

2005 Pontiac G6

2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6

2005 ENGINE**Engine Mechanical - 3.5L (LX9) - G6****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS****Fastener Tightening Specifications**

Application	Specification	
	Metric	English
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 Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	110 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	70 degrees	
Crankshaft Main Bearing Cap Bolt/Stud		
• First Pass	50 N.m	37 lb ft
• Final Pass	77 degrees	
Crankshaft Oil Deflector Nut	25 N.m	18 lb ft
Crankshaft Position Sensor Stud - Side of Engine Block	10 N.m	89 lb in
Cylinder Head Bolt		
• First Pass	60 N.m	44 lb ft
• Final Pass	95 degrees	
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
EGR Valve Assembly Bolt	30 N.m	22 lb ft
EGR Valve Pipe Bolt - Exhaust Manifold	30 N.m	22 lb ft
EGR Valve Pipe Bolt - EGR	25 N.m	18 lb ft
Engine Front Cover Bolt		
• Large Bolt	55 N.m	41 lb ft
• Medium Bolt	55 N.m	41 lb ft
• Small Bolt	27 N.m	20 lb ft
Engine Mount Strut and A/C Compressor Bracket Bolt	50 N.m	37 lb ft

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Engine Mount Strut and Lift Bracket Bolt - Engine Lift Rear	50 N.m	37 lb ft
Engine Mount Strut and Generator Bracket Bolt	50 N.m	37 lb ft
Engine Mount Strut and Support Bracket Bolt	25 N.m	18 lb ft
Engine Oil Pressure Indicator Switch	16 N.m	12 lb ft
Engine Wiring Harness Bracket Bolt	13 N.m	115 lb in
EVAP Purge Valve Bolt	10 N.m	89 lb in
Exhaust Manifold Heat Shield Bolt	10 N.m	89 lb in
Exhaust Manifold Nut	16 N.m	12 lb ft
Exhaust Manifold Stud	18 N.m	13 lb ft
Flywheel Bolt	70 N.m	52 lb ft
Front Oil Gallery Plug - Small	19 N.m	14 lb ft
Front Oil Gallery Plug - Large	33 N.m	24 lb ft
Fuel Feed Pipe to Fuel Injector Rail Bolt	10 N.m	89 lb in
Fuel Injector Rail Bolt	10 N.m	89 lb in
Heated Oxygen Sensor	42 N.m	31 lb ft
Heater Inlet Pipe Nut	25 N.m	18 lb ft
Heater Inlet Pipe Stud	35 N.m	26 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	25 N.m	18 lb ft
Lower Intake Manifold Bolt - Center	20 N.m	15 lb ft
Lower Intake Manifold Bolt - Corner	25 N.m	18 lb ft
MAP Sensor Bolt	10 N.m	89 lb in
Oil Filter Adapter Bolt	25 N.m	18 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Bypass Hole Plug	19 N.m	14 lb ft
Oil Filter Fitting	39 N.m	29 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Pan Bolt	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan Side Bolt	50 N.m	37 lb ft
Oil 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 Tube Clip bolt - Foul Air	10 N.m	89 lb in
Piston Oil Nozzle Bolt	10 N.m	89 lb in
Rear Oil Gallery Plug - 1/4 inch	19 N.m	14 lb ft
Rear Oil Gallery Plug - 3/8 inch	33 N.m	24 lb ft
Spark Plug - Initial Installation	20 N.m	15 lb ft
Spark Plug - After Initial Installation	15 N.m	11 lb ft
Thermostat Bypass Pipe to Engine Front Cover Bolt	10 N.m	89 lb in

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	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
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 degree V-6	
• Displacement	3.5L	214 cu in
• RPO	LX9	
• VIN	L	
• Bore	94 mm	3.70 in
• Stroke	84 mm	3.31 in
• Compression Ratio	9.8:1	
• Firing Order	123456	
• Spark Plug Gap	1.52 mm	0.060 in
Block		
• 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	2.840-2.841 in
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.00031 in
• Cylinder Bore Diameter	93.991-94.009 mm	3.700-3.701 in
• Cylinder Bore Out-of-Round - Diameter - Production	0.020 mm	0.0008 in
• Cylinder Bore Out-of-Round - Diameter - 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

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• Cylinder Head Deck Height	224 mm	8.818 in
• Cylinder Head Deck Surface Flatness	0.05 mm per 152 mm	0.0019 in per 6 in
• Valve Lifter Bore Diameter	21.417-21.455 mm	0.843-0.844 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	0.025 mm	0.001 in
• Camshaft Lobe Lift - Exhaust	6.9263 mm	0.2727 in
• Camshaft Lobe Lift - Intake	6.9263 mm	0.2727 in
Cooling System		
• Capacity	12.4 liters	13.1 quarts
• 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	60.322-60.338 mm	2.375-2.376 in
• Connecting Rod Bore Out-of-Round	0.006 mm	0.00023 in
• Connecting Rod Length - Center to Center	150 mm	5.9 in
• Connecting Rod Side Clearance	0.200-0.241 mm	0.008-0.009 in
• Connecting Rod Journal Diameter	57.122-57.138 mm	2.249-2.250 in
Crankshaft		
• Connecting Rod Journal Diameter	57.122-57.138 mm	2.248-2.249 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.008 mm	0.0003 in
• Connecting Rod Journal Width	21.92-22.08 mm	0.863-0.869 in
• Crankshaft End Play	0.060-0.210 mm	0.0024-0.0083 in
• Crankshaft Main Bearing Journal Width	23.9-24.1 mm	0.941-0.949 in
• Crankshaft Main Bearing Clearance	0.019-0.064 mm	0.0008-0.0025 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	0.008 mm	0.0003 in
• Crankshaft Rear Flange Runout	0.04 mm	0.0016 in
Cylinder Head		
• Combustion Chamber Depth - at Measurement Point	2.2 mm	0.087 in
• Surface Finish - Maximum	2.8 RA	

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• Surface Flatness - Block Deck	0.08 mm Per 152 mm	0.003 in Per 6 in
• Surface Flatness - Exhaust Manifold Deck	0.1 mm	0.004 in
• Surface Flatness - Intake Manifold Deck	0.1 mm	0.004 in
• Valve Guide Bore - Exhaust	8.01 mm	0.315 in
• Valve Guide Bore - Intake	8.01 mm	0.315 in
• Valve Guide Installed Height	16.6 mm	0.654 in
Lubrication System		
• Oil Capacity - with Filter	3.8 liter	4.0 quarts
• Oil Capacity - without Filter	3.3 liter	3.5 quarts
• Oil Pressure - @ 1850 RPM	207-310 kPa	30-45 PSI
Oil Pump		
• Gear Diameter	38.05-38.10 mm	1.498-1.500 in
• Gear Pocket - Depth	30.53-30.59 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	0.18-0.39 mm	0.007-0.015 in
• Second Compression Ring	0.48-0.74 mm	0.019-0.029 in
• Oil Control Ring	0.25-0.74 mm	0.010-0.029 in
Piston Ring to Groove Clearance		
• First Compression Ring	0.03-0.076 mm	0.001-0.003 in
• Second Compression Ring	0.04-0.078 mm	0.002-0.003 in
• Oil Control Ring	0.09 mm	0.004 in
Piston Ring Thickness		
• First Compression Ring	1.164-1.190 mm	0.046-0.047 in
• Second Compression Ring	1.472-1.490 mm	0.058 in
• Oil Control Ring - Maximum	2.440 mm	0.096 in
Piston		
• Piston Diameter - production	93.980-94.020 mm	3.7-3.701 in
• Piston Diameter - service limit	93.960 mm	3.699 in
• Piston Pin Bore Diameter	24.008-24.013 mm	0.9452-0.9454 in
• Piston Ring Groove Width	1.23-1.255 mm	0.048-0.049 in
• Piston to Bore Clearance - production	-0.029 to +0.029 mm	-0.0011 to +0.011 in

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• Piston to Bore Clearance - service limit - Maximum	0.080 mm	0.003 in
Pin		
• Piston Pin Clearance to Connecting Rod Bore - Press Fit	-0.022 to +0.044 mm	-0.0008 to +0.0017 in
• Piston Pin Clearance to Piston Pin Bore	0.008-0.016 mm	0.0003-0.0006 in
• Piston Pin Diameter	23.997-24.000 mm	0.9447-0.9448 in
• Piston Pin Length	59.87-60.13 mm	2.35-2.36 in
Valves		
• Valve Face Angle	45 degrees	
• Valve Seat Angle	46 degrees	
• Valve Seat Depth - Intake - from deck face	7.9-8.1 mm	0.311-0.318 in
• Valve Seat Depth - Exhaust - from deck face	8.9-9.1 mm	0.350-0.358 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 Lifters/Push Rods		
• Push Rod Length - Intake	144.2 mm	5.67 in
• Push Rod Length - Exhaust	152.5 mm	6.0 in
Valve Springs		
• Valve Spring Free Length	50.0 mm	1.91 in
• Valve Spring Installed Height	44.2 mm	1.74 in
• Valve Spring Load - Closed	343 N @44.2 mm	77 lb 1.74 in
• Valve Spring Load - Open	1041 N @33 mm	234 lb 1.299 in
• Valve Spring Total Number of Coils	7.10	

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Rear Bearing Hole Plug	Sealant	12377901	10953504
Coolant Drain Plug	Sealant	12346004	10953480
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Crankshaft Balancer Keyway	Sealant	12378521	88901148
Crankshaft Position Sensor Bolt/Stud Threads	Threadlock	12345382	10953489
Engine Block Coolant Drain Plug Threads	Sealant	12346004	10953480
Engine Block Oil Gallery Plug Threads	Sealant	12346004	10953480

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Engine Front Cover Bolt Threads	Sealant	12346004	10953480
Engine Front Cover Gasket Lower Tabs	Sealant	12346004	10953480
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Cooler Fitting Threads	Sealant	12346004	10953480
Engine Oil Supplement	Lubricant	1052367	992869
Intake Manifold Bolt Threads - Upper and Lower	Threadlock	12345382	10953489
Intake Manifold Coolant Pipe	Sealant	12345493	10953488
Intake Manifold to Engine Block Mating Surface	Sealant	12378521	88901148
Oil Filter Bypass Hole Plug Threads	Sealant	12346004	10953480
Oil Pan Surface at Rear Crankshaft Main Bearing Cap	Sealant	12378521	88901148
Oil Pressure Switch Threads	Sealant	12346004	10953480
Oil Pump Suction Pipe	Sealant	12346004	10953480
Piston and Piston Pin	5W-30 Oil	12345610	993193
Rear Crankshaft Main Bearing Cap	Sealant	1052942	10953466
Throttle Body Stud and Bolts	Threadlock	12345382	10953489
Valve Lifter Guide Bolt Threads	Threadlock	12345382	10953489
Valve Rocker Arm Cover Notch at Cylinder Head and Lower Intake Manifold	Sealant	12378521	88901148
Valve Lifter and Camshaft Prelube	Lubricant	12345501	992704

COMPONENT LOCATOR**DISASSEMBLED VIEWS**

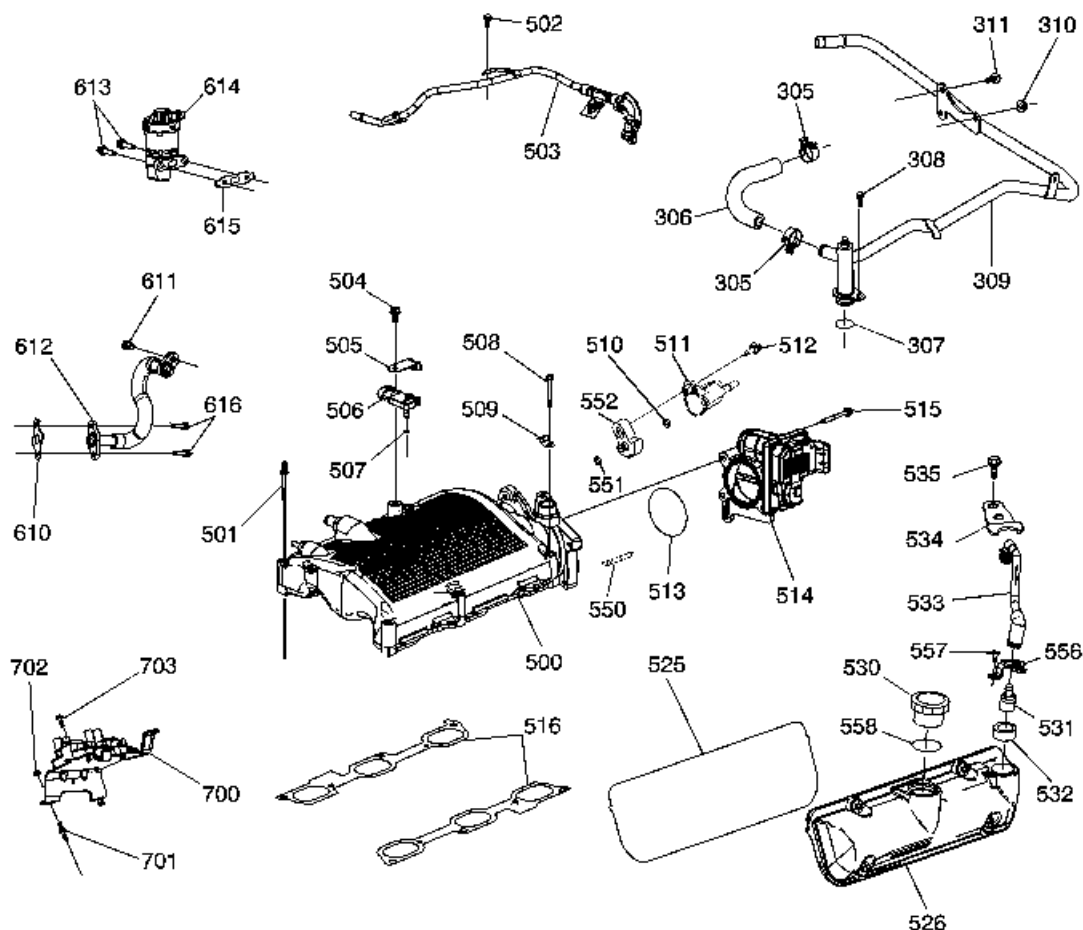


Fig. 1: View Of Upper Intake Manifold and Components
 Courtesy of GENERAL MOTORS CORP.

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
309	Thermostat Bypass Pipe
310	Thermostat Bypass Pipe Nut
311	Thermostat Bypass Pipe Bolt
500	Upper Intake Manifold
501	Upper Intake Manifold Stud
502	Fuel Feed Pipe Bolt
503	Fuel Feed Pipe

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504	MAP Sensor Bolt
505	MAP Sensor Clip
506	MAP Sensor
507	MAP Sensor Seal
508	Upper Intake Manifold Bolt
509	Spark Plug Support Bracket
510	EVAP Purge Valve Seal
511	EVAP Purge Valve
512	EVAP Purge Valve Bolt
513	Throttle Body Seal
514	Throttle Body
515	Throttle Body Bolt
516	Upper Intake Manifold Gasket
525	Valve Rocker Cover Seal
526	Valve Rocker Cover
530	Oil Fill Cap
531	PCV Valve
532	PCV Valve Grommet
533	PCV Tube
534	PCV Tube Clip
535	PCV Tube Bolt
550	Throttle Body Stud
551	EVAP Purge Valve Spacer Plate
552	EVAP Purge Valve Spacer Plate Seal
556	PCV Valve Retainer
557	PCV Valve Retainer Rivet
558	Oil Fill Cap Seal
610	EGR Pipe Gasket
611	EGR Pipe Bolt
612	EGR Pipe
613	EGR Valve Bolt
614	EGR Valve
615	EGR Valve Gasket
616	EGR Pipe Bolt
700	Ignition Coil Assembly
701	Ignition Coil Assembly Stud
702	Ignition Coil Assembly Nut
703	Ignition Coil Assembly Bolt

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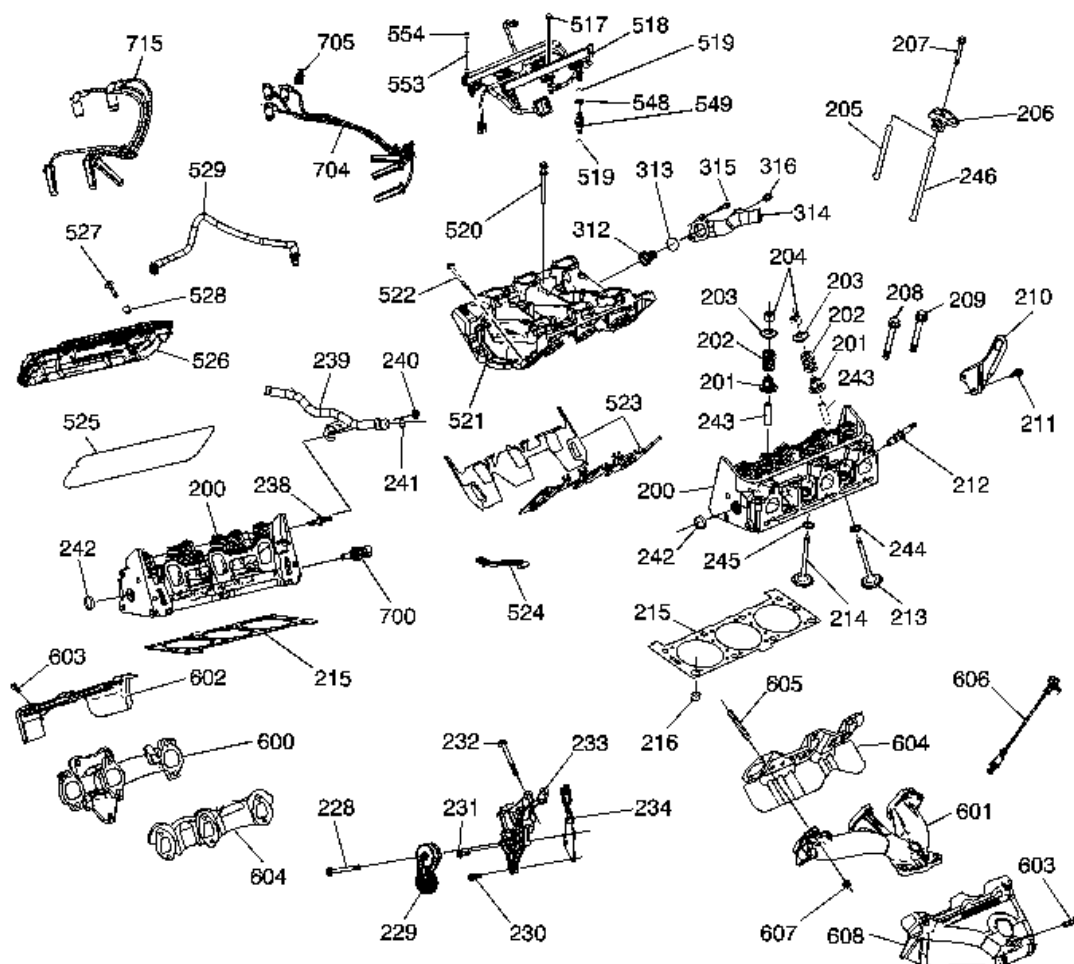


Fig. 2: View Of Lower Intake Manifold, Cylinder Head and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Cylinder Head
200	Cylinder Head
201	Valve Seal
201	Valve Seal
202	Valve Spring
202	Valve Spring
203	Valve Spring Cap
203	Valve Spring Cap
204	Valve Stem Key
205	Valve Pushrod
206	Valve Rocker Arm

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207	Valve Rocker Arm Bolt
208	Cylinder Head Bolt
209	Cylinder Head Bolt
210	Engine Lift Rear Bracket
211	Engine Lift Rear Bracket Bolt
212	Spark Plug
213	Exhaust Valve
214	Intake Valve
215	Cylinder Head Gasket
215	Cylinder Head Gasket
216	Cylinder Head Locating Pin
228	Drive Belt Tensioner Bolt
229	Drive Belt Tensioner
230	Generator Bracket Bolt
231	Generator Bracket Bolt
232	Generator Bracket Bolt
233	Generator Bracket
234	Engine Lift Front Bracket
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
243	Valve Guide
244	Valve Seat
245	Valve Seat
246	Valve Pushrod
312	Engine Coolant Thermostat
313	Engine Coolant Thermostat Seal
314	Water Outlet
315	Water Outlet Bolt
316	Water Outlet Fitting
517	Fuel Rail Bolt
518	Fuel Rail
519	Fuel Injector Seal
519	Fuel Injector Seal
520	Lower Intake Manifold Bolt
521	Lower Intake Manifold
522	Lower Intake Manifold Bolt
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	Lower Intake Manifold Gasket
524	Lower Intake Manifold Seal
525	Valve Rocker Cover Seal
526	Valve Rocker Cover
527	Valve Rocker Cover Bolt
528	Valve Rocker Cover Bolt Grommet
529	PCV Tube
548	Fuel Injector Retaining Clip
549	Fuel Injector
553	Fuel Schrader Valve
554	Fuel Service Port Cap
600	Exhaust Manifold - Right
601	Exhaust Manifold - Left
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
700	Coolant Temperature Sensor
704	Spark Plug Wire Harness - Front
705	Spark Plug Wire Support
715	Spark Plug Wire Harness - Rear

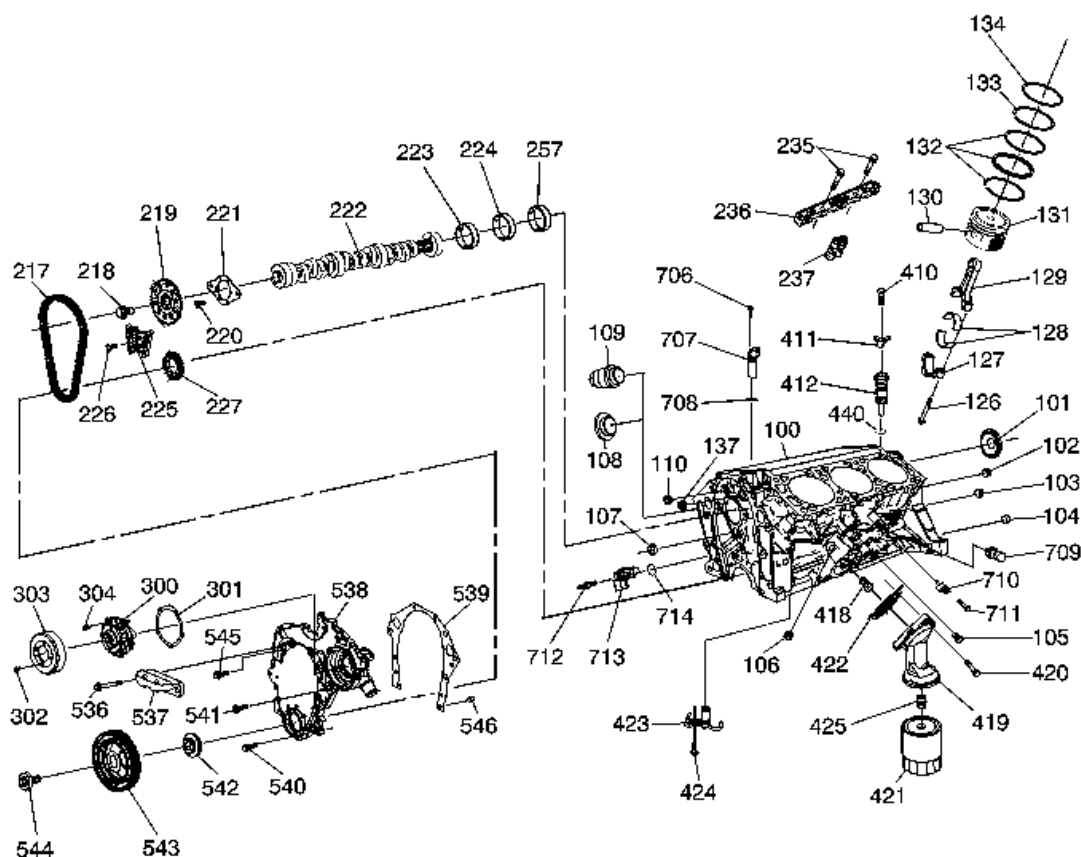


Fig. 3: View Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Camshaft Rear Bearing Hole Plug
102	Engine Block Oil Gallery Plug Assembly - Rear
103	Engine Block Oil Gallery Plug Assembly - Rear
104	Transmission Locating Pin
105	Engine Block Coolant Drain Hole Plug
106	Oil Filter Bypass Hole Plug Assembly
107	Engine Block Oil Gallery Plug Assembly - Front
108	Engine Block Heater Plug
109	Engine Block Heater
110	Engine Block Oil Gallery Plug - Front
126	Connecting Rod Bearing Cap Bolt
127	Connecting Rod Bearing Cap
128	Connecting Rod Bearing

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129	Connecting Rod
130	Piston Pin
131	Piston
132	Piston Ring - Oil Control
133	Piston Ring - Compression
134	Piston Ring - Compression
137	Engine Block Oil Gallery Plug - Front
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
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
419	Oil Filter Adapter
420	Oil Filter Adapter Bolt
421	Oil Filter
422	Oil Filter Adapter Gasket
423	Piston Oil Nozzle
424	Piston Oil Nozzle Bolt
425	Oil Filter Fitting
440	Oil Pump Drive Seal
536	Engine Mount Snubber Bracket Bolt
537	Engine Mount Snubber Bracket Bolt

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	Engine Front Cover
539	Engine Front Cover Gasket
540	Engine Front Cover Bolt
541	Engine Front Cover Bolt
542	Crankshaft Front Oil Seal
543	Crankshaft Balancer
544	Crankshaft Balancer Bolt
545	Engine Front Cover Bolt
546	Engine Front Cover Locating Pin
706	Camshaft Sensor Bolt
707	Camshaft Sensor
708	Camshaft Sensor Seal
709	Engine Oil Pressure Switch
710	Knock Sensor
711	Knock Sensor Bolt
712	Crankshaft Position Sensor Stud
713	Crankshaft Position Sensor
714	Crankshaft Position Sensor Seal

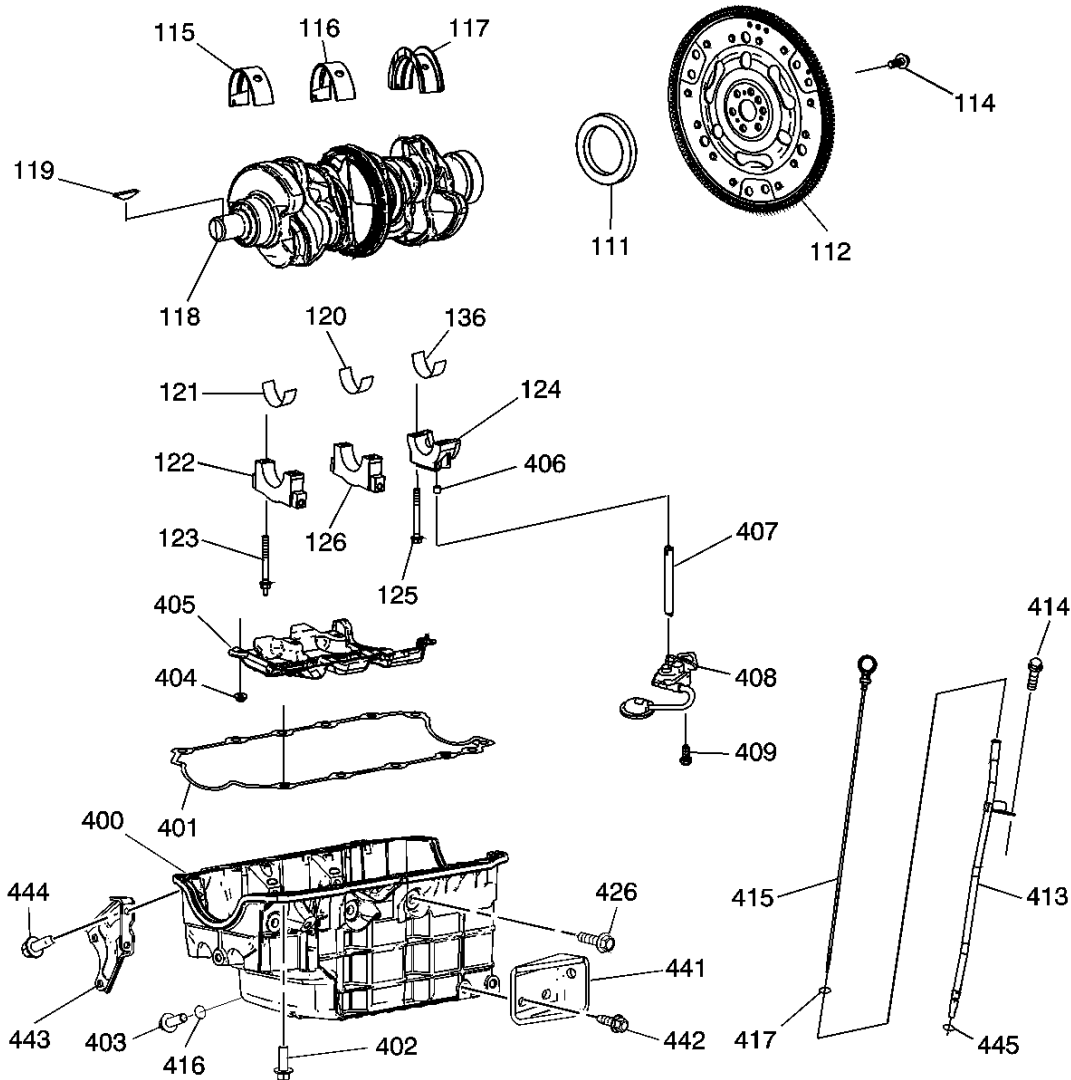


Fig. 4: View Of Crankshaft and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
111	Crankshaft Rear Oil Seal Assembly
112	Flywheel
114	Flywheel Bolt
115	Crankshaft Upper Bearing
116	Crankshaft Upper Bearing
117	Crankshaft Upper Bearing
118	Crankshaft
119	Crankshaft Balancer Key

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120	Crankshaft Lower Bearing
121	Crankshaft Lower Bearing
122	Crankshaft Bearing Cap
123	Crankshaft Bearing Cap Stud
124	Crankshaft Bearing Cap
125	Crankshaft Bearing Cap Bolt
126	Connecting Rod Bearing Cap Bolt
136	Crankshaft Bearing Cap
400	Oil Pan
401	Oil Pan Gasket
402	Oil Pan Bolt
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
441	Oil Pan Support Bracket - to Transmission Bell Housing
442	Oil Pan Support Bracket Bolt - Oil Pan
443	Oil Pan Support Bracket - to Transmission Tail Shaft
444	Oil Pan Support Bracket Bolt - Engine Block
445	Oil Level Indicator Tube O-ring

ENGINE IDENTIFICATION

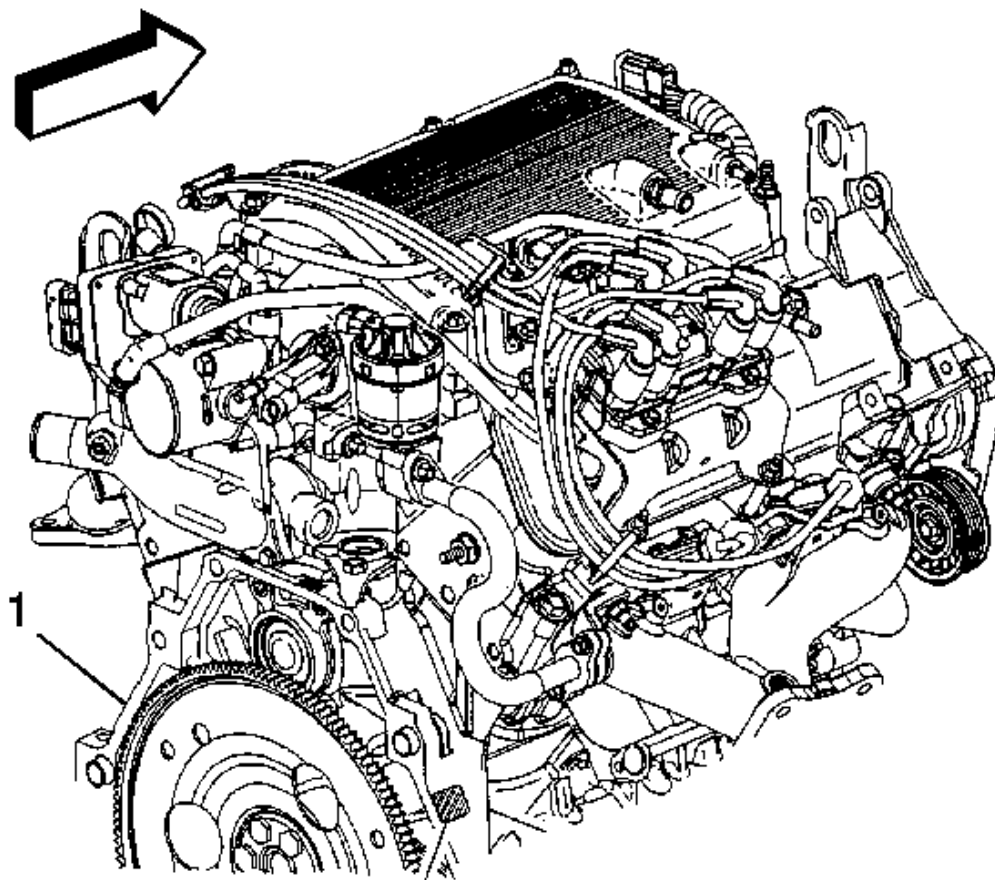


Fig. 5: Locating Engine Identification On Engine Block
Courtesy of GENERAL MOTORS CORP.

The Vehicle Identification Number - VIN derivative (1) for 3500 LX9 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** and **Lubrication Description** in Engine Mechanical. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to **Symptoms - Engine Mechanical** in order to identify the correct procedure for diagnosing the system and where the procedure is located.

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** and **Lubrication Description** in Engine Mechanical.

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

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**

- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- 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 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> .
Restricted exhaust system A severe restriction in the exhaust flow can cause	Repair or replace as required.

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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.	
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 out of time timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• 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 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	Replace the drive belt. Refer to <u>Drive Belt Tensioner Replacement</u> .

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to a misfire condition. A misfire code may be present without an actual misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <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.
Excessive engine oil pressure	Perform an oil pressure diagnosis. Refer to <u>Oil Pressure Diagnosis and Testing</u> .

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.
Excessive rod and main bearing clearance	Replace the bearings as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED**Upper Engine Noise, Regardless of Engine Speed**

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Cause	Correction
Engine oil overfull - oil aeration	Remove excess oil, set to proper level.
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 and/or damaged valve rotators	Replace the valve rotators as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn timing chain dampner	Replace the timing chain dampner.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck Valves (Carbon on the valve stem or valve seat may cause the valve to stay open)	Inspect the following components, and repair as required: • The valves

- The valve guides

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>Electronic Ignition (EI) 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 • The connecting rods • The crankshaft • The crankshaft journals

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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>Electronic Ignition (EI) 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

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

COOLANT IN COMBUSTION CHAMBER**Coolant in Combustion Chamber**

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to <u>Engine Will Not Crank - Crankshaft Will Not Rotate</u>. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore.	

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3. Inspect by performing a **Cylinder Leakage Test**. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component.
4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.

Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket/Faulty lower intake manifold gasket	Replace the head gasket, faulty lower intake manifold gasket and components as required. Refer to Cylinder Head Assemble and Cylinder Head Replacement - Left or Cylinder Head Replacement - Right .
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to Cylinder Head Replacement - Left or Cylinder Head Replacement - Right .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed.	
1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed. 2. Inspect by performing a Cylinder Leakage Test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket/faulty lower intake manifold gasket	Replace the head gasket, lower intake manifold gasket and components as required. Refer to Cylinder Head Assemble and Cylinder Head Replacement - Left or Cylinder Head Replacement - Right .
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to Cylinder Head Replacement - Left

	or Cylinder Head Replacement - Right.
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 gauge 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 gauge at each stroke.
 4. Disconnect the gauge.
 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

Tools Required

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

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

CAUTION: Refer to Battery Disconnect Caution 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**.
4. Measure each cylinder on the compression stroke, with both valves closed.

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

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

IMPORTANT:

- **Normal cylinder leakage is from 12 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**.
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 gauge

Replace the oil pressure gauge.

- Improper oil viscosity or diluted oil

- Install oil of proper viscosity for expected temperature.

- Install new oil if the oil is diluted.

- A worn or dirty oil pump

Clean or replace the oil pump.

- A plugged oil filter

Replace the oil filter.

- A loose or plugged oil pickup screen

Replace the oil pickup screen.

- A hole in the oil pickup tube

Replace the oil pickup tube.

- Excessive rod, main, or cam bearing clearance

Replace the bearings.

- Cracked, porous, or plugged oil gallery

Repair or replace the engine block.

- Missing or improperly installed gallery plugs

Install or repair the plugs as needed.

- A stuck pressure regulator valve

- Inspect the pressure regulator valve for sticking in the bore.
- Inspect the bore for scoring and burrs.
- A worn or poorly machined camshaft

Replace the camshaft.

- Worn valve guides

Repair the valve guides as needed.

Oil Pressure Testing

Tools Required

J 25087-C Oil Pressure Tester. See Special Tools.

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

1. Inspect the oil level.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
3. Remove the oil filter.
4. Assemble the plunger valve in the large hole of the **J 25087-C** base. See Special Tools. Insert the hose in the small hole of the **J 25087-C** base. See Special Tools. Connect the 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. See Special Tools.
7. Start the engine.
8. Inspect the overall oil pressure, the oil pressure switch, and for noisy lifters. Ensure that the engine is at operating temperature before inspecting the oil pressure. The oil pressure should be approximately 207-310 kPa (30-45 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.

You may repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the leak and the cause of leak.

Locating and Identifying the Leak

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

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

Visual Inspection Method

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

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

Powder Method

1. Completely clean the entire engine and surrounding components.
2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area.
3. Operate the vehicle for several miles at normal operation temperature and at varying speeds.
4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.
5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.

Refer to Possible Causes for Leaks if necessary.

Black Light and Dye Method

A dye and light kit is available for finding leaks.

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

Refer to Possible Causes for Leaks if necessary.

Possible Causes for Leaks

Inspect the vehicle for the following conditions:

- Higher than recommended fluid levels
- Higher than recommended fluid pressures
- Plugged or malfunctioning fluid filters or pressure bypass valves
- Plugged or malfunctioning engine ventilation system
- Improperly tightened or damaged fasteners
- Cracked or porous components
- Improper sealants or gaskets where required
- Improper sealant or gasket installation
- Damaged or worn gaskets or seals
- Damaged or worn sealing surfaces

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Results Of Incorrect Operation

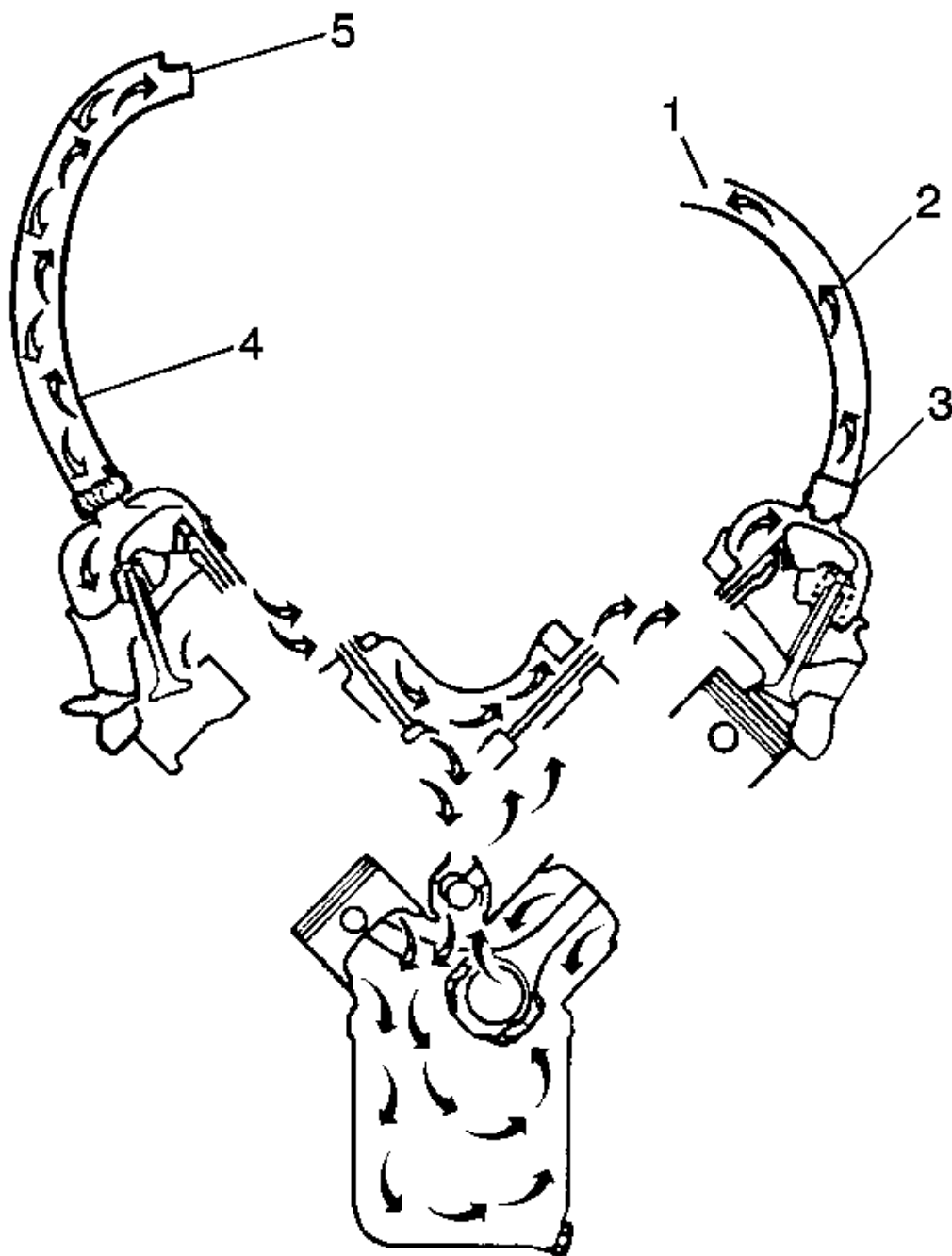


Fig. 6: Crankcase Ventilation System Flow Diagram
Courtesy of GENERAL MOTORS CORP.

- A plugged valve (3) or hose (2 & 4) may cause the following conditions:
 - Rough idle
 - Stalling or a low idle speed
 - Oil leaks
 - Oil in the air cleaner
 - Sludge in the engine
- A leaking crankcase ventilation valve (3) or hose (2 & 4) may cause the following conditions:
 - Rough idle
 - Stalling
 - High idle speed

Functional Test

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

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

If an engine is idling rough, inspect for a clogged crankcase ventilation valve, a dirty vent filter or air cleaner element, or a plugged hose. Replace any components as required. Refer to the following procedure:

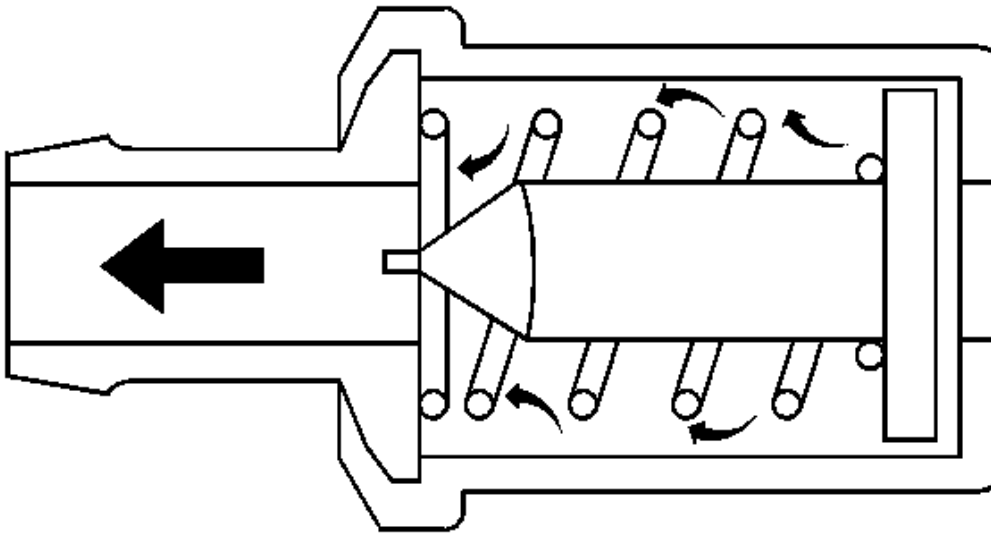


Fig. 7: Crankcase Ventilation Valve Flow Diagram
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankcase ventilation valve from the rocker arm cover.
2. Operate the engine at idle.
3. Place your thumb over the end of the valve in order to check for a vacuum. If there is no vacuum at the valve, check for the following items:
 - Any plugged hoses
 - The manifold port
 - The crankcase ventilation valve
4. Turn OFF the engine. Remove the crankcase ventilation valve. Shake the valve. Listen for the rattle of the check needle inside of the valve. If valve does not rattle, replace the valve.

DRIVE BELT CHIRPING DIAGNOSIS

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
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. • Verify the condition by spraying water on the belt. The noise should stop momentarily.			
1	Check for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 2	Go to Step 3
2	Replace any misaligned pulleys. Is the chirp still present?	Go to Step 3	System OK
3	Check for bent or cracked brackets. Are there any bent or cracked brackets?	Go to Step 4	Go to Step 5
4	Replace any bent or cracked brackets. Is the chirp still present?	Go to Step 5	System OK
5	Check for any loose or missing fasteners. Are there any loose or missing fasteners?	Go to Step 6	Go to Step 7
6	1. Tighten any loose fasteners. 2. Replace any missing fasteners. Refer to <u>Fastener Tightening Specifications</u> . Is the chirp still present?	Go to Step 7	System OK
7	Check for a bent pulley flange. Is there a bent pulley flange?	Go to Step 8	Go to Step 9
8	Replace the pulley. Is the chirp still present?	Go to Step 9	System OK
9	Check for severe pilling, exceeding 1/3 of the belt groove depth.		

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	Is there severe pilling?	Go to Step 10	-
10	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Is the repair complete?	-	System OK

DRIVE BELT SQUEAL DIAGNOSIS**Drive Belt Squeal Diagnosis**

Step	Action	Yes	No
DEFINITION: The following items are indications of 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.			
1	Check for a misaligned pulley. Is there a pulley misaligned?	Go to Step 3	Go to Step 2
2	Check for correct drive belt length. Is the drive belt the correct length?	Go to Step 4	Go to Step 5
3	Repair or replace with new parts as necessary. Is the repair complete?	System OK	-
4	Check the drive belt tensioner for proper operation. Is the drive belt tensioner operating correctly?	Go to Step 3	Go to Step 5
5	Check for correct pulley size. Are the pulleys the correct size?	Go to Step 6	Go to Step 3
6	Check for seized bearings. Is there a seized bearing?	Go to Step 3	System OK

DRIVE BELT WHINE DIAGNOSIS**Drive Belt Whine Diagnosis**

Step	Action	Yes	No
DEFINITION: A high pitched continuous noise that may be caused by a failed bearing.			
1	Check for a worn accessory component bearing. Is a bearing making the noise?	Go to Step 2	System OK
2	Install new part as necessary. Is the repair complete?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS**Drive Belt Rumbling Diagnosis**

Step	Action	Yes	No
DEFINITION:			
A low pitch tapping noise caused by drive belt misalignment			

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- This noise occurs on cold start-up at idle.
- A low frequency noise heard once per revolution of the drive belt

1	Check for severe pilling. Is there severe pilling of more than 1/3 of the rib depth?	Go to Step 2	System OK
2	Clean the drive belt pulleys. Is the repair complete?	System OK	Go to Step 3
3	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . Is the repair complete?	System OK	-

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, 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 belts 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 belts may cause a vibration. While the drive belts are 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 fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.

9: 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.

10: 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.			

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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>Vibration Analysis - Engine</u> in Vibration Diagnosis and Correction
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 30-40 seconds. Does the engine still make the vibration?	Go to <u>Diagnostic Starting Point - Vibration Diagnosis and Correction</u> in Vibration Diagnosis and Correction	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 11	-
6	Inspect for improper, loose, or missing fasteners. Did you find any of these conditions?	Go to Step 7	Go to Step 8
7	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to <u>Fasteners</u> in General Information. Did you complete the repair?	Go to Step 11	-
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Did you find and correct the condition?	Go to Step 11	Go to Step 9
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Did you find and correct the condition?	Go to Step 11	Go to Step 10
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 11	Go to Diagnostic Aids
11	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 belts 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 to the belt may have occurred when it came off of the pulleys. The drive belt may have been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misaligned pulley is found, refer to that accessory drive component for the proper installation procedure for 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 <u>Drive Belt System Description</u>
2	Inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to <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.		

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	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	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to <u>Fasteners</u> in General Information. 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 mispositioning 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	Remove the drive belt. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 4	Go to Step 2
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 4
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement

Removal Procedure

1. Remove the air cleaner assembly. Refer to [Air Cleaner Assembly Replacement](#) in Engine Controls.
2. Remove the engine mount strut. Refer to [Engine Mount Strut Replacement](#).

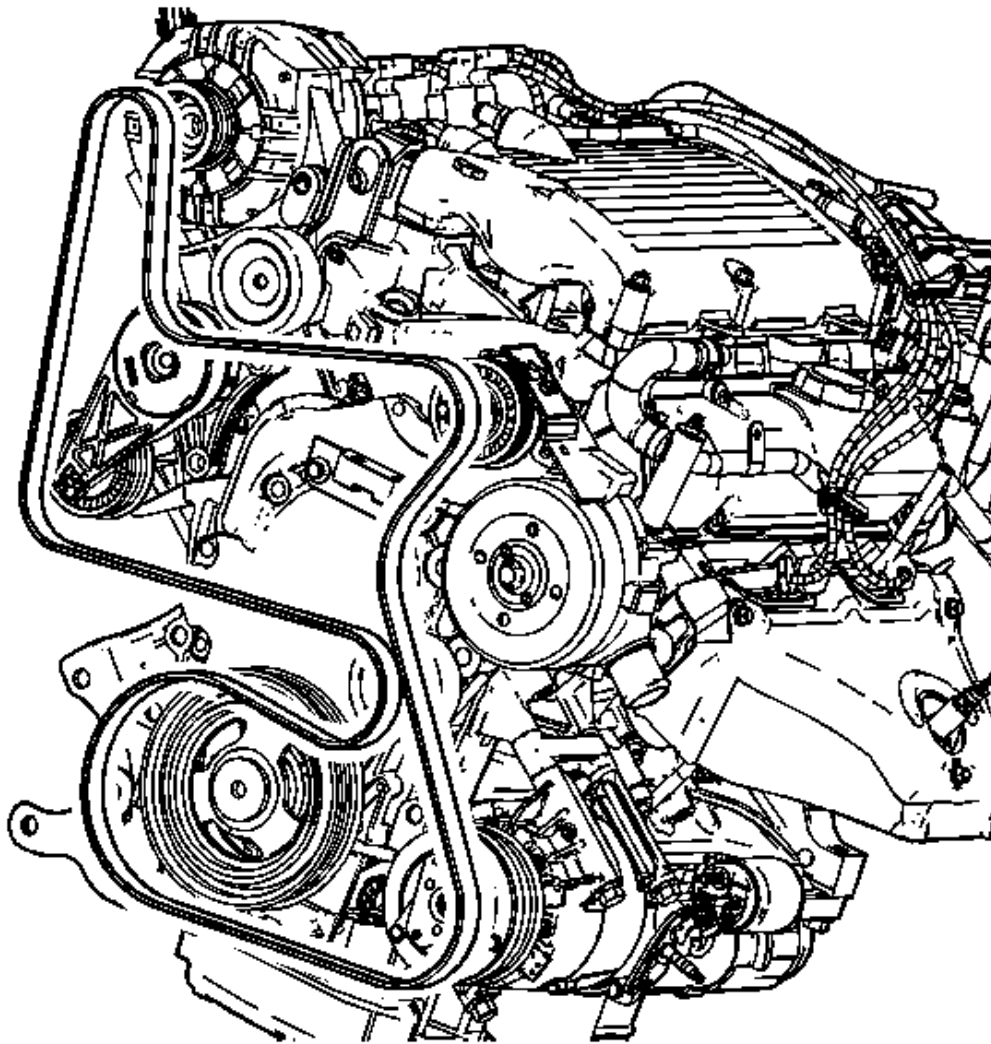
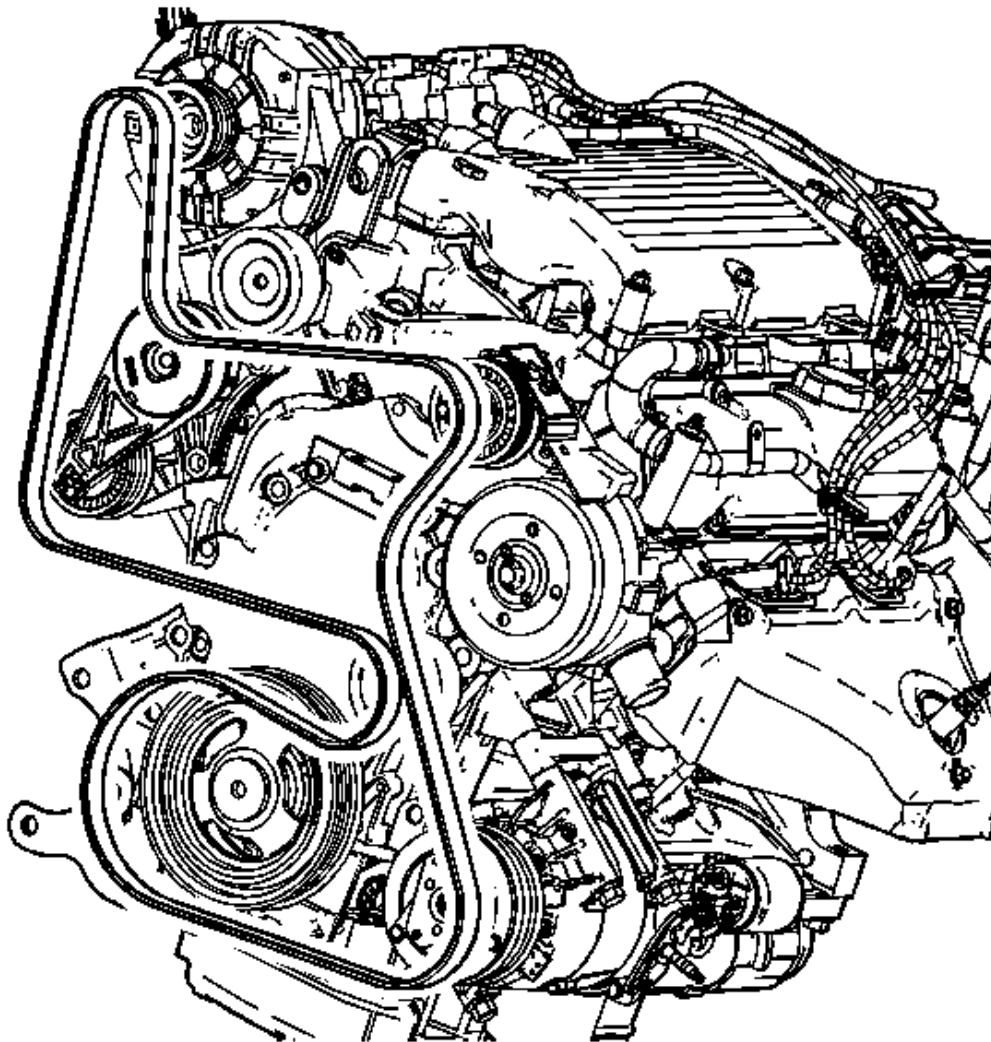


Fig. 8: View Of Drive Belt Routing**Courtesy of GENERAL MOTORS CORP.**

3. Rotate the drive belt tensioner counterclockwise to release the spring tension.
4. Remove the drive belt.

Installation Procedure**Fig. 9: View Of Drive Belt Routing****Courtesy of GENERAL MOTORS CORP.**

1. Rotate the drive belt tensioner counterclockwise to release the spring tension.
2. Install the drive belt.
3. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.
4. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.

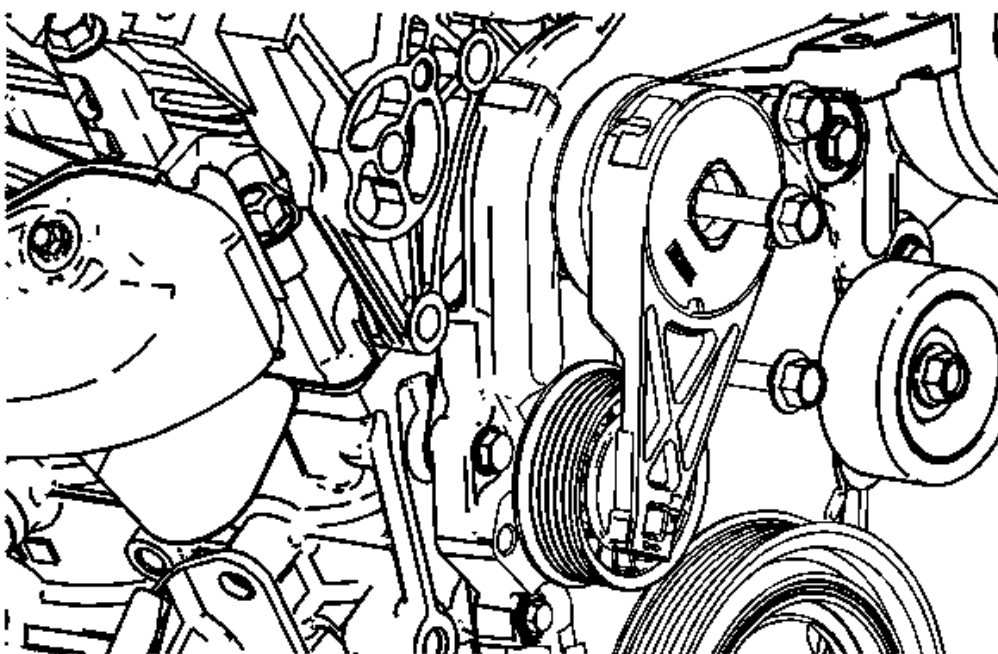
Drive Belt Tensioner Replacement**Removal Procedure**

Fig. 10: View Of Drive Belt Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

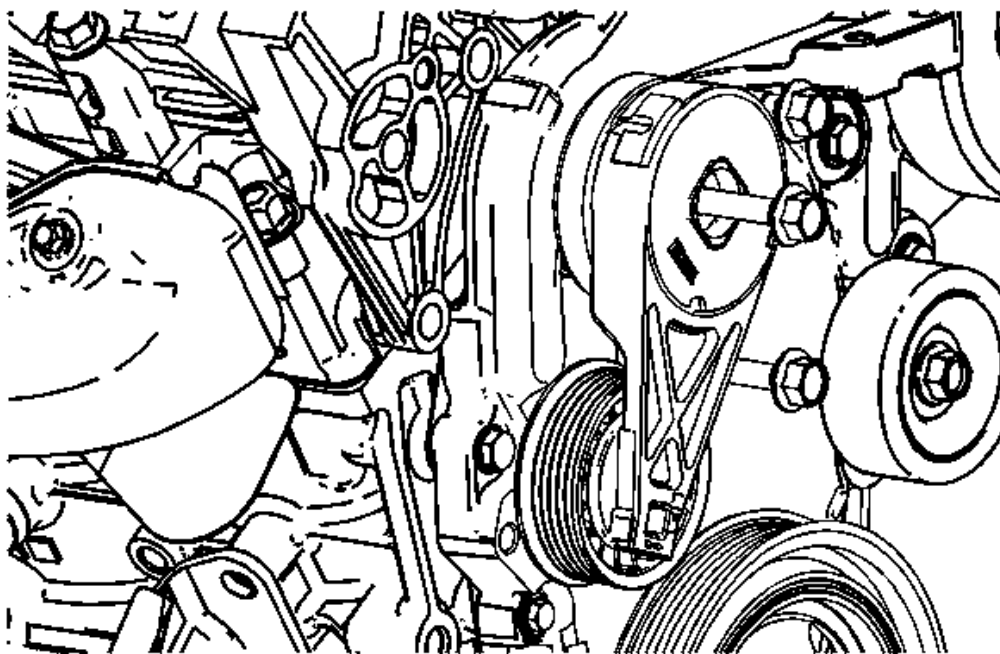


Fig. 11: View Of Drive Belt Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner. **Drive Belt Tensioner Installation.**

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.**

Engine Support Fixture

Tools Required

- J 28467-B Engine Support Fixture. See **Special Tools.**
- J 36462 Engine Support Adapter Leg. See **Special Tools.**

1. Raise the hood.

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

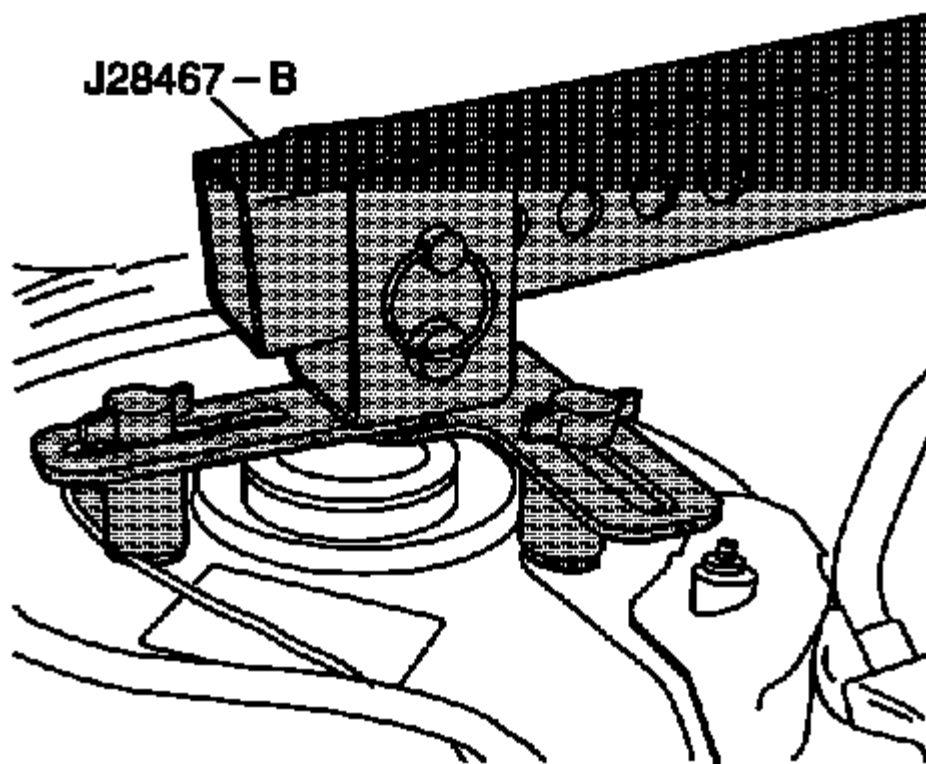


Fig. 12: Installing Thread Support Nuts (J 28467-33A)
Courtesy of GENERAL MOTORS CORP.

3. Install the thread support nuts J 28467-33A onto the strut attaching studs.
4. Install the strut tower support assemblies J 28467-5A over the thread support nuts J 28467-33A.
5. Install the T-bolts J 28467-5 with 5/16 inch washers through the strut tower support assemblies J 28467-5A into the thread support nuts J 28467-33A. Hand tighten the bolts.
6. Install the 2 cross bracket assemblies J 28467-1A over the strut tower tube J 28467-3.
7. Install the strut tower tube J 28467-3 into the strut tower support assemblies J 28467-5A.
8. Install the 1/2 inch x 2.5 inch quick release pin J 28467-10 through the strut tower support assemblies J 28467-5A and the strut tower tube J 28467-3 on one side only.

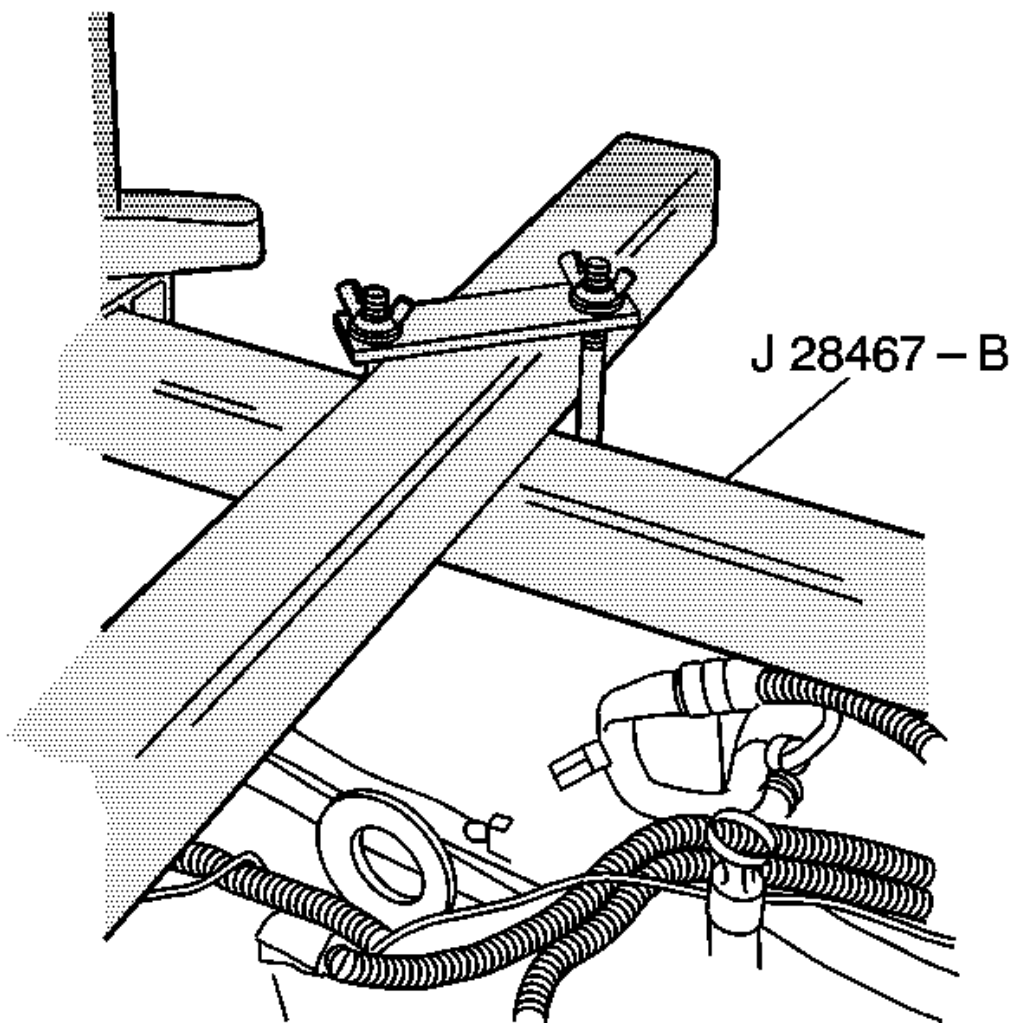


Fig. 13: Installing Radiator Shelf Tube (J 28467-2A)
Courtesy of GENERAL MOTORS CORP.

9. Install the radiator shelf tube J 28467-2A through the driver side cross bracket assembly J 28467-1A on the top of the strut tower tube J 28467-3.
10. Place the rubber padded foot of the front support assembly J 28467-4A on the vehicle radiator shelf. The foot position used in the front support assembly J 28467-4A depends on the vehicle application.
11. Install the 7/16 inch x 2.0 inch quick release pin J 28467-9 through the hole in the front support assembly J 28467-4A in order to level the radiator shelf tube J 28467-2A. The hole used in the front support assembly J 28467-4A depends on the vehicle application.
12. Install the lift hook J 28467-7A through the lift hook bracket J 28467-6A.

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

Engine Mount Inspection

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

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

Engine Mount Replacement

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

2. Remove the tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the engine splash shield. Refer to **Radiator Air Baffle and Deflector Replacement - Lower** in Engine Cooling.

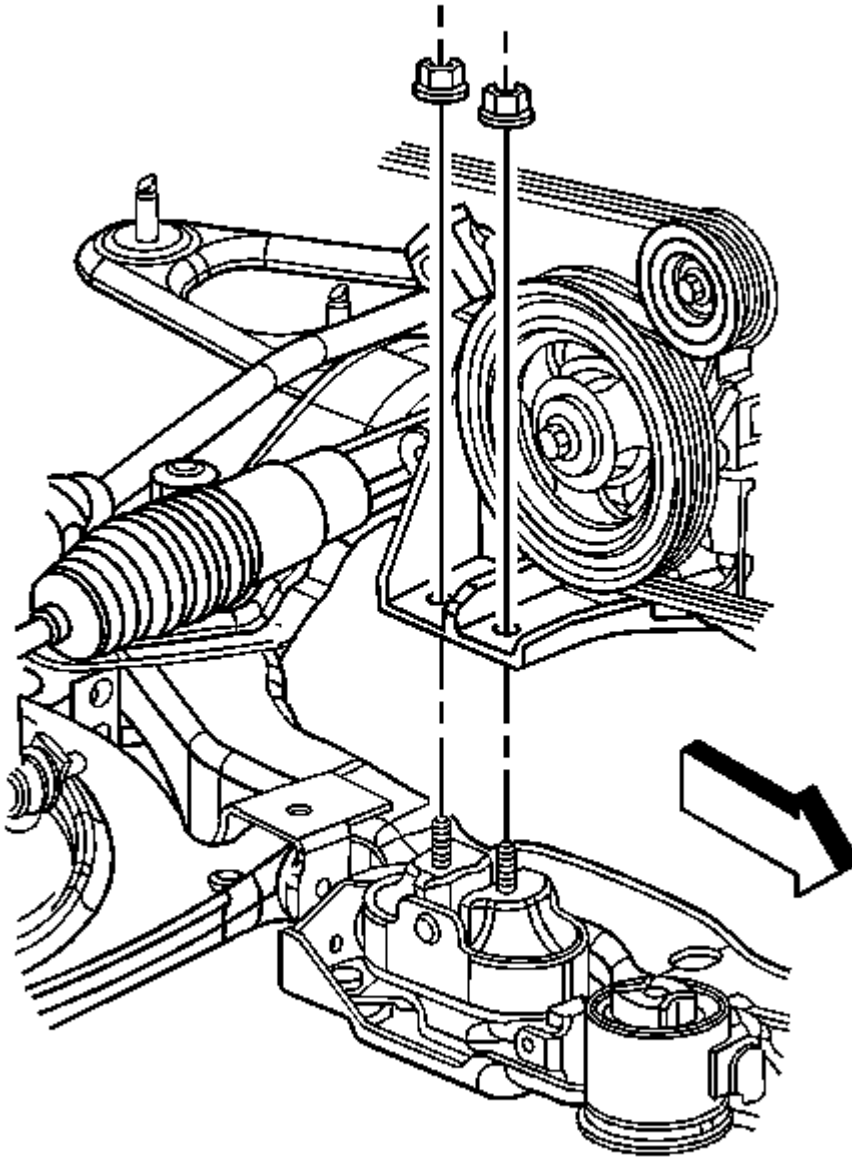


Fig. 14: View Of Engine Mount To Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

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

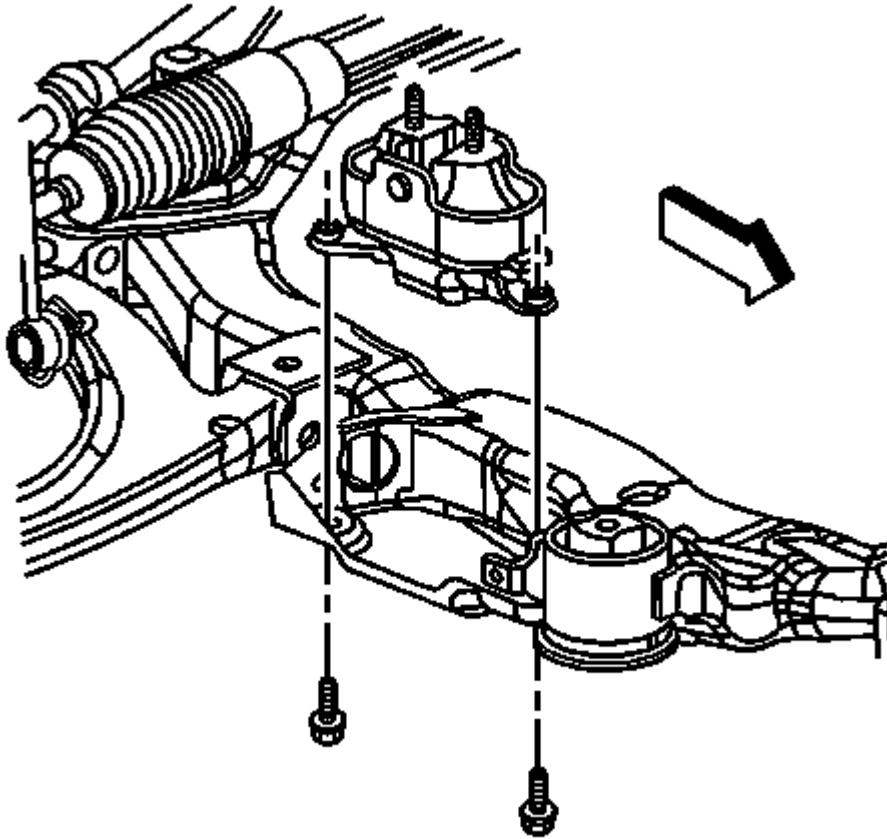


Fig. 15: View Of Frame To Engine Mount Bolts (W/LX9)
Courtesy of GENERAL MOTORS CORP.

5. Remove the motor mount to frame nuts.
6. Using a suitable jackstand, raise the engine.
7. Remove the motor mount from the vehicle.

Installation Procedure

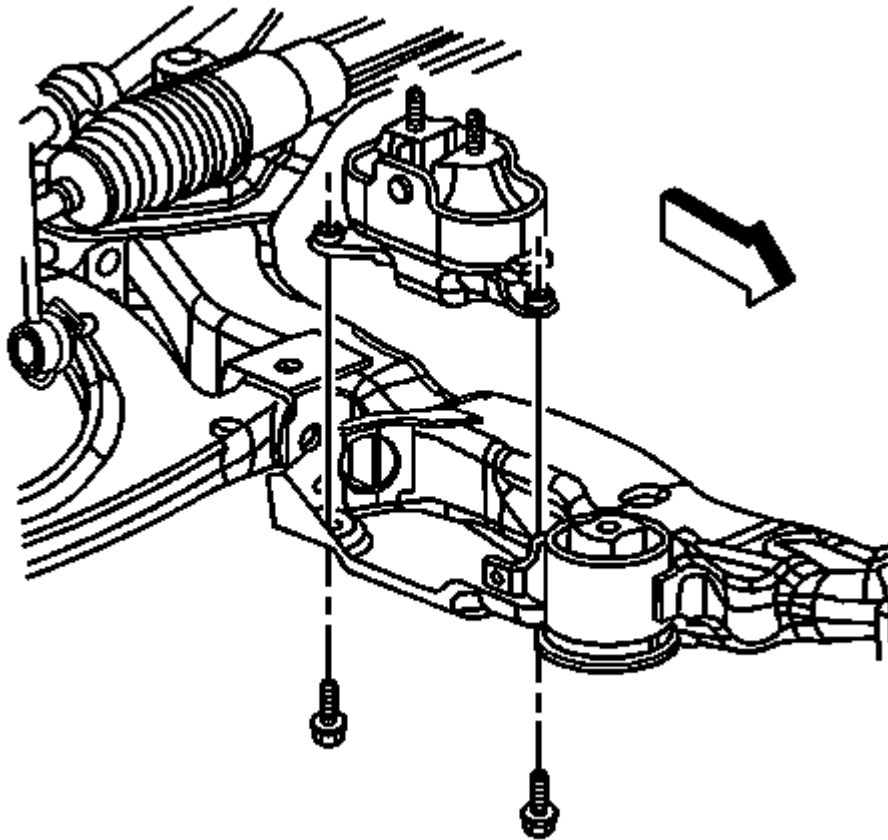


Fig. 16: View Of Frame To Engine Mount Bolts (W/LX9)
 Courtesy of GENERAL MOTORS CORP.

1. Position the motor mount on the frame
2. Use the jackstand to lower the engine mount bracket on to the engine mount.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine mount to frame bolts.

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

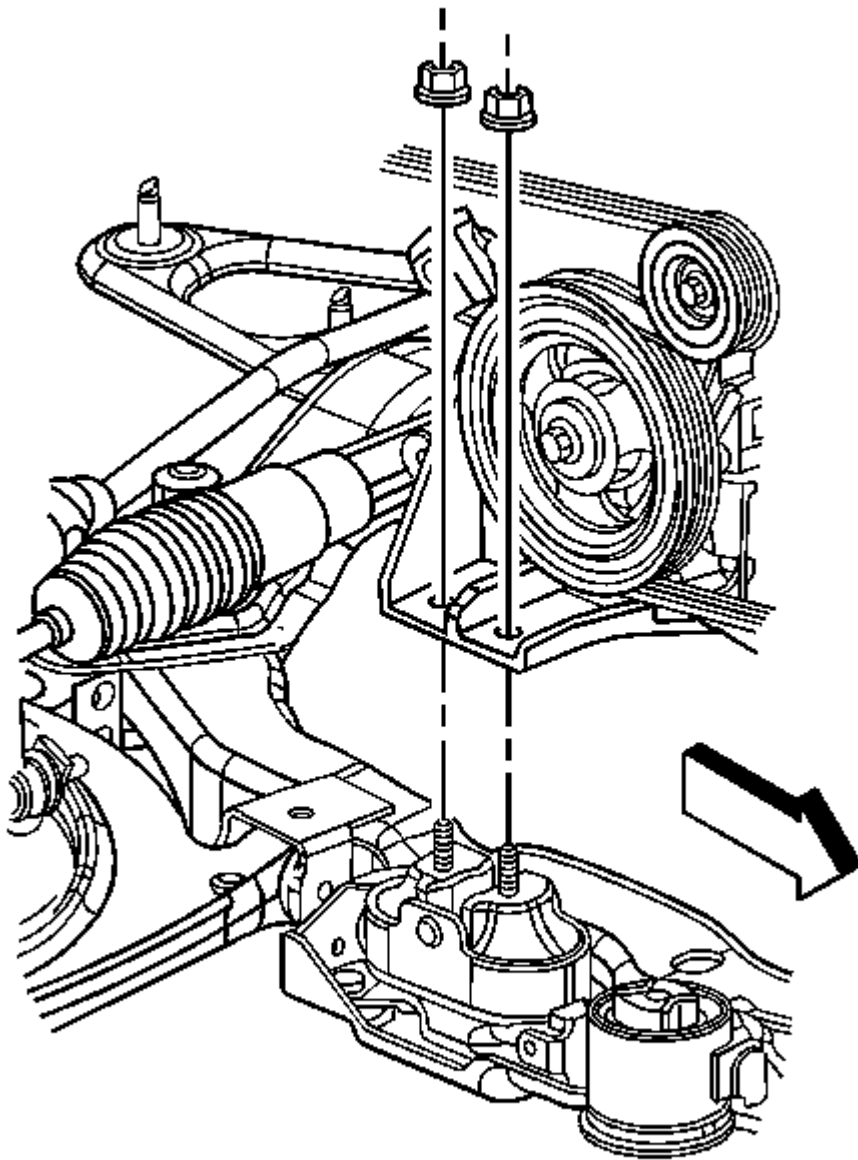


Fig. 17: View Of Engine Mount To Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

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

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

5. Install the engine splash shield. Refer to **Radiator Air Baffle and Deflector Replacement - Lower** in Engine Cooling.
6. Install the tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
7. Lower the vehicle.

Engine Mount Bracket Replacement

Removal Procedure

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

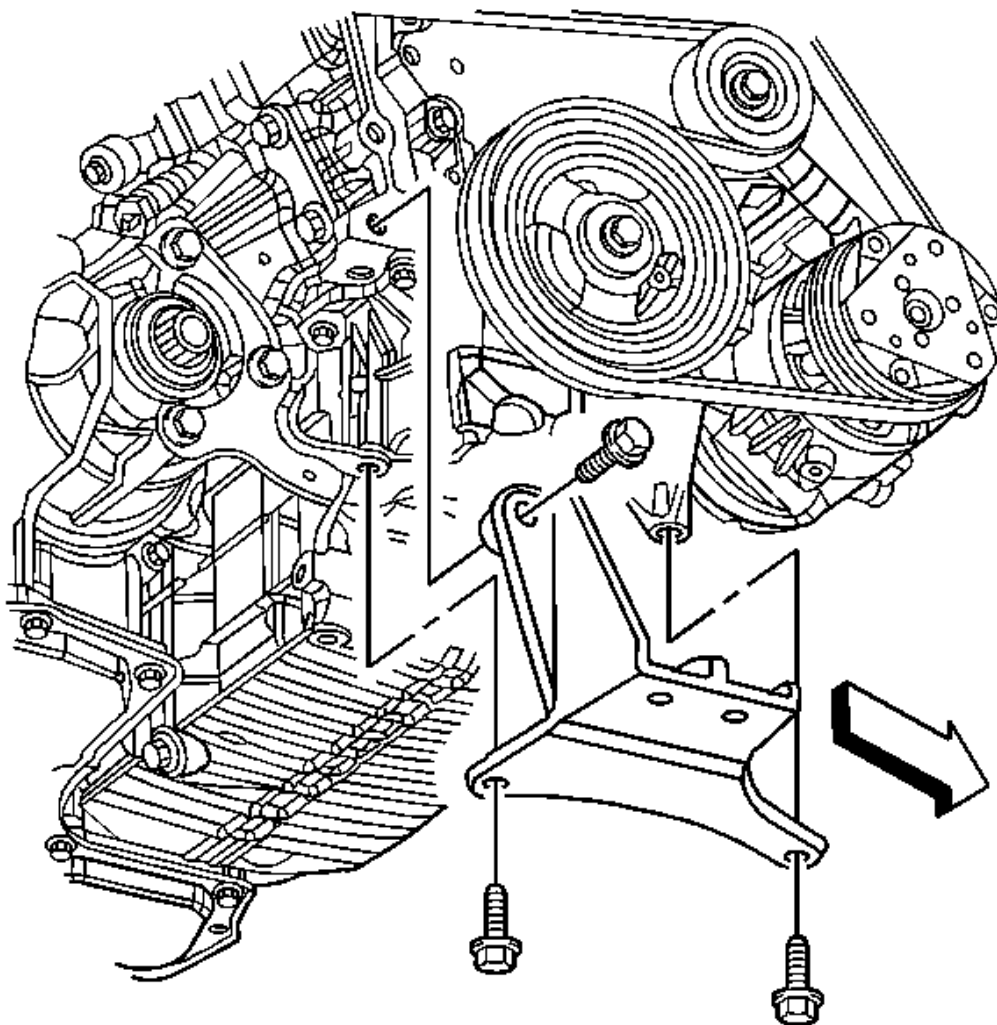


Fig. 18: View Of Engine Mount Bracket Bolts At Engine
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount bracket bolts from the engine.
3. Remove the engine mount bracket from the vehicle.

Installation Procedure

1. Position the engine mount bracket to the engine.

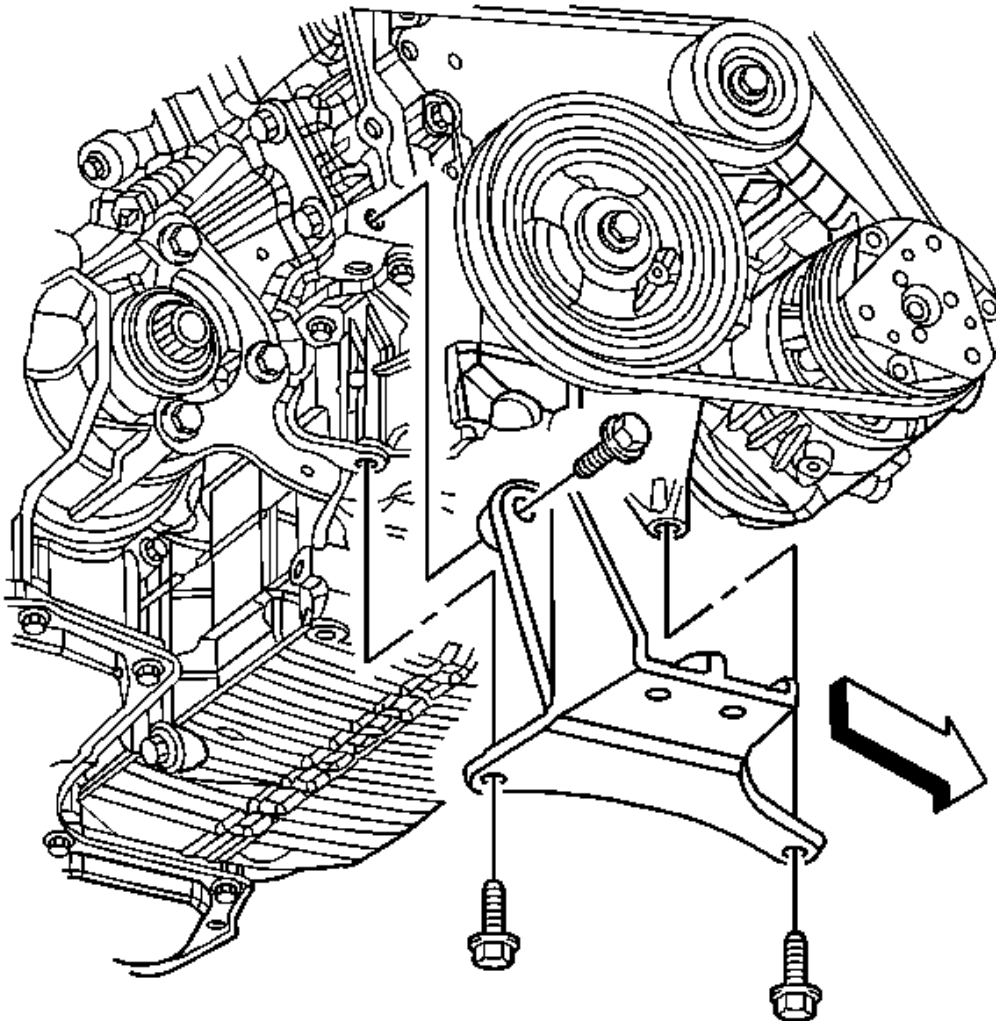


Fig. 19: View Of Engine Mount Bracket Bolts At Engine
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the front mount bracket bolts to the engine. Hand tighten the bolts at this time.

Tighten:

1. Tighten the upper engine mount bracket bolts to 90 N.m (66 lb ft).
 2. Tighten the lower engine mount bracket bolts to 50 N.m (37 lb ft).
3. Install the engine mount. Refer to Engine Mount Replacement.

Engine Mount Strut Replacement

Removal Procedure

1. Remove the air cleaner assembly. Refer to Air Cleaner Assembly Replacement in Engine Controls - 3.5L (LX9).

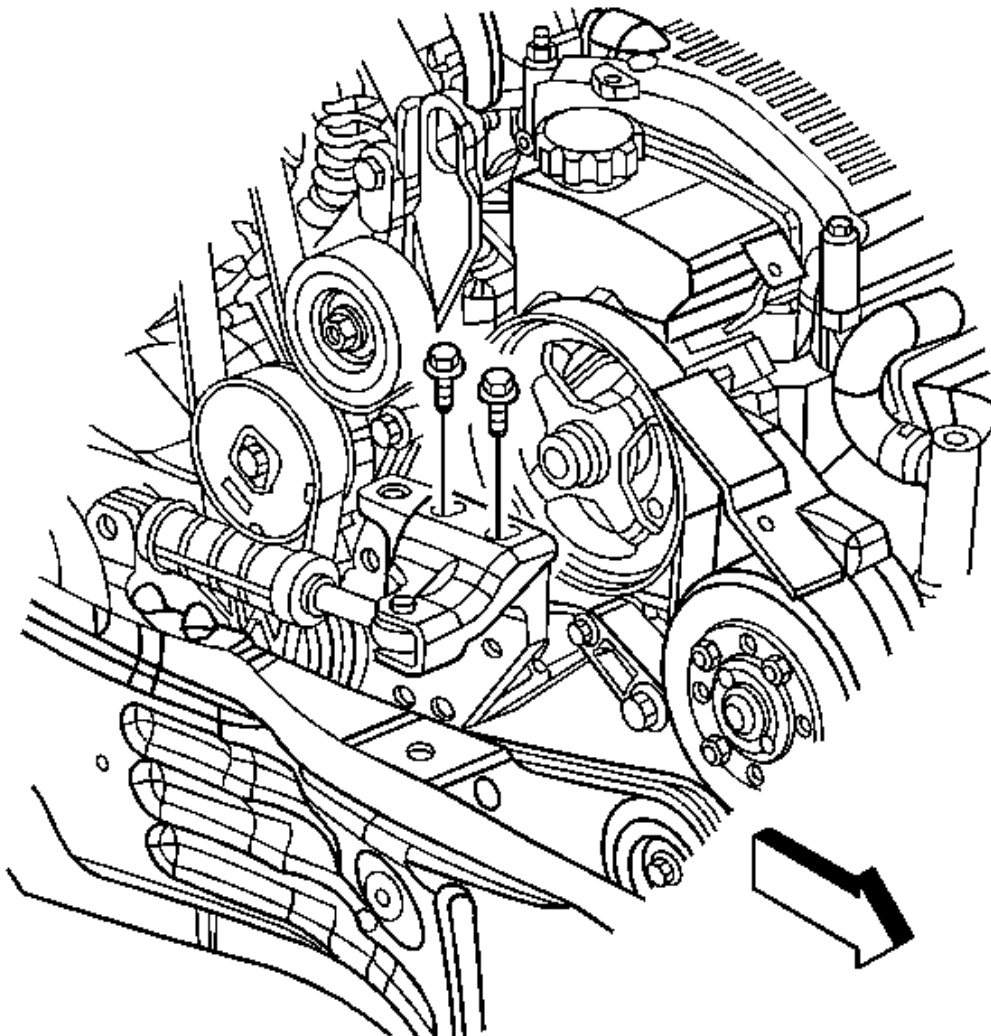


Fig. 20: View Of Engine Mount Strut To Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount strut to engine mount bolts.
3. Rotate the engine mount strut to the vertical position.

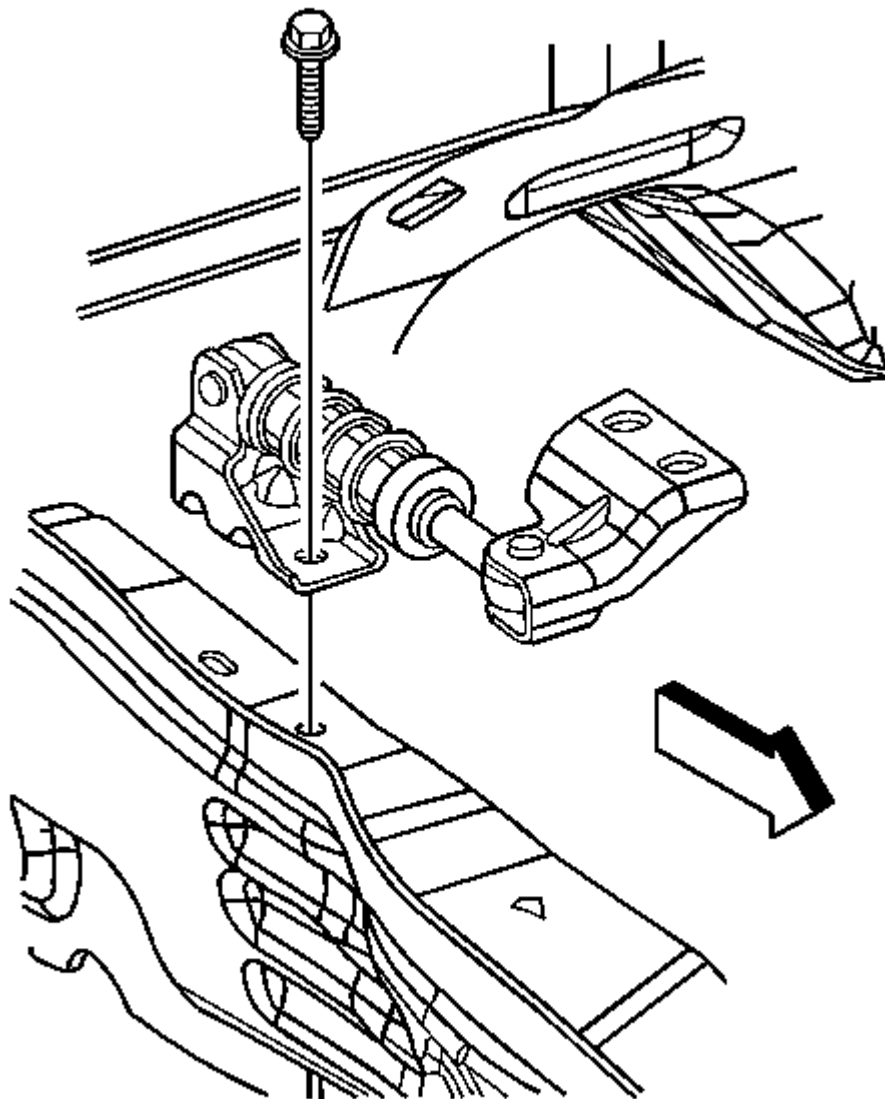


Fig. 21: View Of Engine Mount Strut To Body Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount strut to body bolts.
5. Remove the engine mount strut from the vehicle.

Installation Procedure

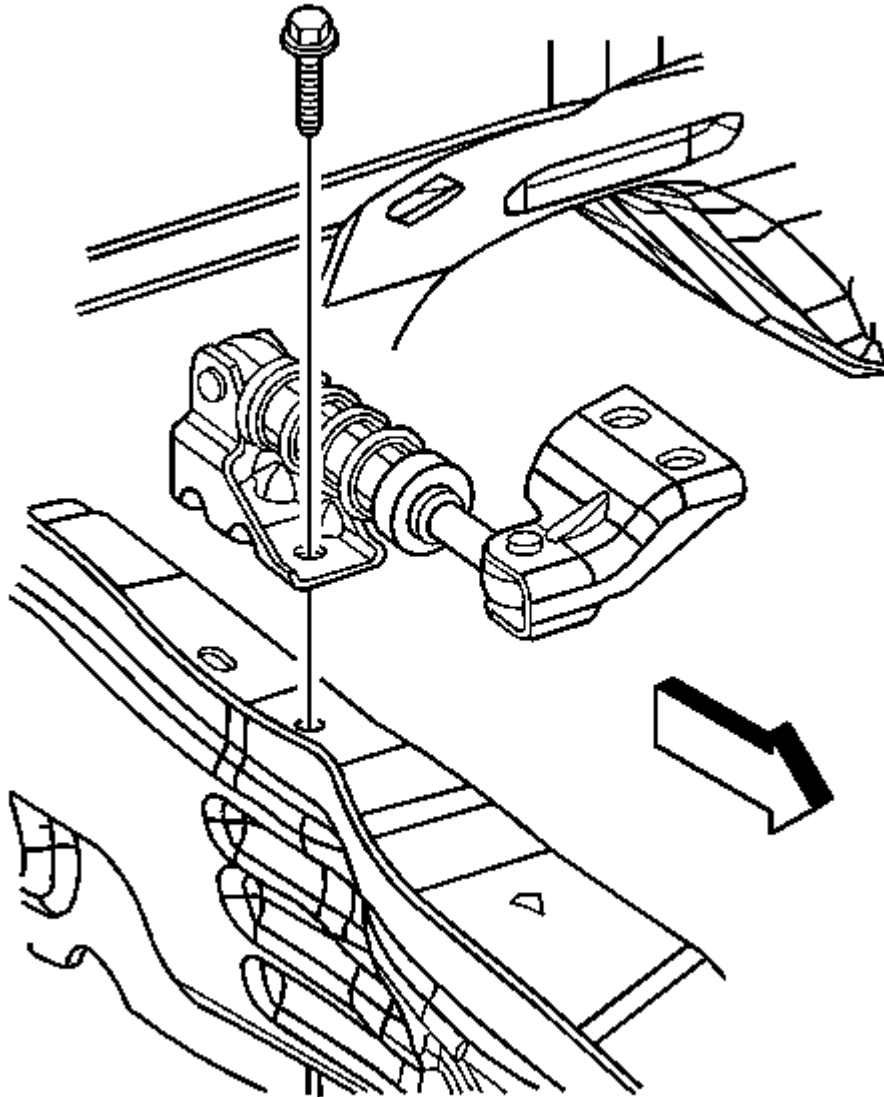


Fig. 22: View Of Engine Mount Strut To Body Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine mount strut in to the vehicle.

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

2. Rotate the engine mount strut to the horizontal position.

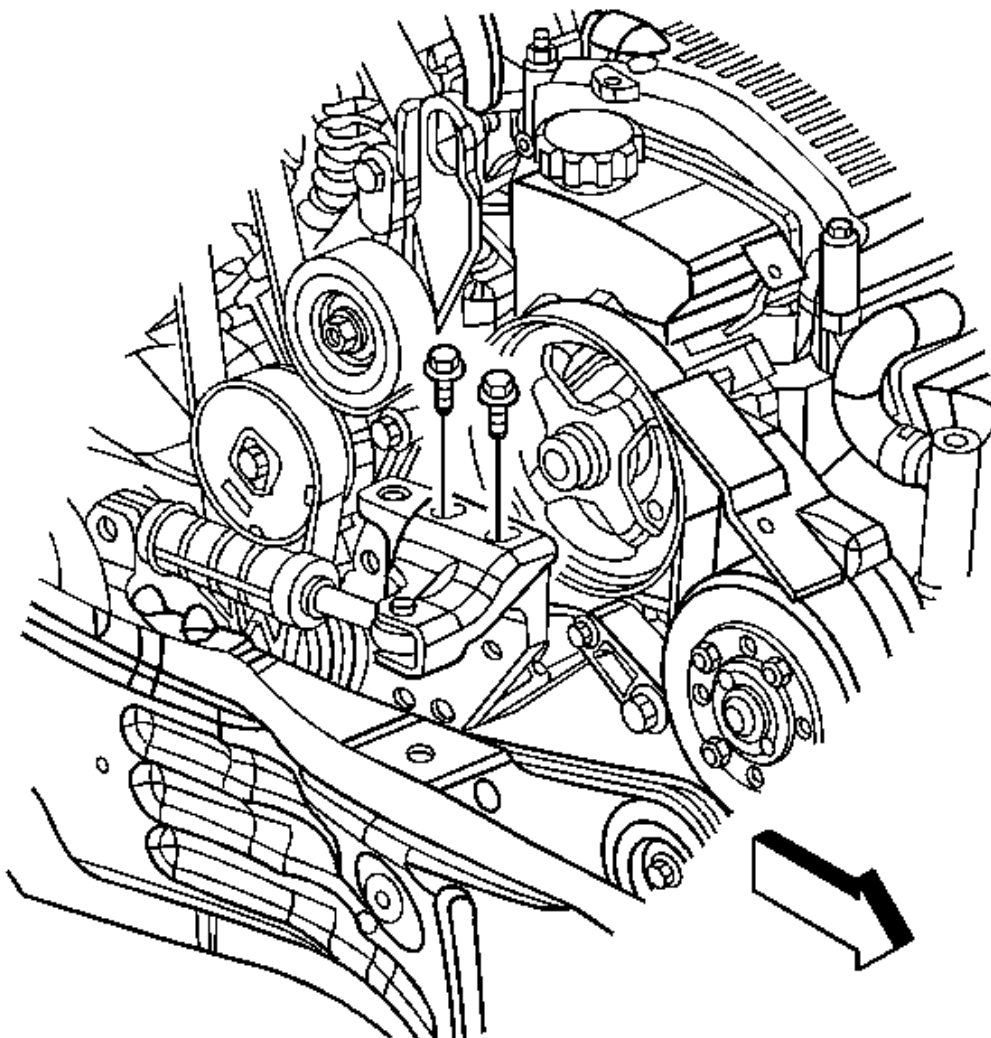


Fig. 23: View Of Engine Mount Strut To Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount strut to bracket bolts.

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

4. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L (LX9).

Engine Mount Strut Bracket Replacement**Removal Procedure**

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

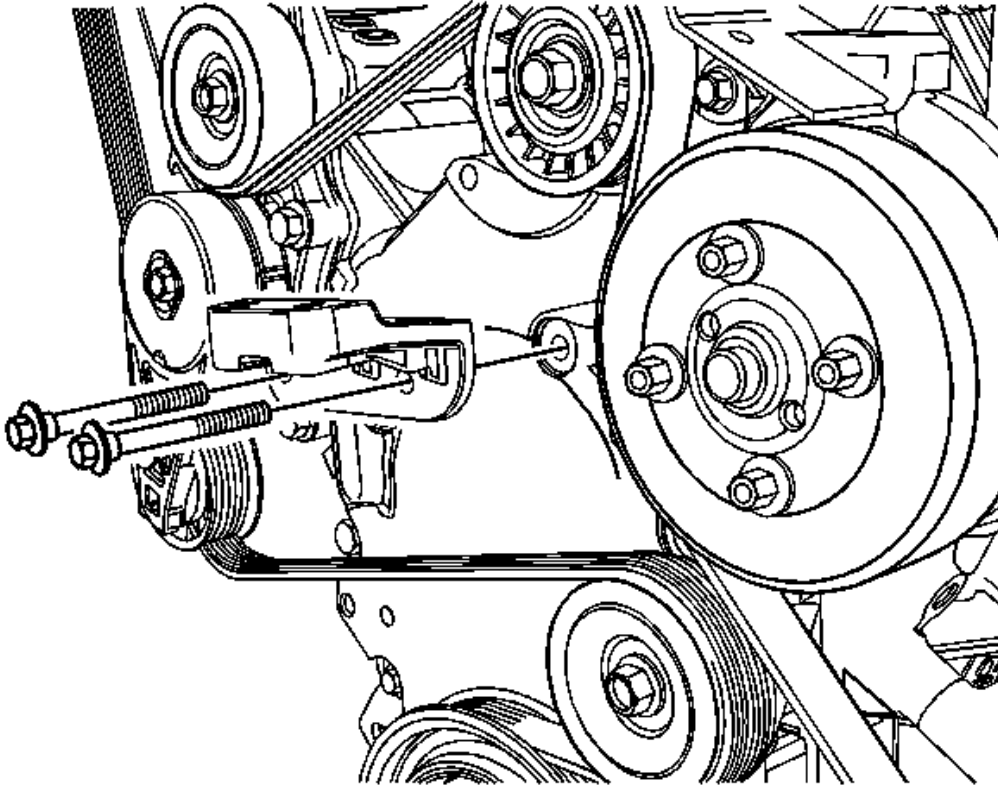


Fig. 24: View Of Engine Mount Strut Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount strut bracket to engine bolts.
3. Remove the engine mount strut bracket from the vehicle.

Installation Procedure

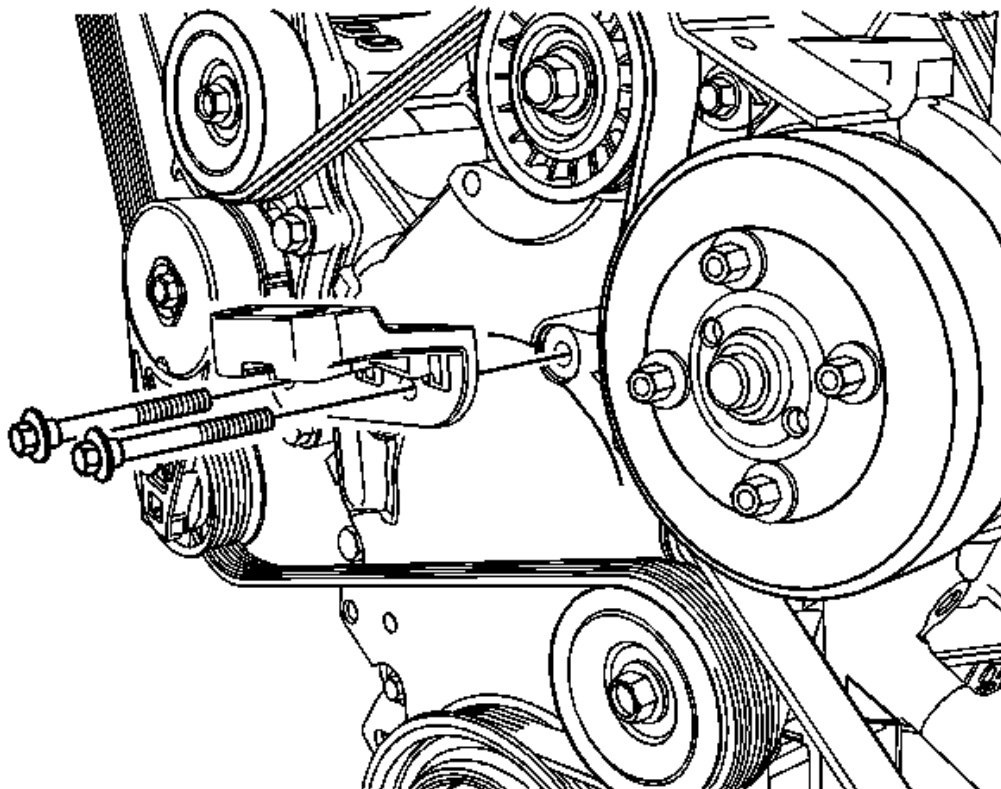


Fig. 25: View Of Engine Mount Strut Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tighten: Tighten the engine mount strut bracket to engine bolts to 25 N.m (18 lb ft).

2. Install the engine mount strut. Refer to Engine Mount Strut Bracket Replacement.

Oil Filter Adapter and Bypass Valve Assembly Replacement

Removal Procedure

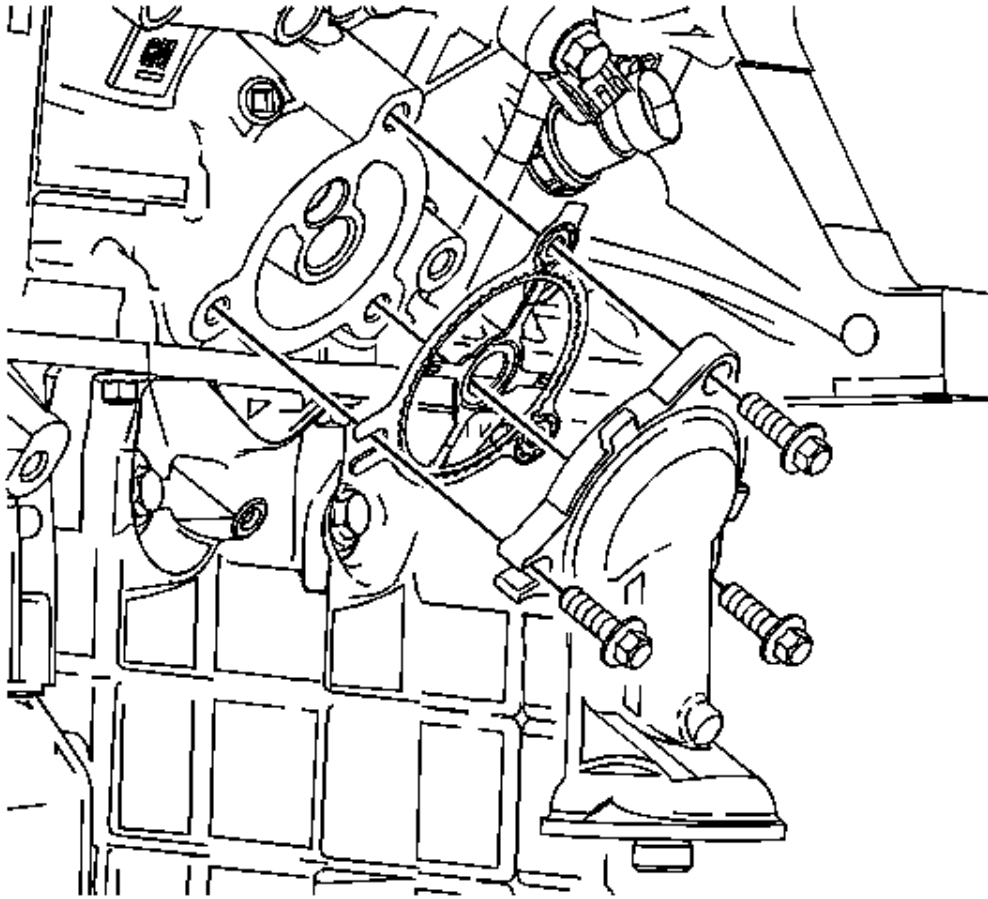


Fig. 26: View Of Oil Filter Adapter And Gasket
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil filter.
3. Remove the oil filter adapter and gasket.

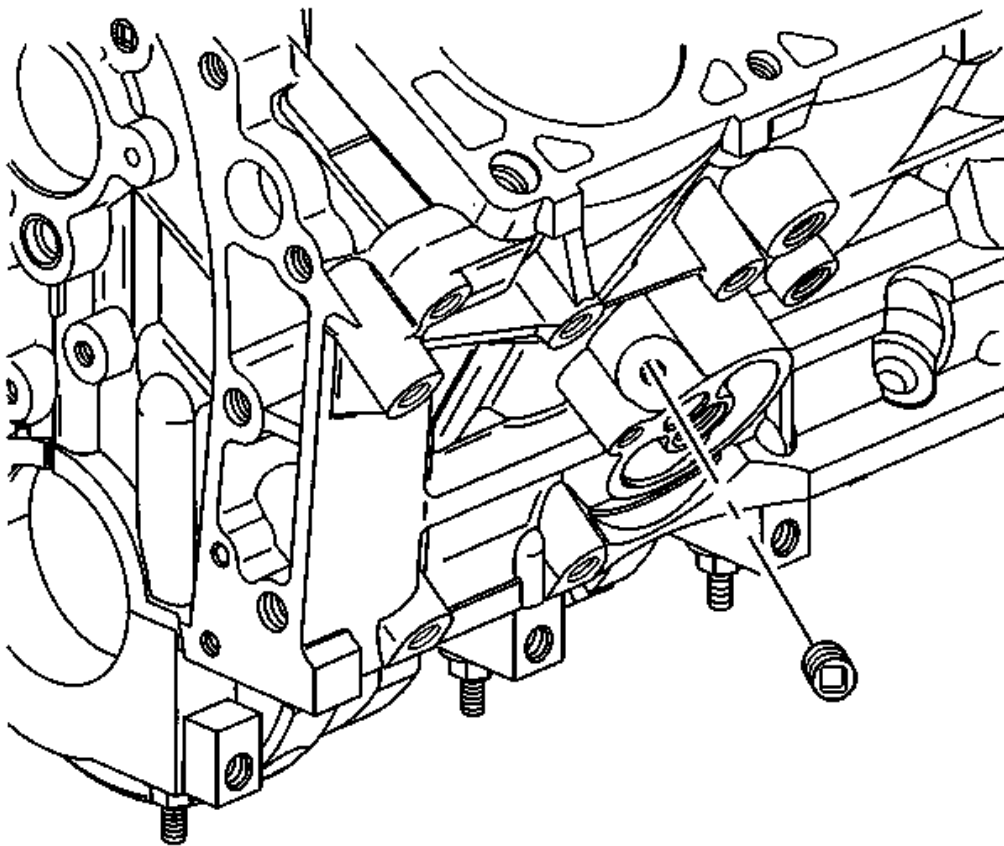


Fig. 27: Oil Filter Bypass Hole Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter bypass hole plug.

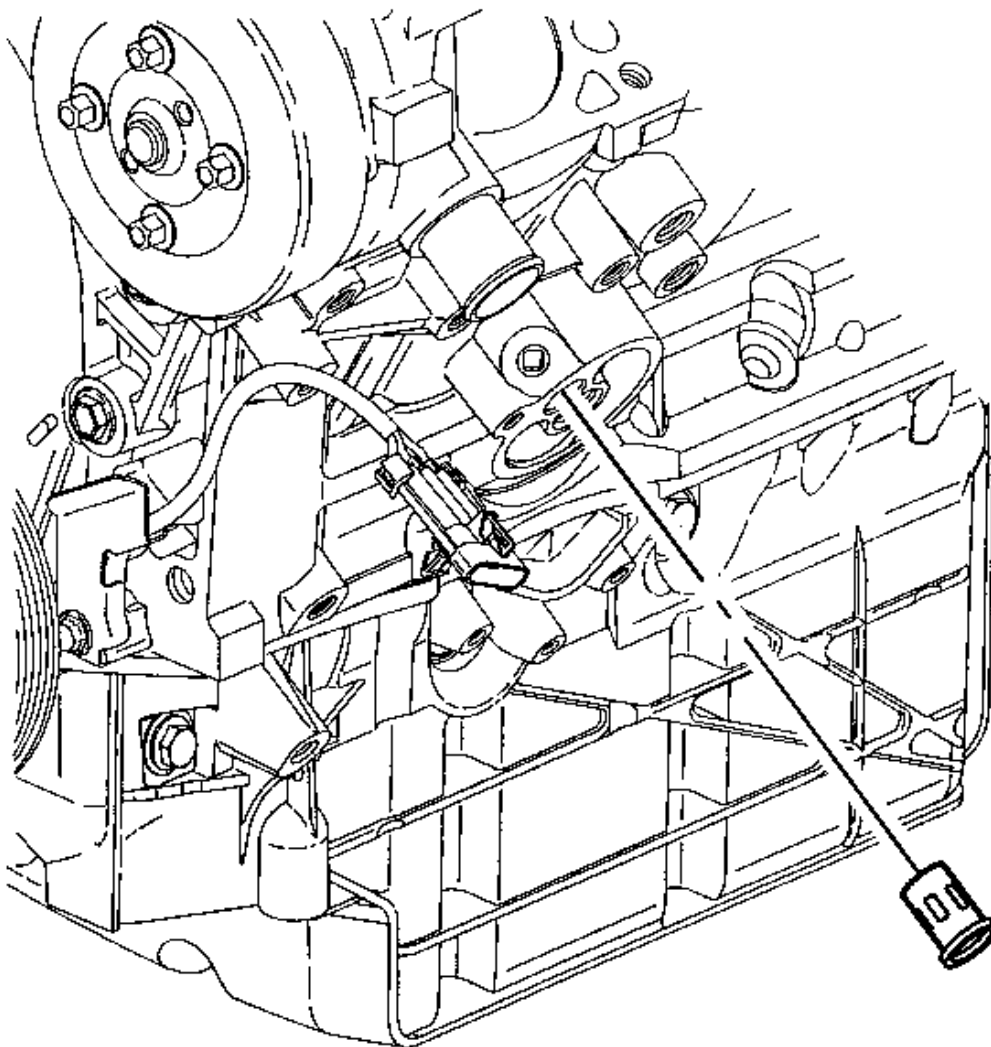


Fig. 28: Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

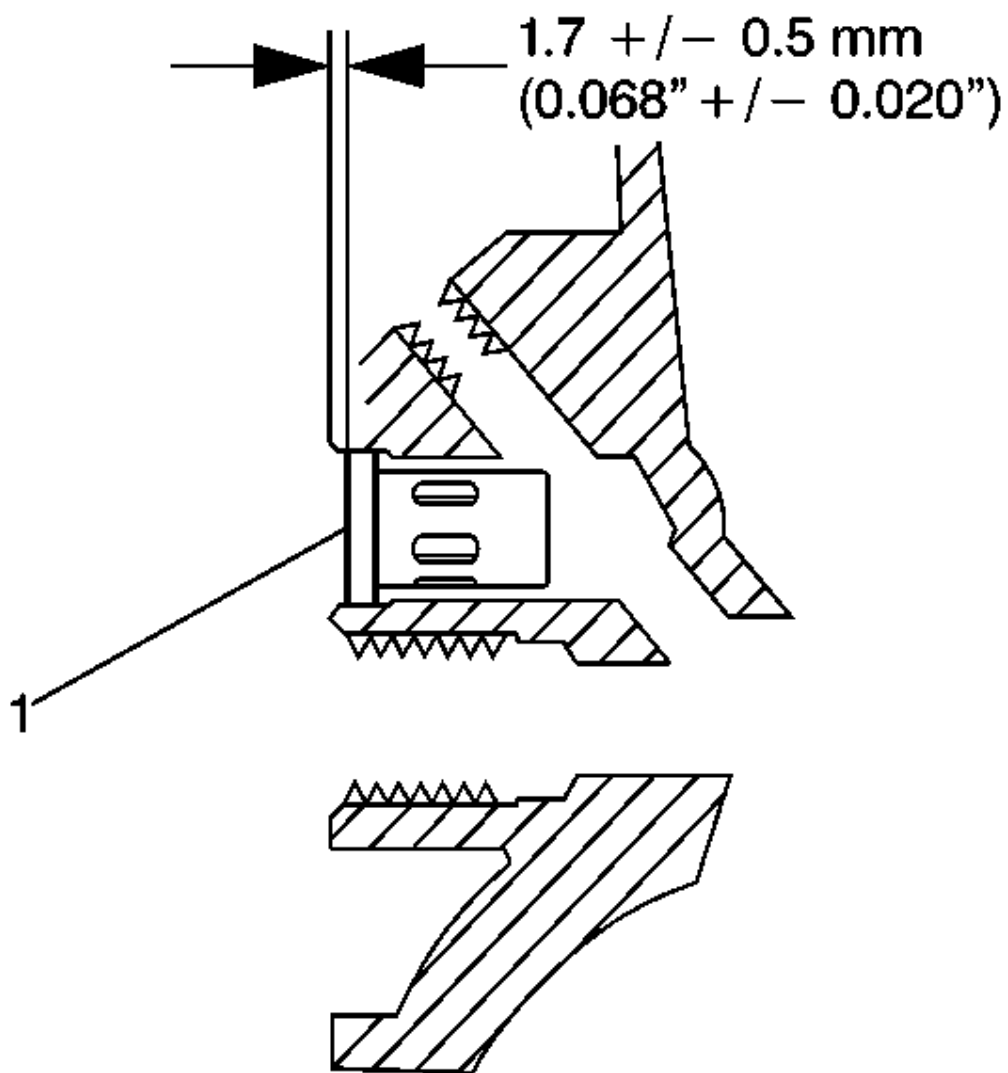


Fig. 29: View Of Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

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

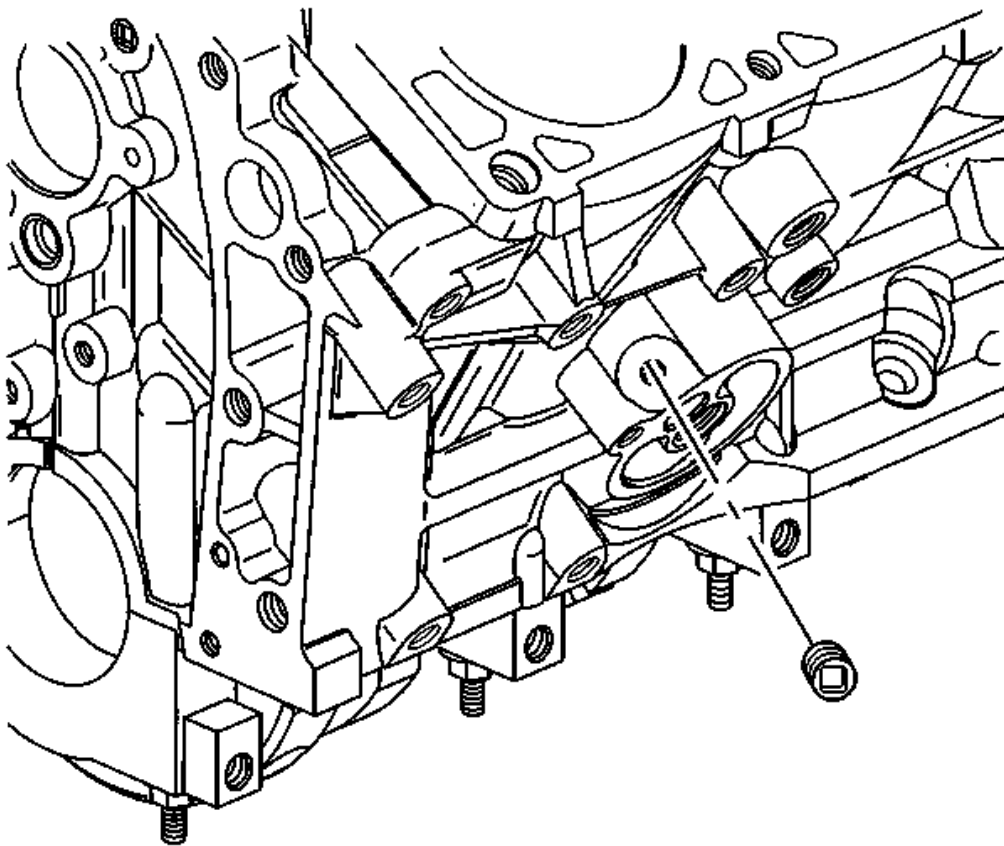


Fig. 30: Oil Filter Bypass Hole Plug
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter bypass hole plug.

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

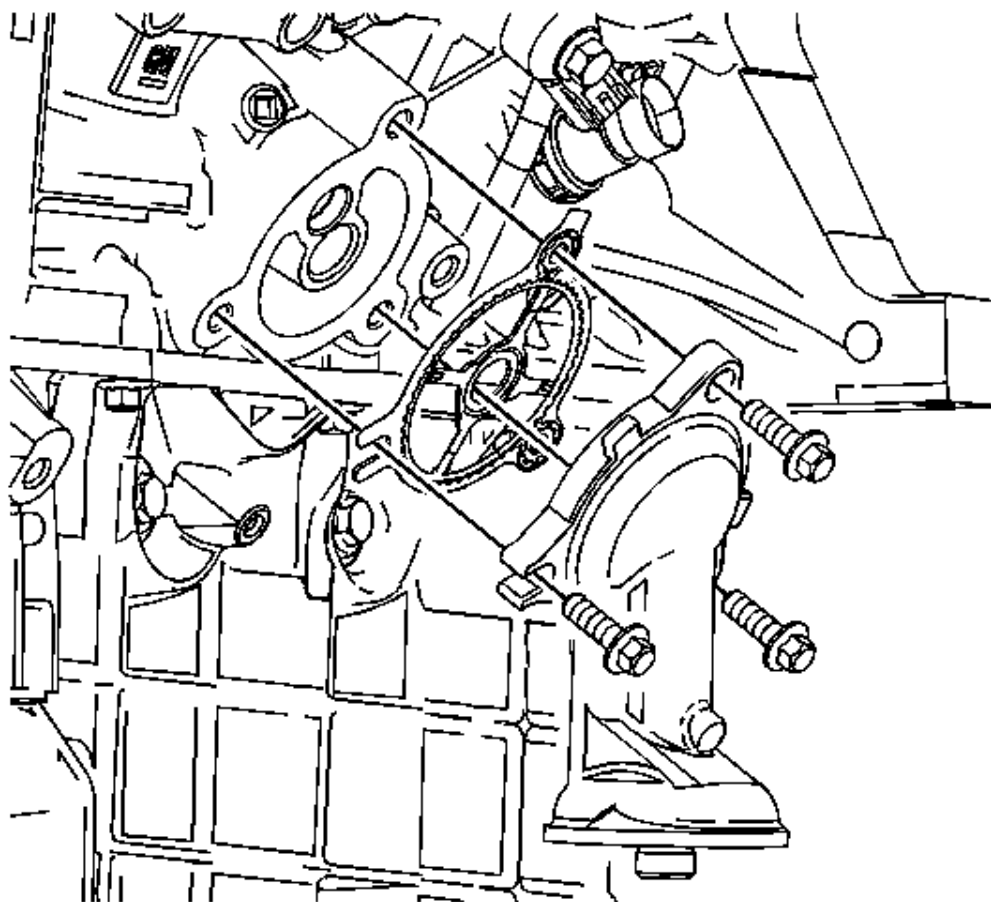


Fig. 31: View Of Oil Filter Adapter And Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter and gasket.

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

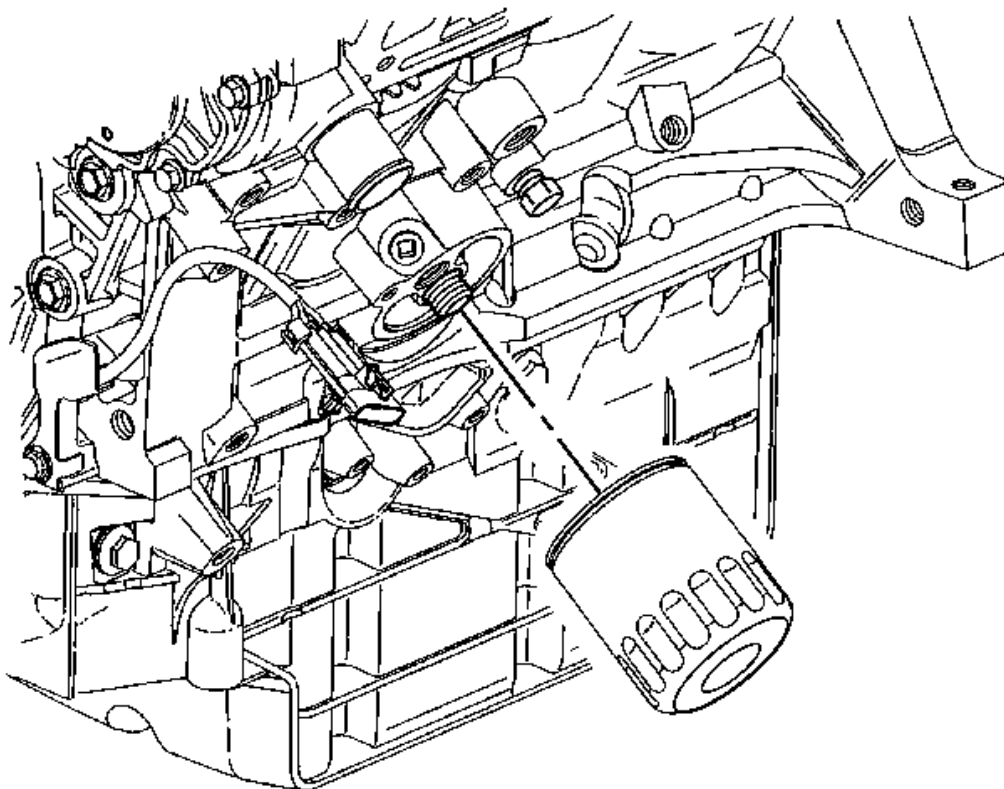


Fig. 32: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Install the oil filter.
5. Lower the vehicle.
6. Check and fill the crankcase as necessary.

Oil Level Indicator and Tube Replacement

Removal Procedure

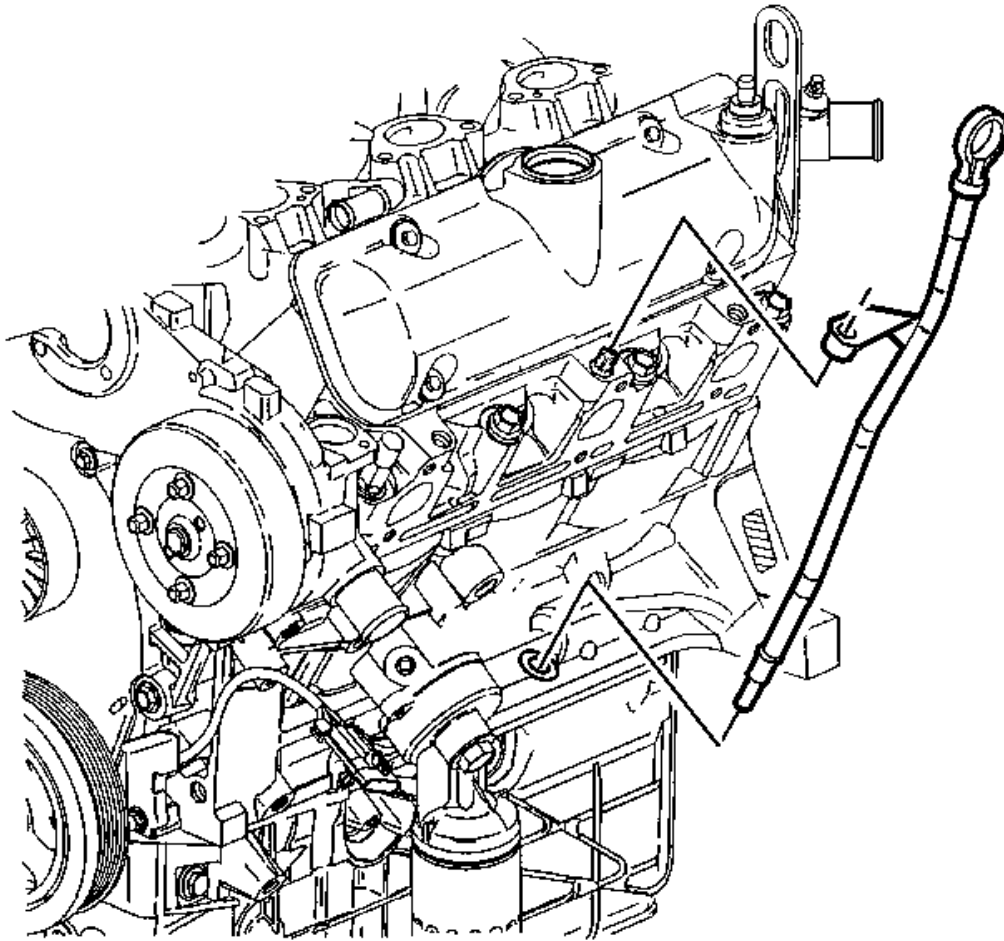


Fig. 33: Removing/Installing Oil Level Indicator & Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

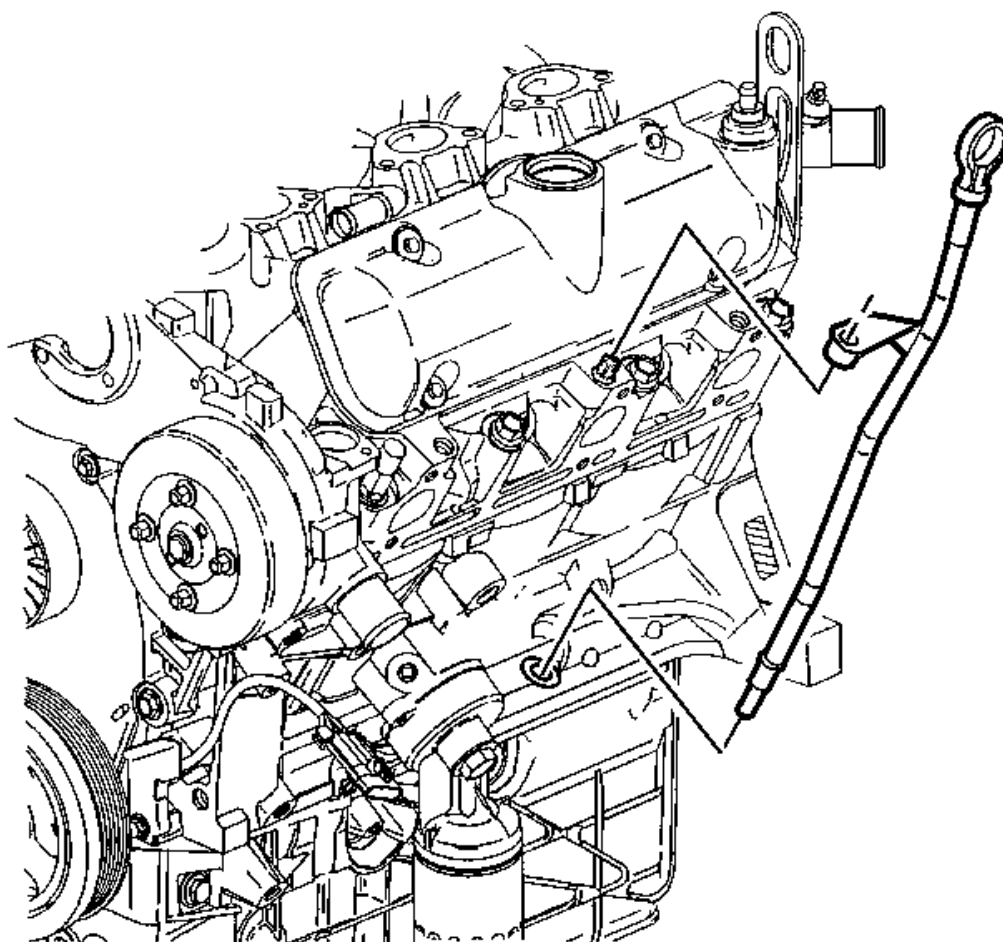


Fig. 34: Removing/Installing Oil Level Indicator & Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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 sealant GM P/N 12346286 (Canadian P/N 10953472) or the equivalent.
3. Install the oil level indicator tube into the engine block.

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. Install the spark plug wire to the number 6 cylinder spark plug.

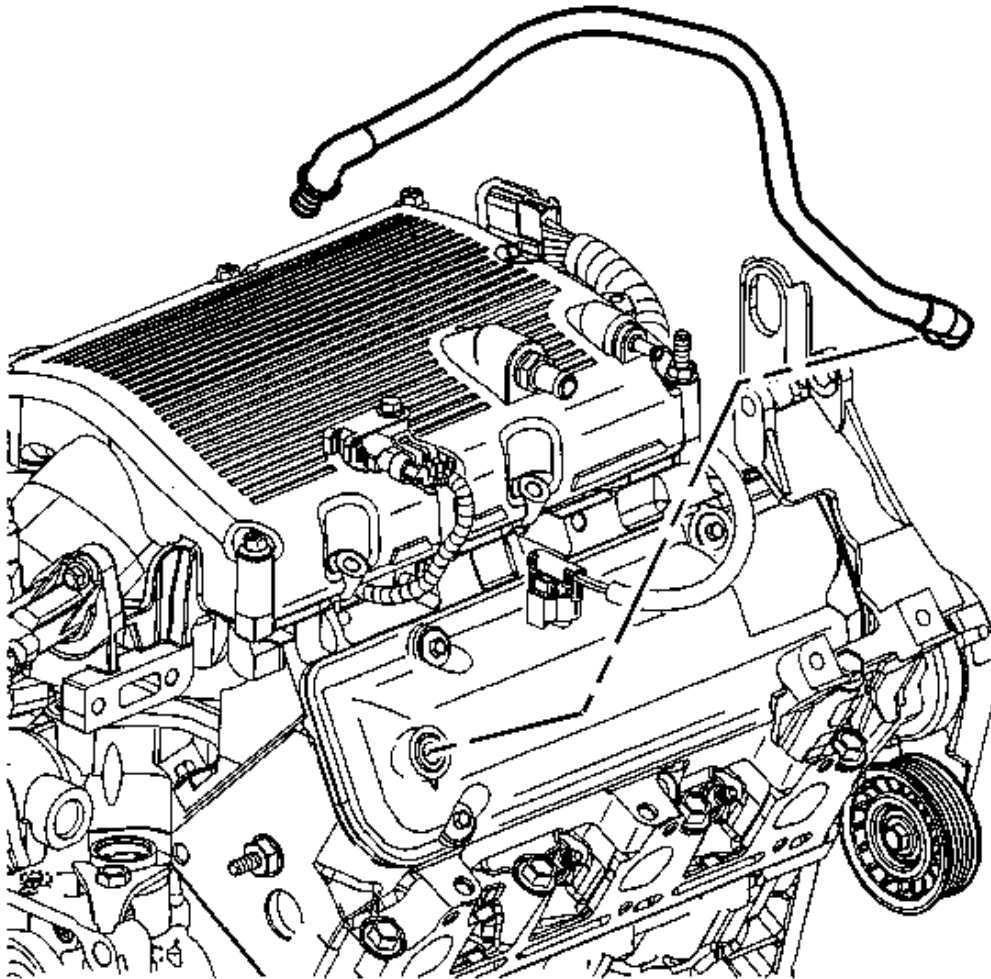
Intake Manifold Replacement - Upper**Removal Procedure**

Fig. 35: View Of Vacuum Hoses
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the vacuum hoses from the following:
 - Evaporative emissions (EVAP) canister purge valve
 - Manifold vacuum source
 - Brake booster
 - Heater and air conditioning (A/C) source
3. Disconnect the electrical connectors from the following:
 - Exhaust gas recirculation (EGR) valve
 - Mass air flow (MAF) sensor
 - Intake air temperature (IAT) sensor
 - Electronic throttle control
 - EVAP canister purge valve
4. Remove the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.5L.
5. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
6. Remove the left side spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
7. Remove the following wiring harnesses from the retainers:
 - Camshaft position (CMP) sensor wiring harness
 - Left side spark plug wire harness
 - Engine wiring harness

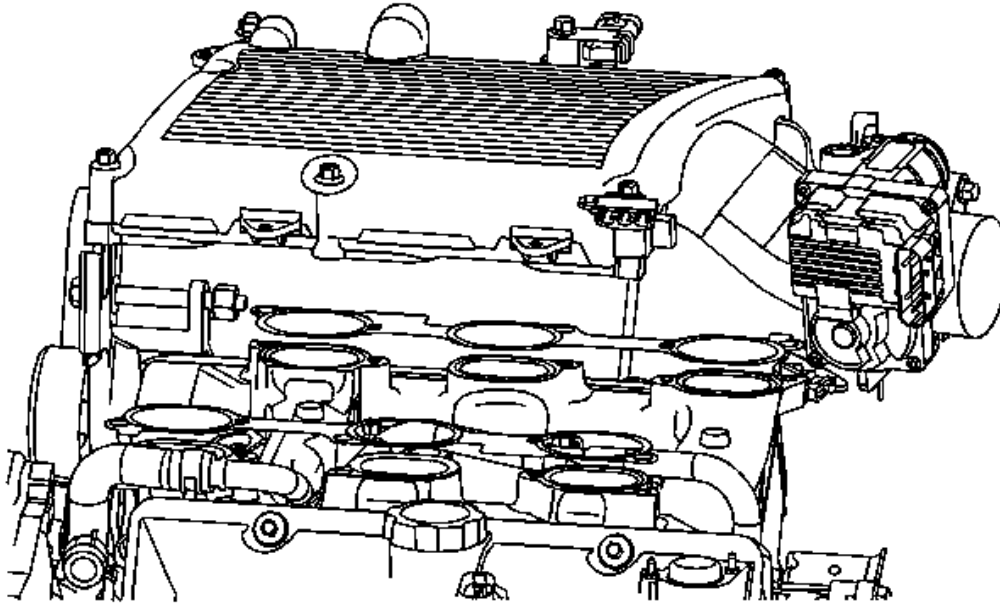


Fig. 36: View Of Upper Intake Manifold Bolts And Stud
Courtesy of GENERAL MOTORS CORP.

8. Remove the ignition coil bracket with the coils. Refer to **Ignition Control Module Replacement** in Engine Controls - 3.5L.
9. Remove the EVAP canister purge solenoid valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 3.5L.
10. Remove the manifold absolute pressure (MAP) sensor and the bracket. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls - 3.5L.
11. Remove the EGR valve. Refer to **Exhaust Gas Recirculation (EGR) Valve Replacement** in Engine Controls - 3.5L.
12. Remove the upper intake manifold bolts and the stud.
13. Remove the upper intake manifold.
14. Remove the upper intake manifold gaskets.

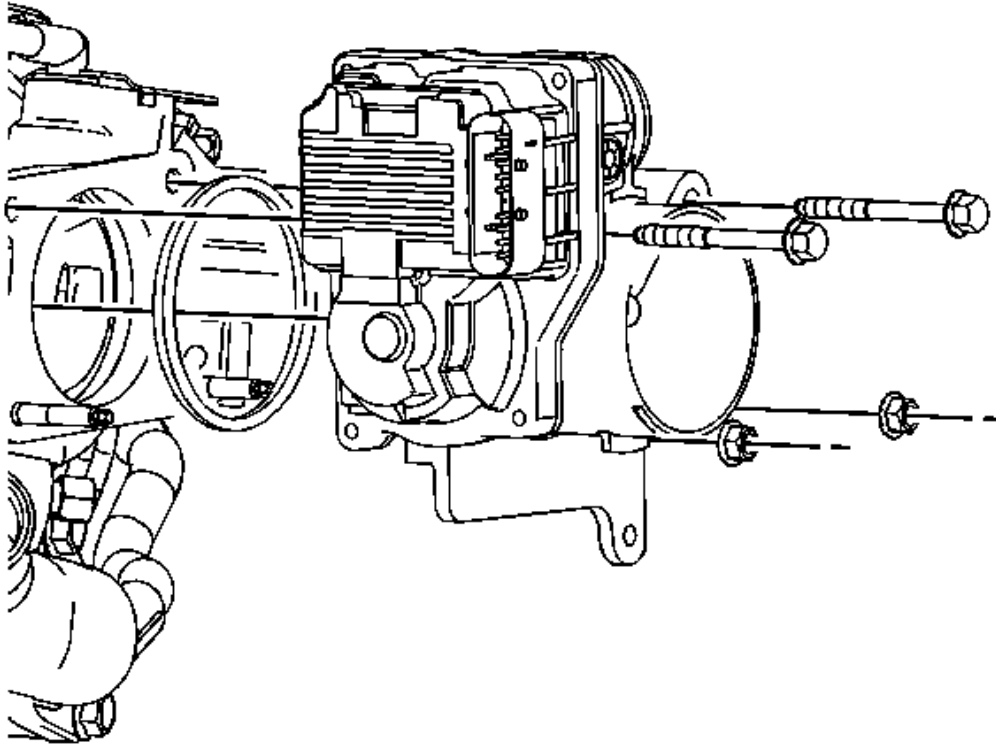


Fig. 37: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

15. If replacing the upper intake manifold, remove the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.5L.
16. Clean the upper intake gasket mating surfaces.

Installation Procedure

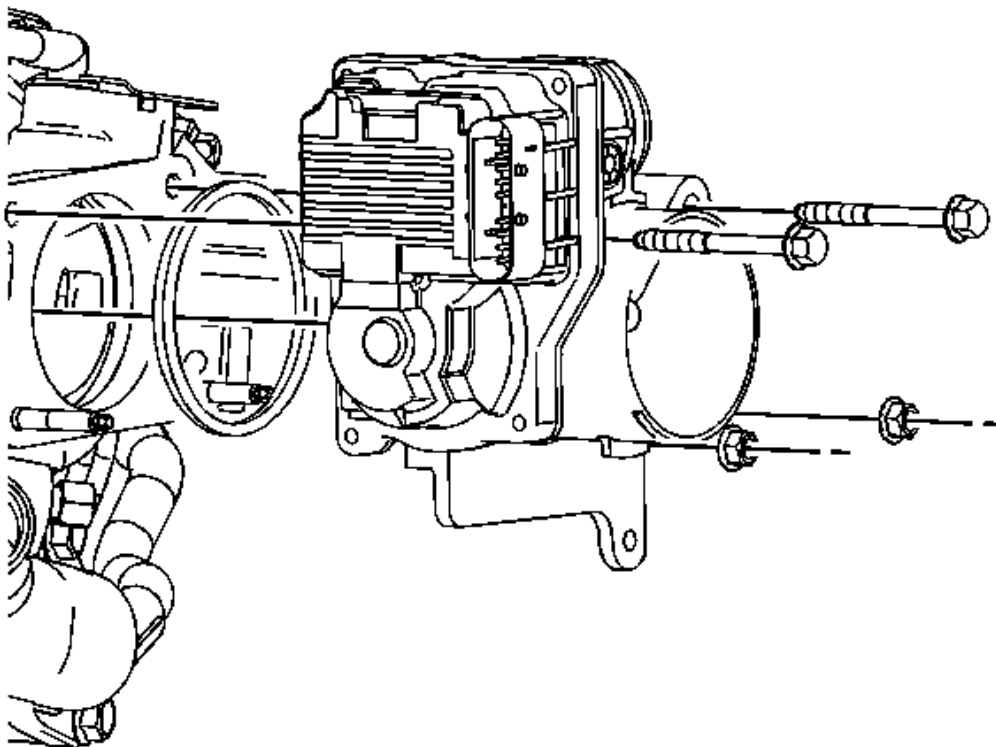


Fig. 38: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

1. If removed, install the throttle body. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 3.5L.

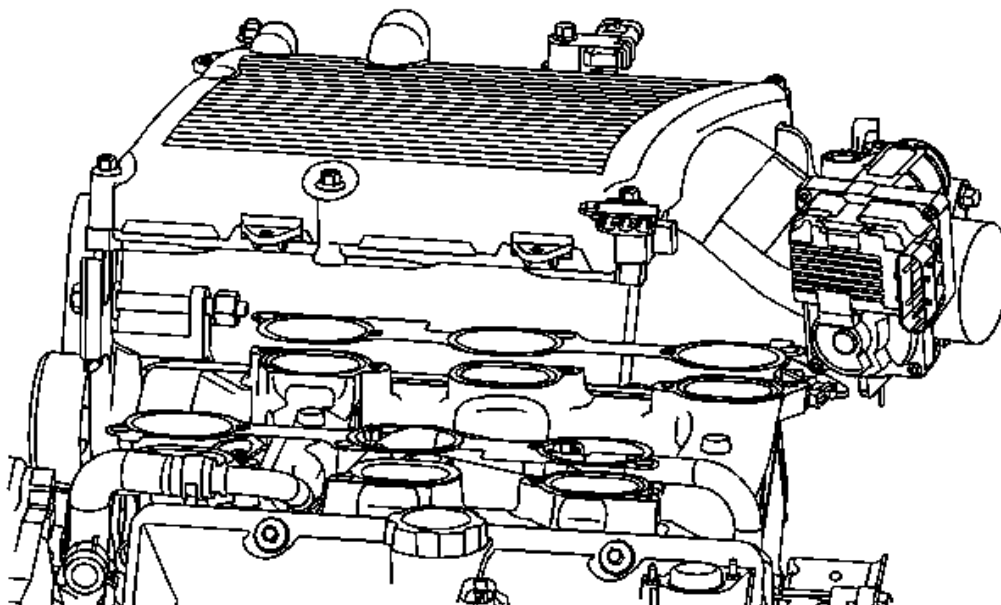


Fig. 39: View Of Upper Intake Manifold Bolts And Stud
Courtesy of GENERAL MOTORS CORP.

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 right 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 - 3.5L.
6. Install the MAP sensor bracket and the sensor. Refer to Manifold Absolute Pressure (MAP) Sensor Replacement in Engine Controls - 3.5L.
7. Install the EVAP canister purge solenoid valve. Refer to Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement in Engine Controls - 3.5L.
8. Install the ignition coil bracket with the coils. Refer to Ignition Control Module Replacement in Engine Controls - 3.5L.
9. Install the following wiring harnesses to the retainers:
 - Engine wiring harness

- Left side spark plug wire harness
 - CMP sensor wiring harness
10. Install the left side spark plug wires to the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
 11. Install the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.5L.
 12. Connect the electrical connectors to the following:
 - EVAP canister purge valve
 - Electronic throttle control
 - IAT sensor
 - MAF sensor
 - EGR valve

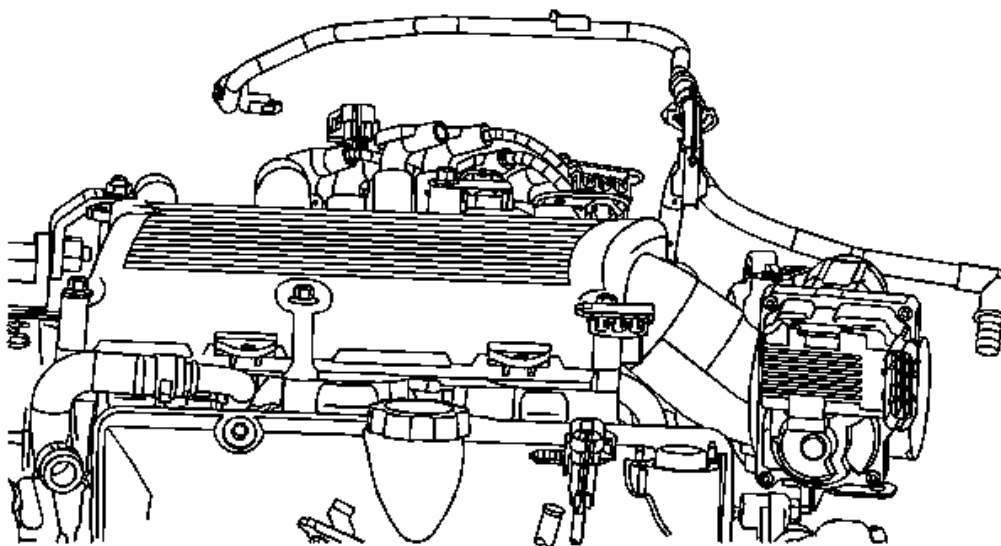


Fig. 40: View Of Vacuum Hoses
Courtesy of GENERAL MOTORS CORP.

