

2004 Pontiac Bonneville SLE

2004 ENGINE Engine Mechanical - 3.8L - Bonneville

2004 ENGINE**Engine Mechanical - 3.8L - Bonneville****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS****Fastener Tightening Specifications**

Application	Specifications	
	Metric	English
A/C Compressor Mounting Fastener	50 N.m	37 lb ft
Accelerator Control Cable Bracket Bolt/Nut	16 N.m	12 lb ft
Balance Shaft Driven Gear Bolt		
• First Pass	22 N.m	16 lb ft
• Final Pass	70 degrees	
Balance Shaft Retainer Bolt	30 N.m	22 lb ft
Battery Negative Cable to Engine Block Bolt	25 N.m	18 lb ft
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Camshaft Sprocket Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	90 degrees	
Camshaft Thrust Plate Bolt	15 N.m	11 lb ft
Canister Purge Solenoid Valve Bracket Bolt	50 N.m	37 lb ft
Canister Purge Vacuum Switch Bolt	50 N.m	37 lb ft
Connecting Rod Bearing Cap Bolts		
• First Pass	27 N.m	20 lb ft
• Final Pass	50 degrees	
Crankshaft Balancer Bolt		
• First Pass	150 N.m	111 lb ft
• Final Pass	76 degrees	
Crankshaft Main Bearing Cap Bolt		
• First Pass	40 N.m	30 lb ft
• Final Pass	110 degrees	
Crankshaft Main Bearing Cap Bolt - Side		
• First Pass	15 N.m	11 lb ft
• Final Pass	45 degrees	
Crankshaft Position Sensor Stud	30 N.m	22 lb ft
Crankshaft Rear Oil Seal Housing Bolt		

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• First Pass	15 N.m	11 lb ft
• Final Pass	50 degrees	
Cruise Control Module Bracket Retaining Nut	9 N.m	80 lb in
Cylinder Head Bolt		
• First Pass	50 N.m	37 lb ft
• Final Pass	120 degrees	
Drive Belt Tensioner Bolt/Nut	50 N.m	37 lb ft
Drive Belt Tensioner Bracket Stud	17 N.m	12 lb ft
EGR Valve Adapter to Cylinder Head Bolt/Stud	50 N.m	37 lb ft
EGR Valve Inlet Pipe to Exhaust Manifold Bolt	29 N.m	21 lb ft
EGR Valve Nut	29 N.m	21 lb ft
EGR Valve Outlet Pipe Bolt/Nut	29 N.m	21 lb ft
EGR Valve Wiring Harness Heat Shield Bolt/Nut	10 N.m	89 lb in
Engine Coolant Temperature Sensor	25 N.m	18 lb ft
Engine Flywheel Bolt		
• First Pass	15 N.m	11 lb ft
• Final Pass	50 degrees	
Engine Front Cover Bolt/Stud		
• First Pass	20 N.m	15 lb ft
• Final Pass	40 degrees	
Engine Lift Bracket Bolt/Nut/Stud	30 N.m	22 lb ft
Engine to Transaxle Mounting Bolt	75 N.m	55 lb ft
Engine Wiring Harness Heat Shield Bolt/Nut	10 N.m	89 lb in
Exhaust Manifold Bolt/Nut	30 N.m	22 lb ft
Exhaust Manifold Heat Shield Nut	20 N.m	15 lb ft
Exhaust Manifold Pipe Nut	40 N.m	30 lb ft
Exhaust Manifold Stud	10 N.m	89 lb in
Flywheel to Torque Converter Bolt	63 N.m	46 lb ft
Fuel Injector Rail Assembly Nut	10 N.m	89 lb in
Fuel Injector Rail Stud	25 N.m	18 lb ft
Fuel Injector Sight Shield Bracket Nut	30 N.m	22 lb ft
Generator Brace Bracket Bolt	50 N.m	37 lb ft
Generator Bracket Bolt	50 N.m	37 lb ft
Heated Oxygen Sensor	42 N.m	31 lb ft
Heated Inlet Pipe Nut	25 N.m	18 lb ft
Ignition Control Module Bracket Stud	17 N.m	12 lb ft
Ignition Control Module Assembly Bracket Bolt	30 N.m	22 lb ft
Ignition Control Module Assembly Bracket Nut	50 N.m	37 lb ft
Ignition Control Module Assembly Nut	8 N.m	71 lb in

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Knock Sensor	18 N.m	13 lb ft
Lower Intake Manifold Bolt	15 N.m	11 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Adapter Bolt		
• First Pass	15 N.m	11 lb ft
• Final Pass	50 degrees	
Oil Gallery Plug	30 N.m	22 lb ft
Oil Level Indicator Tube Stud/Nut	19 N.m	14 lb ft
Oil Level Sensor Bolt	20 N.m	15 lb ft
Oil Pan Bolt	14 N.m	125 lb in
Oil Pan Drain Plug	30 N.m	22 lb ft
Oil Pressure Sensor	16 N.m	12 lb ft
Oil Pump Cover Screw	11 N.m	98 lb in
Oil Pump Pipe and Screen Bolt	15 N.m	11 lb ft
Oil Filter Adapter Bolt	30 N.m	22 lb ft
Right Engine Mount Bracket Stud	8 N.m	71 lb in
Right Engine Mount Bracket to Engine	60 N.m	44 lb ft
Right Engine Mount to Bracket Nut	80 N.m	59 lb ft
Right Engine Mount to Frame Rail Nuts	70 N.m	52 lb ft
Spark Plug - Initial Installation	27 N.m	20 lb ft
Spark Plug - Reinstallation	15 N.m	11 lb ft
Starter Motor Heat Shield Bolt	30 N.m	22 lb ft
Throttle Body Bolt/Nut	10 N.m	89 lb in
Throttle Body Support Bolt	16 N.m	12 lb ft
Timing Chain Dampener Bolt	22 N.m	16 lb ft
Upper Intake Manifold Bolt	10 N.m	89 lb in
Valve Lifter Guide Retainer Bolt	30 N.m	22 lb ft
Valve Rocker Arm Bolt		
• First Pass	15 N.m	11 lb ft
• Final Pass	90 degrees	
Valve Rocker Arm Cover Bolt	10 N.m	89 lb in
Water Outlet Housing Bolt	27 N.m	20 lb ft
Water Pump Bolt		
• Large Bolt	34 N.m	25 lb ft
• Small Bolt	22 N.m	16 lb ft
Water Pump Pulley Bolt	13 N.m	116 lb in

ENGINE MECHANICAL SPECIFICATIONS**Engine Mechanical Specifications**

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Application	Specification	
	Metric	English
General Data		
• Engine Type	90 degrees V-6	
• Displacement	3.8L	231 cu in
• RPO	L36, L67	
• VIN	K, 1	
• Bore	96.52 mm	3.8 in
• Stroke	86.36 mm	3.4 in
• Compression Ratio VIN K - @ 4 Compression Strokes	9.4:1	
• Compression Ratio VIN 1 - @ 4 Compression Strokes	8.5:1	
• Firing Order	1-6-5-4-3-2	
• Spark Plug Gap	1.52 mm	0.60 in
Balance Shaft		
• Bearing Bore Diameter - Front	51.973-51.999 mm	2.0462-2.0472 in
• Bearing Bore Diameter - Rear - In Block	47.584-47.612 mm	1.8735-1.8745 in
• Bearing Inside Diameter - Rear	38.117-38.194 mm	1.5007-1.5037 in
• Bearing Journal Diameter - Rear	38.072-38.105 mm	1.4989-1.5002 in
• Bearing Clearance - Rear	0.0127-0.1219 mm	0.0005-0.0048 in
• End Play	0.0-0.171 mm	0.0-0.0067 in
• Gear Lash	0.050-0.125 mm	0.002-0.0049 in
Block		
• Balance Shaft Bearing Bore Diameter - Front	51.973-51.999 mm	2.0462-2.0472 in
• Balance Shaft Bearing Inside Diameter - Rear	38.118-38.194 mm	1.5007-1.5037 in
• Balance Shaft Bearing Bore Diameter - Rear, In Block	47.584-47.612 mm	1.8735-1.8745 in
• Camshaft Bearing Inside Diameter - Front and Rear	46.970-46.934 mm	1.8428-1.8492 in
• Camshaft Bearing Inside Diameter - Middle #2, #3	46.977-46.942 mm	1.8481-1.8495 in
• Crankshaft Main Bearing Bore Diameter	68.249-68.270 mm	2.6870-2.6878 in
• Cylinder Bore Diameter	98.5 mm	3.8 in
• Cylinder Bore Out-of-Round - Diametral	0.0254 mm	0.001 in
• Cylinder Bore Taper	0.0254 mm	0.001 in
• Cylinder Head Deck Height	216.459 mm	8.522 in
• Cylinder Head Deck Surface Flatness - Overall	0.0762 mm	0.003 in

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• Valve Lifter Bore Diameter	21.424-21.450 mm	0.8435-0.8445 in
Camshaft		
• Camshaft Bearing Inside Diameter - 1 and 4	46.970-46.934 mm	1.8478-1.8492 in
• Camshaft Bearing Inside Diameter - 2 and 3	46.977-46.942 mm	1.8481-1.8495 in
• Camshaft Journal Diameter	47.655-46.858 mm	1.8462-1.8448 in
• Camshaft Journal Out-of-Round	0.00635 mm	0.00025 in
• Camshaft Journal to Bearing Clearance	0.041-0.119 mm	0.0016-0.0047 in
• Camshaft Lobe Duration - Exhaust	330 Crankshaft degrees	
• Camshaft Lobe Duration - Intake	320 Crankshaft degrees	
• Camshaft Lobe Lift - Exhaust	6.56 mm	0.258 in
• Camshaft Lobe Lift - Intake	6.56 mm	0.258 in
• Camshaft Lobe Overlap	96 Crankshaft degrees	
Connecting Rod		
• Connecting Rod Bearing Clearance	0.0127-0.0660 mm	0.0005-0.0026 in
• Connecting Rod Bore Diameter	60.295-60.312 mm	2.37378-2.3745 in
• Connecting Rod Length - Center to Center - S/C	143.205-143.307 mm	5.638-5.642 in
• Connecting Rod Length - Center to Center - Non S/C	145.796-145.898 mm	5.740-5.744 in
• Connecting Rod Side Clearance	0.102-0.508 mm	0.004-0.0200 in
Crankshaft		
• Connecting Rod Journal Diameter	57.1170-57.1475 mm	2.2487-2.2499 in
• Connecting Rod Journal Out-of-Round	0.00508 mm	0.00020 in
• Connecting Rod Journal Taper	0.00889 mm	0.00035 in
• Crankshaft End Play	0.076-0.276 mm	0.003-0.011 in
• Crankshaft Main Bearing Clearance - #1	0.0178-0.0406 mm	0.0007-0.0016 in
• Crankshaft Main Bearing Clearance - #2, 3 and 4	0.0229-0.0457 mm	0.0009-0.0018 in
• Crankshaft Main Journal Diameter	63.470-63.495 mm	2.4988-2.4998 in
• Crankshaft Main Journal Out-of-Round	0.00635 mm	0.00025 in
• Crankshaft Main Journal Taper	0.00889 mm	0.00035 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Runout - from Main 2 & 3 to 1 & 4	0.076 mm	0.003 in
Cylinder Head		
• Combustion Chamber Depth - at Measurement Point	3.9166-5.4356 mm	0.154-0.214 in
• Cylinder Head Height/Thickness	103.492-104.178 mm	4.0745-4.1015 in
• Surface Finish	0.0032 mm	0.000125 in

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• Surface Flatness - Block Deck	0.1016 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.1016 mm	0.004 in
• Surface Flatness - Intake Manifold Deck	0.1016 mm	0.004 in
• Valve Guide Bore - Exhaust	8.001-8.0213 mm	0.3150-0.3158 in
• Valve Guide Bore - Intake	8.001-8.0213 mm	0.3150-0.3158 in
Exhaust Manifold		
• Surface Flatness	0.5 mm	0.02 in
Lubrication System		
• Oil Capacity - with Filter	4.3L	4.5 qts
• Oil Capacity - without Filter	3.76L	4 qts
• Oil Pressure - @ 1850 RPM	414 kPa	60 psi
Oil Pump		
• Gear Pocket - Depth	11.71-11.75 mm	0.461-0.4625 in
• Gear Pocket - Diameter	89.10-89.20 mm	3.508-3.512 in
• Inner Gear Tip Clearance	0.152 mm	0.006 in
• Relief Valve-to-Bore Clearance	0.038-0.076 mm	0.0015-0.003 in
Piston Ring End Gap		
• First Compression Ring	0.25-0.46 mm	0.010-0.018 in
• Second Compression Ring	0.58-0.84 mm	0.023-0.033 in
• Oil Control Ring	0.254-0.762 mm	0.010-0.030 in
Piston Ring to Groove Clearance		
• First Compression Ring	0.033-0.079 mm	0.0013-0.0031 in
• Second Compression Ring	0.033-0.079 mm	0.0013-0.0031 in
• Oil Control Ring	0.023-0.201 mm	0.0009-0.0079 in
Piston Ring Thickness		
• First Compression Ring	1.176-1.197 mm	0.0463-0.0471 in
• Second Compression Ring	1.1476-1.497 mm	0.0581-0.0589 in
• Oil Control Ring	1.854-2.007 mm	0.073-0.079 in
Pistons and Pins - Piston		
• Piston Diameter - Production - S/C	96.489-96.528 mm	3.7988-3.8003 in
• Piston Diameter - Production - Non S/C	96.482-96.497 mm	3.7985-3.7991 in
• Piston Diameter - Service Limit - Minimum - S/C	96.434 mm	3.7966 in
• Piston Diameter - Service Limit - Minimum - Non S/C	96.442 mm	3.7969 in
• Piston Pin Bore Diameter - S/C	23.0065-23.0105 mm	0.9058-0.9059 in

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● Piston Pin Bore Diameter - Non S/C	22.0060-22.0110 mm	0.8664-0.8666 in
● Piston to Bore Clearance - New - VIN K	0.010-0.051 mm	0.0004-0.0020 in
● Piston to Bore Clearance - Used - VIN K	0.050-0.091 mm	0.0020-0.0036 in
● Piston to Bore Clearance - New - VIN 1	-0.0207-0.0437 mm	-0.0008-0.0018 in
● Piston to Bore Clearance - Used VIN 1	0.0193-0.0997 mm	0.0008-0.0039 in
Pistons and Pins - Pin		
● Piston Pin Clearance to Connecting Rod Bore - Press Fit - VIN K	0.0066-0.0217 mm	0.0003-0.0009 in
● Piston Pin Clearance to Piston Pin Bore - VIN K	0.0020-0.0130 mm	0.00008-0.00051 in
● Piston Pin Diameter - VIN K	21.9950-22.000 mm	0.8659-0.8661 in
● Piston Pin Clearance to Connecting Rod Bore - Press Fit - VIN 1	0.0073-0.0225 mm	0.00029-0.00089 in
● Piston Pin Clearance to Piston Pin Bore - VIN 1	0.0065-0.0155 mm	0.00061-0.00026 in
● Piston Pin Diameter - VIN 1	22.995-23.000 mm	0.90531-0.90551 in
Valves		
● Valve Face Angle	46 degrees	
● Valve Face Runout	0.0508 mm	0.002 in
● Valve Head Diameter - Intake	46.37-46.63 mm	1.826-1.836 in
● Valve Head Diameter - Exhaust	38.481-38.735 mm	1.515-1.525 in
● Valve Length	119.464-119.972 mm	4.7033-4.7233 in
● Valve Seat Angle	45 degrees	
● Valve Seat Runout	0.050 mm	0.002 in
● Valve Seat Width - Intake	1.53-2.03 mm	0.060-0.080 in
● Valve Seat Width - Exhaust	2.29-2.79 mm	0.090-0.110 in
● Valve Stem Diameter	7.948-7.965 mm	0.3129-0.3136 in
● Valve Stem-to-Guide Clearance - Intake	0.031-0.071 mm	0.0012-0.0028 in
● Valve Stem-to-Guide Clearance - Exhaust	0.036-0.074 mm	0.0014-0.0029 in
Valve Lifters/Push Rods		
● Push Rod Length - Intake, Yellow	178.13 mm	7.013 in
● Push Rod Length - Exhaust, Green	178.13 mm	7.013 in
● Valve Lifter Diameter	21.387-21.405 mm	0.842-0.843 in
Valve Rocker Arms		
● Valve Rocker Arm Ratio	1.66:1	
Valve Springs		
● Valve Spring Free Length	49.78 mm	1.960 in

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• Valve Spring Installed Height	42.93-44.45 mm	1.690-1.750 in
• Valve Spring Load - Closed	334 N @ 43.69 mm	75 lb @ 1.72 in
• Valve Spring Load - Open	1014 N @ 32.4 mm	228 lb @ 1.277 in
• Valve Spring Total Number of Coils	6.6	

SEALERS, ADHESIVES, AND LUBRICANTS**Sealers, Adhesives, and Lubricants**

Application	Type of Material	GM Part Number	
		United States	Canada
Accelerator Control Cable Bracket Bolt Threads	Threadlock	12345382	10953489
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Crankshaft Position Sensor Bolt/Stud Threads	Threadlock	12345382	10953489
Crankshaft Side Main Bolt Threads	Threadlock	12345493	10953488
Engine Block Coolant Drain Plug Threads	Sealant	12346004	10953480
Engine Block Oil Gallery Plug Threads	Sealant	12346004	10953480
Engine Front Cover Bolt Threads	Sealant	12346004	10953480
Engine Oil	Oil-5W-30	12345616	993182
Engine Oil Supplement	Lubricant	1052367	992869
Exhaust Manifold Bolt and Stud Threads	Threadlock	12345493	10953488
Intake Manifold Bolt Threads - Lower	Threadlock	12345493	10953488
Intake Manifold Coolant Pipe	Sealant	12345493	10953488
Intake Manifold to Engine Block Mating Surface	Sealant	12346286	10953472
Knock Sensor Threads	Sealant	12346004	10953480
Oil Filter Bypass Hole Plug Threads	Sealant	12346004	10953480
Oil Pan	Sealant	12378521	88901148
Oil Pan Bolt Threads	Threadlock	12345382	10953489
Oil Pressure Switch Threads	Sealant	12346004	10953480
Piston and Piston Pin	Oil-5W-30	12345616	993182
Rear Crankshaft Main Bearing Cap	Sealant	1052942	10953466
Supercharger Oil	Lubricant	12345982	10953513
Throttle Body Stud Threads	Threadlock	12345382	10953489
Valve Lifter and Camshaft Prelube	Lubricant	12345501	992704
Valve Rocker Arm Cover Bolt Threads	Threadlock	12345382	10953489
Valve Rocker Arm Bolt Threads	Threadlock	12345493	10953488
Valve Train Component Prelube	Lubricant	1052367	992869

COMPONENT LOCATOR**DISASSEMBLED VIEWS**

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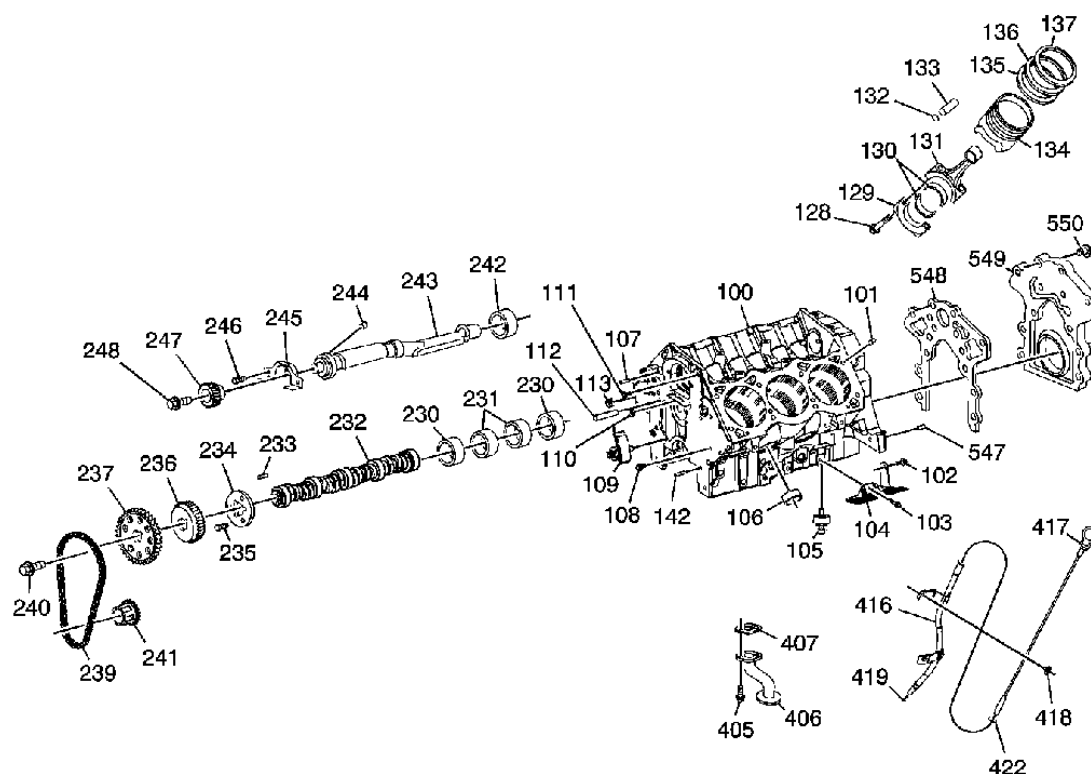


Fig. 1: Engine Block And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Cylinder Head Locator Pins
102	Starter Motor Heat Shield Bolt - Large
103	Starter Motor Heat Shield Bolt - Small
104	Starter Motor Heat Shield
105	Knock Sensor
106	Engine Block Expansion Plug
107	Engine Front Cover Locator Pins - Large
108	Engine Block Coolant Drain Plug
109	Timing Chain Dampener
110	Engine Block Oil Gallery Plug - Front
111	Engine Mount Strut Access Hole Plug
112	Engine Mount Strut Bracket Stud
113	Engine Block Oil Gallery Plug - Right
128	Connecting Rod Bearing Cap Bolt
129	Connecting Rod Bearing Cap
130	Connecting Rod Bearing

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131	Connecting Rod
132	Piston Pin Retainer
133	Piston Pin
134	Piston
135	Piston Oil Control Ring
136	Piston Compression Ring
137	Piston Compression Ring
142	Engine Front Cover Locator Pins - Small
230	Camshaft Bearing - 1 and 4
230	Camshaft Bearing - 1 and 4
231	Camshaft Bearing - 2 and 3
232	Camshaft
233	Camshaft Key
234	Camshaft Thrust Plate
235	Camshaft Thrust Plate Bolt
236	Balance Shaft Drive Gear
237	Camshaft Sprocket
239	Timing Chain
240	Camshaft Sprocket Bolt
241	Crankshaft Sprocket
242	Balance Shaft Rear Bushing
243	Balance Shaft
244	Balance Shaft Gear Pin
245	Balance Shaft Retainer
246	Balance Shaft Retainer Bolt
247	Balance Shaft Driven Gear
248	Balance Shaft Gear Bolt
405	Oil Pump Screen Bolt
406	Oil Pump Screen
407	Oil Pump Screen Gasket
416	Oil Level Indicator Tube
417	Oil Level Indicator
418	Oil Level Indicator Tube Nut
419	Oil Level Indicator Tube Seal
422	Oil Level Indicator Seal
547	Transmission Locator Pin
548	Crankshaft Rear Oil Seal Housing Gasket
549	Crankshaft Rear Oil Seal Housing Gasket
550	Crankshaft Rear Oil Seal Housing

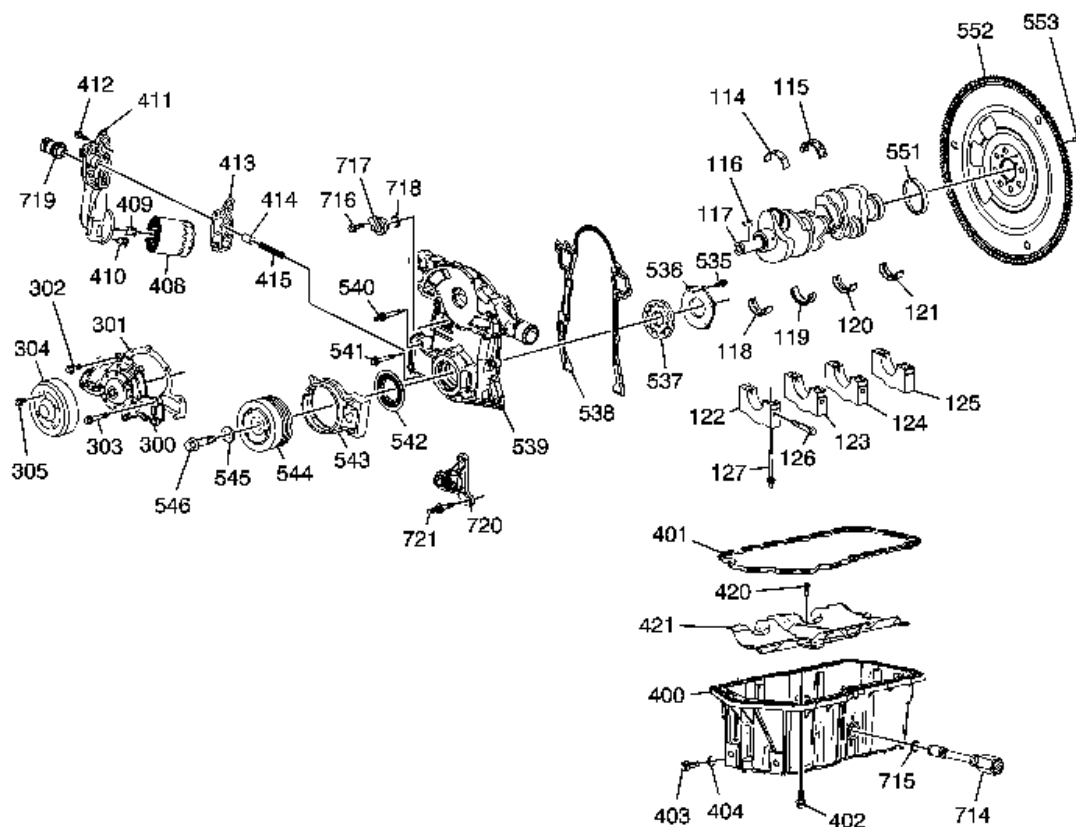


Fig. 2: Crankshaft And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
114	Crankshaft Main Bearing - Upper - 1, 3 and 4
115	Crankshaft Main Bearing - Upper - 2
116	Crankshaft Balancer Key
117	Crankshaft
118	Crankshaft Main Bearing - Lower - 1
119	Crankshaft Main Bearing - Lower - 2
120	Crankshaft Main Bearing - Lower - 3
121	Crankshaft Main Bearing - Lower - 4
122	Crankshaft Main Bearing Cap - 1
123	Crankshaft Main Bearing Cap - 2
124	Crankshaft Main Bearing Cap - 3
125	Crankshaft Main Bearing Cap - 4
126	Crankshaft Main Bearing Cap Bolt - Side
127	Crankshaft Main Bearing Cap Bolt
300	Water Pump

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301	Water Pump Gasket
302	Water Pump Bolt - Short
303	Water Pump Bolt - Long
304	Water Pump Pulley
305	Water Pump Pulley Bolt
400	Oil Pan
401	Oil Pan Gasket
402	Oil Pan Bolt
403	Oil Pan Drain Plug
404	Oil Pan Drain Plug Seal
408	Oil Filter
409	Oil Filter Fitting
410	Oil Filter Bypass Valve
411	Oil Filter Adapter
412	Oil Filter Adapter Bolt
413	Oil Filter Adapter Gasket
414	Oil Pressure Relief Valve
415	Oil Pressure Relief Valve Spring
420	Oil Pan Baffle Bolt
421	Oil Pan Baffle
535	Oil Pump Cover Bolt
536	Oil Pump Cover
537	Oil Pump Gear Set
538	Engine Front Cover Gasket
539	Engine Front Cover
540	Engine Front Cover Stud
541	Engine Front Cover Bolt
542	Crankshaft Front Oil Seal
543	Crankshaft Position Sensor Shield
544	Crankshaft Balancer
545	Crankshaft Balancer Washer
546	Crankshaft Balancer Bolt
551	Crankshaft Rear Oil Seal
552	Flywheel
553	Flywheel Bolt
714	Oil Level Indicator Sensor
715	Oil Level Indicator Switch Seal
716	Camshaft Position Sensor Bolt
717	Camshaft Position Sensor
718	Camshaft Position Sensor Seal
719	Engine Oil Pressure Indicator Sensor
720	

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	Crankshaft Position Sensor
721	Crankshaft Position Sensor Stud

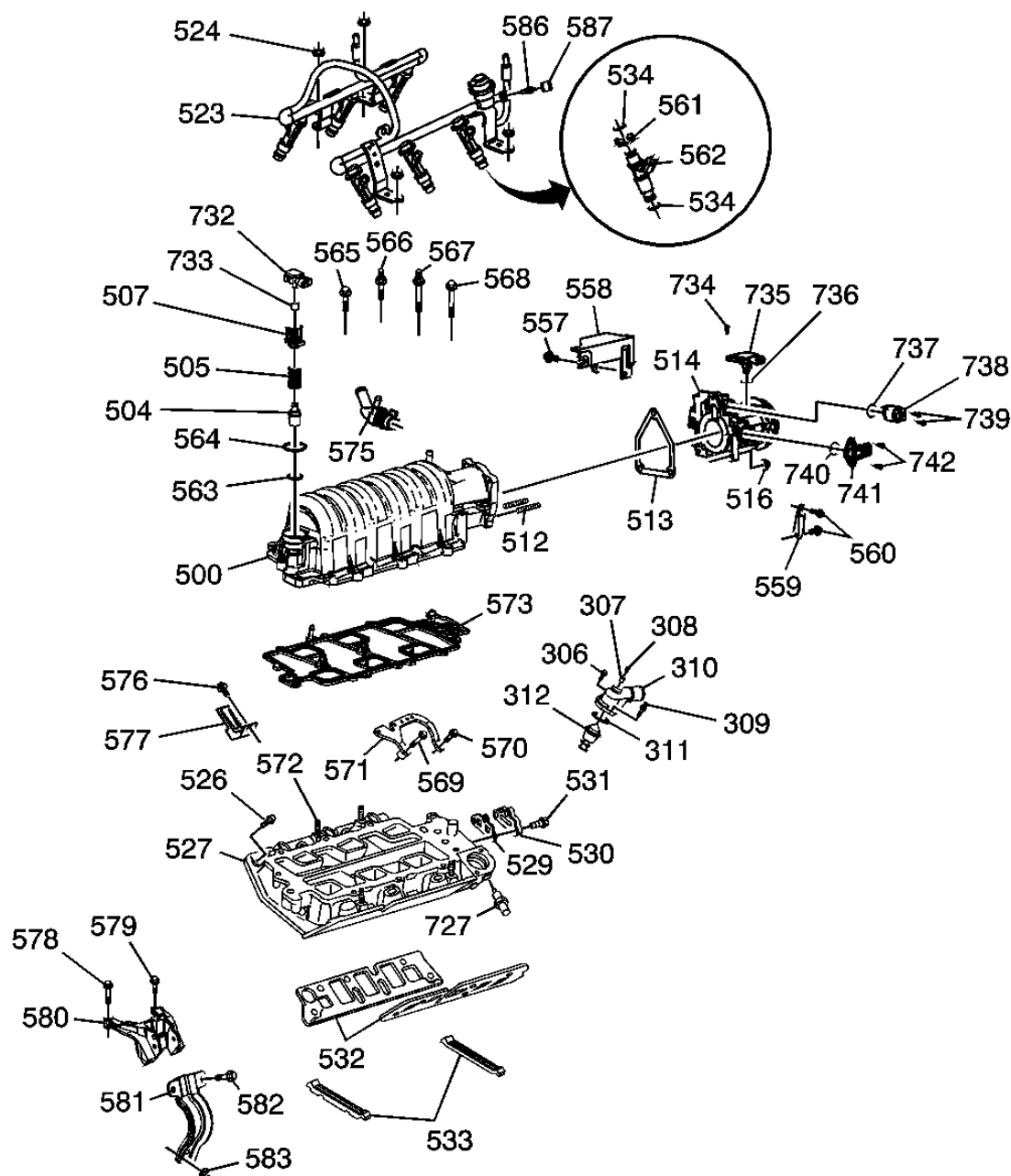


Fig. 3: Intake Manifold And Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
306	Water Outlet Housing Bolt
307	Coolant Bleed Valve Fitting

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308	Coolant Bleed Valve
309	Water Outlet Housing Stud
310	Water Outlet Housing
311	Thermostat Seal
312	Thermostat
500	Intake Manifold - Upper
504	PCV Valve
505	PCV Valve Spring
507	PCV Valve Retainer
512	Throttle Body Stud
513	Throttle Body Gasket
514	Throttle Body
516	Throttle Body Nut
523	Fuel Rail
524	Fuel Rail Nut
526	Intake Manifold Bolt
527	Intake Manifold - Lower
529	Engine Coolant Manifold Gasket
530	Engine Coolant Manifold
531	Engine Coolant Manifold Bolt
532	Intake Manifold Gasket - Lower
533	Intake Manifold Seal - Lower
534	Fuel Injector Seal
534	Fuel Injector Seal
557	Throttle Cable Bracket Bolt
558	Throttle Cable Bracket
559	Throttle Body Support Bracket
560	Throttle Body Support Bracket Bolt
561	Fuel Injector Retaining Clip
562	Fuel Injector
563	PCV Valve Seal - Small
564	PCV Valve Seal - Large
565	Intake Manifold Bolt - Upper - Short
566	Intake Manifold Stud - Upper - Short
567	Intake Manifold Stud - Upper - Long
568	Intake Manifold Bolt - Upper - Long
569	Generator Brace Bracket Bolt - Long
570	Generator Brace Bracket Bolt - Short
571	Generator Brace Bracket
572	Intake Manifold Stud - Lower
573	Intake Manifold Gasket - Upper

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	Vacuum Manifold
576	EVAP Purge Valve Bracket Bolt
577	EVAP Purge Valve Bracket
578	Engine Mounting Strut Bracket Bolt - Upper - Long
579	Engine Mounting Strut Bracket Bolt - Upper - Short
580	Engine Mounting Strut Bracket - Upper
581	Engine Mounting Strut Bracket - Lower
582	Engine Mounting Strut Bracket Bolt - Lower
583	Engine Mounting Strut Bracket Nut - Lower
586	Fuel Schrader Valve
587	Fuel Service Port
727	Engine Coolant Temperature Sensor
732	MAP Sensor
733	MAP Sensor Seal
734	MAF Sensor Bolt
735	MAF Sensor
736	MAF Sensor Seal
737	IAC Sensor Seal
738	IAC Sensor
739	IAC Sensor Bolt
740	TPS Sensor Seal
741	TPS Sensor
742	TPS Sensor Bolt

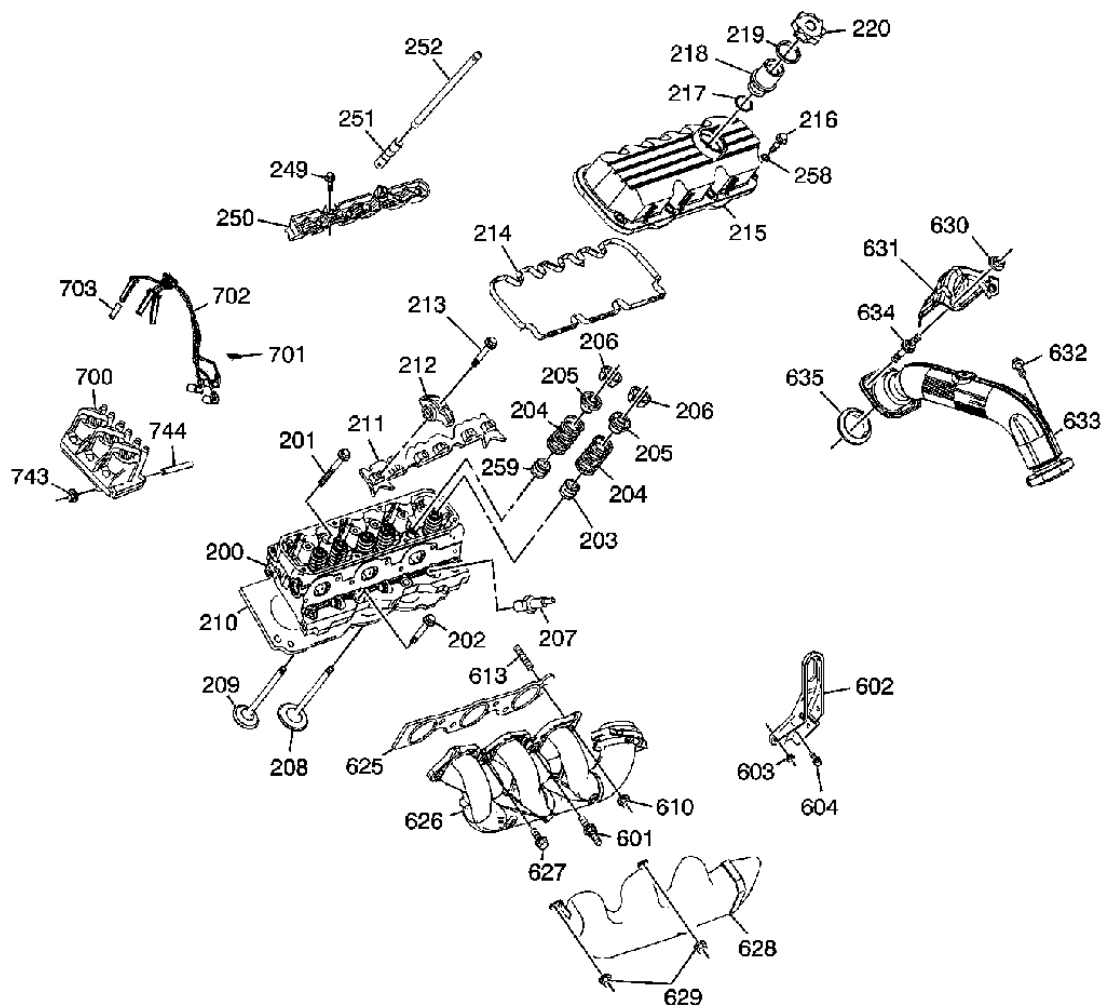


Fig. 4: Cylinder Head And Components - Left - L36
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Cylinder Head
201	Cylinder Head Bolt - Long
202	Cylinder Head Bolt - Short
203	Valve Seal - Exhaust
204	Valve Spring
204	Valve Spring
205	Valve Stem Cap
205	Valve Stem Cap
206	Valve Stem Key
206	Valve Stem Key
207	Spark Plug

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208	Exhaust Valve
209	Intake Valve
210	Cylinder Head Gasket - LH
211	Valve Rocker Arm Retainer
212	Valve Rocker Arm
213	Valve Rocker Arm Bolt
214	Valve Rocker Arm Cover Gasket
215	Valve Rocker Arm Cover - LH
216	Valve Rocker Arm Cover Bolt
217	Oil Fill Tube Seal
218	Oil Fill Tube
219	Oil Fill Cap Seal
220	Oil Fill Cap
249	Valve Lifter Guide Bolt
250	Valve Lifter Guide
251	Valve Lifter
252	Pushrod
258	Valve Rocker Arm Cover Bolt Seal
259	Valve Seal - Intake
601	Exhaust Manifold Stud
602	Engine Lift Bracket
603	Engine Lift Bracket Nut
604	Engine Lift Bracket Bolt
610	Exhaust Manifold Nut
613	Exhaust Manifold Stud - to Cylinder Head
625	Exhaust Manifold Gasket - Left
626	Exhaust Manifold - Left
627	Exhaust Manifold Bolt - Left
628	Exhaust Manifold Heat Shield - Left
629	Exhaust Manifold Heat Shield Nut - Left
630	Power Brake Booster Heat Shield Nut
631	Power Brake Booster Heat Shield
632	Exhaust Crossover Pipe Bolt
633	Exhaust Crossover Pipe
634	Exhaust Crossover Pipe Stud
635	Exhaust Crossover Pipe Seal
700	Electronic Ignition Module
701	Spark Plug Wire Harness Clip
702	Spark Plug Wire Harness
703	Spark Plug Wire Heat Shield
743	Electronic Ignition Module Nut
...	

Electronic Ignition Module Stud

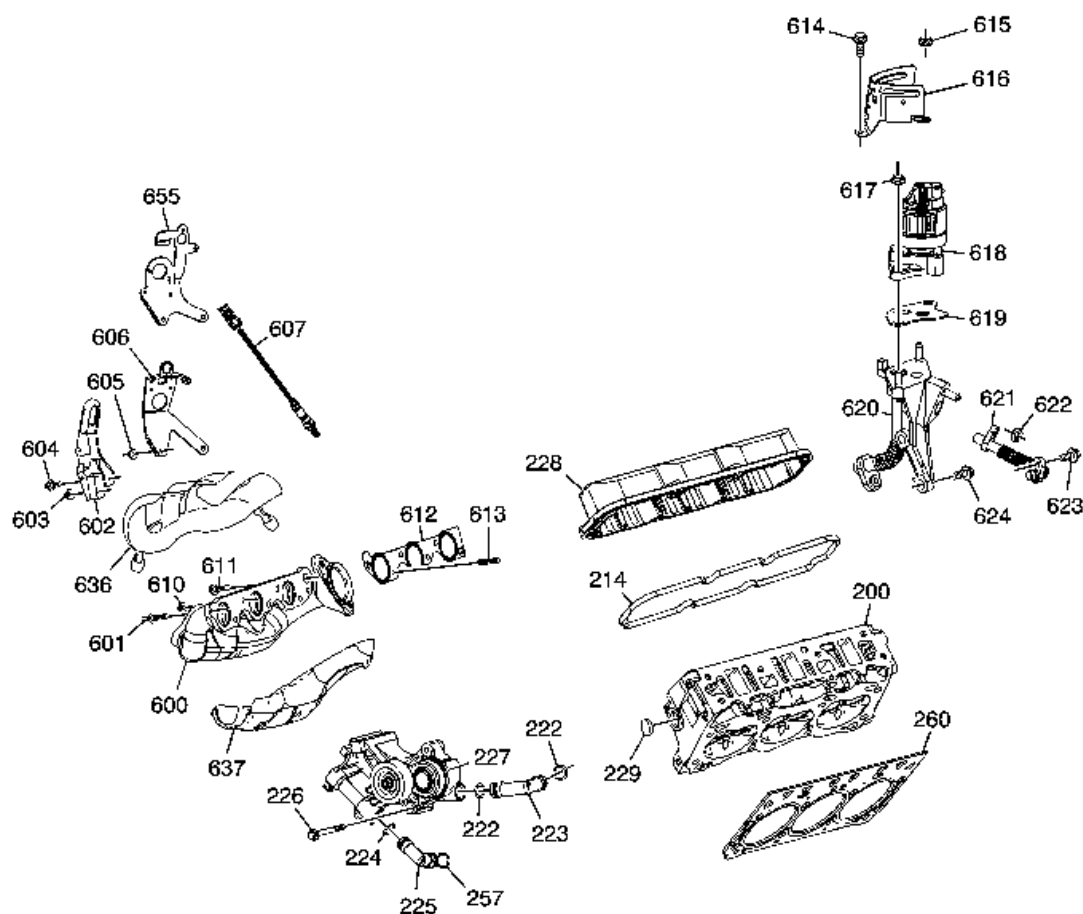


Fig. 5: Cylinder Head & Components - Right
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Cylinder Head
214	Valve Rocker Arm Cover Gasket
222	Thermostat Bypass Pipe Seal - Upper
222	Thermostat Bypass Pipe Seal - Upper
223	Thermostat Bypass Pipe - Upper
224	Thermostat Bypass Pipe Seal - Lower - Small
225	Thermostat Bypass Pipe - Lower
226	Drive Belt Tensioner Bolt
227	Drive Belt Tensioner
228	Valve Rocker Arm Cover - RH
229	Cylinder Head Expansion Plug

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257	Thermostat Bypass Pipe Seal - Lower - Large
260	Cylinder Head Gasket - RH
600	Exhaust Manifold - Right
601	Exhaust Manifold Stud
602	Engine Lift Bracket
603	Engine Lift Bracket Nut
604	Engine Lift Bracket Bolt
605	Engine Sight Shield Bracket - Nut
606	Engine Sight Shield Bracket - L36
607	Heated Oxygen Sensor
610	Exhaust Manifold Nut
611	EGR Valve Adapter Pipe Bolt - to Exhaust Manifold
612	Exhaust Manifold Gasket - Right
613	Exhaust Manifold Stud - to Cylinder Head
614	Engine Wiring Harness Shield Bracket Bolt
615	Engine Wiring Harness Shield Bracket Nut
616	Engine Wiring Harness Shield Bracket
617	EGR Valve Nut
618	EGR Valve
619	EGR Valve Gasket
620	EGR Valve Adapter
621	EGR Valve Outlet Pipe
622	EGR Valve Outlet Pipe Nut
623	EGR Valve Outlet Pipe Bolt
624	EGR Valve Adapter Pipe Bolt - to Cylinder Head
636	Exhaust Manifold Heat Shield - Right - Upper
637	Exhaust Manifold Heat Shield - Right - Lower
655	Engine Sight Shield Bracket - L67

ENGINE IDENTIFICATION

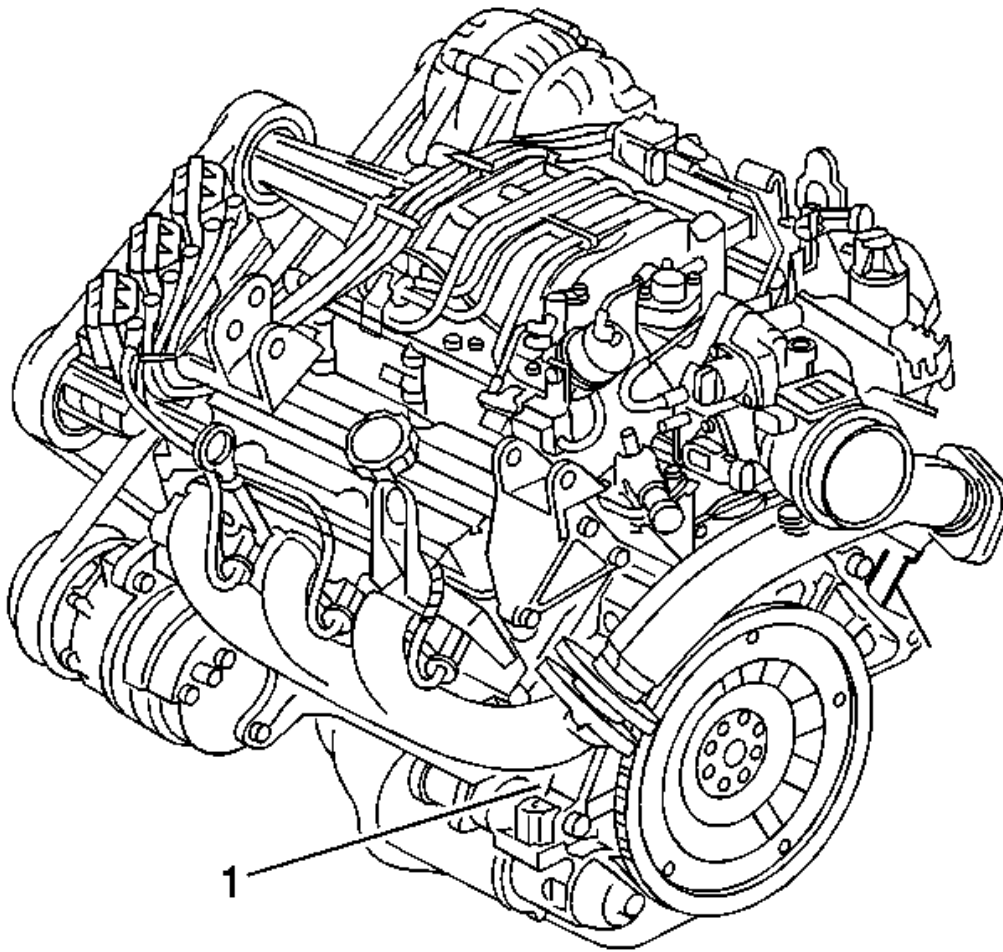


Fig. 6: Locating Primary Vehicle Identification Number (VIN) Derivative
Courtesy of GENERAL MOTORS CORP.

The primary Vehicle Identification Number - VIN derivative for the 3800 - L36 and 3800 - L67 is stamped or laser etched on the left side of the engine block above the starter motor (1).

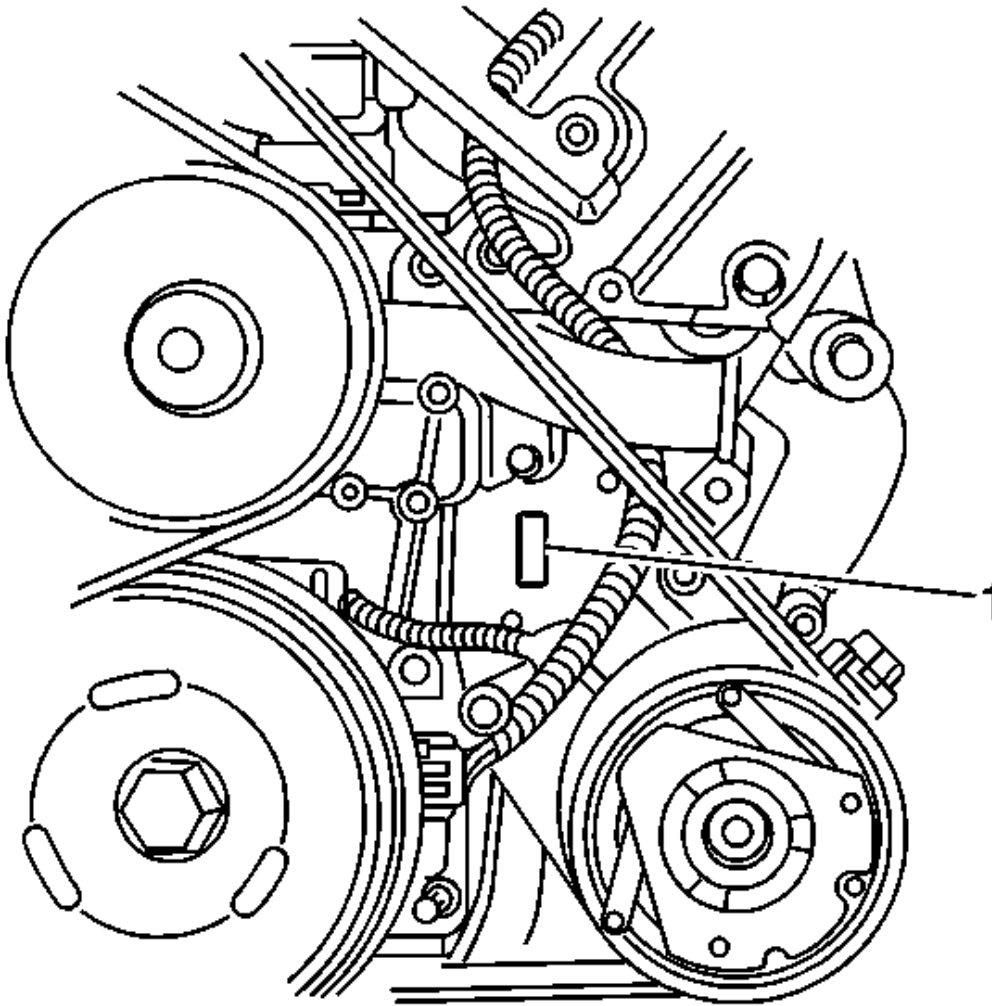


Fig. 7: Locating Secondary Vehicle Identification Number (VIN) Derivative
Courtesy of GENERAL MOTORS CORP.

The secondary Vehicle Identification Number - VIN, derivative for the 3800 - L36 and 3800 - L67 is stamped or laser etched below the water pump on the engine block (1). The Vehicle Identification Number - 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 digit are the last six of the Vehicle Identification Number - VIN.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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
- Drive Belt Excessive Wear Diagnosis
- 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 Replacement</u> .
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .

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misfire condition.	
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position	Replace the valve rocker arms as required.
Worn or bent pushrods	Replace the pushrods.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to <u>Diagnostic Starting Point - Engine Cooling</u> - Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES**Base Engine Misfire with Abnormal Internal Lower Engine Noises**

Cause	Correction
Abnormalities, severe cracking, bumps or missing	Replace the drive belt. Refer to <u>Drive Belt</u>

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areas, in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	<u>Replacement.</u>
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement.</u>
Worn Piston Rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test.</u> • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn Crankshaft Thrust Bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE**Base Engine Misfire with Abnormal Valve Train Noise**

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Worn or bent pushrods	Replace the pushrods.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

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Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to <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	1. Drain the oil. 2. Install the correct viscosity oil.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
High valve lifter leak down rate	Replace the lifters as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

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

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	• 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>Knock Sensor (KS) System Description</u> in Engine Controls.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen • Repair or replace as required.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required:

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	• The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD**Engine Noise Under Load**

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the Knock Sensor System. Refer to <u>Knock Sensor (KS) System Description</u> in Engine Controls.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel, automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals

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- The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE**Engine Will Not Crank - Crankshaft Will Not Rotate**

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

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

Cause	Correction

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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.

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

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

COOLANT IN ENGINE OIL

Coolant in Engine Oil

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

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

ENGINE COMPRESSION TEST

Tools Required

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

Compression Test

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

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge.
2. Turn the engine OFF.

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**.

3. Disable the ignition.
4. Disable the fuel systems.
5. Remove the spark plugs from all the cylinders.
6. Remove the air duct from the throttle body.
7. Block the throttle plate in the open position.

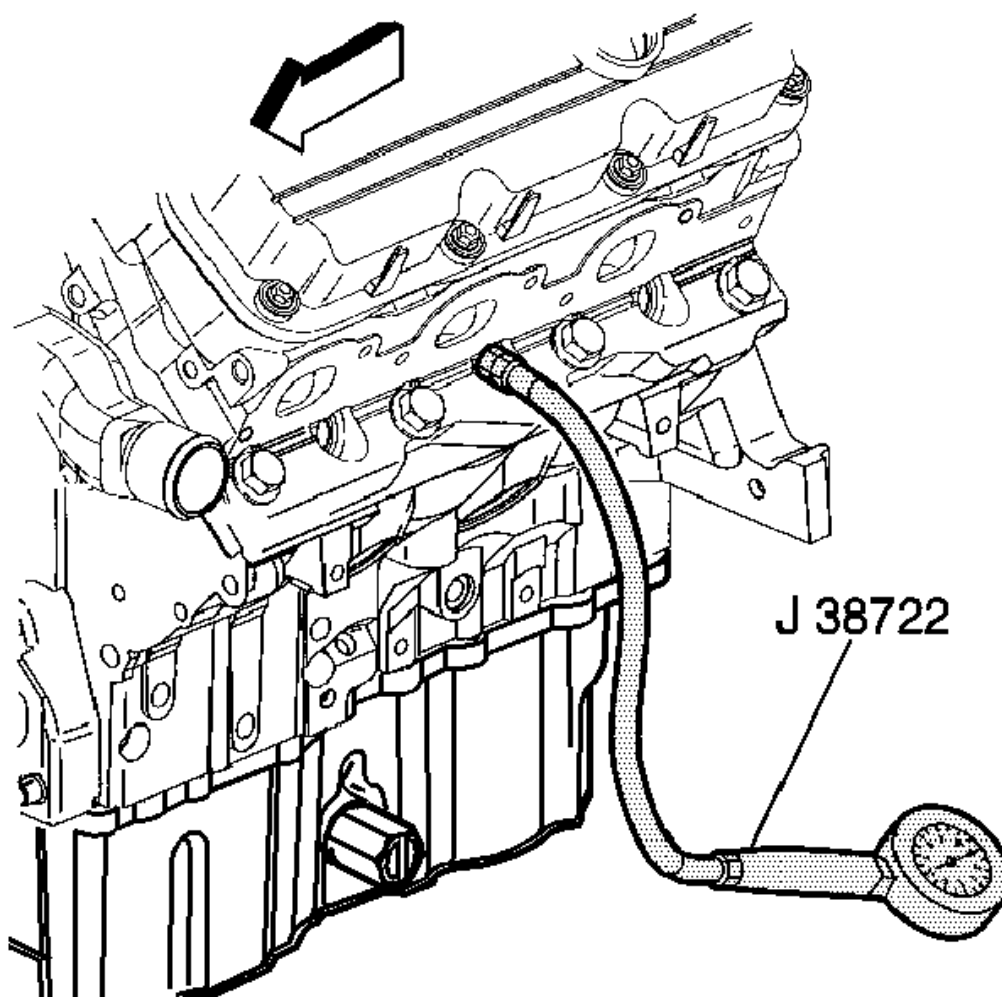


Fig. 8: Positioning Compression Tester
Courtesy of GENERAL MOTORS CORP.

8. Measure the engine compression, using the following procedure:
 1. Firmly install **J 38722** to the spark plug hole. See **Special Tools and Equipment**.
 2. Have an assistant crank the engine through at least four compression strokes in the testing cylinder.
 3. Check and record the readings on **J 38722** at each stroke. See **Special Tools and Equipment**.
 4. Disconnect **J 38722** . See **Special Tools and Equipment**.
 5. Repeat the compression test for each cylinder.
9. 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).
10. The following are 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, or 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, or 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.
 11. Remove the block from the throttle plate.
 12. Install the air duct to the throttle body.
 13. Install the spark plugs.
 14. Install the Powertrain Control Module (PCM) fuse.
 15. Install the ignition fuse to the I/P fuse block.

CYLINDER LEAKAGE TEST

Tools Required

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

Leakage Test

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

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

1. Remove the battery ground - negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
3. Install the **J 35667-A** . See **Special Tools and Equipment**.

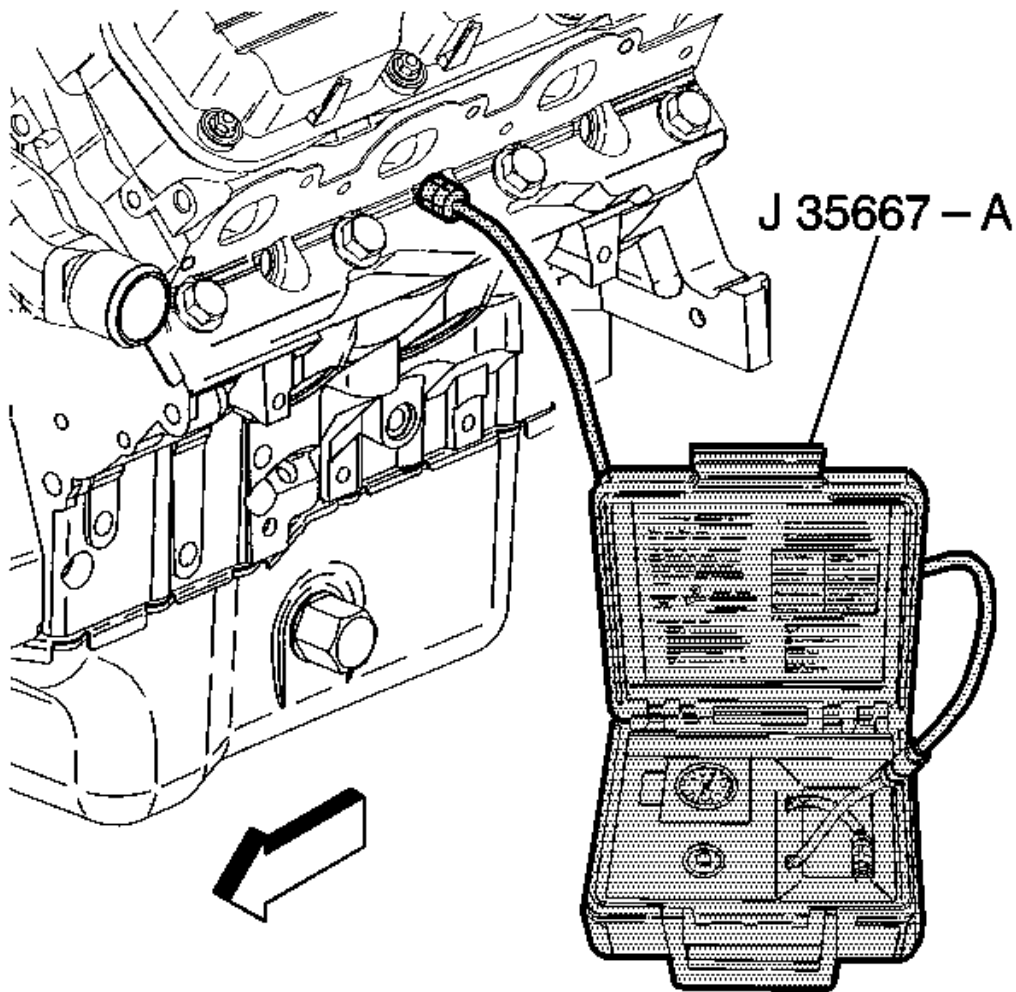


Fig. 9: Positioning Cylinder Head Leakdown Tester
Courtesy of GENERAL MOTORS CORP.

4. Measure each cylinder on the compression stroke, with both valves closed.

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

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

IMPORTANT:

- Normal cylinder leakage is from 12-18 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 four primary areas, 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 the suspect cylinder head and inspect. 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:
 - Remove the piston from the suspect cylinder.
 - Inspect the piston and connecting rod assembly. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
 - Inspect the engine block. Refer to **Engine Block Cleaning and Inspection**.
10. If bubbles are found in the radiator, perform the following procedure:
 - Remove both cylinder heads and inspect. Refer to **Cylinder Head Cleaning and Inspection**.
 - Inspect the engine block. Refer to **Engine Block Cleaning and Inspection**.
11. Remove the **J 35667-A**. See **Special Tools and Equipment**.
12. Install the spark plugs. Refer to **Spark Plug Replacement** in Engine Electrical.
13. Install the battery ground - negative cable.

OIL CONSUMPTION DIAGNOSIS

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

- An improperly read oil level indicator - dipstick
 - Inspect the oil level while the vehicle is parked on a level surface.
 - Allow adequate drain-down time.
- Improper oil viscosity
 - Use the recommended SAE viscosity for prevailing temperatures.
 - Refer to **Explanation of Scheduled Services** for the proper oil viscosity specifications.
- 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 can cause low or no oil pressure:

- Low oil level - fill to the full mark on the oil level indicator.
- Slow idle speed
- Incorrect or malfunctioning oil pressure switch - replace the oil pressure switch.
- Incorrect or malfunctioning oil pressure gage - replace the oil pressure gage.
- Improper oil viscosity or diluted oil
 - Install oil of proper viscosity for expected temperature.
 - Install new oil if it is diluted.
- The oil pump is worn or dirty - clean or replace the oil pump.
- The oil filter is plugged - replace the oil filter.
- The oil pickup screen is loose or plugged - replace the oil pickup screen.
- A hole in the oil pickup tube - replace the oil pickup tube.
- Excessive bearing clearance - replace the bearings.
- Cracked, porous, or plugged oil galleries - repair or replace the engine block.
- The gallery plugs are missing or improperly installed - install or repair as necessary.
- The pressure regulator valve is stuck.
 - Check the pressure regulator valve for sticking in the bore.
 - Check the bore for scoring and burrs.
- The camshaft is worn or poorly machined - replace the camshaft.
- Worn valve guides - repair as needed.

Oil Pressure Testing

Tools Required

J 25087-C Oil Pressure Tester

Oil Pressure Testing

If the vehicle has low oil pressure perform the following tests.

1. Check the oil level.
2. Raise the vehicle and remove the oil filter.
3. Assemble the plunger valve in the large hole of J 25087-C base and the hose in the small hole of J 25087-C base. Connect the gage to the end of the hose.
4. Insert the flat side of the rubber plug in the bypass valve without depressing the bypass valve itself.
5. Install J 25087-C on the filter mounting pad.

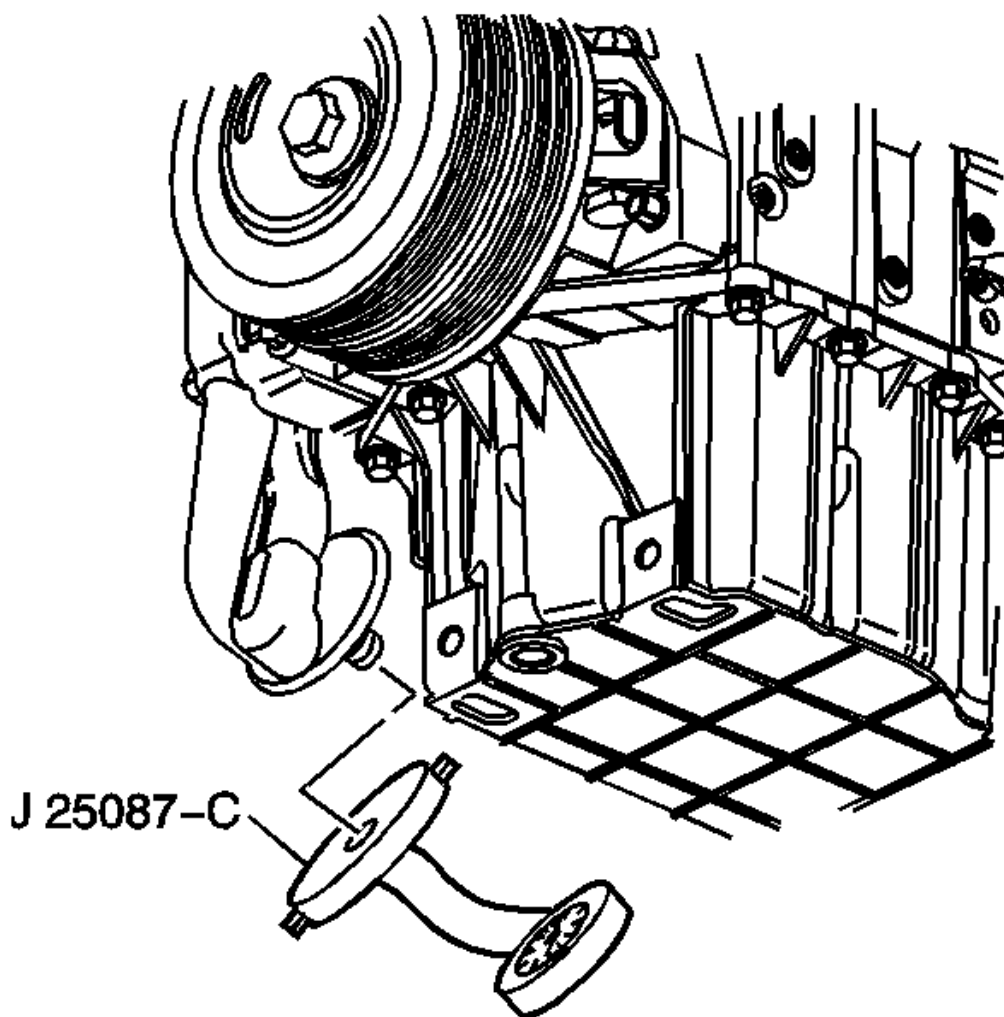


Fig. 10: Positioning Oil Pressure Tester
Courtesy of GENERAL MOTORS CORP.

6. Start the engine and check the overall oil pressure, the oil pressure switch, and for noisy lifters. The engine should be at operating temperature before checking the oil pressure. The oil pressure should be approximately 414 kPa (60 psi) at 1850 RPM using 10W30 engine oil.
7. If adequate oil pressure is indicated, check the oil pressure switch.
8. If a low reading is indicated, press the valve on the tester base 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 would indicate a faulty pump.

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

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

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4	speeds. - Park the vehicle on a level surface, over a large sheet of paper or other clean surface. - Wait 15 minutes. - Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	- Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. - Check for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6
6	- Completely clean the entire engine and surrounding components. - Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. - Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. - Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	- Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. - Check for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 8
	Use J 28428-E High Intensity Black Light Kit in order to identify the type of fluid, and the approximate		

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8	location of the leak. See Special Tools and Equipment. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to Step 1	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Crankcase Ventilation System Inspection/Diagnosis

Concern	Action
External oil leak	Inspect for any of the following conditions:

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	• Plugged positive crankcase ventilation (PCV) valve • Damaged or incorrectly installed PCV valve or PCV valve O-ring • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Plugged PCV valve • Plugged or kinked PCV valve O-ring • Leaking damaged PCV valve or PCV valve O-ring
Stalling or slow idle speed	Inspect for any of the following conditions: • Plugged PCV valve • Leaking damaged PCV valve or PCV valve O-ring
High idle speed	Inspect for a leaking damaged PCV valve or PCV valve O-ring.
Sludge in the engine	Inspect for a plugged PCV valve.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.

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

Test Description

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

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

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

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

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

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

installed.

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

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 15	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 15	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 15	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
	NOTE: Refer to Fastener Notice in Cautions and Notices.		

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11	1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 15	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 13	Go to Step 14
13	Replace the bent pulley. Did you complete the repair?	Go to Step 15	Go to Step 14
14	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the repair?	Go to Step 15	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT SQUEAL DIAGNOSIS**Diagnostic Aids**

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

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

Test Description

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

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

3: The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify the squeal noise is the drive belt or an accessory drive component. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4: This test is to verify that an accessory drive component does not have a seized bearing. With the belt remove test the bearings in the accessory drive components for turning smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

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

6: This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly

and may be turning an accessory drive component in the wrong direction.

7: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misalign pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to Step 9	Go to Step 5
5	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis . Did you find and correct the condition?	Go to Step 9	Go to Step 6
6	Inspect for the correct drive belt length. Refer to Drive Belt Replacement . Did you find and correct the condition?	Go to Step 9	Go to Step 7
7	Inspect for misalignment of a pulley. - Did you find and correct the condition?	Go to Step 9	Go to Step 8
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 9	Go to Diagnostic Aids

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9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3
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DRIVE BELT WHINE DIAGNOSIS**Diagnostic Aids**

The drive belt will not cause the whine noise.

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

Test Description

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

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

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

Drive Belt Whine Diagnosis

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

Did you correct the condition?

System OK

DRIVE BELT RUMBLING DIAGNOSIS**Diagnostic Aids**

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

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

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

Test Description

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

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

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

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

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

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: - A low pitch tapping, knocking, or thumping noise heard at or just above idle. - Heard once per revolution of the drive belt or a pulley. - Rumbling may be caused from: - Pilling, the accumulation of rubber dust that forms small balls or strings in the drive belt pulley groove			

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	○ The separation of the drive belt ○ A damaged drive belt		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belt for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to Drive Belt Replacement . Did you complete the repair?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to Drive Belt Replacement . Did you complete the replacement?	Go to Step 8	-
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

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

Test Description

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

2: This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom such as the exhaust system, or the drivetrain.

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

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

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

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

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
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. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to Vibration Analysis - Engine 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 Drive Belt Replacement . Did you complete the replacement?	Go to Step 10	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 7	Go to Step 8
	NOTE: Refer to Fastener Notice in Cautions and Notices.		
	1. Tighten any loose fasteners. Refer to Fastener		

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7	<u>Tightening Specifications.</u>		
	2. Replace improper or missing fasteners.		
	Did you complete the repair?	Go to Step 10	-
8	Inspect for a bent water pump shaft. Refer to <u>Water Pump Replacement (L36)</u> or <u>Water Pump Replacement (LD8)</u> in Engine Cooling.		
	Did you find and correct the condition?	Go to Step 10	Go to Step 9
9	Inspect for bent or cracked brackets.		
	Did you find and correct the condition?	Go to Step 10	Go to Diagnostic Aids
10	Operate the system in order to verify the repair.		
	Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF DIAGNOSIS**Diagnostic Aids**

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

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

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

Test Description

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

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

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misalign pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misalign pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

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

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

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

Drive Belt Falls Off Diagnosis

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Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice 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 Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
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 Drive Belt Replacement . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	NOTE: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to Fastener Tightening Specifications . Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

2004 Pontiac Bonneville SLE

2004 ENGINE Engine Mechanical - 3.8L - Bonneville

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

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

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

Test Description

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

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

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

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 Belt Dressing Notice 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 Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Inspect the drive belt(s) for the proper installation. Refer to Drive Belt Replacement . 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 Drive Belt Replacement . 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% 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****Fuel Injector Sight Shield Replacement****Removal Procedure**

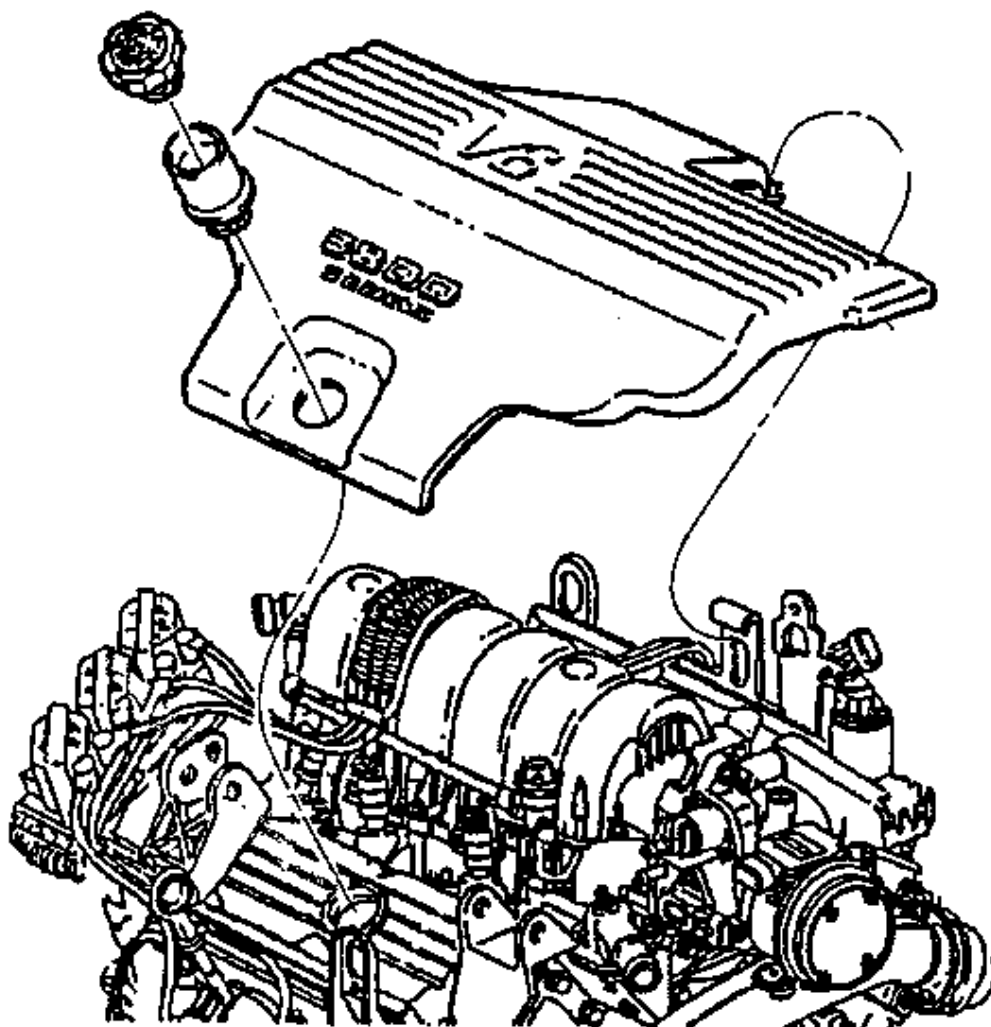


Fig. 11: Identifying Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove oil filler neck.
2. Lift the front of the shield up and pull towards the front of the vehicle.
3. Remove fuel injector sight shield.

Installation Procedure

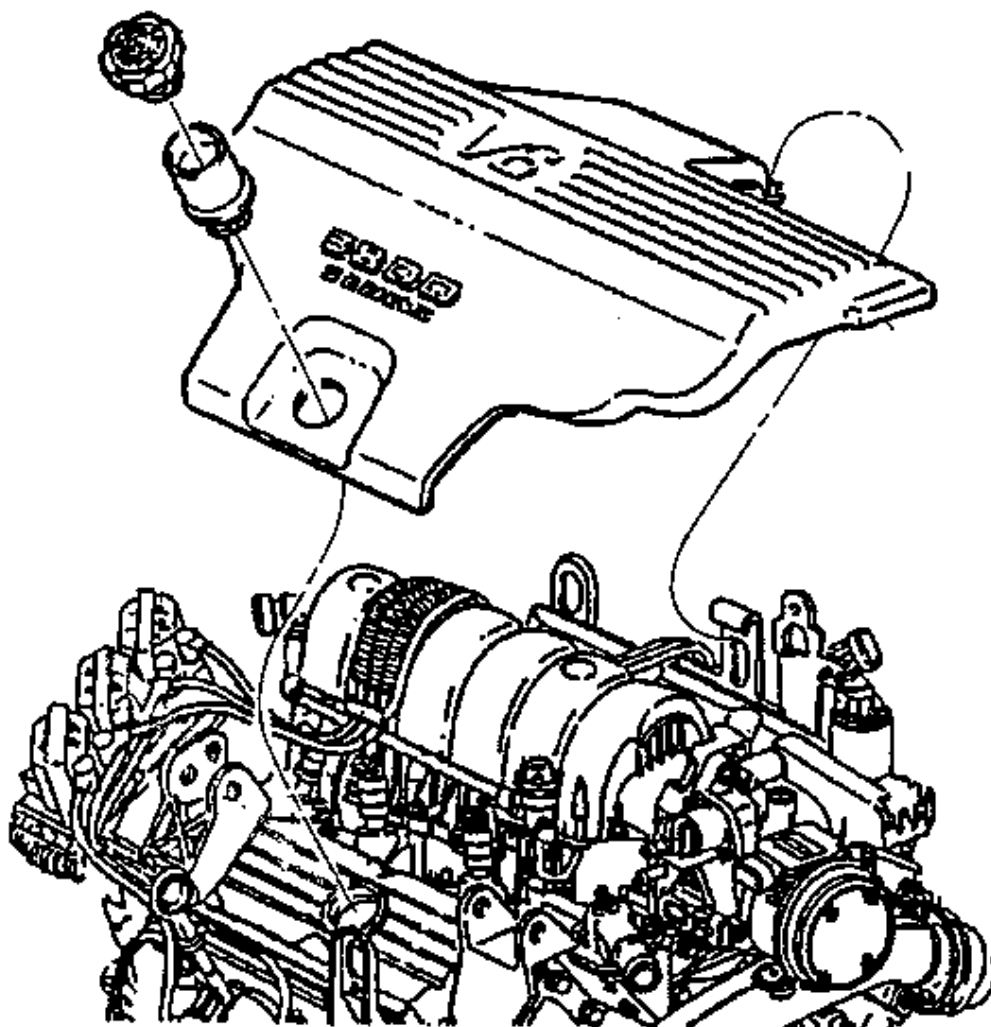


Fig. 12: Identifying Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Align the extension on the rear edge of the shield to the bracket on the rear of the engine.
2. Push the shield rearward and push down to align it with the oil filler hole.
3. Install oil filler neck.

Drive Belt Replacement

Removal Procedure

The drive belt drives all engine mounted accessories. All driven accessories are rigidly mounted to the engine. Drive belt tension is maintained by a spring loaded belt tensioner. A belt squeak when the engine is started or stopped is normal and has no effect on belt durability. The drive belt tensioner can control belt tension over a broad range of belt lengths.

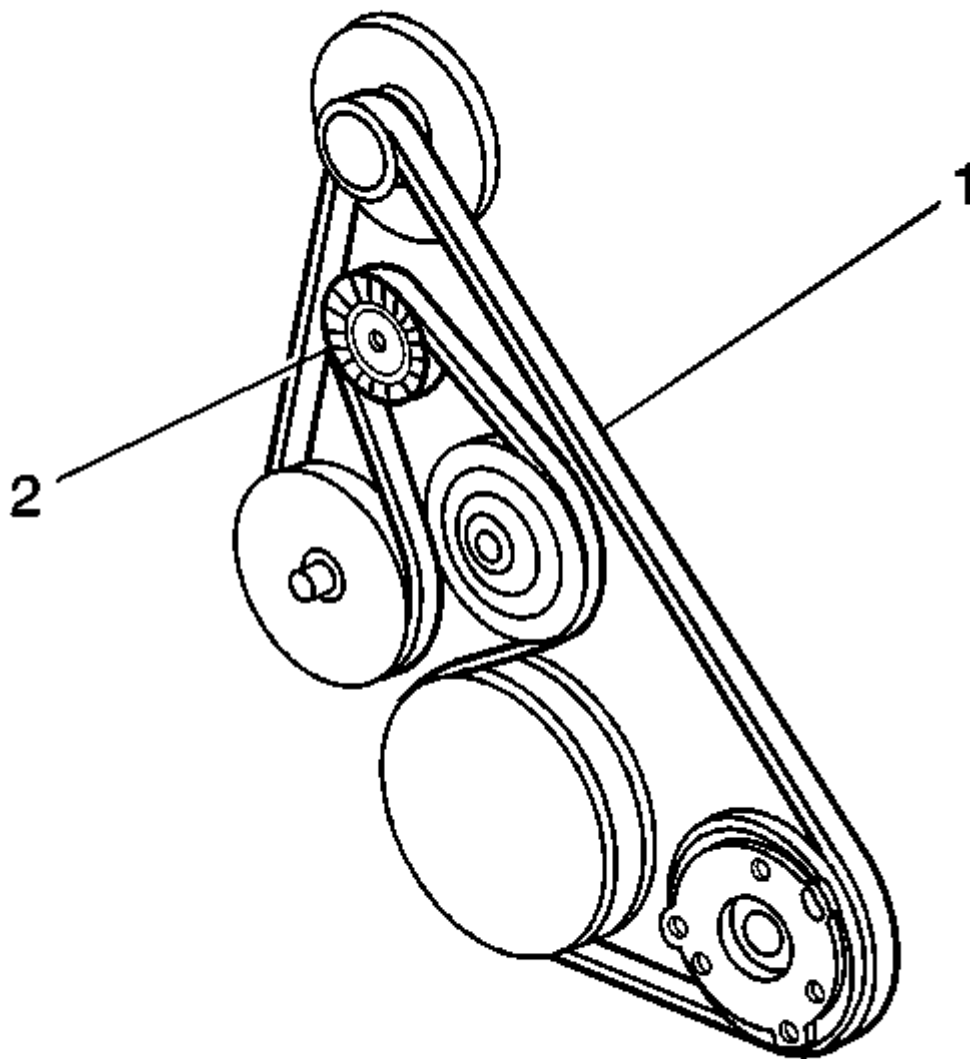


Fig. 13: Accessory Drive Belt Routing & Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Rotate the tensioner (2) counterclockwise to remove the drive belt (1).
2. Remove the accessory drive belt (1) from the engine.

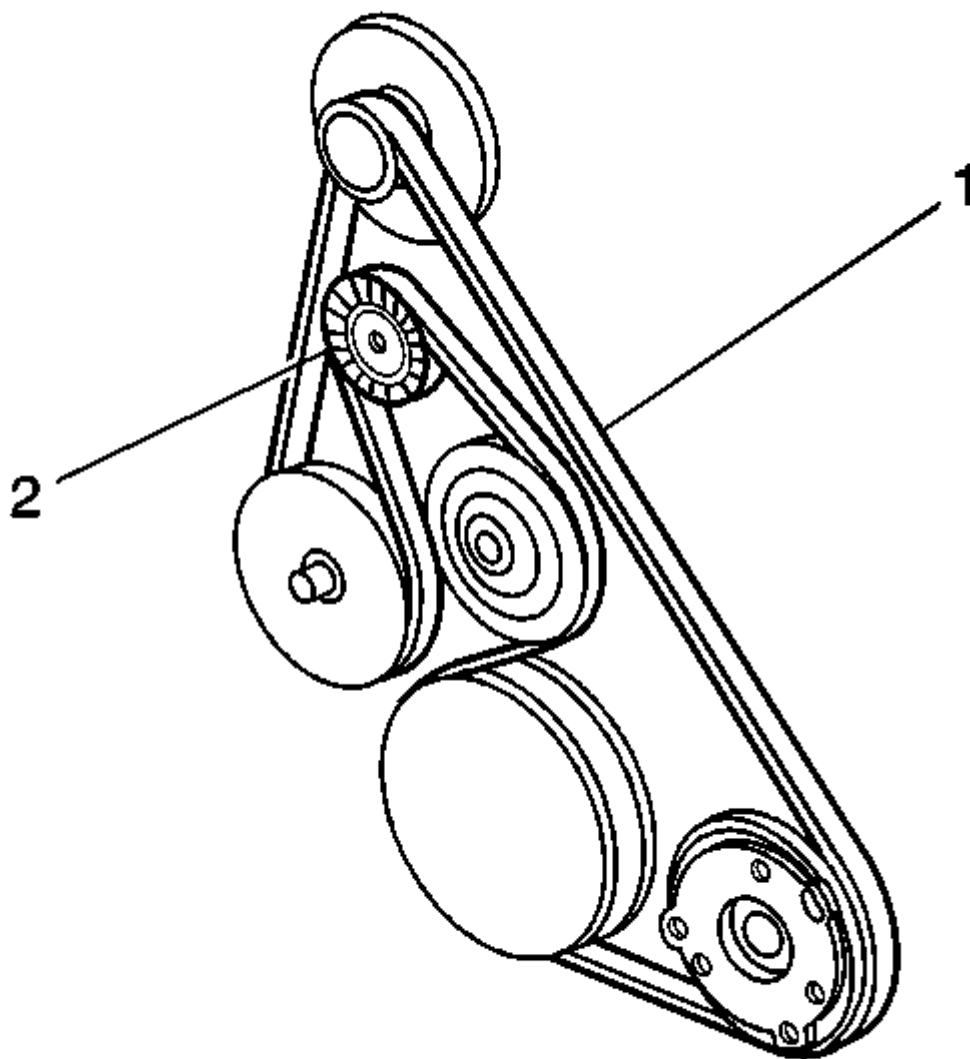
Installation Procedure

Fig. 14: Accessory Drive Belt Routing & Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the accessory drive belt (1) to the pulleys.
2. Rotate the tensioner (2) counterclockwise to install the drive belt (1).

Drive Belt Tensioner Replacement

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.
2. Remove the generator. Refer to **Generator Replacement (L36)** in Engine Electrical.

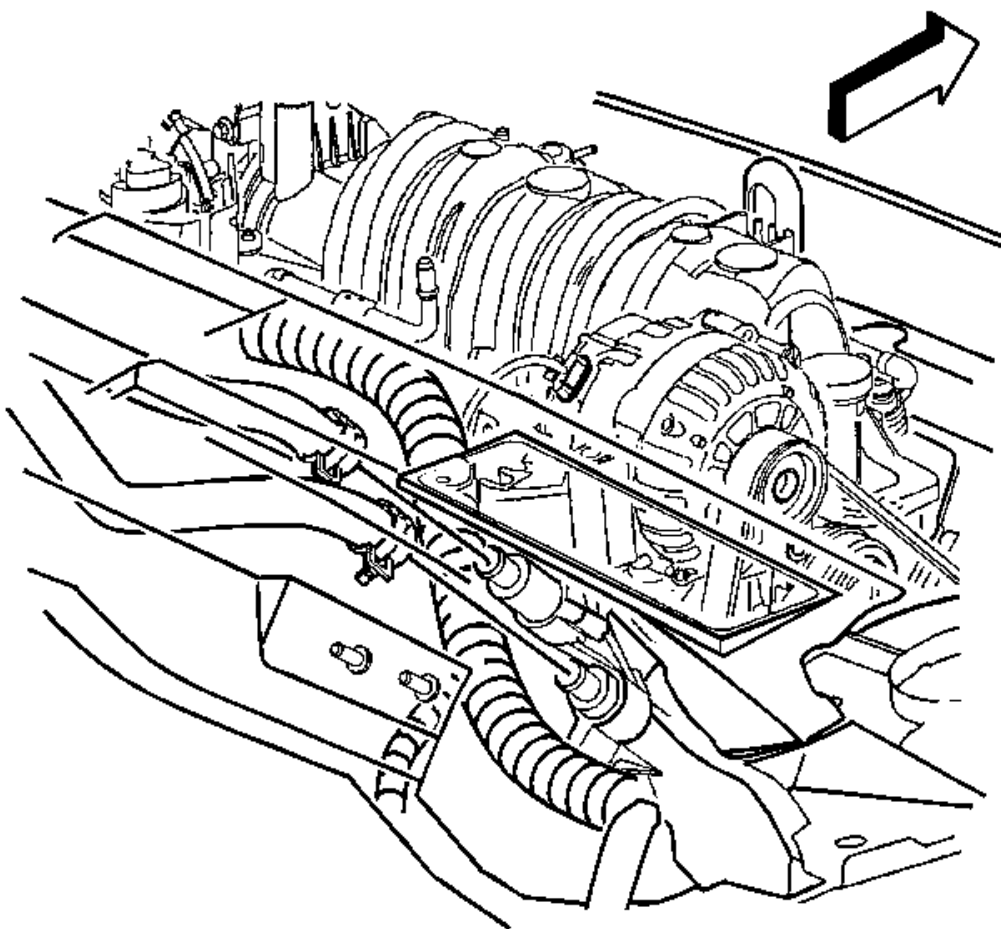


Fig. 15: View Of Heater Hoses At Engine Heater Pipe Adapters
Courtesy of GENERAL MOTORS CORP.

3. Remove the heater hoses from the drive belt tensioner fittings.

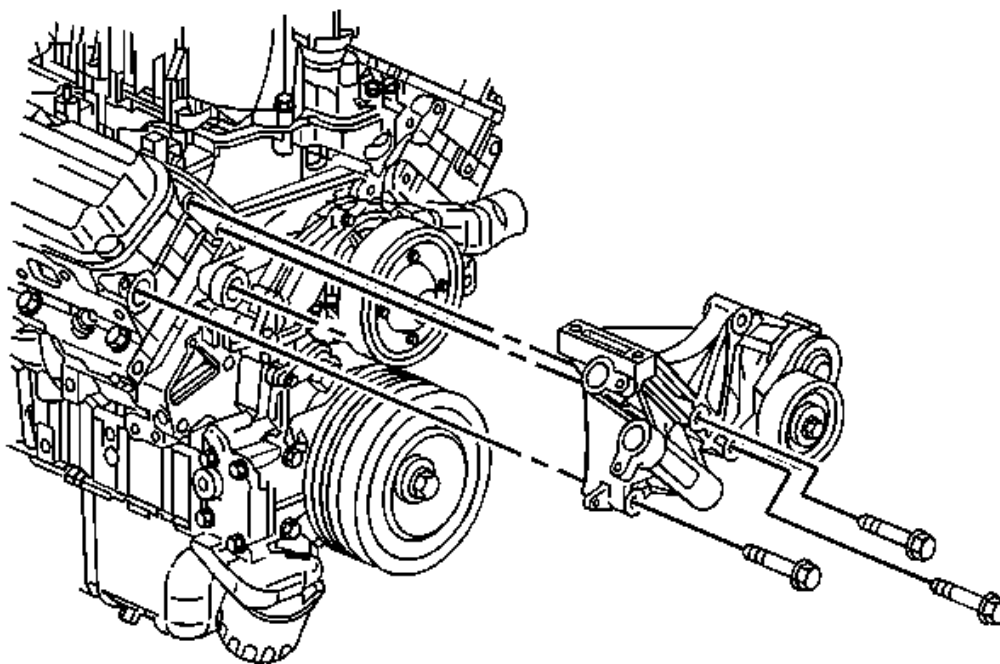


Fig. 16: Locating Drive Belt Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the drive belt tensioner bolts.
5. Remove the drive belt tensioner from the engine.

Installation Procedure

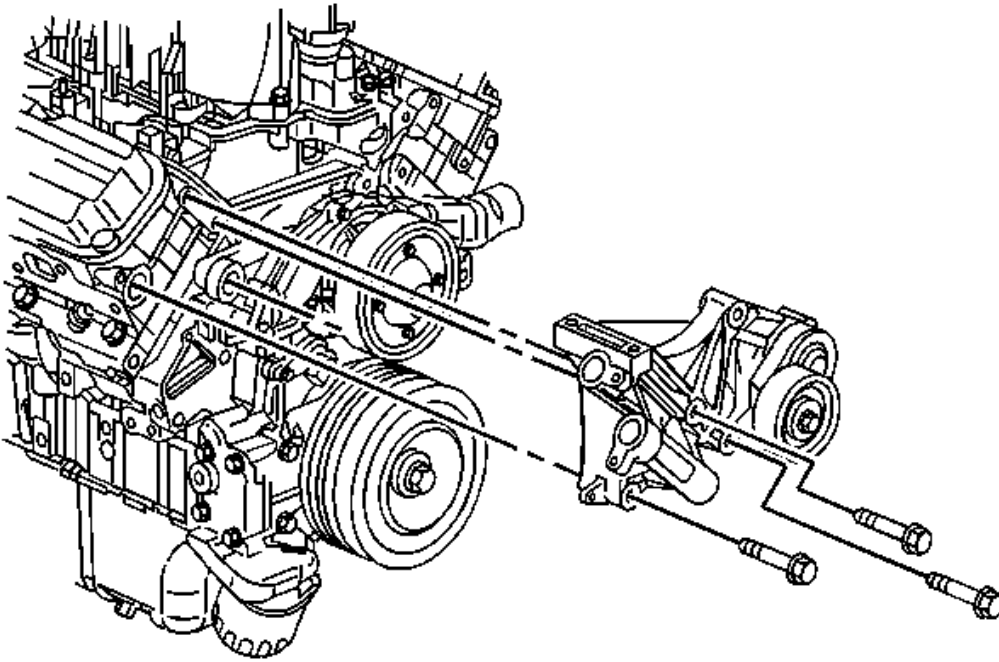


Fig. 17: Locating Drive Belt Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner to the engine.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolts.

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

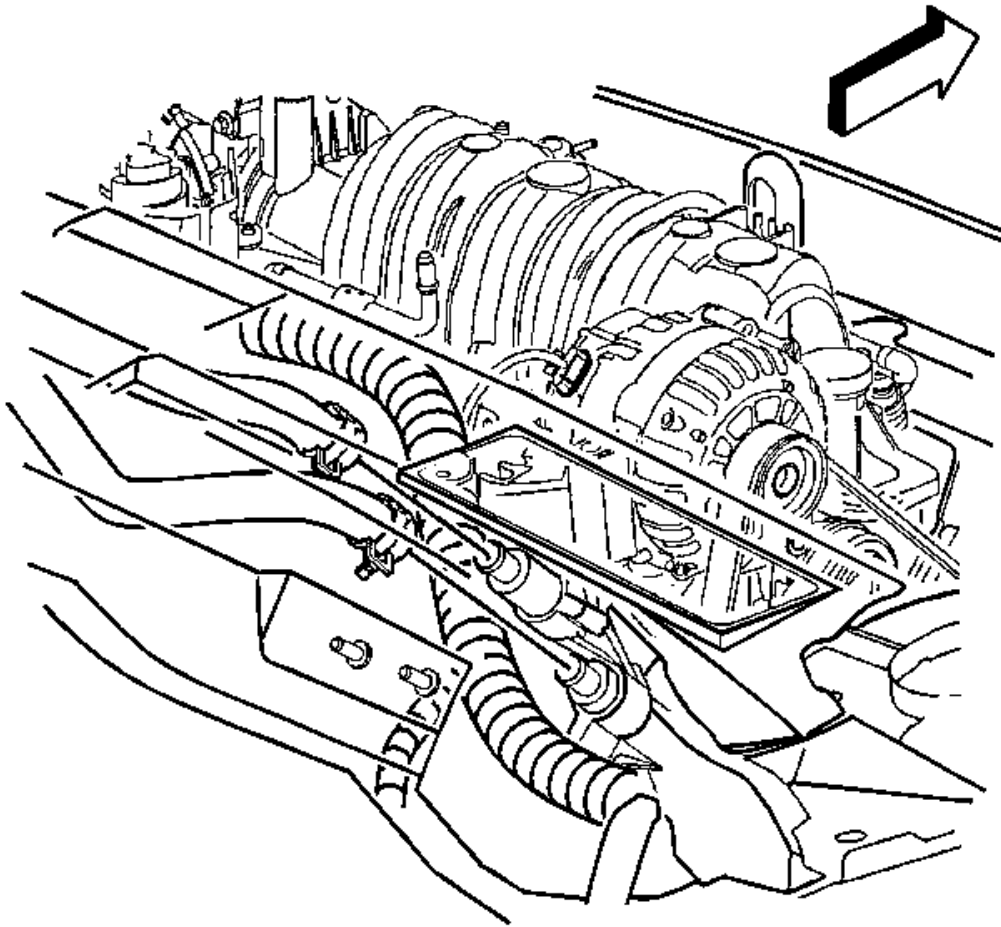


Fig. 18: View Of Heater Hoses At Engine Heater Pipe Adapters
Courtesy of GENERAL MOTORS CORP.

3. Connect the heater hoses to the drive belt tensioner fittings.
4. Install the generator. Refer to **Generator Replacement (L36)** in Engine Electrical.
5. Fill the cooling system. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.

Drive Belt Idler Pulley Replacement (Upper)

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.

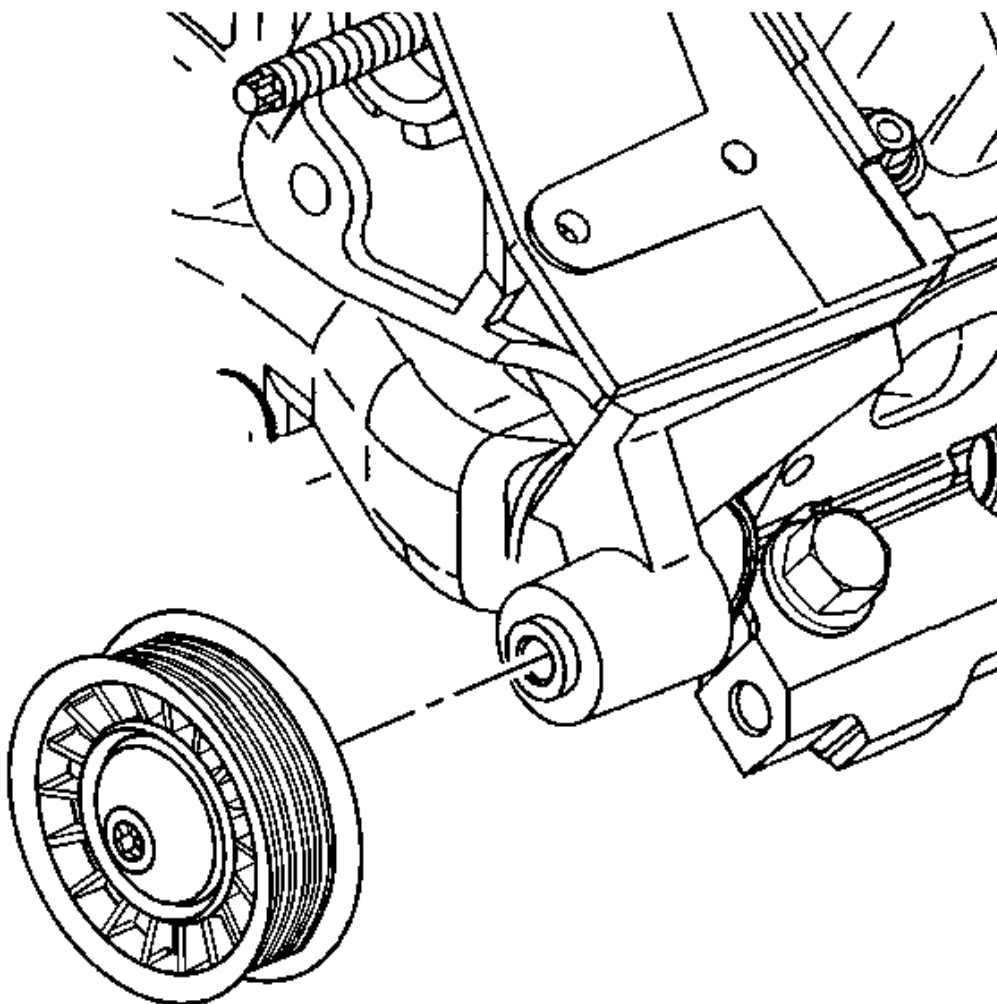


Fig. 19: Identifying Drive Belt Idler Pulley - Upper
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley.

Installation Procedure

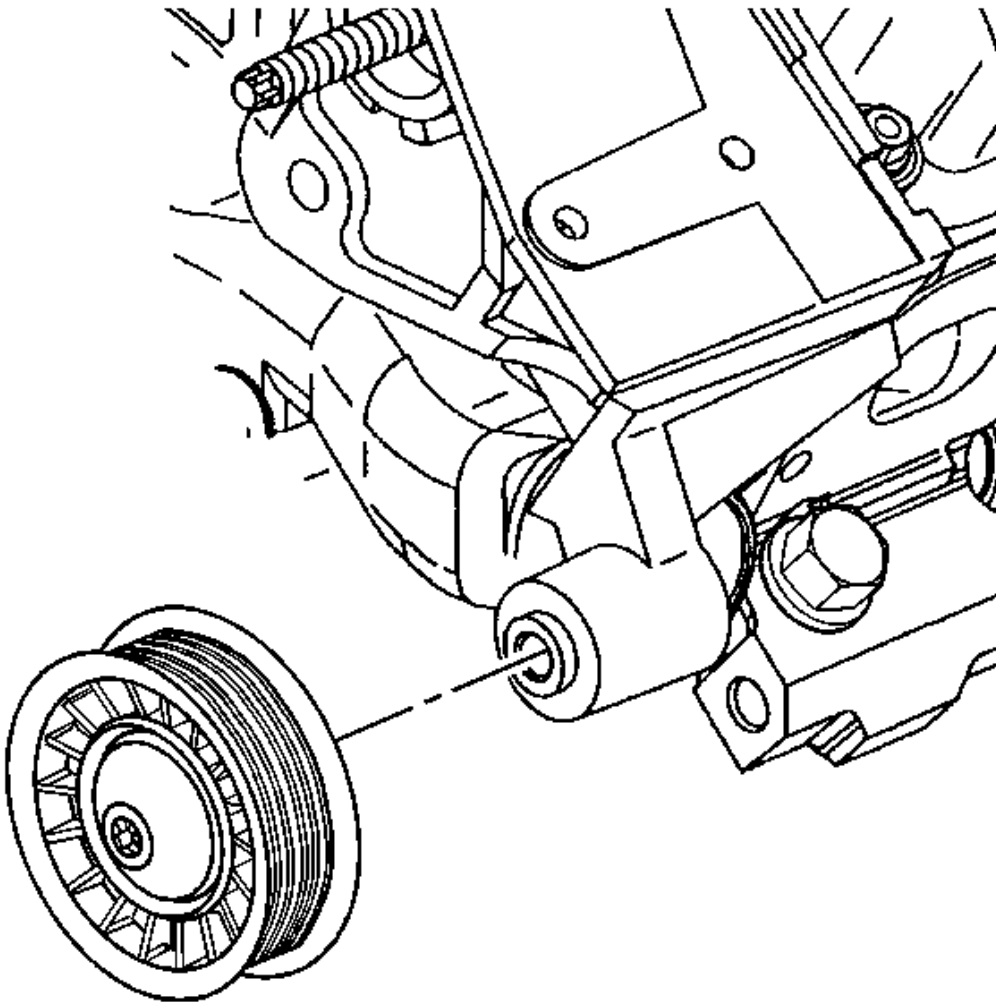


Fig. 20: Identifying Drive Belt Idler Pulley - Upper
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt idler pulley bolt.

Tighten: Tighten the drive belt idler pulley bolt to 50 N.m (37 lb ft).

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

Drive Belt Idler Pulley Replacement (Lower)**Removal Procedure**

1. Remove the supercharger drive belt. Refer to **Drive Belt Replacement**.

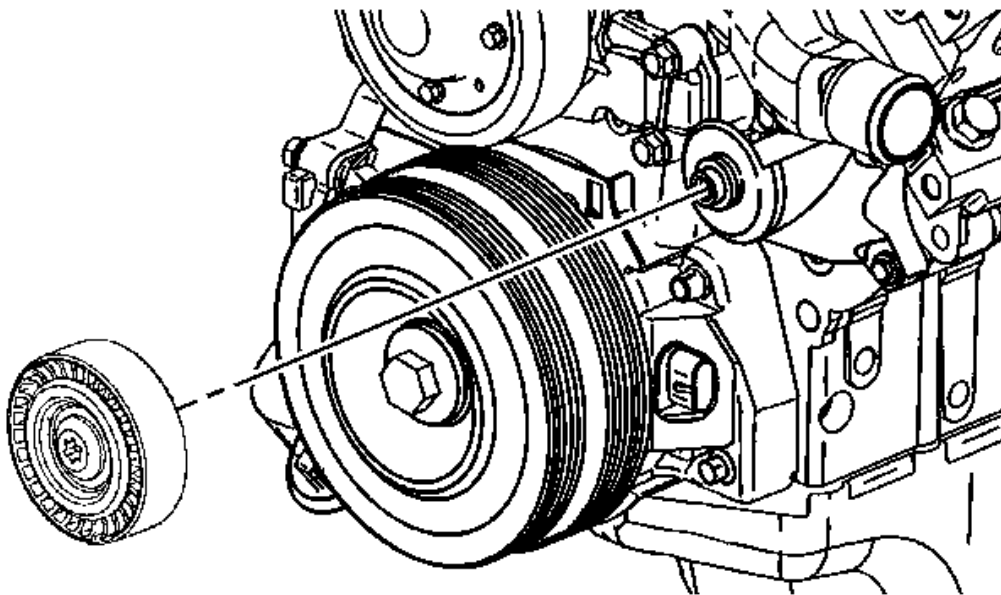


Fig. 21: Identifying Drive Belt Idler Pulley - Lower
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley.

Installation Procedure

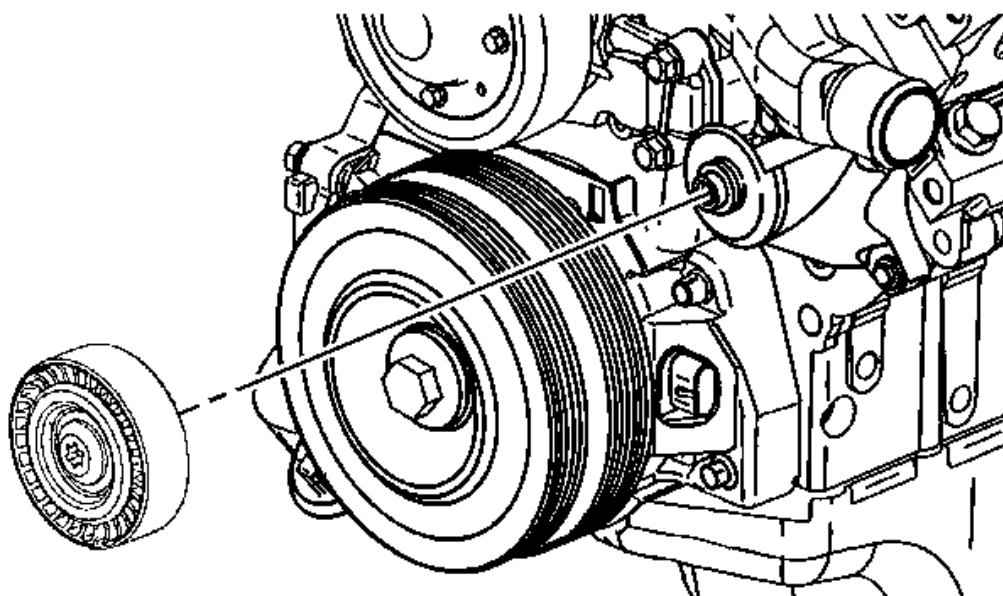


Fig. 22: Identifying Drive Belt Idler Pulley - Lower
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt idler pulley bolt.

Tighten: Tighten the drive belt idler pulley bolt to 50 N.m (37 lb ft).

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

Engine Mount Inspection

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

1. Install the engine support fixture. Refer to Engine Support Fixture.
2. Use the support fixture in order to raise the engine and create a slight tension in the engine mount.
3. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber surface is covered with heat check cracks.

- The rubber is separated from the metal plate of the engine mount.
 - The rubber is split through the center of the engine mount.
4. Refer to the following procedures when replacing the engine mounts or engine mount brackets:
 - **Engine Mount Replacement - Right**
 - **Engine Mount Bracket Replacement - Right**
 5. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket. Refer to **Fastener Tightening Specifications**.
 6. For information on the transaxle mounts, refer to **Transmission Mount Inspection** in Automatic Transaxle - 4T65-E.

Engine Support Fixture**Tools Required**

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools and Equipment**.
- J-28467-501 Engine Support Fixture Adapters

Installation Procedure

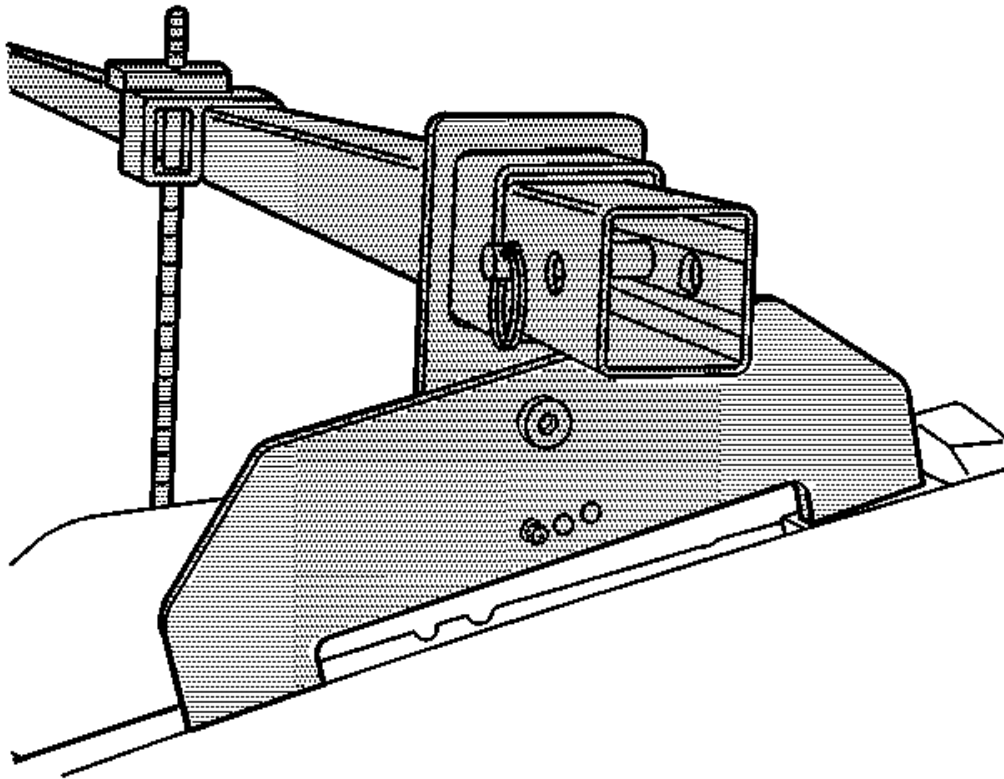


Fig. 23: Positioning Rear Engine Support Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 28467-B** and see **Special Tools and Equipment**. J-28467-501 to the vehicle.
2. Install the radiator shelf tube J 28467-2A on top of the strut tower tube J 28467-3 over the rear engine lift bracket.

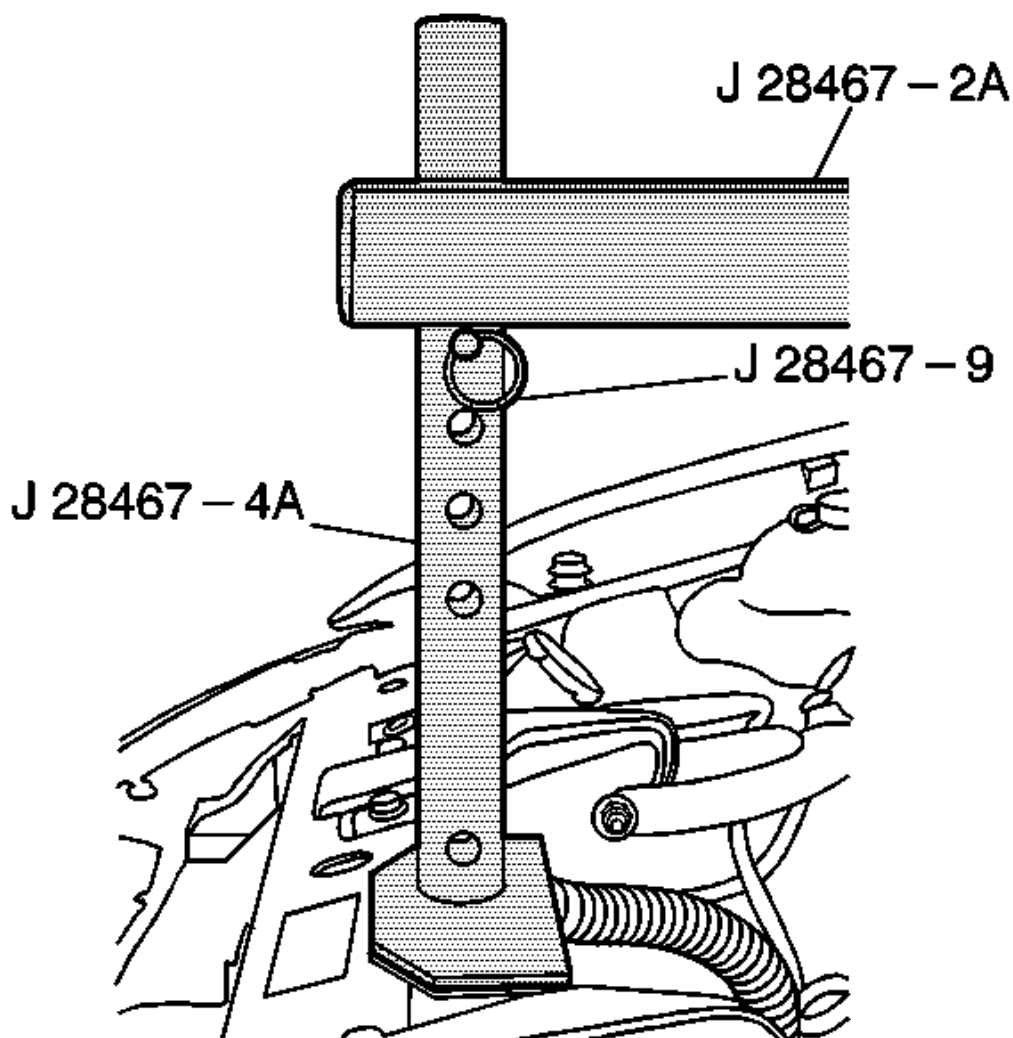


Fig. 24: Positioning Front Engine Support Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the round tube of the front support assembly J 28467-4A through the large hole in the radiator shelf tube, J 28467-2A. The hole used in the radiator shelf tube J 28467-2A depends on the vehicle application.
4. Place the rubber padded foot of the front support assembly J 28467-4A on the upper tie bar.
5. Install the 7/16 in x 2.0 in 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.

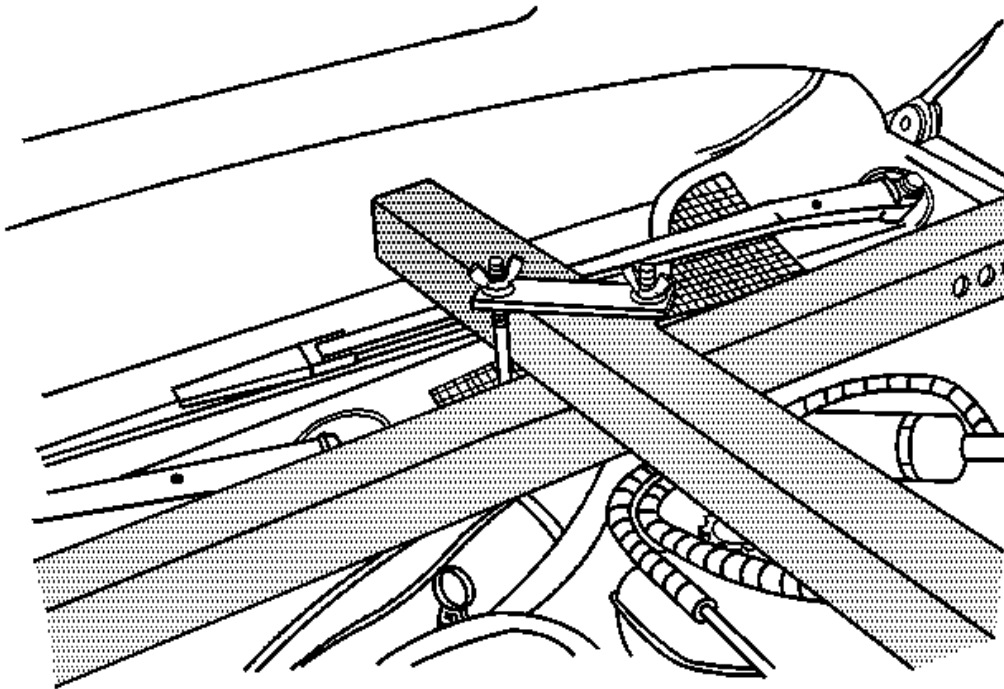


Fig. 25: Positioning Cross Bracket Support Assembly
Courtesy of GENERAL MOTORS CORP.

6. Install the cross bracket assembly J 28467-1A.
7. Hand tighten the cross bracket assembly J 28467-1A wing nuts.

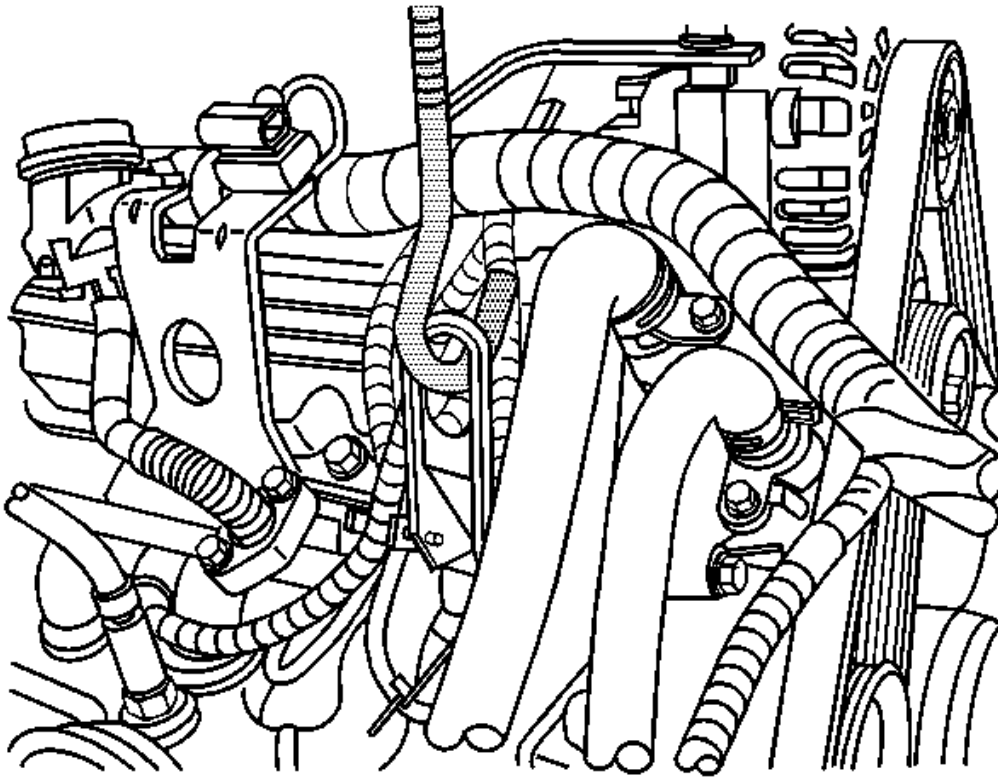


Fig. 26: Positioning Lift Hook Through Front Engine Lift Hook Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the lift hook J 28467-7A through the front engine lift hook bracket. Ensure the hook does not damage the surrounding components.

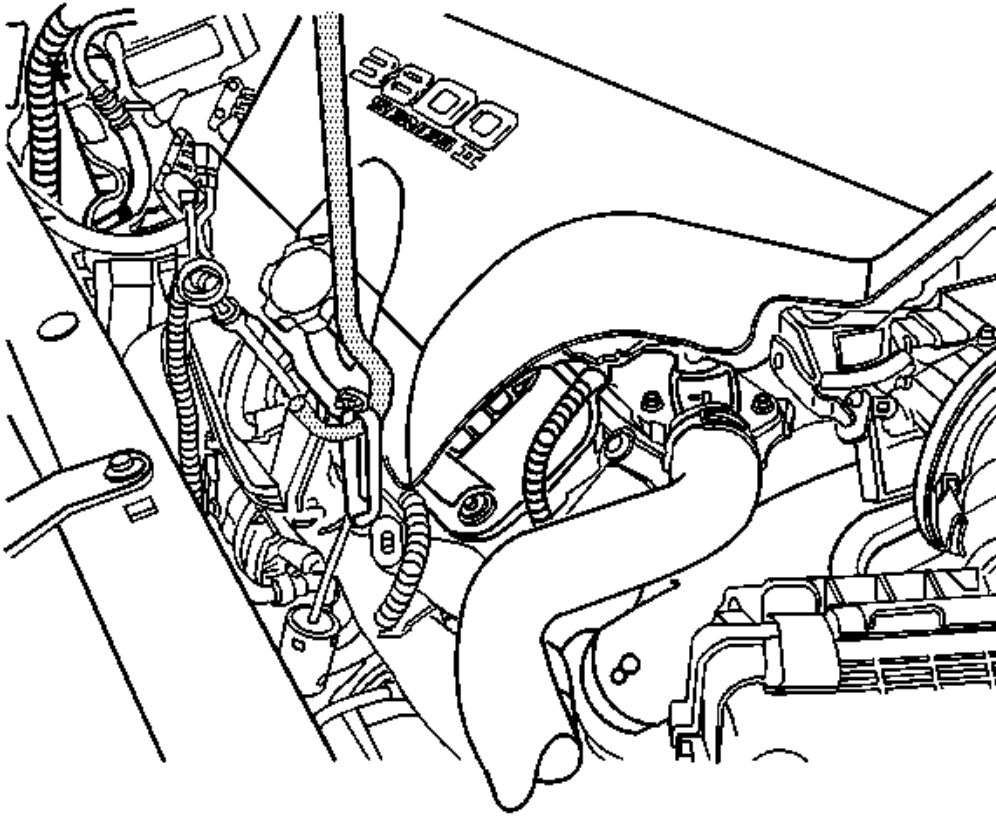


Fig. 27: Positioning Lift Hook Through Rear Engine Lift Hook Bracket
Courtesy of GENERAL MOTORS CORP.

9. Install the lift hook J 28467-7A through the rear engine lift hook bracket. Ensure the hook does not damage the surrounding components.
10. Hand tighten the lift hook wing nuts J 28467-34 securely to remove all slack from the engine support fixture assembly.

Engine Mount Replacement - Right

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Support the engine assembly with a suitable jack.

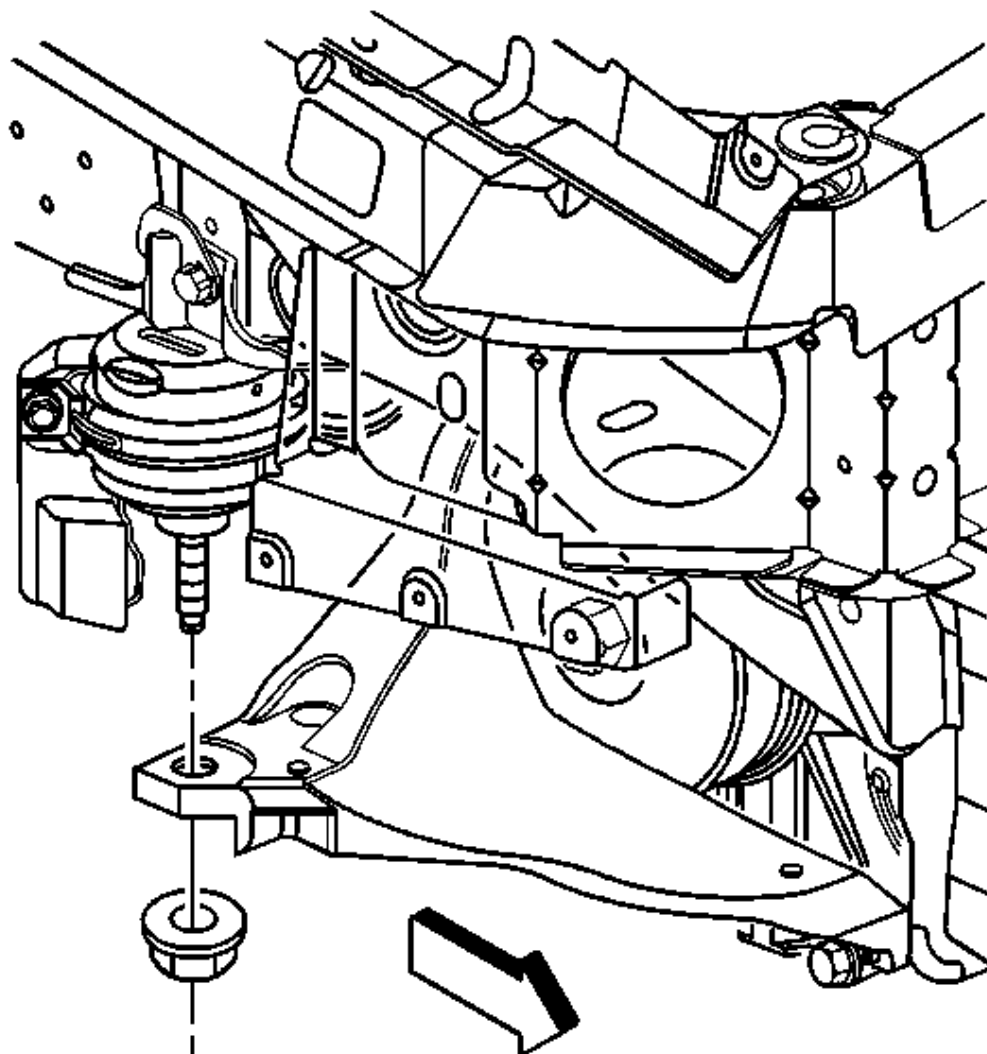


Fig. 28: Locating Right Engine Mount & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

3. Remove the nut securing the right engine mount to the right engine mount bracket.
4. Lower the jack allowing the engine to lower slightly.

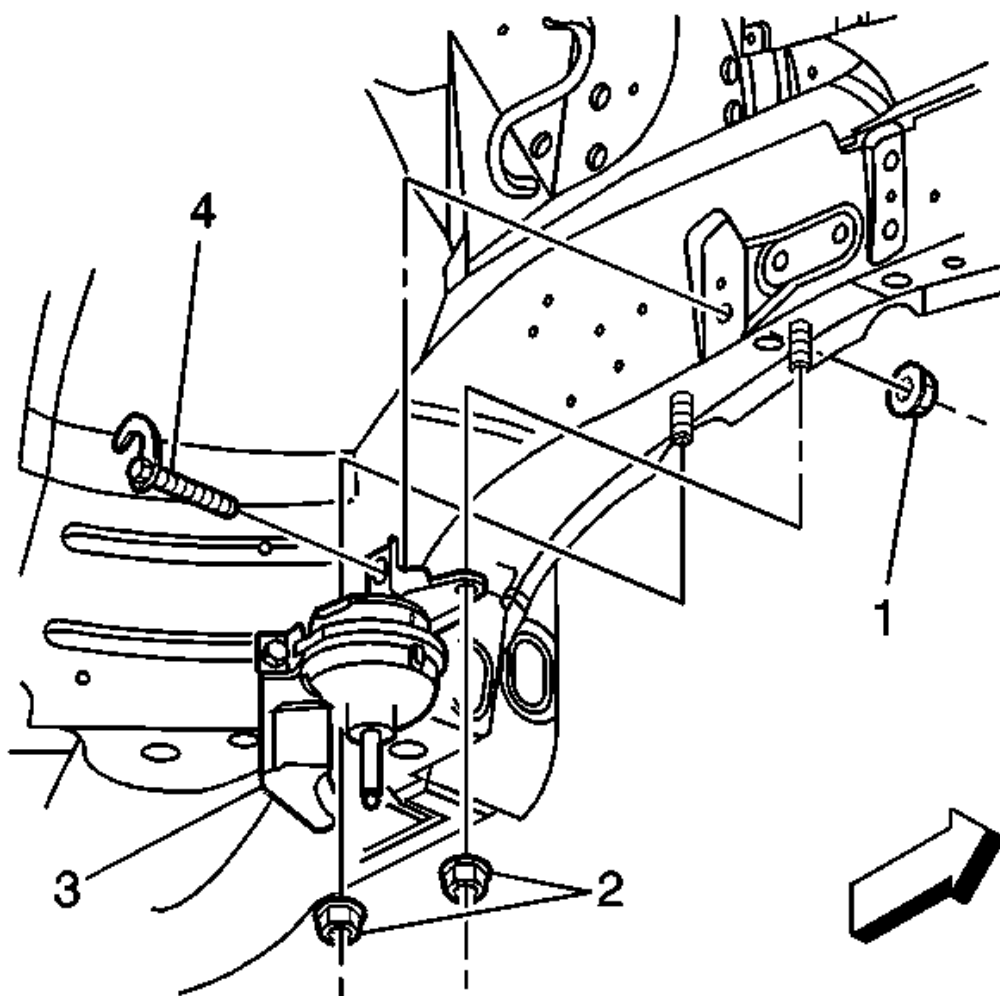


Fig. 29: Locating Right Engine Mount Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolt (4) securing the mount to the body frame rail.
6. Remove the two nuts (2) securing the mount to the body frame rail.
7. Remove the right engine mount (3).

