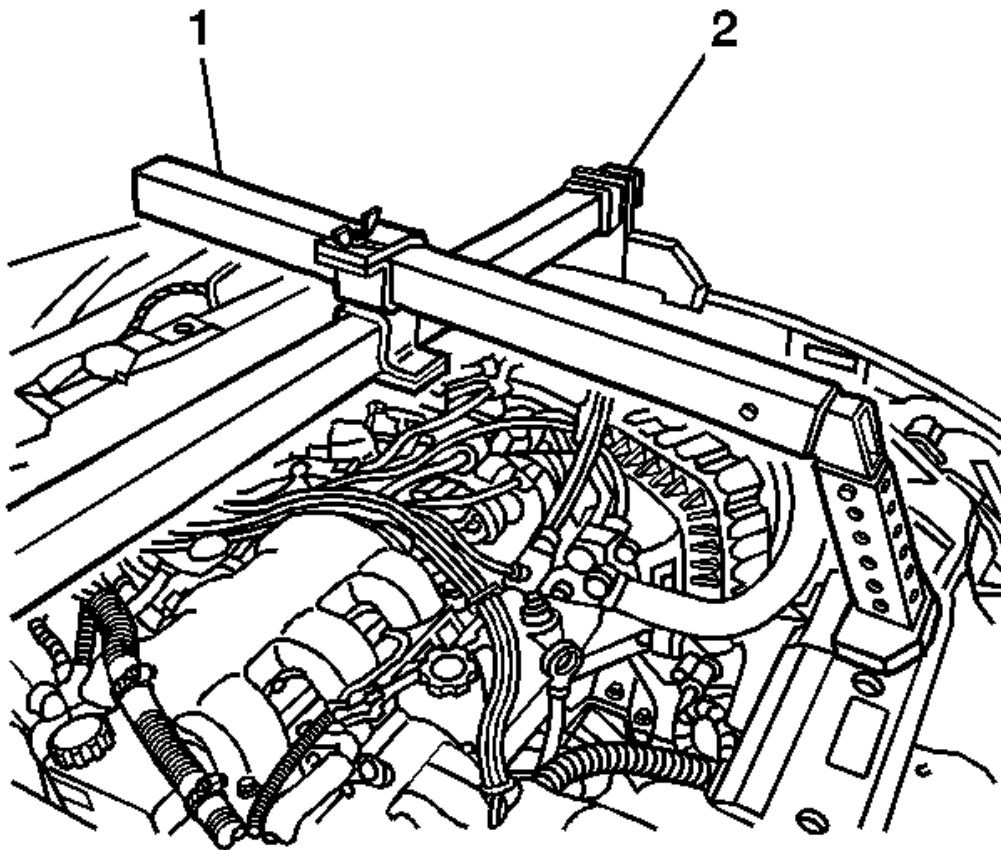


Fig. 14: J 36462-A & Cross Bar
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 36462-A** (1) to the cross bar (2).

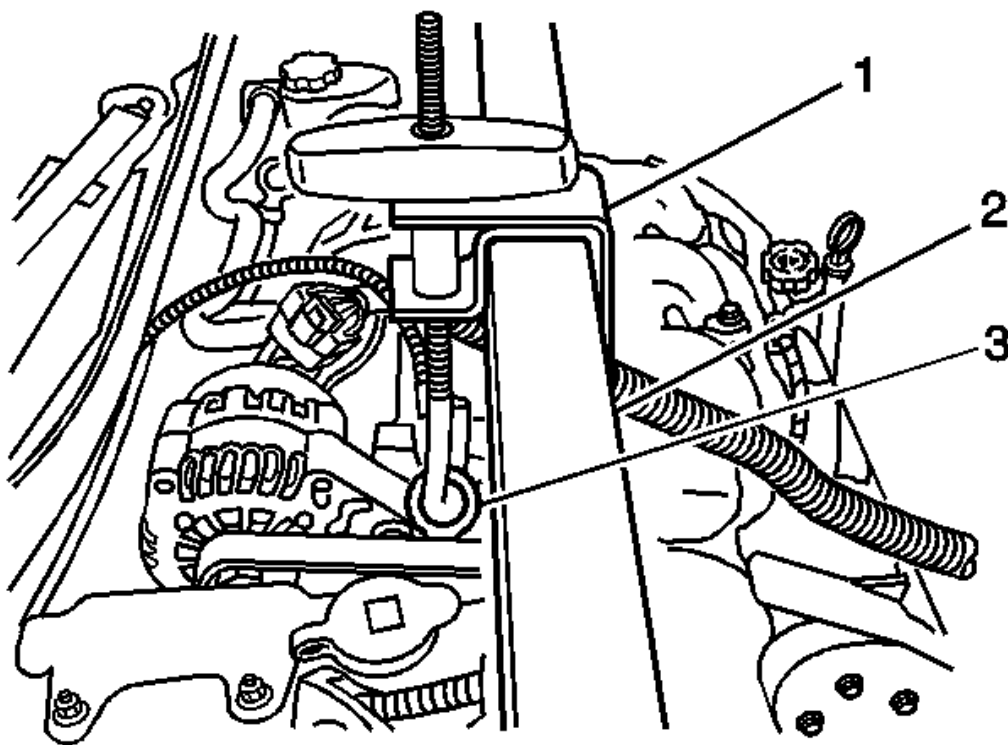


Fig. 15: Support Lift Hook, Cross Bar & Right Engine Lift Hook
Courtesy of GENERAL MOTORS CORP.

6. Install the support lift hook (1) to the cross bar (2).
7. Install the support hook (1) to the right engine lift hook (3).

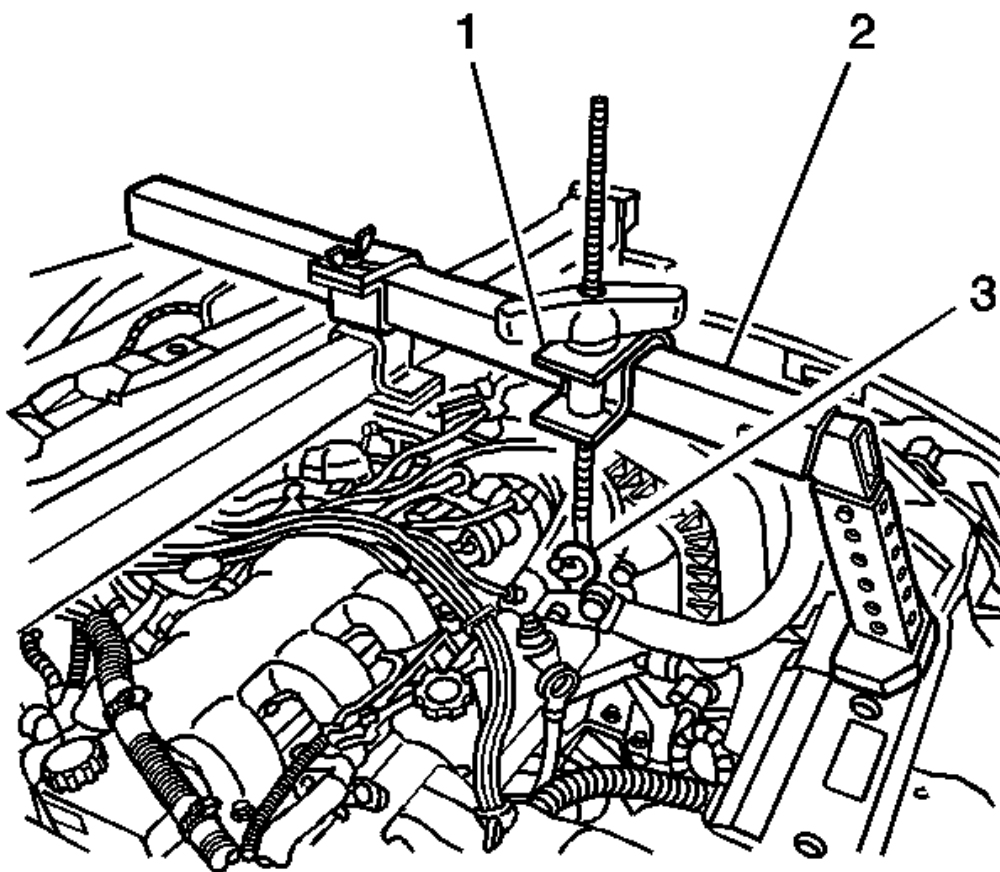


Fig. 16: Support Hook, J 36462-A & Engine Lift Hook
Courtesy of GENERAL MOTORS CORP.

8. Install the support hook (1) to the J 36462-A (2).
9. Install the support hook (1) to the left engine lift hook (3).

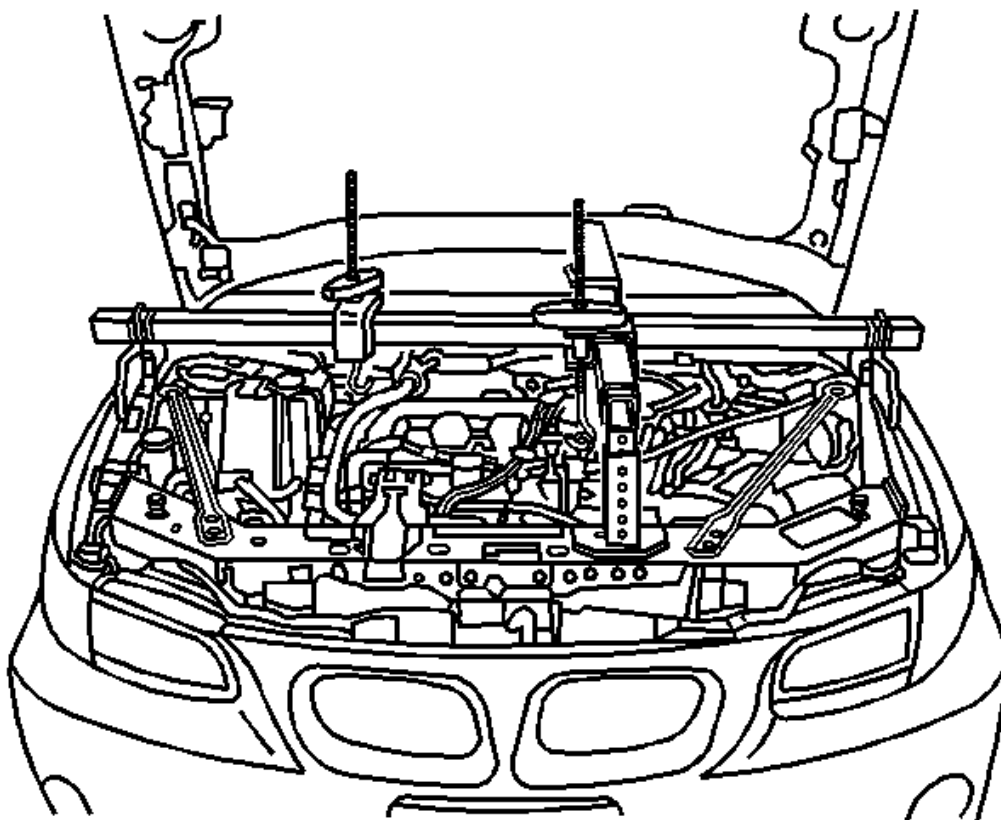


Fig. 17: Raising Engine

Courtesy of GENERAL MOTORS CORP.

10. Raise the engine to release the pressure off of the engine mounts.

Engine Mount Replacement

Removal Procedure

1. Disconnect the battery ground (negative) cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the throttle body air inlet duct.
3. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement**.
4. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
5. Remove the three-way catalytic converter pipe from the right (rear) exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
6. Remove the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and

Wheels.

7. Remove the right engine splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.

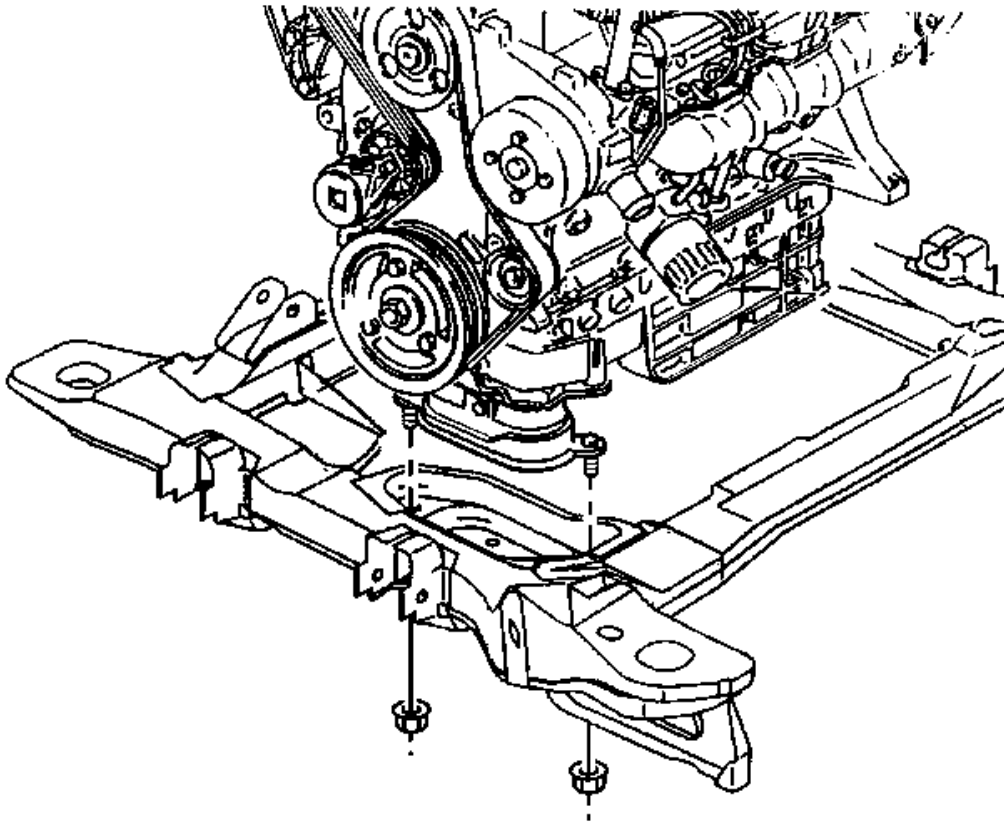


Fig. 18: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount lower nuts.
9. Raise the engine, using the engine support fixture. Refer to **Engine Support Fixture**.

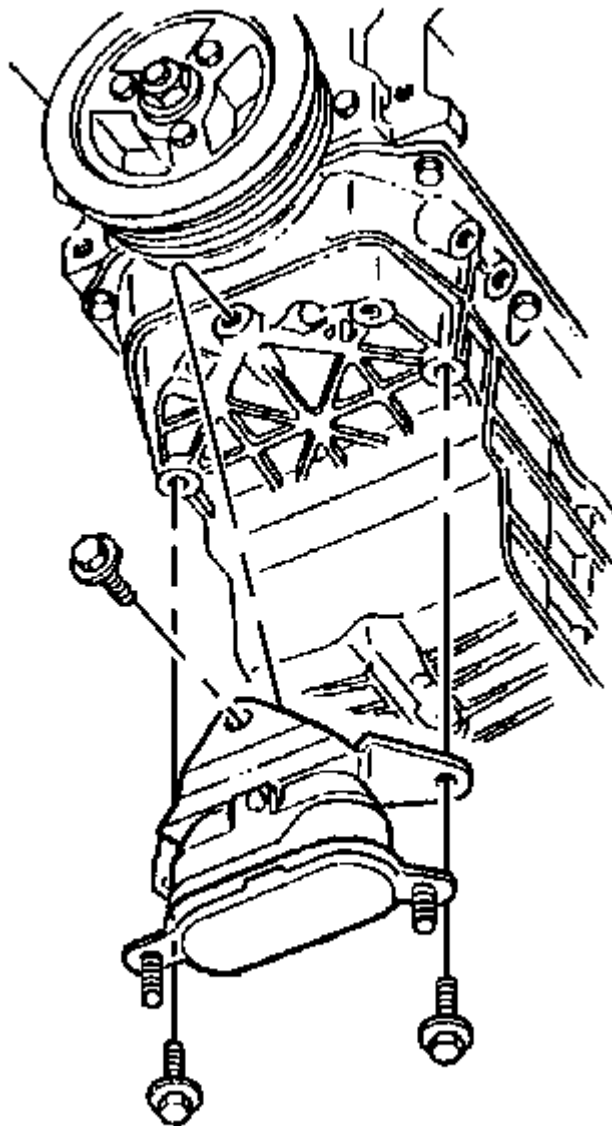


Fig. 19: Engine Mount Bracket To Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

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

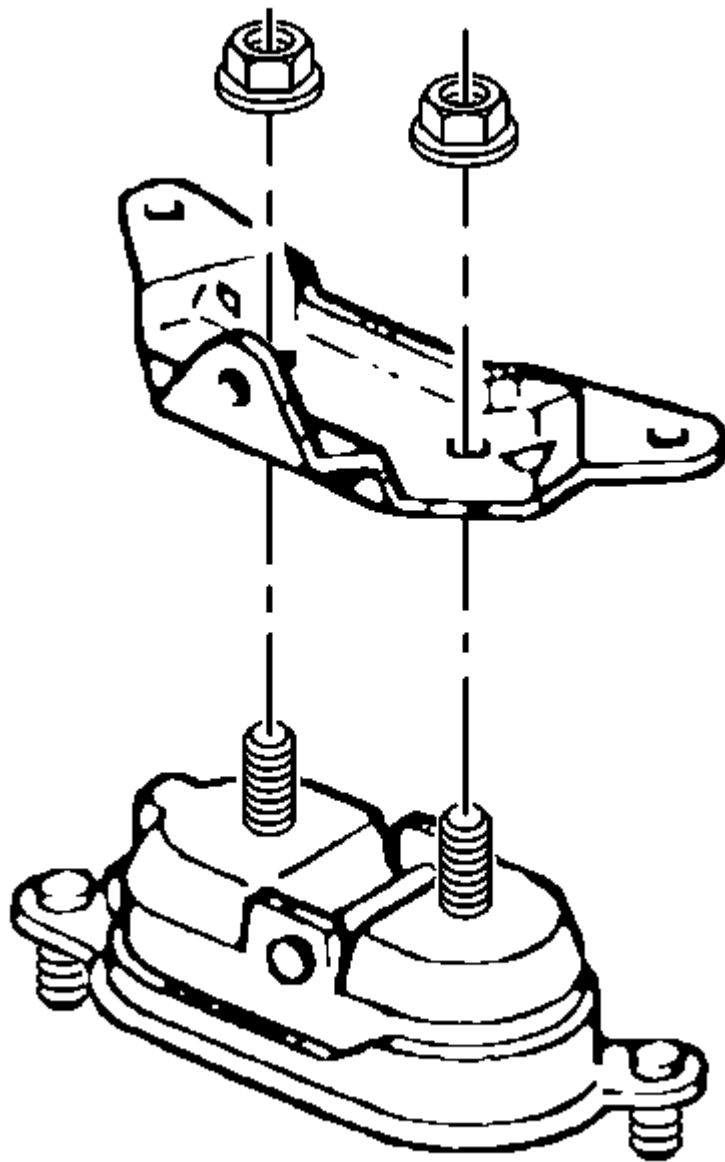


Fig. 20: Identifying Engine Mount Upper Nuts
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine mount bracket. Refer to **Engine Mount Bracket Replacement**.

Installation Procedure

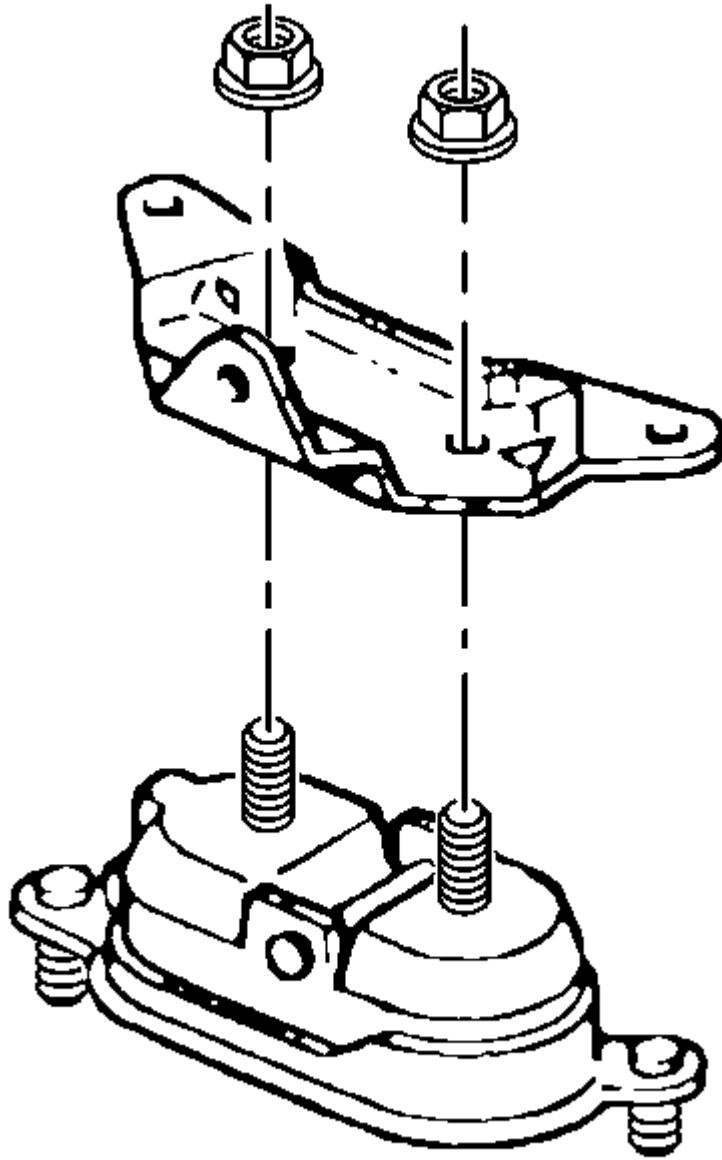


Fig. 21: Identifying Engine Mount Upper Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket. Refer to **Engine Mount Bracket Replacement**.

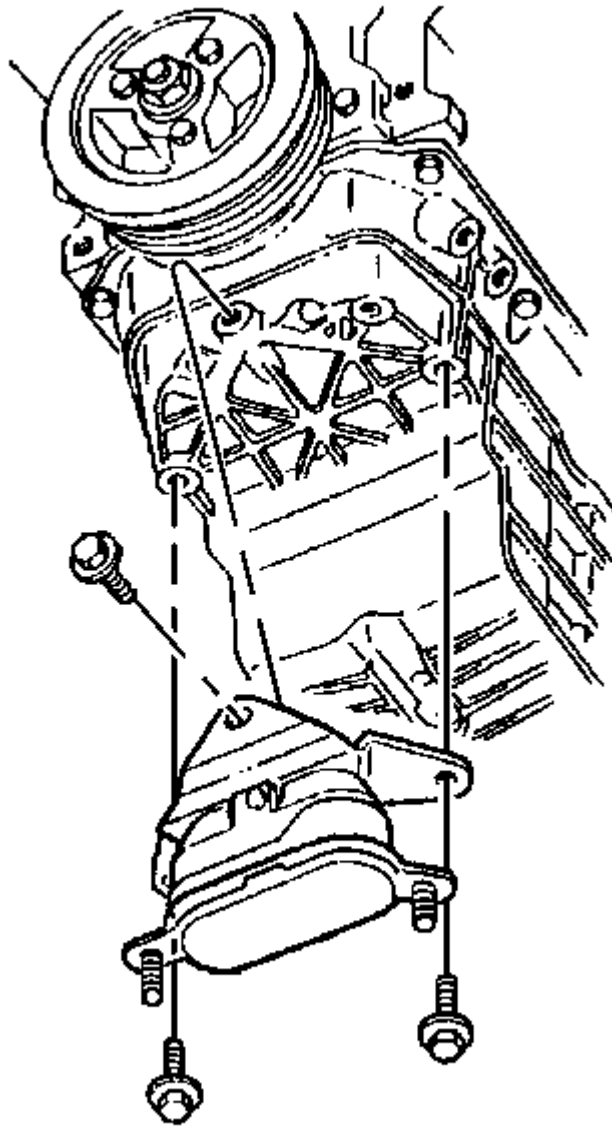


Fig. 22: Engine Mount Bracket To Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount bracket with the engine mount to the oil pan.
3. Install the engine mount bracket-to-oil pan bolts.

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

4. Lower the engine.

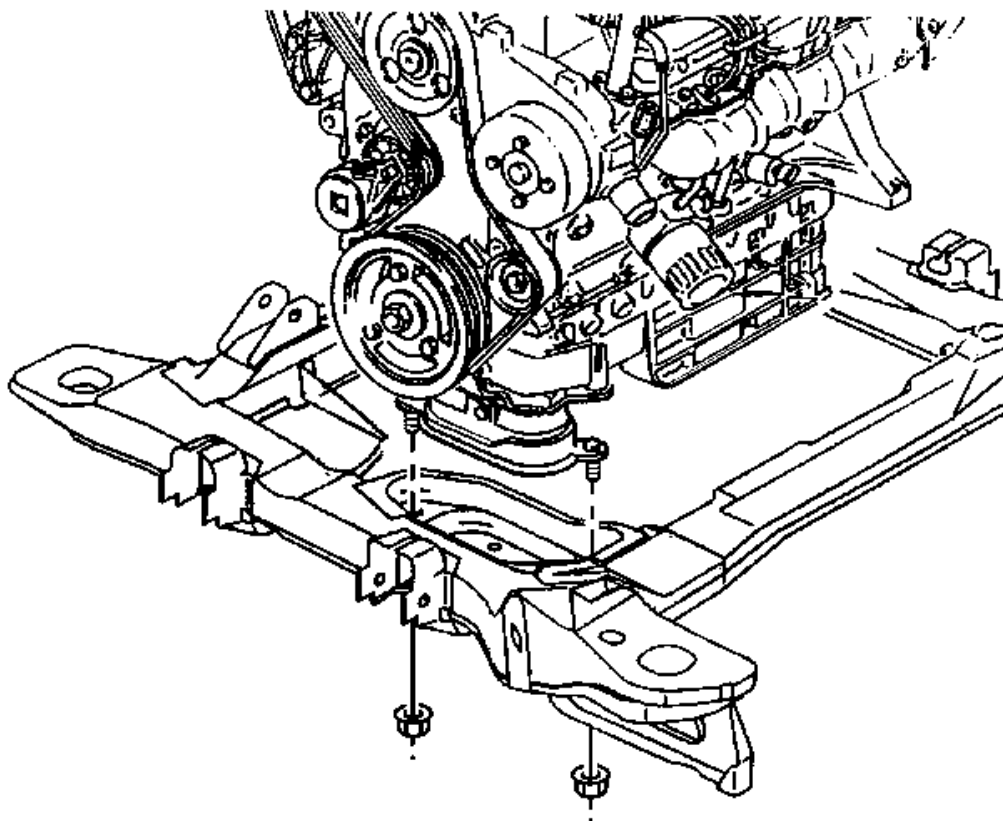


Fig. 23: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount lower nuts.

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

6. Install the right engine splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.
7. Install the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
8. Connect the three-way catalytic converter pipe to the right (rear) exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
9. Lower the vehicle.

10. Remove the engine support fixture.
11. Install the engine mount struts. Refer to **Engine Mount Strut Replacement**.
12. Install the throttle body air inlet duct.
13. Connect the battery ground (negative) cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Mount Bracket Replacement**Removal Procedure**

1. Remove the engine mount. Refer to **Engine Mount Replacement**.

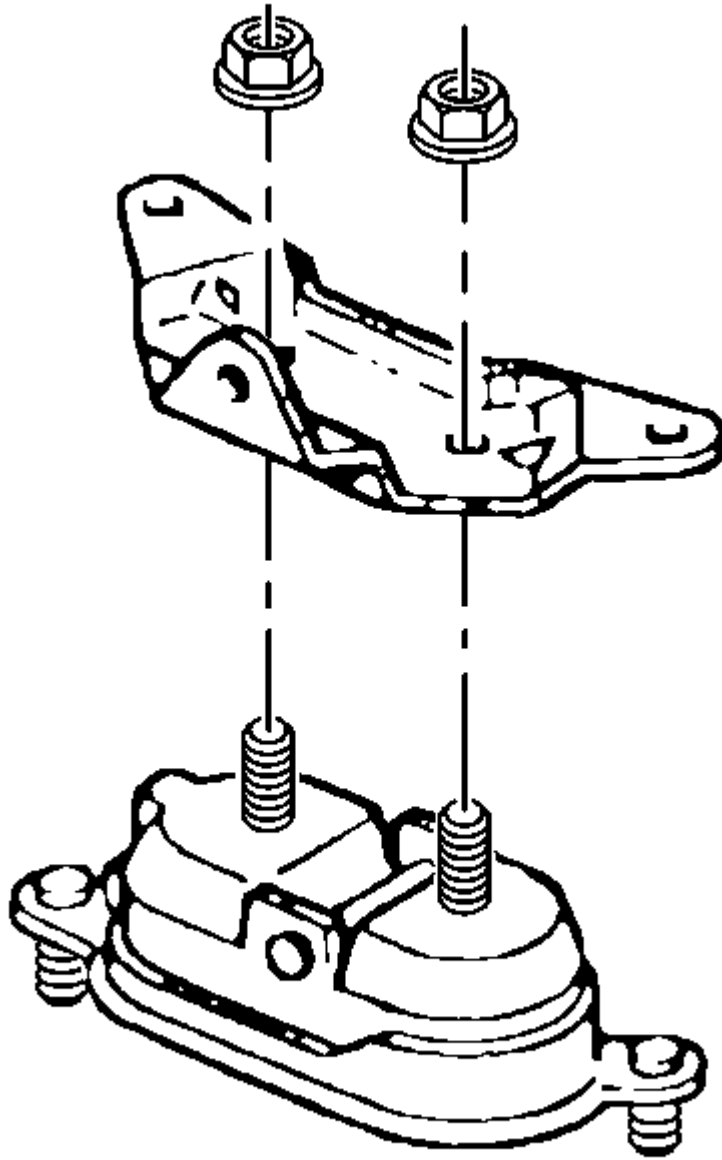


Fig. 24: Identifying Engine Mount Upper Nuts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount upper nuts.
3. Remove the engine mount bracket from the engine mount.

Installation Procedure

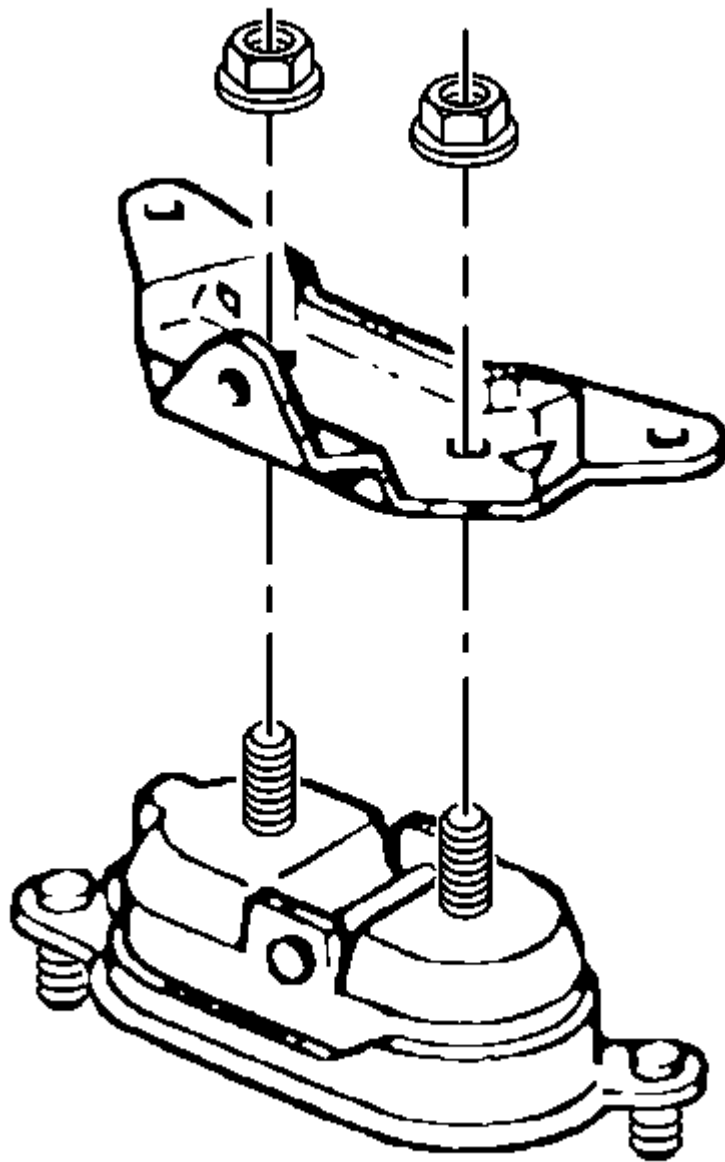


Fig. 25: Identifying Engine Mount Upper Nuts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount upper nuts.

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

3. Install the motor mount. Refer to **Engine Mount Replacement**.
4. Lower the vehicle.
5. Lower the engine.
6. Connect the battery ground (negative) cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Mount Strut Replacement

Removal Procedure

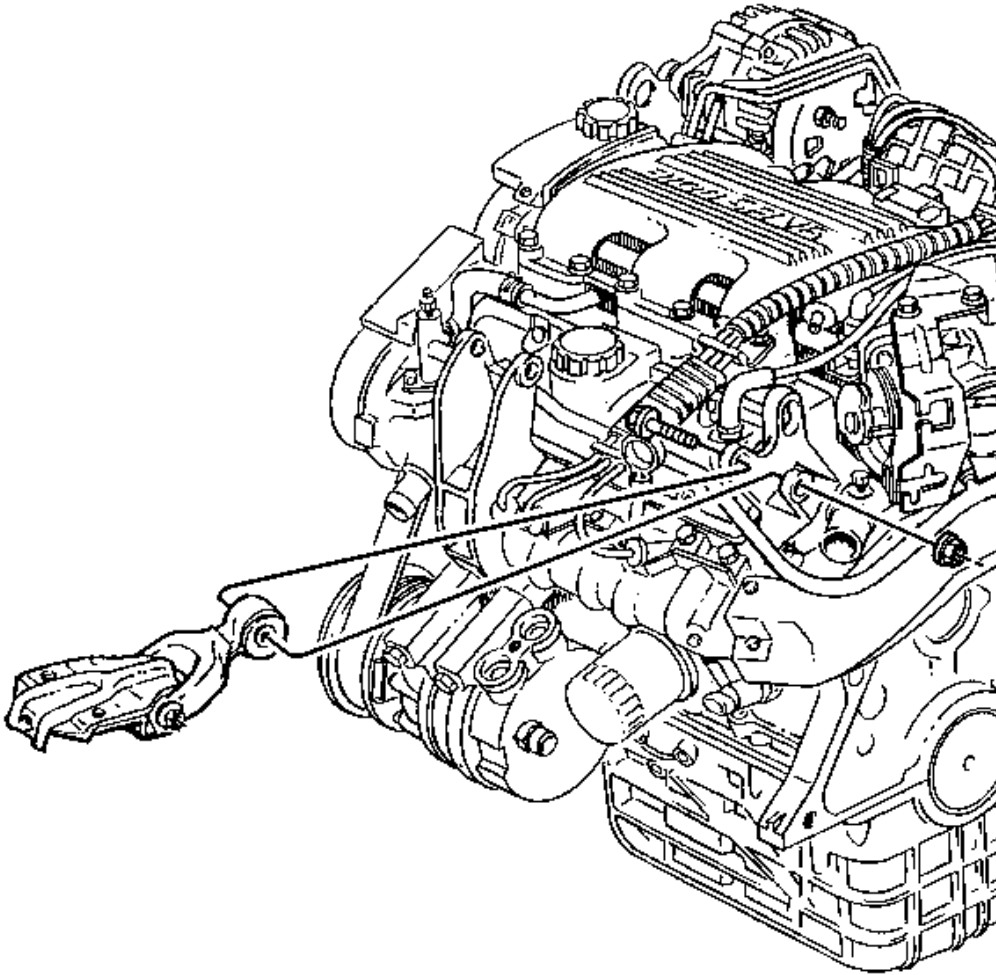


Fig. 26: Engine Mount Strut, Bracket, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt and the nut from the engine mount strut and the engine mount strut bracket.

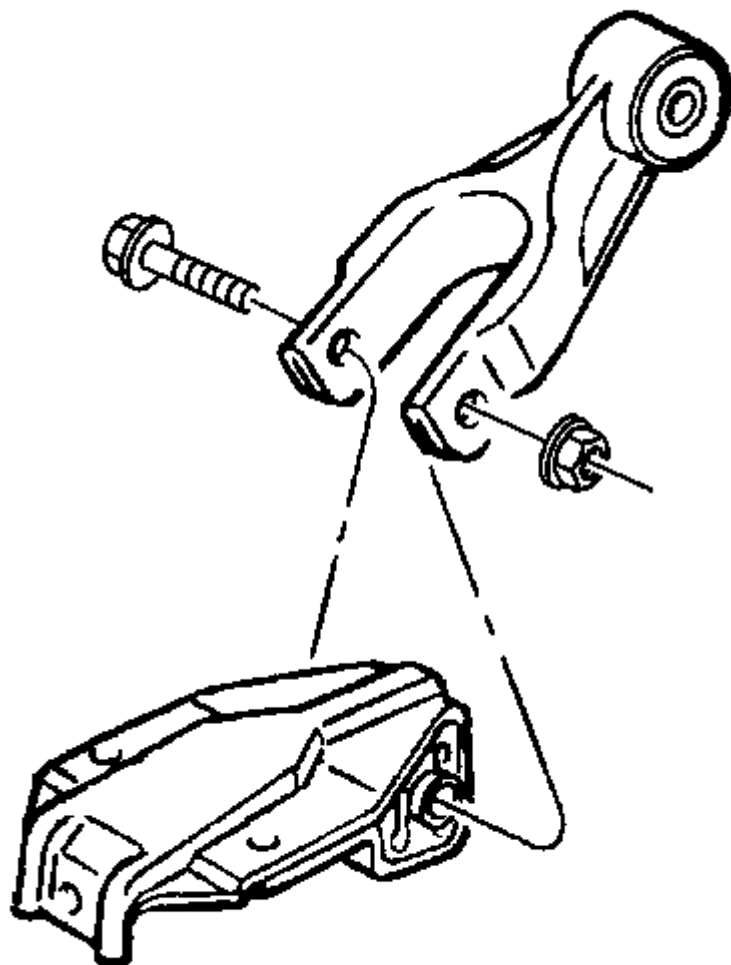


Fig. 27: Engine Mount Strut

Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt and the nut from the engine mount strut at the engine mount strut bracket on the upper radiator support.
3. Remove the engine mount strut.
4. Inspect the rubber in the engine mount strut for the following conditions:
 - Hardness
 - Splitting
 - Cracking

Installation Procedure

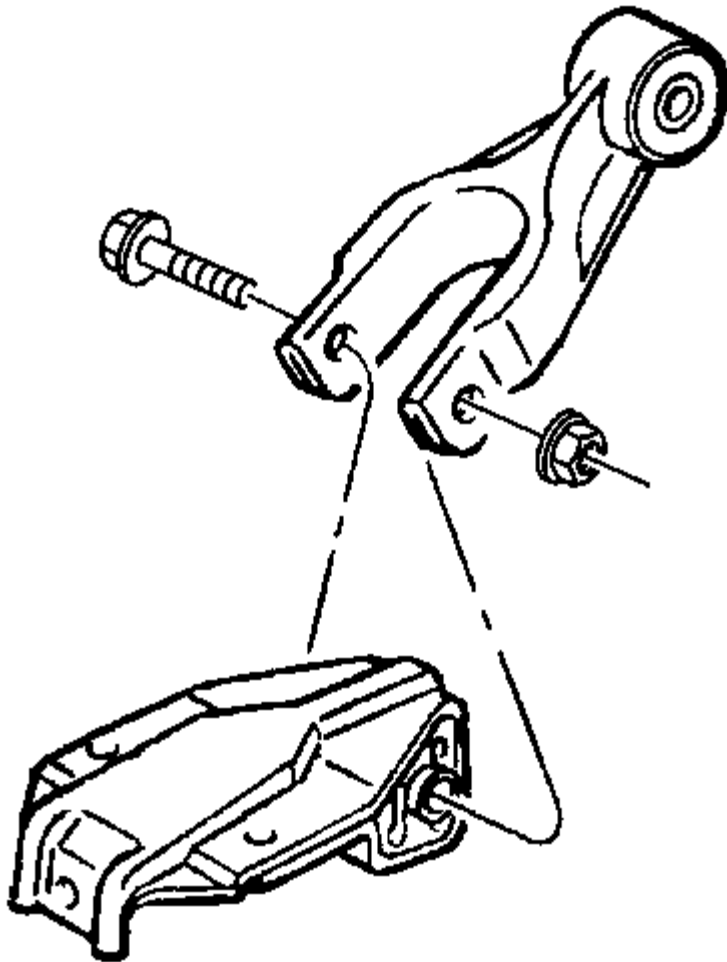


Fig. 28: Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bolt and the nut to the engine mount strut at the engine mount strut bracket on the upper radiator support.

Tighten: Tighten the engine mount strut bolt to 48 N.m (35 lb ft).

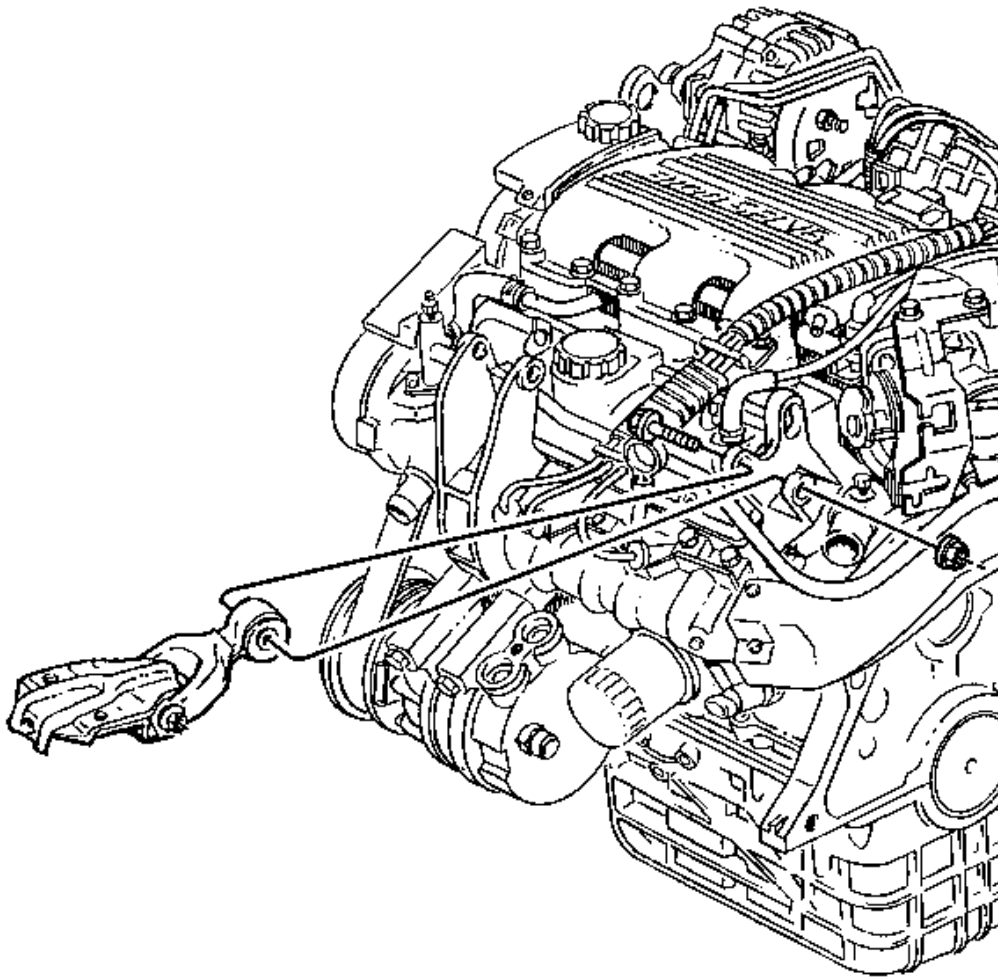


Fig. 29: Engine Mount Strut, Bracket, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the bolt and the nut to the engine mount strut and the engine mount strut bracket.

Tighten: Tighten the engine mount strut nut to 48 N.m (35 lb ft).

Engine Mount Strut Bracket Replacement - Left

Removal Procedure

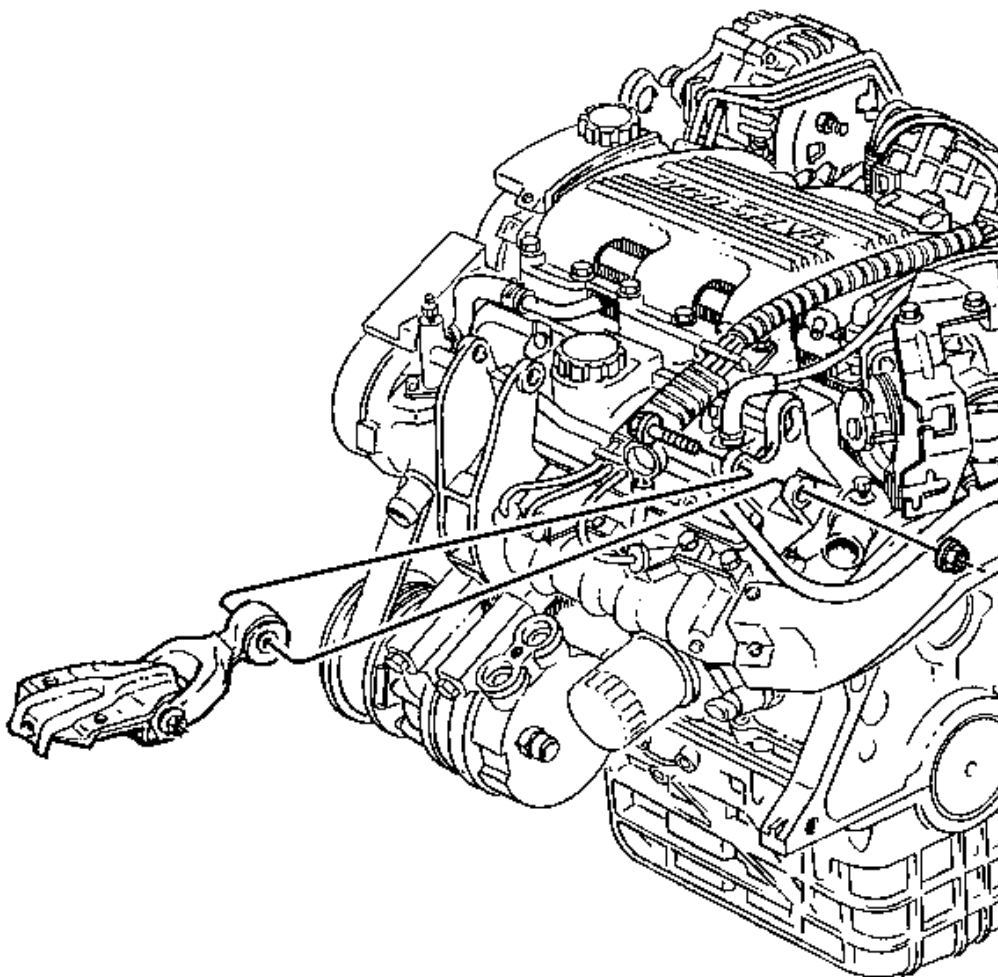


Fig. 30: Engine Mount Strut, Bracket, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut from the left engine mount strut bracket. Refer to **Engine Mount Strut Replacement**.

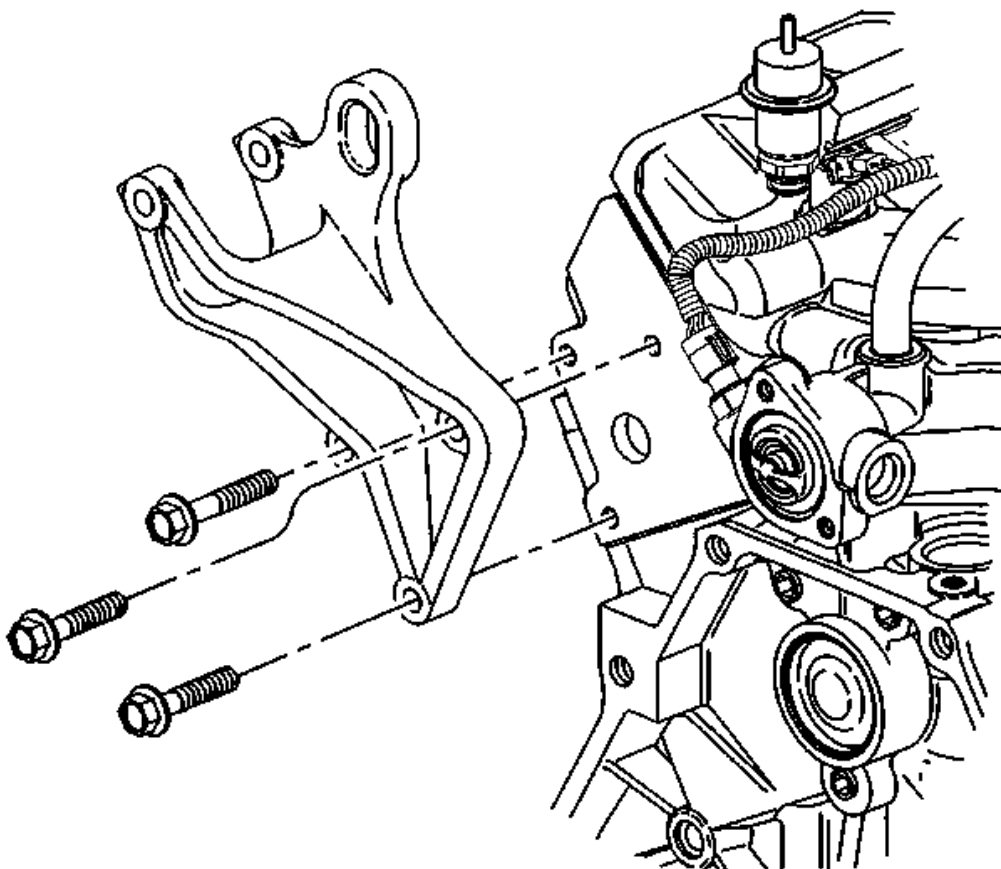


Fig. 31: Engine Mount Strut Bracket & Bolts - Left
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount strut bracket bolts from the left engine mount strut bracket to the cylinder head.
3. Remove the left engine mount strut bracket.

Installation Procedure

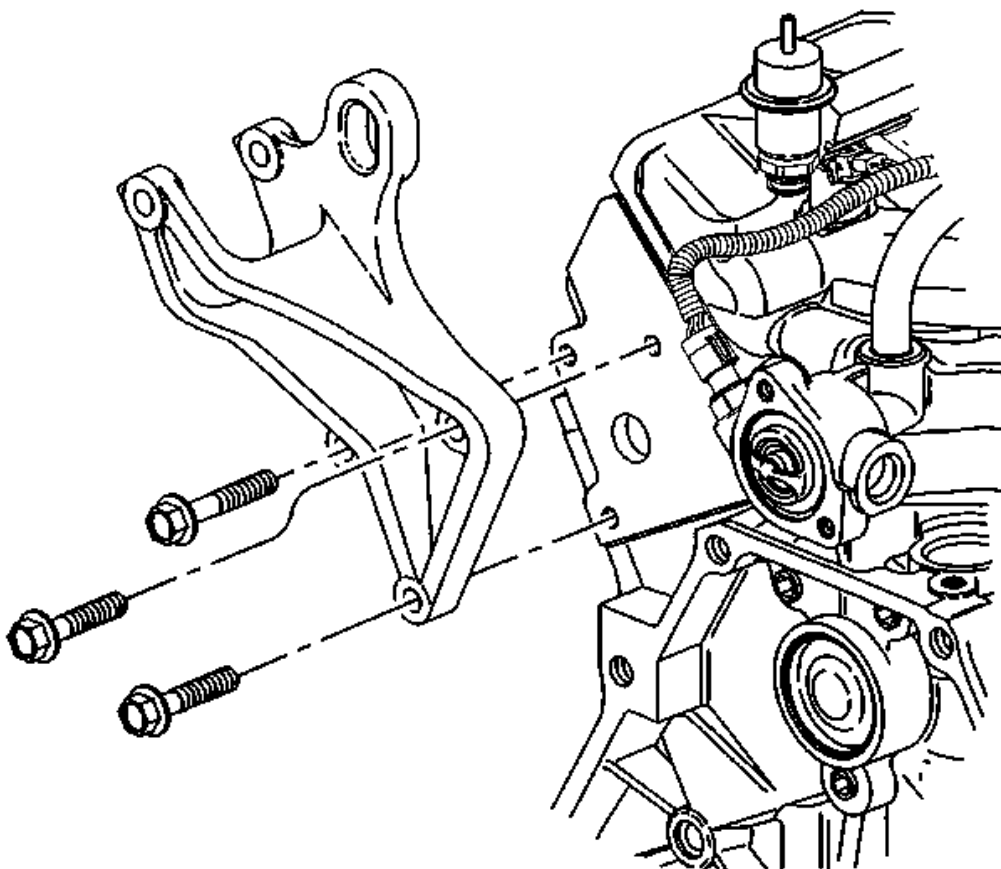


Fig. 32: Engine Mount Strut Bracket & Bolts - Left
Courtesy of GENERAL MOTORS CORP.

1. Install the left engine mount strut bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount strut bracket bolts through the engine mount strut bracket to the cylinder head.

Tighten: Tighten the engine mount strut bracket bolts to 70 N.m (52 lb ft).

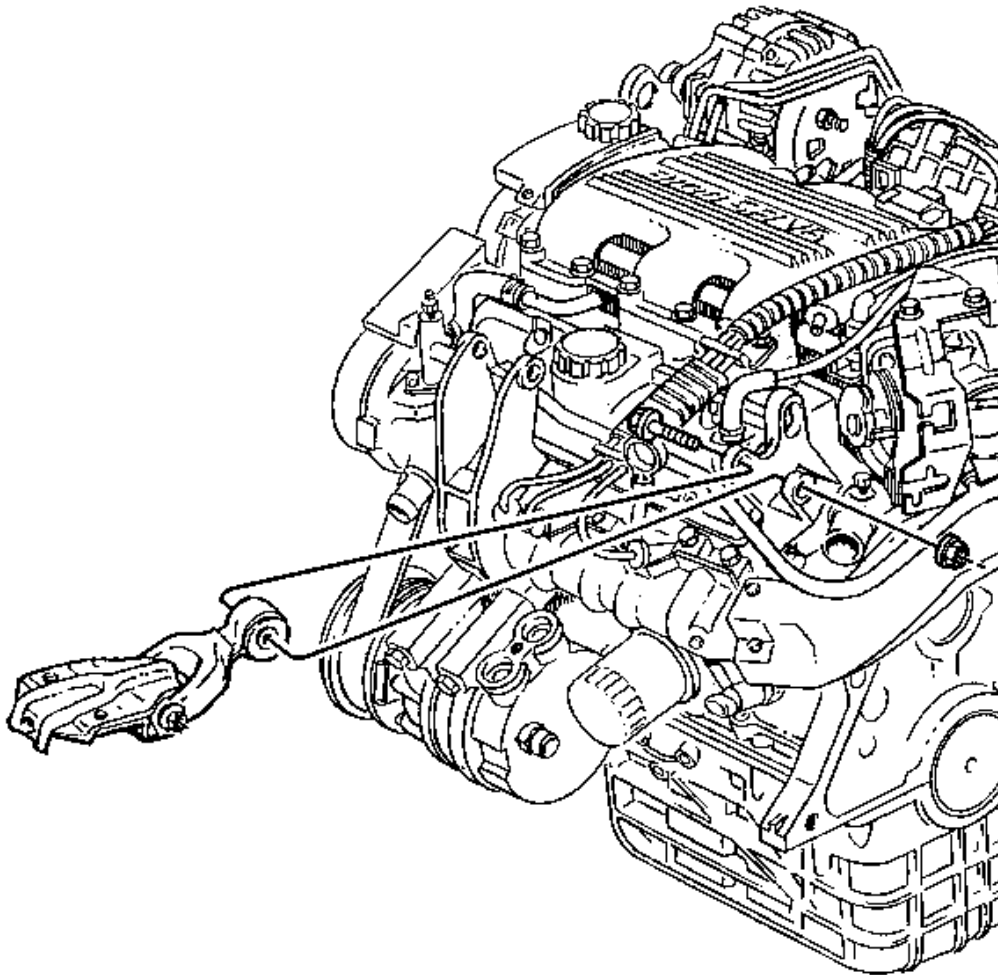


Fig. 33: Engine Mount Strut, Bracket, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount strut to the left engine mount strut bracket. Refer to **Engine Mount Strut Replacement**.

Engine Mount Strut Bracket Replacement - Right

Removal Procedure

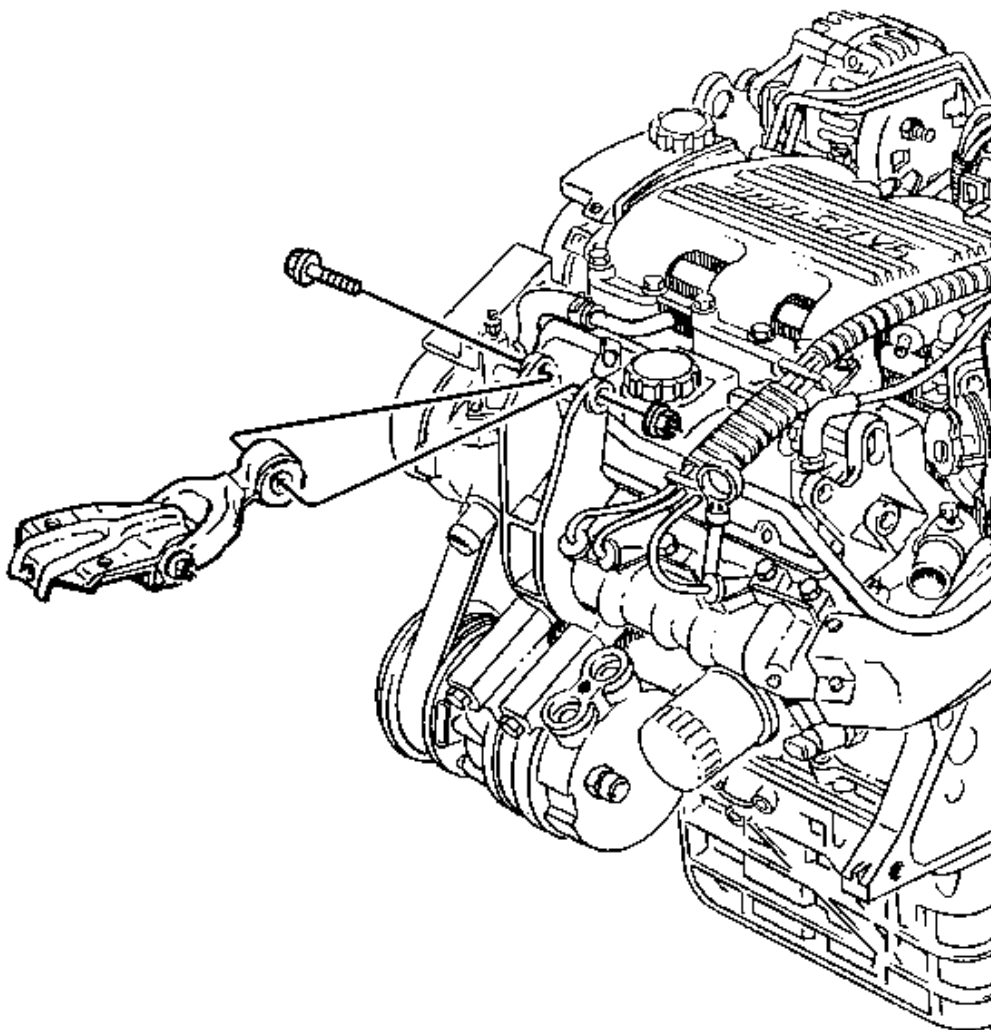


Fig. 34: Engine Mount Strut, Bracket & Bolts - Right
Courtesy of GENERAL MOTORS CORP.

1. Remove the right engine mount strut from the right engine mount strut bracket. Refer to **Engine Mount Strut Replacement**.
2. Remove the air conditioning compressor mounting bolts. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating Ventilation, and Air Conditioning.
3. Remove and set the air conditioning compressor aside.

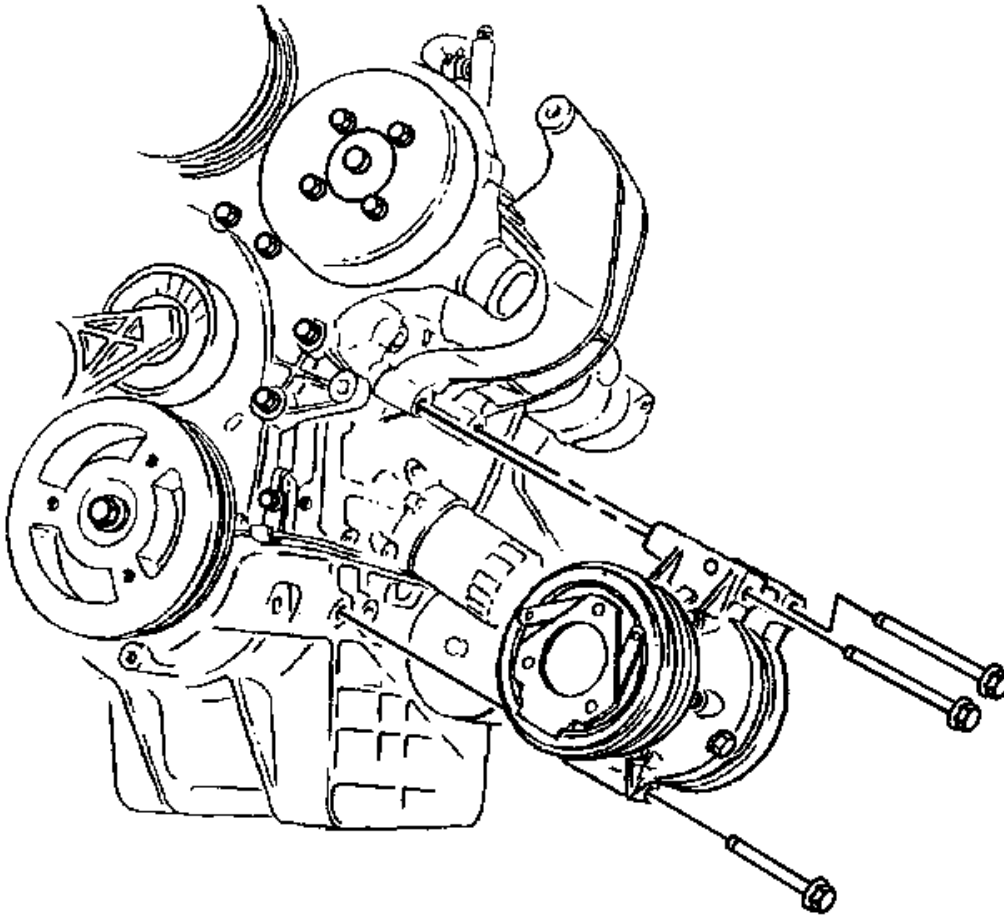


Fig. 35: Right Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts from the right engine mount strut bracket.
5. Remove the right engine mount strut bracket.

Installation Procedure

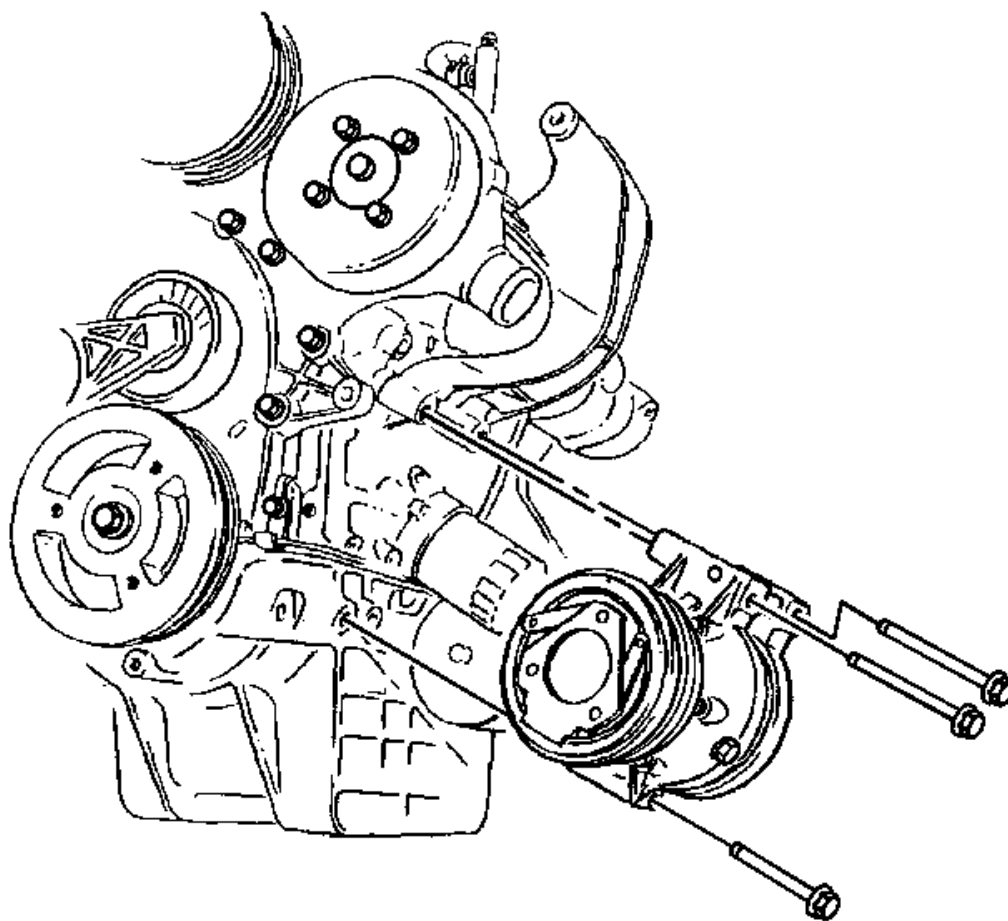


Fig. 36: Right Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the right engine mount strut bracket over the pin locator.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bolts through the right engine mount strut bracket to the cylinder head.

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

3. Install the air conditioner compressor. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating, Ventilation, and Air Conditioning.

Tighten: Tighten the air conditioning compressor mounting bolts to 50 N.m (37 lb ft).

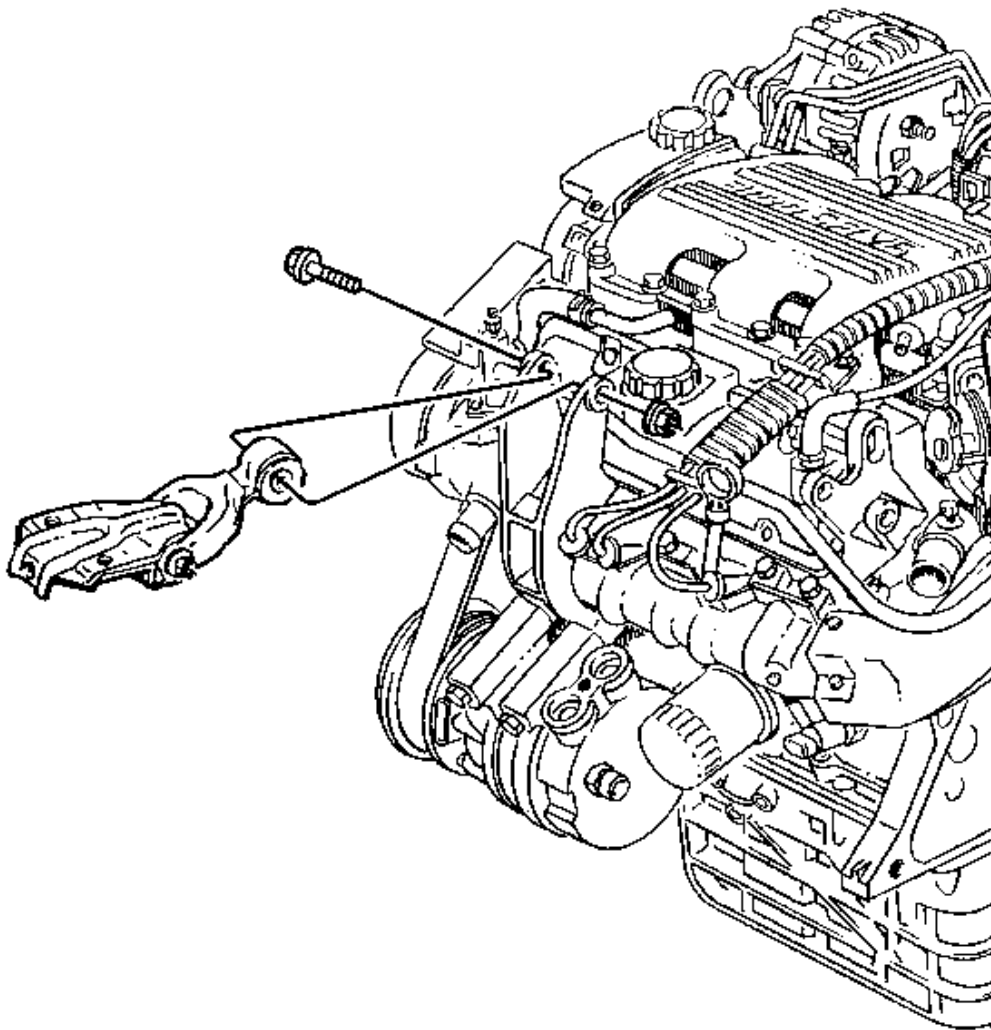


Fig. 37: Engine Mount Strut, Bracket & Bolts - Right
Courtesy of GENERAL MOTORS CORP.

4. Install the right engine mount strut to the right engine mount strut bracket. Refer to **Engine Mount Strut Replacement**.

Engine Mount Strut Bracket Replacement - Upper Radiator Support

Removal Procedure

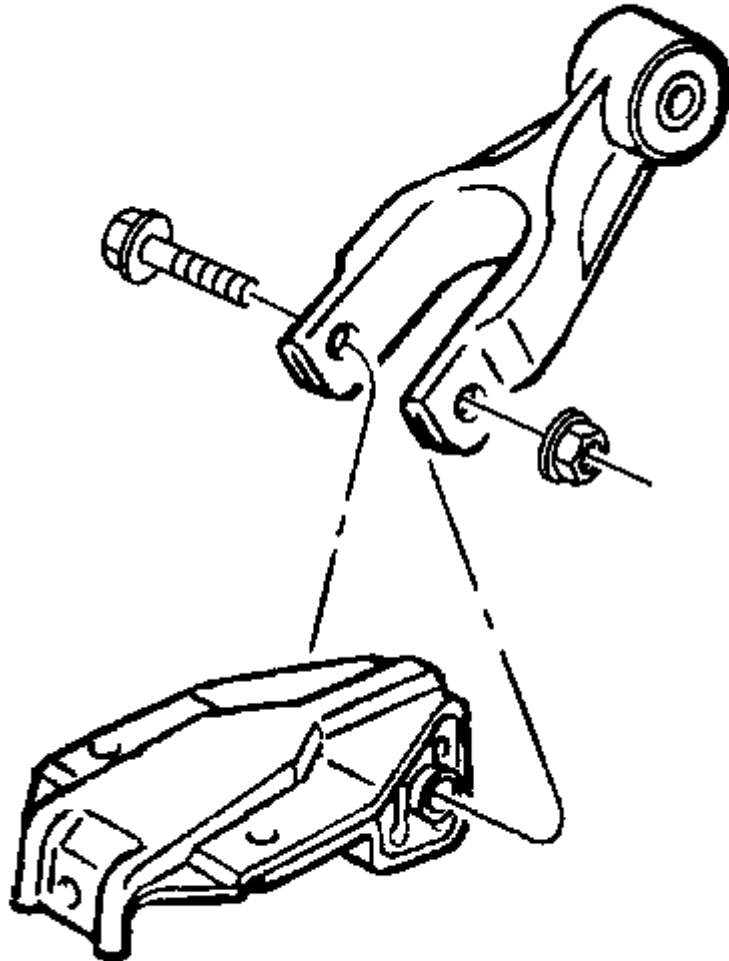


Fig. 38: Engine Mount Strut

Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut from the engine mount strut bracket at the upper radiator support. Refer to **Engine Mount Strut Bracket Replacement - Left** and/or **Engine Mount Strut Bracket Replacement - Right**.

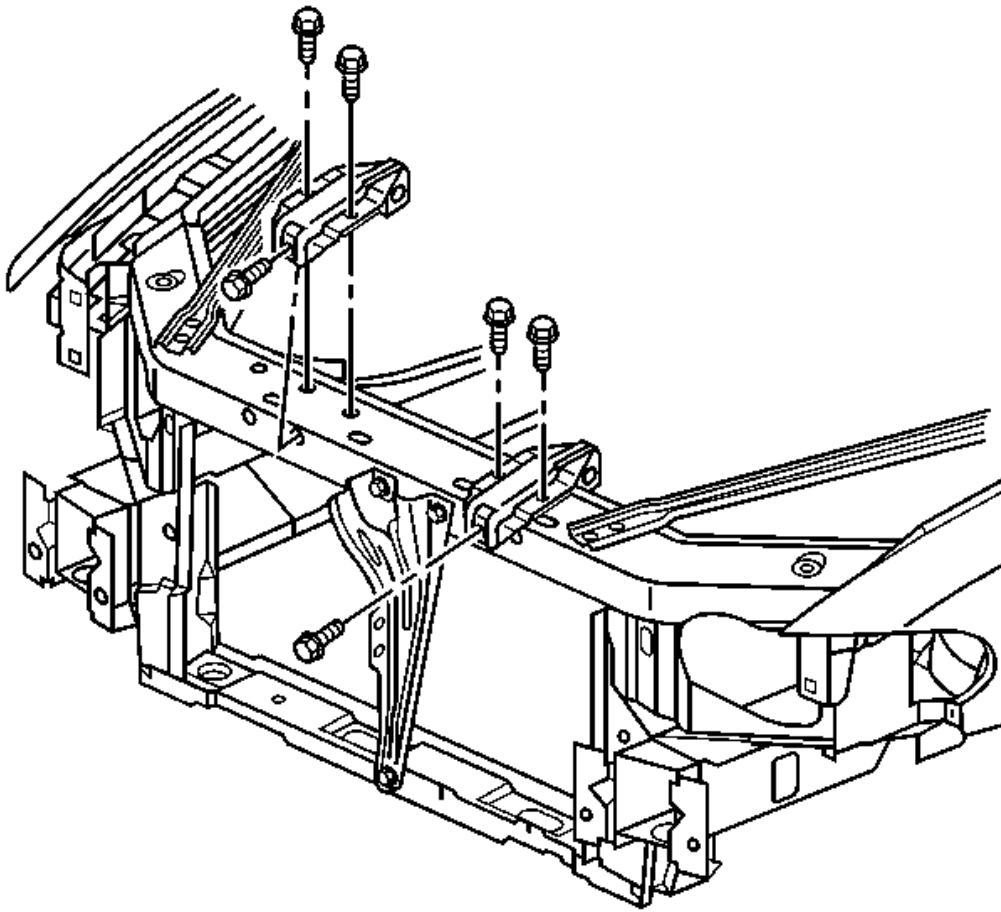


Fig. 39: Removing Horizontal & Vertical Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the horizontal engine mount strut bracket bolt from the engine mount strut bracket.
3. Remove the vertical engine mount strut bracket bolts from the engine mount strut bracket.
4. Remove the engine mount strut bracket from the upper radiator support.

Installation Procedure

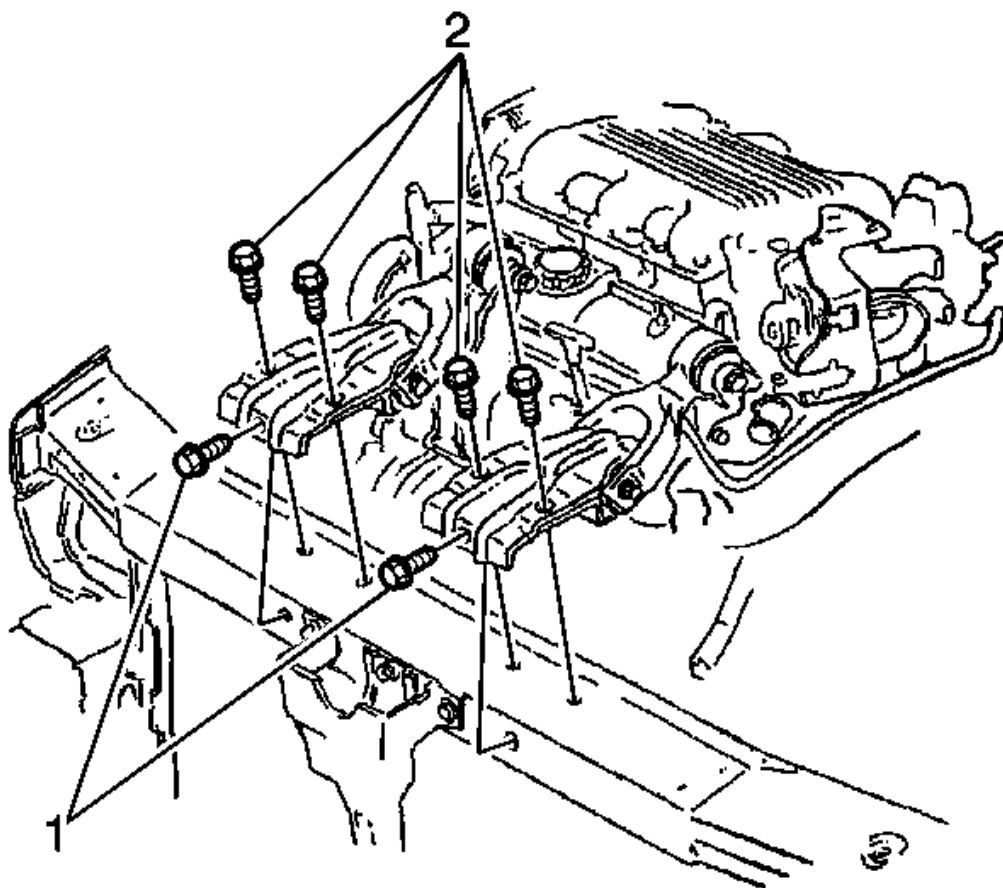


Fig. 40: Installing Horizontal & Vertical Engine Mount Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount strut bracket over the upper radiator support. Make sure that the engine mount strut bracket and the engine mount strut are aligned to the proper holes of the upper radiator support. The proper torque sequence is shown (1, 2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install and tighten the engine mount strut bracket bolts. The following is a mandatory torque sequence:
 1. Tighten the horizontal engine mount strut bracket bolt (1) to the engine mount strut bracket.

Tighten: Tighten the horizontal engine mount strut bracket bolt to 26 N.m (19 lb ft).

2. Tighten the vertical engine mount strut bracket bolts (2) to the engine mount strut bracket.

Tighten: Tighten the vertical engine mount strut bracket bolts to 26 N.m (19 lb ft).

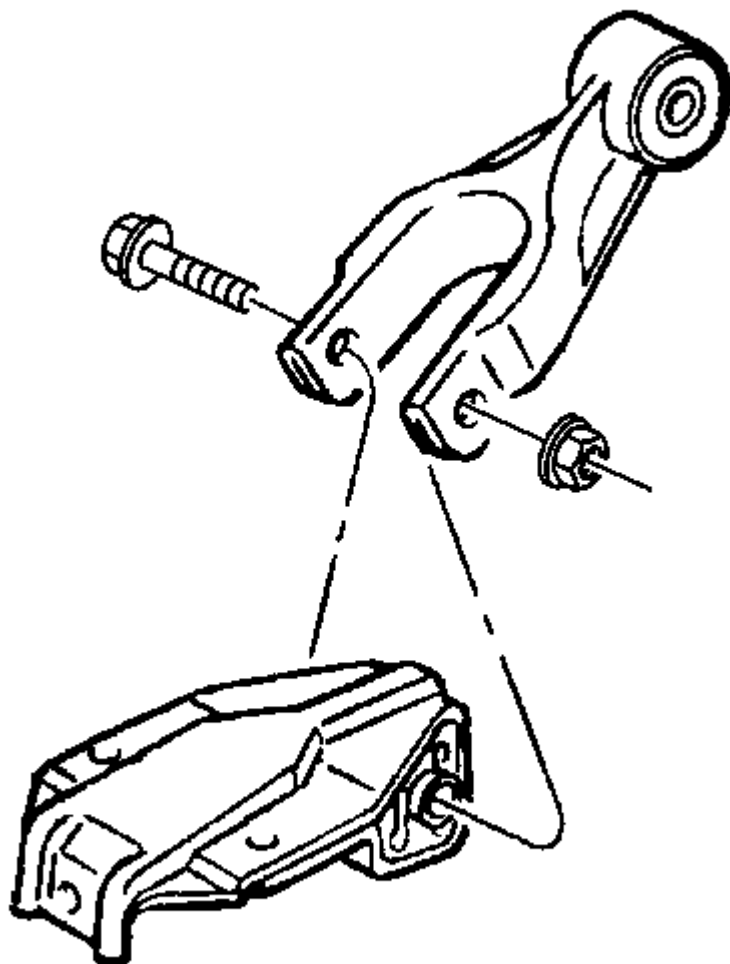


Fig. 41: Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount strut to the engine mount strut bracket at the upper radiator support. Refer to **Engine Mount Strut Bracket Replacement - Left** and/or **Engine Mount Strut Bracket Replacement - Right**.

Oil Filter Adapter and Bypass Valve Assembly Replacement

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

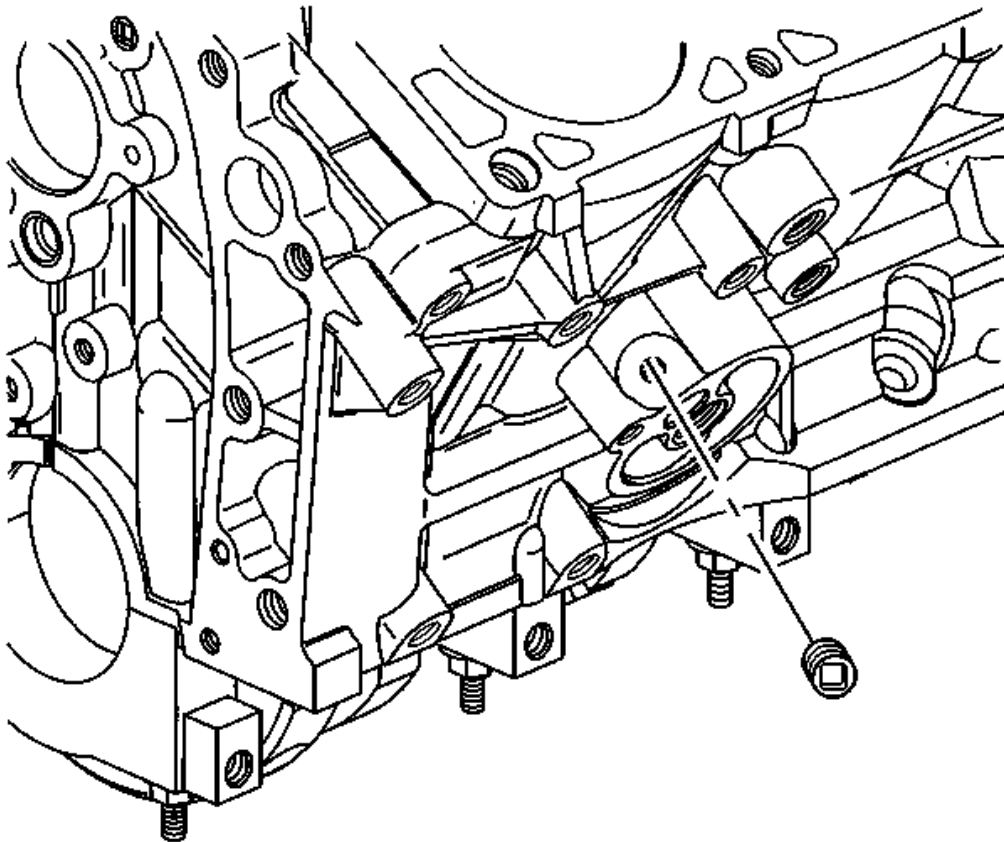


Fig. 42: Oil Filter Bypass Hole Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove oil filter bypass hole plug.

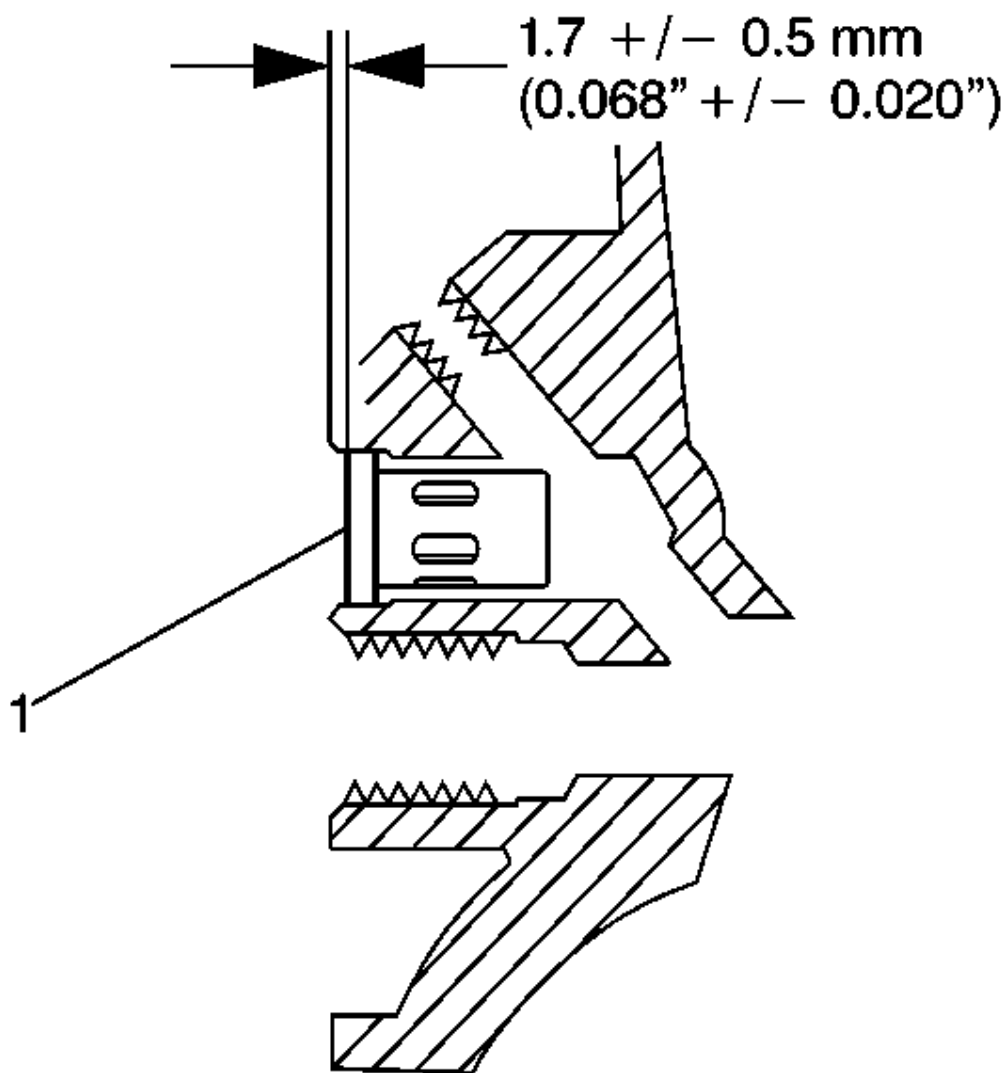


Fig. 43: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

4. Insert a flat-bladed tool into the oil filter bypass hole and force the bypass valve (1) out.

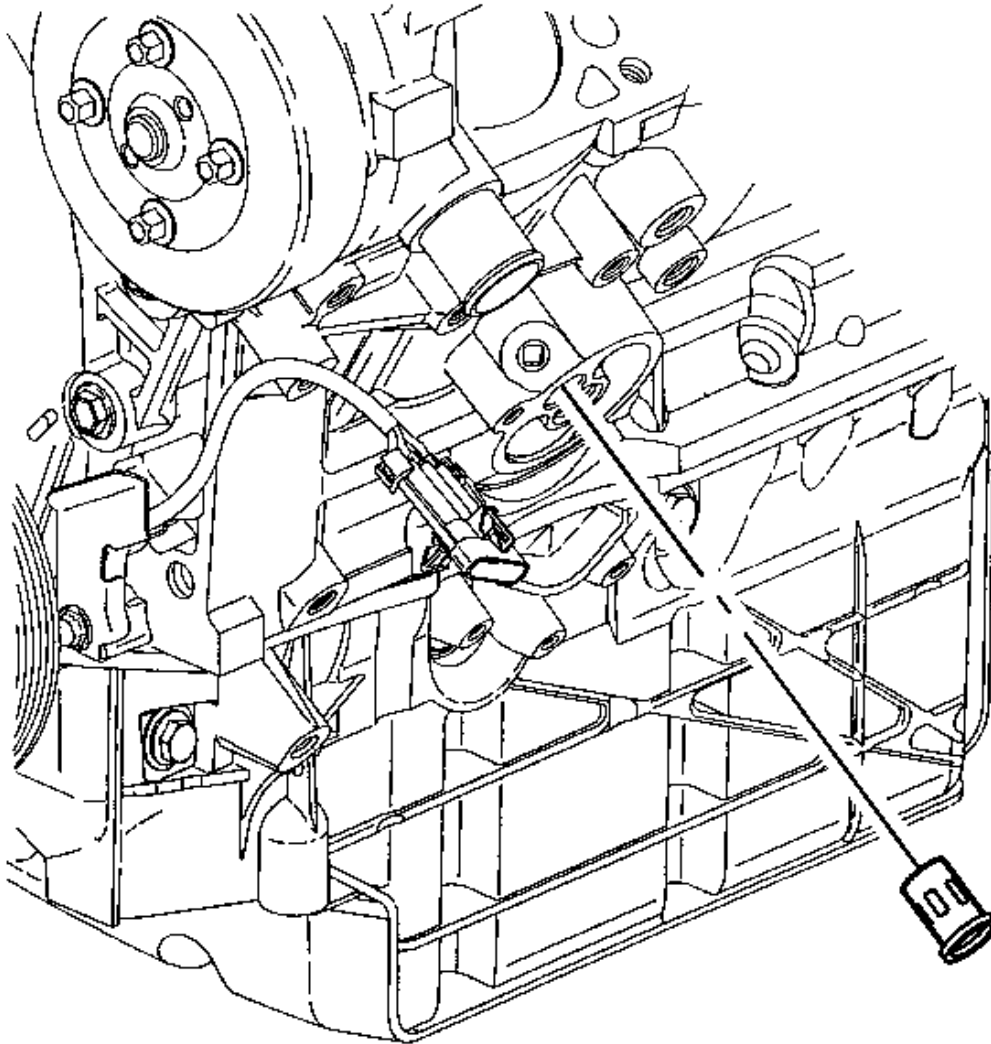


Fig. 44: Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil filter bypass valve.

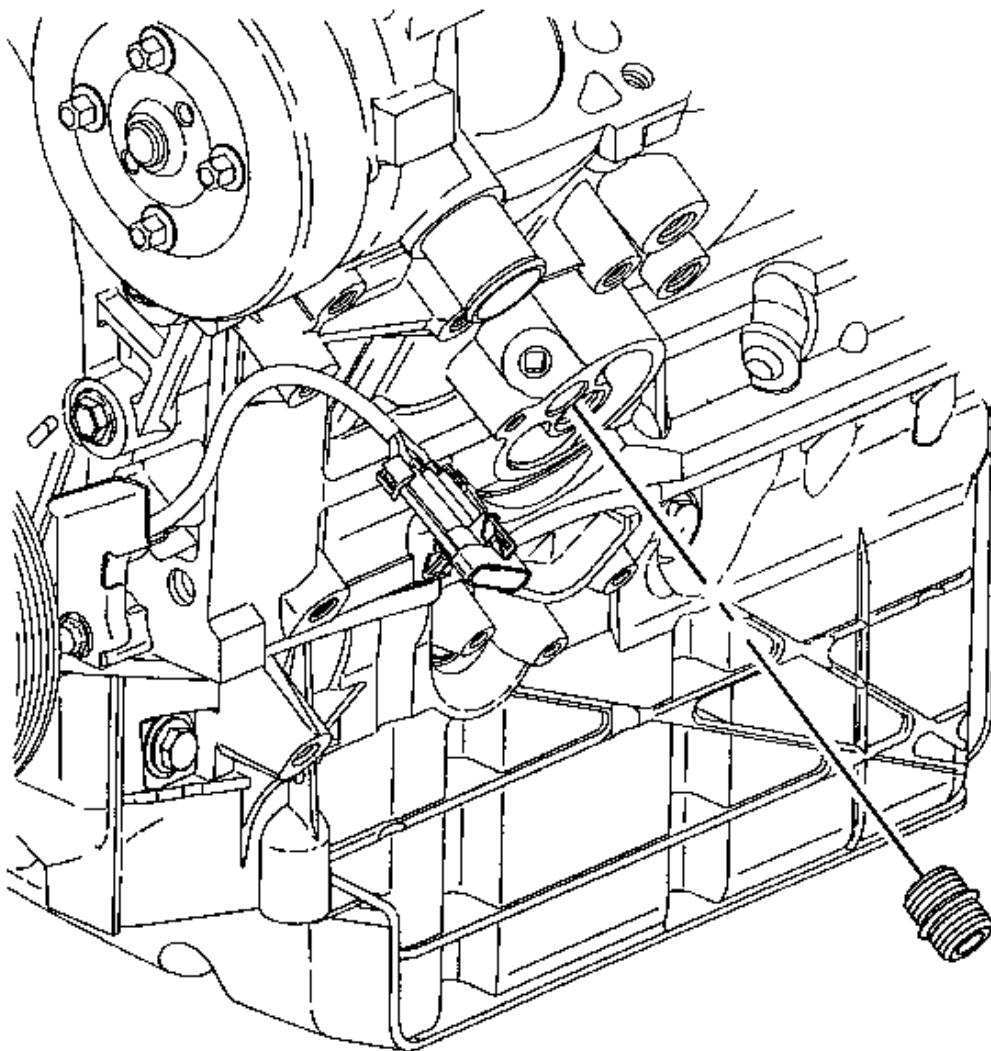


Fig. 45: Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

6. If necessary, remove the oil filter fitting.

Installation Procedure

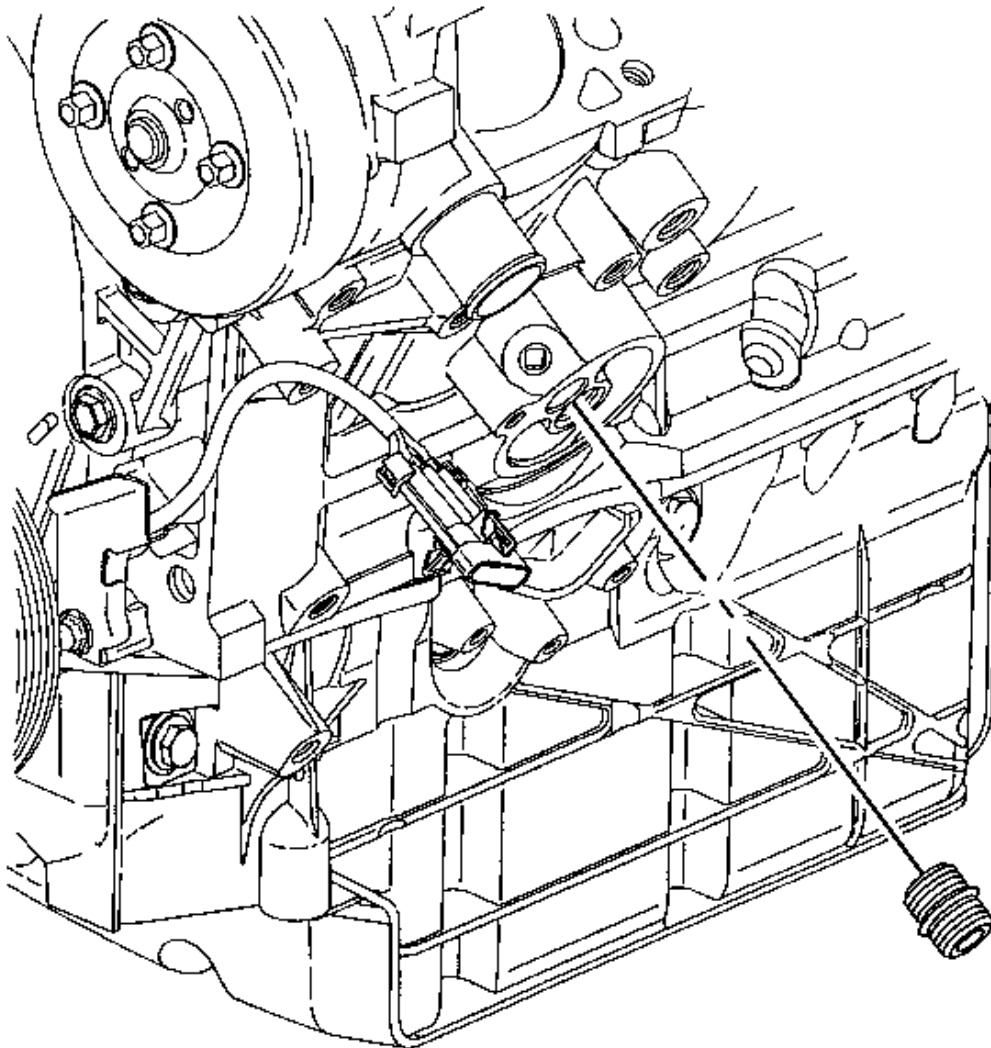


Fig. 46: Oil Filter Fitting

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. If removed, install the oil filter fitting.

Tighten: Tighten the oil filter fitting to 39 N.m (29 lb ft).

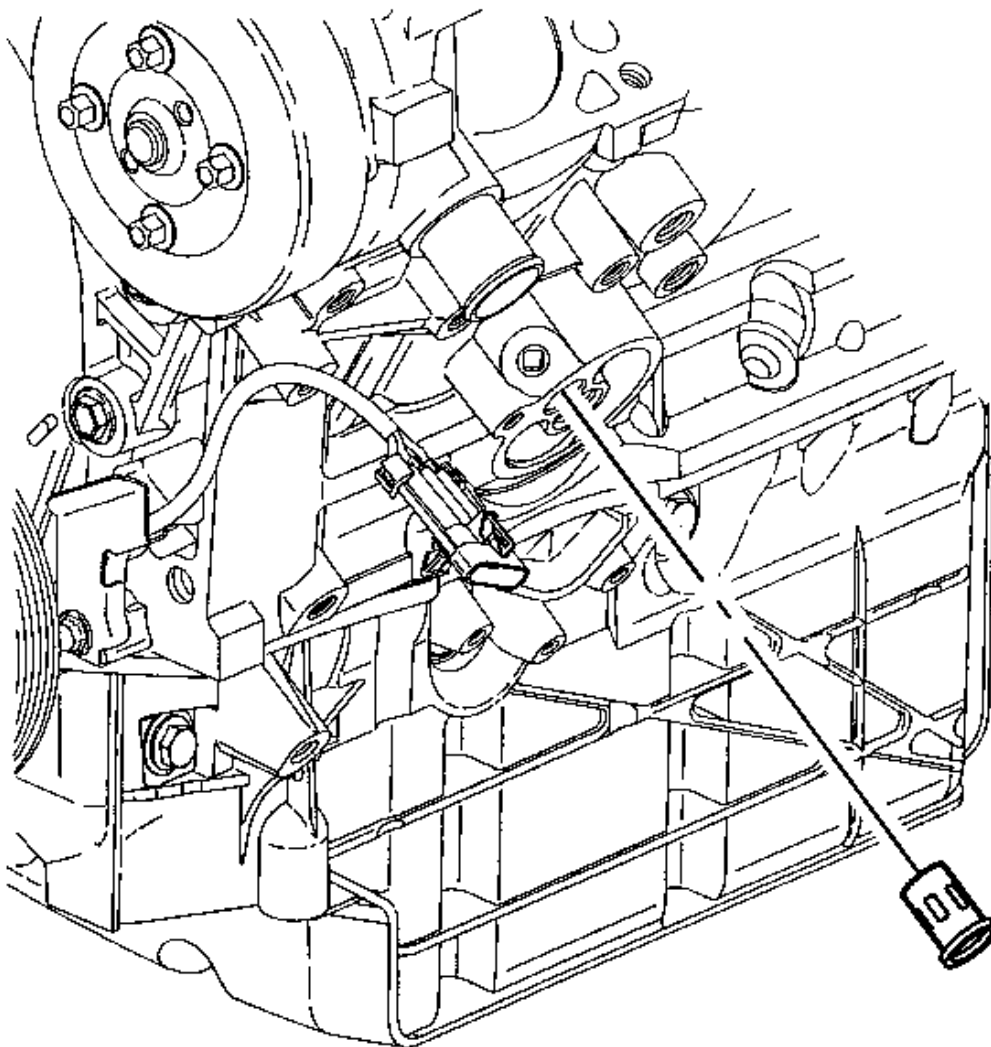


Fig. 47: Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter bypass valve.

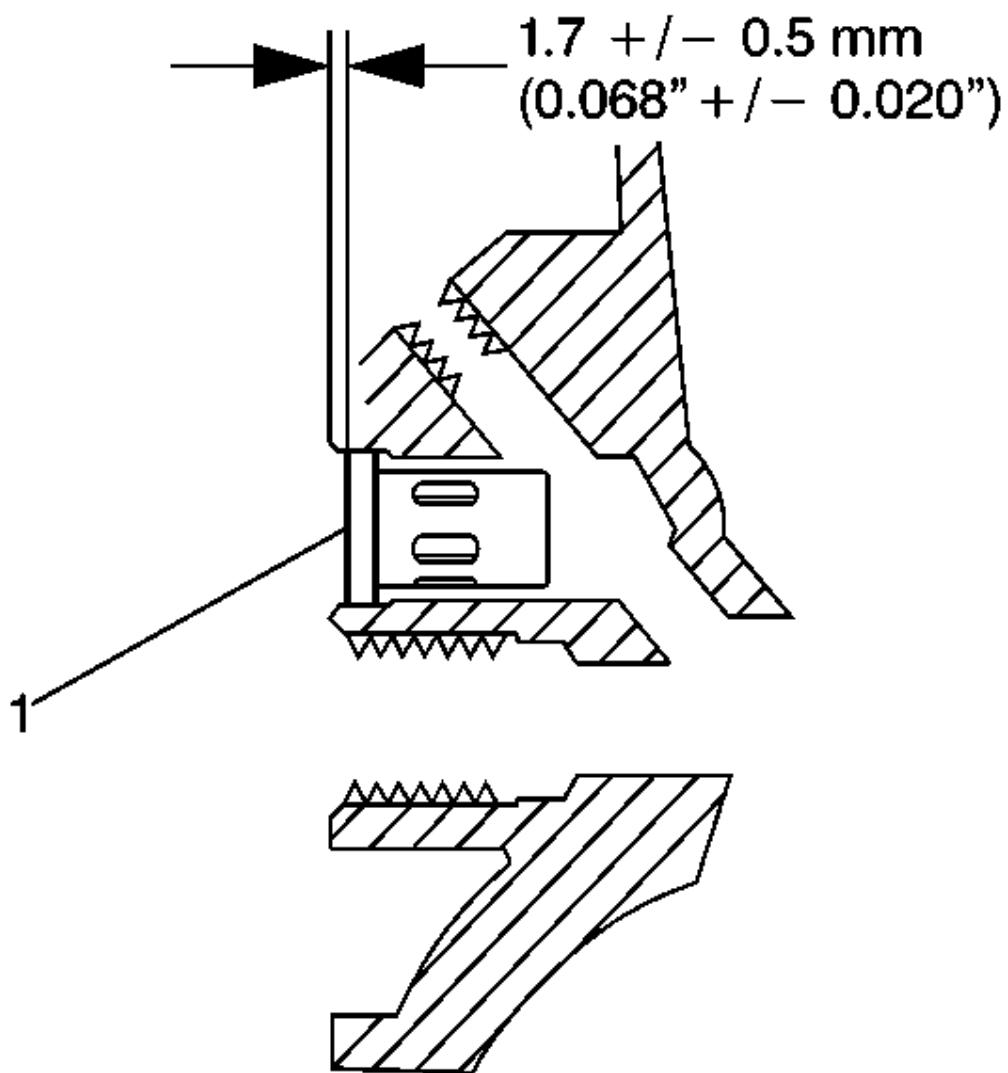


Fig. 48: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter bypass valve (1) to the proper depth.

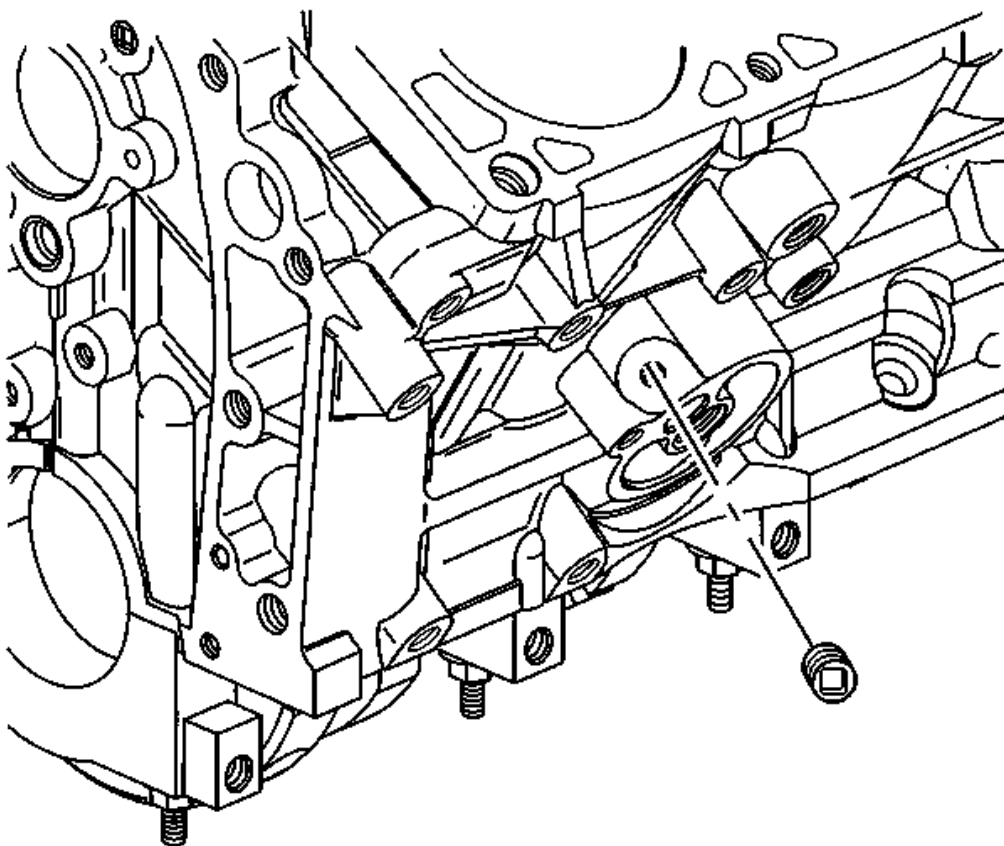


Fig. 49: Oil Filter Bypass Hole Plug
Courtesy of GENERAL MOTORS CORP.

4. Install oil filter bypass hole plug.

Tighten: Tighten the plug to 19 N.m (14 lb ft).

5. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement.**
6. Lower the vehicle.
7. Check and fill engine oil as necessary. Refer to **Engine Oil and Oil Filter Replacement.**

Oil Level Indicator and Tube Replacement

Removal Procedure

1. Disconnect the spark plug wire from the number 6 cylinder spark plug.

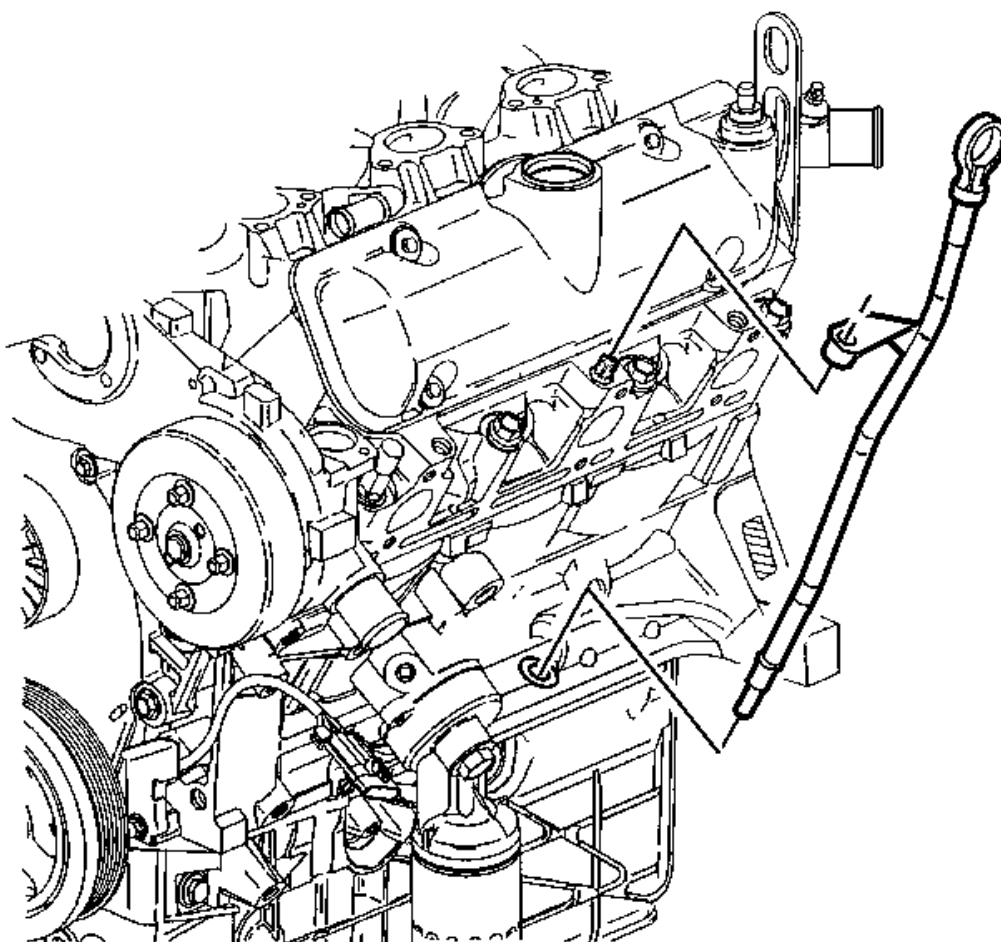


Fig. 50: Removing/Installing Oil Level Indicator & Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator.
3. Remove the oil level indicator tube bracket bolt.
4. Remove the oil level indicator tube.

Installation Procedure

1. Clean the oil level indicator tube.
2. Apply sealant around the oil level indicator tube 12.7 mm (0.50 in) below the bead. Use GM sealant P/N 12345493 (Canadian P/N 10953488) or the equivalent.
3. Install the oil level indicator tube into the engine block.

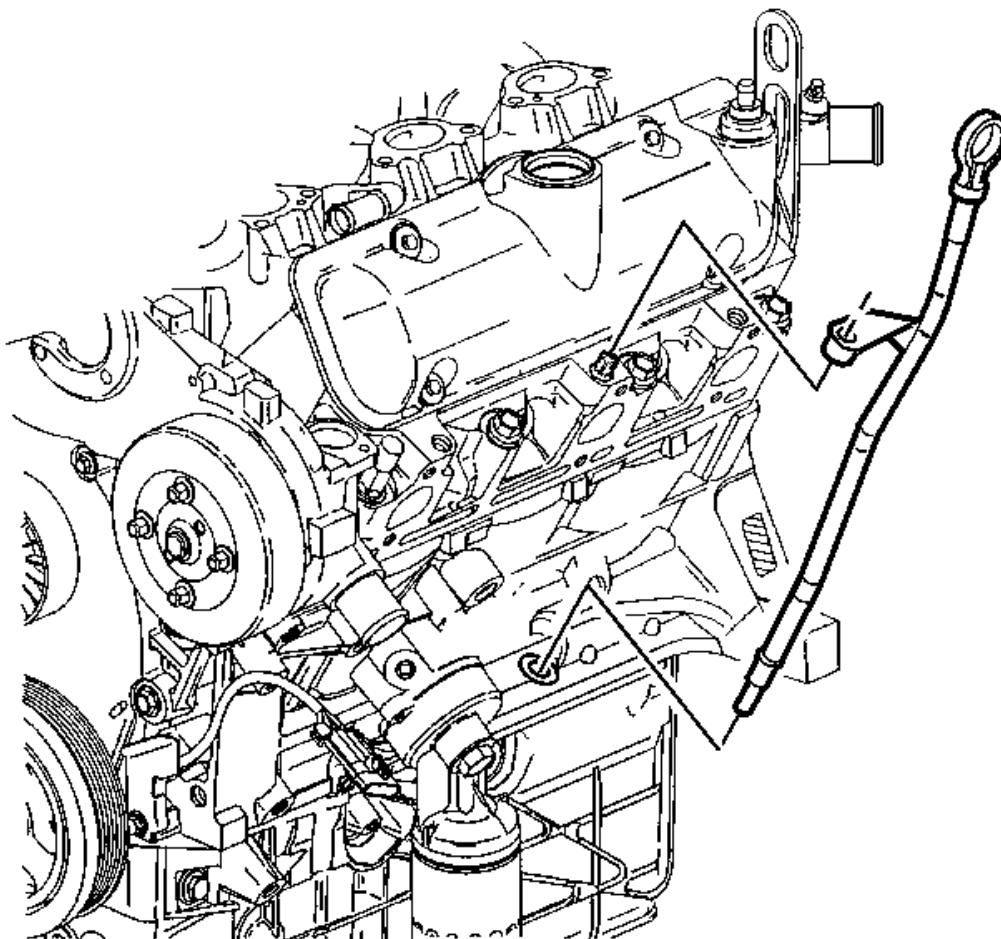


Fig. 51: Removing/Installing Oil Level Indicator & Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil level indicator tube bracket bolt.

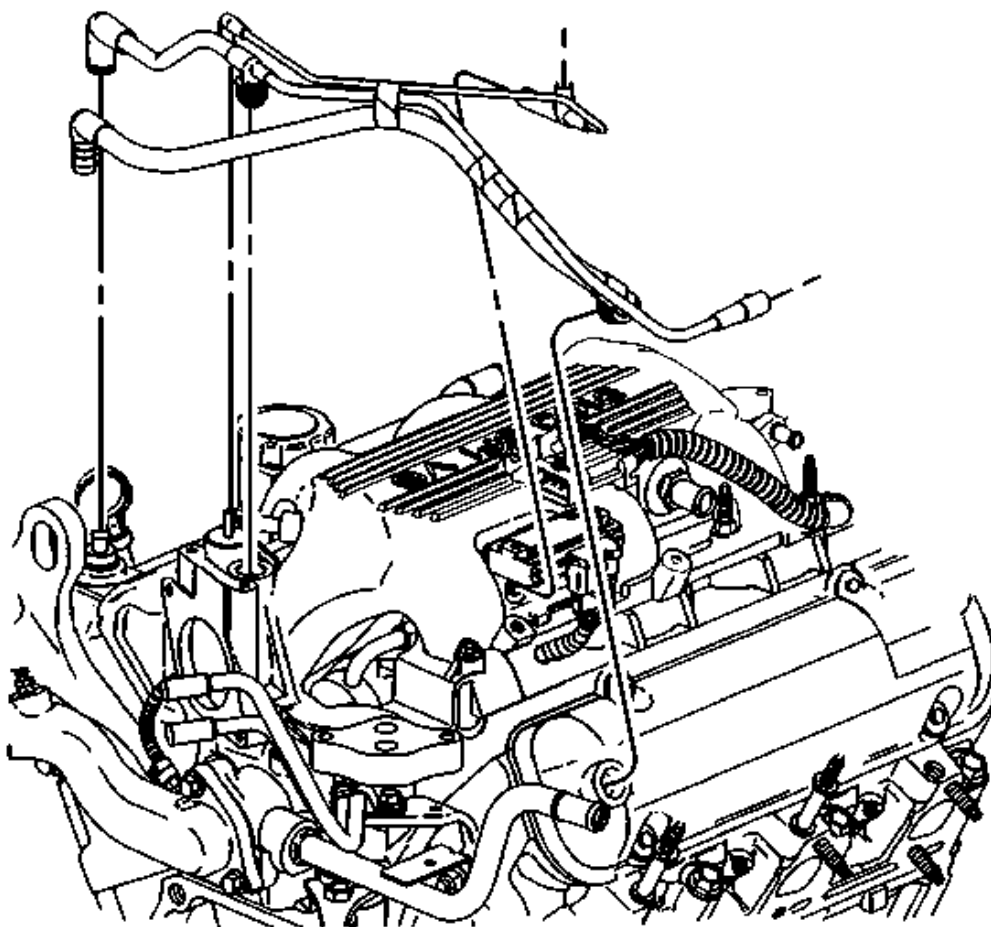
Tighten: Tighten the bolt to 25 N.m (18 lb ft).

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

Intake Manifold Replacement - Upper

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.1L.
3. Remove the accelerator controls cable bracket with the accelerator control and the cruise control cables. Refer to **Accelerator Controls Cable Bracket Replacement** in Engine Controls - 3.1L.

**Fig. 52: Vacuum Hoses****Courtesy of GENERAL MOTORS CORP.**

4. Remove the vacuum hoses from the following:
 - Fuel pressure regulator

- Evaporative emissions (EVAP) canister purge valve
 - Manifold vacuum source
 - Brake booster to the upper intake manifold
 - Windshield washer system
5. Disconnect the electrical connectors from the following:
 - Exhaust gas recirculation (EGR) valve
 - Mass air flow (MAF) sensor
 - Idle air control (IAC) valve
 - Throttle position (T/P) sensor
 - Evaporative emission (EVAP) canister purge valve
 6. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
 7. Remove the left side spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.
 8. Remove the following wiring harnesses from the retainers:
 - Camshaft position (CMP) sensor wiring harness
 - Left side spark plug wire harness
 - Engine wiring harness

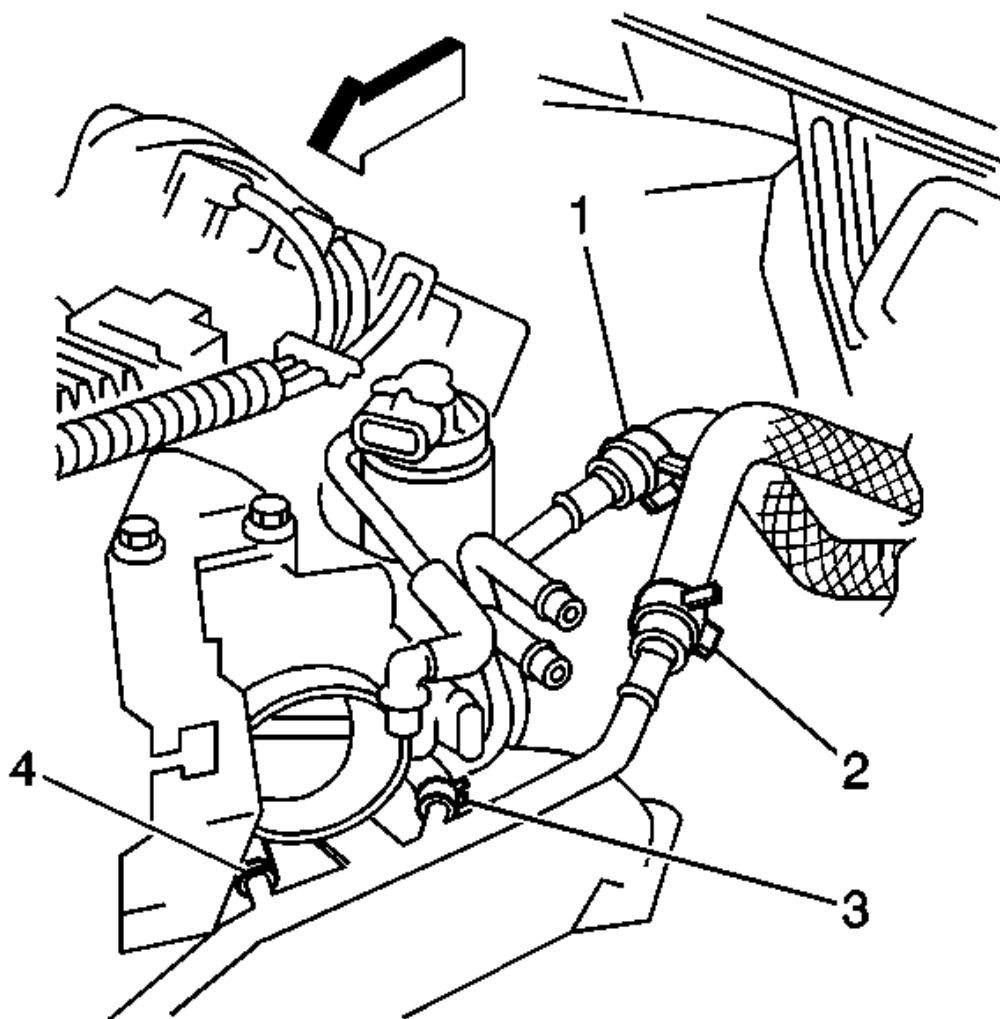


Fig. 53: View Of Throttle Body Hoses, Heater Outlet Hose & Thermostat Bypass Pipe
Courtesy of GENERAL MOTORS CORP.

9. Remove the thermostat bypass pipe coolant hoses (3,4) from the throttle body.
10. Remove the ignition coil bracket with the coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.1L.
11. Remove the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 3.1L.
12. Remove the manifold absolute pressure (MAP) sensor and the bracket. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls - 3.1L.
13. Remove the exhaust gas recirculation (EGR) valve. Refer to **Exhaust Gas Recirculation (EGR) Valve**

Replacement in Engine Controls - 3.1L.

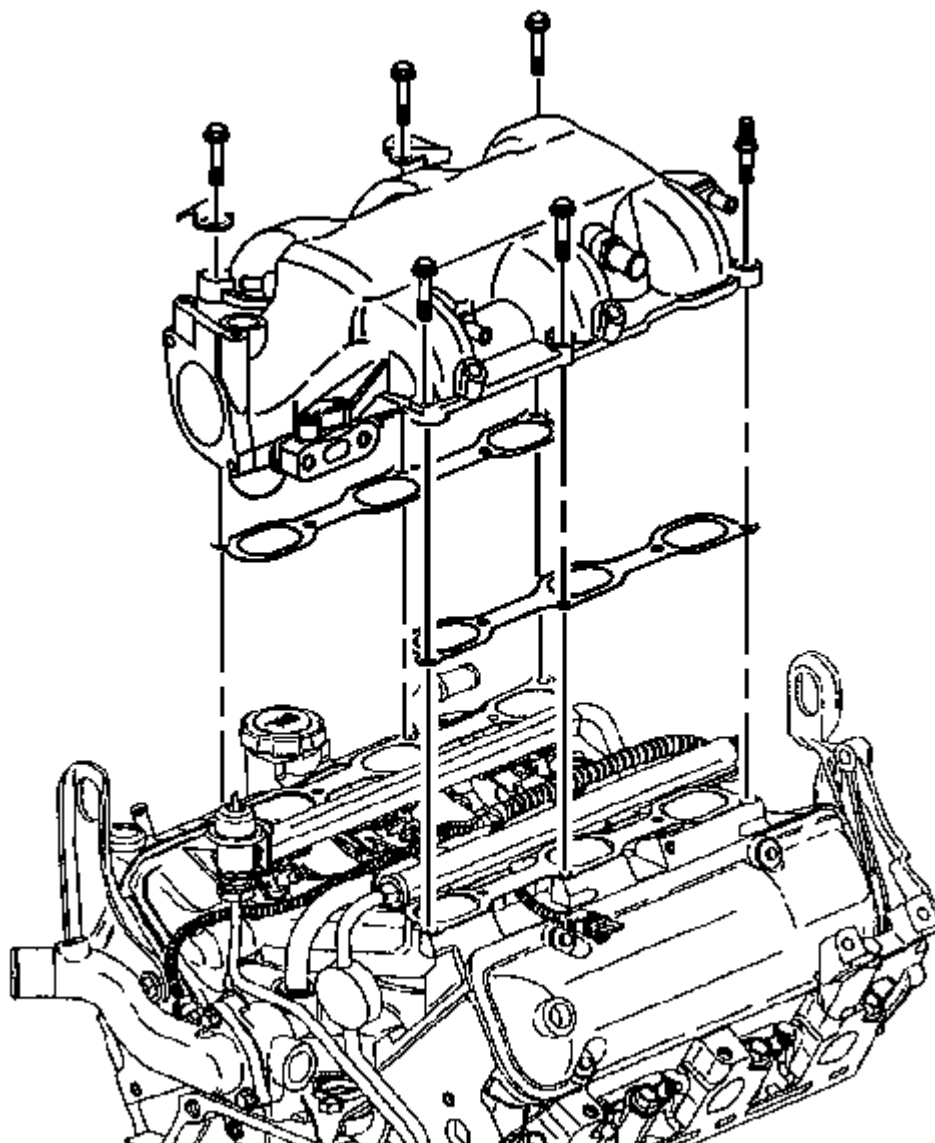


Fig. 54: View Of Upper Intake Manifold & Gaskets
Courtesy of GENERAL MOTORS CORP.

14. Remove the upper intake manifold bolts and the stud.
15. Remove the upper intake manifold.

16. Remove the upper intake manifold gaskets.

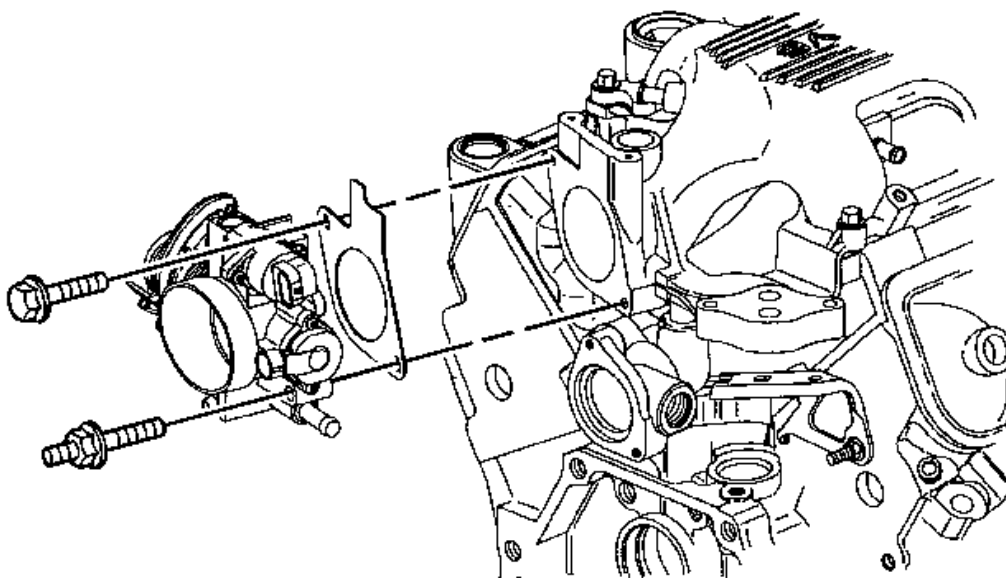


Fig. 55: Throttle Body

Courtesy of GENERAL MOTORS CORP.

17. If replacing the upper intake manifold, remove the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.1L.
18. Clean the upper intake gasket mating surfaces.

Installation Procedure

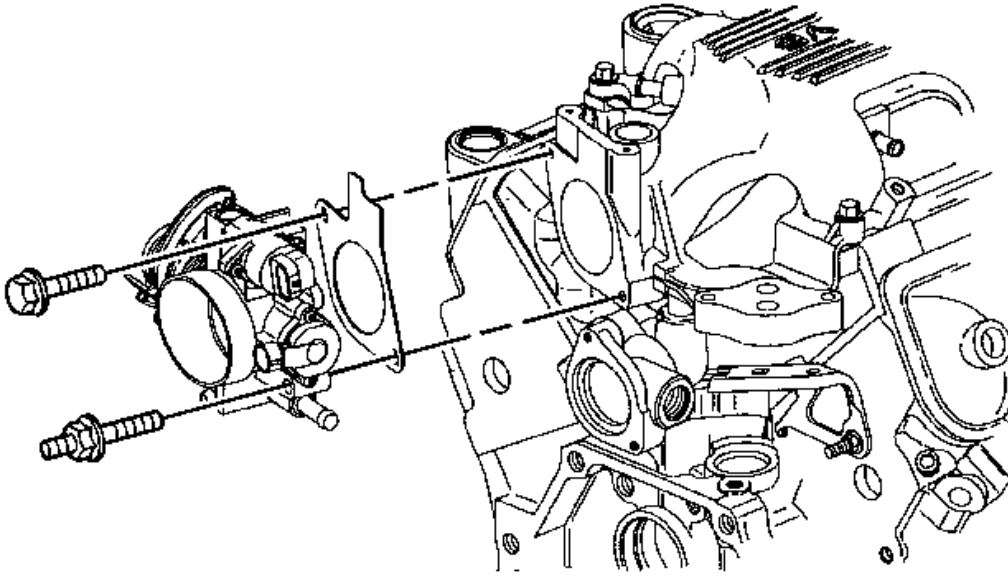


Fig. 56: Throttle Body

Courtesy of GENERAL MOTORS CORP.

1. If removed, install the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.1L.

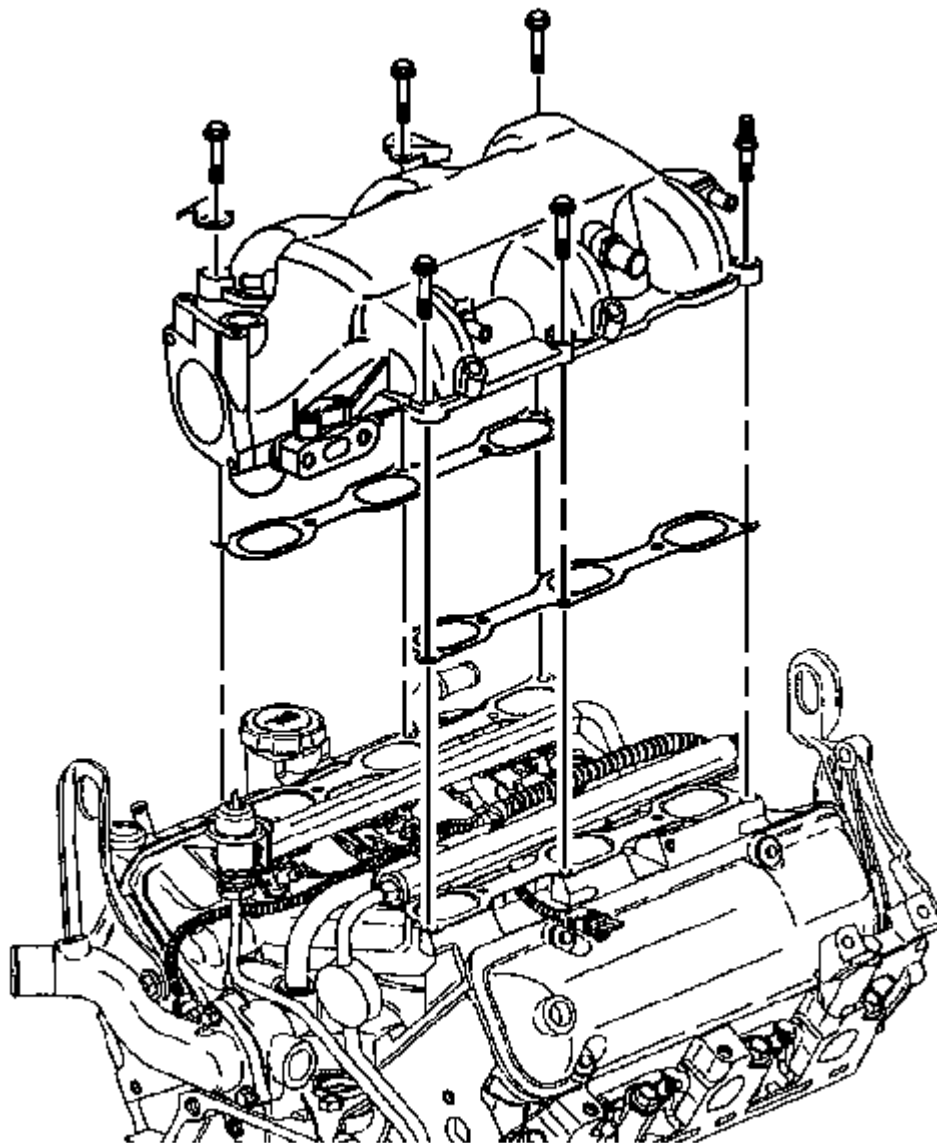


Fig. 57: View Of Upper Intake Manifold & Gaskets
Courtesy of GENERAL MOTORS CORP.

2. Install the upper intake manifold gaskets.
3. Install the upper intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the upper intake manifold bolts and the stud.

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

5. Install the EGR valve. Refer to **Exhaust Gas Recirculation (EGR) Valve Replacement** in Engine Controls - 3.1L.
6. Install the MAP sensor bracket and the sensor. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls - 3.1L.
7. Install the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 3.1L.
8. Install the ignition coil bracket with the coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.1L.

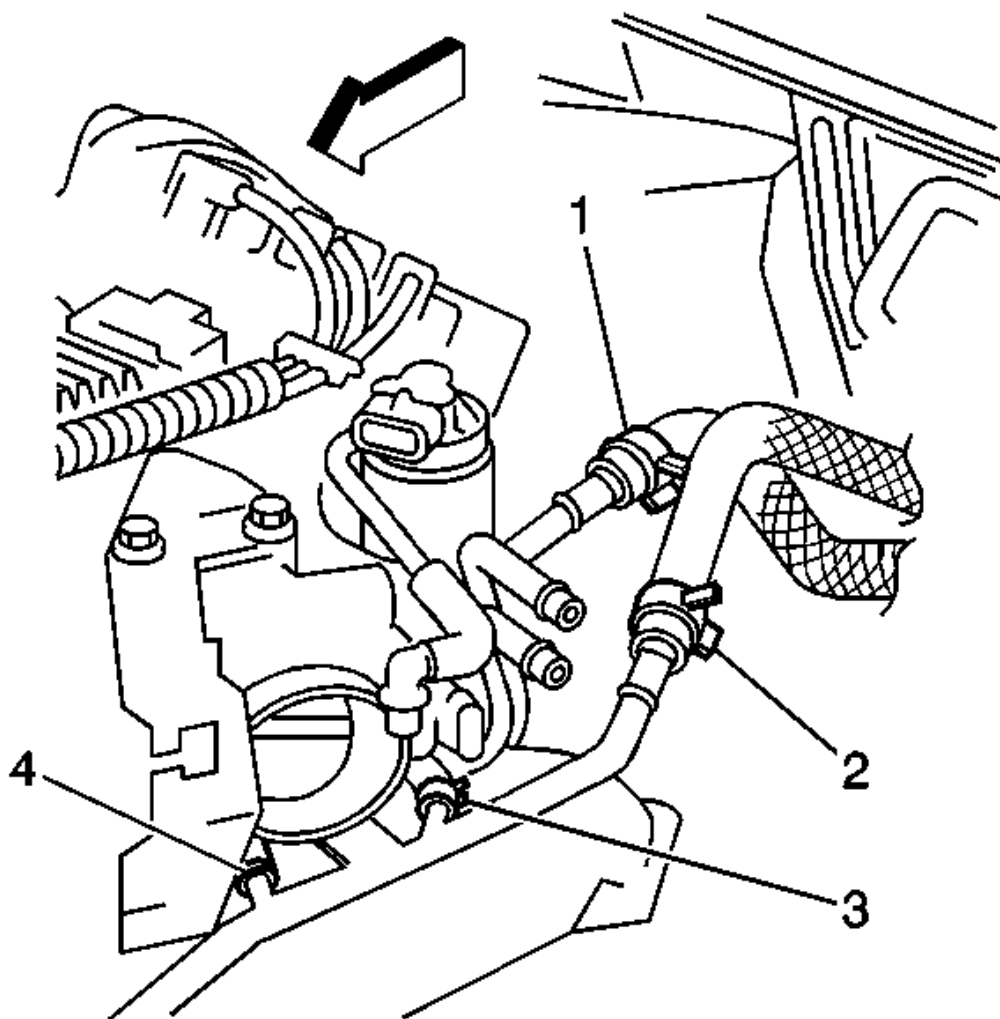


Fig. 58: View Of Throttle Body Hoses, Heater Outlet Hose & Thermostat Bypass Pipe
Courtesy of GENERAL MOTORS CORP.

9. Install the thermostat bypass pipe coolant hoses (3,4) to the throttle body.
10. Install the following wiring harnesses to the retainers:
 - Engine wiring harness
 - Left side spark plug wire harness
 - Camshaft position (CMP) sensor wiring harness
11. Install the left side spark plug wires to the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.

12. Connect the electrical connectors to the following:
- Evaporative emission (EVAP) canister purge valve
 - Throttle position (T/P) sensor
 - Idle air control (IAC) valve
 - Mass air flow (MAF) sensor
 - Exhaust gas recirculation (EGR) valve

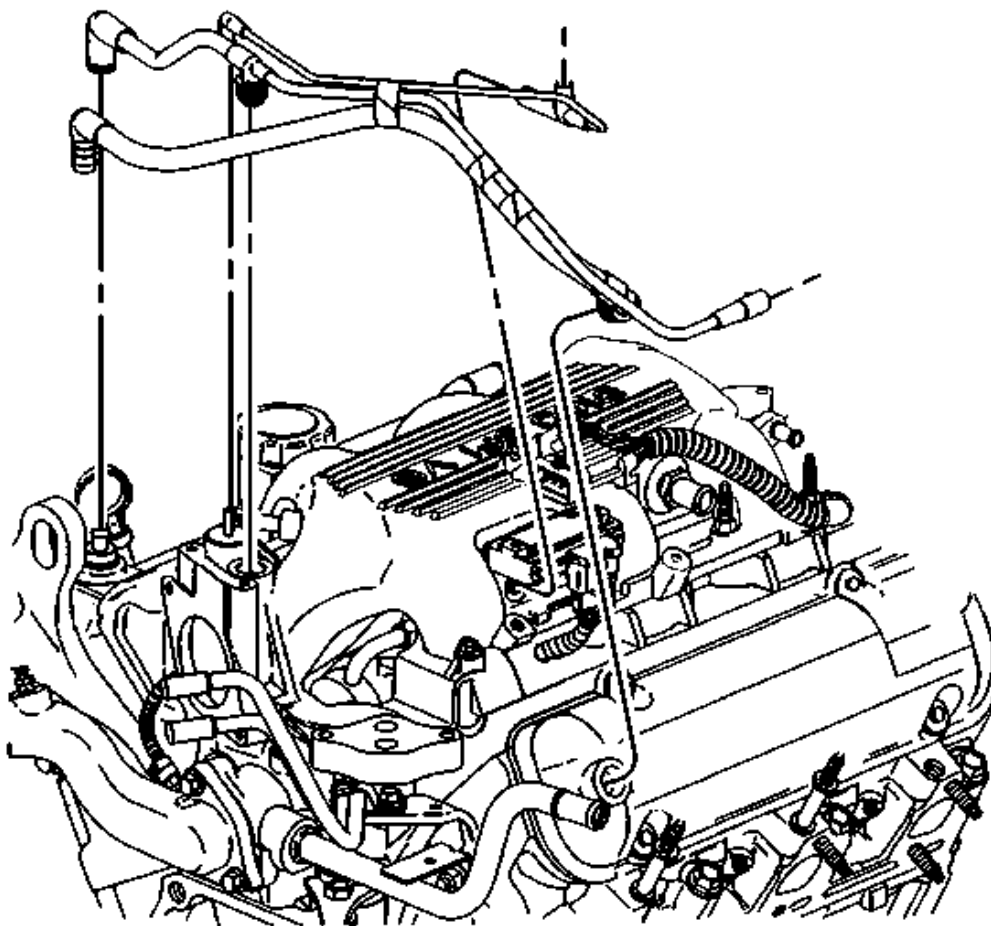


Fig. 59: Vacuum Hoses
Courtesy of GENERAL MOTORS CORP.

13. Install the vacuum hoses to the following:
- Windshield washer system

- Brake booster to the upper intake manifold
 - Manifold vacuum source
 - Evaporative emissions (EVAP) canister purge valve
 - Fuel pressure regulator
14. Install the accelerator controls cable bracket with the accelerator control and the cruise control cables. Refer to **Accelerator Controls Cable Bracket Replacement** in Engine Controls - 3.1L.
 15. Install the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.1L.
 16. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
 17. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

Intake Manifold Replacement - Lower**Removal Procedure**

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the upper intake manifold. Refer to **Intake Manifold Replacement - Upper**.
3. Remove the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left**.
4. Remove the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right**.

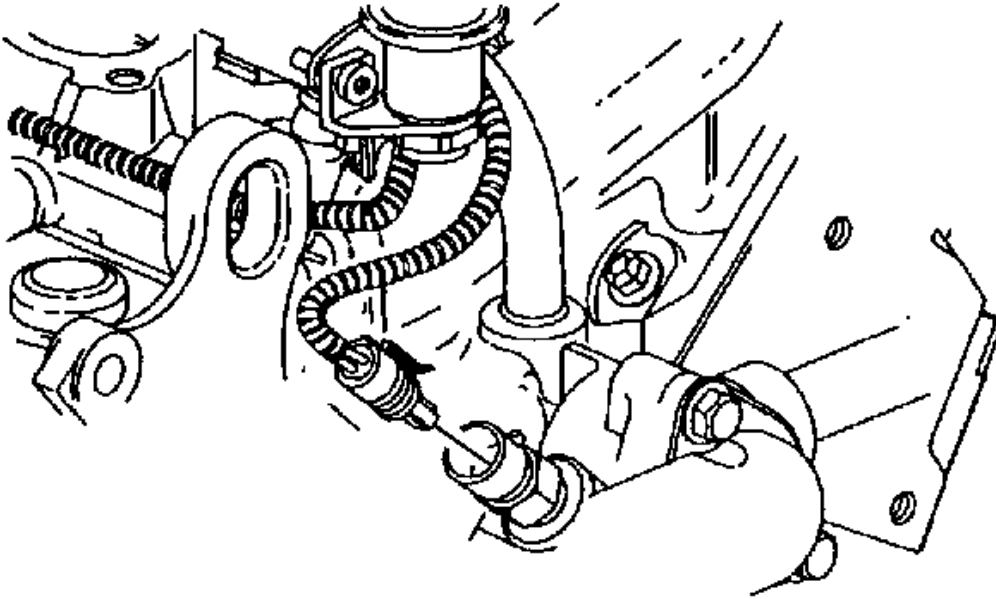


Fig. 60: ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the engine coolant temperature (ECT) sensor electrical connector.

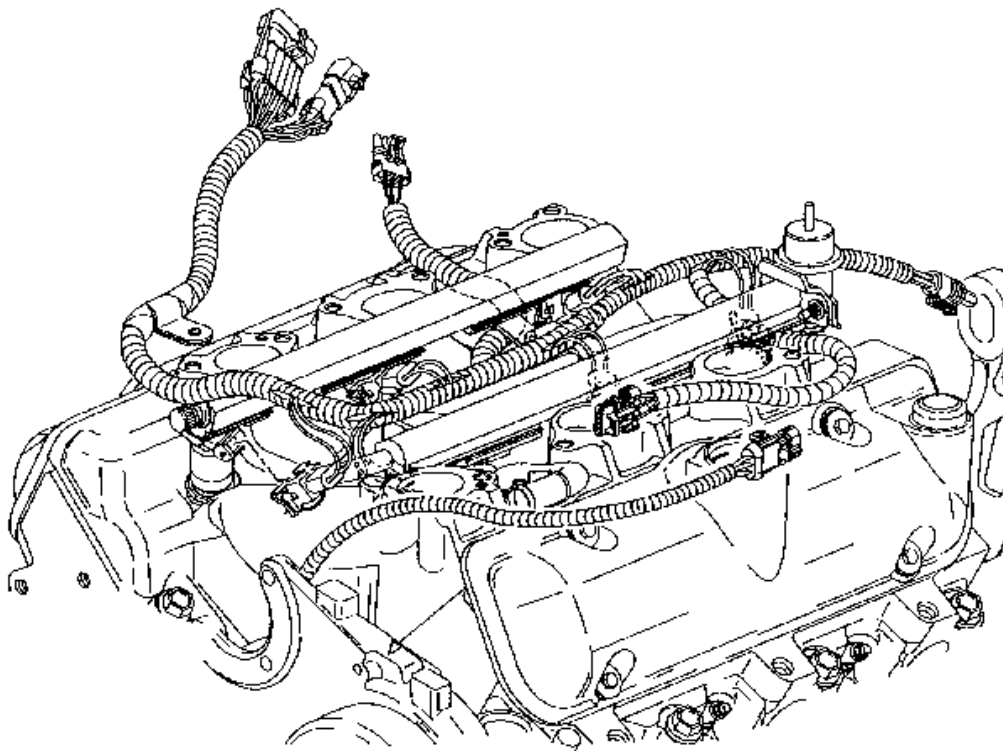


Fig. 61: MAP Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

6. Disconnect and remove the fuel injector and the manifold absolute pressure (MAP) sensor wiring harnesses.

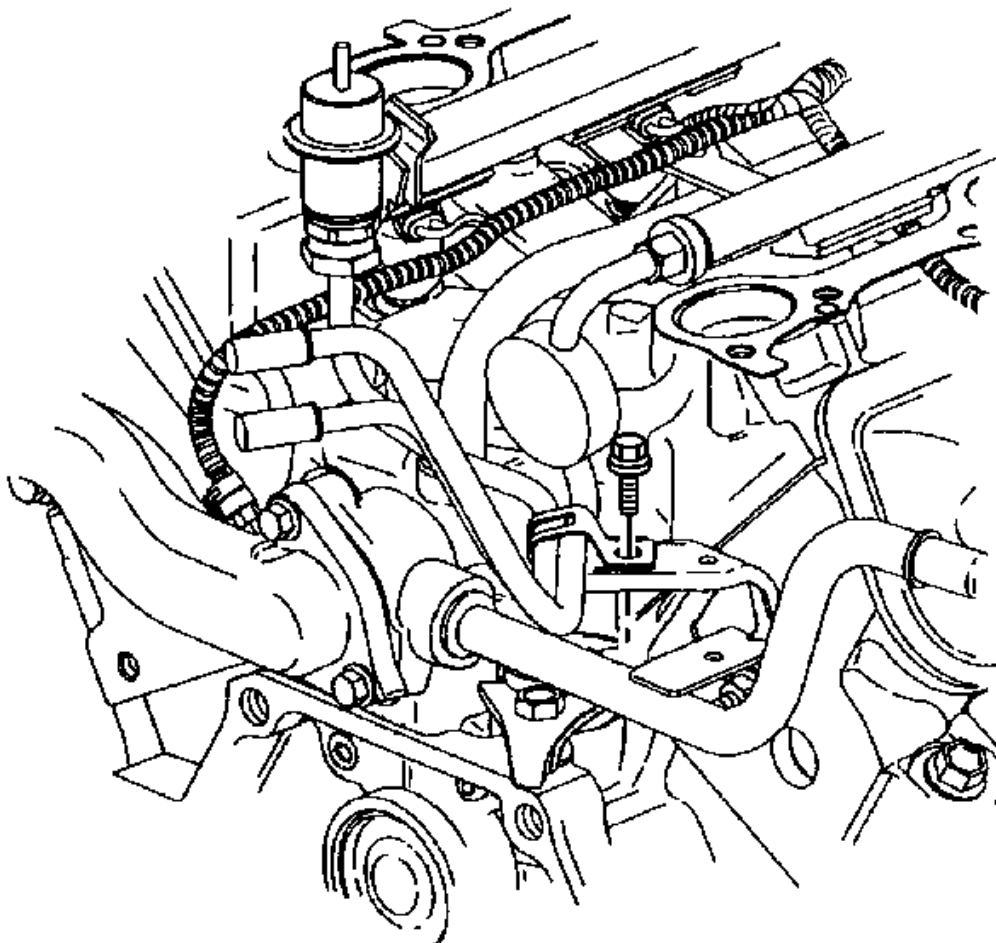


Fig. 62: Fuel Pipe Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the fuel pipe clip bolt.

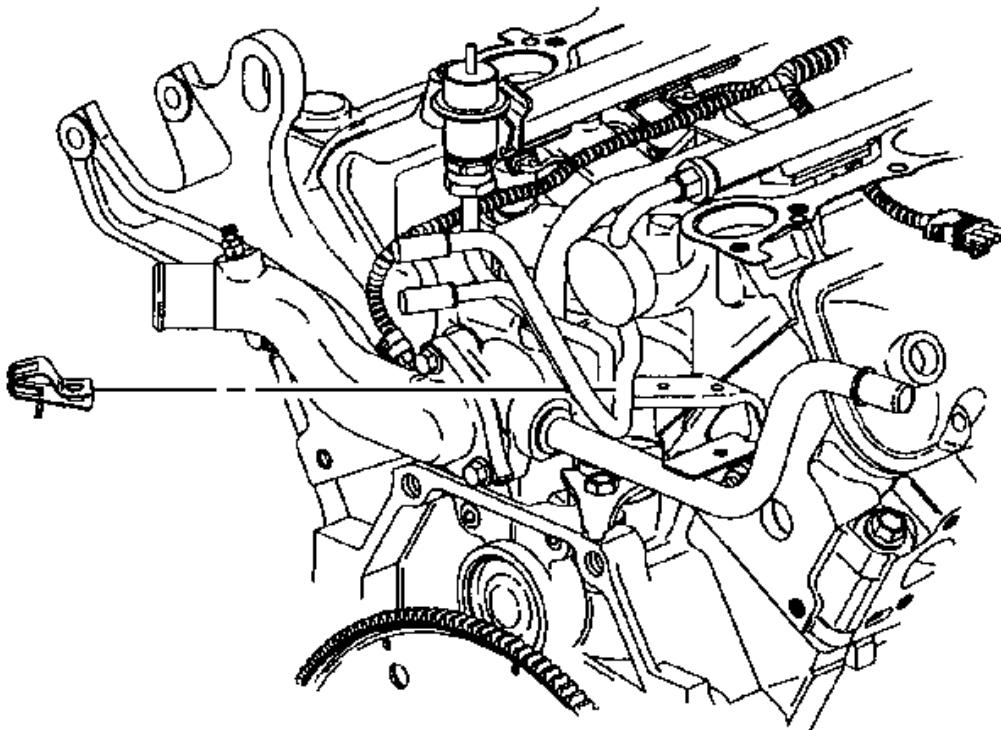


Fig. 63: Fuel Pipe & Clip
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel pipe clip.

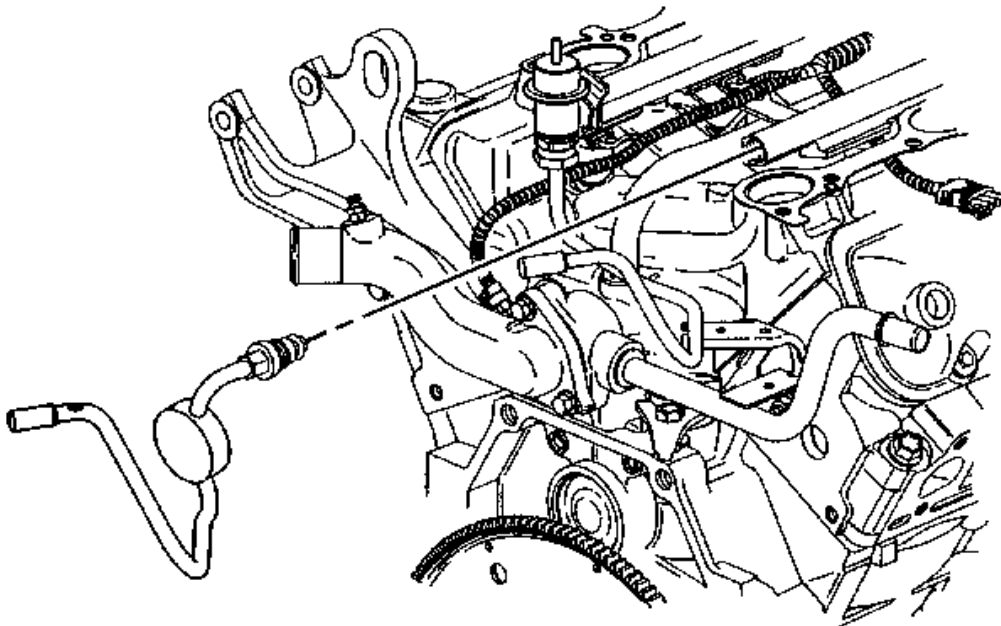


Fig. 64: Fuel Feed Pipe At Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

9. Remove the fuel feed pipe from the fuel injector rail. Refer to **Fuel Hose/Pipes Replacement - Filter to Engine** in Engine Controls - 3.1L.

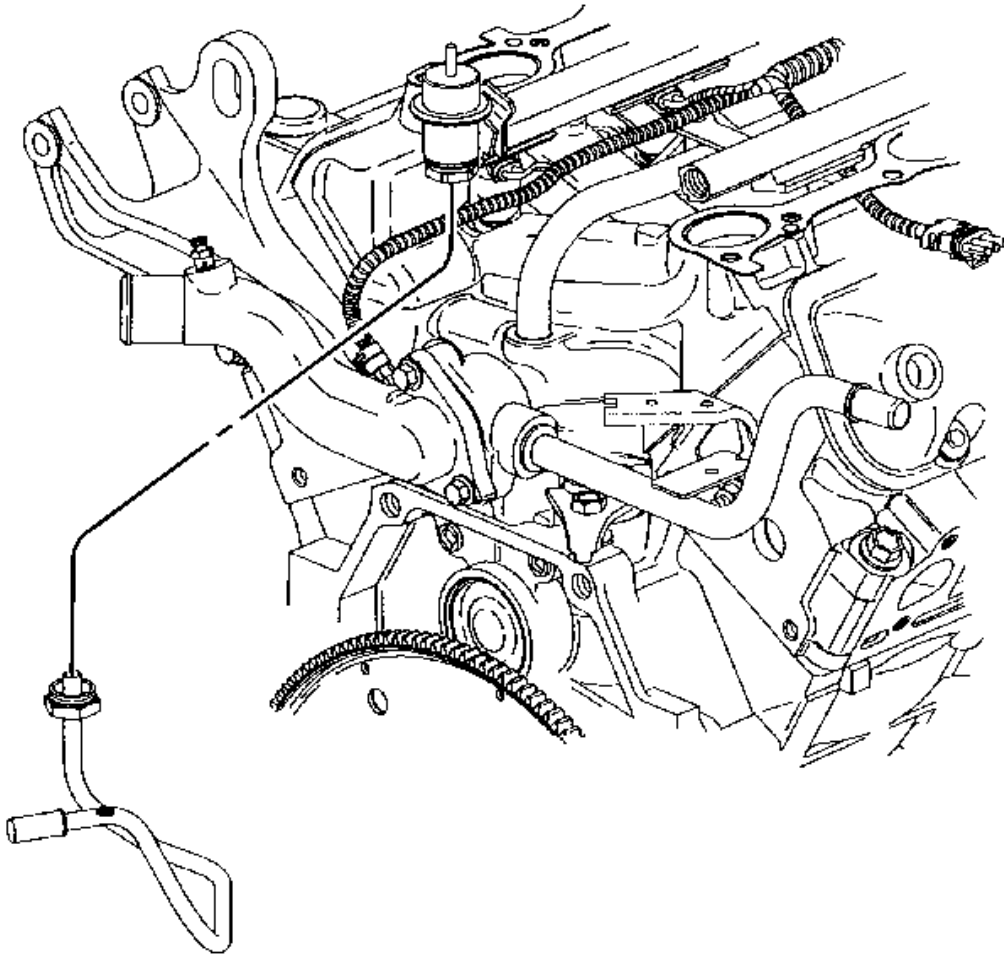


Fig. 65: Fuel Return Pipe At Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

10. Remove the fuel return pipe from the fuel injector rail. Refer to **Fuel Hose/Pipes Replacement - Filter to Engine** in Engine Controls - 3.1L.

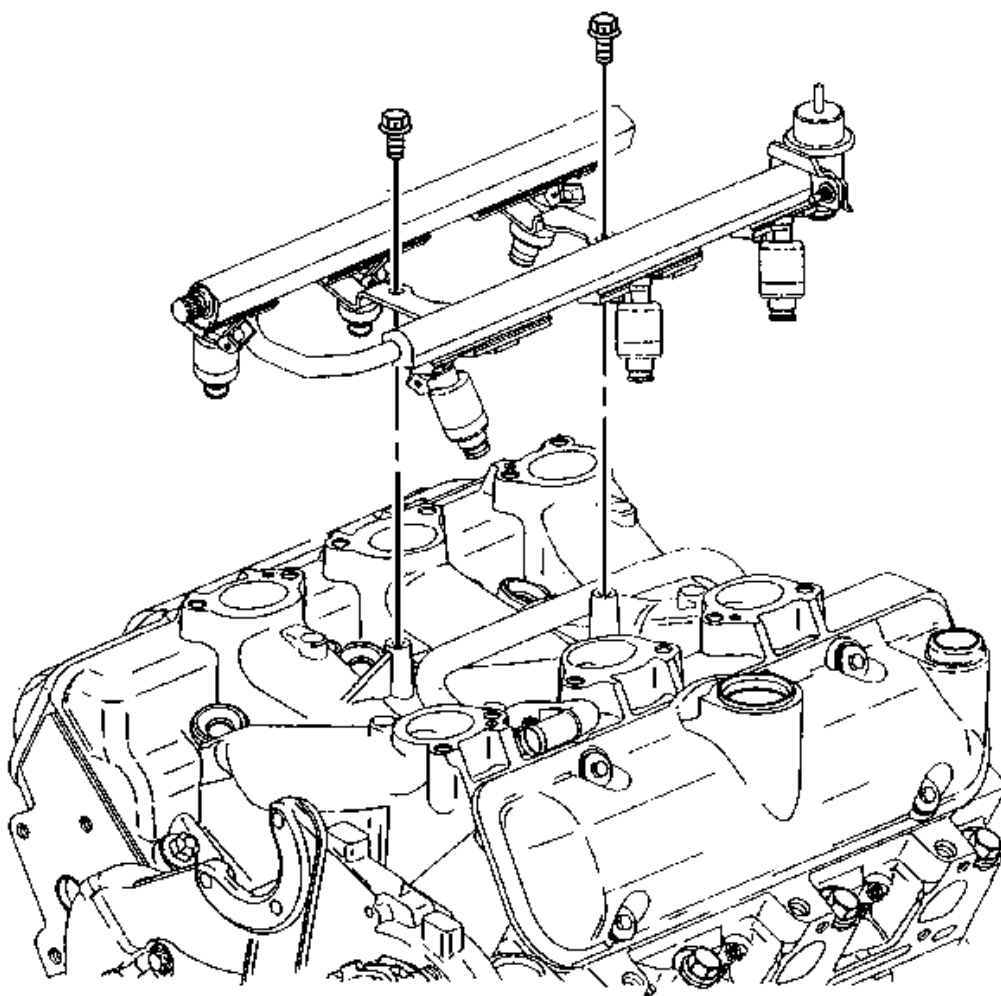


Fig. 66: Fuel Injector Rail

Courtesy of GENERAL MOTORS CORP.

11. Remove the fuel injector rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.1L.
12. Remove the power steering pump from the front engine cover and reposition. Refer to **Power Steering Pump Replacement (3.1L)** or **Power Steering Pump Replacement (3.8L)** in Power Steering System.