13. Install the vacuum hoses to the following:
 - Heater and A/C source
 - Brake booster
 - Manifold vacuum source
 - EVAP canister purge valve

14. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
15. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

Intake Manifold Replacement - Lower**Removal Procedure**

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

1. Disconnect the battery ground negative 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**.
5. Disconnect the engine coolant temperature (ECT) wiring harness.

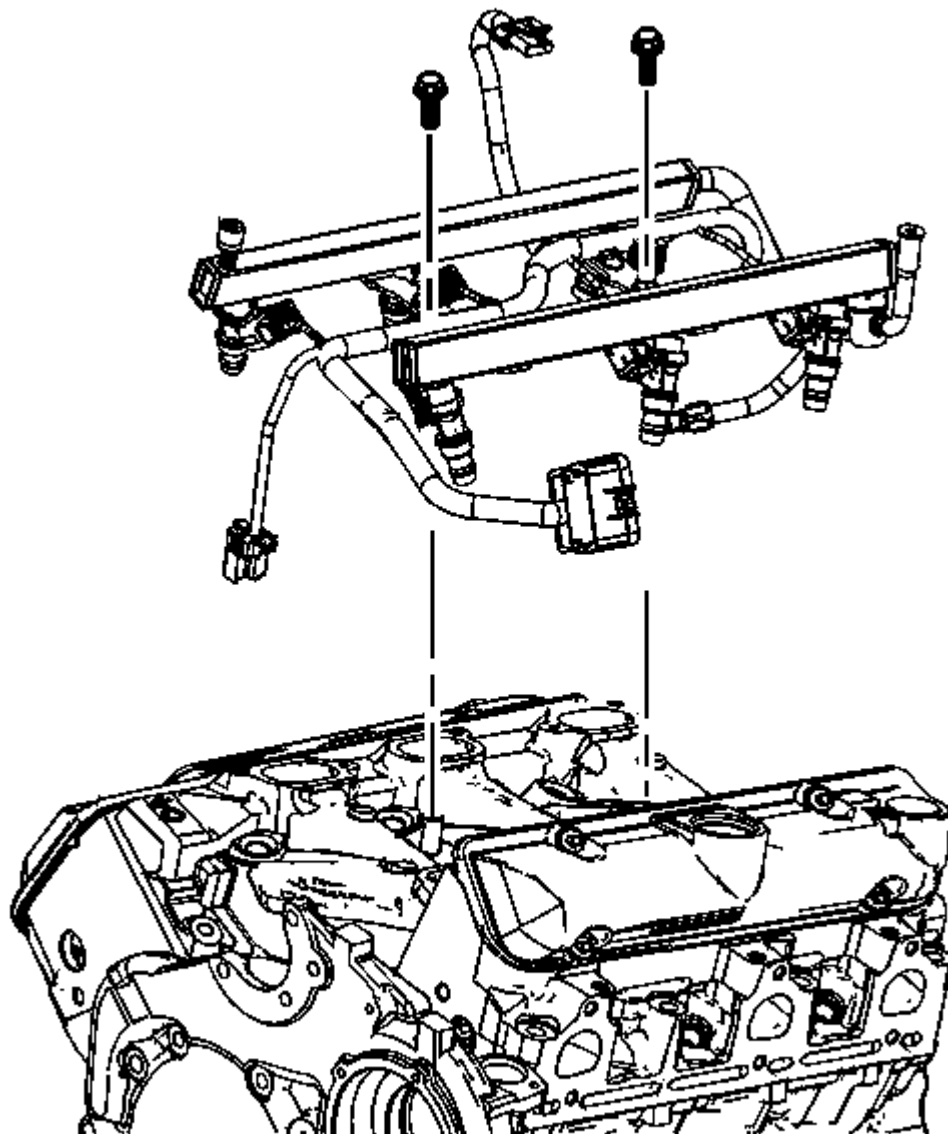


Fig. 41: View Of Fuel Injector And Manifold Air Pressure (MAP) Wiring Harness
 Courtesy of GENERAL MOTORS CORP.

6. Disconnect and remove the fuel injector and manifold air pressure (MAP) wiring harness.
7. Remove the fuel injector rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L.
8. Disconnect the heater inlet pipe with heater hose from the lower intake manifold and reposition.
9. Disconnect the radiator inlet hose from the engine. Refer to **Radiator Hose Replacement - Inlet** in

Engine Cooling.

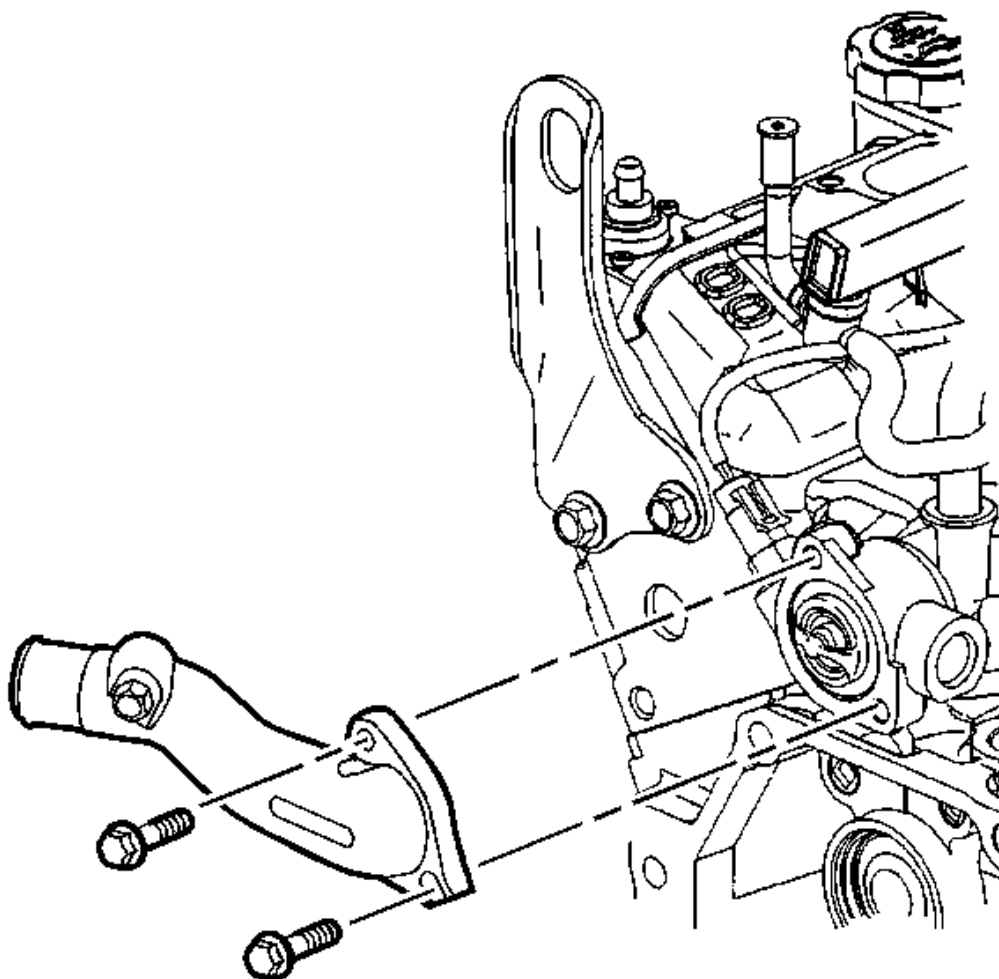


Fig. 42: View Of Water Outlet
Courtesy of GENERAL MOTORS CORP.

10. Remove the water outlet.

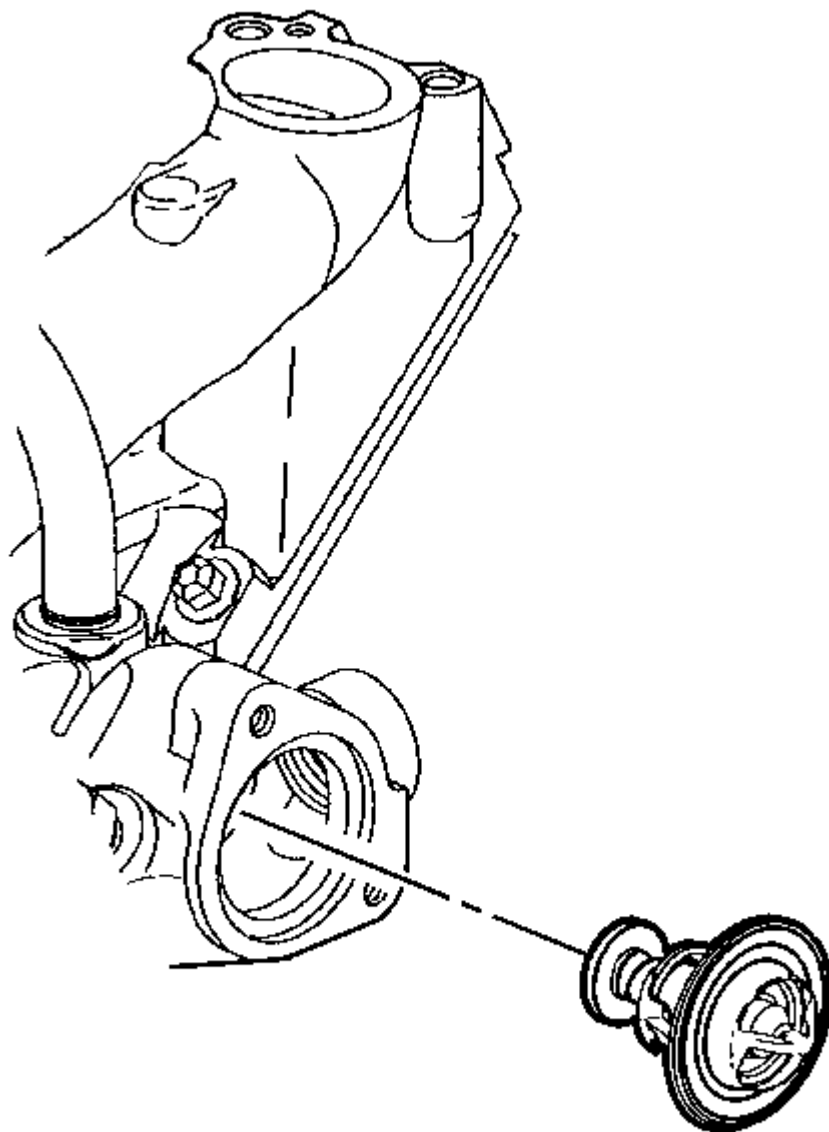


Fig. 43: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

11. Remove the thermostat.

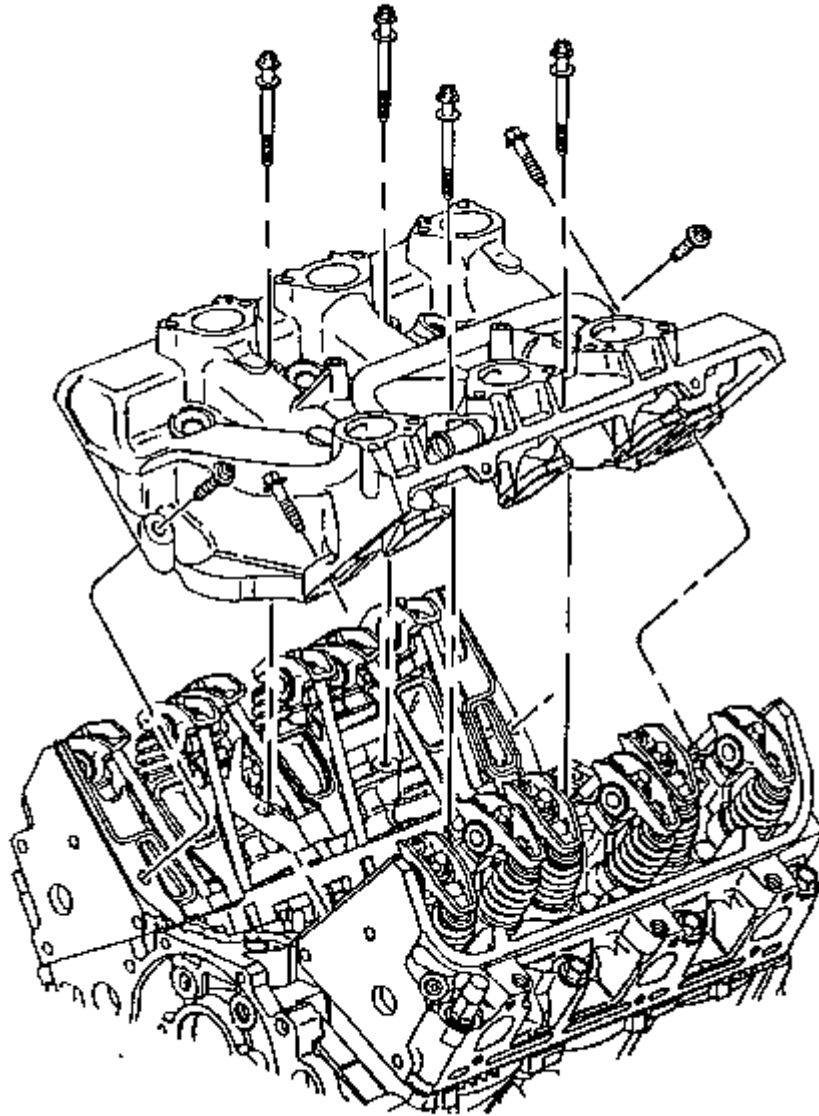


Fig. 44: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the lower intake manifold bolts.
13. Remove the lower intake manifold.
14. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

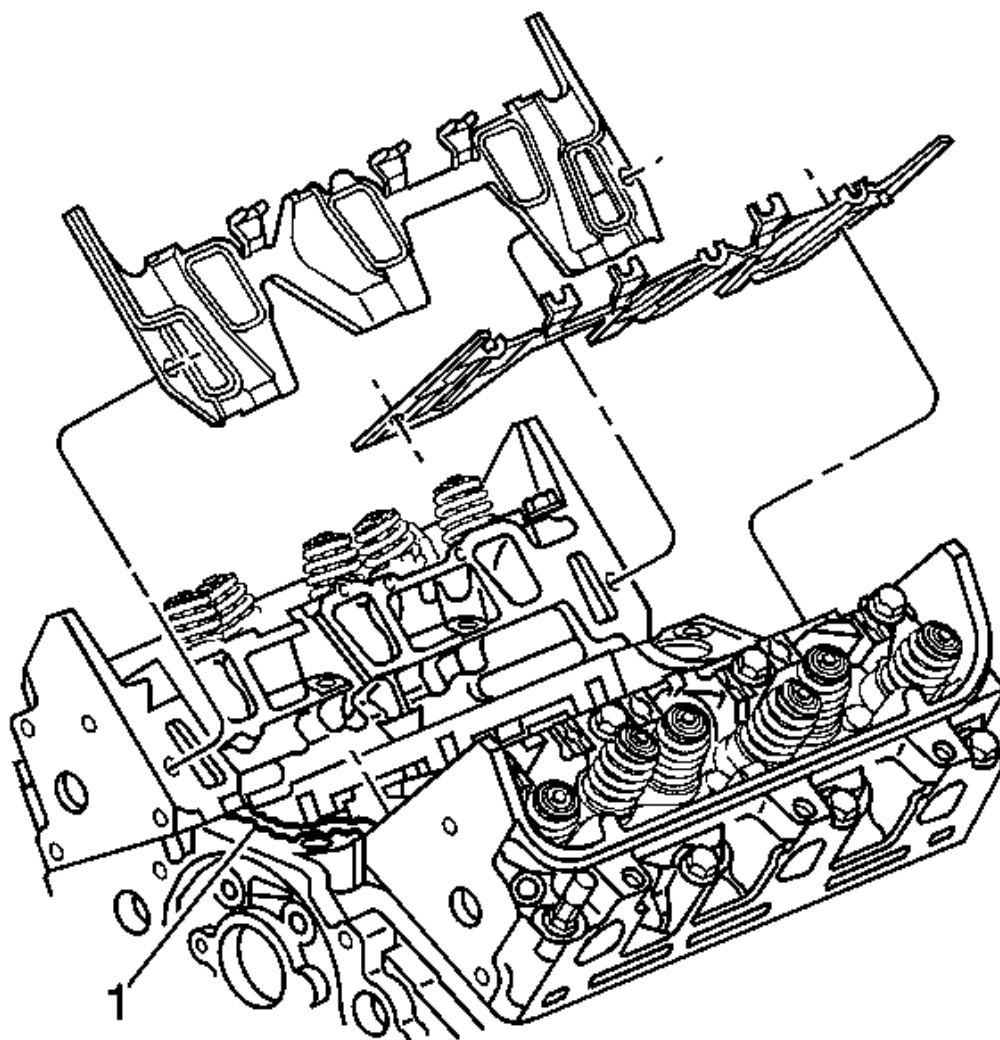


Fig. 45: View Of Lower Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

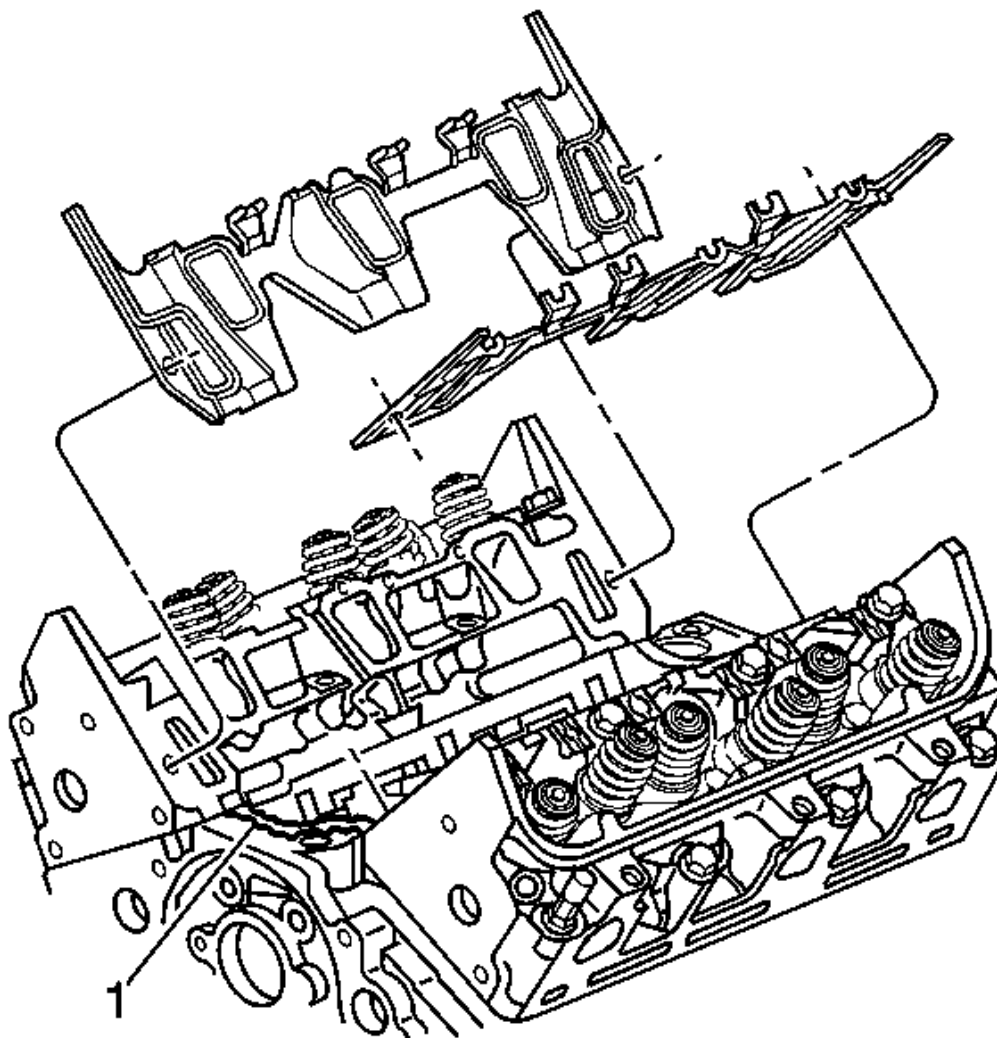


Fig. 46: View Of Lower Intake Manifold Gaskets & Seals
Courtesy of GENERAL MOTORS CORP.

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

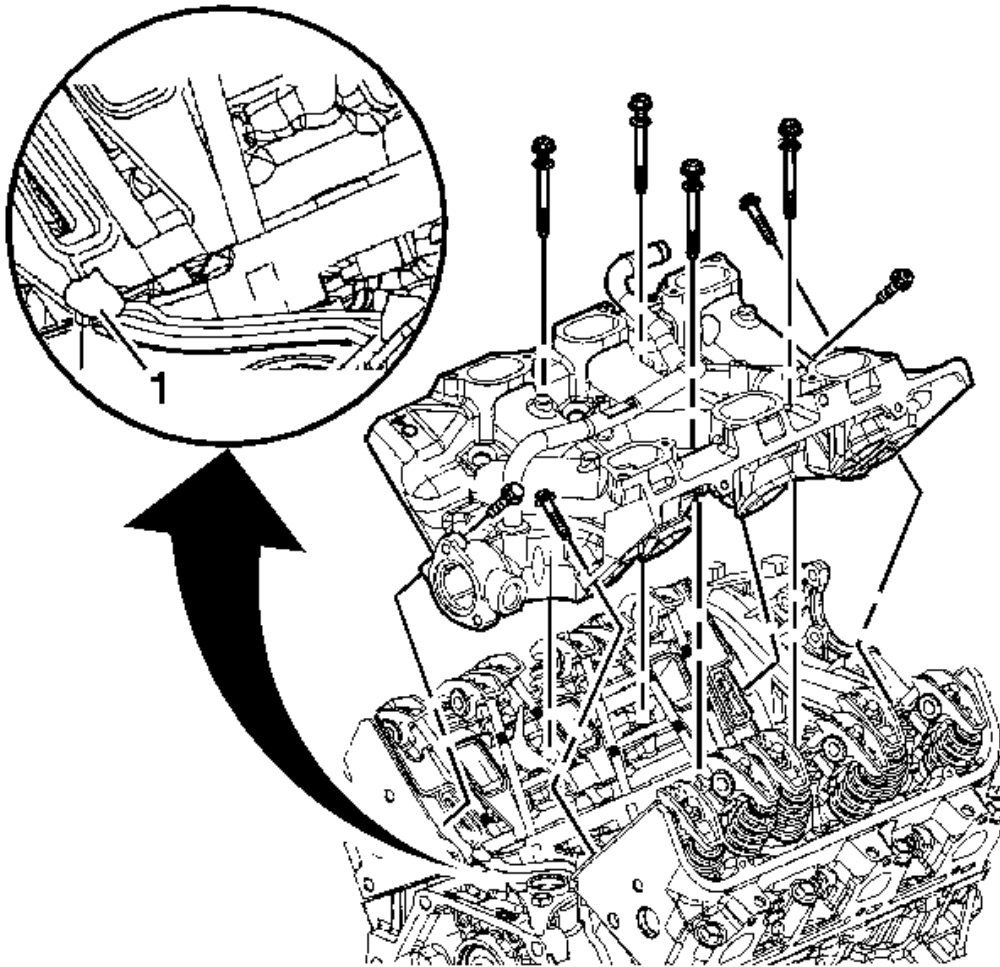


Fig. 47: Installing Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

3. With gaskets and seals in place apply a small drop 8-10 mm (0.31-0.39 in) of RTV sealer GM P/N 12378521 (Canadian P/N 88901148), or equivalent, to the 4 corners of the intake manifold to block joints (1).
4. Install the lower intake manifold.

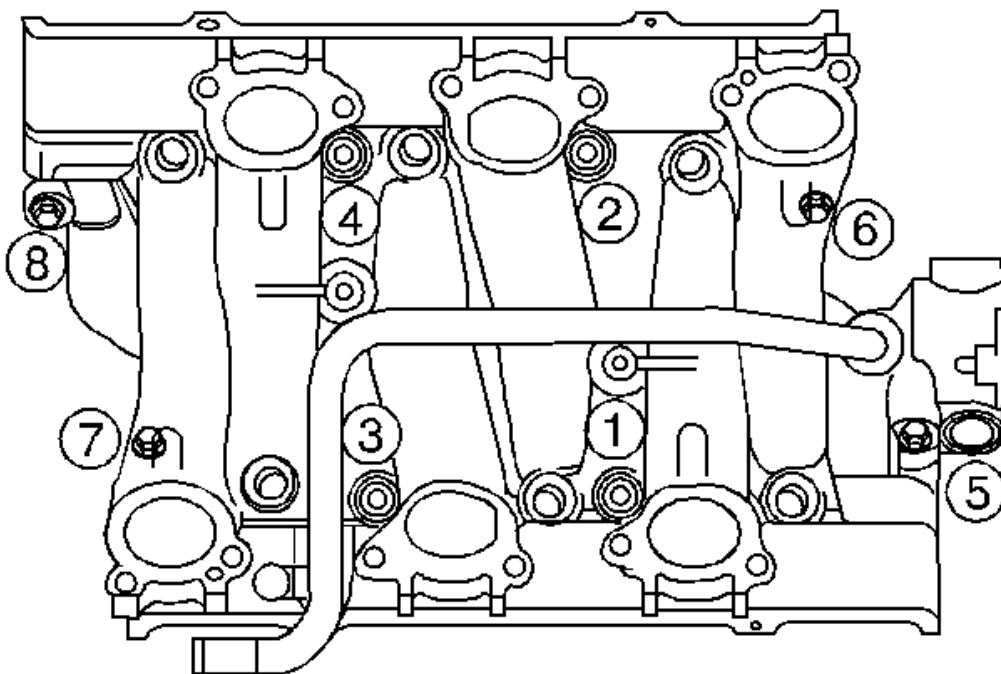


Fig. 48: Lower Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

5. Apply sealer GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the lower intake manifold bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the new lower intake manifold bolts, if applicable, in sequence.

Tighten:

1. Tighten the lower intake manifold bolts in sequence to 13 N.m (115 lb in) on the first pass.

2. Tighten the lower intake manifold bolts (1, 2, 3, 4) in sequence to 20 N.m (15 lb ft) 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.

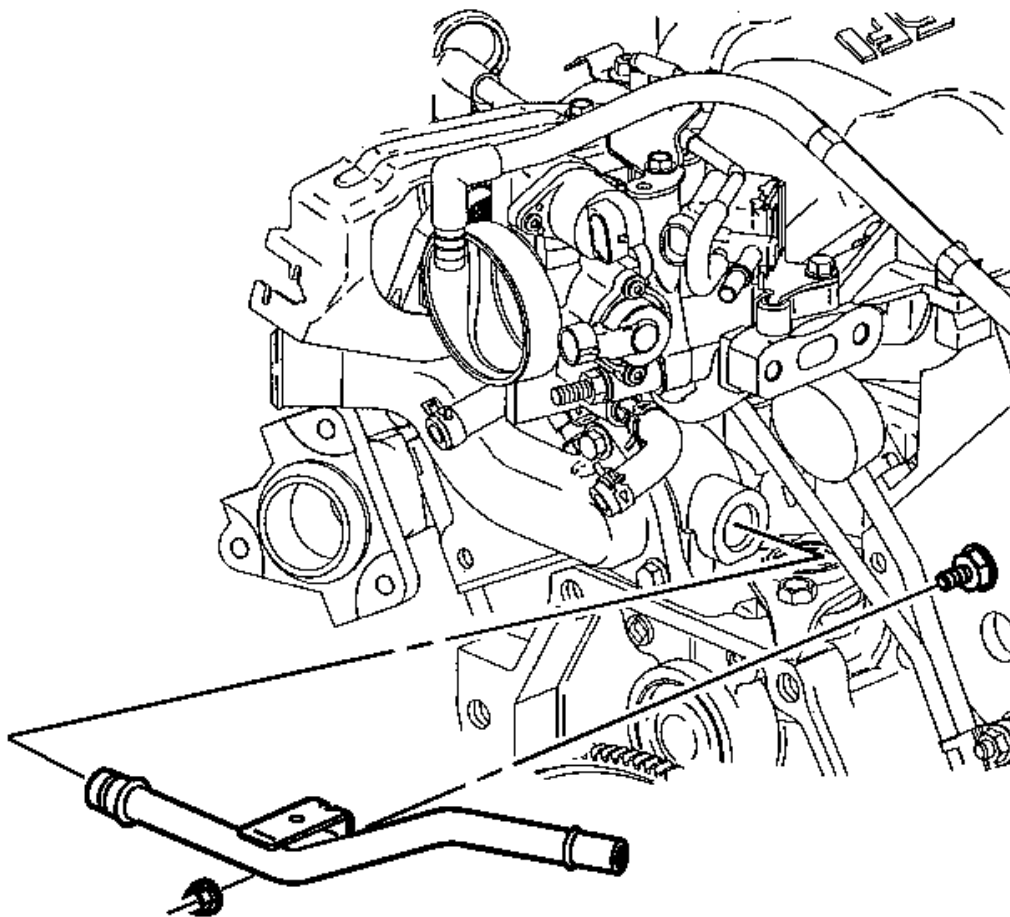


Fig. 49: View Of Heater Inlet Pipe & Nut
Courtesy of GENERAL MOTORS CORP.

7. Install the heater inlet pipe.
8. Install the heater inlet pipe nut.

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

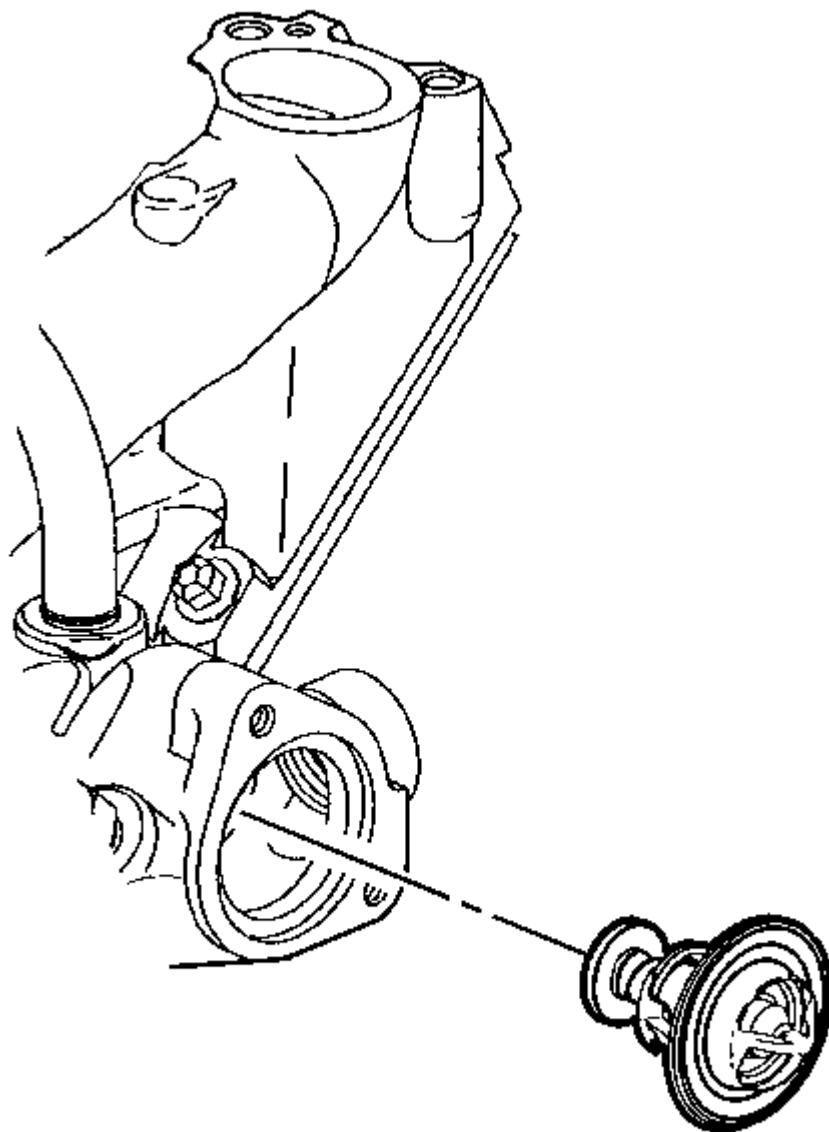


Fig. 50: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

9. Install the thermostat.

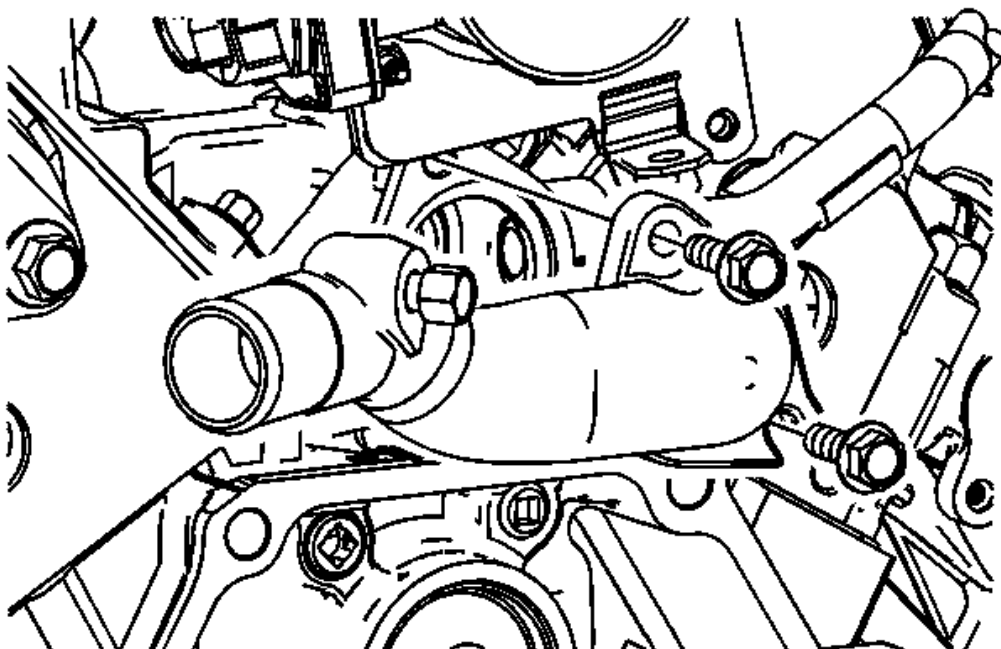


Fig. 51: View Of Water Outlet Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the water outlet bolts. Refer to **Thermostat Replacement** in Engine Cooling.

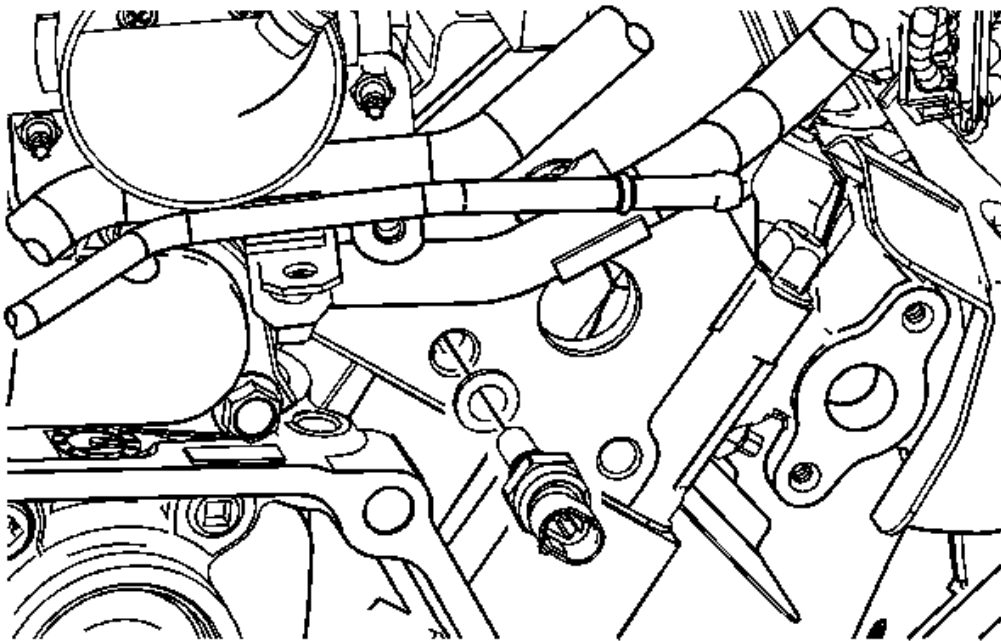


Fig. 52: View Of ECT Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the ECT sensor.

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

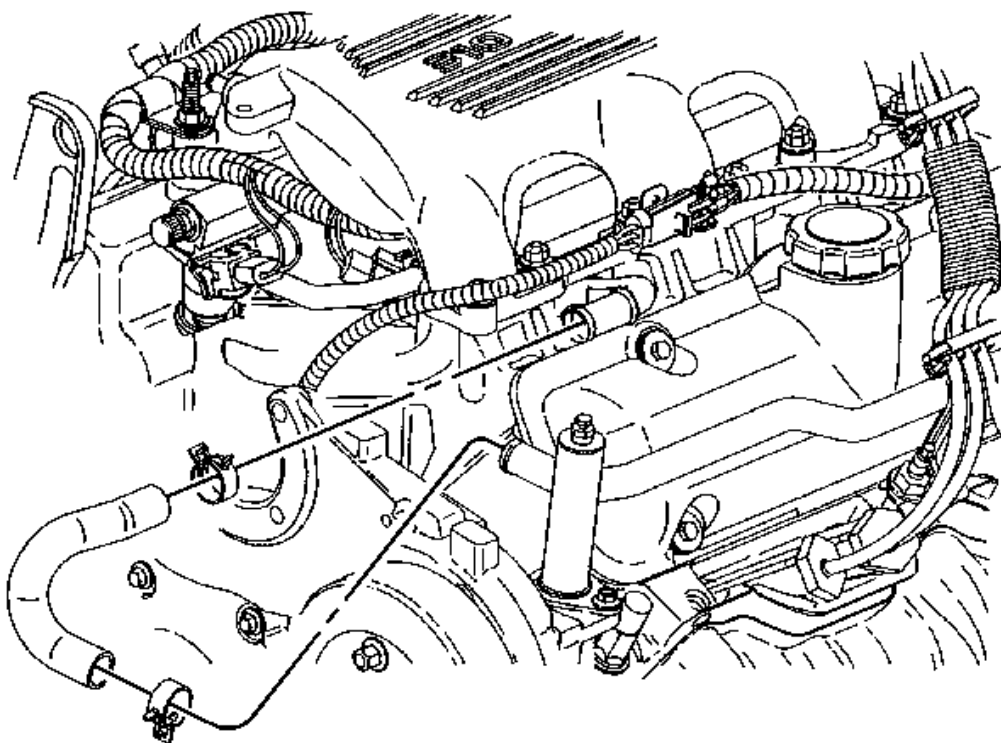


Fig. 53: Thermostat Bypass Hose At Thermostat Bypass Pipe & Lower Intake Manifold Pipe
Courtesy of GENERAL MOTORS CORP.

12. Connect the thermostat bypass hose to the thermostat bypass pipe and lower intake manifold pipe.
13. Connect the radiator inlet hose to the engine. Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.
14. Connect the heater inlet pipe and heater hose to the lower intake manifold.
15. Install the power steering pump to the front engine cover.

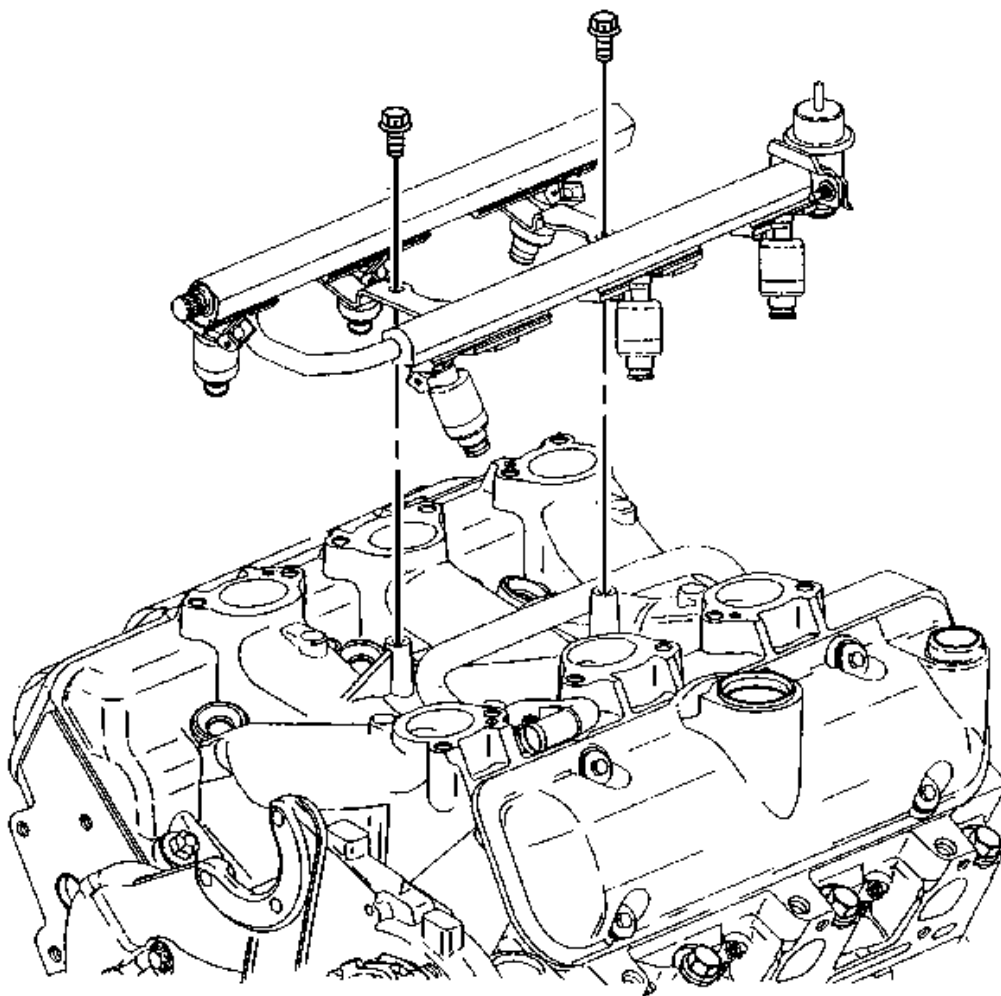


Fig. 54: View Of Fuel Rail With Injectors
Courtesy of GENERAL MOTORS CORP.

16. Install the fuel injector rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L.

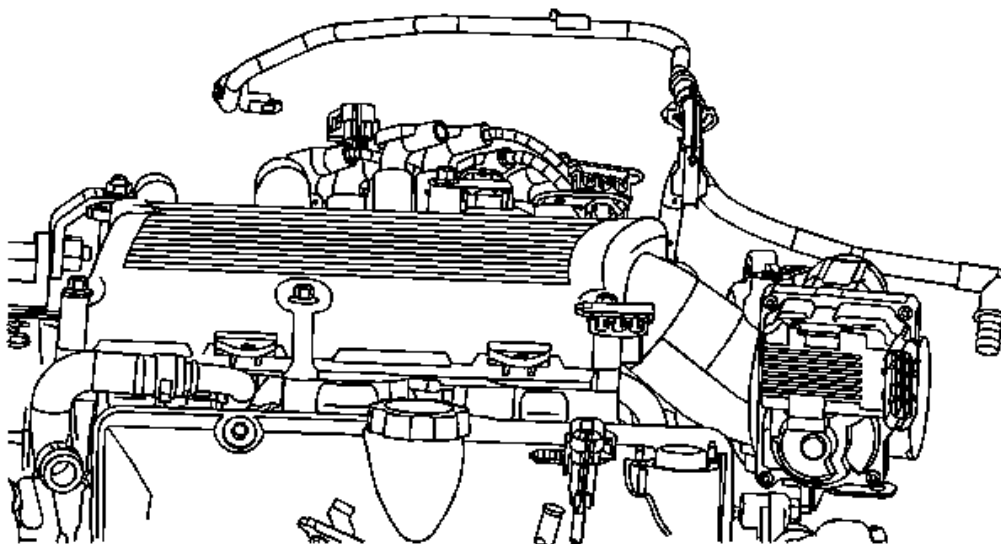


Fig. 55: View Of Vacuum Hoses

Courtesy of GENERAL MOTORS CORP.

17. Connect the fuel feed pipe to the fuel injector rail.

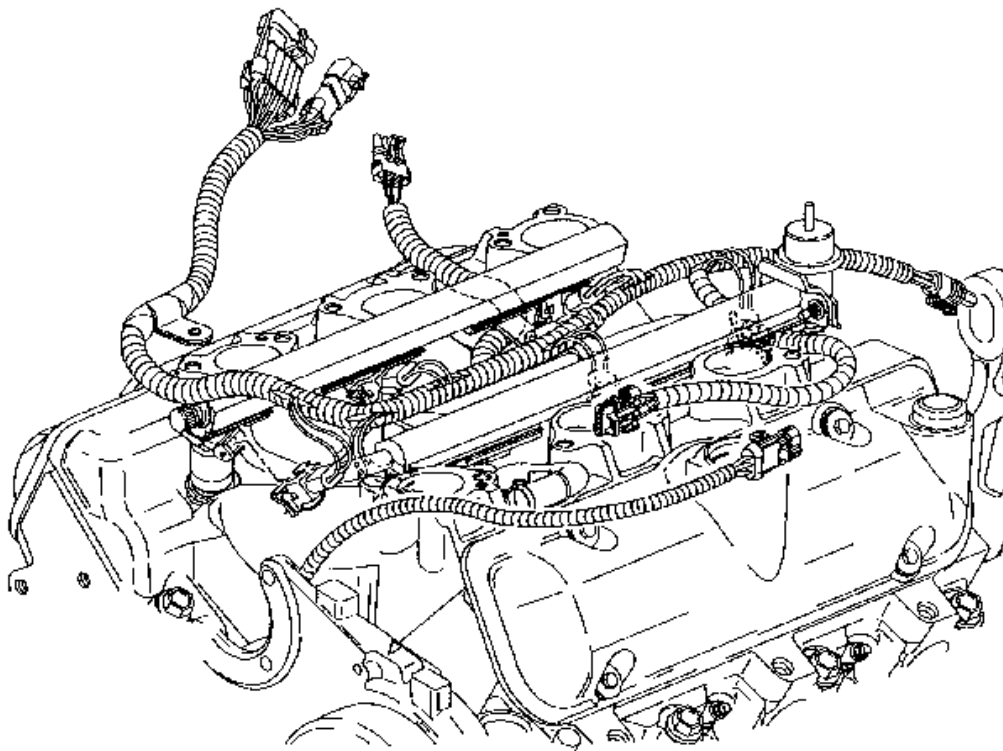


Fig. 56: MAP Sensor Wiring Harness
Courtesy of GENERAL MOTORS CORP.

18. Connect the fuel injector and MAP wiring harness.
19. Connect the ECT wiring harness.
20. Install the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right**.
21. Install the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left**.
22. Install the upper intake manifold. Refer to **Intake Manifold Replacement - Upper**.
23. 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

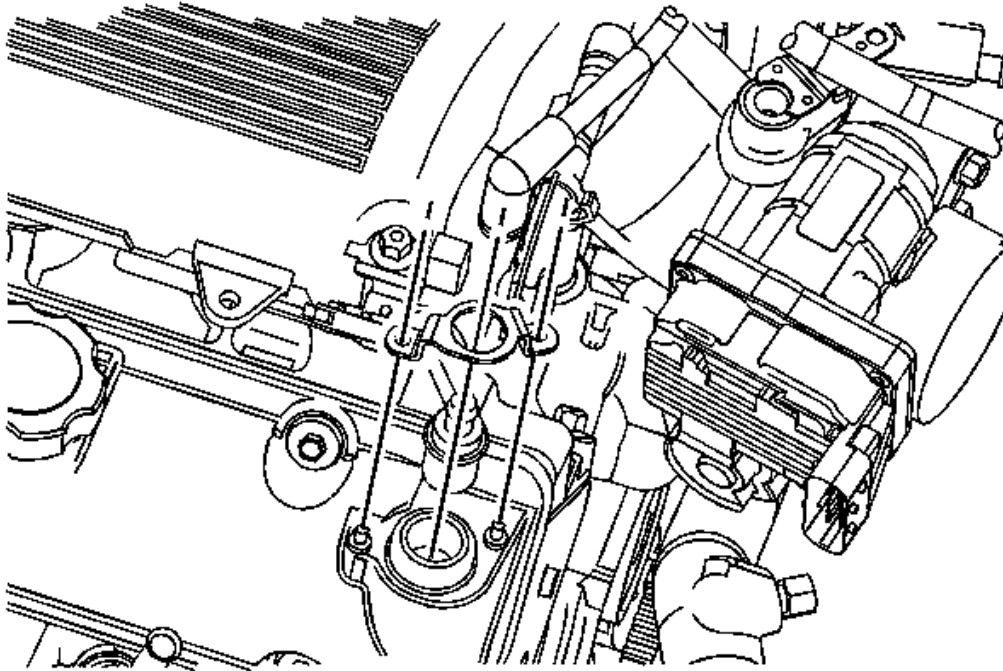


Fig. 57: View Of Vacuum Hose And Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the vacuum hose from positive crankcase ventilation (PCV) valve.
2. Remove the PCV valve retainer.
3. Remove the PCV valve.

Installation Procedure

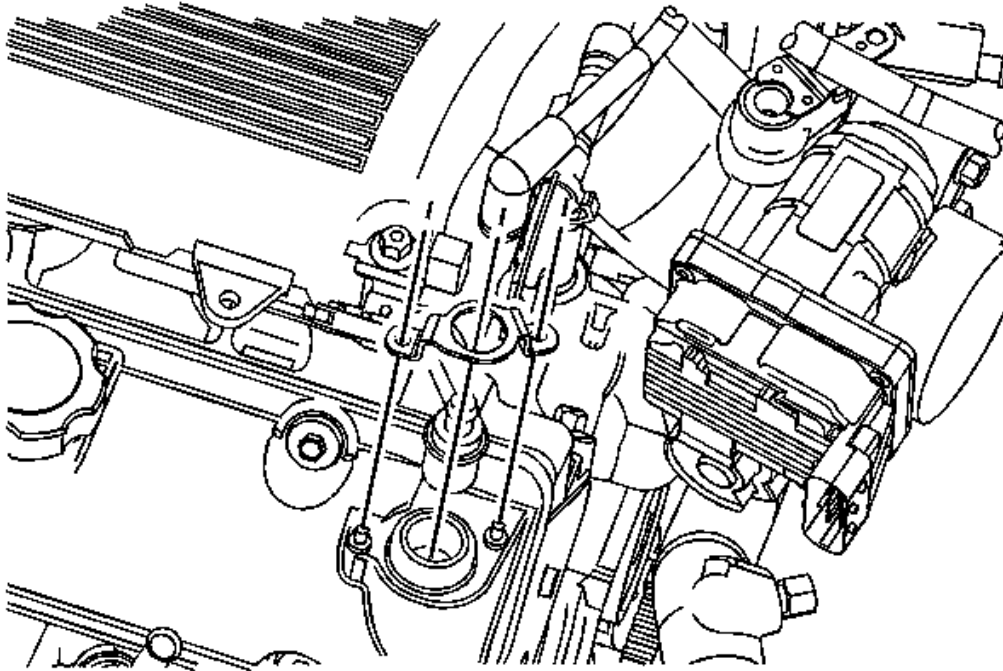


Fig. 58: View Of Vacuum Hose And Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV valve.
2. Install the PCV valve retainer.
3. Connect the vacuum hose to PCV valve.

Valve Rocker Arm Cover Replacement - Left

Removal Procedure

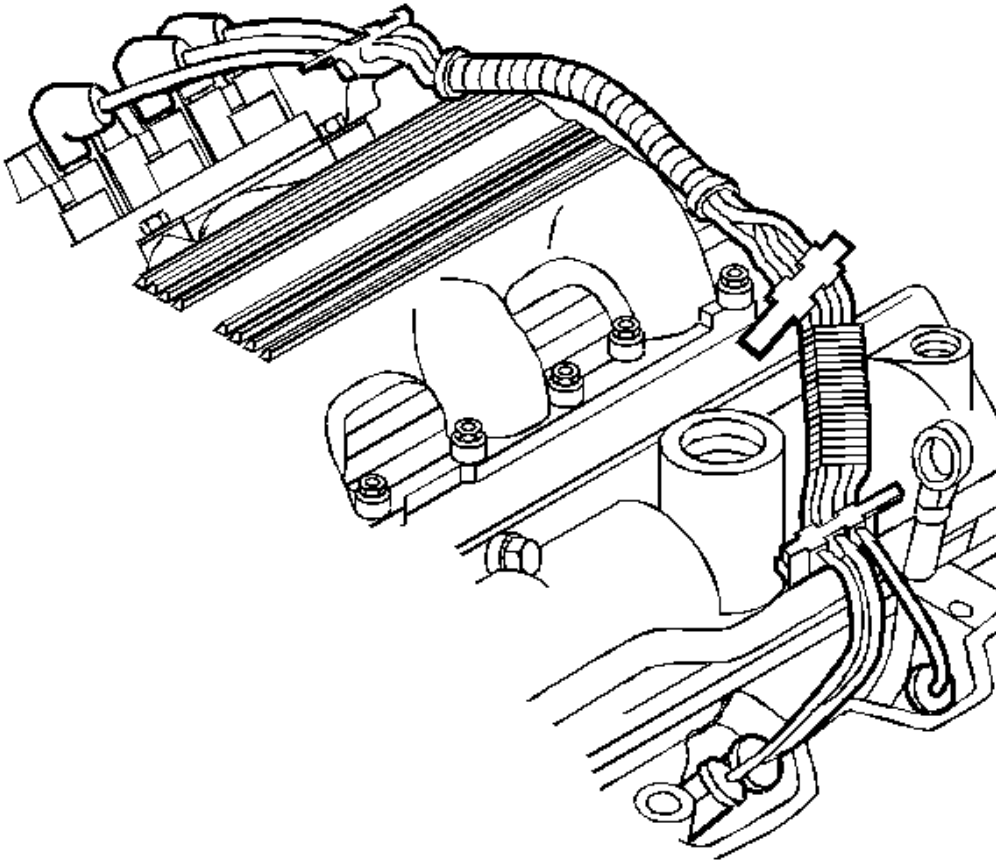


Fig. 59: View Of Front Ignition Wire Harness
Courtesy of GENERAL MOTORS CORP.

1. Partially drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
2. Remove the front ignition wire harness at the upper intake manifold and at the spark plugs.
3. Remove the thermostat bypass pipe. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
4. Disconnect the positive crankcase ventilation (PCV) vacuum hose.

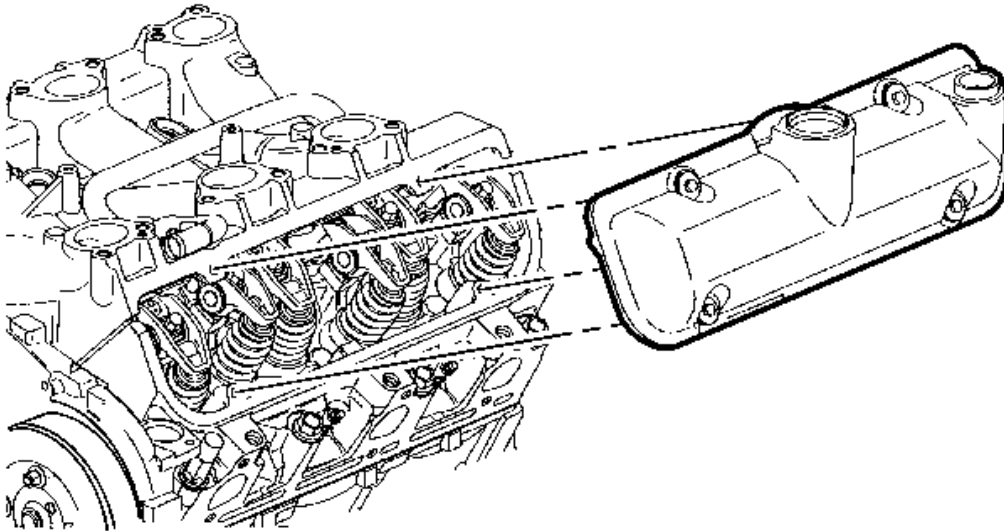


Fig. 60: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the valve rocker arm cover bolts.

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

6. Remove the valve rocker arm cover. Bump the end of the valve rocker cover with the palm of your hand or a soft rubber mallet if the cover adheres to the cylinder head.

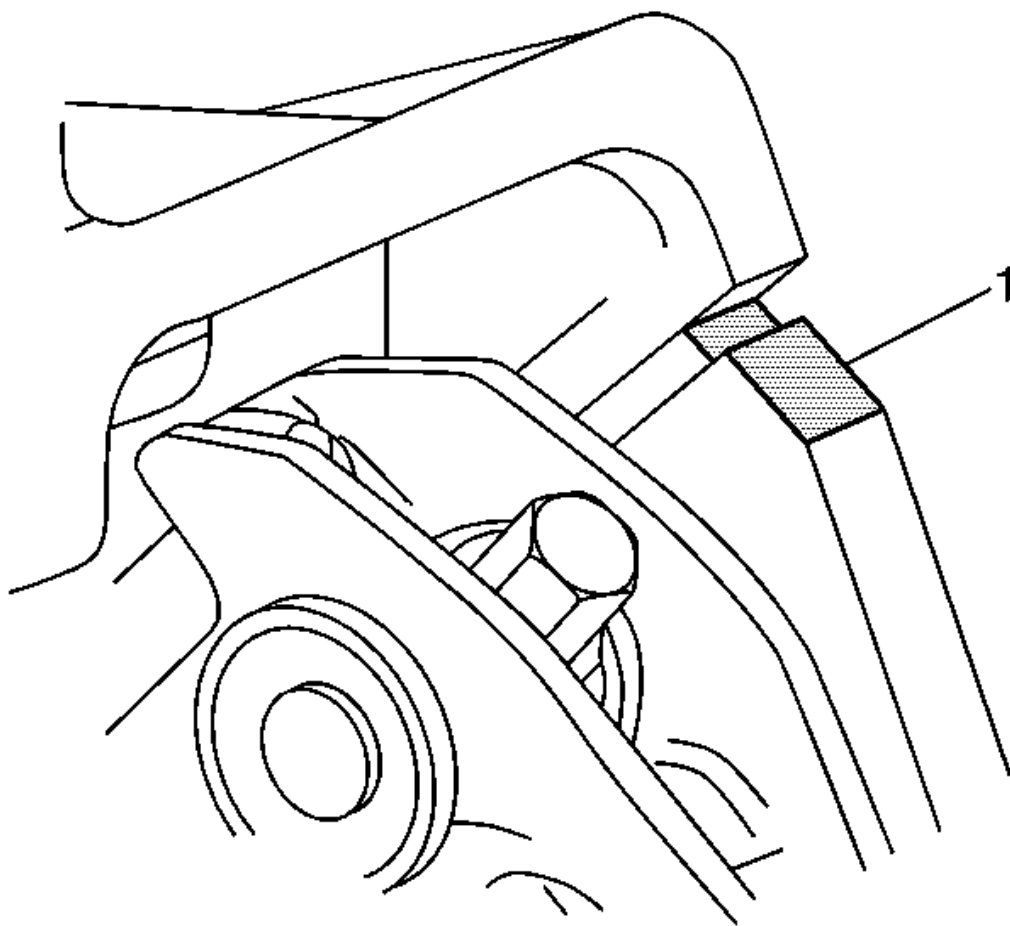


Fig. 61: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

7. Trim the valve cover and sealant away from the lower intake manifold gasket at the cylinder head to the lower intake manifold joints (1).
8. Remove the valve cover gasket.
9. Clean the sealing surface on the cylinder head with degreaser.
10. Clean the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

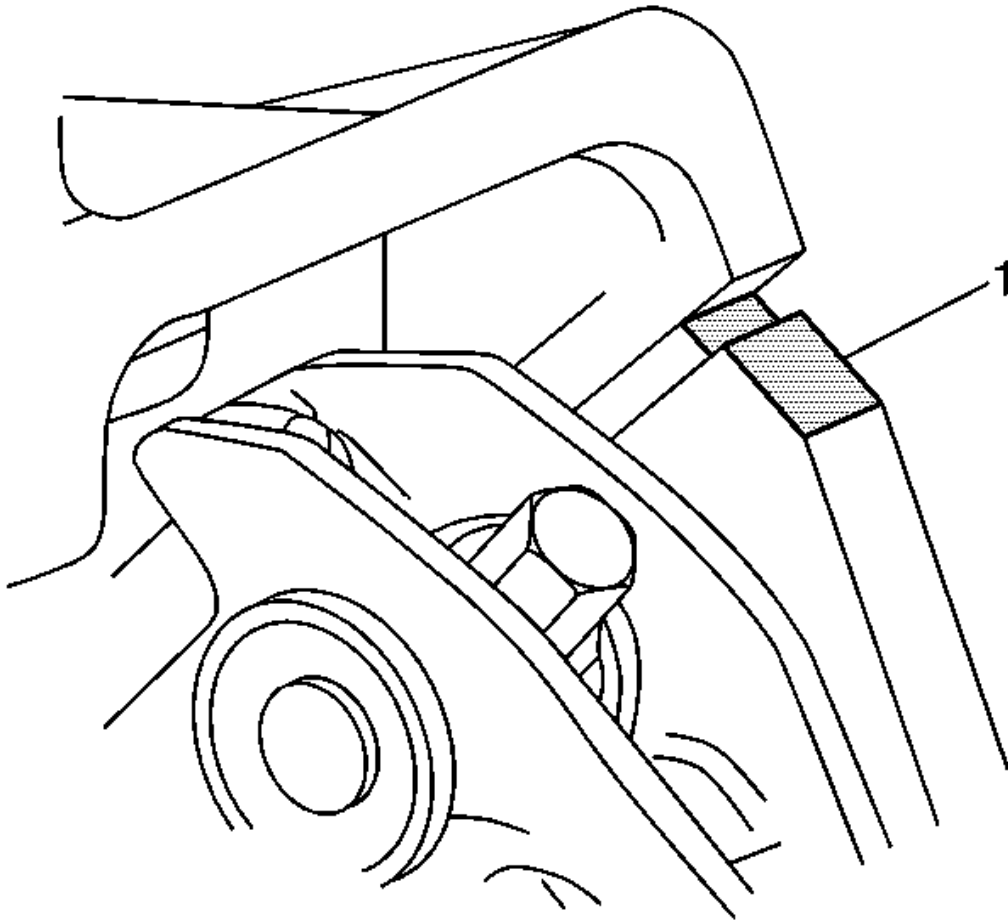


Fig. 62: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent, at the cylinder head to the lower intake manifold joint.

1. Apply sealant at the cylinder head to the lower intake manifold joints (1).

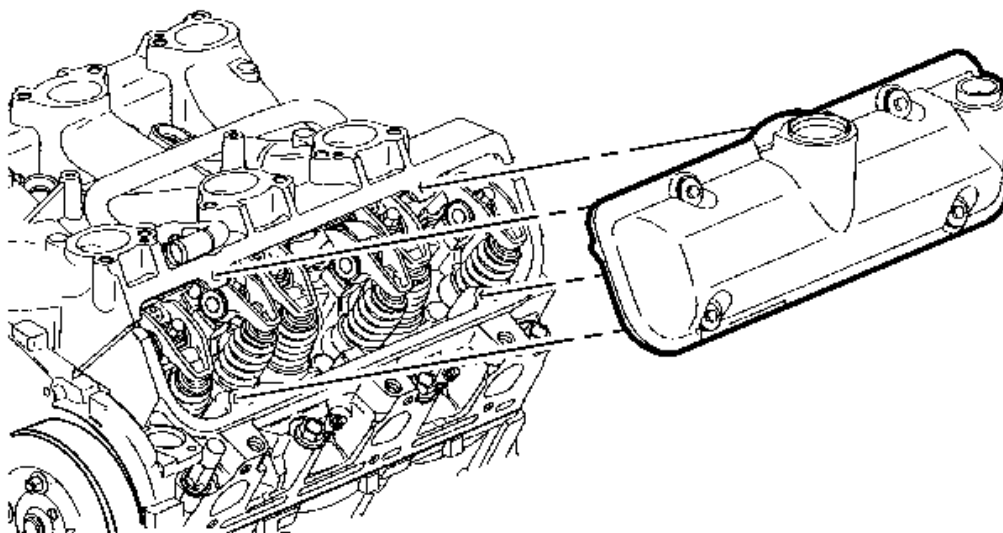


Fig. 63: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

4. Install the valve rocker arm cover bolts.

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

5. Connect the PCV valve vacuum line.
6. Install the thermostat bypass pipe. Refer to Thermostat Bypass Pipes Replacement in Engine Cooling.

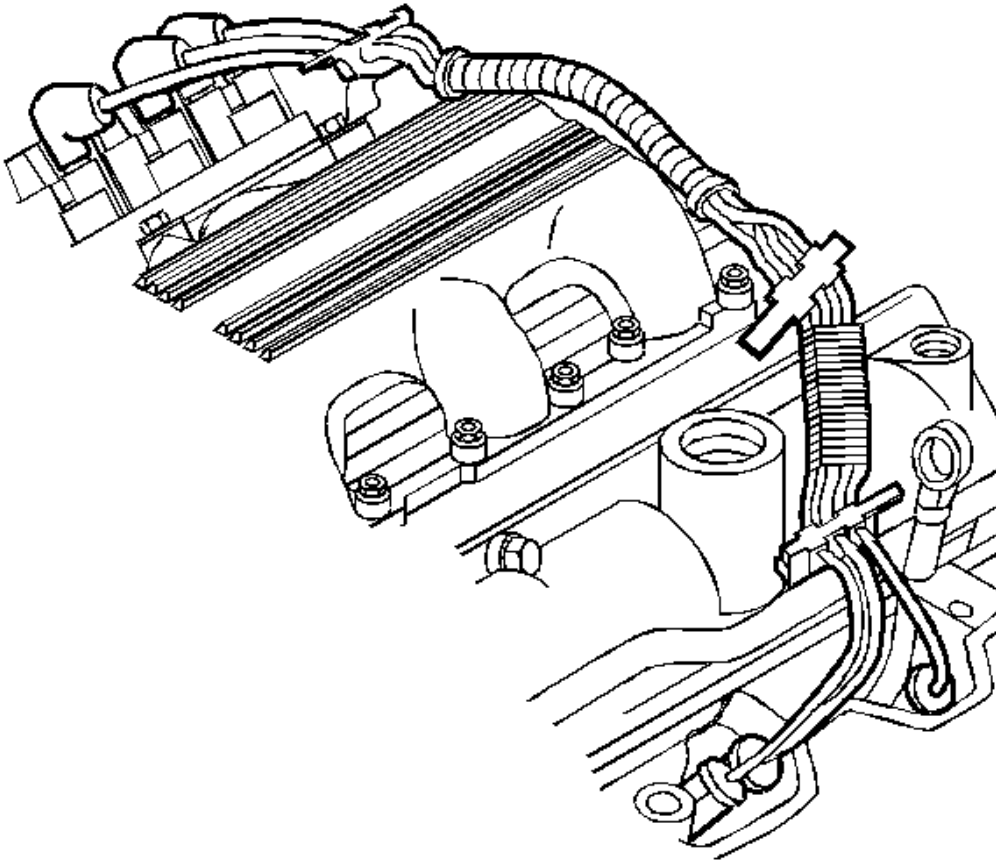


Fig. 64: View Of Front Ignition Wire Harness
Courtesy of GENERAL MOTORS CORP.

7. Install the front ignition wire harness.
8. Refill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

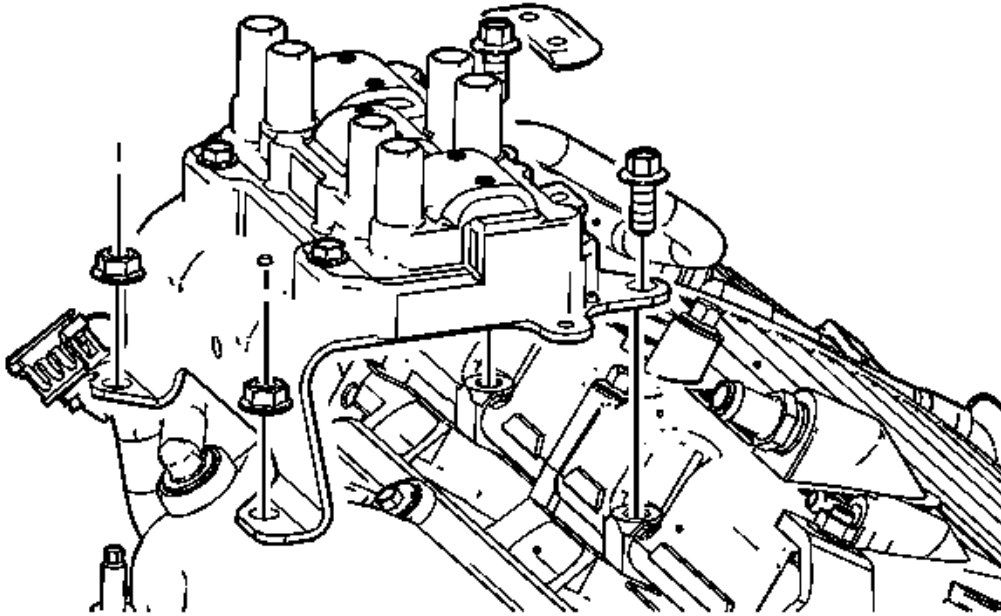


Fig. 65: View Of Ignition Coil Bracket
Courtesy of GENERAL MOTORS CORP.

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** 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 - 3.5L.
6. Disconnect the vacuum hoses from the evaporative emission (EVAP) purge valve.
7. Remove the EVAP purge valve.
8. Remove the ignition coil bracket with the coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 3.5L.
9. Remove the ignition coil bracket studs.
10. Remove the vacuum hose from the grommet in the right valve rocker arm cover.

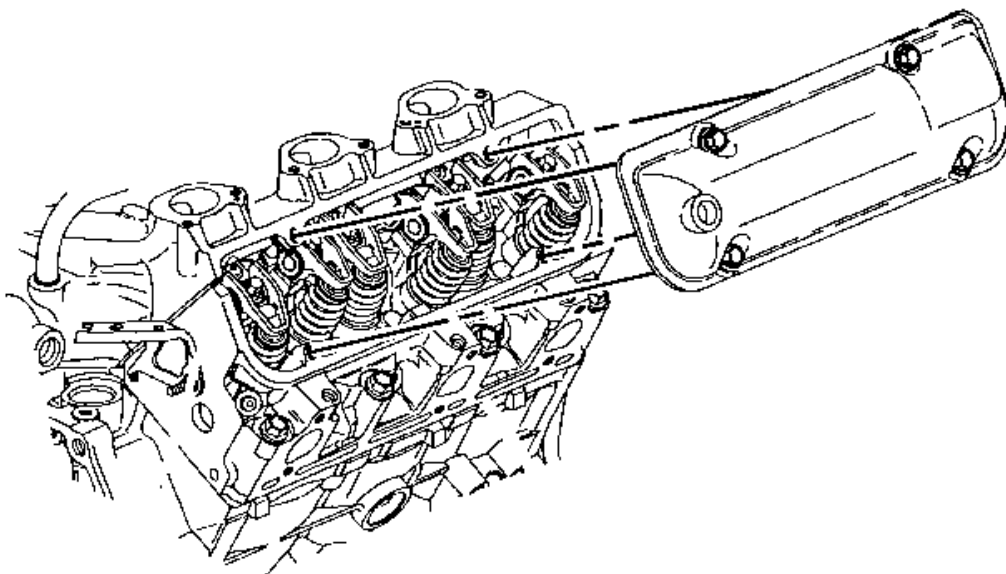


Fig. 66: View Of Valve Rocker Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

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

11. Remove the right valve rocker arm cover bolts.

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

12. Remove the valve rocker arm cover.

Bump the end of the valve rocker cover with the palm of your hand or a soft rubber mallet if the cover adheres to the cylinder head.

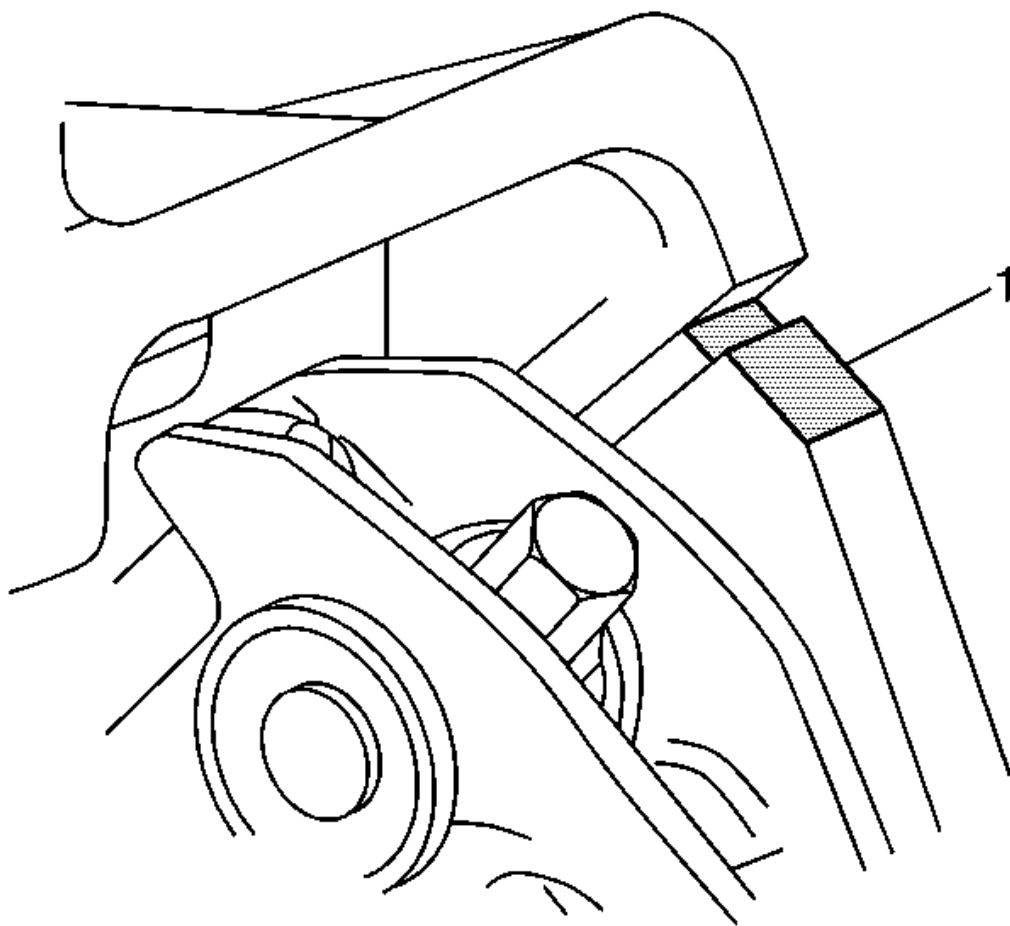


Fig. 67: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

13. Trim the valve gasket and sealant away from the lower intake manifold gasket at the cylinder head to lower intake manifold joints (1).
14. Remove the valve cover gasket.
15. Clean the sealing surface on the cylinder head with degreaser.
16. Clean the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

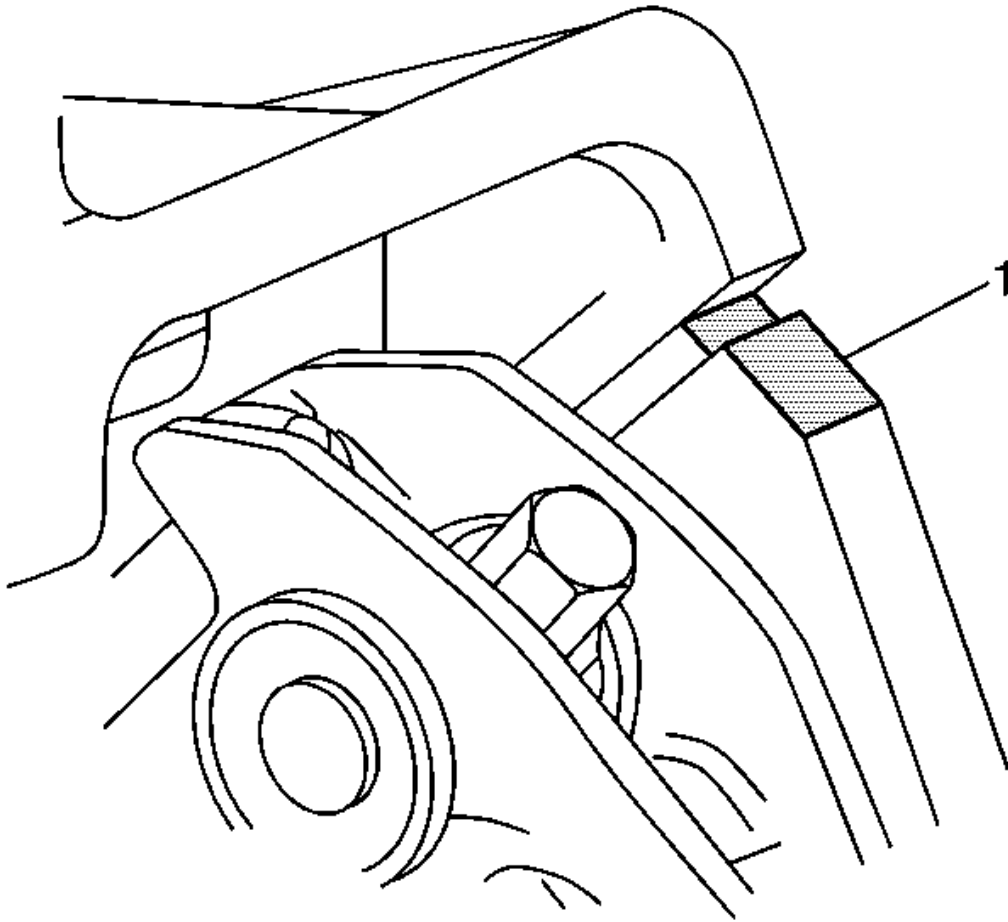


Fig. 68: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, at the cylinder head to lower intake manifold joint.

1. Apply sealant at the cylinder head to lower intake manifold joints (1).

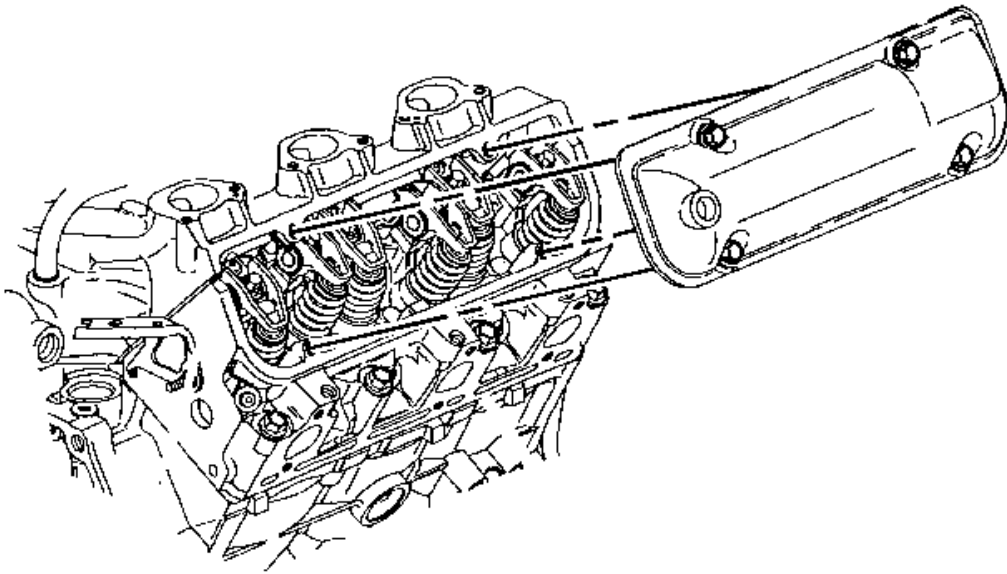


Fig. 69: View Of Valve Rocker Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

4. Install the valve rocker arm cover bolts.

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

5. Install the vacuum hose to the grommet in the right valve rocker arm cover.
6. Install the ignition coil bracket studs.
7. Install the ignition coil bracket with coils. Refer to Ignition Coil(s) Replacement in Engine Controls - 3.5L.
8. Install the EVAP purge valve.
9. Connect the vacuum hoses to the EVAP purge valve.

10. Install the right spark plug wires. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
11. Install the generator bracket. Refer to **Generator Bracket Replacement** in Engine Electrical.
12. Install the generator. Refer to **Generator Replacement** 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.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

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

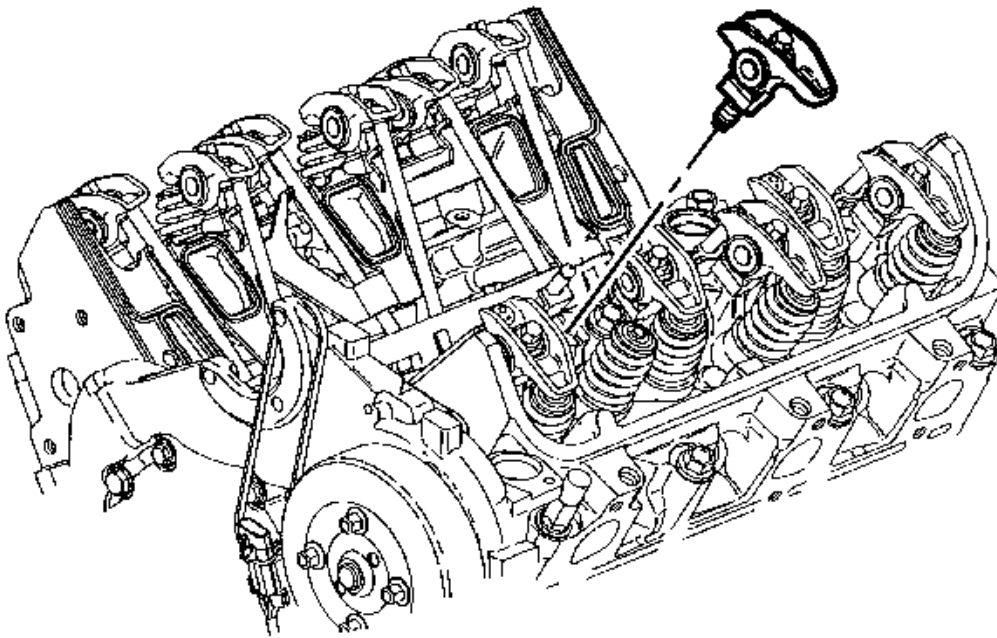


Fig. 70: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep the components separated in order to install the components in the same location.

2. Remove the rocker arm bolts.

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

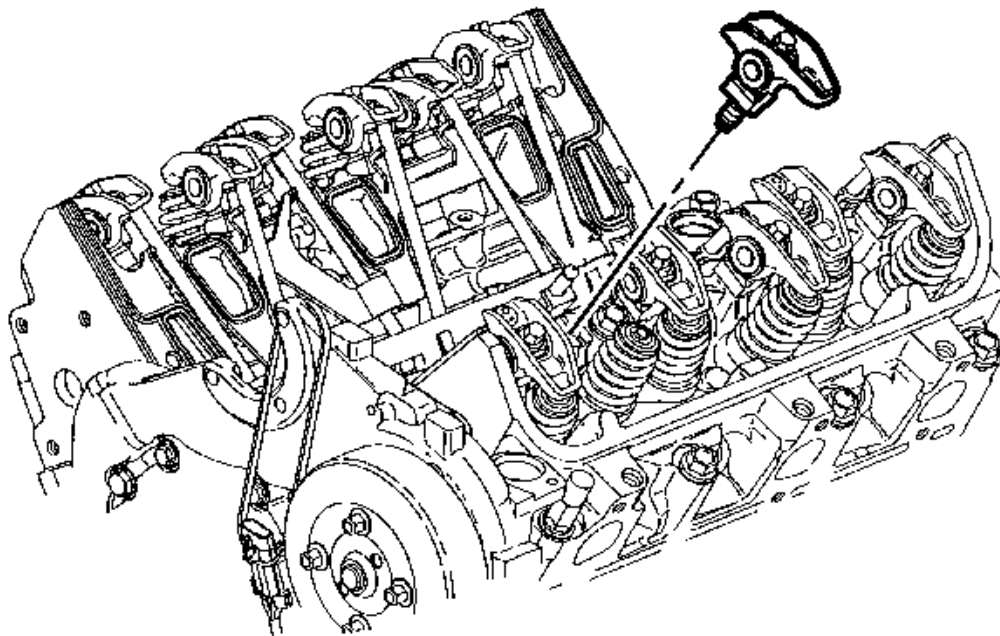
Installation Procedure

Fig. 71: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

1. Install the pushrods in the original location.
 - Coat the ends of the pushrods with GM P/N 1052356 or the equivalent.
 - The intake pushrods are identified with yellow stripes and are 5 3/4 inches long.
 - Exhaust pushrods are identified with green stripes and are 6 inches long.
 - Ensure that the pushrods seat in the lifter.
2. Install the rocker arms.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the rocker arm bolts.

Tighten: Tighten the rocker arm bolts to 32 N.m (24 lb ft).

4. Install the valve rocker 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**.
- **J 38606** Valve Spring Compressor. See **Special Tools**.

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 and debris from the spark plug recess area before removing.**

1. Remove the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L.
2. Remove the rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
3. Install the **J 22794** into the spark plug port. See **Special Tools**. Apply compressed air in order to hold the valves in place.

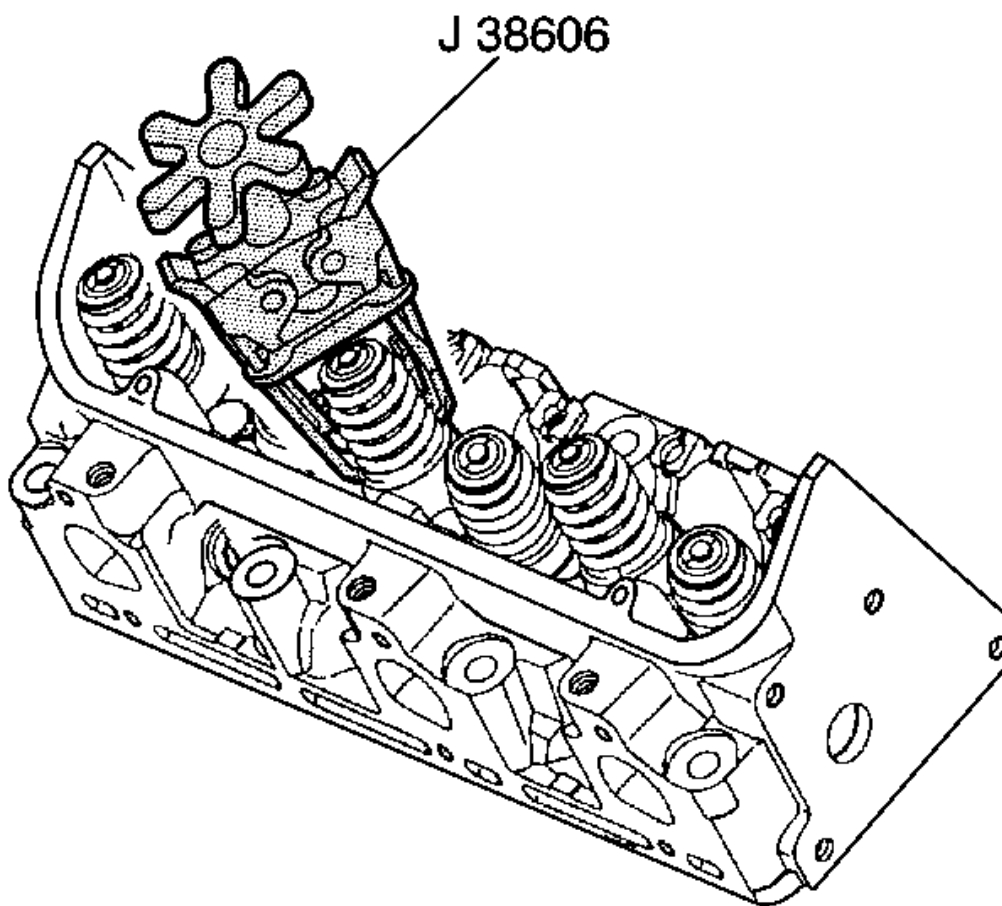


Fig. 72: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 38606** on the valve spring. See **Special Tools**.

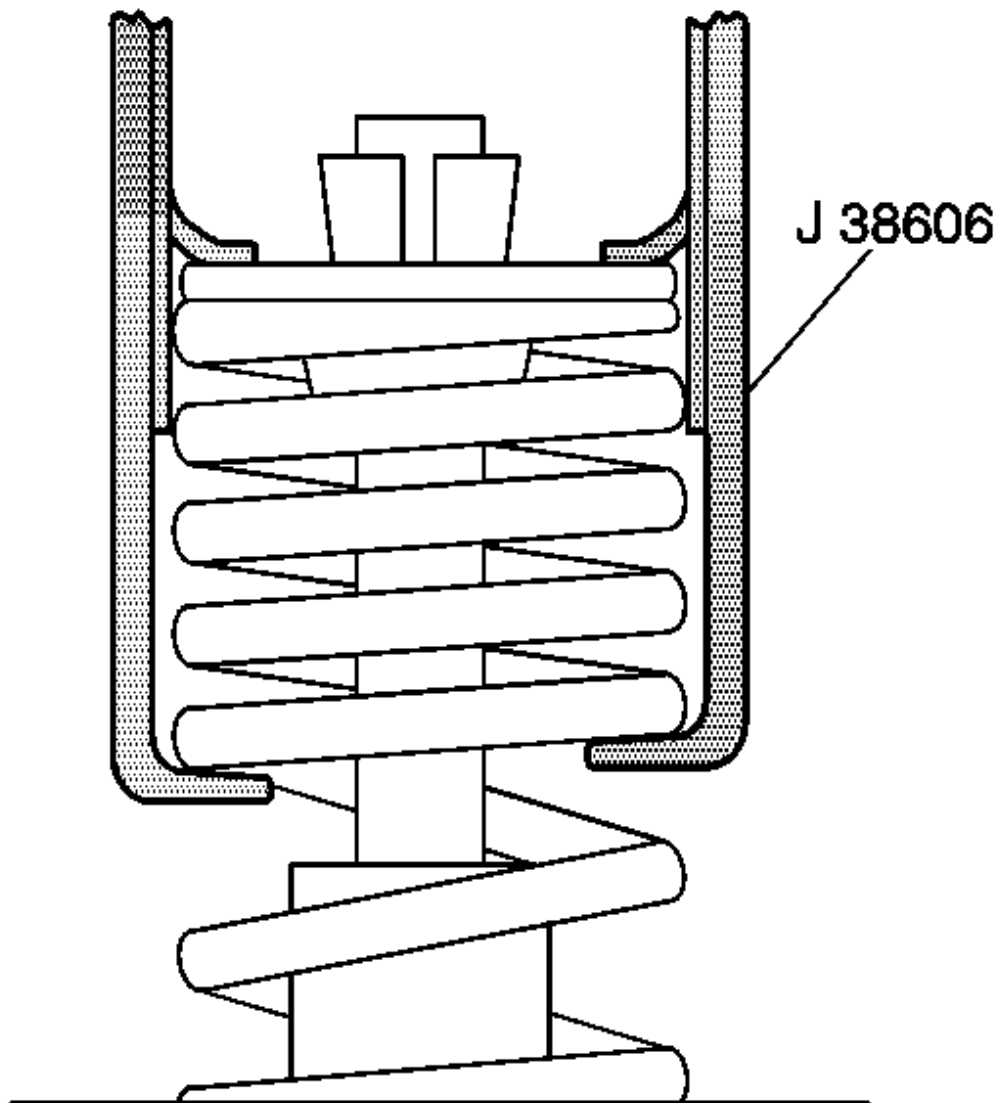


Fig. 73: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

5. Compress the valve spring with the **J 38606** . See Special Tools.

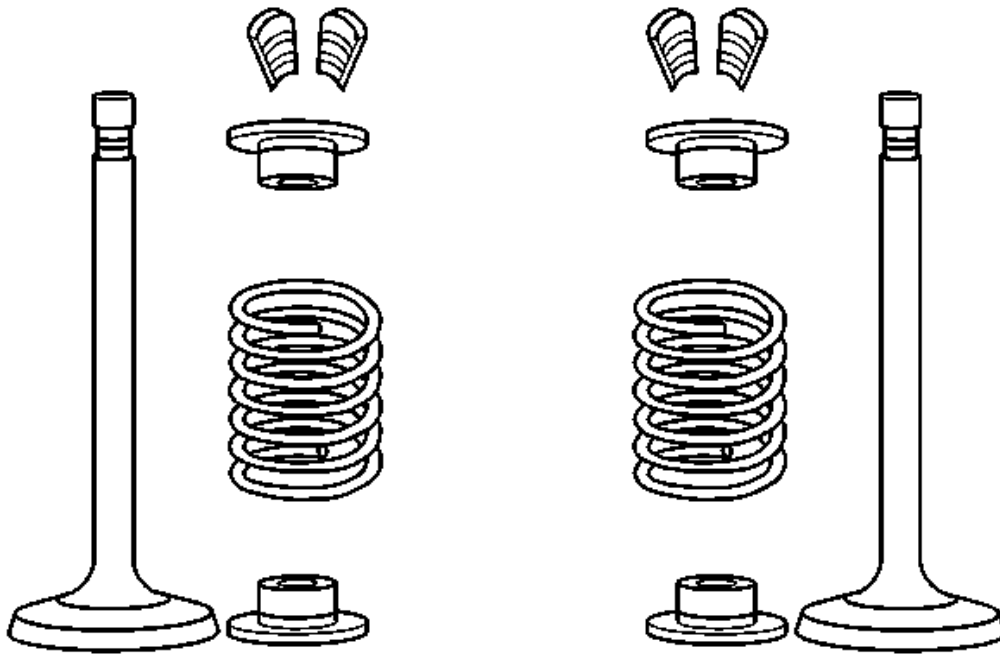


Fig. 74: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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

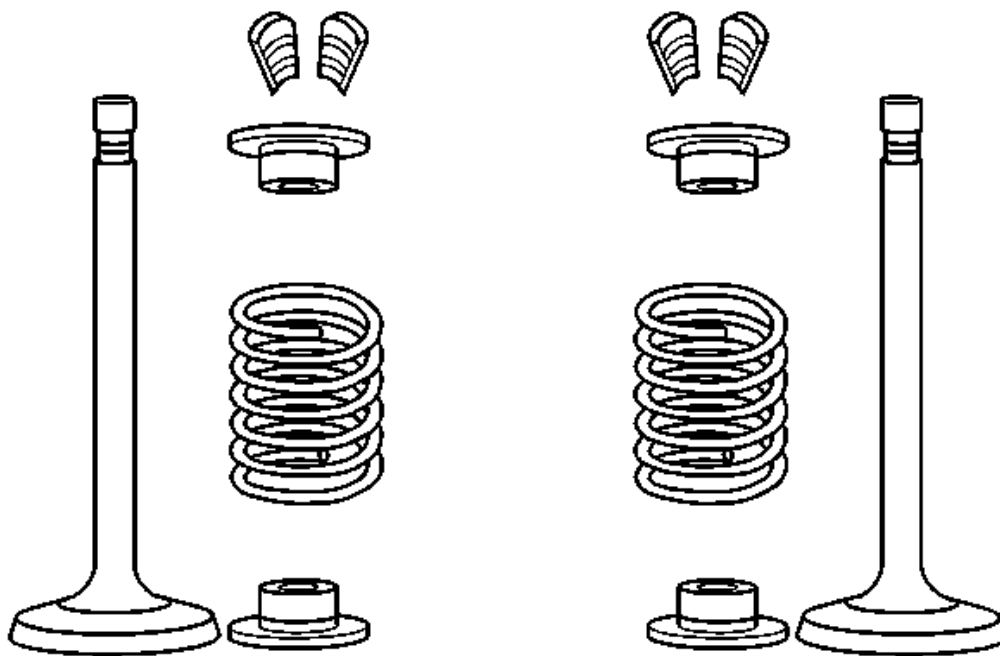


Fig. 75: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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

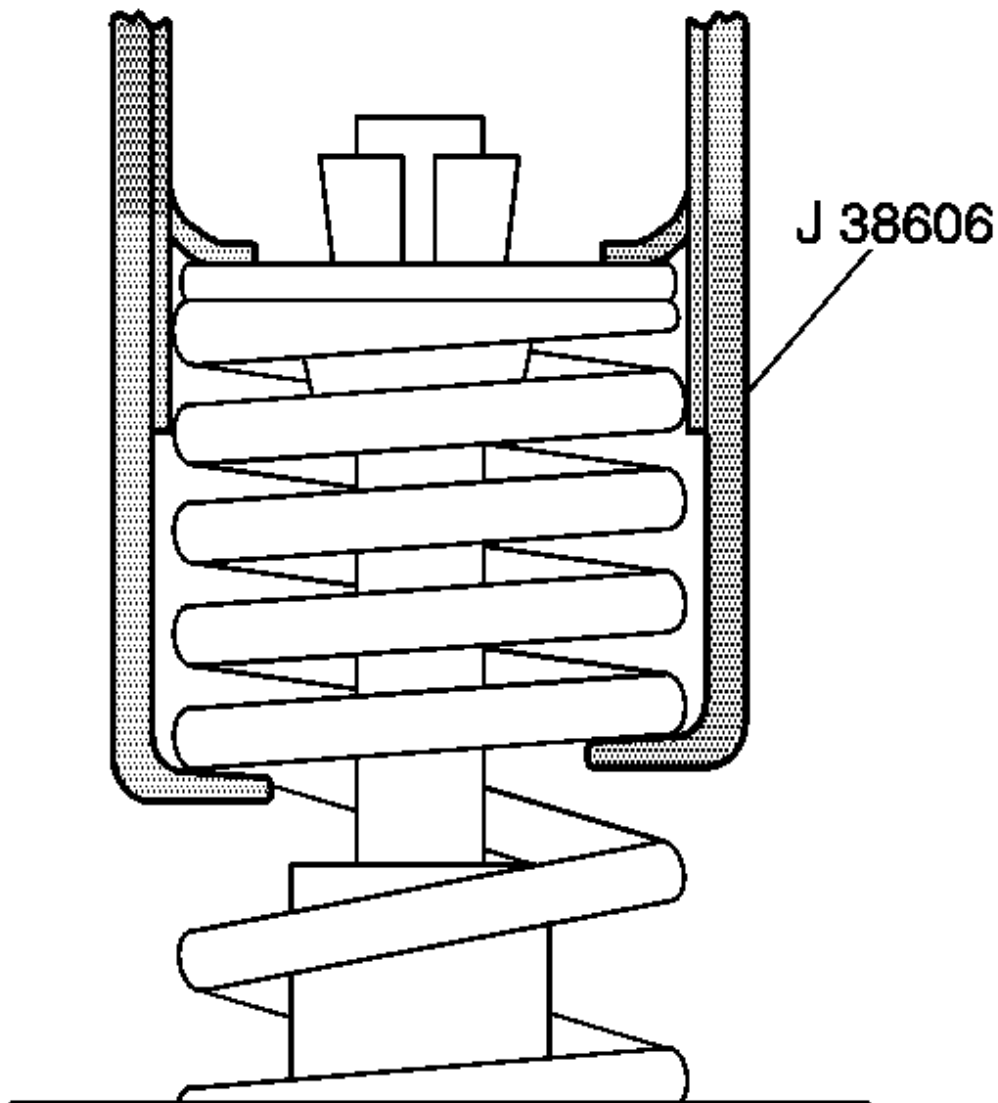


Fig. 76: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

4. Compress the valve spring with the J 38606 .
5. Install the valve locks. If necessary, hold the valve locks in place with grease.

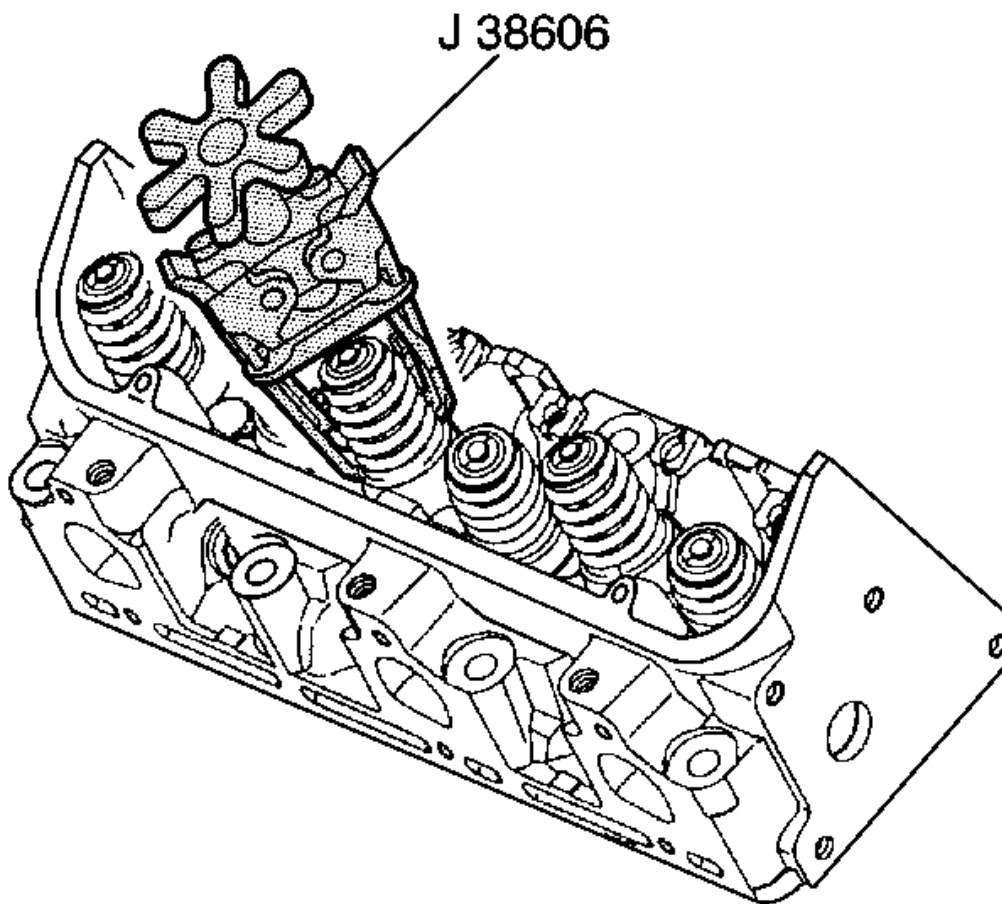


Fig. 77: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Release the valve spring using the J 38606 .
7. Ensure the valve locks are seated.
8. Release the air pressure and remove the **J 22794** from the spark plug port. See **Special Tools**.
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 - 3.5L.

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**.

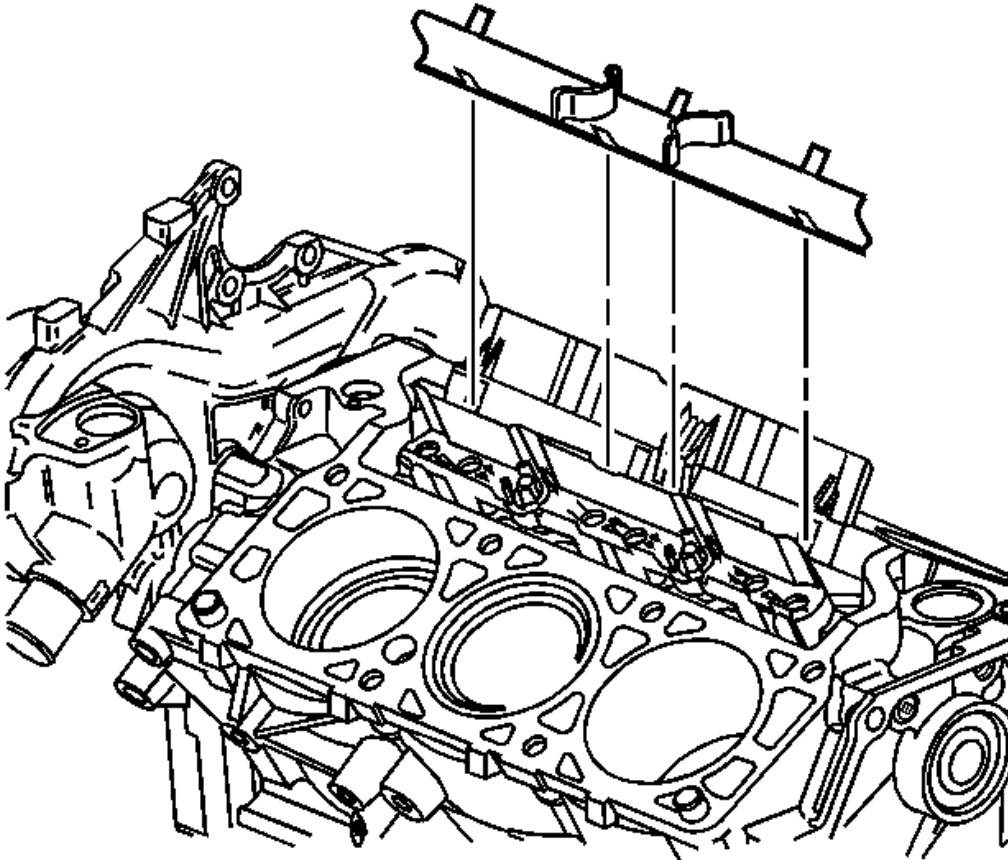


Fig. 78: Intake Manifold Oil Splash Shield
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake manifold oil splash shield

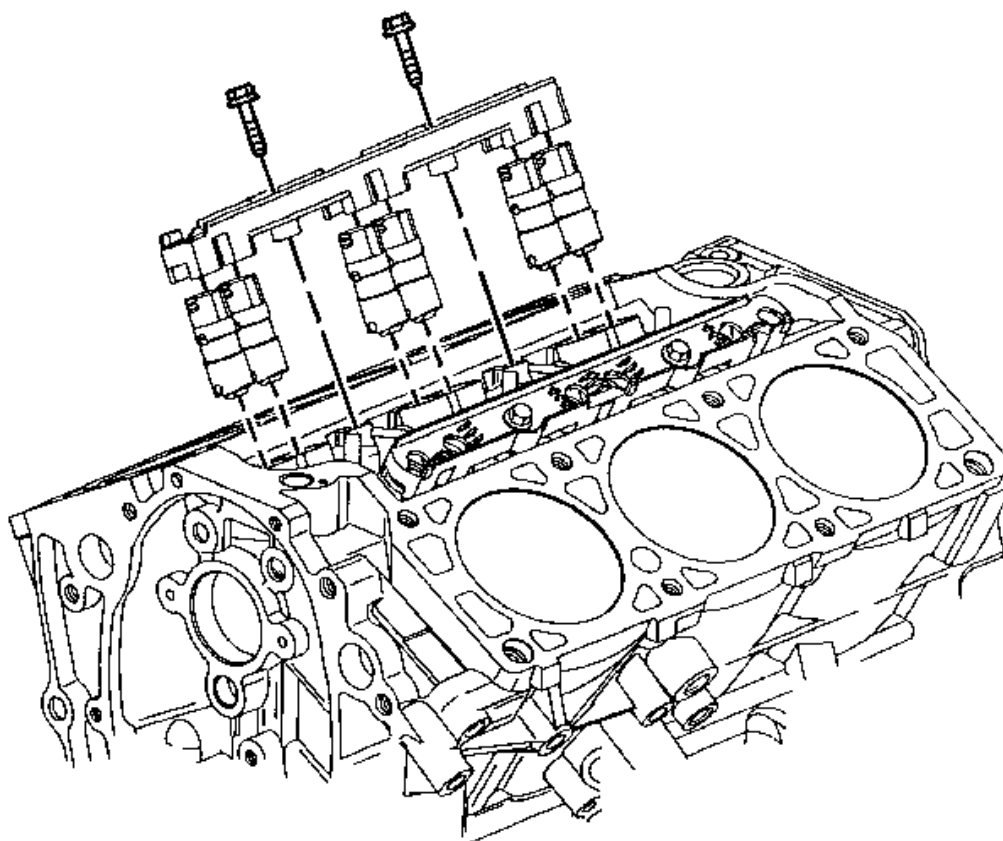


Fig. 79: View Of Lifter Guide
Courtesy of GENERAL MOTORS CORP.

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

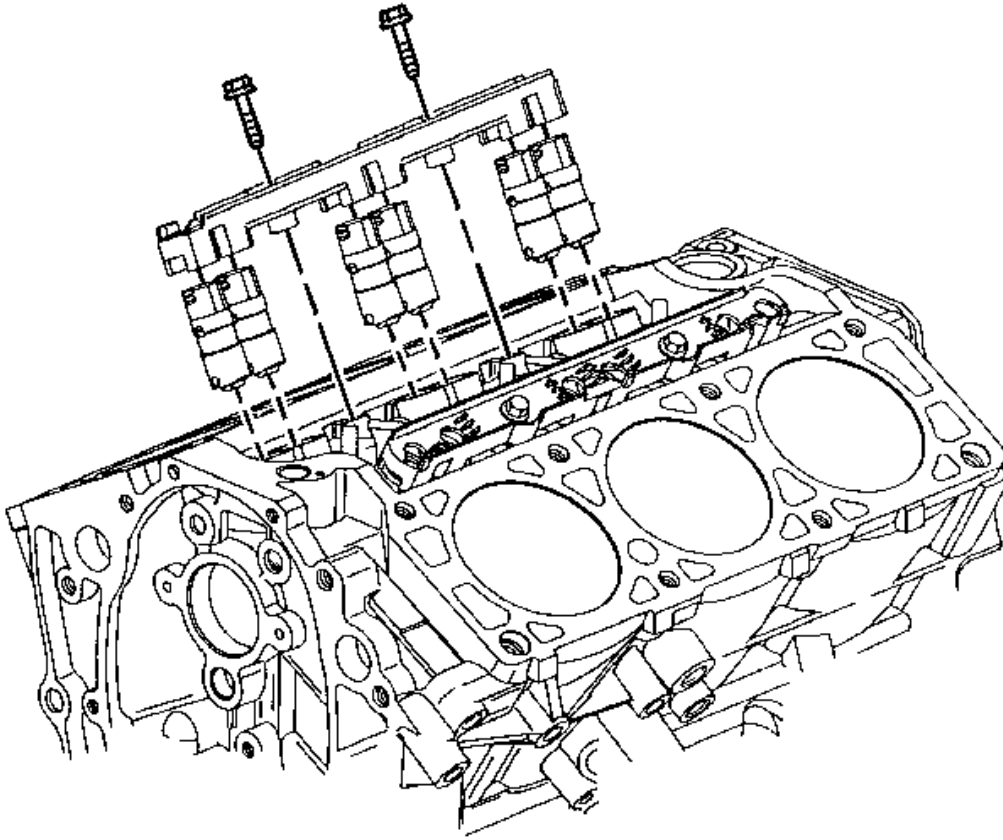


Fig. 80: View Of Lifter Guide
Courtesy of GENERAL MOTORS CORP.

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).

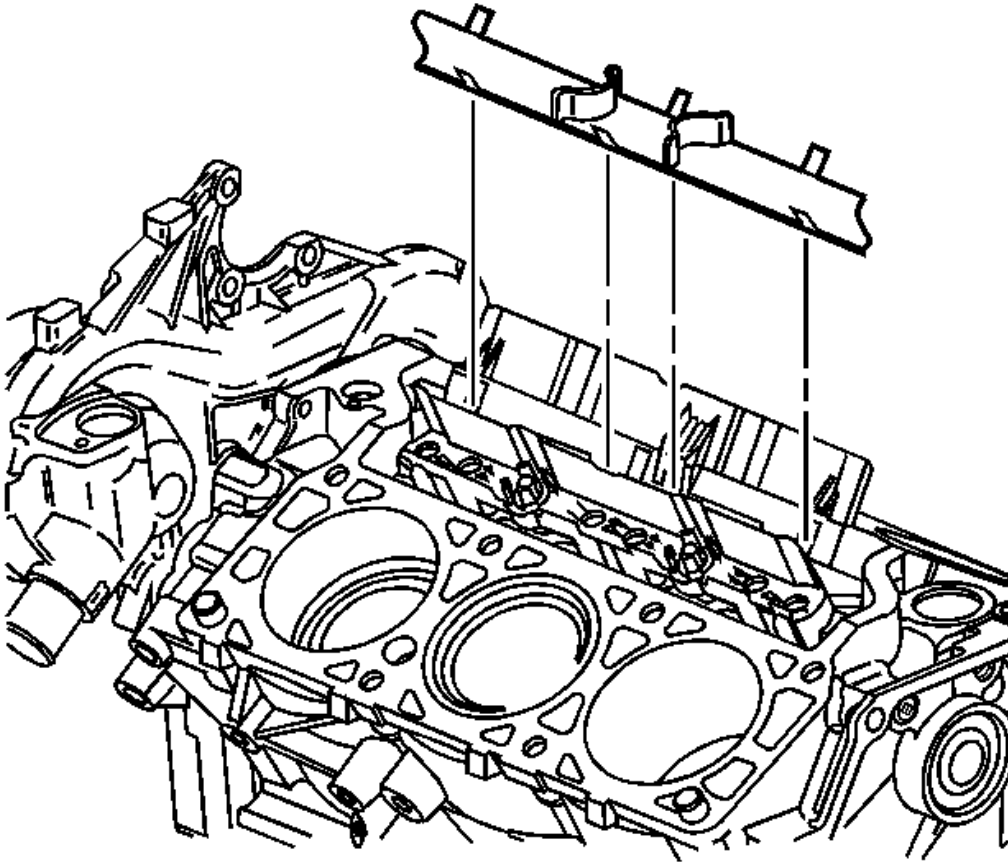


Fig. 81: Intake Manifold Oil Splash Shield
Courtesy of GENERAL MOTORS CORP.

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

Removal Procedure

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

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 **Radiator Air Baffle and Deflector Replacement - Side** in Engine Cooling.
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 (W/LX9)** 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.
9. Install the **J 37096** to the flywheel to prevent flywheel rotation. See **Special Tools**.

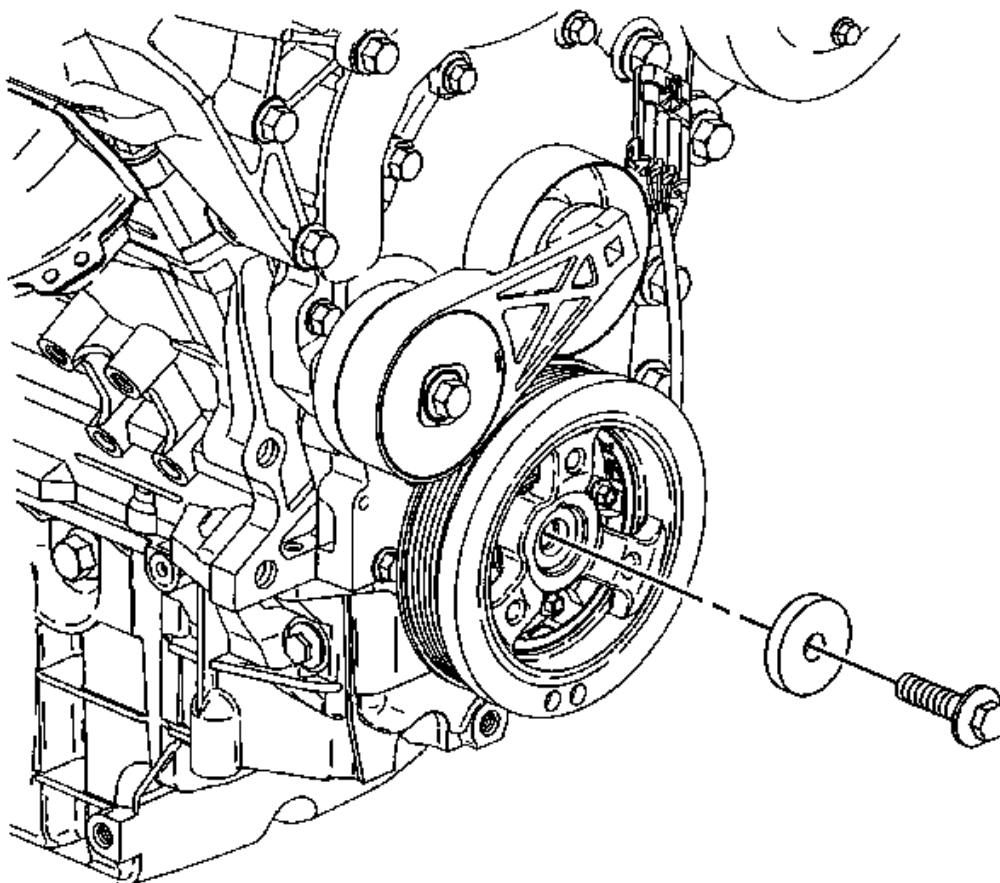


Fig. 82: Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft balancer bolt and the washer.

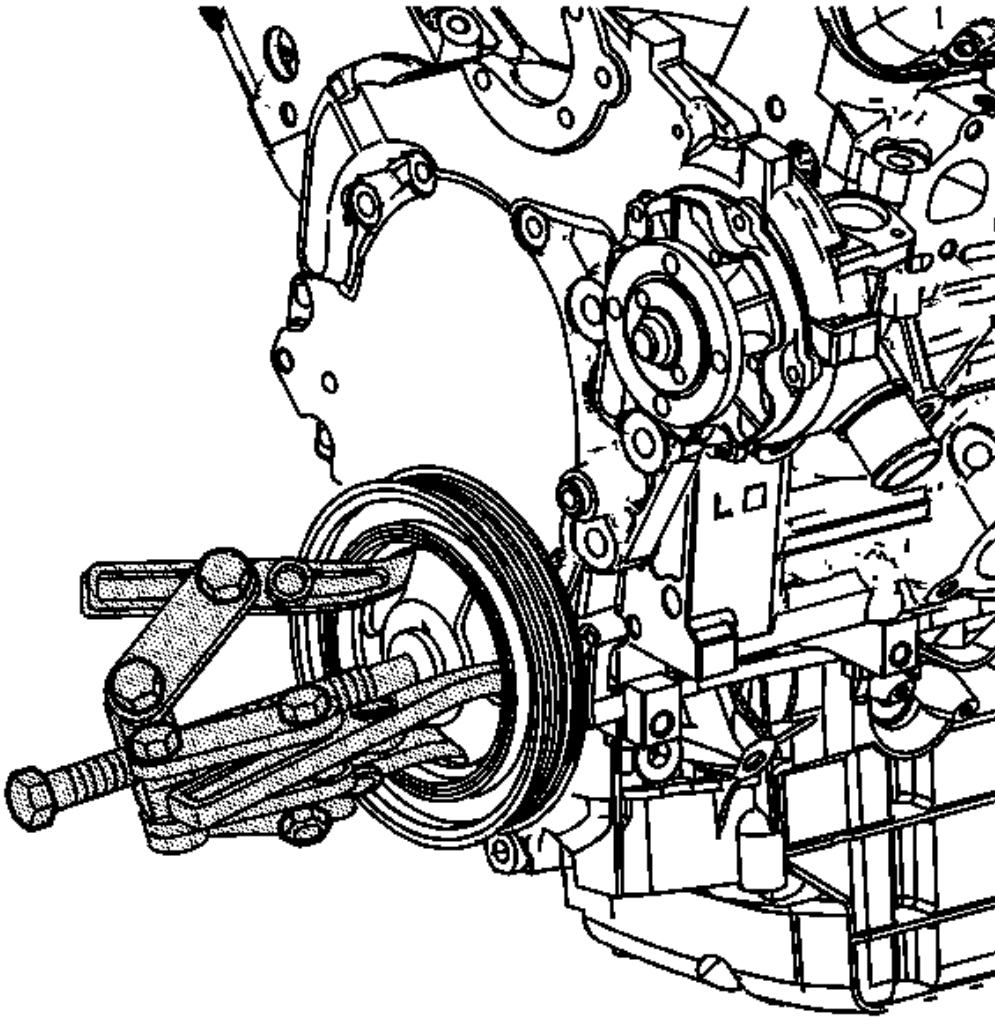


Fig. 83: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft balancer. Use the **J 41816** . See **Special Tools**.

Installation Procedure

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

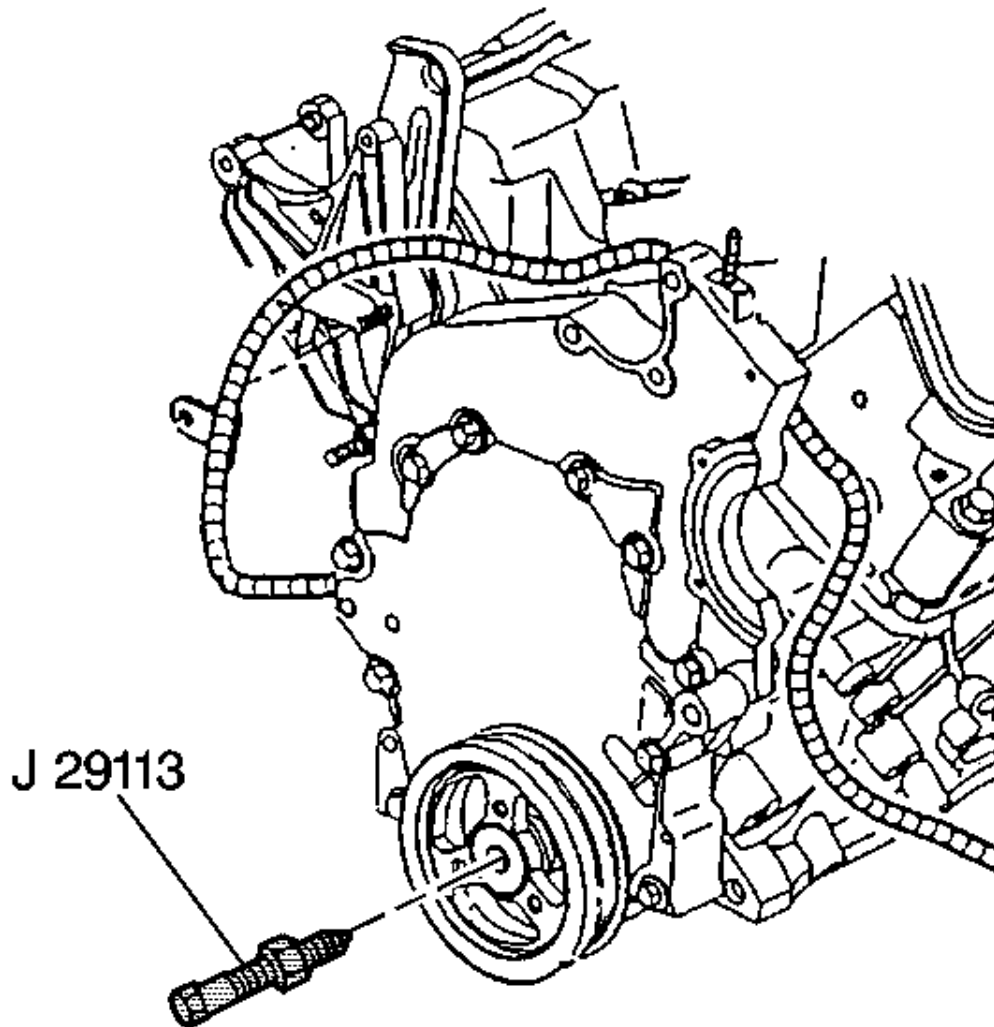


Fig. 84: Installing Crankshaft Balancer Using J 29113
Courtesy of GENERAL MOTORS CORP.

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

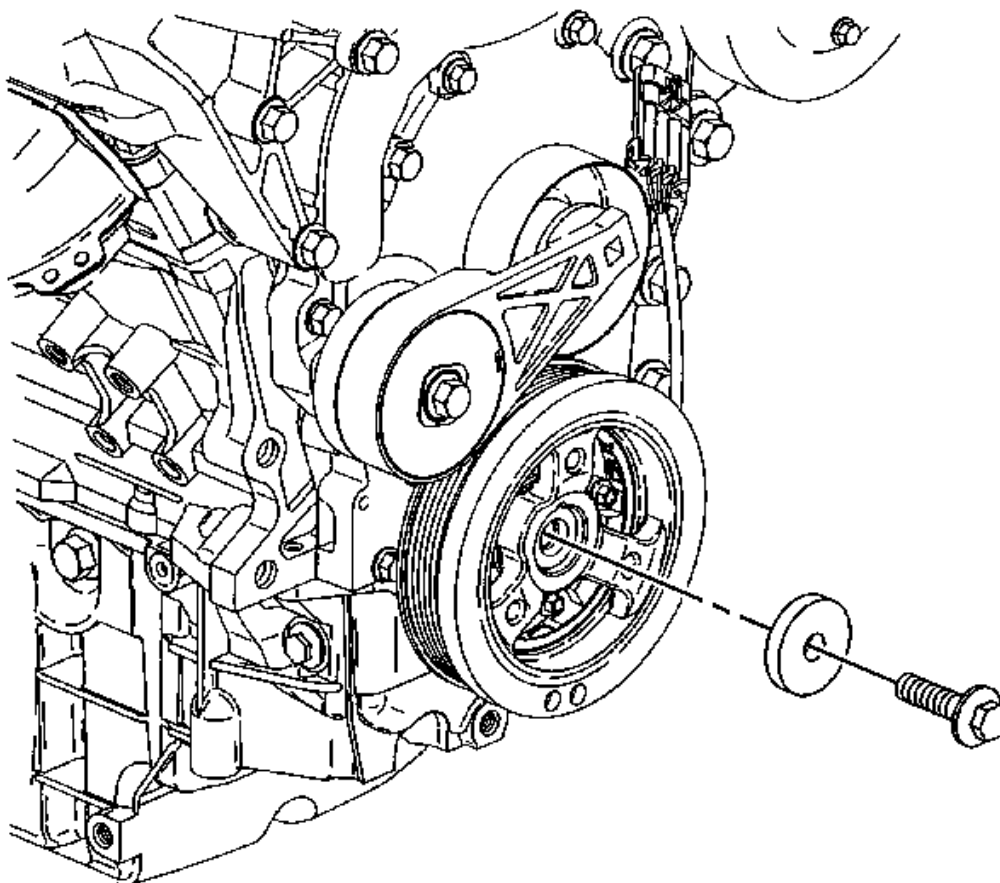


Fig. 85: Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

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 70 degrees. See Special Tools.
6. Remove the **J 45059** from the flywheel. See Special Tools.
 7. Install the torque converter covers.
 8. Raise the frame to the original position.

9. Install and tighten the frame bolts. Refer to **Frame Replacement (W/LX9)** in Frame and Underbody.
10. Install the right engine splash shield. Refer to **Radiator Air Baffle and Deflector Replacement - Side** in Engine Cooling.
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 crankshaft position (CKP) system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.5L.

Oil Pan Replacement

Tools Required

J 28467-B Universal Engine Support Fixture. See **Special Tools**.

Removal Procedure

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. Drain the crankcase.
4. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
5. Remove the right front splash shield. Refer to **Radiator Air Baffle and Deflector Replacement - Side** in Engine Cooling.
6. Remove the wheel speed sensor harness from the right suspension support.
7. Remove the right front ball joint, bolt, and nut. Separate the ball joint from the steering knuckle. Refer to **Lower Control Arm Replacement** in Front Suspension.
8. Remove lower closeout panel.

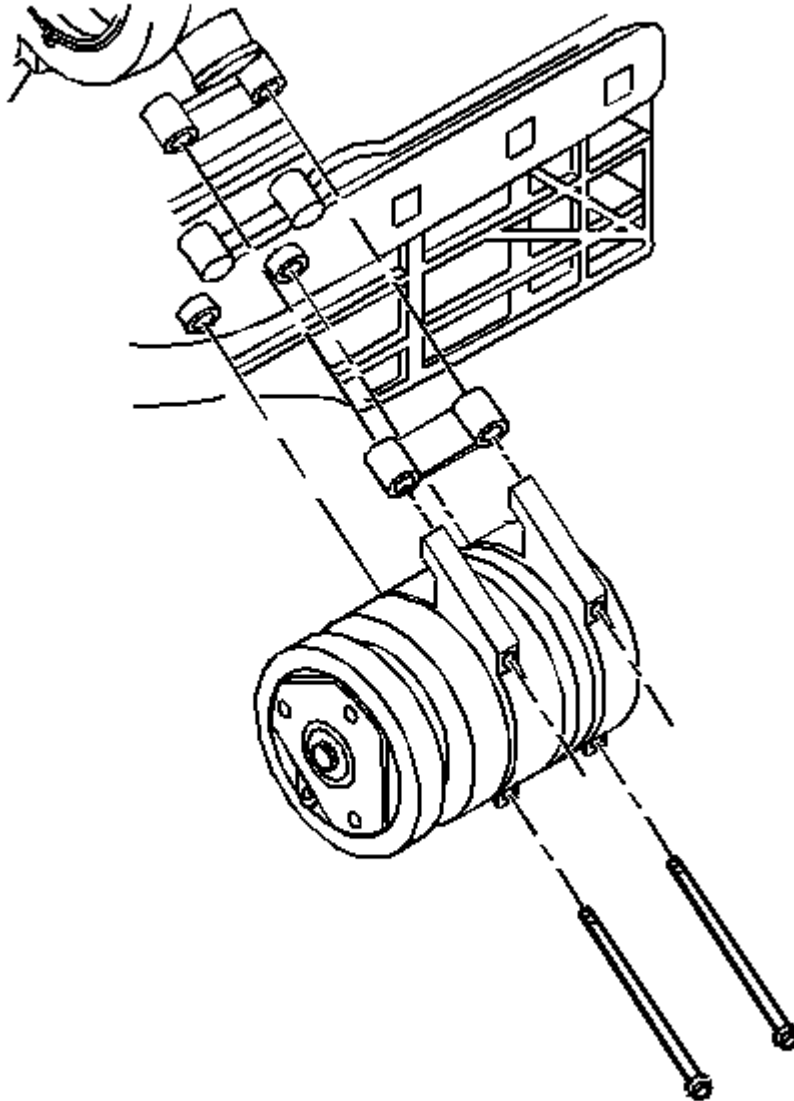


Fig. 86: View Of A/C Compressor, Bolts & Brace
Courtesy of GENERAL MOTORS CORP.

9. Remove the air conditioning (A/C) compressor bolts and position the compressor aside.
10. Remove the braces that support the engine to the transmission.
11. Disconnect the oil level sensor.
12. Remove the retainers that secure the brake line to the frame.

13. Support the engine using the **J 28467-B** or a tall jackstand and a block of wood. See **Special Tools**.
14. Remove the right side engine mount nuts and bolts. Refer to **Engine Mount Replacement**.
15. Loosen the left side cradle bolts. Refer to **Frame Replacement (W/LX9)** in Frame and Underbody.
16. Remove the cradle bolts from the right front and the right rear.
17. Remove the starter. Refer to **Starter Motor Replacement** in Engine Electrical.

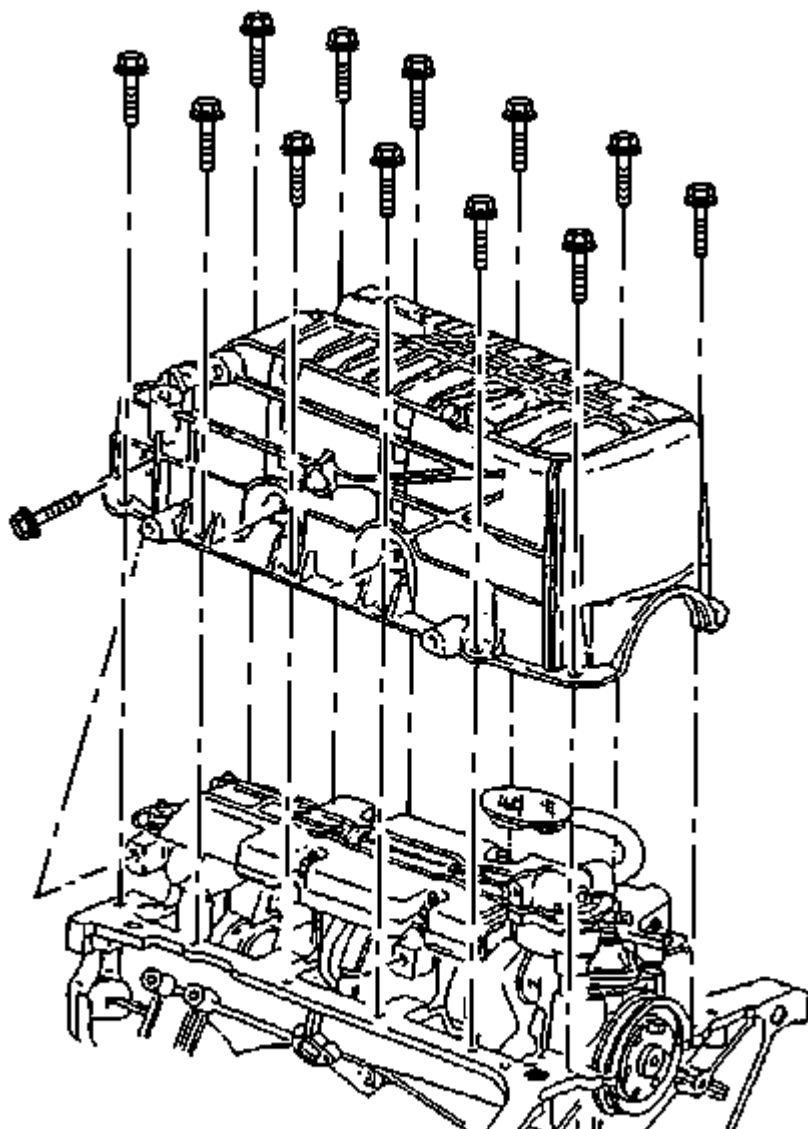


Fig. 87: View Of Oil Pan & Bolts

Courtesy of GENERAL MOTORS CORP.

18. Remove the oil pan side bolts.
19. Remove the oil pan bolts.
20. Remove the oil pan.
21. Remove the oil pan gasket.
22. Clean the following items:
 - The oil pan flanges
 - The oil pan rail
 - The front cover
 - The rear main bearing cap
 - The threaded holes

Installation Procedure

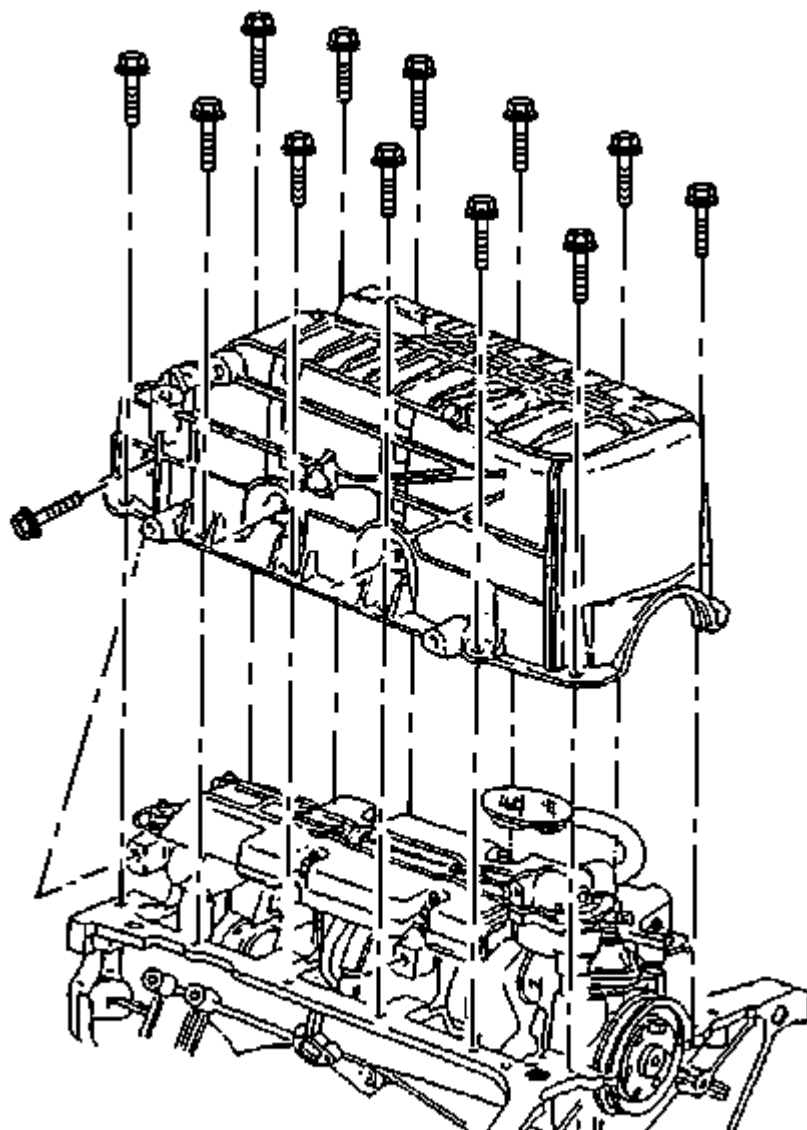


Fig. 88: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a new gasket. If you are installing the rear main bearing cap, place sealant on the oil pan gasket tabs. Place the sealer on the tabs that insert into the gasket groove on the outer surface of the main bearing cap. Use GM P/N 1052080 (Canadian P/N 10953480) or the equivalent.
2. Install the oil pan.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pan bolts.

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

4. Install the oil pan side bolts.

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

5. Install the starter. Refer to Starter Motor Replacement in Engine Electrical.
6. Install the flywheel inspection cover.

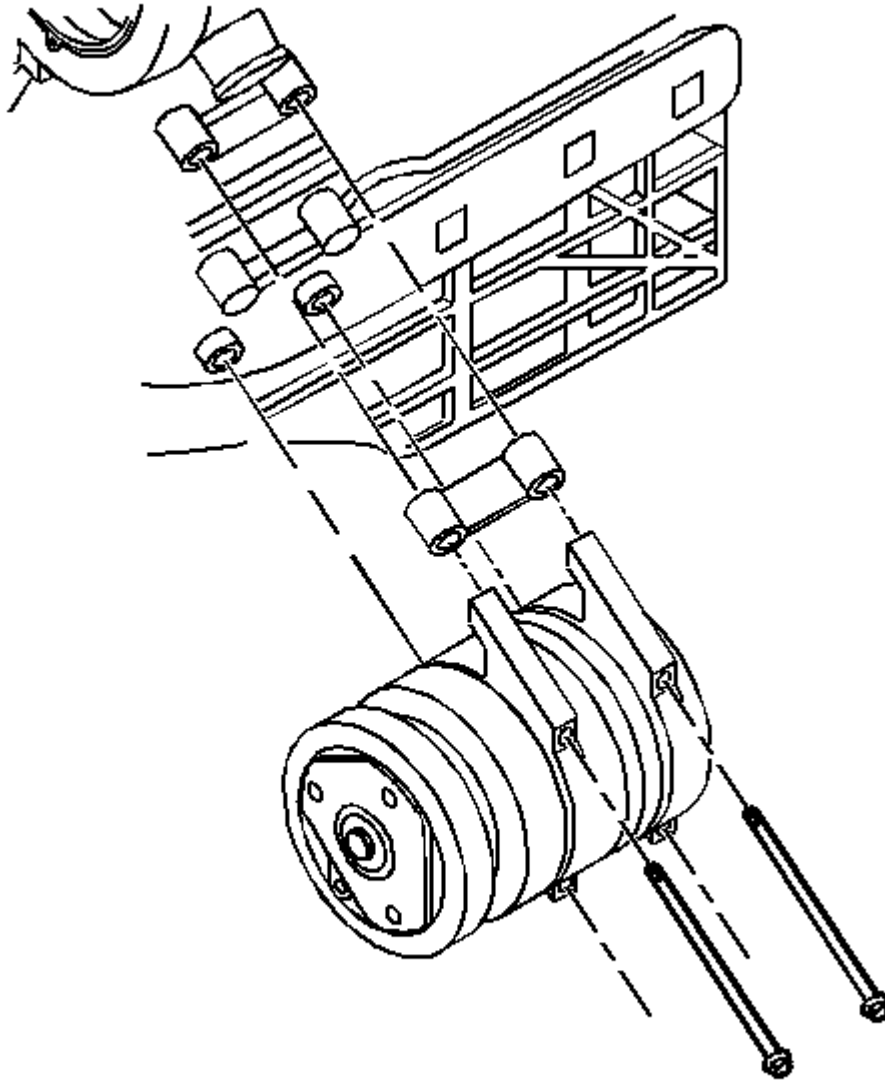


Fig. 89: View Of A/C Compressor To Engine
Courtesy of GENERAL MOTORS CORP.

7. Install the A/C compressor to the engine. Refer to **Compressor Replacement (LX9)** in Heating, Ventilation, and Air Conditioning.
8. Install the frame bolts on the right side. Refer to **Frame Replacement (W/LX9)** in Frame and Underbody.
9. Install engine mount bolts and nuts. Refer to **Engine Mount Replacement**.

10. Install the right side ball joint to the steering knuckle. Refer to **Lower Control Arm Replacement** in Front Suspension.
11. Connect the right front antilock brake system (ABS) wheel speed sensor harness.
12. Install the retainers that support the brake line to the frame.
13. Install the braces that support the engine to the transmission.
14. Install the right front splash shield. Refer to **Radiator Air Baffle and Deflector Replacement - Side** in Engine Cooling.
15. Install the right front tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
16. Install the lower closeout panel.
17. Lower the vehicle.
18. Fill the crankcase.
19. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Oil Pressure Sensor and/or Switch Replacement

Removal Procedure

1. Disconnect the battery negative cable from the battery. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the electrical connector from the engine oil pressure sensor.

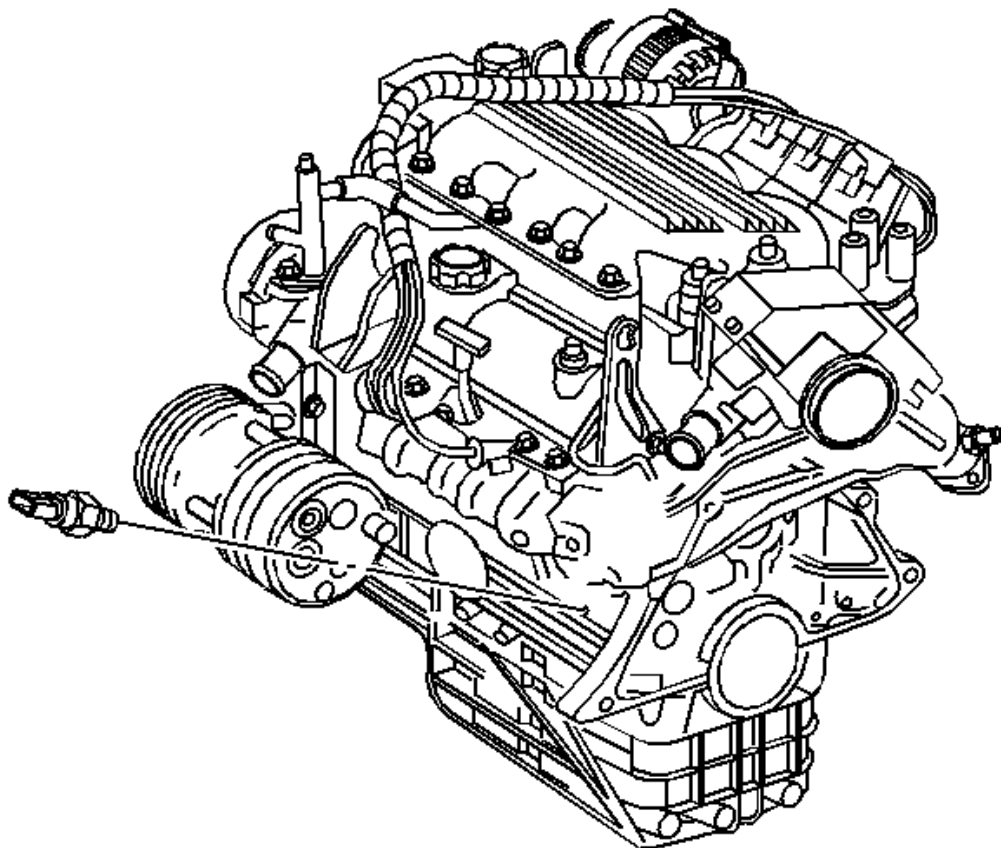


Fig. 90: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch.

Installation Procedure

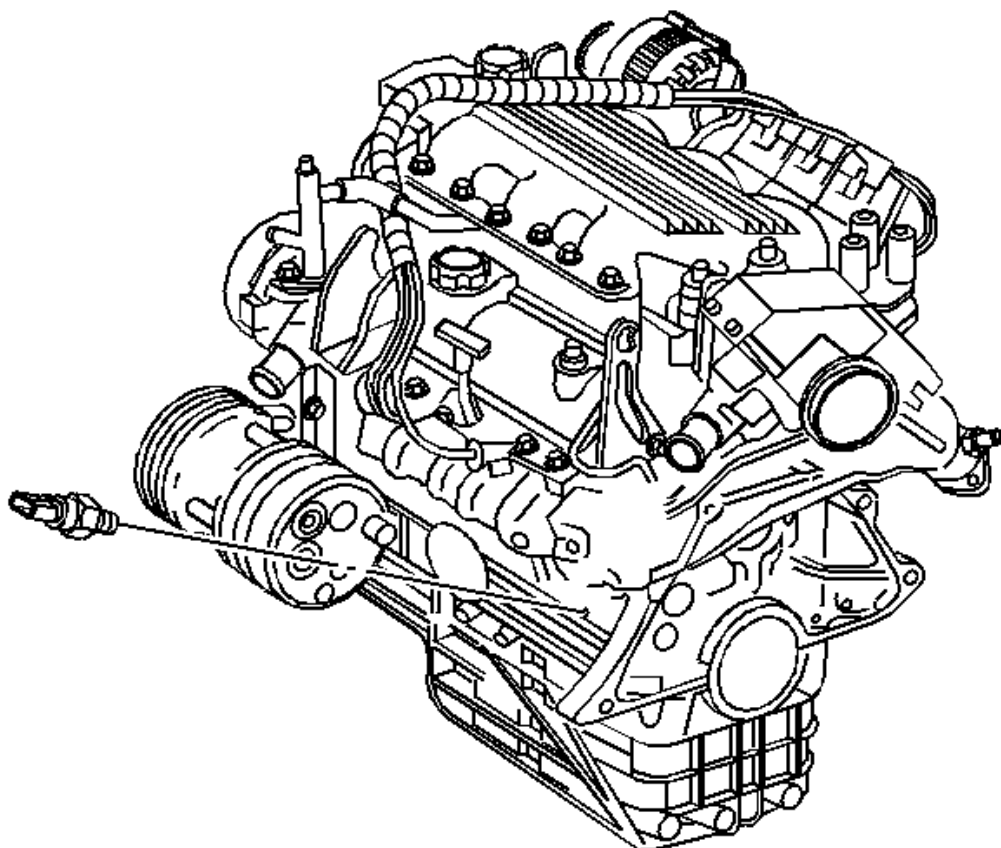


Fig. 91: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine oil pressure switch.

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

2. Install the electrical connector to the engine oil pressure switch.
3. Connect the battery negative cable to the battery. Refer to Battery Negative Cable Disconnect/Connect Procedure in Engine Electrical.