Installation Procedure

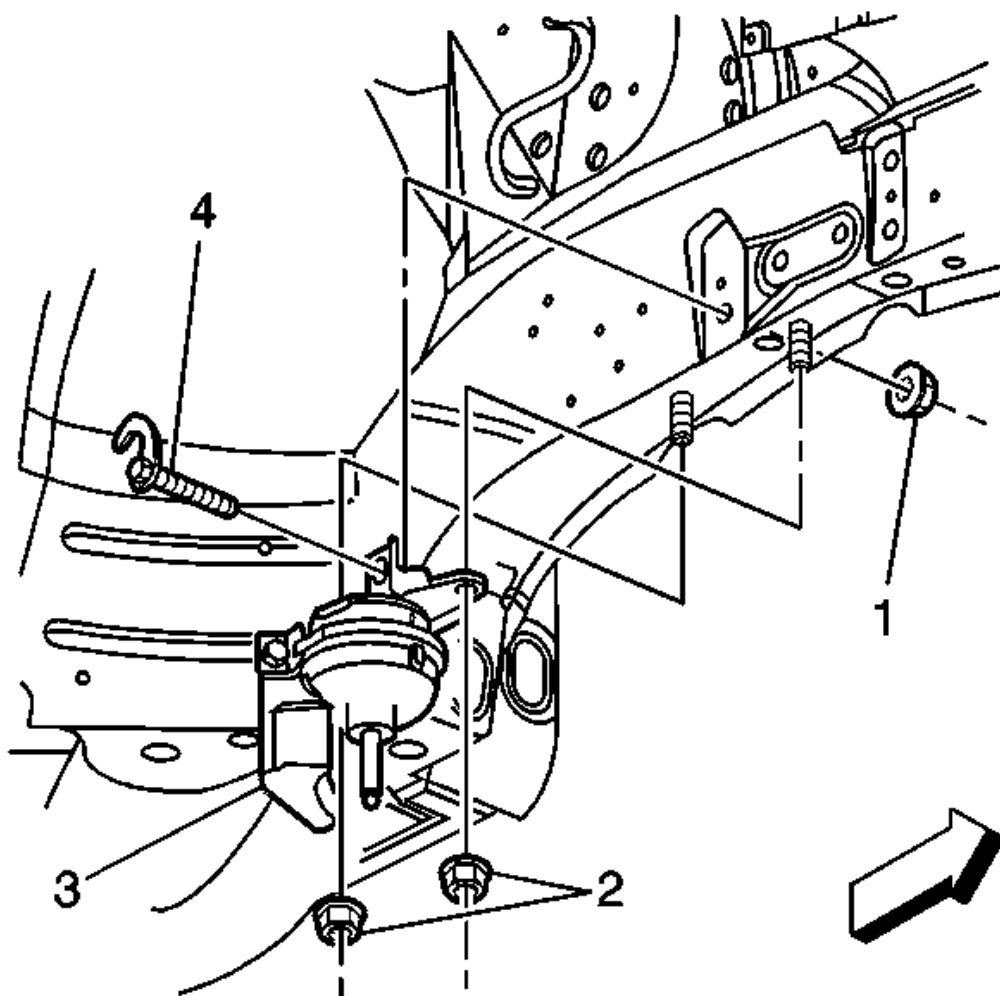


Fig. 30: Locating Right Engine Mount Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Position the right engine mount (3) to the body frame rail.
2. Install the mount attaching bolt (4) and nut (1) to the body frame rail.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the two nuts (2) securing the right engine mount to the body frame rail.

Tighten: Tighten the right engine mount to body frame rail nuts (1, 2) to 70 N.m (52 lb ft).

4. Raise the engine into position.

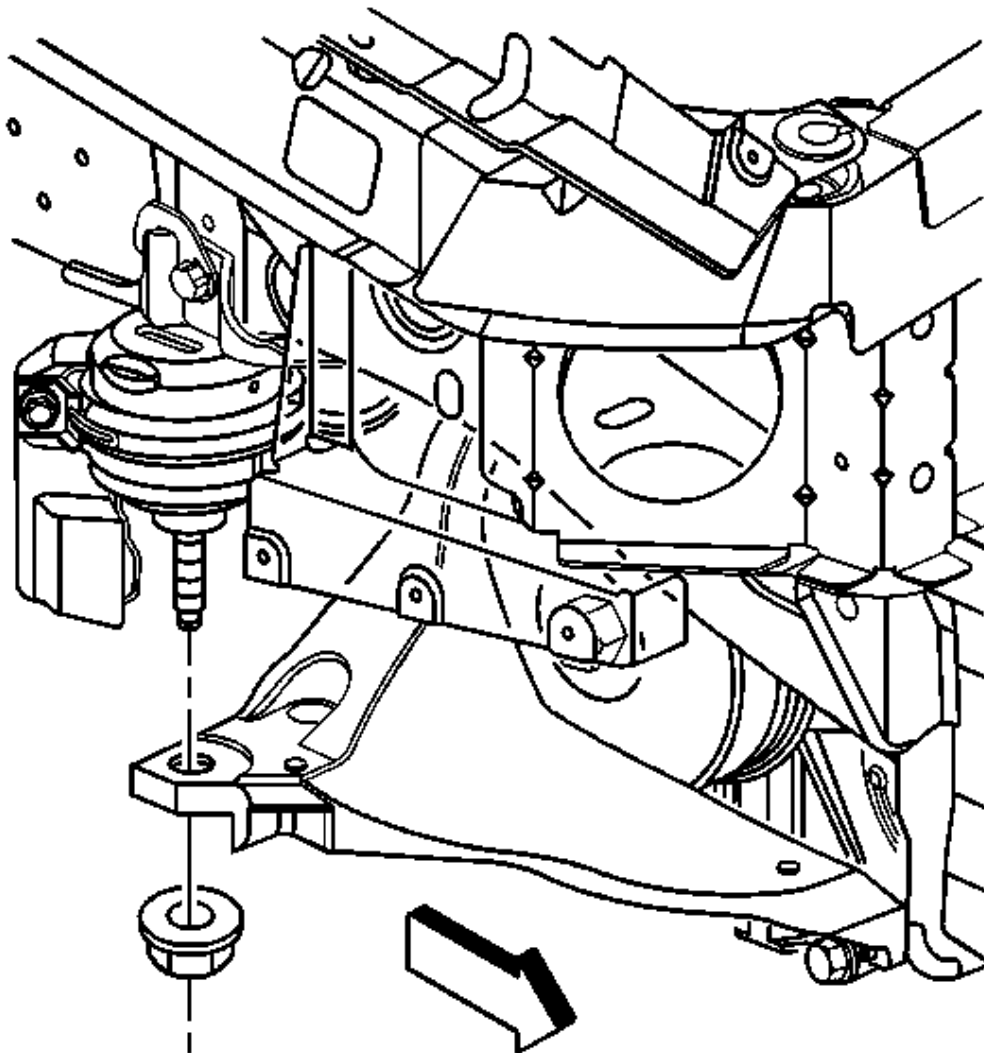


Fig. 31: Locating Right Engine Mount & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the nut securing the right engine mount to the right engine mount bracket.

Tighten: Tighten the right engine mount nut to 80 N.m (59 lb ft).

6. Remove the engine support jack.

7. Lower the vehicle.

Engine Mount Bracket Replacement - Right**Removal Procedure**

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the right front fascia extension. Refer to **Fascia Extension Replacement - Front** in Bumpers.
3. Support the engine assembly with a suitable jack.

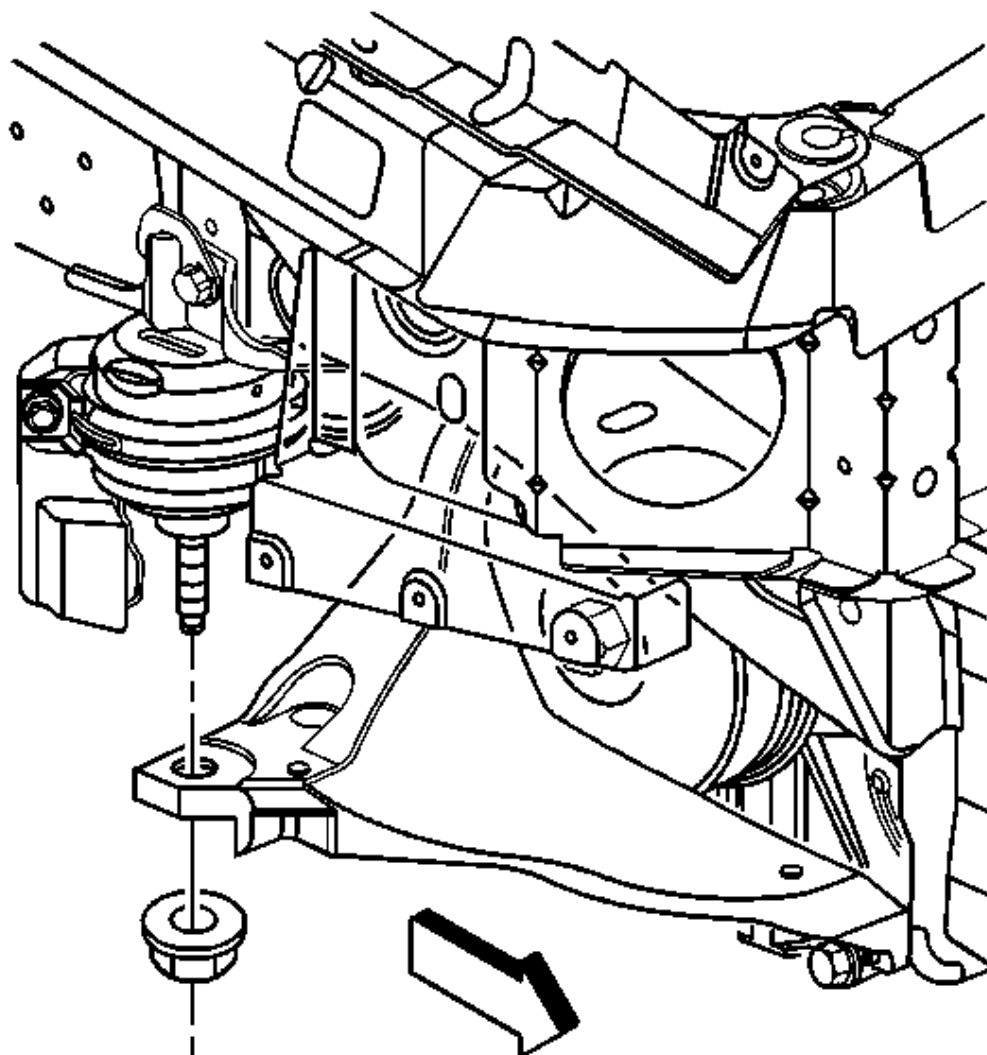


Fig. 32: Locating Right Engine Mount & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the nut securing the right engine mount to the right engine mount bracket.
5. Lower the jack allowing the engine to lower slightly.

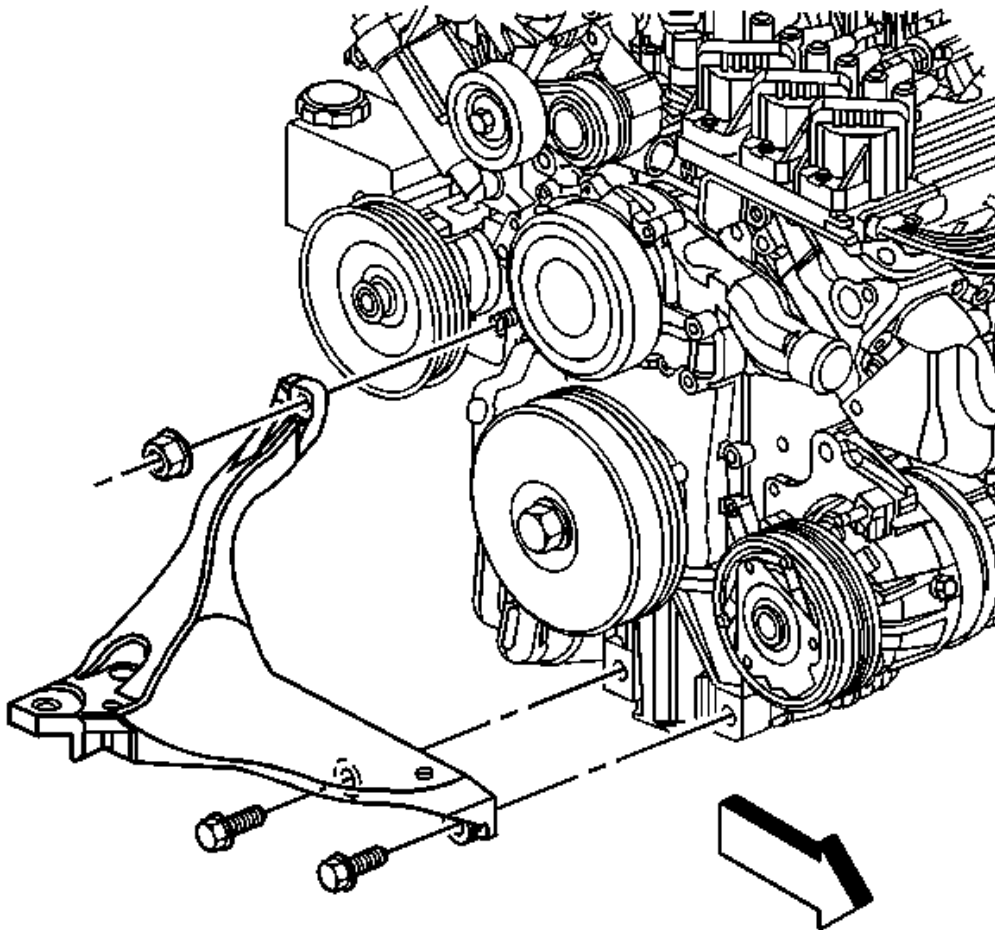


Fig. 33: Locating Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the three fasteners securing the right engine mount bracket to the engine.
7. Remove the right engine mount bracket stud.
8. Remove the right engine mount bracket.

Installation Procedure

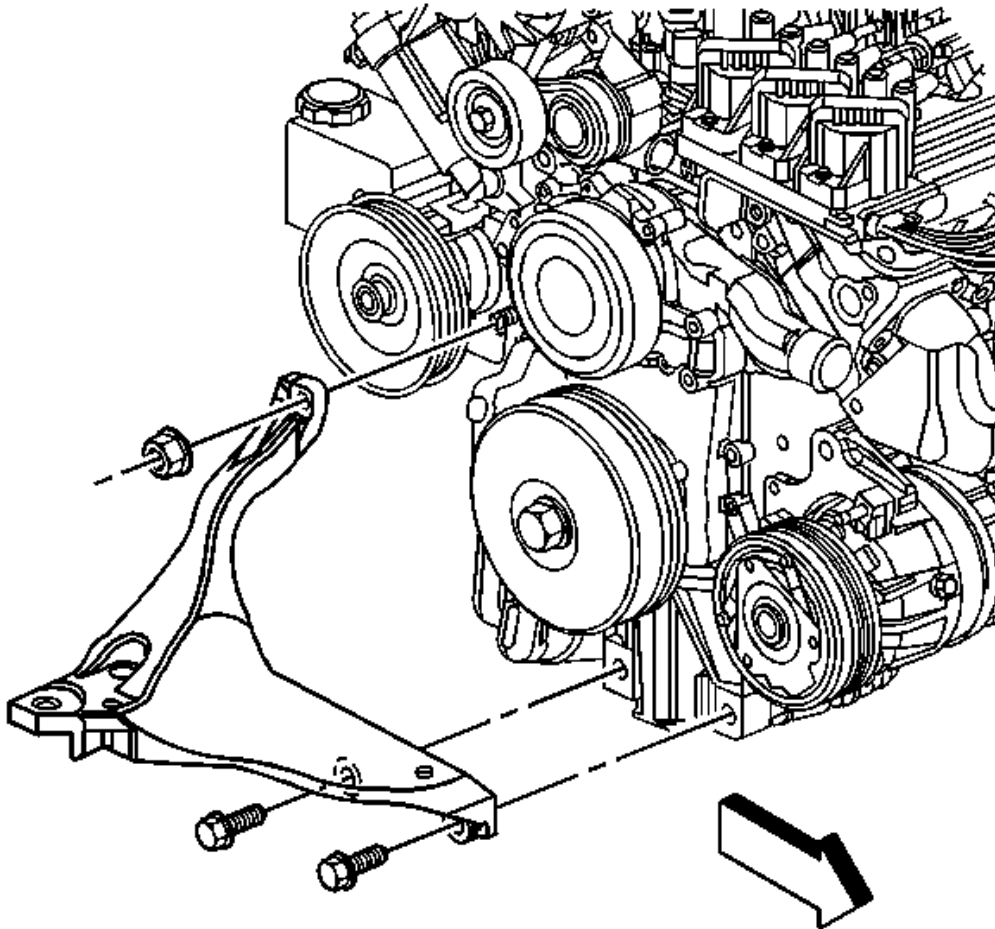


Fig. 34: Locating Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the right engine mount bracket to the front engine mount stud and engine.
2. Apply thread lock compound GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the right engine mount bracket bolts.
3. Loosely install the two lower right engine mount bracket bolts.
4. Apply thread lock compound GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the right engine mount bracket stud.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the right engine mount bracket stud to the engine.

Tighten: Tighten the right engine mount bracket stud to 8 N.m (71 lb in).

6. Install the right engine mount bracket nut to the engine.

Tighten: Tighten the right engine mount bracket fasteners to 60 N.m (44 lb ft).

7. Raise the engine into position.

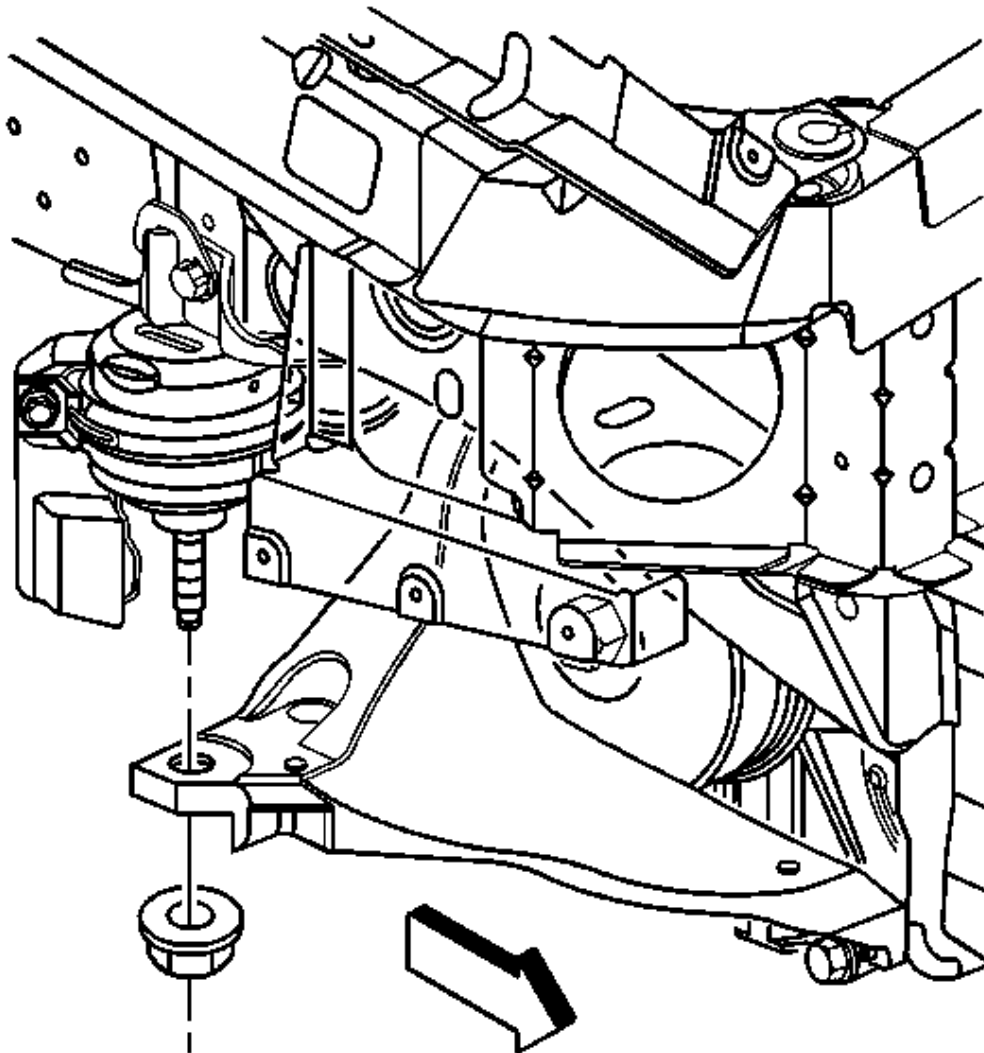


Fig. 35: Locating Right Engine Mount & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the nut securing the right engine mount to the right engine mount bracket.

Tighten: Tighten the right engine mount nut to 80 N.m (59 lb ft).

9. Remove the engine support jack.
10. Install the right front fascia extension. Refer to **Fascia Extension Replacement - Front** in Bumpers.
11. Lower the vehicle.

Positive Crankcase Ventilation (PCV) Valve Replacement

Removal Procedure

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

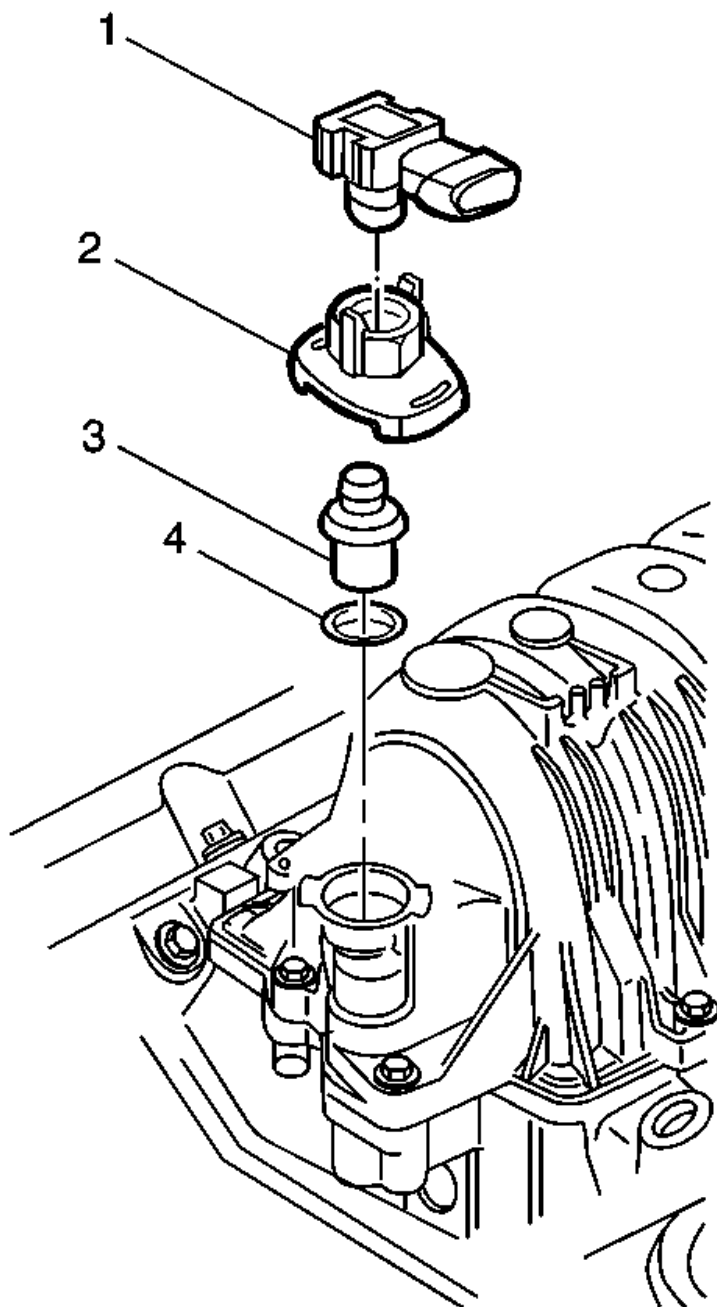


Fig. 36: Identifying PVC Valve & Related Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (1).
3. Use a 16 mm (5/8 in) socket to press the access cover (2) down and rotate 1/4 turn counterclockwise.

4. Remove the access cover.
5. Remove the positive crankcase ventilation (PCV) valve (3) and the O-ring (4) from the intake manifold.

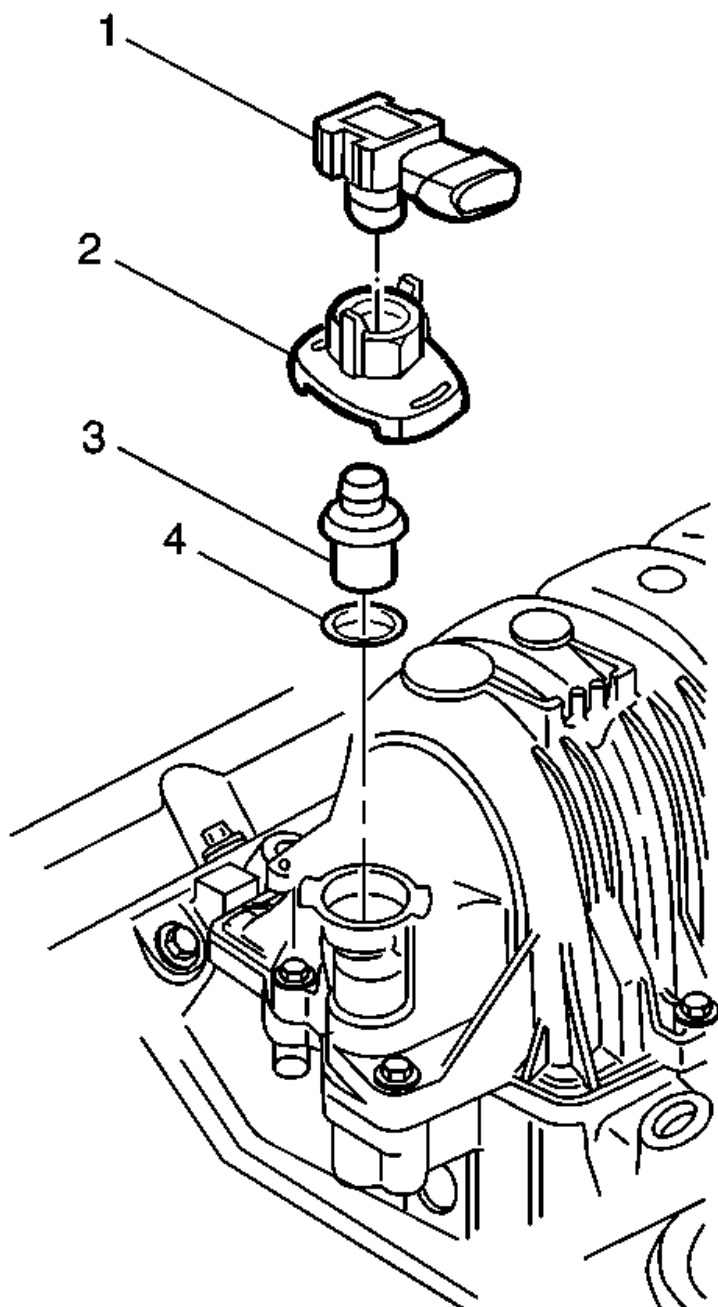
Installation Procedure

Fig. 37: Identifying PVC Valve & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV valve (3) and the O-ring (4) into the intake manifold.
2. Install the access cover (2).
3. Install the MAP sensor (1).
4. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Oil Level Indicator and Tube Replacement

Removal Procedure

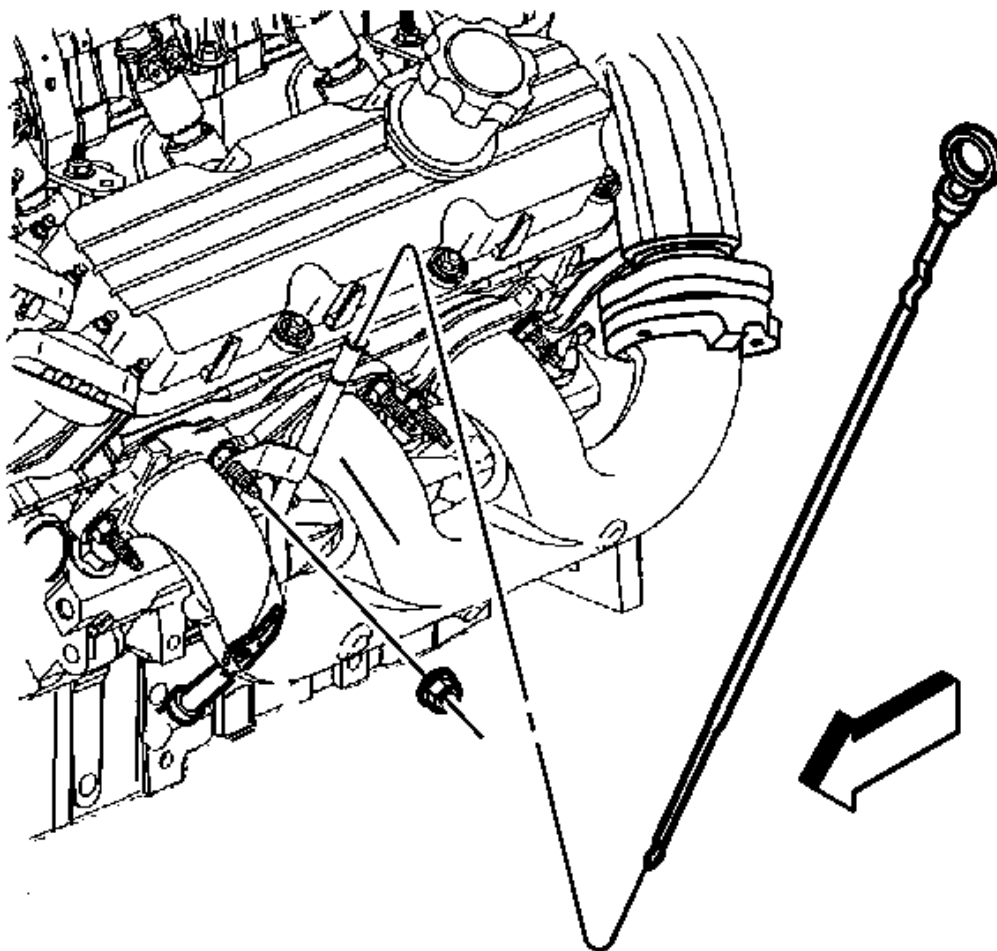


Fig. 38: Locating Oil Level Indicator & Tube

Courtesy of GENERAL MOTORS CORP.

1. Loosen the nut holding the tube to the exhaust manifold.
2. Pull upward on the tube.
3. Remove the oil level indicator and the tube.

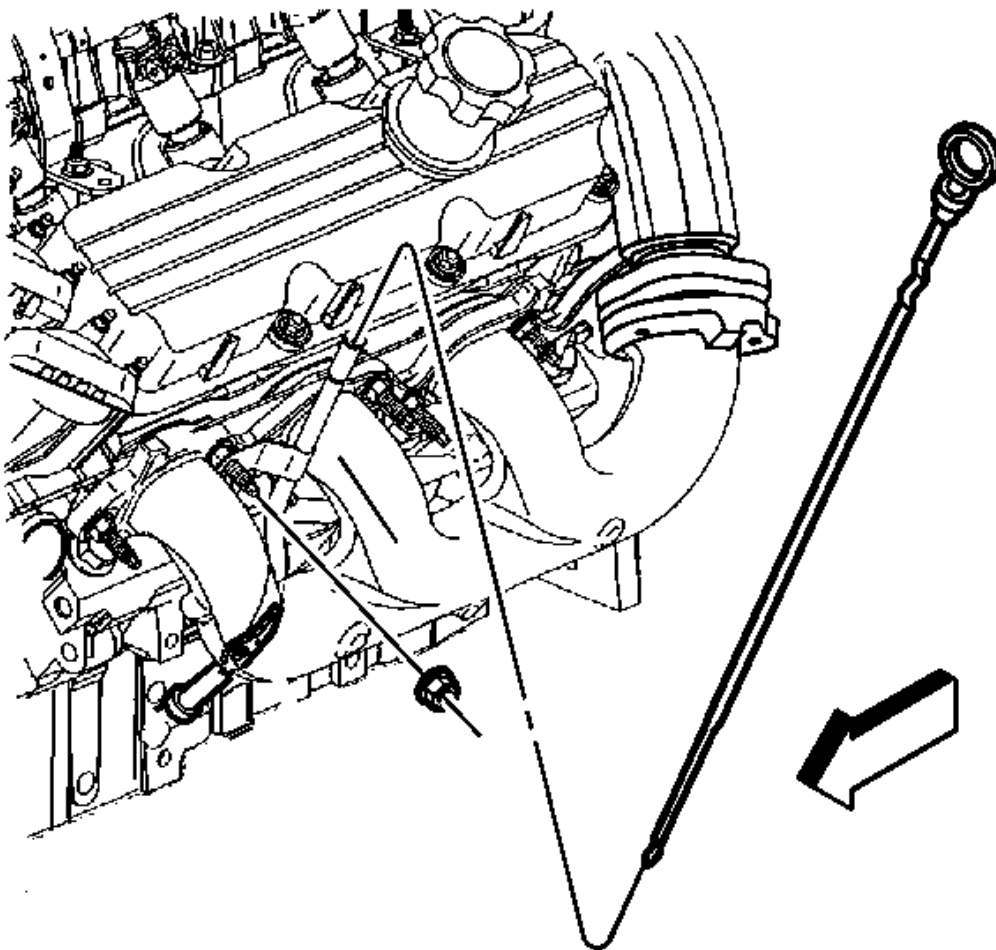
Installation Procedure

Fig. 39: Locating Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the tube assembly to the engine.
 1. Make sure the O-ring is in place.

2. Make sure you fully seat the tube assembly in the engine.

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

2. Slide the tube assembly under the exhaust manifold nut.

Tighten: Tighten the oil level indicator tube nut to 19 N.m (14 lb ft).

Intake Manifold Replacement - Upper

Removal Procedure

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Disconnect the manifold vacuum source.
3. Remove the evaporative emission (EVAP) canister purge valve solenoid and secure the hoses to the air inlet grill. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls.
4. Disconnect the right spark plug wires from the ignition module and position aside.
5. Remove the manifold absolute pressure (MAP) sensor. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls.

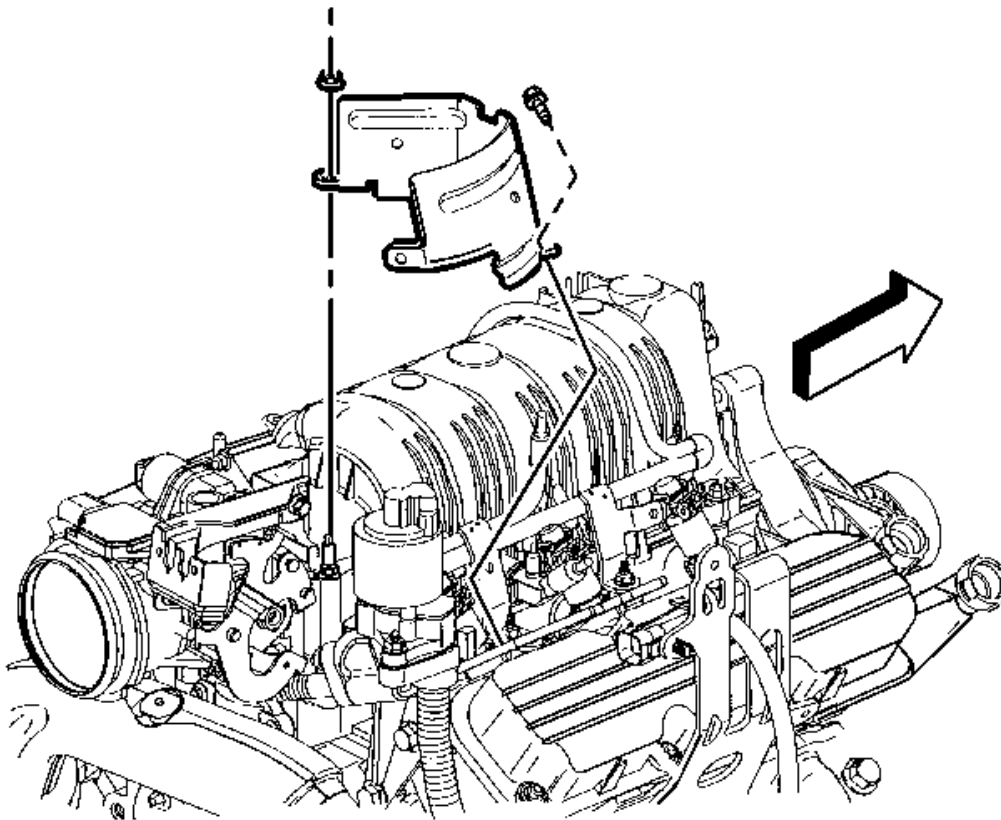


Fig. 40: Locating Engine Wiring Harness Heat Shield
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine wiring harness heat shield fasteners.
7. Remove the engine wiring harness heat shield.
8. Remove the fuel rail mounting bolts and the fuel rail with the injectors. Refer to **Fuel Rail Assembly Replacement** in Engine Controls.

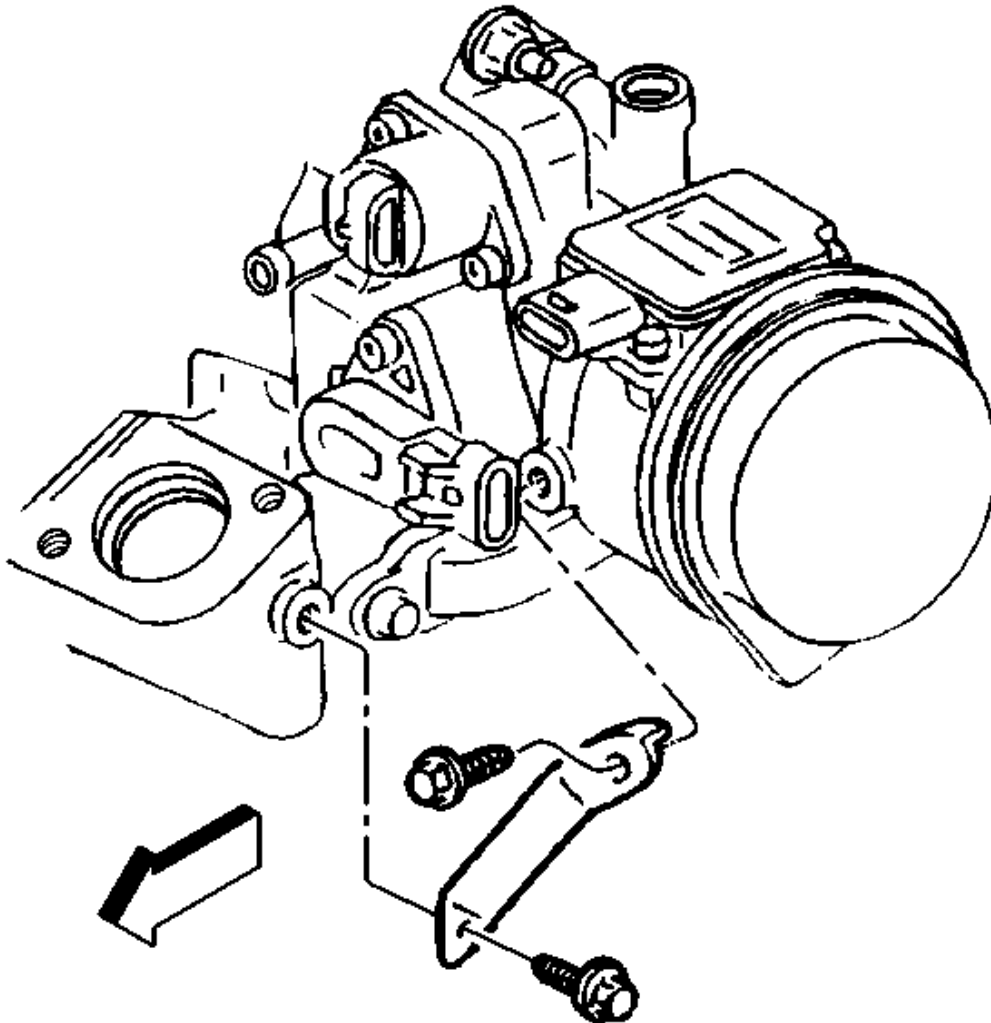


Fig. 41: Locating Throttle Body Support Bracket
Courtesy of GENERAL MOTORS CORP.

9. Remove the throttle body support bracket bolts.
10. Remove the throttle body support bracket.
11. Remove the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls.

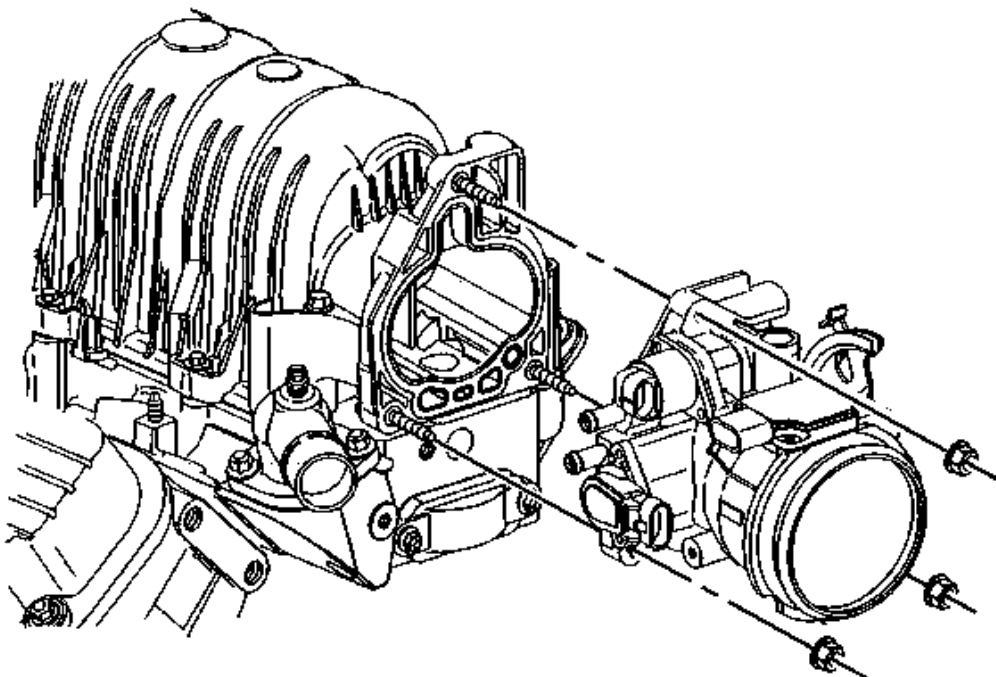


Fig. 42: Identifying Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

12. Remove the nuts securing the throttle body to the upper intake manifold.
13. Remove the throttle body and position aside.
14. Remove the throttle body gasket.

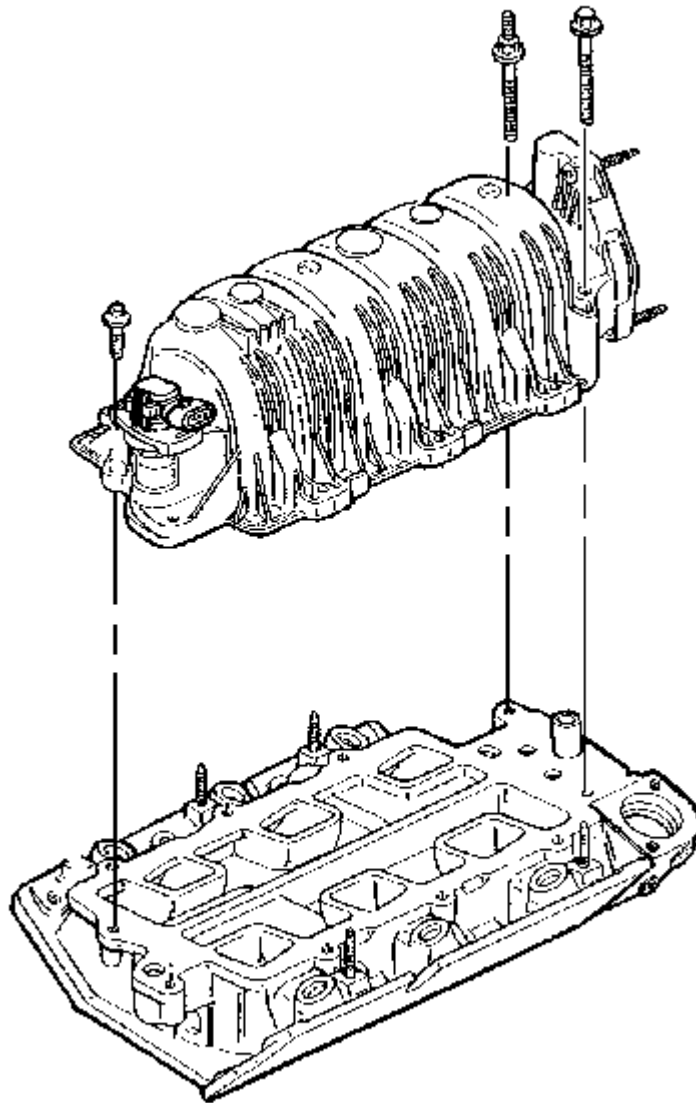


Fig. 43: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

15. Remove the upper intake manifold bolts.
16. Remove the upper intake manifold.
17. Clean and inspect the upper intake manifold. Refer to **Intake Manifold Cleaning and Inspection - Upper.**
18. Clean the lower intake manifold mating surface.

Installation Procedure

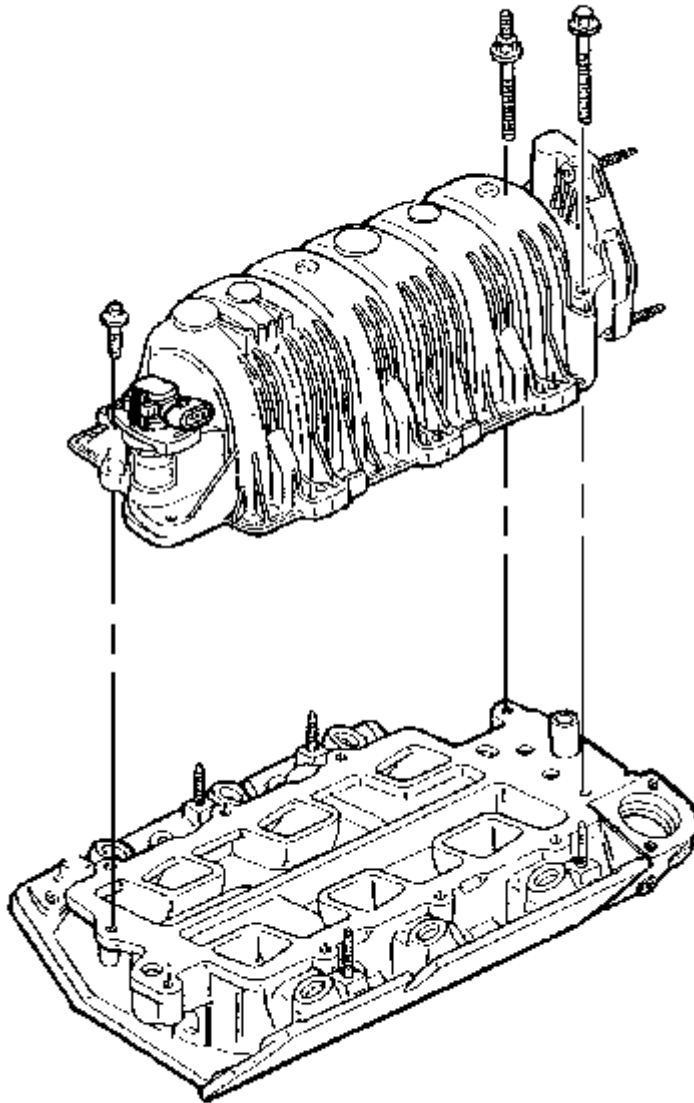


Fig. 44: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any sealer on the gasket.

1. Install the new upper intake manifold gasket.

2. Position the upper intake manifold to the lower intake manifold.

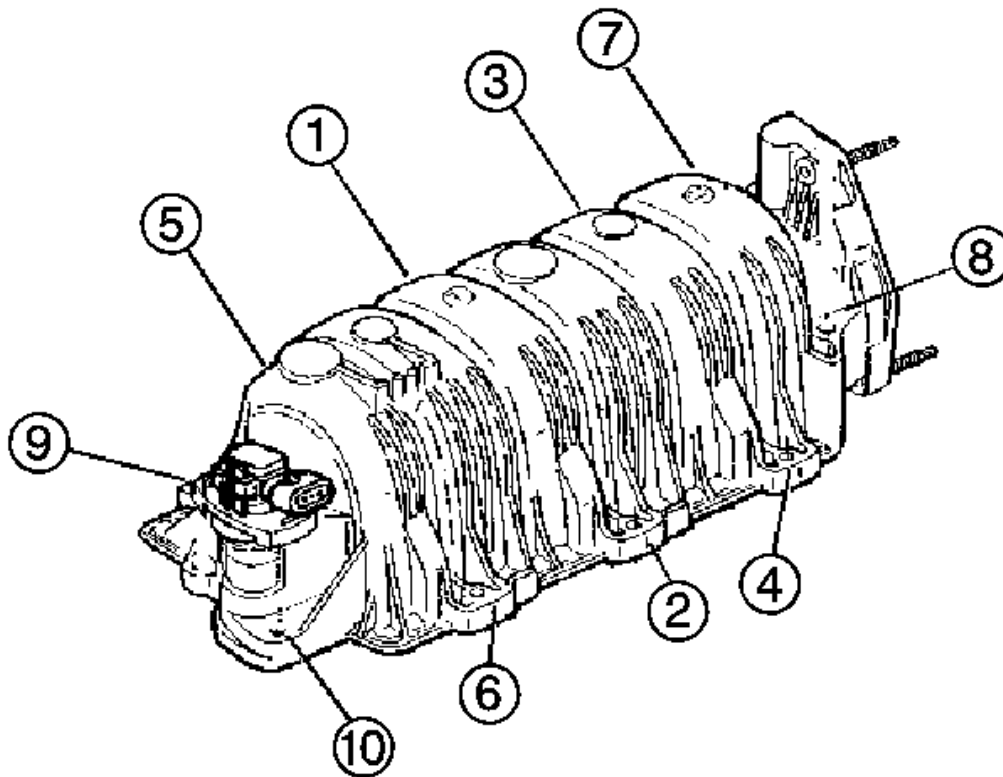


Fig. 45: Upper Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the upper intake manifold bolts.

Tighten: Tighten the upper intake manifold bolts in sequence (1-10) to 10 N.m (89 lb in).

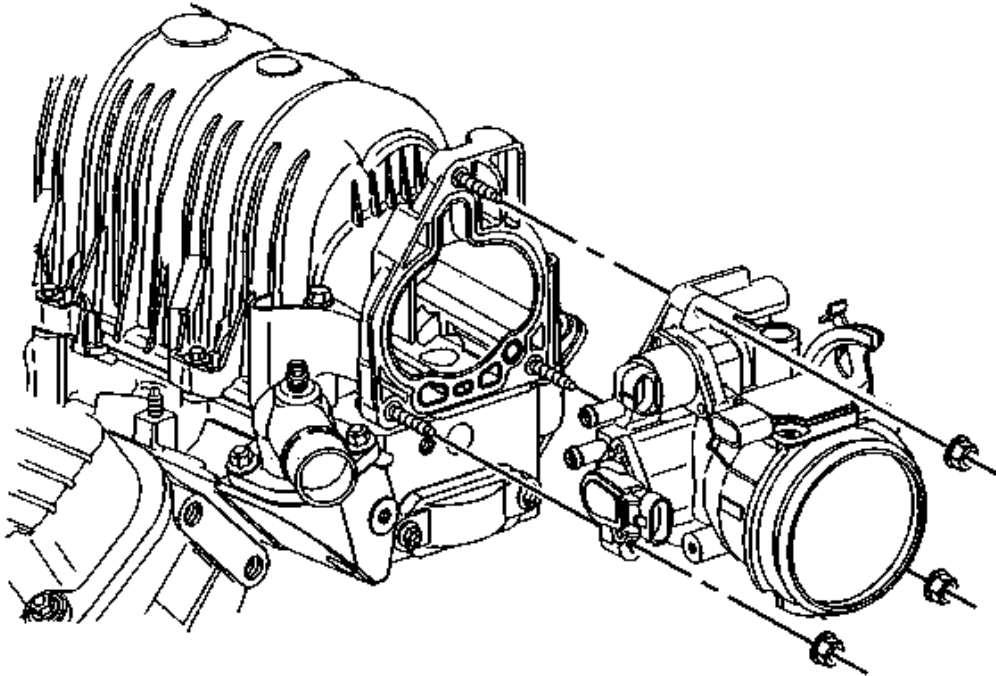


Fig. 46: Identifying Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Position a new throttle body gasket to the upper intake manifold.
5. Install the throttle body to the upper intake manifold.
6. Install the nuts securing the throttle body to the upper intake manifold.

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

7. Install the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls.

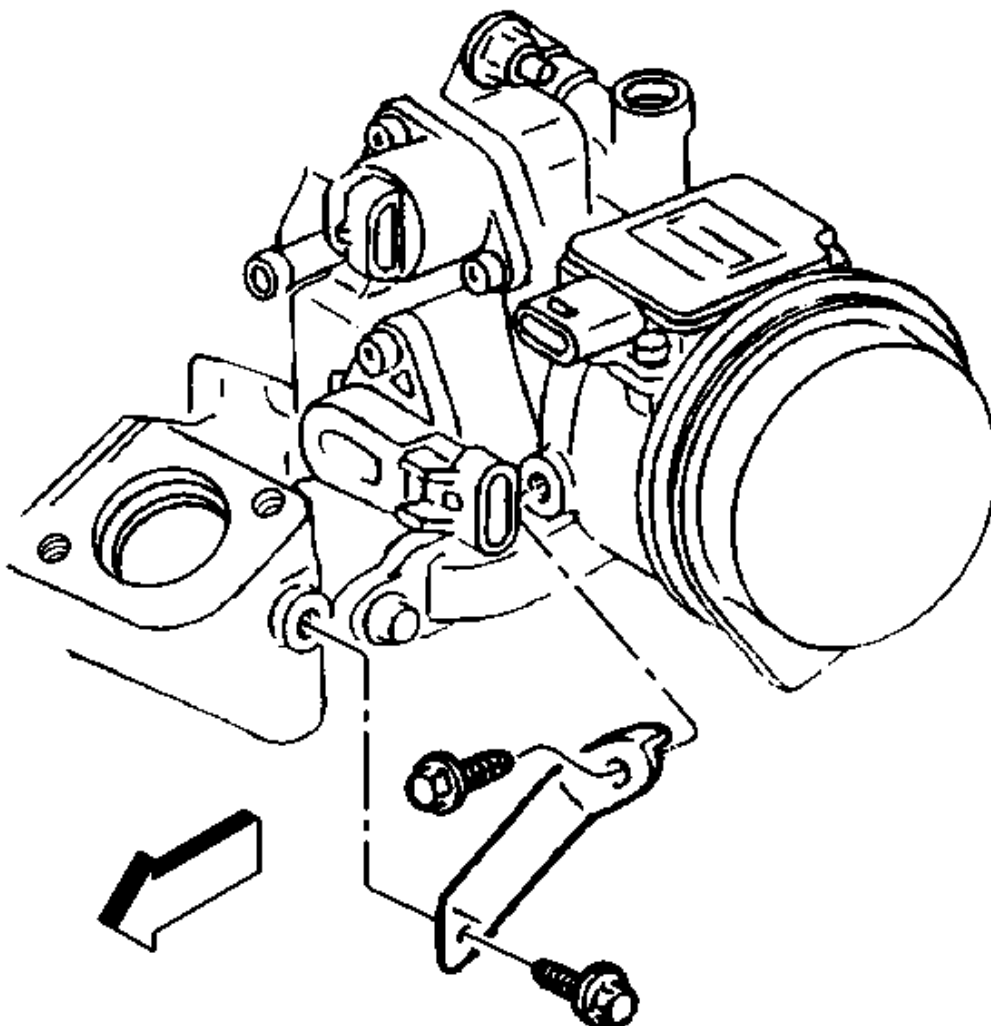


Fig. 47: Locating Throttle Body Support Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the throttle body support bracket.
9. Install the throttle body support bracket bolts.

Tighten: Tighten the throttle body support bracket bolts to 10 N.m (89 lb in).

10. Install the fuel rail assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls.

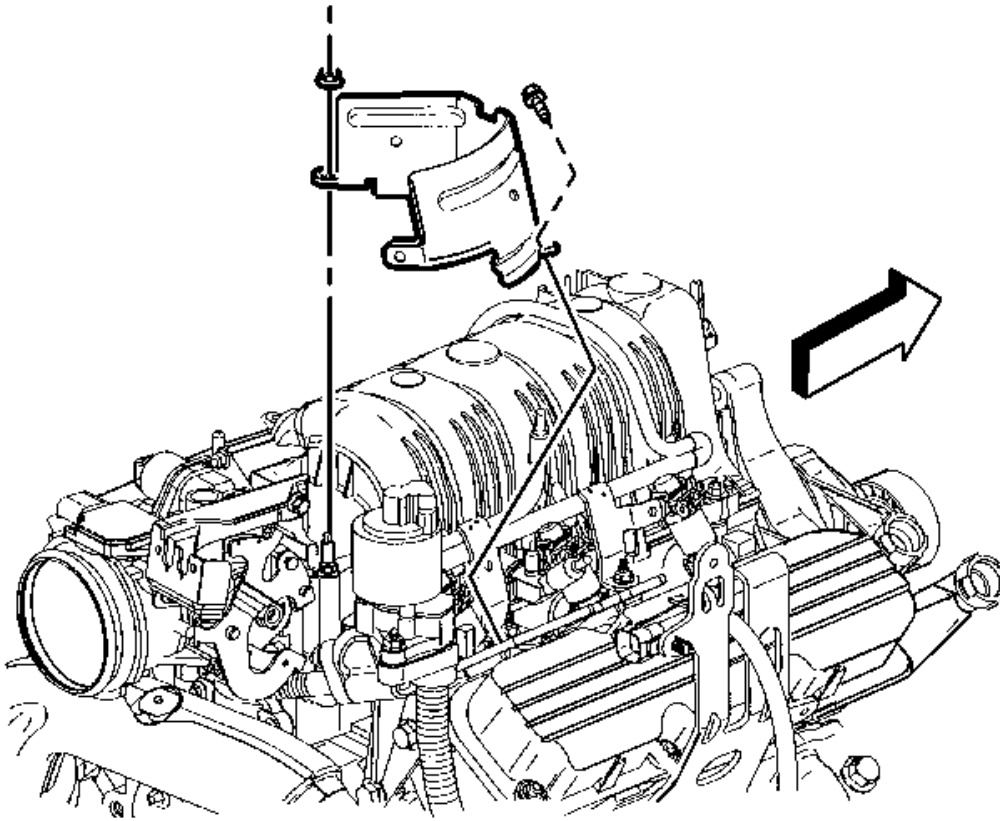


Fig. 48: Locating Engine Wiring Harness Heat Shield
Courtesy of GENERAL MOTORS CORP.

11. Install the engine wiring harness heat shield.
12. Install the engine wiring harness heat shield fasteners.

Tighten: Tighten the engine wiring harness heat shield fasteners to 10 N.m (89 lb in).

13. Install the MAP sensor. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls.
14. Connect the right spark plug wires to the ignition module.
15. Install the evaporative emission canister purge valve solenoid. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls.
16. Connect the manifold vacuum source.
17. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Intake Manifold Replacement - Lower

Removal Procedure

1. Remove the upper intake manifold. Refer to **Intake Manifold Replacement - Upper**.
2. Remove the thermostat housing. Refer to **Thermostat Replacement (L36)** in Engine Cooling.
3. Disconnect the electrical connector from the engine coolant temperature (ECT).
4. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
5. Remove the exhaust gas recirculation (EGR) valve outlet pipe. Refer to **Exhaust Gas Recirculation (EGR) Outlet Pipe Replacement** in Engine Controls.

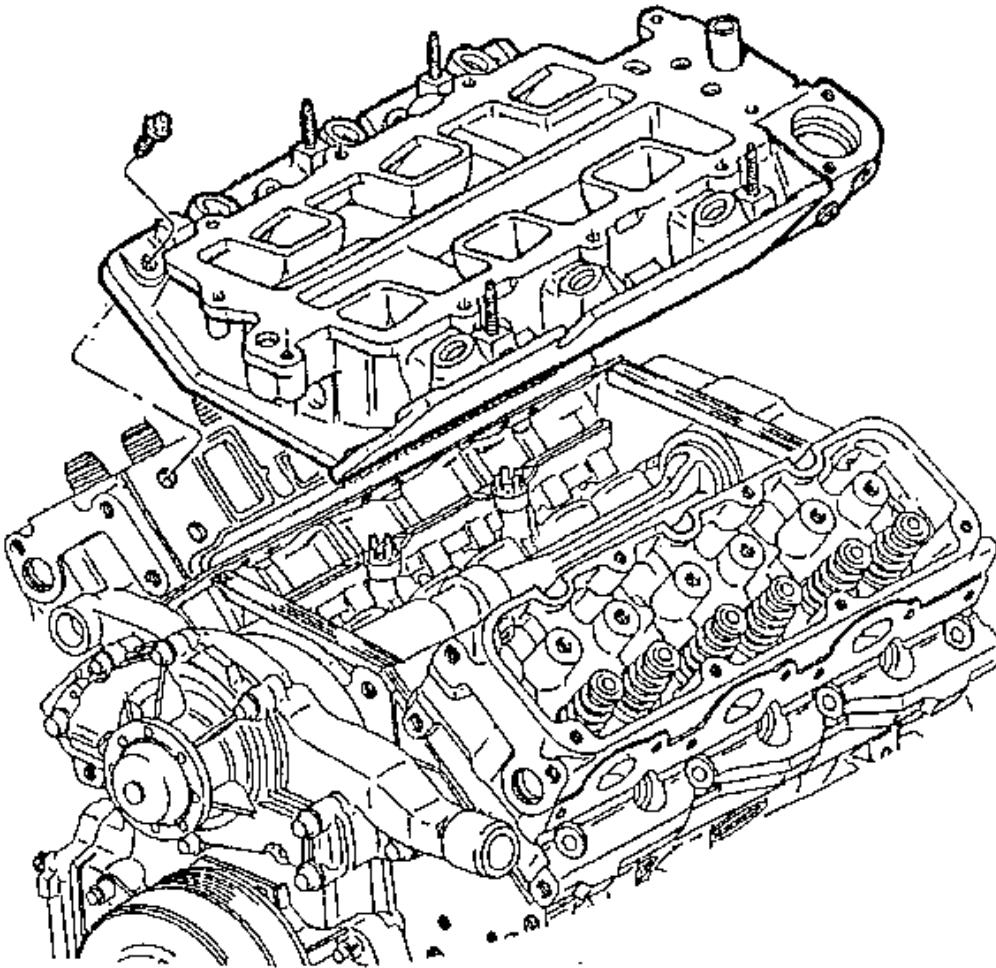


Fig. 49: Identifying Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the lower intake manifold bolts.
7. Remove the lower intake manifold.
8. Clean and inspect the lower intake manifold. Refer to **Intake Manifold Cleaning and Inspection - Lower**.

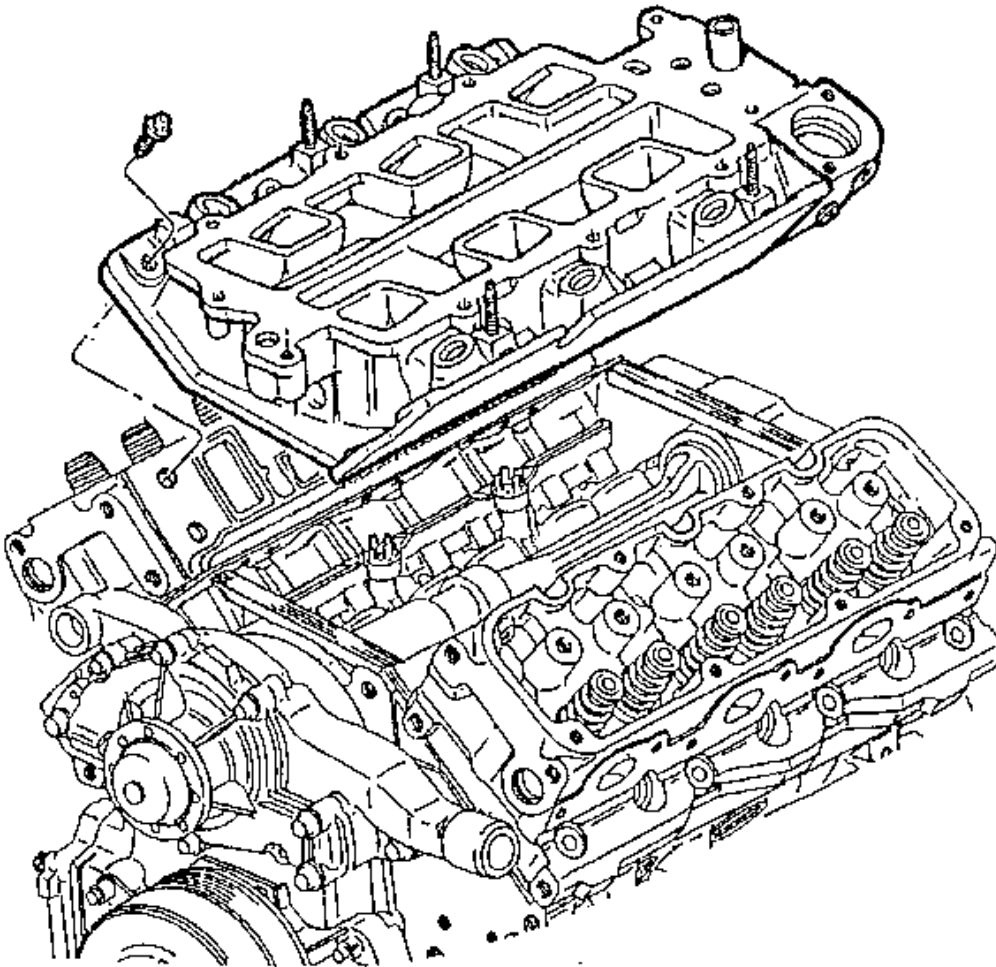
Installation Procedure

Fig. 50: Identifying Lower Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to install the manifold, complete the following steps:

- **Clean the cylinder block, heads and the intake manifold sealing surface of all oil with a suitable solvent.**
- **Apply a GM approved sealer to the ends of the intake manifold seals.**
- **Clean any adhesive compound from the intake manifold bolts and the bolt holes.**
- **Apply threadlocker compound GM P/N 12345739 (Canadian P/N 10953541), or equivalent, to the intake manifold bolt threads before assembly.**

1. Install the lower intake manifold gasket.
2. Install the lower intake manifold.
3. Apply threadlocker 272 GM P/N 12345493 (Canadian P/N 10953488) to the bolt threads.

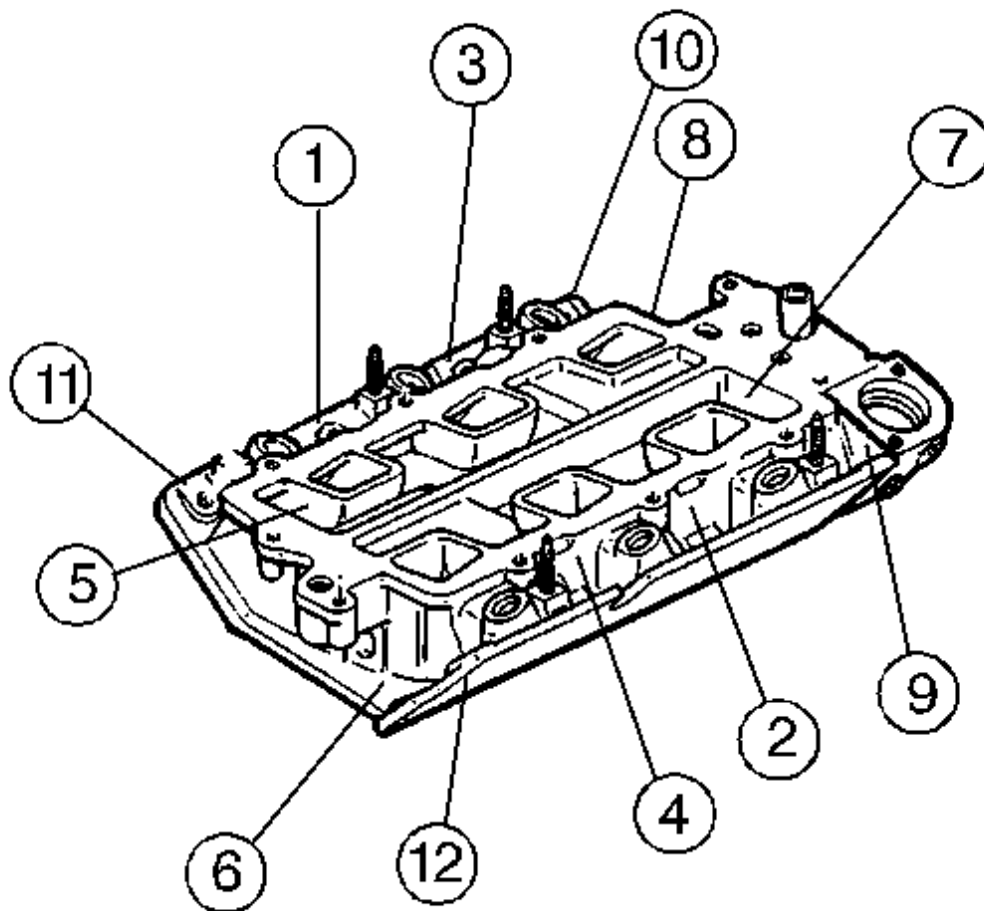


Fig. 51: Lower Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the lower intake manifold bolts.

Tighten: Tighten the lower intake manifold bolts in sequence (1-10) to 15 N.m (11 lb ft).

5. Install the EGR valve outlet pipe. Refer to **Exhaust Gas Recirculation (EGR) Outlet Pipe Replacement** in Engine Controls.
6. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
7. Connect the electrical connector from the ECT.

8. Install the thermostat housing. Refer to **Thermostat Replacement (L36)** in Engine Cooling.
9. Install the upper intake manifold. Refer to **Intake Manifold Replacement - Upper**.

Valve Rocker Arm Cover Replacement - Left**Removal Procedure**

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Disconnect the left spark plug wire harness and position aside.

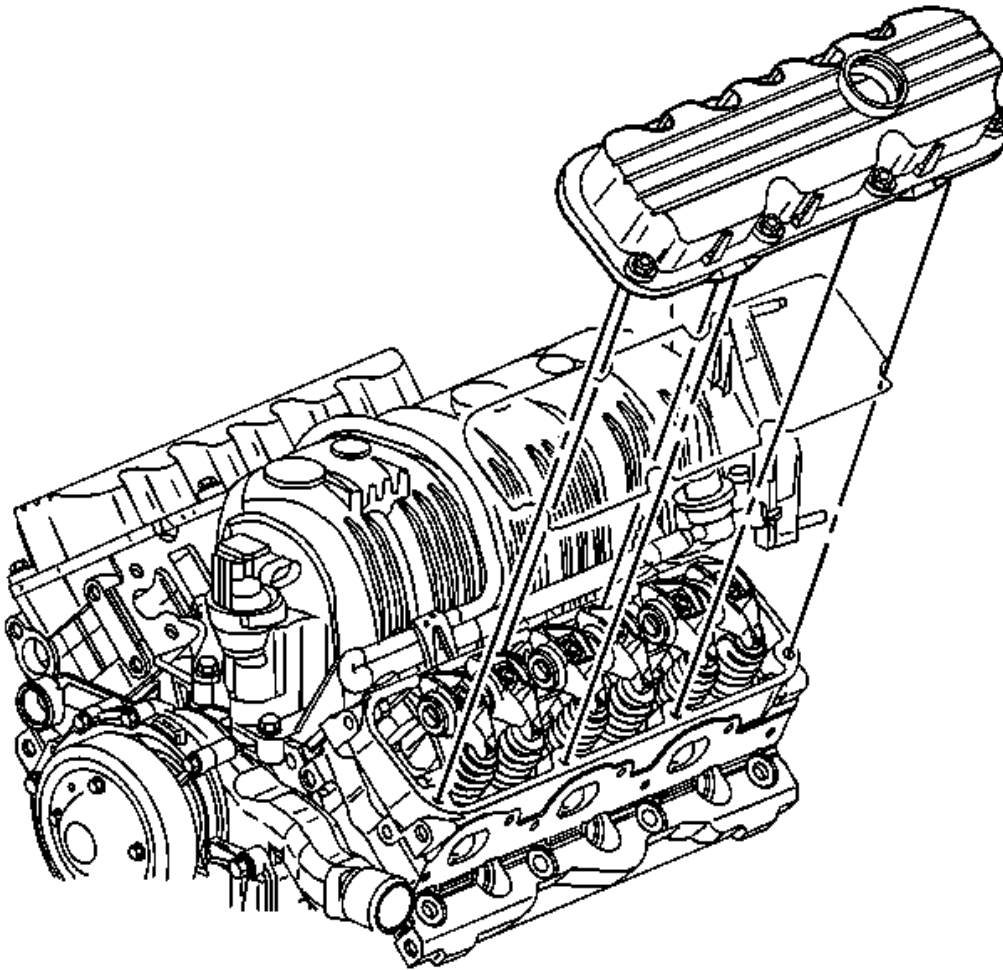


Fig. 52: Locating Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Remove the left valve rocker arm cover bolts.

IMPORTANT: If the valve rocker arm cover adheres to the cylinder head, remove the valve rocker arm cover by bumping the end of the valve rocker arm cover with palm of hand or with a soft rubber mallet.

4. Remove the left valve rocker arm cover.
5. Remove the left valve rocker arm cover gasket.
6. Clean the sealing surface on the cylinder head.
7. Clean the valve rocker arm cover bolts of all thread locking adhesive.
8. Clean and inspect the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection** in the Engine Mechanical - 3.8L Unit Repair.

Installation Procedure

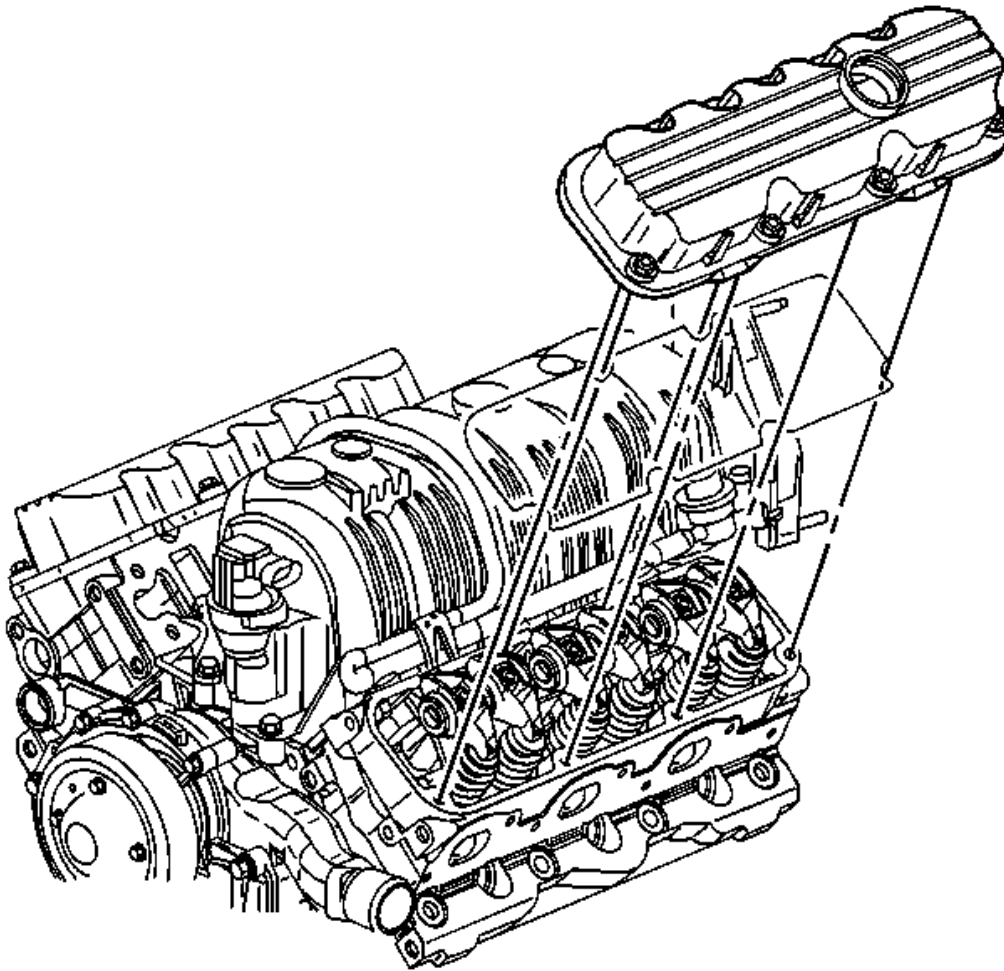


Fig. 53: Locating Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the new valve rocker arm cover gasket. Make sure that valve rocker arm cover gasket is seated properly in the valve rocker arm cover groove.
2. Install the left valve rocker arm cover to the cylinder head.
3. Apply thread lock compound GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the valve rocker arm cover bolt threads.

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

4. Install the left valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

5. Connect the left spark plug wire harness.
6. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Disconnect the right spark plug wire harness and position aside.
3. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
4. Disconnect the vacuum brake booster hose from the vacuum connections and position aside.

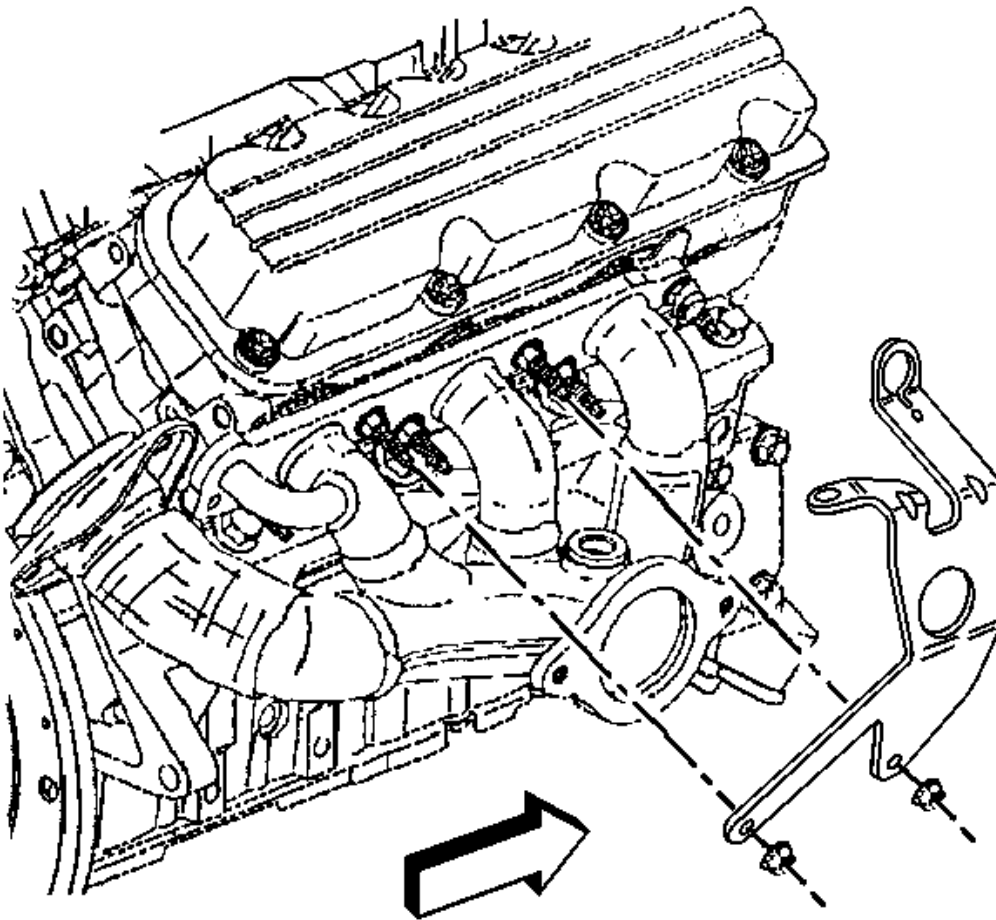


Fig. 54: Locating Fuel Injector Sight Shield Cover Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the 2 nuts attaching the fuel injector sight shield bracket to the right exhaust manifold studs.
6. Remove the fuel injector sight shield bracket.

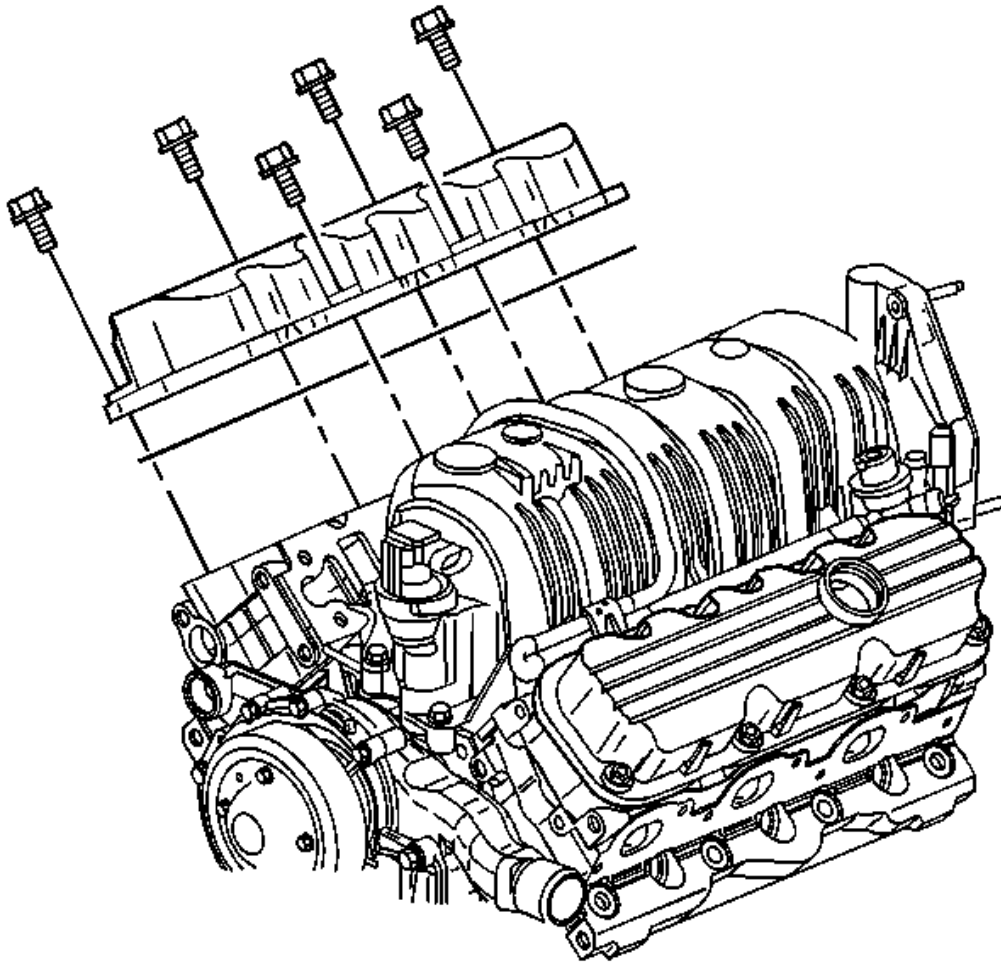


Fig. 55: View Of Right Side Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

7. Remove the right valve rocker arm cover bolts.

IMPORTANT: If the valve rocker arm cover adheres to the cylinder head, remove the valve rocker arm cover by bumping the end of the valve rocker arm cover

with the palm of your hand or a soft rubber mallet.

8. Remove the right valve rocker arm cover.
9. Remove the right valve rocker arm cover gasket.
10. Clean the sealing surface on the cylinder head.
11. Clean the valve rocker arm cover bolts of all threadlocker adhesive.
12. Clean and inspect the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

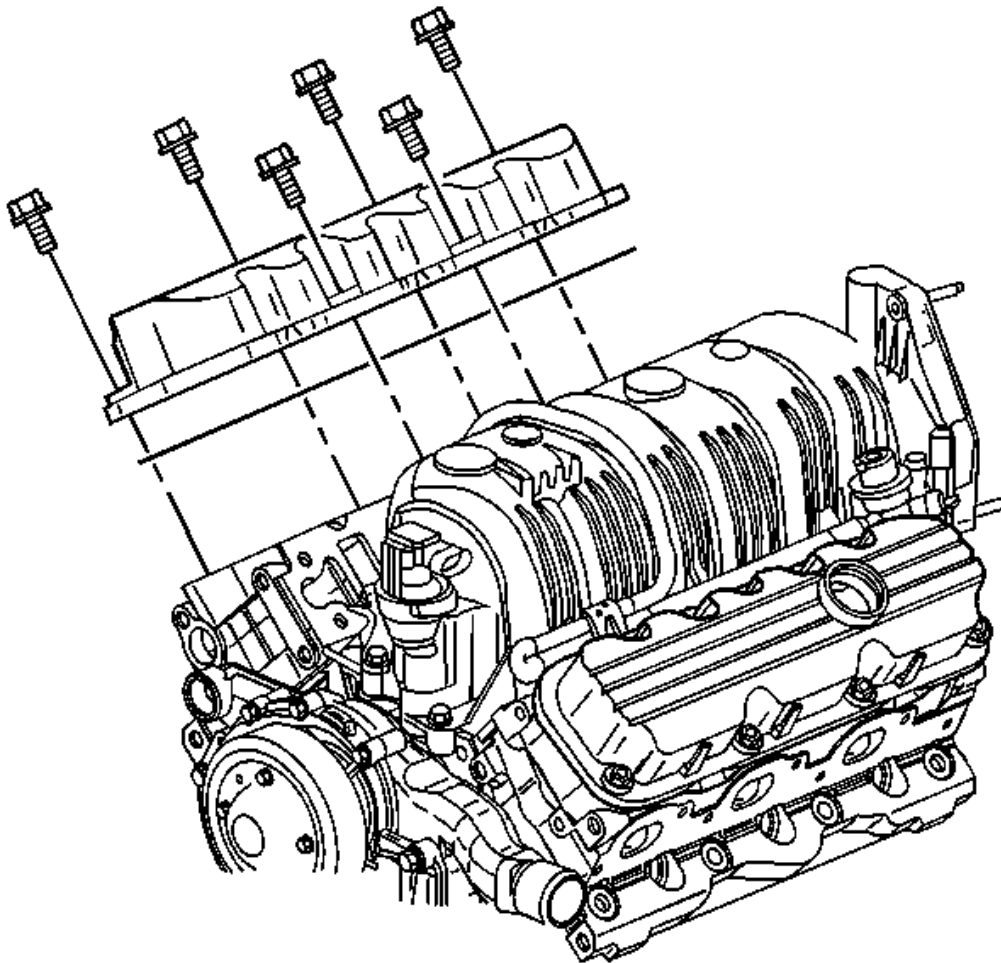


Fig. 56: View Of Right Side Valve Rocker Arm Cover

Courtesy of GENERAL MOTORS CORP.

1. Install the new valve rocker arm cover gasket. Make sure that the valve rocker arm cover gasket is seated properly in the valve rocker arm cover groove.
2. Install the right valve rocker arm cover to the cylinder head.
3. Apply threadlocker compound GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the valve rocker arm cover bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the right valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

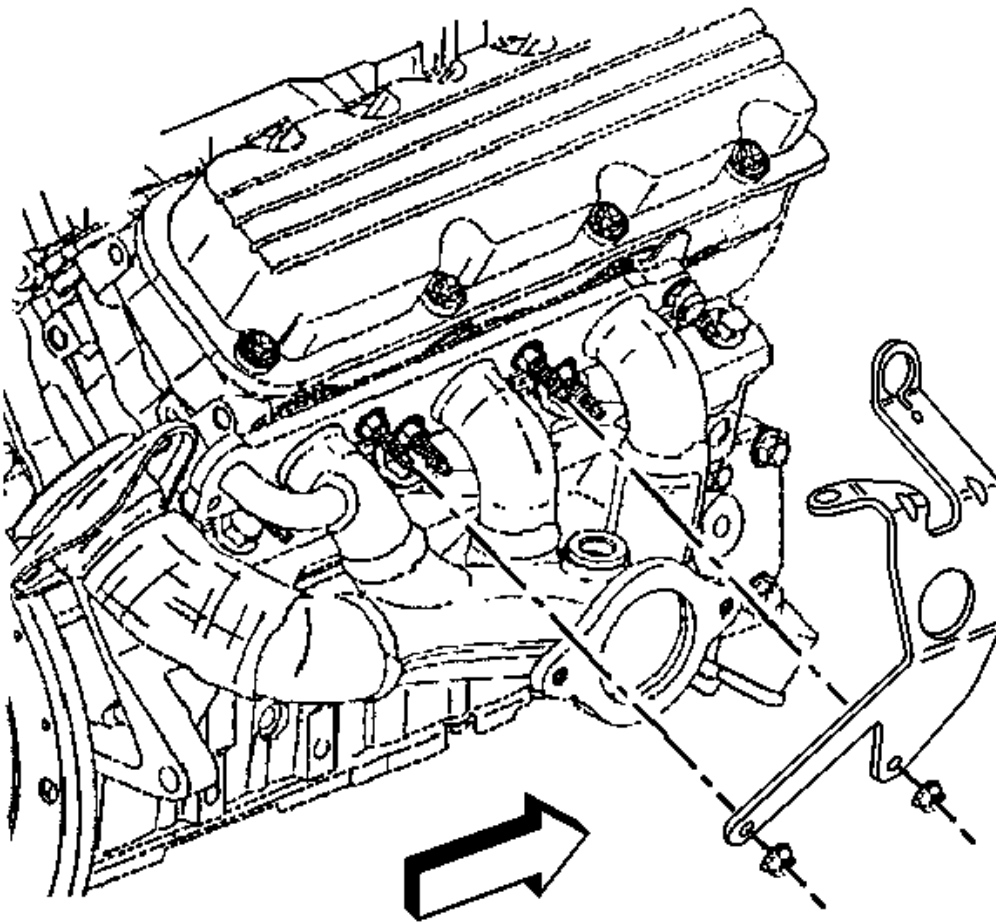


Fig. 57: Locating Fuel Injector Sight Shield Cover Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel injector sight shield bracket.
6. Install the 2 nuts attaching the fuel injector sight shield bracket to the right exhaust manifold studs.

Tighten: Tighten the fuel injector sight shield bracket to right exhaust manifold stud nuts to 30 N.m (22 lb ft).

7. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
8. Connect the vacuum brake booster hose to the vacuum connections.
9. Connect the right spark plug wire harness.
10. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Valve Rocker Arm and Push Rod Replacement

Tools Required

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

Removal Procedure

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

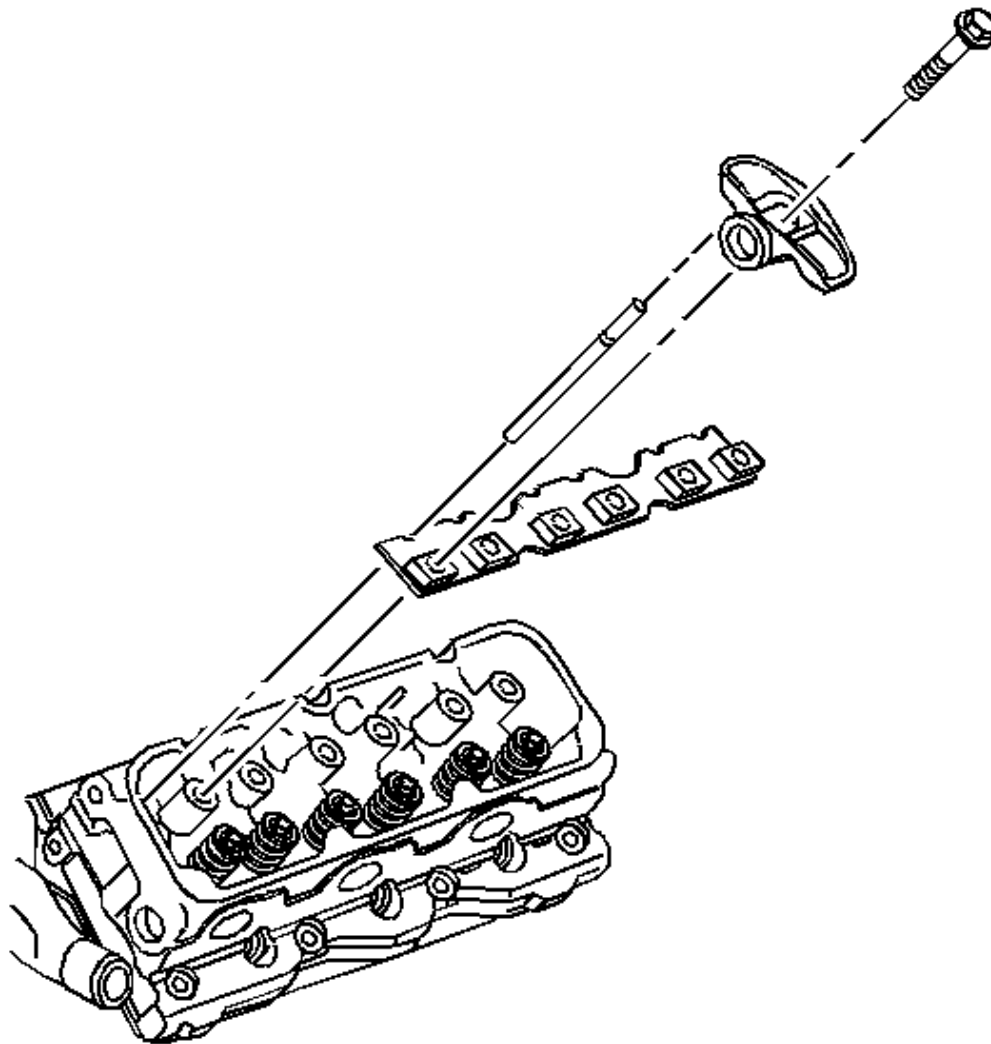


Fig. 58: View Of Valve Rocker Arm, Bolt, Push Rod & Push Rod Guide Plate
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pedestal retaining bolts.
4. Remove the pedestal.

IMPORTANT:

- Place the assemblies on a clean surface.
- Store the components in order. Reassemble the components in the same location and with the same mating surfaces as when removed.

5. Remove the rocker arm assembly.
6. Remove the pushrods.
7. Clean the bolts of all thread adhesive.
8. Clean and inspect the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection** in the Engine Mechanical - 3.8L Unit Repair.

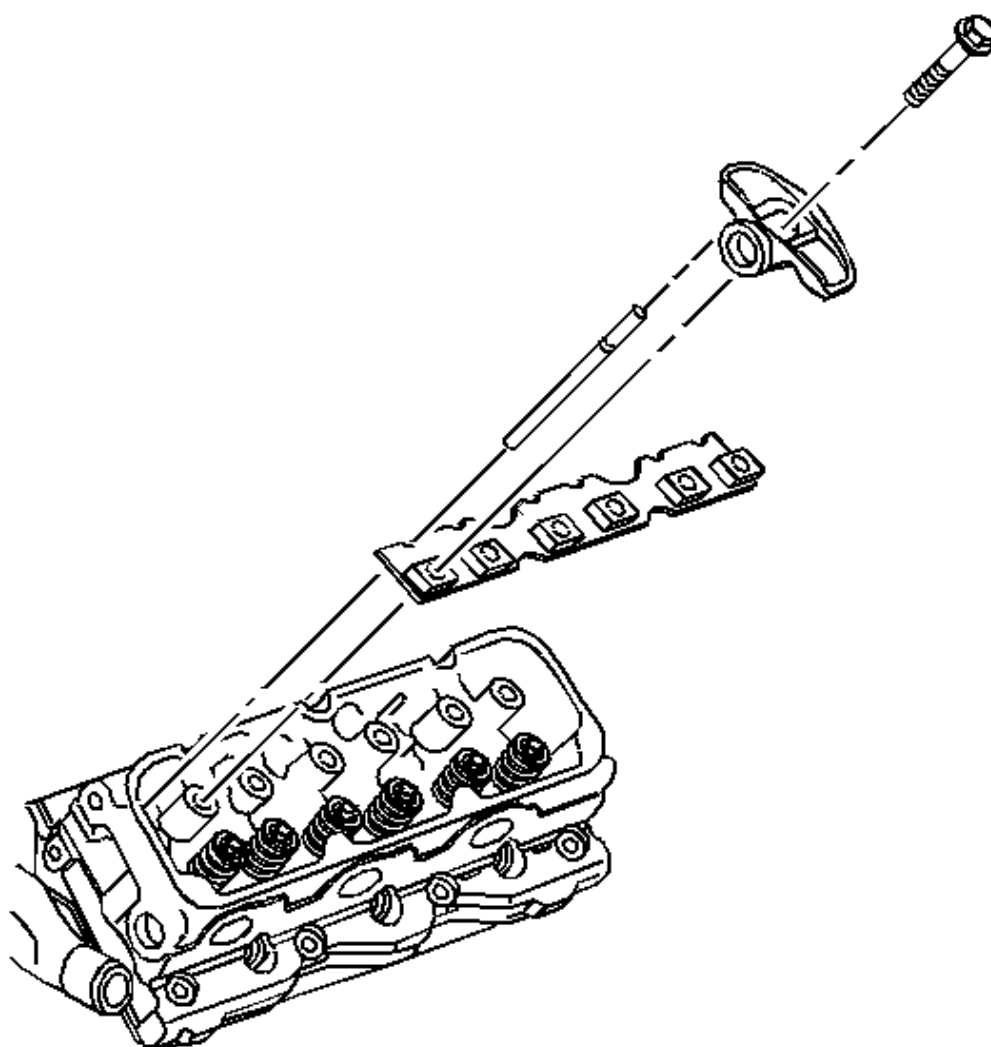
Installation Procedure

Fig. 59: View Of Valve Rocker Arm, Bolt, Push Rod & Push Rod Guide Plate
Courtesy of GENERAL MOTORS CORP.

1. Install the pushrods.
2. Install the valve rocker arm assembly.
3. Install the pedestal.

NOTE: The two bolts which fasten the lower intake manifold to the cylinder head are accessible only after the upper intake is removed. The bolts are located in the right front and left rear corners of the lower intake manifold. Remove the upper intake manifold to service the lower intake.

4. Apply GM P/N 12345493 (Canadian P/N 10953488) threadlocker compound or equivalent to the valve rocker arm bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the valve rocker arm pedestal retaining bolts.

Tighten: Tighten the valve rocker arm bolts to 15 N.m (11 lb ft) + 90 degrees using **J 45059** . See Special Tools and Equipment.

6. Install the left valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Left.
7. Install the right valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Right.
8. Listen for valve train noise.

Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- **J 22794** Spark Plug Port Adapter. See Special Tools and Equipment.
- J 38606 Valve Spring Compressor
- **J 42863** Valve Stem Seal Installer. See Special Tools and Equipment.

Removal Procedure

1. Remove the rocker arm assemblies. Refer to Valve Rocker Arm and Push Rod Replacement.
2. Remove the spark plugs.

IMPORTANT: Rotate the engine so that the piston in the cylinder that you are servicing is at top dead center before removing the valve keys. Do this in order to eliminate the possibility of the valve falling into the cylinder.

3. Install the **J 22794** into the cylinder head. See Special Tools and Equipment. Charge the cylinder with compressed air in order to hold the valves closed.

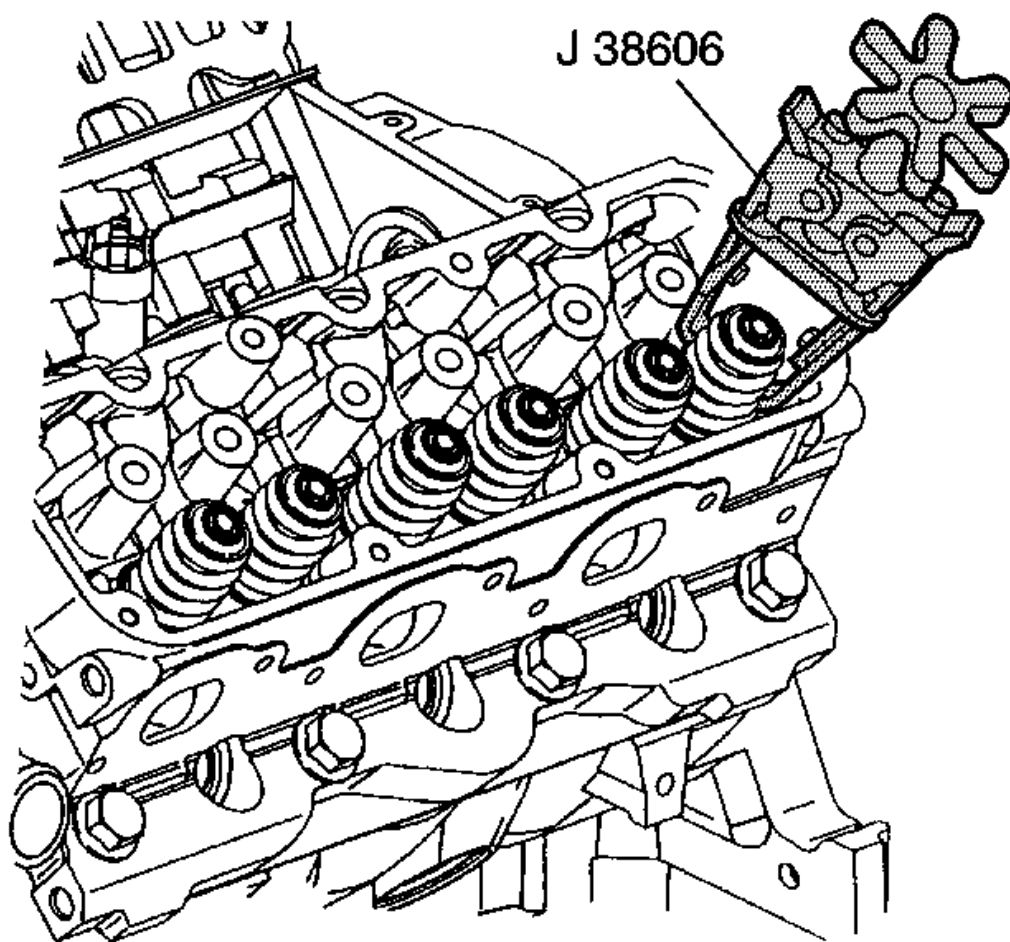


Fig. 60: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

4. Use the J 38606 in order to compress the valve spring.

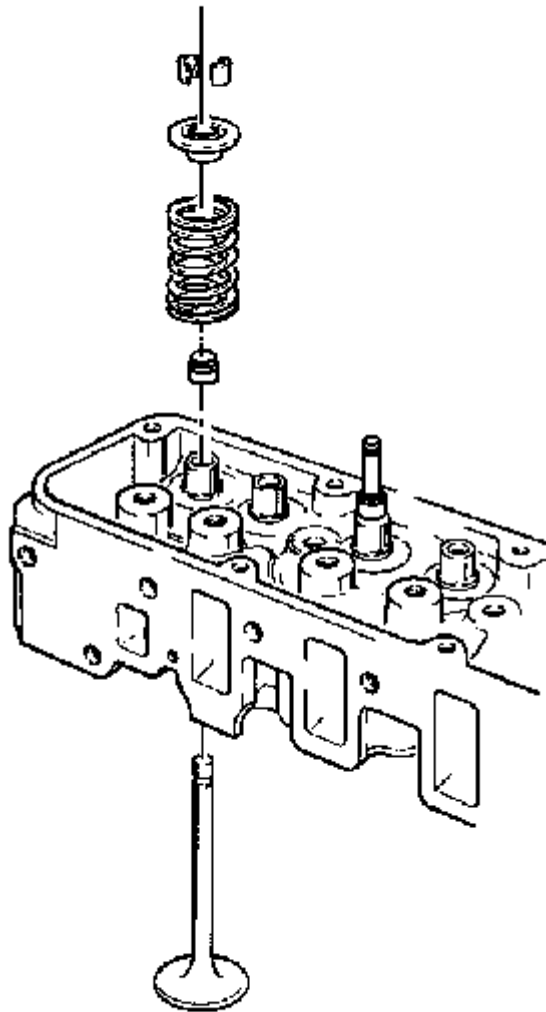


Fig. 61: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve keys.
6. Remove the valve cap.
7. Remove the valve spring.
8. Pry up on the bottom of the seal in order to remove the valve stem oil seal.

Installation Procedure

1. Place the oil seal over the valve stem so the seal begins to contact the valve guide.

IMPORTANT: Use hand pressure only when installing the valve stem oil seal using the J 42863 . See Special Tools and Equipment. Using too much force may cause the oil seal to leak and possibly lead to excessive oil consumption.

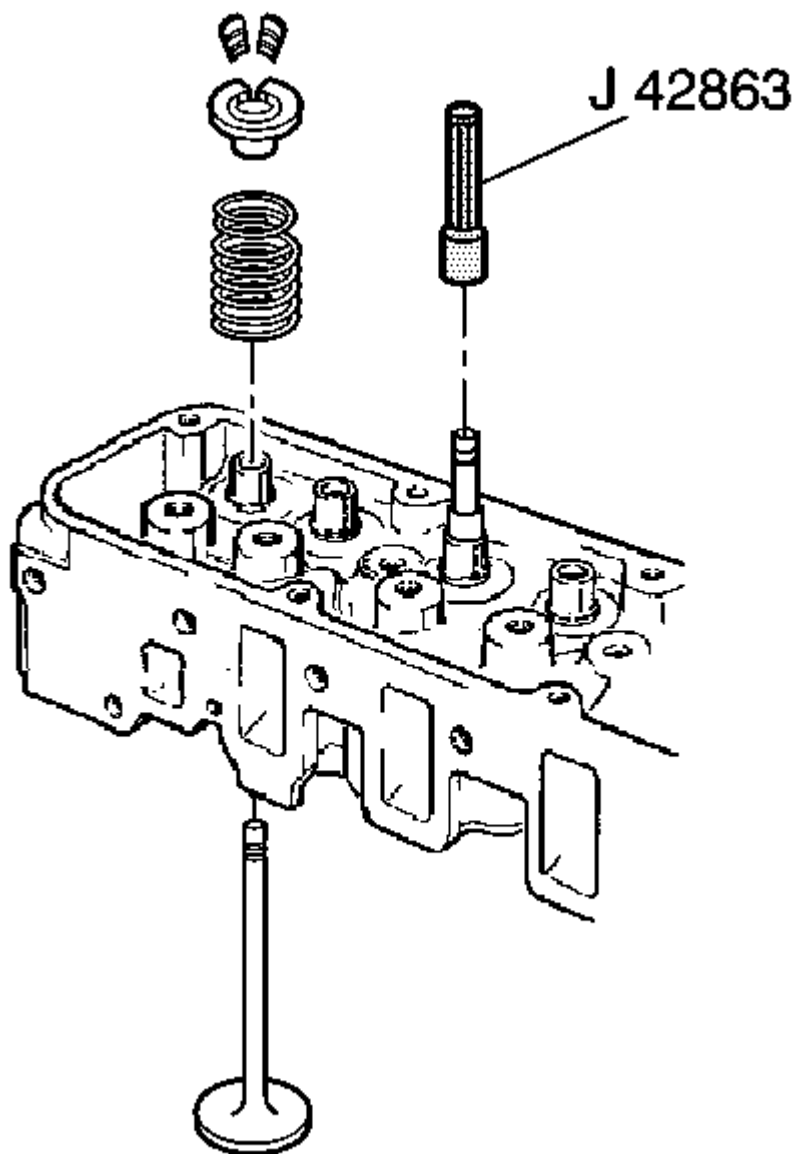


Fig. 62: Installing Valve Stem Oil Seal

Courtesy of GENERAL MOTORS CORP.

2. Use the **J 42863** in order to push the valve stem seal over the guide. See Special Tools and Equipment.

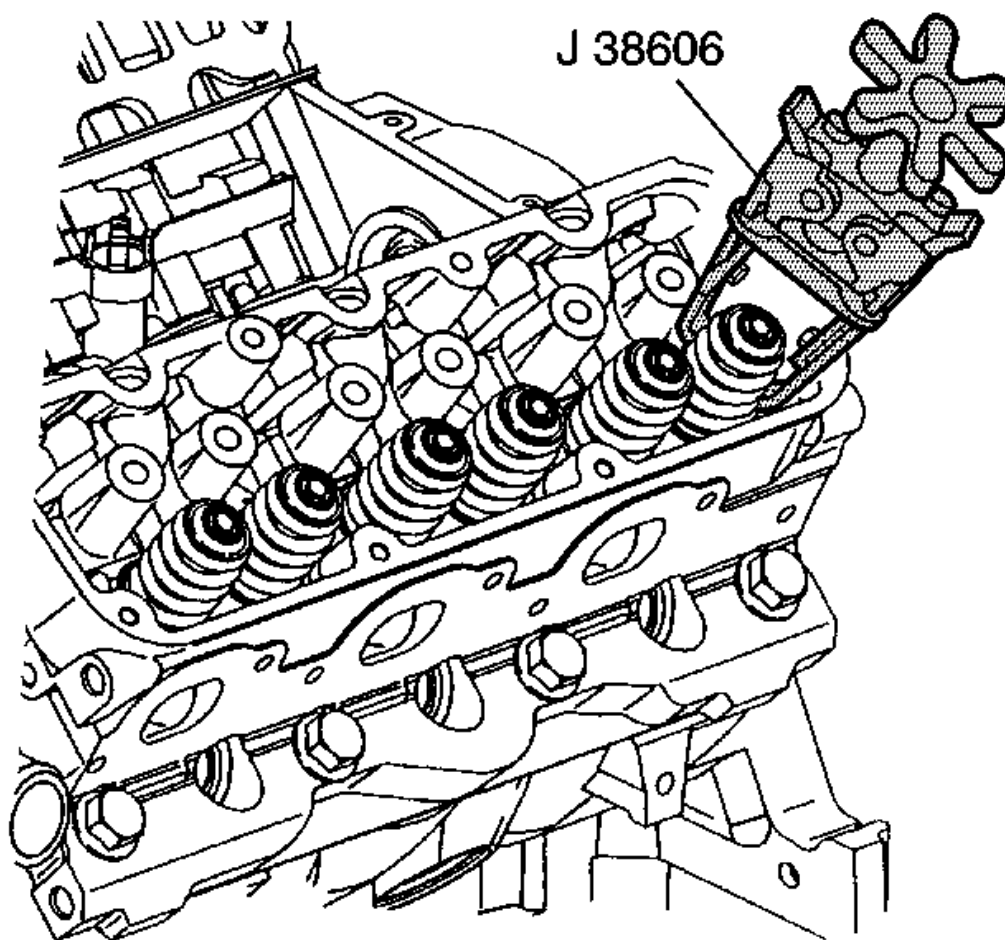


Fig. 63: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 38606** in order to install the valve spring. Install the valve cap.
4. Install the valve keys.
5. Repeat the previous steps for each valve.
6. Depressurize the cylinder.
7. Remove the **J 22794** . See Special Tools and Equipment.
8. Install the spark plug.

9. Install the valve rocker arm assemblies. Refer to Valve Rocker Arm and Push Rod Replacement.

Valve Lifter Replacement

Removal Procedure

IMPORTANT: Keep all of the valve train parts in order. Reinstall the valve train parts in their original locations and with the same mating surfaces as when removed.

1. Remove the rocker arms, pushrods, and the pedestals. Refer to Valve Rocker Arm and Push Rod Replacement.
2. Remove the lower intake manifold and gaskets. Refer to Intake Manifold Replacement - Lower.

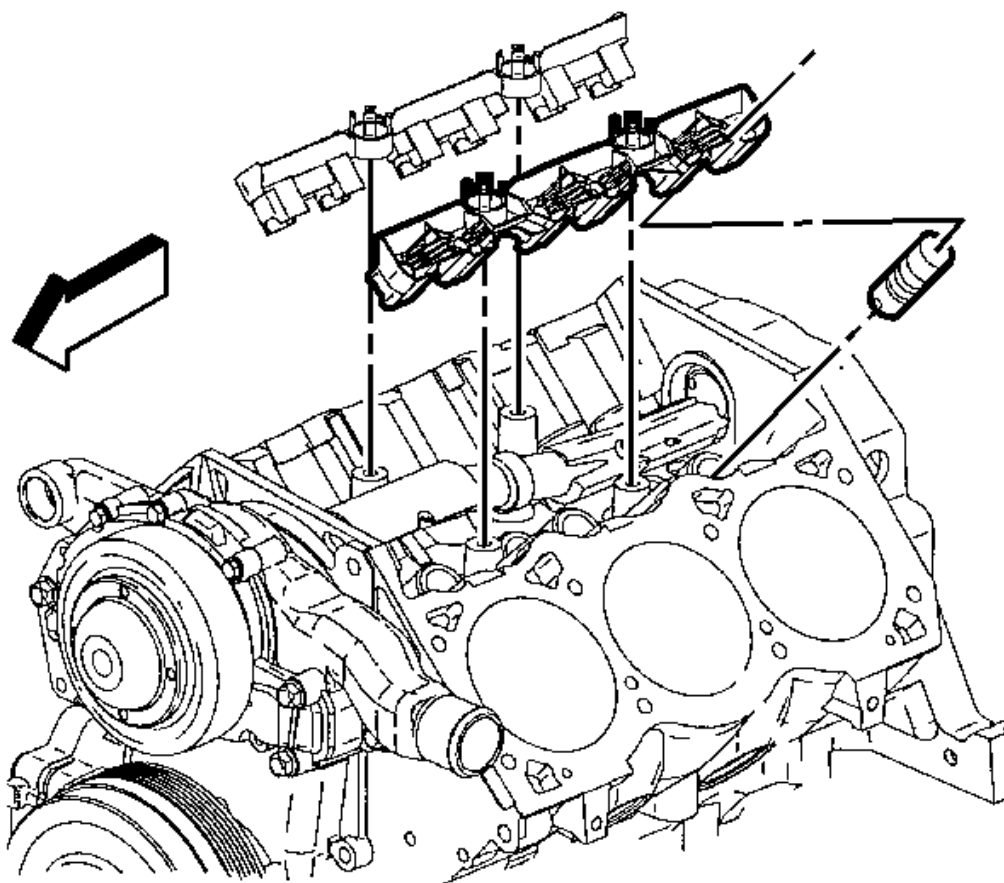


Fig. 64: Removing/Installing Valve Lifters & Guides

Courtesy of GENERAL MOTORS CORP.

3. Remove the valve guide retainer bolts.
4. Remove the valve guide retainer.
5. Remove the valve lifter guides.
6. Remove the valve lifters.
7. Clean and inspect the valve lifters and guides. Refer to **Valve Lifters and Guides Cleaning and Inspection** in the Engine Mechanical - 3.8L Unit Repair.

Installation Procedure

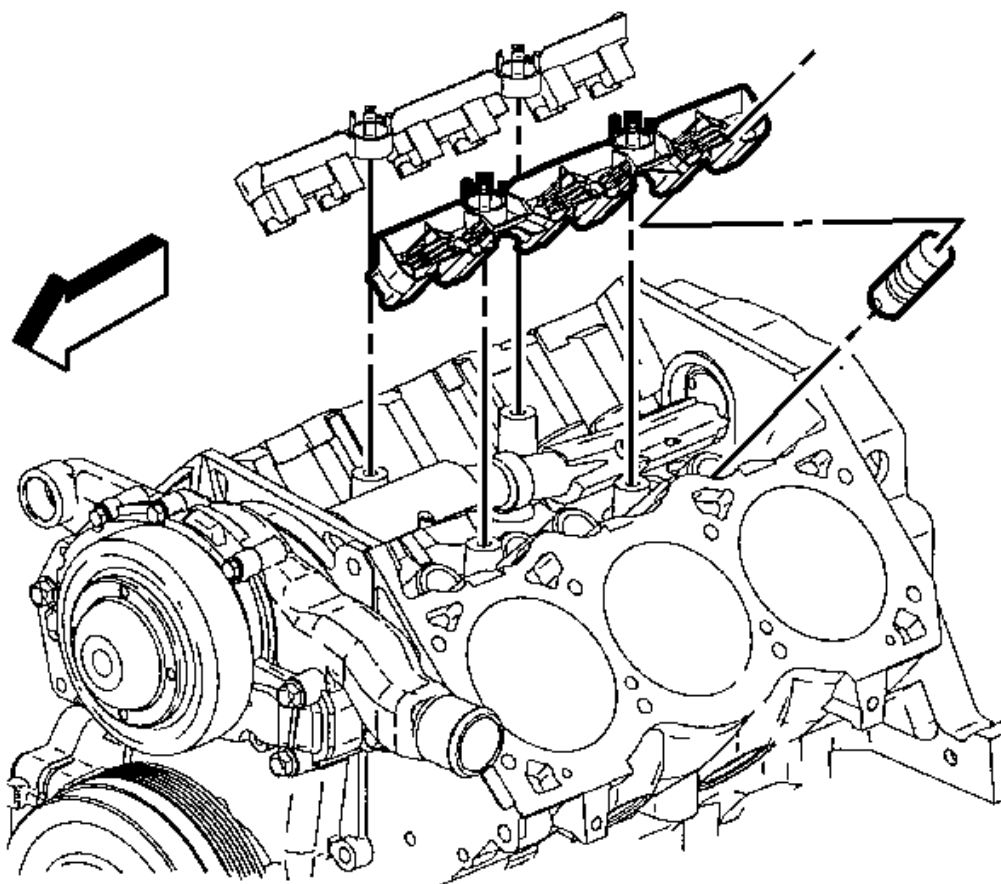


Fig. 65: Removing/Installing Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Dip the valve lifters in prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.

2. Install the valve lifters.
3. Install the valve lifter guides.
4. Install the valve guide retainer.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the valve guide retainer bolts.

Tighten: Tighten the valve guide retainer bolts to 30 N.m (22 lb ft).

6. Install the lower intake manifold and gaskets. Refer to **Intake Manifold Replacement - Lower**.
7. Install the valve rocker arms, pushrods, and the pedestals. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Crankshaft Balancer Replacement

Tools Required

- **J 45059** Torque Angle Meter. See **Special Tools and Equipment**.
- **J 37096** Flywheel Holding Tool. See **Special Tools and Equipment**.
- **J 38197-A** Crankshaft Balancer Remover. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.

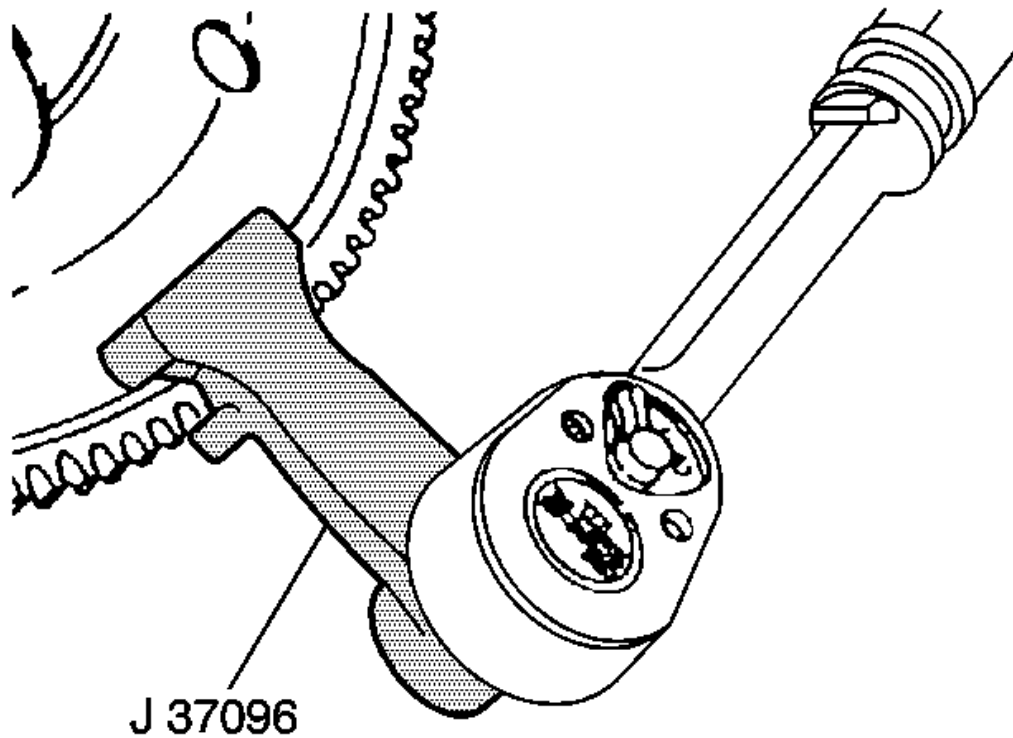


Fig. 66: Holding Flywheel

Courtesy of GENERAL MOTORS CORP.

3. Use the **J 37096** in order to hold the flywheel. See **Special Tools and Equipment**.
4. Remove the balancer bolt.

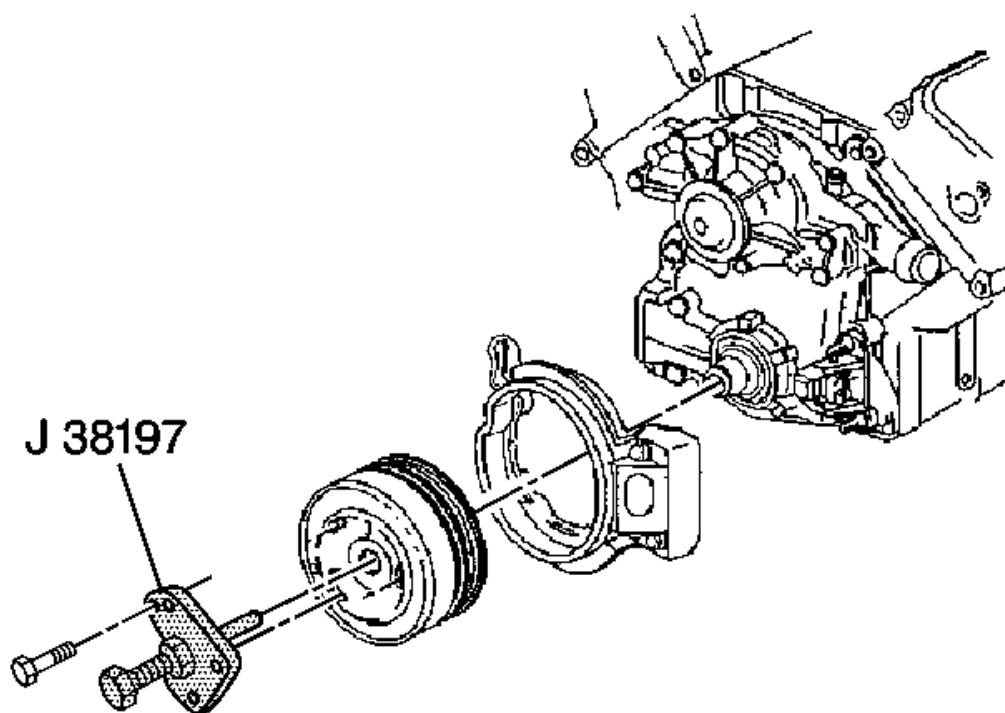


Fig. 67: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not separate the pulley from the balancer. Service the pulley and the balancer as an assembly.

5. Use the **J 38197-A** in order to remove the crankshaft balancer. See **Special Tools and Equipment**. Attach 1/4 inch bolts to the pulley. Screw the bolts in 1/4 inch.
6. Clean and inspect the crankshaft balancer. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

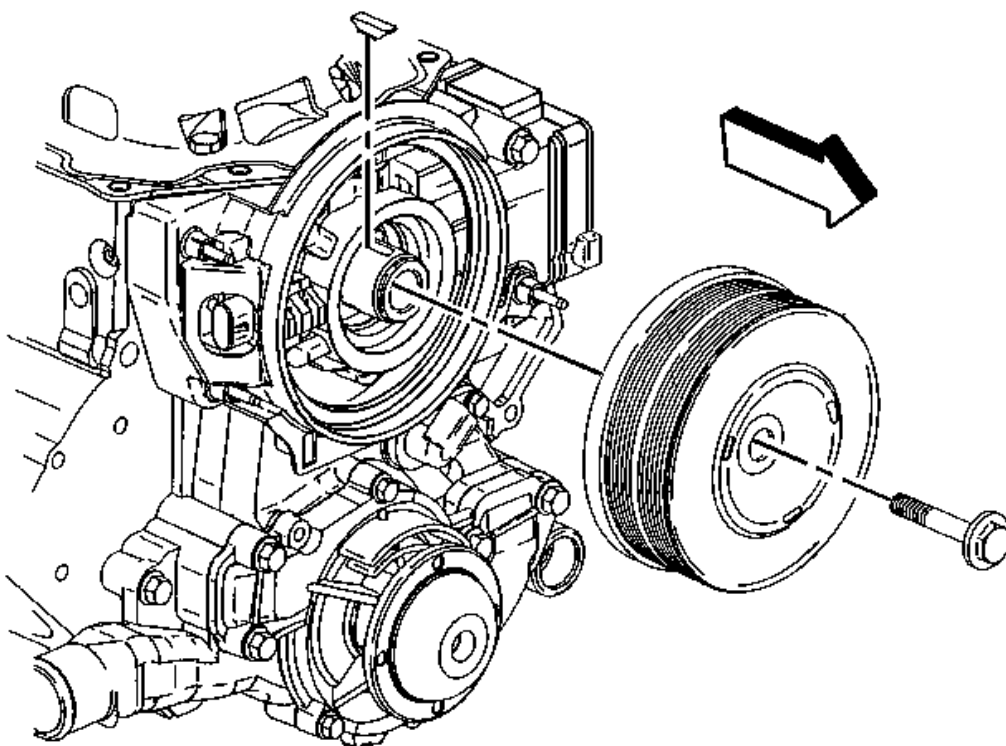


Fig. 68: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft balancer.

Lubricate the seal surface with engine oil.

2. Use the **J 37096** in order to hold the flywheel. See **Special Tools and Equipment**.

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

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

3. Install the crankshaft balancer bolt.

Tighten: Tighten the crankshaft balancer bolt to 150 N.m (111 lb ft). Use the **J 45059** in order to tighten the bolt an additional 76 degrees. See **Special Tools and Equipment**.

4. Install the right front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and

Wheels.

5. Install the drive belt. Refer to **Drive Belt Replacement**.
6. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 3.8L.