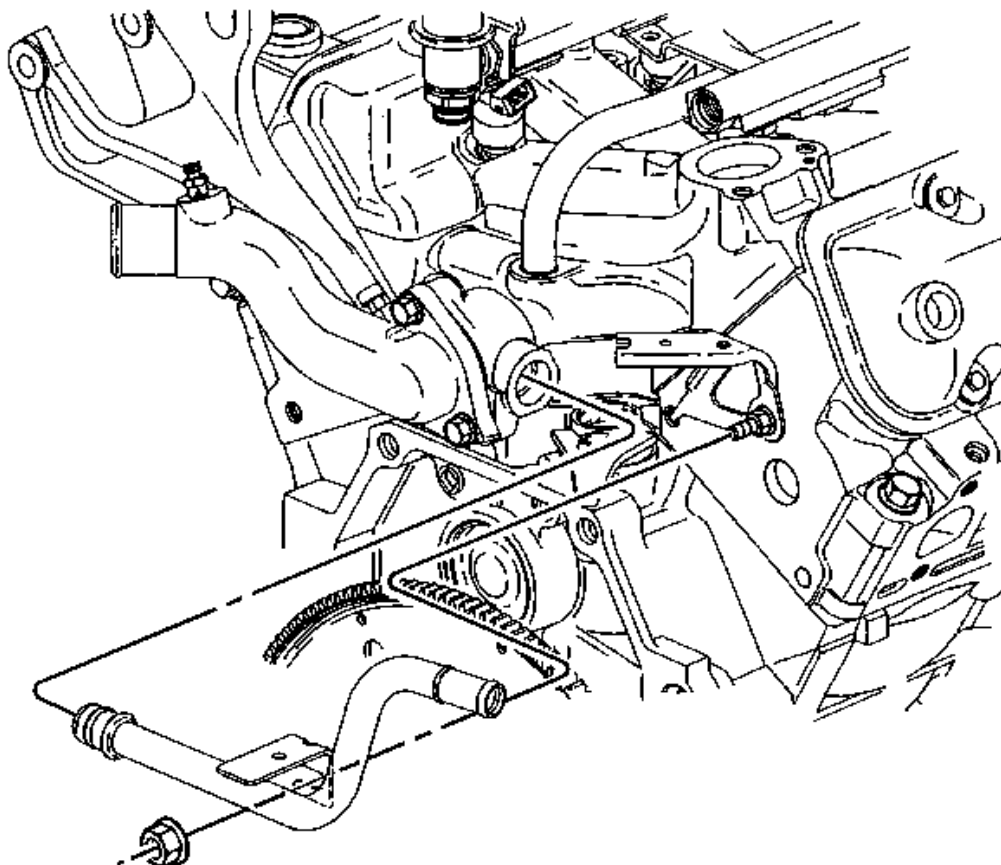


Fig. 67: Heater Inlet Pipe & Nut
Courtesy of GENERAL MOTORS CORP.

13. Remove the heater inlet pipe nut.
14. Remove the heater inlet pipe with heater hose from the lower intake manifold and reposition.
15. Remove the radiator inlet hose from the engine. Refer to **Radiator Hose Replacement - Inlet (3.1L)** or **Radiator Hose Replacement - Inlet (3.8L)** in Engine Cooling.

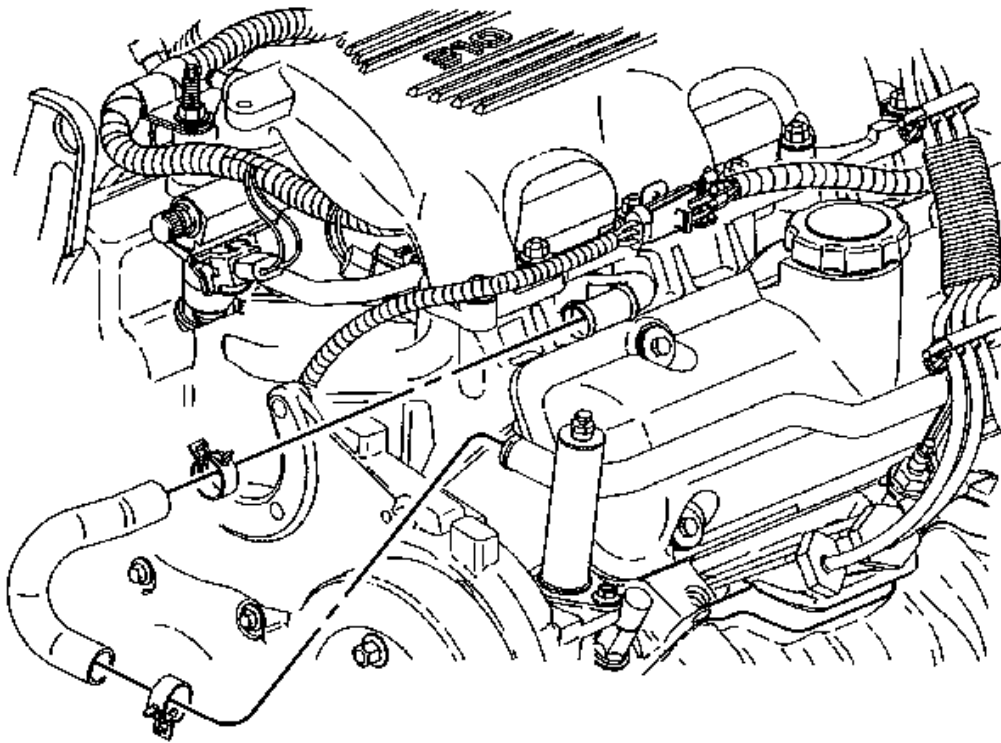


Fig. 68: Thermostat Bypass Hose At Thermostat Bypass Pipe & Lower Intake Manifold Pipe
Courtesy of GENERAL MOTORS CORP.

16. Remove the thermostat bypass hose from the thermostat bypass pipe and lower intake manifold pipe.

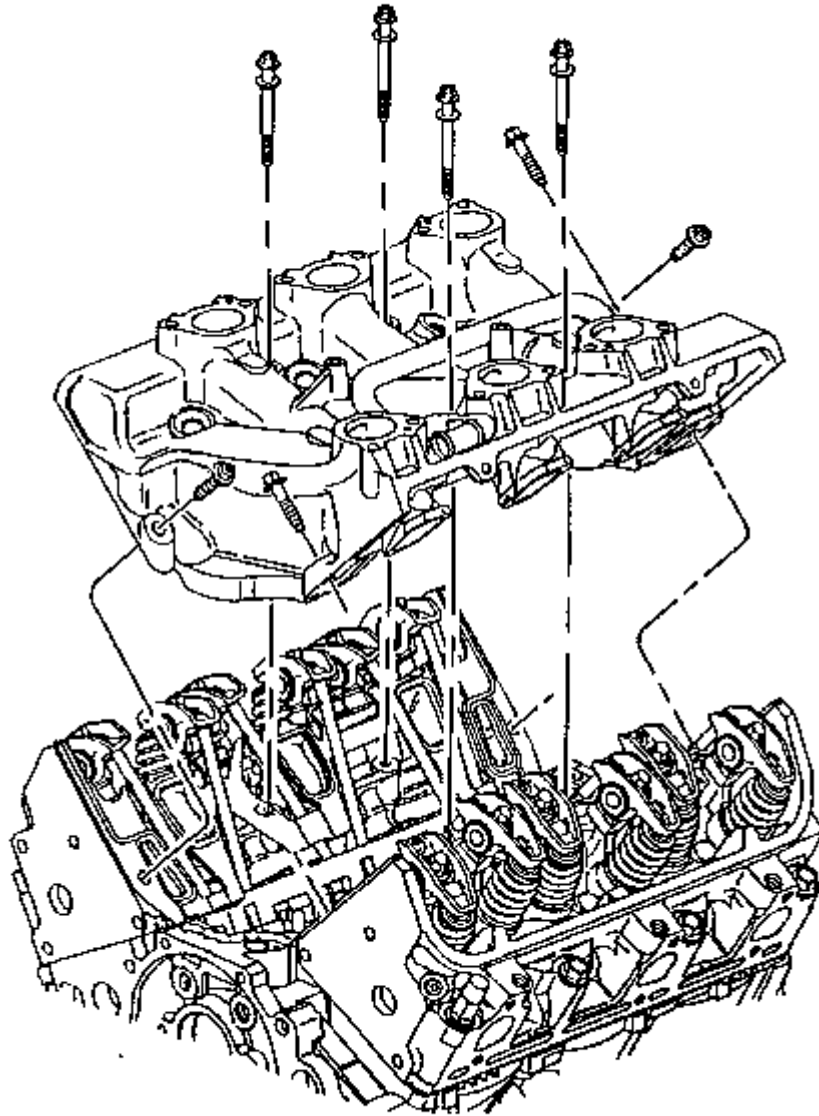


Fig. 69: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

17. Remove the lower intake manifold bolts.
18. Remove the lower intake manifold.
19. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

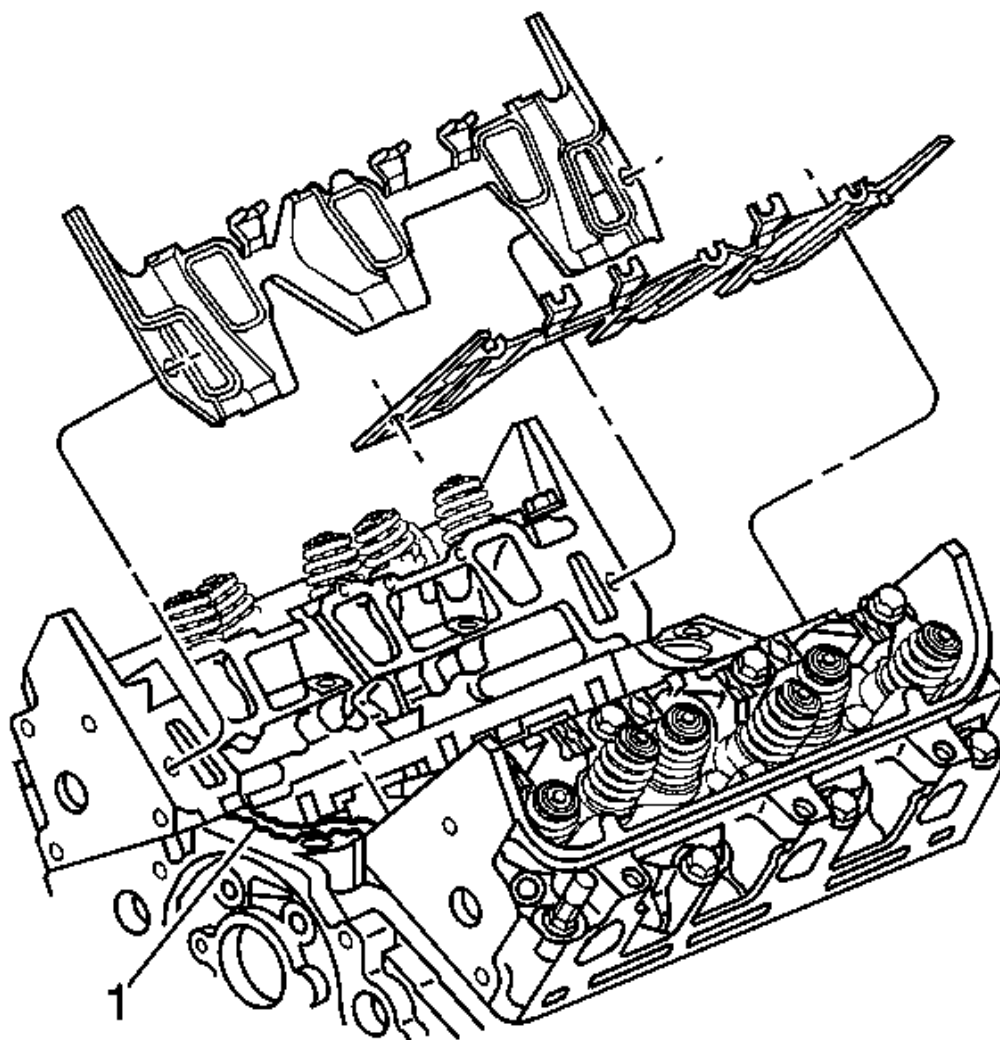


Fig. 70: Lower Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

20. Remove the lower intake manifold gaskets and seals.
21. Clean the lower intake manifold gasket mating surfaces.
22. Remove and clean all the RTV sealant from the lower intake manifold and the engine block (1).

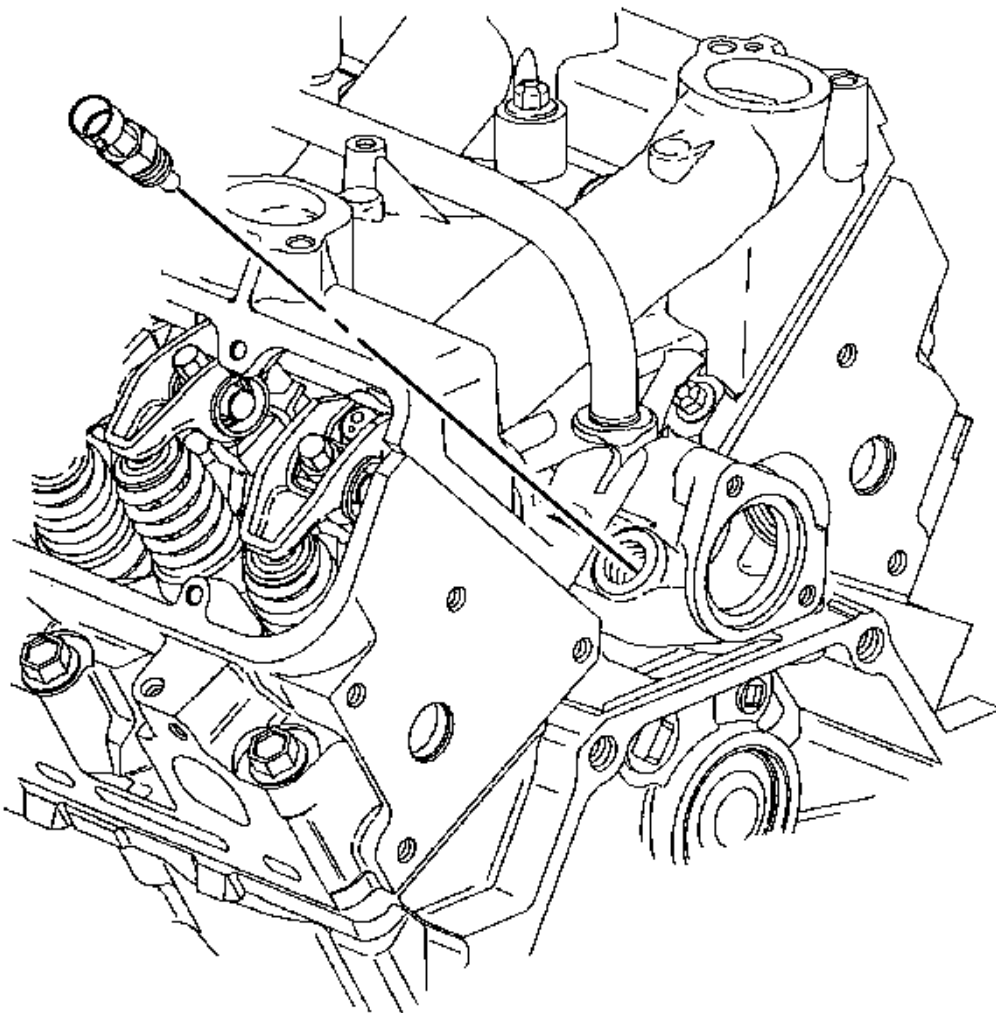


Fig. 71: ECT Sensor

Courtesy of GENERAL MOTORS CORP.

23. Remove the ECT sensor.

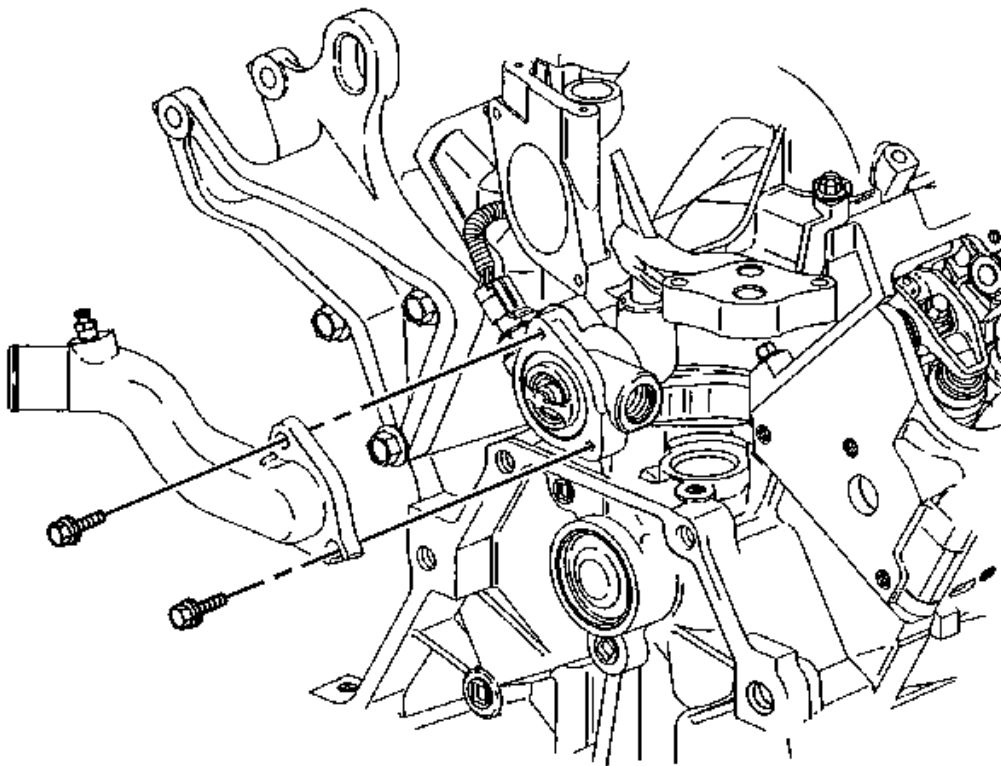


Fig. 72: Water Outlet & Bolts
Courtesy of GENERAL MOTORS CORP.

24. Remove the water outlet bolts.
25. Remove the water outlet.

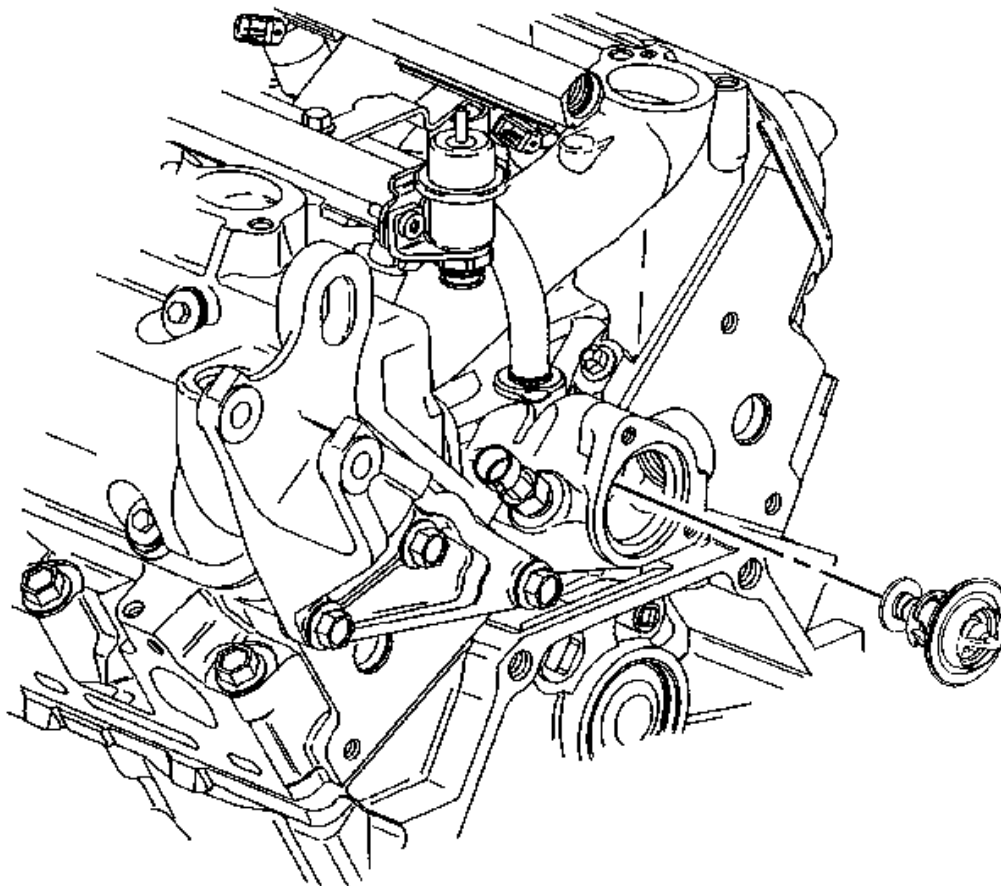


Fig. 73: Thermostat
Courtesy of GENERAL MOTORS CORP.

26. Remove the thermostat.

Installation Procedure

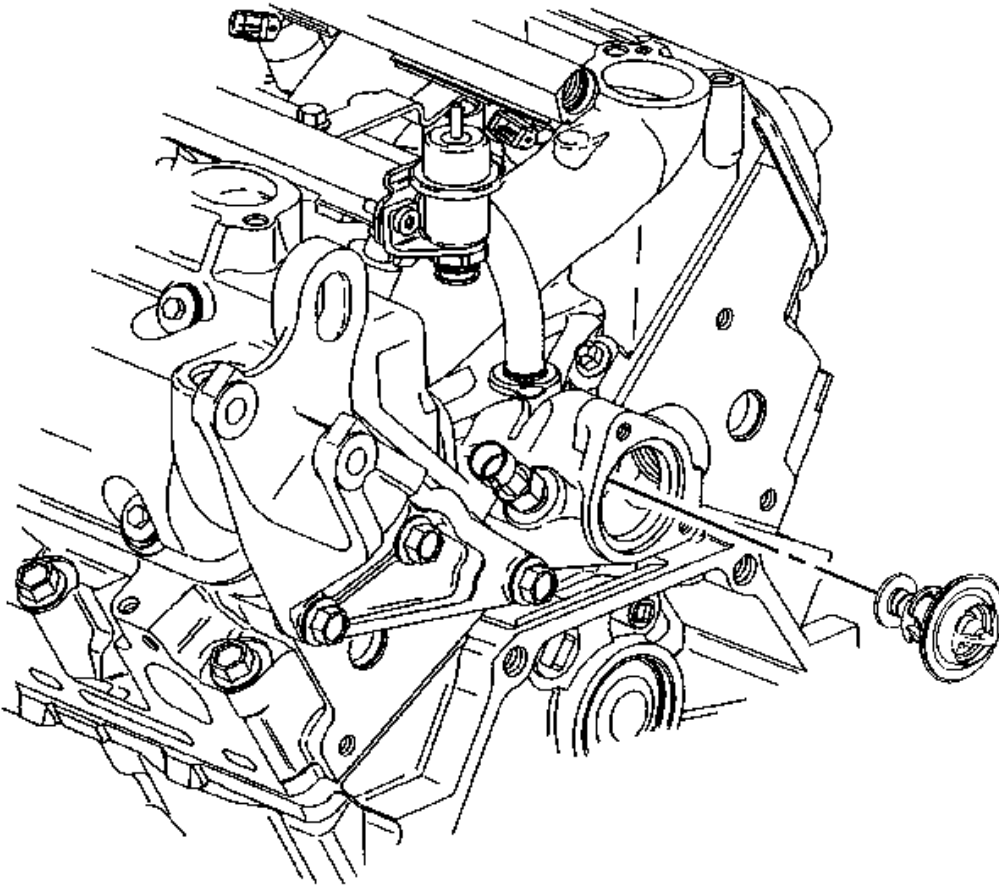


Fig. 74: Thermostat

Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat.

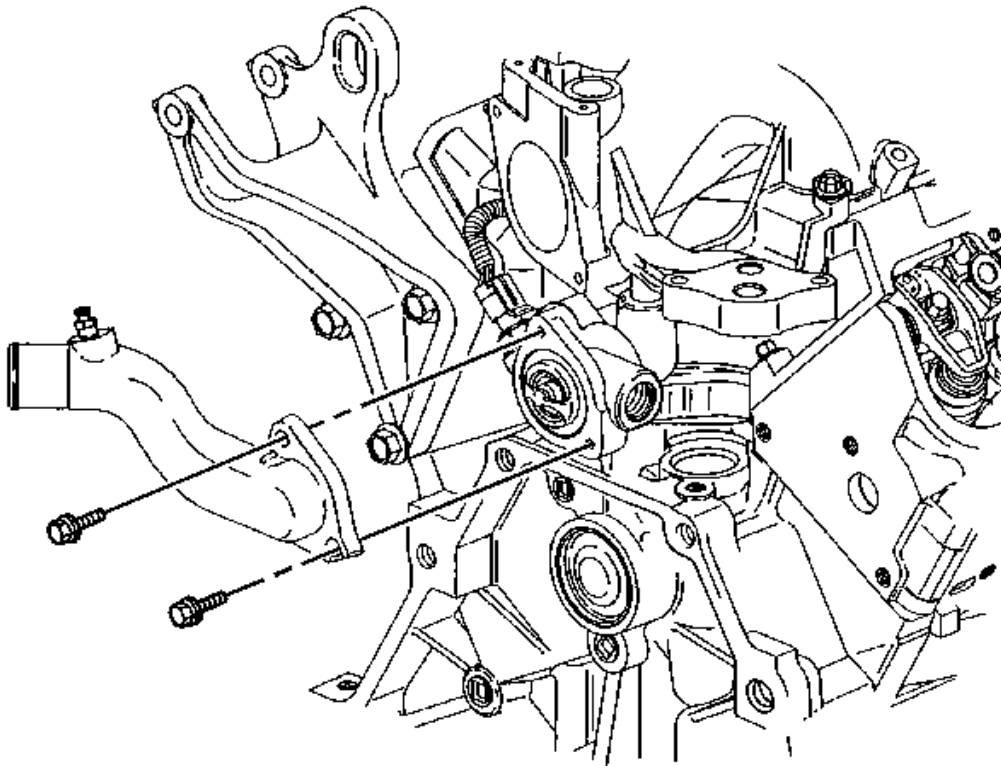


Fig. 75: Water Outlet & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the water outlet.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water outlet bolts.

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

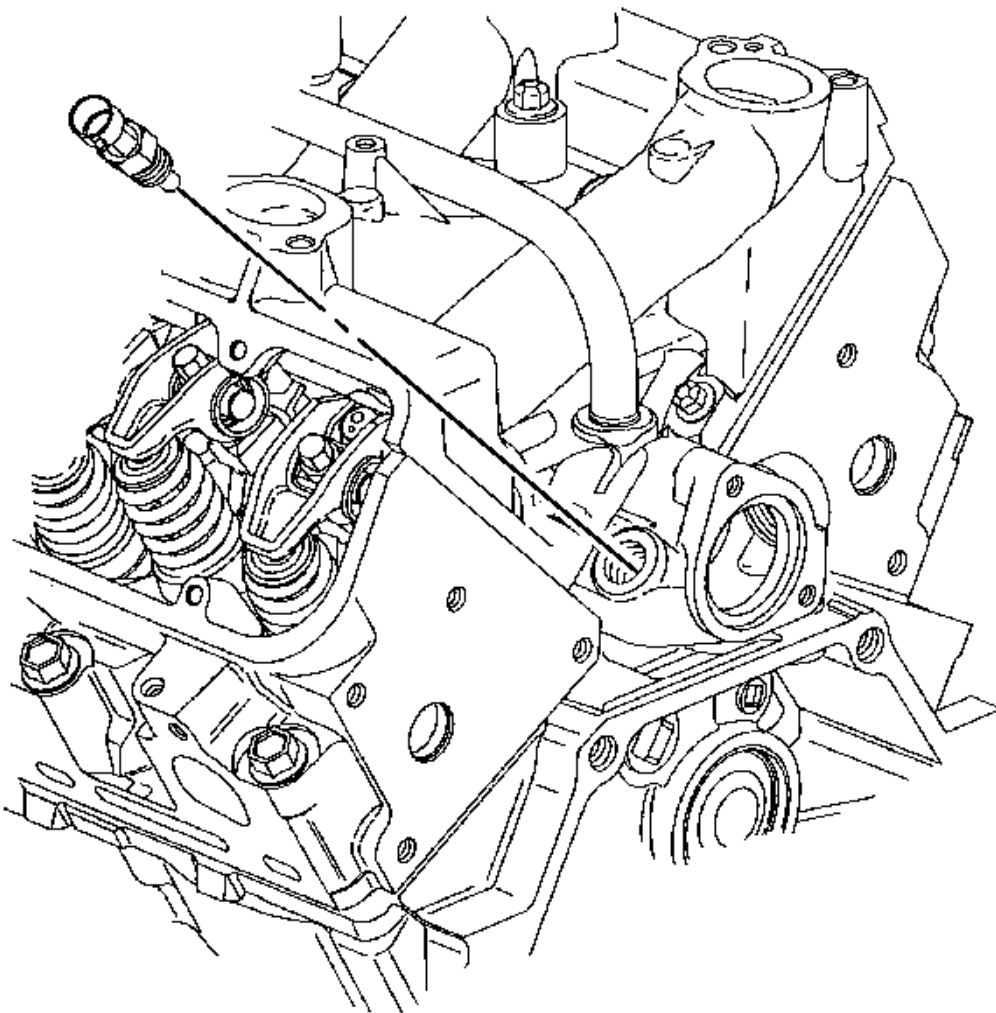


Fig. 76: ECT Sensor

Courtesy of GENERAL MOTORS CORP.

4. Install the ECT sensor.

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

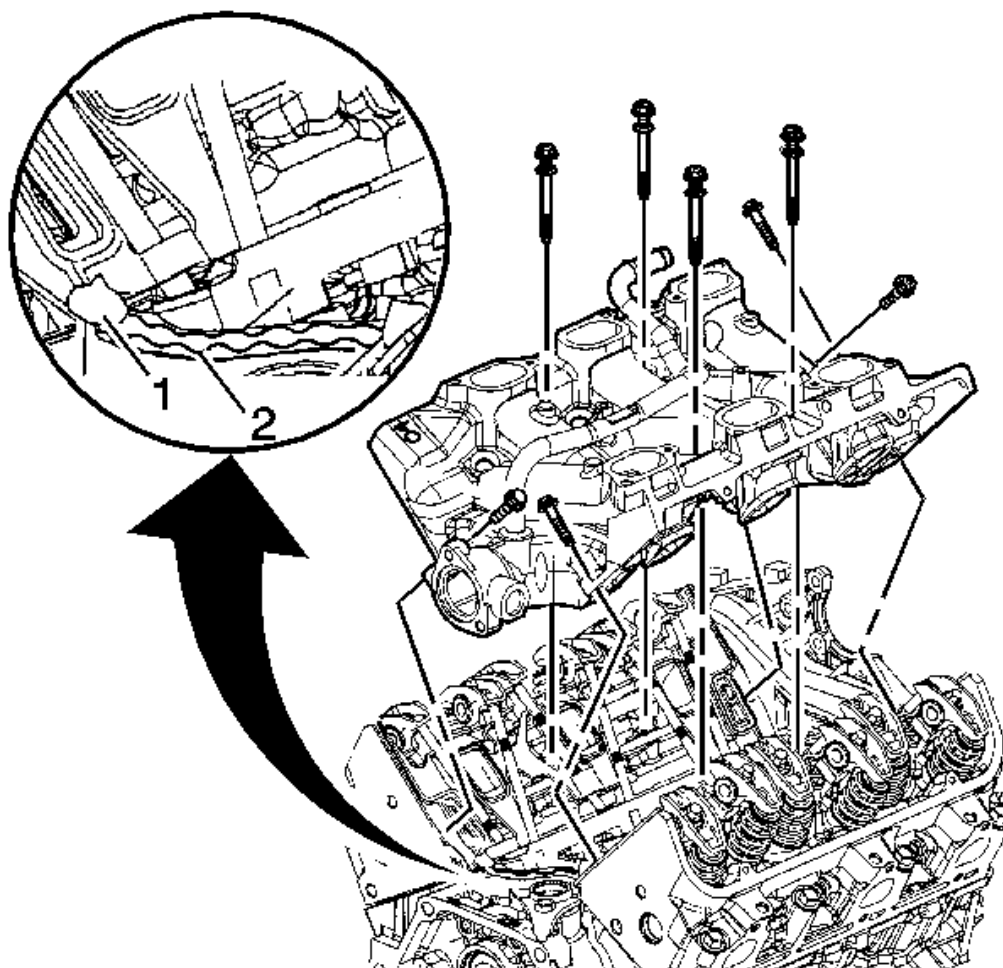


Fig. 77: Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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.

5. Install the lower intake manifold gaskets.
6. With gaskets in place apply a small drop 8-10 mm (0.31-0.39 in) of RTV sealer GM P/N 12346141 (Canadian P/N 10953433) or equivalent to the 4 corners of intake manifold to block joint (1).
7. Connect the 2 small drops with a bead of RTV sealer that is between 8-10 mm (0.31-0.39 in) wide and 3.0-5.0 mm (0.12-0.20 in) thick (2).
8. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

9. Install the lower intake manifold.

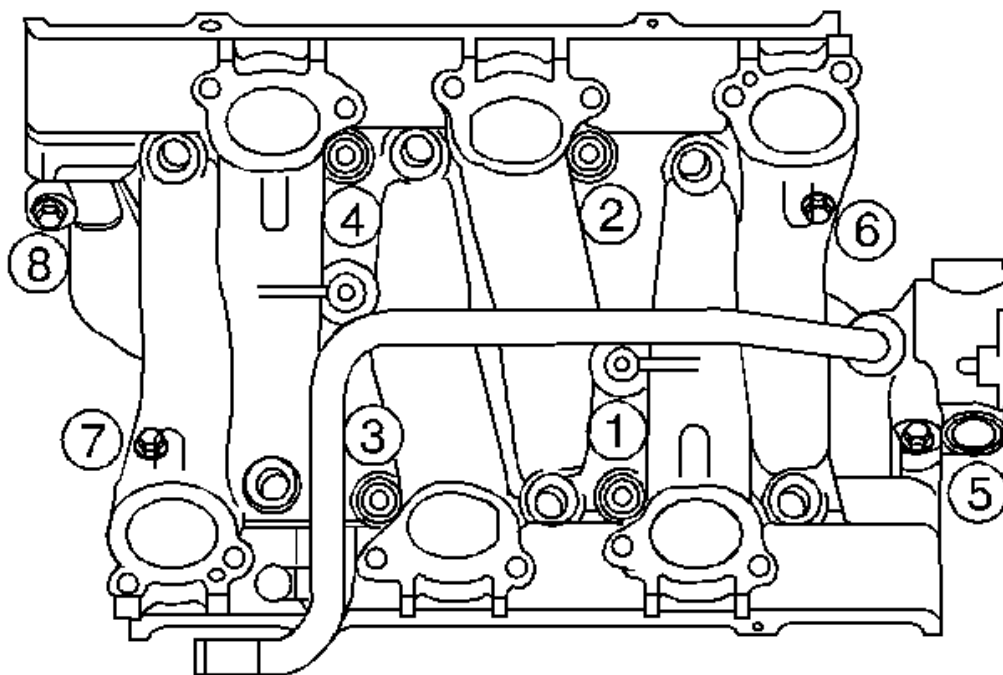


Fig. 78: Lower Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: All lower intake manifold bolts need to be cleaned, free of any foreign material, and reused only if new bolts are unavailable. Use GM P/N 12345382 (Canadian P/N 10953489) or equivalent and apply to the old intake manifold bolt threads.

IMPORTANT: Manufacturer recommends the center bolts be fully torqued before the diagonal bolts to assure proper seal ability.

IMPORTANT: Lower intake manifold bolts in location 6 and 7 should be torqued to

specification using a crows foot type tool.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Install the lower intake manifold bolts.

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.

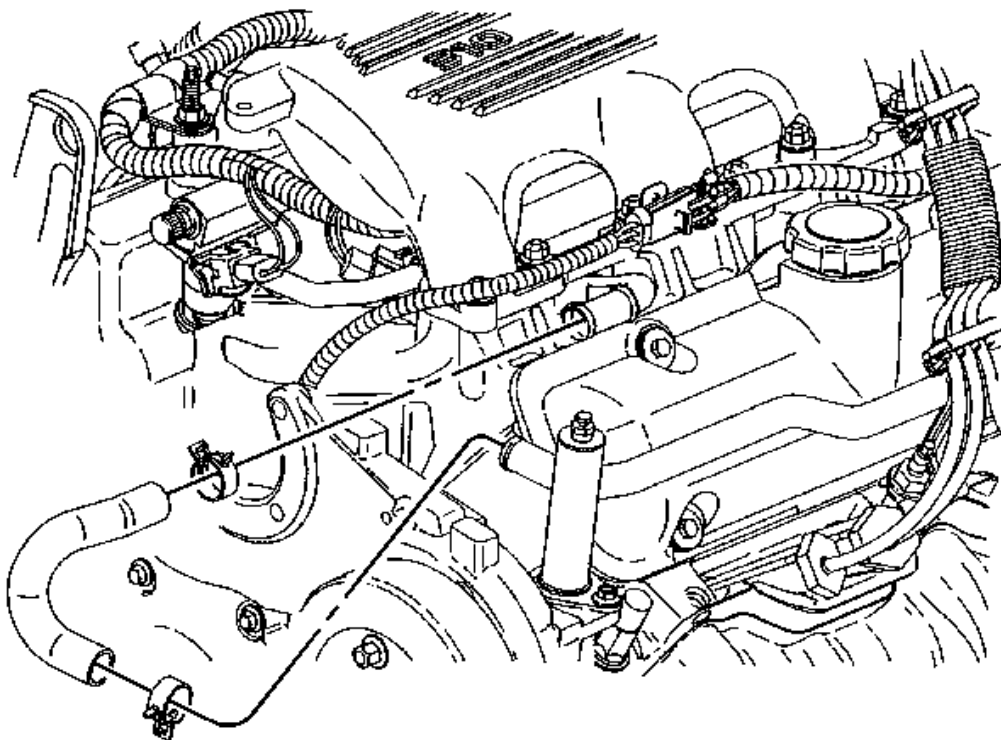


Fig. 79: Thermostat Bypass Hose At Thermostat Bypass Pipe & Lower Intake Manifold Pipe
Courtesy of GENERAL MOTORS CORP.

11. Connect the thermostat bypass hose to the thermostat bypass pipe and lower intake manifold pipe.
12. Connect the radiator inlet hose to the engine. Refer to Radiator Hose Replacement - Inlet (3.1L) or Radiator Hose Replacement - Inlet (3.8L) in Engine Cooling.

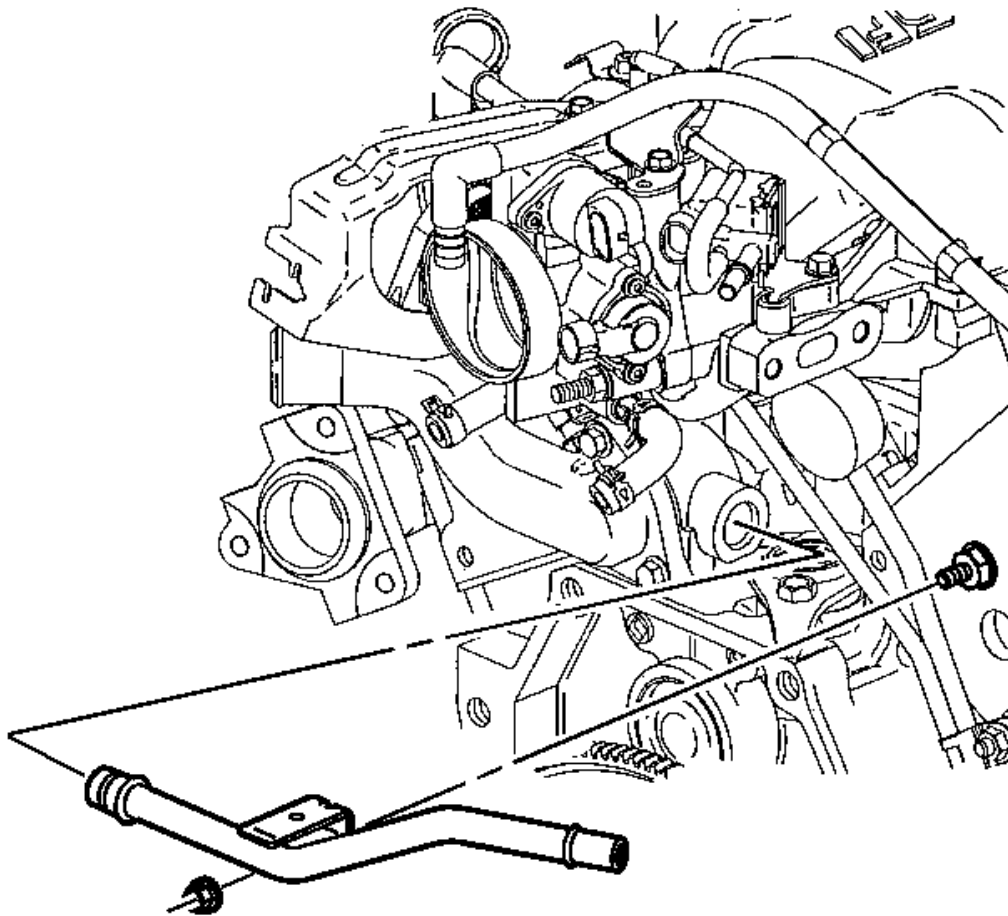


Fig. 80: View Of Heater Inlet Pipe & Nut
Courtesy of GENERAL MOTORS CORP.

13. Install the heater inlet pipe.
14. Install the heater inlet pipe nut.

Tighten: Tighten the heater inlet pipe nut to 25 N.m (18 lb ft).

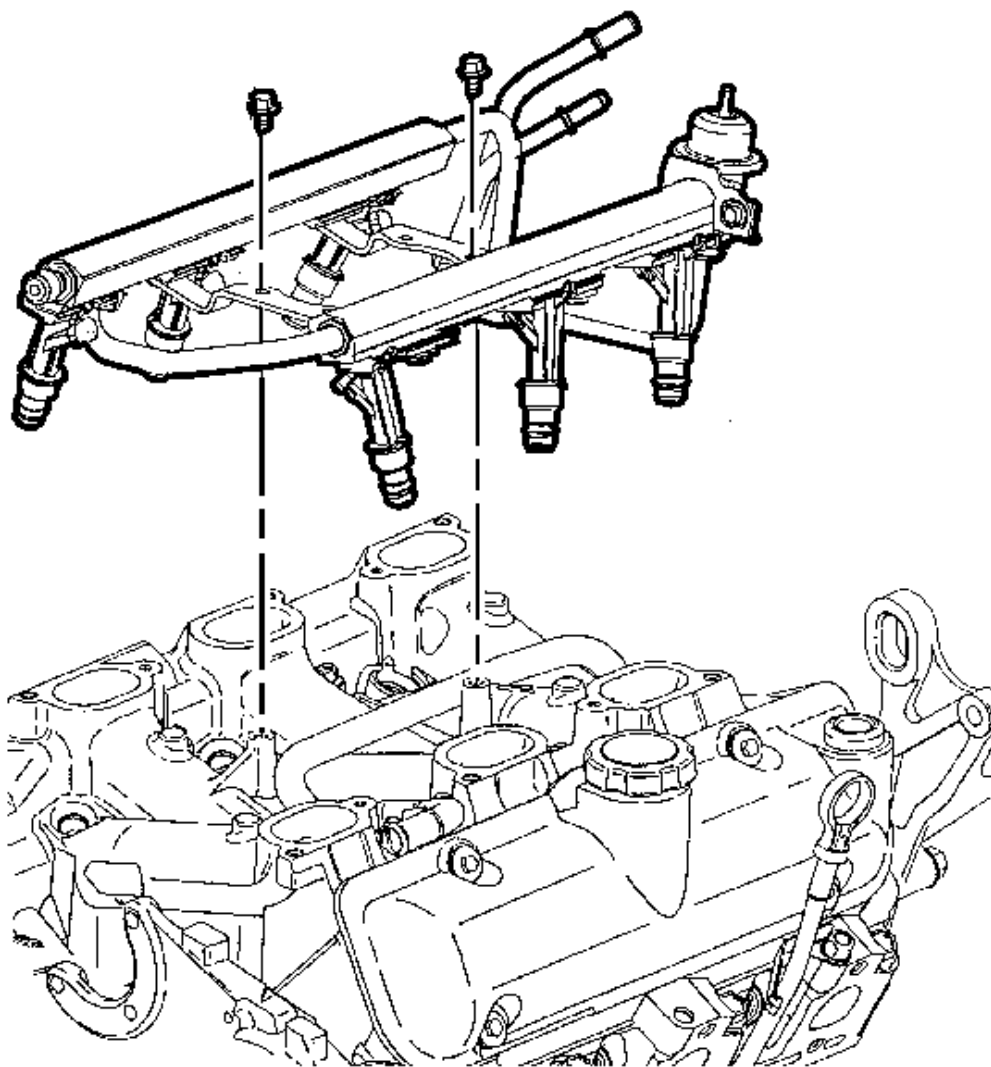


Fig. 81: View Of Fuel Injector Rail Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not press on the fuel pressure regulator valve when installing the fuel injector rail assembly.

15. Install the fuel rail assembly.
 1. Install the fuel injector O-rings using GM P/N 12345616 (Canadian P/N 993182) or equivalent.
 2. Install the injector nozzles into the lower intake manifold injector bores.

3. Press on the injector rail using the palms of both hands until the injectors are fully seated.
16. Install the fuel injector bolts.

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

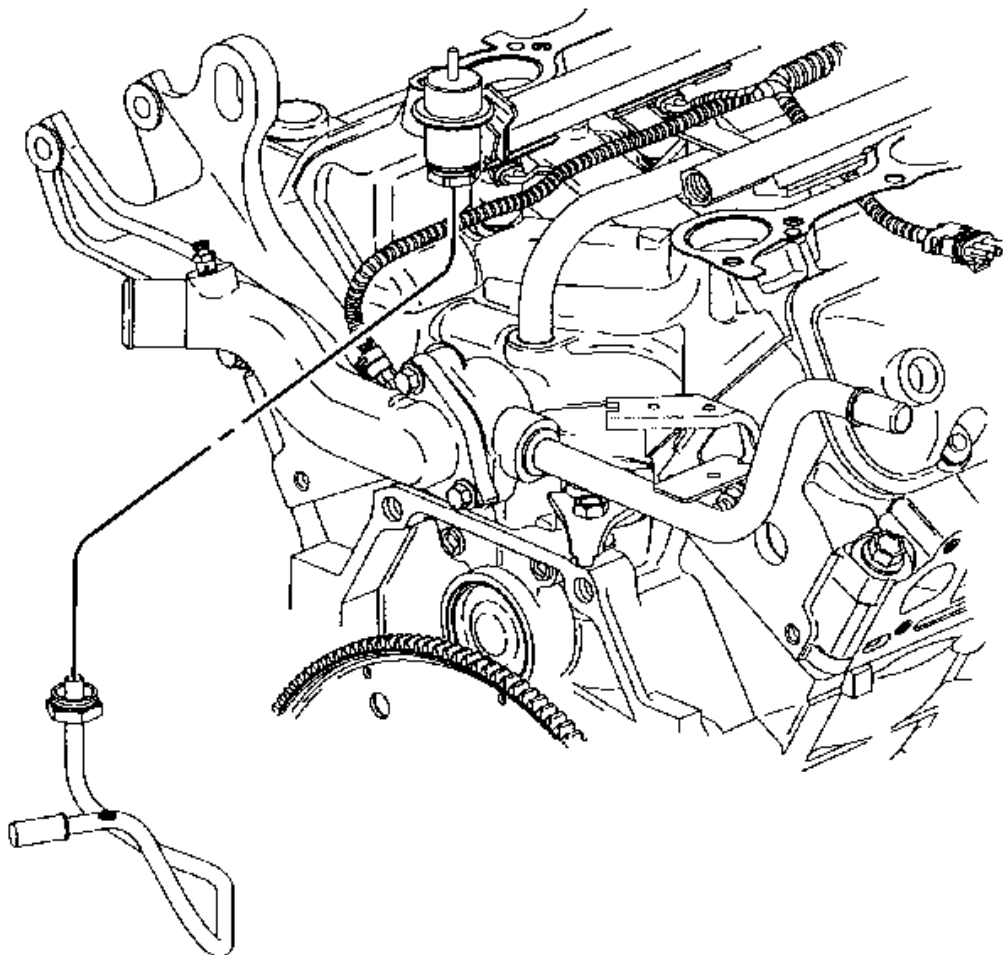


Fig. 82: Fuel Return Pipe At Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

17. Connect the fuel return pipe to the fuel injector rail. Refer to **Fuel Hose/Pipes Replacement - Filter to Engine** in Engine Controls - 3.1 L.

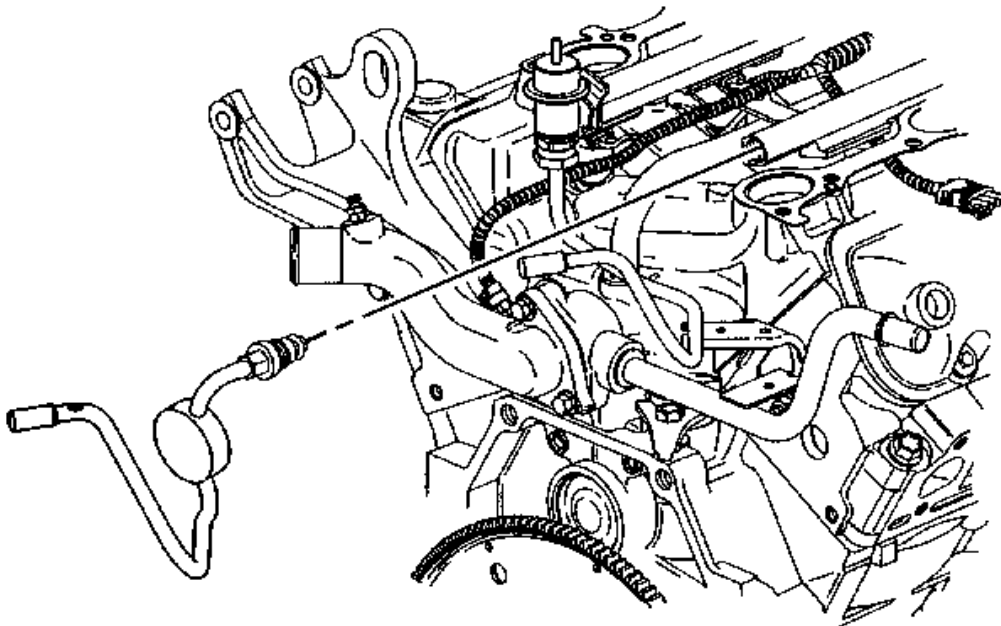


Fig. 83: Fuel Feed Pipe At Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

18. Connect the fuel feed pipe to the fuel injector rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls.

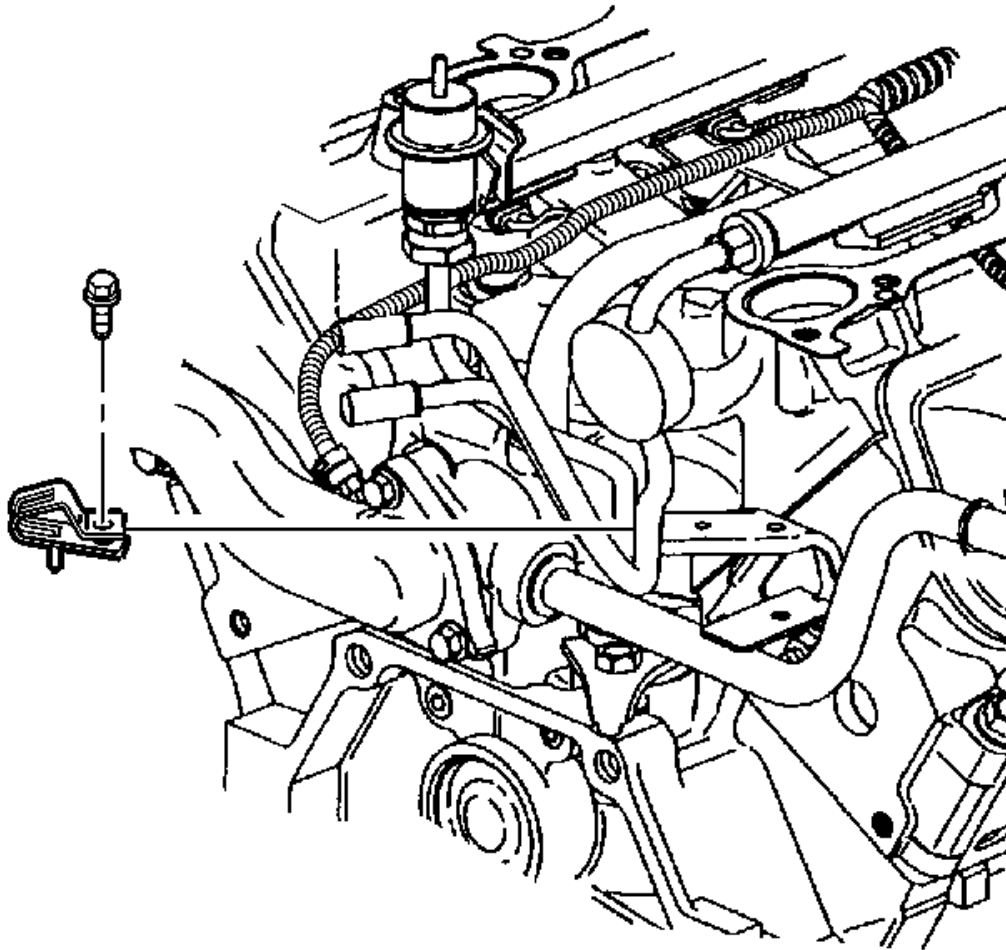


Fig. 84: Fuel Feed & Return Pipe Retaining Clip
Courtesy of GENERAL MOTORS CORP.

19. Install the fuel feed and return pipe retaining clip.
20. Install the fuel feed and return pipe retaining clip bolt.

Tighten: Tighten the fuel feed and return pipe retaining clip bolt to 8 N.m (71 lb in).

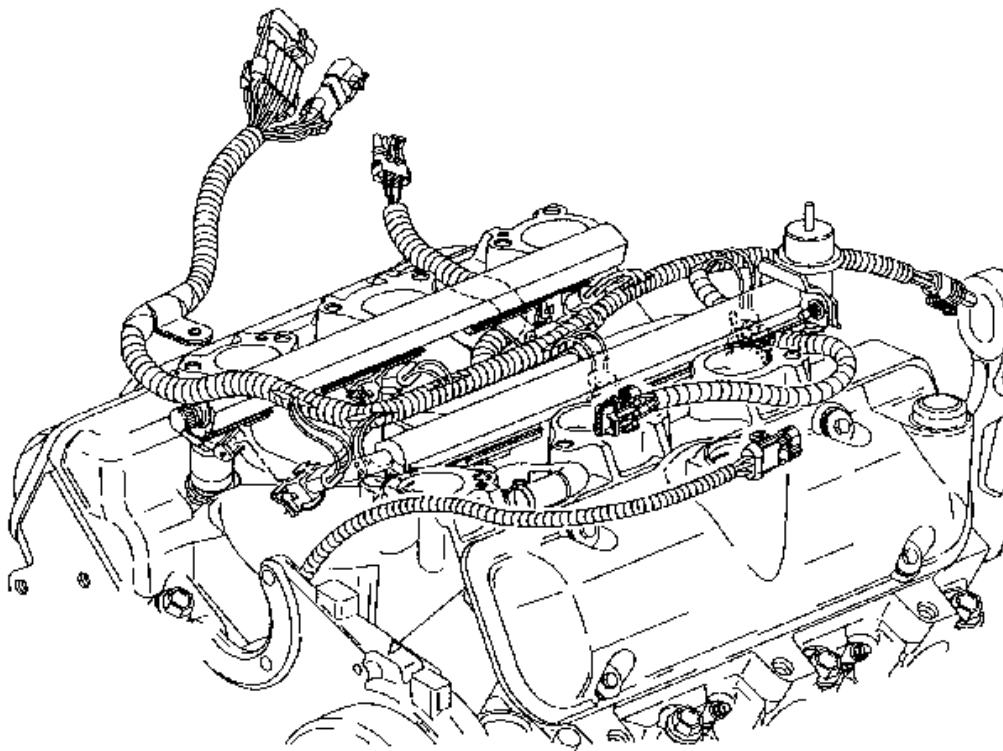


Fig. 85: MAP Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

21. Install and connect the fuel injector and manifold air pressure (MAP) wiring harness.

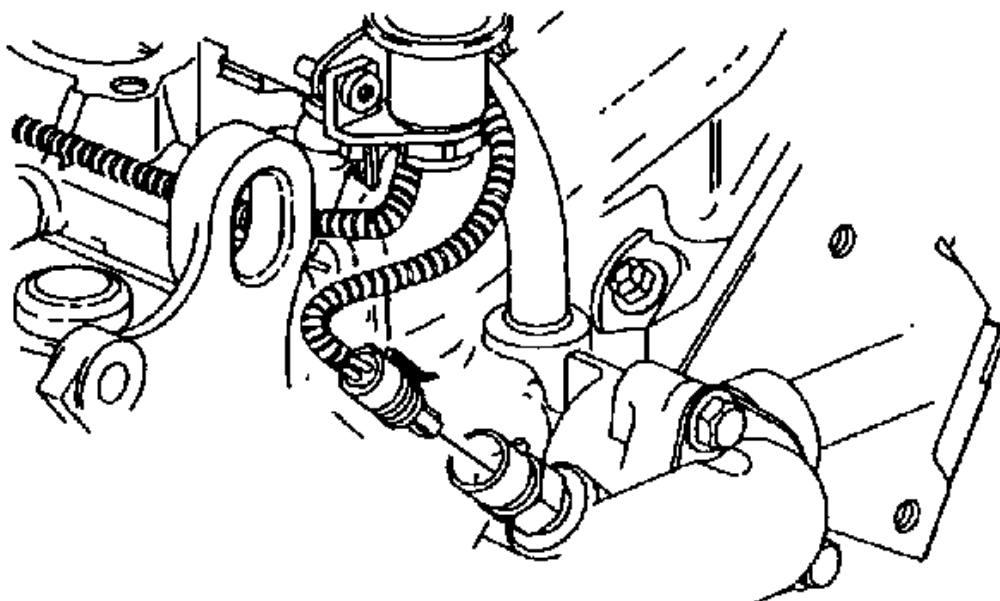


Fig. 86: ECT Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

22. Connect the engine coolant temperature (ECT) wiring harness.
23. Install the right (rear) valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right.**
24. Install the generator. Refer to **Generator Replacement (3.1L)** or **Generator Replacement (3.8L)** in Engine Electrical.
25. Install the left (front) valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left.**
26. Install the upper intake manifold. Refer to **Intake Manifold Replacement - Upper.**
27. Connect the battery ground (negative) cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Positive Crankcase Ventilation (PCV) Valve Replacement

Removal Procedure

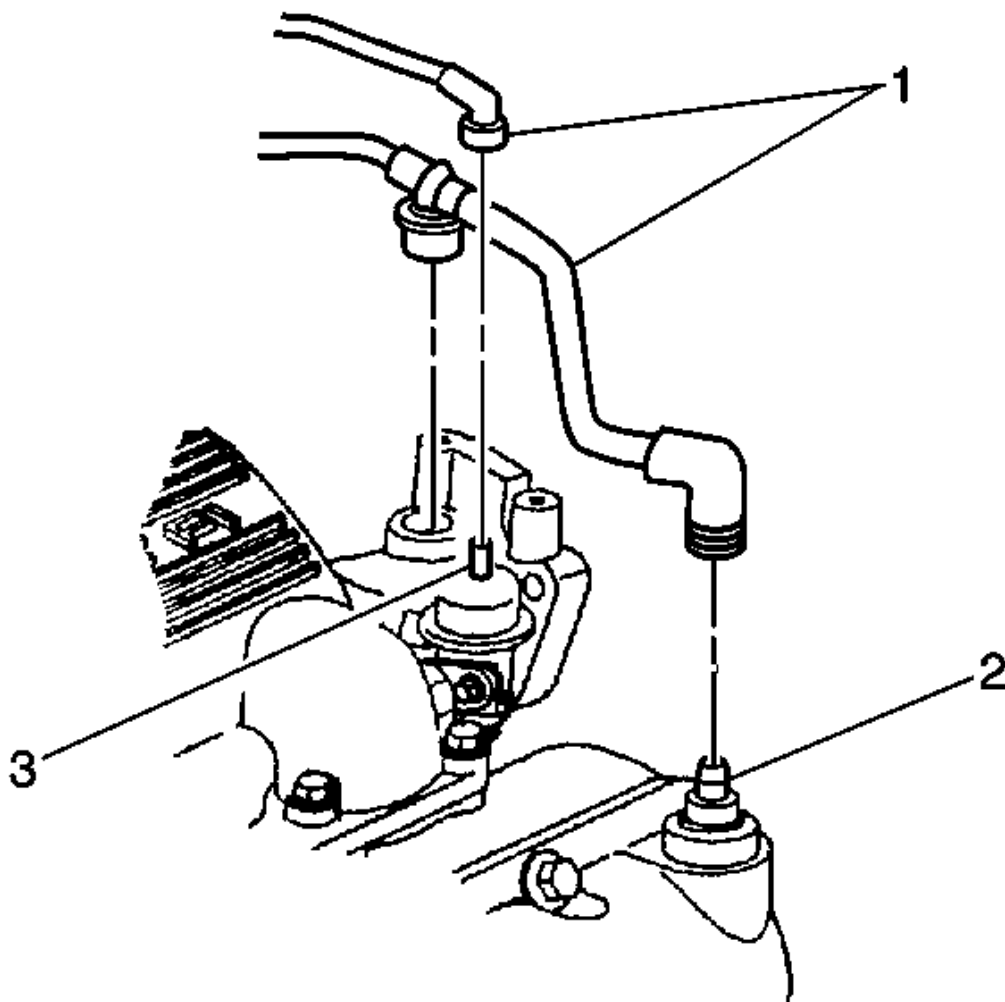


Fig. 87: PVC Valve, Vacuum Hoses & Fuel Pressure Regulator
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the vacuum hoses (1) from the fuel pressure regulator (3) and the positive crankcase ventilation (PCV) valve (2).
2. Remove the PCV valve (2).

Installation Procedure

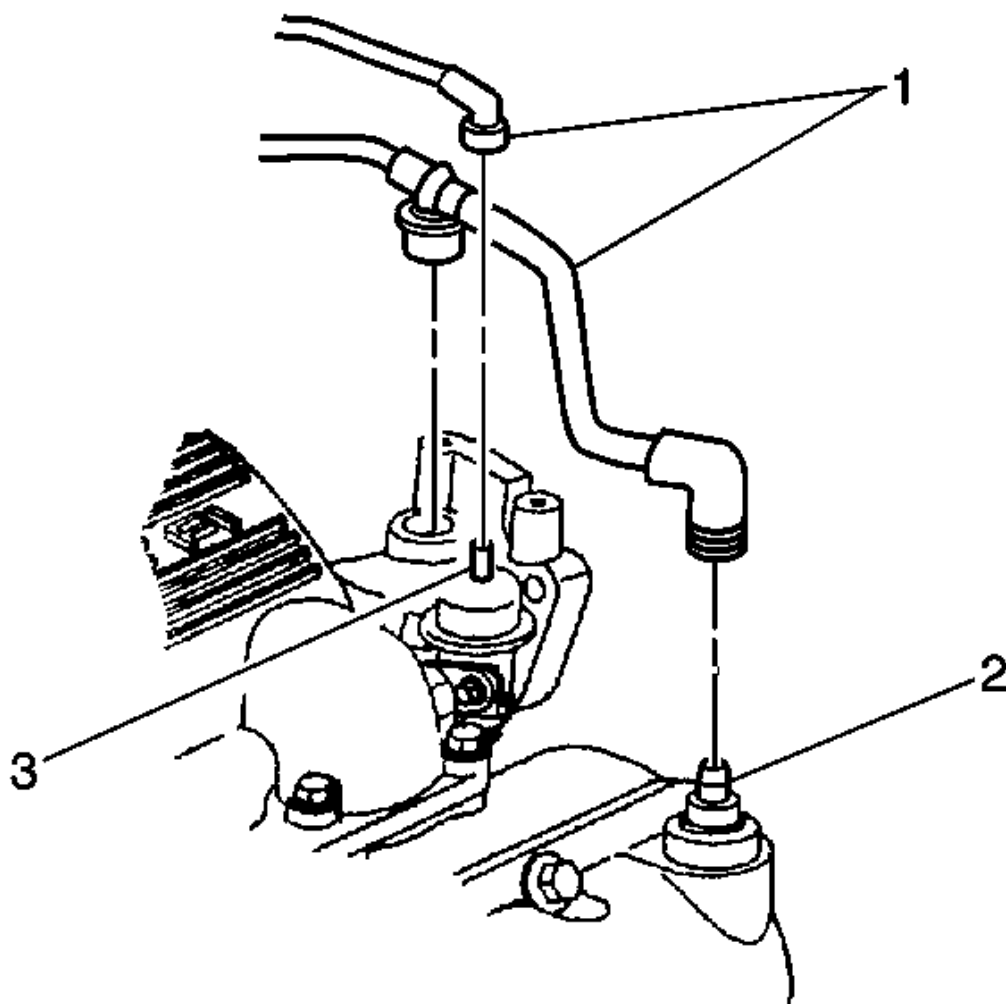


Fig. 88: PCV Valve, Vacuum Hoses & Fuel Pressure Regulator
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV valve (2).
2. Connect the vacuum hoses (1) to the fuel pressure regulator (3) and the PCV valve (2).

Valve Rocker Arm Cover Replacement - Left

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
2. Remove the left spark plug wires. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.

3. Remove the thermostat bypass hose and the pipe. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
4. Remove the positive crankcase ventilation (PCV) valve from the left valve rocker arm cover.

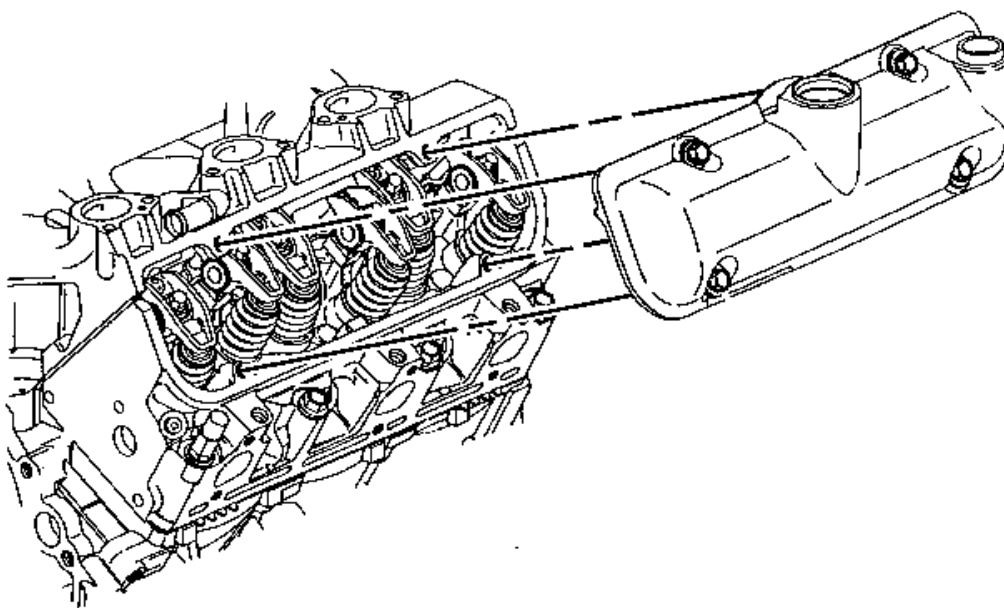


Fig. 89: Left Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the left valve rocker arm cover bolts.
6. Remove the left valve rocker arm cover.
7. Remove the left valve rocker arm cover gasket.
8. Clean the valve rocker arm cover.
9. Clean the valve rocker arm cover gasket mating surfaces.

Installation Procedure

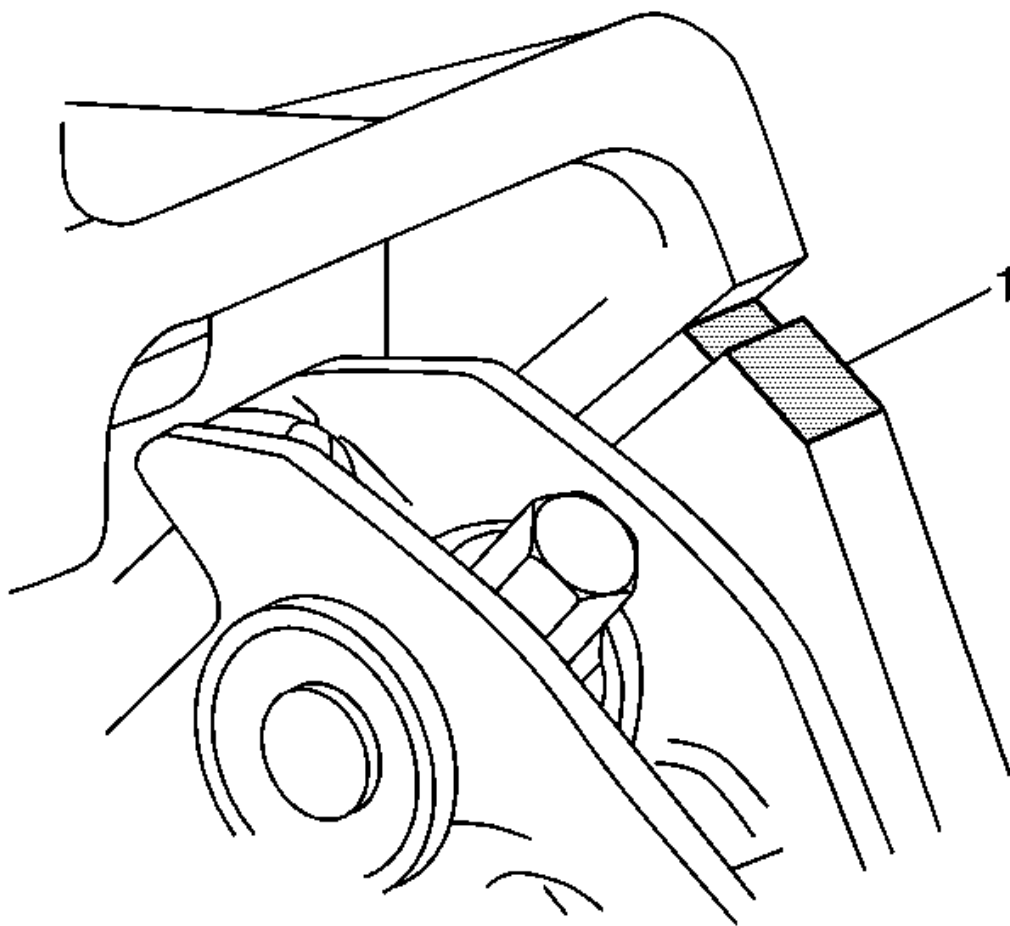


Fig. 90: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply sealant GM P/N 12346286 (Canadian P/N 10953472) or equivalent at the cylinder head to lower intake manifold joint.

1. Apply sealant at the cylinder head to lower intake manifold joint at the rear of the lower intake manifold (1).

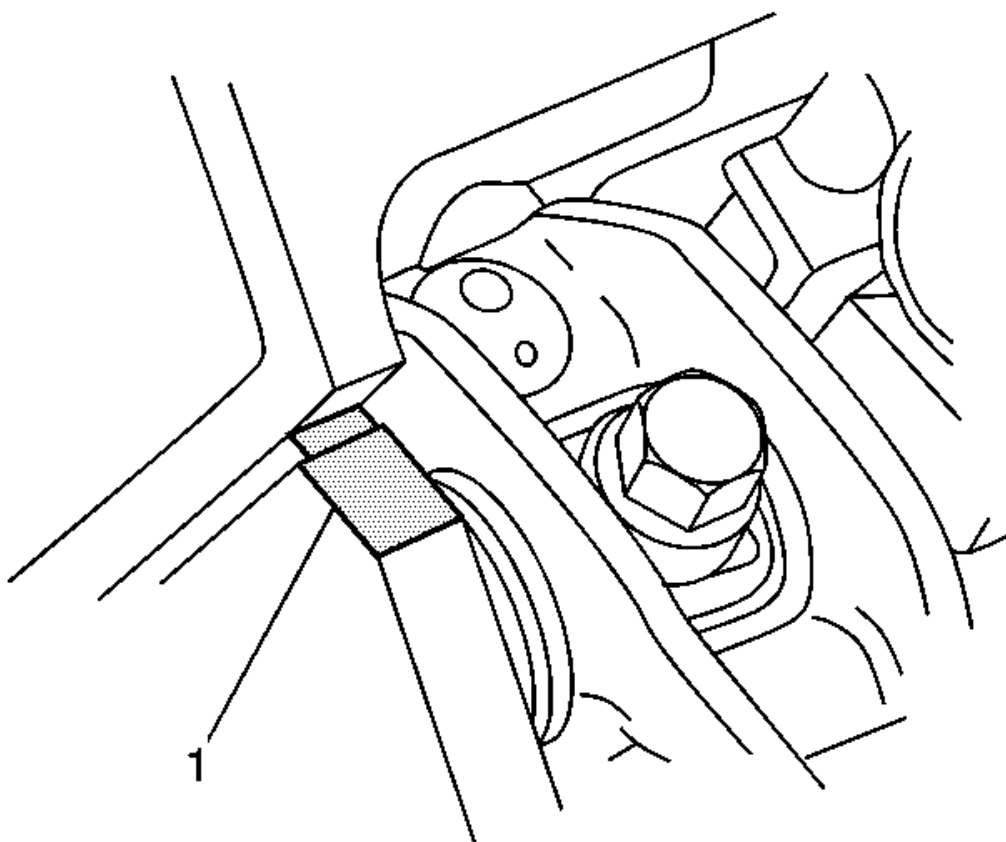


Fig. 91: Cylinder Head To Lower Intake Manifold Joint At Front Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant at the cylinder head to lower intake manifold joint at the front of the lower intake manifold (1).
3. Install a new left valve rocker arm cover gasket.

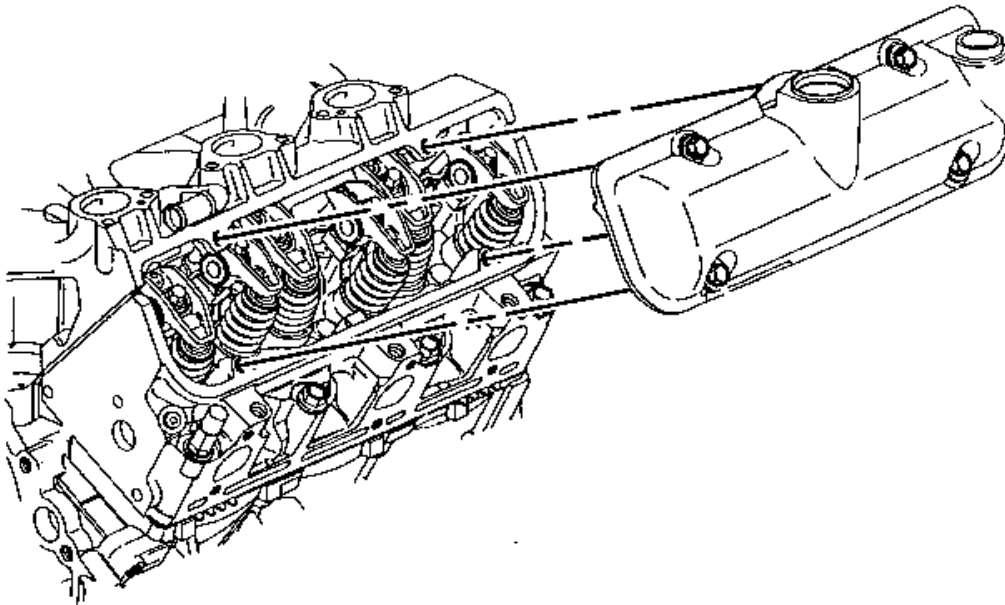


Fig. 92: Left Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the left valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the left valve rocker arm cover bolts.

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

6. Install the PCV valve to the left valve rocker arm cover.
7. Install the thermostat bypass pipe. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
8. Install the left spark plug wires. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.
9. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
10. Inspect for leaks.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Remove the generator. Refer to **Generator Replacement (3.1L)** or **Generator Replacement (3.8L)** in Engine Electrical.
4. Remove the generator bracket. Refer to **Generator Bracket Replacement** in Engine Electrical.
5. Remove the right spark plug wires. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.
6. Remove the EVAP purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 3.1L.
7. Remove the ignition coil bracket with the coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.1L.
8. Remove the Ignition Coil bracket Studs.
9. Remove the vacuum hose from the grommet in the right valve rocker arm cover.

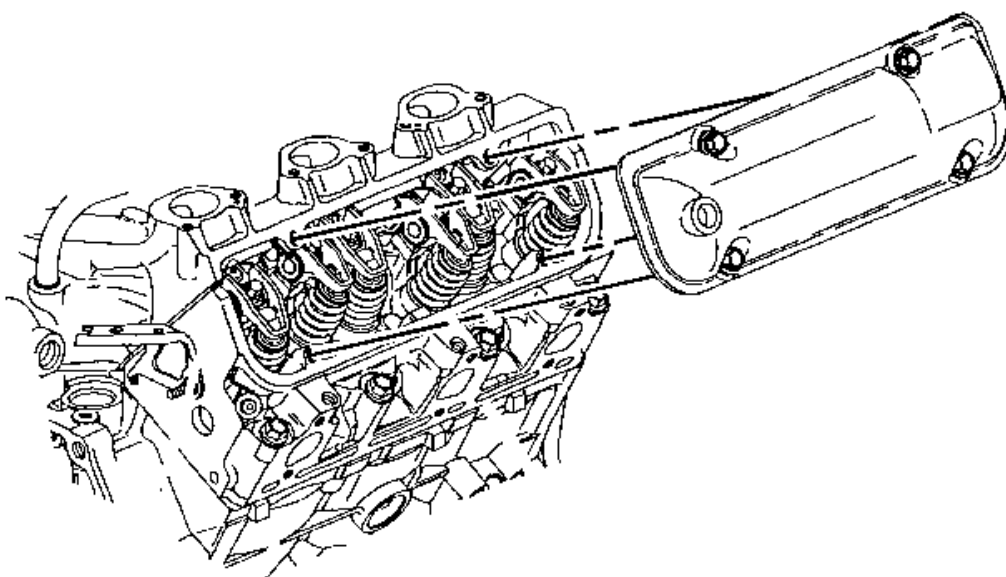


Fig. 93: Right Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the right valve rocker arm cover bolts.
11. Remove the right valve rocker arm cover.
12. Remove the right valve rocker arm cover gasket.
13. Clean the valve rocker arm cover.
14. Clean the valve rocker arm cover gasket mating surfaces.

Installation Procedure

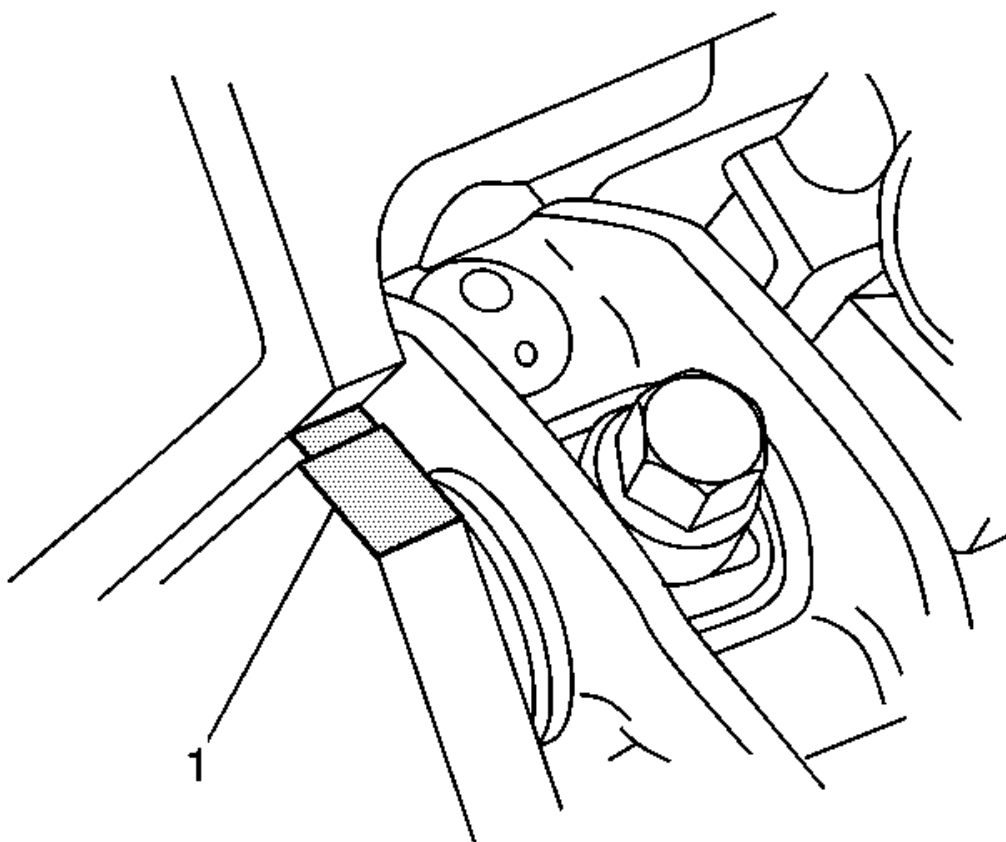


Fig. 94: Cylinder Head To Lower Intake Manifold Joint At Front Of Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply sealant GM P/N 12346286 (Canadian P/N 10953472) or equivalent at the cylinder head to lower intake manifold joint.

1. Apply sealant at the cylinder head to lower intake manifold joint at the rear of the lower intake manifold (1).

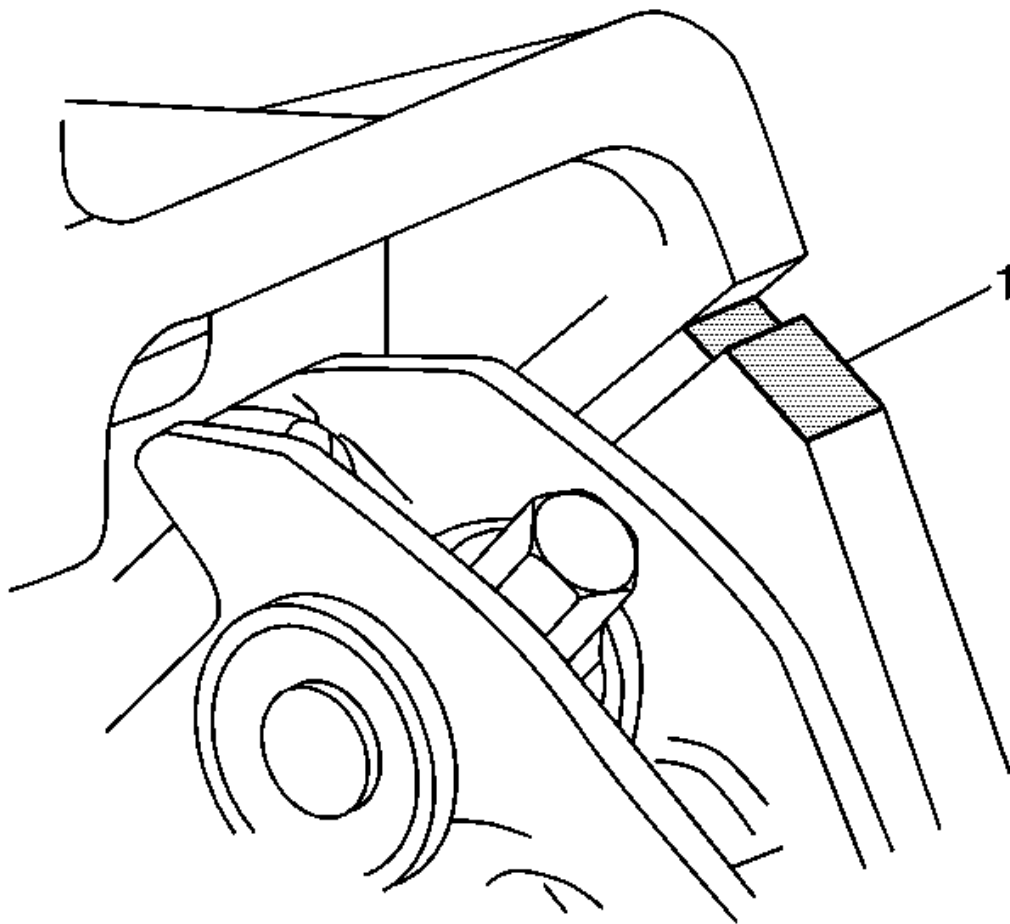


Fig. 95: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant at the cylinder head to lower intake manifold joint at the front of the lower intake manifold (1).
3. Install a new right valve rocker arm cover gasket.

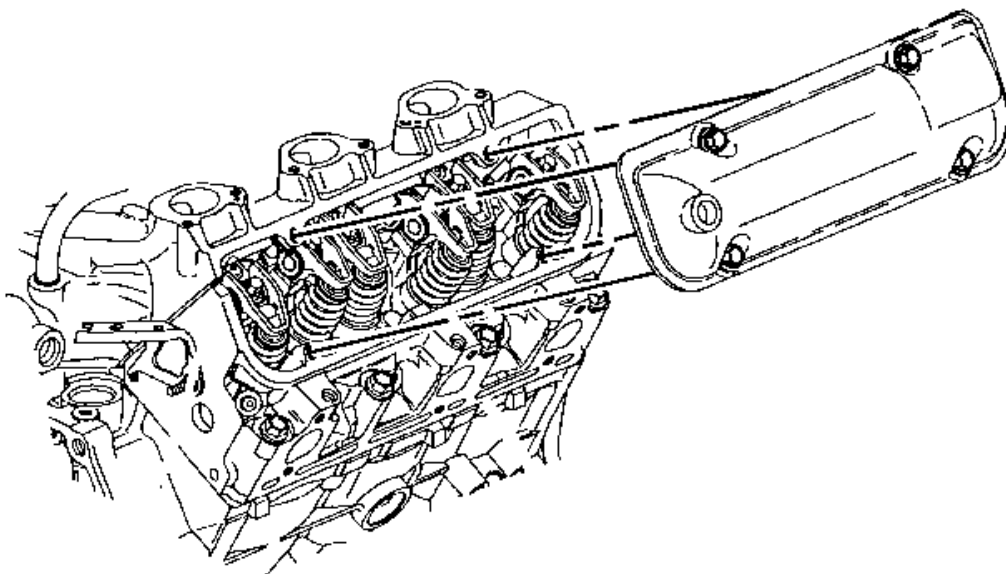


Fig. 96: Right Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the right valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the right valve rocker arm cover bolts.

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

6. Install the vacuum hose to the grommet in the right valve rocker arm cover.
7. Install the ignition coil bracket studs.
8. Install the ignition coil bracket with the coils. Refer to Ignition Coil(s) Replacement in Engine Controls - 3.1L.
9. Install the EVAP purge valve. Refer to Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement in Engine Controls - 3.1L.
10. Install the right spark plug wires. Refer to Spark Plug Wire Replacement in Engine Controls - 3.1L.
11. Install the generator bracket. Refer to Generator Bracket Replacement in Engine Electrical.
12. Install the generator. Refer to Generator Replacement (3.1L) or Generator Replacement (3.8L) in Engine Electrical.
13. Install the drive belt. Refer to Drive Belt Replacement.

14. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
15. Inspect for leaks.

Valve Rocker Arm and Push Rod Replacement

Tools Required

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

Removal Procedure

1. Remove the left or the right valve rocker arm covers. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right**.

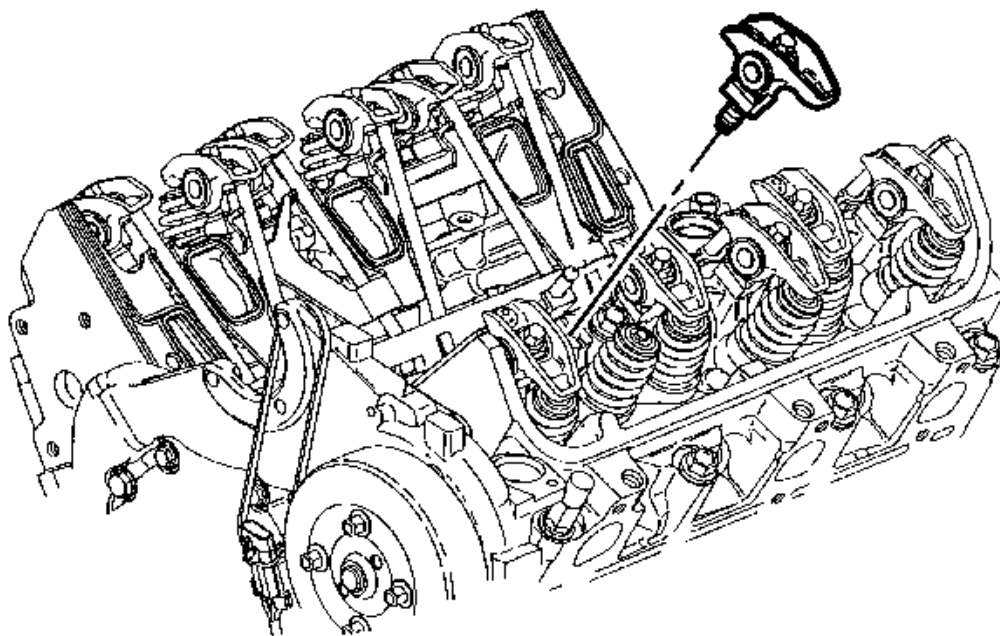


Fig. 97: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

2. Remove the rocker arm bolts.

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

IMPORTANT: Use care when removing the pushrods. Ensure that they do not fall down into the lifter valley.

3. Remove the rocker arms.
4. Remove the pushrods.

Installation Procedure

1. Coat the ends of the pushrods with prelube GM P/N 1052367 (Canadian P/N 992869) or the equivalent.

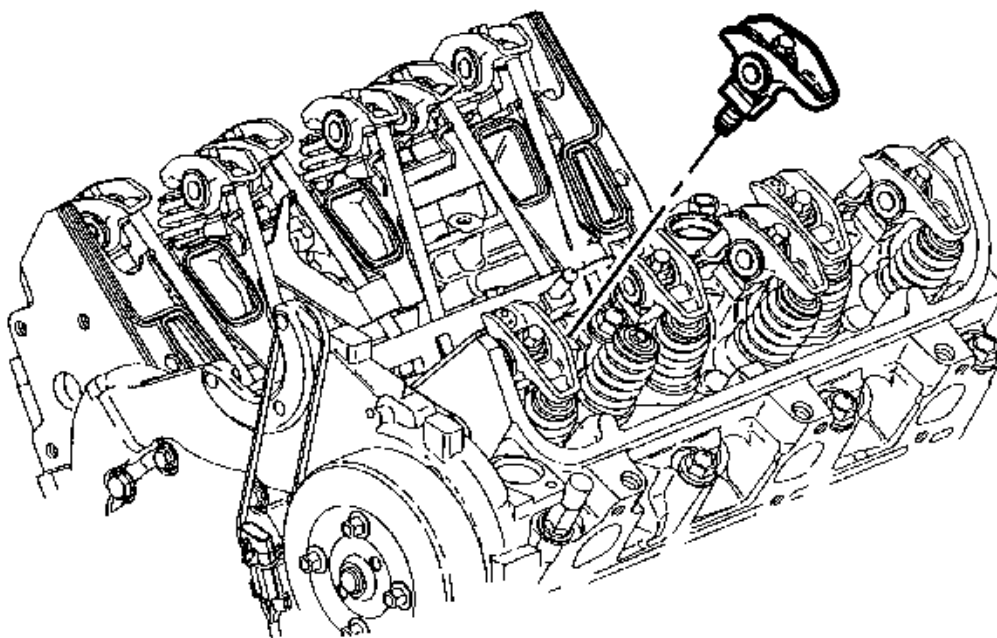


Fig. 98: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake pushrods measure 144 mm (5.68 in) long.
The exhaust pushrods measure 152.5 mm (6.0 in) long.

2. Install the pushrods and the rocker arms to their original location.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the valve rocker arm bolts.

Tighten:

1. Tighten the bolts to 19 N.m (14 lb ft).
2. Use the **J 45059** rotate the bolts an additional 30 degrees. See **Special Tools and Equipment**.
4. Install the left or the right valve rocker arm covers. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right**.

Valve Stem Oil Seal and Valve Spring Replacement**Tools Required**

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

Removal Procedure**IMPORTANT:**

- **Before you remove 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.**
 - **Break the spark plug loose, and clean any dirt or debris from the spark plug recess area before removing.**
 - **Do not remove the spark plug when the engine is hot.**
1. Remove the spark plug from the cylinder that is being serviced. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.
 2. Remove the rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
 3. Install the **J 22794** to the spark plug port. See **Special Tools and Equipment**. Apply compressed air in order to hold the valves in place.

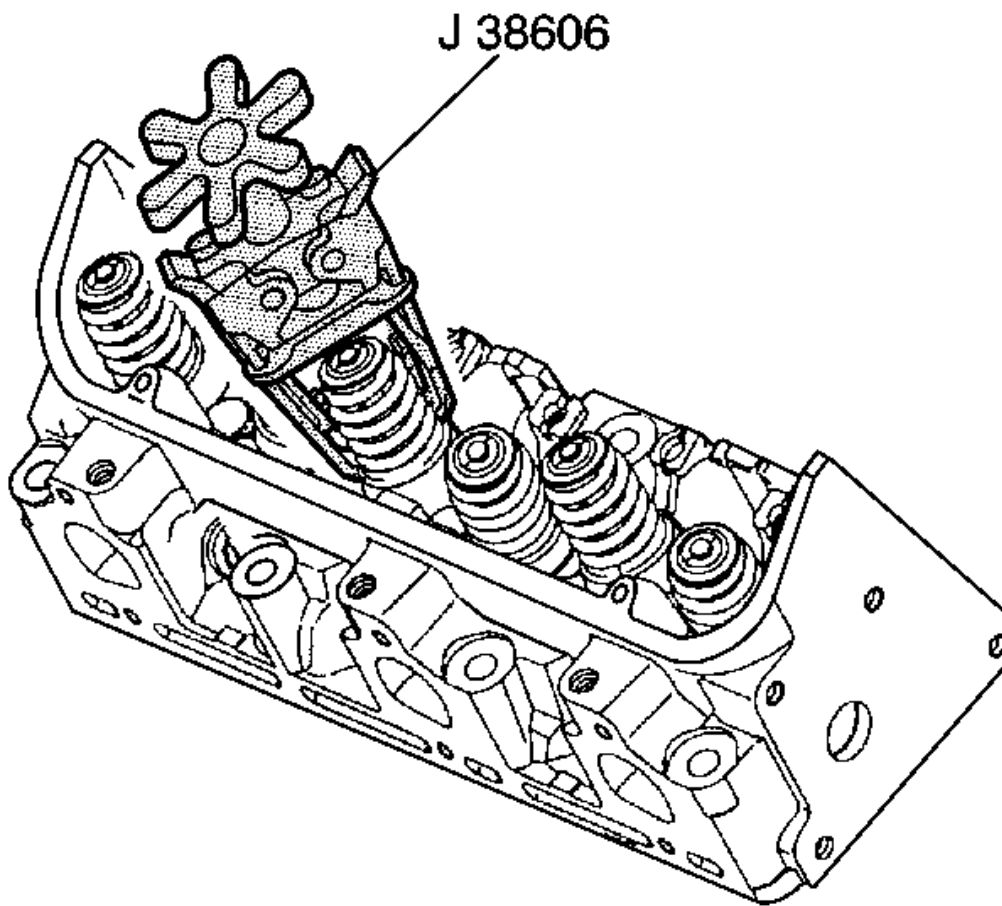


Fig. 99: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 38606** on the valve spring.

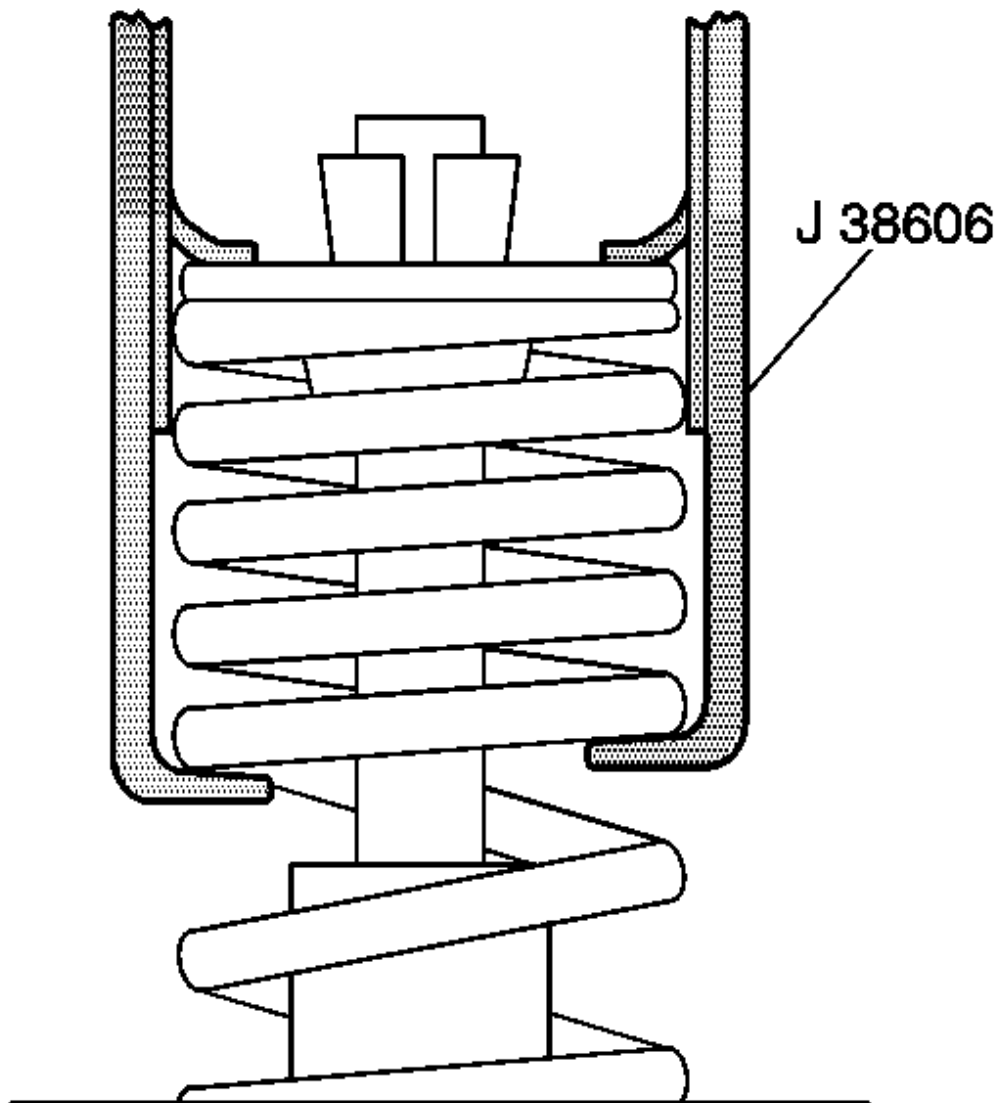


Fig. 100: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

5. Compress the valve spring with the **J 38606** .

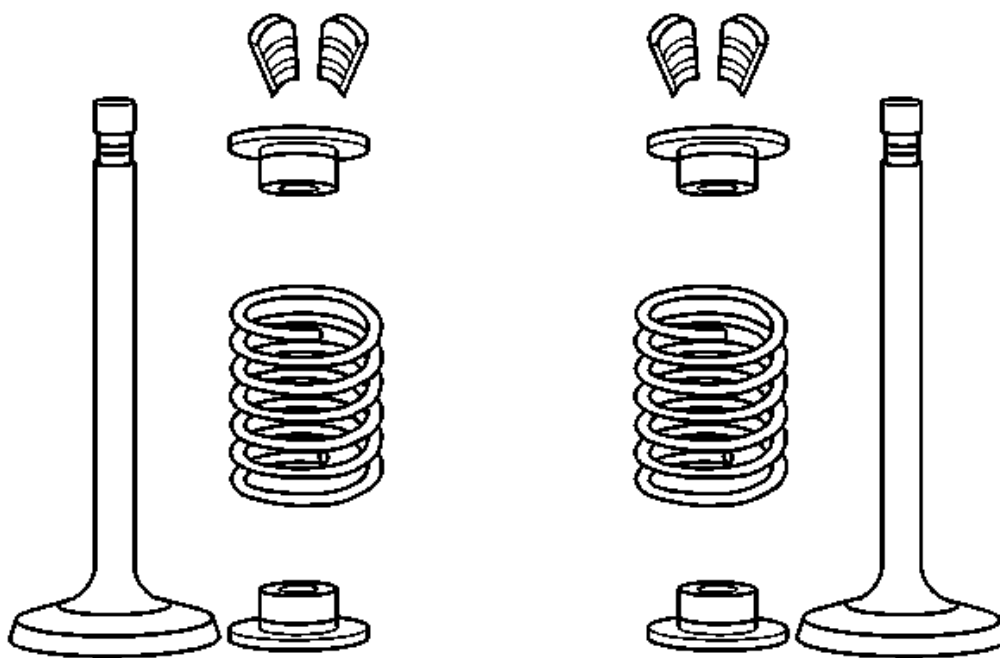


Fig. 101: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve locks.
7. Remove the valve cap.
8. Remove the valve spring.
9. Inspect the valve spring for damage. Refer to Cylinder Head Cleaning and Inspection.
10. Remove the valve stem oil seal.

Installation Procedure

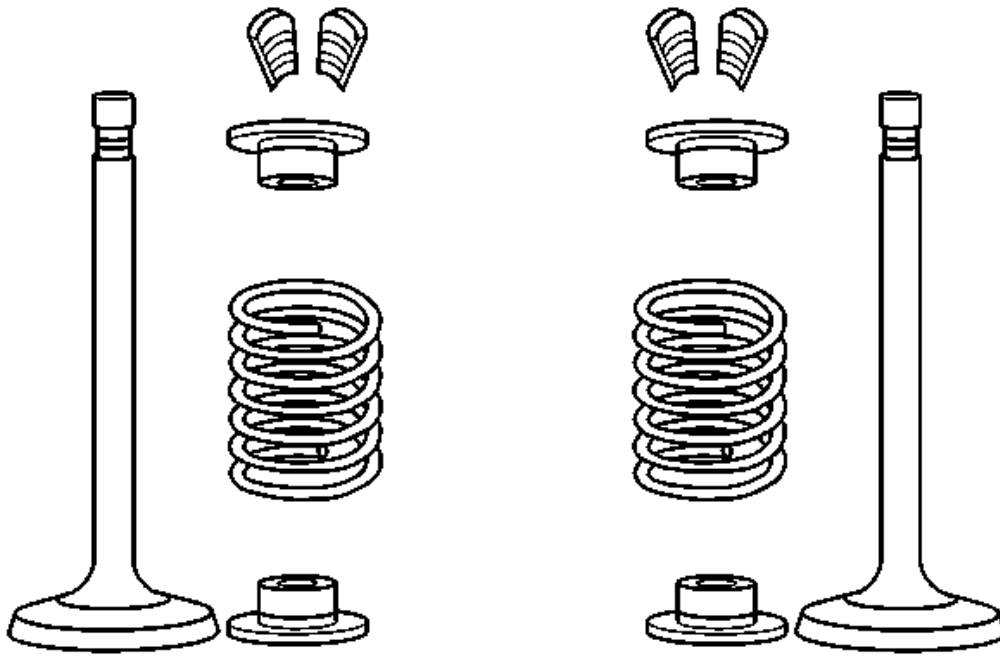


Fig. 102: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

1. Install the valve stem oil seal.
2. Install the valve spring.
3. Install the valve cap.

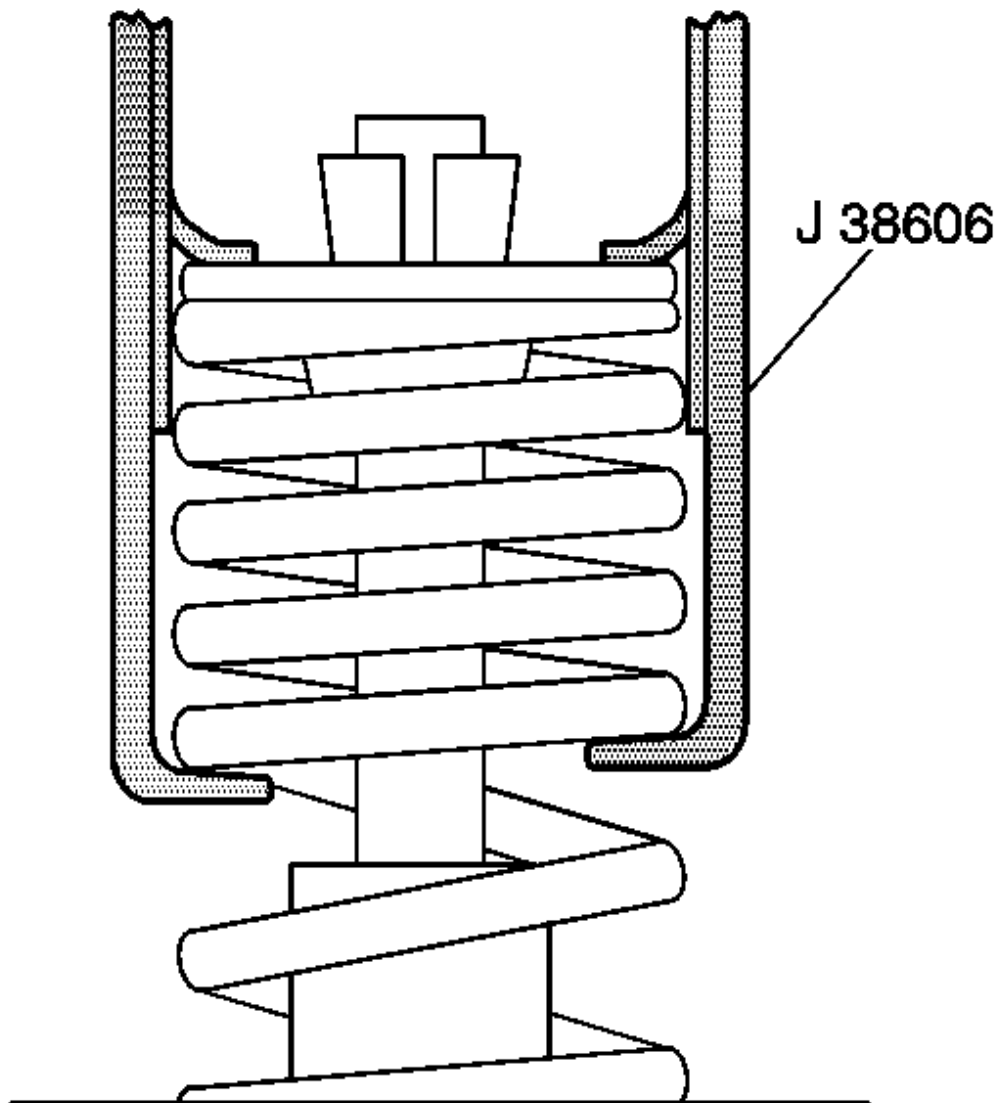


Fig. 103: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

4. Compress the valve using the **J 38606** . See **Special Tools and Equipment**.
5. Install the valve locks. If necessary, hold the valve locks in place with grease.

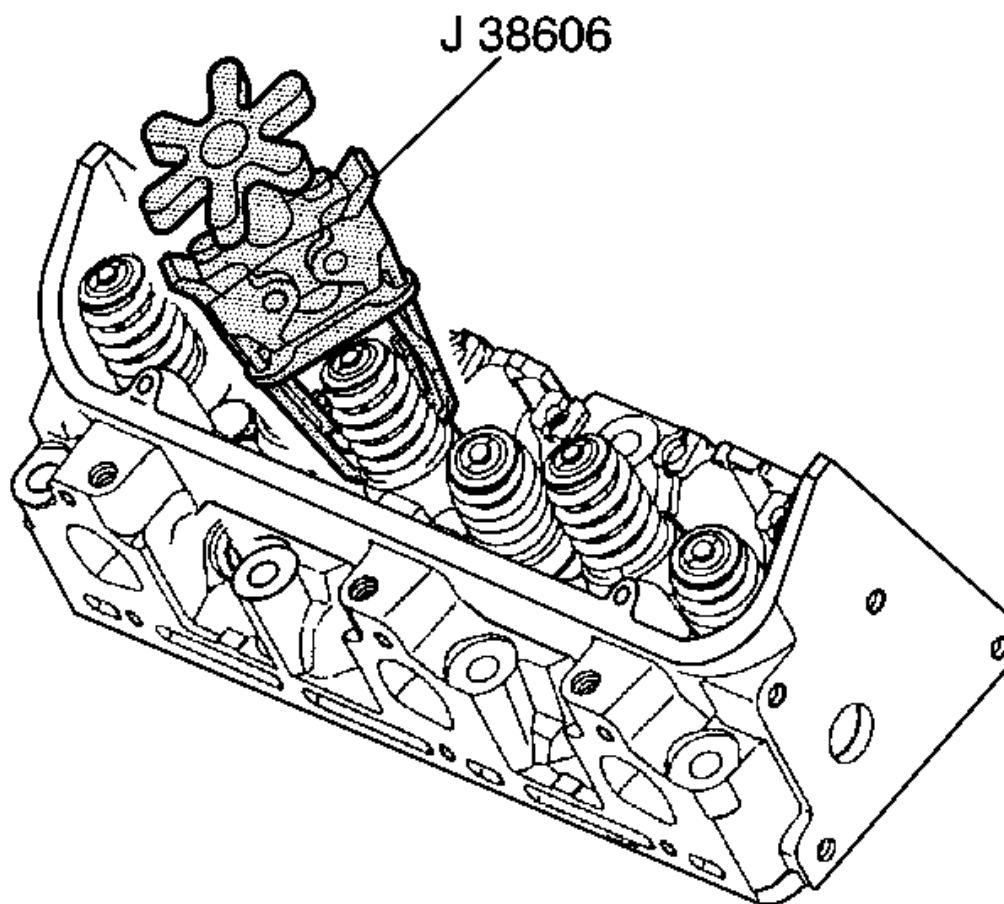


Fig. 104: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Release the valve spring using the **J 38606** . See **Special Tools and Equipment**.
7. Ensure that the valve locks are seated.
8. Release the air pressure and remove the **J 22794** from the spark plug port. See **Special Tools and Equipment**.
9. Install the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
10. Install the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.

Valve Lifter Replacement

Removal Procedure

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

2. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

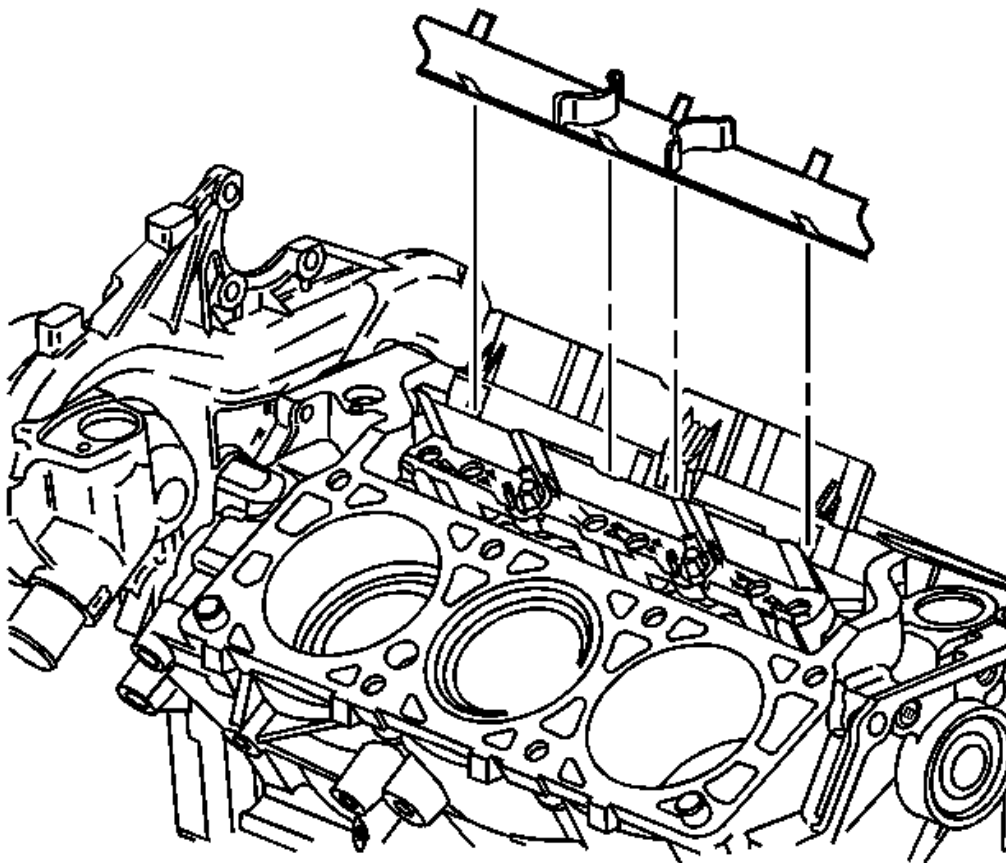


Fig. 105: Intake Manifold Oil Splash Shield
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake manifold oil splash shield

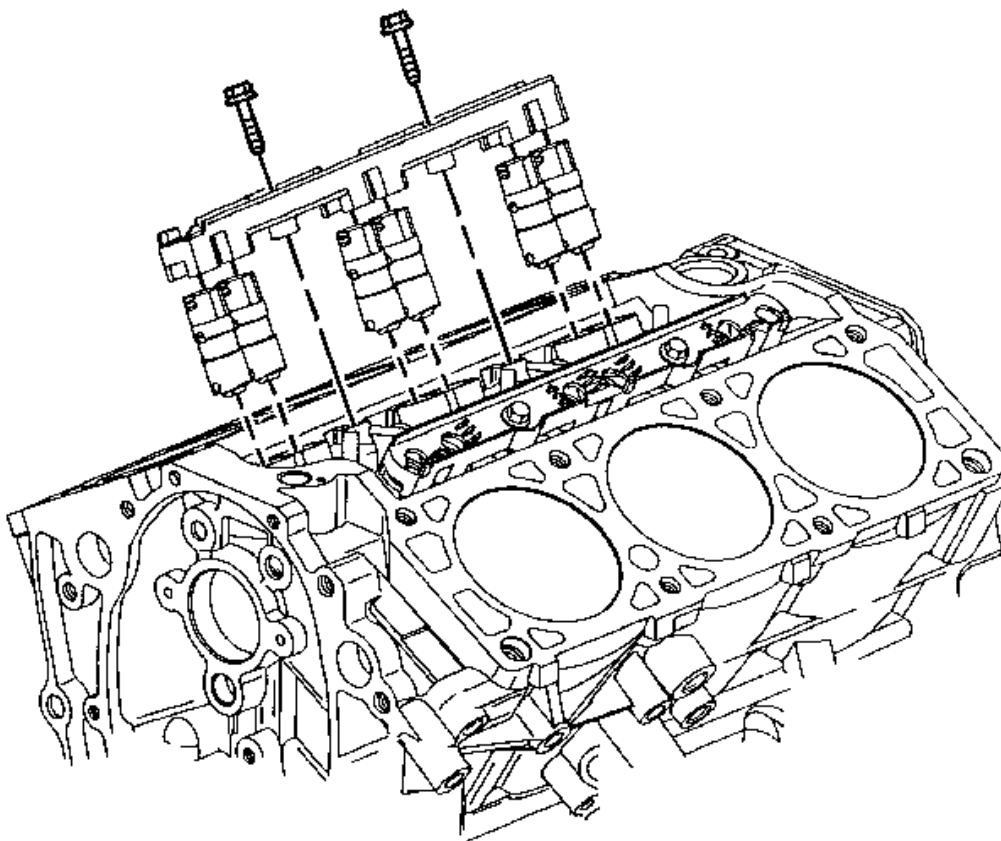


Fig. 106: Lifter Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the lifter guide bolts.
5. Remove the valve lifter guides.
6. Remove the valve lifters.
7. Clean all gasket surfaces with degreaser.
8. Clean the valve train parts.
9. Inspect the valve lifters and the cam lobes for wear. Refer to **Valve Lifters Cleaning and Inspection.**

Installation Procedure

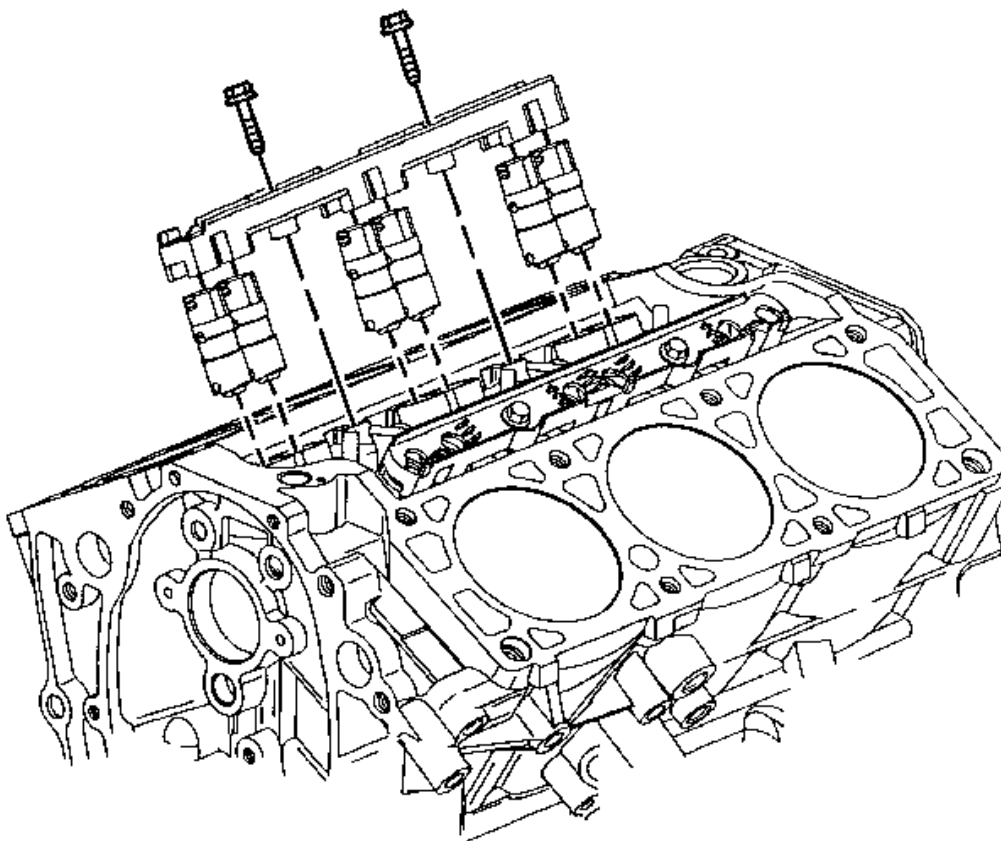


Fig. 107: Lifter Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve lifters with prelube GM P/N 1052367 (Canadian P/N 992869) or equivalent.
2. Install the valve lifters to the same location from which they were removed.
3. Install the valve lifter guides.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve lifter guide bolts.

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

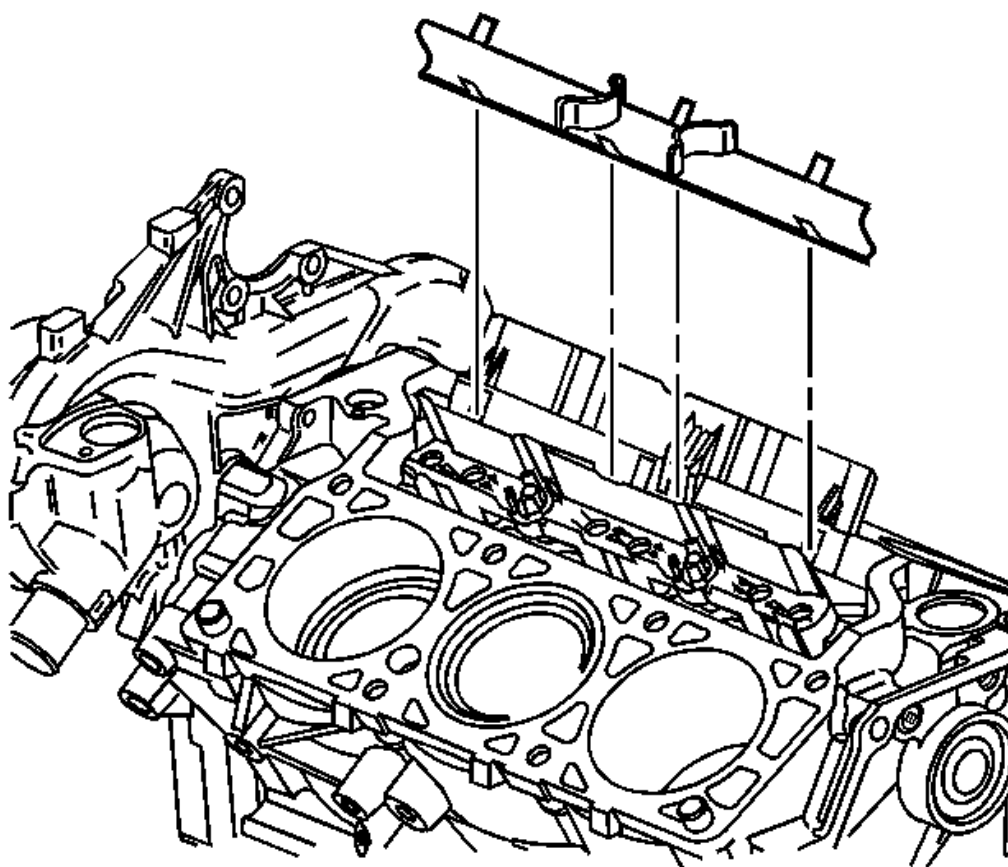


Fig. 108: Intake Manifold Oil Splash Shield
Courtesy of GENERAL MOTORS CORP.

5. Install the intake manifold oil splash shield
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 **Intake Manifold Replacement - Lower**.

Crankshaft Balancer Replacement

Tools Required

- **J 24420-C** Harmonic Balancer Puller. See **Special Tools and Equipment**.
- **J 29113** Crankshaft Balancer Installer. See **Special Tools and Equipment**.
- **J 37096** Flywheel Holder. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

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.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
4. Remove the right engine splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.
5. Install the jack stands to the frame.
6. Loosen the left frame bolts and remove the right side frame bolts. Refer to **Frame Replacement** in Frame and Underbody.
7. Using the jack stands, lower the right side of the frame to access the crankshaft balancer.
8. Remove the torque converter covers. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65 - E.
9. Install the **J 37096** to the flywheel to prevent flywheel rotation. See **Special Tools and Equipment**.

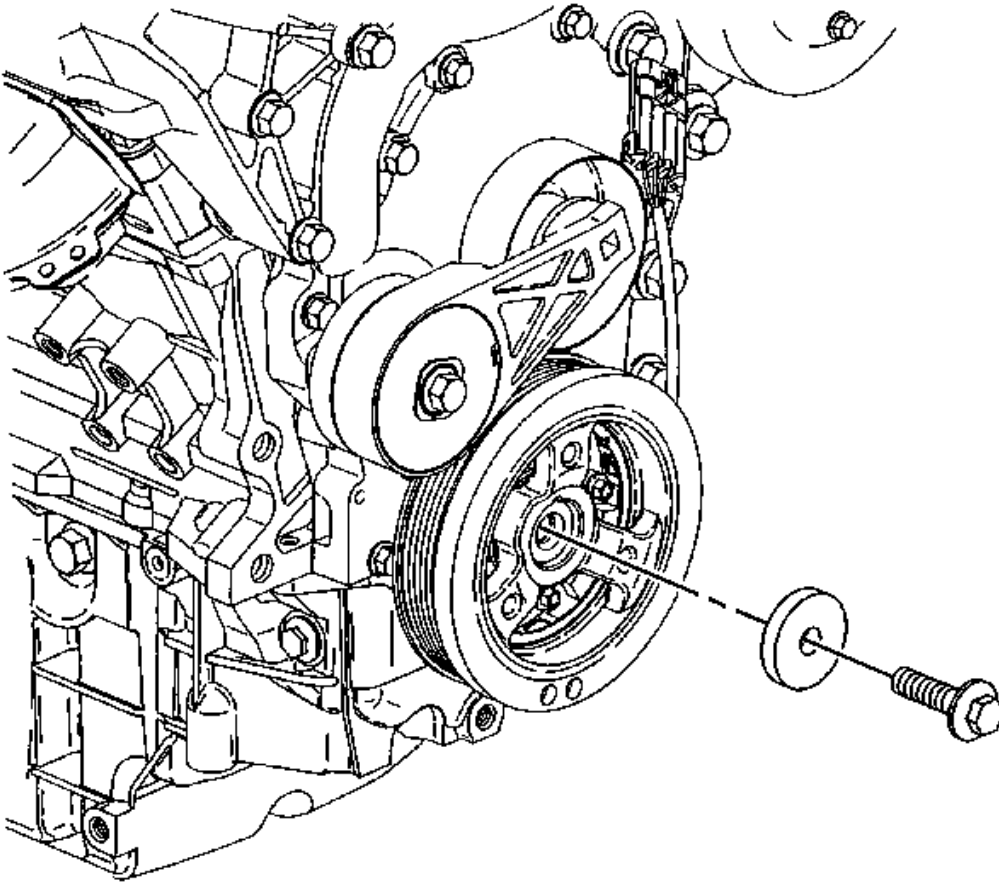


Fig. 109: Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft balancer bolt and the washer.

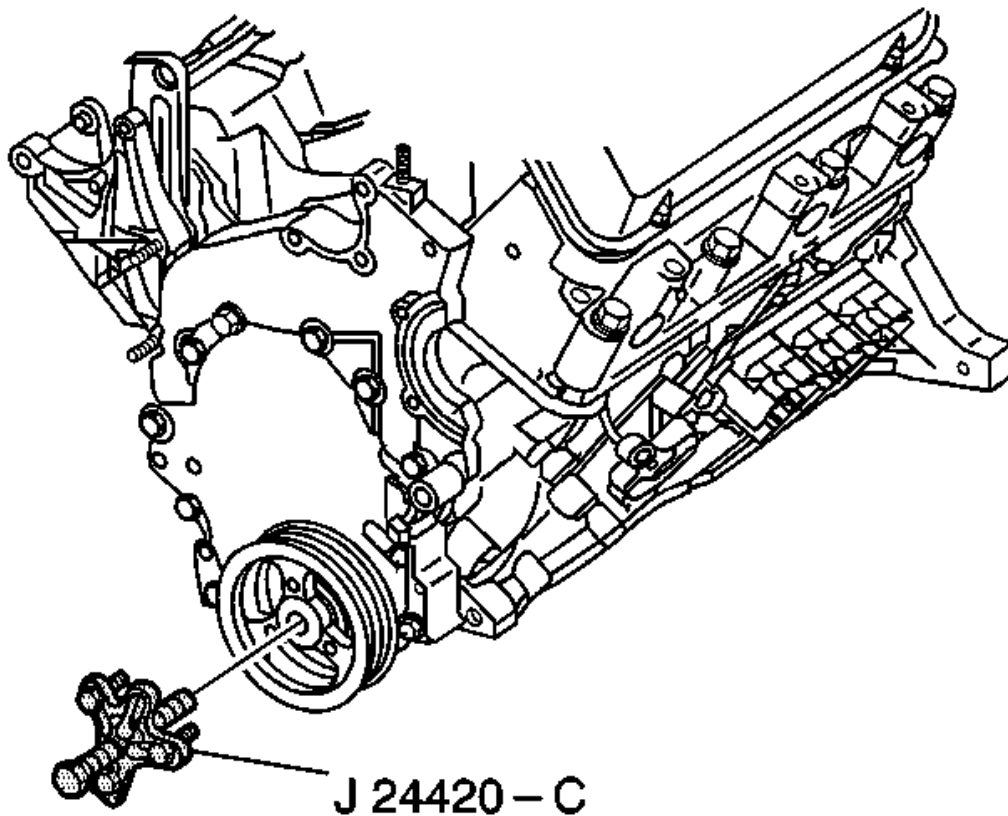


Fig. 110: Removing Crankshaft Balancer Using J 24420-C
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft balancer. Use the **J 24420-C**.

Installation Procedure

1. Apply sealant GM P/N 12346286 (Canadian P/N 10953472) or the equivalent to the keyway of the balancer.

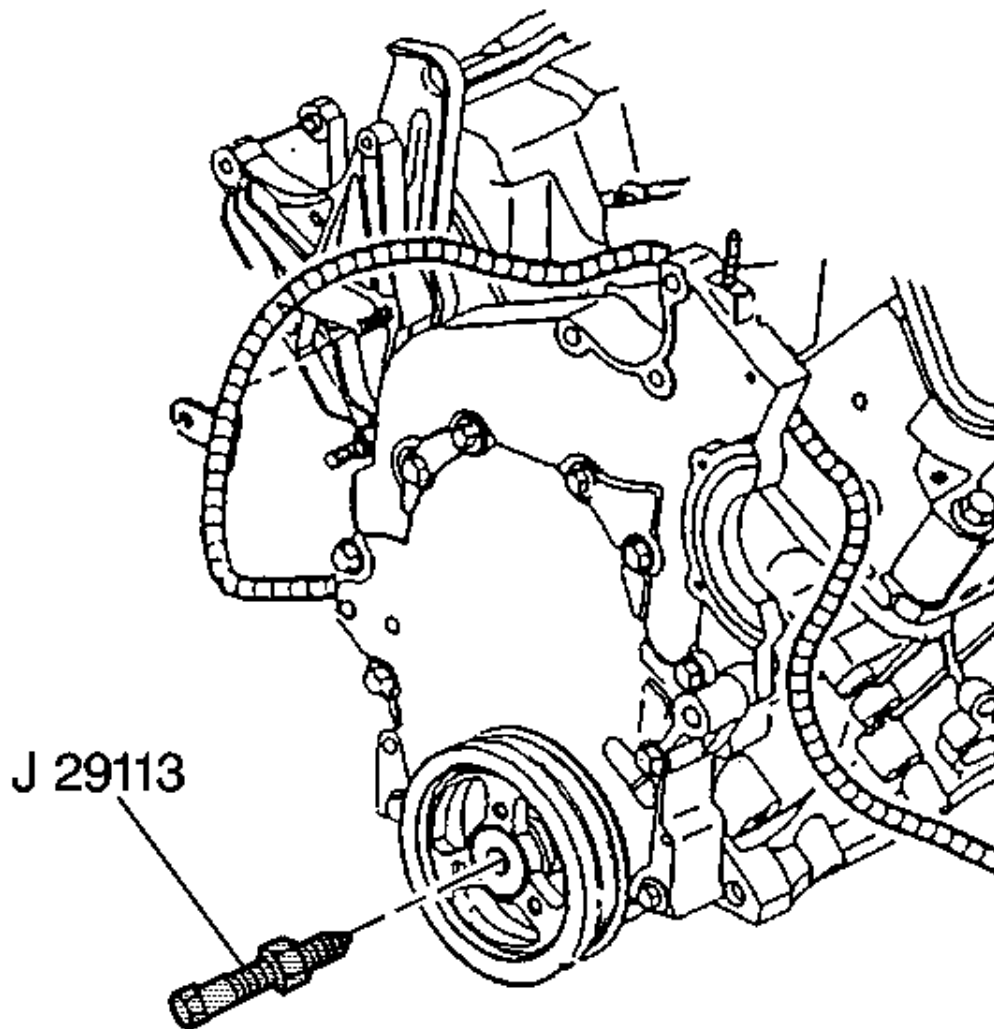


Fig. 111: Installing Crankshaft Balancer Using J 29113
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft balancer. Use the **J 29113** . See **Special Tools and Equipment**.
3. Remove the **J 29113** . See **Special Tools and Equipment**.
4. Install the **J 37096** to the flywheel to prevent flywheel rotation. See **Special Tools and Equipment**.

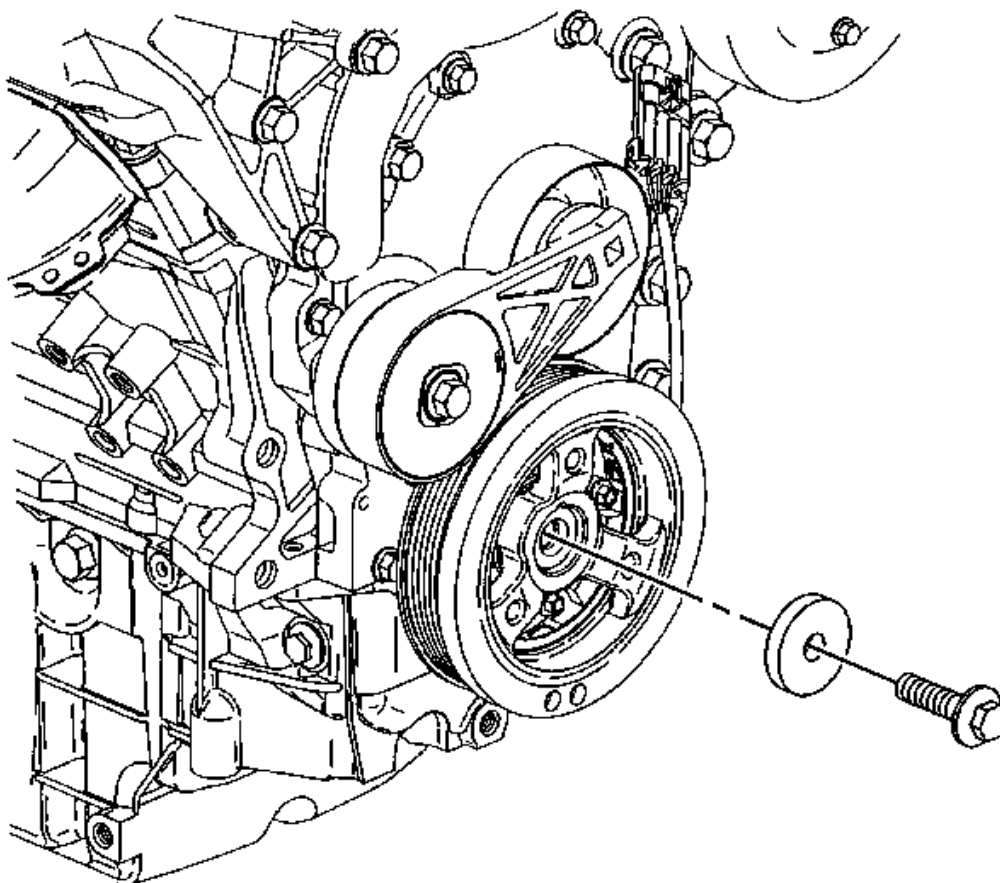


Fig. 112: Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the crankshaft balancer washer and the bolt.

Tighten:

1. Tighten the bolt to 70 N.m (52 lb ft).
 2. Use the **J 45059** to rotate the crankshaft balancer bolt an additional 72 degrees. See Special Tools and Equipment.
6. Remove the **J 37096** from the flywheel. See Special Tools and Equipment.
 7. Install the torque converter covers. Refer to Torque Converter Cover Replacement in Automatic Transaxle - 4T65 - E.

8. Raise the frame to the original position.
9. Install and tighten the frame bolts. Refer to **Frame Replacement** in Frame and Underbody.
10. Install the right engine splash shield. Refer to **Splash Shield Replacement - Engine** in Body Front End.
11. Install the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
12. Lower the vehicle.
13. Install the drive belt. Refer to **Drive Belt Replacement**.
14. Perform a CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.1L.

Oil Pan Replacement

Tools Required

J 39505 Torque Wrench Adapter. See **Special Tools and Equipment**.

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the left and the right engine mount struts. Refer to **Engine Mount Strut Replacement**.
3. Remove the drive belt. Refer to **Drive Belt Replacement**.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
6. Remove the A/C compressor mounting bolts, reposition and secure the A/C compressor. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating, Ventilation and Air Conditioning.
7. Remove the 3-way catalytic converter pipe from the right exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
8. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

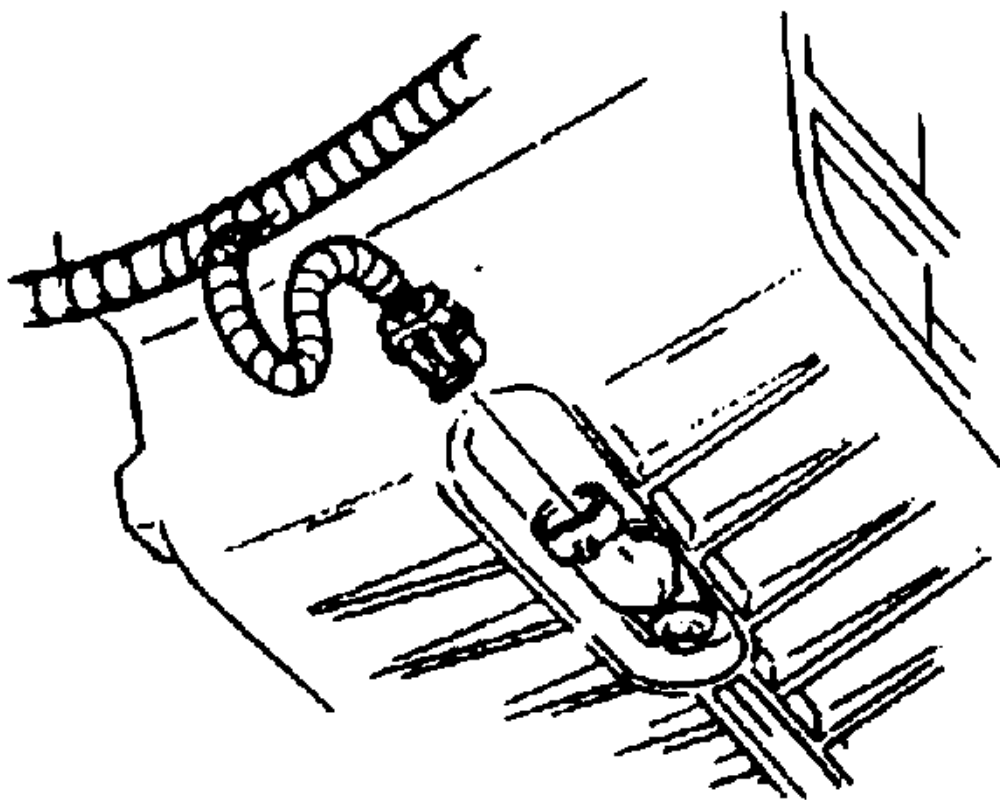


Fig. 113: Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the oil level sensor electrical connector.
10. Remove the starter motor. Refer to **Starter Motor Replacement (3.8L)** or **Starter Motor Replacement (3.1L)** in Engine Electrical.
11. Remove the transaxle brace from the oil pan. Refer to **Automatic Transmission Brace Replacement** in Automatic Transaxle-4T65-E.
12. Loosen the transaxle mount lower nuts. Refer to **Automatic Transmission Mount Replacement** in Automatic Transaxle-4T65-E.
13. Remove the engine mount lower nuts. Refer to **Engine Mount Replacement**.
14. Lower the vehicle.
15. Use the engine support fixture to raise the engine.
16. Raise the vehicle.
17. Remove the steering shaft intermediate pinch bolt. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.

18. Remove the engine mount bracket with the engine mount from the oil pan. Refer to **Engine Mount Bracket Replacement**.
19. Remove the right lower ball joint from the steering knuckle. Refer to **Lower Ball Joint Replacement** in Front Suspension.
20. Remove the right outer tie rod from the steering knuckle. Refer to **Rack and Pinion Outer Tie Rod End Replacement** in Power Steering System.
21. Install jackstands to the frame assembly.
22. Remove the right side frame bolts.
23. Loosen the left side frame bolts.
24. Using the jackstands lower the right side of the frame.

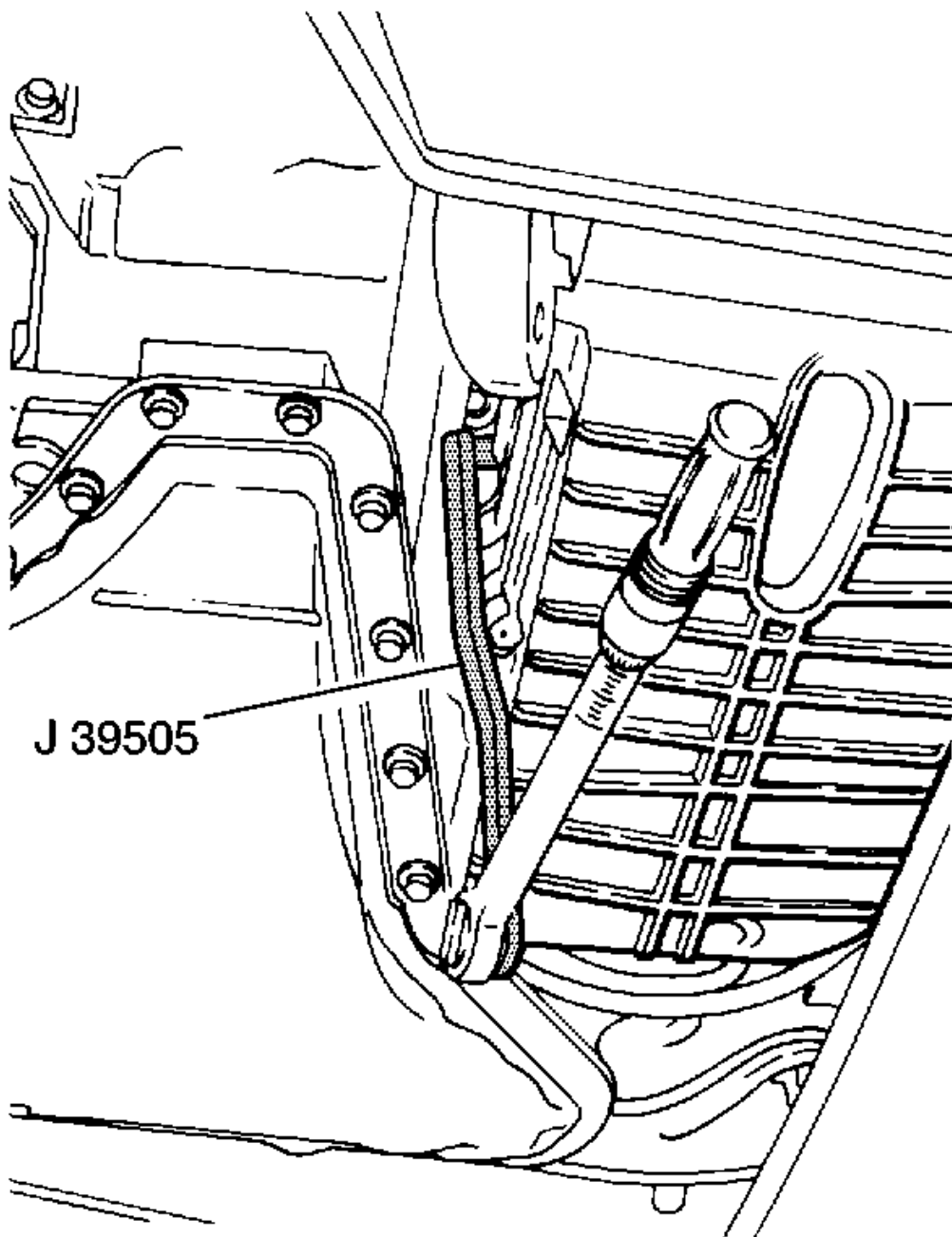


Fig. 114: Removing/Installing Right Oil Pan Side Bolts Using J 39505
Courtesy of GENERAL MOTORS CORP.

25. Use the **J 39505** in order to remove the right oil pan side bolts. See **Special Tools and Equipment**.

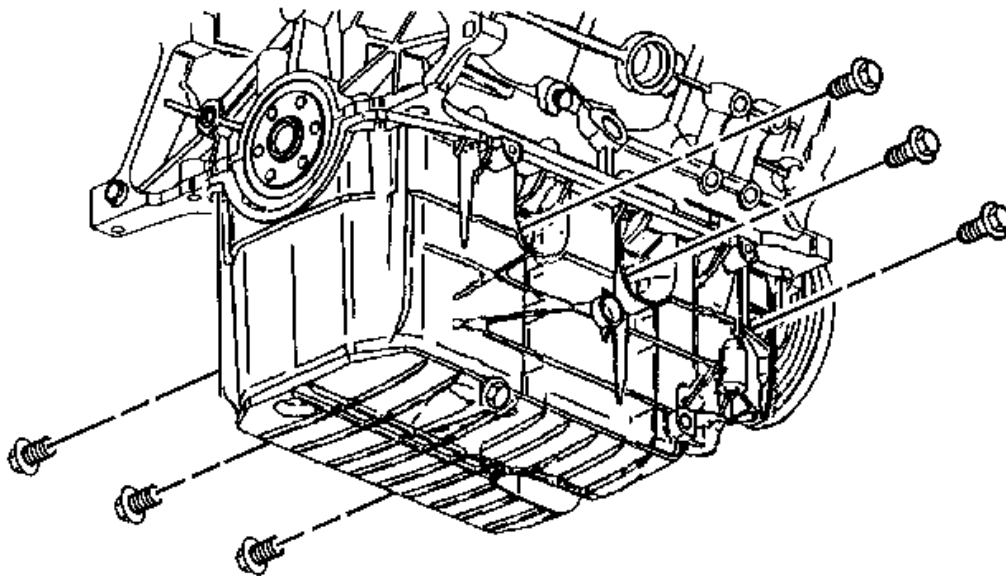


Fig. 115: Left Oil Pan Side Bolts
Courtesy of GENERAL MOTORS CORP.

26. Remove the left oil pan side bolts.

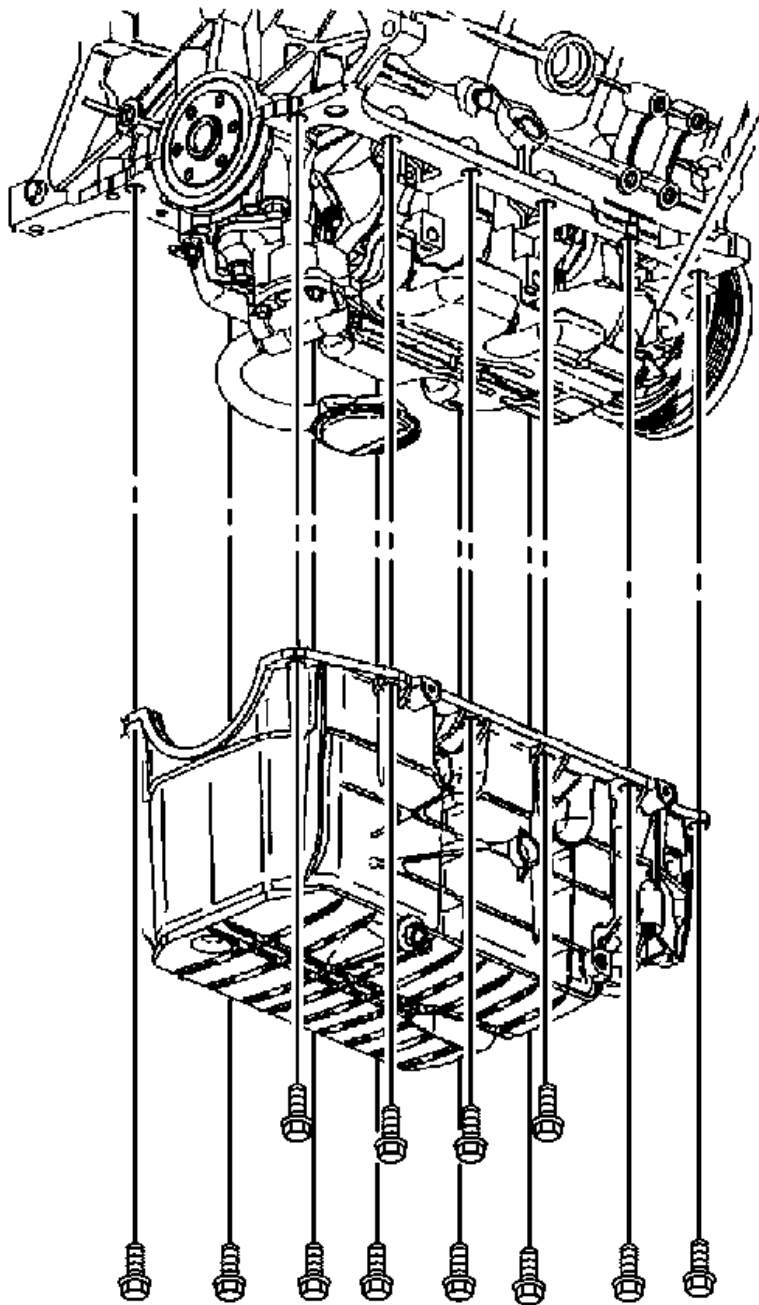


Fig. 116: Oil Pan & Bolts

Courtesy of GENERAL MOTORS CORP.

27. Remove the oil pan bolts.
28. Remove the oil pan.

29. Remove the oil pan gasket.
30. Clean the oil pan and the engine block gasket mating surface.

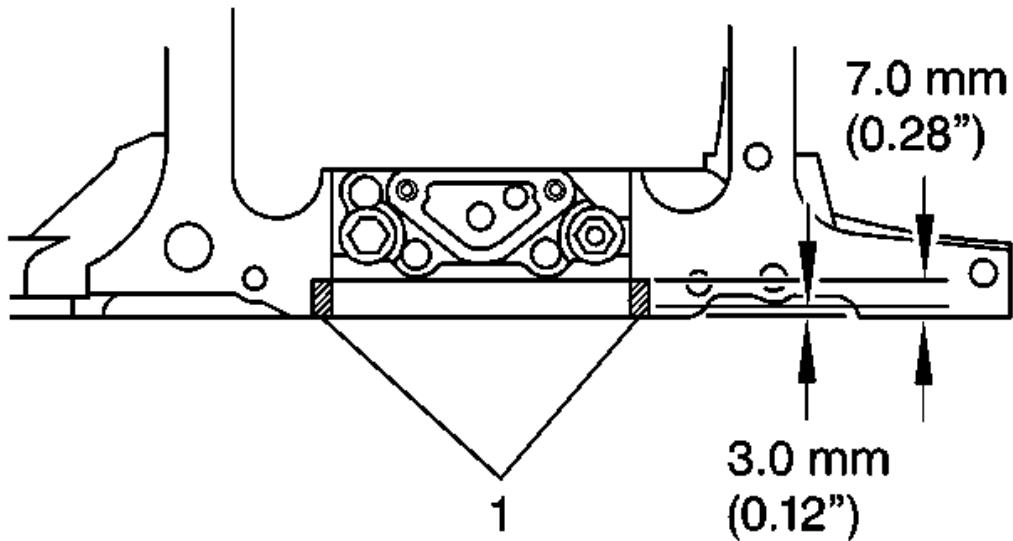
Installation Procedure

Fig. 117: Sealant Application At Rear Main Bearing Cap & Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 1052942 (Canadian P/N 10953466) at the rear main bearing cap and the engine block (1).
2. Install the oil pan gasket.

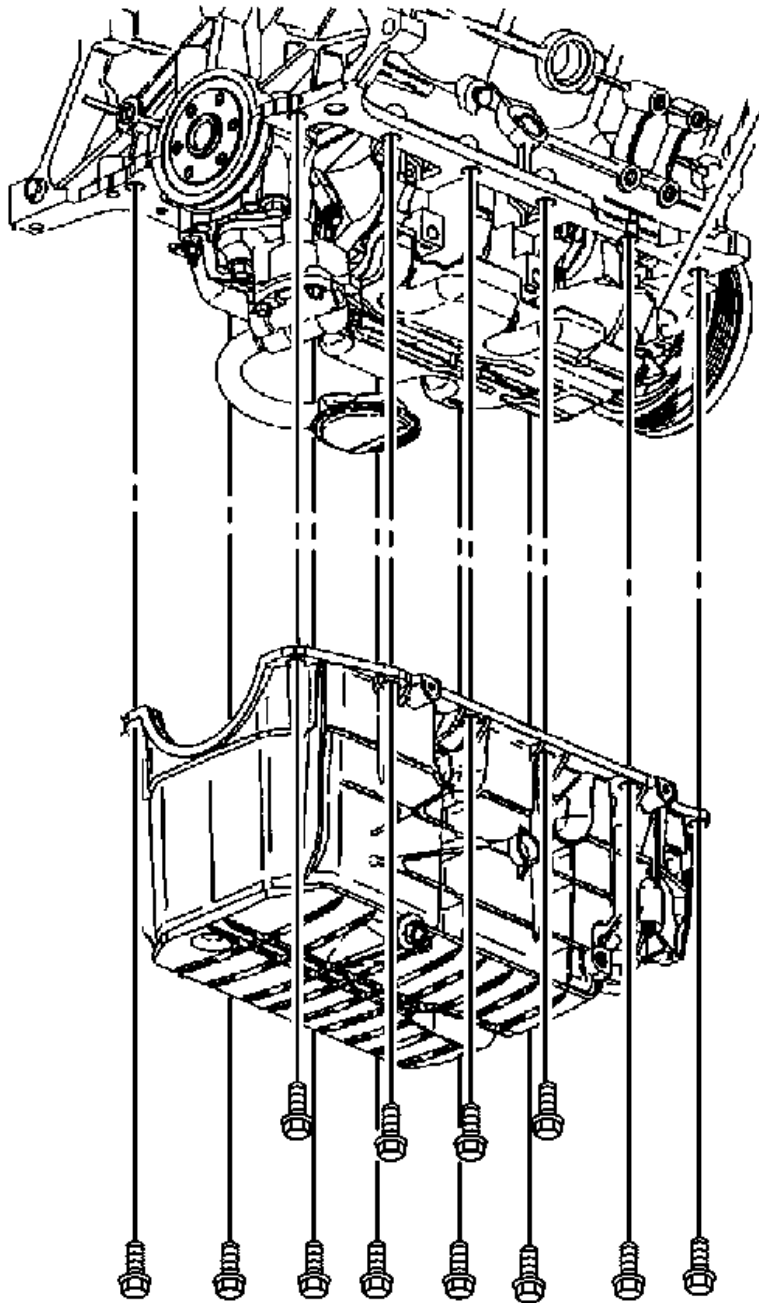


Fig. 118: Oil Pan & Bolts

Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pan bolts.

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

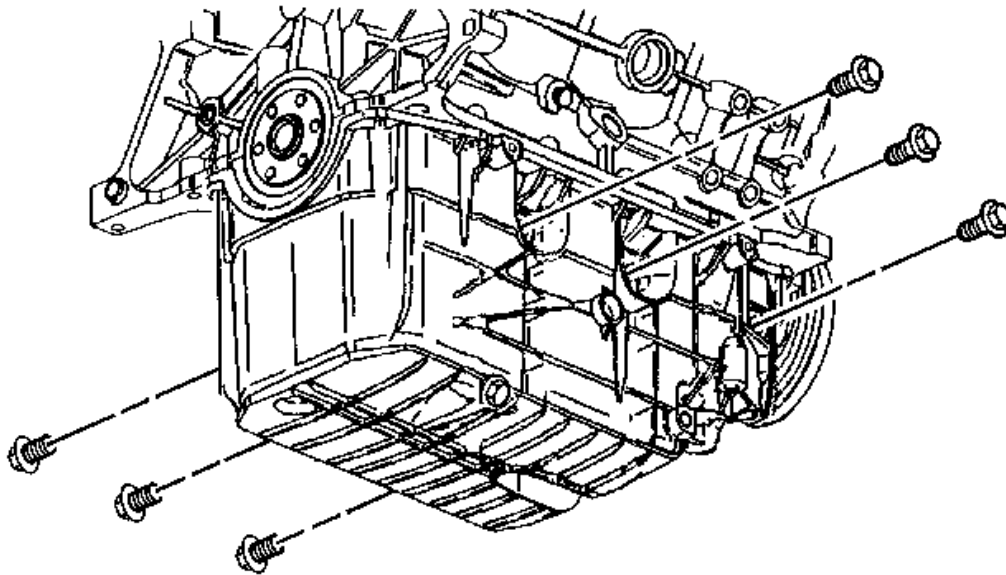


Fig. 119: Left Oil Pan Side Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the left oil pan side bolts.

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

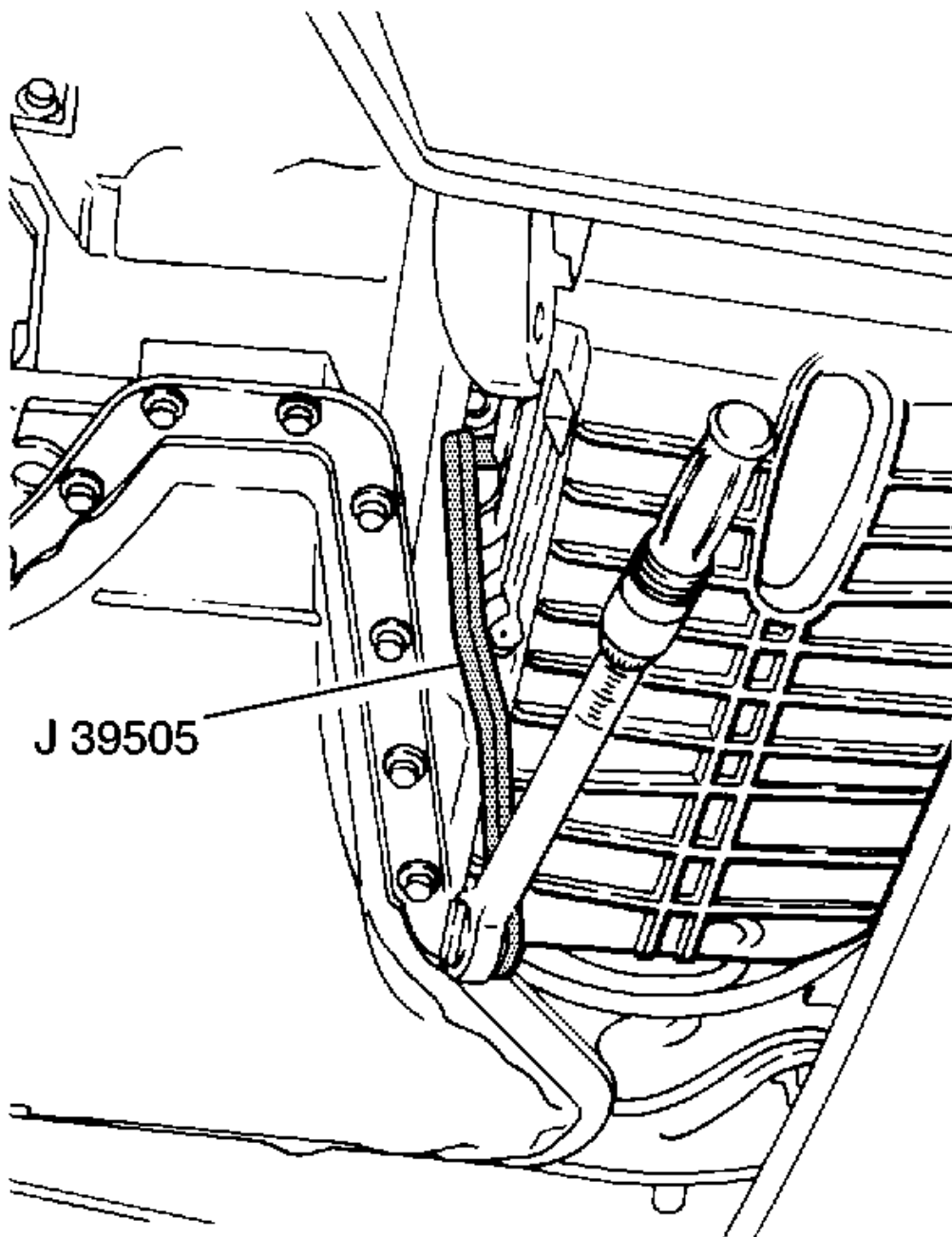


Fig. 120: Removing/Installing Right Oil Pan Side Bolts Using J 39505
Courtesy of GENERAL MOTORS CORP.

6. Use the **J 39505** in order to install the right oil pan side bolts. See **Special Tools and Equipment**.

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

7. Use the jackstands to raise the frame to the original position
8. Install the right side frame bolts and tighten the left side frame bolts. Refer to **Frame Replacement** in Frame and Underbody.
9. Remove the jackstands from the frame assembly.
10. Install the right lower ball joint to the steering knuckle. Refer to **Lower Ball Joint Replacement** in Front Suspension.
11. Install the right outer tie rod to the steering knuckle. Refer to **Rack and Pinion Outer Tie Rod End Replacement** in Power Steering System.
12. Install the engine mount bracket with the engine mount to the oil pan. Refer to **Engine Mount Bracket Replacement**.
13. Install the steering shaft intermediate pinch bolt. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.
14. Lower the vehicle.
15. Use the engine support fixture to lower the engine.
16. Raise and the vehicle.
17. Install the transaxle mount lower nuts. Refer to **Automatic Transmission Mount Replacement** in Automatic Transaxle-4T65-E.
18. Install the engine mount lower nuts. Refer to **Engine Mount Replacement**.
19. Install the transaxle brace to the oil pan. Refer to **Automatic Transmission Brace Replacement** in Automatic Transaxle-4T65-E.
20. Install the starter motor. Refer to **Starter Motor Replacement (3.8L)** or **Starter Motor Replacement (3.1L)** in Engine Electrical.