Oil Pump Replacement

Removal Procedure

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

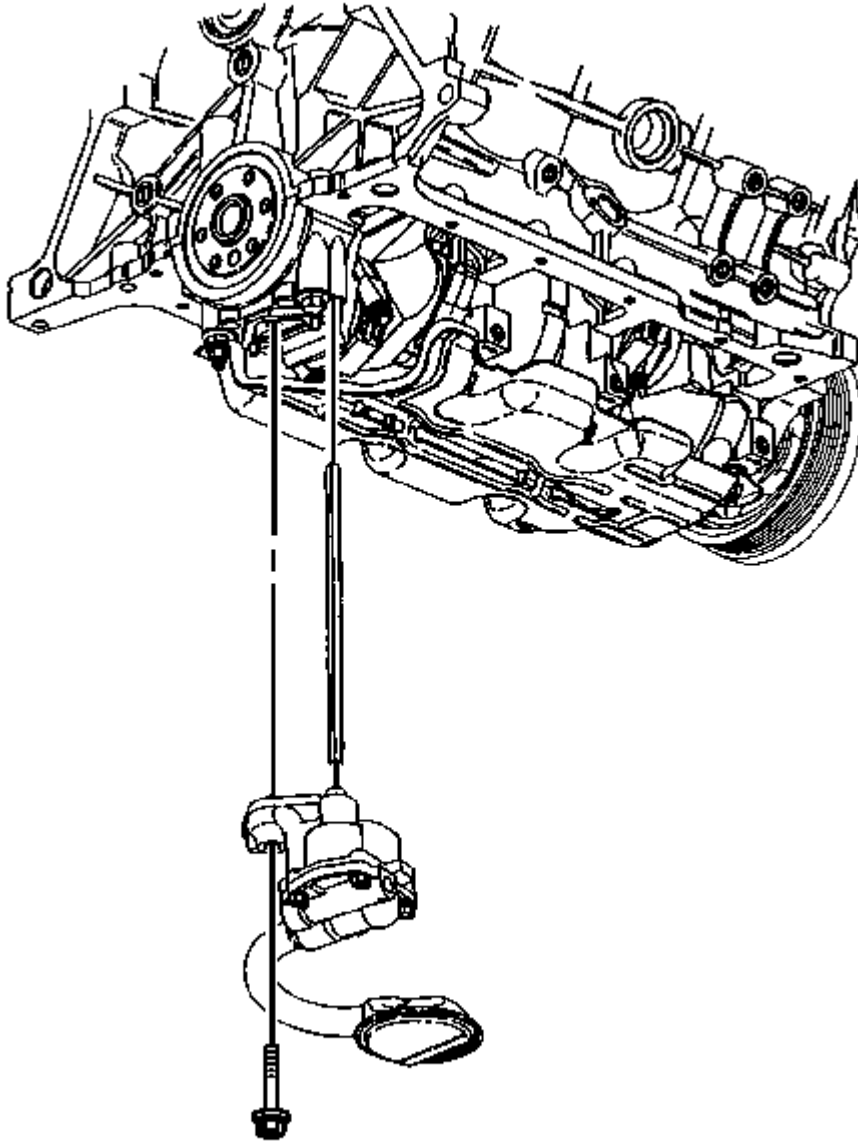


Fig. 92: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

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

4. Inspect the oil pump drive shaft and the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

Installation Procedure

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

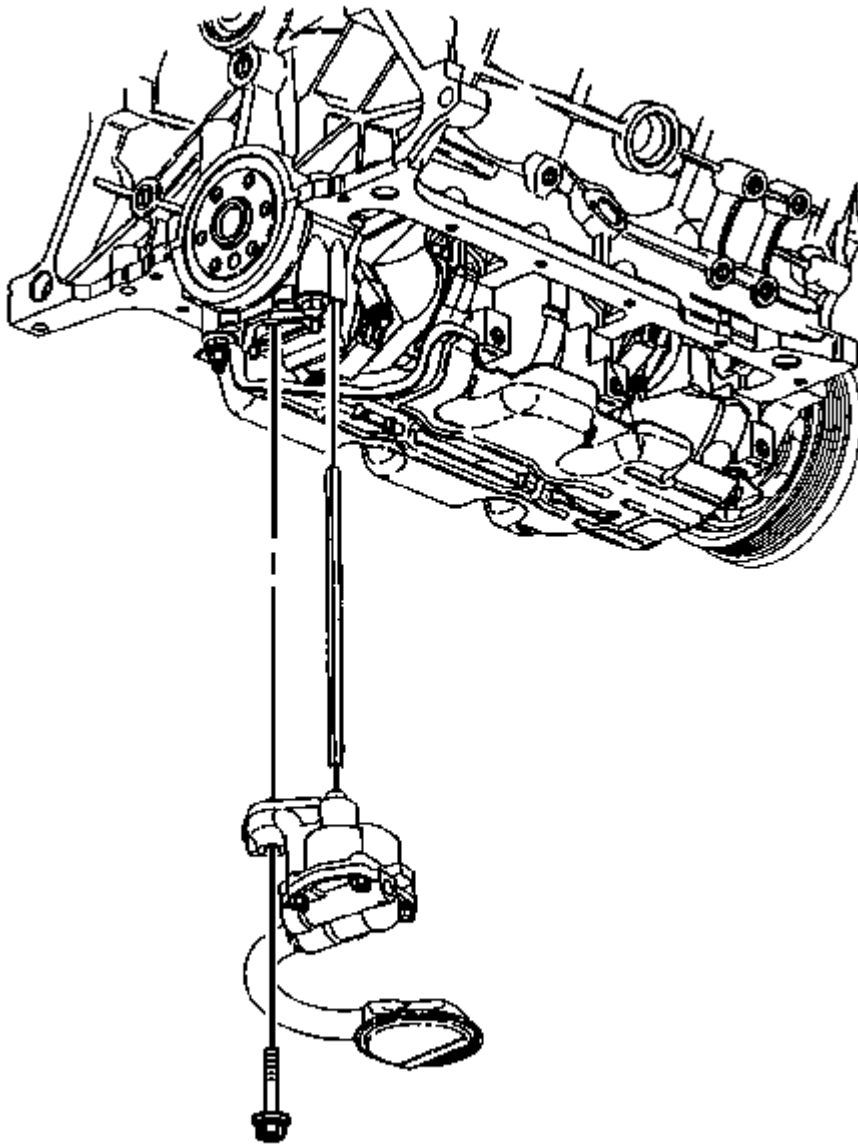


Fig. 93: Removing/Installing Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pump bolt.

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

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

Oil Pump Drive Replacement

Removal Procedure

1. Remove the air intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls - 3.5L.

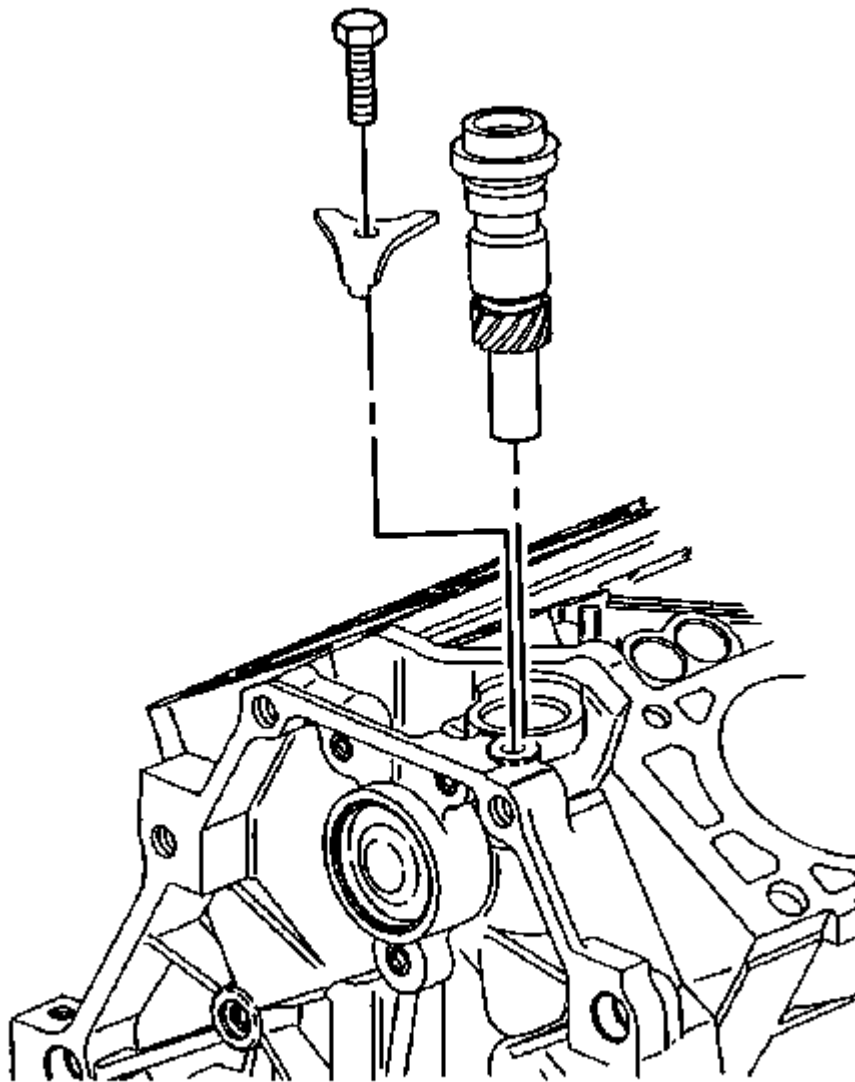


Fig. 94: Oil Pump, Drive Bolt, & Clamp
Courtesy of GENERAL MOTORS CORP.

Remove the oil pump drive bolt.

2. Remove the oil pump drive clamp.
3. Remove the oil pump drive.
4. Remove the oil pump drive seal.

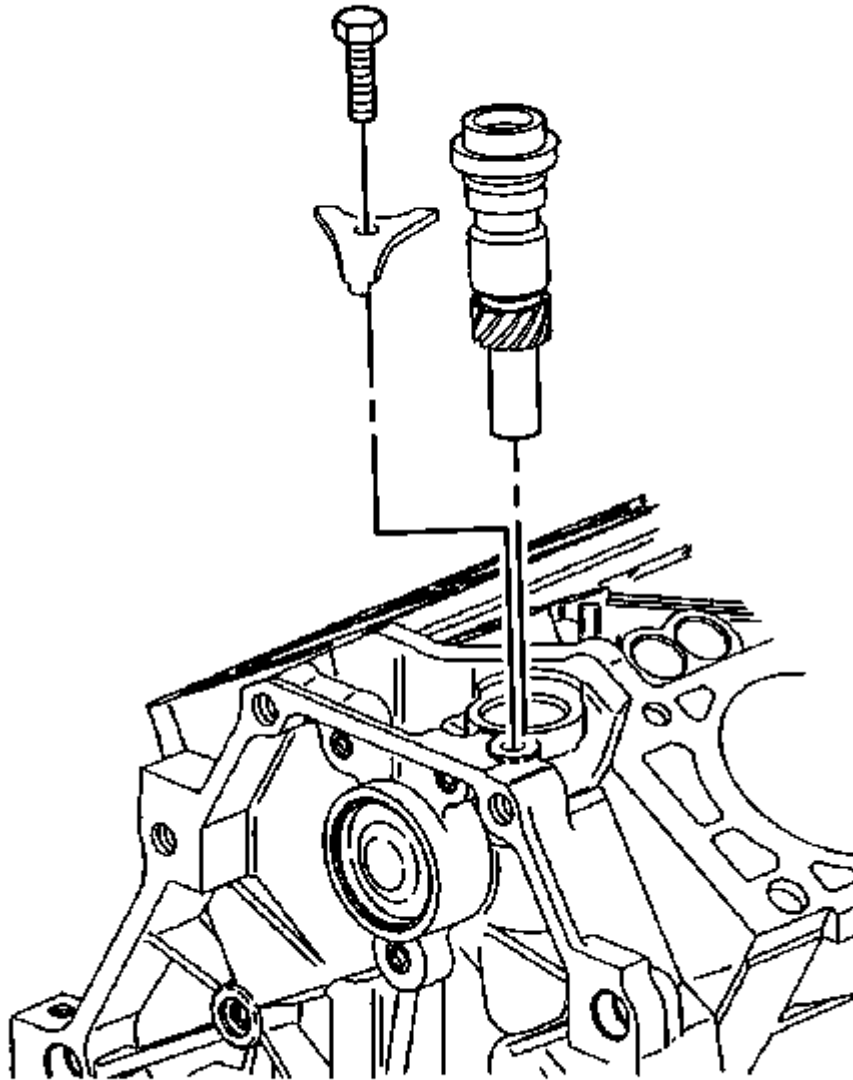
Installation Procedure

Fig. 95: 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).

6. Install the air intake duct. Refer to Air Cleaner Intake Duct Replacement in Engine Controls - 3.5L.

Crankshaft Front Oil Seal Replacement

Tools Required

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

Removal Procedure

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

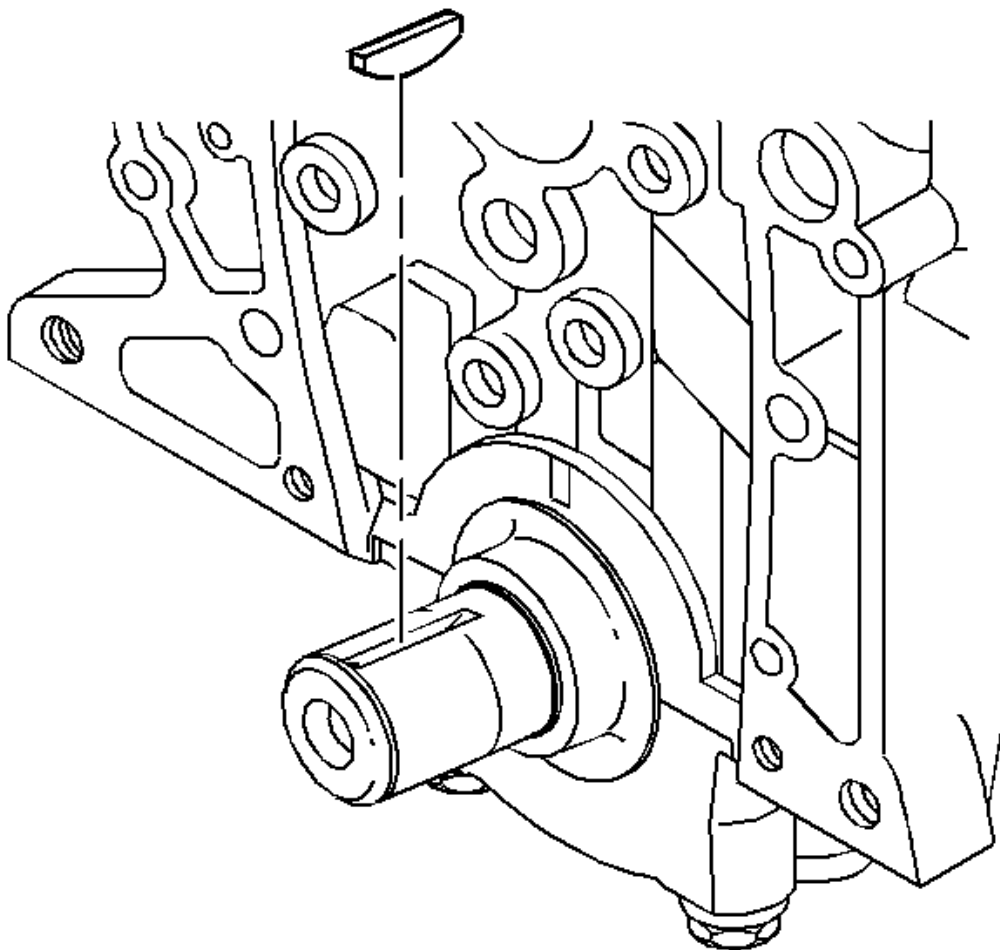


Fig. 96: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the crankshaft.

2. Remove the crankshaft key from the keyway.

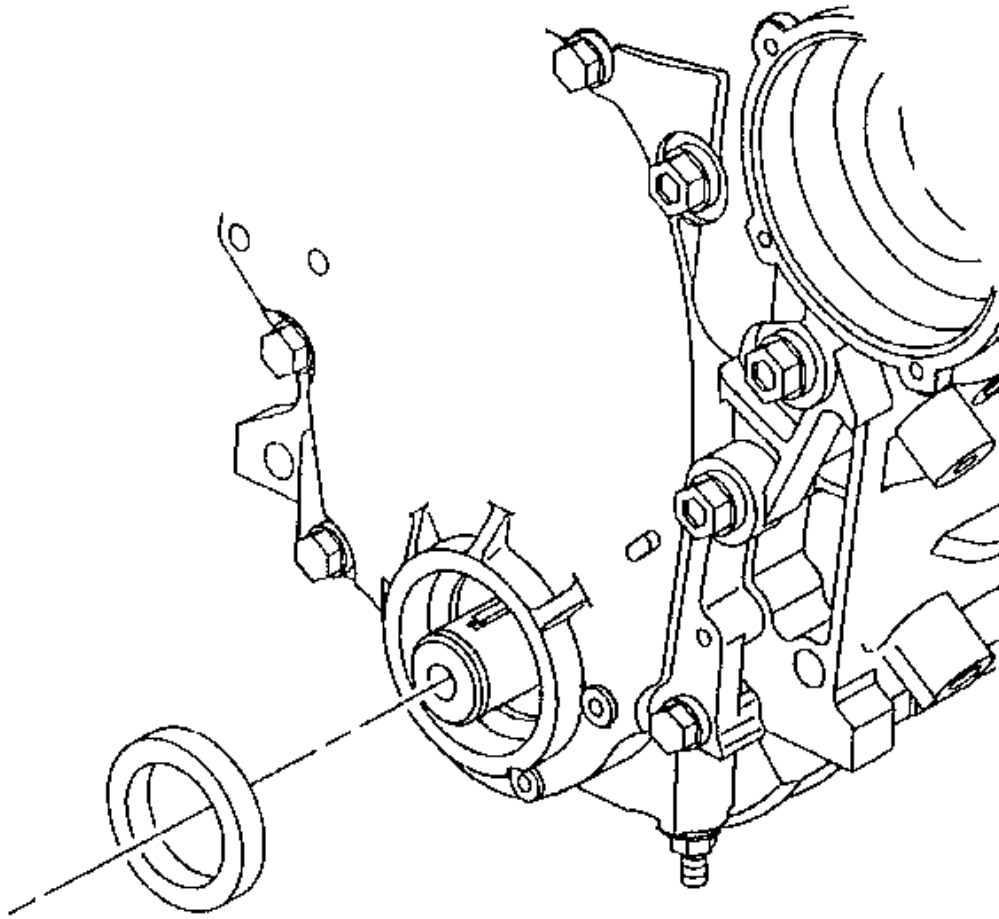


Fig. 97: View Of Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Pry out the oil seal using a large screwdriver or the equivalent.
4. Inspect the following items for scratches:
 - The front cover
 - The crankshaft

Installation Procedure

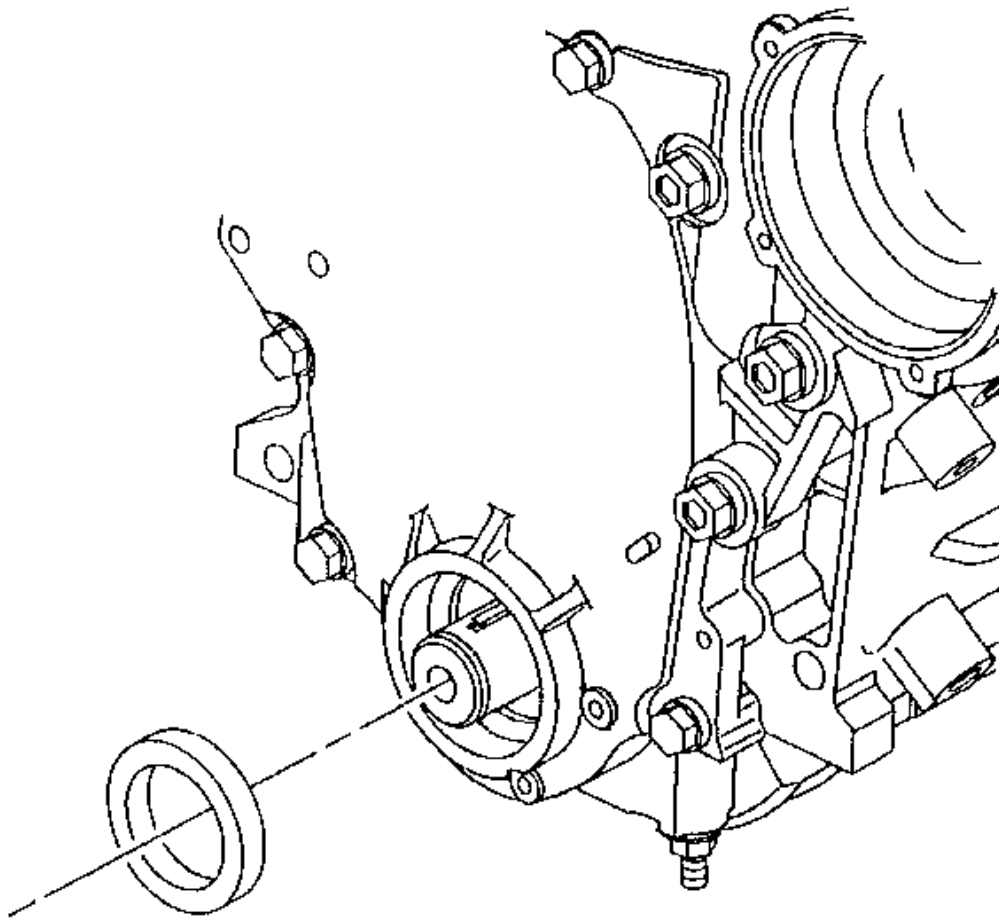


Fig. 98: View Of Oil Seal

Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil seal using clean engine oil.
2. Insert the oil seal into the front cover with the lip facing the engine. Use the **J 35468** . See **Special Tools**.

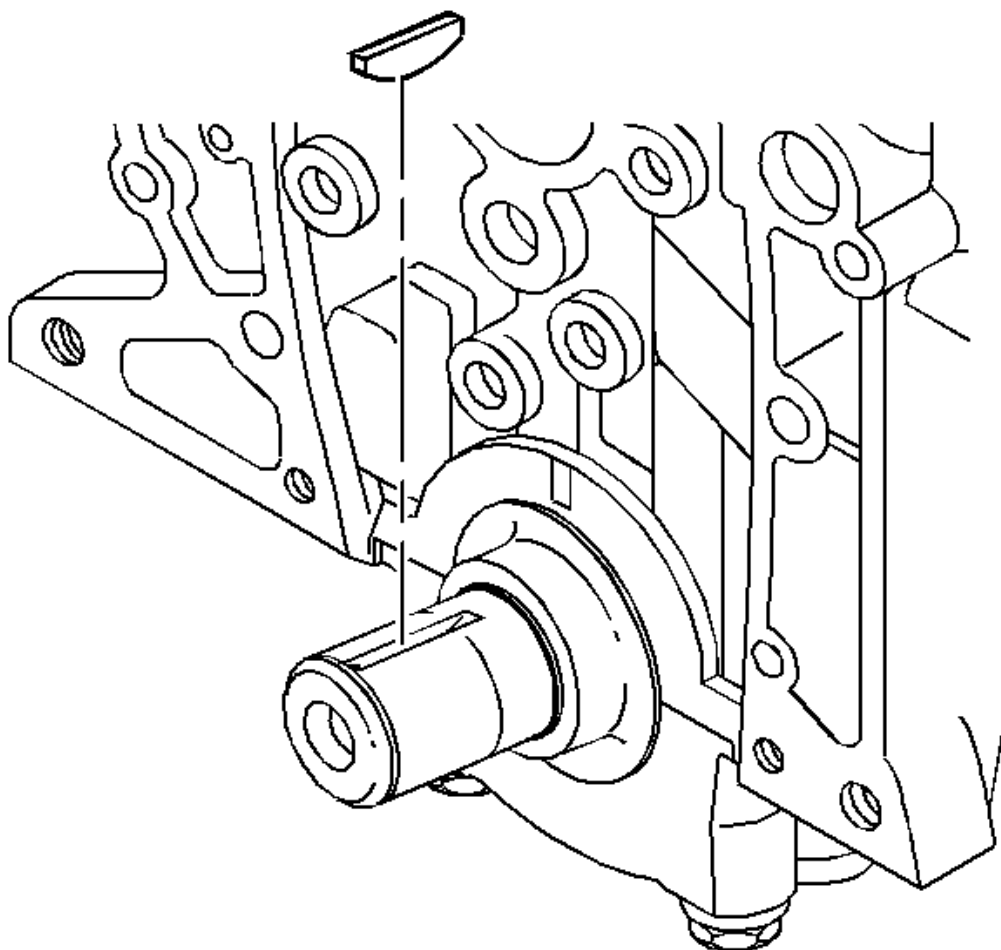


Fig. 99: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft key into the keyway.
4. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

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. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
4. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
5. Remove the oil pan. Refer to **Oil Pan Replacement**.
6. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
7. Remove the thermostat bypass pipe from the engine front cover. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
8. Remove the radiator outlet hose from the engine front cover. Refer to **Radiator Hose Replacement - Outlet** in Engine Cooling.
9. Remove the water pump from the engine front cover. Refer to **Water Pump Replacement** in Engine Cooling.

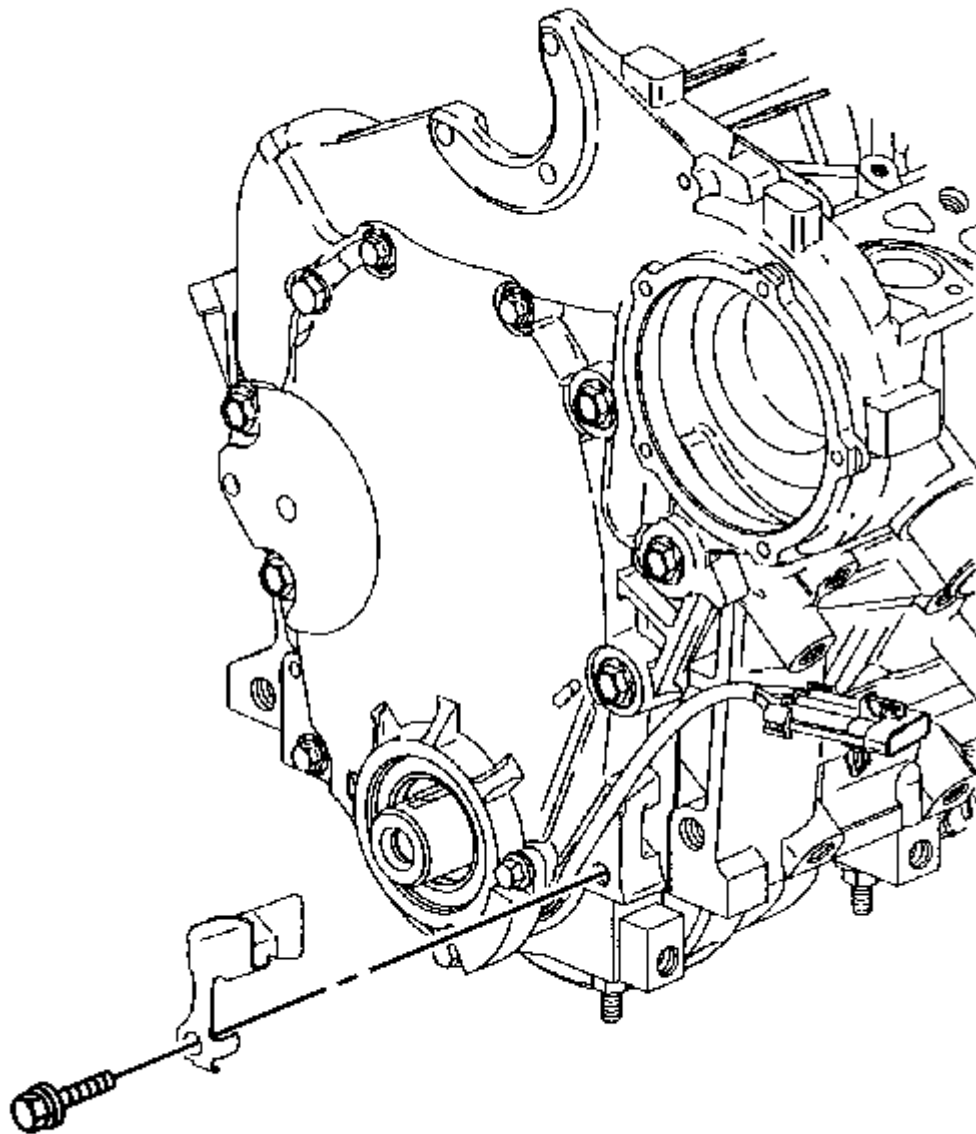


Fig. 100: View Of Lower Crankshaft Position Sensor Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft position (CKP) sensor wiring harness bracket bolt.
11. Remove the CKP sensor wiring harness bracket.

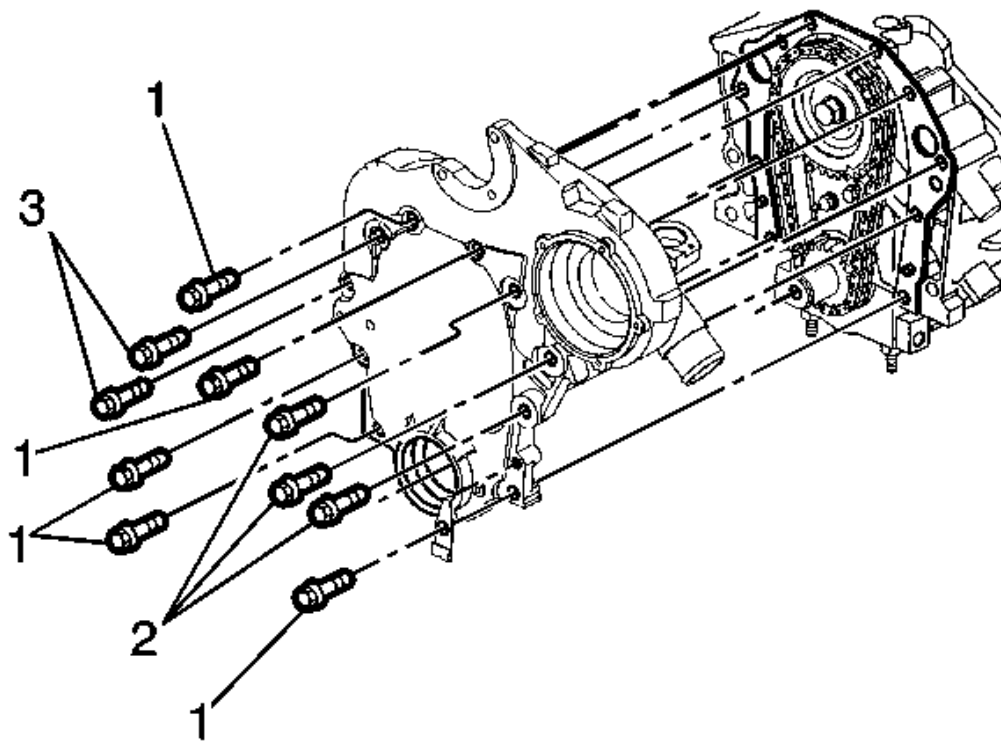


Fig. 101: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine front cover bolts.
13. Remove the engine front cover.

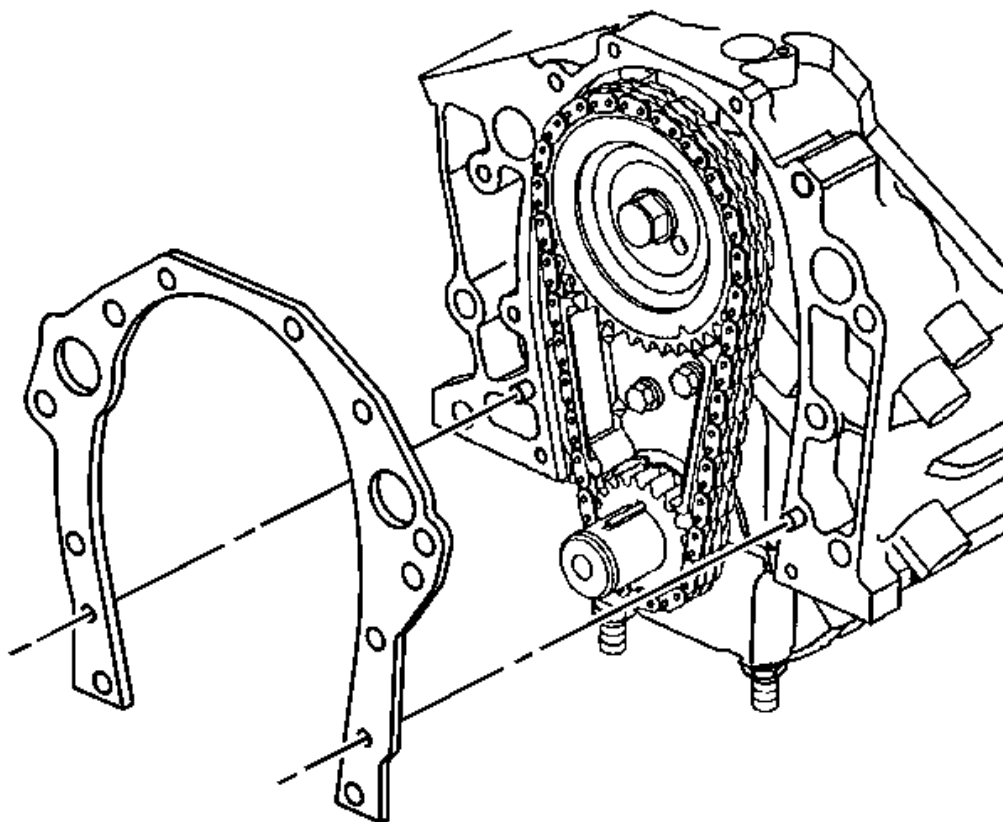


Fig. 102: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine front cover gasket.
15. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.
16. If replacing the engine front cover, remove the drive belt shield bolt and the drive belt shield.
17. If replacing the engine front cover remove the water pump. Refer to **Water Pump Replacement** in Engine Cooling.

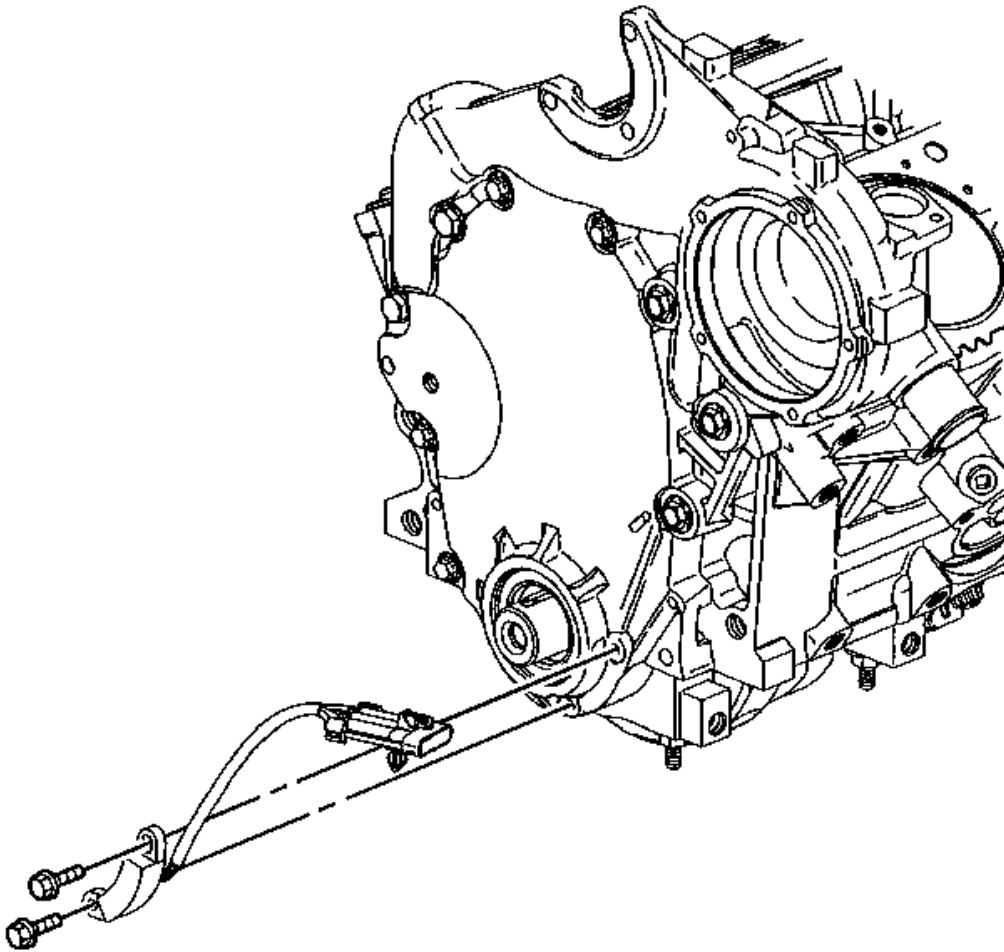


Fig. 103: Crankshaft Position Sensor At Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

18. If replacing the engine front cover, remove the 24X CKP sensor. Refer to **Crankshaft Position (CKP) Sensor Replacement** in Engine Controls - 3.5L.

Installation Procedure

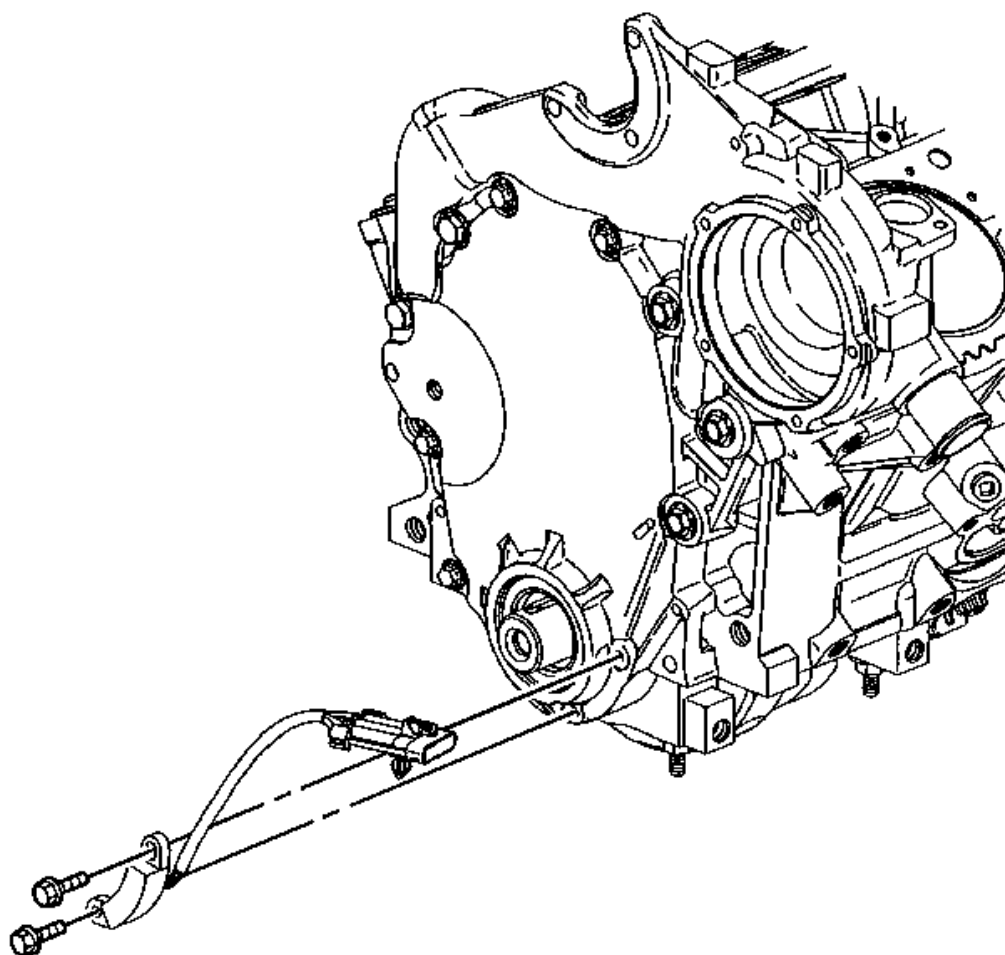


Fig. 104: Crankshaft Position Sensor At Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. If removed, install the 24X CKP sensor. Refer to **Crankshaft Position (CKP) Sensor Replacement** in Engine Controls - 3.5L.
2. If removed install the water pump. Refer to **Water Pump Replacement** in Engine Cooling.

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

3. If removed, install the drive belt shield.

Install the drive belt shield bolt.

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

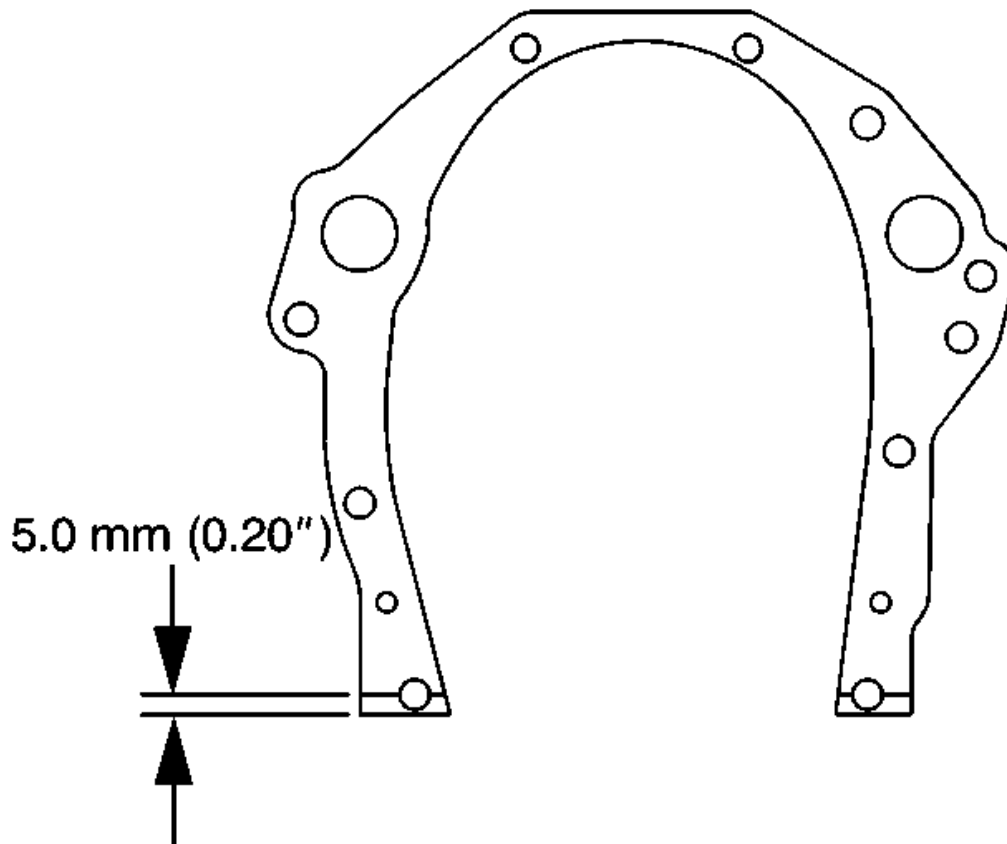


Fig. 105: Applying Sealer To Lower Tabs Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

4. Apply sealant to both sides of the engine front cover gasket with GM P/N 12346004 (Canadian P/N 10953480) or equivalent.

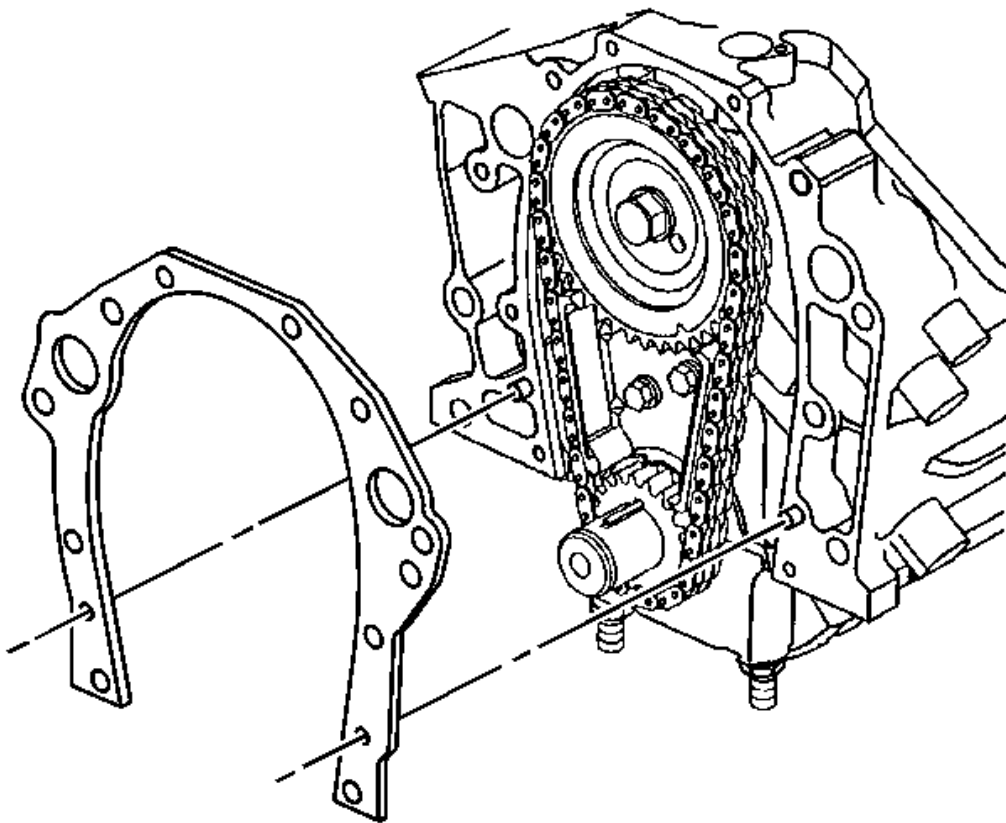


Fig. 106: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover gasket.

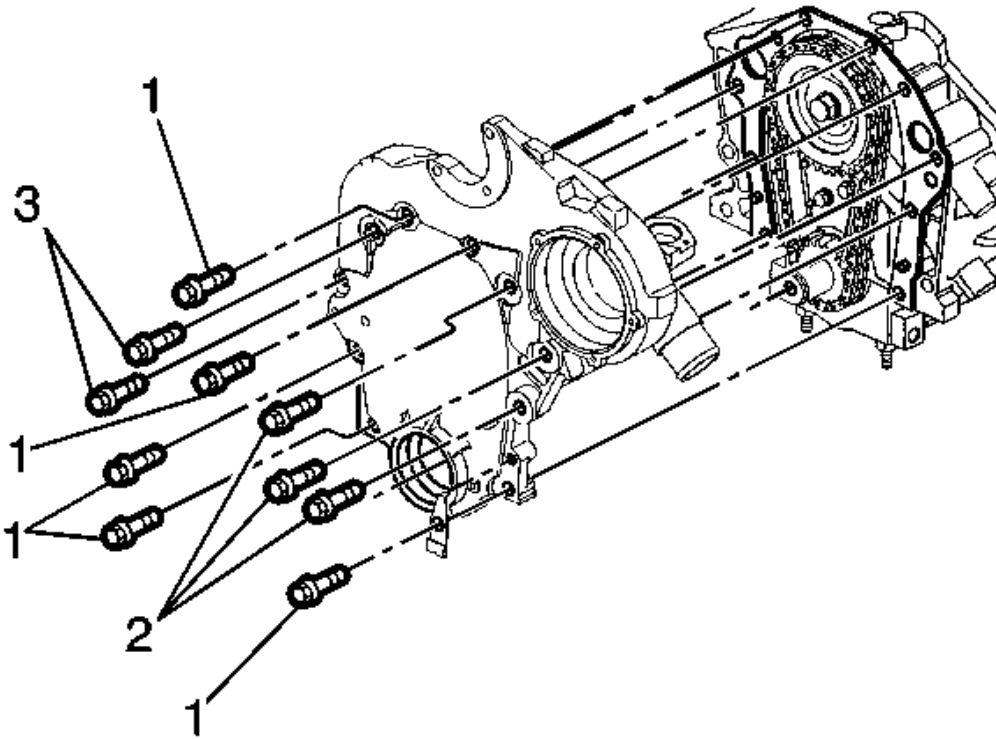


Fig. 107: Removing/Installing Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

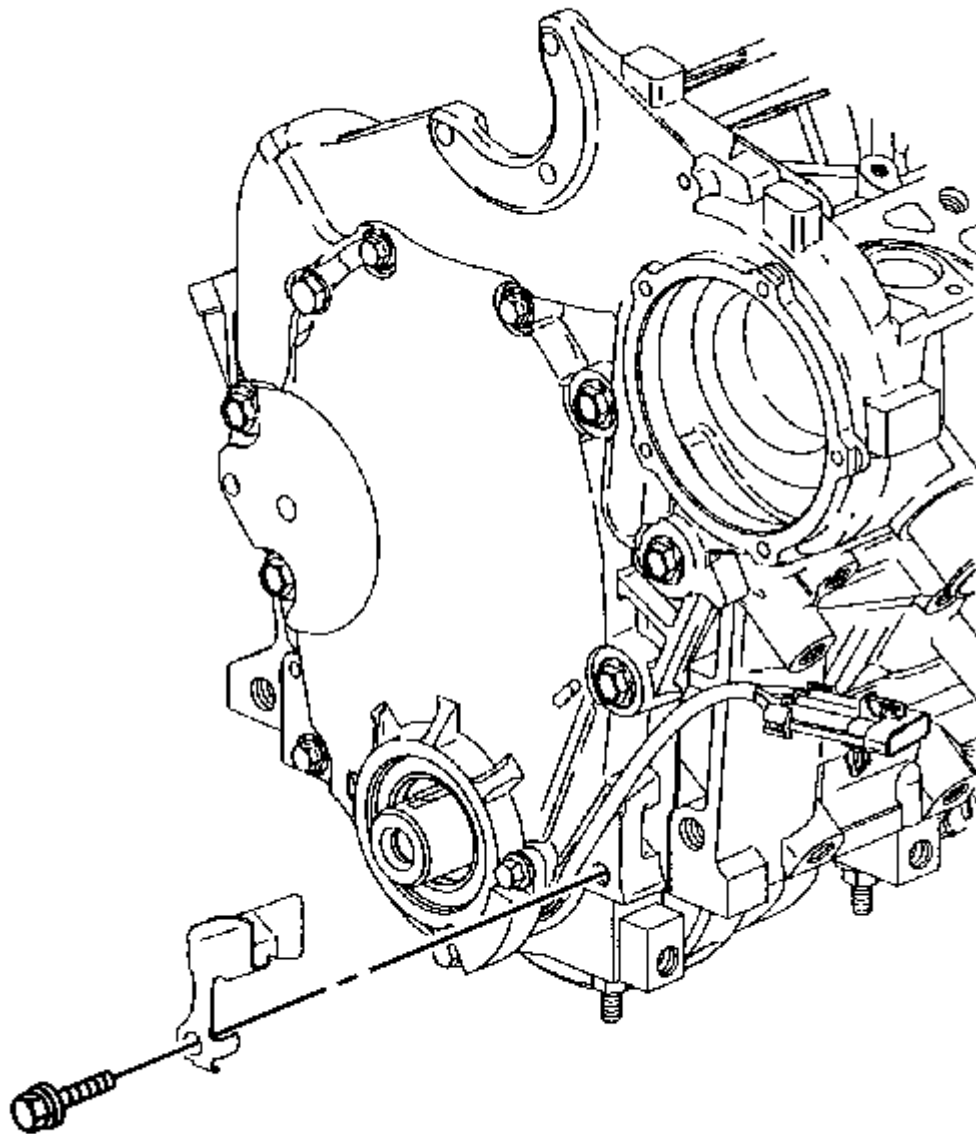


Fig. 108: View Of Lower Crankshaft Position Sensor Wiring Harness Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the CKP sensor wiring harness bracket.
9. Install the CKP sensor wiring harness bracket bolt.

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

10. Install the radiator outlet hose to the engine front cover. Refer to **Radiator Hose Replacement - Outlet** in Engine Cooling.
11. Install the thermostat bypass pipe to the engine front cover. Refer to **Thermostat Bypass Pipes Replacement** in Engine Cooling.
12. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
13. Install the oil pan. Refer to **Oil Pan Replacement**.
14. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
15. Fill the crankcase with new engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
16. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
17. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
18. Perform the CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.5L.

Timing Chain and Sprockets Replacement**Removal Procedure**

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

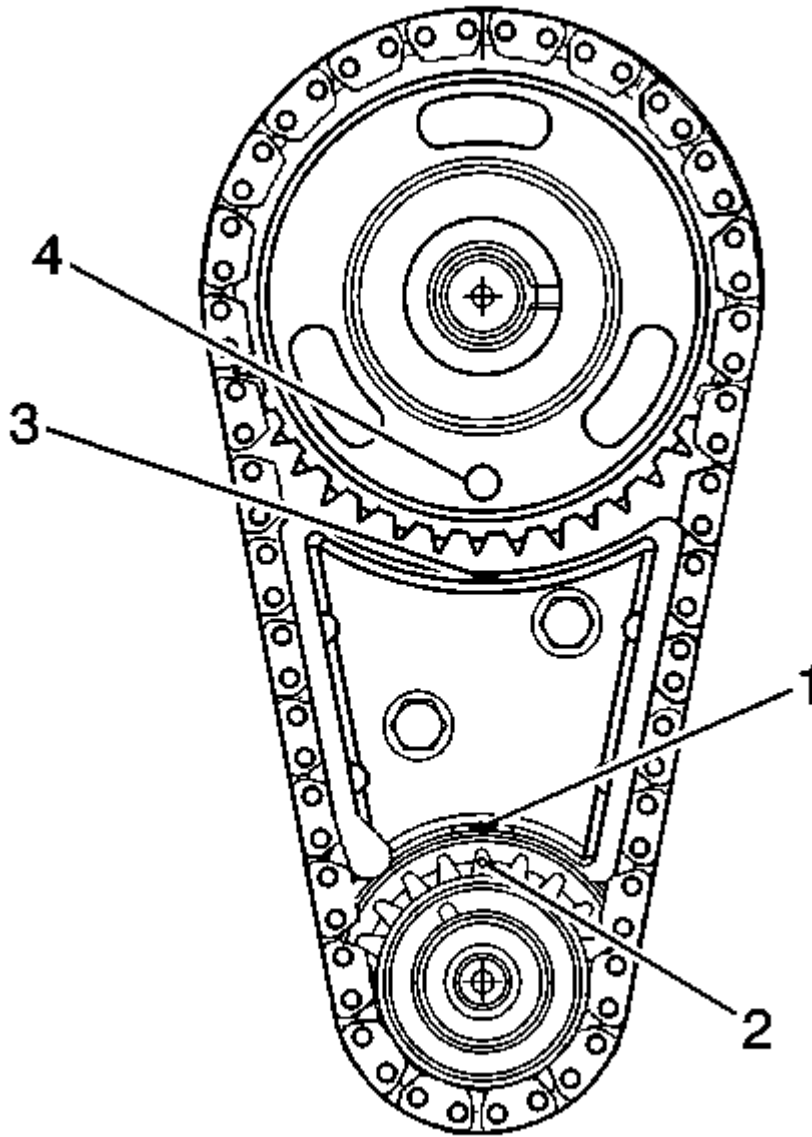


Fig. 109: Aligning The Dowel In The Camshaft With The Dowel Hole In The Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Rotate the crankshaft until the timing marks in the following locations are aligned:
 - The camshaft alignment pin (4).
 - The timing chain dampener (1) to the crankshaft sprocket (2).

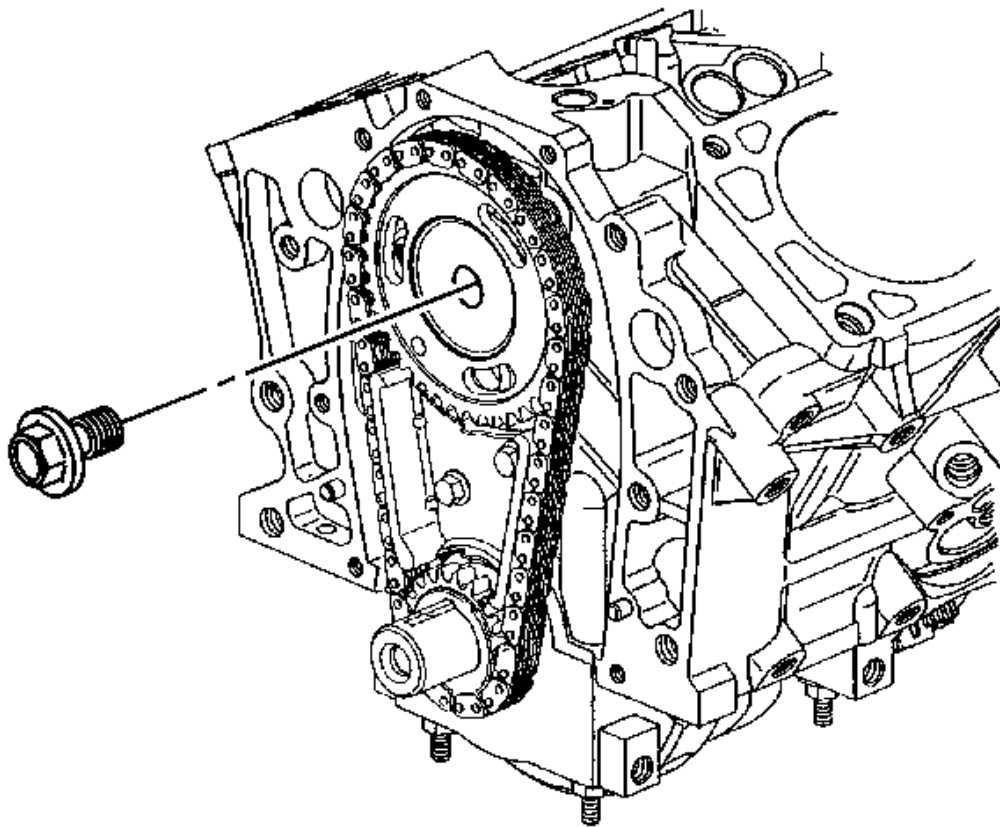


Fig. 110: View Of Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft sprocket bolt.

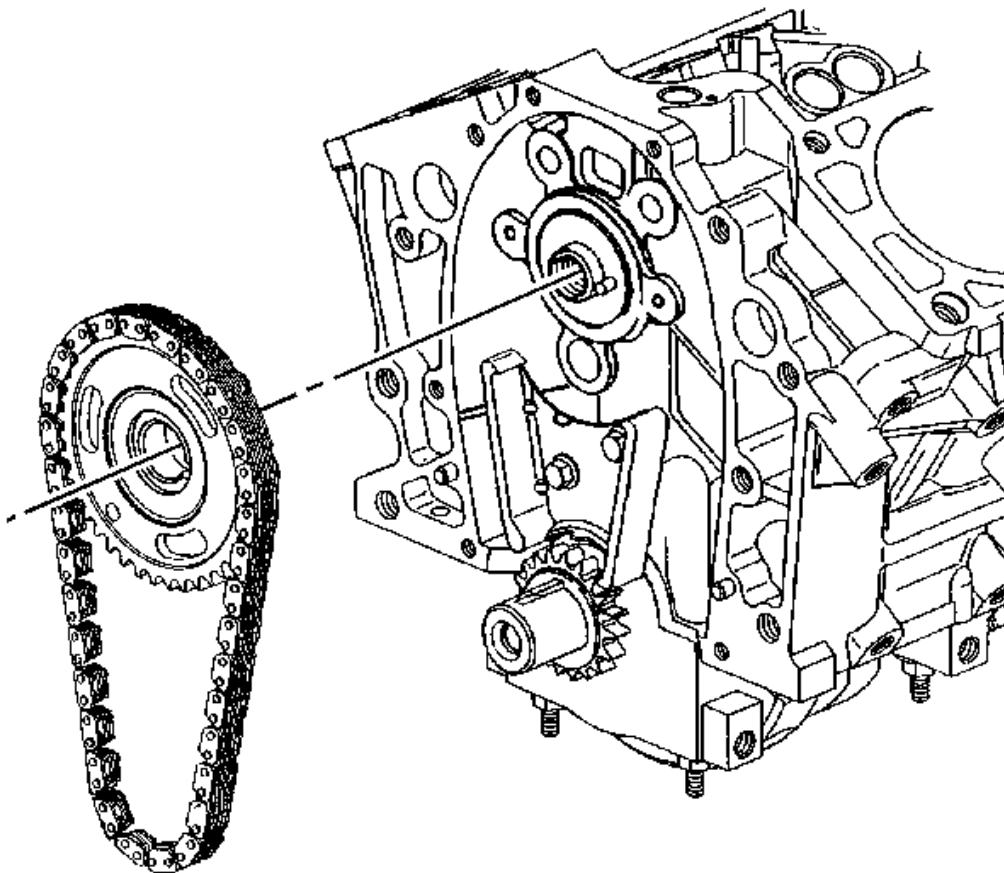


Fig. 111: View Of Camshaft Sprocket With Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft sprocket with the timing chain.

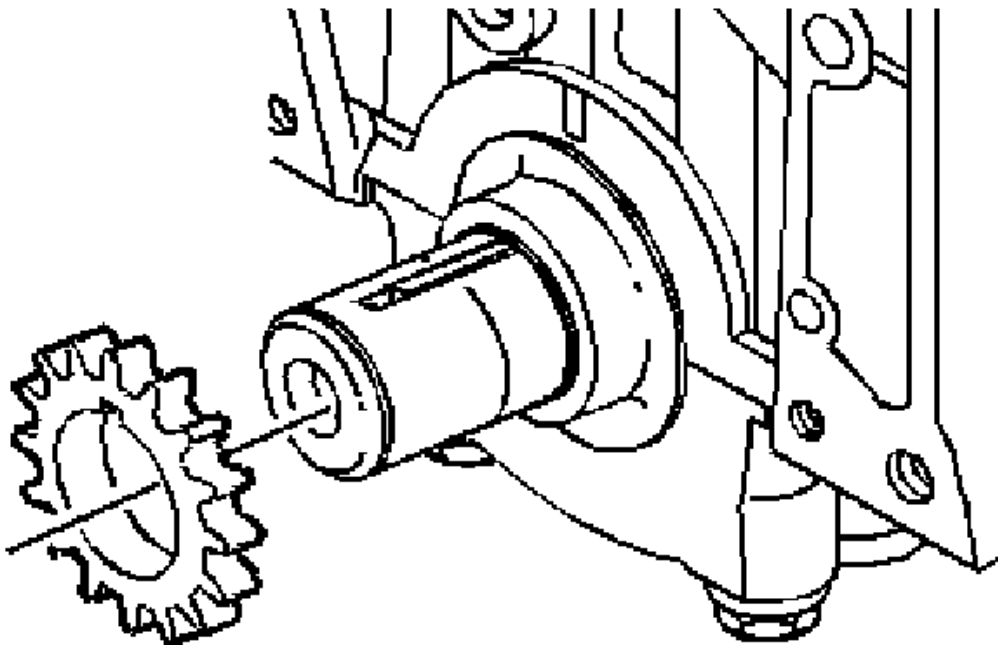


Fig. 112: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket.

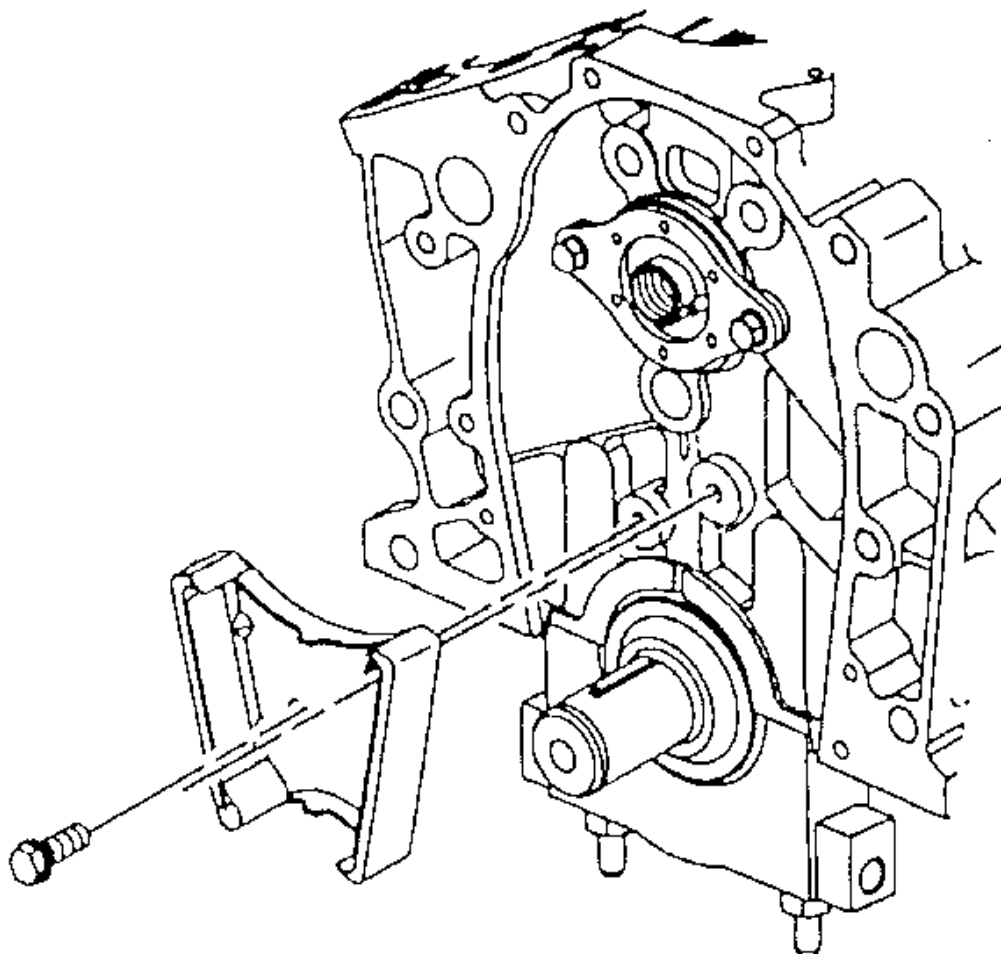


Fig. 113: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

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

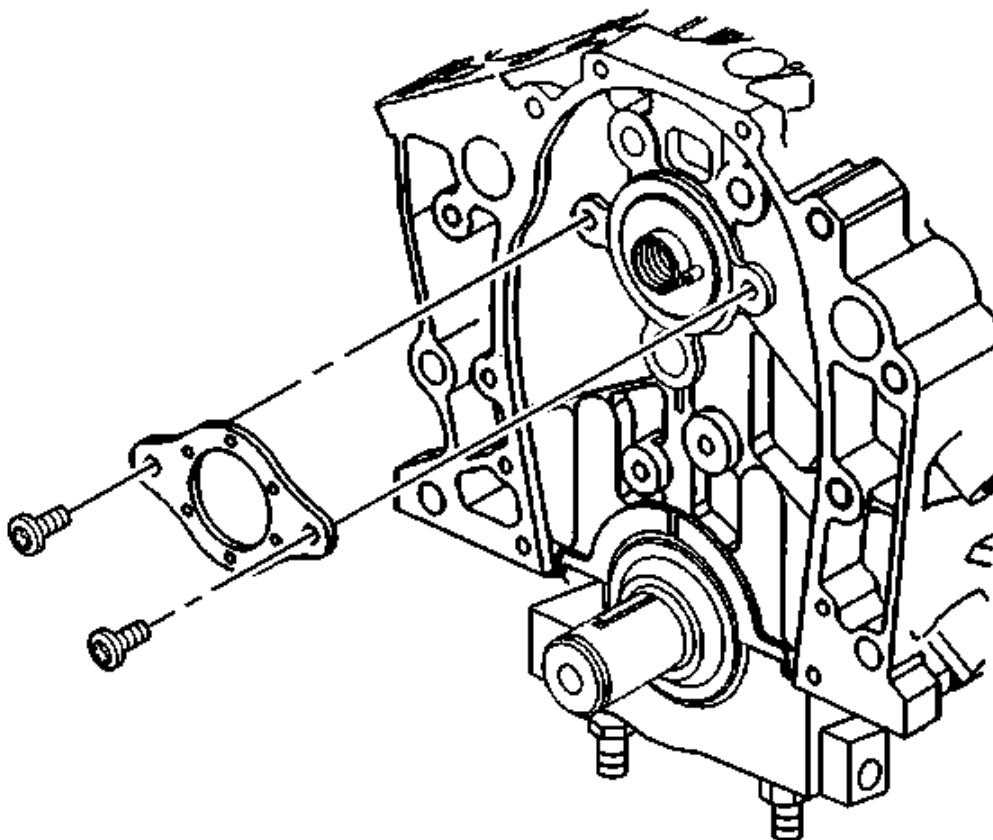


Fig. 114: Locating Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

8. If necessary, remove the camshaft thrust plate bolts.
9. Remove the camshaft thrust plate.
10. Clean and inspect the timing chain and the gears. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

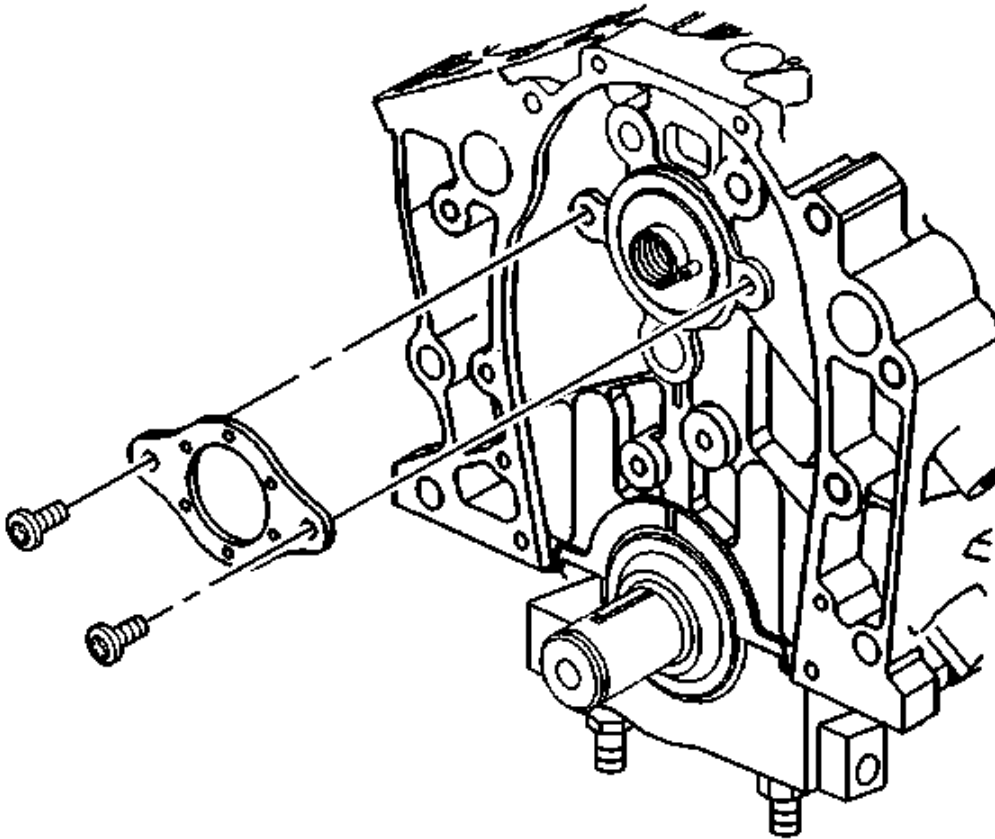


Fig. 115: Locating Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

1. If removed, install the camshaft thrust plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft thrust plate bolts.

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

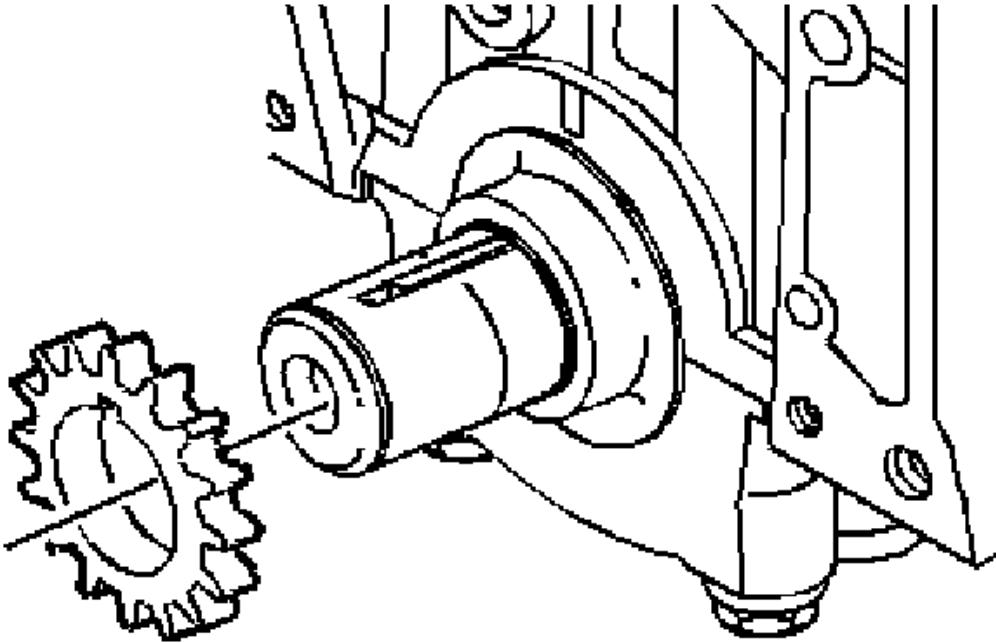


Fig. 116: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket.
4. Apply engine oil supplement (EOS) GM P/N 1052367 (Canadian P/N 992869), or equivalent, to the sprocket thrust surface.

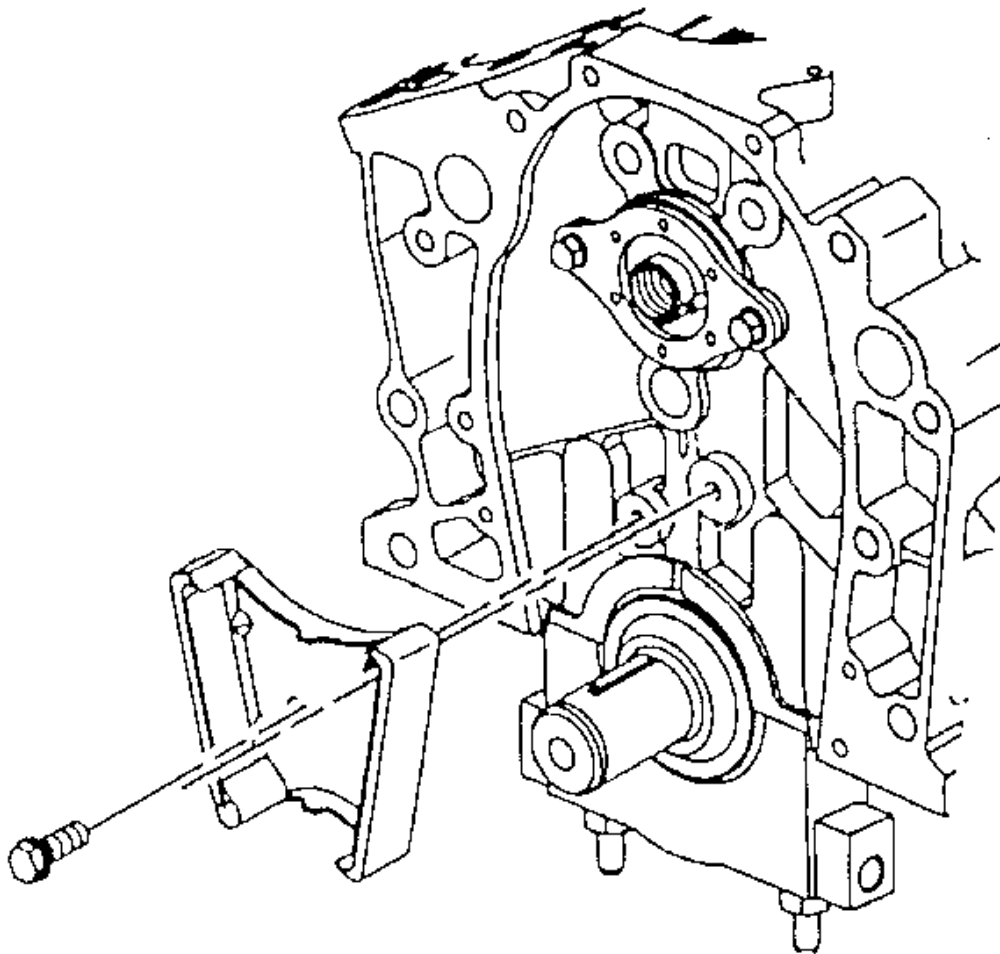


Fig. 117: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain dampener.
6. Install the timing chain dampener bolts.

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

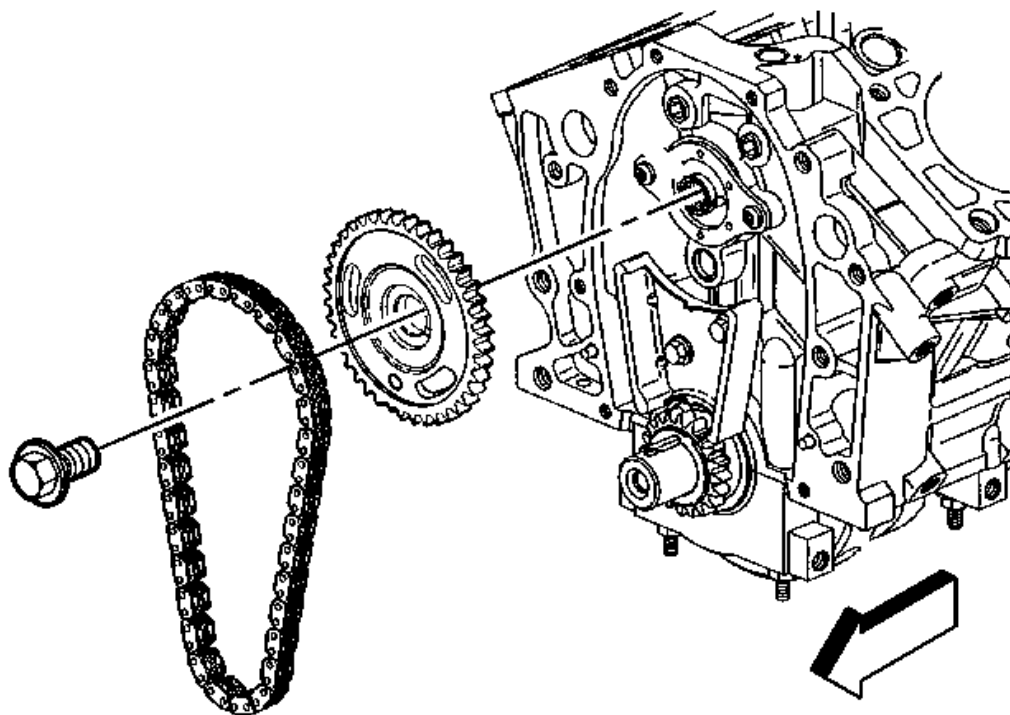


Fig. 118: Identifying Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the timing chain onto the camshaft gear.

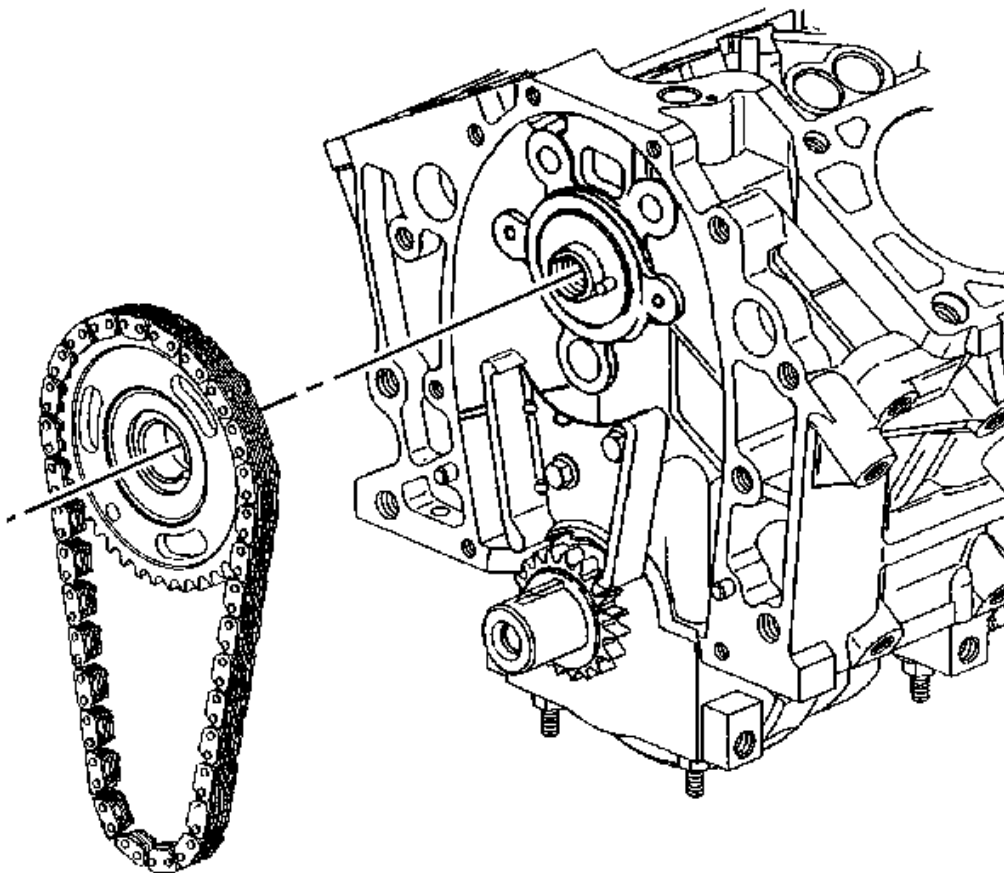


Fig. 119: View Of Camshaft Sprocket With Timing Chain
Courtesy of GENERAL MOTORS CORP.

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

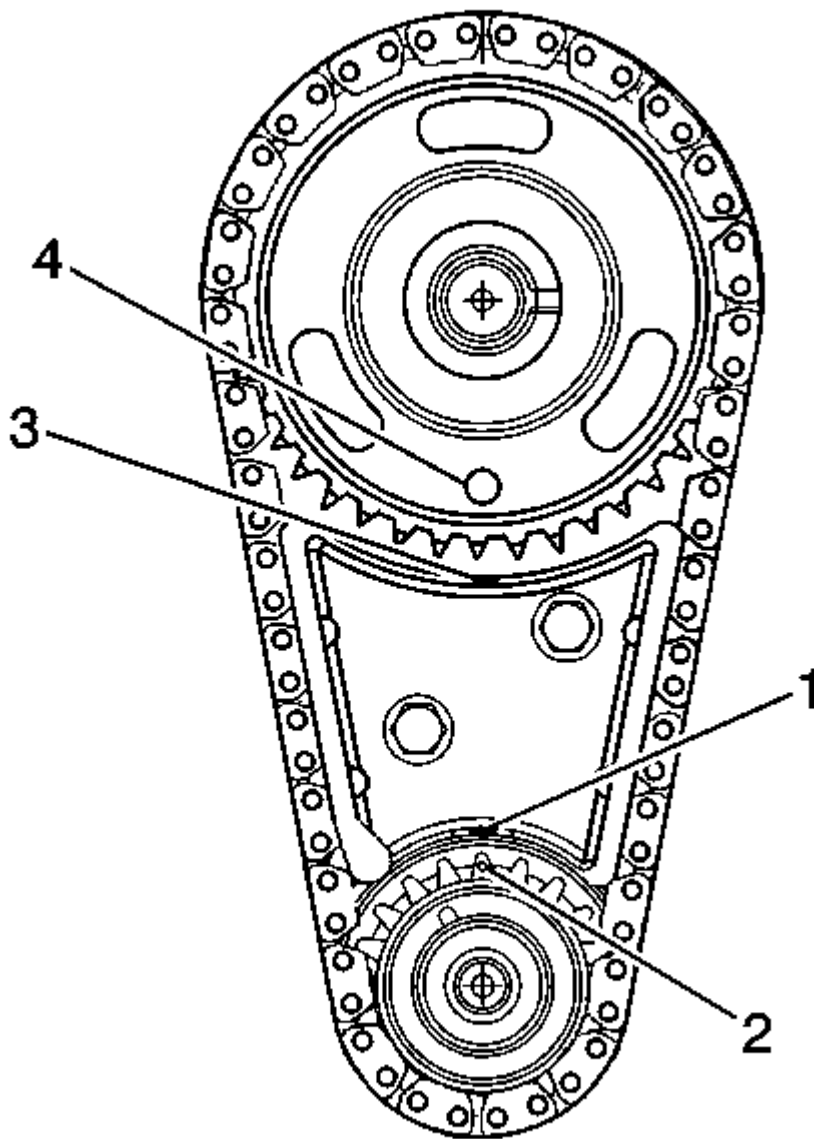


Fig. 120: Aligning The Dowel In The Camshaft With The Dowel Hole In The Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

9. Align the crankshaft timing mark (2) to the timing mark on the bottom of the timing chain dampener (1).
10. Align the timing mark on the camshaft gear, center line of the locator hole (4), with the timing mark on the top of the chain dampener (3).
11. Align the dowel in the camshaft with the dowel hole in the camshaft sprocket (1).

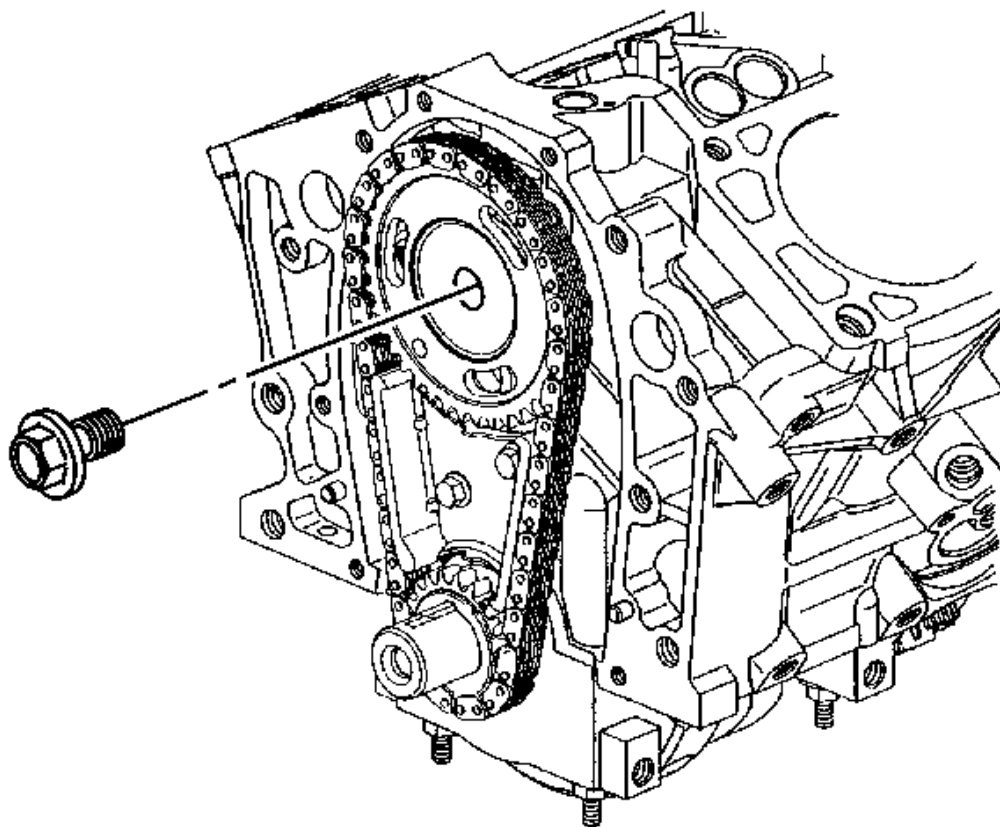


Fig. 121: View Of Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

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

12. Install the camshaft sprocket bolt.

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

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

Cylinder Head Replacement - Left

Tools Required

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

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 manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
8. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
9. Remove the left spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
10. Remove the left spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L.
11. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.

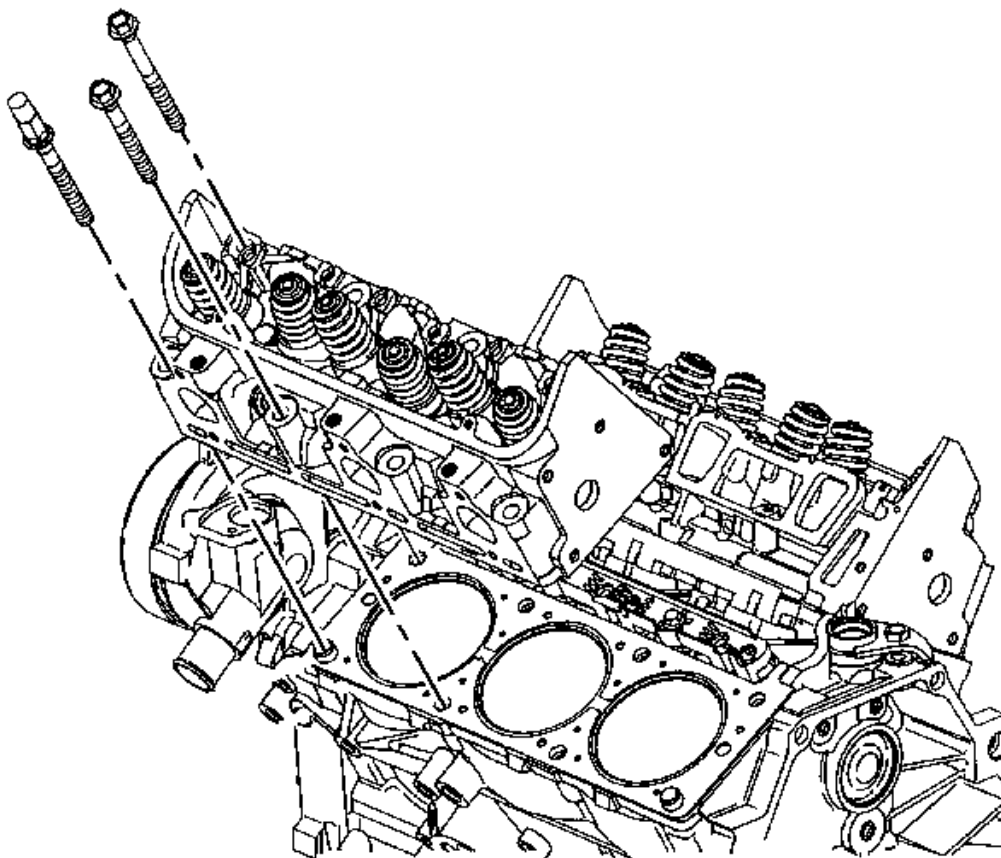


Fig. 122: Left Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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

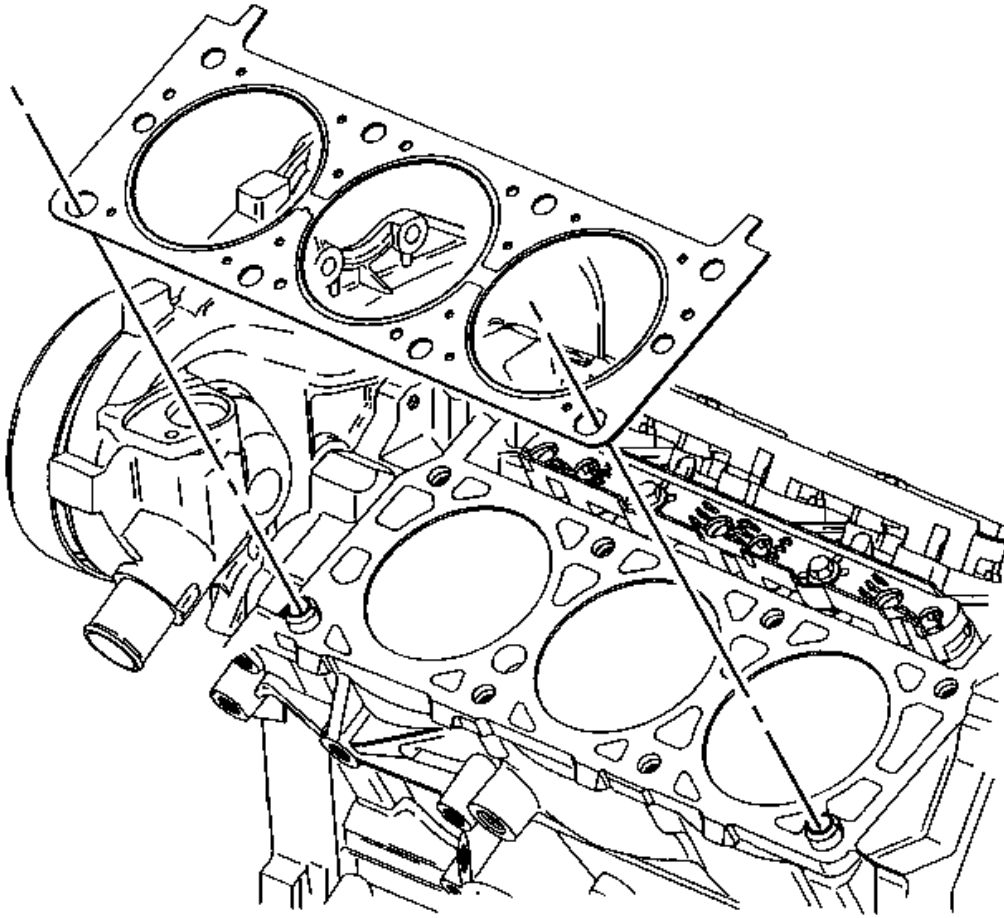


Fig. 123: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

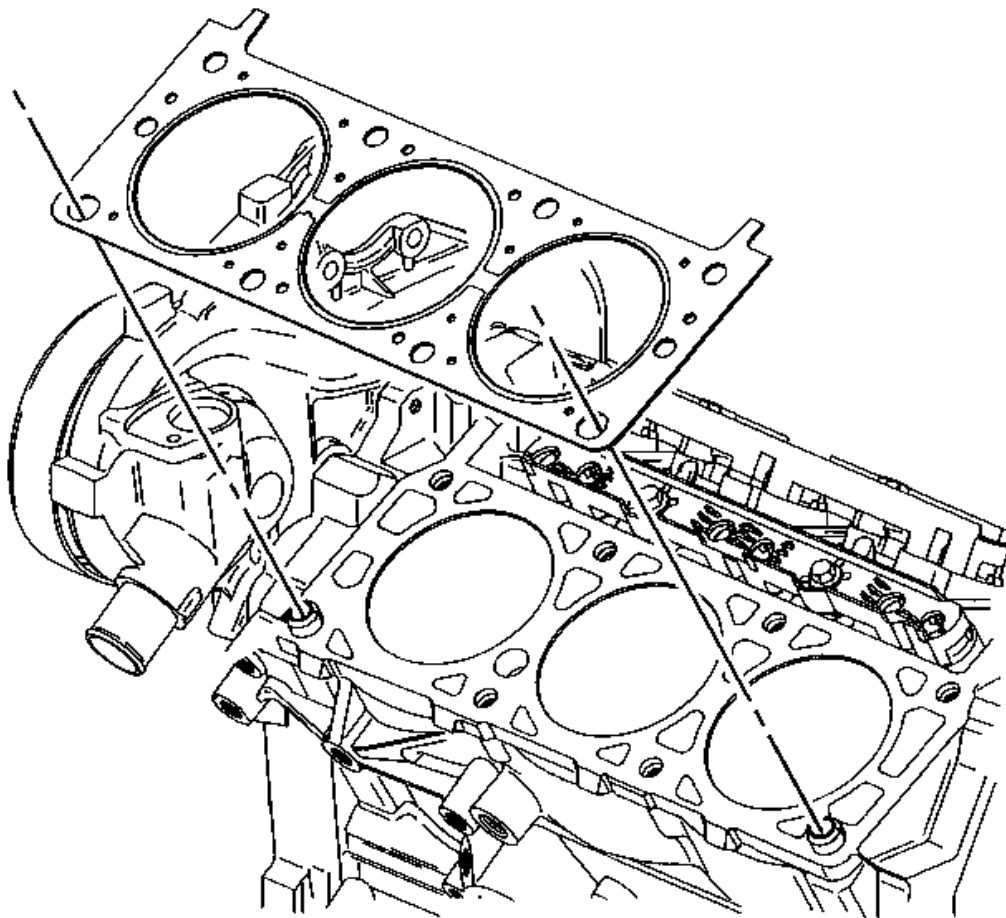


Fig. 124: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new left cylinder head gasket.

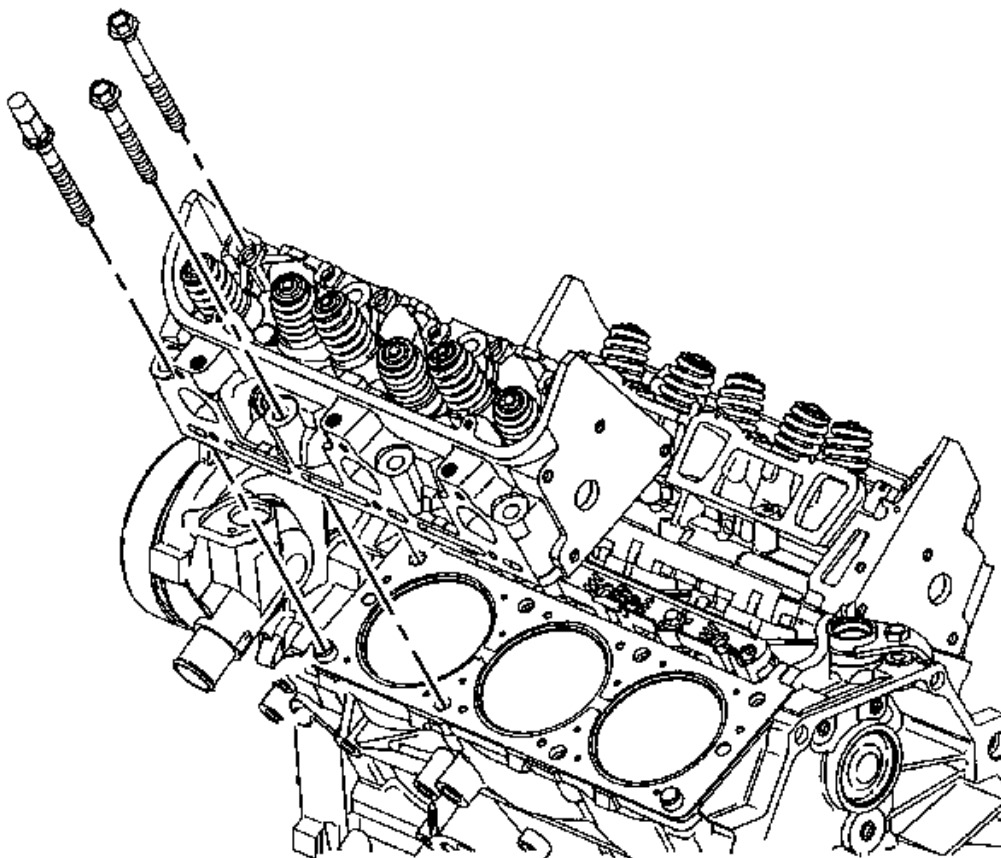


Fig. 125: Left Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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

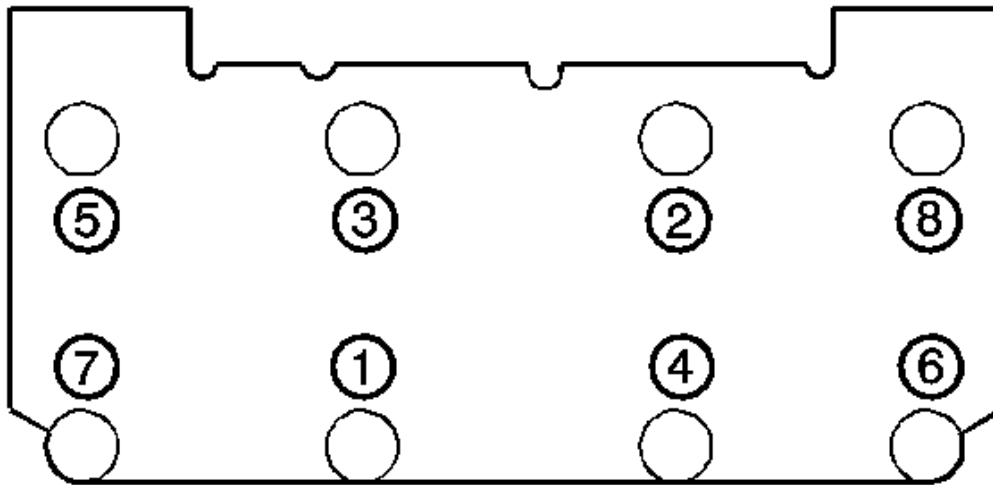


Fig. 126: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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 bolts in sequence an additional 95 degrees. See **Special Tools**.
4. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
5. Install the left spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L.
6. Install the left spark plug wires to the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
7. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
8. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
9. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
10. Install the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
11. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
12. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
13. Inspect for leaks.

Cylinder Head Replacement - Right**Tools Required**

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

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 push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
7. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
8. Remove the right spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
9. Remove the right spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L.

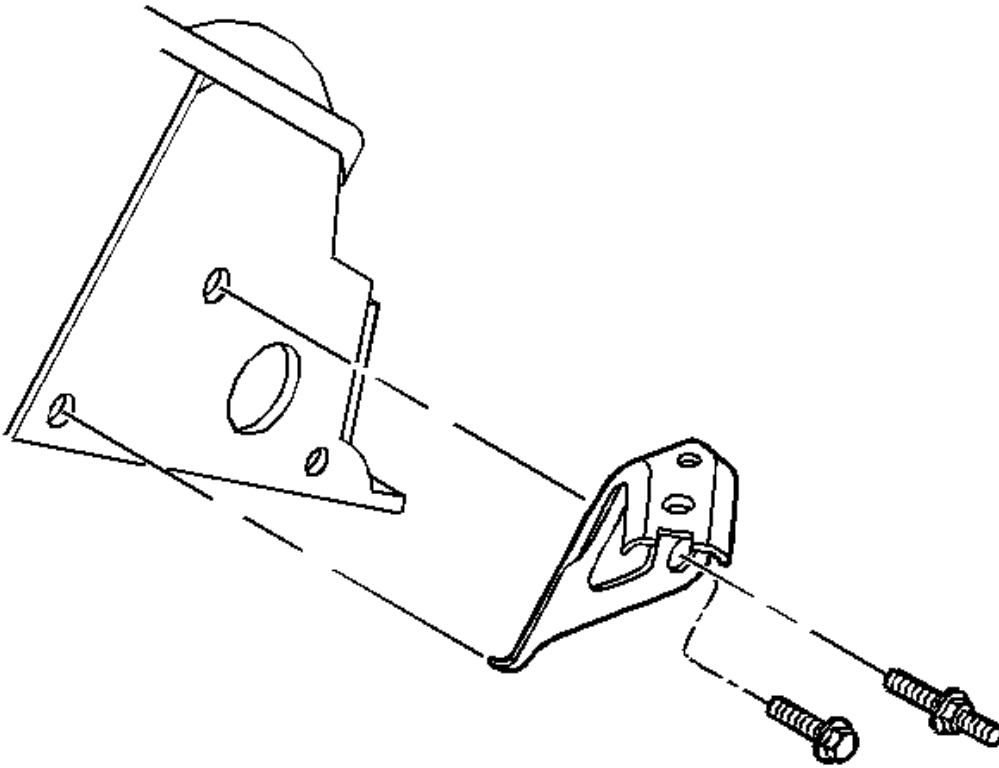


Fig. 127: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

10. Remove the fuel line bracket bolt and the stud.
11. Remove the fuel line bracket.
12. Remove the generator. Refer to **Generator Replacement** in Engine Electrical.
13. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.

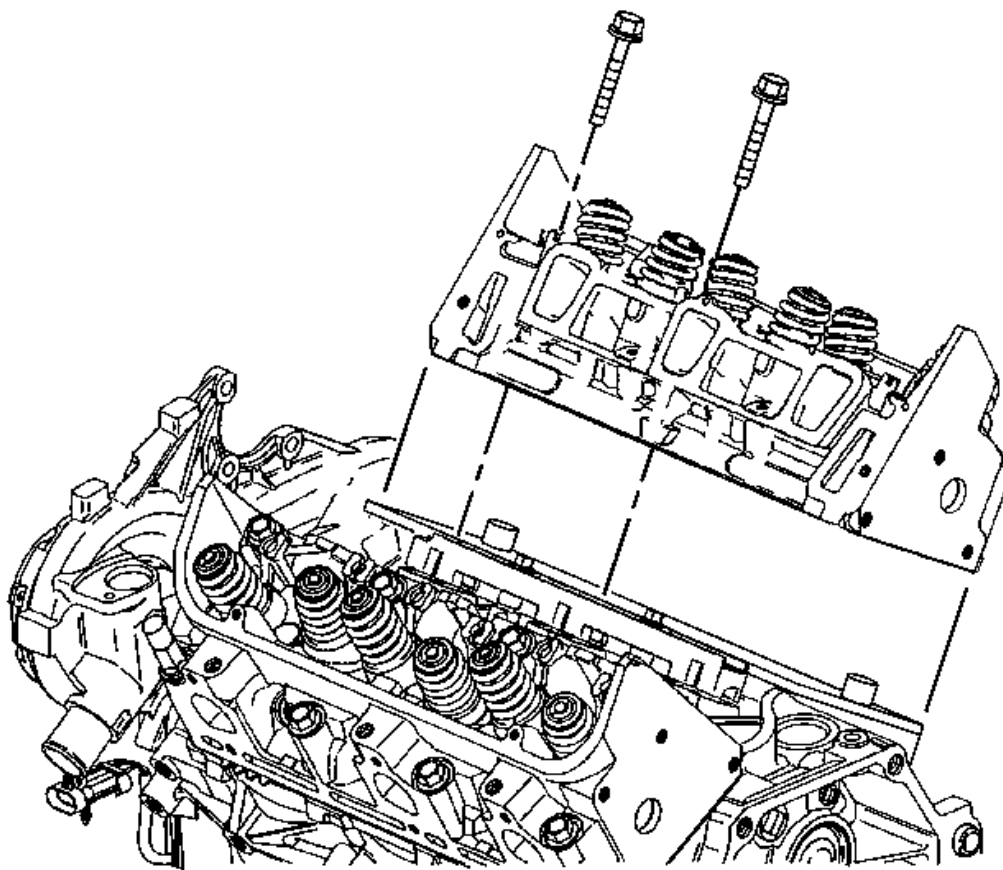


Fig. 128: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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

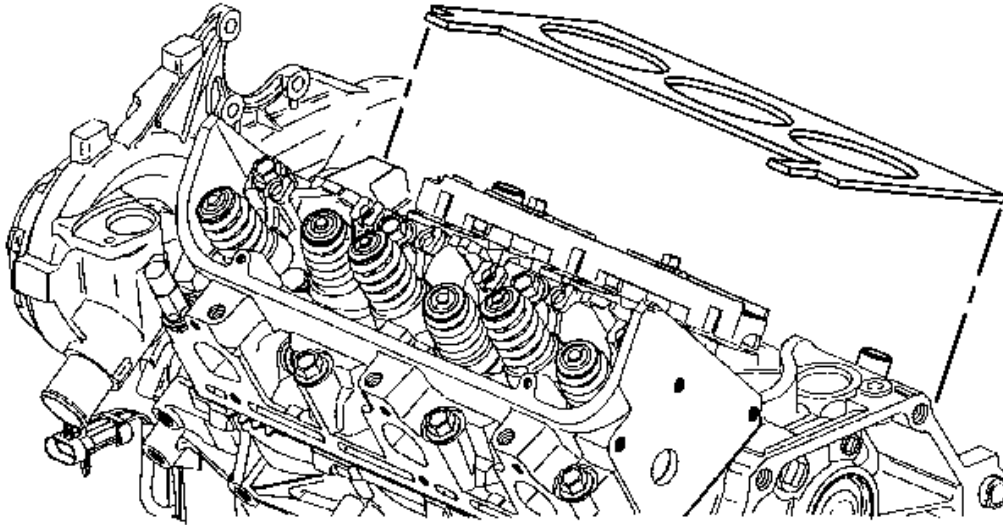


Fig. 129: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

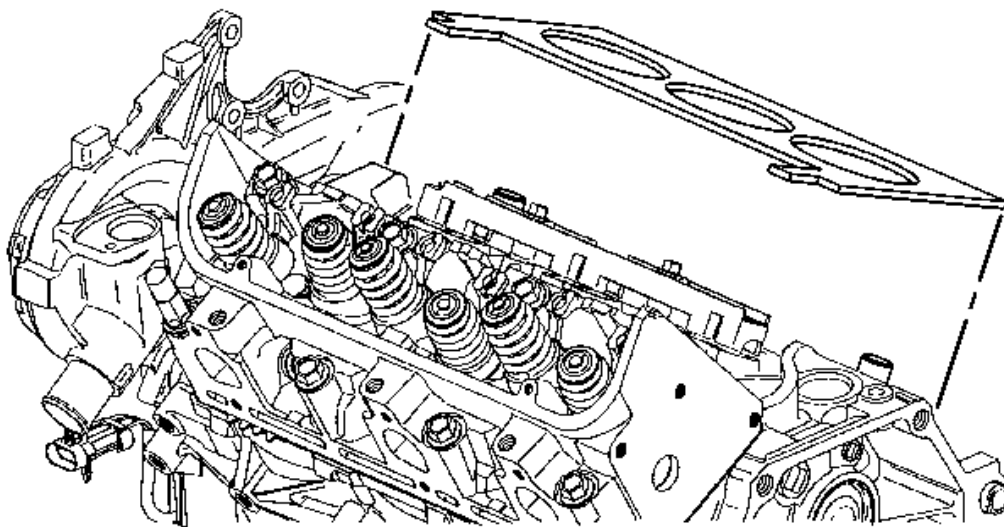


Fig. 130: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new right cylinder head gasket.

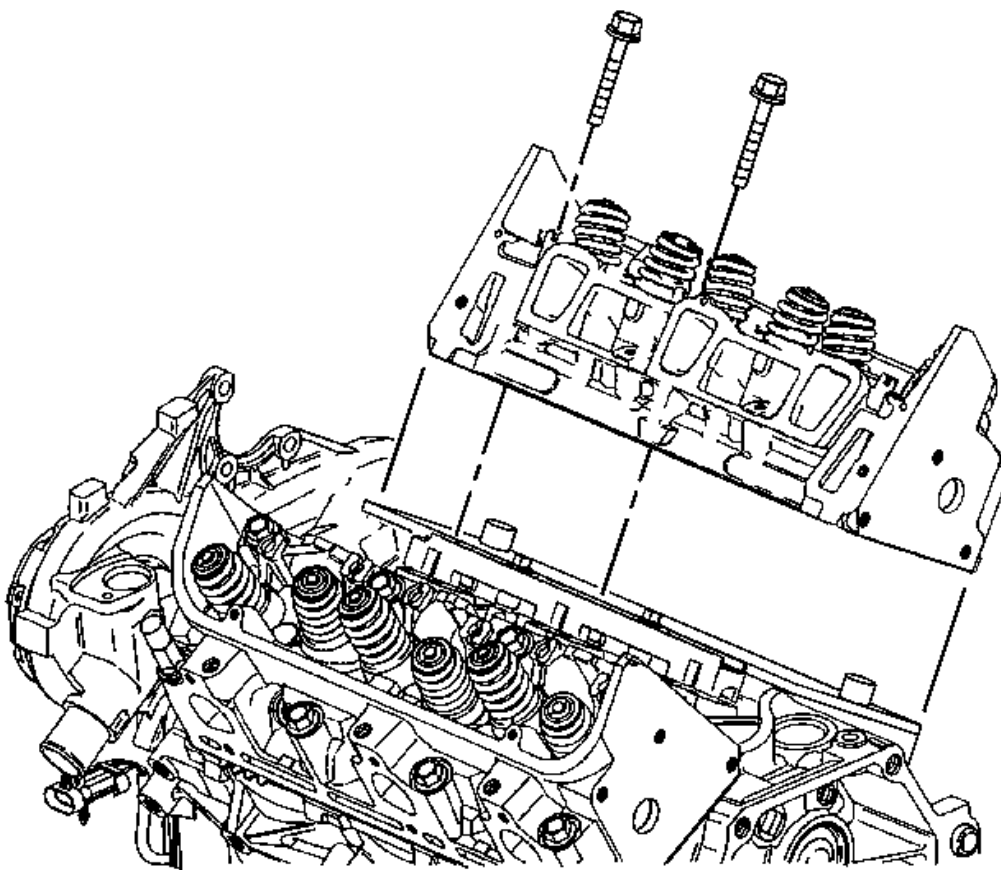


Fig. 131: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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

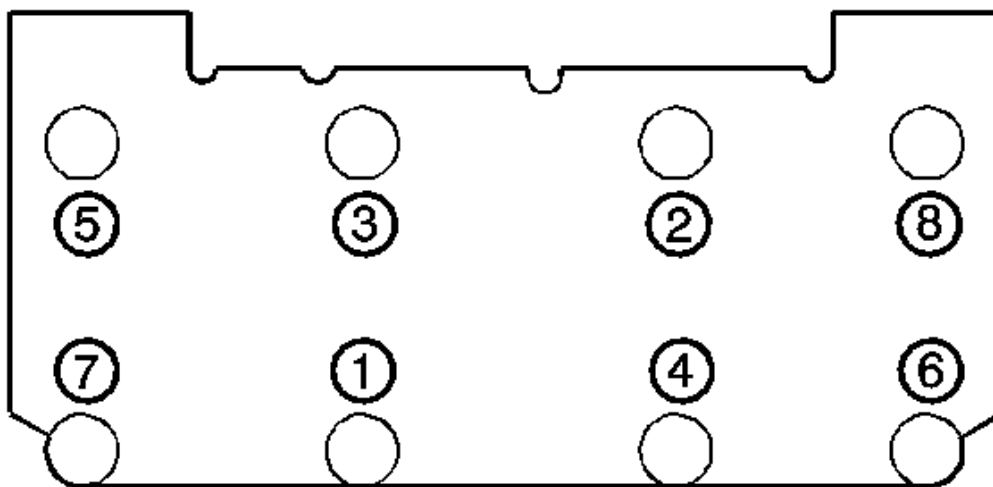


Fig. 132: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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 bolts in sequence an additional 95 degrees. See **Special Tools**.
4. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right**.
 5. Install the generator. Refer to **Generator Replacement** in Engine Electrical.

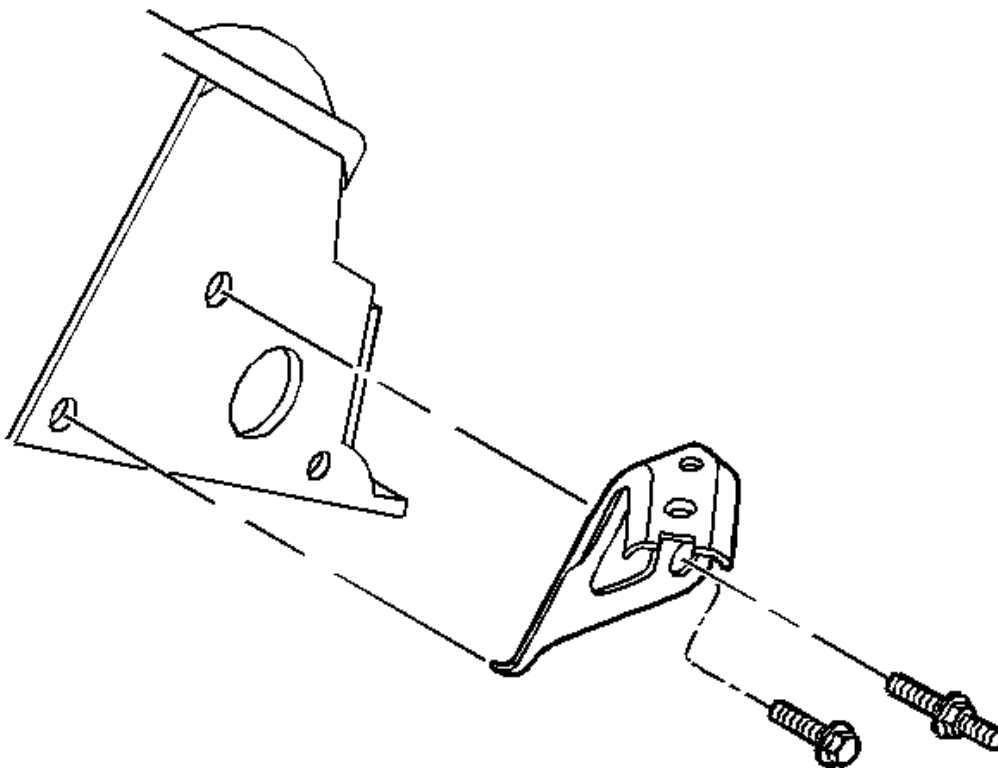


Fig. 133: Removing/Installing Fuel Line Bracket
Courtesy of GENERAL MOTORS CORP.

6. Install the fuel line bracket.
7. Install the fuel line bracket bolt and the stud.

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

8. Install the right spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.5L.
9. Install the right spark plug wires to the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine Controls - 3.5L.
10. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
11. Install the push rods 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.

Engine Flywheel Replacement**Tools Required**

J 37096 Flywheel Holder. See Special Tools.

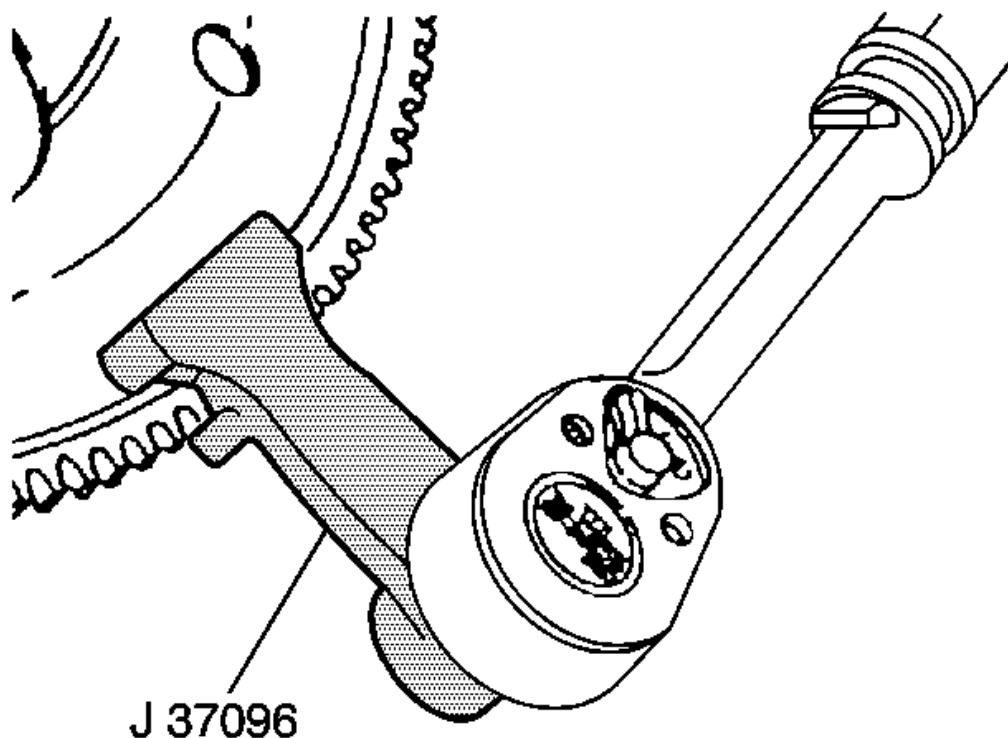
Removal Procedure

Fig. 134: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transaxle. Refer to Transmission Replacement in Automatic Transaxle - 4T40-E/4T45-E.
2. Use the **J 37096** to secure the flywheel in order to prevent the crankshaft from rotating. See Special Tools.

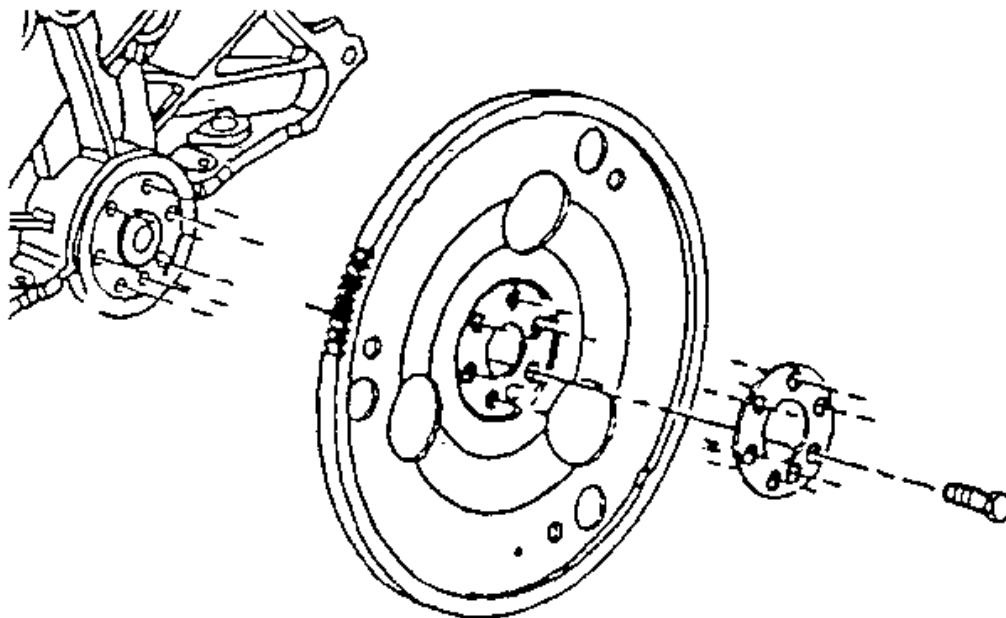


Fig. 135: Identifying Engine Flywheel & Components
Courtesy of GENERAL MOTORS CORP.

3. Loosen the 6 flywheel bolts.
4. Remove 5 of the 6 flywheel bolts leaving one 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

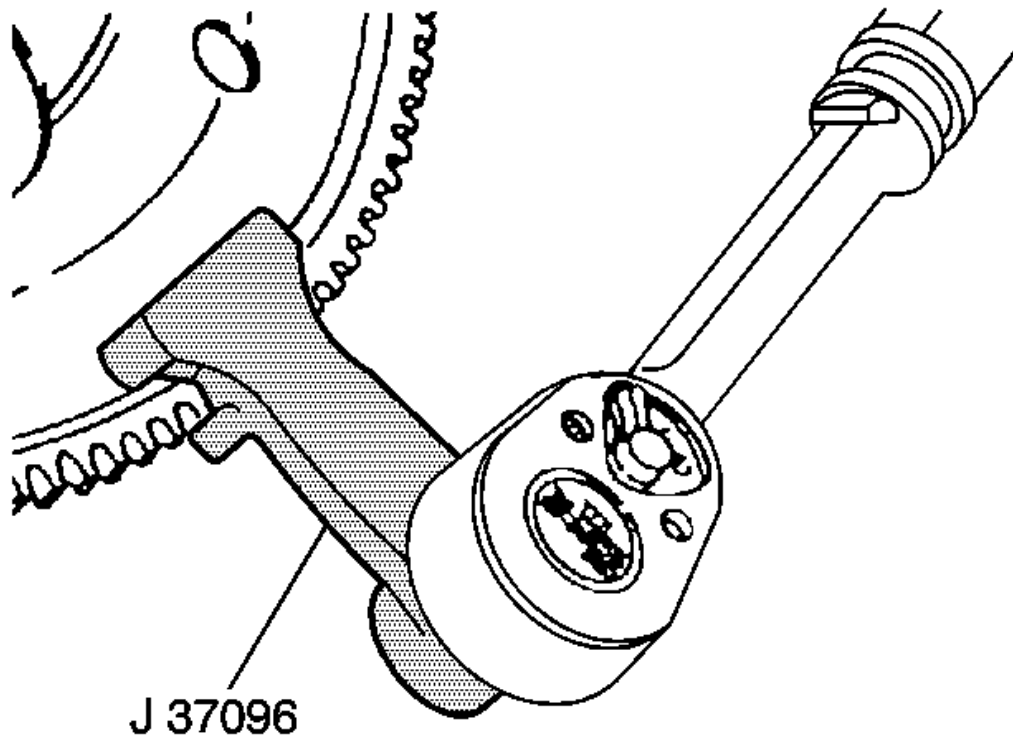


Fig. 136: Holding Flywheel
Courtesy of GENERAL MOTORS CORP.

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**.

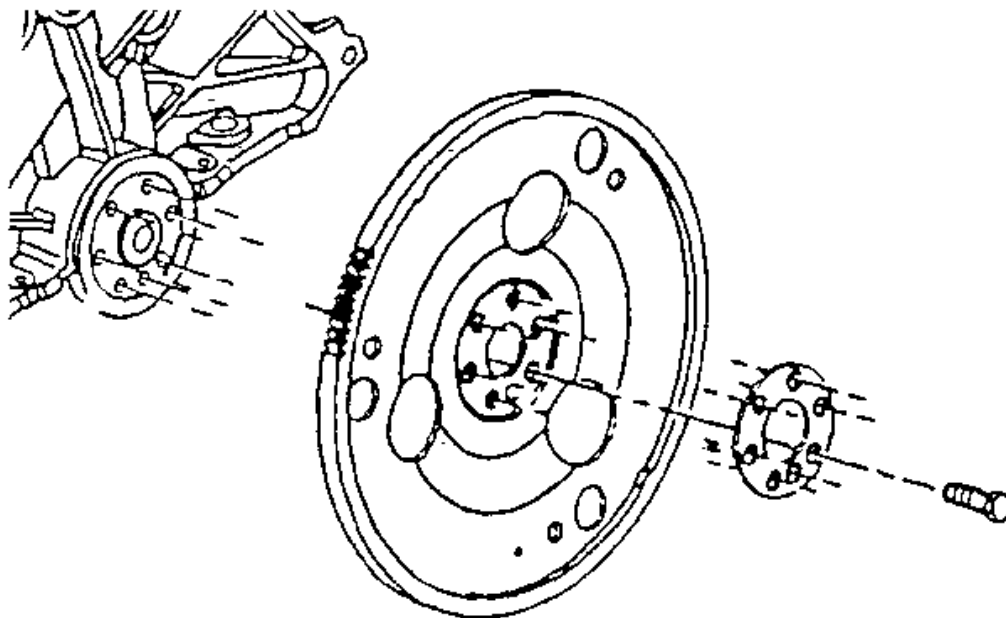


Fig. 137: Identifying Engine Flywheel & Components
Courtesy of GENERAL MOTORS CORP.

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 inspect the engine flywheel runout at 3 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 - 4T40-E/4T45-E.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 34686 Rear Main Seal Installer. See Special Tools.

Removal Procedure

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

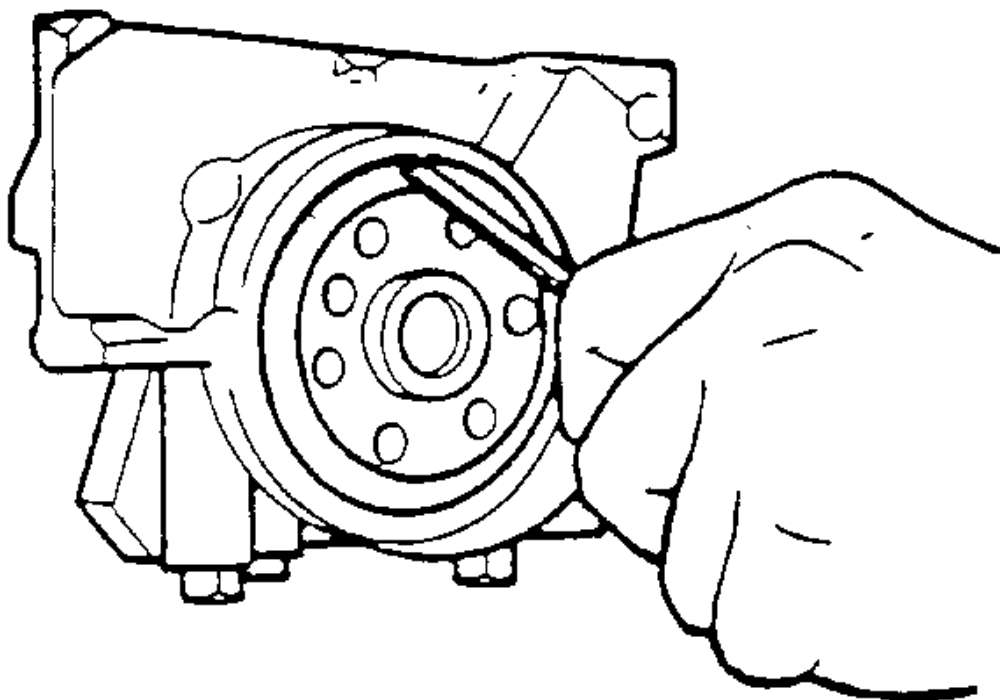


Fig. 138: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

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.

IMPORTANT: Do not apply or use any oil lubrication on the crankshaft rear oil seal or the seal installer J 34686 . See Special Tools. Do not touch the sealing lip of the oil seal once the protective sleeve is removed. Doing so will damage/deform the seal.

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 a crocus cloth before proceeding.

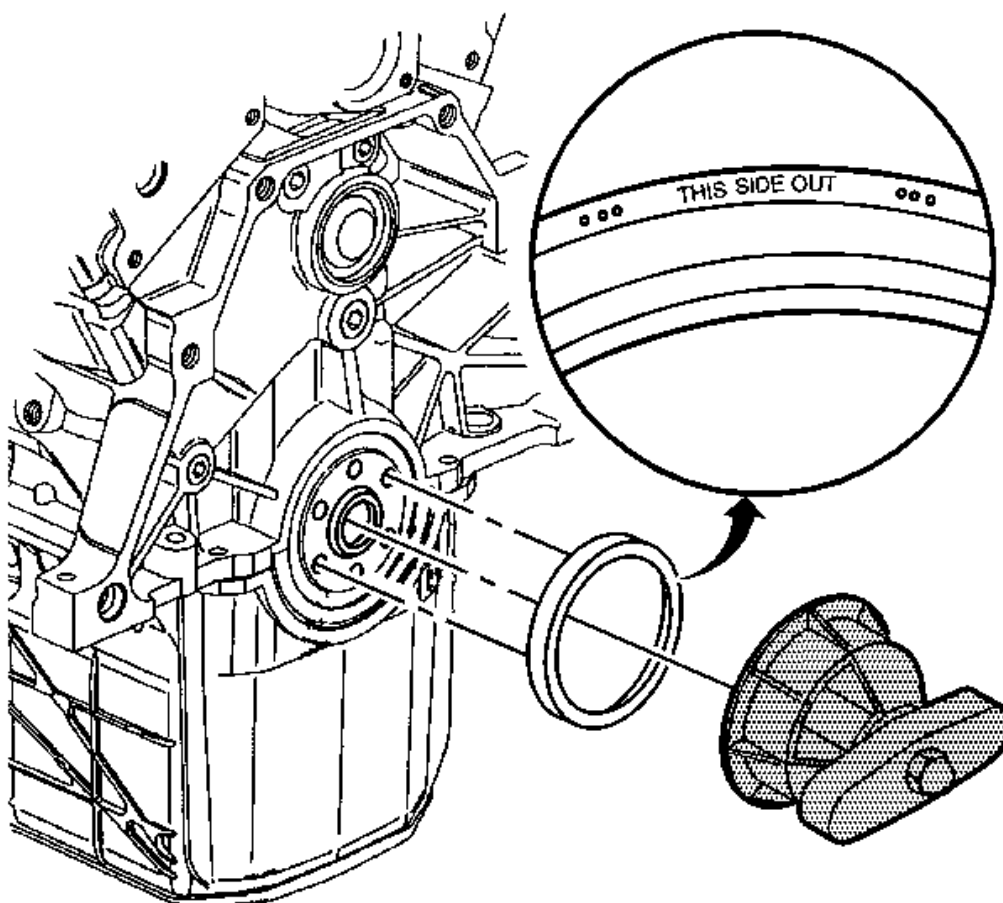


Fig. 139: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Carefully remove the protection sleeve from the new crankshaft rear oil seal.
2. Install the crankshaft rear oil seal into 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**.

3. Install the **J 34686** onto the rear of the crankshaft. See **Special Tools**. 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**.
6. Remove the **J 34686** from the crankshaft. See **Special Tools**.
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**.

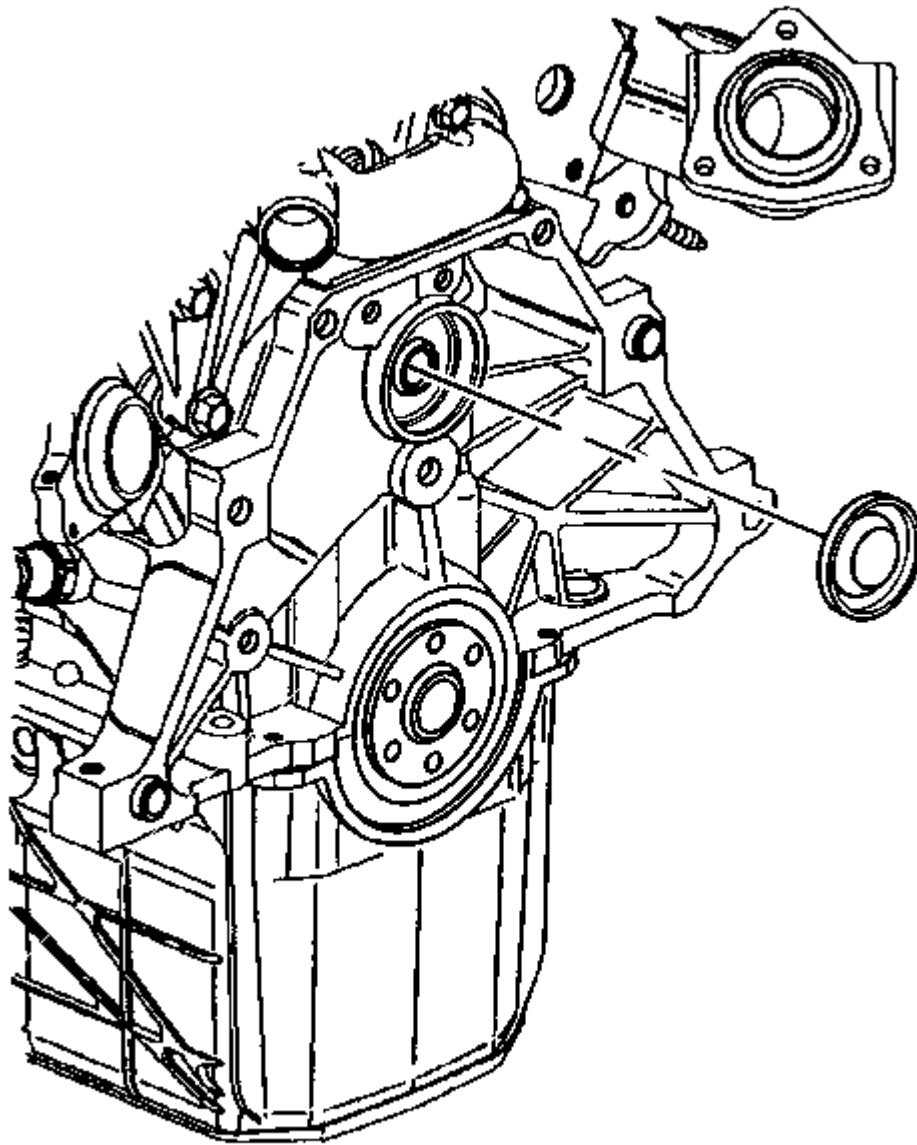


Fig. 140: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft rear bearing hole plug.

Installation Procedure

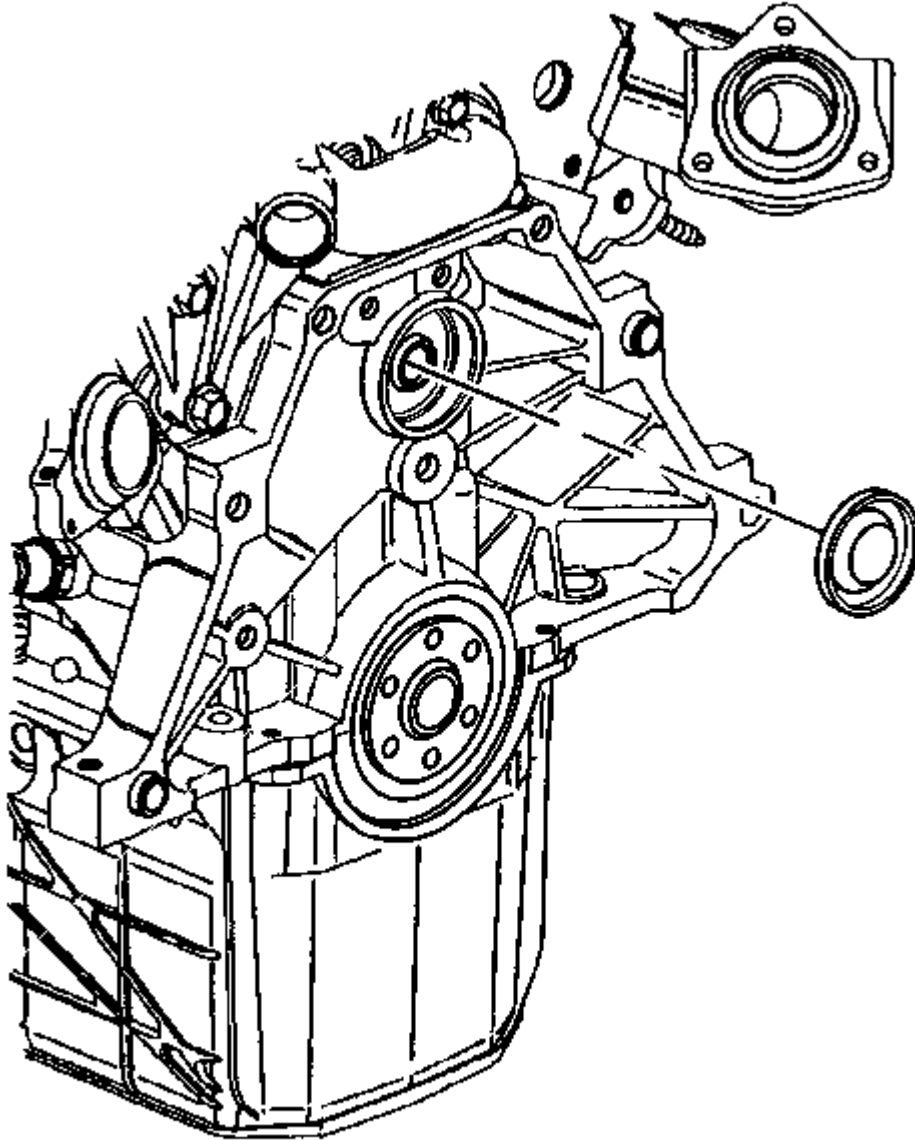


Fig. 141: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

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

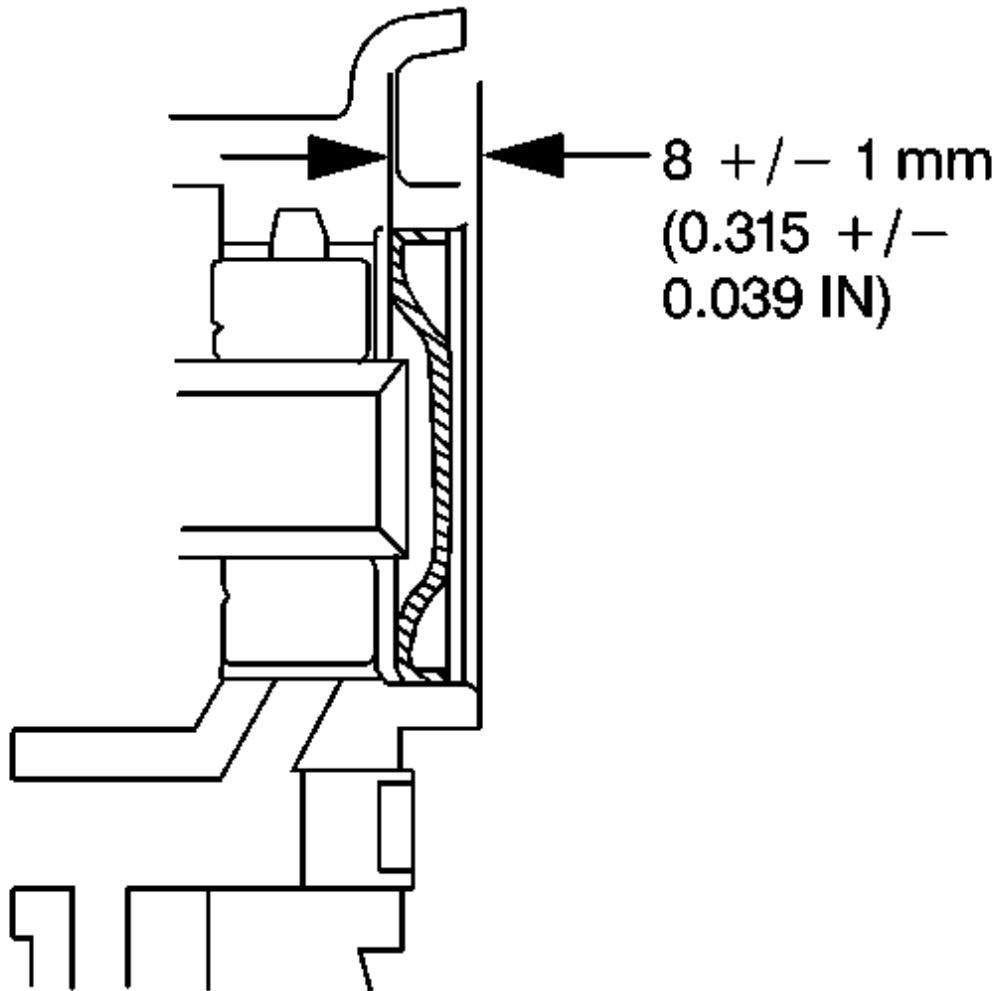


Fig. 142: Illustrating Proper Camshaft Rear Bearing Plug Specifications
Courtesy of GENERAL MOTORS CORP.

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

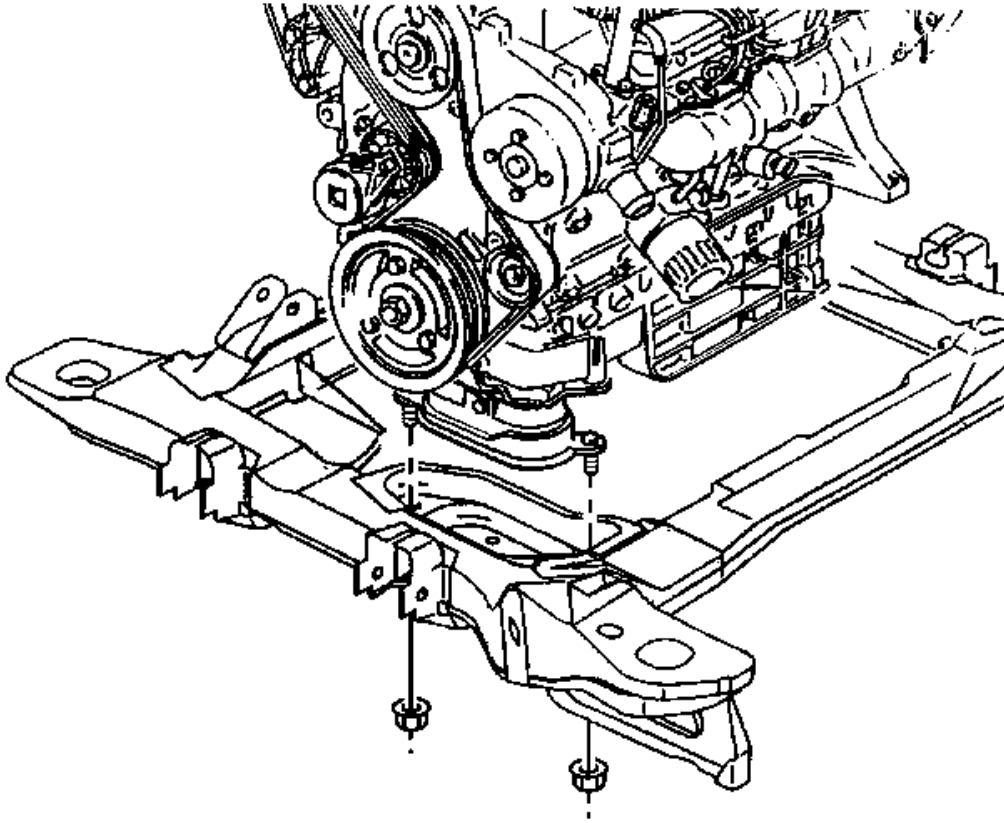


Fig. 143: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

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 - 3.5L.
5. Remove the hood. Refer to **Hood Replacement** in Body Front End.
6. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
7. Remove the drive belt. Refer to **Drive Belt Replacement**.
8. Disconnect the following electrical connectors:
 - The knock sensor (KS)
 - The camshaft position (CMP) sensor

- The crankshaft position (CKP) sensor
 - The heated oxygen sensor (HO2S)
 - The manifold absolute pressure (MAP) sensor
 - The exhaust gas recirculation (EGR) valve
 - The evaporative emission (EVAP) canister purge solenoid
 - The electronic throttle control
 - The ignition coil
 - The 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 catalytic converters. Refer to **Catalytic Converter Replacement (Front)** or **Catalytic Converter Replacement (Rear)** 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, Turbine Shaft Seal Replacement** in Automatic Transaxle - 4T40-E/4T45-E.
 14. Remove the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
 15. Remove the air conditioning (A/C) compressor. DO NOT discharge the A/C system. Support the compressor. Refer to **Compressor Replacement (LX9)** in Heating, Ventilation, and Air Conditioning.
 16. Remove the torque converter bolts. Refer to **Torque Converter, Turbine Shaft Seal Replacement** in Automatic Transaxle - 4T40-E/4T45-E.

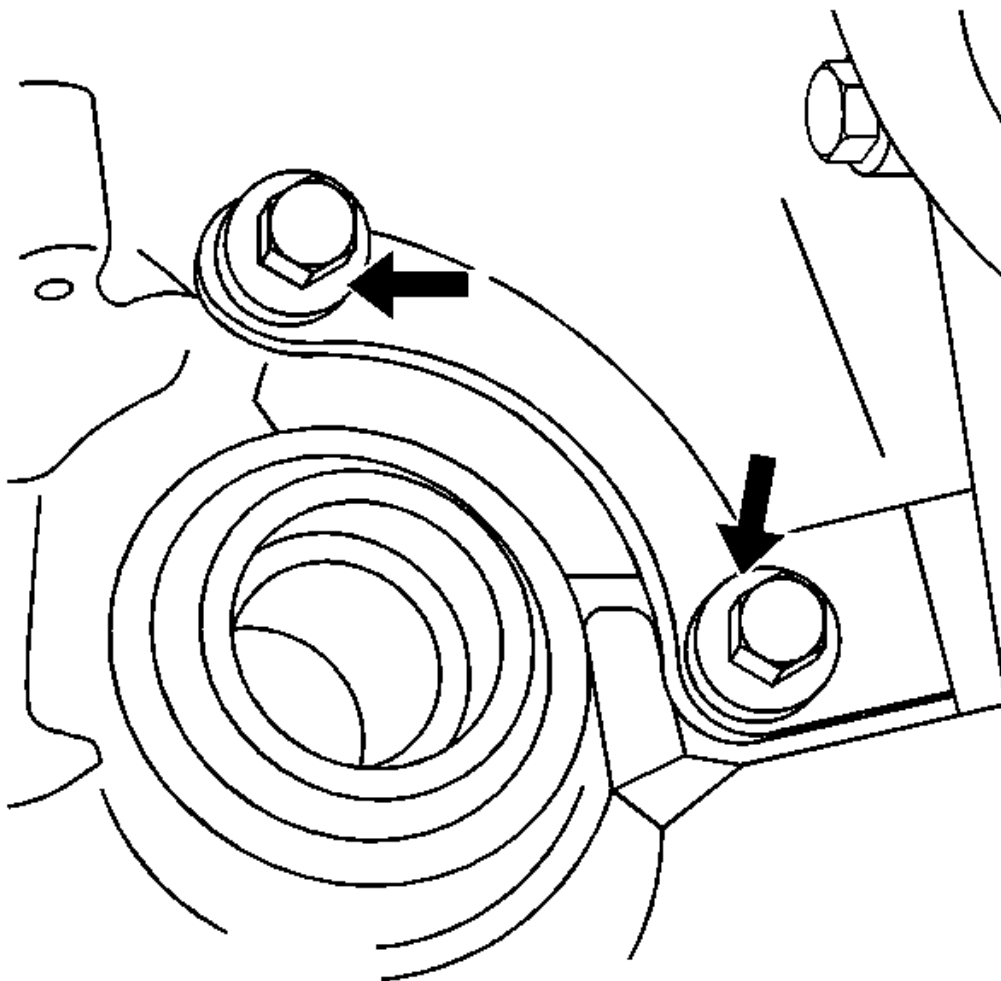


Fig. 144: Identifying Transmission-To-Engine Brace Bolts
Courtesy of GENERAL MOTORS CORP.