Crankshaft Front Oil Seal Replacement

Tools Required

J 35354 Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

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

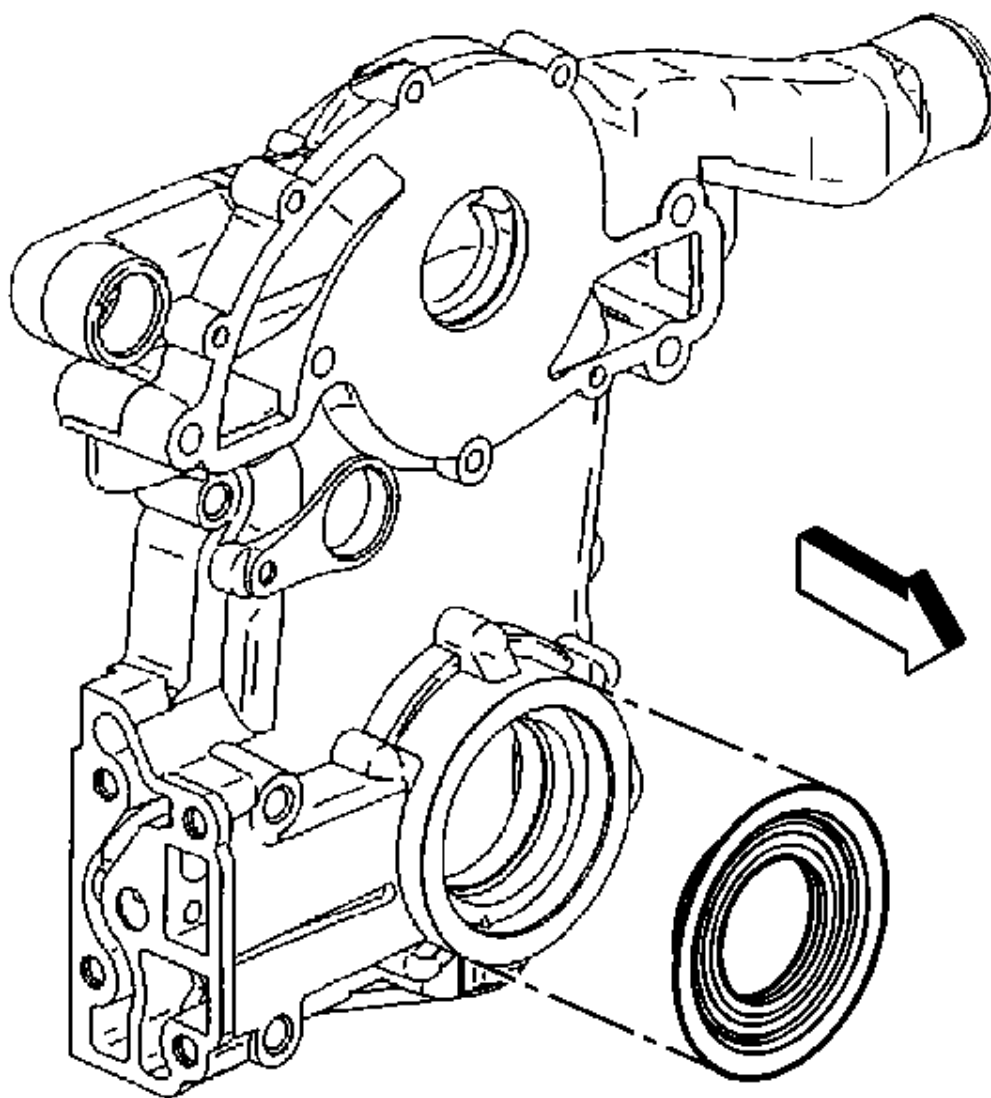


Fig. 69: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the seal bore or the contact surfaces.

2. Use a screwdriver in order to pry out the crankshaft front oil seal.

Installation Procedure

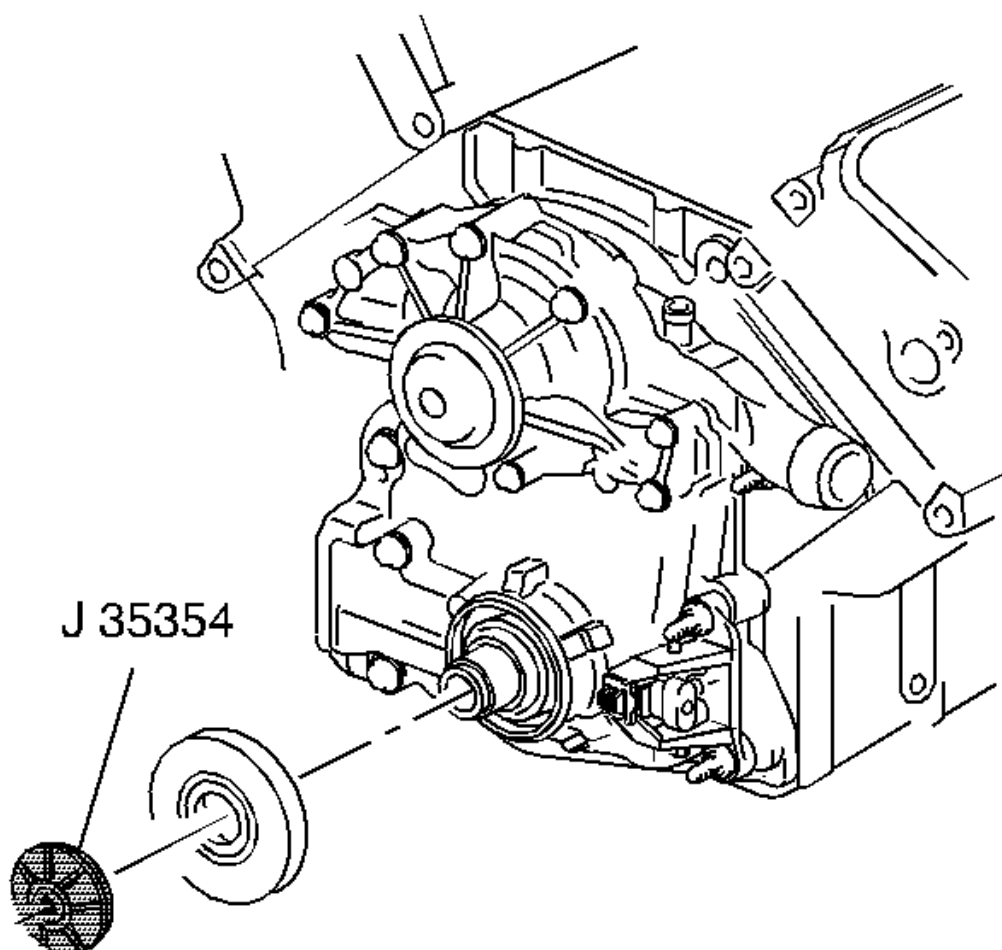


Fig. 70: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 35354** in order to install the oil seal. See **Special Tools and Equipment**.
2. Use the crankshaft balancer bolt with the tool.
3. Tighten the bolt until the crankshaft front oil seal is seated in the engine front cover.
4. Remove the **J 35354** . See **Special Tools and Equipment**.
5. Coat the inside seal surface of the crankshaft balancer with lubricant GM P/N 10522497 or equivalent.
6. Install the crankshaft balancer and the bolt. Refer to **Crankshaft Balancer Replacement**.

Engine Front Cover Replacement

Tools Required

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

Removal Procedure

1. Remove the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right**.
2. Remove the drive belt tensioner assembly. Refer to **Drive Belt Tensioner Replacement**.
3. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

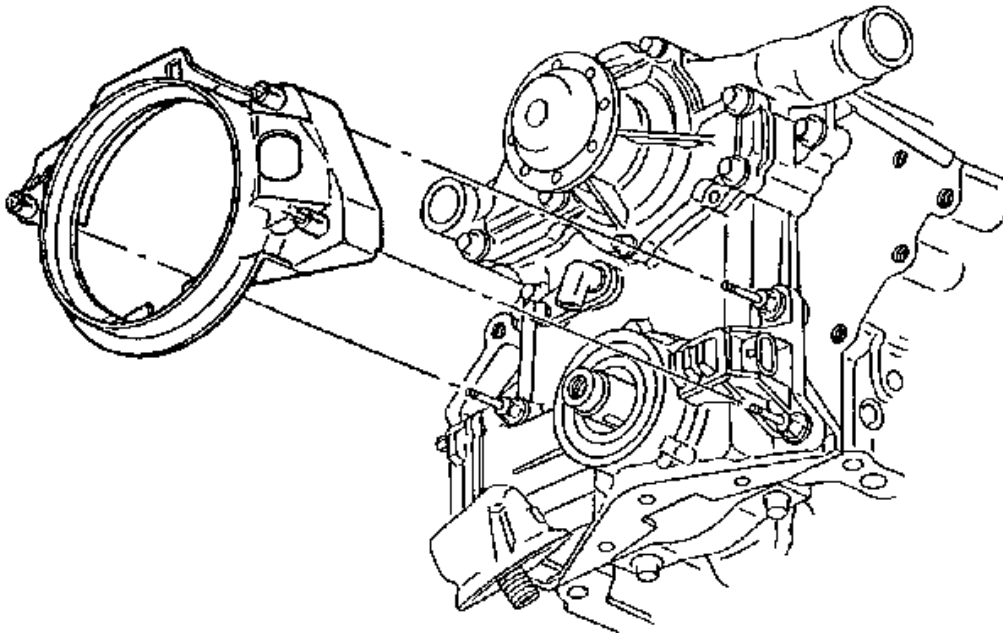


Fig. 71: Identifying Crankshaft Position Sensor Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft sensor shield.
5. Remove the crankshaft sensor.
6. Remove the oil pan to engine front cover bolts.

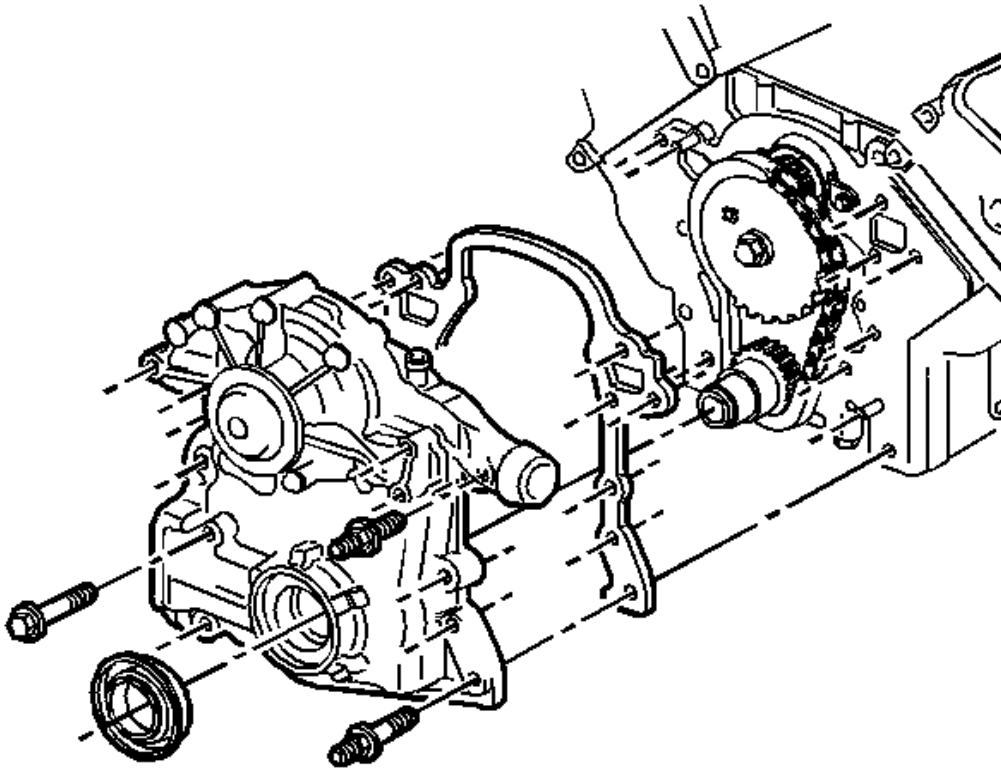


Fig. 72: Identifying Engine Front Cover Components
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine front cover attaching bolts.
8. Remove the engine front cover.
9. Inspect the timing chain for overall in and out movement. Movement should not exceed 25 mm (1 in).
10. Inspect the timing sprockets for wear.
11. Clean the gasket mating surfaces at the cylinder block.
12. If the oil pan gasket is excessively swollen, the oil pan must be removed and the gasket replaced.
13. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

Installation Procedure

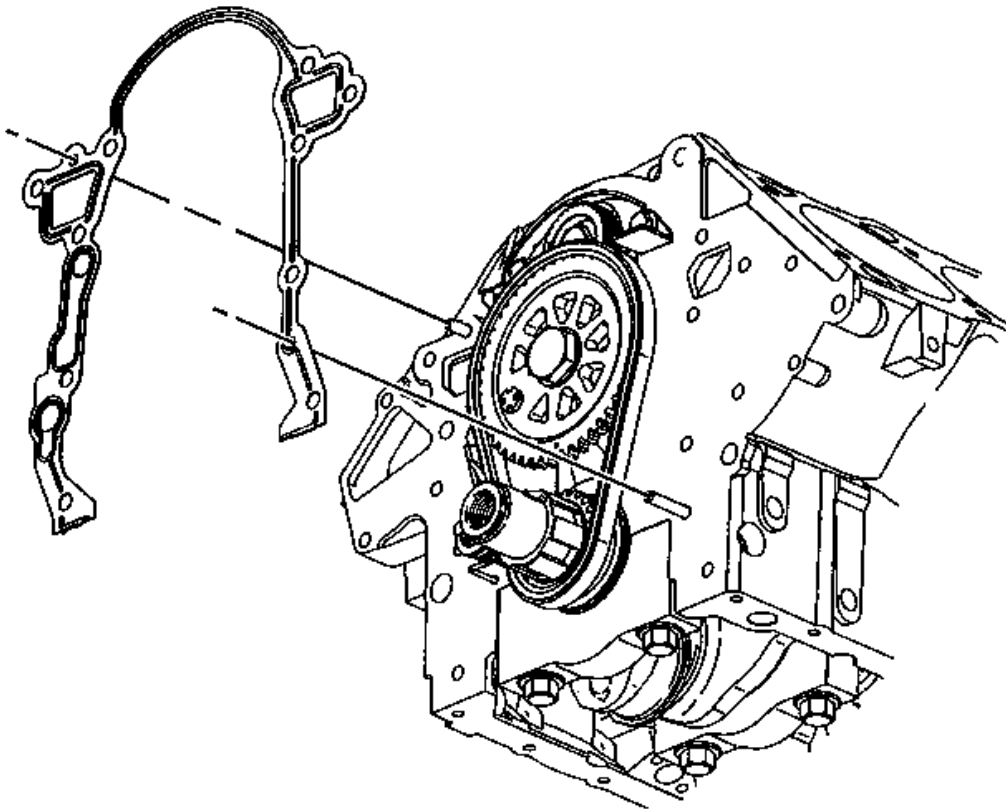


Fig. 73: Identifying Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover gasket.

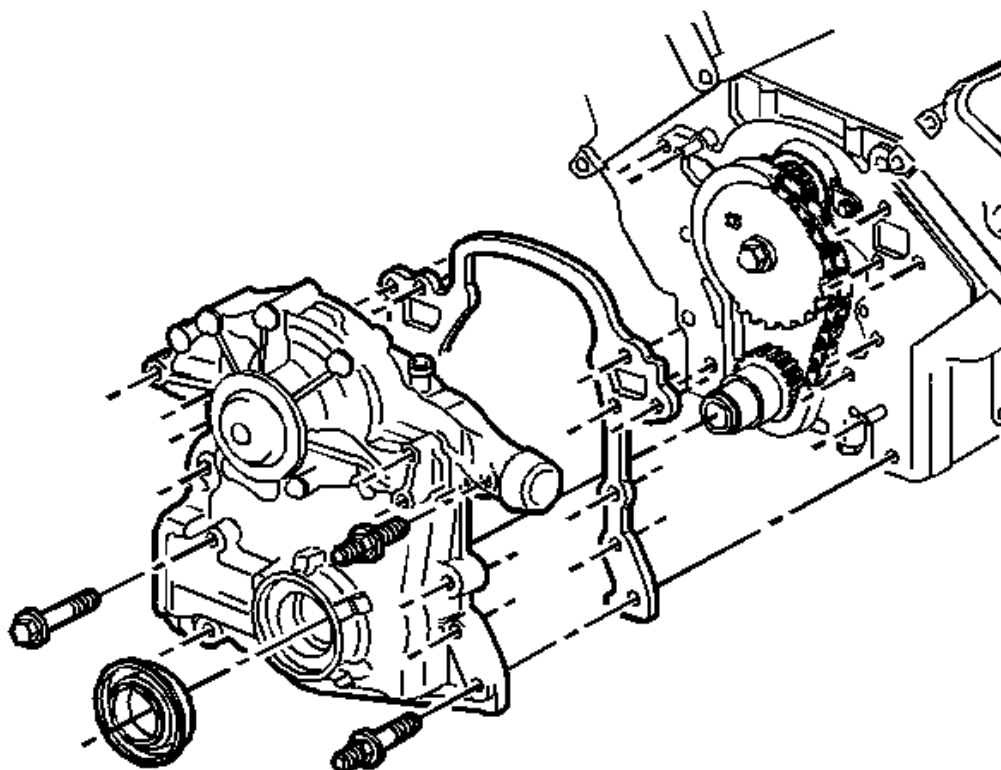


Fig. 74: Identifying Engine Front Cover Components
Courtesy of GENERAL MOTORS CORP.

2. Install the engine front cover.
3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the engine front cover attaching bolts.

Tighten: Tighten the engine front cover bolts to 20 N.m (15 lb ft). Use the **J 45059** in order to rotate the bolts an additional 40 degrees. See Special Tools and Equipment.

5. Install the oil pan to the engine front cover bolts.

Tighten: Tighten the oil pan bolts to 14 N.m (125 lb in).

6. Install the drive belt tensioner assembly. Refer to Drive Belt Tensioner Replacement.

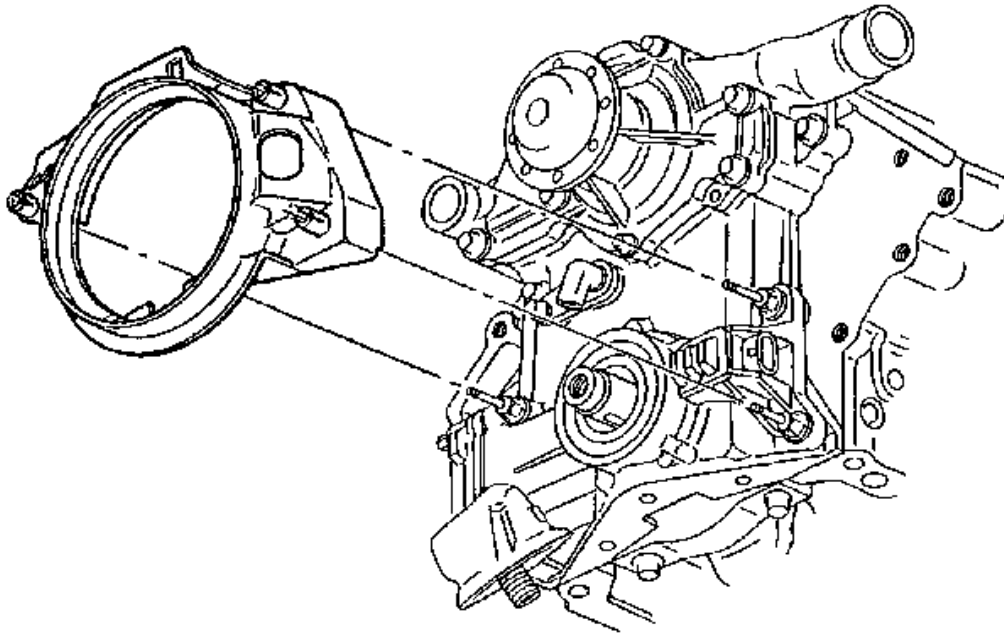


Fig. 75: Identifying Crankshaft Position Sensor Shield
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not adjust the crankshaft sensor.

7. Install the crankshaft sensor.
8. Install the crankshaft sensor shield.
9. Install the crankshaft balancer and bolt. Refer to **Crankshaft Balancer Replacement**.
10. Install the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right**.

Oil Pump Cover and Gear Set Replacement

Removal Procedure

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the oil filter adapter.
3. Remove the pressure regulator valve and the spring. Refer to **Oil Filter Adapter and Bypass Valve Assembly Replacement**.

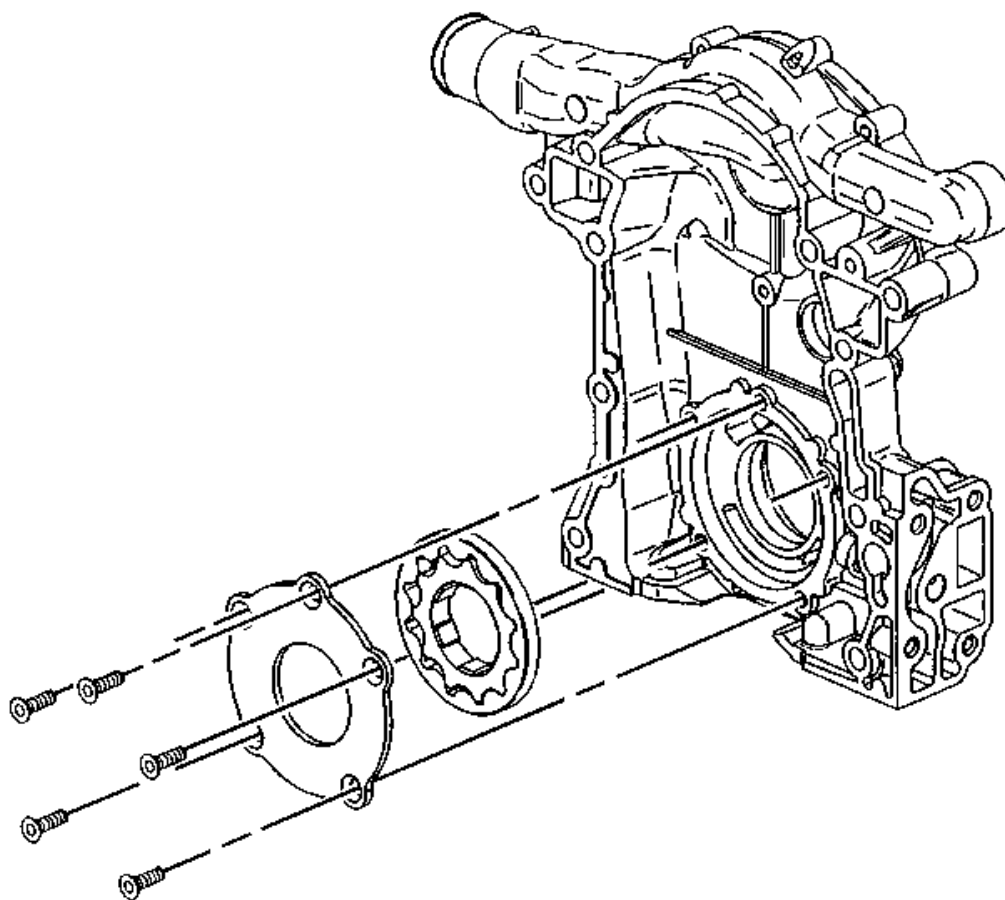


Fig. 76: Identifying Oil Pump Cover & Gear Set
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover attaching screws.
5. Remove the oil pump cover.
6. Remove the oil pump gear set.
7. Clean and inspect the oil pump gear set and housing. Refer to **Oil Pump Cleaning and Inspection** in the Engine Mechanical - 3.8L Unit Repair.

Installation Procedure

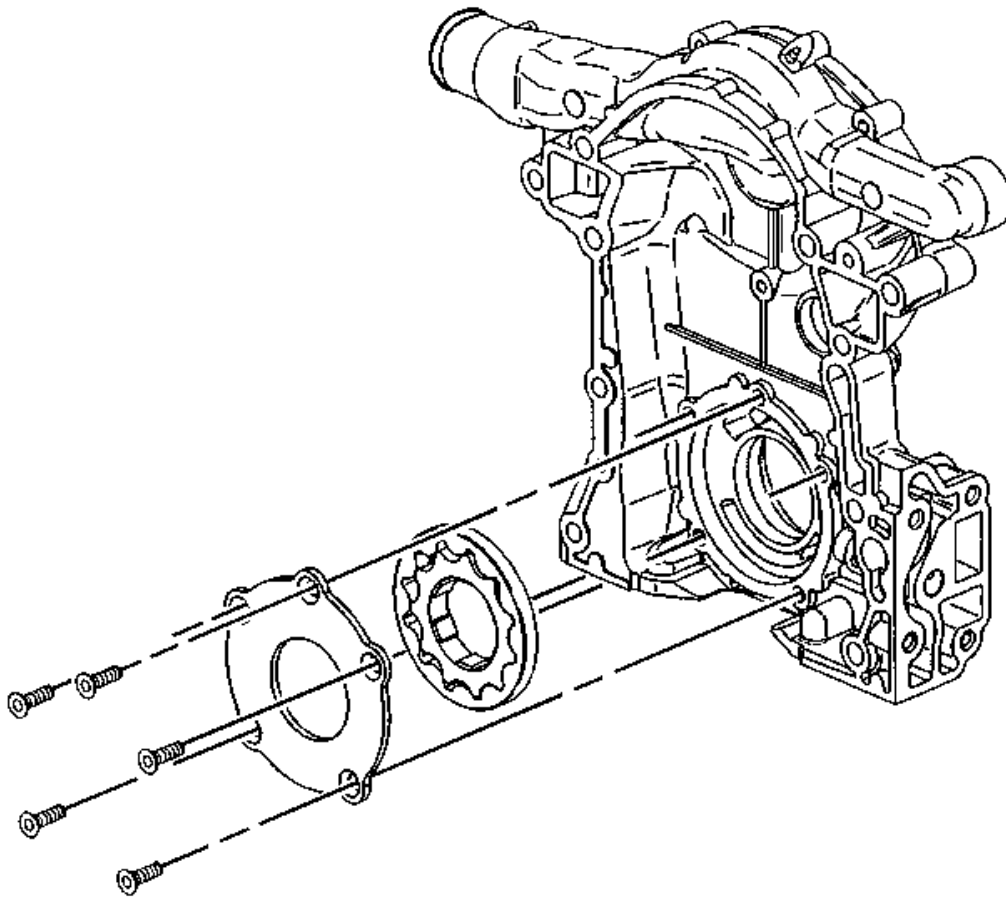


Fig. 77: Identifying Oil Pump Cover & Gear Set
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil pump gears with petroleum jelly.
2. Install the oil pump gear set.
3. Pack the oil pump gears with petroleum jelly.
4. Install the oil pump cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pump cover screws.

Tighten: Tighten the oil pump cover screws to 11 N.m (98 lb in).

6. Install the oil filter adapter with a new gasket. Install the pressure regulator valve and the spring. Refer to **Oil Filter Adapter and Bypass Valve Assembly Replacement**.
7. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

NOTE: Do not run the engine until the oil pressure is tested. Running the engine without measurable oil pressure will cause extensive damage.

NOTE: Stop the engine and remove the oil pan if the oil pressure does not build up immediately. Check the oil pump pipe and the screen for a clogged screen, damaged pipe, or a damaged gasket. Running the engine without measurable oil pressure will cause extensive damage.

8. Inspect the oil pressure.
9. Inspect for the proper fluid levels.
10. Inspect for leaks.

Oil Filter Adapter and Bypass Valve Assembly Replacement

Tools Required

- **J 45059** Torque Angle Meter. See **Special Tools and Equipment**.
- **J 41712** Oil Pressure Switch Socket. See **Special Tools and Equipment**.

Removal Procedure

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

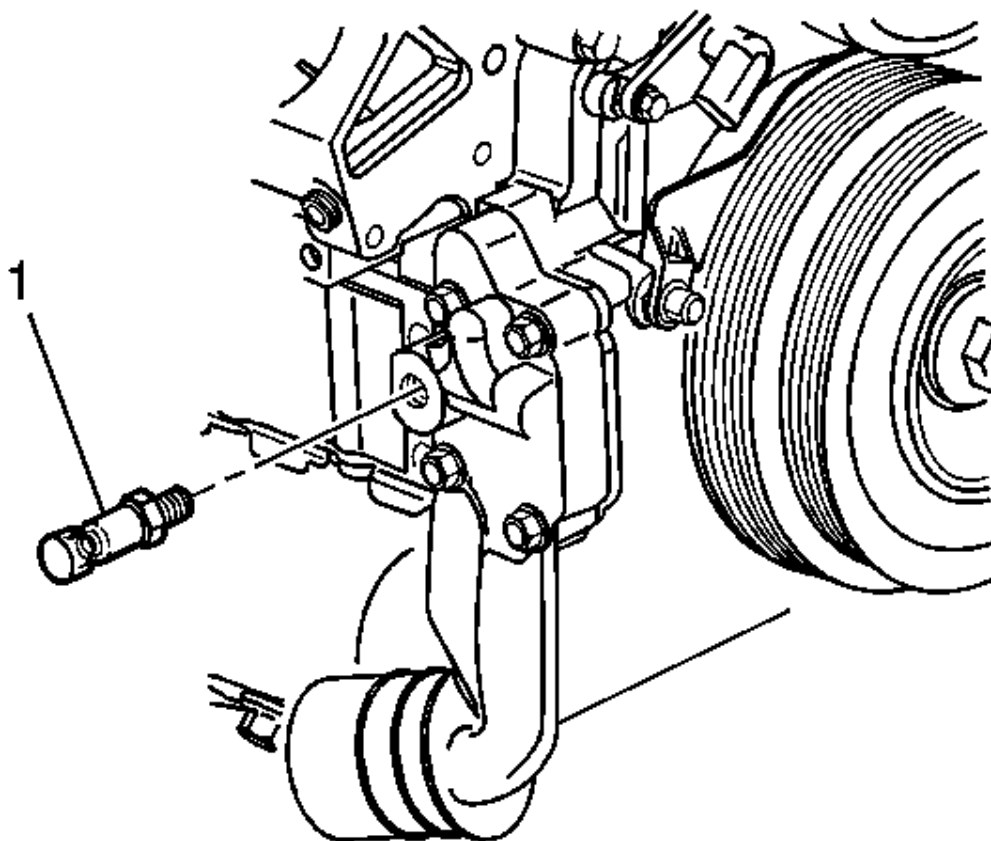


Fig. 78: Locating Engine Oil Pressure Sensor/Switch
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the electrical connector from the engine oil pressure switch (1).
3. Remove the engine oil pressure switch (1) from the oil filter adapter using the **J 41712** . See **Special Tools and Equipment**.

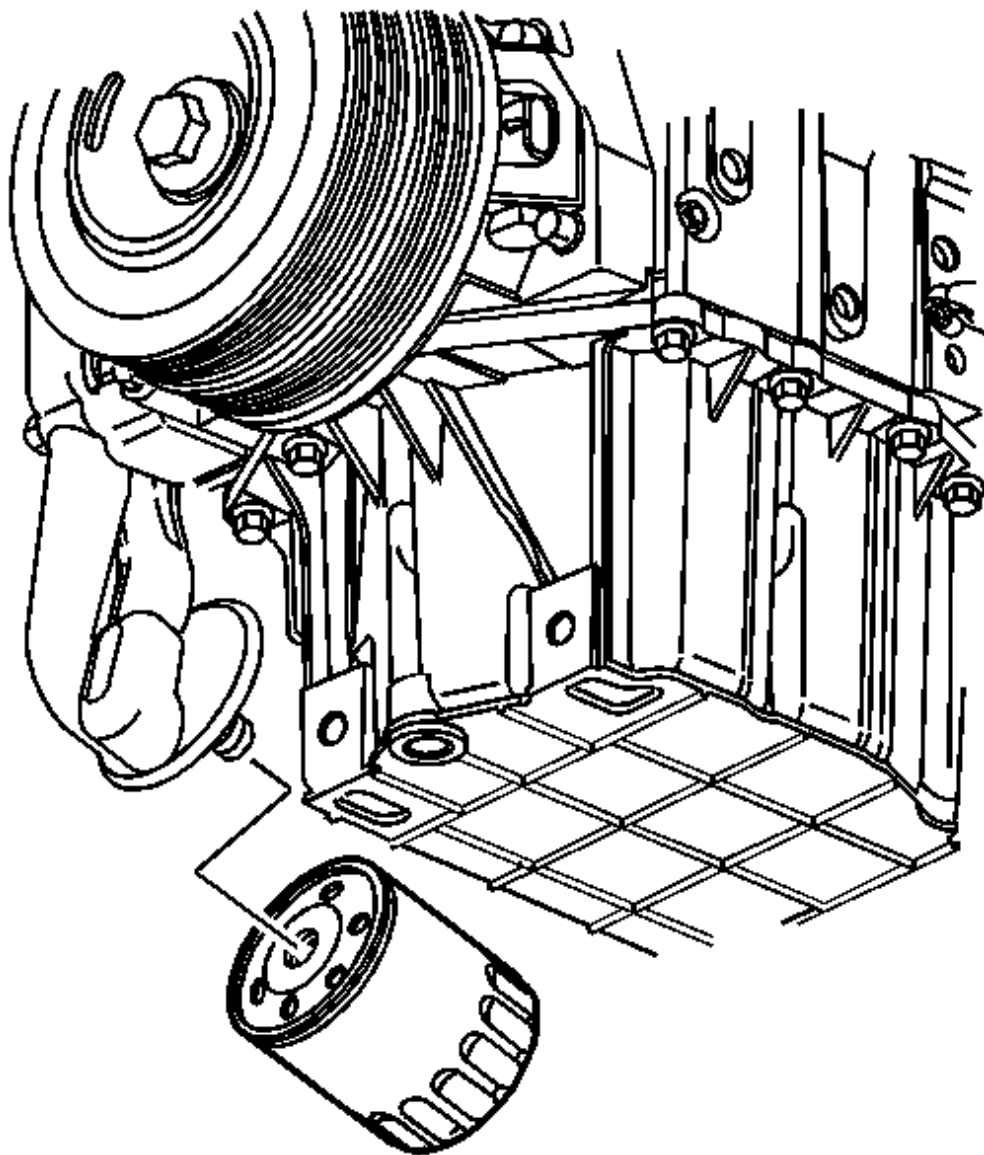


Fig. 79: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter.

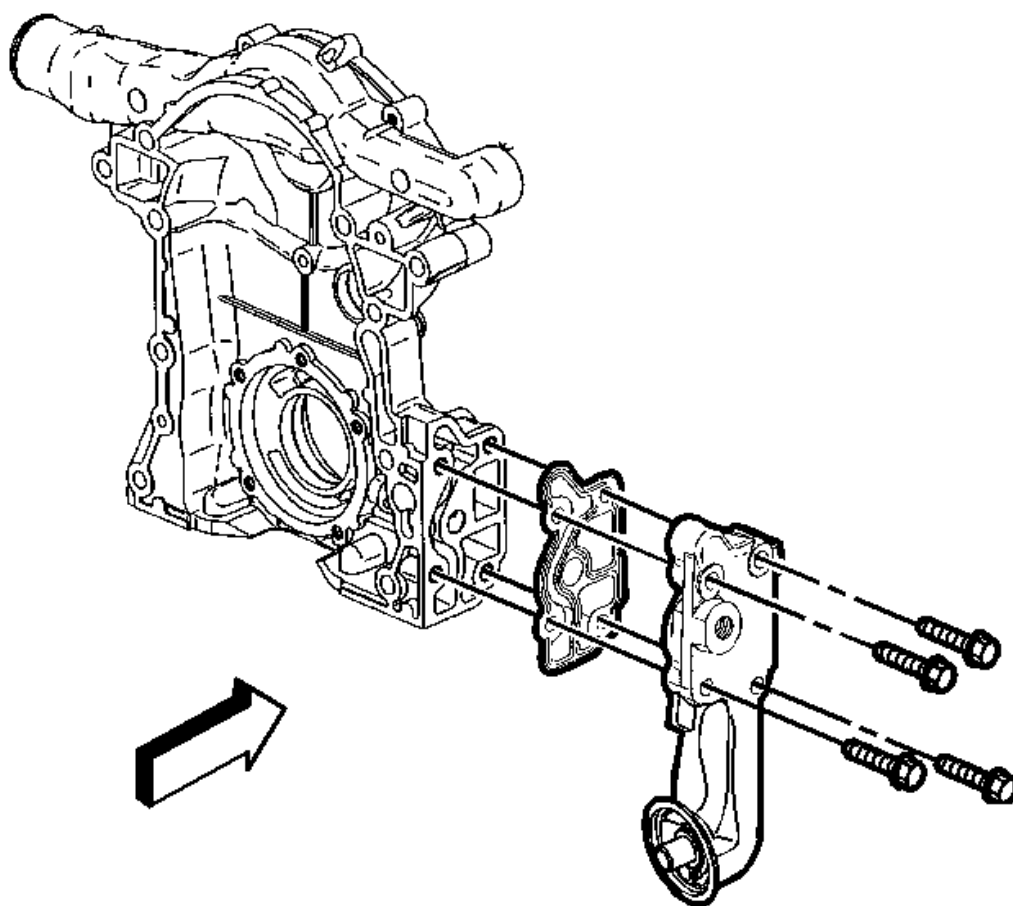


Fig. 80: Locating Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

5. Remove the 3 oil filter adapter bolts from the engine front cover.
6. Remove the following components:
 1. The oil filter adapter.
 2. The oil filter adapter gasket.
 3. The oil pressure relief valve.
 4. The oil pressure relief valve spring.
7. Clean all parts in a suitable solvent and allow to dry.
8. Inspect the following components:
 - Oil pressure valve for burrs
 - Valve bore for burrs

- Valve spring for loss of tension

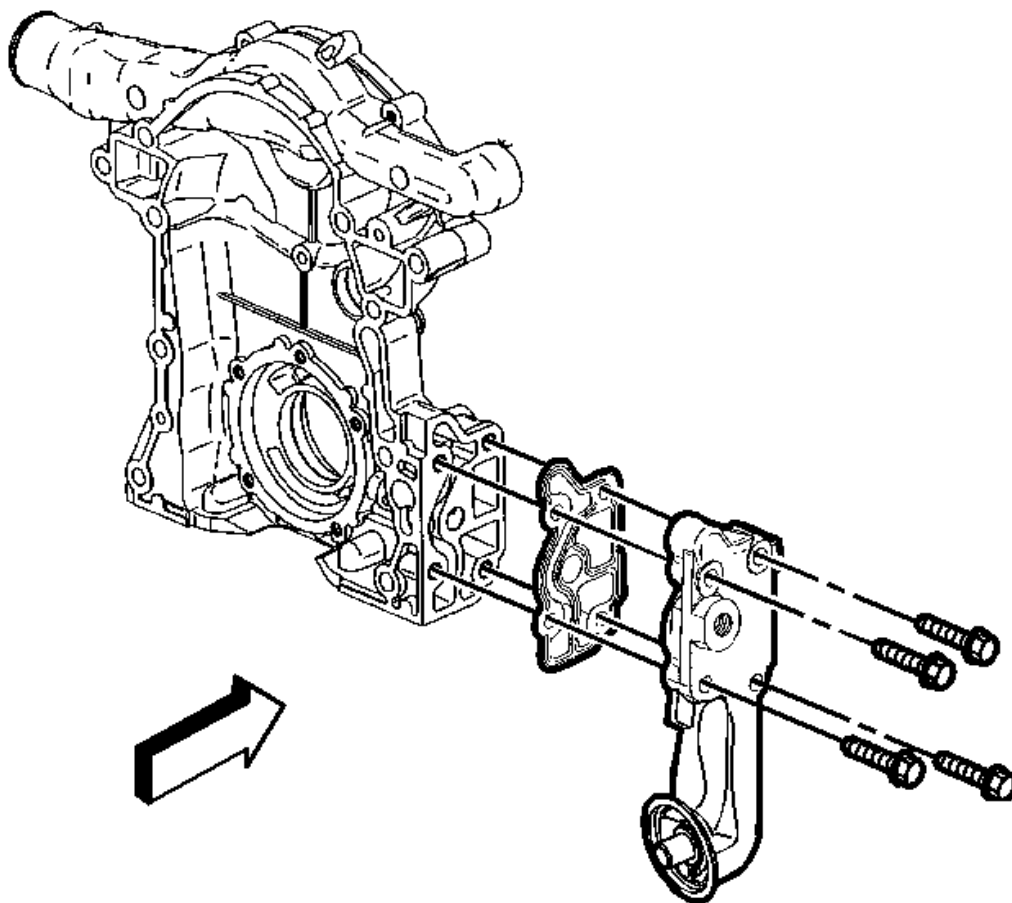
Installation Procedure

Fig. 81: Locating Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

1. Install the spring into the engine front cover.
2. Install the oil pressure valve into the engine front cover.
3. Install a new oil filter adapter gasket.
4. Install the oil filter adapter.

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

5. Install the oil filter adapter bolts.

Tighten: Tighten the oil filter adapter bolts to 15 N.m (11 lb ft). Use the **J 45059** to tighten the oil filter adapter bolts an additional 50 degrees. See Special Tools and Equipment.

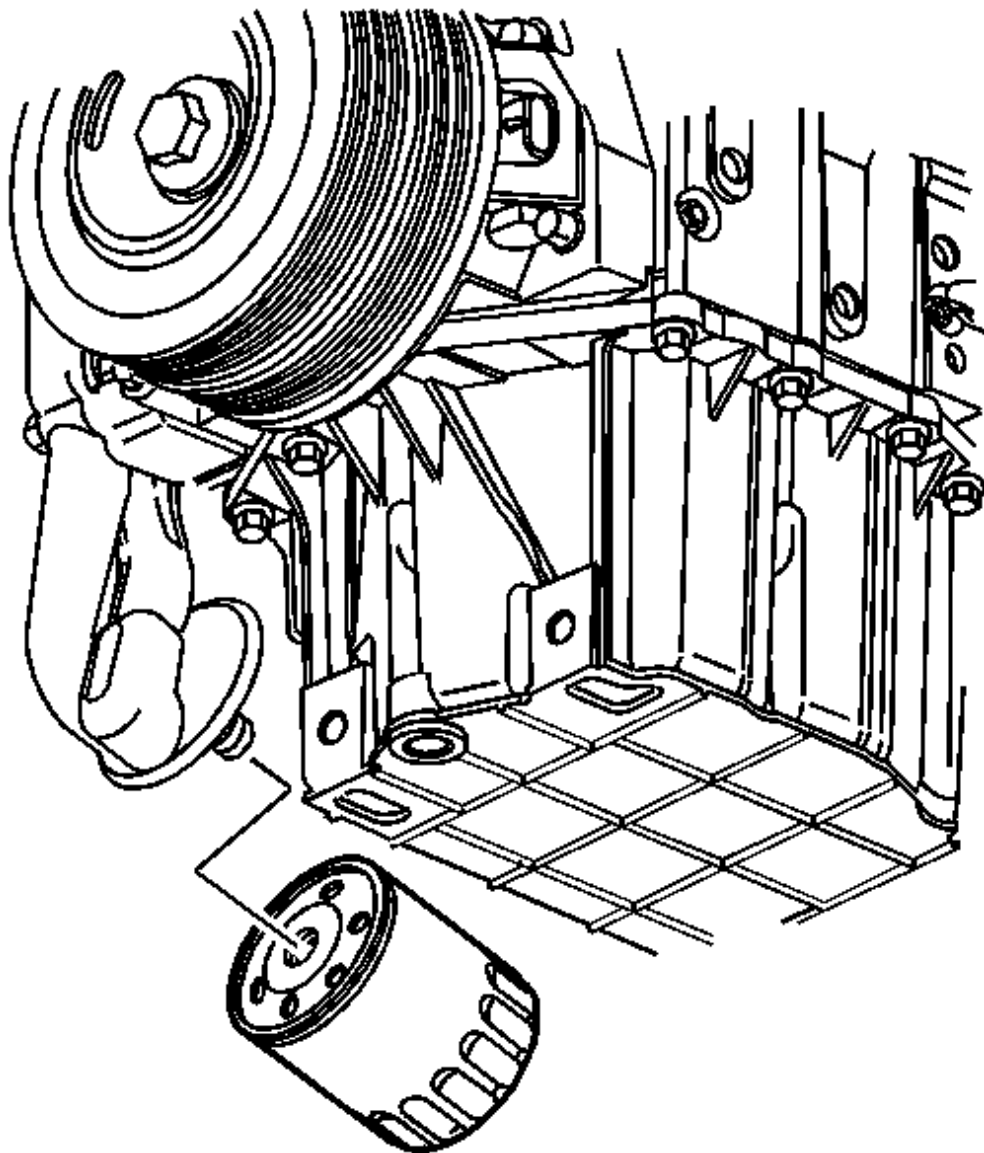


Fig. 82: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Lightly oil the replacement oil filter gasket with clean oil.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

7. Install the new oil filter.

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

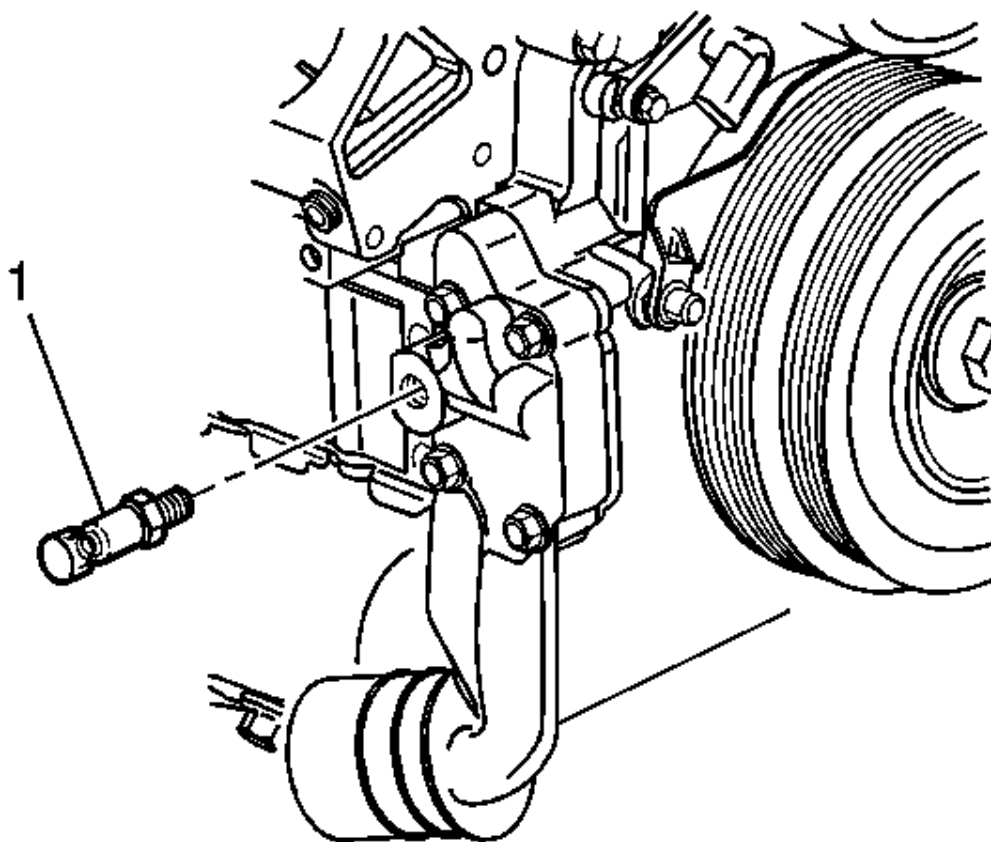


Fig. 83: Locating Engine Oil Pressure Sensor/Switch
Courtesy of GENERAL MOTORS CORP.

8. Install the engine oil pressure switch (1) to the oil filter adapter using the **J 41712** . See **Special Tools and Equipment**.

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

9. Connect the electrical connector to the engine oil pressure switch (1).
10. Lower the vehicle.
11. Inspect for oil leaks after engine start up.
12. Adjust the engine oil level to the full mark.

Timing Chain and Sprockets Replacement**Tools Required**

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

Removal Procedure

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

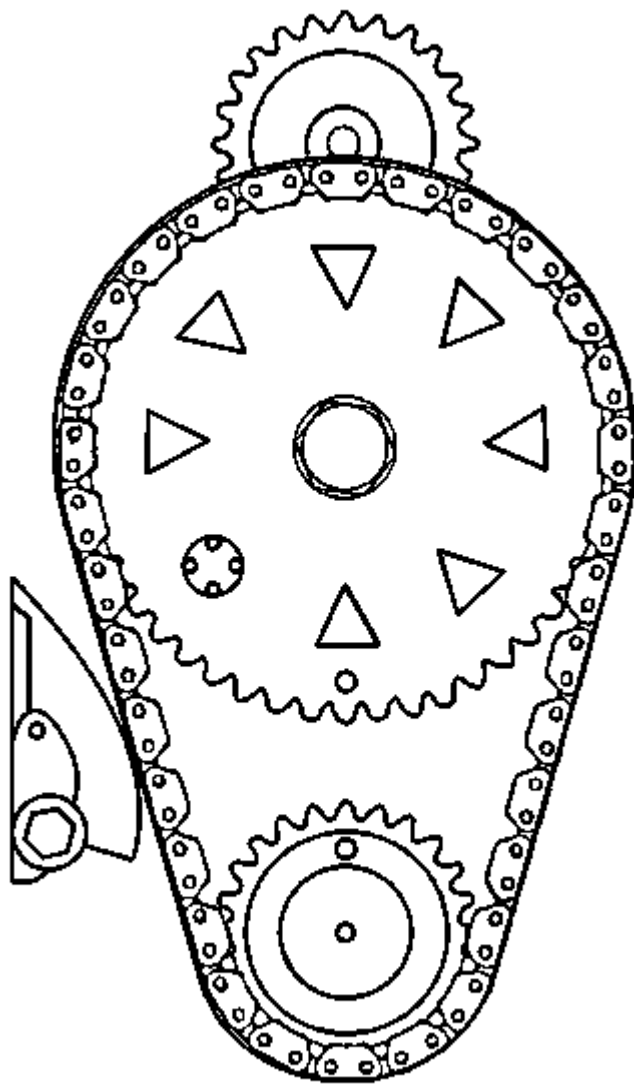


Fig. 84: Locating Sprocket Timing Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the timing marks on the timing sprockets. Position the timing marks as close together as possible.

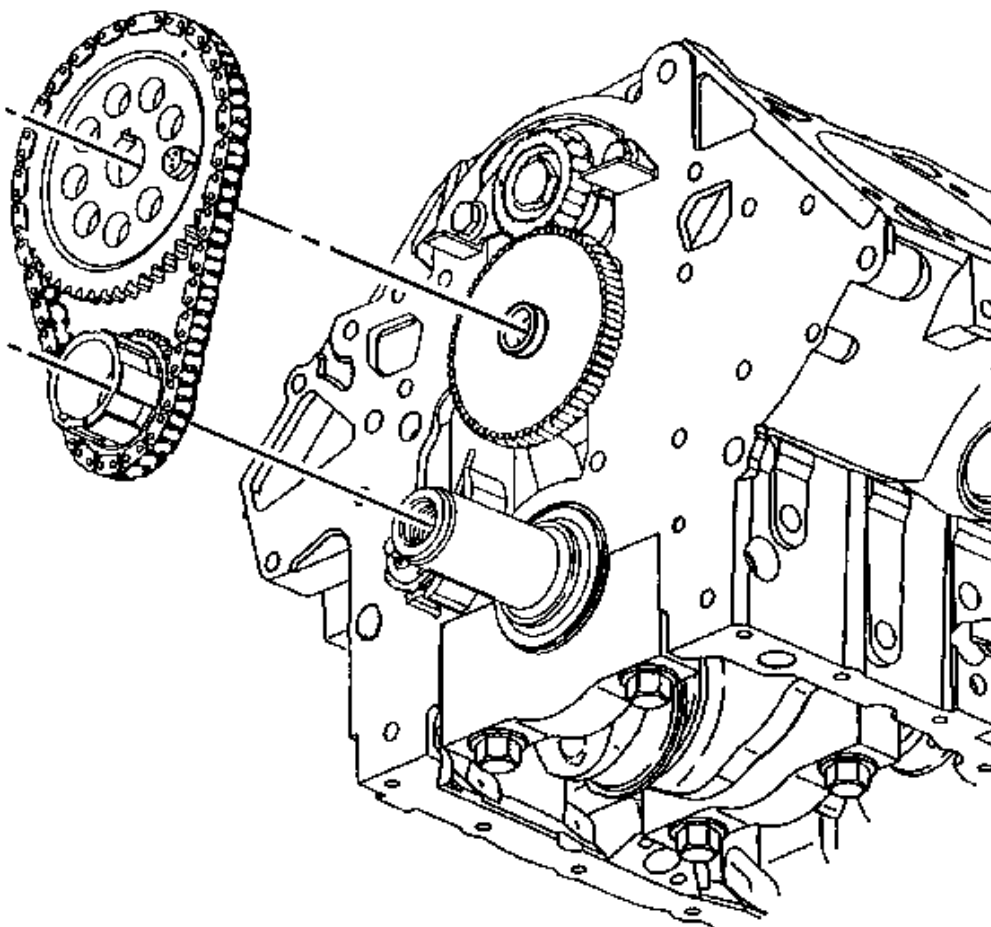


Fig. 85: Locating Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain dampener.
4. Remove the camshaft sprocket bolt.
5. Remove the camshaft sprocket.
6. Remove the timing chain.
7. Clean and inspect the timing chain and sprockets. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

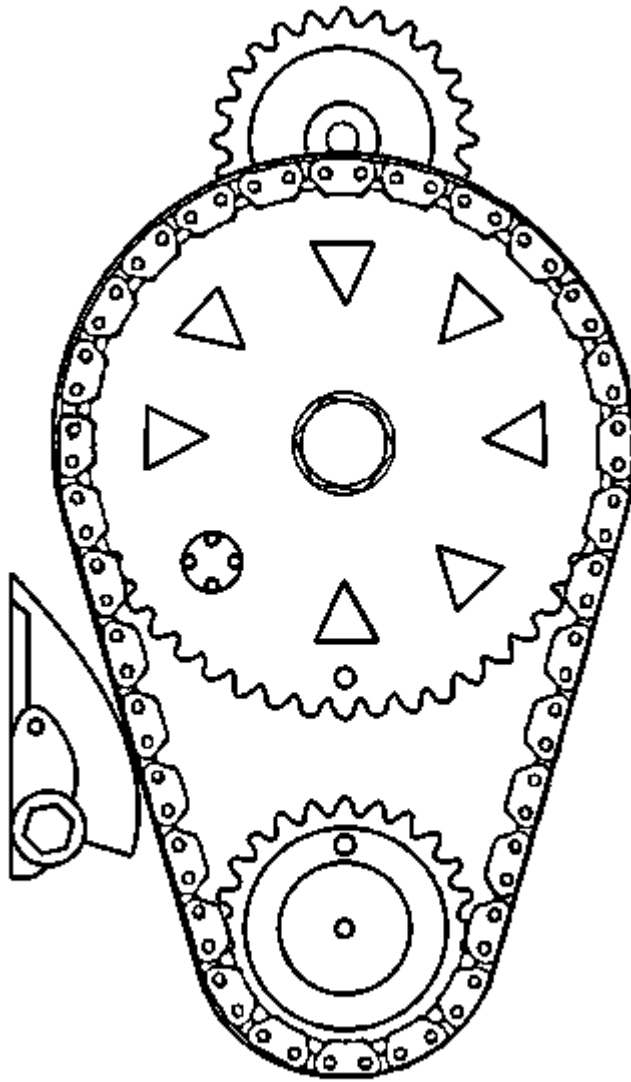


Fig. 86: Locating Sprocket Timing Alignment Marks
Courtesy of GENERAL MOTORS CORP.

1. Turn the crankshaft so that the number one piston is at top dead center.
2. Turn the camshaft so that the timing mark is straight down with the sprocket temporarily installed.
3. Assemble the timing chain on the sprockets. Ensure that the timing marks are in the closest together position.

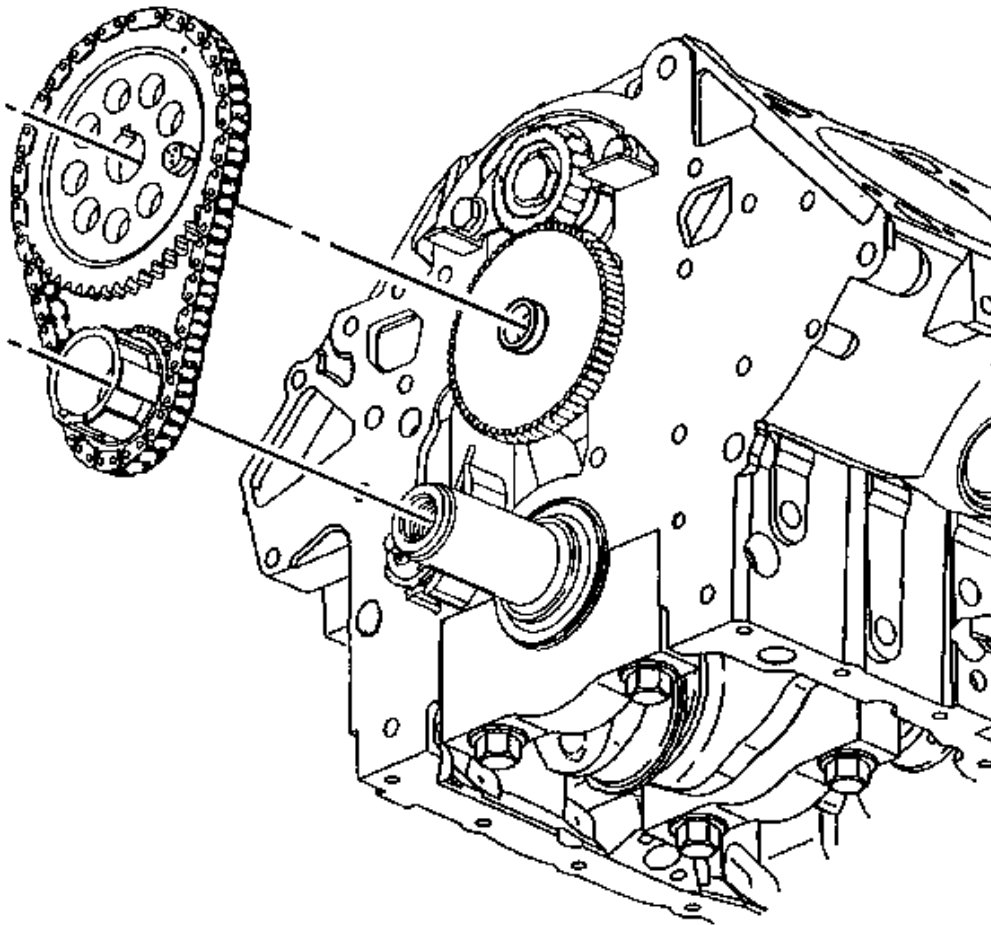


Fig. 87: Locating Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Install the timing chain and the crankshaft sprocket.
5. Install the camshaft sprocket.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the camshaft sprocket bolt.

Tighten: Tighten the camshaft sprocket bolt to 100 N.m (74 lb ft). Use the **J 45059** in order to tighten the

bolt an additional 90 degrees. See **Special Tools and Equipment**.

7. Install the timing chain dampener.
8. Install the timing chain dampener bolt.

Tighten: Tighten the timing chain dampener bolt to 22 N.m (16 lb ft).

9. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

Cylinder Head Replacement - Left

Tools Required

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

Removal Procedure

1. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.8L
3. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left (L36)** in Engine Exhaust.
4. Remove the left valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left**.
5. Remove the electronic ignition module. Refer to **Ignition Control Module Replacement** in Engine Controls - 3.8L.
6. Remove the valve rocker arm assemblies and the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

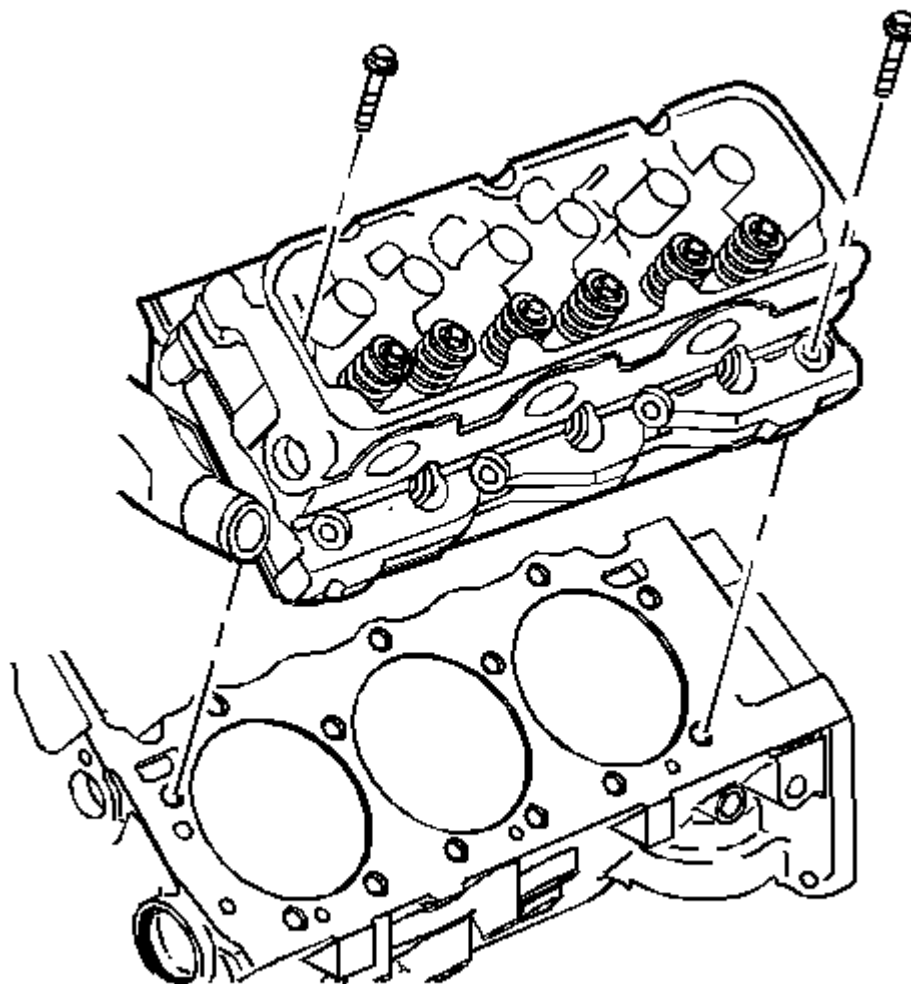


Fig. 88: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head bolts. Discard the bolts.
8. Remove the cylinder head.

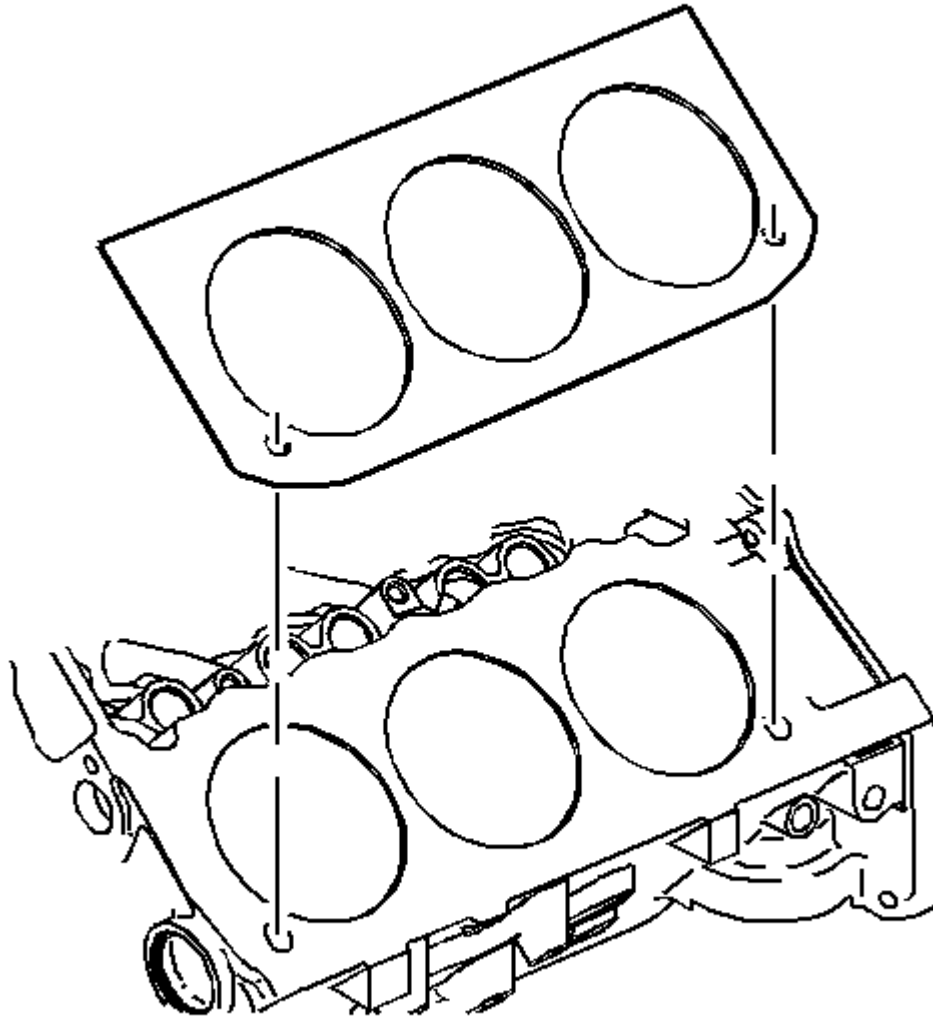


Fig. 89: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove the cylinder head gasket.
10. Clean all of the gasket mating surfaces.
11. Clean and inspect the cylinder head. Refer to Cylinder Head Cleaning and Inspection.

Installation Procedure

NOTE: This engine uses special torque to yield head bolts. This design bolt

requires a special tightening procedure. Failure to follow the given procedure will cause head gasket failure and possible engine damage.

1. Clean the threads in the block using the appropriate tap.

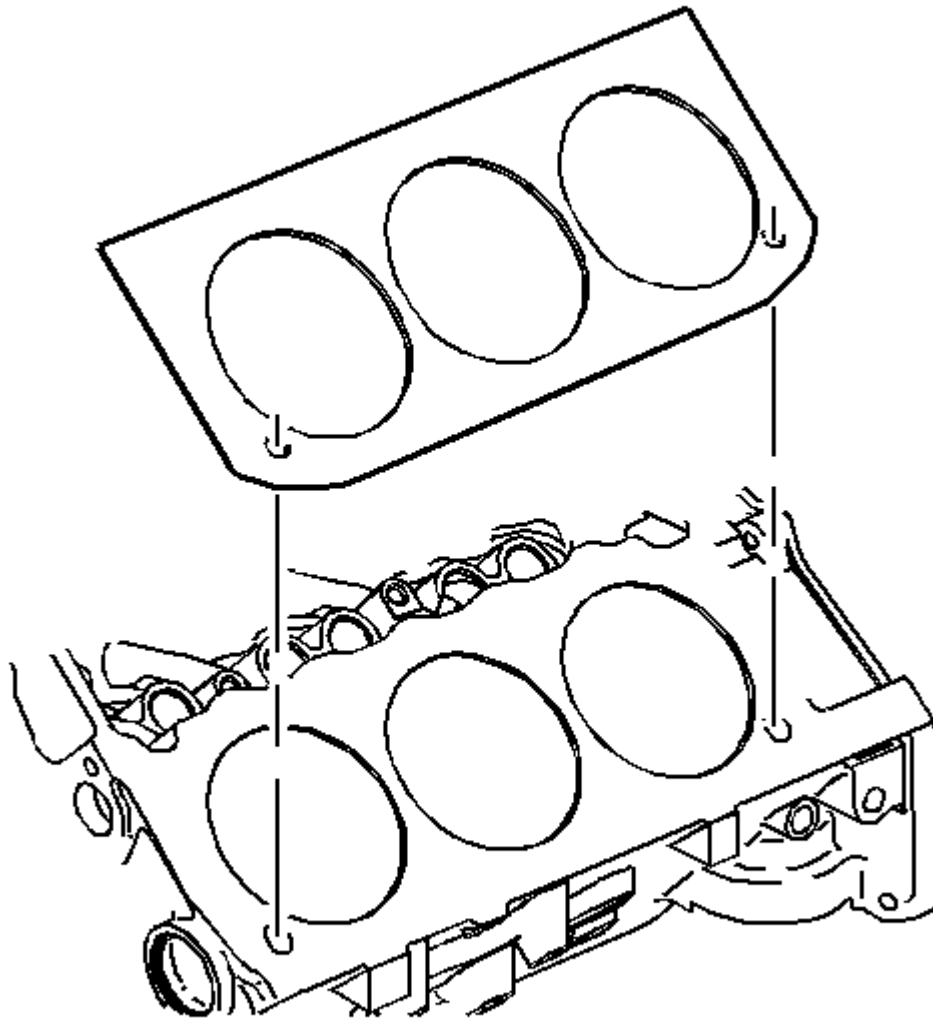


Fig. 90: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the head gasket with the arrow pointing to the front of the engine.

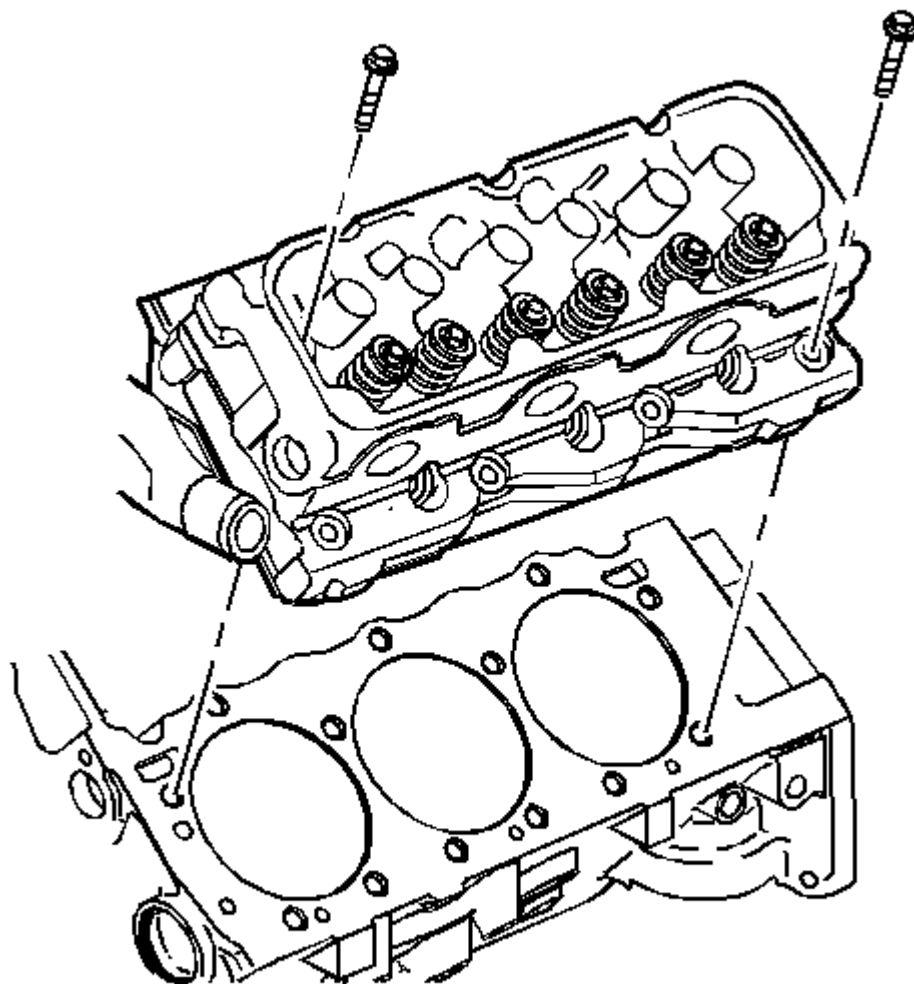


Fig. 91: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head.

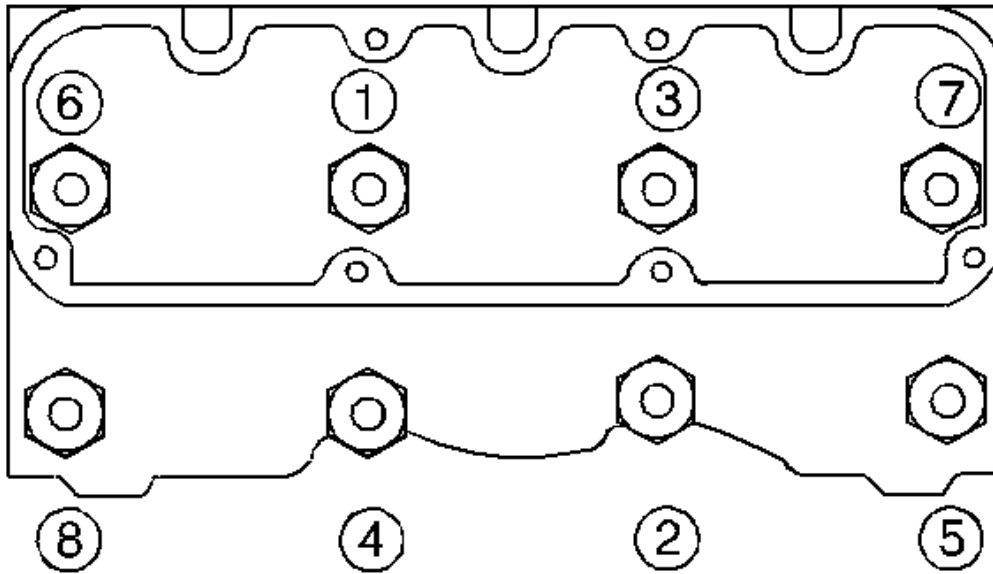


Fig. 92: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the new cylinder head bolts.

Tighten:

- Tighten the cylinder head bolts in sequence (1-8) to 50 N.m (37 lb ft).
 - Rotate each bolt 120 degrees in sequence (1-8). Use the **J 45059** . See Special Tools and Equipment.
5. Install the valve rocker arm assemblies and the pushrods. Refer to Valve Rocker Arm and Push Rod Replacement.
 6. Install the electronic ignition module. Refer to Ignition Control Module Replacement in Engine Controls - 3.8L.
 7. Install the left valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Left.
 8. Install the left exhaust manifold. Refer to Exhaust Manifold Replacement - Left (L36) in Engine Exhaust.
 9. Install the spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.8L.
 10. Install the lower intake manifold. Refer to Intake Manifold Replacement - Lower.

Cylinder Head Replacement - Right**Tools Required**

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

Removal Procedure

1. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 3.8L.
3. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right (L36)** in Engine Exhaust.
4. Remove the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Right**.
5. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
6. Remove the valve rocker arm assemblies and the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

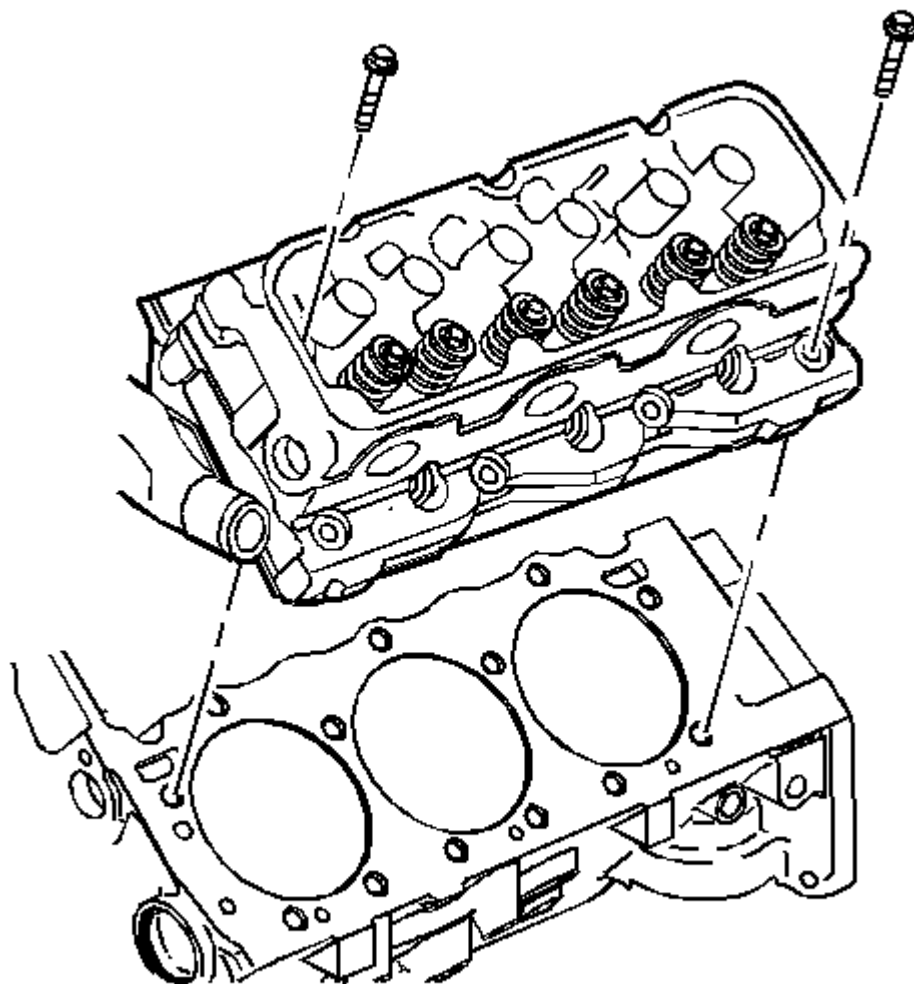


Fig. 93: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head bolts. Discard the bolts.
8. Remove the cylinder head.

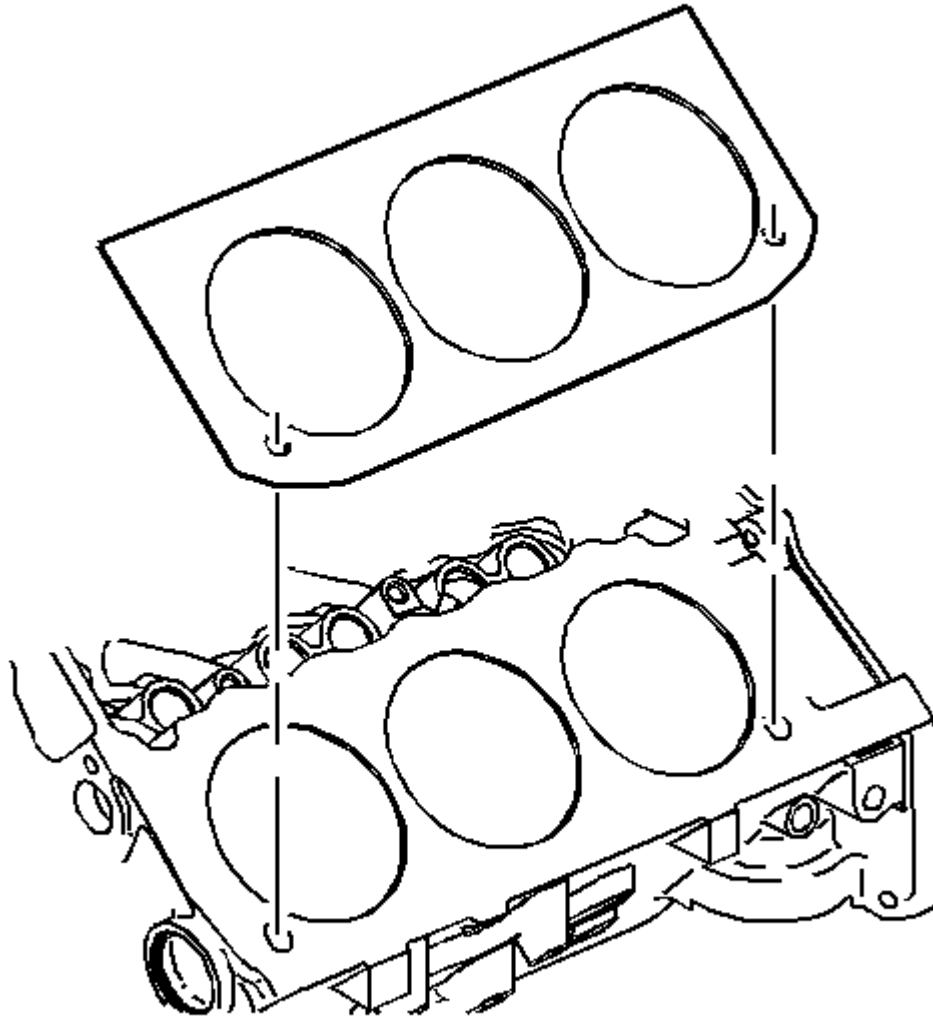


Fig. 94: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove the cylinder head gasket.
10. Clean all of the gasket mating surfaces.
11. Clean and inspect the cylinder head. Refer to Cylinder Head Cleaning and Inspection.

Installation Procedure

NOTE: This engine uses special torque to yield head bolts. This design bolt

requires a special tightening procedure. Failure to follow the given procedure will cause head gasket failure and possible engine damage.

1. Clean the threads in the block using the appropriate tap.

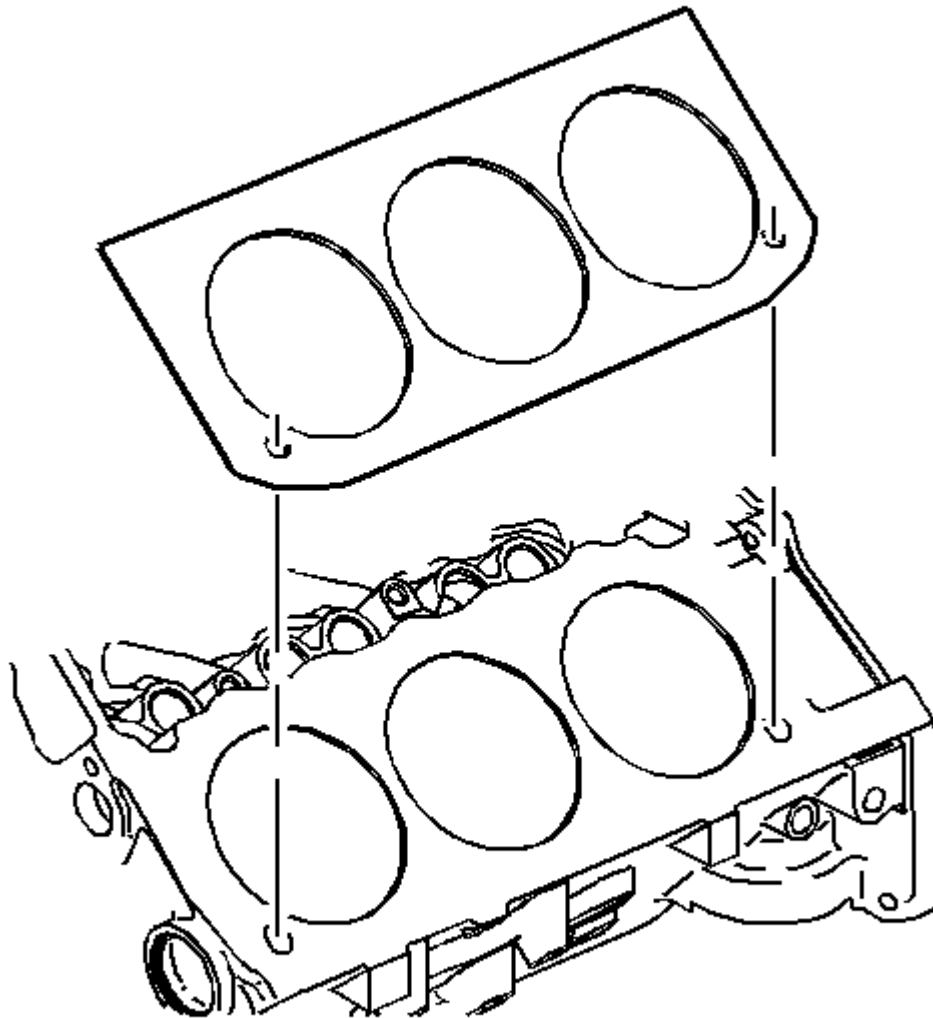


Fig. 95: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the head gasket with the arrow pointing to the front of the engine.

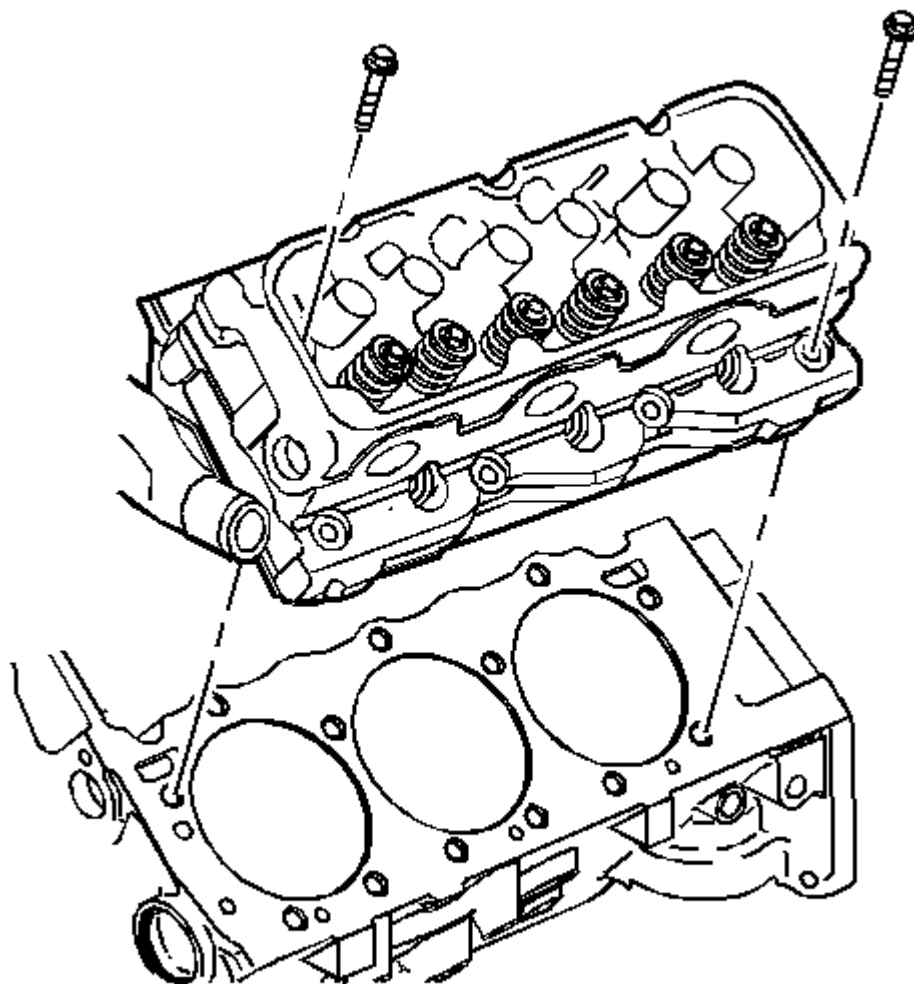


Fig. 96: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head.

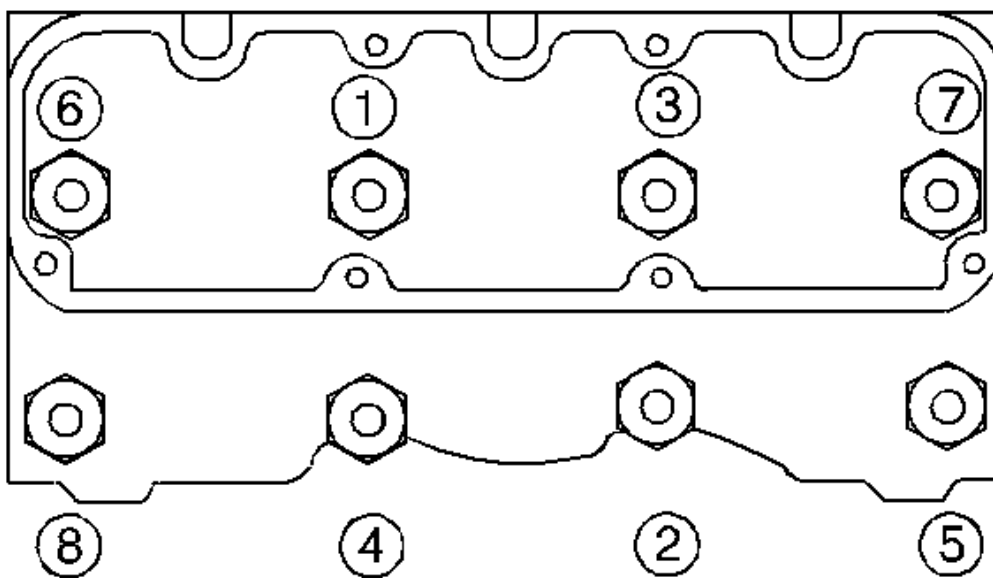


Fig. 97: Identifying Cylinder Head Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the new cylinder head bolts.

Tighten:

- Tighten the cylinder head bolts in sequence (1-8) to 50 N.m (37 lb ft).
 - Rotate each bolt 120 degrees in sequence (1-8). Use the **J 45059** . See Special Tools and Equipment.
5. Install the valve rocker arm assemblies and the pushrods. Refer to Valve Rocker Arm and Push Rod Replacement.
 6. Install the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.
 7. Install the right valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Right.
 8. Install the right exhaust manifold. Refer to Exhaust Manifold Replacement - Right (L36) in Engine Exhaust.
 9. Install the spark plugs. Refer to Spark Plug Replacement in Engine Controls - 3.8L.
 10. Install the lower intake manifold. Refer to Intake Manifold Replacement - Lower.

Oil Pan Replacement

Removal Procedure

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
2. Remove the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right**.

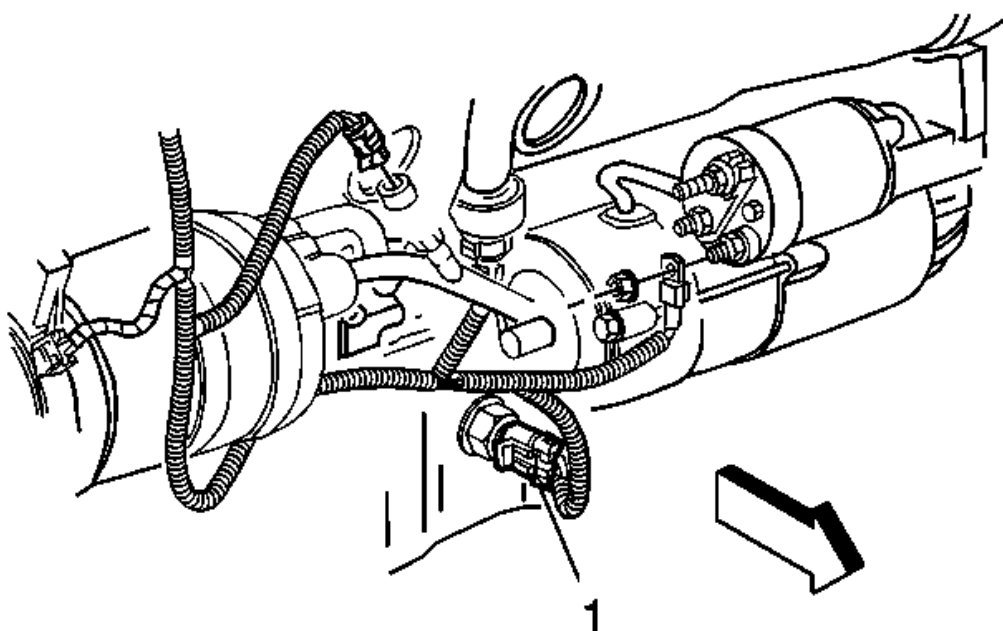


Fig. 98: Locating Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the electrical connector (1) from engine oil level sensor.
4. Remove the engine oil level sensor from the oil pan.
5. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65-E.

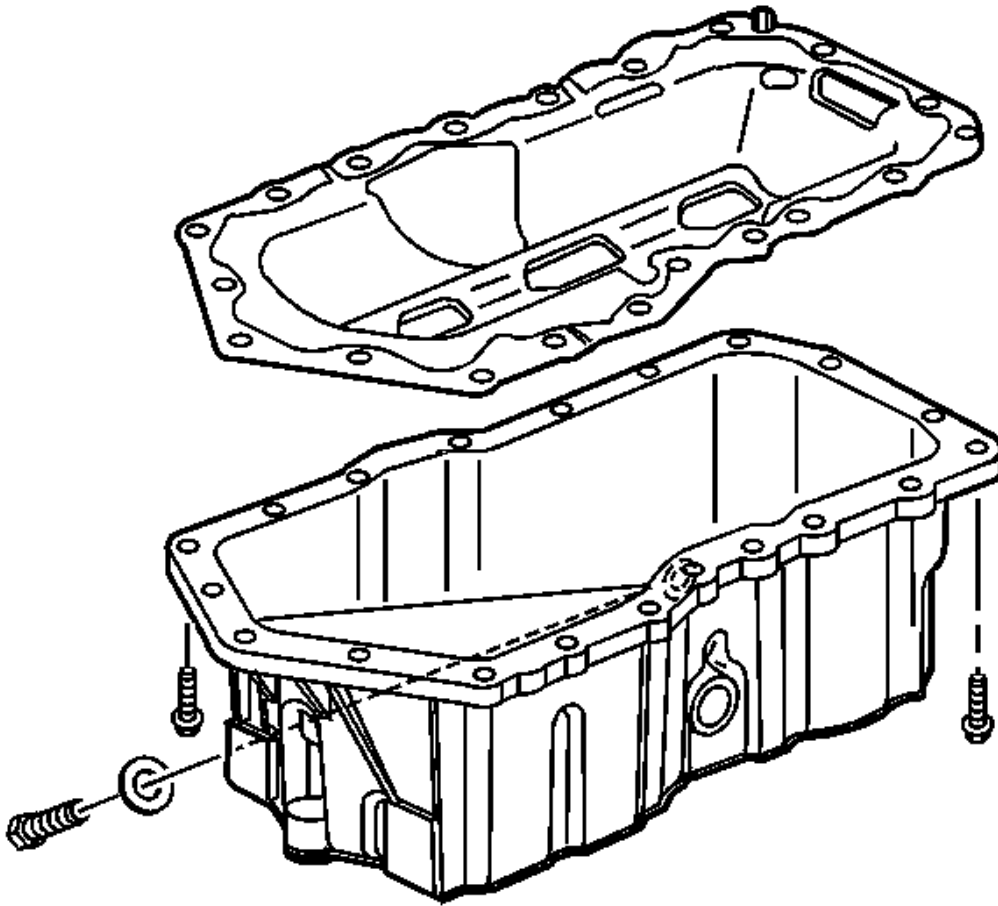


Fig. 99: Identifying Oil Pan Components
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan bolts.
7. Remove the oil pan.
8. Remove the oil pump pipe and screen. Refer to **Oil Pump Pipe and Screen Assembly Replacement**.
9. Remove the oil pan gasket.
10. Clean the cylinder block mating surfaces.
11. Clean and inspect the oil pan. Refer to **Oil Pan Cleaning and Inspection** in Engine Mechanical - 3.8L Unit Repair.

Installation Procedure

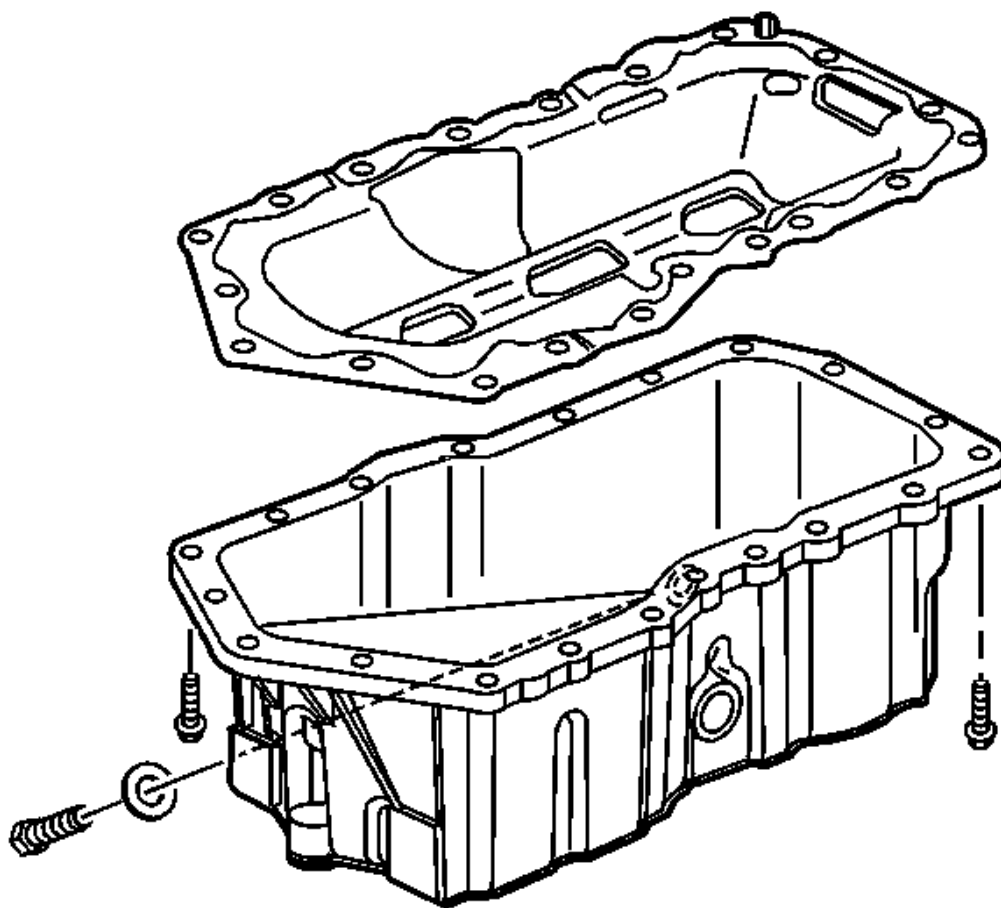


Fig. 100: Identifying Oil Pan Components
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump pipe and screen. Refer to **Oil Pump Pipe and Screen Assembly Replacement**.
2. Apply a continuous bead 3.0 mm (0.19 in) thick of RTV GM P/N 12378521 (Canadian P/N 88901148), or equivalent to the oil pan flange on the block as well as an additional drop to all four corners of the block where the front and rear covers meet.
3. Install the oil pan.
4. Apply one drop of GM P/N 12345382 (Canadian P/N 10953489) to each bolt.

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

5. Install the oil pan bolts.

Tighten: Tighten the oil pan bolts to 14 N.m (124 lb in).

6. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65-E.

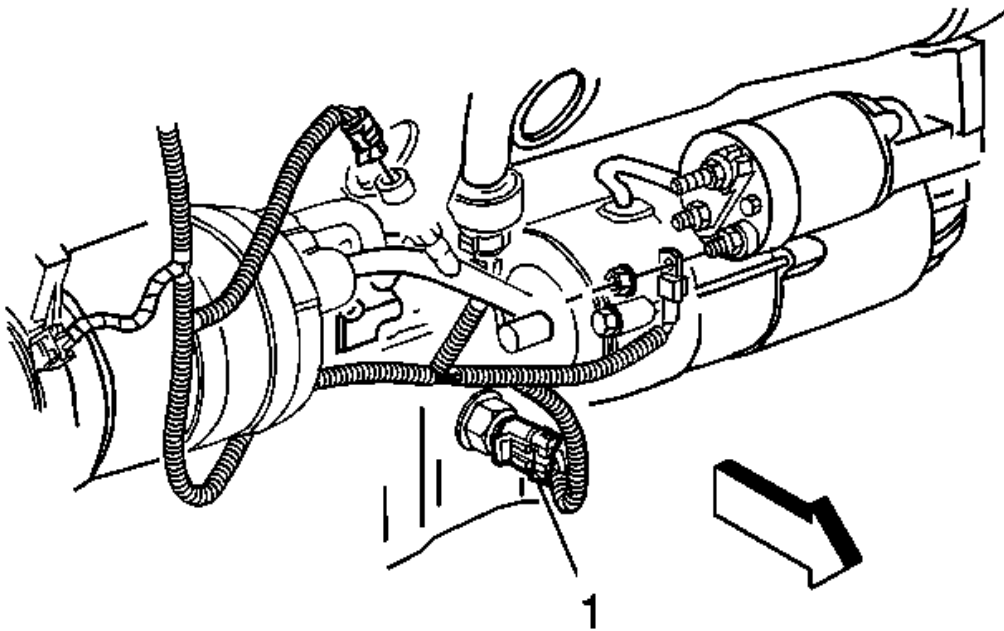


Fig. 101: Locating Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Component Fastener Tightening Notice.

7. Install the engine oil level sensor into the oil pan.

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

8. Connect the electrical connector (1) to the engine oil level sensor.
9. Install the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right**.
10. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
11. Inspect for oil leaks after engine start up.

Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

J 41712 Oil Pressure Switch Socket. See Special Tools and Equipment.

Removal Procedure

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

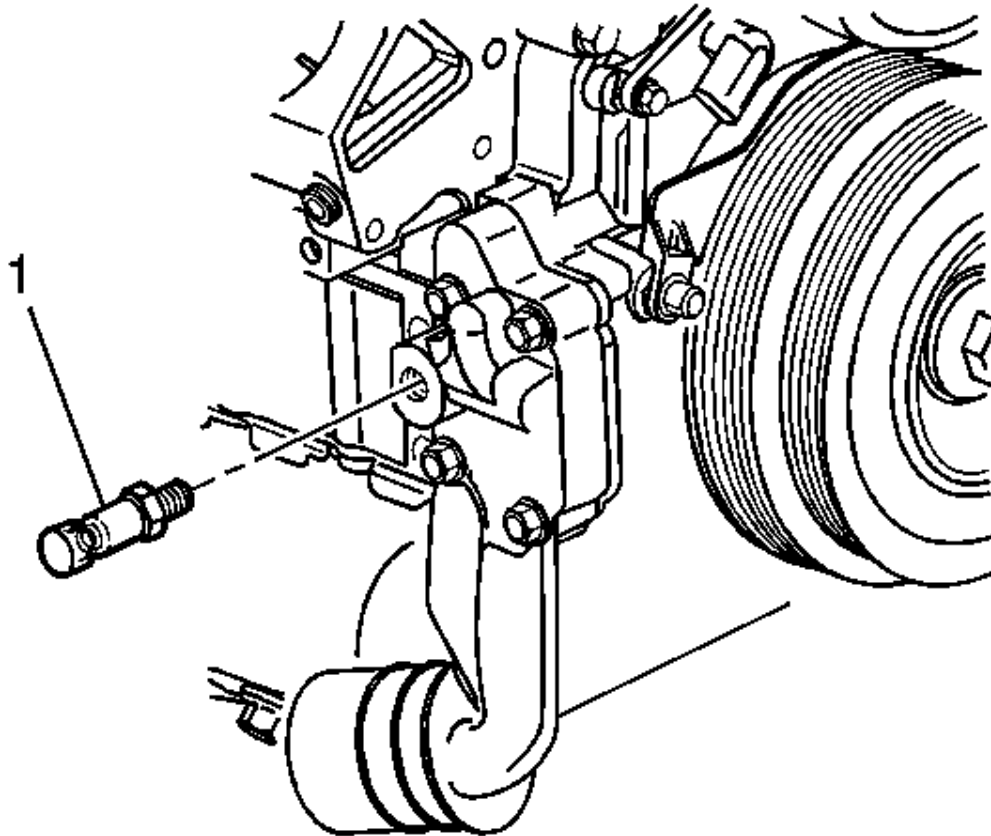


Fig. 102: Locating Engine Oil Pressure Sensor/Switch
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the electrical connector from the engine oil pressure switch (1).
3. Remove the engine oil pressure switch (1) from the oil filter adapter using the **J 41712** . See Special Tools and Equipment.

Installation Procedure

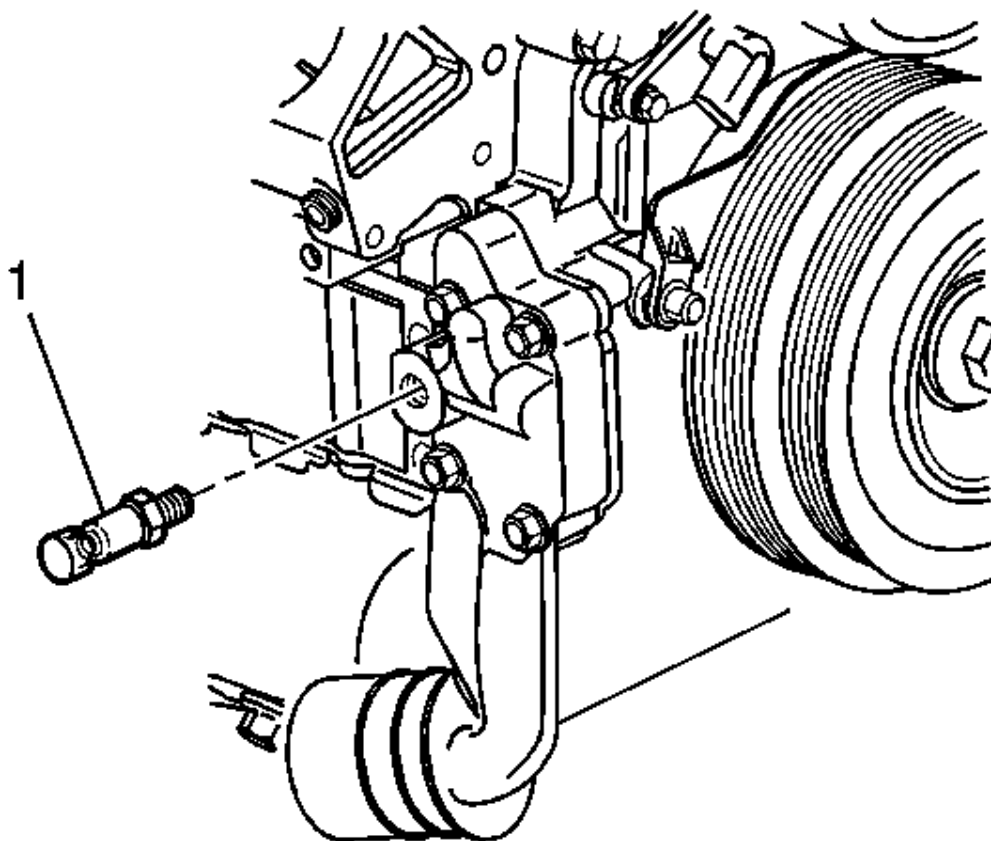


Fig. 103: Locating Engine Oil Pressure Sensor/Switch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

1. Install the engine oil pressure switch (1) to the oil filter adapter using the **J 41712** . See Special Tools and Equipment.

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

2. Connect the electrical connector to the engine oil pressure switch (1).
3. Lower the vehicle.
4. Inspect for oil leaks after engine start up.
5. Adjust the engine oil level to the full mark.

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

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

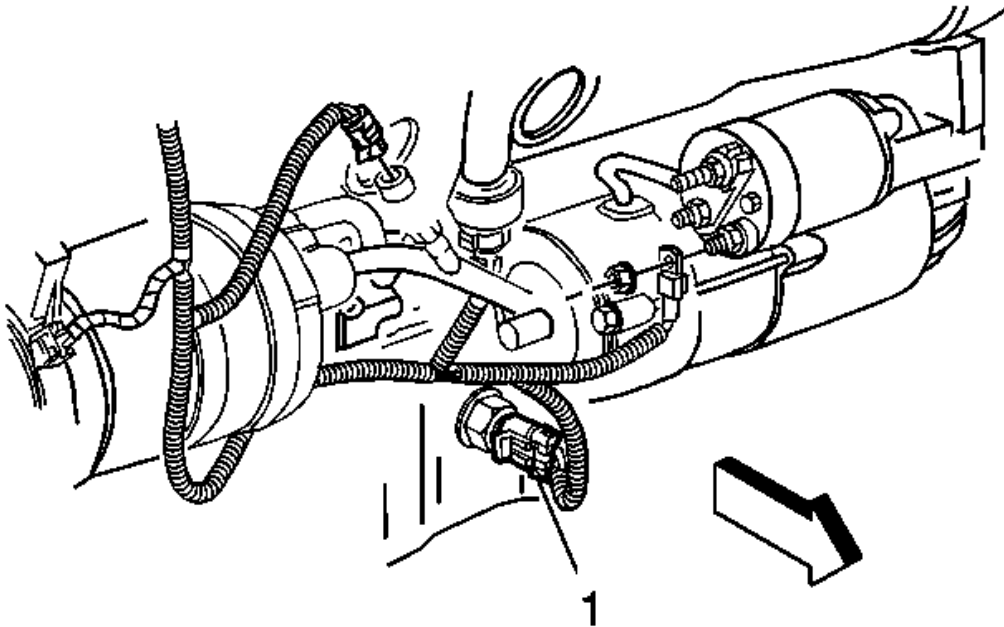


Fig. 104: Locating Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the electrical connector (1) from engine oil level sensor.
3. Remove the engine oil level sensor from the oil pan.

Installation Procedure

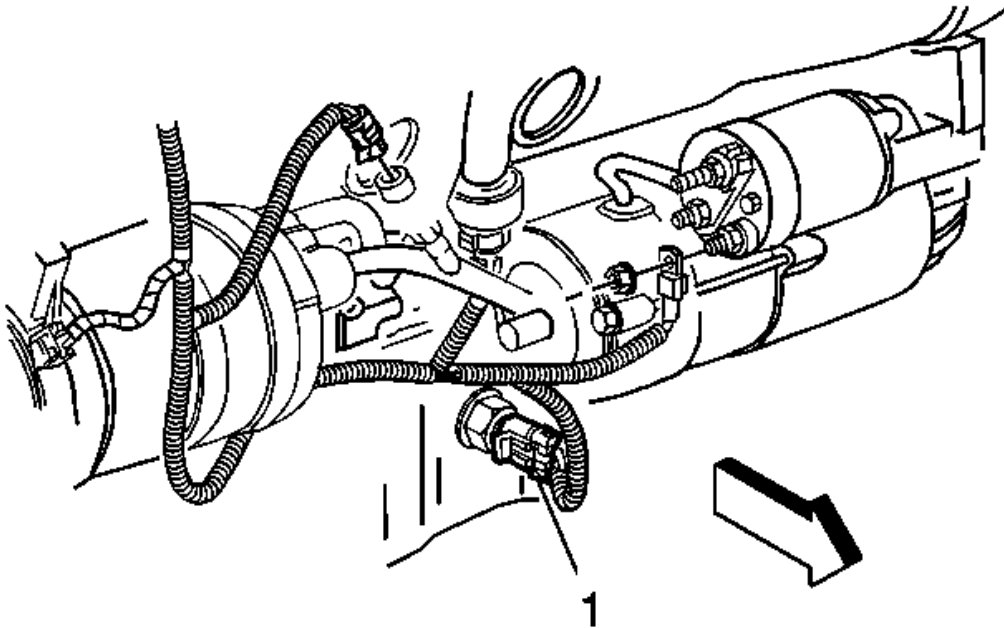


Fig. 105: Locating Engine Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

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

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

2. Connect the electrical connector (1) to the engine oil level sensor.
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
4. Inspect for oil leaks after engine start up.

Oil Pump Pipe and Screen Assembly Replacement

Removal Procedure

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

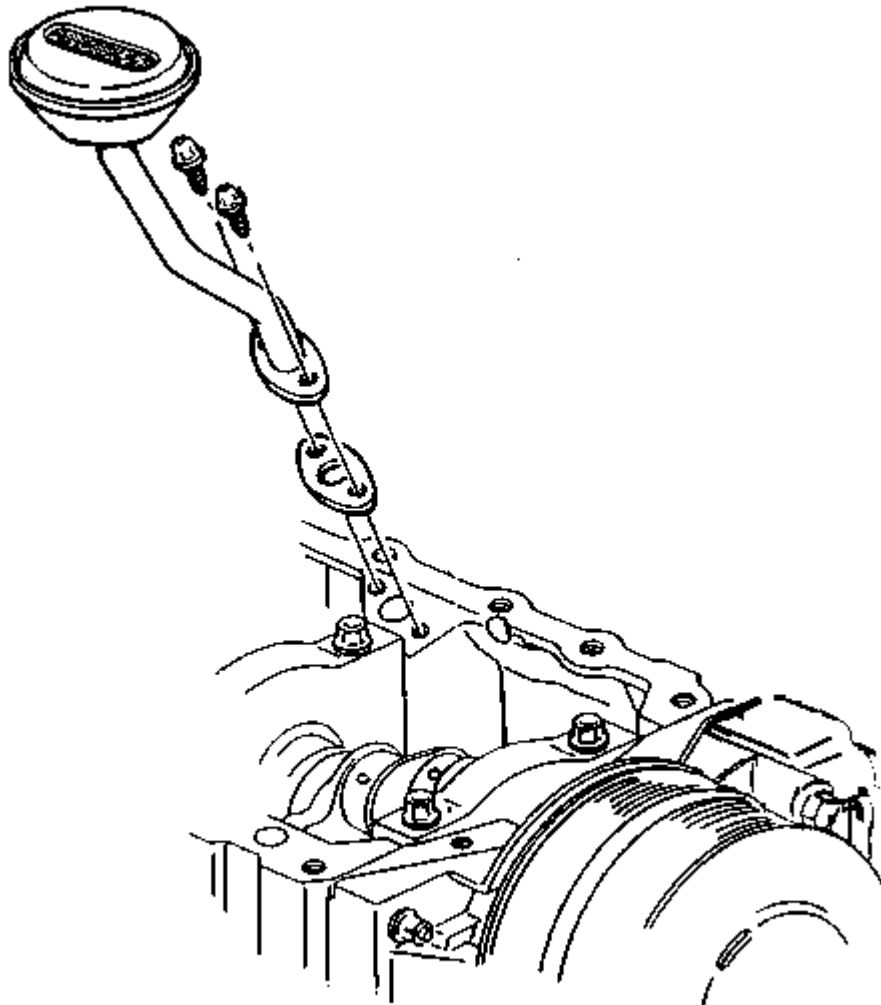


Fig. 106: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump pipe screen bolts.
3. Remove the oil pump screen.
4. Remove the gasket.
5. Use solvent in order to clean the screen and the housing. Blow dry the screen and the housing.
6. Clean the gasket mating surfaces.

Installation Procedure

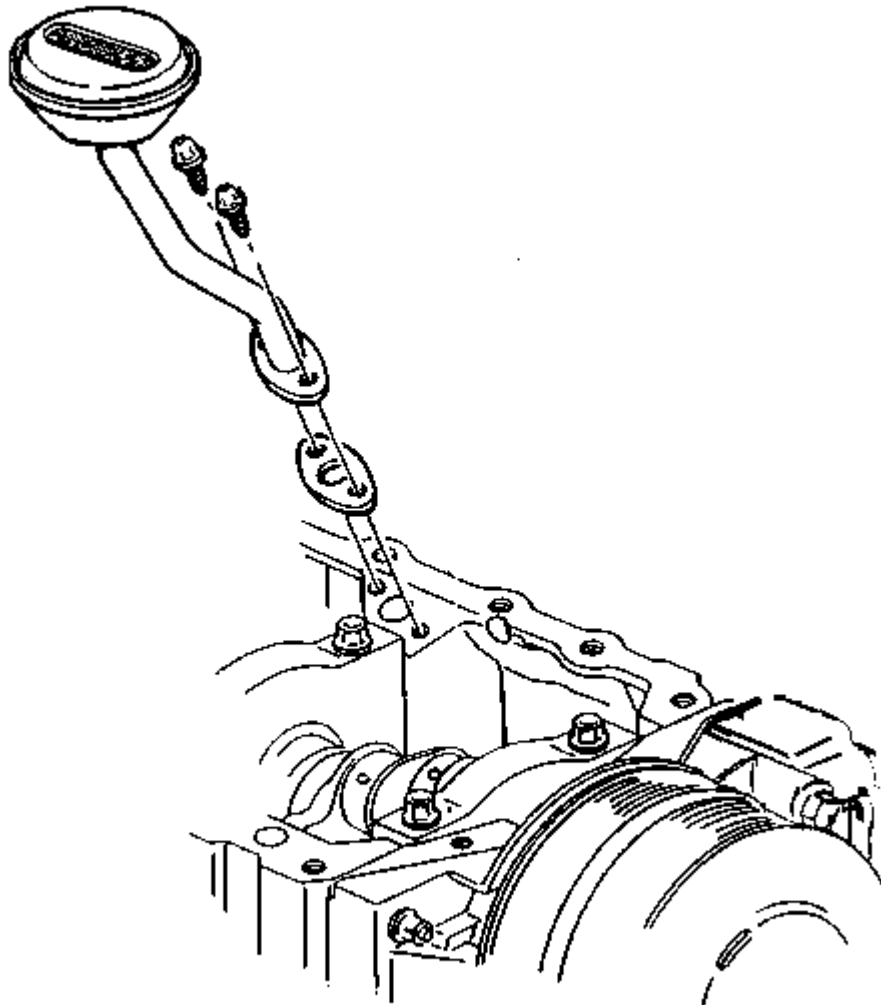


Fig. 107: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump screen gasket.
2. Install the oil pump screen.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump screen bolts.

Tighten: Tighten the oil pump screen bolts to 15 N.m (11 lb ft).

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

Engine Flywheel Replacement

Tools Required

- **J 8001** Dial Indicator Set. See **Special Tools and Equipment**.
- **J 45059** Torque Angle Meter. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the transaxle. Refer to **Transmission Replacement** in Automatic Transaxle - 4T65-E.

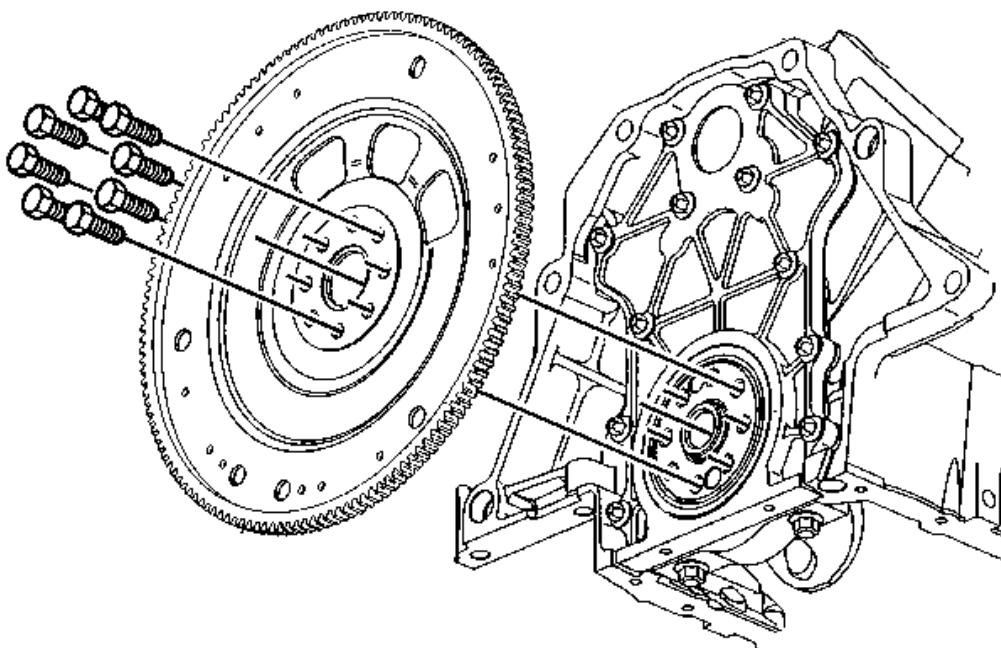


Fig. 108: Identifying Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the 8 bolts attaching the flywheel to the crankshaft flange. Discard the bolts.
3. Remove the flywheel.
4. Inspect the crankshaft mating surfaces for burrs.
5. Clean and inspect the engine flywheel. Refer to **Engine Flywheel Cleaning and Inspection**.

Installation Procedure

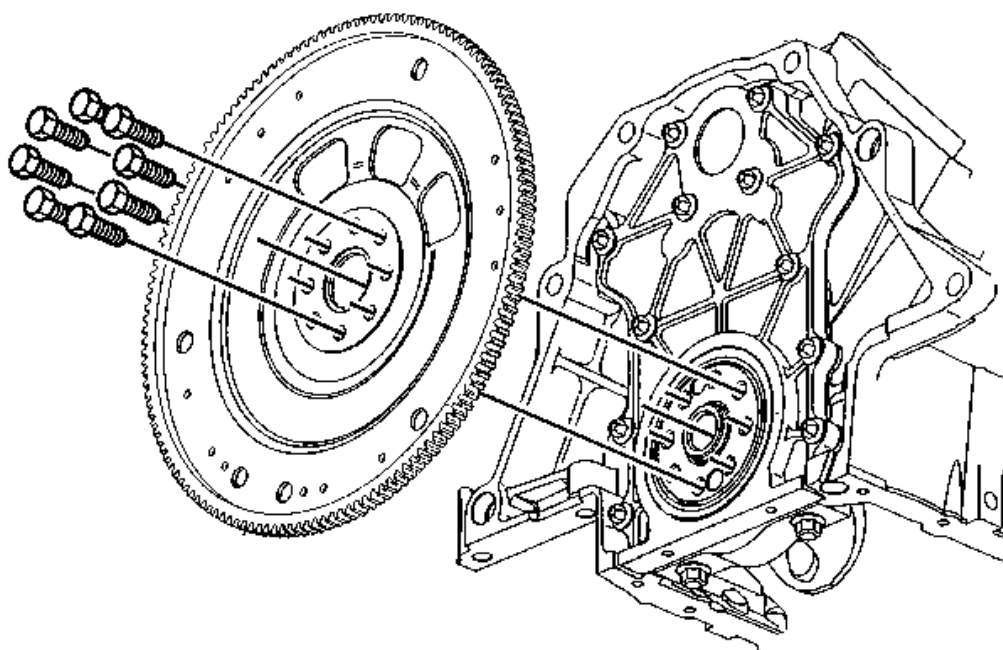


Fig. 109: Identifying Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the flywheel bolts.

Tighten: Tighten the new flywheel bolts to 15 N.m (11 lb ft). Use the **J 45059** in order to tighten the bolts an additional 50 degrees. See Special Tools and Equipment.

3. Install the **J 8001** to the engine block. See Special Tools and Equipment.
4. Check the flywheel runout at the 3 attaching bosses. Ensure that the crankshaft end-play is held in one direction when checking flywheel runout. Flywheel runout should not exceed 0.381 mm (0.015 in).
5. If flywheel runout is out of specification, tap on the high side with a mallet in order to correct runout.
6. Replace the flywheel if runout cannot be corrected.
7. Install the transaxle. Refer to Transmission Replacement in Automatic Transaxle - 4T65-E.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 38196 Rear Crankshaft Seal Installer

Removal Procedure

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Confirm the crankshaft rear oil seal leak.

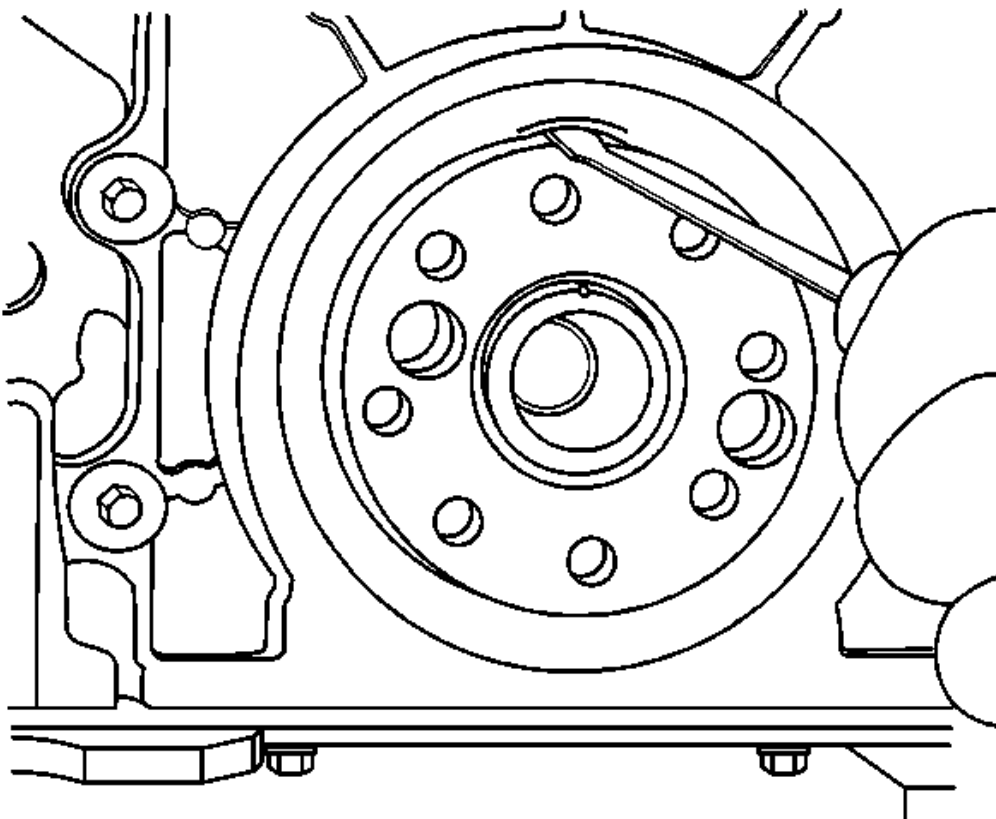


Fig. 110: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure not to damage the crankshaft OD surface or chamfer with the flat-bladed tool.

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

necessary around the crankshaft rear oil seal.

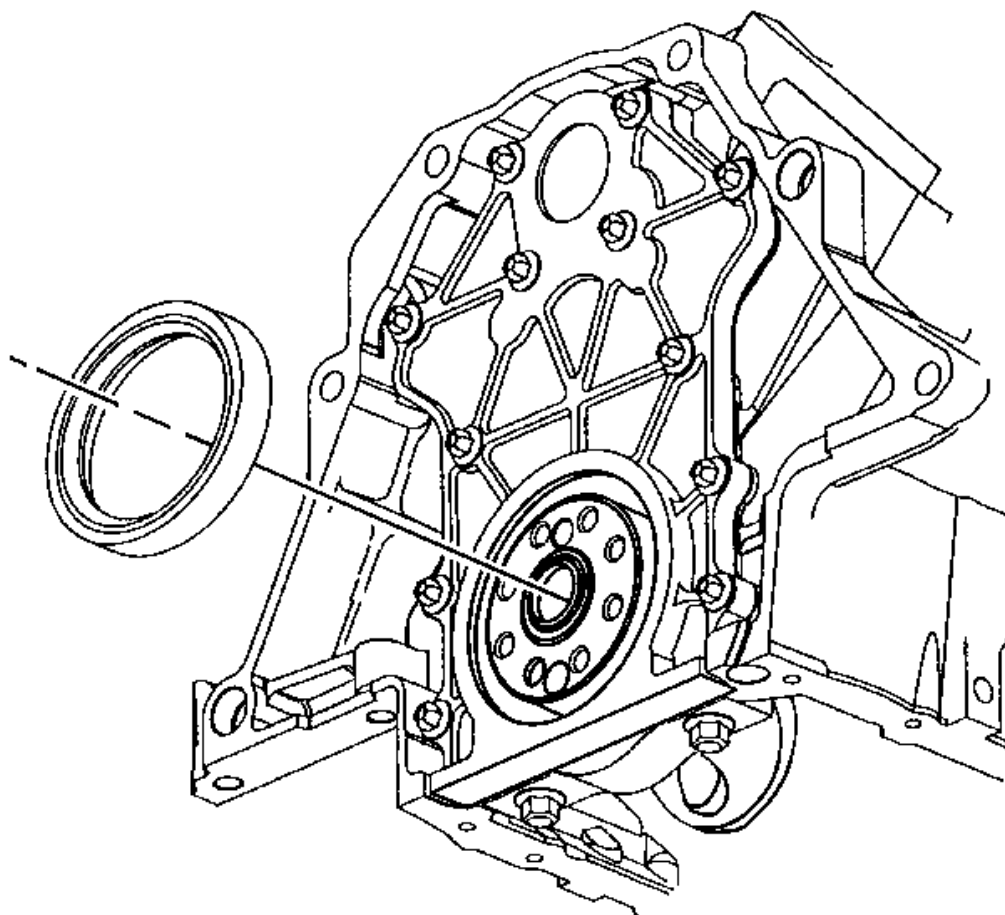


Fig. 111: Locating Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

4. Inspect the ID of the bore. Correct or replace the crankshaft rear oil seal housing as required.
5. Inspect the crankshaft for nicks or burrs on the surface that contacts the crankshaft rear oil seal.
6. Repair or replace the crankshaft as required.

Installation Procedure

1. Apply engine oil to the inside and the outside diameter of the new crankshaft rear oil seal.
2. Slide the new crankshaft rear oil seal over the mandrel until the back of the crankshaft rear oil seal bottoms squarely against the collar of the J 38196.