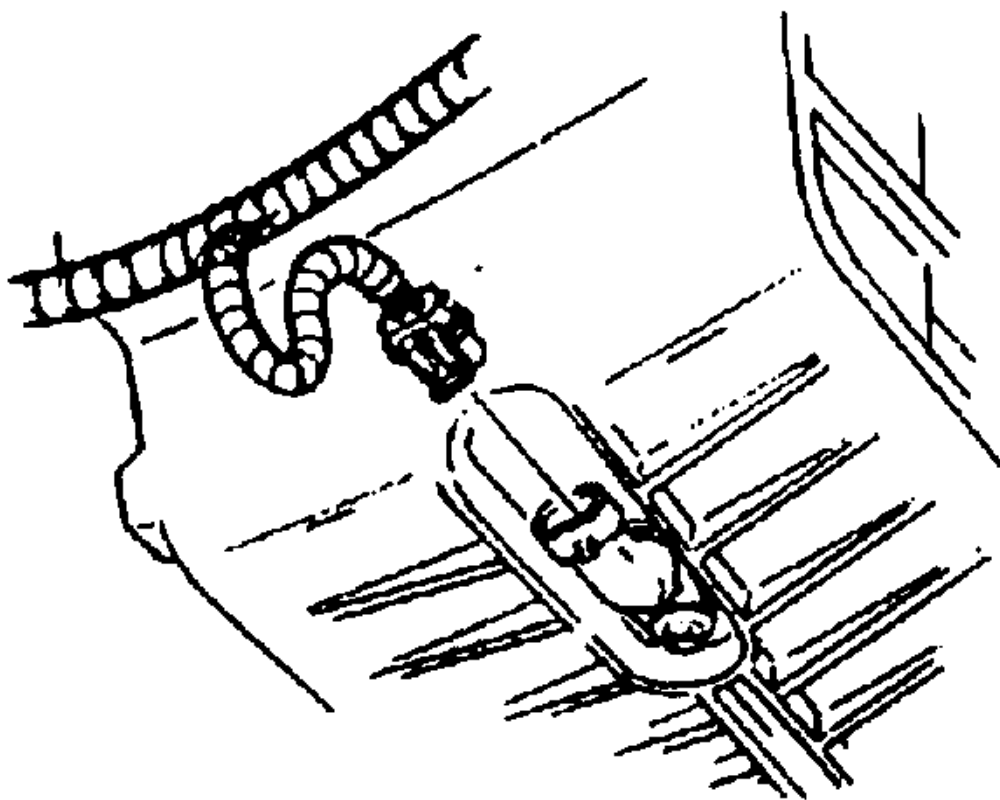


Fig. 121: Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

21. Connect the oil level sensor electrical connector.
22. Install the 3-way catalytic converter pipe to the right exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
23. Install the A/C compressor. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating, Ventilation and Air Conditioning.
24. Lower the vehicle.
25. Remove the engine support fixture.
26. Install the left and the right engine mount struts. Refer to **Engine Mount Strut Replacement**.
27. Install the drive belt. Refer to **Drive Belt Replacement**.
28. Fill the engine with new engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
29. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
30. Inspect for leaks.

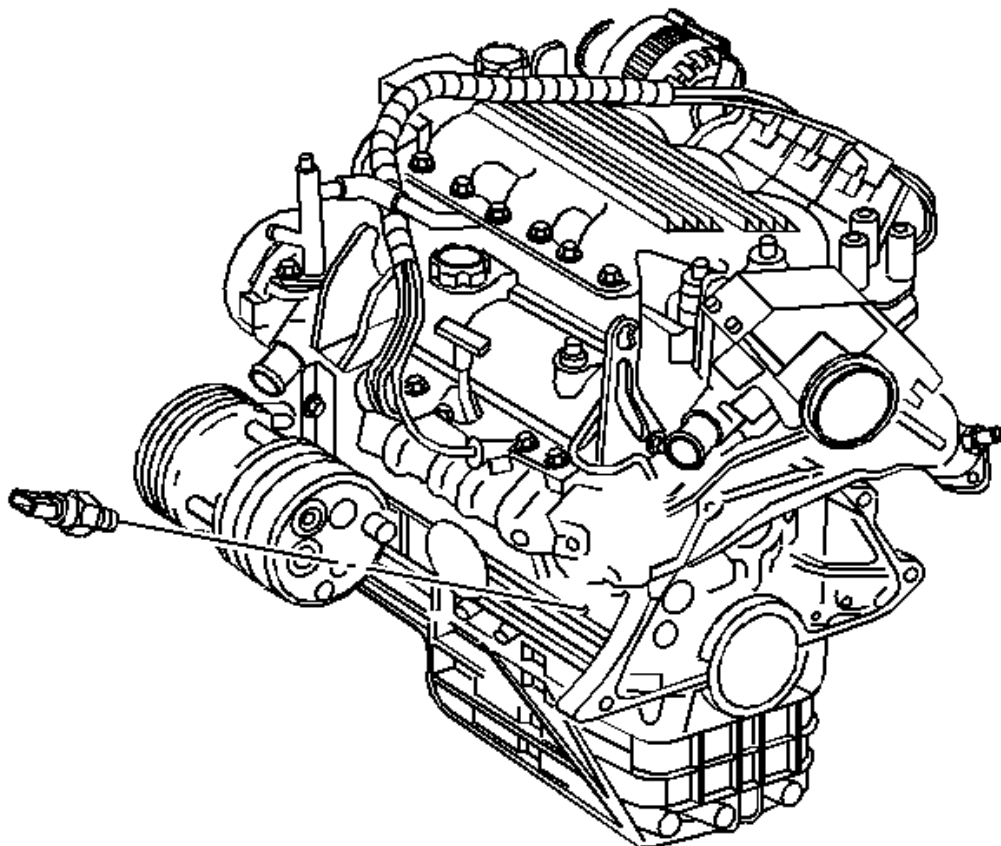
Engine Oil Pressure Sensor and/or Switch Replacement**Removal Procedure**

Fig. 122: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Disconnect the engine oil pressure sensor electrical connector.
4. Remove the engine oil pressure sensor.

Installation Procedure

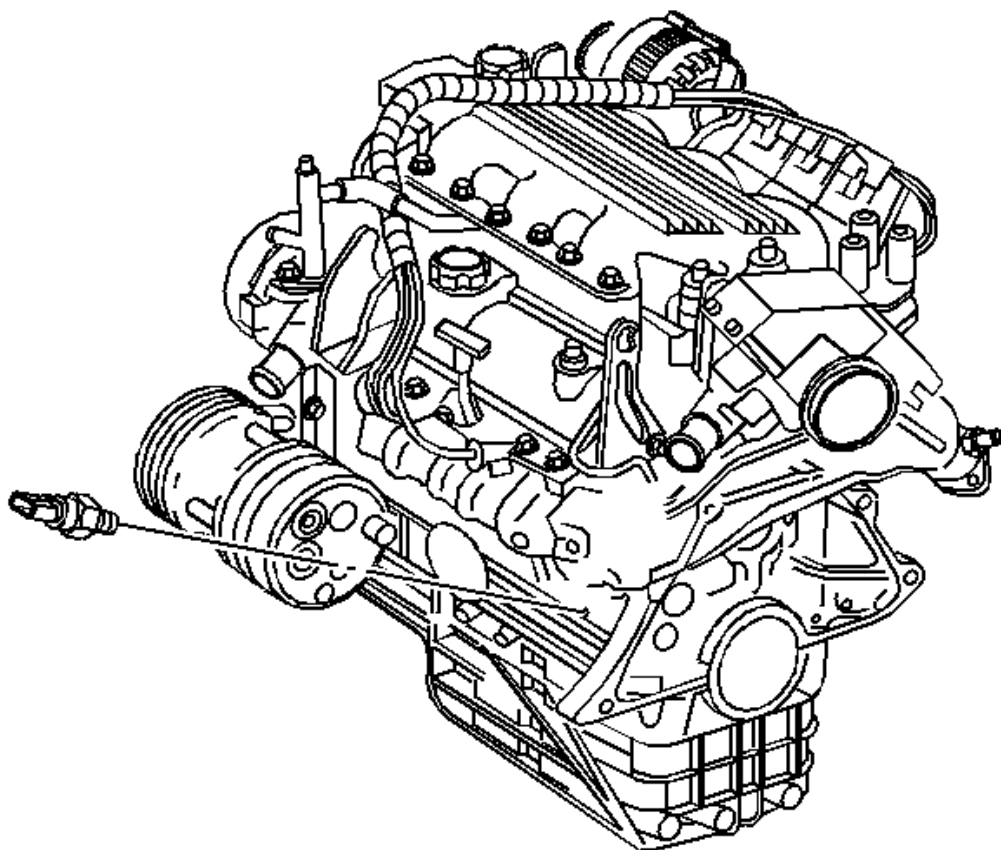


Fig. 123: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine oil pressure indicator switch.

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

2. Connect the engine oil pressure sensor electrical connector.
3. Lower the vehicle.
4. Check and fill the crankcase as necessary. Refer to Engine Oil and Oil Filter Replacement.
5. Connect the negative battery cable. Refer to Battery Negative Cable Disconnect/Connect Procedure in Engine Electrical.

Engine Oil Level Sensor and/or Switch Replacement

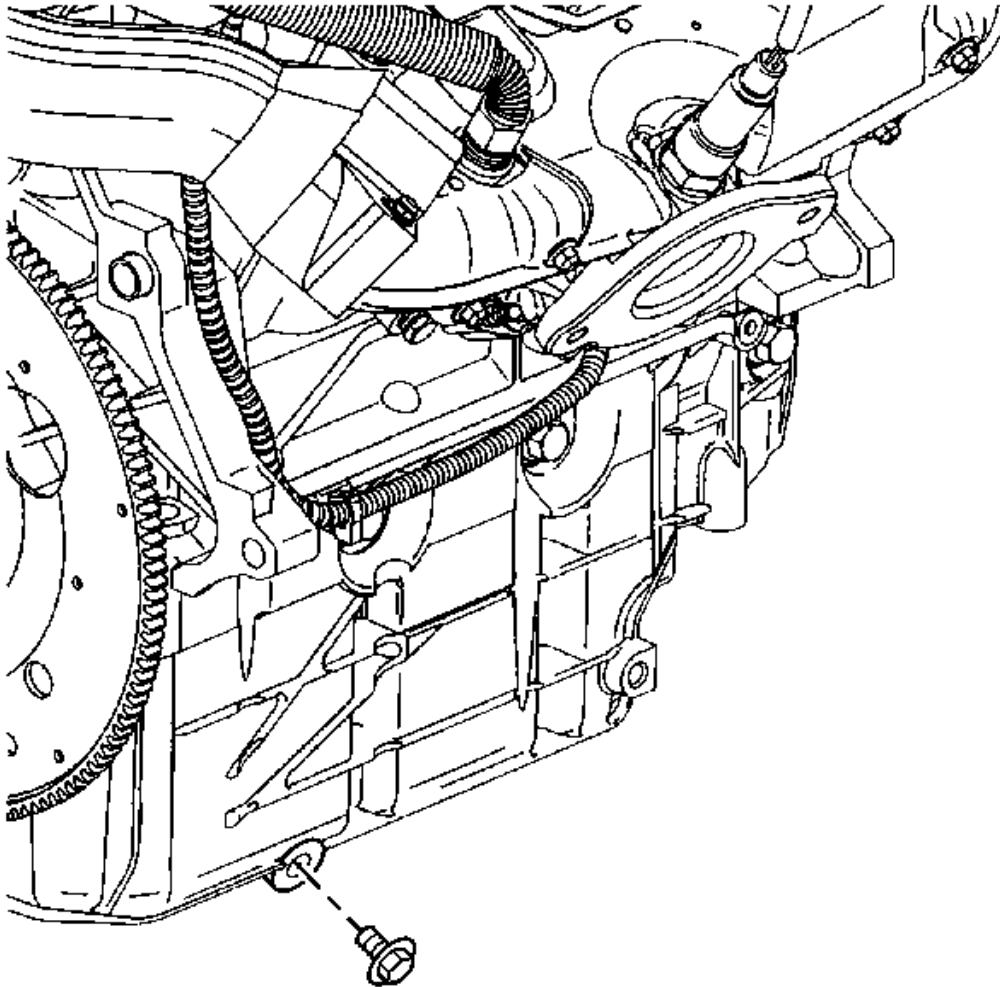
Removal Procedure

Fig. 124: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the engine oil drain plug and drain the engine oil.

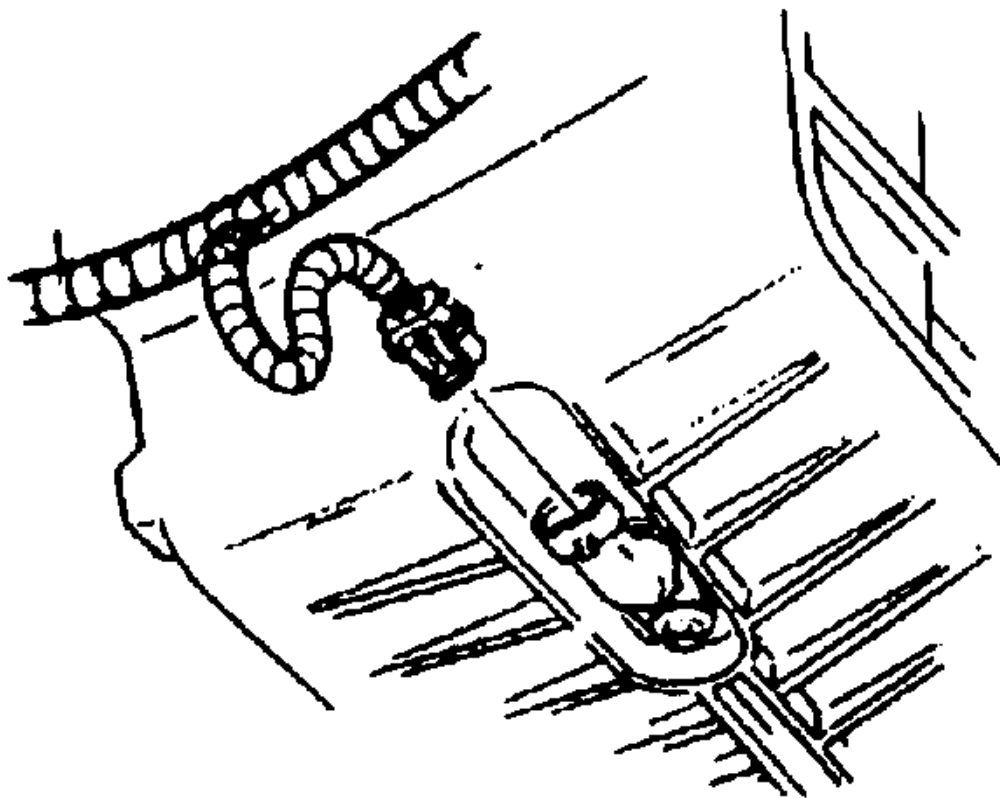


Fig. 125: Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the engine oil level sensor electrical connector.
4. Remove the bolt from the engine oil level sensor.
5. Remove the engine oil level sensor from the oil pan.

Installation Procedure

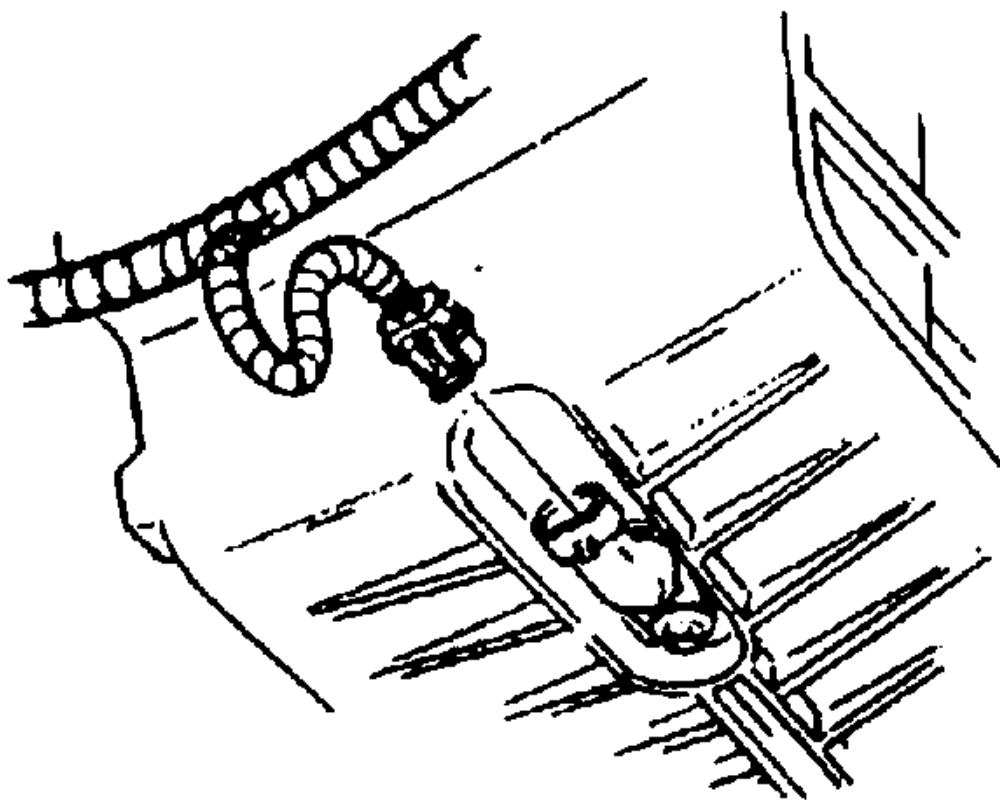


Fig. 126: Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine oil level sensor bolt.

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

3. Connect the engine oil level sensor electrical connector.

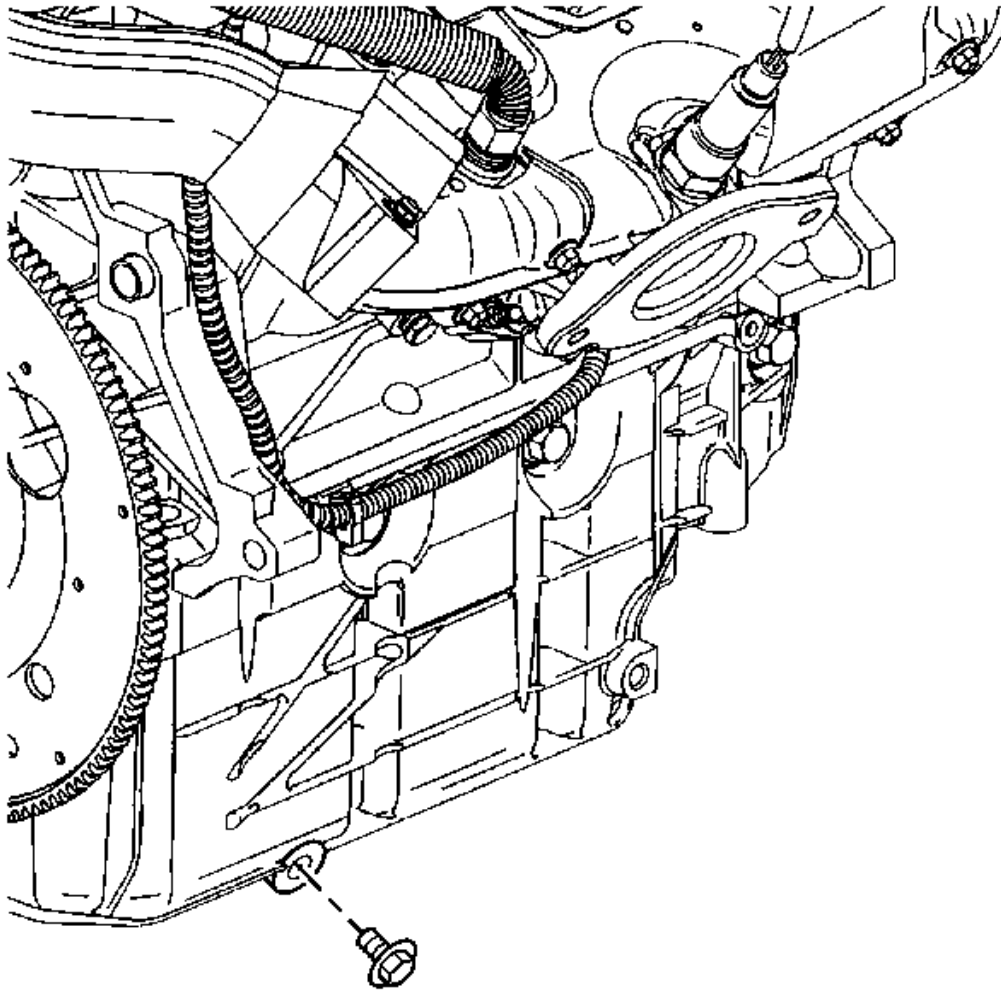


Fig. 127: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

4. Install the engine oil pan drain plug.

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

5. Lower the vehicle.
6. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

Oil Pump Replacement

Removal Procedure

1. Remove the oil pan. Refer to **Oil Pan Replacement**.

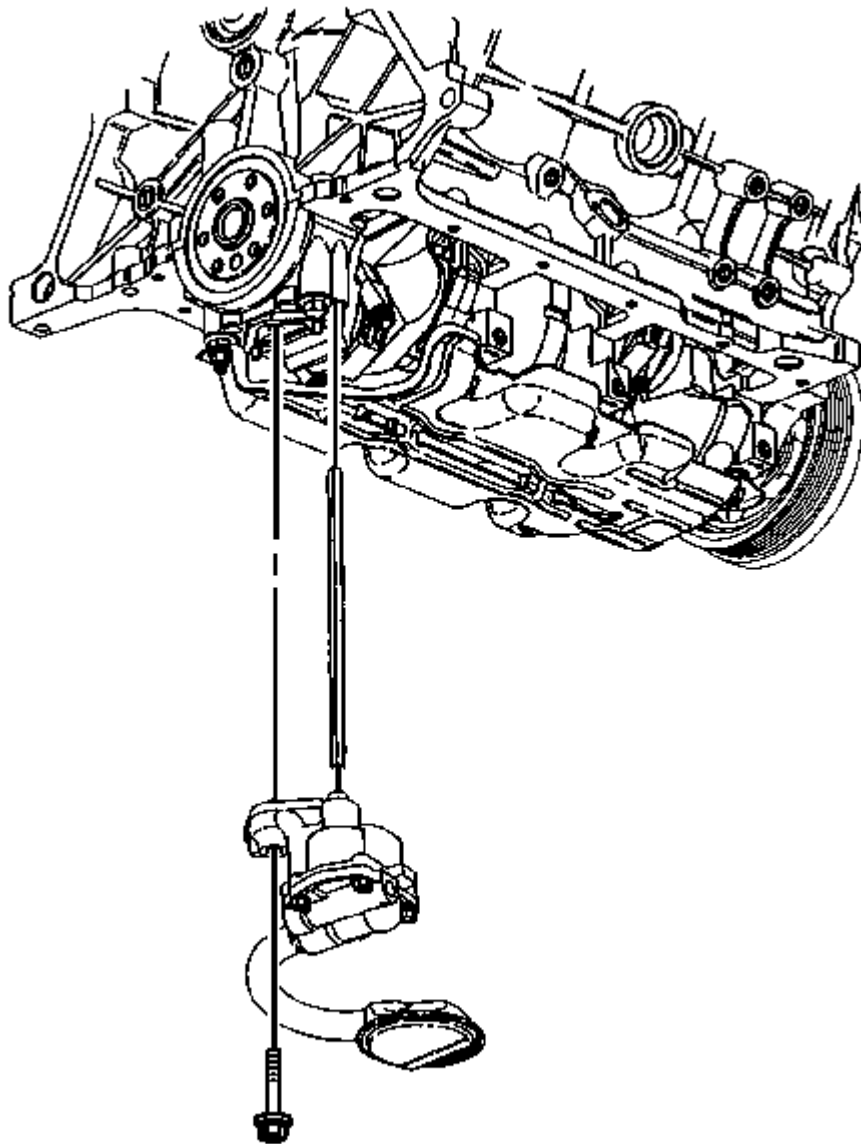


Fig. 128: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump bolt.
3. Remove the oil pump and the oil pump driveshaft.

4. Inspect the driveshaft at both ends for rounding of the corners.
5. Inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

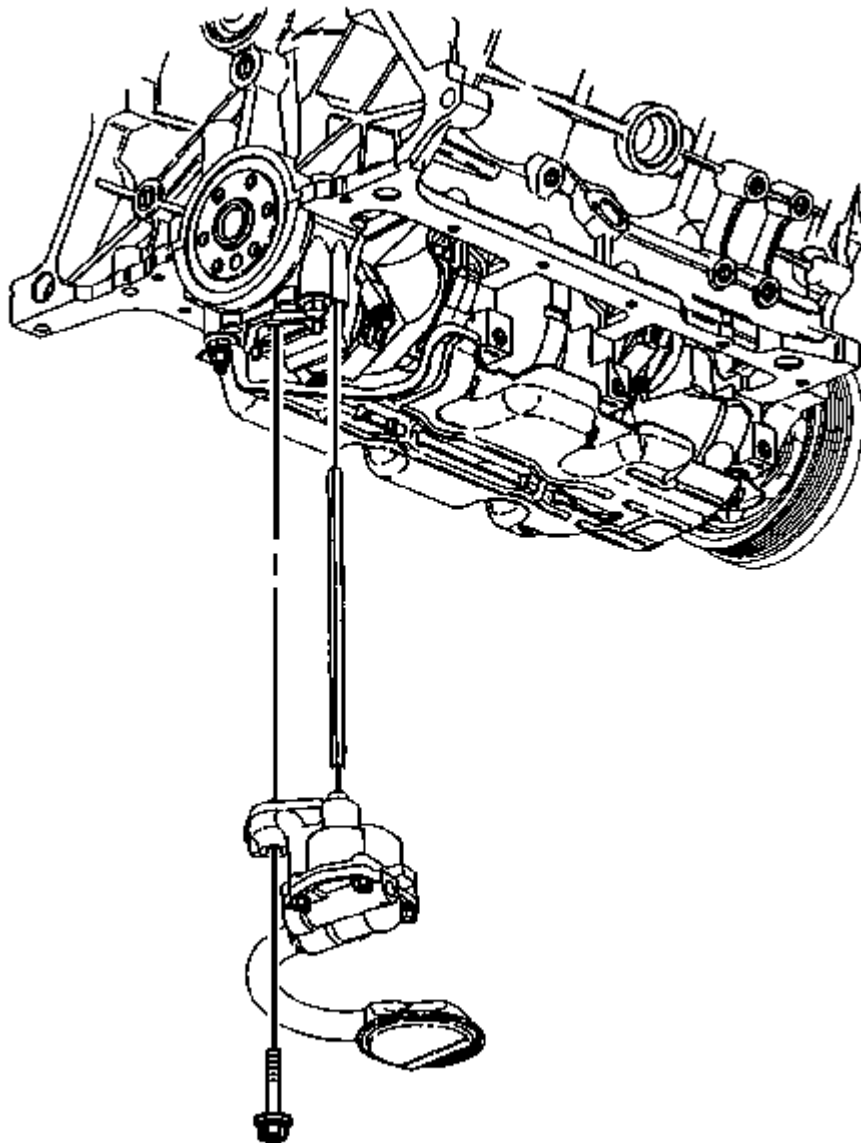
Installation Procedure

Fig. 129: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil pump driveshaft and the oil pump.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pump mounting 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

1. Remove the upper intake manifold. Refer to Intake Manifold Replacement - Upper.

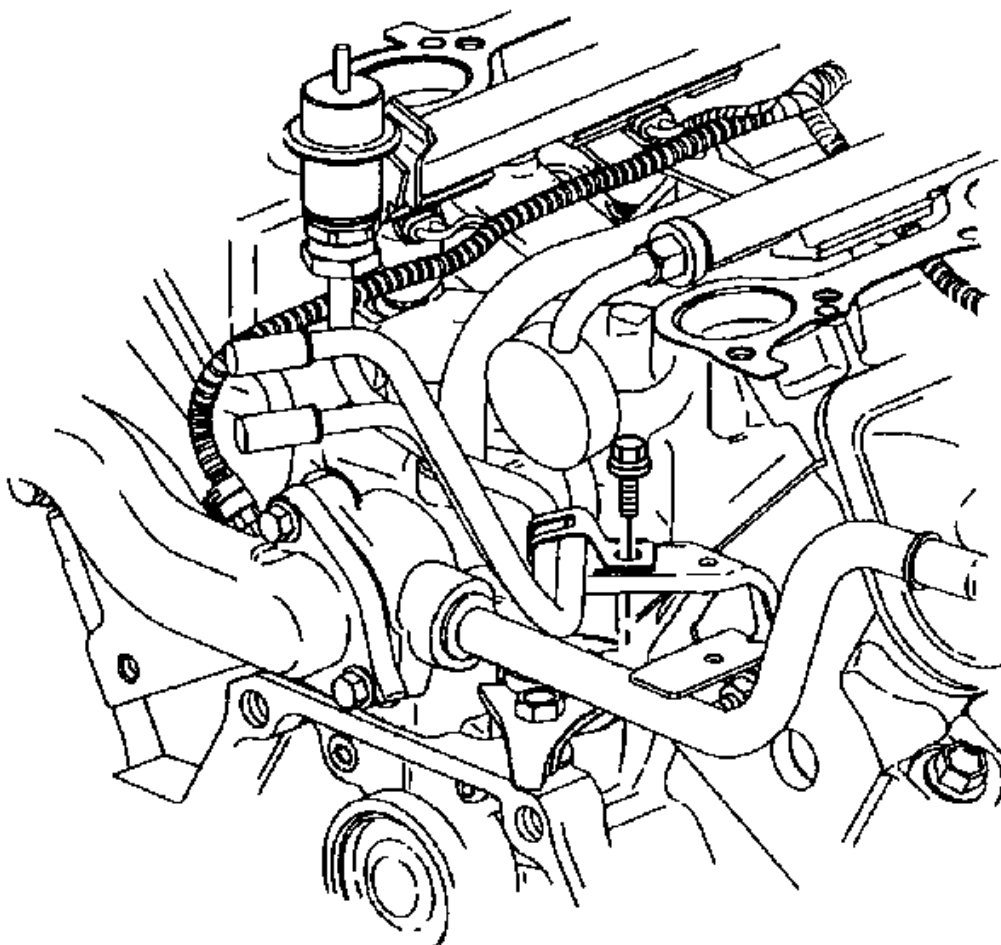


Fig. 130: Fuel Pipe Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel pipe clip bolt and the clip.
3. Remove the fuel feed and the fuel return pipes from the fuel injector rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.1L

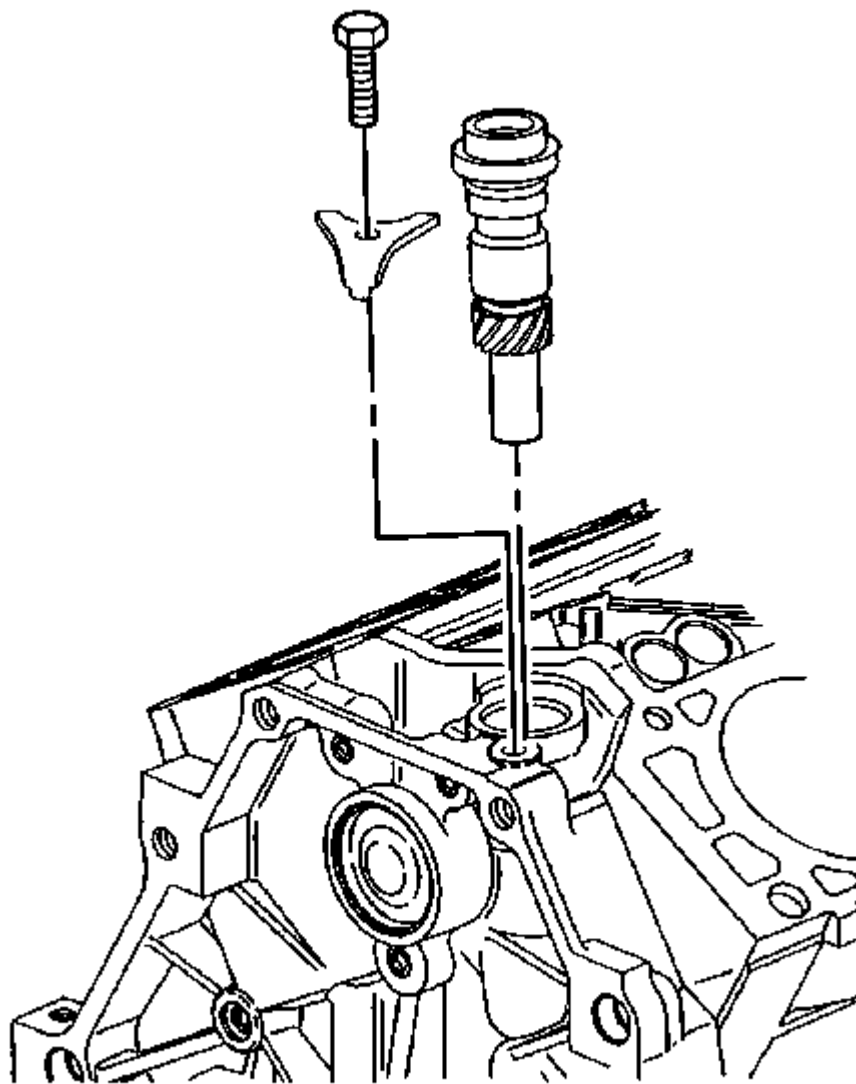


Fig. 131: Oil Pump, Drive Bolt, & Clamp
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump drive bolt.
5. Remove the oil pump drive clamp.
6. Remove the oil pump drive.
7. Remove the oil pump drive seal.

Installation Procedure

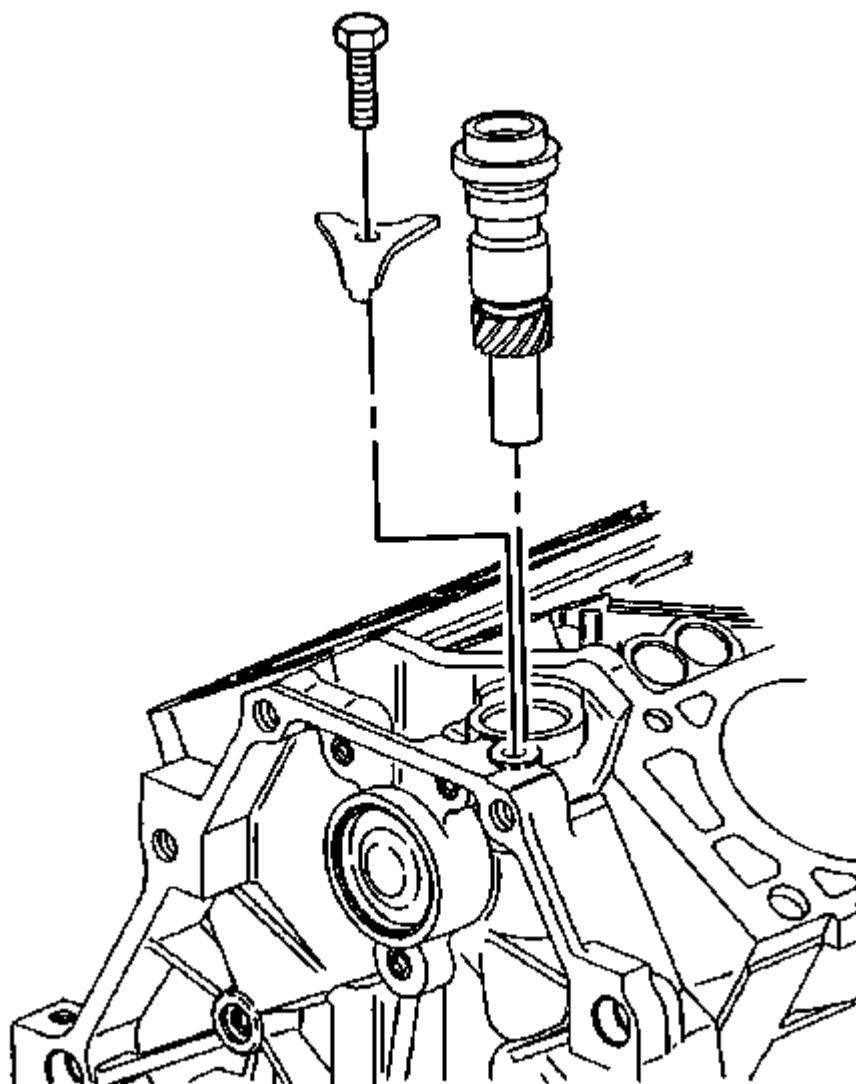


Fig. 132: Oil Pump, Drive Bolt, & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump drive seal. Coat the seal or bore in the engine block with engine oil.
2. Coat the drive gear on the oil pump drive with prelube GM P/N 1052367 (Canadian P/N 992869) or the equivalent.
3. Install the oil pump drive.
4. Install the oil pump drive clamp.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pump drive bolt.

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

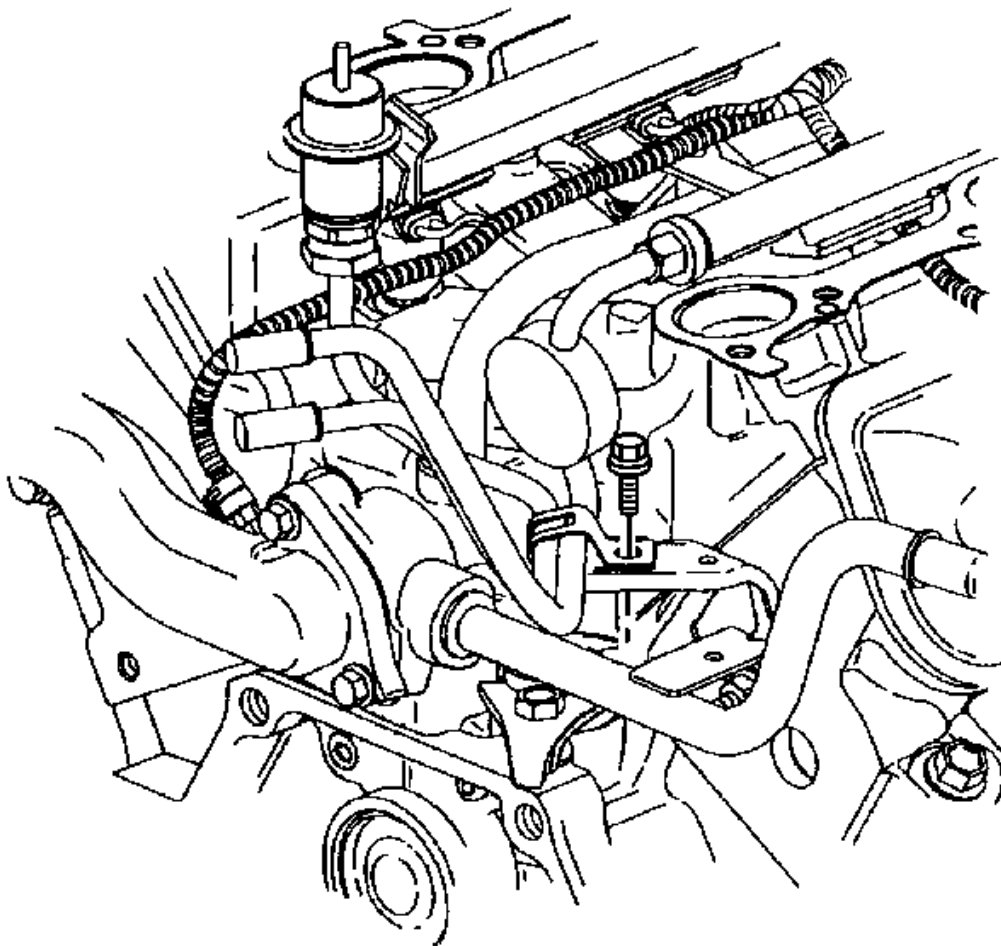


Fig. 133: Fuel Pipe Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the fuel feed and the fuel return pipes to the fuel injector rail. Refer to Fuel Rail Assembly Replacement in Engine Controls - 3.1L
7. Install the fuel pipe clip and the bolt.

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

8. Install the upper intake manifold. Refer to **Intake Manifold Replacement - Upper**.

Crankshaft Front Oil Seal Replacement

Tools Required

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

Removal Procedure

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

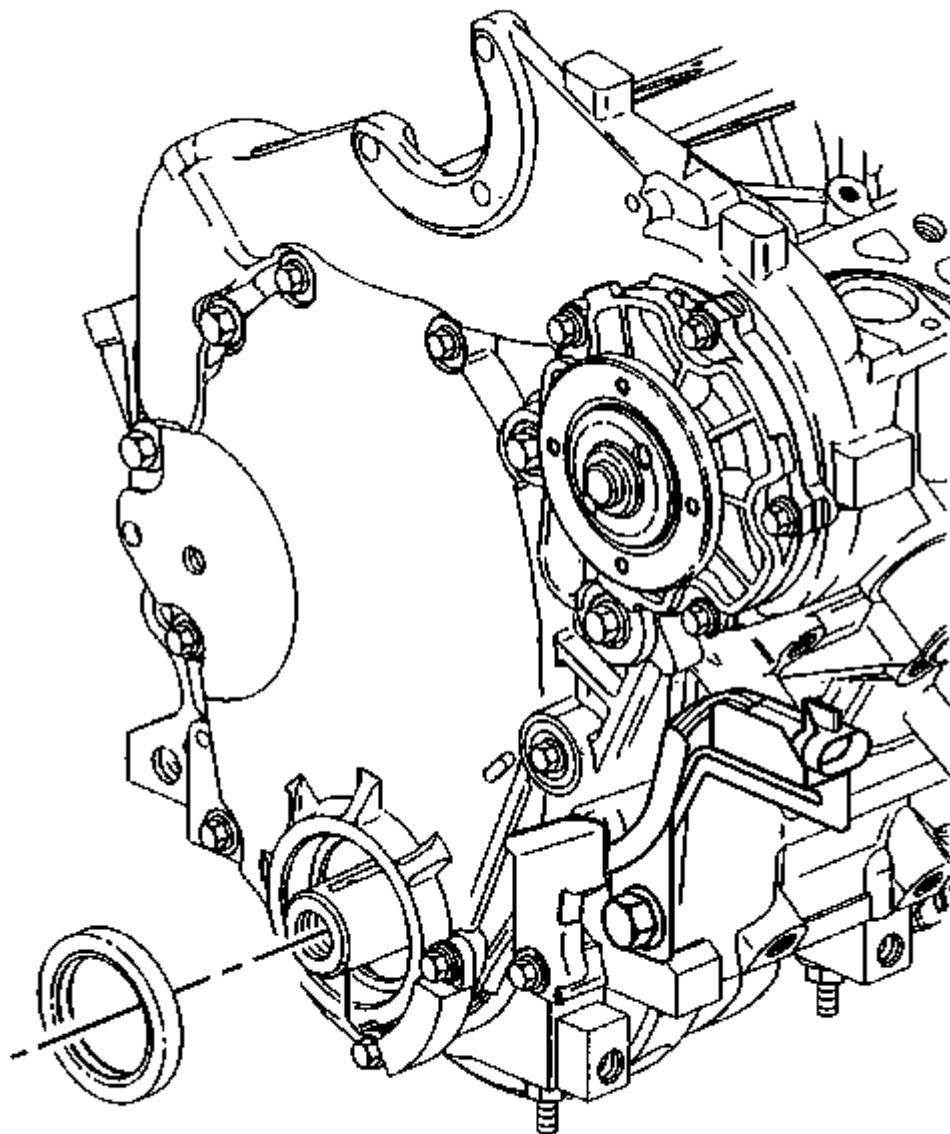


Fig. 134: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

2. Pry out the crankshaft front oil seal with a flat-bladed tool such as a large screwdriver. Refer to the instructions supplied with the replacement part.
3. Inspect the crankshaft, the crankshaft balancer and the engine front cover for wear and/or damage. Replace or repair the crankshaft, the crankshaft balancer and/or engine front cover as necessary.

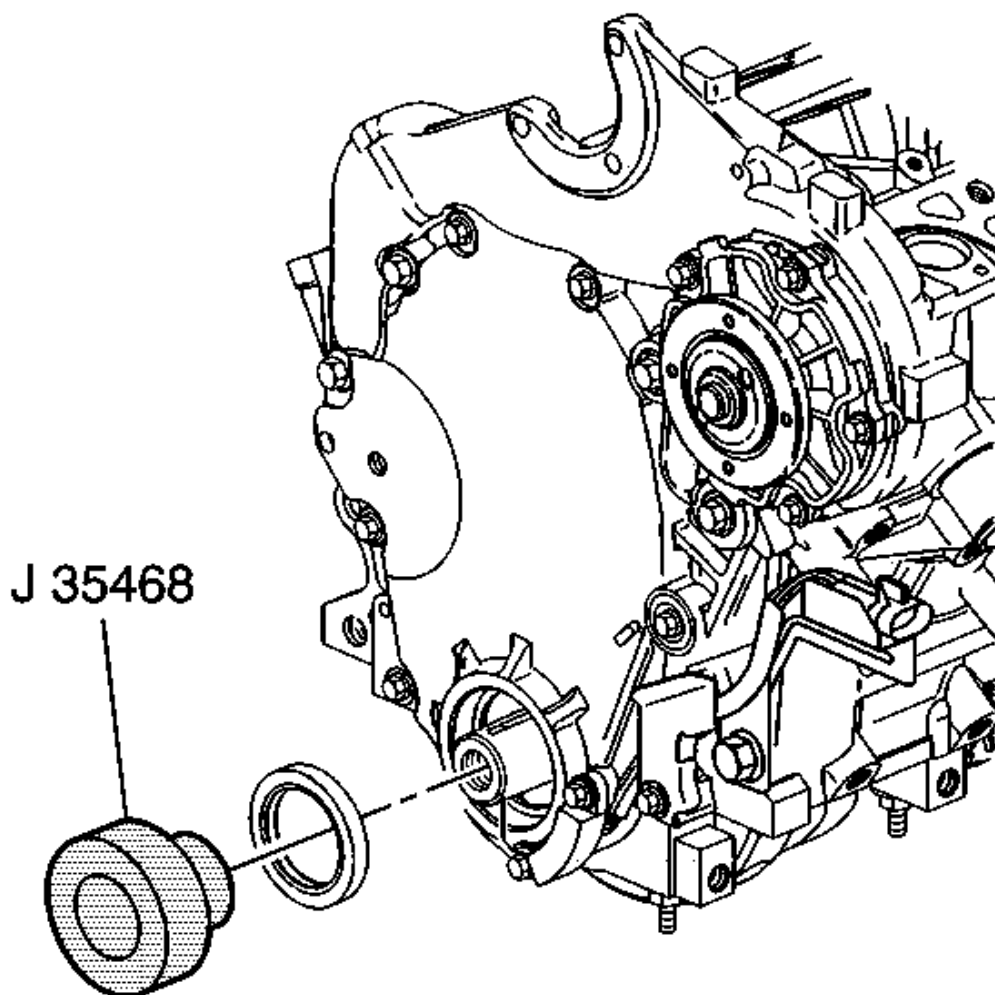
Installation Procedure

Fig. 135: Installing Crankshaft Front Oil Seal Using J 35468
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the crankshaft front oil seal with engine oil in order to make installation easier.

IMPORTANT: Ensure that the crankshaft front oil seal lip faces the engine.

2. Install the crankshaft front oil seal using the **J 35468** . See **Special Tools and Equipment**.

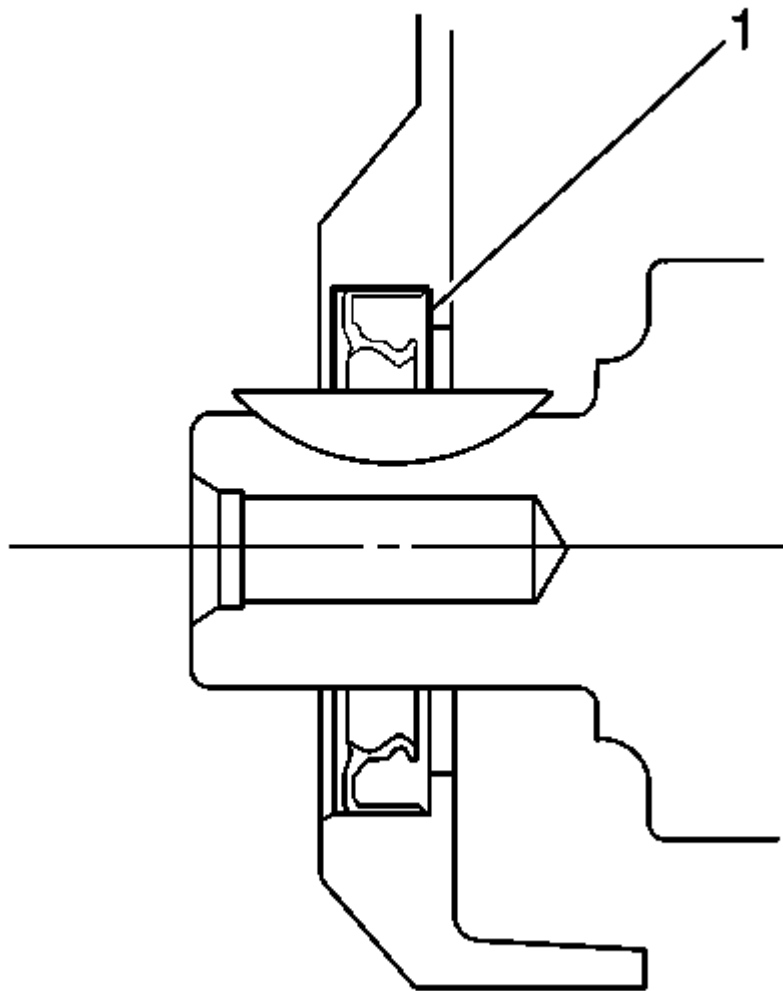


Fig. 136: Correct Installation Position Of Oil Seal To Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

3. Ensure the crankshaft front oil seal is installed flush to the engine front cover (1).
4. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
5. Inspect for leaks.

Engine Front Cover Replacement

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Remove the coolant recovery reservoir. Refer to **Coolant Recovery Reservoir Replacement** in Engine Cooling.
5. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
6. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
7. Remove the power steering pump with lines. Move the power steering pump aside. Refer to **Power Steering Pump Replacement (3.1L)** or **Power Steering Pump Replacement (3.8L)** in Power Steering System.
8. Remove the thermostat bypass pipe from the engine front cover. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
9. Remove the radiator outlet hose from the coolant pump. Refer to **Radiator Hose Replacement - Outlet (3.1L)** or **Radiator Hose Replacement - Outlet (3.8L)** in Engine Cooling.
10. Remove the drive belt shield bolt and the shield.

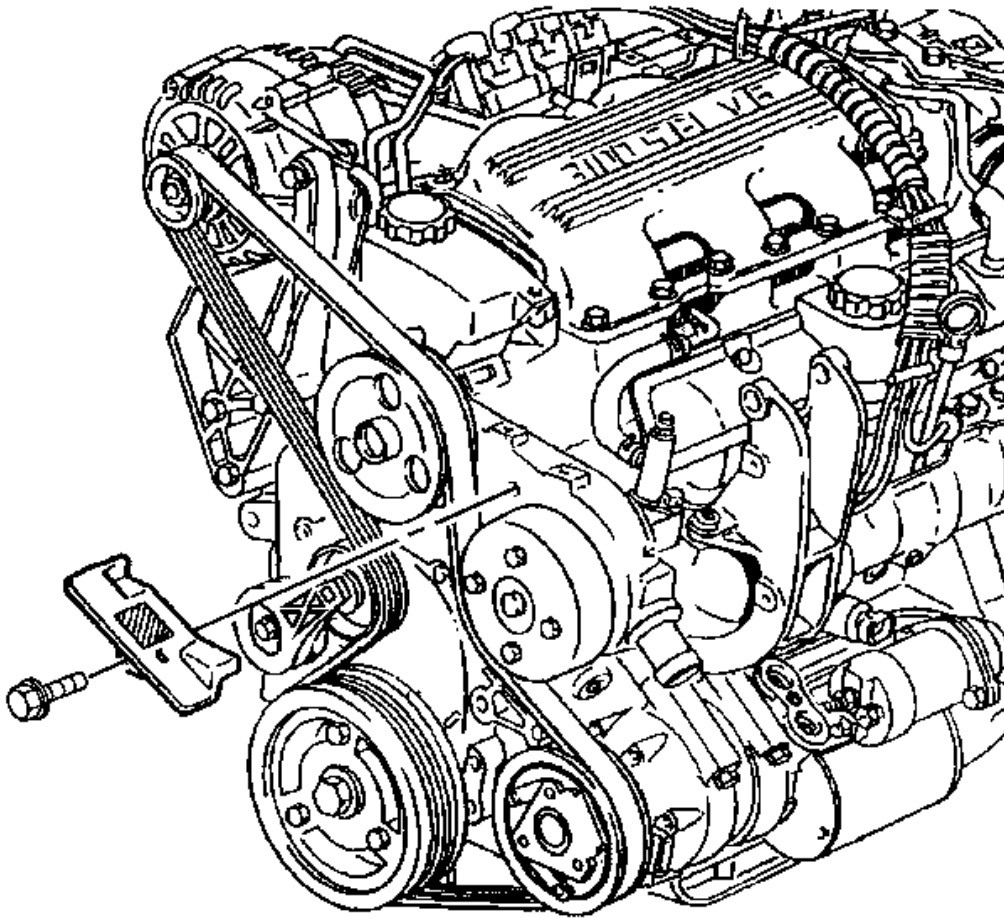


Fig. 137: Drive Belt Shield & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the water pump pulley bolts.
12. Remove the water pump pulley.

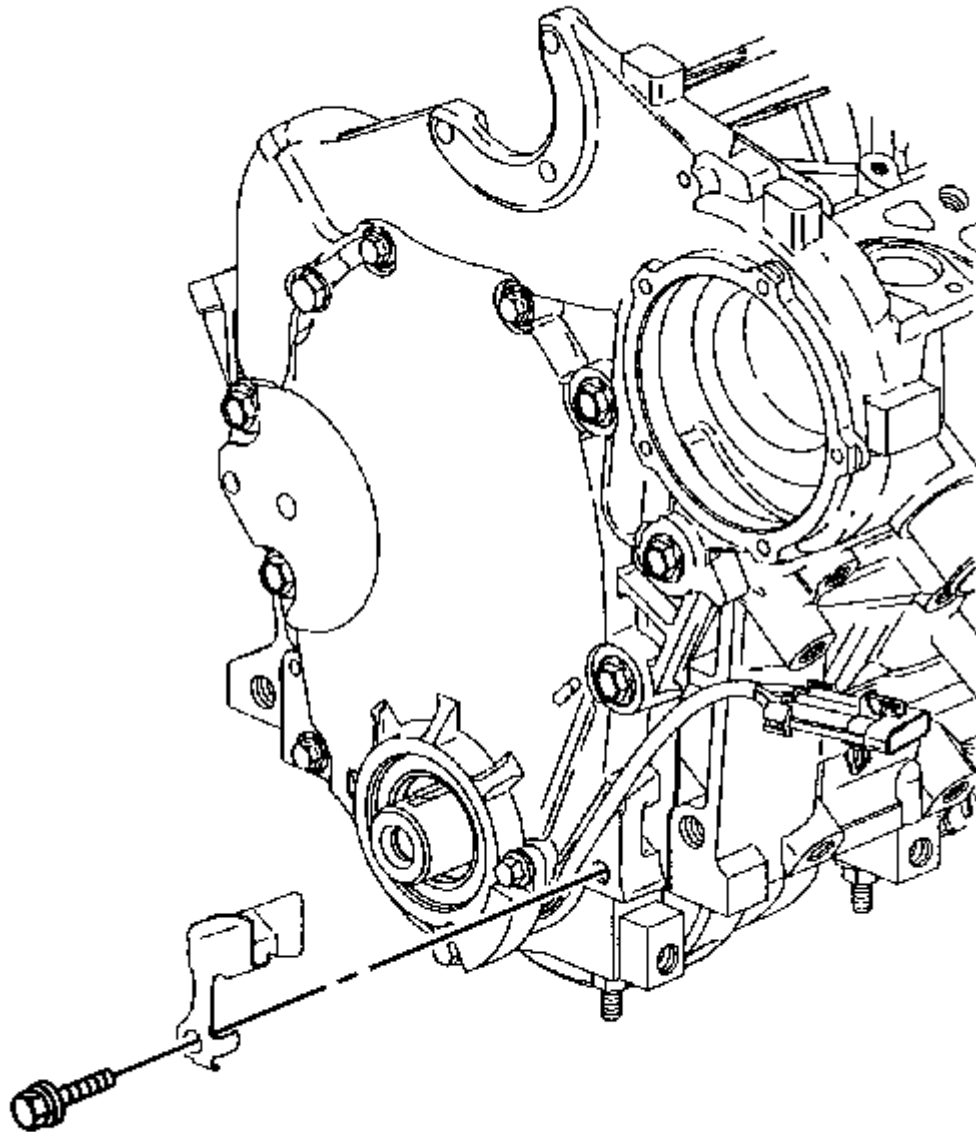


Fig. 138: View Of Lower Crankshaft Position Sensor Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the crankshaft position sensor electrical connector.
14. Remove the lower crankshaft position sensor wiring harness bracket bolt and the bracket from the engine front cover.

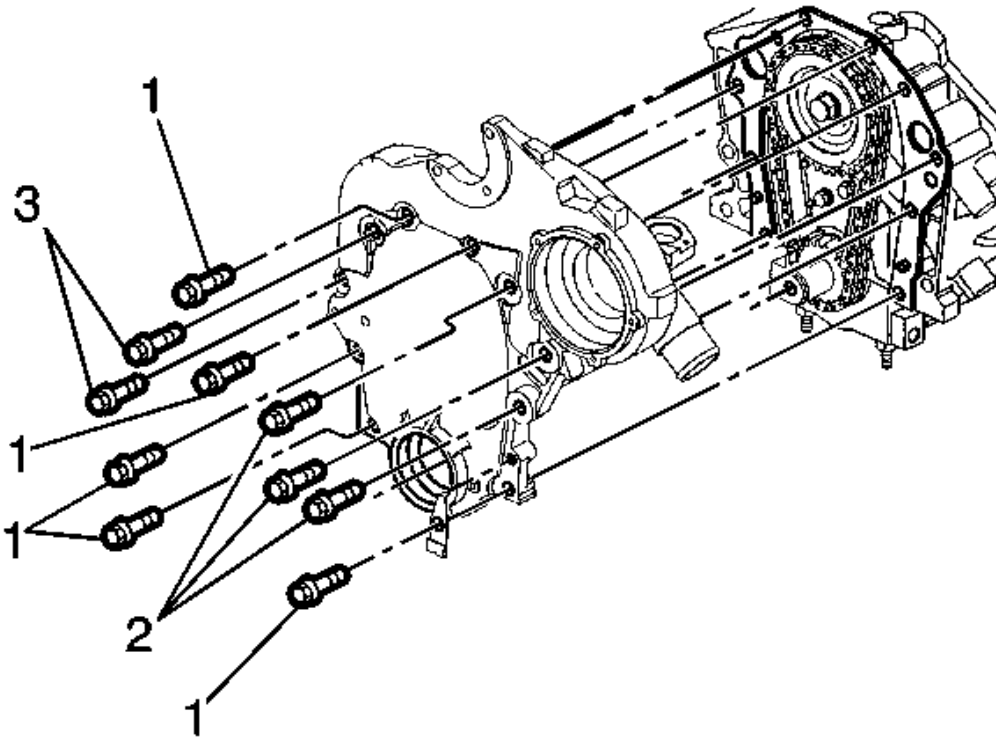


Fig. 139: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

15. Remove the engine front cover bolts (1,2,3).
16. Remove the engine front cover.

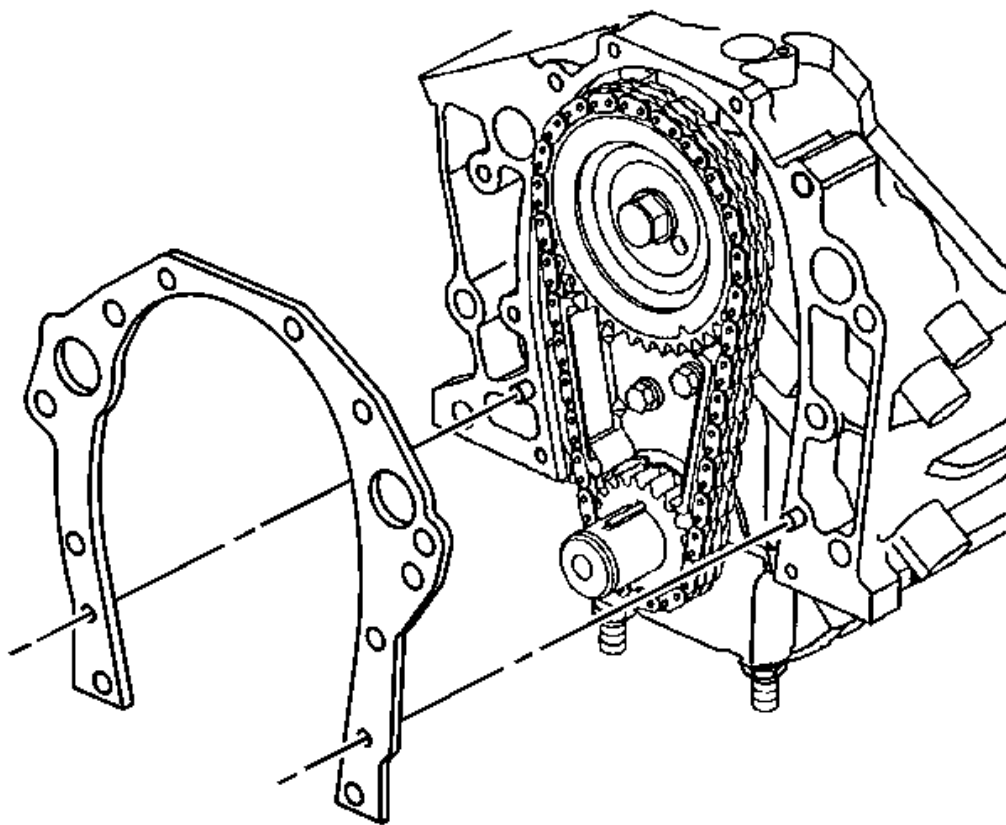


Fig. 140: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

17. Remove the engine front cover gasket.
18. Clean the engine front cover and engine block gasket mating surfaces.
19. Inspect the engine front cover for damage to the engine front cover, crankshaft front oil seal or the gasket mating surface.

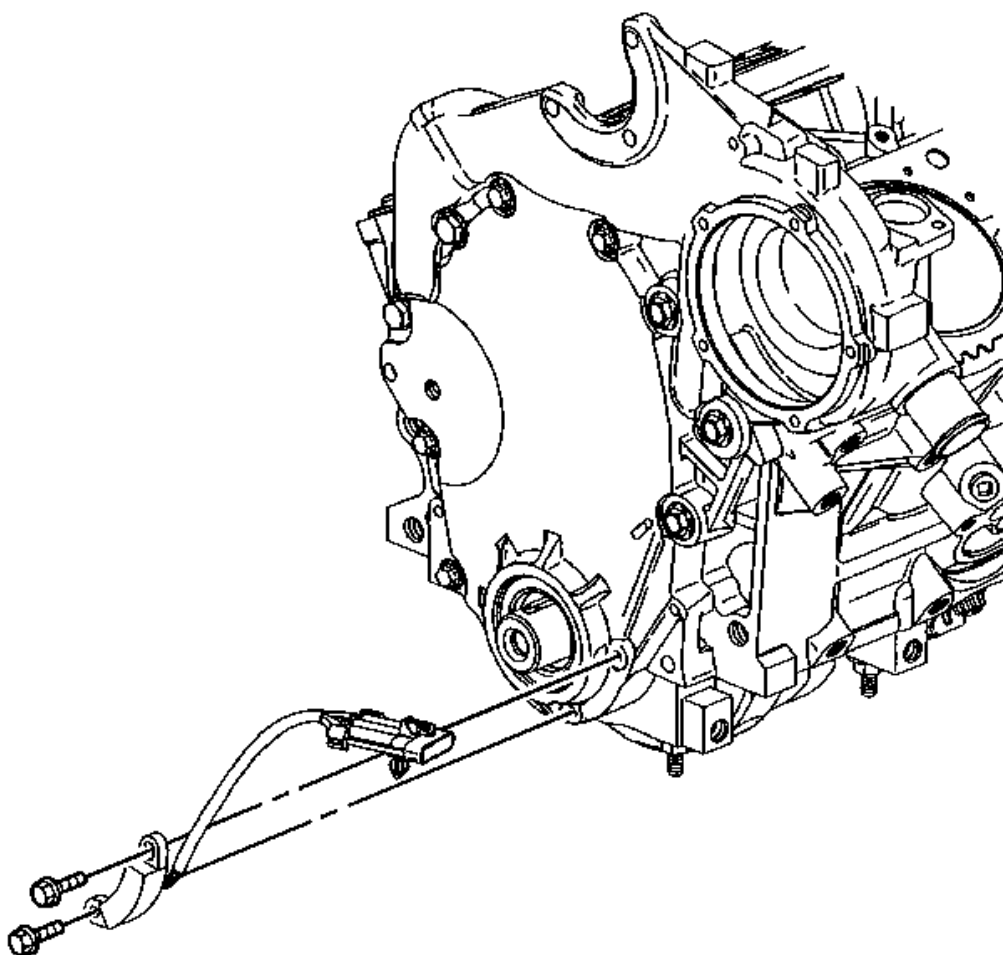


Fig. 141: Crankshaft Position Sensor At Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

20. If replacing the engine front cover, remove the crankshaft position sensor from the engine front cover. Refer to **Crankshaft Position (CKP) Sensor Replacement (7X)** or **Crankshaft Position (CKP) Sensor Replacement (24X)** in Engine Controls - 3.1L.
21. If replacing the engine front cover, remove the water pump from the engine front cover. Refer to **Water Pump Replacement (3.1L)** or **Water Pump Replacement (3.8L)** in Engine Cooling.

Installation Procedure

1. If removed, install the water pump to the engine front cover. Refer to **Water Pump Replacement (3.1L)** or **Water Pump Replacement (3.8L)** in Engine Cooling.

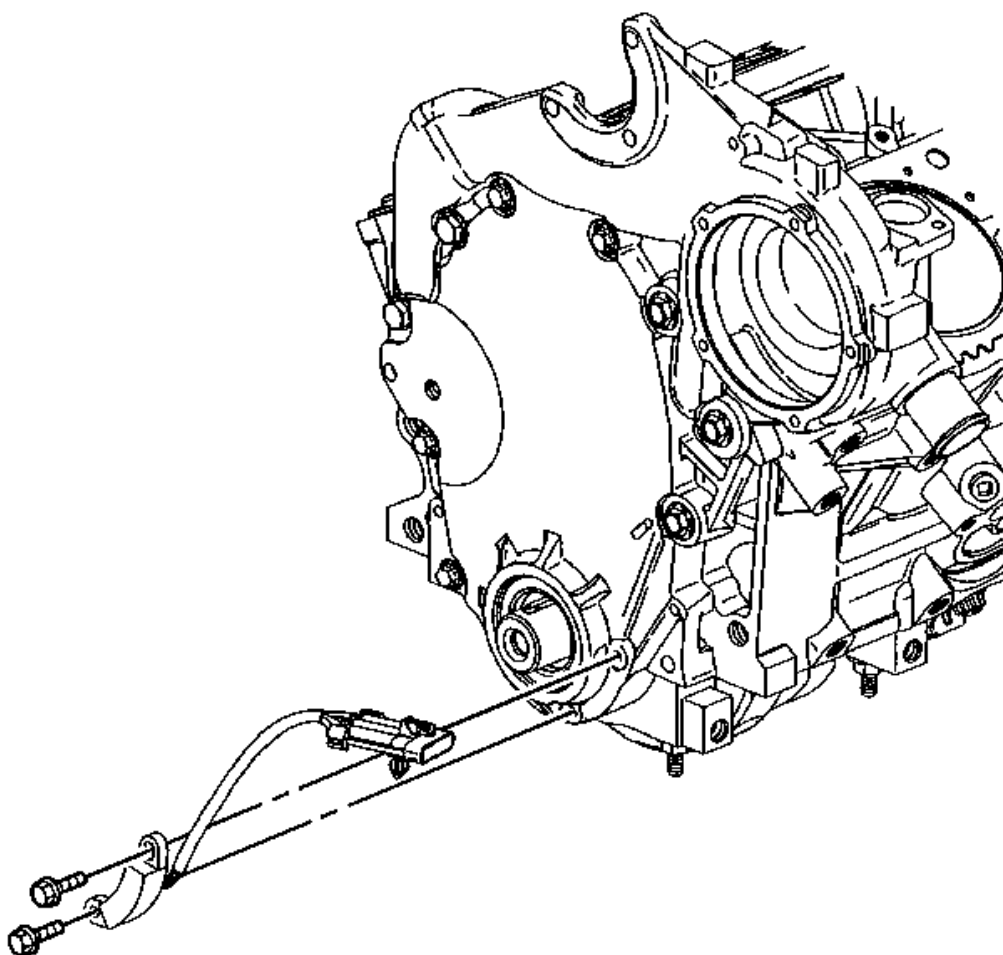


Fig. 142: Crankshaft Position Sensor At Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

2. If removed, install the crankshaft position sensor to the engine front cover. Refer to **Crankshaft Position (CKP) Sensor Replacement (7X)** or **Crankshaft Position (CKP) Sensor Replacement (24X)** in Engine Controls - 3.1L.

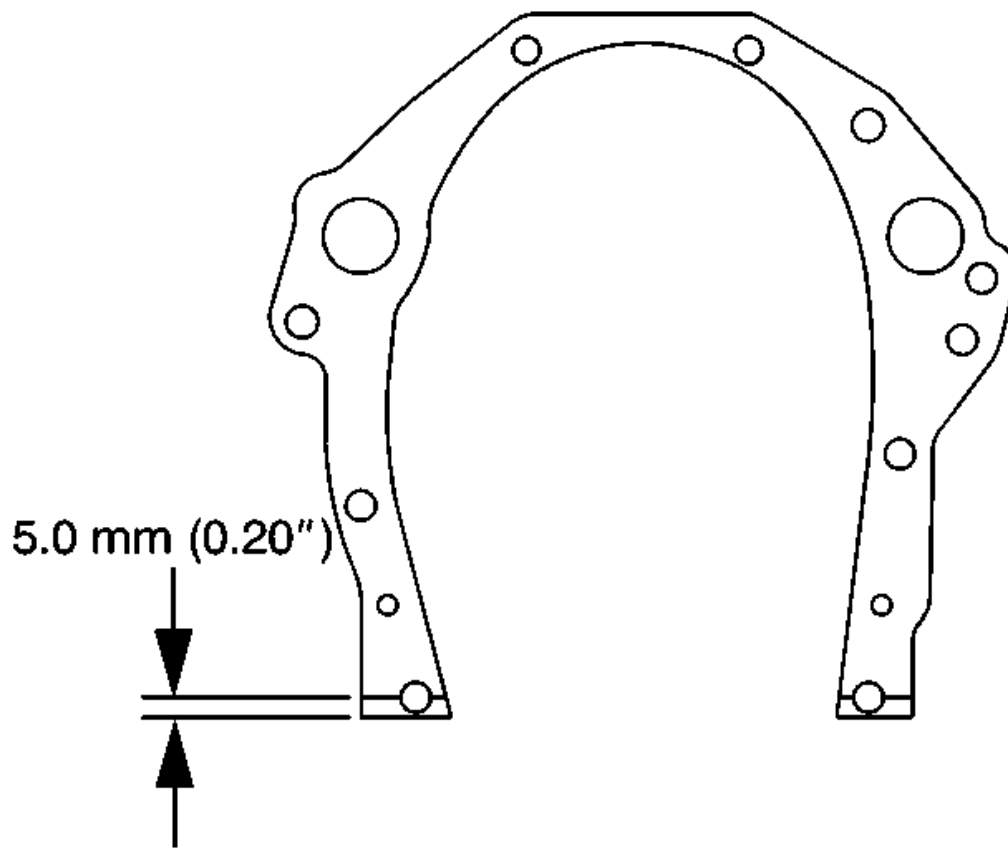


Fig. 143: Applying Sealer To Lower Tabs Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

3. Coat both sides of the lower tabs of the engine front cover gasket with sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent.

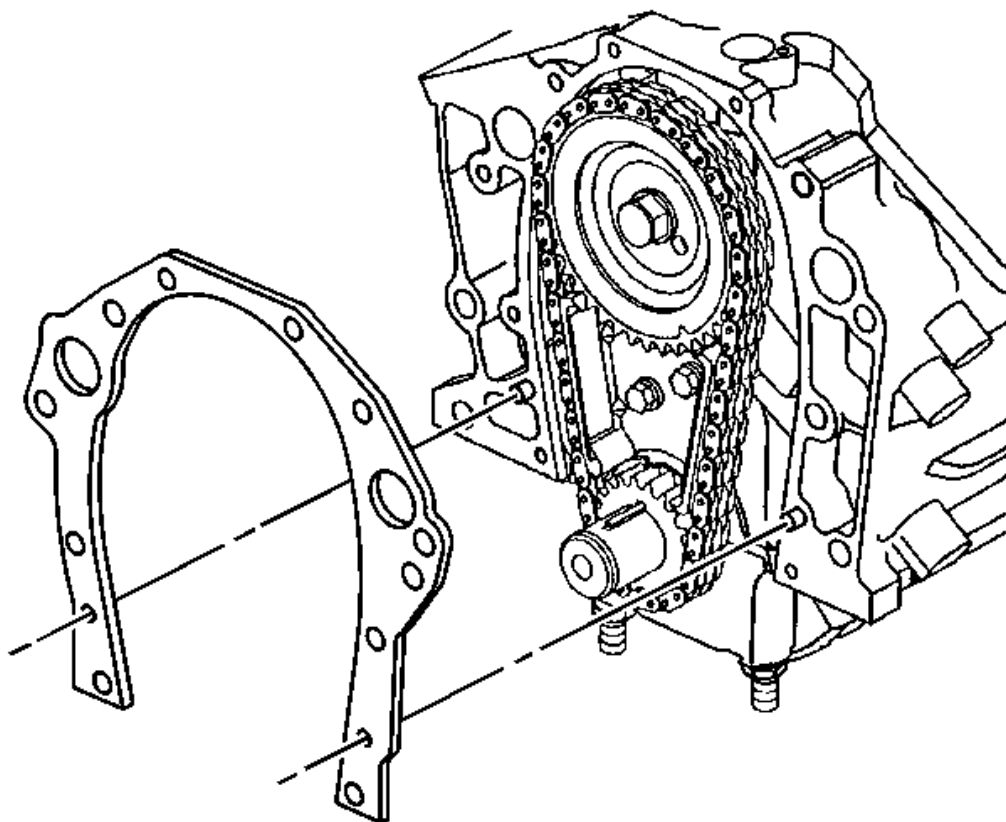


Fig. 144: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

4. Install the engine front cover gasket.

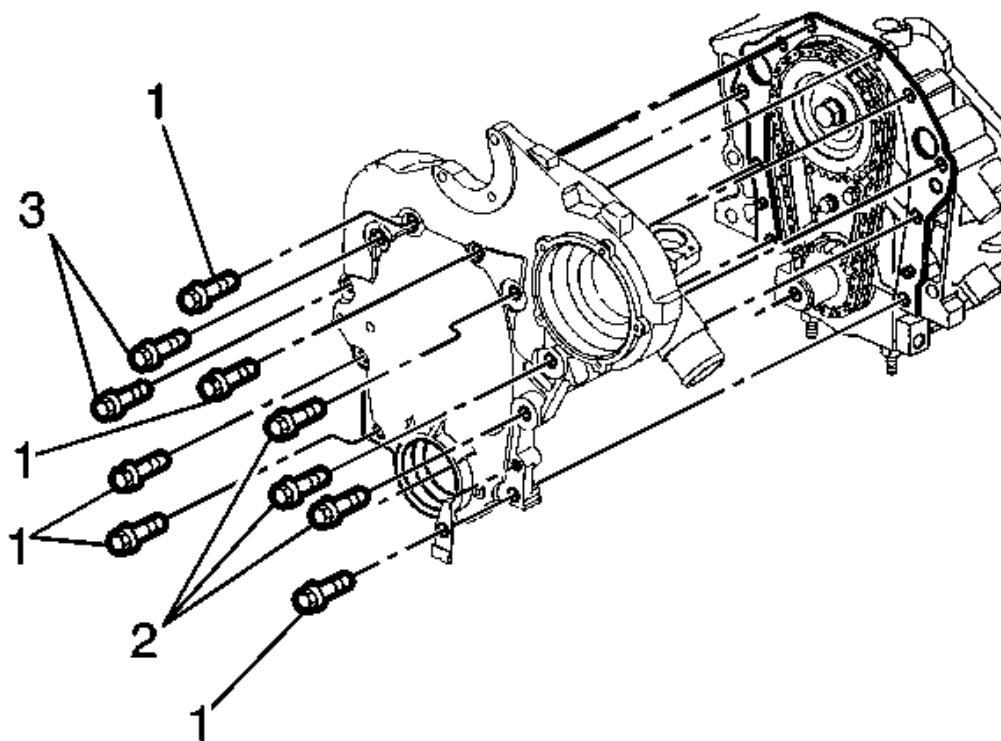


Fig. 145: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the engine front cover bolts (1, 2, 3).

Tighten:

- Tighten the small engine front cover bolts (1) to 27 N.m (20 lb ft).
- Tighten the large engine front cover bolts (2,3) to 55 N.m (41 lb ft).

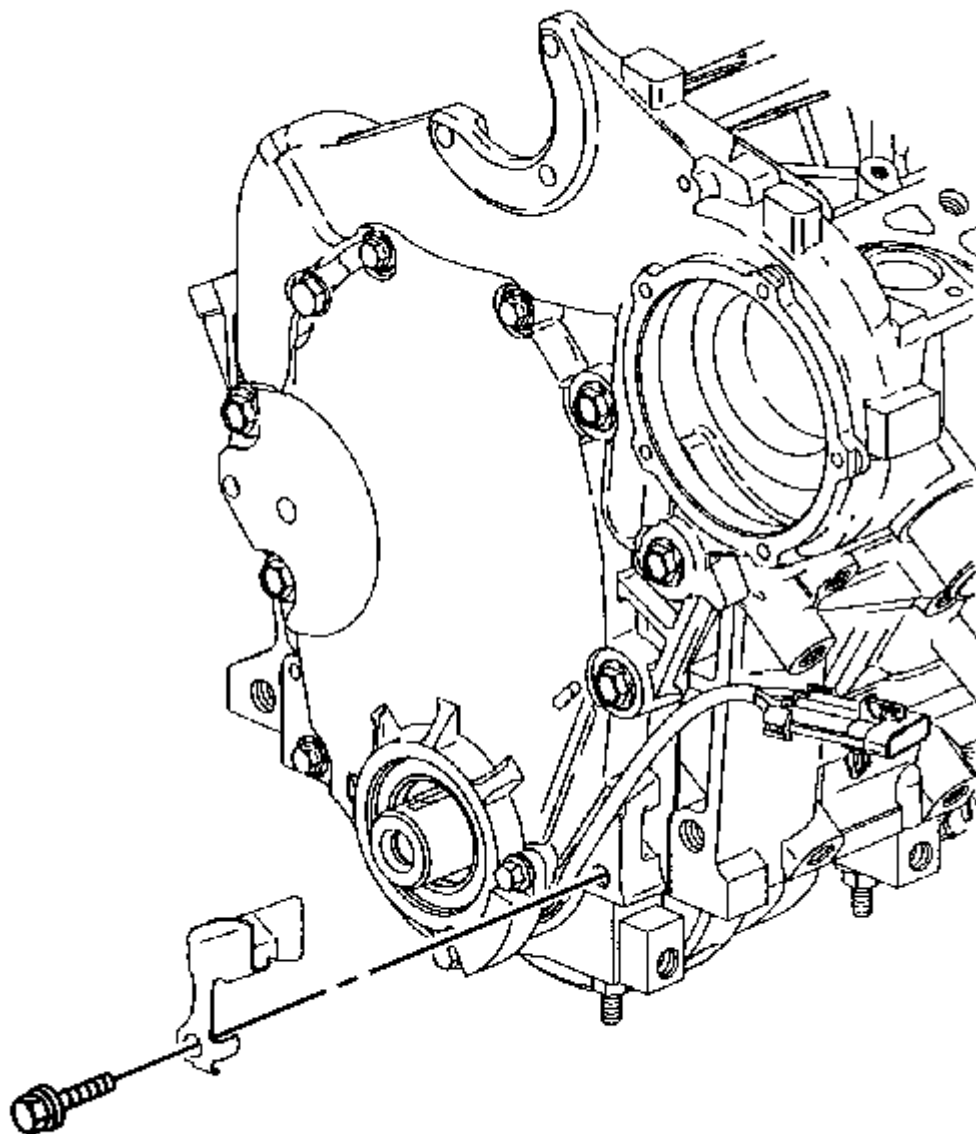


Fig. 146: View Of Lower Crankshaft Position Sensor Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the lower crankshaft position sensor wiring harness bracket and the bolt to the engine front cover.

Tighten: Tighten the bolt to 27 N.m (20 lb ft).

8. Connect the crankshaft position sensor electrical connector.

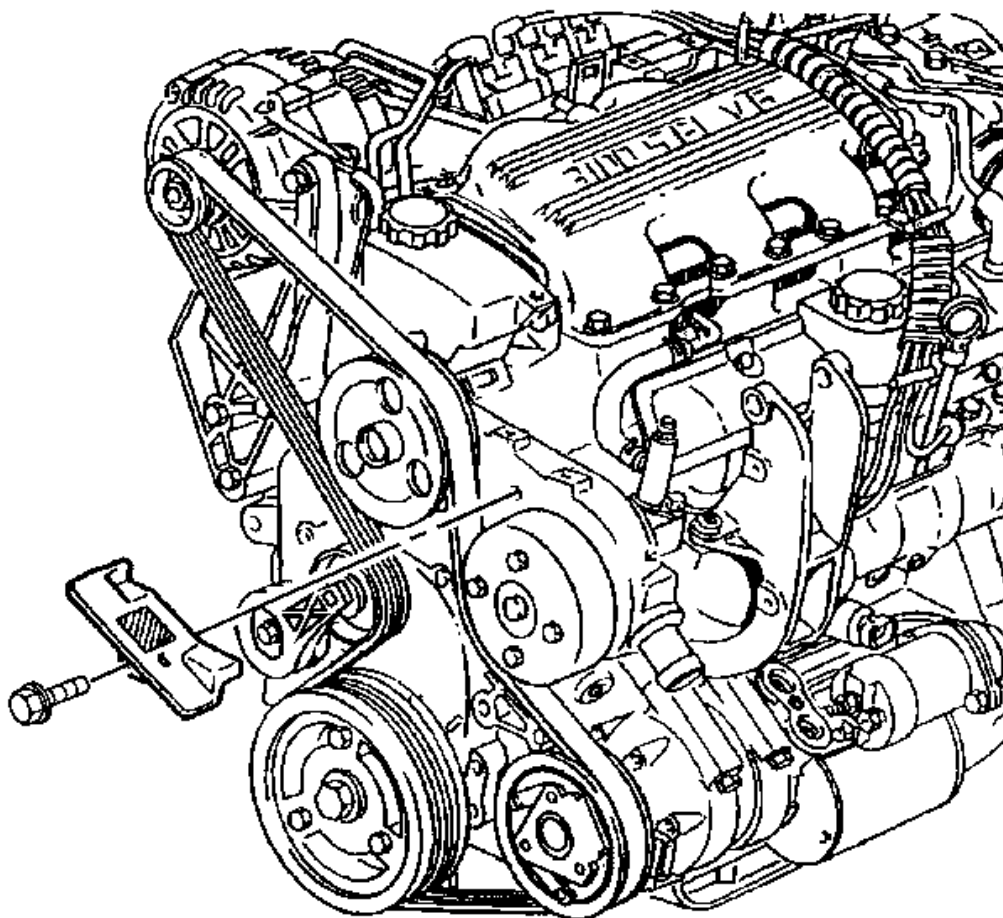


Fig. 147: Drive Belt Shield & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the drive belt shield.
10. Install the drive belt shield bolt.

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

11. Install the water pump pulley.
12. Install the water pump pulley bolts.

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

13. Install the radiator outlet hose to the coolant pump. Refer to **Radiator Hose Replacement - Outlet**

(3.1L) or Radiator Hose Replacement - Outlet (3.8L) in Engine Cooling.

14. Install the thermostat bypass pipe to the engine front cover. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
15. Install the power steering pump with lines. Refer to **Power Steering Pump Replacement (3.1L)** or **Power Steering Pump Replacement (3.8L)** in Power Steering System.
16. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
17. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
18. Fill the crankcase with new engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
19. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
20. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
21. Perform a CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.1L.

Timing Chain and Sprockets Replacement

Removal Procedure

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

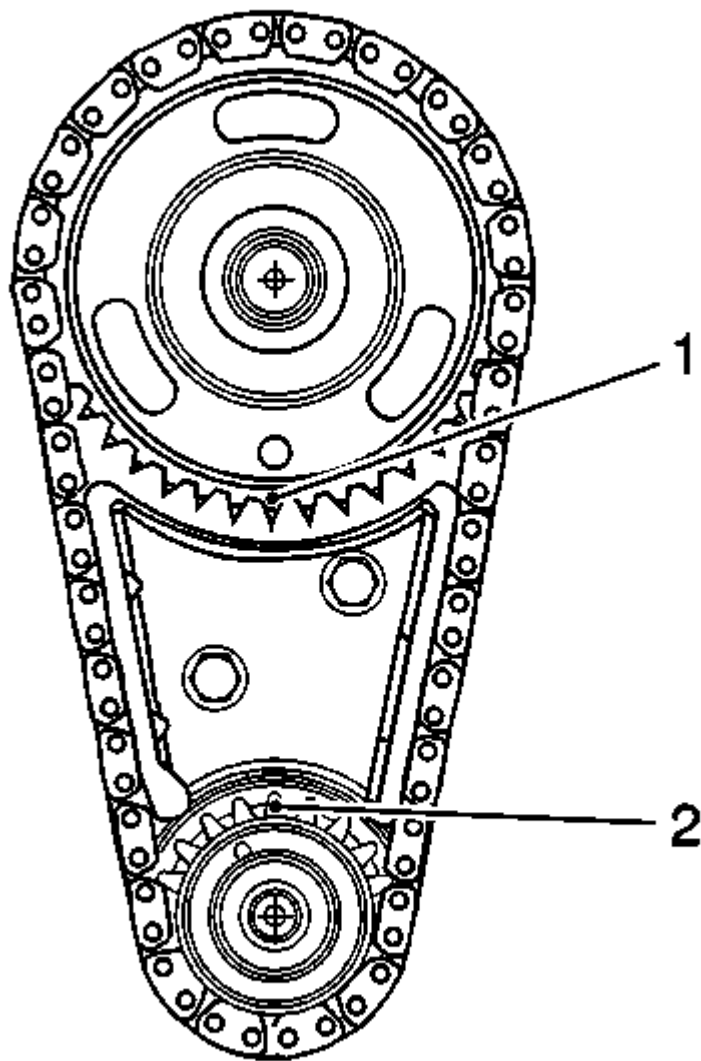


Fig. 148: Crankshaft & Camshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Rotate the crankshaft until the timing marks in the following locations are aligned:
 - The timing chain dampener to the crankshaft sprocket (2).
 - The timing chain dampener to the camshaft sprocket locator hole (1).

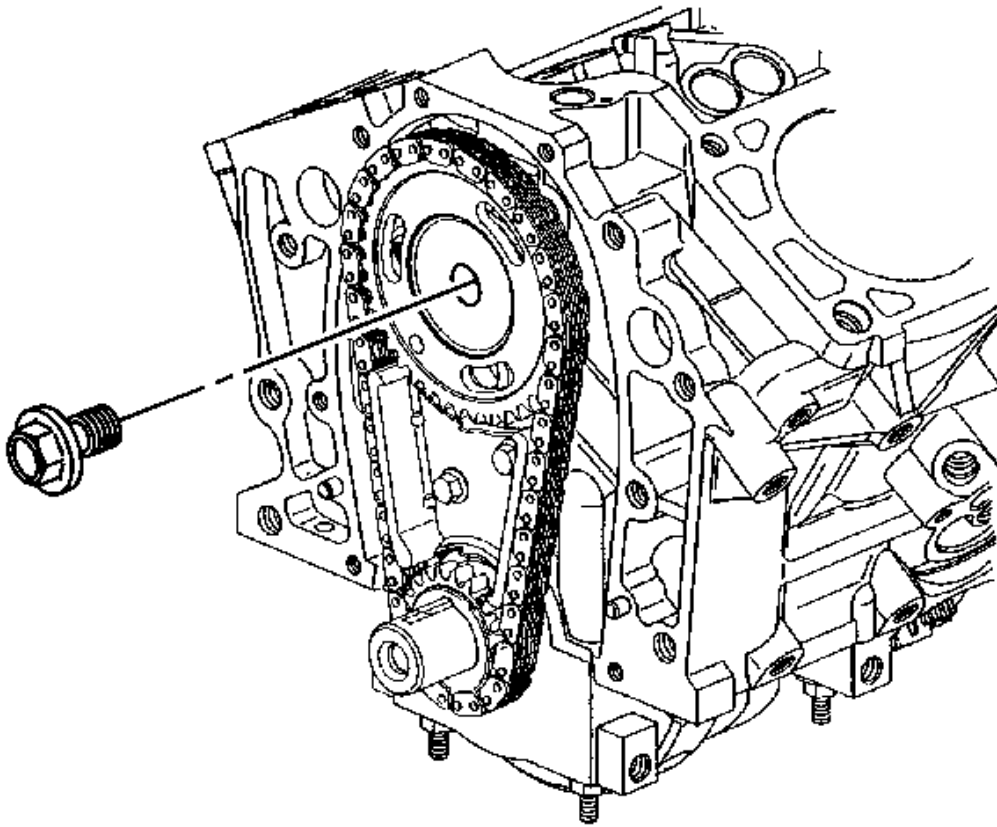


Fig. 149: Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft sprocket bolt.

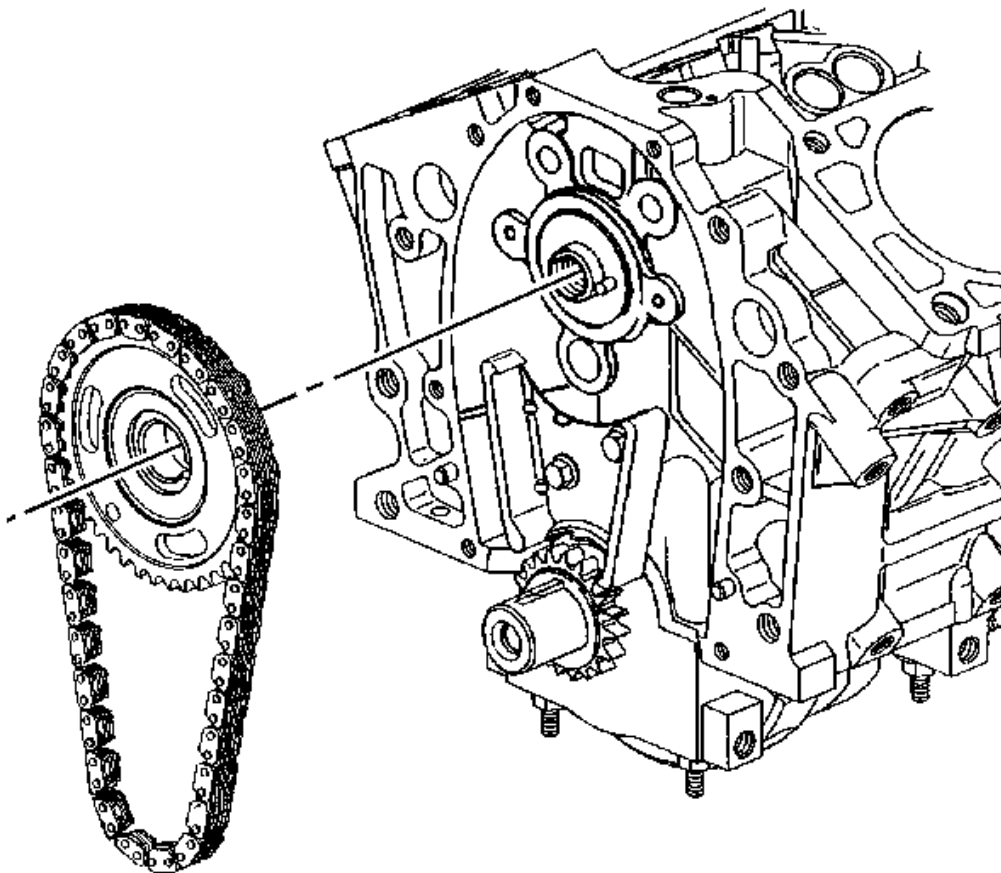


Fig. 150: Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft sprocket with the timing chain.

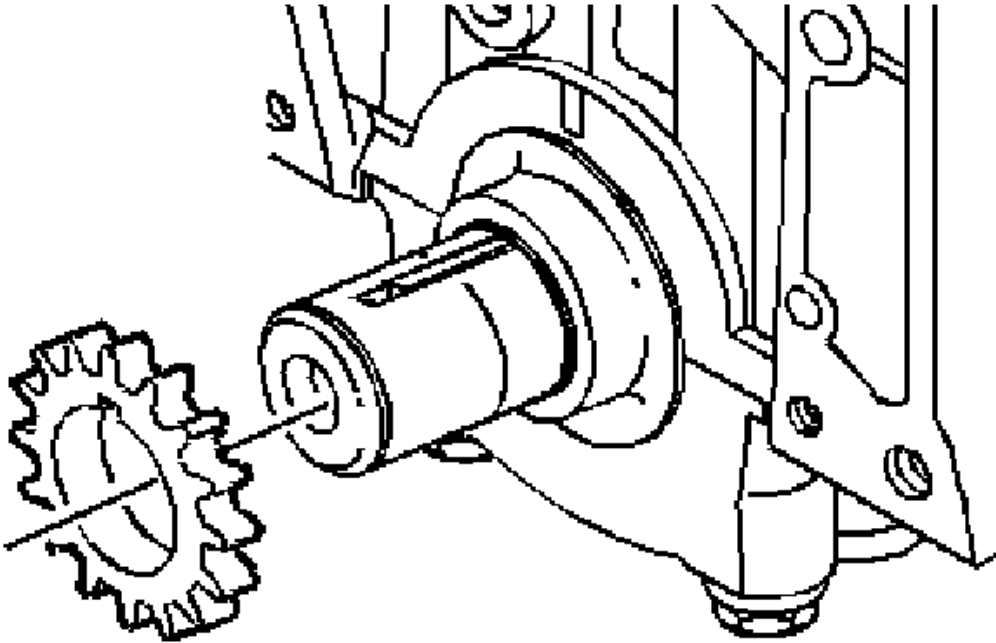


Fig. 151: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket.

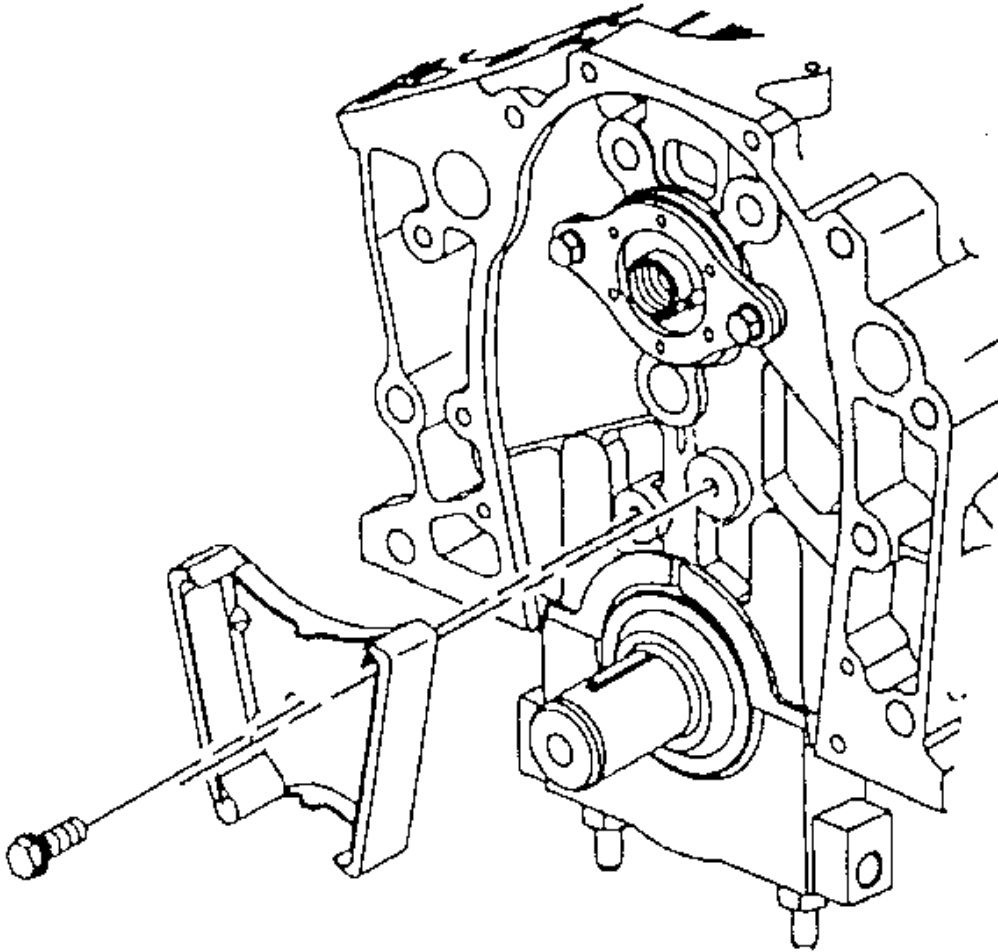


Fig. 152: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

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

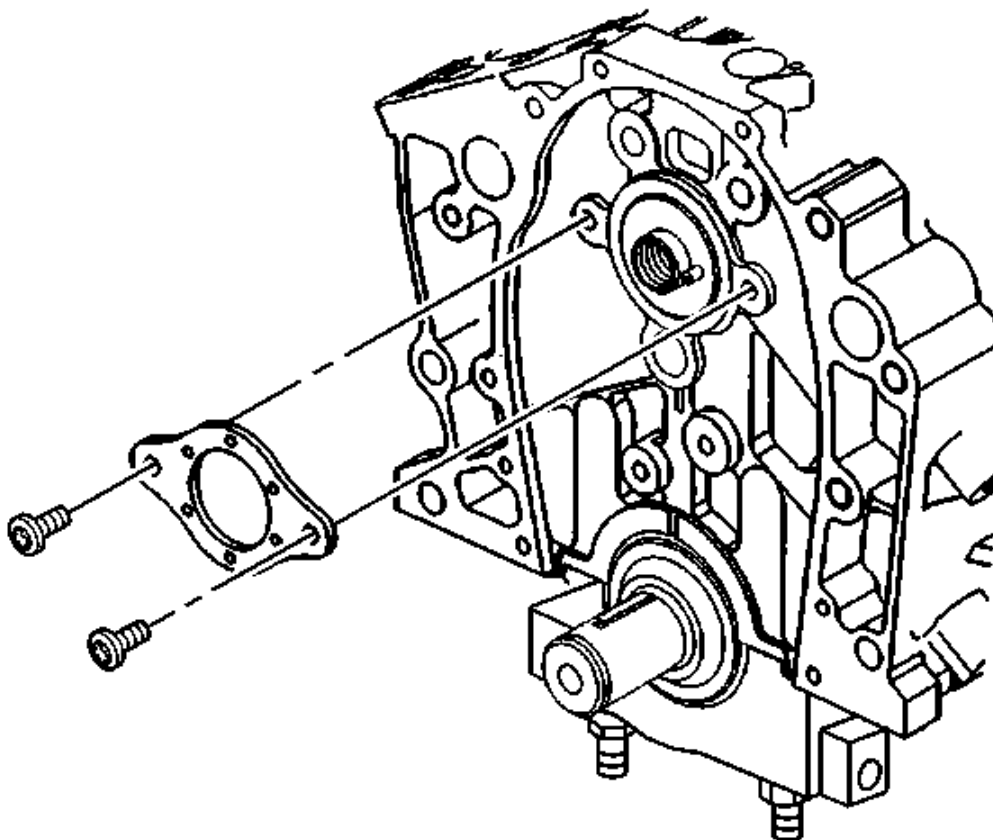


Fig. 153: Camshaft Thrust Plate & Screws
Courtesy of GENERAL MOTORS CORP.

8. If necessary remove the camshaft thrust plate screws.
9. Remove the camshaft thrust plate.

Installation Procedure

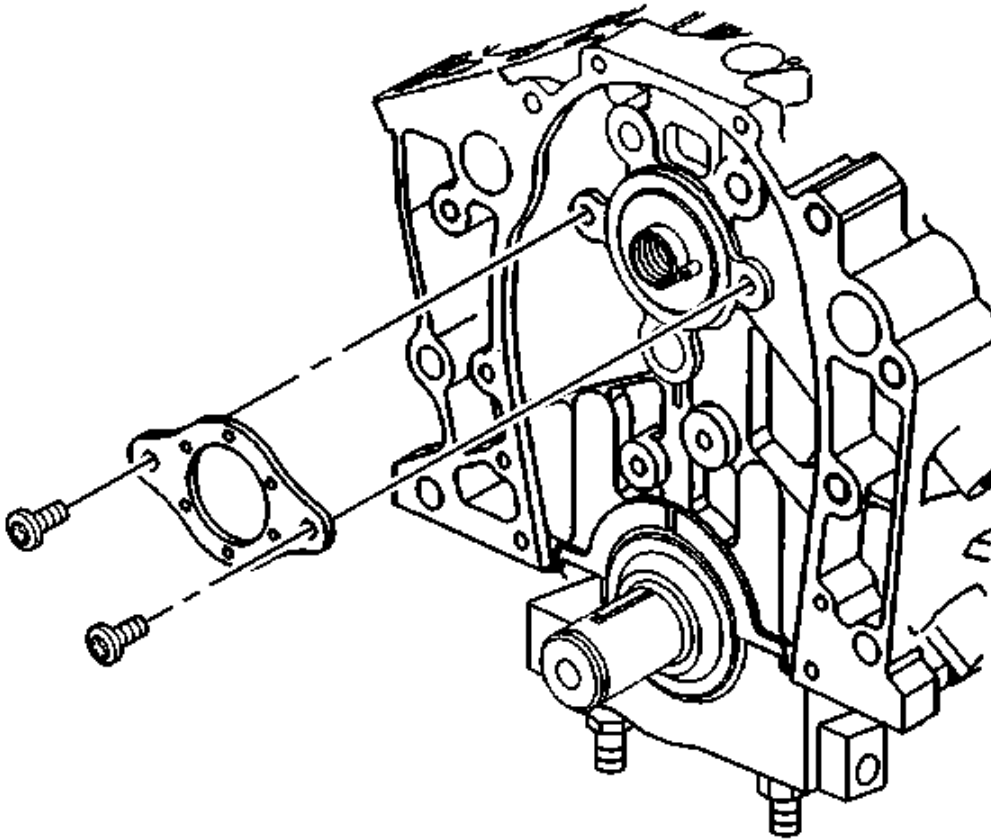


Fig. 154: Camshaft Thrust Plate & Screws
Courtesy of GENERAL MOTORS CORP.

1. If removed install the camshaft thrust plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft thrust plate screws.

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

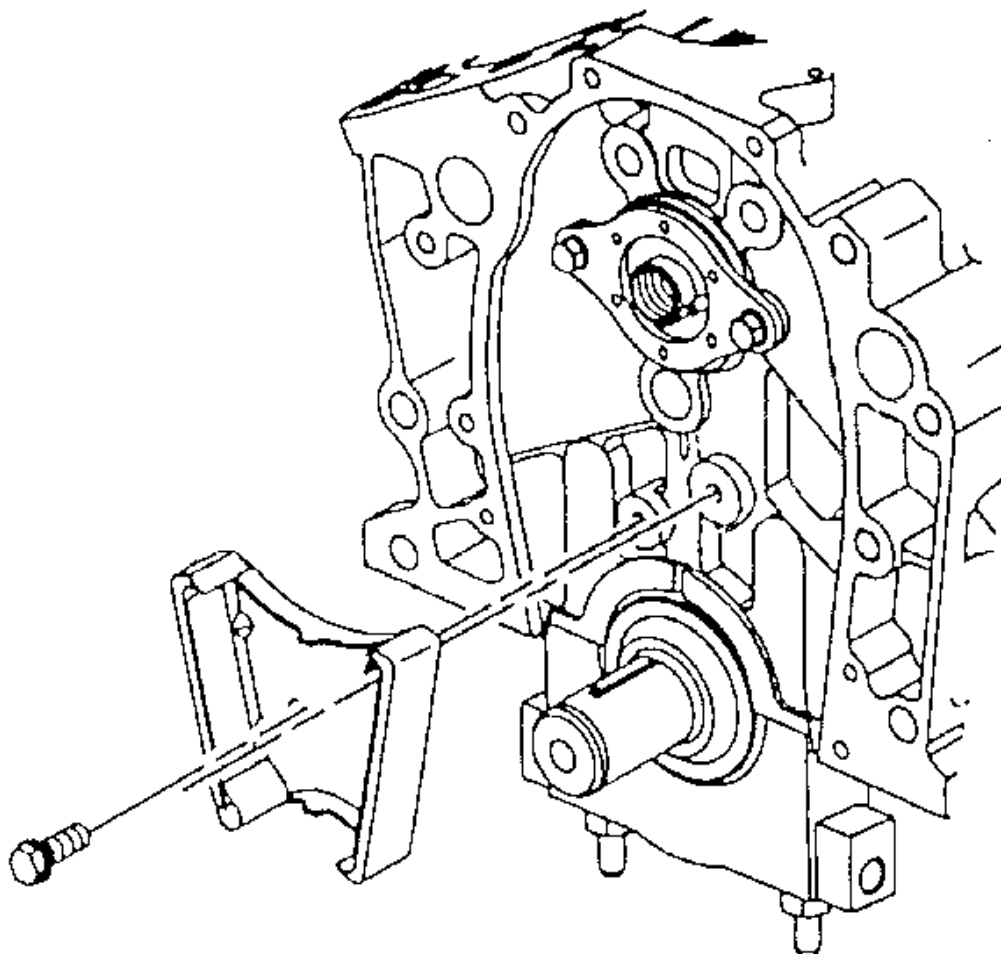


Fig. 155: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain dampener and the bolts to the block.

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

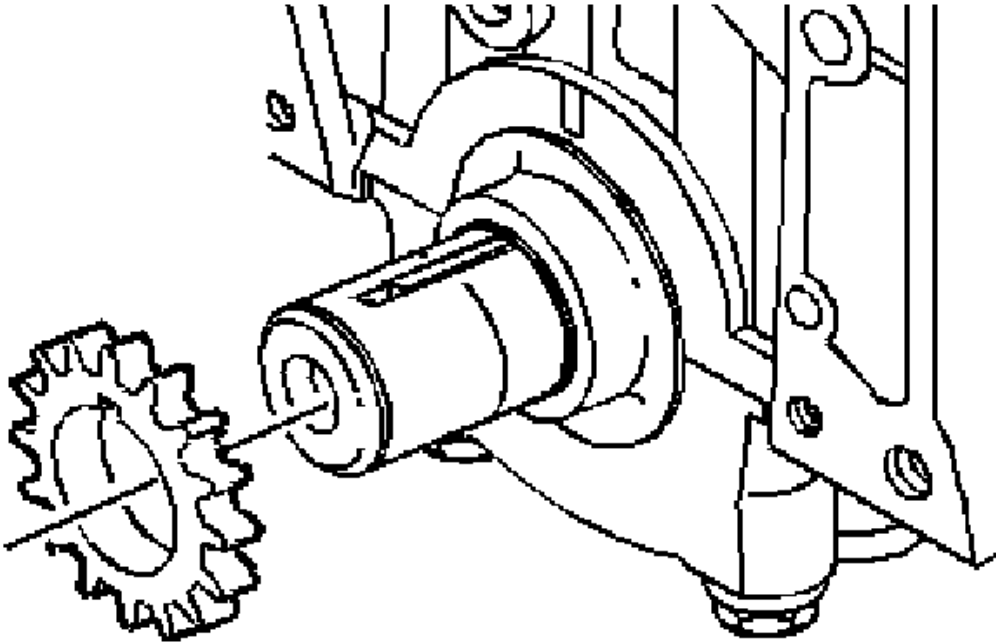


Fig. 156: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft sprocket.
5. Apply Engine Oil Supplement (EOS) GM P/N 1052367 (Canadian P/N 992869) or the equivalent to the sprocket thrust surface.

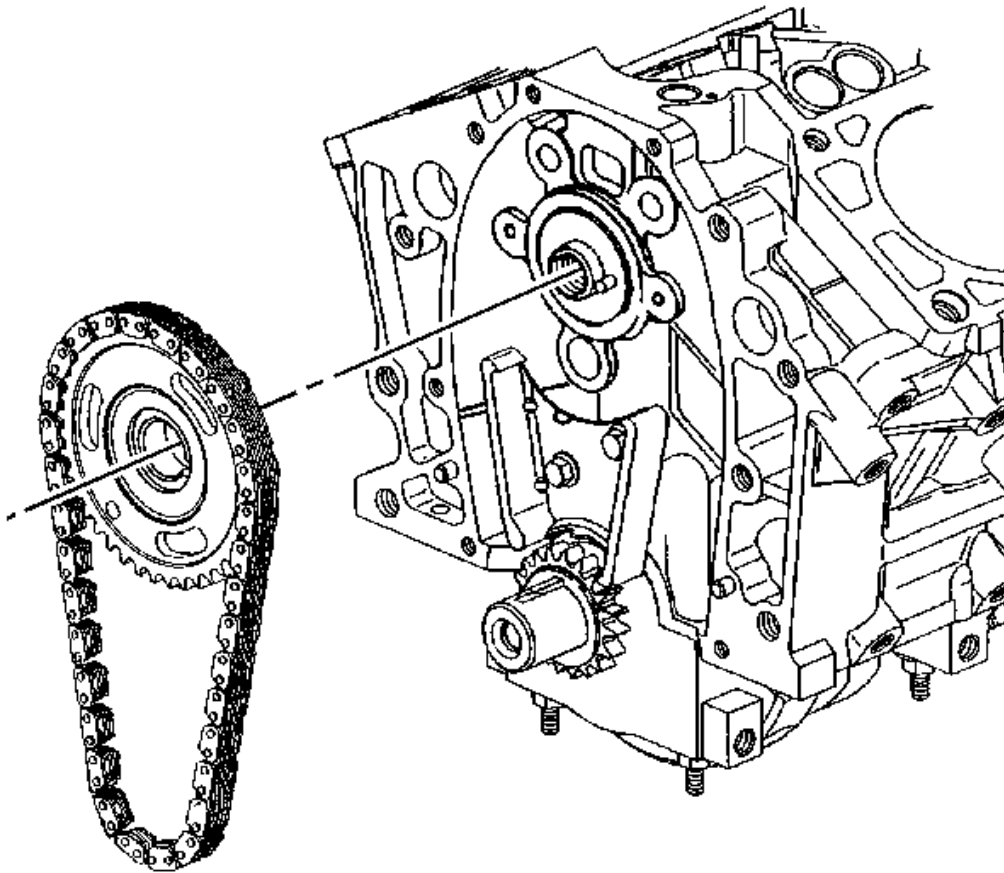


Fig. 157: Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Hold the camshaft sprocket with the chain hanging down, and install the chain to the crankshaft gear.

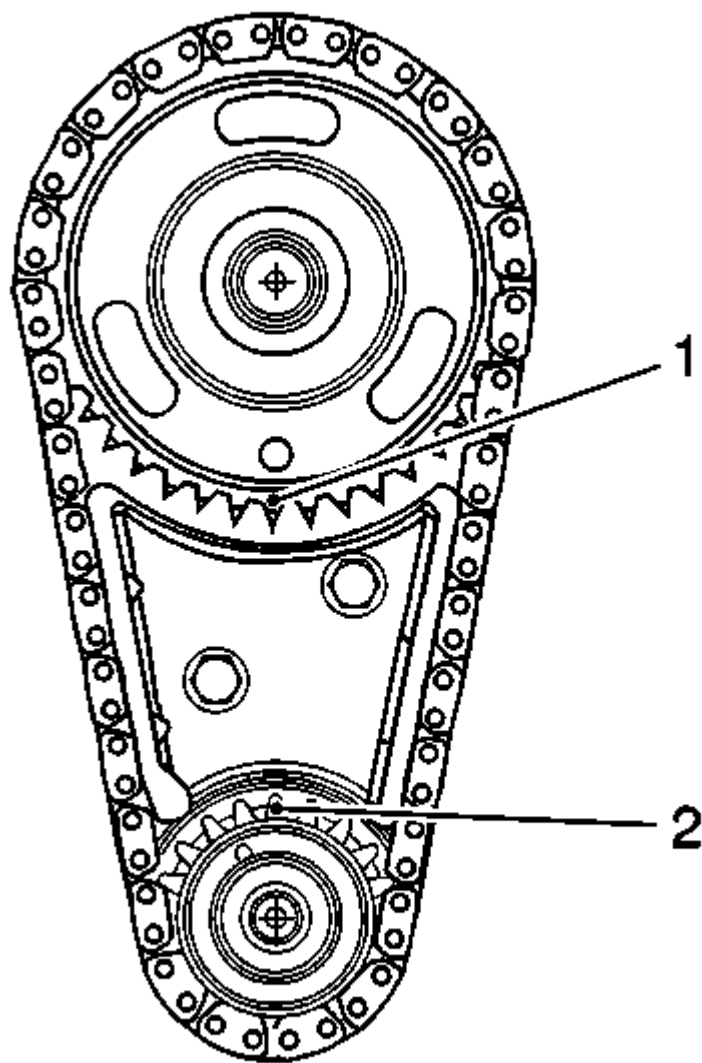


Fig. 158: Crankshaft & Camshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

7. Align the crankshaft timing mark to the timing mark on the bottom of the timing chain dampener (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 with the timing mark on top of the timing chain dampener (1).

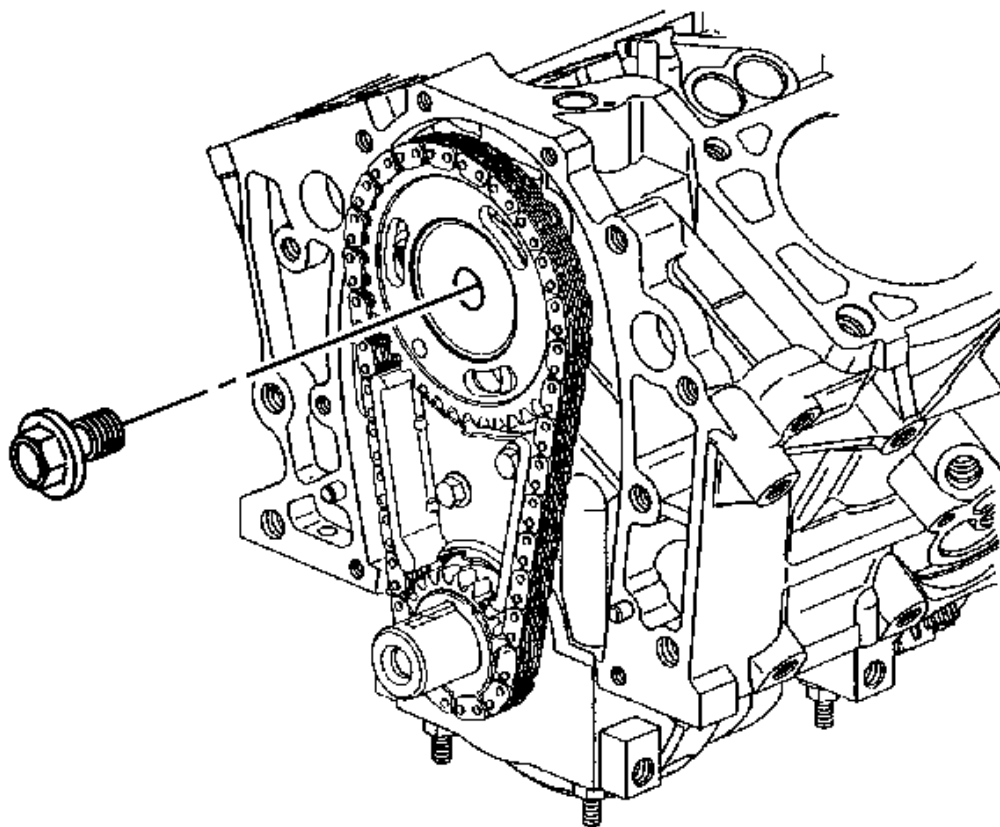


Fig. 159: Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Draw the camshaft sprocket onto the camshaft using the mounting bolt.

10. Install the camshaft sprocket bolt.

Tighten: Tighten the bolt to 140 N.m (103 lb ft).

11. Coat the crankshaft and the camshaft sprocket with engine oil.
12. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

Cylinder Head Replacement - Left

Tools Required

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

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Lower the vehicle.
5. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
6. Remove the valve rocker arms and the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
7. Remove the exhaust crossover pipe. Refer to **Exhaust Crossover Pipe Replacement (3.1L)** or **Exhaust Crossover Pipe Replacement (3.8L)** in Engine Exhaust.
8. Remove the right engine mount strut bracket. Refer to **Engine Mount Strut Bracket Replacement - Right**.
9. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
10. Remove the left spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.
11. Remove the left spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.
12. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left (3.1L)** or **Exhaust Manifold Replacement - Left (3.8L)** in Engine Exhaust.

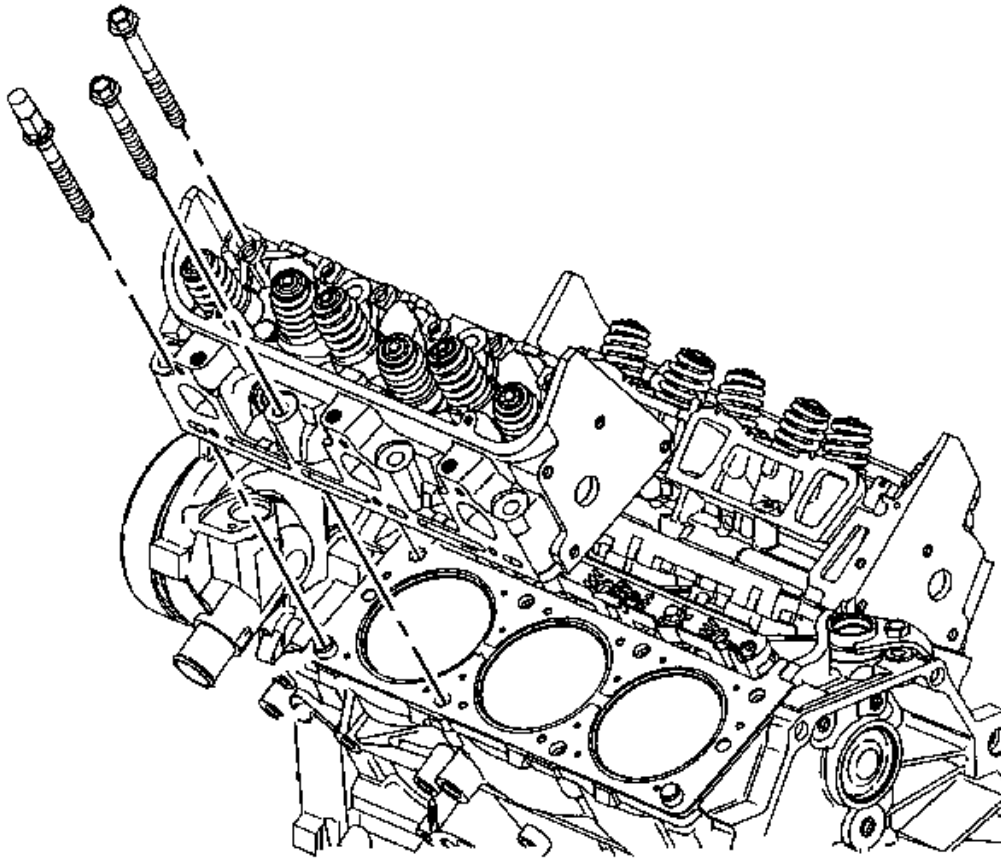


Fig. 160: Left Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the left cylinder head bolts and discard the bolts.
14. Remove the left cylinder head.

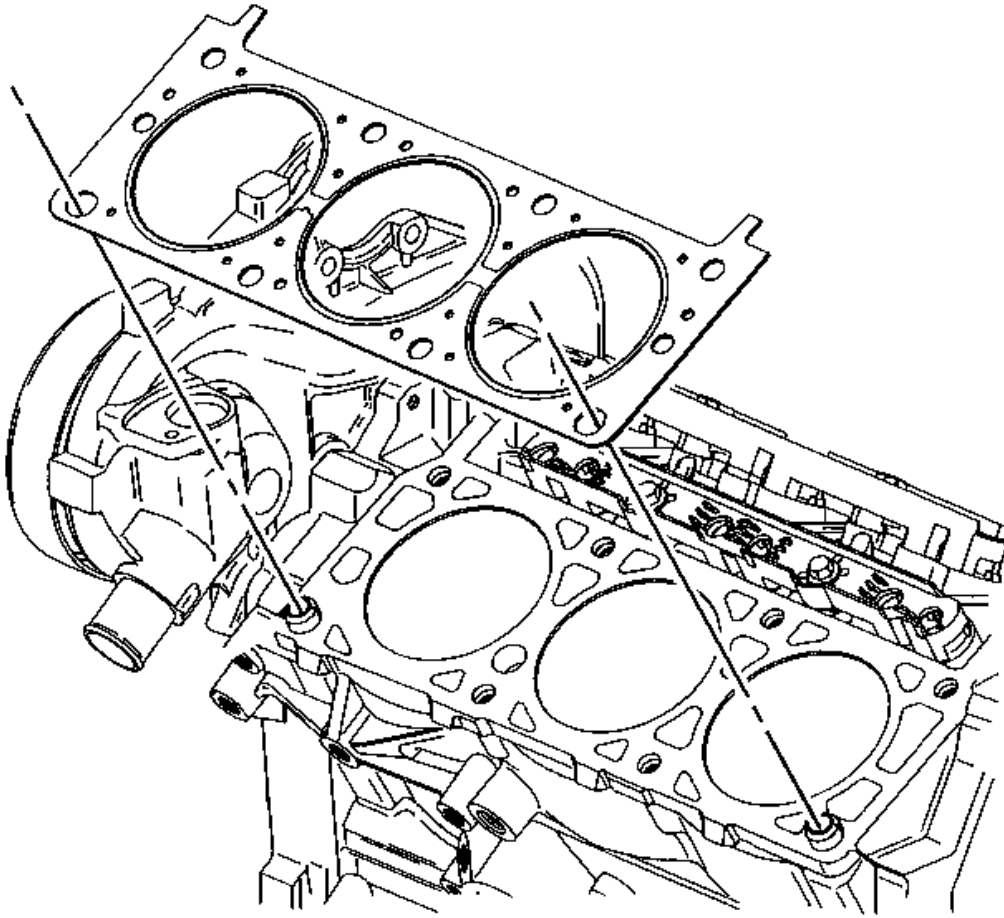


Fig. 161: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

15. Remove the left cylinder head gasket.
16. Clean and inspect the left cylinder head and the gasket mating surfaces. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

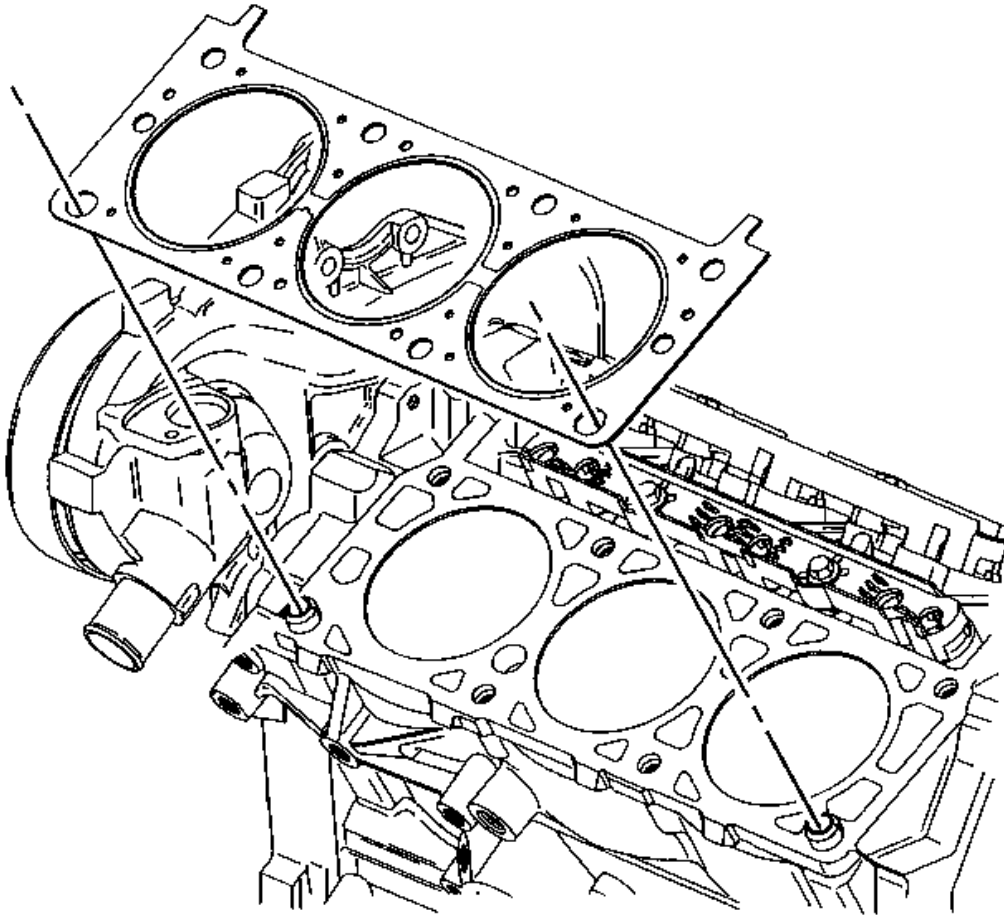


Fig. 162: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new left cylinder head gasket.

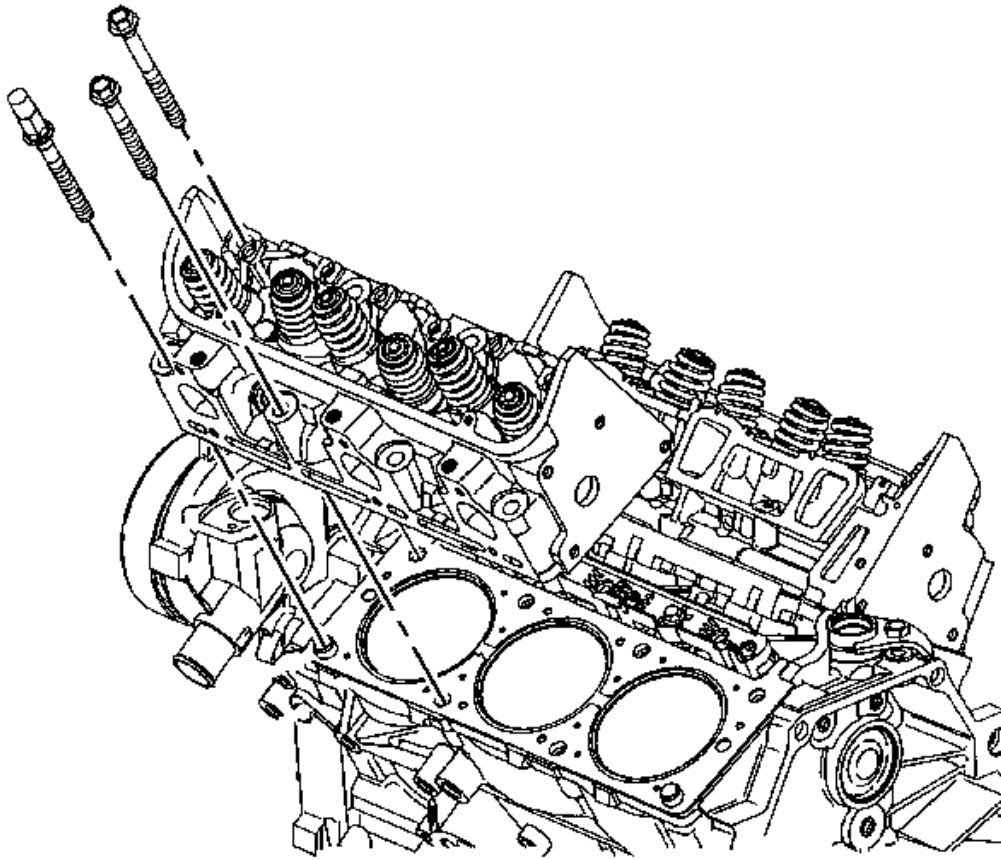


Fig. 163: Left Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the left cylinder head over the locator pins and the gasket.

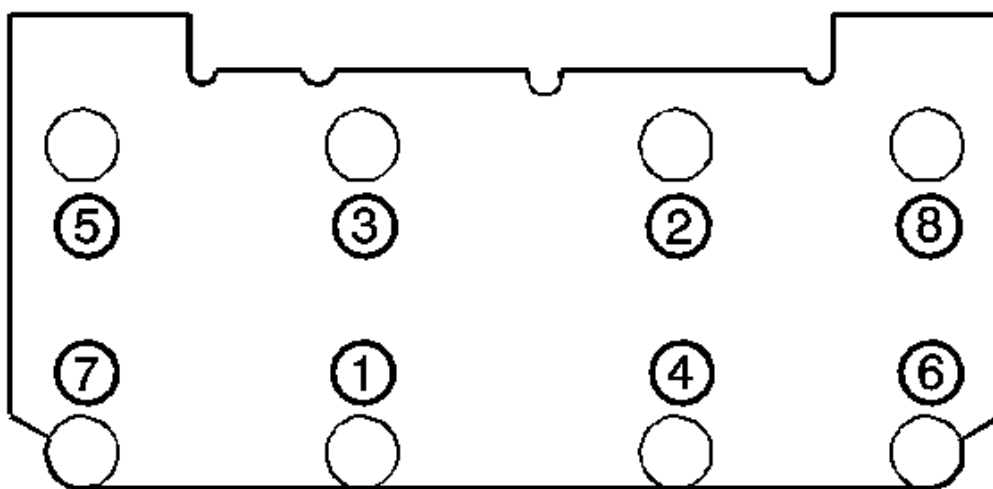


Fig. 164: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the new cylinder head bolts.

Tighten:

1. Tighten the bolts in sequence to 60 N.m (44 lb ft).
2. Use the **J 45059** to rotate the cylinder head bolts in sequence an additional 95 degrees. See Special Tools and Equipment.
4. Install the left exhaust manifold. Refer to Exhaust Manifold Replacement - Left (3.1L) or Exhaust Manifold Replacement - Left (3.8L) in Engine Exhaust.
5. Install the left spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.1L.
6. Install the left spark plug wires to the spark plugs. Refer to Spark Plug Wire Replacement in Engine Controls - 3.1L.
7. Install the oil level indicator tube. Refer to Oil Level Indicator and Tube Replacement.
8. Install the right engine mount strut bracket. Refer to Engine Mount Strut Bracket Replacement - Right.
9. Install the exhaust crossover pipe. Refer to Exhaust Crossover Pipe Replacement (3.1L) or Exhaust Crossover Pipe Replacement (3.8L) in Engine Exhaust.
10. Install the valve rocker arms and pushrods. Refer to Valve Rocker Arm and Push Rod Replacement.
11. Install the lower intake manifold. Refer to Intake Manifold Replacement - Lower.

12. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
13. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
14. Inspect for leaks.

Cylinder Head Replacement - Right**Tools Required**

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

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Lower the vehicle.
5. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
6. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
7. Remove the exhaust crossover pipe. Refer to **Exhaust Crossover Pipe Replacement (3.1L)** or **Exhaust Crossover Pipe Replacement (3.8L)** .
8. Remove the right spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.

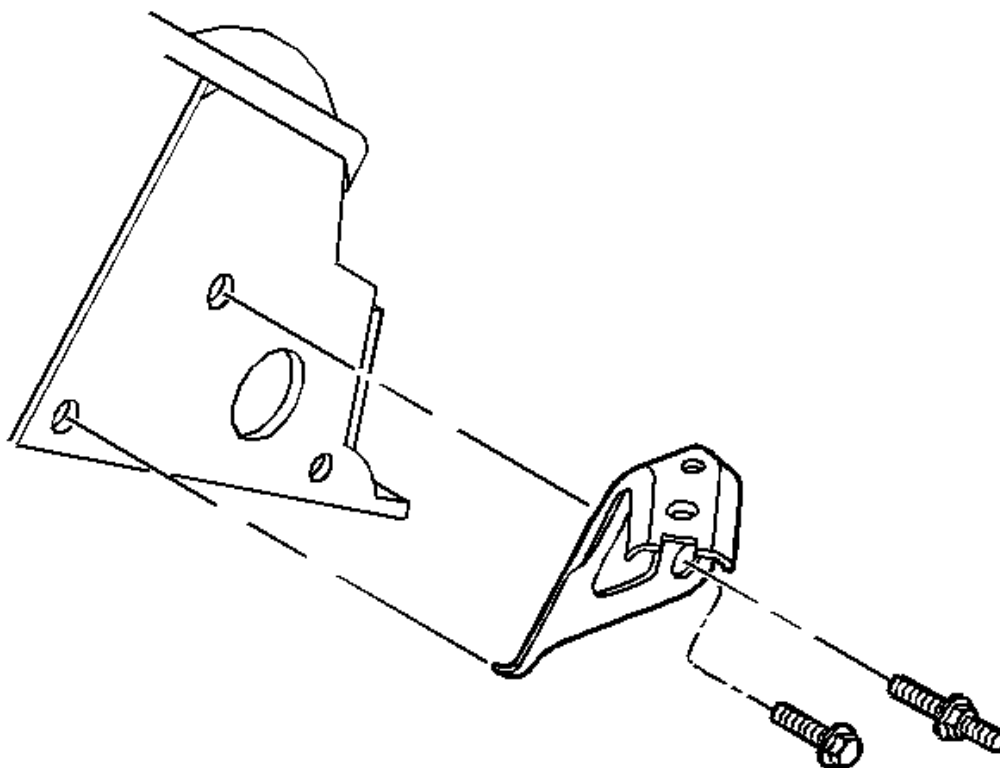


Fig. 165: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

9. Remove the fuel line bracket bolts/studs and the bracket.
10. Remove the generator. Refer to **Generator Replacement (3.1L)** or **Generator Replacement (3.8L)** in Engine Electrical.
11. Remove the right spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.
12. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right (3.1L)** or **Exhaust Manifold Replacement - Right (3.8L)** in Engine Exhaust.

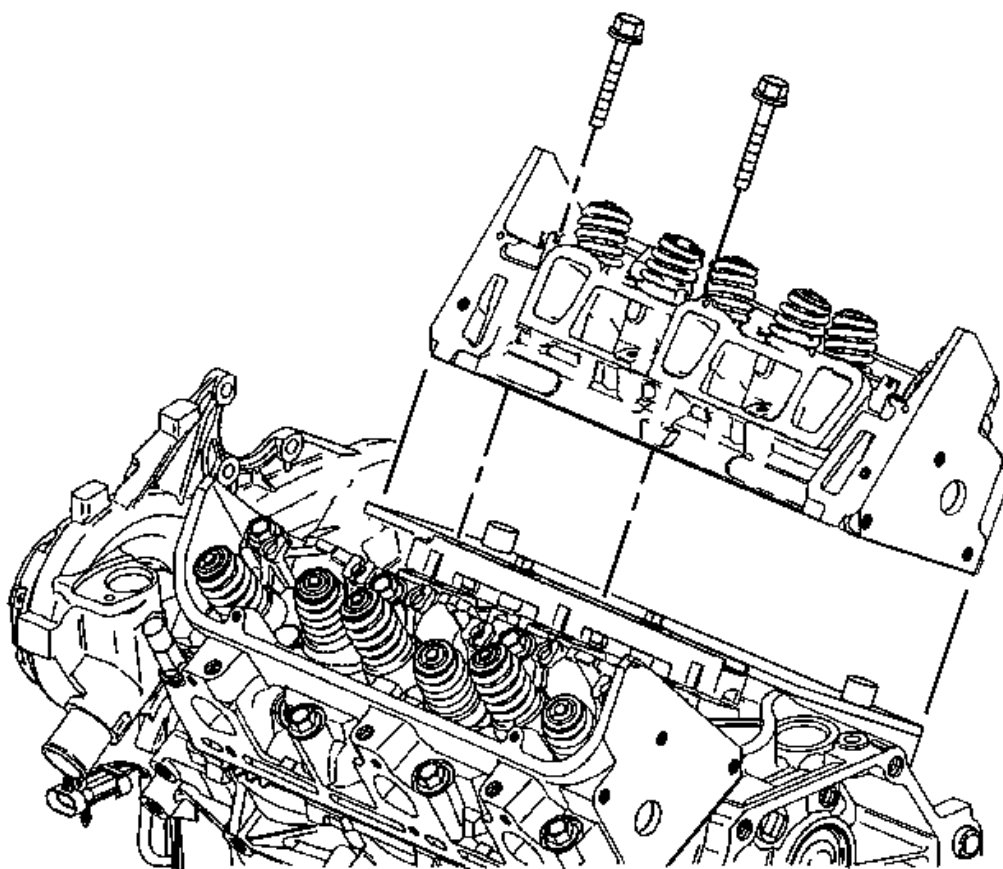


Fig. 166: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the right cylinder head bolts and discard the bolts.
14. Remove the right cylinder head.

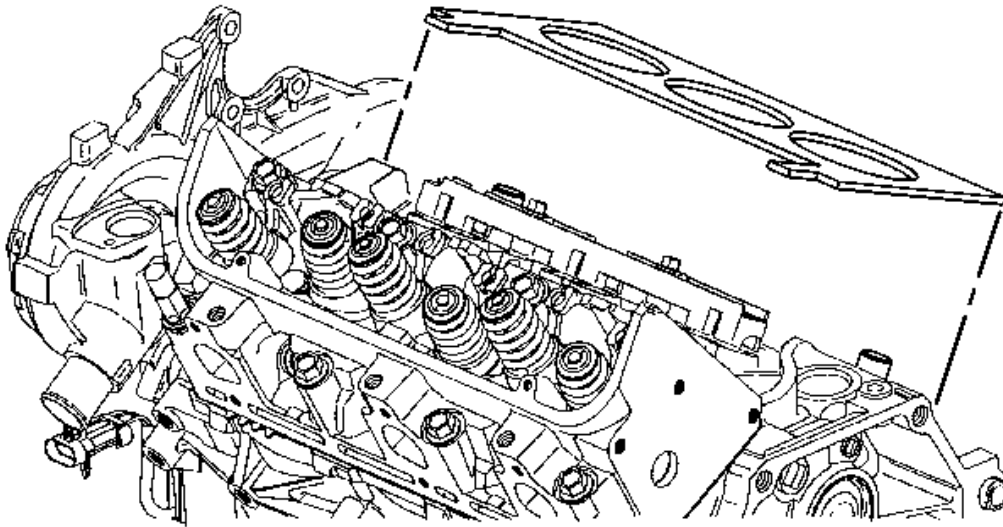


Fig. 167: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

15. Remove the right cylinder head gasket.
16. Clean and inspect the right cylinder head and the gasket mating surfaces. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

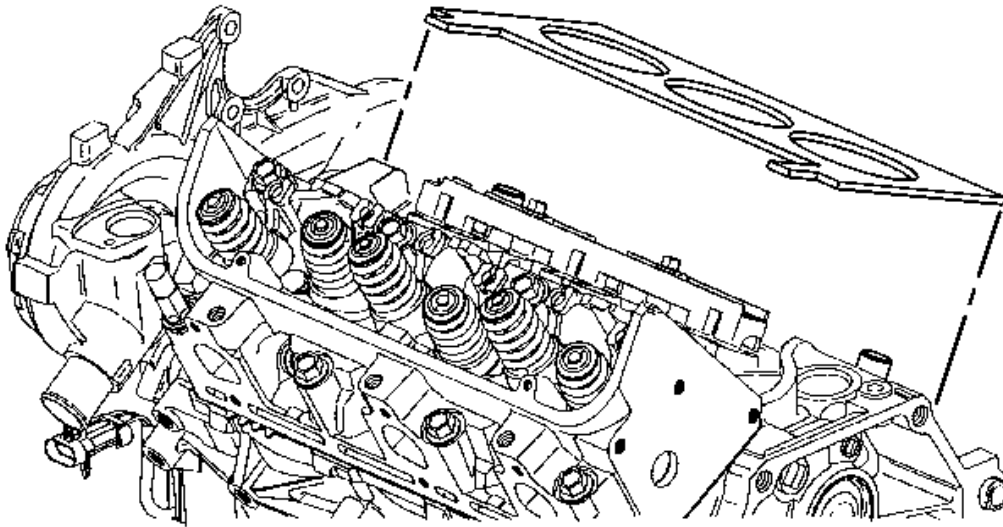


Fig. 168: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new right cylinder head gasket.

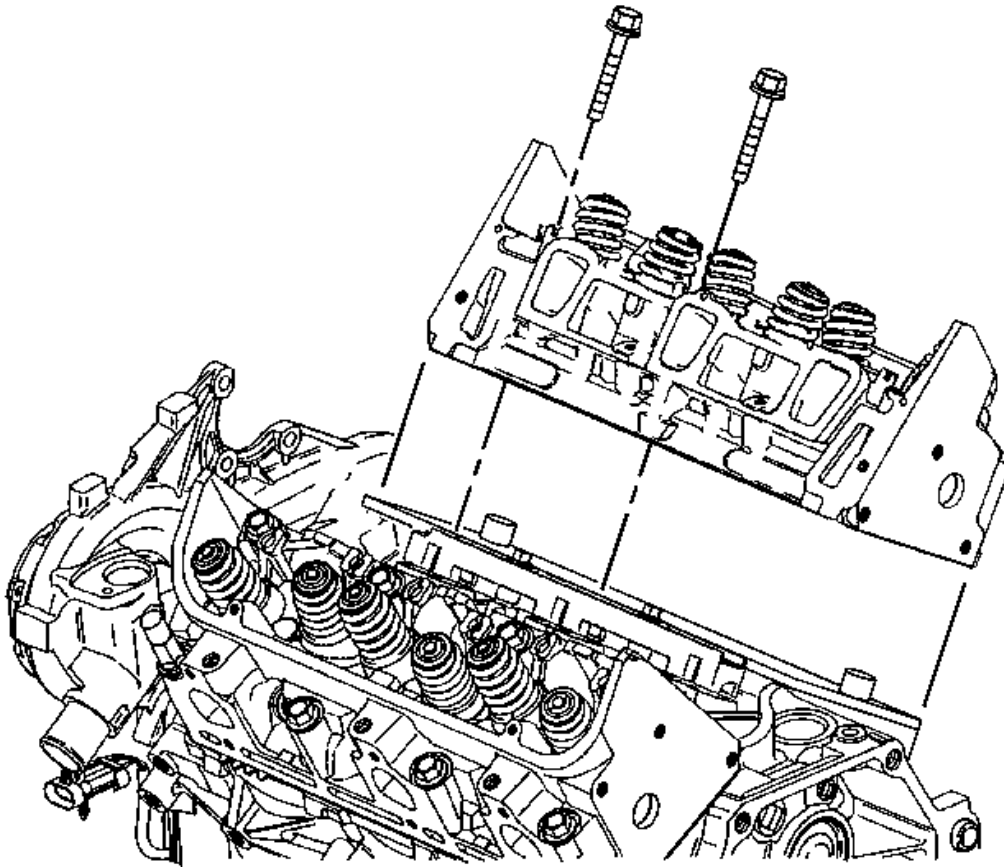


Fig. 169: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the right cylinder head over the locator pins and the gasket.

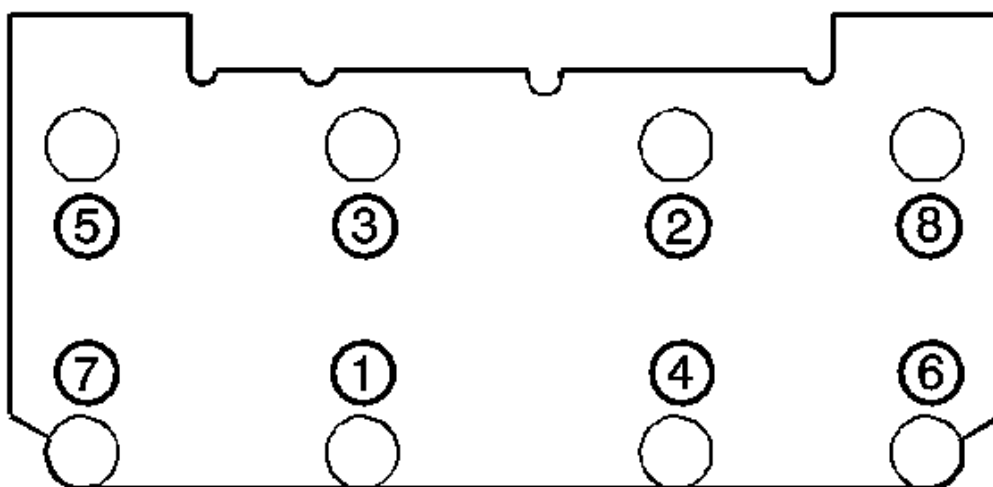


Fig. 170: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the new cylinder head bolts

Tighten:

1. Tighten the bolts in sequence to 60 N.m (44 lb ft).
 2. Use the **J 45059** to rotate the cylinder head bolts in sequence an additional 95 degrees. See Special Tools and Equipment.
4. Install the right exhaust manifold. Refer to Exhaust Manifold Replacement - Right (3.1L) or Exhaust Manifold Replacement - Right (3.8L) .
 5. Install the right spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.1L.
 6. Install the generator. Refer to Generator Replacement (3.1L) or Generator Replacement (3.8L) in Engine Electrical.

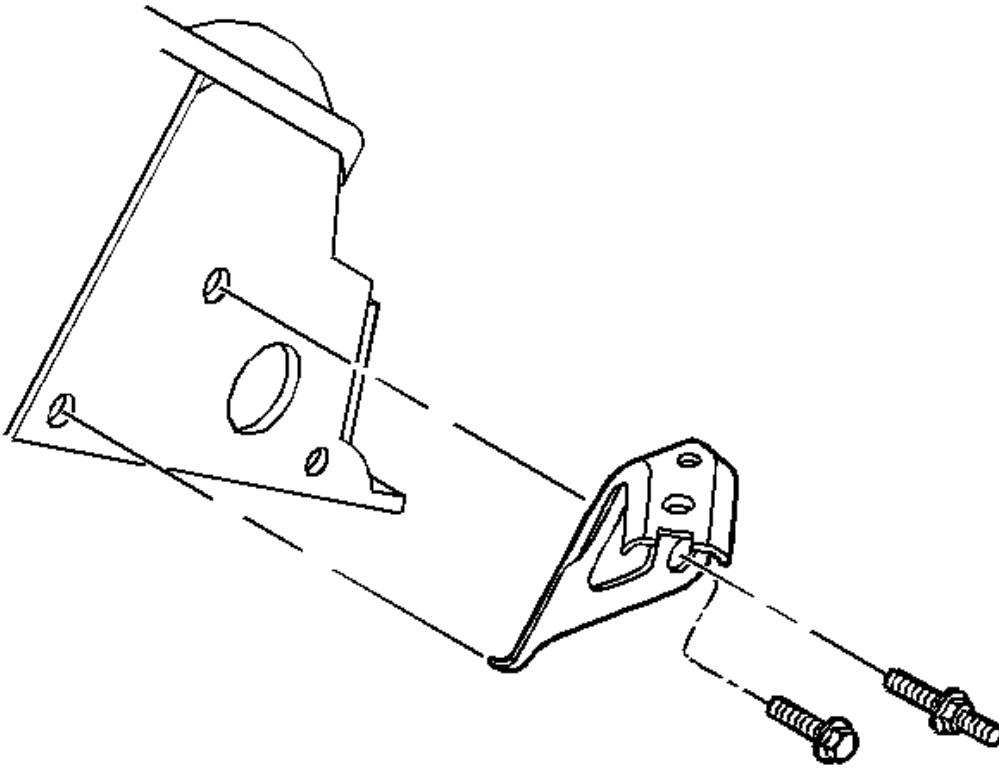


Fig. 171: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the fuel line bracket.
8. Install the fuel pipe bracket bolt and stud.

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

9. Install the right spark plug wires to the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.1L.
10. Install the exhaust crossover pipe. Refer to **Exhaust Crossover Pipe Replacement (3.1L)** or **Exhaust Crossover Pipe Replacement (3.8L)** .
11. Install the pushrods and valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.
12. Install the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
13. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
14. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
15. Inspect for leaks.

Connecting Rod Bearing Replacement**Tools Required**

- **J 5239** Connecting Rod Bolt Guide Set. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

Removal Procedure

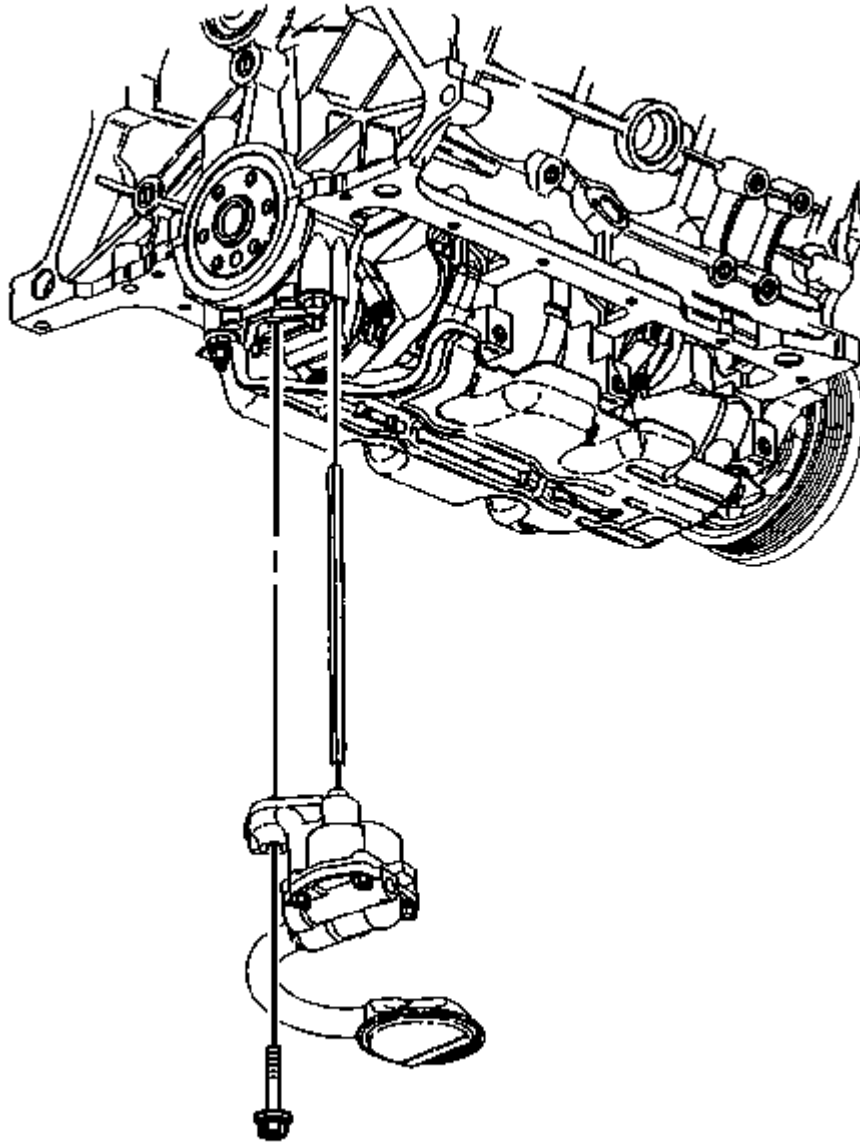


Fig. 172: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the spark plugs from the cylinders that are being serviced. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.
3. Position the connecting rod to be serviced to Bottom Dead Center (BDC) by rotating the crankshaft.

4. Remove the oil pump bolt.
5. Remove the oil pump and the oil pump driveshaft.

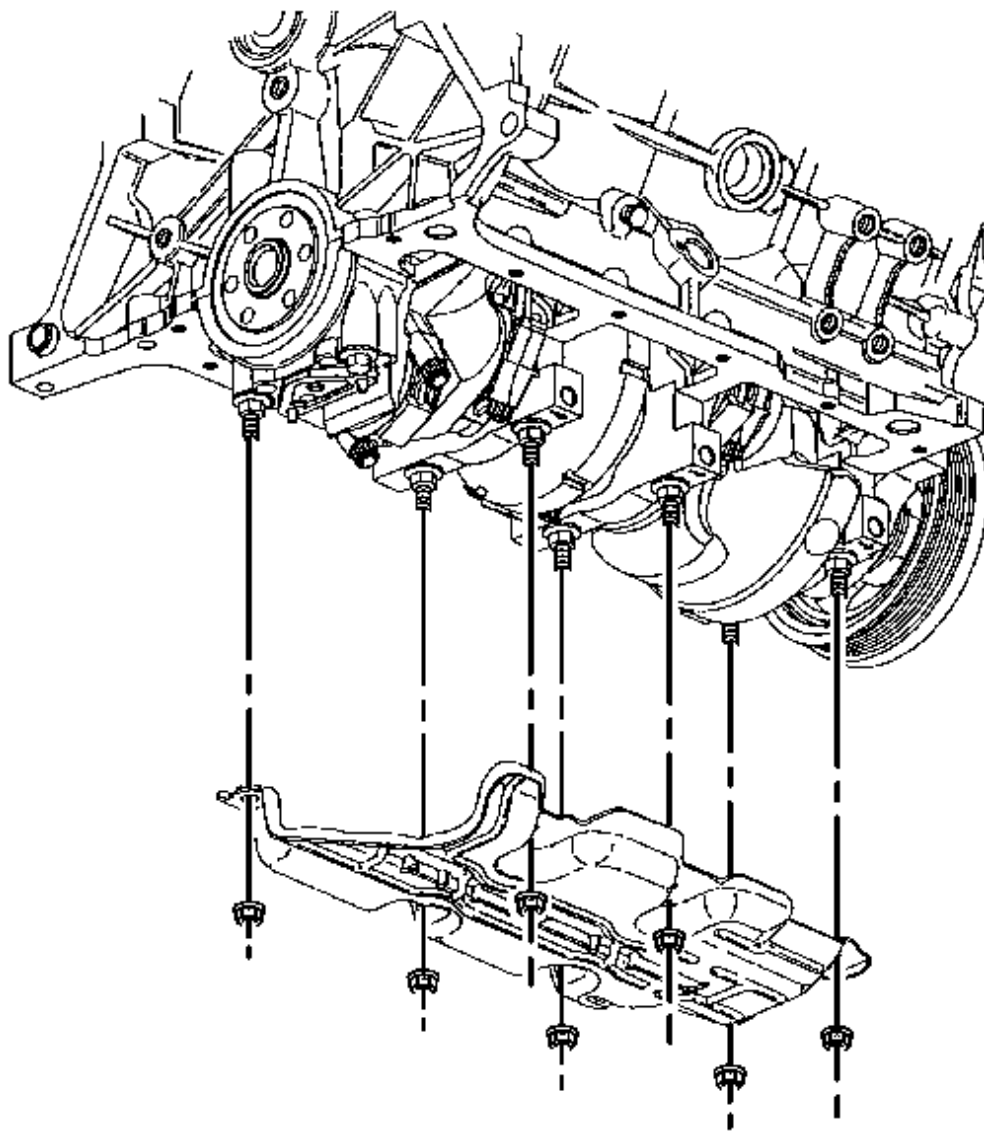


Fig. 173: Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft oil deflector nuts.

7. Remove the crankshaft oil deflector.

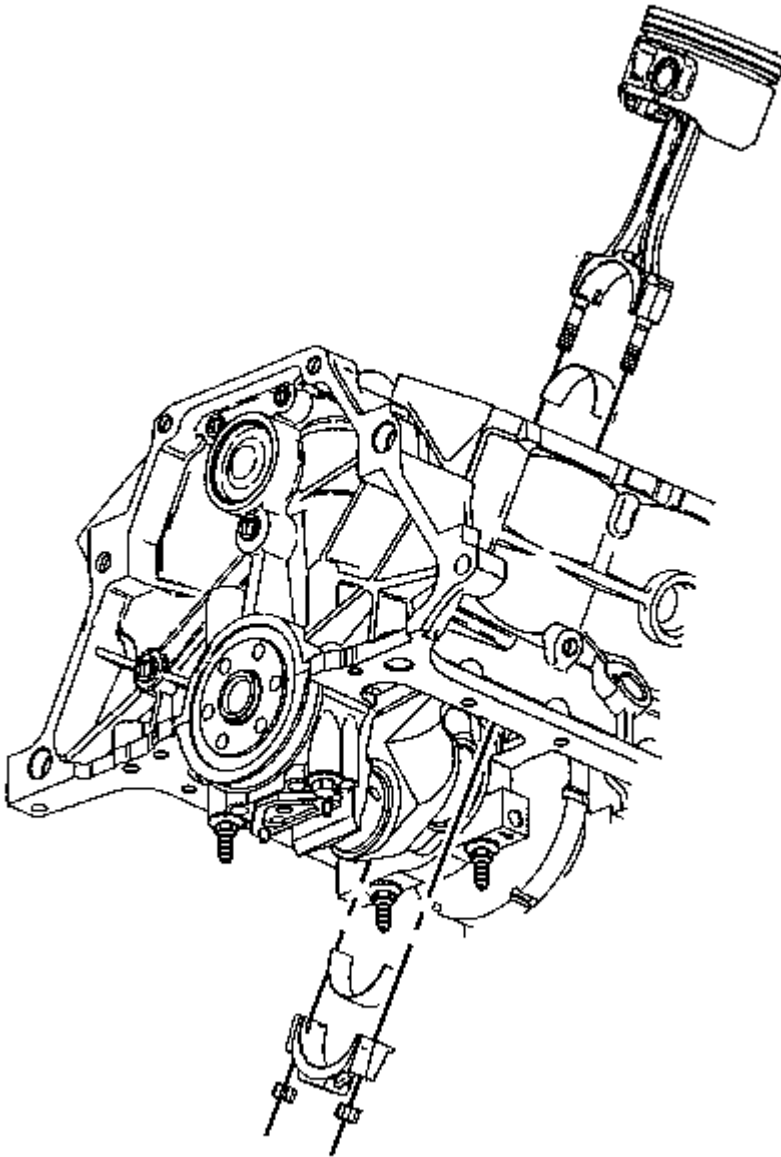


Fig. 174: Connecting Rod Cap, Nuts & Lower Connecting Rod Bearing
Courtesy of GENERAL MOTORS CORP.

8. Remove the connecting rod cap nuts.

9. Remove the connecting rod cap and the lower connecting rod bearing.

IMPORTANT: Keep the bearings with the original connecting rod and cap. Do this in order to reassemble the connecting rod.

10. Remove the lower connecting rod bearing from the connecting rod cap.
11. Install the **J 5239** to the connecting rod. See **Special Tools and Equipment**.
12. Use the **J 5239** to push up the connecting rod and the piston to access the upper connecting rod bearing. See **Special Tools and Equipment**.
13. Remove the upper connecting rod bearing.
14. Wipe the oil from the bearings.
15. Inspect the connecting rod bearings. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
16. Measure the bearing clearance. Refer to **Engine Mechanical Specifications**.