17. Remove the transaxle brace.

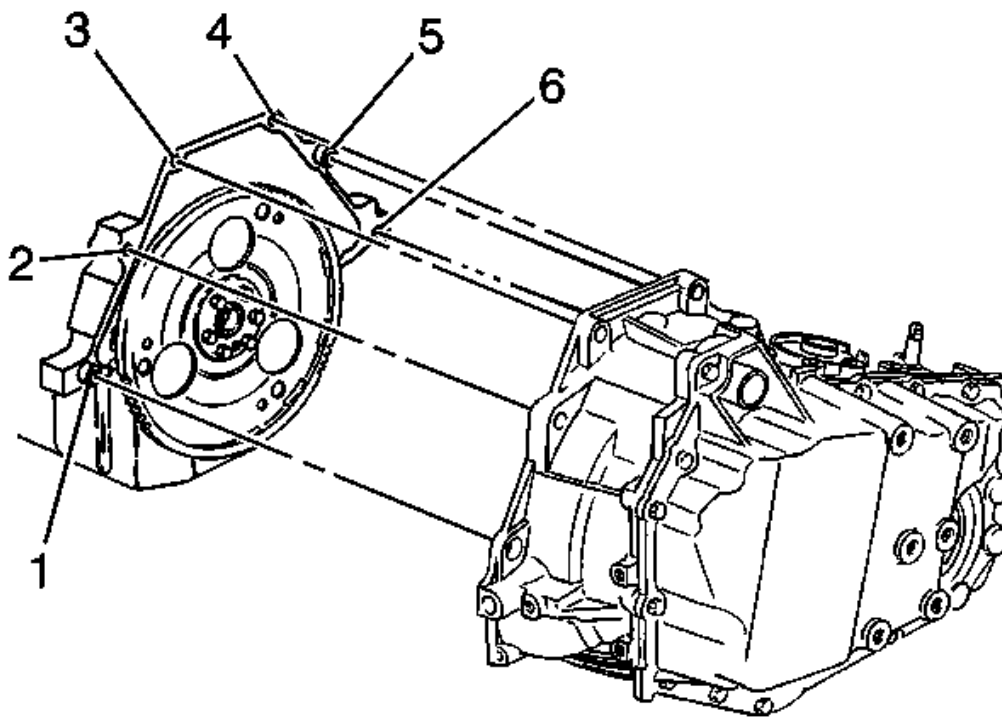


Fig. 145: View of Transaxle To Engine Mounting
Courtesy of GENERAL MOTORS CORP.

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** in Engine Cooling.
20. Lower the vehicle and support the transaxle.
21. Remove the heater outlet and inlet hoses from the engine.
22. Remove the vacuum hoses from the upper intake manifold.
23. Remove the brake booster vacuum hose from the upper intake manifold.
24. Remove the fuel lines from the fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L.
25. Remove the radiator inlet hose from the engine. Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.
26. Install the engine lifting device to the engine.
27. Remove the upper transaxle-to-engine bolts (3, 4, 5) and the stud (2).
28. Remove the engine from the vehicle.
29. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

30. Install the engine to the engine stand.

Installation Procedure

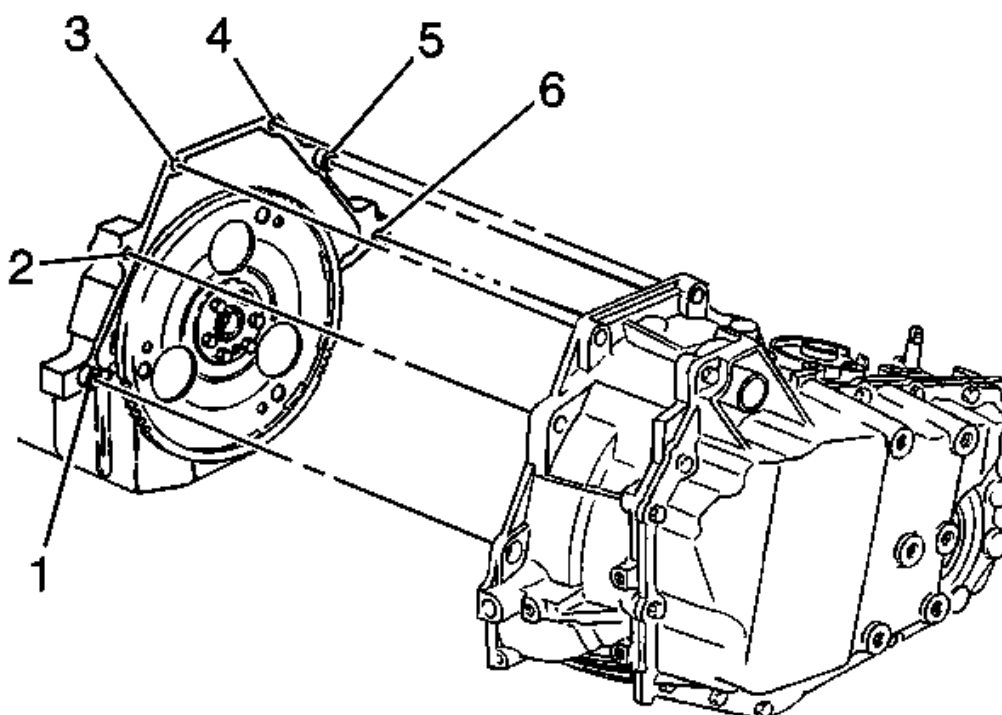


Fig. 146: View of Transaxle To Engine Mounting
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine from the engine stand.
2. Install the flywheel. Refer to Engine Flywheel Replacement.
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 radiator inlet hose to the engine. Refer to Radiator Hose Replacement - Inlet in Engine

Cooling.

7. Install the fuel lines to the fuel rail. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 3.5L.
8. Install the brake booster vacuum hose to the upper intake manifold.
9. Install the vacuum hoses to the upper intake manifold.
10. Install the heater inlet and outlet hoses to the engine.
11. Raise the vehicle and remove the transaxle support.
12. Install the radiator outlet hose to the engine. Refer to **Radiator Hose Replacement - Outlet** in Engine Cooling.
13. 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).

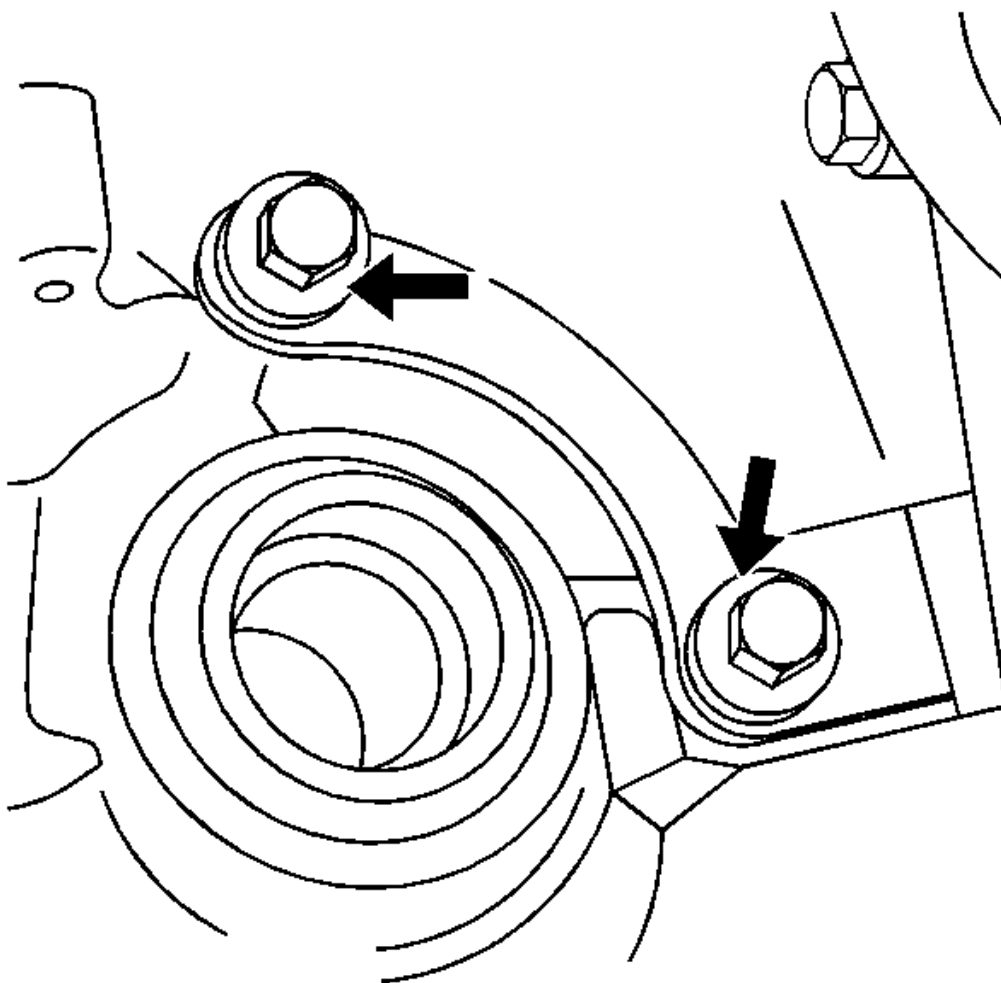


Fig. 147: Identifying Transmission-To-Engine Brace Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the transaxle brace.

Tighten: Tighten the transmission-to-engine brace bolts to 72 N.m (53 lb ft).

15. Install the torque converter bolts. Refer to **Torque Converter, Turbine Shaft Seal Replacement** in Automatic Transaxle - 4T40-E/4T45-E.
16. Install the A/C compressor. Refer to **Compressor Replacement (LX9)** in Heating, Ventilation, and Air Conditioning.
17. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.

18. Install the torque converter covers. Refer to **Torque Converter, Turbine Shaft Seal Replacement** in Automatic Transaxle - 4T40-E/4T45-E.

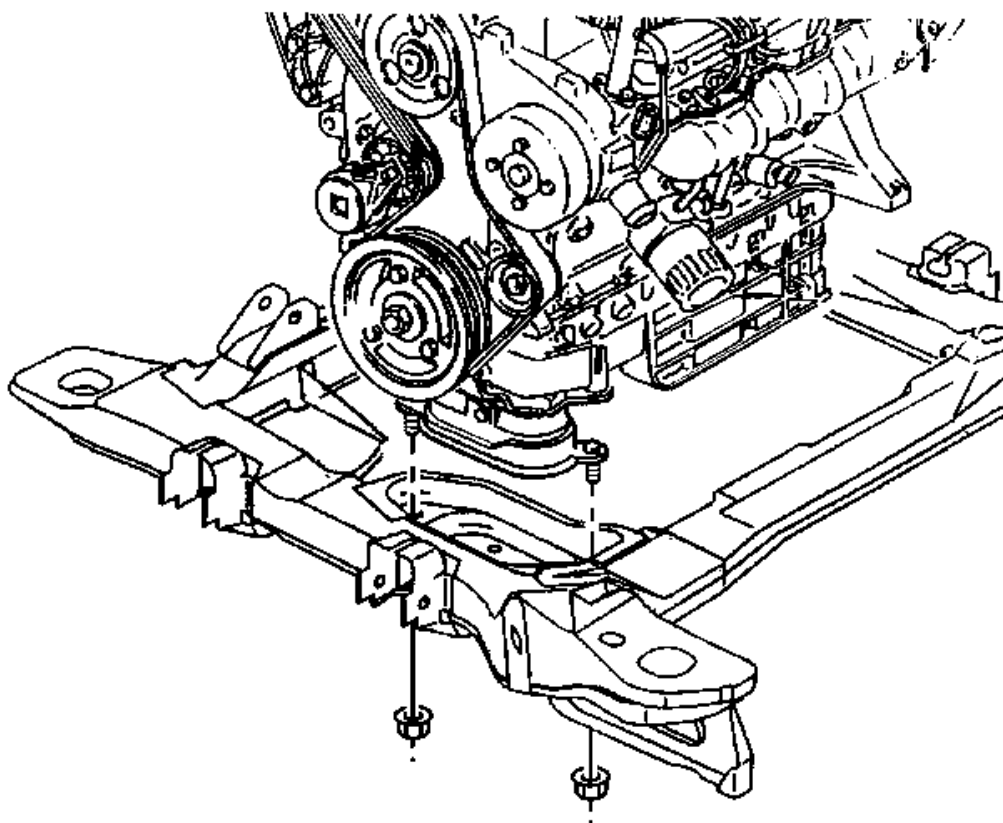


Fig. 148: Identifying Engine Mount Lower Nuts
Courtesy of GENERAL MOTORS CORP.

19. Install the engine mount lower nuts.

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

20. Install the engine wiring harness grounds to the transaxle.
21. Install the engine wiring harness ground nut to the transaxle stud.

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

22. Install the catalytic converters. Refer to **Catalytic Converter Replacement (Front)** or **Catalytic Converter Replacement (Rear)** in Engine Exhaust.

23. Lower the vehicle.
24. Connect the following electrical connectors:
 - The body wiring harness-to-engine harness
 - The ignition coil
 - The electronic throttle control
 - The EVAP canister purge solenoid
 - The EGR valve
 - The MAP sensor
 - The HO2S
 - The CKP sensor
 - The CMP sensor
 - The KS
25. Install the drive belt. Refer to **Drive Belt Replacement**.
26. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.
27. Install the hood. Refer to **Hood Replacement** in Body Front End.
28. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 3.5L.
29. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
30. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
31. Fill cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
32. Perform a CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.5L.
33. Inspect for leaks.

Engine Oil and Oil Filter Replacement

Removal Procedure

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

1. Remove the negative battery cable.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the oil pan bolt.

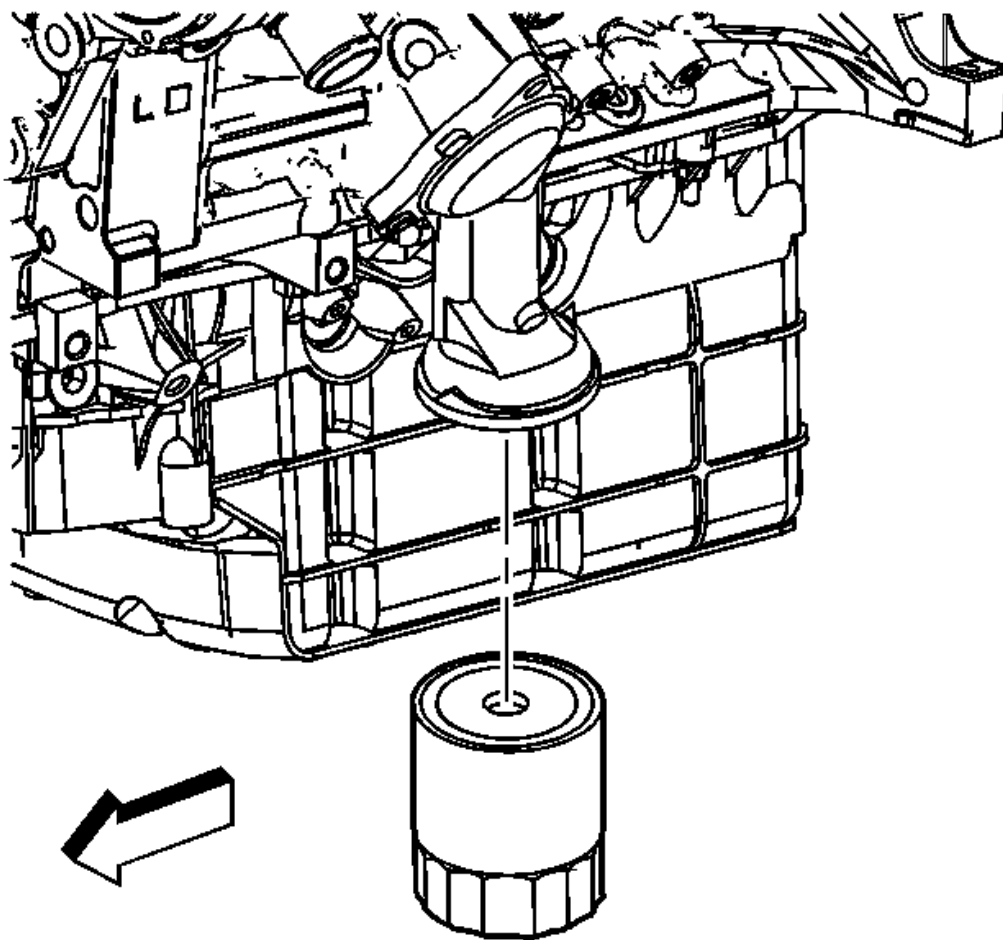


Fig. 149: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter.

Installation Procedure

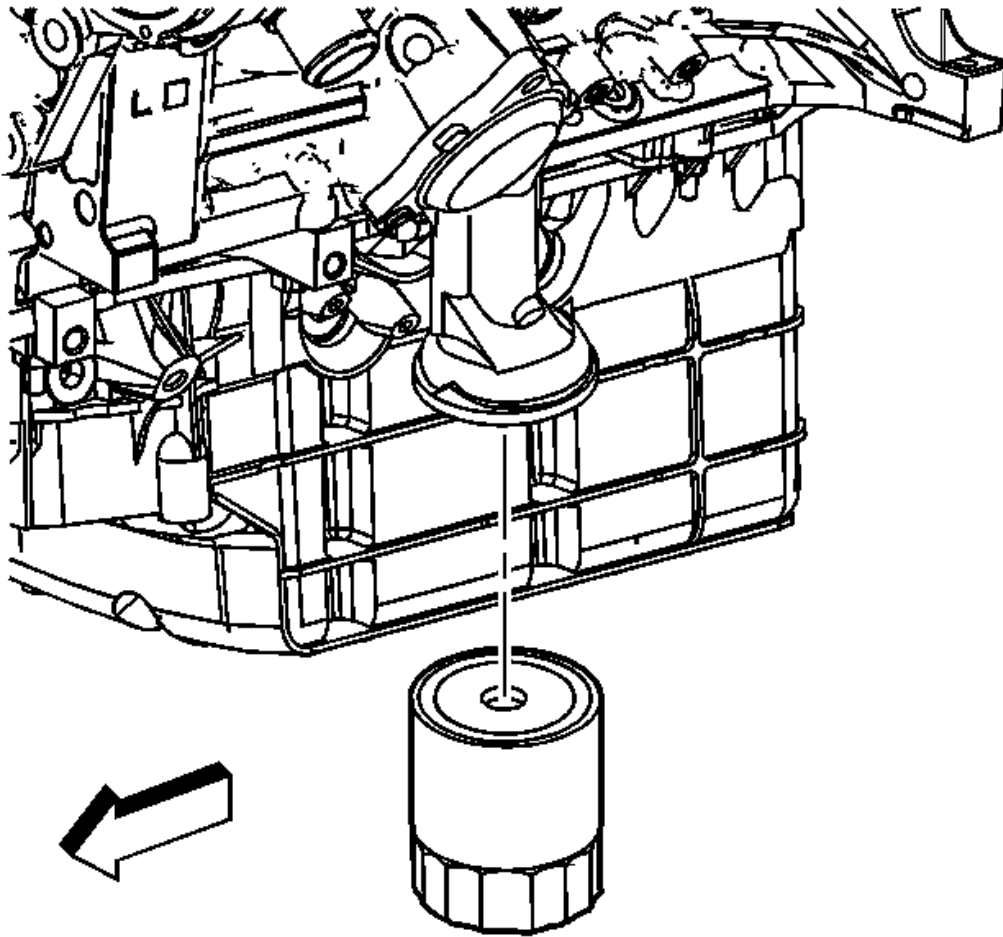


Fig. 150: Removing Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Install the oil filter.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pan drain bolt.

Tighten: Tighten the oil pan drain bolt to 26 N.m (19 lb ft).

Lower the vehicle.

3. Fill the engine with oil to the appropriate mark.

4. Install negative battery cable.
5. Start engine and inspect for leaks.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

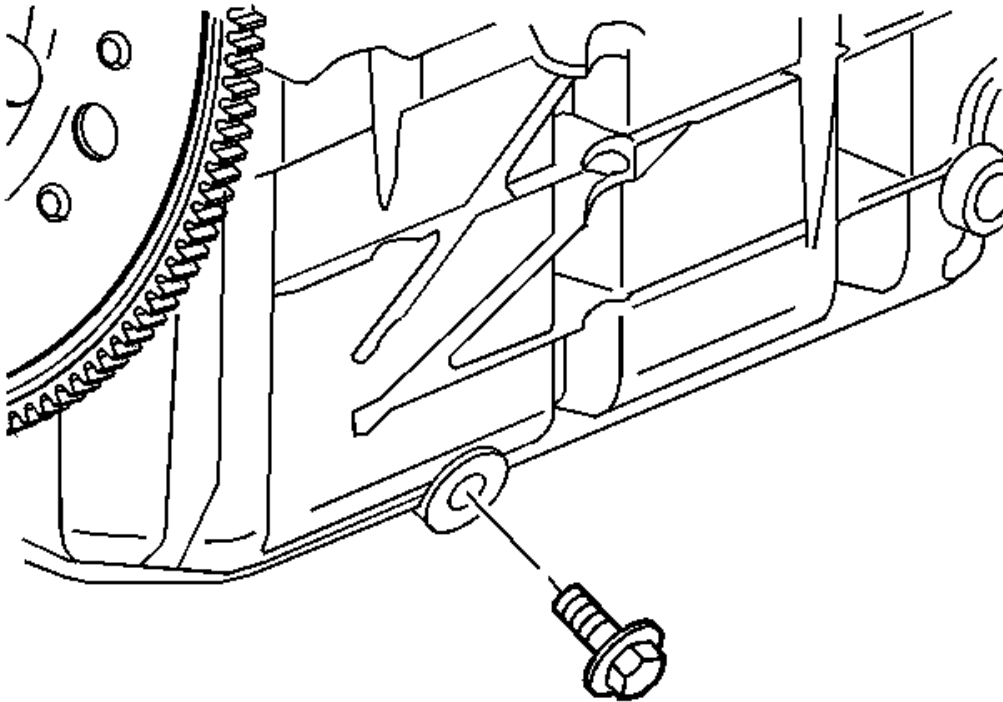


Fig. 151: Removing Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

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

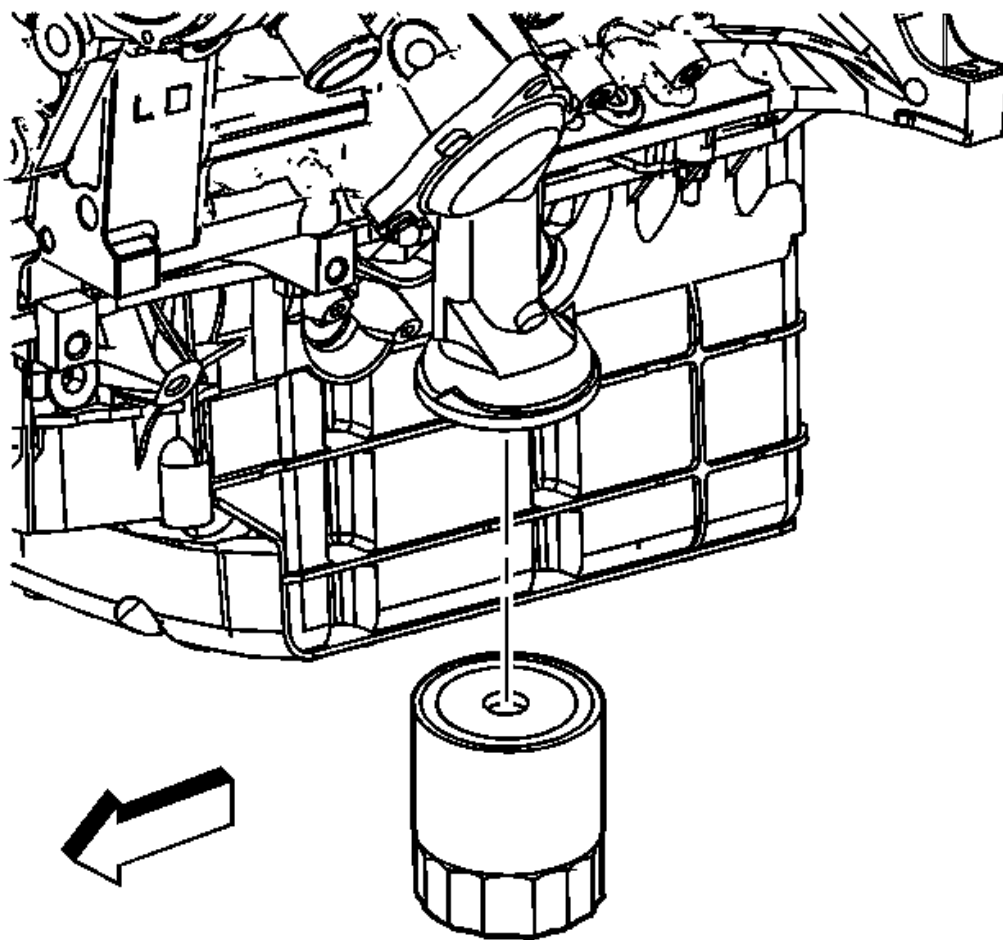


Fig. 152: Removing Oil Filter

Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter.

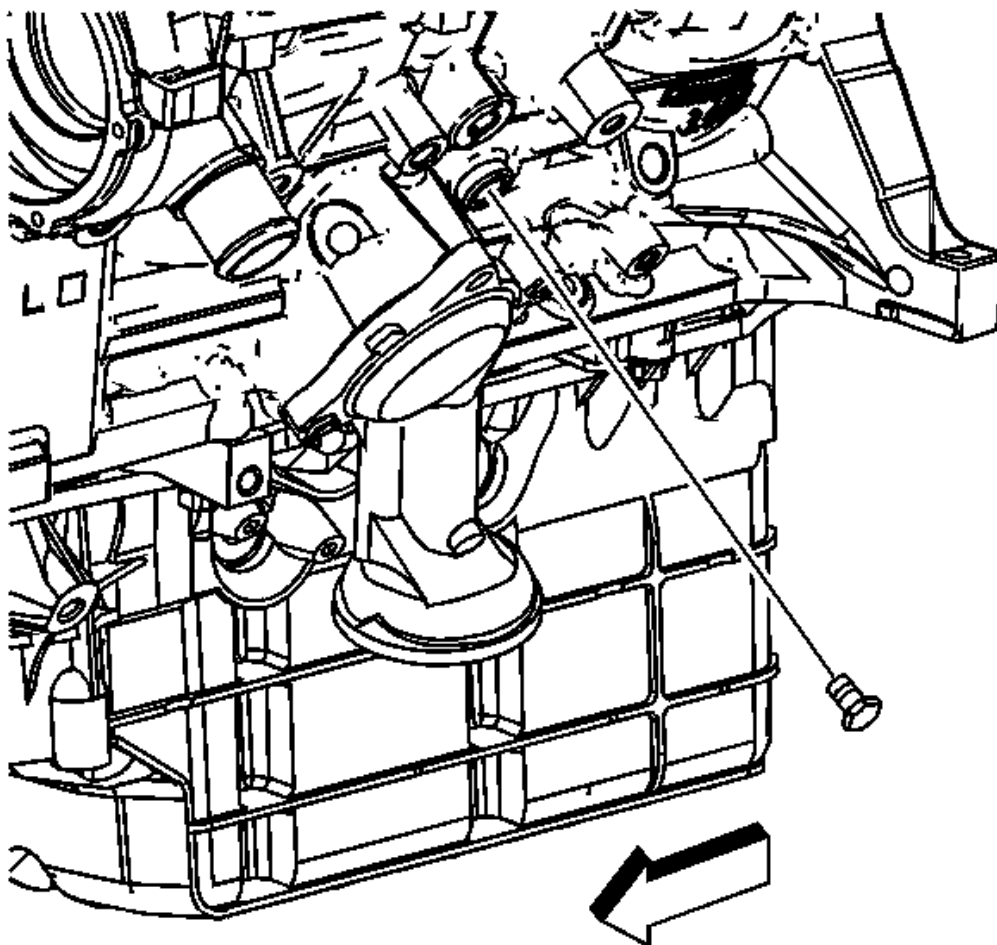


Fig. 153: Removing Coolant Drain Plug From Left Side
Courtesy of GENERAL MOTORS CORP.

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

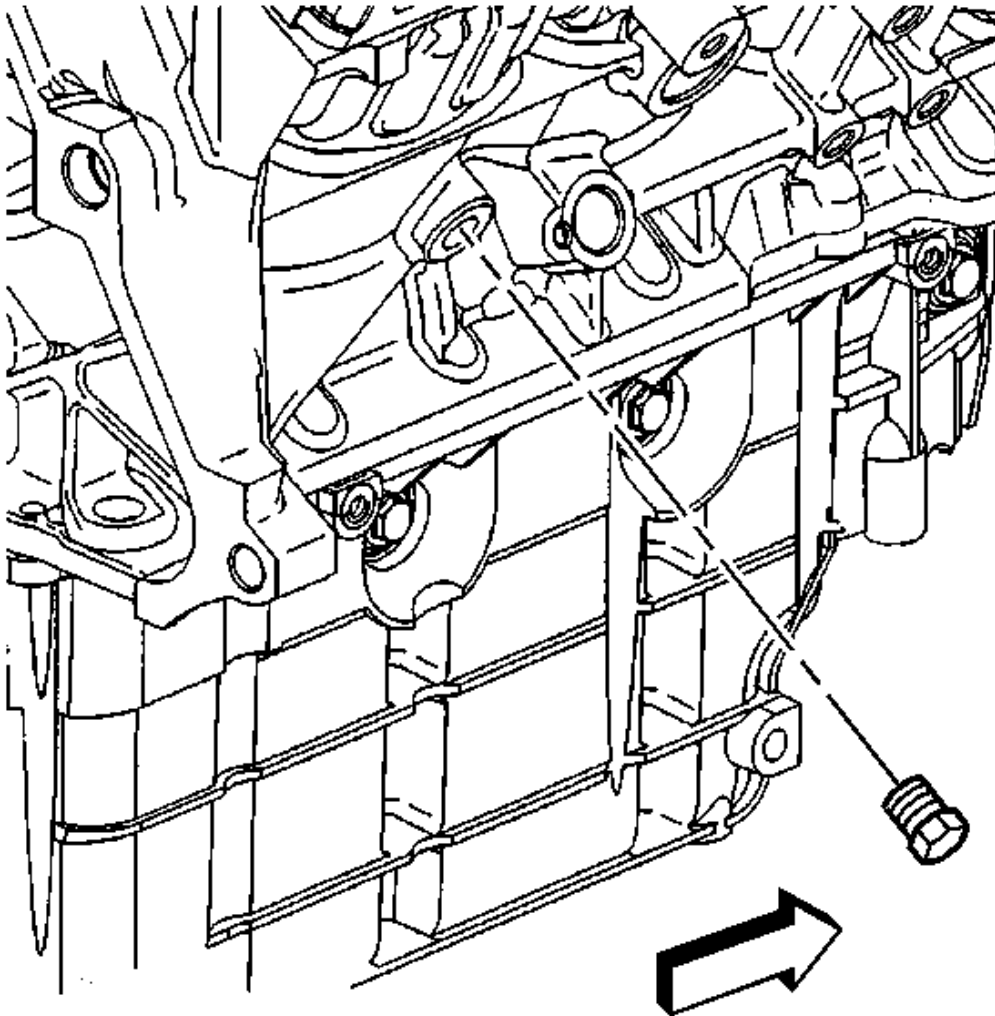


Fig. 154: Removing Coolant Drain Plug From Right Side
Courtesy of GENERAL MOTORS CORP.

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

Crankshaft Balancer Removal

Tools Required

- J 41816-A Crankshaft Balancer Remover

- EN 46359 Puller End Protector. See Special Tools.

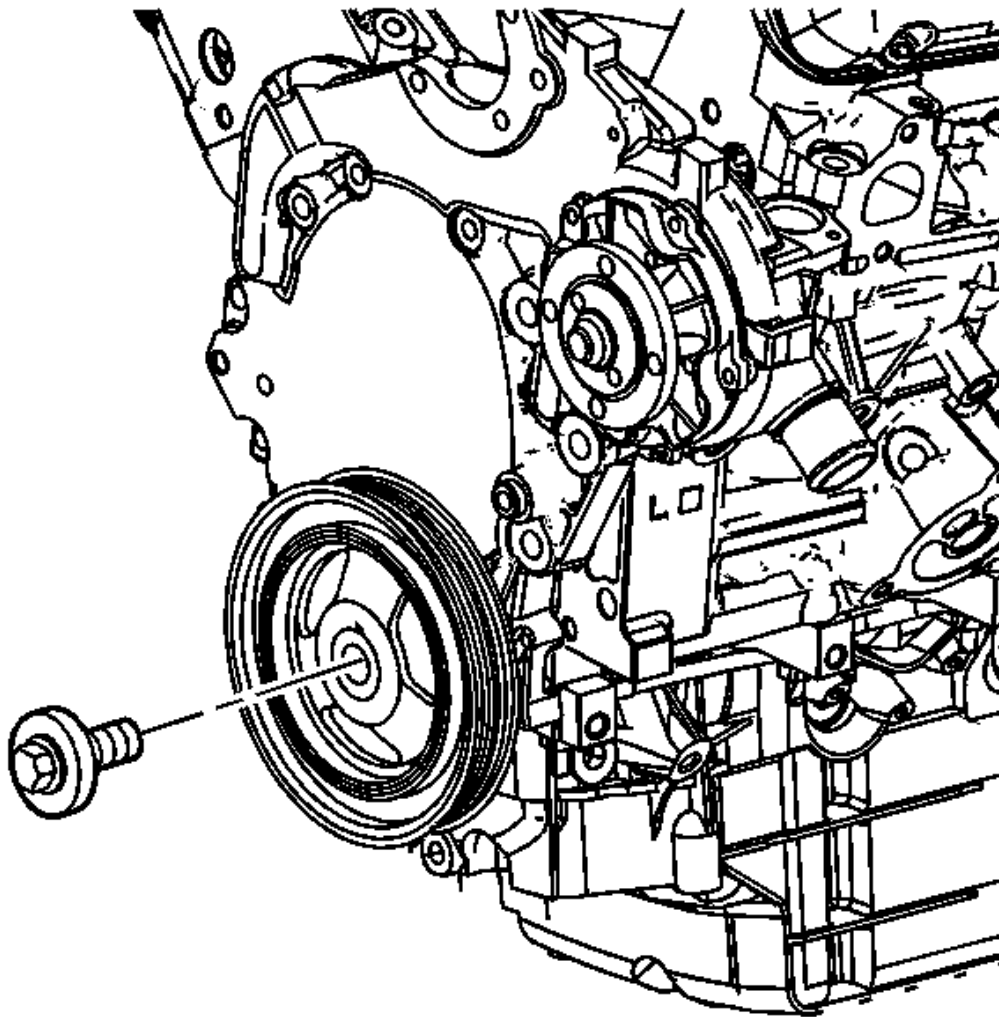


Fig. 155: Removing Crankshaft Balancer Bolt And Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt and washer.

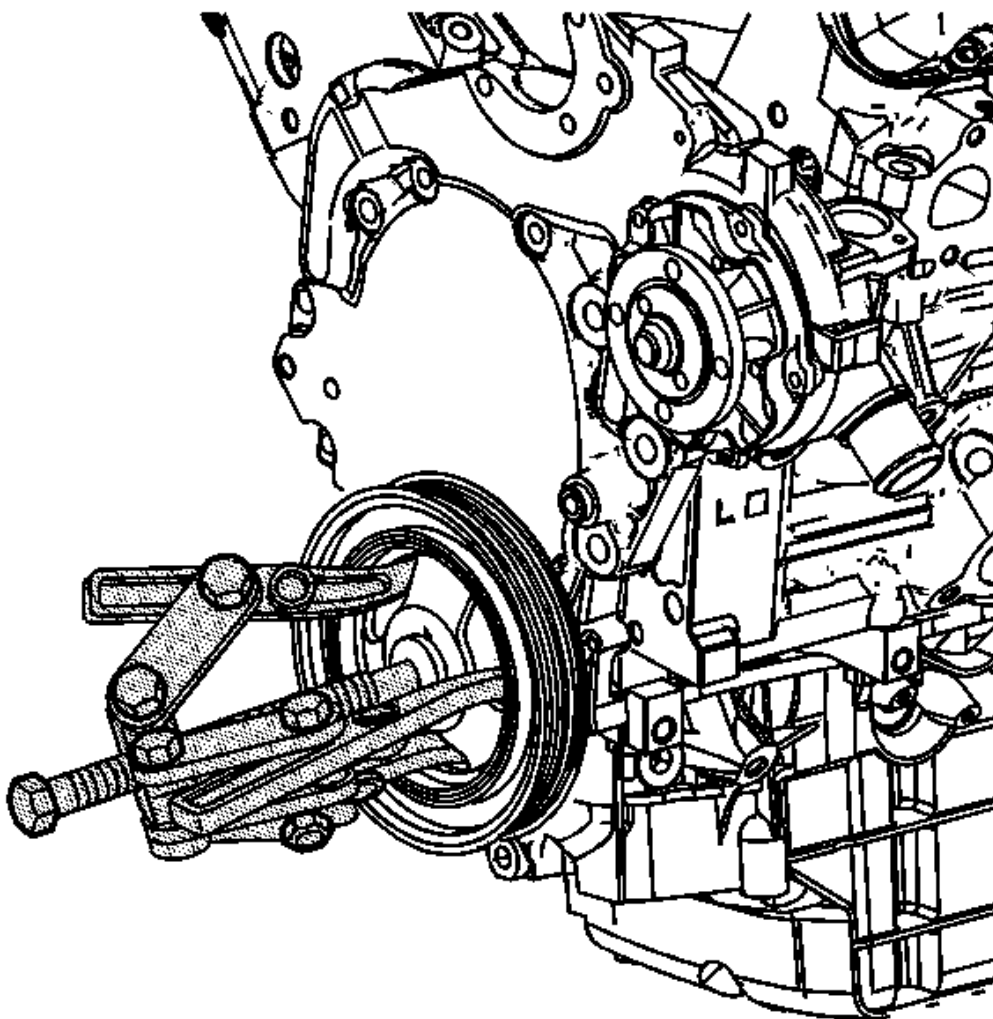


Fig. 156: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the crankshaft balancer using the J 41816-A along with EN 46359 or equivalent. See Special Tools.

Engine Flywheel Removal

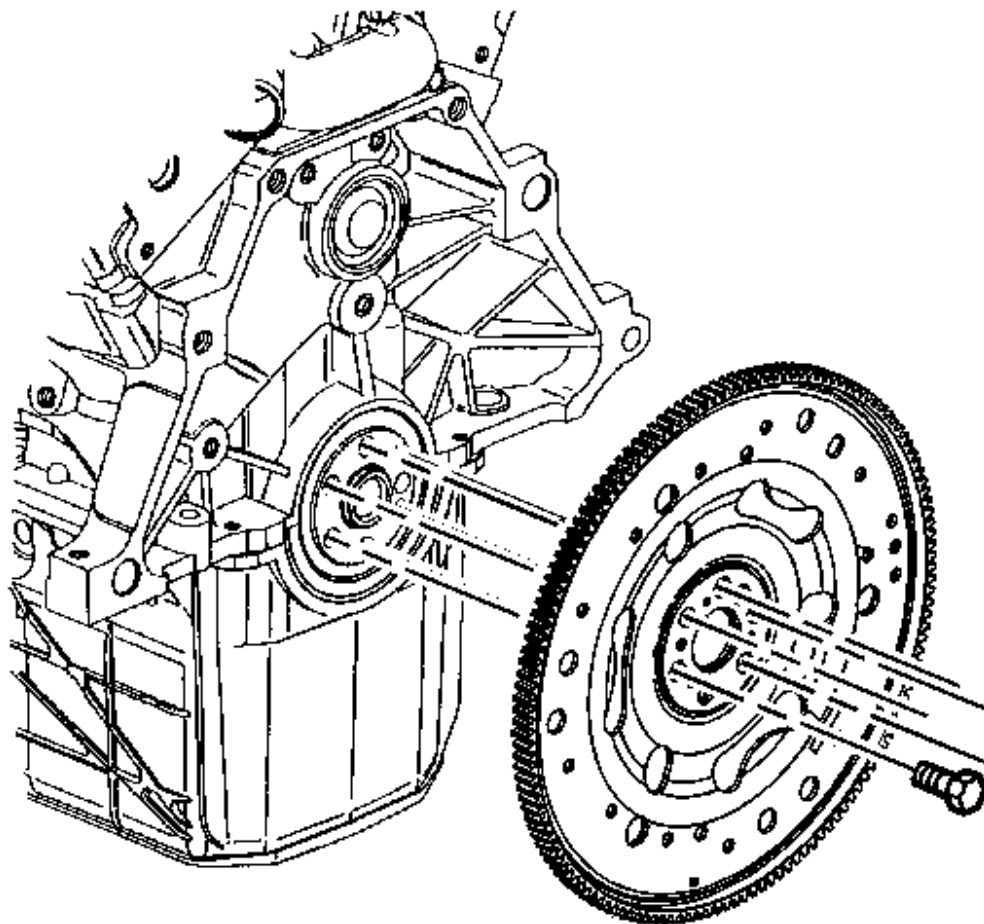


Fig. 157: View Of Flywheel

Courtesy of GENERAL MOTORS CORP.

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

Drive Belt Tensioner Removal

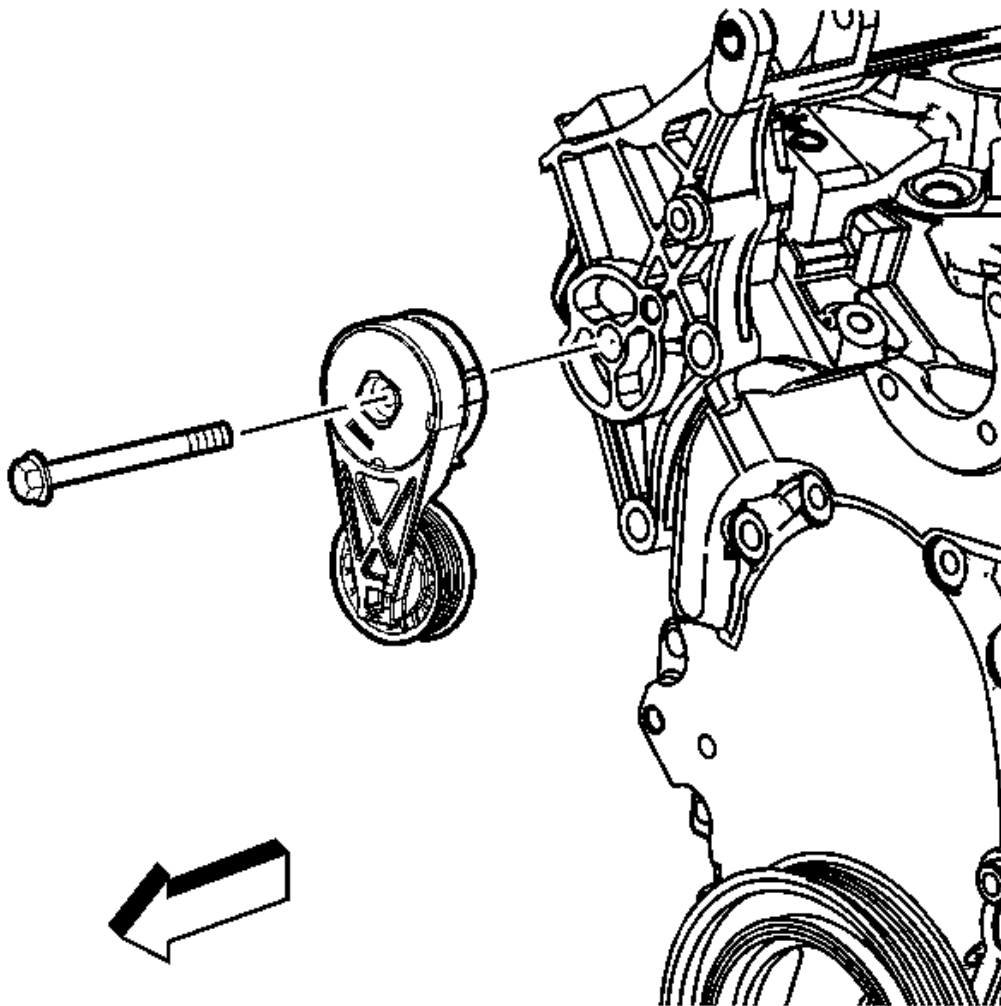


Fig. 158: Removing Drive Belt Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

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

Engine Lift Bracket and Generator Bracket Removal

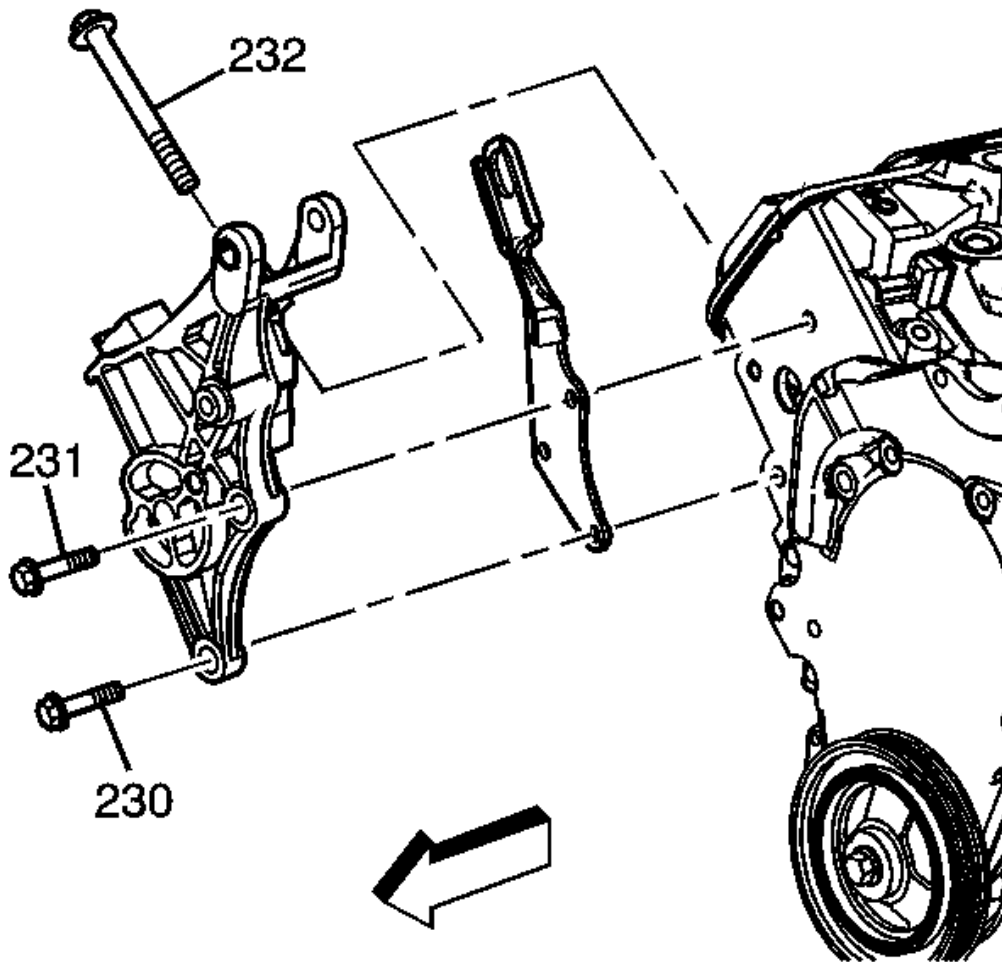


Fig. 159: Removing Generator Bracket Assembly Bolts (230, 231, 232)
 Courtesy of GENERAL MOTORS CORP.

1. Remove the generator bracket assembly bolts (230, 231, 232).
2. Remove the generator assembly bracket.
3. Remove the front engine lift hook.

Engine Mount Support and Strut Bracket Removal

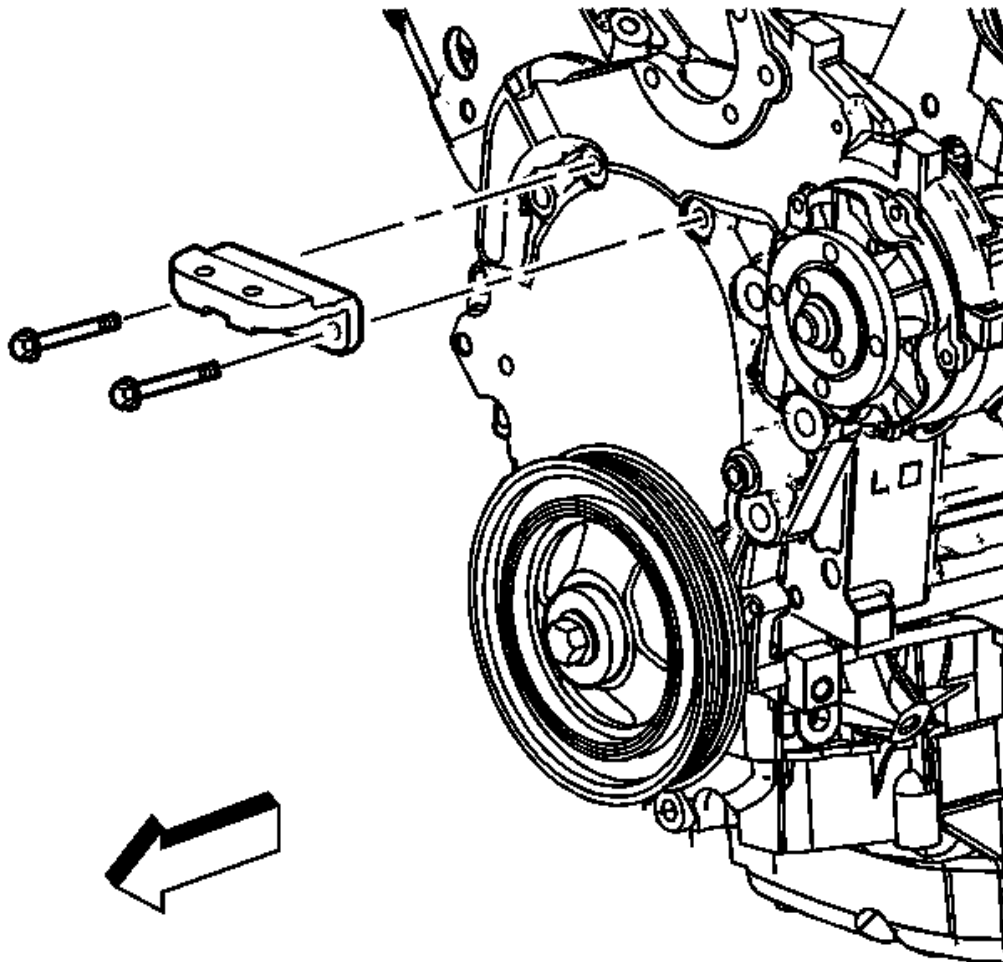


Fig. 160: Removing Engine Mount Support And Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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

Engine Lift Bracket Removal - Rear

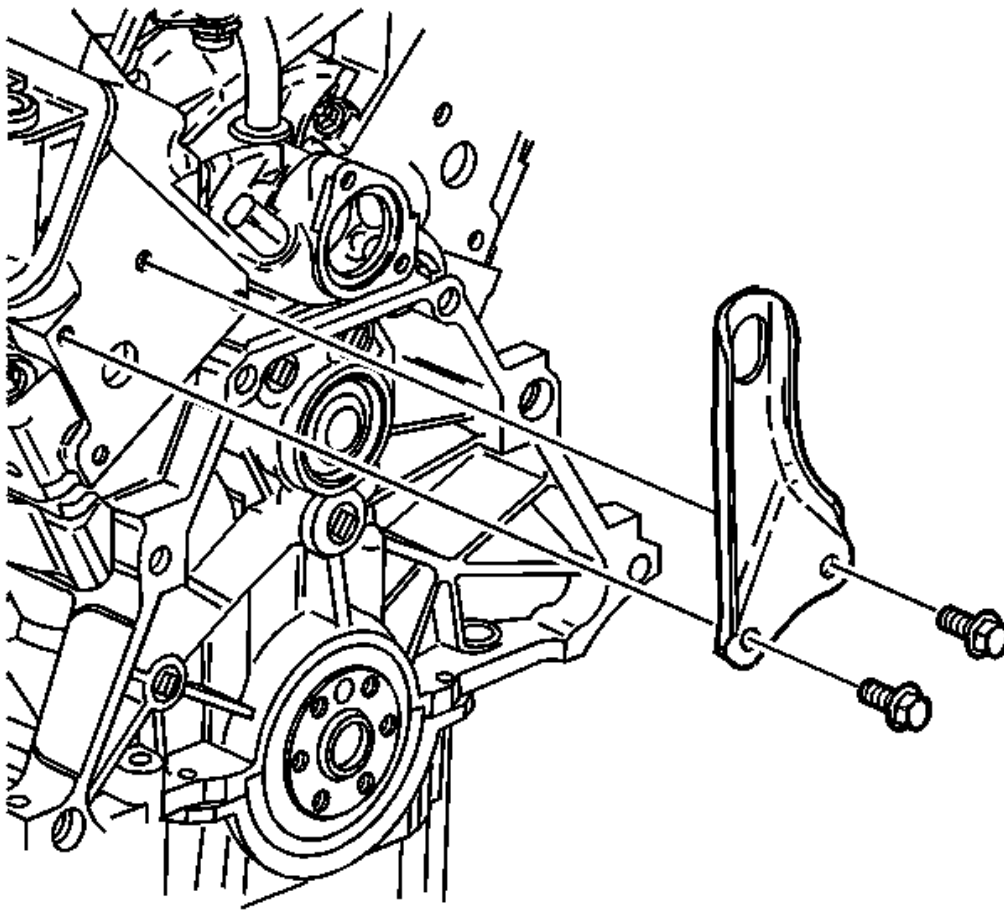


Fig. 161: Removing Rear Engine Lift Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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

Oil Level Indicator and Tube Removal

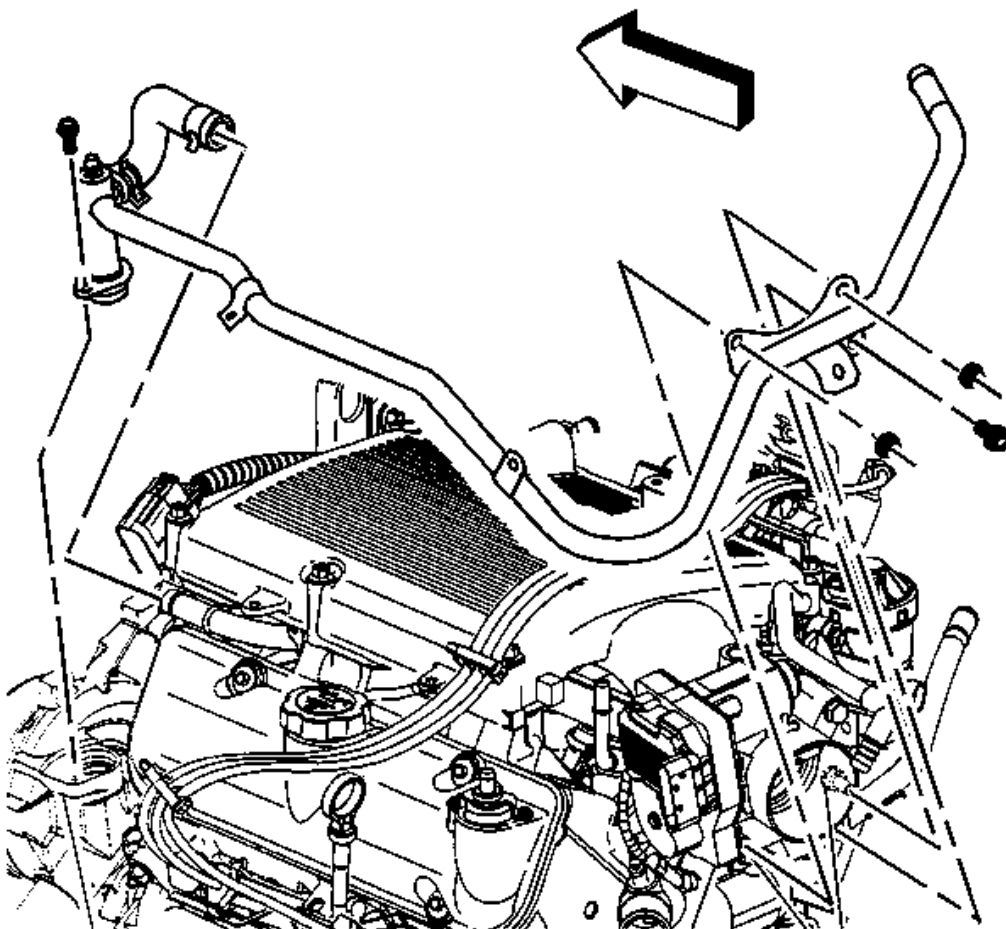


Fig. 162: View Of Thermostat Bypass Pipe Hose And Thermostat Bypass Pipe
 Courtesy of GENERAL MOTORS CORP.

1. Remove the thermostat bypass pipe hose from the thermostat bypass pipe.

IMPORTANT: Passenger cars will have a 16 pin connector attached to the bypass pipe.
 Passenger vans will have the connector attached to the drive belt shield.

2. Remove the 16 pin connector.
3. Remove the spark plug wires from the spark plugs and set aside.
4. Remove the spark plug wire clip from the pipe.
5. Remove the heated oxygen sensor connector from pipe.
6. Remove the thermostat bypass pipe to throttle body nuts.

7. Remove the thermostat bypass pipe to throttle body bolt.
8. Remove the thermostat bypass pipe to engine front cover bolt.
9. Remove the thermostat bypass pipe.

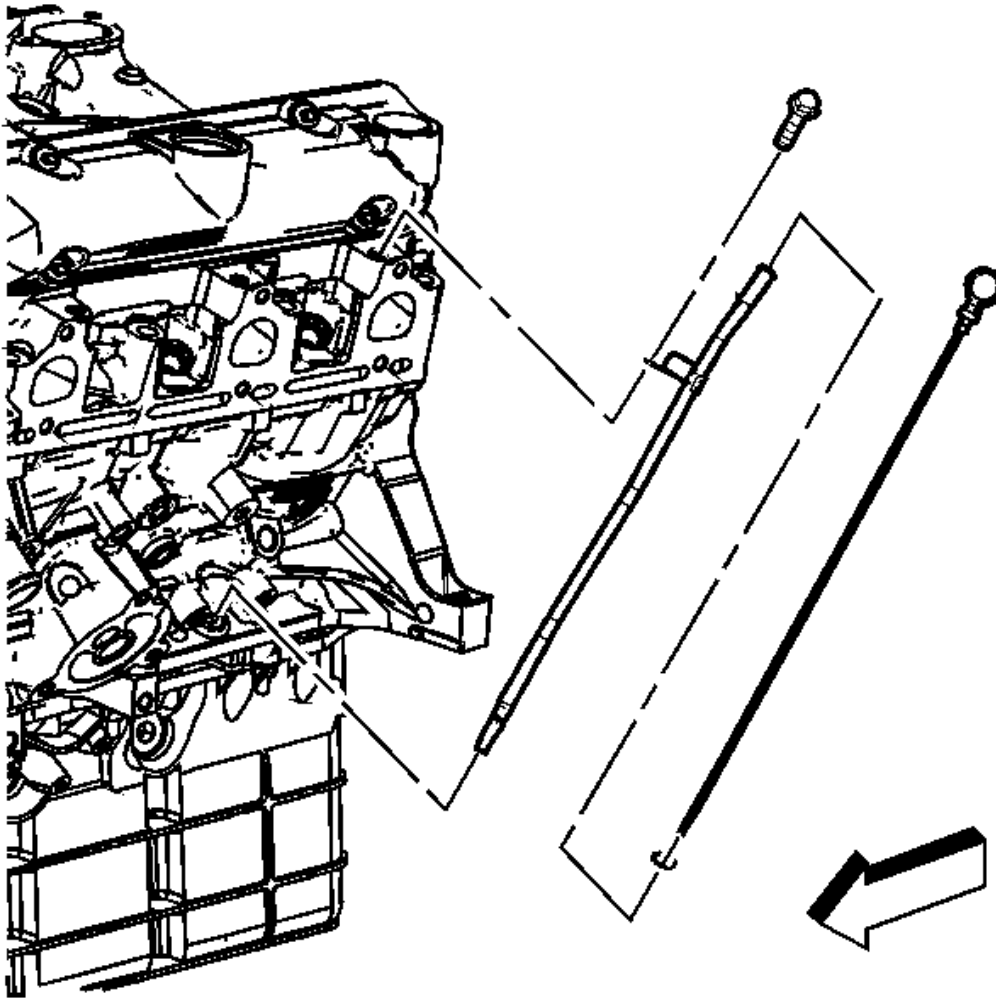


Fig. 163: Removing Oil Level Indicator Tube Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove the oil level indicator tube bolt.
11. Remove the oil level indicator and oil level indicator tube.

Oil Filter Adapter Removal

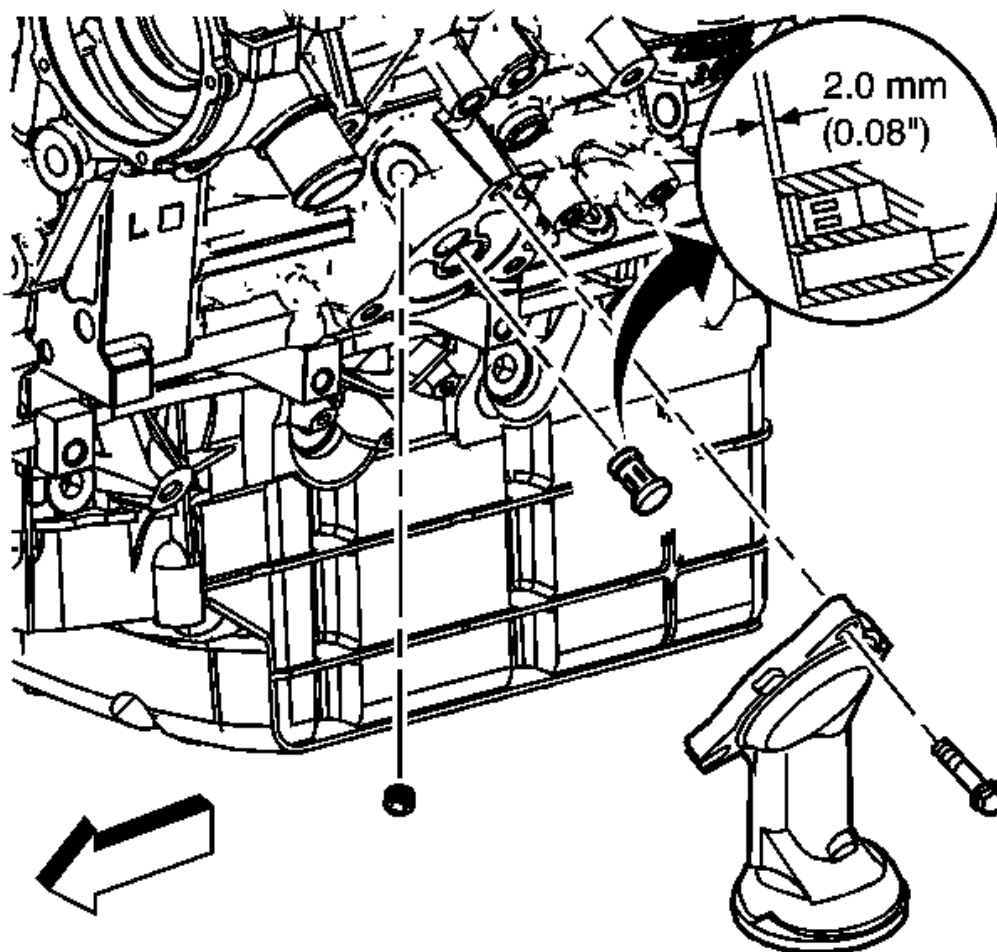


Fig. 164: Removing Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter bolts.
2. Remove the oil filter adapter and gasket.
3. Remove the oil filter bypass hole plug.

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

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

Exhaust Manifold Removal - Left

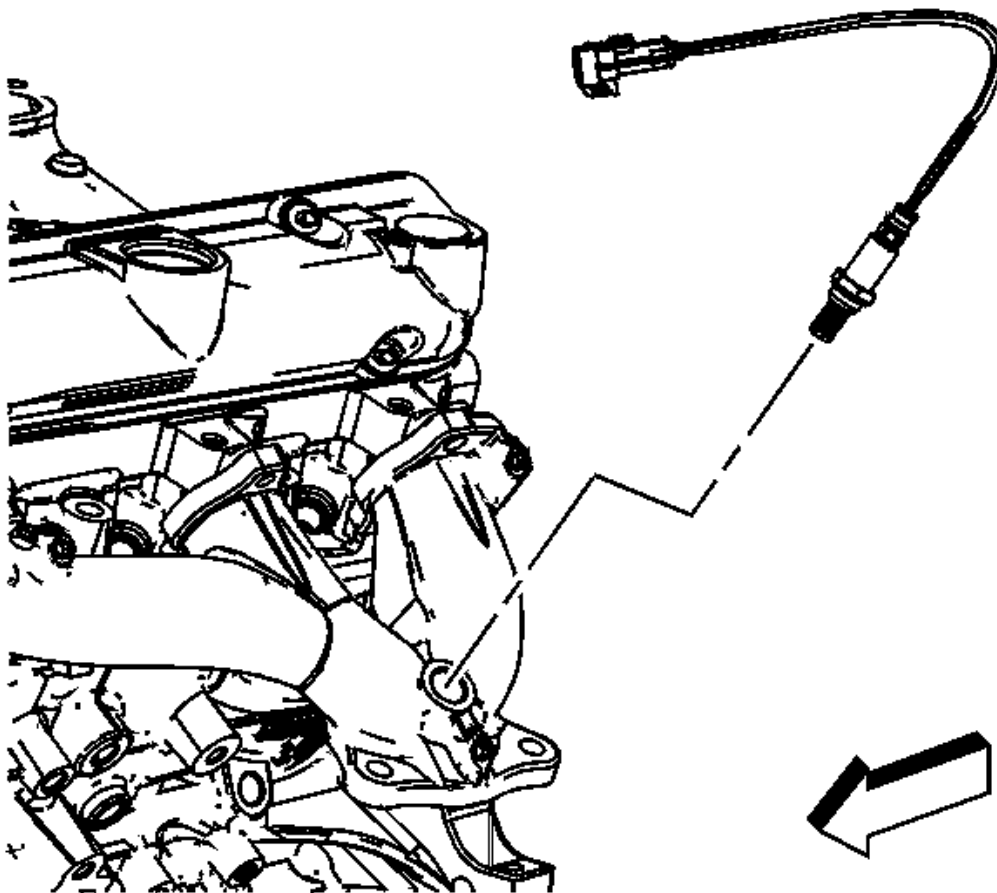


Fig. 165: Removing Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the heated oxygen sensor.

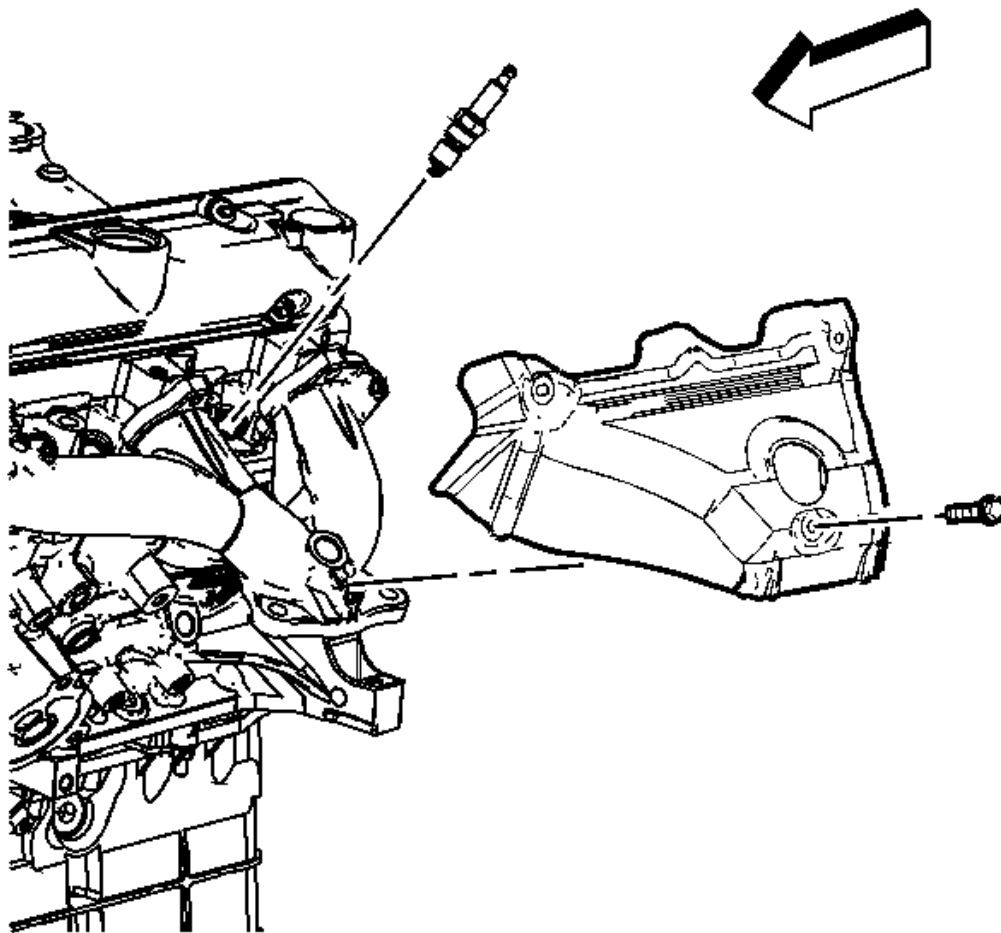


Fig. 166: Removing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

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

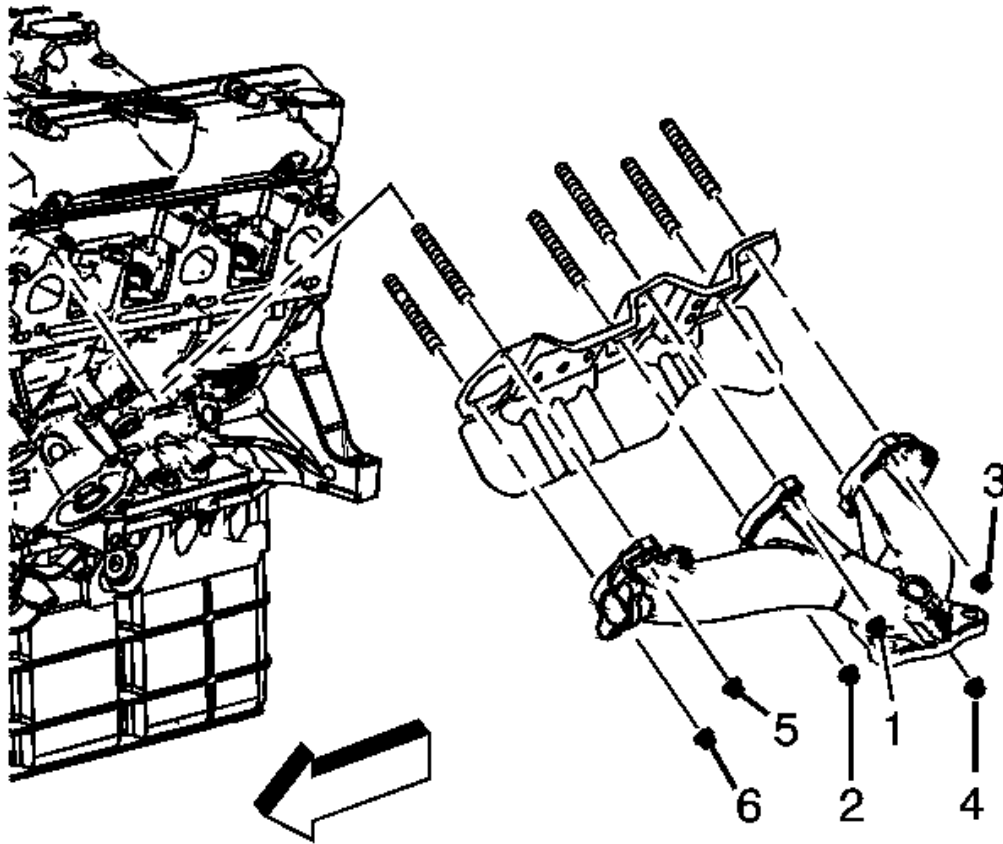


Fig. 167: Removing Exhaust Manifold Nuts (1, 2, 3, 4, 5, 6)
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust manifold nuts (1, 2, 3, 4, 5, 6).
6. Remove the exhaust manifold.
7. Remove the exhaust manifold gasket.
8. Remove the exhaust studs, if required.

Exhaust Manifold Removal - Right

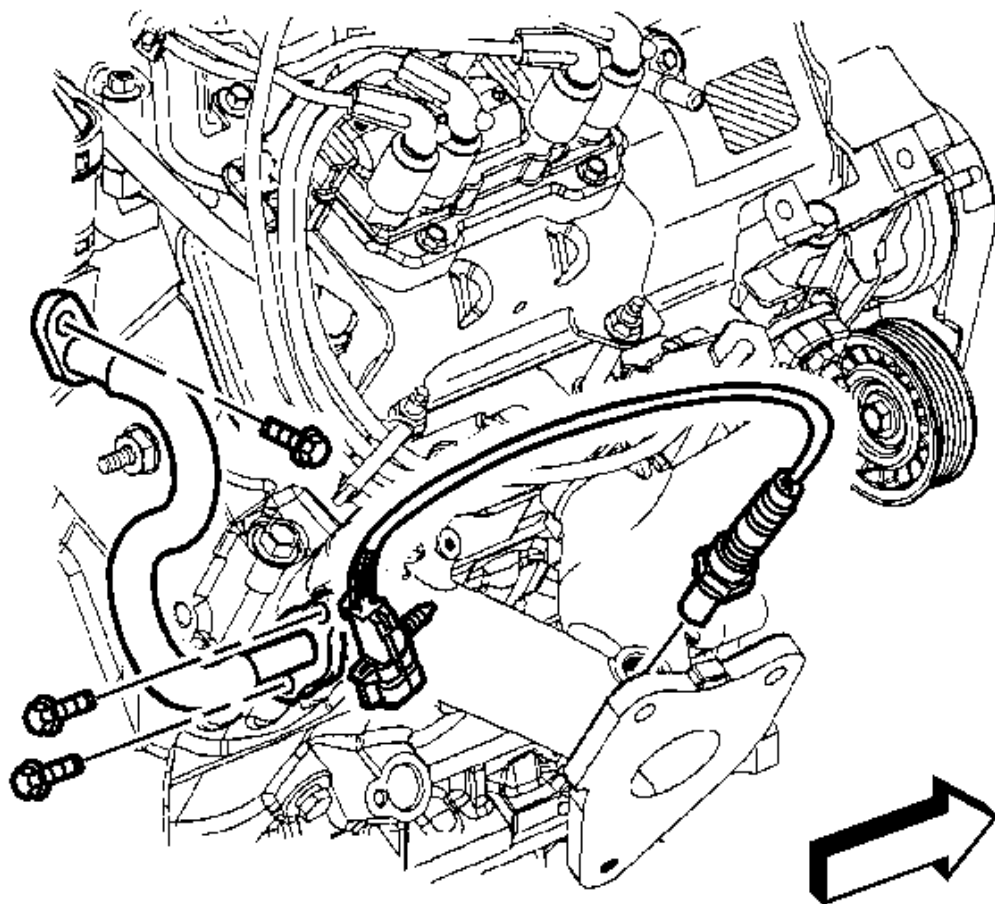


Fig. 168: Removing Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the heated oxygen sensor.
2. Remove the spark plug wires.
3. Remove the spark plugs.
4. Remove the exhaust gas recirculation (EGR) pipe bolts from the exhaust manifold.
5. Remove the EGR pipe bolt at the EGR valve.
6. Remove the EGR pipe.

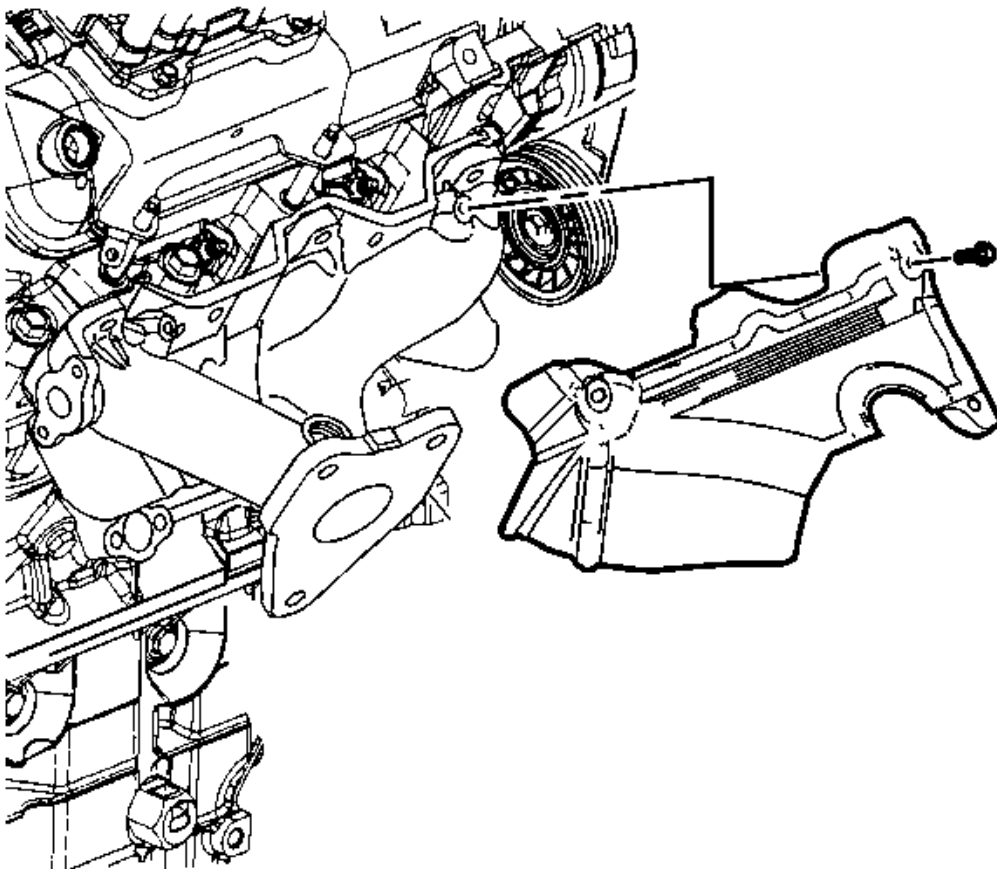


Fig. 169: Removing Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the exhaust manifold heat shield bolts.
8. Remove the exhaust manifold heat shields.

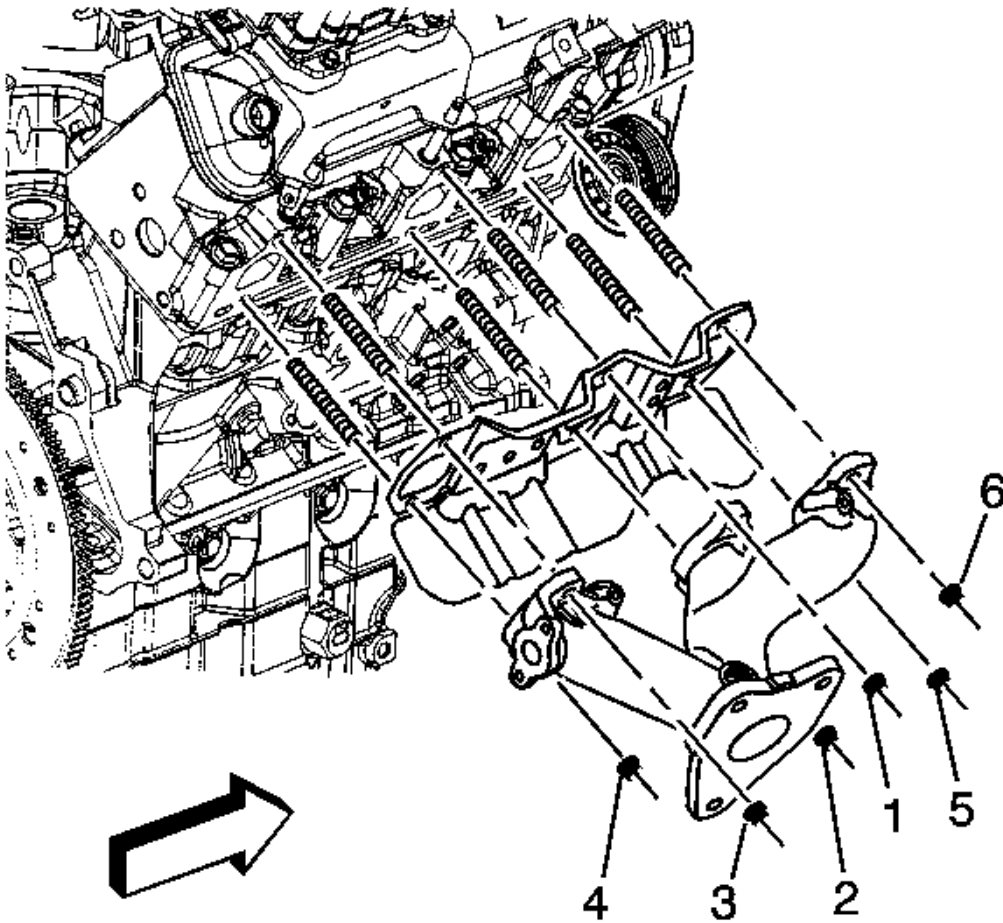


Fig. 170: Removing Exhaust Manifold Nuts (1, 2, 3, 4, 5, 6)
 Courtesy of GENERAL MOTORS CORP.

9. Remove the exhaust manifold nuts (1, 2, 3, 4, 5, 6).
10. Remove the exhaust manifold.
11. Remove the exhaust manifold gasket.
12. Remove the exhaust studs, if required.

Water Outlet and Thermostat Removal

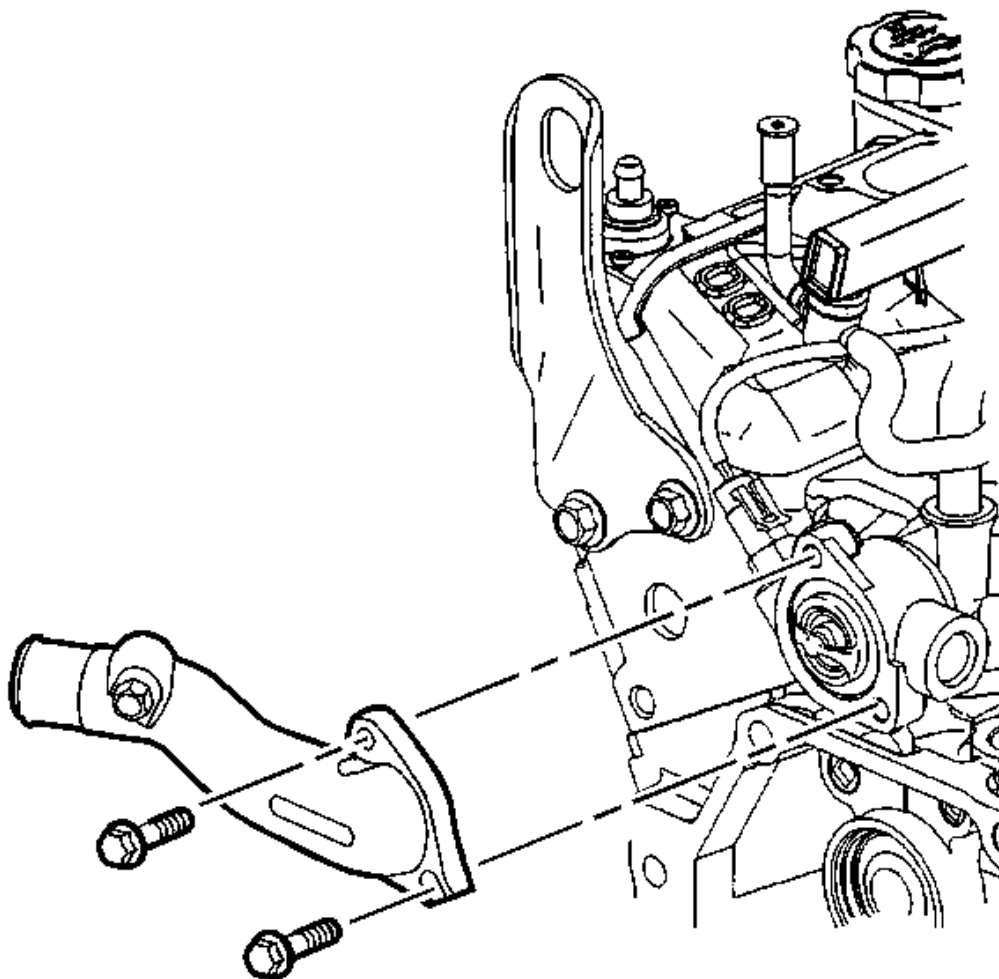


Fig. 171: Removing Water Outlet
Courtesy of GENERAL MOTORS CORP.

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

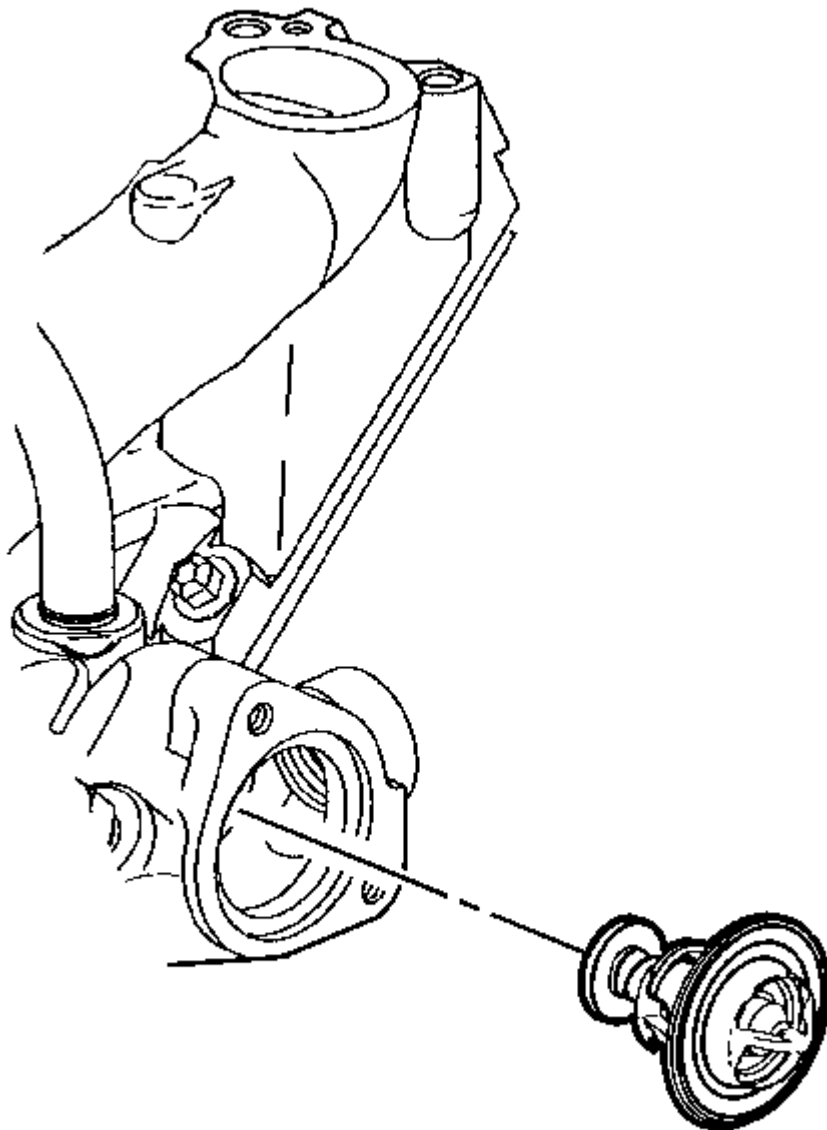


Fig. 172: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

3. Remove the thermostat.

Valve Rocker Arm Cover Removal - Left

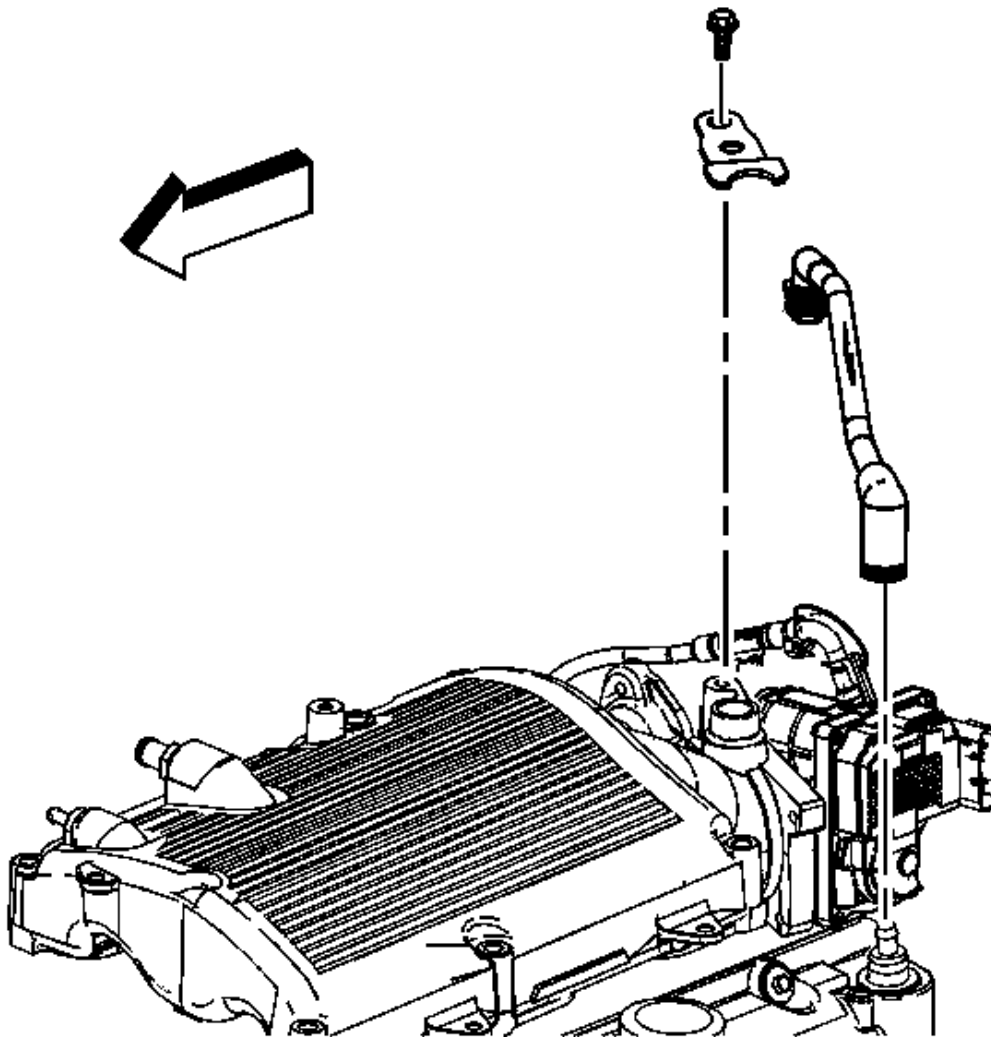


Fig. 173: Removing PCV Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the positive crankcase ventilation (PCV) tube bolt and clip.
2. Remove the PCV tube.

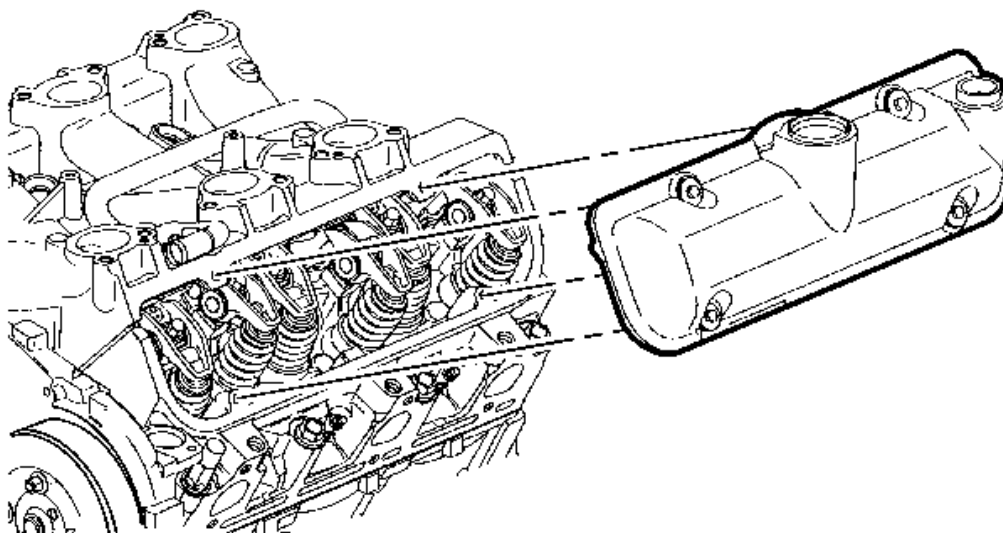


Fig. 174: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

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.

3. Remove the valve rocker arm cover bolts.

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

4. Remove the valve rocker arm cover.

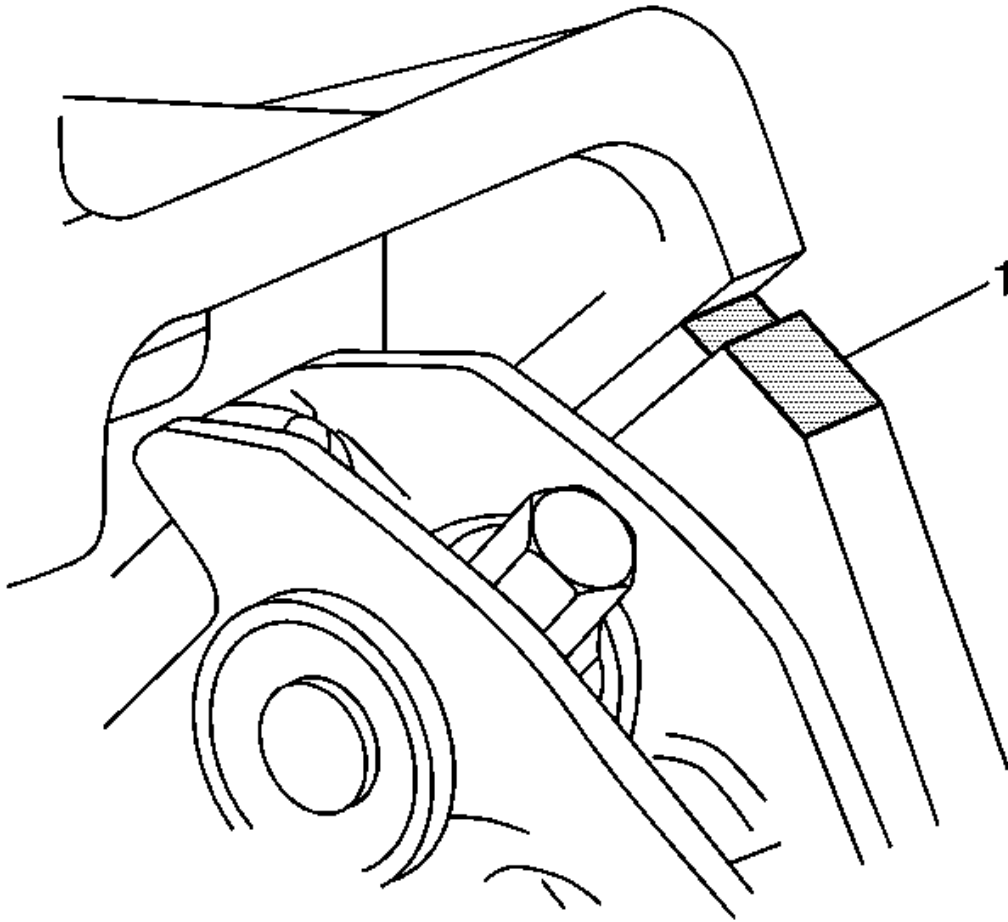


Fig. 175: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

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

Valve Rocker Arm Cover Removal - Right

Tools Required

J 37088-A Fuel Line Disconnect Tool Set. See **Special Tools**.

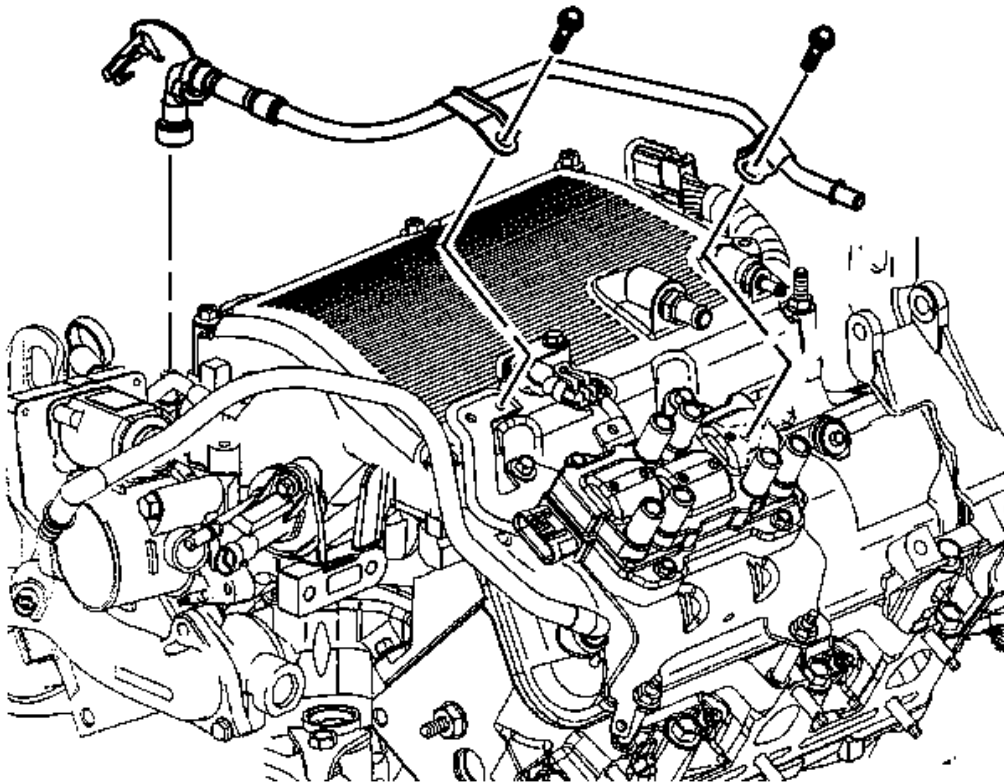


Fig. 176: Removing Fuel Feed Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel feed pipe bolts.
2. Remove the fuel feed pipe secondary latch.
3. Using **J 37088-A** remove the fuel feed pipe. See **Special Tools**.

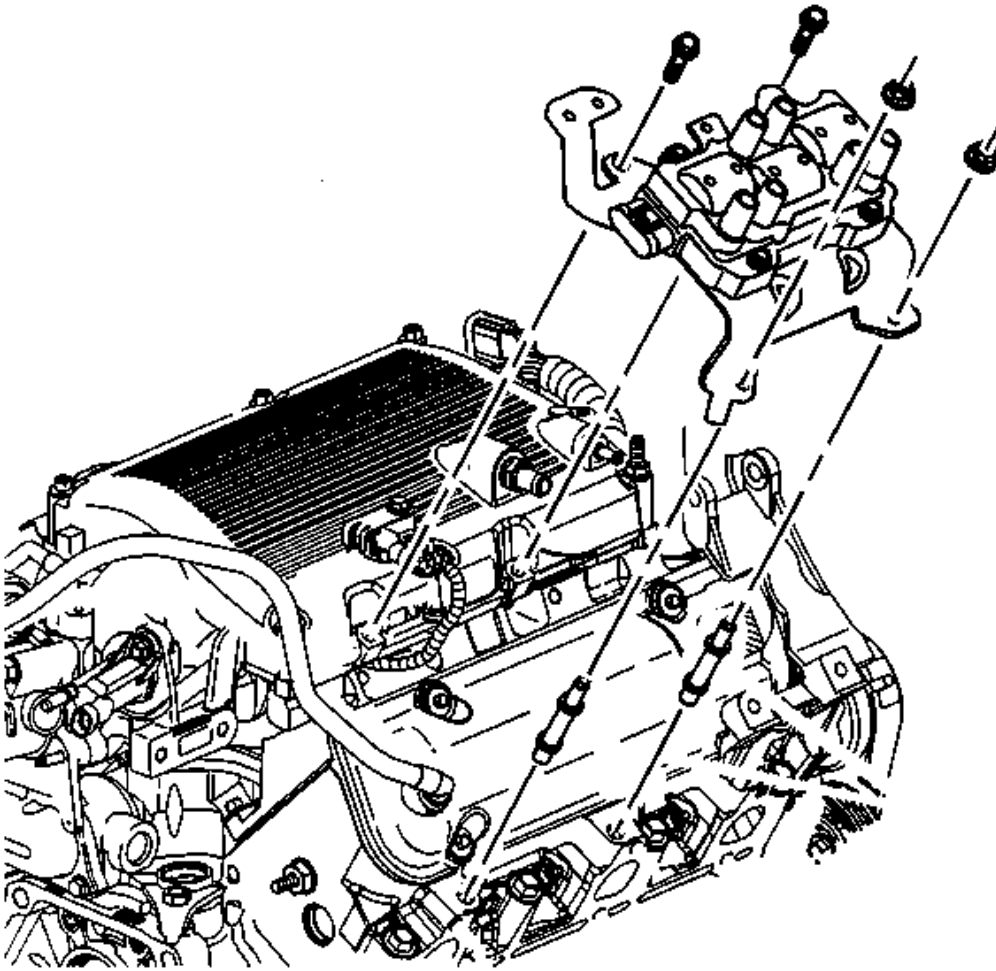


Fig. 177: Removing Remaining Spark Plug Wires From Their Retainers
Courtesy of GENERAL MOTORS CORP.

4. Remove any remaining spark plug wires from their retainers.
5. Remove the ignition coil assembly bolts and nuts.
6. Remove the ignition coil assembly.
7. Remove the ignition coil assembly studs, if necessary.

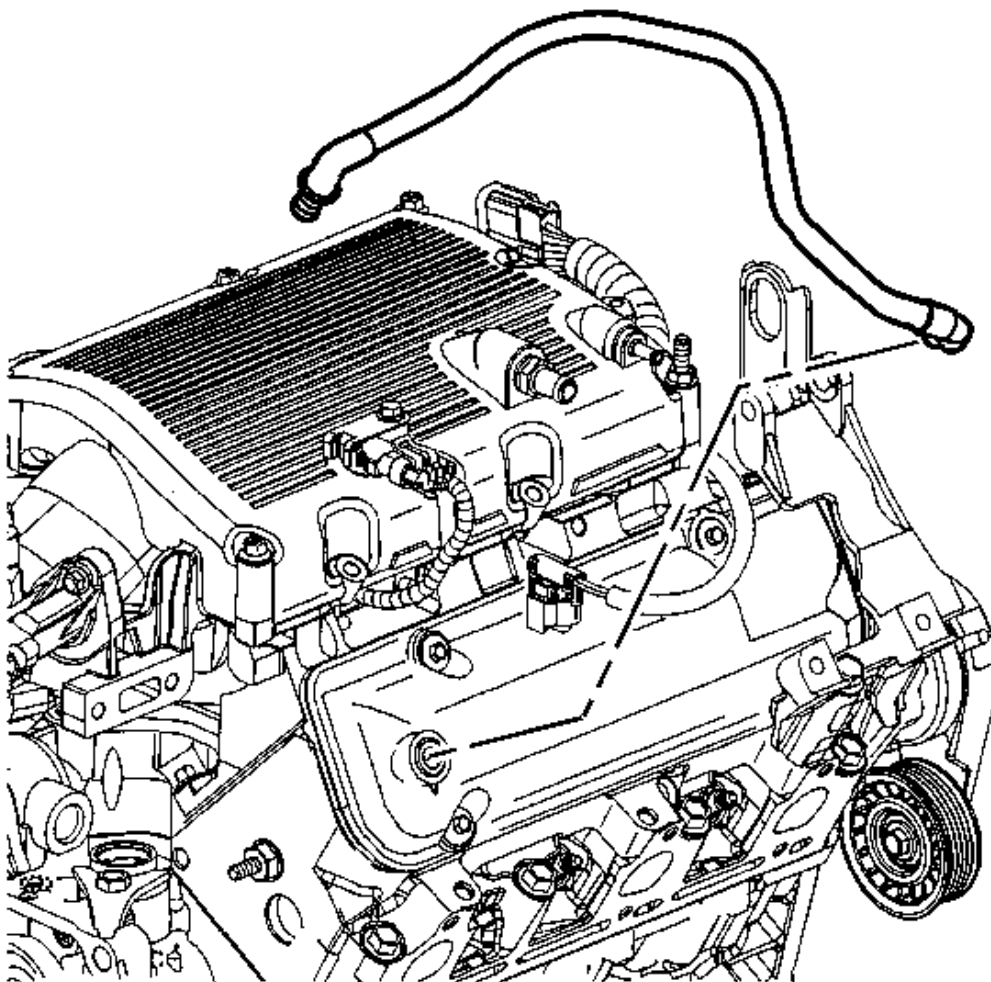


Fig. 178: Removing Vacuum Hoses
Courtesy of GENERAL MOTORS CORP.

8. Remove the positive crankcase ventilation tube from the valve rocker arm cover.

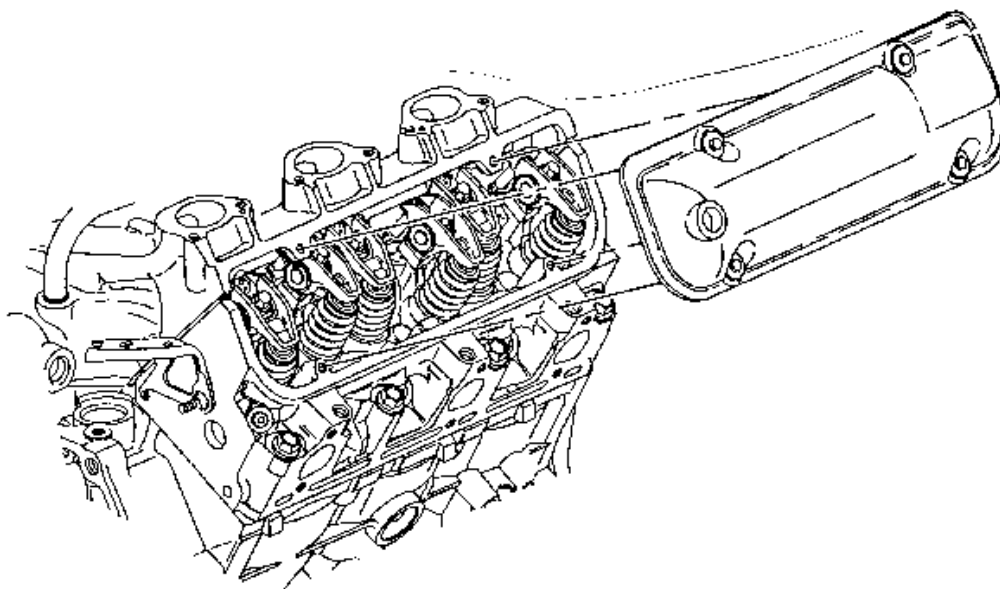


Fig. 179: View Of Valve Rocker Arm Cover - Right
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve rocker arm cover bolts.

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

10. Remove the valve rocker arm cover.
11. Cut the RTV in the channel where the intake, cylinder head and valve rocker arm cover meet with a suitable tool.
12. Remove the valve rocker arm cover gasket.

Intake Manifold Removal - Upper

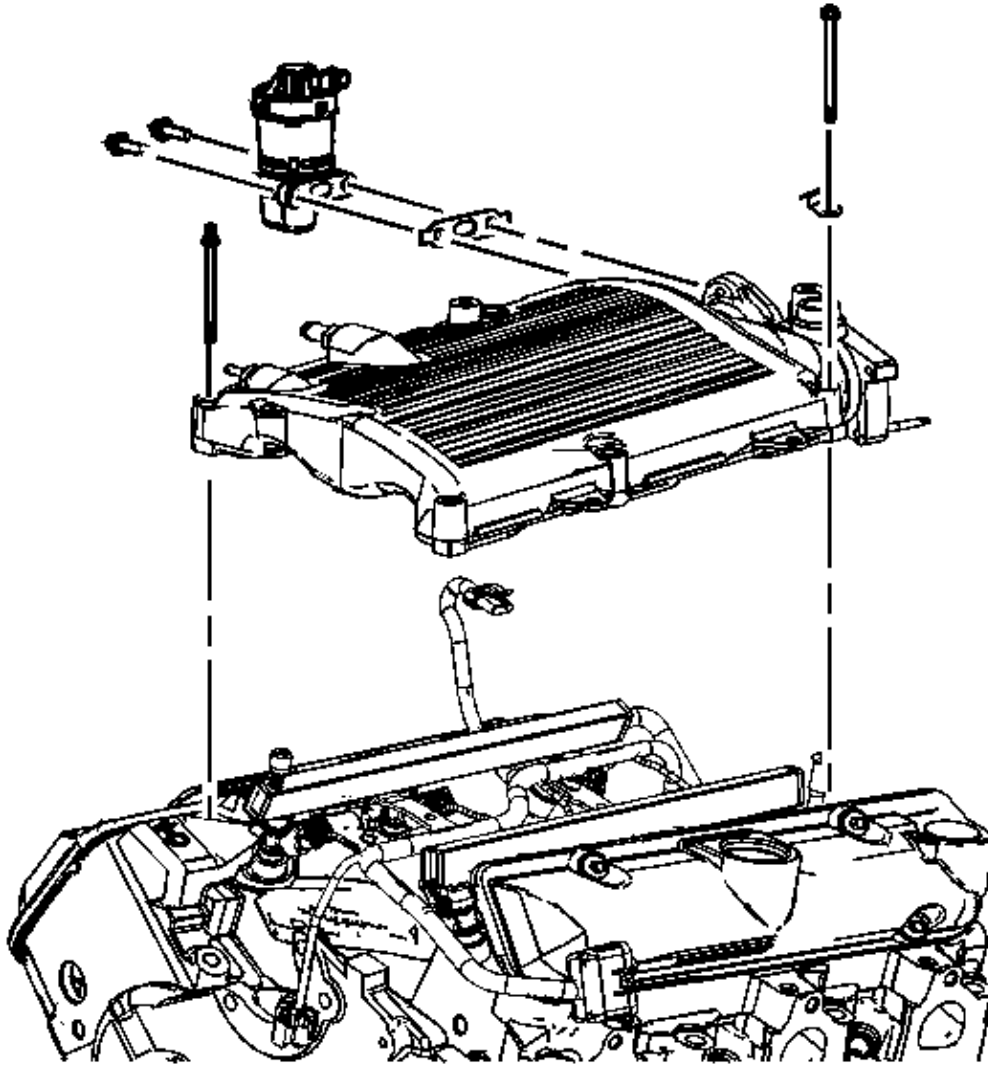


Fig. 180: Removing Upper Intake Manifold And Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the connector from manifold absolute pressure (MAP) sensor.
2. Remove the exhaust gas recirculation (EGR) bolts.
3. Remove the EGR.
4. Remove the upper intake manifold bolts or studs.
5. Remove the upper intake manifold and gaskets.

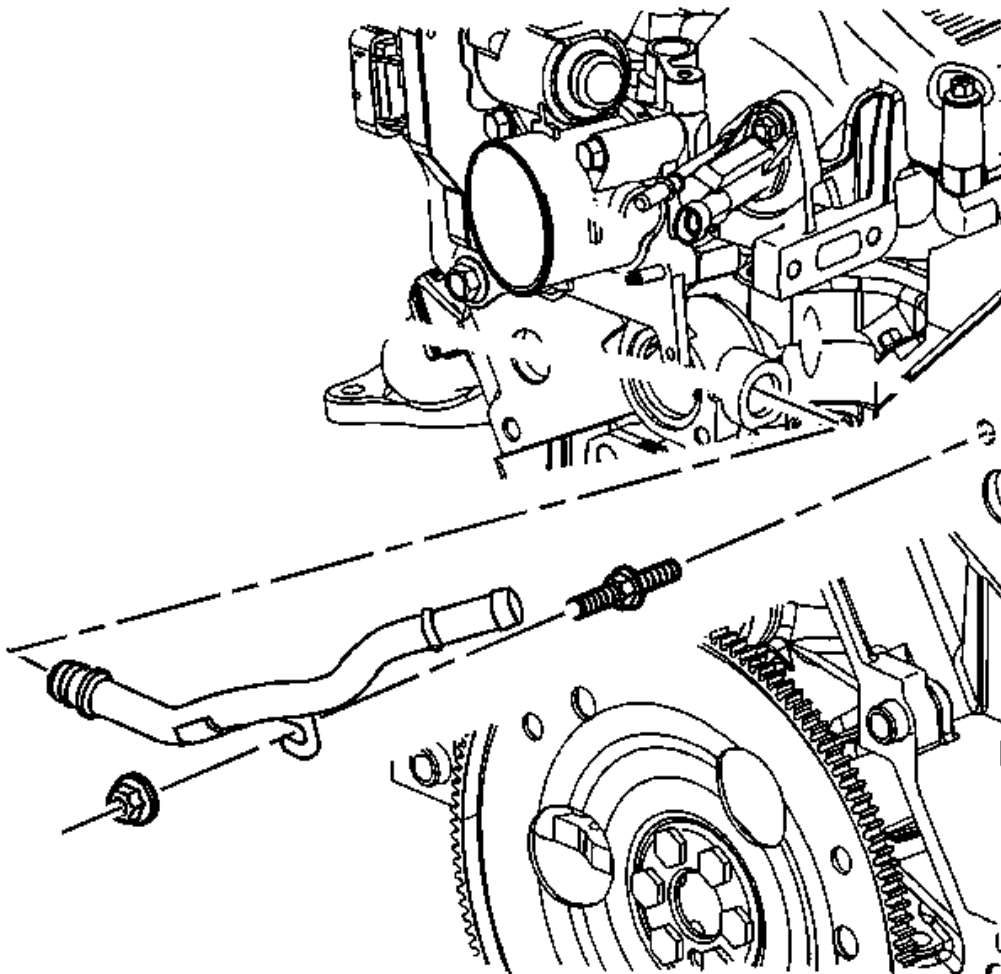
Intake Manifold Removal - Lower

Fig. 181: Removing Heater Inlet Pipe Nut
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater inlet pipe nut.
2. Remove the heater inlet pipe.
3. Remove the heater inlet pipe stud, if necessary.

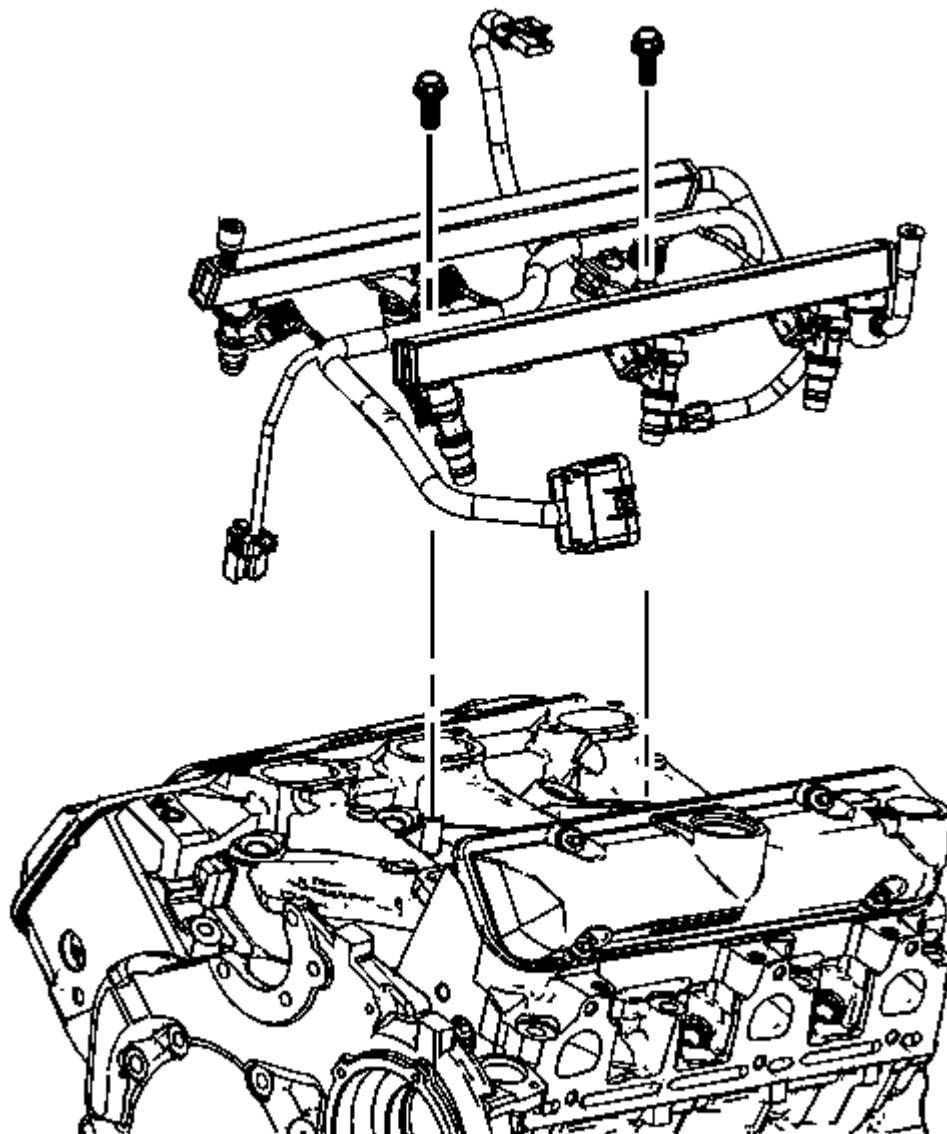


Fig. 182: Disconnecting And Removing Fuel Injector And Manifold Air Pressure (MAP) Wiring Harness

Courtesy of GENERAL MOTORS CORP.

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

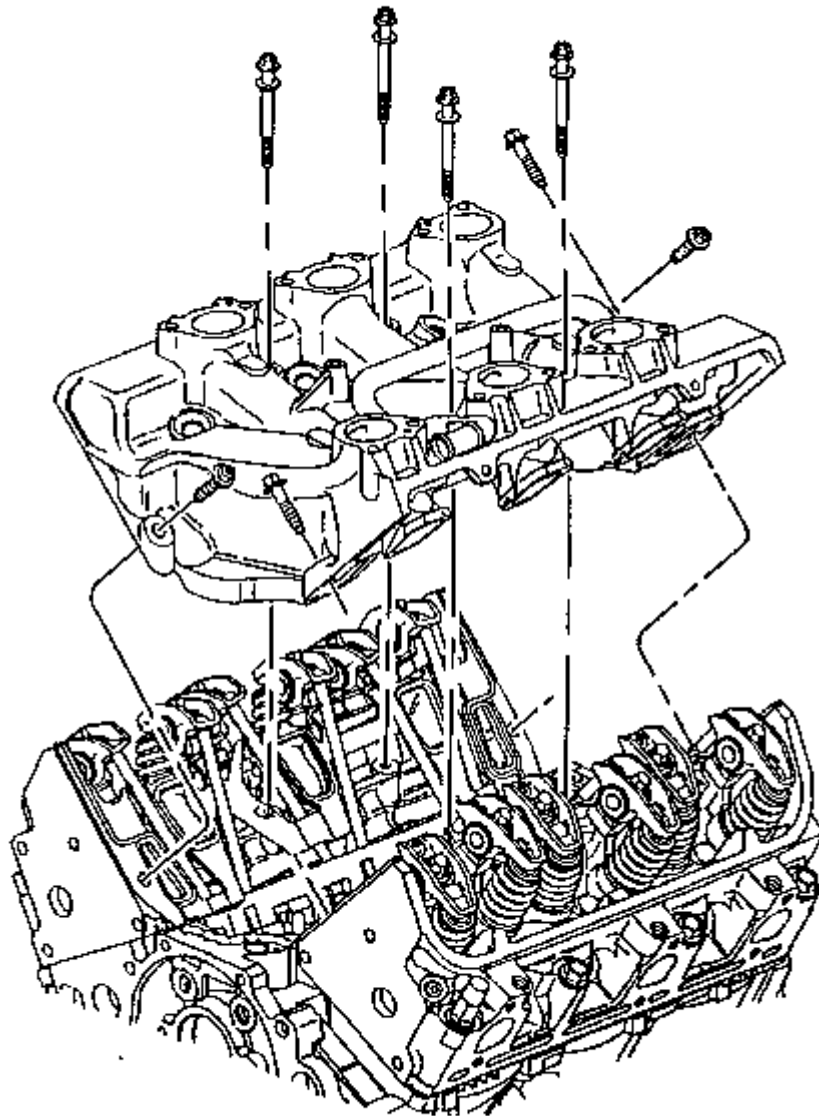


Fig. 183: View Of Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Valve Rocker Arm and Push Rod Removal

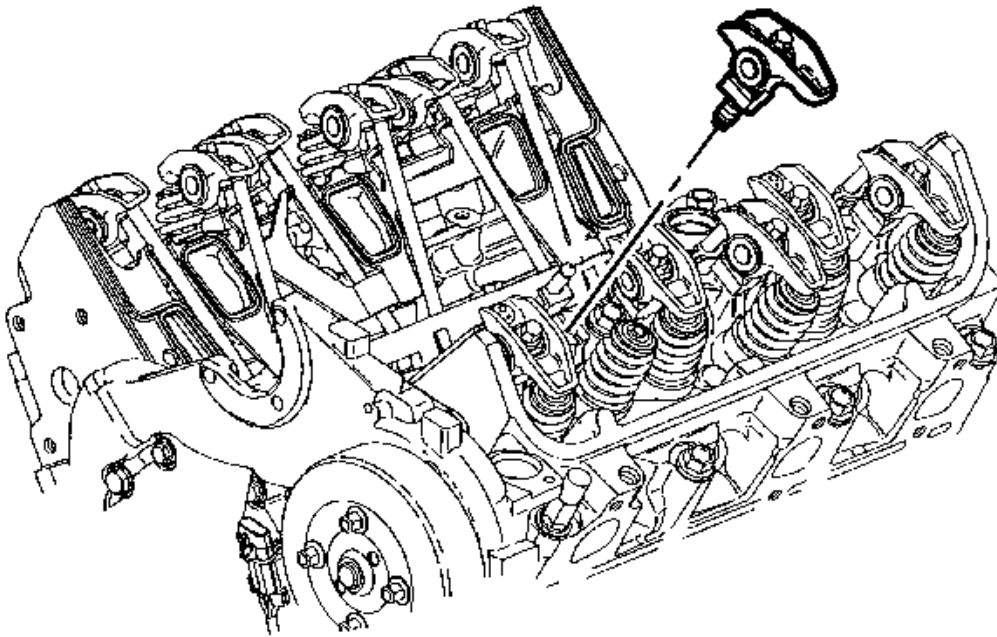


Fig. 184: Loosening Valve Rocker Arm Bolts
Courtesy of GENERAL MOTORS CORP.

1. Loosen the valve rocker arm bolts.

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

2. Remove the valve rocker arms.

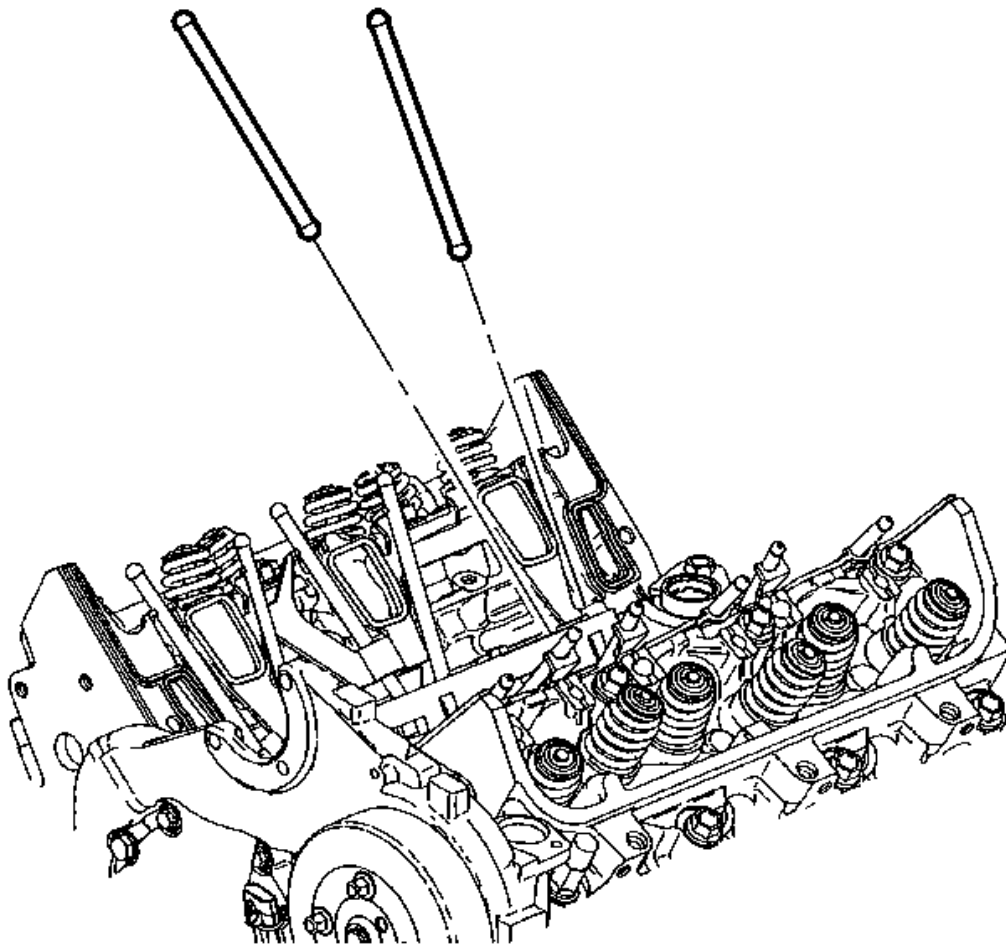


Fig. 185: Removing Push Rods
Courtesy of GENERAL MOTORS CORP.

3. Remove the push rods.
 - The intake push rods measure 144.18 mm (5.68 in).
 - The exhaust push rods measure 152.51 mm (6.0 in).

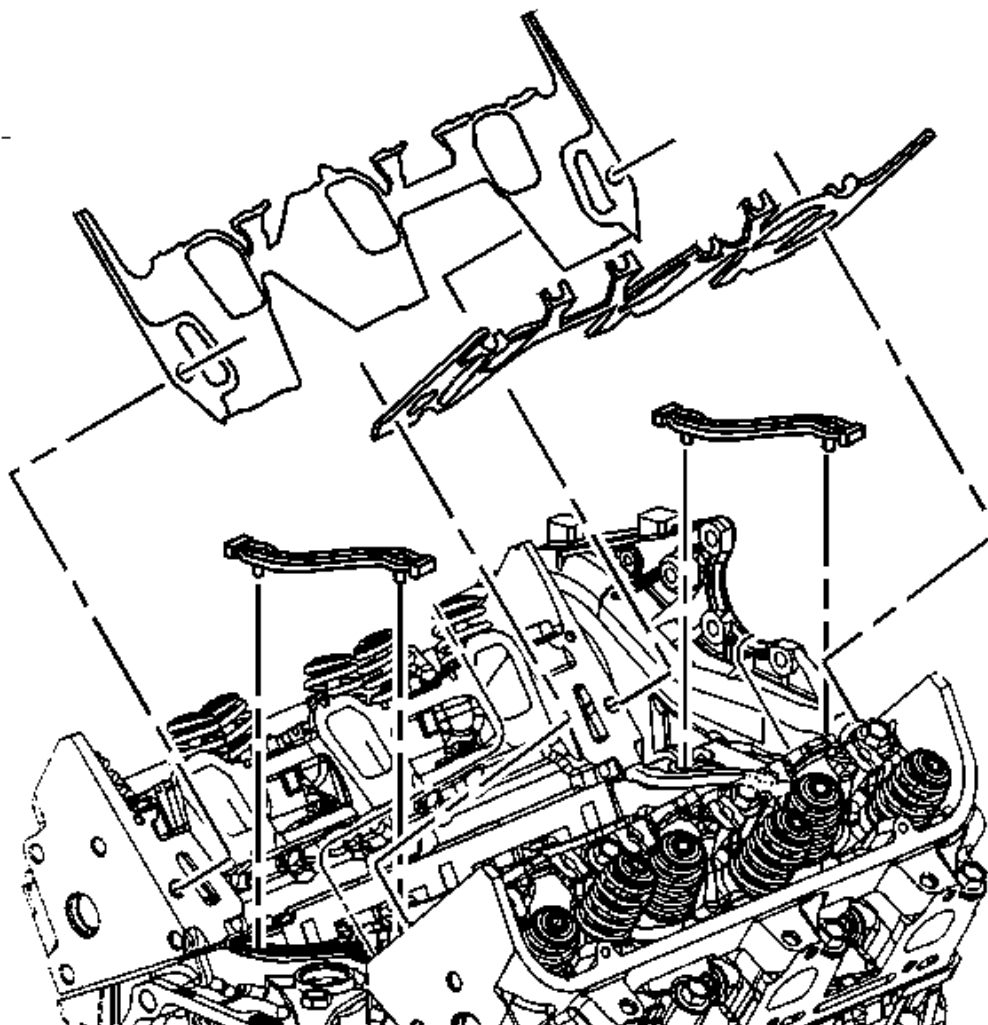


Fig. 186: Removing Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold gaskets.

Valve Lifter Removal

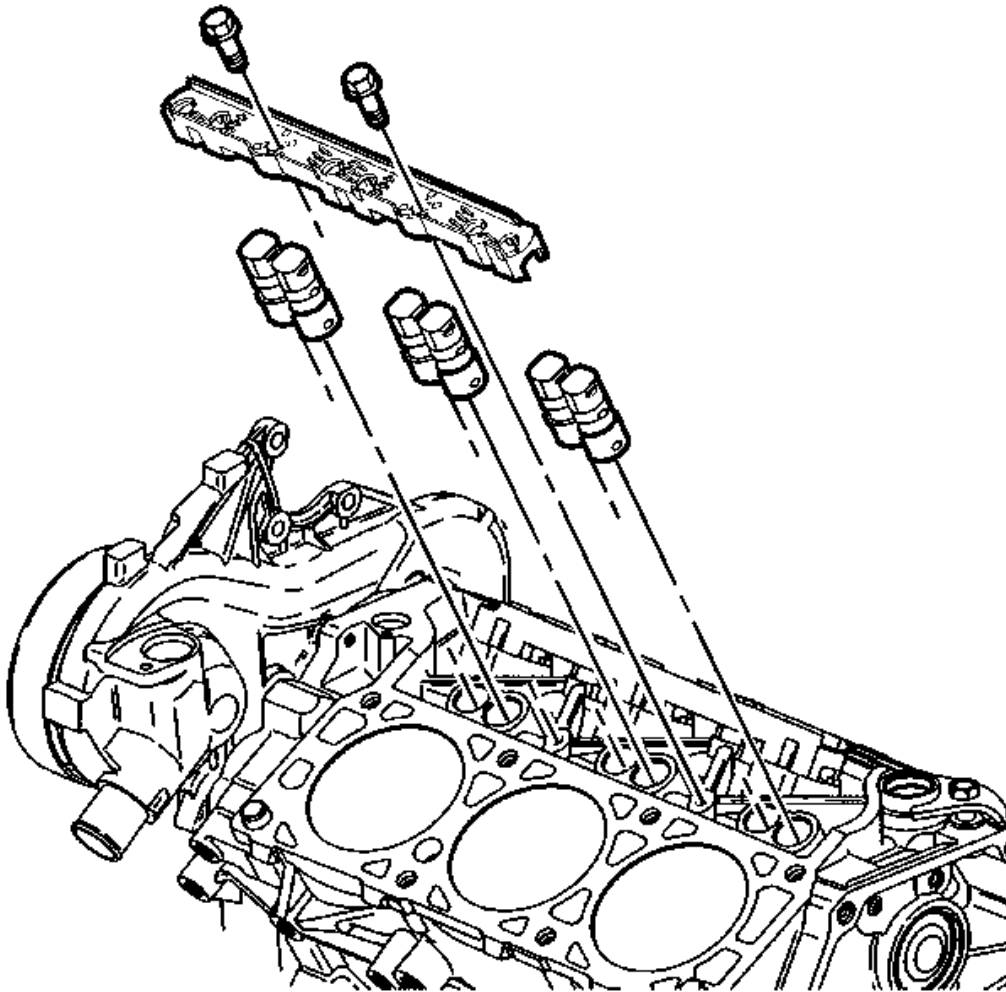


Fig. 187: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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

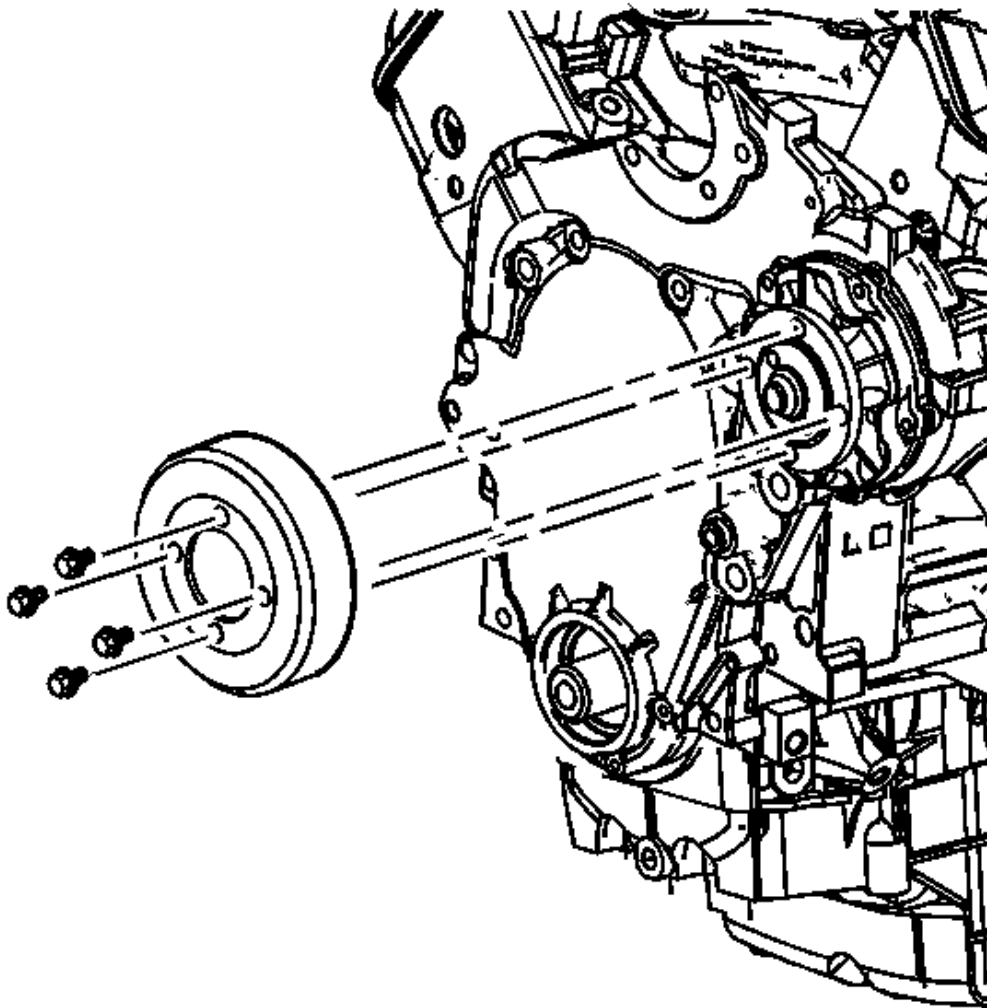


Fig. 188: Removing Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

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

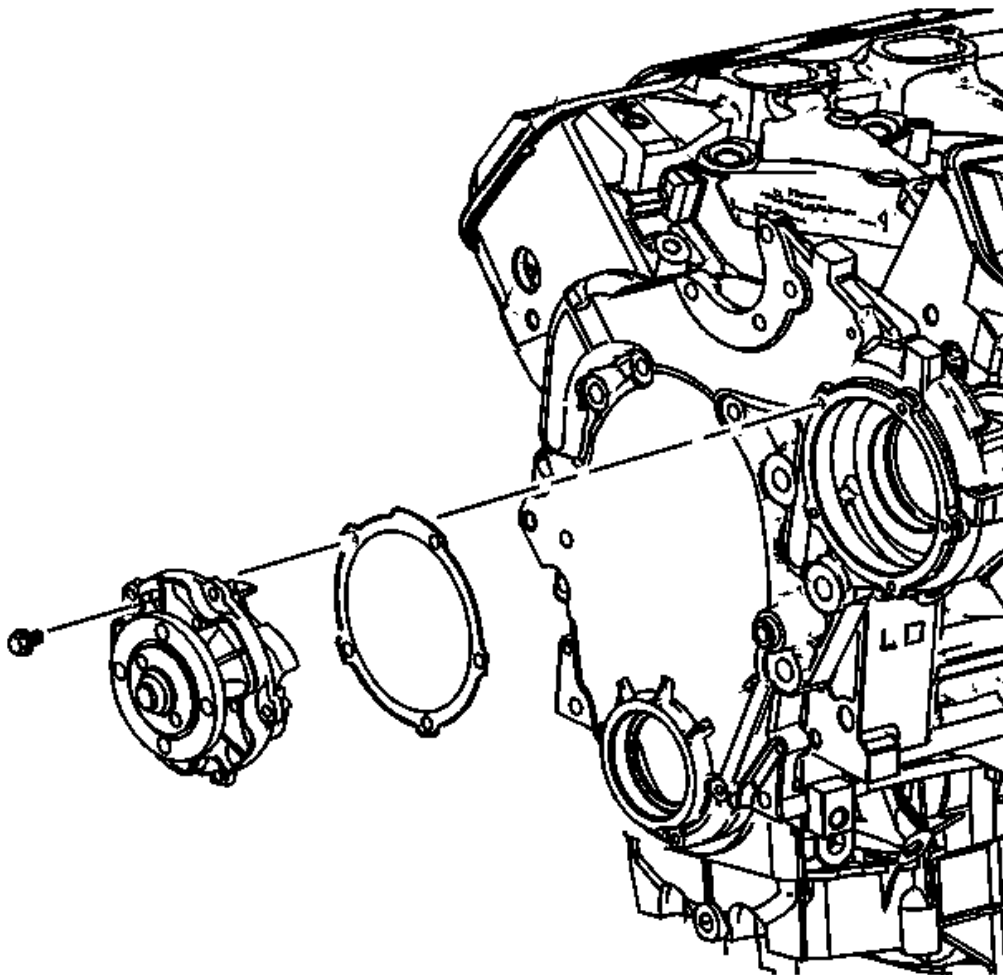


Fig. 189: Removing Water Pump
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Head Removal - Left

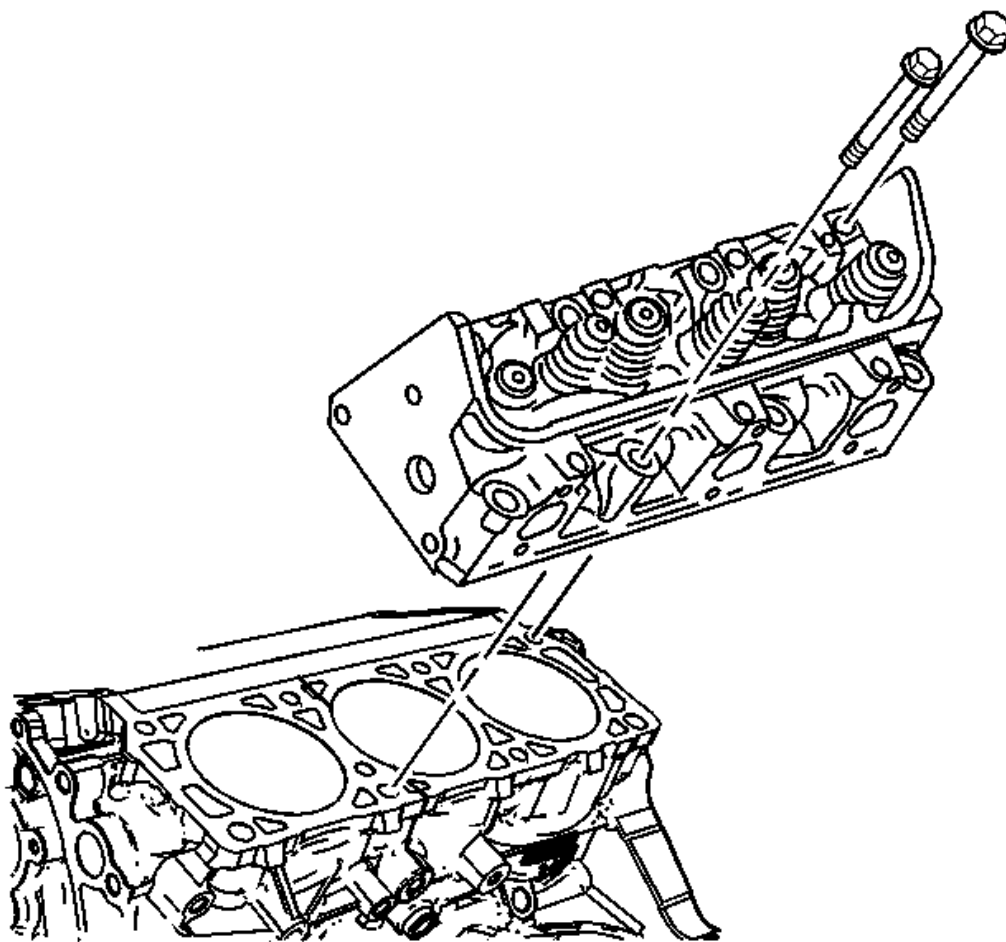


Fig. 190: Removing/Installing Cylinder Head

Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolt and discards.
2. Remove the cylinder head.

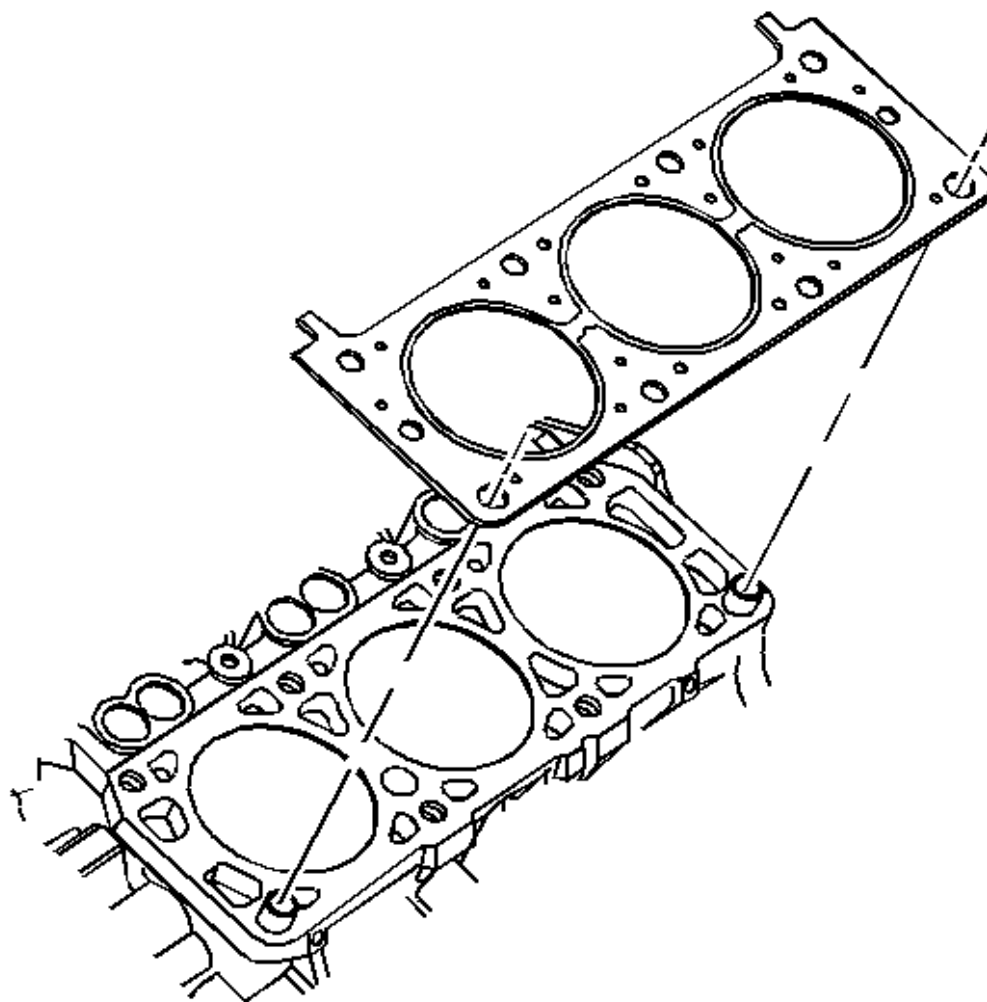


Fig. 191: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Head Removal - Right

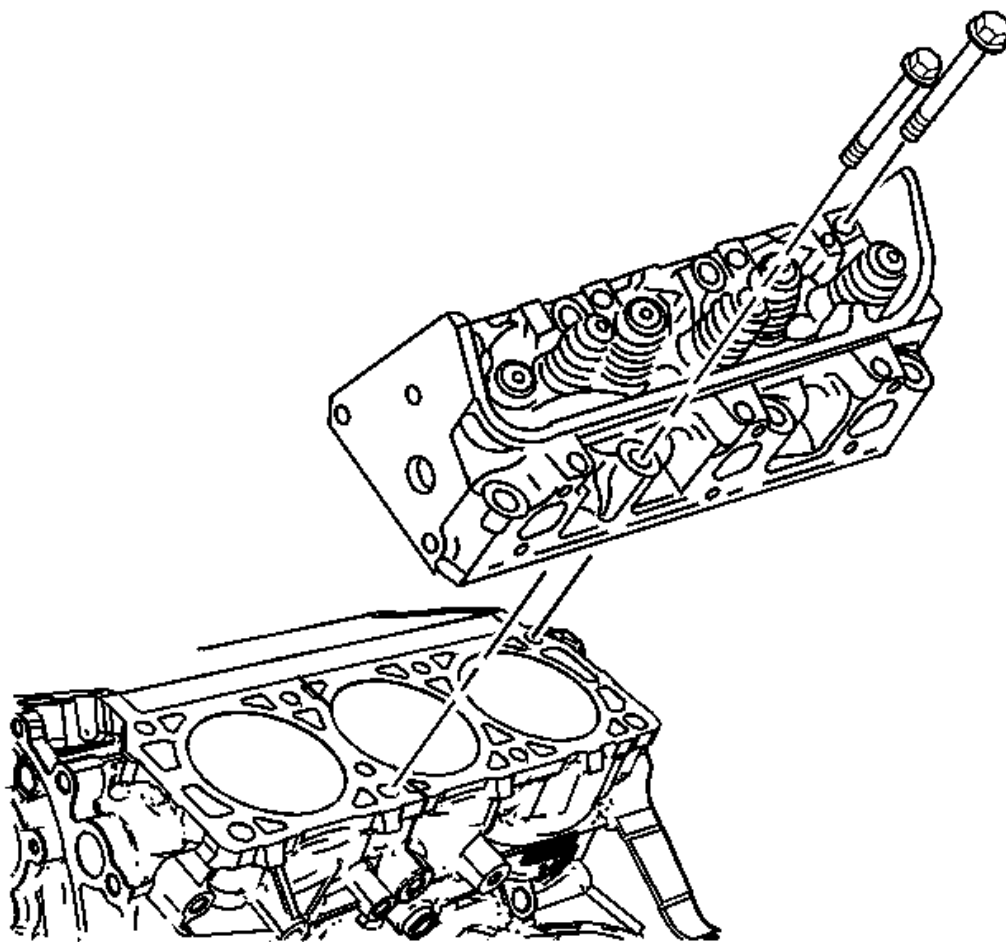


Fig. 192: Removing/Installing Cylinder Head

Courtesy of GENERAL MOTORS CORP.