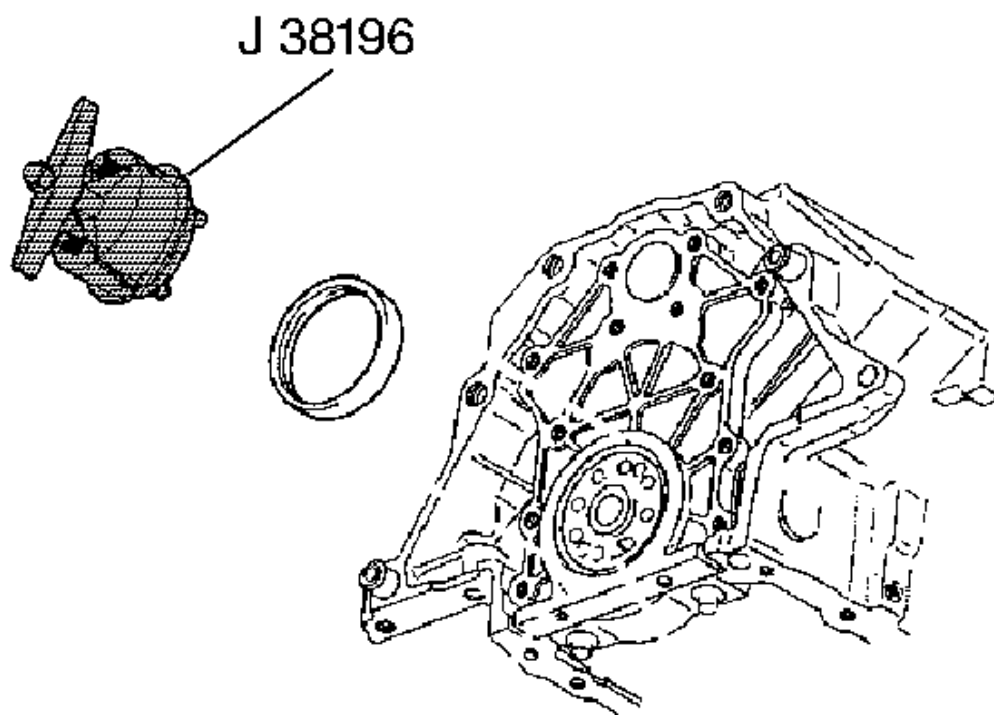


Fig. 112: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the crankshaft rear oil seal using the following steps:
 1. Attach the J 38196 to the crankshaft by hand, or tighten the attaching screws.

Tighten: Tighten the screws to 5 N.m (54 lb in).

2. Turn the T-handle of the J 38196 so that the collar pushes the seal into the bore. Turn the handle until the collar is tight against the case. This will ensure that the crankshaft rear oil seal is seated properly between the crankshaft and the crankshaft rear oil seal housing.
 3. Loosen the T-handle of J 38196 until it comes to a stop. This will ensure that the collar will be in the proper position for installing another new crankshaft rear oil seal.
 4. Remove the attaching screws.
4. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.
5. Inspect for proper fluid levels.

6. Inspect for leaks.

Crankshaft Rear Oil Seal and Housing Replacement

Tools Required

- **EN-47623** Rear Main Seal Installer. See **Special Tools and Equipment**.
- **J 45059** Torque Angle Meter. See **Special Tools and Equipment**.
- **J 8092** Driver Handle. See **Special Tools and Equipment**.

Removal Procedure

1. Drain the engine coolant from the cooling system. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.
2. Remove the engine oil pan. Refer to **Oil Pan Replacement**.
3. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

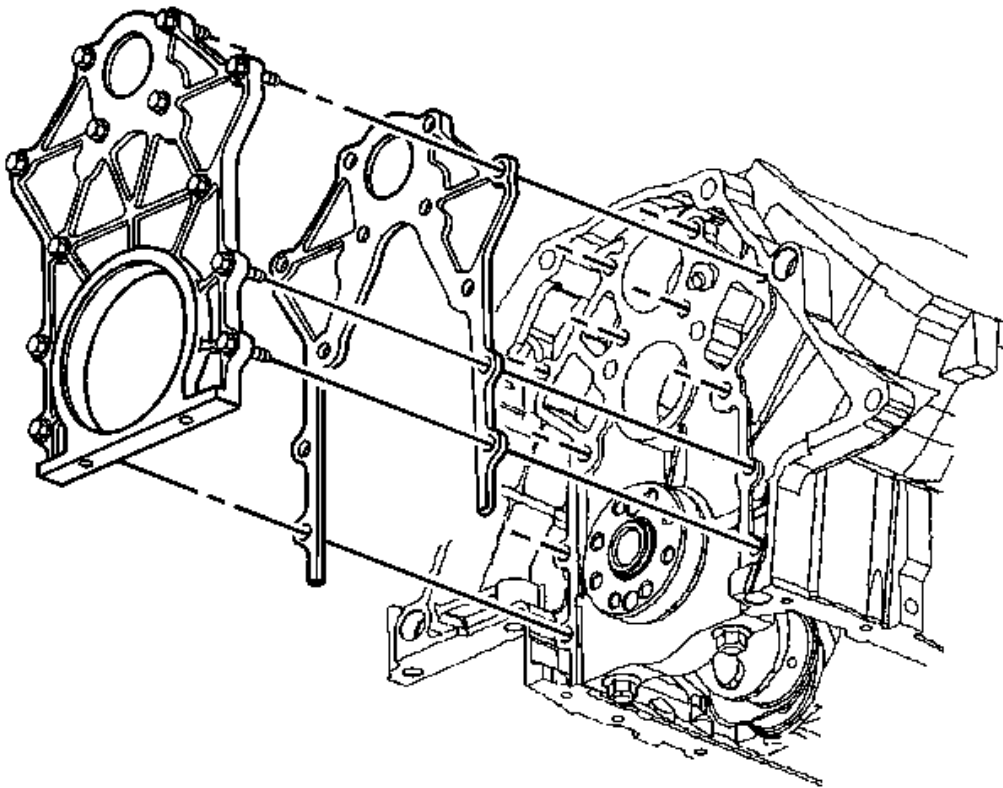


Fig. 113: Locating Crankshaft Rear Oil Seal Housing & Housing Gasket

Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft rear oil seal housing bolts.
5. Remove the crankshaft rear oil seal housing.

IMPORTANT: Make sure not to damage the crankshaft OD surface with any tool.

6. Remove the gasket from the crankshaft rear oil seal housing and the cylinder block.

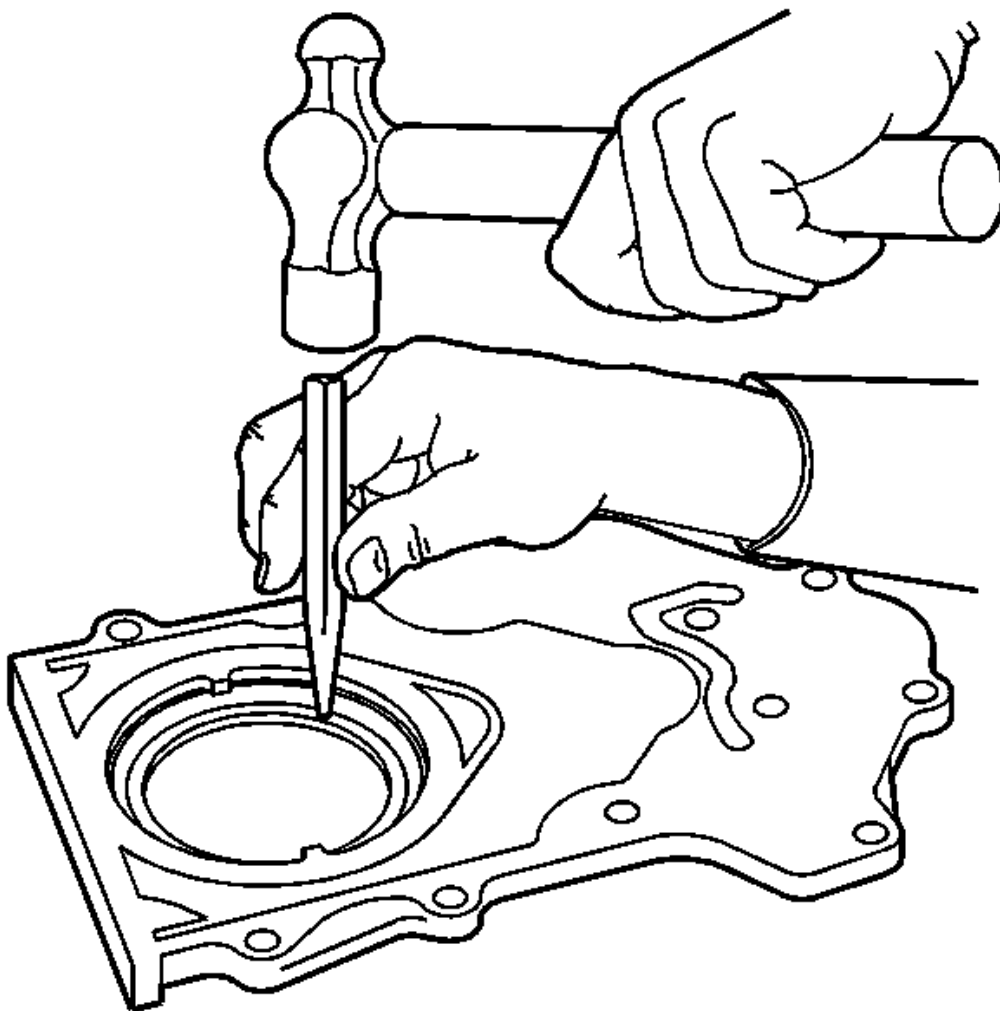


Fig. 114: Locating Crankshaft Rear Oil Seal In Housing
Courtesy of GENERAL MOTORS CORP.

7. Place the crankshaft rear oil seal housing face down on a clean surface and support with blocks of wood.
8. Use a suitable driving tool and hammer and lightly tap around the outer edge of the seal to remove it.
9. Clean and inspect the crankshaft rear oil seal housing making sure it is free of any foreign material.
10. With all bolts removed from the housing, place it face up on a flat clean surface.

Installation Procedure

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.

1. Carefully remove protection sleeve from the new rear oil seal assembly.

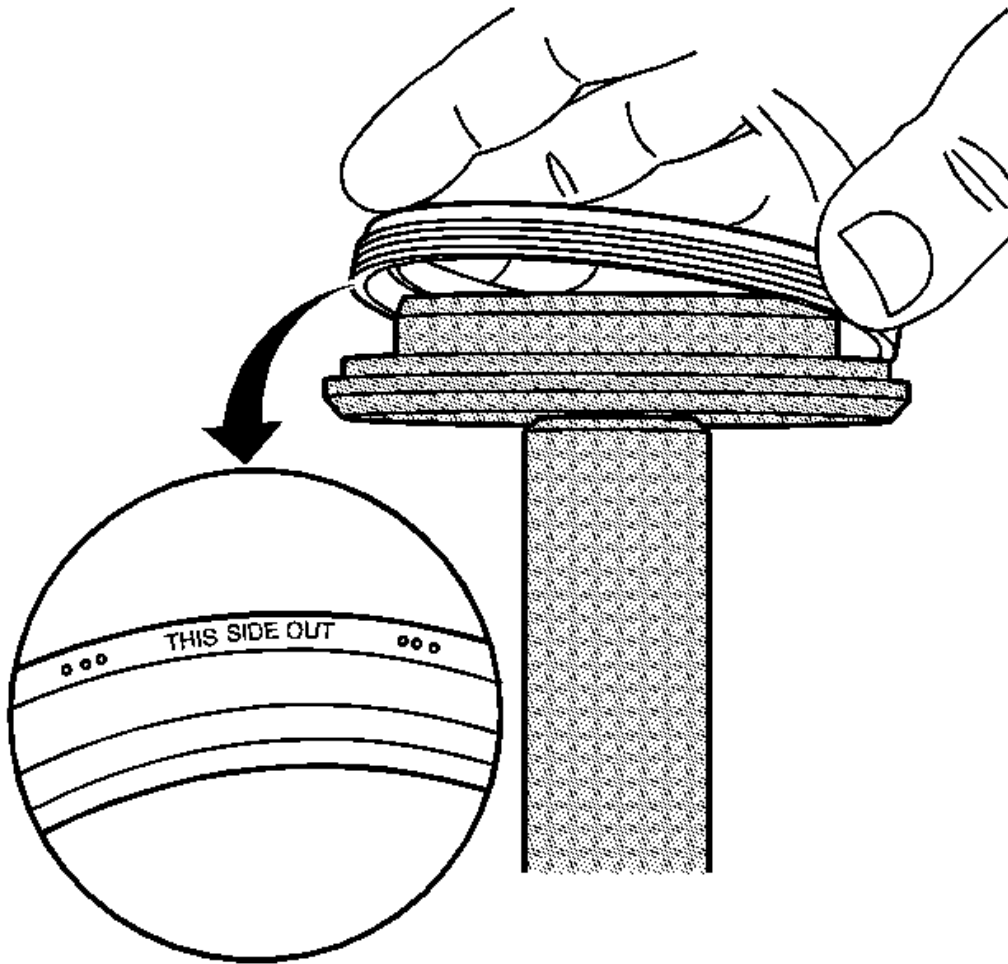


Fig. 115: Positioning Rear Seal To EN-47623

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Notice the direction of the rear oil seal. The new design seal is a reverse style as opposed to what has been used in the past. "THIS SIDE OUT" has been stamped into the seal as shown in the graphic.

2. Install the seal onto the **EN-47623** by placing the seal on an angle and using a twisting motion until it is fully seated. See Special Tools and Equipment.

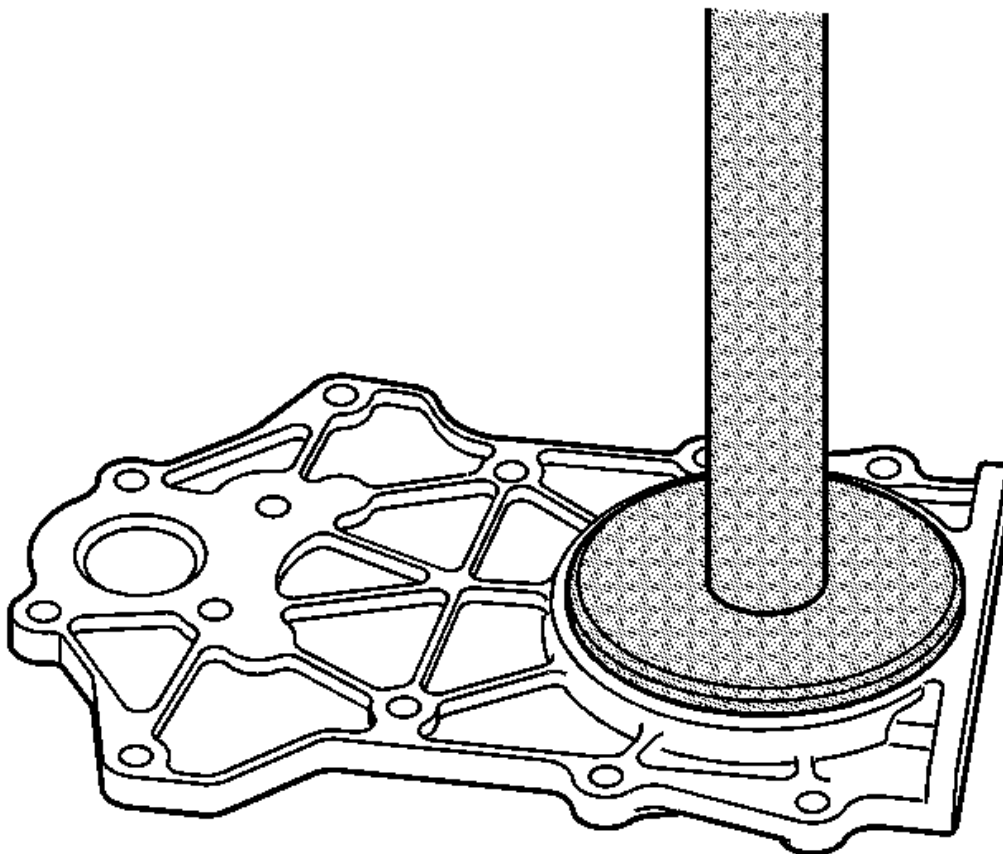


Fig. 116: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Using the **EN-47623** and, install the rear main crankshaft oil seal into the housing using constant downward force until the seal is fully seated. See **Special Tools and Equipment**.

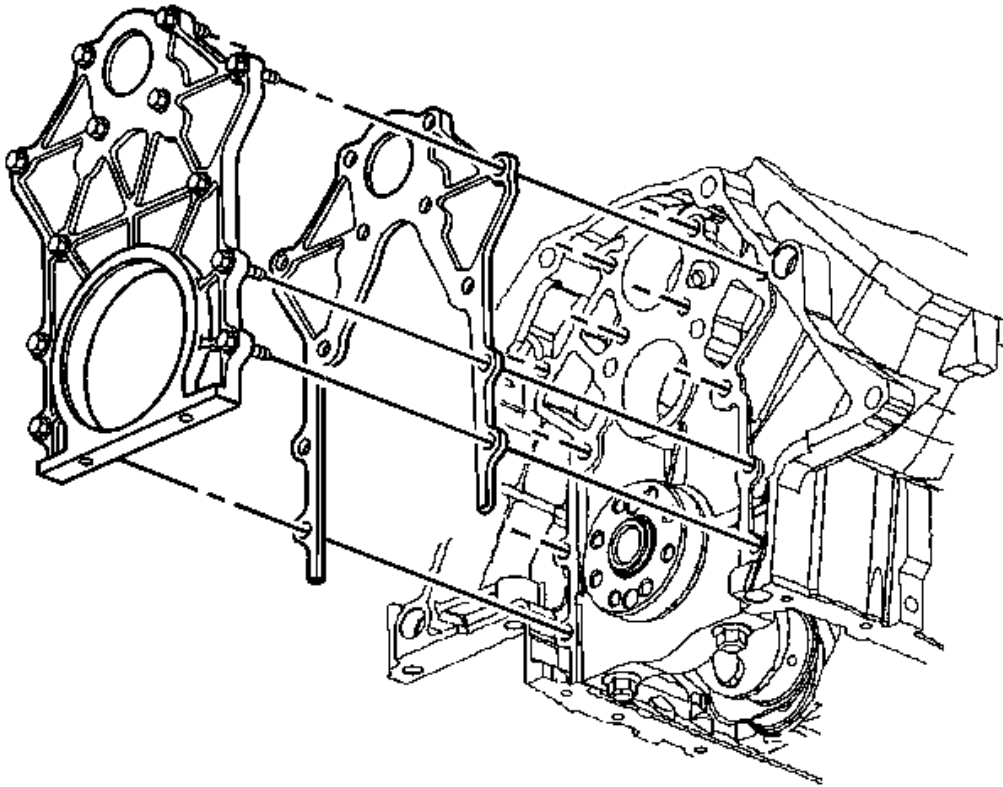


Fig. 117: Locating Crankshaft Rear Oil Seal Housing & Housing Gasket
Courtesy of GENERAL MOTORS CORP.

4. Clean the crankshaft sealing surface with a clean, lint free towel. Inspect the crankshaft sealing surface and leading edge of the crankshaft for burrs/sharp edges that could damage the rear main oil seal. Remove any burrs or sharp edges with crocus cloth before proceeding.

NOTE: Do not use a sealant or adhesive when installing this component. Use of a sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

IMPORTANT: Always install a new crankshaft rear oil seal housing gasket.

5. Install a new crankshaft rear oil seal housing gasket and the housing onto the engine.

IMPORTANT: The plastic inserts found on the rear oil seal housing retaining bolts are used to aid in production assembly only. The inserts are not required for service.

6. Install the crankshaft rear oil seal housing bolts and finger tighten.

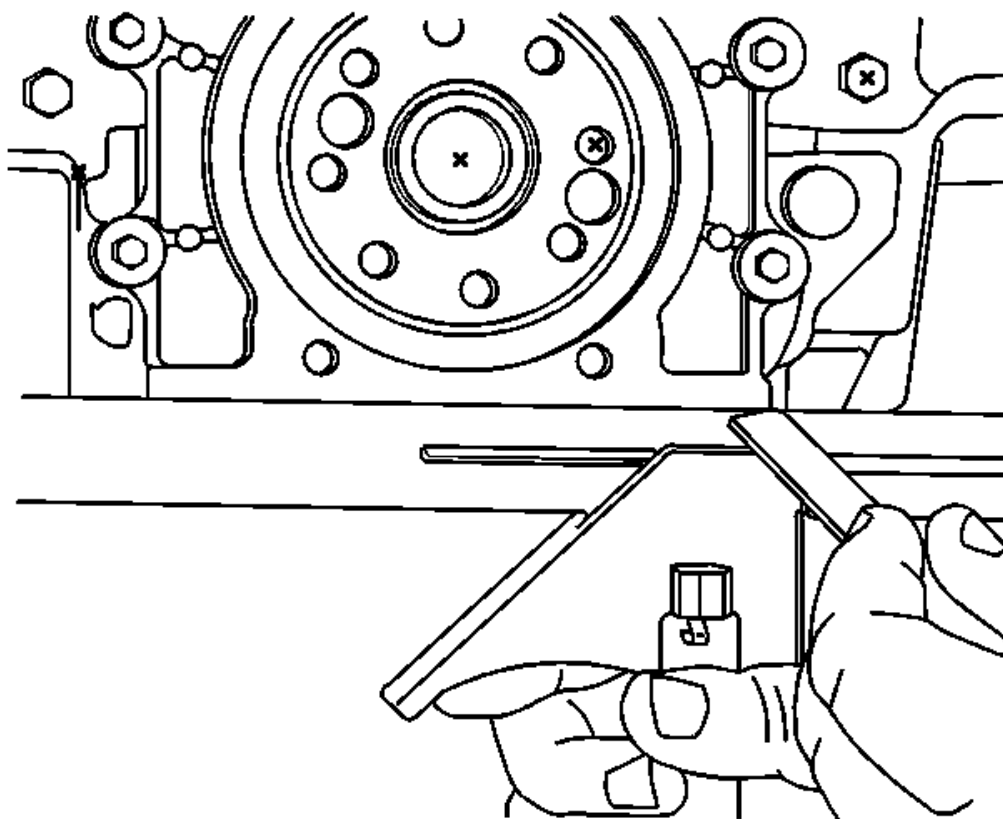


Fig. 118: Measuring Cylinder Block Oil Pan & Rear Oil Seal Housing Flange Clearance
Courtesy of GENERAL MOTORS CORP.

NOTE: Correct alignment of the housing is crucial to sealing ability of the rear main and the oil pan. Take care when installing the housing to ensure that the housing is properly aligned. Failure to follow these procedures may result in oil leaks.

7. Place a straight edge on the engine block oil pan flange and the crankshaft rear oil seal housing flange. Use a feeler gage to ensure that there is no more than a 0.10 mm (0.004 in) step on each side. If necessary, gently rotate the crankshaft rear oil seal housing to make the step equal on each side.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the crankshaft rear oil seal housing bolts.

Tighten: Tighten the crankshaft rear oil seal housing bolts to 15 N.m (11 lb ft). Use the **J 45059** to tighten the bolts an additional 50 degrees. See **Special Tools and Equipment**.

9. Recheck the step height on each side to ensure that the crankshaft rear oil seal housing did not move. If the step height is beyond specification, reinstall the crankshaft rear oil seal housing and measure the step again. Replace the crankshaft rear oil seal housing if the clearance is still beyond specification.
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.
11. Install the engine oil pan. Refer to **Oil Pan Replacement**.
12. Fill the cooling system with engine coolant. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.

Engine Replacement

Tools Required

J 38185 Hose Clamp Pliers. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the hood. Refer to **Hood Replacement** in Body Front End.
2. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
4. Disconnect the vacuum brake booster hose from the vacuum connections and position aside.
5. Disconnect the fuel feed and return lines from the fuel rail and secure to the air inlet grille. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls.
6. Remove the evaporative emission (EVAP) canister purge valve solenoid and secure the hose to the air inlet grille. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls.

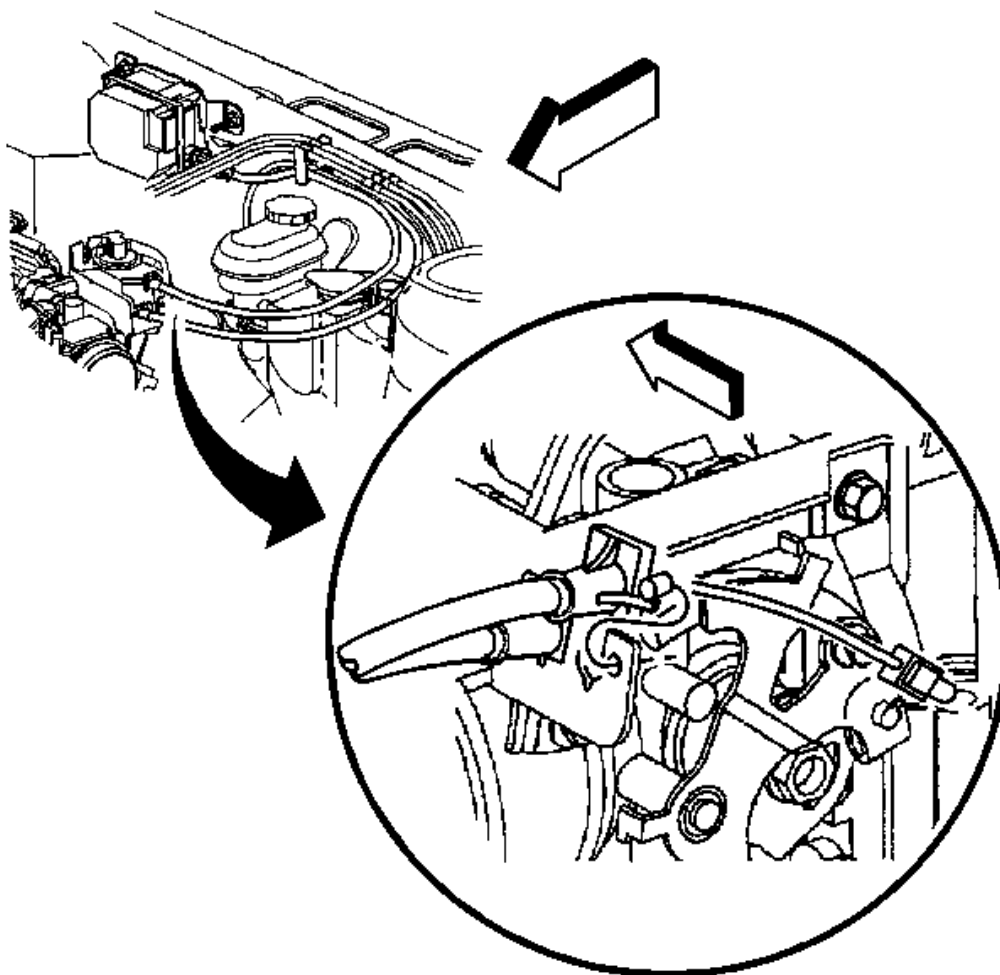


Fig. 119: Locating Cruise Control Cable Throttle Body Bracket & Lever
Courtesy of GENERAL MOTORS CORP.

7. Push the lock release and remove the cruise control cable from the throttle body bracket and lever.
8. Disconnect the electrical connector from the cruise control module.

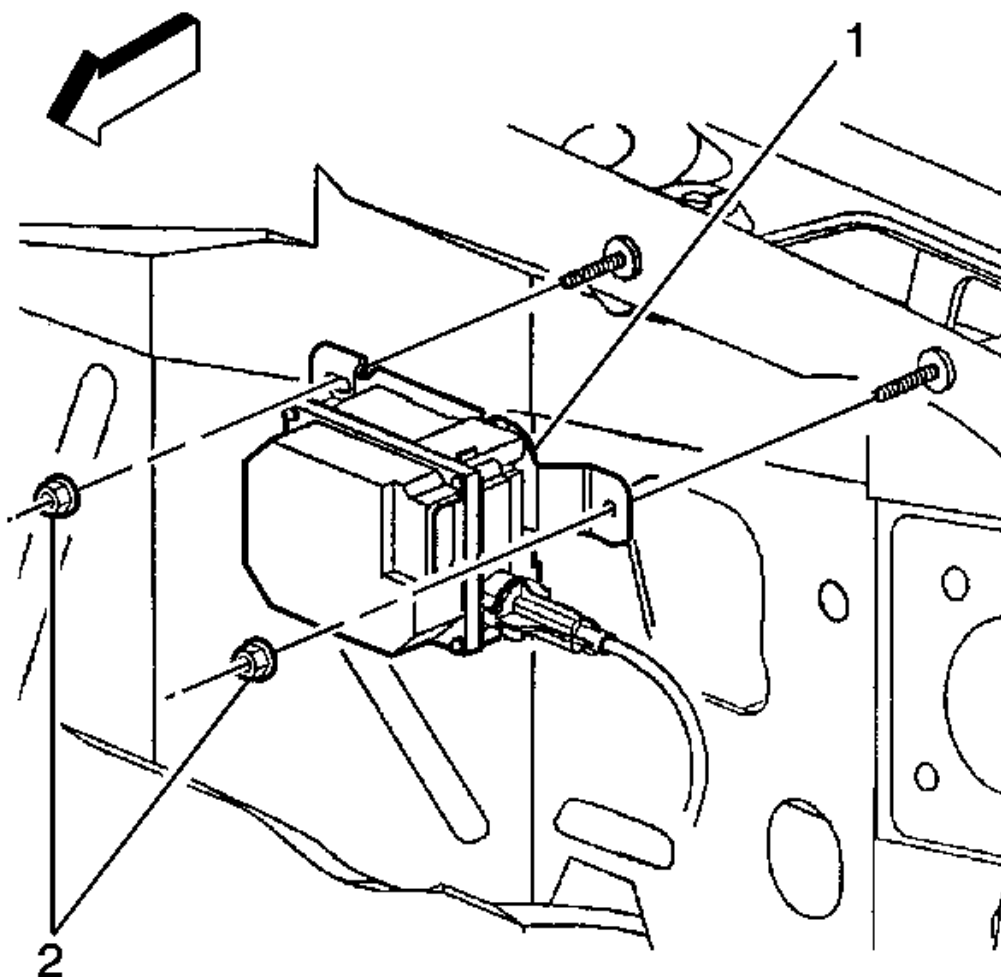


Fig. 120: Locating Retaining Nuts & Cruise Control Module
Courtesy of GENERAL MOTORS CORP.

9. Remove the retaining nuts (2) and the cruise control module (1) from the mounting studs.

CAUTION: In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a **NEW** cable whenever you remove the engine from the vehicle.
In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

10. Remove the accelerator control cable. Refer to **Cruise Control Cable Replacement** in Cruise Control.
11. Remove the drive belt. Refer to **Drive Belt Replacement**.
12. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

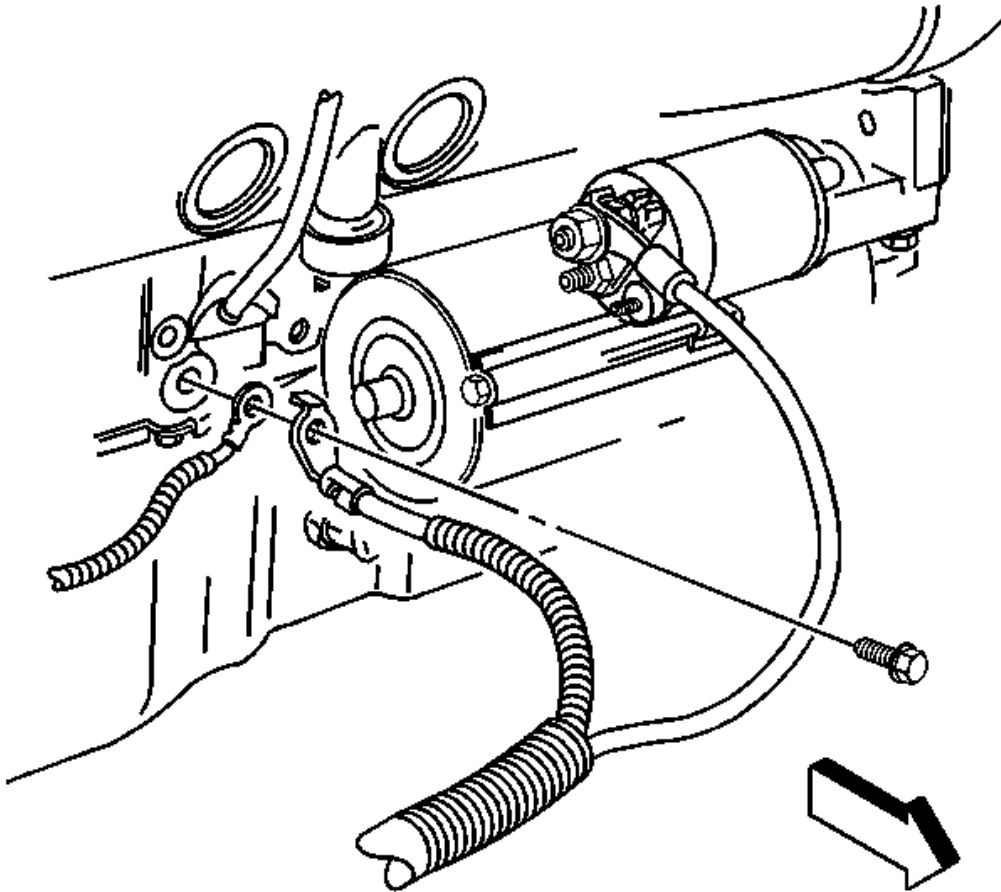


Fig. 121: Locating Battery Negative Cable & Engine Harness Ground Lead-To-Engine Block Bolt
Courtesy of GENERAL MOTORS CORP.

13. Remove the bolt securing both the battery negative cable and the engine harness ground lead to the engine block.

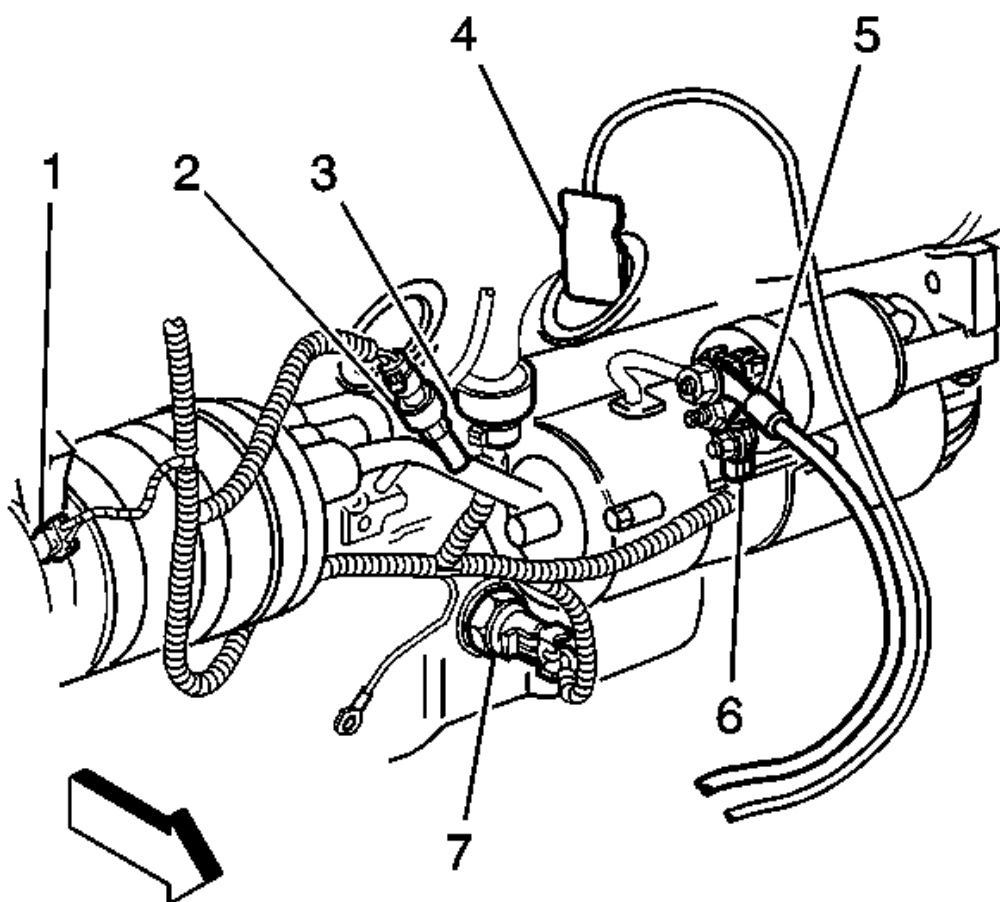


Fig. 122: Locating Specified Components Wiring Harness Connectors Near Starter
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the wiring harness connectors from the following components:
- The A/C compressor clutch (1)
 - The A/C pressure sensor (2)
 - The knock sensor #1 (3)
 - The engine coolant block heater (4)
 - The oil level sensor (7)

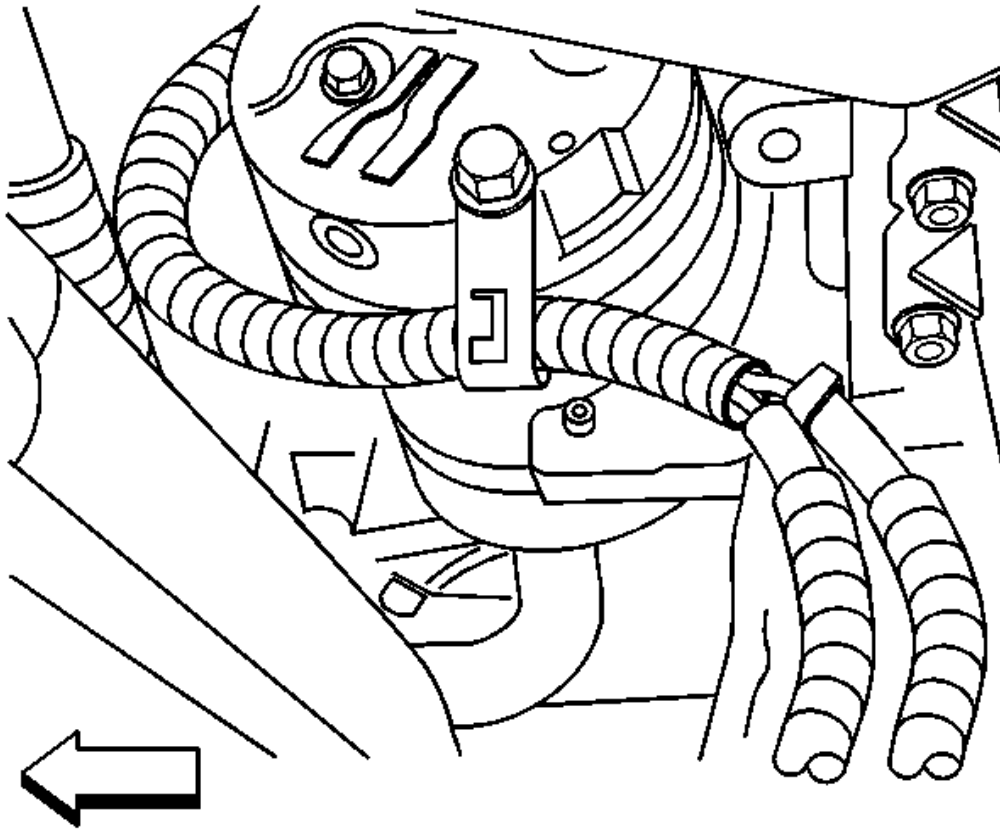


Fig. 123: Locating A/C Compressor Wiring Harness Rear Harness Clip
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the wiring harness from the harness clip at the rear of the A/C compressor.
16. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65-E.
17. Remove the starter motor. Refer to **Starter Motor Replacement (L36)** in Engine Electrical.
18. Remove the bolts securing the flywheel to the torque converter.

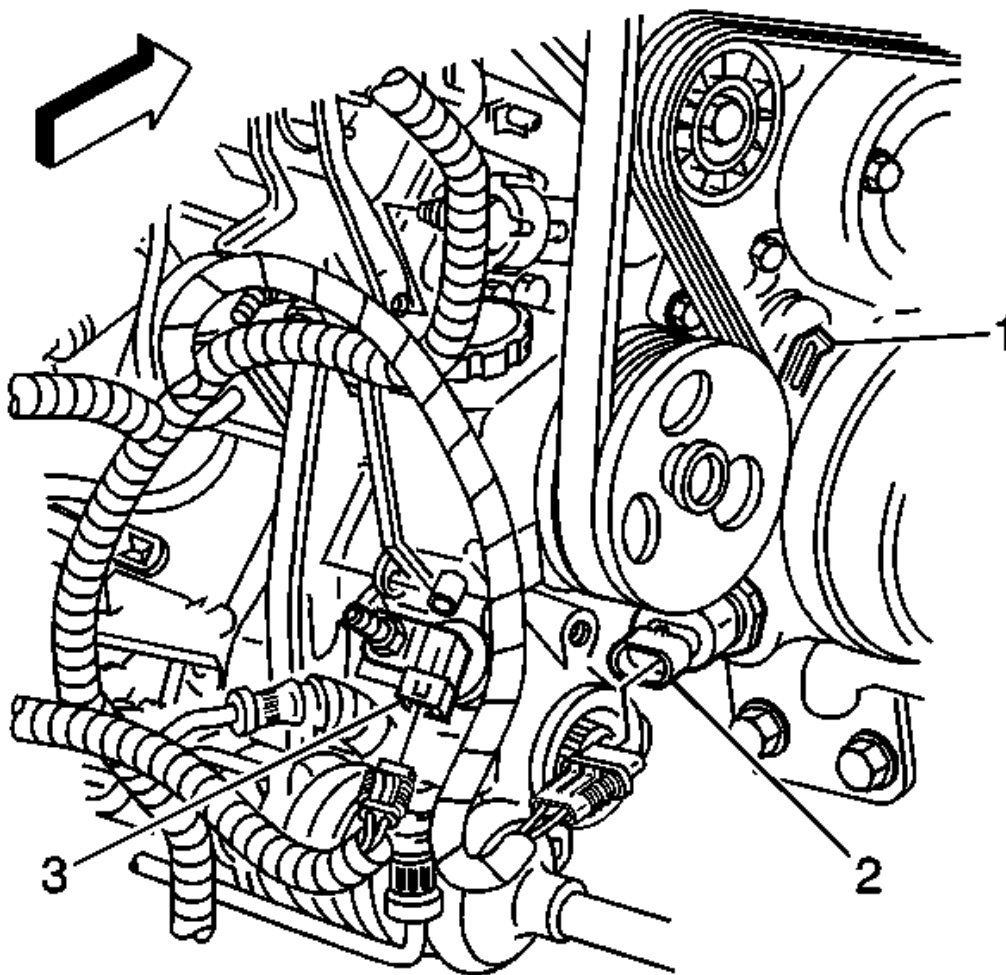


Fig. 124: Locating Specified Wiring Harness Electrical Connectors Near Cowl
Courtesy of GENERAL MOTORS CORP.

19. Disconnect and secure the following wiring harness electrical connectors to the cowl:
- The knock sensor #2 located behind the right exhaust manifold
 - The oil pressure sensor (2)
 - The vehicle speed sensor (VSS) (3)

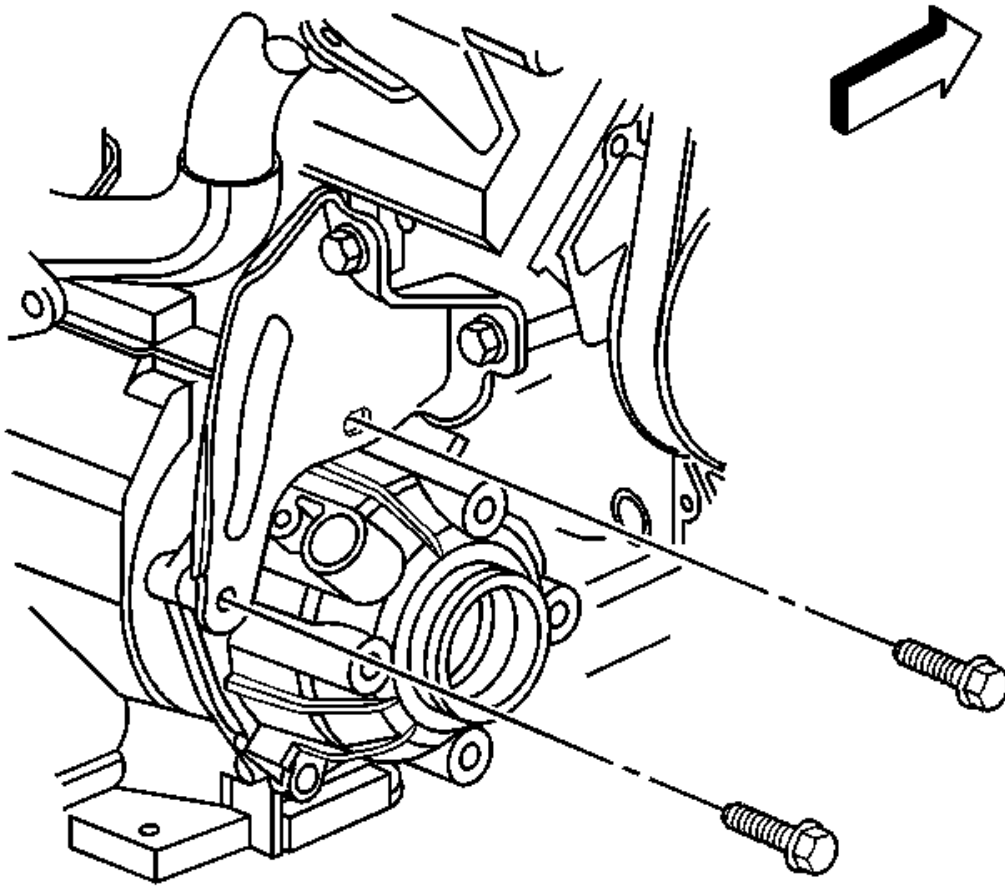


Fig. 125: Transaxle Brace To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

20. Remove the 2 bolts securing the transaxle brace to the transaxle.

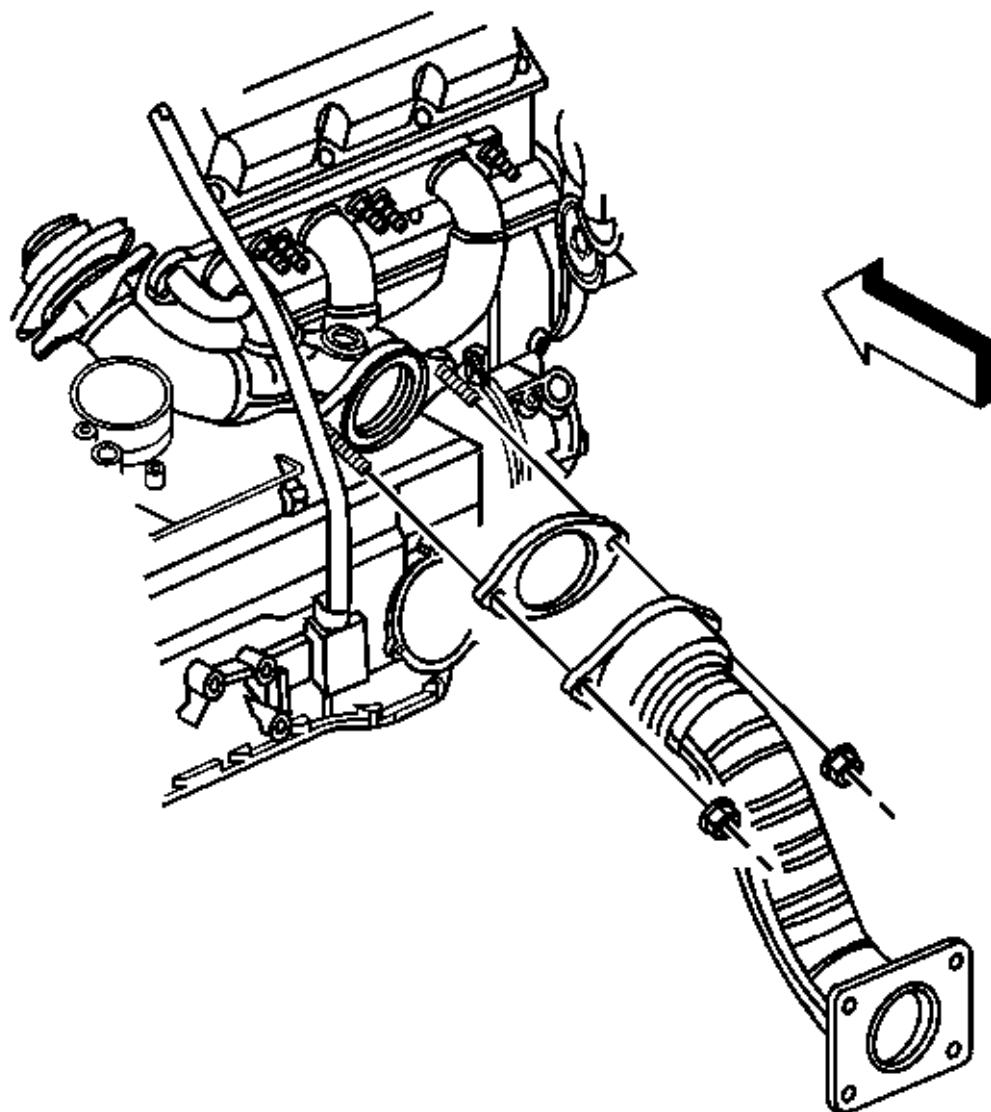


Fig. 126: Locating Exhaust Manifold Pipe-To-Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

CAUTION: Always wear protective goggles and gloves when removing exhaust parts as falling rust and sharp edges from worn exhaust components could result in serious personal injury.

21. Remove the 2 nuts attaching the exhaust manifold pipe to the right exhaust manifold.

22. Remove the exhaust manifold pipe from the right exhaust manifold studs, allowing it to rest on top of the power steering gear heat shield.
23. Remove the gasket. Do not reuse the gasket.
24. Remove the right front fascia extension. Refer to **Fascia Extension Replacement - Front** in Bumpers.

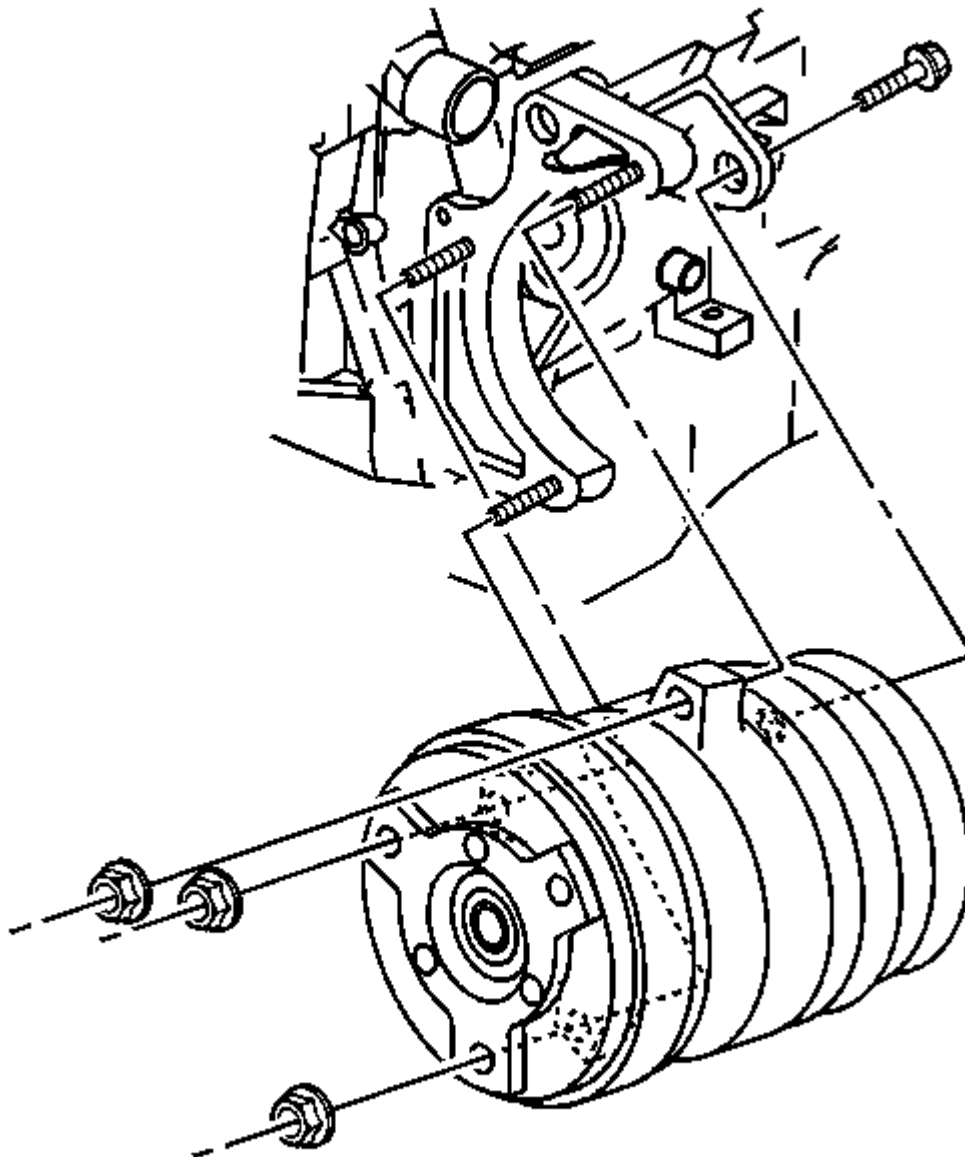


Fig. 127: Identifying A/C Compressor Mounting Nuts & Bolt

Courtesy of GENERAL MOTORS CORP.

25. Remove the front A/C compressor mounting nuts.
26. Remove the rear A/C compressor mounting bolt.
27. Slide the A/C compressor forward off of the mounting studs and allow the compressor to rest on top of the engine frame.
28. Lower the vehicle.

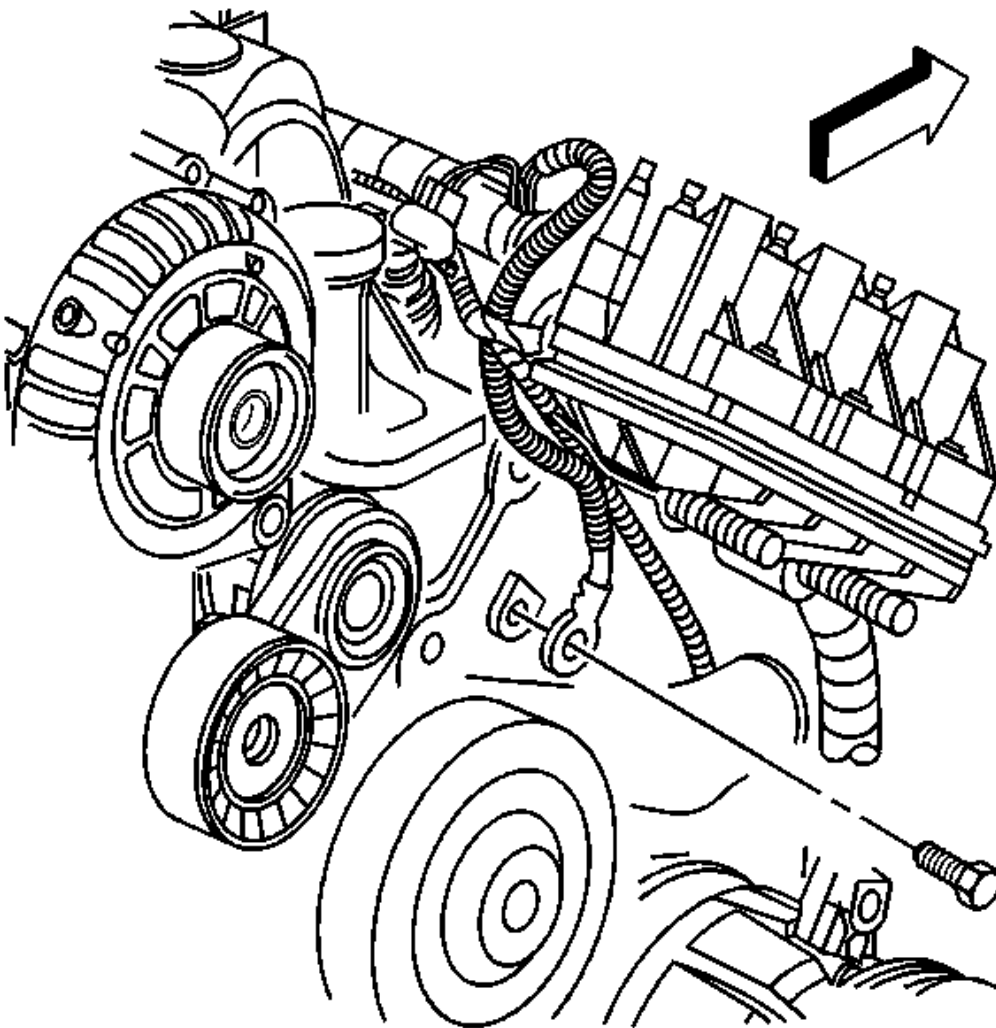


Fig. 128: Locating Powertrain Control Module (PCM) Ground Located At Left Front Cylinder Head

Courtesy of GENERAL MOTORS CORP.

29. Remove the bolt securing the powertrain control module (PCM) ground located at the left front cylinder head.

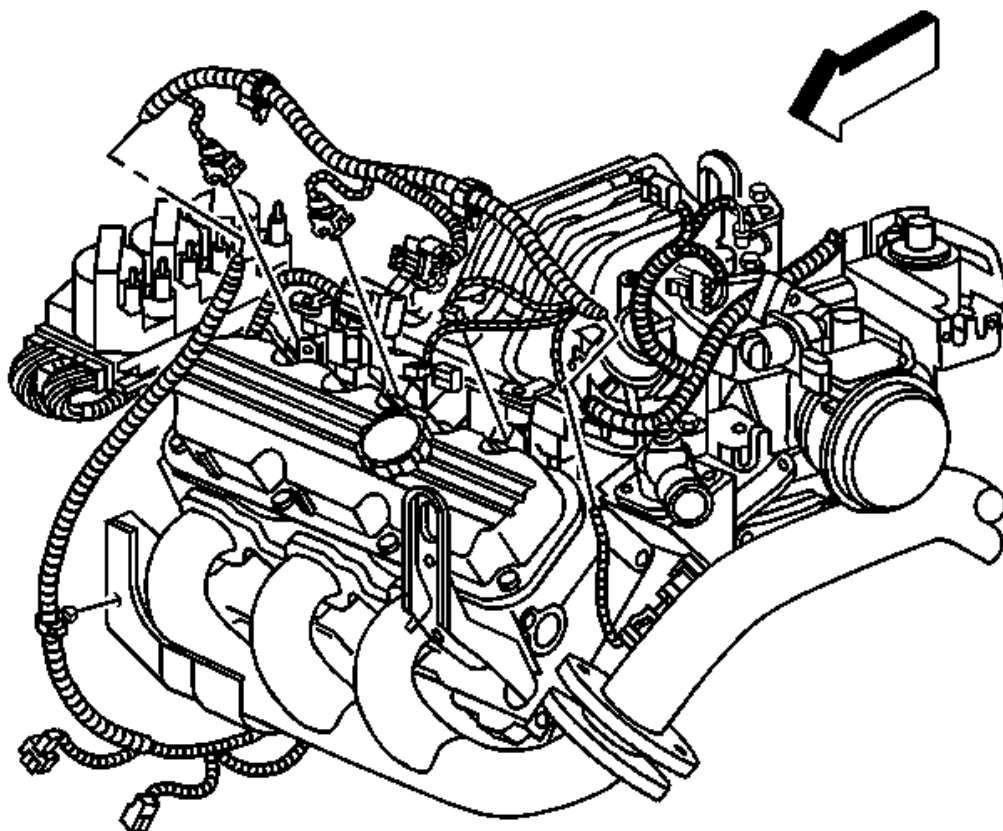


Fig. 129: Locating Specified Wiring Harness Electrical Connectors At Left Side Of Engine
Courtesy of GENERAL MOTORS CORP.

30. Disconnect the wiring harness electrical connectors from the following components on the left side of the engine:
- The fuel injectors
 - The ignition harness
 - The boost control solenoid, L67 only
 - The engine coolant temperature (ECT) sensor
 - The throttle position (TP) sensor
 - The idle air control (IAC) valve
 - The mass air flow (MAF) sensor

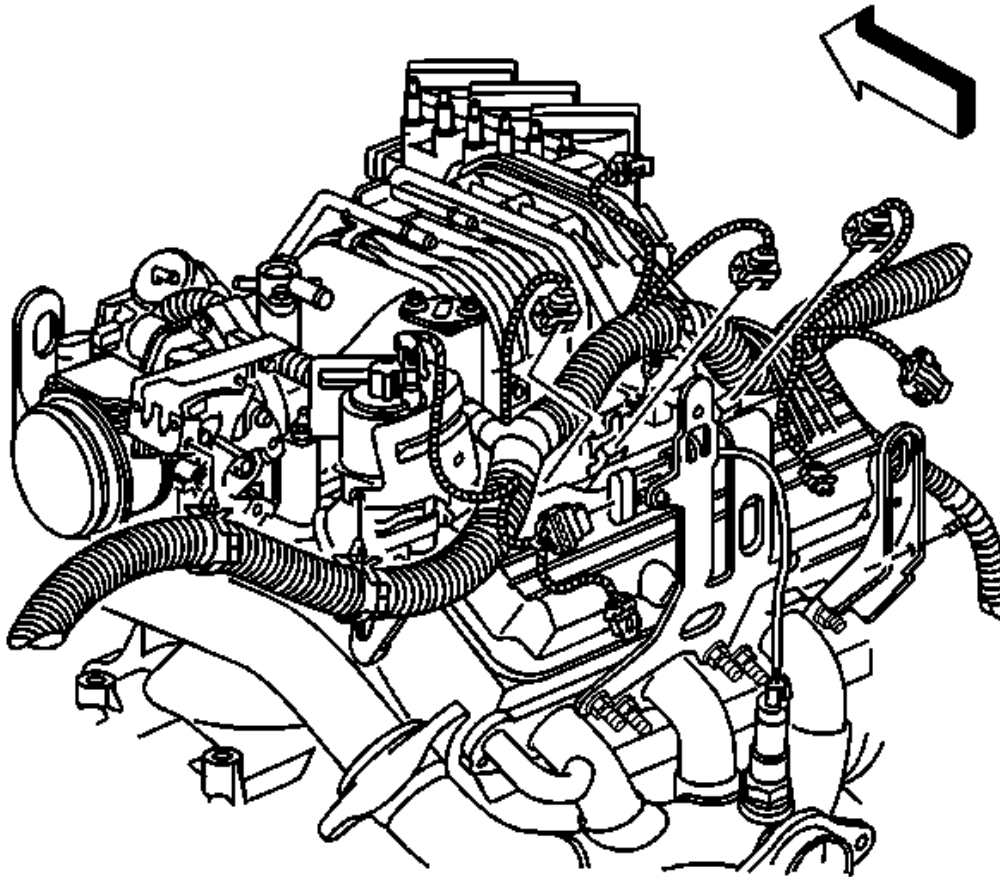


Fig. 130: Locating Specified Wiring Harness Electrical Connectors At Right Side Of Engine
Courtesy of GENERAL MOTORS CORP.

31. Disconnect the wiring harness connectors from the following components on the right side of the engine:
 - The fuel injectors
 - The exhaust gas recirculation (EGR) valve
 - The manifold absolute pressure (MAP) sensor
 - The heated oxygen sensor (HO2S)
 - The generator
32. Secure the engine wiring harness rearward to the air inlet grille.
33. Remove the generator. Refer to **Generator Replacement (L36)** in Engine Electrical.
34. Remove the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls.
35. Install the engine support fixture. Refer to **Engine Support Fixture**.

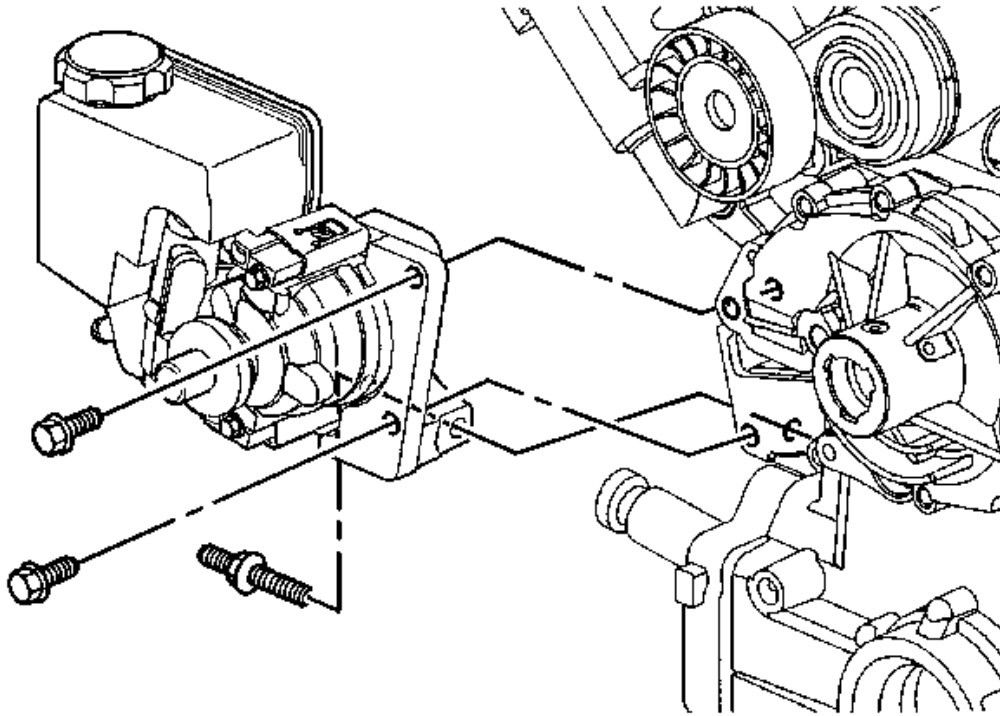


Fig. 131: Identifying Front Power Steering Pump Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

36. Remove the 2 front power steering pump mounting bolts.
37. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
38. Remove the side power steering pump mounting bolt.
39. Position the power steering pump against the cowl, allowing it to rest on top of the transaxle housing.
40. Remove the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right**.

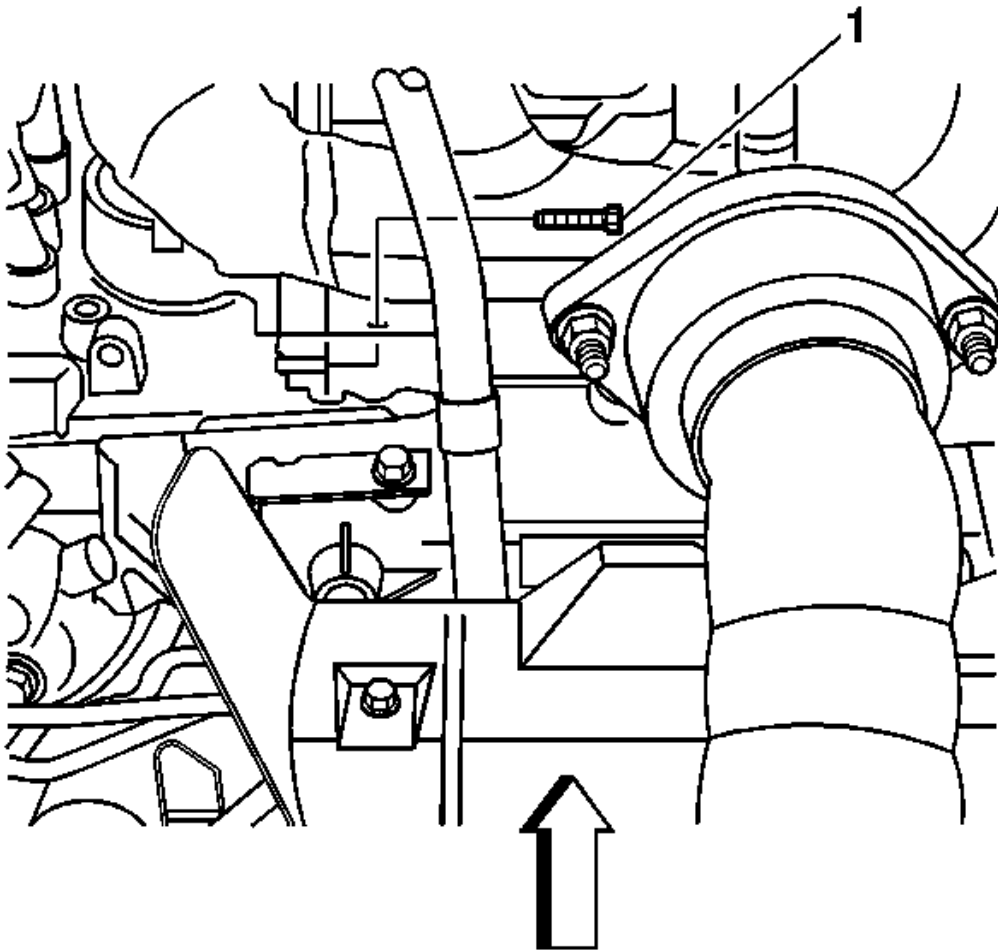


Fig. 132: Locating Right Lower Engine-To-Transaxle Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

41. Remove the right lower engine to transaxle mounting bolt (1).
42. Drain the cooling system. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.
43. Lower the vehicle.

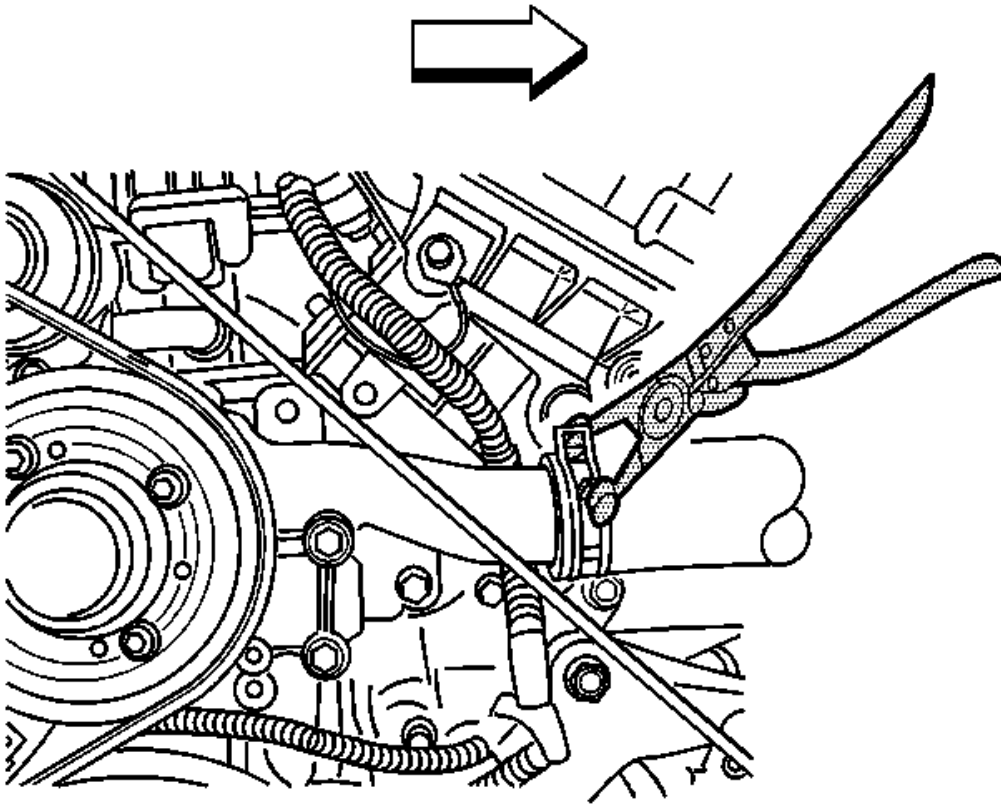


Fig. 133: Locating Radiator Inlet Hose At Water Pump
Courtesy of GENERAL MOTORS CORP.

44. Position the **J 38185** to the clamp in order to remove the radiator inlet hose from the water pump. See **Special Tools and Equipment**.

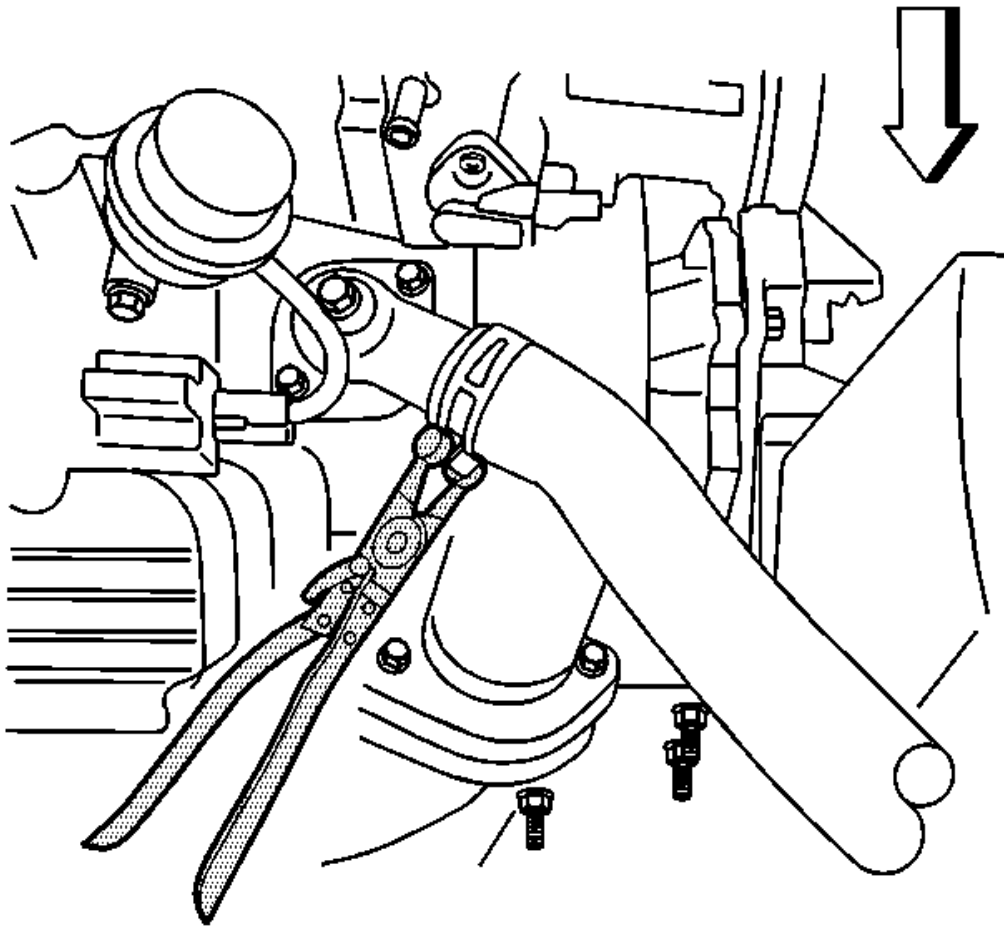


Fig. 134: Locating Radiator Outlet Hose At Thermostat Housing
 Courtesy of GENERAL MOTORS CORP.

45. Position the **J 38185** to the clamp in order to remove the radiator outlet hose from the thermostat housing. See **Special Tools and Equipment**.

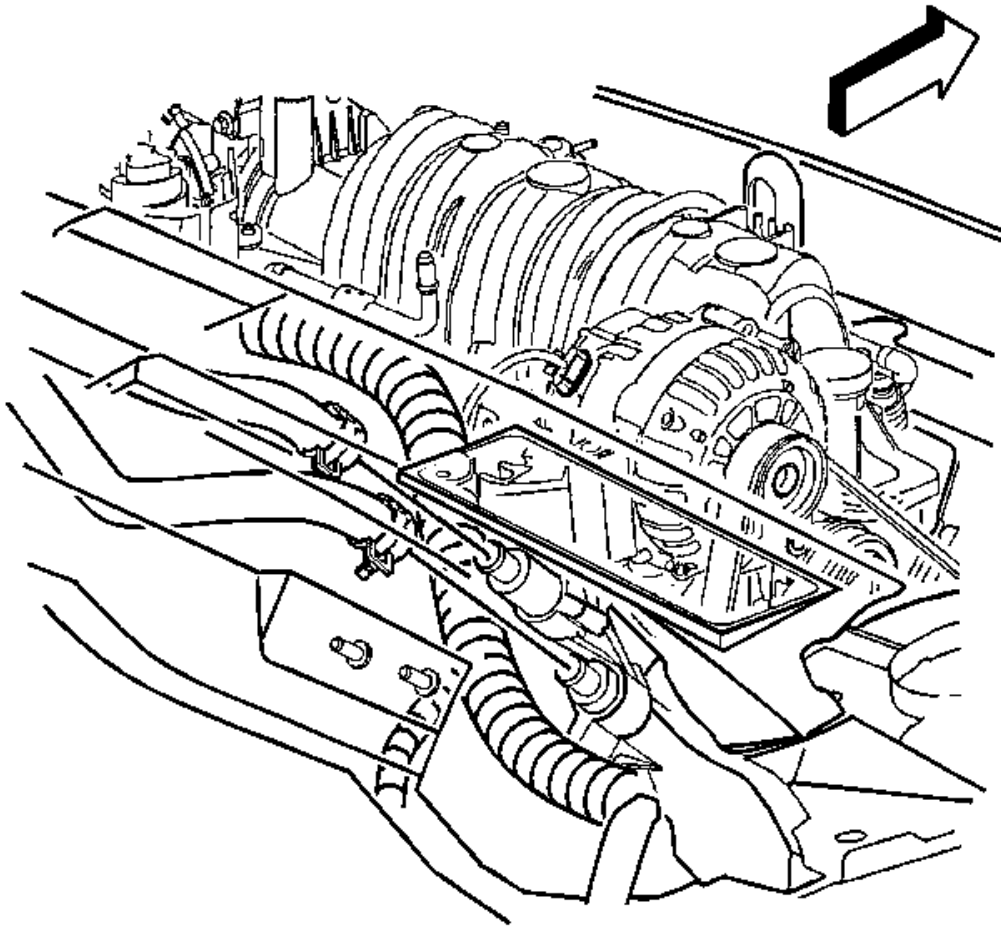


Fig. 135: View Of Heater Hoses At Engine Heater Pipe Adapters
Courtesy of GENERAL MOTORS CORP.

46. Remove the heater hoses from the drive belt tensioner fittings.
47. Using a block of wood between a floor jack and the transaxle, support the transaxle at the pan.
48. Remove the engine support fixture. Refer to **Engine Support Fixture**.

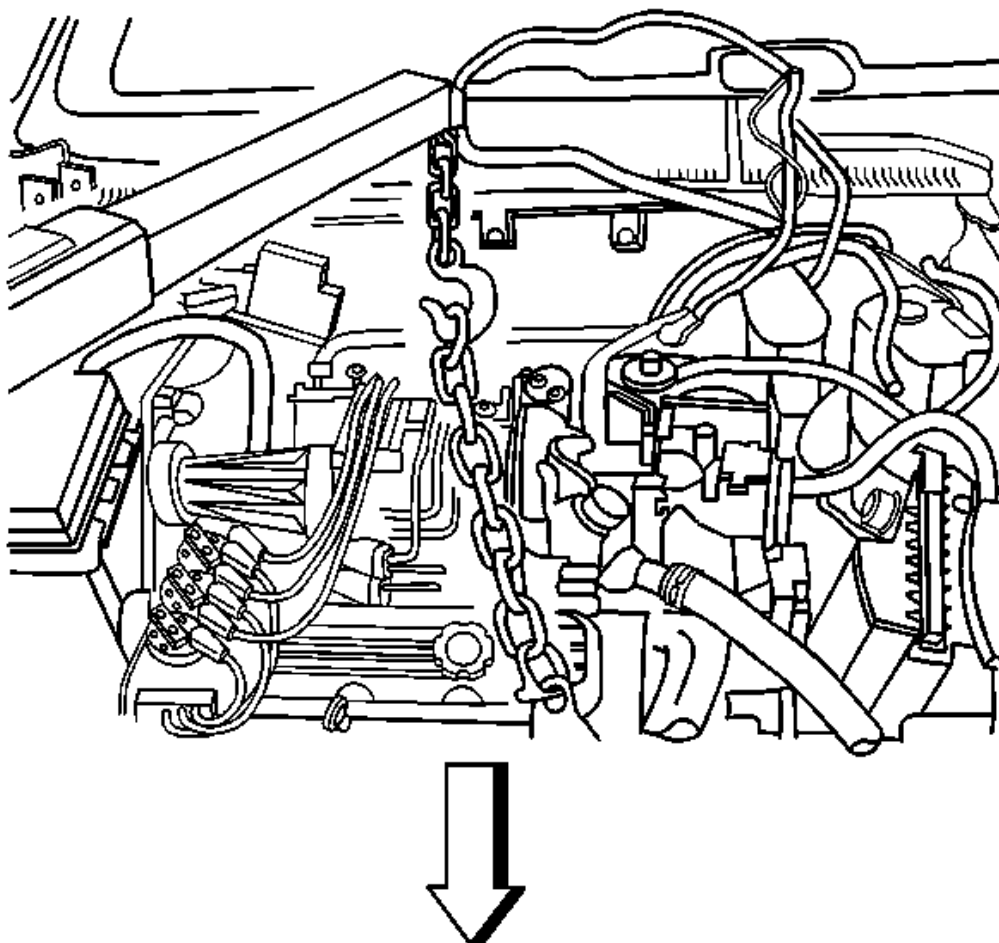


Fig. 136: Positioning Engine Lift Chain To Engine Lift Brackets
Courtesy of GENERAL MOTORS CORP.

49. Install an engine lift chain to the engine lift brackets and attach to an engine lift devise.
50. Remove the remaining engine to transaxle mounting bolts.

IMPORTANT: Ensure clearance is maintained between the engine and the following:

- The A/C accumulator
- The A/C accumulator hose
- The A/C compressor
- The A/C compressor hose

- The engine wiring electrical harness
- The vacuum brake booster

51. Carefully raise the engine from the engine compartment.
52. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

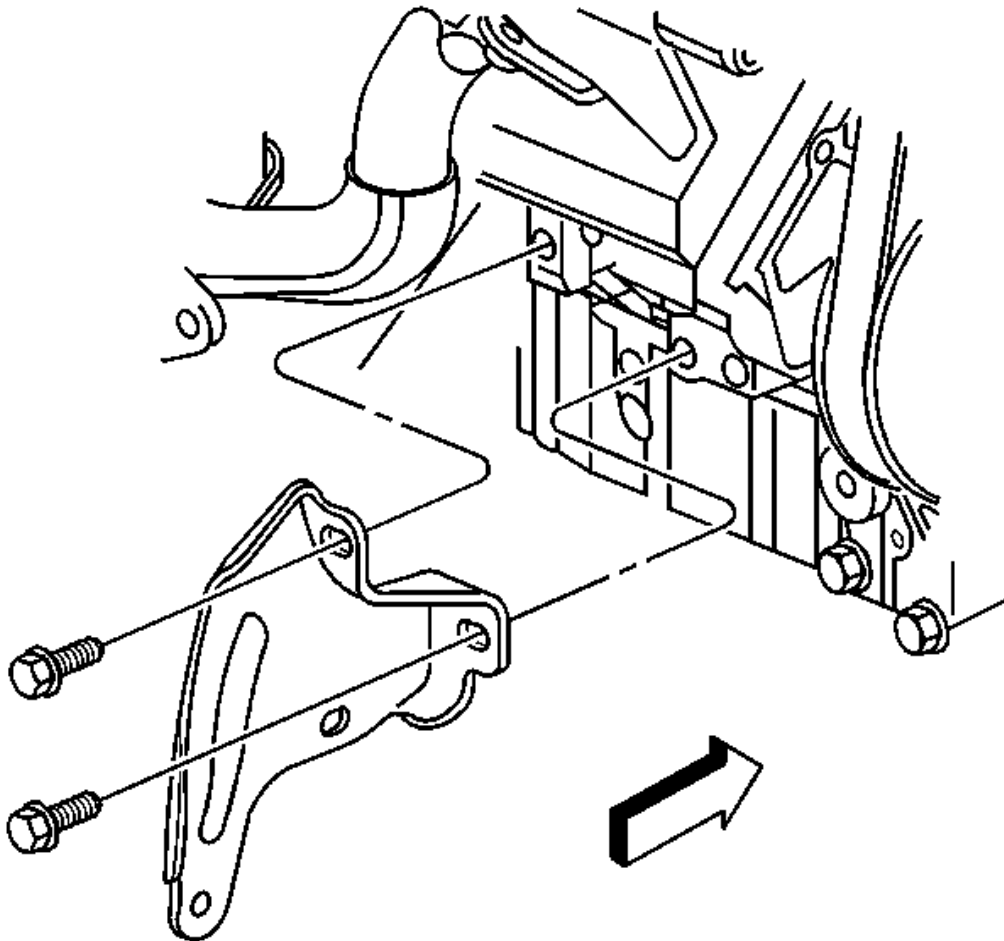


Fig. 137: Locating Strut Bracket-To-Engine Bolts
Courtesy of GENERAL MOTORS CORP.

53. Remove the 2 bolts securing the transaxle brace to the engine.
54. Remove the exhaust manifold pipe. Refer to **Exhaust Manifold Pipe Replacement** in Engine Exhaust.

Installation Procedure

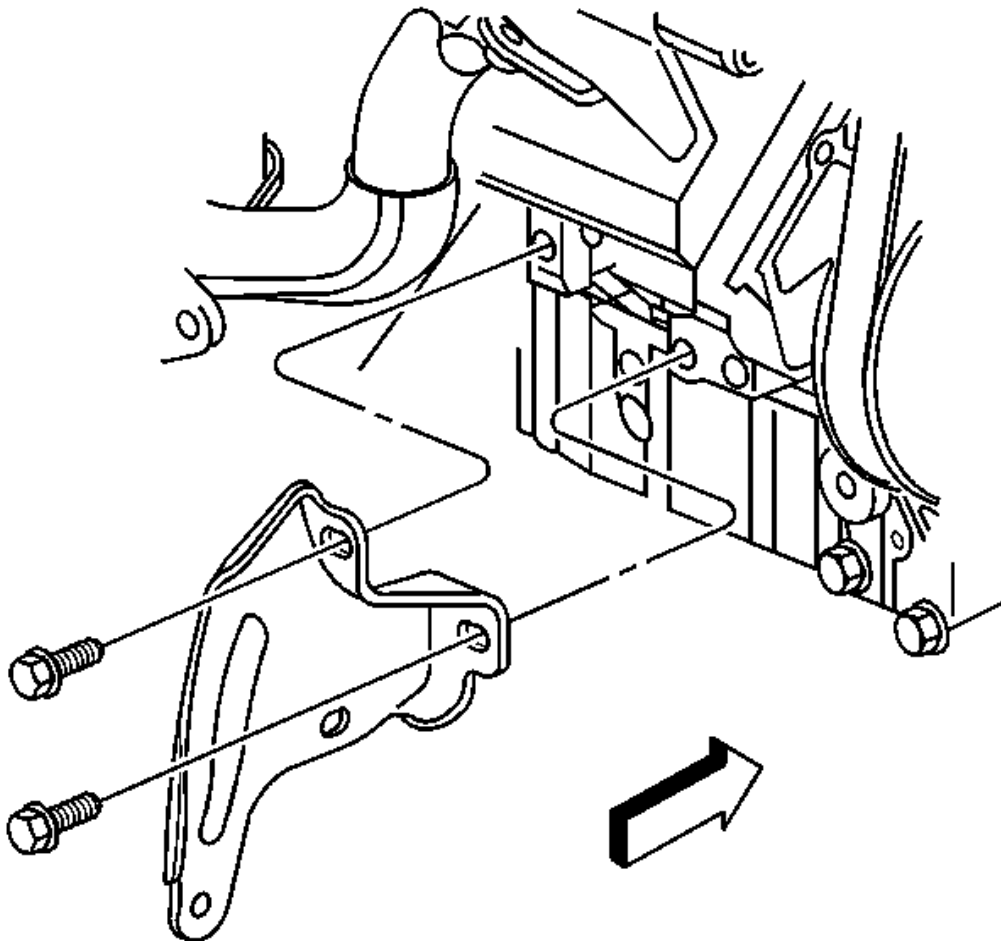


Fig. 138: Locating Strut Bracket-To-Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Loosely install the 2 bolts securing the transaxle brace to the engine. Do not tighten at this time.
2. Install the exhaust manifold pipe. Refer to **Exhaust Manifold Pipe Replacement** in Engine Exhaust.

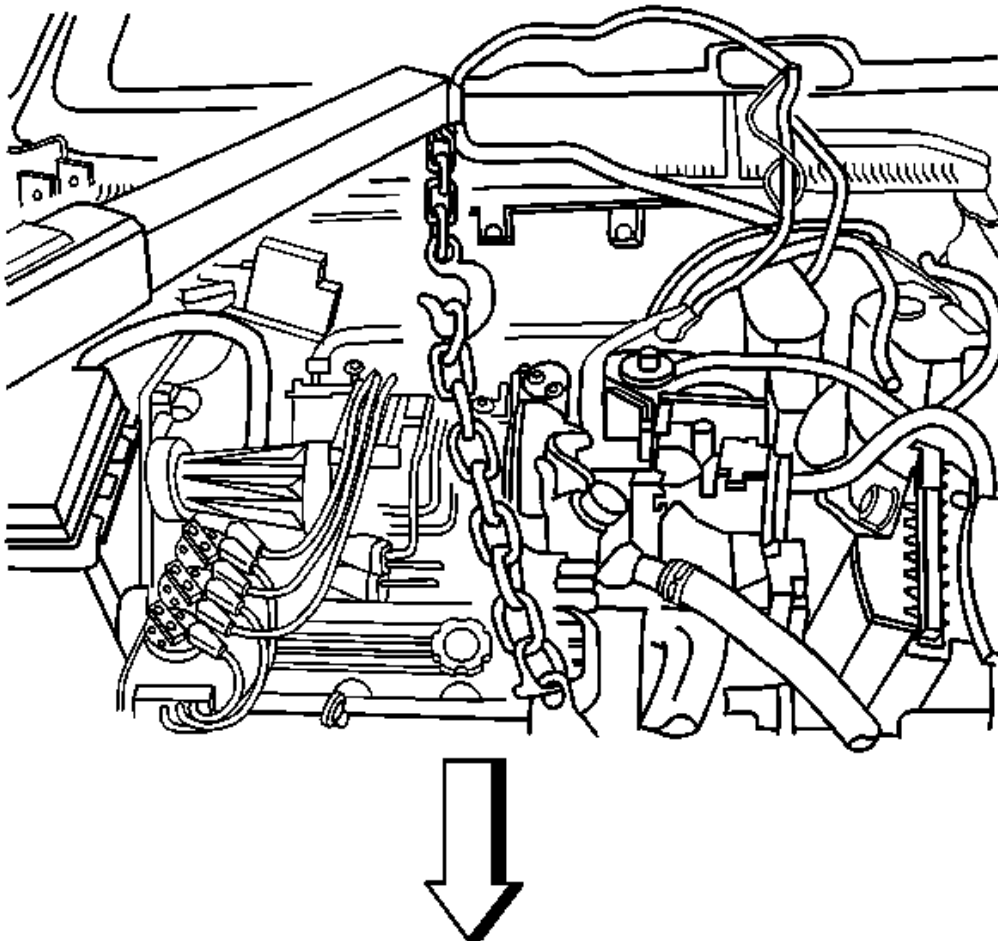


Fig. 139: Positioning Engine Lift Chain To Engine Lift Brackets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure clearance is maintained between the engine and the following:

- The A/C accumulator
- The A/C accumulator hose
- The A/C compressor
- The A/C compressor hose
- The engine wiring electrical harness
- The vacuum brake booster

3. Carefully lower the engine into the engine compartment.
4. Align the engine dowels to the transaxle cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the 5 upper engine to transaxle mounting bolts.

Tighten: Tighten the engine to transaxle mounting bolts to 75 N.m (55 lb ft).

6. Remove the engine lift chain from the engine lift brackets.
7. Install the engine support fixture. Refer to Engine Support Fixture.
8. Remove the support jack from under the transaxle.

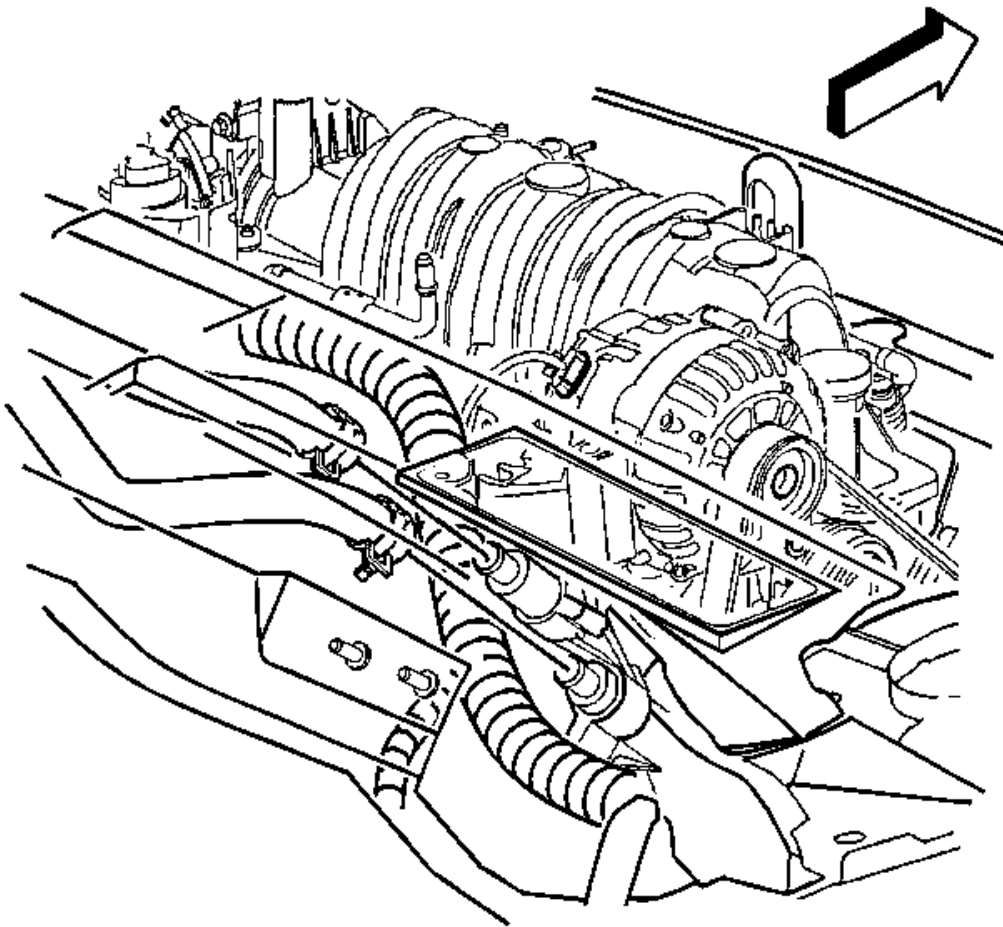


Fig. 140: View Of Heater Hoses At Engine Heater Pipe Adapters
Courtesy of GENERAL MOTORS CORP.

9. Connect the heater hoses to the drive belt tensioner fittings.

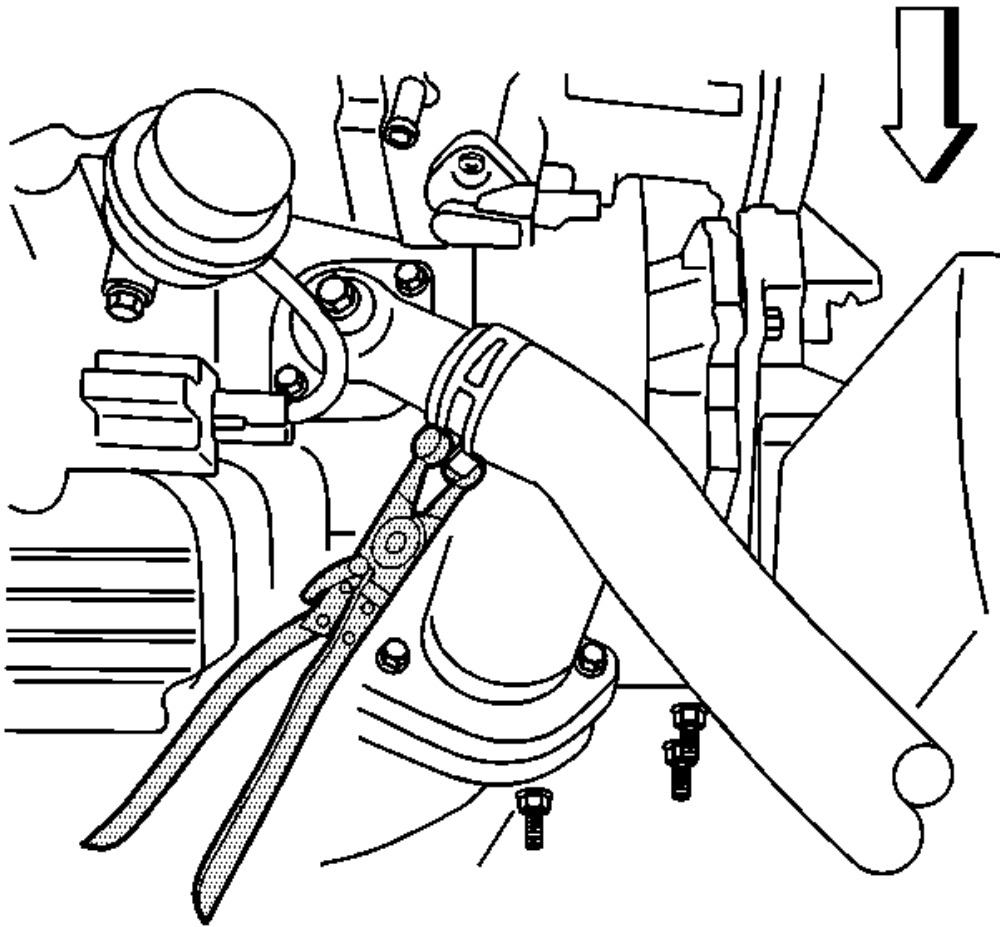


Fig. 141: Locating Radiator Outlet Hose At Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

10. Position the **J 38185** to the clamp in order to connect the radiator outlet hose to the thermostat housing. See **Special Tools and Equipment**.

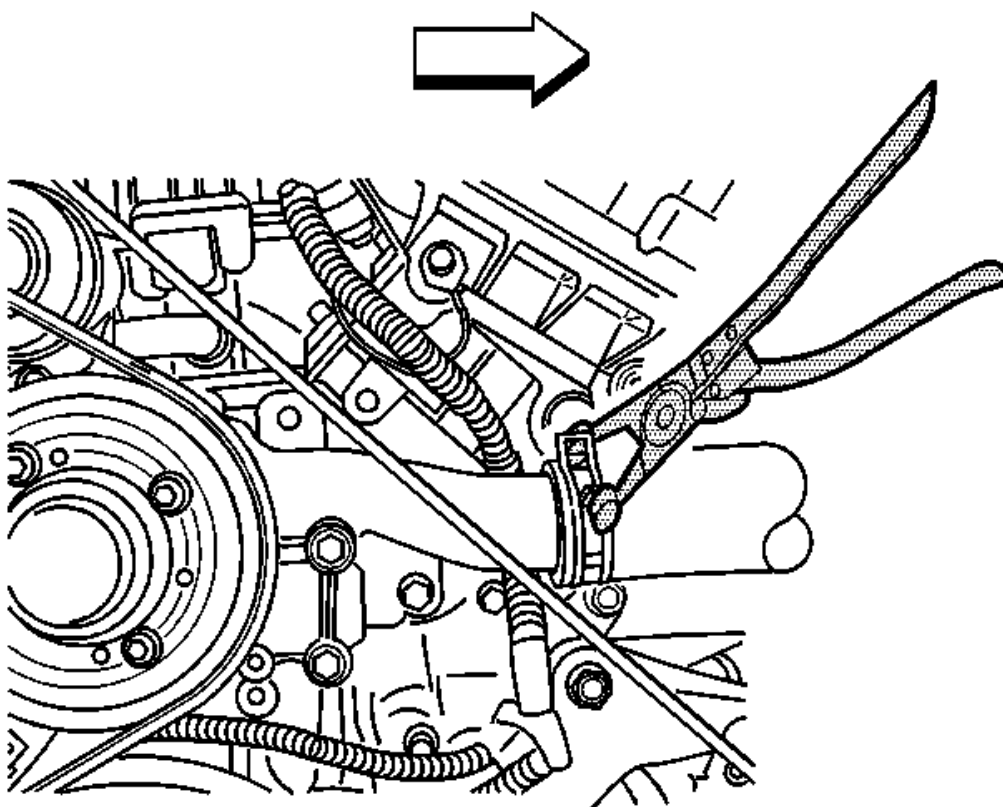


Fig. 142: Locating Radiator Inlet Hose At Water Pump
Courtesy of GENERAL MOTORS CORP.

11. Position the **J 38185** to the clamp in order to connect the radiator inlet hose to the water pump. See **Special Tools and Equipment**.
12. Fill the cooling system. Refer to **Draining and Filling Cooling System (L36)** in Engine Cooling.
13. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

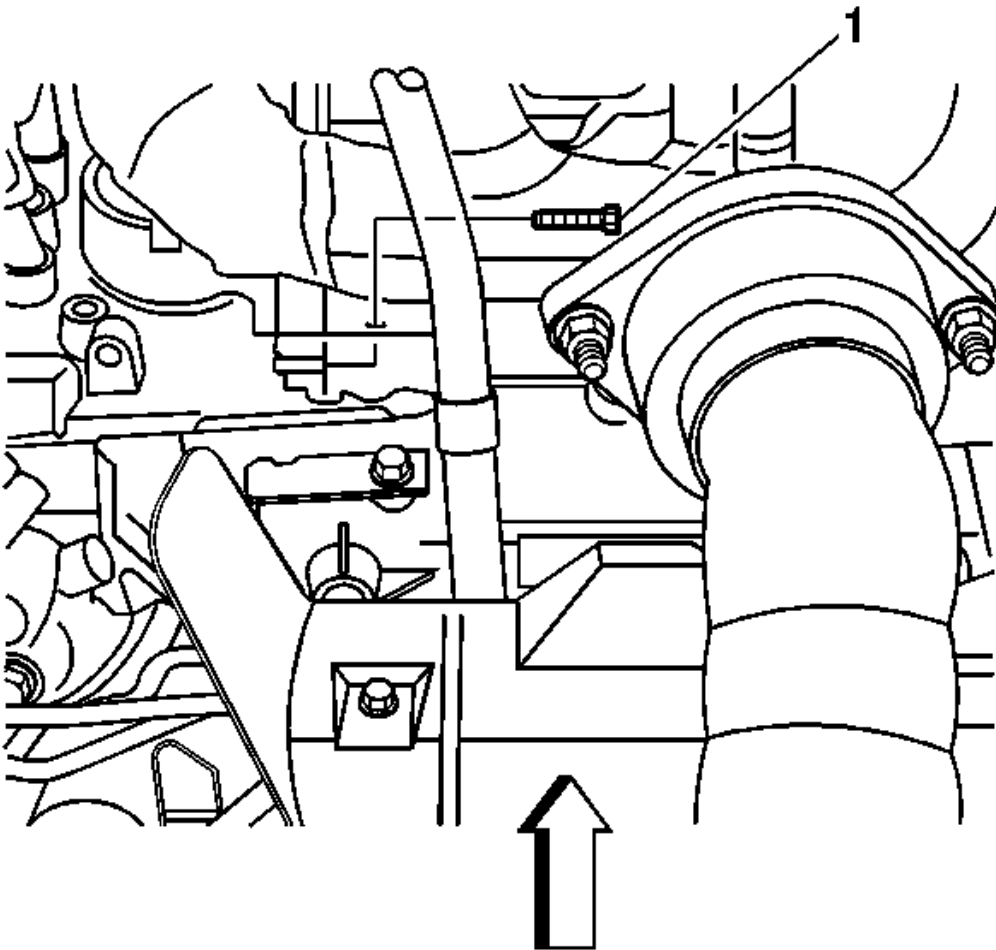


Fig. 143: Locating Right Lower Engine-To-Transaxle Mounting Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the right lower engine to transaxle mounting bolt (1).

Tighten: Tighten the engine to transaxle mounting bolt to 75 N.m (55 lb ft).

15. Install the right engine mount bracket. Refer to **Engine Mount Bracket Replacement - Right.**

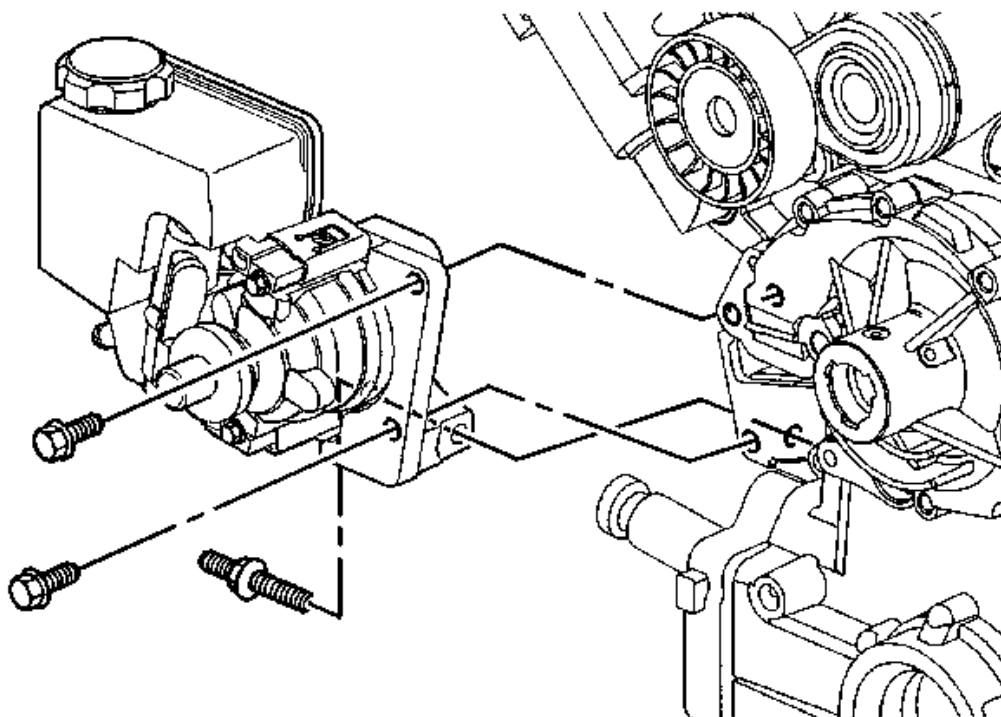


Fig. 144: Identifying Front Power Steering Pump Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

16. Position the power steering pump to the engine.
17. Loosely install the side power steering pump mounting bolt. Do not tighten at this time.
18. Lower the vehicle.
19. Install the 2 front power steering pump mounting bolts.

Tighten: Tighten the power steering pump mounting bolts to 27 N.m (20 lb ft).

20. Remove the engine support fixture. Refer to **Engine Support Fixture**.
21. Install the air cleaner intake duct. Refer to **Air Cleaner Intake Duct Replacement** in Engine Controls.
22. Install the generator. Refer to **Generator Replacement (L36)** in Engine Electrical.

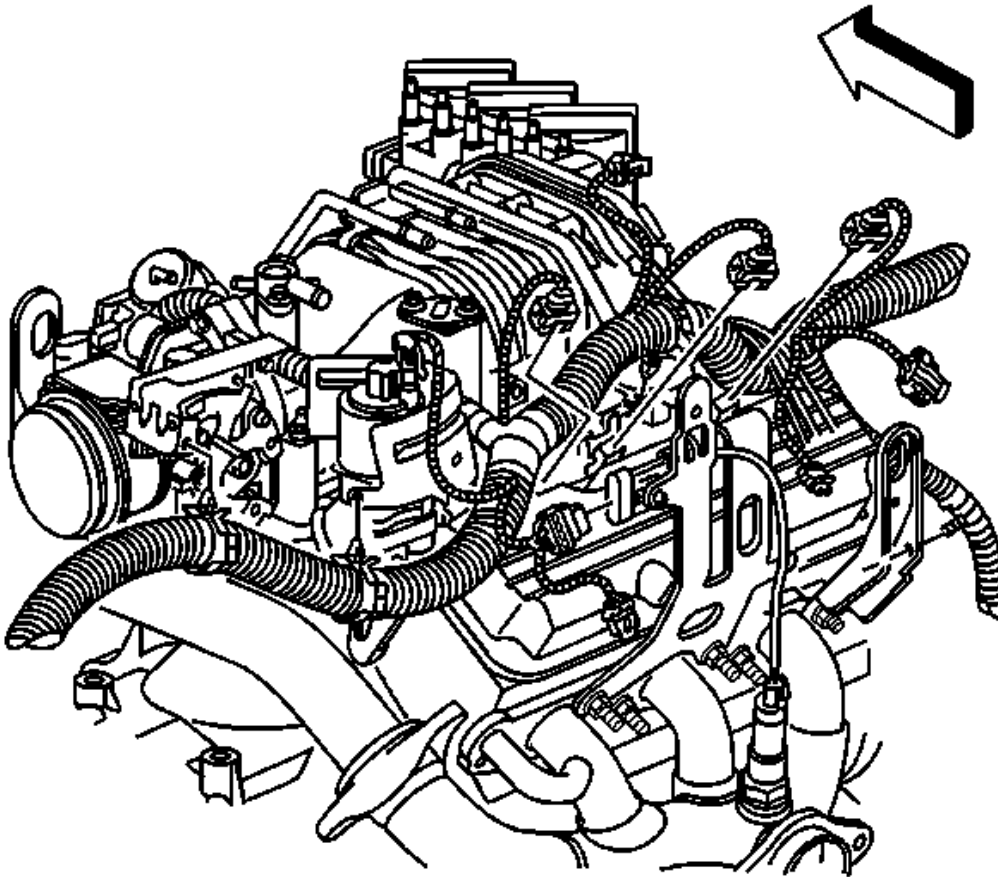


Fig. 145: Locating Specified Wiring Harness Electrical Connectors At Right Side Of Engine
Courtesy of GENERAL MOTORS CORP.

23. Position the engine wiring electrical harness to the engine.
24. Connect the wiring harness electrical connectors to the following components on the right side of the engine:
 - The fuel injectors
 - The EGR valve
 - The MAP sensor
 - The HO2S
 - The generator

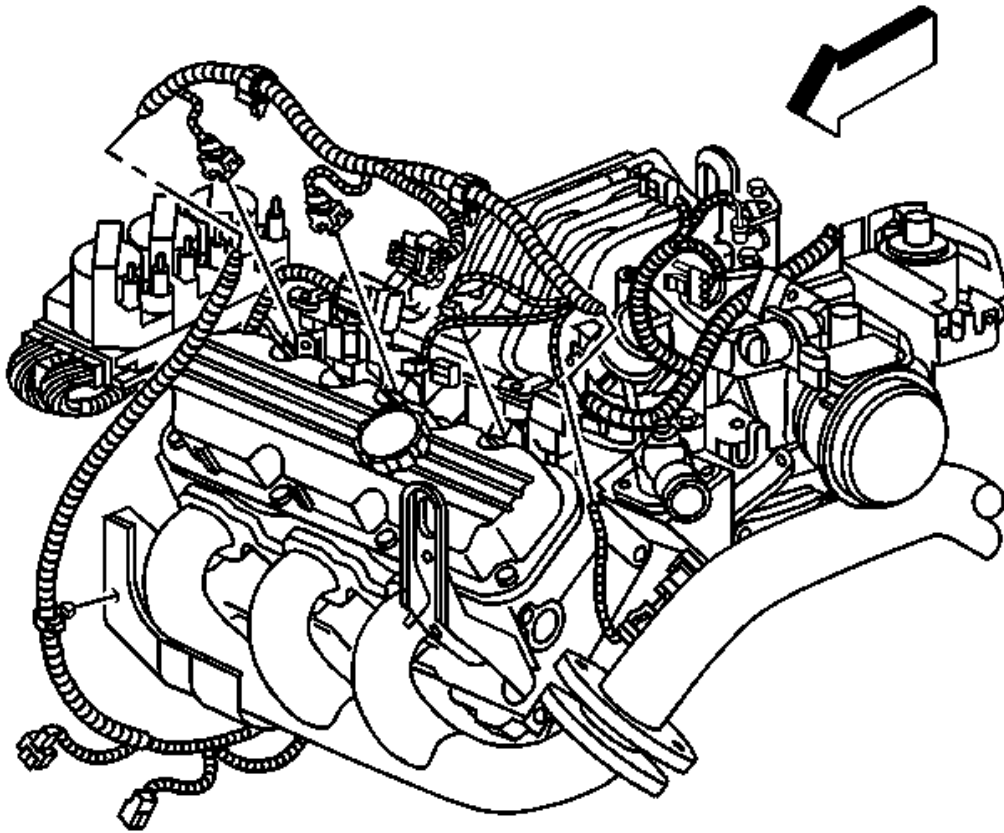


Fig. 146: Locating Specified Wiring Harness Electrical Connectors At Left Side Of Engine
Courtesy of GENERAL MOTORS CORP.

25. Connect the wiring harness electrical connectors to the following components on the left side of the engine:
- The fuel injectors
 - The ignition harness
 - The boost control solenoid, L67 only
 - The ECT sensor
 - The TP sensor
 - The IAC valve
 - The MAF sensor

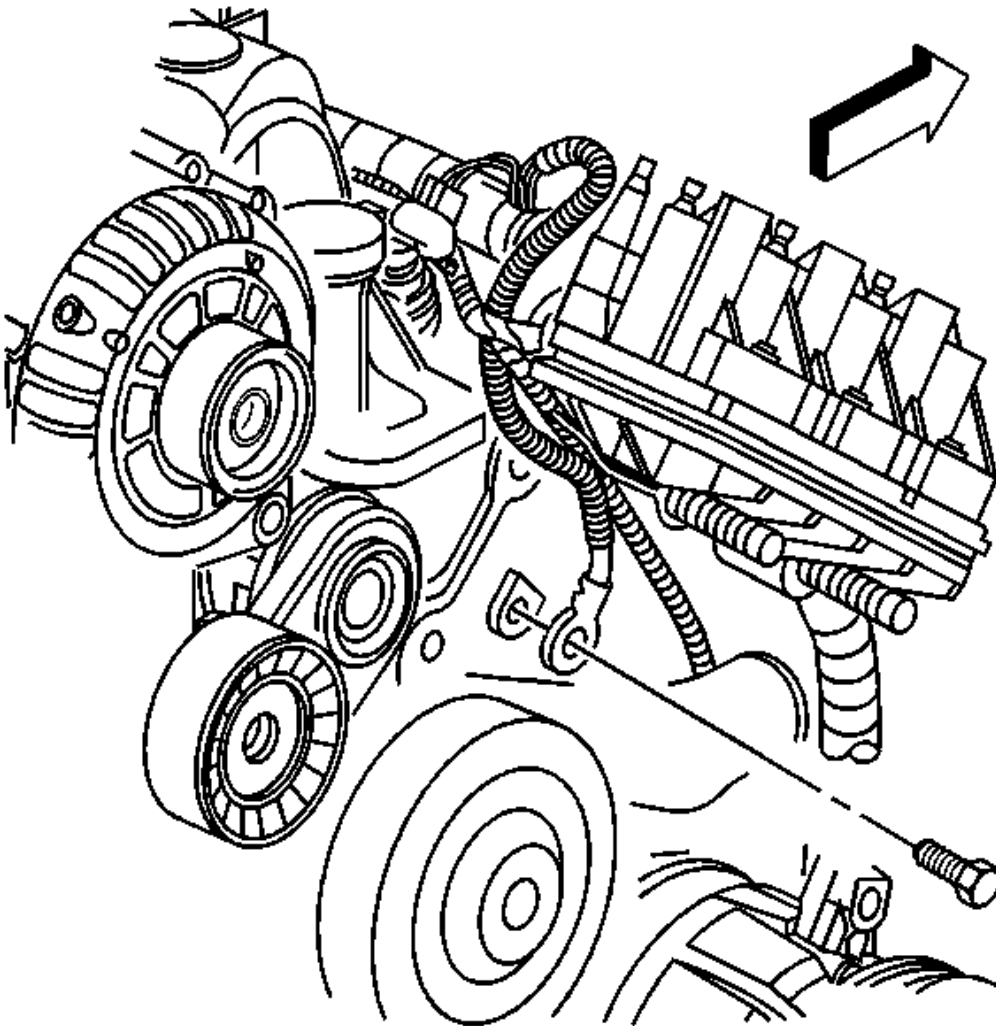


Fig. 147: Locating Powertrain Control Module (PCM) Ground Located At Left Front Cylinder Head

Courtesy of GENERAL MOTORS CORP.

26. Install the bolt securing the PCM ground to the left front cylinder head.

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

27. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
28. Tighten the side power steering pump mounting bolt previously installed in step 14.

Tighten: Tighten the power steering pump mounting bolt to 27 N.m (20 lb ft).

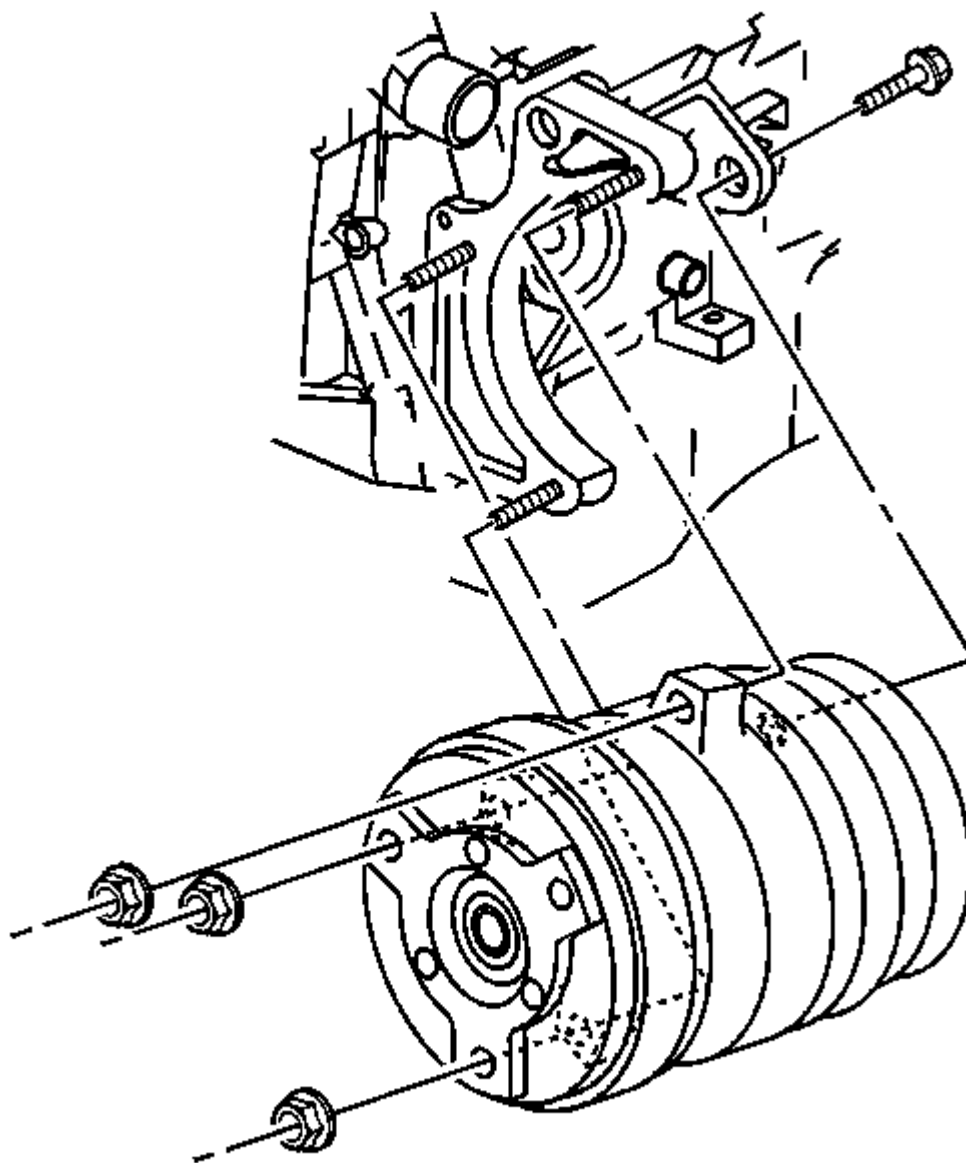


Fig. 148: Identifying A/C Compressor Mounting Nuts & Bolt
Courtesy of GENERAL MOTORS CORP.

29. Slide the A/C compressor rearward over the mounting studs.
30. Install the rear A/C compressor mounting bolt.

31. Install the front A/C compressor mounting nuts.

Tighten: Tighten the A/C compressor mounting fasteners to 50 N.m (37 lb ft).

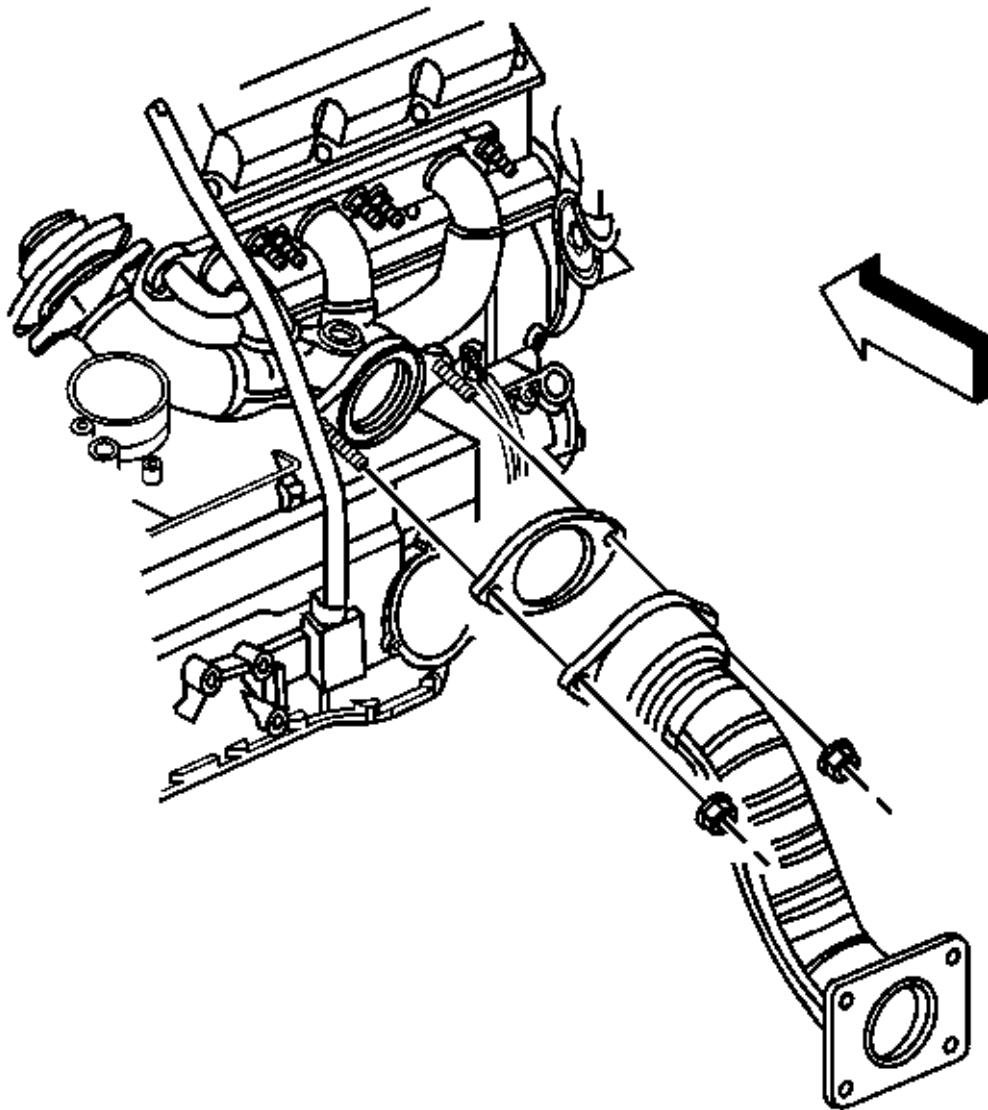


Fig. 149: Locating Exhaust Manifold Pipe-To-Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

32. Place a NEW exhaust manifold pipe gasket over the right exhaust manifold studs.

33. Position the exhaust manifold pipe to the right exhaust manifold.
34. Install the 2 nuts attaching the exhaust manifold pipe to the right exhaust manifold.

Tighten: Tighten the exhaust manifold pipe nuts to 40 N.m (30 lb ft).

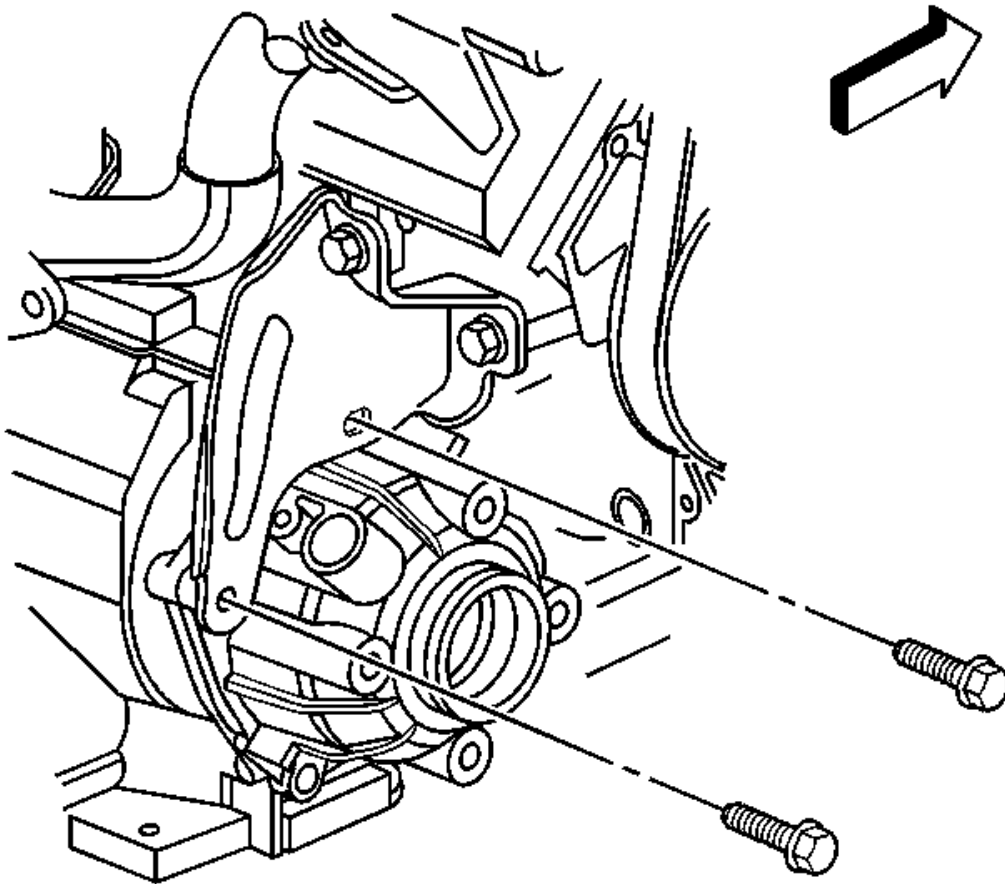


Fig. 150: Transaxle Brace To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

35. Install the 2 bolts securing the transaxle brace to the transaxle.

Tighten the 2 bolts previously installed in step 1.

Tighten: Tighten the transaxle brace bolts to 65 N.m (48 lb ft).