Installation Procedure

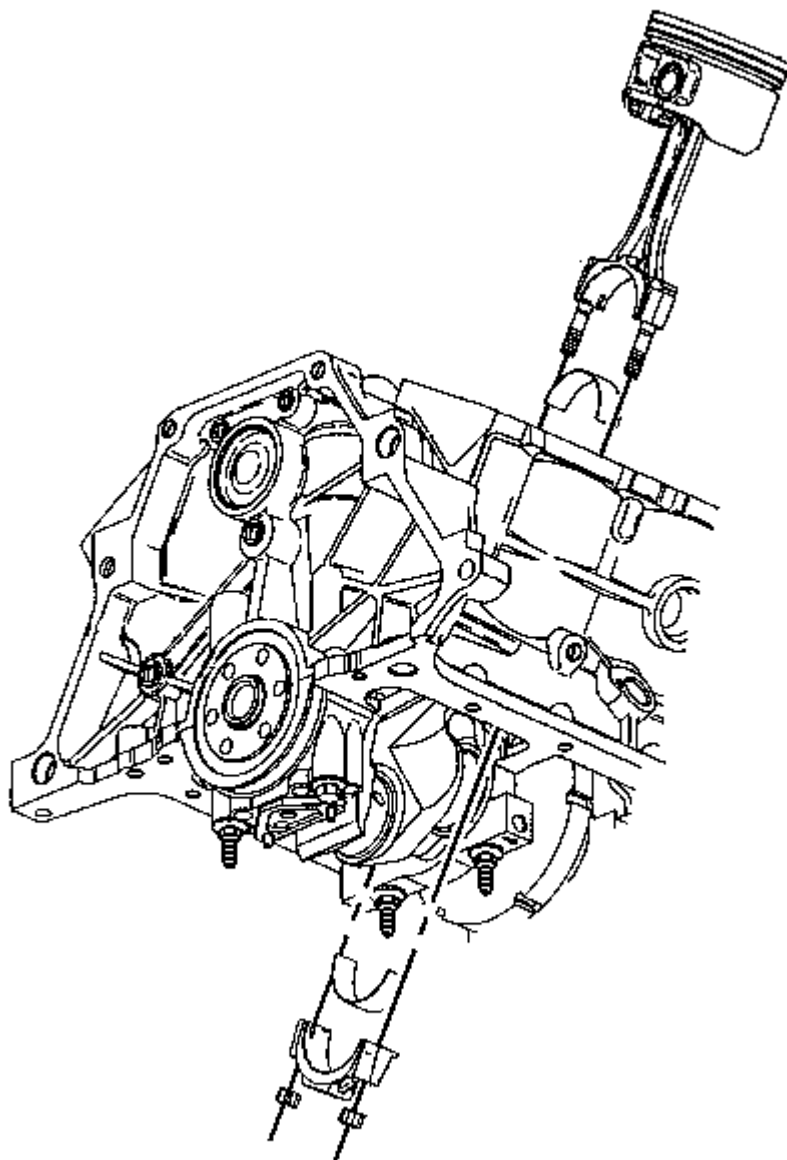


Fig. 175: Connecting Rod Cap, Nuts & Lower Connecting Rod Bearing
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not scrape, shim, or file bearing inserts. If the bearing surface of the insert is touched with bare fingers, the skin oil and acids will etch the bearing surface.

IMPORTANT: Ensure that the connecting rod cap bolt holes and the connecting rod cap mating surfaces are clean and dry.

1. Use clean engine oil in order to lubricate the bearing surface.
2. Install the upper connecting rod bearing.
3. Use the **J 5239** to pull down the piston, the connecting rod and the upper connecting rod bearing. See **Special Tools and Equipment**.
4. Remove the **J 5239** . See **Special Tools and Equipment**.
5. Install the lower connecting rod bearing to the connecting rod cap.
6. Install the connecting rod cap.

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

7. Install the connecting rod cap nuts.

Tighten:

1. Tighten the nuts to 20 N.m (15 lb ft).
 2. Use the **J 45059** to rotate the nuts an additional 75 degrees. See **Special Tools and Equipment**.
8. Pry the connecting rod back and forth in order to check for binding. If necessary, loosen and then retighten the connecting rod cap nuts.

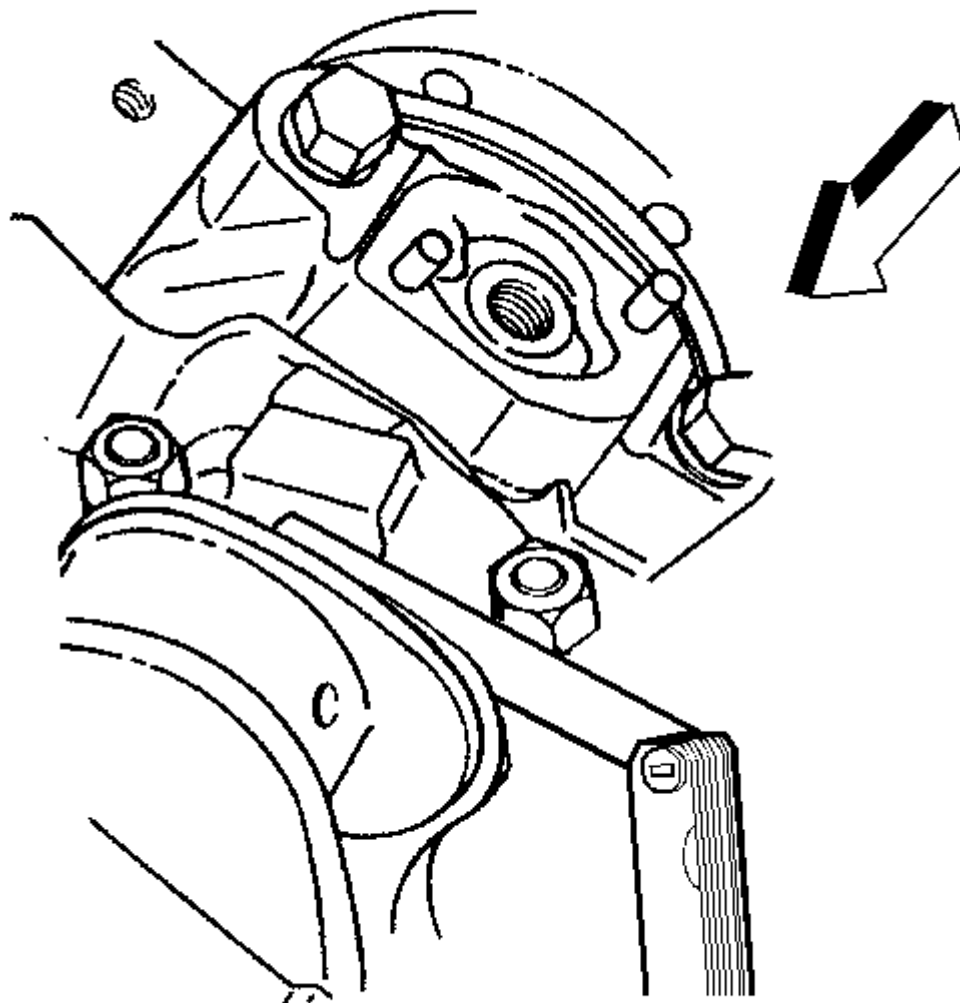


Fig. 176: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

9. Measure the connecting rod side clearance. Refer to **Engine Mechanical Specifications**.

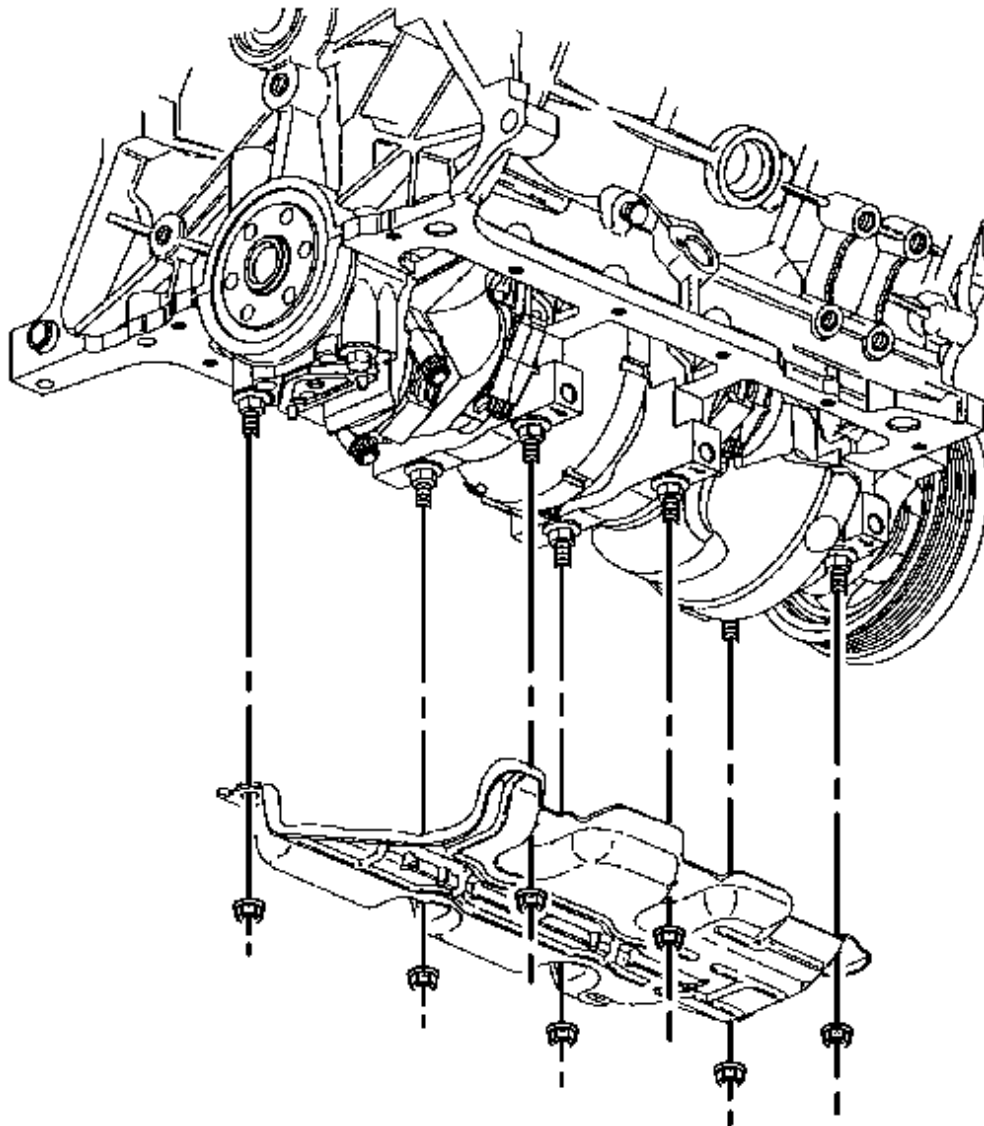


Fig. 177: Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft oil deflector.
11. Install the crankshaft oil deflector nuts.

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

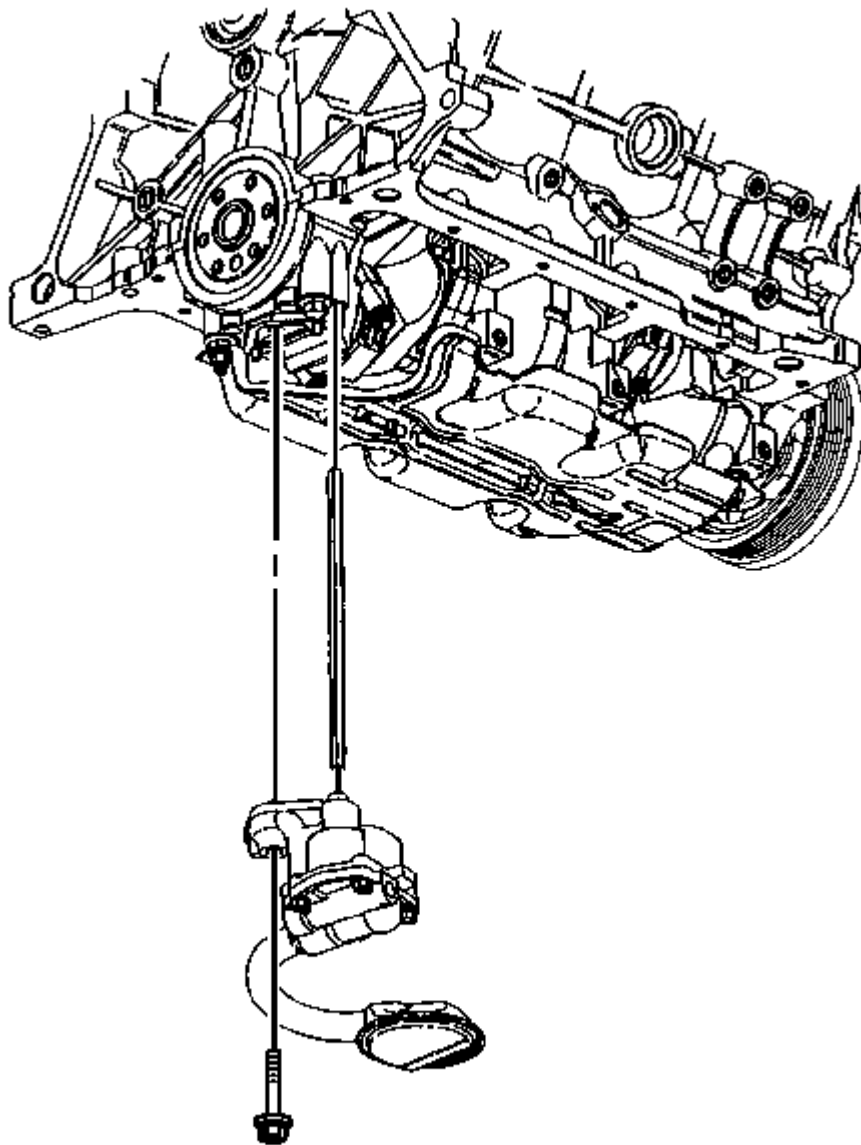


Fig. 178: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

12. Install the oil pump driveshaft and the oil pump.
13. Install the oil pump mounting bolt.

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

14. Install the spark plugs to the cylinders that was serviced. Refer to **Spark Plug Replacement** in Engine Controls - 3.1L.
15. Install the oil pan. Refer to **Oil Pan Replacement**.
16. Inspect for proper oil pressure.
17. Inspect for leaks.

Engine Flywheel Replacement

Tools Required

J 37096 Flywheel Holder. See **Special Tools and Equipment**.

Removal Procedure

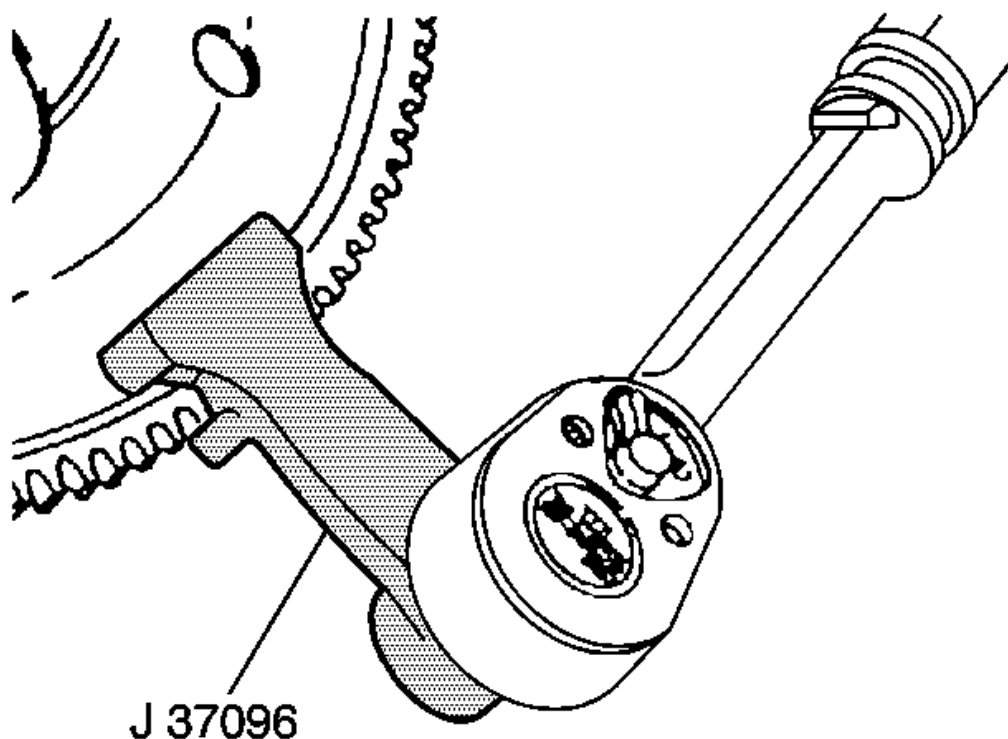


Fig. 179: Holding Flywheel

Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transaxle. Refer to **Transmission Replacement** in Automatic Transaxle - 4T65E.
2. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating. See **Special**

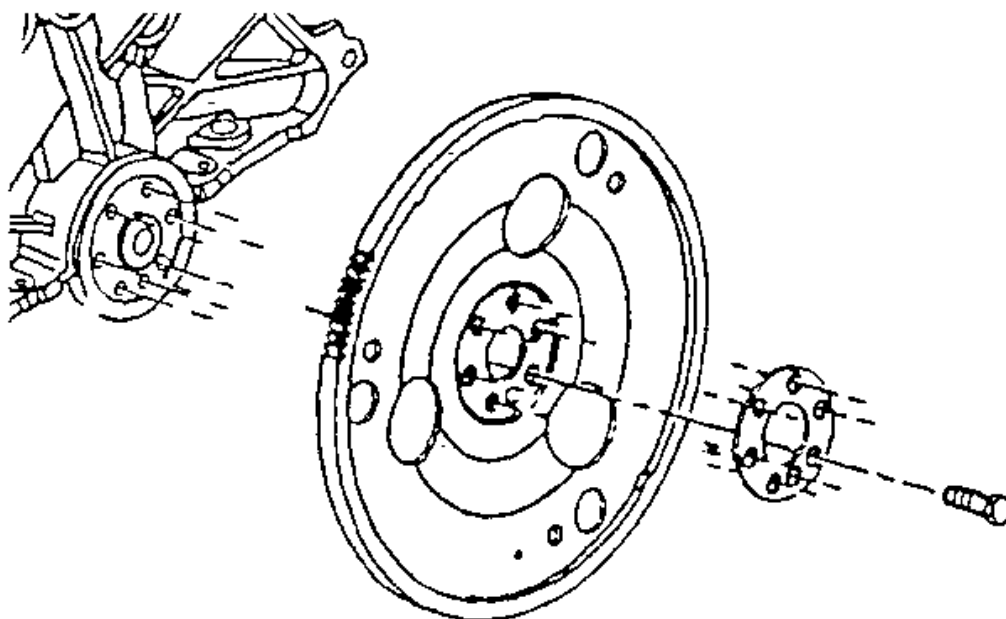
Tools and Equipment.

Fig. 180: Identifying Engine Flywheel & Components
Courtesy of GENERAL MOTORS CORP.

3. Loosen the 6 flywheel bolts.
4. Remove 5 of the 6 flywheel bolts leaving 1 bolt at the top of the crankshaft rotation.
5. Grip the flywheel and remove the remaining bolt. Do not drop the flywheel when removing the final bolt.
6. Remove the engine flywheel retainer and the flywheel.
7. Clean the engine flywheel bolt threads and bolt holes.

Installation Procedure

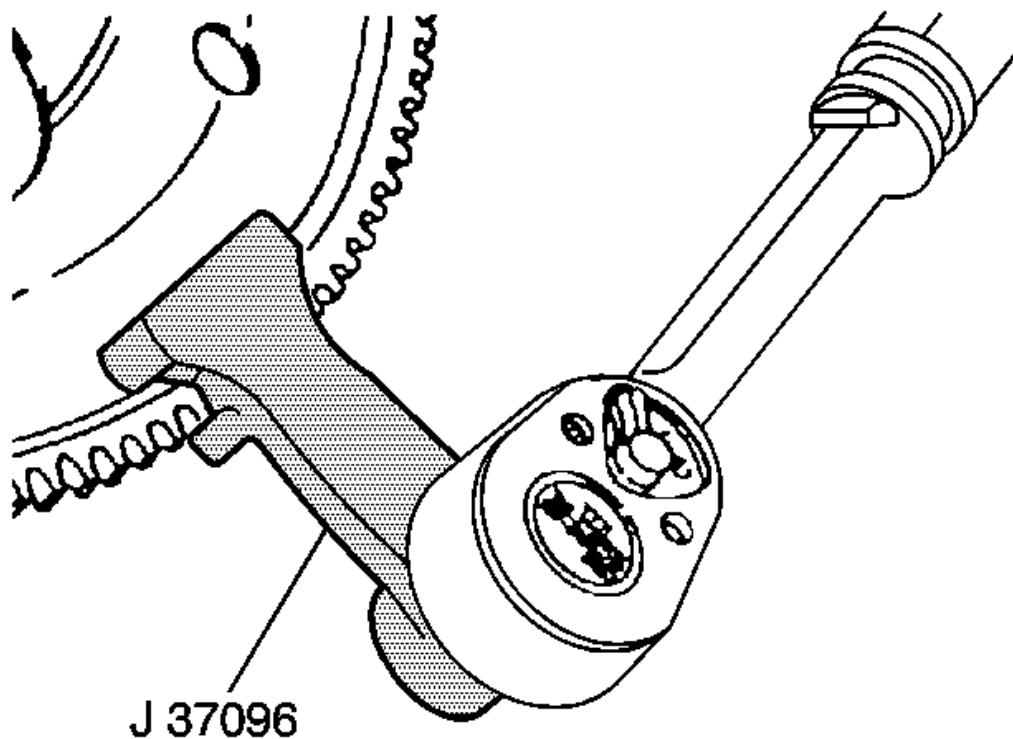


Fig. 181: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel and the flywheel retainer.
2. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating. See **Special Tools and Equipment**.

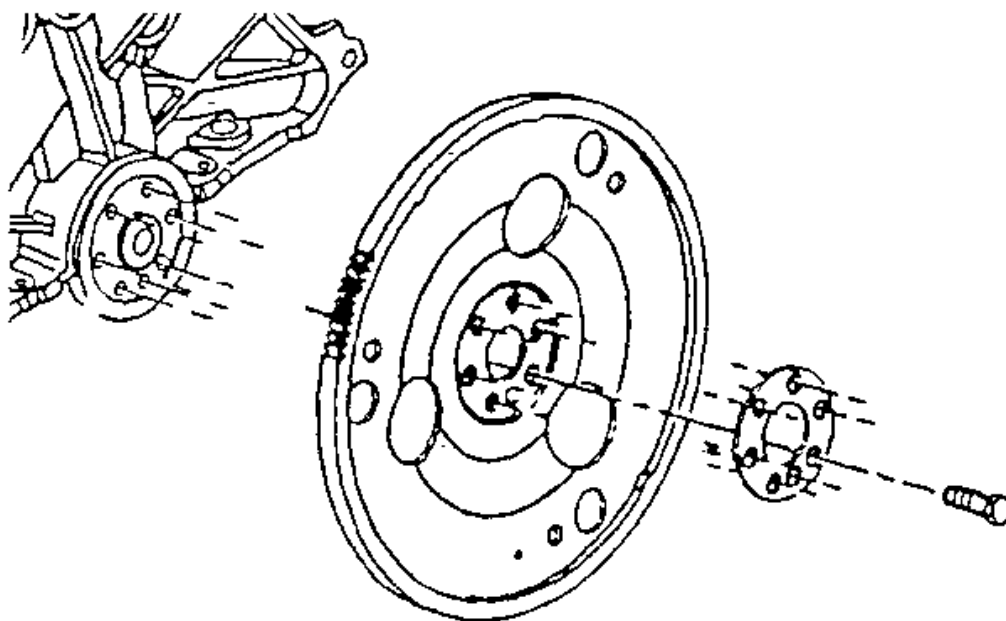


Fig. 182: Identifying Engine Flywheel & Components
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine flywheel bolts.

Tighten: Tighten the bolts to 71 N.m (52 lb ft).

4. Measure the flywheel runout:
 1. Install a dial indicator on the engine block and check the engine flywheel runout at three attaching bosses. Refer to **Engine Mechanical Specifications**.
 2. If the condition cannot be corrected, replace the engine flywheel.
5. Install the automatic transaxle. Refer to **Transmission Replacement** in Automatic Transaxle - 4T65E.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 34686 Rear Main Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

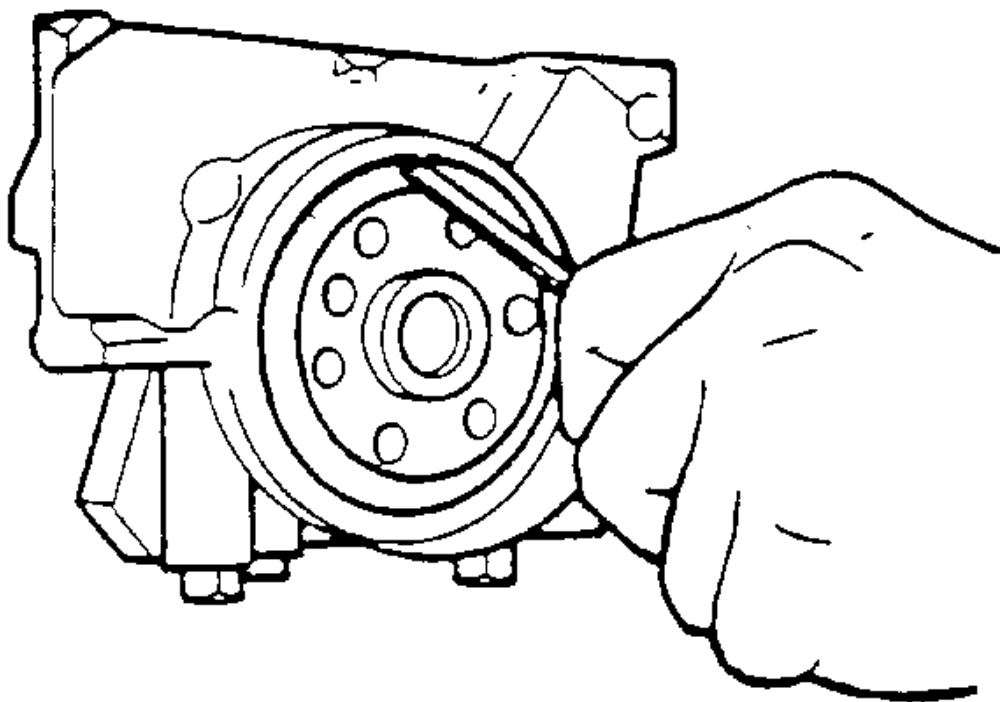


Fig. 183: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the crankshaft rear oil seal.
 1. Insert a flat-bladed tool or similar tool through the dust lip at an angle.
 2. Pry the crankshaft rear oil seal out by moving the handle of the tool towards the end of the crankshaft.
 3. Repeat as necessary around the crankshaft rear oil seal.

Installation Procedure

1. Entirely coat the new crankshaft rear oil seal with engine oil.

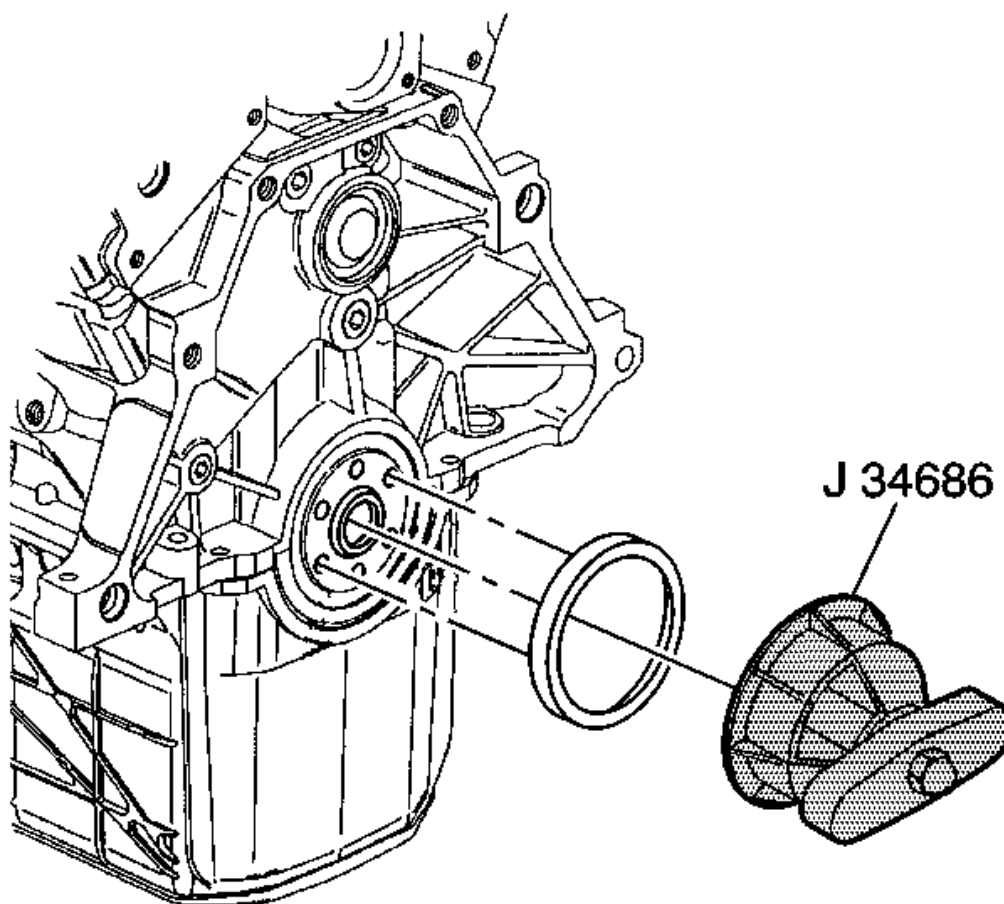


Fig. 184: Installing crankshaft Rear Oil Seal Using J 34686
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft rear oil seal onto the **J 34686** . See Special Tools and Equipment.
3. Install the **J 34686** onto the rear of the crankshaft. See Special Tools and Equipment. Hand tighten the screws in order to ensure the seal will be installed squarely over the crankshaft.
4. Install the crankshaft rear oil seal to the crankshaft.
5. Tighten the wing nut on the **J 34686** until it bottoms. See Special Tools and Equipment.
6. Remove the **J 34686** from the crankshaft. See Special Tools and Equipment.
7. Install the engine flywheel. Refer to Engine Flywheel Replacement.

Camshaft Rear Bearing Hole Plug Replacement

Removal Procedure

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

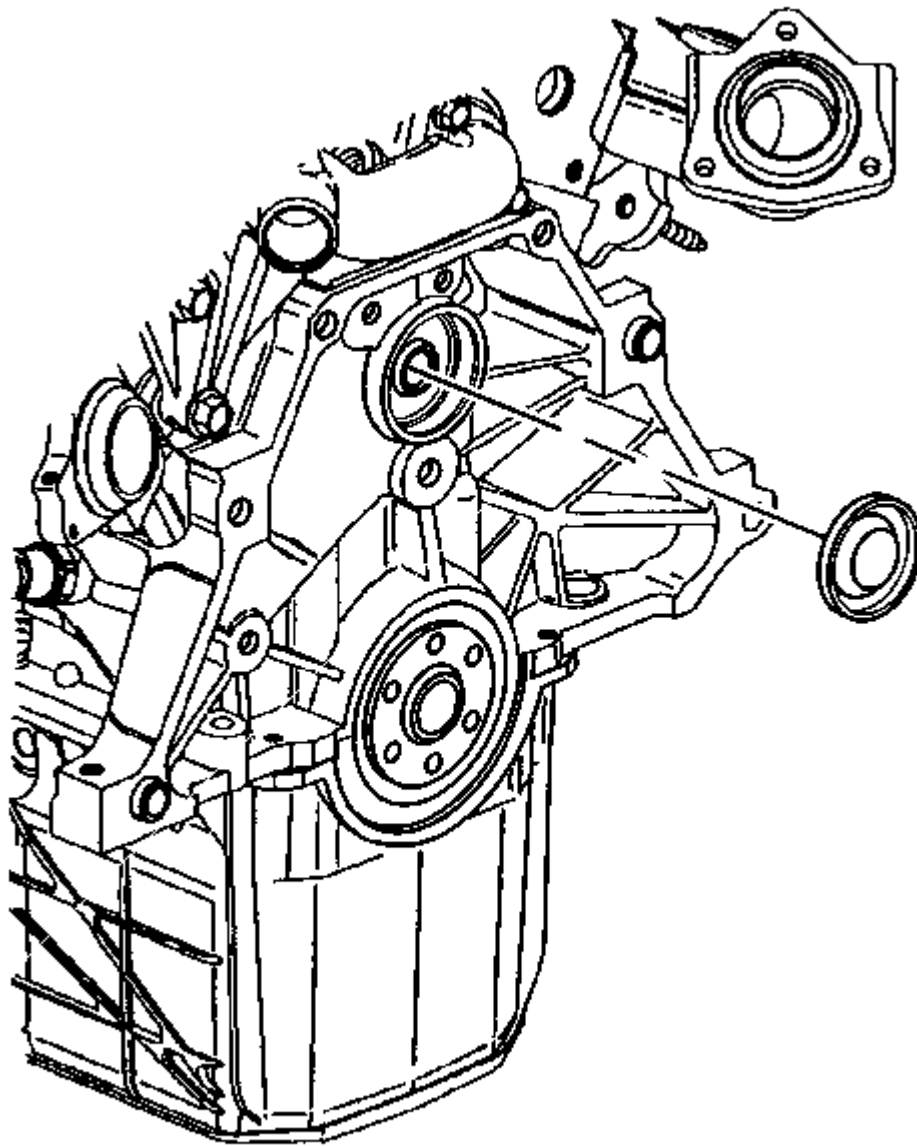


Fig. 185: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft rear bearing hole plug.

Installation Procedure

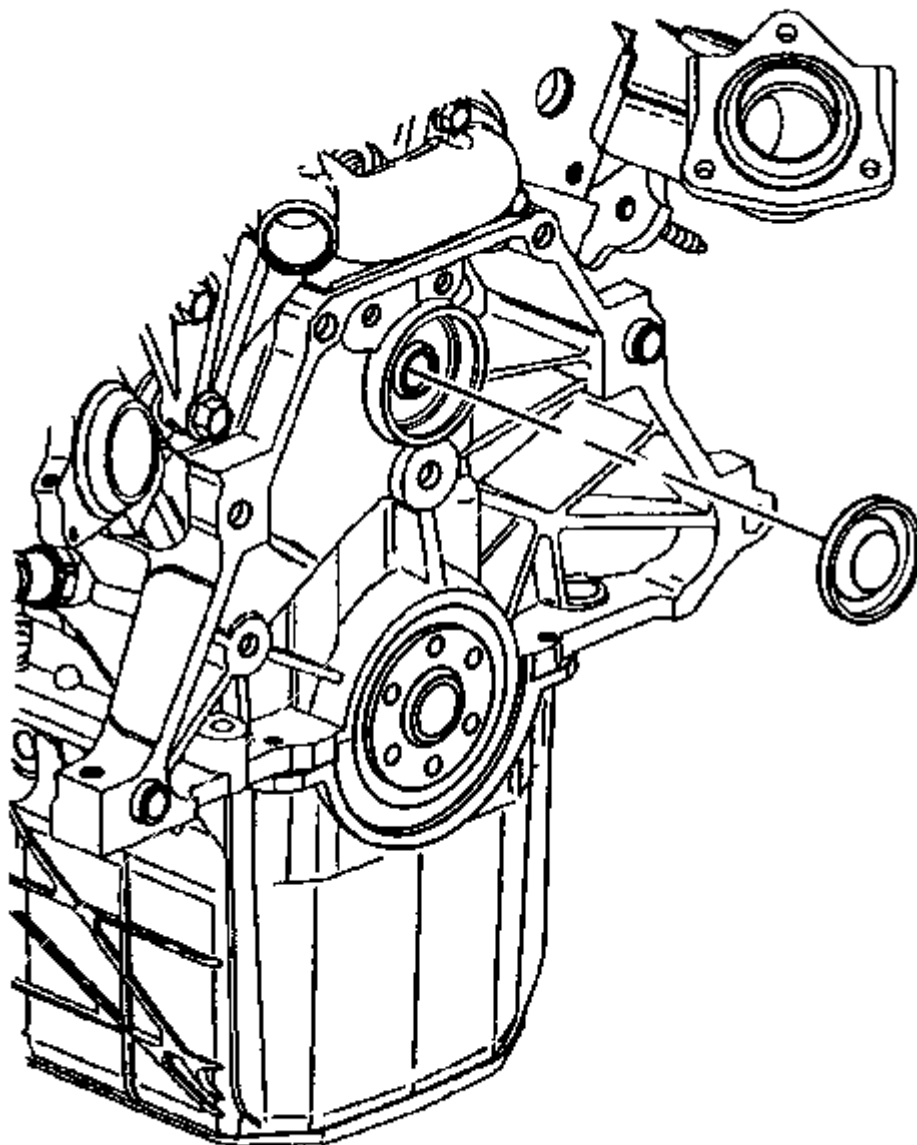


Fig. 186: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

1. Coat the camshaft rear bearing hole plug with sealer. Use sealer GM P/N 12377901 (Canadian P/N 10953504) or the equivalent.

2. Install the camshaft rear bearing hole plug.

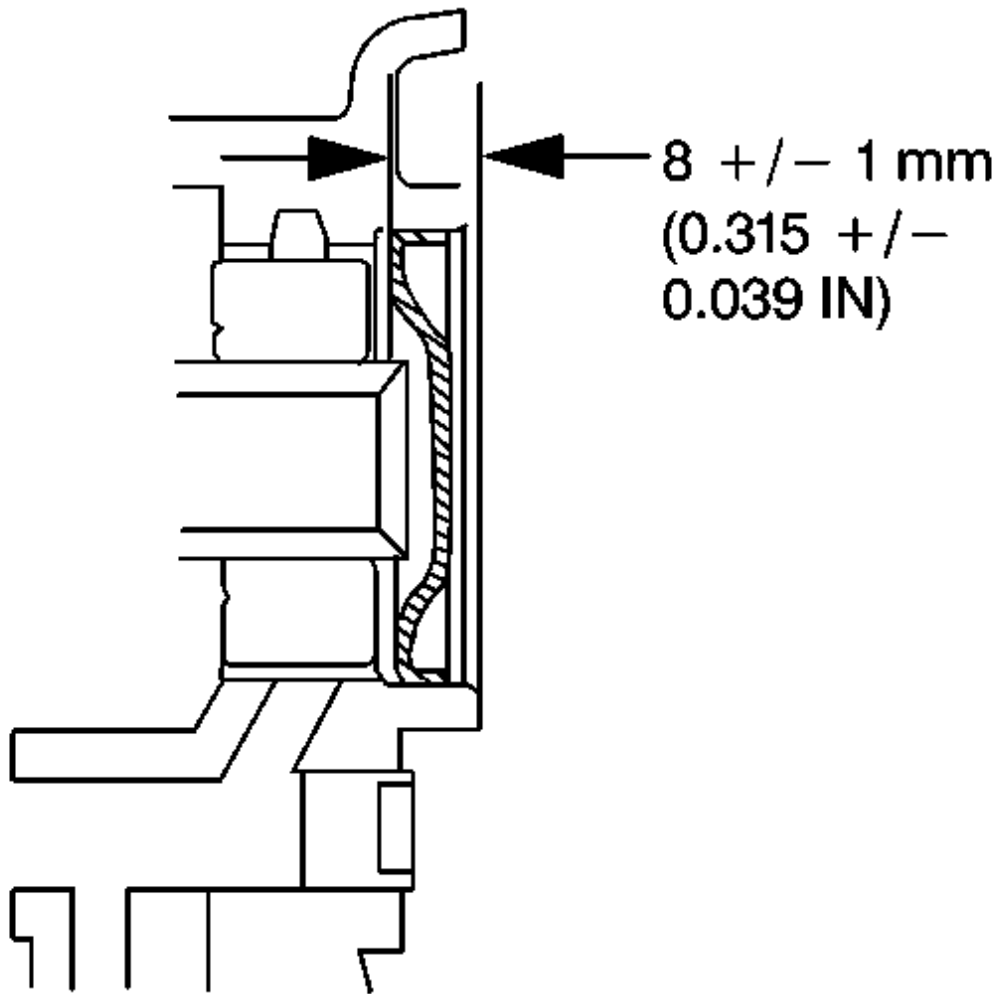


Fig. 187: Camshaft Rear Bearing Plug Installation Position
Courtesy of GENERAL MOTORS CORP.

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

Engine Replacement

Removal Procedure

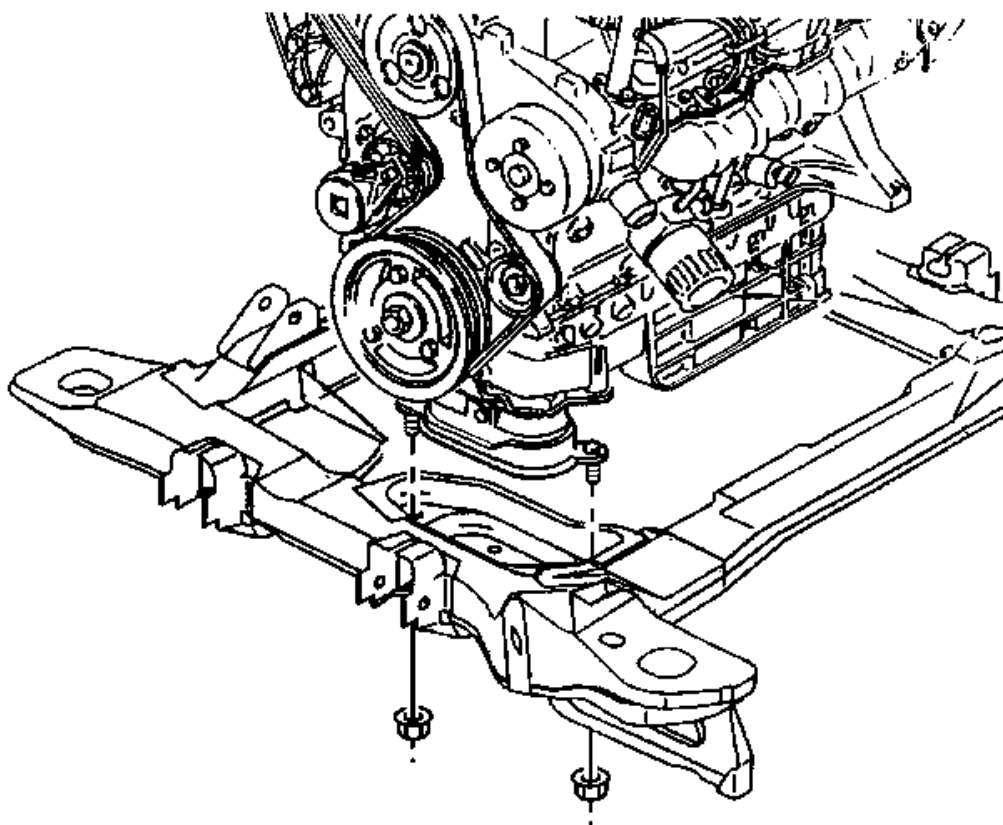


Fig. 188: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
3. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.1L.
5. Remove the hood. Refer to **Hood Replacement** in Body Front End.
6. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement**.
7. Remove the drive belt. Refer to **Drive Belt Replacement**.
8. Disconnect the following electrical connectors:
 - Knock sensor
 - Camshaft position (CMP) sensor

- Crankshaft position (CKP) sensor
 - Heated oxygen sensor (HO2S)
 - Manifold absolute pressure (MAP) sensor
 - Exhaust gas recirculation (EGR) valve
 - Evaporative emissions (EVAP) canister purge solenoid
 - Throttle position (T/P) sensor
 - Idle air control (IAC) valve
 - Ignition coil
 - Body wiring harness-to-engine harness
9. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
 10. Remove the 3-way catalytic converter pipe from the right exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
 11. Remove the engine wiring harness grounds from the transaxle.
 12. Remove the engine mount lower nuts.
 13. Remove the torque converter covers. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65E.
 14. Remove the starter motor. Refer to **Starter Motor Replacement (3.8L)** or **Starter Motor Replacement (3.1L)** in Engine Electrical.
 15. Remove the A/C compressor. DO NOT discharge the A/C system. Support the compressor. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating, Ventilation, and Air Conditioning.
 16. Remove the torque converter bolts. Refer to **Flywheel to Torque Converter Bolt Replacement** in Automatic Transaxle - 4T65E.
 17. Remove the transaxle brace. Refer to **Automatic Transmission Brace Replacement** in Automatic Transaxle - 4T65E.

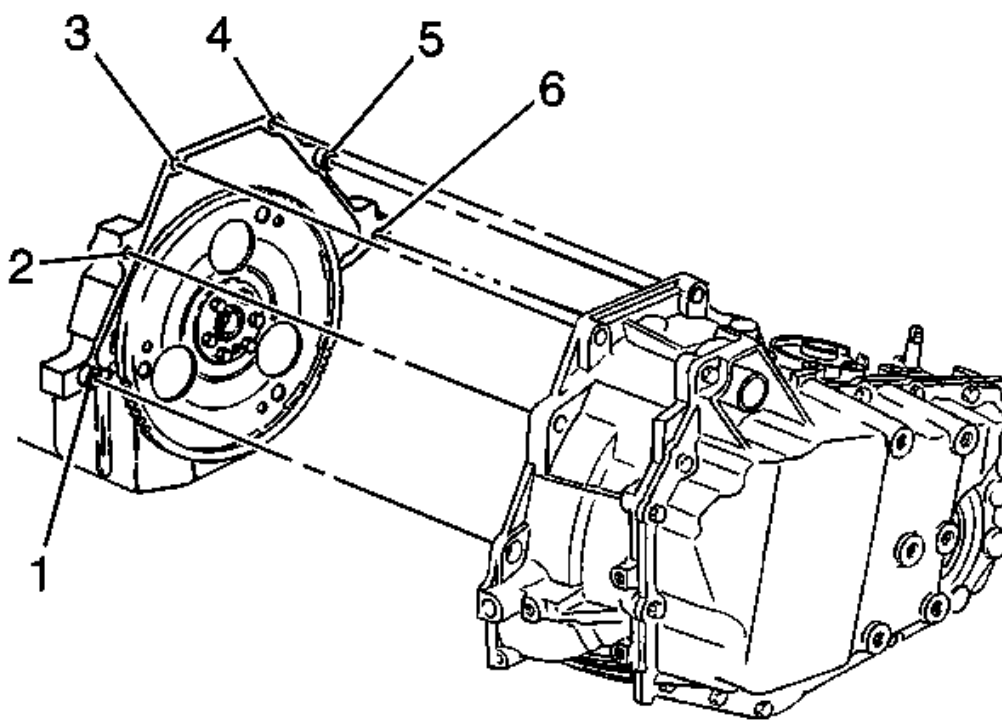


Fig. 189: View of Transaxle To Engine Mounting
 Courtesy of GENERAL MOTORS CORP.

18. Remove the lower transaxle-to-engine bolt (6) and the stud (1).
19. Remove the radiator outlet hose from the engine. Refer to **Radiator Hose Replacement - Outlet (3.1L)** or **Radiator Hose Replacement - Outlet (3.8L)** in Engine Cooling.
20. Lower the vehicle and support the transaxle.
21. Remove the accelerator control and the cruise control cable with the bracket from the throttle body. Refer to **Accelerator Controls Cable Bracket Replacement** in Engine Controls - 3.1L.
22. Remove the heater outlet and inlet hoses from the engine.
23. Remove the vacuum hoses from the upper intake manifold.
24. Remove the brake booster vacuum hose from the upper intake manifold.
25. Remove the fuel lines from the fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** and **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls - 3.1L.
26. Remove the radiator inlet hose from the engine. Refer to **Radiator Hose Replacement - Inlet (3.1L)** or **Radiator Hose Replacement - Inlet (3.8L)** in Engine Cooling.
27. Remove the power steering pump and reposition. Refer to **Power Steering Pump Replacement (3.1L)** or **Power Steering Pump Replacement (3.8L)** in Power Steering System.

28. Install the engine lifting device to the engine.
29. Remove the upper transaxle-to-engine bolts (3,4,5) and the stud (2).
30. Remove the engine from the vehicle.
31. Remove the flywheel. Refer to **Engine Flywheel Removal**.
32. Install the engine to the engine stand.

Installation Procedure

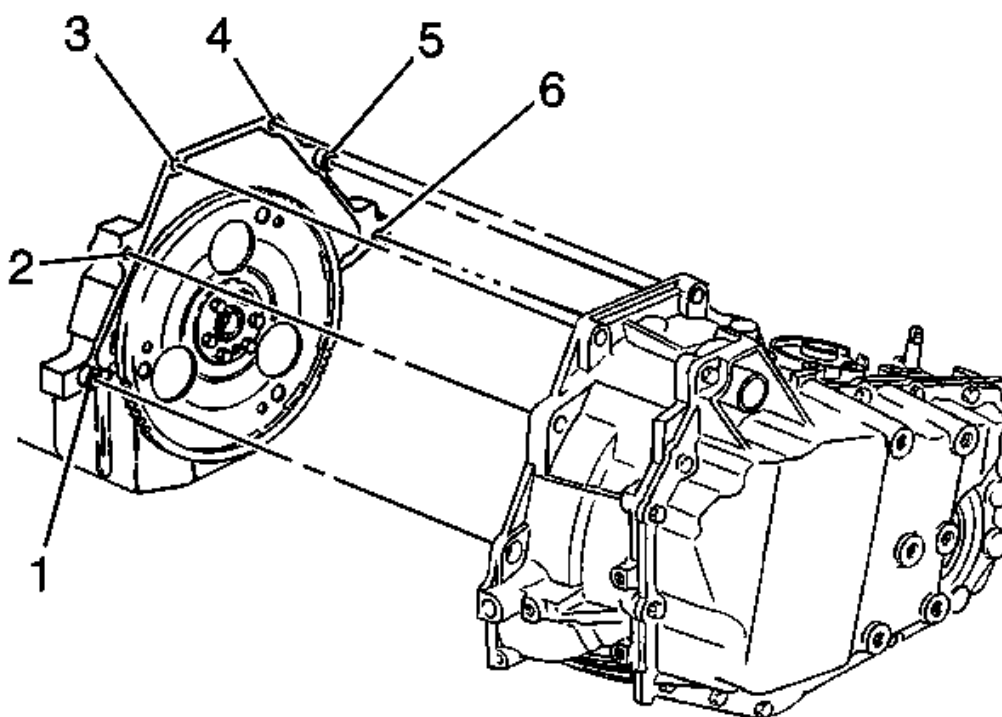


Fig. 190: View of Transaxle To Engine Mounting
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine from the engine stand.
2. Install the flywheel. Refer to **Engine Flywheel Installation**.
3. Install the engine to the vehicle.

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

4. Install the upper transaxle-to-engine bolts (3,4,5) and the stud (2).

Tighten: Tighten the bolts (3,4,5) and the stud (2) to 75 N.m (55 lb ft).

5. Remove the engine lifting device.
6. Install the power steering pump. Refer to **Power Steering Pump Replacement (3.1L)** or **Power Steering Pump Replacement (3.8L)** in Power Steering System.
7. Install the radiator inlet hose to the engine. Refer to **Radiator Hose Replacement - Inlet (3.1L)** or **Radiator Hose Replacement - Inlet (3.8L)** in Engine Cooling.
8. Install the fuel lines to the fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** and **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls - 3.1L.
9. Install the brake booster vacuum hose to the upper intake manifold.
10. Install the vacuum hoses to the upper intake manifold.
11. Install the heater inlet and outlet hoses to the engine.
12. Install the accelerator control and the cruise control cable with the bracket to the throttle body. Refer to **Accelerator Controls Cable Bracket Replacement** in Engine Controls - 3.1L.
13. Raise the vehicle and remove the transaxle support.
14. Install the radiator outlet hose to the engine. Refer to **Radiator Hose Replacement - Outlet (3.1L)** or **Radiator Hose Replacement - Outlet (3.8L)** in Engine Cooling.
15. Install the lower transaxle-to-engine bolt (6) and the stud (1).

Tighten: Tighten the bolt (6) and the stud (1) to 75 N.m (55 lb ft).

16. Install the transaxle brace. Refer to **Automatic Transmission Brace Replacement** in Automatic Transaxle - 4T65E.
17. Install the torque converter bolts. Refer to **Flywheel to Torque Converter Bolt Replacement** in Automatic Transaxle - 4T65E.
18. Install the A/C compressor. Refer to **Compressor Replacement (3.1L)** or **Compressor Replacement (3.8L)** in Heating, Ventilation, and Air Conditioning.
19. Install the starter motor. Refer to **Starter Motor Replacement (3.8L)** or **Starter Motor Replacement (3.1L)** in Engine Electrical.
20. Install the torque converter covers. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65E.

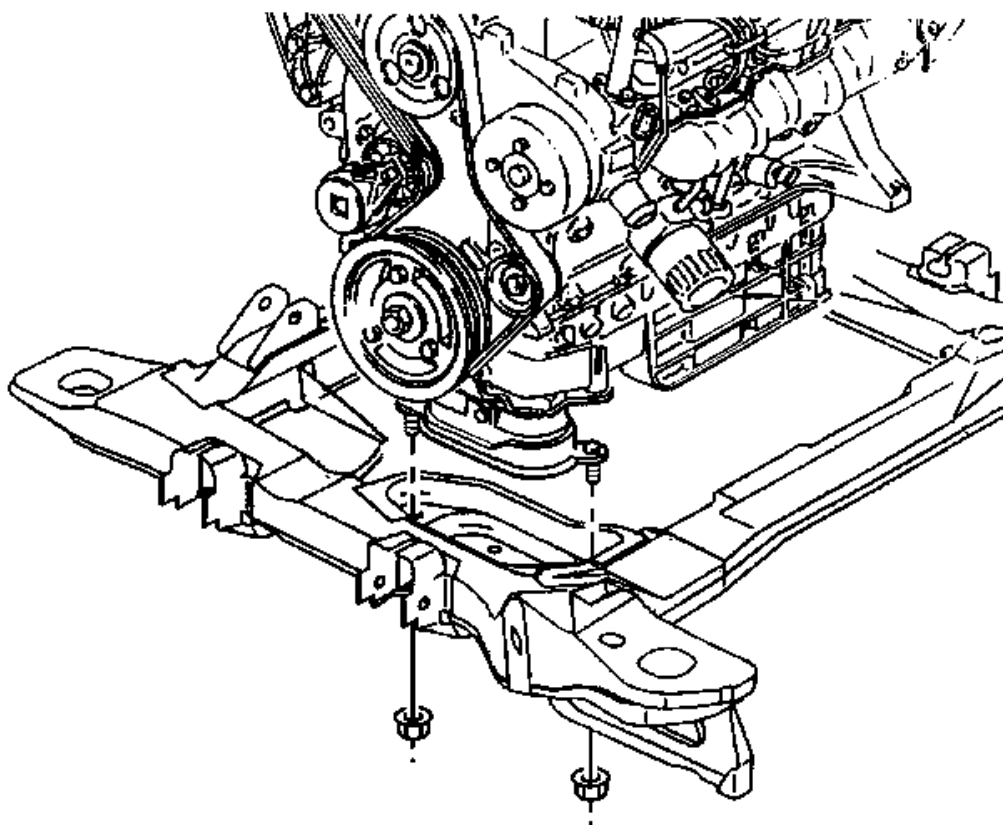


Fig. 191: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

21. Install the engine mount lower nuts.

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

22. Install the engine wiring harness grounds to the transaxle.
23. Install the engine wiring harness ground nut to the transaxle stud.

Tighten: Tighten the nut to 35 N.m (26 lb ft).

24. Install the 3-way catalytic converter pipe to the right exhaust manifold. Refer to **Catalytic Converter Replacement (3.1L)** or **Catalytic Converter Replacement (3.8L)** in Engine Exhaust.
25. Lower the vehicle.
26. Connect the following electrical connectors:
 - Body wiring harness-to-engine harness

- Ignition coil
 - Idle air control (IAC) valve
 - Throttle position (T/P) sensor
 - Evaporative emissions (EVAP) canister purge solenoid
 - Exhaust gas recirculation (EGR) valve
 - Manifold absolute pressure (MAP) sensor
 - Heated oxygen sensor (HO2S)
 - Crankshaft position (CKP) sensor
 - Camshaft position (CMP) sensor
 - Knock sensor
27. Install the drive belt. Refer to **Drive Belt Replacement**.
 28. Install the engine mount struts. Refer to **Engine Mount Strut Replacement**.
 29. Install the hood. Refer to **Hood Replacement** in Body Front End.
 30. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.1L.
 31. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
 32. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
 33. Fill cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
 34. Check and fill the power steering system as necessary. Refer to **Checking and Adding Power Steering Fluid** in Power Steering System.
 35. Perform a CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.1L.
 36. Inspect for leaks.

Engine Oil and Oil Filter Replacement

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position the oil drain pan under the engine oil drain plug.

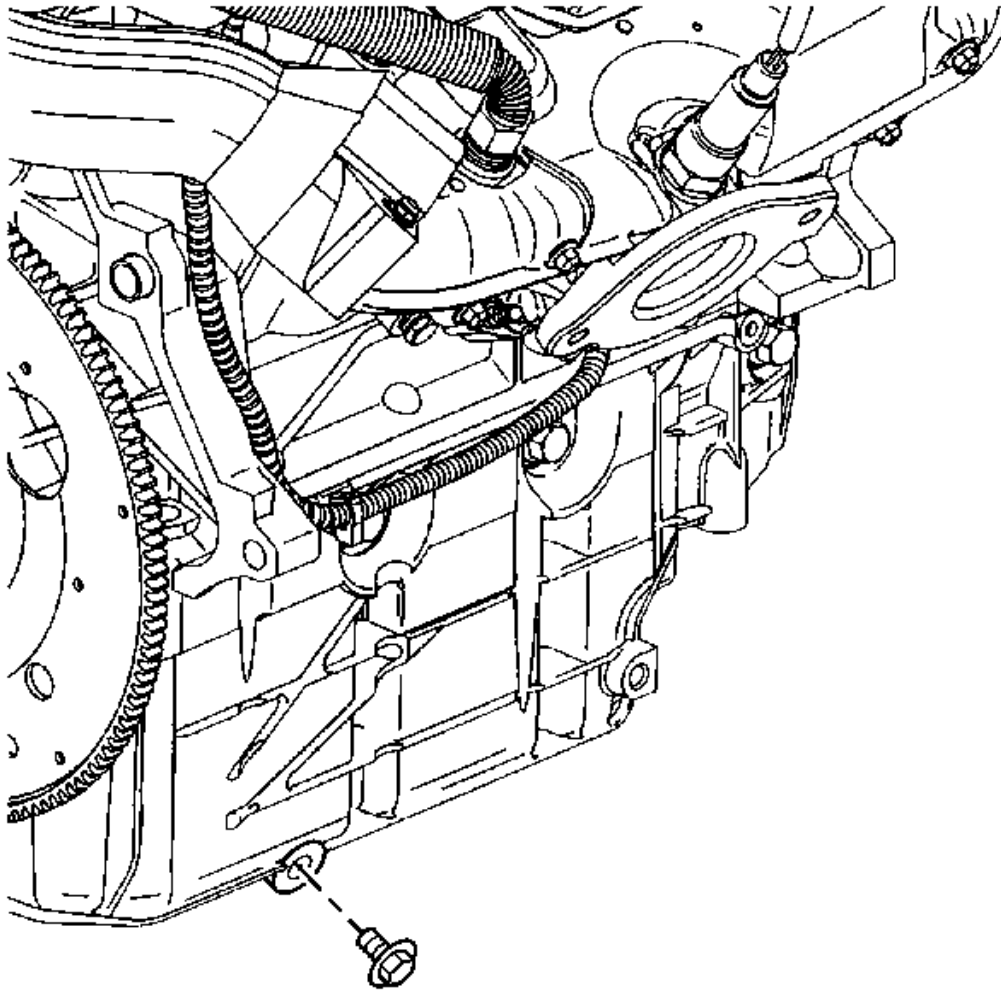


Fig. 192: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, repair or replace if necessary.
5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, repair or replace oil pan if necessary.

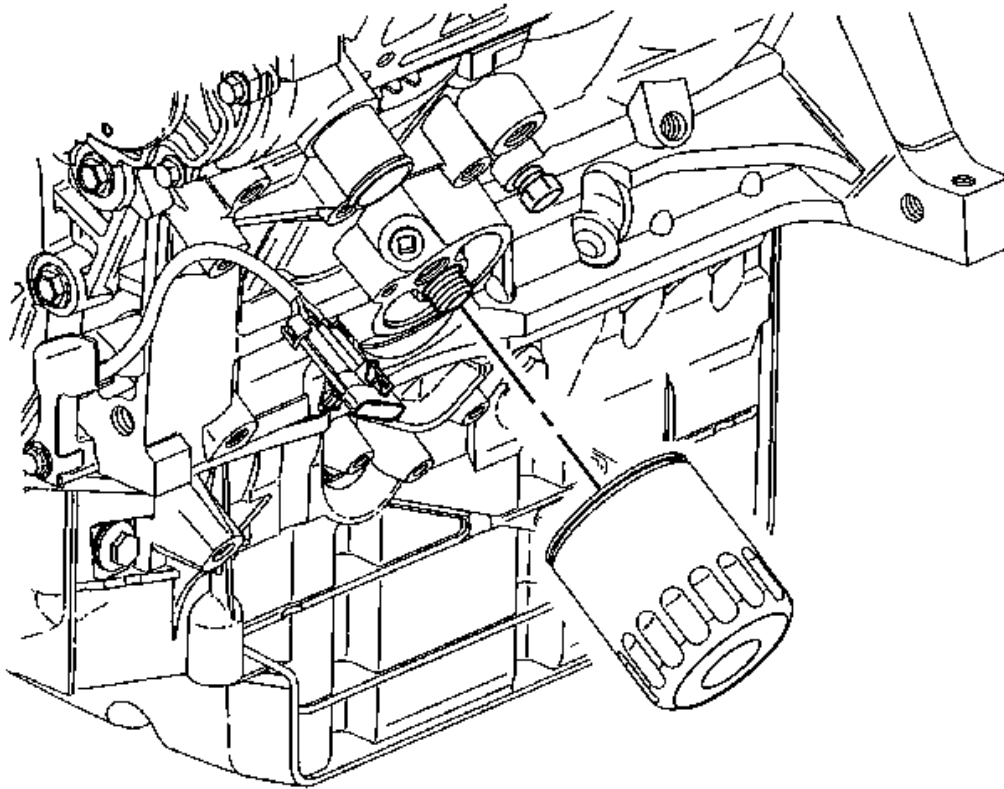


Fig. 193: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.
7. Clean and inspect the oil filter sealing area on the engine block, repair or replace if necessary.

Installation Procedure

1. Lightly oil the replacement oil filter gasket with clean oil and install the new oil filter.

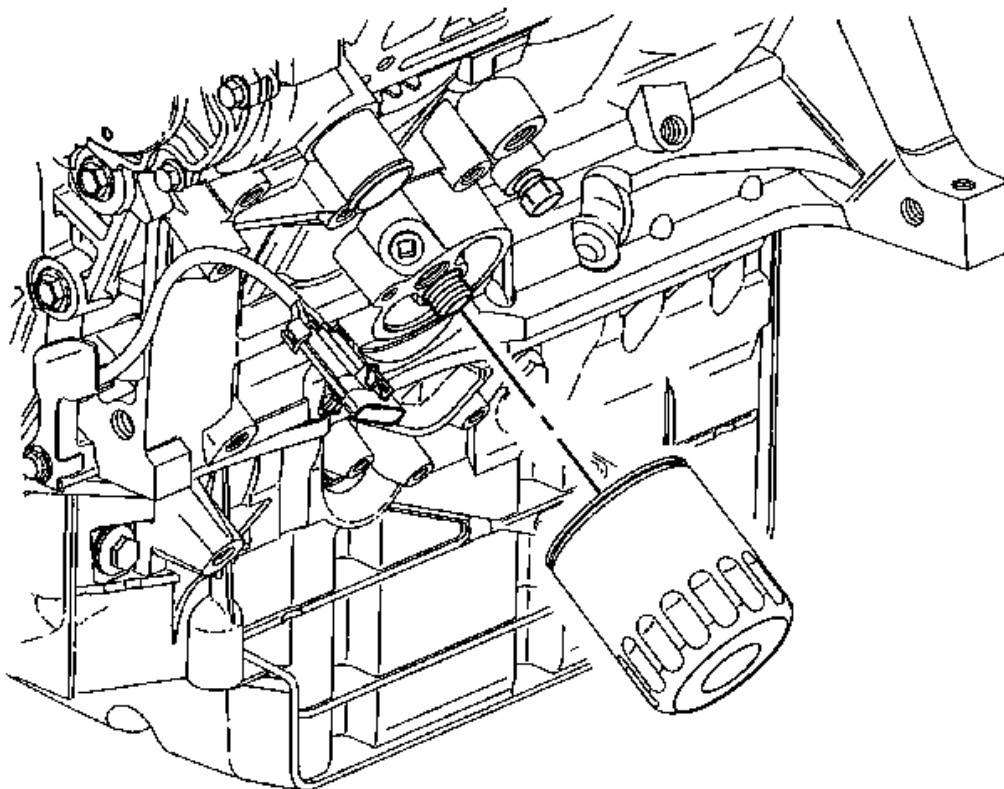


Fig. 194: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the new oil filter.

Tighten: Tighten the new oil filter to 3/4 to 1 full turn, after the oil filter gasket contacts the oil filter mounting surface.

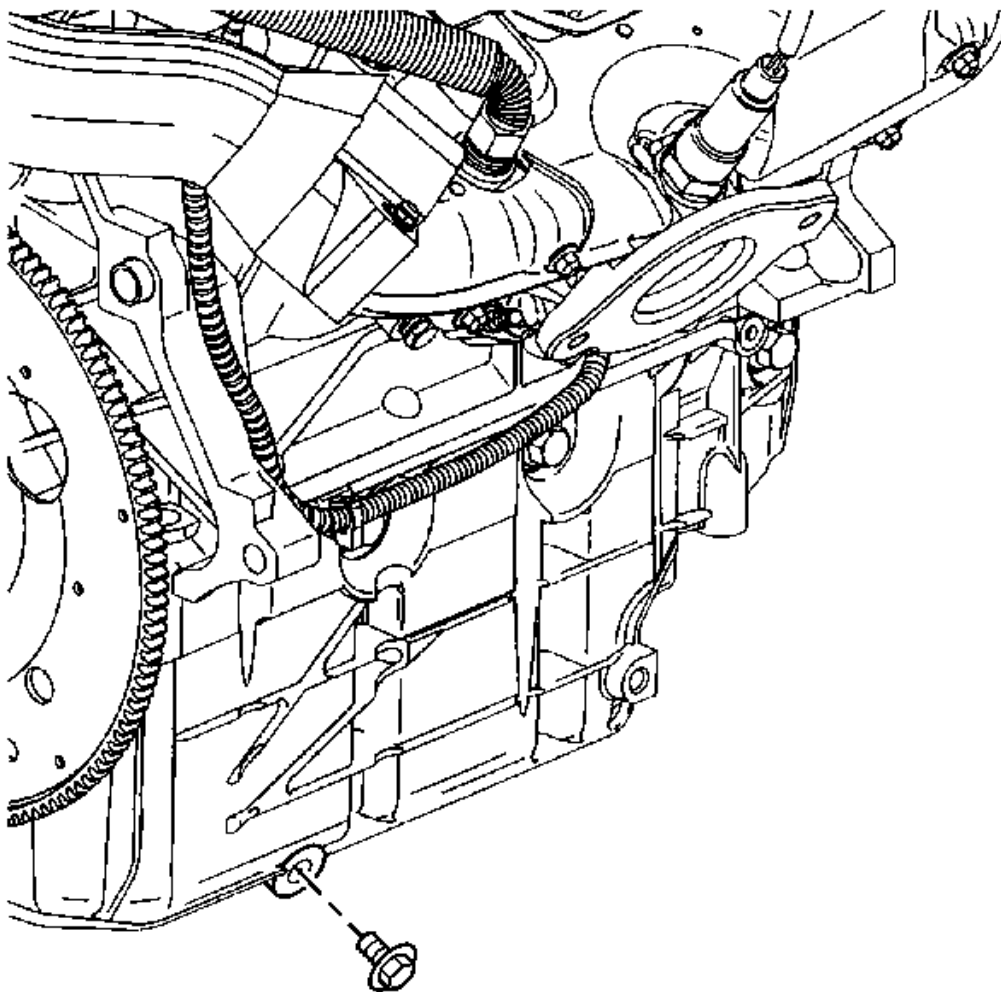


Fig. 195: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Install the engine oil pan drain plug.

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

4. Remove the oil drain pan.
5. Lower the vehicle.
6. Fill the engine with new engine oil.
7. Start the engine.
8. Inspect for oil leaks after engine start up.

9. Turn off the engine and allow the oil a few minutes to drain back into the oil pan.
10. Remove the oil level indicator from the oil level indicator tube.
11. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
12. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.
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 of the engine oil on the oil level indicator.
15. If necessary, adjust the oil level by adding or draining the engine oil.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

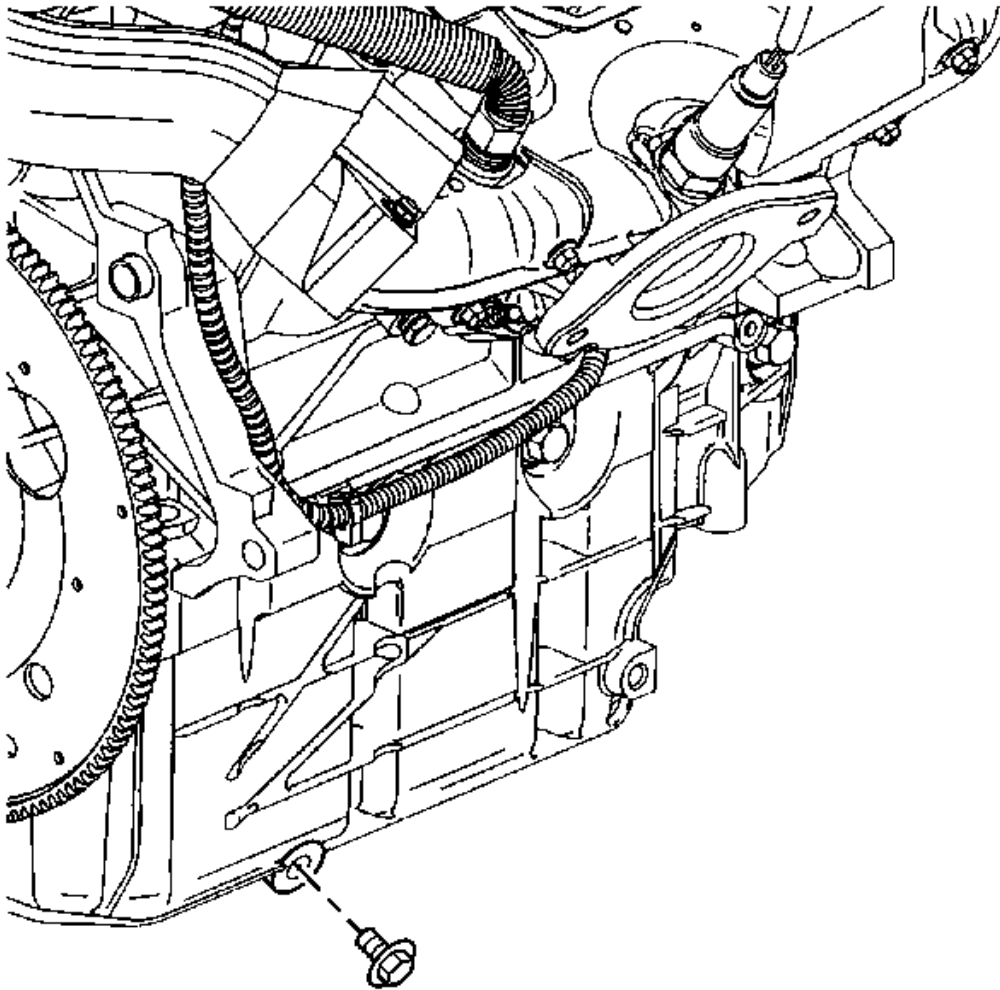


Fig. 196: View Of Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

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

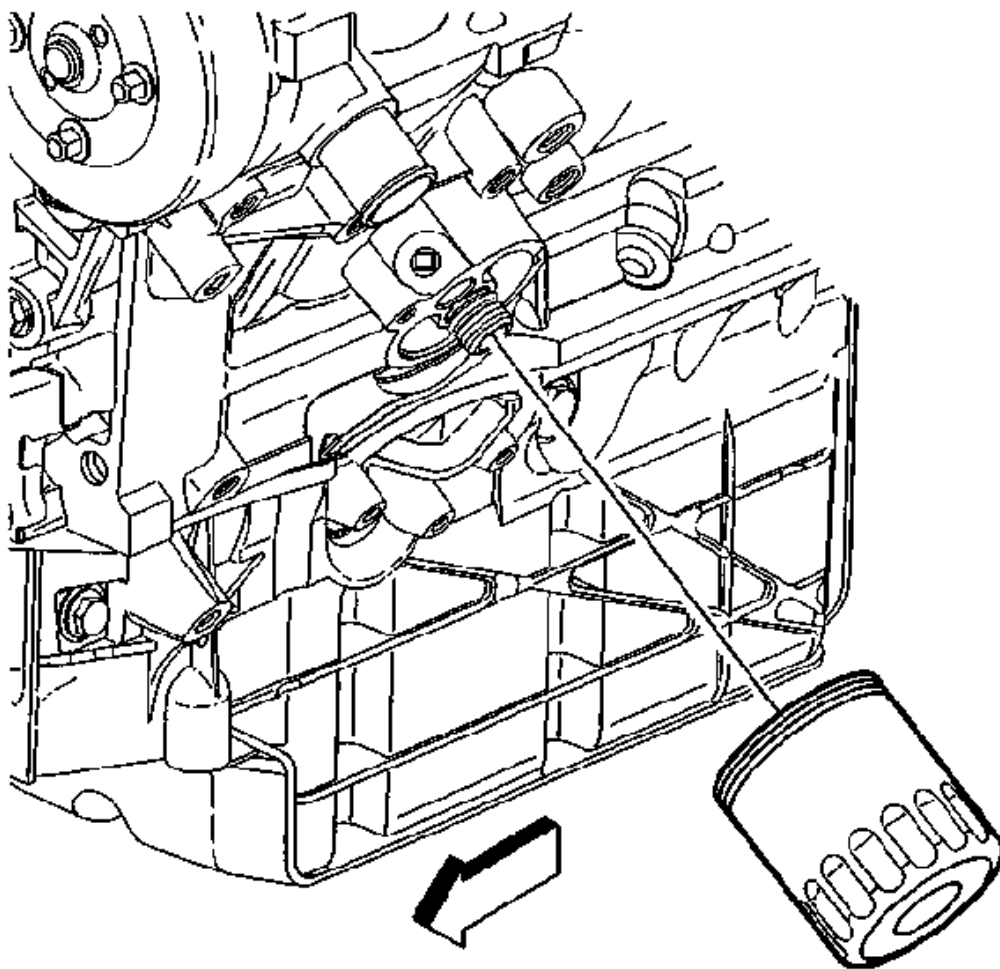


Fig. 197: Removing/Installing Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

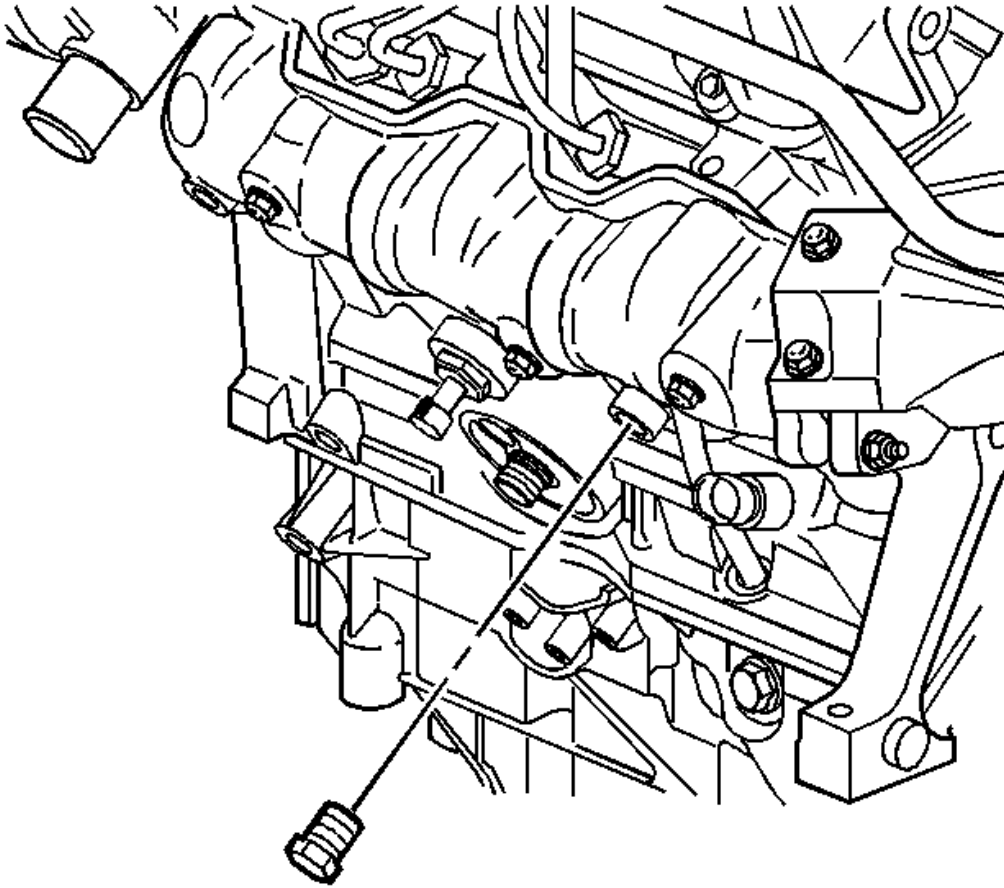


Fig. 198: Locating Left Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the coolant drain plug from the left side, if applicable.

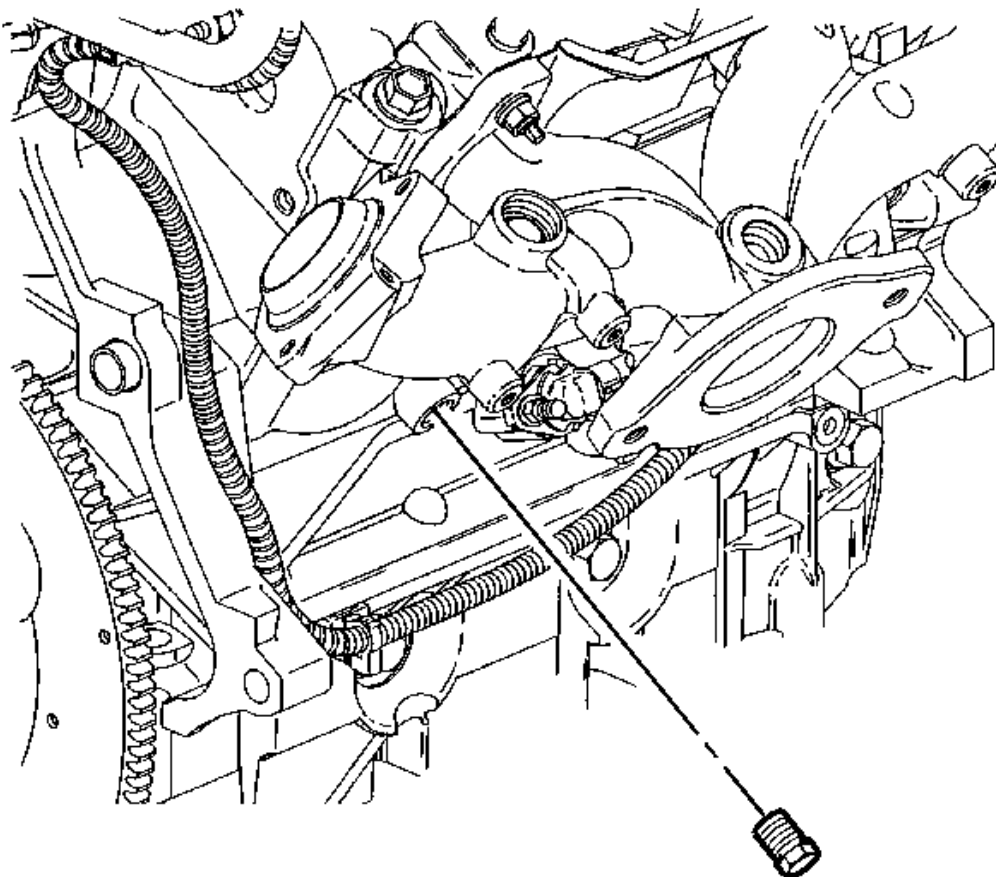


Fig. 199: Locating Right Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Remove the coolant drain plug from the right side.
6. Drain the coolant.

Crankshaft Balancer Removal

Tools Required

J 24420-C Harmonic Balancer Puller. See **Special Tools and Equipment**.

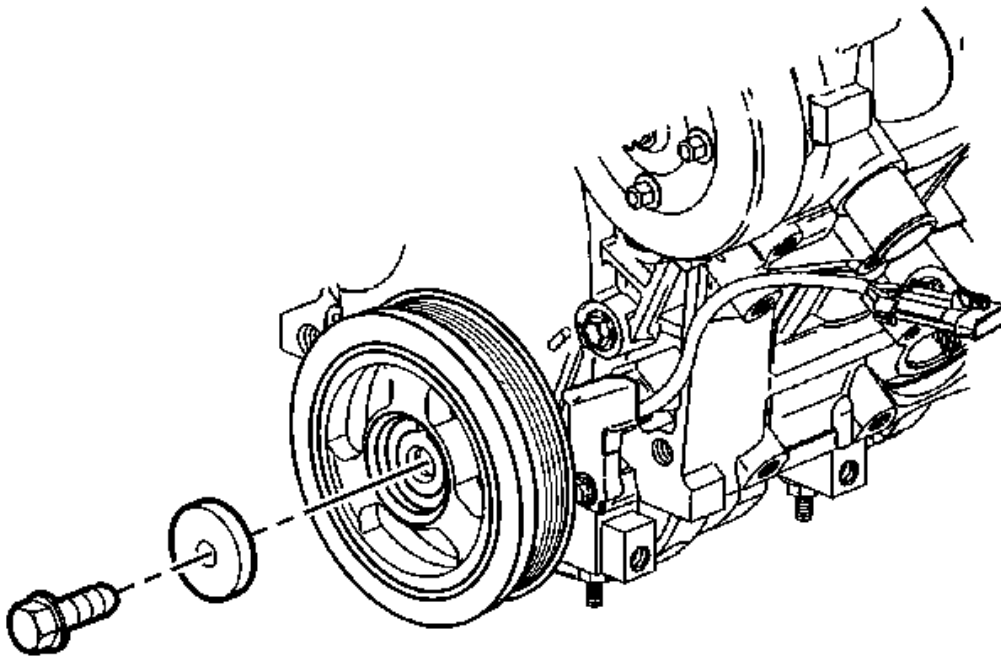


Fig. 200: Installing Crankshaft Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer retaining bolt and washer.

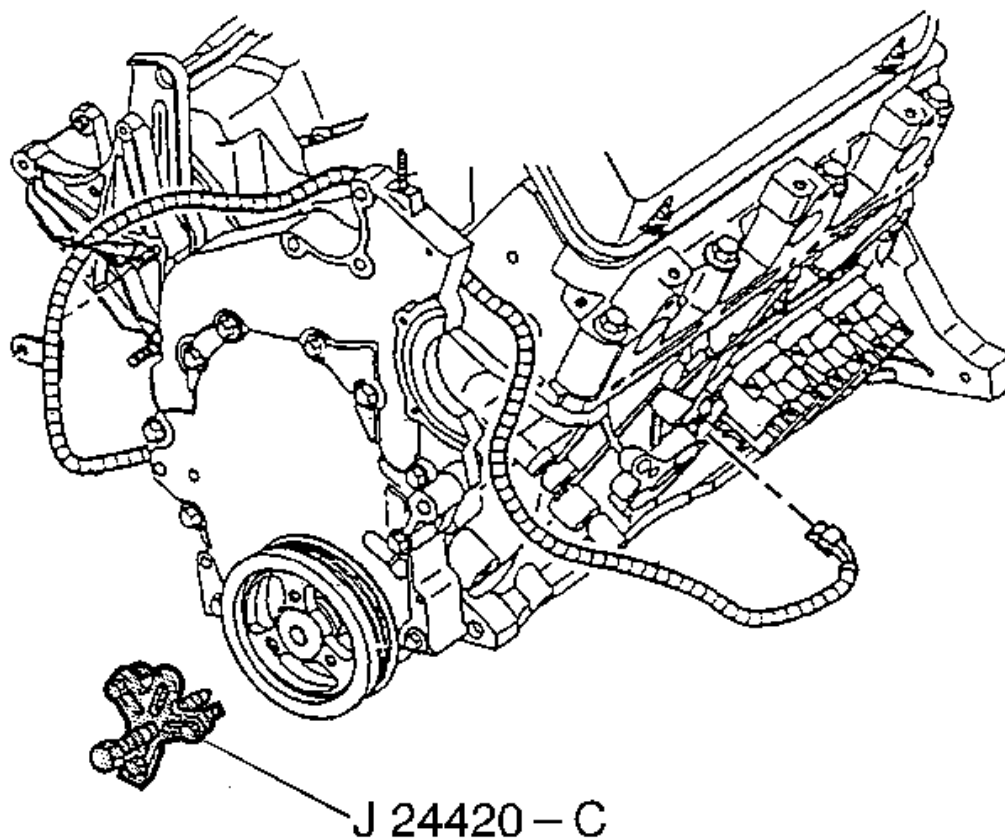


Fig. 201: Removing Crankshaft Balancer Using J 24420-C
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer using the **J 24420-C** . See **Special Tools and Equipment**.

Engine Flywheel Removal

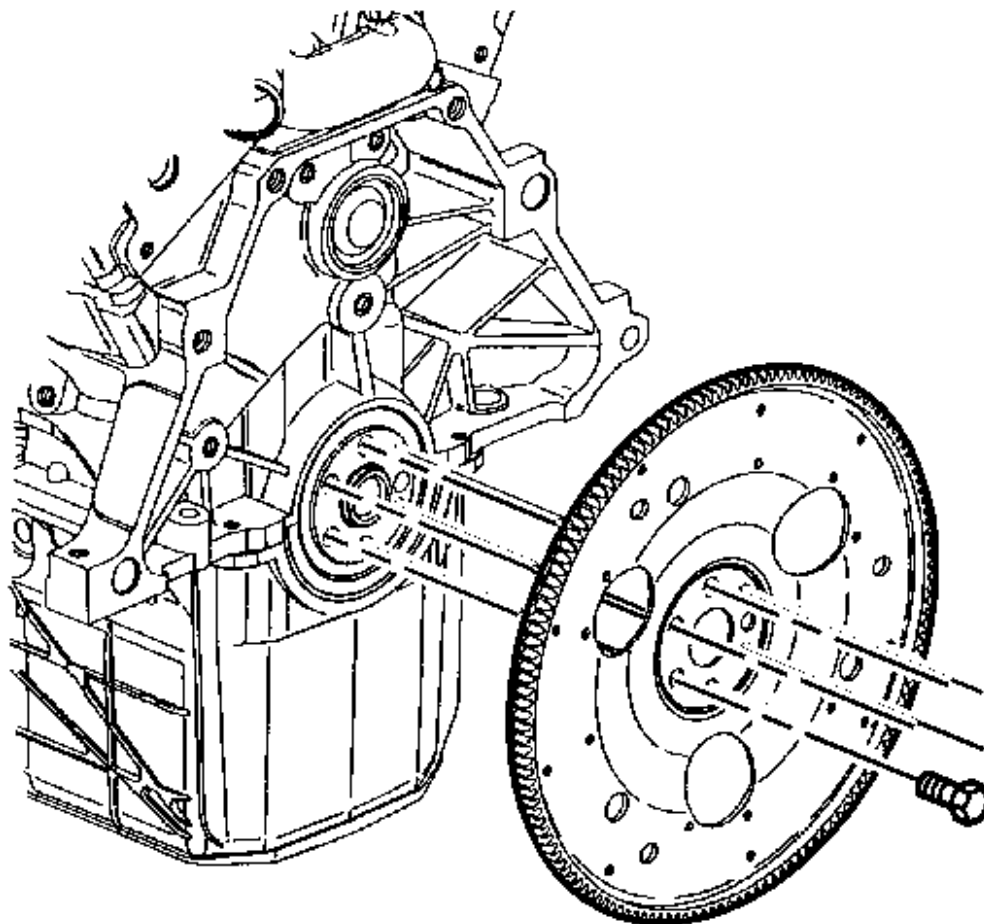


Fig. 202: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

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

Drive Belt Tensioner Removal

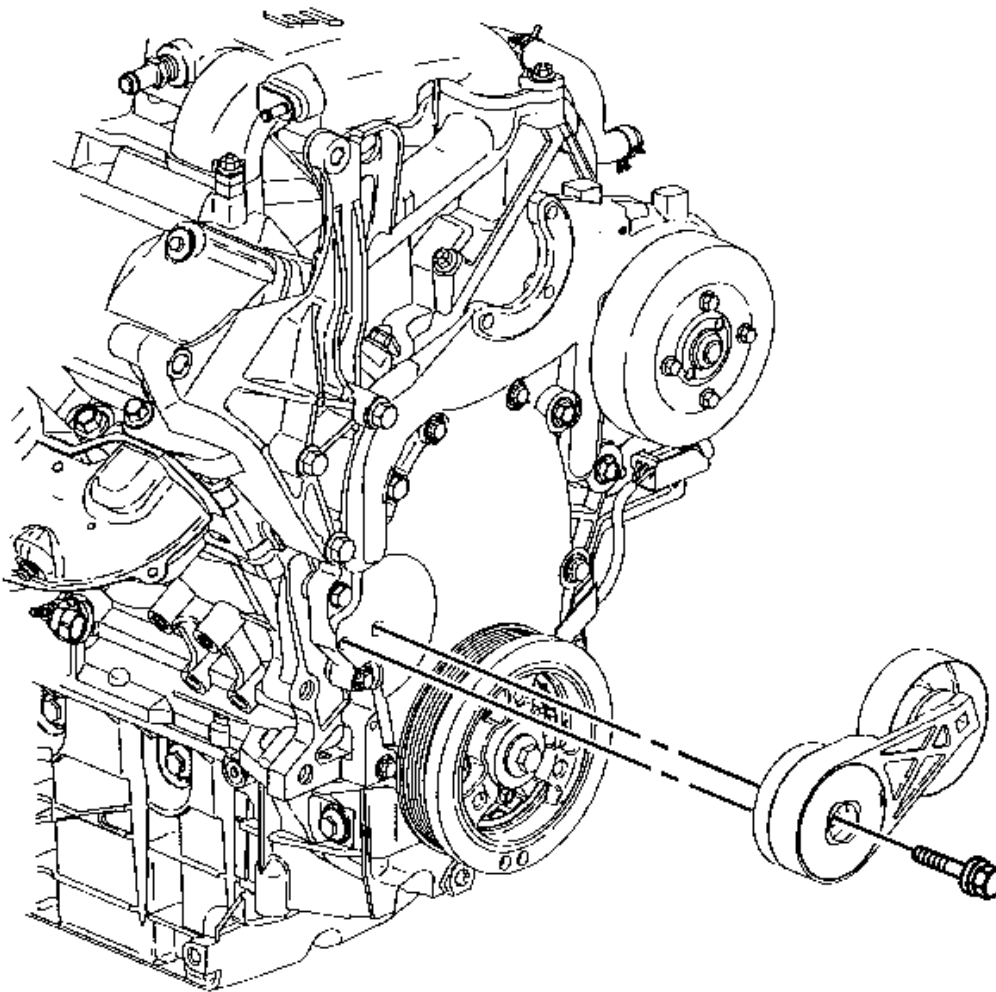


Fig. 203: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Engine Mount Strut and Air Conditioning Compressor Bracket Removal

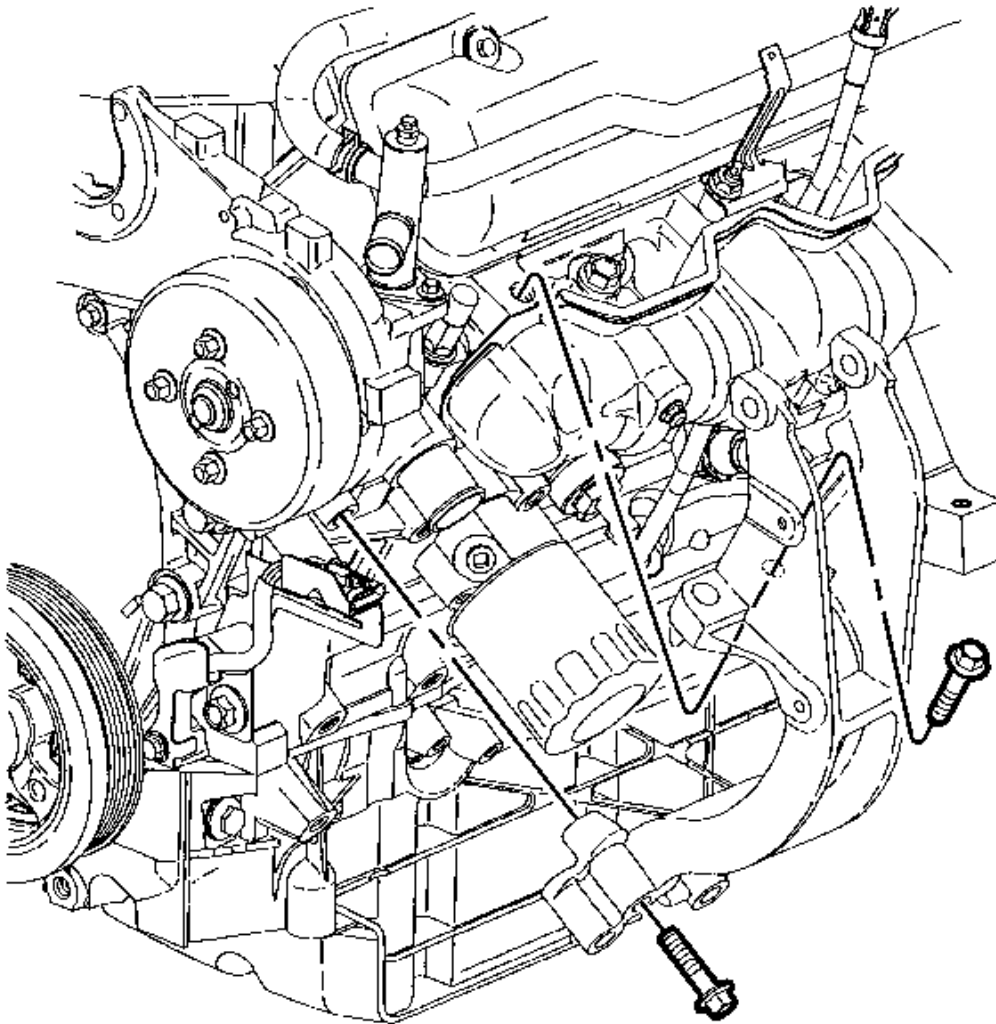


Fig. 204: Removing Engine Mount Strut & A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut and A/C compressor bracket bolts.
2. Remove the engine mount strut and A/C compressor bracket.

Engine Mount Strut and Engine Lift Bracket Removal

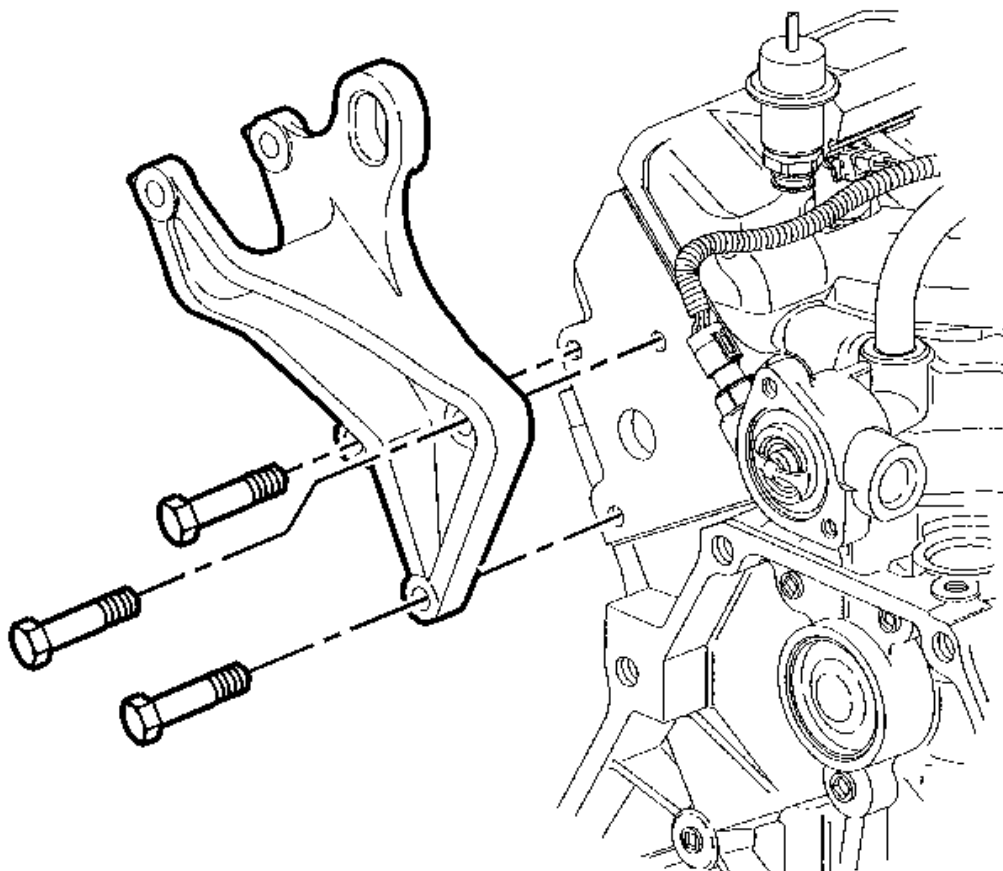


Fig. 205: Engine Mount Strut & Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut and lift bracket bolts.
2. Remove the engine mount strut and lift bracket.

Engine Lift Bracket and Generator Bracket Removal

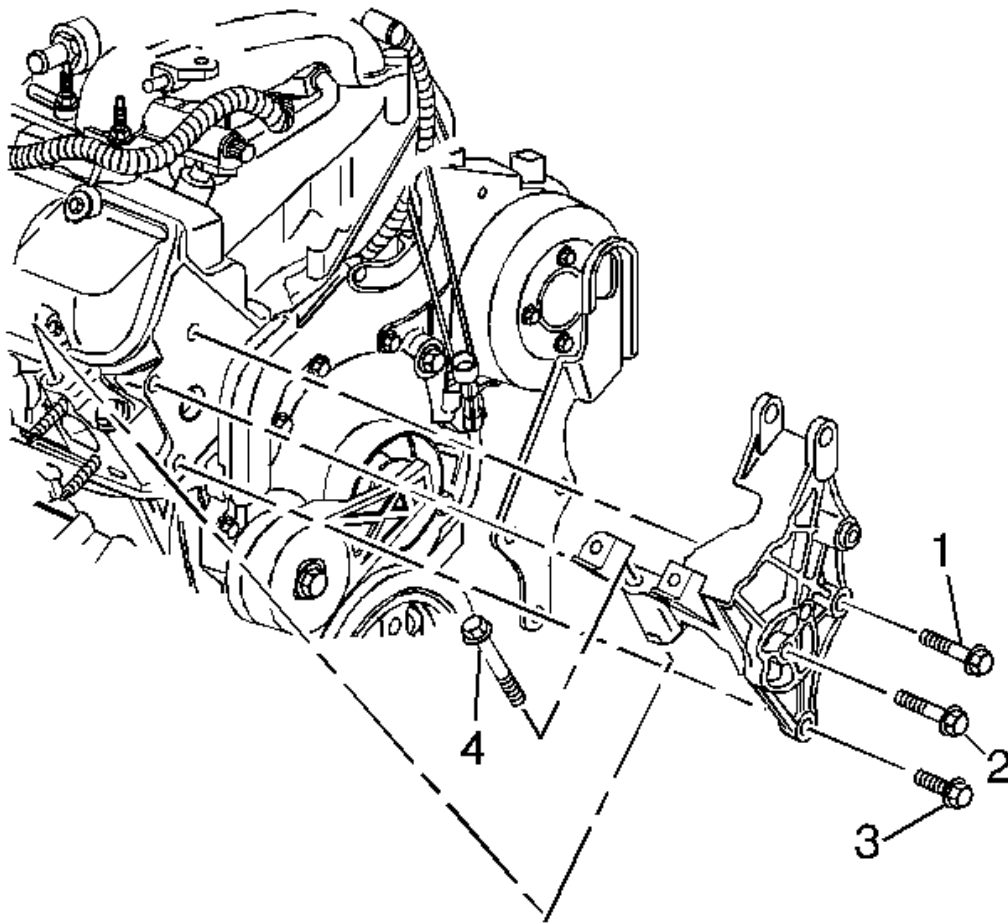


Fig. 206: Generator Bracket & Bolts
 Courtesy of GENERAL MOTORS CORP.

1. Remove the generator bracket bolts (1-4).
2. Remove the generator bracket.
3. Remove the front engine lift bracket.

Oil Level Indicator and Tube Removal

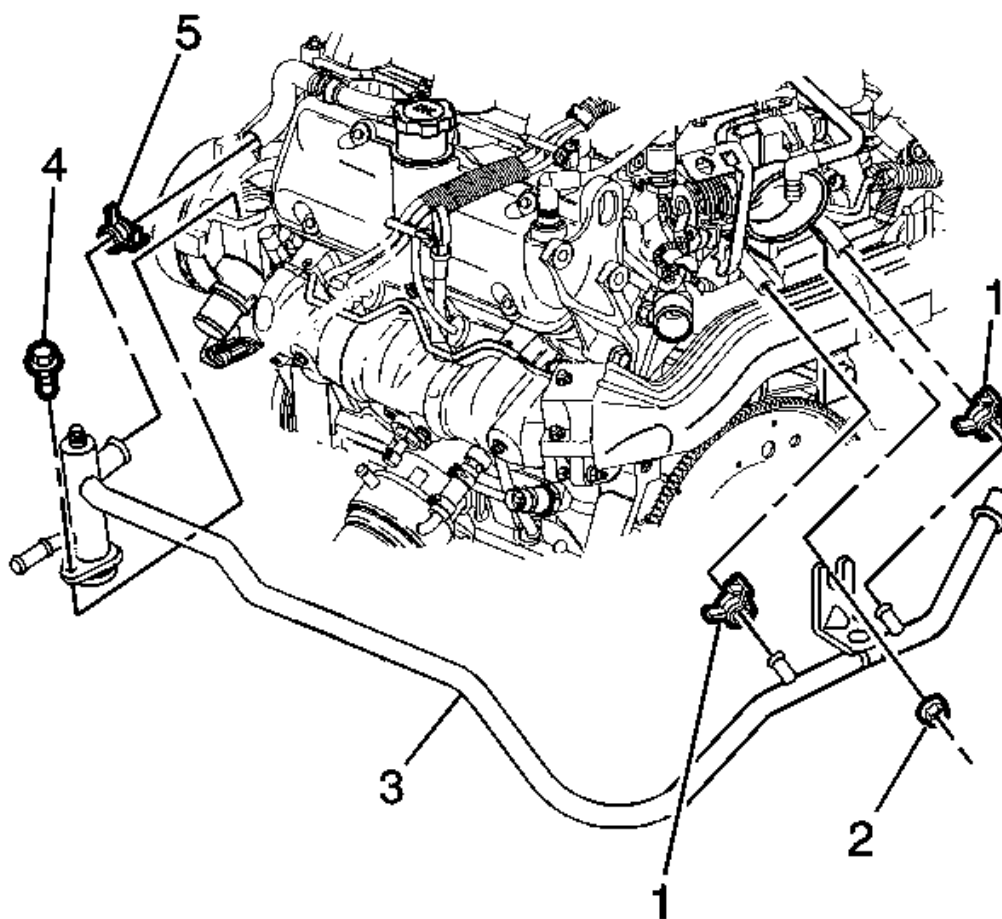


Fig. 207: Thermostat Bypass Pipe & Components
 Courtesy of GENERAL MOTORS CORP.

1. Remove the thermostat bypass pipe to throttle body nut (2).
2. Remove the thermostat bypass pipe to throttle body hose clamps (1).
3. Remove the thermostat bypass pipe to engine front cover bolt (4).
4. Remove the thermostat bypass pipe hose clamp (5) and hose from pipe.
5. Remove the thermostat bypass pipe (3).

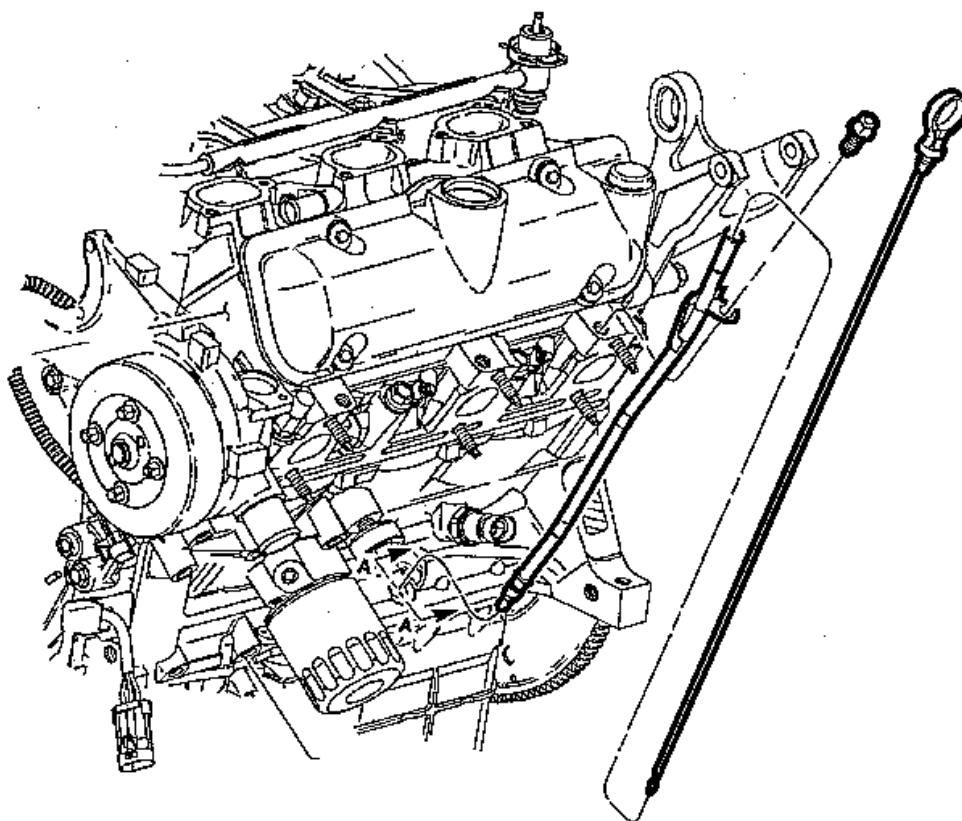


Fig. 208: Oil Level Indicator Tube & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil level indicator tube bolt.
7. Remove the oil level indicator and oil level indicator tube.

Oil Filter Adapter Removal

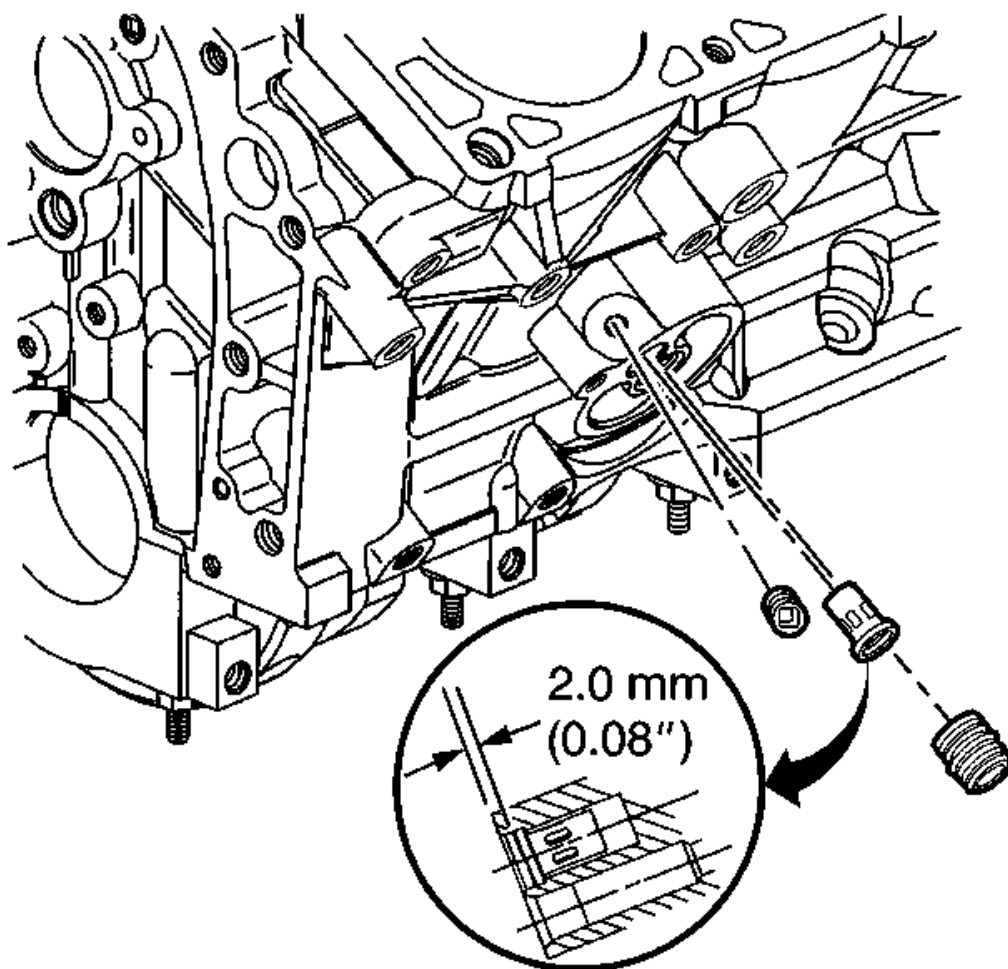


Fig. 209: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter bypass hole plug.

IMPORTANT: Do not remove the oil filter fitting unless replacement or repair is needed.

2. Remove the oil filter fitting, if necessary.

IMPORTANT: Do not pry against the threads in oil filter bypass hole when removing the bypass valve.

3. Remove the oil filter bypass valve, by prying out with a suitable tool.

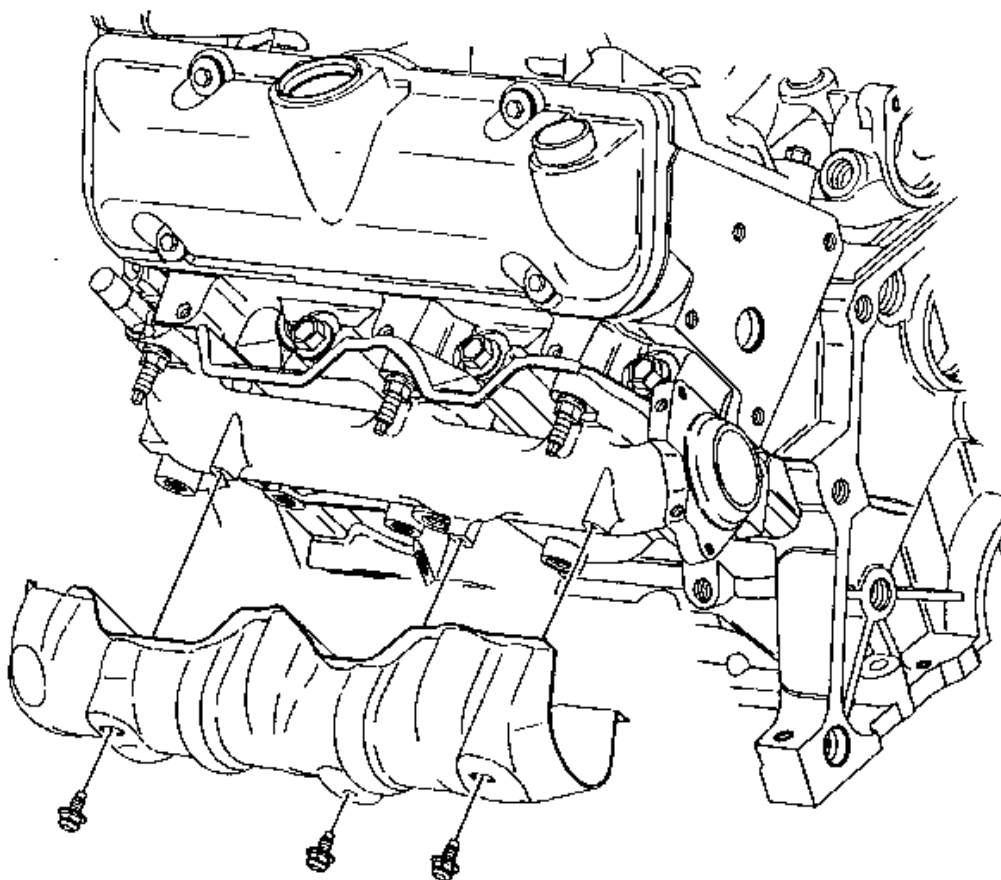
Exhaust Manifold Removal - Left

Fig. 210: View Of Exhaust Manifold Heat Shield & Bolts - Left
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires.
2. Remove the spark plugs.
3. Remove the exhaust manifold heat shield bolts.
4. Remove the exhaust manifold heat shield.

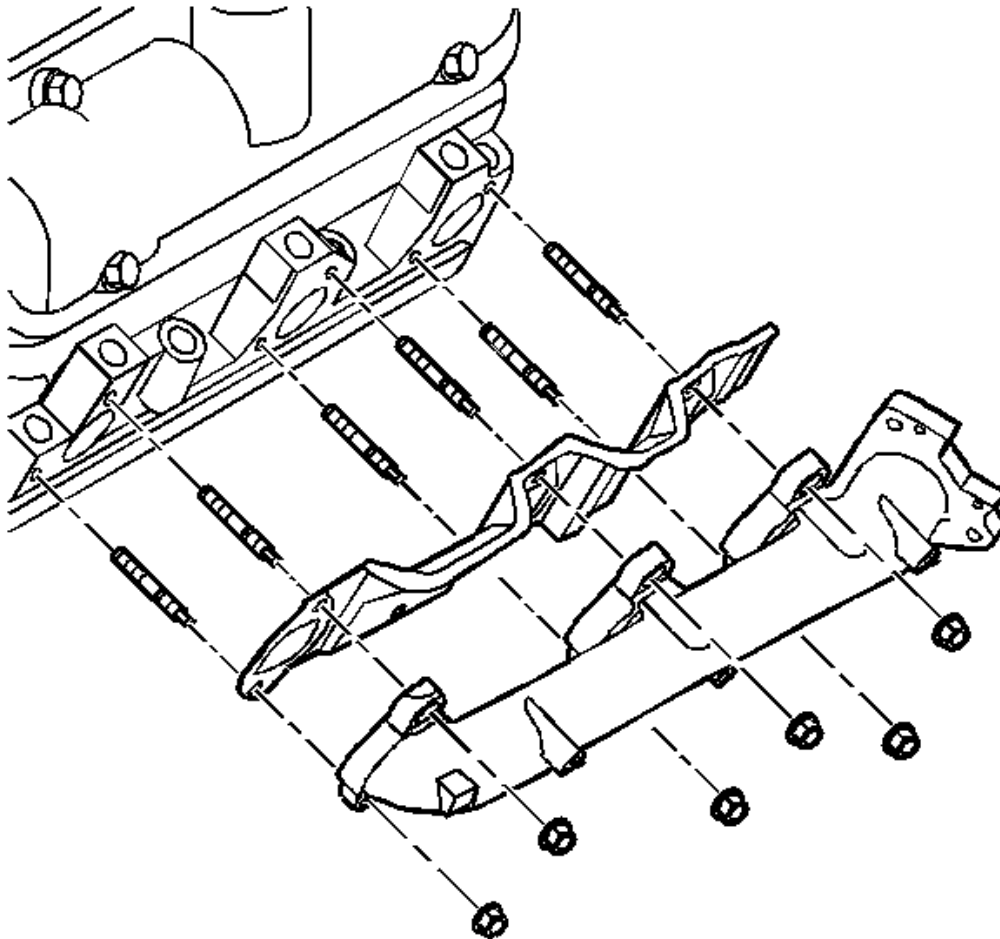


Fig. 211: View Of Exhaust Manifold & Exhaust Manifold Gasket - Left
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust manifold nuts.
6. Remove the exhaust manifold.
7. Remove the exhaust manifold gasket.
8. Remove the exhaust studs, if required.

Exhaust Manifold Removal - Right

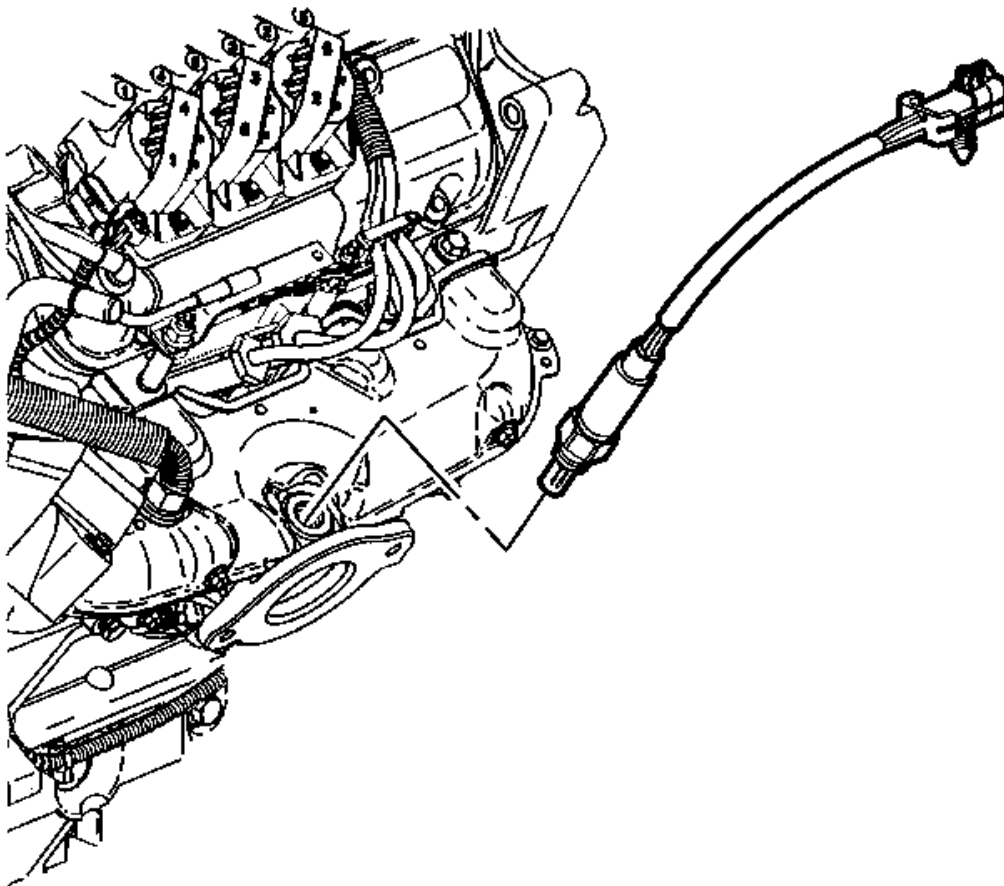


Fig. 212: Identifying Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires.
2. Remove the spark plugs.
3. Remove the EGR pipe from the exhaust manifold.
4. Remove the heated oxygen sensor.

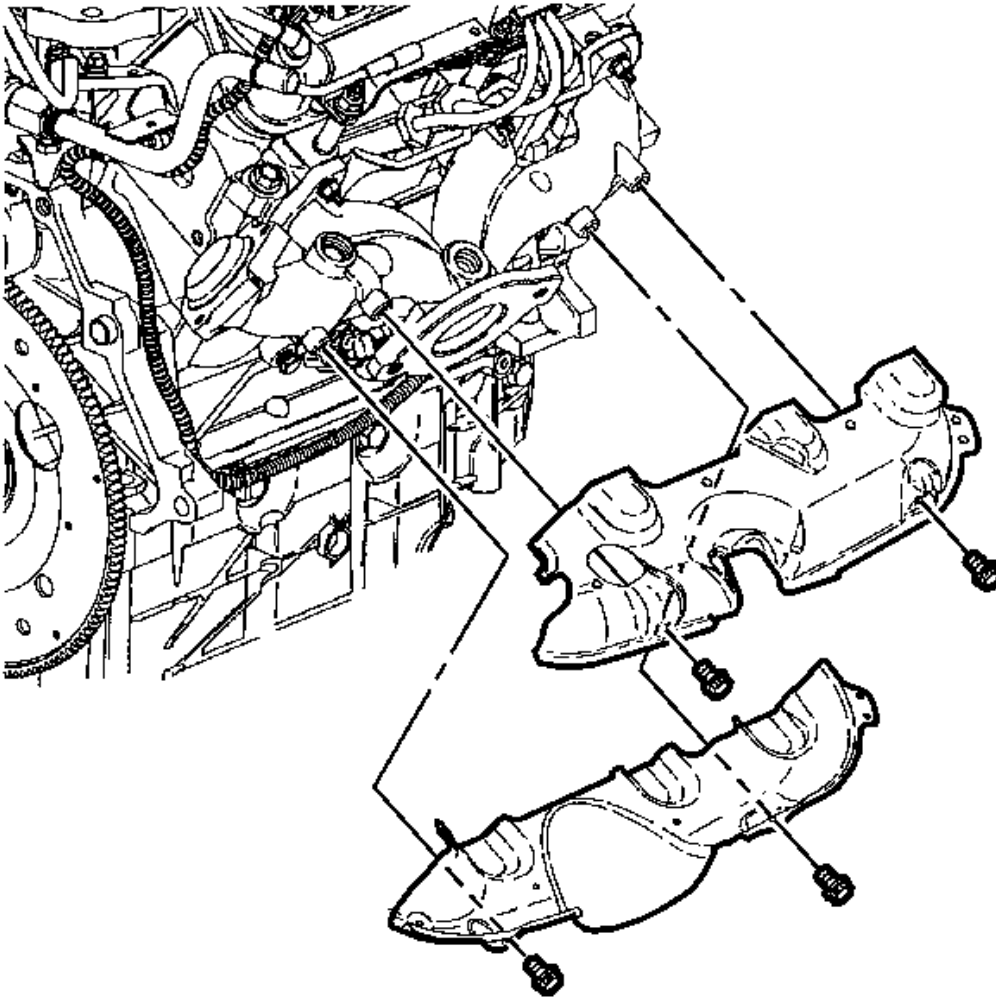


Fig. 213: View Of Right Exhaust Manifold Heat Shields & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust manifold heat shield bolts.
6. Remove the exhaust manifold heat shields.

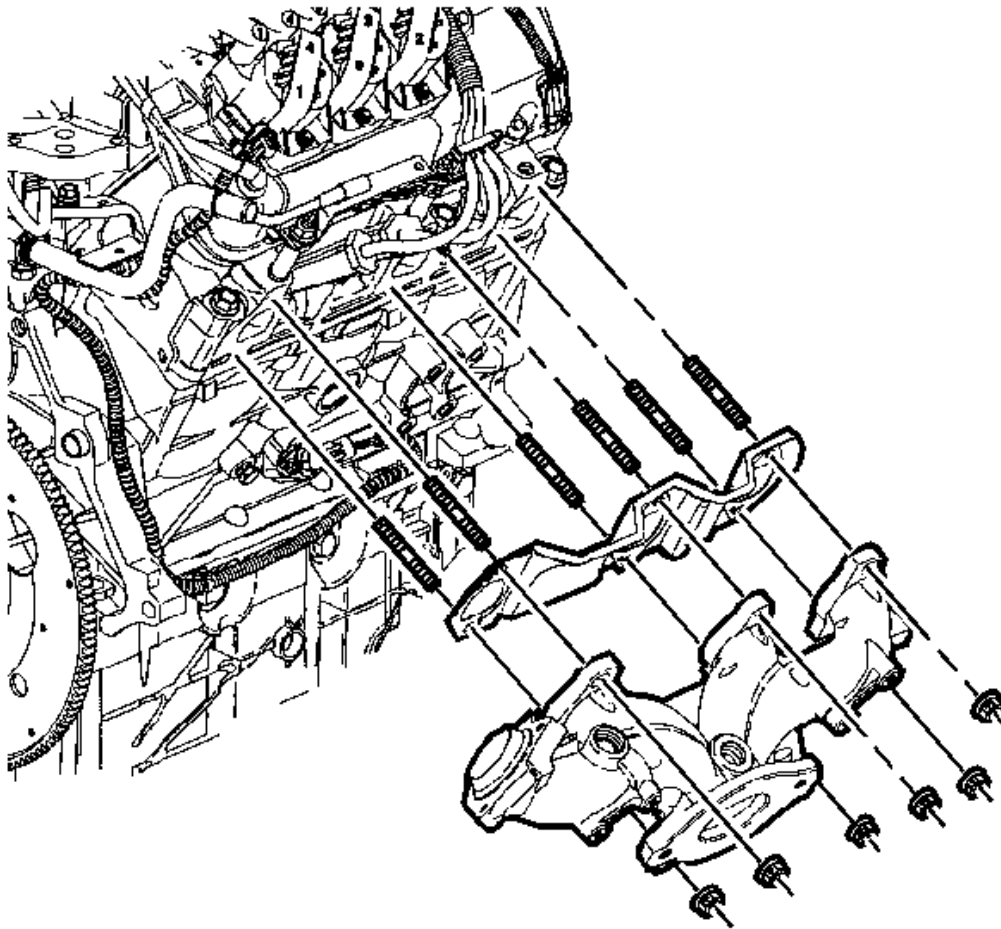


Fig. 214: Right Exhaust Manifold (3.4L)
Courtesy of GENERAL MOTORS CORP.

7. Remove the exhaust manifold nuts.
8. Remove the exhaust manifold.
9. Remove the exhaust manifold gasket.
10. Remove the exhaust studs, if required.

Water Outlet and Thermostat Removal

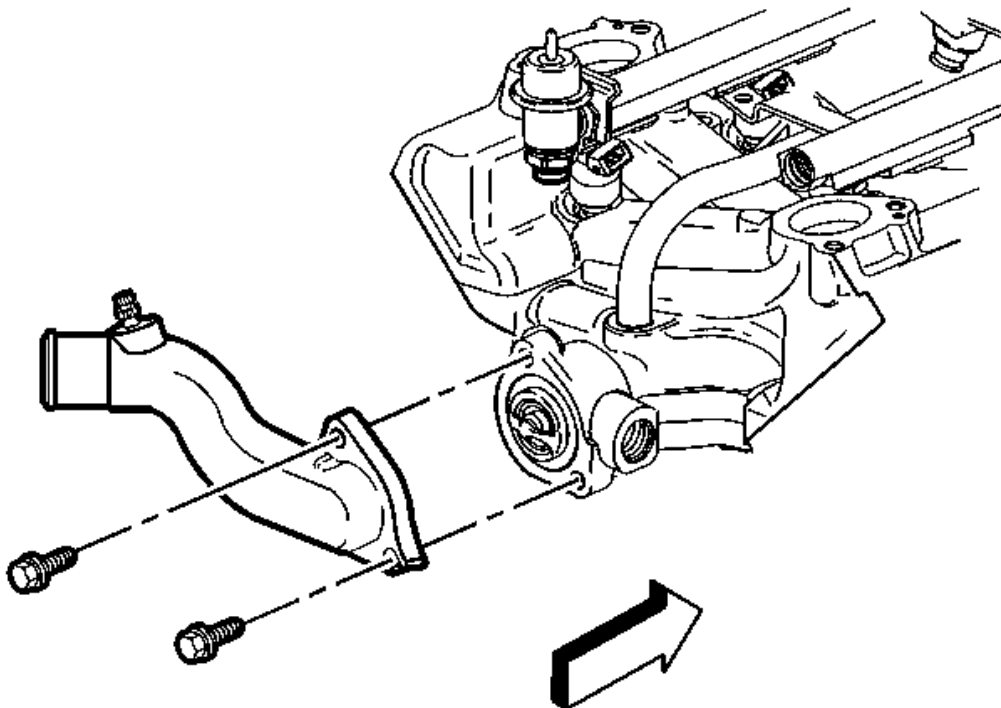


Fig. 215: Removing Water Outlet
Courtesy of GENERAL MOTORS CORP.

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

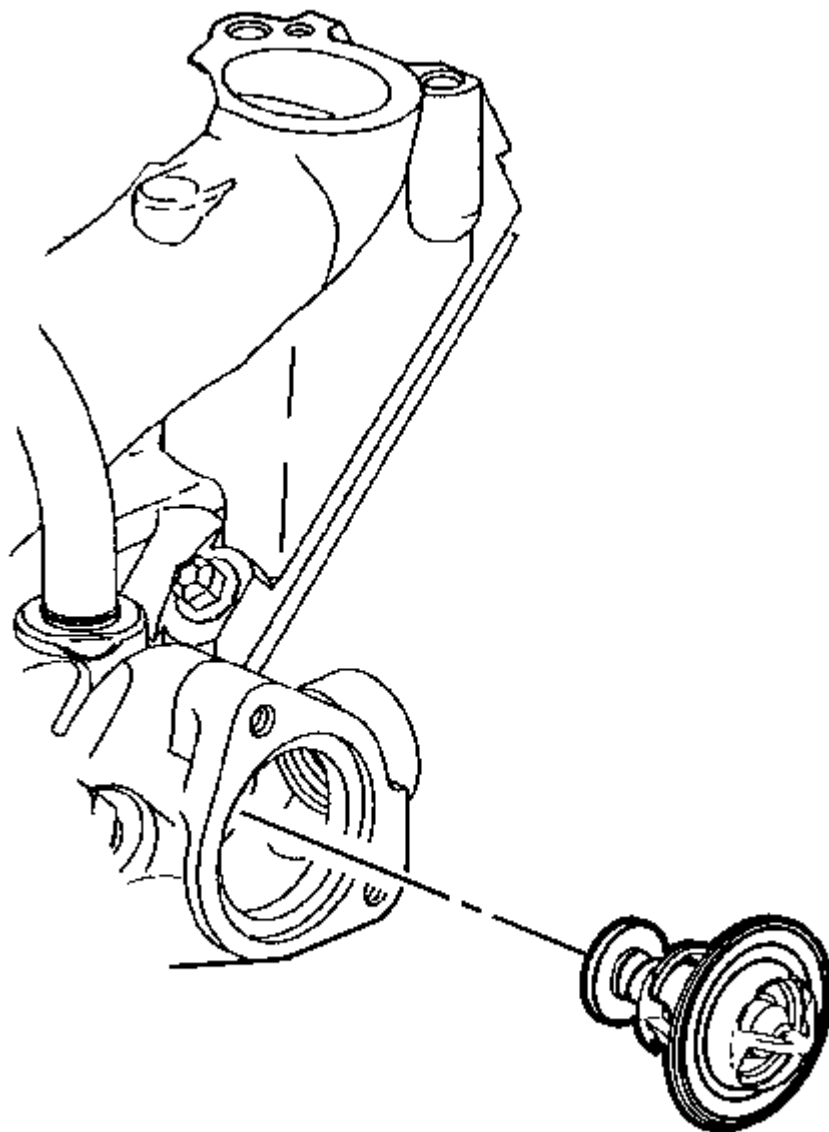


Fig. 216: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

3. Remove the thermostat.

Valve Rocker Arm Cover Removal - Left

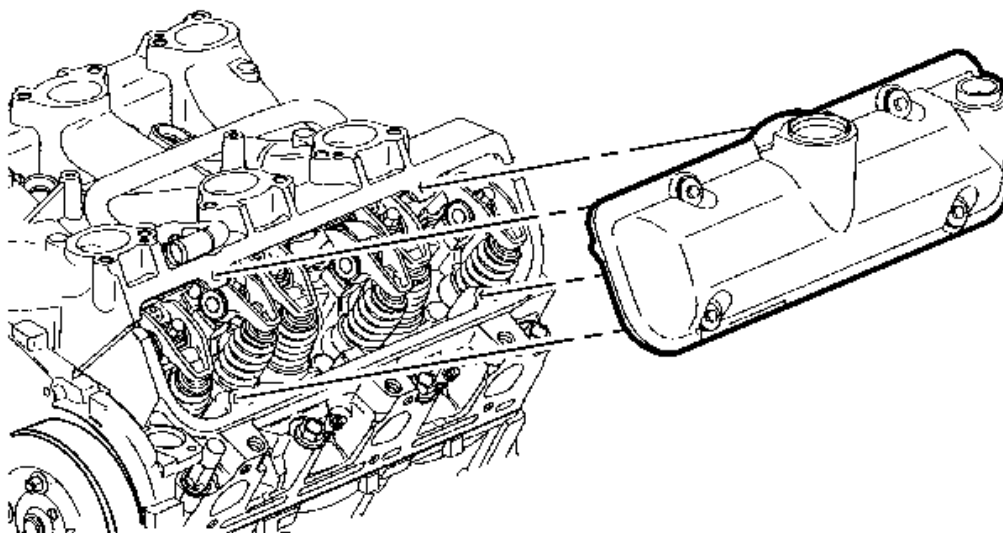


Fig. 217: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

NOTE: Valve rocker arm cover gasket and sealant must be carefully trimmed away from lower intake manifold gasket. Failure to do so will damage the lower intake manifold gasket, causing a severe oil leak.

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

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.

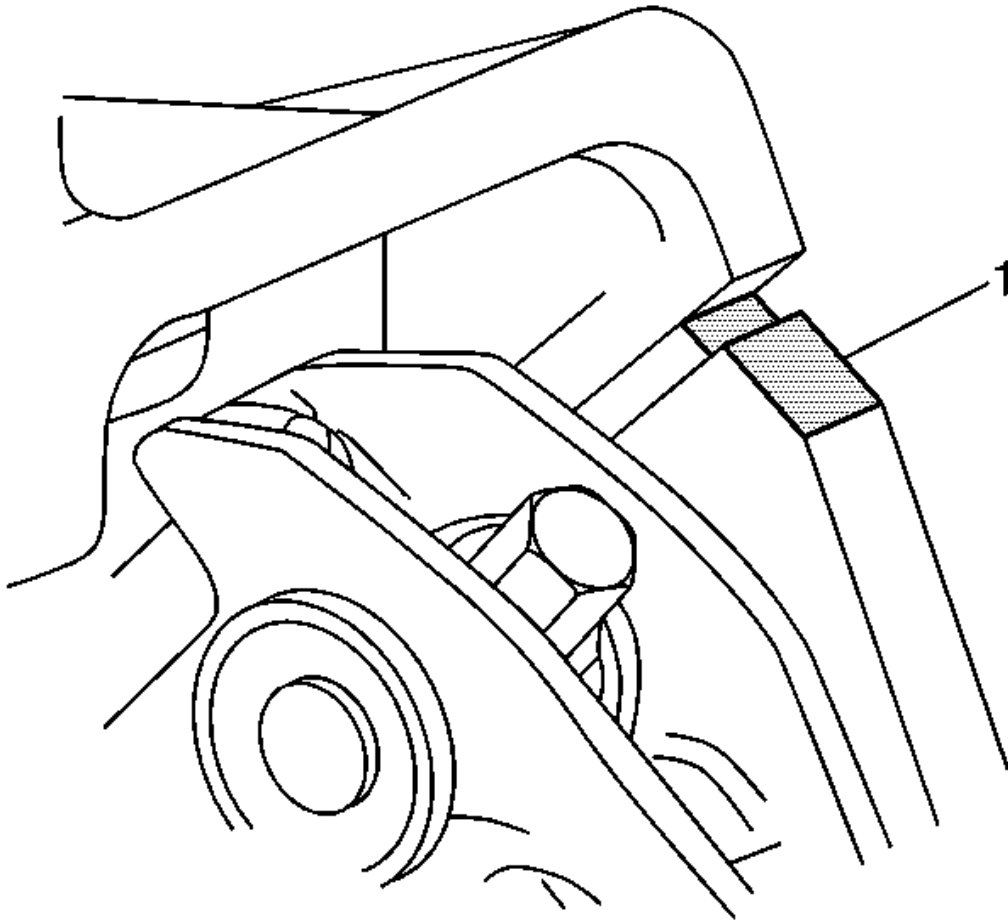


Fig. 218: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

3. Trim valve cover gasket and sealant away from lower intake manifold gasket at the cylinder head to lower intake manifold joints (1).
4. Remove the valve rocker arm cover gasket.

Valve Rocker Arm Cover Removal - Right

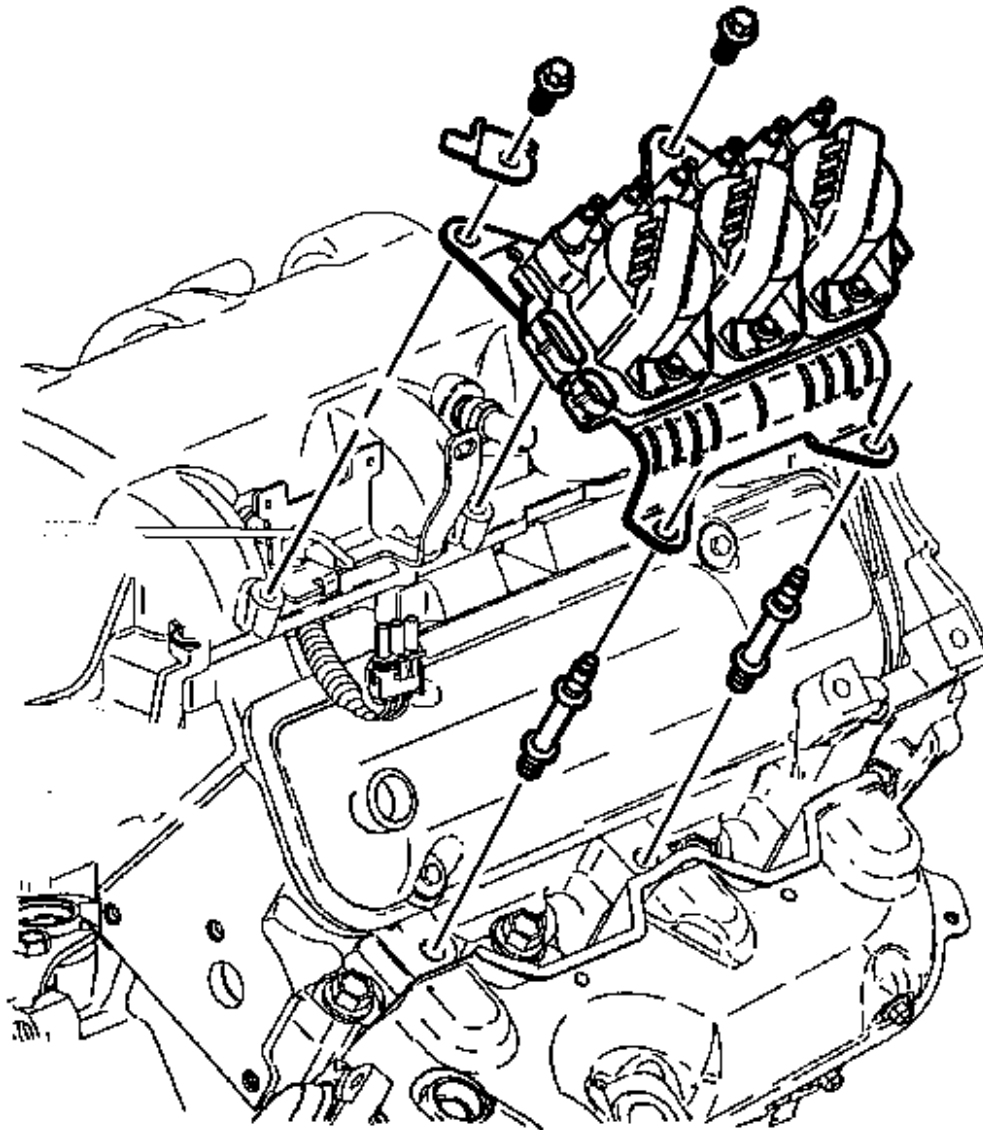


Fig. 219: Electric Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

1. Remove the electronic ignition control module nuts and bolts.
2. Remove the electronic ignition control module.
3. Remove the electronic ignition control module studs.

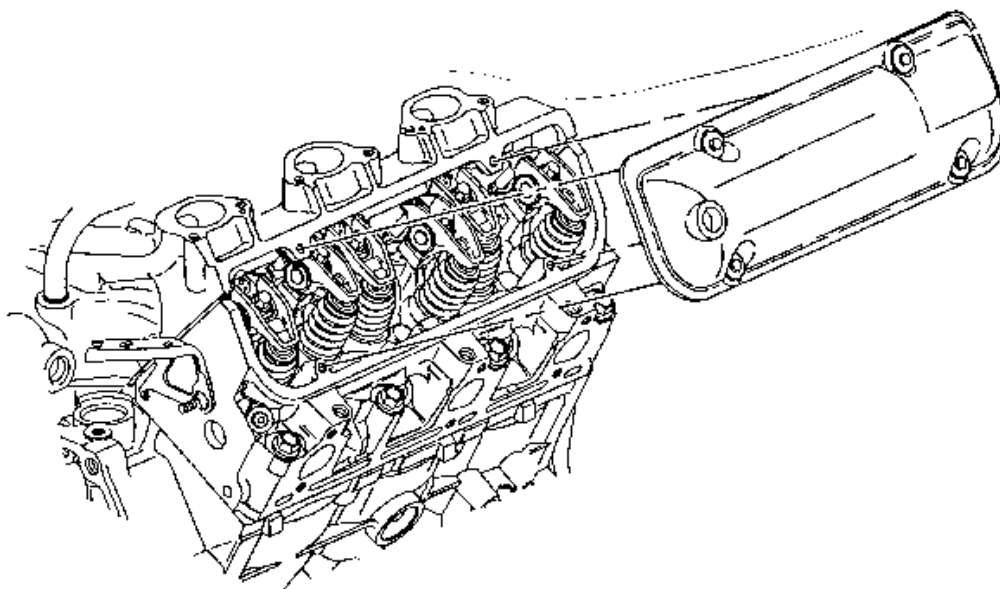


Fig. 220: View Of Valve Rocker Arm Cover - Right
Courtesy of GENERAL MOTORS CORP.

NOTE: Valve rocker arm cover gasket and sealant must be carefully trimmed away from lower intake manifold gasket. Failure to do so will damage the lower intake manifold gasket, causing a severe oil leak.

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 bolts.
5. Remove the valve rocker arm cover.

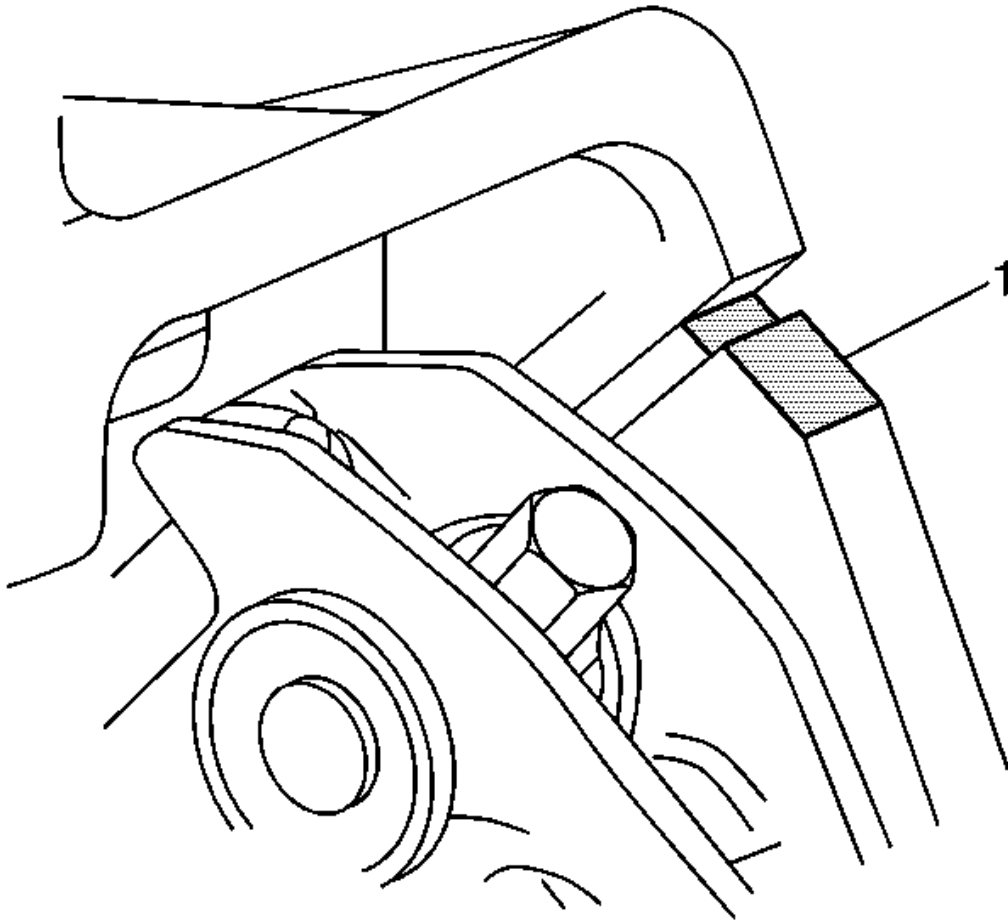


Fig. 221: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

6. Trim valve cover gasket and sealant away from lower intake manifold gasket at the cylinder head to lower intake manifold joints (1).
7. Remove the valve rocker arm cover gasket.

Intake Manifold Removal - Upper

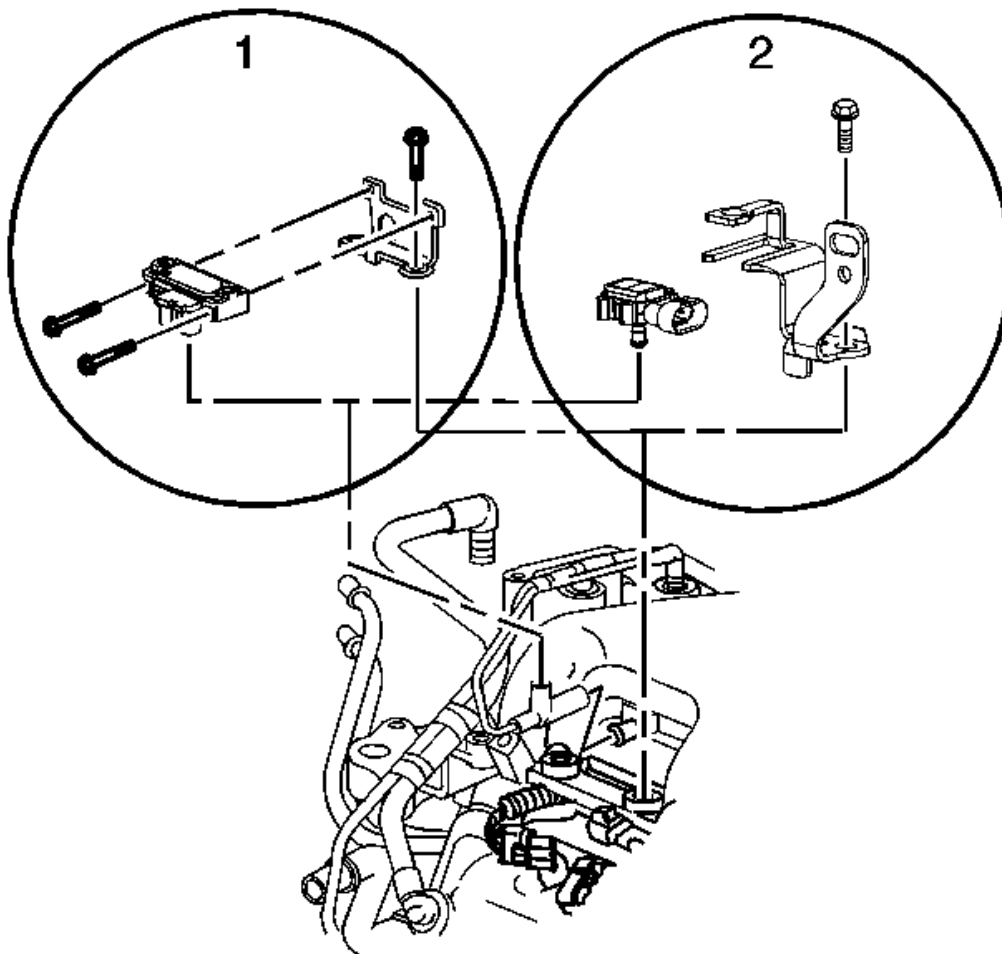


Fig. 222: View Of MAP Sensor & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the manifold absolute pressure (MAP) sensor electrical connector.
2. Remove the MAP sensor bolts (1).
3. Remove the MAP sensor from bracket.
4. Remove the MAP sensor bracket and bracket bolt (1, 2).

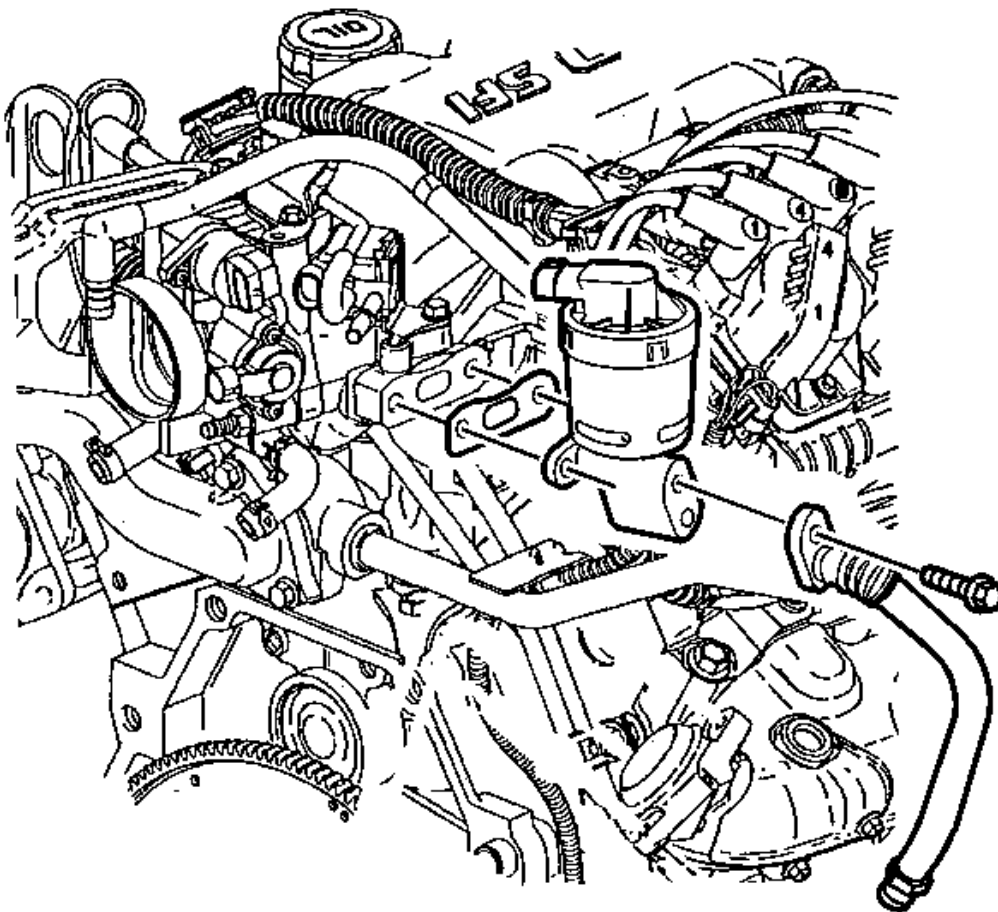


Fig. 223: EGR Valve, Bolt & Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust gas recirculation (EGR) valve pipe and bolt from the EGR valve.
6. Remove the EGR valve bolts.
7. Remove the EGR valve and gasket.

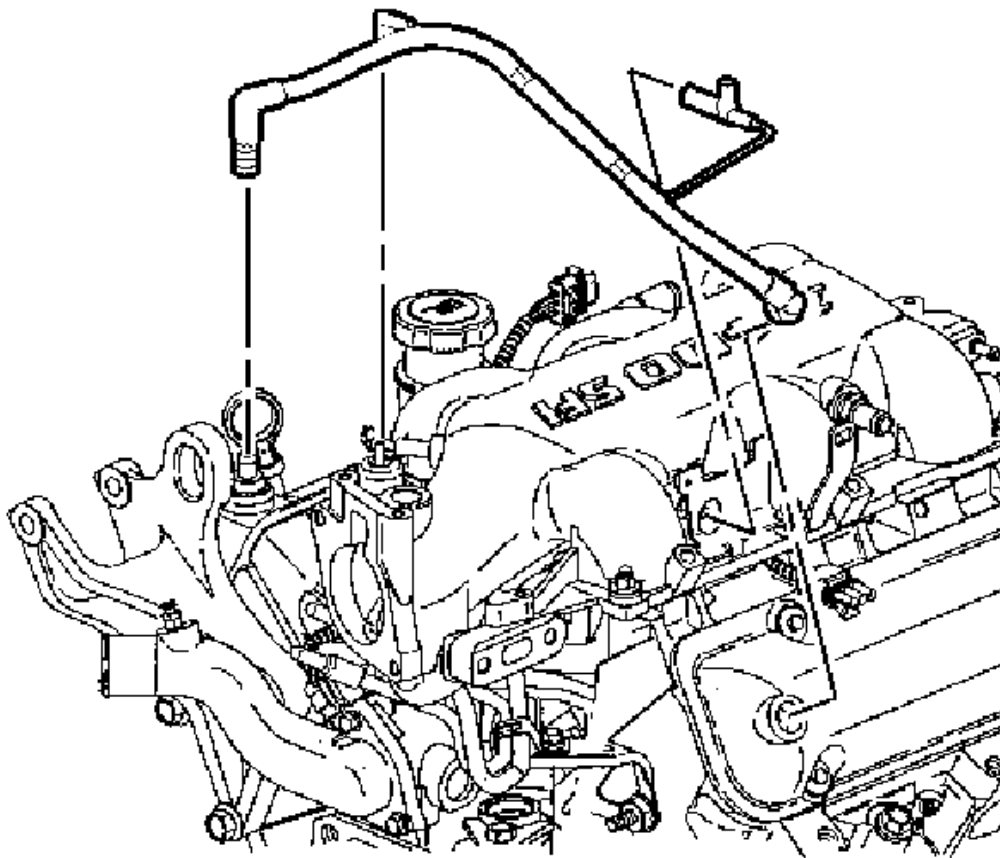


Fig. 224: Vacuum Harness Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the vacuum harness assembly.

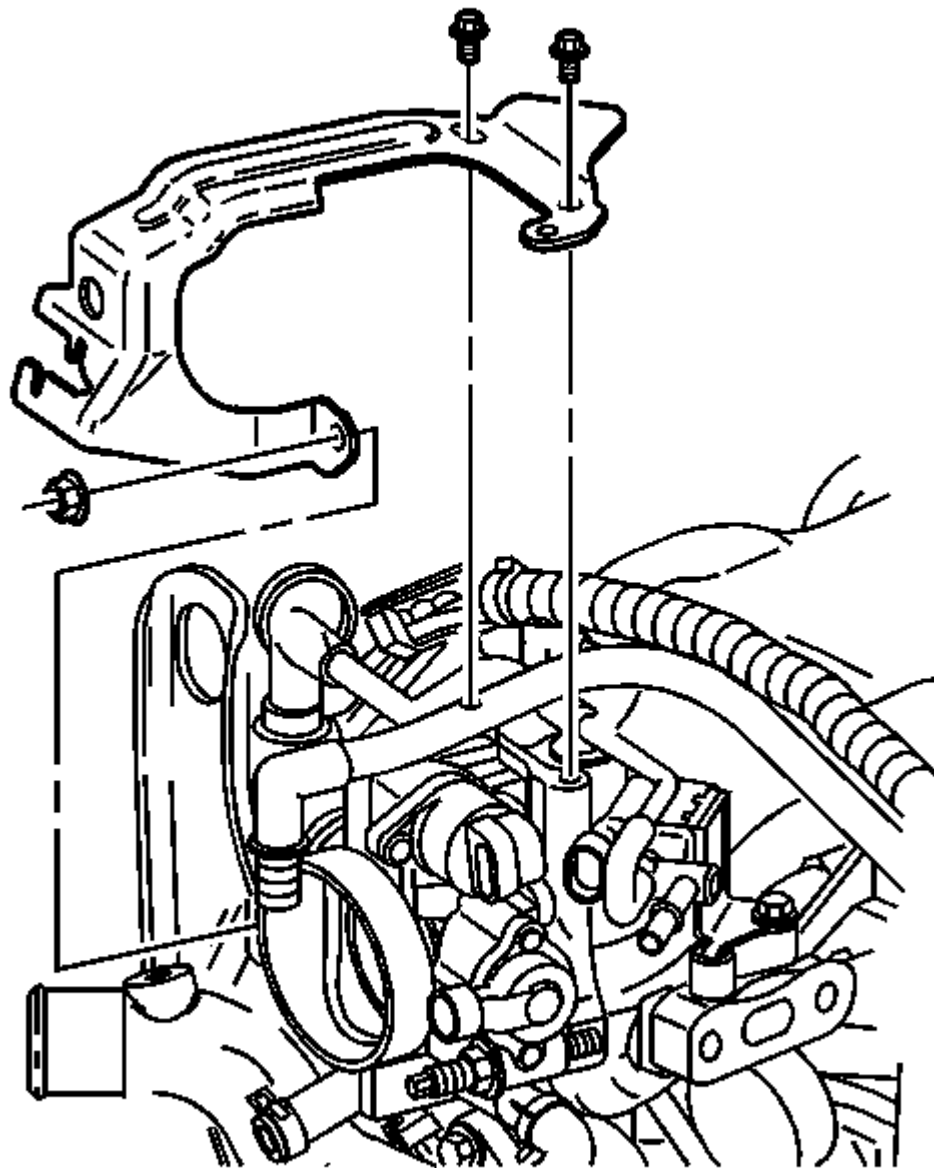


Fig. 225: Accelerator Cable Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the accelerator cable bracket and bracket bolts.

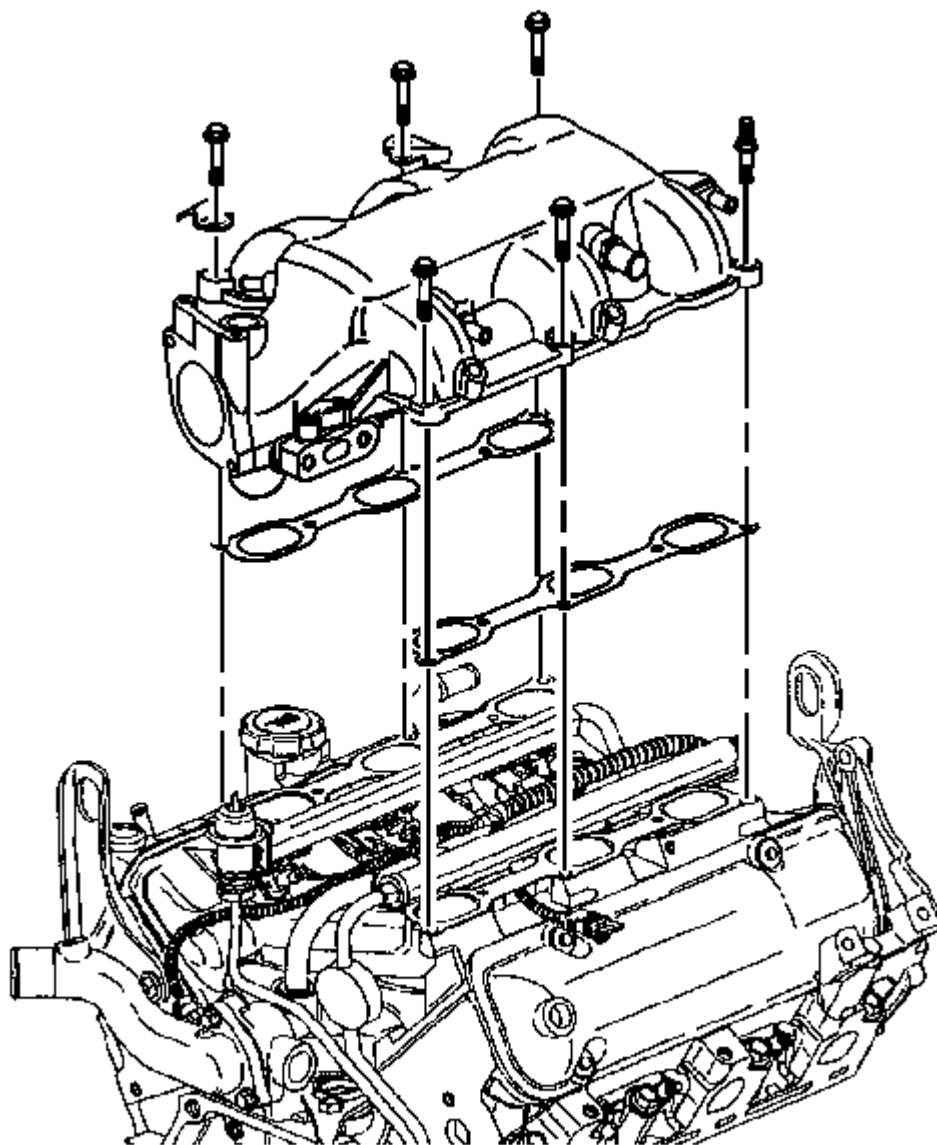


Fig. 226: View Of Upper Intake Manifold & Gaskets
Courtesy of GENERAL MOTORS CORP.