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

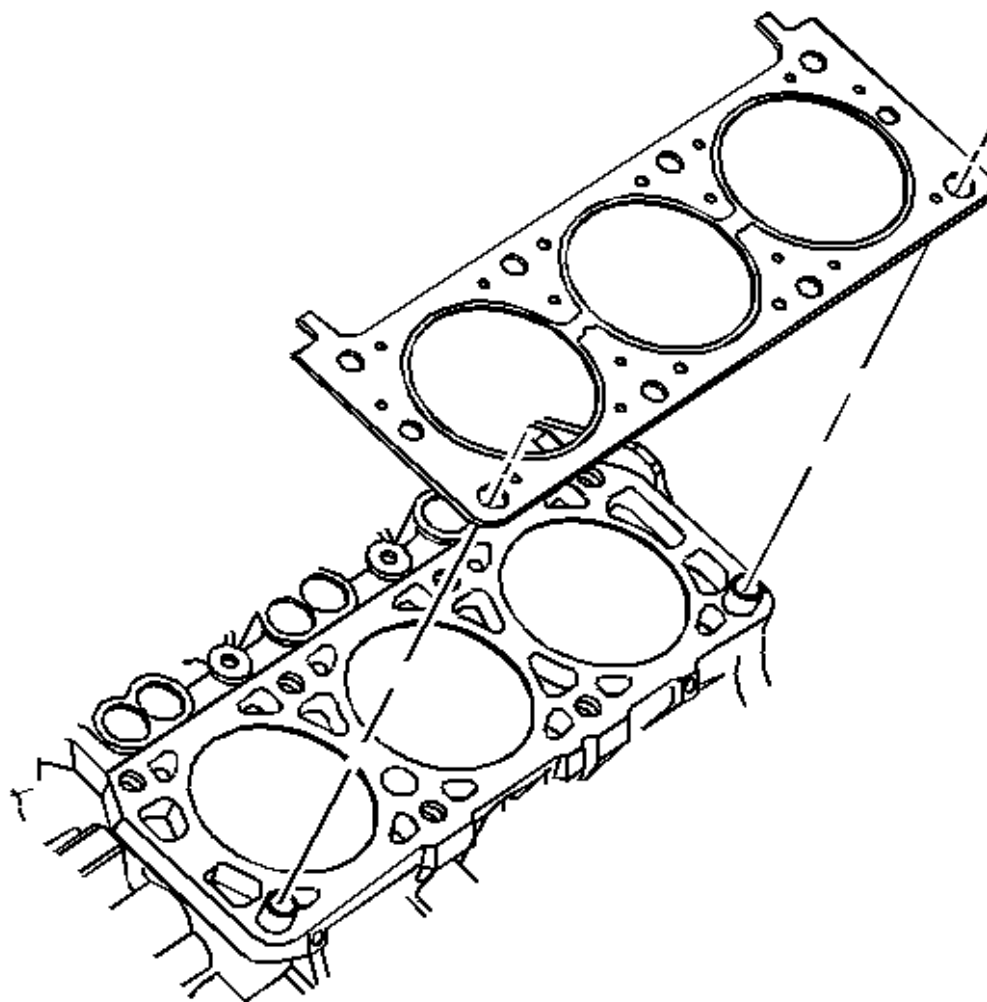


Fig. 193: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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

Oil Pan Removal

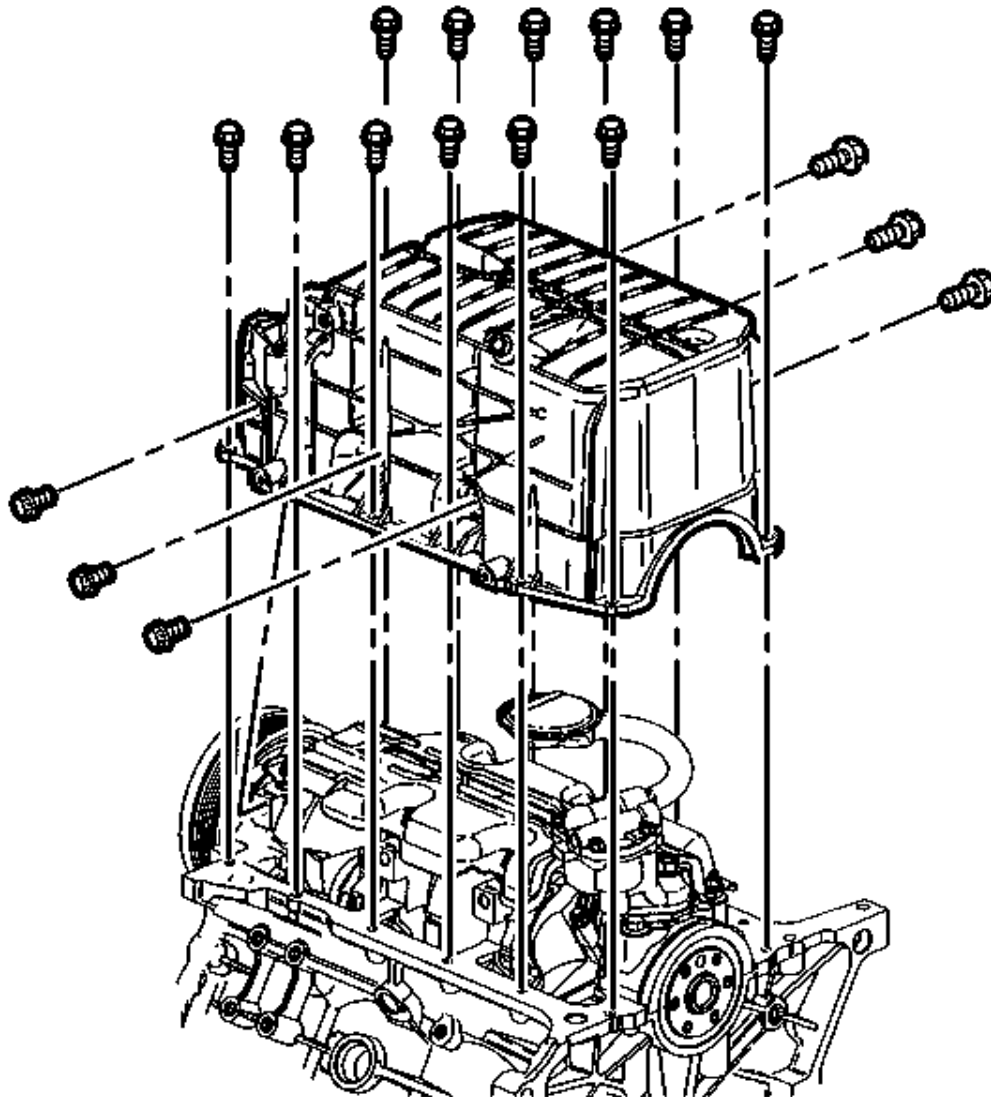


Fig. 194: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan support bracket bolts and brackets as needed
2. Remove the oil pan side bolts.
3. Remove the oil pan bolts.
4. Remove the oil pan.
5. Remove the oil pan gasket.

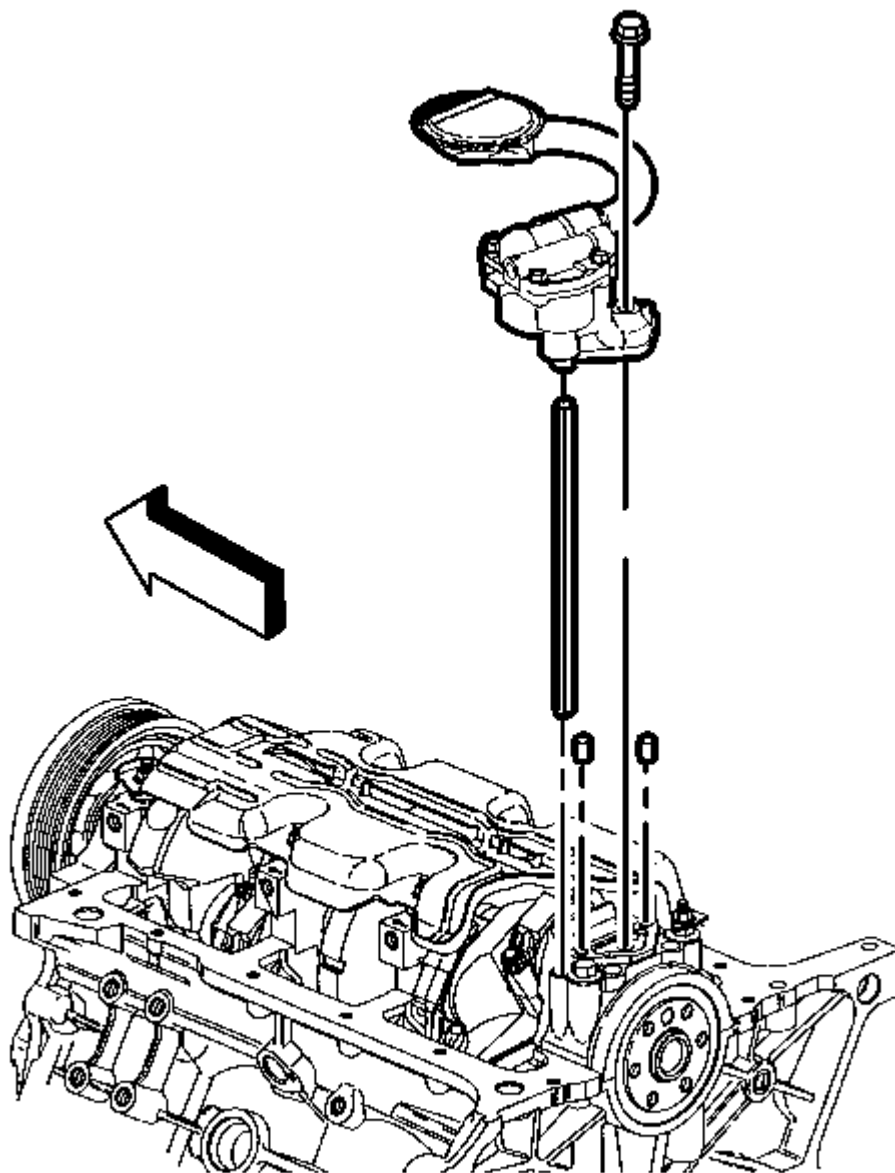
Oil Pump Removal

Fig. 195: View Of Oil Pump & Oil Pump Drive Shaft
Courtesy of GENERAL MOTORS CORP.

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

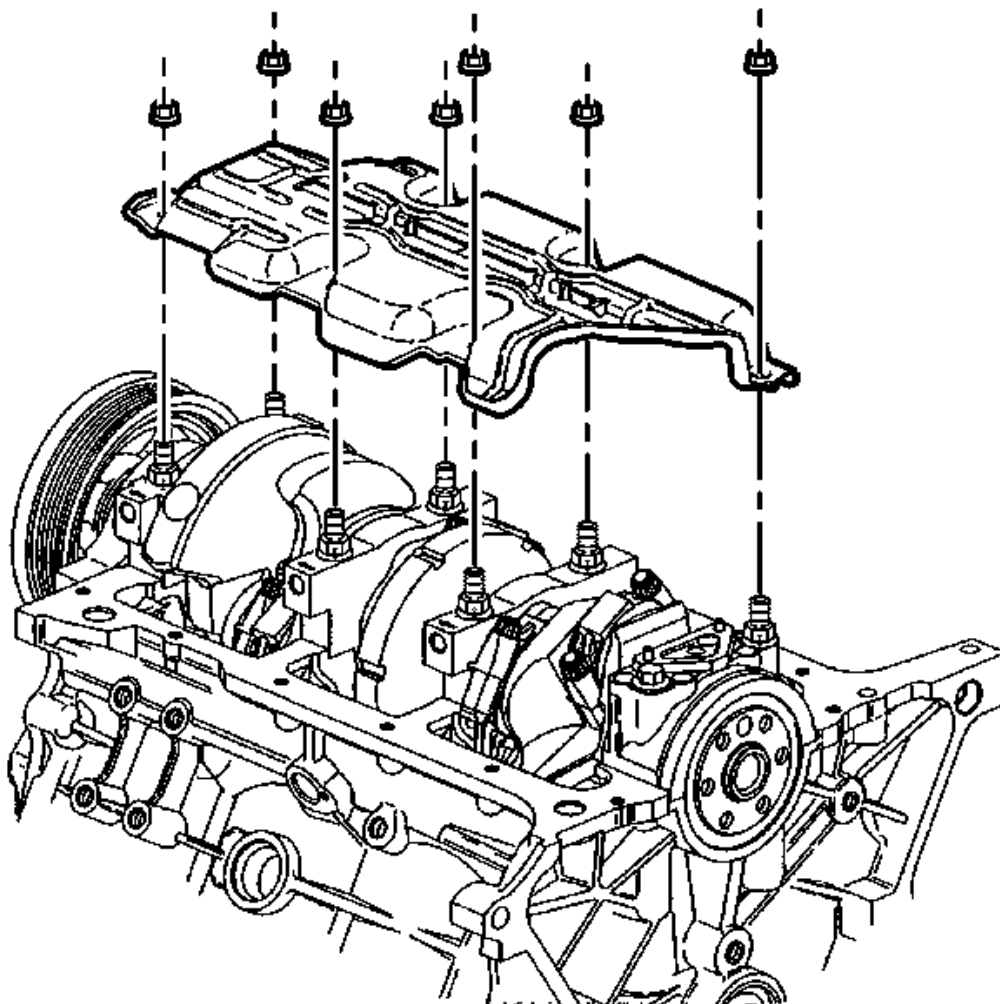


Fig. 196: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

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

Oil Pump Drive Removal

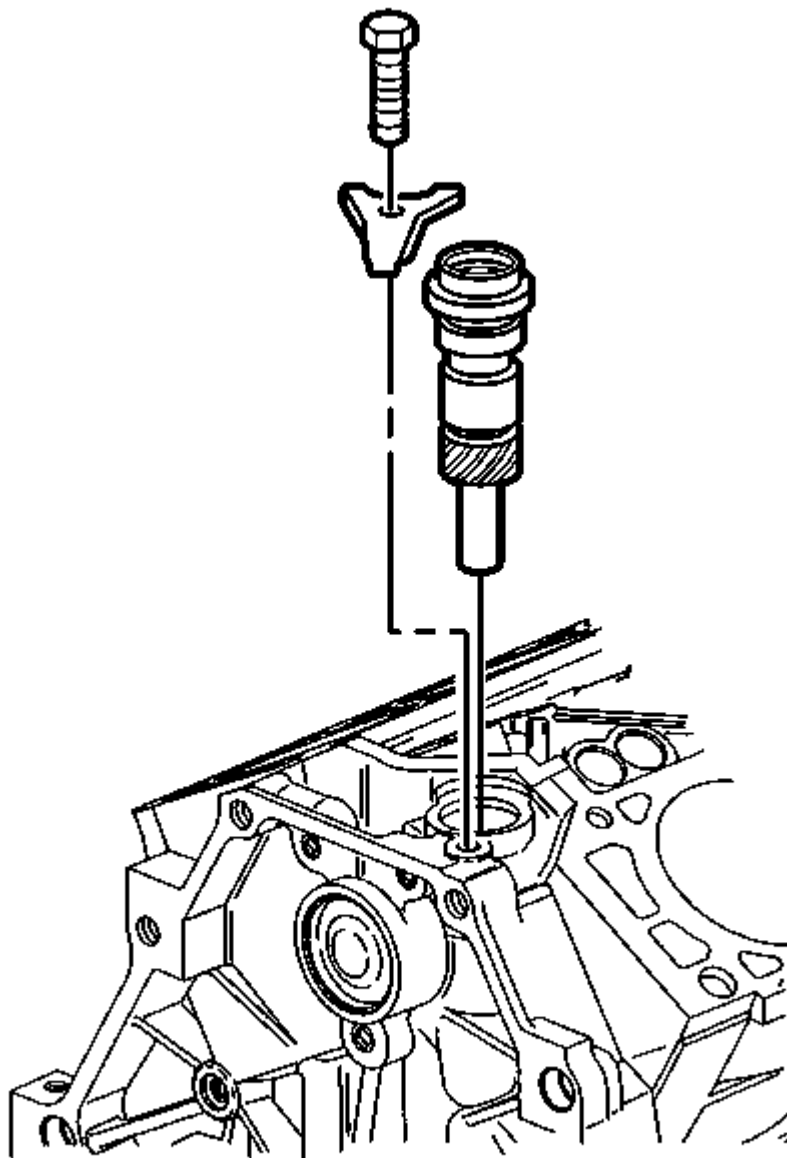


Fig. 197: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

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

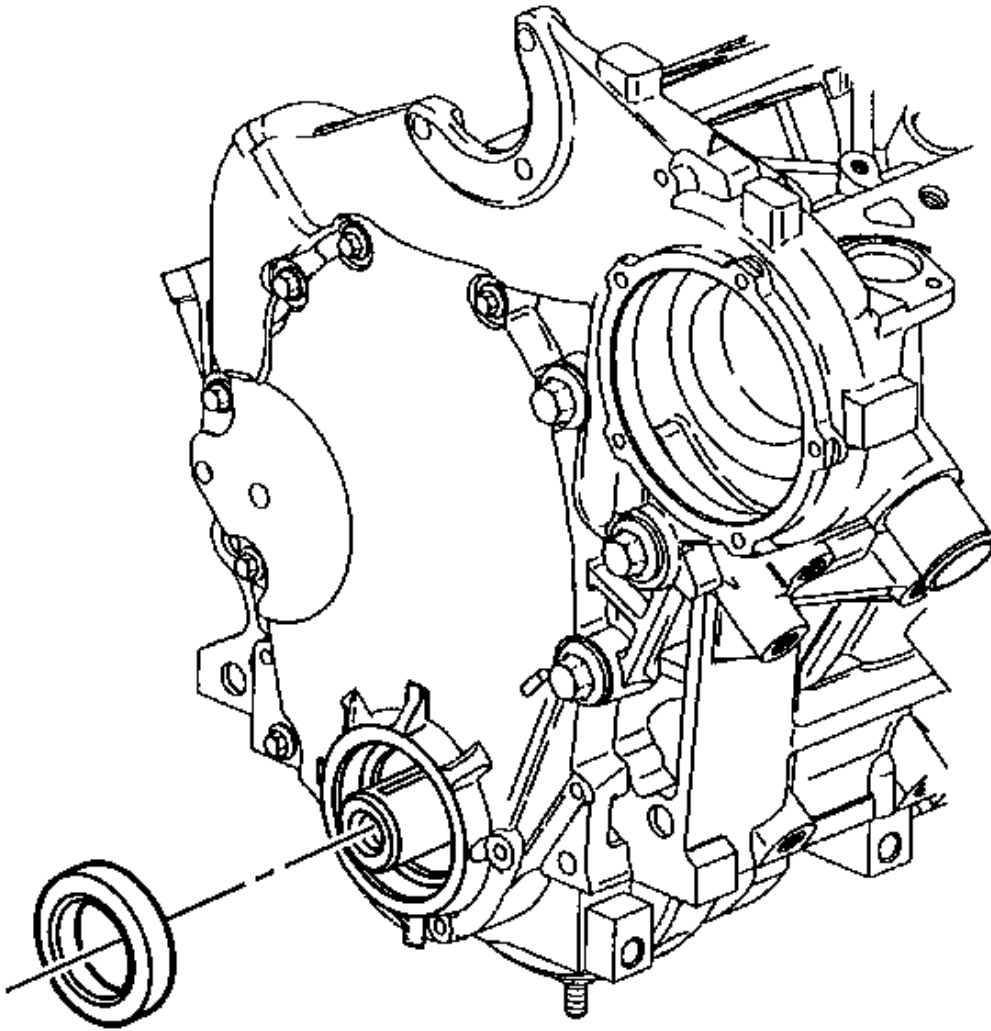
Crankshaft Front Oil Seal Removal

Fig. 198: View Of 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

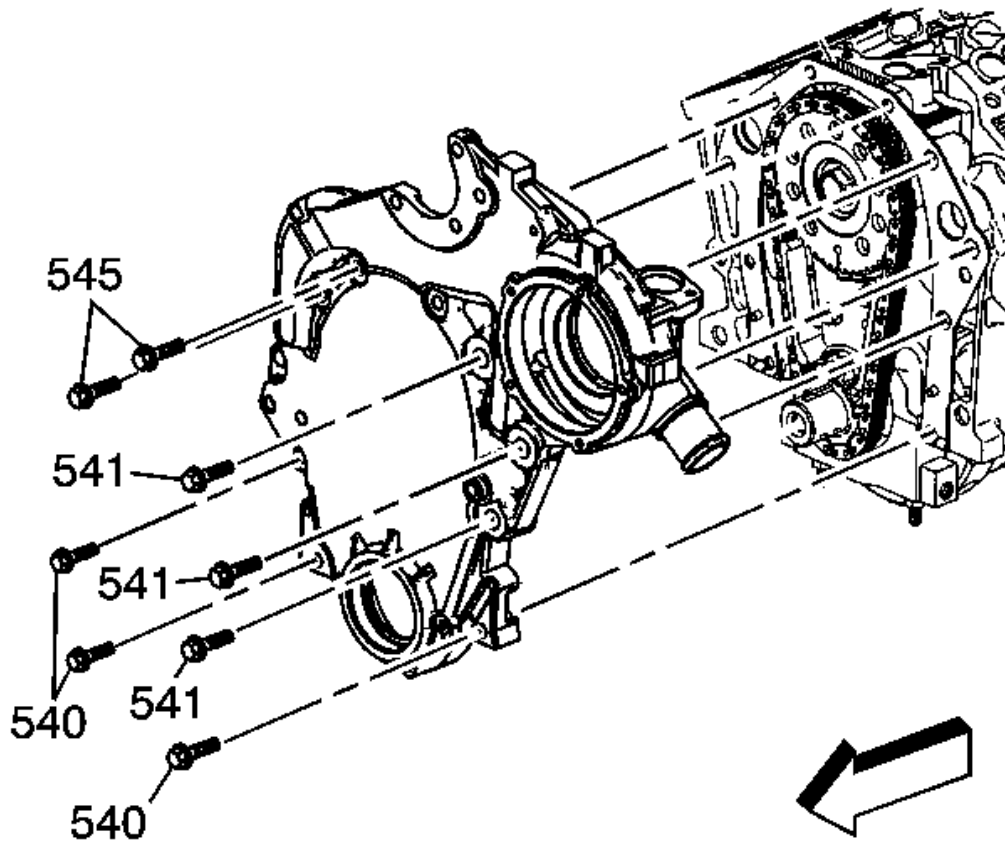


Fig. 199: View Of Engine Front Cover Bolts (540, 541, 545)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover bolts (540, 541, 545).
2. Remove the engine front cover.
3. Remove the engine front cover gasket.

Timing Chain and Sprockets Removal

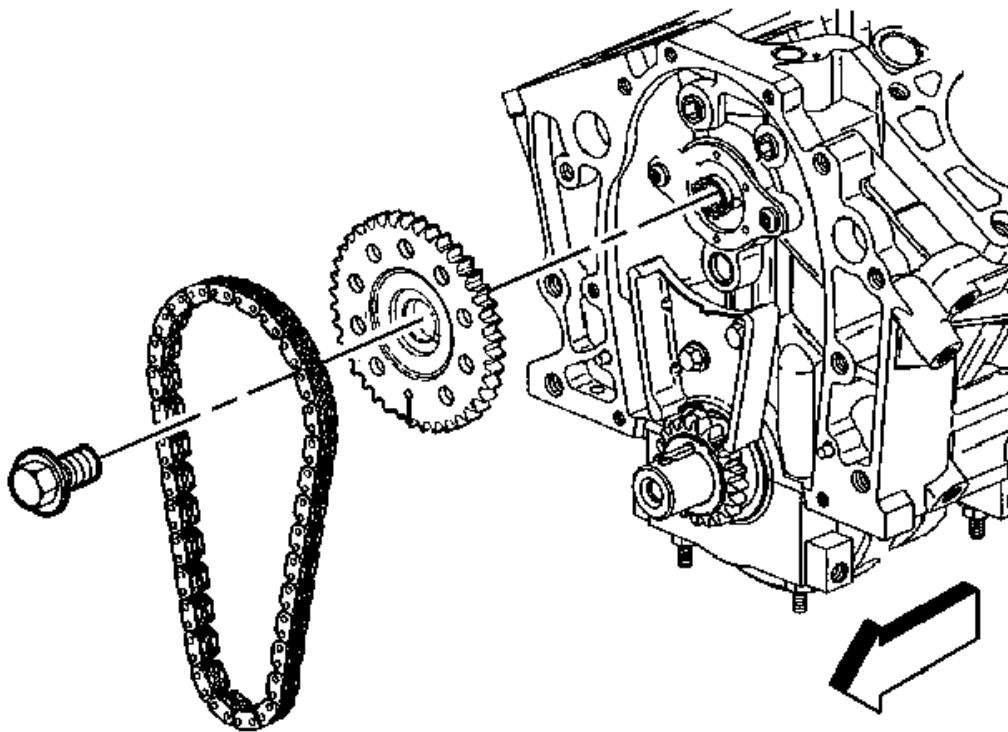


Fig. 200: View Of Timing Chain & Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

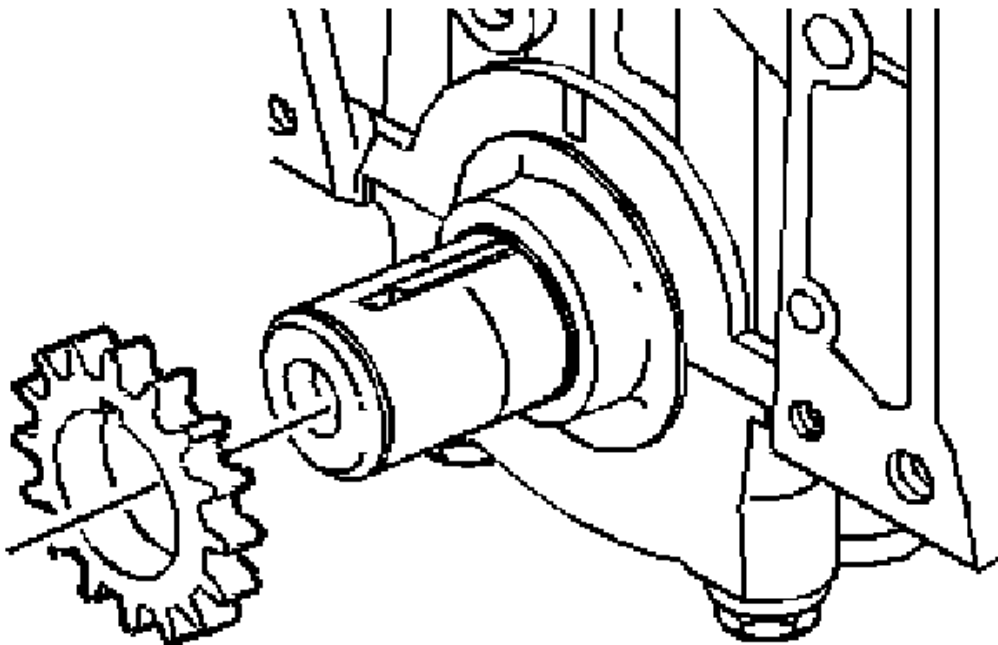


Fig. 201: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft sprocket.

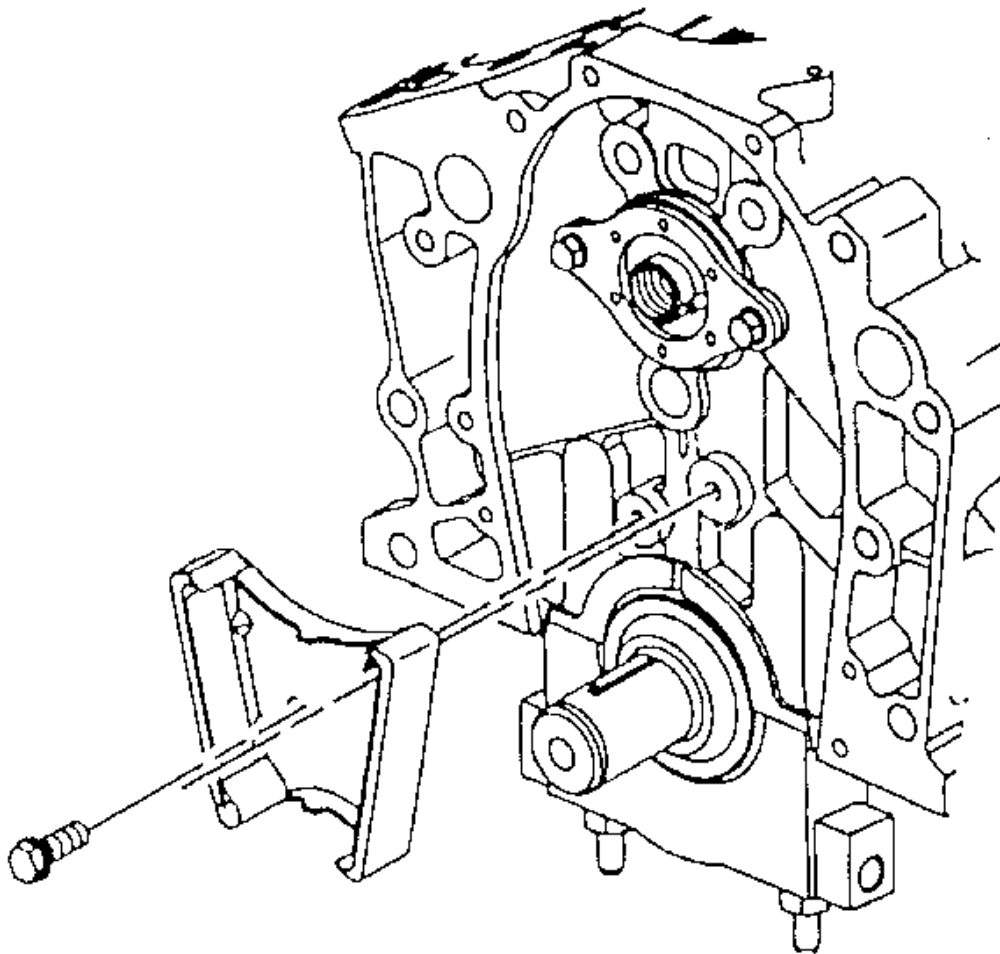


Fig. 202: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Camshaft Removal

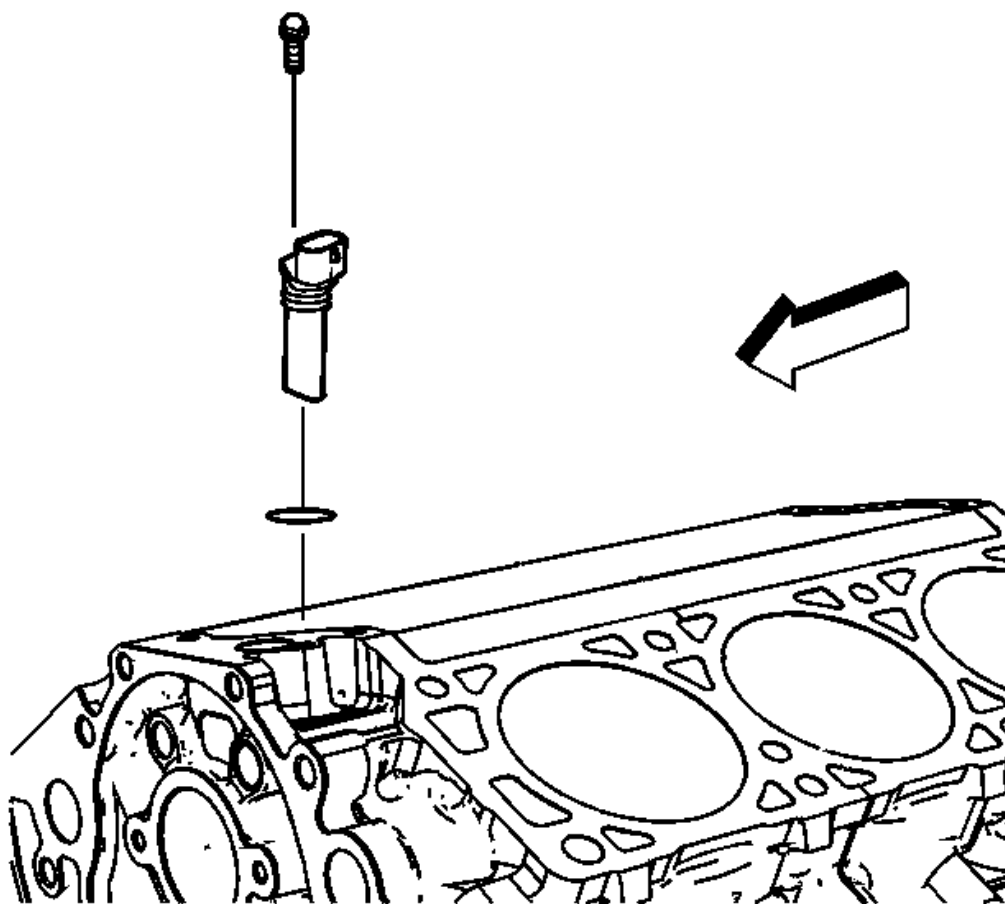


Fig. 203: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position sensor bolt.
2. Remove the camshaft position sensor.

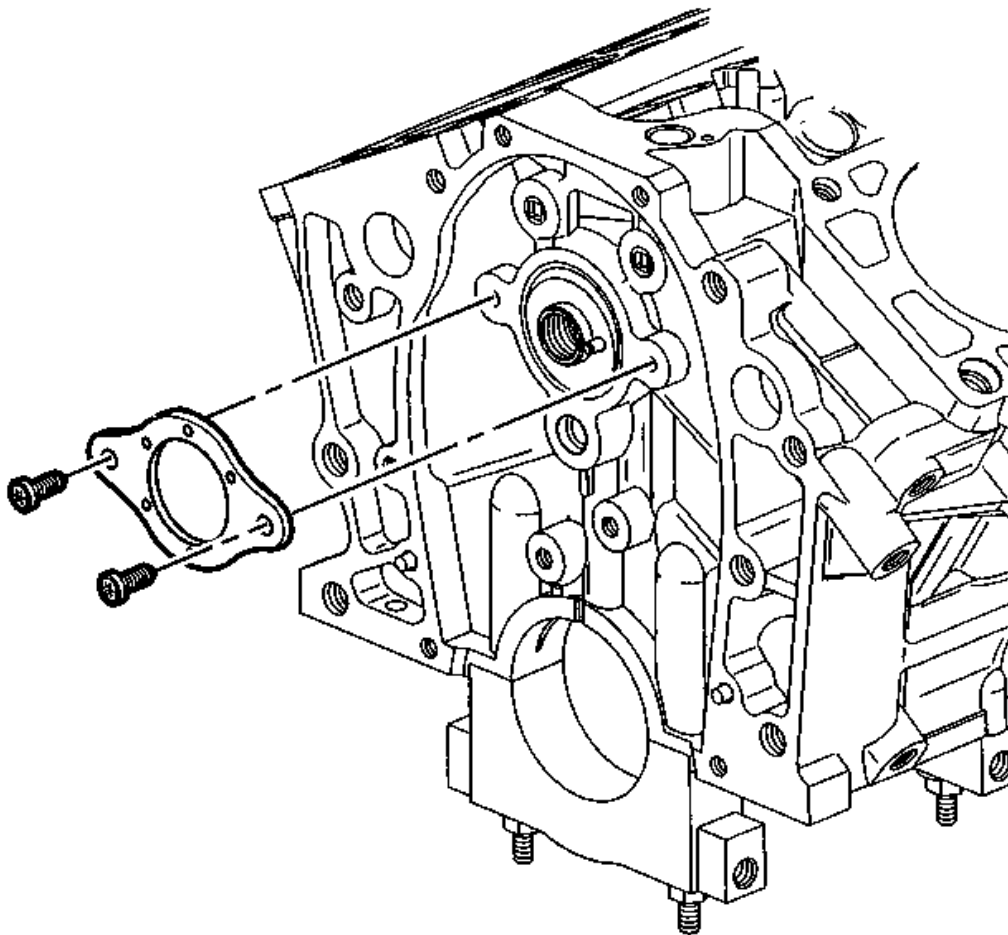


Fig. 204: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

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

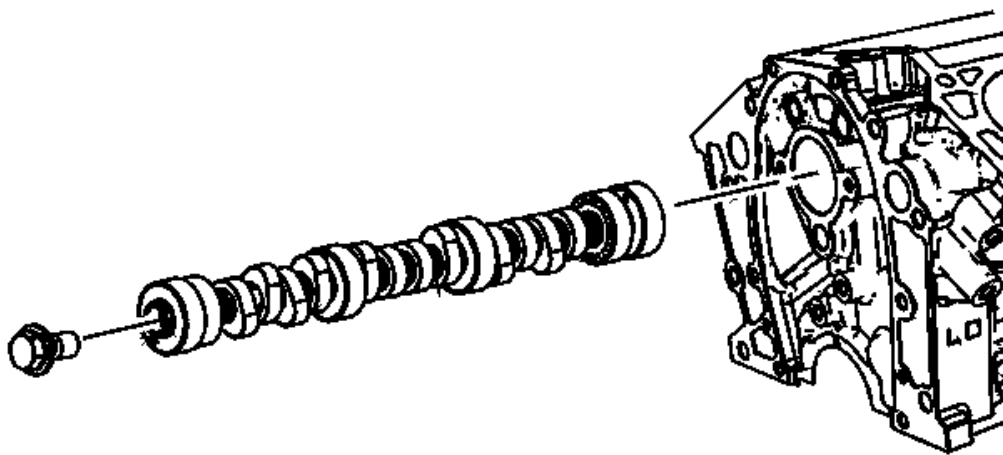


Fig. 205: View Of Camshaft

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.

5. Complete the following steps in order to remove the camshaft.
 1. Install the camshaft sprocket bolt into the camshaft. Tighten finger tight only.
 2. Carefully rotate and remove the camshaft from the engine block.

Piston, Connecting Rod, and Bearing Removal

Tools Required

- **J 24270** Cylinder Bore Ridge Reamer. See Special Tools.
- **J 41556** Connecting Rod Guide. See Special Tools.

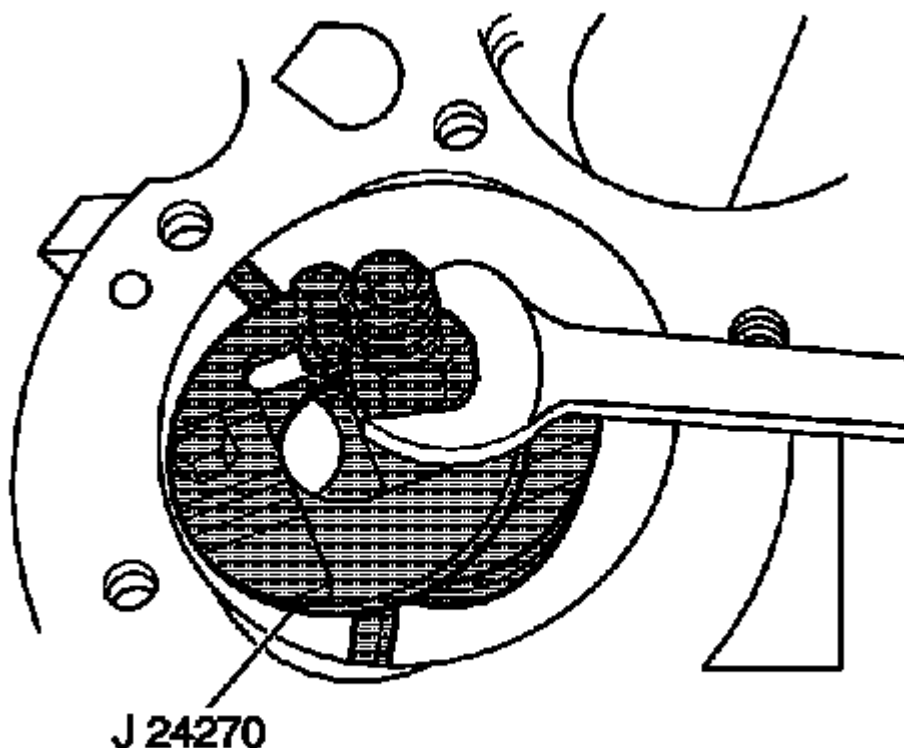


Fig. 206: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Mark the piston with the number of the cylinder from which the piston is being removed.
2. Mark the connecting rod and the connecting rod cap in order to ensure correct assembly.

NOTE: If there is a pronounced ridge at the top of the piston travel, the ridge must be removed with a ridge reamer before the piston and connecting rod assembly are removed. Applying force may break the piston rings or damage the piston.

3. Use the **J 24270** in order to remove the cylinder bore ring ridge. See **Special Tools**. Complete the following steps:
 1. Turn the crankshaft until the piston is at the bottom of the stroke.
 2. Cover the piston with a cloth.
 3. Remove the cylinder ring ridge.
 4. Turn the crankshaft until the piston is at the top of the stroke.
 5. Remove the cloth.
 6. Remove the metal shavings from the cylinder and piston.

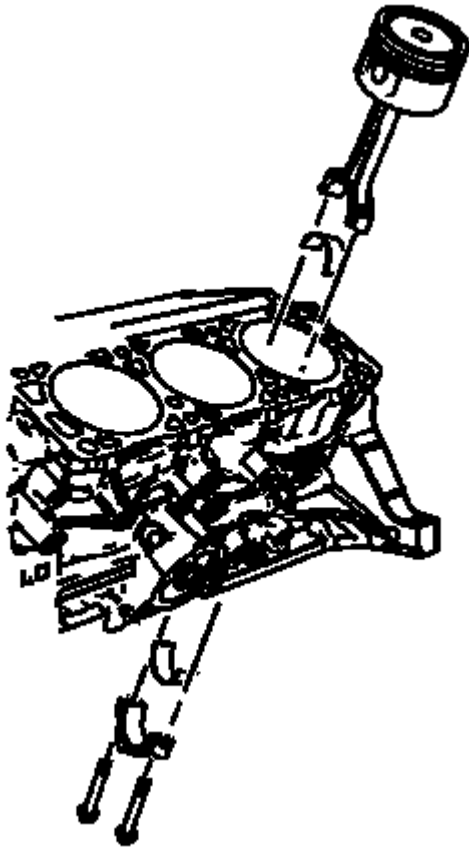


Fig. 207: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.
6. Remove the connecting rod bearing half.
7. Install **J 41556** into the connecting rod. See **Special Tools**.
8. Remove the connecting rod and piston assembly from the engine with a suitable tool.

Crankshaft Rear Oil Seal Removal

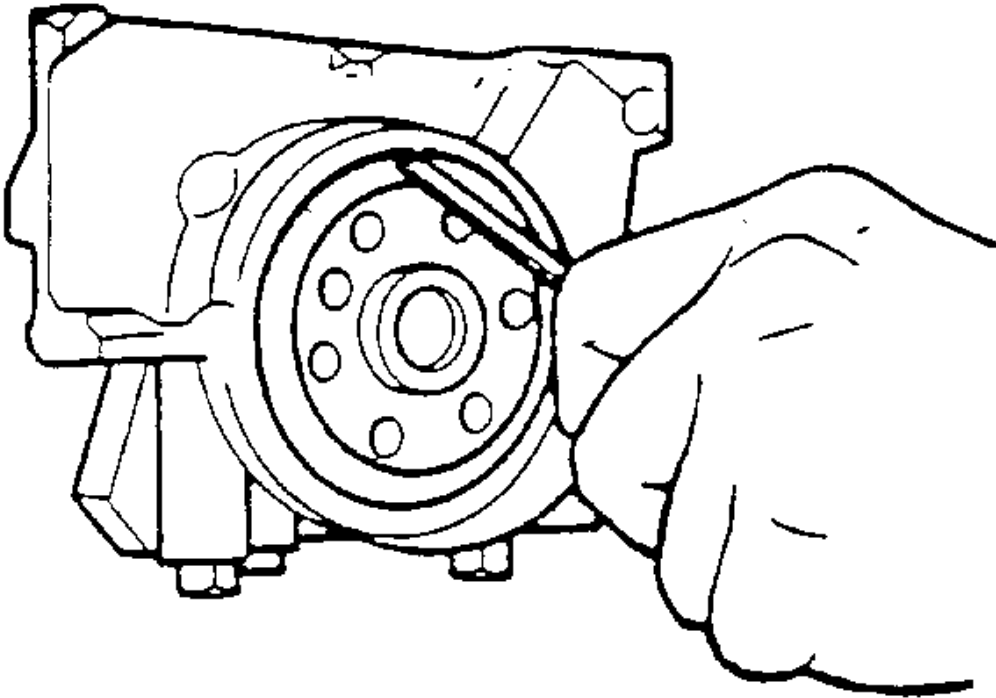


Fig. 208: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

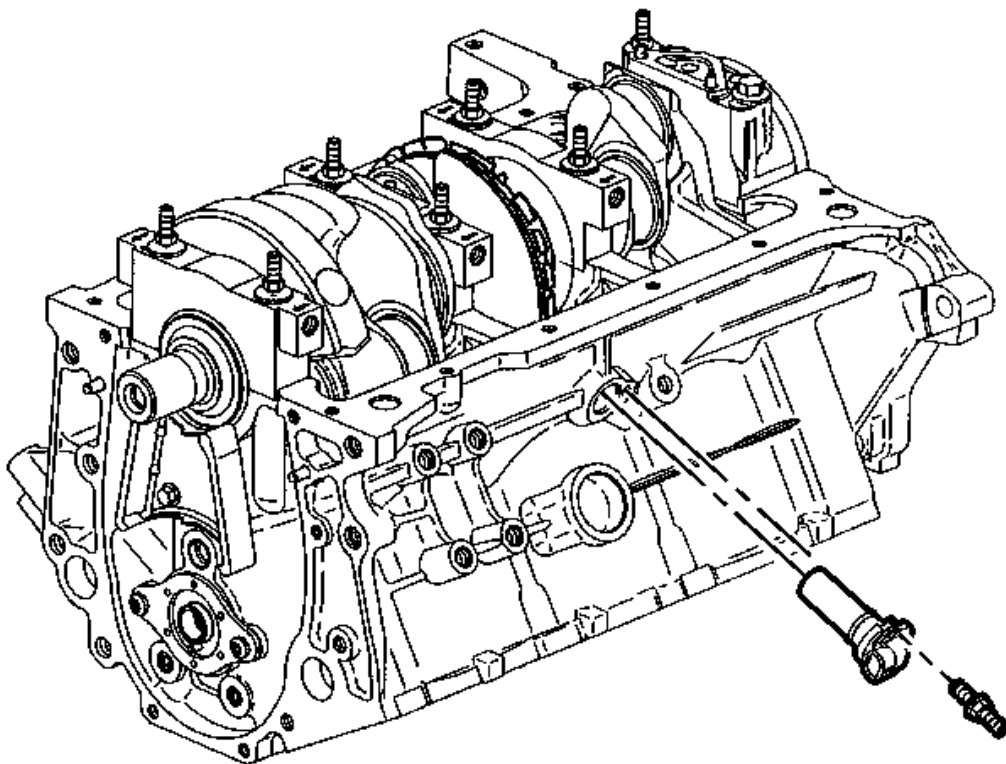


Fig. 209: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

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.

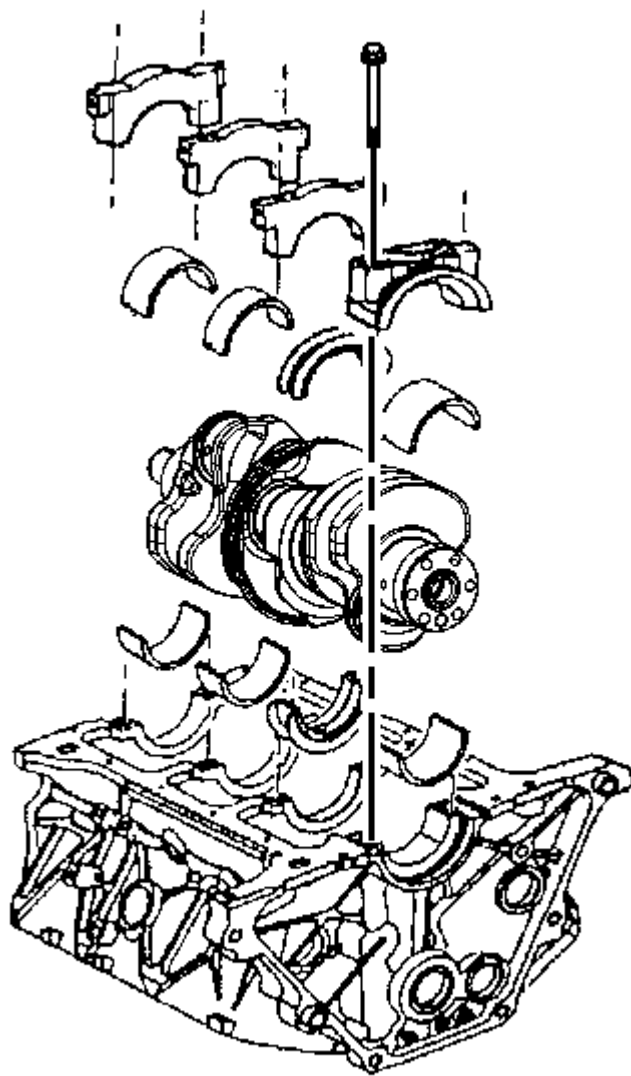


Fig. 210: View Of Crankshaft

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.

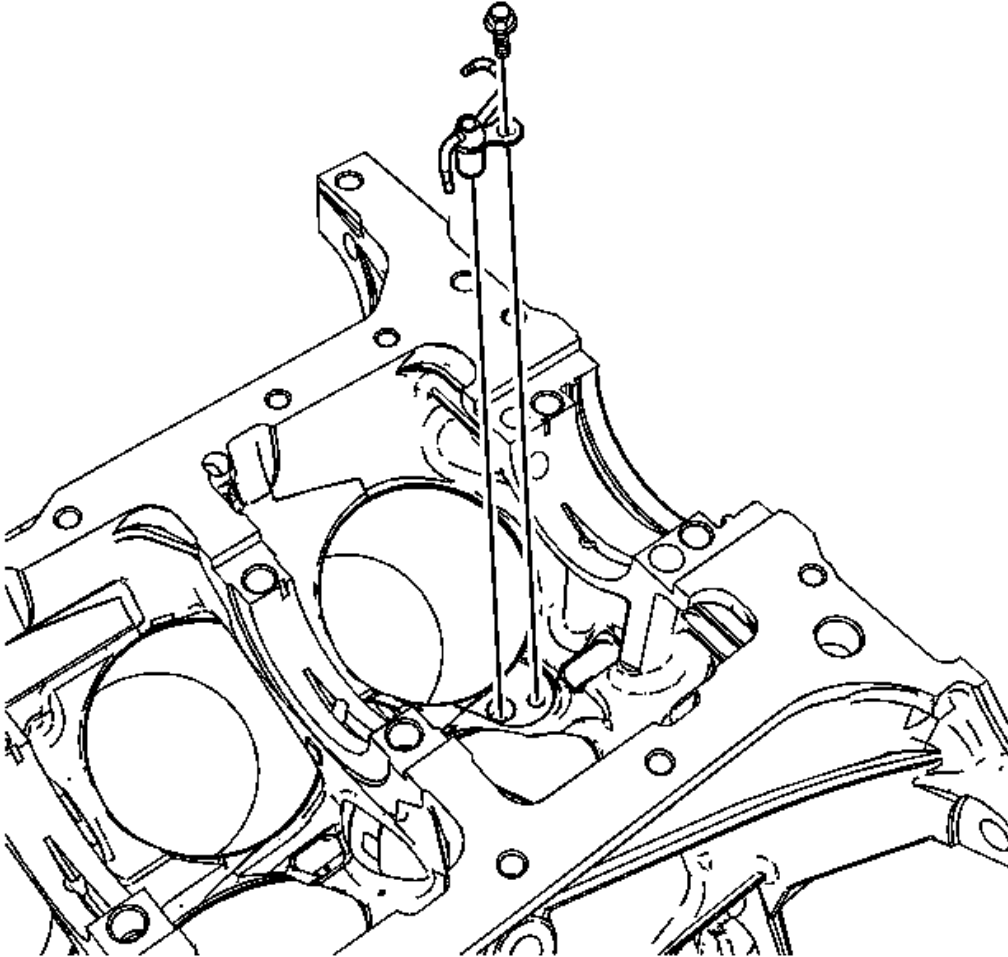
Piston Oil Nozzle Removal

Fig. 211: Piston Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt retaining the piston oil nozzle to the engine block.
2. Remove the piston oil nozzle.

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Remover/Installer. See **Special Tools**.

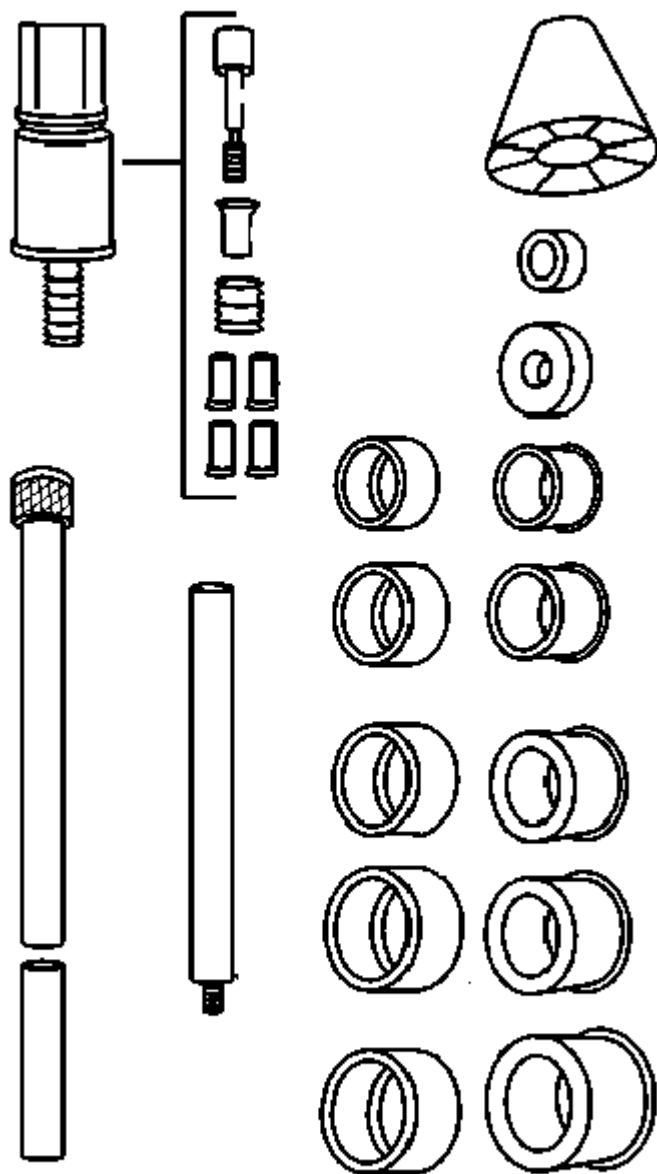


Fig. 212: Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

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

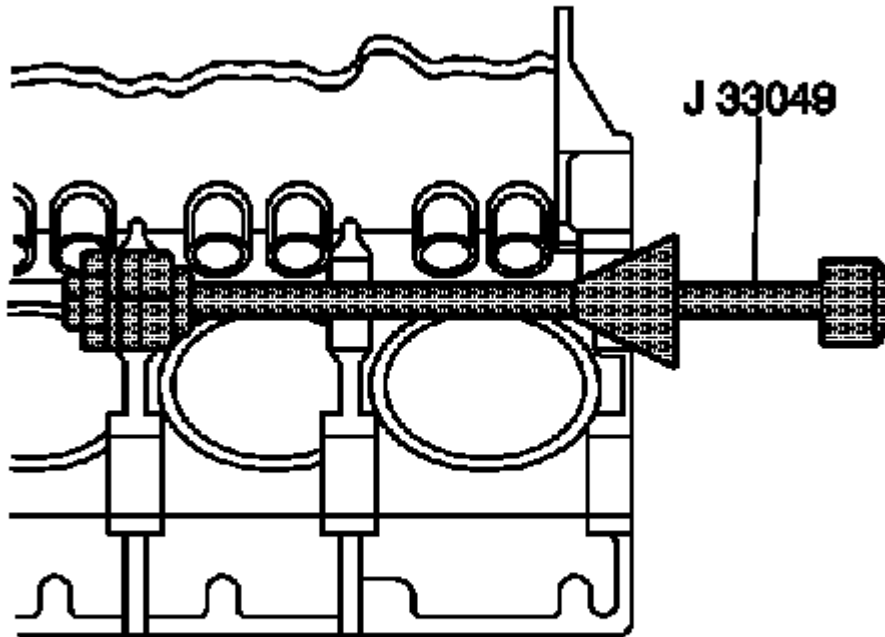


Fig. 213: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

3. Drive out the camshaft bearings. Use the **J 33049** . See Special Tools.

Engine Block Disassemble

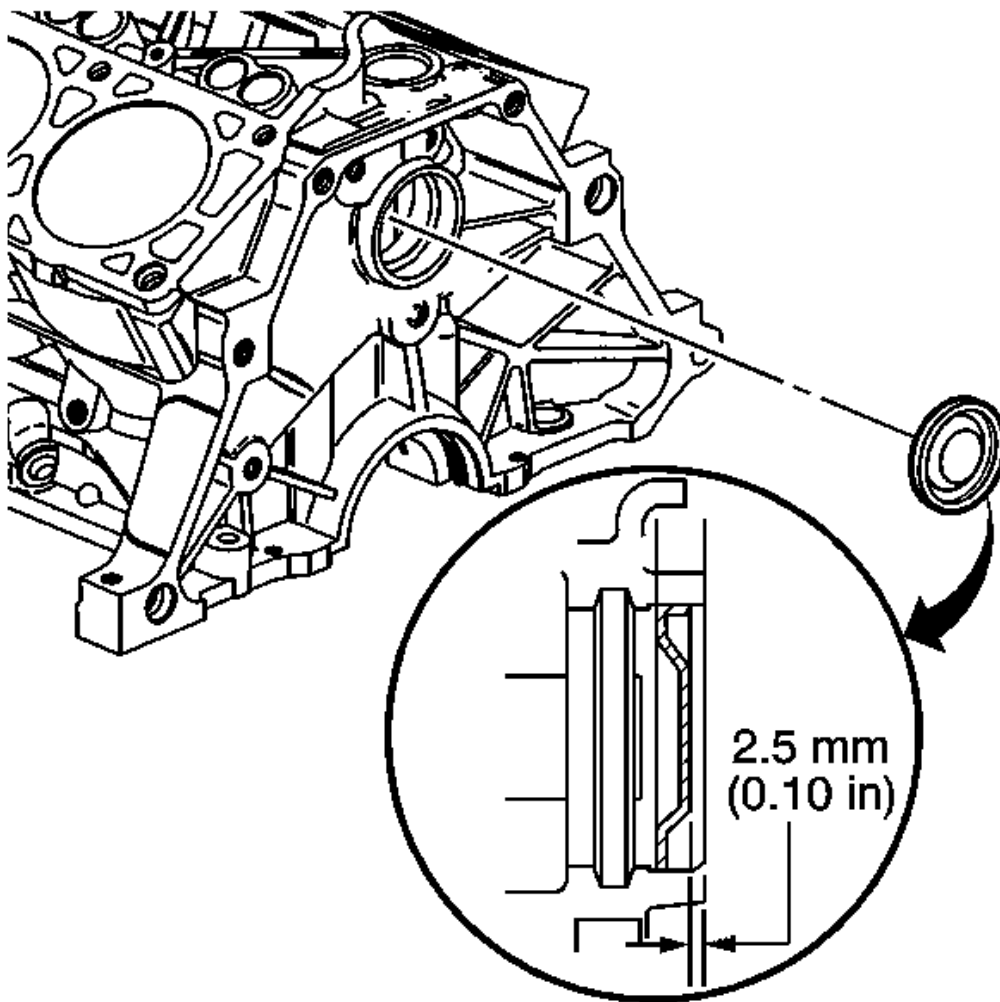


Fig. 214: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the camshaft rear bearing hole plug.

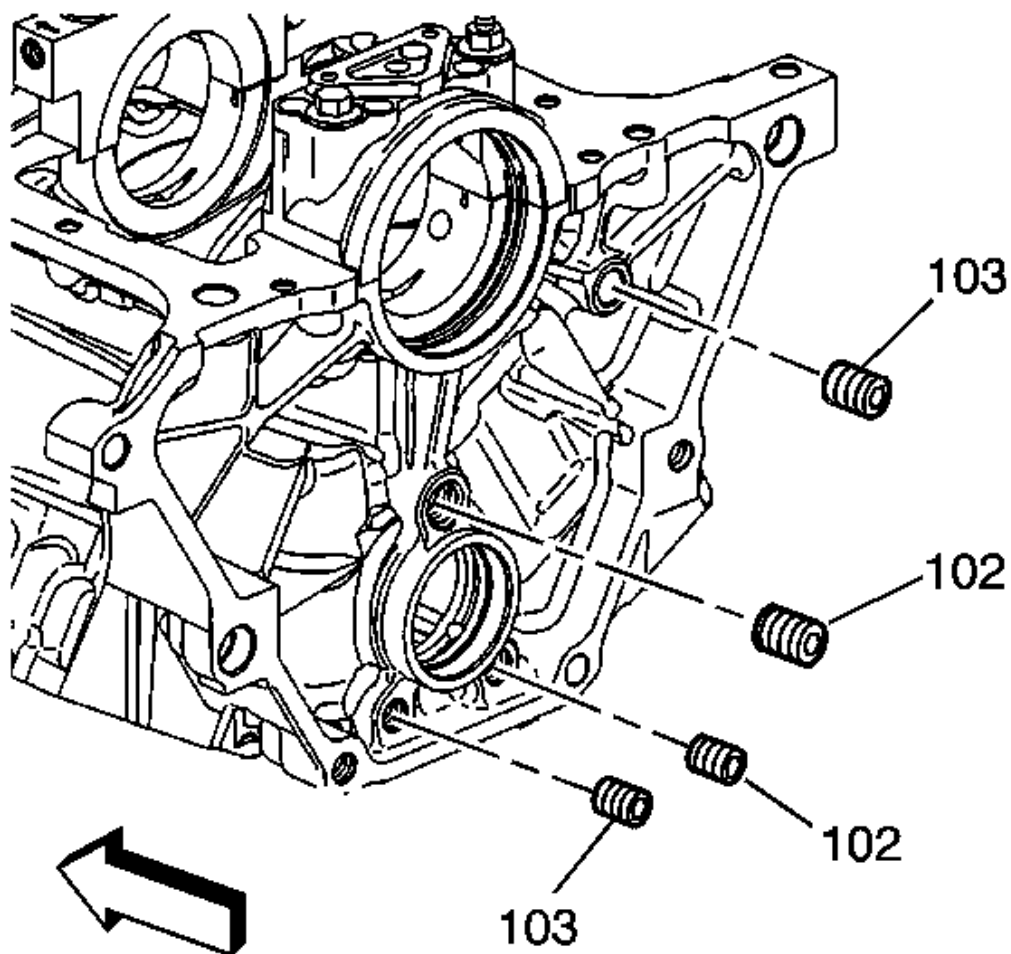


Fig. 215: View Of Rear Oil Gallery Plugs (102, 103)
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear oil gallery plugs (102, 103).

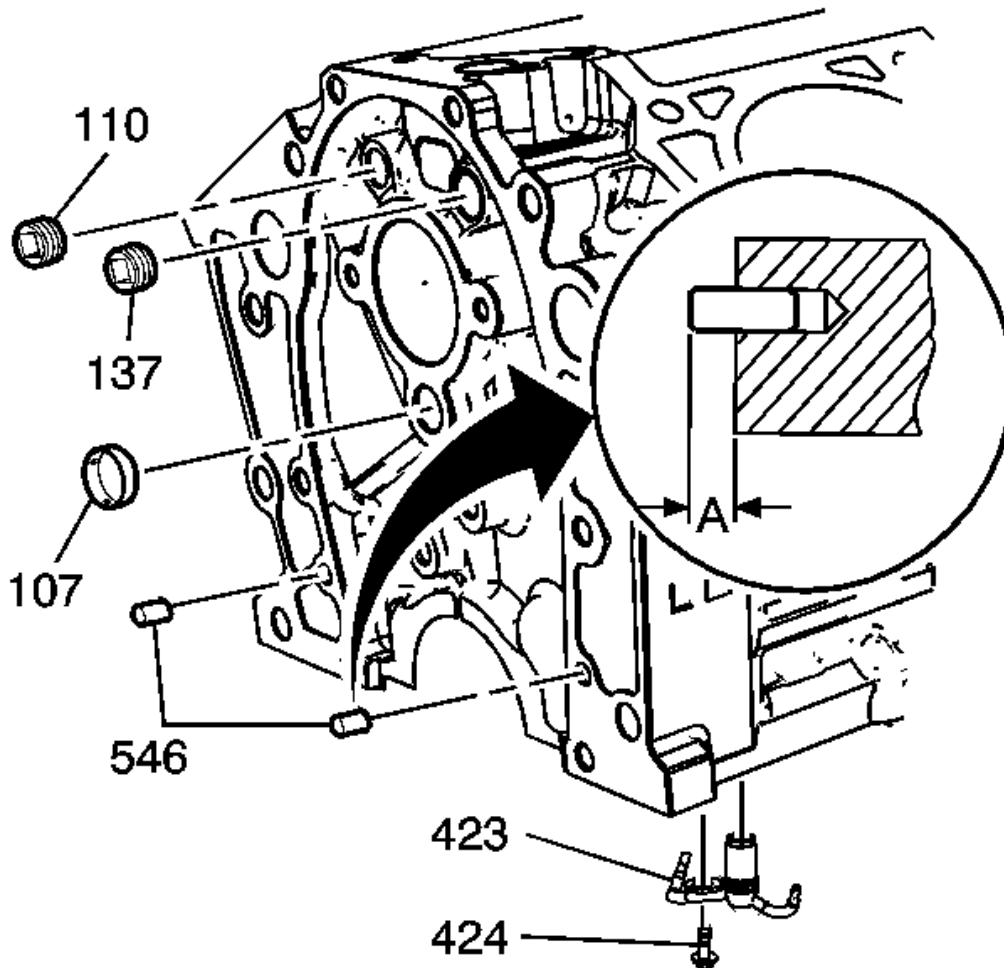


Fig. 216: View Of Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

3. Remove the front oil gallery plugs (107, 110, 137).
4. Remove the engine front cover locating pins (546).
5. Remove the piston oil nozzle bolt (424) and nozzle (423).

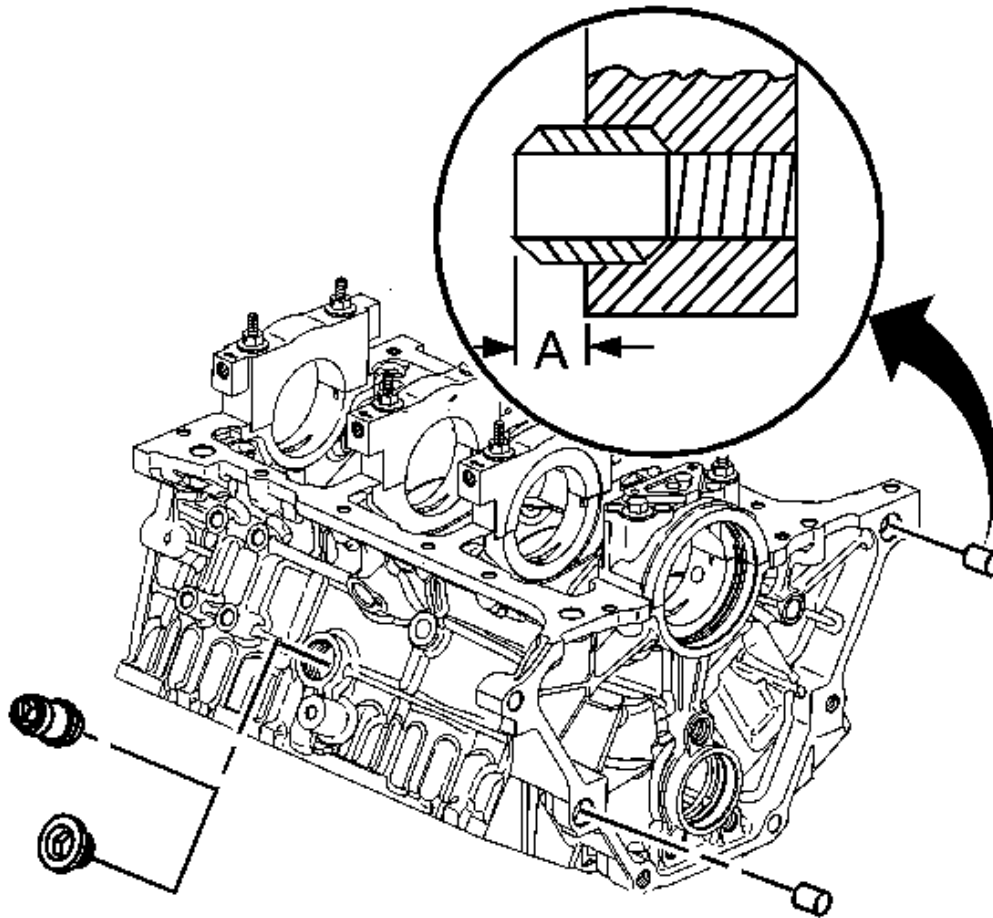


Fig. 217: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine block plug, if applicable.
7. Remove the engine block heater, if applicable.
8. Remove the transmission locating pins.

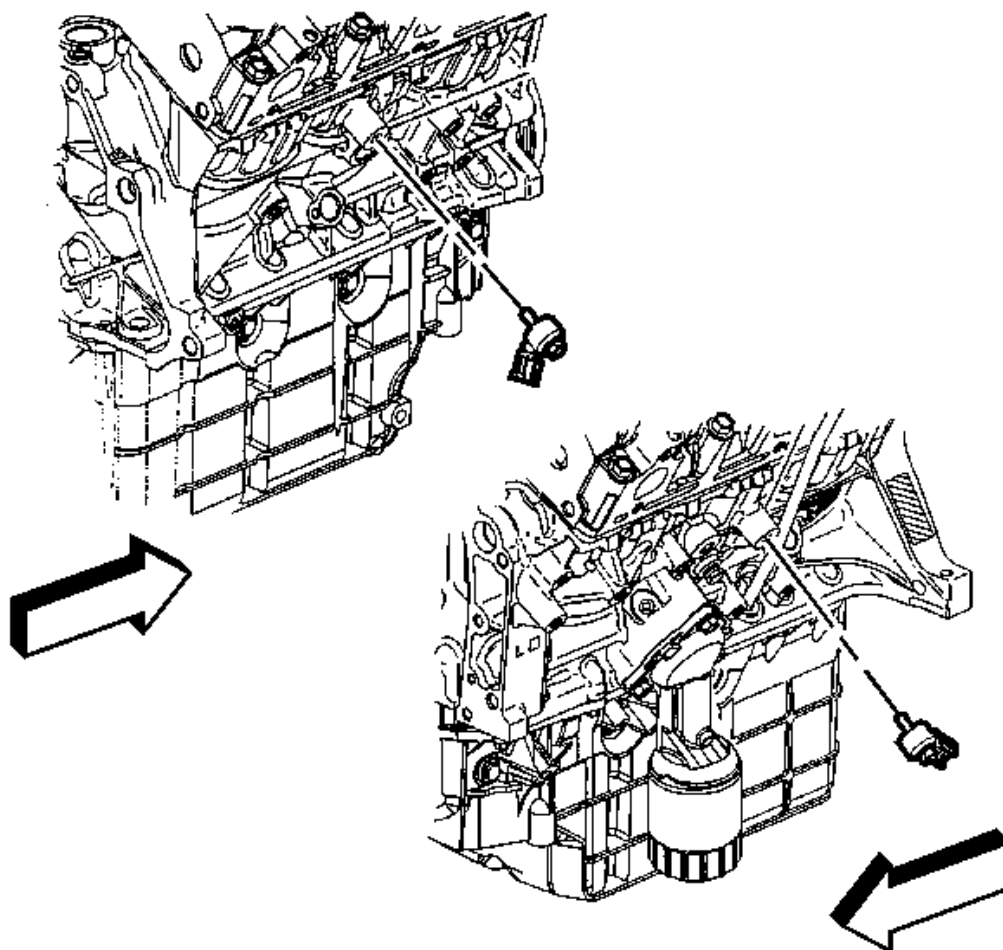


Fig. 218: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

9. Remove the knock sensors.

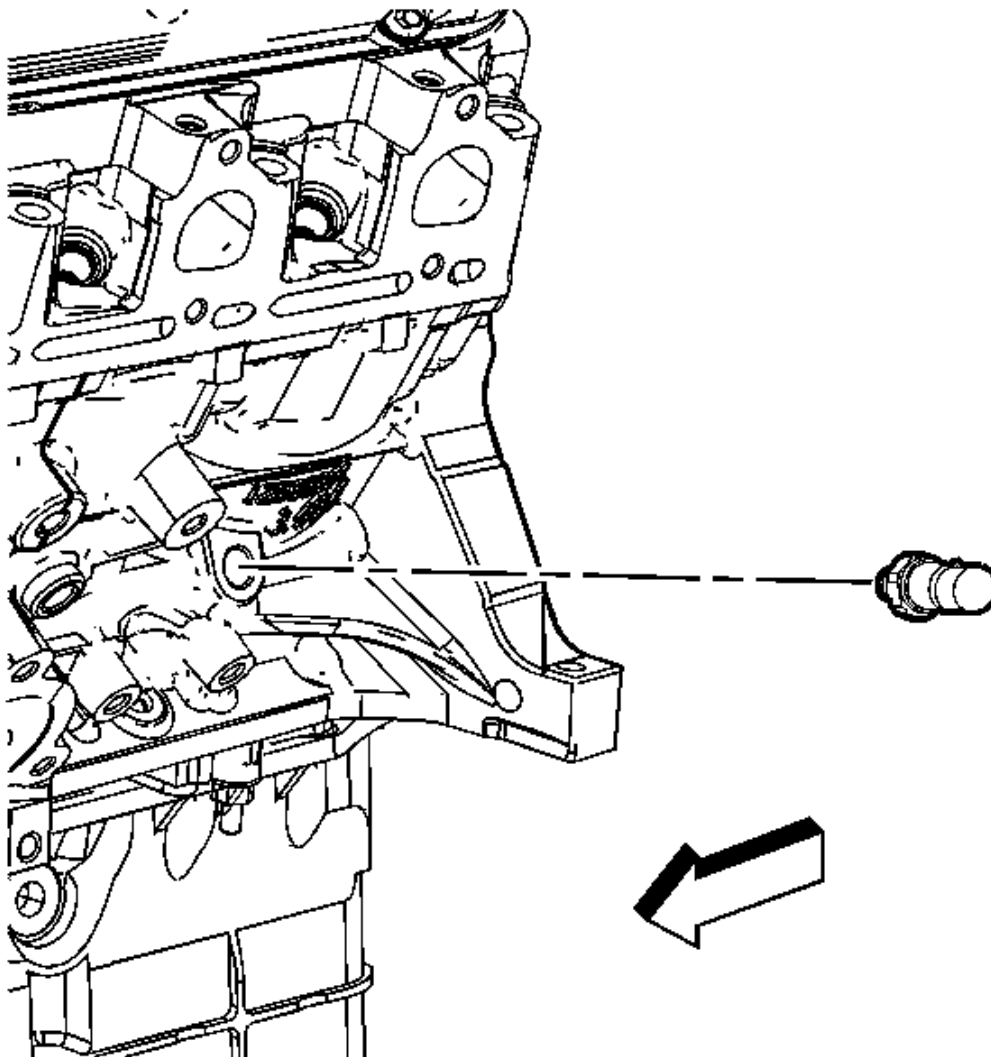


Fig. 219: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine oil pressure indicator switch.

Engine Block Cleaning and Inspection

Tools Required

- **J 8001** Dial Indicator Set. See **Special Tools**.

- J 8087 Cylinder Bore Gage

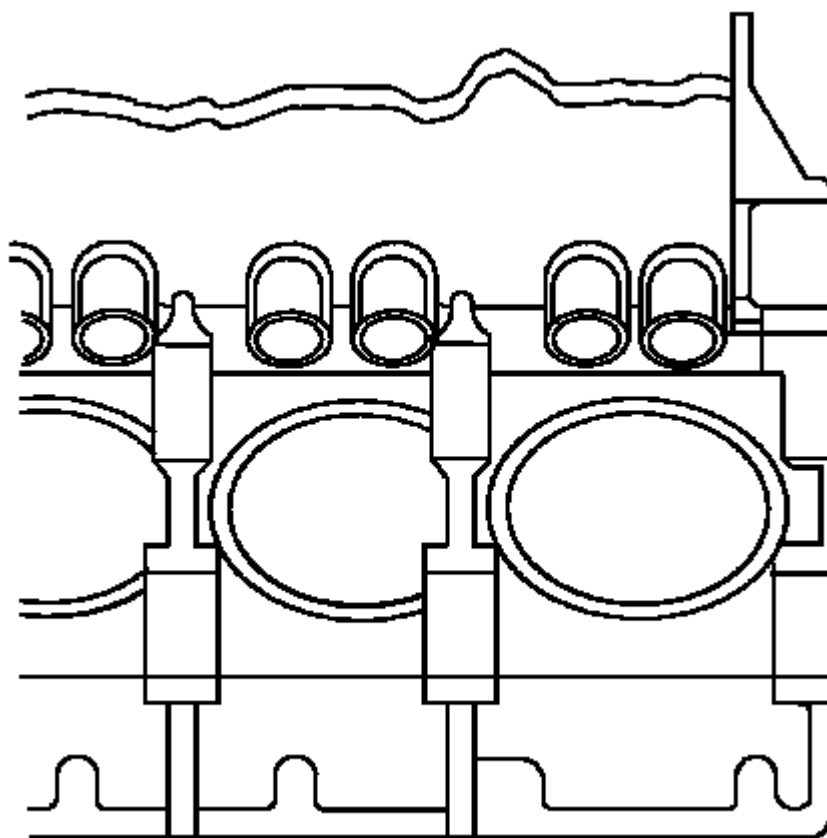


Fig. 220: View Of Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
2. Boil the engine block in caustic solution.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes.
8. Clean the holes with a tap. Drill out the holes and install thread inserts, as needed.

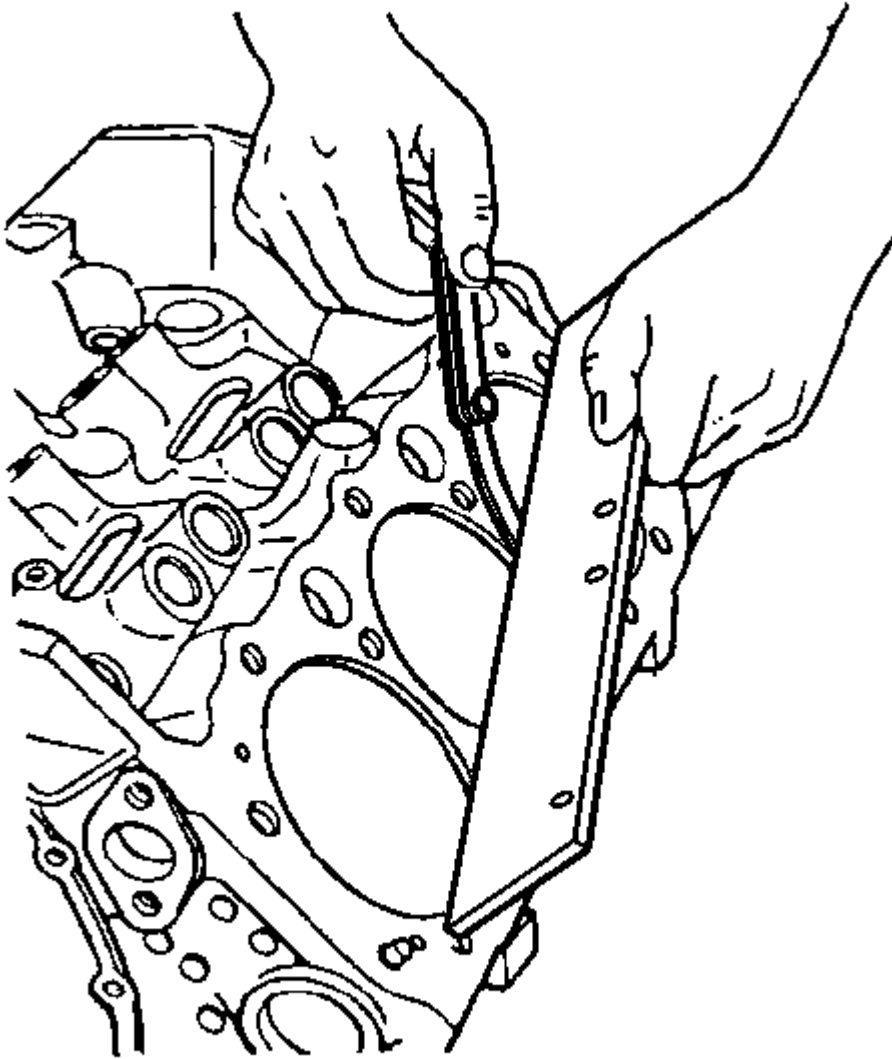


Fig. 221: Testing Block Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

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.

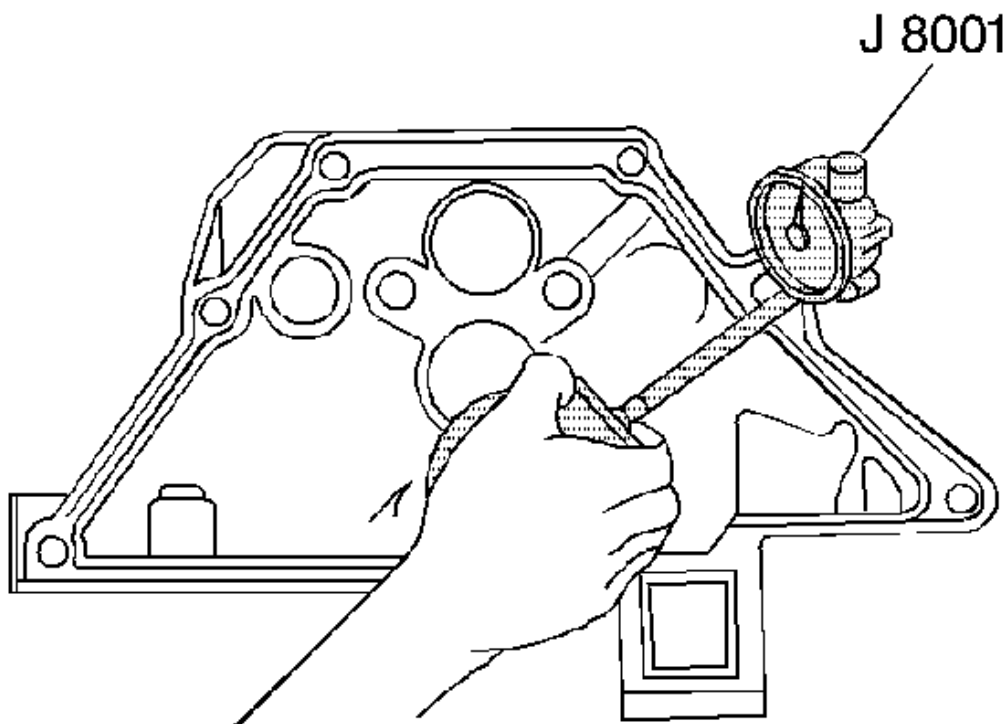


Fig. 222: Inspect Mating Surfaces Of Transmission Case
Courtesy of GENERAL MOTORS CORP.

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**.
 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.

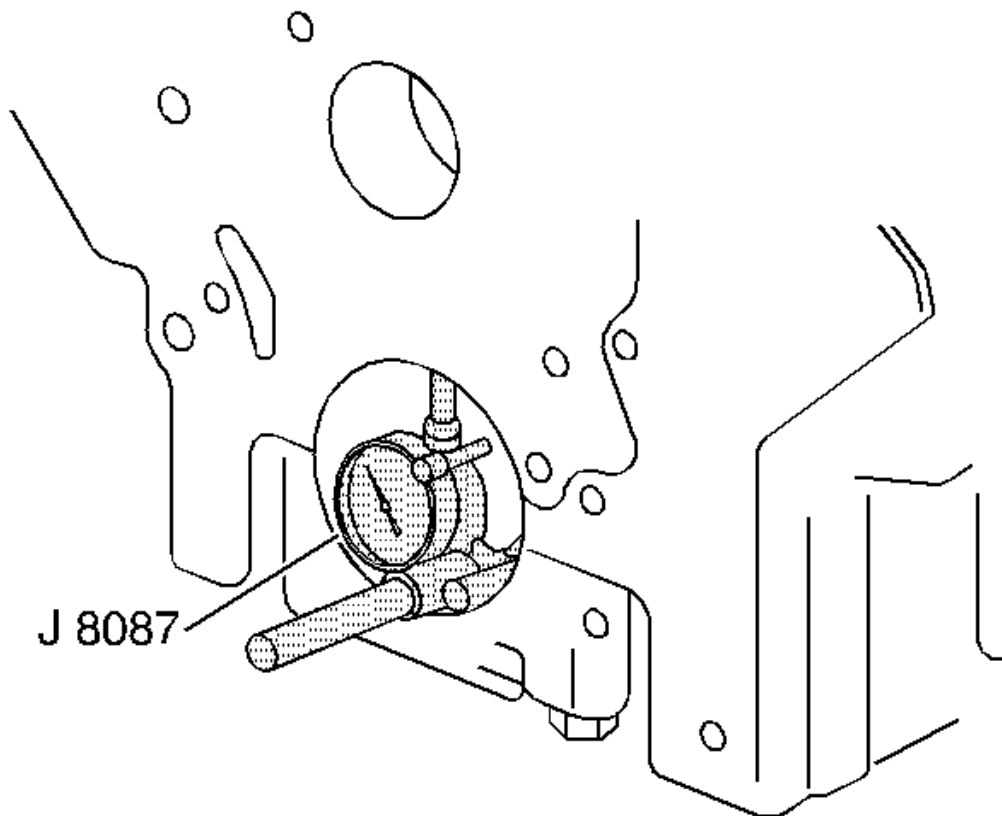


Fig. 223: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

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.

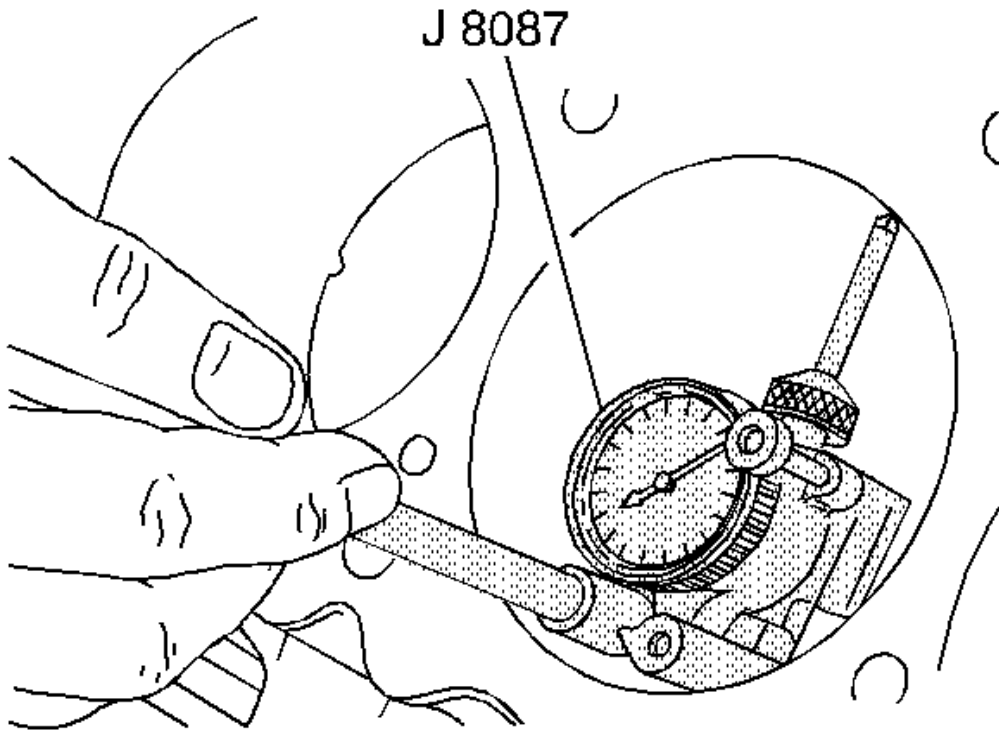


Fig. 224: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

15. Use the J 8087 in order to inspect the cylinder bores. Inspect the bores for the following conditions:

- Wear
- Taper
- Runout
- Ridging

IMPORTANT: If the bore is worn beyond the limits, refit the bore with 0.5 mm (0.02 in) oversized pistons.

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.

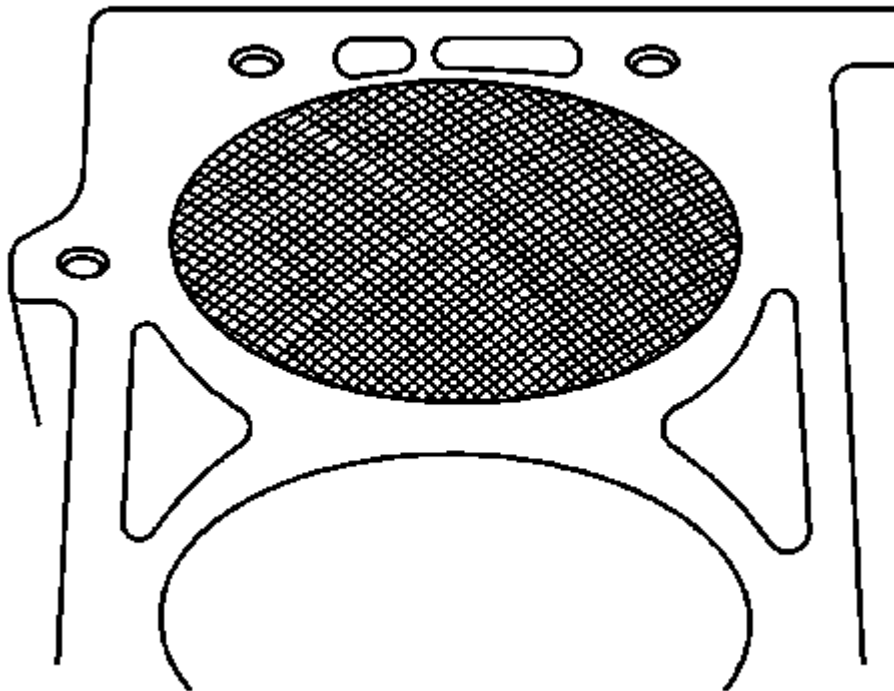


Fig. 225: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

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

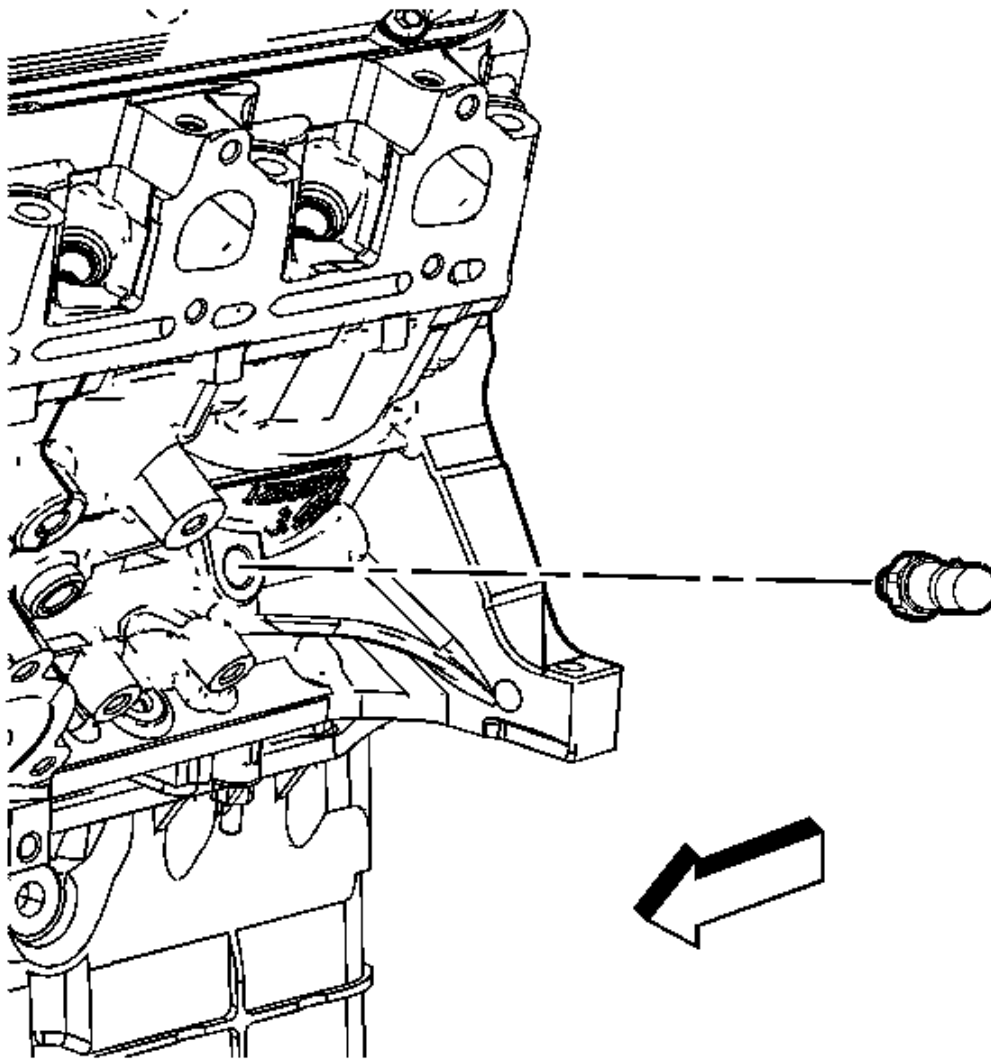


Fig. 226: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice 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).

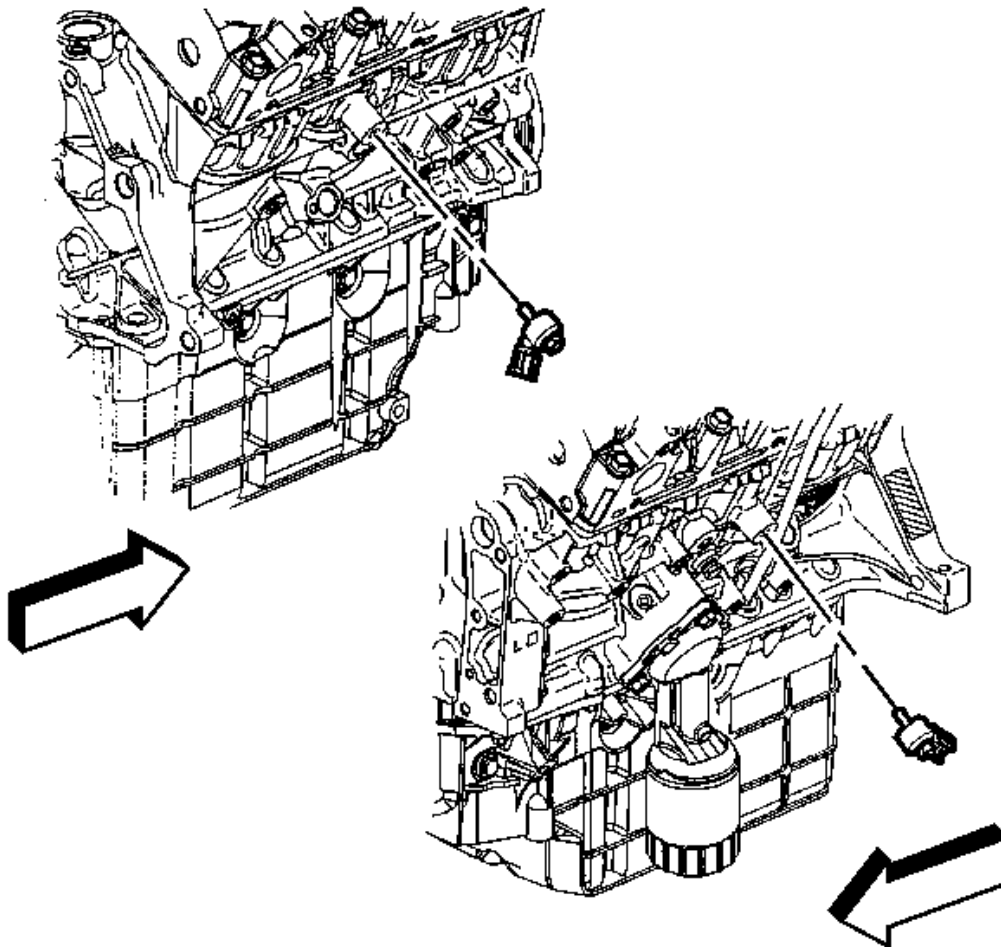


Fig. 227: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

3. Install the knock sensors.

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

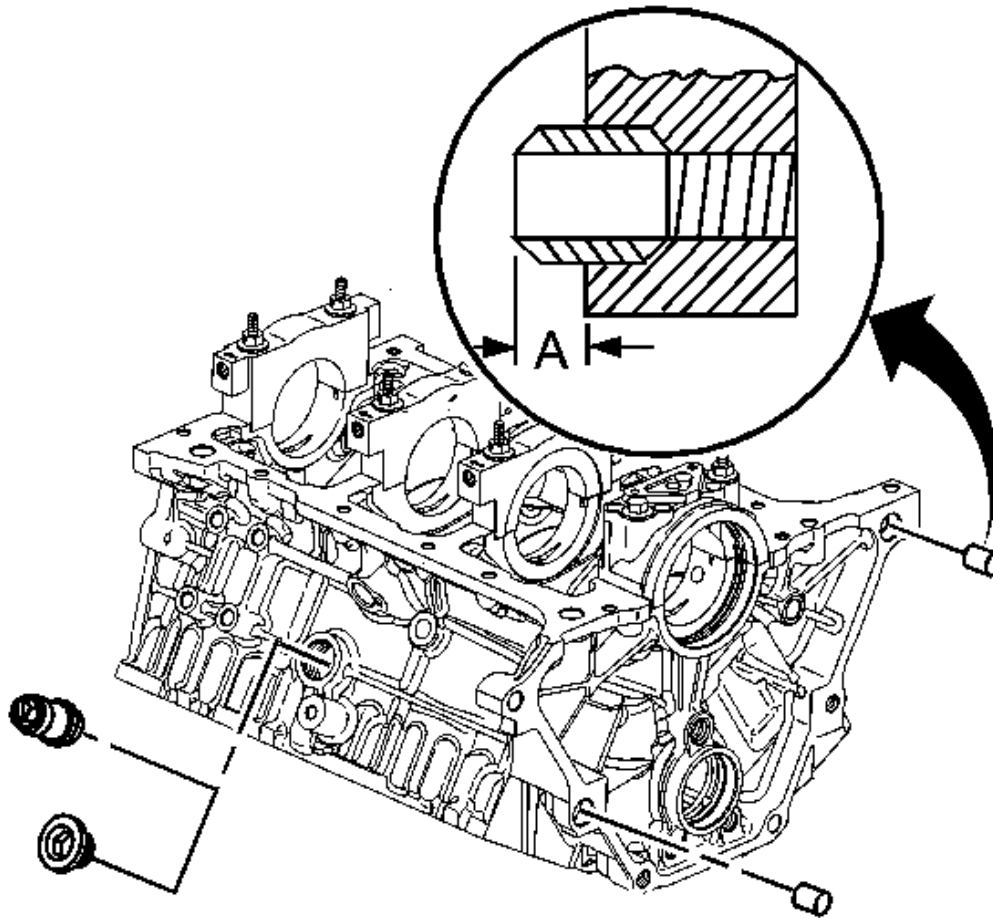


Fig. 228: View Of Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the engine block plug or engine block heater, if applicable.
5. Install the engine block plug or engine block heater, if applicable.

Tighten: Tighten the engine block plug or engine block heater to 60 N.m (44 lb ft).

6. Install the transmission locating pins. The installation height should be 8.3-9.3 mm (0.327-0.366 in) (A).

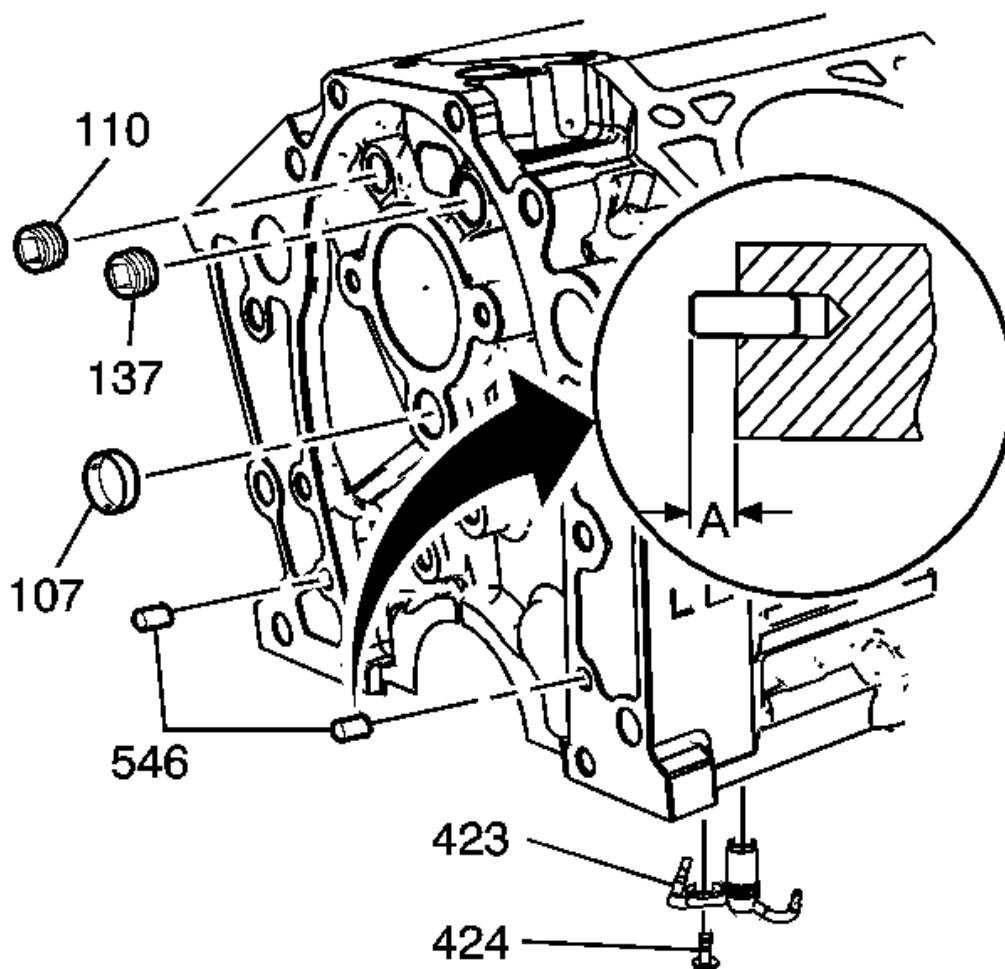


Fig. 229: View Of Front Oil Gallery Plugs (107, 110, 137)
Courtesy of GENERAL MOTORS CORP.

7. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the front oil gallery plug threads (110, 137).
8. Install the front oil gallery plug (110).

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

9. Install the front oil gallery plug (137).

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

10. Apply sealer GM P/N 12377901 (Canadian P/N 10953504), or equivalent to the front oil gallery plug (107).
11. Install the front oil gallery plug (107) so that it is 2.3 mm (0.10 in) below flush of the engine block.
12. Install the engine front cover locating pins (546). The installation height should be 5.8-8.2 mm (0.228-0.323 in) (A).

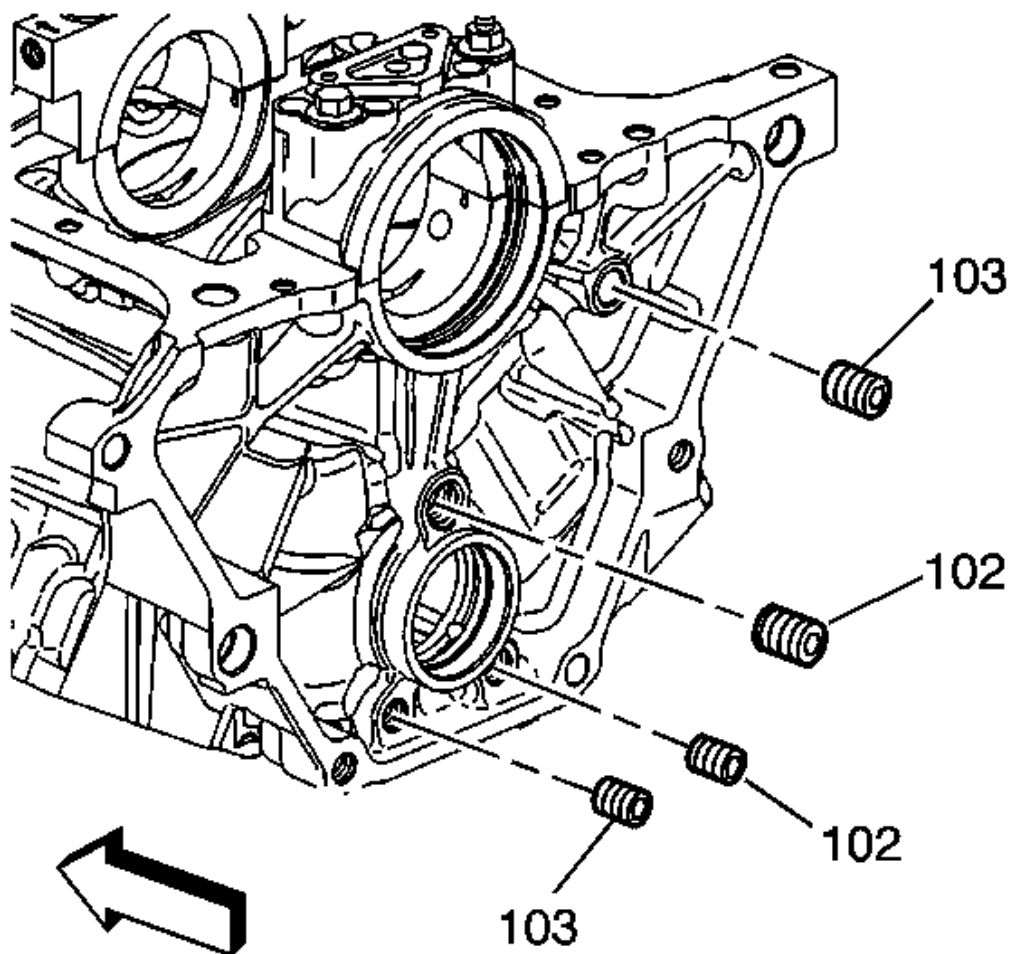


Fig. 230: View Of Rear Oil Gallery Plugs (102, 103)
Courtesy of GENERAL MOTORS CORP.

13. Install the piston oil nozzle and bolt.

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

14. Apply Sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the rear oil gallery plugs.
15. Install the rear oil gallery plugs (103).

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

16. Install the rear oil gallery plugs (102).

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

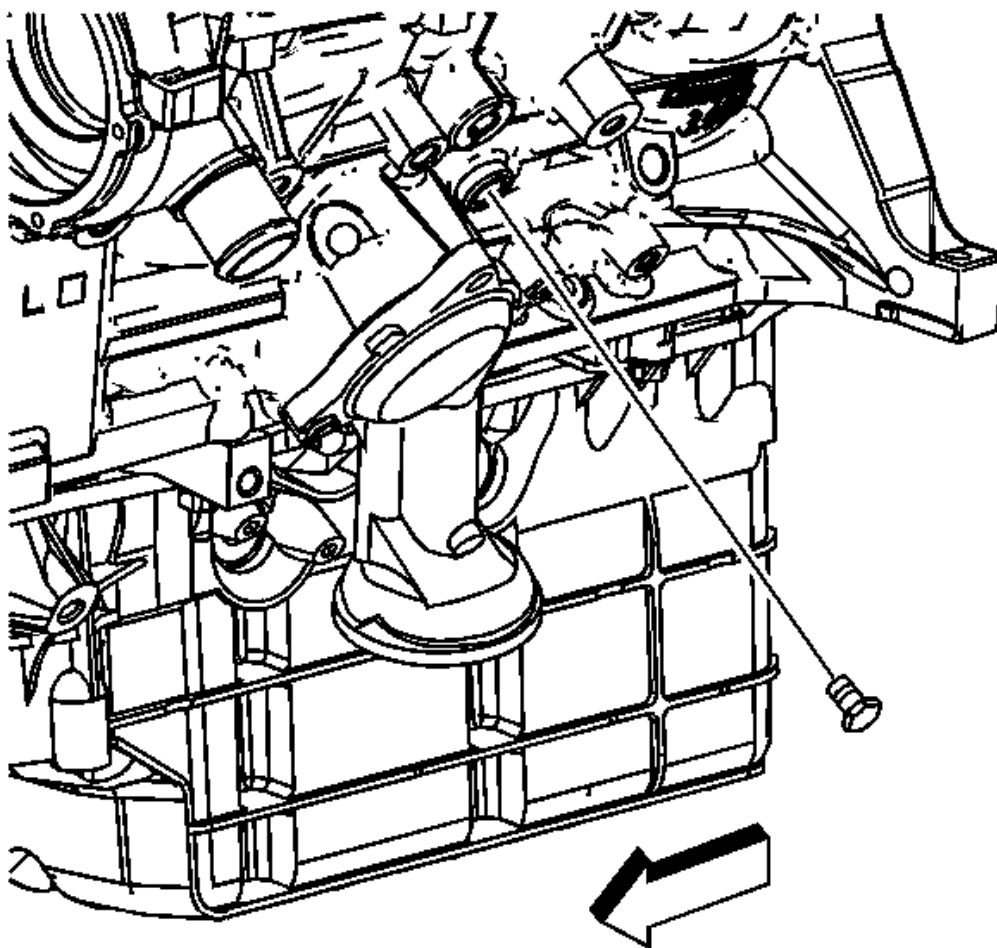


Fig. 231: View Of Coolant Drain Plug From Left Side
Courtesy of GENERAL MOTORS CORP.

NOTE: Maximum gasket performance is achieved when using new fasteners,

which contain a thread-locking patch. If the fasteners are not replaced, a thread locking chemical must be applied to the fastener threads. Failure to replace the fasteners or apply a thread-locking chemical MAY reduce gasket sealing capability.

17. Apply sealer GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the left and right coolant drain plug threads.
18. Install the left coolant drain plug.

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

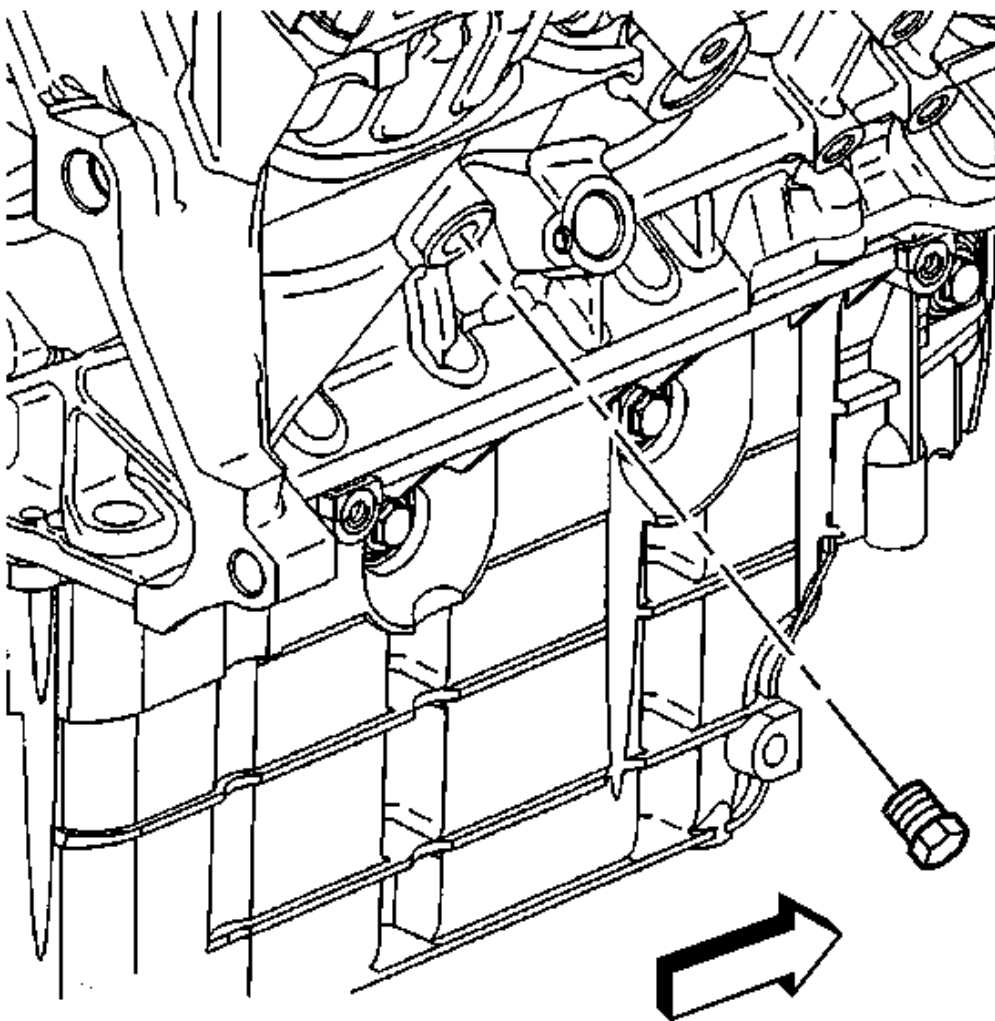


Fig. 232: View Of Coolant Drain Plug From Right Side
Courtesy of GENERAL MOTORS CORP.

19. Install the right coolant drain plug.

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

Piston Oil Nozzle Cleaning and Inspection

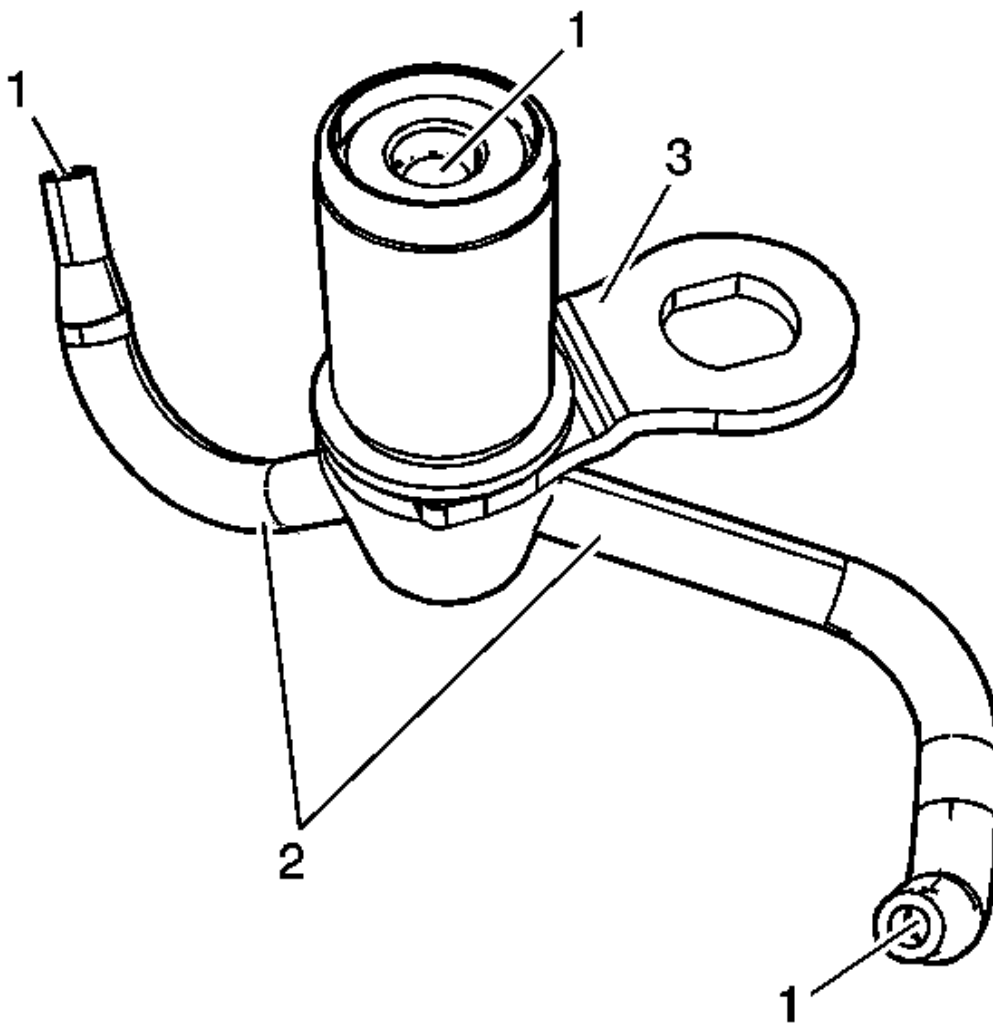


Fig. 233: View Of Piston Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston oil nozzle in cleaning solvent.

CAUTION: Wear safety glasses in order to avoid eye damage.

2. Dry the nozzle with compressed air.
3. Inspect the piston oil nozzle for the following:
 - For cracks or damage
 - Plugged oil passages (1)
 - Bent, misaligned, or cracked oil nozzle tubes (2)
 - Bent or broken clip (3)

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

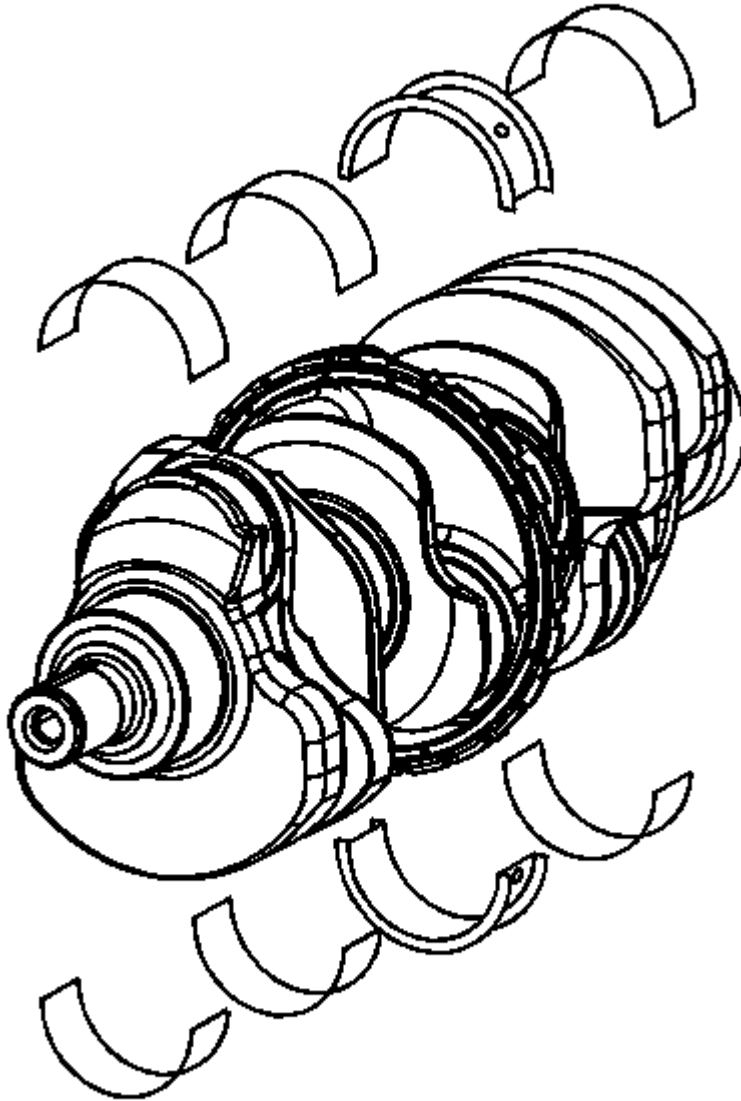


Fig. 234: View Of Crankshaft And Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use Care when handling the crankshaft. Avoid damage to the crankshaft position sensor reluctor wheel teeth. Nicks, burrs or other damage to the teeth may effect on-board diagnostics (OBD) 2 system performance.

1. Clean the crankshaft of the following elements:

- Oil
- Sludge
- Carbon

2. Inspect the crankshaft oil passages for obstructions.

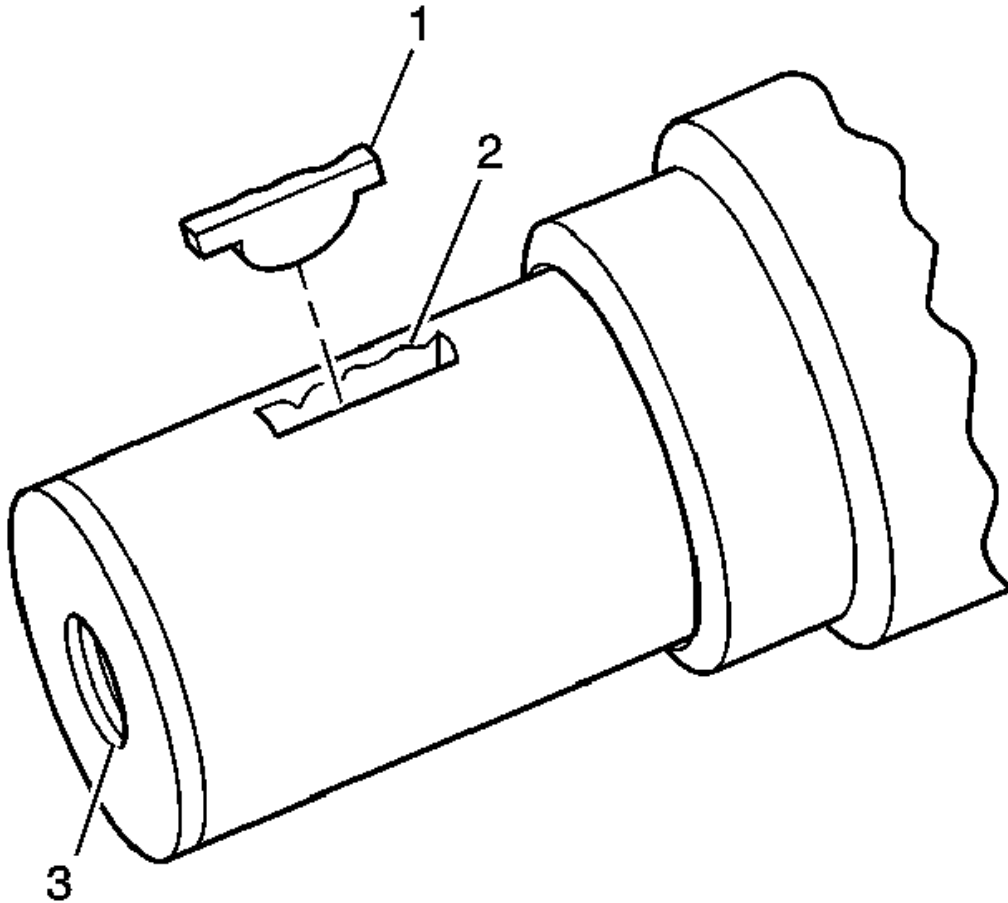


Fig. 235: Inspecting Crankshaft Keyway
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft keyway for the following conditions:
- A worn crankshaft key (1)
 - A worn crankshaft keyway (2)
4. Inspect the crankshaft threads (3) for damage.

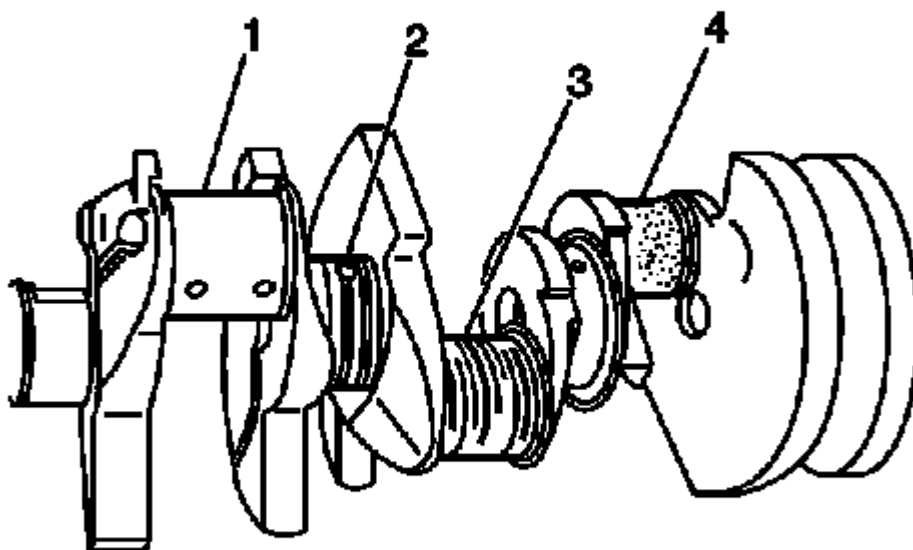


Fig. 236: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If cracks, severe gouges or burned spots are found, replace the crankshaft. Remove slight roughness using a fine polishing cloth soaked in clean engine oil. Remove any burrs using a fine oil stone.

5. Inspect the crankshaft bearing journals and the crankshaft thrust surfaces for the following conditions:
 - Wear without any grooves or scratches (1)
 - Grooves or scoring (2)
 - Scratches or excessive wear (3)
 - Pitting or embedded bearing material (4)-Inspect the corresponding crankshaft bearing inserts for embedded material and determine the source of the material.
 - Overheating or discoloration

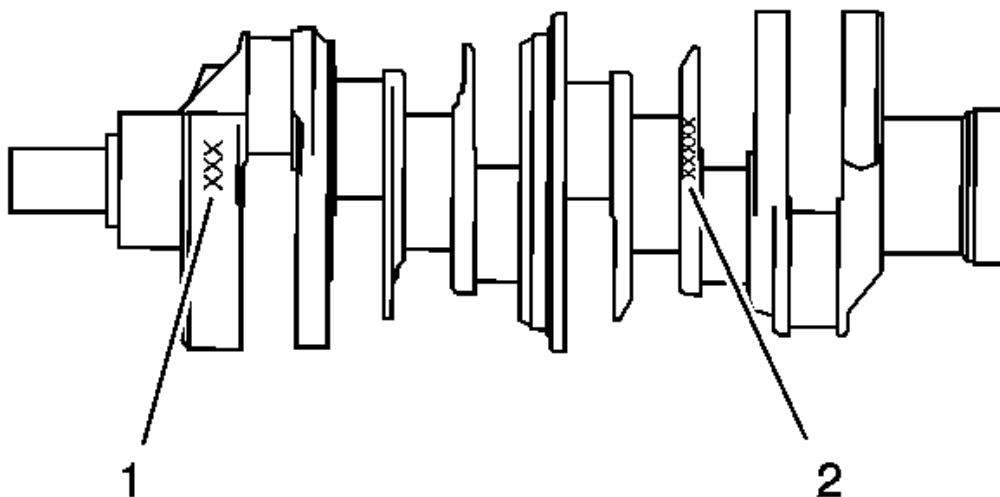


Fig. 237: Crankshaft Identification Locations
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This engine has been built with two available crankshafts. It is not recommended by the manufacturer that the two different material crankshafts be interchanged. Engine drivability and performance may be affected in doing so.

6. Inspect the crankshaft for specific materials.
 - If the crankshaft has three digits in location (1) of the graphic then the crankshaft is made of iron.
 - If the crankshaft has five digits in location (2) of the graphic then the crankshaft is made of steel.

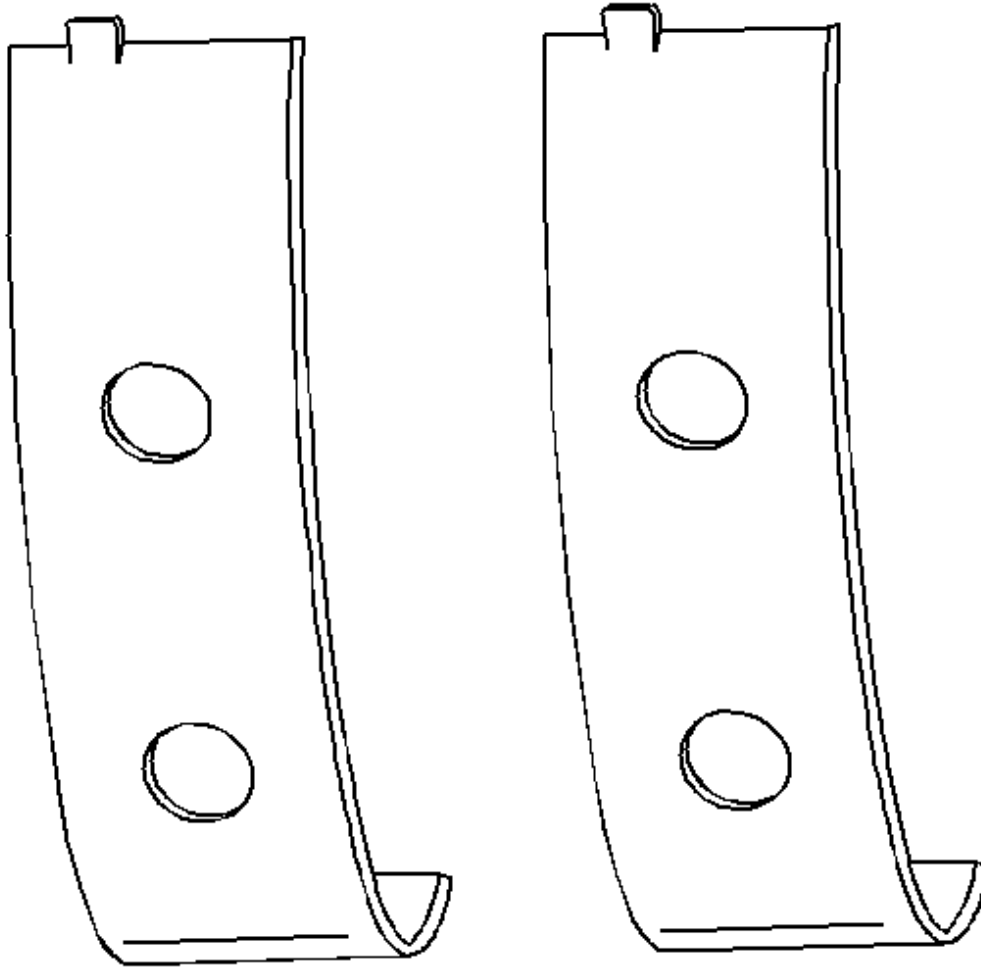


Fig. 238: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

7. The crankshaft bearings are the precision insert type.
8. 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

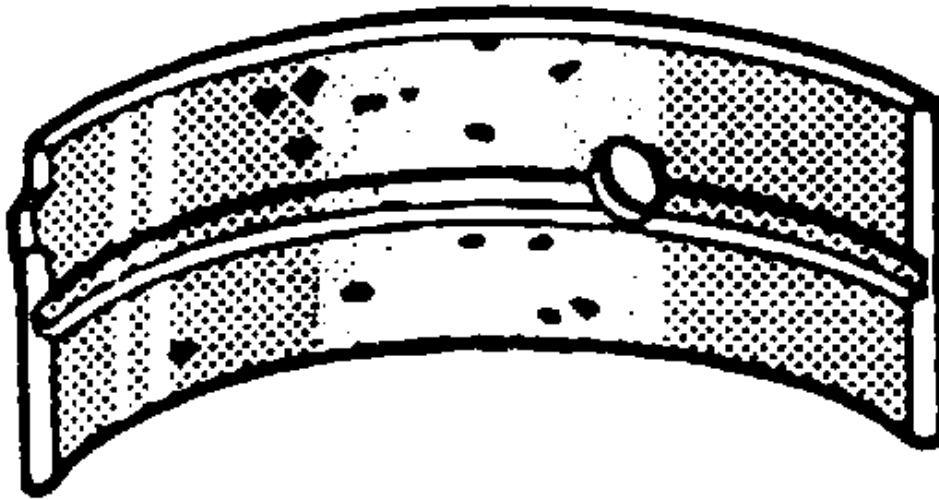


Fig. 239: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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.

9. Inspect the crankshaft main bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.
10. 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.

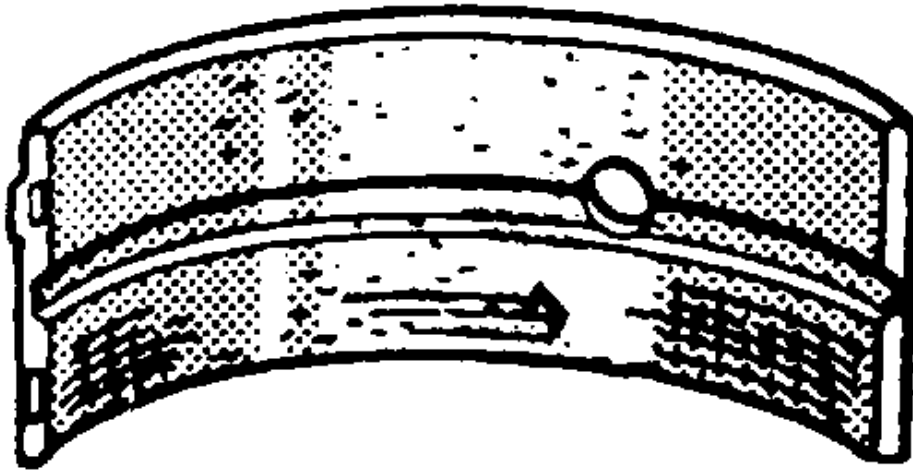


Fig. 240: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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

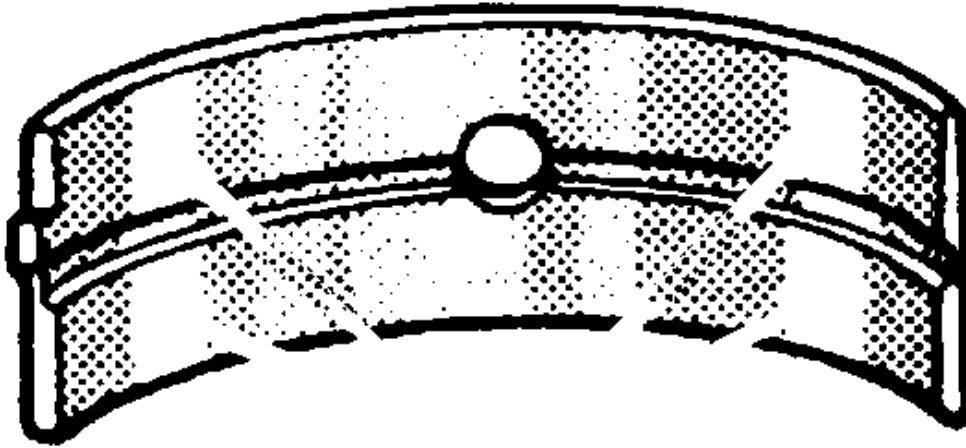


Fig. 241: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

13. Inspect the crankshaft main bearings for improper seating indicated by bright, polished sections.
14. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

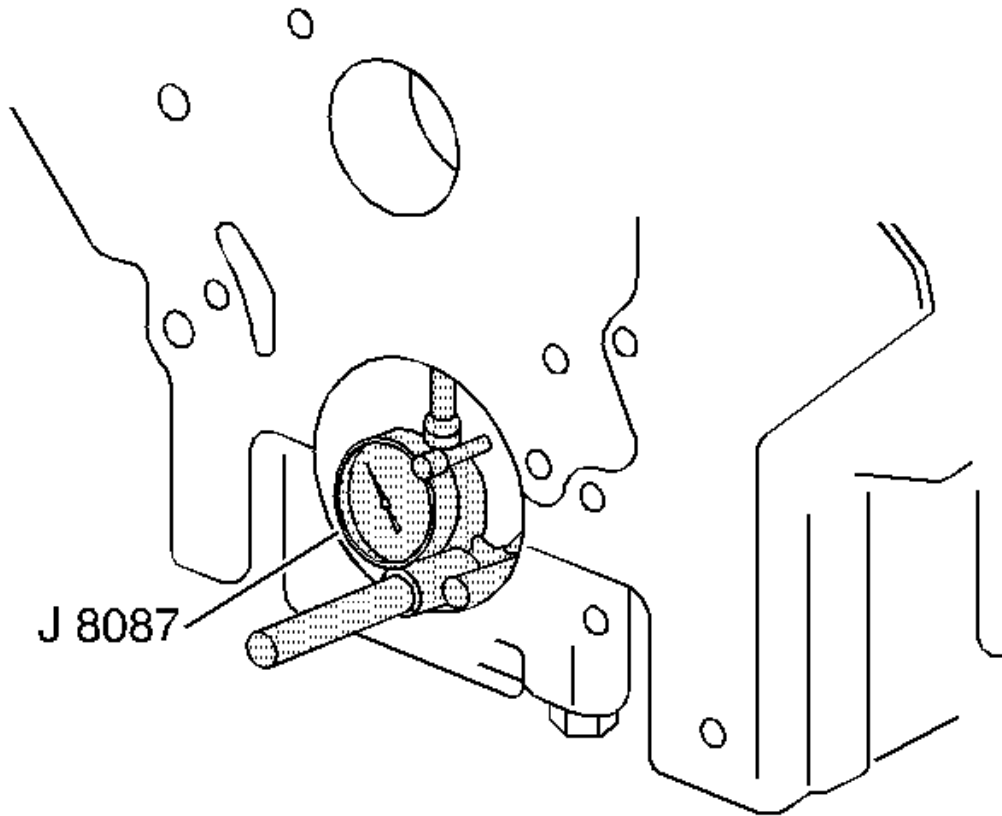


Fig. 242: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

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.

15. Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:
 1. Tighten the bearing cap to specification.
 2. Use the **J 8087** in order to measure the bearing bore for taper and out-of-round. See **Special Tools**. Record the readings for bearing selection.
 3. No taper or out-of-round should exist.

Bearing Selection

Measure the bearing clearance to determine the correct replacement bearing insert size. There are two methods to measure bearing clearance. Method A gives more reliable results and is preferred.

- 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.

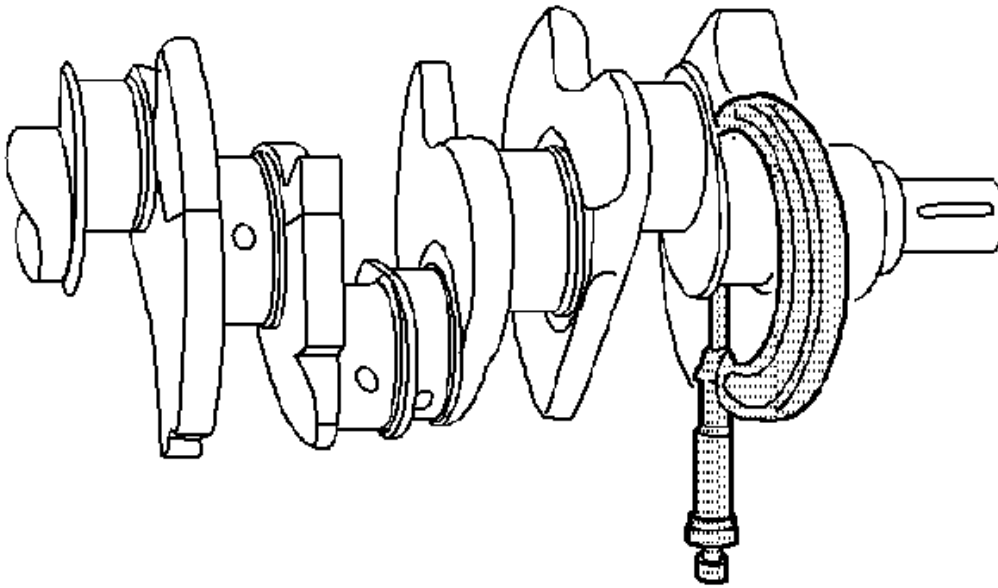
Method A

Fig. 243: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not mix inserts of different nominal size in the same bearing bore.

1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
2. Measure the crankshaft bearing journal taper and runout.
3. Install the crankshaft bearing inserts. Tighten the bearing cap bolts to specification using **J 45059** . See **Special Tools**.
4. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
5. Measure the crankshaft main bearing inside diameter with an inside micrometer.
6. Select a set of bearing inserts that will produce the desired clearance.
7. If the specified clearances cannot be met, the crankshaft journals must be reconditioned and undersized bearing inserts installed.

Method B

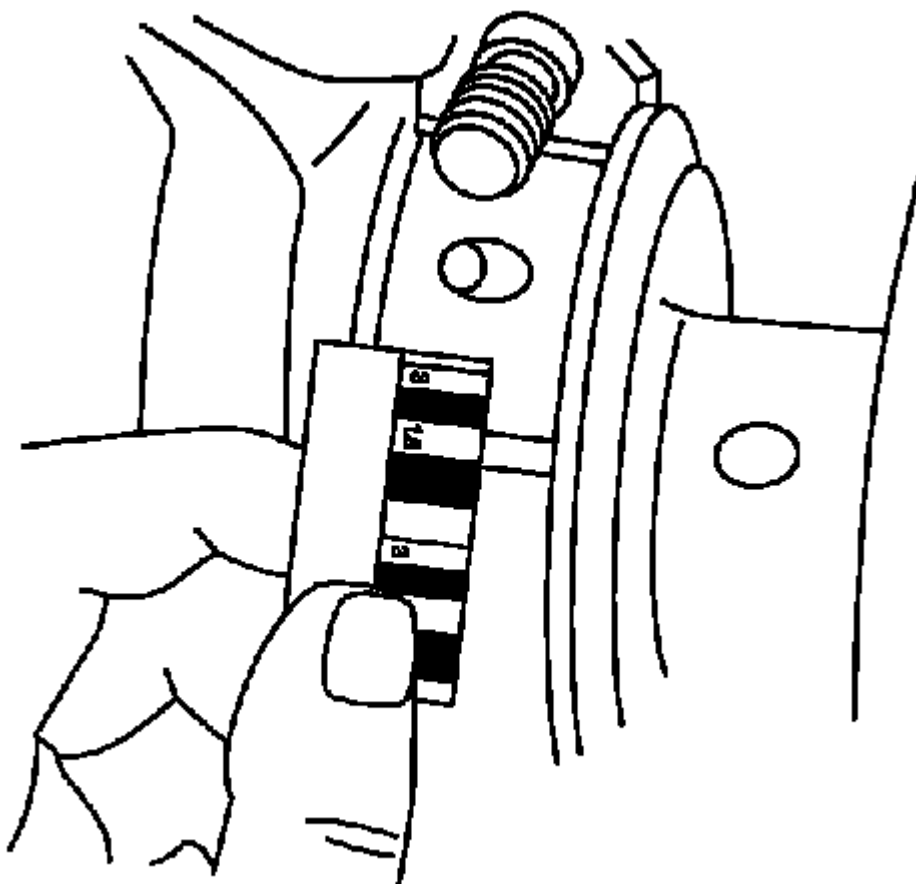


Fig. 244: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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 45059** . See **Special Tools**.

IMPORTANT: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale printed on the gaging plastic package.
8. Remove the gaging plastic.
9. Select a set of bearing inserts that will produce the desired clearance.

Crankshaft Balancer Cleaning and Inspection

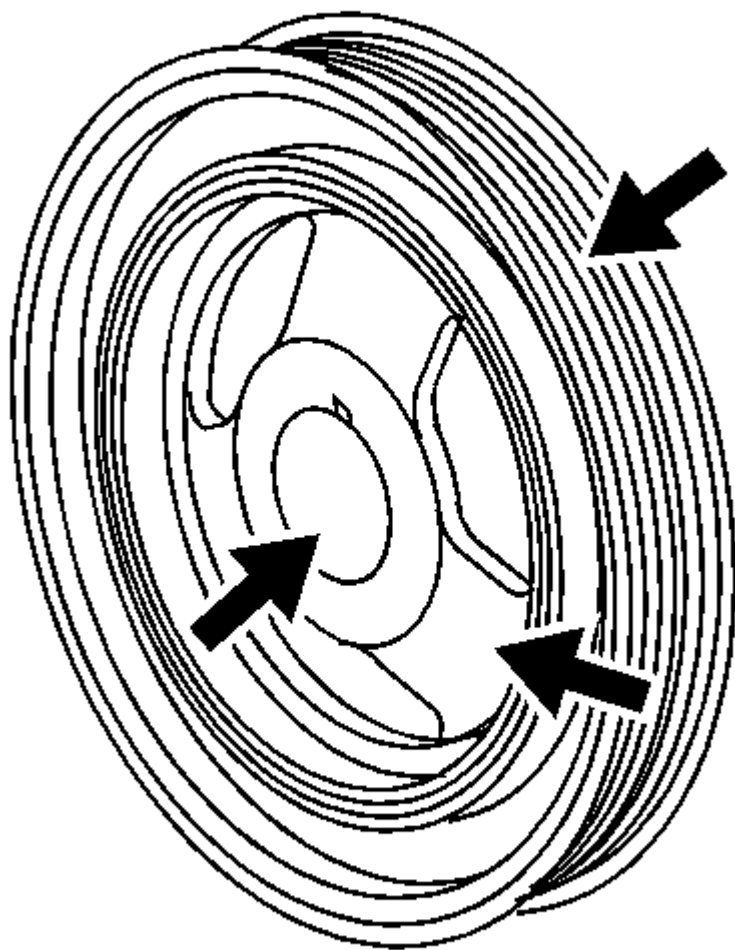


Fig. 245: Cleaning Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Inspect the crankshaft balancer for the following:

IMPORTANT: A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced. Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

- Worn, grooved, or damaged hub seal surface

IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt, debris, nicks, gouges or other damage. Minor imperfections may be removed with a fine file.