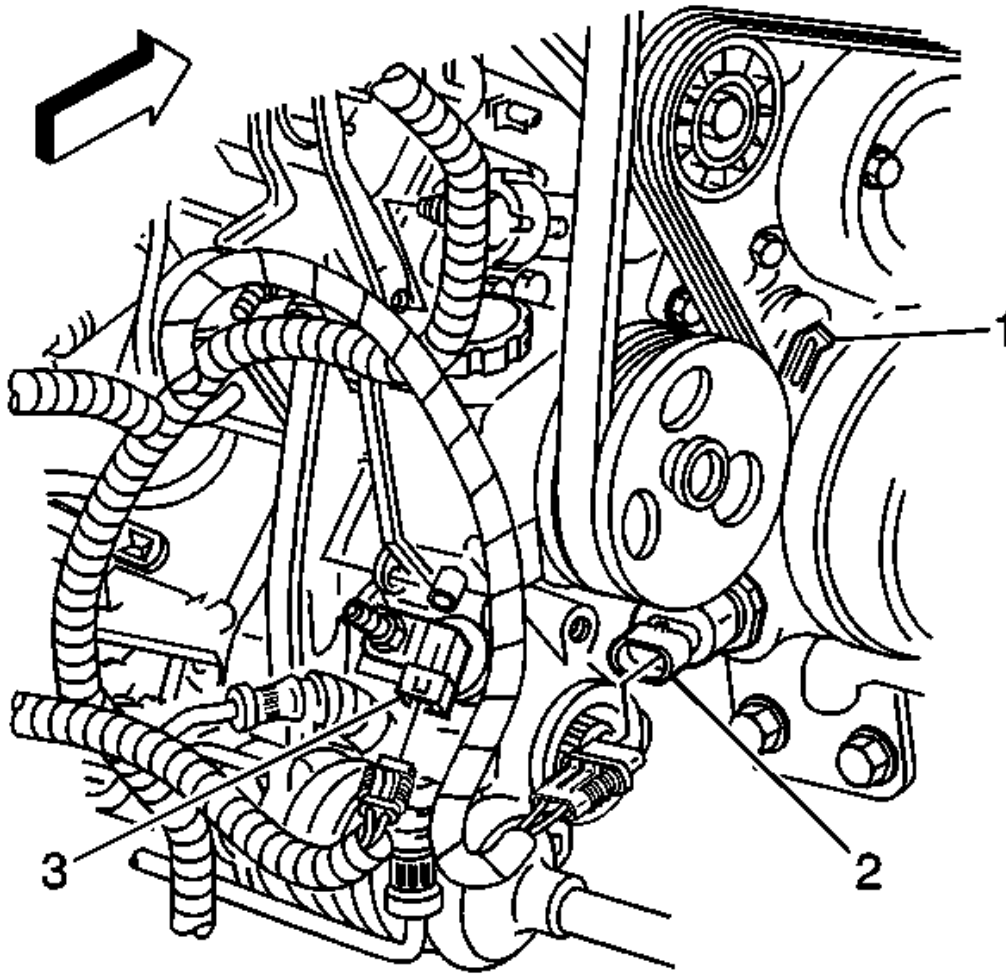


Fig. 151: Locating Specified Wiring Harness Electrical Connectors Near Cowl
Courtesy of GENERAL MOTORS CORP.

36. Connect the wiring harness electrical connectors to the following components
 - The knock sensor #2, located behind the right exhaust manifold
 - The oil pressure sensor (2)
 - The VSS (3)
37. Install the bolts securing the flywheel to the torque converter.

Tighten: Tighten the flywheel to torque converter bolts to 63 N.m (46 lb ft).

38. Install the starter motor. Refer to **Starter Motor Replacement (L36)** in Engine Electrical.

39. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** in Automatic Transaxle - 4T65-E.

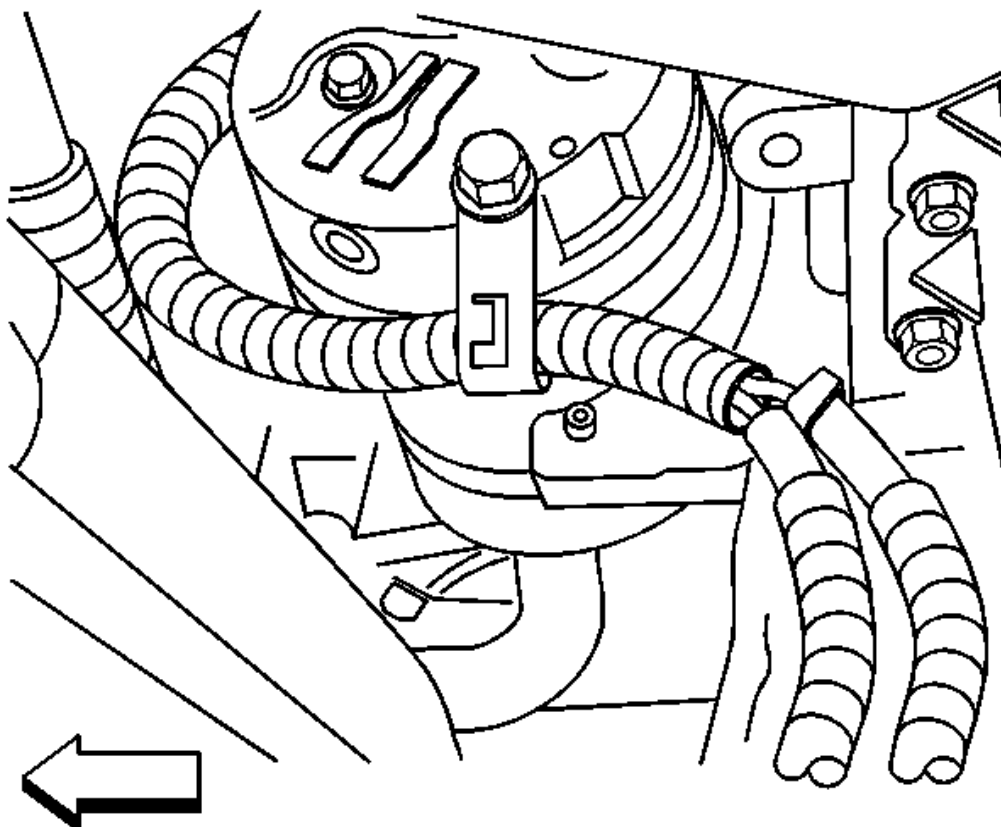


Fig. 152: Locating A/C Compressor Wiring Harness Rear Harness Clip
Courtesy of GENERAL MOTORS CORP.

40. Connect the wiring harness to the harness clip at the rear of the A/C compressor.

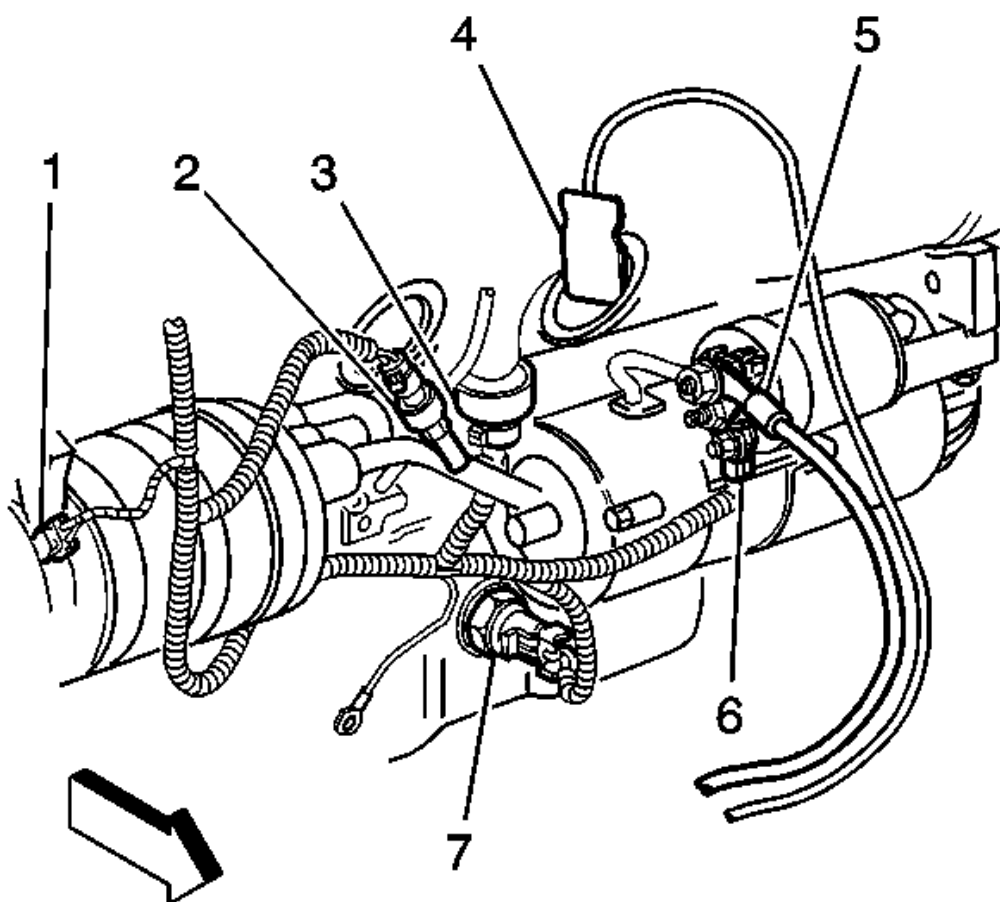


Fig. 153: Locating Specified Components Wiring Harness Connectors Near Starter
Courtesy of GENERAL MOTORS CORP.

41. Connect the wiring harness connectors to the following components:
- The A/C compressor clutch (1)
 - The A/C pressure sensor (2)
 - The knock sensor #1 (3)
 - The engine coolant block heater (4)
 - The oil level sensor (7)

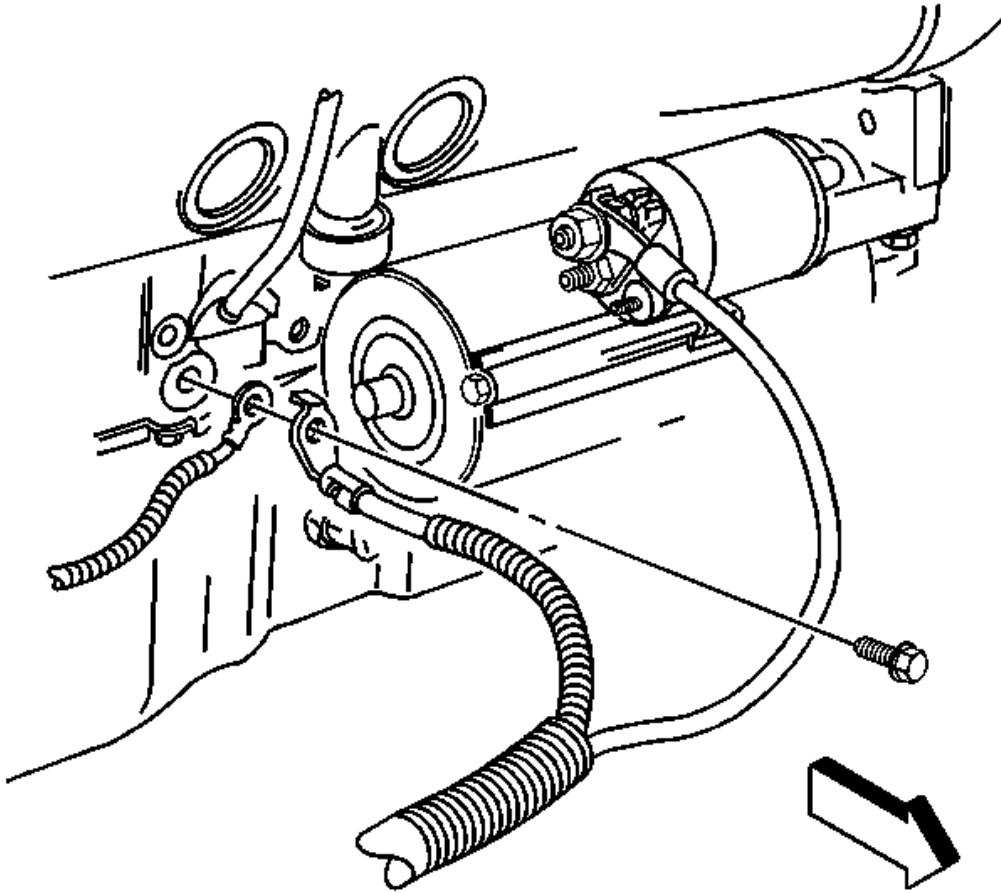


Fig. 154: Locating Battery Negative Cable & Engine Harness Ground Lead-To-Engine Block Bolt
Courtesy of GENERAL MOTORS CORP.

42. Install the bolt in order to secure both the battery negative cable and the engine harness ground lead to the engine block.

Tighten: Tighten the battery negative cable to engine block bolt to 25 N.m (18 lb ft).

43. Install the right front fascia extension. Refer to **Fascia Extension Replacement - Front** in Bumpers.
44. Lower the vehicle.
45. Install the drive belt. Refer to **Drive Belt Replacement**.

CAUTION: In order to avoid possible injury or vehicle damage, always replace the accelerator control cable with a NEW cable whenever you remove the engine from the vehicle.

In order to avoid cruise control cable damage, position the cable out of the way while you remove or install the engine. Do not pry or lean against the cruise control cable and do not kink the cable. You must replace a damaged cable.

46. Remove the accelerator control cable. Refer to Cruise Control Cable Replacement in Cruise Control.

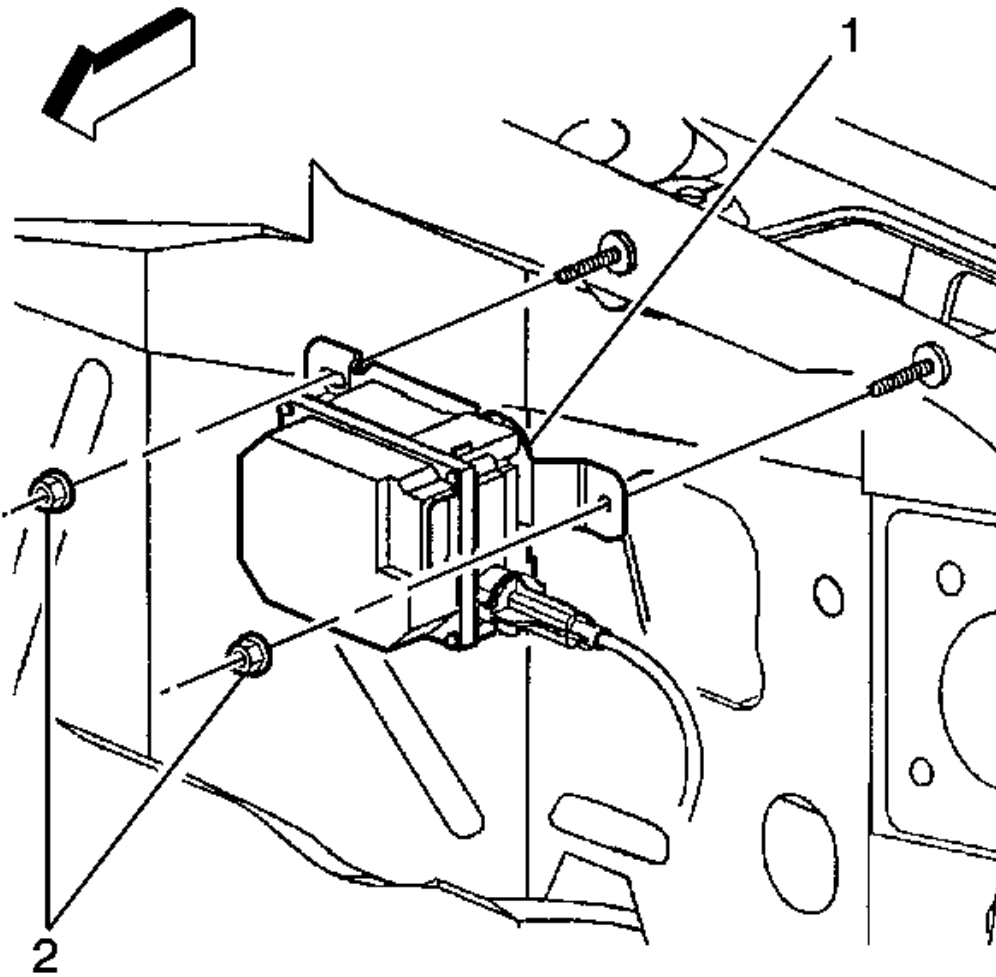


Fig. 155: Locating Retaining Nuts & Cruise Control Module
Courtesy of GENERAL MOTORS CORP.

47. Position the cruise control module (1) to the mounting studs on the cowl.

Install the 2 cruise control module bracket retaining nuts (2).

Tighten: Tighten the cruise control module bracket retaining nuts to 9 N.m (80 lb ft).

48. Connect the electrical connector to the cruise control module.

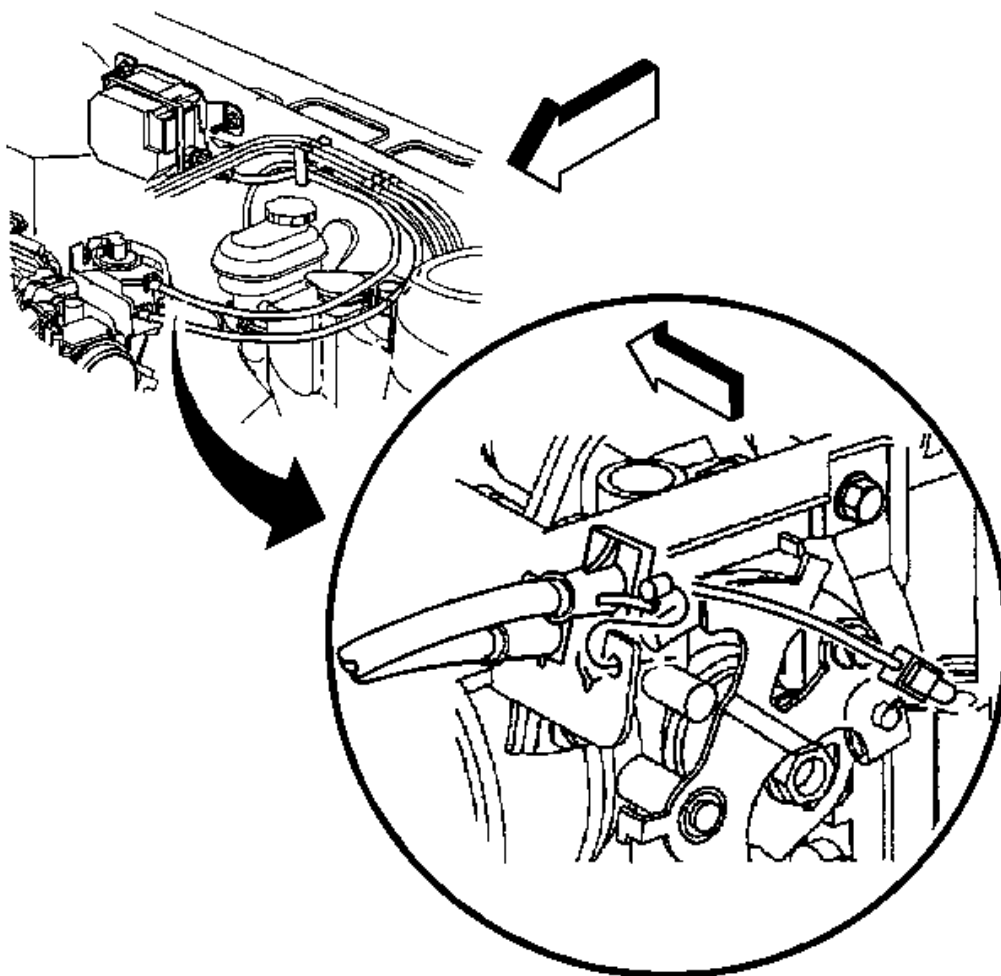


Fig. 156: Locating Cruise Control Cable Throttle Body Bracket & Lever
Courtesy of GENERAL MOTORS CORP.

49. Install the cruise control cable to the throttle body lever.
50. Slide the cruise control cable fully into the throttle body bracket until it snaps into place.
51. Install the EVAP canister purge valve solenoid. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls.
52. Connect the fuel feed and return lines to the fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls.

53. Connect the vacuum brake booster hose to the vacuum connections.
54. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
55. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
56. Install the hood. Refer to **Hood Replacement** in Body Front End.
57. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

Engine Final Test and Inspection

Complete the following procedure after the engine is installed in the vehicle:

1. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any parts are binding.
2. Start the engine and listen for abnormal conditions.
3. Check the vehicle oil pressure gage or light and confirm that the engine has acceptable oil pressure.
4. Run the engine at approximately 1,000 RPM until the engine reaches normal operating temperature.
5. While the engine continues to idle raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
6. Inspect for oil, coolant and exhaust leaks while the engine is idling.
7. Lower the vehicle.
8. Perform the crankshaft position (CKP) variation learn. Refer to **CKP System Variation Learn Procedure** in Engine Controls.
9. Perform a final inspection for the proper engine oil and coolant levels.
10. Road test the vehicle.

Engine Oil and Oil Filter Replacement**Removal Procedure**

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position the oil drain pan under the engine oil drain plug.
3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, repair or replace if necessary.
5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, repair or replace oil pan if necessary.

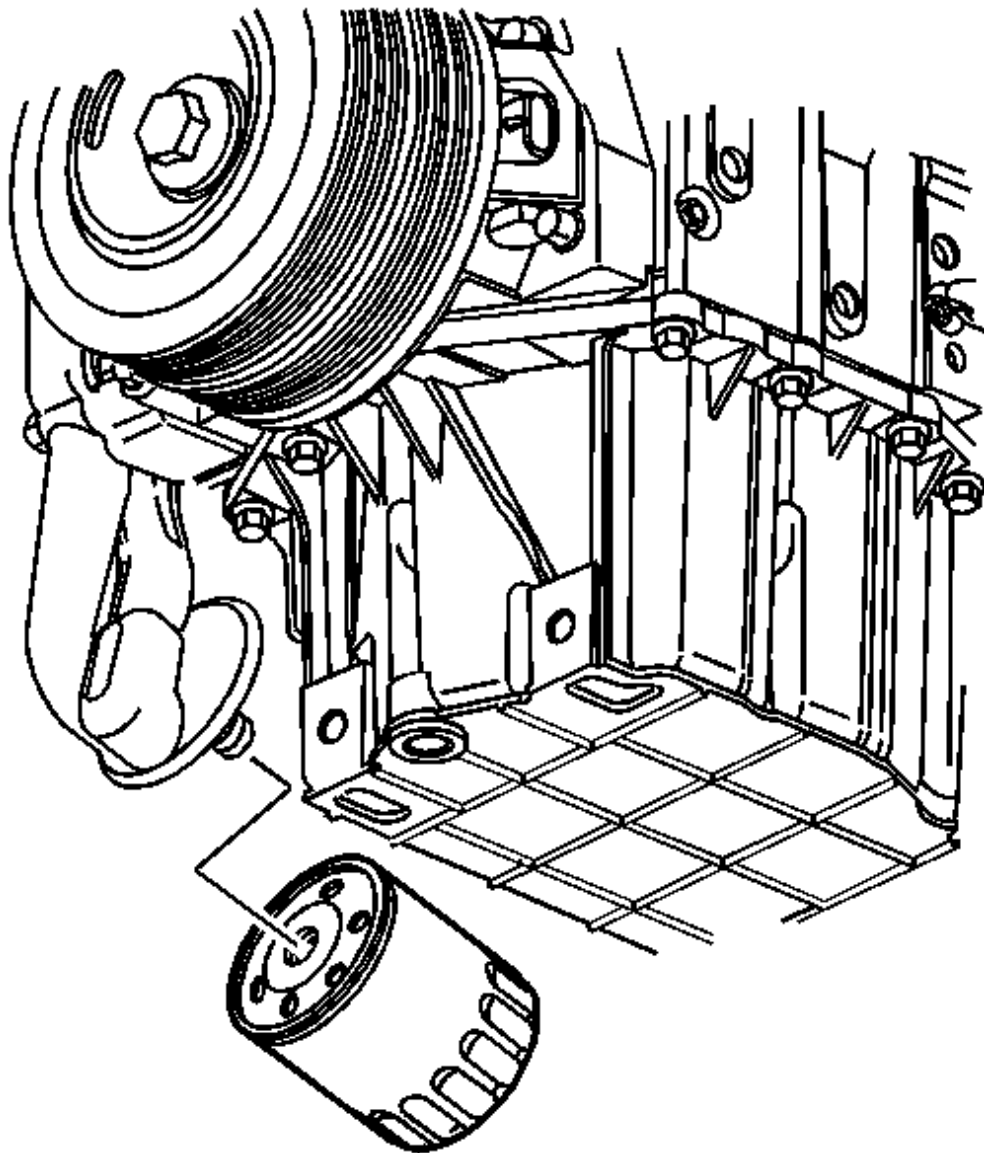


Fig. 157: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

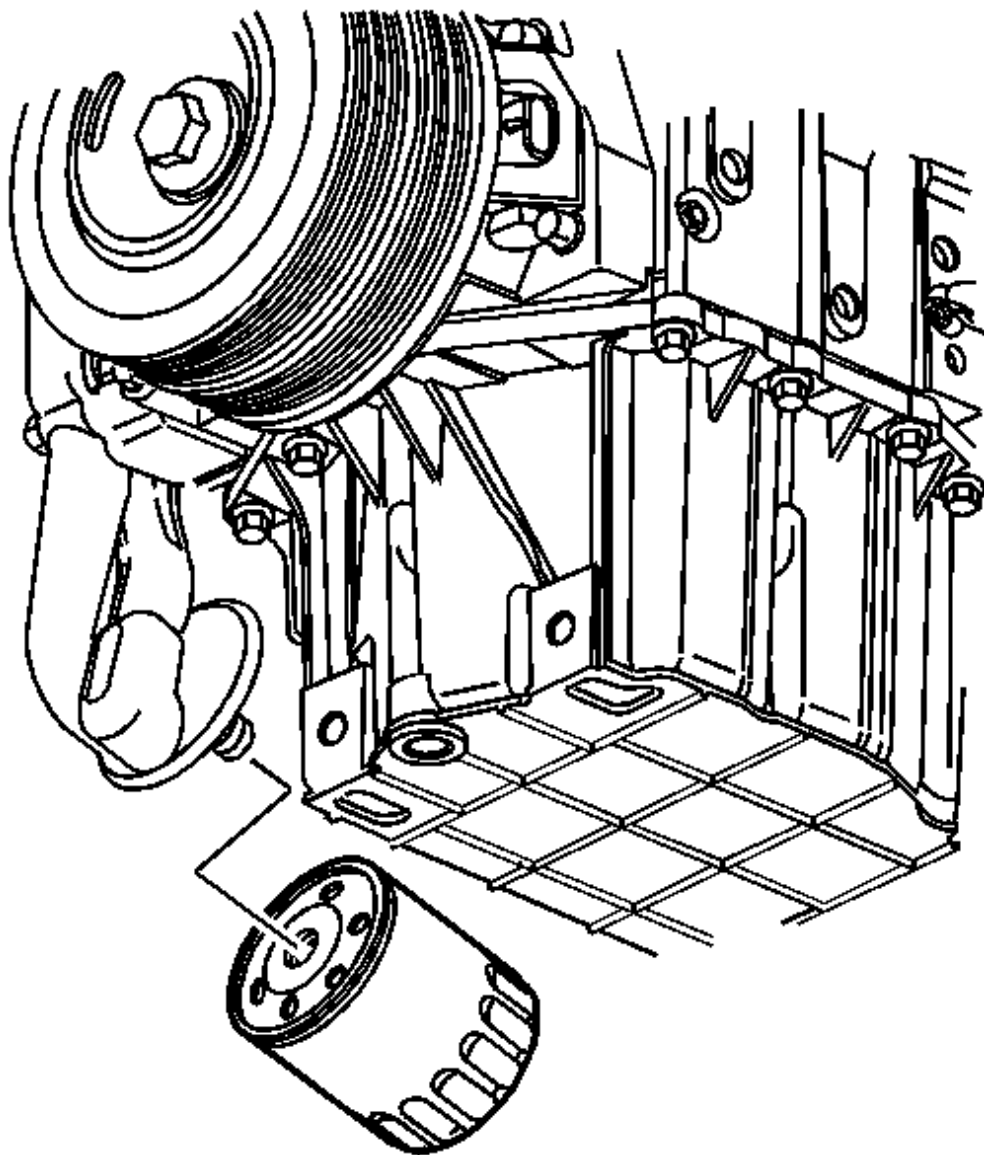


Fig. 158: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Lightly oil the replacement oil filter gasket with clean oil.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

2. Install the new oil filter.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine oil drain plug.

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

4. Lower the vehicle.
5. Fill the engine with new engine oil. Refer to **Capacities - Approximate Fluid** in Maintenance and Lubrication.
6. Inspect for oil leaks after engine start up.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

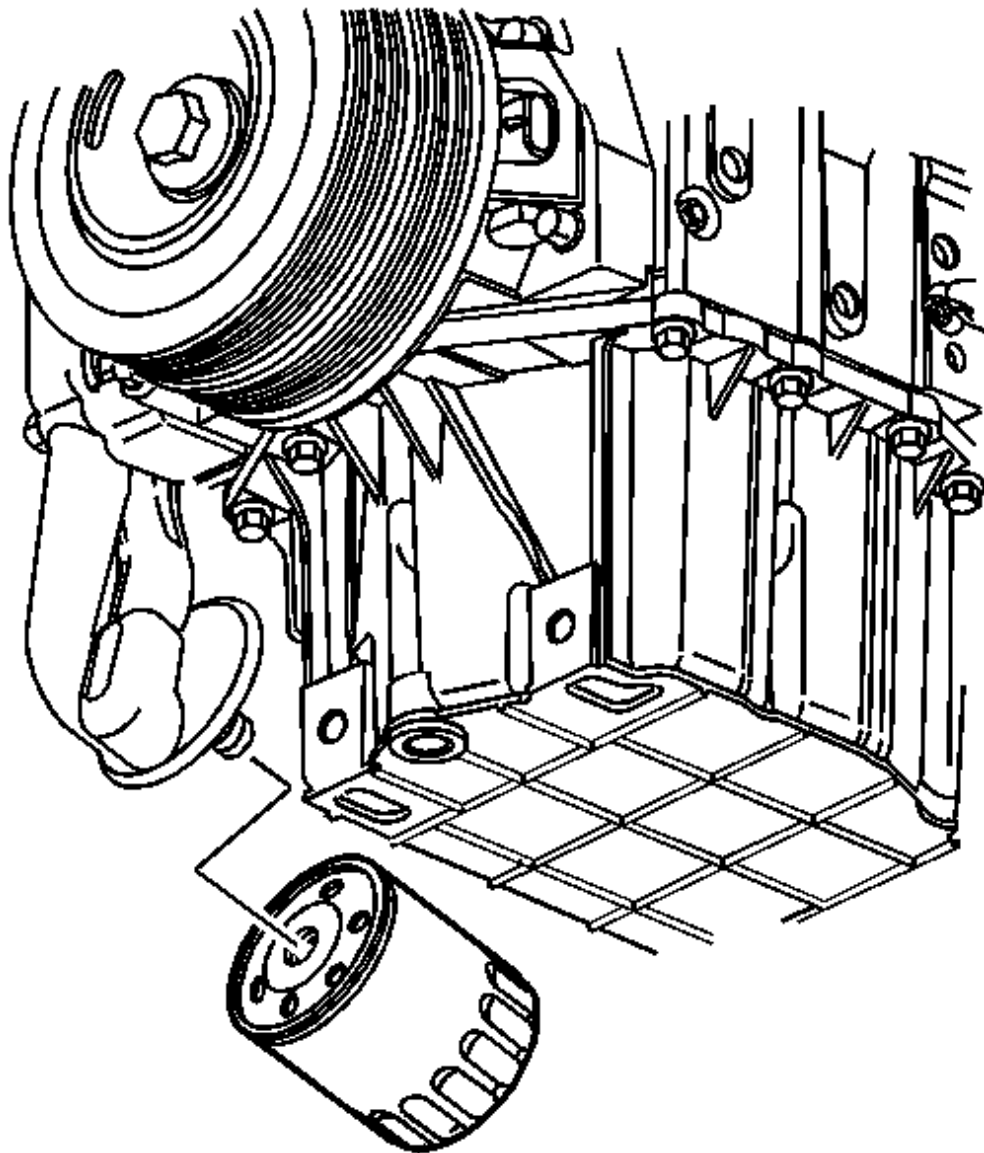


Fig. 159: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil drain plug.
2. Drain the engine oil.
3. Remove the oil filter.

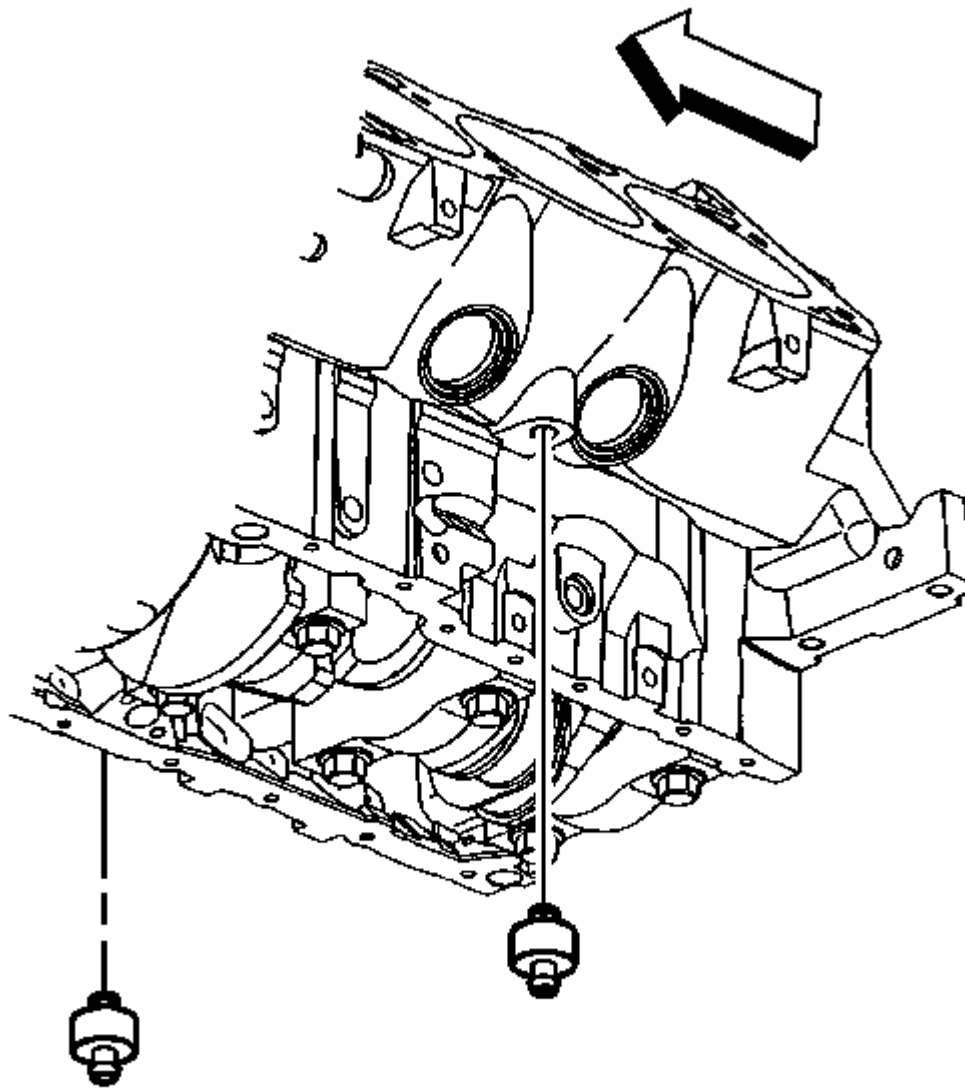


Fig. 160: Locating Knock Sensors
Courtesy of GENERAL MOTORS CORP.

4. Remove the knock sensors.
5. Drain the coolant.

Crankshaft Balancer Removal

Tools Required

- **J 37096** Flywheel Holder. See Special Tools and Equipment.
- **J 38197-A** Crankshaft Balancer Remover. See Special Tools and Equipment.

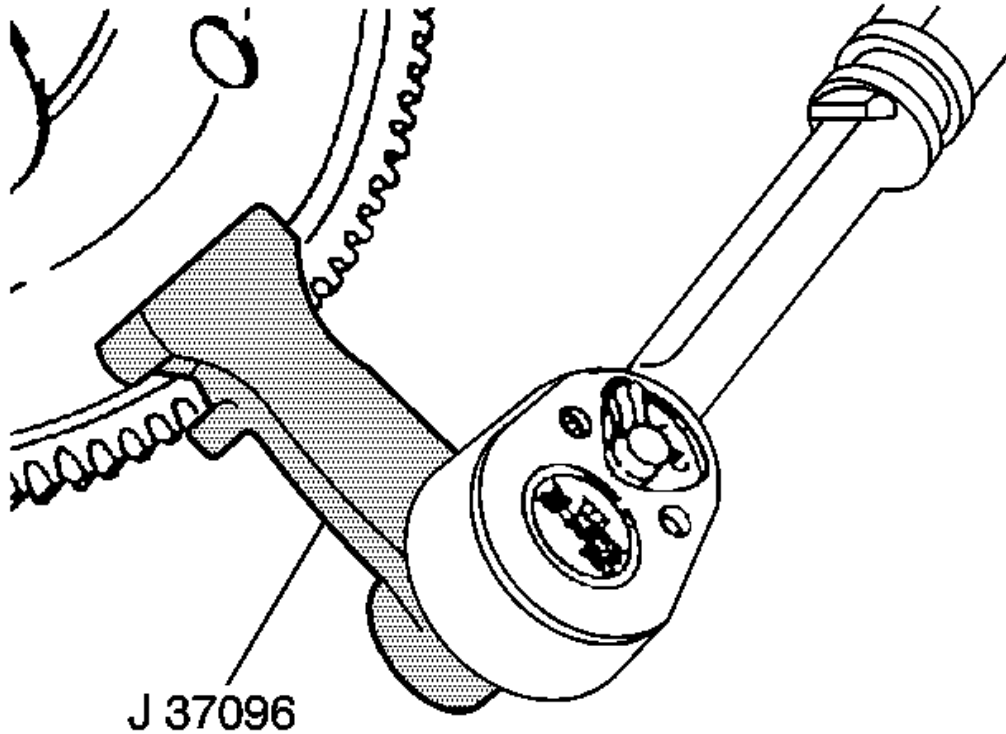
Removal Procedure

Fig. 161: Holding Flywheel

Courtesy of GENERAL MOTORS CORP.

1. Use **J 37096** in order to hold the flywheel. See Special Tools and Equipment.

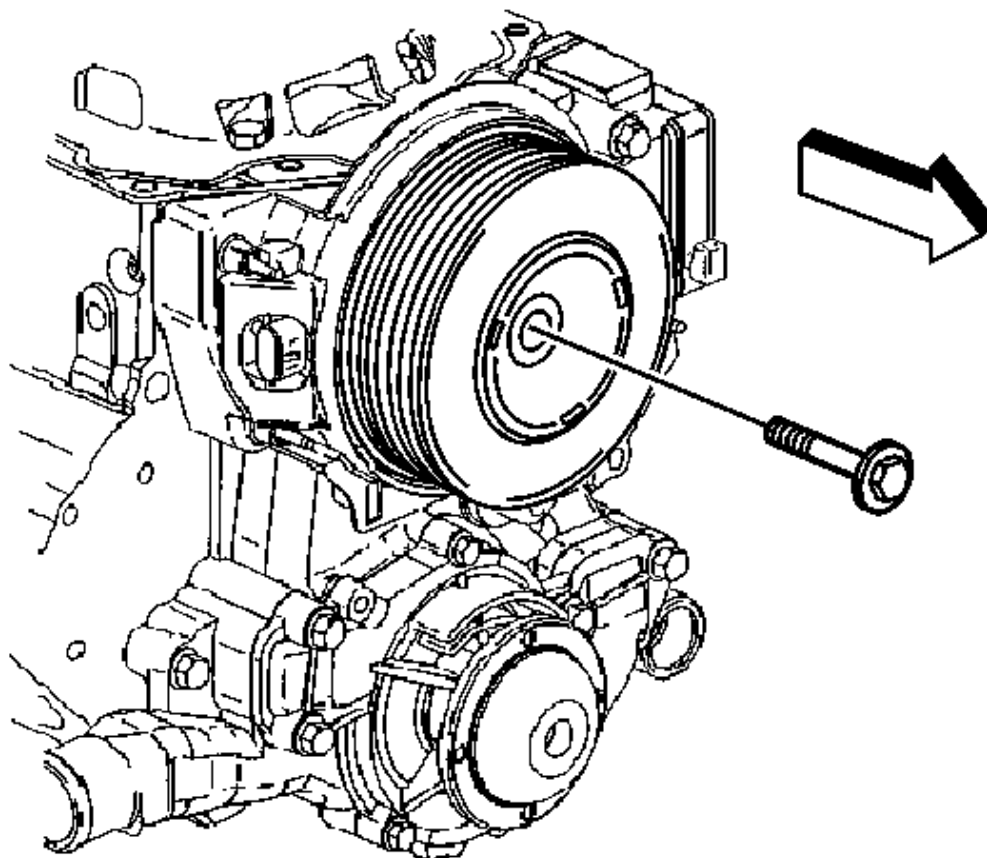


Fig. 162: Locating Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt.

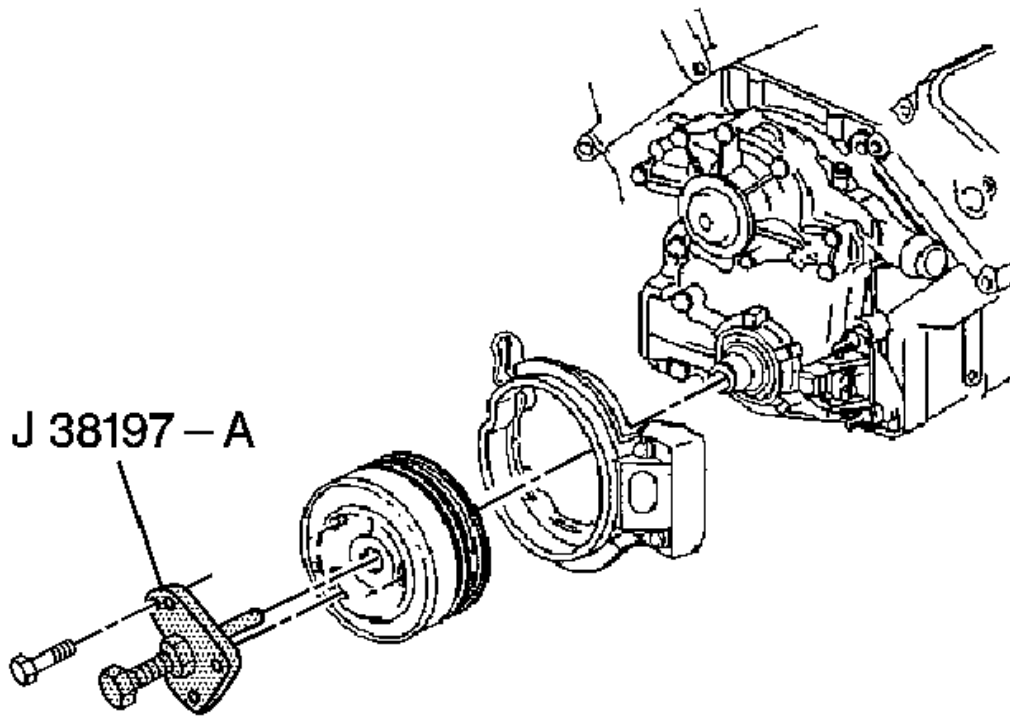


Fig. 163: Locating Crankshaft Pulley/Balancer Assembly
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Do not separate the crankshaft pulley from the crankshaft balancer.
Service the crankshaft pulley and the crankshaft balancer as an assembly.**

3. Use the **J 38197-A** in order to remove the crankshaft balancer. See **Special Tools and Equipment**.
 1. Invert J 38197-2 so the leg of the tool is facing away from the crankshaft balancer.
 2. Install the silver screws J 38197-4 to the crankshaft balancer.
 3. Turn J 38197-1 to remove the crankshaft balancer from the crankshaft.
 4. Remove J 38197-1, J 38197-2, and J 38197-4 from the crankshaft balancer.

Engine Flywheel Removal

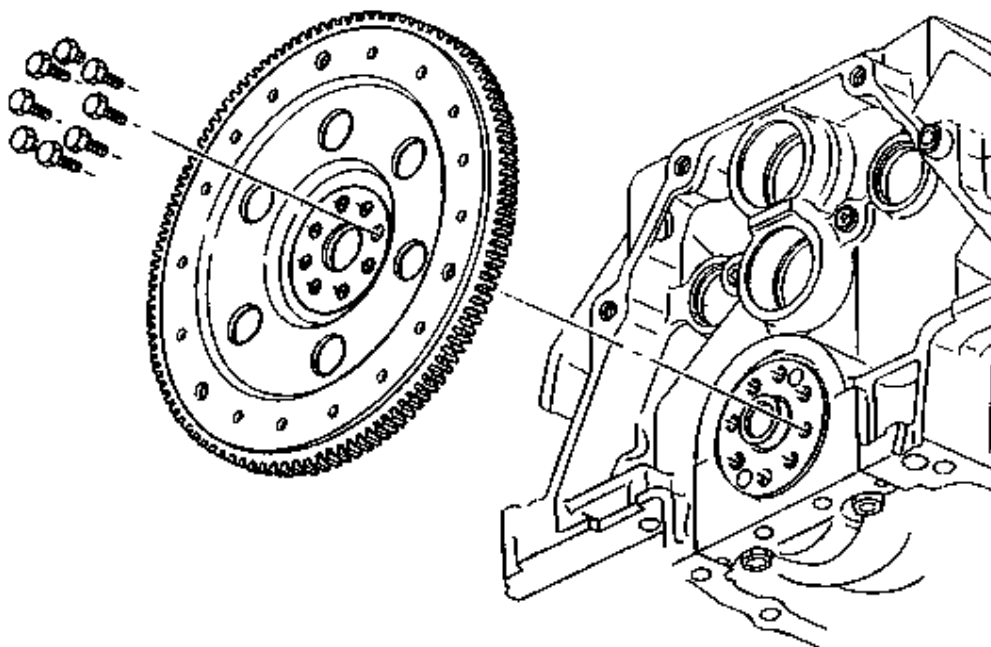


Fig. 164: Locating Engine Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

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

Drive Belt Tensioner Removal

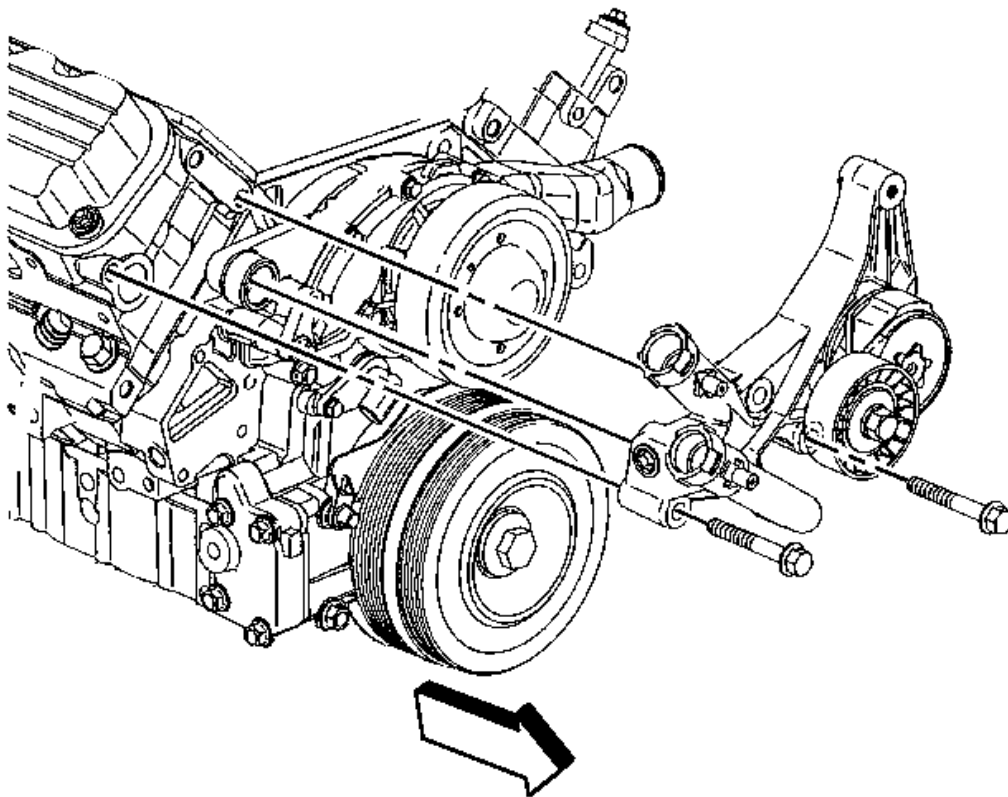


Fig. 165: Locating Drive Belt Tensioner Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner bracket bolts.
2. Remove the drive belt tensioner bracket.

Oil Level Indicator and Tube Removal

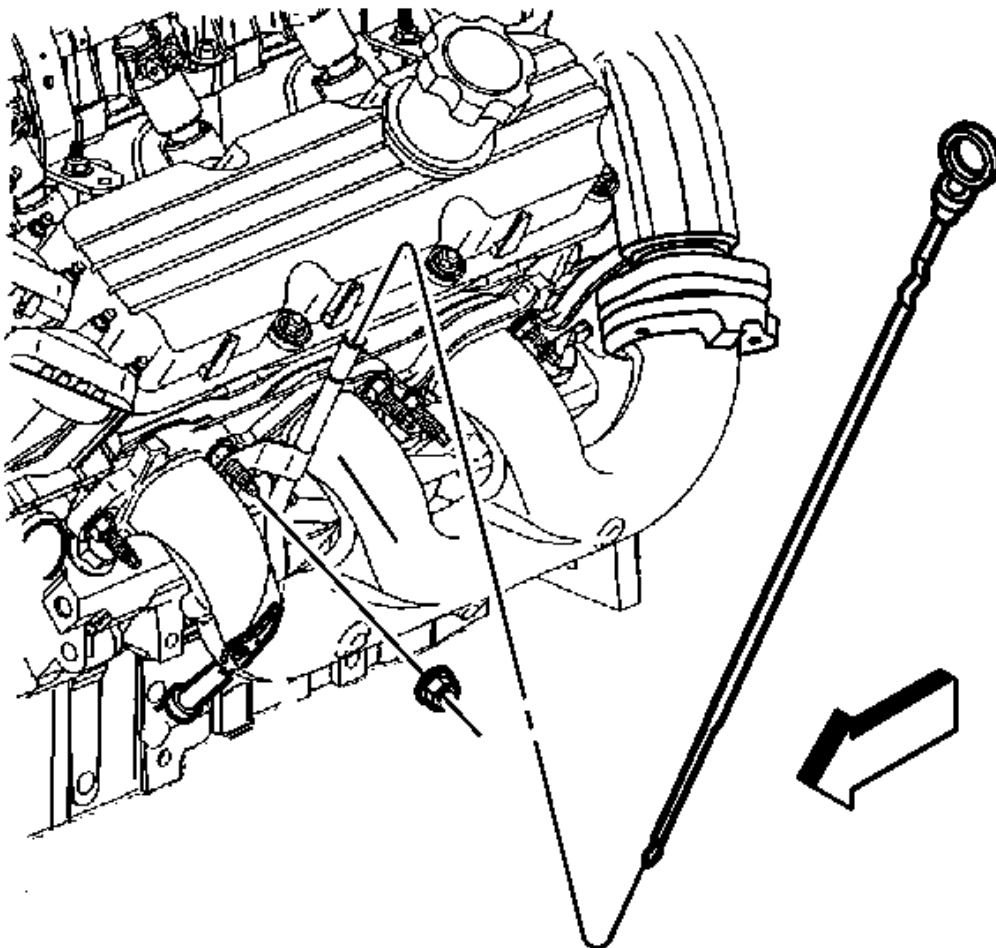


Fig. 166: Locating Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Remove the oil level indicator tube nut.
3. Remove the oil level indicator tube.

Water Outlet and Thermostat Removal

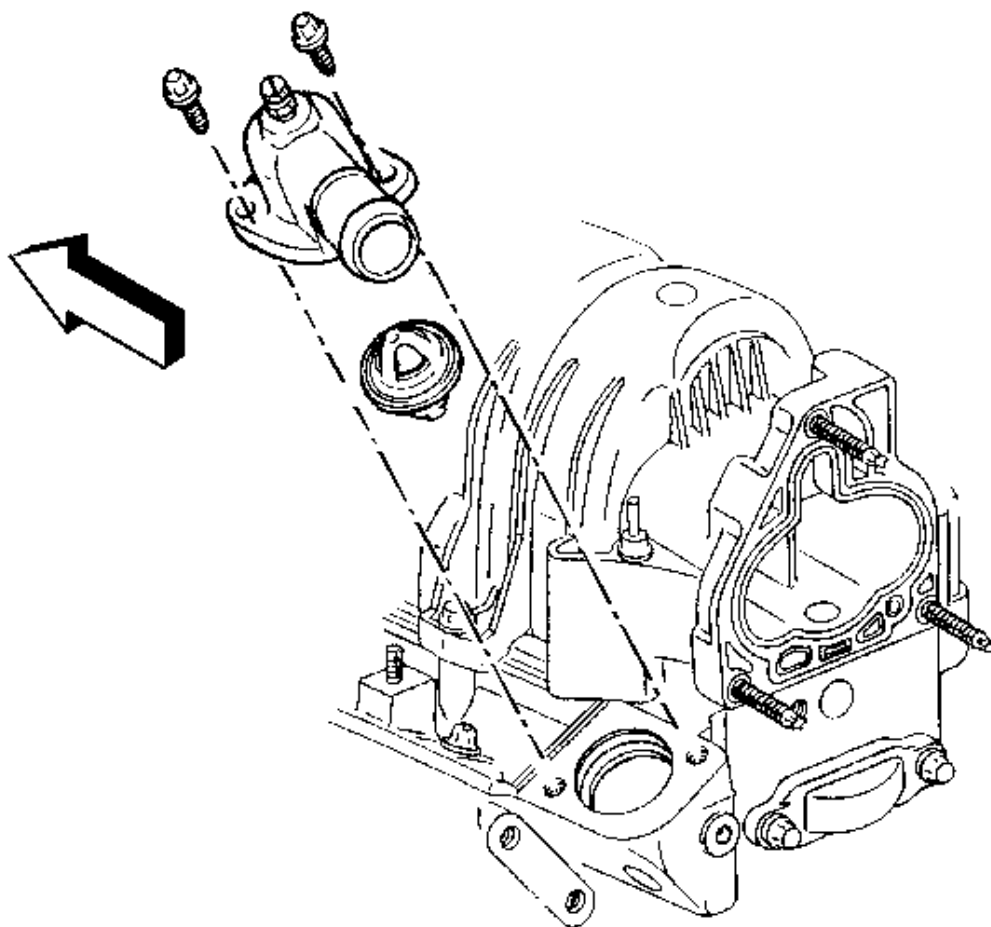


Fig. 167: Identifying Water Outlet & Thermostat
Courtesy of GENERAL MOTORS CORP.

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

Water Pump Removal

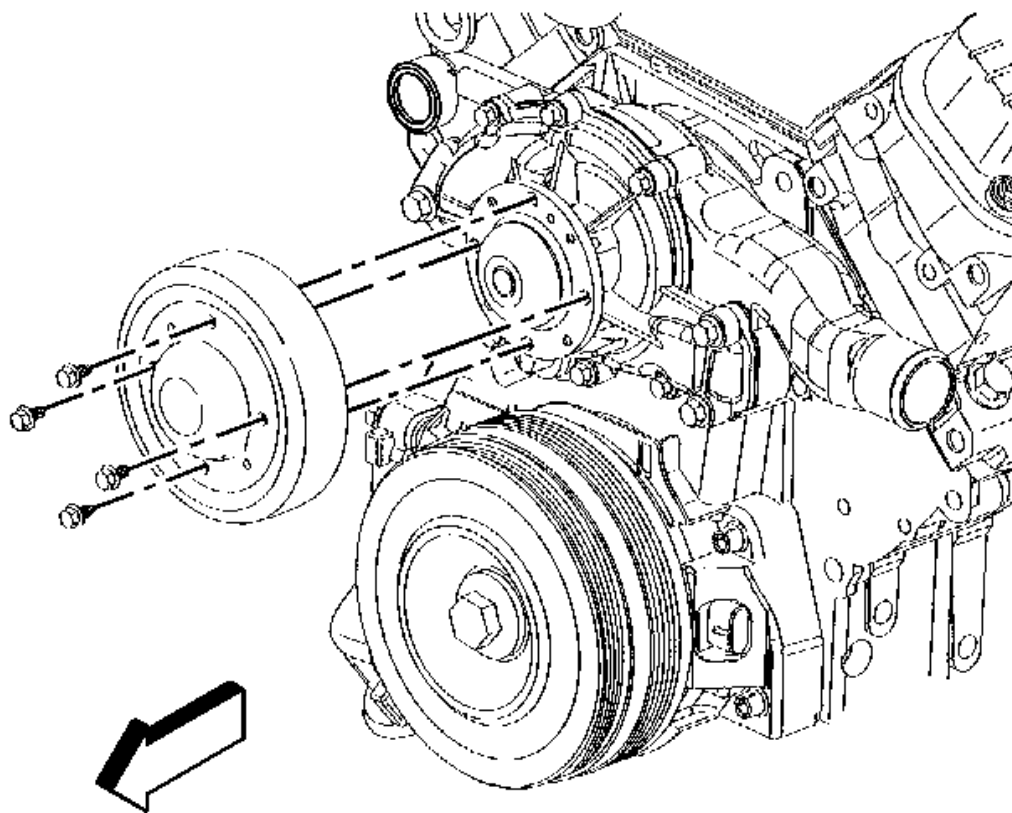


Fig. 168: Identifying Water Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

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

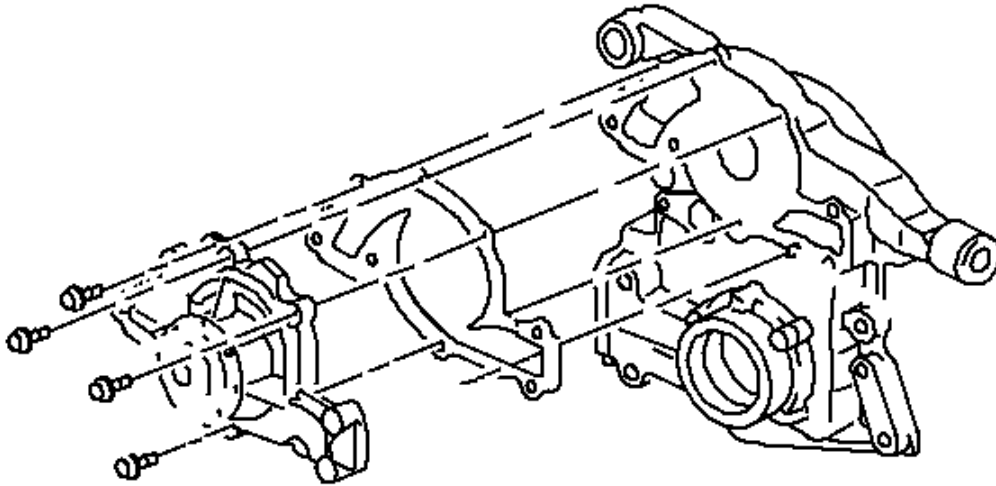


Fig. 169: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

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

Intake Manifold Removal - Upper

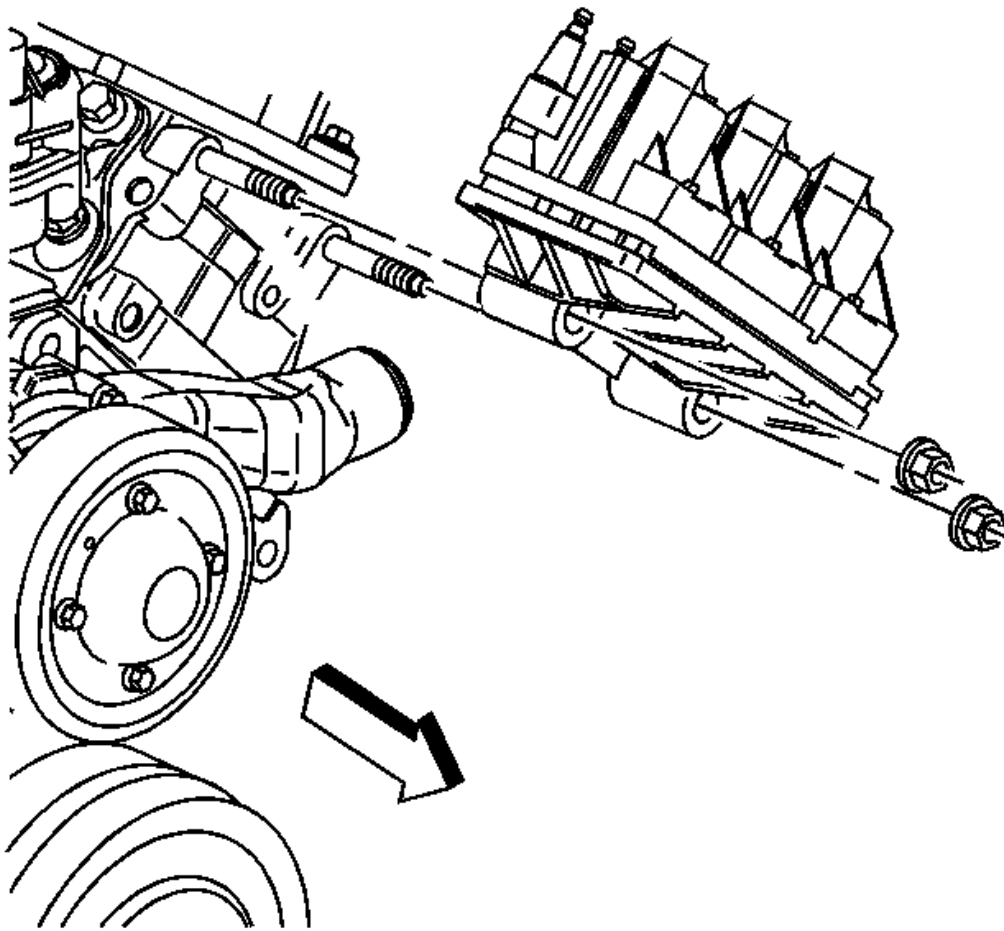


Fig. 170: Identifying Ignition Control Module Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires.
2. Disconnect the ignition wires from the fuel injector rail.
3. Disconnect the ignition control module connector from the ignition control module assembly.
4. Remove the ignition control module assembly nuts.
5. Remove the ignition control module assembly.

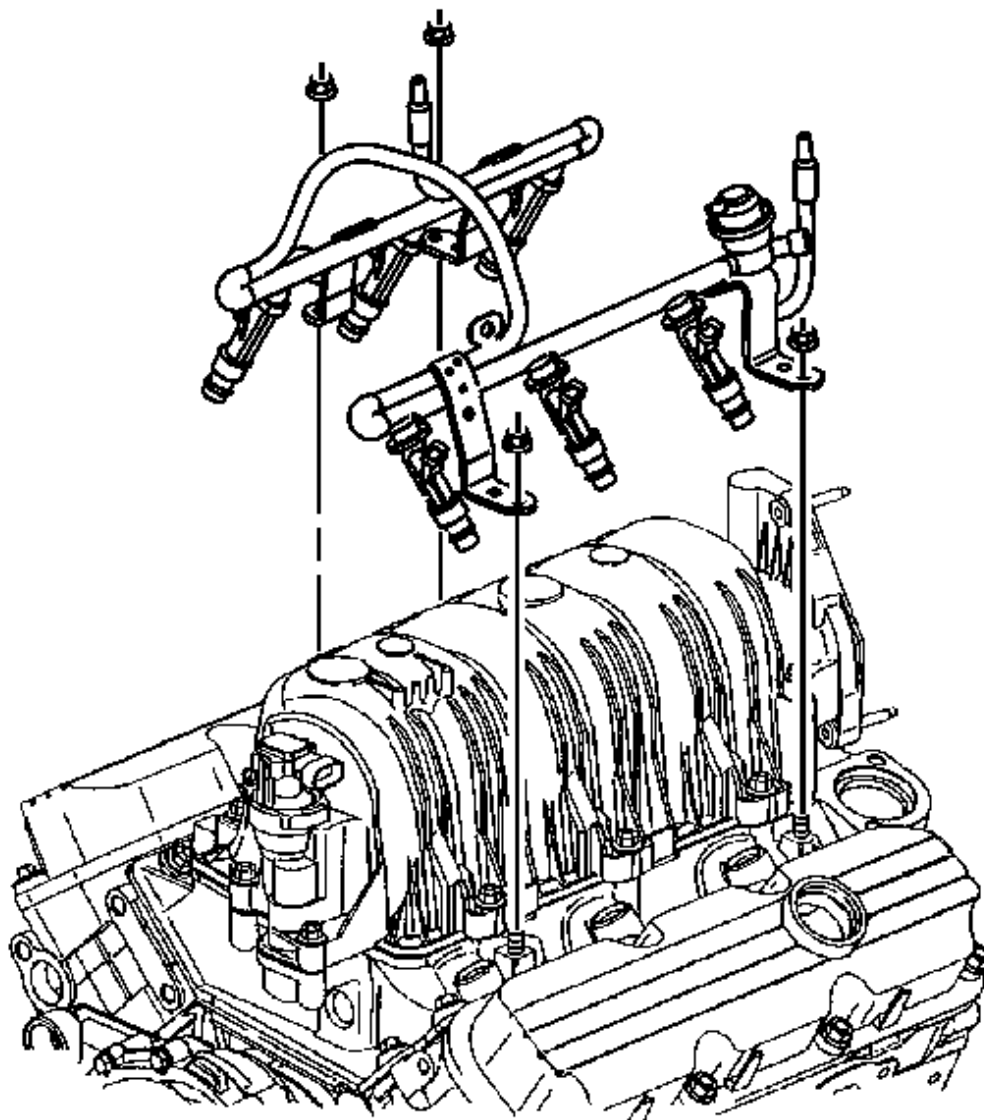


Fig. 171: Identifying Fuel Injector Rail Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the fuel injector rail nuts.
7. Remove the fuel injector rail.

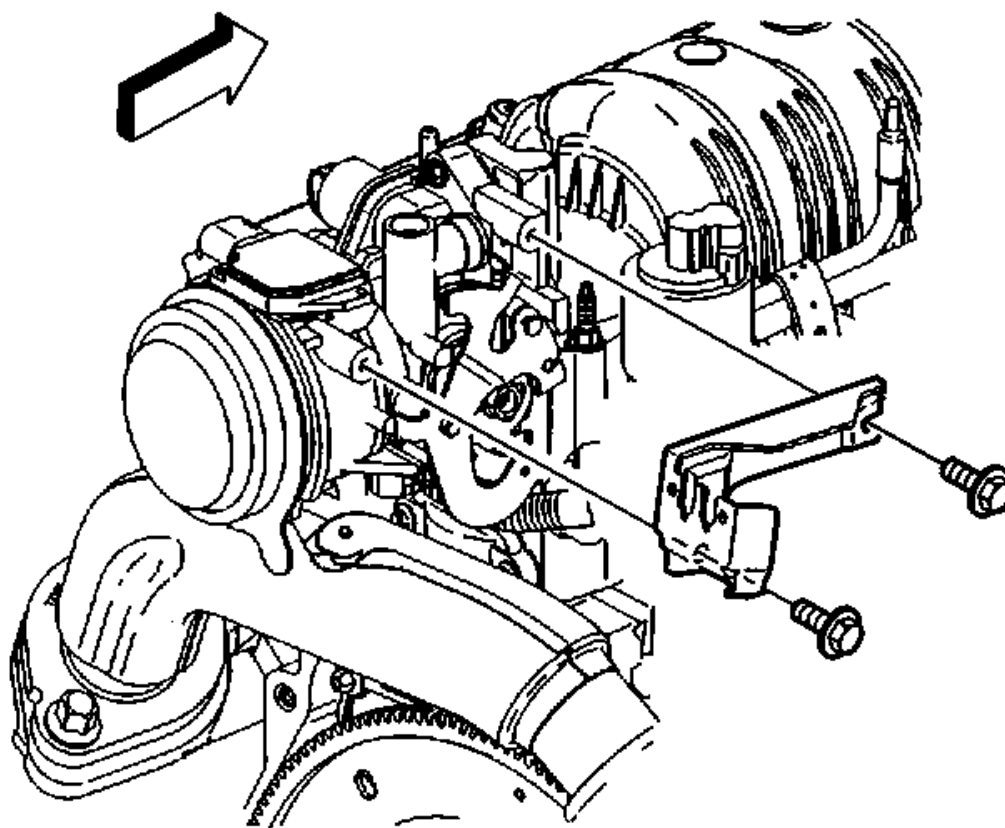


Fig. 172: Identifying Accelerator Control Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the accelerator control cable bracket bolts.
9. Remove the accelerator control cable bracket from the intake manifold.

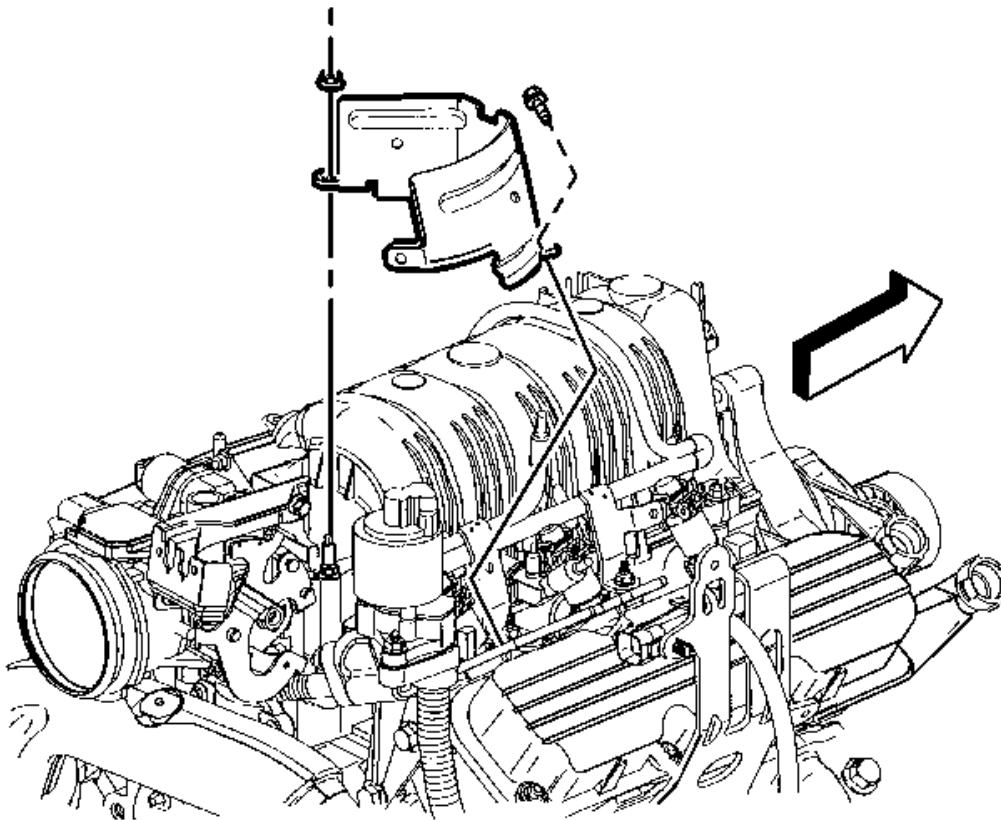


Fig. 173: Locating Engine Wiring Harness Heat Shield
Courtesy of GENERAL MOTORS CORP.

10. Remove the engine wiring harness heat shield bolt and nut.
11. Remove the engine wiring harness heat shield.

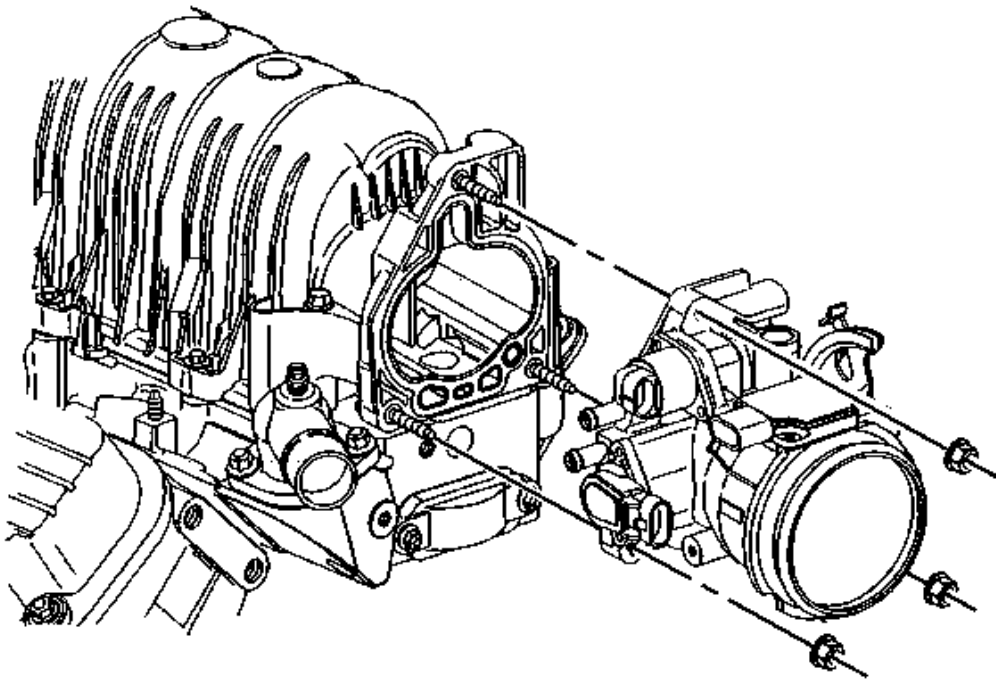


Fig. 174: Identifying Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

12. Remove the throttle body nuts.
13. Remove the throttle body.
14. Remove the throttle body gasket.

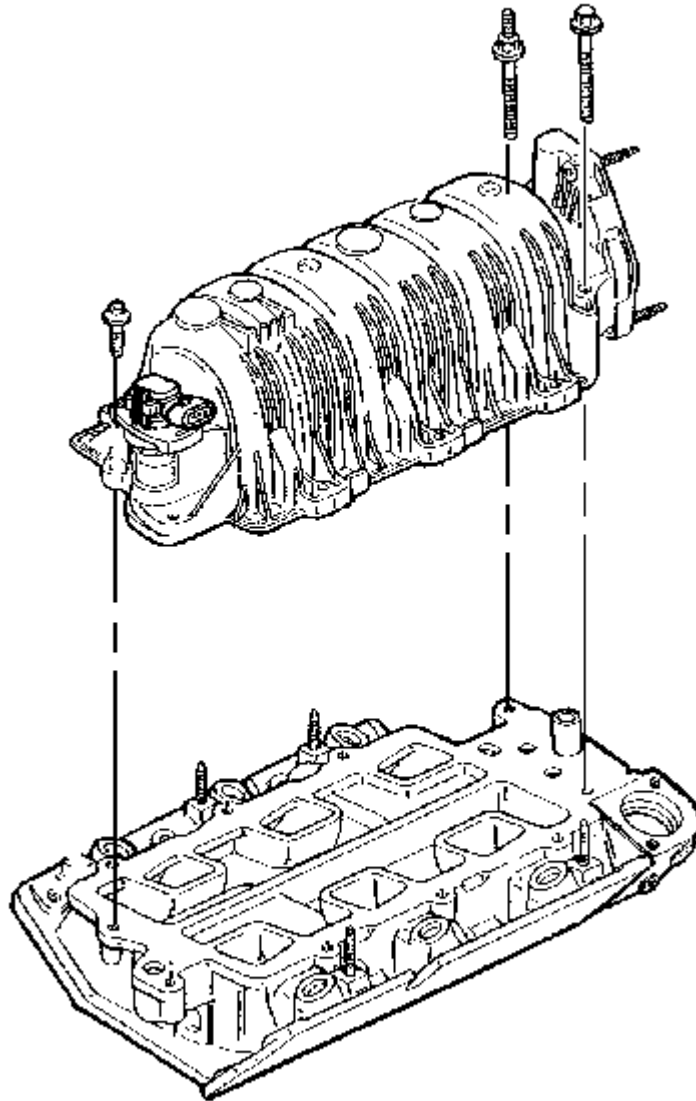


Fig. 175: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

15. Remove the upper intake manifold bolts and nuts.
16. Remove the upper intake manifold.

Exhaust Gas Recirculation (EGR) and EGR Pipe Removal

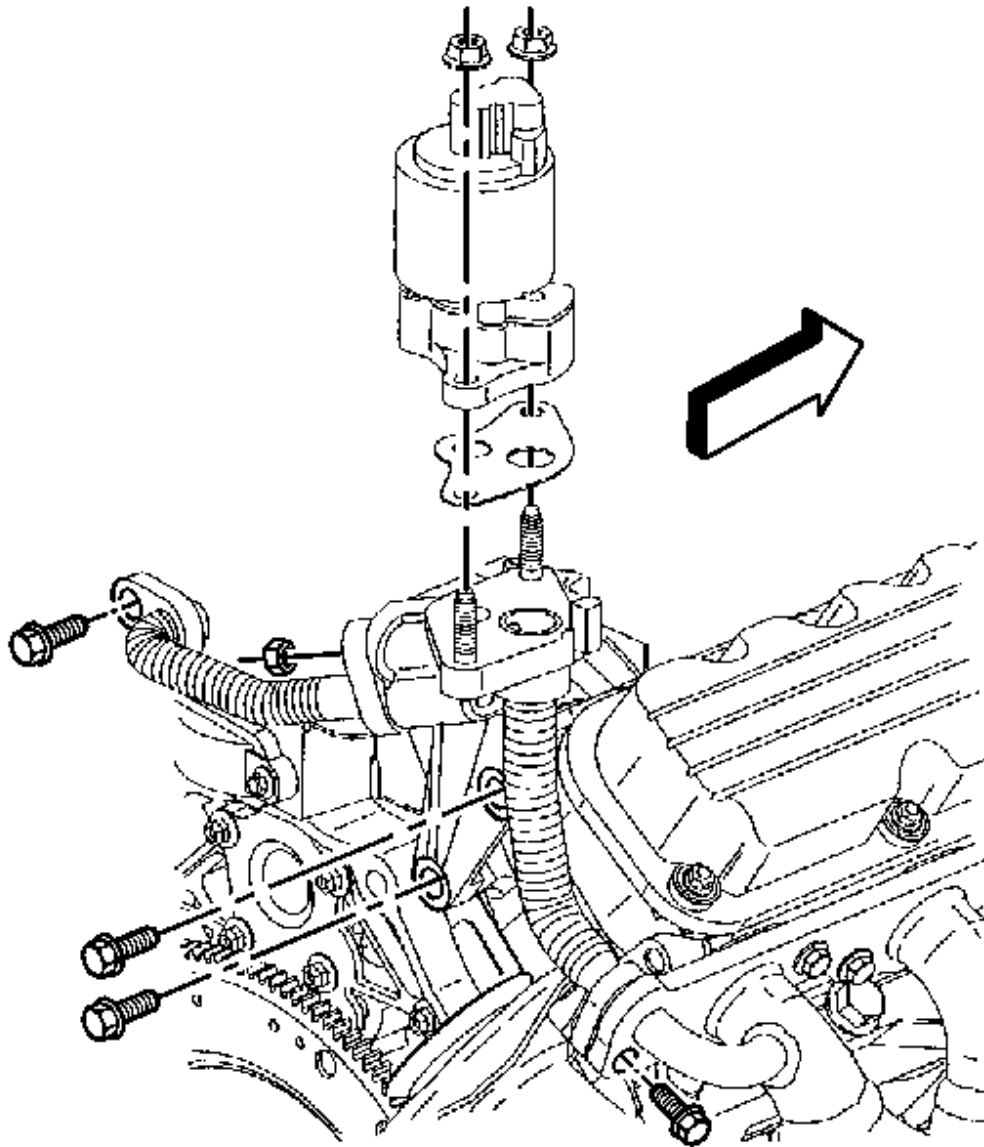


Fig. 176: View Of EGR Valve Adapter Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the EGR valve nuts, EGR valve and gasket.
2. Remove the EGR valve adapter inlet pipe bolt from the RH exhaust manifold.
3. Remove the EGR valve outlet pipe bolt, nut and pipe from the lower intake manifold and the EGR valve adapter assembly.

4. Remove the EGR valve adapter assembly bolts.
5. Remove the EGR valve adapter assembly from the cylinder head.

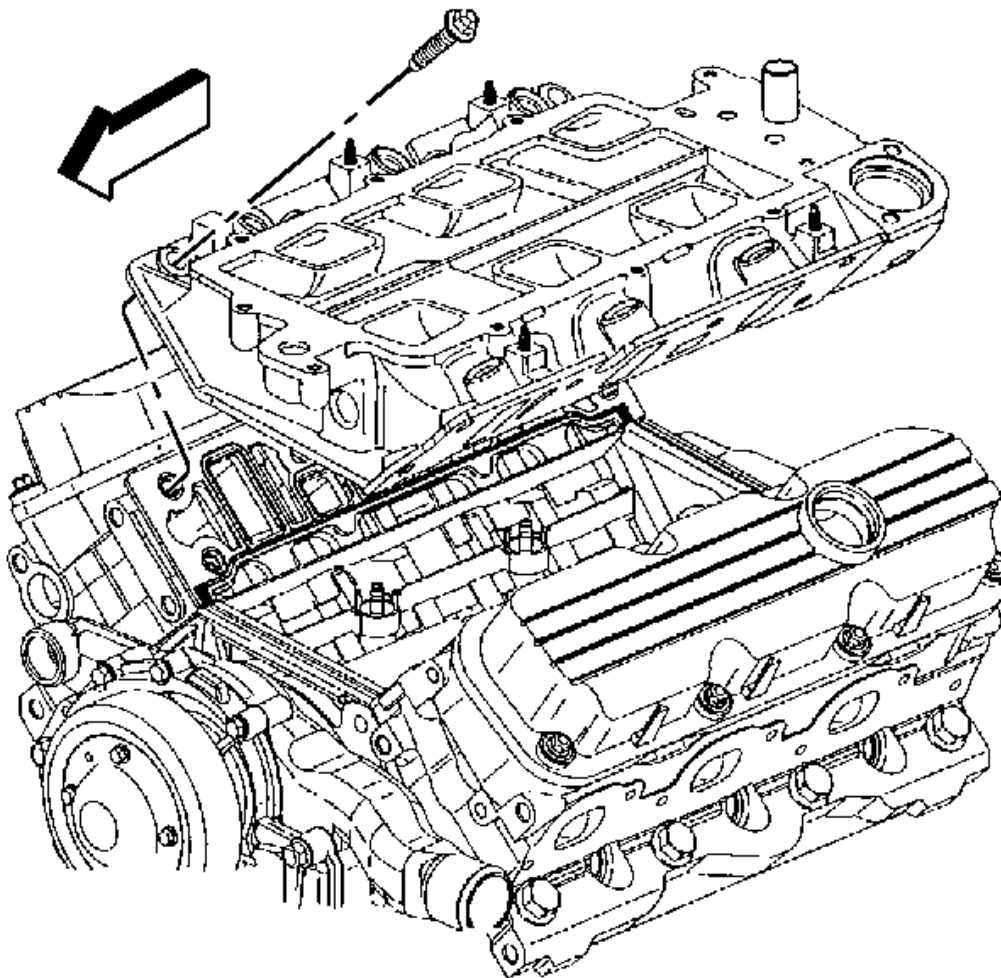
Intake Manifold Removal - Lower

Fig. 177: Identifying Lower Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bolts which fasten the lower intake manifold to the cylinder head are accessible only after the upper intake is removed. The bolts are located in the right front and left rear corners of the lower intake manifold. Remove the upper intake manifold to service the lower intake.

1. Remove the EGR outlet pipe from the intake manifold.
2. Remove the lower intake manifold bolts.
3. Remove the lower intake manifold.
4. Remove the lower intake manifold gasket.

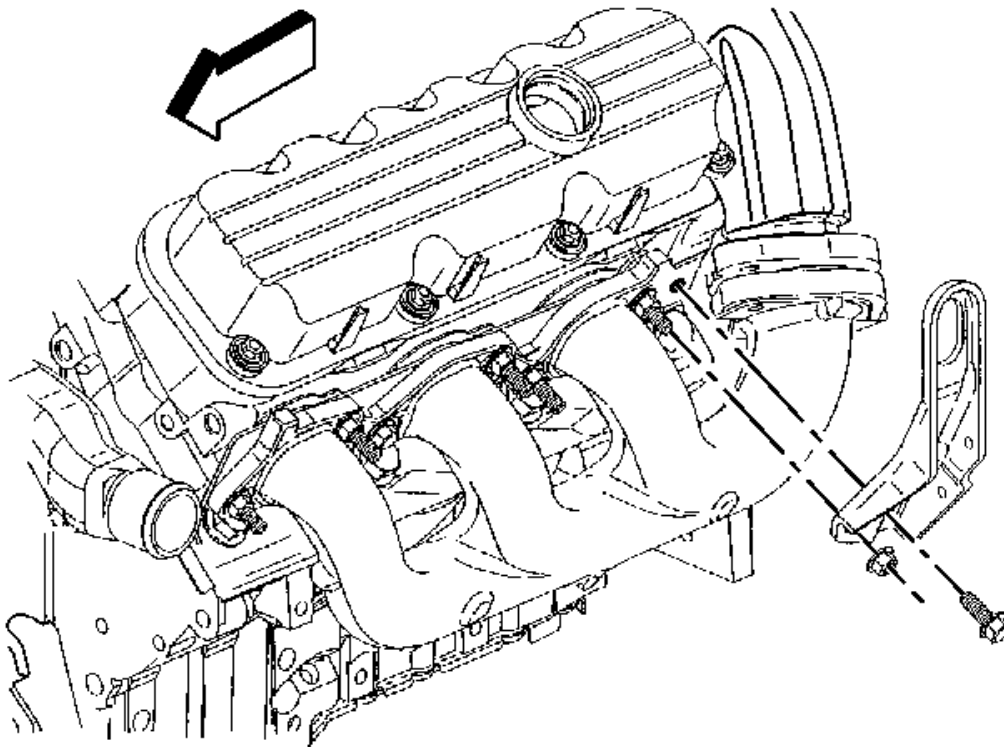
Exhaust Manifold Removal - Left

Fig. 178: Locating Left Engine Lift Hook
Courtesy of GENERAL MOTORS CORP.

1. Remove the left engine lift hook nut and bolt.
2. Remove the left engine lift hook.
3. Remove the left side spark plugs.

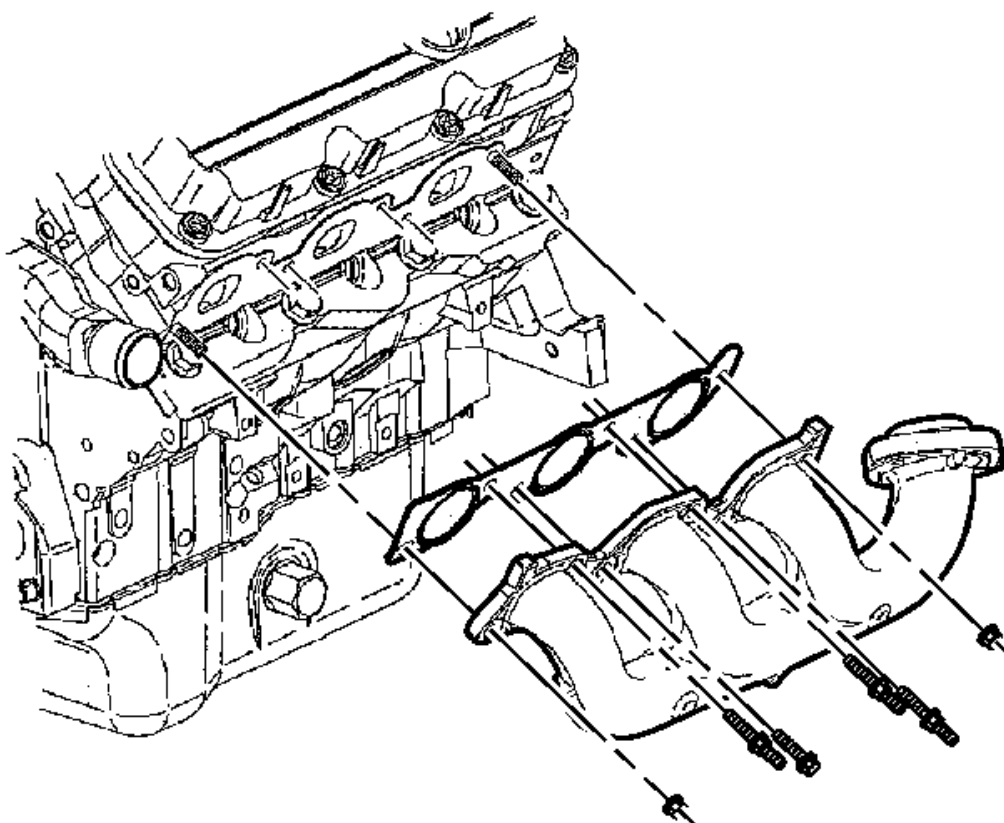


Fig. 179: Removing/Installing Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold bolt and studs.
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket.

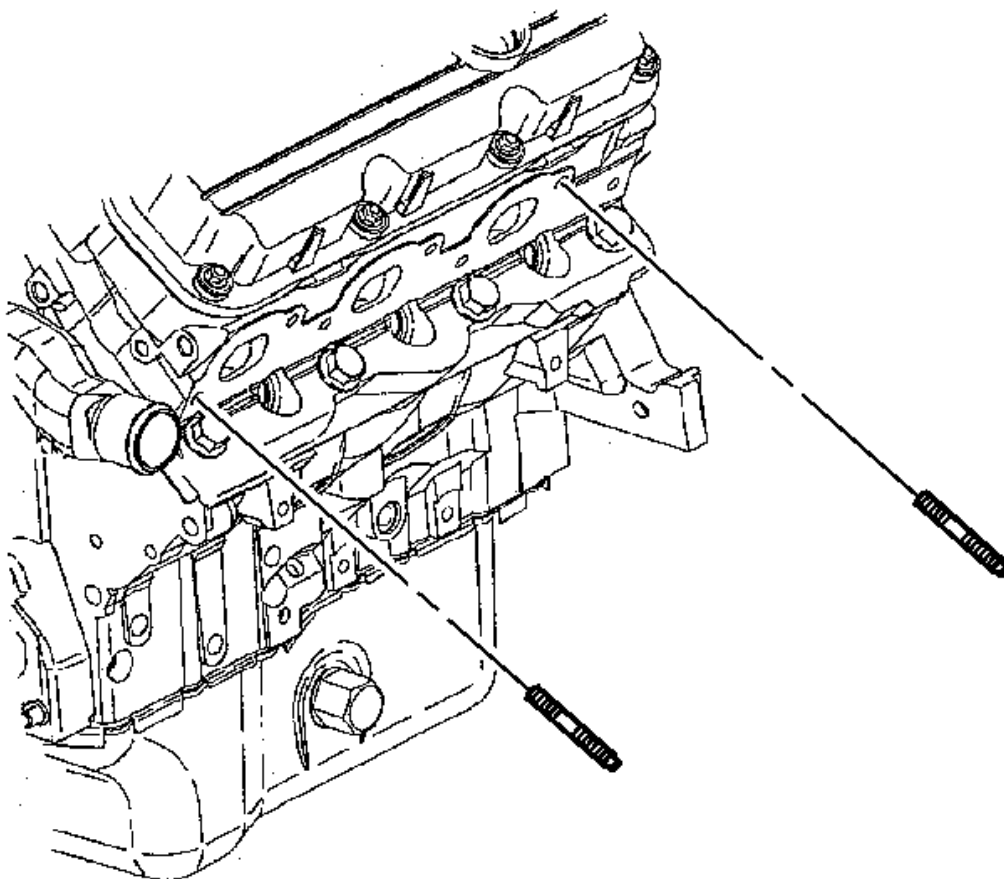


Fig. 180: Identifying Left Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

7. Remove the exhaust manifold studs.

Exhaust Manifold Removal - Right

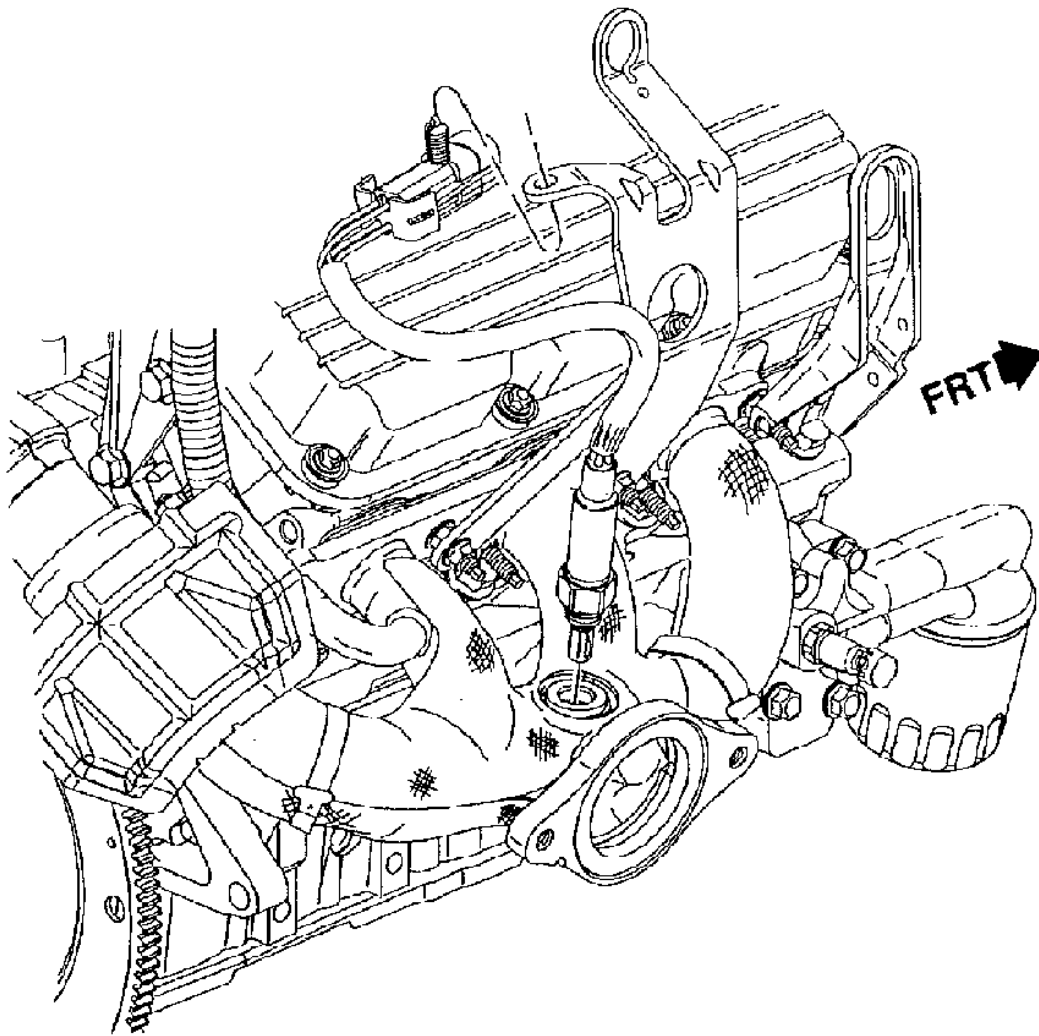


Fig. 181: Locating Heated Oxygen Sensor Lead
Courtesy of GENERAL MOTORS CORP.

1. Remove the heated oxygen sensor lead.

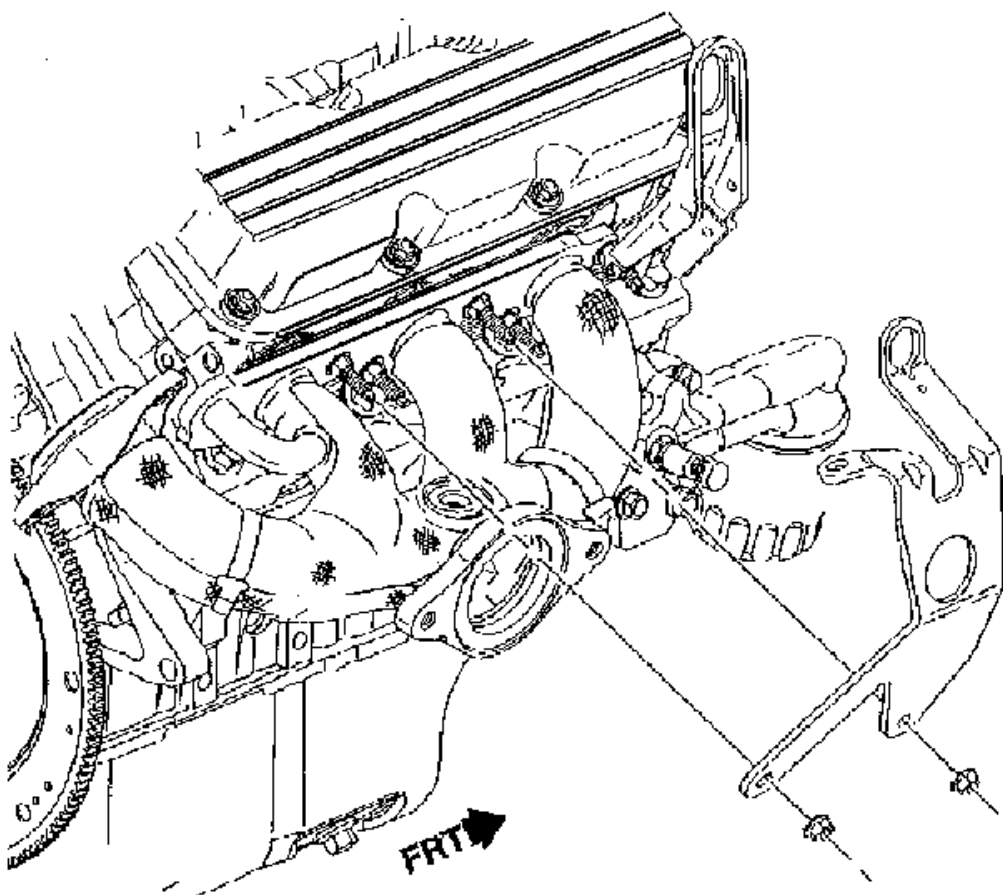


Fig. 182: Identifying Fuel Injector Sight Shield Mounting Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector sight shield mounting bracket nuts.
3. Remove the fuel injector sight shield mounting bracket.

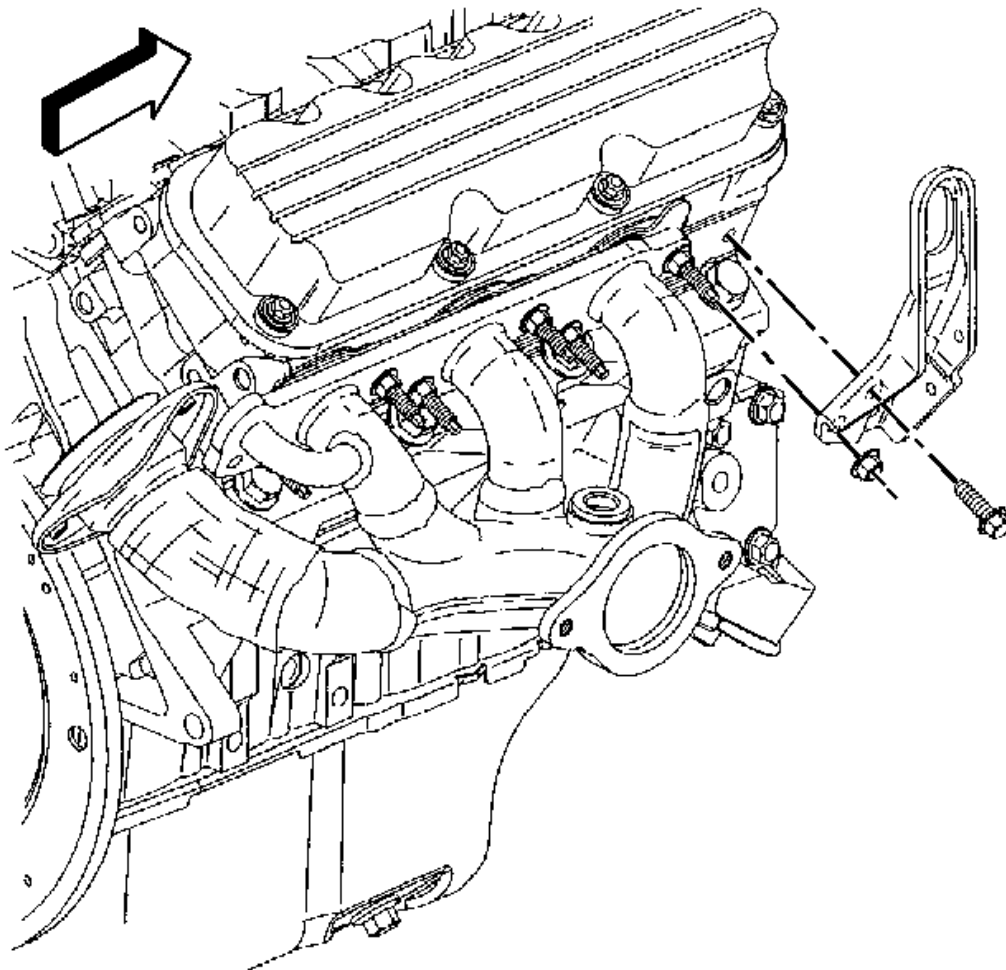


Fig. 183: Removing/Installing Right Engine Lift Hook Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the right engine lift hook nut and bolt.
5. Remove the right engine lift hook bracket.
6. Remove the right side spark plugs.

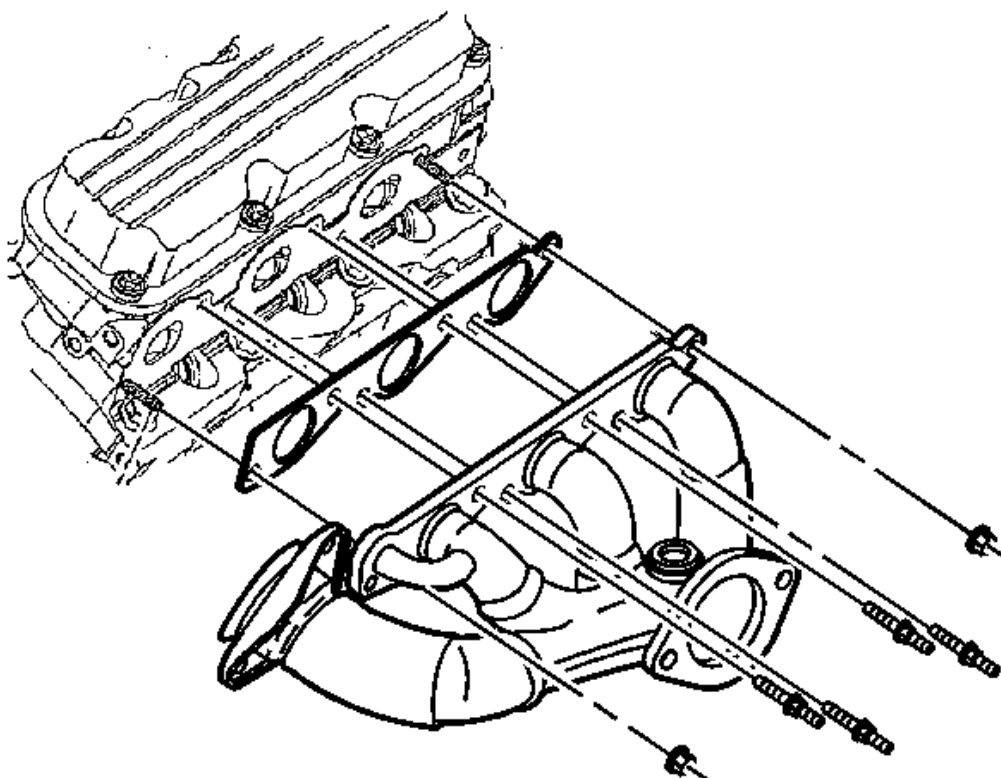


Fig. 184: Locating Right Exhaust Manifold Components (Without A.I.R.)
Courtesy of GENERAL MOTORS CORP.

7. Remove the exhaust manifold studs.
8. Remove the exhaust manifold.
9. Remove the exhaust manifold gasket.

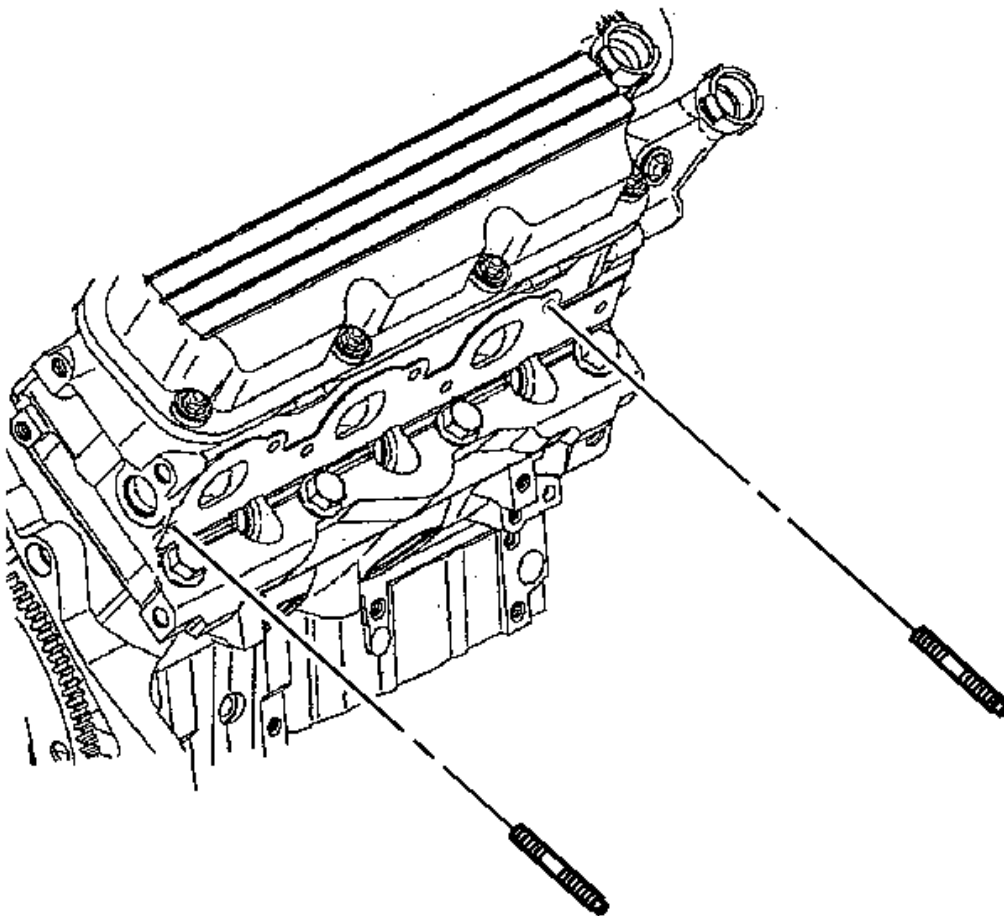


Fig. 185: Removing/Installing Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

10. Remove the exhaust manifold studs.

Valve Rocker Arm Cover Removal - Left

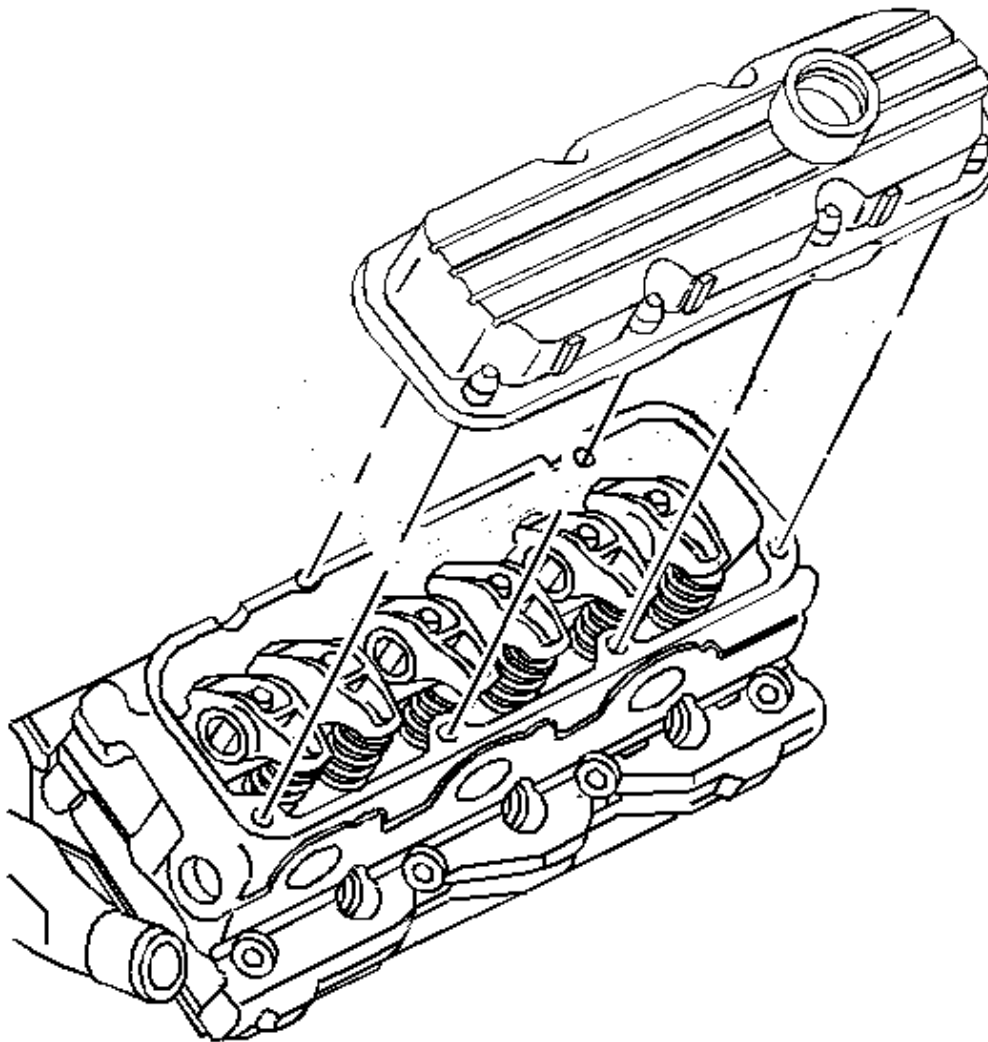


Fig. 186: Locating Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

Valve Rocker Arm Cover Removal - Right

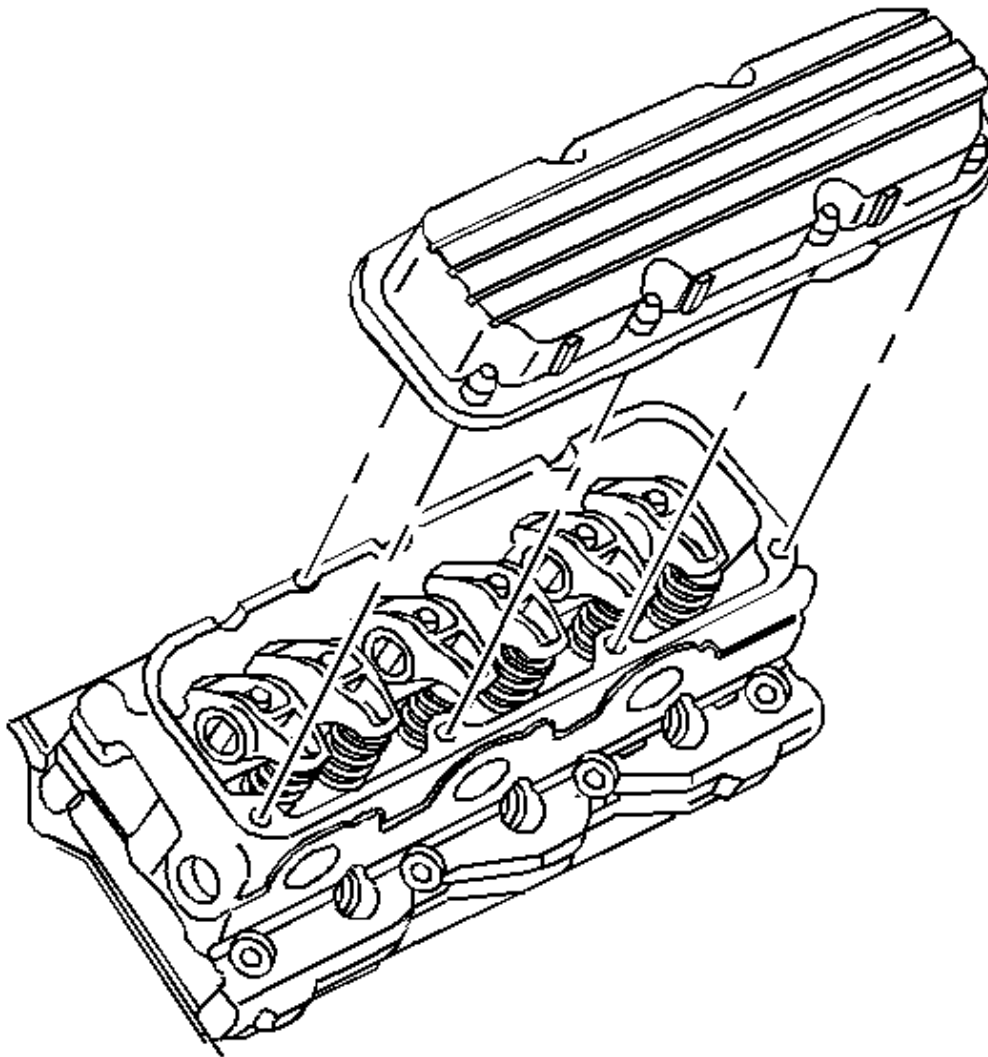


Fig. 187: Locating Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

Valve Rocker Arm and Push Rod Removal

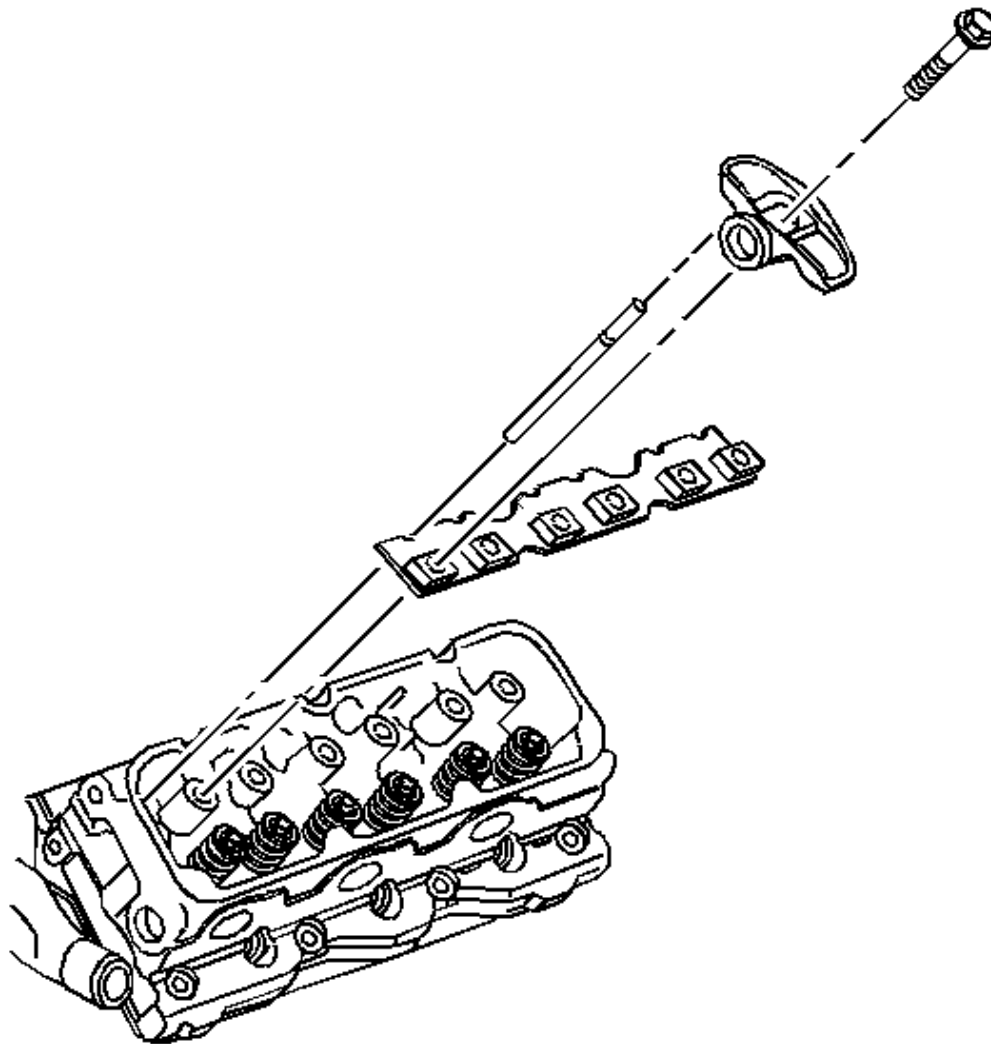


Fig. 188: View Of Valve Rocker Arm, Bolt, Push Rod & Push Rod Guide Plate
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm bolts.
2. Remove the valve rocker arm.
3. Remove the push rods.
4. Remove the push rod guide plate.

Cylinder Head Removal - Left

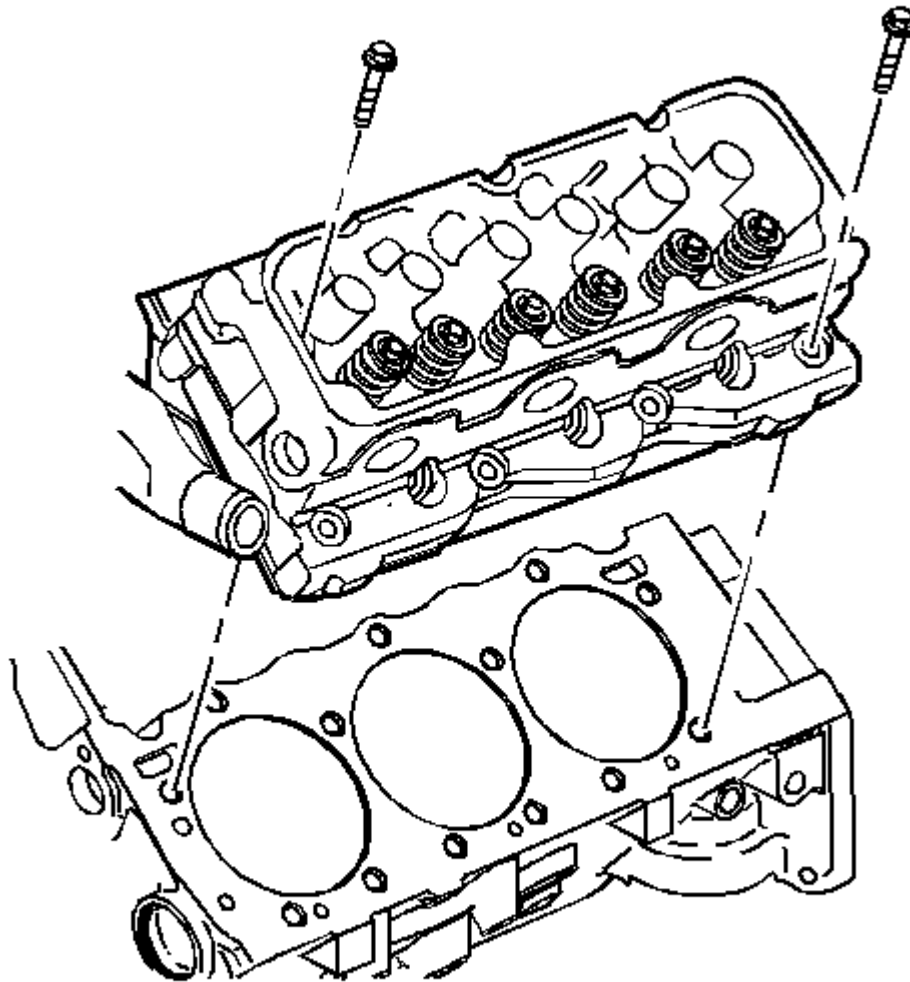


Fig. 189: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts.
2. Discard the cylinder head bolts.
3. Remove the cylinder head.
4. Remove the cylinder head gasket.

Cylinder Head Removal - Right

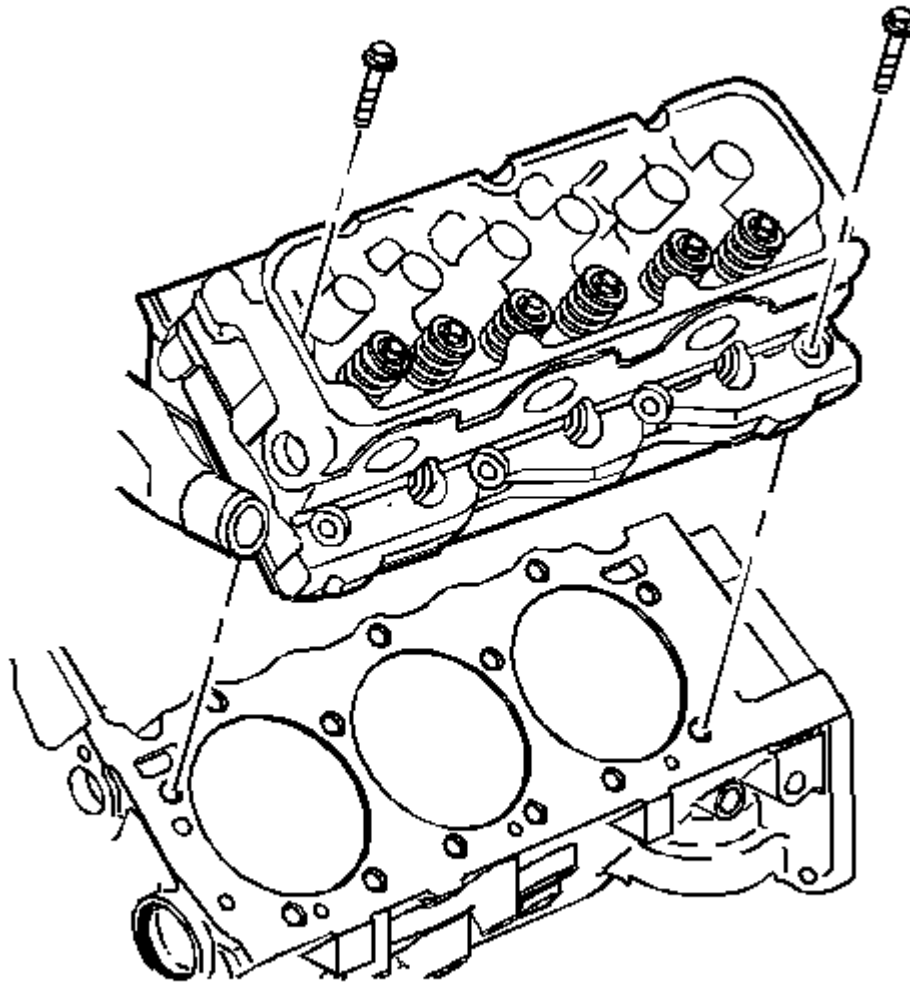


Fig. 190: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head bolts.
2. Discard the cylinder head bolts.
3. Remove the cylinder head.
4. Remove the cylinder head gasket.

Valve Lifter Removal

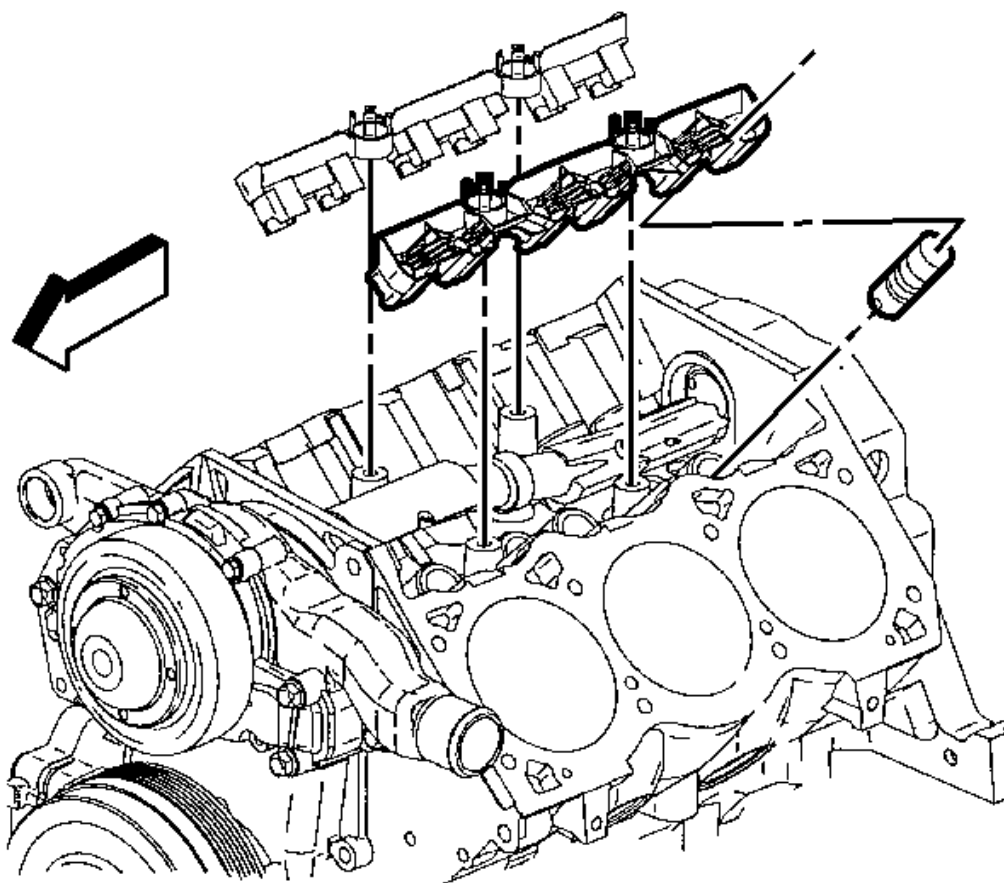


Fig. 191: Removing/Installing Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve lifter guide retainer bolts.
2. Remove the valve lifter guide retainers.
3. Remove the valve lifters.

Oil Pan Removal

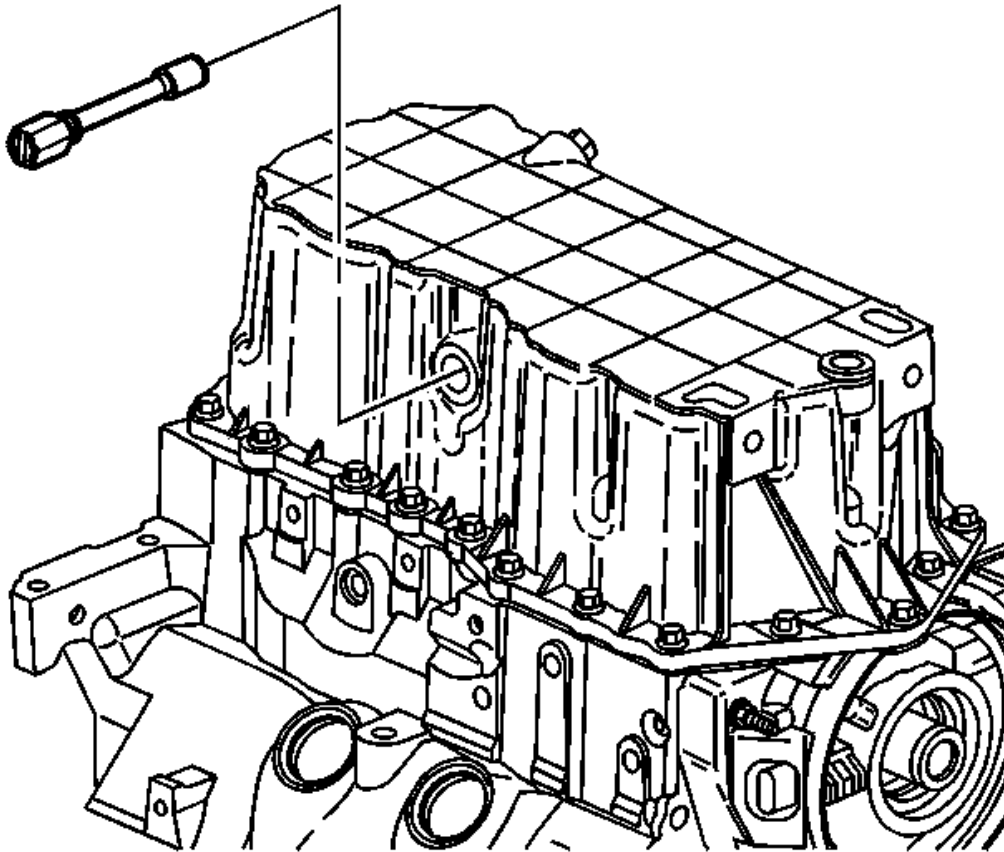


Fig. 192: Locating Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Remove the oil level sensor, located in the oil pan, before the oil pan is removed. The sensor may be damaged if the oil pan is removed first.