10. Remove the purge valve bracket bolt, hose and valve assembly.
11. Remove the throttle body bolts.
12. Remove the throttle body and gasket.
13. Remove the upper intake manifold bolts.

14. Remove the upper intake manifold and gaskets.

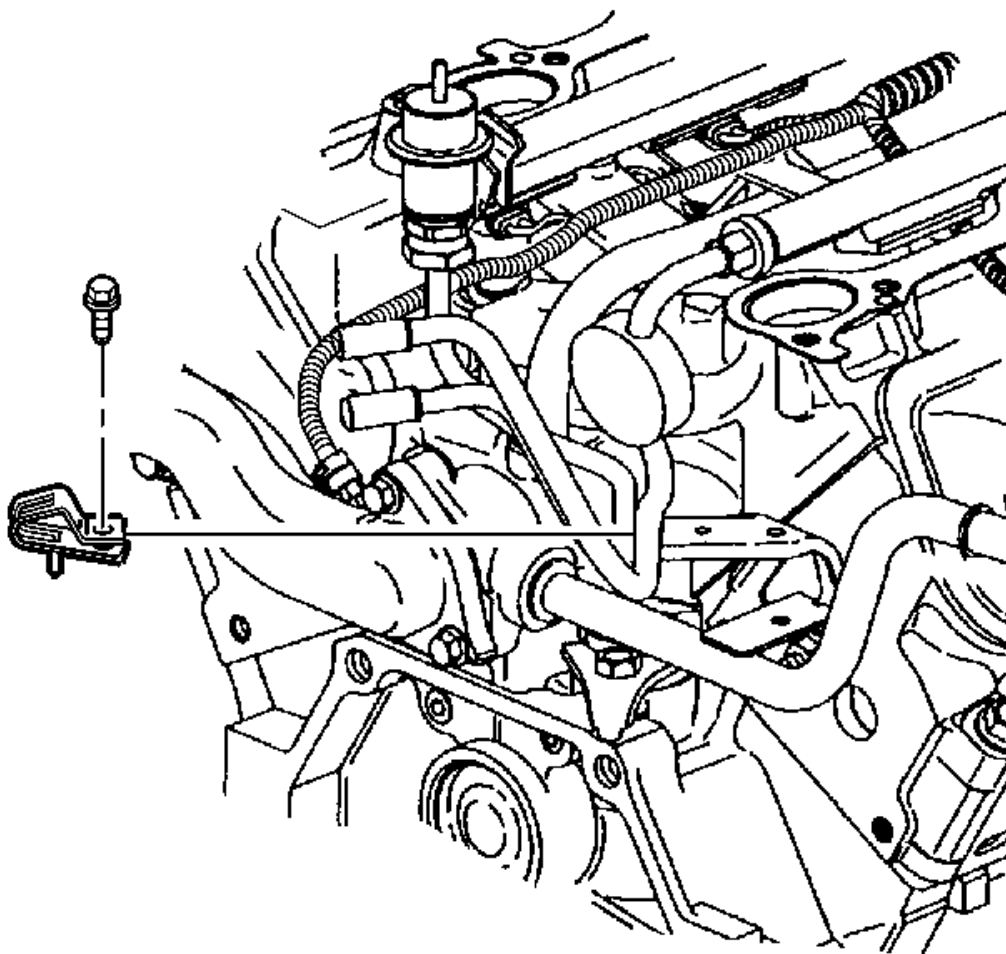
Intake Manifold Removal - Lower

Fig. 227: Fuel Feed & Return Pipe Retaining Clip
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel feed and return pipe retaining clip bolt.
2. Remove the fuel feed and return pipe retaining clip.

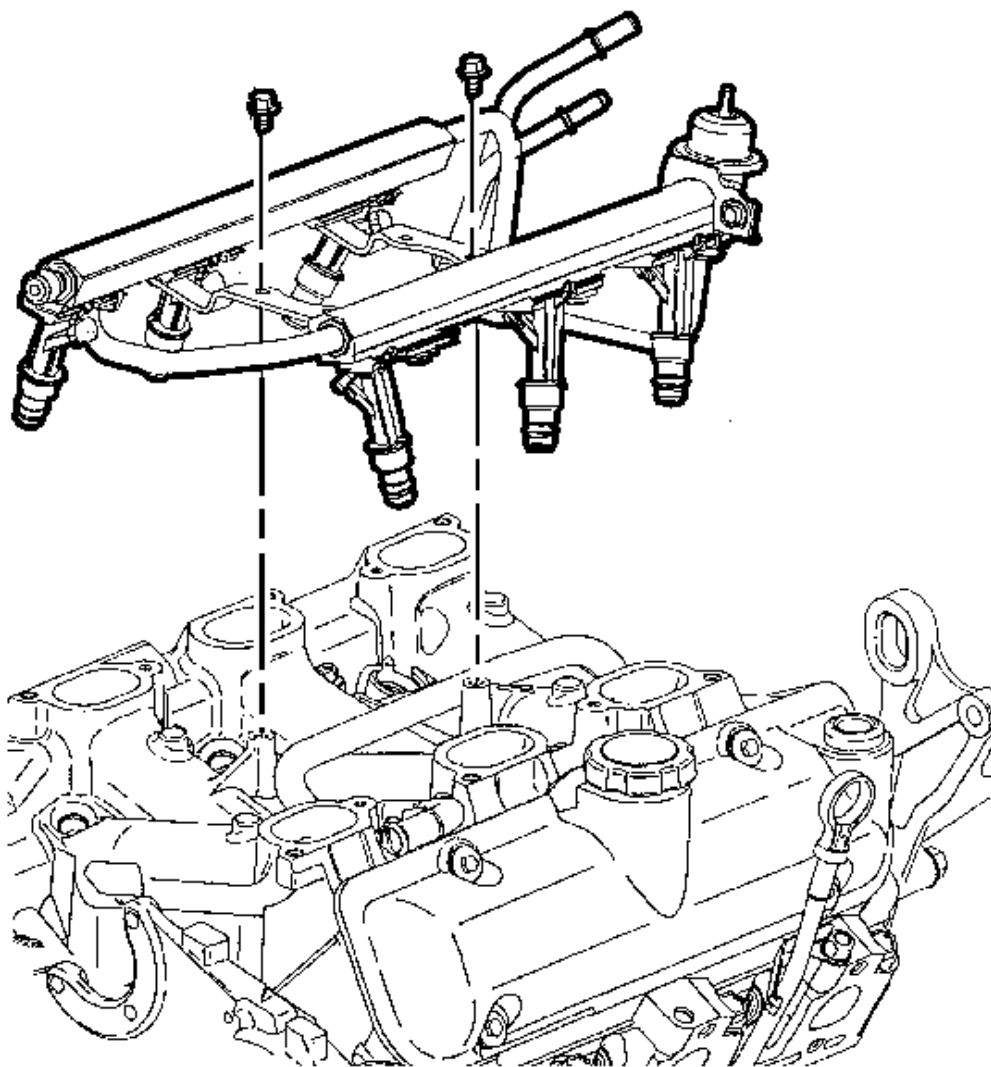


Fig. 228: View Of Fuel Injector Rail Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel injector rail bolts.
4. Remove the fuel injector rail assembly.

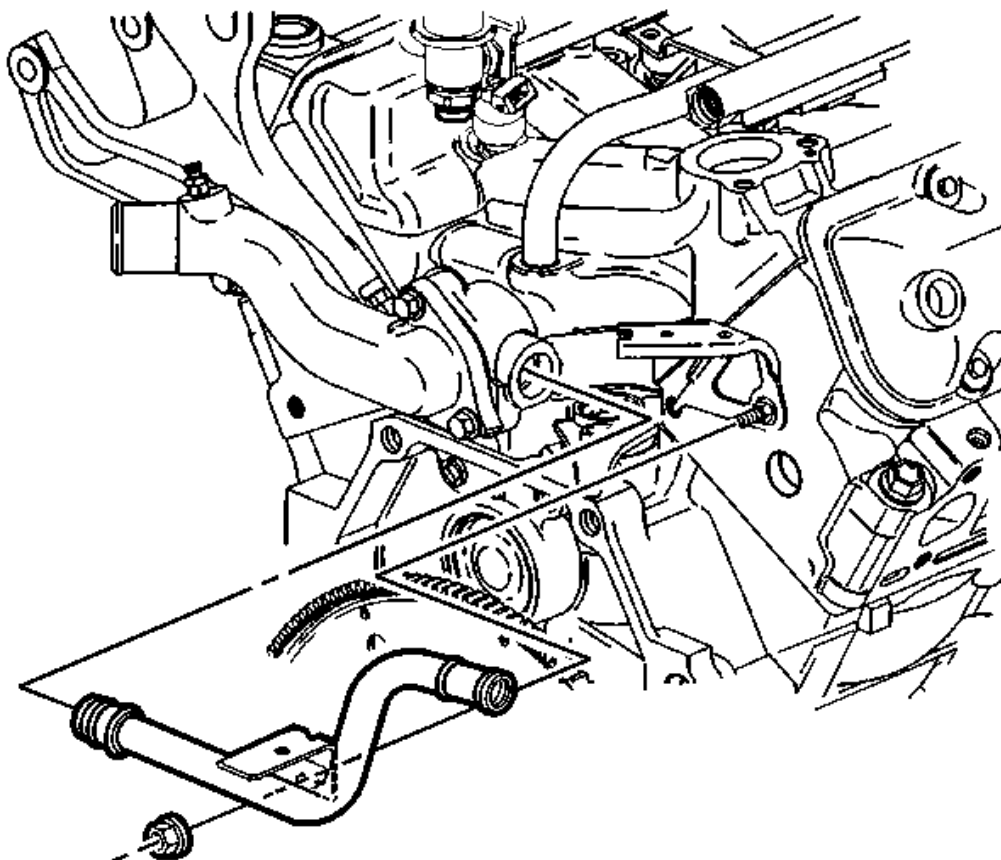


Fig. 229: Heater Inlet Pipe & Nut
Courtesy of GENERAL MOTORS CORP.

5. Remove the heater inlet pipe nut.
6. Remove the heater inlet pipe.

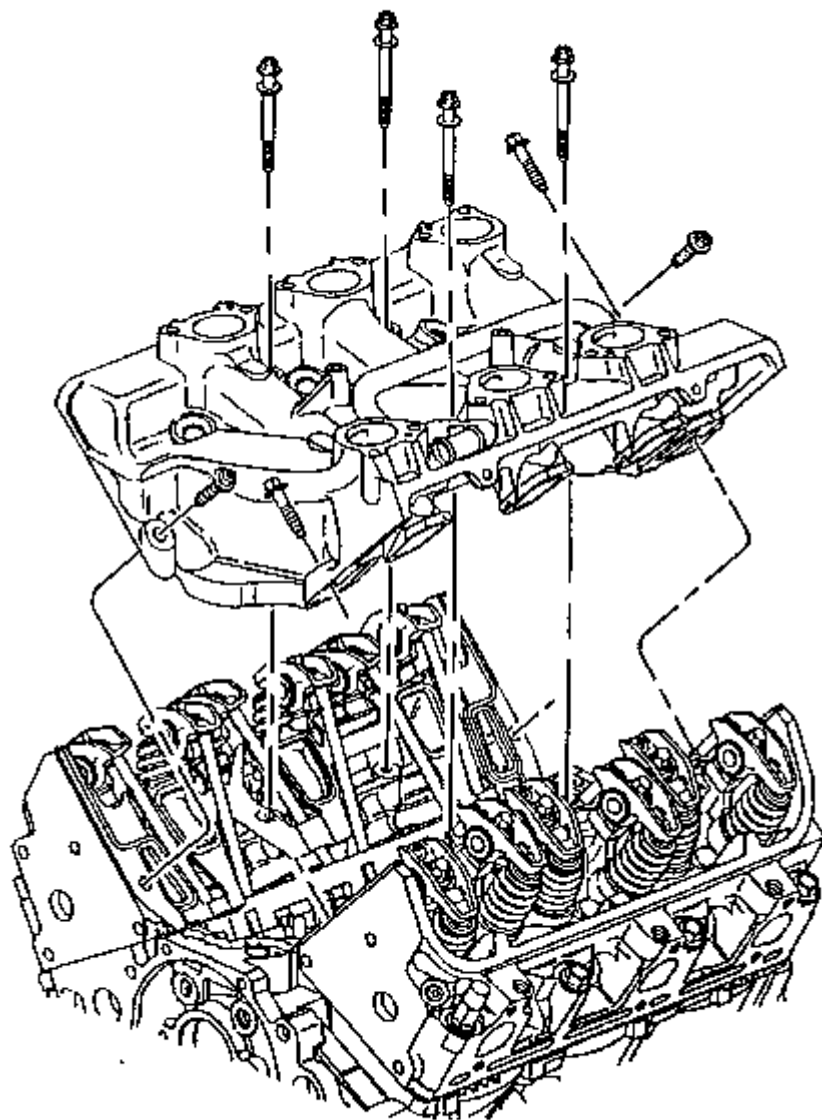


Fig. 230: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the lower intake manifold bolts.
8. Remove the lower intake manifold.

Valve Rocker Arm and Push Rod Removal

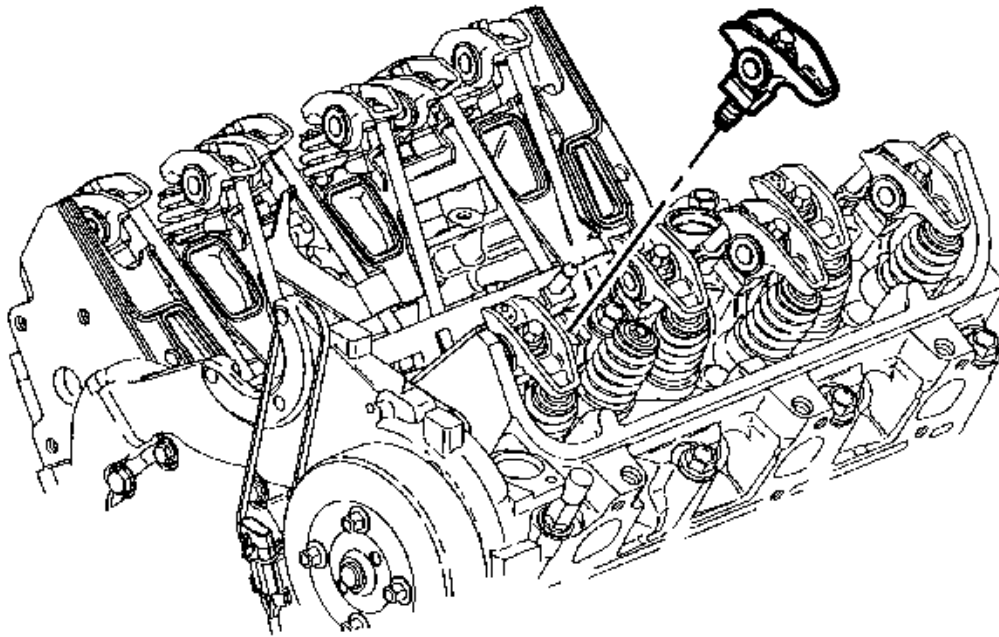


Fig. 231: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

1. Remove 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 were removed.

2. Remove the valve rocker arms.

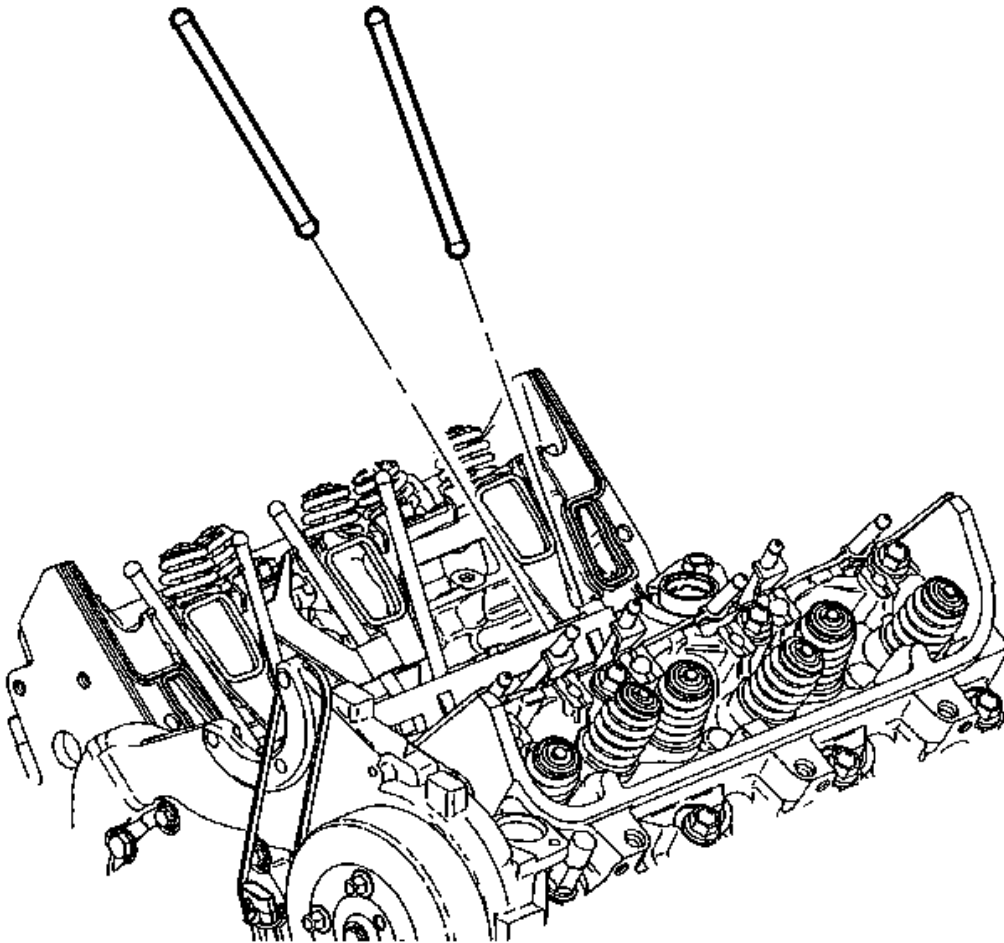


Fig. 232: Removing/Installing Push Rods
Courtesy of GENERAL MOTORS CORP.

3. Remove the push rods.
 - The intake push rods measure 146 mm (5.75 in).
 - The exhaust push rods measure 152.51 mm (6.0 in).

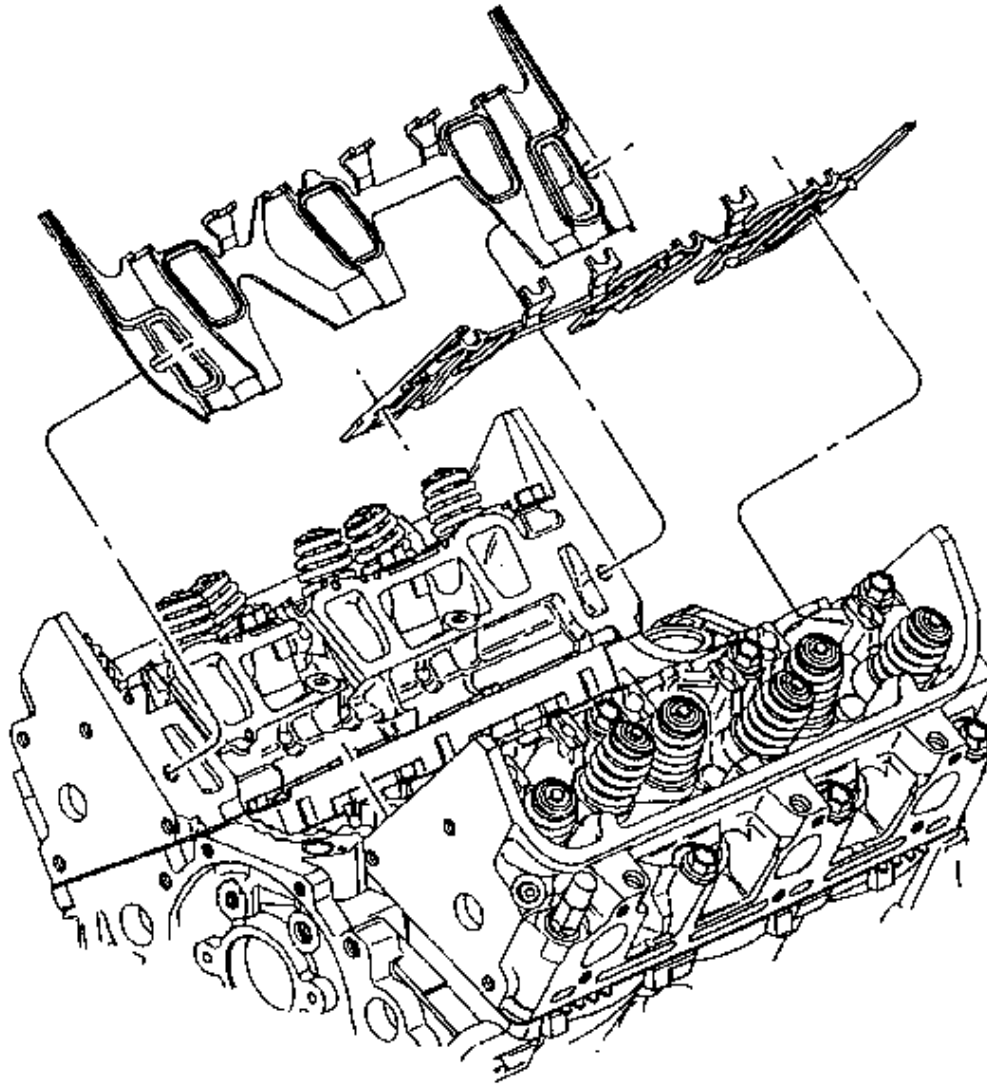


Fig. 233: Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold gaskets.

Valve Lifter Removal

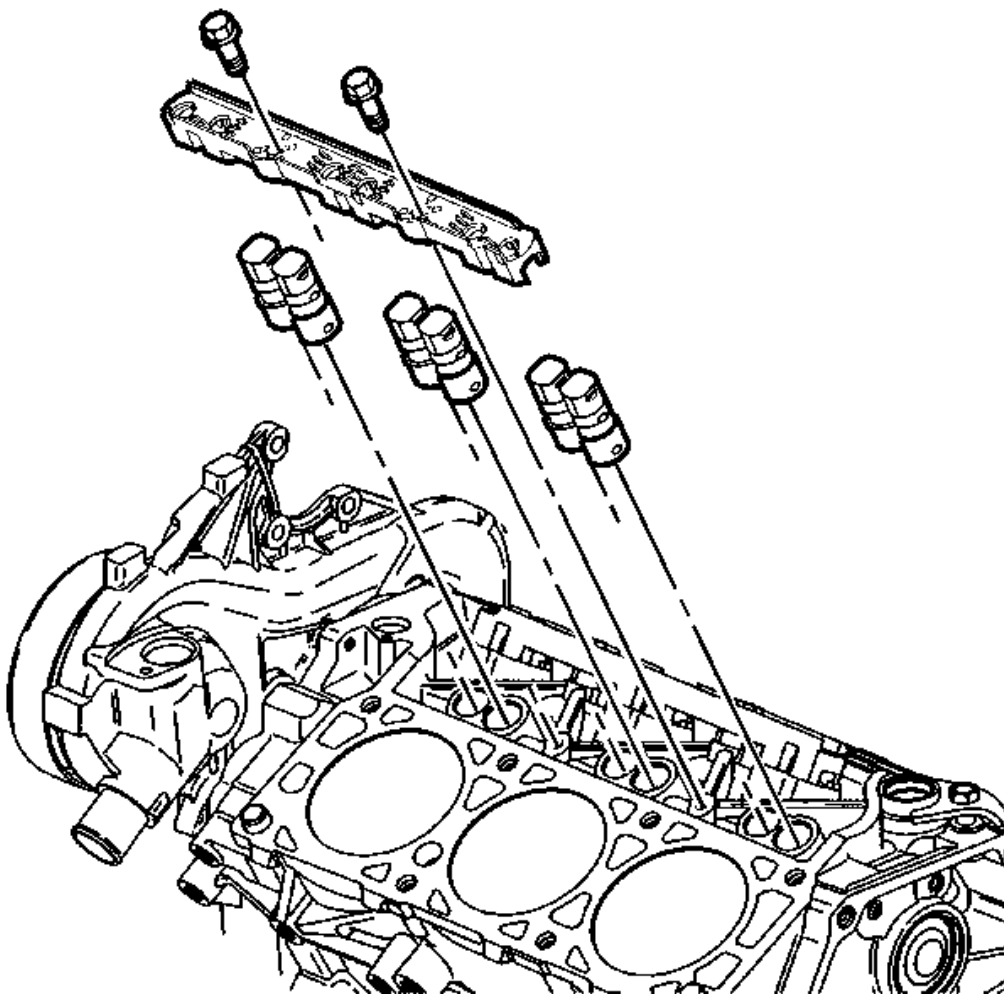


Fig. 234: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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

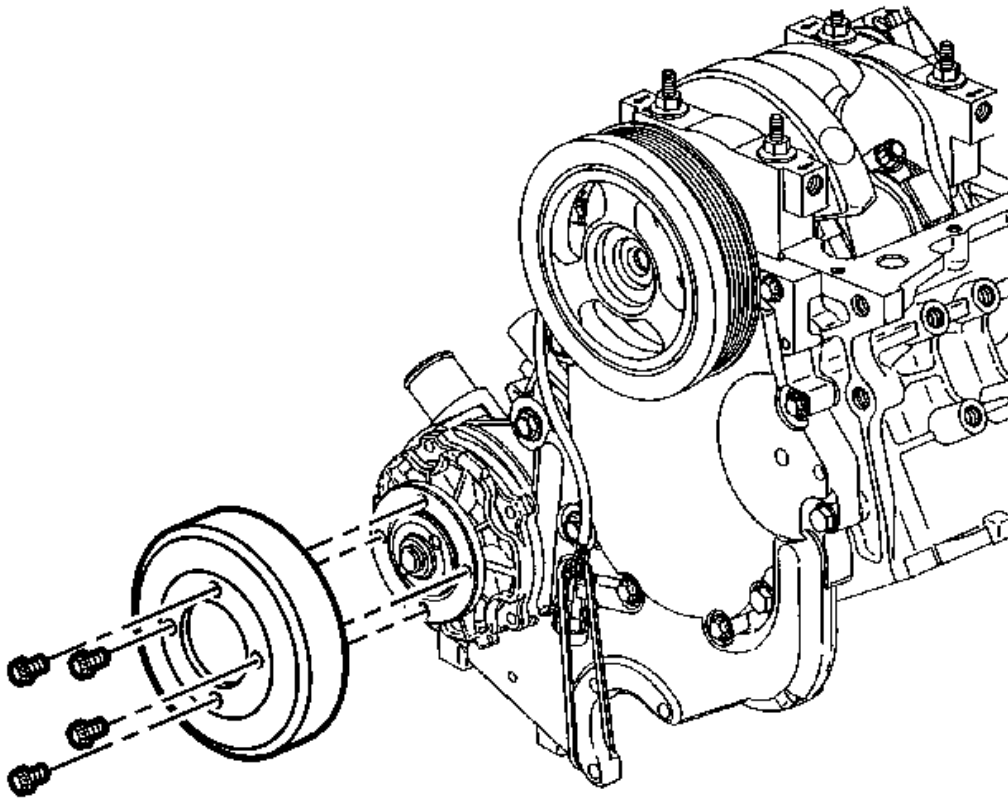


Fig. 235: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump pulley bolts.
2. Remove the water pump pulley.

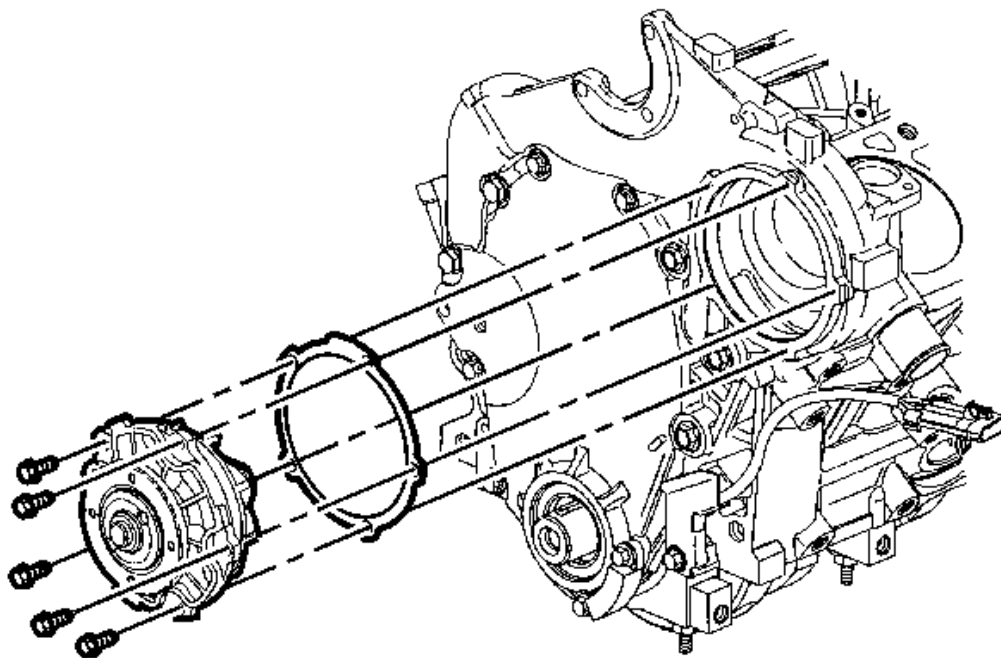


Fig. 236: View Of Water Pump Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gasket.

Cylinder Head Removal - Left

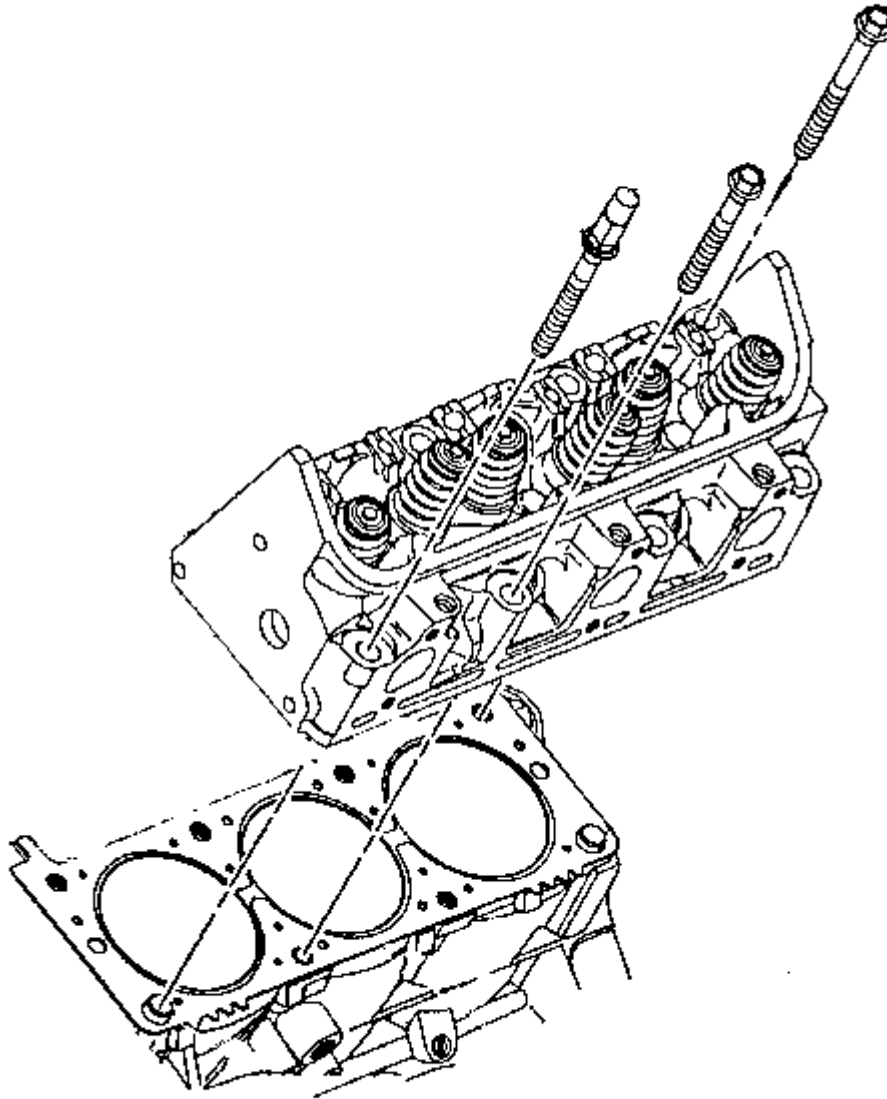


Fig. 237: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts and discard.
2. Remove the cylinder head.

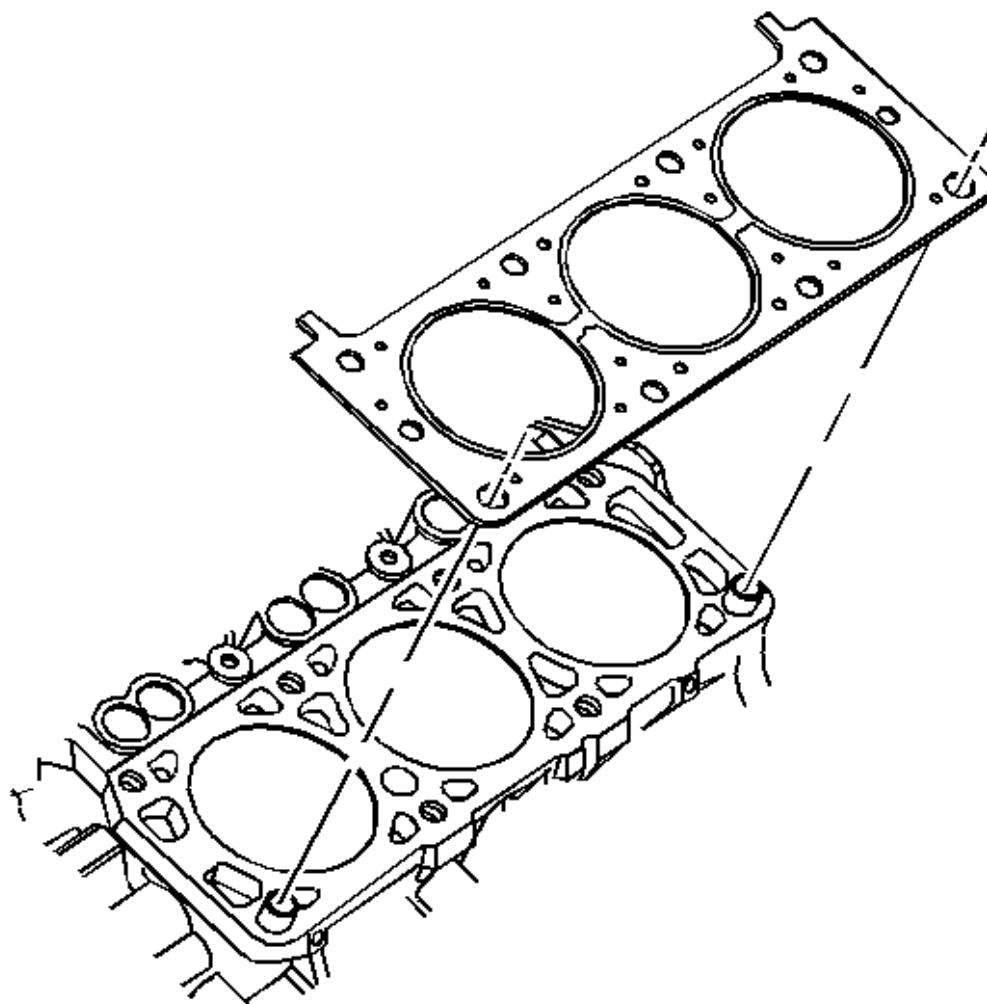


Fig. 238: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Remove the cylinder head locator dowel pins if required.

Cylinder Head Removal - Right

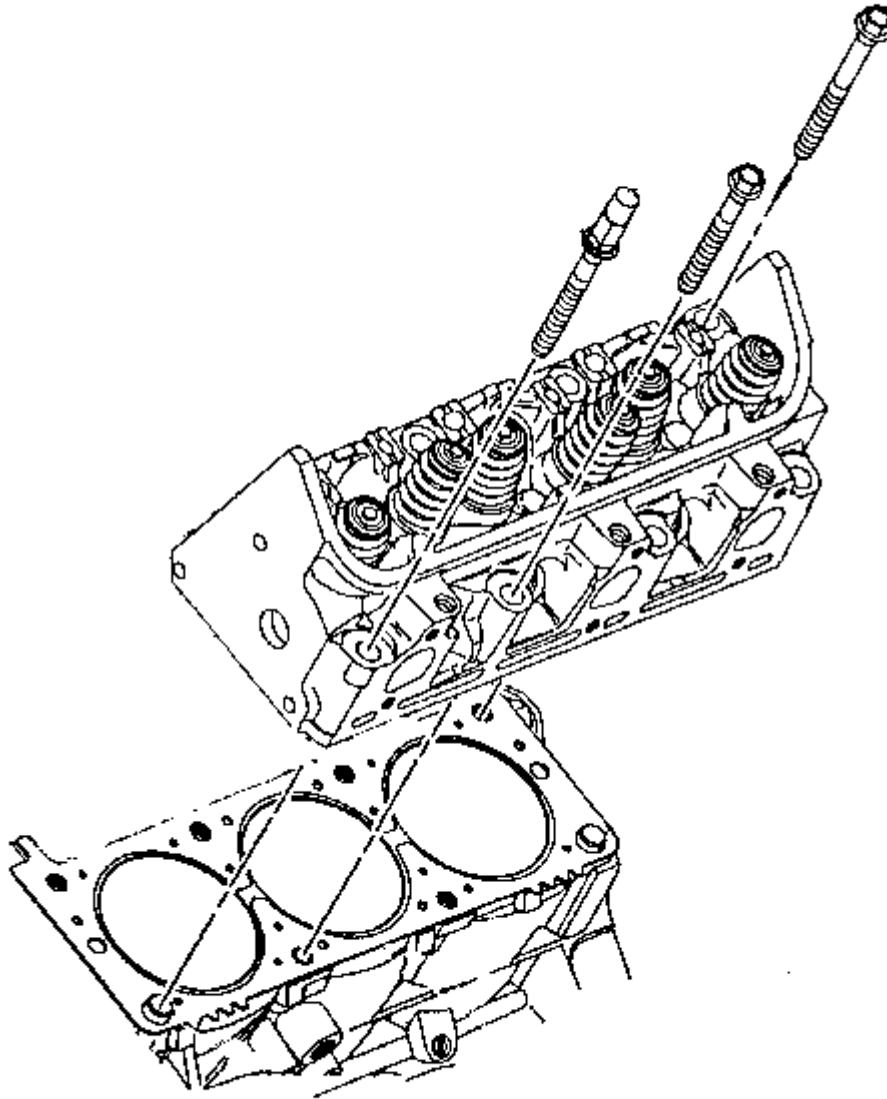


Fig. 239: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts and discard.
2. Remove the cylinder head.

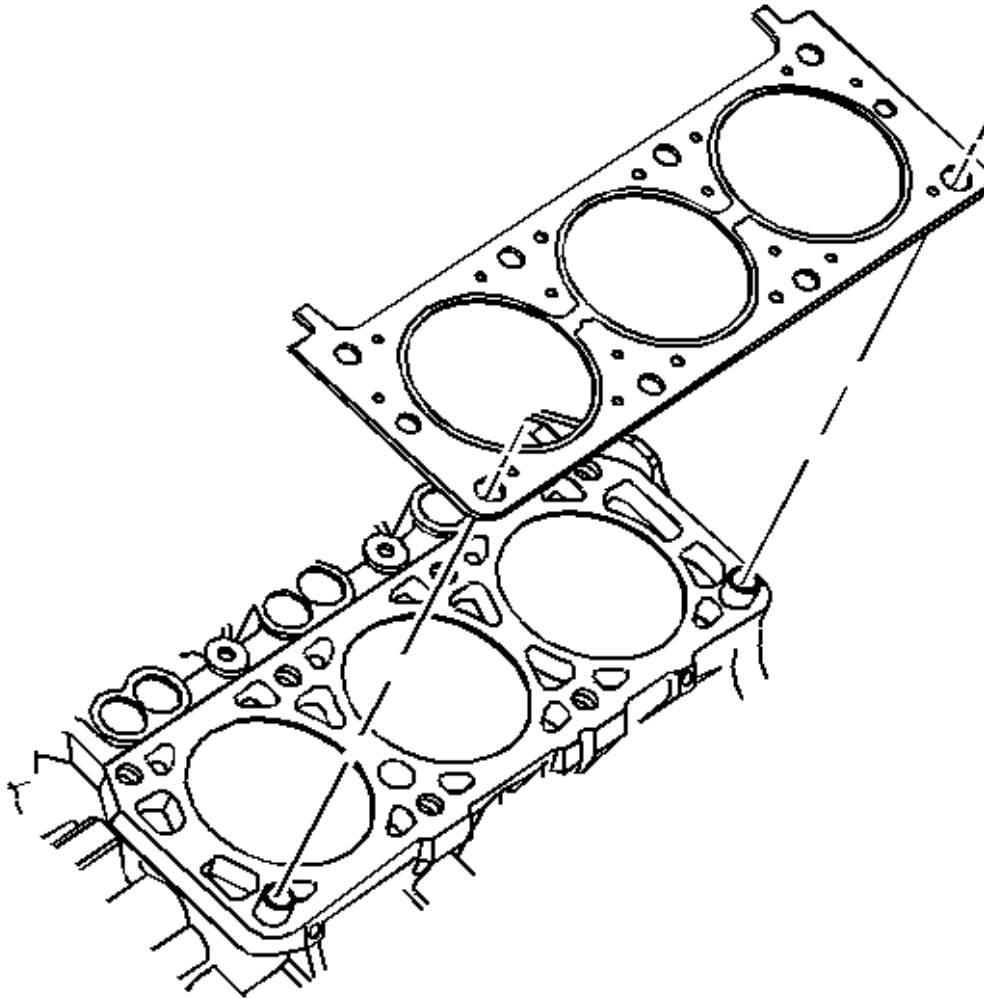


Fig. 240: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Remove the cylinder head locator dowel pins if required.

Oil Pan Removal

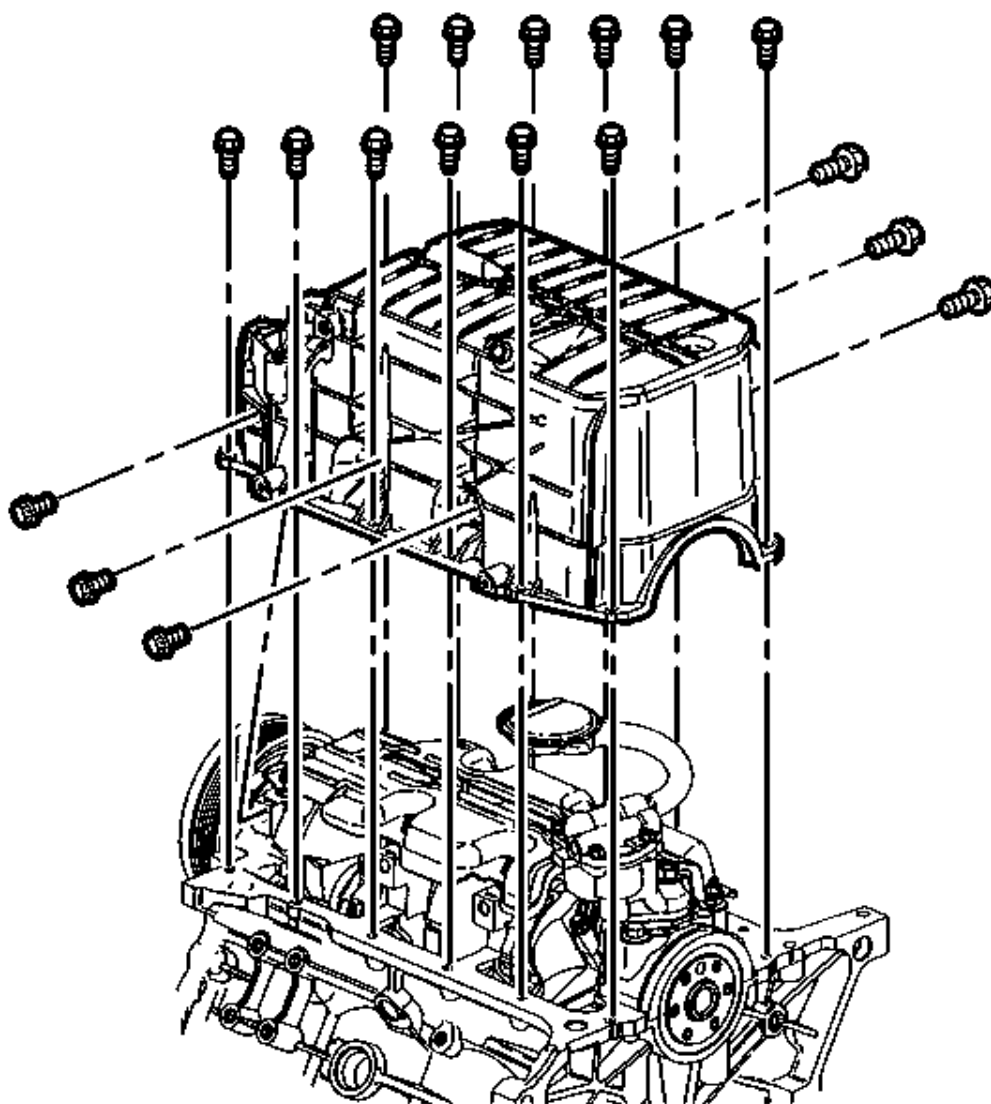


Fig. 241: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan side bolts.
2. Remove the oil pan bolts.
3. Remove the oil pan.
4. Remove the oil pan gasket.

Oil Pump Removal

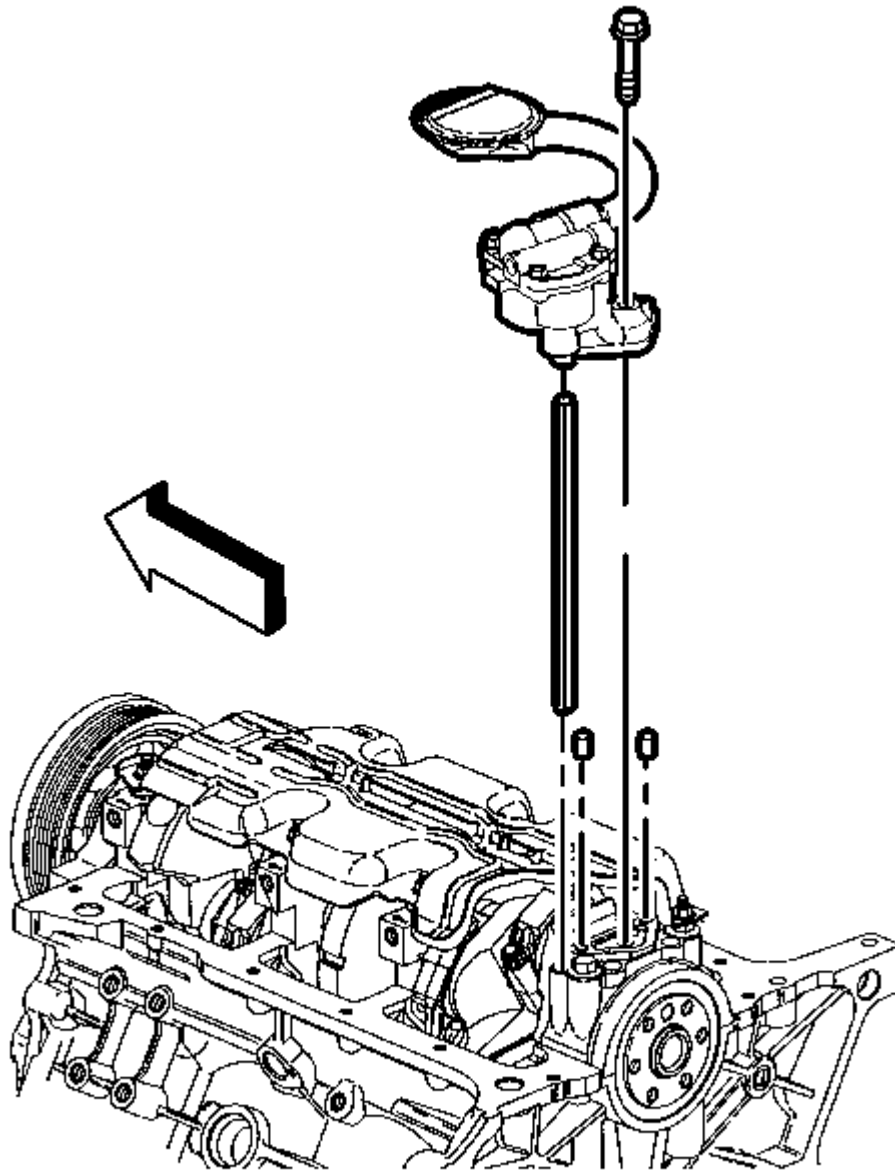


Fig. 242: Removing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolt.
2. Remove the oil pump and oil pump drive shaft.

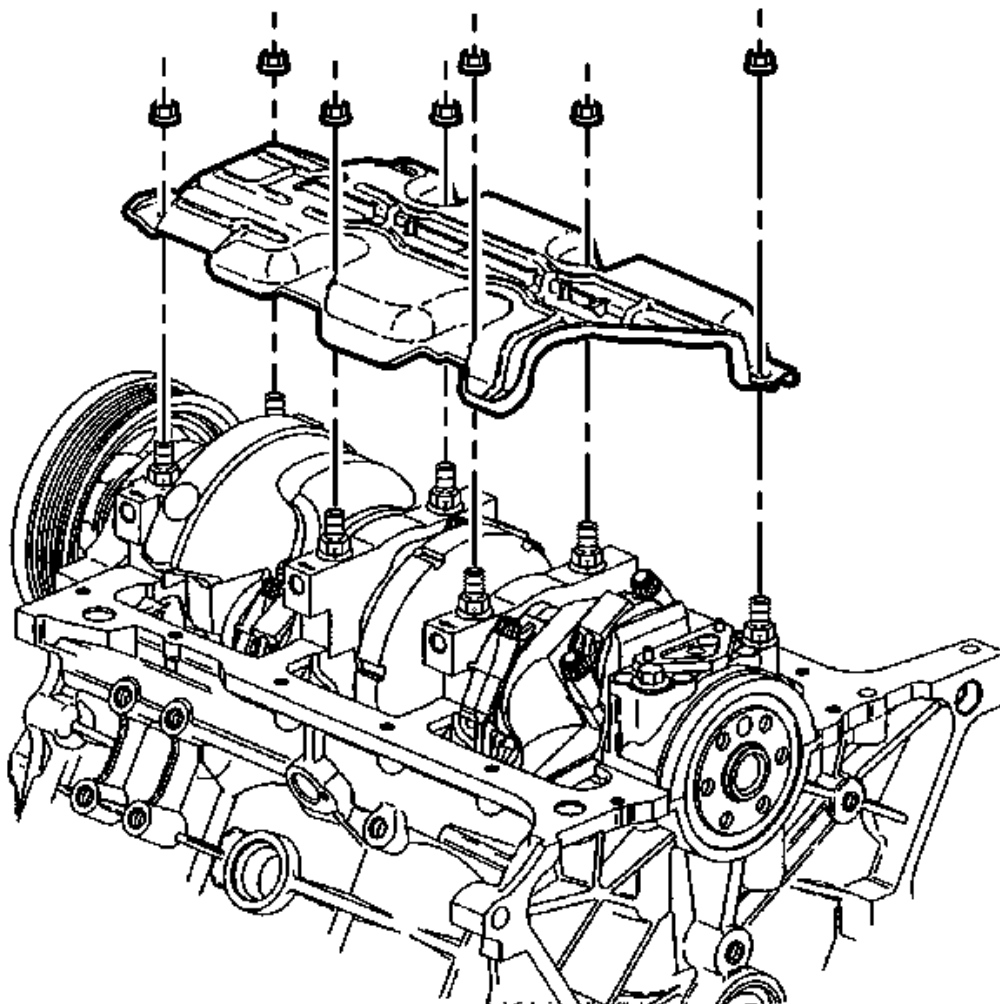


Fig. 243: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft oil deflector nuts.
4. Remove the crankshaft oil deflector.

Oil Pump Drive Removal

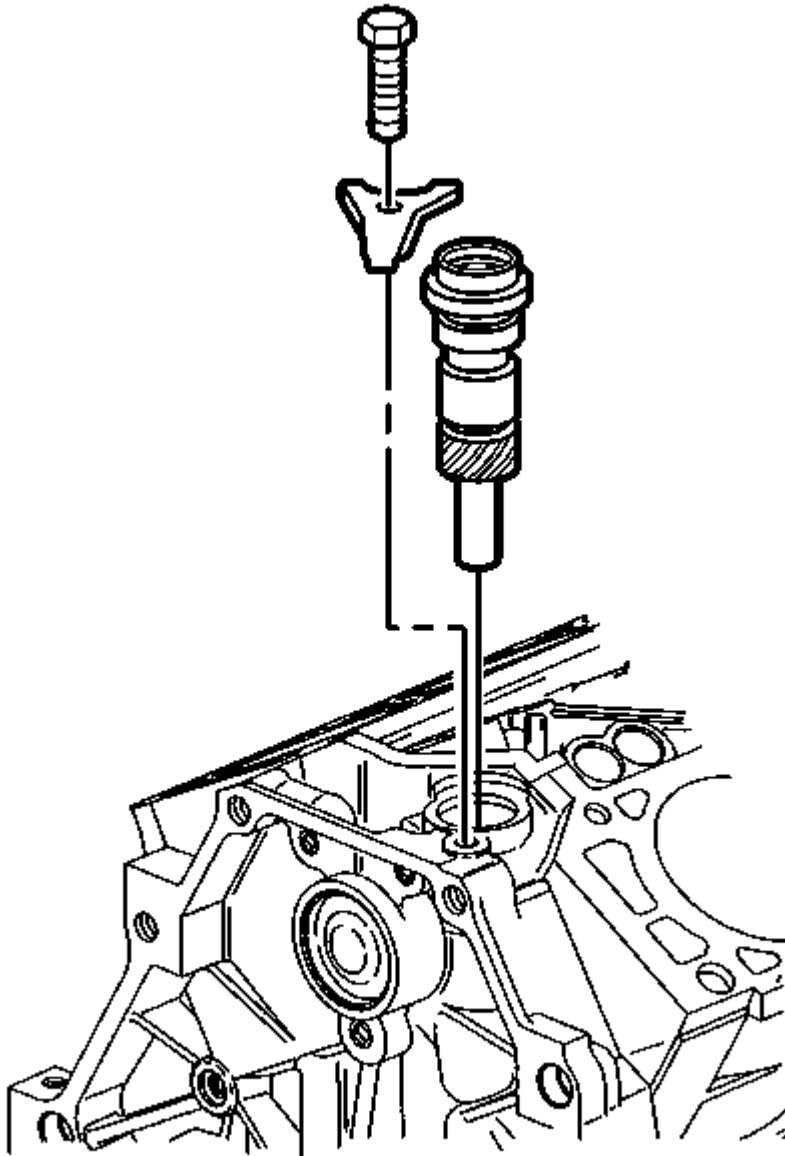


Fig. 244: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump drive clamp bolt.
2. Remove the oil pump drive clamp.
3. Remove the oil pump drive.

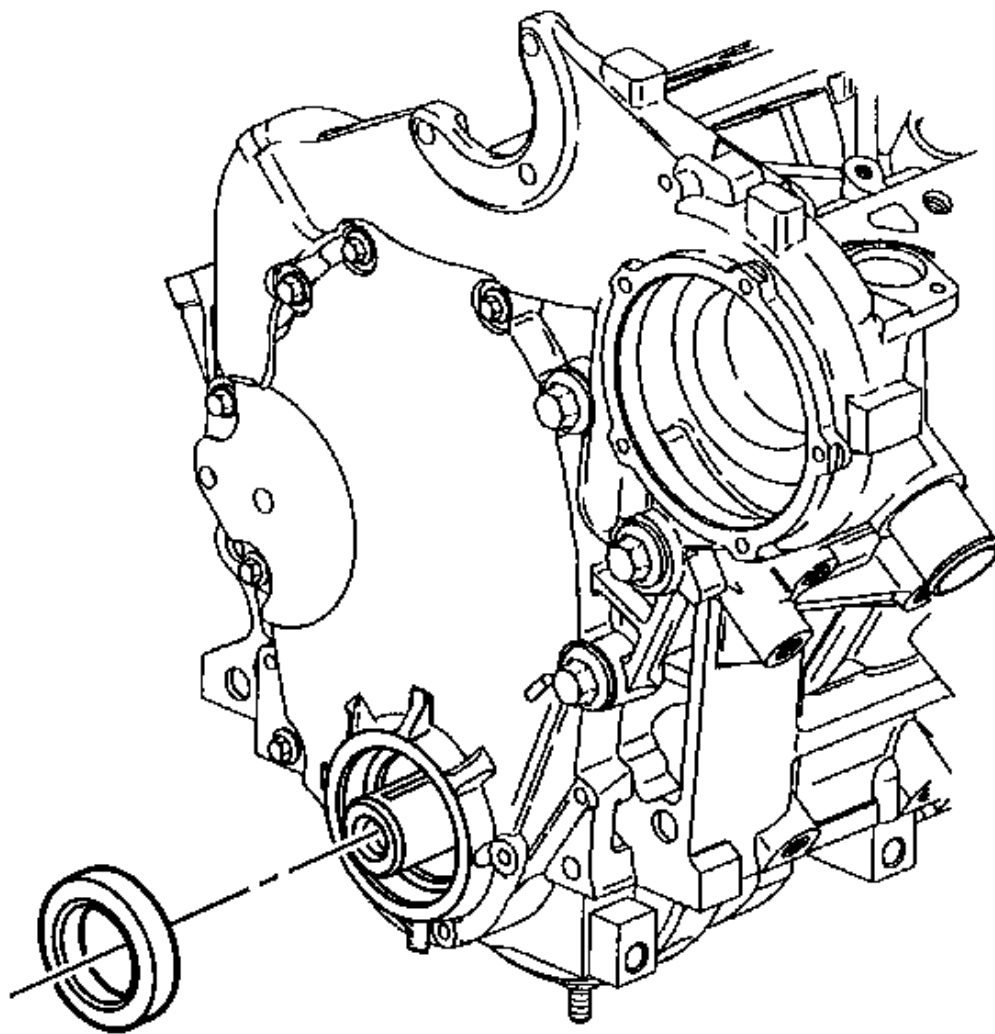
Crankshaft Front Oil Seal Removal

Fig. 245: Removing 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

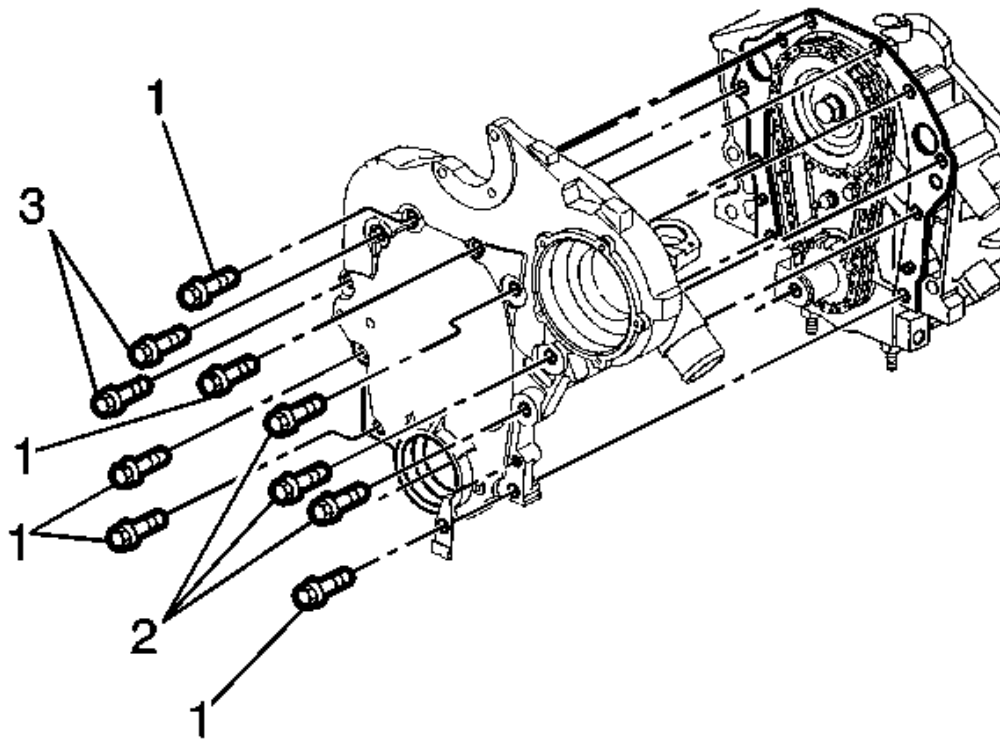


Fig. 246: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover bolts (1, 2, 3).
2. Remove the engine front cover.
3. Remove the engine front cover gasket.

Timing Chain and Sprockets Removal

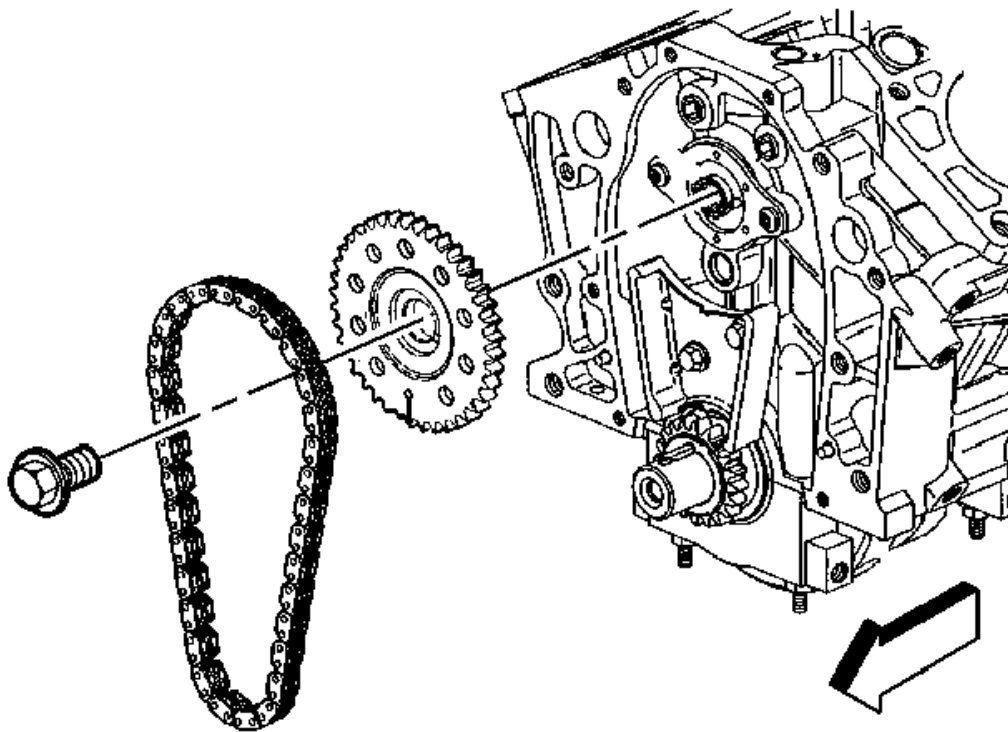


Fig. 247: View Of Timing Chain & Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft sprocket bolt.
2. Remove the camshaft sprocket and timing chain.

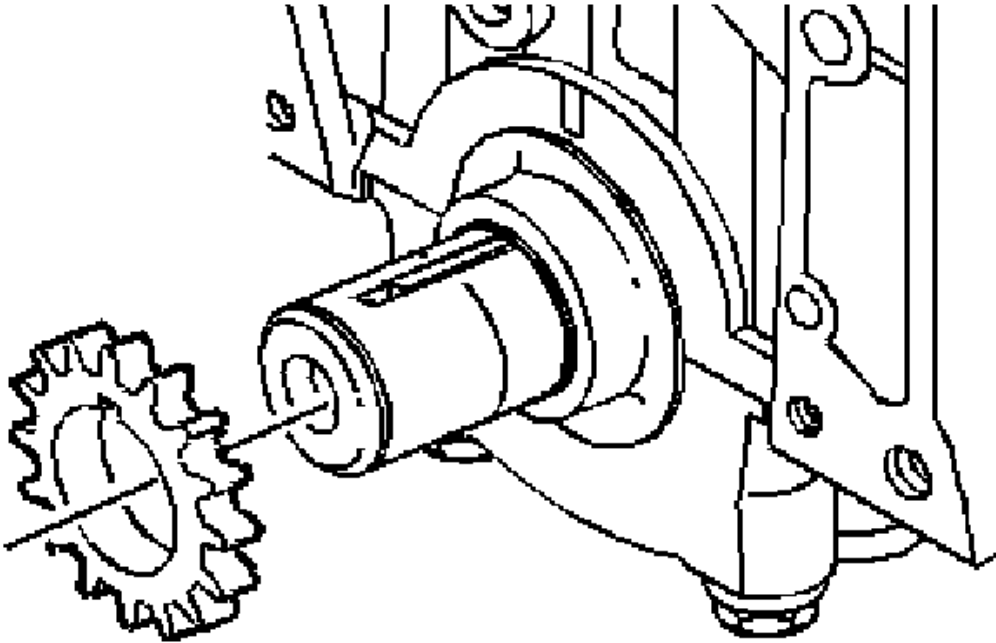


Fig. 248: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft sprocket.

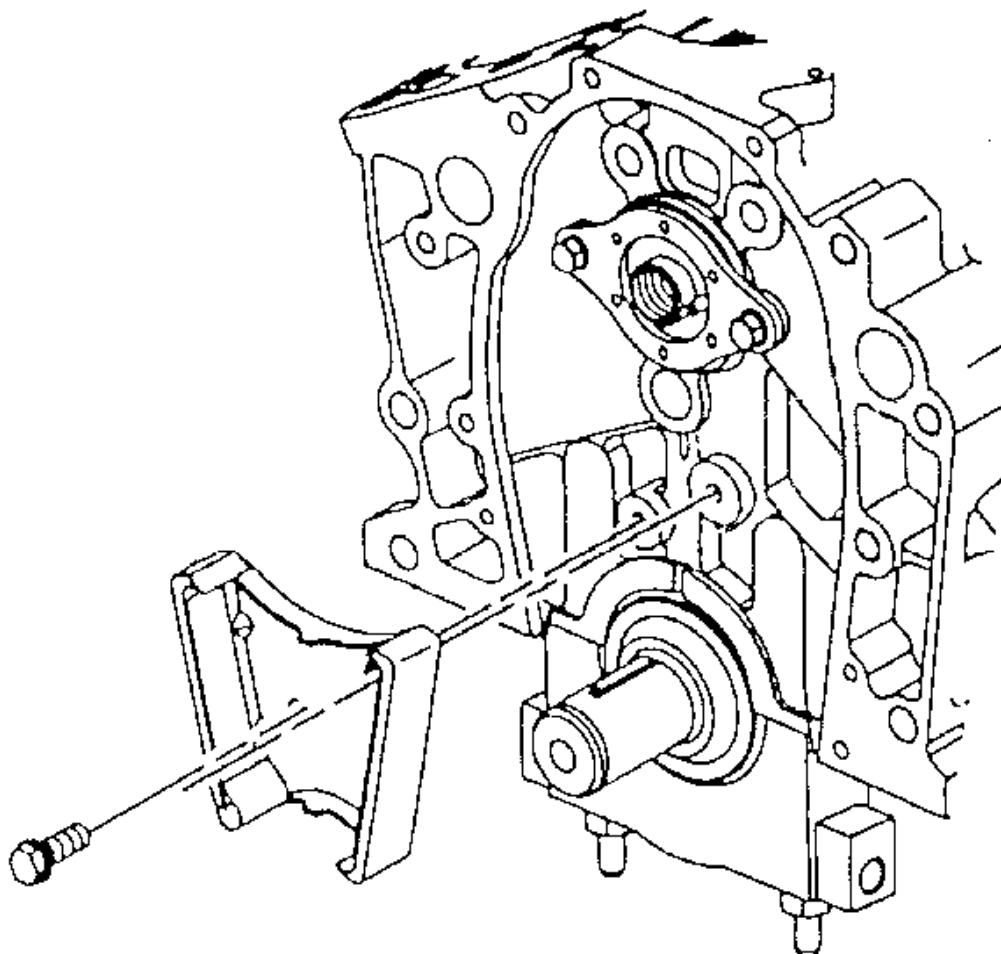


Fig. 249: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain dampener bolts.
5. Remove the timing chain dampener.

Camshaft Removal

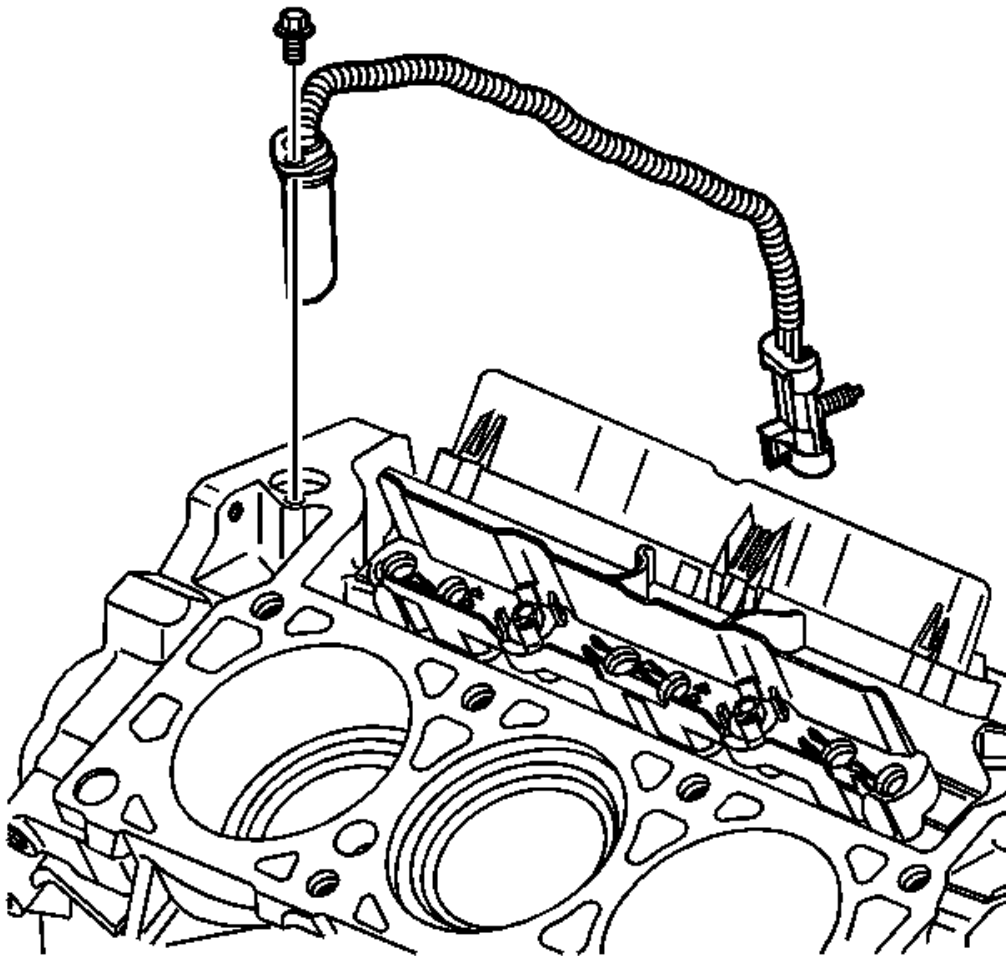


Fig. 250: Camshaft Position Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position sensor and sensor bolt.

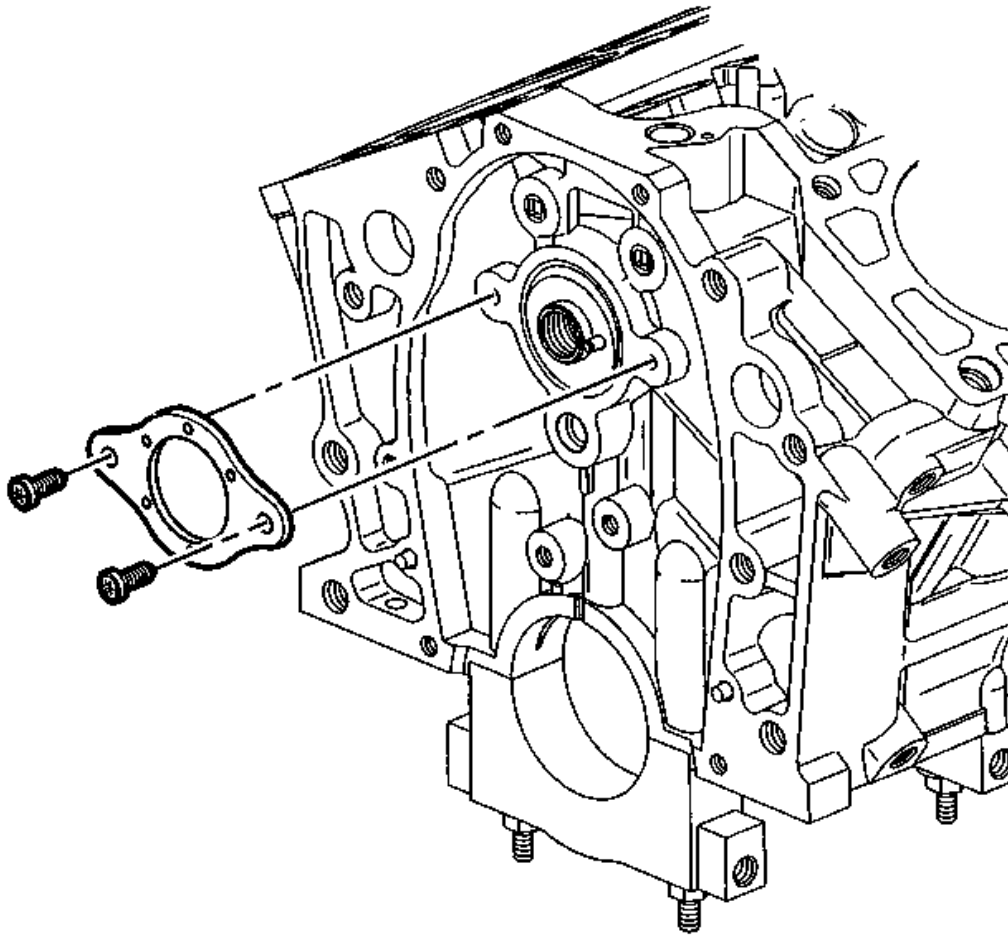


Fig. 251: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft thrust plate screws.
3. Remove the camshaft thrust plate.

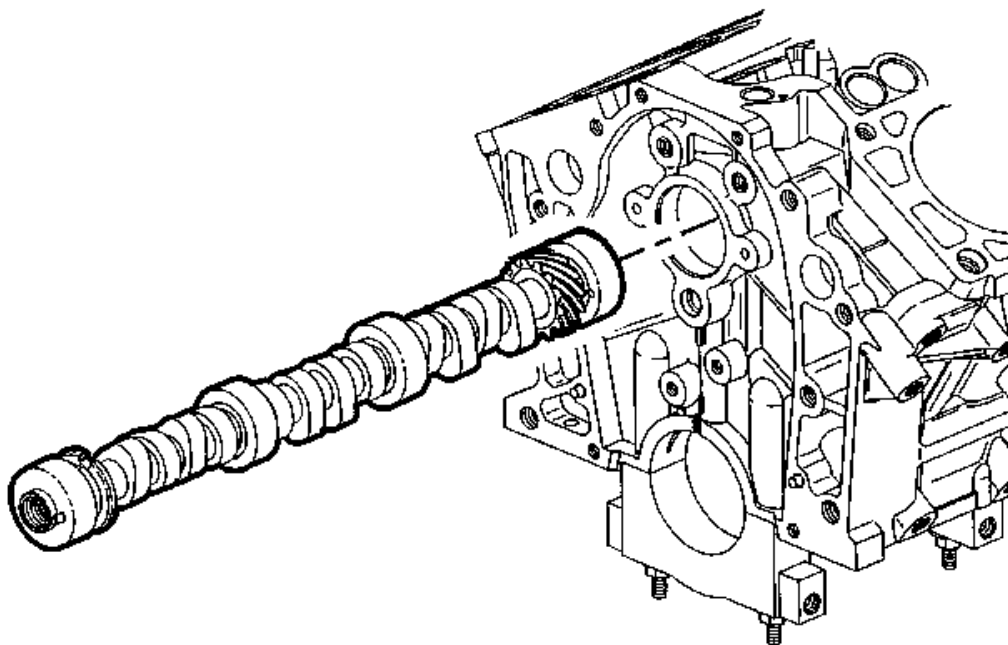


Fig. 252: View Of Camshaft

Courtesy of GENERAL MOTORS CORP.

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

4. Complete the following steps in order to remove the camshaft:
 1. Install a large screwdriver in the camshaft bolt hole. Do not damage the threads.
 2. Carefully rotate and pull the camshaft out of the camshaft bearings.

Piston, Connecting Rod, and Bearing Removal

Tools Required

- **J 24270** Ridge Reamer. See **Special Tools and Equipment**.
- **J 5239** Connecting Rod Bolt Guide. See **Special Tools and Equipment**.

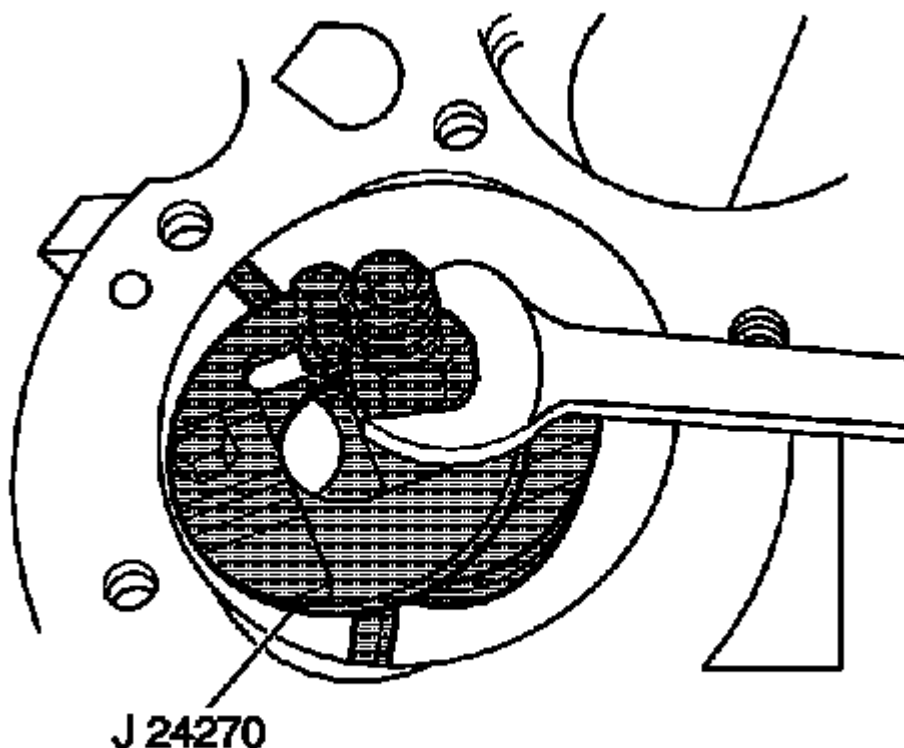


Fig. 253: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

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 and Equipment.

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.

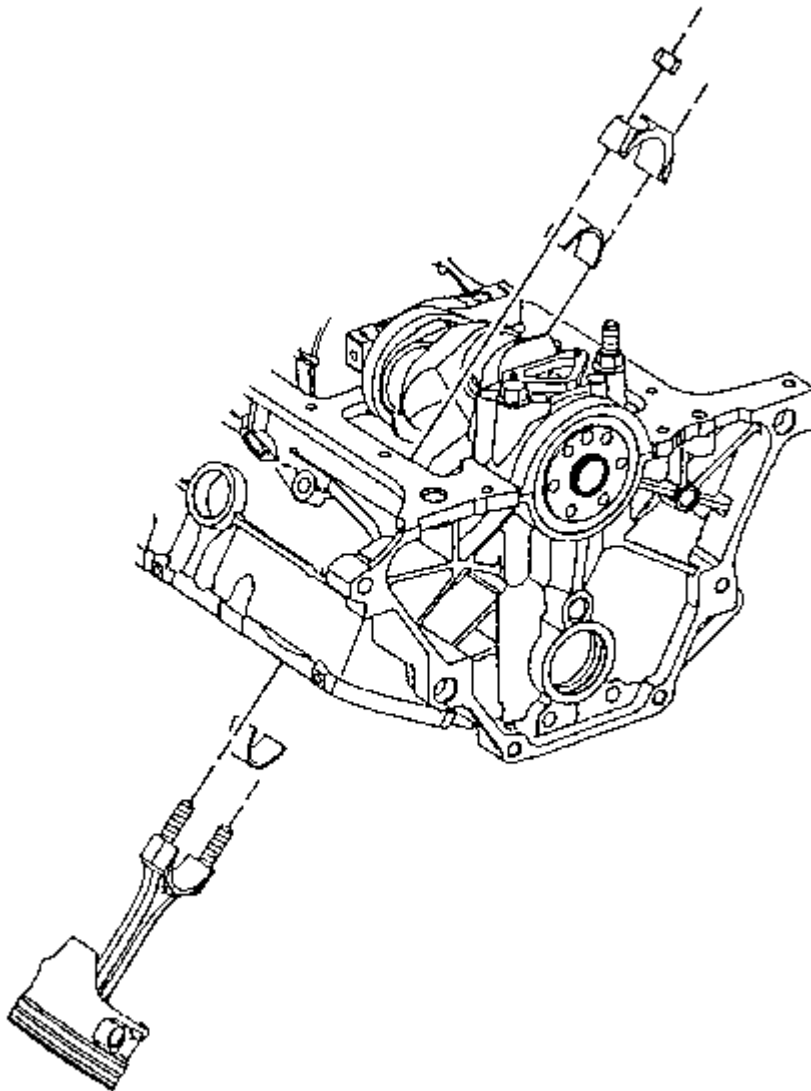


Fig. 254: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the connecting rod nuts and cap.
5. Remove the connecting rod cap and bearing half.

NOTE: Install thread protector in order to avoid damage to the crankshaft journal.

6. Install **J 5239** onto the connecting rod bolts. See Special Tools and Equipment.
7. Remove the connecting rod and piston assembly.
8. Push out the assembly using a suitable tool.

Crankshaft Rear Oil Seal Removal

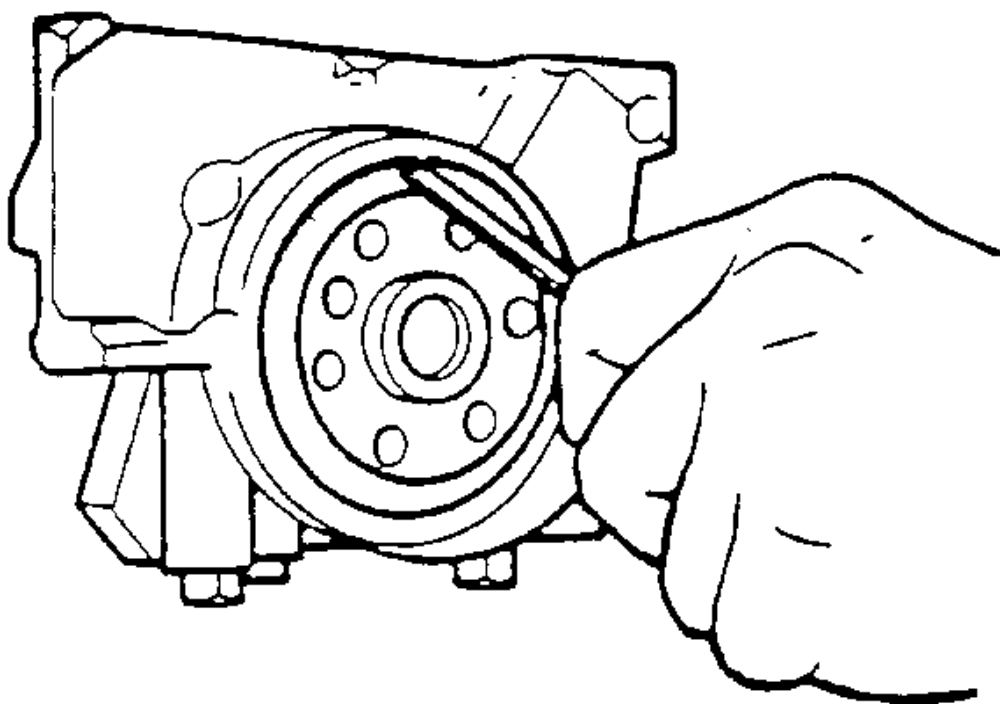


Fig. 255: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal.

IMPORTANT: Do not damage the crankshaft or seal bore.

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

Crankshaft and Bearings Removal

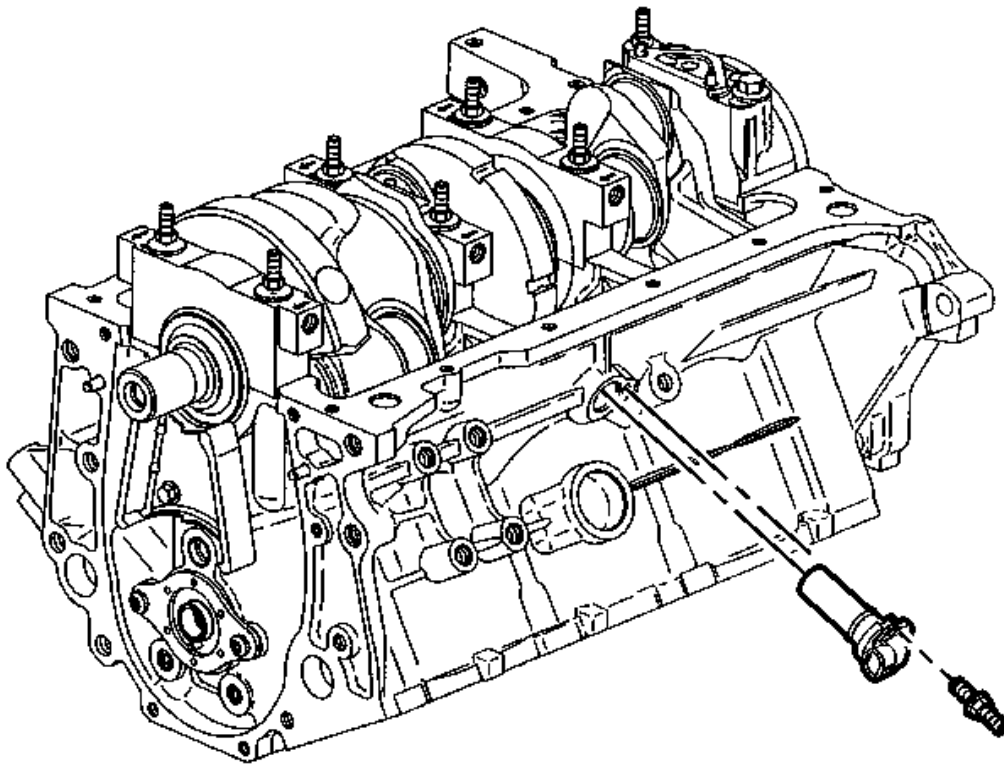


Fig. 256: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

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.

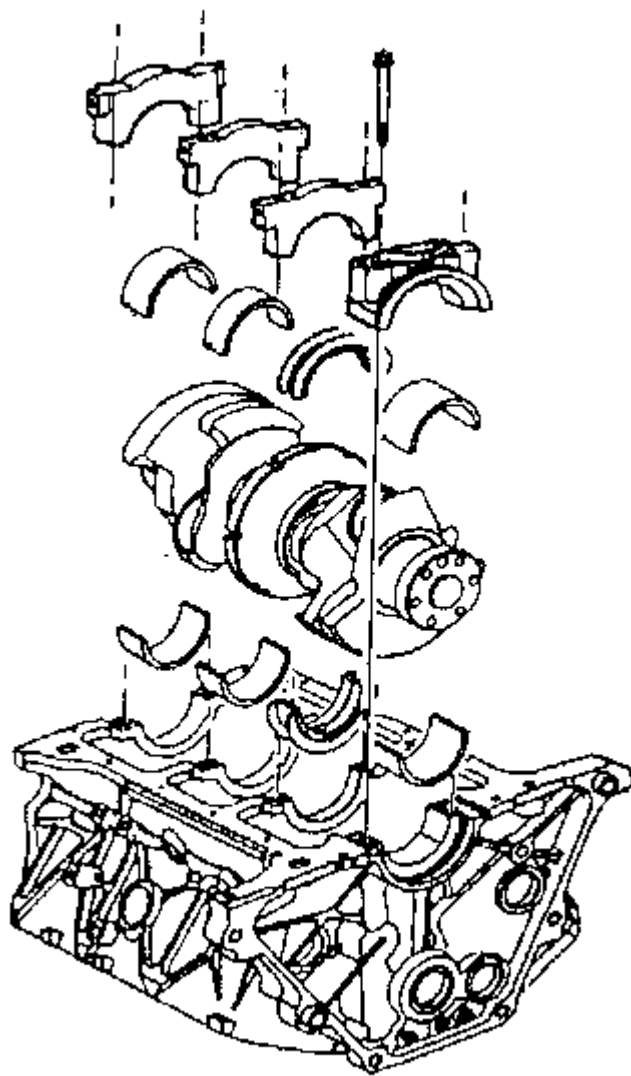


Fig. 257: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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.

6. Remove the crankshaft.
7. Remove the upper crankshaft main bearing halves.

Camshaft Bearing Removal**Tools Required**

J 33049 Camshaft Bearing Remover/Installer

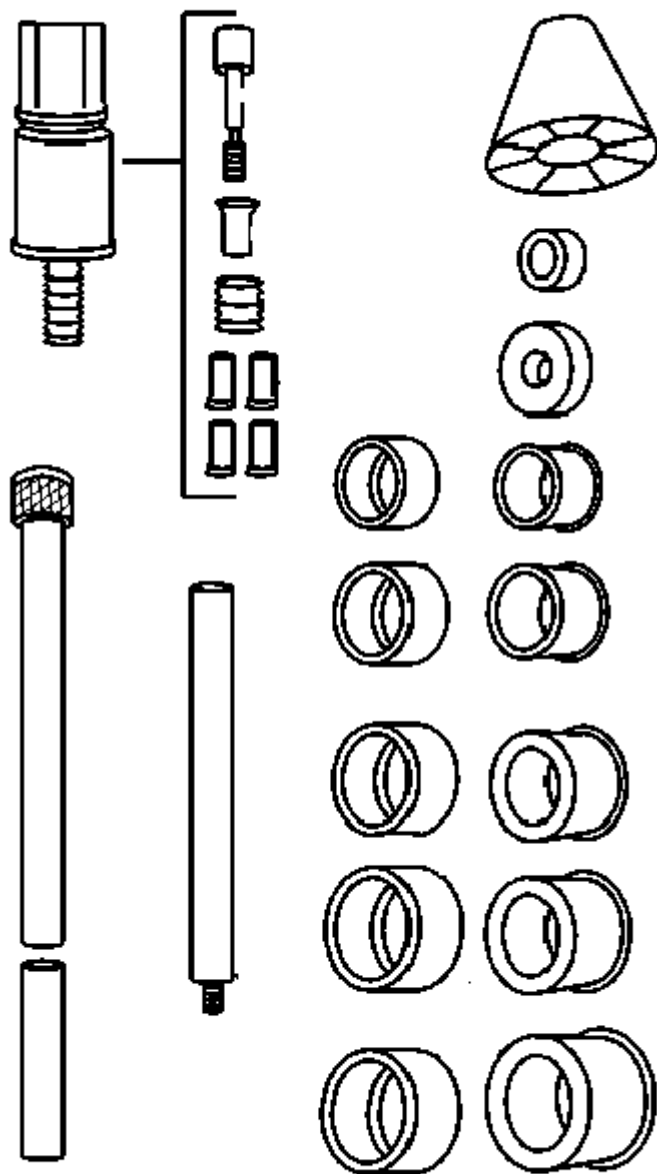


Fig. 258: Camshaft Bearing Service Set
 Courtesy of GENERAL MOTORS CORP.

1. Select the expander assembly and driving washer.
2. Assemble the **J 33049** .

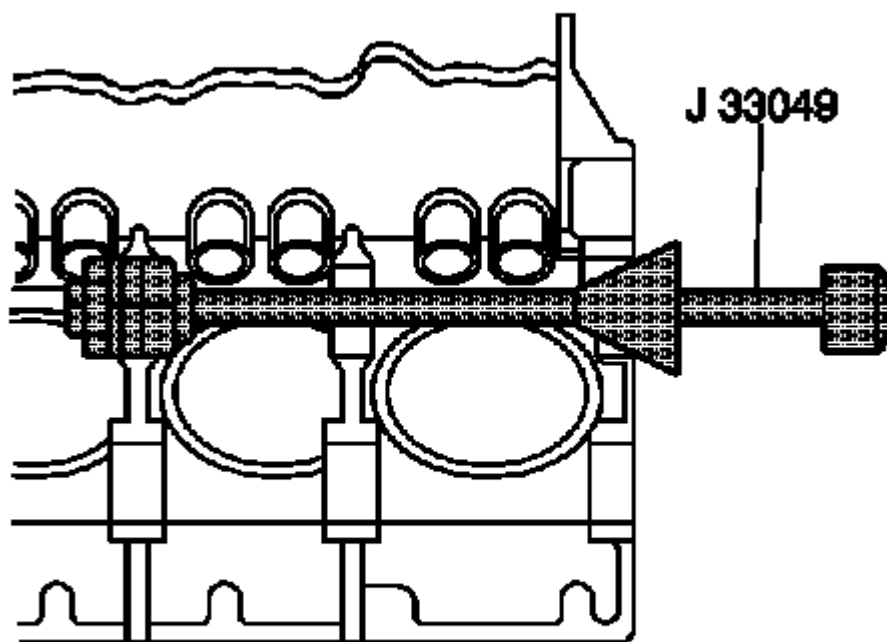


Fig. 259: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

3. Drive out the camshaft bearings. Use the **J 33049** .

Engine Block Disassemble

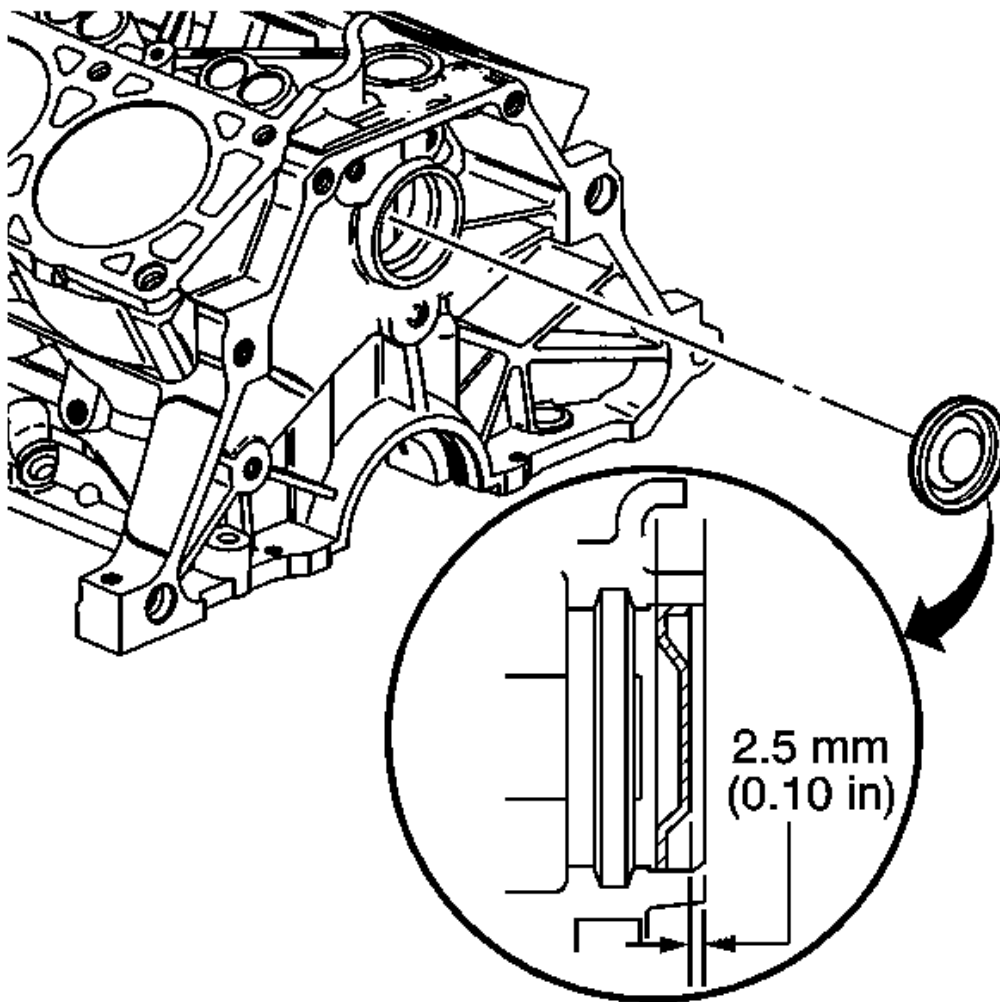


Fig. 260: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft rear bearing hole plug.

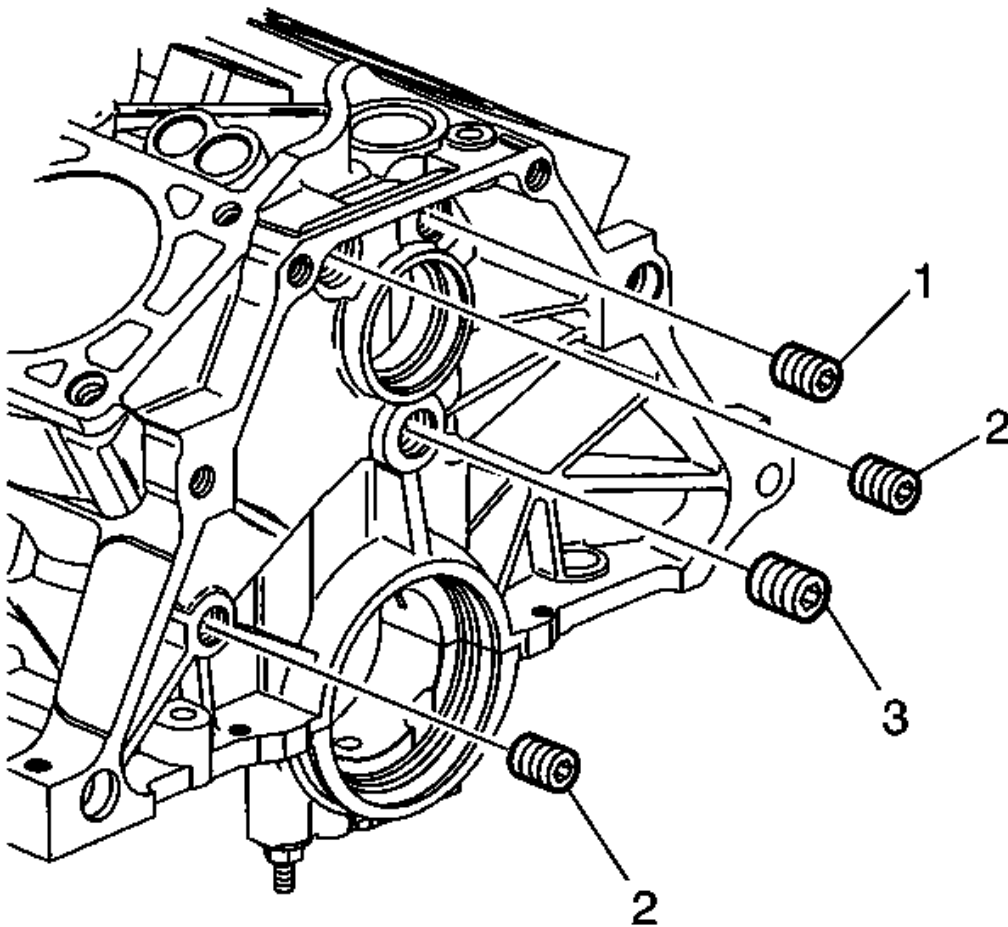


Fig. 261: Rear Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear oil gallery plugs (1, 2, 3).

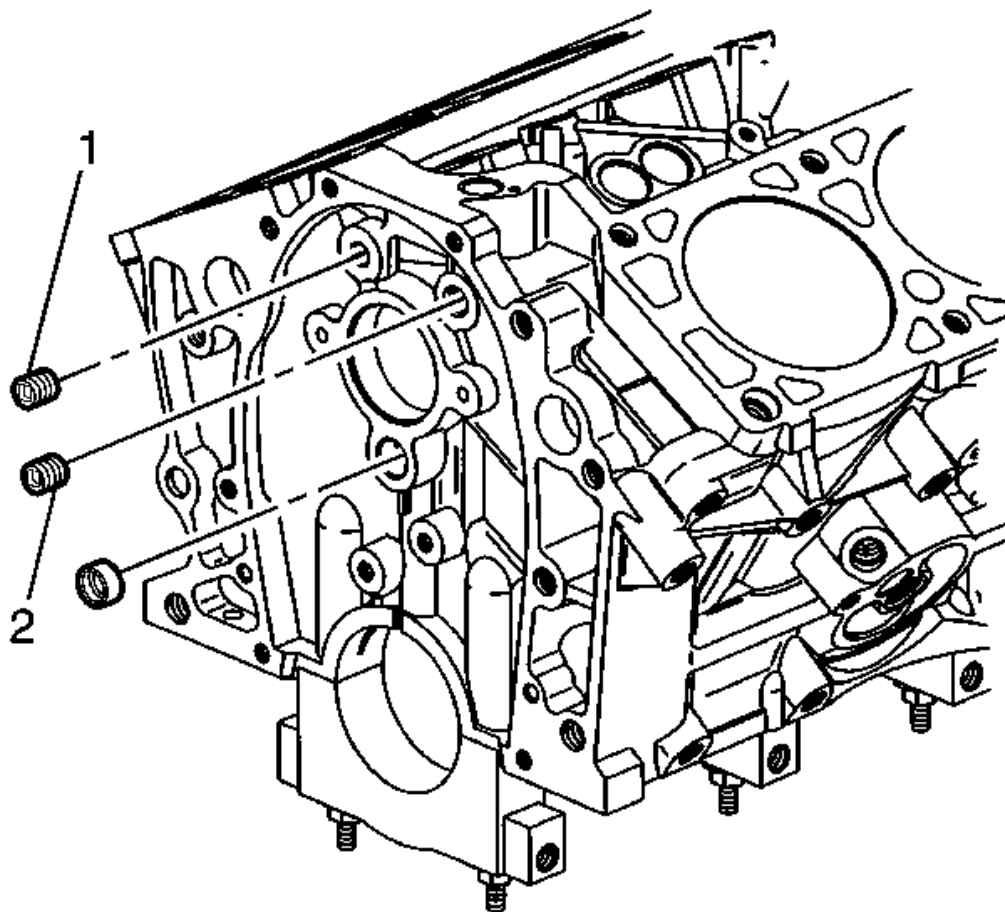


Fig. 262: Front Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

3. Remove the front oil gallery plugs (1, 2).
4. Remove all of the remaining engine block plugs.

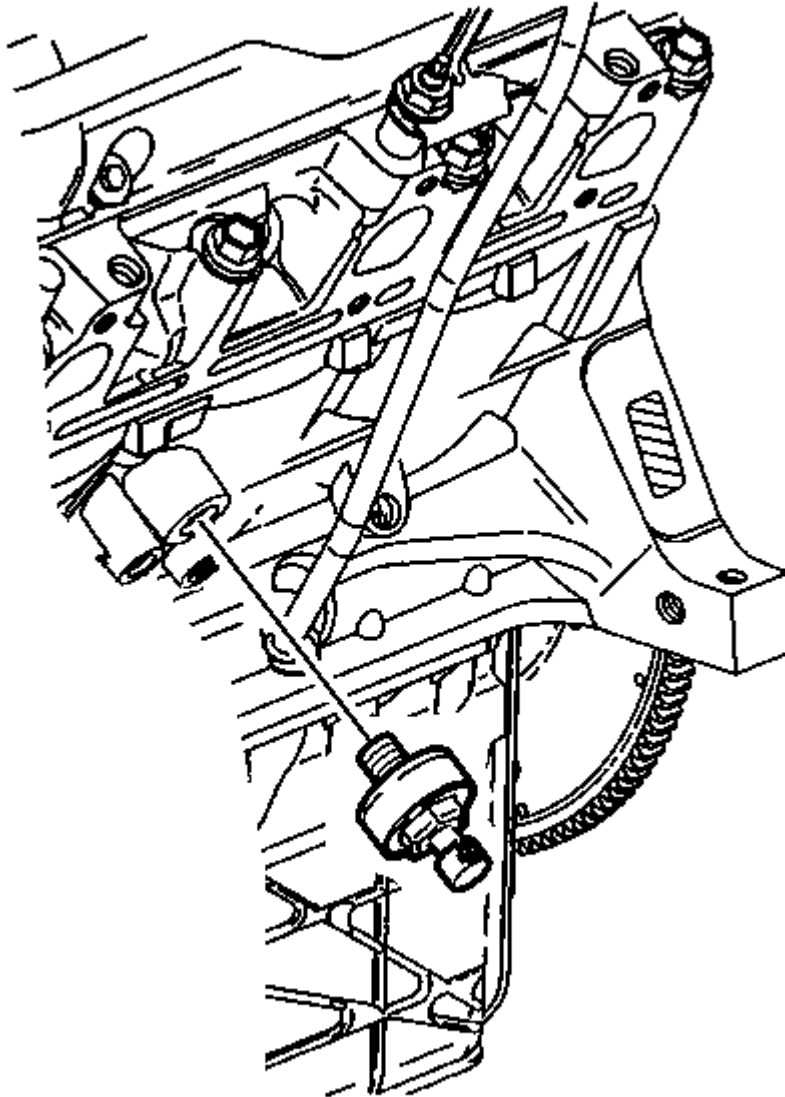


Fig. 263: Removing Knock Sensor
Courtesy of GENERAL MOTORS CORP.

5. Remove the knock sensor.

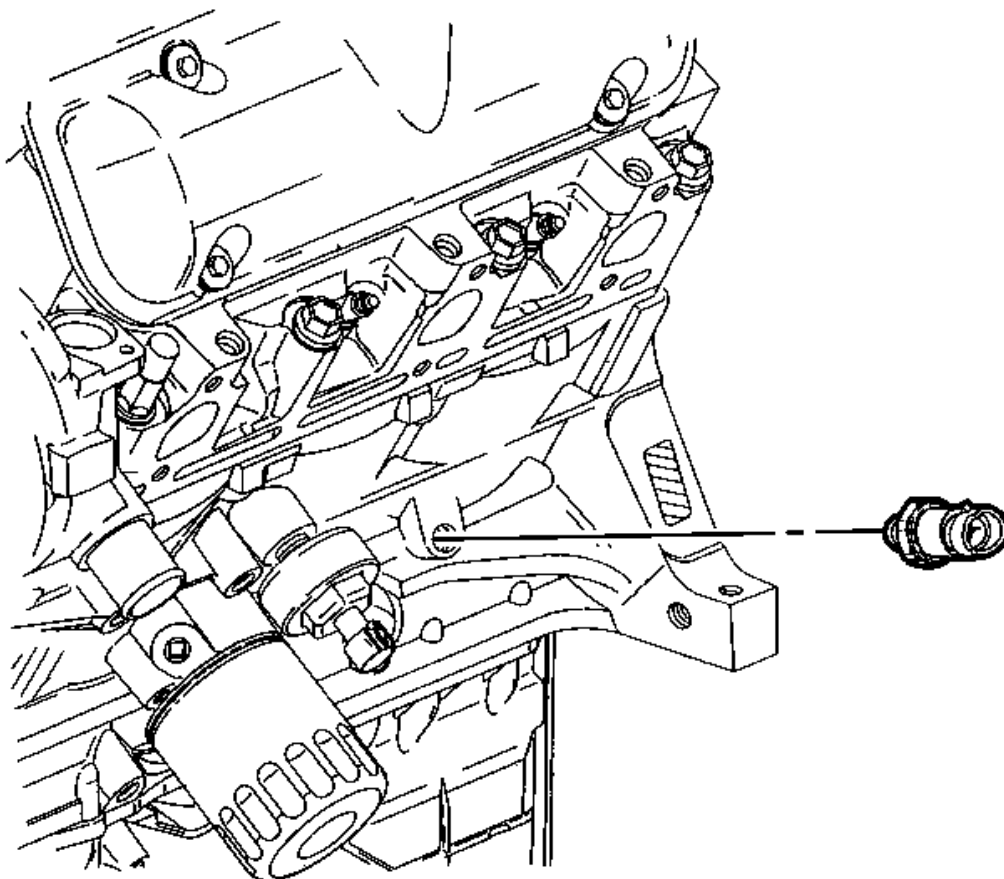


Fig. 264: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil pressure switch.

Engine Block Cleaning and Inspection

Tools Required

- **J 8001** Dial Indicator Set. See **Special Tools and Equipment**.
- **J 8087** Cylinder Bore Gage. See **Special Tools and Equipment**.

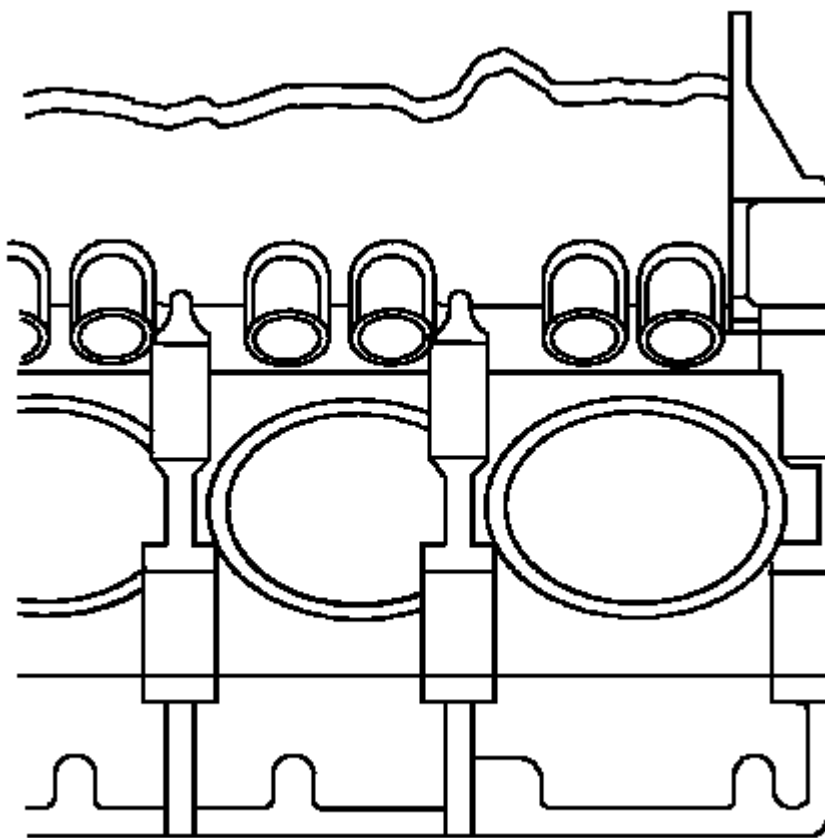


Fig. 265: Gasket Mating Surface
Courtesy of GENERAL MOTORS CORP.

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.

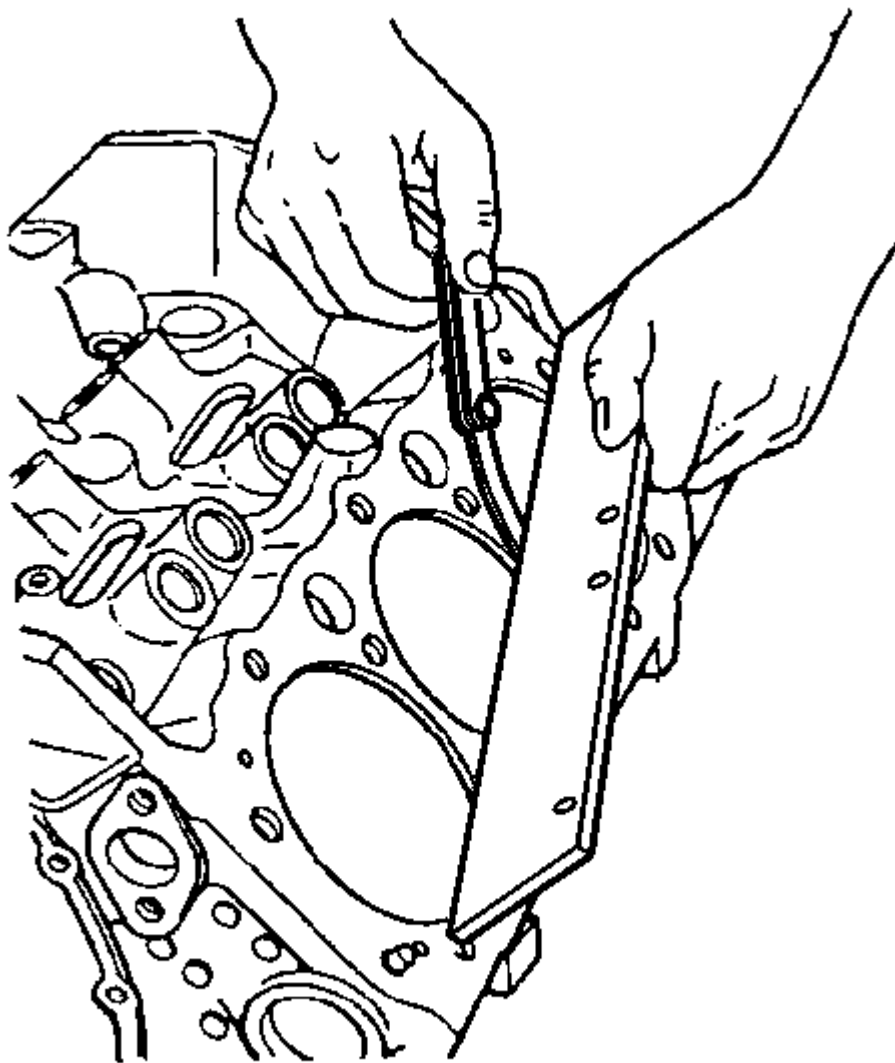


Fig. 266: Testing Block Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

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.

Inspect the front cover attaching area for nicks.

Use a flat mill file in order to remove any nicks.

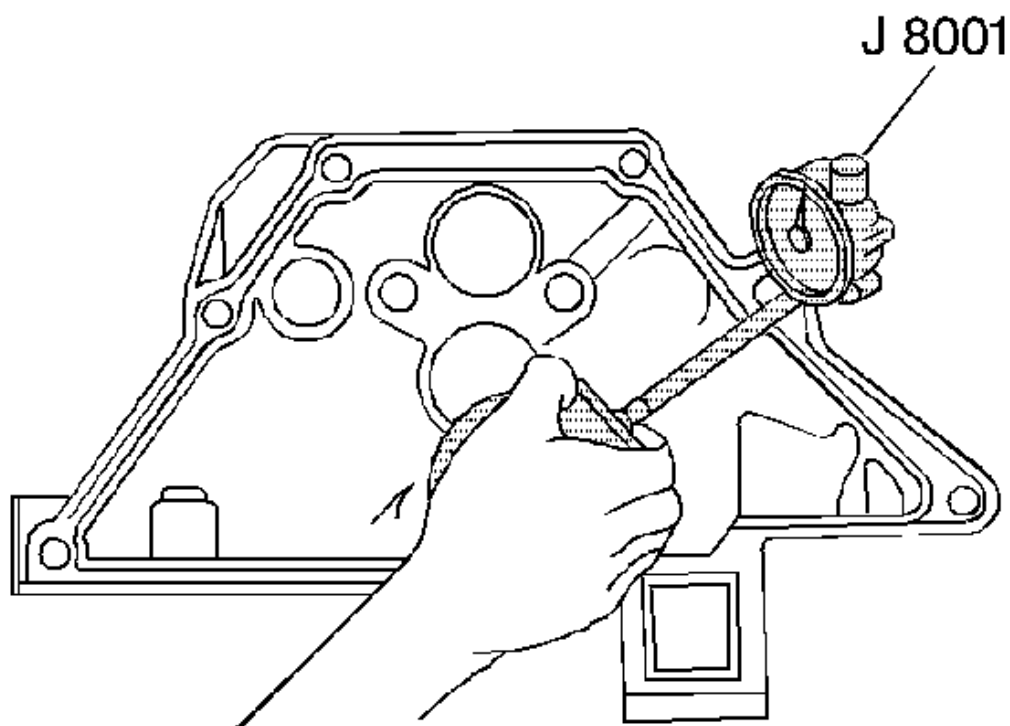


Fig. 267: Inspect Mating Surfaces Of Transmission Case
Courtesy of GENERAL MOTORS CORP.

11. Inspect the mating surfaces of the transmission case.

NOTE: A broken flywheel may result if the transmission case mating surface is not flat.

12. 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 and Equipment**.
 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.

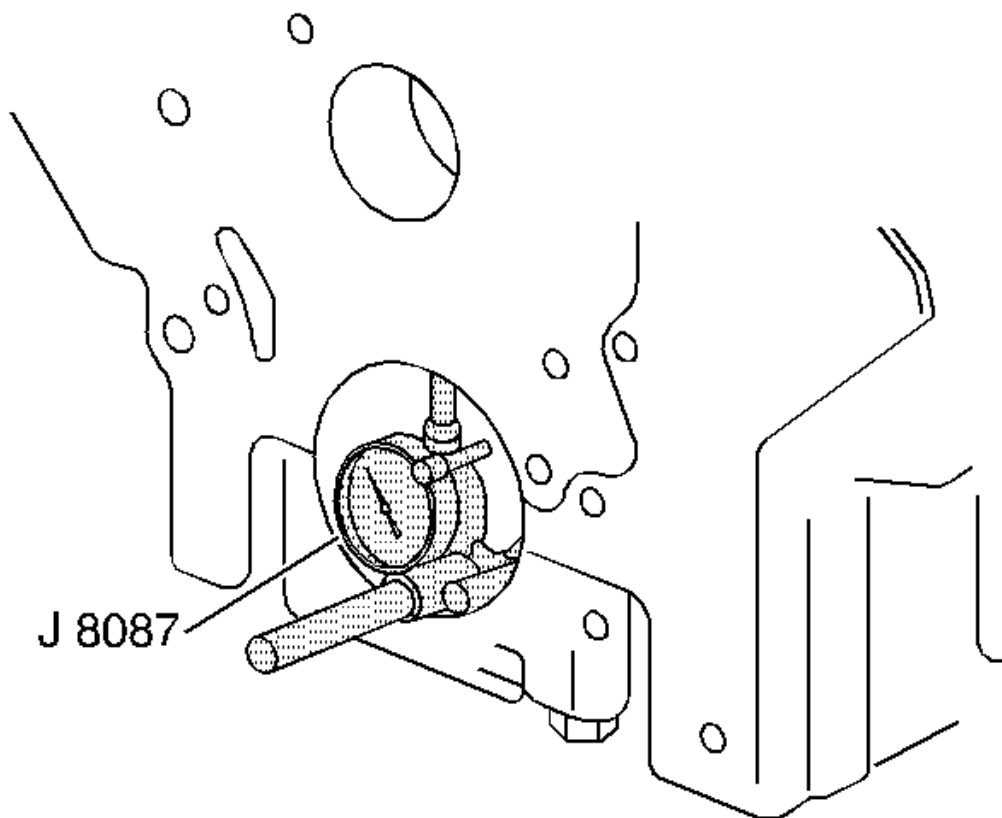


Fig. 268: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Perform the following inspections, and reconditioning if necessary, with the crankshaft main bearing caps installed and tightened to specification.

13. 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
14. Replace the engine block if the bores are out of specification.

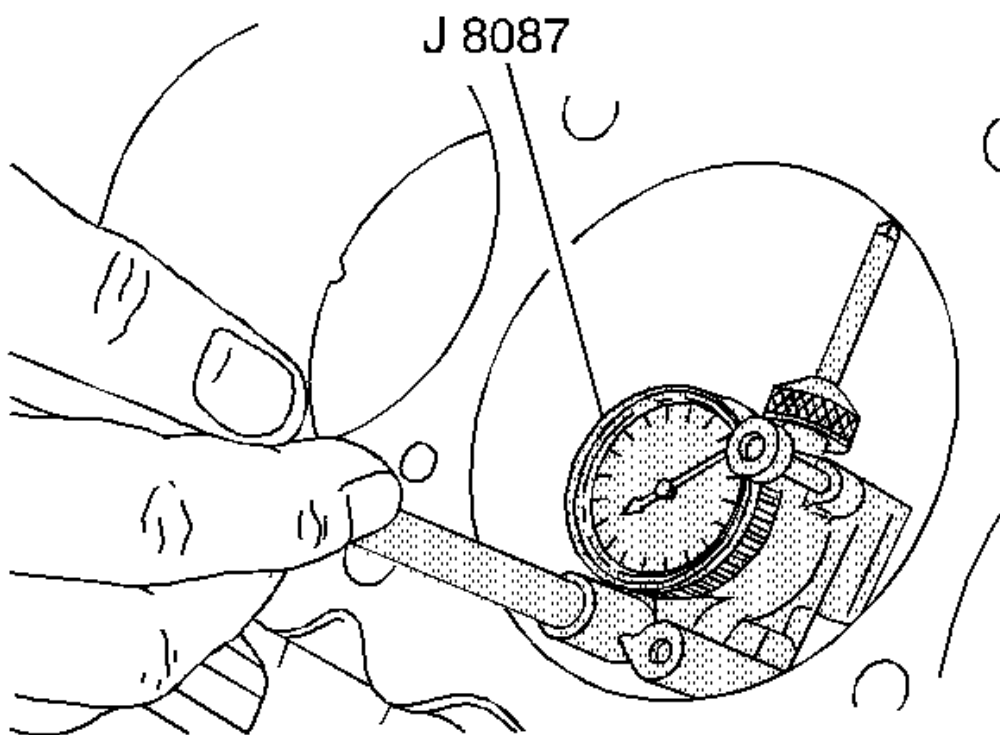


Fig. 269: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

15. Use the **J 8087** in order to inspect the cylinder bores. See **Special Tools and Equipment**. 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.

16. Leave sufficient material in order to allow honing when fitting the piston.

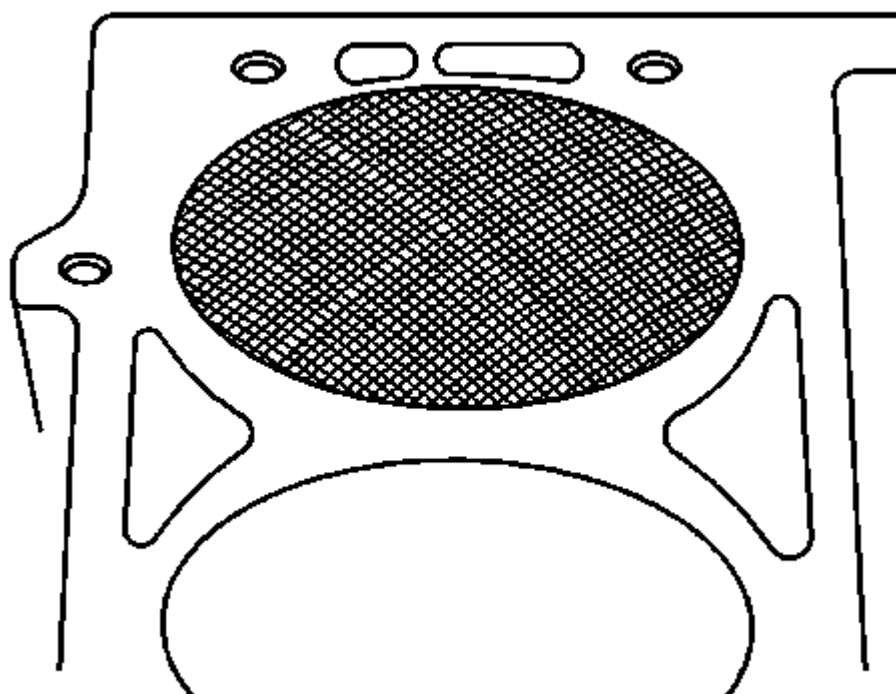
Cylinder Boring and Honing

Boring Procedure

1. Before honing or boring, measure all of the new pistons. Select the smallest piston for the piston fitting. 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. 270: Identifying Cylinder Bore Cross Hatch Pattern**

Courtesy of GENERAL MOTORS CORP.

3. Make full strokes in the cylinder to eliminate taper. Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

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

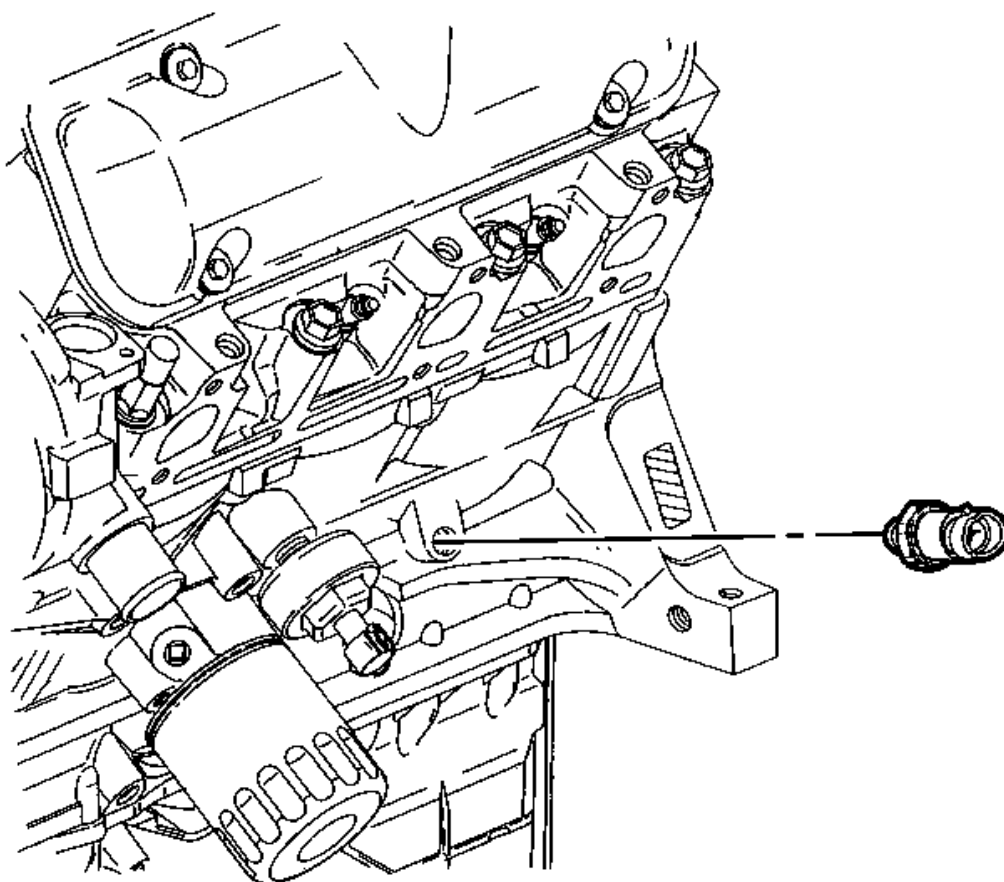


Fig. 271: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004, (Canadian P/N 10953480), or the equivalent to the oil pressure switch threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine oil pressure switch.

Tighten: Tighten the engine oil pressure switch to 16 N.m (12 lb ft).

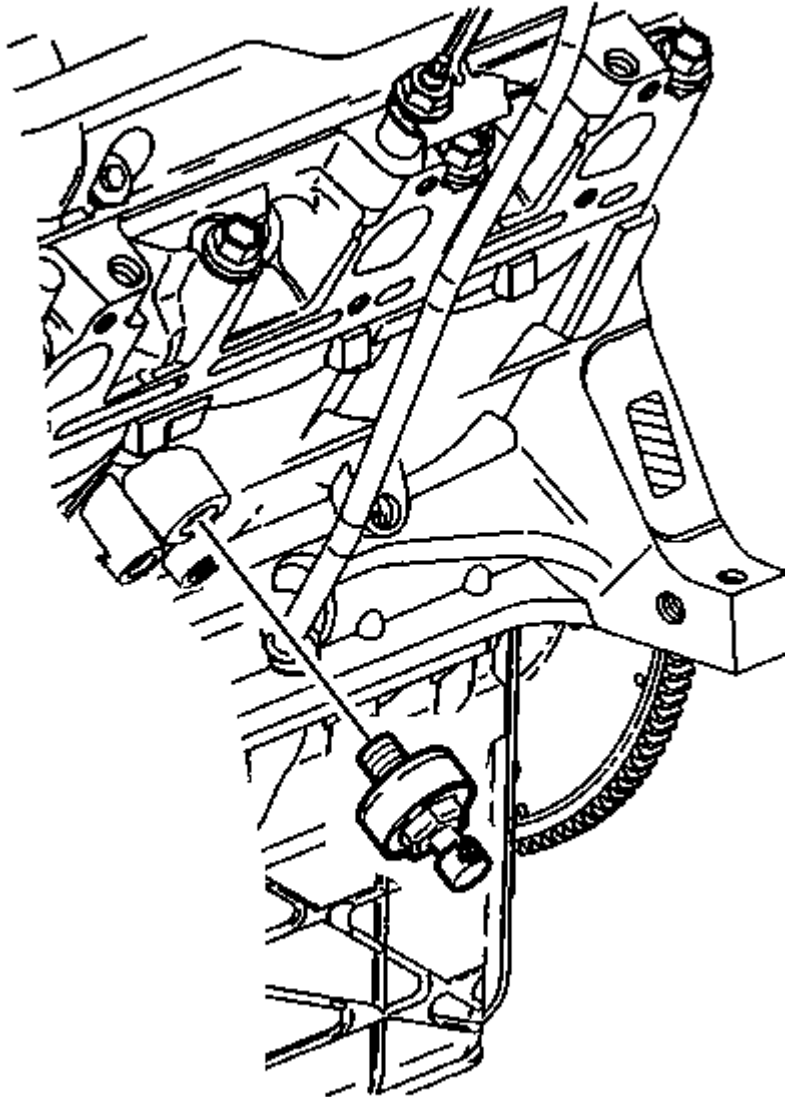


Fig. 272: Removing Knock Sensor
Courtesy of GENERAL MOTORS CORP.

3. Install the knock sensor.

Tighten: Tighten the knock sensor to 19 N.m (14 lb ft).

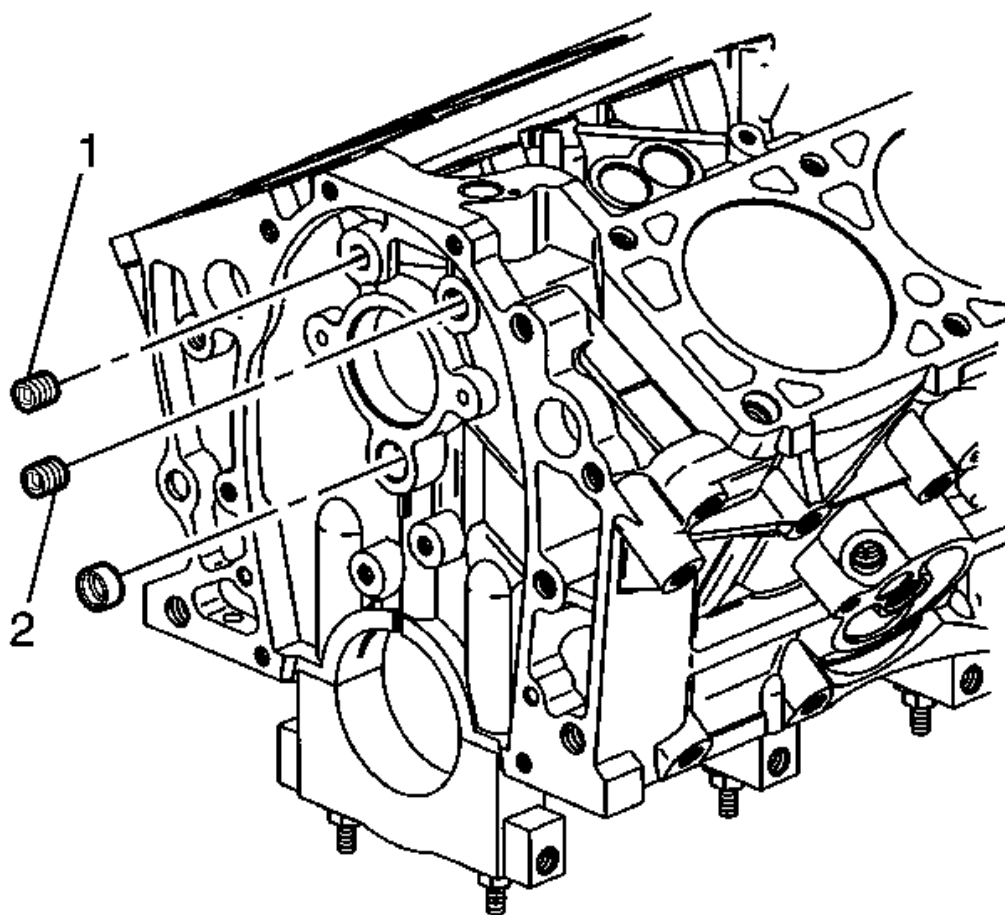


Fig. 273: Front Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the front oil gallery plug threads (1 and 2).
5. Install the front oil gallery plug (1).

Tighten: Tighten the oil gallery plug (1) to 19 N.m (14 lb ft).

6. Install the front oil gallery plug (2).

Tighten: Tighten the oil gallery plug (2) to 33 N.m (24 lb ft).

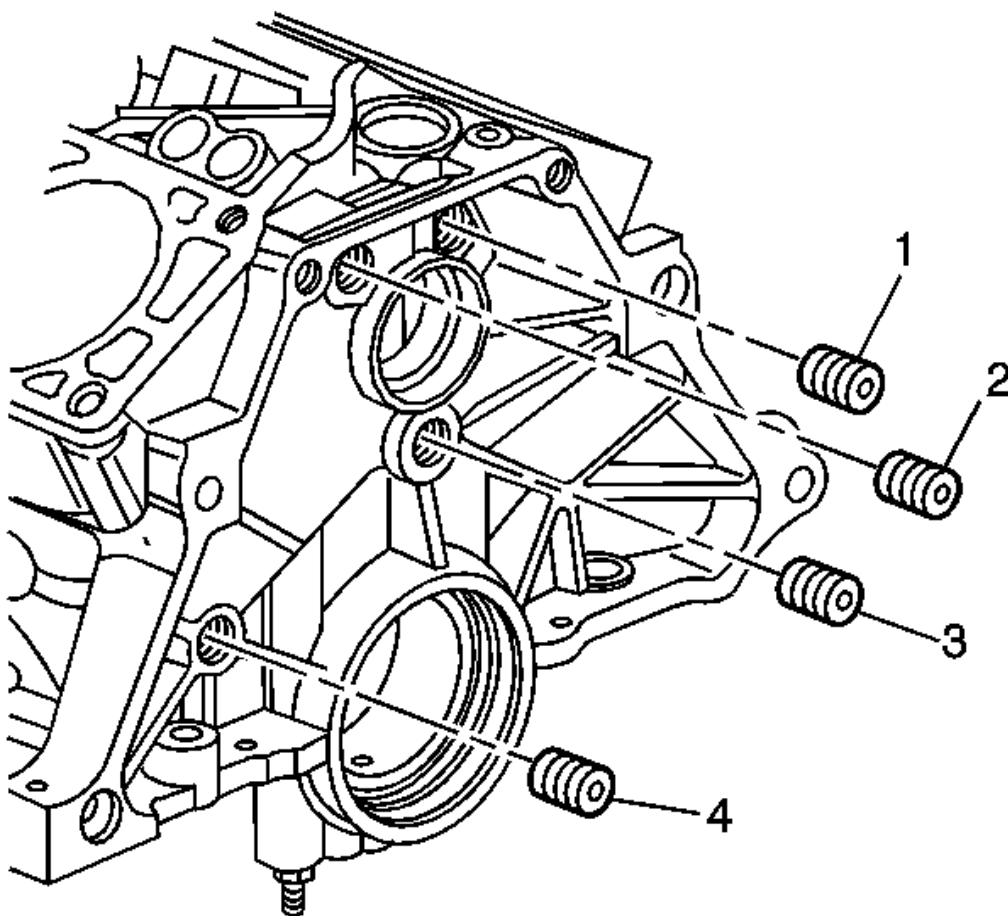


Fig. 274: Rear Oil Gallery Plugs

Courtesy of GENERAL MOTORS CORP.

7. Apply sealer GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the rear oil gallery plug threads (1 and 4).
8. Install the rear oil gallery plugs (1 and 4).

Tighten: Tighten the oil gallery plugs (1 and 4) to 19 N.m (14 lb ft).

9. Install the rear oil gallery plugs (2 and 3).

Tighten: Tighten the oil gallery plugs (2 and 3) to 33 N.m (24 lb ft).

10. Apply sealer GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the engine block plugs.

11. Install the remaining engine block plugs.

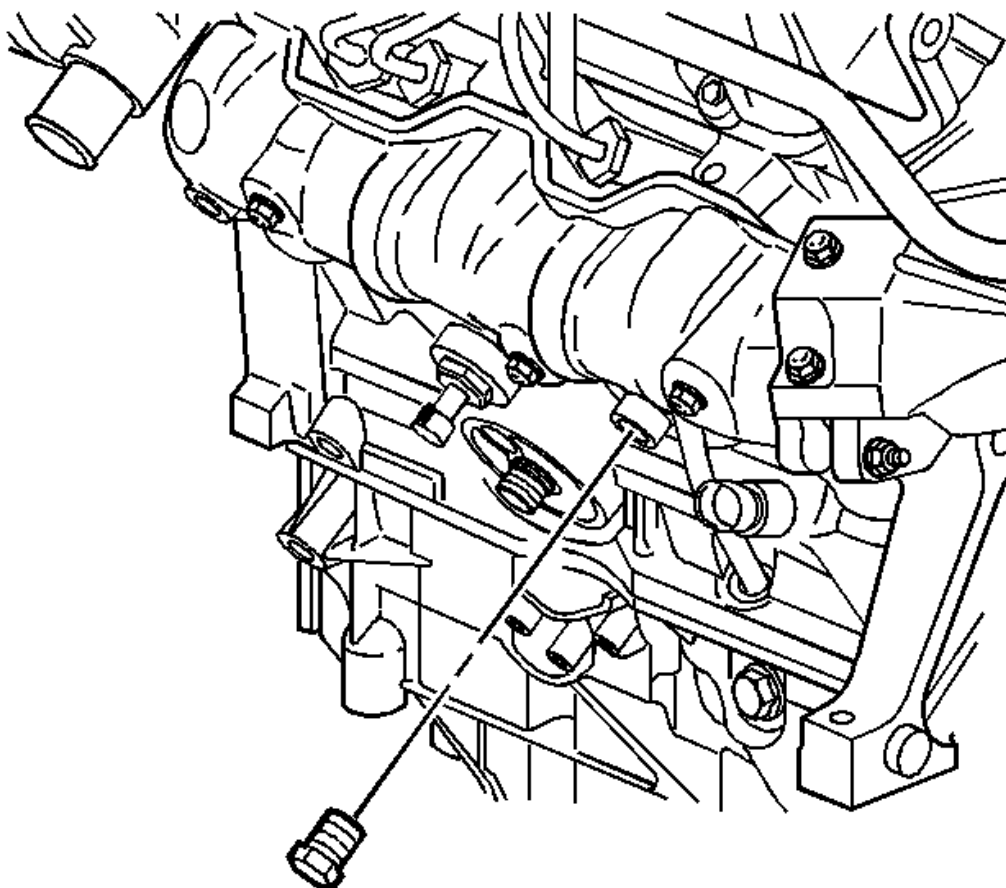


Fig. 275: Locating Left Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

12. Apply sealant GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the coolant drain plug threads.
13. Install the left coolant drain plug.

Tighten: Tighten the coolant drain plug to 19 N.m (14 lb ft).

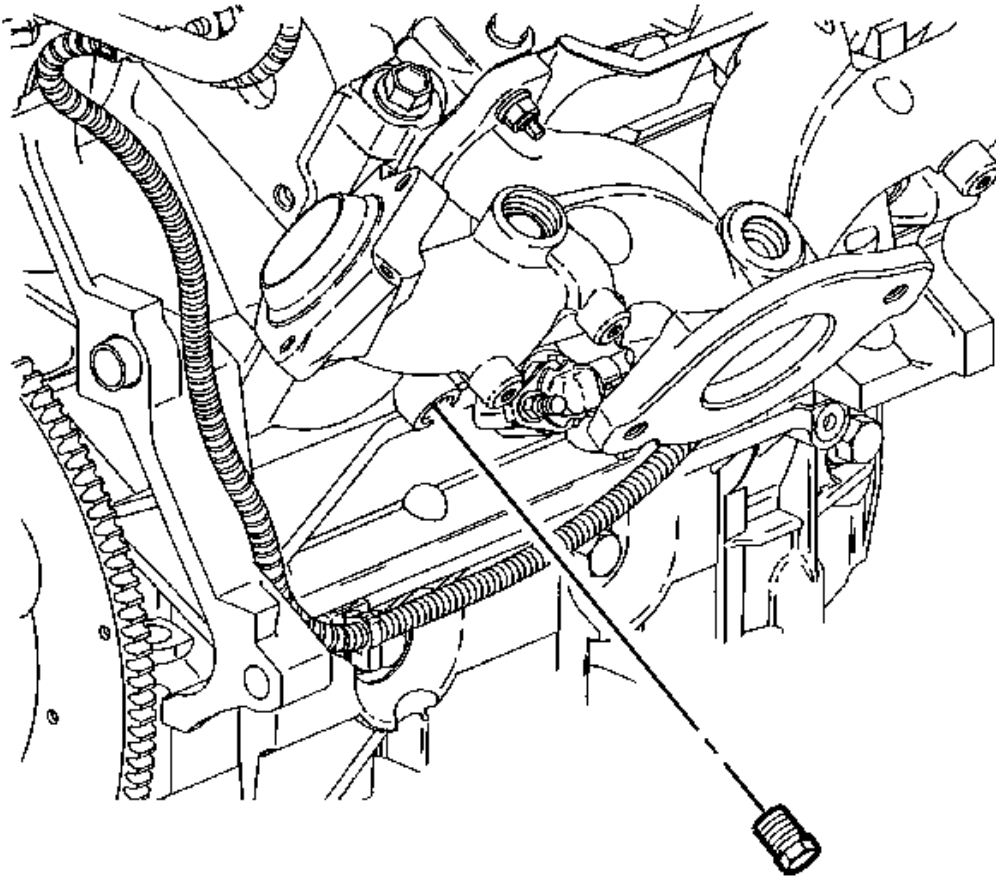


Fig. 276: Locating Right Coolant Drain Plug
Courtesy of GENERAL MOTORS CORP.

14. Apply sealant GM P/N 12346004, (Canadian P/N 10953480) or the equivalent to the coolant drain plug threads.
15. Install the right coolant drain plug.

Tighten: Tighten the coolant drain plug to 19 N.m (14 lb ft).

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage
- **J 36660-A** Torque Angle Meter

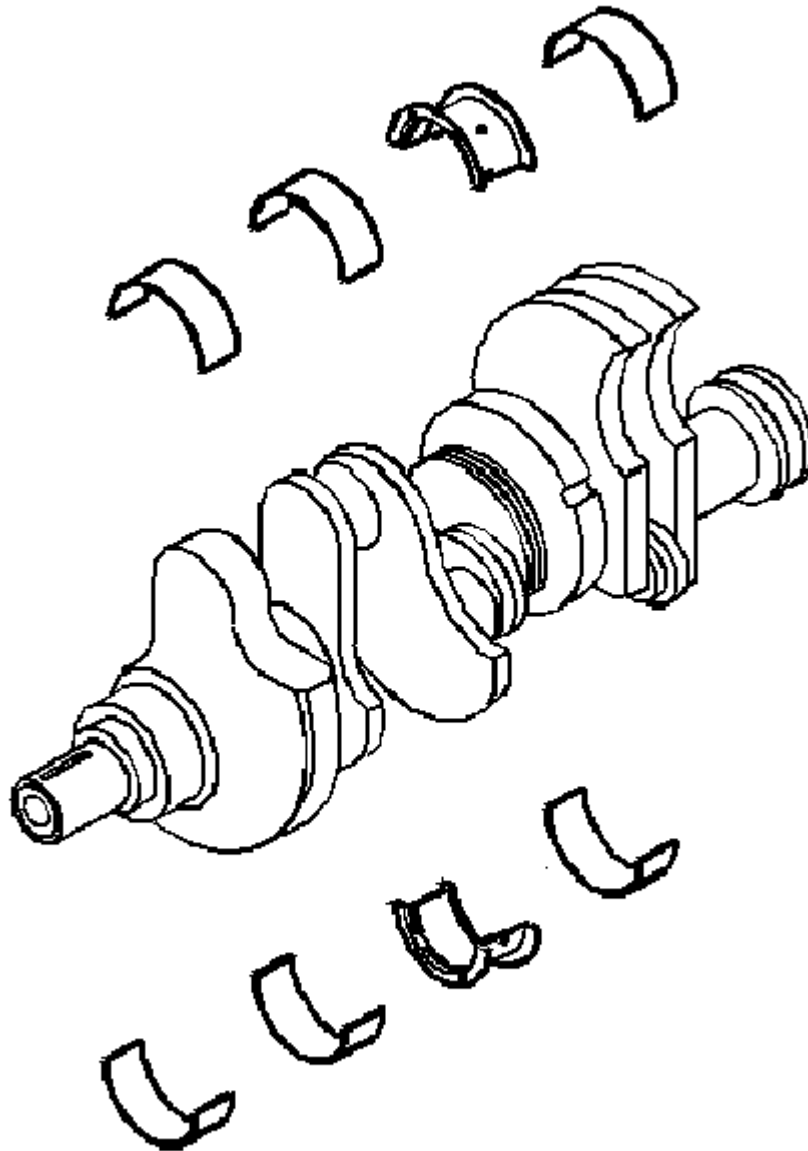


Fig. 277: View Of Crankshaft & Bearings
Courtesy of GENERAL MOTORS CORP.

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 II system performance.

1. Clean the crankshaft of the following elements:
 - Oil
 - Sludge
 - Carbon
2. Inspect the crankshaft oil passages for obstructions.

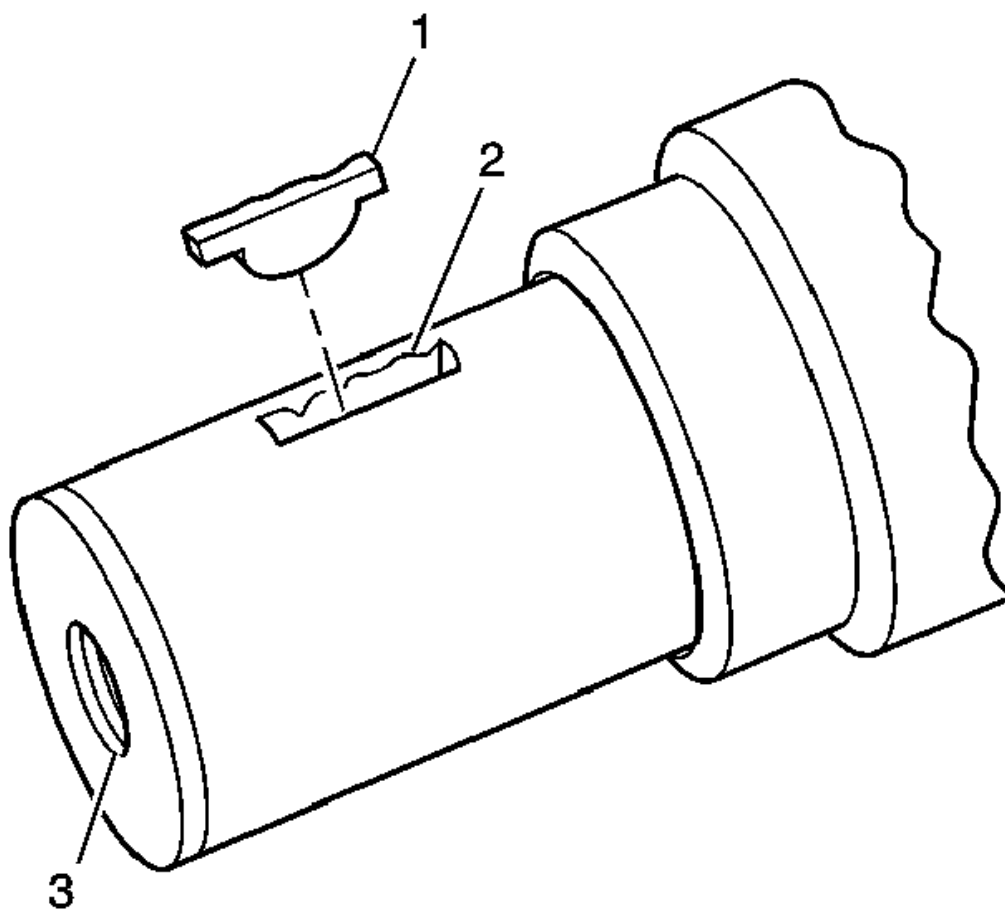


Fig. 278: Crankshaft Key, Keyway & Threads
Courtesy of GENERAL MOTORS CORP.

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.

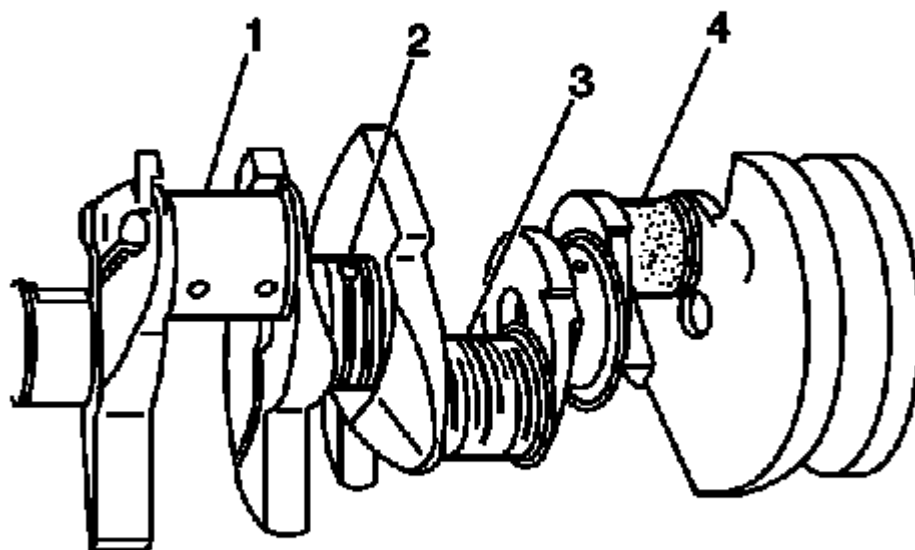


Fig. 279: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

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 - discoloration

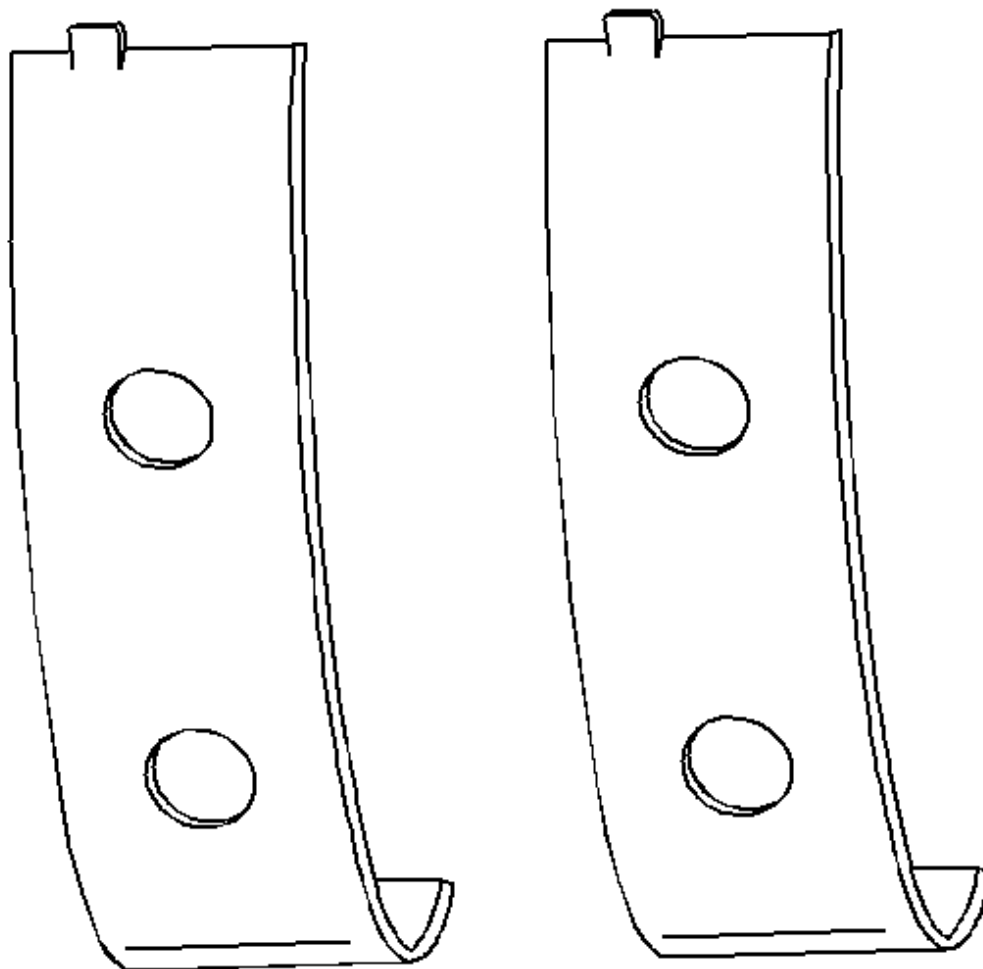


Fig. 280: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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

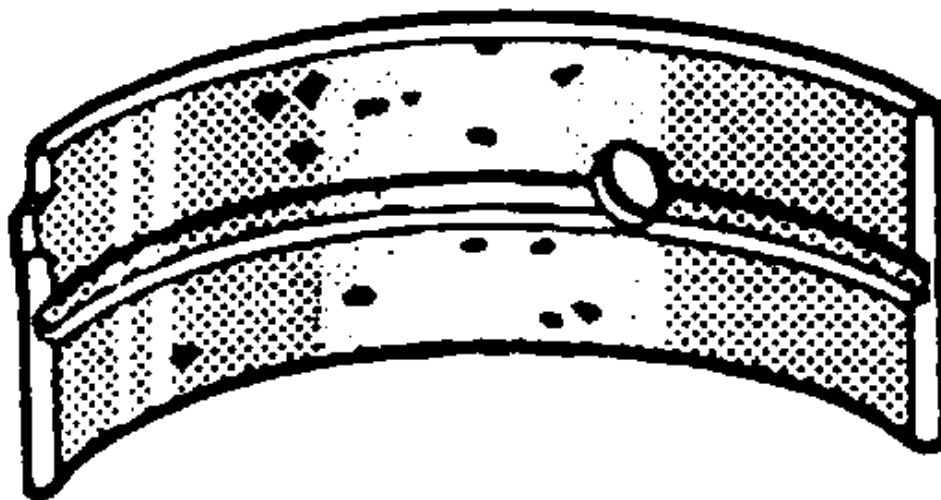


Fig. 281: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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.

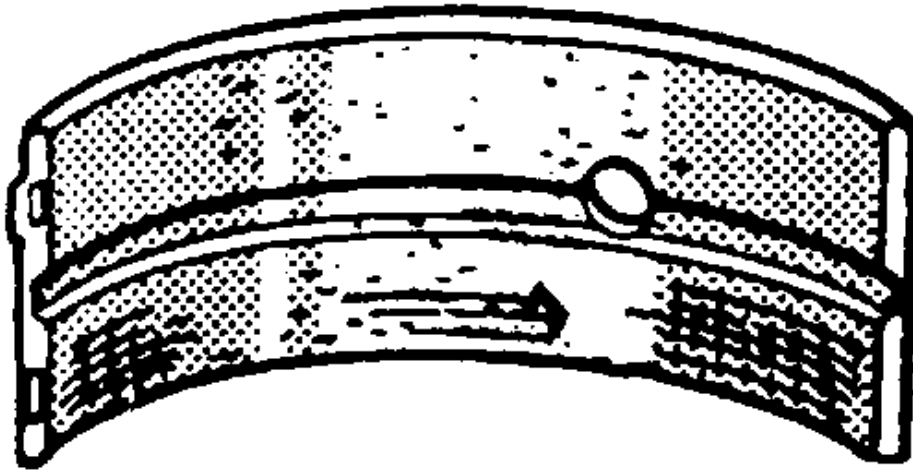


Fig. 282: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

10. Inspect the crankshaft bearings for excessive scoring or discoloration.
11. Inspect the crankshaft main bearings for dirt or imbedded debris.

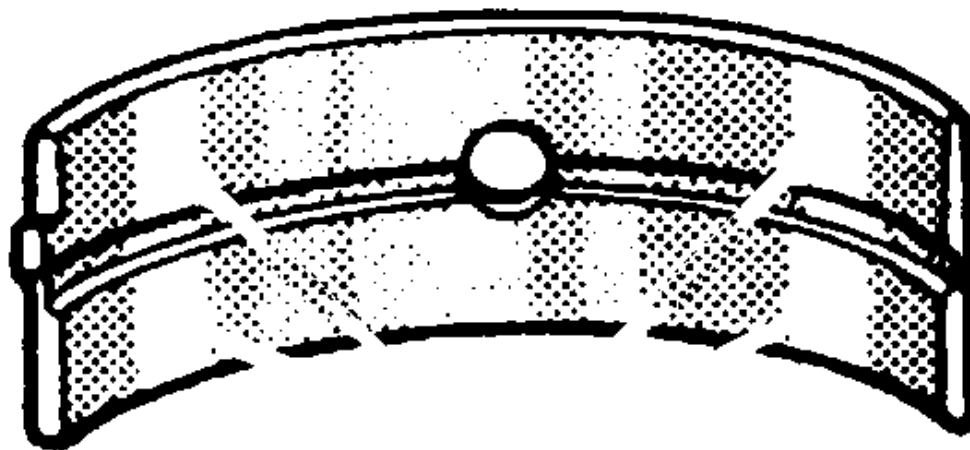


Fig. 283: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

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.