- Dirty or damaged belt grooves.
- Worn, chunking or deteriorated rubber between the hub and pulley

Engine Flywheel Cleaning and Inspection

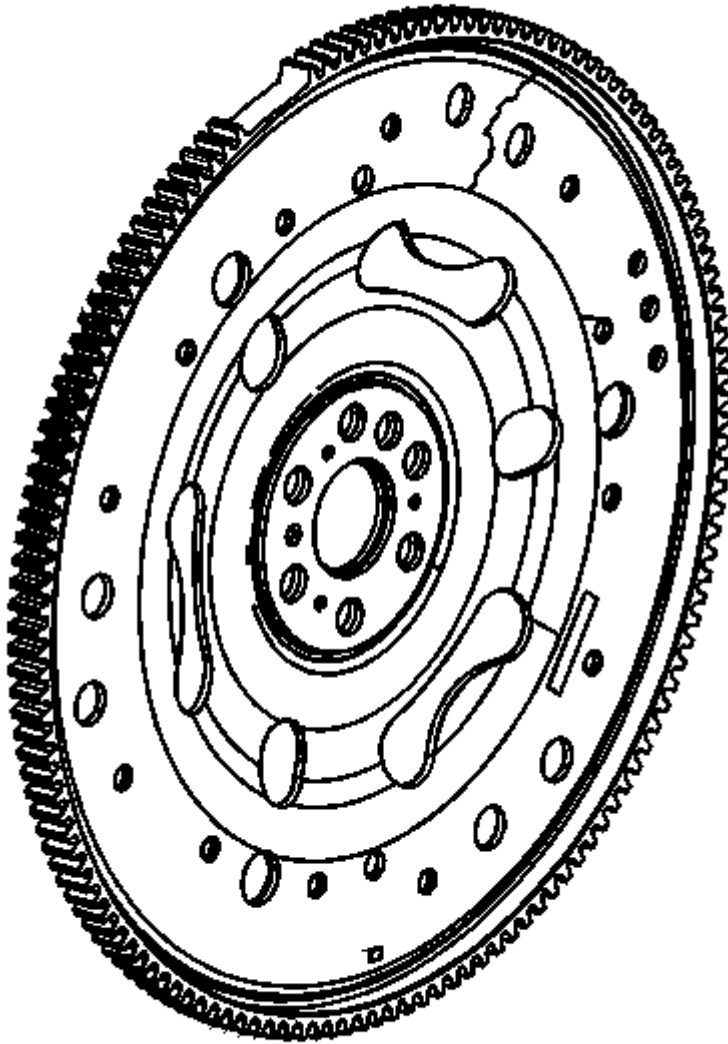


Fig. 246: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the engine flywheel with solvent.
2. Dry the engine flywheel with compressed air.
3. Inspect the engine flywheel for the following:

- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations

IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.

- Welded areas that retain the ring gear onto the flywheel for cracking

Piston and Connecting Rod Disassemble

Tools Required

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

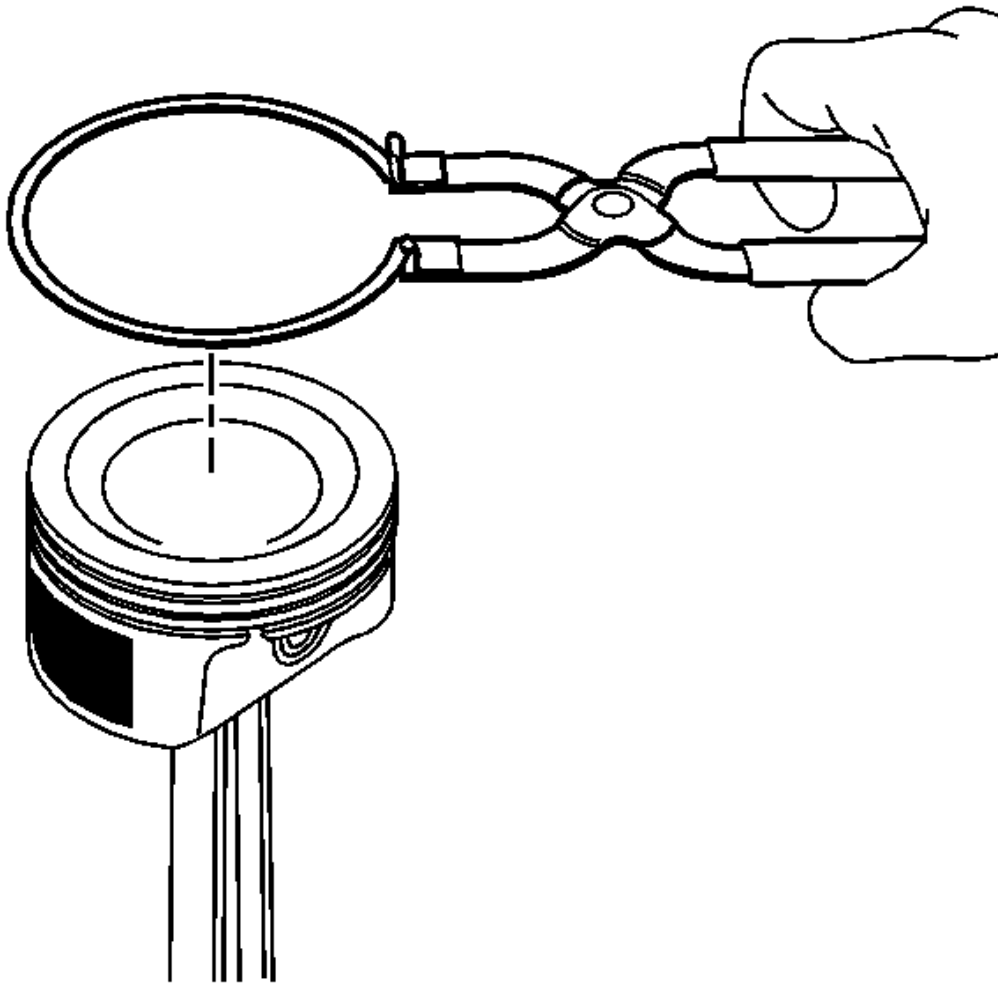


Fig. 247: View Of Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This procedure is to be used for oversized pistons only. Standard size pistons are supplied as an assembly consisting of a piston, piston pin, connecting rod and piston rings.

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

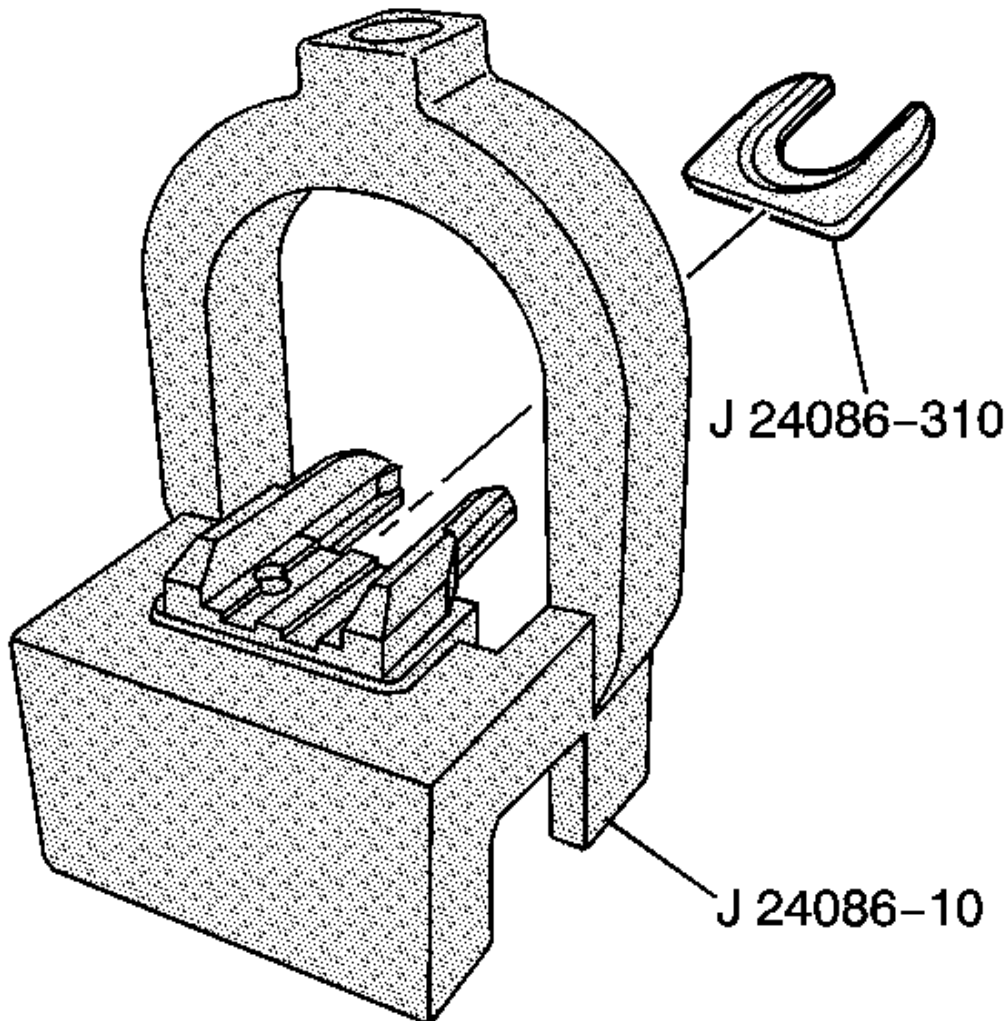


Fig. 248: Installing J 24086-310 Into J 24086-10
Courtesy of GENERAL MOTORS CORP.

2. Install fork insert J 24086-310 into fixture J 24086-10 piston pin remover/installer base, which are part of J 24086-C . See **Special Tools**.

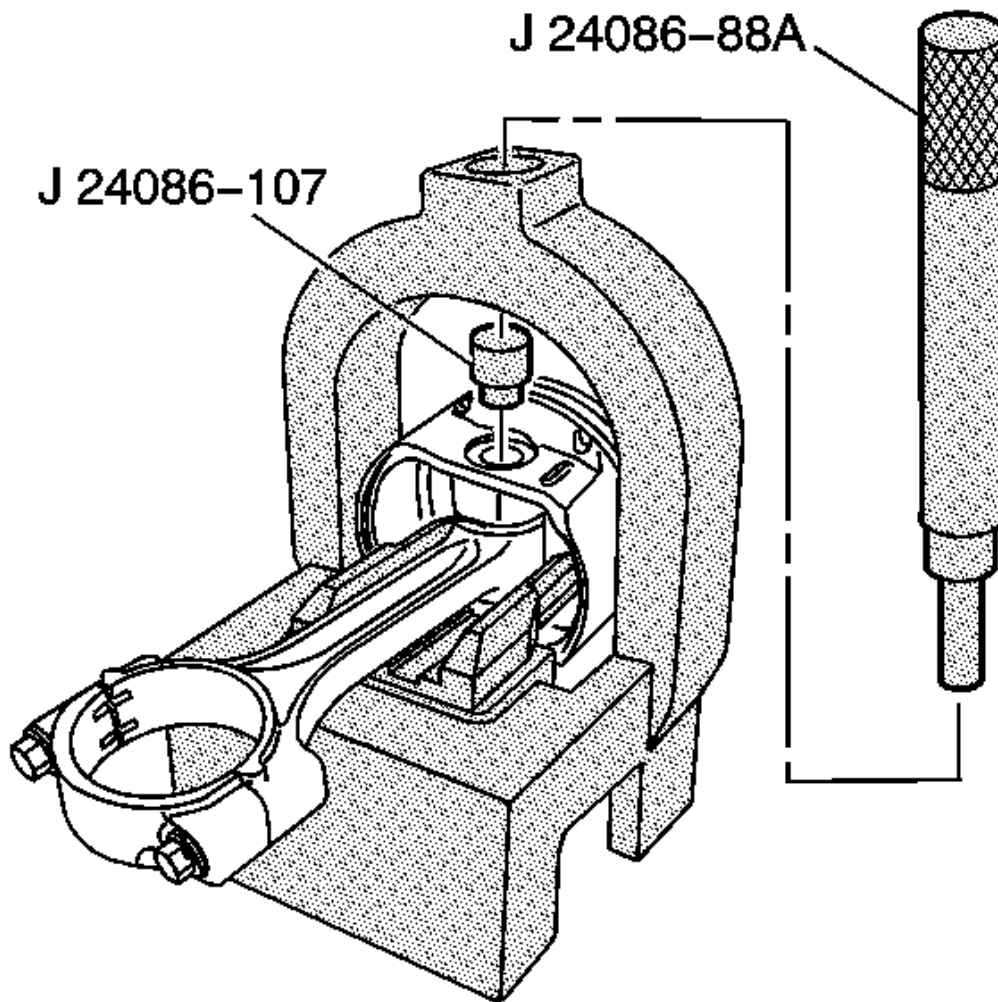


Fig. 249: View Of J 24086-107 & J 24086-88A
Courtesy of GENERAL MOTORS CORP.

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, which are part of **J 24086-C** . See **Special Tools**.

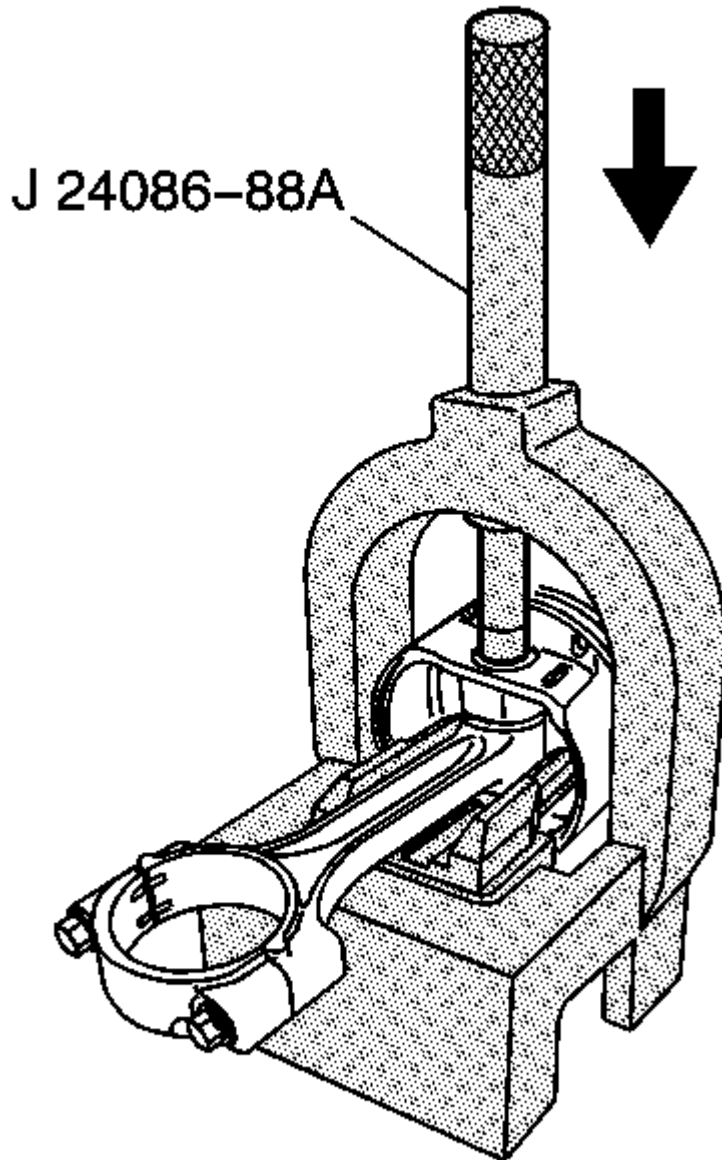


Fig. 250: View Of J 24086-88A
Courtesy of GENERAL MOTORS CORP.

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 organize the piston and the matching piston pin.

Piston, Connecting Rod, and Bearings Cleaning and Inspection**Tools Required**

J 8087 Cylinder Bore Gage. See **Special Tools**.

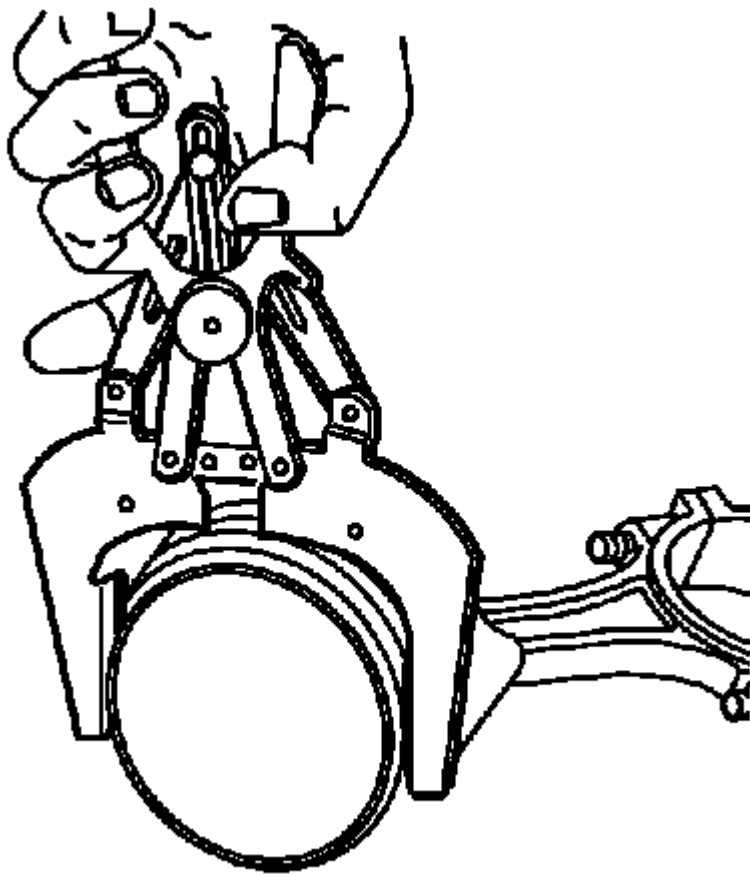


Fig. 251: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

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

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

IMPORTANT: Some steps in this procedure may reflect on a disassembled oversized piston. Others will only apply to the standard size pistons that are NOT to be disassembled.

1. Clean the piston and connecting rod in solvent.
2. Dry off the piston and connecting rod with compressed air.
3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.

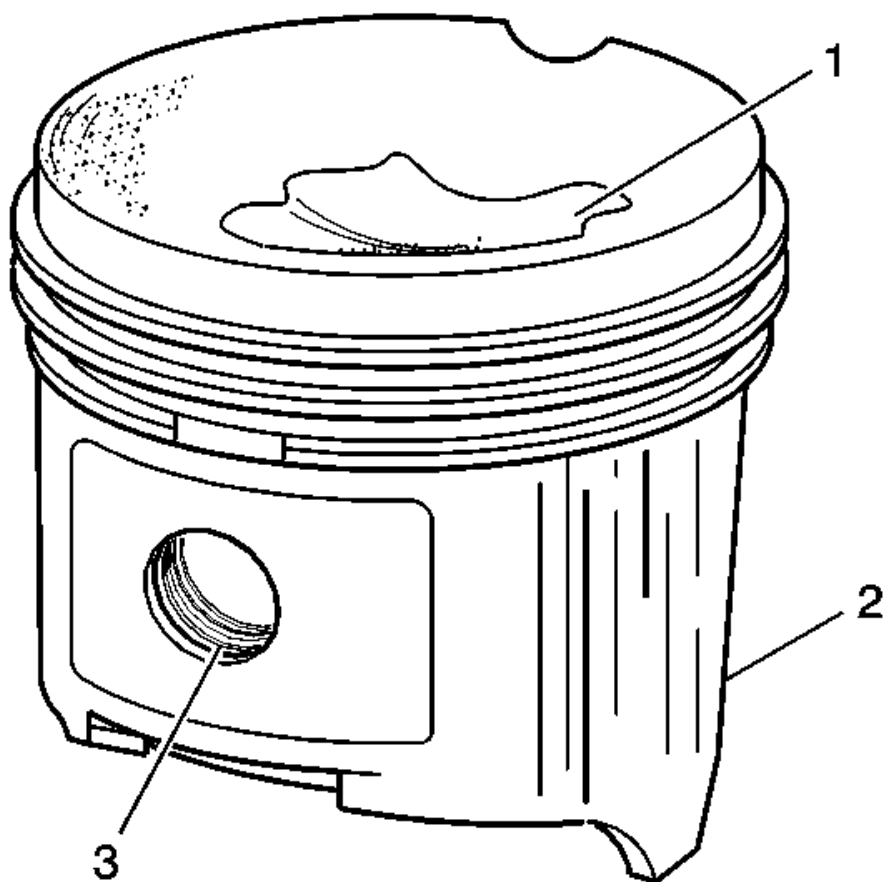


Fig. 252: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the piston for the following:
 - Eroded areas (1) on the top of the piston
 - Scuffed or damaged skirt (2)
 - Damage to the pin bore (3)

- Cracks in the piston ring lands, the piston skirt, or the pin bosses
 - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind
6. Inspect the piston pin for scoring, wear or other damage.

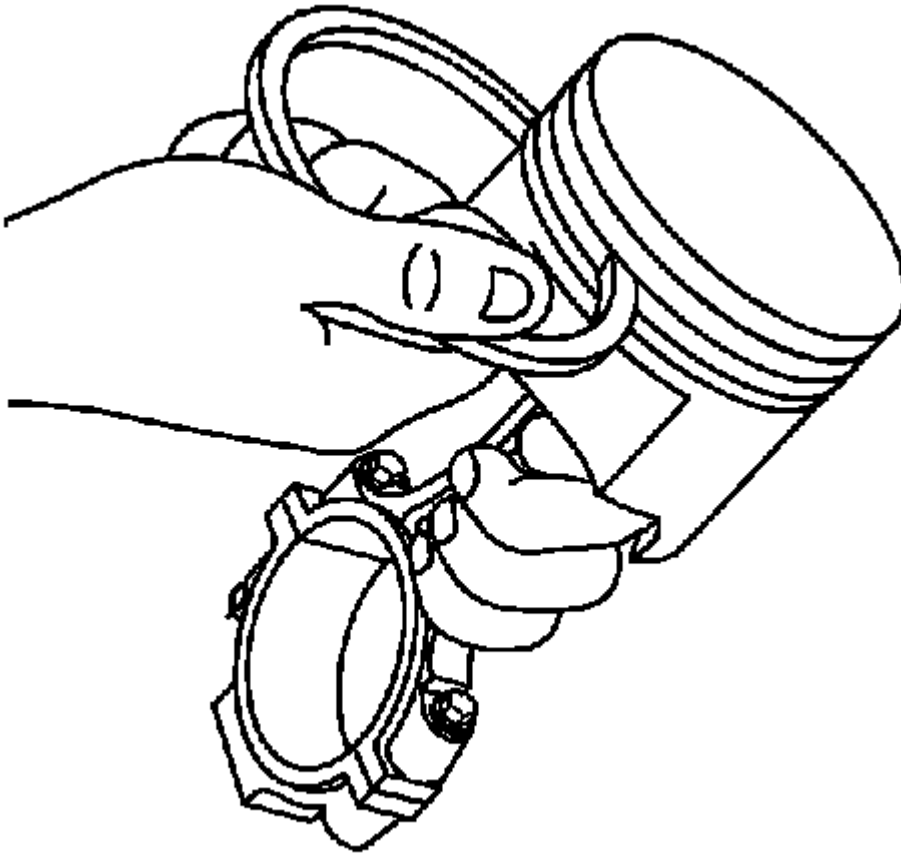


Fig. 253: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring-to-piston ring groove side clearance.
1. Insert the edge of the piston ring into the piston ring groove.
 2. Roll the piston ring completely around the piston ring groove.
 - If binding is caused by distorted piston ring groove, replace the piston.
 - If binding is caused by a distorted piston ring, replace the piston ring.

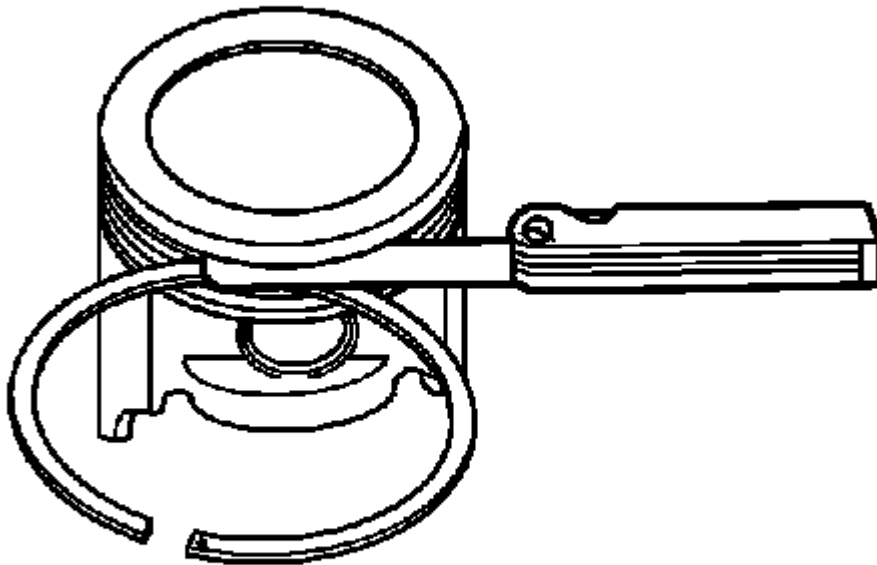


Fig. 254: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gage.
9. If the side clearance is too small try another ring set.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
 - Proper ring-to-piston ring groove clearance for the top ring is 0.03-0.076 mm (0.001-0.003 in).
 - Proper ring-to-piston ring groove clearance for the second ring is 0.04-0.078 mm (0.002-0.003 in).

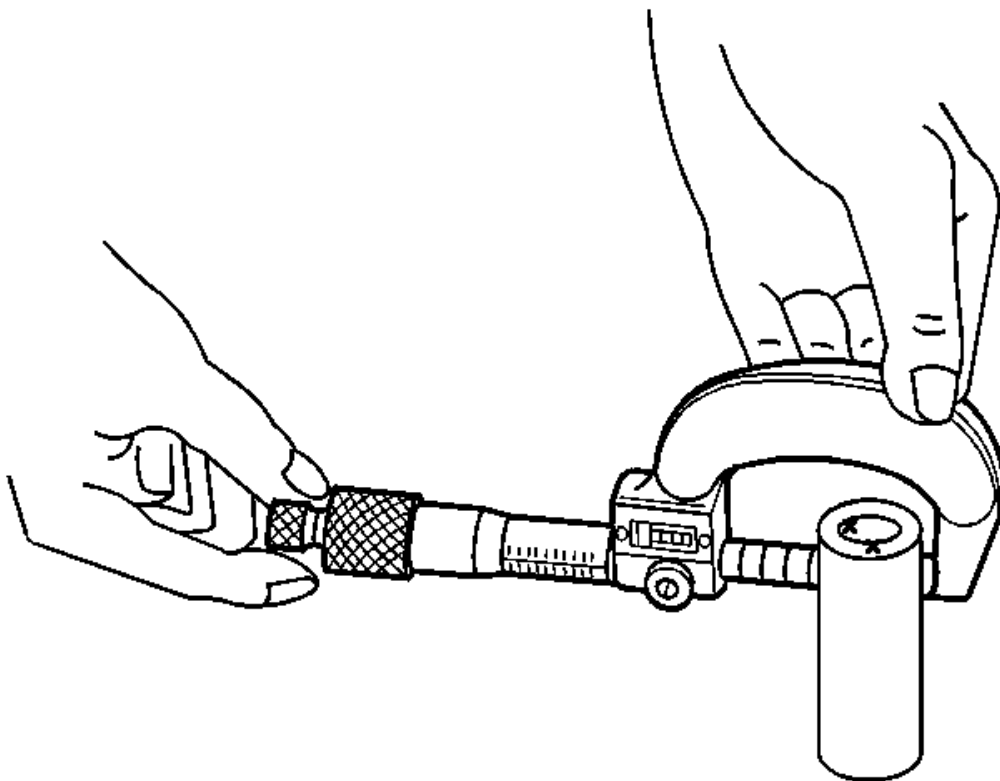


Fig. 255: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

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

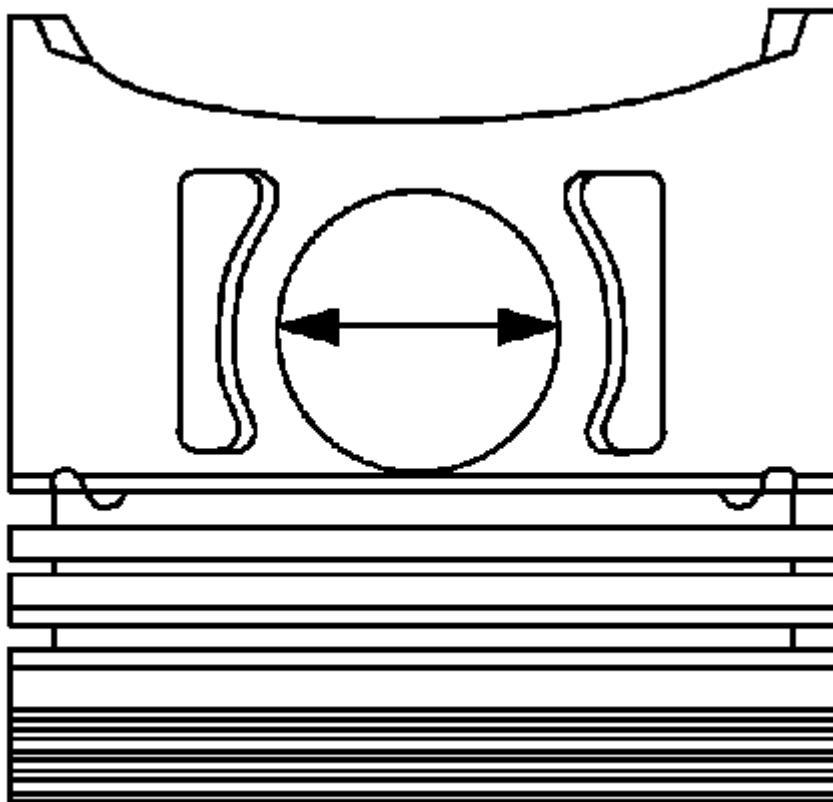


Fig. 256: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When fitting pistons, consider both the pistons and the cylinder bore conditions together. Production and service pistons have the same nominal weight and may be intermixed without affecting engine balance. If necessary, used pistons may be fitted selectively to any cylinder of the engine, providing the pistons are in good condition and the same weight. Do not cut oversize pistons down or the engine balance may be affected. Finish hone when selecting the pistons.

12. Measure the piston pin bore using an inside micrometer.
13. Subtract the piston pin diameter from the piston pin bore diameter in order to determine the piston pin-to-piston pin bore clearance.
14. Piston-to-piston pin bore clearance must measure 0.008-0.016 mm (0.0003-0.0006 in). Replace the piston and the piston pin if the piston and the piston pin are not within specifications.

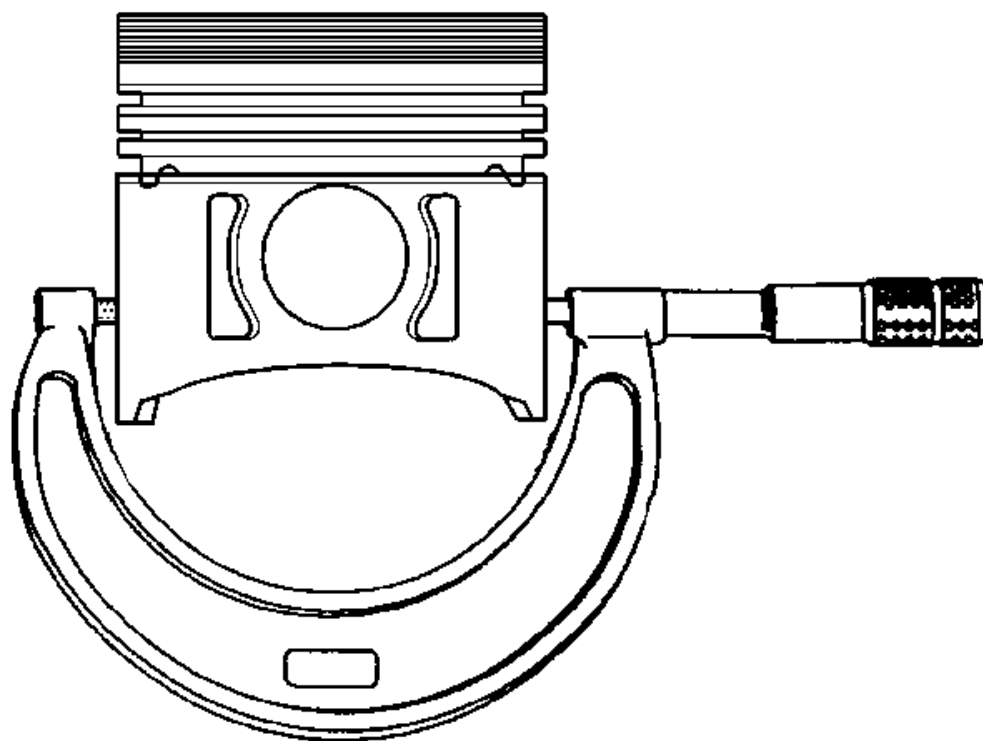


Fig. 257: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

15. Measure the piston diameter with a micrometer at a right angle to the piston bore with the piston pin removed, and record the measurement. Measure the piston at 43 mm (1.692 in) from dome of piston. Piston diameter must measure no less than 93.960 mm (3.699 in). Replace the piston and the pin as an assembly if the piston is not within specifications.

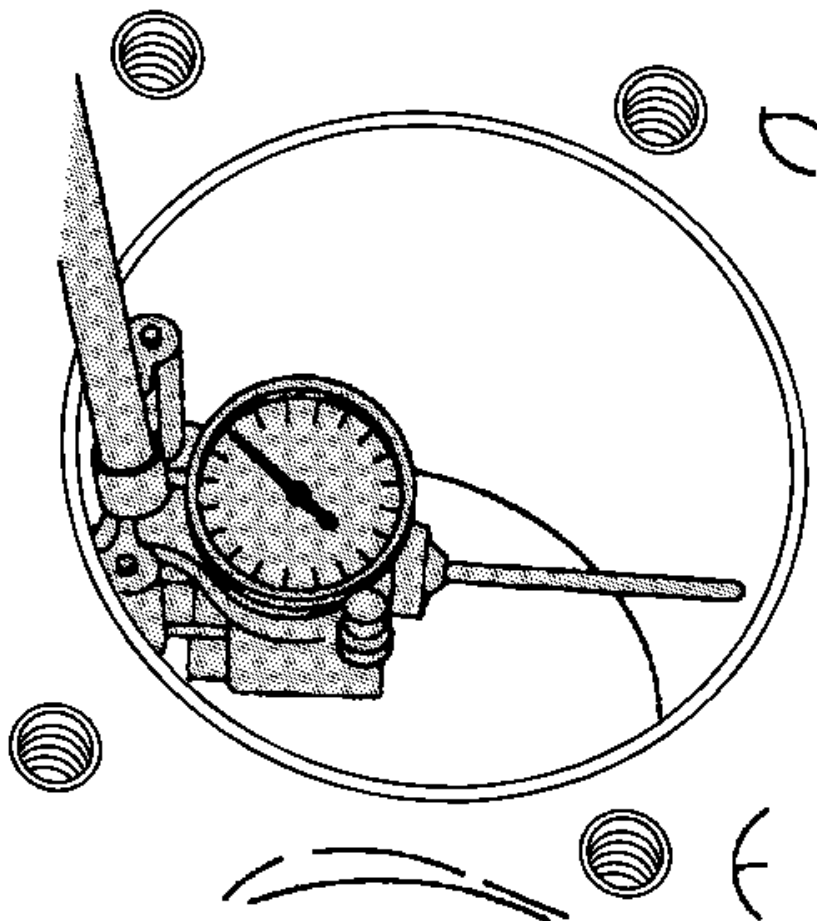


Fig. 258: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

16. Measure the cylinder bore, using **J 8087** . See **Special Tools**.

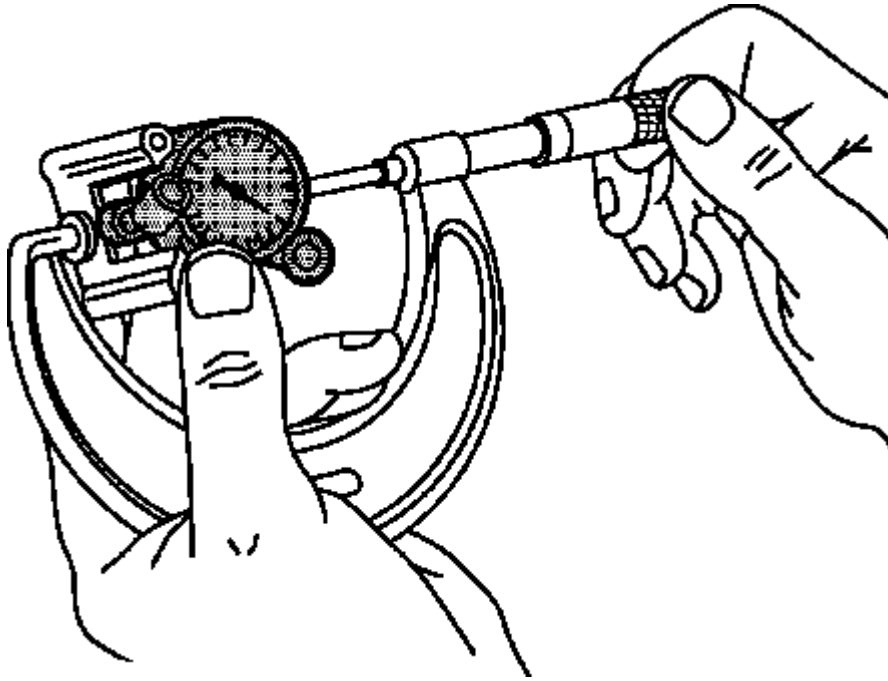


Fig. 259: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

17. Measure the **J 8087** . See **Special Tools**. Record this reading.
18. Subtract the diameter of the piston from the diameter of the cylinder bore to determine the piston-to-bore clearance. The cylinder bore clearance must be no more than 0.080 mm (0.003 in).
19. If a used piston is not acceptable, inspect the service piston size and determine if a new piston may be selected. Service pistons are available in standard and 0.5 mm (0.012 in) oversize.
20. When a piston has been selected, mark the piston in order to identify the cylinder for which the piston was fitted.

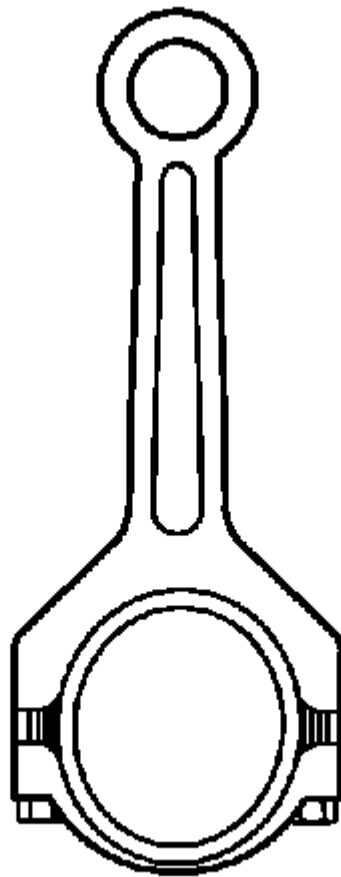


Fig. 260: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

21. 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.

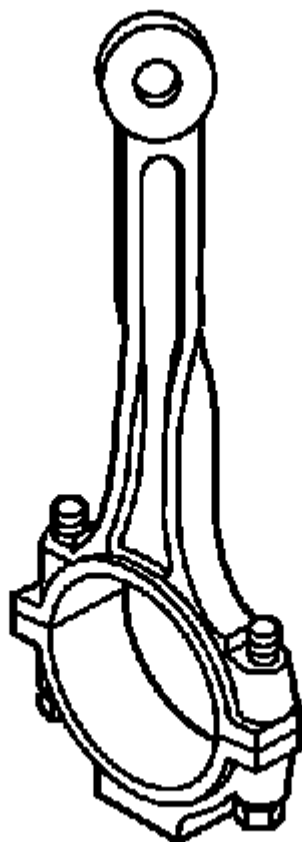


Fig. 261: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

22. Inspect the connecting rod for twisting.
 1. Install the connecting rod cap.
 2. Place the connecting rod assembly on a checking fixture. Inspect the assembly for bending or twisting.
 3. Do not attempt to straighten the connecting rod. Ensure that the connecting rod meets the following conditions:
 - The connecting rods are not bent more than 0.18 mm (0.007 in).
 - The connecting rods are not twisted more than 0.38 mm (0.0015 in).
 4. Replace any bent or twisted connecting rods.
 5. Inspect the new connecting rods before using the new rods.
23. Inspect the connecting rod for damage to the bearing cap and bolt threads.

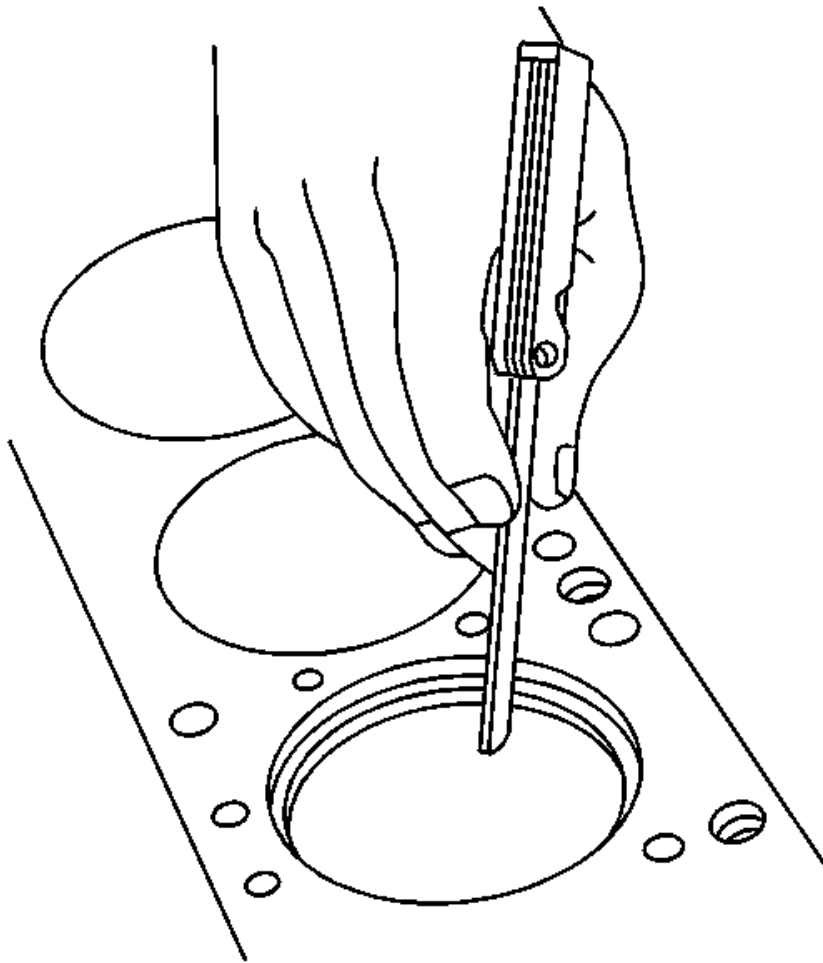


Fig. 262: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

24. 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 0.18-0.39 mm (0.007-0.015 in), the second compression ring must measure 0.48-0.74 mm (0.019-0.029 in).
4. Select another size ring set if the end gap exceeds specifications. If ring gap clearance is below specifications, increase the gap by carefully filing off excess material.

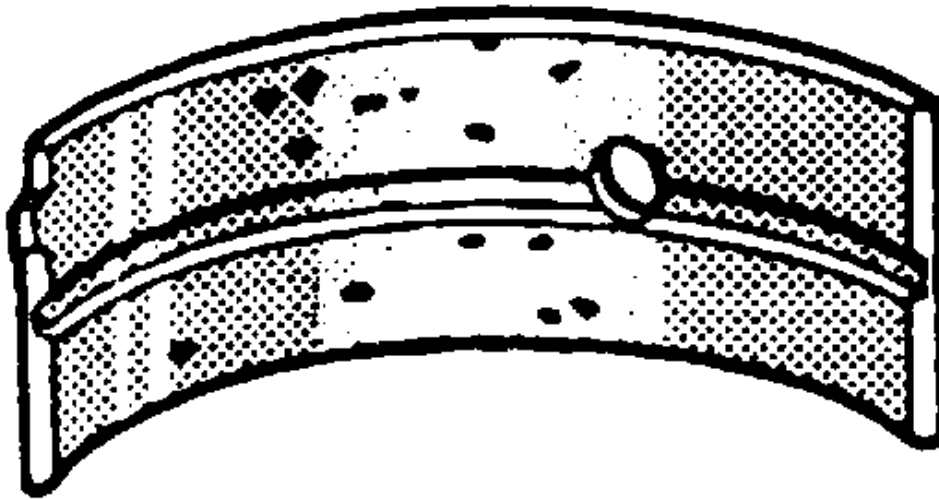


Fig. 263: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

25. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the connecting rod bearing halves may indicate fatigue.

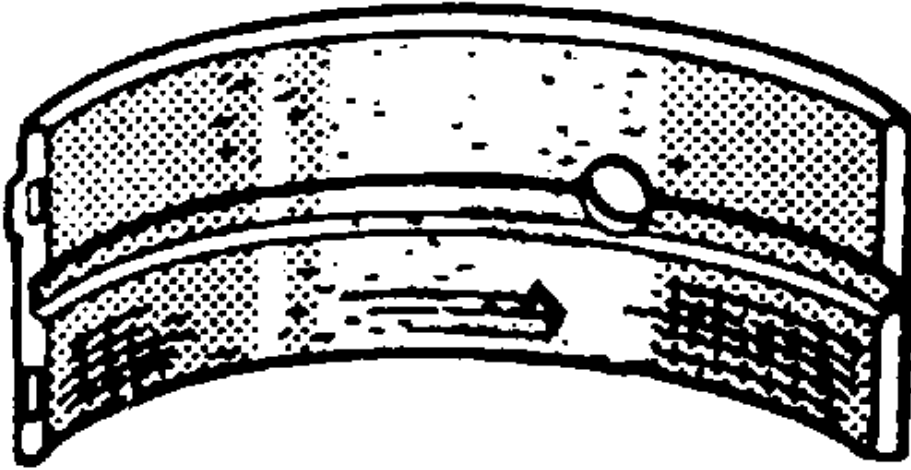


Fig. 264: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

26. Inspect the connecting rod bearings for excess scoring or discoloration.
27. Inspect the connecting rod bearings for dirt or debris imbedded into the connecting rod bearing halves.

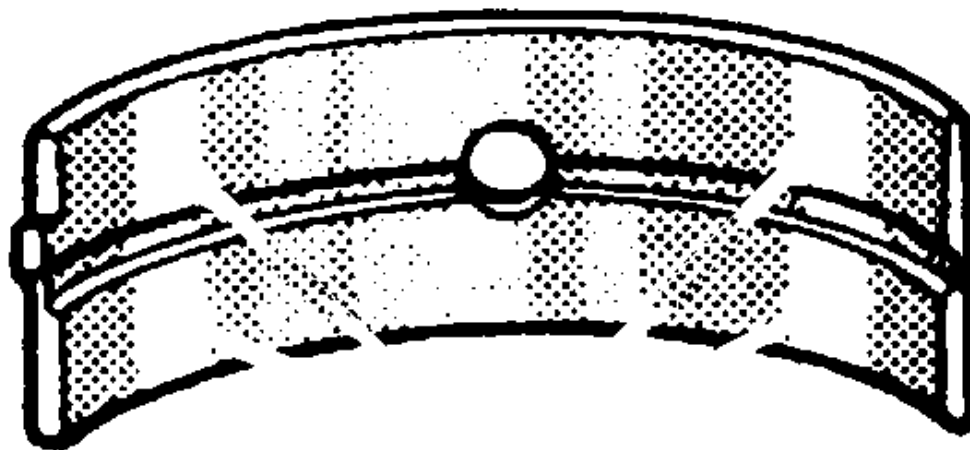


Fig. 265: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

28. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearings.
29. 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/Installer Set. See **Special Tools**.

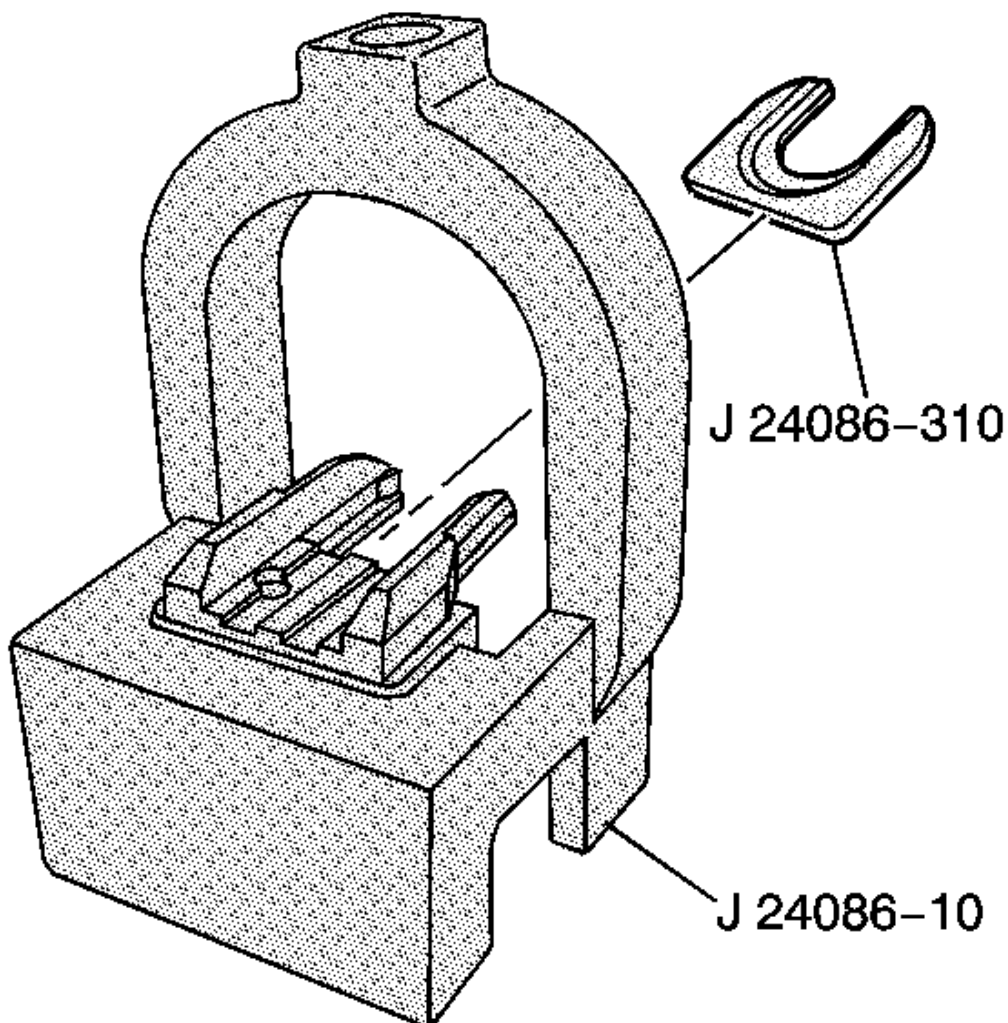


Fig. 266: Installing J 24086-310 Into J 24086-10
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This procedure is to be used for oversized pistons only. Standard size pistons are supplied as an assembly consisting of a piston, piston pin, connecting rod and piston rings. Assemble the piston for the specific cylinder with the connecting rod for the corresponding crankshaft journal.

1. Install fork insert J 24086-310 into fixture J 24086-10, which are part of J 24086-C . See Special Tools.

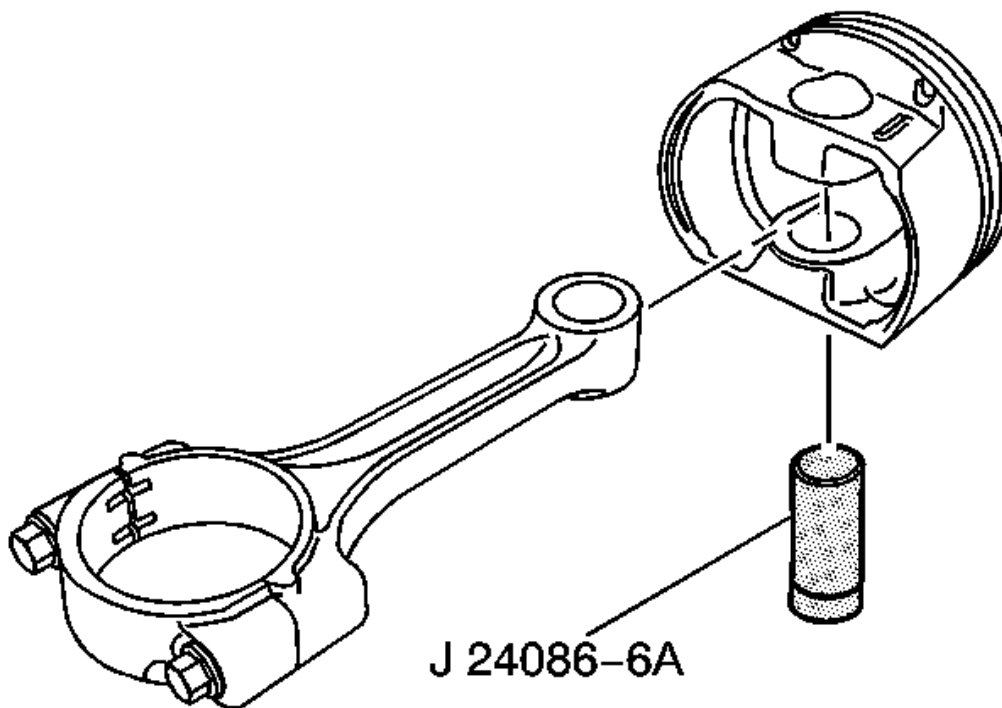


Fig. 267: Assemble J 24086-C With Piston Assembly
Courtesy of GENERAL MOTORS CORP.

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, which are part of J 24086-C . See Special Tools.

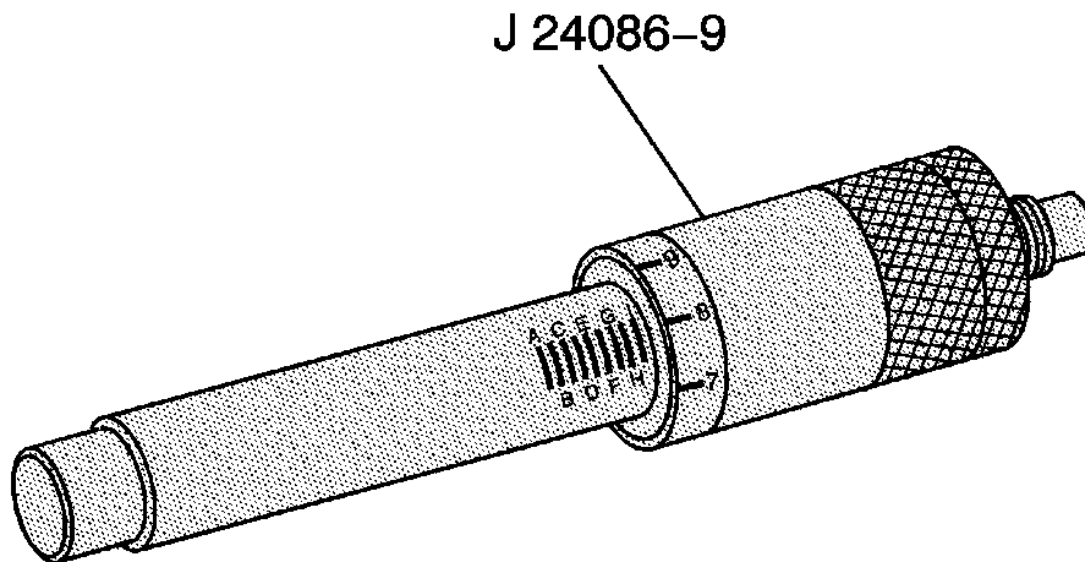


Fig. 268: Closeup View Of J 24086-9
Courtesy of GENERAL MOTORS CORP.

4. Adjust installation pin J 24086-9 to G-4.

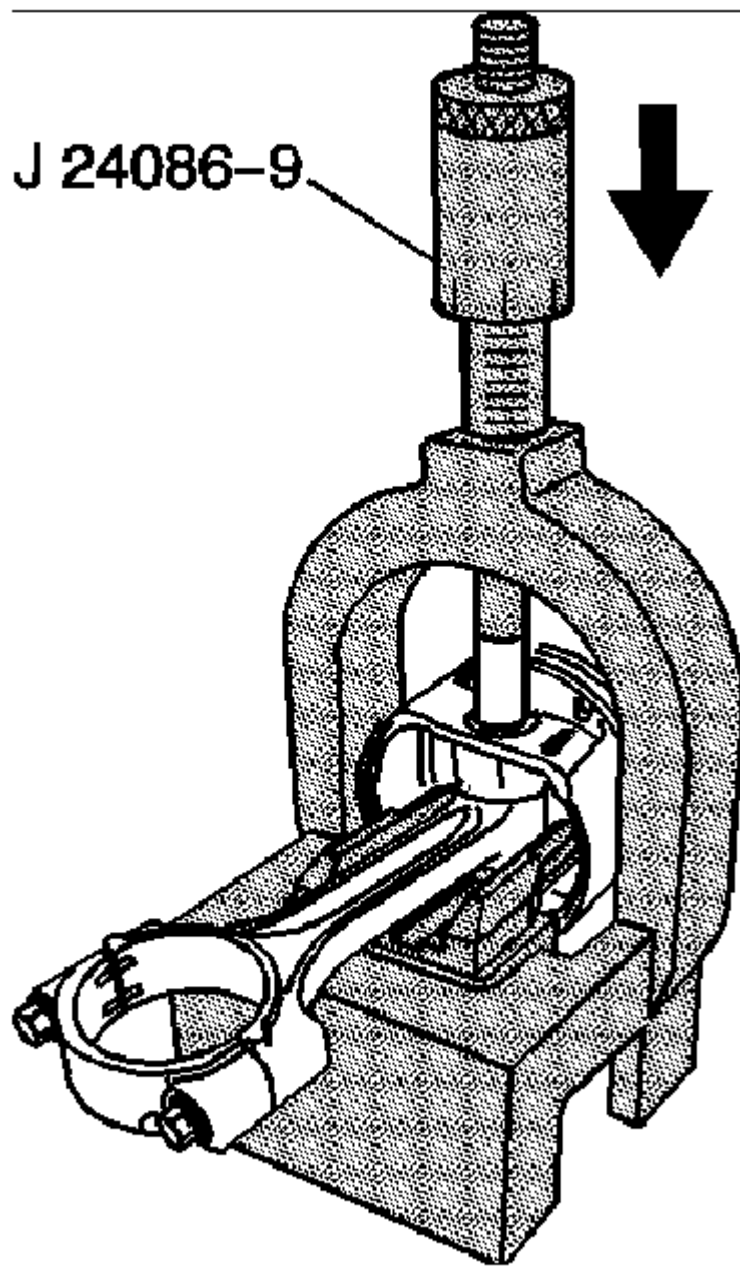


Fig. 269: View Of J 24086-9

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, which are part of **J 24086-C** and to the piston pin. See **Special Tools**.
6. Press pin J 24086-9 until it bottoms on fixture J 24086-10.

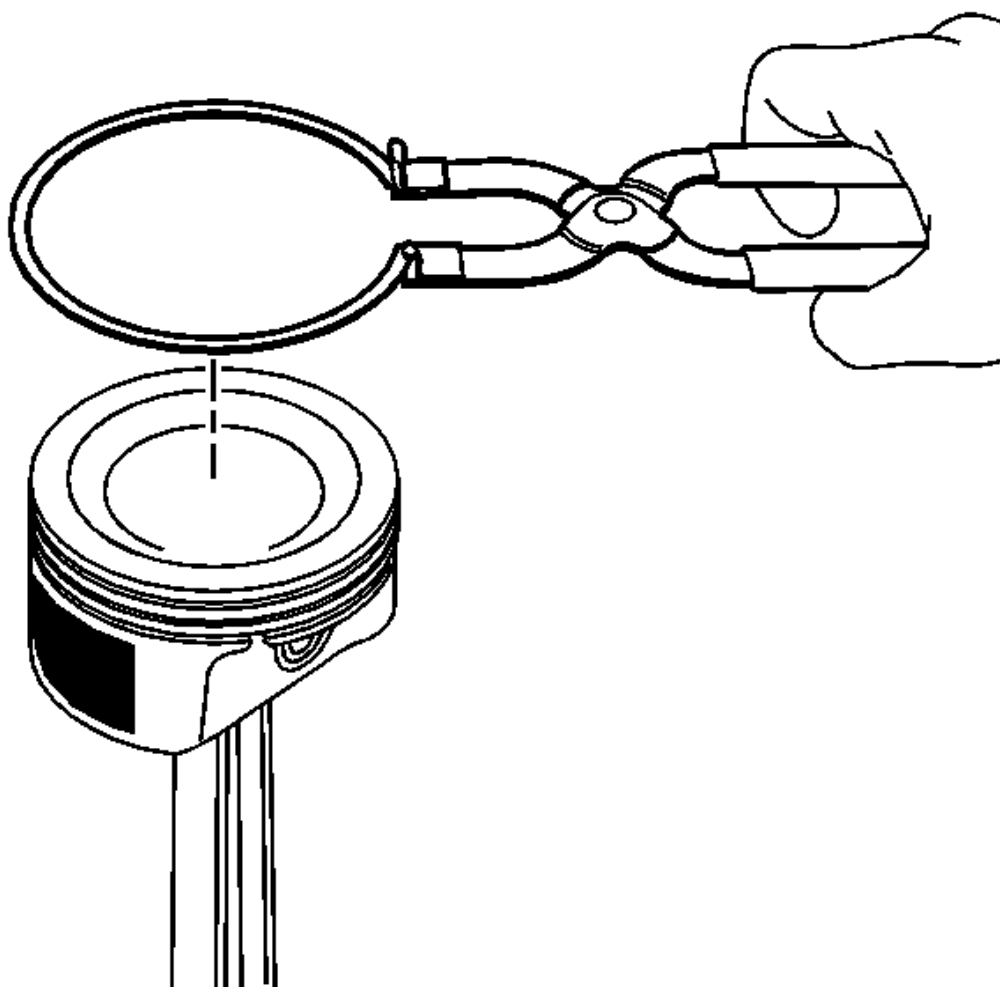


Fig. 270: View Of Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

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**.

1. Clean the camshaft with cleaning solvent.

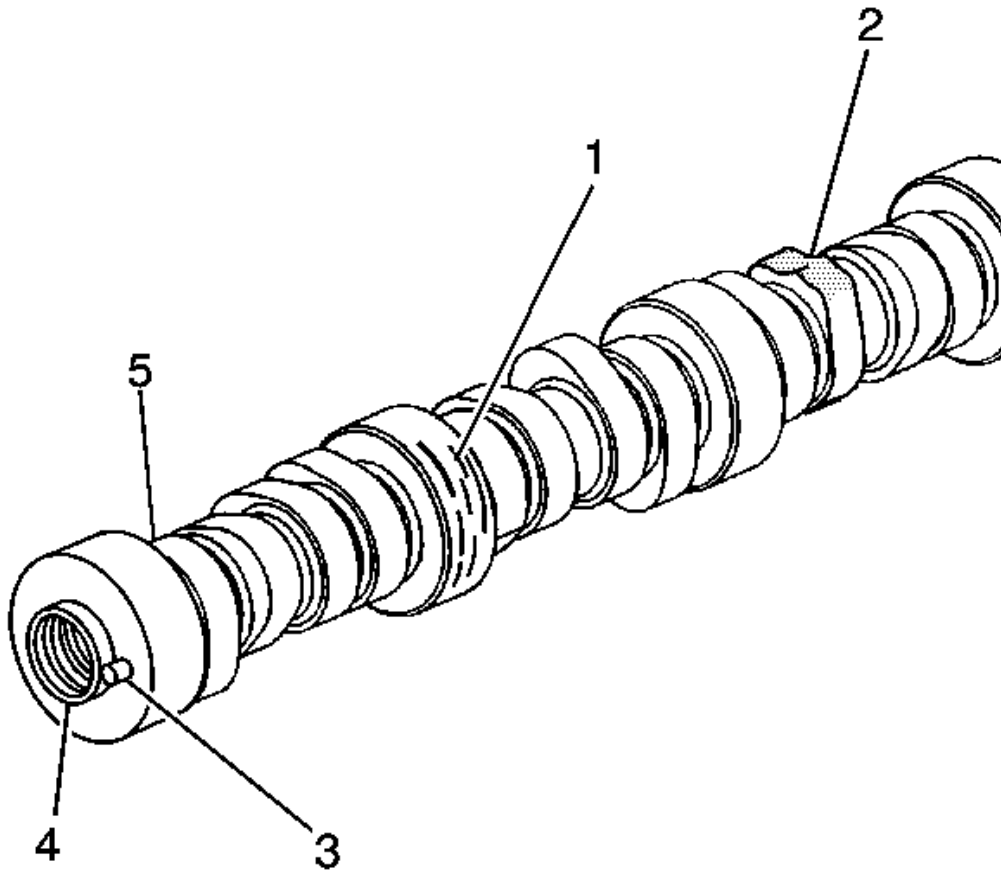


Fig. 271: Inspecting Camshaft
Courtesy of GENERAL MOTORS CORP.

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)

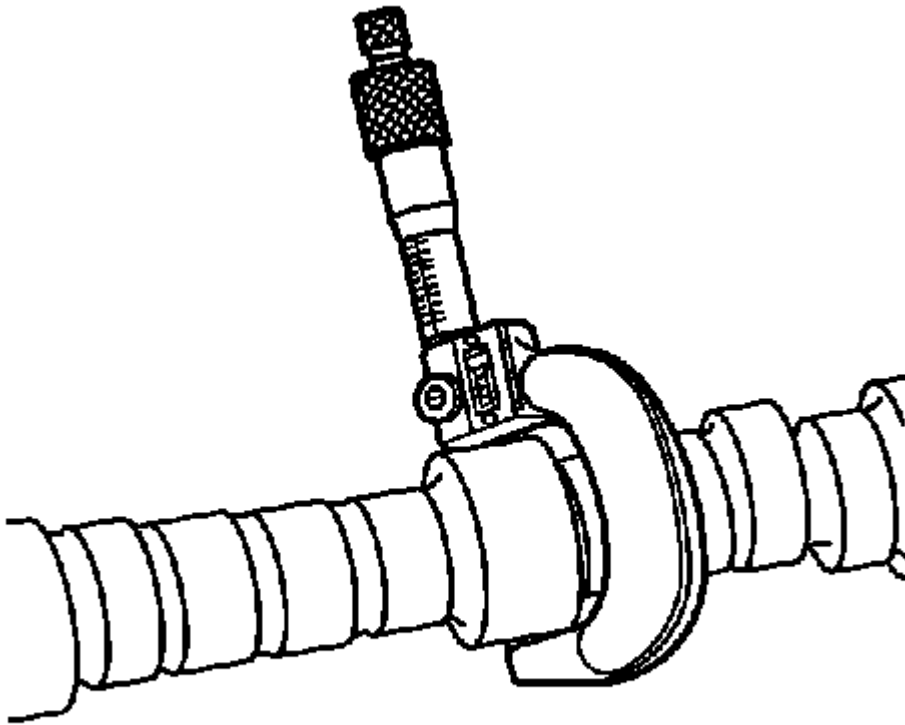


Fig. 272: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft journals using a micrometer.

If the camshaft journals are not within specifications, replace the camshaft.

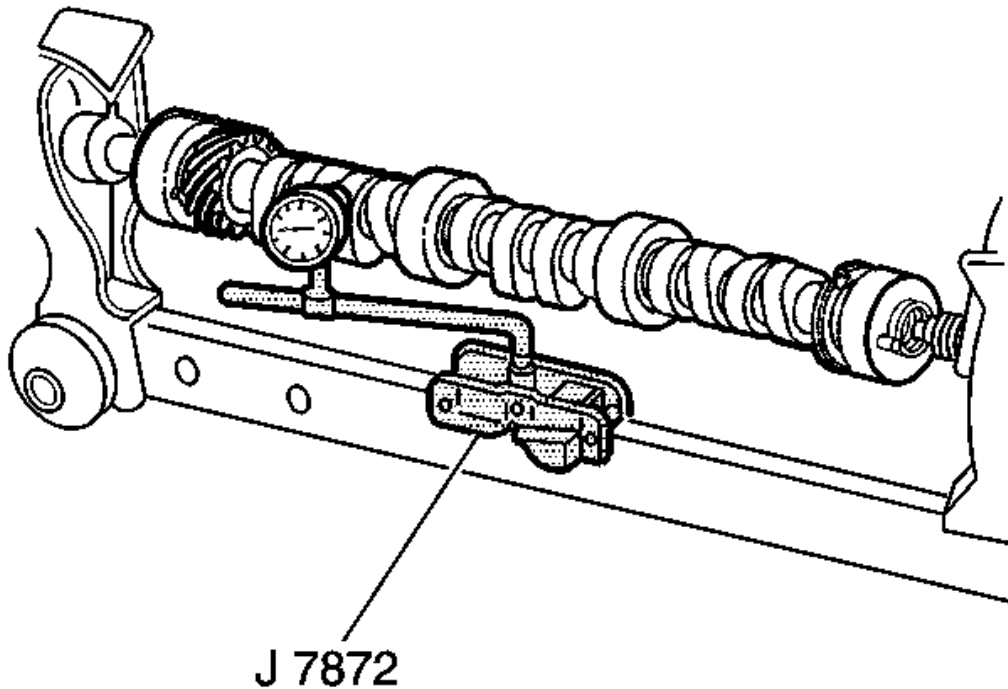


Fig. 273: Measuring Camshaft With J 7872
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft runout using the **J 7872** . See **Special Tools**.
 1. Mount the camshaft in V-blocks between the centers.
 2. Use the **J 7872** in order to measure the intermediate camshaft journal. See **Special Tools**.
5. Measure the camshaft lobe lift using the **J 7872** . See **Special Tools**.
 1. Lubricate the camshaft using GM P/N United States 12345501, GM P/N Canada 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**.
6. If the runout or lobe lift is not within specifications, replace the camshaft.

Timing Chain and Sprockets Cleaning and Inspection

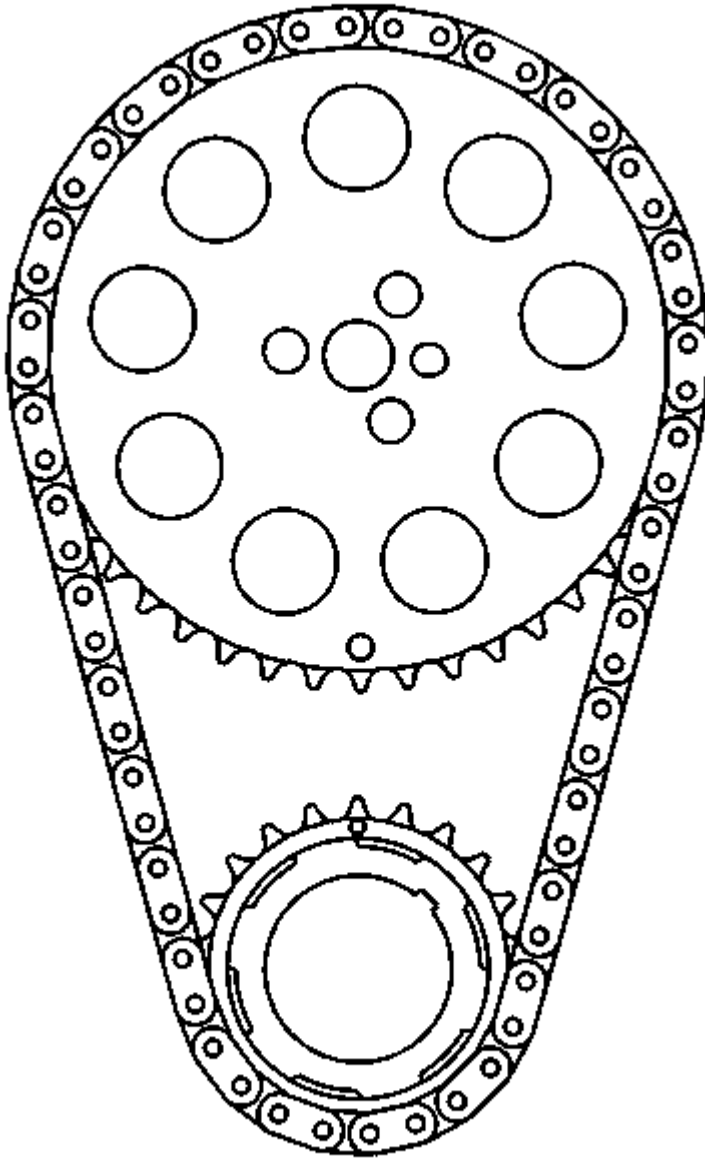


Fig. 274: View Of Camshaft & Crankshaft Sprockets Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

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

1. Clean all components with cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.

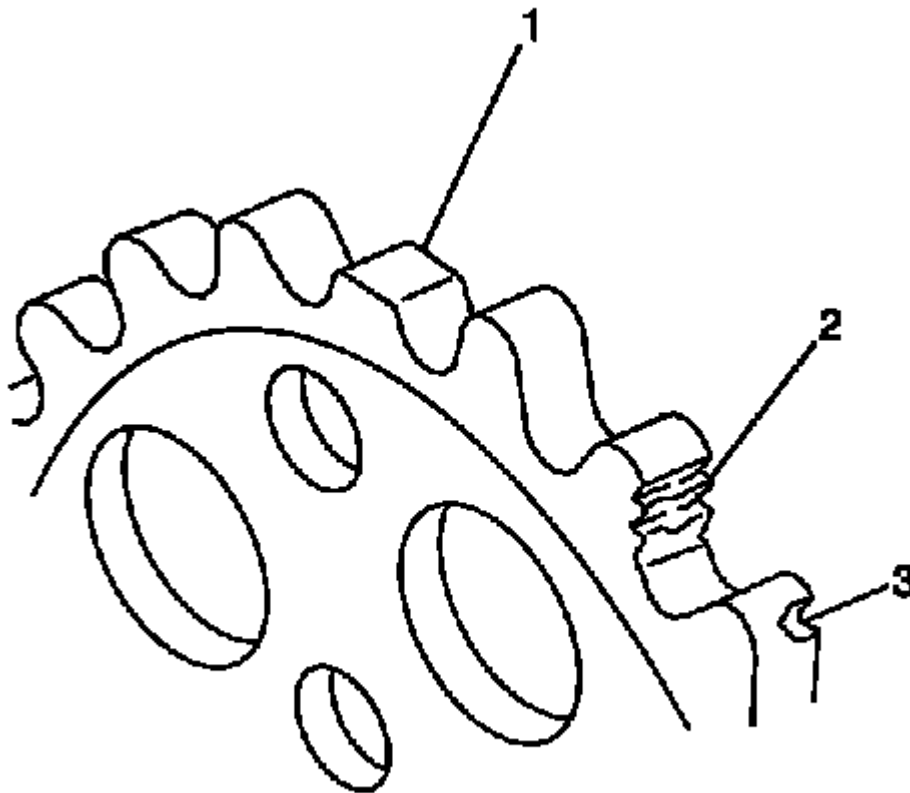


Fig. 275: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft and crankshaft sprockets for:
 - Worn teeth (1)
 - Broken teeth (2)
 - Chipped teeth (3)
5. Inspect the timing chain dampener for excessive wear or cracks.

Valve Lifters Cleaning and Inspection

1. Clean the valve lifters in cleaning solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the valve lifters with compressed air.

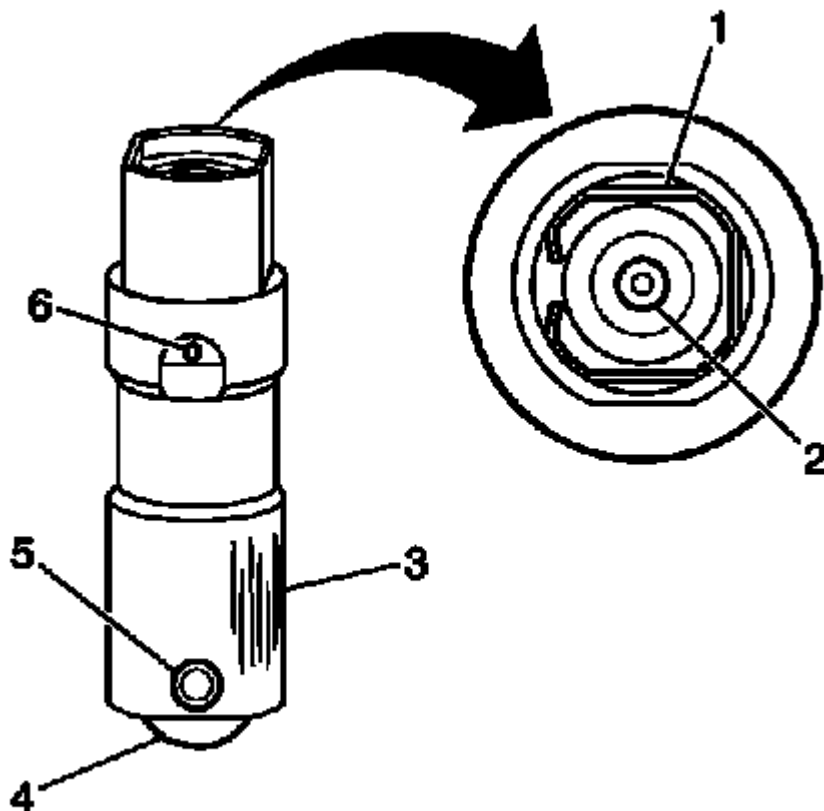


Fig. 276: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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.

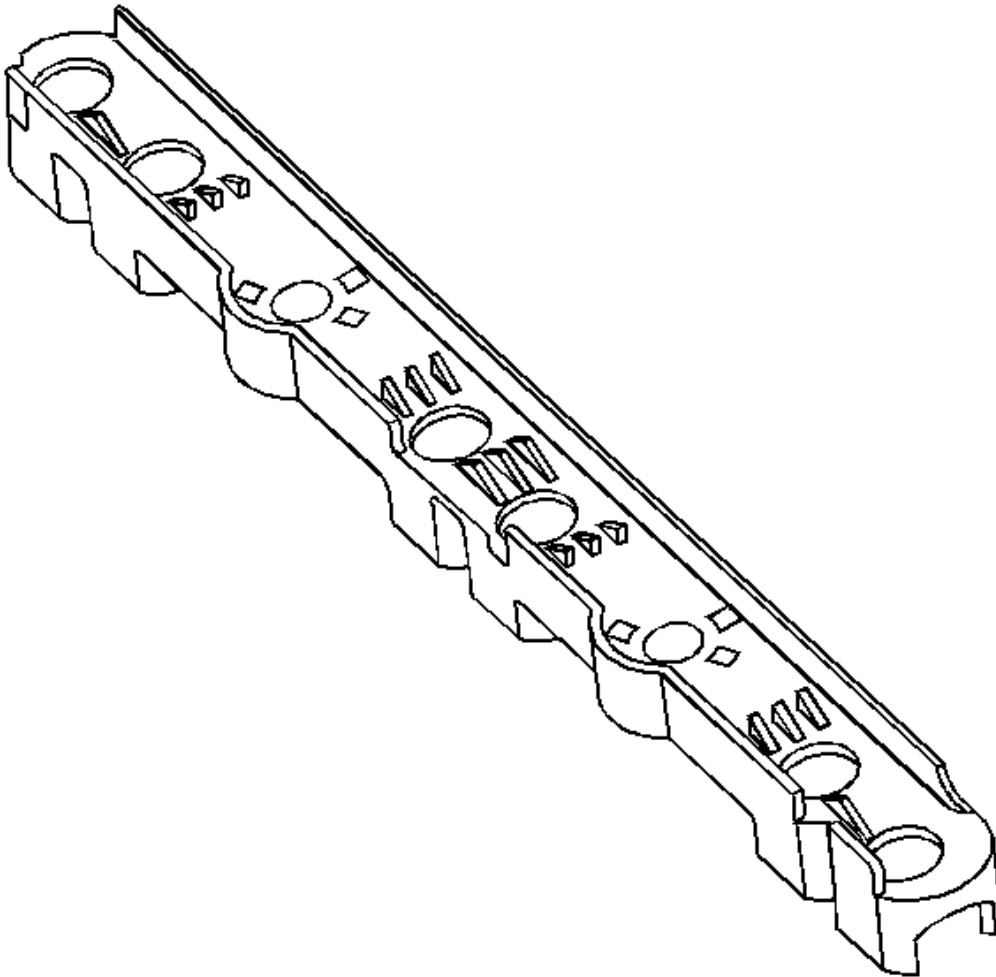


Fig. 277: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter guides for the following:
 - For cracks or damage
 - Excessive wear in the lifter mounting bores

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 Caution in Cautions and Notices.

2. Dry the valve rocker arms and push rods with compressed air.

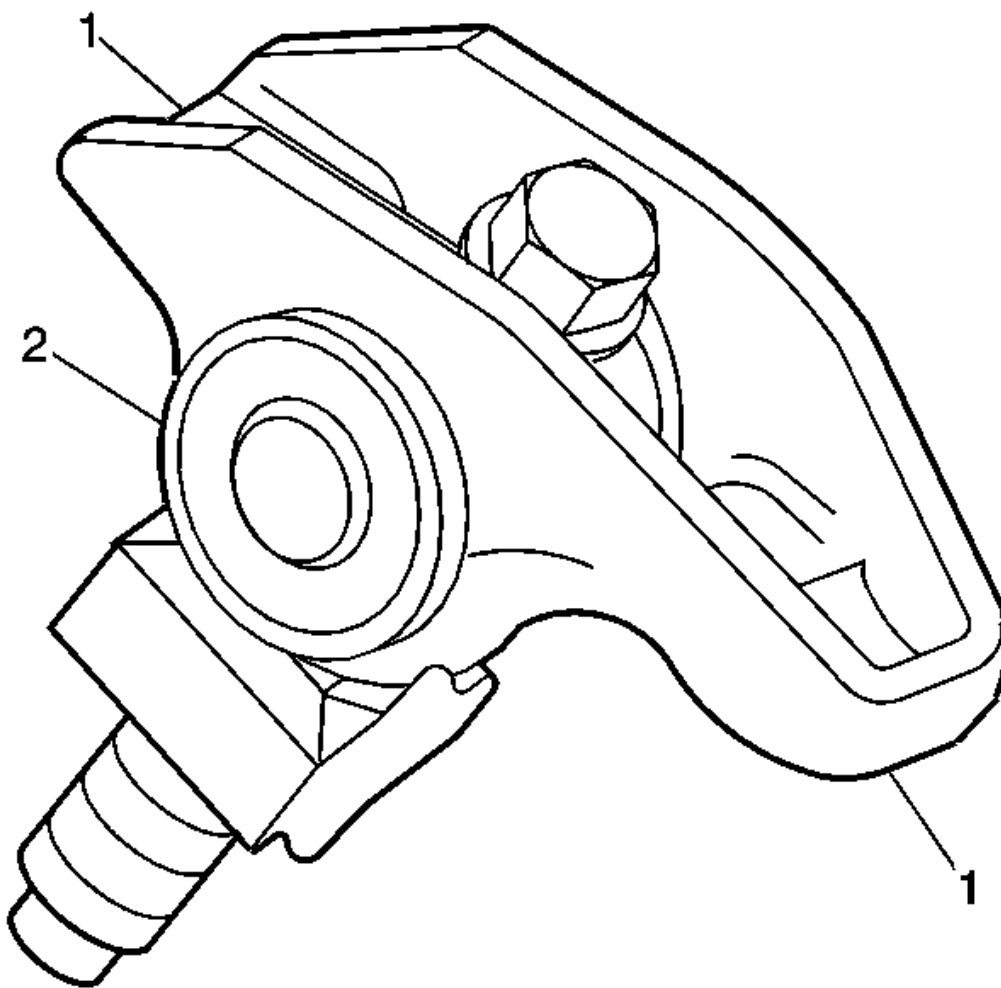


Fig. 278: Identifying Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

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

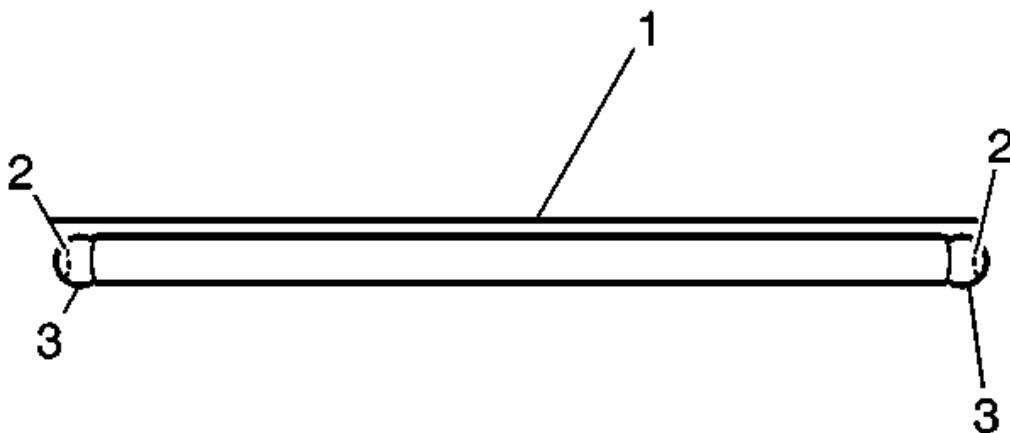


Fig. 279: Inspecting Push Rods

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**.

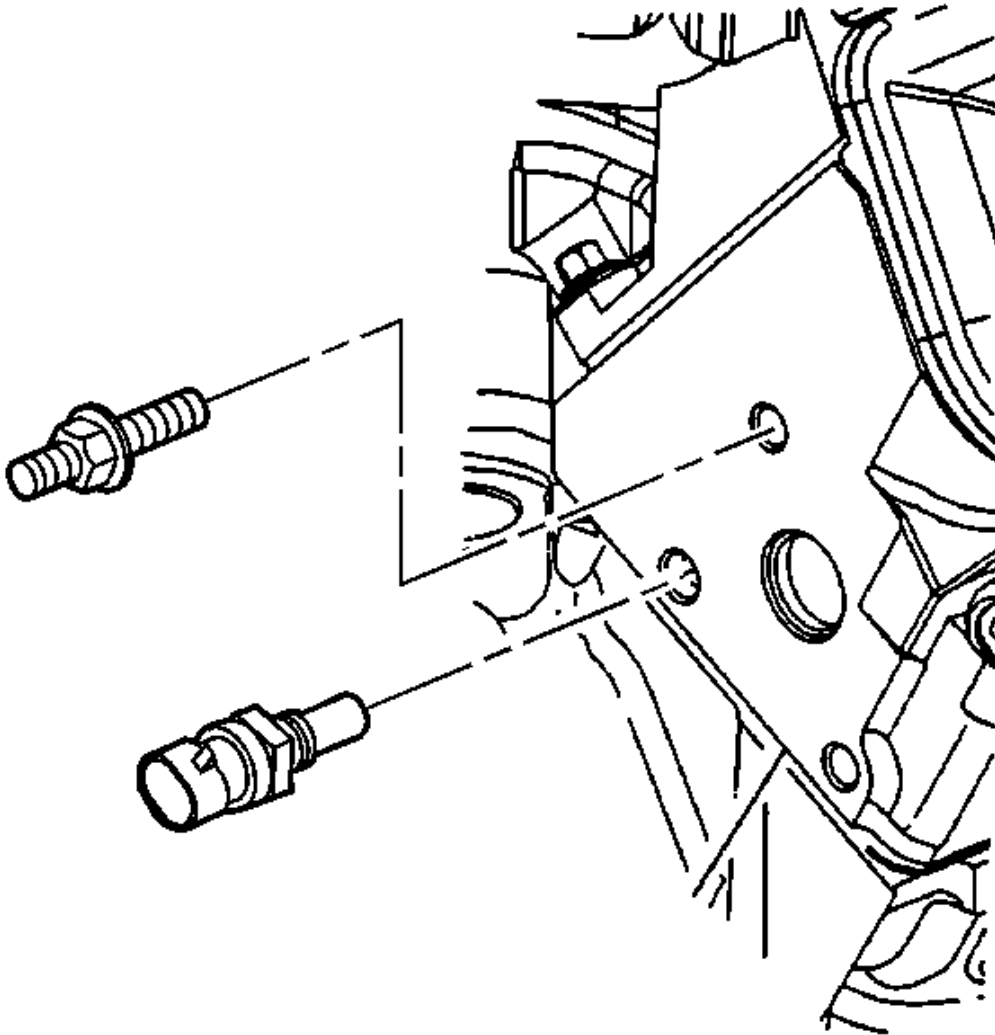


Fig. 280: View Of Heater Inlet Pipe Stud And Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the heater inlet pipe stud from the right cylinder head, if required.
2. Remove the coolant temperature sensor from the right cylinder head, if required.

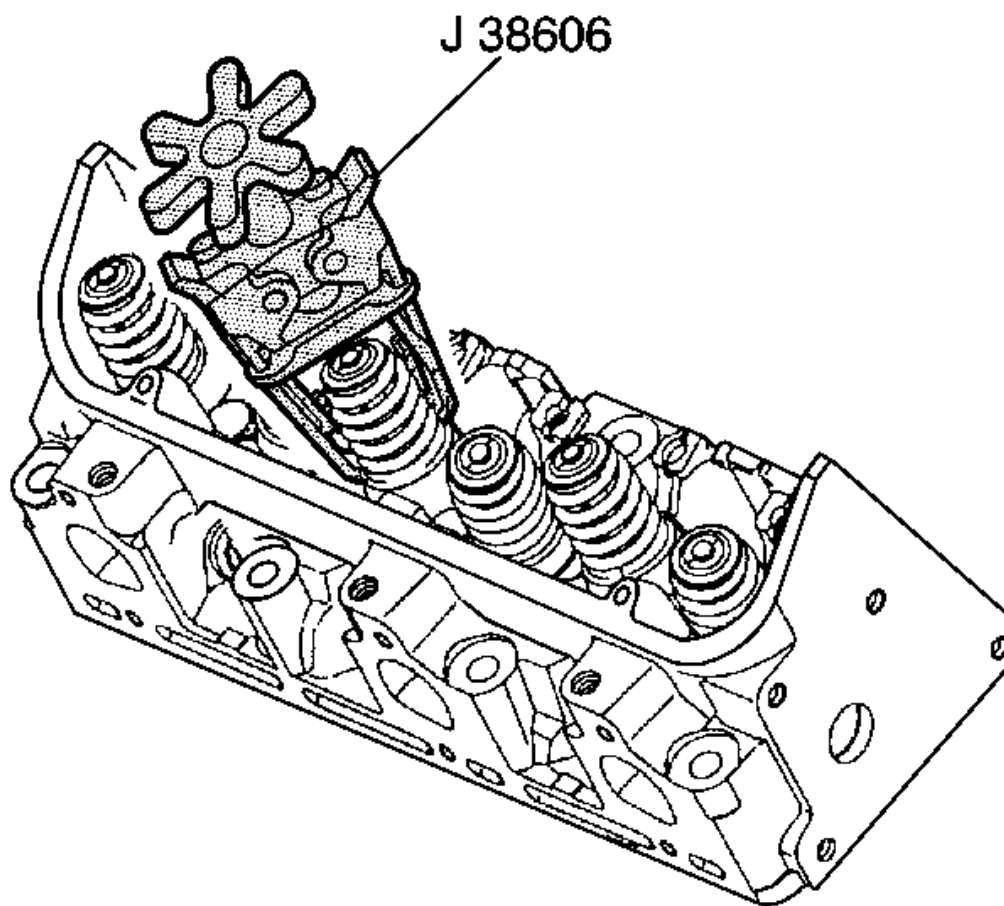


Fig. 281: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

3. Compress the valve springs using the **J 38606** . See **Special Tools**.

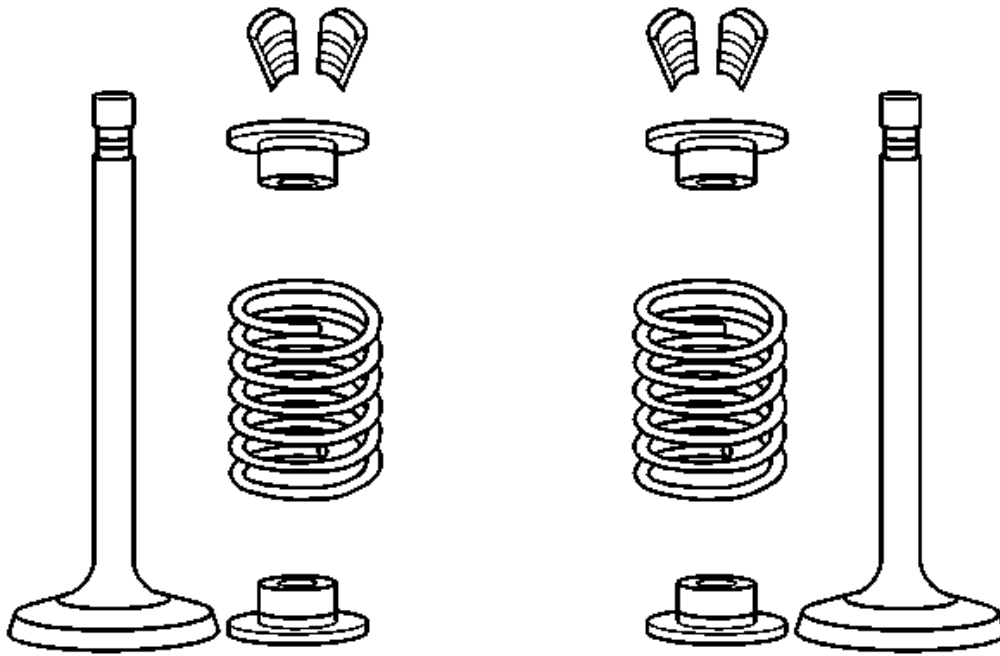


Fig. 282: Valve Locks, Caps, Seats & Spring

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

IMPORTANT: Ensure that the valve train components are marked, organized or sorted when disassembling the cylinder head. Install the valve train components in the original location from which the component were removed.

4. Remove the valve spring cap keys.
5. Remove the valve spring caps.
6. Remove the valve 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**.
- **J 9666** Valve Spring Tester

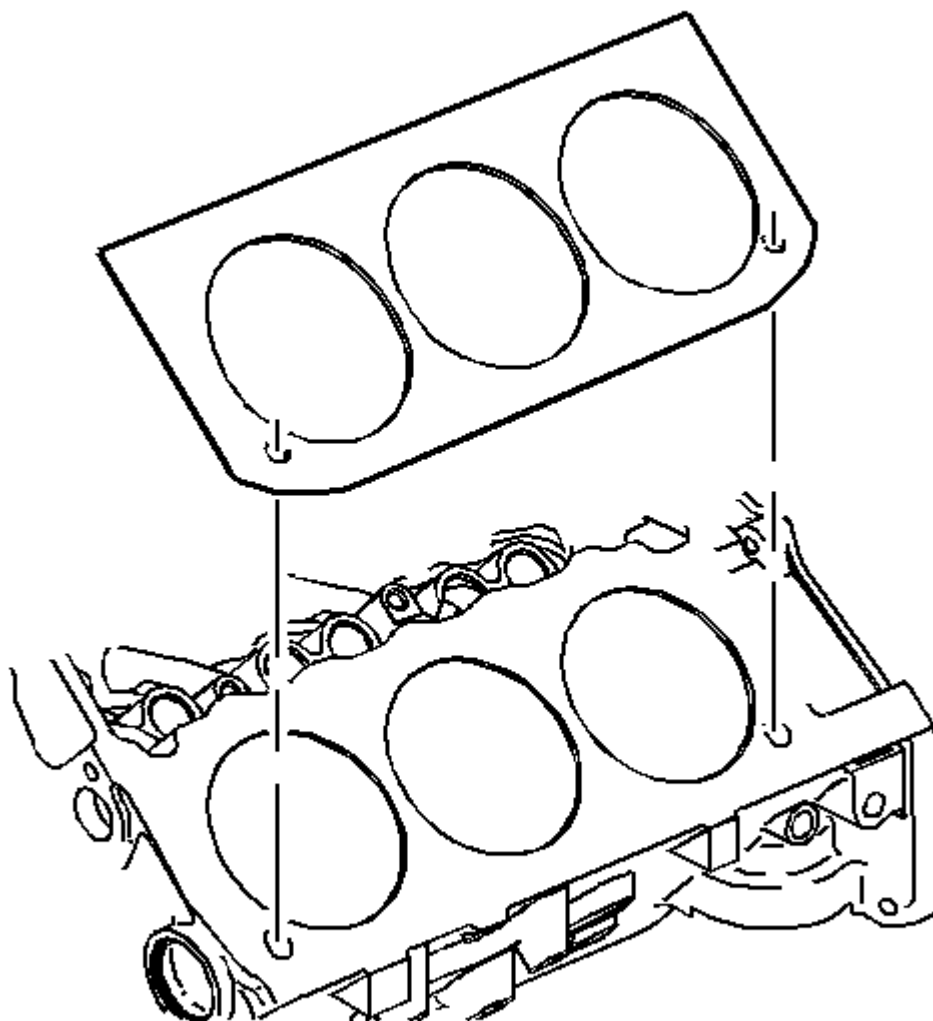


Fig. 283: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

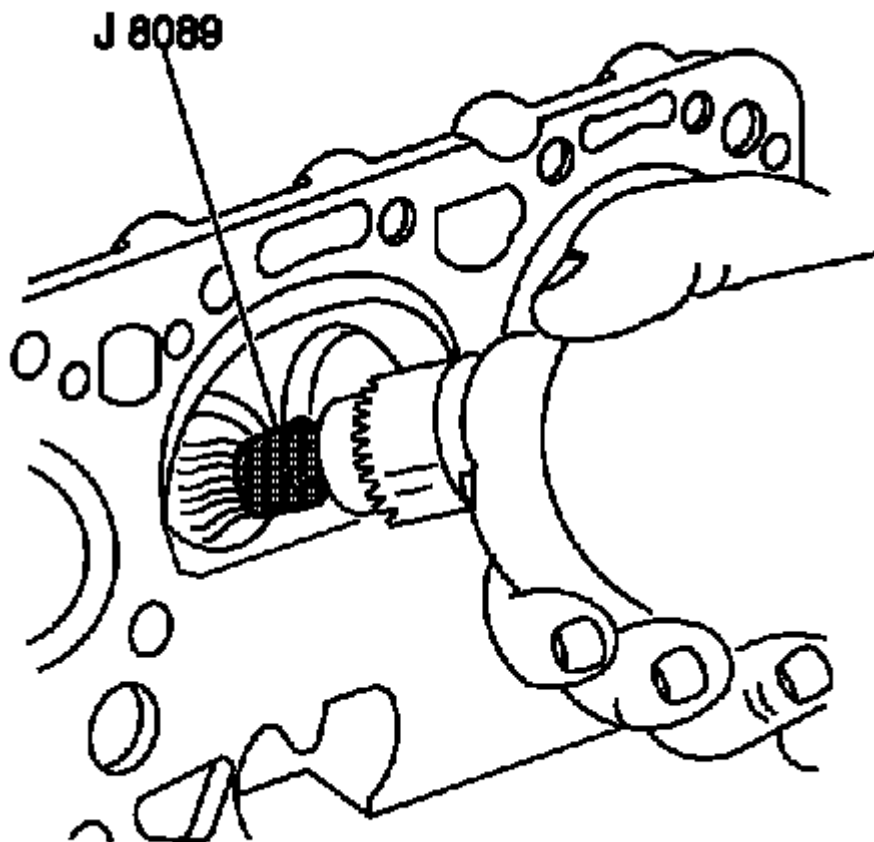


Fig. 284: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

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**.

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.

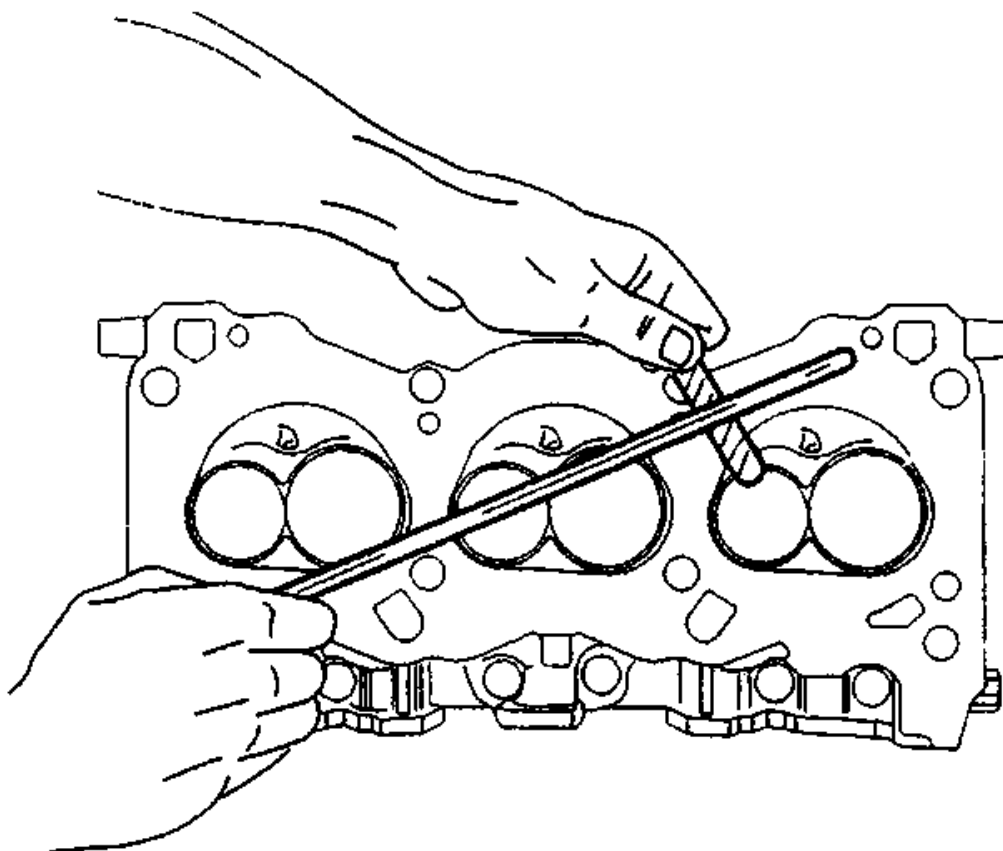


Fig. 285: Inspecting Cylinder Head Mating Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

5. Inspect the cylinder head mating surfaces for flatness. Replace the cylinder head if it is outside of the specification limit.
6. Inspect the cylinder head for cracks.

7. Inspect the cylinder head deck for corrosion. Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head.

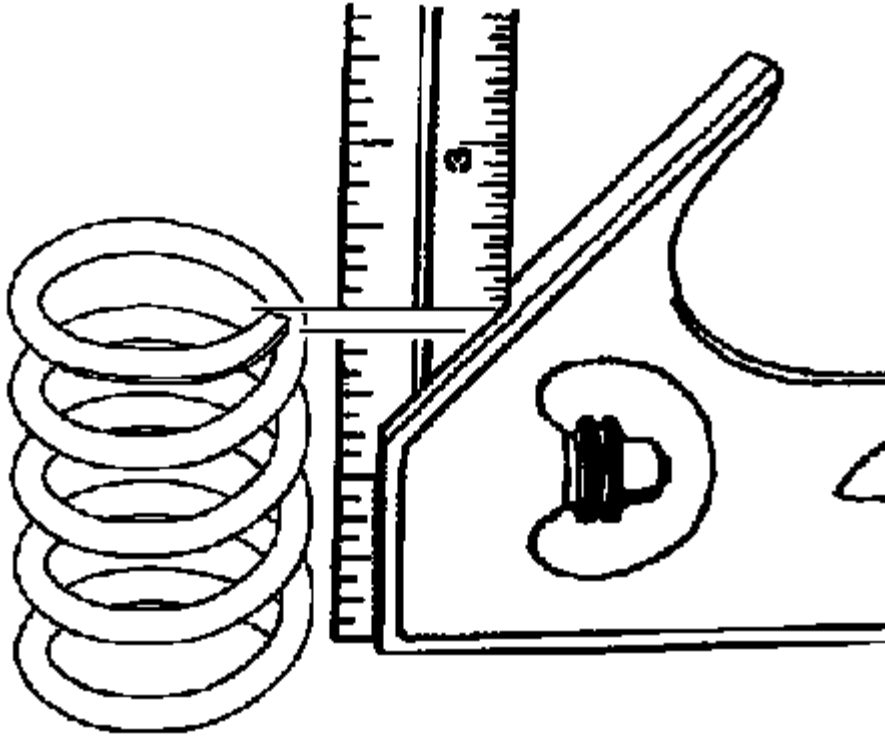


Fig. 286: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

8. Inspect the valve springs for squareness.

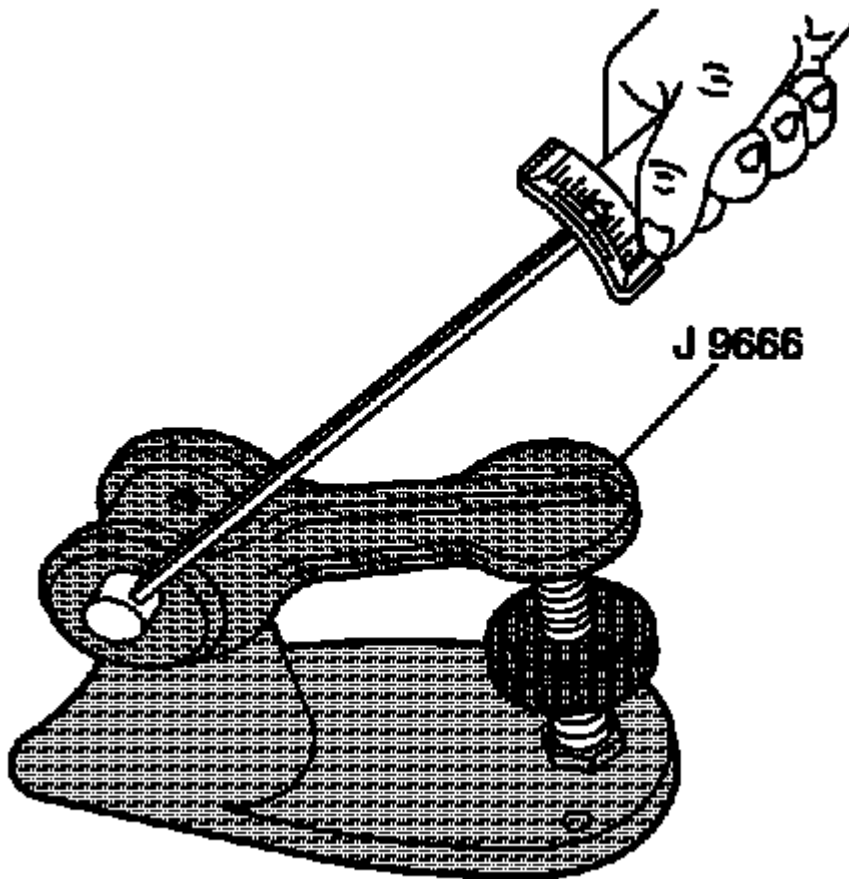


Fig. 287: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

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**.

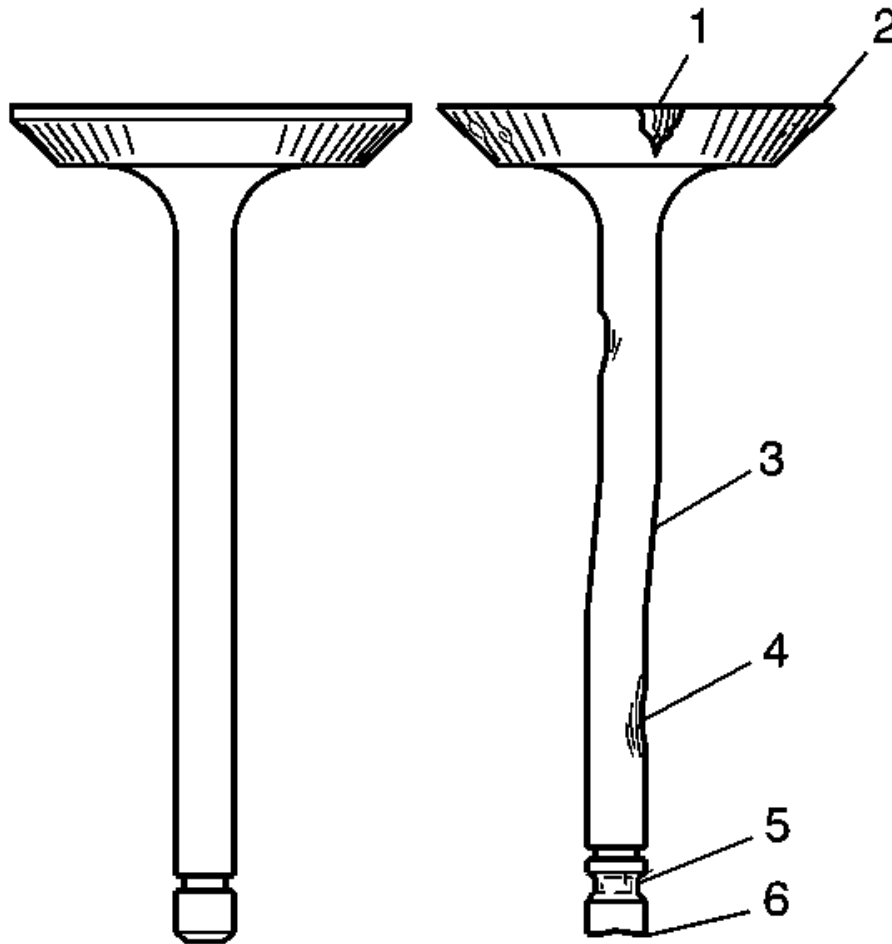


Fig. 288: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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)

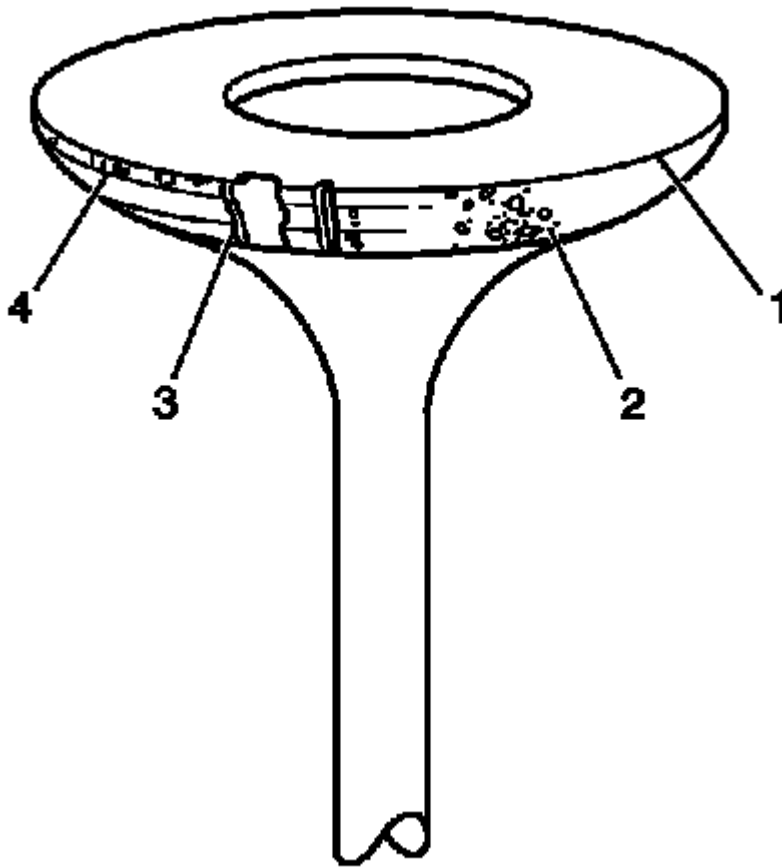


Fig. 289: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

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.

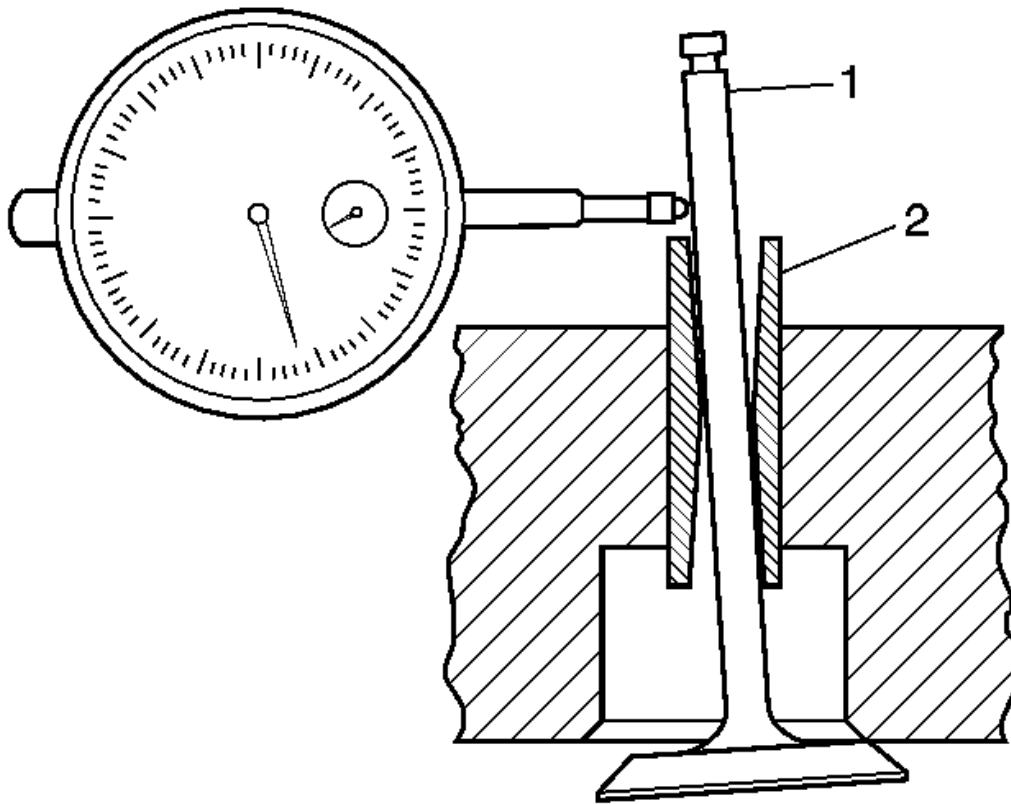


Fig. 290: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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.

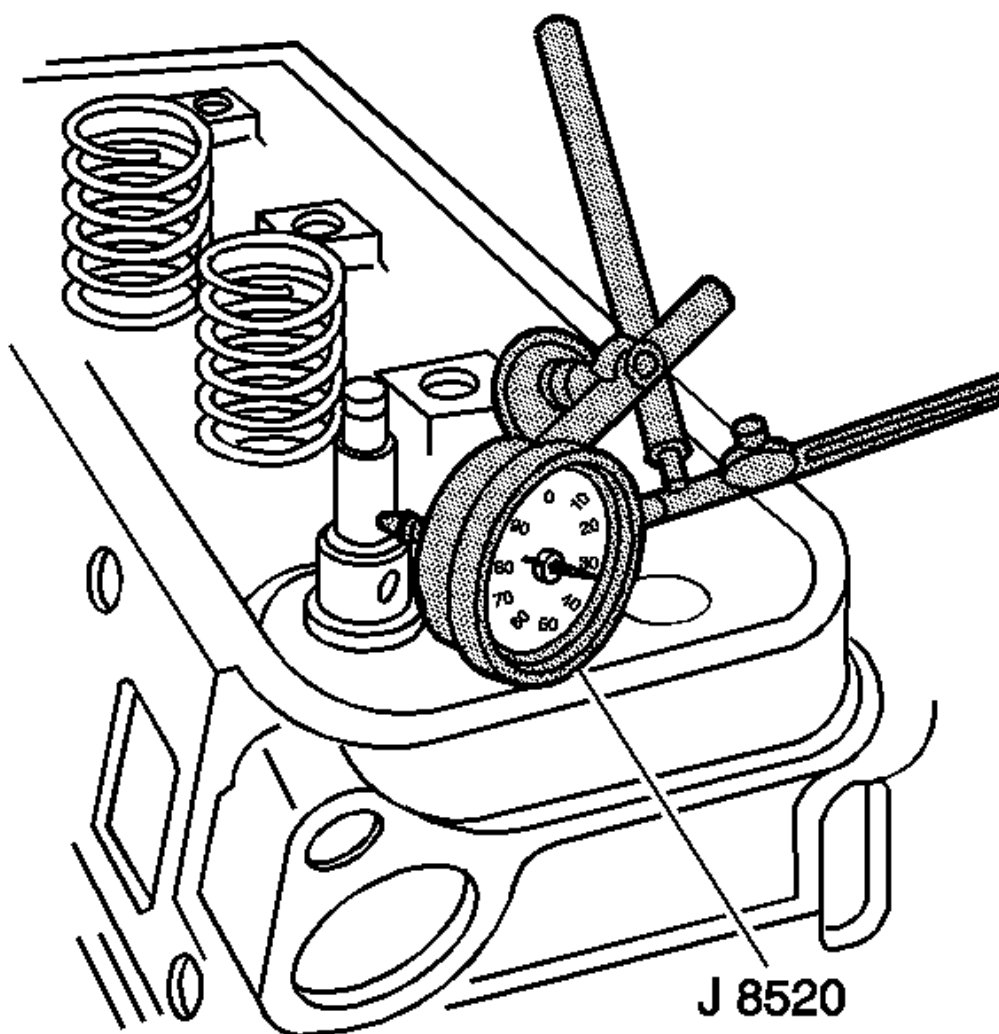


Fig. 291: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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**.

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.

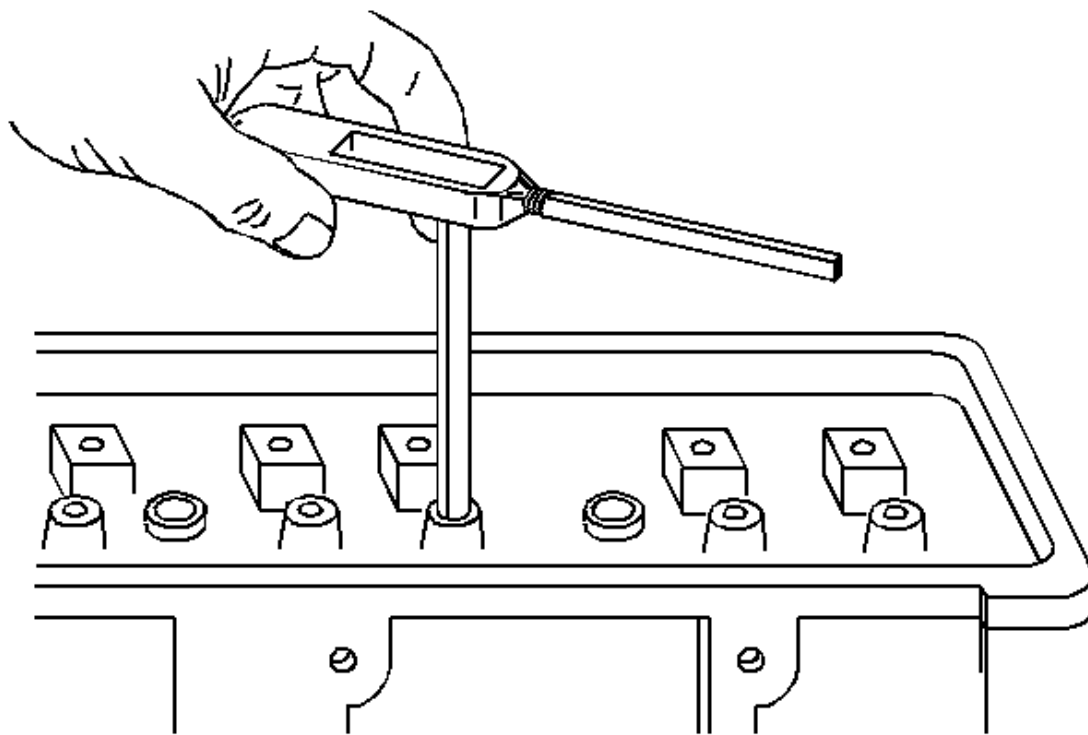


Fig. 292: Reaming Valve Guides For Oversize Valves
Courtesy of GENERAL MOTORS CORP.

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.

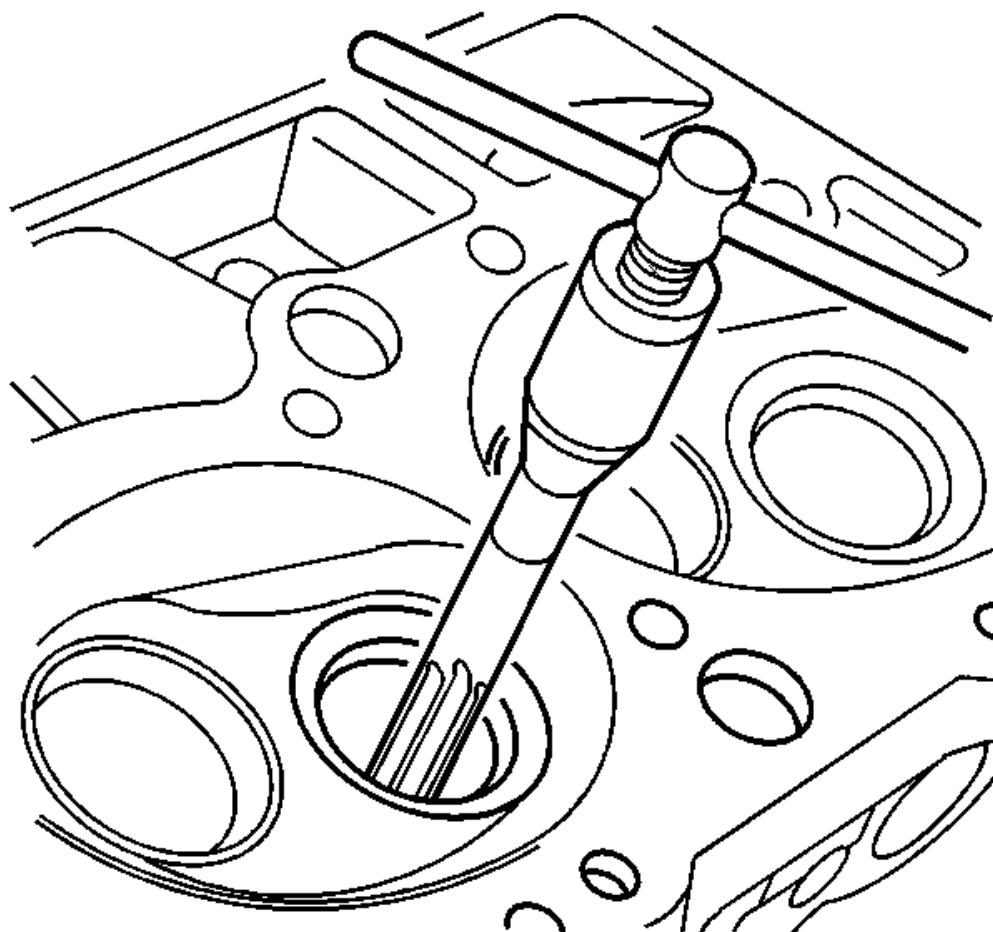


Fig. 293: Reaming Valve Guide

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.

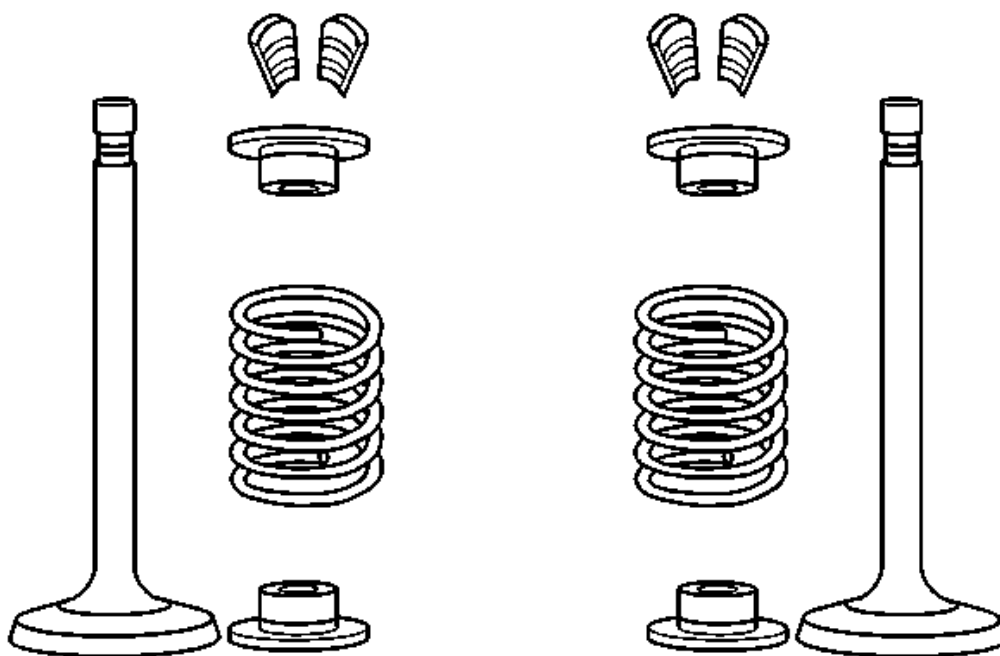


Fig. 294: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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.

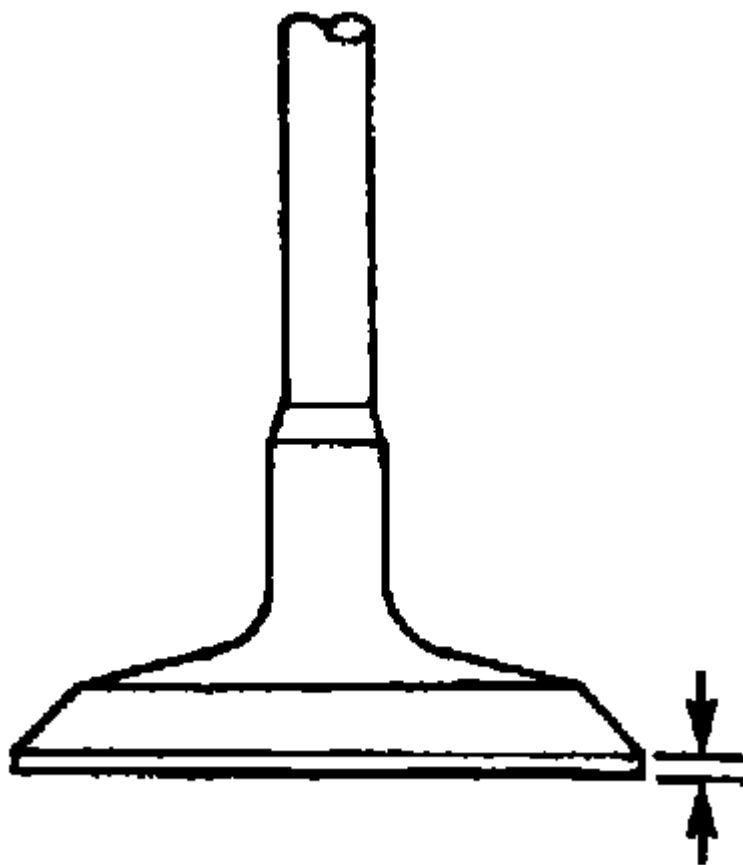


Fig. 295: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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.

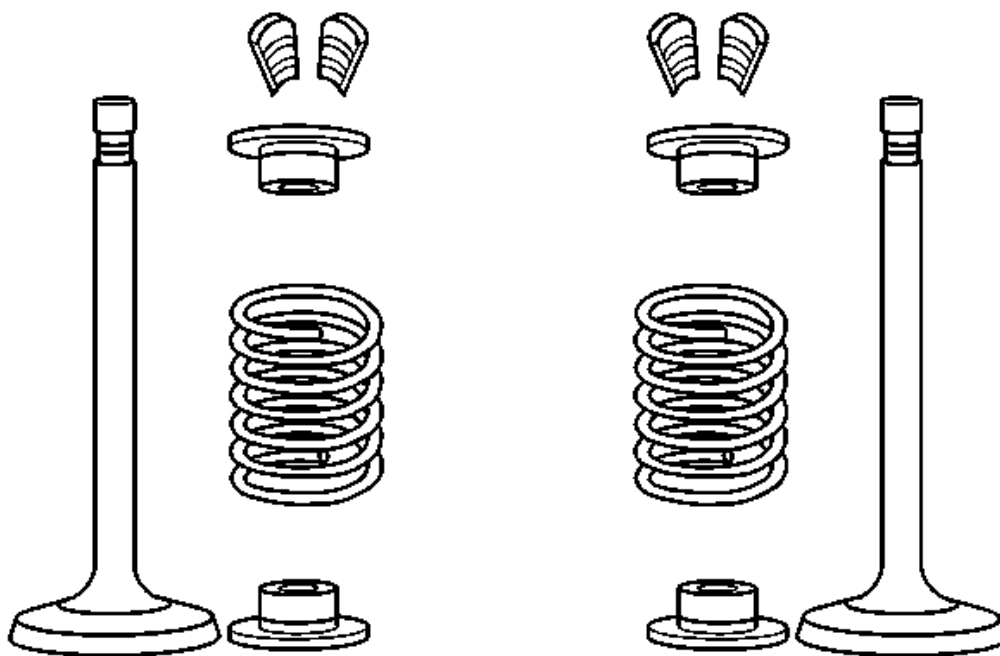


Fig. 296: Valve Locks, Caps, Seats & Spring
Courtesy of GENERAL MOTORS CORP.

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 tap the new or reconditioned valves into the valve seat.
4. Install the valve stem oil seals.
5. Install the valve springs.
6. Install the valve spring caps.

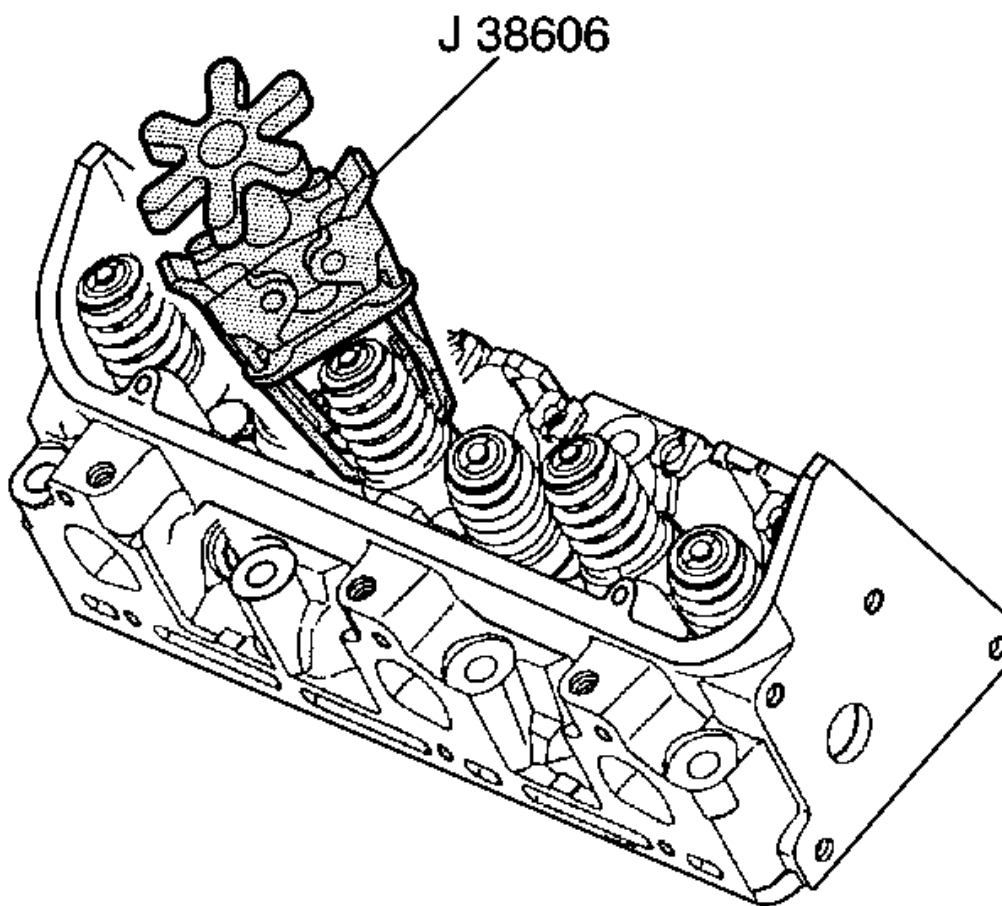


Fig. 297: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

7. Compress the valve springs using the **J 38606** . See **Special Tools**.
8. Install the valve spring cap keys. Hold the valves in place with grease, if necessary.
9. Release the valve springs.
10. Ensure that the valve locks are seated.
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 P/N 88894006 as needed. If more than 2 shims are needed replace the cylinder head or valve.

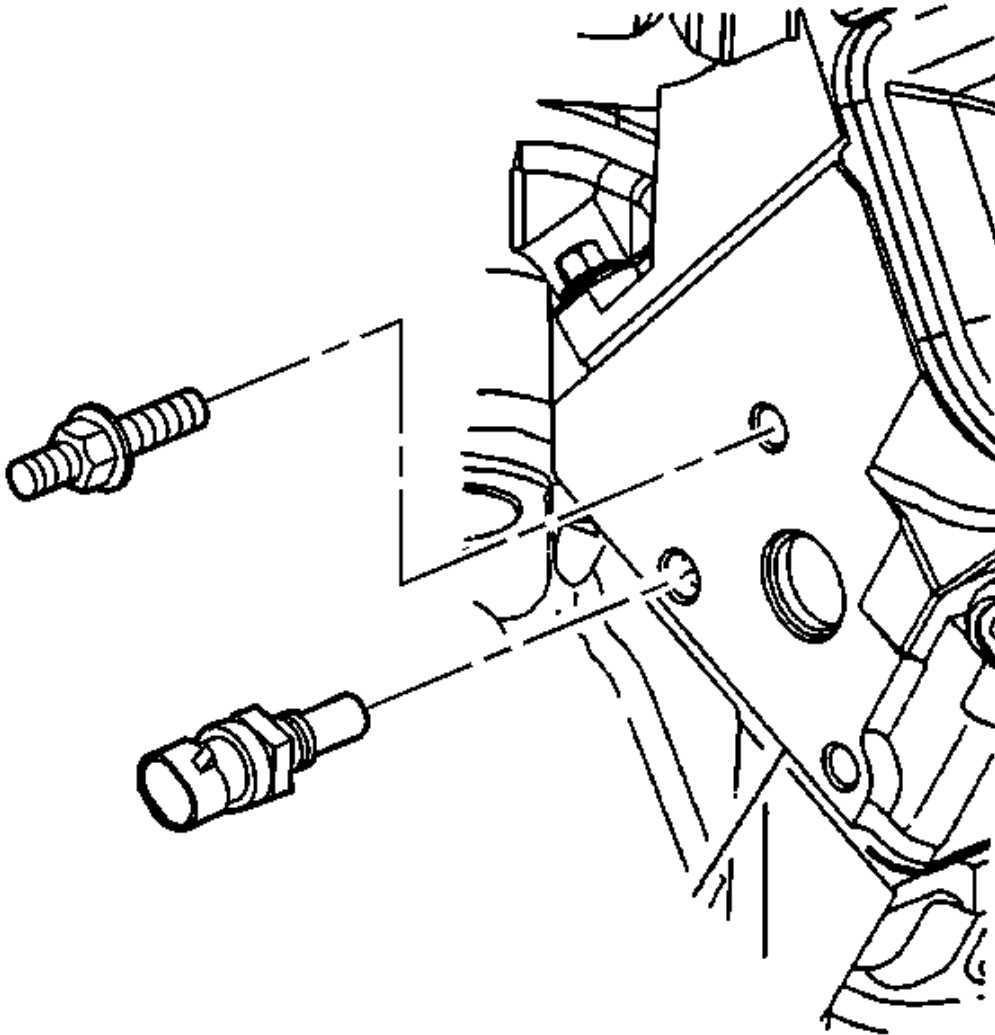


Fig. 298: View Of Heater Inlet Pipe Stud And Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

13. Apply sealer P/N 21485278 to the coolant temperature sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

14. Install the coolant temperature sensor, if required.

Tighten: Tighten the coolant temperature sensor to 23 N.m (17 lb ft).

15. Install the heater inlet pipe stud, if required.

Tighten: Tighten the heater inlet pipe stud to 35 N.m (26 lb ft).

Oil Pump Disassemble

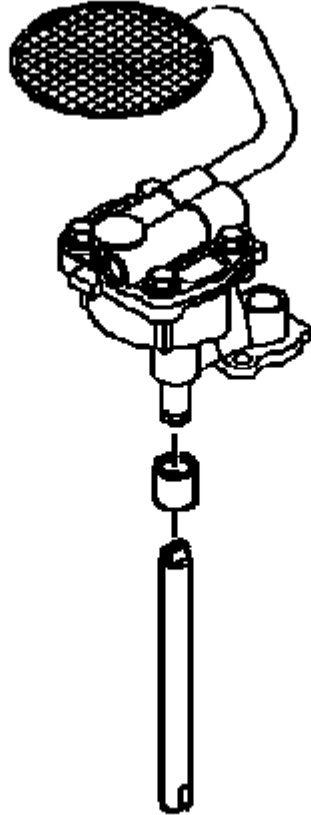


Fig. 299: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump driveshaft and oil pump driveshaft retainer.

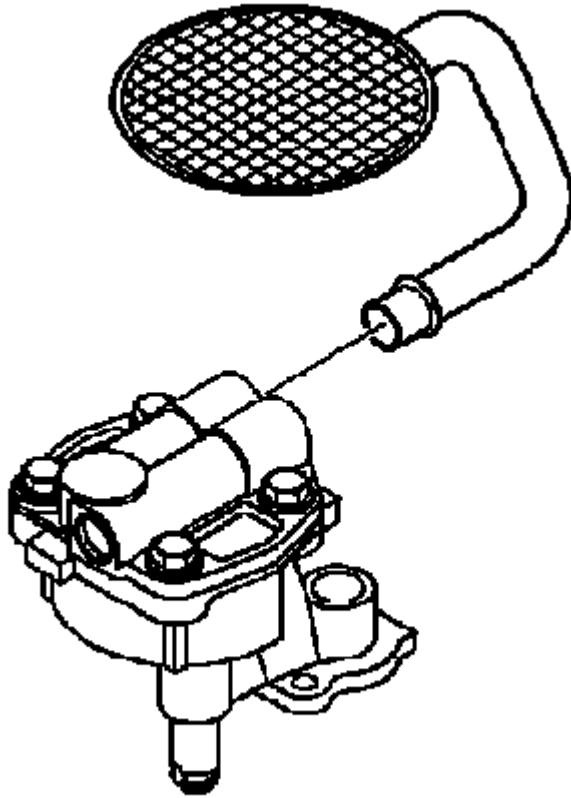


Fig. 300: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

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.

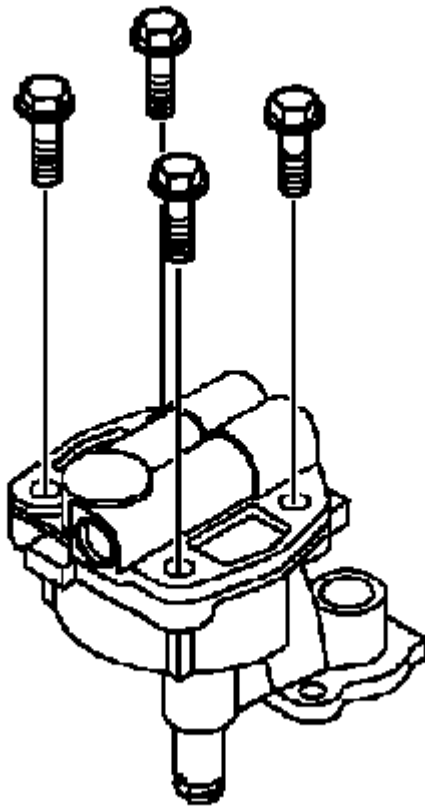


Fig. 301: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover bolts.

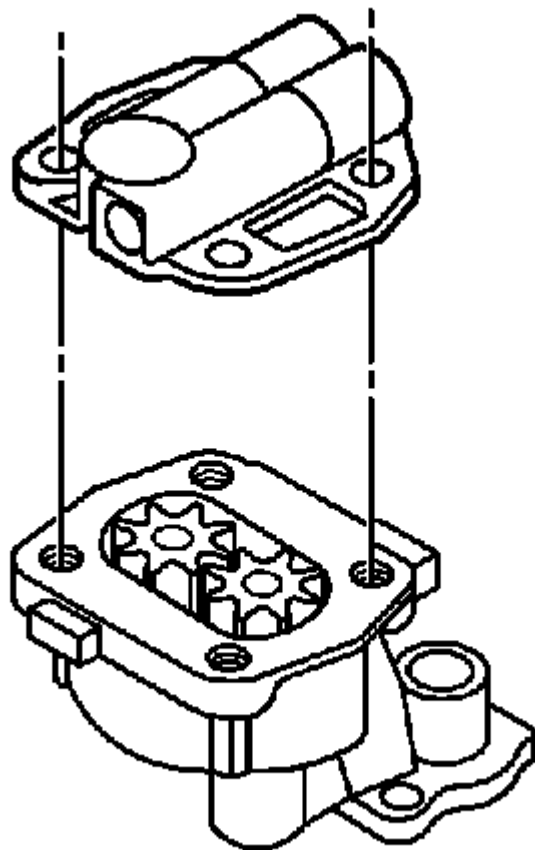


Fig. 302: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover.

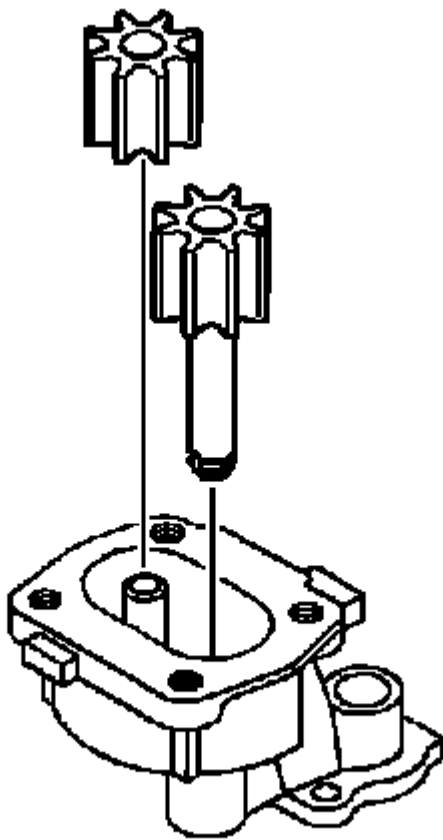


Fig. 303: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump drive gear and the oil pump driven gear.
6. Matchmark the gear teeth for assembly.

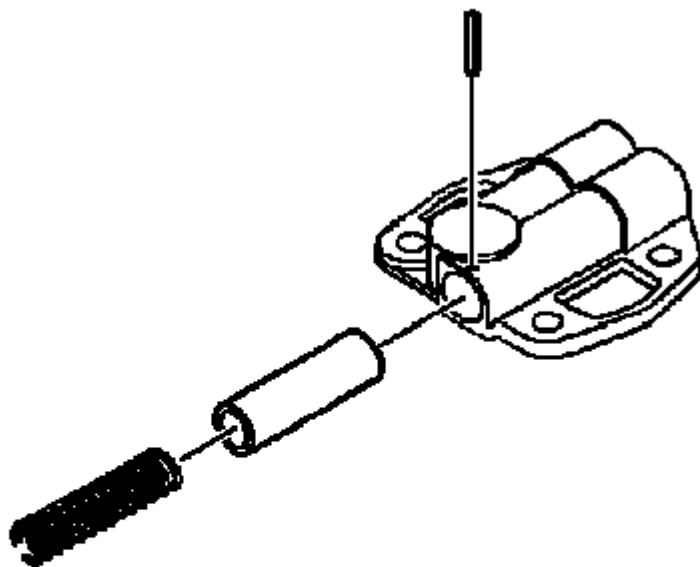


Fig. 304: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

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

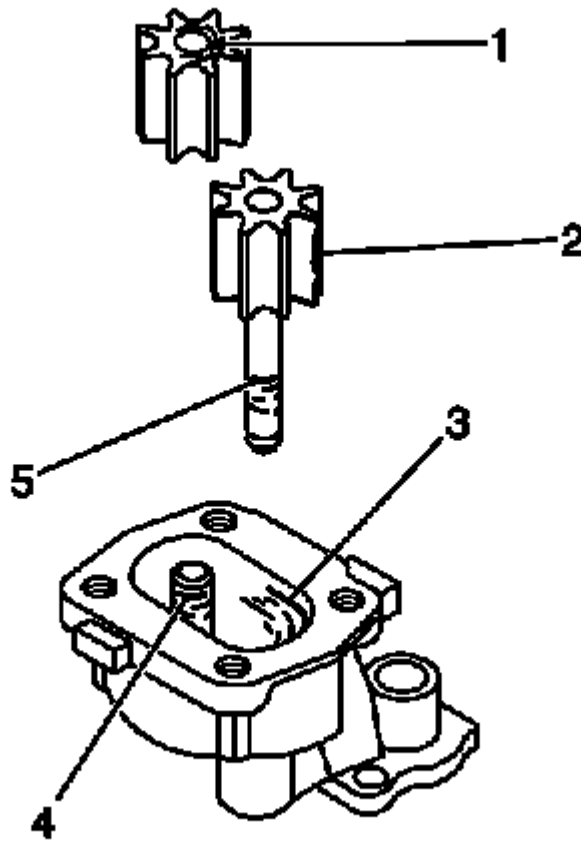


Fig. 305: Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

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).

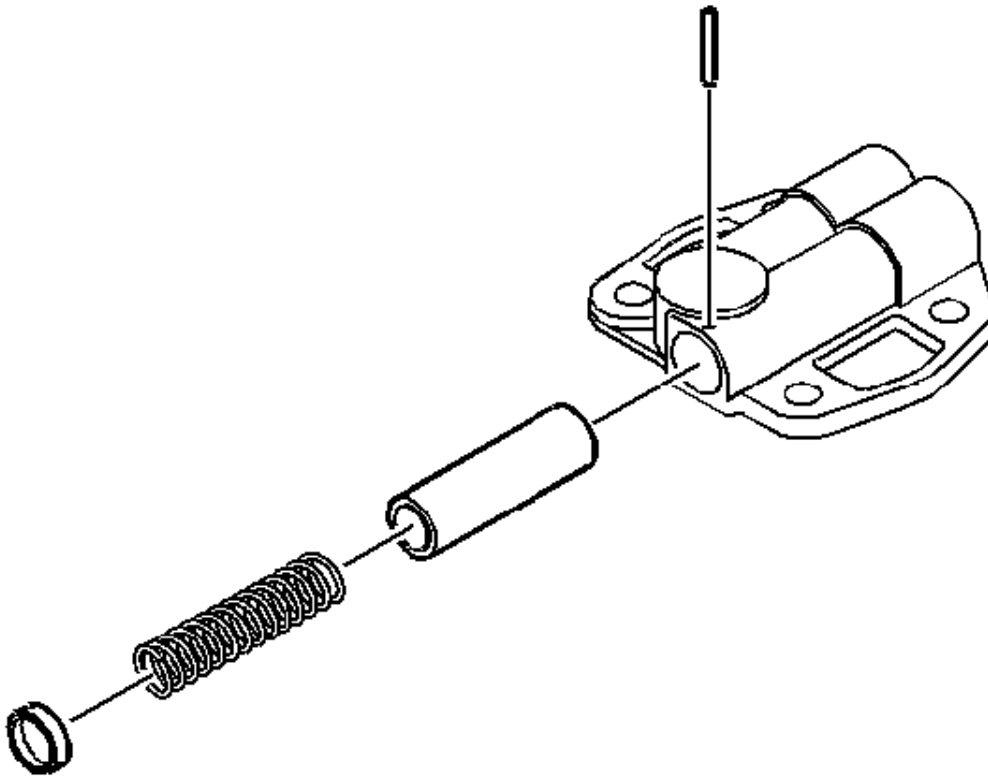


Fig. 306: View Of Pressure Regulator Valve & Spring
Courtesy of GENERAL MOTORS CORP.