1. Remove the oil level sensor.

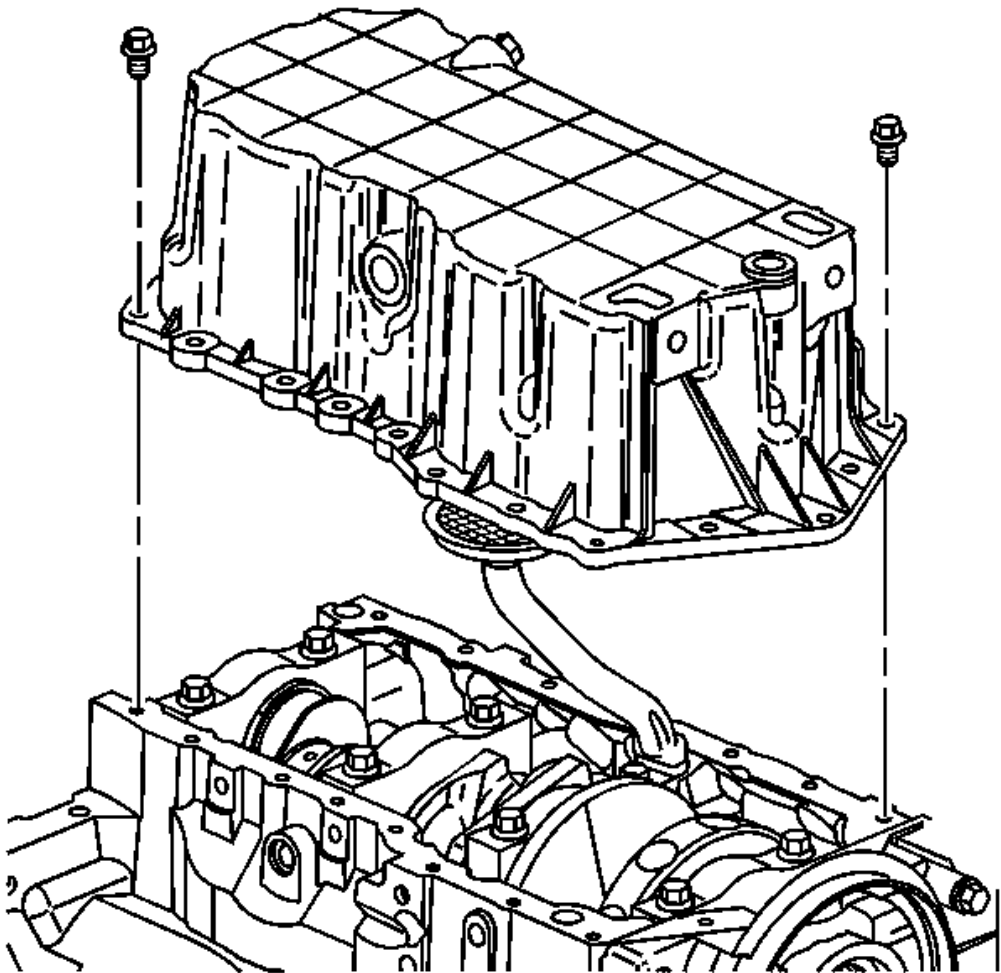


Fig. 193: Locating Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan bolts.
3. Remove the oil pan using pry points between the pan and engine block if required.
4. Remove the oil pan gasket if required.

Oil Pump Pipe and Screen Assembly Removal

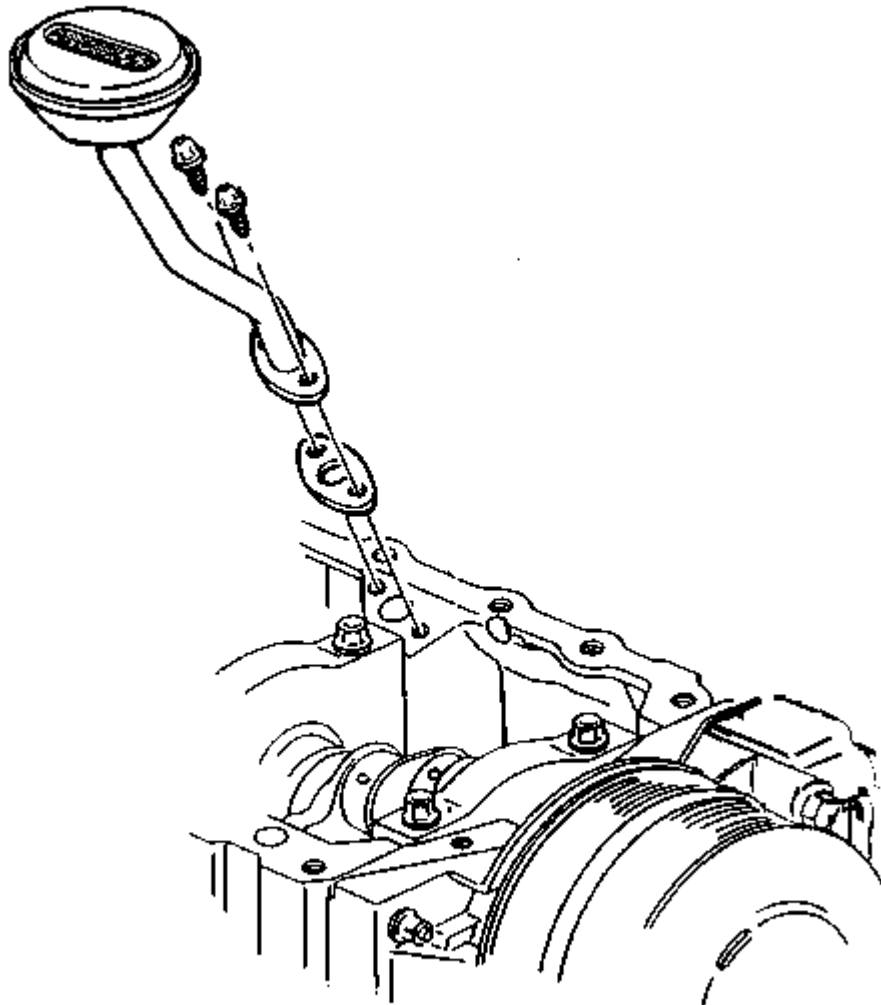


Fig. 194: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump pipe and screen assembly bolts.
2. Remove the oil pump pipe and screen assembly.
3. Remove the oil pump pipe and screen assembly gasket.
4. Use solvent to clean the oil pump pipe and screen.

Crankshaft Front Oil Seal Removal

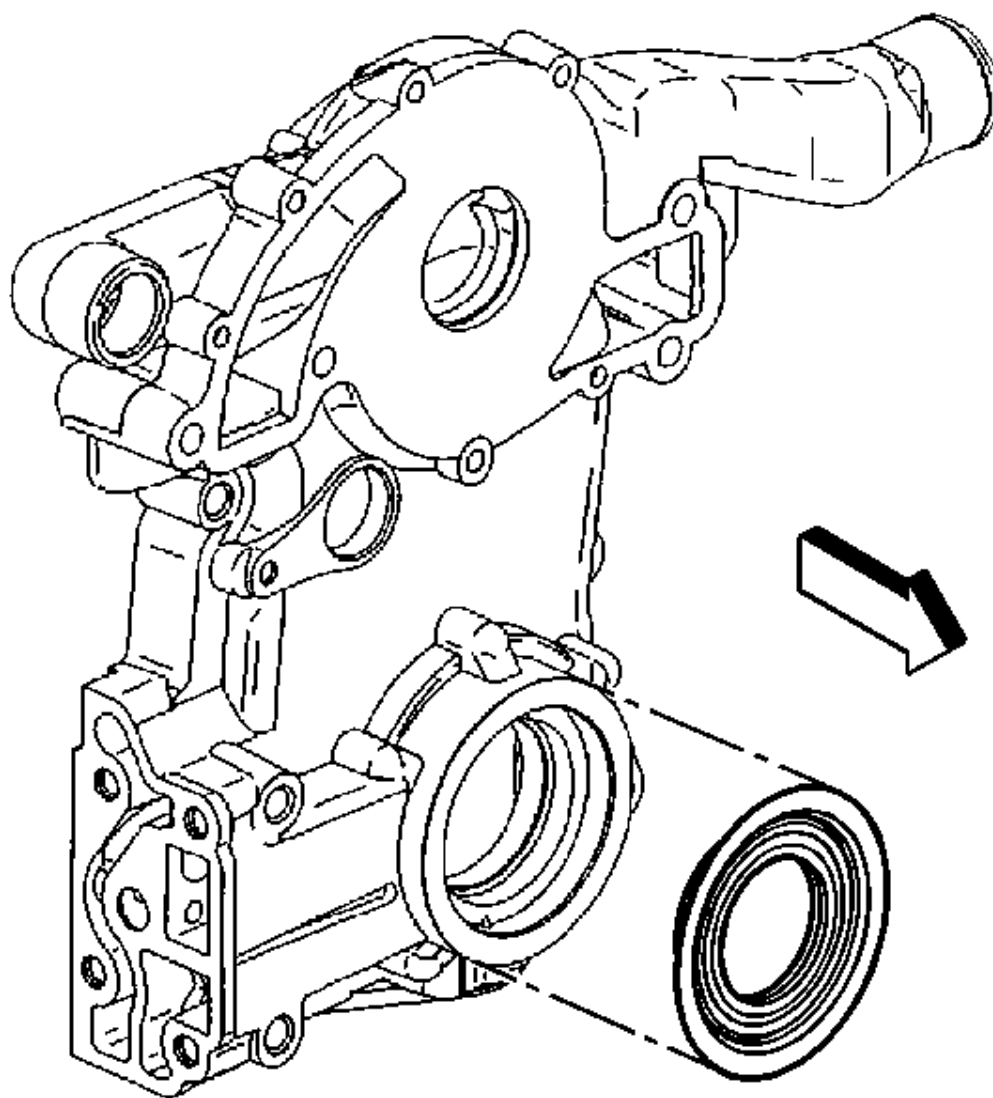


Fig. 195: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the seal bore or the contact surfaces.

Use a screwdriver to pry out the crankshaft front oil seal.

Engine Front Cover Removal

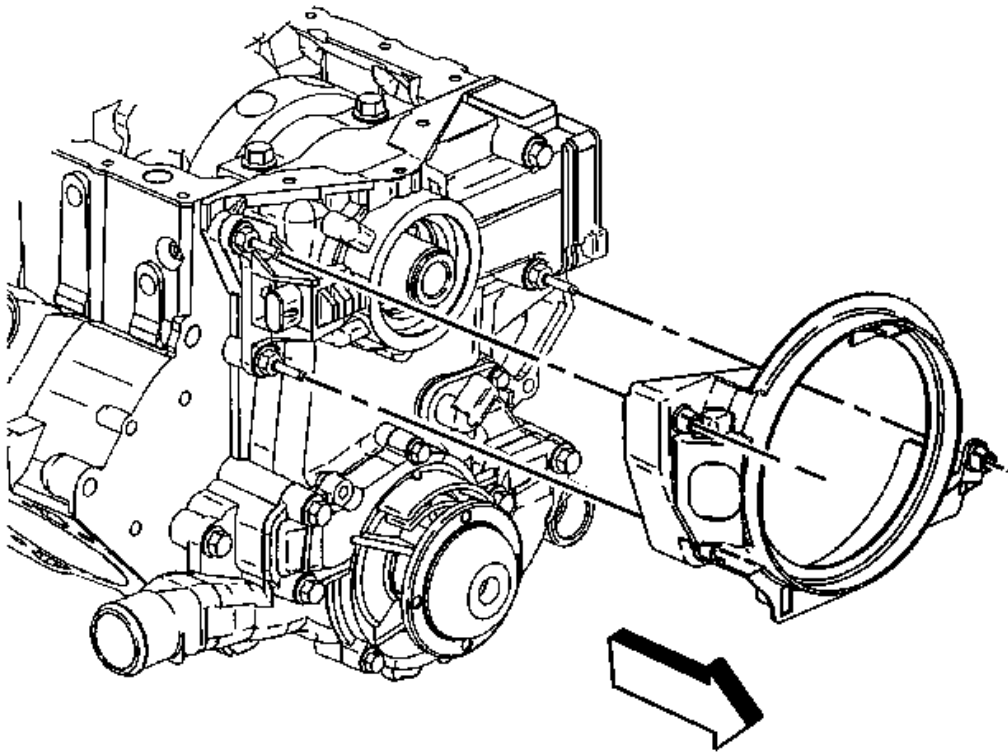


Fig. 196: Locating Crankshaft Position Sensor Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor shield.

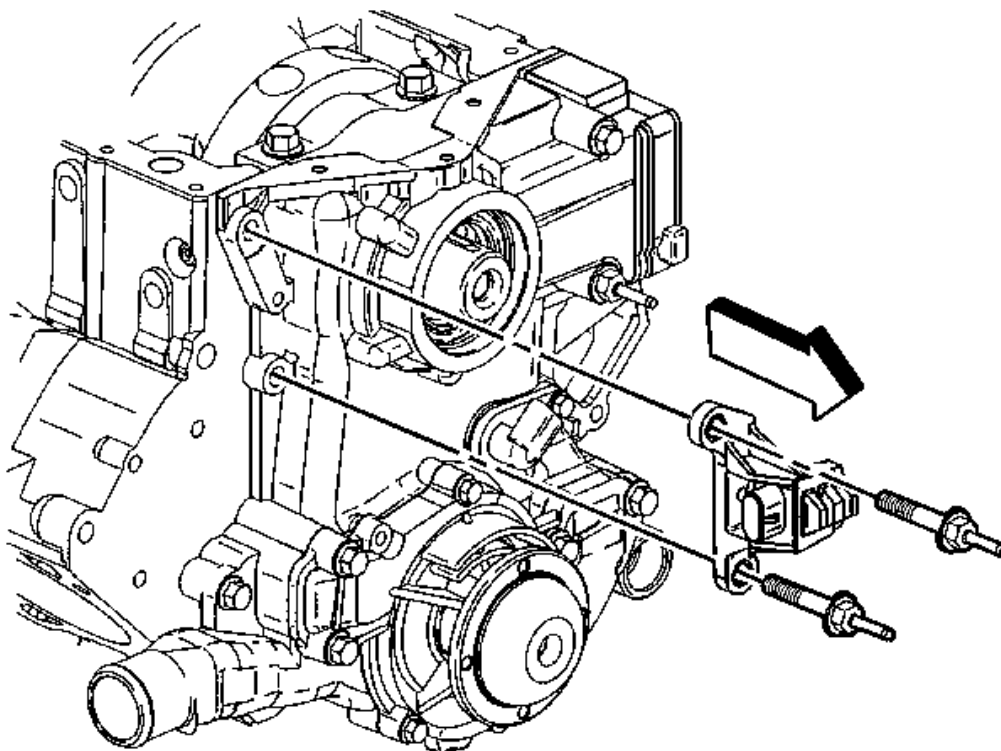


Fig. 197: Locating Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft position sensor studs.
3. Remove the crankshaft position sensor.

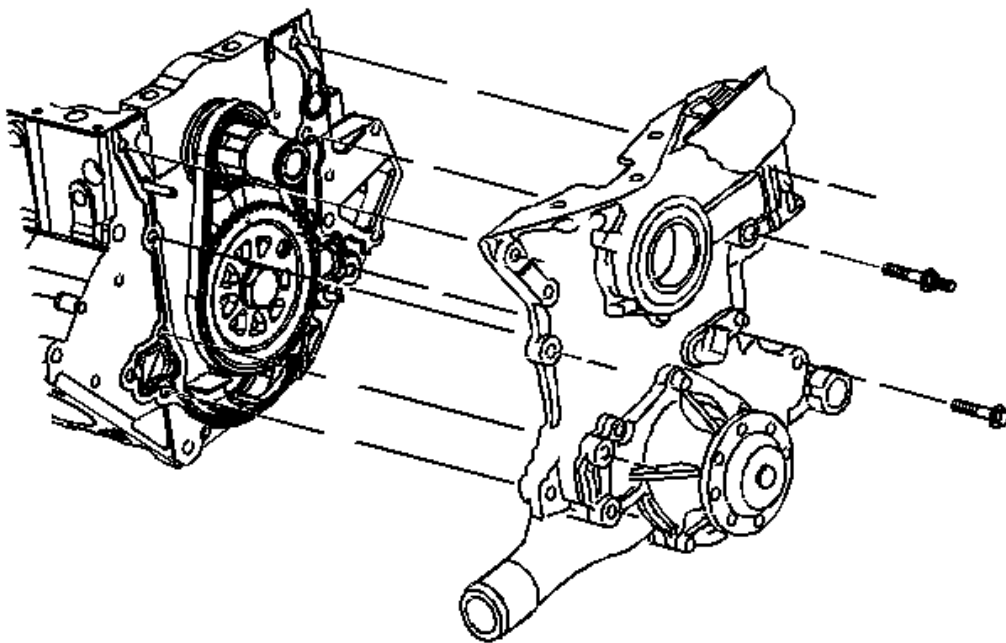


Fig. 198: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine front cover bolts and stud.
5. Remove the engine front cover.

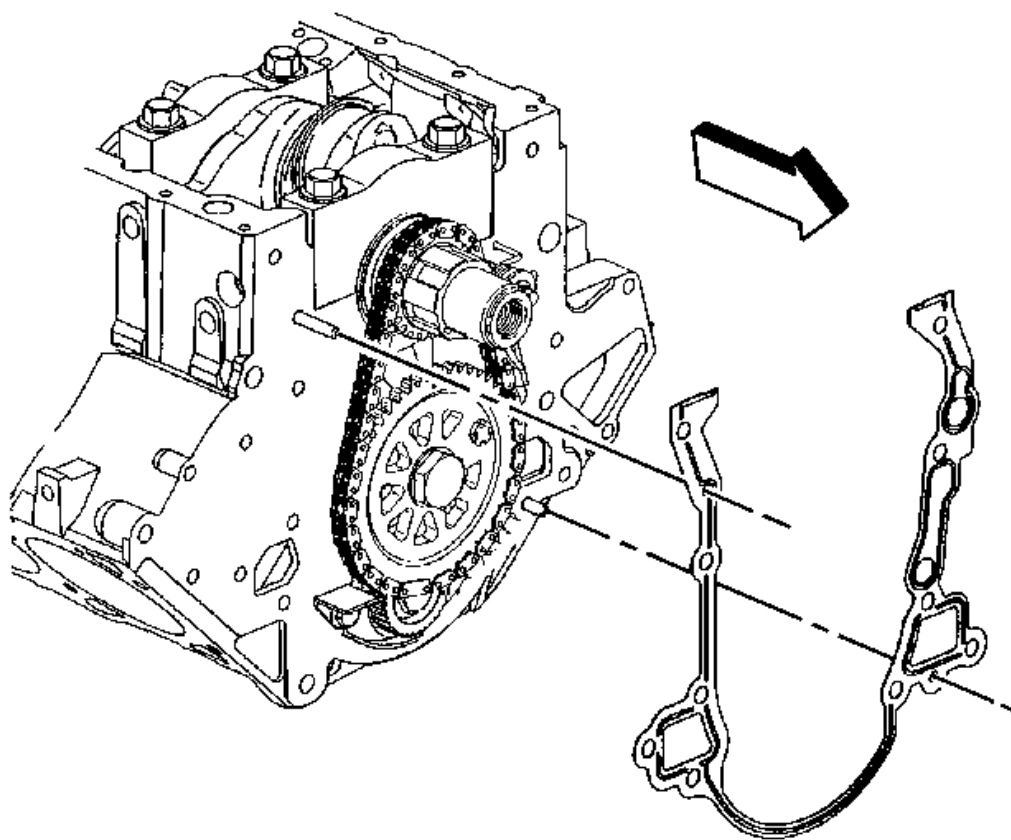


Fig. 199: Locating Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine front cover gasket.

Oil Filter Adapter Removal

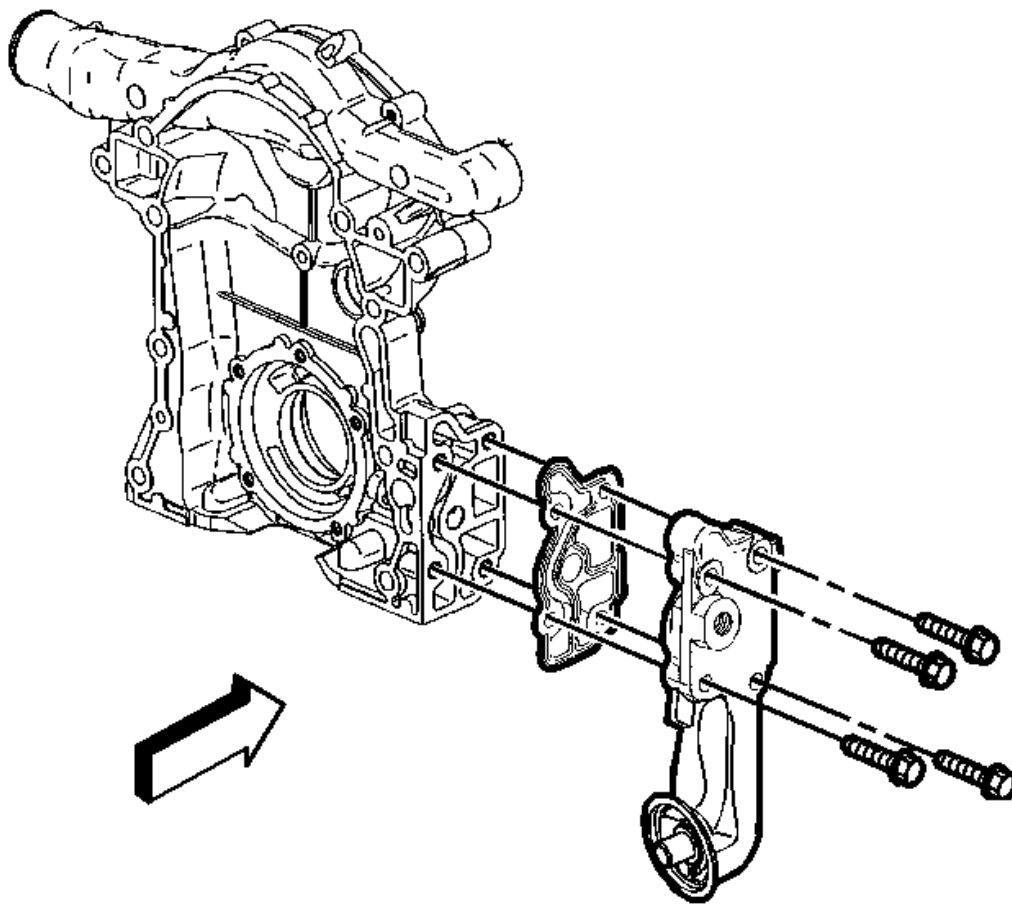


Fig. 200: Locating Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter bolts from the engine front cover.
2. Remove the oil filter adapter.
3. Remove the oil filter adapter gasket.
4. Remove the oil pressure relief valve.
5. Remove the oil pressure relief valve spring.

Timing Chain and Sprockets Removal

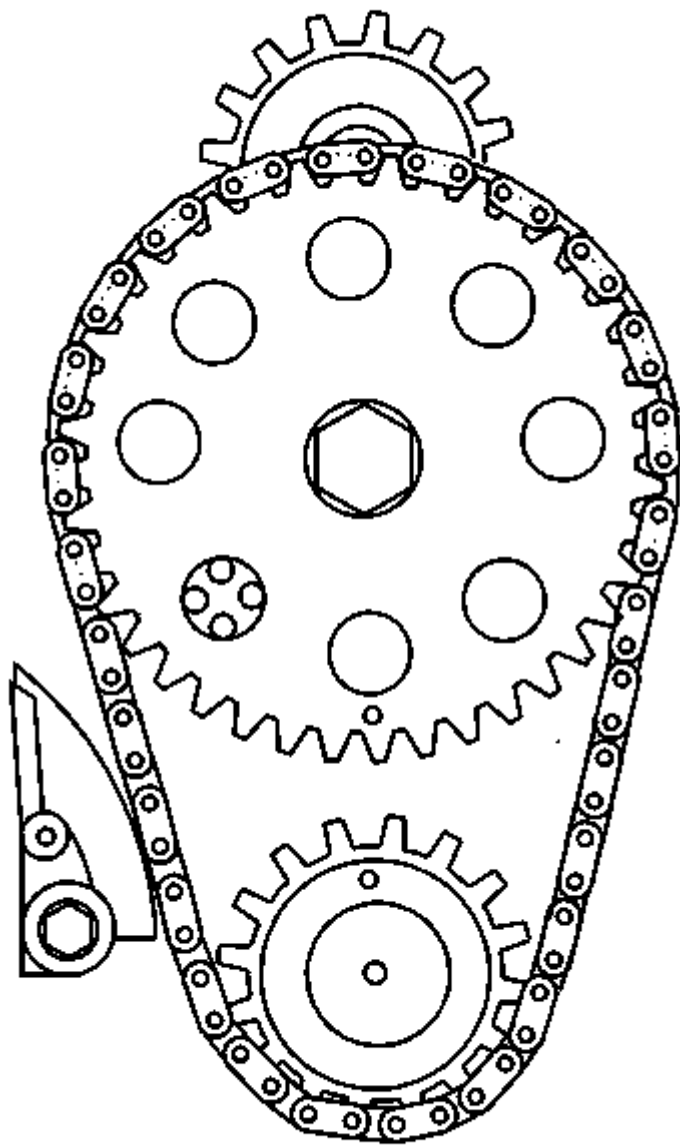


Fig. 201: Aligning Timing Chain & Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

1. Align the timing marks on the sprockets.

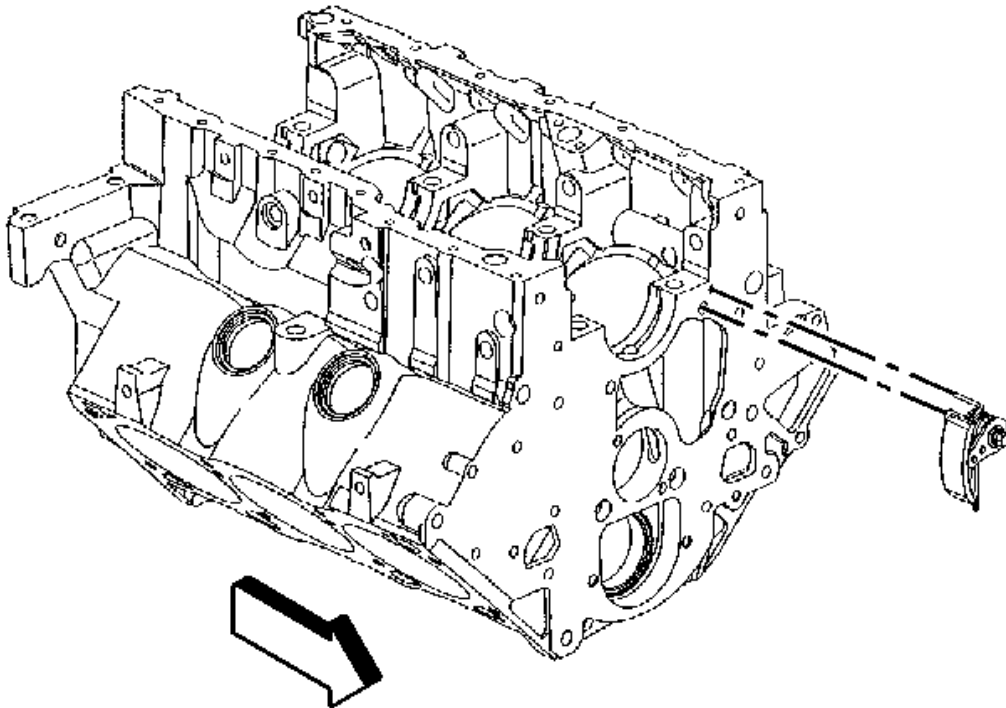


Fig. 202: View Of Timing Chain Dampener
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing chain dampener.

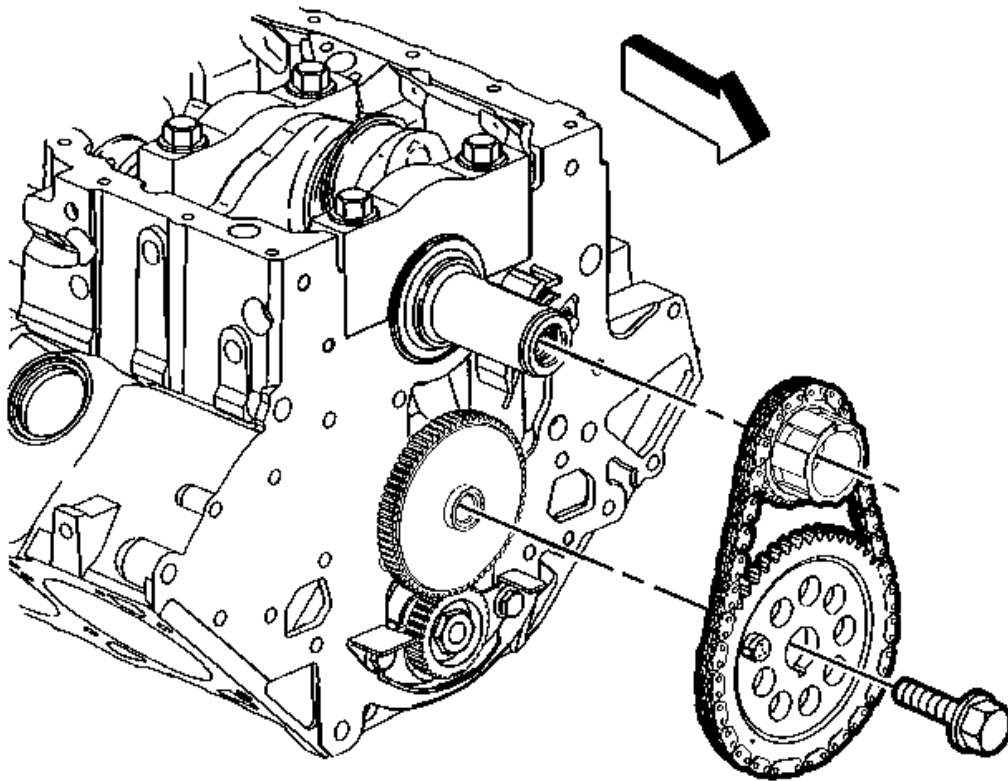


Fig. 203: Identifying Camshaft Sprocket Bolt (L36)
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft sprocket bolt.
4. Remove the camshaft sprocket.
5. Remove the timing chain.
6. Remove the crankshaft sprocket.
7. Remove the crankshaft balancer key.

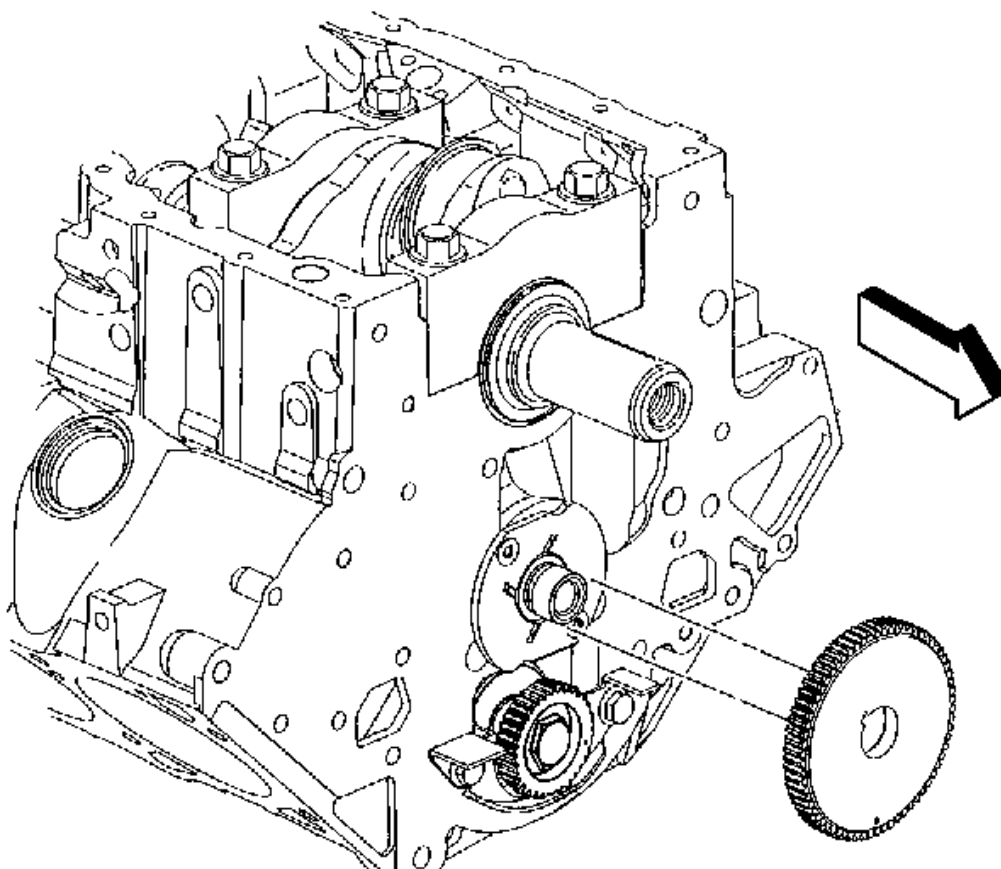


Fig. 204: Removing Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

8. Remove the balance shaft drive gear.

Balance Shaft Removal

Tools Required

J 6125-1B Slide Hammer. See **Special Tools and Equipment**.

Removal Procedure

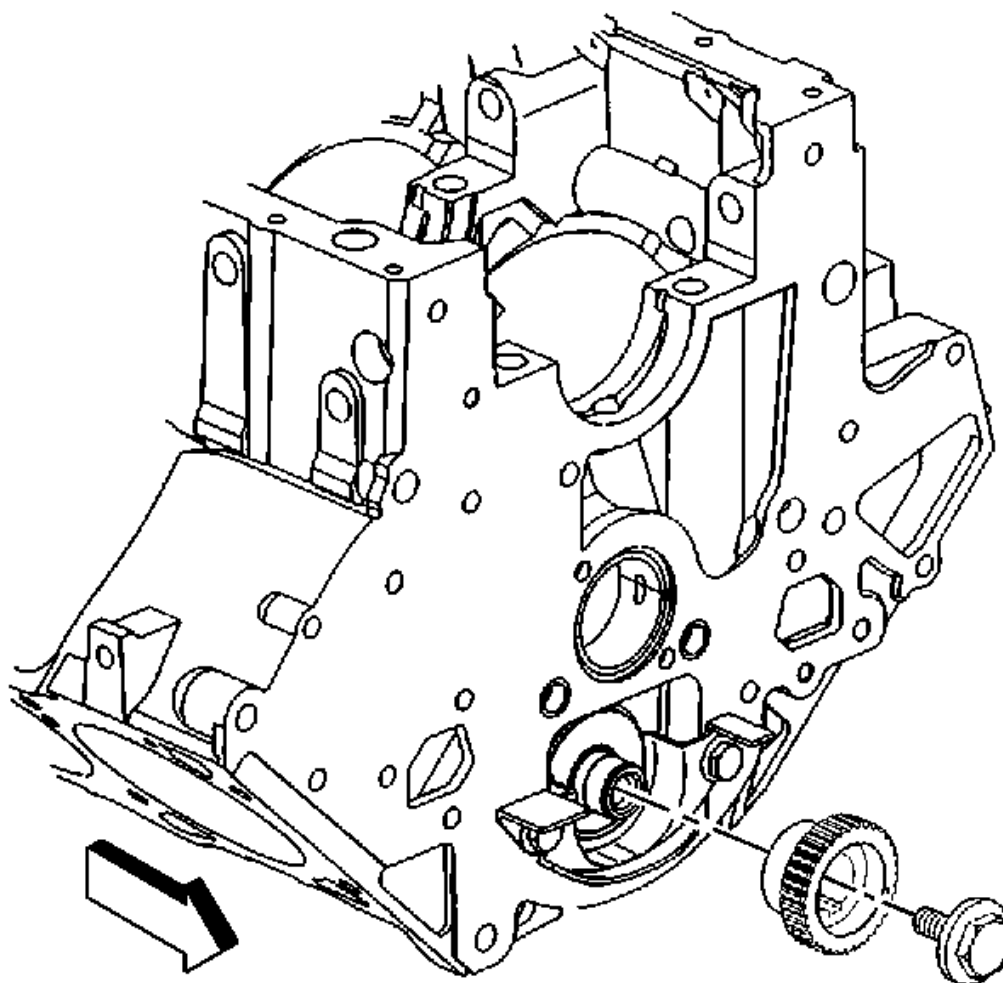


Fig. 205: Locating Balance Shaft Driven Gear & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft driven gear bolt.
2. Remove the balance shaft driven gear.

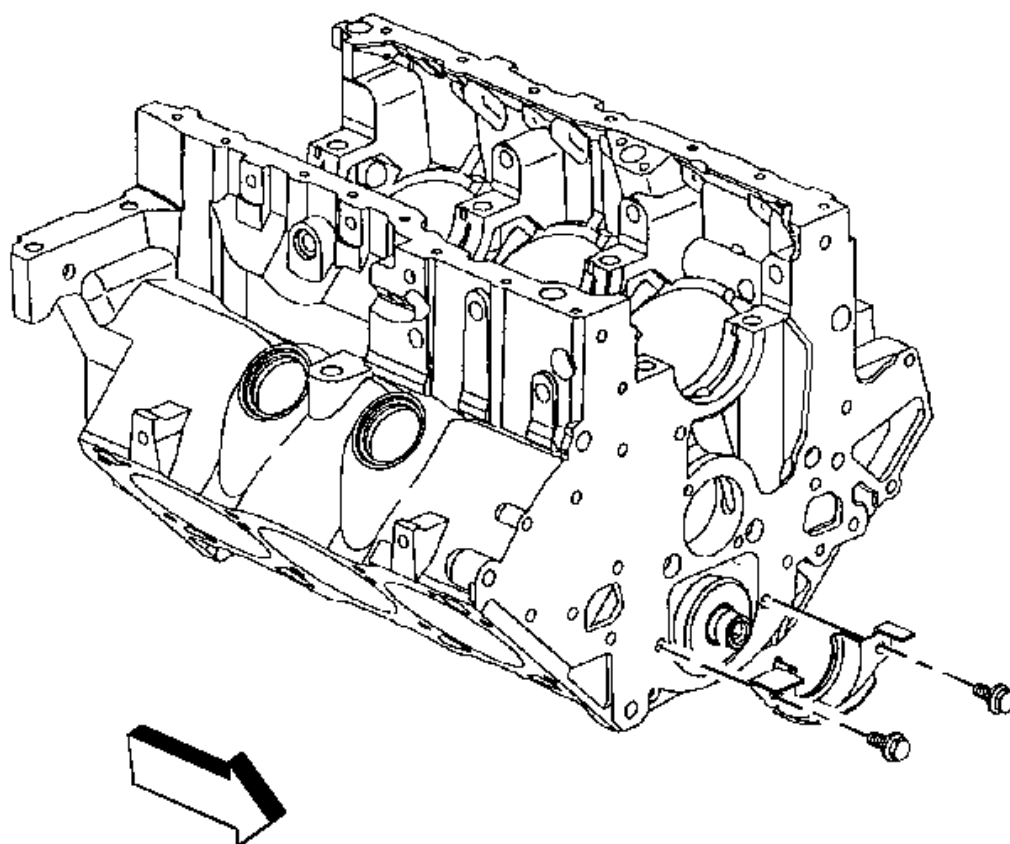


Fig. 206: Locating Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the balance shaft retainer bolts.
4. Remove the balance shaft retainer.

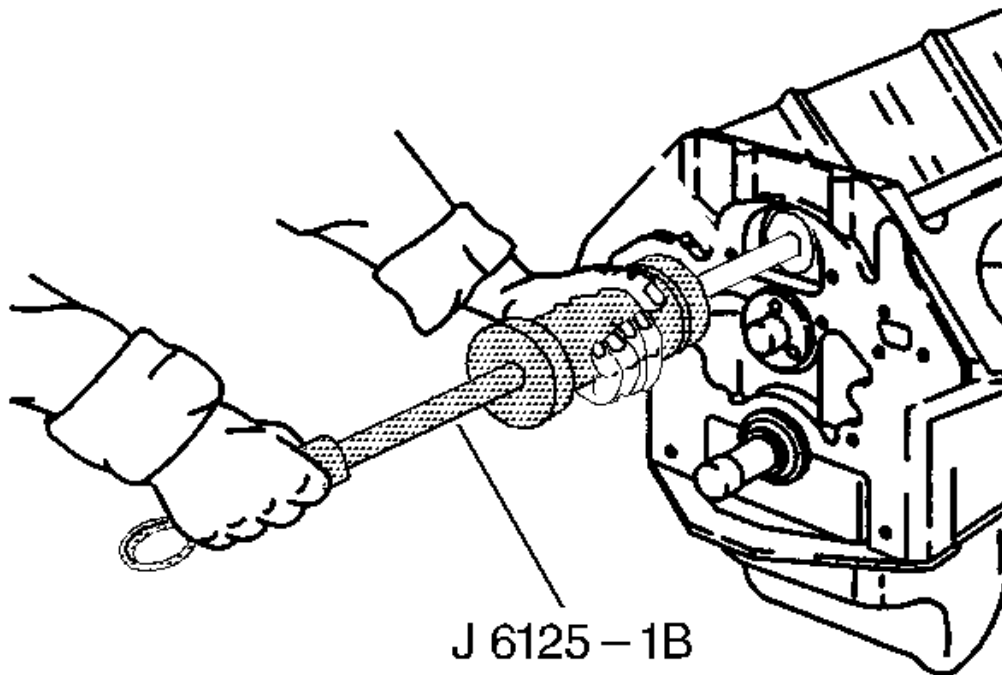


Fig. 207: Removing Balance Shaft
Courtesy of GENERAL MOTORS CORP.

5. Use **J 6125-1B** to remove the balance shaft. See Special Tools and Equipment.

Camshaft Removal

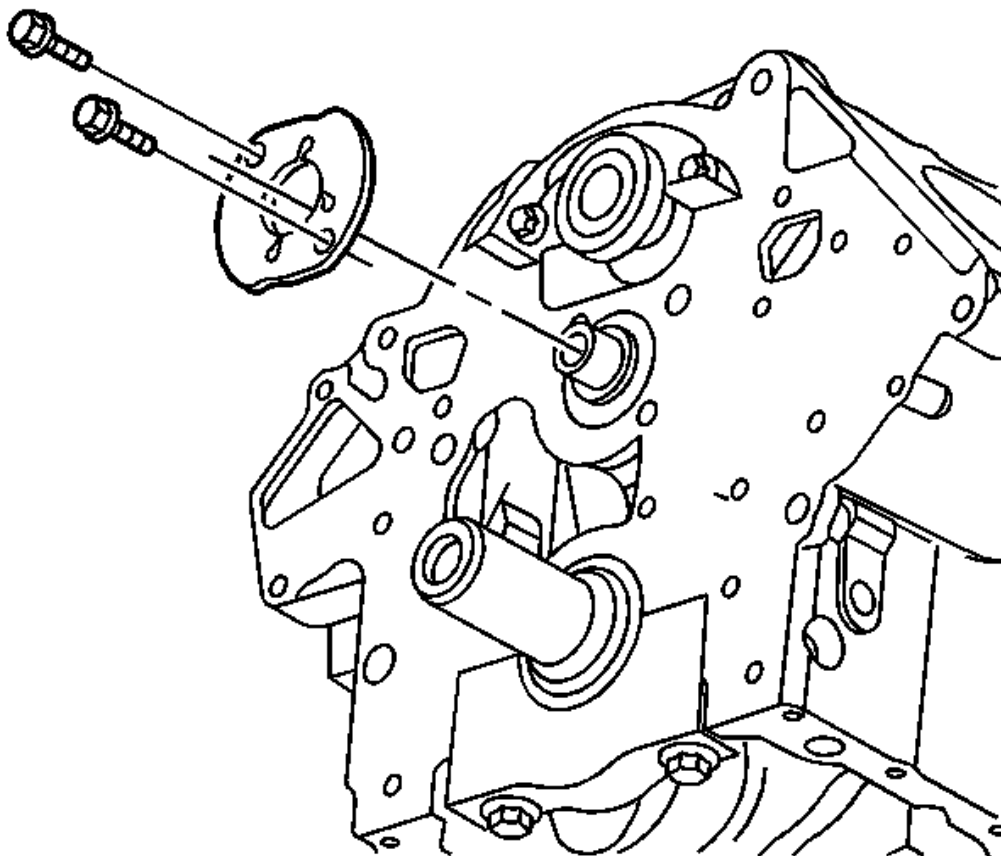


Fig. 208: Identifying Camshaft Thrust Plate & Screws
Courtesy of GENERAL MOTORS CORP.

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

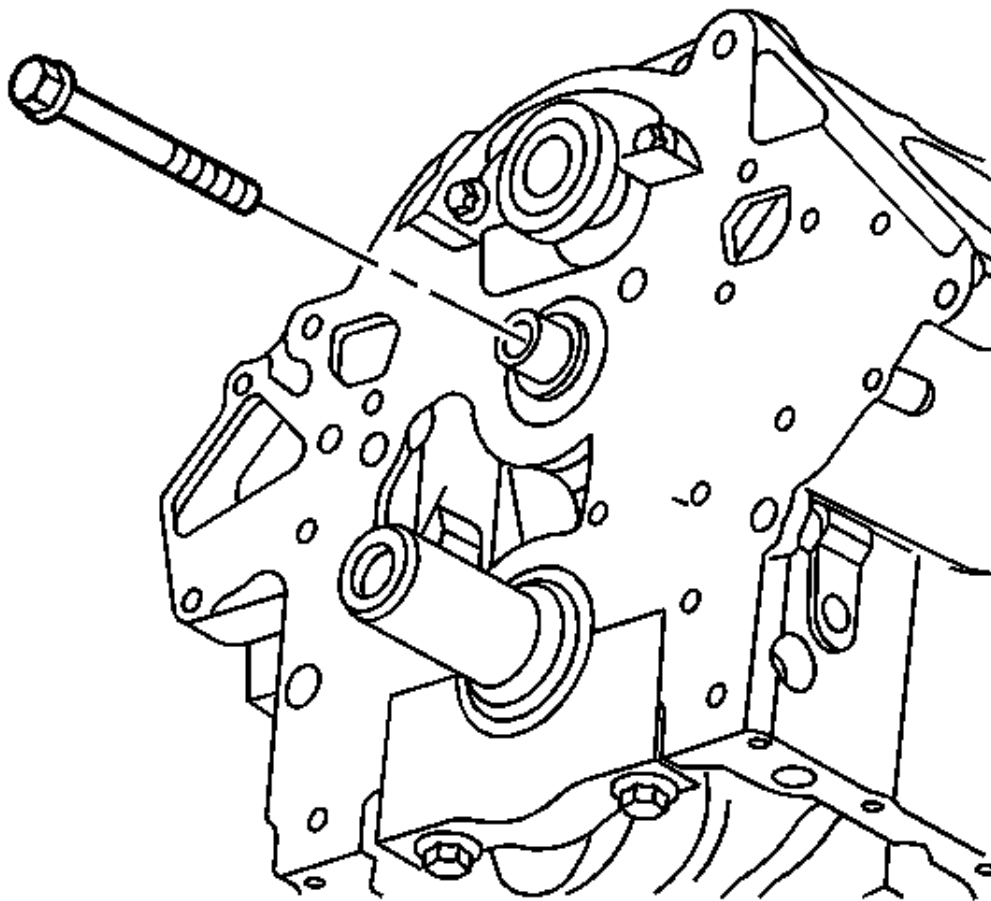


Fig. 209: Locating Camshaft Front Bolt Hole
Courtesy of GENERAL MOTORS CORP.

3. Install one 1/2-20 x 6.0 inch bolt in the camshaft front bolt hole.

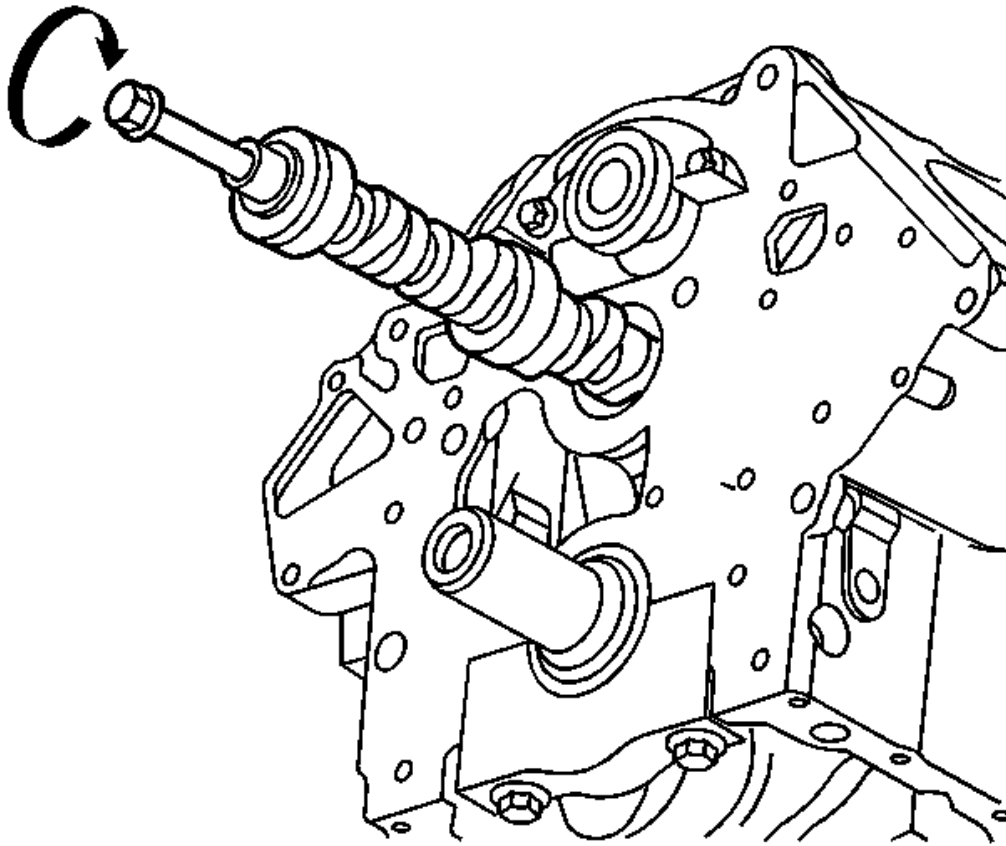


Fig. 210: Removing Camshaft
Courtesy of GENERAL MOTORS CORP.

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

4. Carefully rotate and pull the camshaft out of the bearings.

Crankshaft Rear Oil Seal Removal

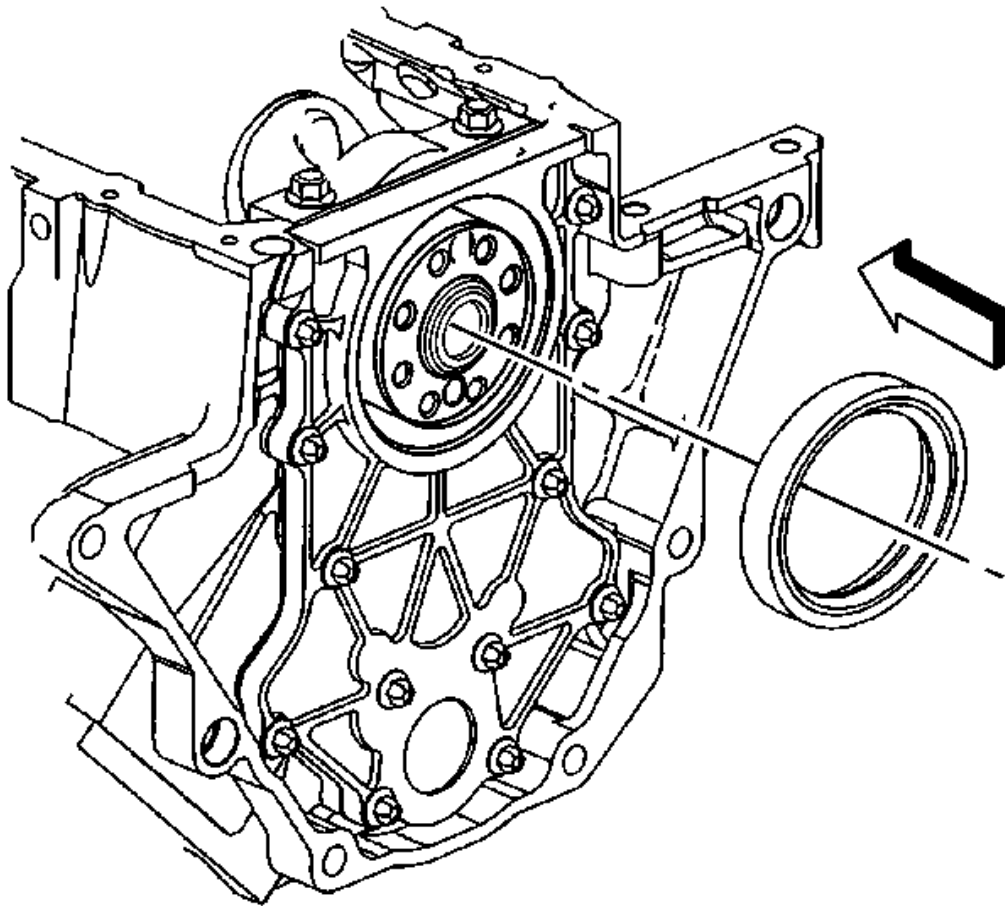


Fig. 211: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not damage the crankshaft or the crankshaft rear oil seal housing.

Pry the crankshaft rear oil seal out with a screwdriver.

Crankshaft Rear Oil Seal and Housing Removal

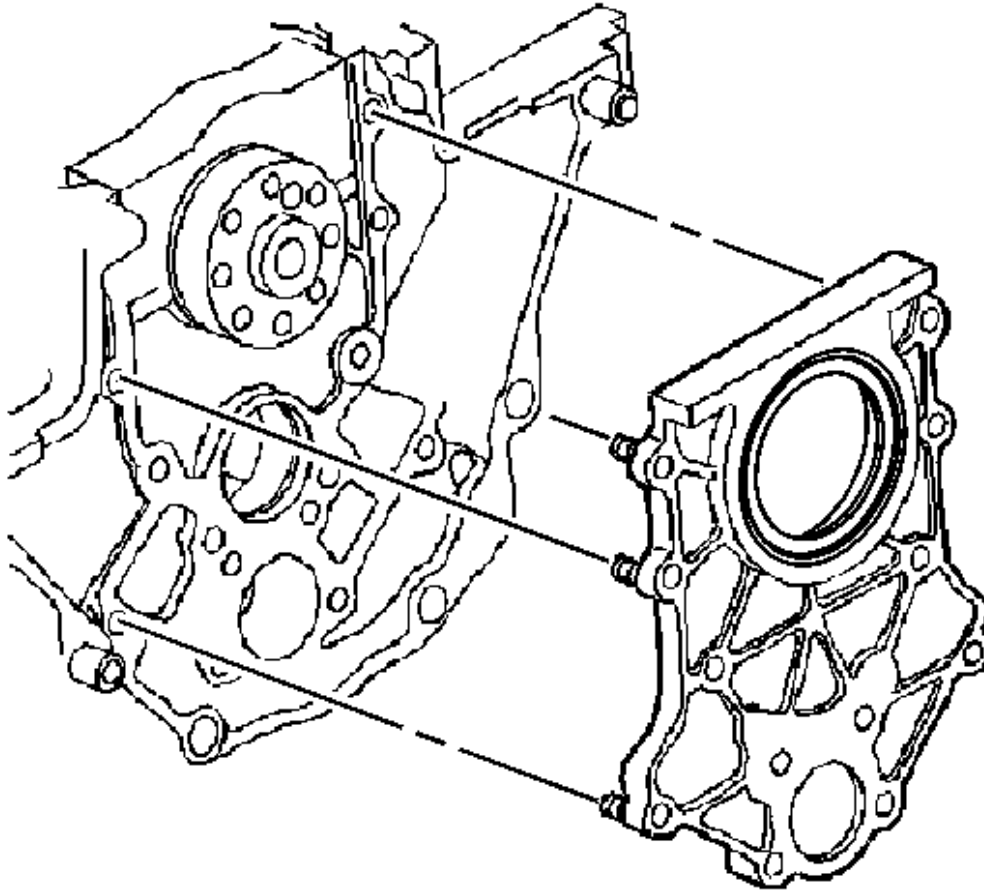


Fig. 212: Locating Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal housing bolts.

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.

2. Remove the crankshaft rear oil seal housing and gasket.

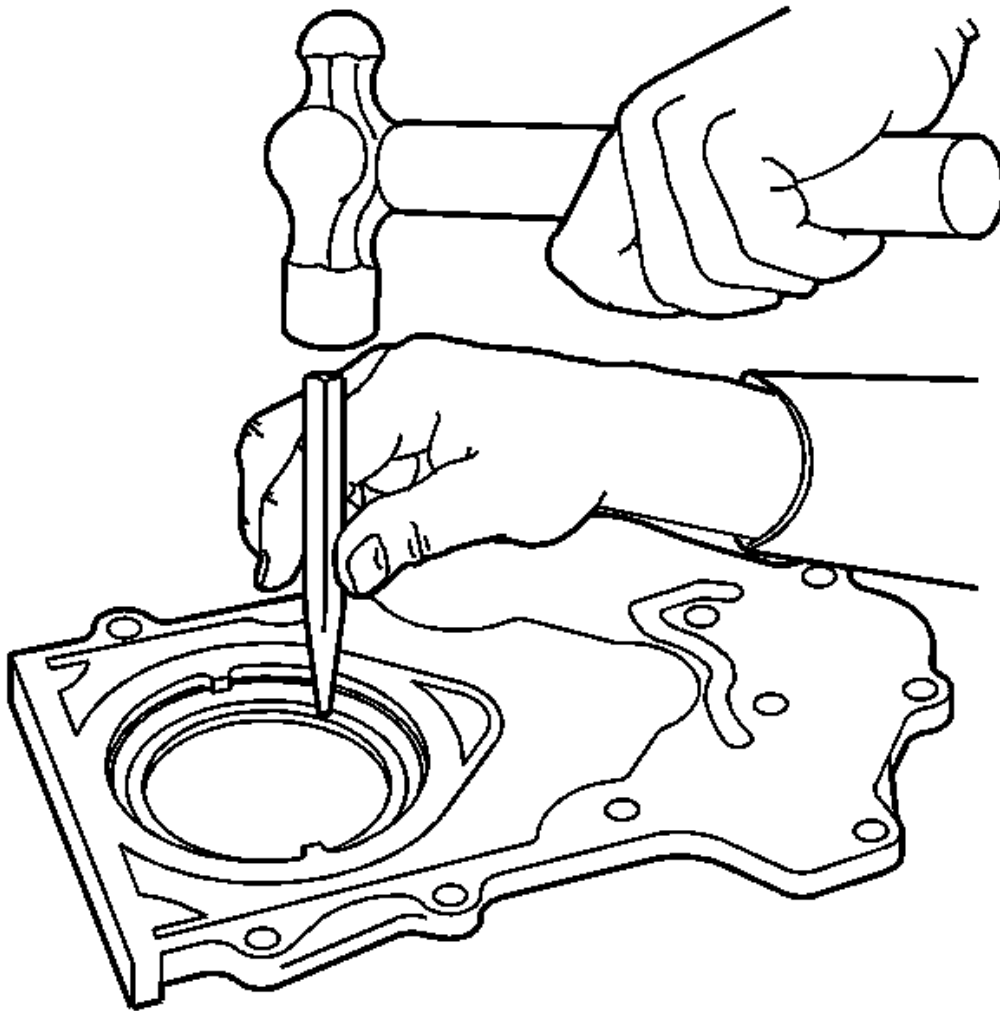


Fig. 213: Locating Crankshaft Rear Oil Seal In Housing
Courtesy of GENERAL MOTORS CORP.

3. Place the crankshaft rear oil seal housing face down on a clean surface and support with blocks of wood.
4. Use a suitable driving tool and hammer and lightly tap around the outer edge of the seal to remove it.

Piston, Connecting Rod, and Bearing Removal

Tools Required

- **J 41507** Connecting Rod Guide Assembly. See **Special Tools and Equipment**.
- **J 24270** Cylinder Ridge Reamer. See **Special Tools and Equipment**.

Removal Procedure

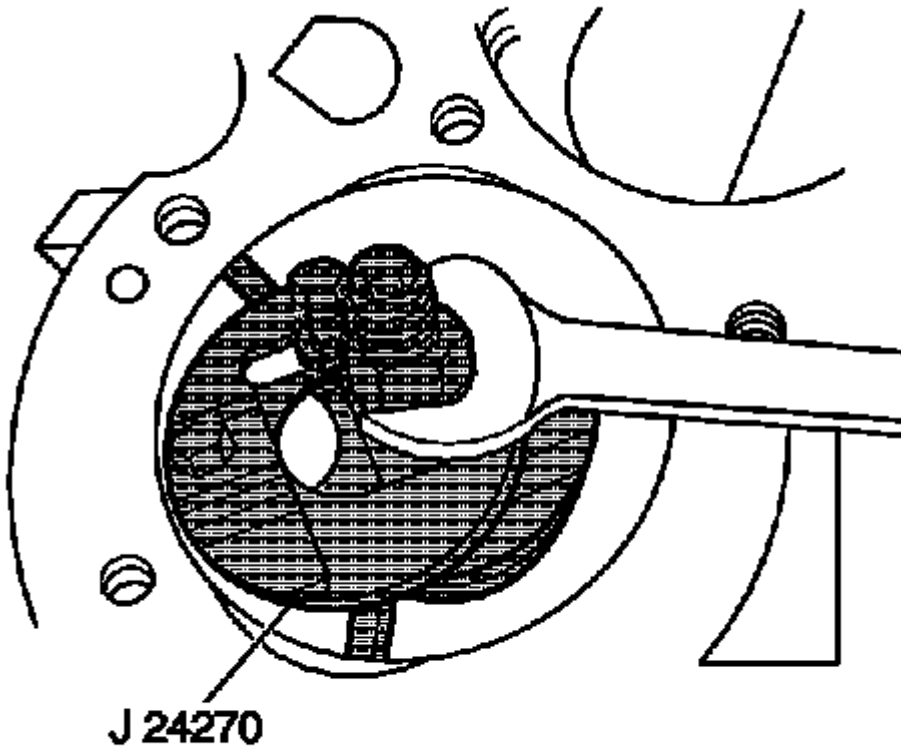


Fig. 214: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Mark the connecting rod cap and the connecting rod for proper installation.

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.

2. Use the **J 24270** to remove the cylinder bore ring ridge. See Special Tools and Equipment.
 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.

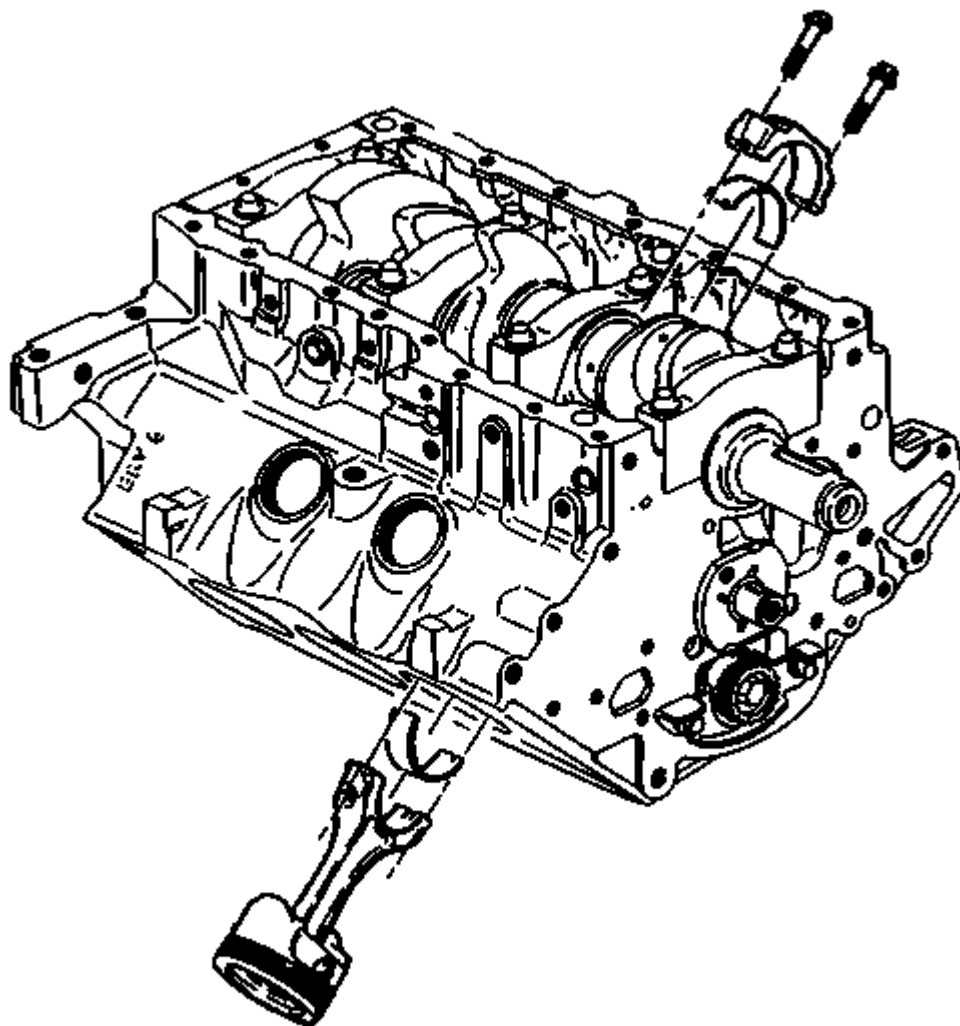


Fig. 215: Identifying Connecting Rod Bolts & Cap
Courtesy of GENERAL MOTORS CORP.

3. Remove the connecting rod bolts.
4. Remove the connecting rod cap.

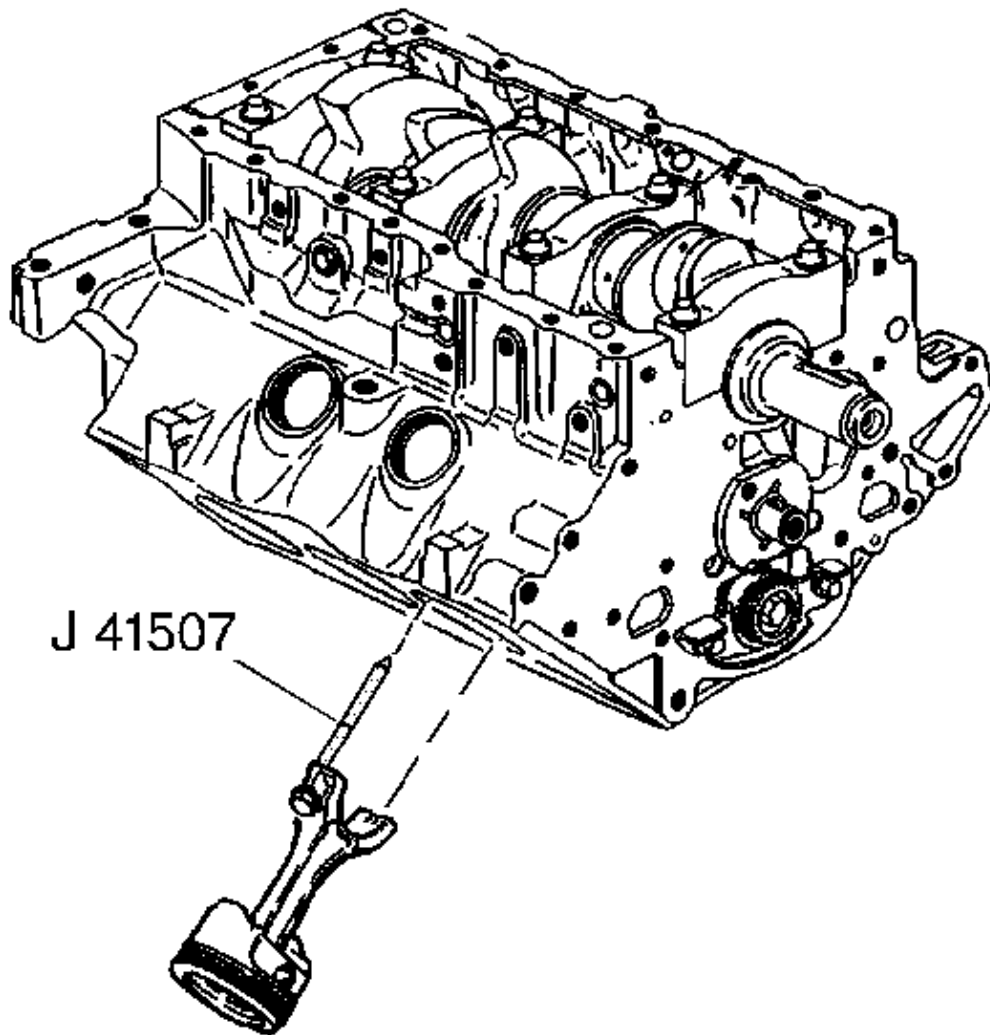


Fig. 216: Locating J 41507 To Connecting Rod
Courtesy of GENERAL MOTORS CORP.

5. Install **J 41507** to the connecting rod. See **Special Tools and Equipment**. Hand tighten the tool to the connecting rod.
6. Use hand pressure on **J 41507** to push the connecting rod towards the top of the cylinder. See **Special Tools and Equipment**.

IMPORTANT: Mark the piston with the number of the cylinder from which it was removed. Mark the piston as to what is the front for proper reassembly.

7. Remove the piston, the connecting rod, and the connecting rod bearings.

Crankshaft and Bearings Removal

Tools Required

- **J 6125-1B** Slide Hammer. See **Special Tools and Equipment**.
- **J 41348** Main Bearing Cap Puller. See **Special Tools and Equipment**.

Removal Procedure

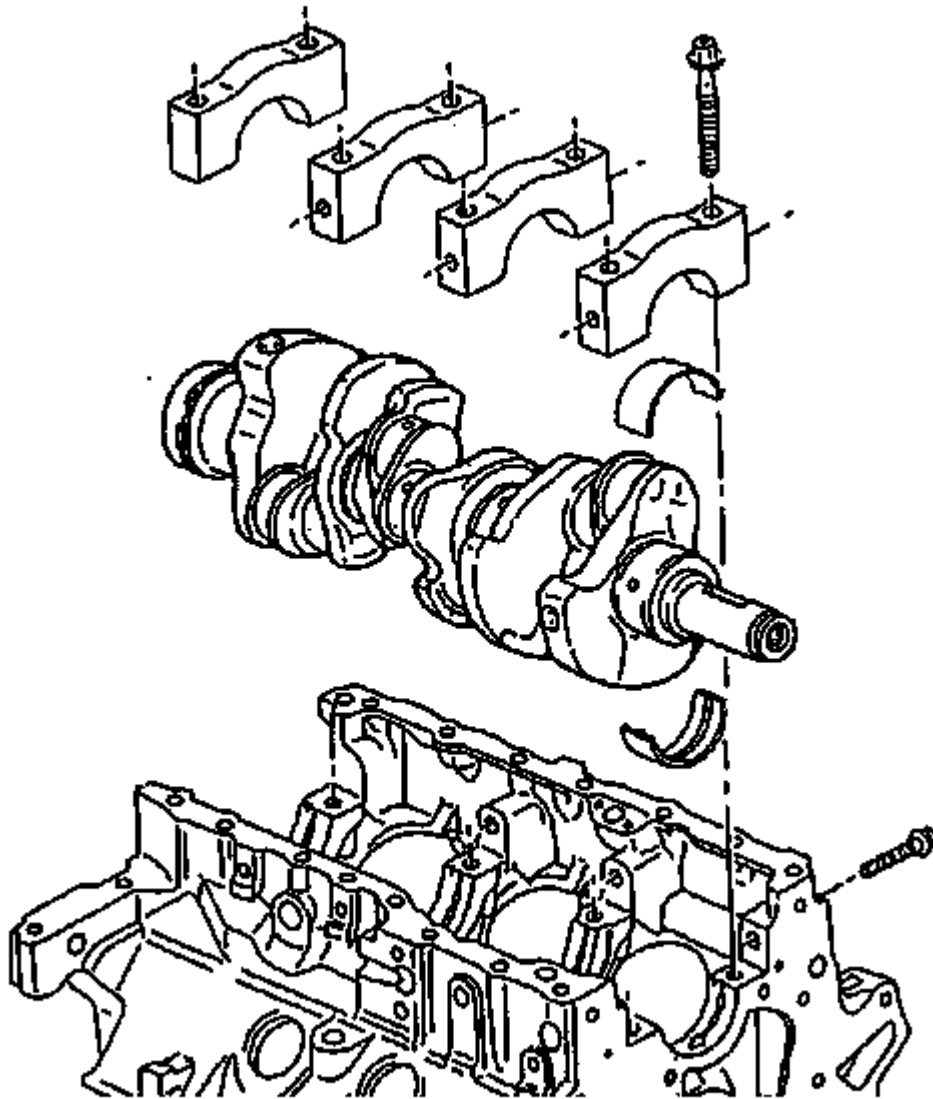


Fig. 217: View Of Crankshaft, Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This engine has side bolts on all of the main caps except the rear cap. These bolts must be removed to service the caps.

1. Remove the crankshaft main bearing cap side bolts.
2. Remove the crankshaft main bearing cap bolts.

NOTE: Main bearing caps are press fit. Remove the caps carefully for service. J 41348 has been designed to work with J 6125-B in order to prevent damage to the bearing and cap. J 41348 **MUST** be installed properly into the bolt holes of the caps and J 6125-B attached to J 41348 in order to properly remove the main cap without damaging the bearing or the cap. Any deviation from this procedure may cause damage to the cap and the bearing and may result in future engine damage.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install **J 41348** into the crankshaft main bearing cap bolt holes. See Special Tools and Equipment.

Tighten: Tighten the bolts on **J 41348** to 12 N. See Special Tools and Equipment.m (100 lb in).

4. Install **J 6125-1B** to **J 41348** . See Special Tools and Equipment.

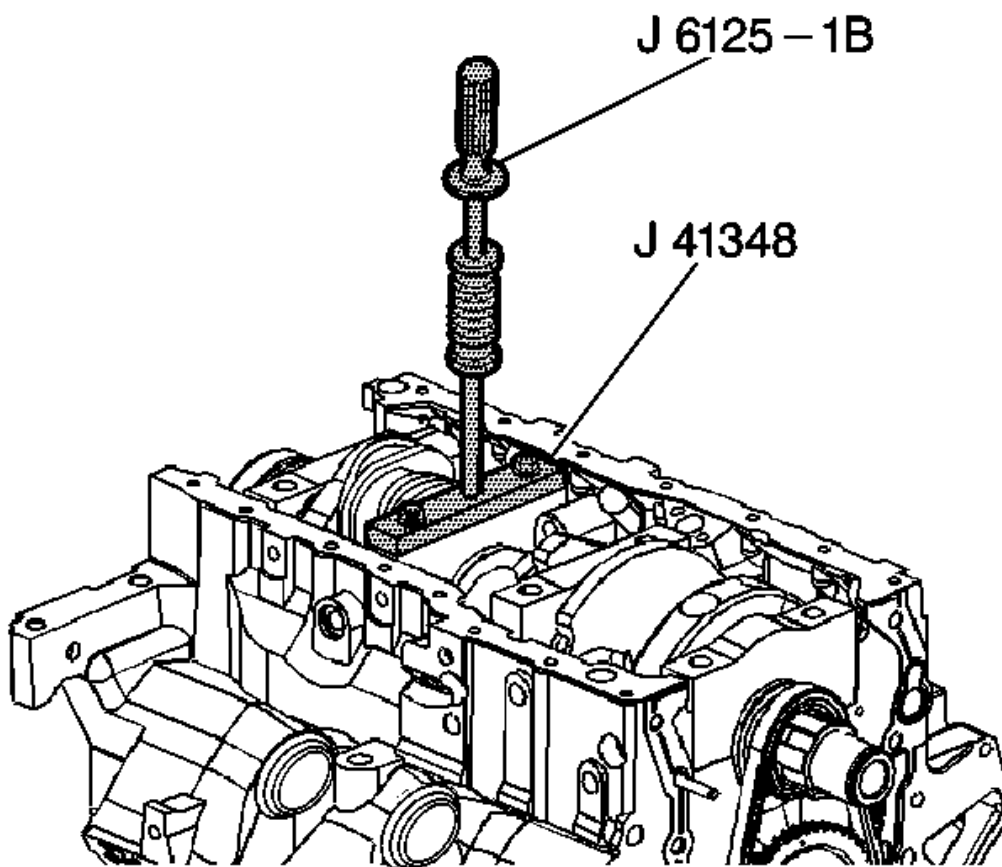


Fig. 218: Removing Crankshaft Main Lower Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Use **J 6125-1B** to remove the crankshaft main lower bearing caps. See **Special Tools and Equipment**.

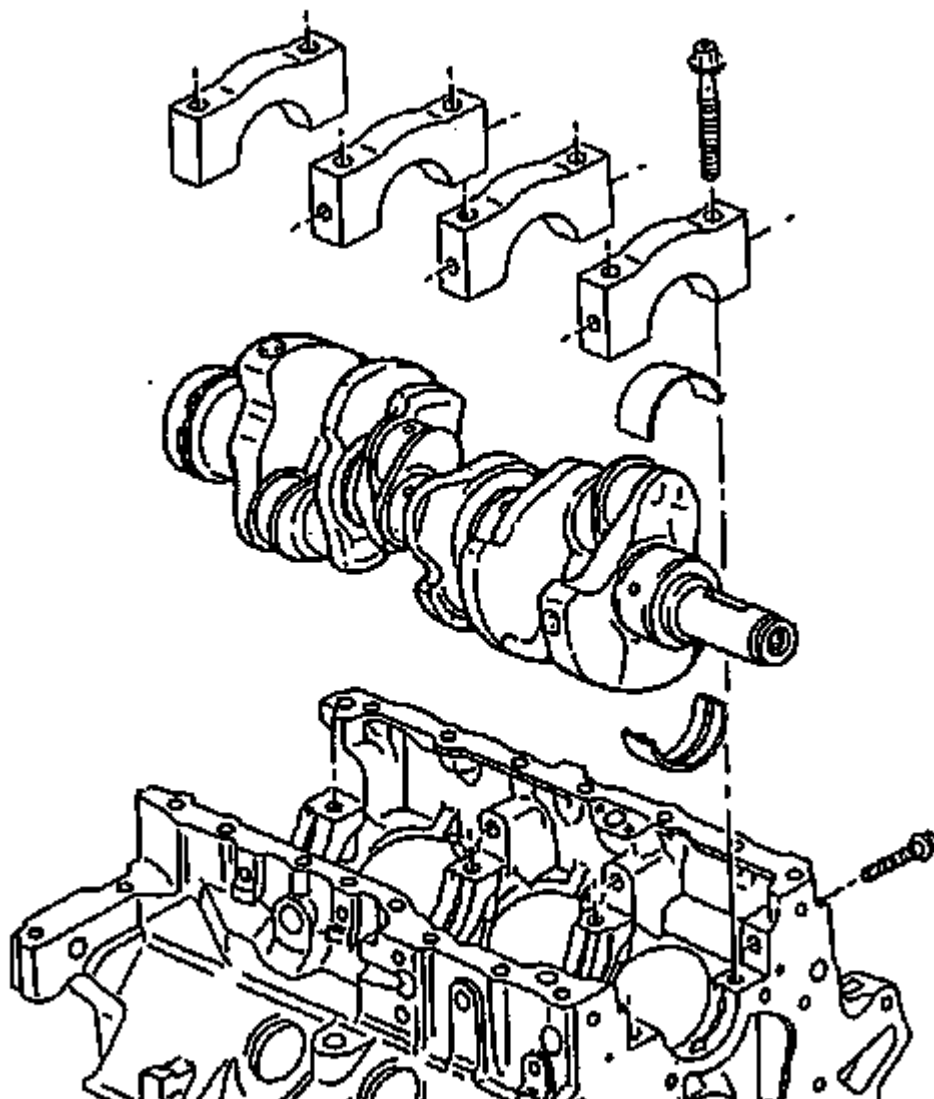


Fig. 219: View Of Crankshaft, Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft.

7. Remove the upper main bearings from the engine block.

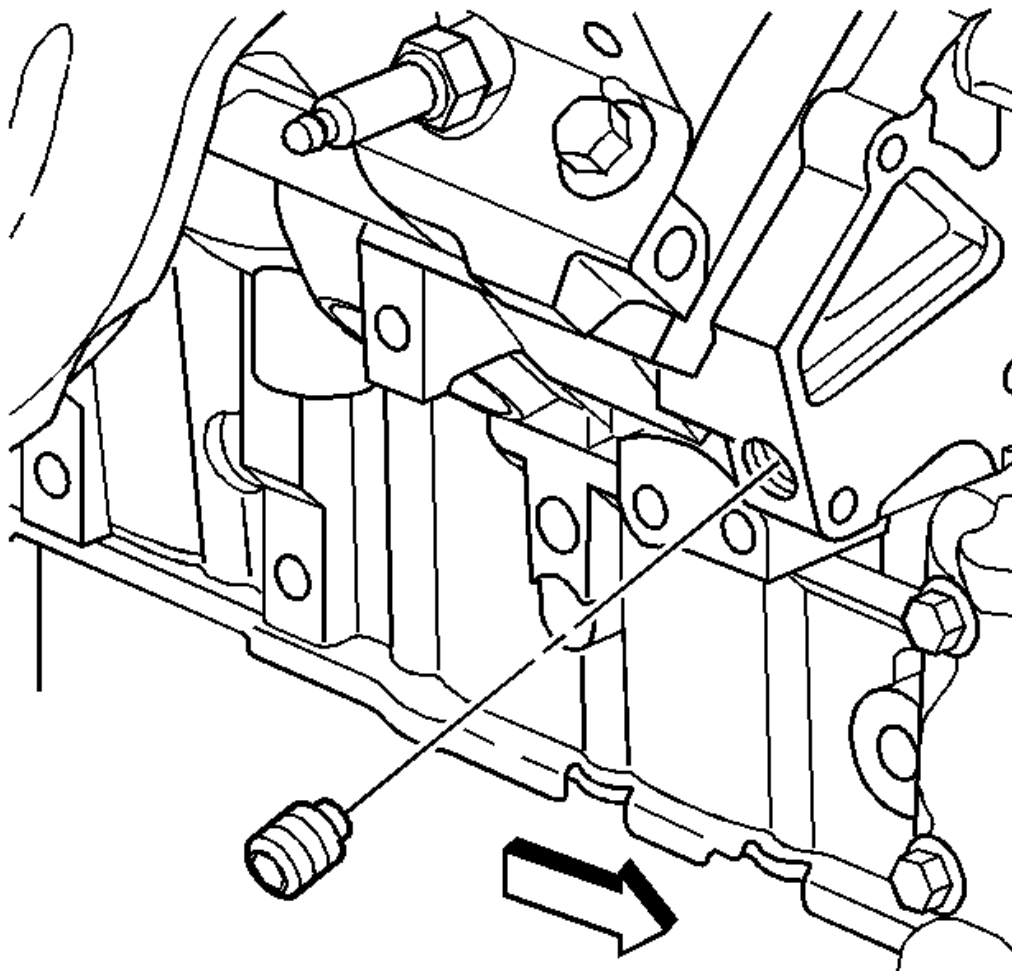
Engine Block Plug Removal

Fig. 220: Locating Threaded Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the threaded coolant jacket plugs.

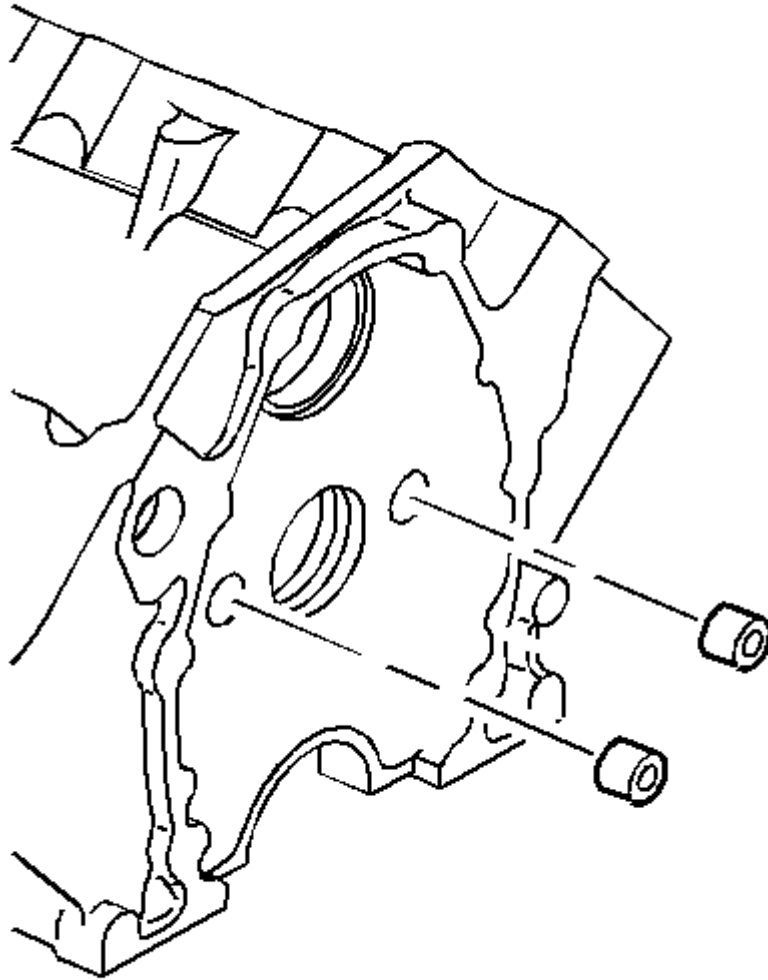


Fig. 221: Locating Engine Block Plugs
Courtesy of GENERAL MOTORS CORP.

2. Remove the remaining plugs using the following procedure.
 1. Obtain a suitable self-threading screw.
 2. Drill a hole into the plug.
 3. Install the self-threading screw.
 4. Use the screw to pry out the plug.

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Remover/Installer. See Special Tools and Equipment.

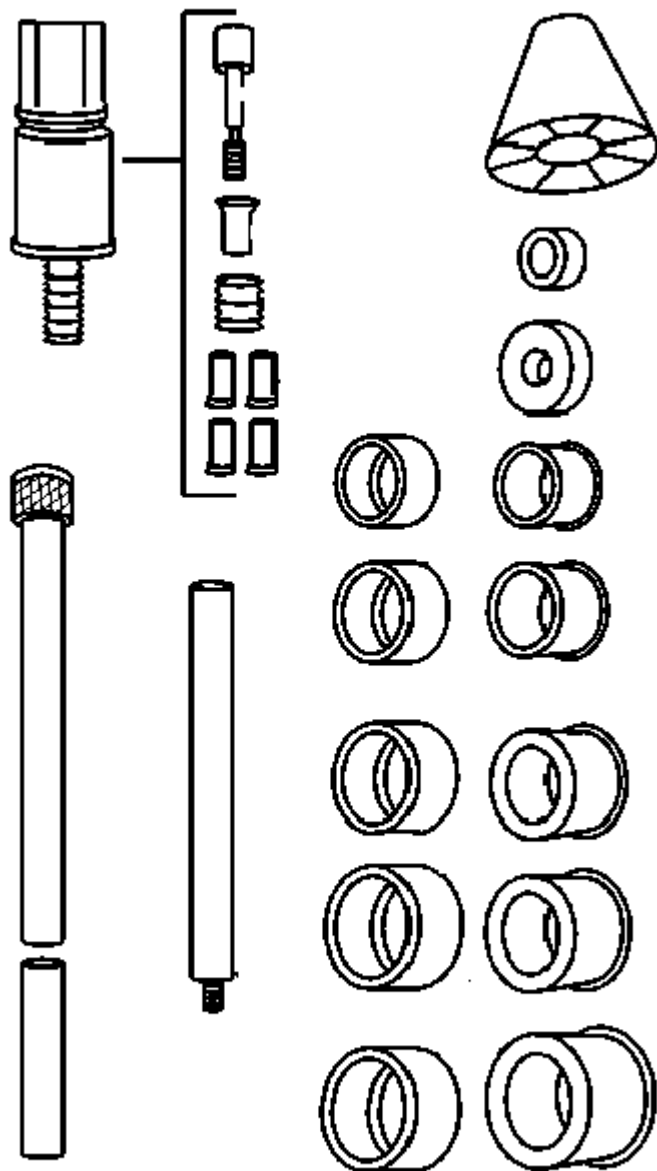
Removal Procedure

Fig. 222: Camshaft Bearing Service Set

Courtesy of GENERAL MOTORS CORP.

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

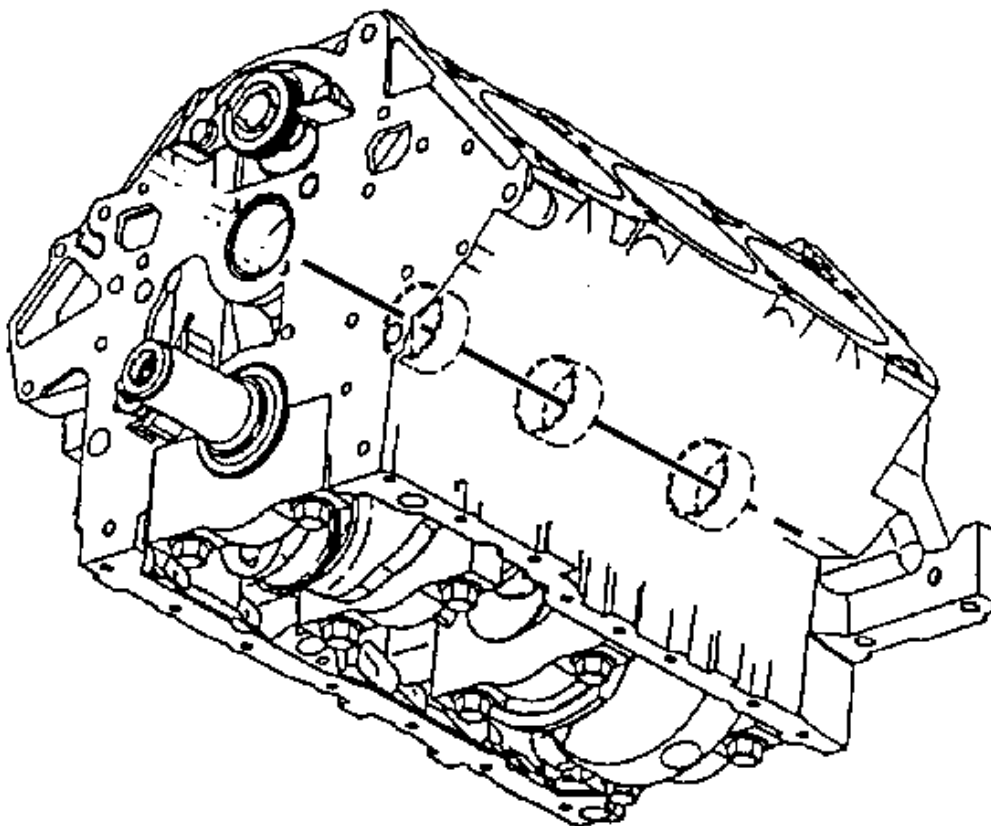


Fig. 223: Locating Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

3. Drive out the camshaft bearings.

Balance Shaft Bearing and/or Bushing Removal

Tools Required

J 36995 Balance Shaft Bearing Remover/Installer. See Special Tools and Equipment.

Removal Procedure

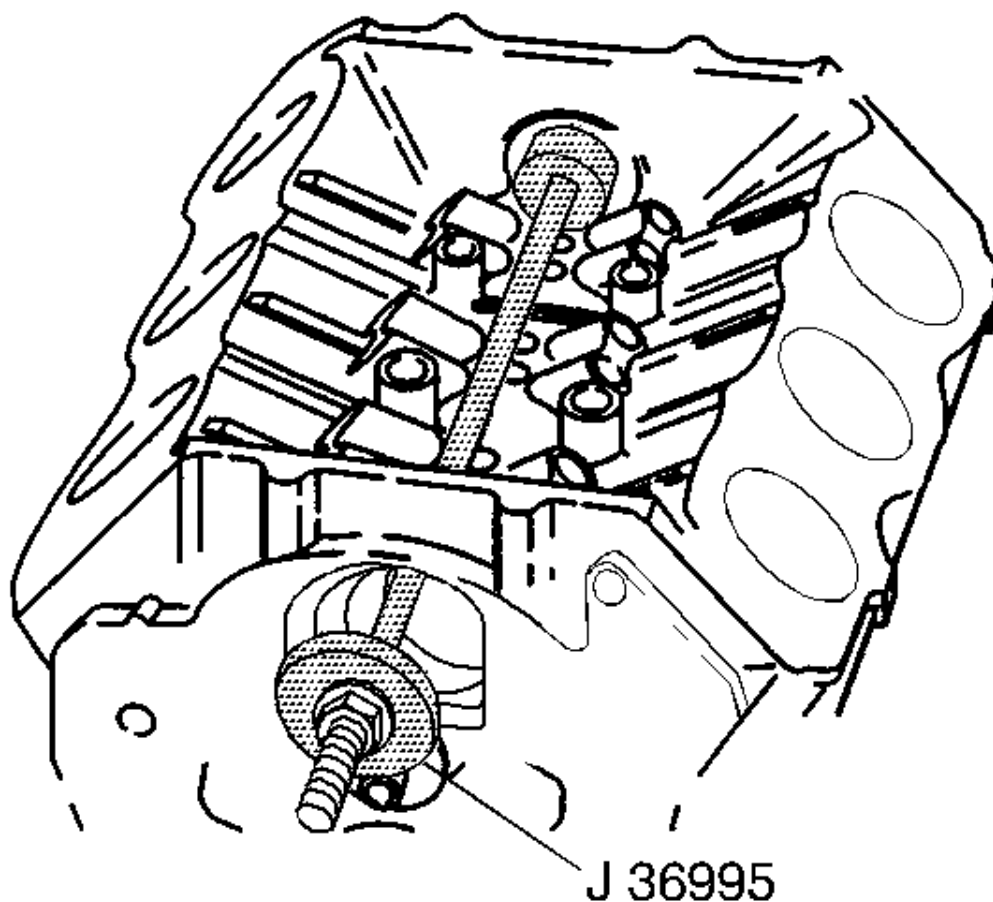


Fig. 224: Removing Balance Shaft Bearing
Courtesy of GENERAL MOTORS CORP.

1. Use **J 36995** to remove the balance shaft bearing. See Special Tools and Equipment.
2. Use **J 36995** to remove the balance shaft bushing. See Special Tools and Equipment. It may take a considerable amount of force to loosen the bushing from the block bore.

Engine Block Cleaning and Inspection

Tools Required

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

Inspection Procedure

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. Clean the holes with a tap. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair**.

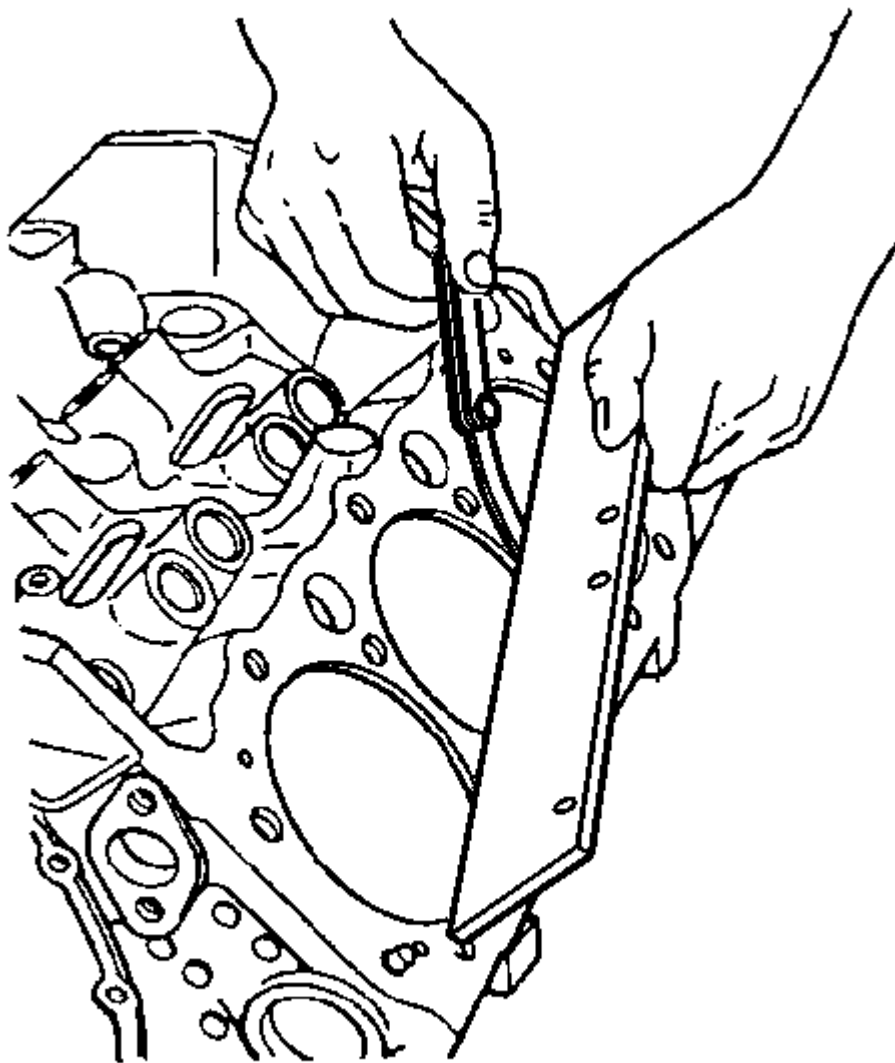


Fig. 225: Testing Block Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

8. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
9. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

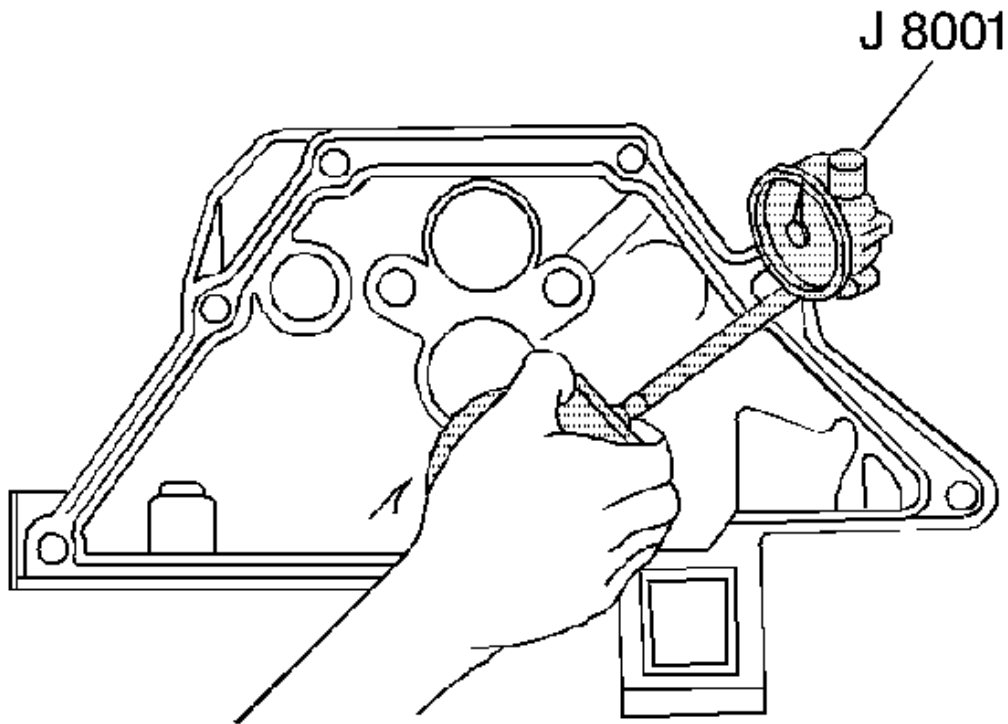


Fig. 226: Inspect Mating Surfaces Of Transmission Case
Courtesy of GENERAL MOTORS CORP.

10. Inspect the mating surfaces of the transmission case.

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

11. Use the following procedure to measure the engine block flange runout at the six mounting bolt hole bosses:
 1. Temporarily install the crankshaft. Measure the crankshaft flange runout.
 2. Hold the gauge plate flat against the crankshaft flange.
 3. Place **J 8001** on the transmission mounting bolt hole boss. See **Special Tools and Equipment**. Set the indicator to 0.
 4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.254 mm (0.010 in).
 5. Recheck the crankshaft flange runout if the readings vary more than 0.254 mm (0.010 in).

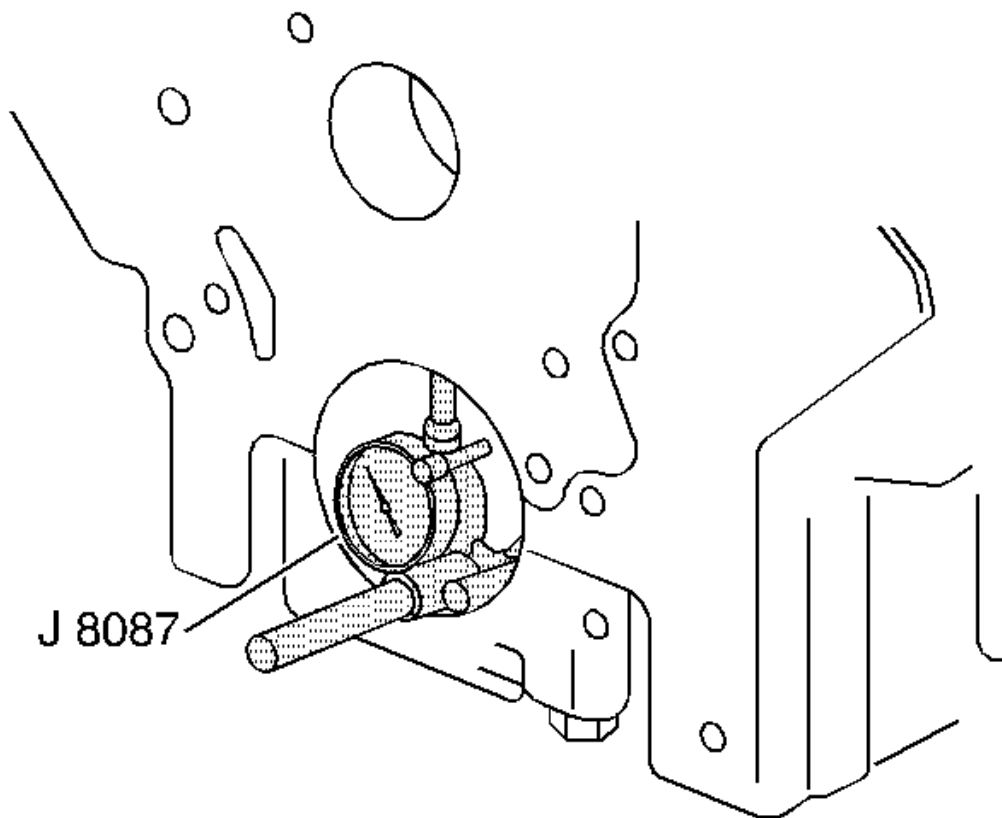


Fig. 227: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

12. Inspect the crankshaft main bearing bores. Use J 8087 to measure the bearing bore concentricity and alignment at the following locations:
 - The camshaft
 - The crankshaft

IMPORTANT: Recondition the engine block with the crankshaft main bearing caps and the crankshaft main bearing cap side bolts installed and tightened to specification.

13. Ensure that the crankshaft main bearing caps are installed correctly. The arrows should point toward the front of the engine.
14. Replace the engine block if the bores are out of specification.

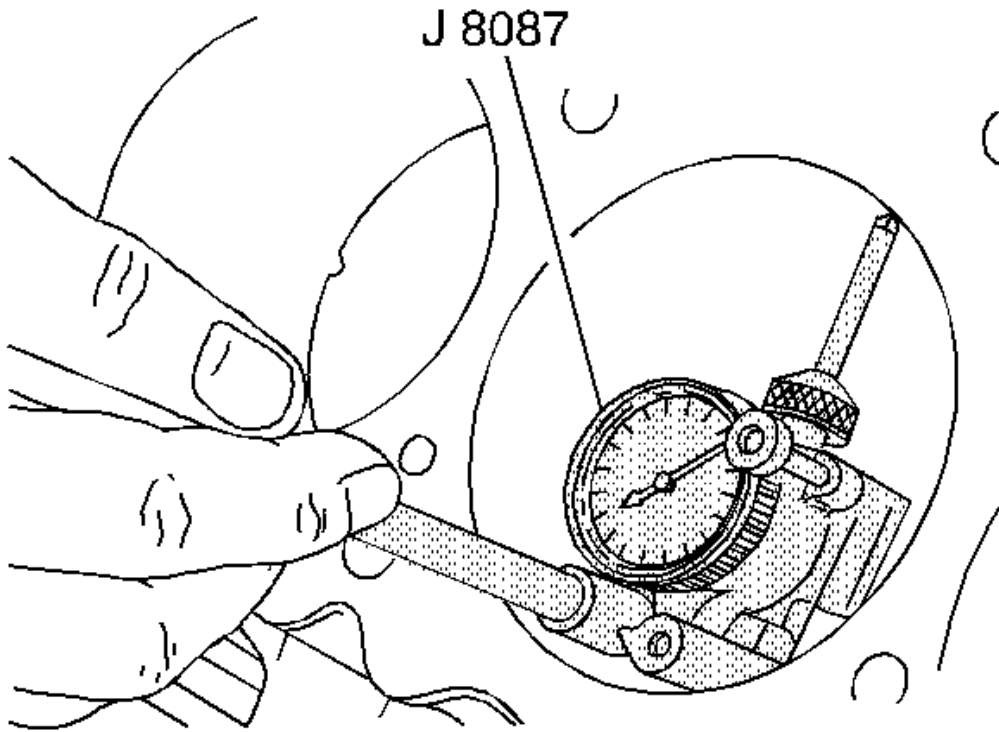


Fig. 228: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

15. Use J 8087 to inspect the cylinder bores. Inspect for the following items:

- Wear
- Taper
- Run-out
- Ridging

IMPORTANT: If the bore is worn beyond the limits, refit the bore with oversized pistons. Select the smallest available oversize piston. Refer to Cylinder Boring and Honing.

16. Leave sufficient material 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.
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.**

IMPORTANT: **The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.**

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. 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.
6. True up the refinished cylinder bores. Final hone each cylinder bore to remove all stone or cutter marks.
7. 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.
8. Permanently mark the piston for the cylinder to which the piston has been fitted.
9. Apply clean engine oil to each bore to prevent rusting.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

J 8087 Cylinder Bore Gage. See Special Tools and Equipment.

Inspection Procedure

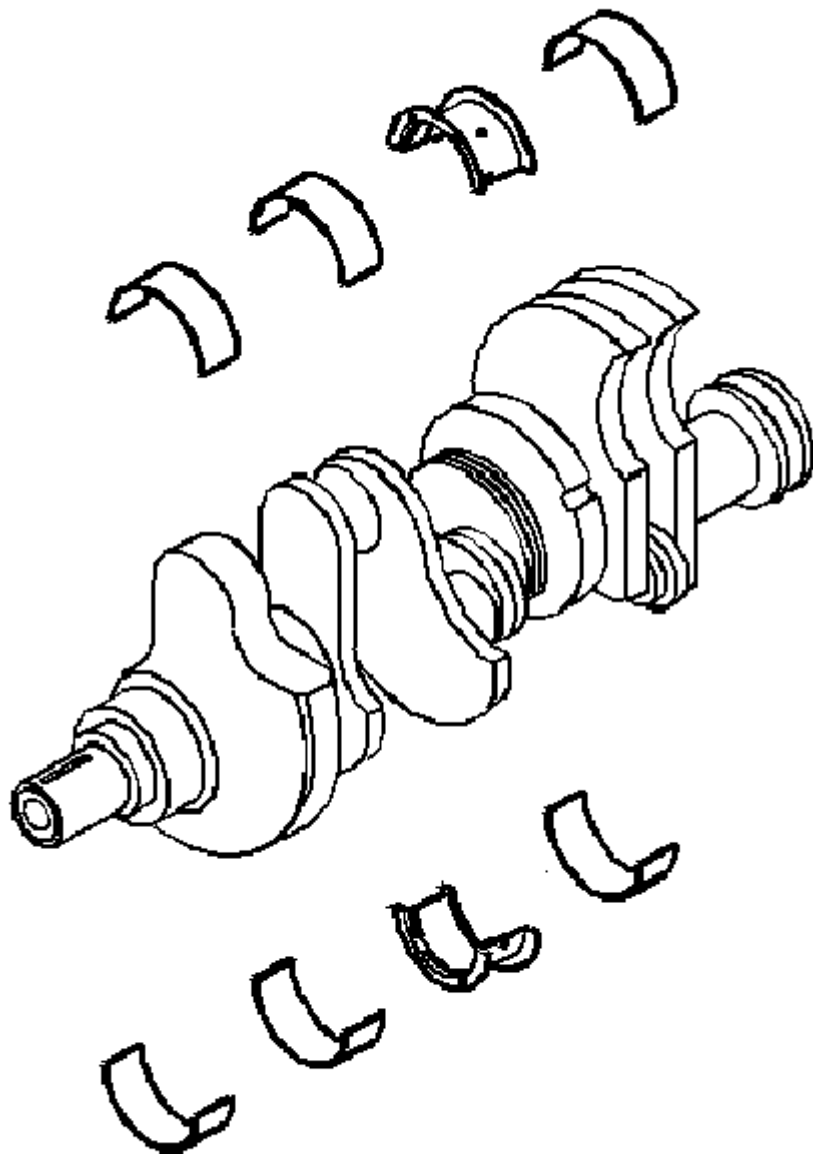


Fig. 229: View Of Crankshaft & Bearings
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft of the following elements:
 - Oil
 - Sludge
 - Carbon
2. Inspect the crankshaft oil passages for obstructions.
3. Inspect the crankshaft keyway for nicks or wear.
4. Inspect the crankshaft threads.

IMPORTANT: If cracks, severe gouges or burned spots are found, the crankshaft must be replaced. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

5. Inspect the crankshaft bearing journals and the crankshaft thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves
 - Overheating, discoloration
6. Inspect the corresponding crankshaft bearings for embedded foreign material and determine the source.

IMPORTANT: Note the location of the crankshaft main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

7. Inspect the crankshaft bearings for uneven side-to-side wear. This may indicate a bent crankshaft or a tapered bearing journal.

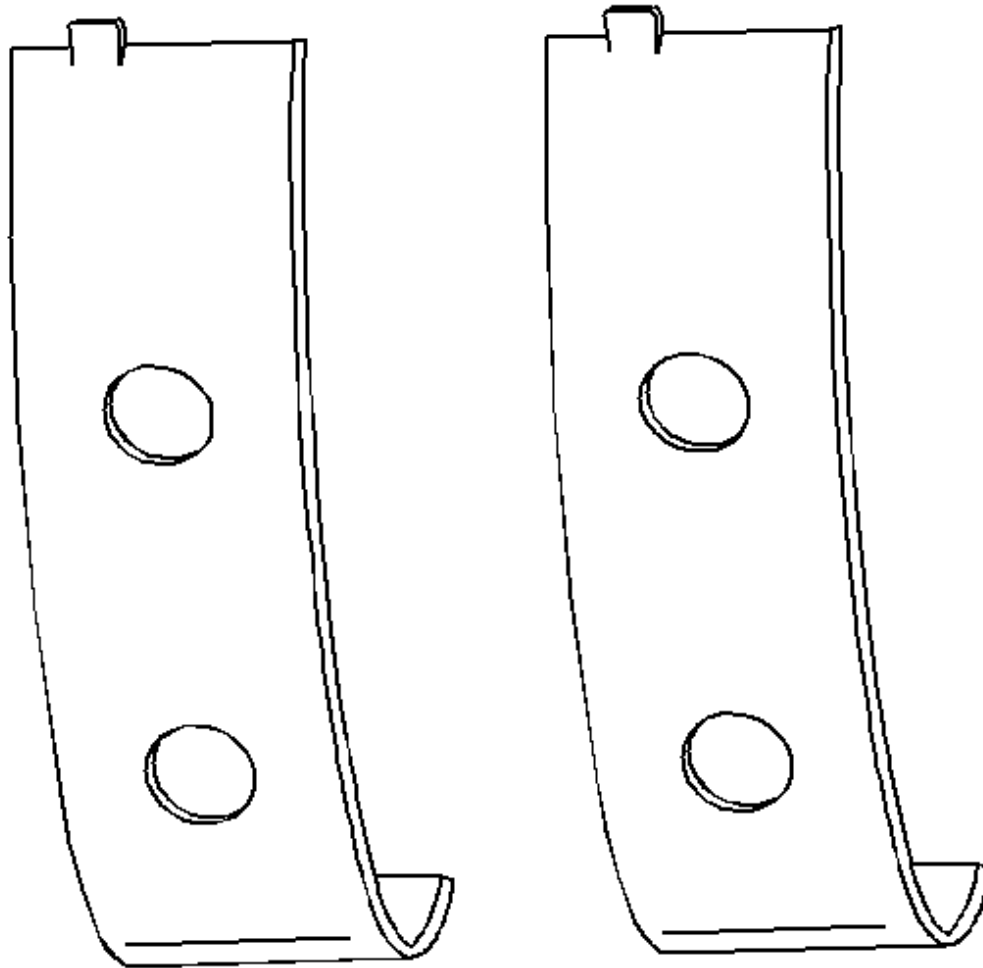


Fig. 230: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft bearings are the precision insert type. The crankshaft bearings are available in standard and various undersizes.

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

9. Inspect the thrust surfaces of the main thrust bearing for the following conditions:
- Wear
 - Grooving, grooves are caused by irregularities of the crankshaft thrust surface.

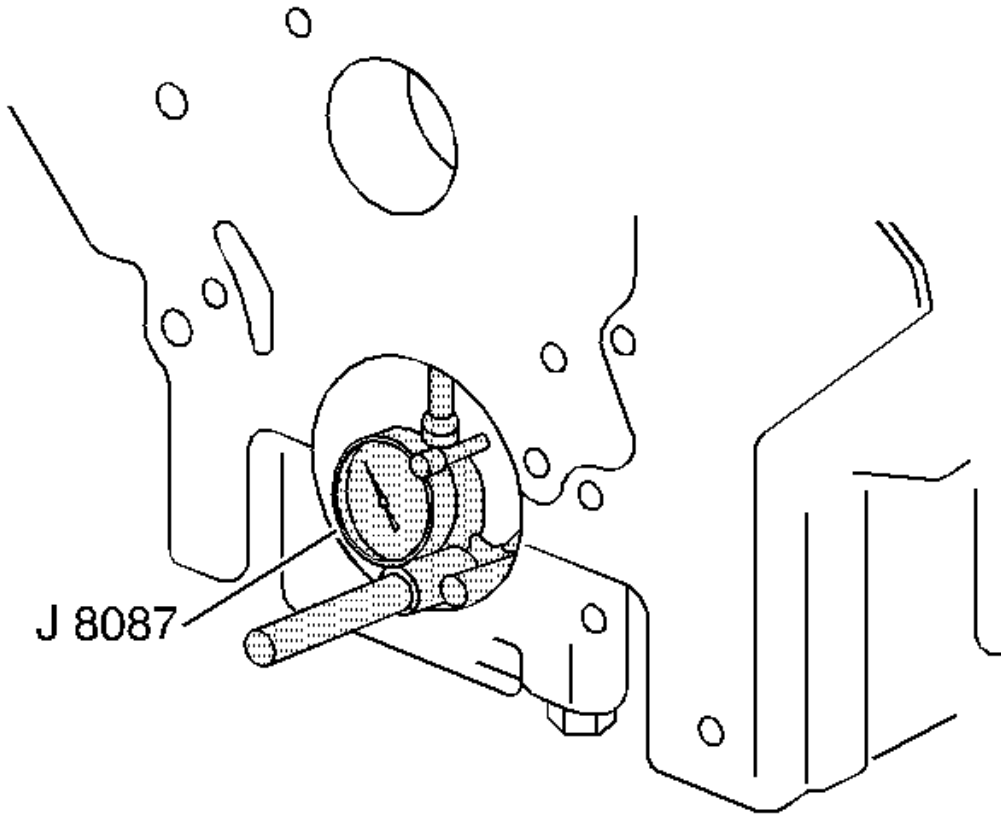


Fig. 231: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

10. Using the **J 8087** inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure: See **Special Tools and Equipment**.
1. Tighten the bearing cap to specification.
 2. Measure the bearing bore using **J 8087** for taper and out-of-round. See **Special Tools and Equipment**.
 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

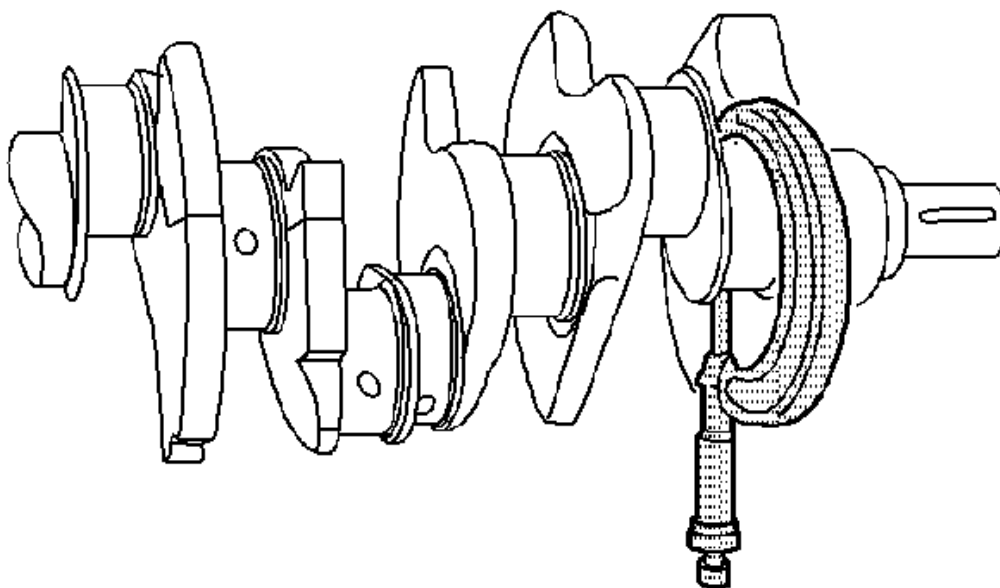


Fig. 232: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

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.
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.

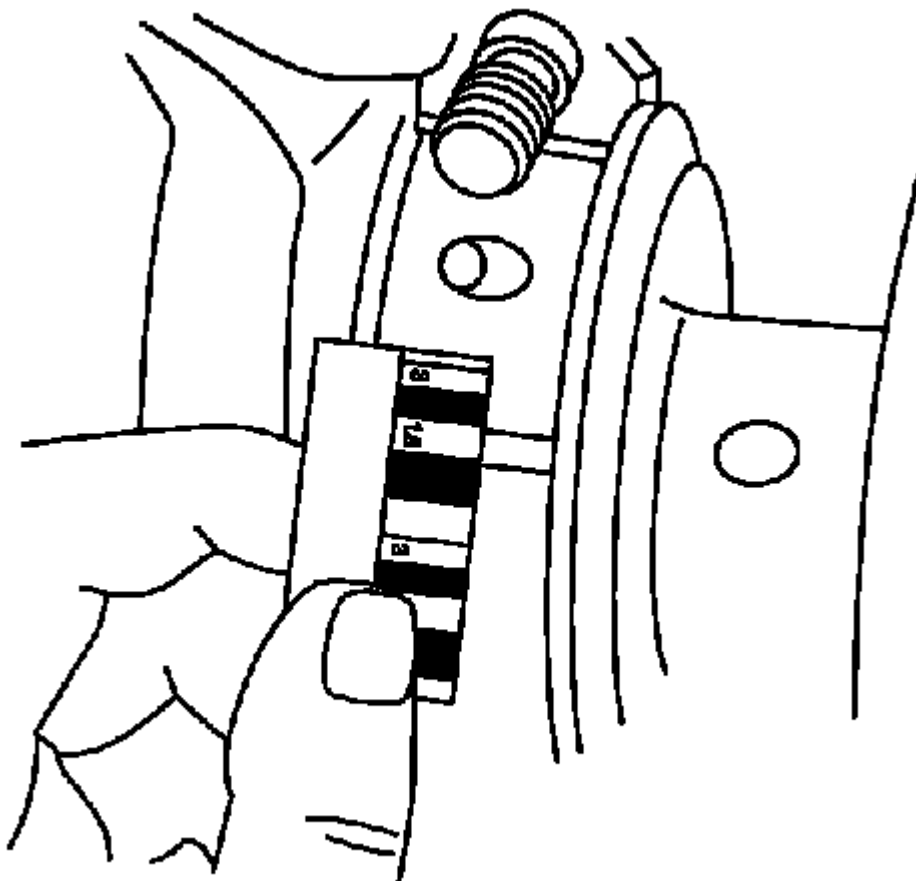
Method B

Fig. 233: 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.

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

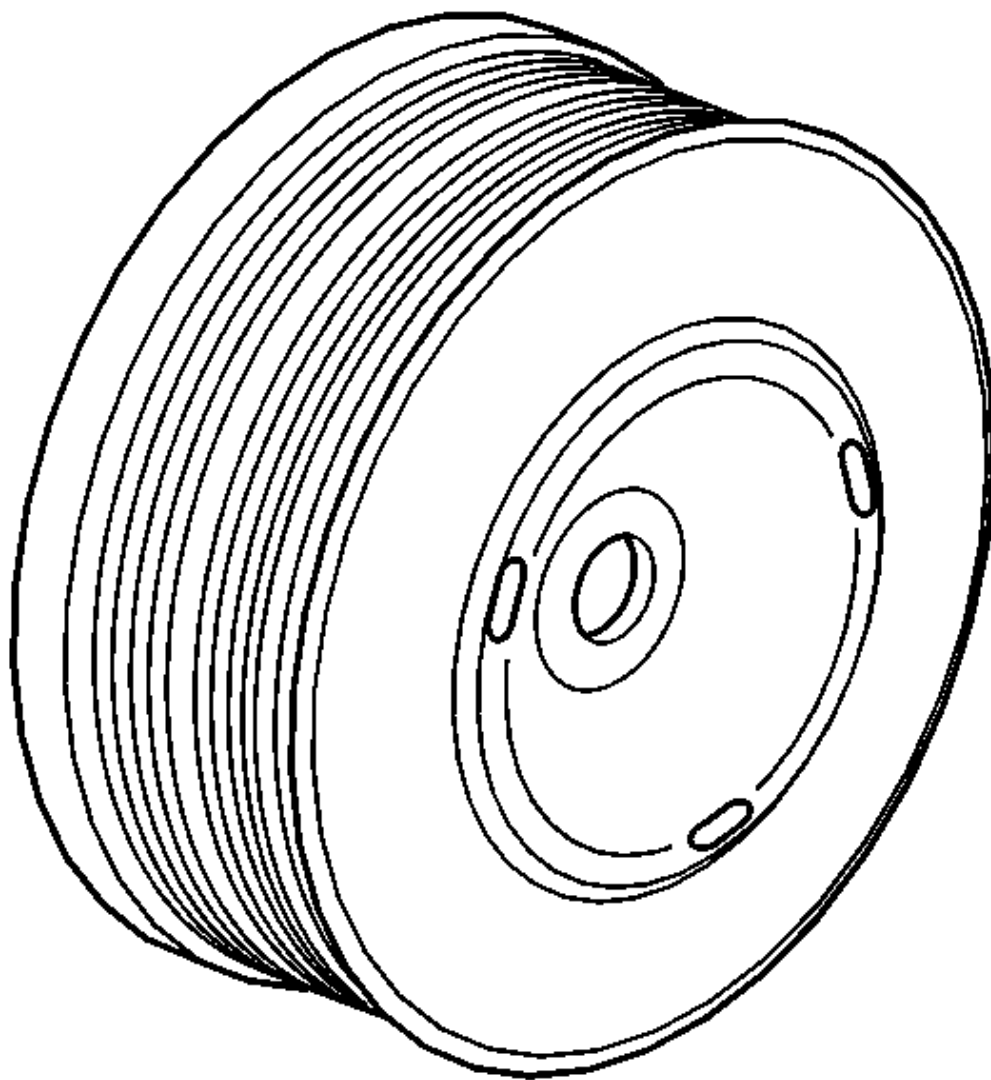


Fig. 234: Inspecting Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

- Inspect the crankshaft balancer for damage.
- Inspect the outside of the crankshaft balancer mounting shaft for grooves.
- Replace the crankshaft balancer if grooves are present and appear to be causing an oil leak.

Engine Flywheel Cleaning and Inspection

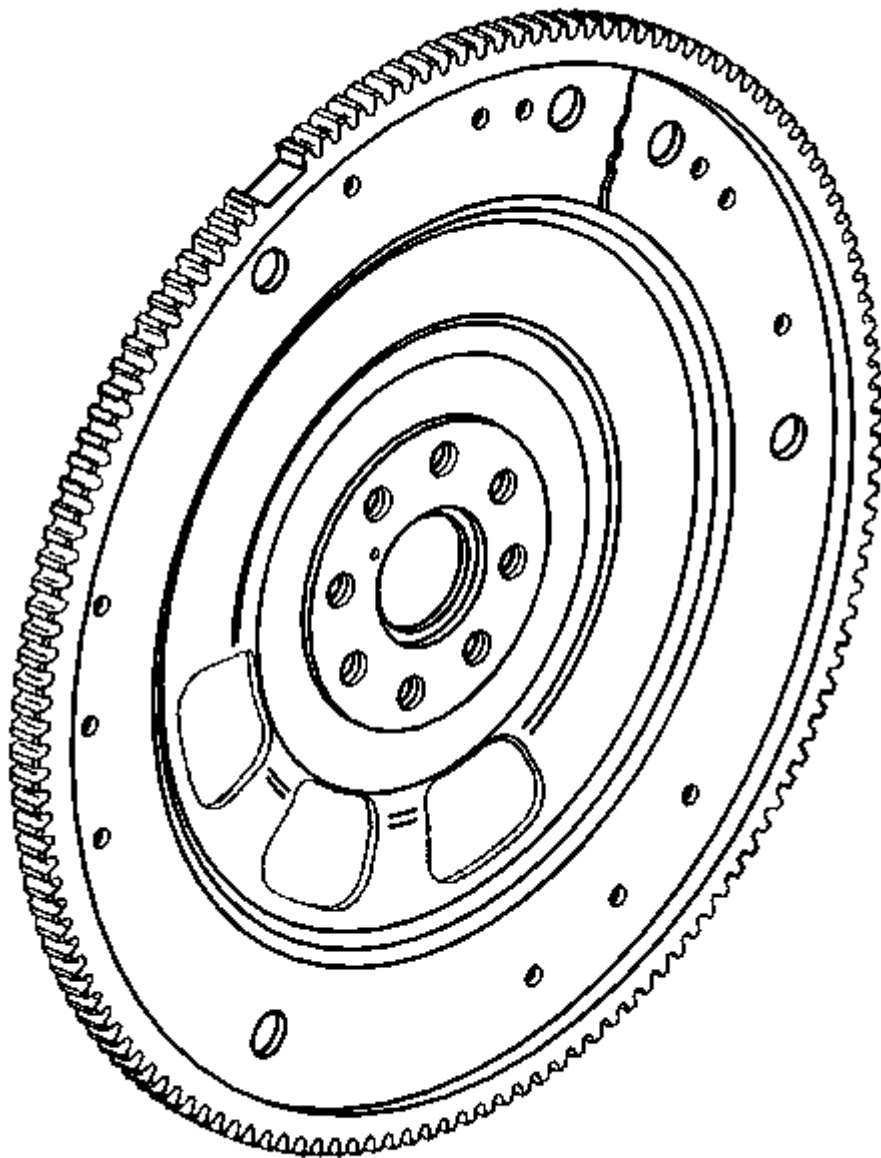


Fig. 235: Inspecting Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel.
2. Inspect the engine flywheel for damage and cracks.
3. Inspect the engine flywheel ring gear for damaged teeth.