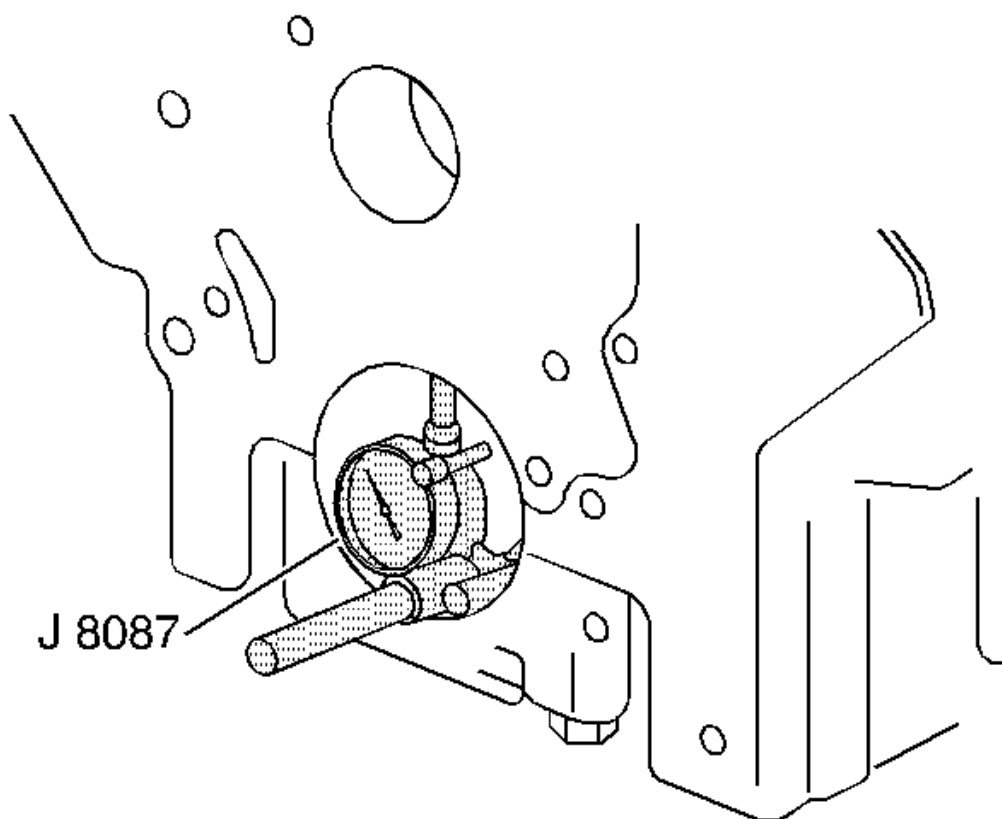


Fig. 284: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

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. 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.

- 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

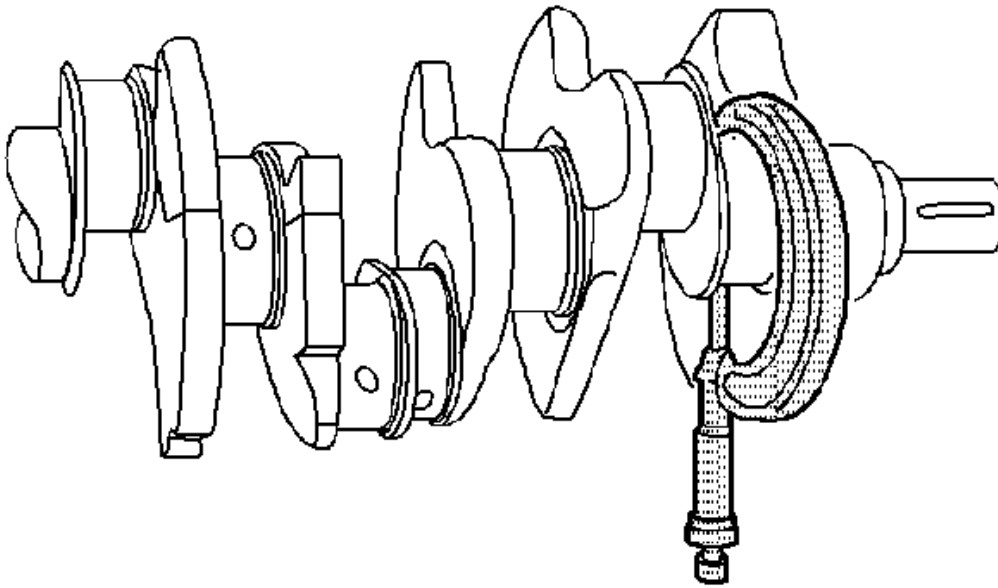


Fig. 285: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

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 36660-A .
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.

Method B

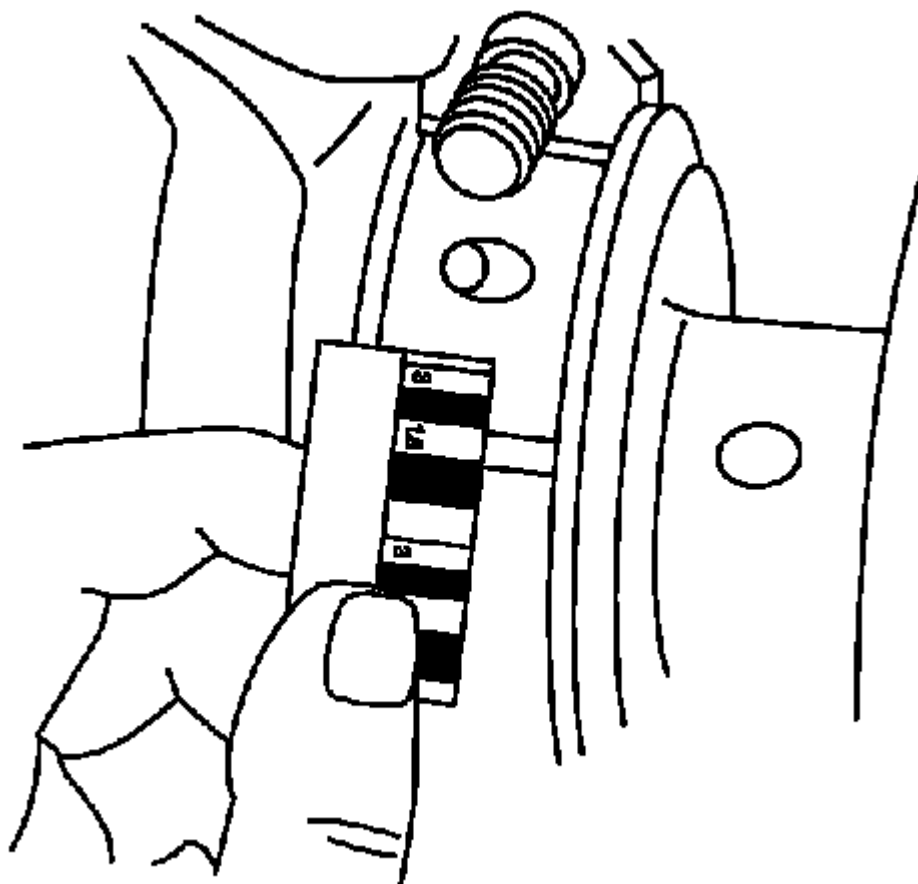


Fig. 286: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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.

5. Install the bearing cap bolts to specification using J 36660-A .

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

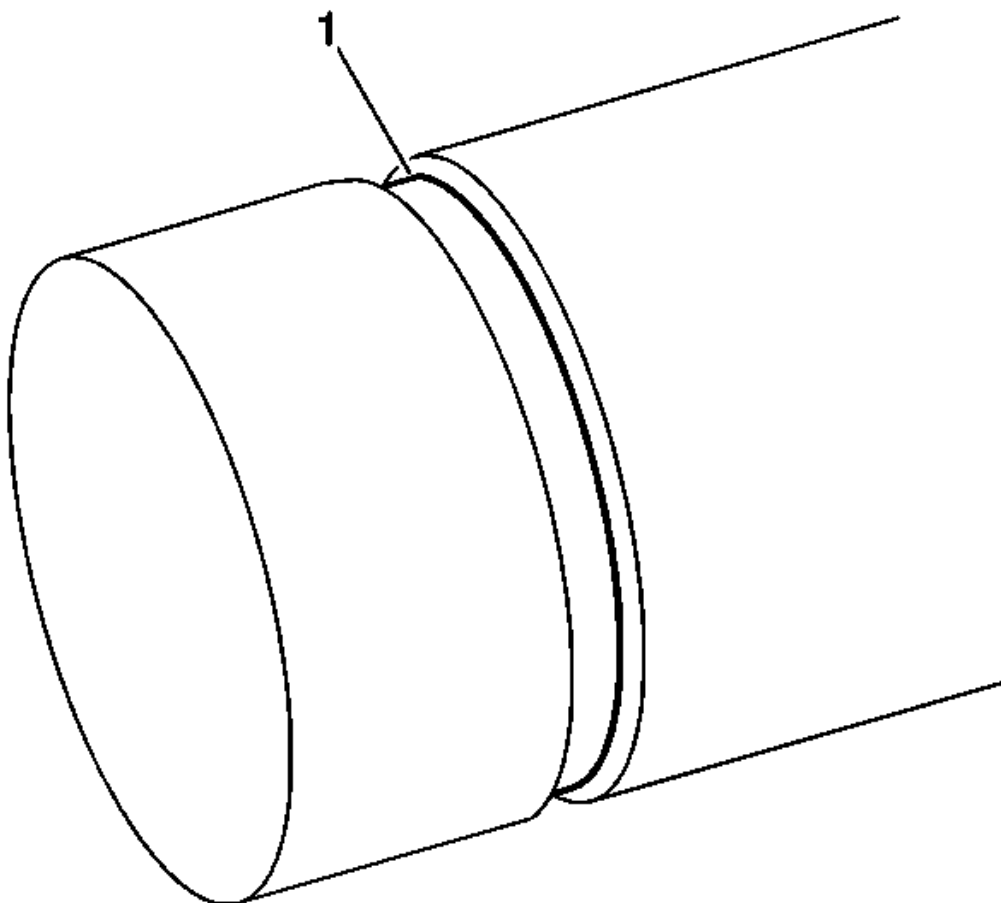


Fig. 287: Crankshaft Balancer Sealing Area
Courtesy of GENERAL MOTORS CORP.

- Inspect the crankshaft balancer sealing area for grooves (1).
- Inspect the crankshaft balancer belt ribs for dents or damage.
- Replace the crankshaft balancer if necessary.

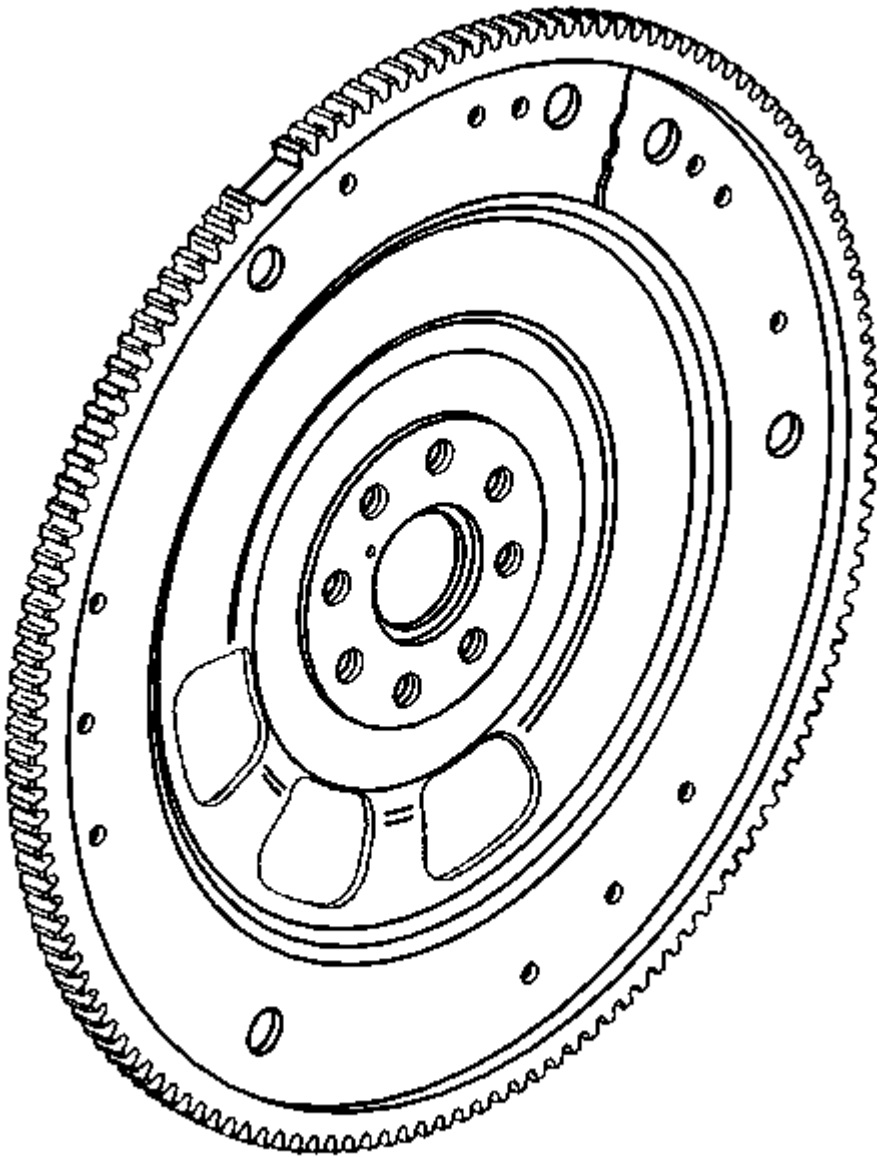
Engine Flywheel Cleaning and Inspection

Fig. 288: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

- Inspect the engine flywheel for cracks.
- Inspect the engine flywheel teeth for damage.
- Replace the engine flywheel if necessary.

Piston and Connecting Rod Disassemble

Tools Required

J 24086-C Piston Pin Remover/Installer Set. See **Special Tools and Equipment**.

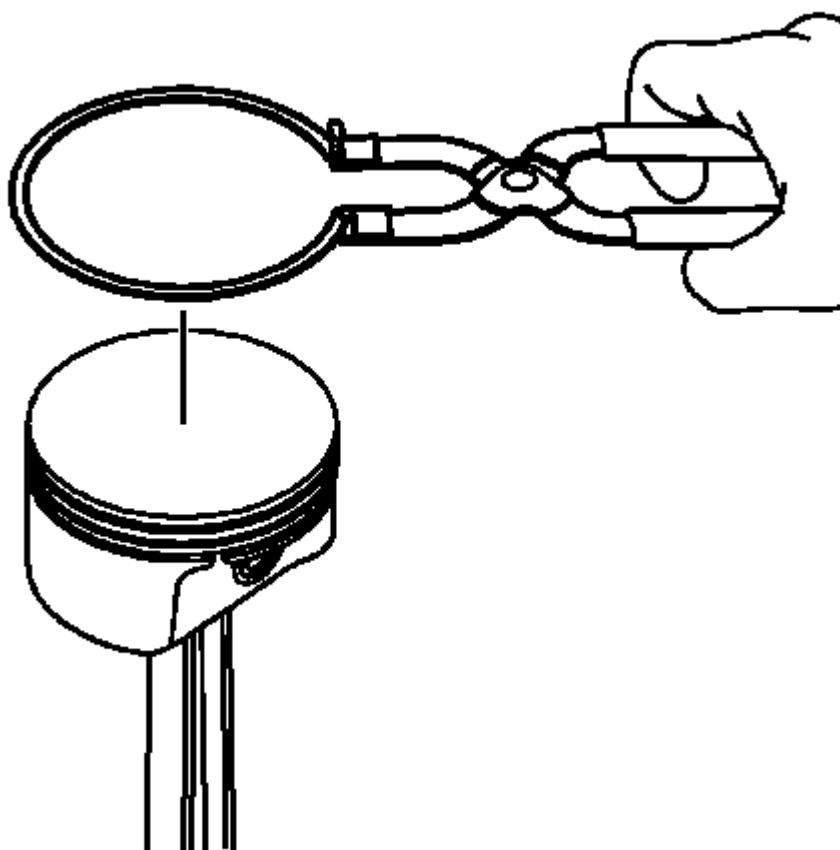


Fig. 289: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

1. Using piston ring pliers, remove the piston rings from the piston.

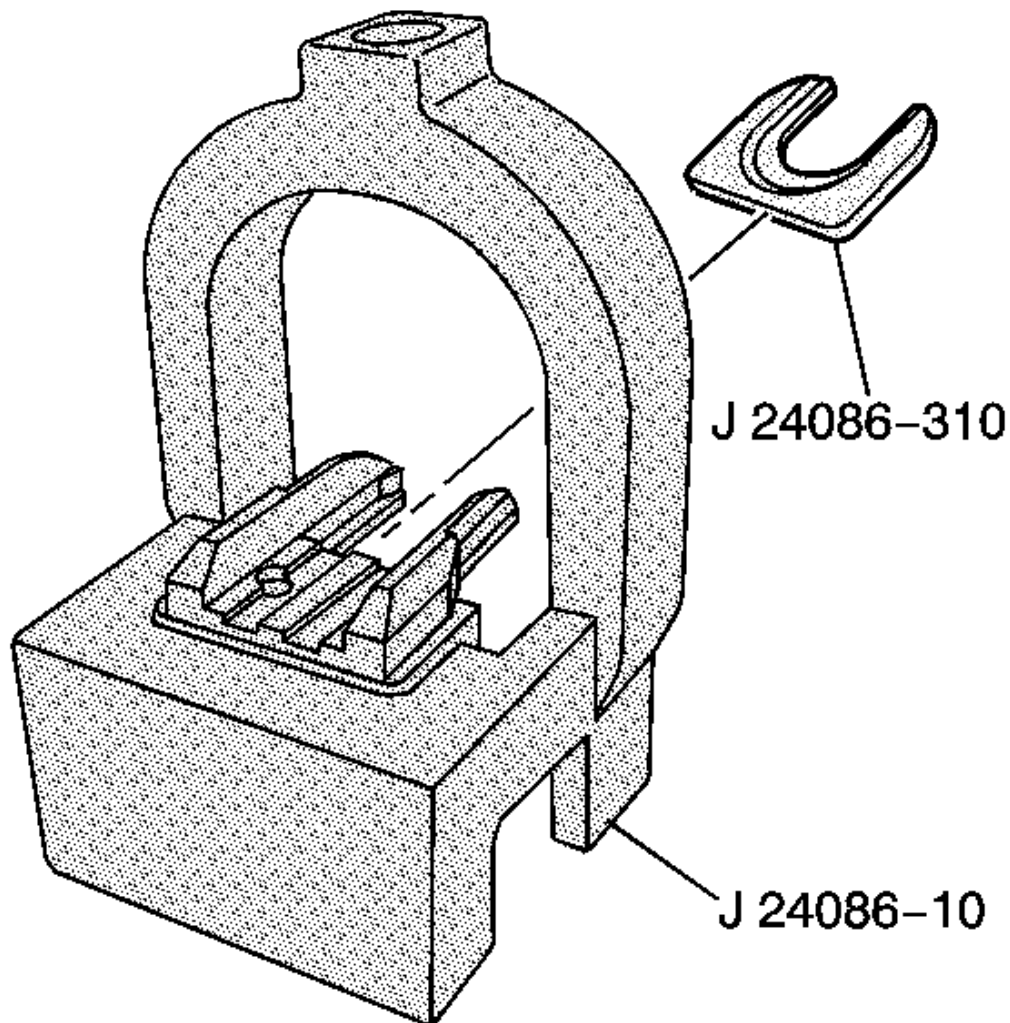


Fig. 290: Installing J 24086-310 Into J 24086-10
Courtesy of GENERAL MOTORS CORP.

2. Install fork insert J 24086-310 into fixture **J 24086-10** Piston Pin Remover/Installer Base.

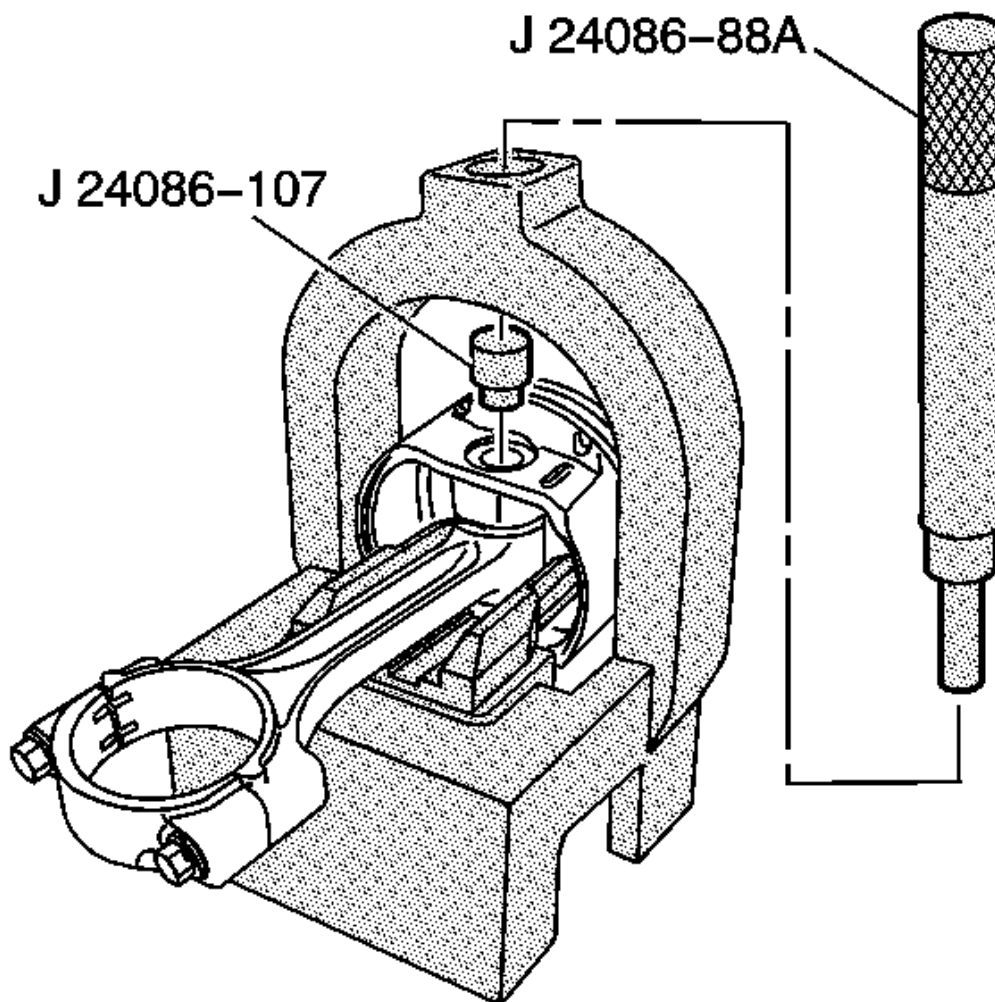


Fig. 291: View Of J 24086-107 & J 24086-88A
Courtesy of GENERAL MOTORS CORP.

3. Install the piston and connecting rod assembly onto **J 24086-10**.
4. Install the J 24086-107 onto the piston pin and J 24086-88A through the fixture and onto J 24086-107.

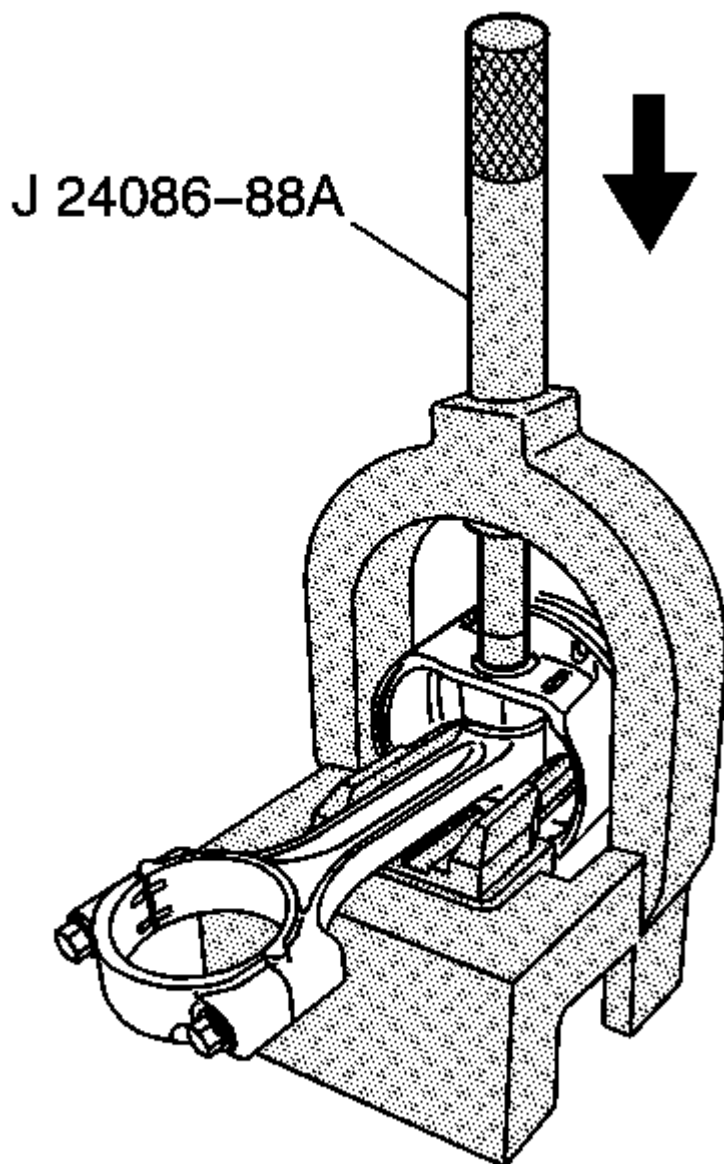


Fig. 292: View Of J 24086-88A
Courtesy of GENERAL MOTORS CORP.

NOTE: After the installer hub bottoms on the support assembly, do not exceed 35 000 kPa (5,000 psi) pressure, this could cause damage to the tool.

5. Press the piston pin from the piston and connecting rod assembly.

6. The piston and pin are a matched set and are not to be serviced separately. Mark, sort or organize the piston and the matching piston pin.

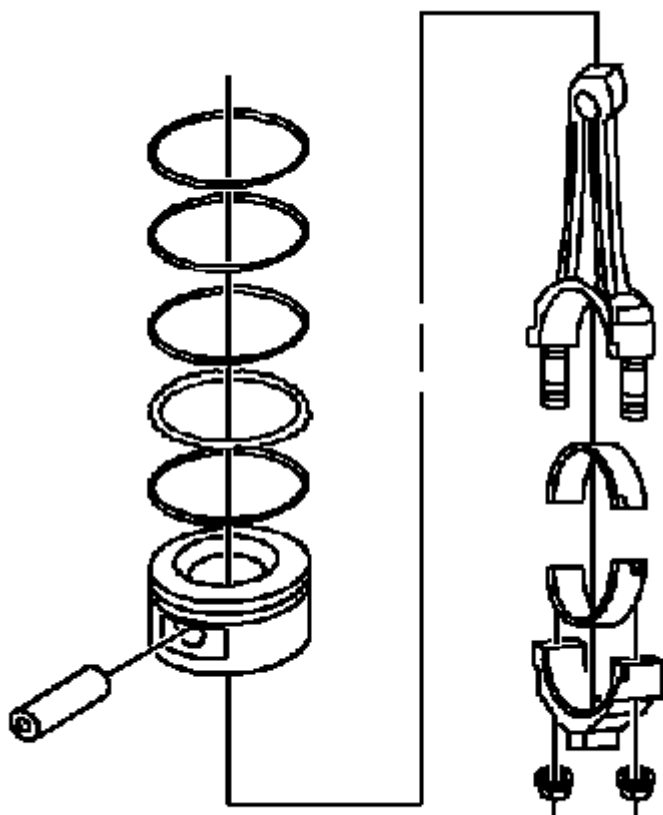
Piston, Connecting Rod, and Bearings Cleaning and Inspection**Tools Required****J 8087** Cylinder Bore Gage

Fig. 293: Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Bodily injury may occur if the cleaning solvent is inhaled or exposed to the skin.

IMPORTANT: Measurement of all components should be taken with the components at room temperature. Do not use a wire brush in order to clean any part of the piston.

1. Clean the piston and connecting rod in solvent.

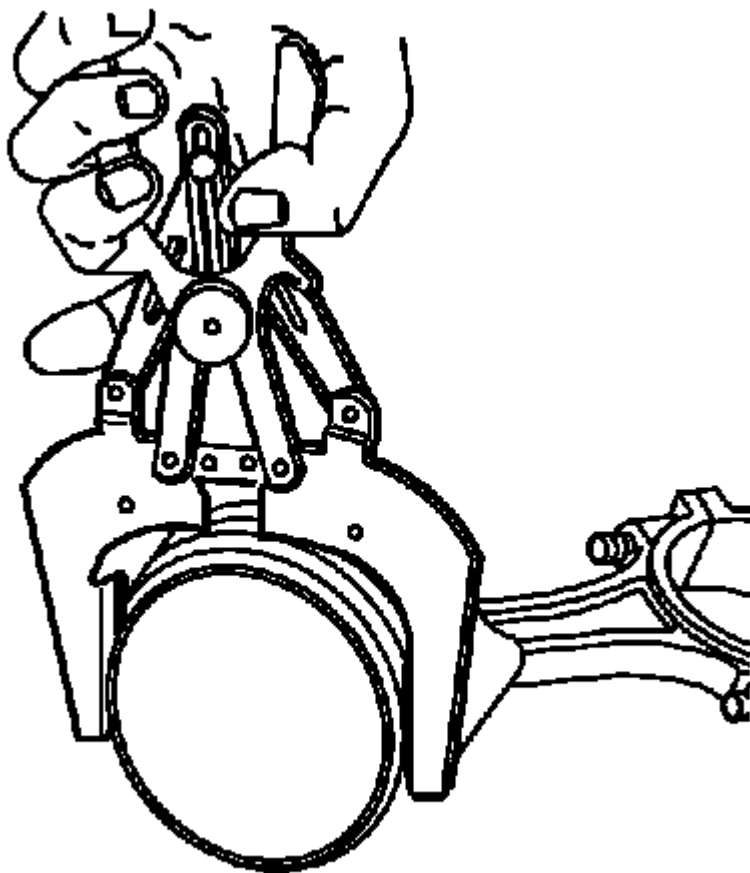


Fig. 294: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

2. Clean the piston ring grooves with a suitable ring groove cleaning tool.
3. Clean the piston oil lubrication holes and slots.

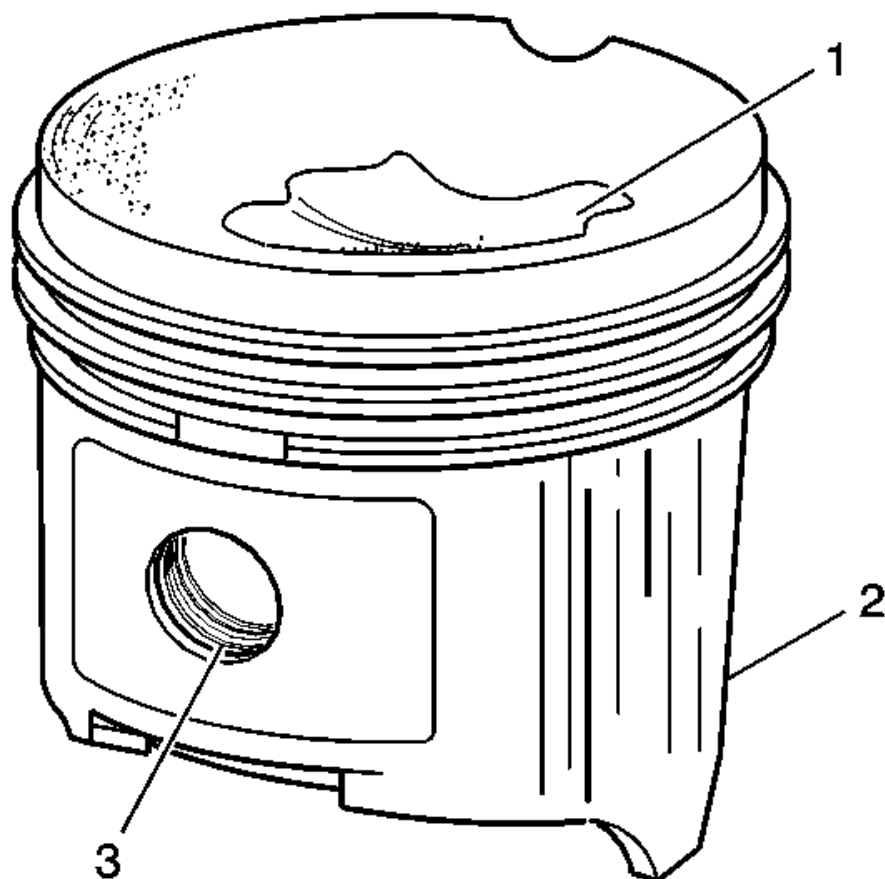


Fig. 295: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

4. 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
5. Inspect the piston pin for scoring, wear or other damage.

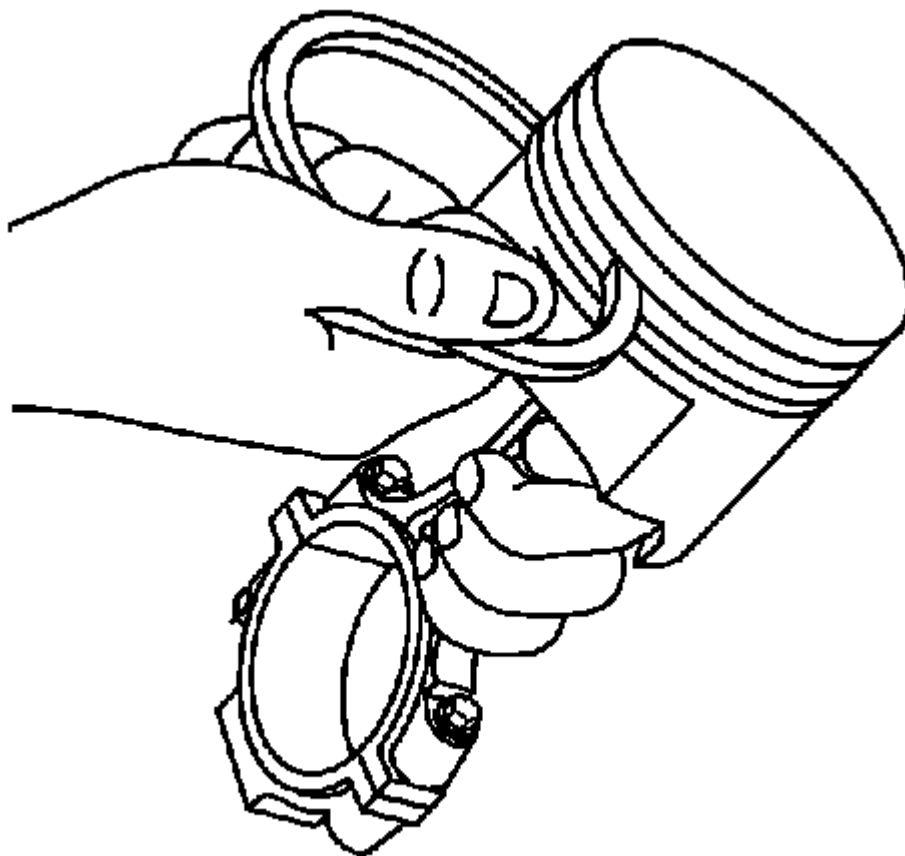


Fig. 296: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

6. 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.

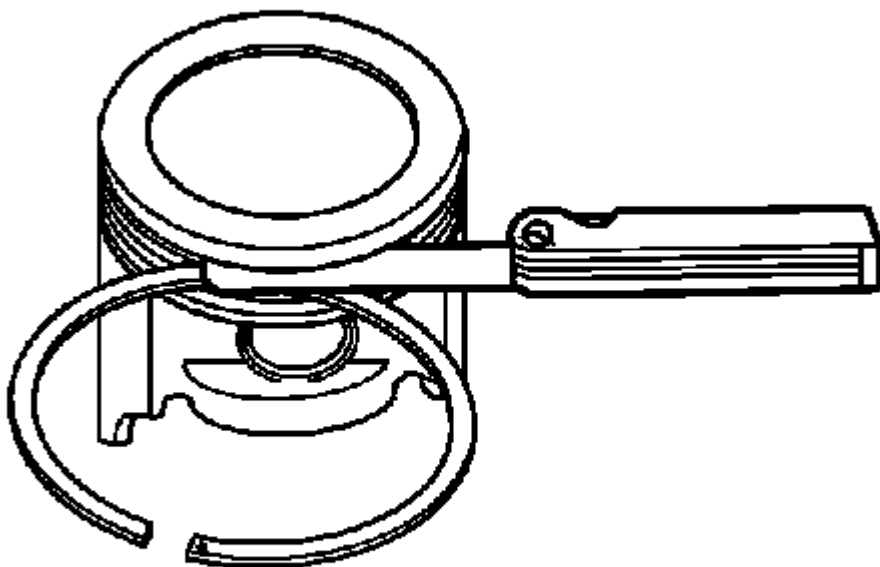


Fig. 297: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance with a feeler gage.
8. If the side clearance is too small try another ring set.
9. 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 0.04-0.086 mm (0.00158-0.00338 in).
 - Proper ring-to-piston ring groove clearance for the second ring is 0.04-0.087 mm (0.00158-0.00342 in).

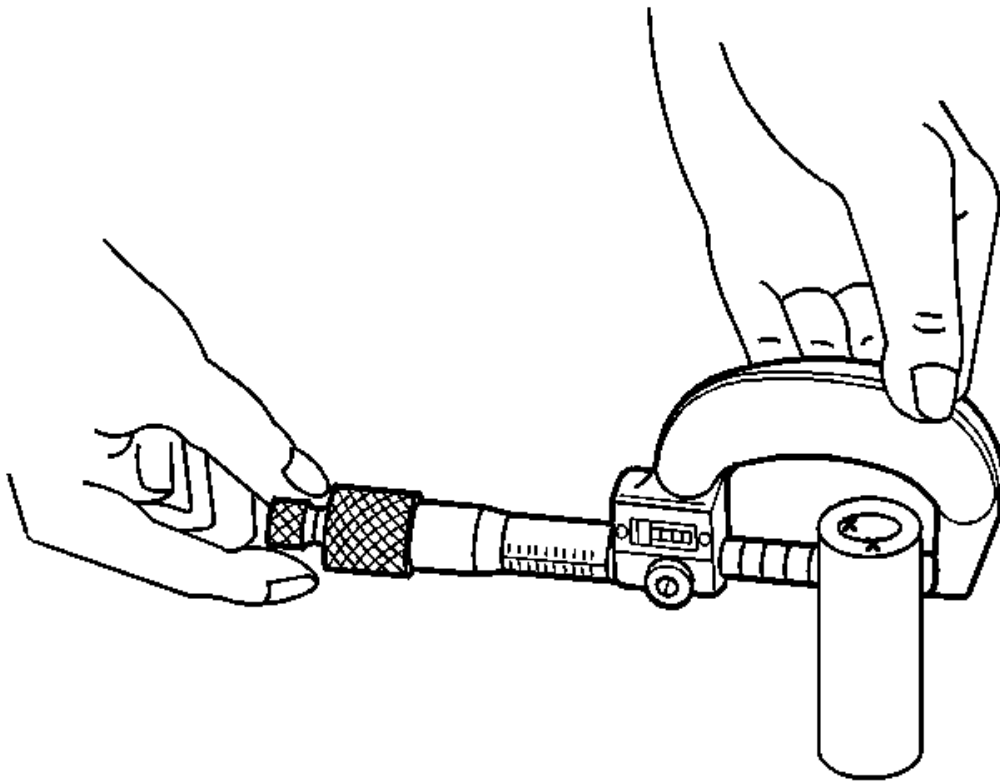


Fig. 298: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

10. Measure the piston pin diameter using an outside micrometer.

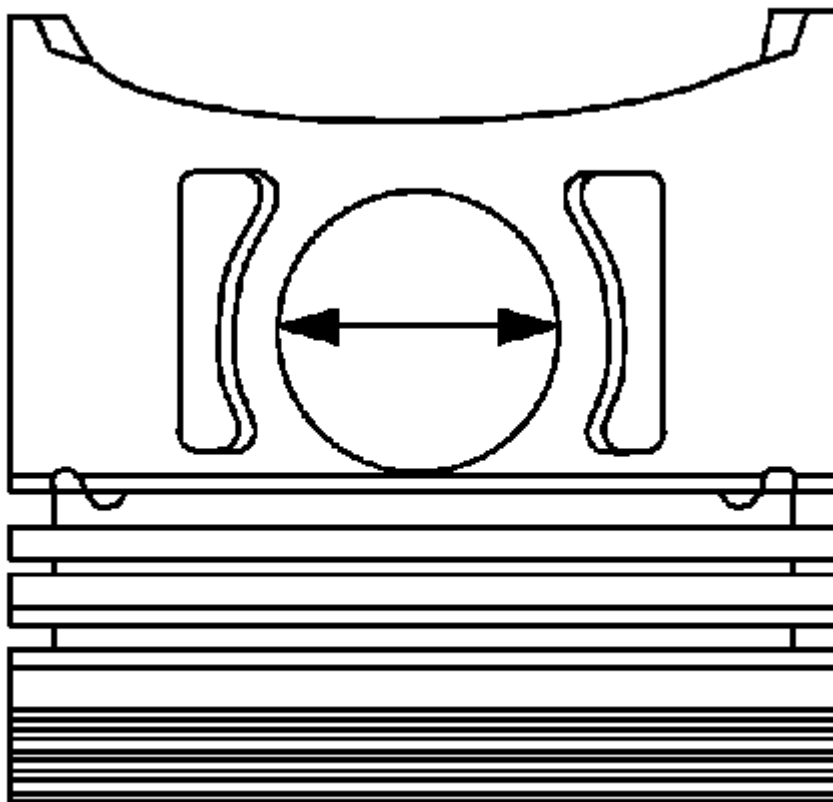


Fig. 299: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

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 piston.

11. Measure the piston pin bore using an inside micrometer.
12. Subtract the piston pin diameter from the piston pin bore diameter in order to determine the piston pin-to-piston pin bore clearance.
13. Piston-to-piston pin bore clearance must measure 0.0096-0.0215 mm (0.0004-0.0008 in). Replace the piston and the piston pin if the piston and the piston pin are not within specifications.

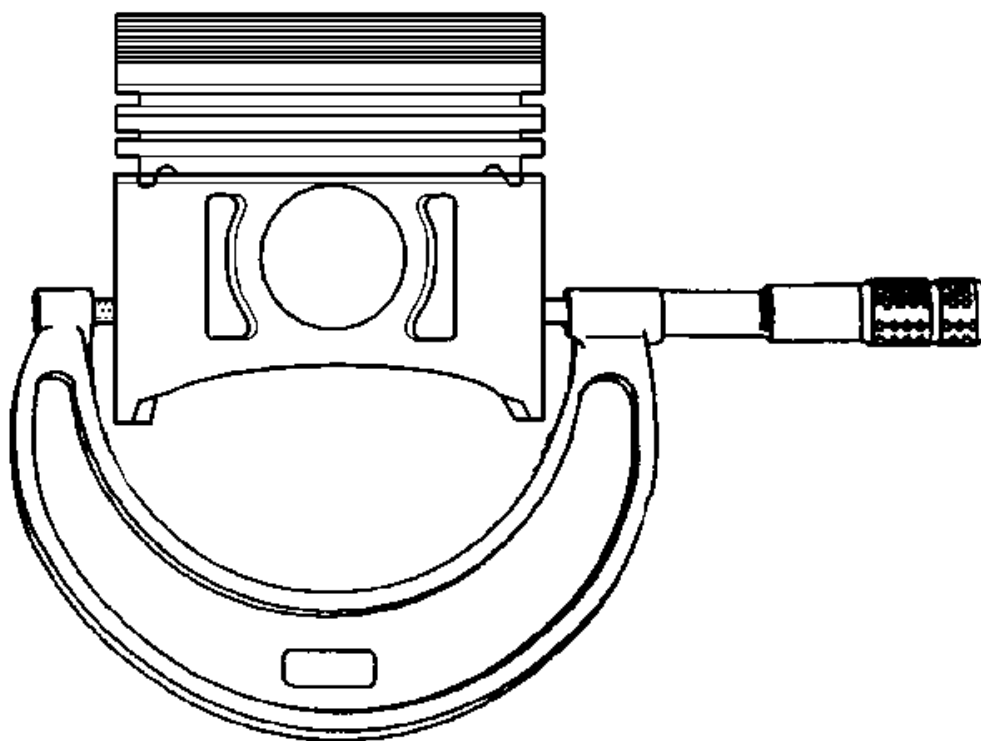


Fig. 300: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

14. 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 49.8 mm (1.9606 in) from dome of piston. Piston diameter must measure 88.966-88.984 mm (3.5026-3.5033 in). Replace the piston and the pin as an assembly if the piston is not within specifications.

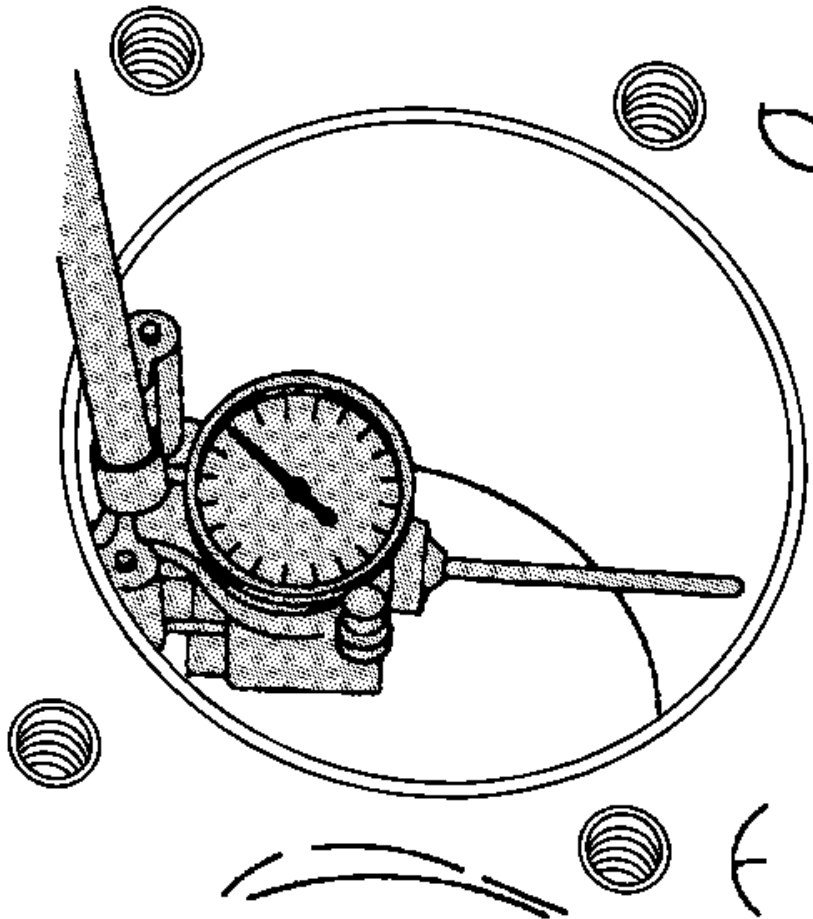


Fig. 301: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

15. Measure the cylinder bore, using **J 8087** .

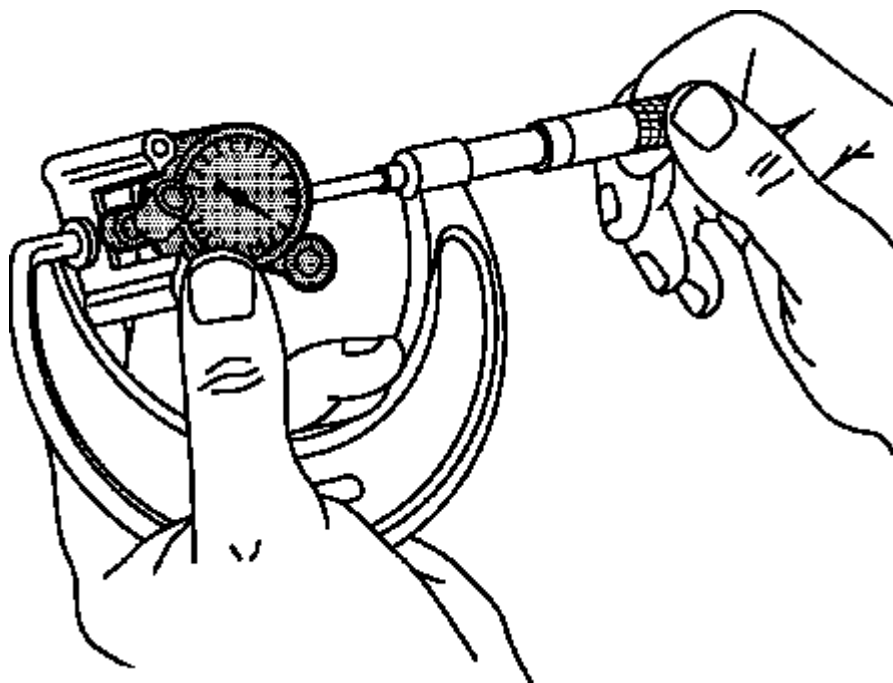


Fig. 302: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

16. Measure the **J 8087** . Record this reading.
17. 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 0.07-0.053 mm (0.0013-0.0027 in).
18. If a used piston is not acceptable, inspect the service piston sizes and determine if a new piston may be selected. Service pistons are available in standard, and 0.5 mm (0.012 in) oversize.
19. When a piston has been selected, mark the piston in order to identify the cylinder for which the piston was fitted.

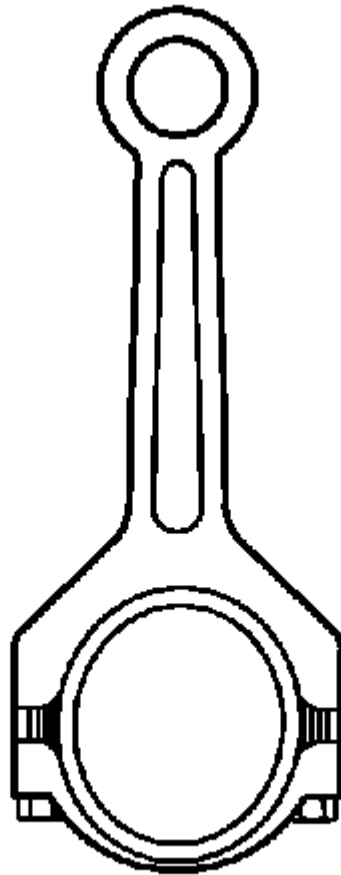


Fig. 303: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

20. 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.

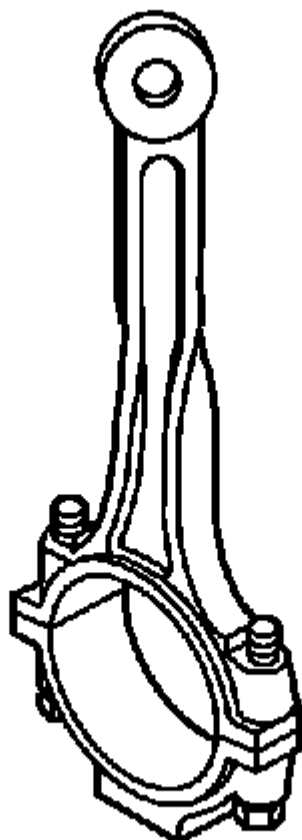


Fig. 304: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

21. 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 0.038 mm (0.0015 in).
4. Replace any bent or twisted connecting rods.
 5. Inspect the new connecting rods before using the new rods.
22. Inspect the connecting rod for damage to the bearing cap and bolt threads.

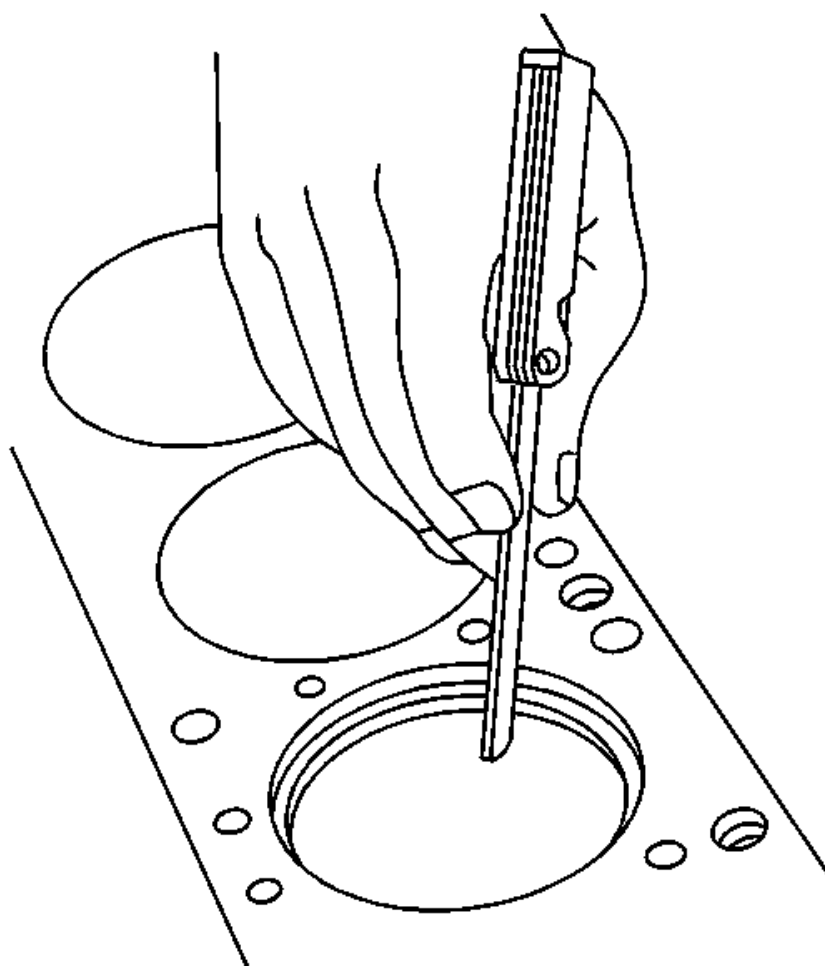


Fig. 305: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

23. 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 0.15-0.36 mm (0.006-0.014 in), the second compression ring, 0.5-0.71 mm (0.019-0.027 lb in).
4. Select another size ring set if the end gap exceeds specification. If ring gap clearance is below

specification, increase the gap by carefully filling off excess material.

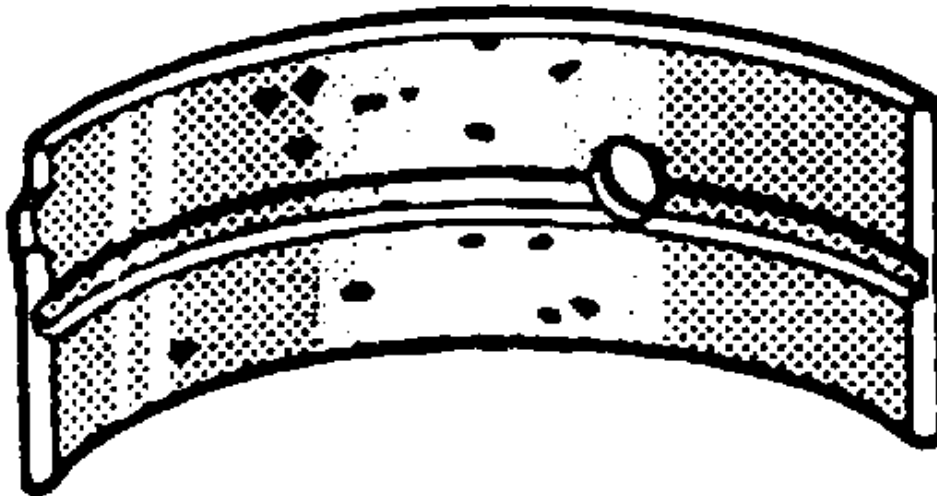


Fig. 306: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

24. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the connecting rod bearing halves may indicate fatigue.

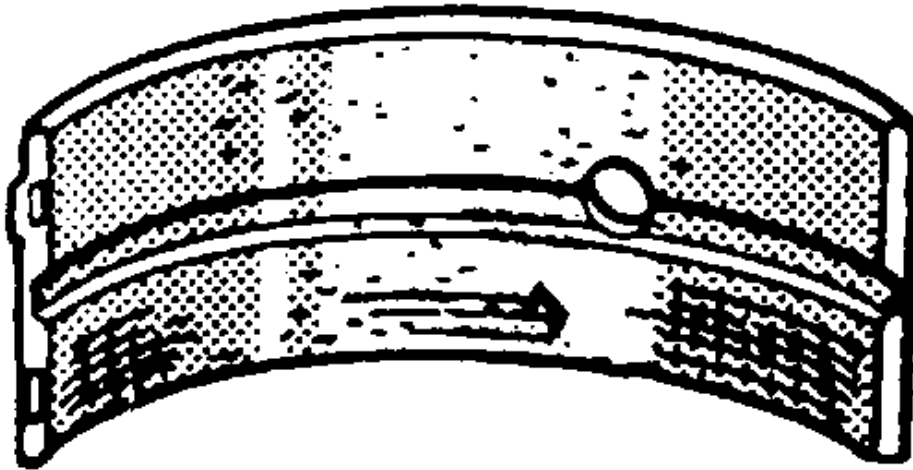


Fig. 307: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

25. Inspect the connecting rod bearings for excess scoring or discoloration.
26. Inspect the connecting rod bearings for dirt or debris imbedded into the connecting rod bearing halves.

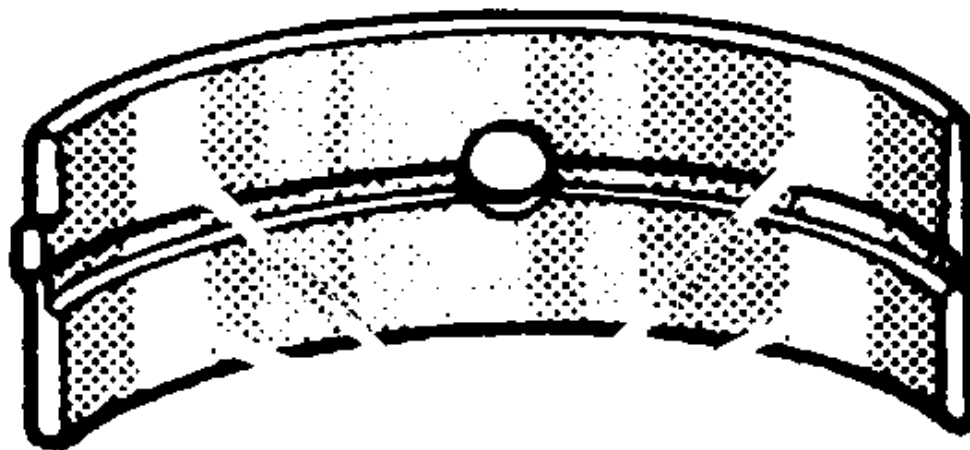


Fig. 308: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

27. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearings.
28. Inspect the inside of the connecting rod bearing and the outside diameter of the connecting rod bearing journal for wear. This indicates high spots.

Piston and Connecting Rod Assemble

Tools Required

J 24086-C Piston Pin Remover and Installer Set. See **Special Tools and Equipment**.

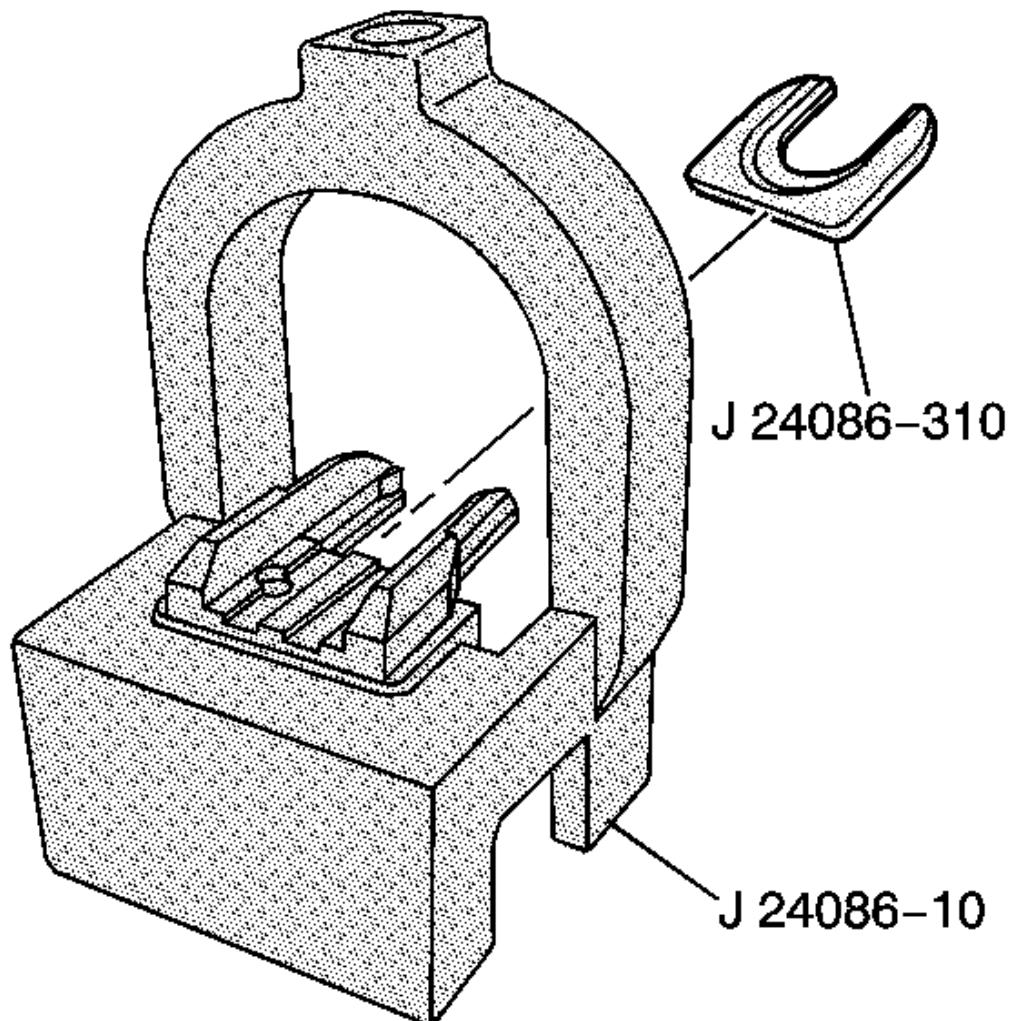


Fig. 309: Installing J 24086-310 Into J 24086-10
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Assemble the piston for the specific cylinder with the connecting rod for the corresponding crankshaft journal.

1. Install the fork insert J 24086-310 into fixture J 24086-10

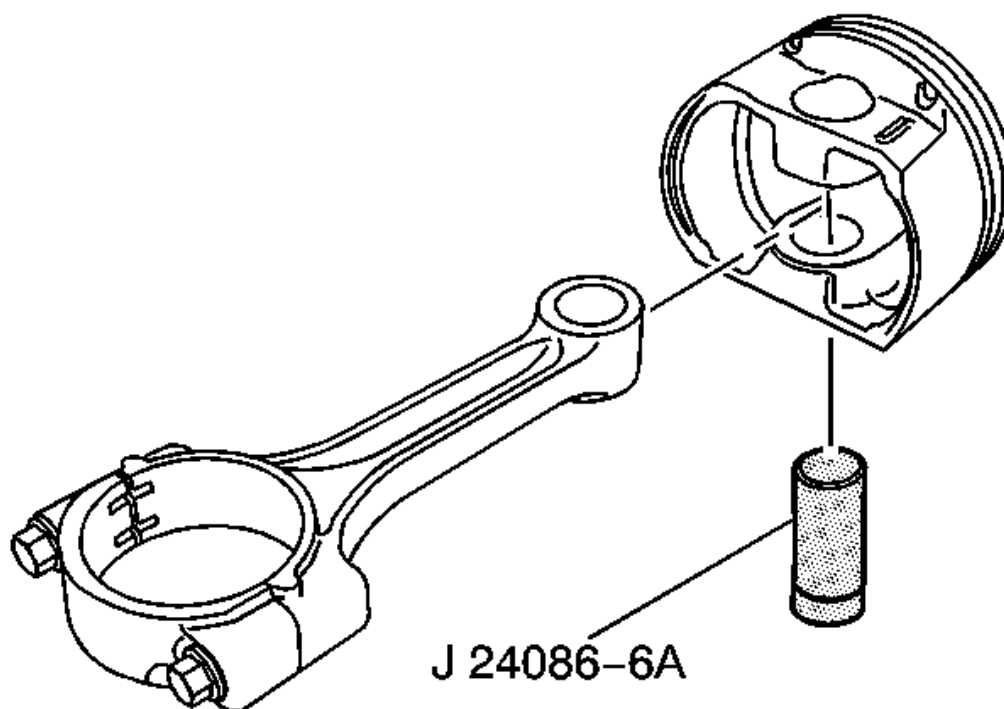


Fig. 310: Piston, Connecting Rod & Adapter J 24086-6A
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the piston pin with clean engine oil.

IMPORTANT: Ensure that the marks on the piston and connecting rod are aligned the same as when removed. If installing a new piston, ensure that the arrow on top faces towards the front of the engine. If no identification marks were made during disassembly, ensure that the flat area on the bottom of the piston pin skirt is aligned with the small dimple above the connecting rod crankshaft bearing bore.

3. Assemble the piston, connecting rod and adapter J 24086-6A and install onto fixture J 24086-10 .

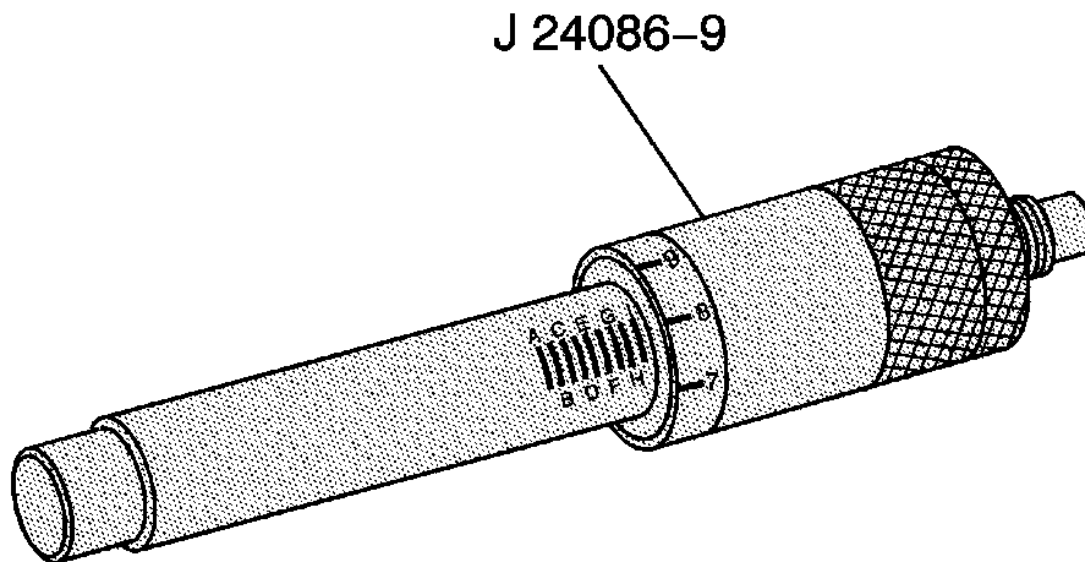


Fig. 311: Closeup View Of J 24086-9
Courtesy of GENERAL MOTORS CORP.

4. Adjust installation pin **J 24086-9** to G-4.

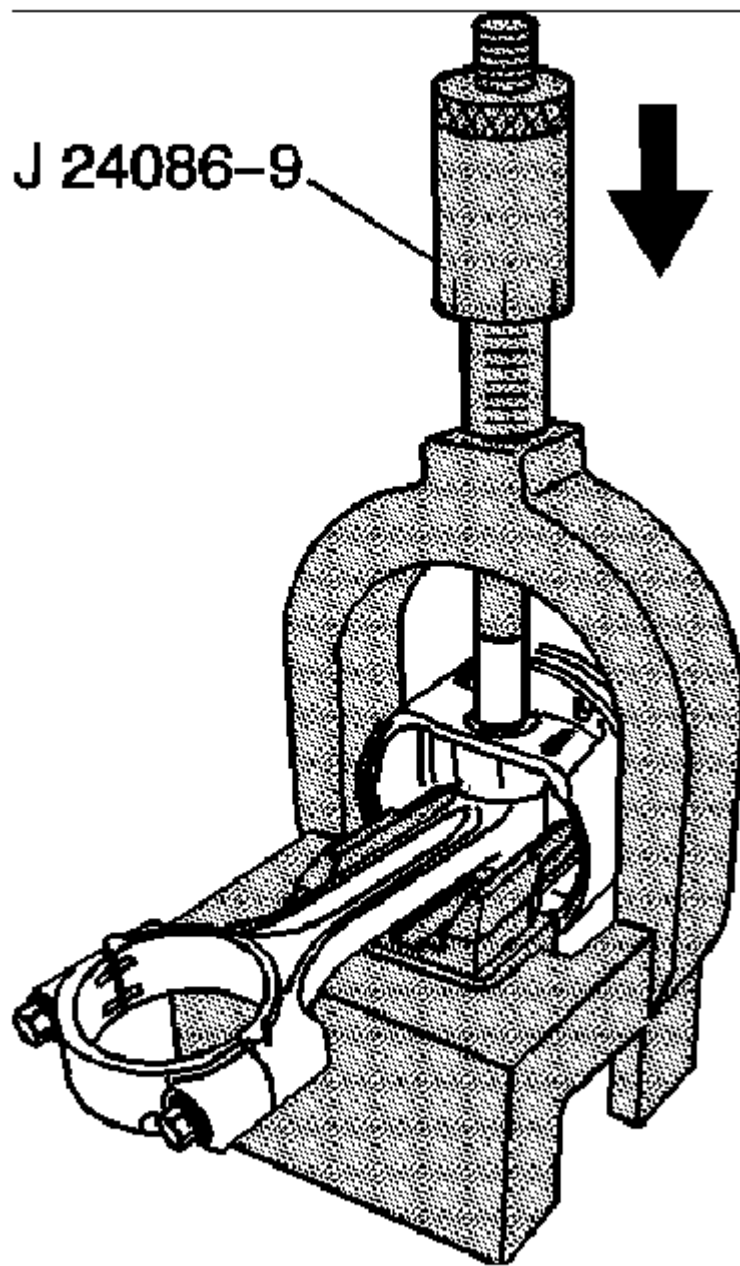


Fig. 312: View Of J 24086-9

Courtesy of GENERAL MOTORS CORP.

NOTE: After the installer hub bottoms on the support assembly, do not exceed 35

000 kPa (5,000 psi) pressure, this could cause damage to the tool.

5. Insert pin J 24086-9 through fixture J 24086-10 and to the piston pin.
6. Press pin J 24086-9 until the install bottoms on fixture J 24086-10 .

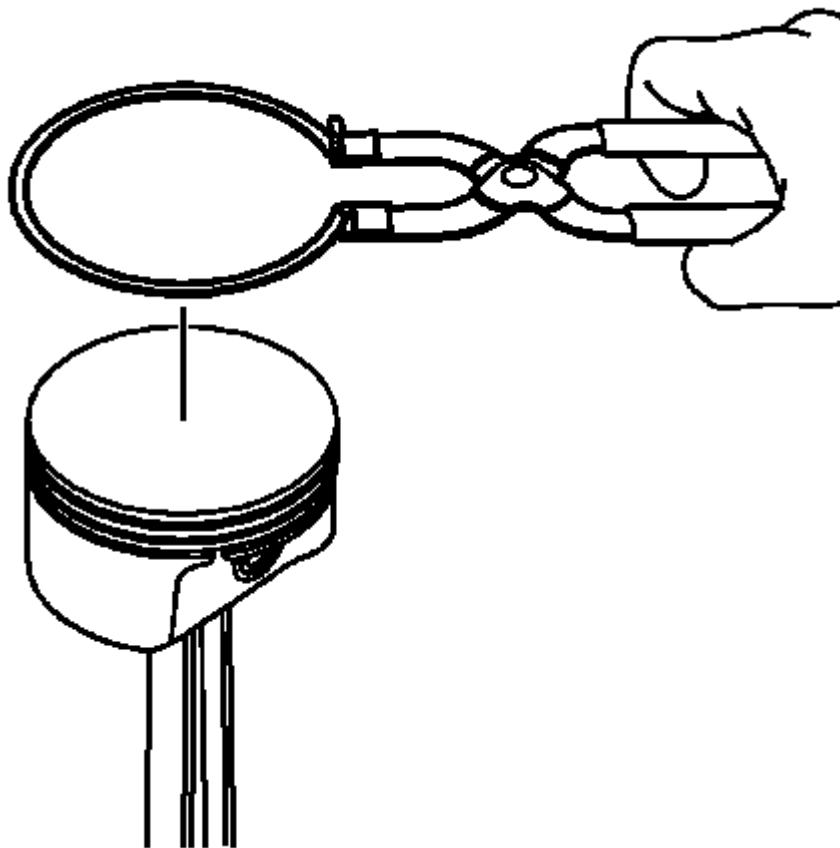


Fig. 313: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

IMPORTANT: To provide an effective compression seal, the ring gaps must be staggered a minimum of 90 degrees.

7. Using piston ring pliers, install the piston rings onto the piston.
 1. Install the oil control ring spacer into the bottom groove of the piston.
 2. Install the lower oil control ring.

The oil control rings do not have a dimple or orientation mark and may be installed in either direction.

3. Install the upper oil control ring.
4. Install the middle compression ring with the dot facing up.
5. Install the top compression ring in either direction. The ring has no orientation markings.

Camshaft and Bearings Cleaning and Inspection

Tools Required

J 7872 Magnetic Base Dial Indicator Set. See **Special Tools and Equipment**.

1. Clean the camshaft with cleaning solvent.

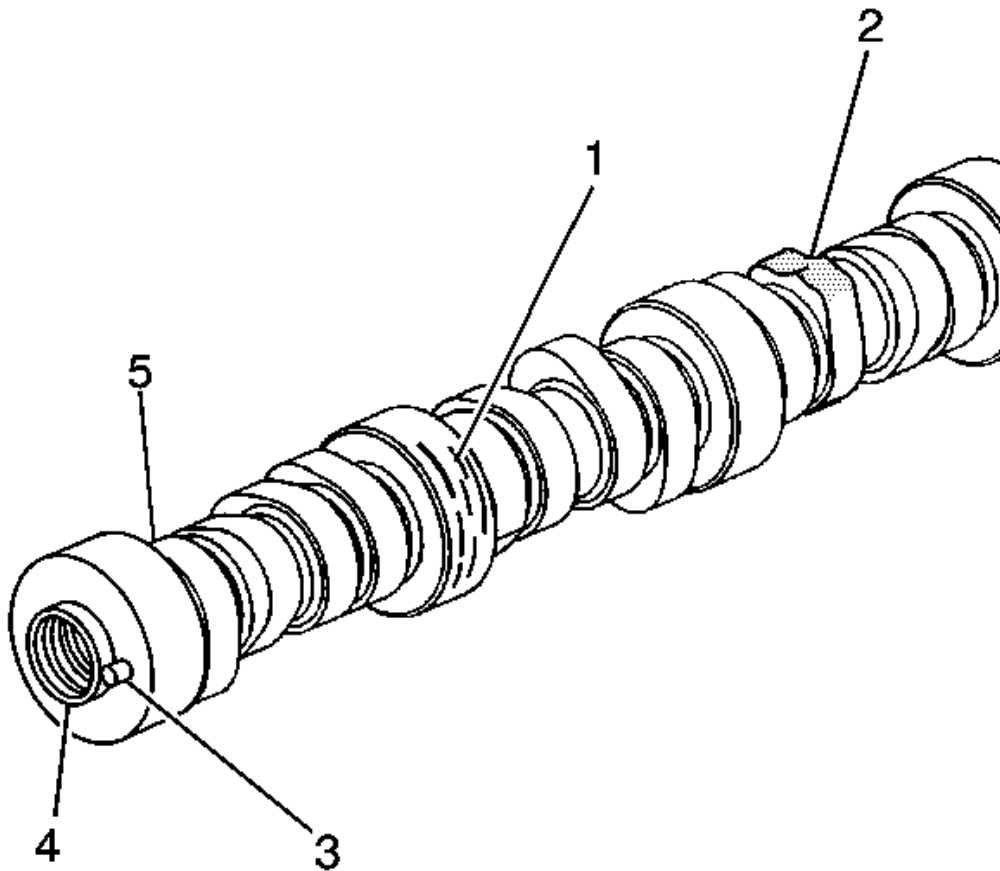


Fig. 314: Inspecting Camshaft For Damage
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

2. Inspect the camshaft for the following conditions:

- Scored camshaft bearing journals (1)
- Damaged camshaft lobes (2)
- Damaged camshaft sprocket locator pins (3)
- Damaged threads (4)
- Damage to the camshaft reluctor tooth (5)

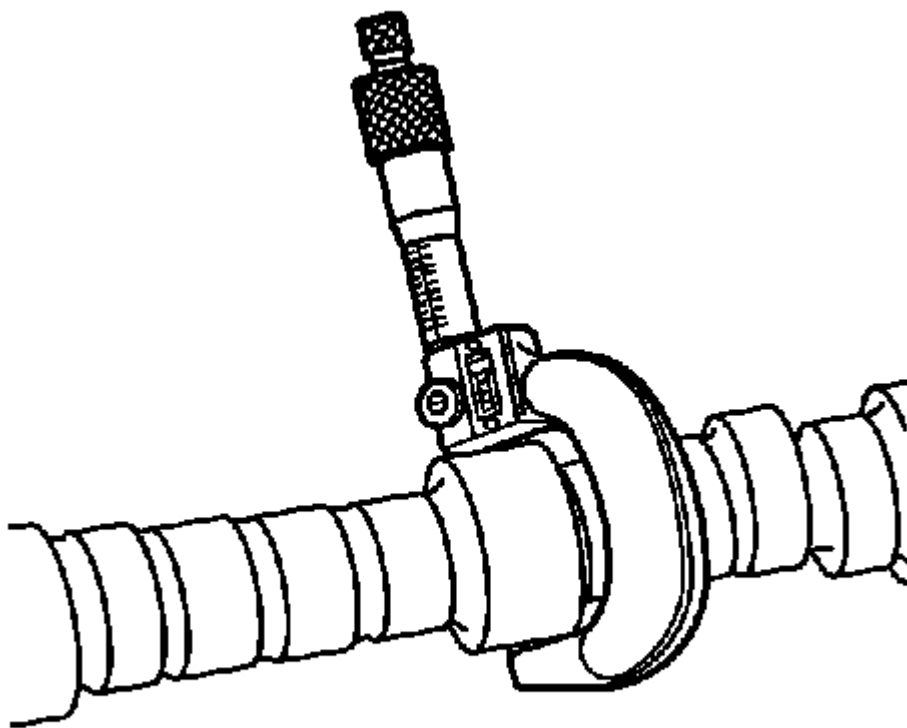


Fig. 315: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft journals using a micrometer.

If the camshaft journals are not within specifications, replace the camshaft.

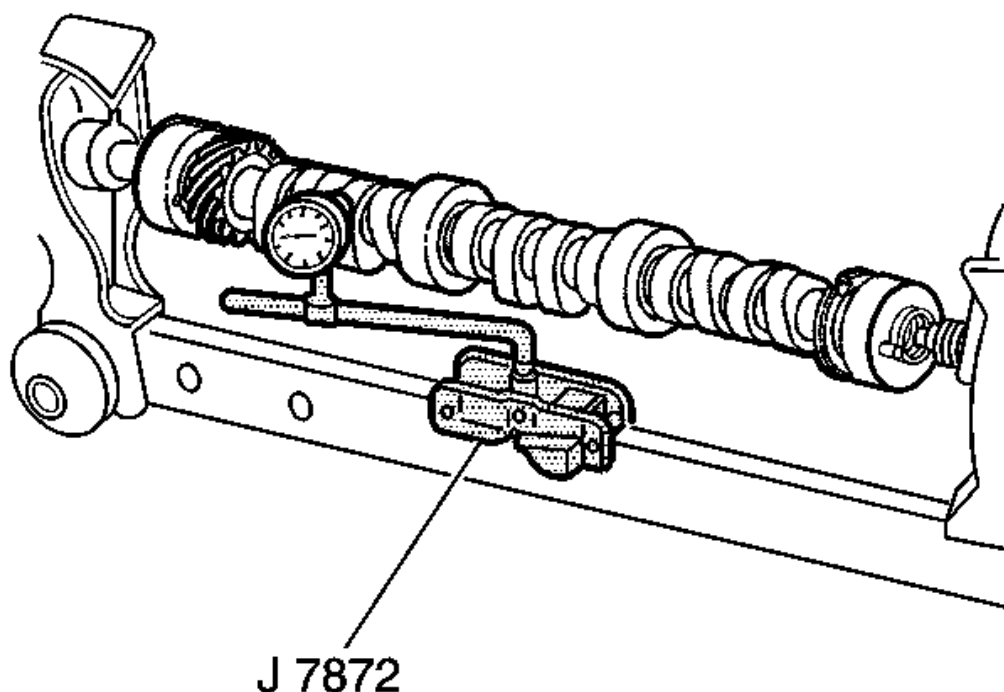


Fig. 316: Measuring Camshaft Runout Using J 7872
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft runout using the **J 7872** . See **Special Tools and Equipment**.
 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 and Equipment**.
5. Measure the camshaft lobe lift using the **J 7872** . See **Special Tools and Equipment**.
 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 and Equipment**.
6. If the runout or lobe lift is not within specifications, replace the camshaft.

Timing Chain and Sprockets Cleaning and Inspection

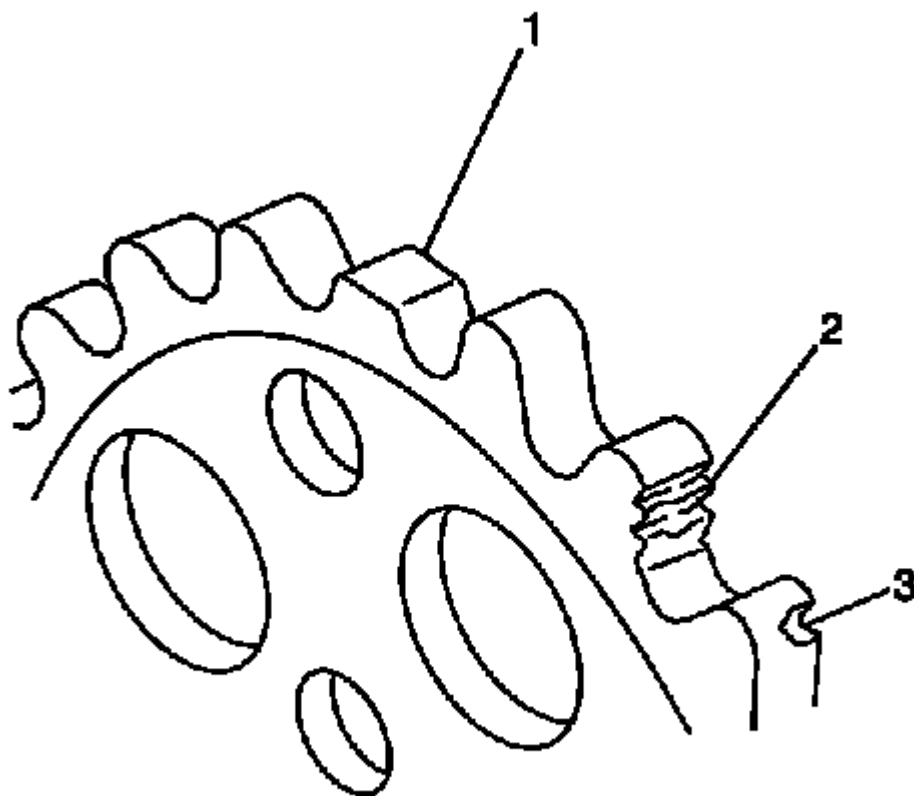


Fig. 317: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

- Inspect the timing chain sprockets for teeth that are worn (1), broken (2), or chipped (3).
- Inspect the timing chain for binding or stretching.
- Inspect the timing chain dampener for excessive wear or cracks.
- Replace the timing chain and sprockets as needed.

Valve Lifters Cleaning and Inspection

1. Clean the valve lifters in cleaning solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution in Cautions and Notices.

2. Dry the valve lifters with compressed air.

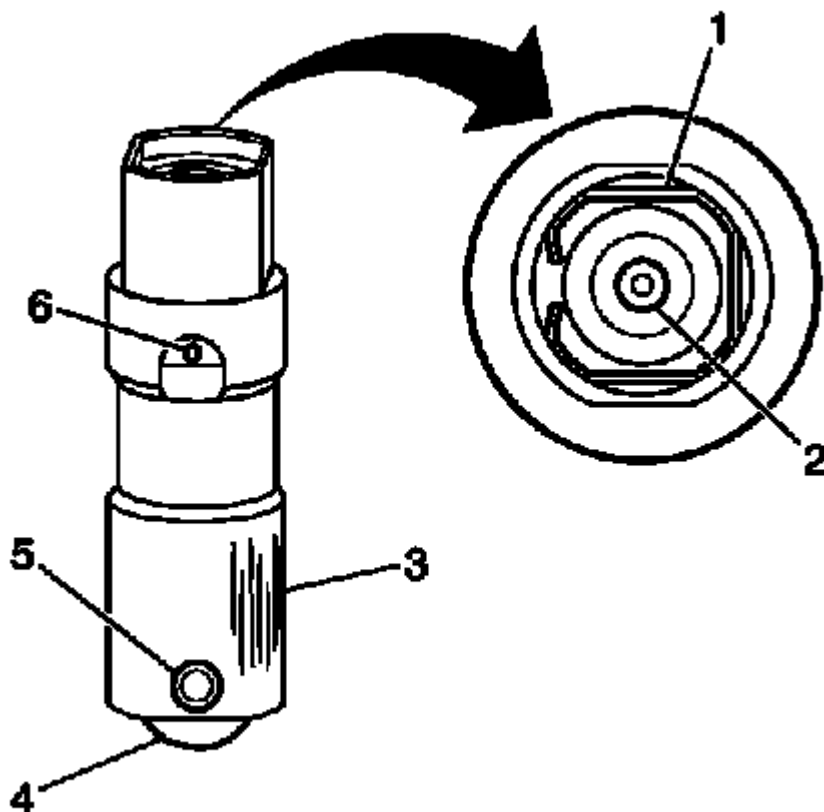


Fig. 318: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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.

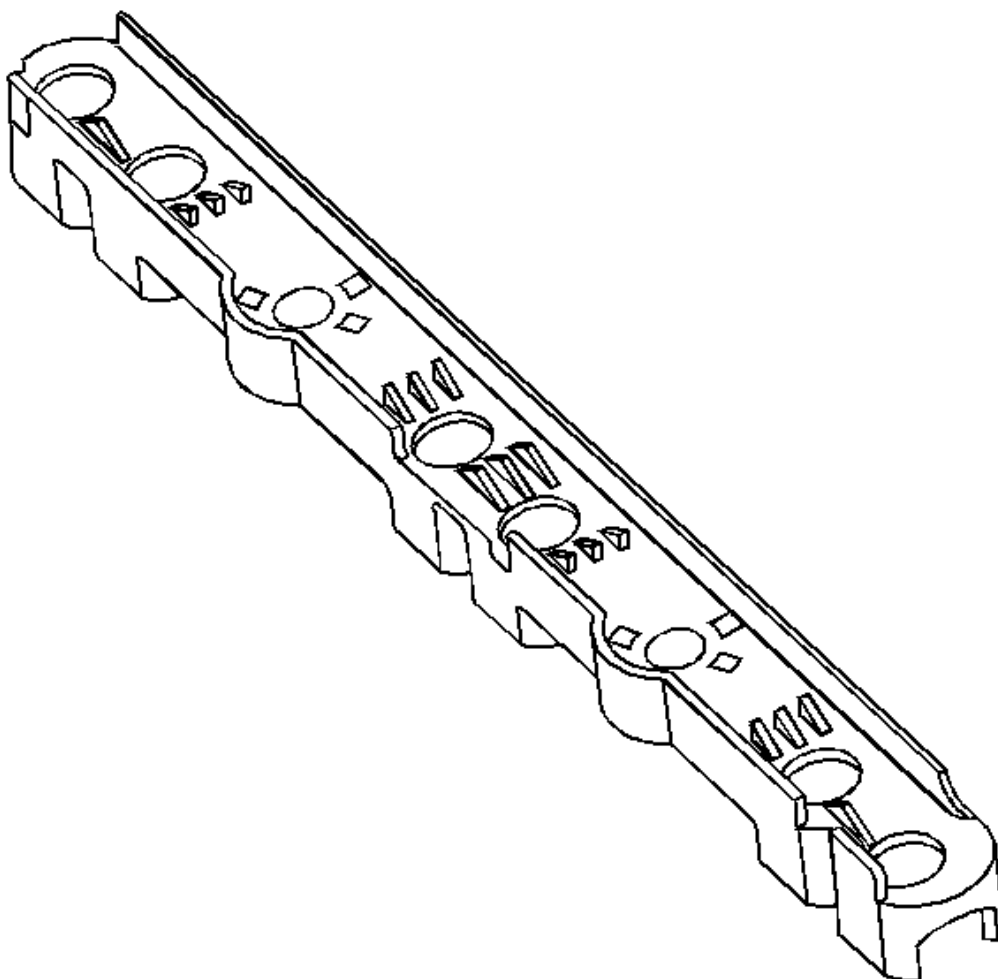


Fig. 319: Inspecting Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter guides for the following:
 - For cracks or damage
 - Excessive wear in the lifter mounting bores

Valve Rocker Arm and Push Rods Cleaning and Inspection

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

1. Clean the valve rocker arms and push rods in cleaning solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution in Cautions and Notices.

2. Dry the valve rocker arms and push rods with compressed air.

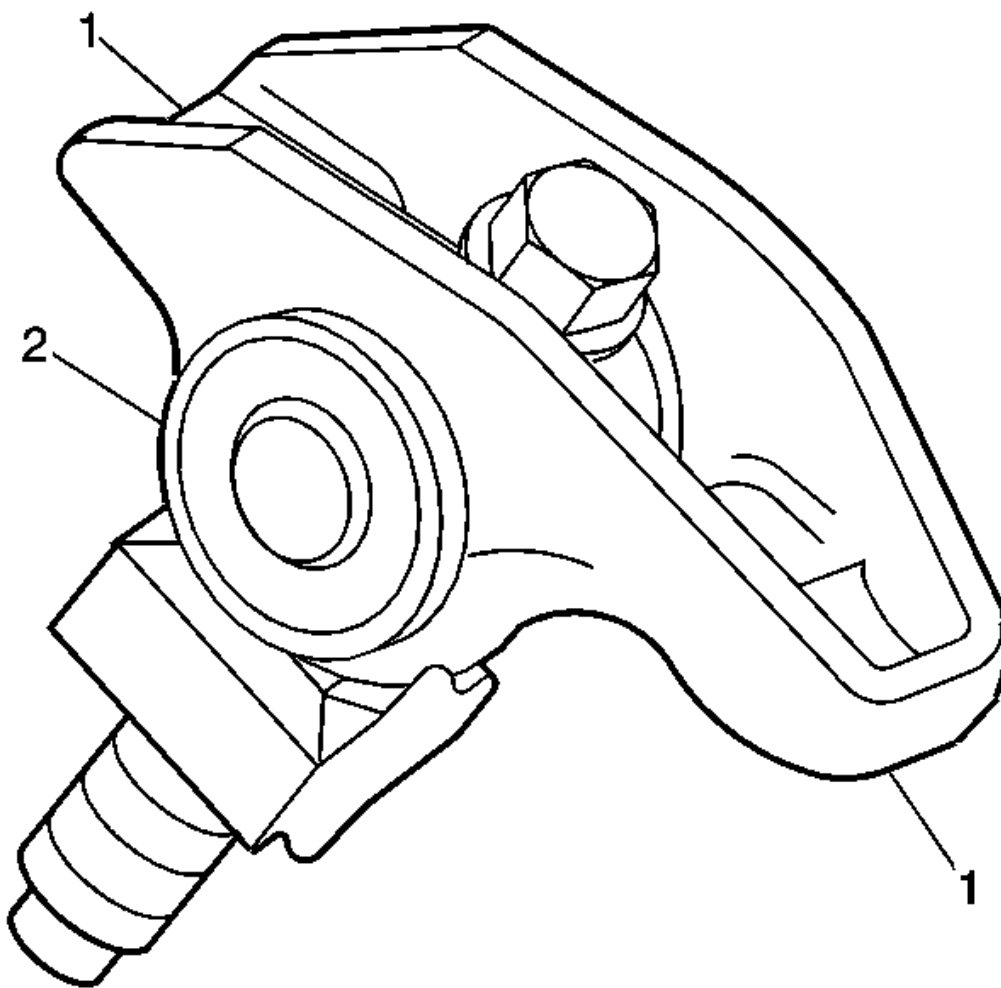


Fig. 320: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

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

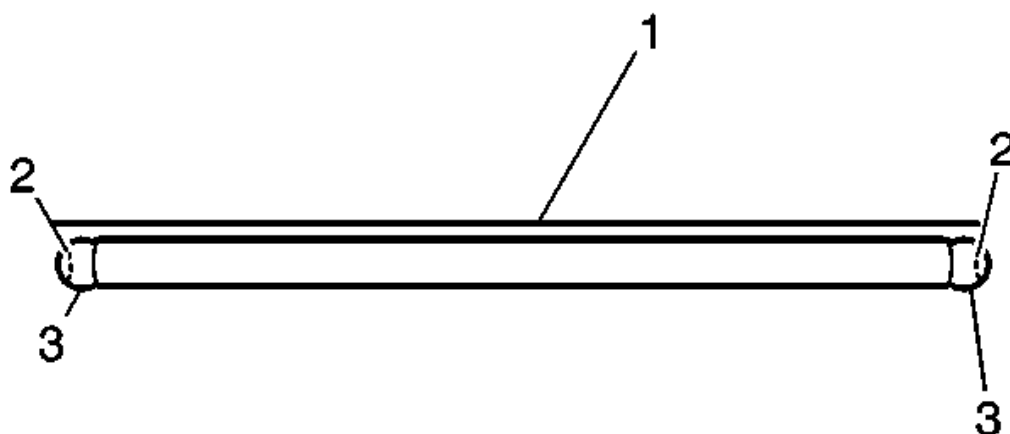


Fig. 321: Inspecting Push Rods

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

J 38606 Valve Spring Compressor. See **Special Tools and Equipment**.

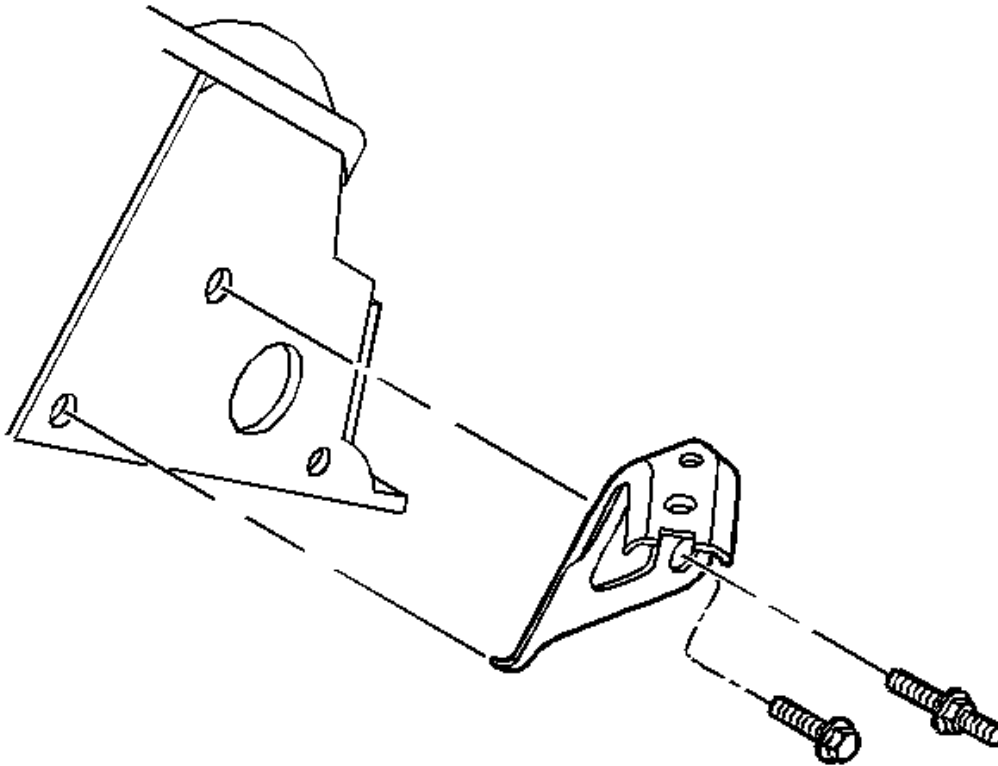


Fig. 322: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

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 components were removed.

1. Remove the fuel line bracket bolt and stud.
2. Remove the fuel line bracket.

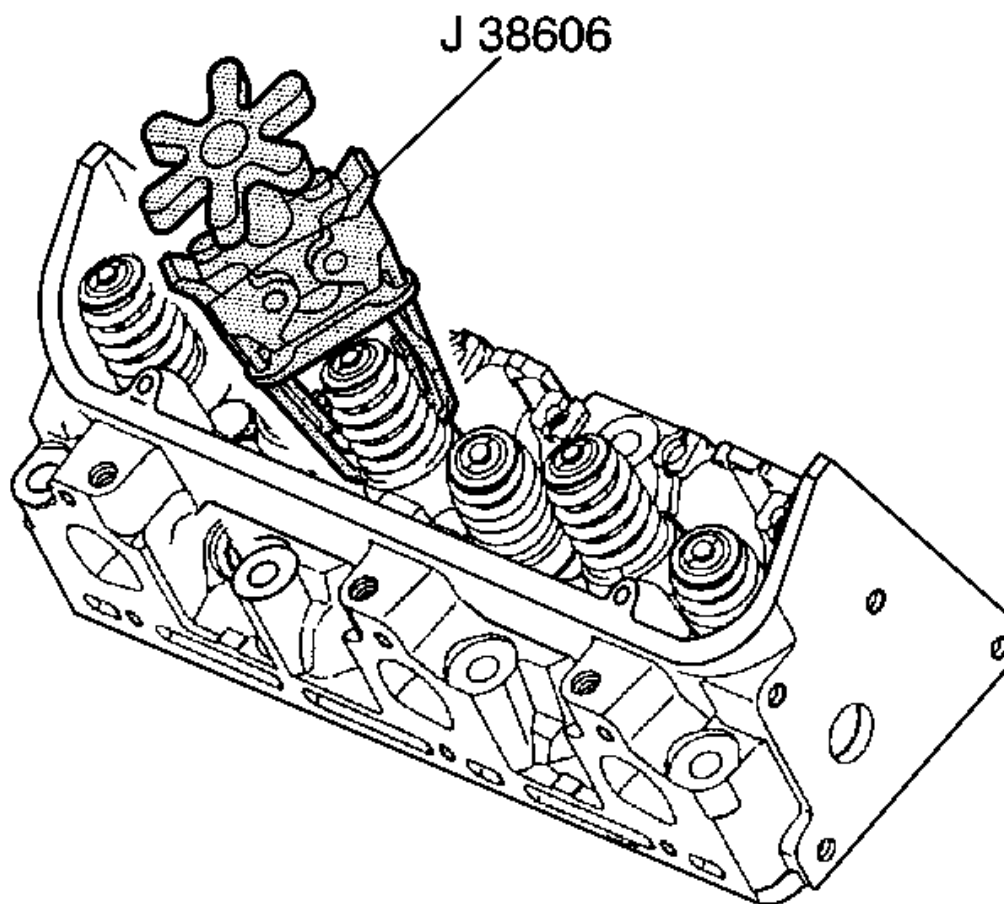


Fig. 323: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

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.

3. Compress the valve springs using the J 38606 . See Special Tools and Equipment.

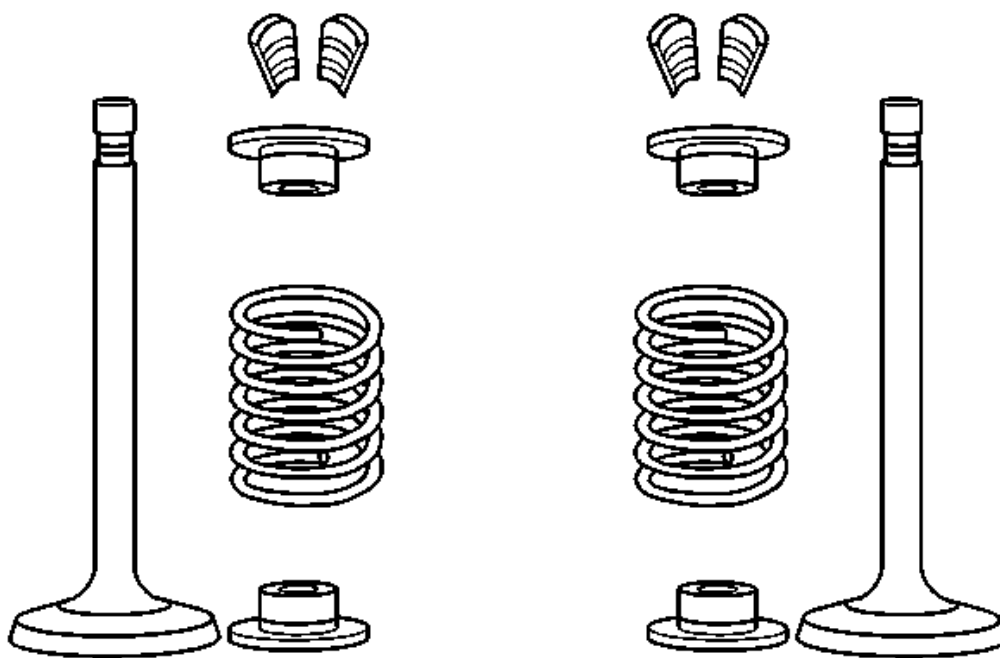


Fig. 324: Valve Locks, Caps, Seats & Spring
 Courtesy of GENERAL MOTORS CORP.

4. Remove the valve spring cap keys.
5. Remove the valve spring caps.
6. Remove the valve springs.
7. Remove the valves.
8. Remove the valve stem oil seals and spring seats as an assembly.

Cylinder Head Cleaning and Inspection

Tools Required

- **J 8089** Carbon Removing Brush. See **Special Tools and Equipment**.
- **J 9666** Valve Spring Tester

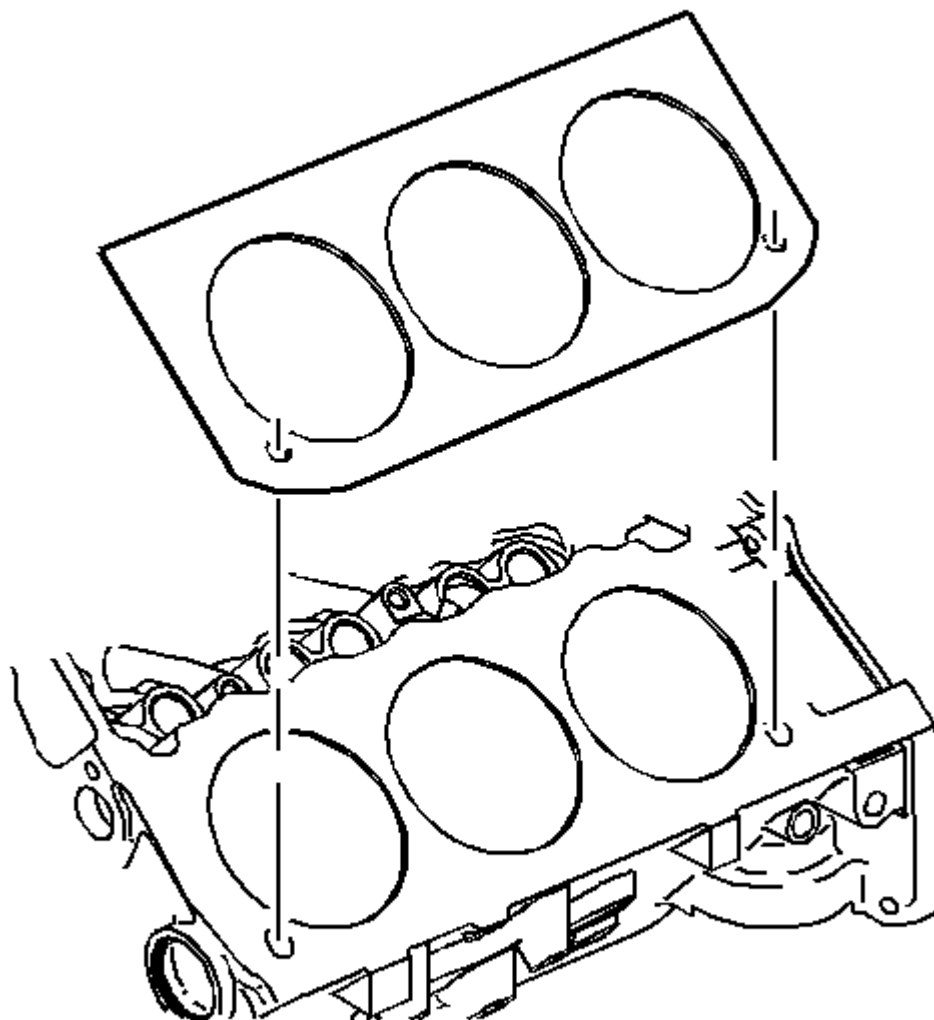


Fig. 325: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surfaces. Inspect for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. The following conditions may cause gasket failure:
 - Improper installation
 - A loose or warped cylinder head
 - Missing, off location, or not fully seated dowel pins
 - Low torque on the cylinder head bolts

- Cylinder head bolts with the incorrect length
- A warped engine block surface
- Scratched surfaces
- Excessive intake manifold torque
- Cracked engine block threaded holes

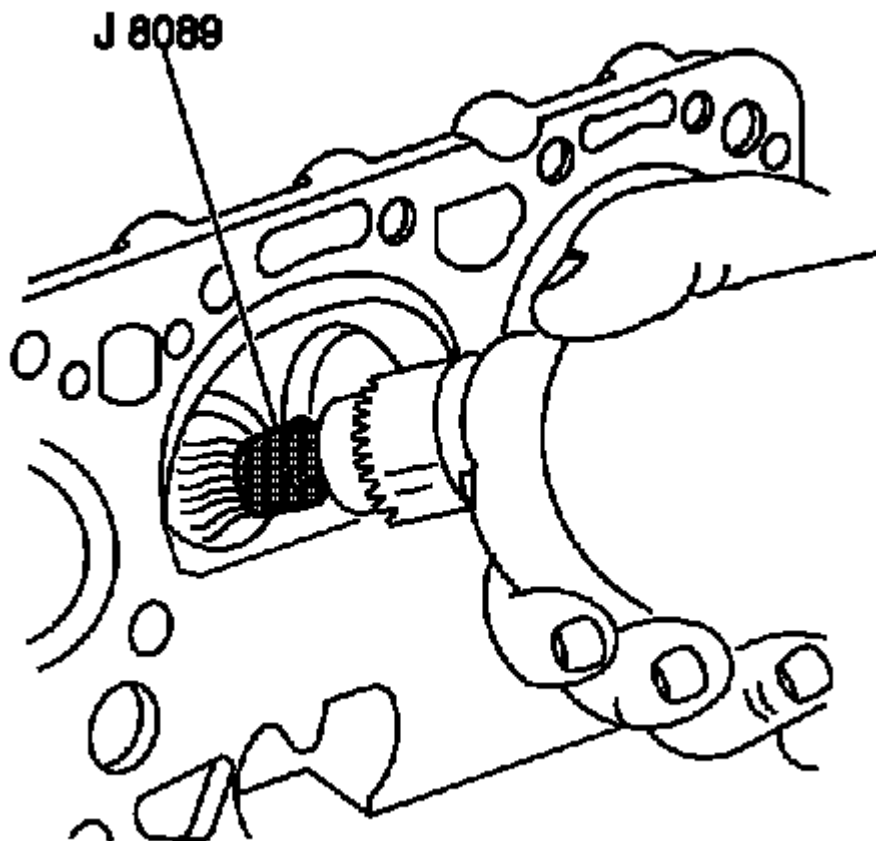


Fig. 326: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: Do not scuff the chamber.

3. Use the **J 8089** in order to remove the carbon from the combustion chambers. See Special Tools and Equipment.
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.

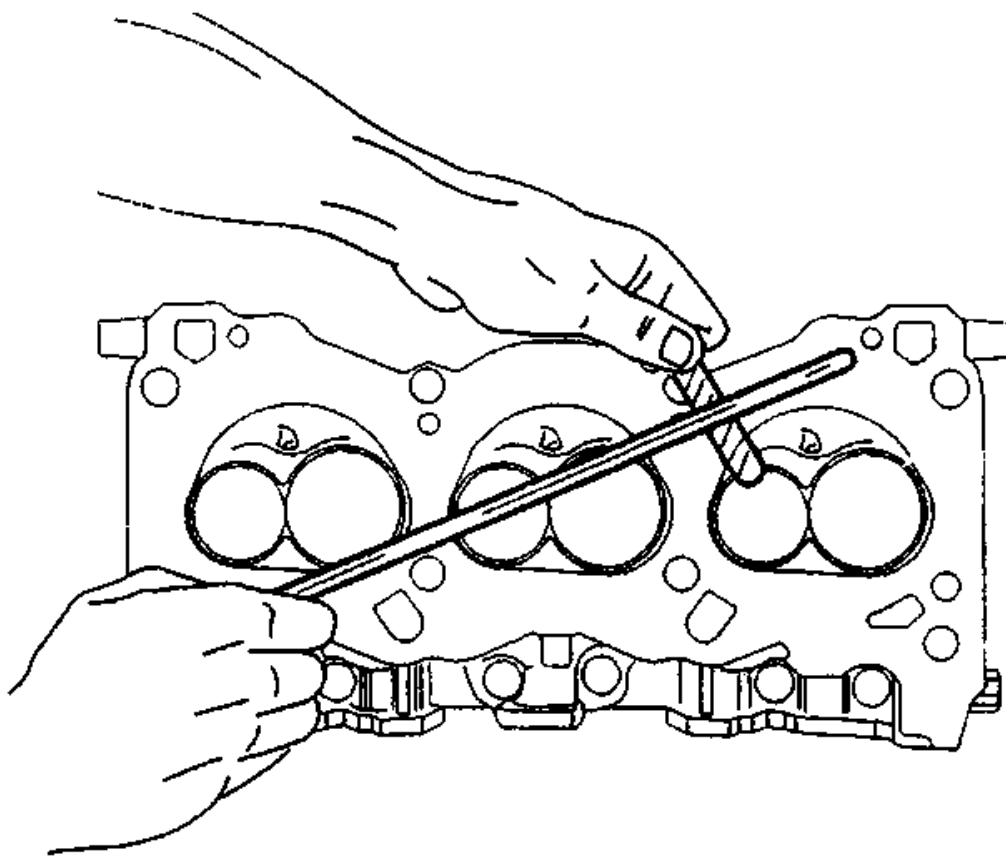


Fig. 327: Inspecting Cylinder Head Mating Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

5. Inspect the cylinder head mating surfaces for flatness. Recondition the cylinder head mating surface, if necessary, by milling. Replace the cylinder head if you must remove more than 0.25 mm (0.010 in).
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.

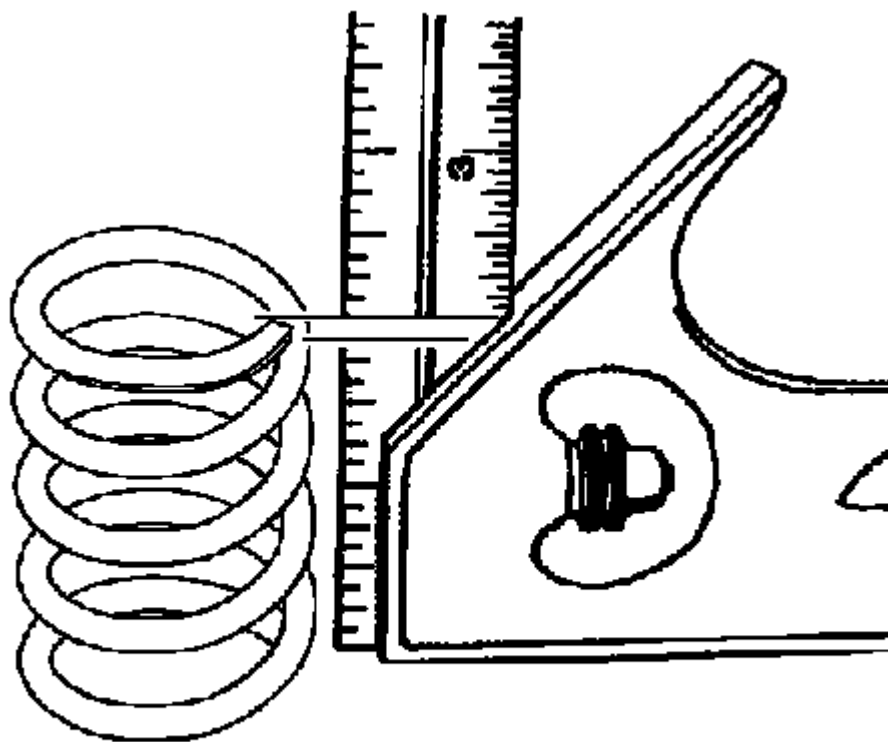


Fig. 328: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

8. Inspect the valve springs for squareness.

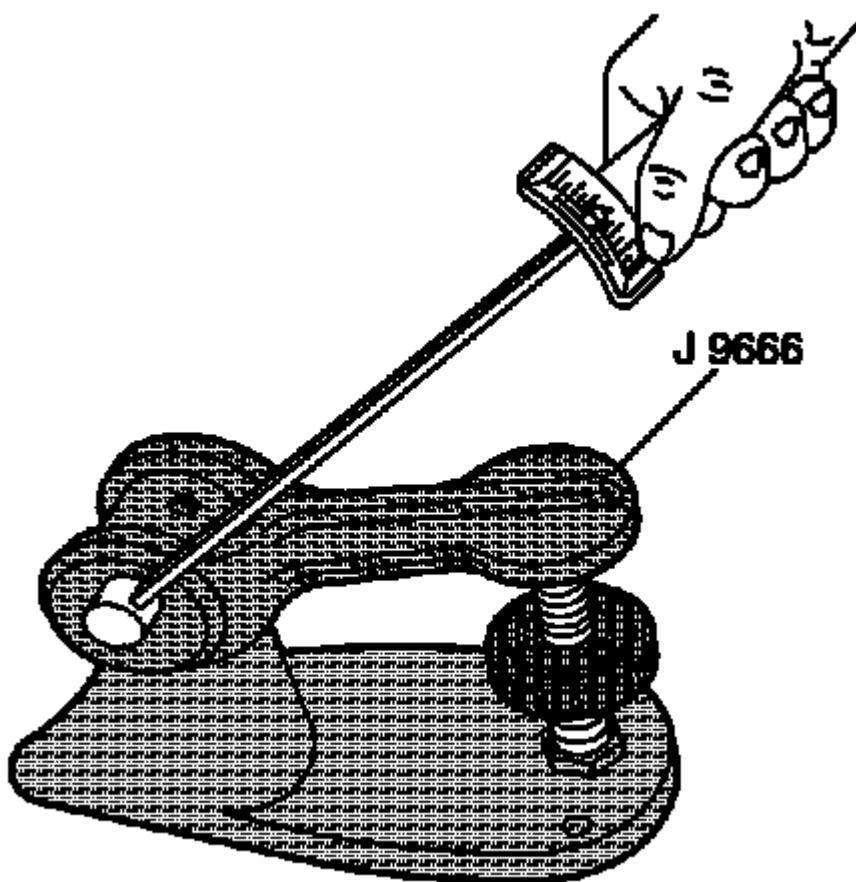


Fig. 329: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

9. Use the **J 9666** in order to measure the valve spring tension.

Replace the spring if the spring tension is not within specification.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

J 8520 Camshaft Lobe Lift Indicator Set. See **Special Tools and Equipment**.

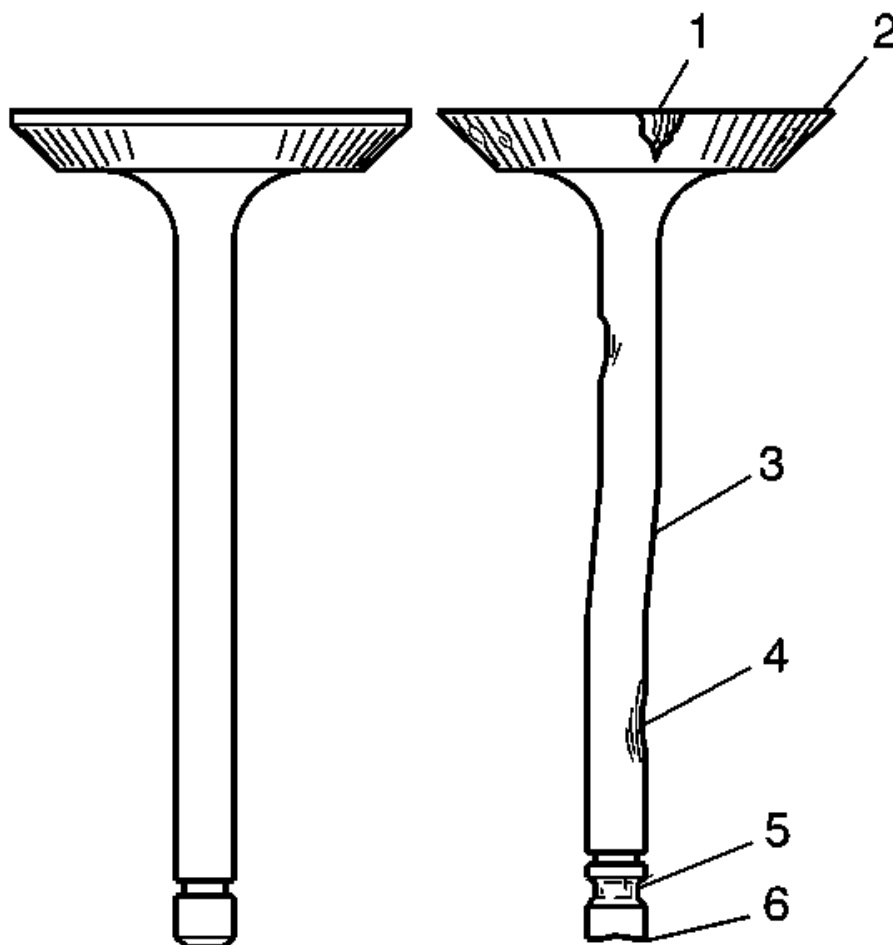


Fig. 330: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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)

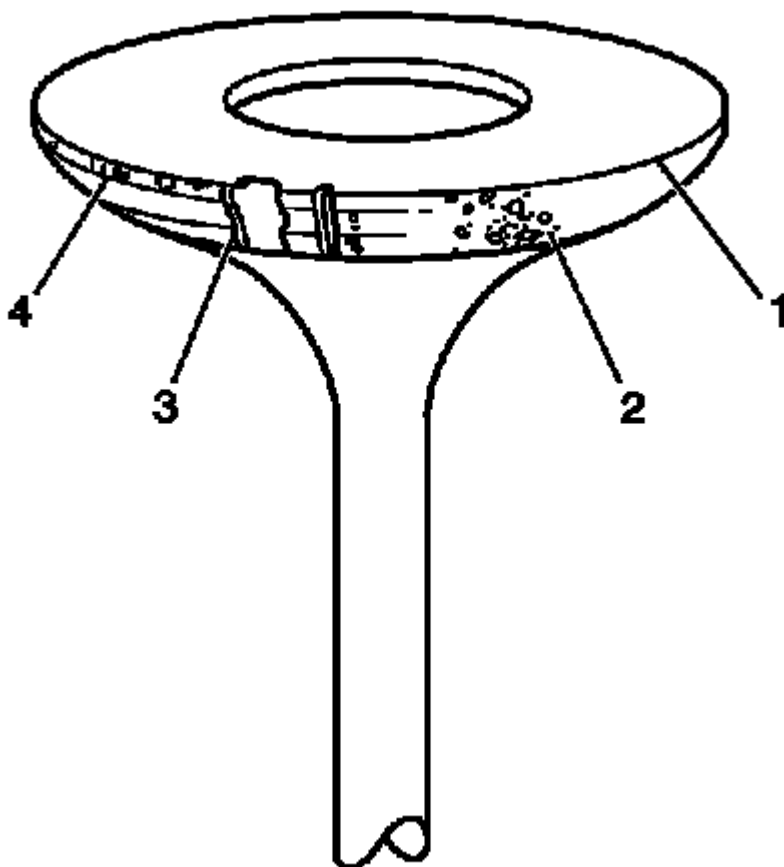


Fig. 331: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

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.

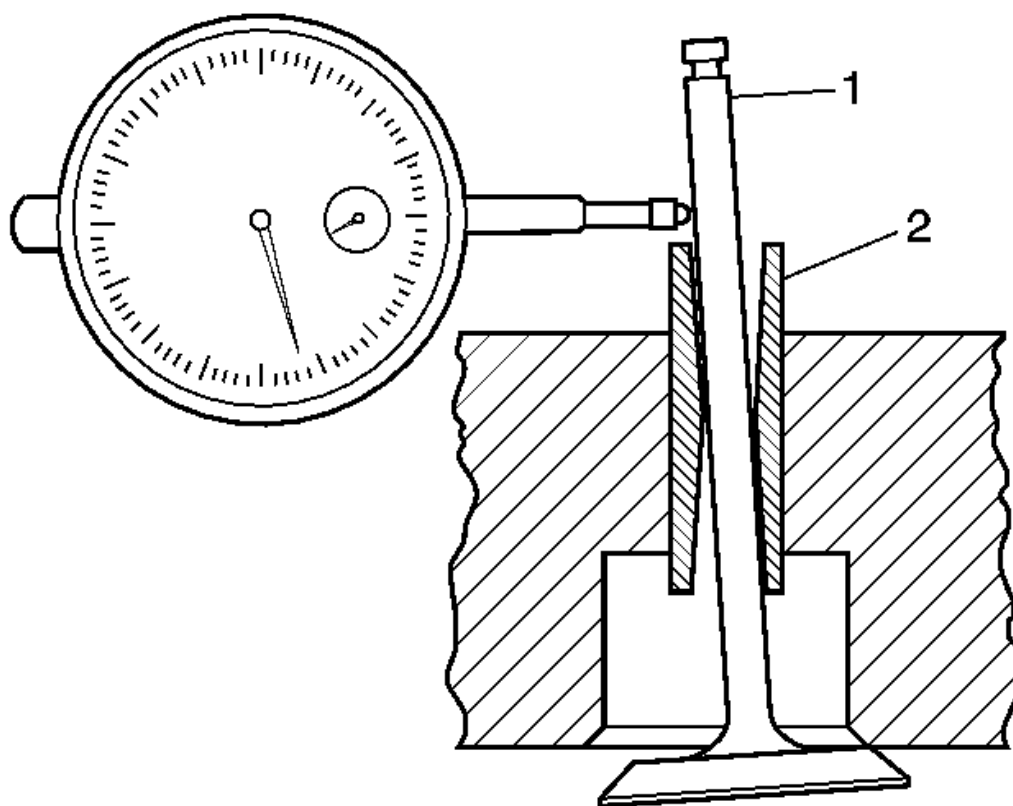


Fig. 332: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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

- Excessive engine oil consumption

4. Inspect for excessive valve stem (1) to guide (2) clearance.

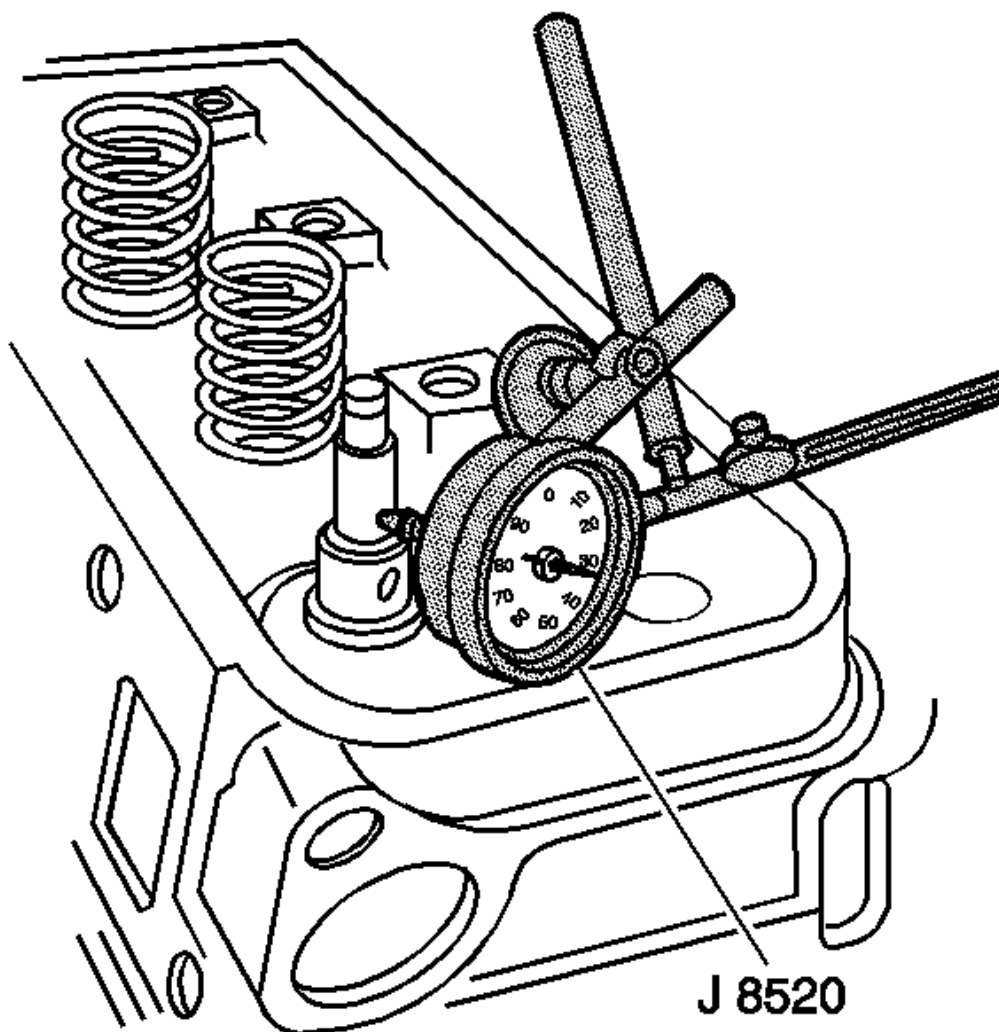


Fig. 333: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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 and Equipment**.

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.

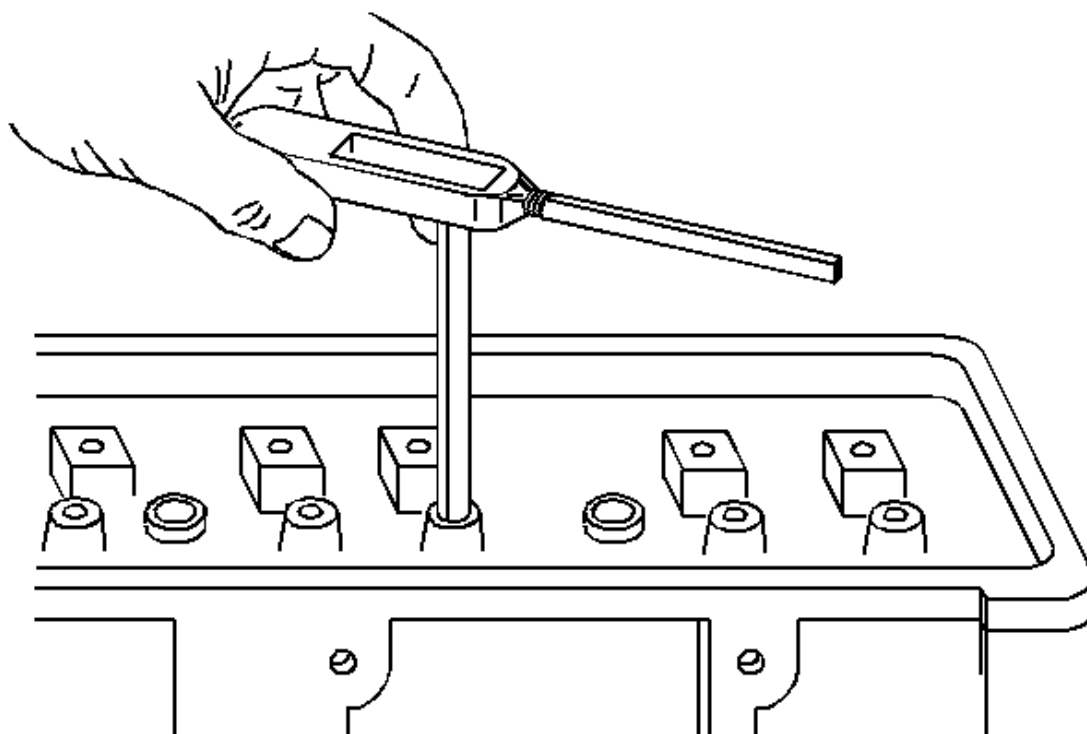


Fig. 334: Reaming Valve Guides For Oversize Valves
Courtesy of GENERAL MOTORS CORP.

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.

6. Ream the valve guides for oversize valves if the clearance exceeds the specifications.

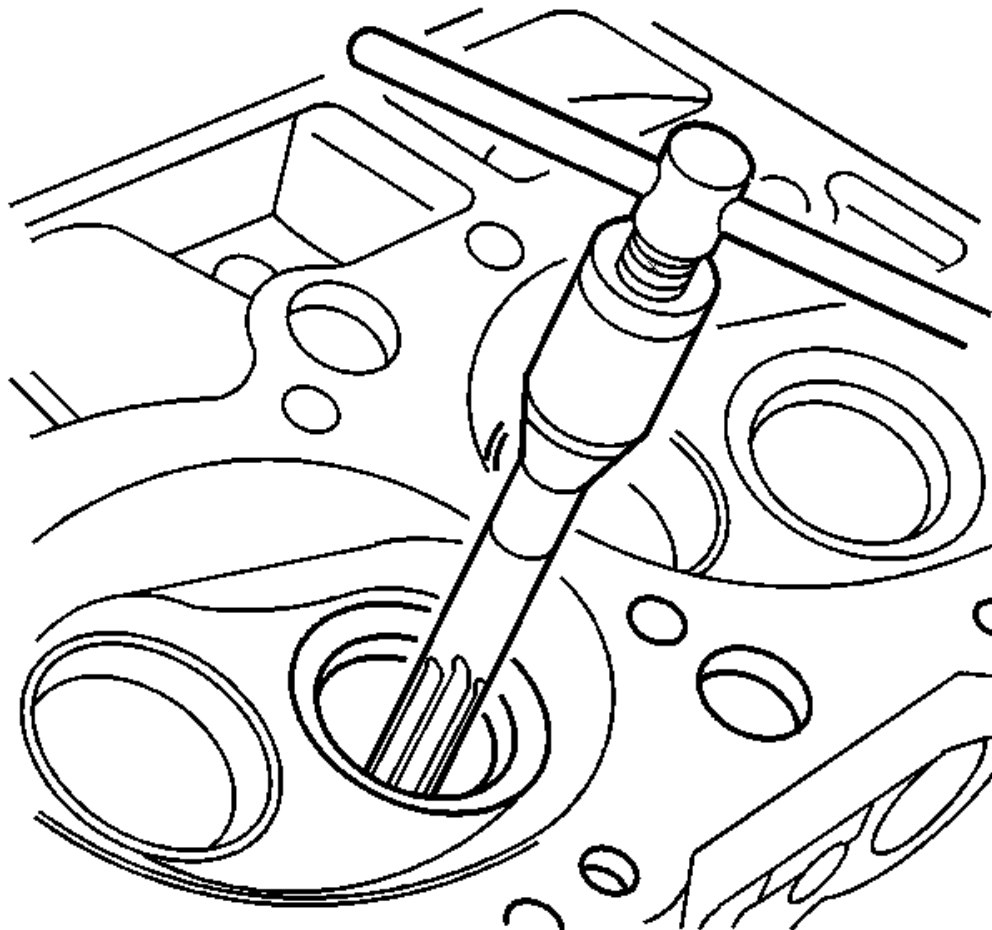


Fig. 335: Reaming Valve Guide
Courtesy of GENERAL MOTORS CORP.

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.

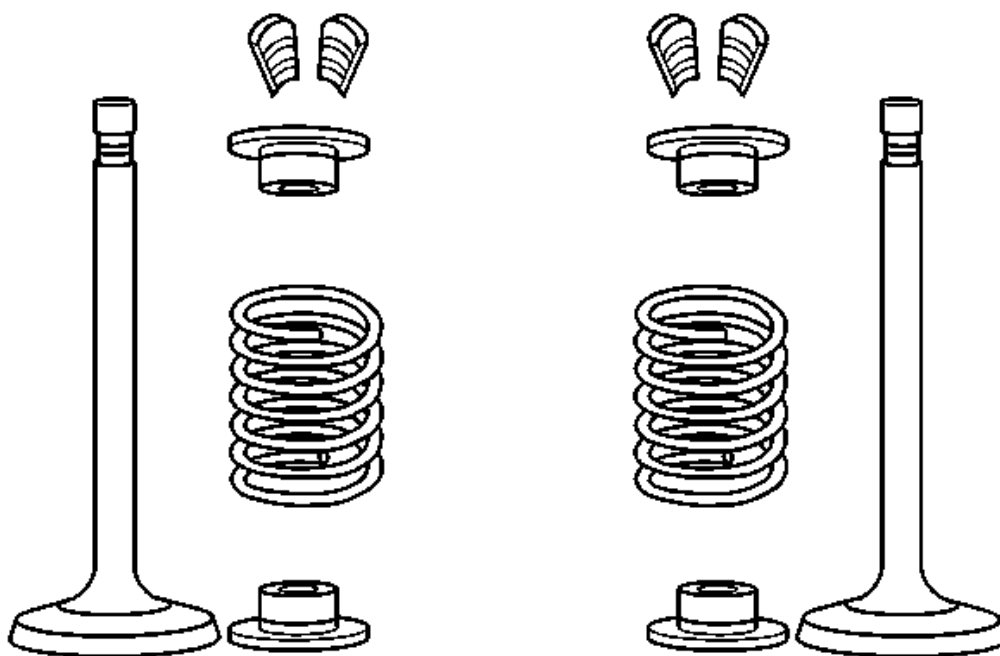


Fig. 336: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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.

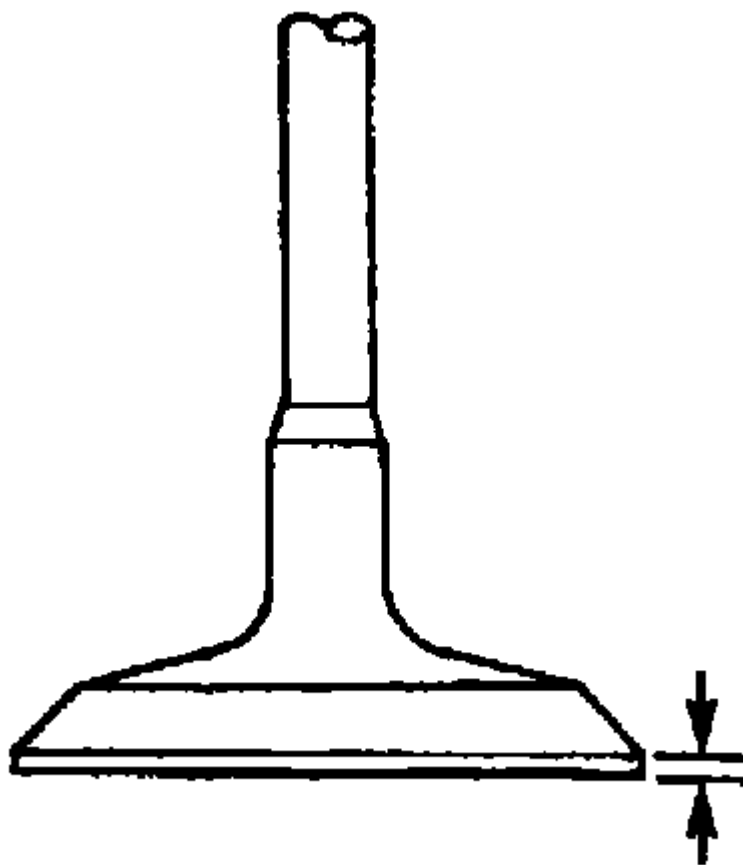


Fig. 337: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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

J 38606 Valve Spring Compressor. See Special Tools and Equipment.

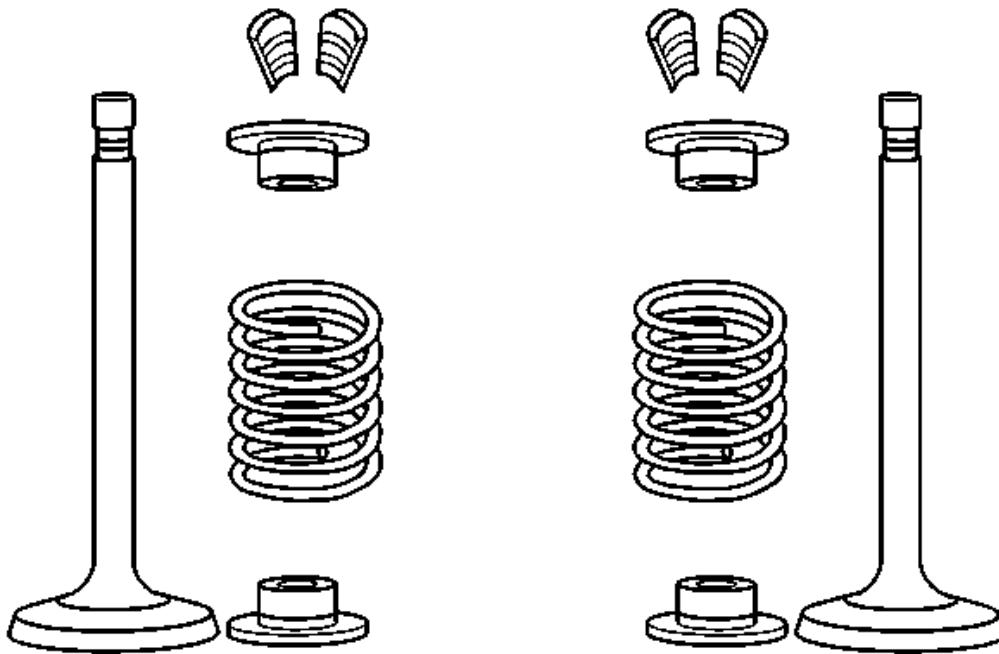


Fig. 338: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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 lap the reconditioned valves into the valve seat.
4. Install the valve stem oil seals.
5. Install the valve springs.
6. Install the valve spring caps.

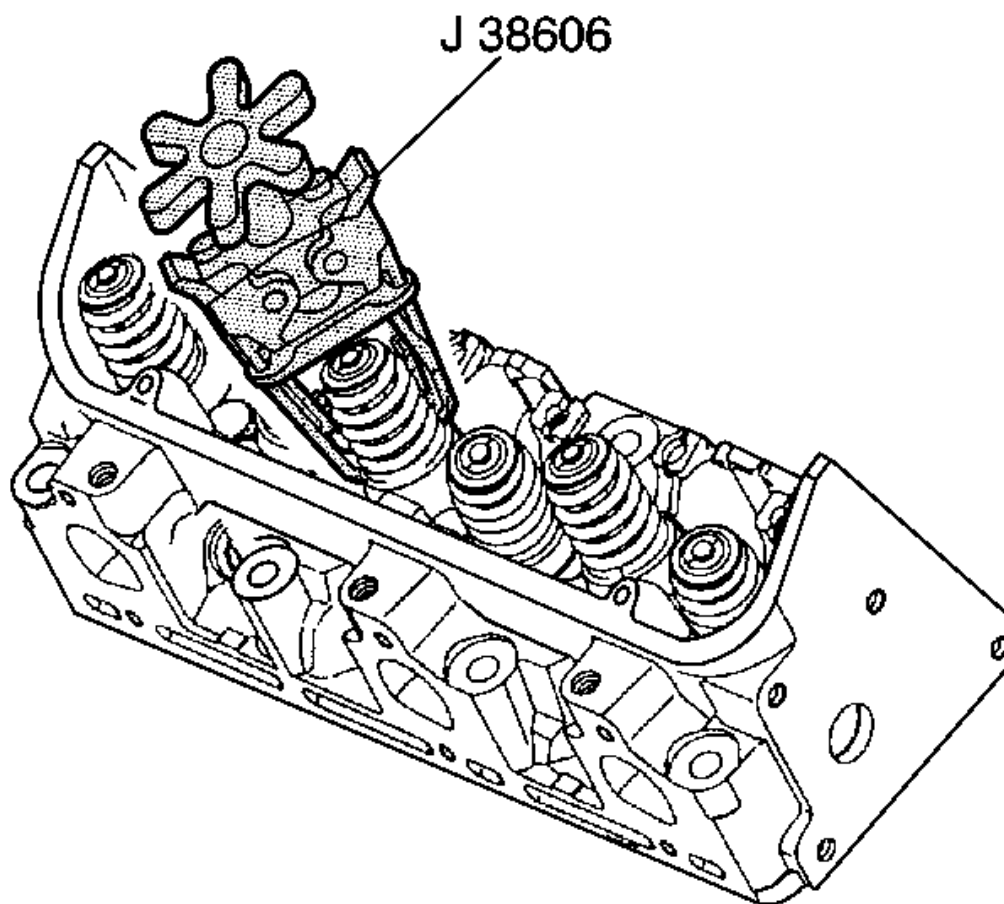


Fig. 339: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

7. Compress the valve springs using the **J 38606** . See **Special Tools and Equipment**.
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.
11. Measure valve spring installed height.
12. If the valve spring installed height is not within specifications install 0.25 mm (0.010 in) rocker arm shims as needed. If more than 2 shims are needed replace the cylinder head or valve.

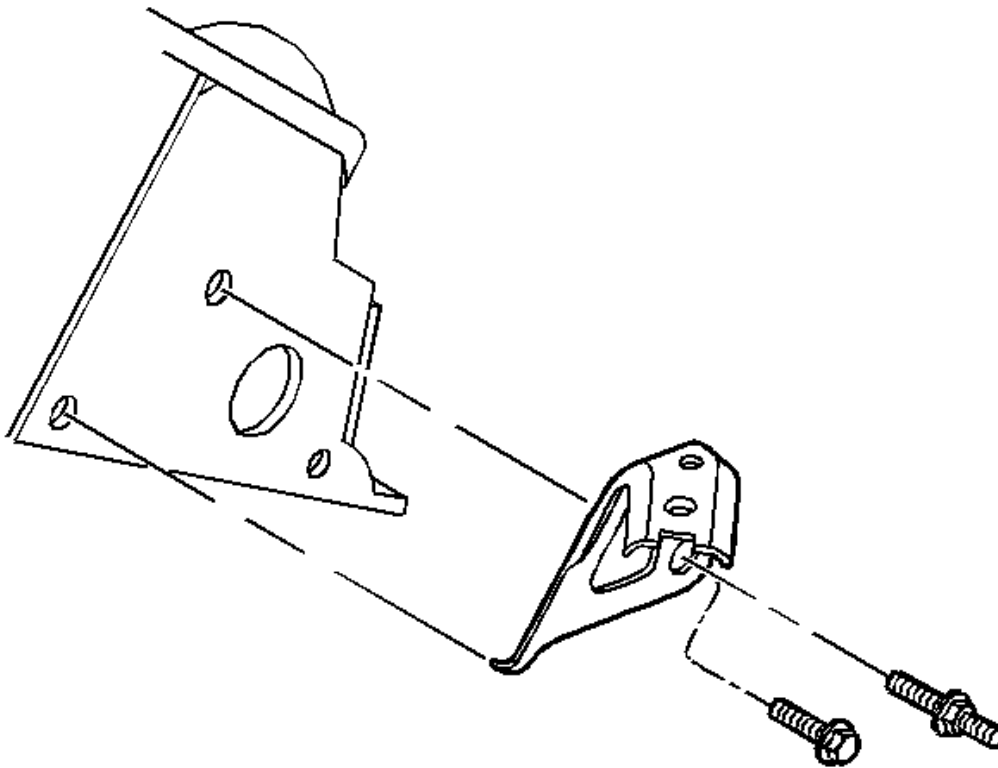


Fig. 340: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

13. Install the fuel line bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

14. Install the fuel line bracket bolt or stud.

Tighten: Tighten the fuel line bracket bolt or stud to 50 N.m (37 lb ft).

Oil Pump Disassemble

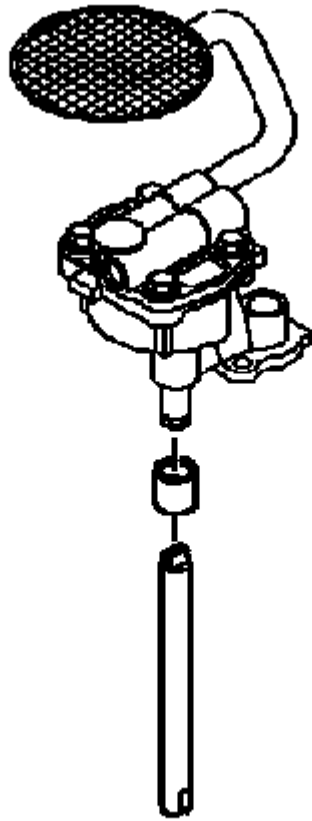


Fig. 341: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

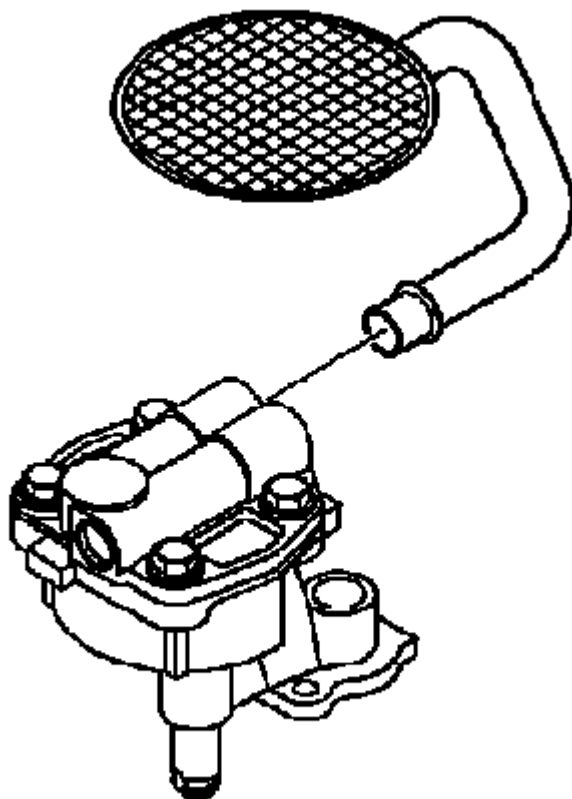


Fig. 342: View Of Oil Pump Screen

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

2. Remove the oil pump screen, if necessary.

The oil pump screen has a press fit into the oil pump cover.

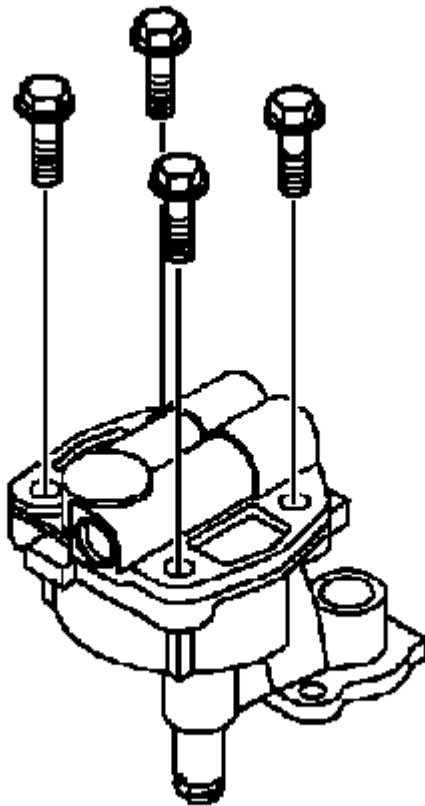


Fig. 343: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover bolts.

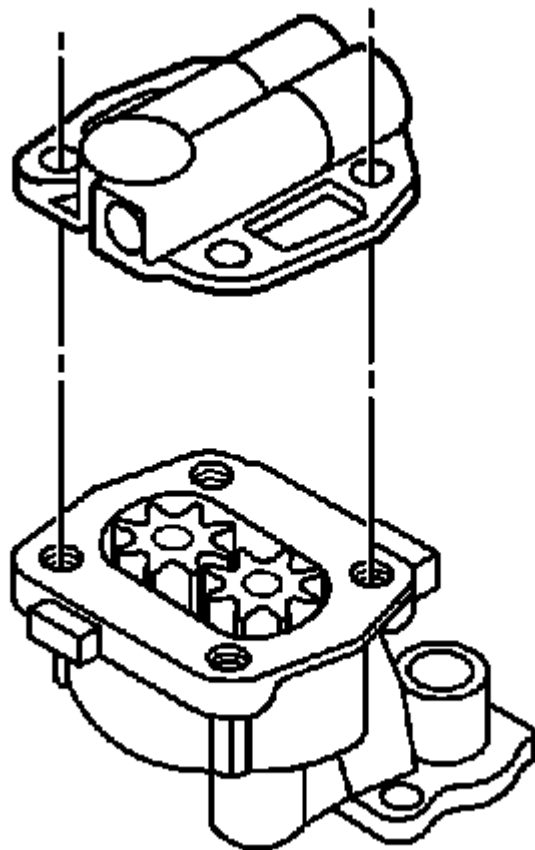


Fig. 344: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover.

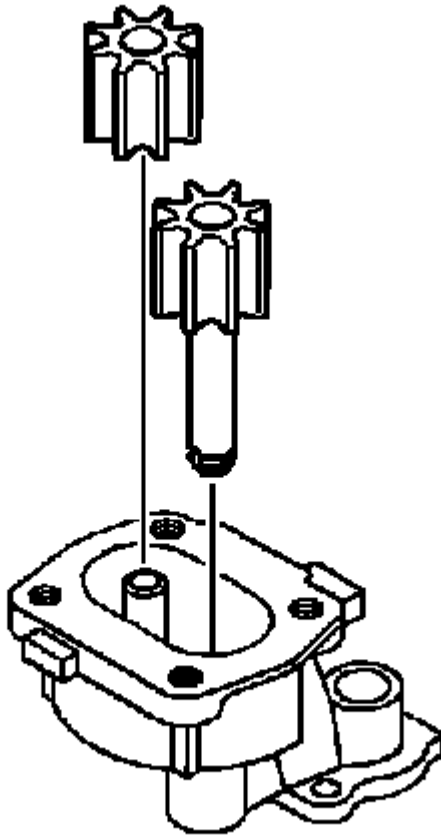


Fig. 345: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

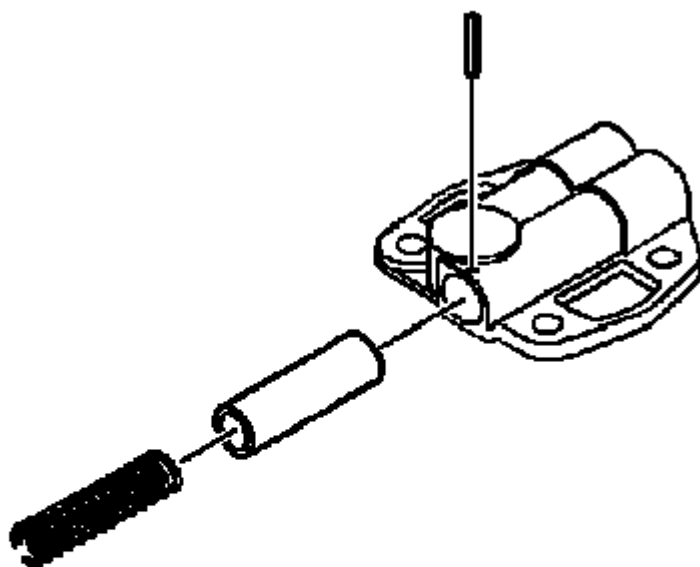


Fig. 346: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

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 in Cautions and Notices.

3. The oil pump pressure relief valve. If the valve is stuck, soak the pump housing in cleaning solvent.

Oil Pump Cleaning and Inspection

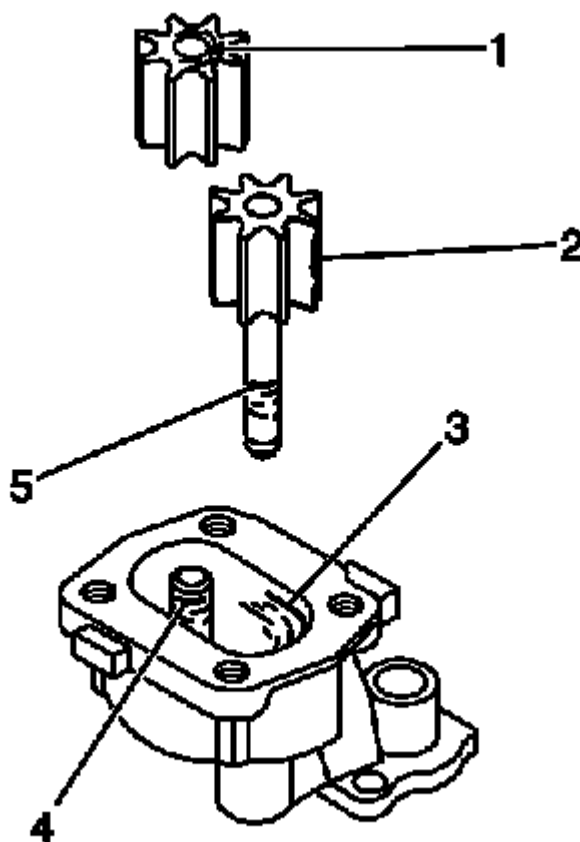


Fig. 347: Inspecting Oil Pump Housing & Gears, Idler Shaft, & Drive Gear Shaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

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).

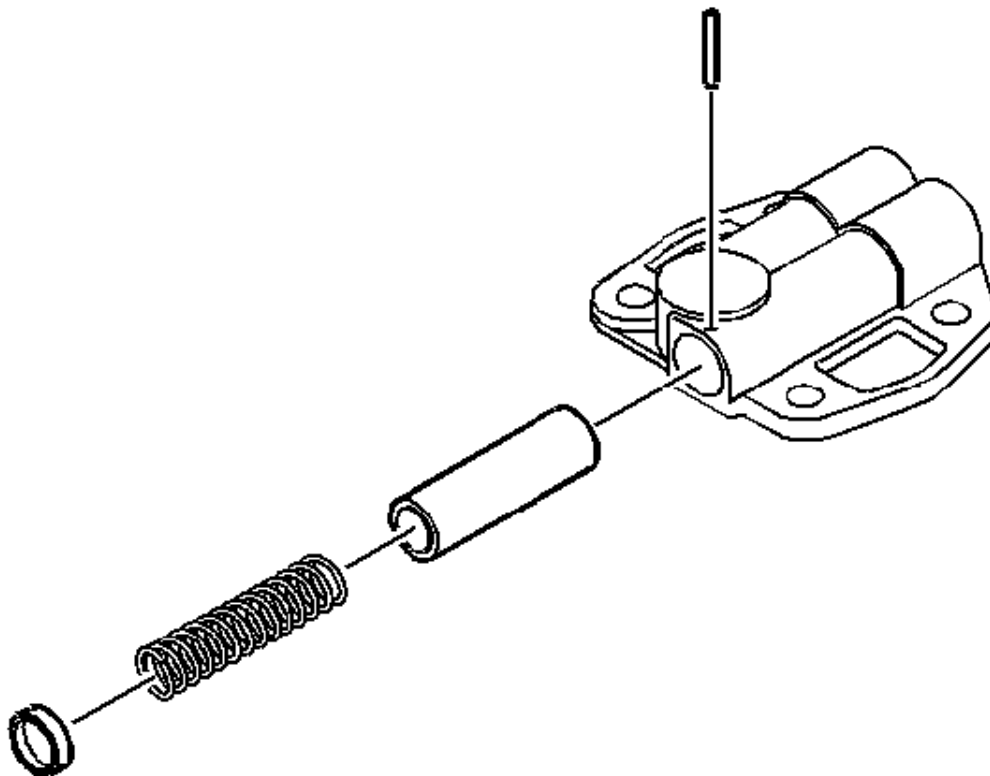


Fig. 348: View Of Pressure Regulator Valve & Spring
Courtesy of GENERAL MOTORS CORP.

8. Inspect the pressure regulator valve for the following conditions:

- Scoring
- Sticking

Burrs may be removed using a fine oil stone.

9. Inspect the pressure regulator valve spring for the following conditions:

- Loss of tension
- Bending

10. Inspect the suction pipe and screen assembly for the following conditions:

- Looseness

If the suction pipe is loose, bent or has been removed, replace the pump body cover and suction pipe.

- Broken wire mesh or screen

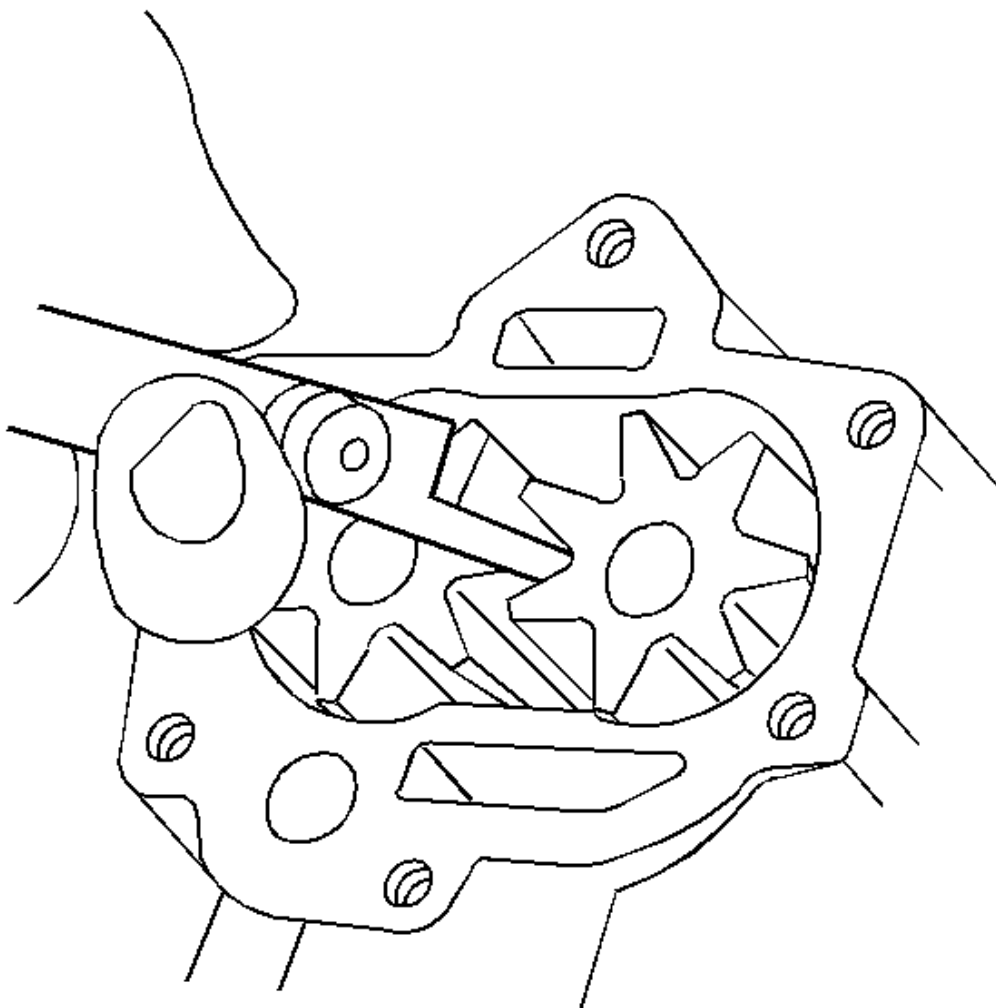


Fig. 349: Measuring Oil Pump Gear Lash

Courtesy of GENERAL MOTORS CORP.