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

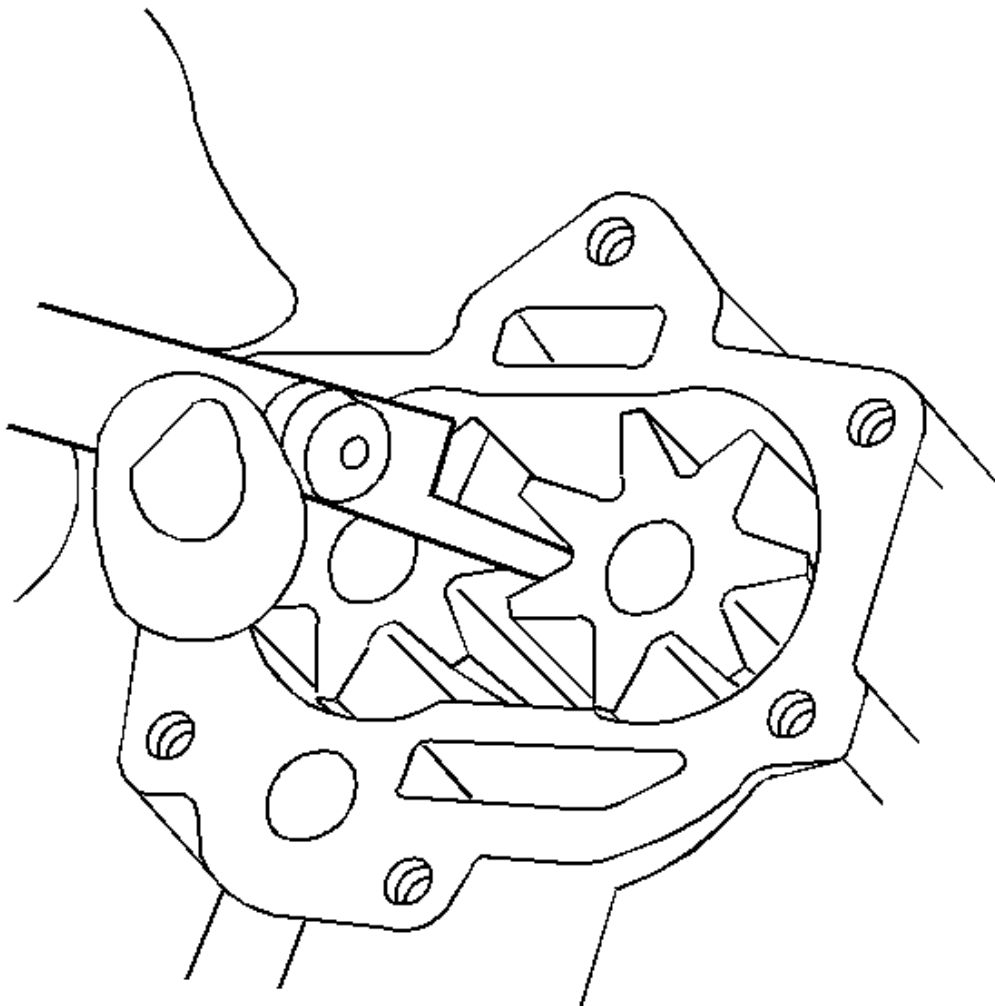


Fig. 307: Measuring Oil Pump Gear Lash

Courtesy of GENERAL MOTORS CORP.

11. Measure the oil pump gear lash. Install the gears, and measure in several places.

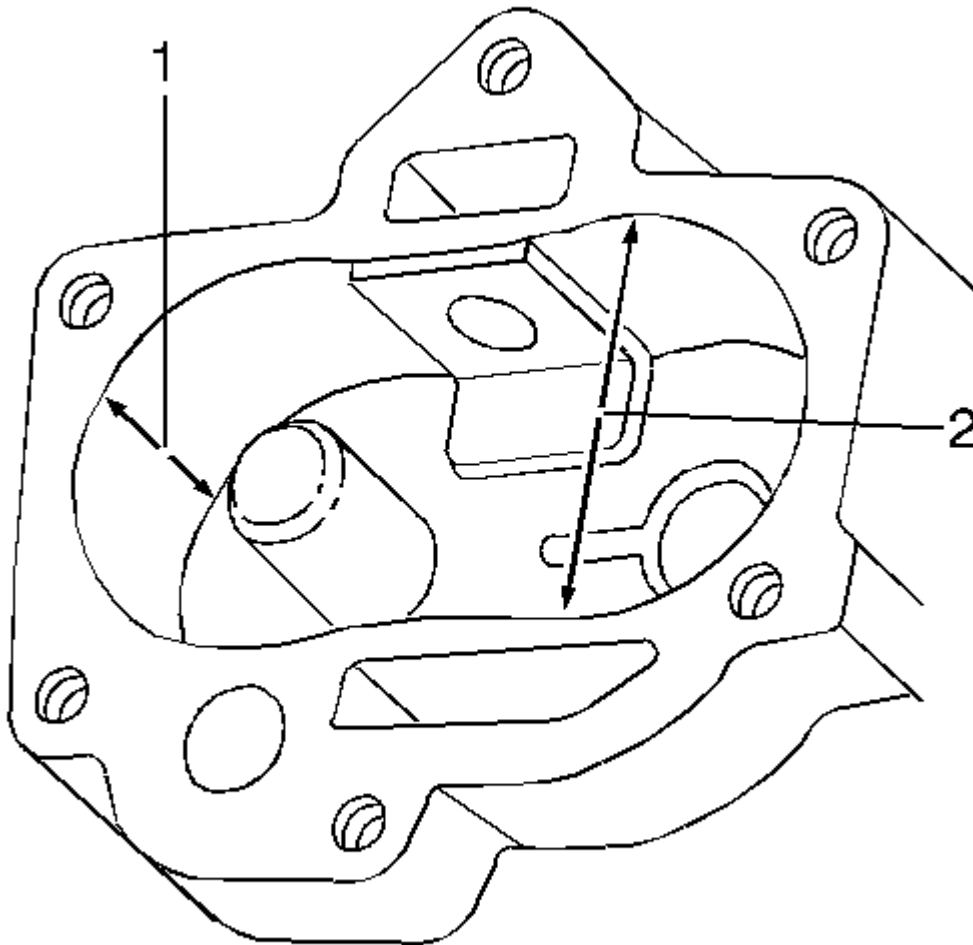


Fig. 308: Checking Oil Pump Housing Gear Pocket
Courtesy of GENERAL MOTORS CORP.

12. Measure the oil pump housing gear pocket (1, 2).

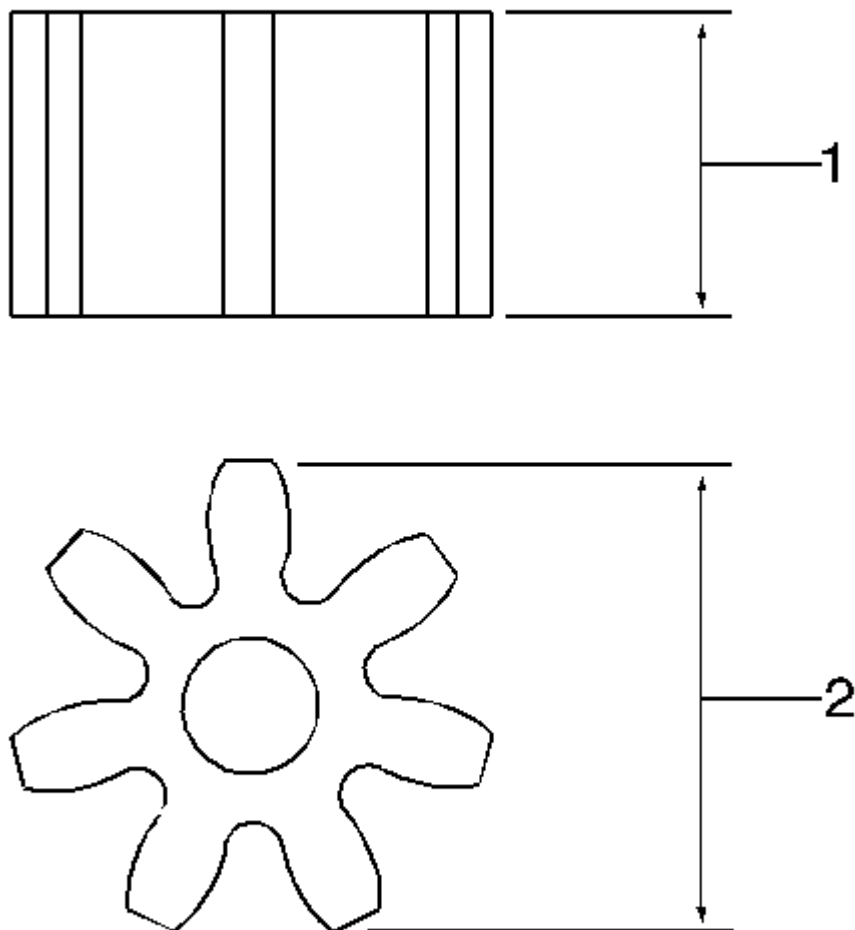


Fig. 309: View Of Oil Pump Gears
Courtesy of GENERAL MOTORS CORP.

13. Measure the oil pump gears (1, 2).

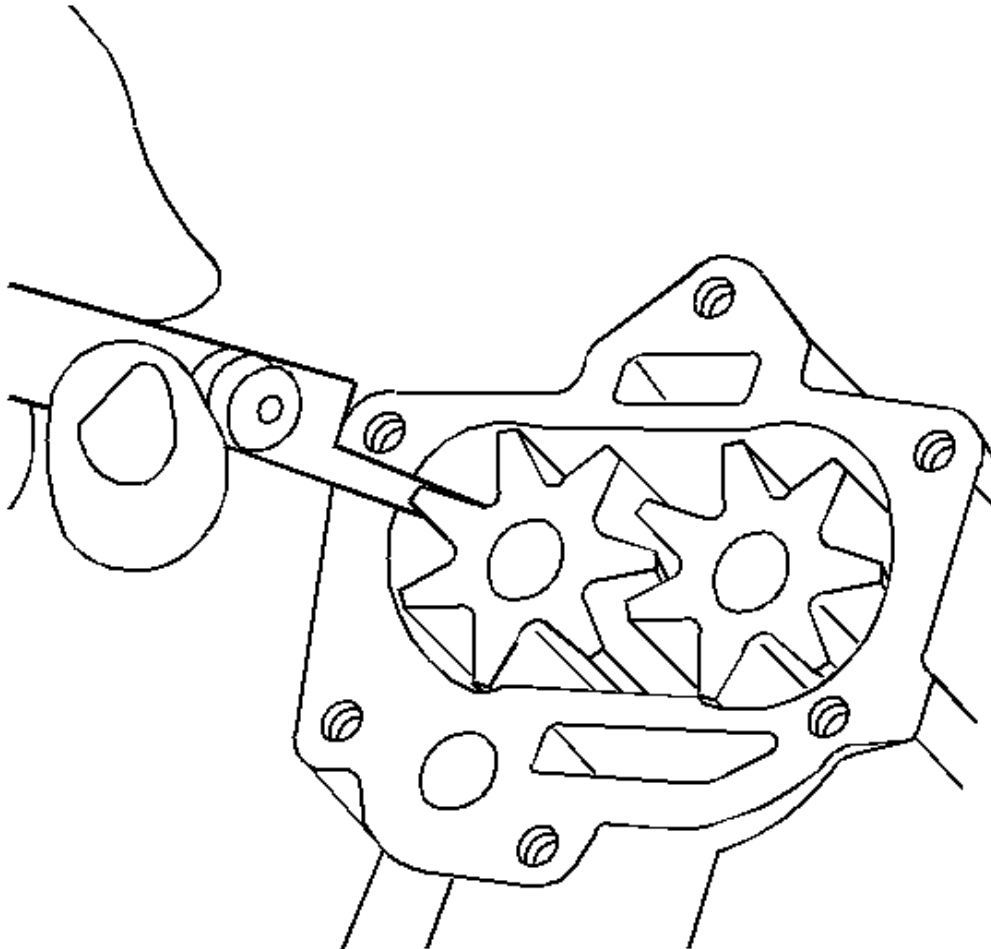


Fig. 310: Measuring Oil Pump Gear Side Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When deciding pump serviceability based on end clearance, consider depth of the wear pattern in the pump cover.

14. Measure the oil pump gear side clearance.

Oil Pump Assemble

Tools Required

J 22144 Oil Suction Pipe Installer. See **Special Tools**.

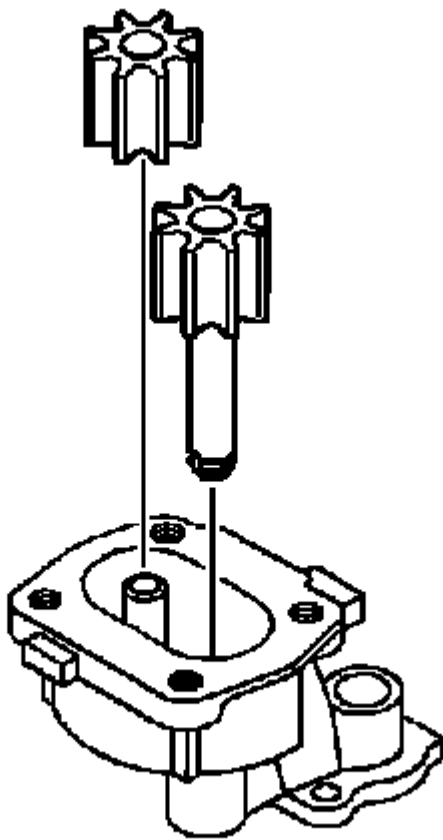


Fig. 311: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all the internal oil pump parts using engine oil during assembly.
2. Install the oil pump gears.

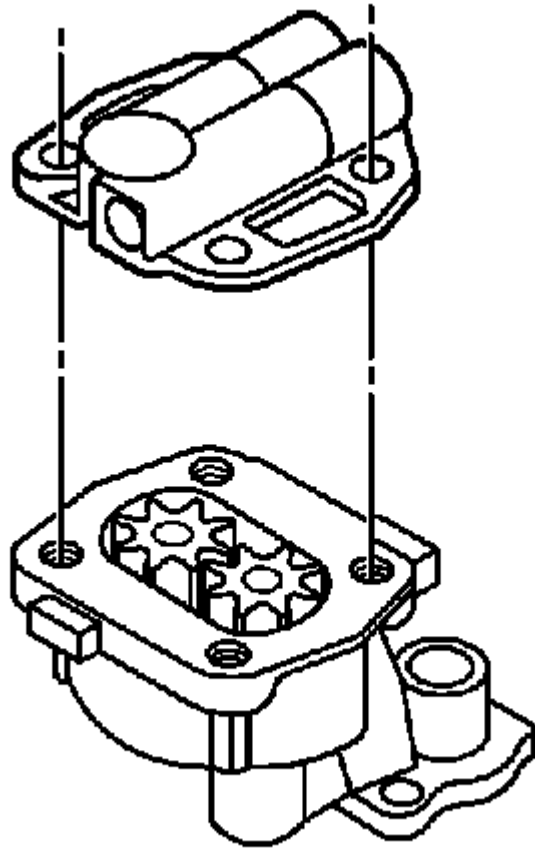


Fig. 312: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

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).

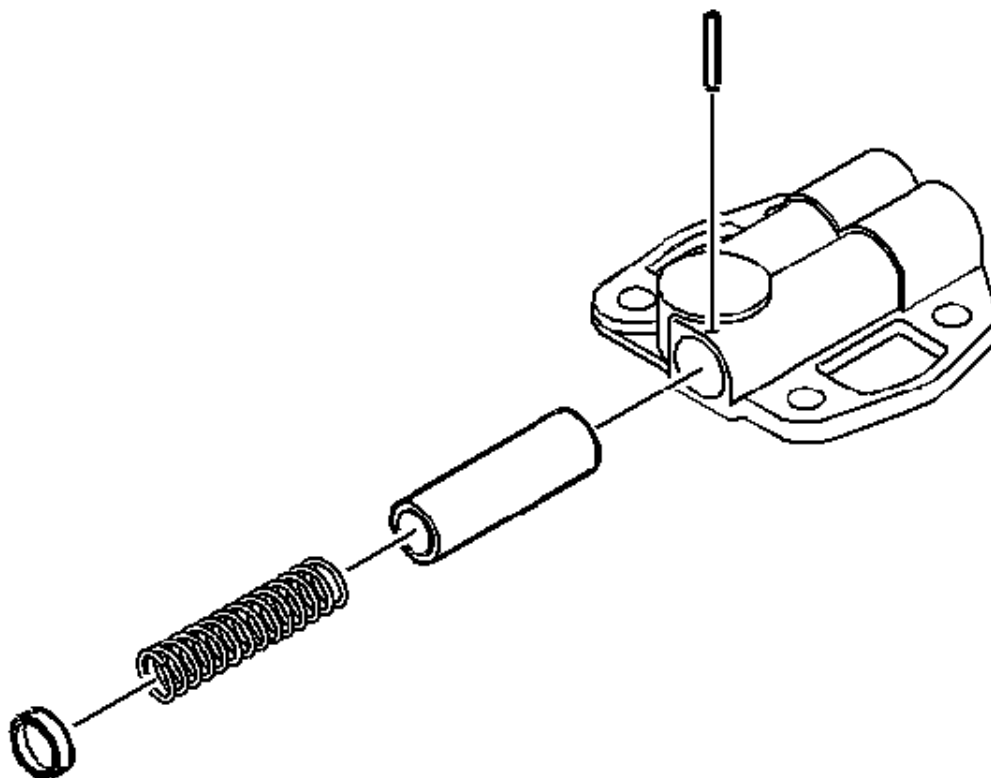


Fig. 313: View Of Pressure Regulator Valve & Spring
Courtesy of GENERAL MOTORS CORP.

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 **J 22144** and a plastic hammer. See **Special Tools**.

Engine Front Cover Cleaning and Inspection

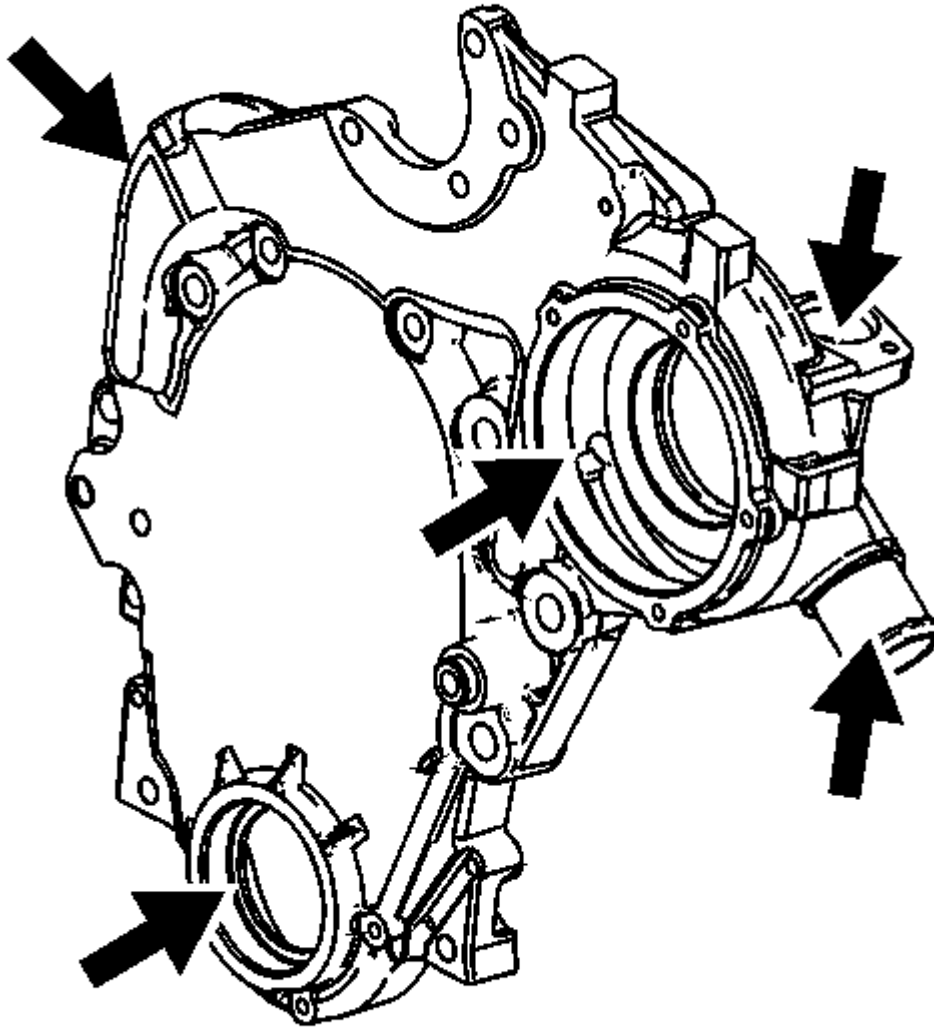


Fig. 314: Cleaning Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the engine front cover with solvent.
2. Dry the engine front cover with compressed air.
3. Inspect the engine front cover sealing surfaces for damage.

4. Inspect the engine front cover threaded holes.
5. Repair or replace the engine front cover as needed.

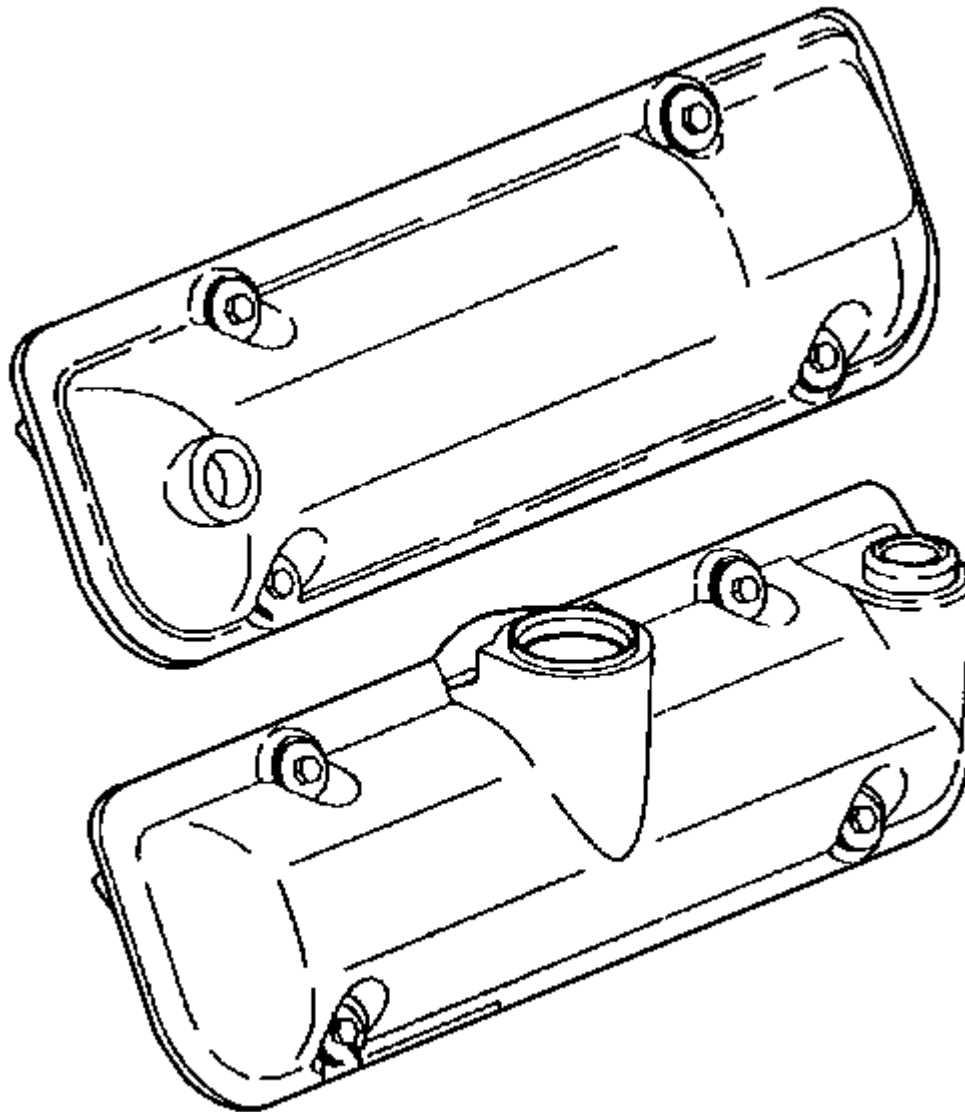
Valve Rocker Arm Cover Cleaning and Inspection

Fig. 315: Cleaning 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 solvent.
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

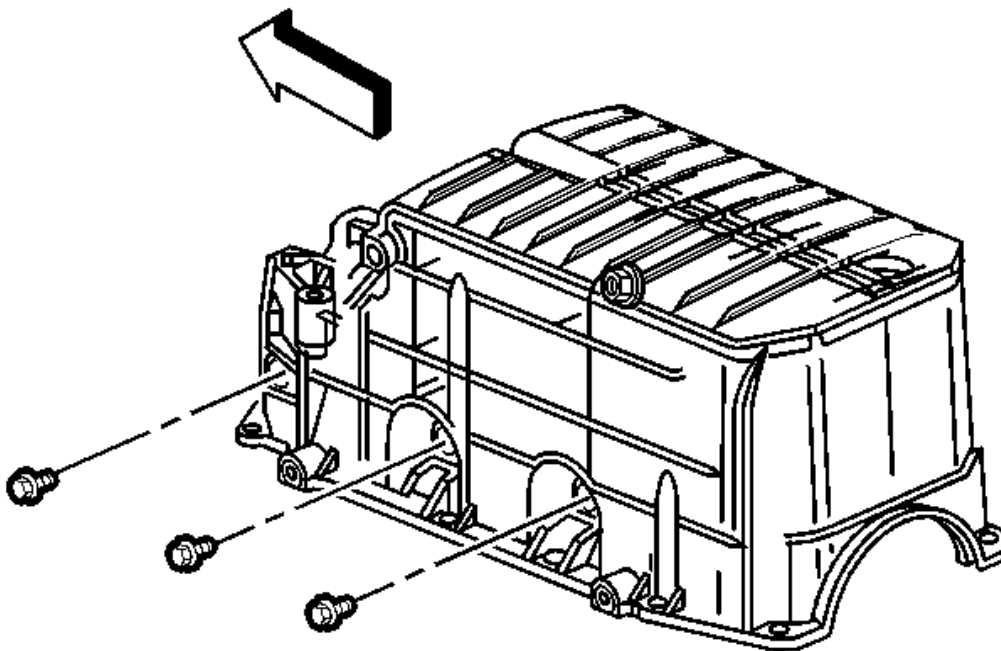


Fig. 316: Oil Pan
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the oil pan with solvent. Remove all sludge and debris from the oil pan.

2. Dry the oil pan with compressed air.
3. Inspect the oil pan sealing surface for damage and replace if necessary.

Intake Manifold Cleaning and Inspection - Lower**Tools Required**

J 21882 Oil Suction Pipe Installer. See Special Tools.

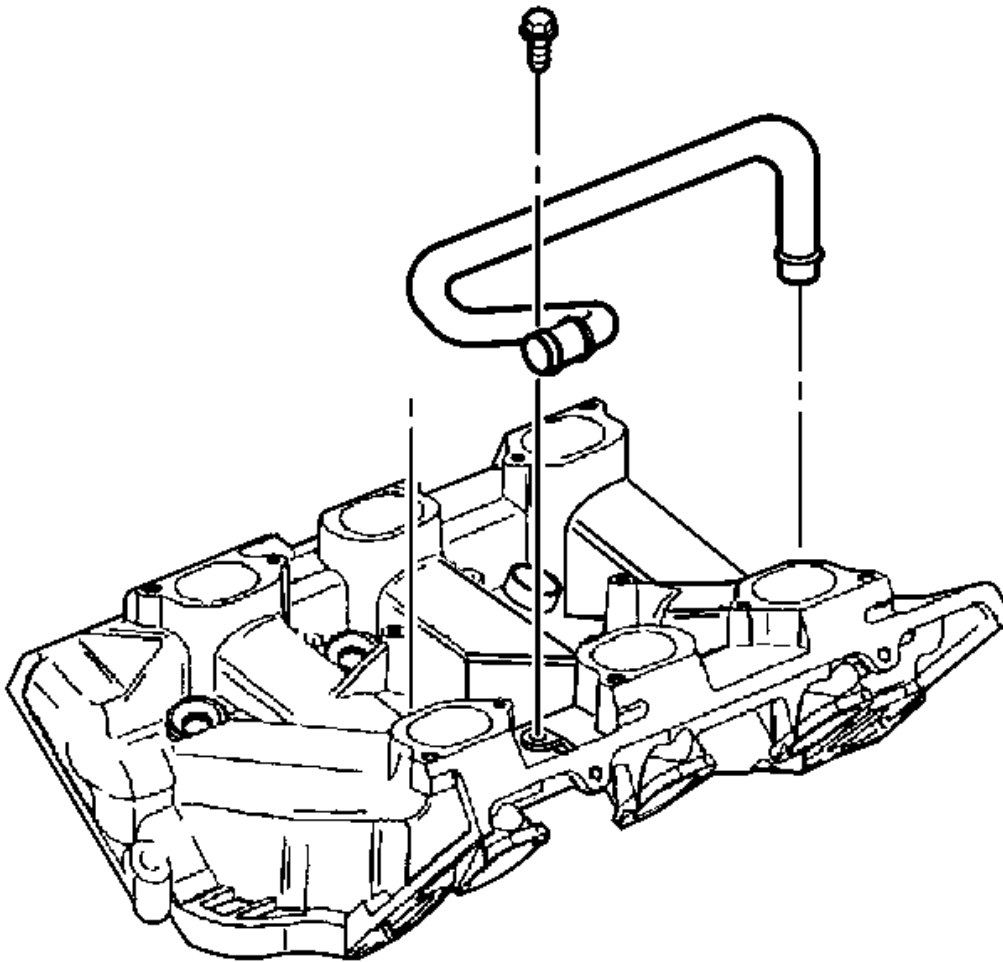


Fig. 317: Identifying Intake Manifold Coolant Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold coolant pipe bolt, if required.

2. Remove the intake manifold coolant pipe, if required.

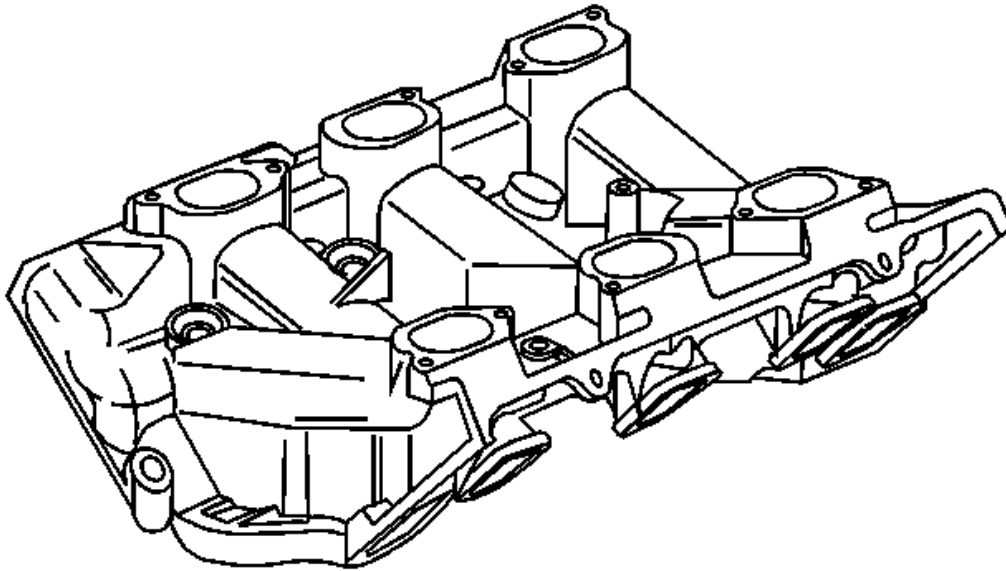


Fig. 318: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

3. Clean the intake manifold gasket mating surfaces using GM P/N 12346139 (Canadian P/N 10953463) or equivalent.
4. Clean the fuel injector bores.
5. Inspect the intake manifold for damage.
6. Repair or replace the intake manifold as necessary.

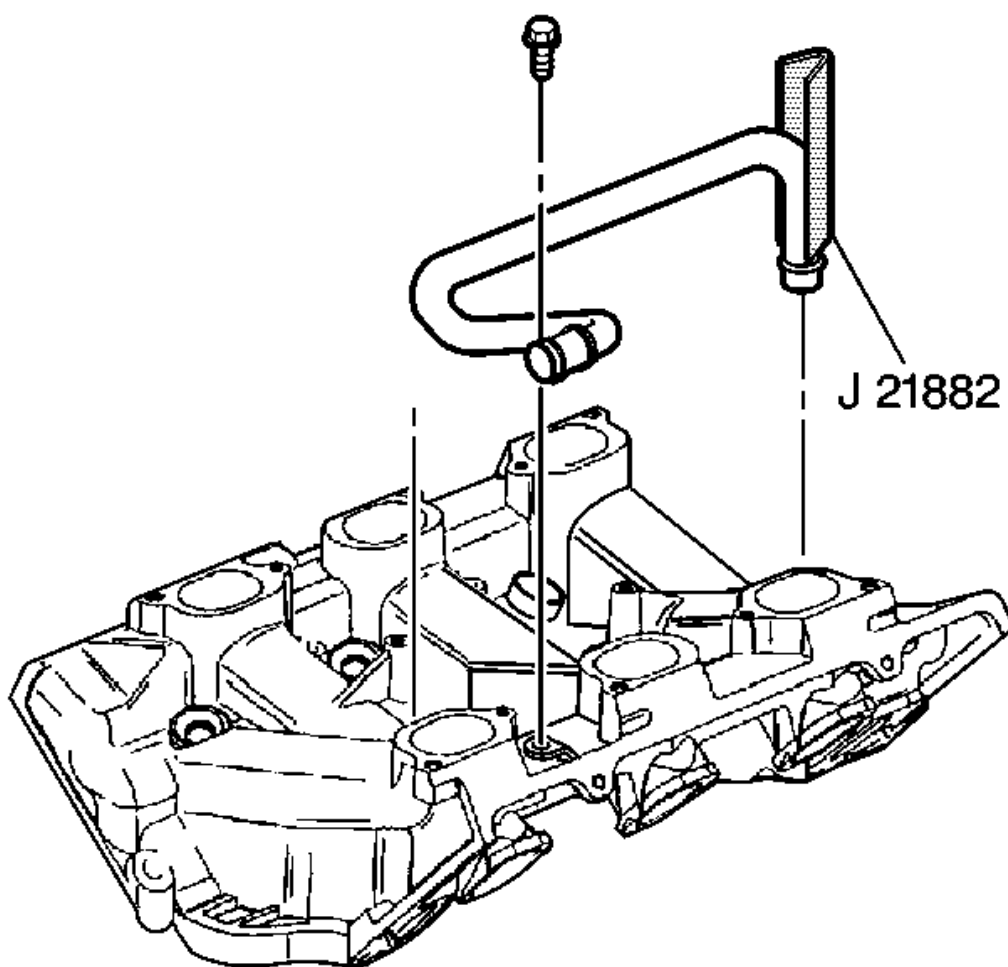


Fig. 319: View Of J 21882

Courtesy of GENERAL MOTORS CORP.

7. Apply sealant GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the end of the intake manifold coolant pipe, if required.
8. Install the intake manifold coolant pipe using **J 21882** . See **Special Tools**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the intake manifold coolant pipe bolt.

Tighten: Tighten the intake manifold coolant pipe bolt to 10 N.m (89 lb in).

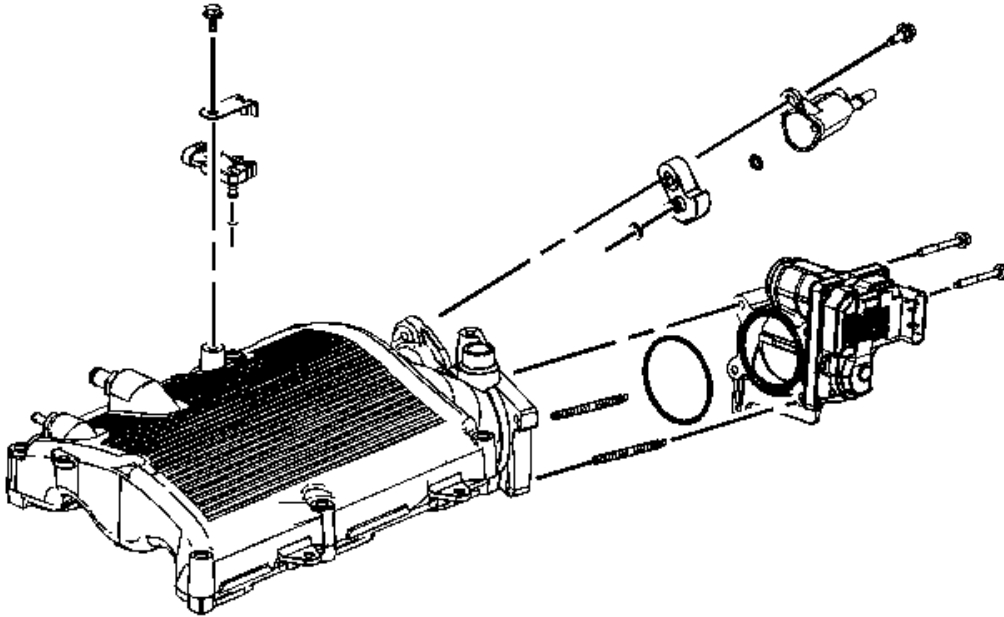
Intake Manifold Cleaning and Inspection - Upper

Fig. 320: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body bolts.
2. Remove the throttle body.
3. Remove the throttle body studs, if required.
4. Remove the manifold absolute pressure (MAP) sensor bolt and clip.
5. Remove the MAP sensor.
6. Remove the evaporative emissions (EVAP) purge valve bolt.
7. Remove the EVAP purge valve.

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

8. Clean the intake manifold with solvent.
9. Dry the intake manifold with compressed air.
10. Inspect all gasket mating surfaces for nicks or cracks and replace if necessary.
11. Inspect the EVAP purge valve seal for damage and replace if necessary.

12. Install the EVAP purge valve.

NOTE: Refer to Fastener Notice in Cautions and Notices.

13. Install the EVAP purge valve bolt.

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

14. Inspect the MAP sensor seal for damage and replace if necessary.

15. Install the MAP sensor.

16. Install the MAP sensor clip and bolt.

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

17. Install the throttle body studs, if required.

Tighten: Tighten the throttle body studs to 6 N.m (53 lb in).

18. Inspect the throttle body seal for damage and replace if necessary.

19. Install the throttle body.

20. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the throttle body bolt threads.

21. Install the throttle body bolts.

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

Exhaust Manifold Cleaning and Inspection

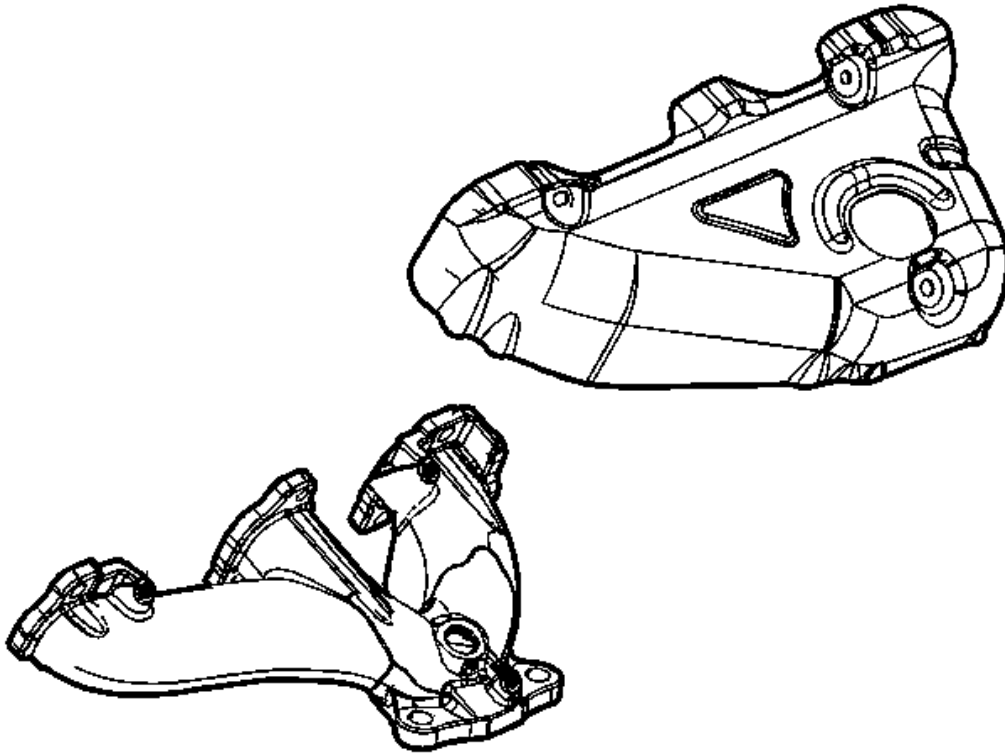


Fig. 321: View Of Exhaust Manifolds
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the exhaust manifold and heat shield in solvent.
2. Dry the exhaust manifold and heat shield with compressed air.
3. Inspect the exhaust manifold for cracks or damage.

Water Pump Cleaning and Inspection

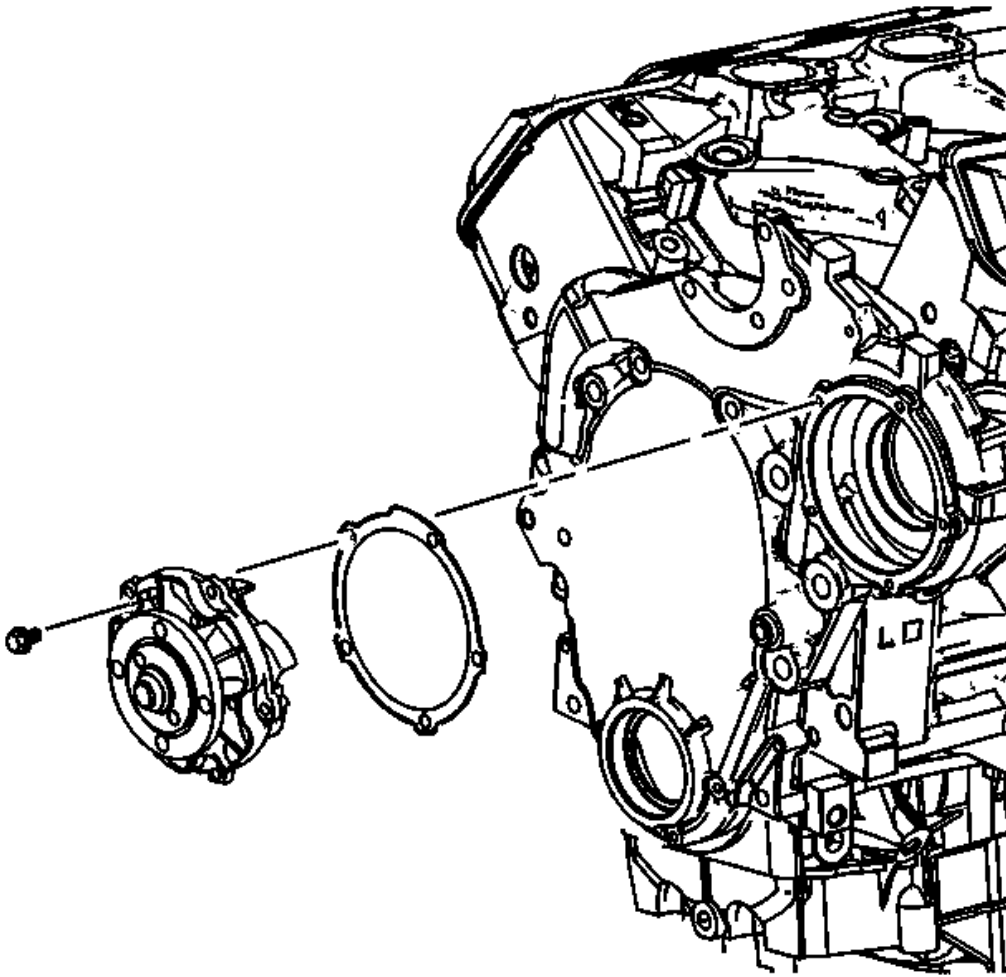


Fig. 322: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove all gasket material from the sealing surface.
2. Inspect the water pump impeller for damage.
3. Inspect the water pump shaft for looseness.
4. Replace the water pump if necessary.

Thread Repair

General purpose thread repair kits are available commercially.

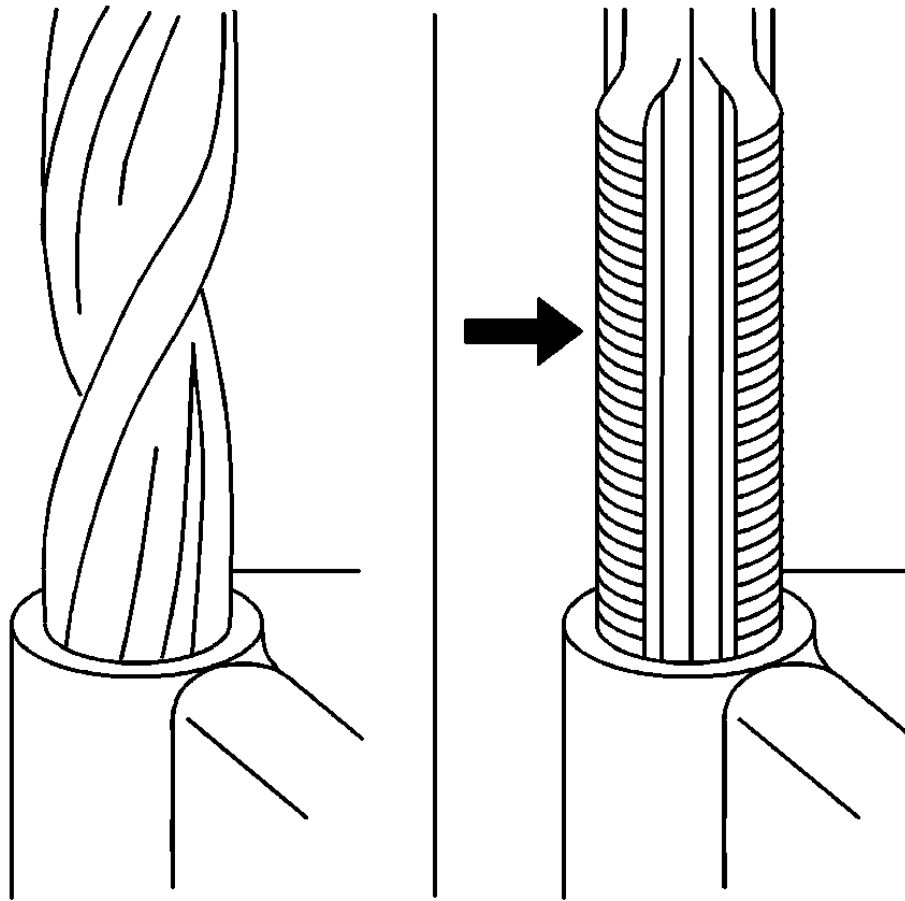


Fig. 323: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

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.

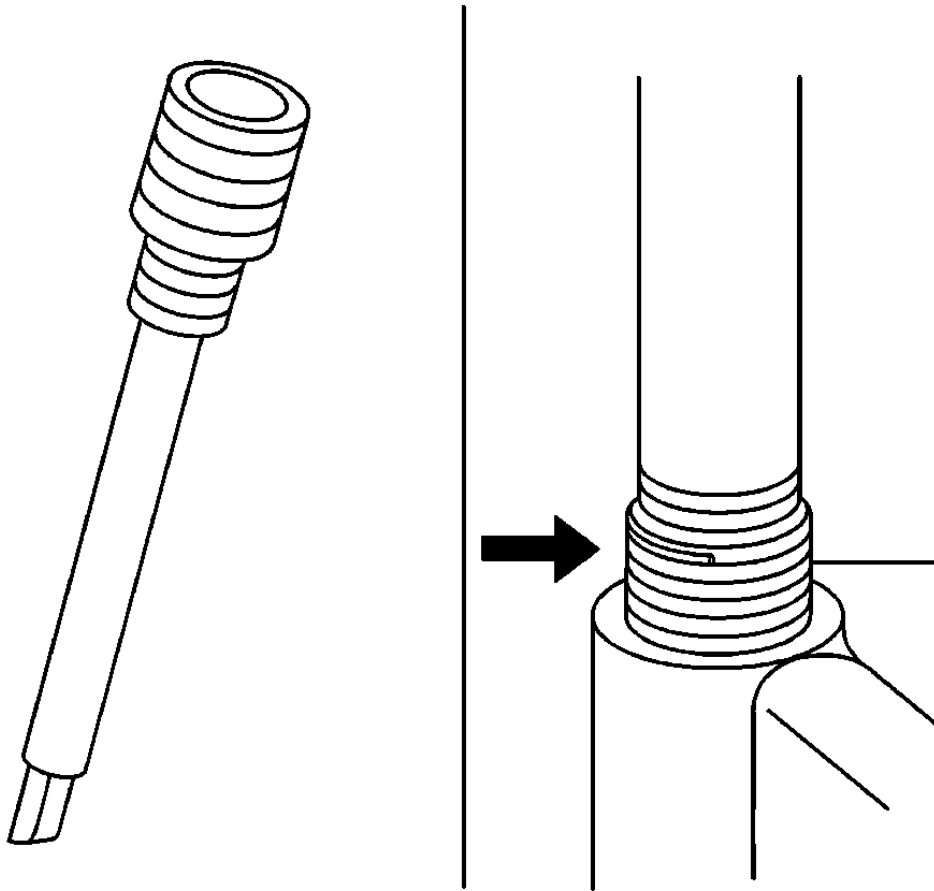


Fig. 324: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

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.

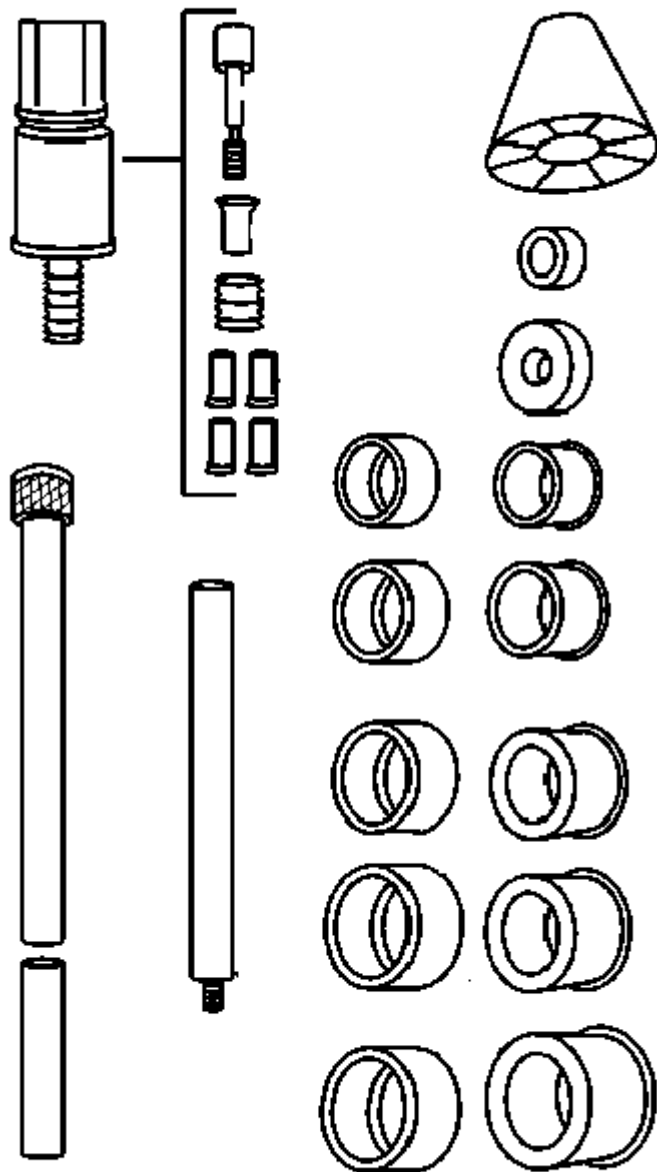
9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

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.

Camshaft Bearing Installation**Tools Required**

J 33049 Camshaft Bearing Remover/Installer



Courtesy of GENERAL MOTORS CORP.

1. Assemble the J 33049 according to the manufacturer's instructions.

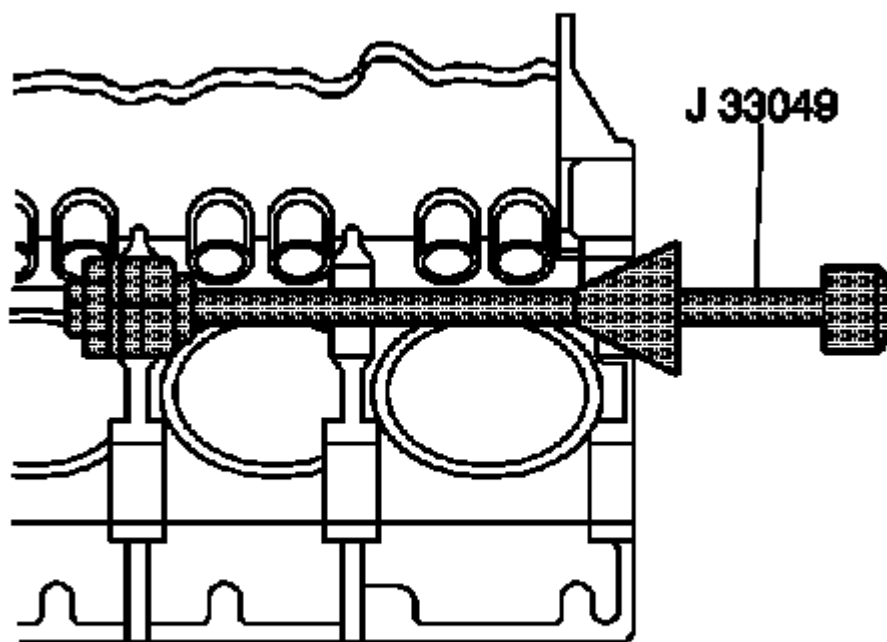


Fig. 326: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

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 .
 3. Install the third camshaft bearing.
 4. Install the second camshaft bearing.
 5. Install the outer camshaft bearings.

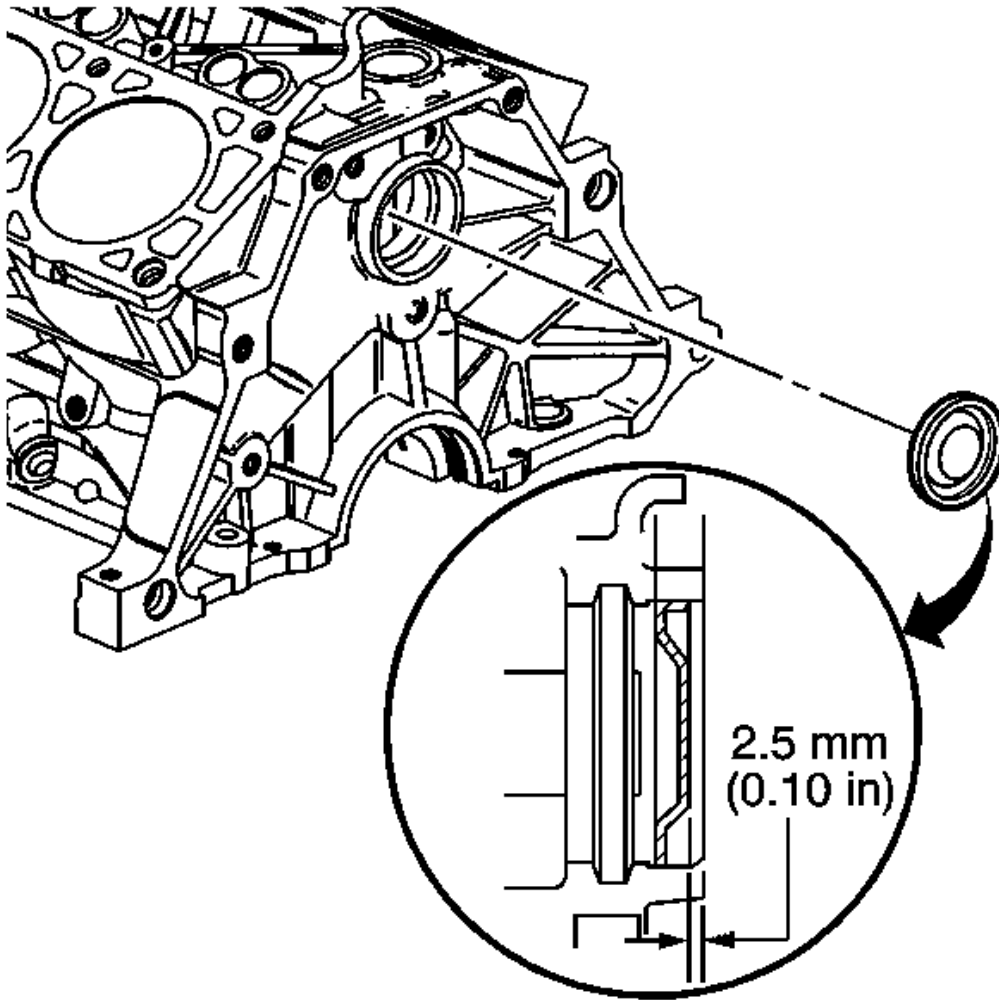


Fig. 327: Identifying Camshaft Rear Bearing Hole Plug Installation Depth
Courtesy of GENERAL MOTORS CORP.

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.

Piston Oil Nozzle Installation

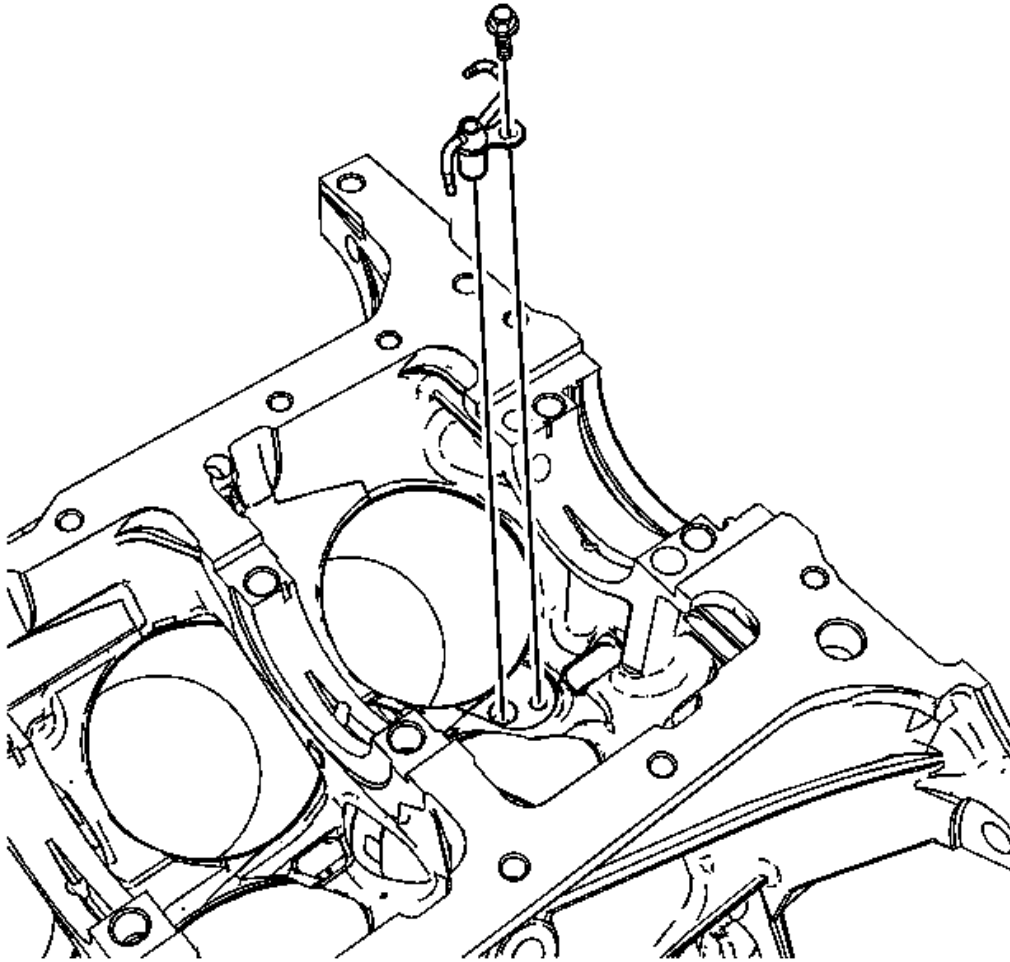


Fig. 328: View Of Piston Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

1. Position the piston oil nozzle into the engine block.

NOTE: Refer to Fastener Notice .

2. Install the bolt retaining the piston oil nozzle to the engine block.

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

Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter. See Special Tools.

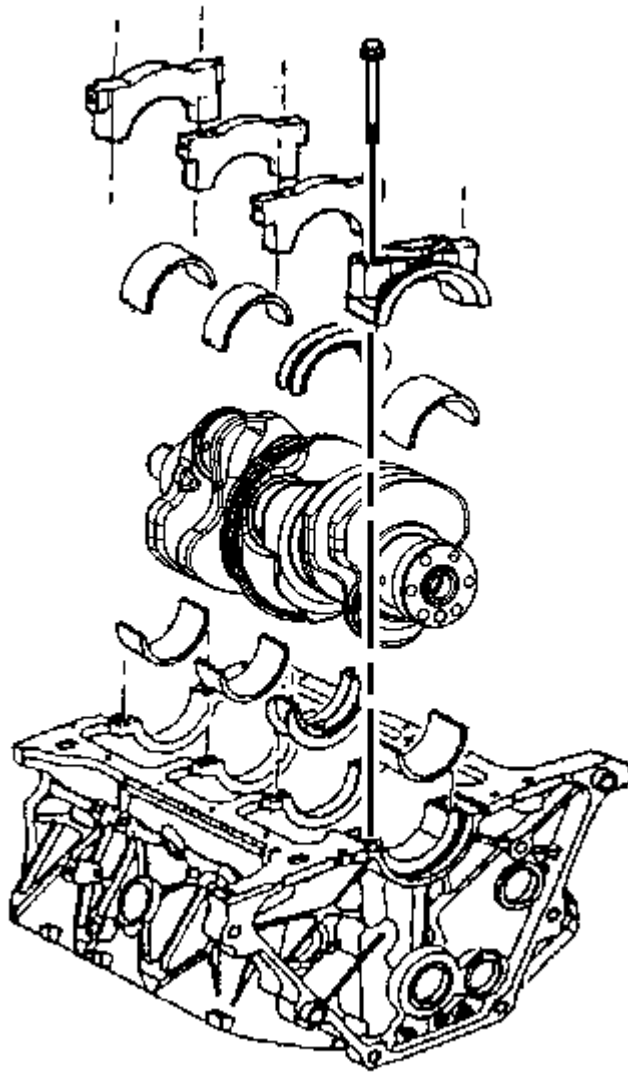


Fig. 329: View Of Crankshaft And Bearings
Courtesy of GENERAL MOTORS CORP.

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**.m (37 lb ft) plus 77 degrees.

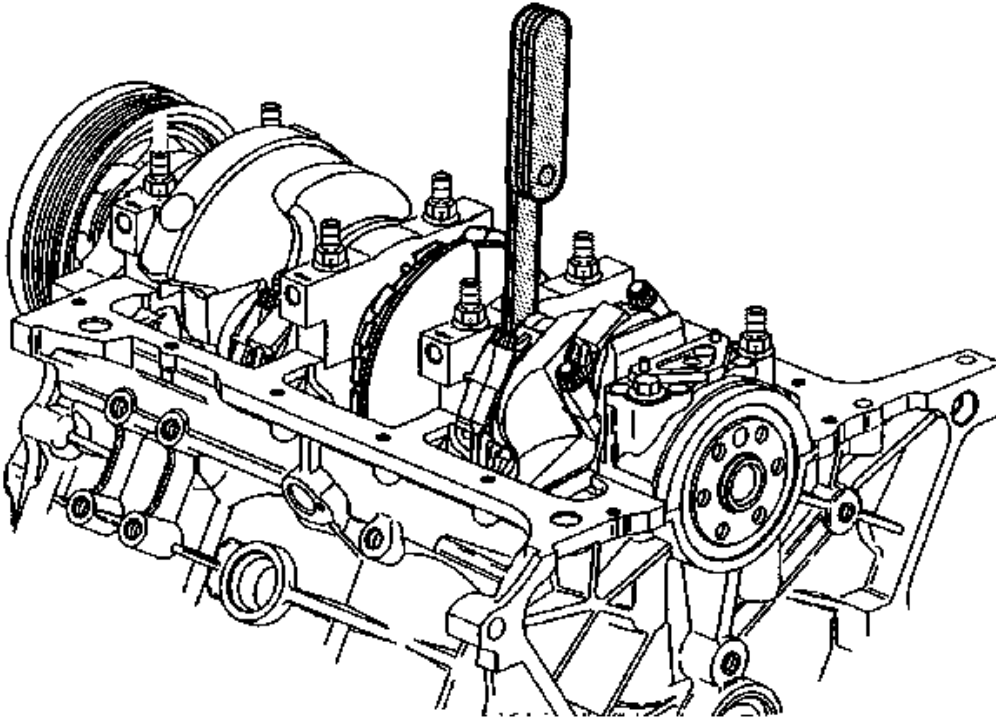


Fig. 330: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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.

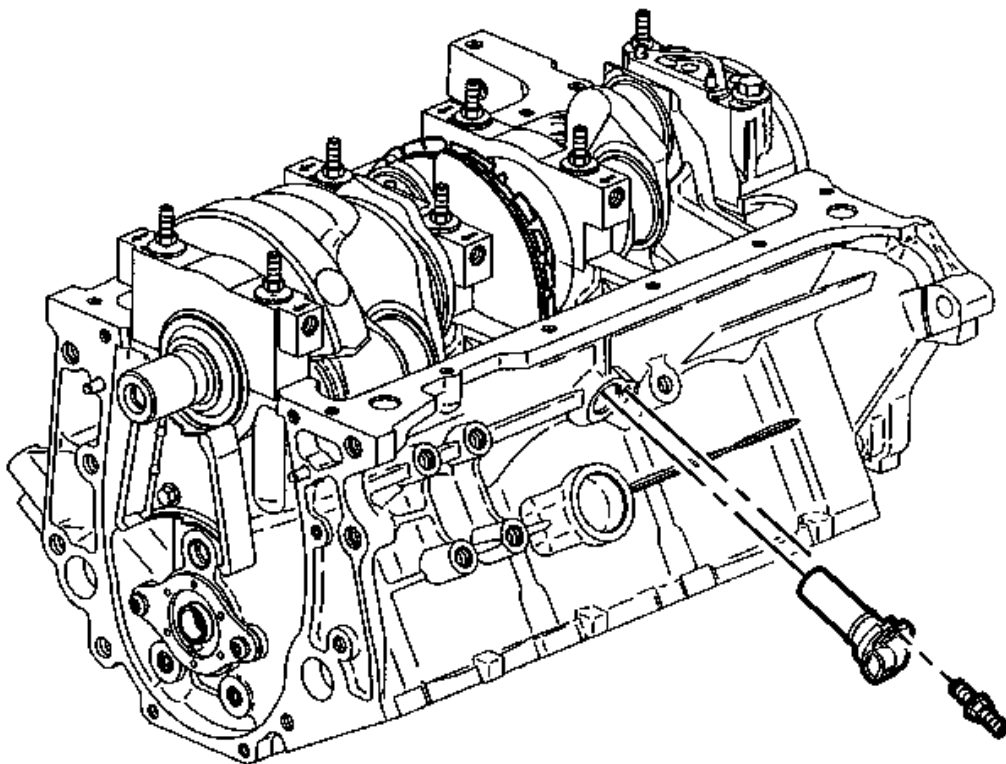


Fig. 331: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

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**.

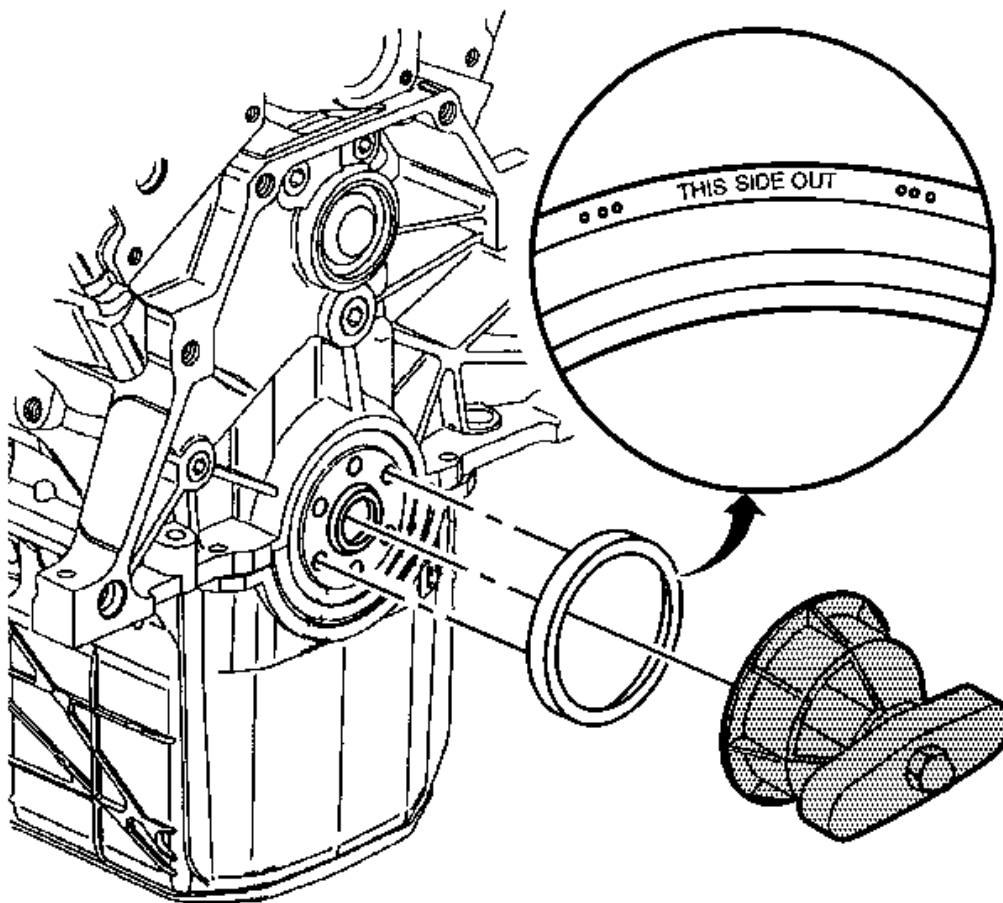


Fig. 332: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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**.

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**.
 2. Attach the **J 34686** to the crankshaft by hand, or tighten attaching screws to 5 N. See **Special Tools**.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**.

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 8037** Ring Compressor. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.

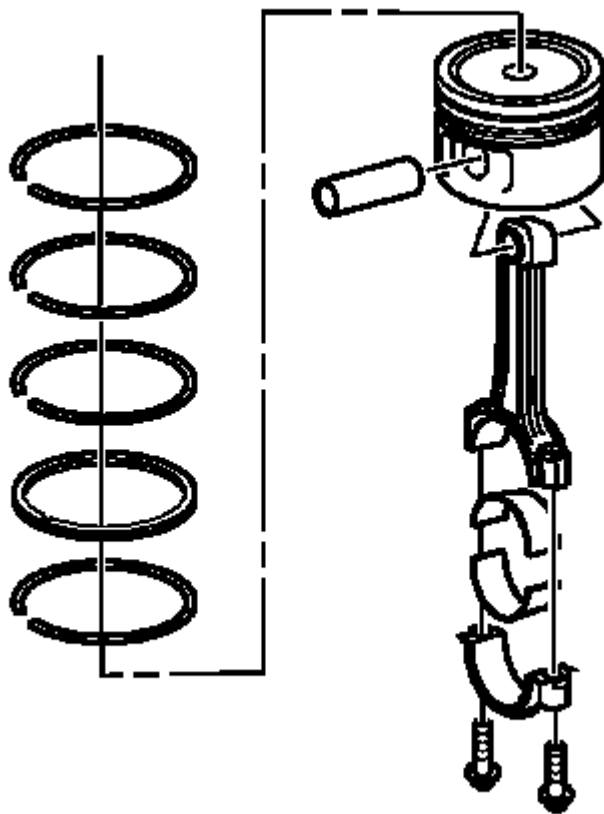


Fig. 333: View Of Piston Components
Courtesy of GENERAL MOTORS CORP.

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**.
5. Install the **J 41556** into the connecting rod. See **Special Tools**.

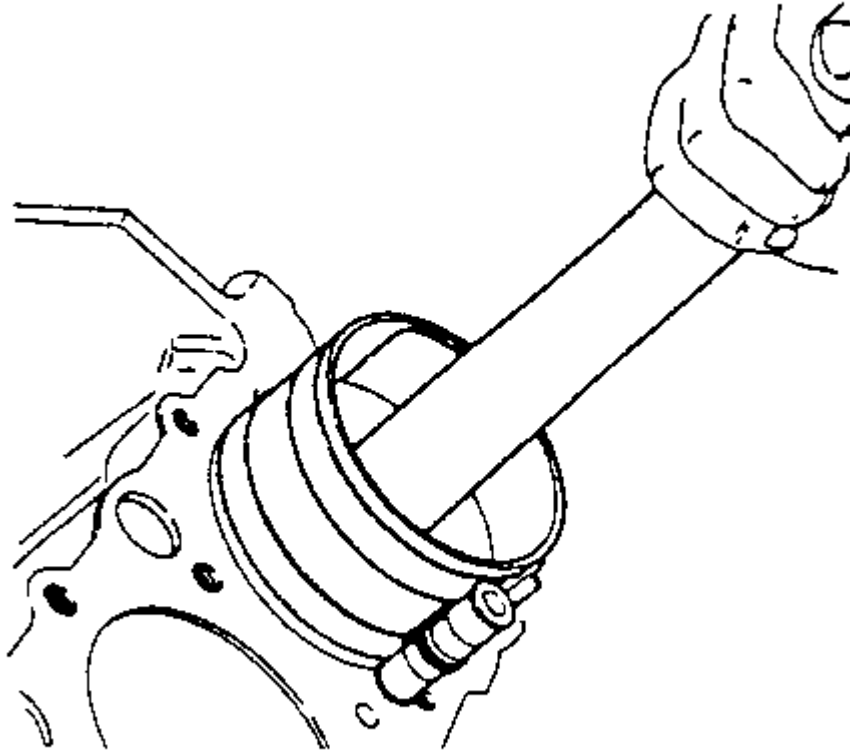


Fig. 334: Installing Piston & Connecting Rod Assembly Into Cylinder
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The piston alignment mark **MUST** be facing the front of the engine block.

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.

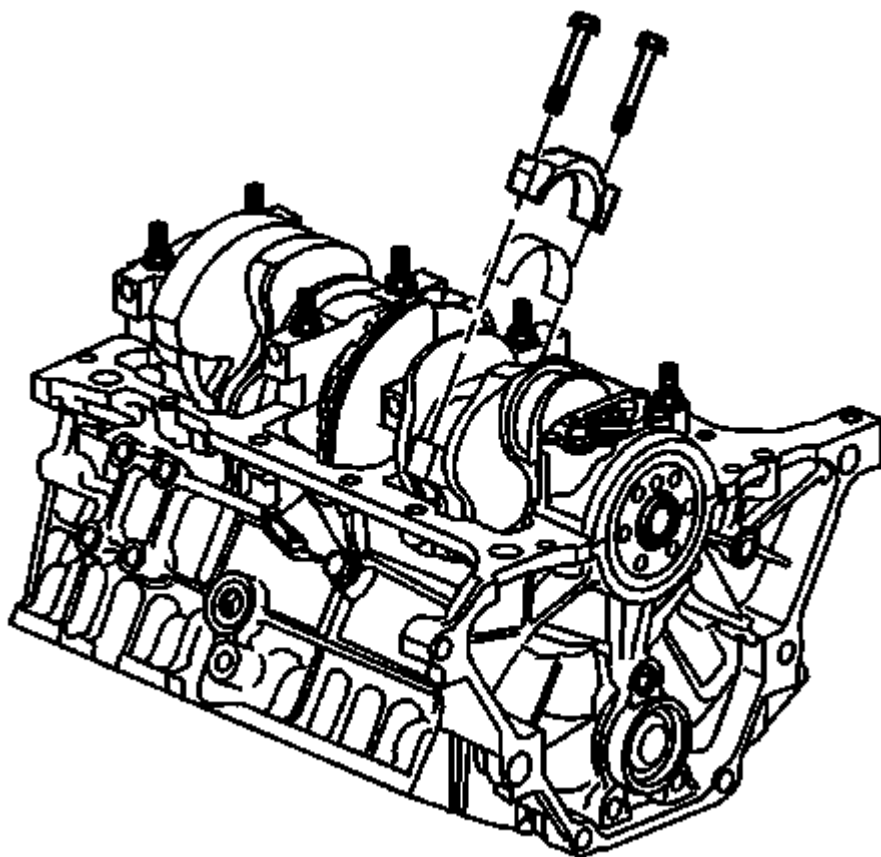


Fig. 335: View Of Bearing, Bearing Cap And Bolts
Courtesy of GENERAL MOTORS CORP.

8. Using **J 41556** , guide the connecting rod end onto the crankshaft journal. See **Special Tools**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the bearing, bearing cap and bolts.

Tighten:

1. Tighten the connecting rod bearing cap bolts a first pass to 25 N.m (18 lb ft).
2. Tighten the connecting rod bearing cap bolts a final pass to 110 degrees using the **J 45059** . See **Special Tools**.

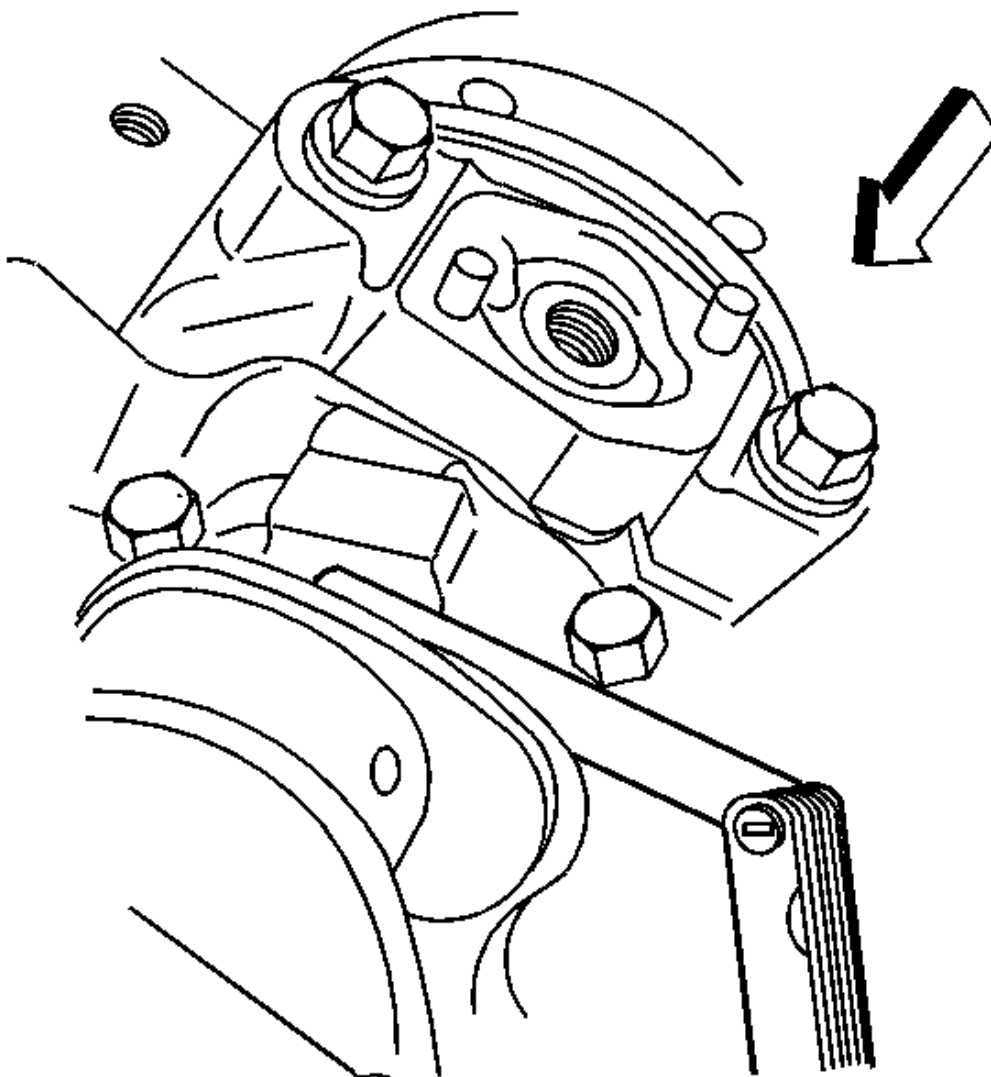


Fig. 336: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

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

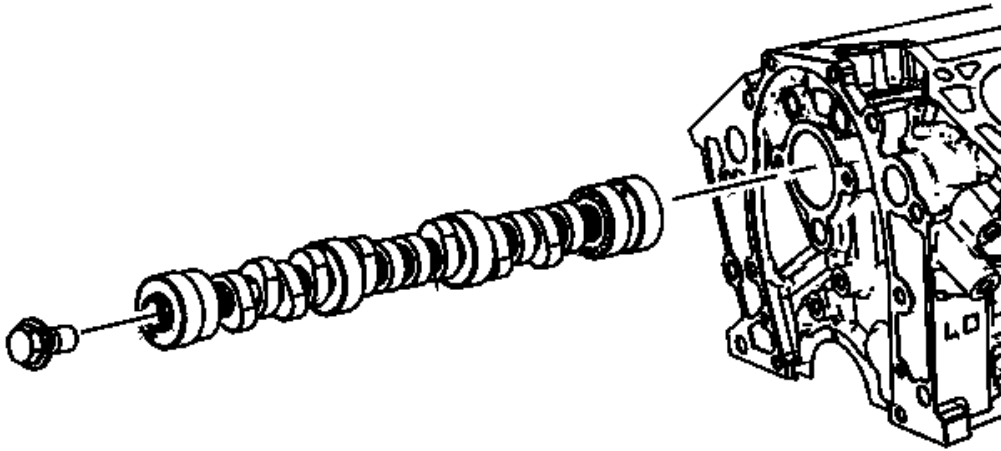


Fig. 337: Inspecting Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

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 the camshaft sprocket bolt into the camshaft. Tighten finger tight only.
 2. Carefully rotate the camshaft while installing the camshaft into the camshaft bearings.

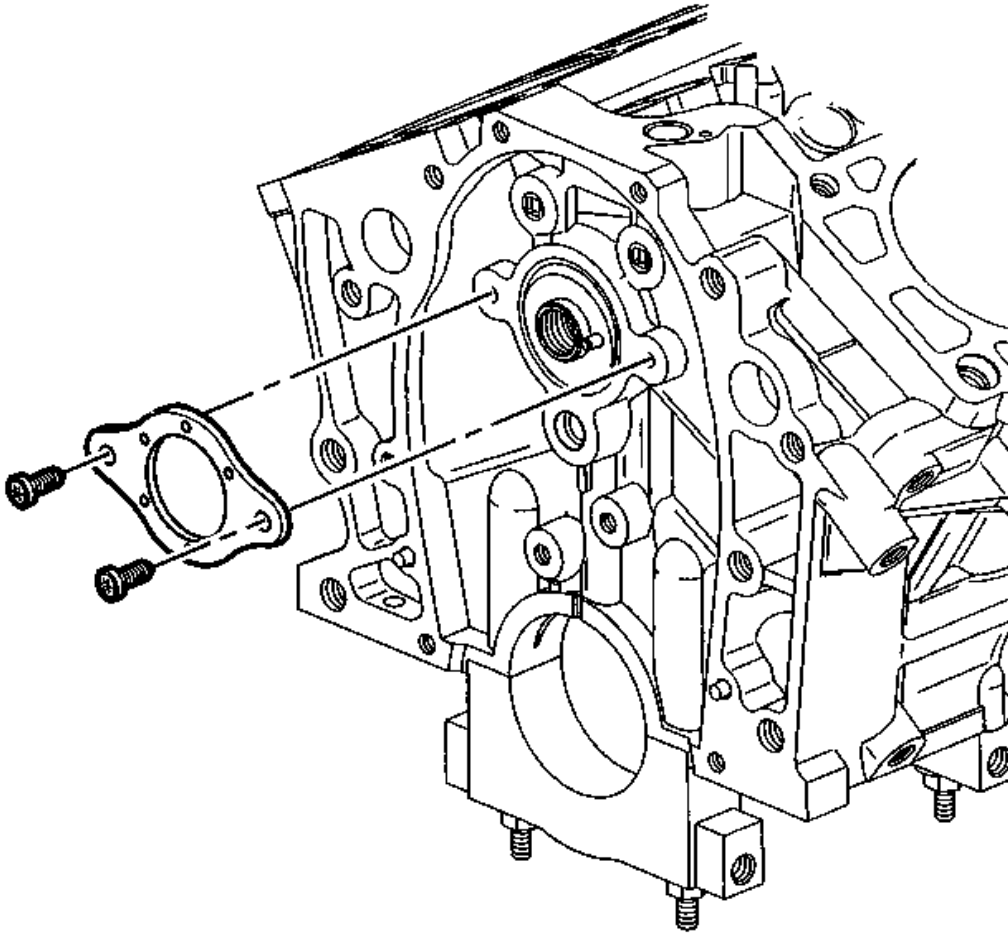


Fig. 338: View Of Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

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).

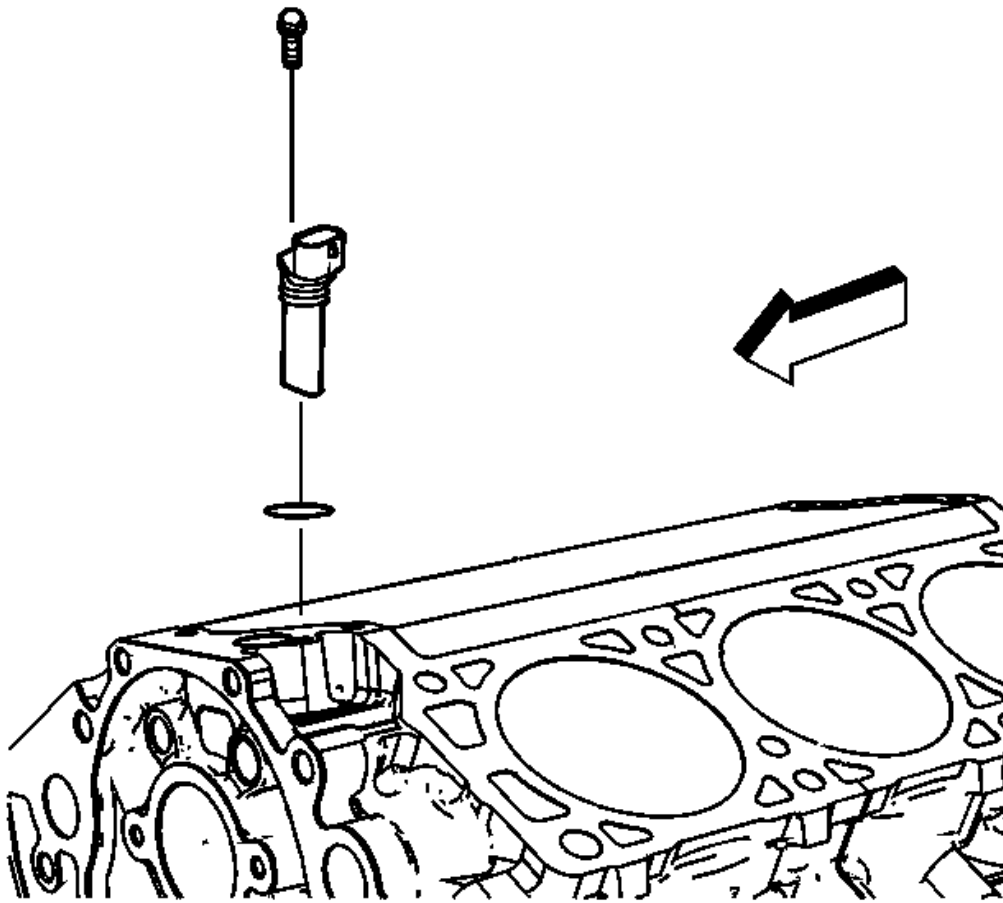


Fig. 339: View Of Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft position sensor.
7. Install the camshaft position sensor bolt.

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

Timing Chain and Sprockets Installation

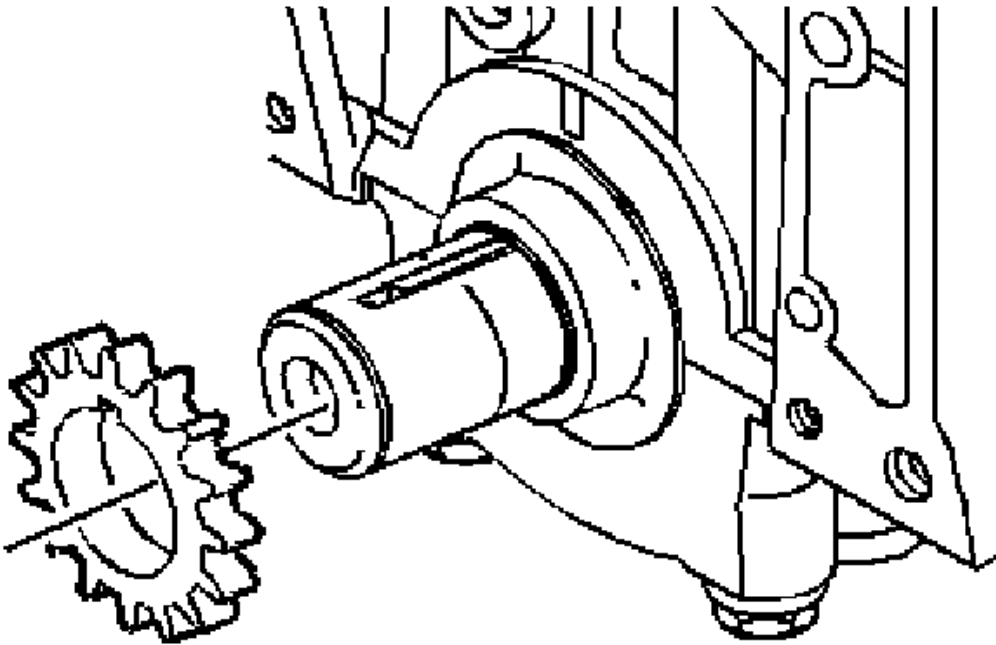


Fig. 340: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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.

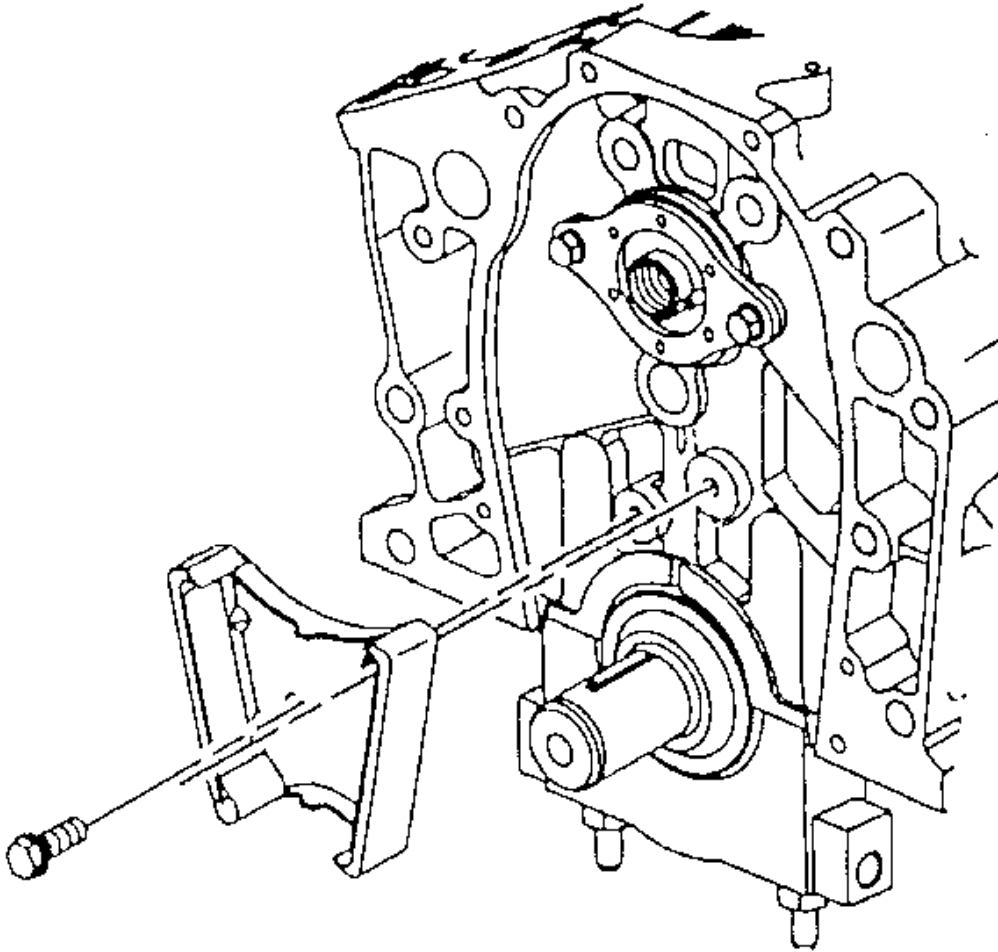


Fig. 341: View Of Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

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).

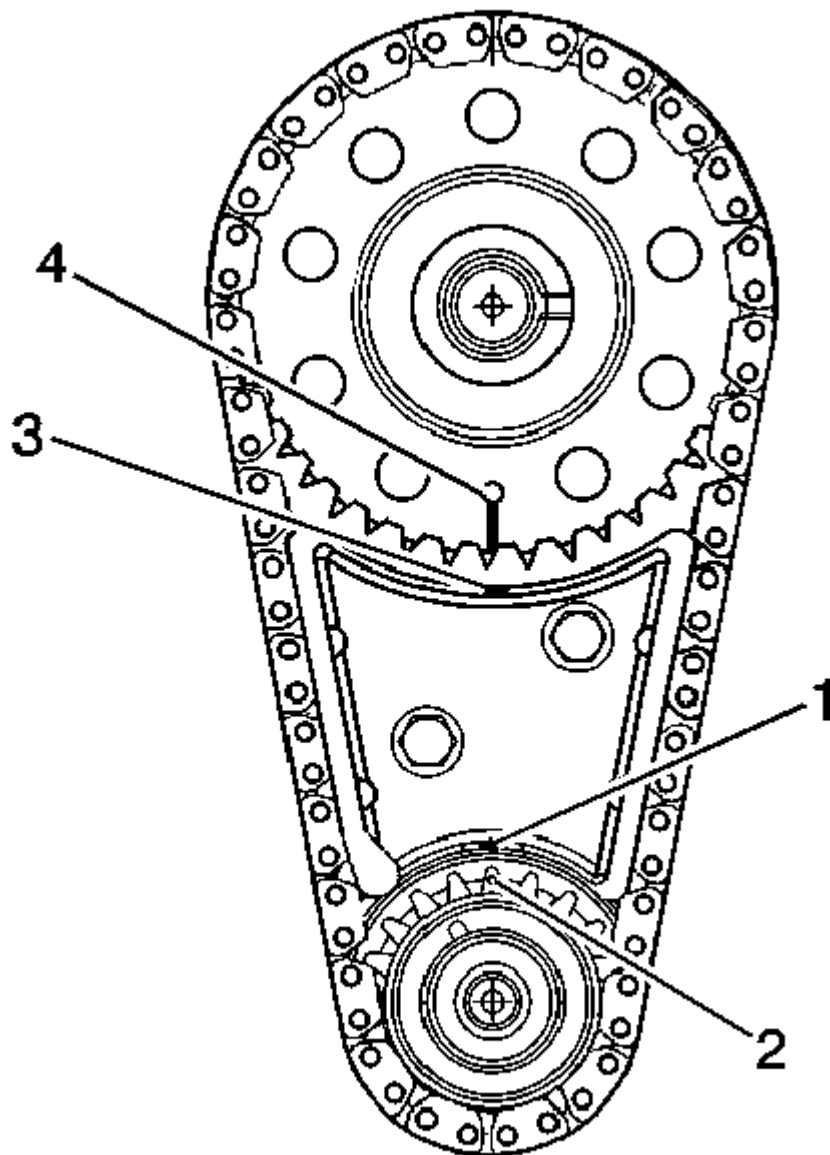


Fig. 342: Locating Timing Marks

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).

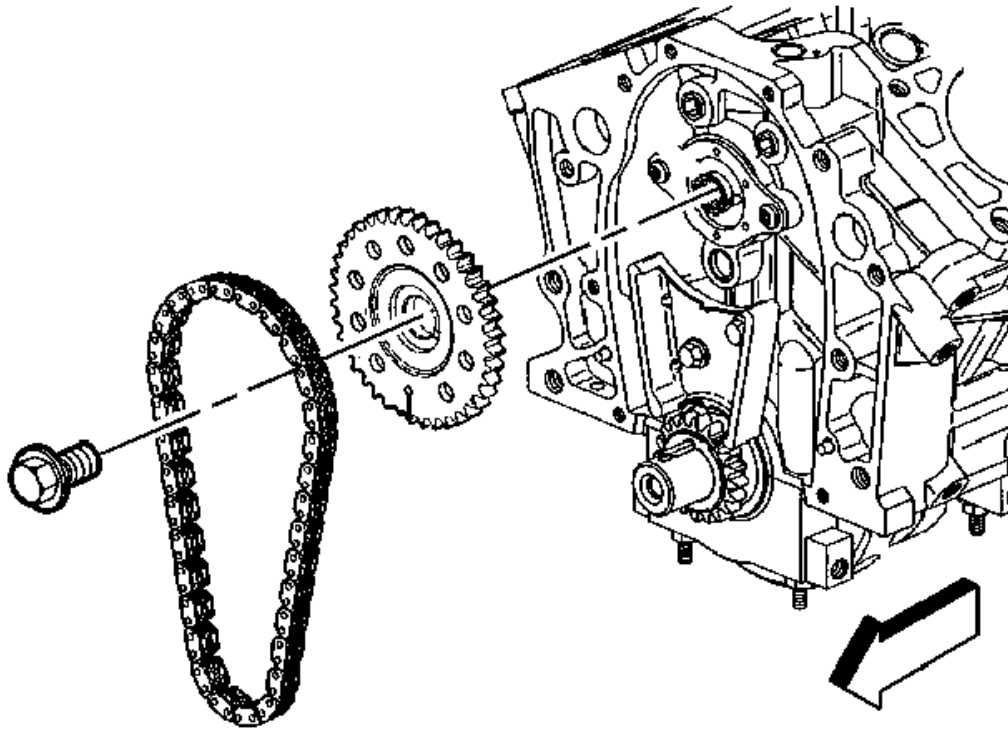


Fig. 343: View Of Timing Chain & Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

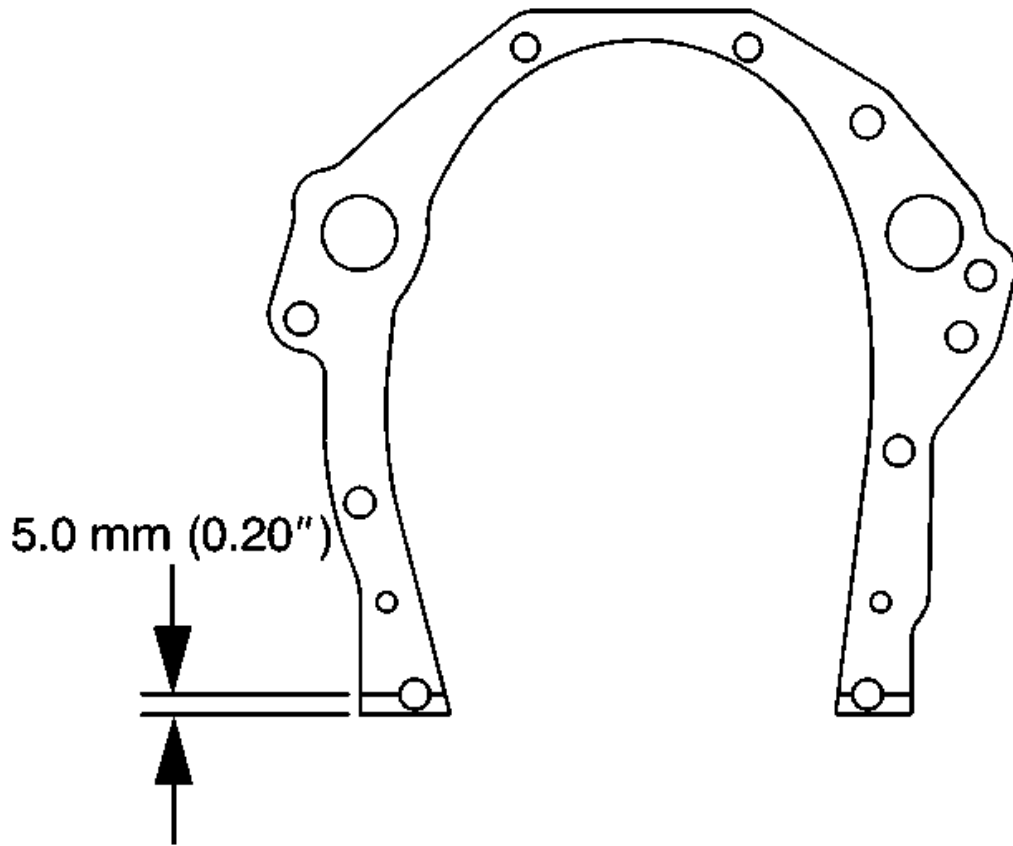


Fig. 344: Applying Sealer To Lower Tabs Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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. Apply the sealer no less than 5.0 mm (0.20 in) wide.

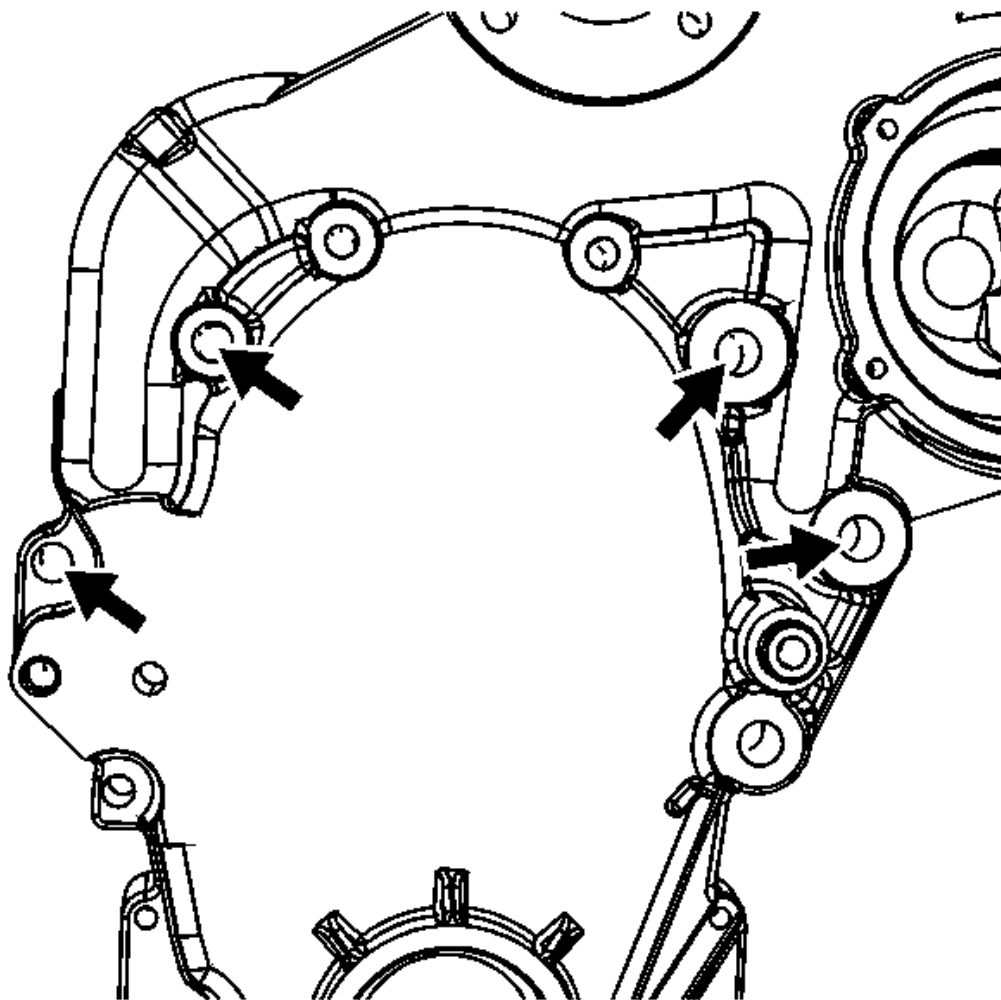


Fig. 345: Bolt Sealer Locations In Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the engine front cover.
4. Apply sealer GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the bolts in the locations pointed out in the graphic.

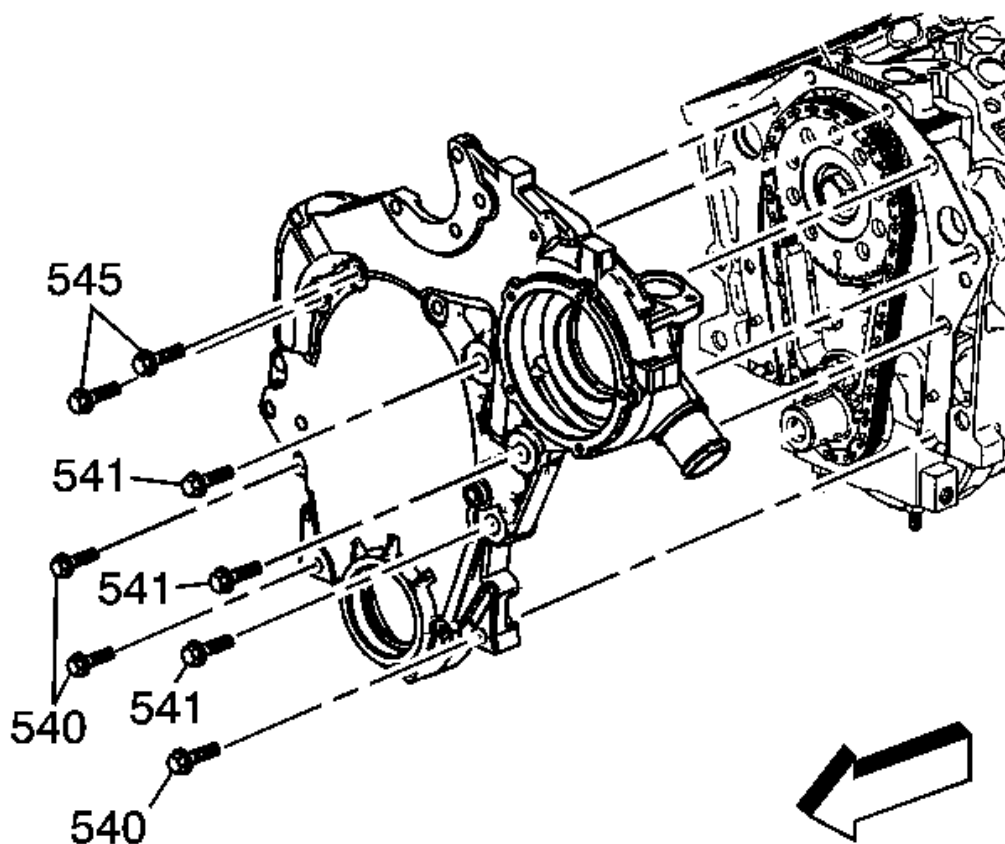


Fig. 346: View Of Engine Front Cover Bolts (540, 541, 545)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the engine front cover bolts (545).

Tighten: Tighten the engine front cover bolts to 27 N.m (20 lb ft).

6. Install the engine front cover bolts (540, 541).

Tighten: Tighten the engine front cover bolts to 55 N.m (41 lb ft).

Crankshaft Front Oil Seal Installation

Tools Required

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

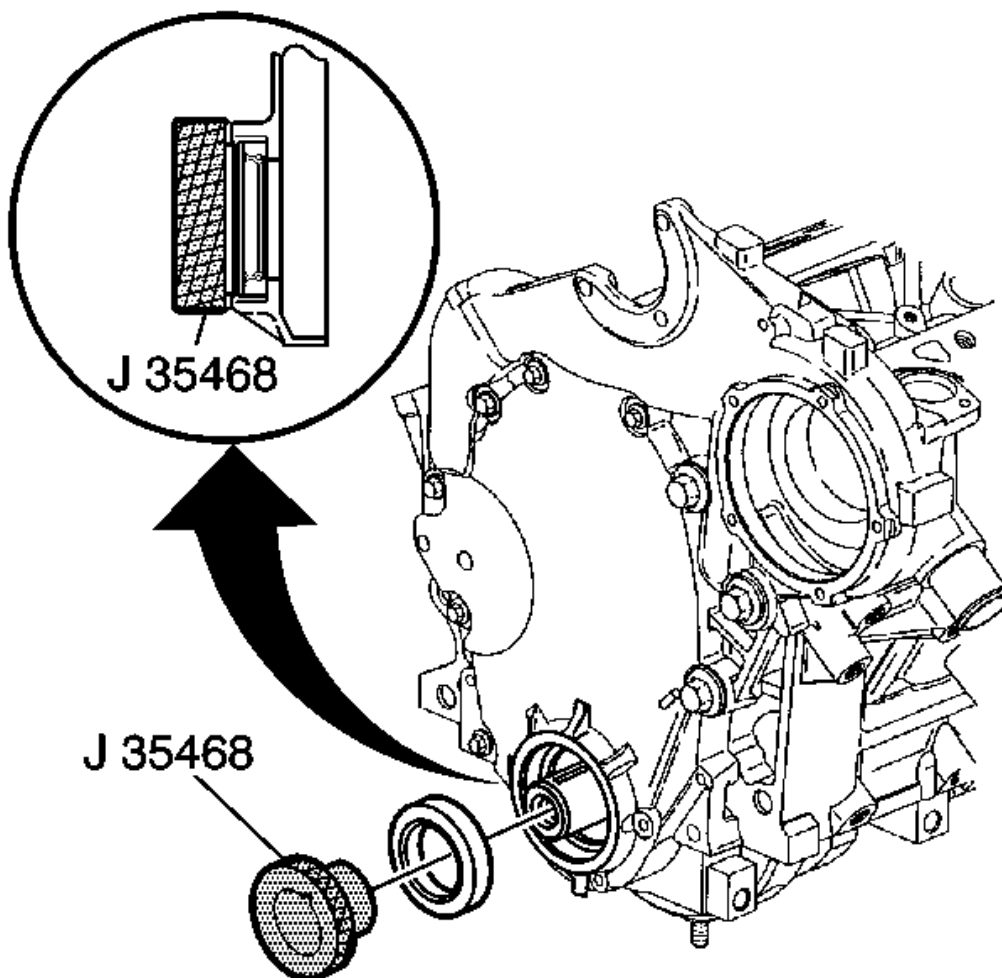


Fig. 347: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

Oil Pump Drive Installation

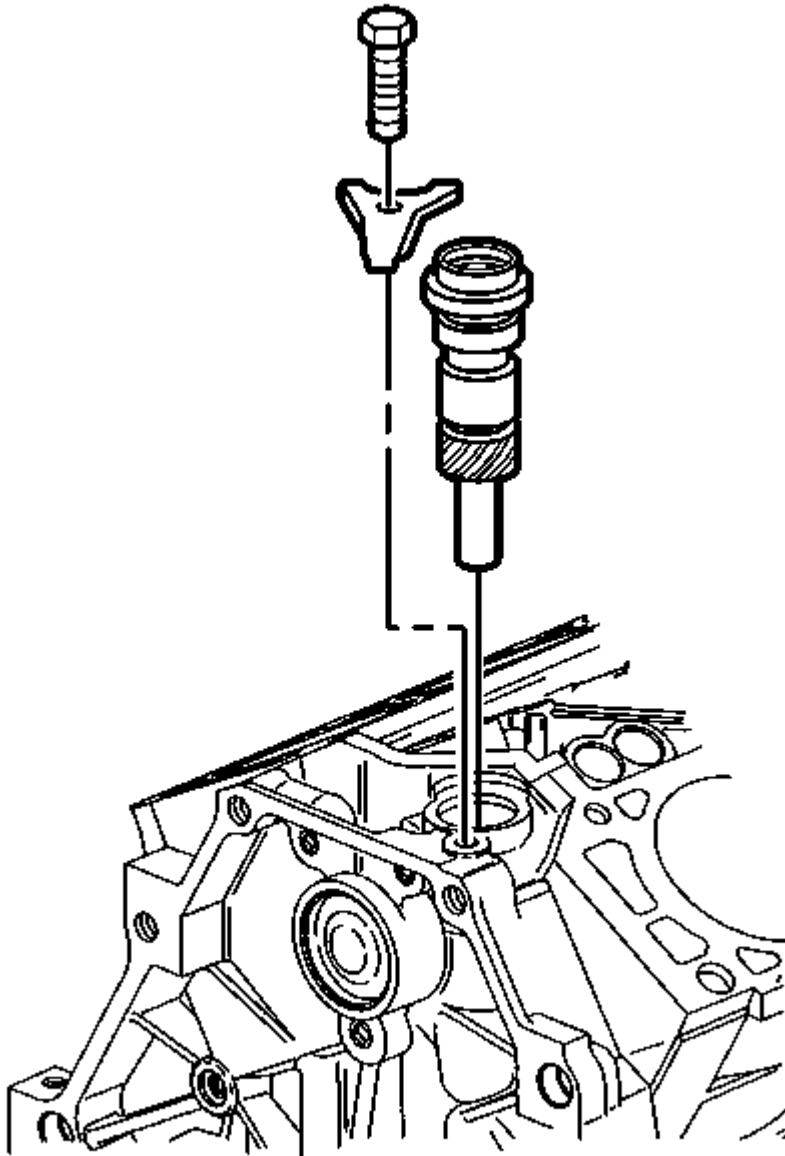


Fig. 348: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

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

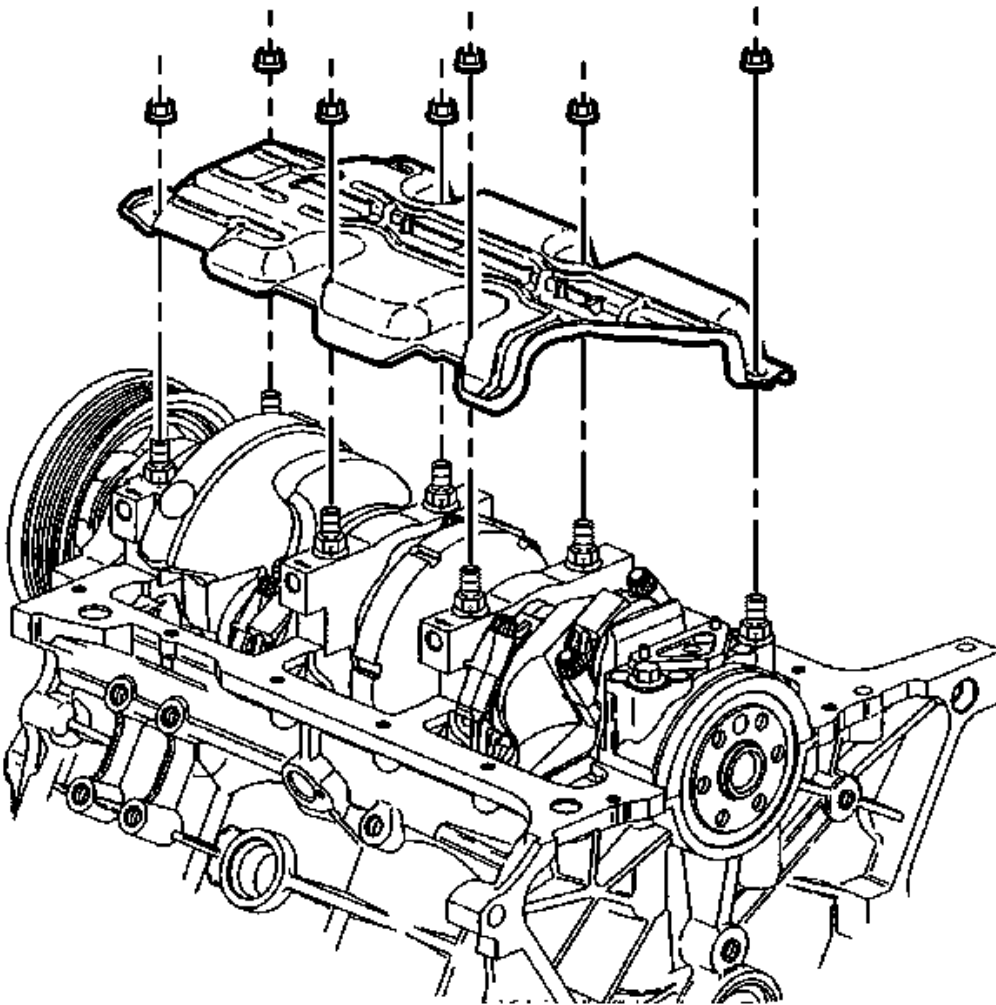


Fig. 349: View Of Crankshaft Oil Deflector & Nuts

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).

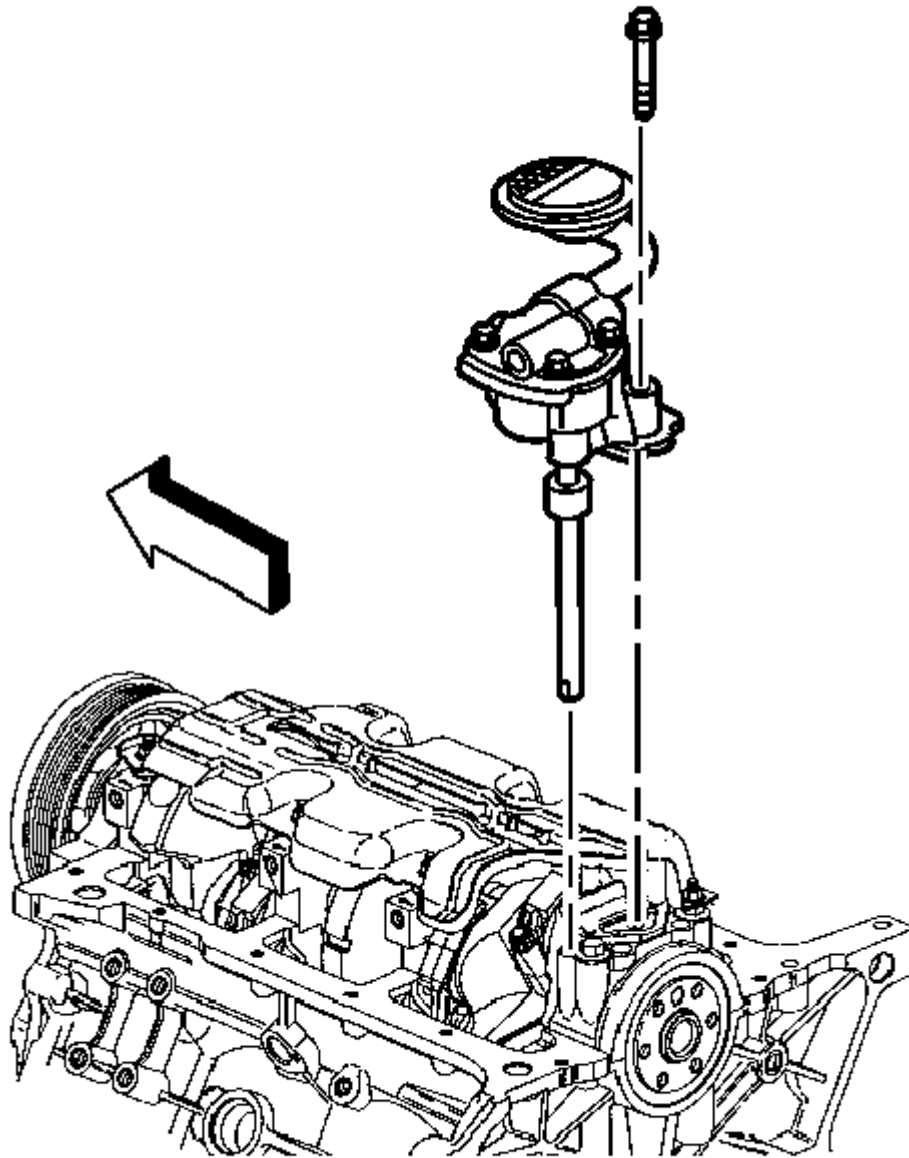


Fig. 350: Oil Pump

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the oil pump driveshaft retainer. During assembly, install a **NEW** oil pump driveshaft retainer.

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

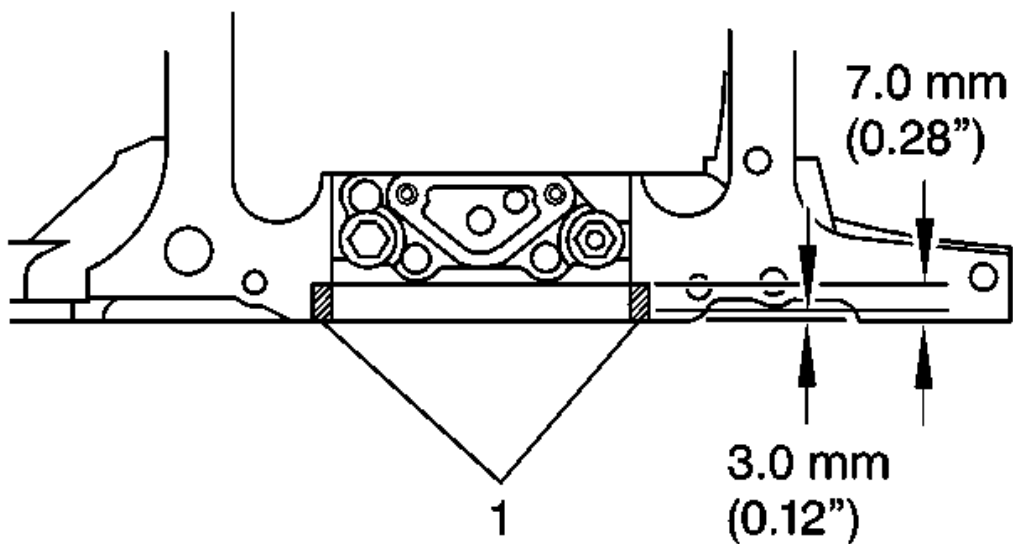


Fig. 351: Illustrating Proper Sealer Application
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12378521, (Canadian P/N 88901148) or the equivalent to both sides of the crankshaft rear main bearing cap (1). Press sealer into gap using a putty knife.

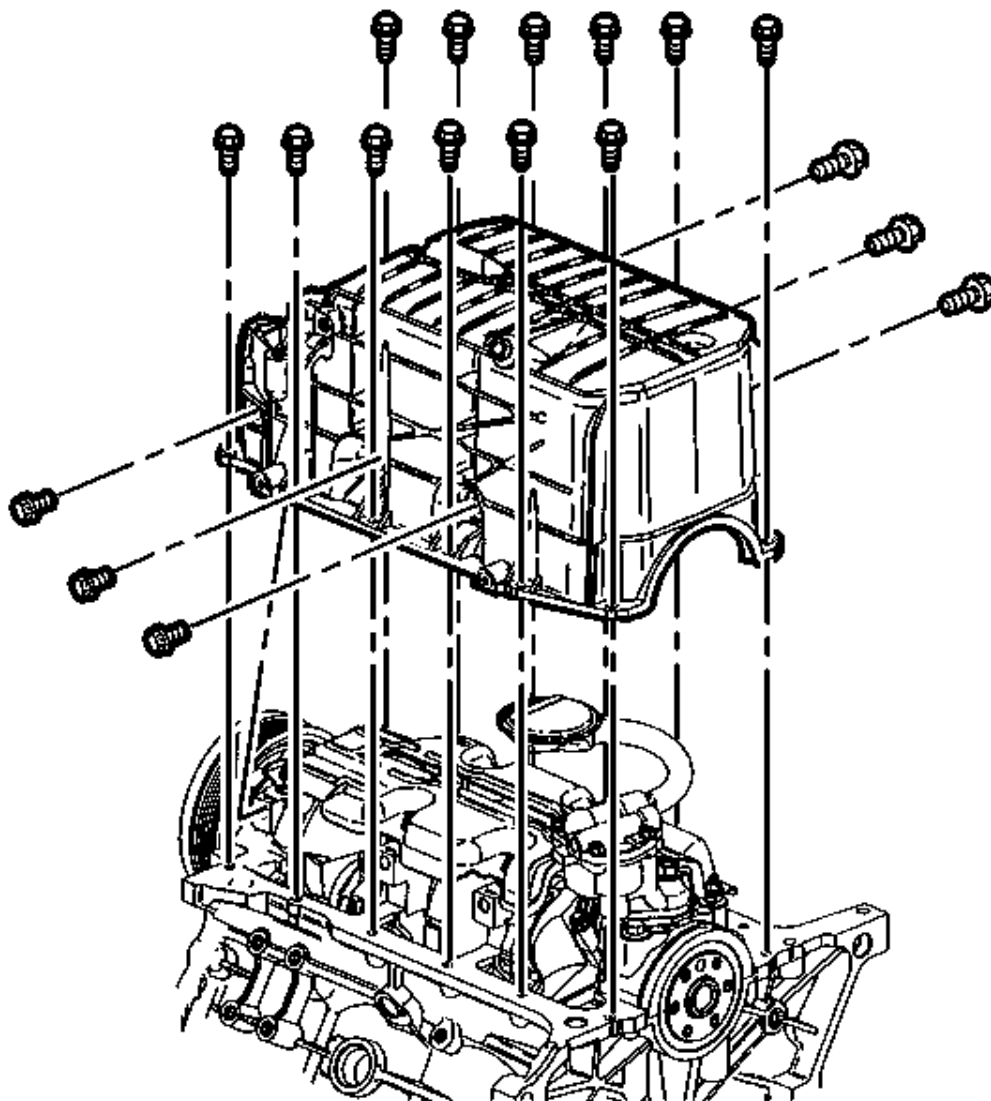


Fig. 352: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

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).

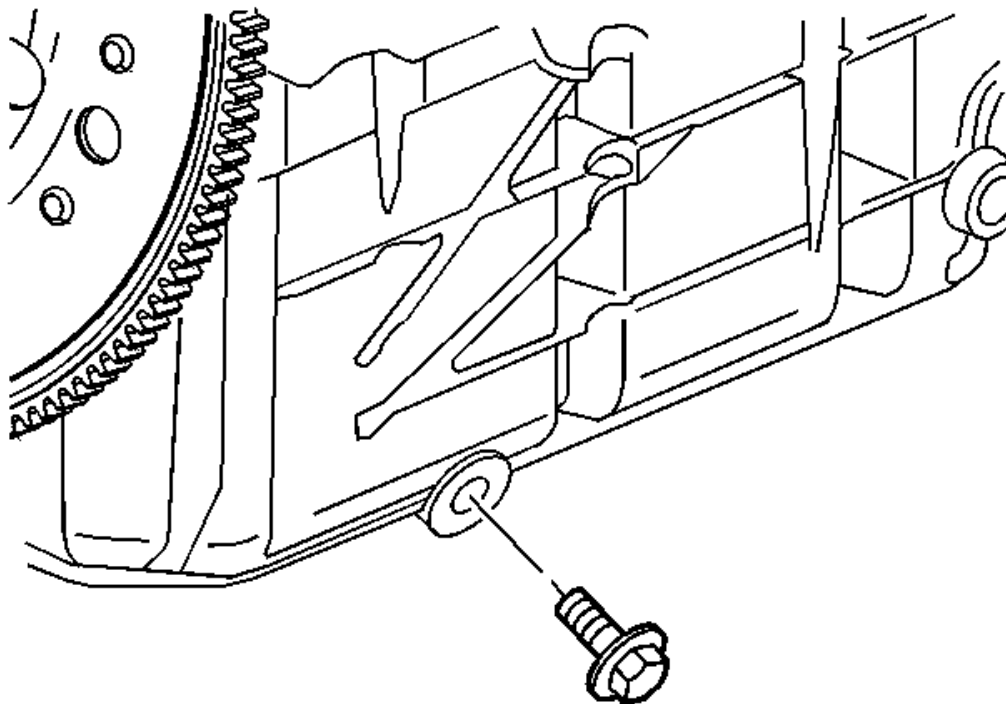


Fig. 353: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain to 25 N.m (18 lb ft).

Cylinder Head Installation - Left

Tools Required

J 45059 Angle Meter. See Special Tools.

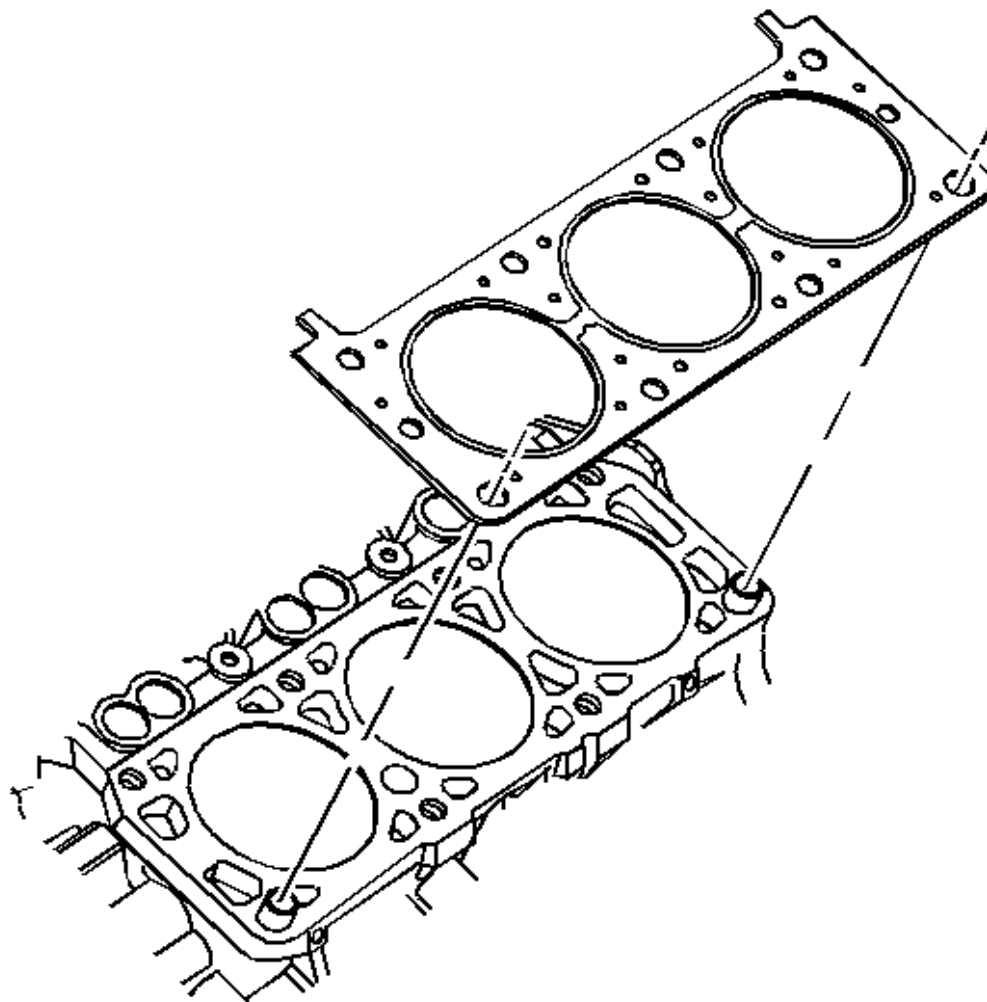


Fig. 354: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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

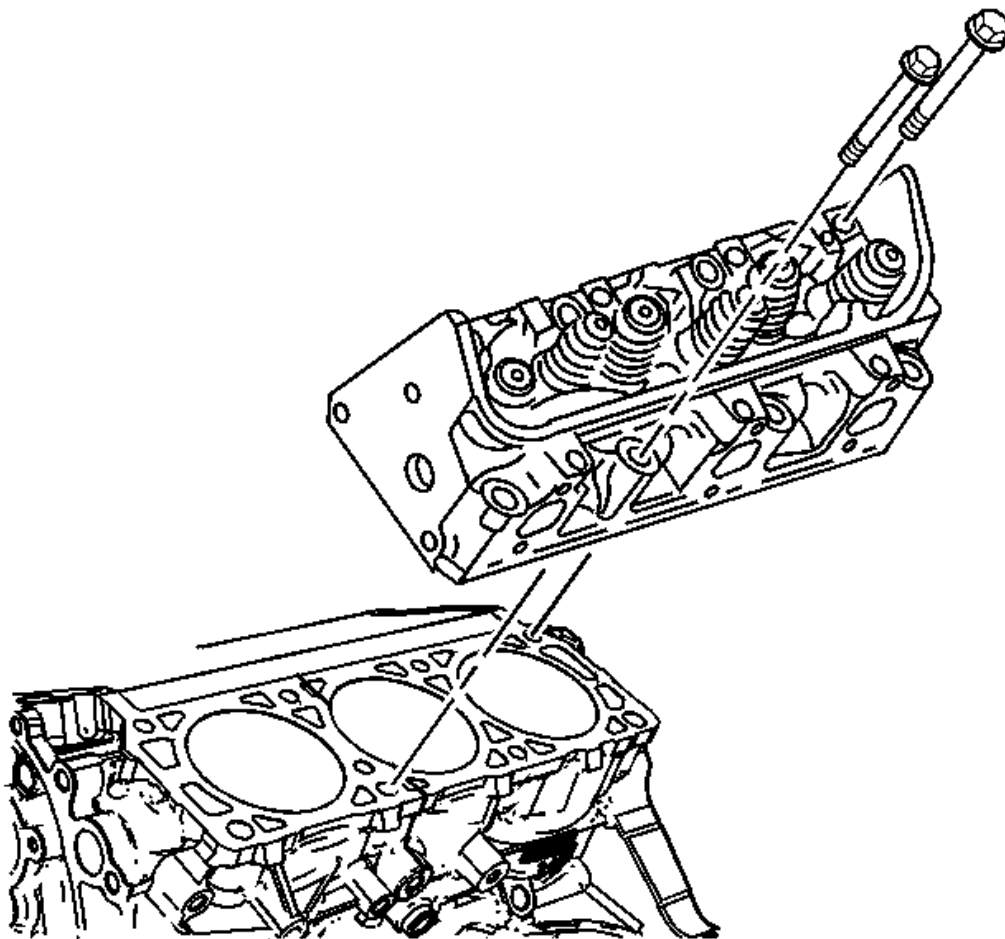


Fig. 355: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

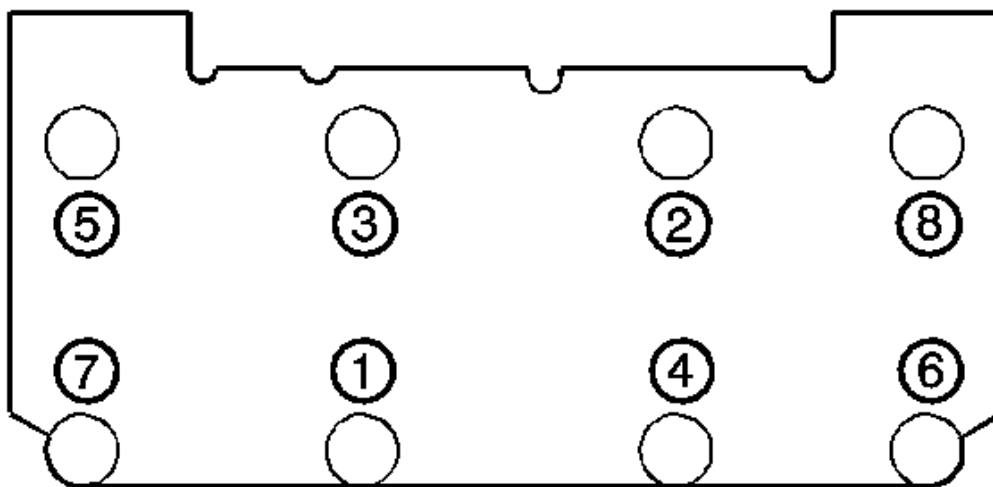


Fig. 356: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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**.

Cylinder Head Installation - Right

Tools Required

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

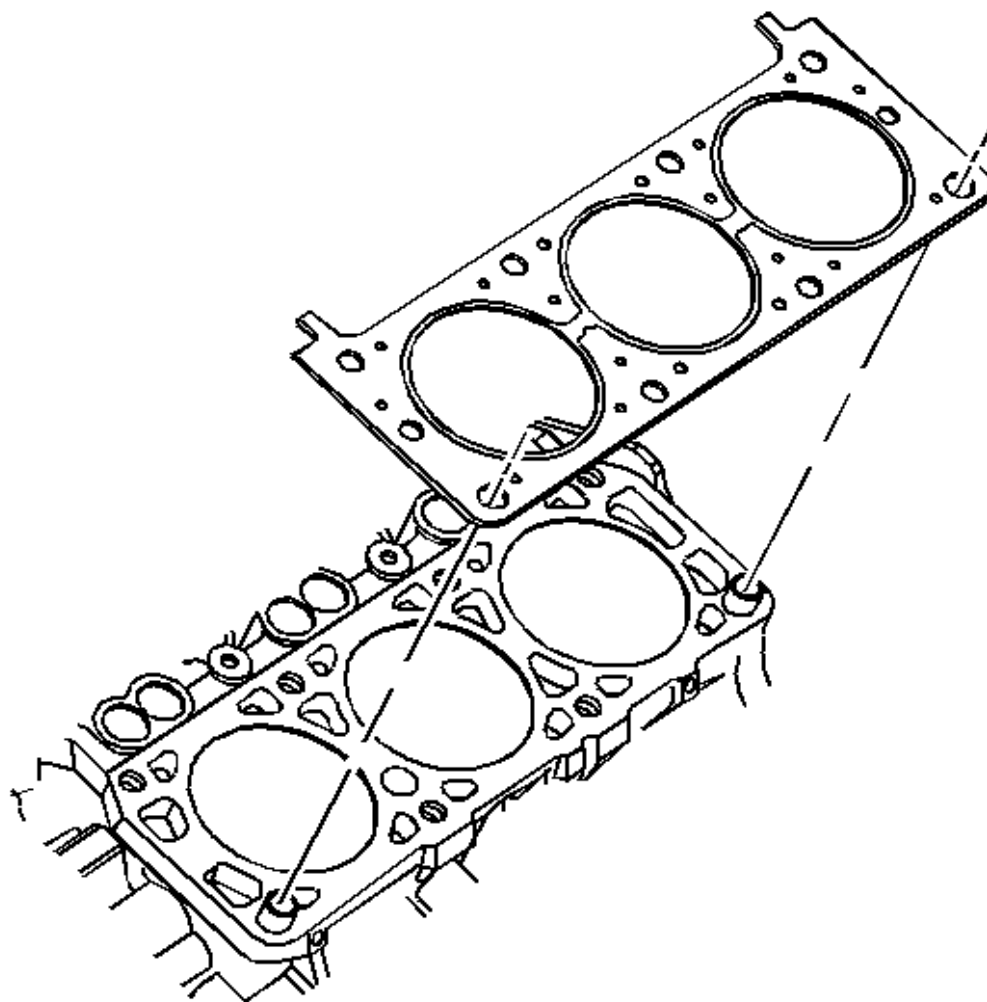


Fig. 357: View Of Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

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.

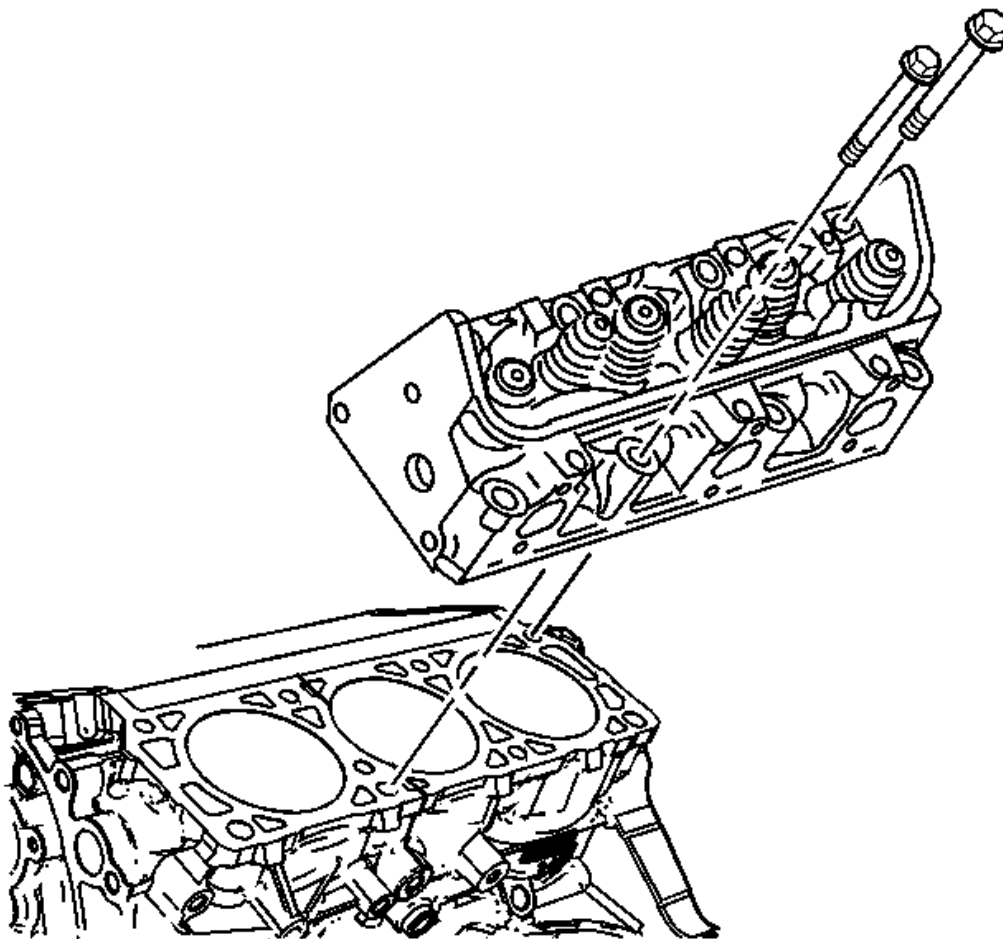


Fig. 358: Removing/Installing Cylinder Head
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head.

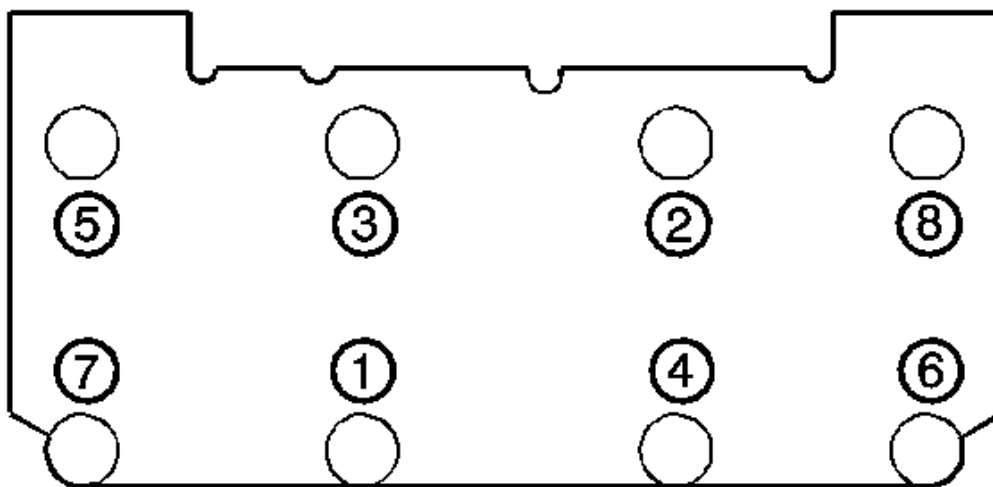


Fig. 359: View Of Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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**.

Water Pump Installation

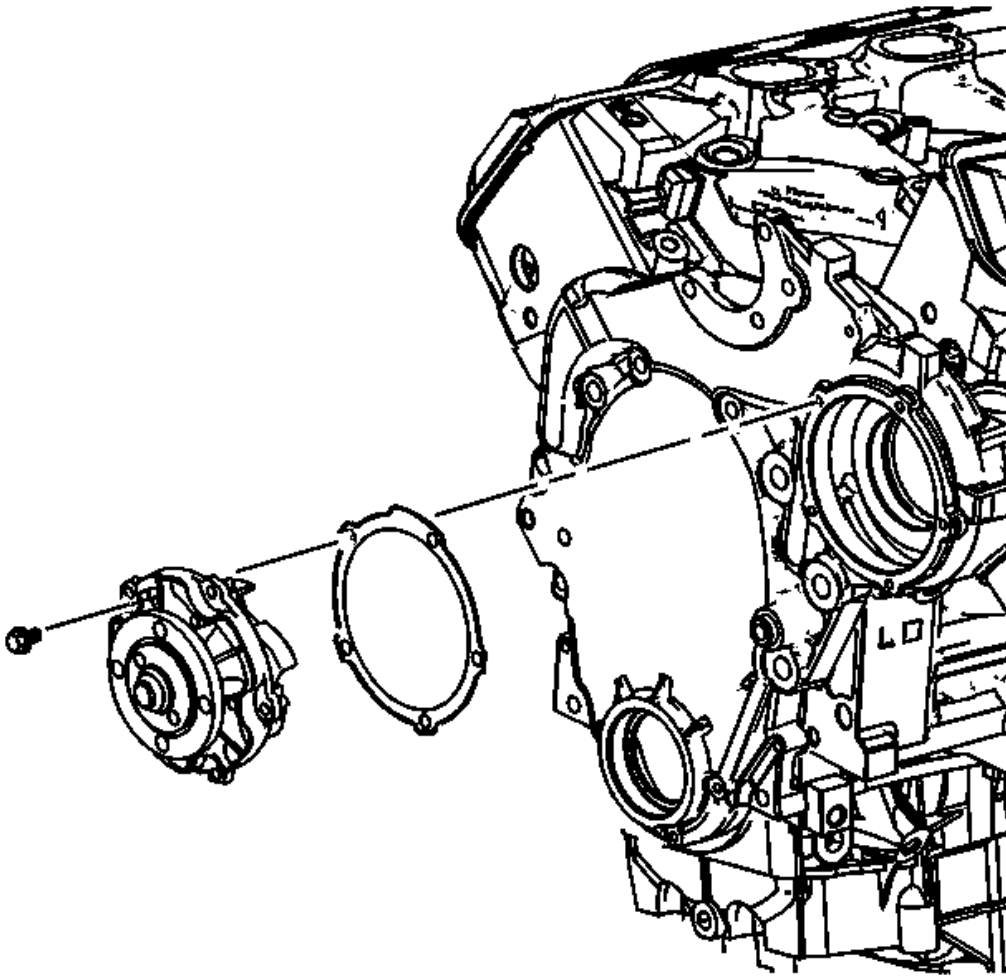


Fig. 360: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

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).