4. Replace the flywheel if any damage is found.

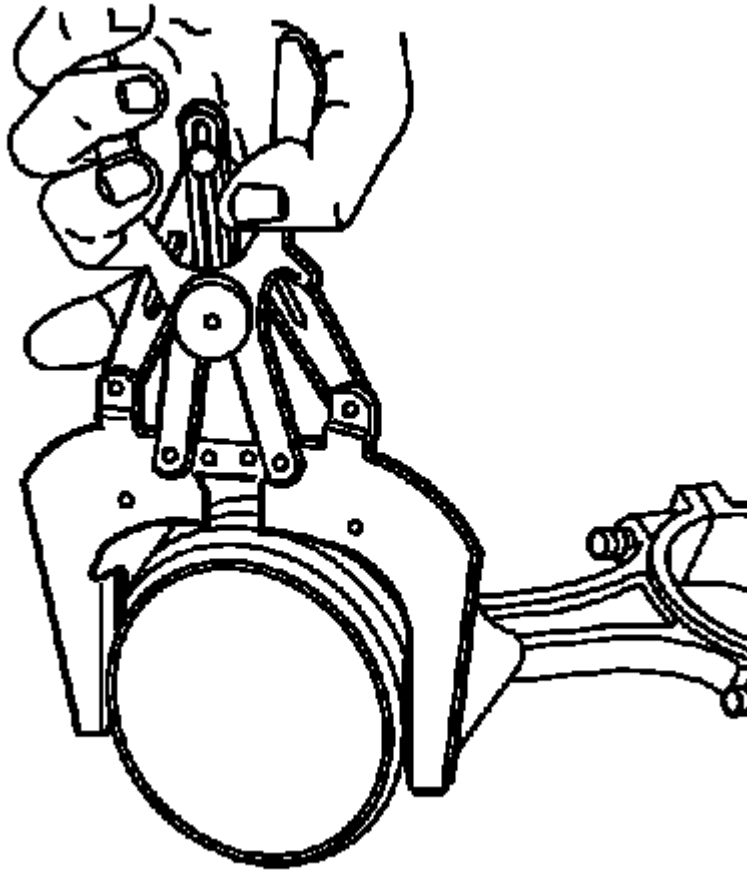
Piston and Connecting Rod Disassemble

Fig. 236: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Remove the piston rings. Use a suitable tool to expand the rings. Piston rings must not be reused.

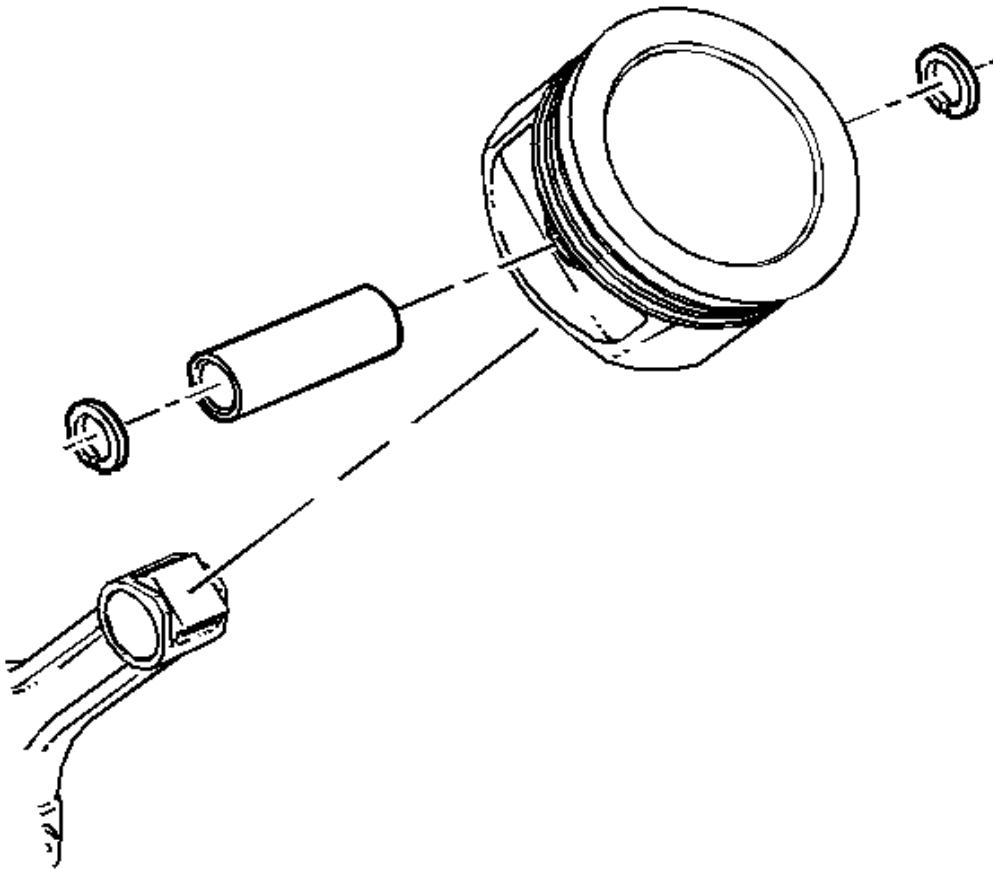


Fig. 237: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

NOTE: When removing or installing the piston pin retainer and piston pin do not damage the piston or the retaining groove in the piston. Damage to the piston or retaining groove can lead to severe engine damage.

2. Remove the piston pin retaining clips.
3. Remove the piston pin.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

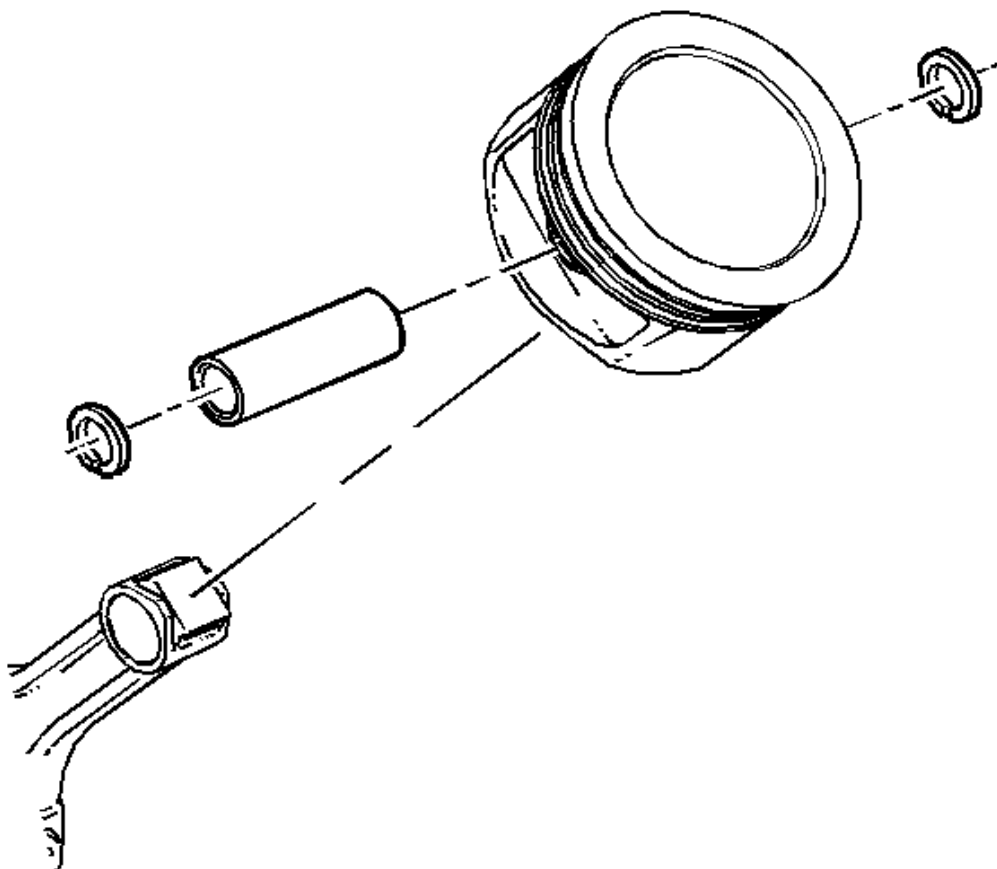


Fig. 238: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston and connecting rod in solvent.

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

2. Dry the components with compressed air.

NOTE: The piston ring groove must only be cleaned with a ring groove cleaning tool. Proper engine performance and durability depends on the straightness and smoothness of the ring groove. Cleaning the piston ring groove with an improper tool can damage the piston ring groove and effect the performance and durability of the engine.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.

NOTE: The oil lubrication holes/slots must be cleaned with a suitable tool. Proper engine performance and durability depends on the cleanliness and smoothness of the holes/slots. Cleaning the oil lubrication holes/slots with an improper tool may damage the oil lubrication holes/slots and effect the performance and durability of the engine.

4. Clean the piston oil lubrication holes and slots.

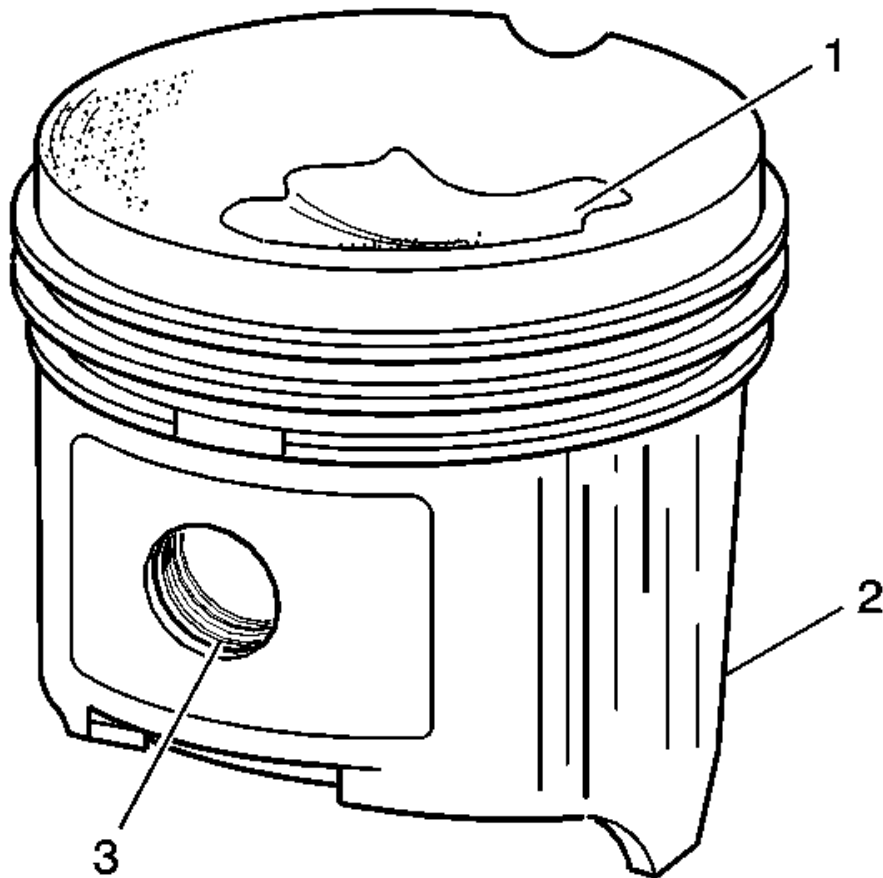


Fig. 239: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the piston for the following conditions:
 - Eroded areas (1) on 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 for scoring, wear or other damage.

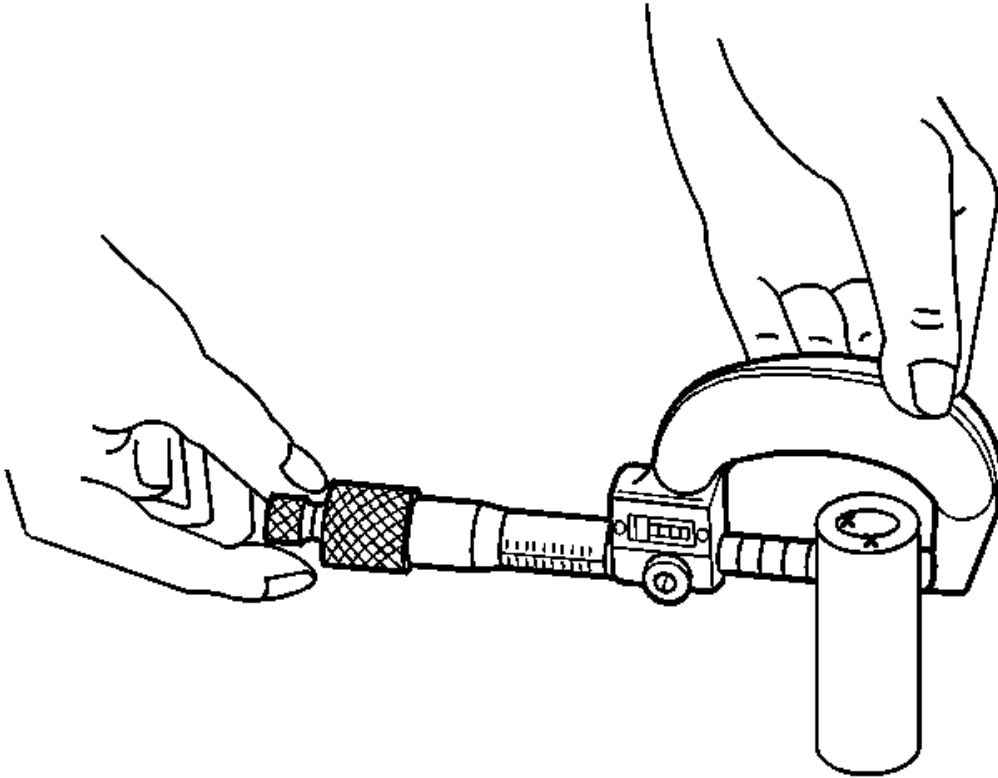


Fig. 240: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

7. To determine the piston-to-bore clearance, use a micrometer and measure the piston pin.

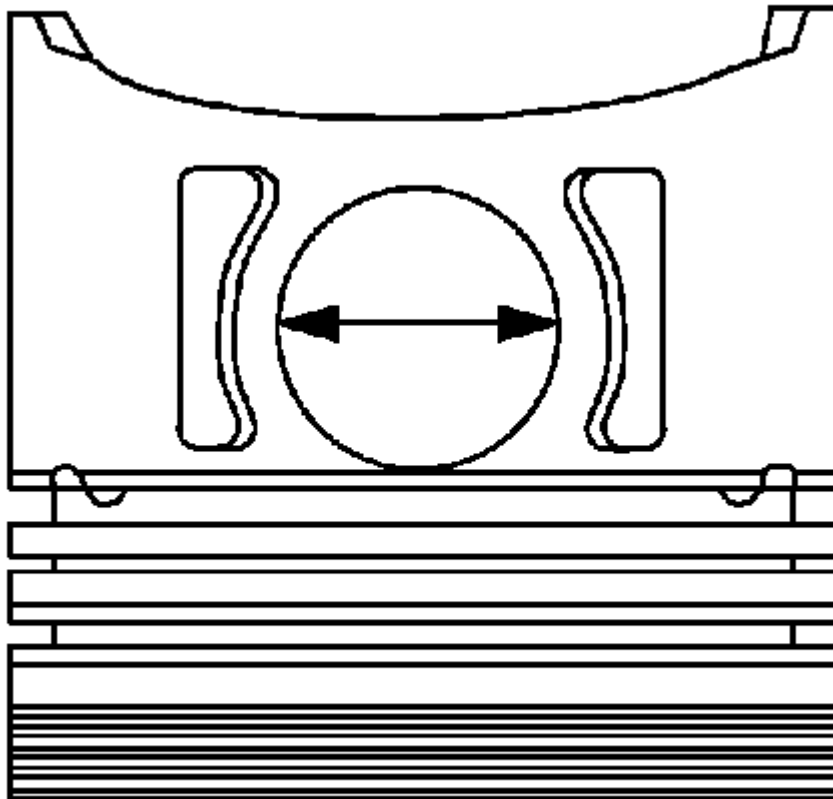


Fig. 241: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

8. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
9. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter.

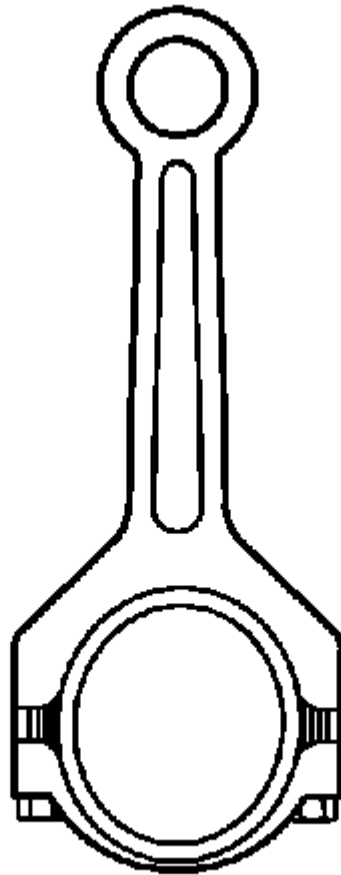


Fig. 242: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

10. Inspect the connecting rod for an out-of-round bearing bore.

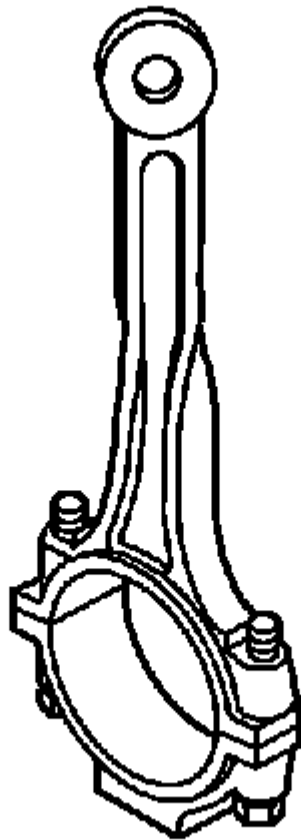


Fig. 243: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod for twisting.

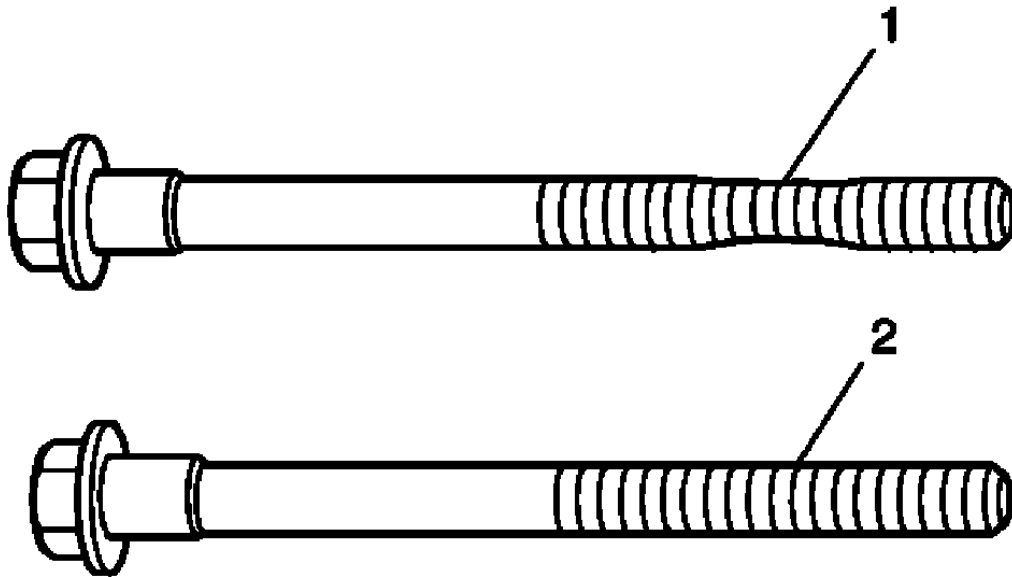


Fig. 244: Inspecting Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

12. Inspect the connecting rod cap bolts for stretch (compare to known good bolt) (1) is a stretched bolt, (2) is a new or good bolt.

Piston and Connecting Rod Assemble

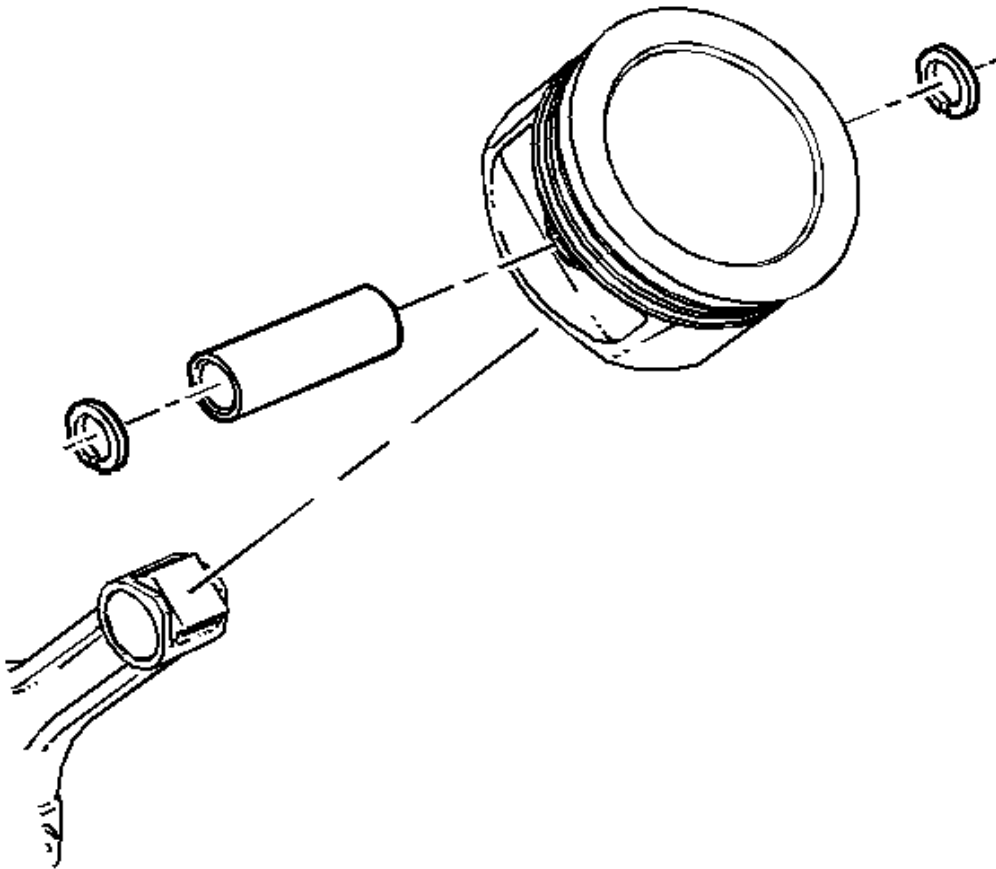


Fig. 245: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Coat the piston pin with oil.
2. Install one piston pin retainer into the retaining groove.
3. Install the connecting rod and piston pin. The connecting rod can be installed in either direction. Push the piston pin in until it bottoms against the installed piston pin retainer.
4. Install the second piston pin retainer.
5. Ensure the piston pin moves freely.

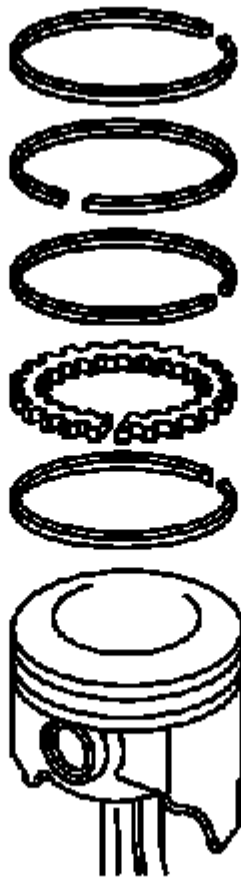


Fig. 246: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

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 and oil seal, the ring gaps must be staggered a minimum of 90 degrees.

6. Using the 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 Indicator Set. See Special Tools and Equipment.

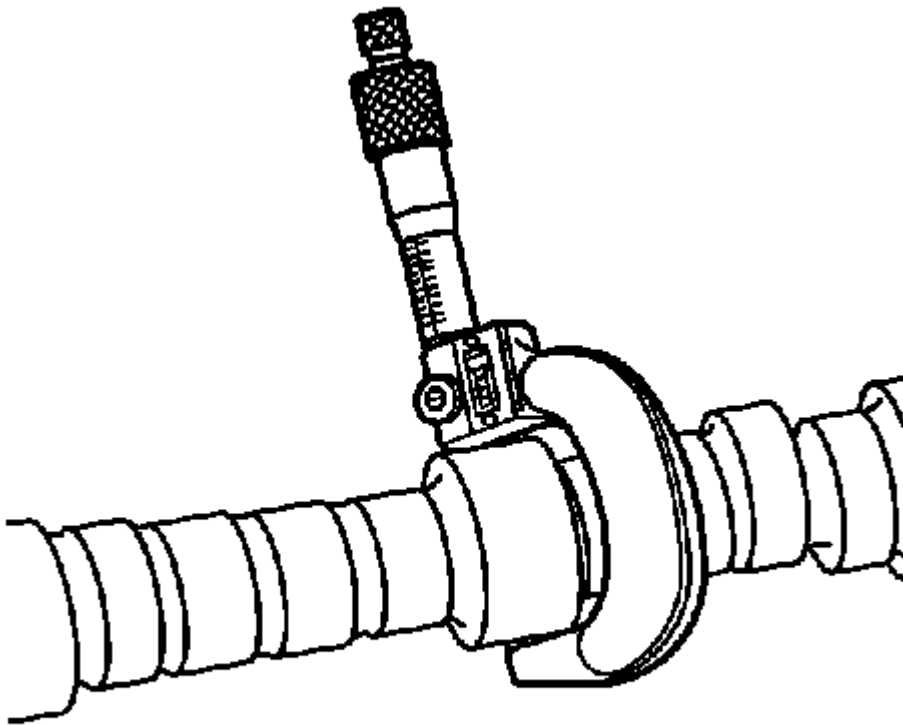
Inspection Procedure

Fig. 247: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

1. Measure the camshaft journals with a micrometer.

If the camshaft journals are not within specifications, replace the camshaft. The measurement should be 47.655-46.858 mm (1.8462-1.8448 in). If the measurement is not within specifications the engine camshaft must be replaced.

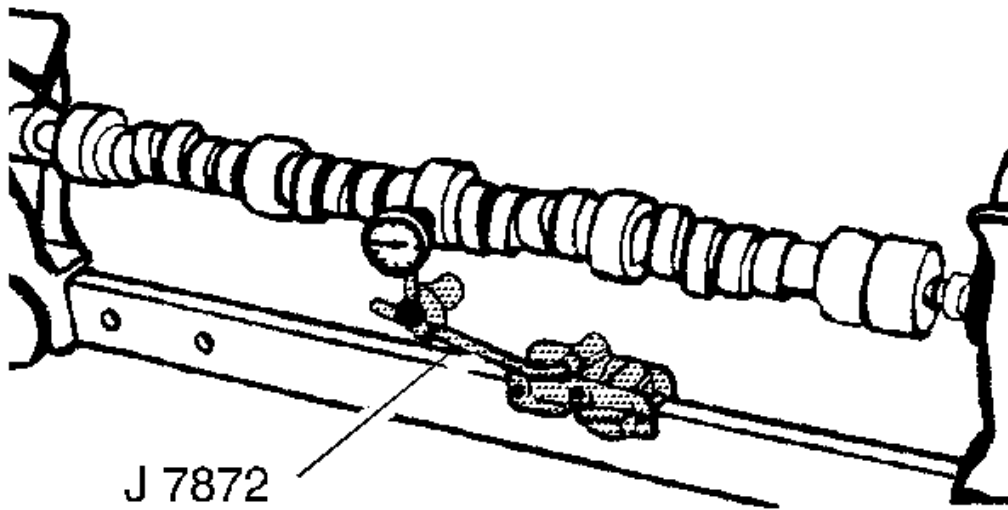


Fig. 248: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

2. Measure the camshaft runout using **J 7872** . See **Special Tools and Equipment**.
 1. Mount the camshaft in V-blocks between centers.
 2. Use **J 7872** to check the intermediate camshaft journal. See **Special Tools and Equipment**.
3. If the runout exceeds specifications, the camshaft is bent and should be replaced. If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.

Timing Chain and Sprockets Cleaning and Inspection

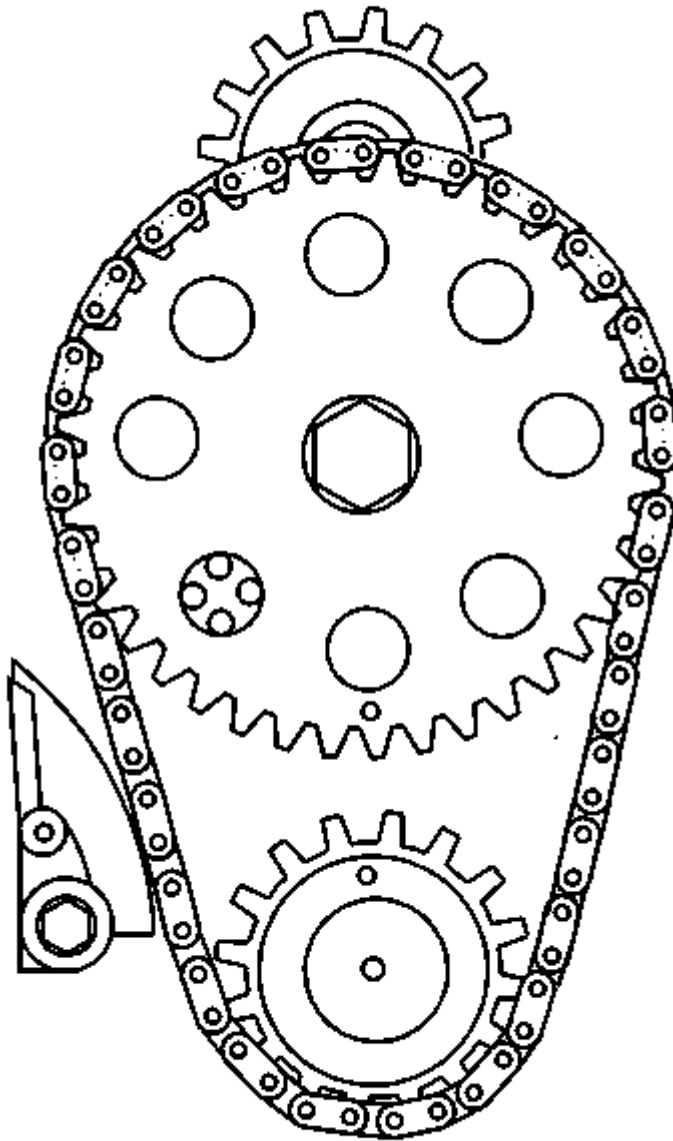


Fig. 249: Aligning Timing Chain & Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain and sprockets for damage.
2. Inspect the timing chain for overall in and out movement. Movement should not exceed 25 mm (1 in).
3. Inspect the sprockets for wear.

Valve Rocker Arm and Push Rods Cleaning and Inspection

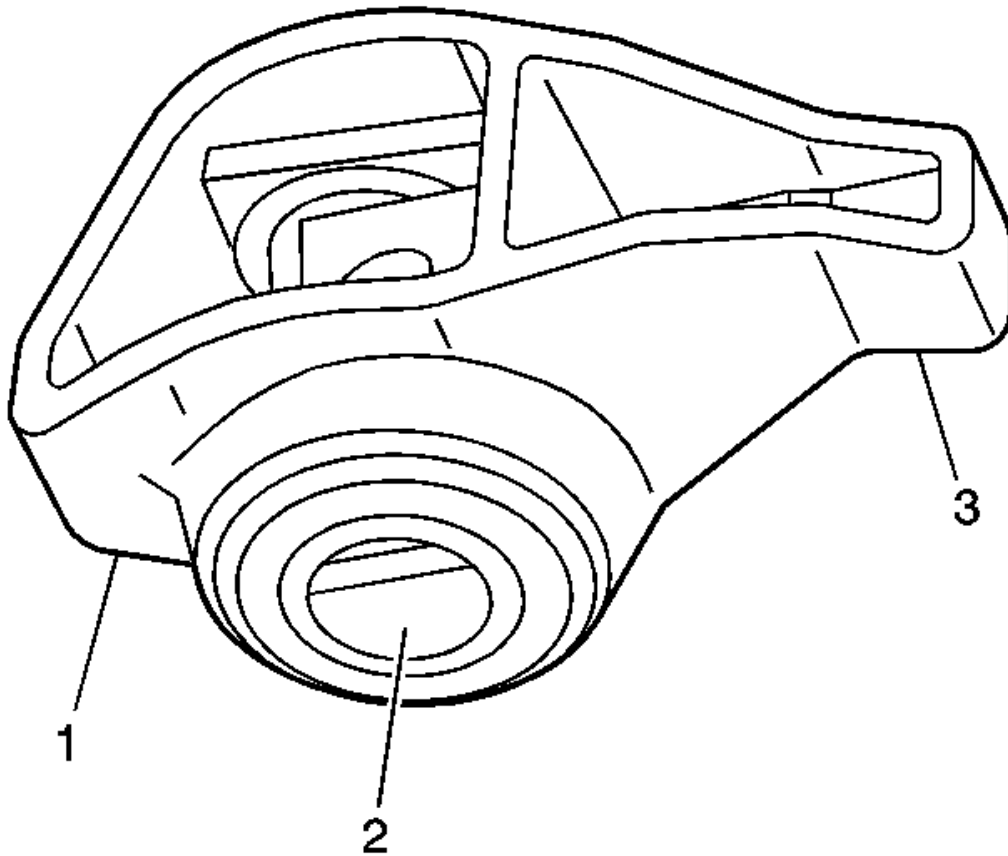


Fig. 250: Identifying Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

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

IMPORTANT: Parts that are to be reused must be marked, sorted, and organized for assembly.

- Clean the components with cleaning solvent.

- Dry the components with compressed air.
- Inspect the valve rocker components for the following:
 - Valve rocker arm valve pushrod socket contact surface (1)

The contact surface must be smooth with no scoring or excessive wear.

- Valve rocker arm roller pivot for binding or damage (2)
- Valve rocker arm valve stem contact surface (3)

The contact surface should be smooth with no scoring or excessive wear.

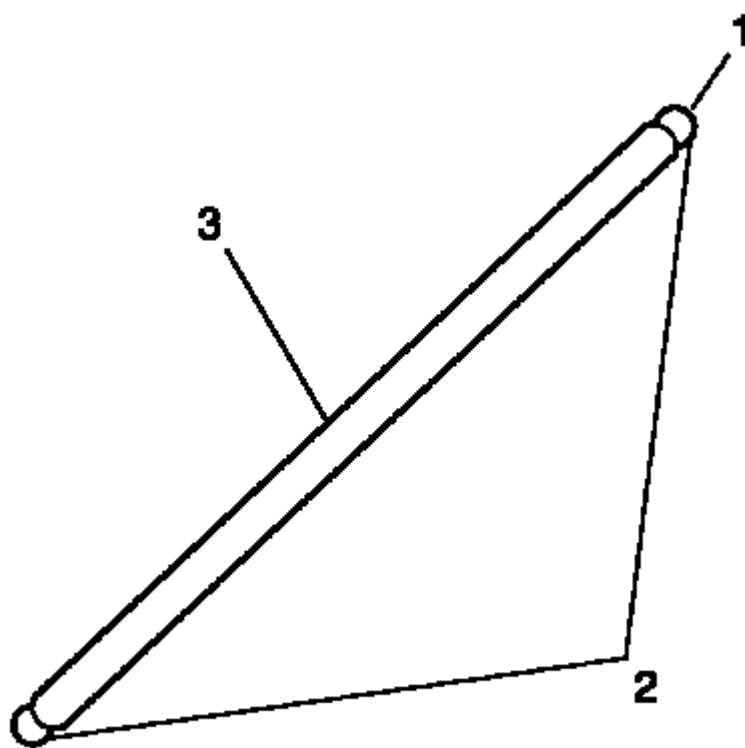


Fig. 251: Pushrod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

- Inspect the valve pushrods for the following:
 - Restriction of the oil passage (1)
 - Wear or scoring of the end contact surfaces (2)

The end contact surfaces must be smooth with no scoring or excessive wear.

- Shaft for bends (3)

Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.

Valve Lifters and Guides Cleaning and Inspection

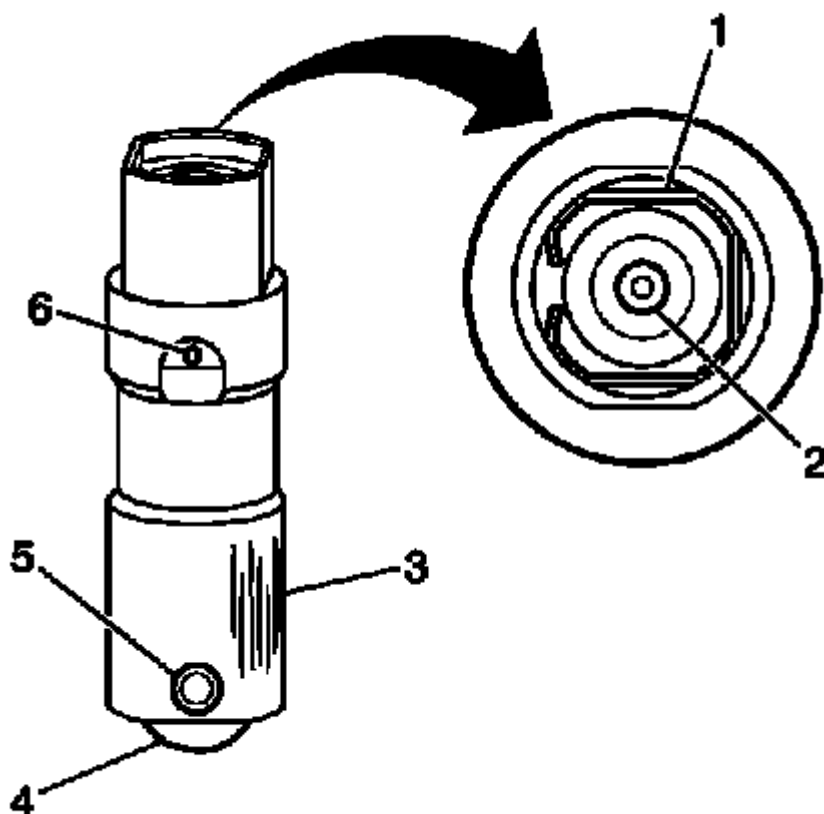


Fig. 252: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

1. Keep the valve lifters in order so they can be installed in their original position.

IMPORTANT: When new valve lifters are installed, coat the valve lifters with camshaft and lifter prelude GM P/N United States 12345501, GM P/N Canada 992704 or the equivalent.

2. Inspect the following areas of the valve lifters:
 - The retaining clip (1)
 - The push rod socket for wear (2)
 - The valve lifter body for wear and scuffing (3)
 - The valve lifter bore for wear
 - The valve lifter roller assembly for wear (4)

- The valve lifter roller pin for damage (5)
 - The oil hole for plugging (6)
3. Inspect the valve lifter guides for cracks or damage.

Cylinder Head Disassemble

Tools Required

J 38606 Valve Spring Compressor

Disassemble Procedure

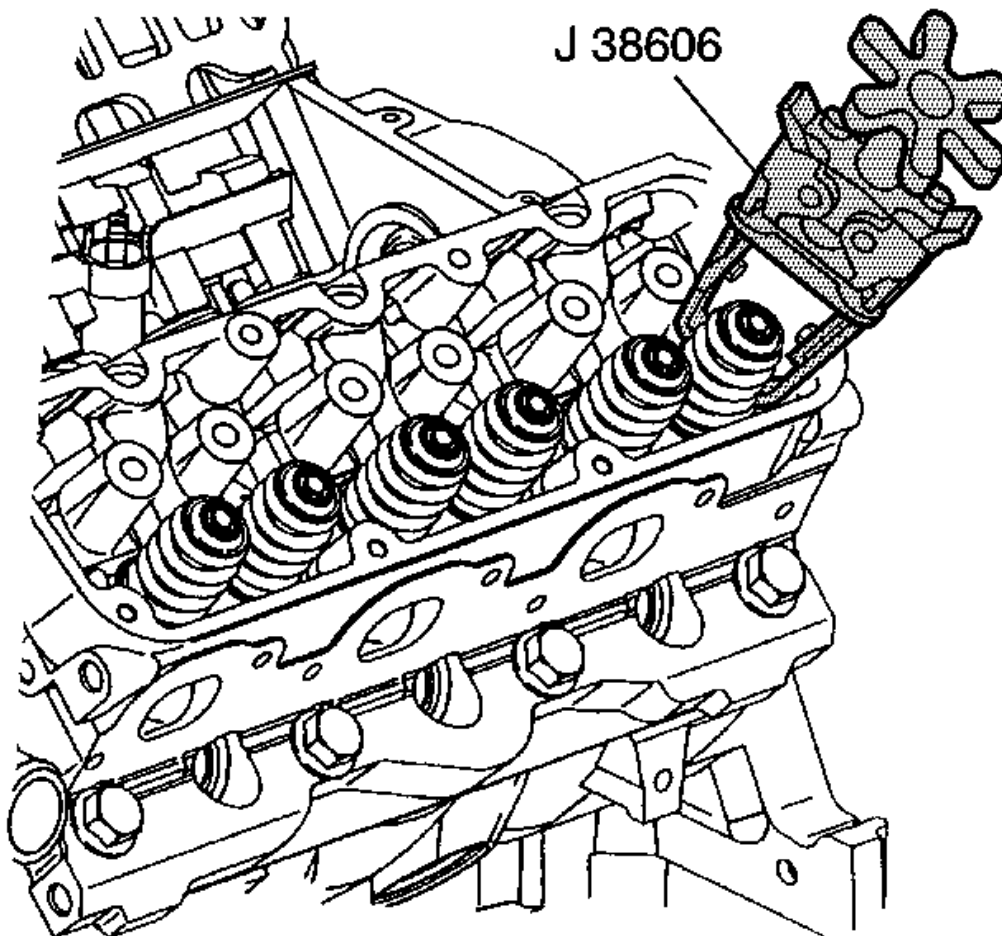


Fig. 253: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During disassembly, ensure the valve train components are kept together and identified so they can be reinstalled in their original locations and with the same mating surfaces as when removed.

1. Use J 38606 to compress the valve spring.

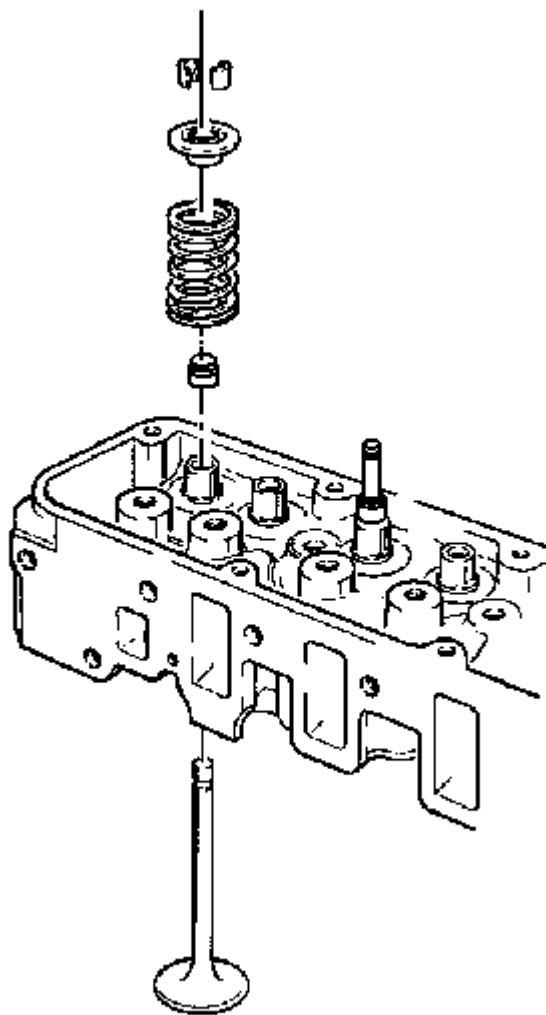


Fig. 254: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve keys.

3. Remove the valve cap and spring.
4. Remove the valve stem oil seal by prying up on the bottom.

Cylinder Head Cleaning and Inspection

Tools Required

J 9666 Valve Spring Tester

Inspection Procedure

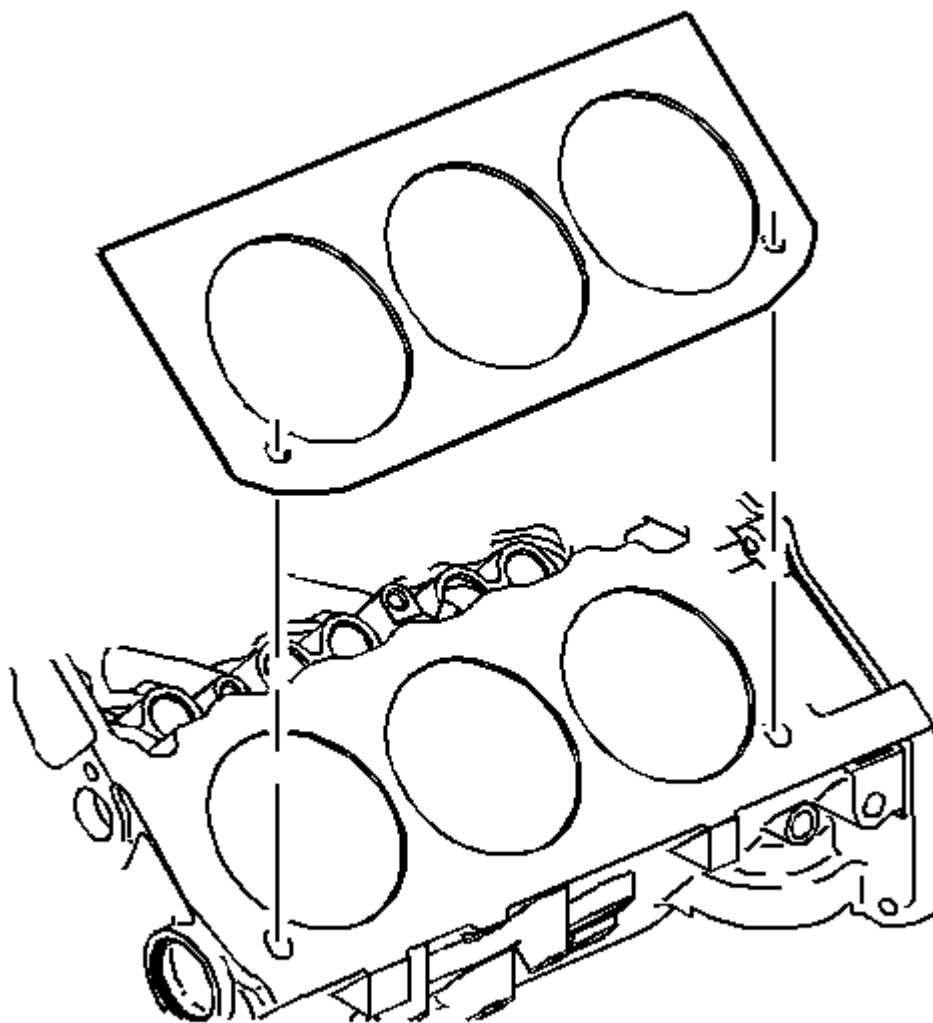


Fig. 255: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head gasket and the mating surfaces for leaks, corrosion, and blowby.
2. If the gasket failed, determine the cause. Gasket failure is caused by the following conditions:
 - Improper installation
 - A loose or warped cylinder head
 - Missing dowel pins
3. Clean the cylinder head of all foreign material. Do not use a motorized wire brush on any gasket sealing surface.
4. Clean the threaded holes.
5. Inspect the cylinder head for cracks typically between the valve seats and inside of the exhaust ports.

IMPORTANT: Do not attempt to weld the cylinder head. If the cylinder head is damaged, replace the cylinder head.

6. Inspect the cylinder head deck for corrosion.

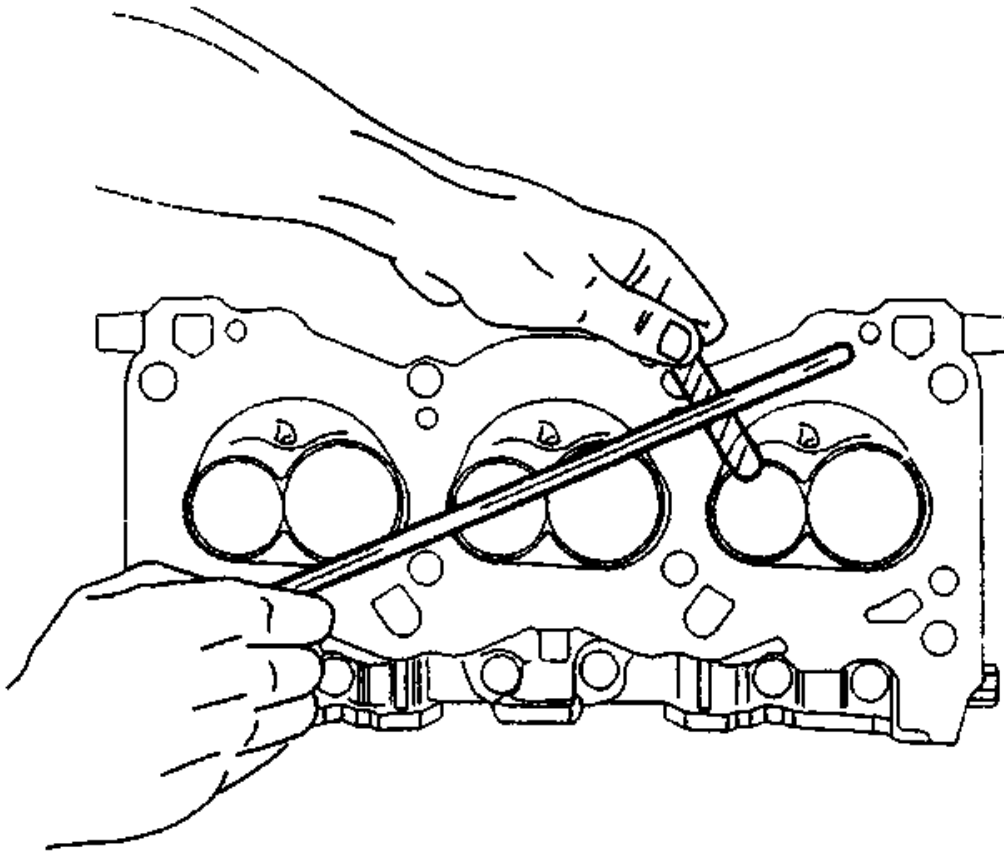


Fig. 256: Inspecting Cylinder Head Mating Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

7. Inspect the following locations for flatness:
 - The cylinder head deck
 - The intake manifold mating surface
 - The exhaust manifold mating surface
8. Recondition the surfaces by parallel grinding. Replace the cylinder head if more than 0.254 mm (0.010 in) is removed.

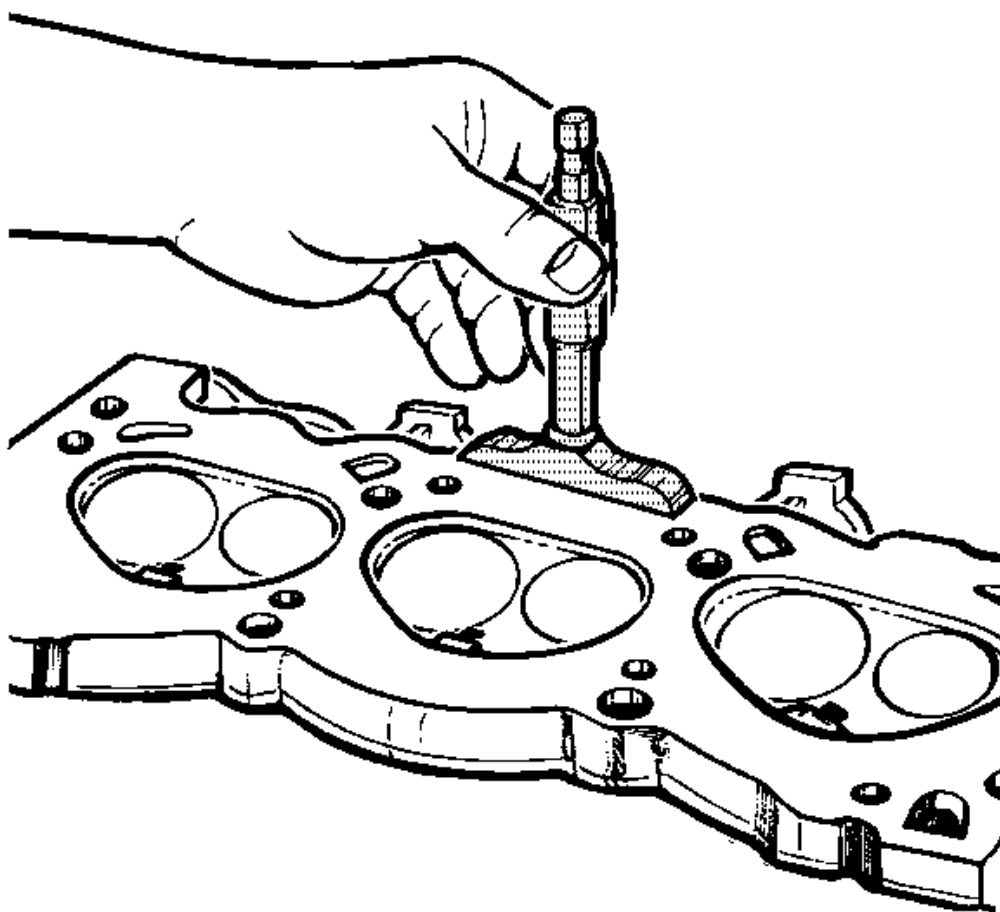


Fig. 257: Measuring Height From Deck Surface To Cast Pads
Courtesy of GENERAL MOTORS CORP.

9. Measure the height from the deck surface to the cast pads. Do this to determine if the cylinder head has sufficient deck surface thickness to resurface.

New cylinder heads measure from 1.372-1.676 mm (0.054-0.066 in). If the cylinder head does not meet the minimum thickness after resurfacing, replace the cylinder head.

10. Inspect all of the threaded holes for damage. Repair the threaded holes, if necessary.
11. Inspect the valve seating surfaces.
12. Inspect the cooling jacket plugs.
13. Inspect the valve guides for wear. Clean the valve guides.
14. Inspect the valve seats for excessive wear and hot spots.

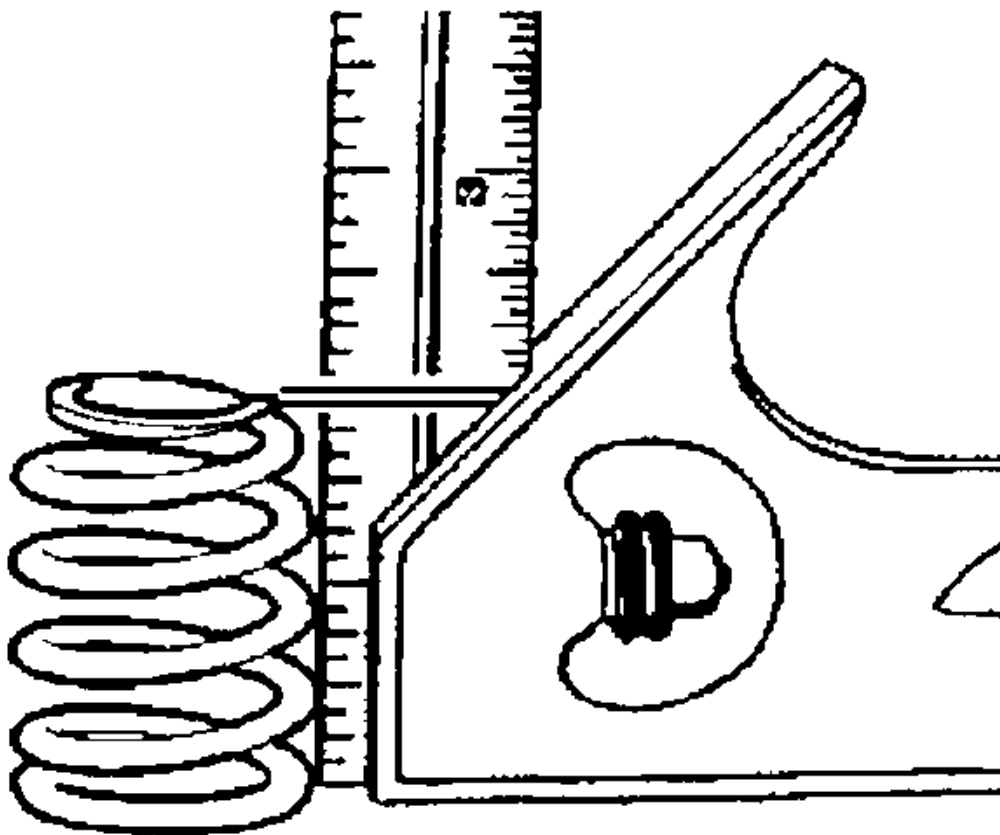


Fig. 258: Inspecting Valve Spring Squareness
Courtesy of GENERAL MOTORS CORP.

15. Inspect the valve springs for squareness.
16. Inspect the valve spring ends. If the valve spring ends are not parallel, the valve spring is bent. Replace the bent valve spring.

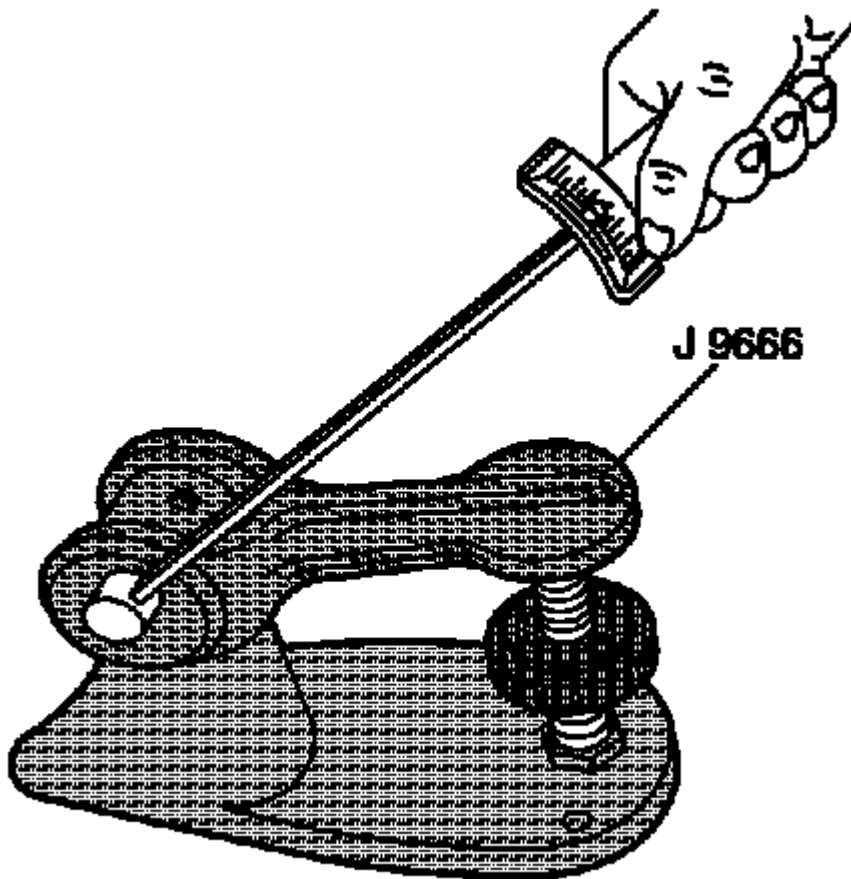


Fig. 259: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

17. Using the J 9666 test the valve spring load. Replace the spring if the valve spring load is less than 334 N.m at 43.69 mm (75 lb at 1.72 in).
18. Inspect the valve spring seating surface of the valve spring retainers for wear or gouging. If the seating surface is damaged, replace the valve spring retainers.
19. Use the following procedure to measure the valve seat concentricity:
 1. Lift the valve off its seat.
 2. Apply a dab of blue dye to the valve face.
 3. Seat and rotate the valve.

The blue dye traces transferred to the valve seat are an indication of concentricity of the valve seat.

20. Use the following procedure to measure the valve runout:
 1. Clean off the blue dye.
 2. Apply blue dye to the valve seat.
 3. Seat and rotate the valve.

The traces of blue dye transferred to the valve indicates valve runout.

4. Recondition the valve seat or valve face, if needed.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

J 8001 Dial Indicator Set. See Special Tools and Equipment.

Grinding Procedure

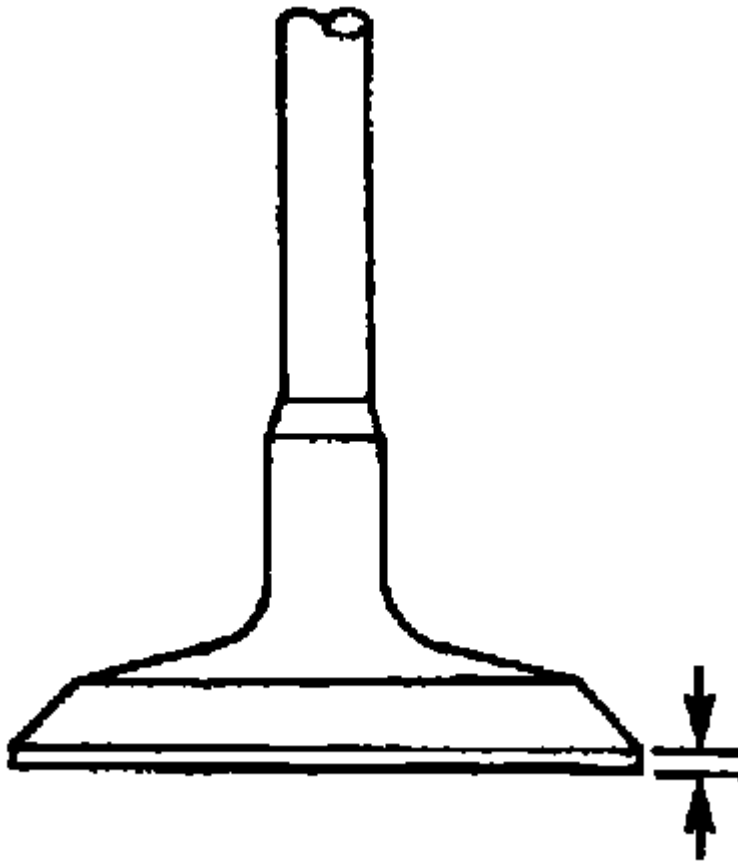


Fig. 260: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

1. Recondition the valve seats by grinding. Use an oscillating type valve seat grinder. Follow the grinder manufacturer's instructions. If the valve seat is too wide after grinding, use a 20 degree stone or a 70 degree stone in order to narrow the valve seat. The 20 degree stone will lower the seat. The 70 degree stone will raise the seat. Replace or recondition the valves if the seats are reconditioned.
2. After grinding the valves, measure the valve margin. Replace the valve if less than the minimum recommended specification (0.79 mm (0.031 in)).

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

NOTE: Clean the valve guides before reaming. Packing of chips or carbon may result in the reamer jamming into the valve guide or broken reamer flutes.

3. Clean any foreign material from the valves. Use a wire brush to remove carbon. Do not scratch the valve stem. Soak the valves in cleaning solvent to remove varnish.
4. Use a suitable tool to clean the valve guides.
5. Follow the grinder manufacturer's instructions. Ensure that the new surface is perpendicular to the valve stem.

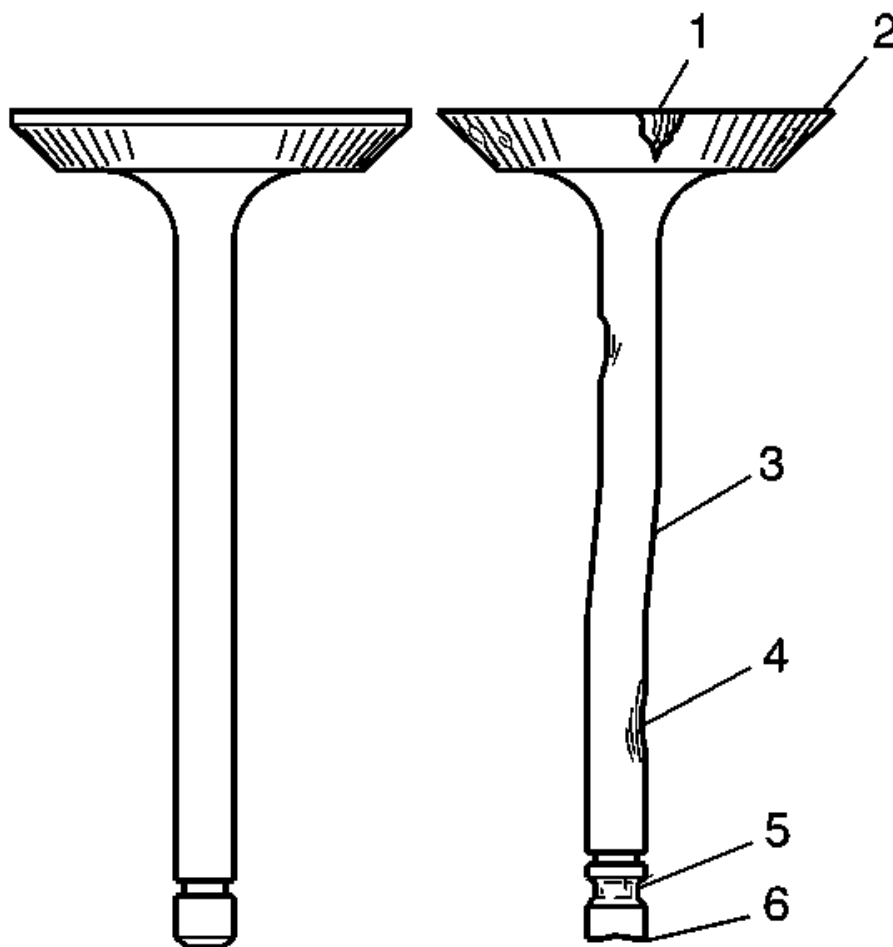


Fig. 261: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve key grooves for chipped or worn lands (5). Replace the valve if the valve key groove is

damaged.

7. Inspect the valve stem tip for wear (6). Recondition the valve stem tip by grinding.
8. Inspect the valve stem for burrs and scratches (4). Use an oil stone to remove burrs and minor scratches.
9. Inspect the valve stem for straightness (3). Use V blocks to inspect the valve head for bending or distortion. Replace any bent or distorted valves.
10. Inspect the valve face for grooving (1, 2). If the groove is so deep that refacing the valve face would result in a knife edge, replace the valve.

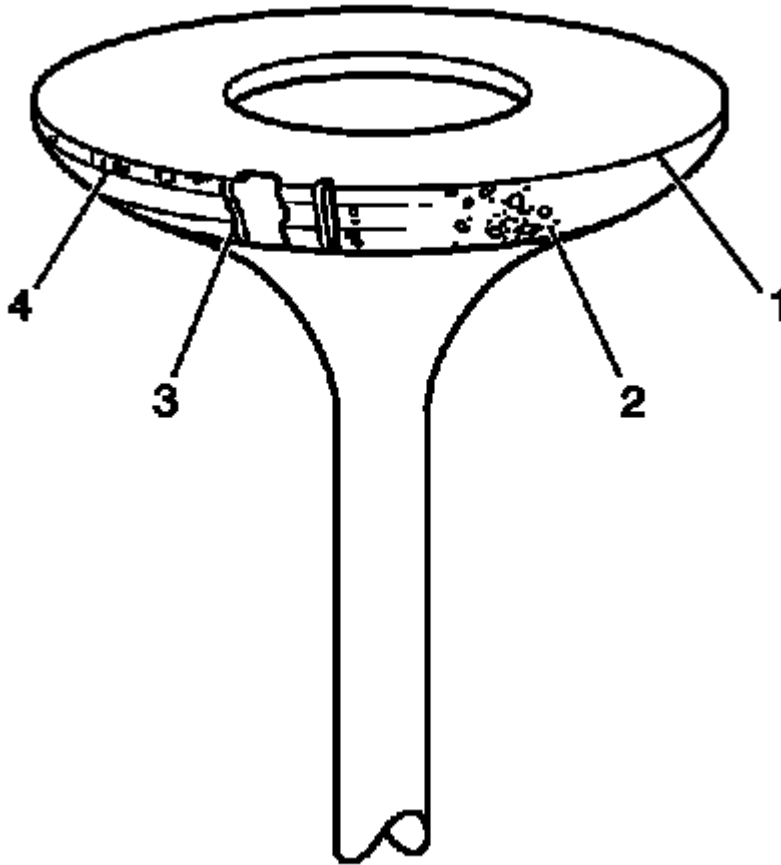


Fig. 262: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

11. Inspect the valve face for burning, pitting, or cracking (1, 2, 3, 4). If pieces of the valve face are broken off, replace the valve and inspect the corresponding piston and cylinder head area for damage.

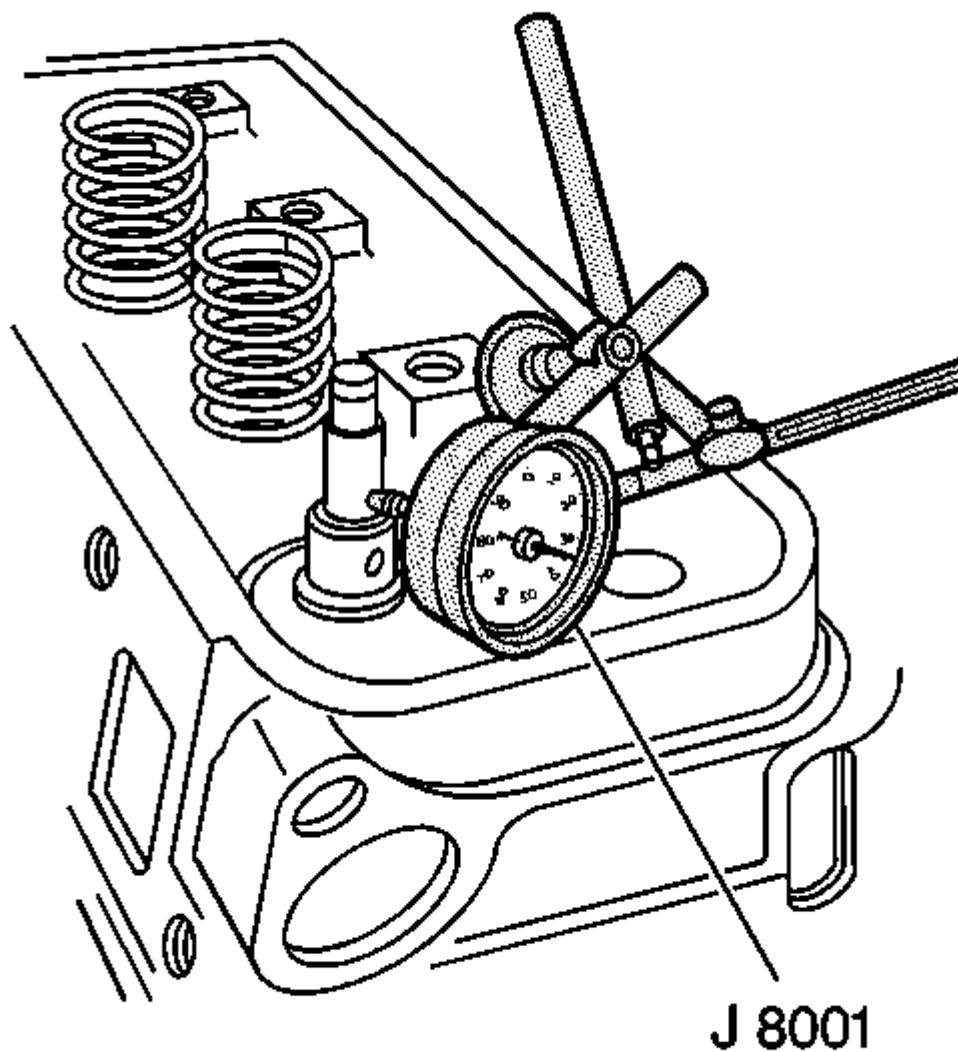


Fig. 263: Measuring Valve Stem Clearance
Courtesy of GENERAL MOTORS CORP.

12. Measure the valve stem clearance:
 1. Insert the valve into the guide.
 2. Lift the valve 2 mm (1/8 in) off of the seat.
 3. Move the valve from side to side.
 4. Use **J 8001** to measure the amount of movement. See Special Tools and Equipment.

The intake valve stem clearance should be between 0.031-0.071 mm (0.0012-0.0028 in).

The exhaust valve stem clearance should be between 0.036-0.074 mm (0.0014-0.0029 in).

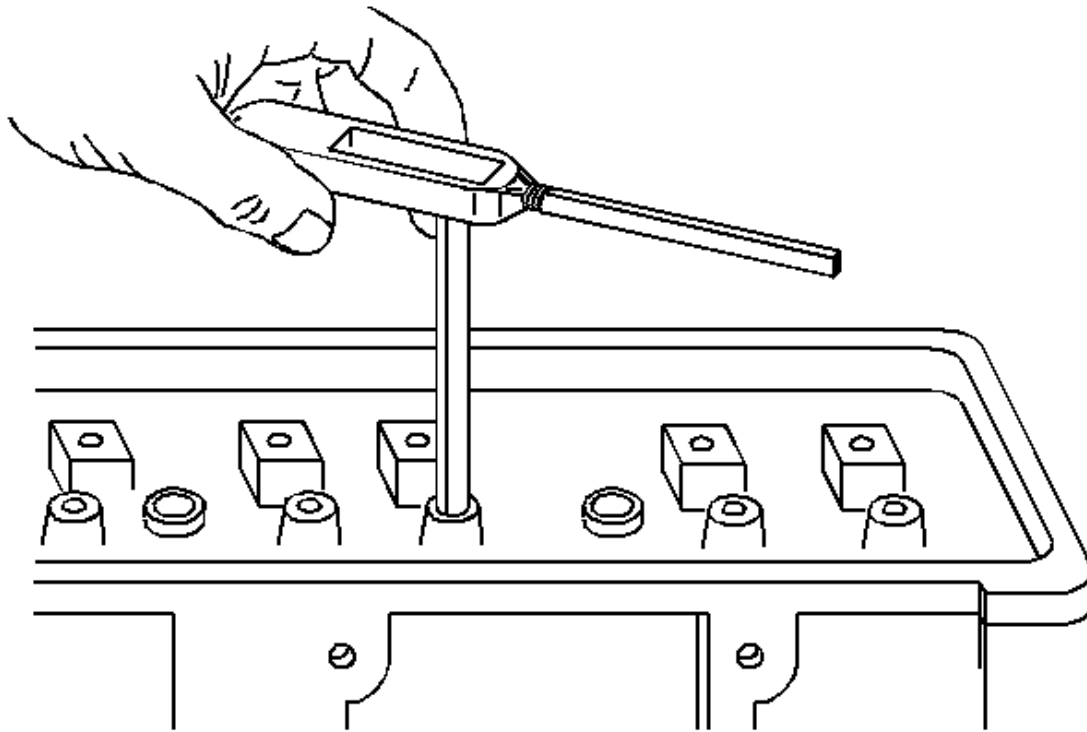


Fig. 264: Reaming Valve Guides For Oversize Valves
Courtesy of GENERAL MOTORS CORP.

**IMPORTANT: Clean the valve guide before reaming to avoid breaking the reamer flutes.
Do not push down on the reamer.**

13. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
14. Ream the valve guide bores for the oversize valves.
15. Recondition the valve seats after reaming the valve guide bores or installing the new valve guides.

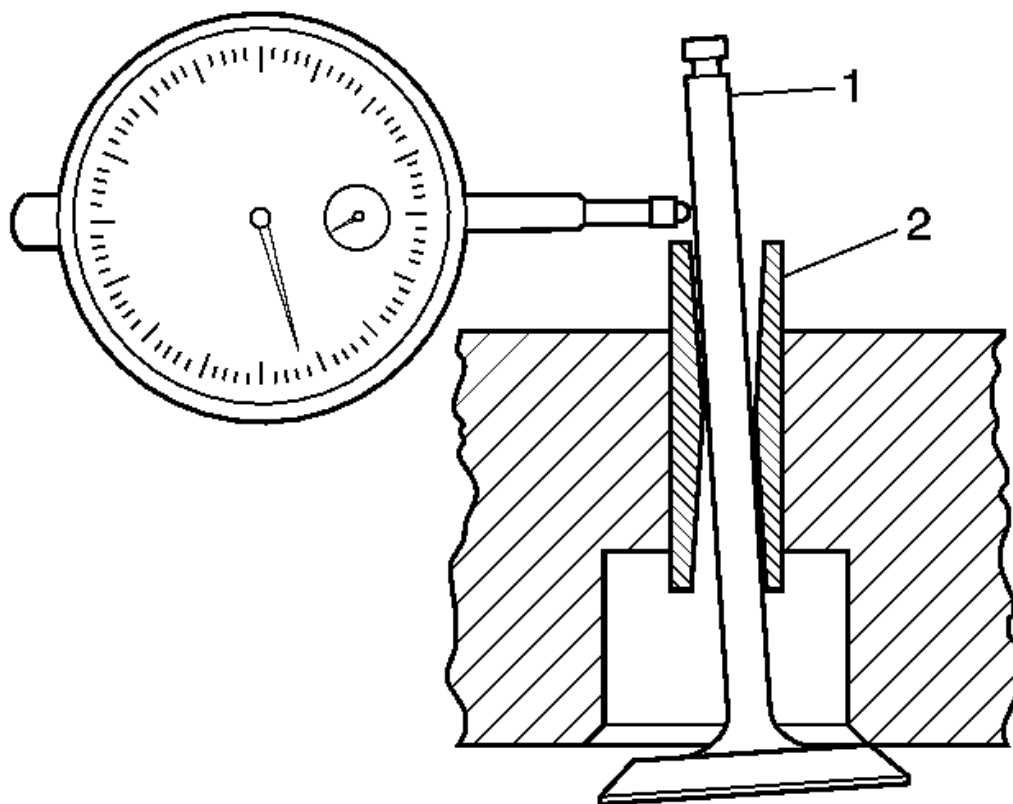


Fig. 265: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

16. Inspect the valve stem for straightness. Use V blocks to inspect the valve head for bending or distortion. Replace any bent or distorted valves.

- It is essential that the valve guide bores are free of carbon or dirt to ensure the proper centering of the pilot in the guide.

The valve seats should be concentric to within 0.05 mm (0.031 in) total indicator reading.

- Reface pitted valves on a valve refacing machine to ensure the correct relationship between the valve head and the valve stem.
- Replace the valve if the valve stem is warped (2), or if the valve stem shows signs of excessive wear.
- Inspect the valve key area (1) for damage and carbon build up.
- Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.
- Use the manufacturer's recommendations of equipment for the proper results.

Cylinder Head Assemble**Tools Required**

- **J 38606** Valve Spring Compressor. See Special Tools and Equipment.
- **J 42863** Valve Seal Installer. See Special Tools and Equipment.

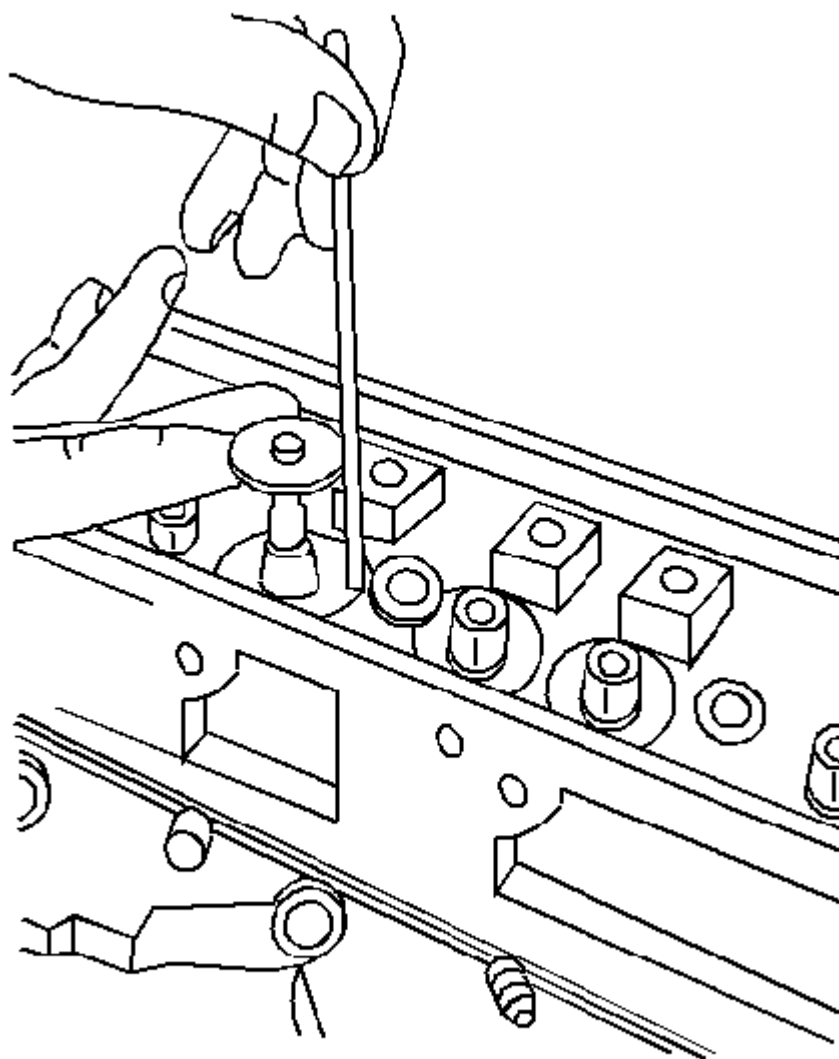
Assemble Procedure

Fig. 266: Measuring Valve Stem Installed Height

Courtesy of GENERAL MOTORS CORP.

1. Install the valves. The valves are available in standard size and 0.381 mm (0.015 in) oversize. Use oversize valve seals if oversized valves are used.
2. Use the following procedure to measure the valve stem height:
 1. Place the valve on the guide. Hold the valve in the closed position.
 2. Use a valve stem height gauge to measure the valve stem height.
 3. The measurement should be 49-50 mm (1.93-1.97 in).

NOTE: **Use hand pressure only when installing the valve seal using J 42863. Using too much force may cause damage to the oil seal and possibly lead to excessive oil consumption.**

3. Use the following procedure to measure the valve spring installed height:
 1. Place the valve in the valve guide.
 2. Install the valve spring cap and the valve cap keys.
 3. Seat the valve spring retainer by pulling up.
 4. Use a steel machinists' rule to measure the distance from the spring seat to the bottom of the valve spring cap.
 5. The measurement should be 42-44 mm (1.69-1.75 in).

If the measurement is not within specifications add shims under the valve spring.

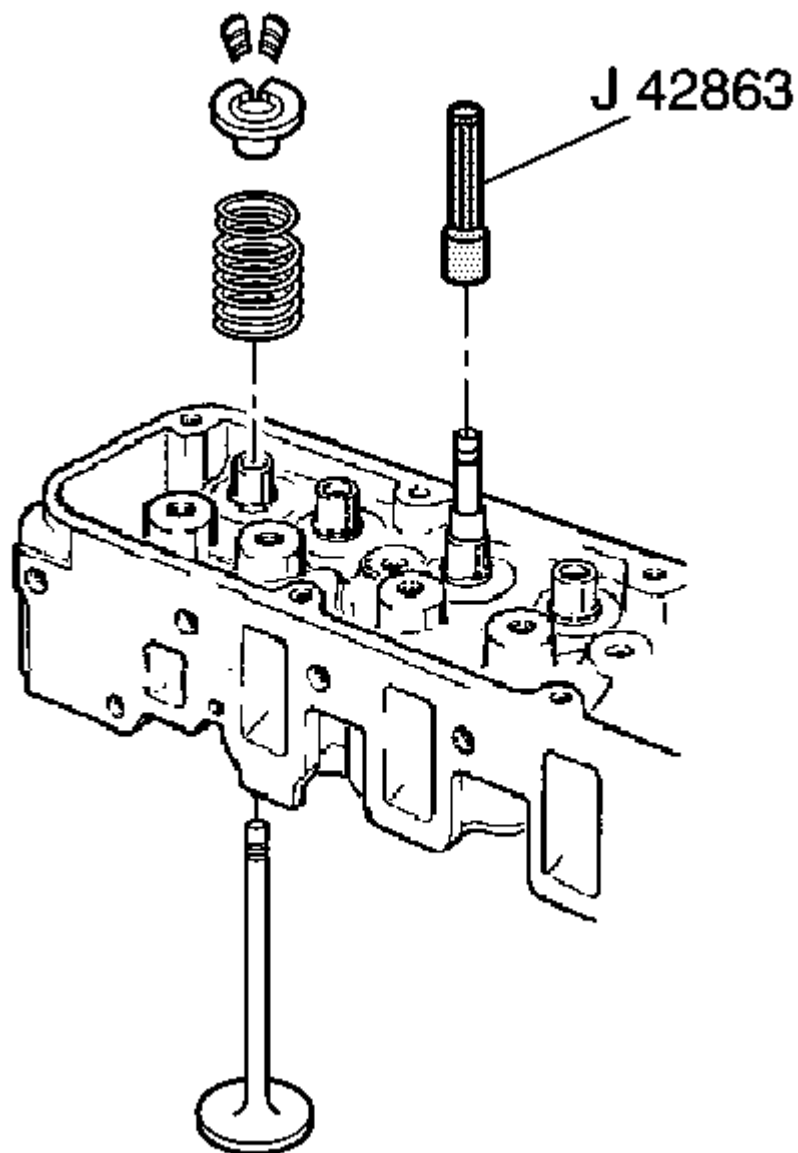


Fig. 267: Installing Valve Stem Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use hand pressure only when installing the valve seal using J 42863 . See **Special Tools and Equipment**. Using too much force may cause damage to the oil seal and possibly lead to excessive oil consumption.

4. Place the valve stem oil seal over the valve stem so the seal begins to contact the valve guide.
5. Use **J 42863** to push the valve stem oil seal over the valve guide. See **Special Tools and Equipment**.

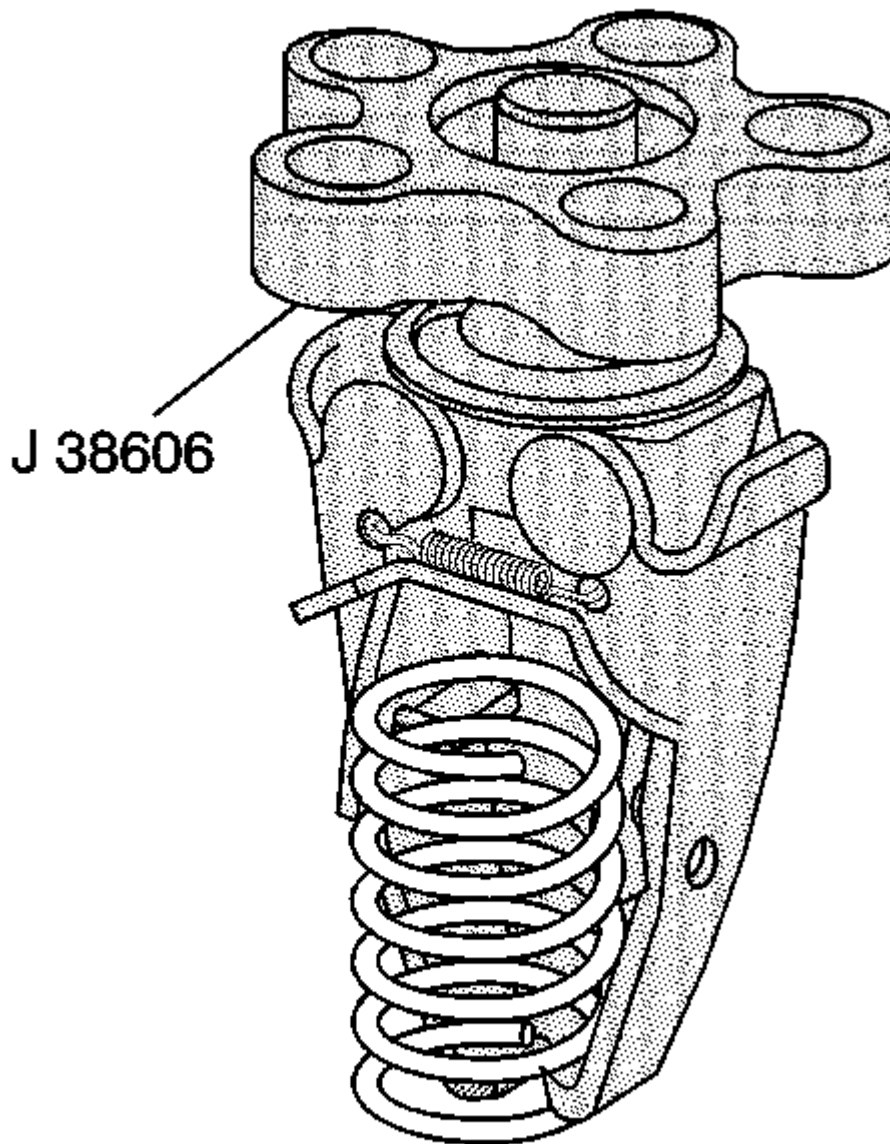


Fig. 268: Installing Valve Spring & Valve Cap
Courtesy of GENERAL MOTORS CORP.

6. Use **J 38606** to install the valve spring and the valve cap. See **Special Tools and Equipment**.

7. Install the valve keys.

Oil Pump Disassemble

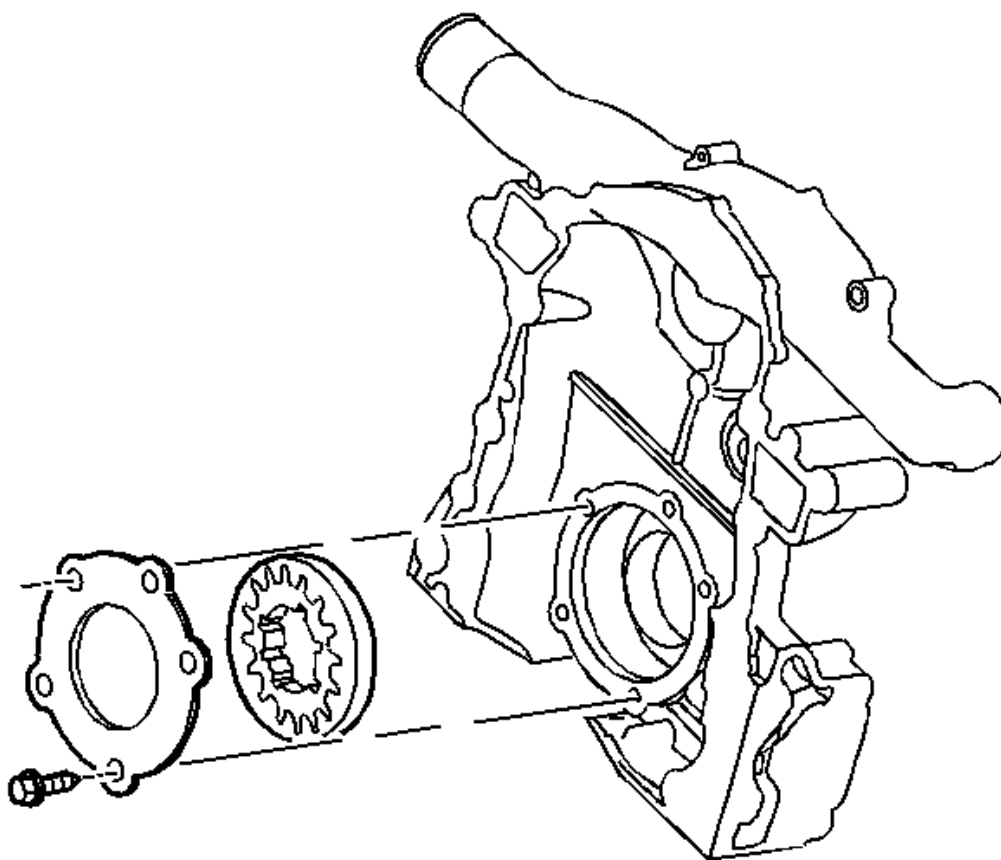


Fig. 269: Exploded View Of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump cover screws.
2. Remove the oil pump cover.
3. Remove the oil pump gears.

Oil Pump Cleaning and Inspection

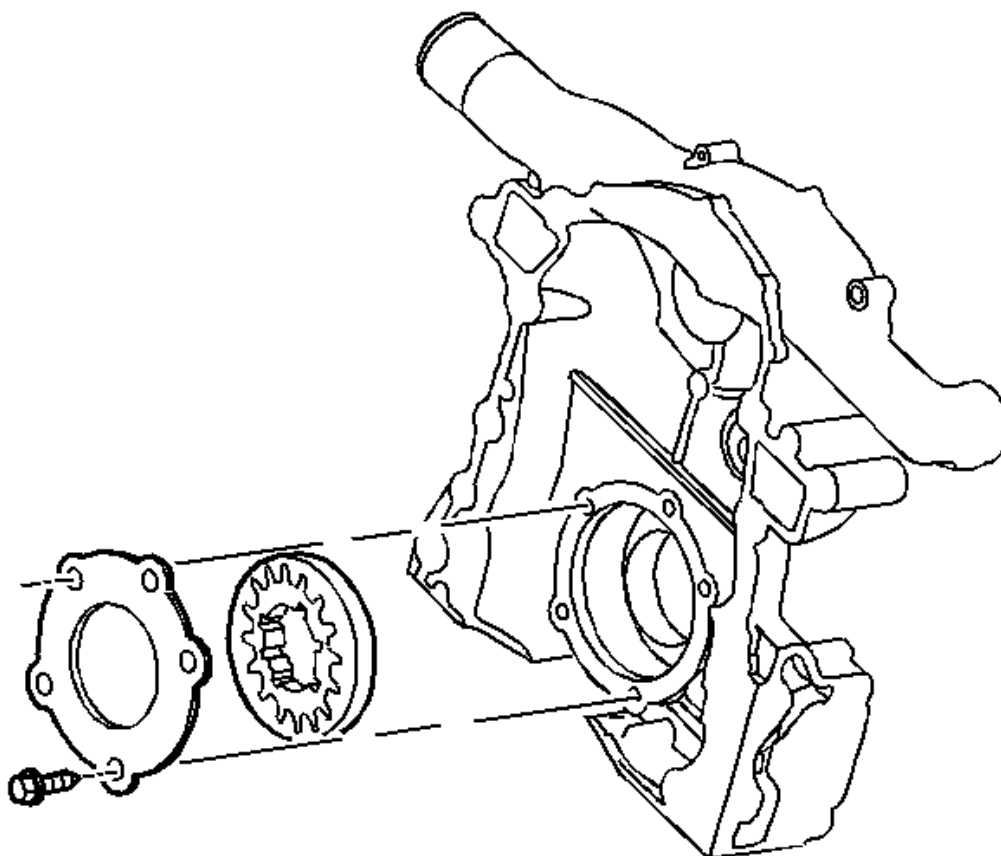


Fig. 270: Exploded View Of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Cleaning Solvent Caution in Cautions and Notices.

1. Use a suitable solvent to clean the oil pump.
2. Remove all old gasket material from the engine front cover and from the engine block.
3. Inspect the oil pump cover and the engine front cover for the following damage:
 - Cracks
 - Scoring
 - Porous or damaged casting
 - Damaged threads
 - Excessive wear

4. Inspect the pressure regulator valve for the following damage:
 - Scoring
 - Sticking in the bore
 - Burrs
 - Foreign material
5. Inspect the pressure regulator spring for loss of tension or bending. Replace the pressure regulator spring if damaged.
6. Inspect the oil pump gears for the following conditions:
 - Chipping
 - Galling
 - Scoring
 - Excessive wear

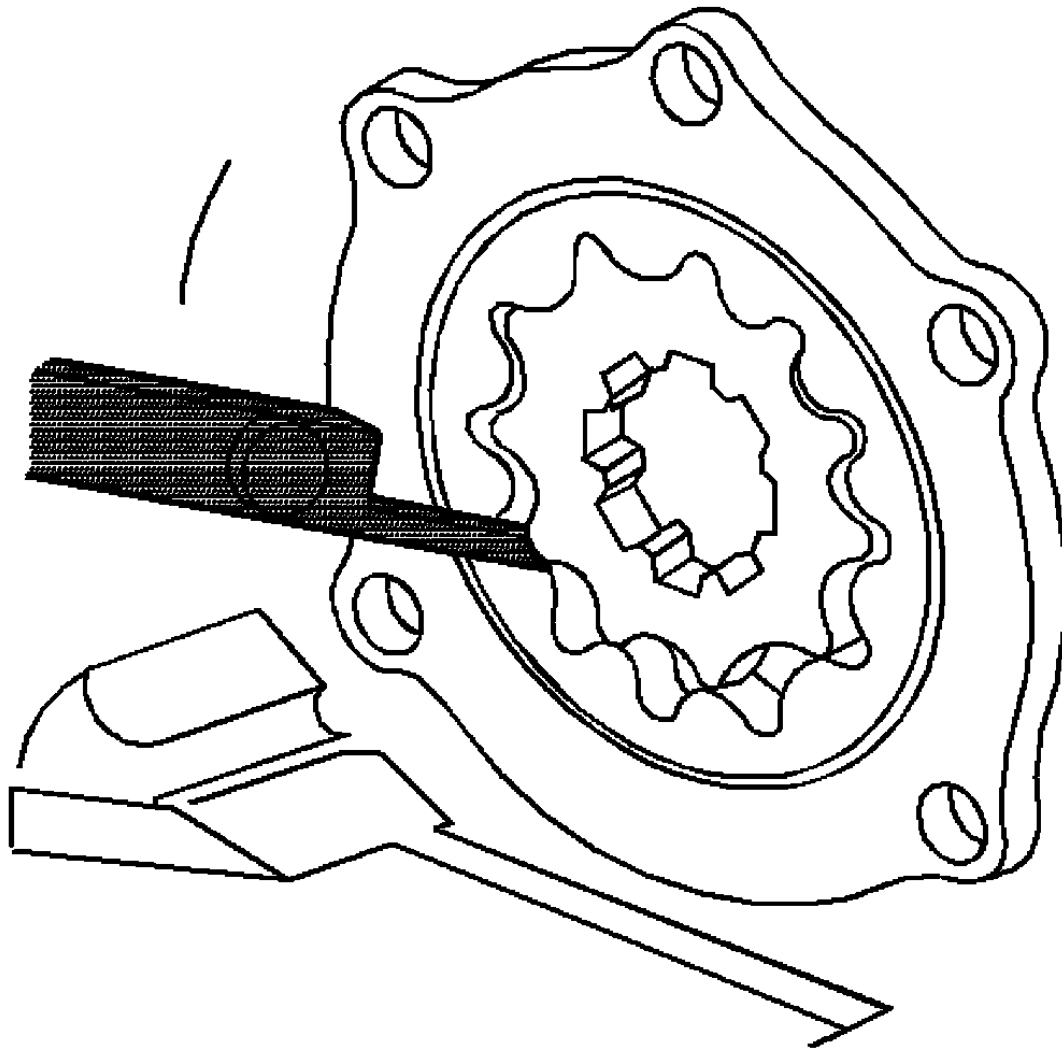


Fig. 271: Measuring Inner Oil Pump Gear Tip Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the inner oil pump gear tip clearance.

If the clearance for the inner oil pump gear tip is greater than 0.152 mm (0.006 in) the oil pump must be replaced.

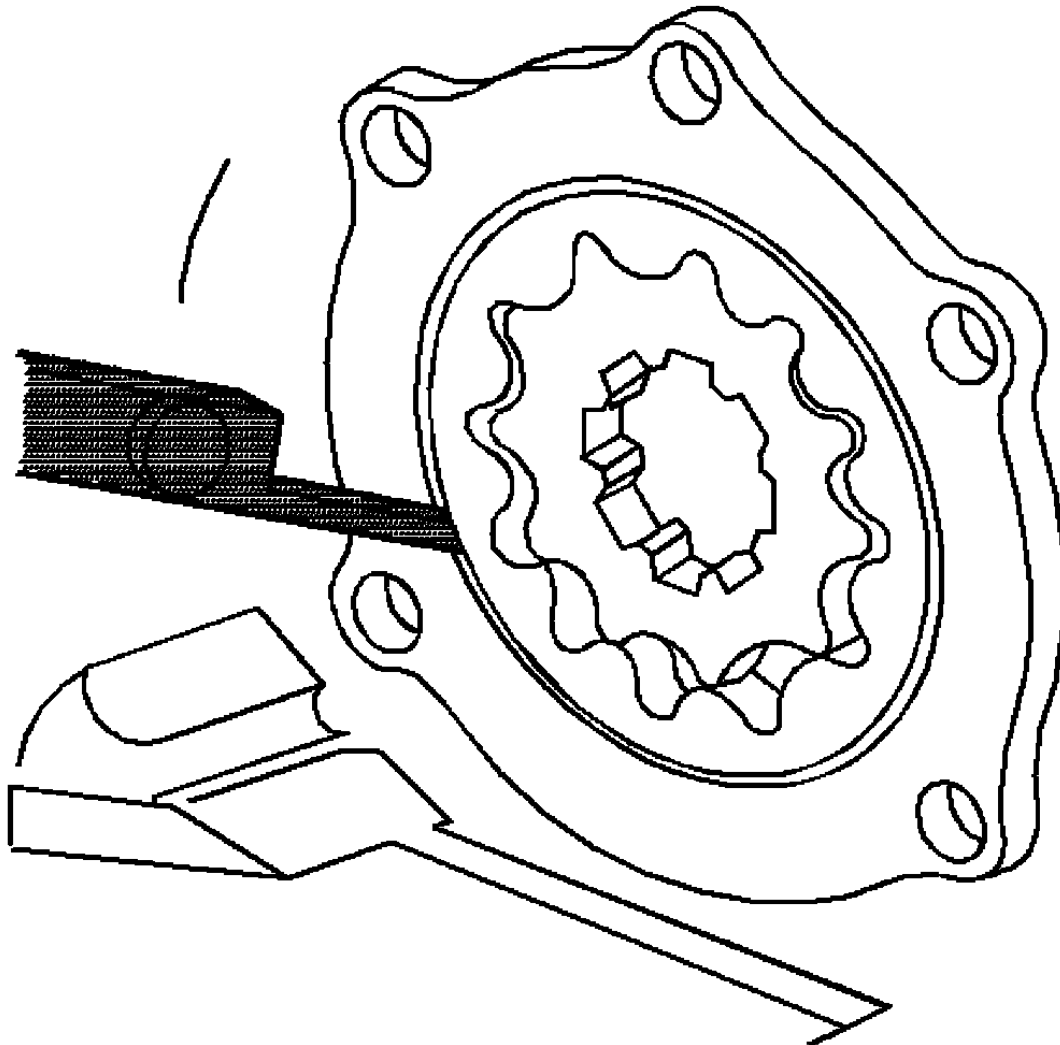


Fig. 272: Measuring Outer Oil Pump Gear Tip Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the outer oil pump gear diameter clearance.

If the outer oil pump gear diameter clearance is greater than 0.381 mm (0.015 in) the oil pump must be replaced.

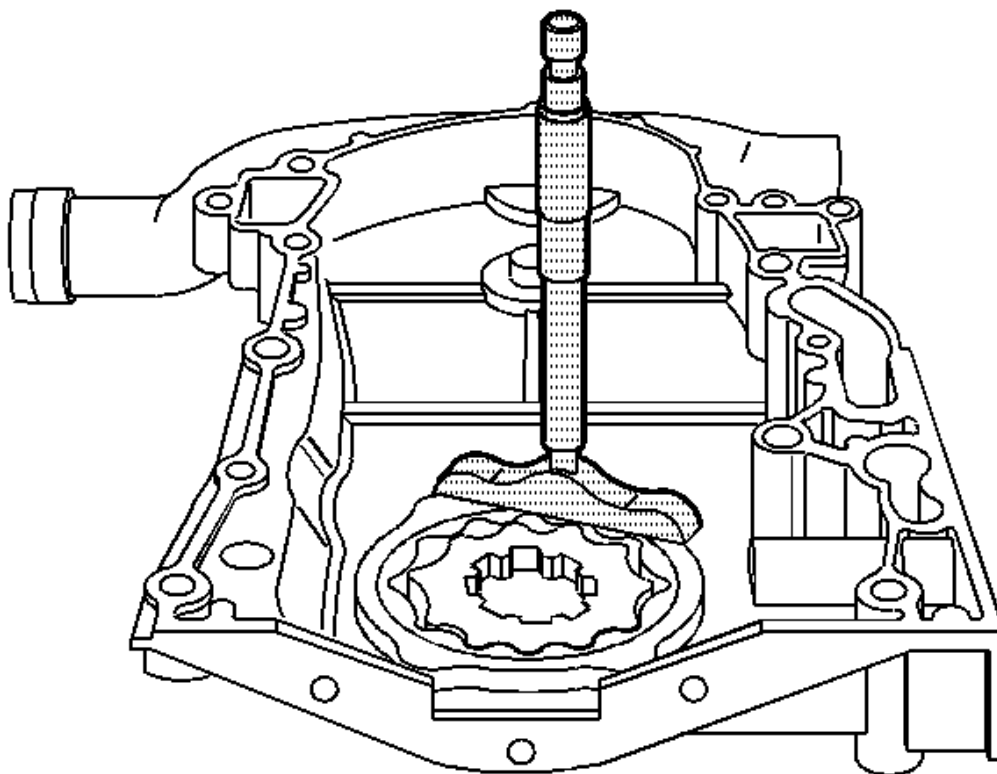


Fig. 273: Measuring Oil Pump Gear End Clearance
Courtesy of GENERAL MOTORS CORP.

9. Measure the oil pump gear end clearance.
10. Measure the pressure regulator valve-to-bore clearance.

If the pressure regulator valve-to-bore clearance is greater than 0.076 mm (0.003 in) the oil pump must be replaced.

Engine Front Cover Cleaning and Inspection

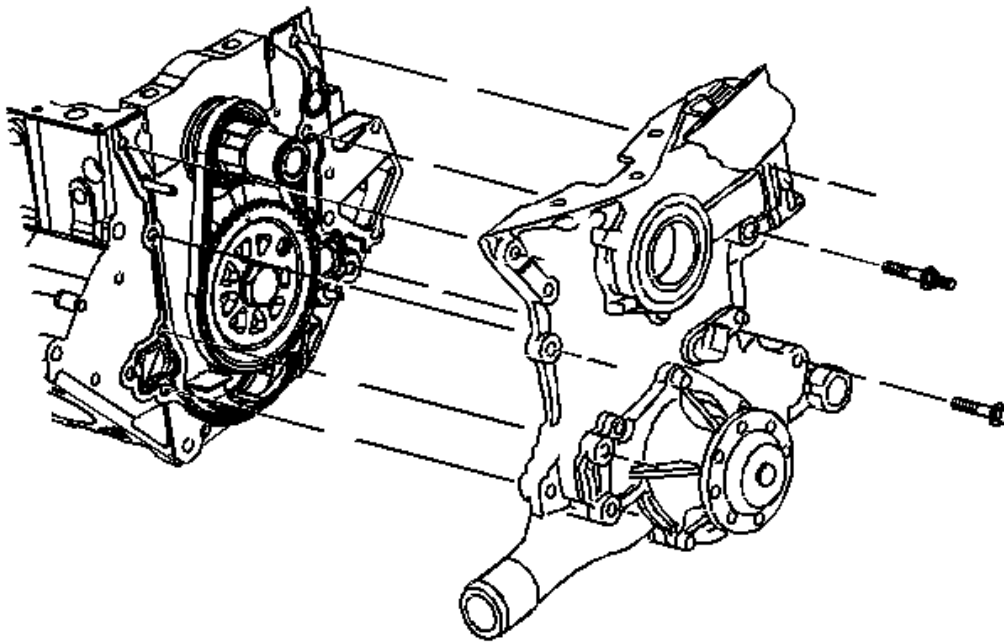


Fig. 274: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine front cover mating surface.
2. Clean the engine front cover.
3. Inspect the engine front cover threaded holes.
4. Inspect the engine front cover for damage.
5. Inspect the engine front cover mating surfaces for nicks.
6. Repair or replace the engine front cover as necessary.

Oil Pump Assemble

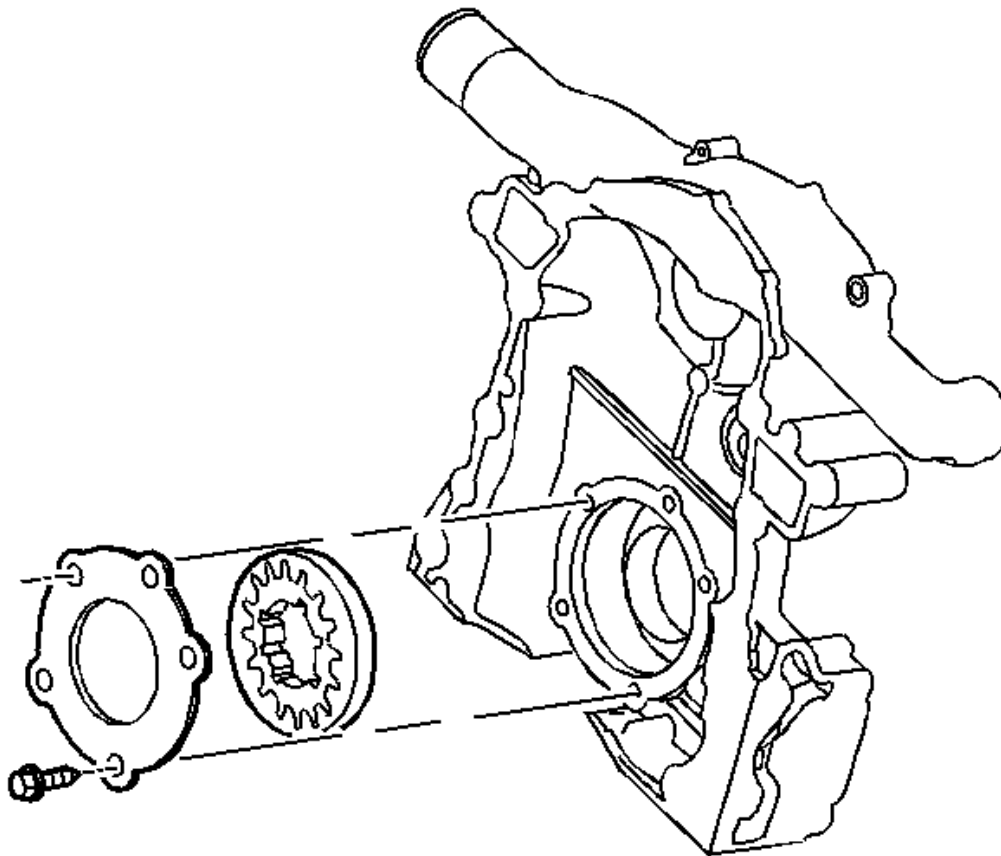


Fig. 275: Exploded View Of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil pump gears with petroleum jelly.
2. Install the oil pump gears.
3. Pack the oil pump cavity with petroleum jelly.
4. Install the oil pump cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pump cover screws.

Tighten: Tighten the screws to 11 N.m (98 lb in).

Valve Rocker Arm Cover Cleaning and Inspection

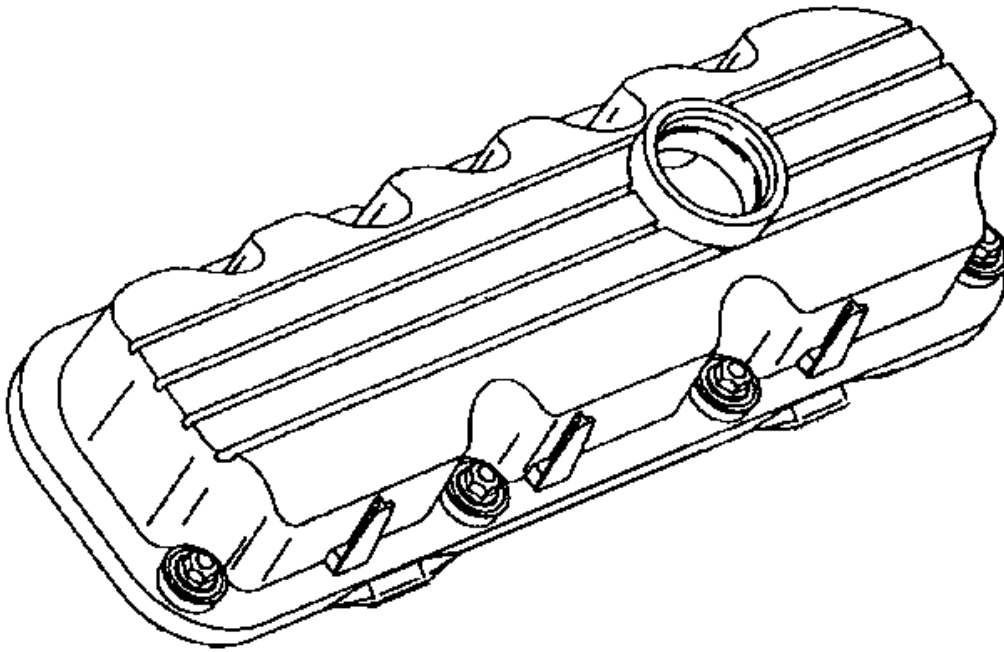


Fig. 276: Inspecting Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Clean the valve rocker arm cover mating surface.
2. Clean the valve rocker arm cover. Remove all the sludge and the oil deposits.
3. Inspect the valve rocker arm cover for damage. Replace the valve rocker arm cover if any damage is found.

Oil Pan Cleaning and Inspection

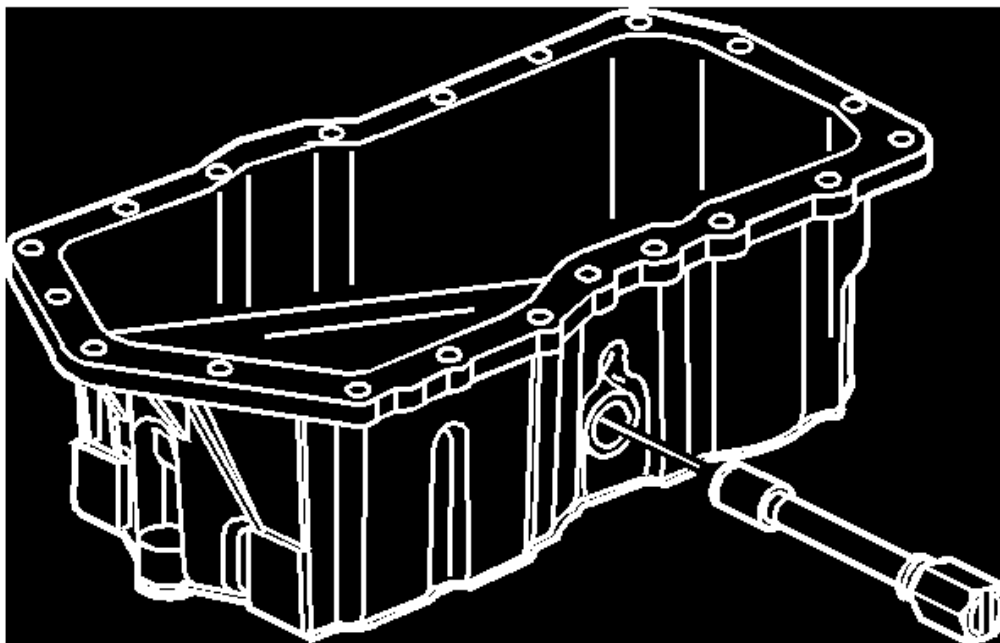


Fig. 277: Inspecting Oil Pan

Courtesy of GENERAL MOTORS CORP.

- Clean the oil pan mating surface.
- Clean the oil pan. Remove all the sludge and the oil deposits.
- Inspect the threads for the oil level sensor and the engine oil drain plug.
- Inspect the oil pan for distortion.
- Repair or replace the oil pan as necessary.

Intake Manifold Cleaning and Inspection - Upper

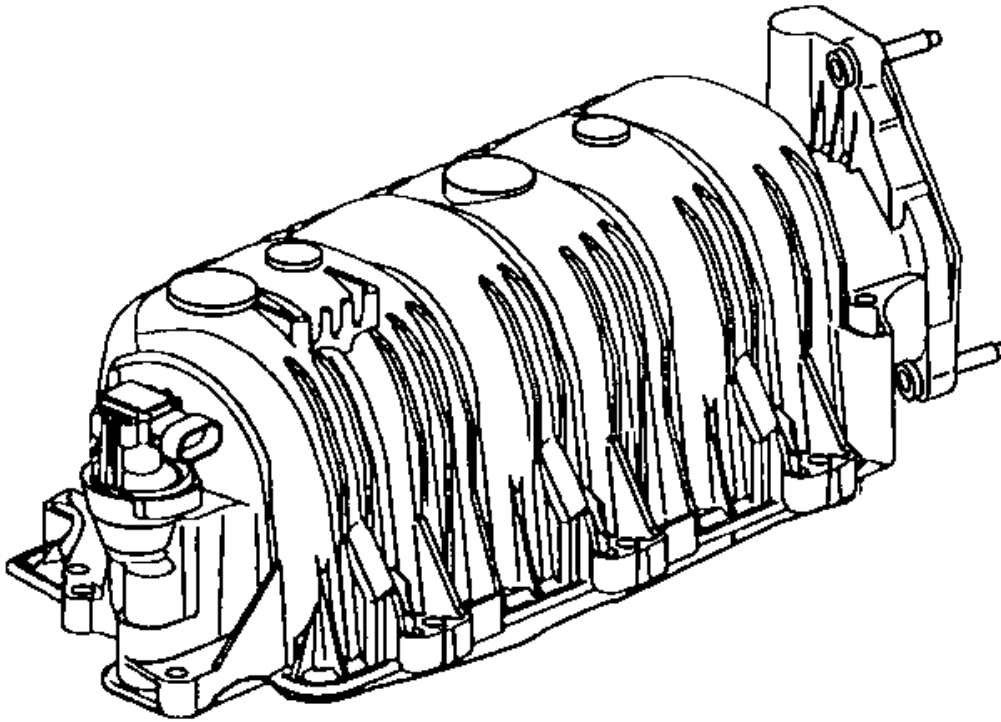


Fig. 278: Inspecting Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

- Clean the upper intake manifold mating surfaces.
- Clean the upper intake manifold.
- Inspect the upper intake manifold for damage.
- Replace the upper intake manifold as necessary.

Intake Manifold Cleaning and Inspection - Lower

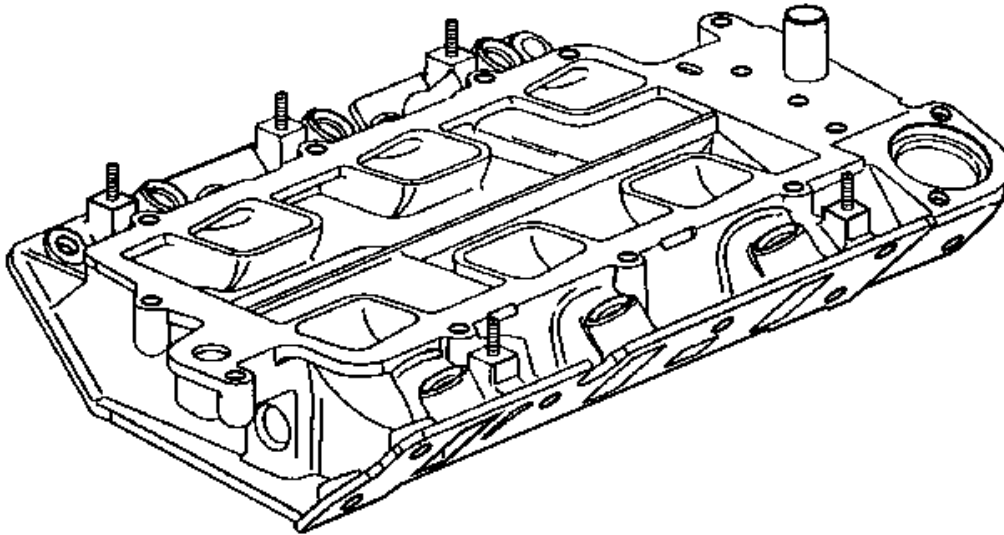


Fig. 279: Inspecting Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

- Clean the lower intake manifold mating surfaces.
- Clean the lower intake manifold.
- Inspect the threaded holes for damage.
- Inspect the lower intake manifold for damage or nicks in the mating surfaces.
- Replace or repair the lower intake manifold as necessary.

Exhaust Manifold Cleaning and Inspection

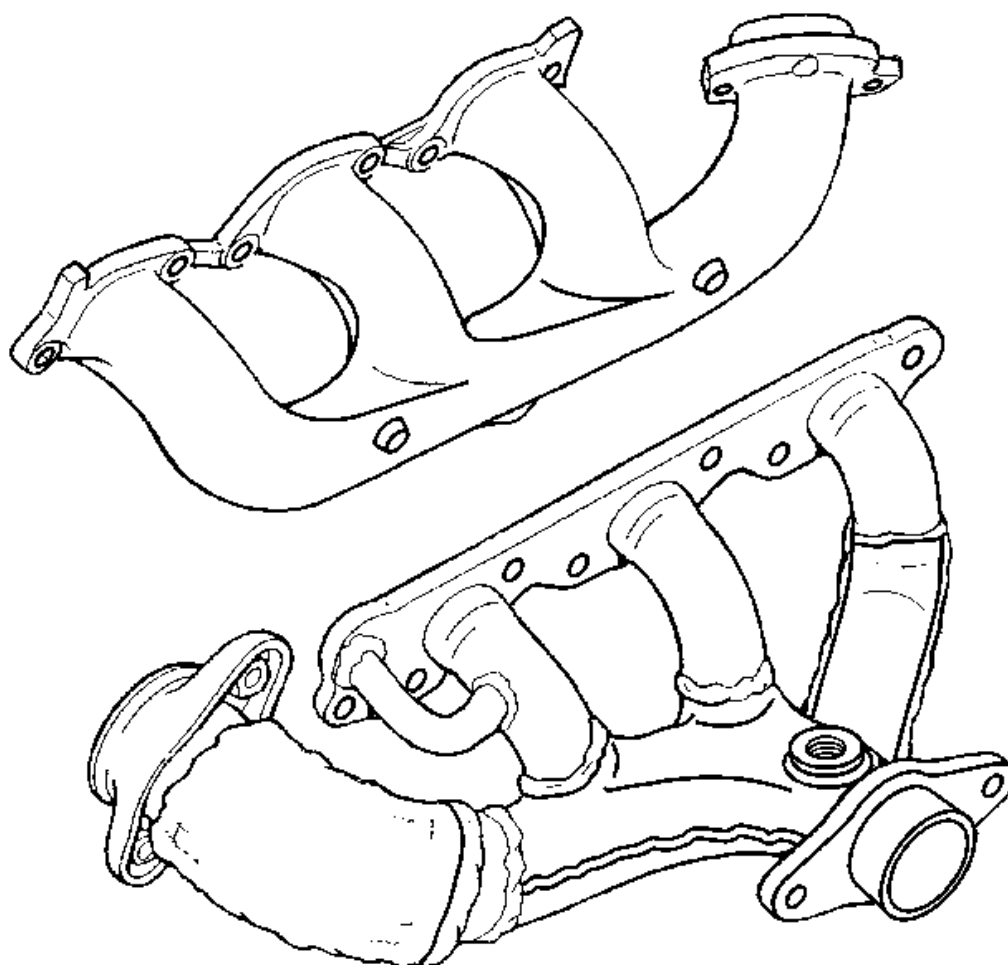


Fig. 280: Inspecting Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the exhaust manifold mating surfaces.
2. Clean the exhaust manifold.
3. Inspect the exhaust manifold mating surfaces for damage.

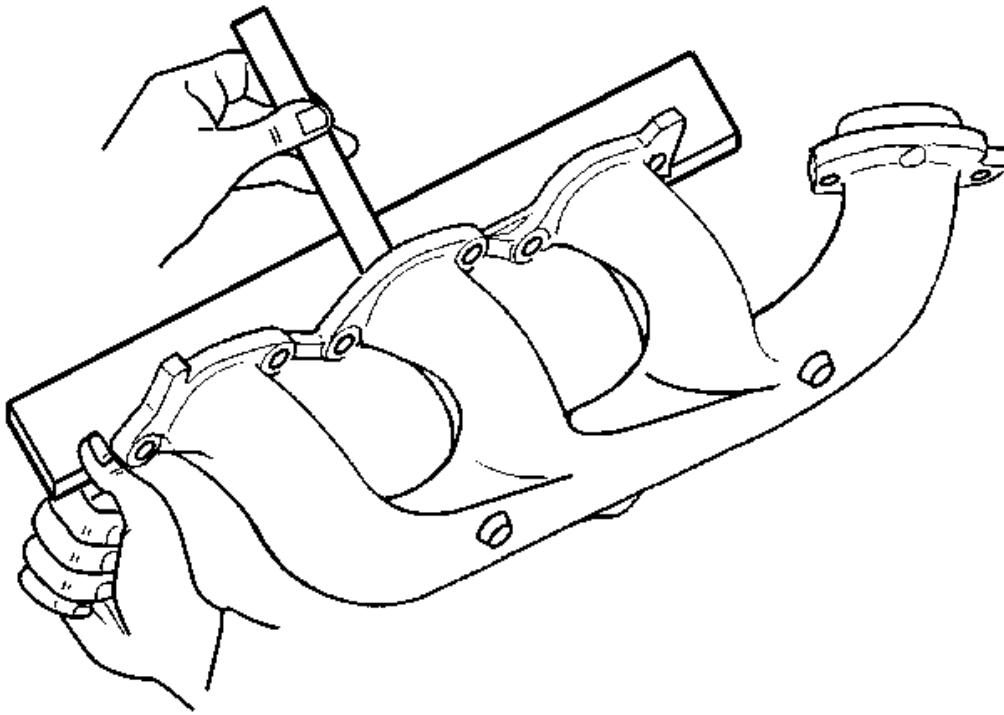


Fig. 281: Inspecting Exhaust Manifold Flange For Straightness
Courtesy of GENERAL MOTORS CORP.

4. Inspect the exhaust manifold flange for straightness, using a straight edge and a feeler gage.
5. If the exhaust manifold flange is warped more than 0.05 mm (0.002 in) replace the exhaust manifold.

Water Pump Cleaning and Inspection

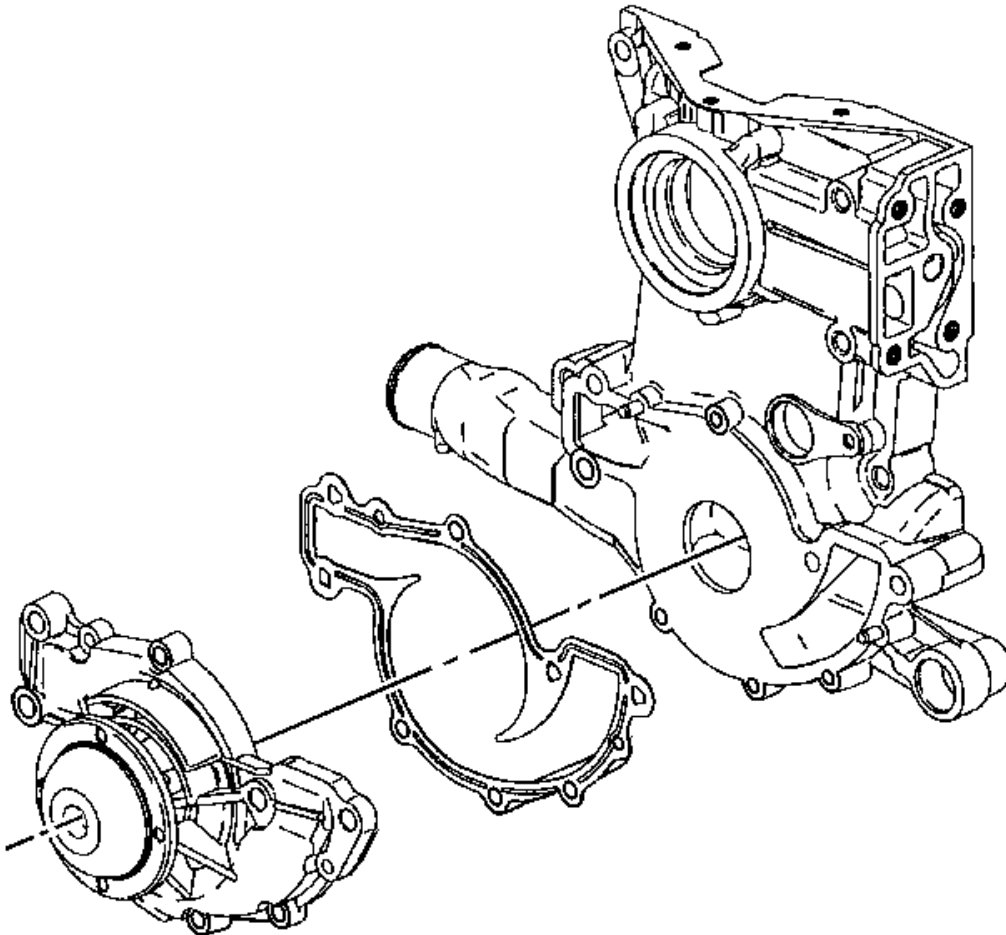


Fig. 282: Inspecting Water Pump & Components
Courtesy of GENERAL MOTORS CORP.