11. Measure the oil pump gear lash. Install the gears, and measure in several places.

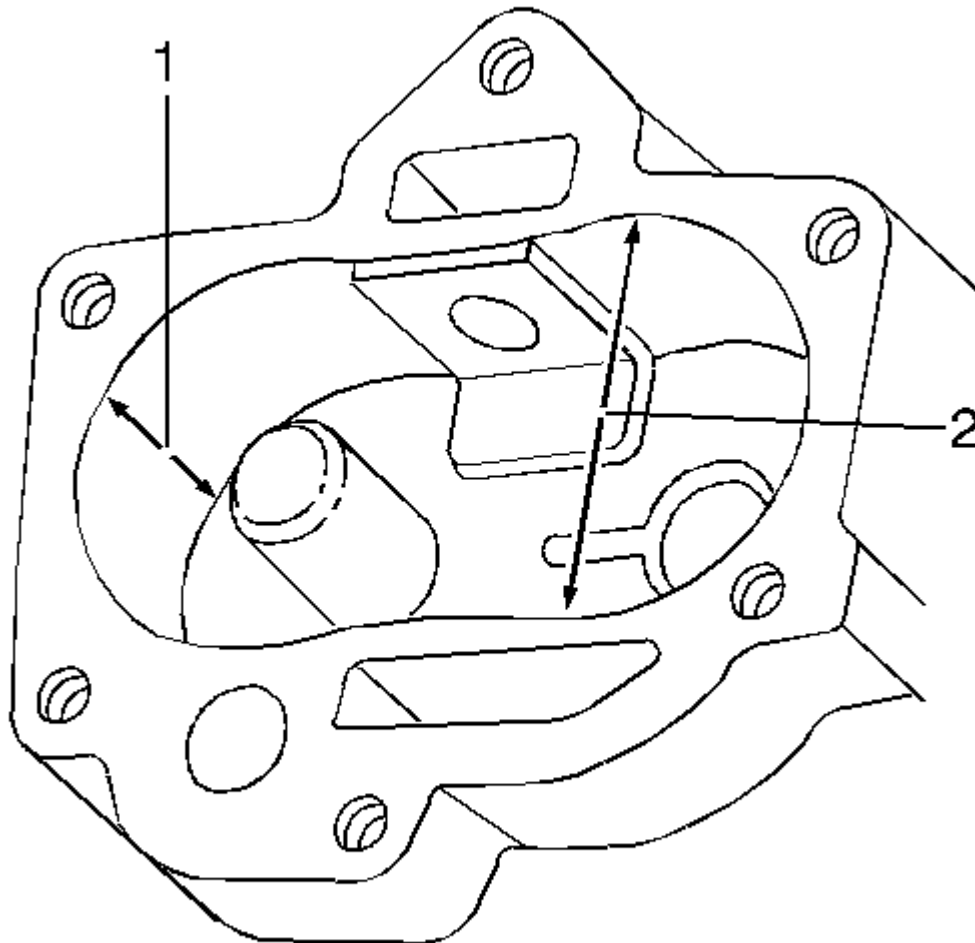


Fig. 350: Measuring Oil Pump Gear Lash
Courtesy of GENERAL MOTORS CORP.

12. Measure the oil pump housing gear pocket (1, 2).

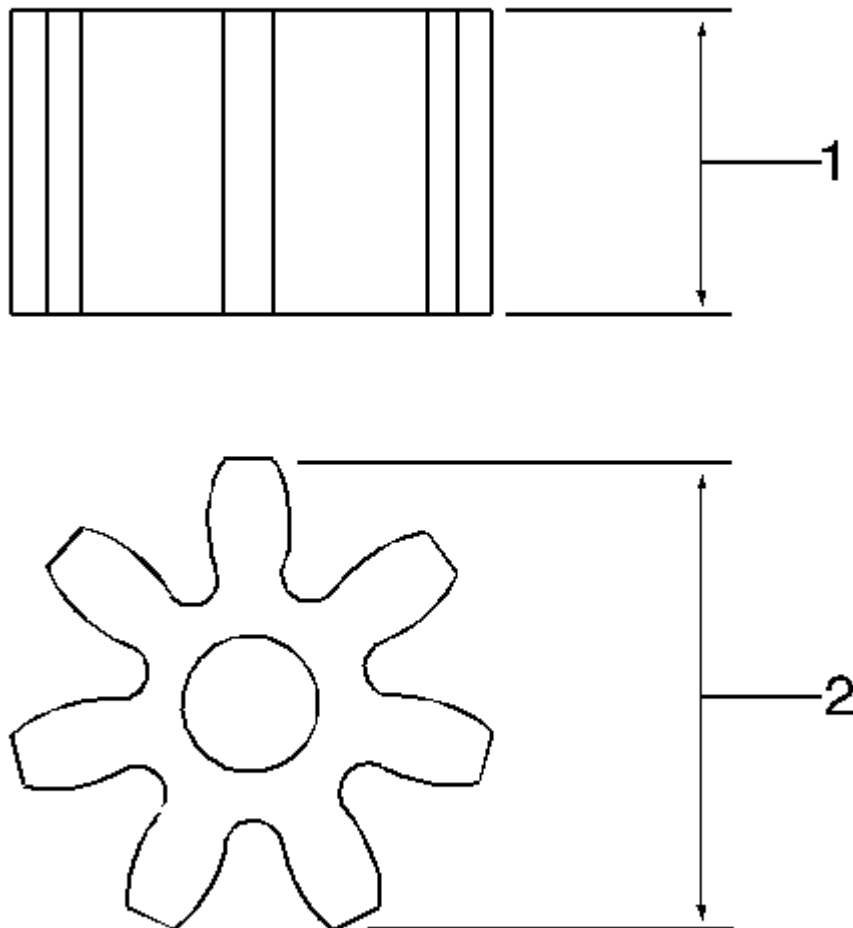


Fig. 351: Measuring Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

13. Measure the oil pump gears (1, 2).

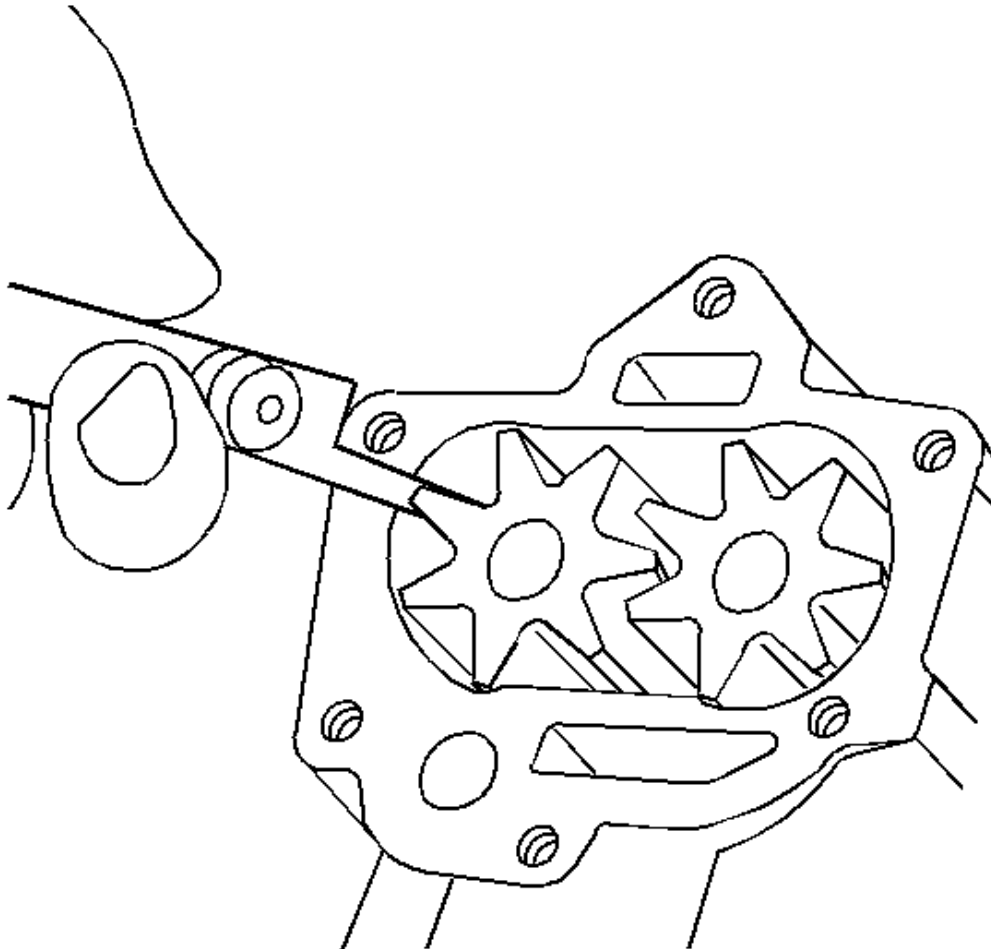


Fig. 352: Measure Oil Pump Gear Side Clearance
Courtesy of GENERAL MOTORS CORP.

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 21882** Oil Suction Pipe Installer. See Special Tools and Equipment.

- **J 22144** Oil Suction Pipe Installer. See **Special Tools and Equipment**.

1. Lubricate all the internal oil pump parts using engine oil during assembly.

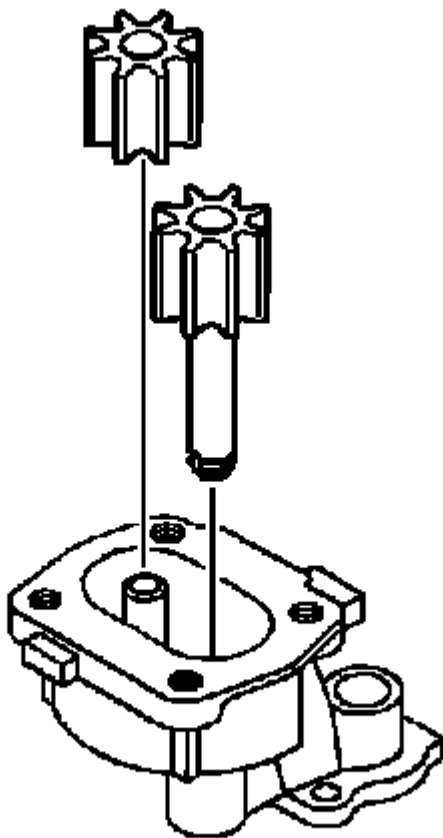


Fig. 353: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pump gears.

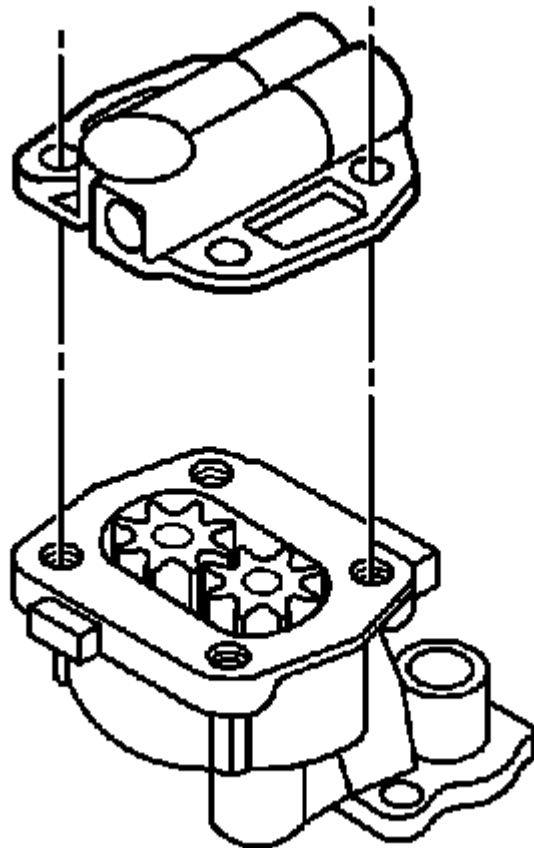


Fig. 354: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pump cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump cover bolts.

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

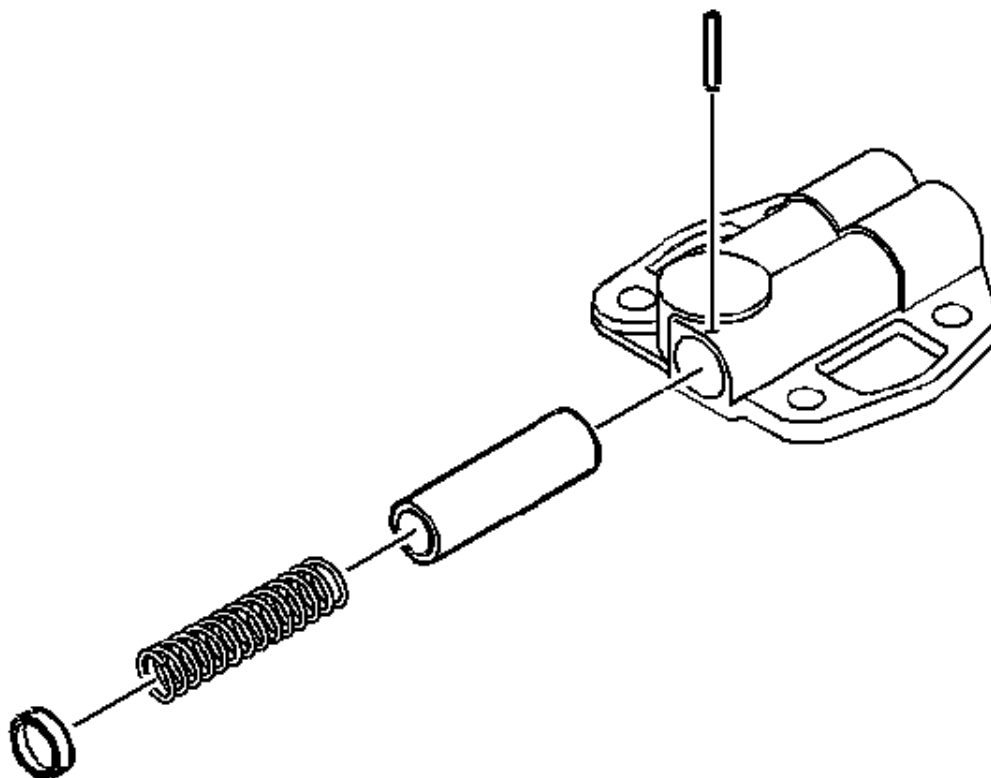


Fig. 355: View Of Pressure Regulator Valve & Spring
Courtesy of GENERAL MOTORS CORP.

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. Use the **J 21882** for 5/8 inch pipe or for 3/4 inch pipe. See **Special Tools and Equipment**.

Engine Front Cover Cleaning and Inspection

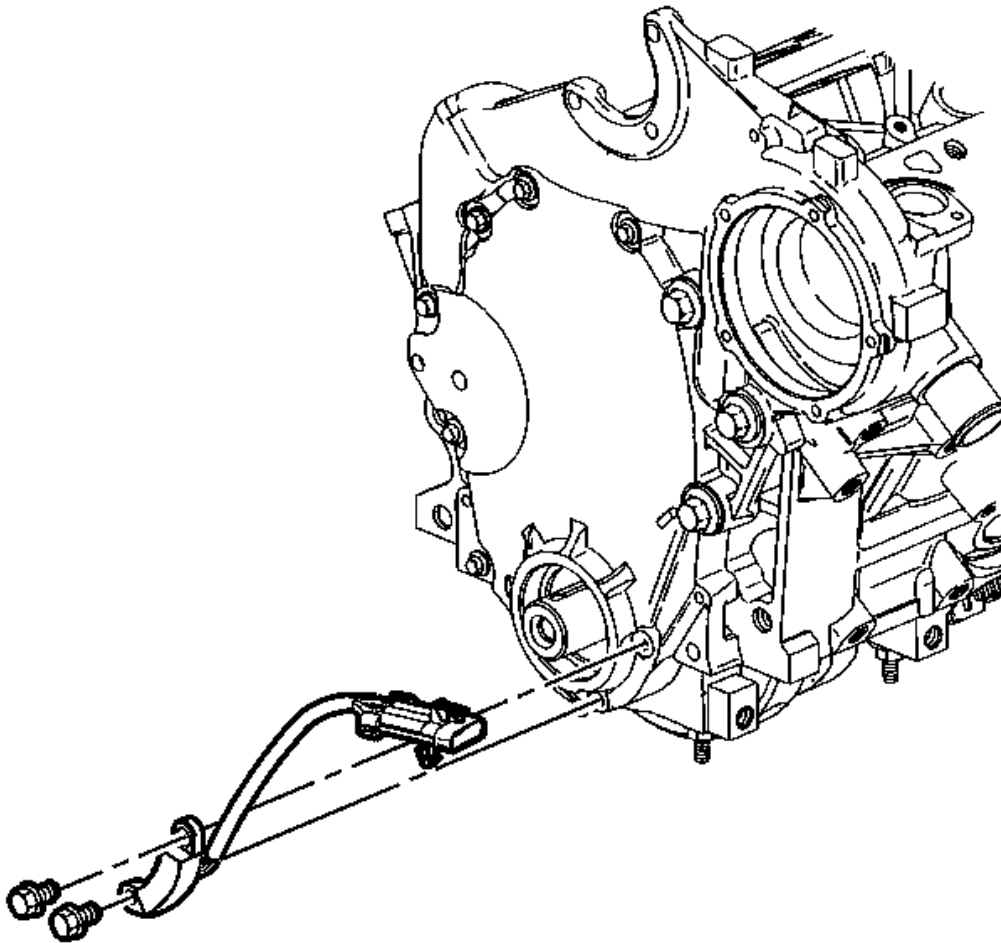


Fig. 356: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor bolts from the engine front cover.
2. Remove the crankshaft position sensor.

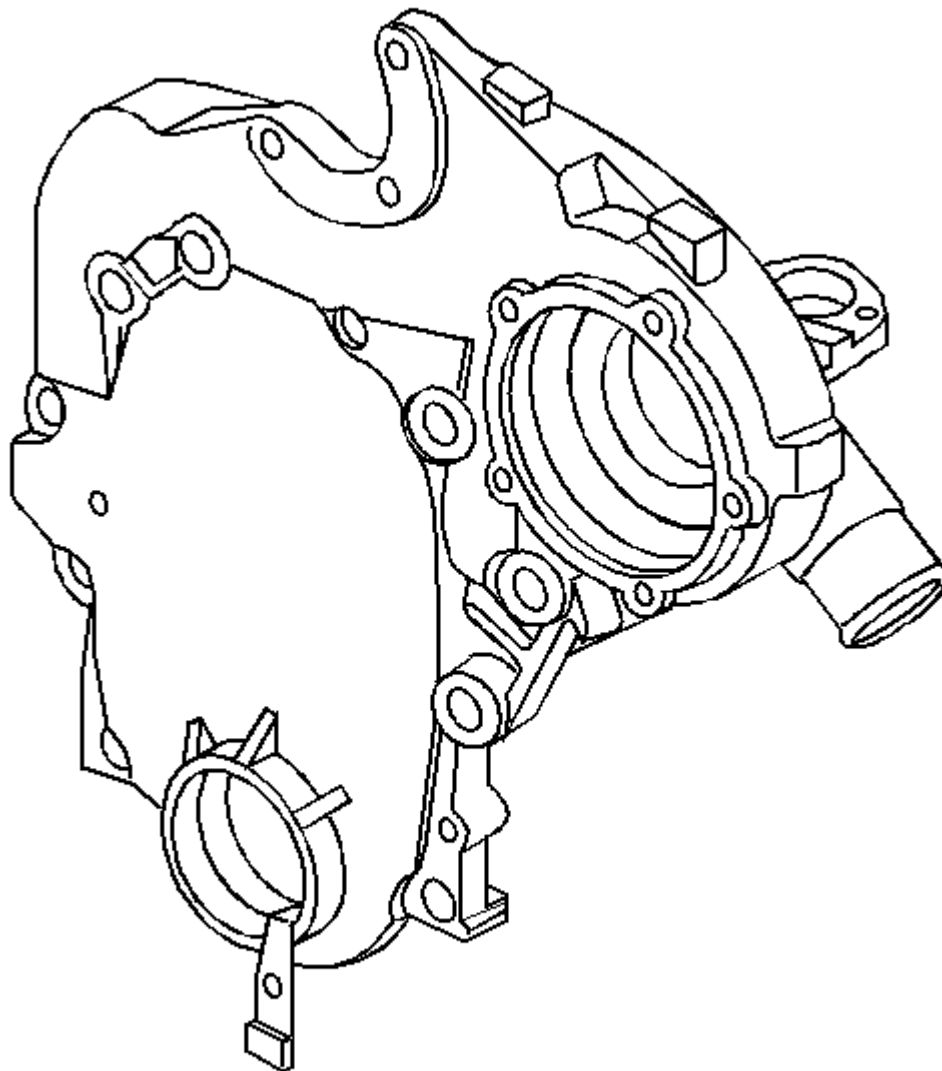


Fig. 357: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

3. Clean the engine front cover with cleaning solvent.
4. Inspect the engine front cover sealing surfaces for damage.

5. Inspect the engine front cover threaded holes.
6. Repair or replace the engine front cover as necessary.

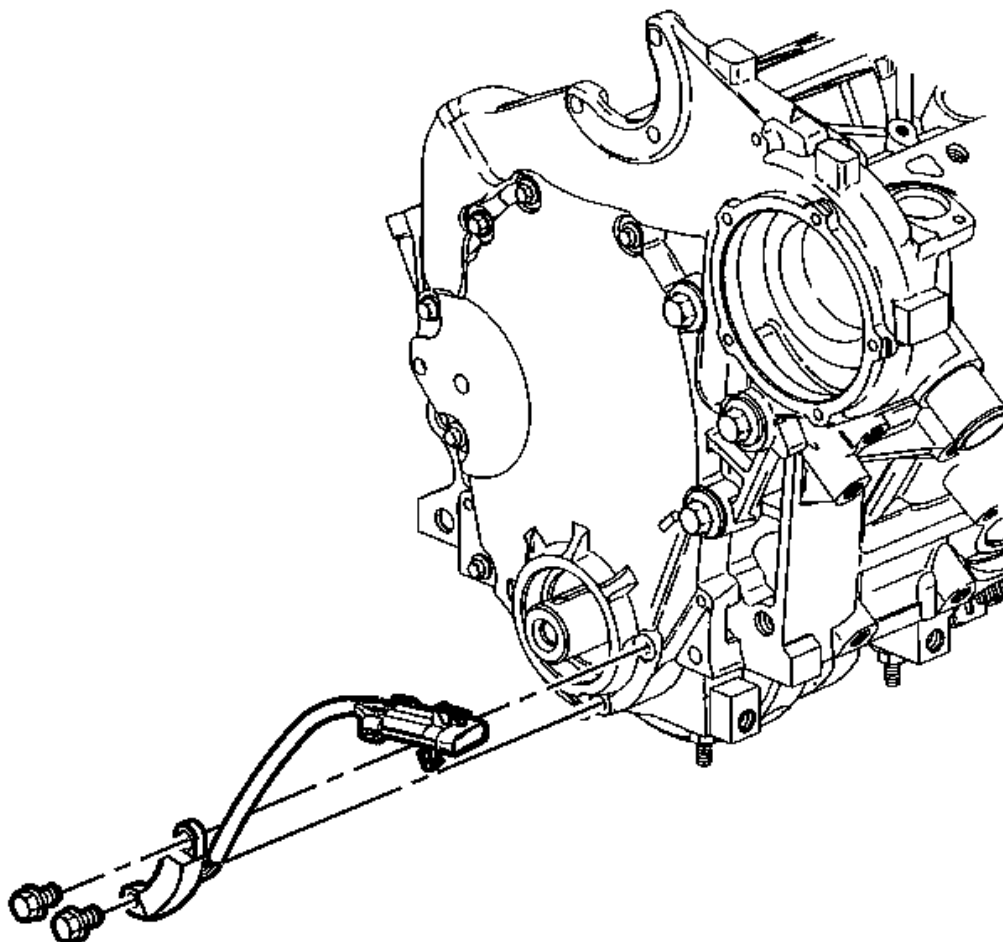


Fig. 358: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft position sensor to the engine front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the crankshaft position sensor bolts. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or the equivalent to the threads.

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

Valve Rocker Arm Cover Cleaning and Inspection

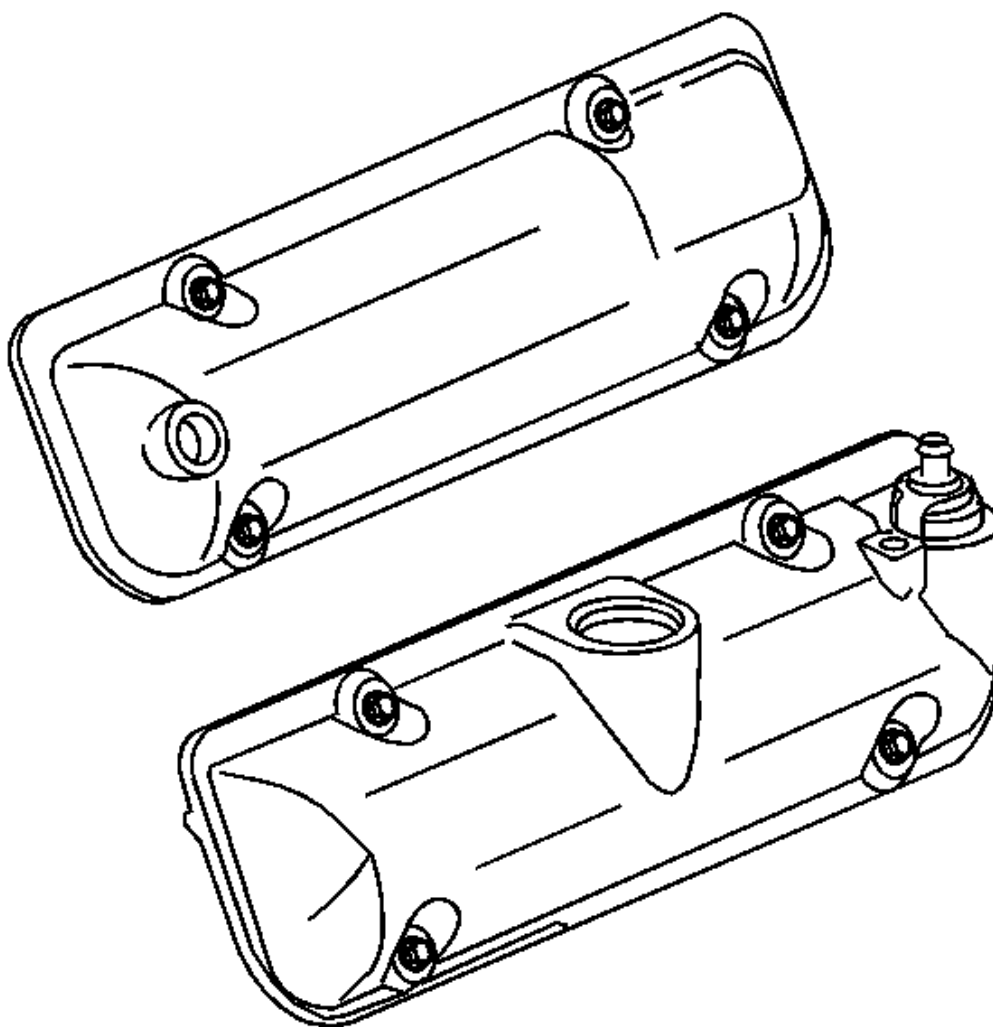


Fig. 359: Valve Rocker Arm Covers
Courtesy of GENERAL MOTORS CORP.

1. Remove all rubber grommets from the valve rocker arm covers.
2. Inspect the rubber grommets, if cracked or torn replace.

CAUTION: Bodily injury may occur if the cleaning solvent is inhaled or exposed

to the skin.

3. Clean the valve rocker arm covers with GM P/N 12346139 (Canadian P/N 88901247) or equivalent.
4. Dry the valve rocker arm covers with compressed air.
5. Inspect the valve rocker arm covers for damage and replace if necessary.
6. Install all rubber grommets into the valve rocker arm covers.

Oil Pan Cleaning and Inspection

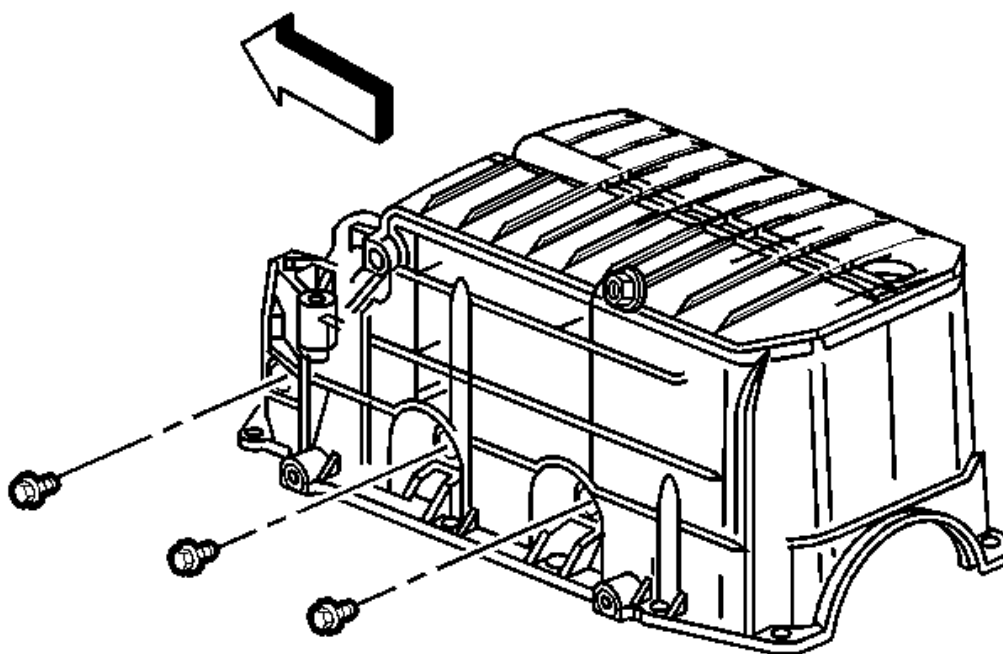


Fig. 360: Oil Pan & Bolts

Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level sensor bolt, if equipped.
2. Remove the oil level sensor, if equipped.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

3. Clean the oil pan in solvent. Remove all sludge and debris from the bottom of the oil pan.
4. Inspect the oil pan sealing surfaces for damage.

Replace the oil pan if necessary.

5. Install the oil level sensor, if equipped.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the oil level sensor bolt, if equipped.

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

Intake Manifold Cleaning and Inspection - Lower

Tools Required

J 21882 Oil Suction Pipe Installer. See Special Tools and Equipment.

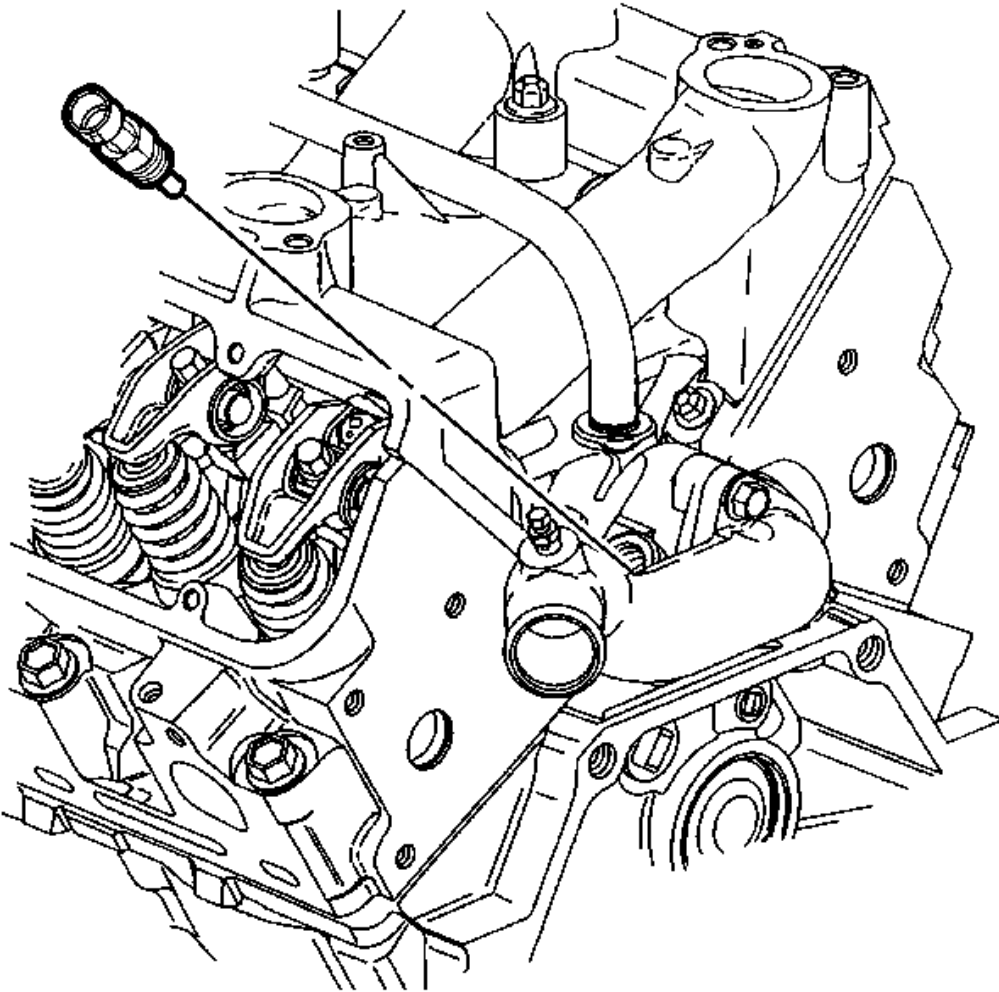


Fig. 361: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

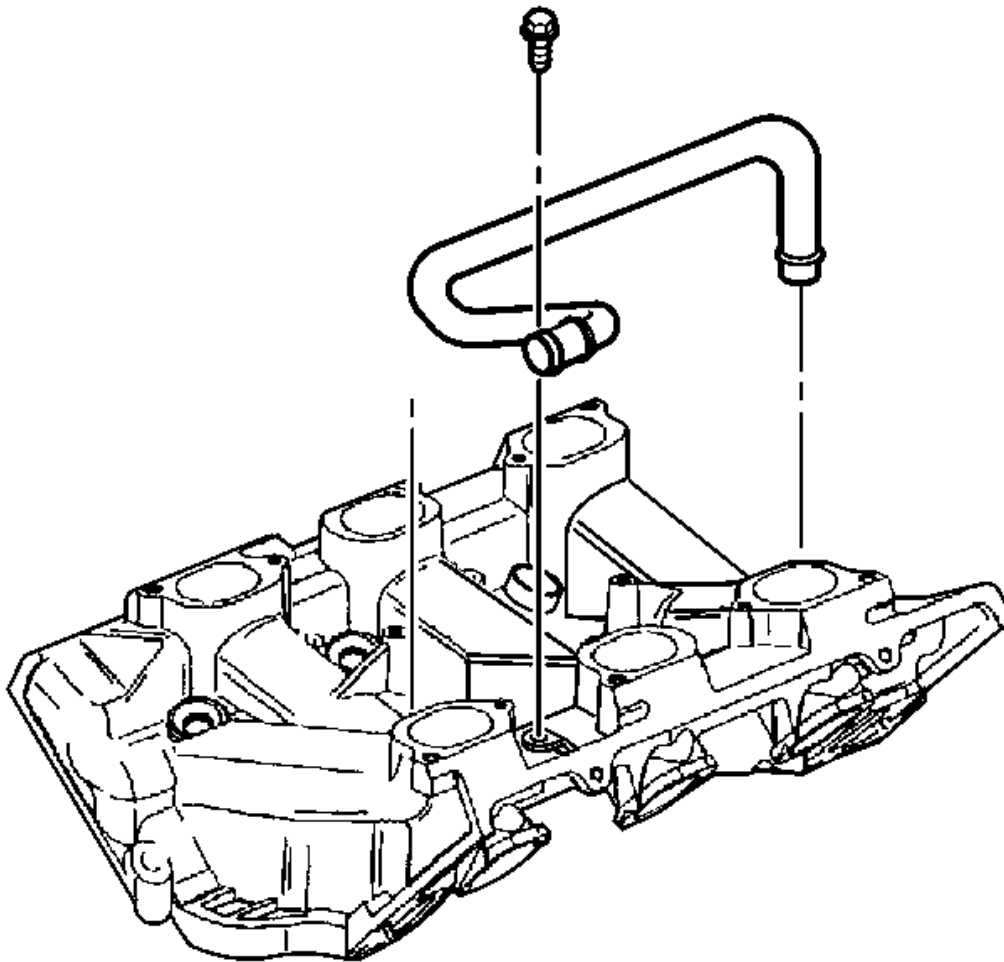


Fig. 362: Intake Manifold Coolant Pipe & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the intake manifold coolant pipe bolt if required.
3. Remove the intake manifold coolant pipe if required.

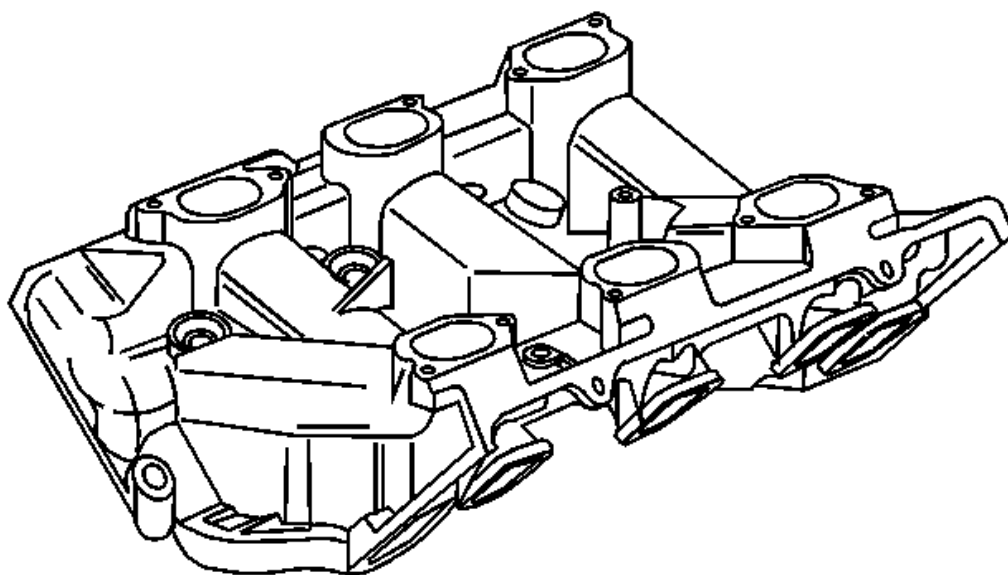


Fig. 363: Lower Intake Manifold Removed
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean the intake manifold mating surfaces.

4. Clean the intake manifold gasket mating surfaces.
5. Clean the fuel injector bores.
6. Inspect the threaded holes for damage.
7. Inspect the intake manifold mating surfaces for damage.
8. Repair or replace the intake manifold as necessary.

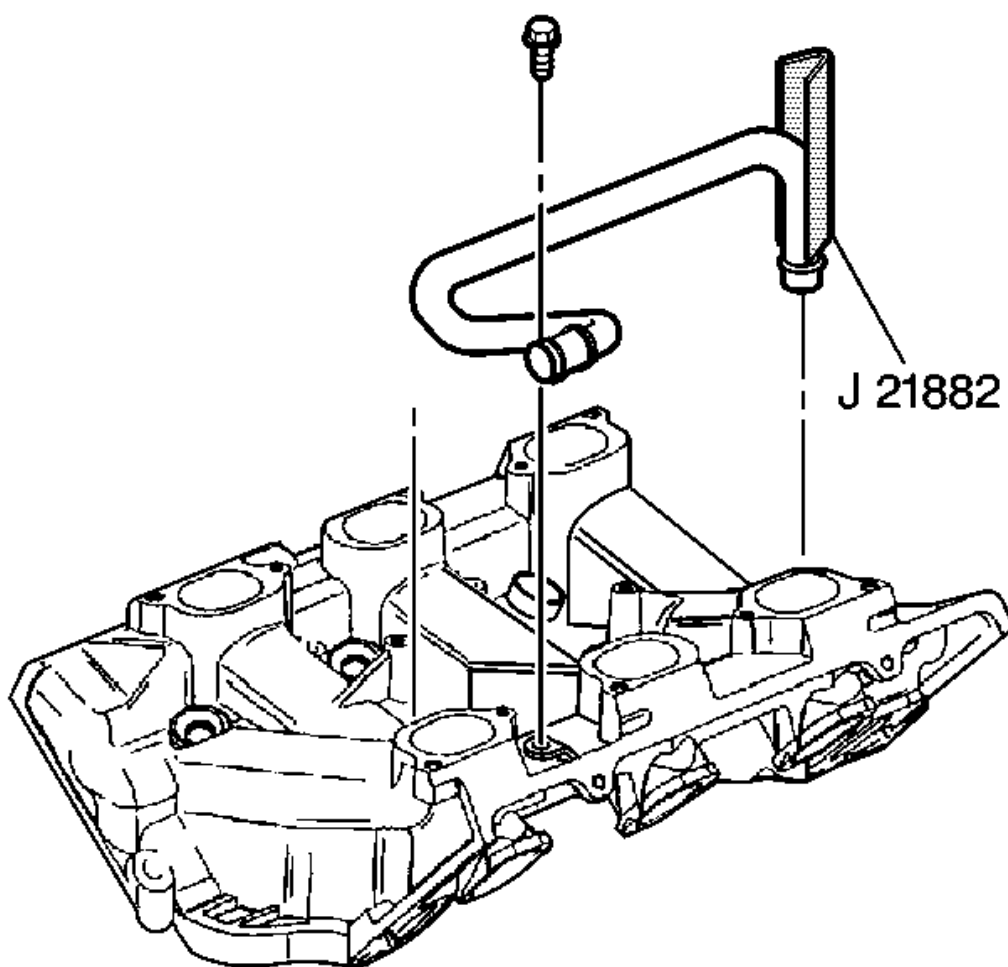


Fig. 364: Install The Intake Manifold Coolant Pipe Using J 21882
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the end of a new intake manifold coolant pipe.
10. Install the intake manifold coolant pipe using the **J 21882** . See **Special Tools and Equipment**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Install the intake manifold coolant pipe bolt.

Tighten: Tighten the intake manifold coolant pipe bolt to 10 N.m (89 lb in).

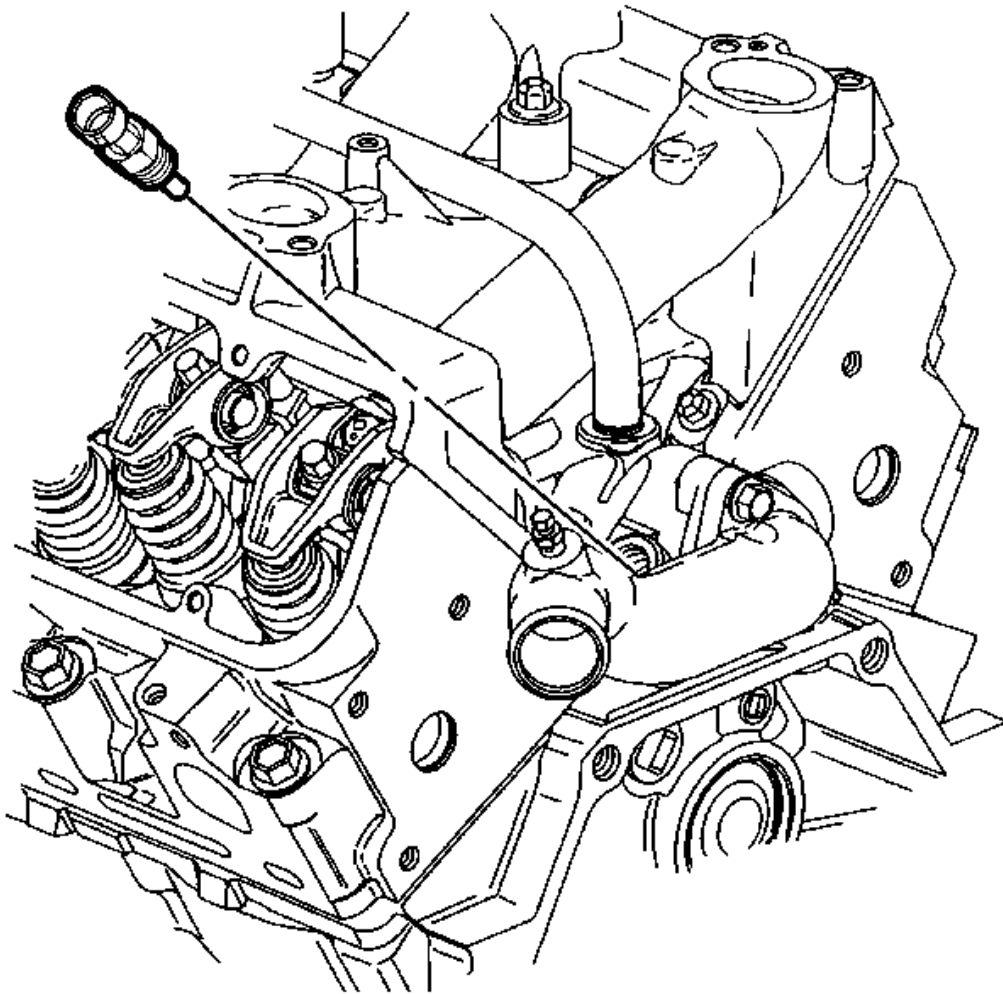


Fig. 365: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

12. Install the engine coolant temperature sensor. Apply sealer GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the coolant temperature sensor.

Tighten: Tighten the engine coolant temperature sensor to 23 N.m (17 lb ft).

Intake Manifold Cleaning and Inspection - Upper

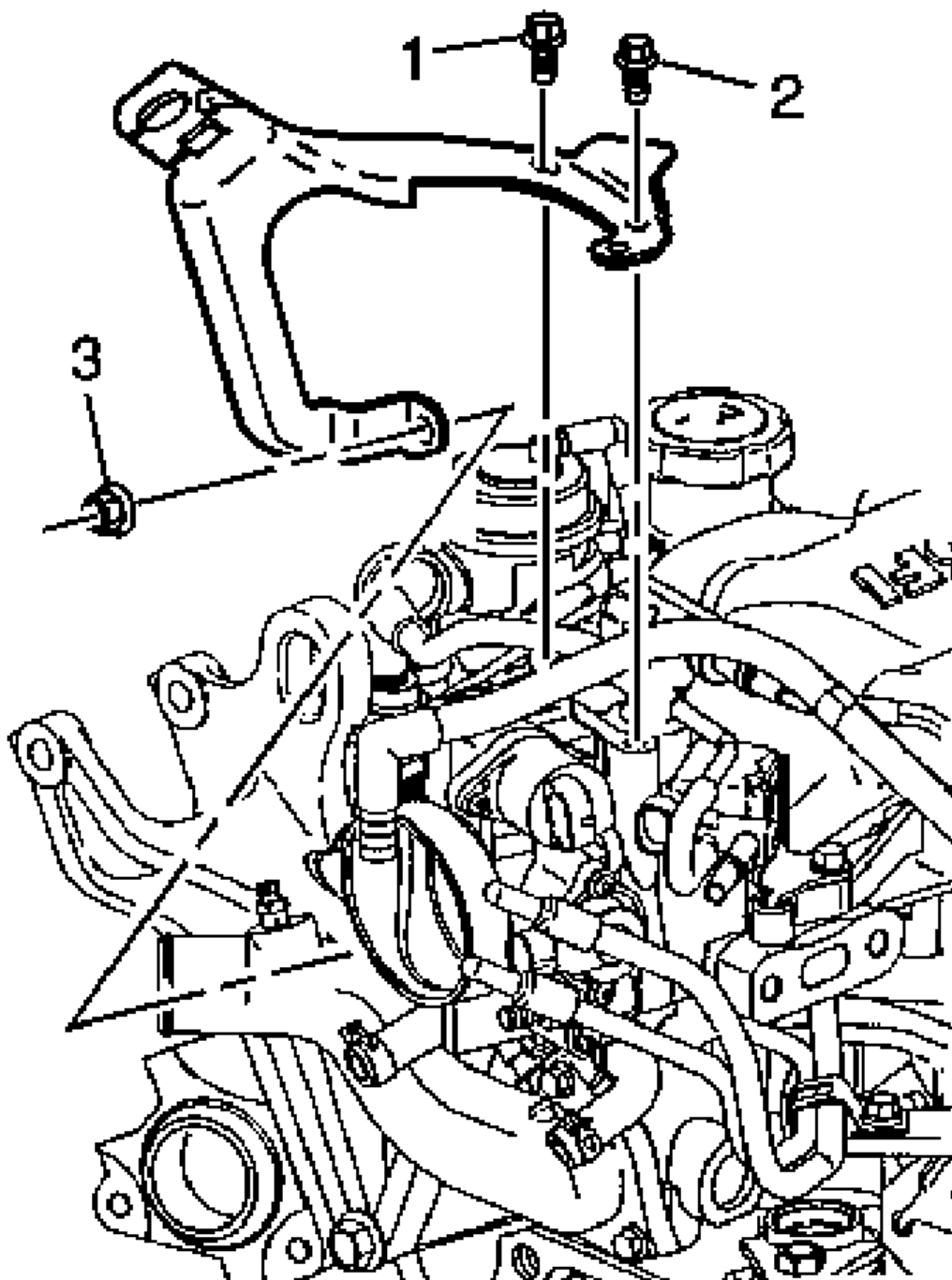


Fig. 366: Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the accelerator control cable bracket bolts (1, 2) and the nut (3).
2. Remove the accelerator control cable bracket.

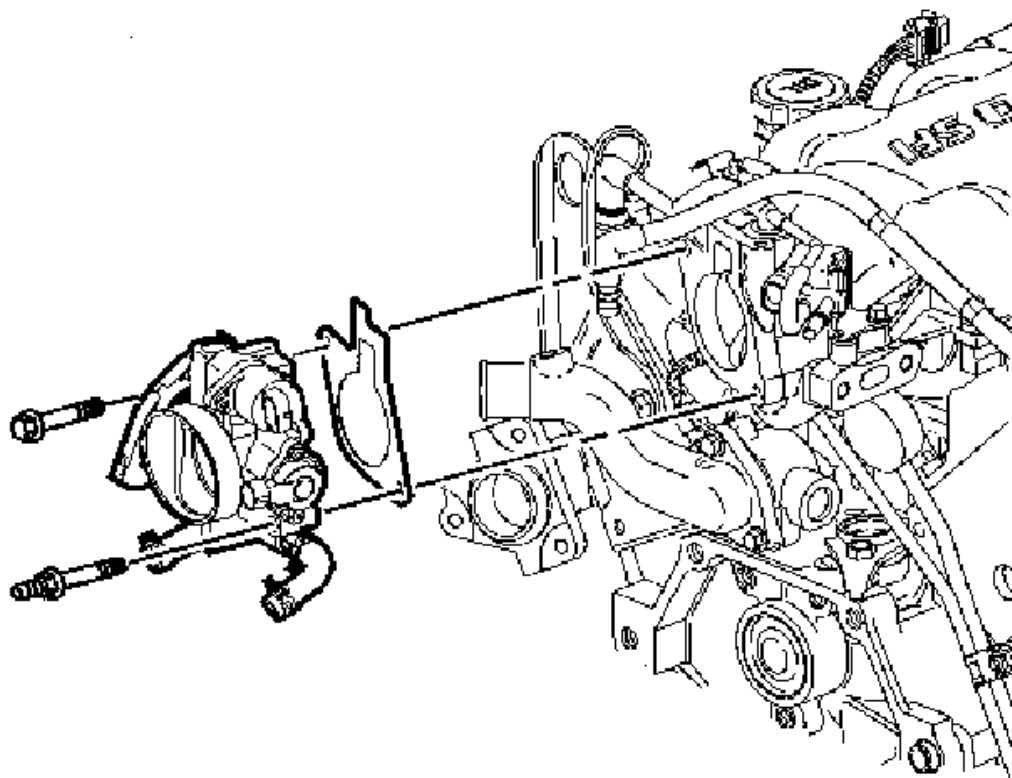


Fig. 367: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body bolt and stud.
4. Remove the throttle body.
5. Remove the throttle body gasket.

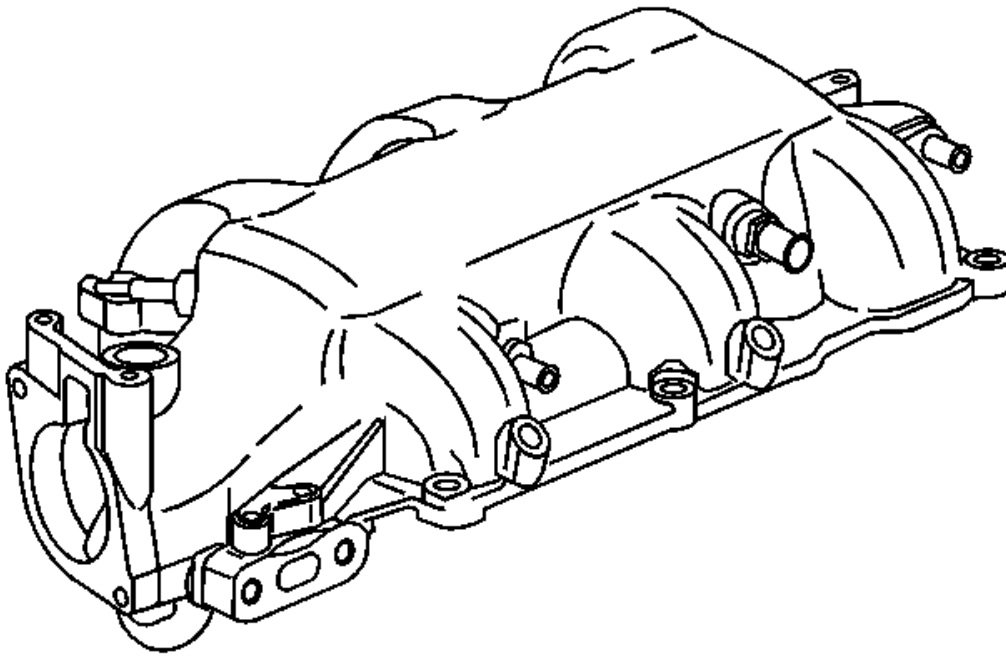


Fig. 368: Upper Intake Manifold Removed
Courtesy of GENERAL MOTORS CORP.

6. Clean the intake manifold gasket surfaces.
7. Clean the intake manifold bolts and studs.
8. Inspect the intake manifold mating surfaces for nicks or cracks.

Replace the intake manifold if damaged.

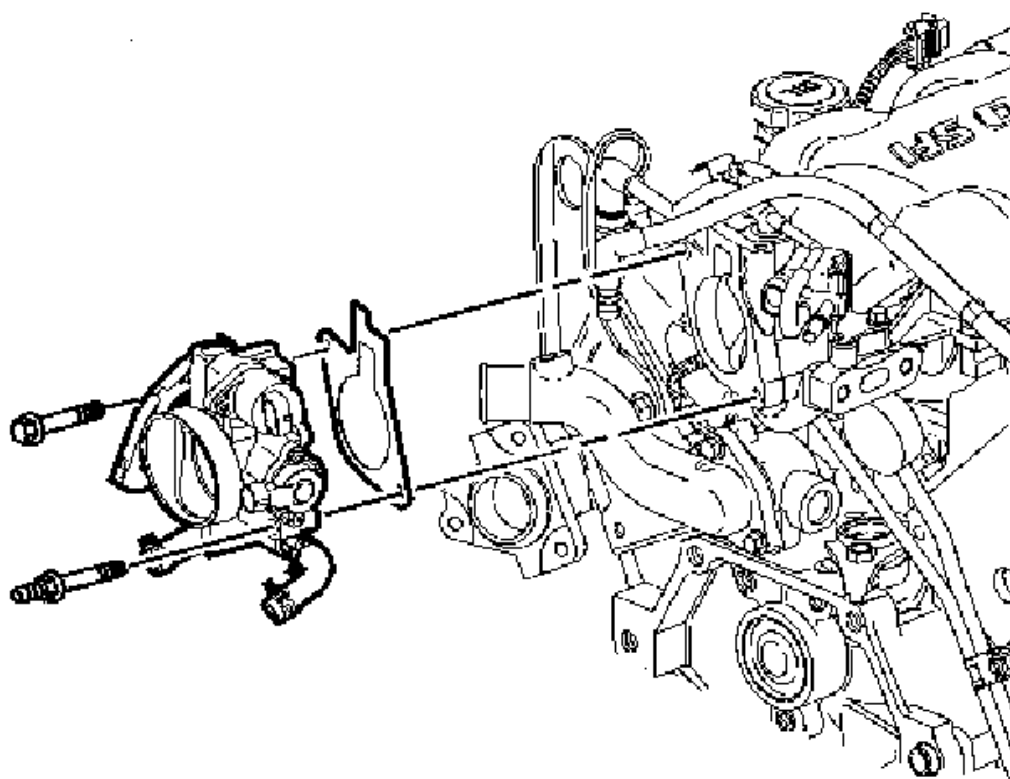


Fig. 369: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

9. Install the throttle body gasket.
10. Install the throttle body.
11. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

12. Install the throttle body bolt and stud.

Tighten: Tighten the throttle body bolt and stud to 25 N.m (18 lb ft).

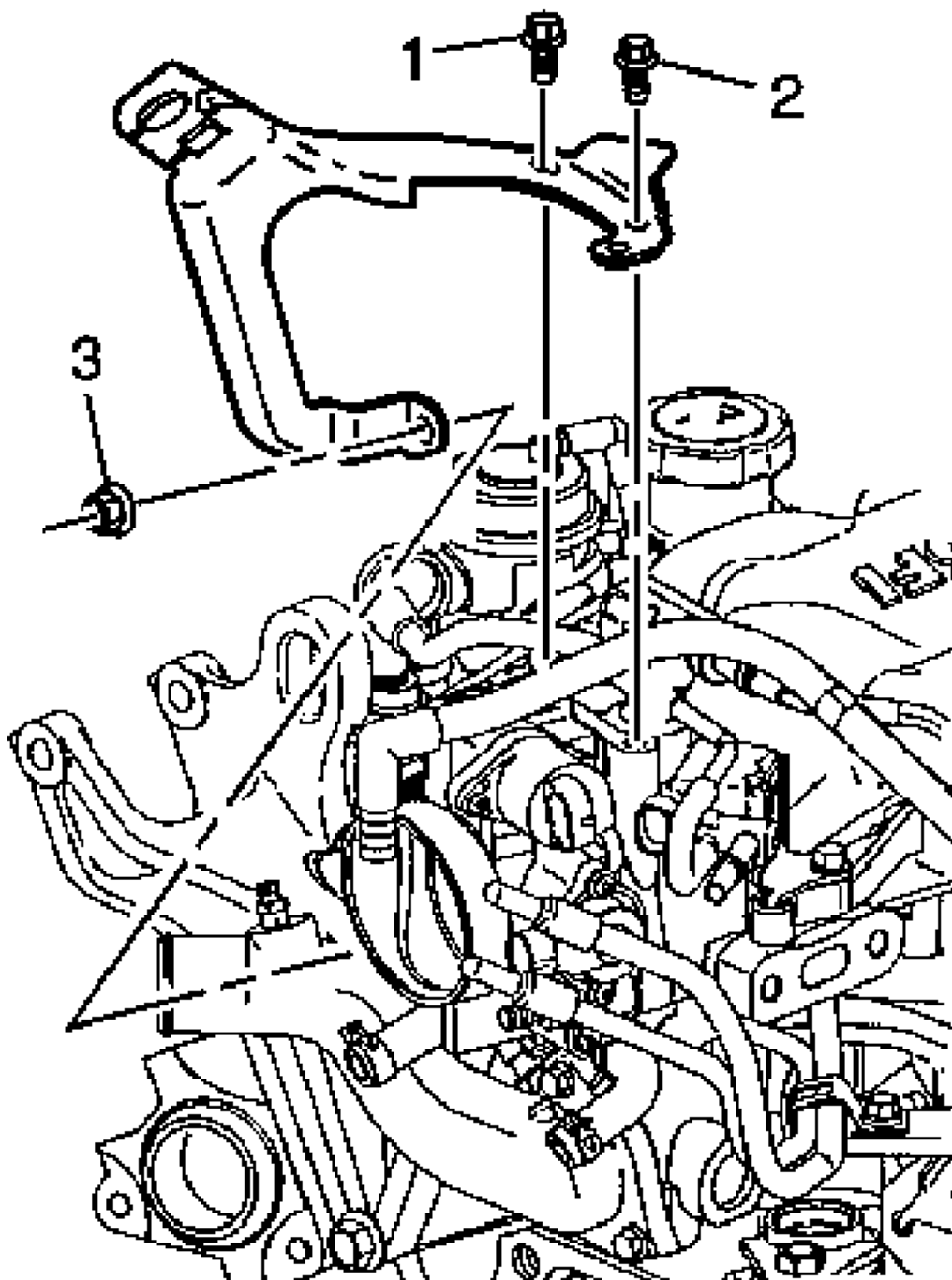


Fig. 370: Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

13. Install the accelerator control cable bracket.
14. Install the accelerator control cable bracket bolts and nut.

Tighten: Tighten the accelerator control cable bracket bolts in sequence (1, 2, 3) to 13 N.m (115 lb in).

Exhaust Manifold Cleaning and Inspection

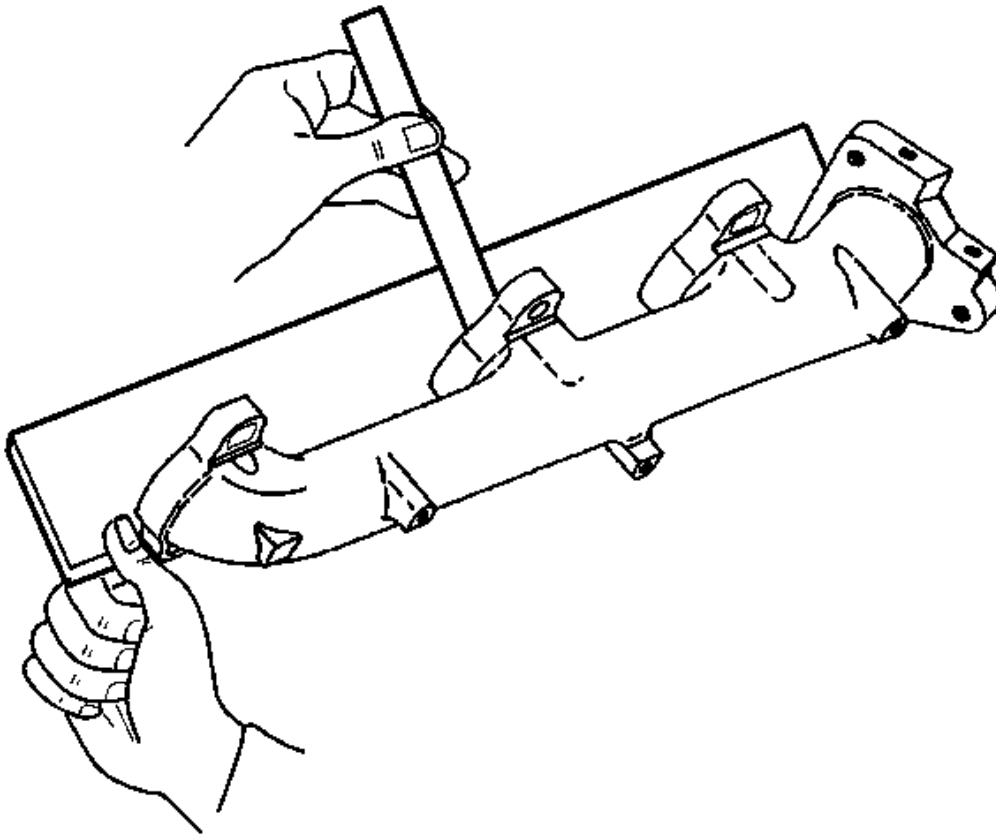


Fig. 371: Inspecting Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exhaust manifold mating surface for flatness.
2. Inspect the exhaust manifold for cracks or damage.

Replace the exhaust manifold if necessary.

Water Pump Cleaning and Inspection

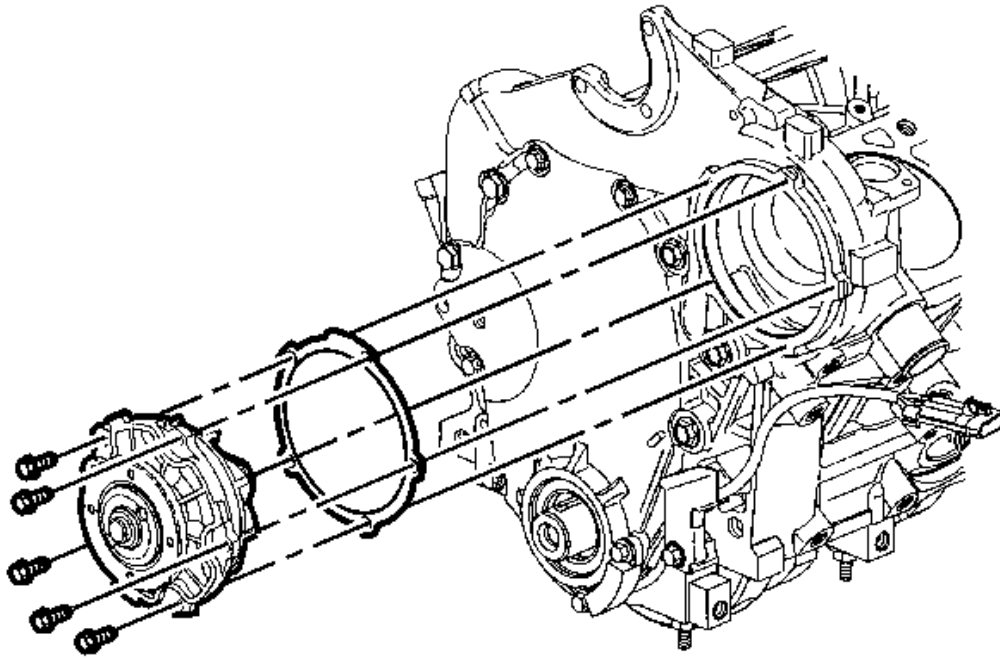


Fig. 372: View Of Water Pump Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

Thread Repair

General purpose thread repair kits are available commercially.

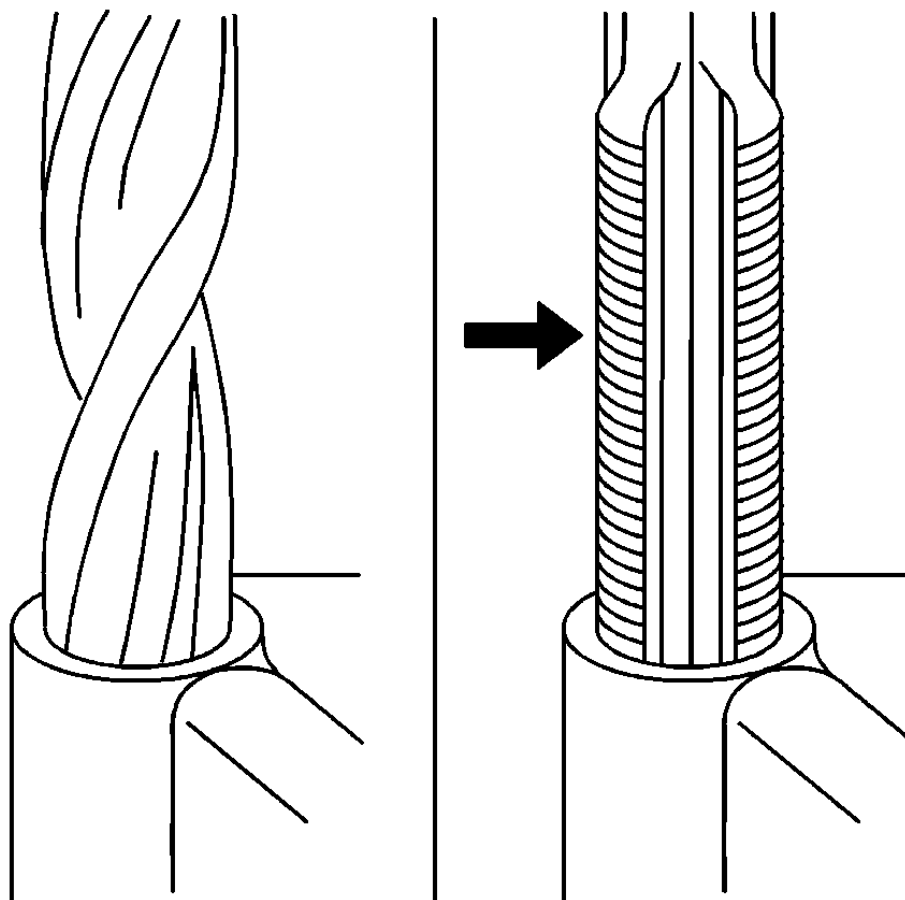


Fig. 373: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

IMPORTANT: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use.
Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

1. Determine the size, the pitch, and the depth of the damaged thread.
2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
3. Drill out the damaged thread.
4. Remove the chips.
5. Apply clean engine oil to the top thread.

6. Use the tap in order to cut new thread.
7. Clean the thread.

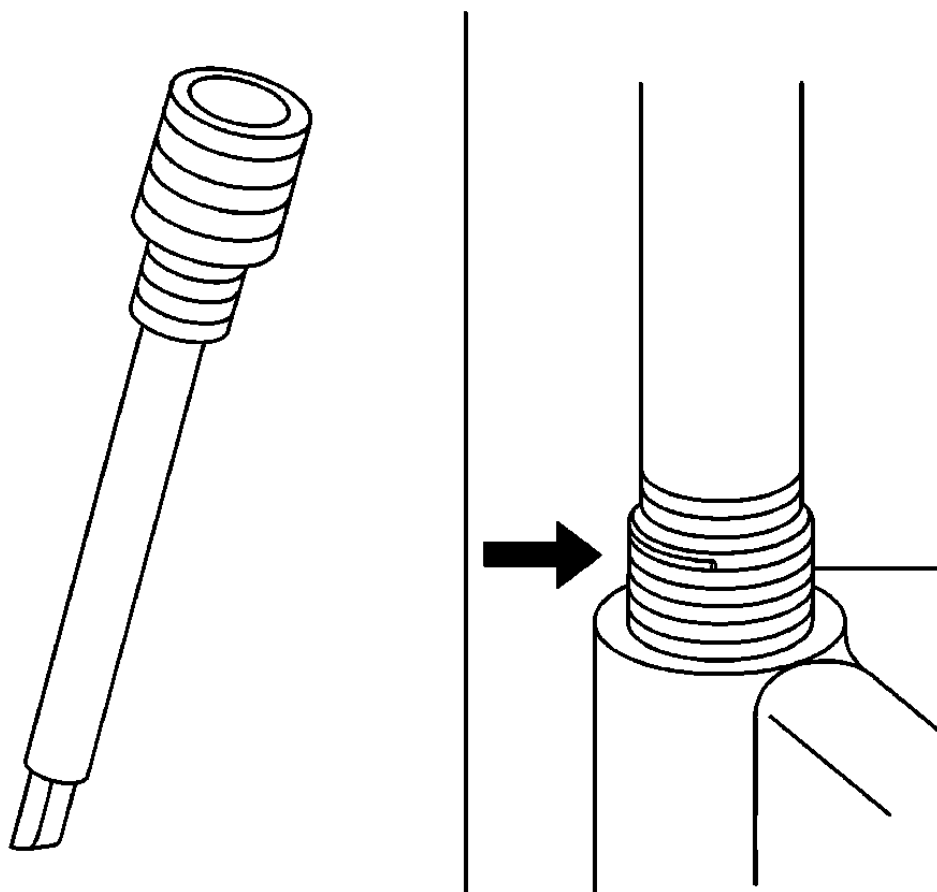


Fig. 374: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

IMPORTANT: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

Service Prior to Assembly

Dirt will cause premature wear of the rebuilt engine. Clean all 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.

Engine Prelubing

Tools Required

J 45299 Engine Preluber. See Special Tools and Equipment.

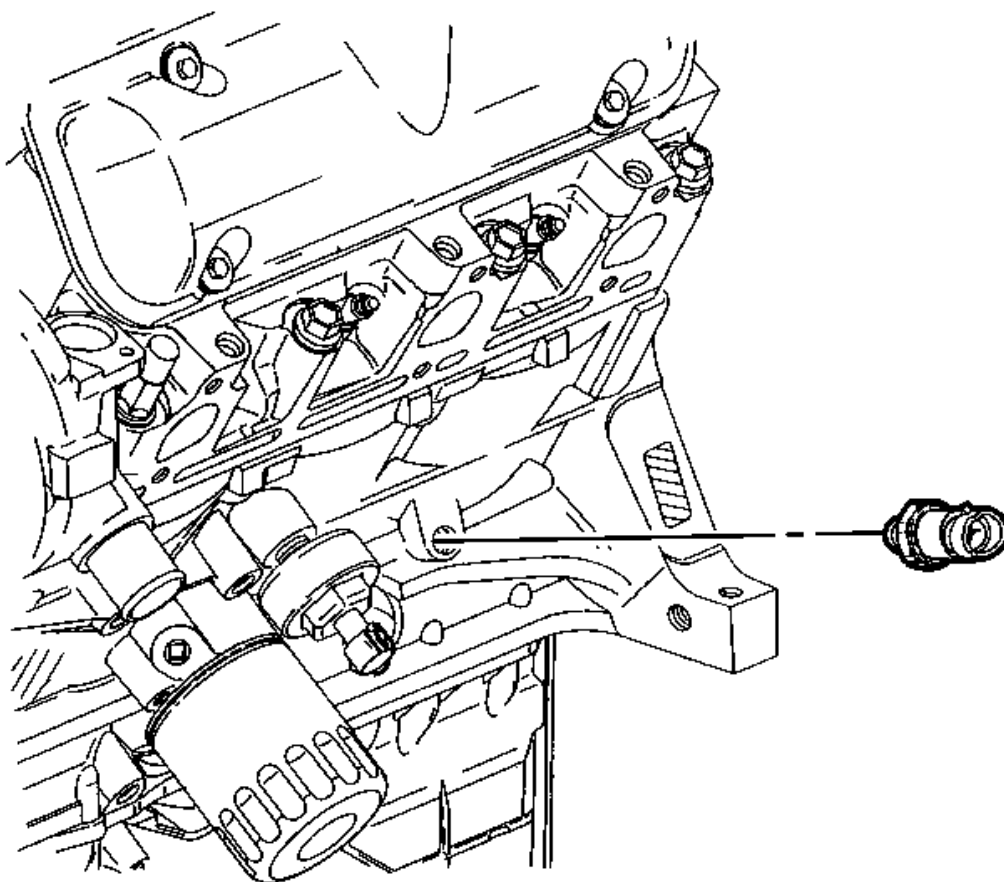


Fig. 375: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

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

3. Locate the oil pressure sensor on left side of engine and remove.
4. Install the 1/4 inch adapter P/N 509373.

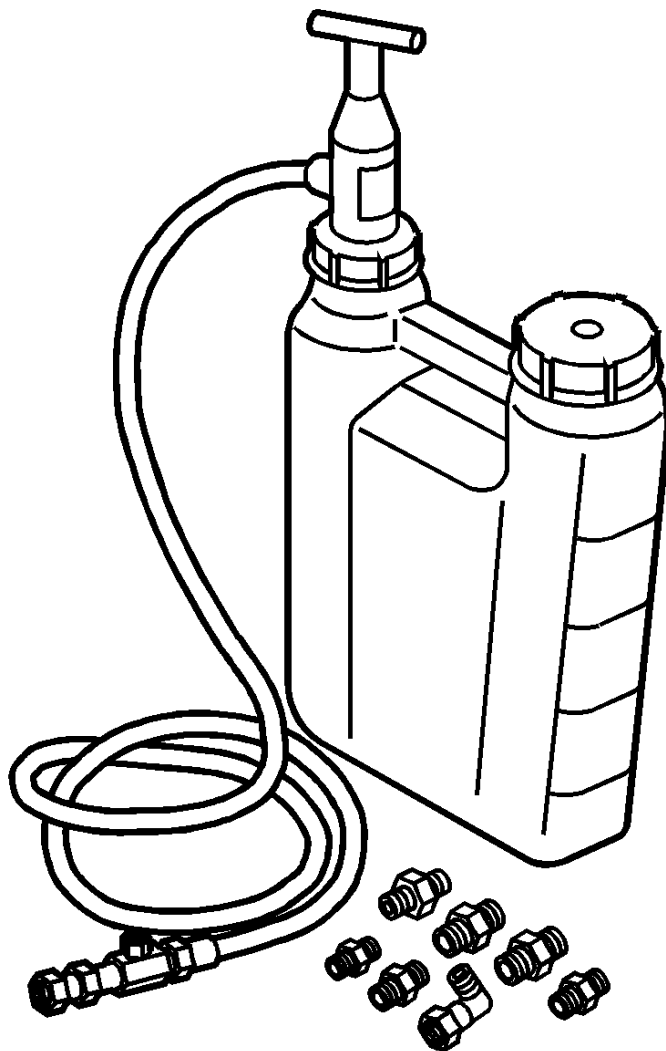


Fig. 376: Identifying Engine Preluber J 45299

Courtesy of GENERAL MOTORS CORP.

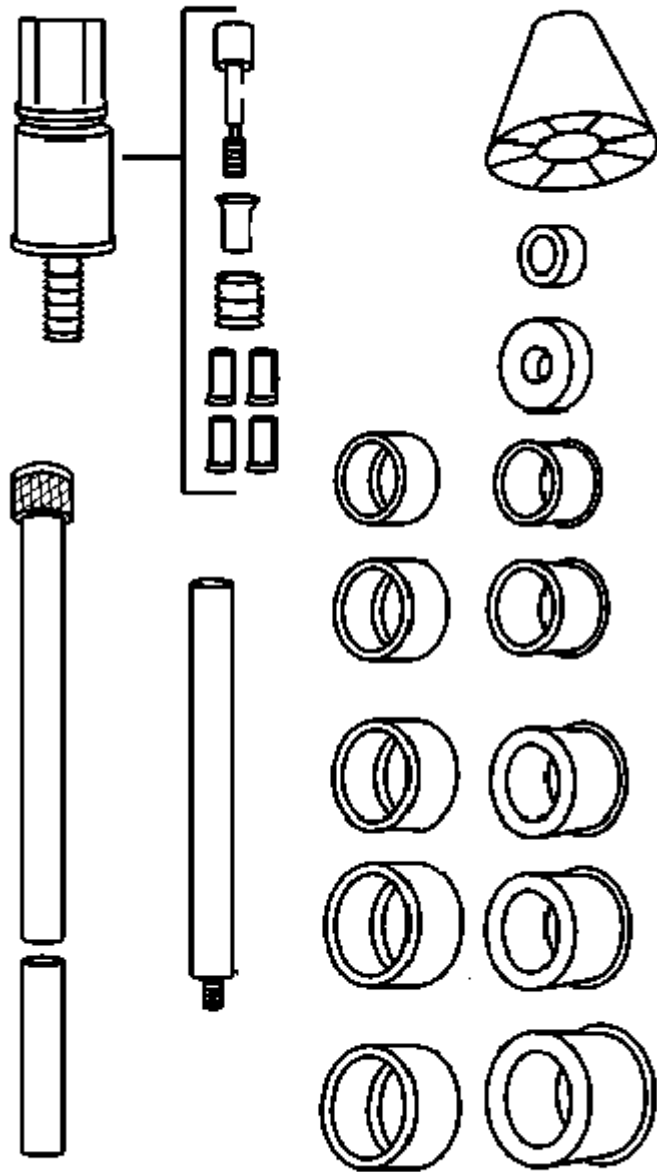
5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on **J 45299** to flow a minimum of 1-2 quarts of engine oil. See **Special Tools and Equipment**. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the oil pressure sensor.

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

9. Top off the engine oil to the proper level.

Camshaft Bearing Installation**Tools Required**

J 33049 Camshaft Bearing Remover/Installer. See **Special Tools and Equipment**.



Courtesy of GENERAL MOTORS CORP.

1. Assemble the **J 33049** according to the manufacturer's instructions. See **Special Tools and Equipment**.

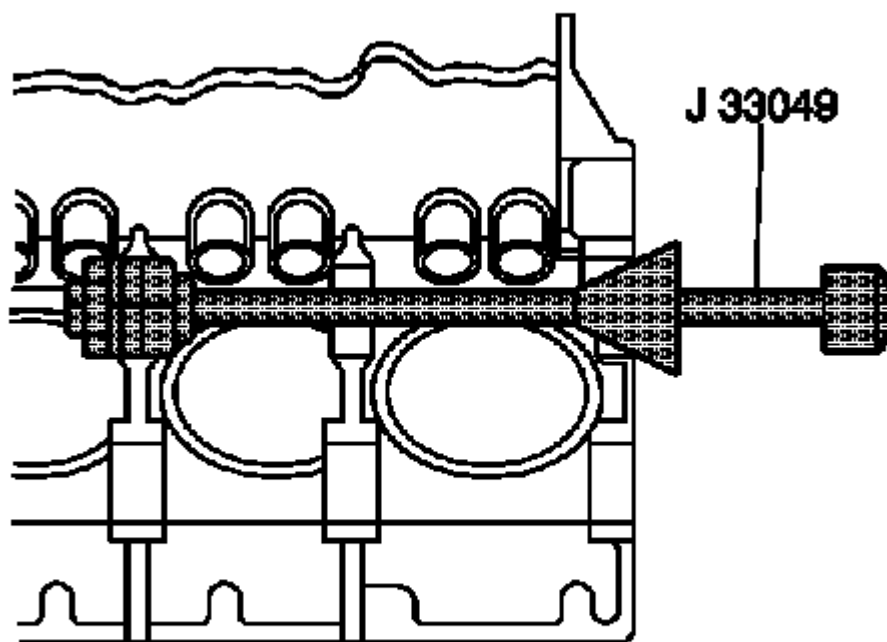


Fig. 378: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

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 and Equipment**.
 3. Install the third camshaft bearing.
 4. Install the second camshaft bearing.
 5. Install the outer camshaft bearings.

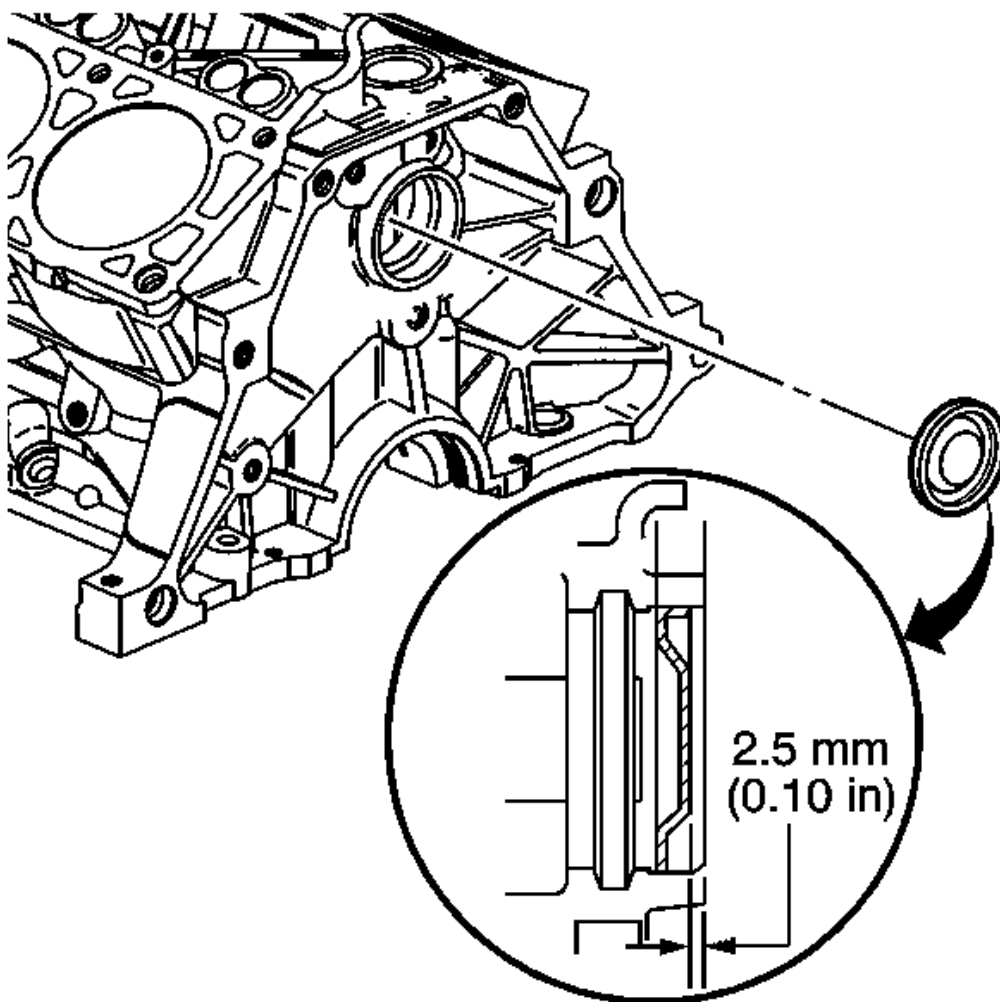


Fig. 379: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

3. Apply sealer GM P/N United States 12377901, GM P/N Canada 10953504 or the equivalent to the camshaft rear bearing hole plug.
4. Install the camshaft rear bearing hole plug.

Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

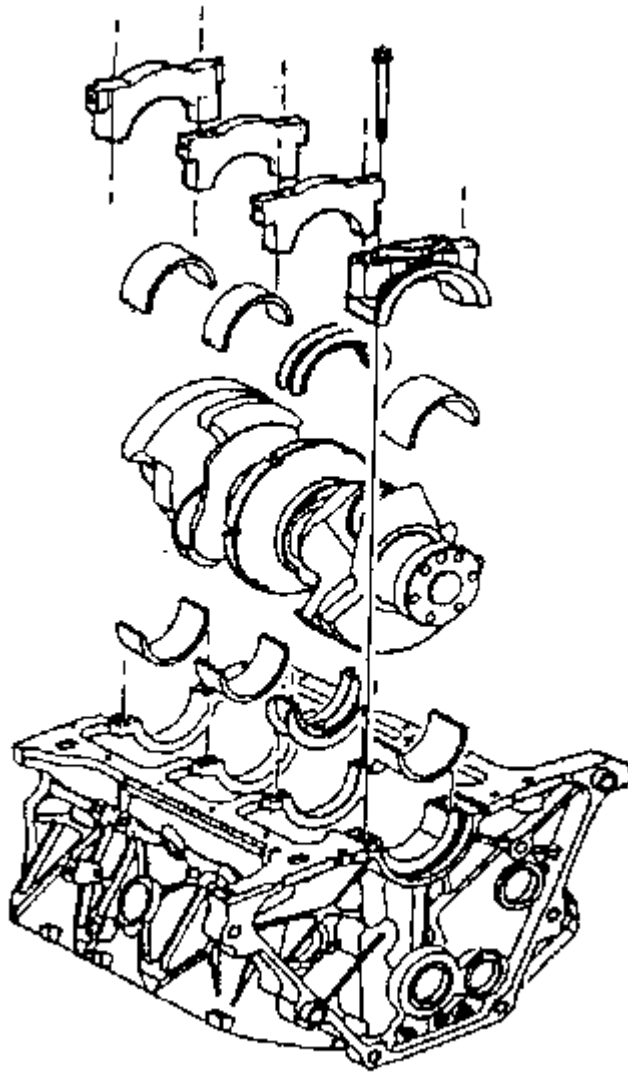


Fig. 380: View Of Crankshaft, Main Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

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 in Cautions and Notices.

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. See **Special Tools and Equipment**.m (37 lb ft) plus 77 degrees.

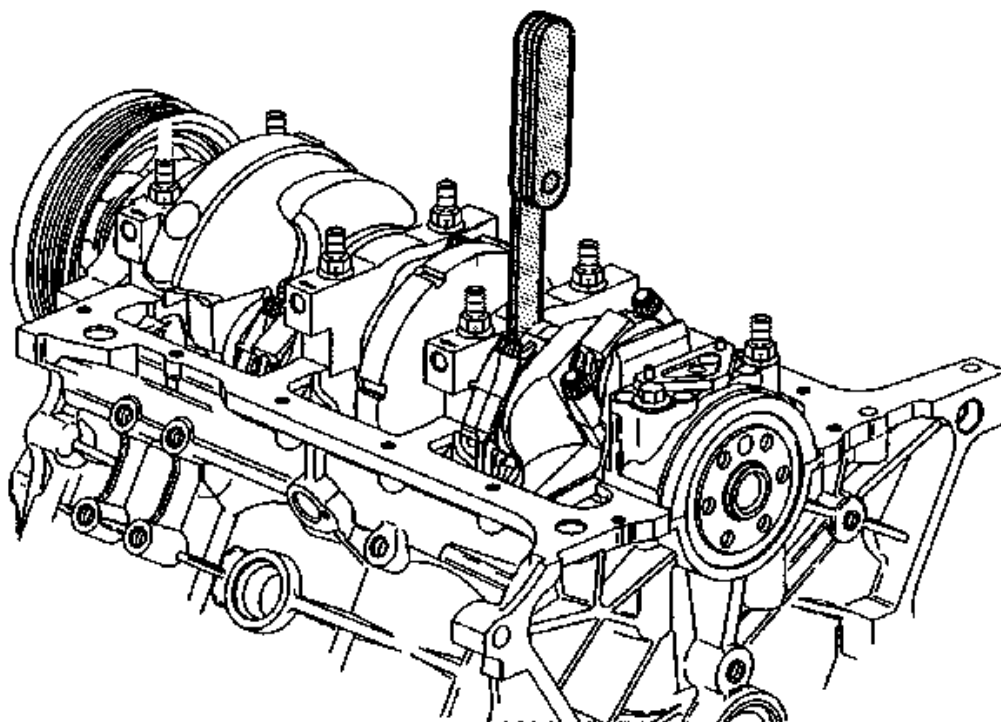


Fig. 381: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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.

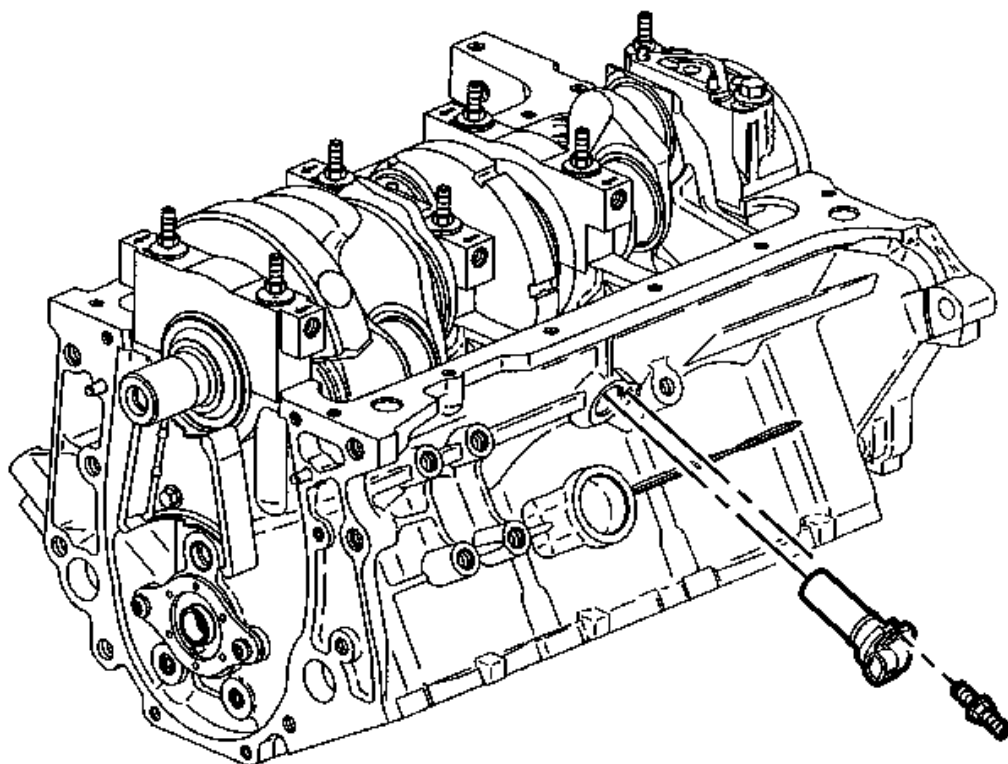


Fig. 382: View Of Crankshaft Position Sensor & Stud
Courtesy of GENERAL MOTORS CORP.

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

J 34686 Rear Main Seal Installer. See **Special Tools and Equipment**.

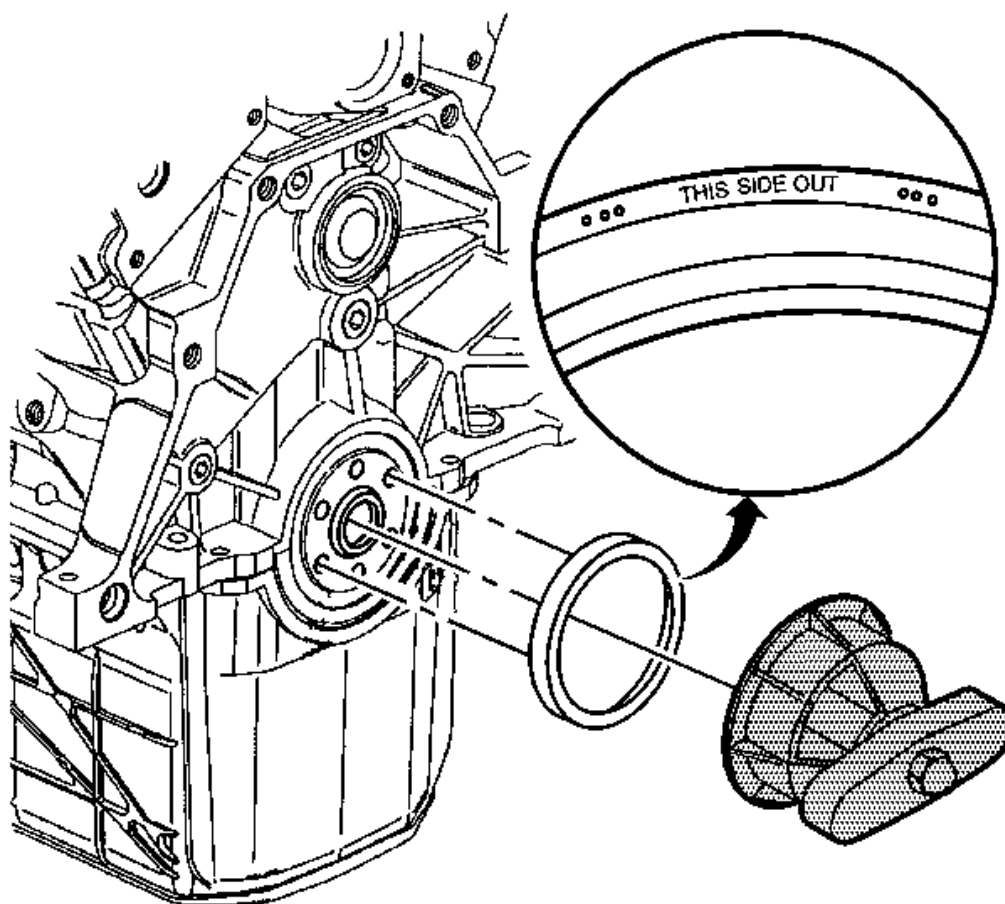


Fig. 383: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not apply or use any oil lubrication on the crankshaft rear oil seal, or the seal installer. Do not touch the sealing lip of the oil seal once the protective sleeve is removed. Doing so will damage/deform the 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 proceeding.

IMPORTANT: Notice the direction of the rear oil seal. The new design seal is a reverse style as opposed to what has been used in the past. "THIS SIDE OUT" has

been stamped into the seal as shown in the graphic.

1. Carefully remove the protection sleeve from the new crankshaft rear oil seal.
2. Install the crankshaft rear oil seal onto the **J 34686** by sliding the crankshaft rear oil seal over the mandrel using a twisting motion until the back of the crankshaft rear oil seal bottoms squarely against the collar of the tool. See **Special Tools and Equipment**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Perform the following steps in order to install the crankshaft rear oil seal:
 1. Align the dowel pin of the **J 34686** with the dowel pin in the crankshaft. See **Special Tools and Equipment**.
 2. Attach the **J 34686** to the crankshaft by hand, or tighten attaching screws to 5 N. See **Special Tools and Equipment**.m (45 lb in).
 3. Turn the T-handle of the **J 34686** in order to engage allow the collar to push the seal into the bore. See **Special Tools and Equipment**.

Turn the handle until the collar is tight against the engine block. Ensure that the seal is seated properly.

4. Loosen the T-handle until the T-handle comes to a stop.
5. Remove the attaching screws.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 5239** Connecting Rod Guide. See **Special Tools and Equipment**.
- **J 8037** Piston Ring Compressor. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

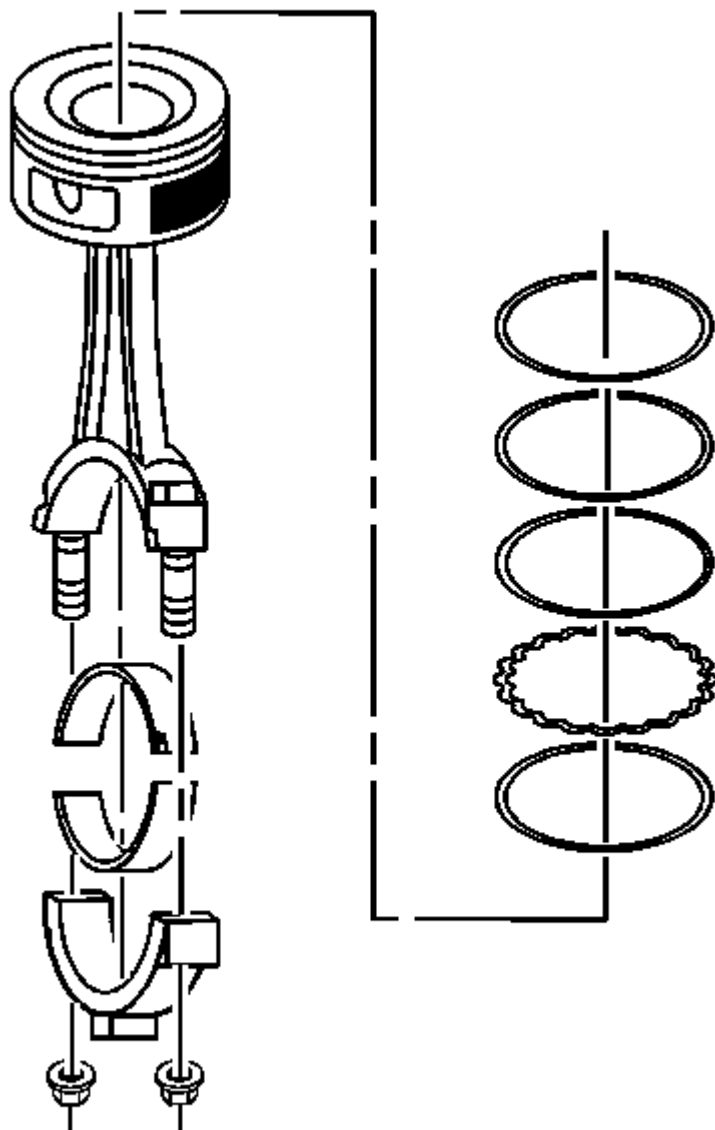


Fig. 384: Piston, Piston Rings, & Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore. The piston alignment mark **MUST** face the front of the engine block.

1. Lightly lubricate the following components with clean engine oil:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces
2. Stagger the oil control ring end gaps a minimum of 90 degrees.
3. Stagger the compression ring end gaps a minimum of 25 mm (1.0 in).
4. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools and Equipment**.

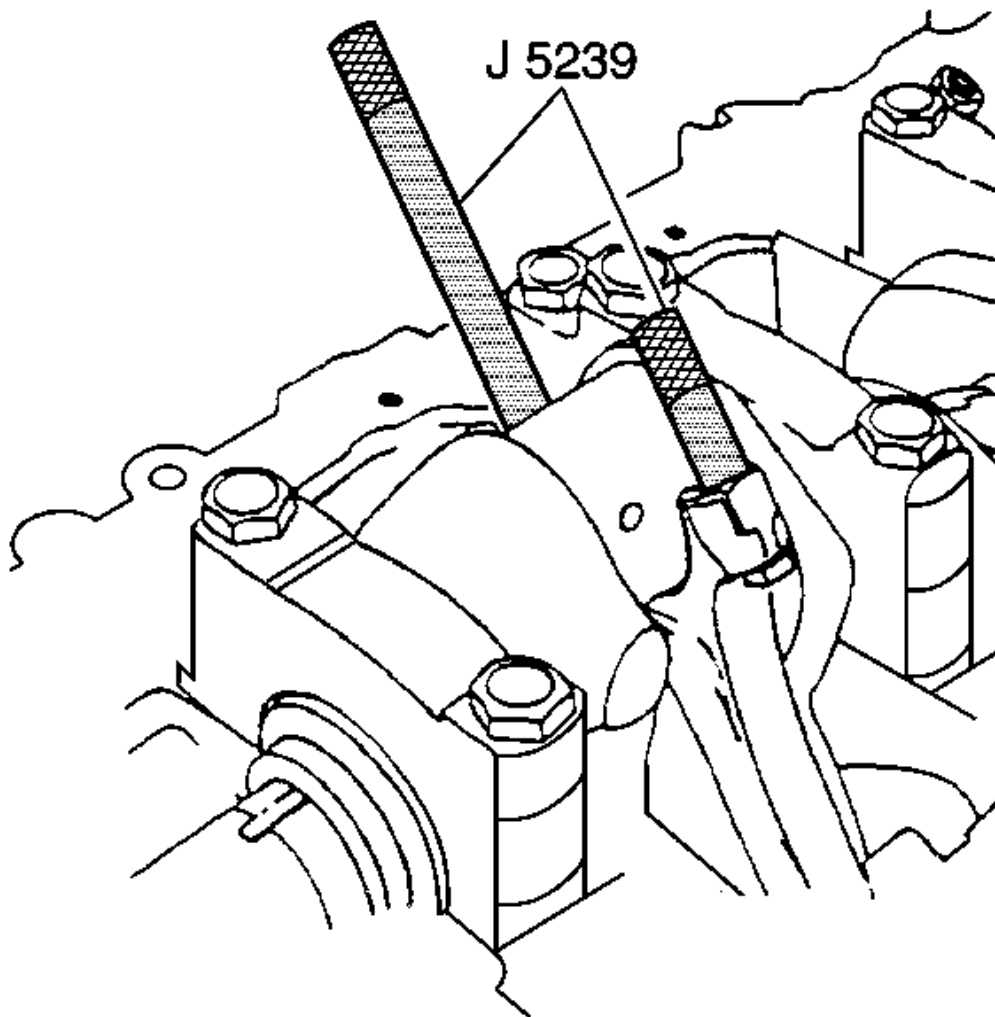


Fig. 385: Protecting Crankshaft Journals Using J 5239

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The piston alignment mark **MUST** be facing the front of the engine block.

5. Install the **J 5239** on the connecting rod bolts. See Special Tools and Equipment.

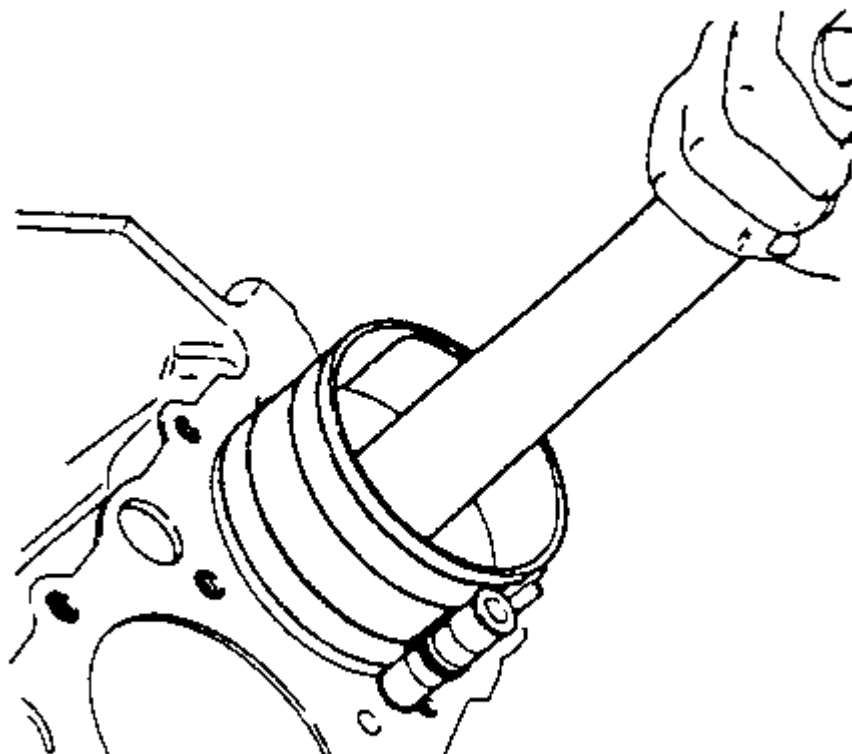


Fig. 386: Hold Piston Ring Compressor Against Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Install the piston and connecting rod assembly into the proper cylinder bore.
7. 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.

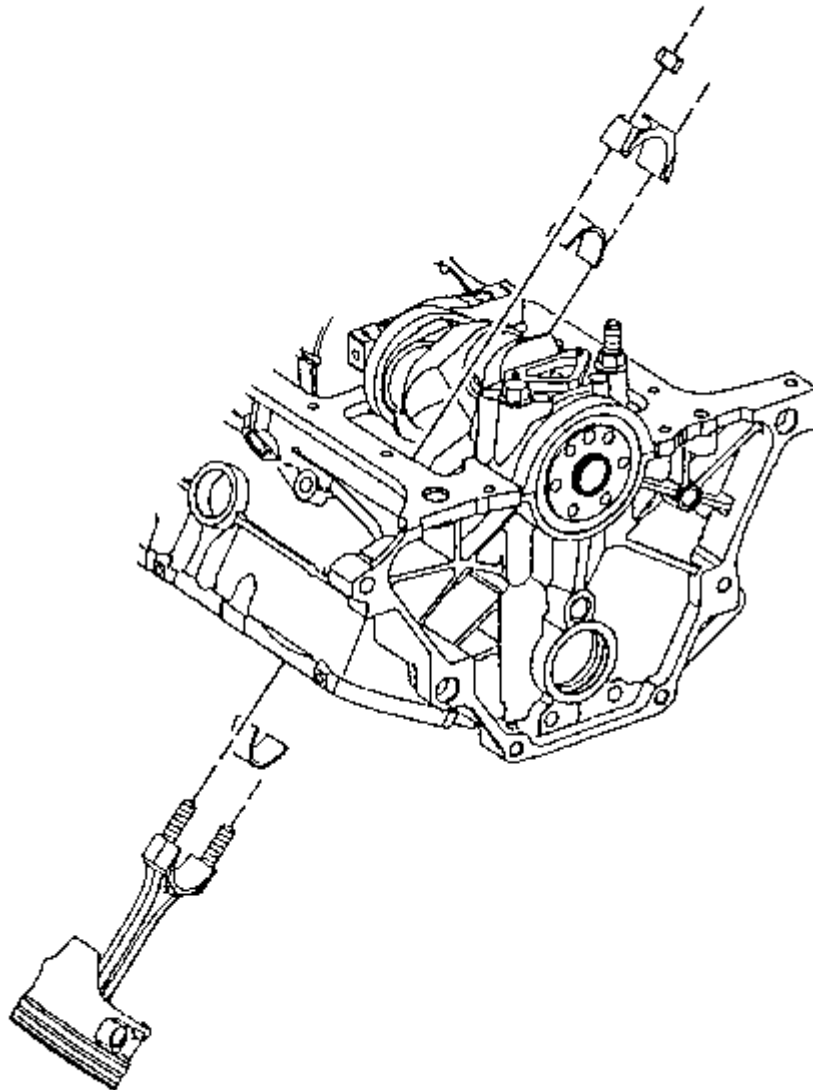


Fig. 387: View Of Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

8. Guide the connecting rod end onto the crankshaft journal.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the bearing, cap, and nuts.

Tighten:

1. Tighten the connecting rod bearing cap nuts a first pass to 20 N.m (15 lb ft).
2. Tighten the connecting rod bearing cap nuts a second pass to 75 degrees using the **J 45059** . See **Special Tools and Equipment**.

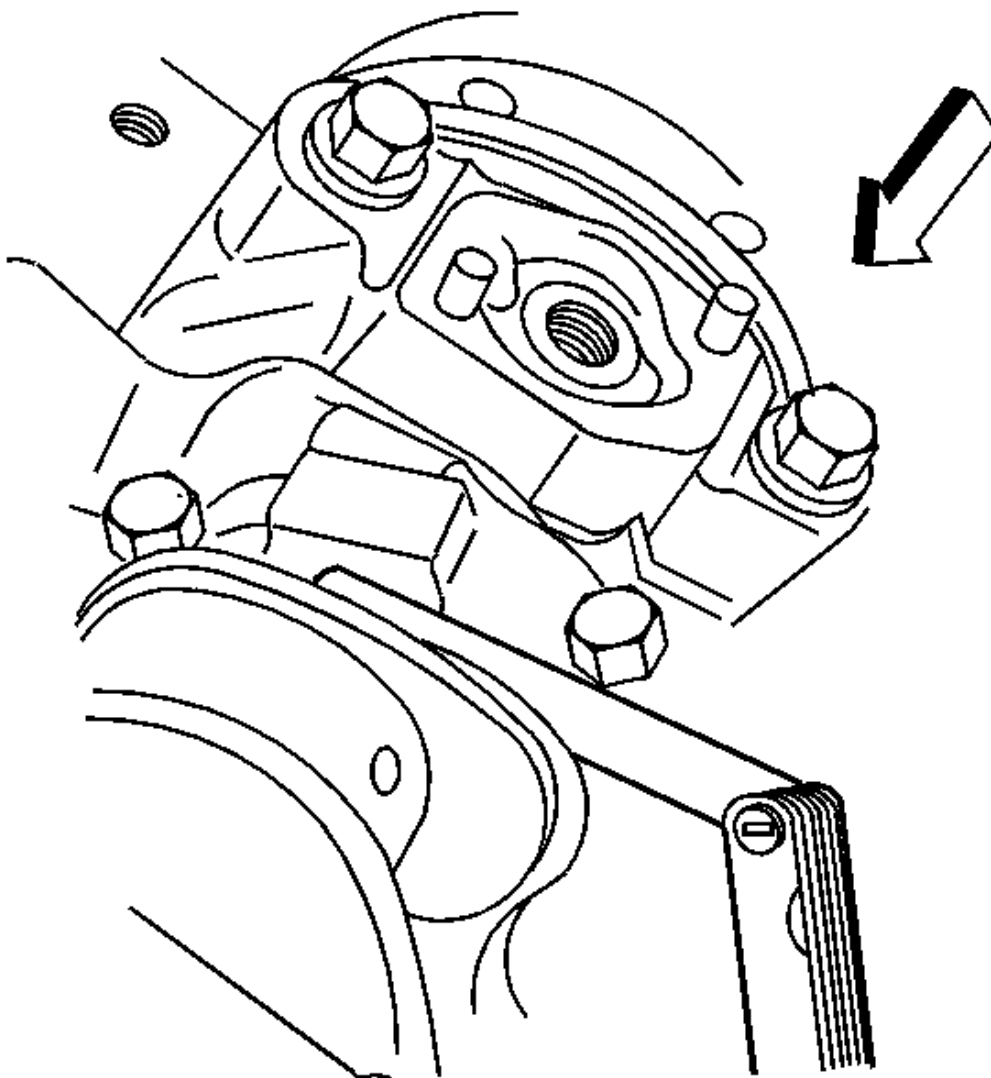


Fig. 388: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

10. 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.

11. 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).

Camshaft Installation

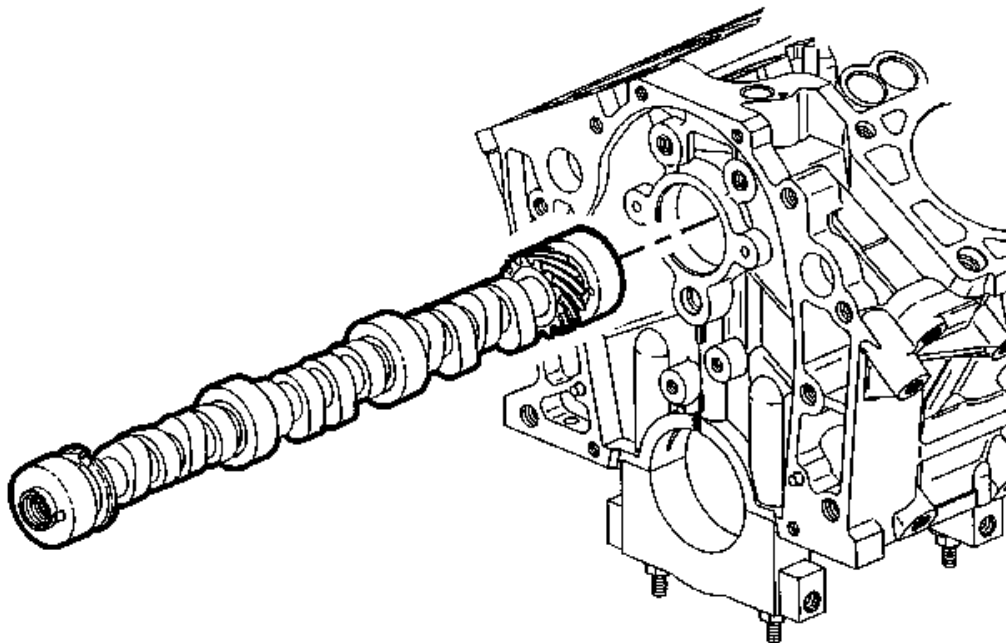


Fig. 389: View Of Camshaft

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 large screwdriver into the camshaft bolt hole for support. Do not damage the threads.
 2. Rotate the camshaft while installing the camshaft into the camshaft bearings.

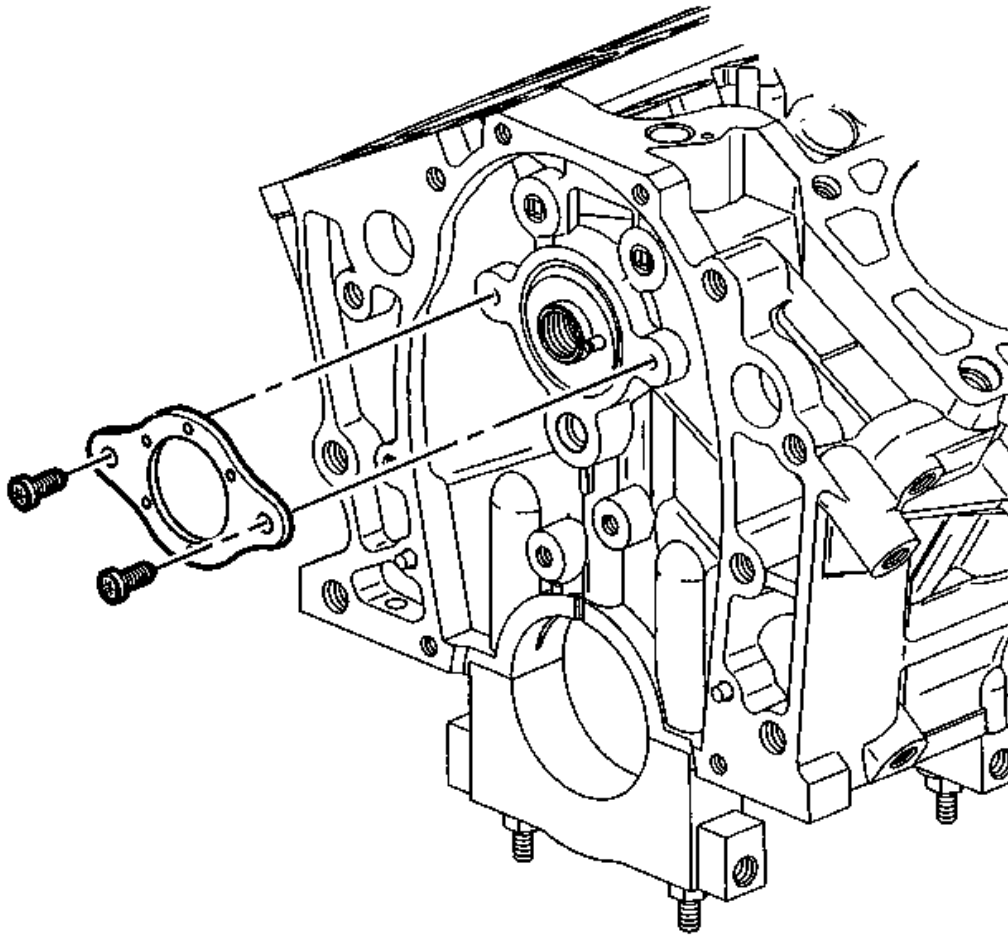


Fig. 390: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

4. Install the camshaft thrust plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the camshaft thrust plate screws.

Tighten: Tighten the camshaft thrust plate screws to 10 N.m (89 lb in).

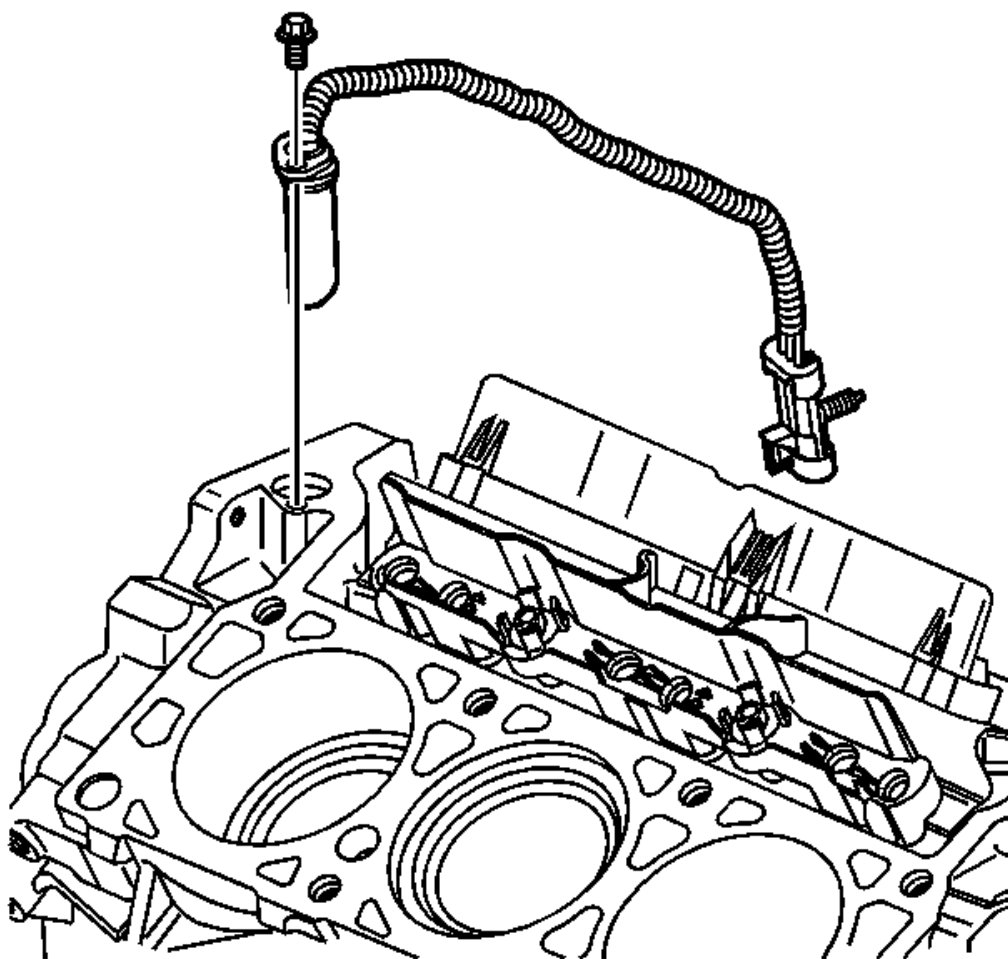


Fig. 391: Camshaft Position Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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

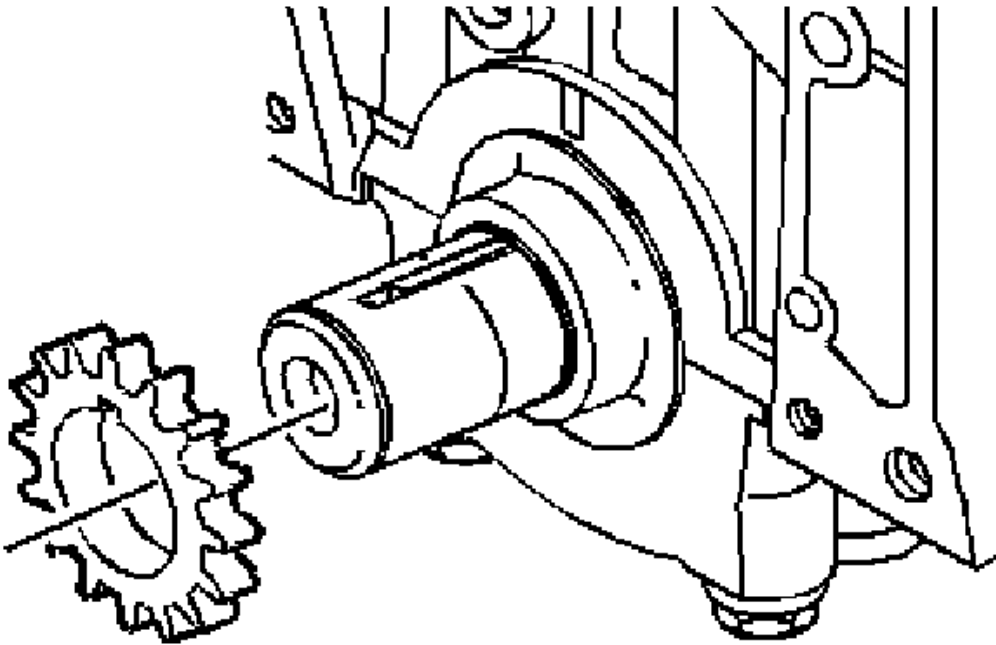


Fig. 392: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft sprocket.
2. Apply prelube GM P/N United States 12345501, GM P/N Canada 992704 or the equivalent to the crankshaft sprocket thrust surface.

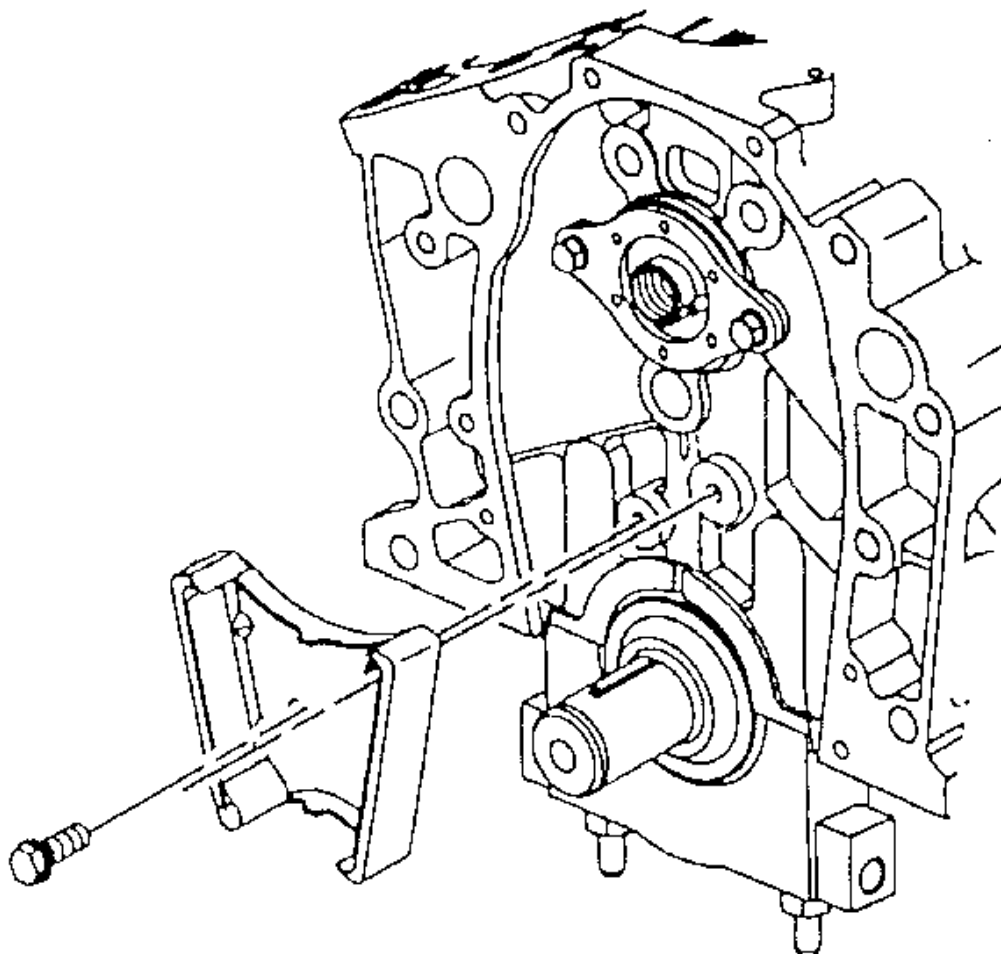


Fig. 393: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing chain dampener.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the timing chain dampener bolts.

Tighten: Tighten the timing chain dampener bolt to 21 N.m (15 lb ft).

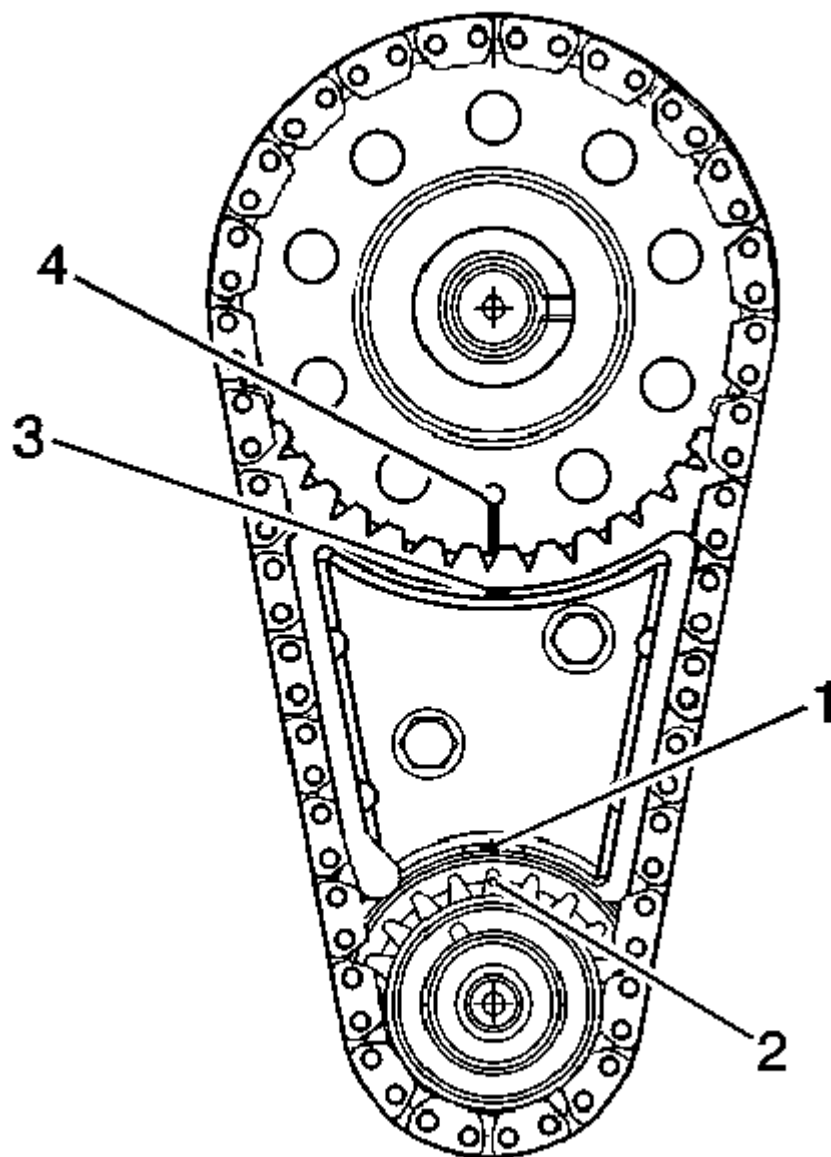


Fig. 394: Crankshaft Gear, Camshaft Gear & Timing Chain Dampener Timing Marks
Courtesy of GENERAL MOTORS CORP.

5. Align the crankshaft timing mark (2) to the timing mark on the bottom of the timing chain dampener (1).
6. Hold the camshaft sprocket with the timing chain hanging down and install the timing chain to the crankshaft gear.
7. Align the timing mark on the camshaft gear (4) with the timing mark on top of the timing chain dampener

(3).

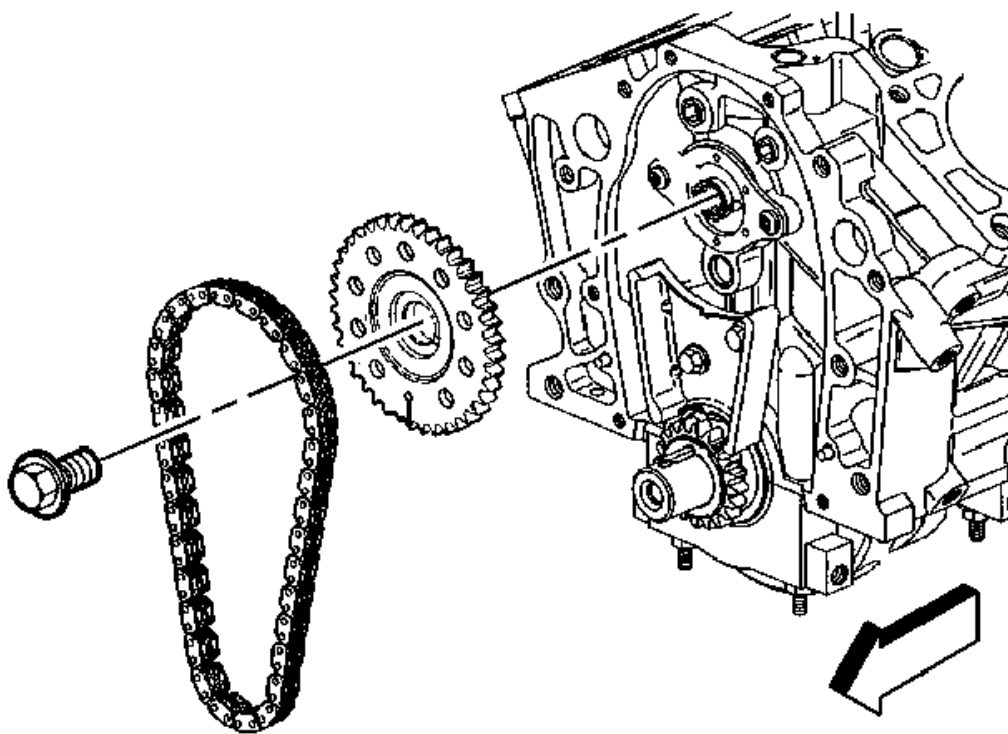


Fig. 395: View Of Timing Chain & Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

8. Align the dowel in the camshaft with the dowel hole in the camshaft sprocket.
9. Draw the camshaft sprocket onto the camshaft using the mounting bolt.
10. Coat the crankshaft and camshaft sprocket with engine oil.

Tighten: Tighten the bolt to 140 N.m (103 lb ft).

Engine Front Cover Installation

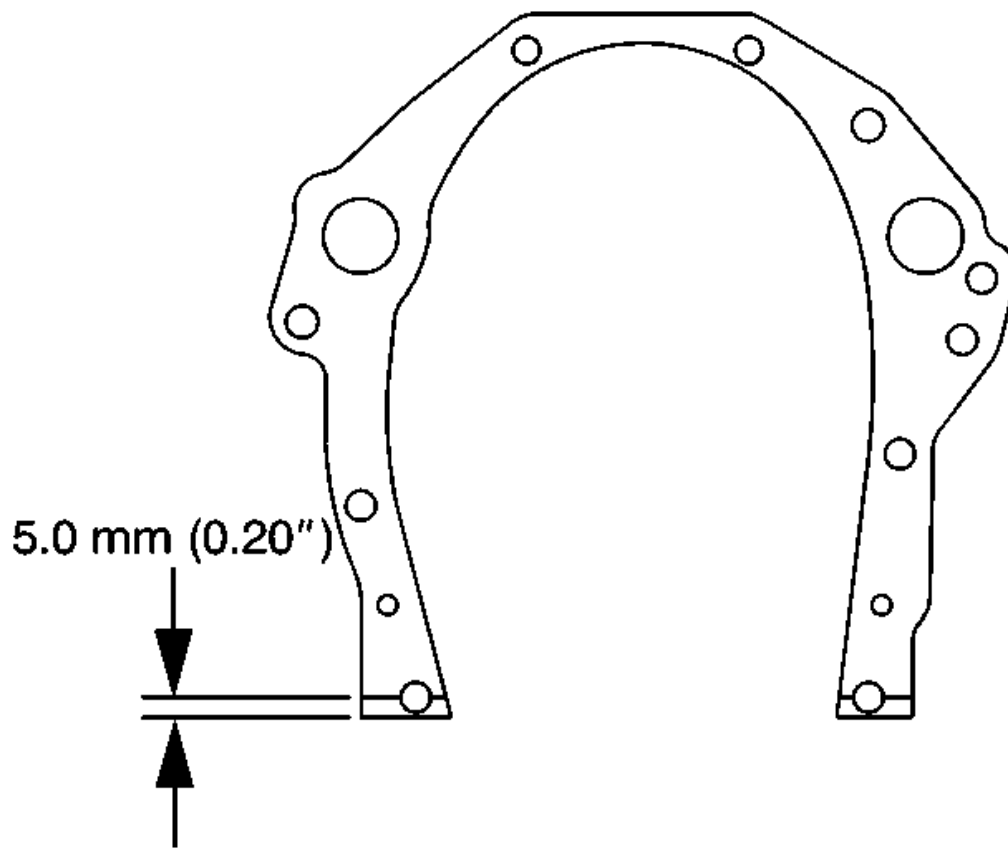


Fig. 396: Applying Sealer To Lower Tabs Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover gasket.
2. Apply sealer GM P/N 12346004, (Canadian P/N 10953480) or equivalent to both sides of the lower tabs of the engine front cover gasket.

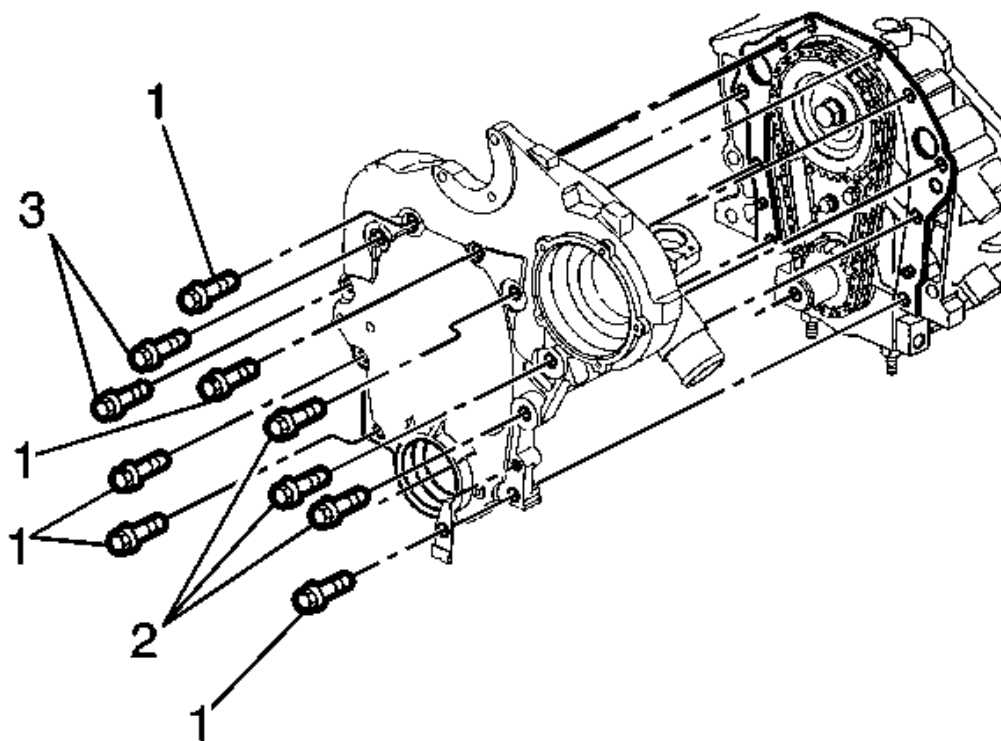


Fig. 397: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the engine front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the engine front cover bolts (3).

Tighten: Tighten the engine front cover bolts (3) to 55 N.m (41 lb ft).

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

Tighten: Tighten the engine front cover bolts (1) to 55 N.m (41 lb ft).

6. Install the engine front cover bolts (2).

Tighten: Tighten the engine front cover bolts (2) to 27 N.m (20 lb ft).

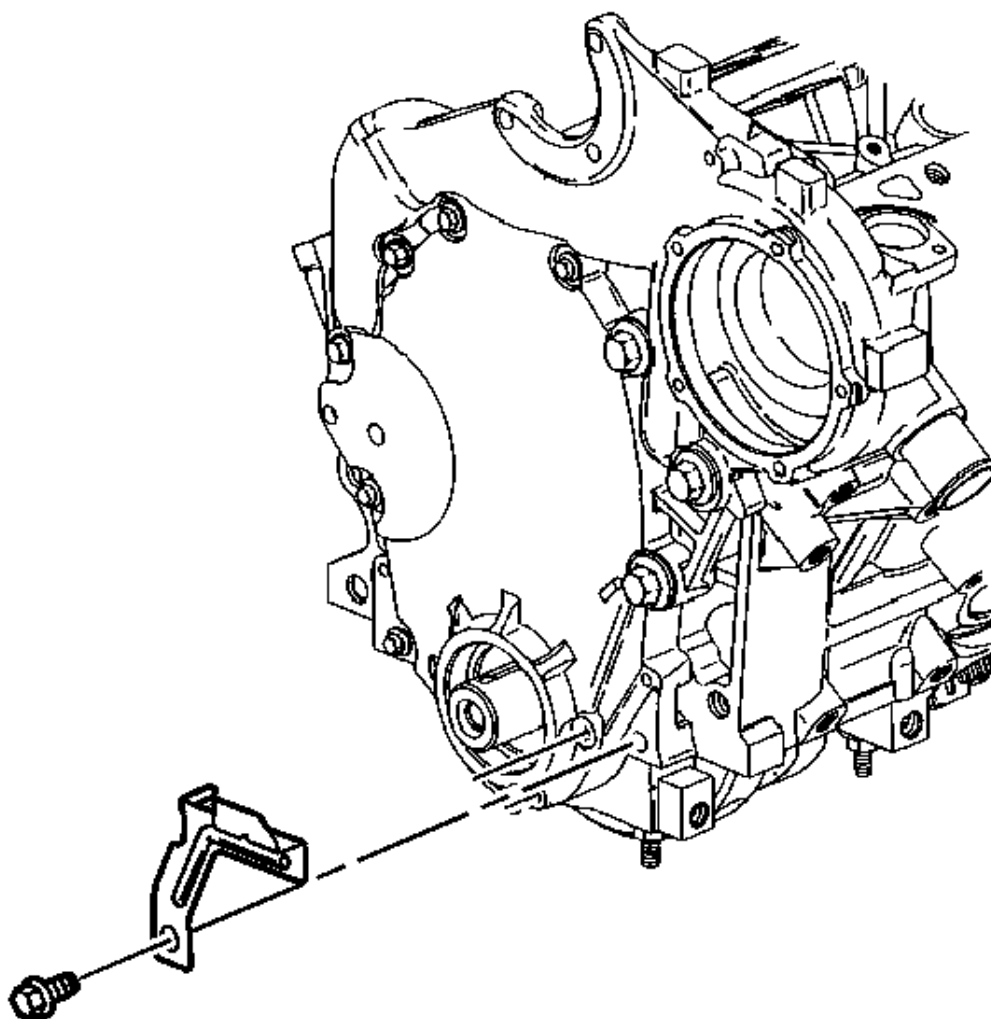


Fig. 398: Crankshaft Position Sensor Wiring Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft position sensor wiring bracket.
8. Install the crankshaft position sensor wiring bracket bolt.

Tighten: Tighten the crankshaft position sensor wiring bracket bolt to 27 N.m (20 lb ft).

Crankshaft Front Oil Seal Installation

Tools Required

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

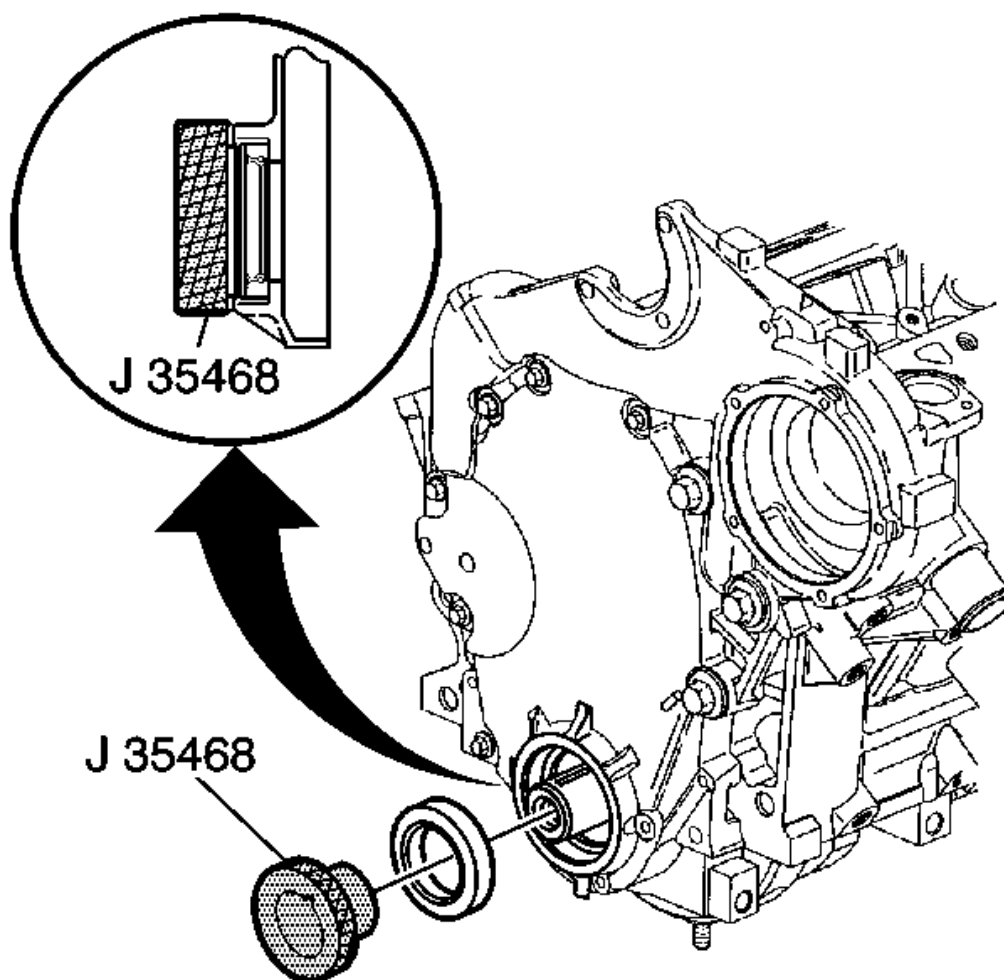


Fig. 399: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

Oil Pump Drive Installation

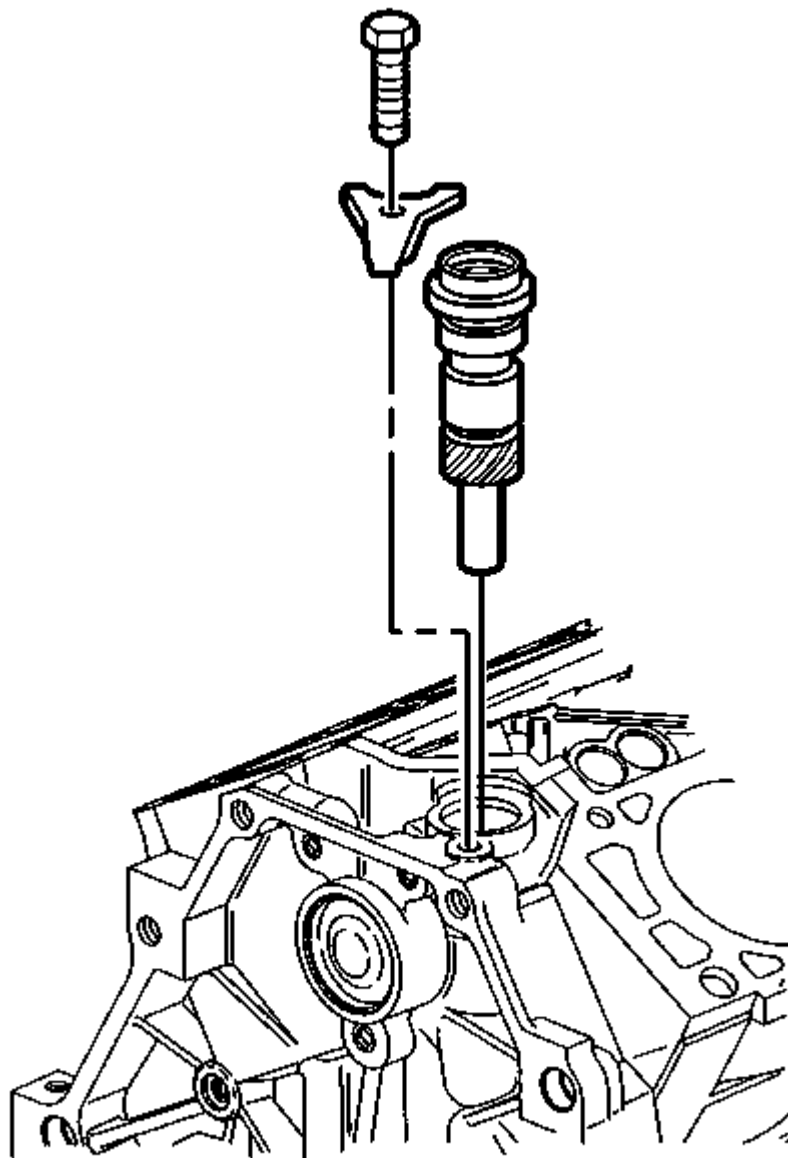


Fig. 400: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Apply prelube GM P/N United States 12345501, GM P/N Canada 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 in Cautions and Notices.

5. Install the oil pump drive gear clamp bolt.

Tighten: Tighten the oil pump drive gear clamp bolt to 36 N.m (27 lb ft).

Oil Pump Installation

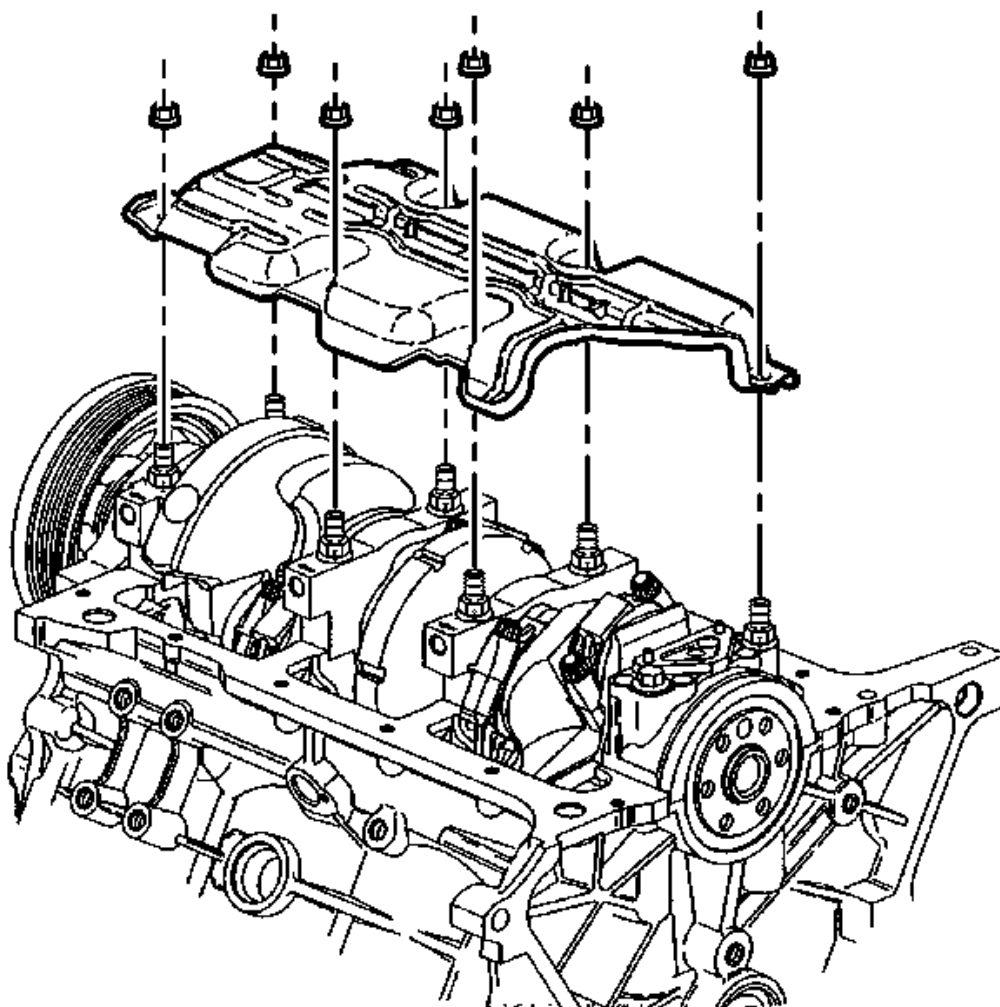


Fig. 401: View Of Crankshaft Oil Deflector & Nuts

Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft oil deflector.

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

2. Install the crankshaft oil deflector nuts.

Tighten: Tighten the crankshaft oil deflector nuts to 25 N.m (18 lb ft).

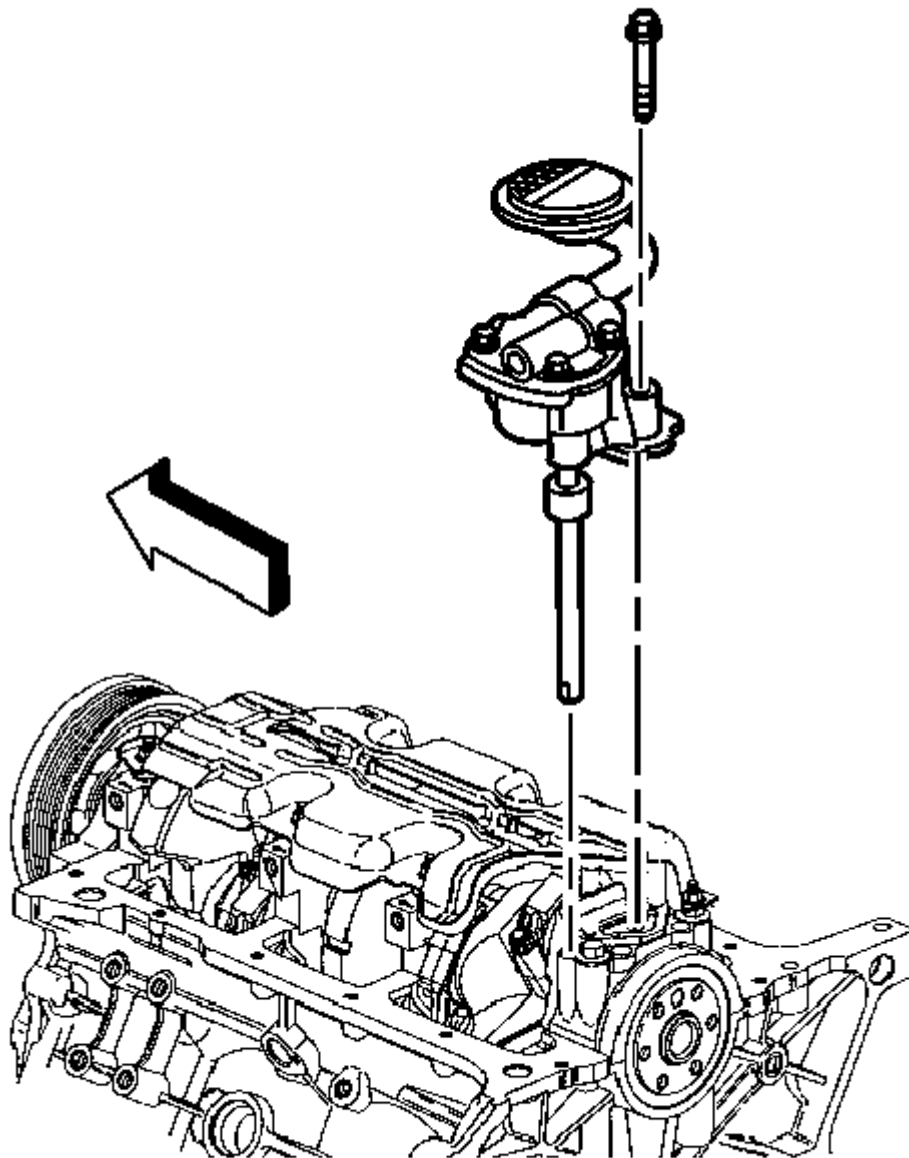


Fig. 402: Oil Pump & Bolts

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.
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

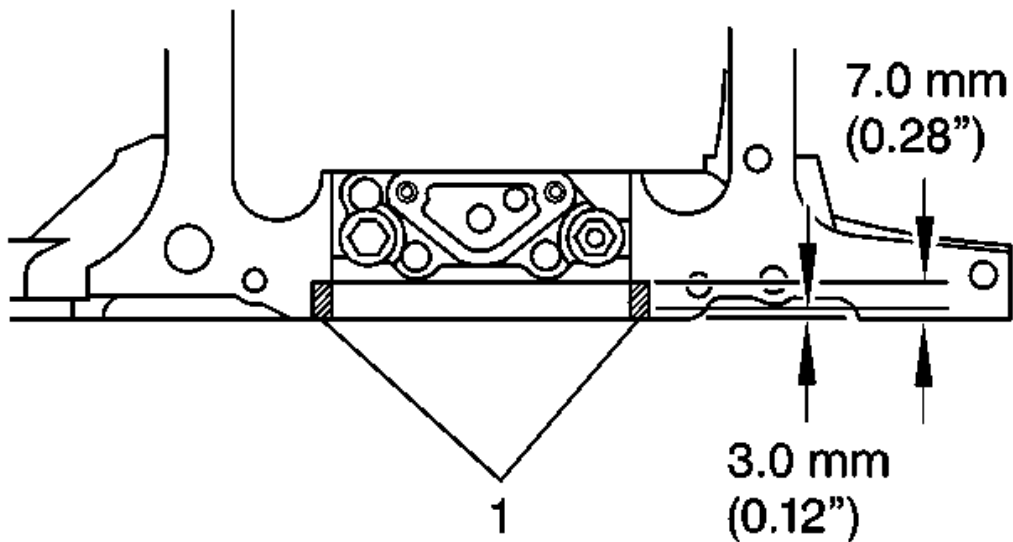


Fig. 403: Sealant Application At Rear Main Bearing Cap & Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346141 (Canadian P/N 10953433) or the equivalent to both sides of the crankshaft rear main bearing cap (1). Press sealer into gap using a putty knife.

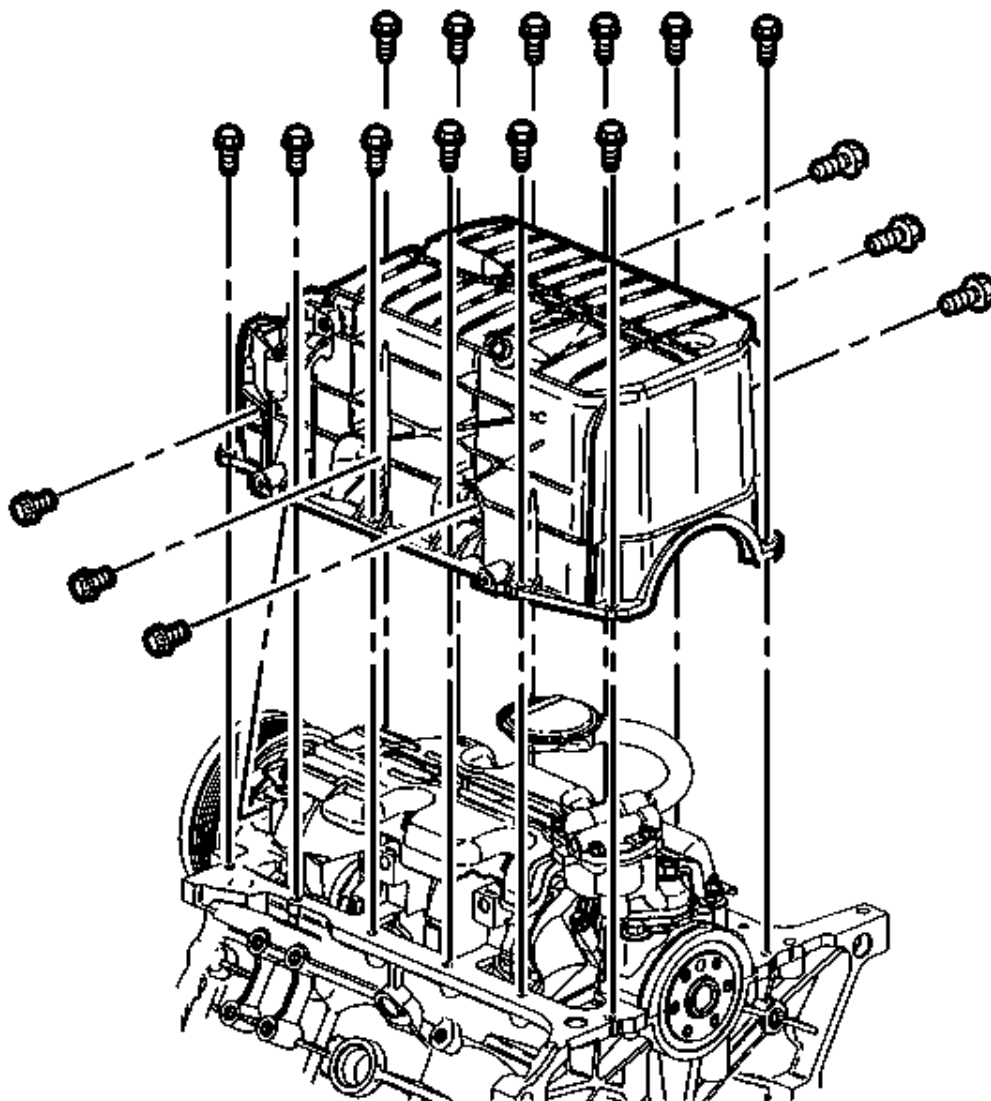


Fig. 404: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice In Cautions and Notices.