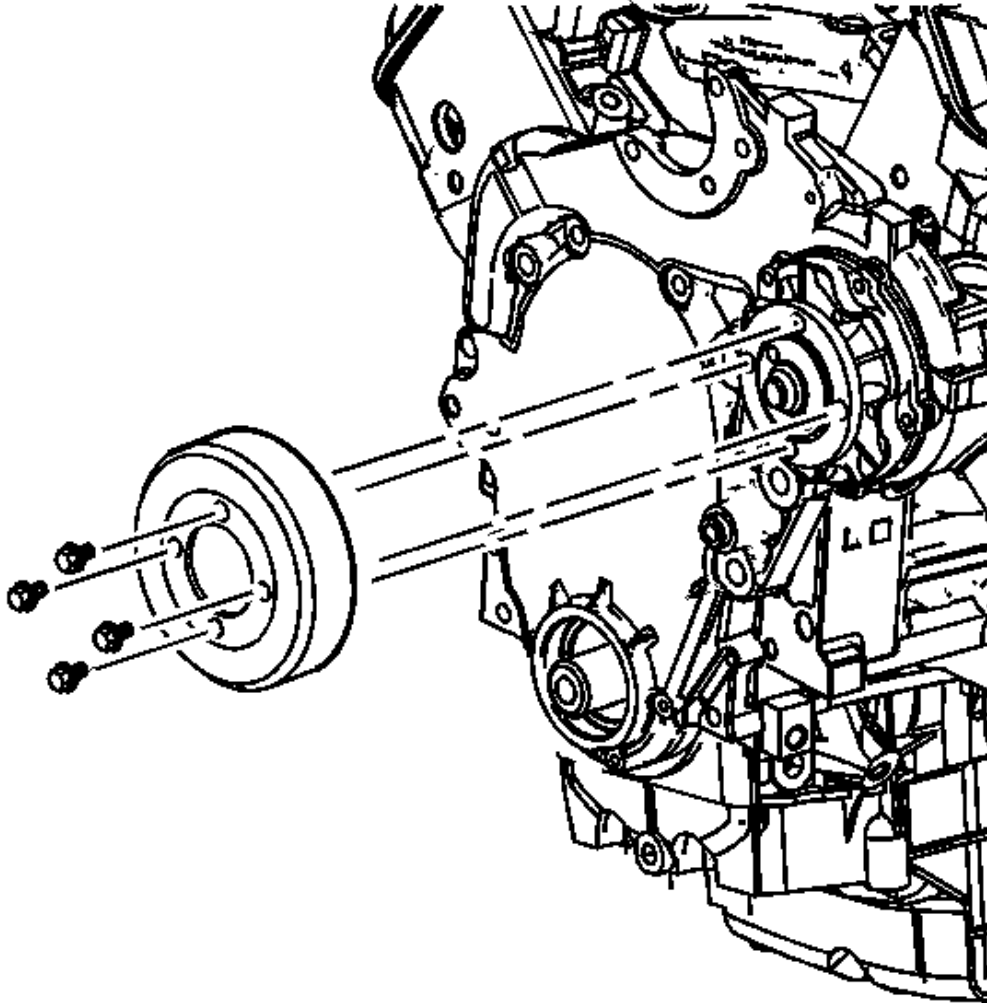


Fig. 361: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

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

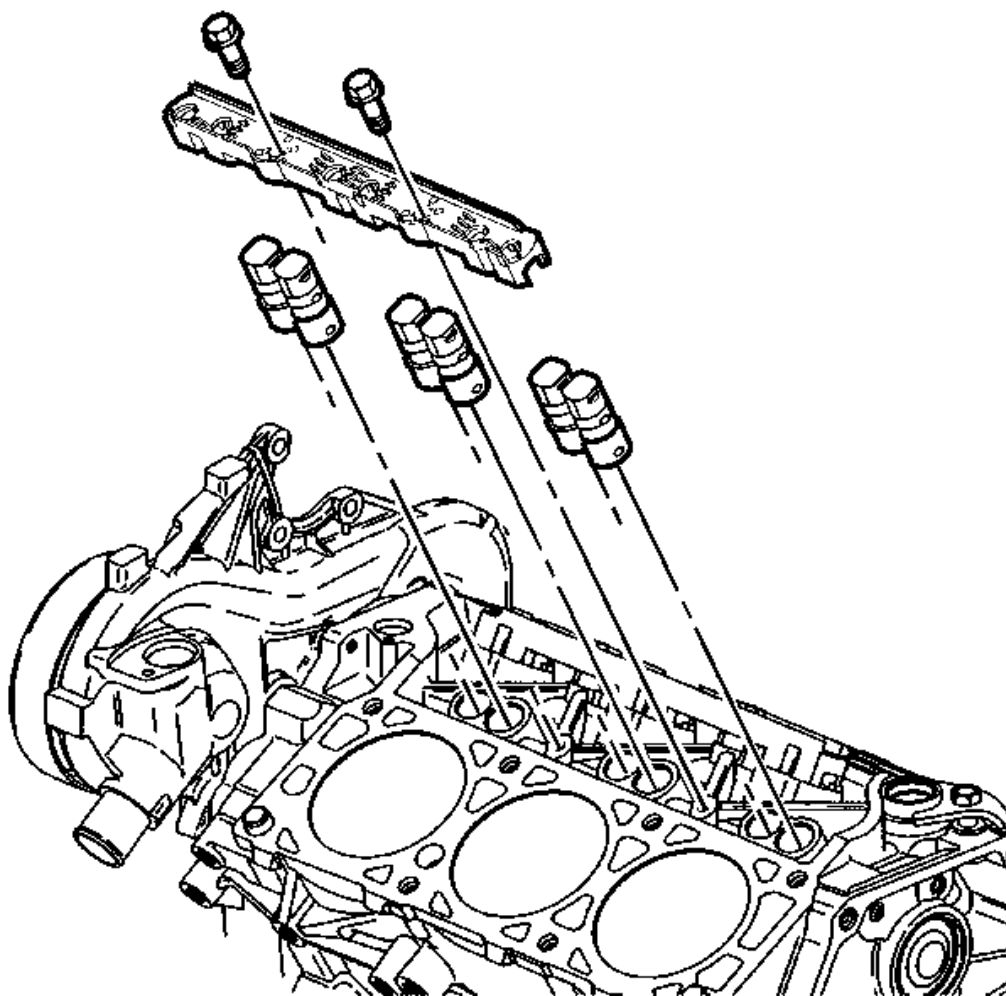


Fig. 362: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

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

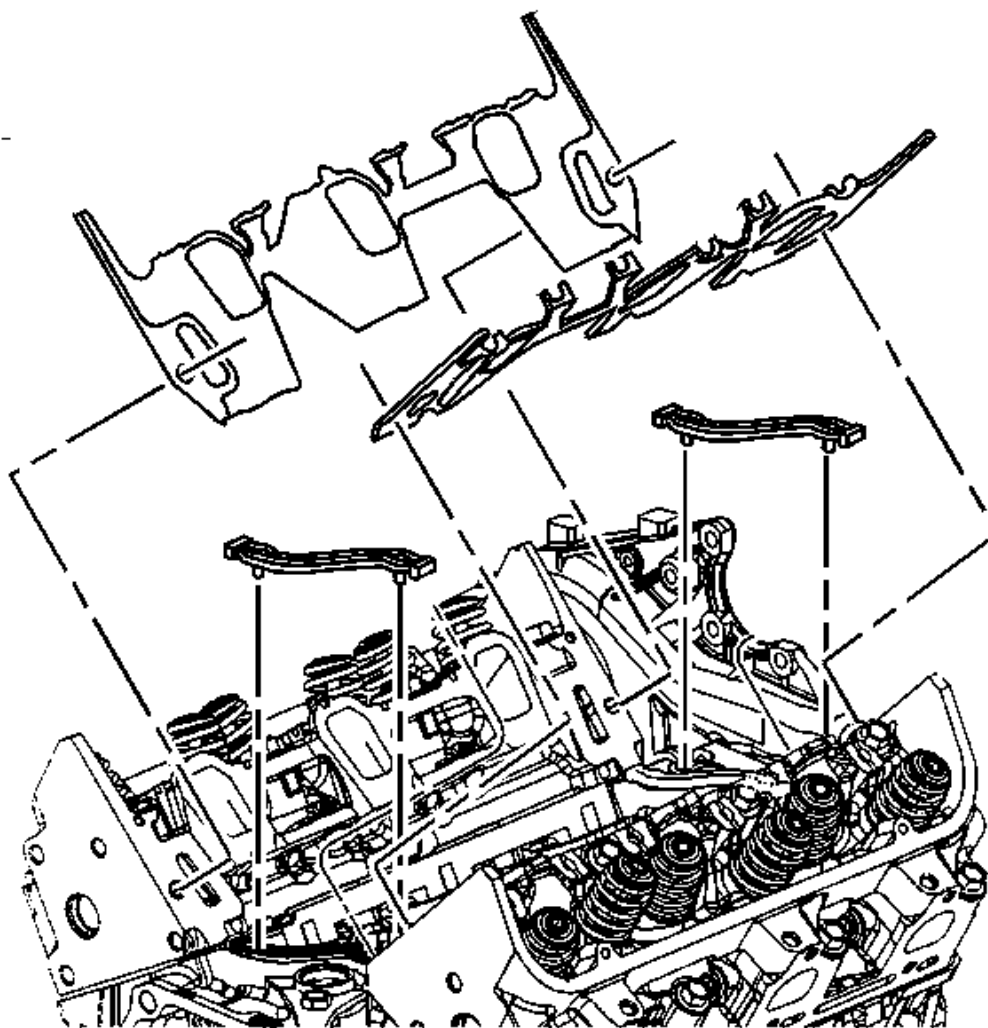


Fig. 363: View Of Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: Room temperature vulcanizing (RTV) sealer is not to be placed under the lower intake manifold gaskets.

1. Install the lower intake manifold gaskets.

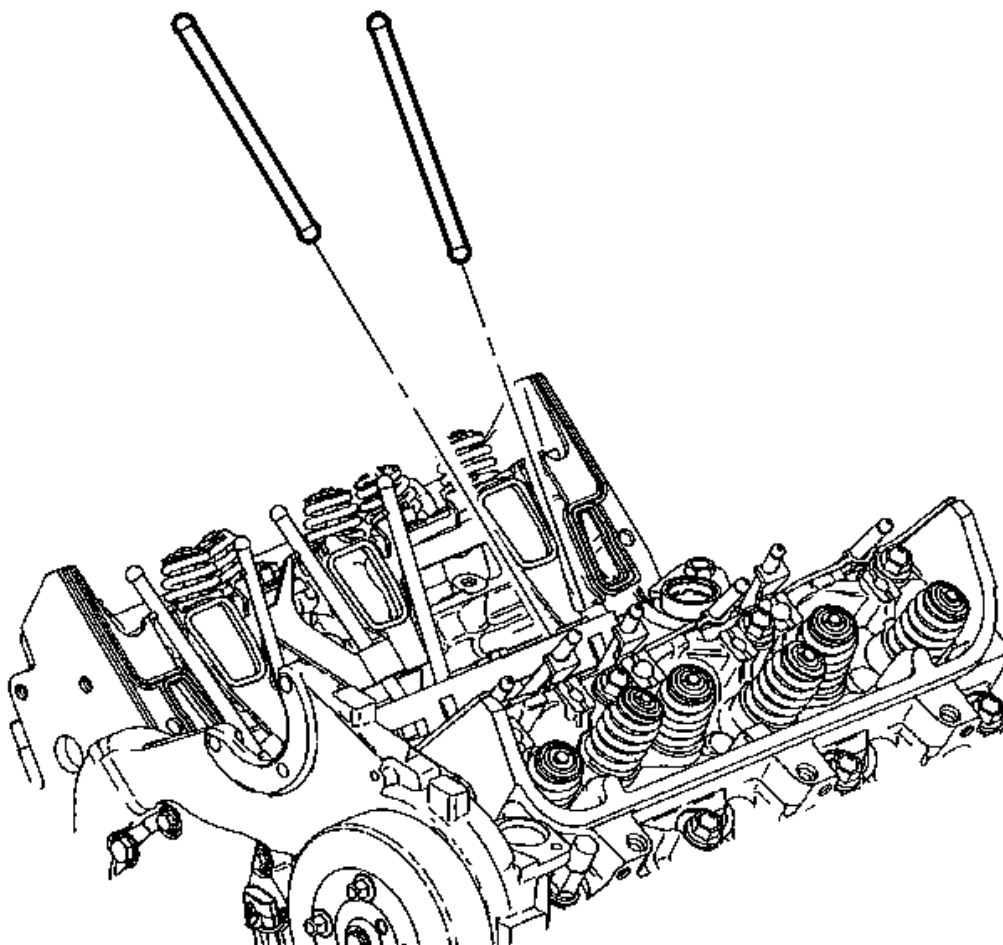


Fig. 364: View Of Push Rods

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) and the exhaust valve push rods measure 152.5 mm (6.0 in) in length.

3. Install the push rods in their original location.

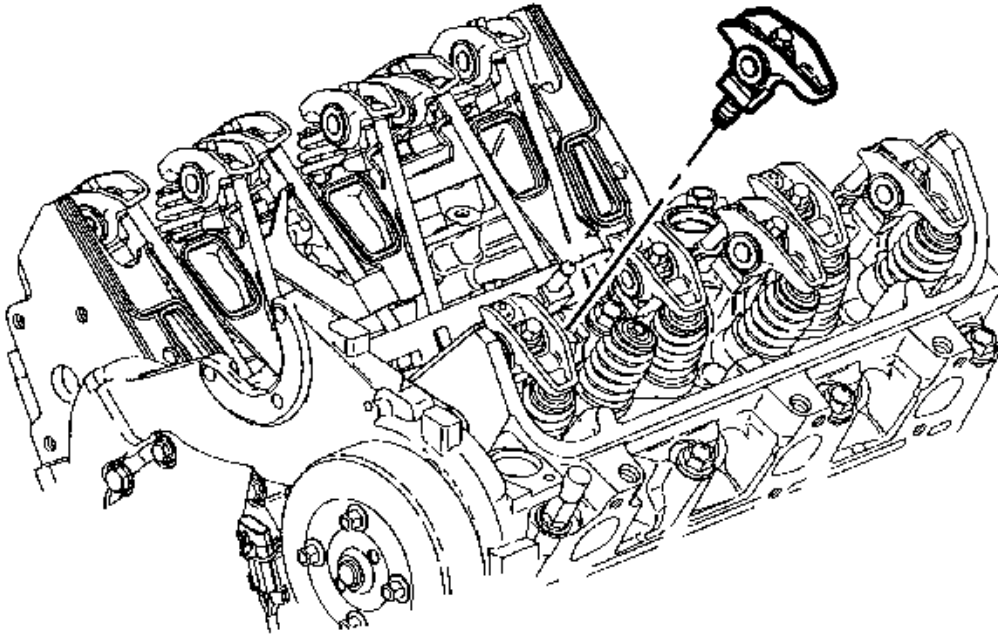


Fig. 365: View Of Valve Rocker Arm Bolts
Courtesy of GENERAL MOTORS CORP.

4. Coat the rocker arm friction surfaces using prelude GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

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

5. Install the valve rocker arms in their original positions.

NOTE: Refer to Fastener Notice 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

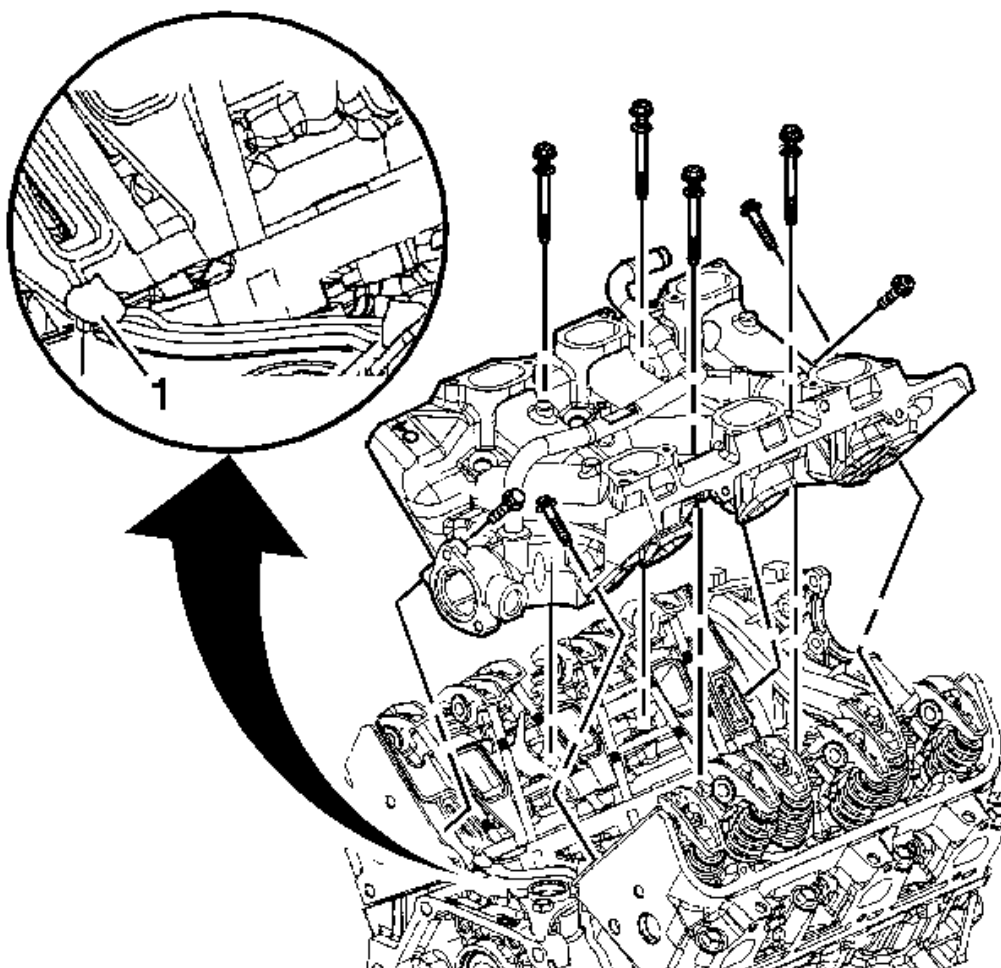


Fig. 366: Installing Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

1. With gaskets and seals in place apply a small drop 8-10 mm (0.31-0.39 in) of RTV sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the 4 corners of the intake manifold to block joints (1).
2. Install the lower intake manifold.

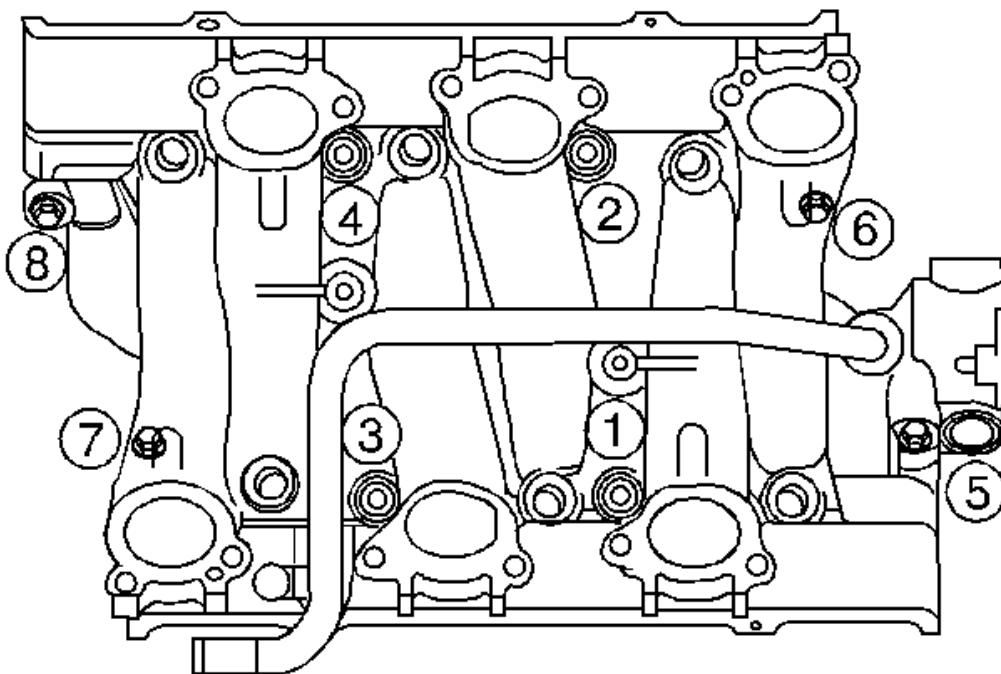


Fig. 367: Lower Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

3. Apply sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the lower intake manifold bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the lower intake manifold bolts.

Tighten:

1. Tighten the center lower intake manifold bolts (1, 2, 3, 4) in sequence to 20 N.m (15 lb ft).

2. Tighten the visible corner lower intake manifold bolts (5, 8,) to 25 N.m (18 lb ft).
3. Tighten the hidden corner lower intake manifold bolts (6, 7) to 25 N.m (18 lb ft).

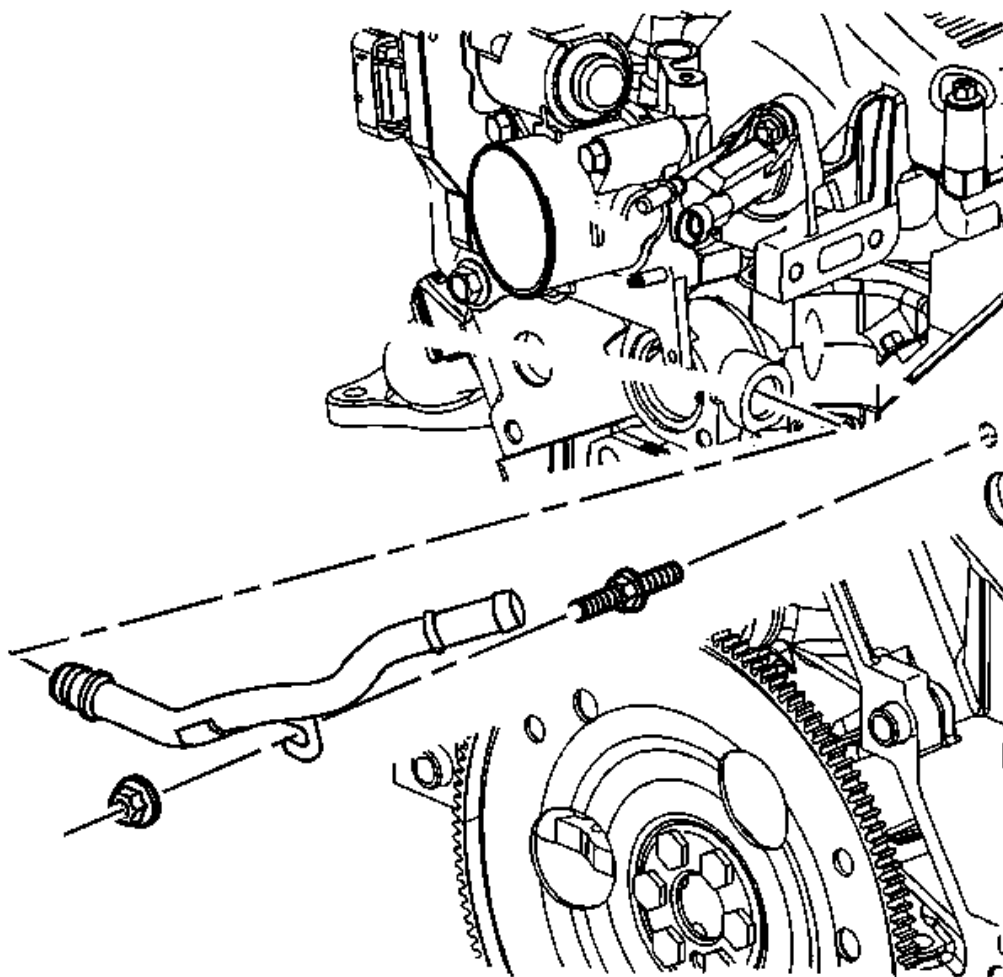


Fig. 368: View Of Heater Inlet Pipe Nut
Courtesy of GENERAL MOTORS CORP.

5. Inspect the heater inlet pipe and seal for damage and replace if necessary.
6. Install the heater inlet pipe stud, if necessary.

Tighten: Tighten the heater inlet pipe stud to 35 N.m (26 lb ft).

7. Install the heater inlet pipe.

8. Install the heater inlet pipe nut.

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

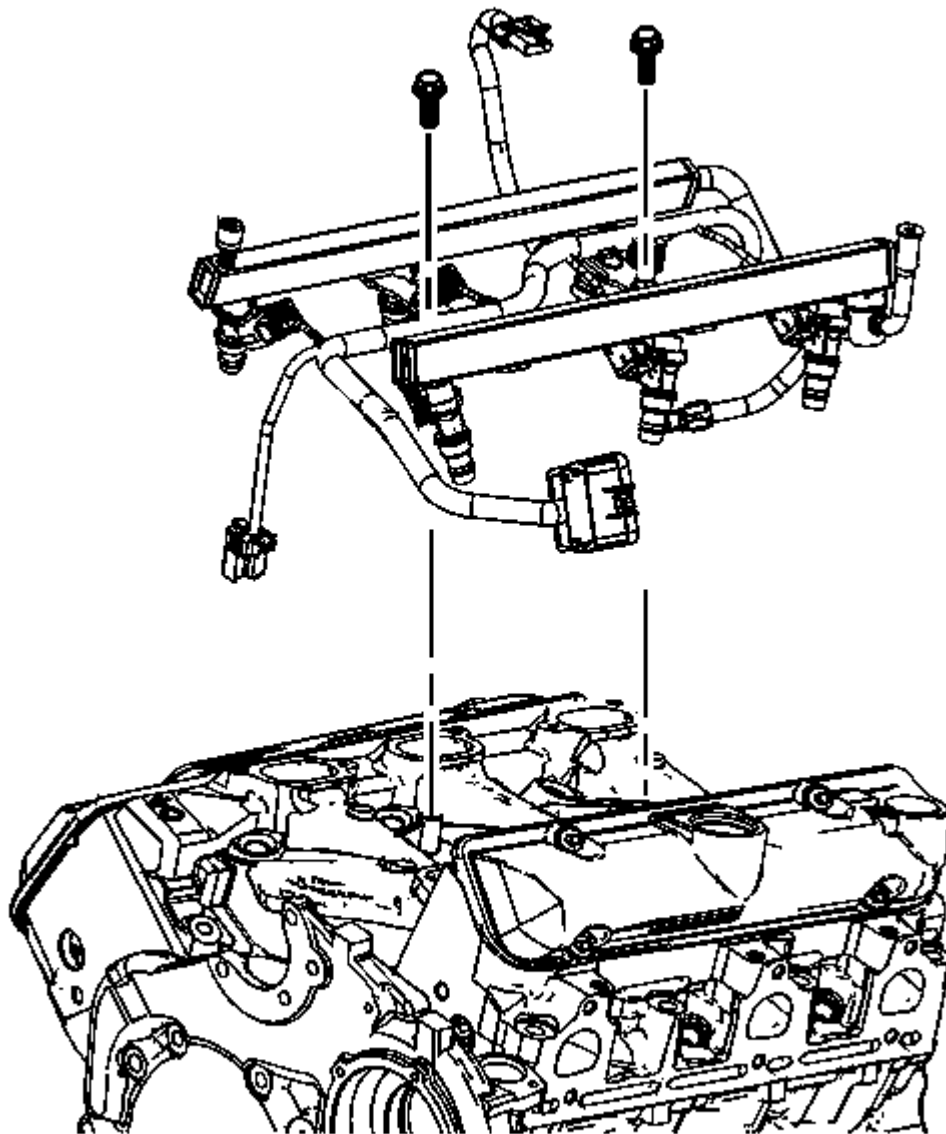


Fig. 369: View Of Fuel Injector And Manifold Air Pressure (MAP) Wiring Harness
Courtesy of GENERAL MOTORS CORP.

9. Inspect the fuel rail, fuel injectors, and fuel injector O-rings for damage and replace if necessary.
10. Lubricate the fuel injector O-ring using GM P/N 12345616 (Canadian P/N 993182) or equivalent.
11. Install the injector nozzles into the lower intake manifold injector bores.
12. Press on the injector rail using the palms of both hands until the injectors are fully seated.
13. Install the fuel injector rail bolts.

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

Intake Manifold Installation - Upper

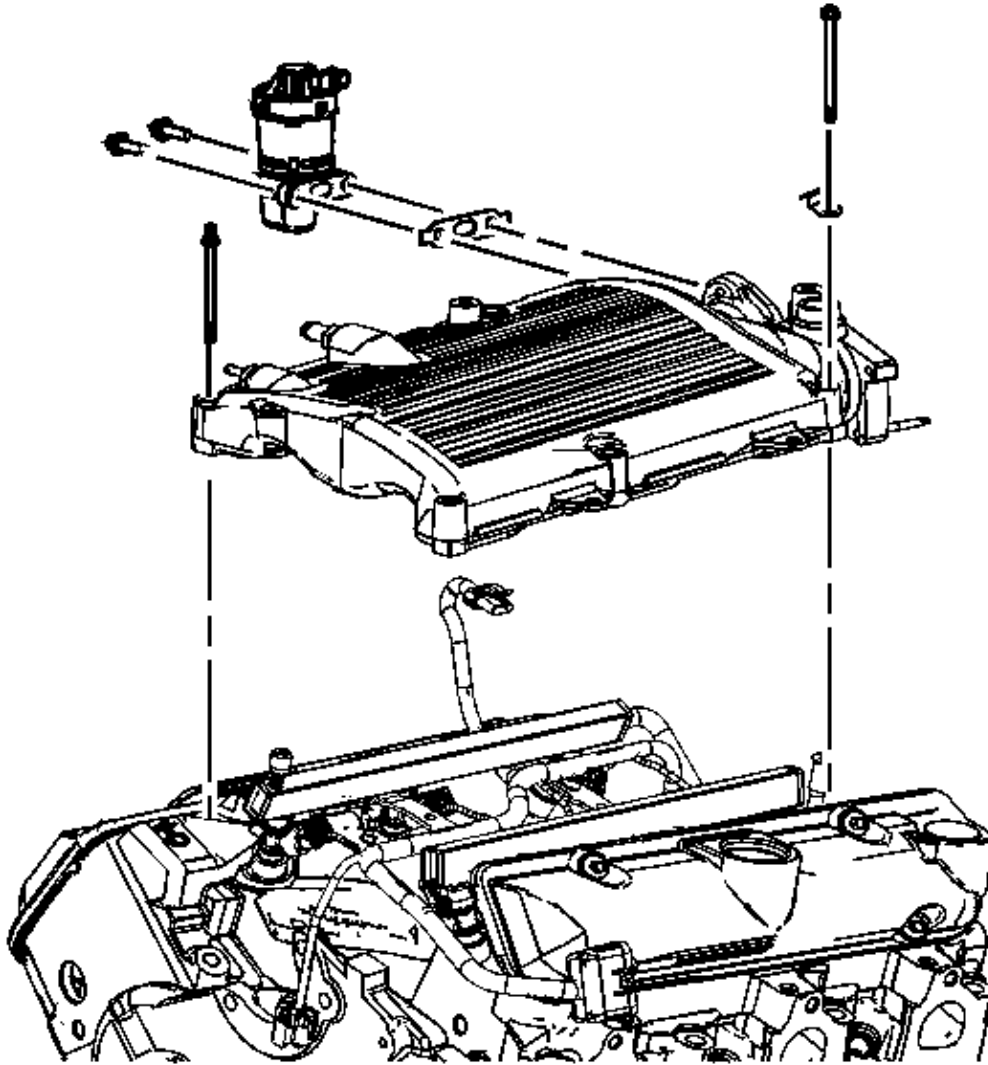


Fig. 370: View Of Upper Intake Manifold And Components
Courtesy of GENERAL MOTORS CORP.

1. Install the upper intake manifold gaskets and manifold.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the upper intake manifold bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the upper intake manifold bolts and stud.

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

4. Install the exhaust gas recirculation (EGR) gasket and EGR.
5. Install the EGR bolts.

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

6. Reconnect the manifold absolute pressure (MAP) sensor.

Valve Rocker Arm Cover Installation - Left

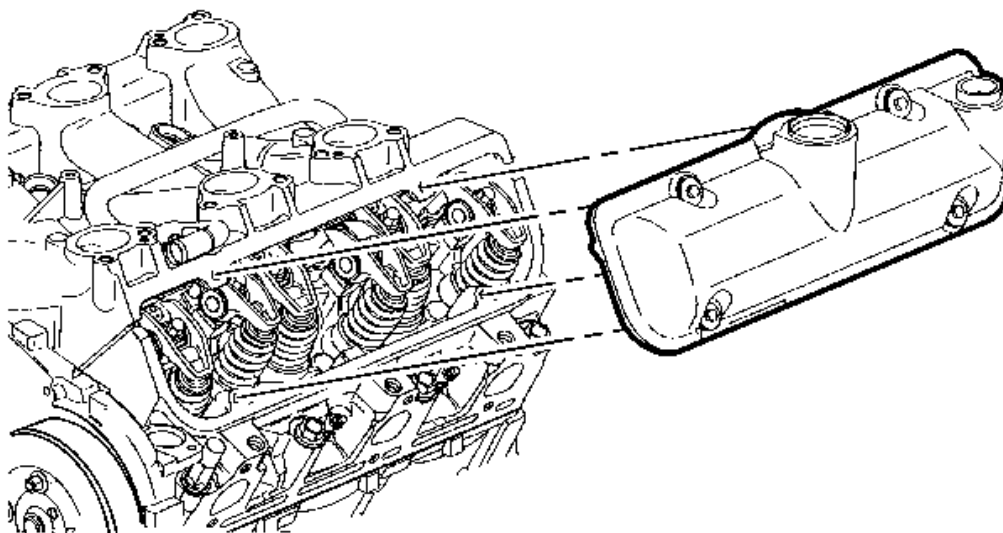


Fig. 371: View Of Valve Rocker Arm Cover - Left
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

1. Install the valve rocker arm cover gasket into the valve rocker arm cover.

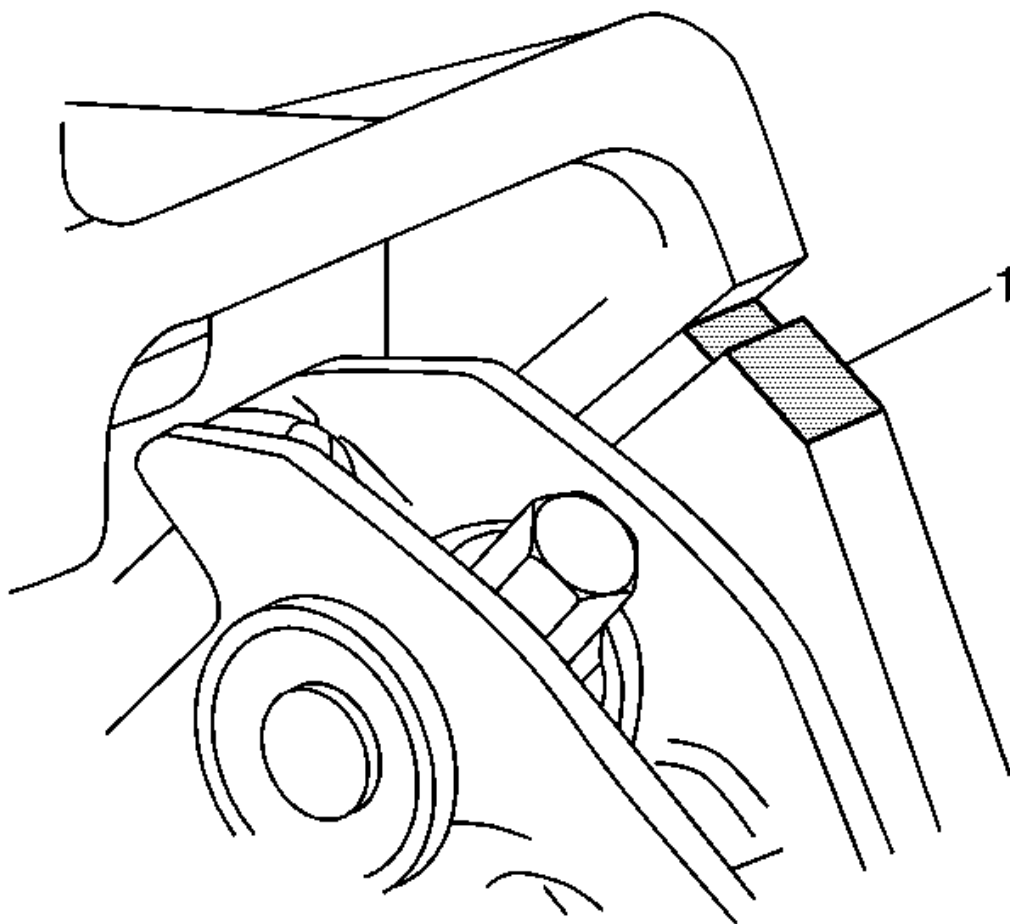


Fig. 372: Identifying Cylinder Head To Lower Intake Manifold Joint
Courtesy of GENERAL MOTORS CORP.

2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

4. Install the valve rocker arm cover bolts, if necessary.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

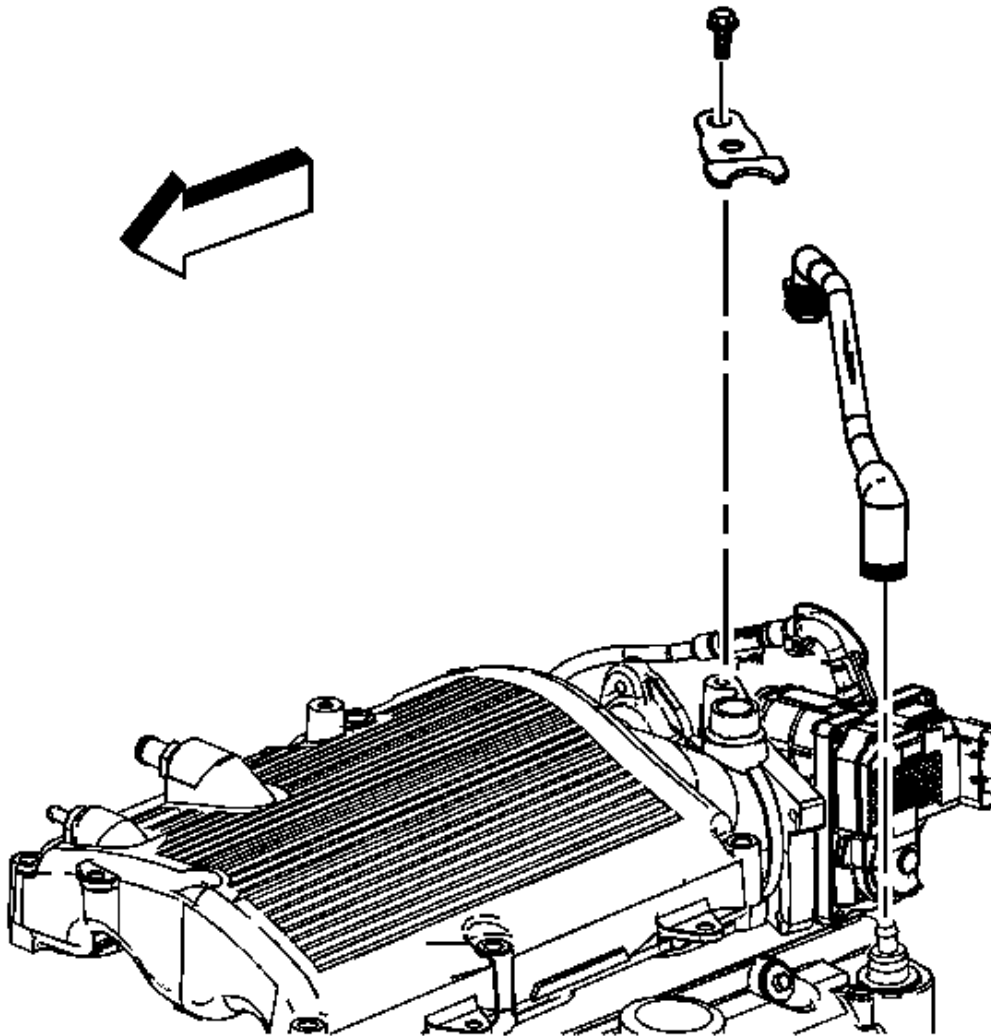


Fig. 373: View Of PCV Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the PCV tube.
6. Install the PCV clip and tube bolt.

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

Valve Rocker Arm Cover Installation - Right

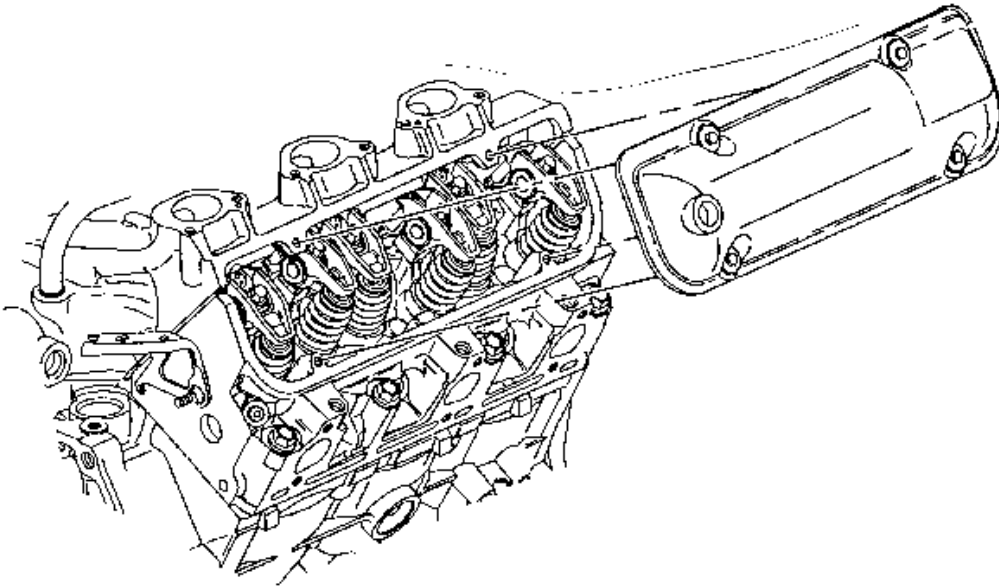


Fig. 374: View Of Valve Rocker Arm Cover - Right
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All gasket-mating surfaces need to be free of oil and foreign material. Use GM P/N 12346139 (Canadian P/N 10953463) or equivalent to clean surfaces.

1. Install the valve rocker arm cover gasket into the valve rocker arm cover.

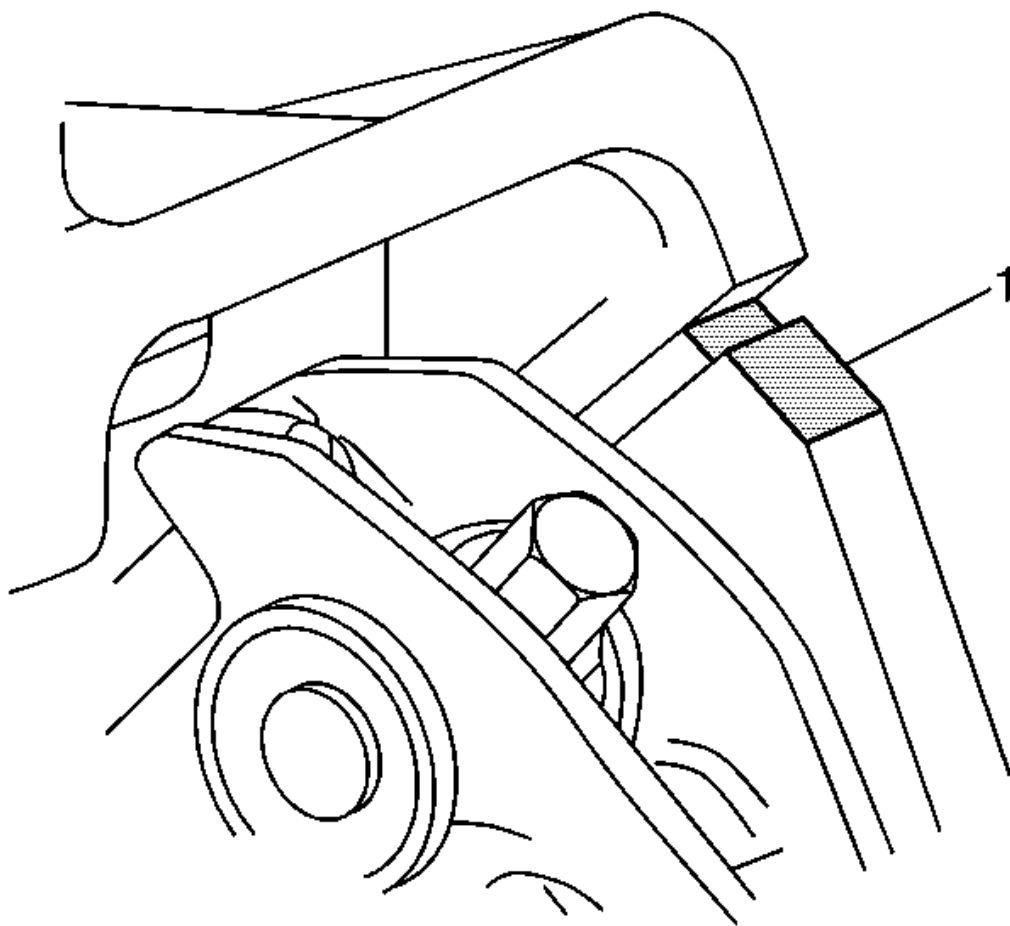


Fig. 375: Identifying Cylinder Head To Lower Intake Manifold Joint
 Courtesy of GENERAL MOTORS CORP.

2. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the surfaces where the cylinder head and intake manifold meet (1).
3. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

4. Install the valve rocker arm cover bolts, if necessary.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

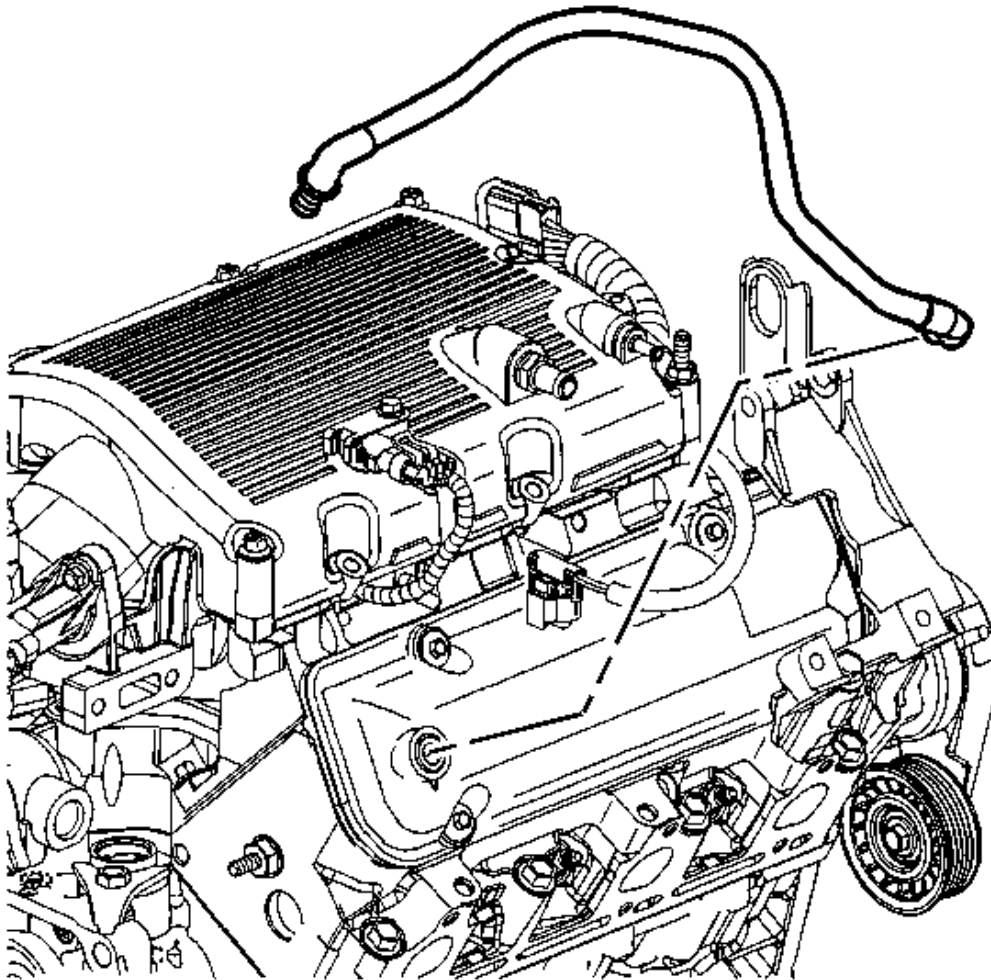


Fig. 376: View Of Vacuum Hoses
Courtesy of GENERAL MOTORS CORP.

5. Install the Positive Crankcase Ventilation (PCV) tube into the valve rocker arm cover.

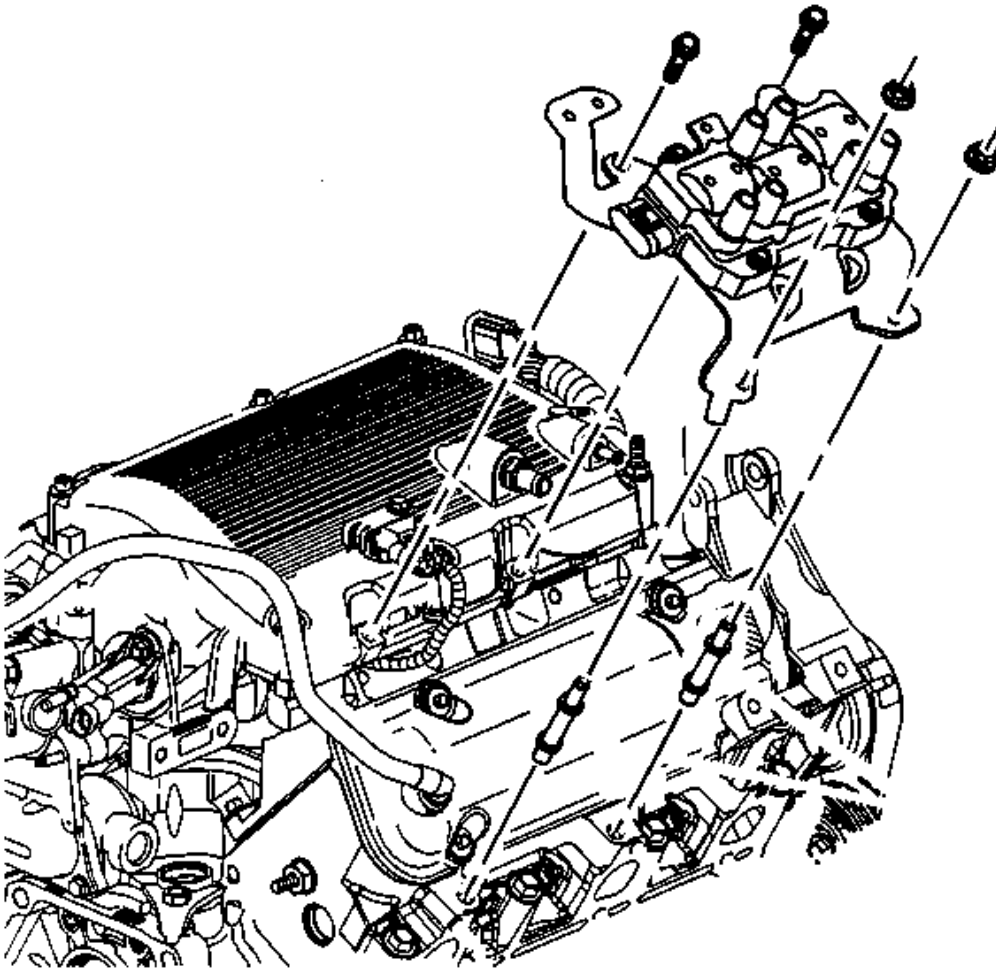


Fig. 377: View Of Remaining Spark Plug Wires And Their Retainers
Courtesy of GENERAL MOTORS CORP.

6. Install the ignition coil assembly studs, if necessary.

Tighten: Tighten the ignition coil assembly studs to 25 N.m (18 lb ft).

7. Install the ignition coil assembly.
8. Install the ignition coil assembly bolts and nuts.

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

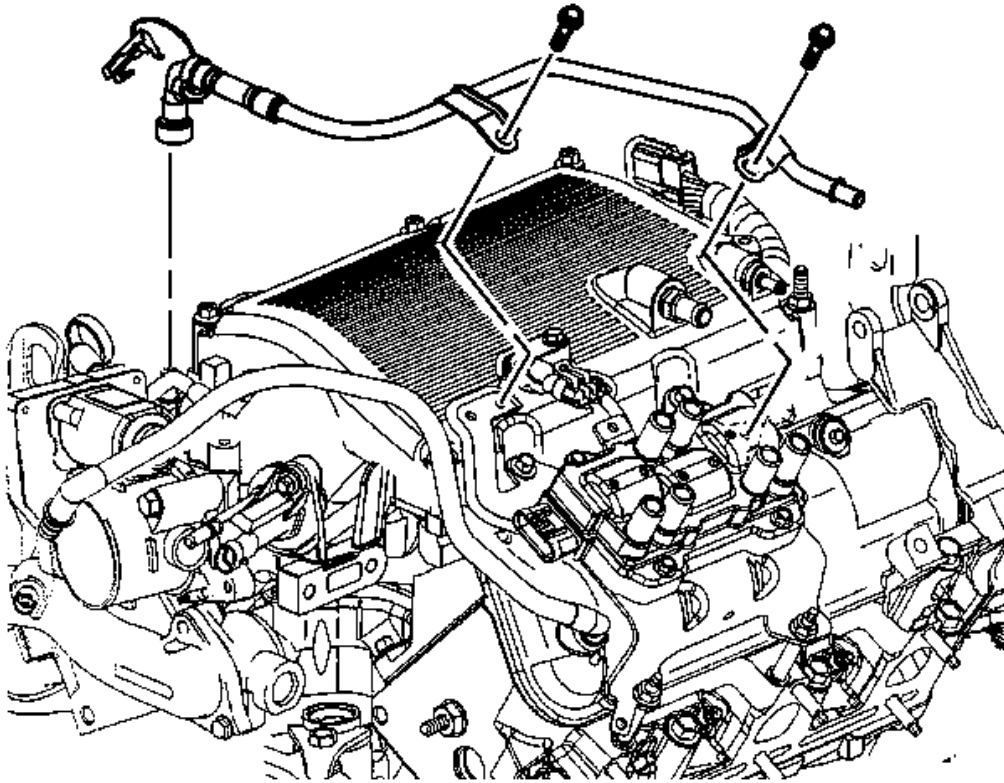


Fig. 378: View Of Fuel Feed Pipe Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the fuel feed pipe.
10. Install the fuel feed pipe secondary latch.
11. Install the fuel feed pipe bolts.

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

Water Outlet and Thermostat Installation

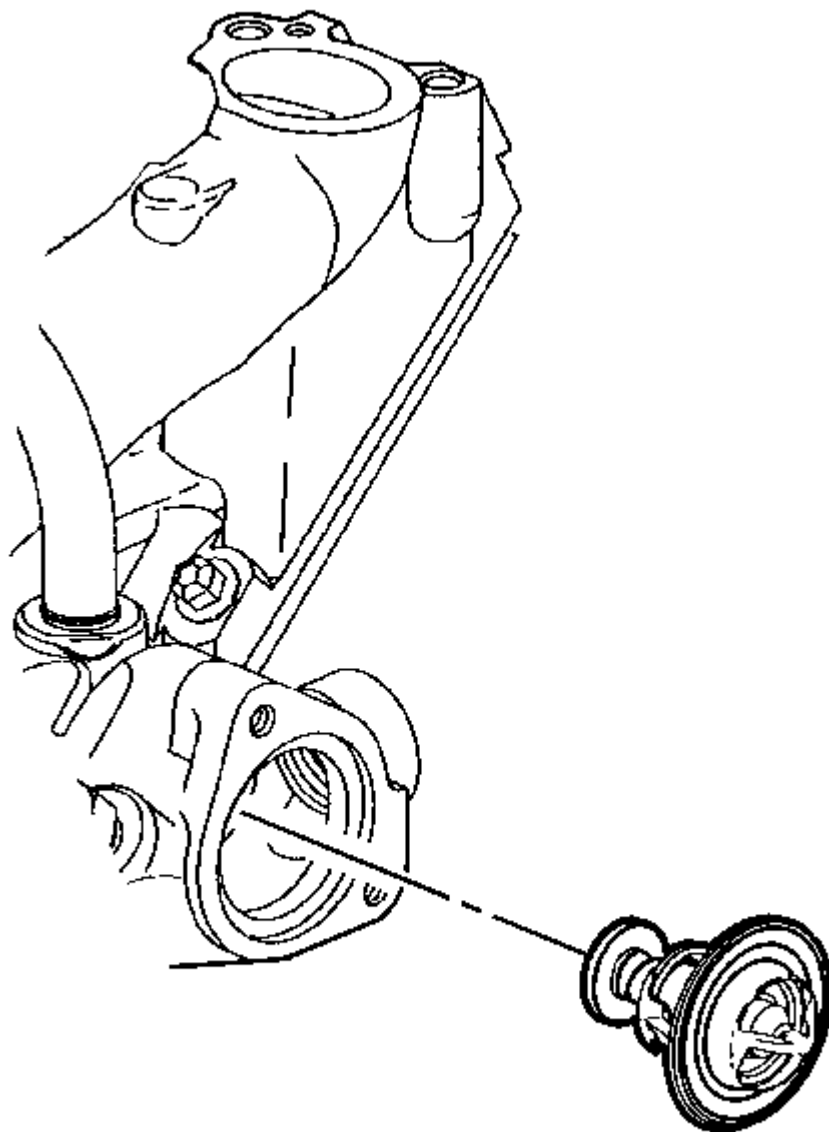


Fig. 379: Locating Thermostat
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat.
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

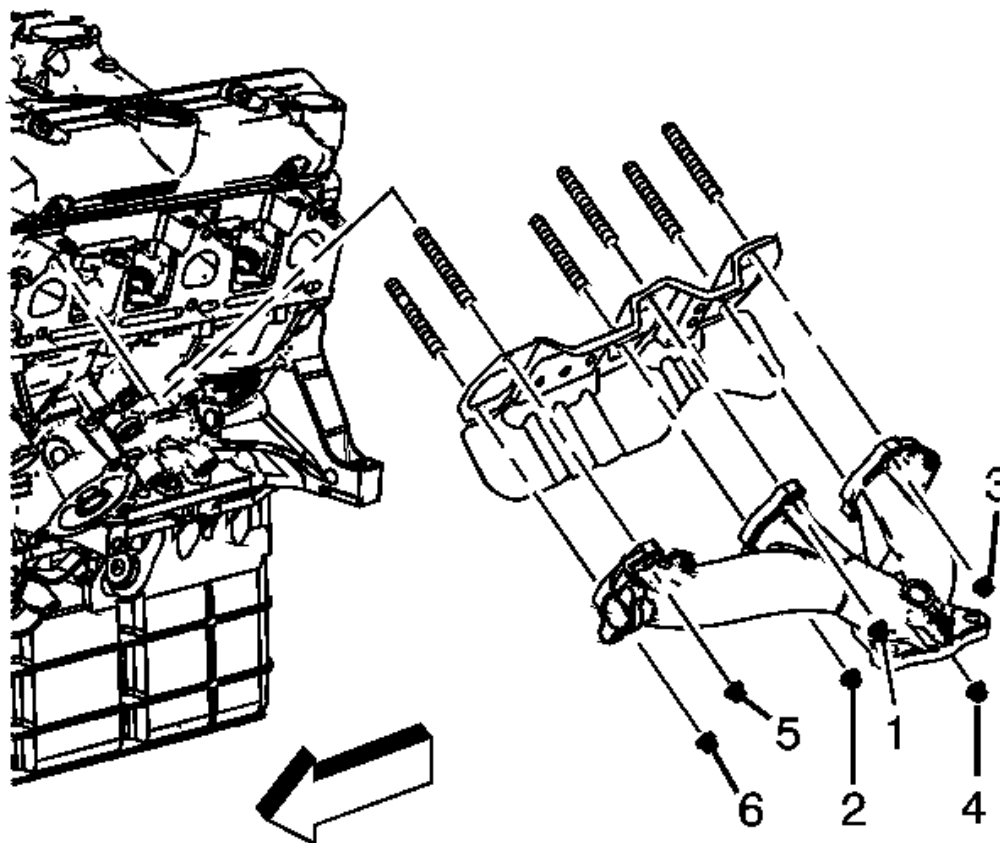


Fig. 380: View Of Exhaust Manifold Nuts (1, 2, 3, 4, 5, 6)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs, if required.

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.

Tighten: Tighten the exhaust manifold nuts in sequence to 16 N.m (12 lb ft).

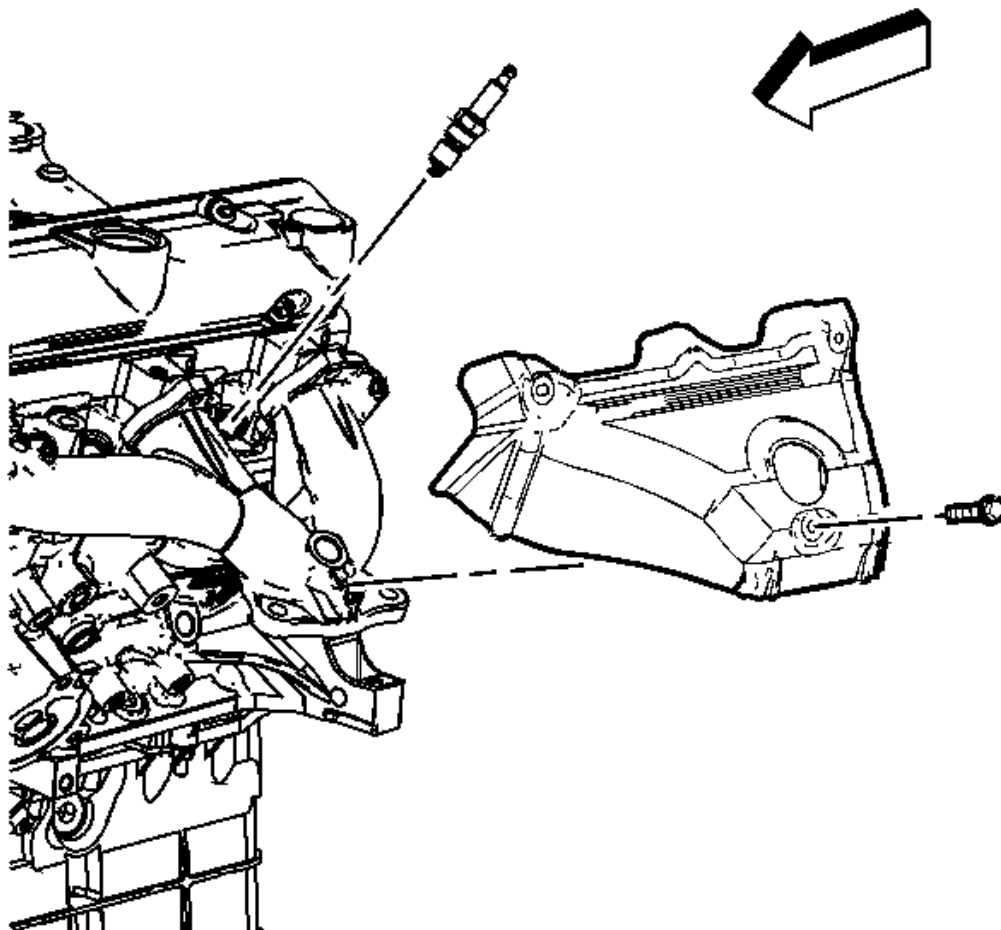


Fig. 381: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust manifold heat shield.
6. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

7. Install the spark plugs.

Tighten:

- Tighten the spark plugs to 20 N.m (15 lb ft) when installing spark plugs into a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when installing spark plugs after initial installation.

8. Install the spark plug wires.

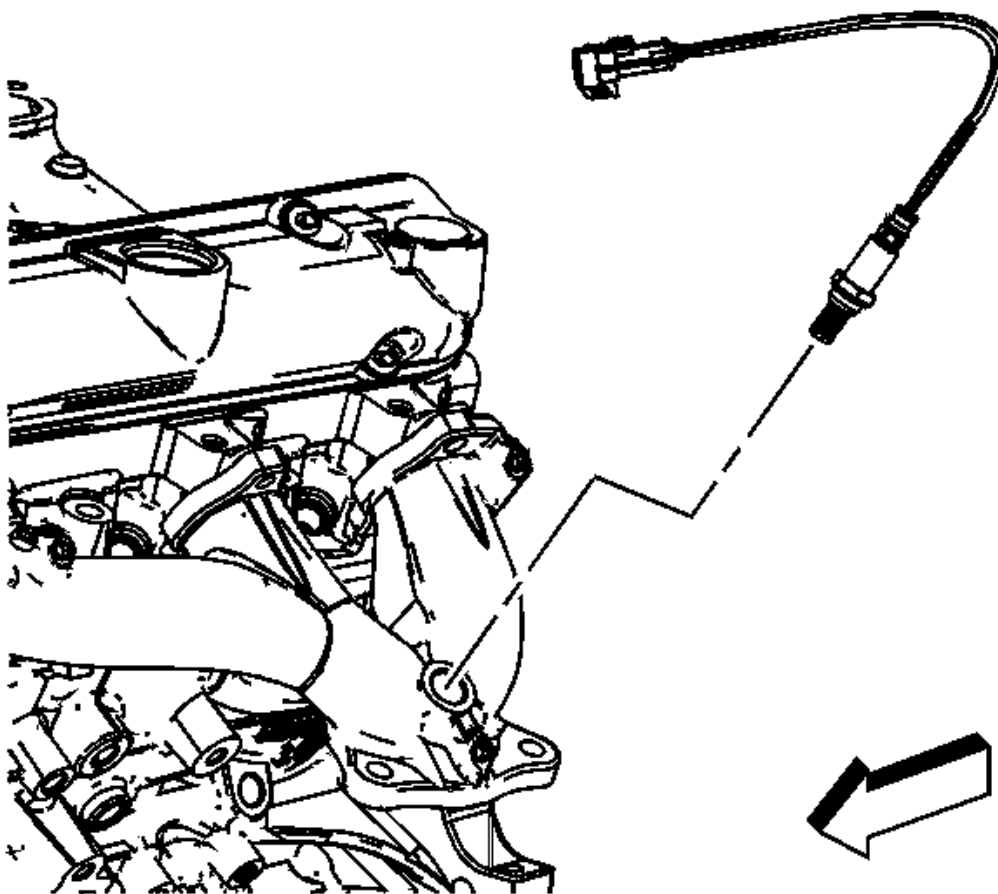


Fig. 382: View Of Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

9. Install the heated oxygen sensor.

Tighten: Tighten the heated oxygen sensor to 42 N.m (31 lb ft).

Exhaust Manifold Installation - Right

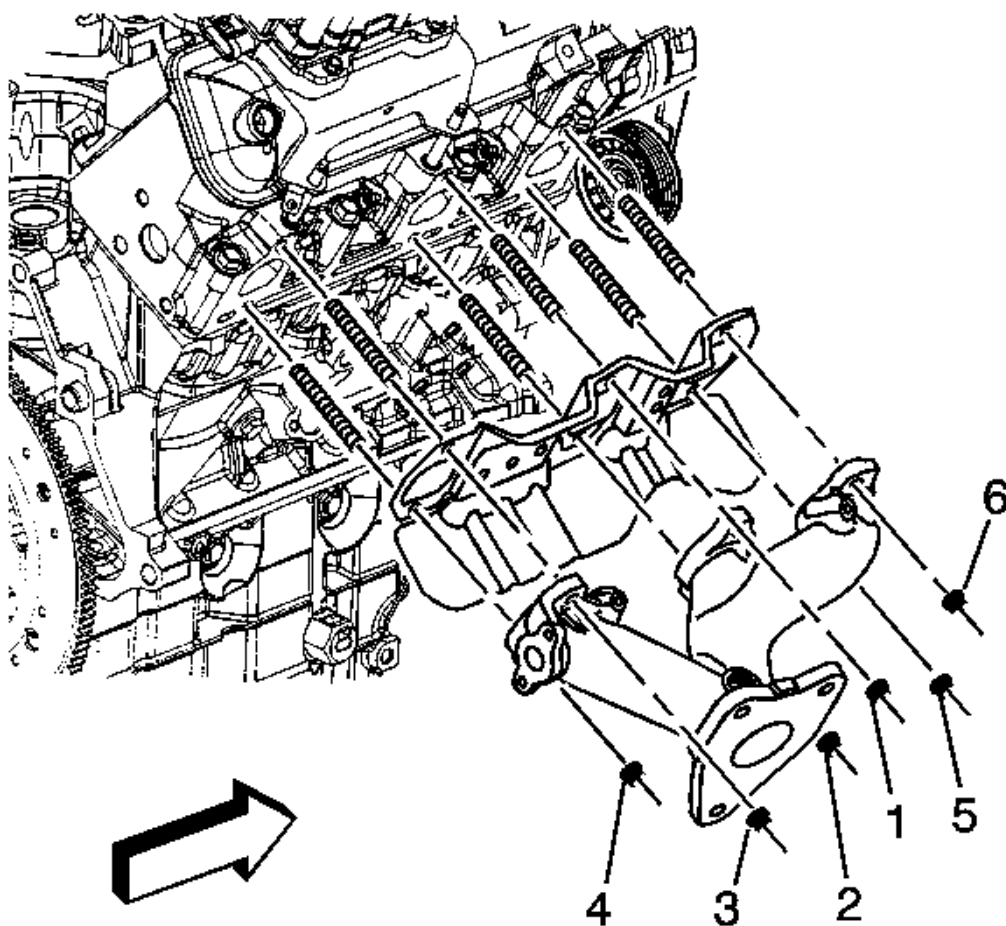


Fig. 383: Removing Exhaust Manifold Nuts (1, 2, 3, 4, 5, 6)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs, if required.

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.

Tighten: Tighten the exhaust manifold nuts in sequence to 16 N.m (12 lb ft).

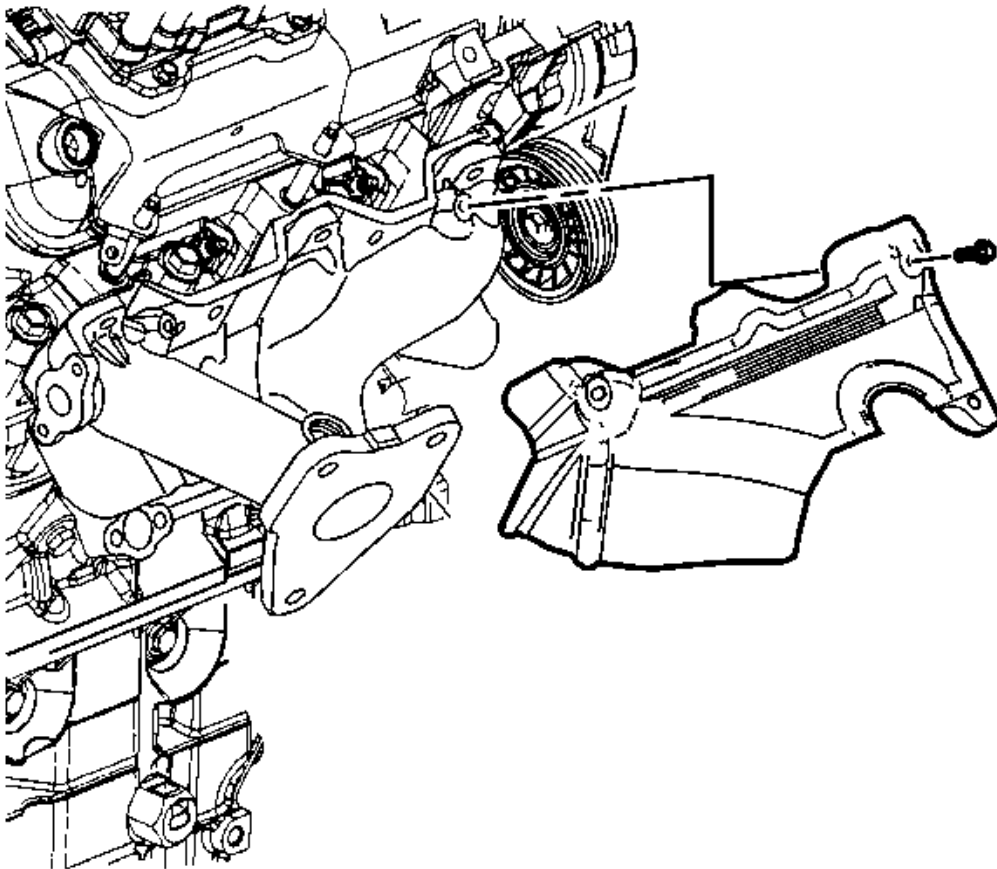


Fig. 384: Removing Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust manifold heat shield.
6. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

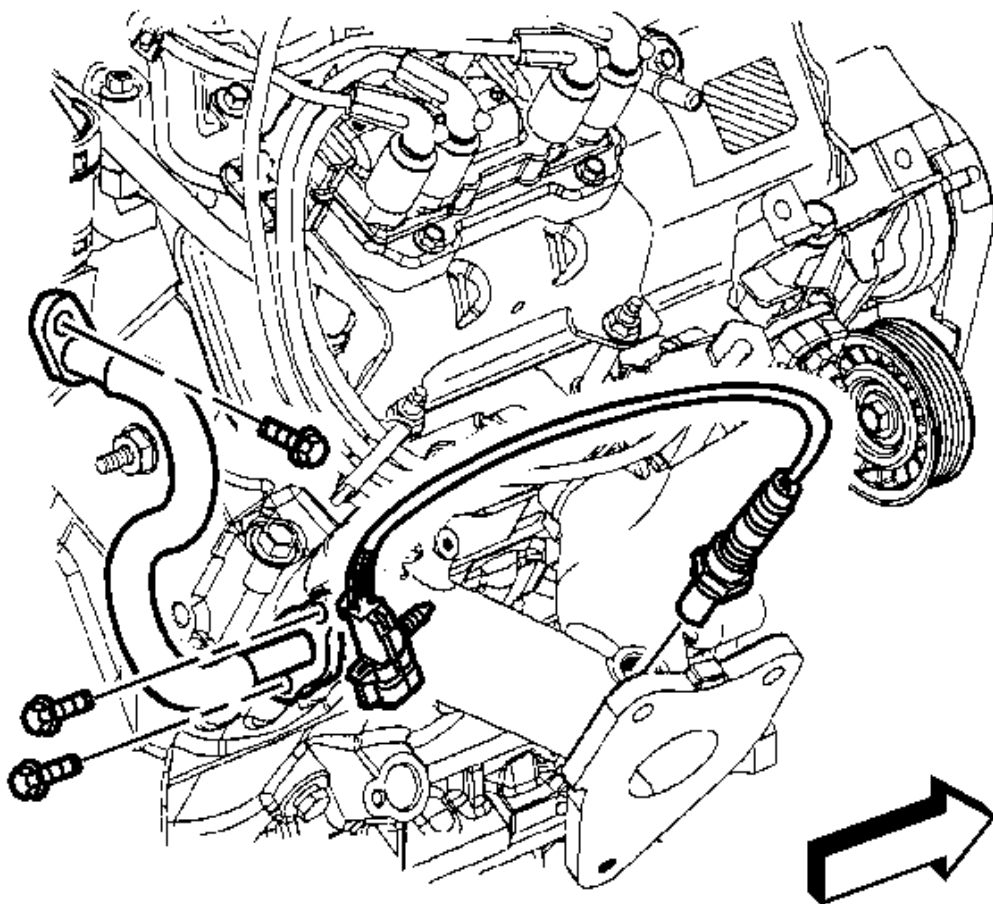


Fig. 385: Removing Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the Exhaust Gas Recirculation (EGR) pipe.
8. Install the EGR pipe bolt to the EGR Valve.

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

9. Install the EGR pipe bolts to the exhaust manifold.

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

10. Install the spark plugs.

Tighten:

- Tighten the spark plugs to 20 N.m (15 lb ft) when installing spark plugs into a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when installing spark plugs after initial installation.

11. Install the spark plug wires.
12. Install the heated oxygen sensor.

Tighten: Tighten the heated oxygen sensor to 42 N.m (31 lb ft).

Oil Filter Adapter Installation

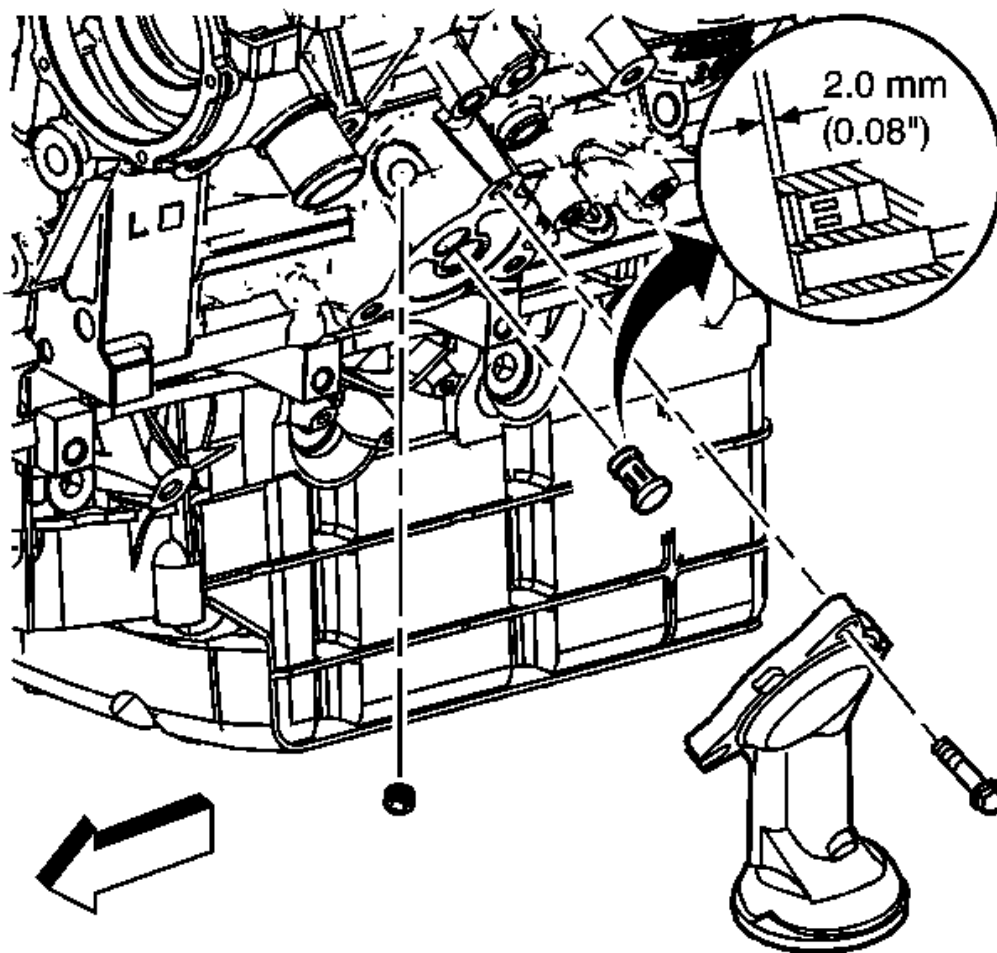


Fig. 386: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

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

1. Install the oil filter bypass valve.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter bypass hold plug.

Tighten: Tighten the oil filter bypass hole plug to 19 N.m (14 lb ft).

3. Install the oil filter adapter.
4. Apply threadlocker P/N 21485277 to the bolt threads if required.
5. Install the oil filter adapter bolts.

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

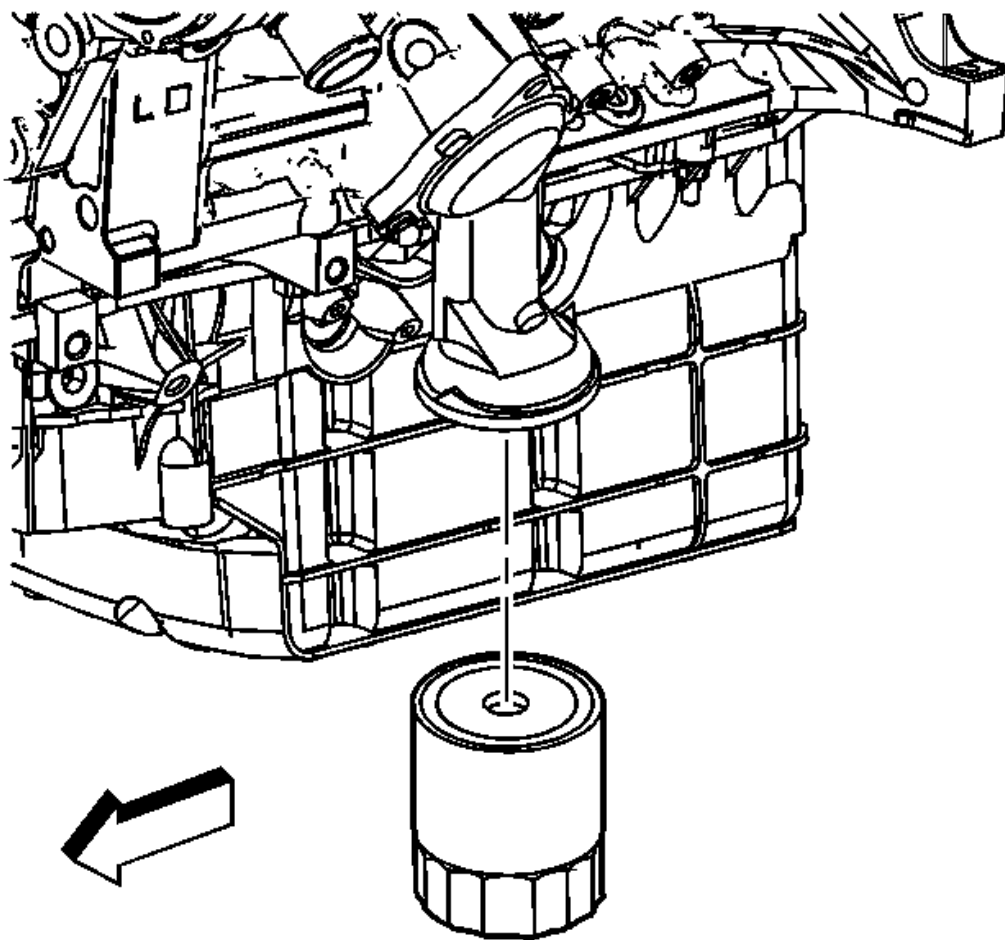


Fig. 387: View Of Oil Filter

Courtesy of GENERAL MOTORS CORP.

6. Install the oil filter.

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

Oil Level Indicator and Tube Installation

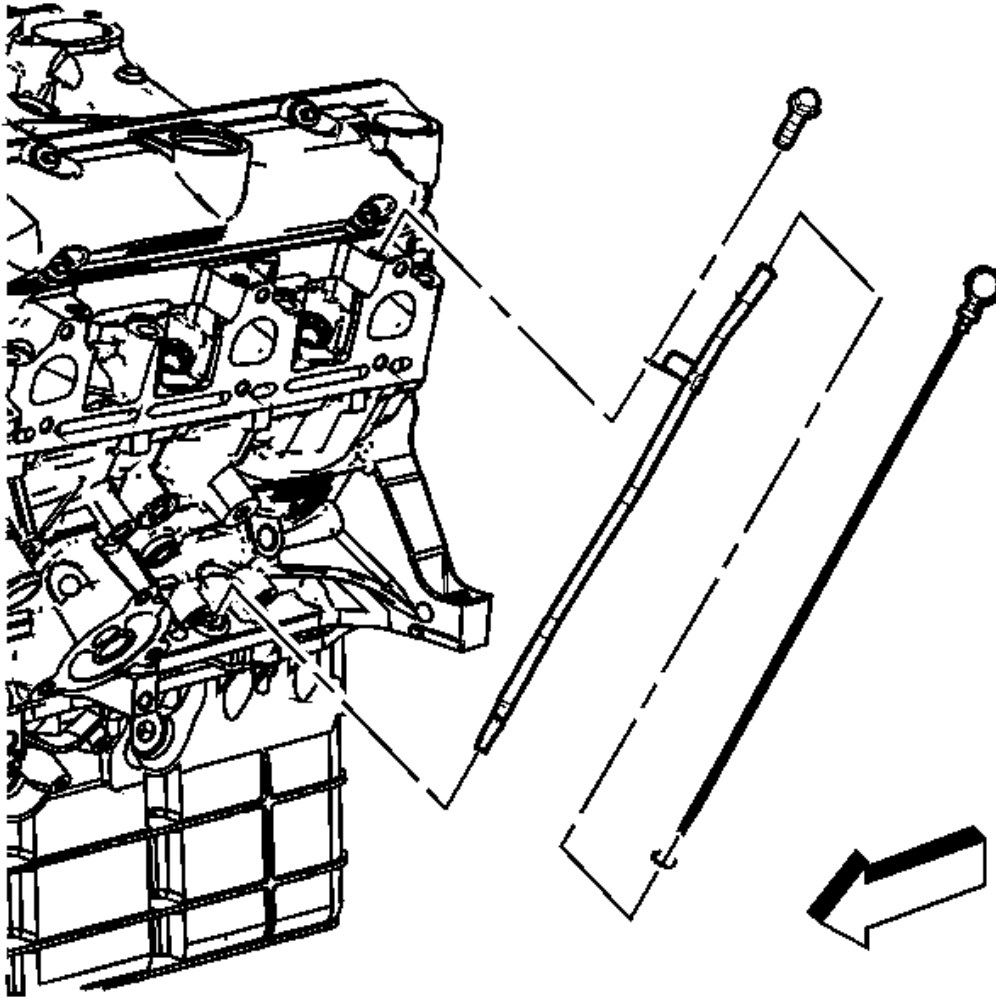


Fig. 388: View Of Oil Level Indicator Tube Bolt
 Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube and oil level indicator.

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).

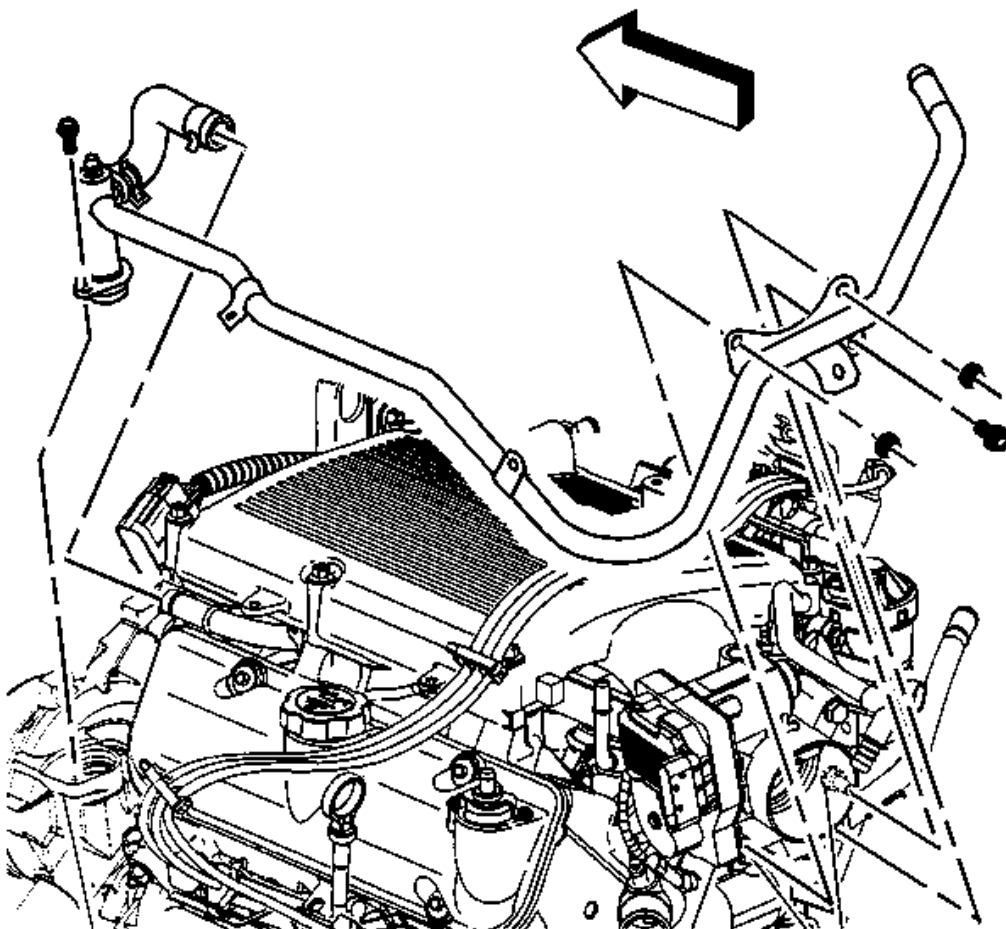


Fig. 389: View Of Thermostat Bypass Pipe Hose And Thermostat Bypass Pipe
Courtesy of GENERAL MOTORS CORP.

3. Install the thermostat bypass pipe.
4. Install the thermostat bypass pipe to engine front cover bolt.

Tighten: Tighten the thermostat bypass pipe to engine front cover bolt to 10 N.m (89 lb in).

5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the throttle body studs.
6. Install the thermostat bypass pipe to throttle body bolt and nuts.

Tighten: Tighten the thermostat bypass pipe to throttle body bolt and nuts to 10 N.m (89 lb in).

7. Install the heated oxygen sensor connector to the thermostat bypass pipe.

8. Install the spark plug wire clip to the thermostat bypass pipe.
9. Install the spark plug wires onto the spark plugs.

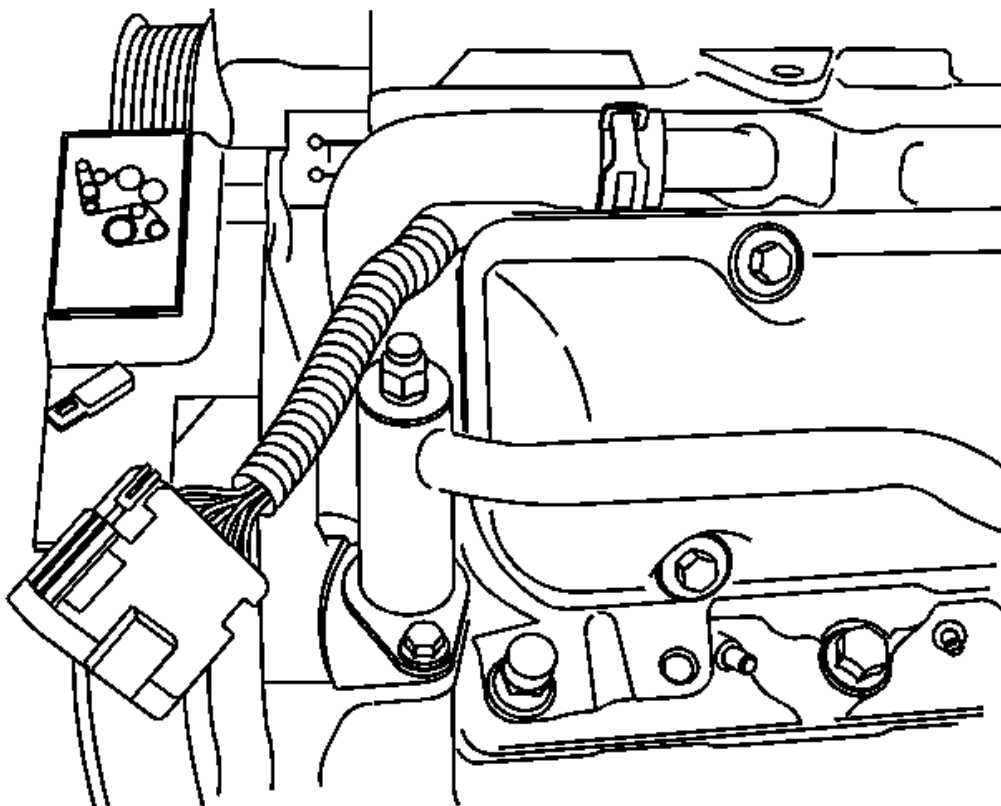


Fig. 390: Positioning 16 Pin Connector Harness
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Passenger cars will have a 16 spin connector attached to the bypass pipe.
Passenger vans will have the connector attached to the drive belt shield.

10. Position the 16 pin connector harness as shown in the graphic and secure the connector in its respective location.
11. Install the thermostat bypass pipe hose to pipe.

Engine Lift Bracket Installation - Rear

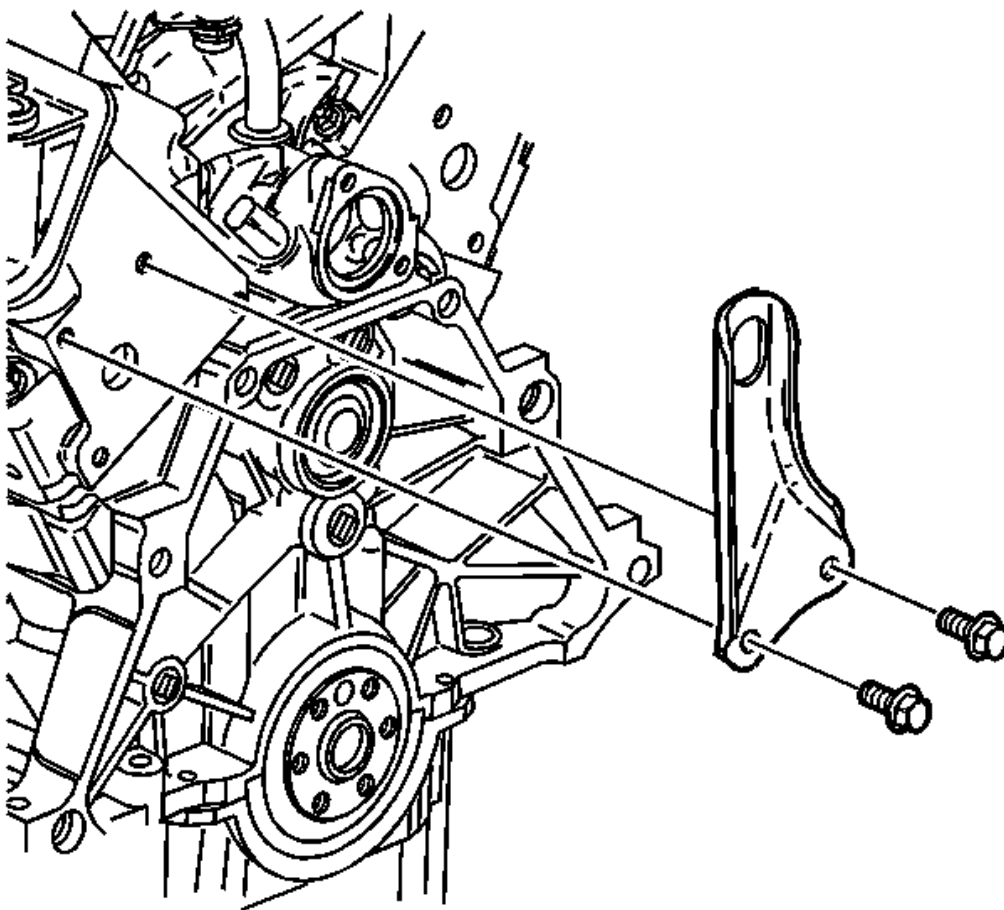


Fig. 391: View Of Rear Engine Lift Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the rear engine lift bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the rear engine lift bracket bolts.

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

Engine Mount Support and Strut Bracket Installation

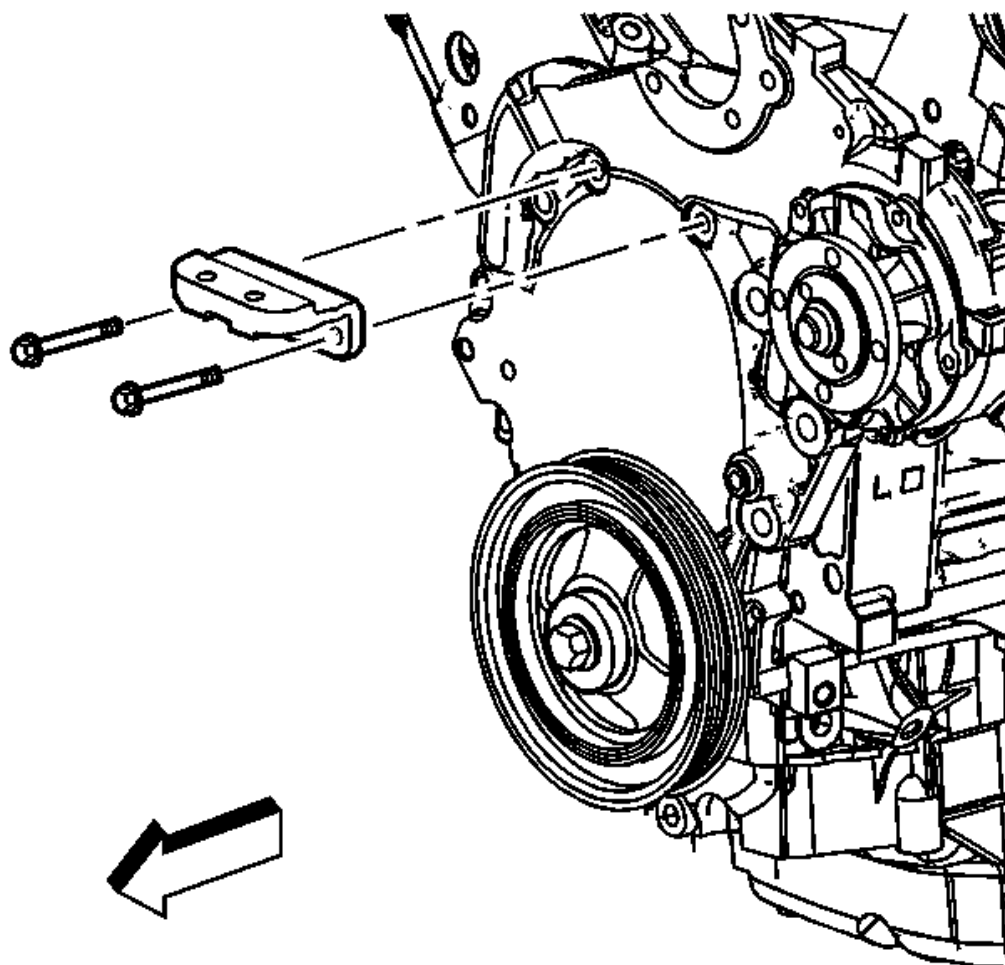


Fig. 392: View Of Engine Mount Support And Strut Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount support and strut bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount support and strut bracket bolts.

Tighten: Tighten the engine mount support and strut bracket bolts to 25 N.m (18 lb ft).

Engine Lift Bracket and Generator Bracket Installation

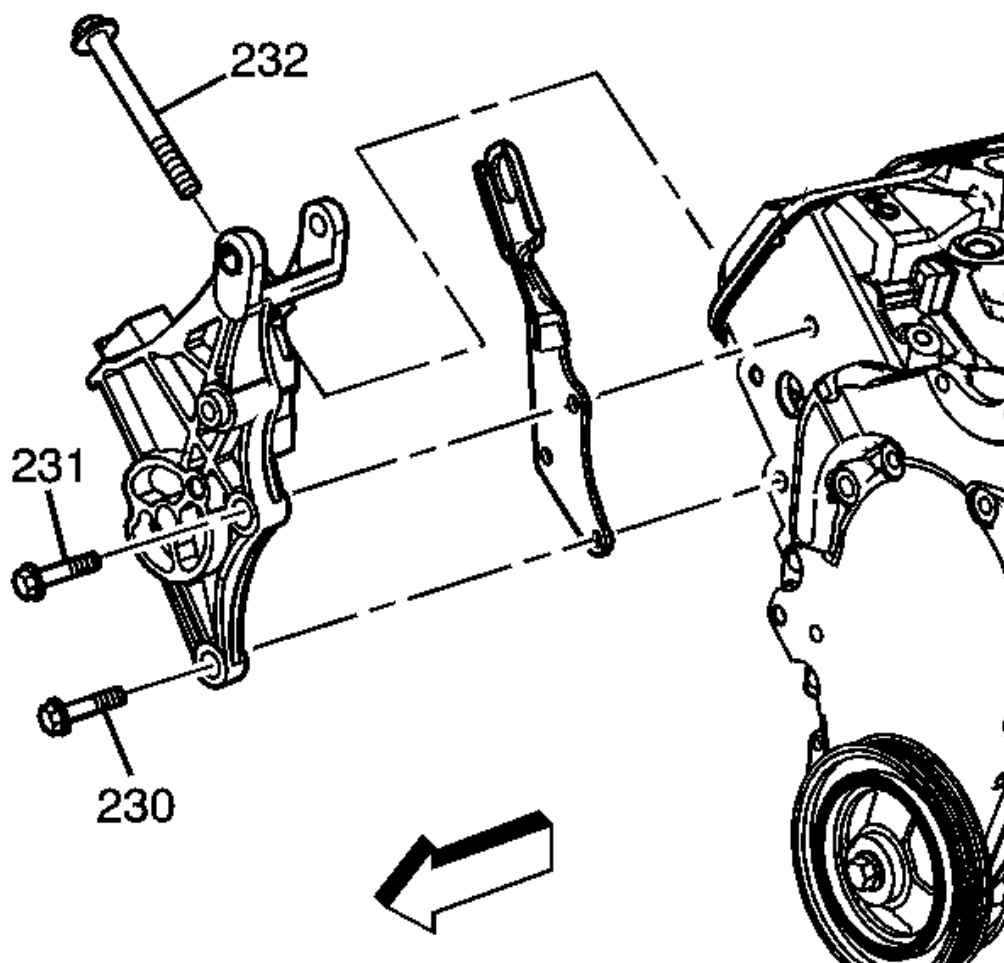


Fig. 393: View Of Generator Bracket Assembly Bolts (230, 231, 232)

Courtesy of GENERAL MOTORS CORP.

1. Install the front engine lift hook.
2. Install the generator bracket assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the generator bracket assembly bolts (230, 231, 232).

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

Drive Belt Tensioner Installation

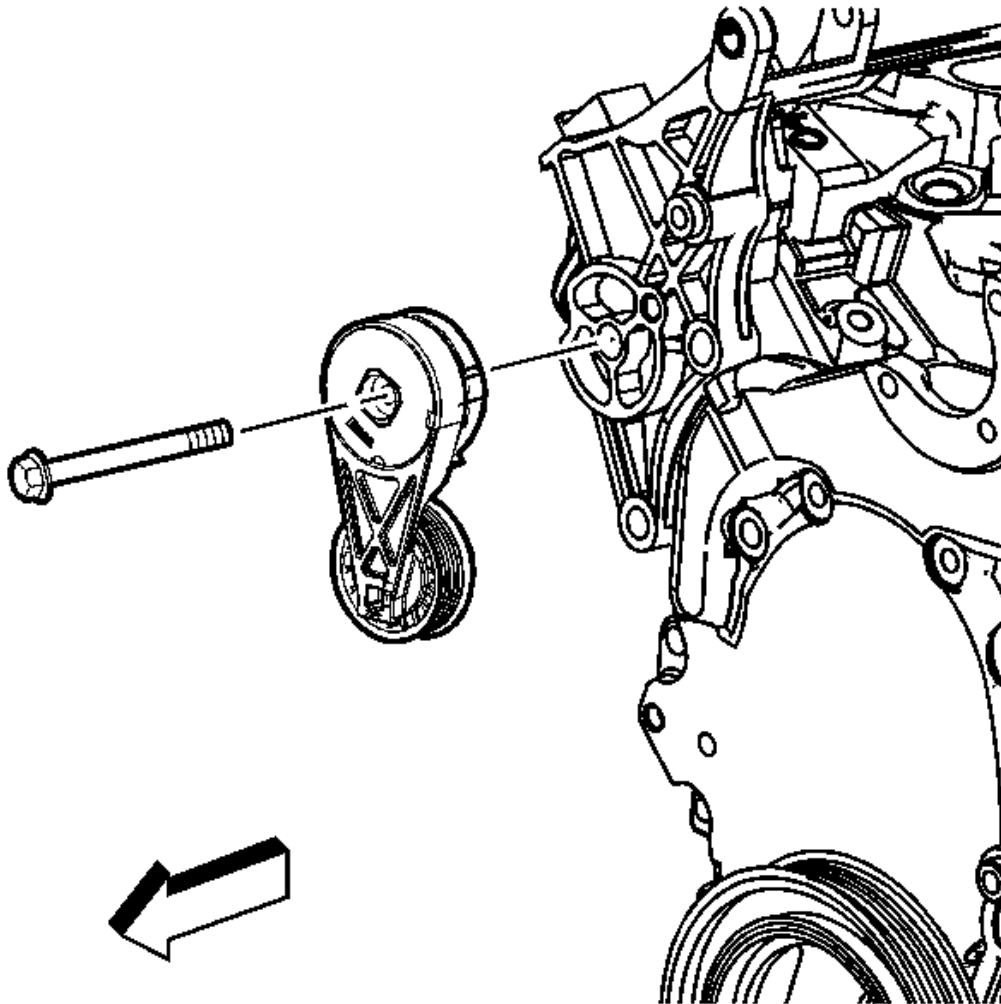


Fig. 394: View Of Drive Belt Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

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

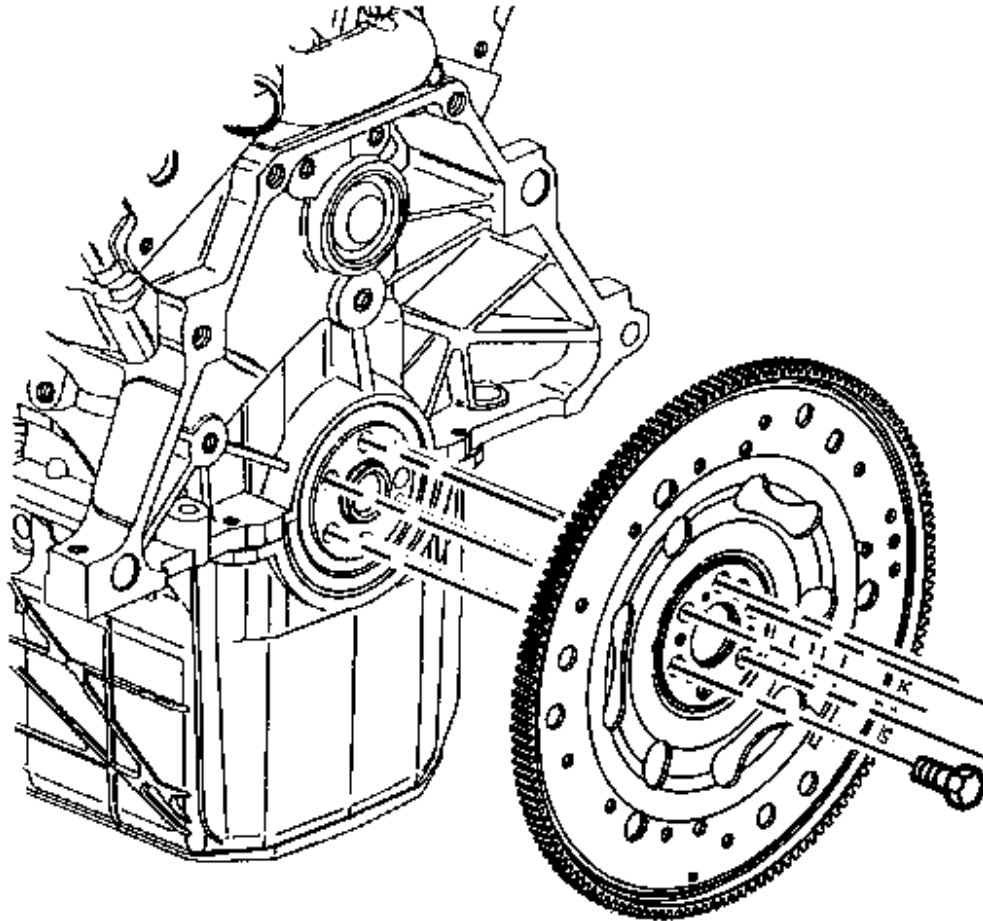


Fig. 395: View Of Flywheel

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** Balancer and Crank Sprocket Puller. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.

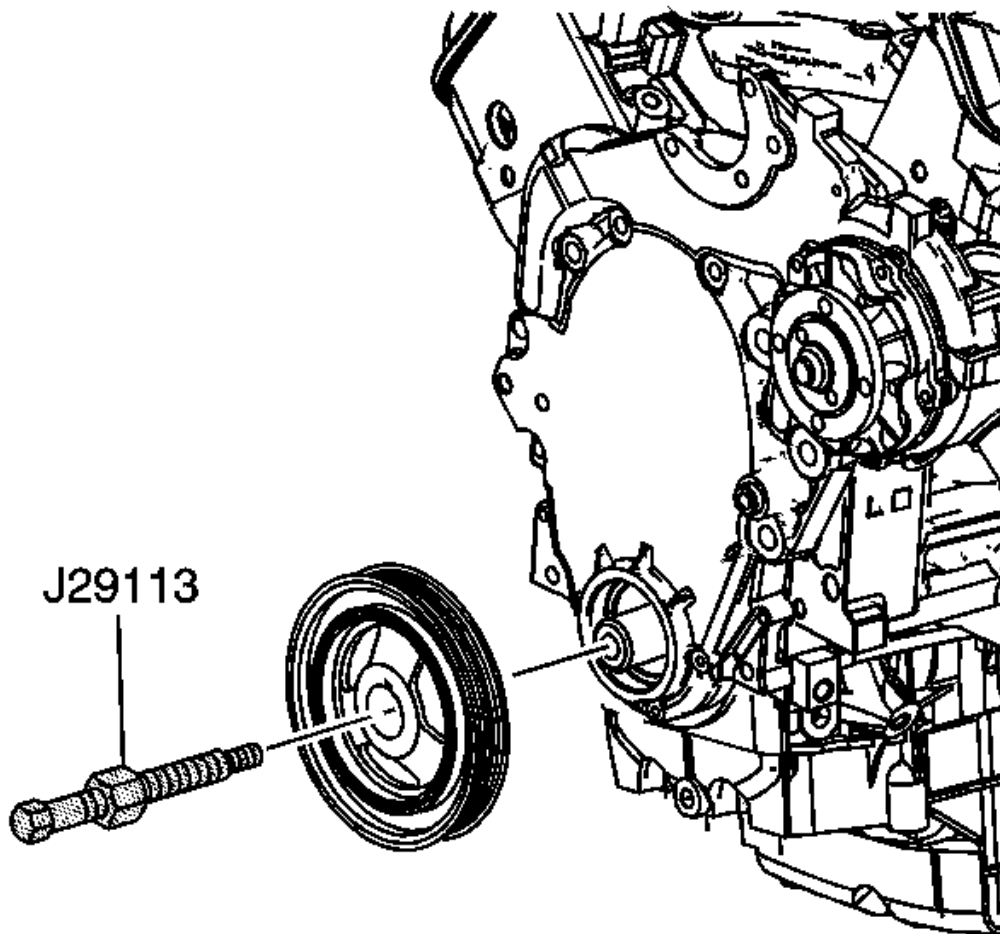


Fig. 396: Installing J 29113 Onto Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) or the equivalent to the keyway of the crankshaft balancer.
2. Place the crankshaft balancer into position over the key in the crankshaft.

NOTE: Do NOT use a power-assisted tool with the special tool in order to remove

or install this component. You cannot properly control the alignment of this component using a power-assisted tool, and this can damage the component.

3. Install the **J 29113** onto the crankshaft. See Special Tools.
4. Rotate the hex nut on the **J 29113** to install the crankshaft balancer onto the crankshaft. See Special Tools.
5. Remove the **J 29113** from the crankshaft. See Special Tools.

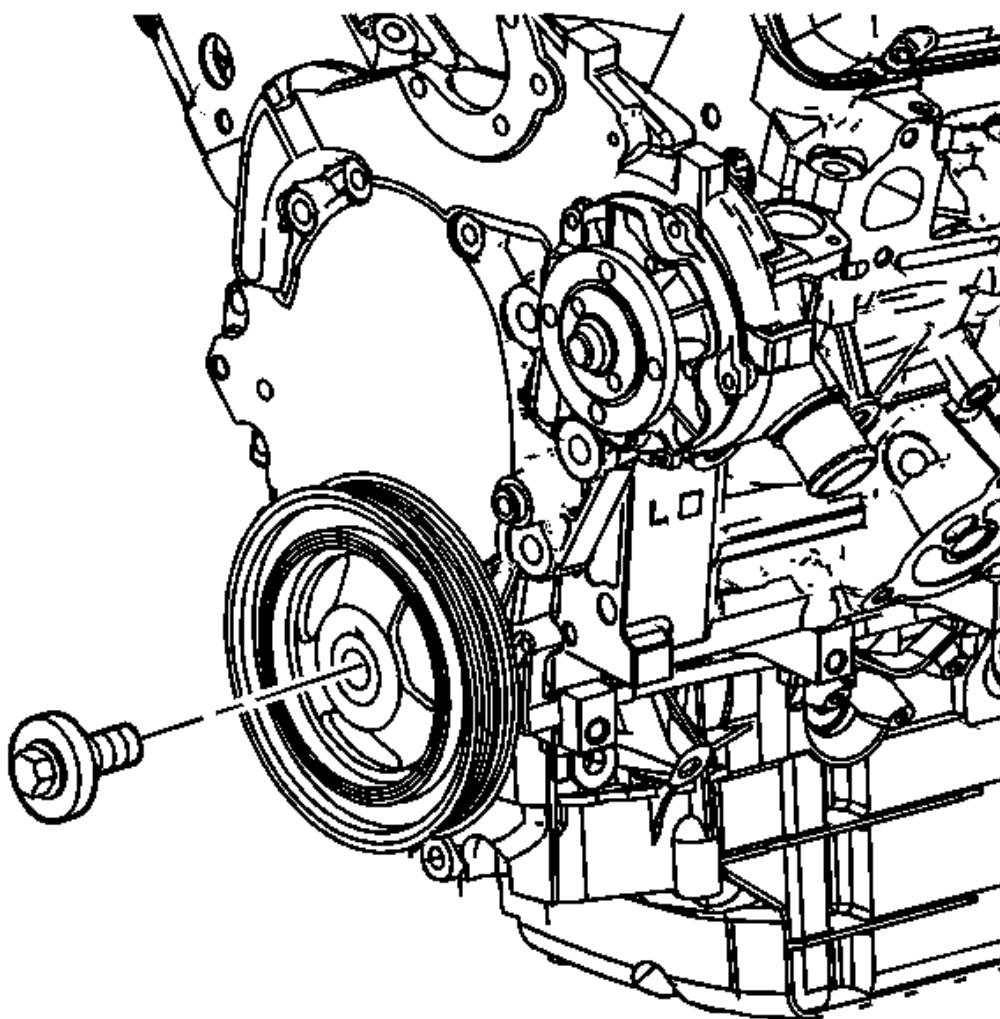


Fig. 397: View Of Crankshaft Balancer Bolt And Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 70 degrees using the **J 45059** . See **Special Tools**.

Engine Prelubing

Tools Required

J 45299 Engine Preluber. See **Special Tools**.

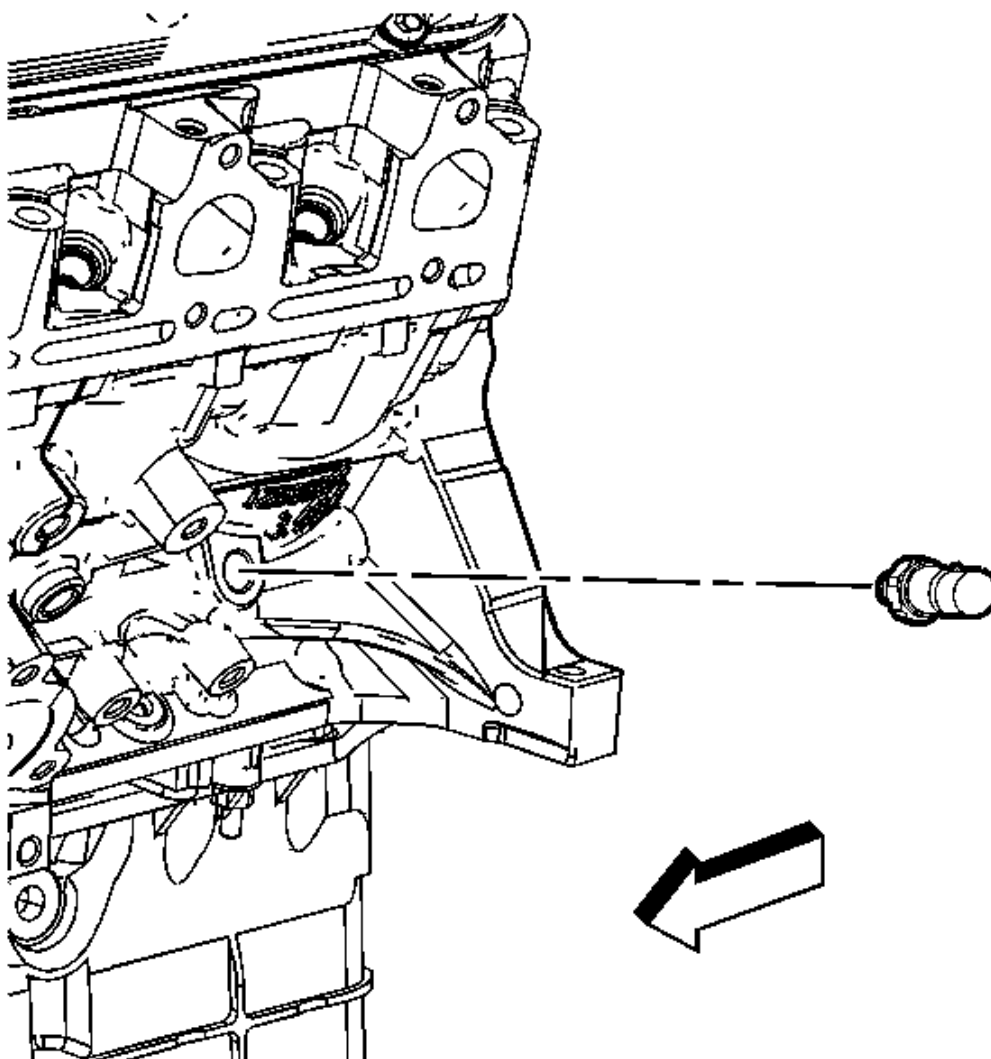


Fig. 398: Locating Engine Oil Pressure Indicator Switch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: A constant/continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter, fill with clean engine oil, and reinstall.

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

2. Locate the engine oil pressure indicator switch on the left side of the engine and remove.
3. Install the 1/4 inch adapter P/N 509373.

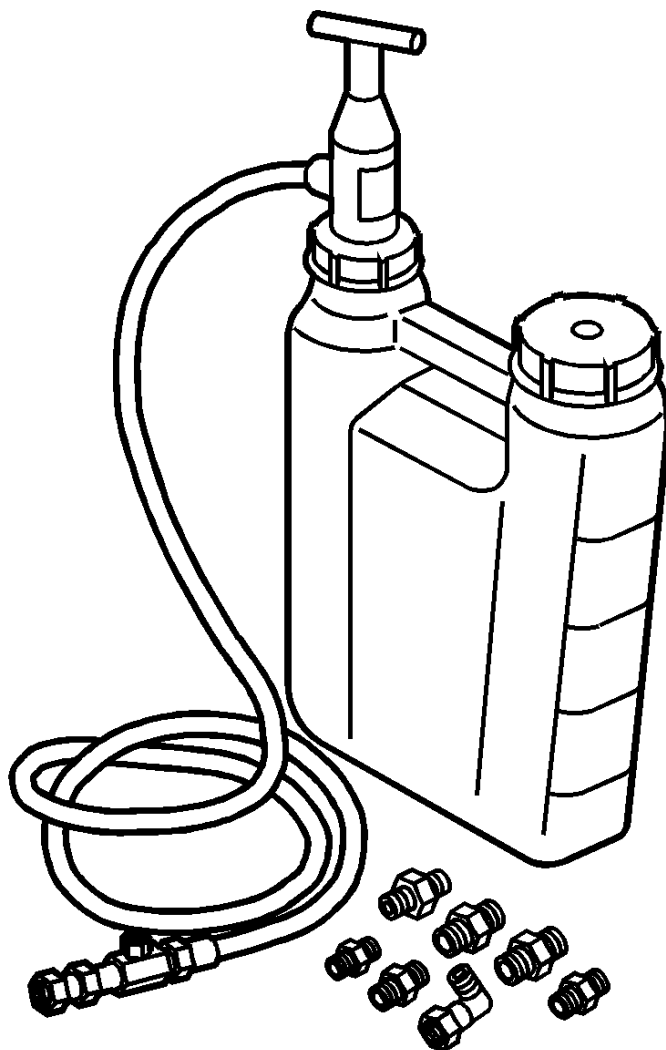


Fig. 399: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

4. Install the flexible hose to the adapter and open the valve.
5. Pump the handle on **J 45299** to flow a minimum of 1-2 quarts of engine oil. See **Special Tools**. Observe the flow of engine oil through the flexible hose and into the engine assembly.
6. Close the valve and remove the flexible hose and adapter from the engine.
7. Install the engine oil pressure indicator switch.

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

8. Top off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

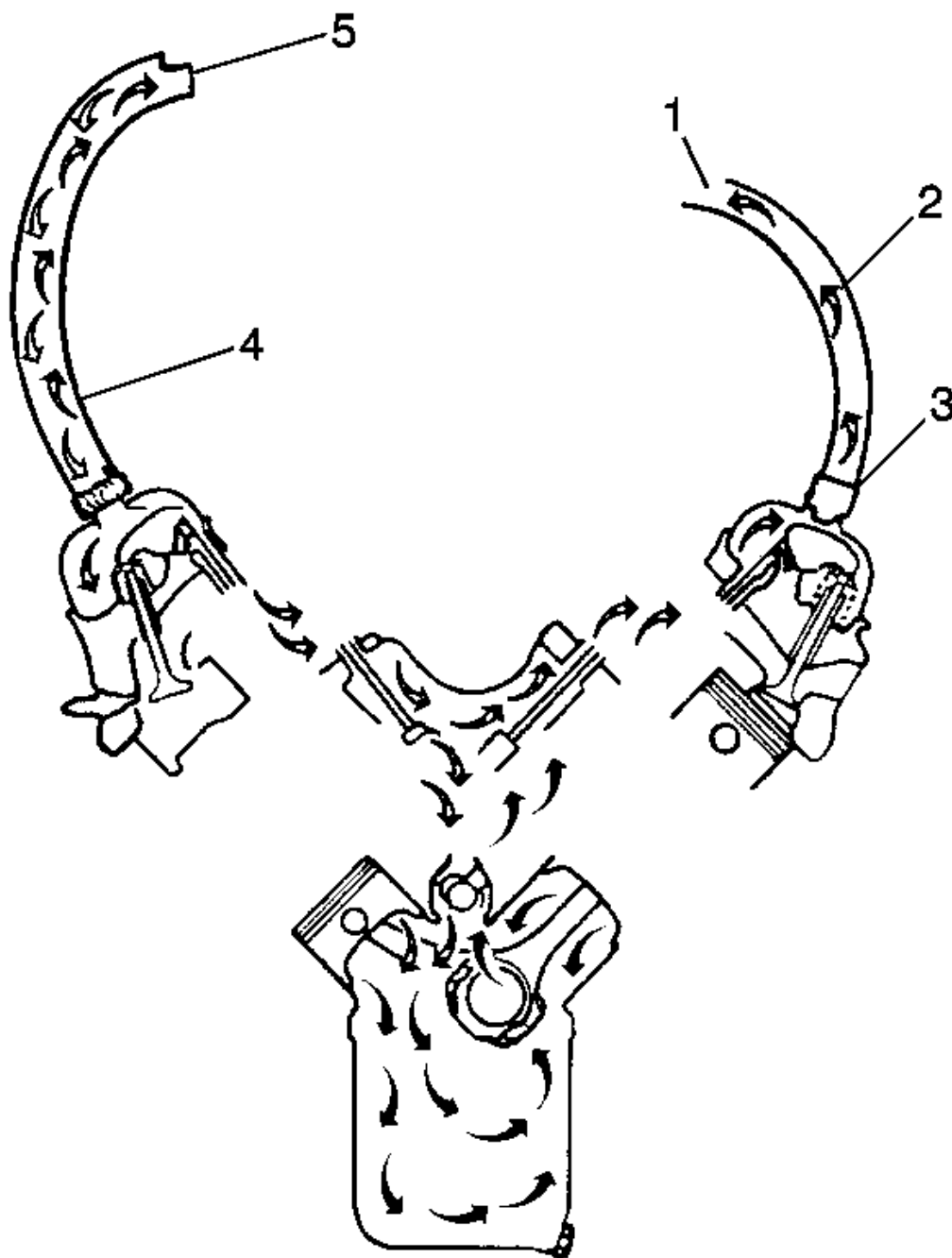


Fig. 400: Crankcase Ventilation System Flow Diagram
Courtesy of GENERAL MOTORS CORP.

A 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

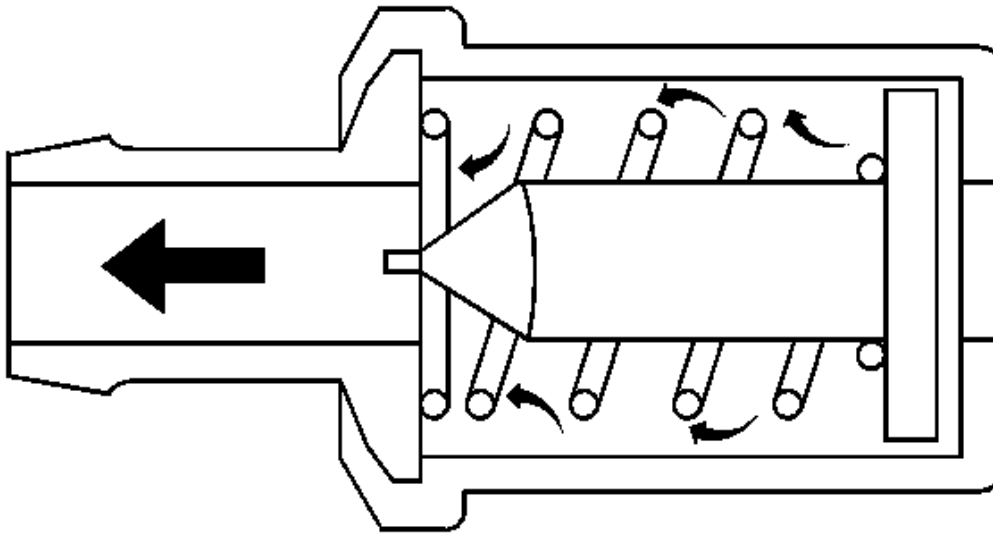


Fig. 401: Crankcase Ventilation Valve Flow Diagram
Courtesy of GENERAL MOTORS CORP.

The primary control is through the positive crankcase ventilation (PCV) valve 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 crankshaft balancer pulley
- The accessory drive components
 - 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.

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 - accessory belt end, the right bank cylinders are 2, 4, 6. The left bank cylinders are 1, 3, 5.

Four main bearings support the crankshaft. The crankshaft is retained by the bearing caps. The bearing caps are machined with the block for proper alignment and clearances. The main bearing caps are drilled and tapped for the structural oil pan side bolts.

The aluminum cylinder heads have individual intake and exhaust ports for each cylinder. The valve guides are pressed in. The roller rocker arms are located on a pedestal in a slot in the cylinder head. The roller rocker arms are retained on individual threaded bolts.

The crankshaft is forged steel - some applications use cast 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 pistons also have 2 polymer coated patches on the skirt for noise reduction. The piston pin is offset 0.8 mm (0.031 in) towards the major thrust side. This placement allows for a gradual change in thrust pressure against the cylinder wall as the piston travels its path. The pins are made of chromium steel and have a floating fit in the pistons. The pins are retained in the connecting rods by 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 component changes for 2005.

Fastener Changes

No fastener changes for 2005.

Torque Values and/or Fastener Tightening Strategies

No torque value changes for 2005.

Changed Engine Specifications

No specification changes for 2005.

New Sealants and/or Adhesives

No new sealants and or adhesives for 2005.

Disassembly and Assembly Procedure Revisions

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No changes for 2005.

Engine Mechanical Diagnostic Procedure Revisions

No revisions for 2005.

New Special Tools Required

No changes for 2005.

LUBRICATION DESCRIPTION

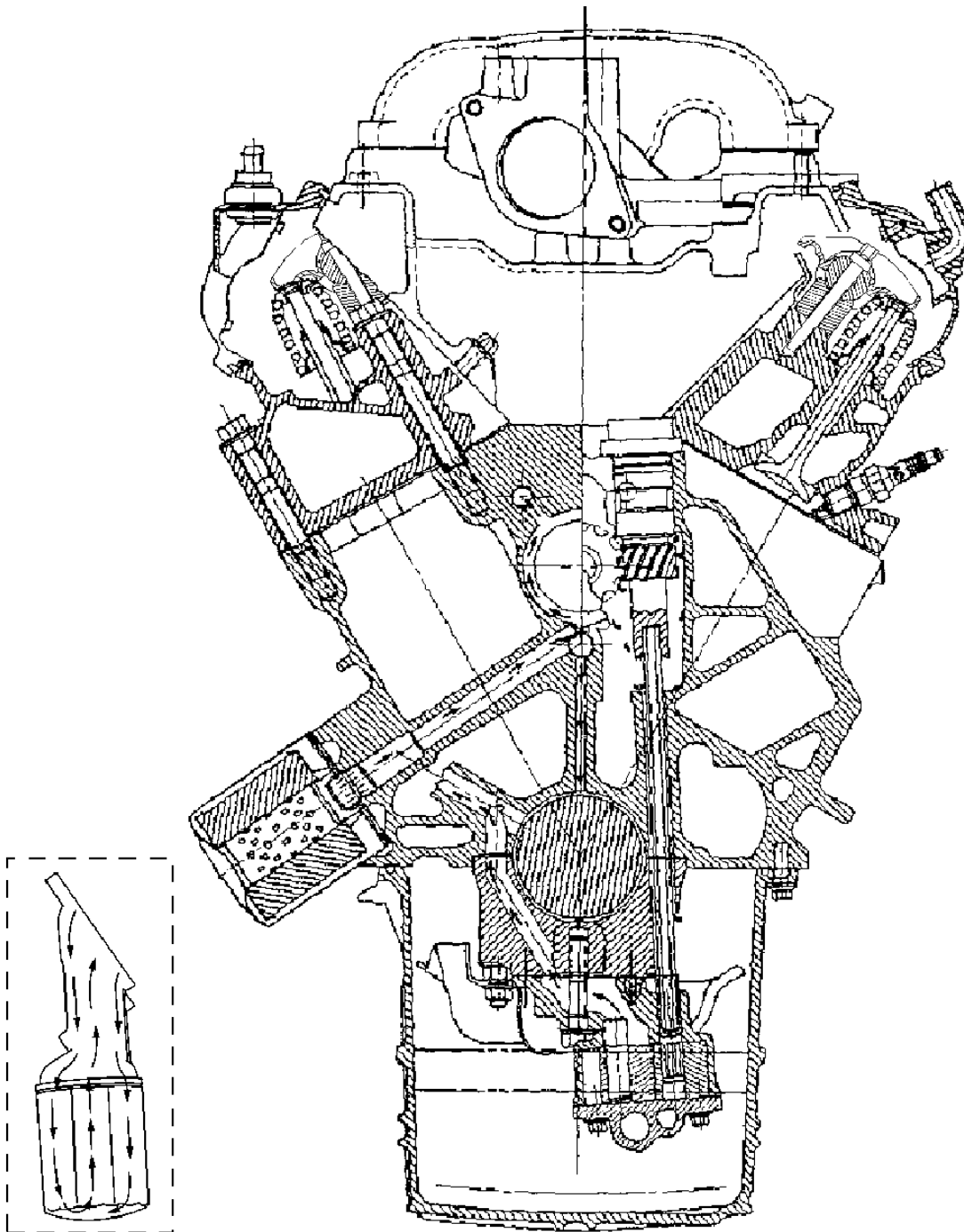


Fig. 402: Front View Of Engine
Courtesy of GENERAL MOTORS CORP.

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 piston oil nozzle lubricates the pistons and cylinder walls in cylinders 5 and 6. A nonserviceable check valve integrated into the nozzle prevents oil bleed down from the nozzle when the engine is not running.

The hydraulic lifters pump oil up through the pushrods to the rocker arms. The cast dams in the crankcase casting direct the oil that drains back from the rocker arms in order to supply the camshaft lobes. The camshaft chain drive is lubricated by indirect oil splash.

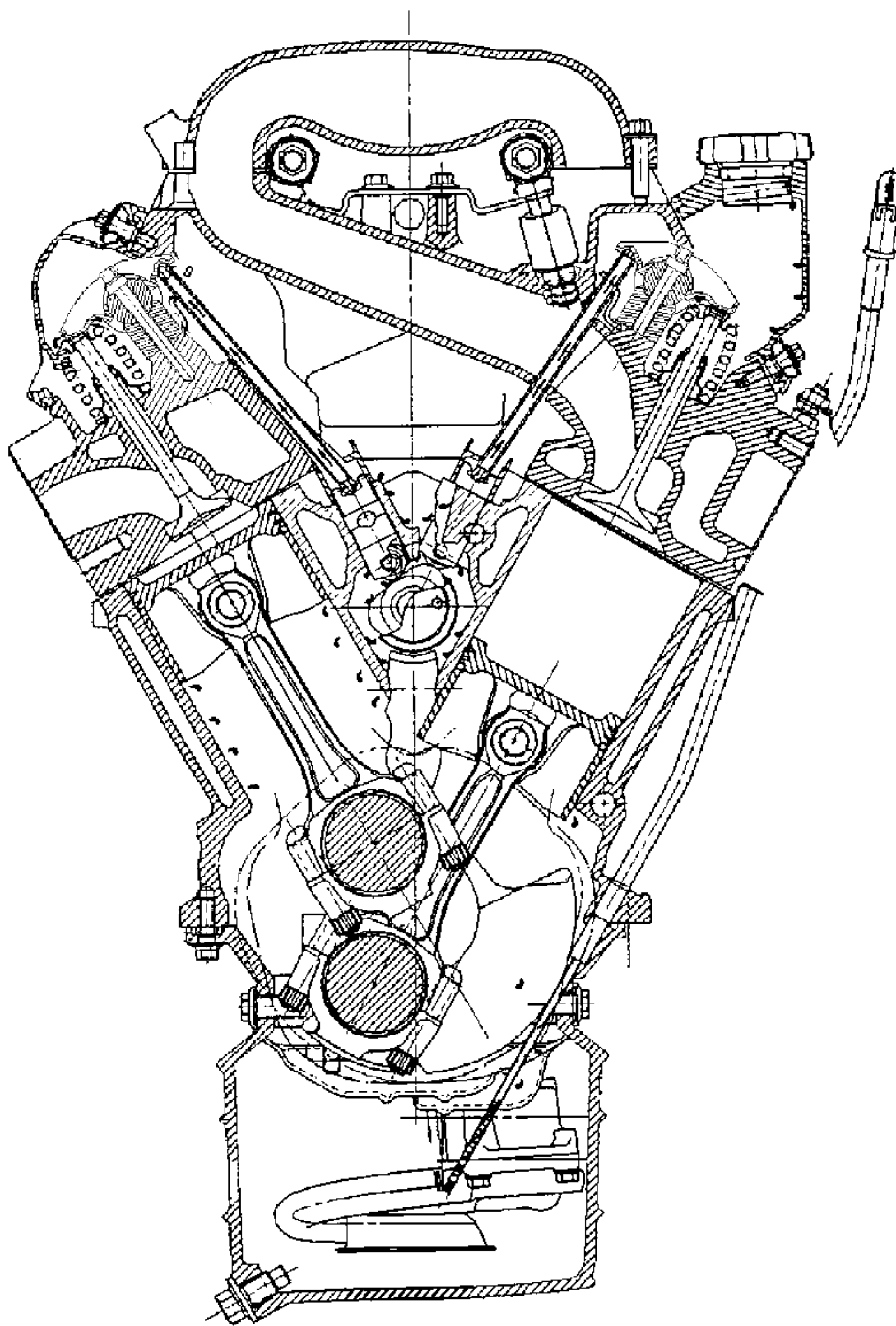


Fig. 403: Rear View Of Engine

Courtesy of GENERAL MOTORS CORP.

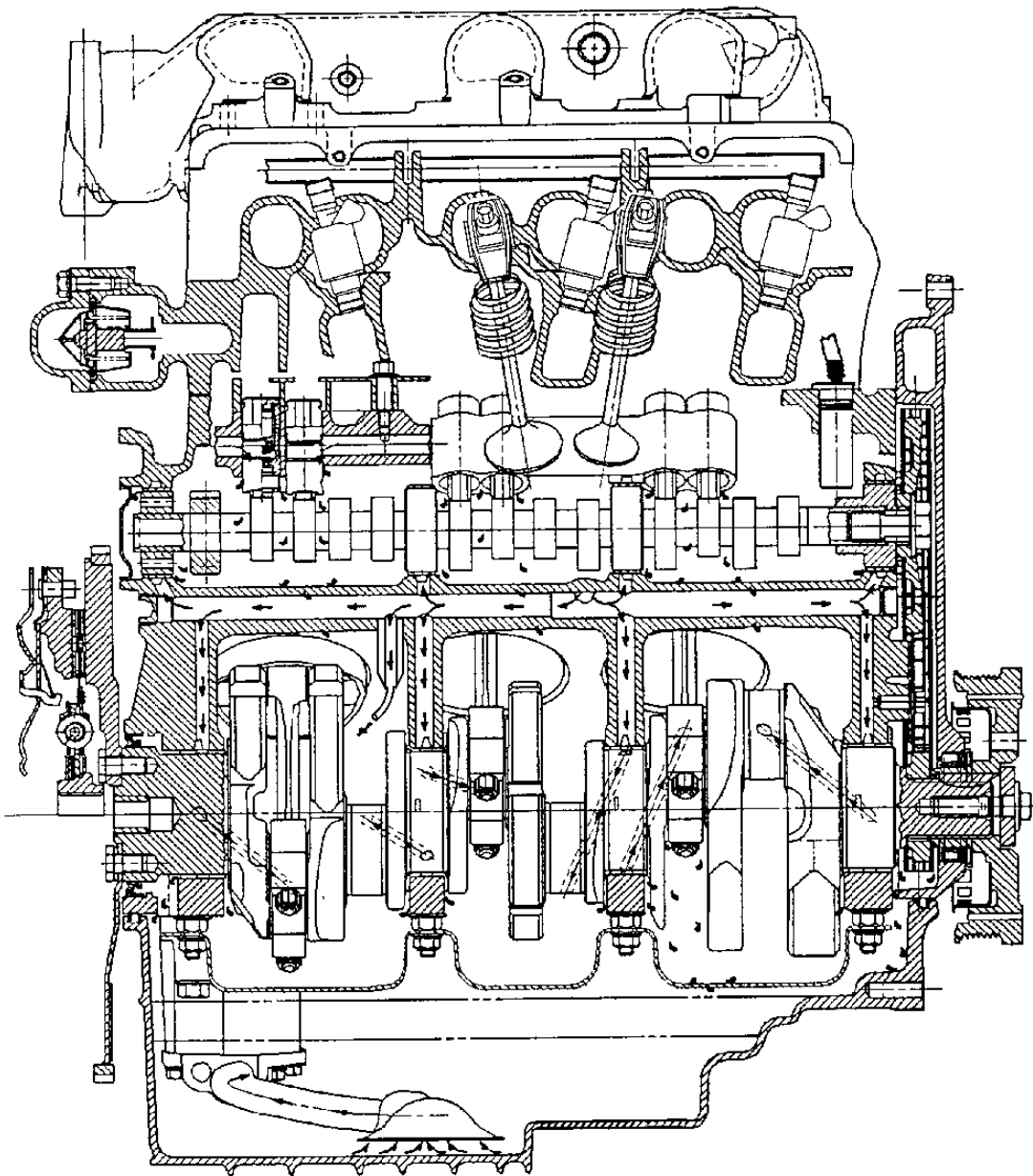


Fig. 404: Right View Of Engine

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

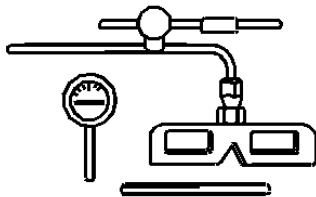
SPECIAL TOOLS

Special Tools

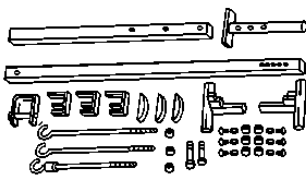
Illustration	Tool Number/Description

2005 Pontiac G6

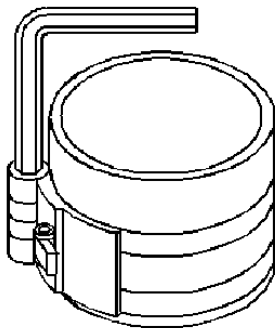
2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6



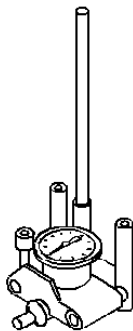
J 7872
Magnetic Base Dial Indicator



J 8001
Dial Indicator Set



J 8037
Ring Compressor

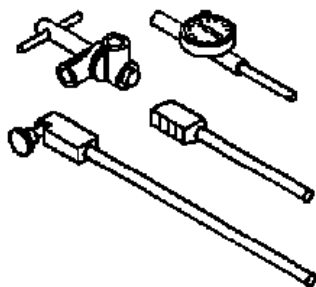


J 8087
Cylinder Bore Gage

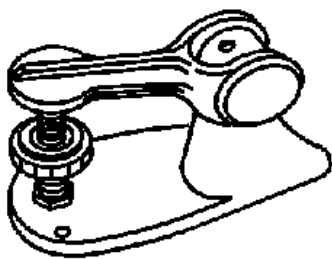
J 8089
Carbon Removal Brush

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J 8520
Cam Lobe Lift Indicator



J 9666
Valve Spring Tester

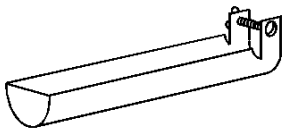


J 21882
Oil Suction Pipe Installer

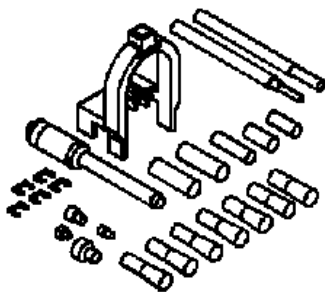
J 22144
Oil Suction Pipe Installer

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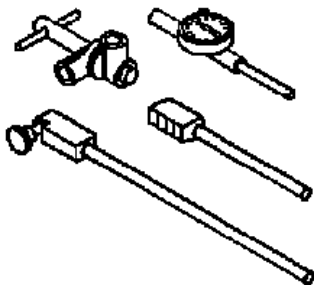
2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6



J 22794
Spark Plug Port Adapter



J 24086-C
Piston Pin Remover/Installer Set

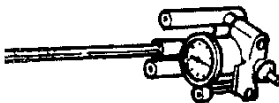
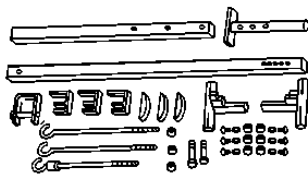
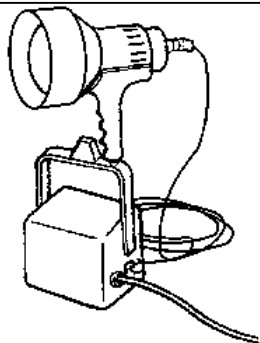
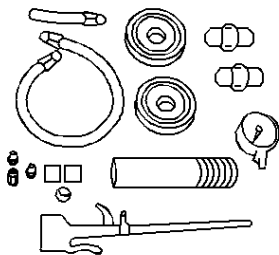


J 24270
Cylinder Bore Ridge Reamer

J 25087-C
Oil Pressure Tester

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J 28428-E
High Intensity Black Light Kit

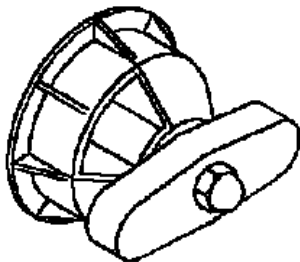
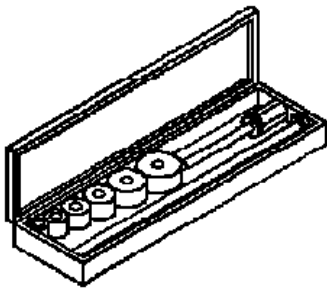
J 28467-B
Universal Engine Support Fixture

J 29113
Balancer and Crank Sprocket Installer

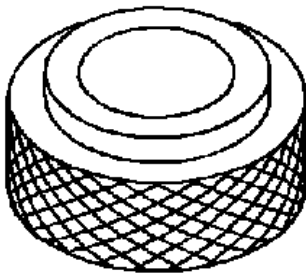
J 33049
Camshaft Bearing Service Set

2005 Pontiac G6

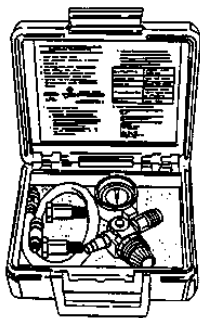
2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6



J 34686
Rear Main Seal Installer



J 35468
Cover Aligner and Seal Installer



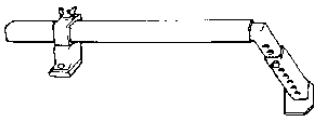
J 35667-A
Cylinder Leakdown Tester

J 36462

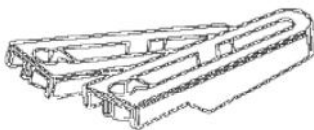
2005 Pontiac G6

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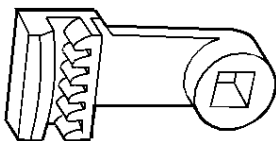
Engine Support Adapter Leg



J 37088-A
Fuel Line Disconnect Tool Set



J 37096
Flywheel Holder



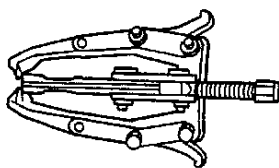
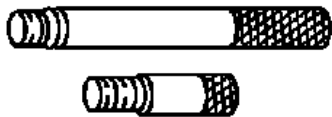
J 38606
Valve Spring Compressor



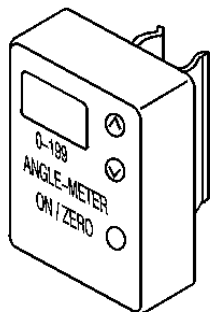
J 41556
Connecting Rod Guide

2005 Pontiac G6

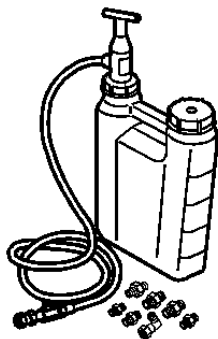
2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6



J 41816
Crankshaft Balancer Remover



J 45059
Angle Meter



J 45299
Engine Preluber

EN 46359
Puller End Protector

2005 Pontiac G6

2005 ENGINE Engine Mechanical - 3.5L (LX9) - G6