4. Install the oil pan bolts.

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

5. Install the oil pan side bolts.

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

Cylinder Head Installation - Left

Tools Required

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

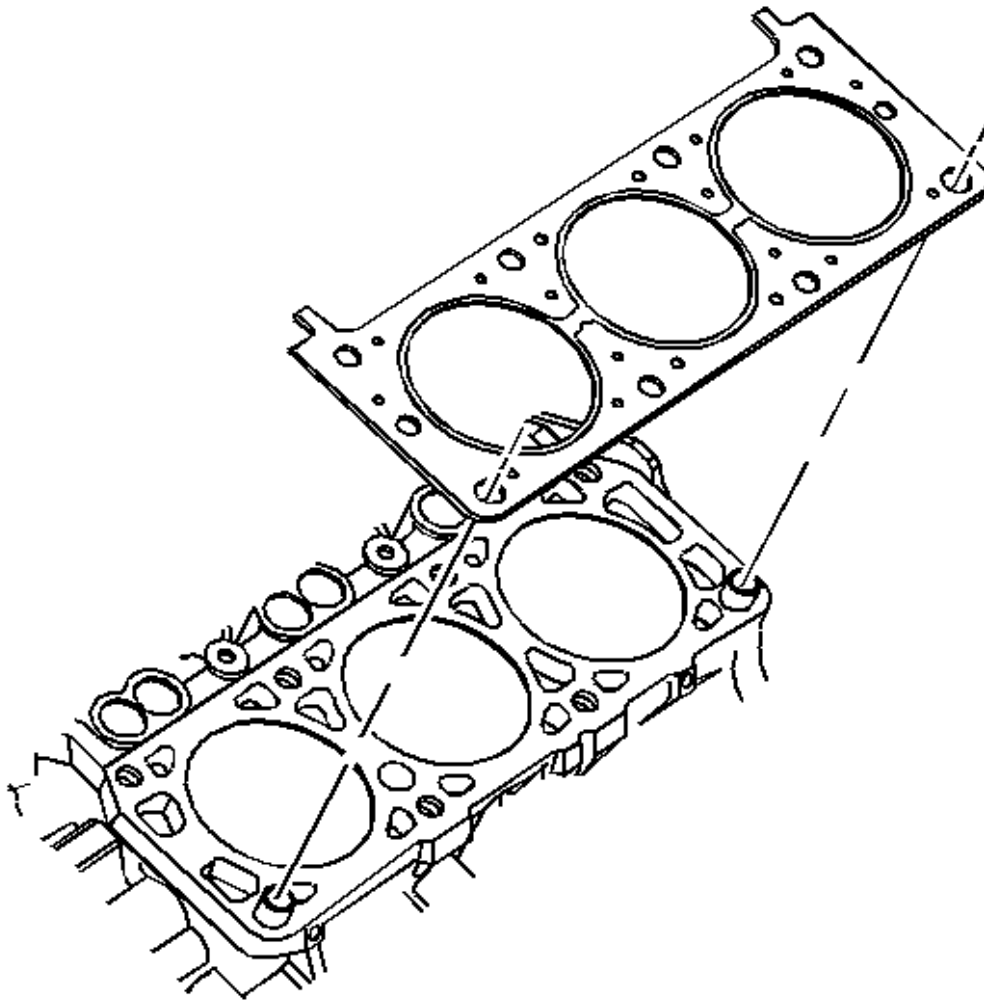


Fig. 405: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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.
2. Inspect the cylinder head locator dowel pins for proper installation.
3. Install the cylinder head gasket.

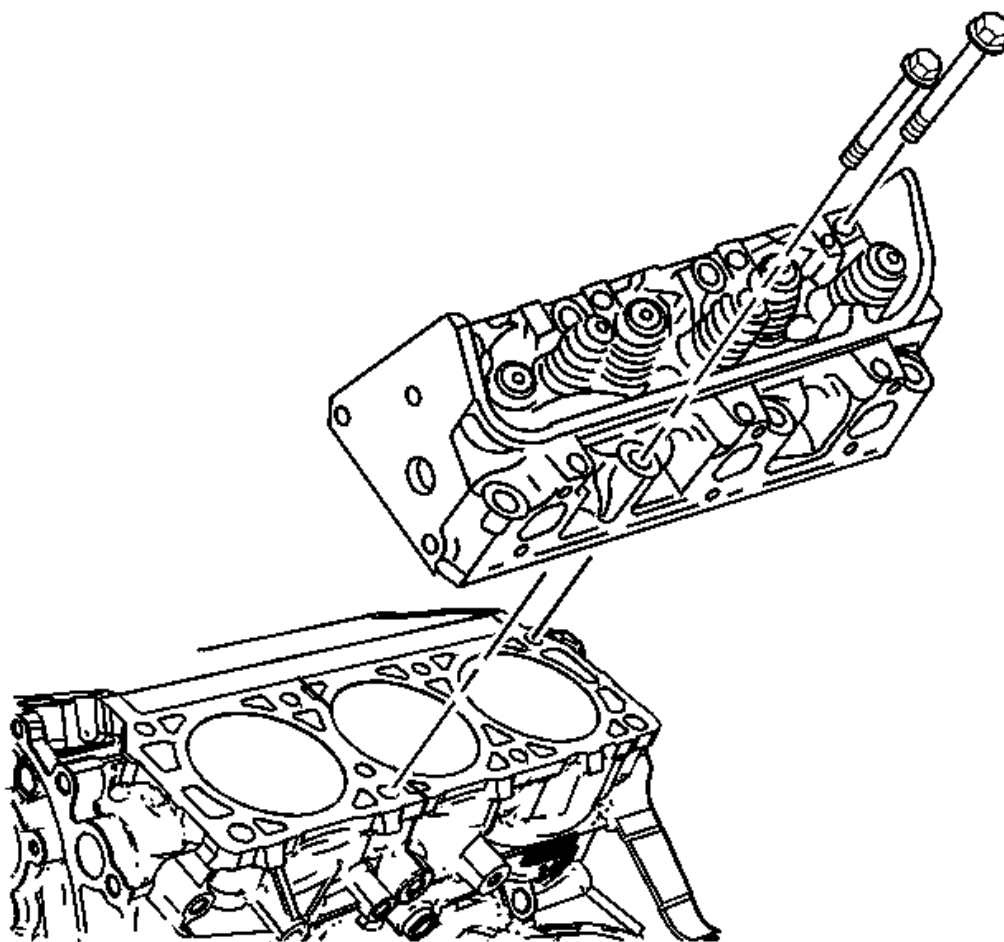


Fig. 406: Removing/Installing Cylinder Head

Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

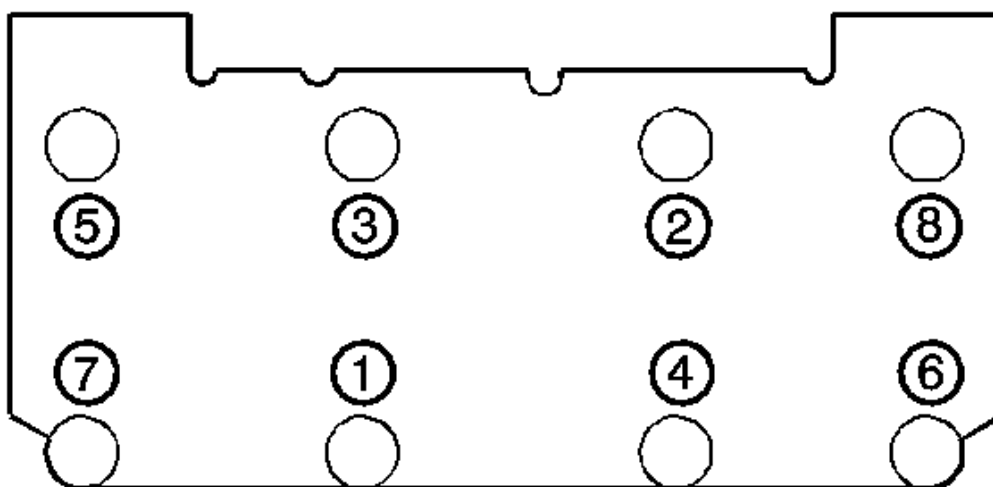


Fig. 407: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 and Equipment.

Cylinder Head Installation - Right

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

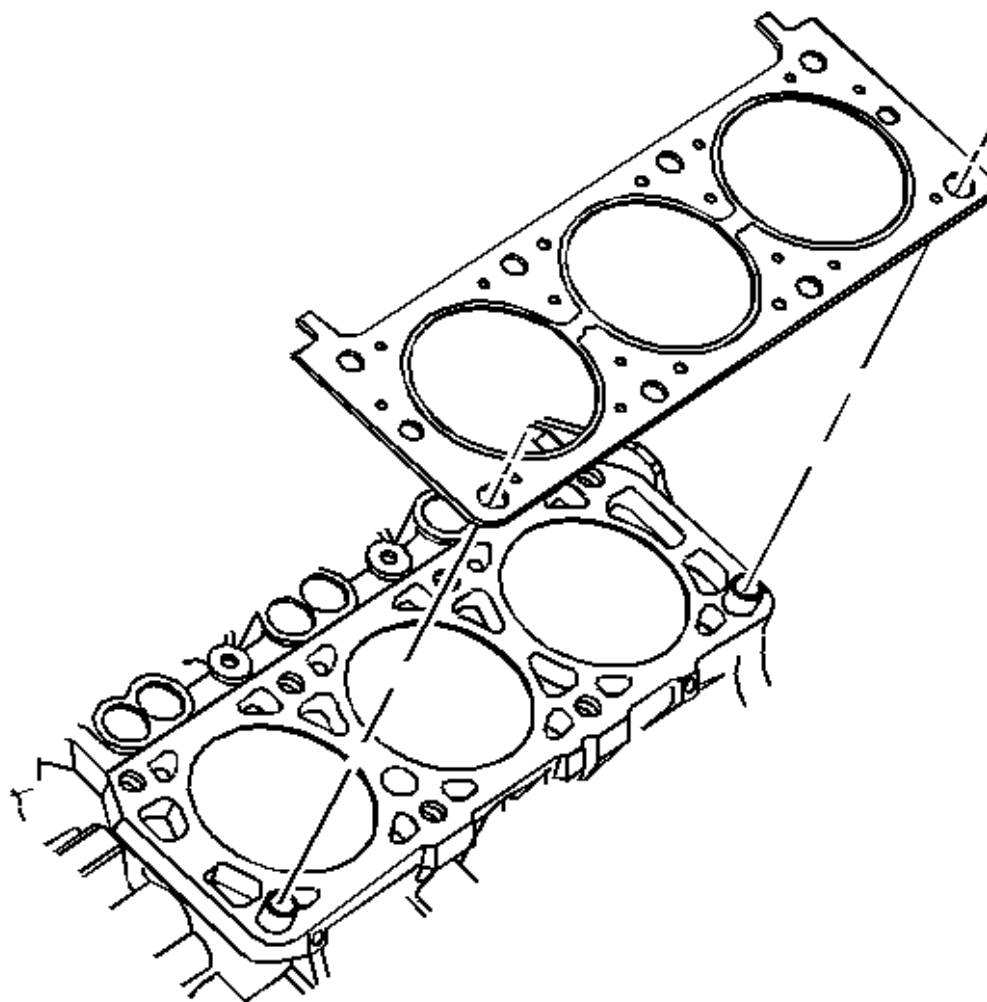


Fig. 408: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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

3. Install the cylinder head gasket.

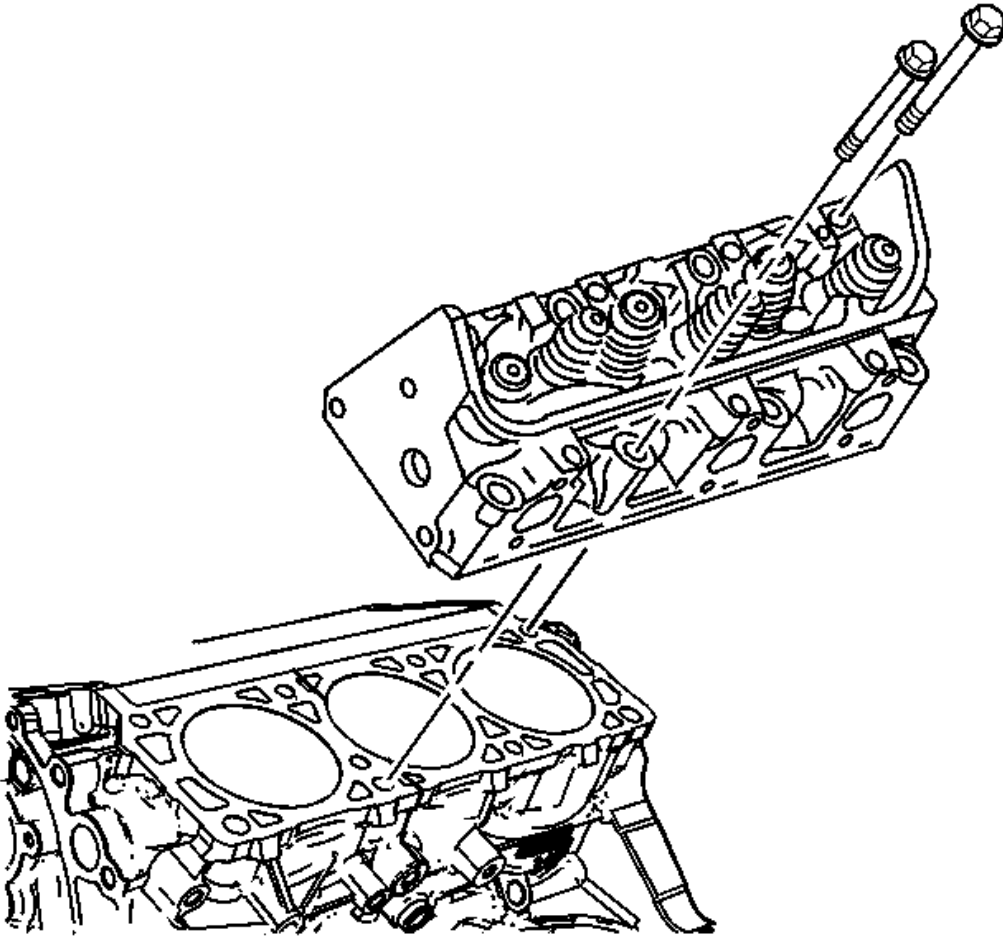


Fig. 409: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

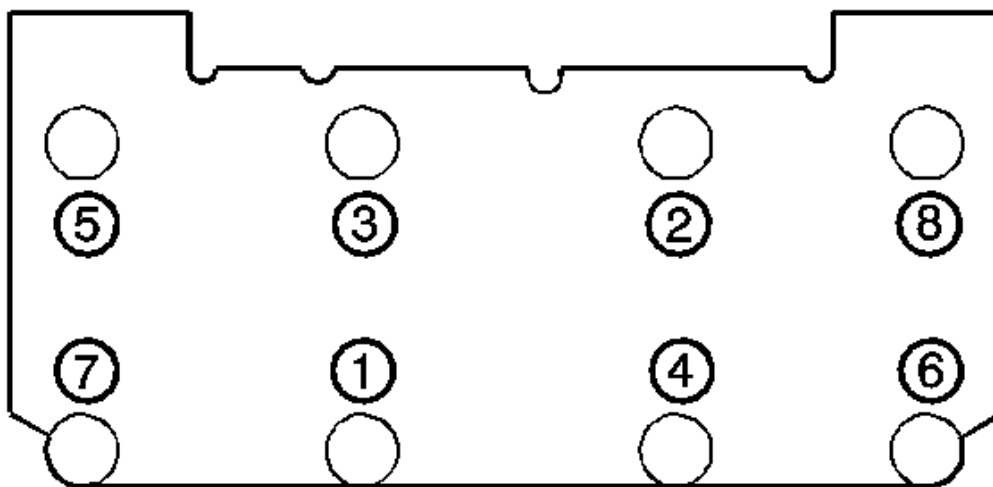


Fig. 410: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 and Equipment**.

Water Pump Installation

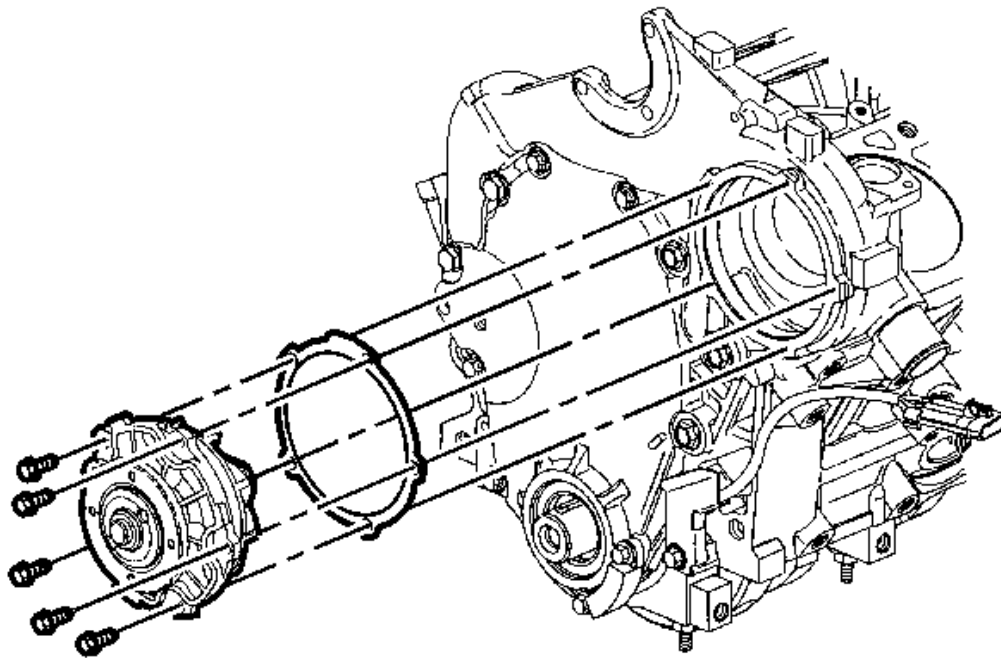


Fig. 411: View Of Water Pump Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump gasket.
2. Install the water pump.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water pump bolts.

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

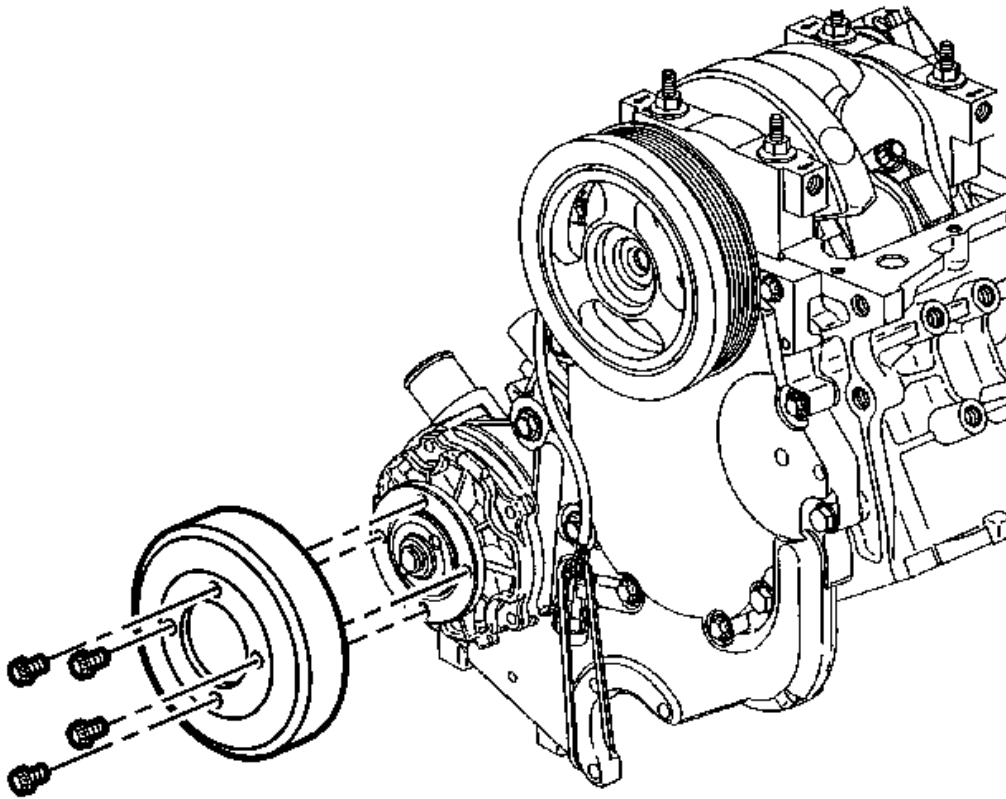


Fig. 412: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

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

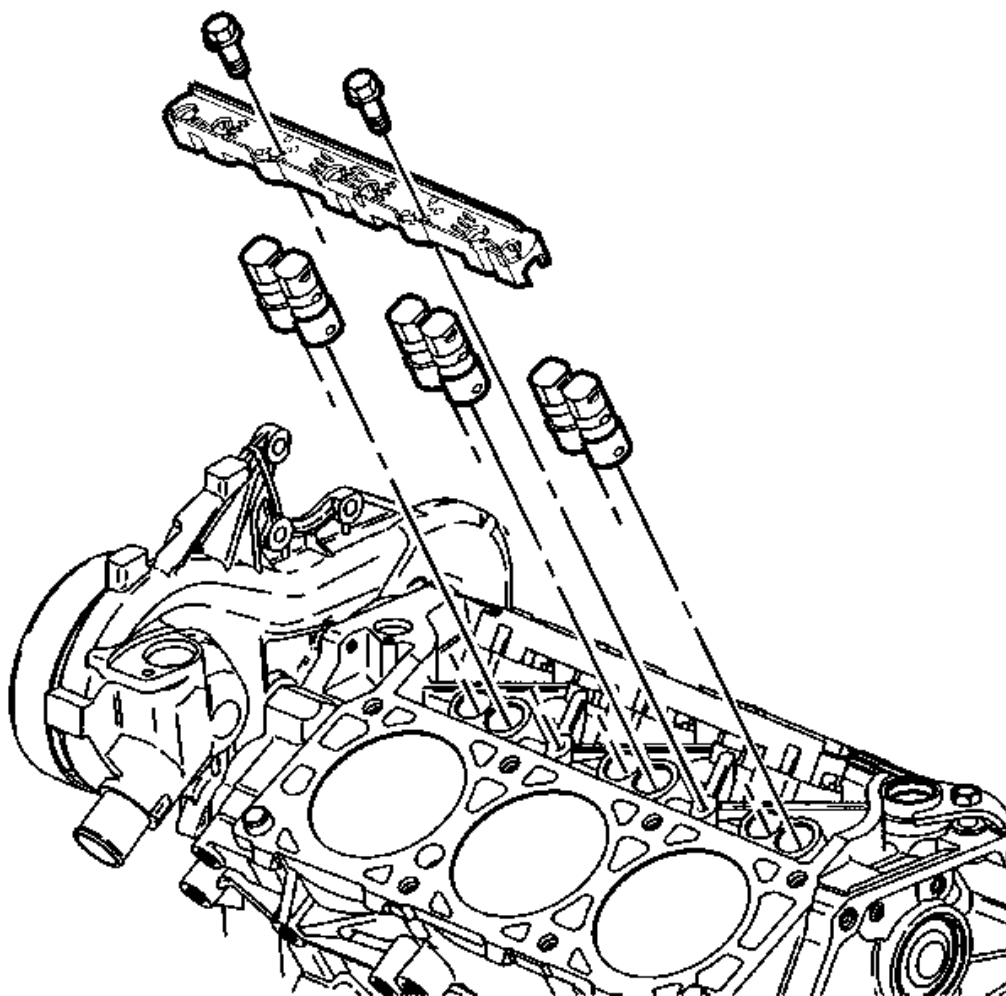


Fig. 413: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

4. Install the valve lifter guides and guide bolts.

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

Valve Rocker Arm and Push Rod Installation

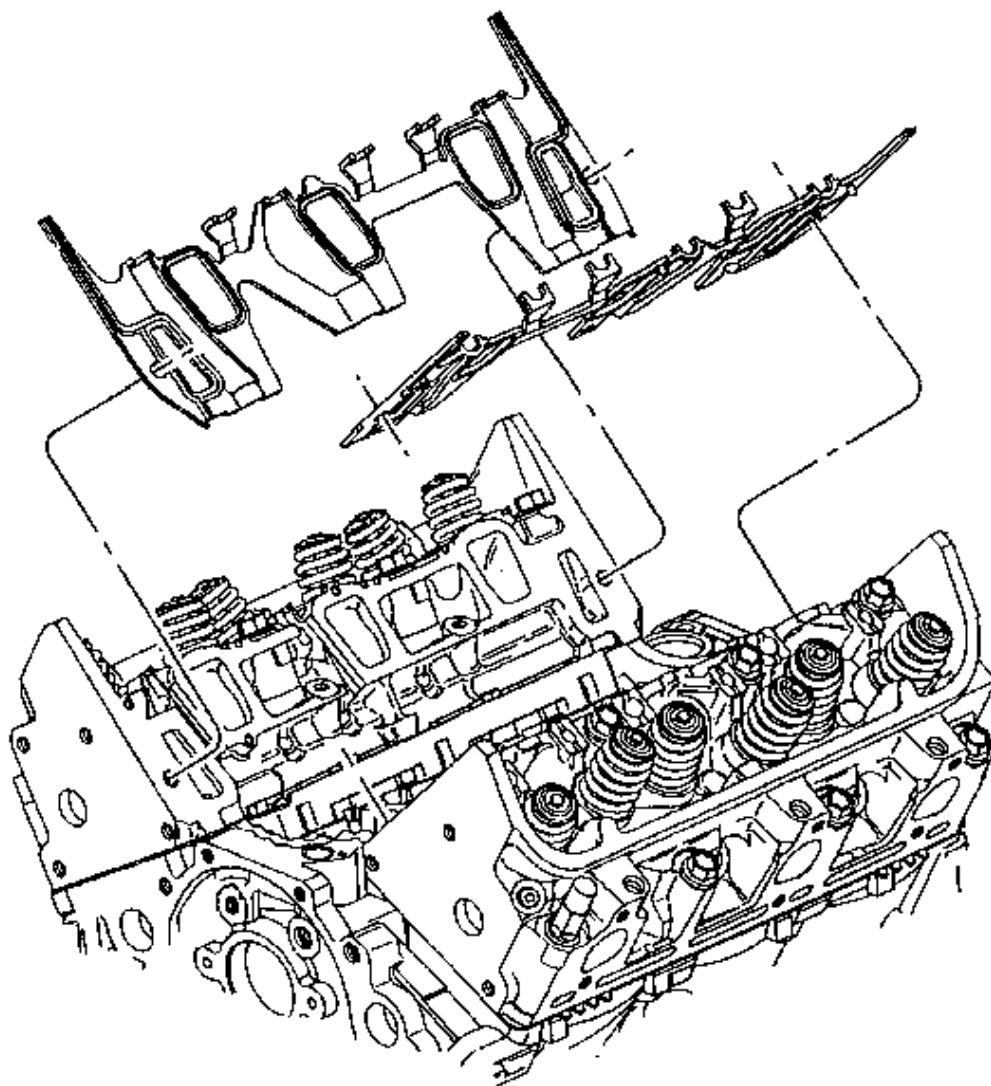


Fig. 414: Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

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.

1. Install the lower intake manifold gaskets.

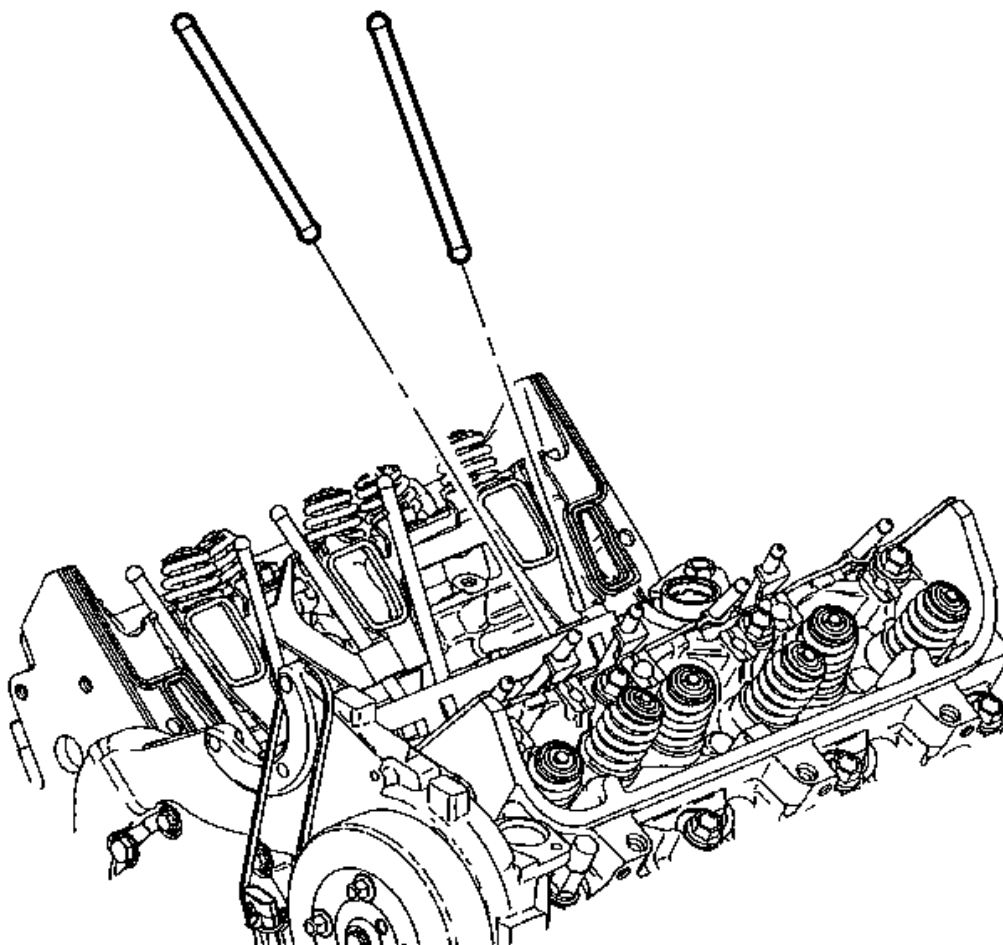


Fig. 415: Removing/Installing Push Rods
Courtesy of GENERAL MOTORS CORP.

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 146.0 mm (5.75 in) in length. The exhaust valve push rods measure 152.5 mm (6.0 in) in length.

3. Install the push rods in their original location.

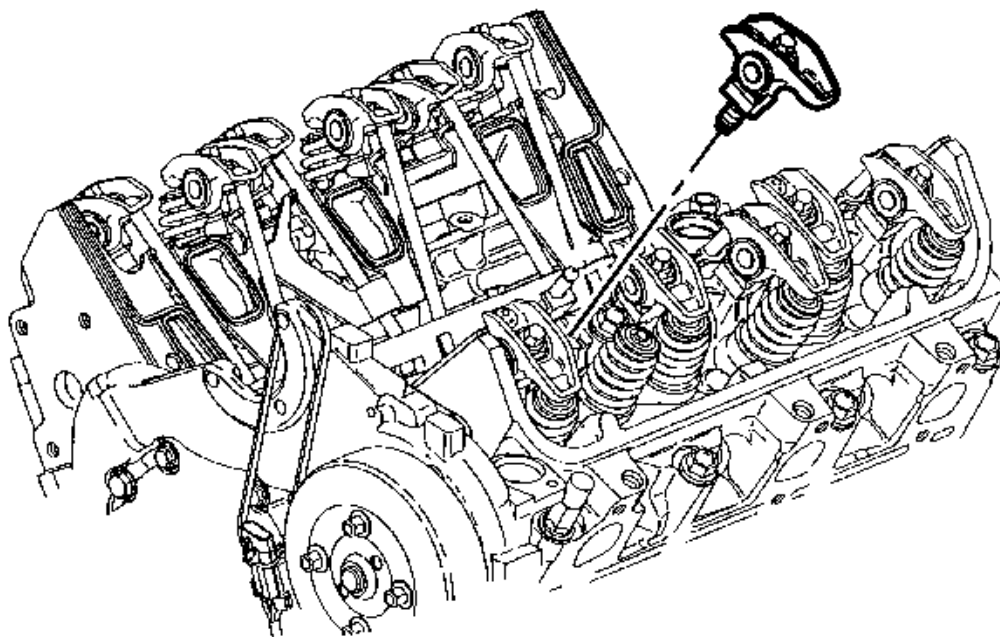


Fig. 416: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

4. Coat the rocker arm friction surfaces using prelude GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

IMPORTANT: Shims 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 in Cautions and Notices.

6. Install the valve rocker arm bolts.

Tighten: Tighten the valve rocker arm bolts to 32 N.m (24 lb ft).

Intake Manifold Installation - Lower

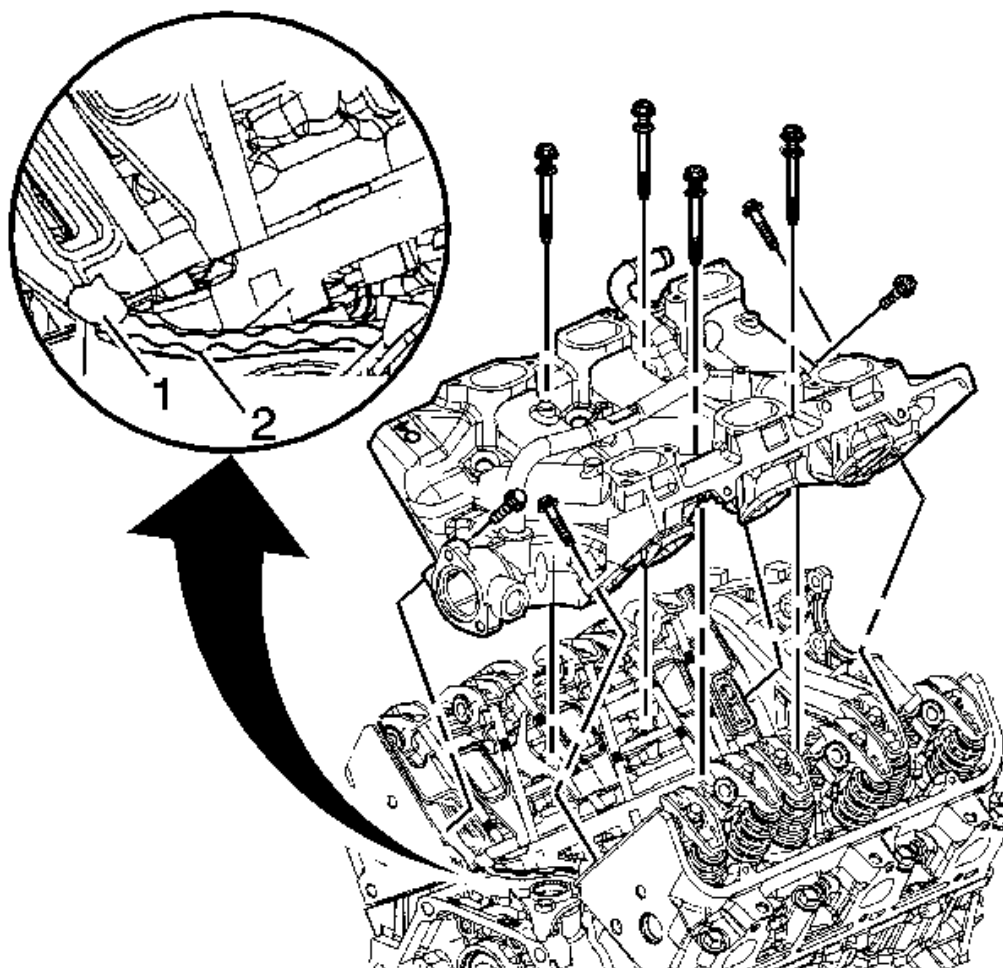


Fig. 417: Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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. Install the lower intake manifold gaskets.
2. With gaskets in place apply a small drop 8-10 mm (0.31-0.39 in) of RTV sealer GM P/N 12346141 (Canadian P/N 10953433) or equivalent to the 4 corners of the intake manifold to block joint (1).
3. Connect the 2 small drops with a bead of RTV sealer that is between 8-10 mm (0.31-0.39 in) wide and 3.0-5.0 mm (0.12-0.20 in) thick (2).
4. Install the lower intake manifold.

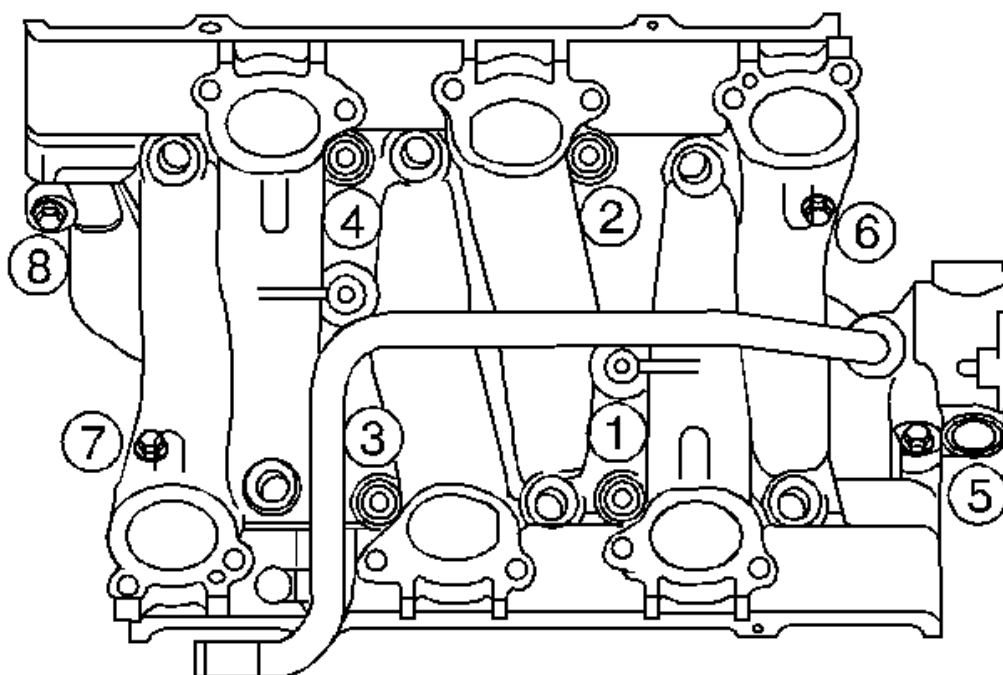


Fig. 418: Lower Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: All lower intake manifold bolts need to be cleaned, free of any foreign material, and reused only if new bolts are unavailable. Use GM P/N 12345382 (Canadian P/N 10953489) or equivalent and apply to the old intake manifold bolt threads.

IMPORTANT: Manufacturer recommends the center bolts be fully torqued before the diagonal bolts to assure proper seal ability.

IMPORTANT: Lower intake manifold bolts in location 6 and 7 should be torqued to

specification using a crows foot type tool.

5. Install the lower intake manifold bolts.

Tighten:

1. Tighten the lower intake manifold bolts (1, 2, 3, 4) in sequence to 7 N.m (62 lb in) on the first pass.
2. Tighten the lower intake manifold bolts (5, 6, 7, 8) in sequence to 13 N.m (115 lb in) on the first pass.
3. Tighten the lower intake manifold bolts (1, 2, 3, 4) in sequence to 13 N.m (115 lb in) on the final pass.
4. Tighten the lower intake manifold bolts (5, 6, 7, 8) in sequence to 25 N.m (18 lb ft) on the final pass.

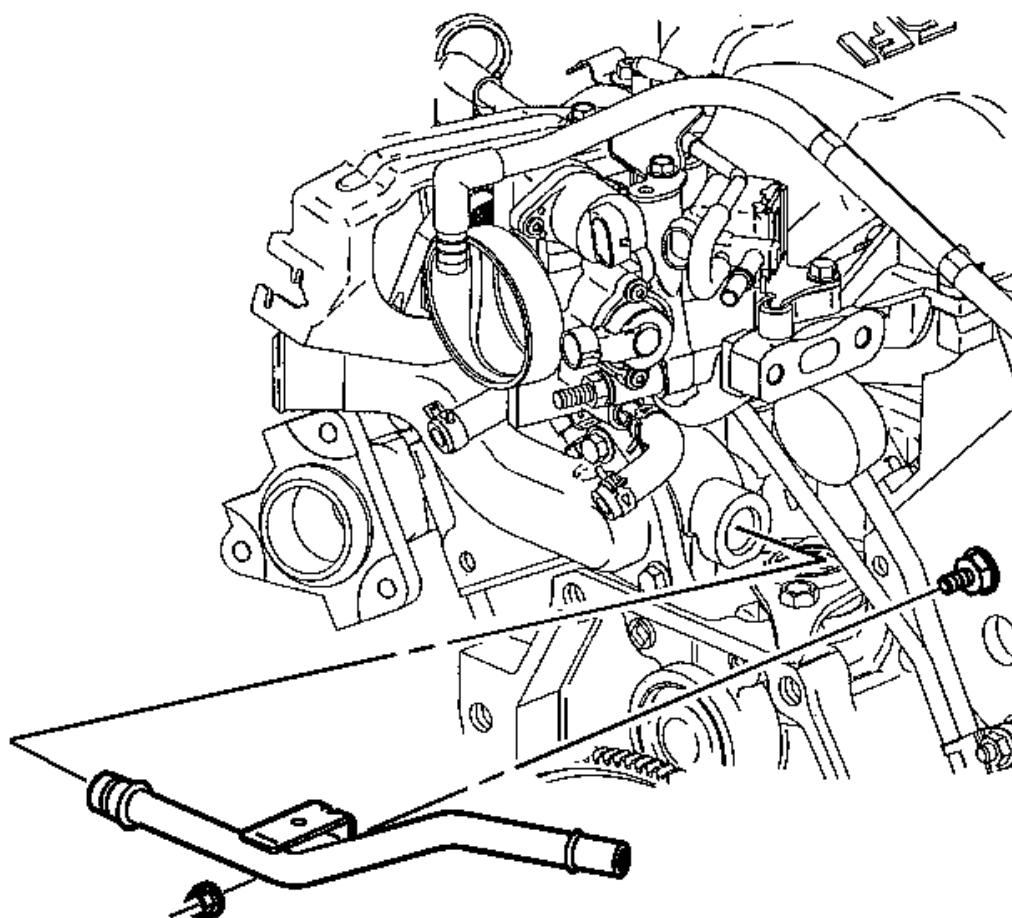


Fig. 419: View Of Heater Inlet Pipe & Nut

Courtesy of GENERAL MOTORS CORP.

6. Install the heater inlet pipe.
7. Install the heater inlet pipe nut.

Tighten: Tighten the heater inlet pipe nut to 25 N.m (18 lb ft).

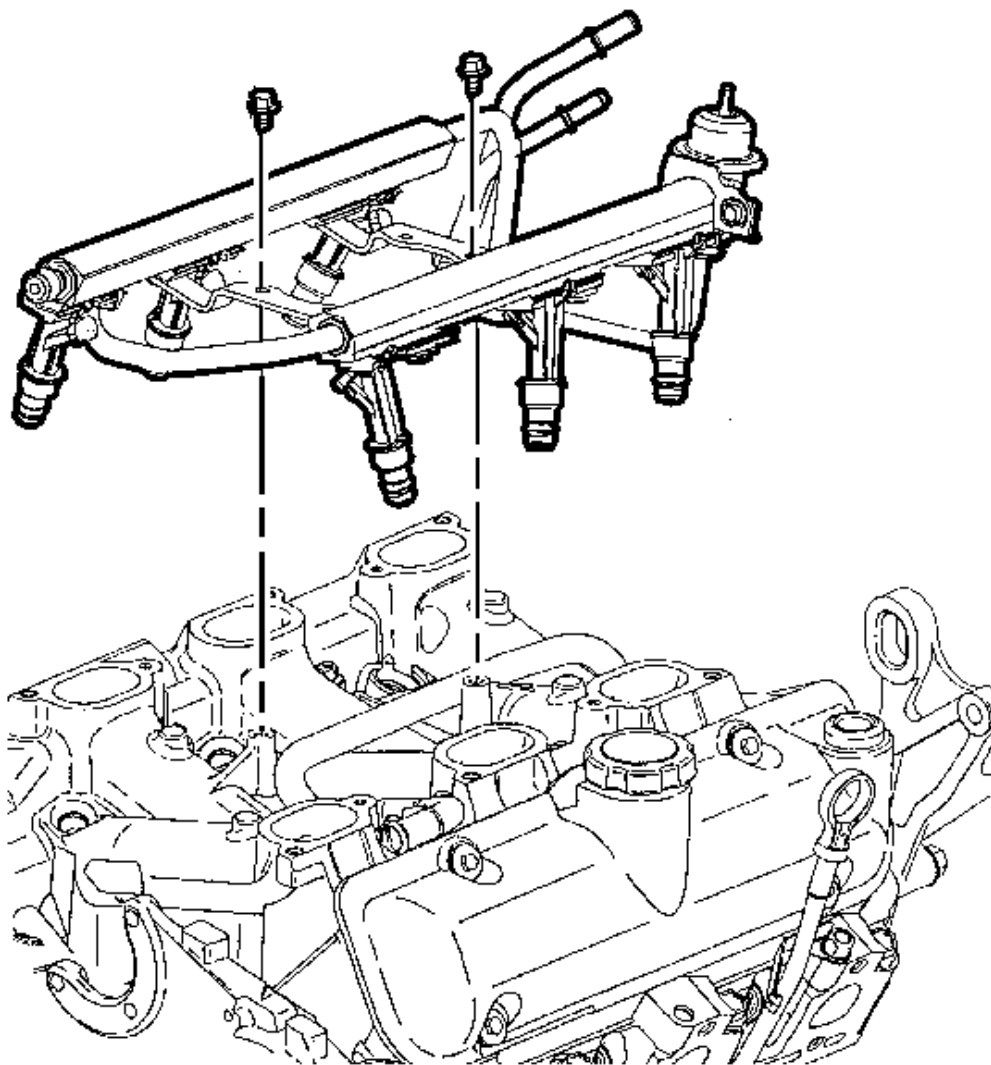


Fig. 420: View Of Fuel Injector Rail Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the fuel injector O-ring seals twice. Install NEW fuel injector O-ring seals during assembly.

IMPORTANT: Do not press on the fuel pressure regulator valve when installing the fuel injector rail assembly.

8. Install the fuel injector rail assembly.
 1. Install the fuel injector O-rings using GM P/N 12345616, (Canadian P/N 993182) or equivalent.
 2. Install the injector nozzles into the lower intake manifold injector bores.
 3. Press on the injector rail using the palms of both hands until the injectors are fully seated.
9. Install the fuel injector rail bolts.

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

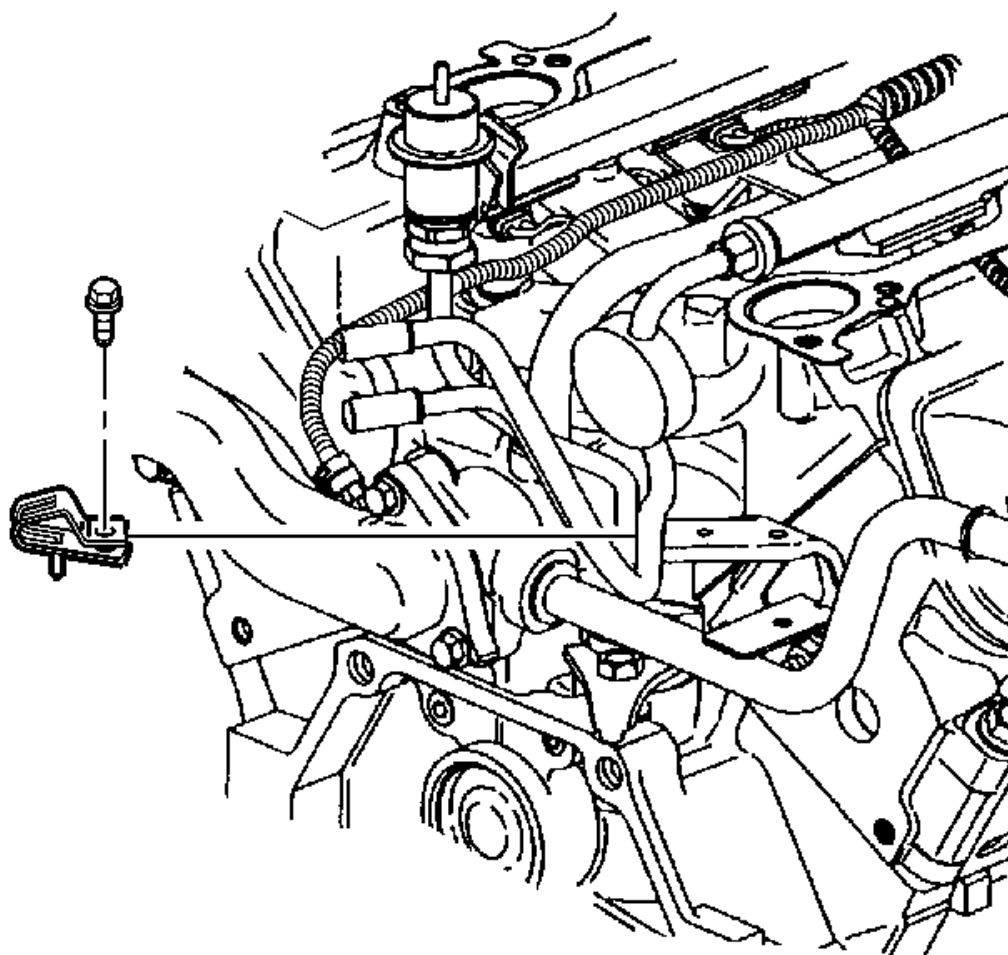


Fig. 421: Fuel Feed & Return Pipe Retaining Clip
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the fuel injector O-ring seals twice. Install NEW fuel injector O-ring seals during assembly.

10. Install the fuel feed and return pipe retaining clip.
11. Install the fuel feed and return pipe retaining clip bolt.

Tighten: Tighten the fuel feed and return pipe retaining clip bolt to 8 N.m (71 lb in).

Intake Manifold Installation - Upper

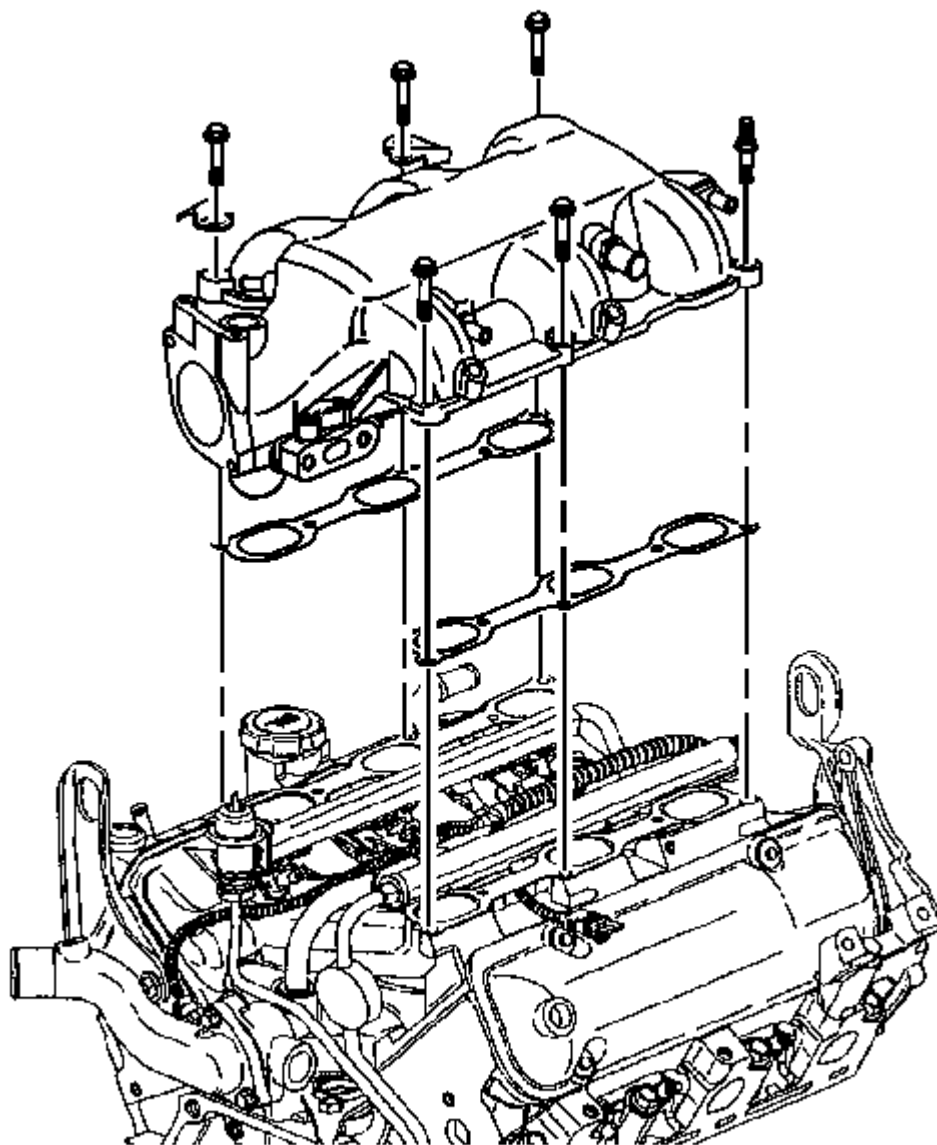


Fig. 422: View Of Upper Intake Manifold & Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the upper intake manifold gaskets.
2. Install the upper intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the upper intake manifold bolts and studs. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads.

Tighten: Tighten the upper intake manifold bolts and studs to 25 N.m (18 lb ft).

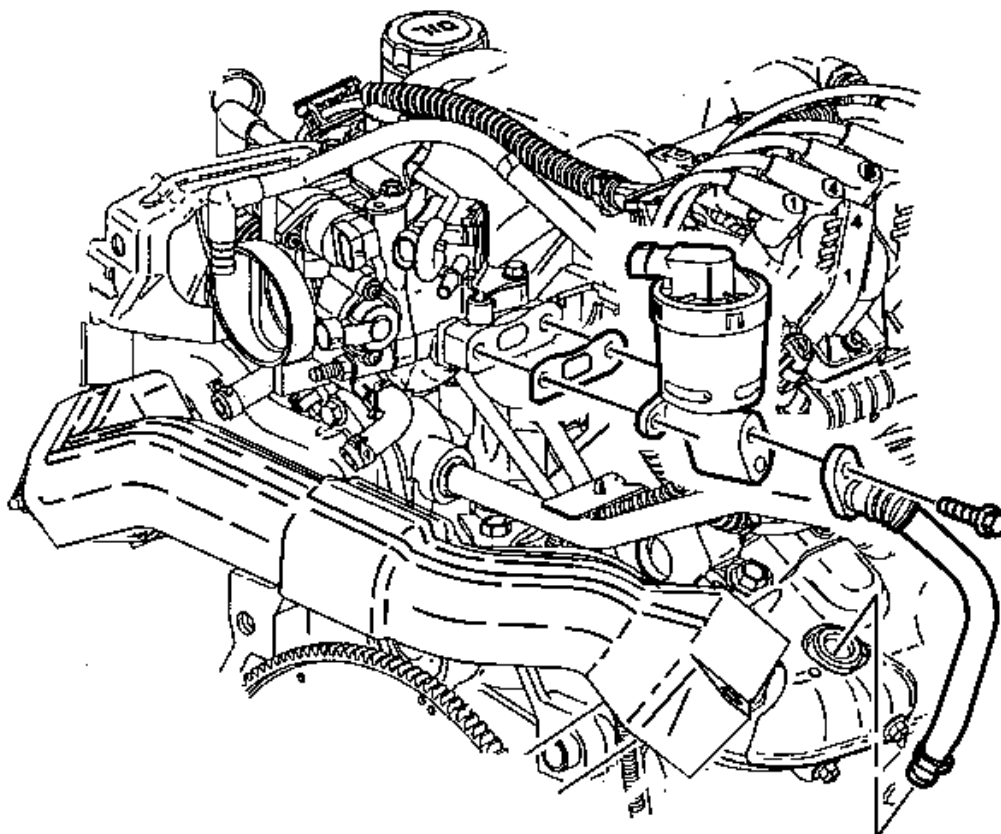


Fig. 423: EGR Valve Pipe & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust gas recirculation (EGR) valve pipe and bolt to the EGR.

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

5. Install the EGR valve.
6. Install the EGR valve bolts.

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

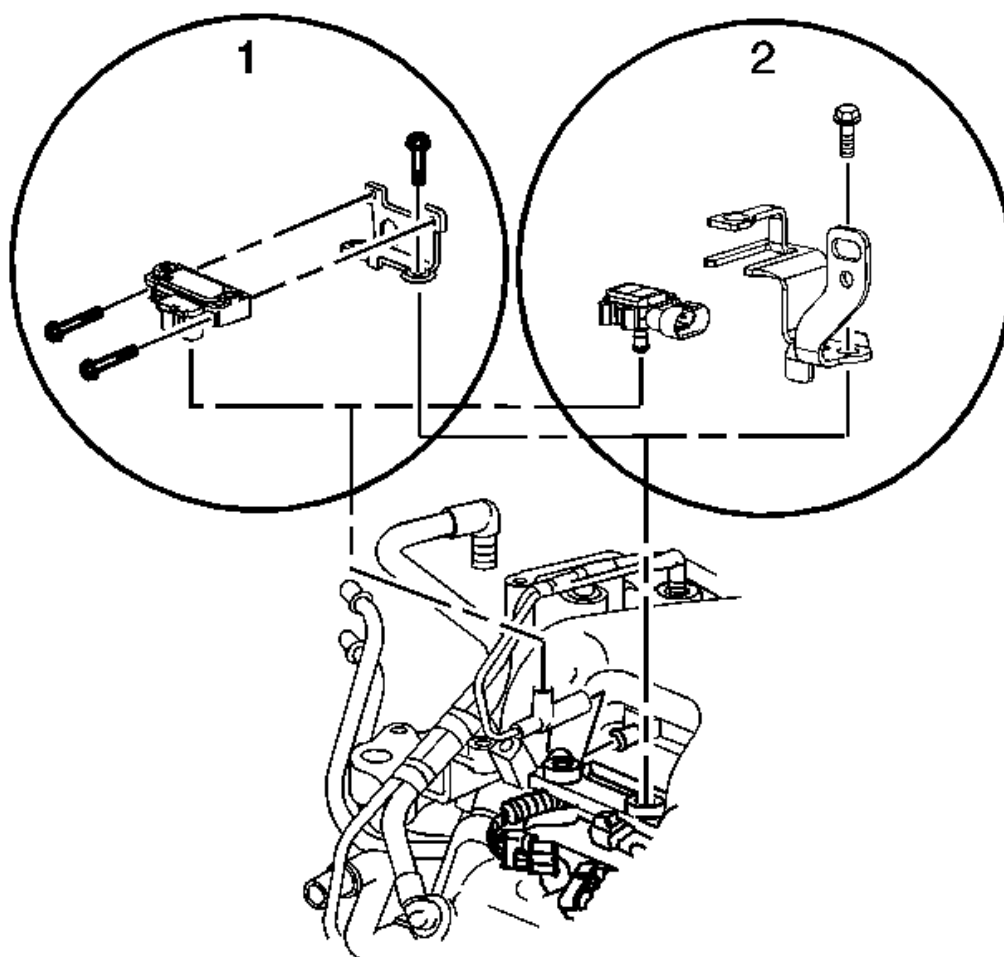


Fig. 424: View Of MAP Sensor & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the manifold absolute pressure (MAP) sensor bracket and bolt.

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

8. Install the MAP sensor (1, 2).
9. Install the MAP sensor bolts (1).

Tighten: Tighten the MAP sensor bolts to 5 N.m (44 lb in).

10. Install the MAP sensor electrical connector.

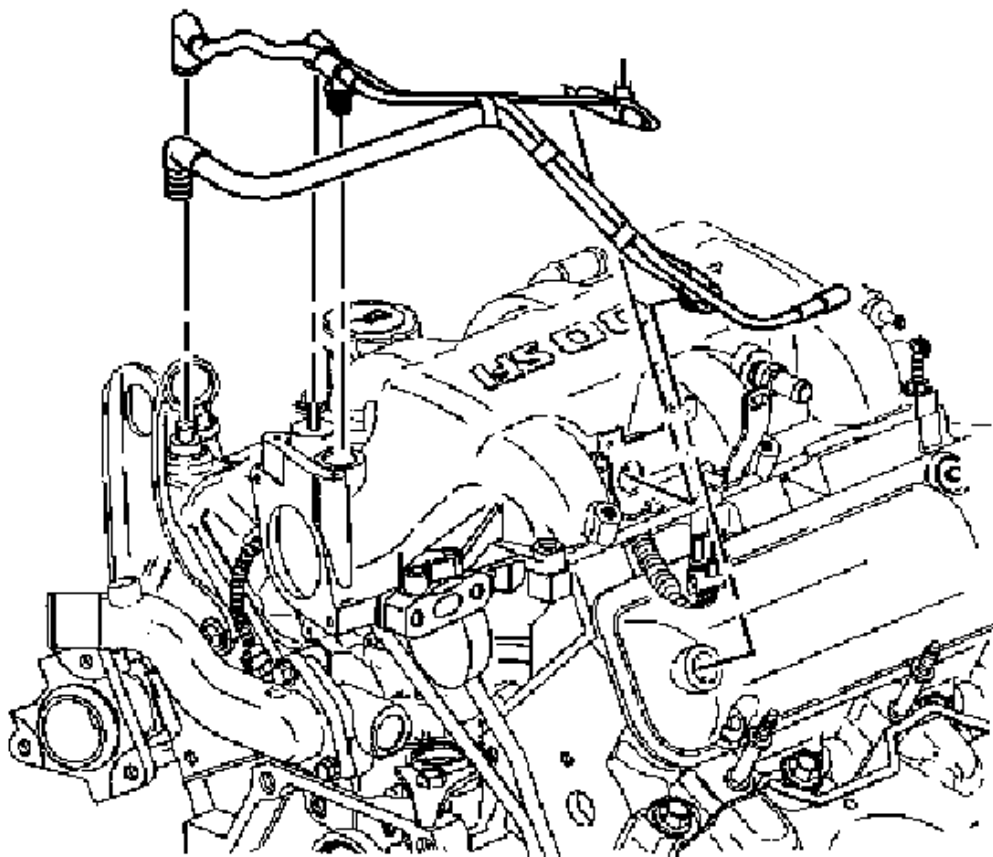


Fig. 425: Vacuum Lines At Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

11. Install the vacuum lines to the upper intake manifold.
12. Install the throttle cable bracket.
13. Install the throttle cable bracket bolts.

Tighten: Tighten the throttle cable bracket bolts to 13 N.m (115 lb in).

Valve Rocker Arm Cover Installation - Left

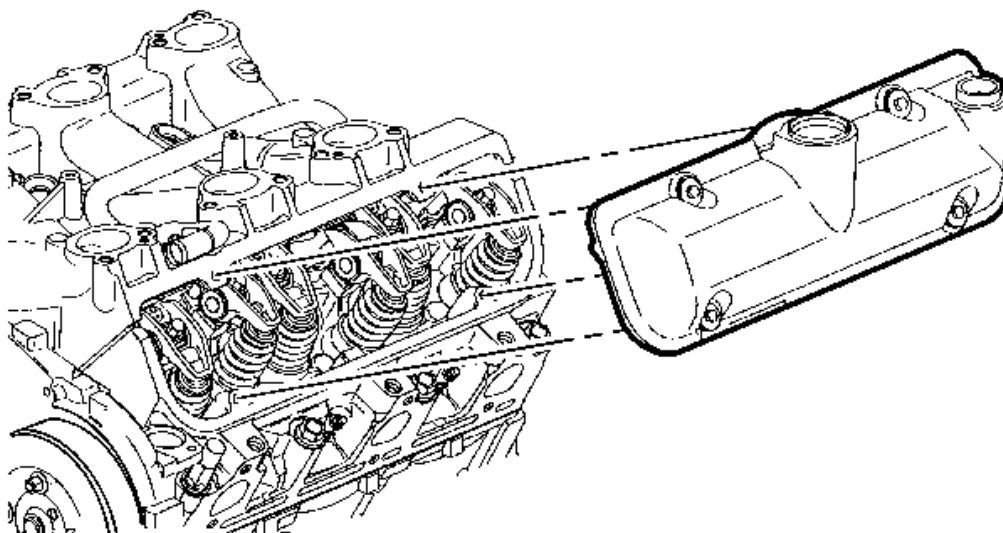


Fig. 426: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

1. Install the valve rocker arm cover gasket into the valve rocker arm cover.
2. Apply sealer GM P/N 12346141, (Canadian P/N 10953433) or the equivalent to the notches where the cylinder head and intake manifold meet.
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

Valve Rocker Arm Cover Installation - Right

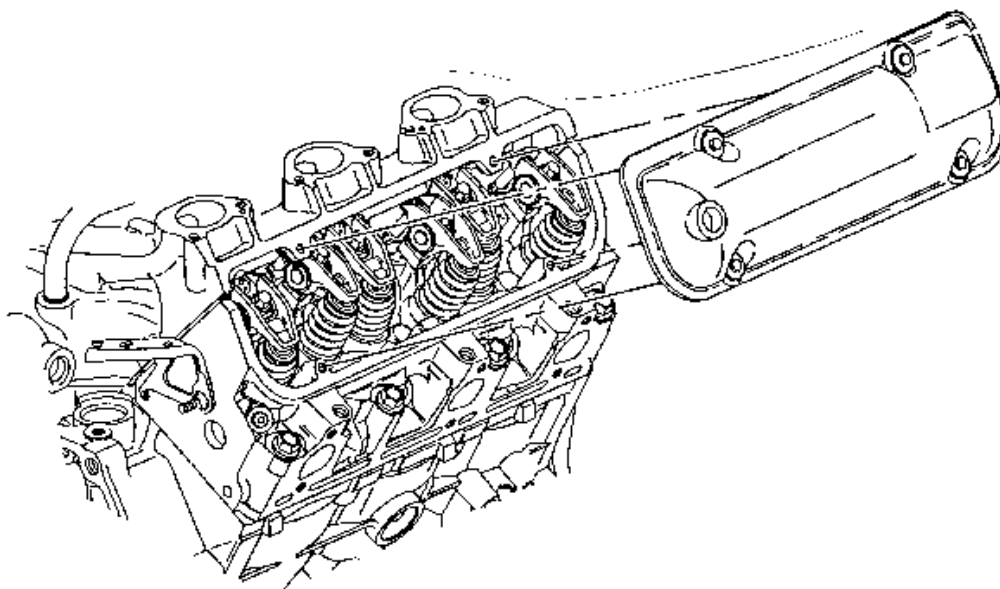


Fig. 427: View Of Valve Rocker Arm Cover - Right
Courtesy of GENERAL MOTORS CORP.

1. Install the valve rocker arm cover gasket into the valve rocker arm cover.
2. Apply sealer GM P/N 12346141, (Canadian P/N 10953433) or the equivalent to the notches where the cylinder head and intake manifold meet.
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

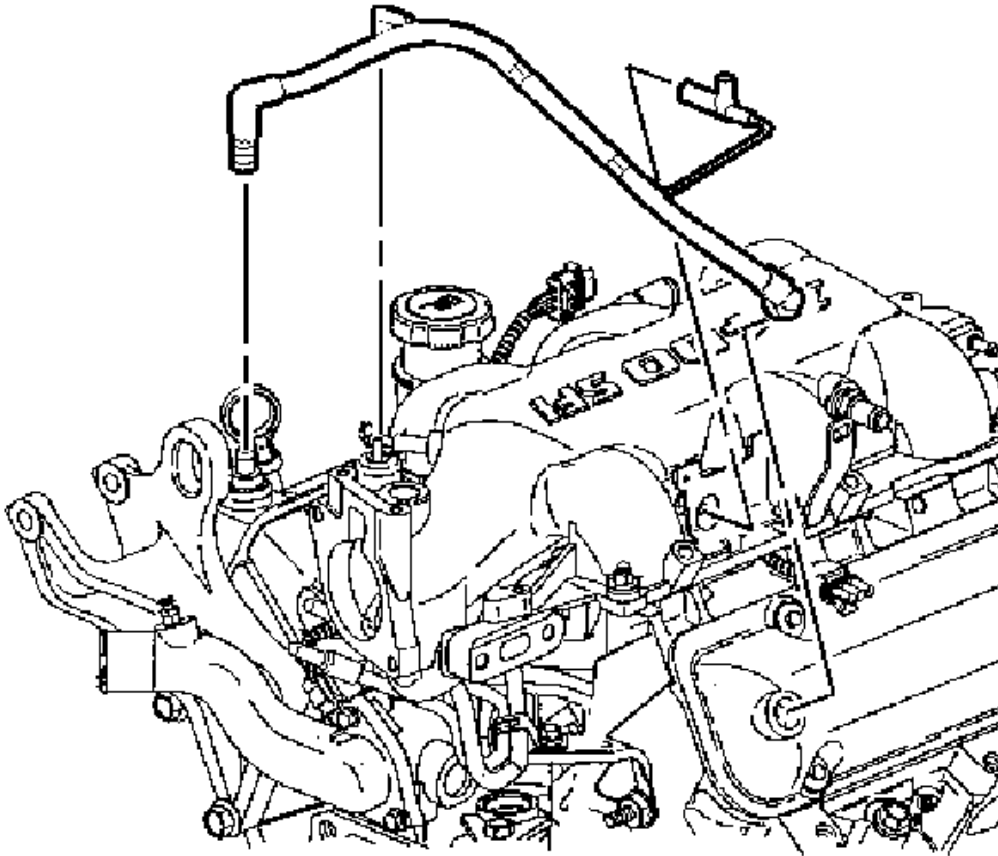


Fig. 428: Vacuum Harness Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the vacuum lines from the upper intake manifold.

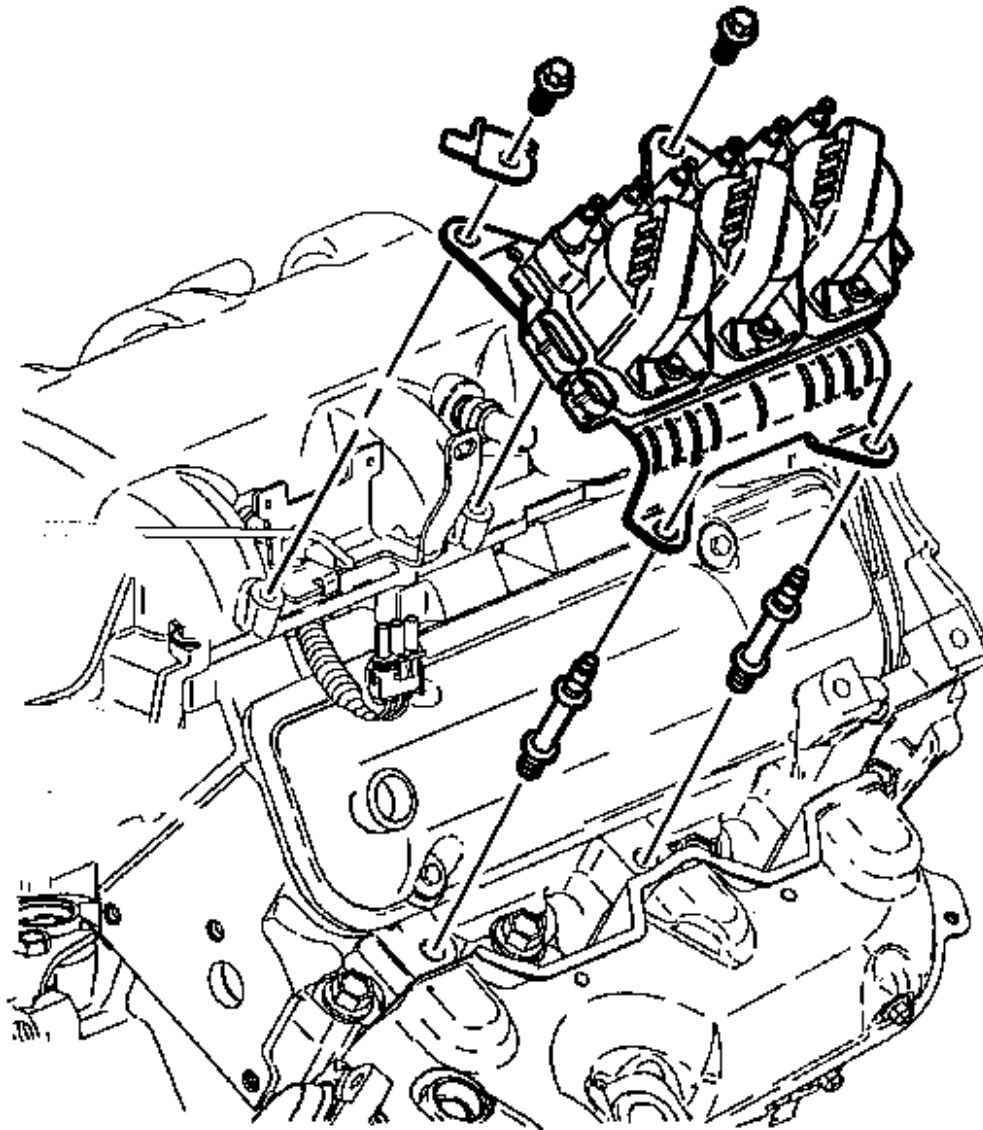


Fig. 429: Electric Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

6. Install the ignition coil studs.

Tighten: Tighten the ignition coil studs to 25 N.m (18 lb ft).

7. Install the electronic ignition control module.

8. Install the electronic ignition control module nuts and bolts.

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

Water Outlet and Thermostat Installation

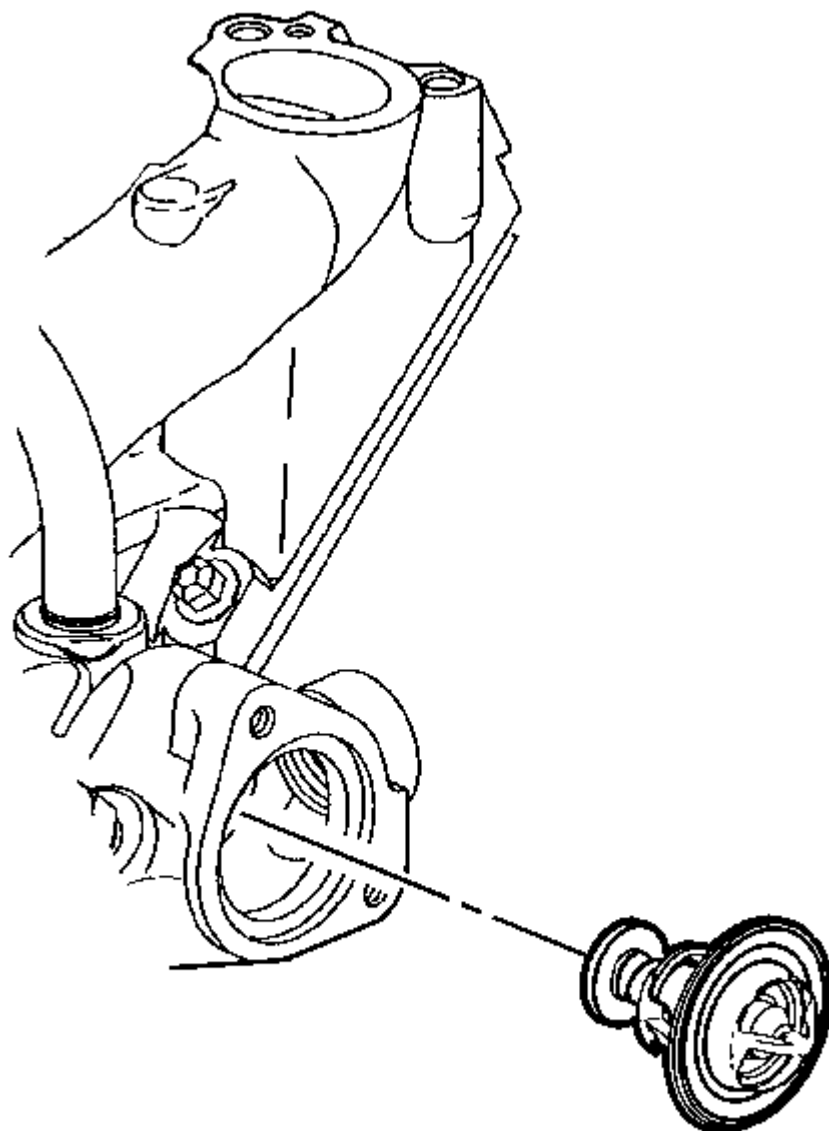


Fig. 430: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat.

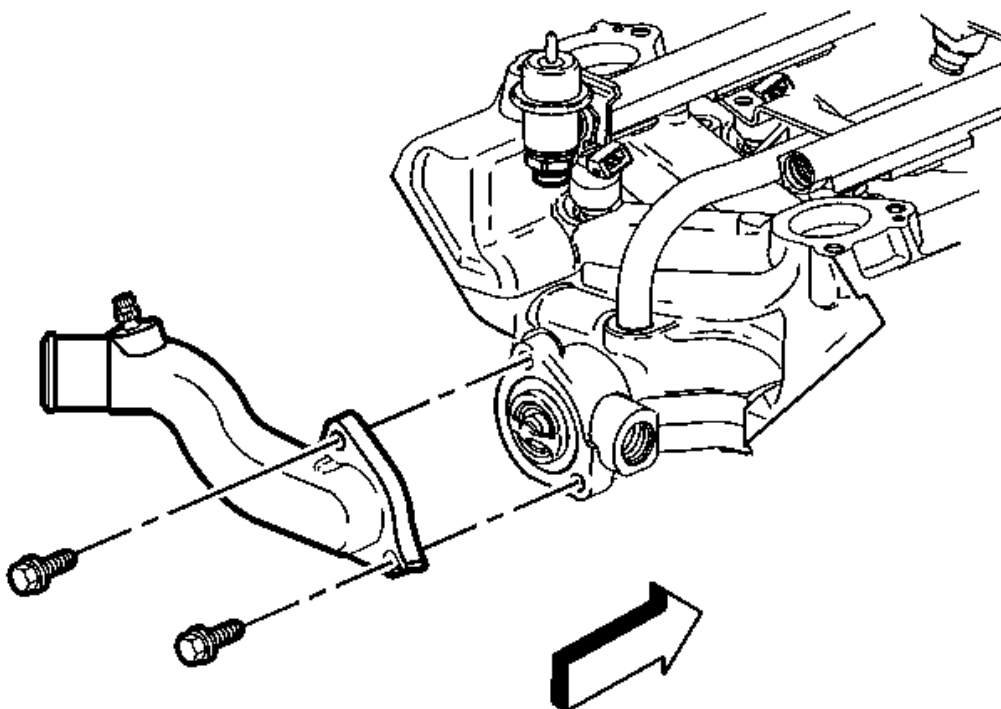


Fig. 431: Removing Water Outlet
Courtesy of GENERAL MOTORS CORP.

2. Install the water outlet.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water outlet bolts.

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

Exhaust Manifold Installation - Left

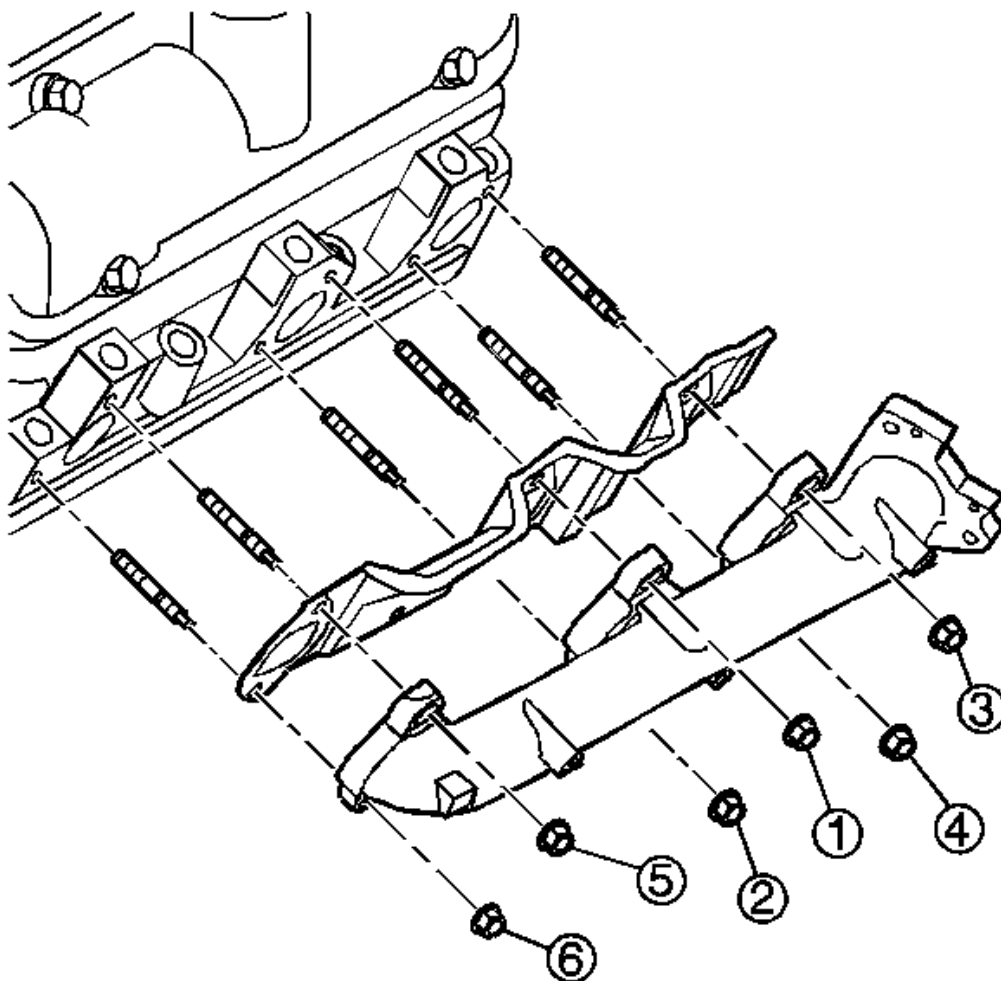


Fig. 432: Left Exhaust Manifold Nut Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs.

Tighten: Tighten the exhaust manifold studs to 18 N.m (13 lb ft).

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold.
4. Install the exhaust manifold nuts in sequence.

Tighten: Tighten the exhaust manifold nuts in sequence to 16 N.m (12 lb ft).

5. Install the left side spark plugs.

Tighten:

- Tighten the spark plugs to 27 N.m (20 lb ft) when installing spark plugs into a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when re-installing after initial installation.

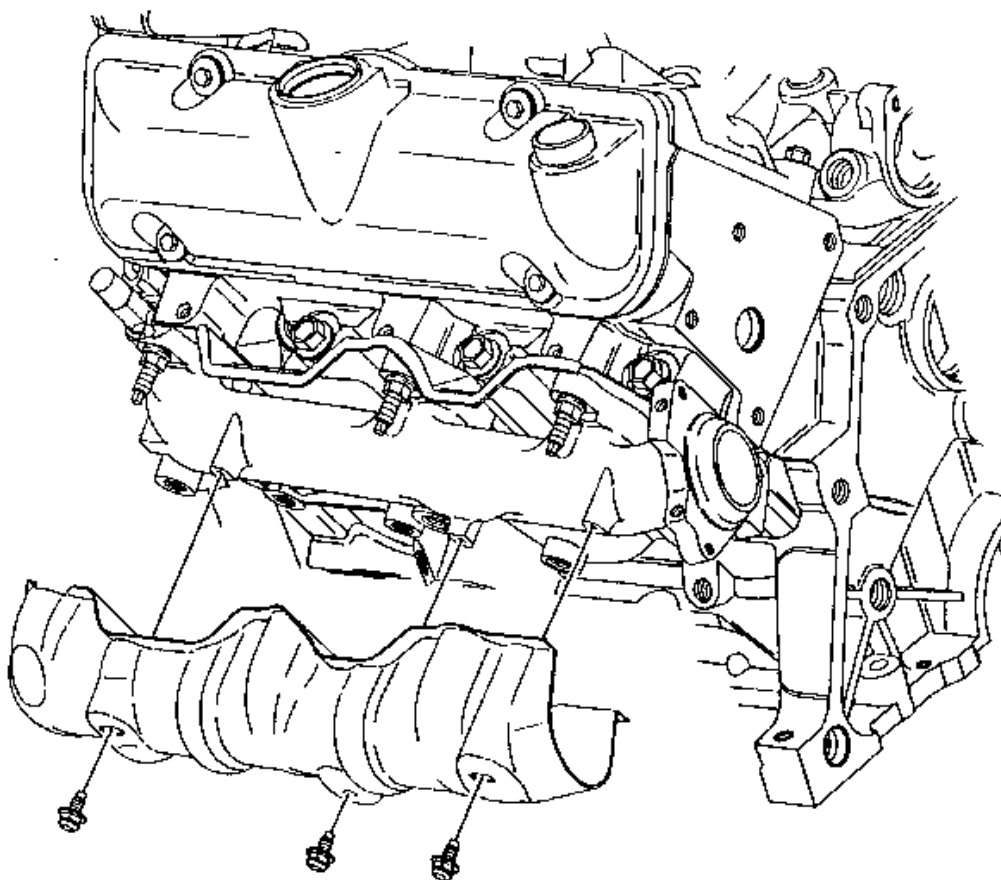


Fig. 433: View Of Exhaust Manifold Heat Shield & Bolts - Left
Courtesy of GENERAL MOTORS CORP.

6. Install the exhaust manifold heat shield.
7. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

Exhaust Manifold Installation - Right

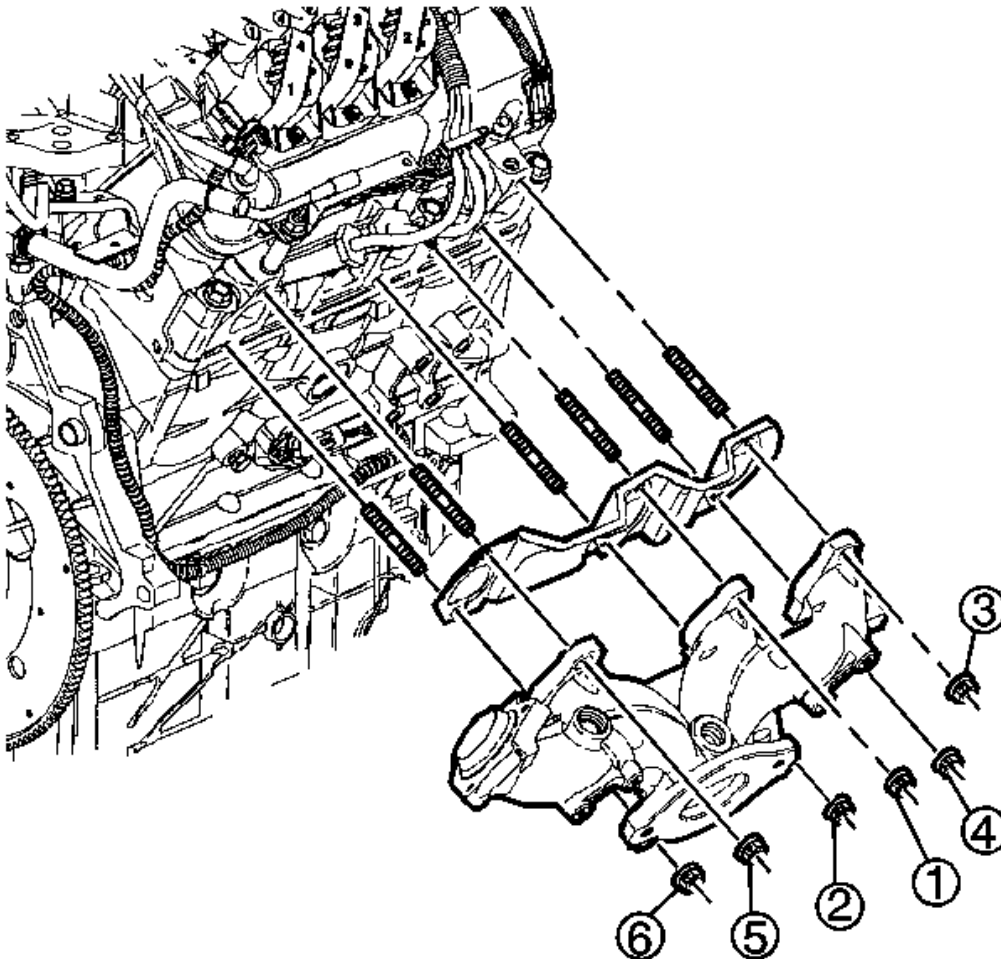


Fig. 434: Right Exhaust Manifold Nut Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs.

Tighten: Tighten the exhaust manifold studs to 18 N.m (13 lb ft).

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold.

4. Install the exhaust manifold nuts in sequence.

Tighten: Tighten the exhaust manifold nuts in sequence to 16 N.m (12 lb ft).

5. Install the right side spark plugs.

Tighten:

- Tighten the spark plugs to 27 N.m (20 lb ft) when installing spark plugs into a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when re-installing after initial installation.

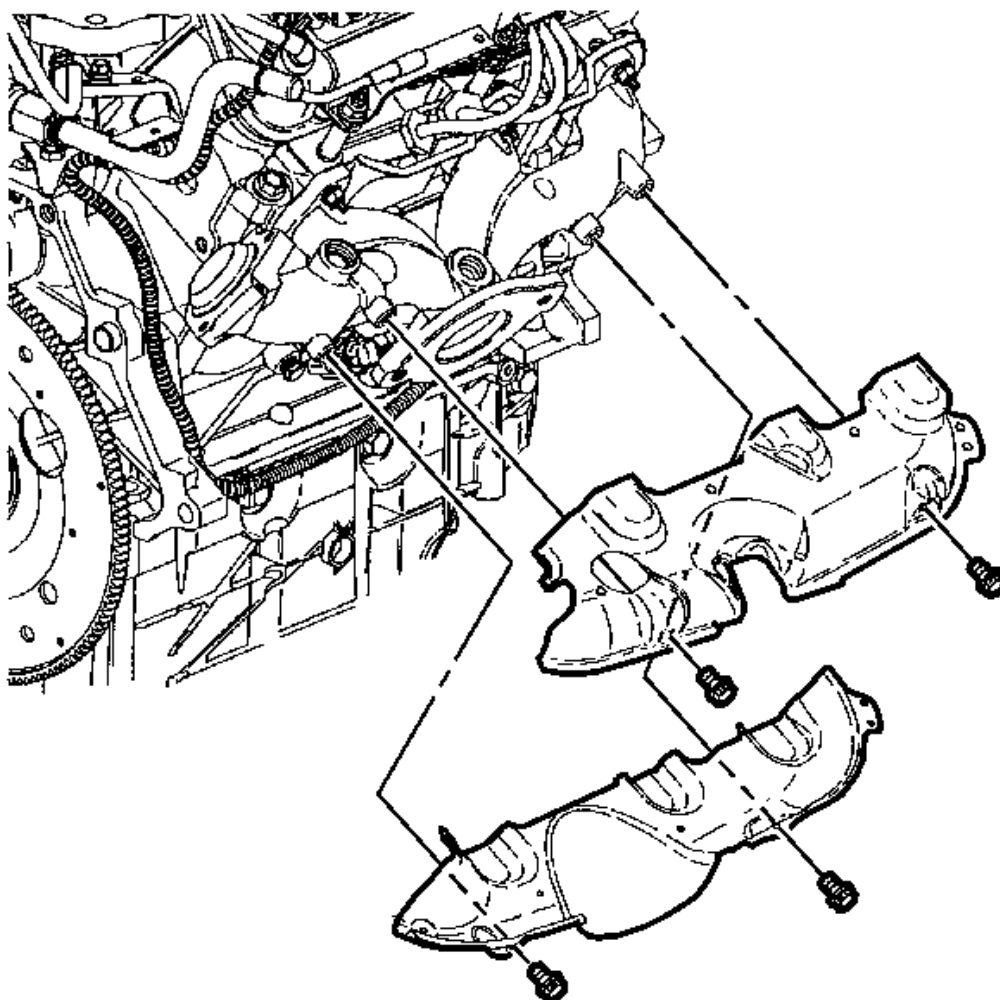


Fig. 435: View Of Right Exhaust Manifold Heat Shields & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the lower exhaust manifold heat shield.
7. Install the upper exhaust manifold heat shield.
8. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

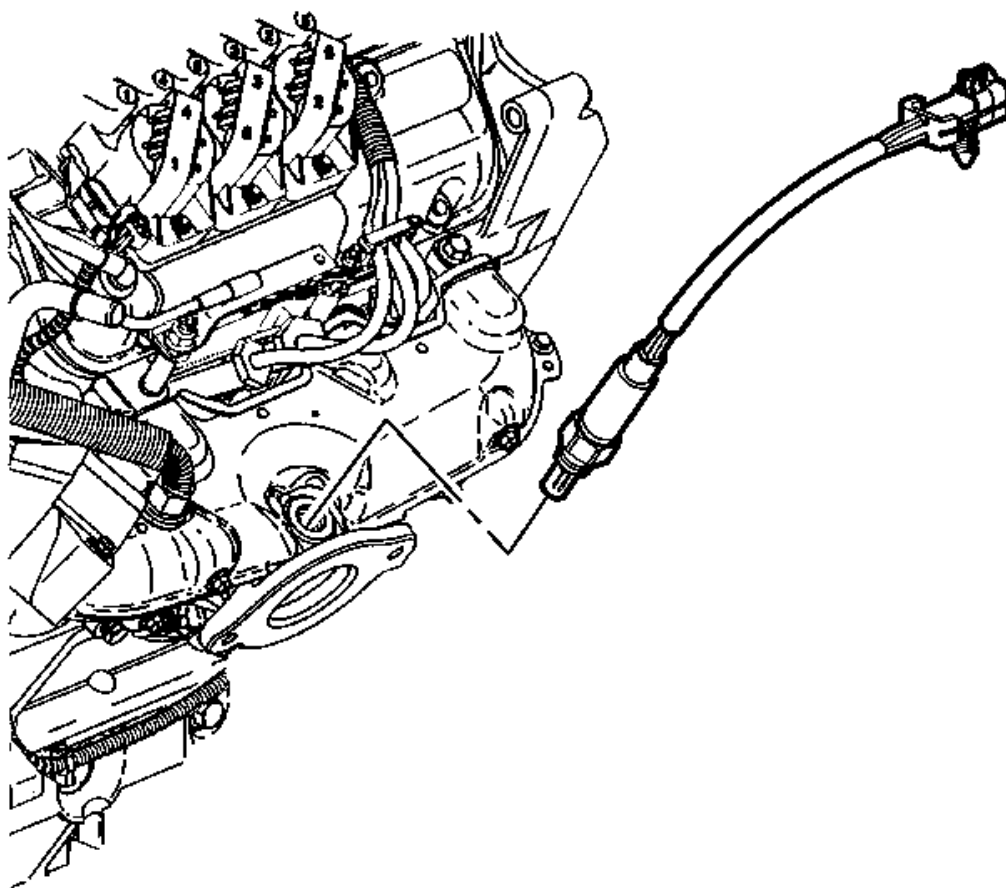


Fig. 436: Identifying Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

9. Coat the threads of the heated oxygen sensor with anti-seize compound.
10. Install the heated oxygen sensor.

Tighten: Tighten the heated oxygen sensor to 42 N.m (31 lb ft).

11. Install the EGR pipe to the exhaust manifold.

Tighten: Tighten the EGR pipe nut to 25 N.m (18 lb ft).

12. Install the spark plug wires.

Oil Filter Adapter Installation

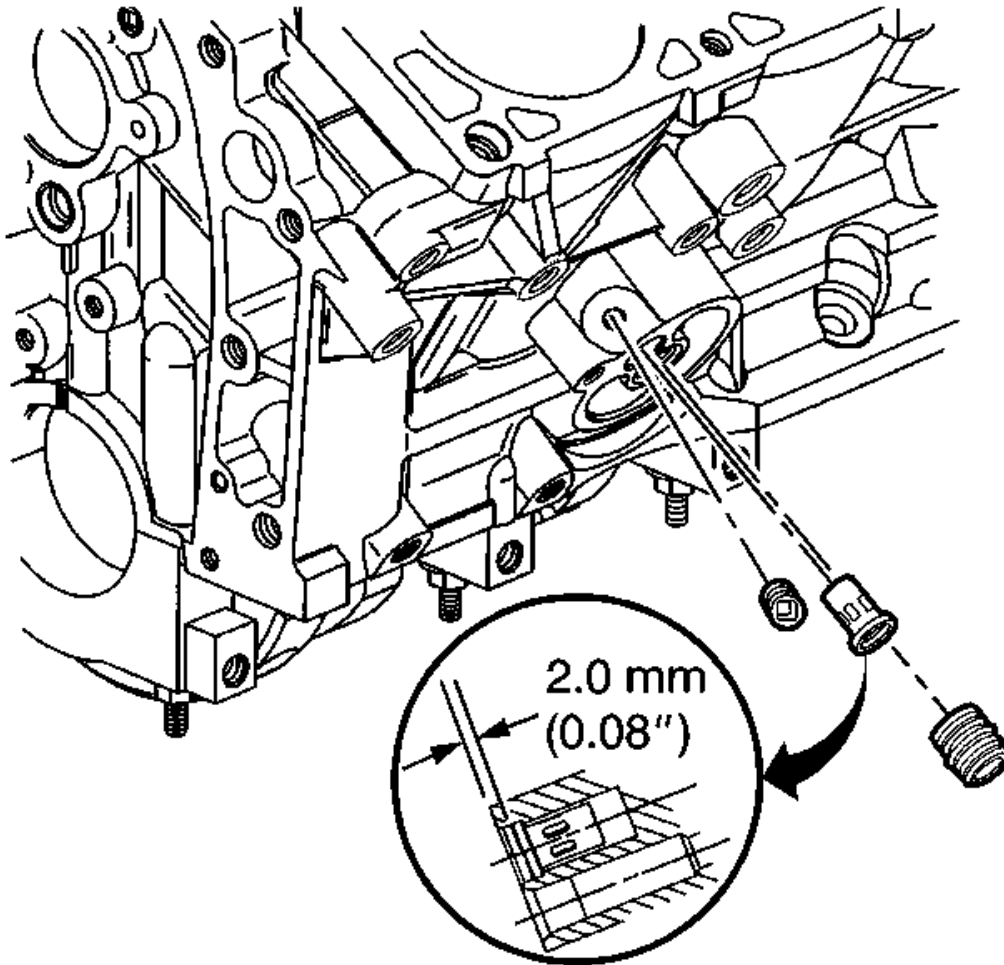


Fig. 437: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil filter bypass valve.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter fitting, if necessary.

Tighten: Tighten the oil filter fitting to 39 N.m (29 lb ft).

3. Install the oil filter bypass valve plug. Apply sealer GM P/N 12345739 (Canadian P/N 10953541) or the equivalent to the threads.

Tighten: Tighten the oil filter bypass valve plug to 19 N.m (14 lb ft).

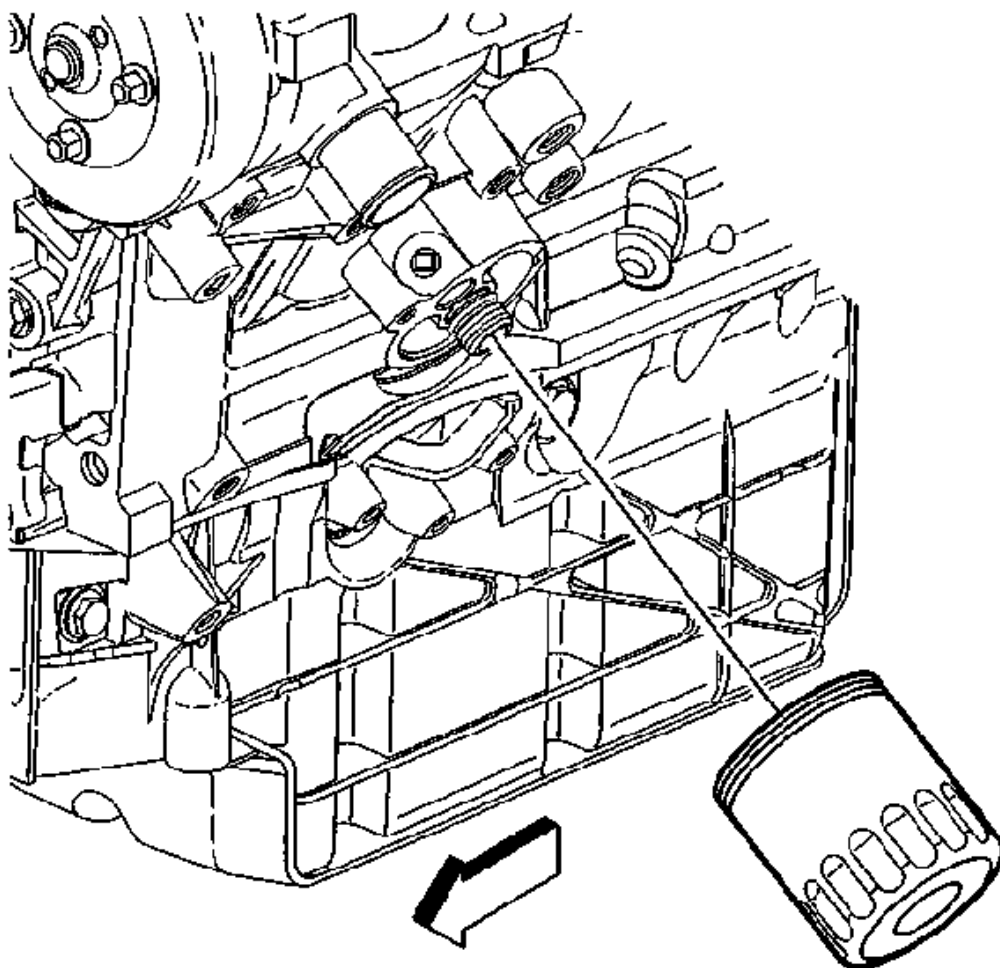


Fig. 438: Removing/Installing Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Install the oil filter.

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

Oil Level Indicator and Tube Installation

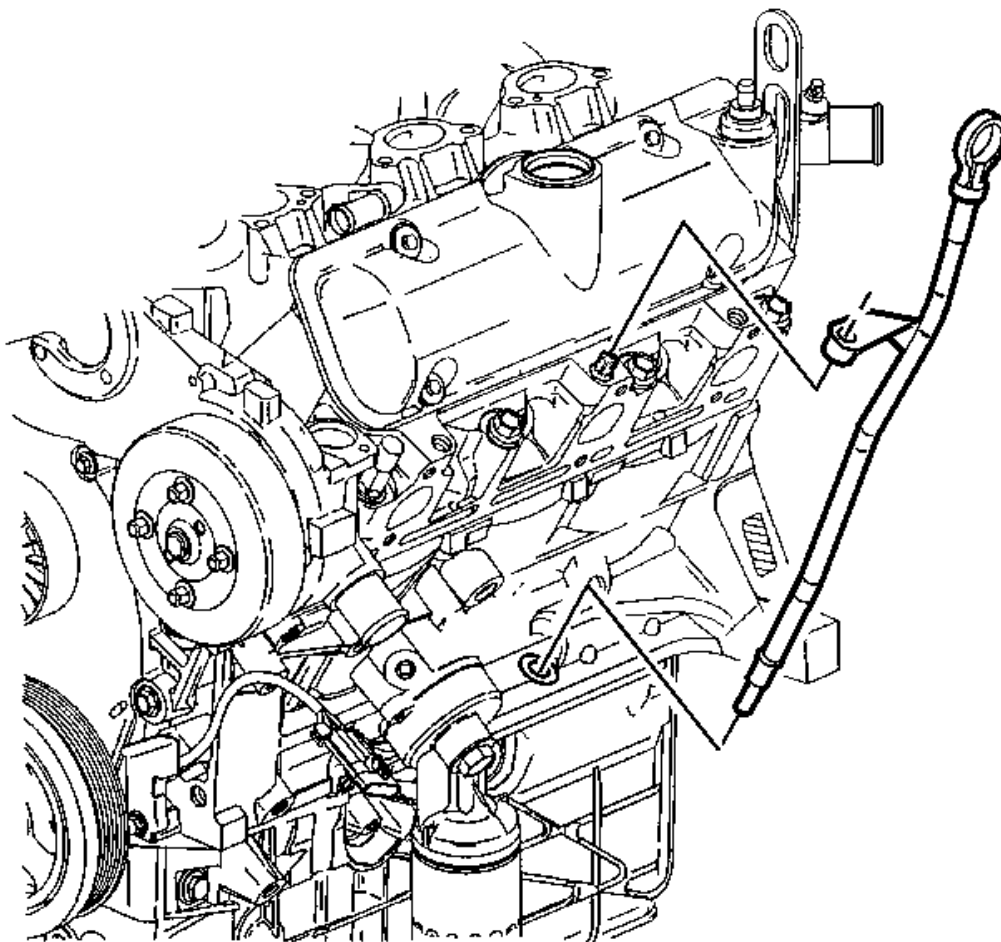


Fig. 439: Removing/Installing Oil Level Indicator & Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator and oil level indicator tube.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil level indicator tube bolt.

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

3. Install the thermostat bypass pipe (3).

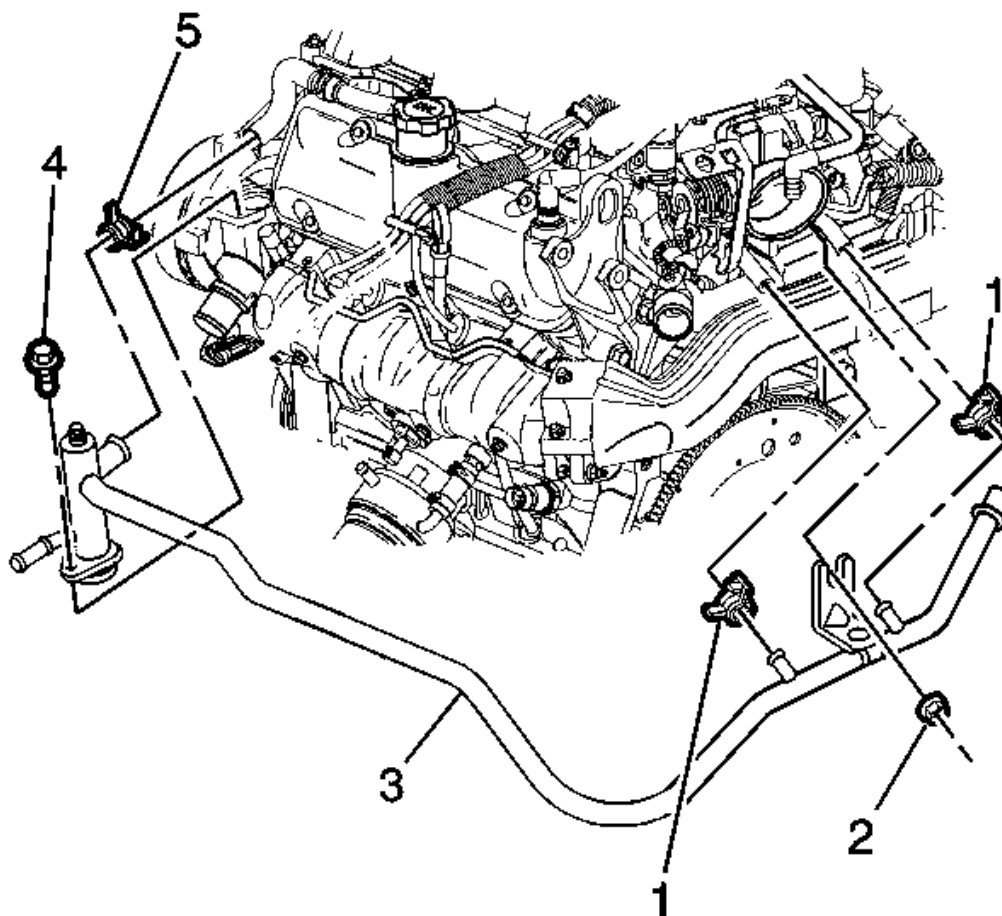


Fig. 440: Thermostat Bypass Pipe & Components
Courtesy of GENERAL MOTORS CORP.

4. Install the thermostat bypass pipe (3) and hose clamp (5).
5. Install the thermostat bypass pipe to engine front cover bolt (4).

Tighten: Tighten the thermostat bypass pipe to engine front cover bolt to 11 N.m (98 lb in).

6. Install the thermostat bypass pipe (3) to throttle body hose clamps (1).
7. Install the thermostat bypass pipe to throttle body nut (2).

Tighten: Tighten the thermostat bypass pipe to throttle body nut to 25 N.m (18 lb ft).

Engine Lift Bracket and Generator Bracket Installation

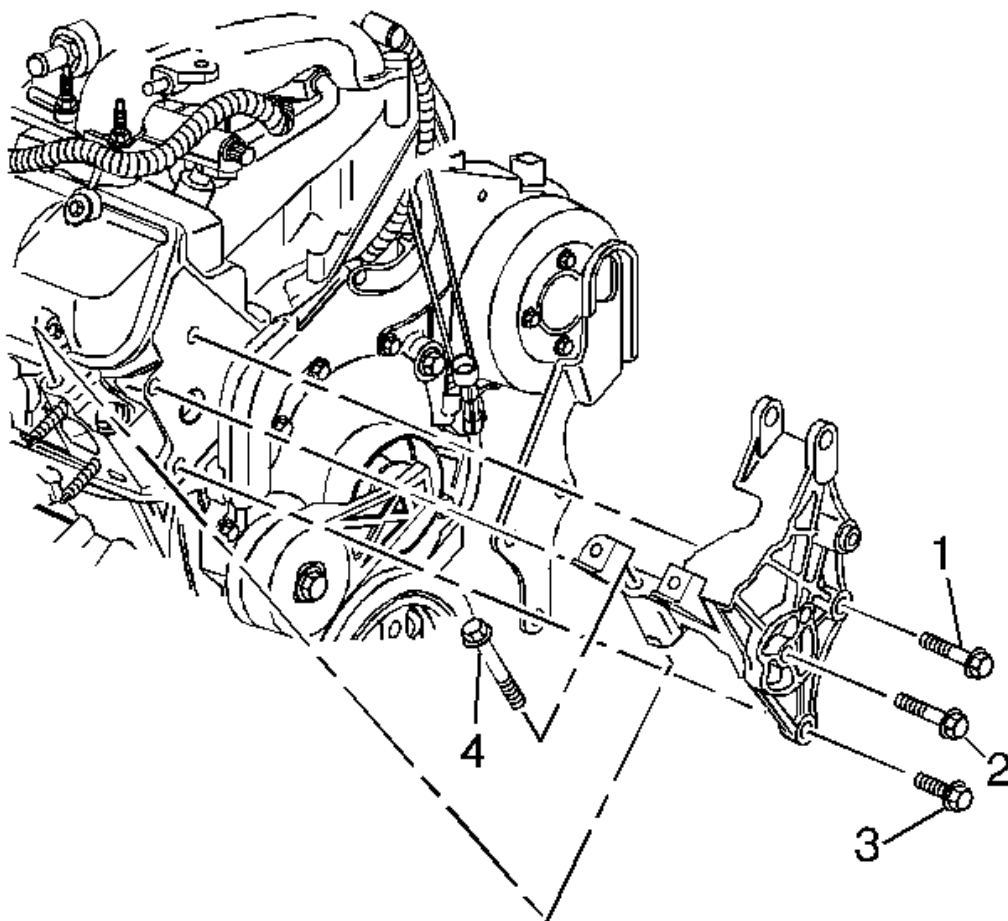


Fig. 441: Generator Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the front engine lift hook.
2. Install the generator bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the generator bracket bolts.

Tighten: Tighten the generator bracket bolts in sequence (1, 2, 3, 4) to 50 N.m (37 lb ft).

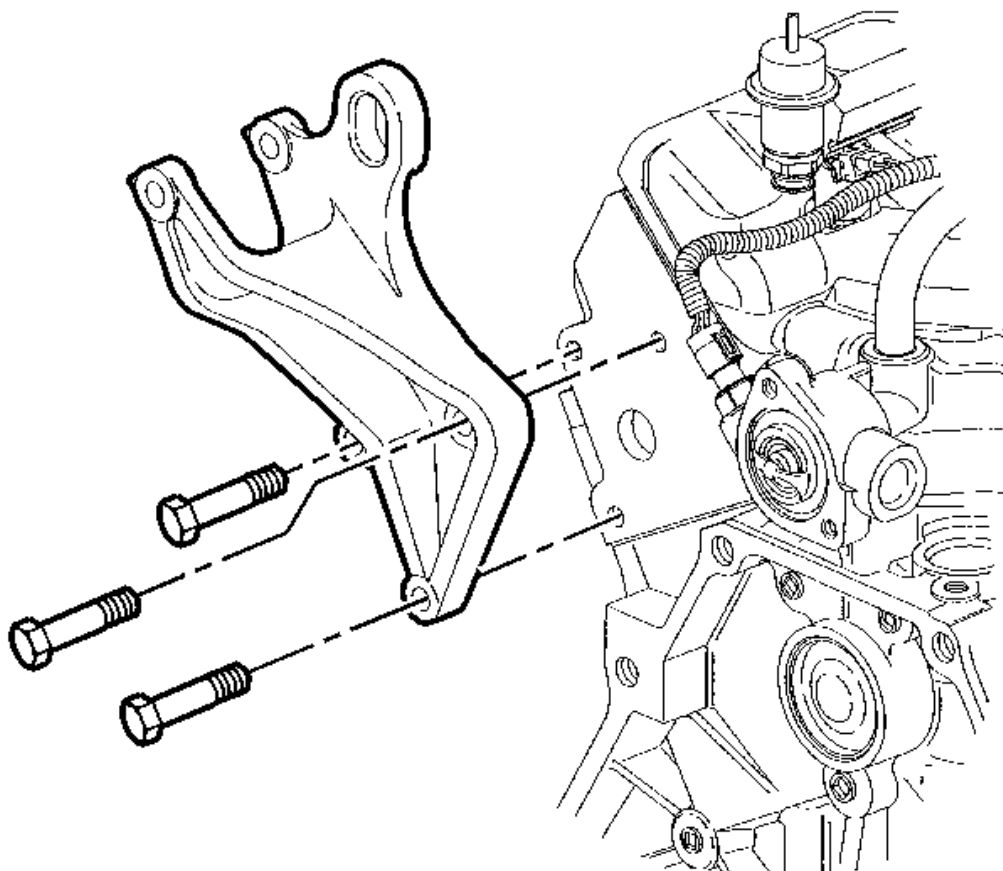
Engine Mount Strut and Engine Lift Bracket Installation

Fig. 442: Engine Mount Strut & Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut and lift bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tighten: Tighten the engine mount strut and lift bracket bolts to 70 N.m (52 lb ft).

Engine Mount Strut and Air Conditioning Compressor Bracket Installation

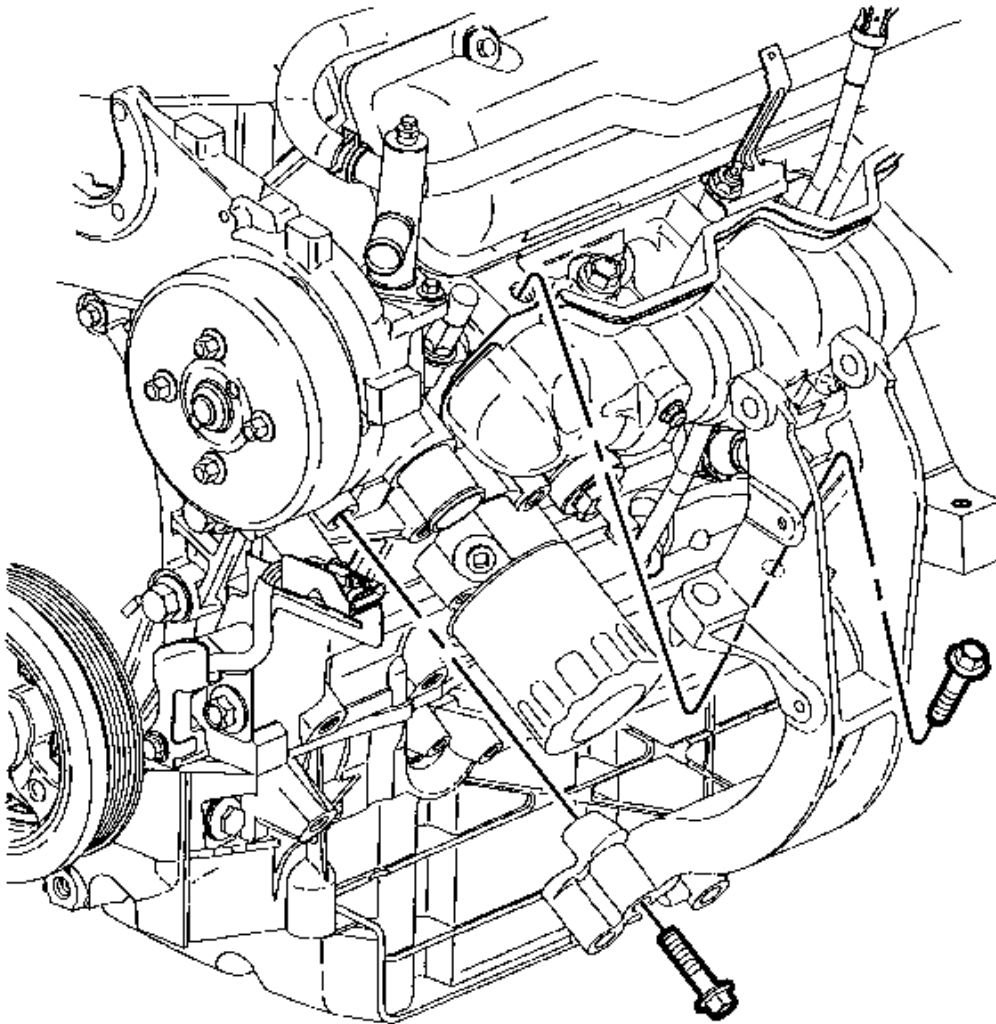


Fig. 443: Removing Engine Mount Strut & A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut and A/C Compressor bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount strut and A/C Compressor bracket bolts.

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

Drive Belt Tensioner Installation

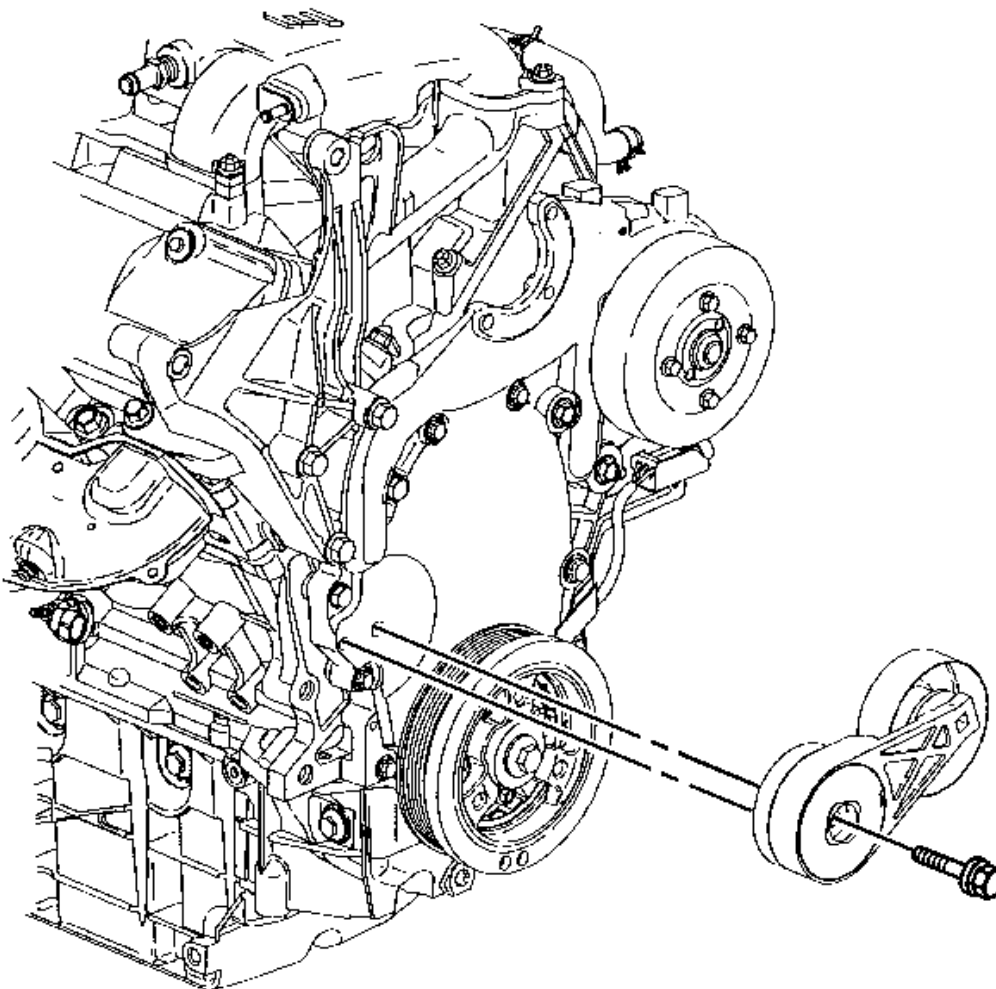


Fig. 444: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolt.

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

Engine Flywheel Installation

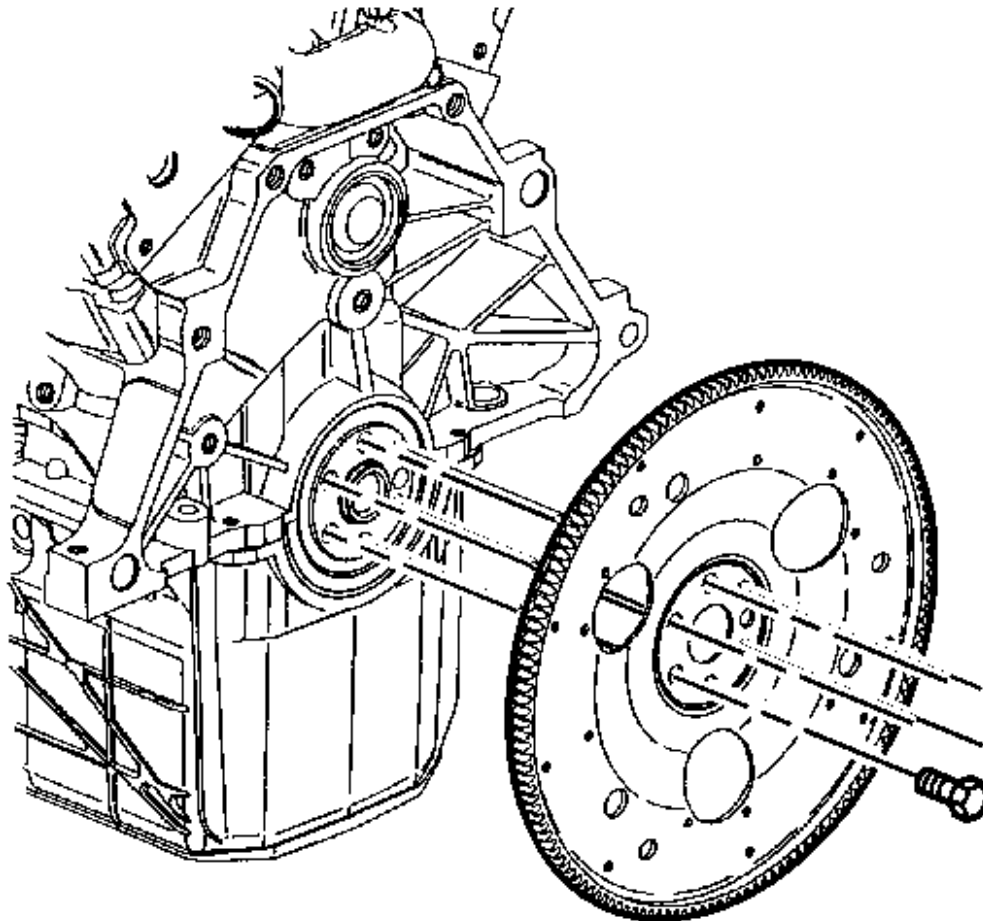


Fig. 445: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the flywheel bolts.

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

Crankshaft Balancer Installation

Tools Required

- **J 29113** Crankshaft Balancer Installer. See **Special Tools and Equipment**.
- J 36660-A Torque Angle Meter

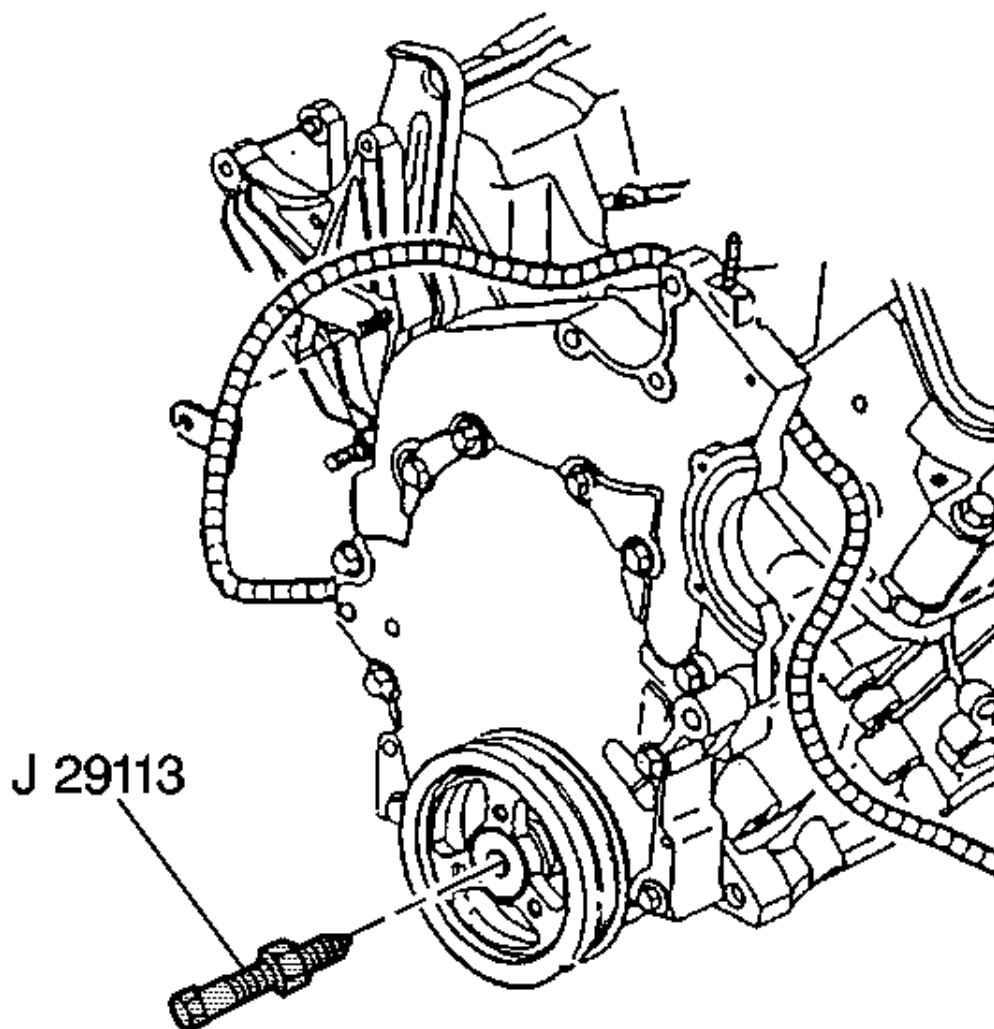


Fig. 446: Installing Crankshaft Balancer Using J 29113
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346141, (Canadian P/N 10953433) or the equivalent to the keyway of the crankshaft balancer.
2. Place the crankshaft balancer into position over the key in the crankshaft.

3. Install the **J 29113** onto the crankshaft. See **Special Tools and Equipment**.
4. Pull the crankshaft balancer into position.
5. Remove the **J 29113** from the crankshaft balancer. See **Special Tools and Equipment**.

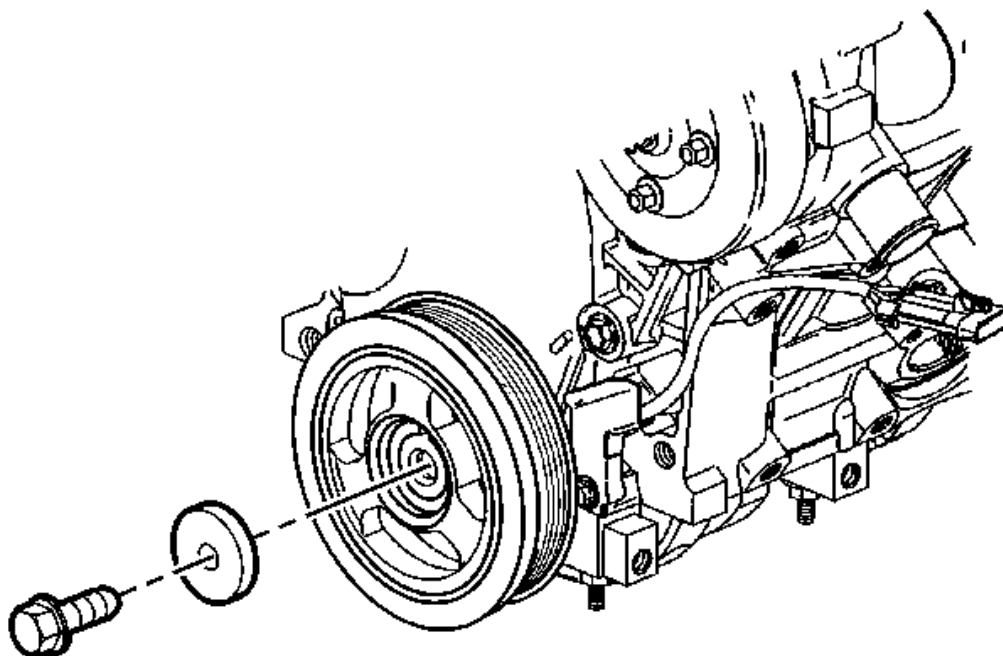


Fig. 447: Installing Crankshaft Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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.

6. Install the crankshaft balancer washer and bolt.

Tighten:

- Tighten the crankshaft balancer bolt a first pass to 70 N.m (52 lb ft).
- Tighten the crankshaft balancer bolt a final pass to 85 degrees using the J 36660-A .

Rotating the Engine for Service Access**Tools Required**

J 41131 Engine Tilt Strap. See **Special Tools and Equipment**.

1. Remove the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.1L.
2. Apply the parking brake.
3. Put the transaxle in the Neutral position.
4. Remove the engine mount struts. Refer to **Engine Mount Strut Replacement**.

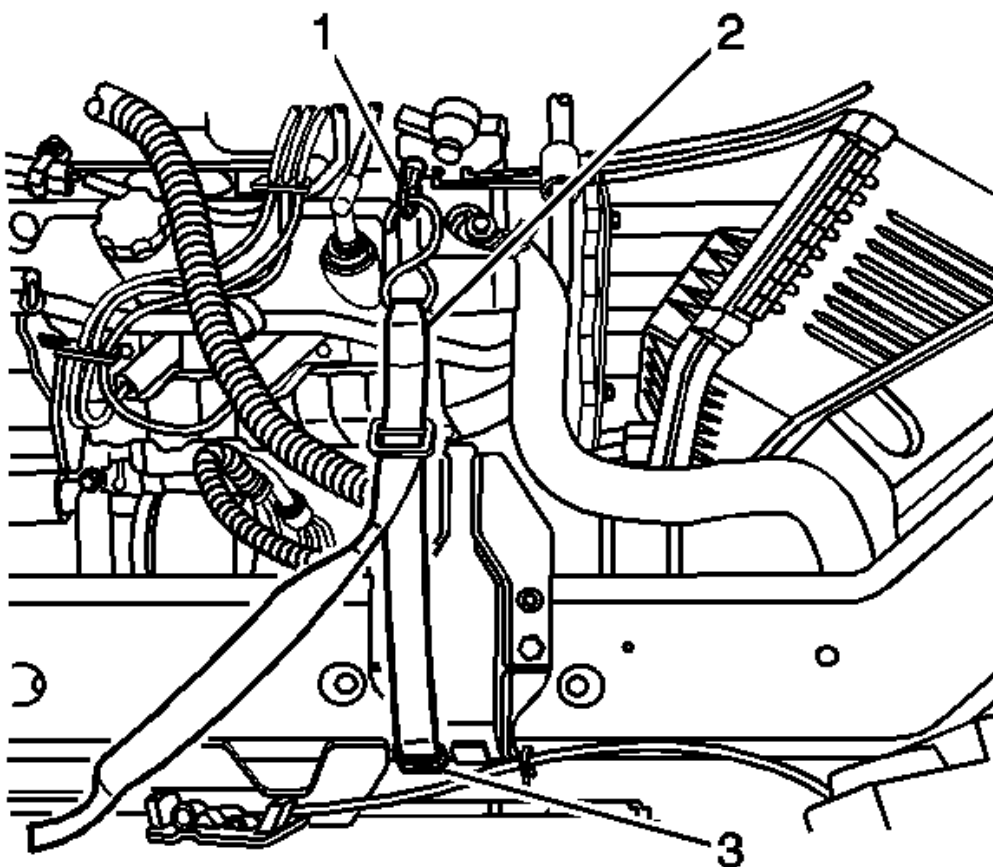


Fig. 448: Engine Lift Bracket, J 41131 & Upper Radiator Support
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 41131** (2) to the engine lift bracket (1) and the upper radiator support (3). See **Special Tools**

and Equipment.

6. Rotate the engine forward for component access.

DESCRIPTION AND OPERATION**CRANKCASE VENTILATION SYSTEM DESCRIPTION****General Description**

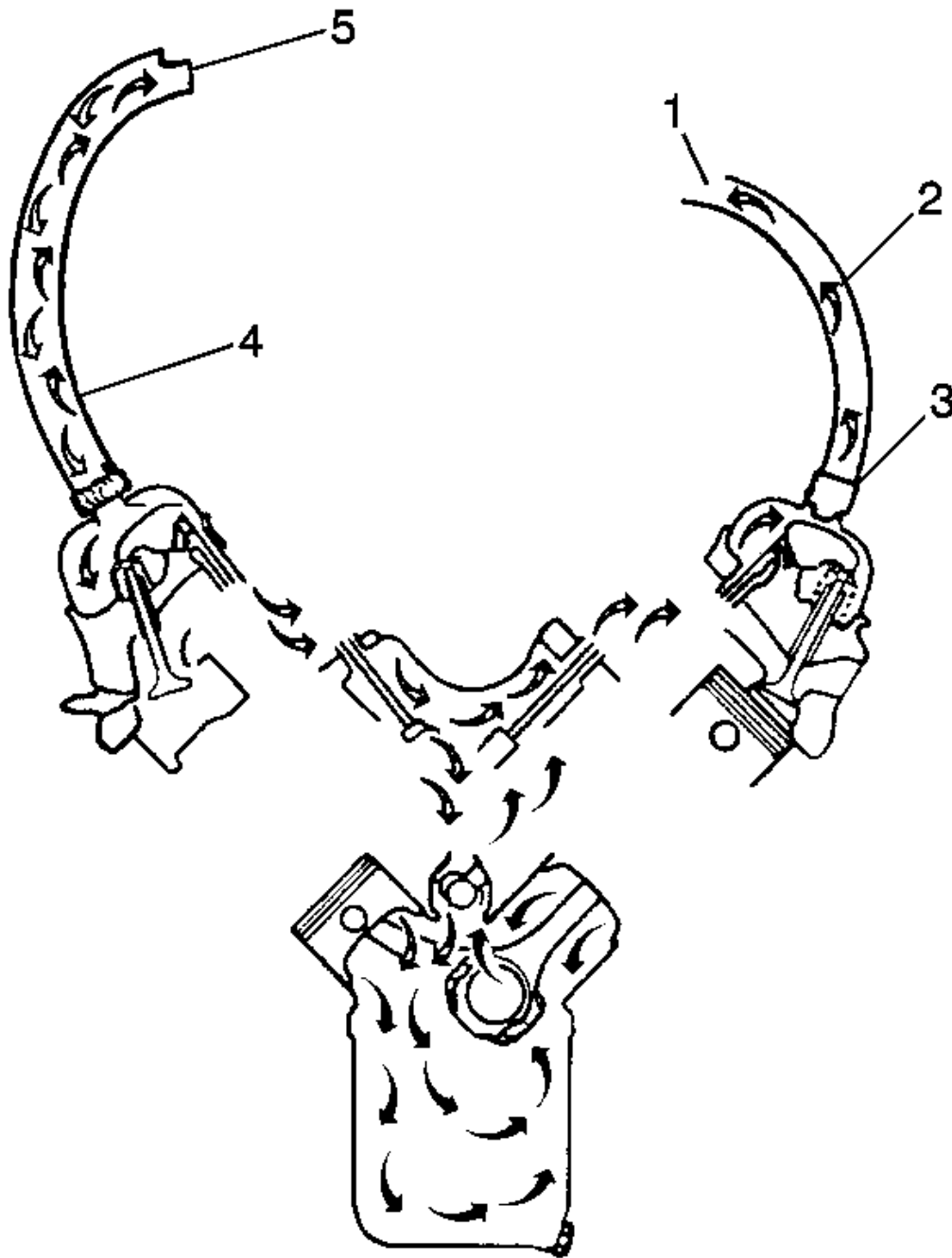


Fig. 449: Crankcase Ventilation System Flow Diagram
 Courtesy of GENERAL MOTORS CORP.

The crankcase ventilation system is used to consume crankcase vapors (1) in the combustion process instead of venting them to atmosphere. Fresh air from the throttle body is supplied to the crankcase, mixed with blow by gases and then passed through a positive crankcase ventilation (PCV) valve (3) into the intake manifold.

Operation

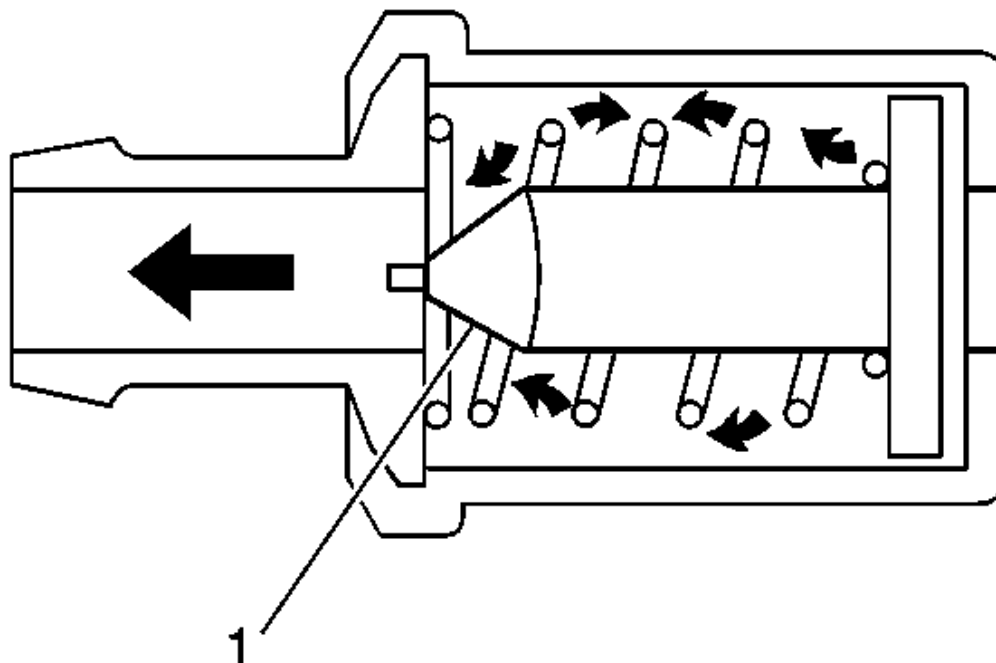


Fig. 450: PCV Valve

Courtesy of GENERAL MOTORS CORP.

The primary control is through the PCV valve (1) which meters the flow at a rate depending on inlet vacuum. To maintain idle quality, the PCV valve restricts the flow when inlet 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 into the throttle body to be consumed by normal combustion.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley

- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump
 - The generator
 - The A/C compressor
 - The water pump

The drive belt system uses one belt. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belt is made of different types of rubbers (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

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.

Starting from the front of the engine, the left bank cylinders are 1, 3, 5. The right bank cylinders are 2, 4, 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 cast nodular iron 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 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 chromium steel. The pins have a floating fit in the pistons. The pins are retained in the connecting rods by a press fit.

The connecting rods are made of forged steel. Full pressure lubrication is directed to the connecting rods by drilled oil passages from the adjacent main bearing journal.

A roller rocker type valve train is used. Motion is transmitted from the camshaft through the hydraulic roller lifter and from the pushrod to the roller rocker arm. The rocker arm pivots on the needle roller bearings. The rocker arm transmits the camshaft motion to the valve. The rocker arm pedestal is located in a slot in the cylinder head. The rocker arm is retained in the cylinder head by a bolt. The pushrod is located by the rocker arm.

The intake manifold is a 2-piece cast aluminum unit. The intake manifold centrally supports a fuel rail with 6 fuel injectors.

The exhaust manifolds are cast nodular iron.

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

No new components for 2004.

Fastener Changes

No fastener changes from 2004.

Torque Values and/or Fastener Tightening Strategies

- Crankshaft Position Sensor Wiring Bracket Bolt was 40 N.m (30 lb ft) is now 27 N.m (20 lb ft).
- Spark Plug - New Cylinder Head was 27 N.m (20 lb ft) is now 20 N.m (15 lb ft).

- Lower Intake Manifold Bolt Strategy is now First Pass 7 N.m (62 lb in); Final Pass 13 N.m (115 lb in).

Changed Engine Specifications

A new Engine Mechanical Specifications chart has been implemented into the 2004 service manual.

New Sealants and/or Adhesives

No new sealants and/or adhesives for 2004.

Disassembly and Assembly Procedure Revisions

- Oil Level Indicator and Tube Removal and Installation procedure has been revised.
- Exhaust Manifold - Left/Right Removal and Installation procedure has been revised.
- Water Outlet Removal and Installation is now Water Outlet and Thermostat Removal and Installation.
- Valve Rocker Arm Cover Removal and Installation - Left/Right procedure has been revised.
- Camshaft and Bearings Cleaning and Inspection procedure has been revised.
- Intake Manifold Cleaning and Inspection - Lower procedure has been revised.
- Valve Rocker Arm and Push Rod Installation procedure has been revised.
- Engine Prelubing procedure has been added.

Engine Mechanical Diagnostic Procedure Revisions

- Coolant in Combustion Chamber Diagnostic Procedure has been added.
- Coolant in Engine Oil Diagnostic Procedure has been added.

New Special Tools Required

J 45299 Engine Preluber has been added.

LUBRICATION DESCRIPTION

2004 Buick Century

2004 ENGINE Engine Mechanical - 3.1L - Century & Regal

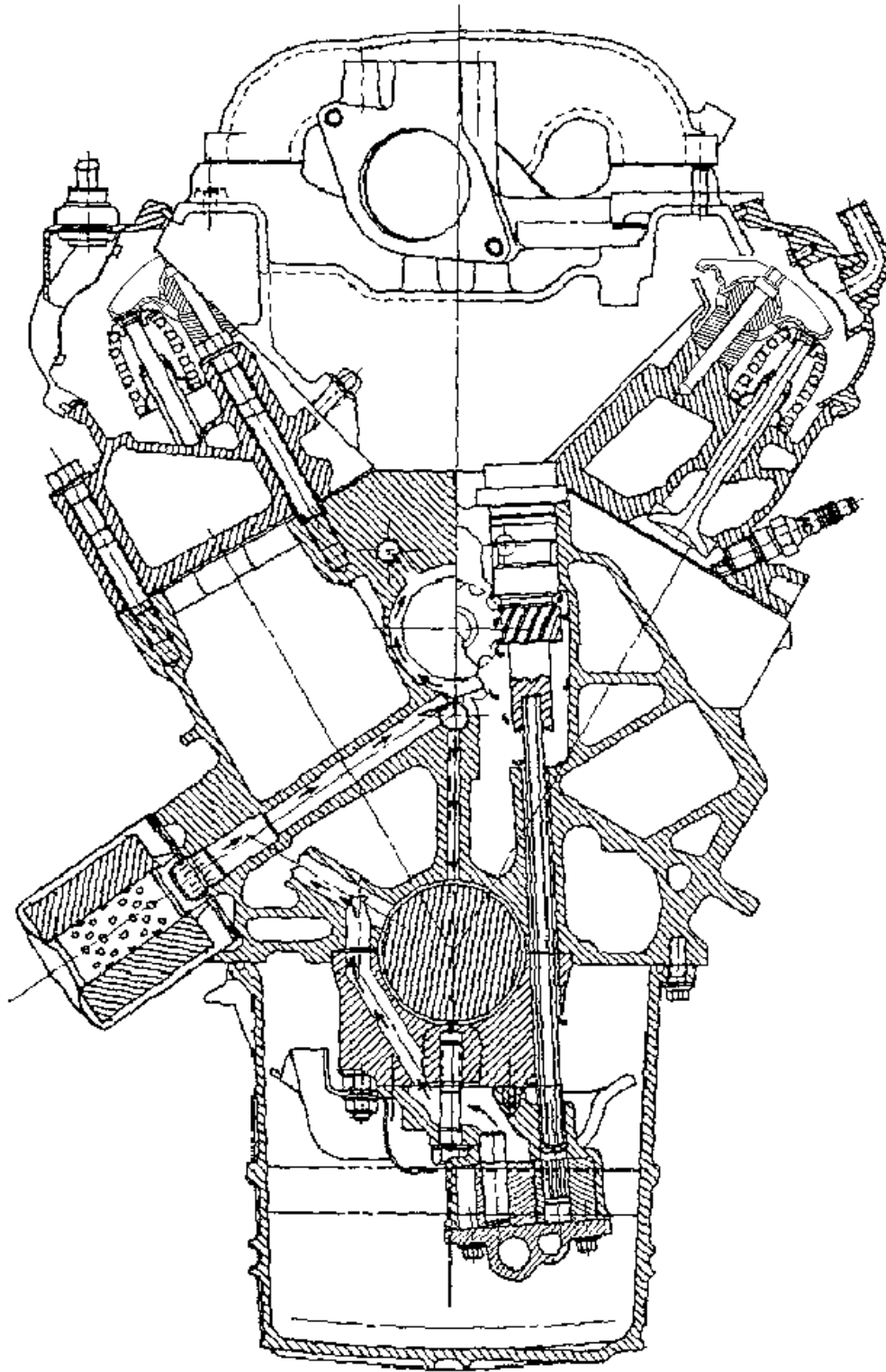


Fig. 451: Front View**Courtesy of GENERAL MOTORS CORP.**

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.

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.

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 in order to supply the camshaft lobes. The camshaft chain drive is lubricated by indirect oil splash.

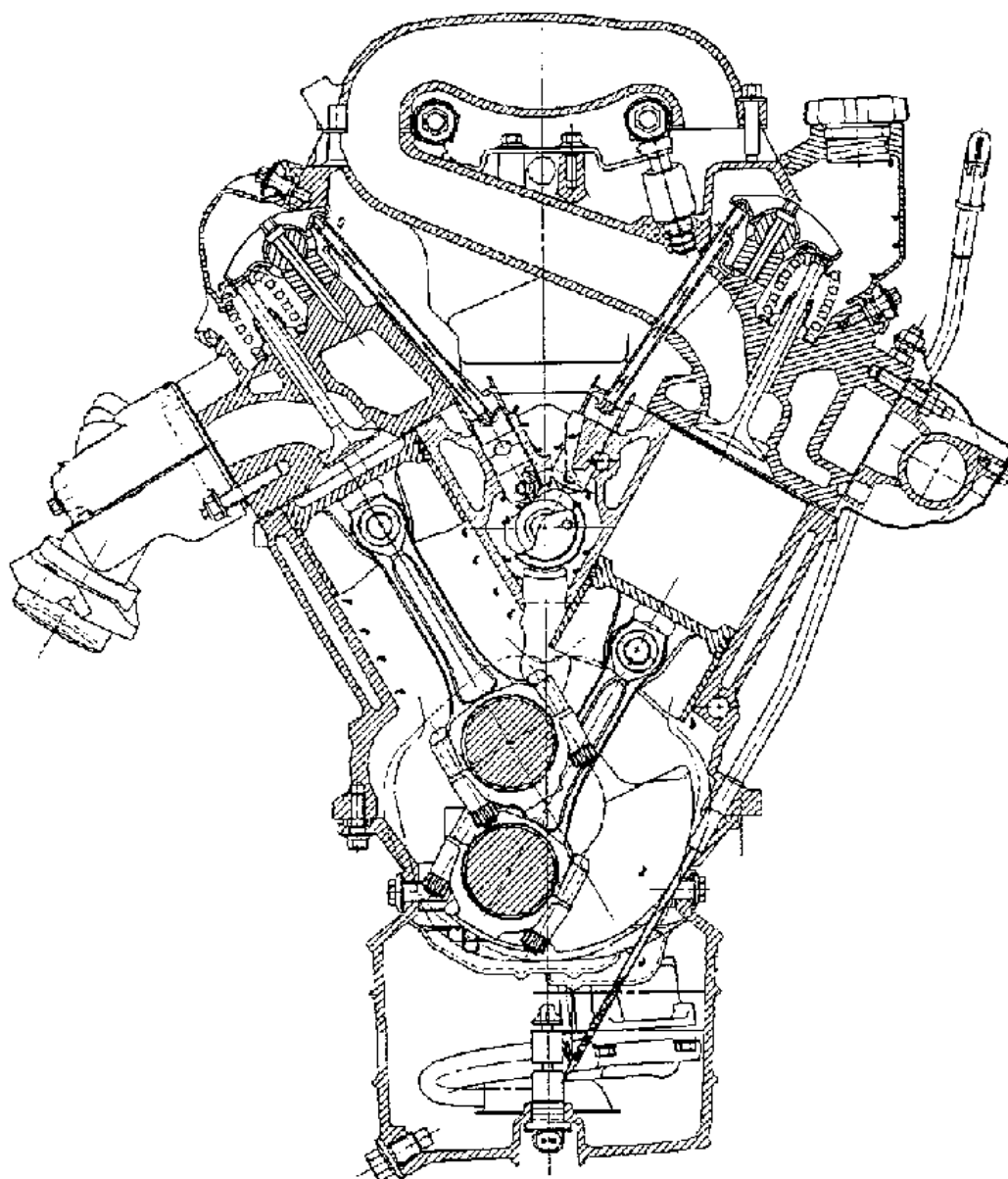
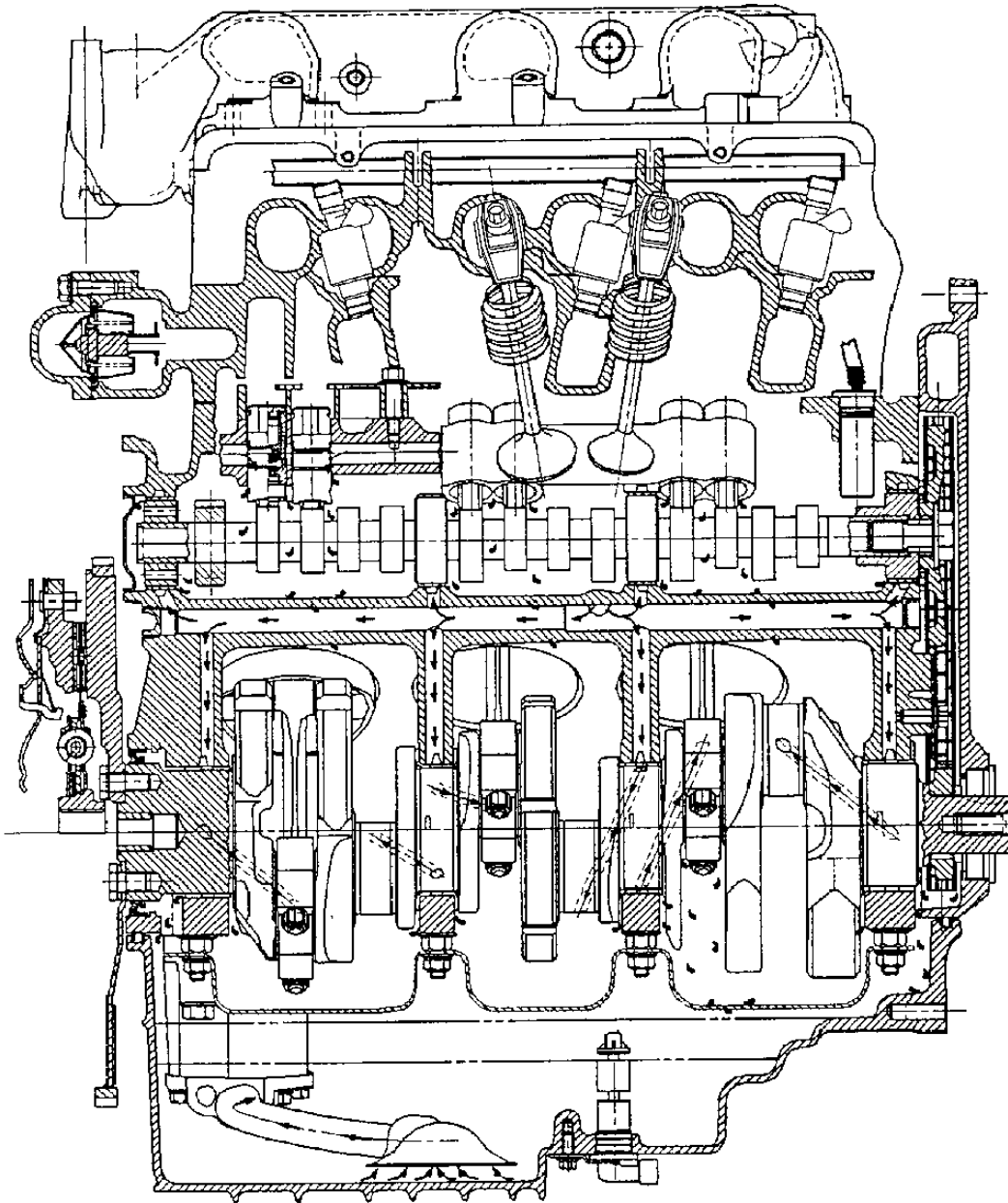


Fig. 452: Rear View

Courtesy of GENERAL MOTORS CORP.

**Fig. 453: Right View**

Courtesy of GENERAL MOTORS CORP.

CLEANLINESS AND CARE

An automobile engine is a combination of many of the following surfaces:

- Machined

- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

NOTE: **Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.**

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

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

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to Engine Electrical.

SEPARATING PARTS

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. If possible, bump the components sideways rather than using prying tools in order to remove the components. This technique prevents damage when the bonding strength of the RTV sealant is stronger than the component itself. Perform bumping at the bends or at the reinforced areas in order to prevent part distortion.

REPLACING ENGINE GASKETS

1. Do not reuse any gasket unless otherwise specified. Reusable gaskets will be identified in the service procedure. Do not apply sealant to any gasket or sealing surface unless called out in the service procedure.
2. Use a rubber mallet in order to separate components. Bump the part sideways in order to loosen the components. Perform the bumping at the bends or at the reinforced areas in order to prevent the distortion of components.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a components.

Do not use the following items in order to clean the gasket surfaces:

- Abrasive pads
- 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.

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
- 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

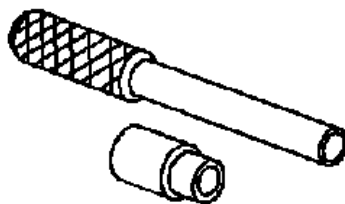
SPECIAL TOOLS

Special Tools

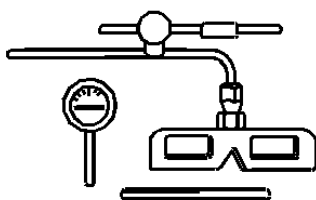
Illustration	Tool Number/Description

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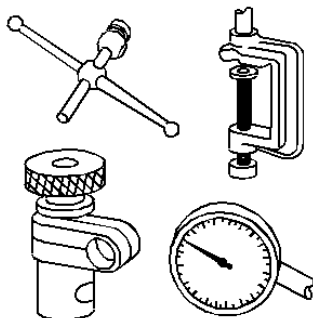
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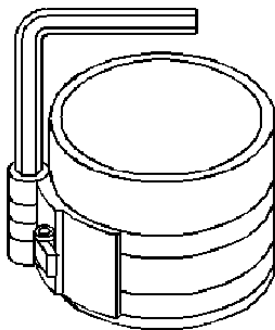
J 5239
Connecting Rod Bolt Guide



J 7872
Magnetic Base Dial Indicator Set



J 8001
Dial Indicator Set

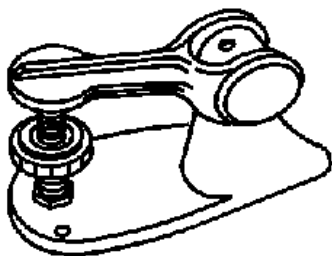
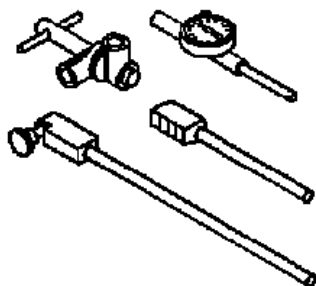
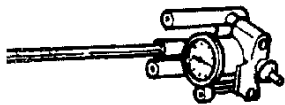


J 8037
Piston Ring Compressor

J 8087
Cylinder Bore Gage

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J 8089
Carbon Removing Brush

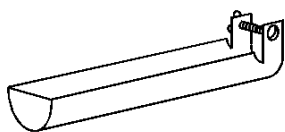
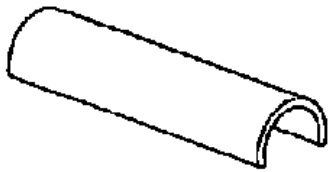
J 8520
Camshaft Lobe Lift Indicator Set

J 9666
Valve Spring Tester

J 21882
Oil Suction Pipe Installer

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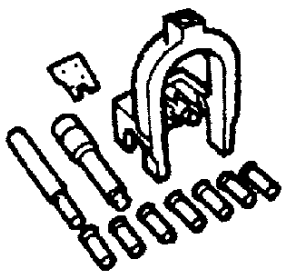
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J 22144
Oil Suction Pipe Installer



J 22794
Spark Plug Port Adapter

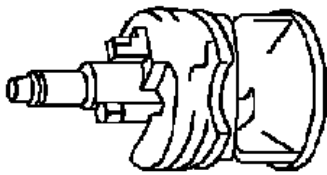


J 24086-C
Piston Pin Remover and Installer Set

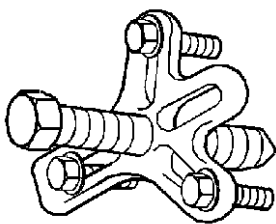
J 24270
Ridge Reamer

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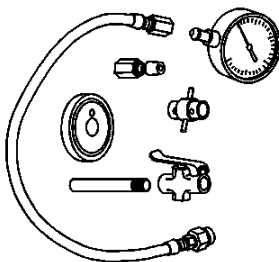
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J 24420-C
Harmonic Balancer Puller



J 25087-C
Oil Pressure Test Kit



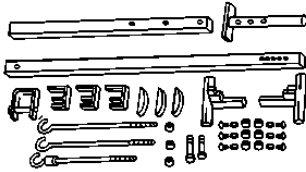
J 28428-E
High Intensity Black Light

J 28467-B

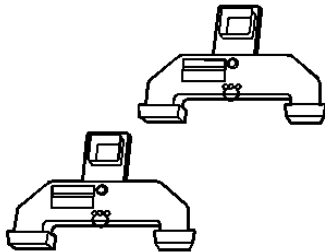
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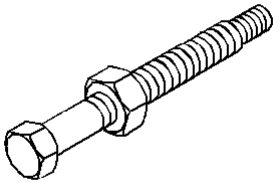
Universal Engine Support Fixture



J 28467-501 Engine Support Fixture Adapters



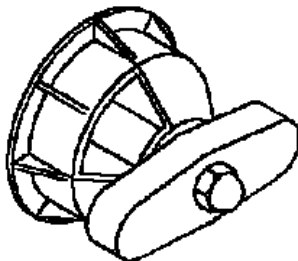
J 29113 Crankshaft Balancer Installer



J 33049 Camshaft Bearing Remover/Installer

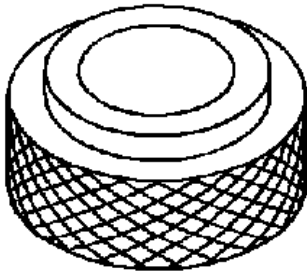


J 34686 Rear Main Seal Installer



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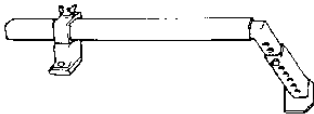
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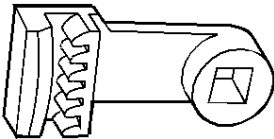
J 35468
Cover Aligner and Seal Installer



J 35667-A
Cylinder Leakdown Tester



J 36462-A
Engine Support Adapter Leg Set

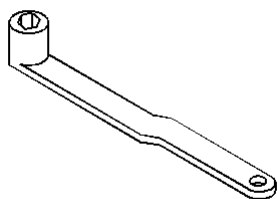
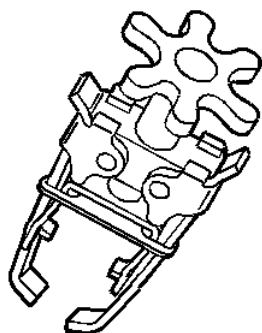


J 37096
Flywheel Holder

J 38606
Valve Spring Compressor

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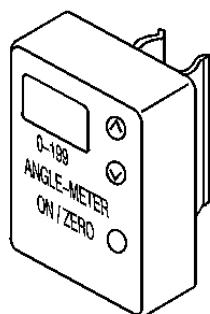
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J 39505
Torque Wrench Adapter



J 41131
Engine Tilt Strap



J 45059
Angle Meter

J 45299
Engine Preluber

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