1. Clean the water pump mating surface.
2. Clean the water pump.
3. Inspect the water pump shaft for looseness.
4. Inspect the water pump vanes for damage.
5. Inspect the water pump mating surfaces for nicks.
6. Repair or replace the water pump as necessary.

Balance Shaft Cleaning and Inspection

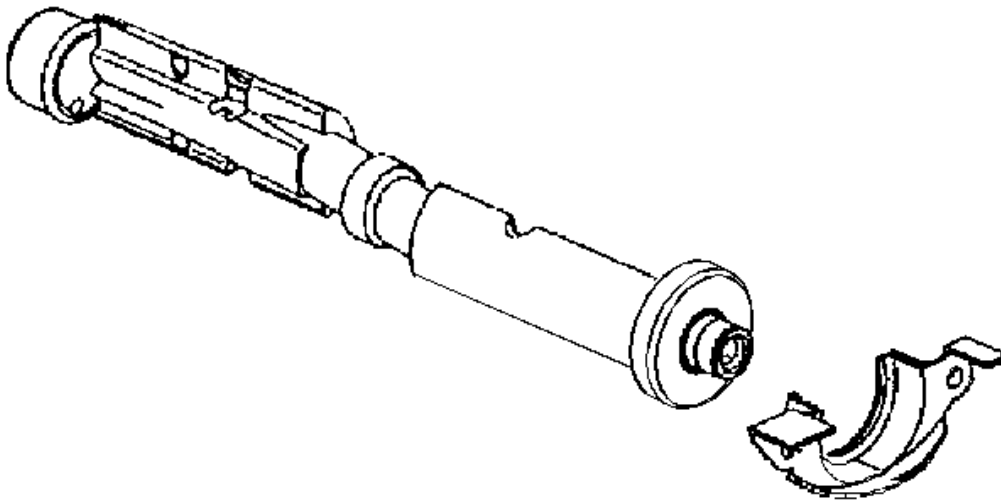


Fig. 283: Inspecting Balance Shaft
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shaft.
2. Inspect the balance shaft bearing/bushing journals for excessive wear.
3. Inspect the balance shaft driven gear and the balance shaft drive gear for nicks and burrs.
4. Inspect the balance shaft retainer for damage.
5. Inspect the balance shaft threads for damage.
6. Repair or replace the balance shaft components as necessary.

Thread Repair

General purpose thread repair kits are available commercially.

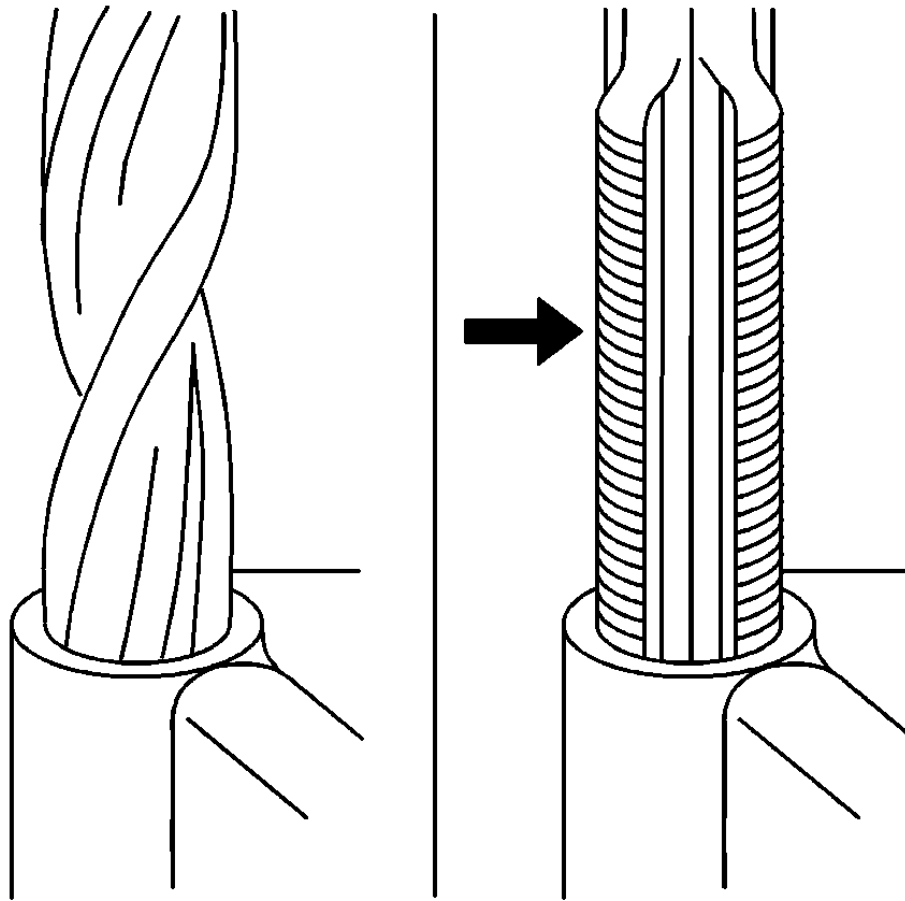


Fig. 284: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

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.

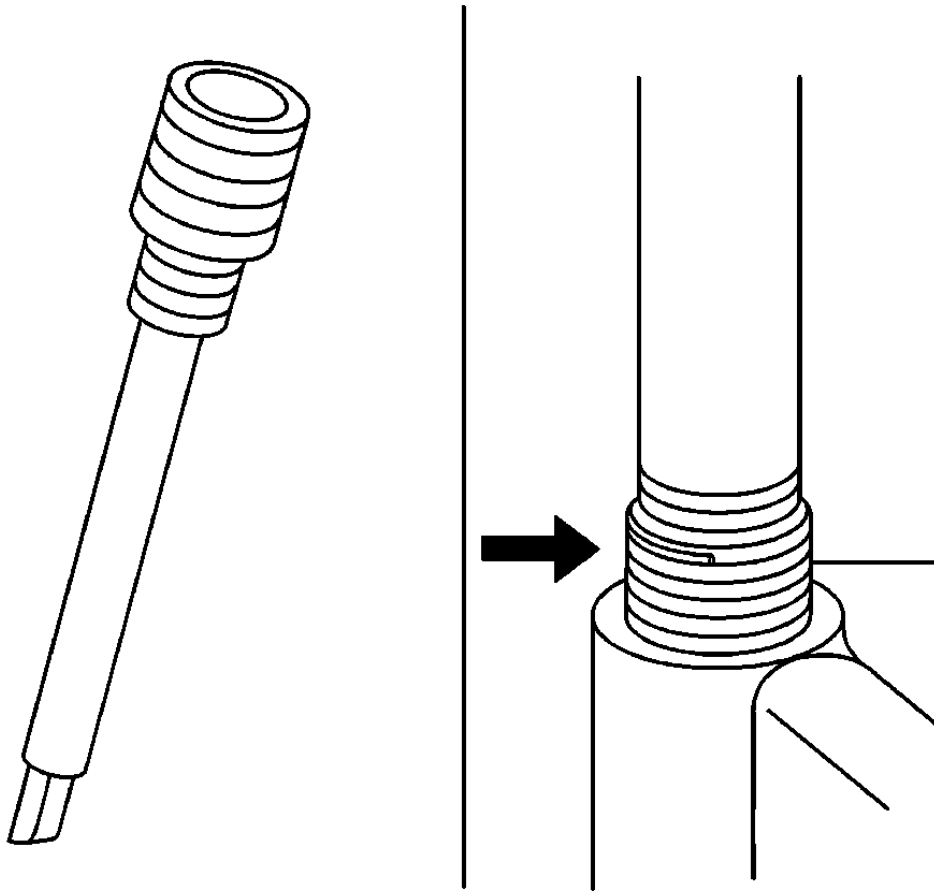


Fig. 285: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.

IMPORTANT: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

Service Prior to Assembly

Dirt will cause premature wear of the rebuilt engine. Clean all of the components. Use the proper tools in order to measure components when inspecting for excessive wear. Repair or replace the components that are not within the manufacturers specification. When components are reinstalled into an engine, return the components to their original location, position, and direction. During assembly, lubricate all of the moving parts with clean engine oil or engine assembly lubricant unless otherwise specified. This will provide initial lubrication when the engine is first started.

Engine Prelubing

Tools Required

J 45299 Engine Preluber. See Special Tools and Equipment.

Engine Prelubing Procedure

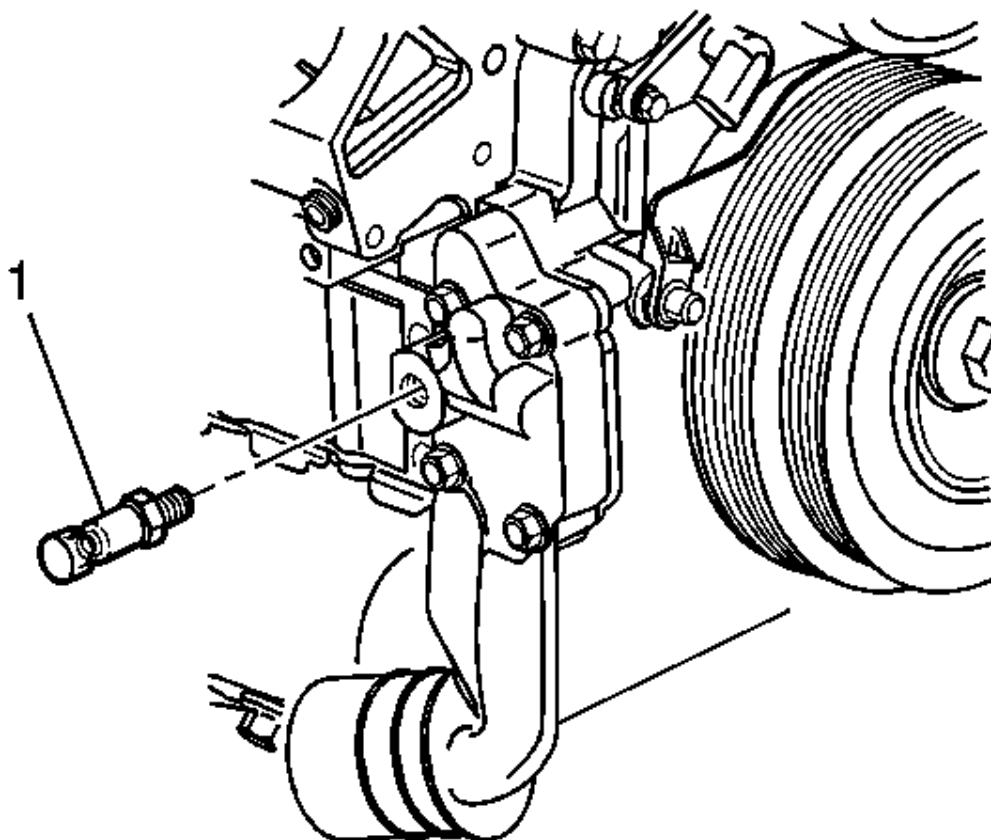


Fig. 286: Locating Engine Oil Pressure Sensor/Switch
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant/continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter and fill with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

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

3. Locate the oil pressure sensor (1) on left side of engine and remove.
4. Install the 1/4 inch adapter P/N 509373.

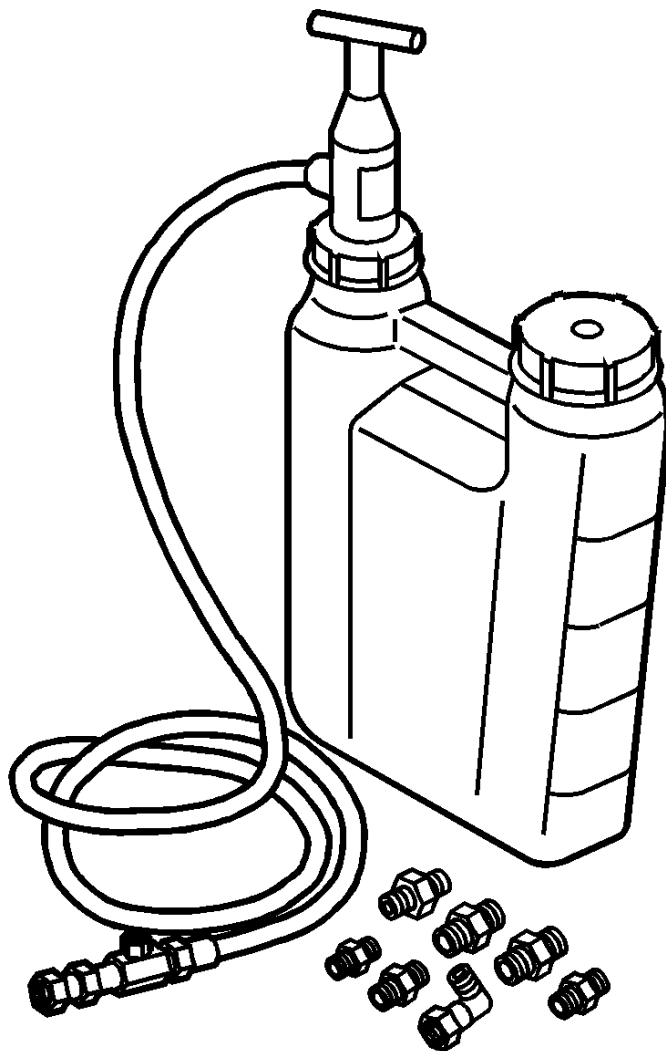


Fig. 287: Identifying Engine Preluber J 45299

Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on **J 45299** to flow a minimum of 1-2 quarts (1-1. See Special Tools and Equipment.9 liters) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the oil pressure sensor.

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

9. Top off the engine oil to the proper level.

Balance Shaft Bearing and/or Bushing Installation**Tools Required**

- J 21465-13 Drive Handle Extension
- **J 36995** Balance Shaft Bearing Remover/Installer. See Special Tools and Equipment.

Installation Procedure

1. Dip the balance shaft bushing in clean engine oil.

IMPORTANT: The **J 36995** installs the balance shaft bushing to the correct depth. See Special Tools and Equipment. The balance shaft bushing is properly installed when **J 36995** fully contacts the balance shaft bore or the engine block/transaxle mounting flange. See Special Tools and Equipment.

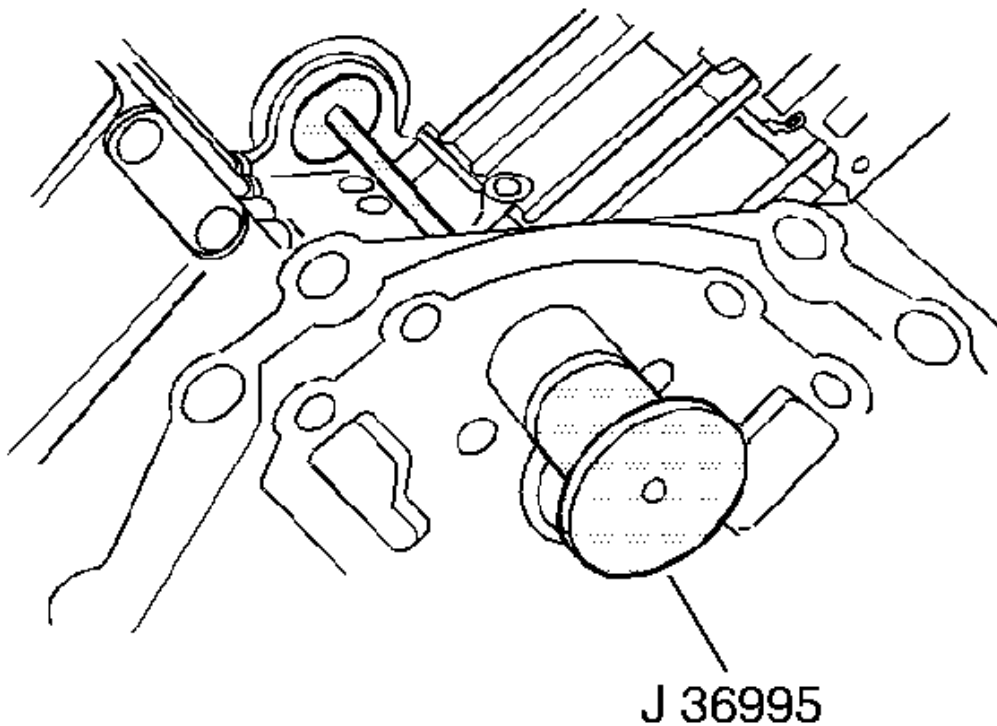


Fig. 288: Installing Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

2. Use the balance shaft bushing installers to install the balance shaft bushing.
3. Remove **J 36995** . See **Special Tools and Equipment**.
4. Dip the balance shaft bearing into clean engine oil.

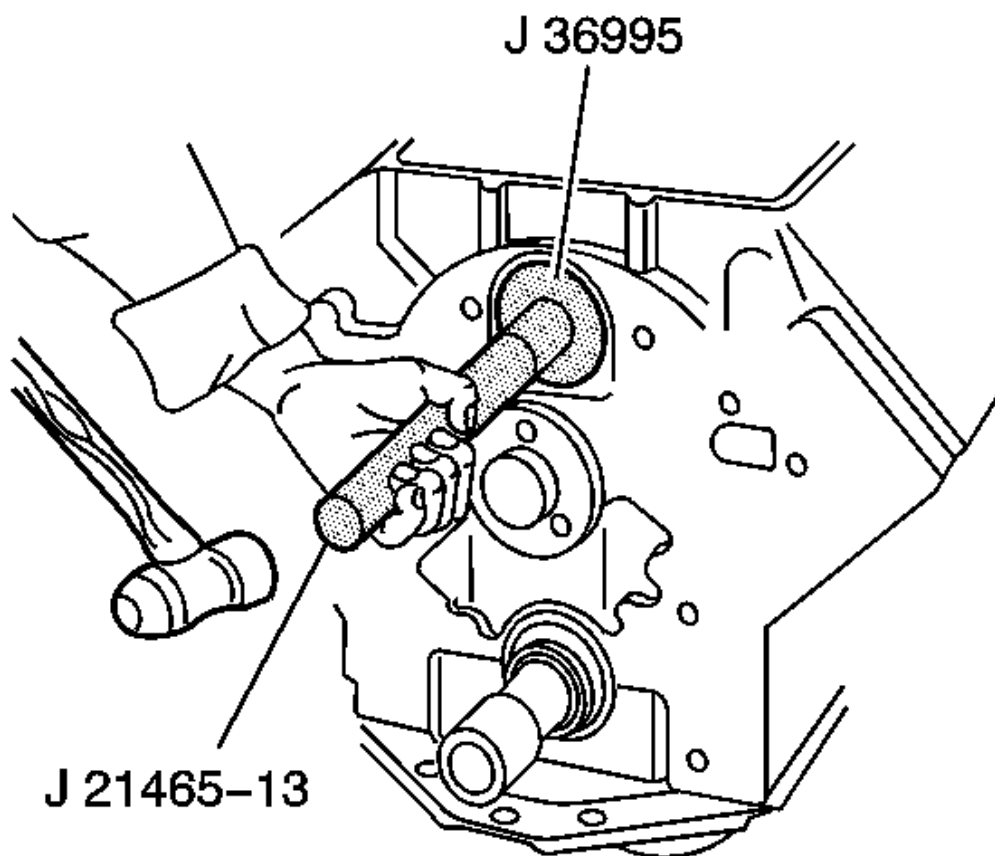


Fig. 289: Installing Balance Shaft Bearing Into Engine Block
Courtesy of GENERAL MOTORS CORP.

5. Use J 21465-13 and J 36995 to install the balance shaft bearing into the engine block. See **Special Tools and Equipment**.

Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Service Set

Installation Procedure

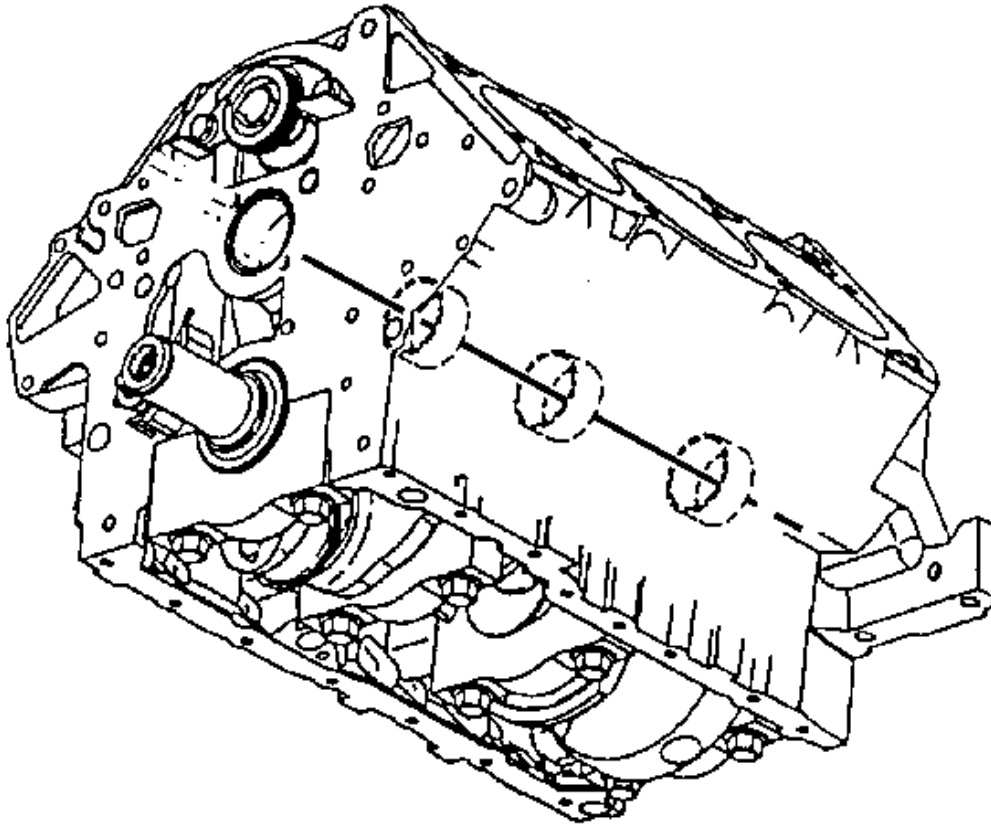


Fig. 290: Locating Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

1. Select the camshaft bearings.

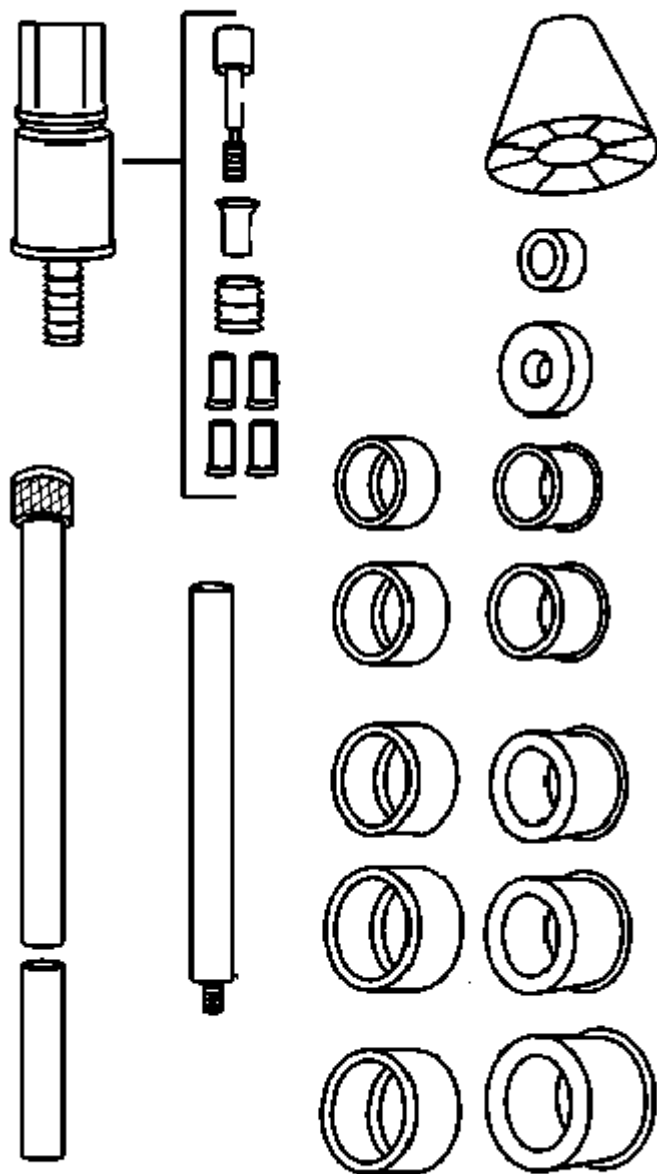


Fig. 291: Camshaft Bearing Service Set
Courtesy of GENERAL MOTORS CORP.

2. Use the following procedure to install the camshaft bearings:
 1. Assemble J 33049 according to the manufacturer's instructions.
 2. Place the bearing on the tool.

NOTE: Severe engine damage may result if the oil holes are not correctly aligned.

3. Index the bearing oil holes with the engine block oil passages.

Engine Block Plug Installation

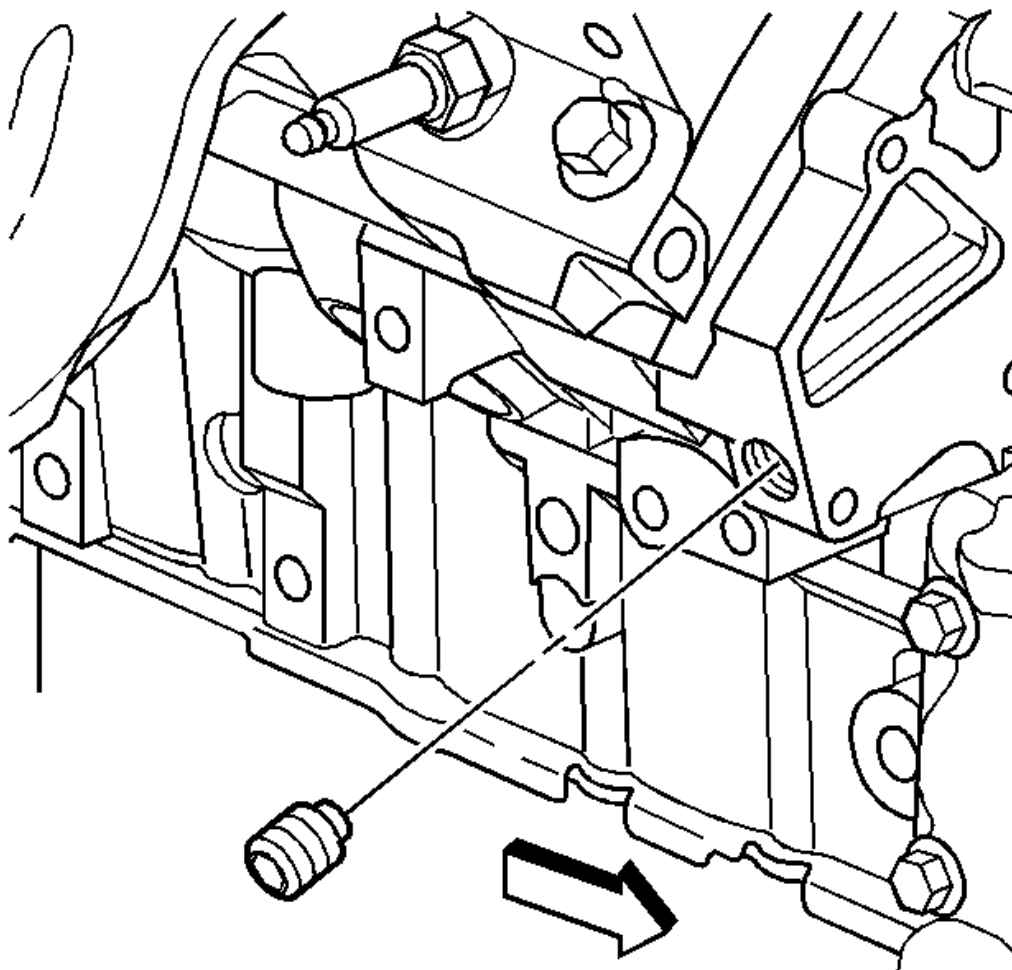


Fig. 292: Locating Threaded Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the threaded oil gallery plugs.

Tighten: Tighten the oil gallery plugs to 30 N.m (22 lb ft).

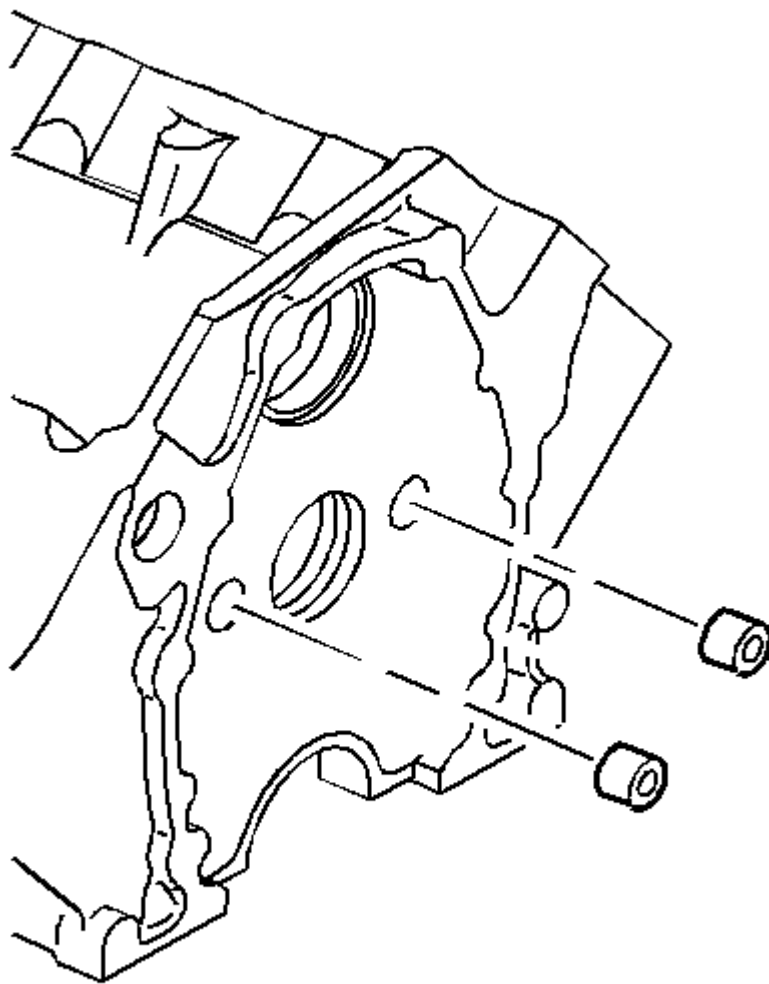


Fig. 293: Locating Engine Block Plugs
Courtesy of GENERAL MOTORS CORP.

2. Install the remaining oil gallery plugs using GM P/N 12346004 (Canadian P/N 10953480) or the equivalent.

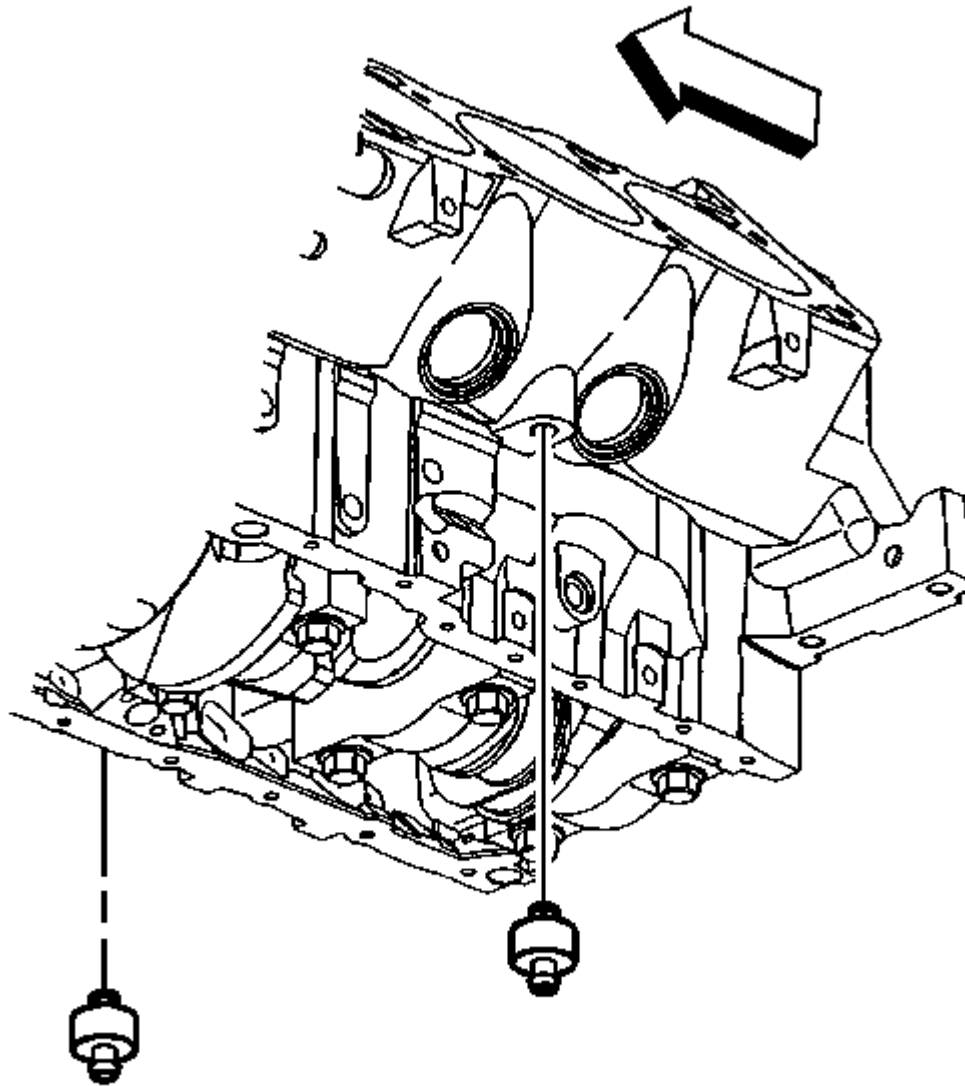


Fig. 294: Locating Knock Sensors
Courtesy of GENERAL MOTORS CORP.

3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or the equivalent to the threads of the knock sensor.
4. Install the knock sensors.

Tighten: Tighten the knock sensors to 18 N.m (13 lb ft).

5. Install the knock sensor heat shield and bolts, if applicable.

Tighten: Tighten the knock sensor heat shield bolts to 50 N.m (37 lb ft).

Crankshaft and Bearings Installation

Tools Required

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

Installation Procedure

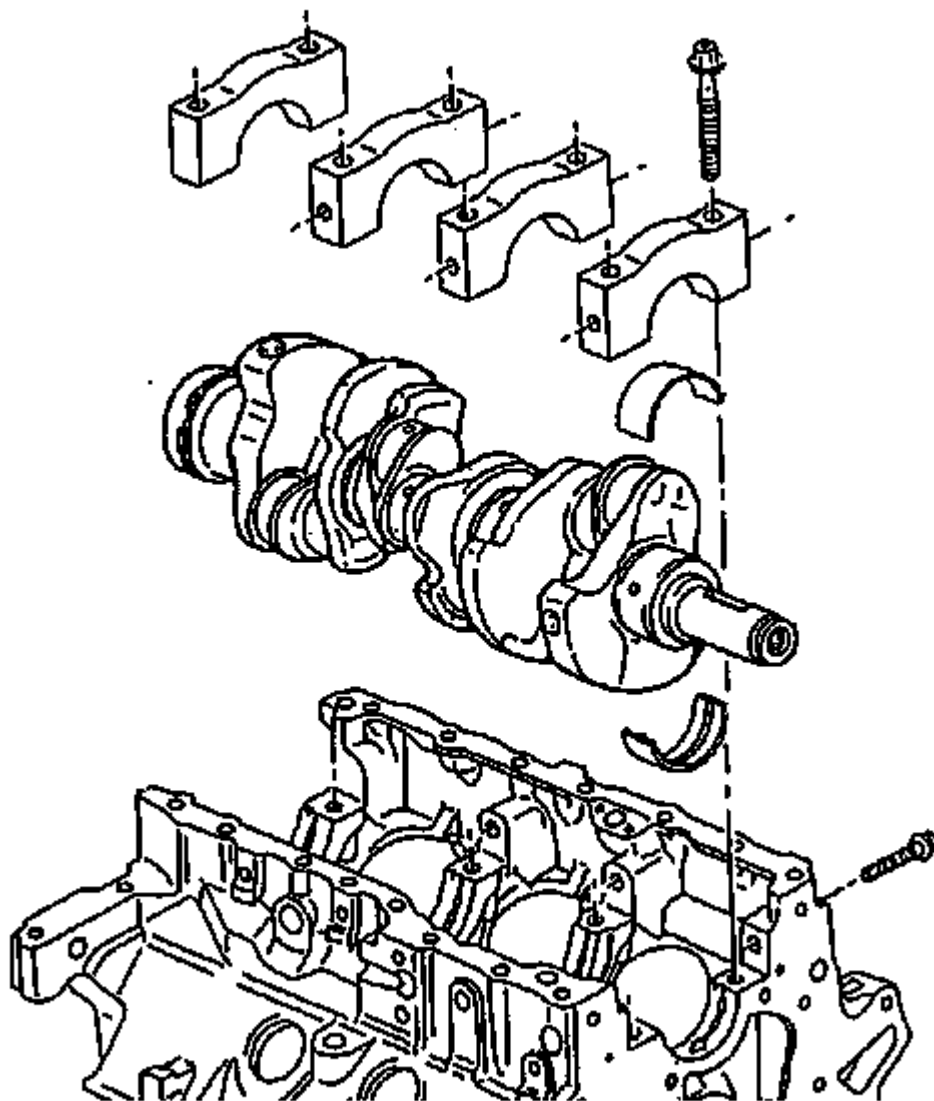


Fig. 295: View Of Crankshaft, Bearings And Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft main bearings.
2. Install the crankshaft. Lubricate the crankshaft to crankshaft main bearing contact areas with engine oil or engine assembly lubricant.

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.

3. Install the lower crankshaft main bearings into the main bearing caps.

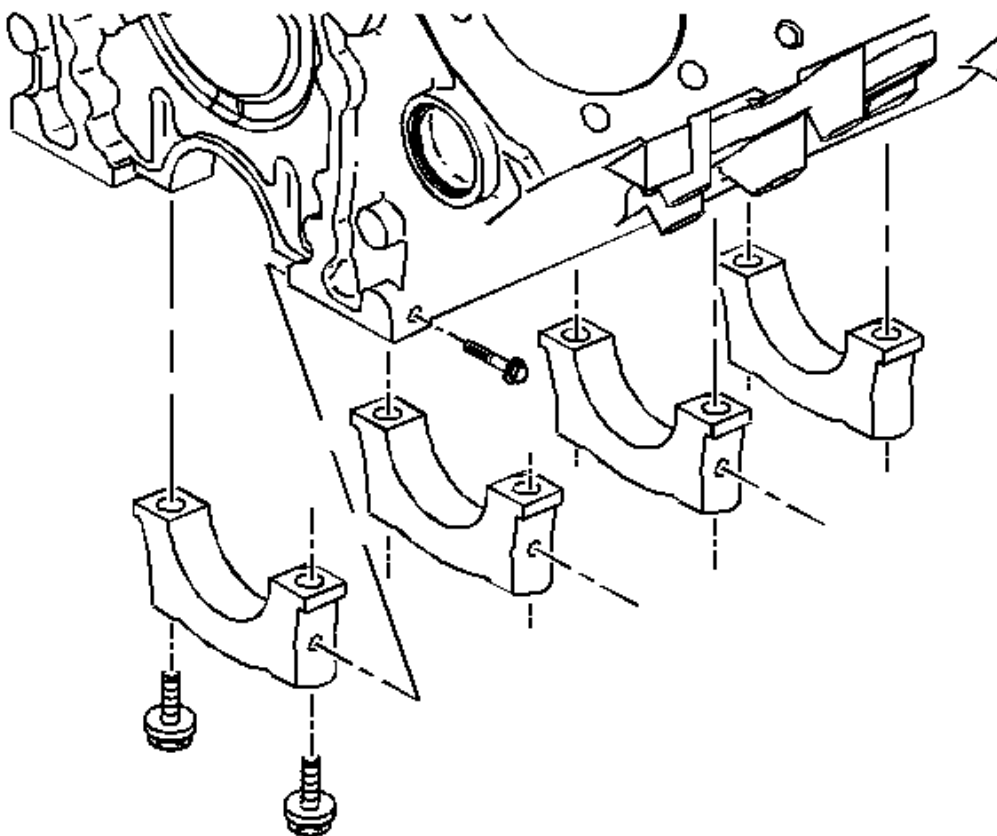


Fig. 296: Installing Crankshaft Main Bearing Caps & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the crankshaft main bearing cap bolts. Start the crankshaft main bearing cap bolts by hand. Ensure

the bottom of the crankshaft main bearing cap is parallel to the bottom of the channel.

Tighten:

- Tighten the crankshaft main bearing cap bolts in equal increments. Do not completely tighten a bolt at a time in order to prevent the cap from being cocked.
- Tighten the bolts to 70 N.m (52 lb ft) to fully seat the crankshaft main bearing caps. Loosen the bolts 360 degrees counterclockwise.
- Tighten the bolts to 20 N.m (15 lb ft), then 40 N.m (30 lb ft).
- Use **J 45059** to tighten the bolts in steps: 35 degrees plus 35 degrees plus 40 degrees for a total of 110 degrees. See **Special Tools and Equipment**.

5. Install the side main bolts. Apply GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the side main bolts.

Tighten: Tighten the side crankshaft main bearing cap bolts to 15 N.m (11 lb ft). Use **J 45059** to tighten the bolts an additional 45 degrees. See **Special Tools and Equipment**.

Piston, Connecting Rod, and Bearing Installation**Tools Required**

- **J 8037** Piston Ring Compressor. See **Special Tools and Equipment**.
- **J 41507** Connecting Rod Guide Assembly. See **Special Tools and Equipment**.
- **J 45059** Angle Meter. See **Special Tools and Equipment**.

Installation Procedure

1. Position the crankshaft so the connecting rod journal is opposite the piston and connecting rod assembly being installed. This will aid in the installation of the connecting rod assembly.
2. Lubricate the cylinder wall with engine oil.
3. Install the connecting rod bearing inserts.
4. Lubricate the connecting rod bearing insert surface with engine oil.

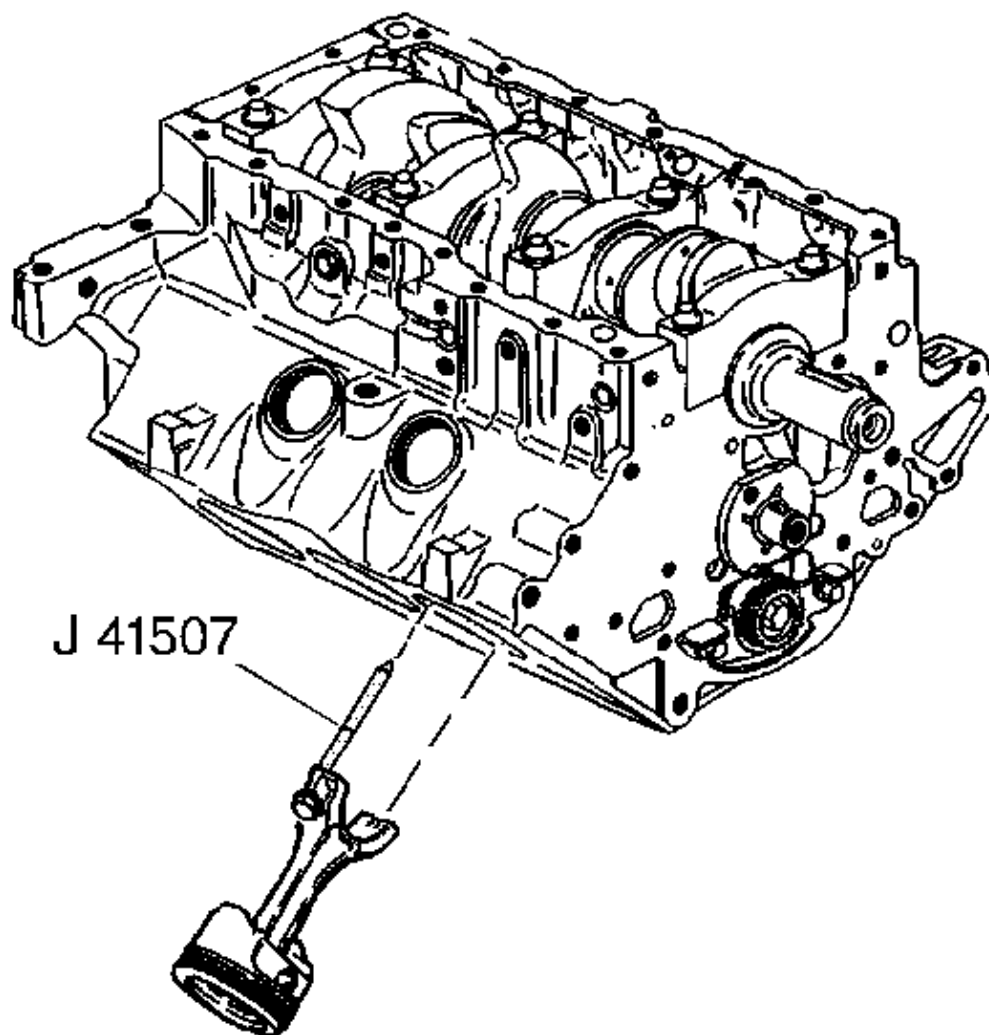


Fig. 297: Installing J 41507 To Connecting Rod
Courtesy of GENERAL MOTORS CORP.

5. Install **J 41507** to the connecting rod. See Special Tools and Equipment. Hand tighten the tool to the connecting rod.
6. Install **J 8037** to the piston. See Special Tools and Equipment.

NOTE: Guide the lower connecting rod end carefully to avoid damaging the crankshaft journal.

7. Use **J 8037** to compress the piston rings for installation of the piston and connecting rod assembly. See **Special Tools and Equipment**.

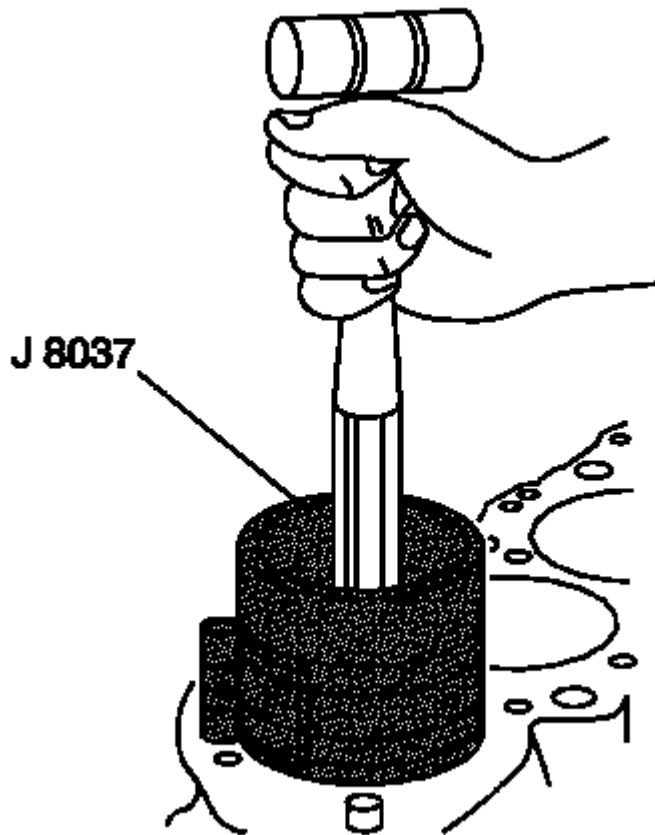


Fig. 298: Installing Piston & Connecting Rod Assembly Into Engine
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the arrow on top of the piston or the markings made during removal face towards the front of the engine or are in the same location as when removed.

8. Install the piston and connecting rod assembly into the engine.
9. Use **J 41507** to pull the connecting rod into place. See **Special Tools and Equipment**.
10. Remove **J 41507** . See **Special Tools and Equipment**.

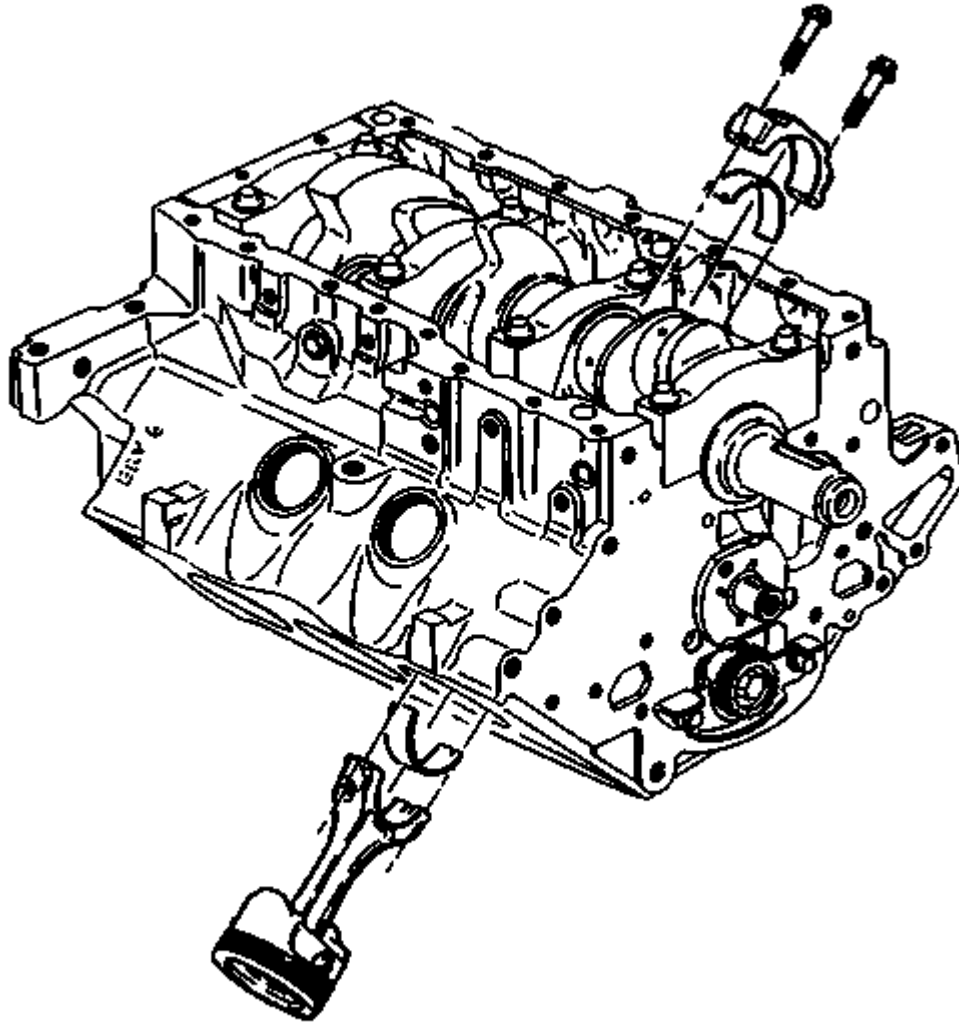


Fig. 299: Identifying Connecting Rod Bolts & Cap
Courtesy of GENERAL MOTORS CORP.

11. Install the connecting rod bearing cap.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

12. Install the connecting rod bearing cap bolts.

Tighten: Tighten the connecting rod bearing cap bolts to 27 N.m (20 lb ft) plus 50 degrees using **J 45059** . See Special Tools and Equipment.

13. Pry the connecting rod back and forth and check for binding. If necessary, loosen and retighten the connecting rod bearing cap.

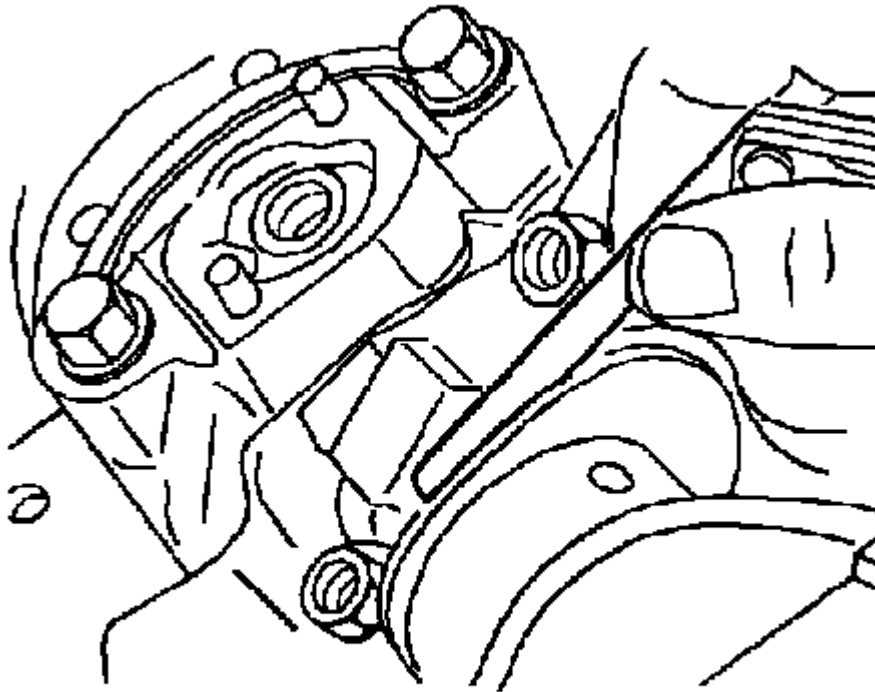


Fig. 300: Measuring Connecting Side Clearance
Courtesy of GENERAL MOTORS CORP.

14. Measure the connecting rod side clearance.

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

- **EN-47623** Rear Main Seal Installer. See Special Tools and Equipment.
- **J 8092** Drive Handle. See Special Tools and Equipment.
- **J 45059** Angle Meter. See Special Tools and Equipment.

Installation Procedure

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.

1. Clean and inspect the crankshaft rear oil seal housing making sure it is free of any foreign material.
2. With all bolts removed from the housing, place it face up on a flat clean surface.
3. Carefully remove protection sleeve from the new rear oil seal assembly.

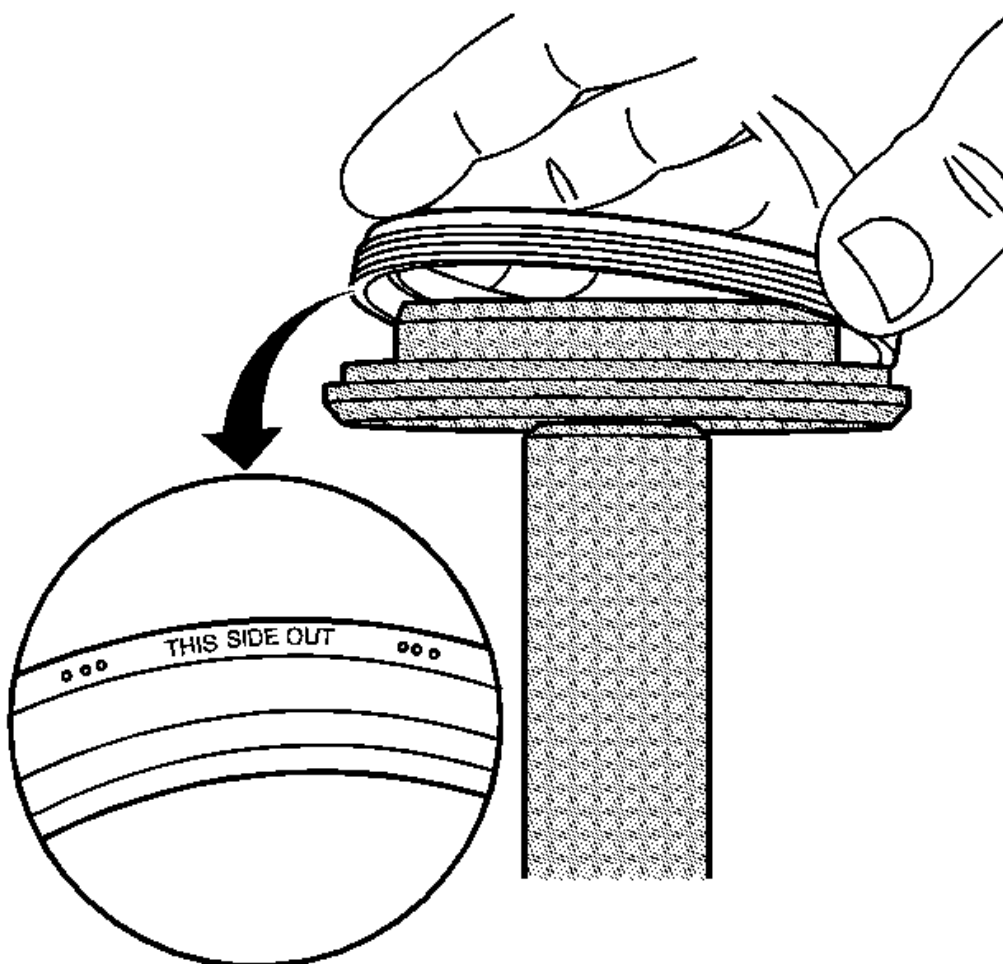


Fig. 301: Positioning Rear Seal To EN-47623

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Notice the direction of the rear oil seal. The new design seal is a reverse style as opposed to what has been used in the past. "THIS SIDE OUT" has been stamped into the seal as shown in the graphic.

4. Install the seal onto **EN-47623** by placing the seal on an angle and using a twisting motion until it is fully seated. See **Special Tools and Equipment**.

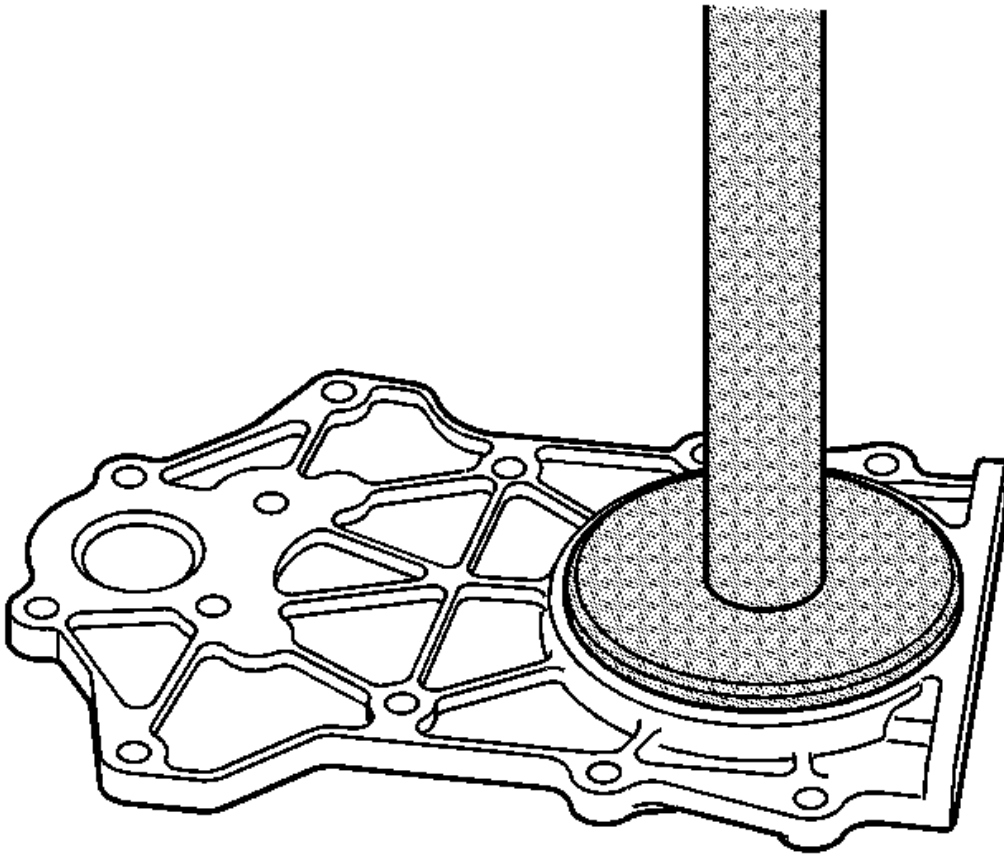


Fig. 302: Installing Crankshaft Rear Oil Seal

Courtesy of GENERAL MOTORS CORP.

5. Place **EN-47623** along with **J 8092** onto the housing as shown and apply a constant downward force until the seal is fully seated. See **Special Tools and Equipment**.

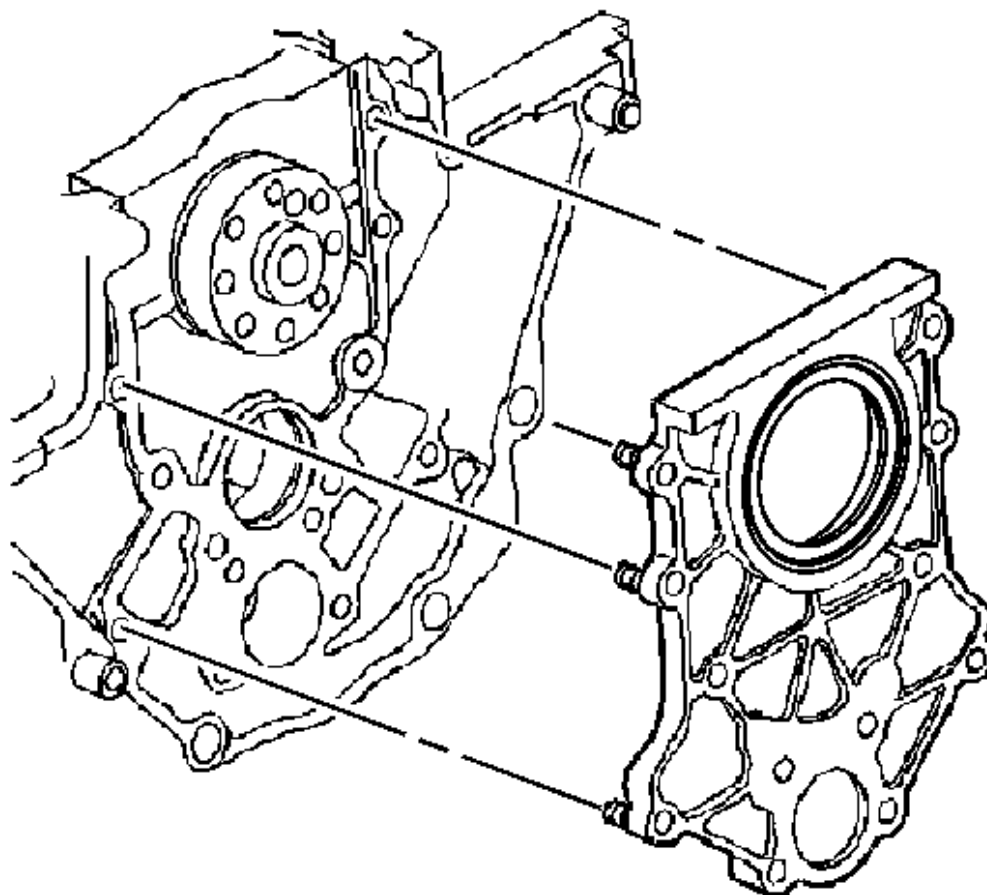


Fig. 303: Locating Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

6. Clean the crankshaft sealing surface with a clean, lint free towel. Inspect the crankshaft sealing surface and leading edge of the crankshaft for burrs/sharp edges that could damage the rear main oil seal. Remove any burrs or sharp edges with crocus cloth before proceeding.

NOTE: Do not use a sealant or adhesive when installing this component. Use of a sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

IMPORTANT: Always install a new crankshaft rear oil seal housing gasket.

7. Install a new crankshaft rear oil seal housing gasket and the housing onto the engine.

IMPORTANT: The plastic inserts found on the rear oil seal housing retaining bolts are used to aid production assembly only. The inserts are not required for service.

8. Install the crankshaft rear oil seal housing bolts and finger tighten.

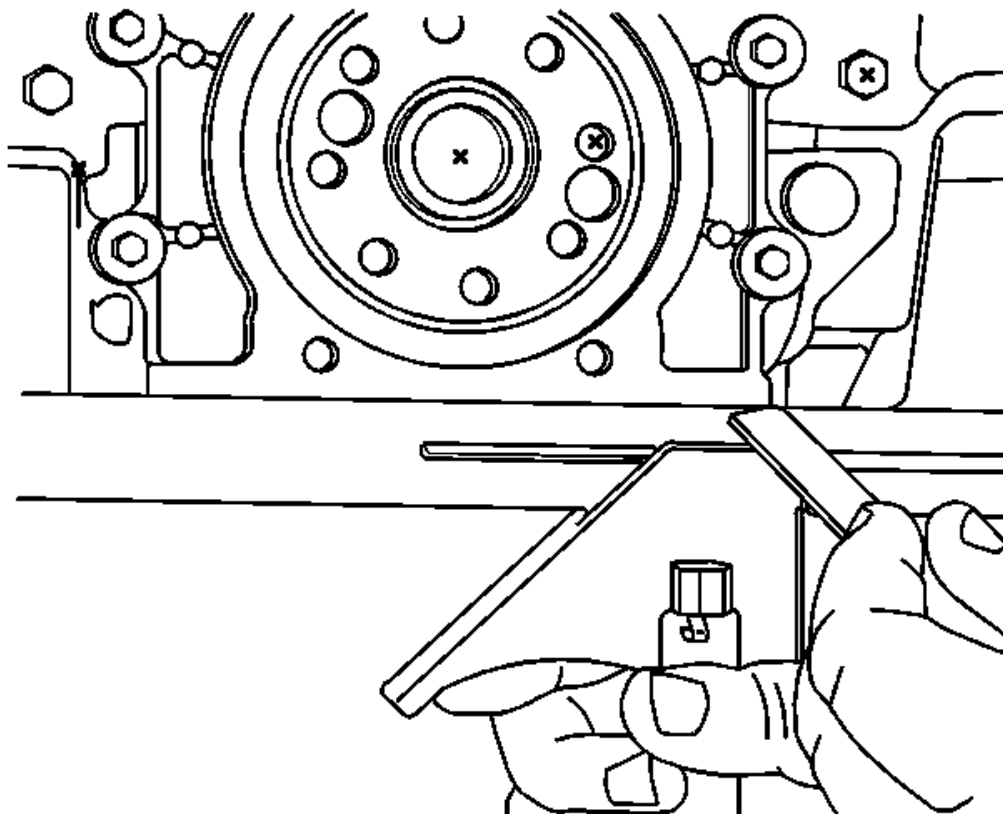


Fig. 304: Measuring Cylinder Block Oil Pan & Rear Oil Seal Housing Flange Clearance
Courtesy of GENERAL MOTORS CORP.

9. Place a straight edge on the engine block oil pan flange and the crankshaft rear oil seal housing flange. Use a feeler gage to ensure there is no more than 0.10 mm (0.004 in) step on each side. If necessary, gently rotate the crankshaft rear oil seal housing to make the step equal on each side.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Tighten the crankshaft rear oil seal housing bolts.

Tighten: Tighten the crankshaft rear oil seal housing bolts to 15 N.m (11 lb ft). Use **J 45059** to tighten the bolts an additional 50 degrees. See **Special Tools and Equipment**.

11. Recheck the step height on each side to ensure the crankshaft rear oil seal housing did not move. If the step height is beyond specification, reinstall the crankshaft rear oil seal housing and measure the step again. Replace the crankshaft rear oil seal housing if the clearance is still beyond specification.

Camshaft Installation

1. Coat the camshaft with prelube GM P/N 12345501 (Canadian P/N 992704) or the equivalent.
2. Install the camshaft.

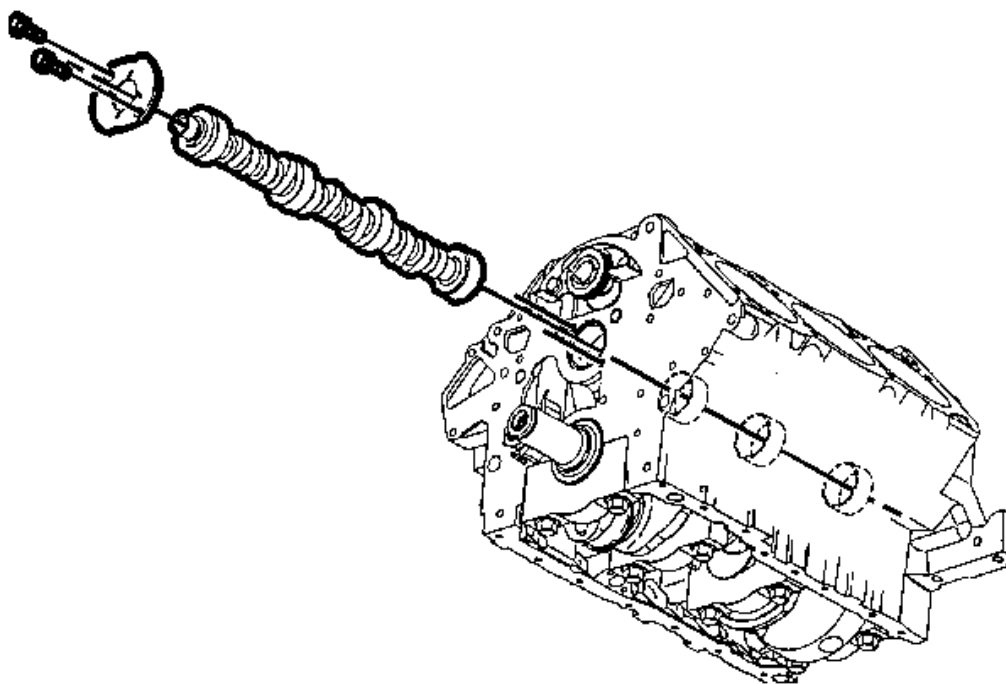


Fig. 305: Installing Camshaft & Camshaft Thrust Plate
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft thrust plate.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft thrust plate bolts.

Tighten: Tighten the bolts to 15 N.m (11 lb ft).

Balance Shaft Installation

Tools Required

- **J 8001** Dial Indicator Set. See Special Tools and Equipment.
- **J 21465-13** Drive Handle Extension
- **J 36996** Balance Shaft Installer. See Special Tools and Equipment.
- **J 45059** Angle Meter. See Special Tools and Equipment.

Installation Procedure

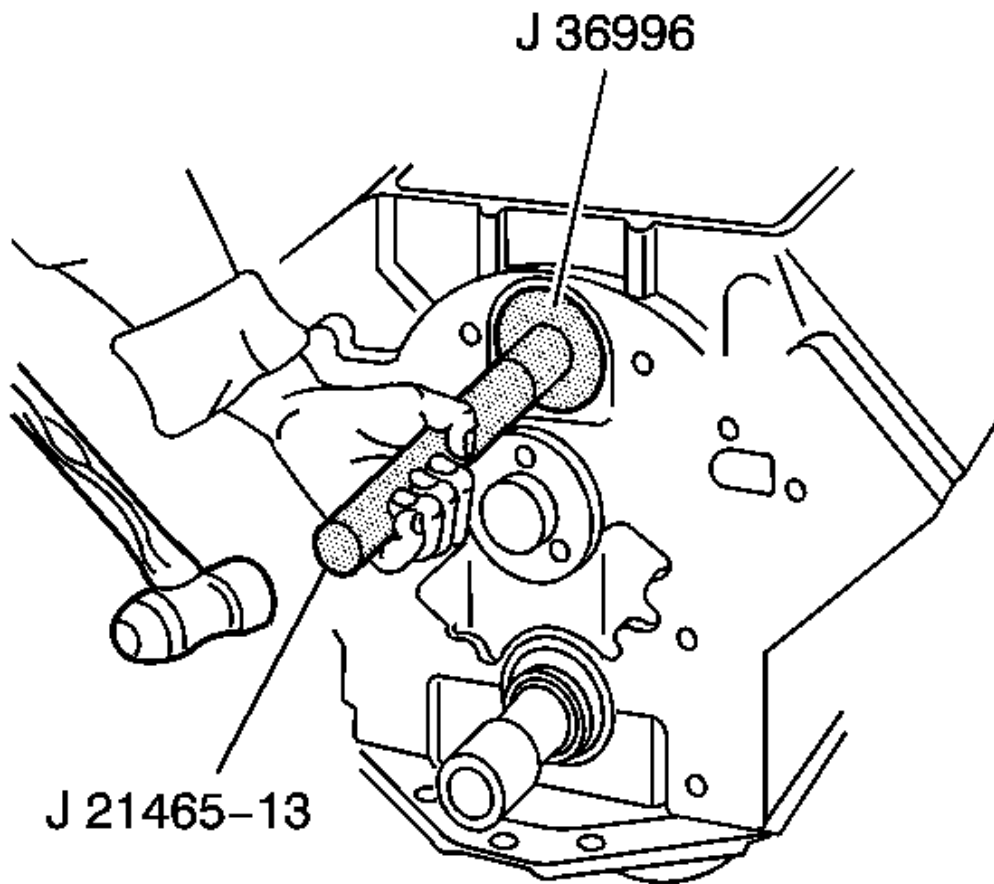


Fig. 306: Installing Balance Shaft Into Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Use J 21465-13 and J 36996 to install the balance shaft into the engine block. See **Special Tools and Equipment**.

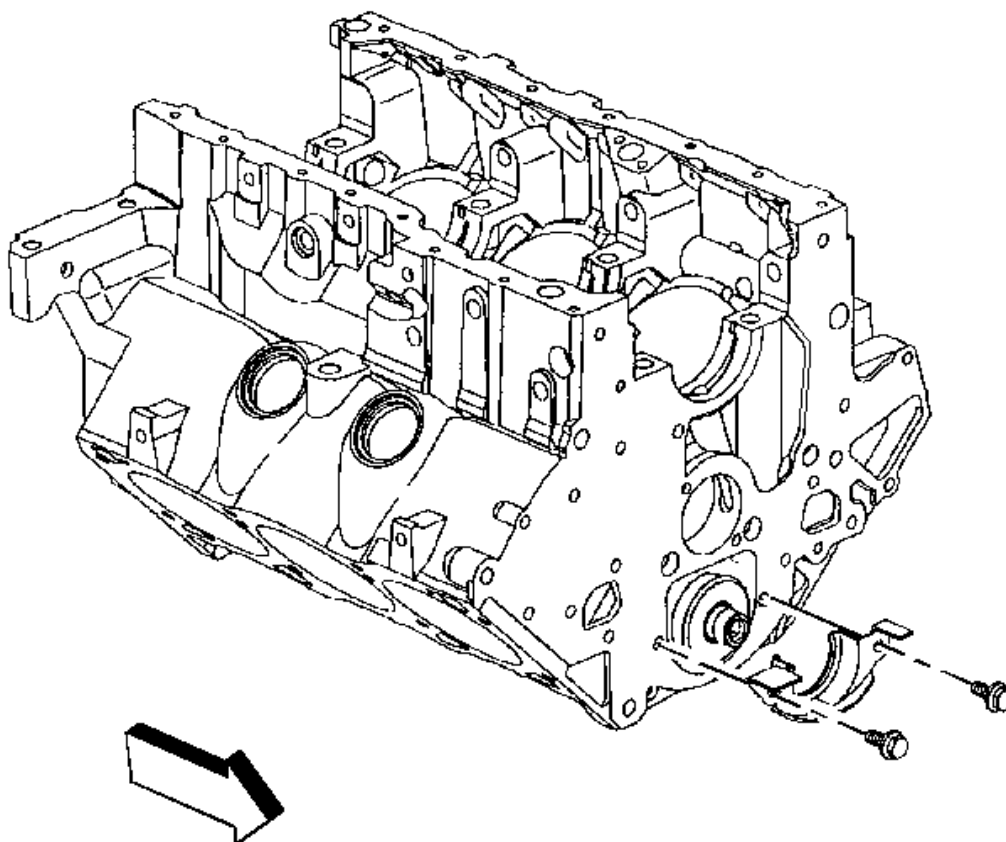


Fig. 307: Locating Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the balance shaft retainer.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the balance shaft retainer bolts.

Tighten: Tighten the balance shaft retainer bolts to 30 N.m (22 lb ft).

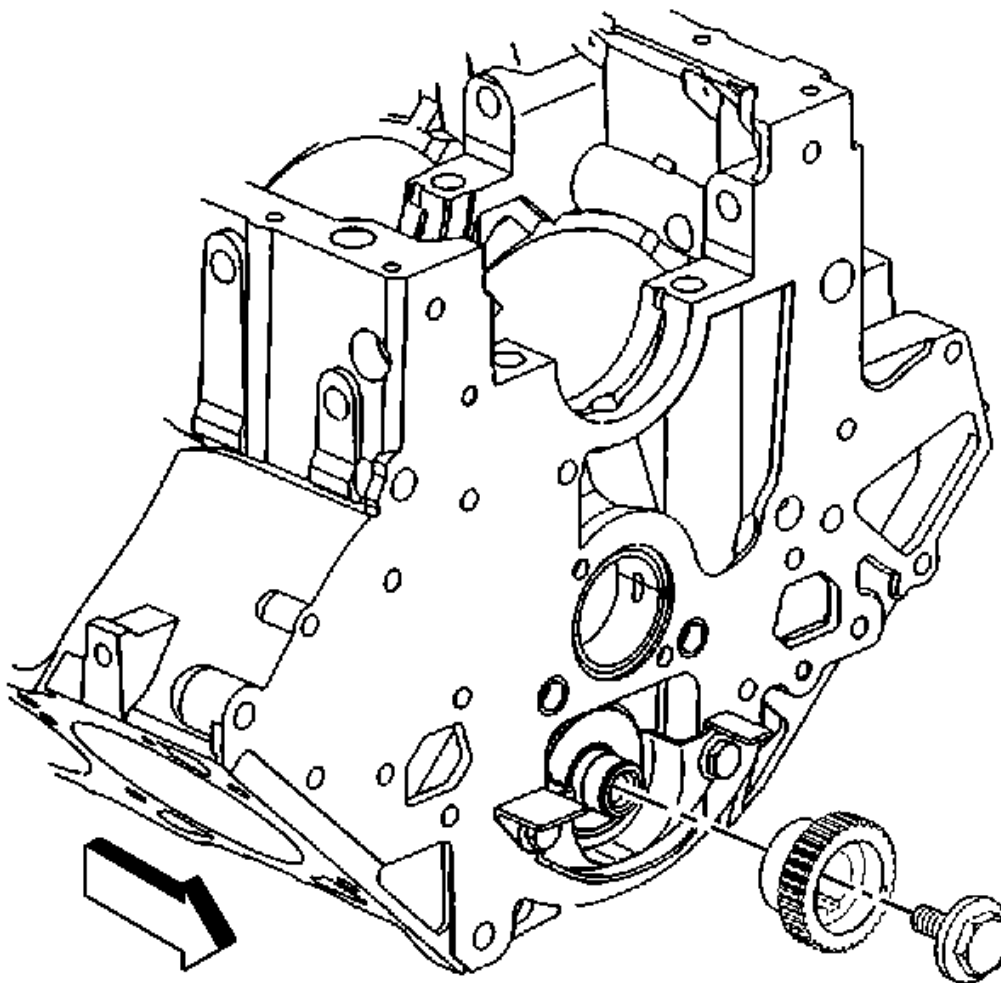


Fig. 308: Locating Balance Shaft Driven Gear & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the balance shaft driven gear.

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

5. Install the balance shaft driven gear bolt.

Tighten: Tighten the balance shaft driven gear bolt to 22 N.m (16 lb ft). Use **J 45059** to tighten the bolt an additional 70 degrees. See **Special Tools and Equipment**.

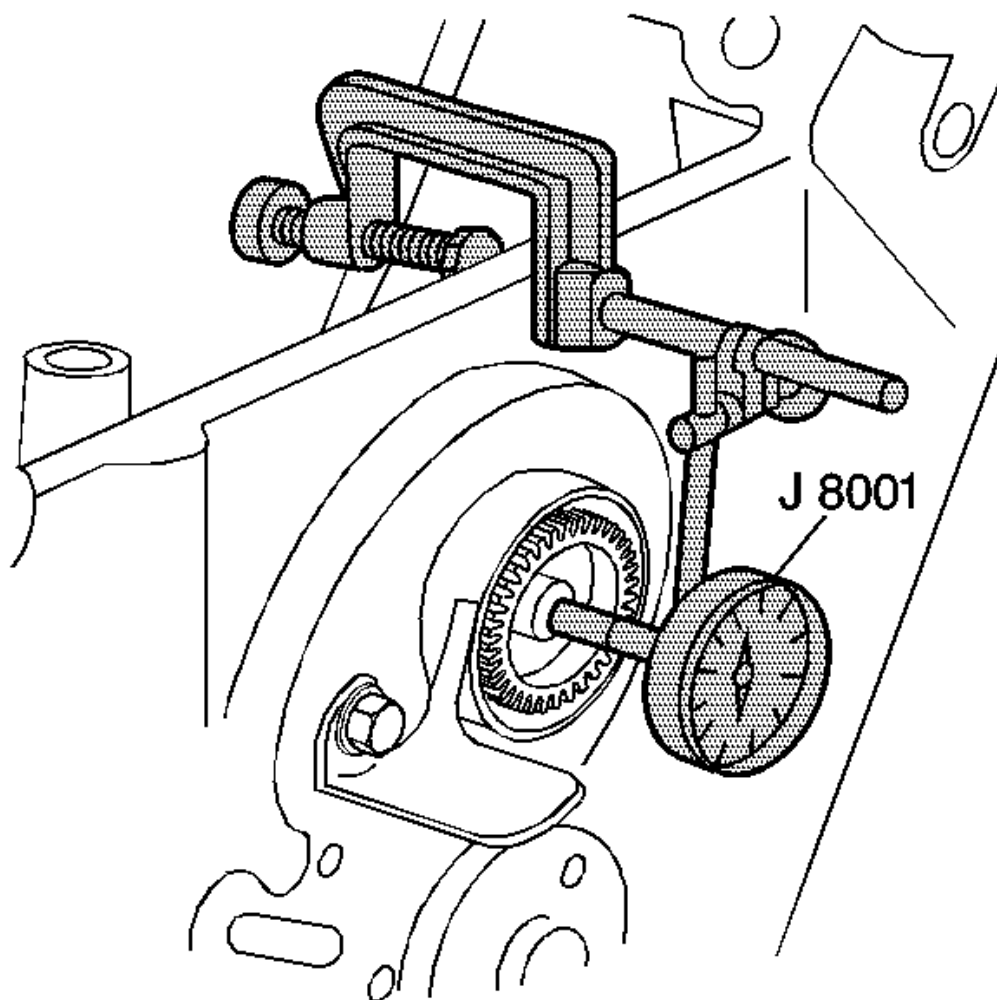


Fig. 309: Measuring Balance Shaft End Play
Courtesy of GENERAL MOTORS CORP.

6. Using **J 8001** measure the balance shaft end play. See **Special Tools and Equipment**. End play must not exceed 0.028 mm (0.008 in).

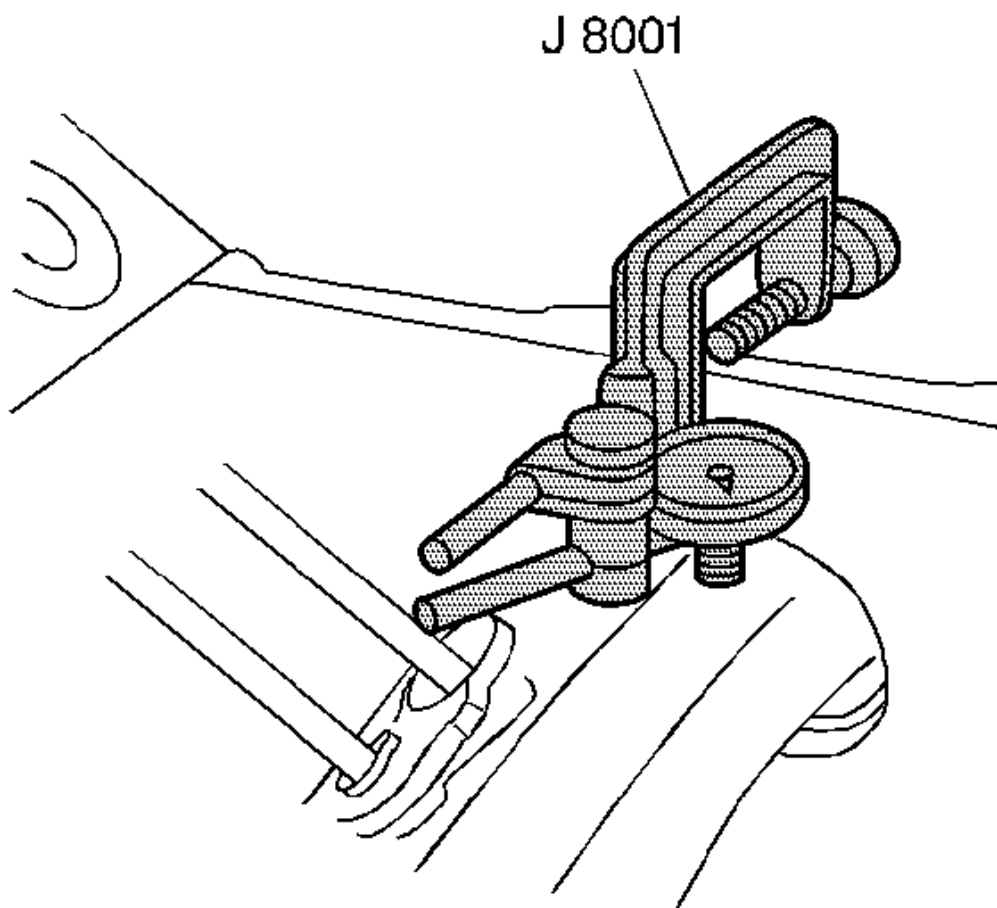


Fig. 310: Measuring Balance Shaft Radial Play At Rear
Courtesy of GENERAL MOTORS CORP.

7. Using **J 8001** measure the balance shaft radial play at the rear. See **Special Tools and Equipment**. Radial play must be between 0.0127-0.119 mm (0.0005-0.0047 in).
8. Install the balance shaft drive gear.
9. Install the camshaft sprocket.
10. Turn the camshaft so the timing mark on the camshaft sprocket is straight down.
11. Remove the camshaft sprocket and balance shaft drive gear.
12. Turn the balance shaft so the timing mark on the balance shaft driven gear points straight down.
13. Partially install the balance shaft drive gear so the gear teeth are not engaged.
14. Align the marks on the balance shaft driven gear and the balance shaft drive gear. Do this by turning the balance shaft.

15. Once marks are aligned, fully seat balance shaft drive gear and engage gear teeth.
16. Turn the crankshaft so the number one piston is at top dead center.
17. Install the timing chain and camshaft sprocket.

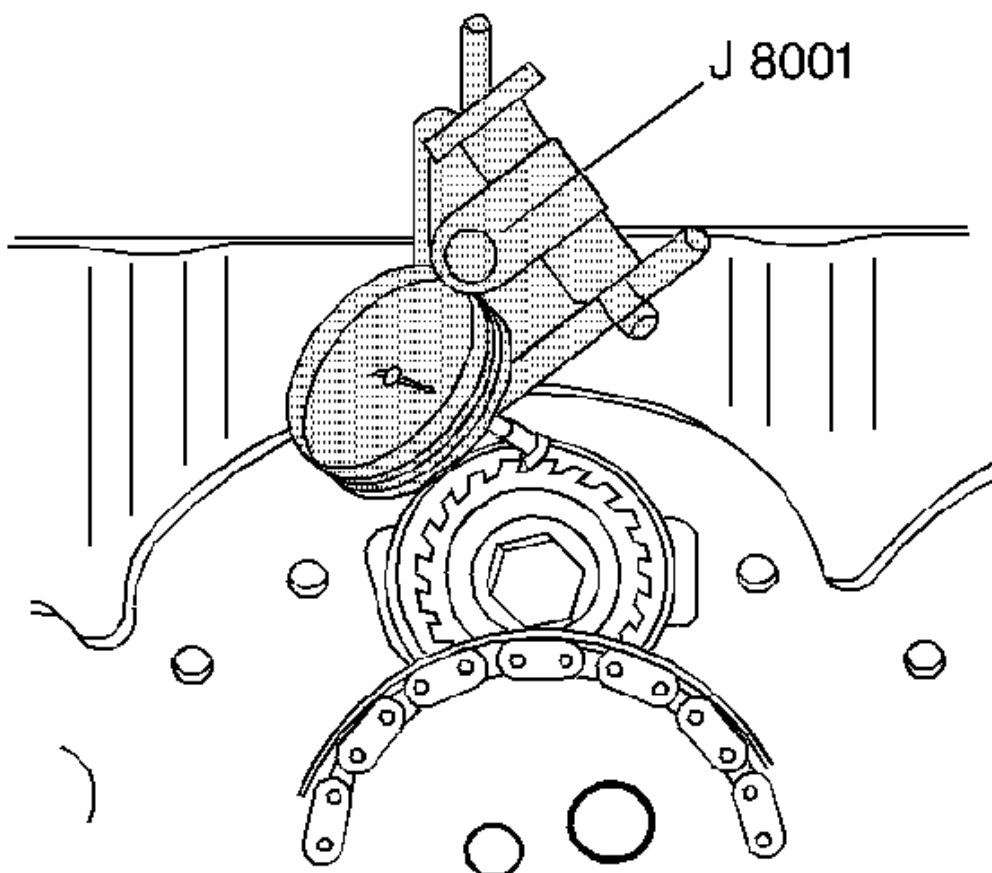


Fig. 311: Measuring Gear Lash At Four Places
Courtesy of GENERAL MOTORS CORP.

18. Using **J 8001** measure the gear lash at four places. See **Special Tools and Equipment**. Measure every quarter turn. Gear lash must be between 0.050-0.127 mm (0.002-0.005 in).

Timing Chain and Sprockets Installation (L36)

Tools Required

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

Installation Procedure

1. Install the crankshaft balancer key into the crankshaft keyway.

The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.

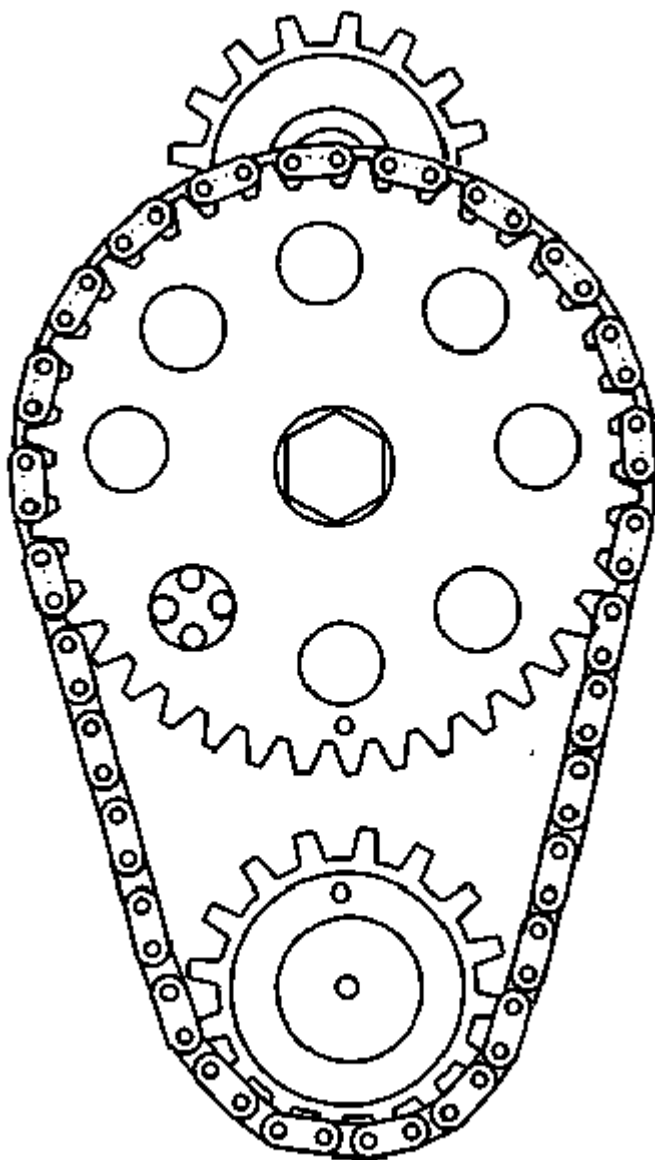


Fig. 312: Installing Timing Chain On Sprockets, Aligning Timing Marks

Courtesy of GENERAL MOTORS CORP.

2. Install the timing chain on the sprockets. Align the timing marks.
3. Install the timing chain, the crankshaft sprocket, and the camshaft sprocket.

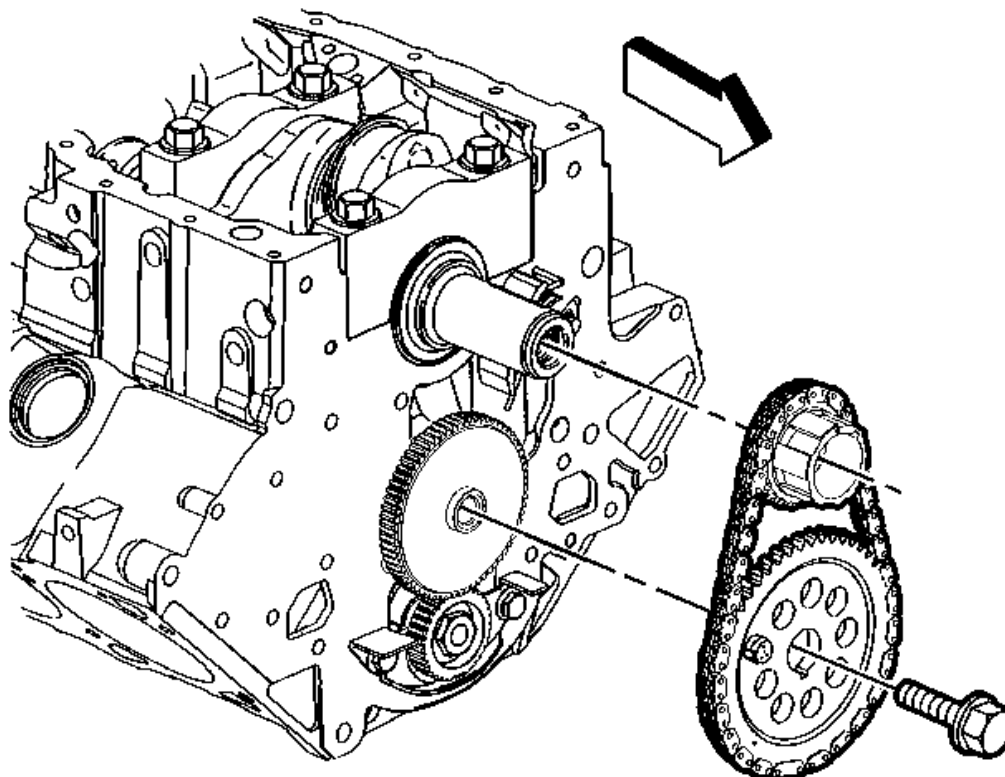


Fig. 313: Identifying Camshaft Sprocket Bolt (L36)
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft sprocket bolt.

Tighten: Tighten the camshaft sprocket bolt to 100 N.m (74 lb ft). Use **J 45059** to tighten the camshaft sprocket bolt an additional 90 degrees. See Special Tools and Equipment.

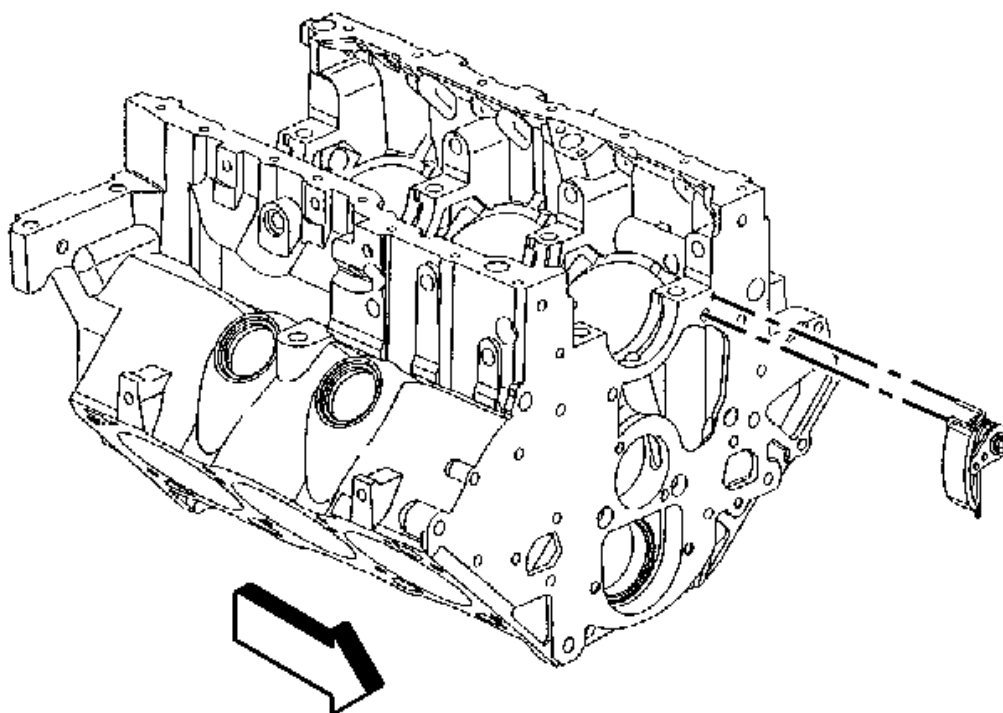


Fig. 314: View Of Timing Chain Dampener
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain dampener.

Tighten: Tighten the timing chain dampener bolt to 22 N.m (16 lb ft).

Engine Front Cover Installation

Tools Required

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

Installation Procedure

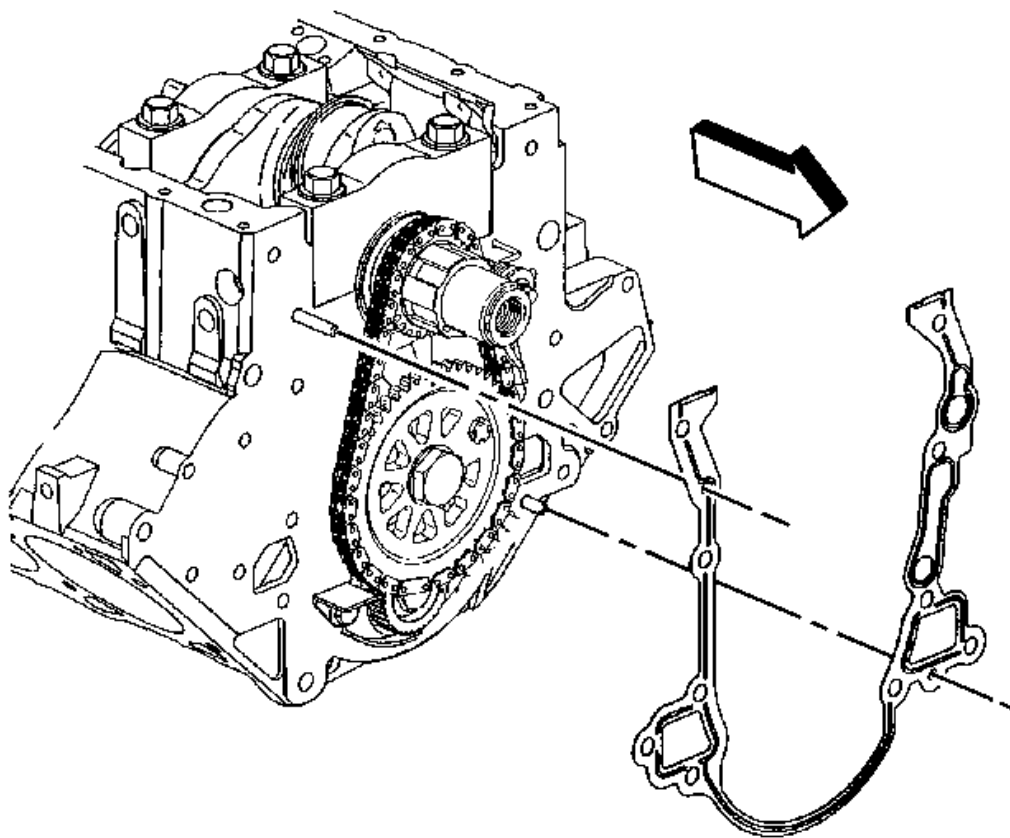


Fig. 315: Locating Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover gasket.

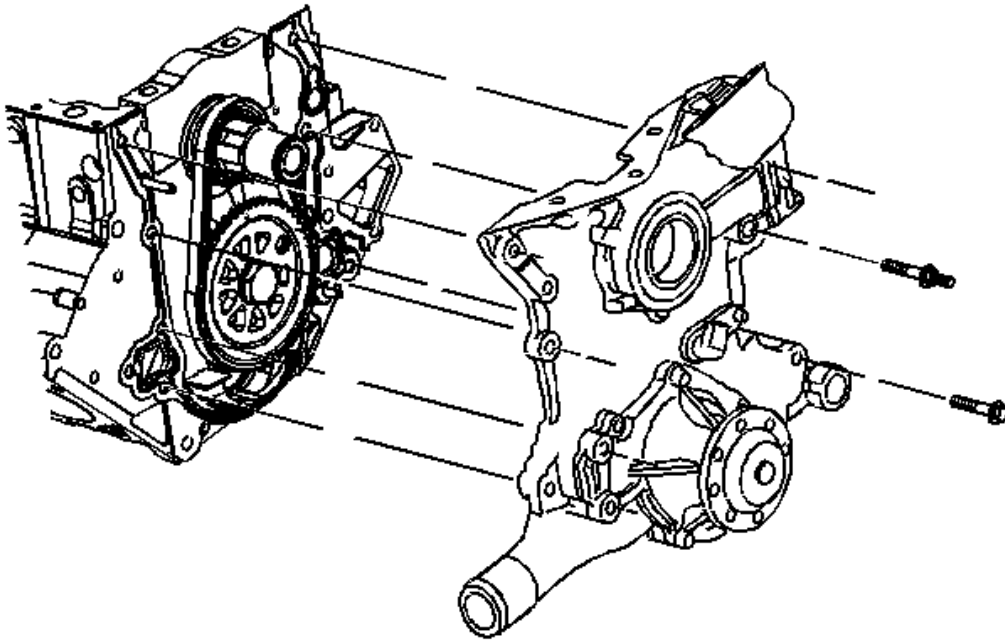


Fig. 316: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

2. Install the engine front cover.

Align the cogs on the crankshaft sprocket with the cogs on the oil pump in the engine front cover.

3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or the equivalent to the engine front cover bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the engine front cover bolts.

Tighten: Tighten the engine front cover bolts to 20 N.m (15 lb ft). Use the **J 45059** to tighten the engine front cover bolts an additional 40 degrees. See **Special Tools and Equipment**.

5. Install the oil pan to engine front cover bolts.

Tighten: Tighten the oil pan bolts to 14 N.m (125 lb in).

6. Install the oil filter.

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

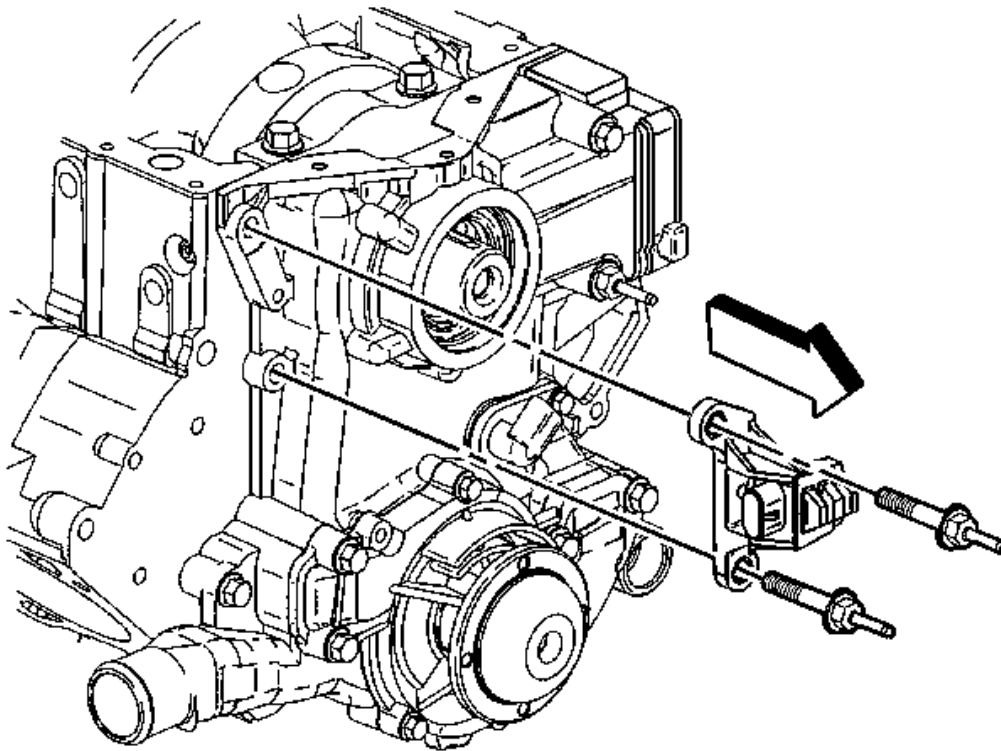


Fig. 317: Locating Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft position (CKP) sensor.

Tighten: Tighten the CKP sensor studs to 30 N.m (22 lb ft).

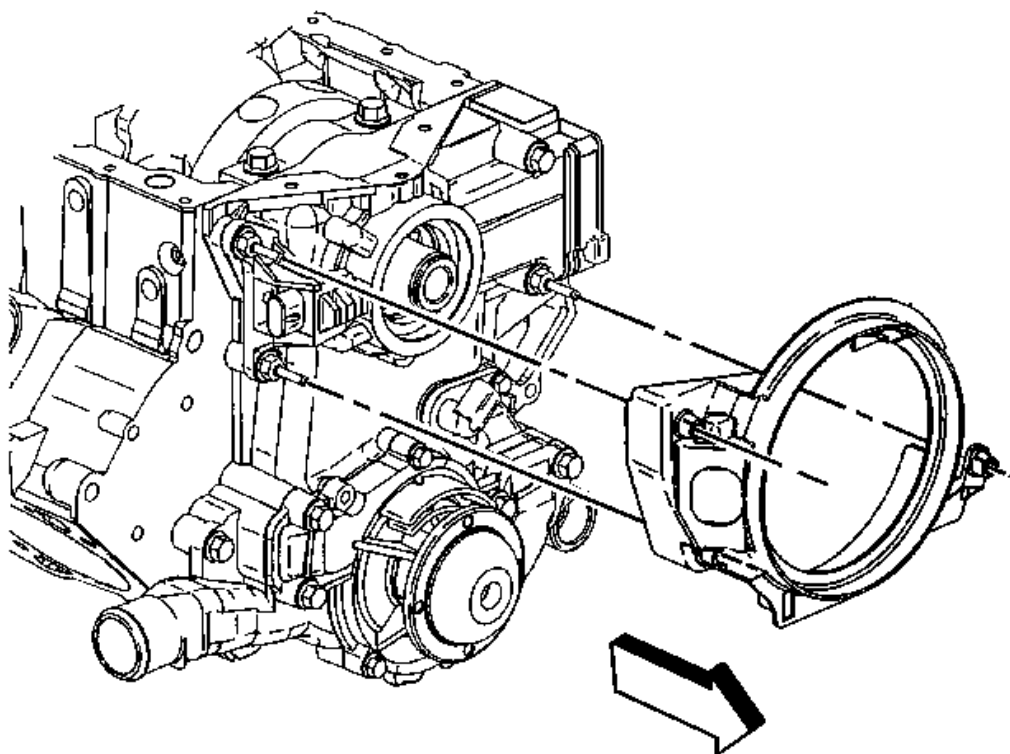


Fig. 318: Locating Crankshaft Position Sensor Shield
Courtesy of GENERAL MOTORS CORP.

8. Install the CKP sensor shield.

Crankshaft Front Oil Seal Installation

Tools Required

J 35354 Seal Installer. See **Special Tools and Equipment**.

Installation Procedure

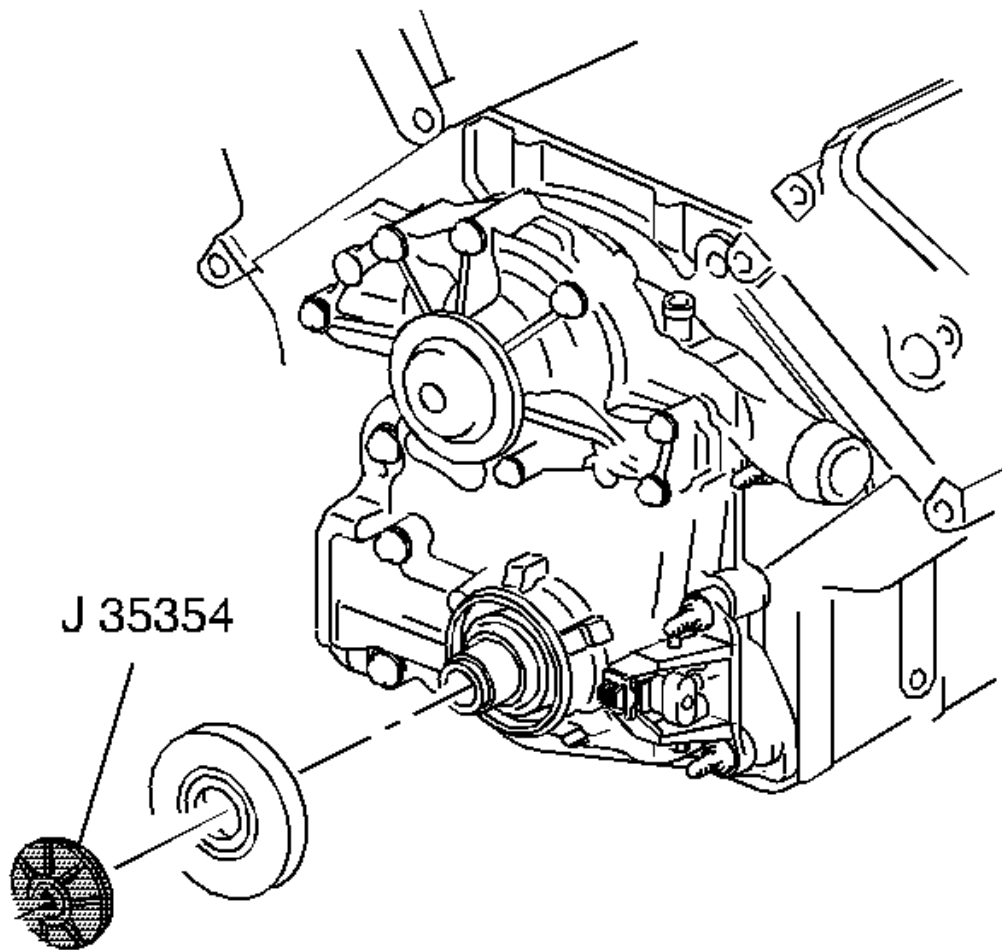


Fig. 319: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Coat the inside diameter of the crankshaft front oil seal with lubricant GM P/N 12345616 (Canadian P/N 993182) or the equivalent.
2. Use **J 35354** and a soft faced hammer to install the crankshaft front oil seal. See **Special Tools and Equipment**.
3. Remove **J 35354** . See **Special Tools and Equipment**.

Oil Filter Adapter Installation

Tools Required

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

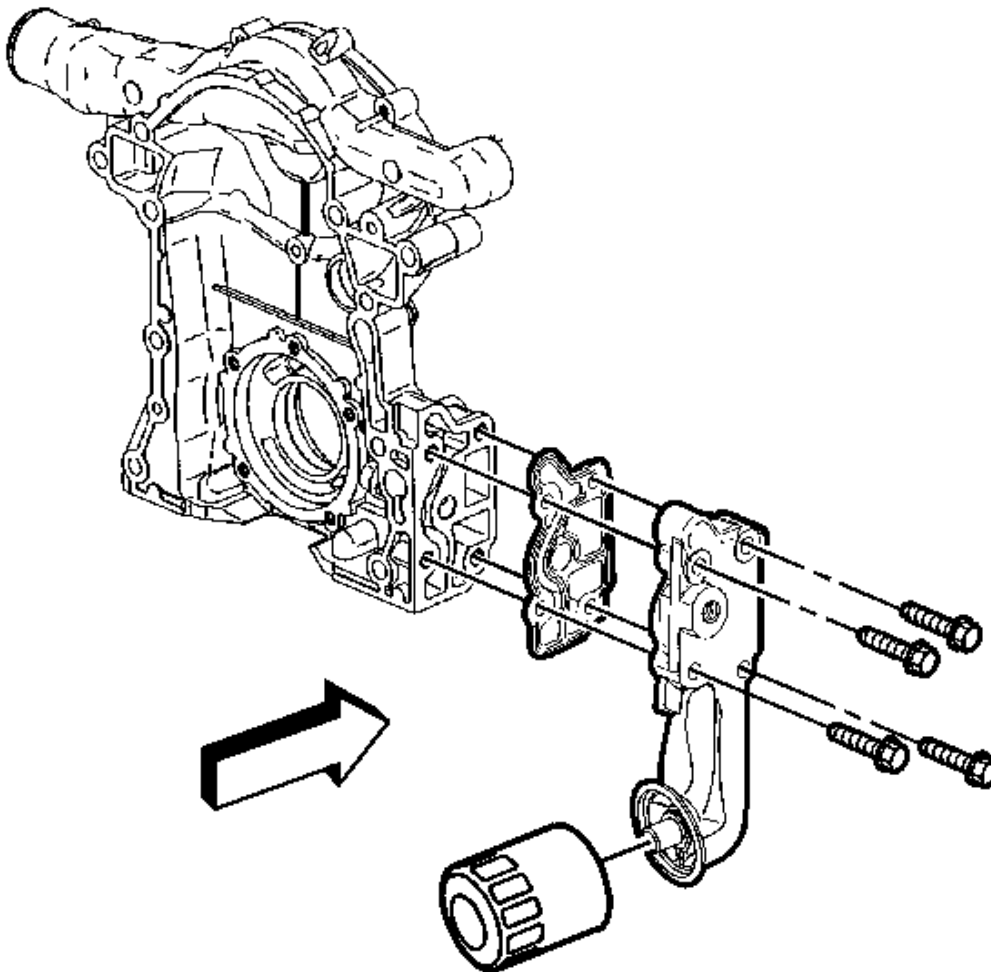
Installation Procedure

Fig. 320: Locating Oil Filter Adapter Components
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pressure relief valve spring into the engine front cover.
2. Install the oil pressure relief valve into the engine front cover.
3. Install a new oil filter adapter gasket.
4. Install the oil filter adapter.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil filter adapter bolts.

Tighten: Tighten the oil filter adapter bolts to 15 N.m (11 lb ft).

Using **J 45059** rotate each bolt an additional 50 degrees. See **Special Tools and Equipment**.

6. Install the oil filter.

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

Oil Pump Pipe and Screen Assembly Installation

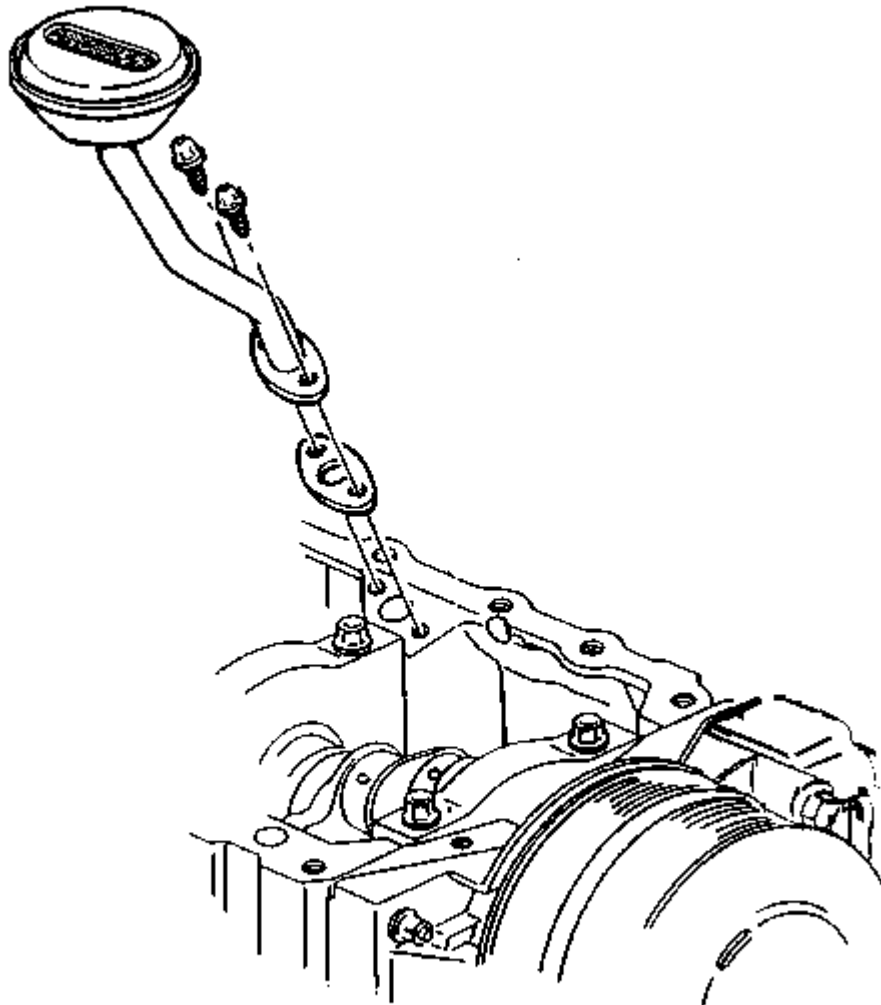


Fig. 321: View Of Oil Pump Pipe & Screen Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump pipe and screen assembly gasket.

IMPORTANT: The oil pan gasket must be installed before the oil pump pipe and screen assembly.

2. Install the oil pan gasket.
3. Install the oil pump pipe and screen assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump pipe and screen assembly bolts.

Tighten: Tighten the bolts to 15 N.m (11 lb ft).

Oil Pan Installation

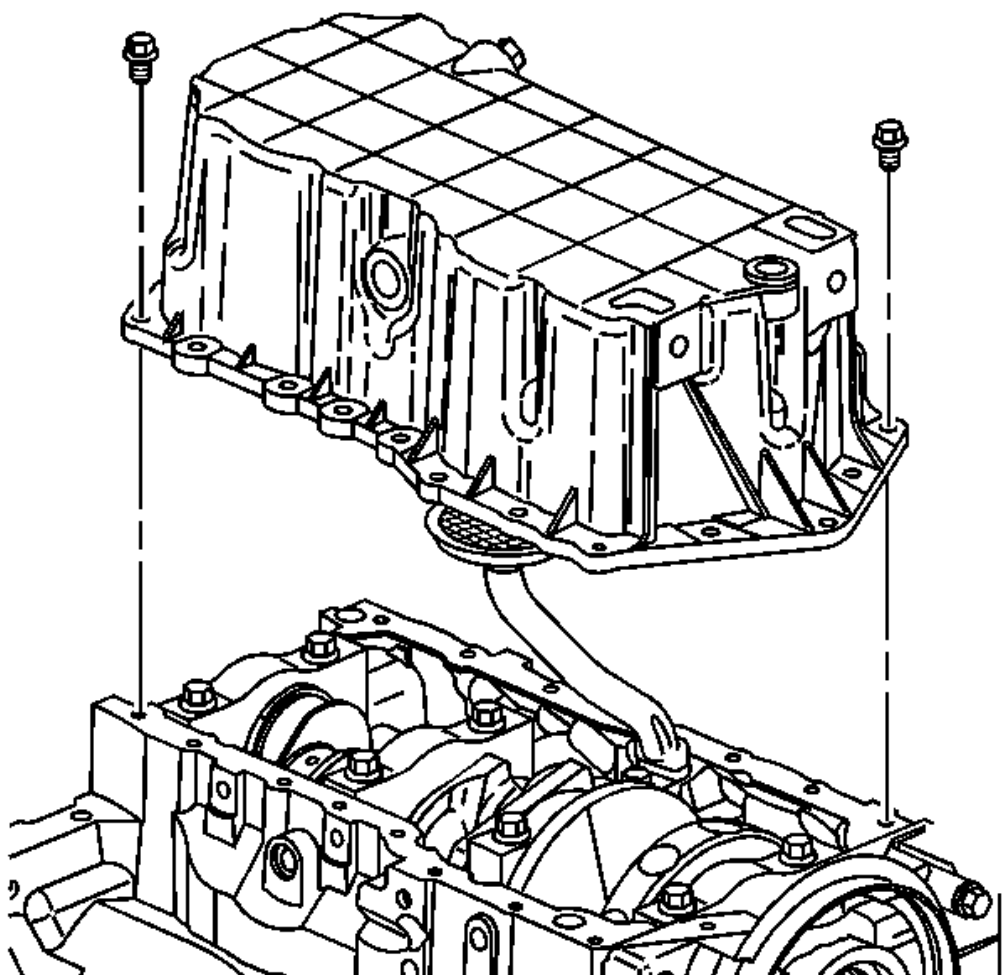


Fig. 322: Locating Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply a continuous bead 3.0 mm (0.19 in) thick of RTV GM P/N 12378521 (Canadian P/N 88901148), or equivalent to the oil pan flange on the block as well as an additional drop to all four corners of the

block where the front and rear covers meet.

2. Install the oil pan.
3. Clean the oil pan bolts.
4. Apply one drop of GM P/N 12345382 (Canadian P/N 10953489), to each bolt.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pan bolts.

Tighten: Tighten the bolts to 14 N.m (125 lb in).

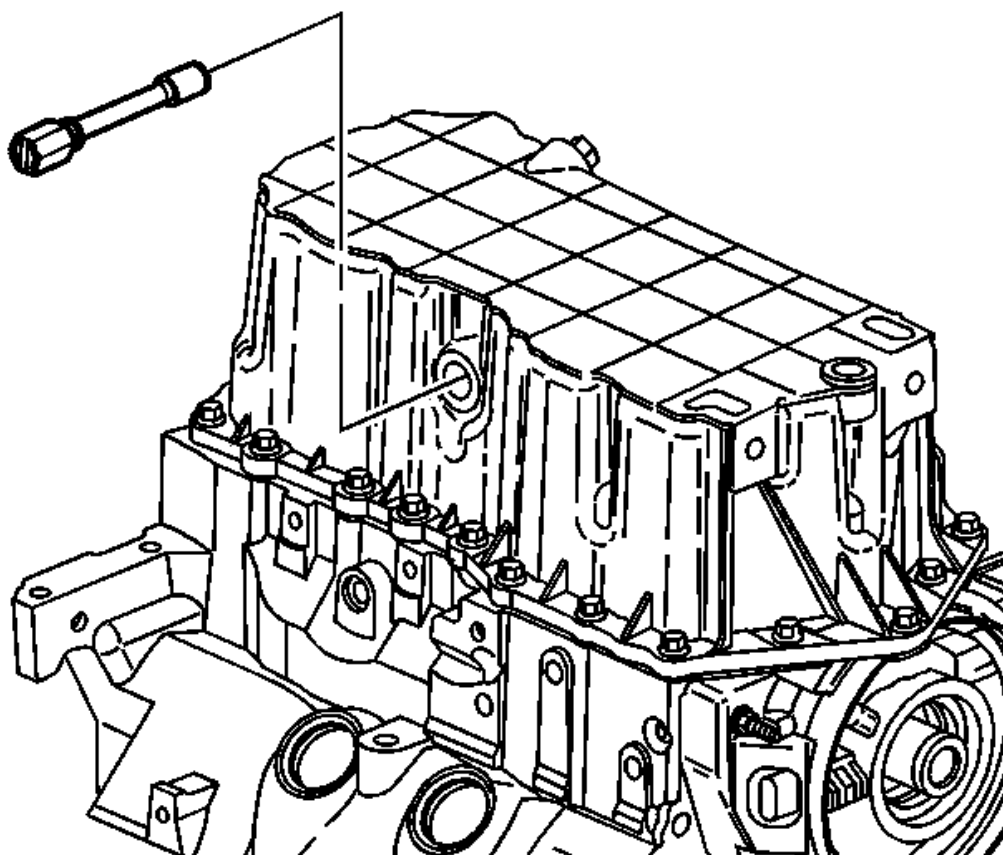


Fig. 323: Locating Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the oil level sensor, located in the oil pan, after the oil pan is

installed. The sensor may be damaged if the oil level sensor is installed first.

6. Install the oil level sensor.

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

Valve Lifter Installation

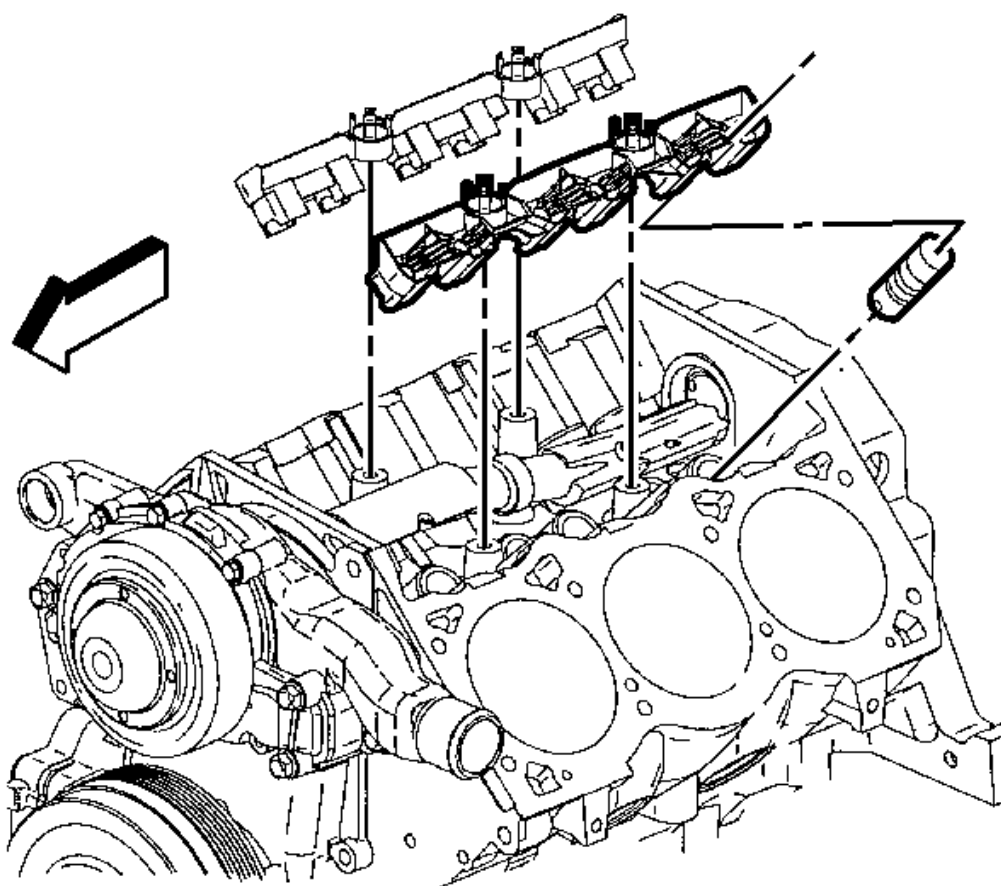


Fig. 324: Removing/Installing Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Dip the valve lifters in prelube GM P/N 12345501 (Canadian 992704) or the equivalent.
2. Install the valve lifters.
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 valve lifter guide bolts to 30 N.m (22 lb ft).

Cylinder Head Installation - Right

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

Installation Procedure

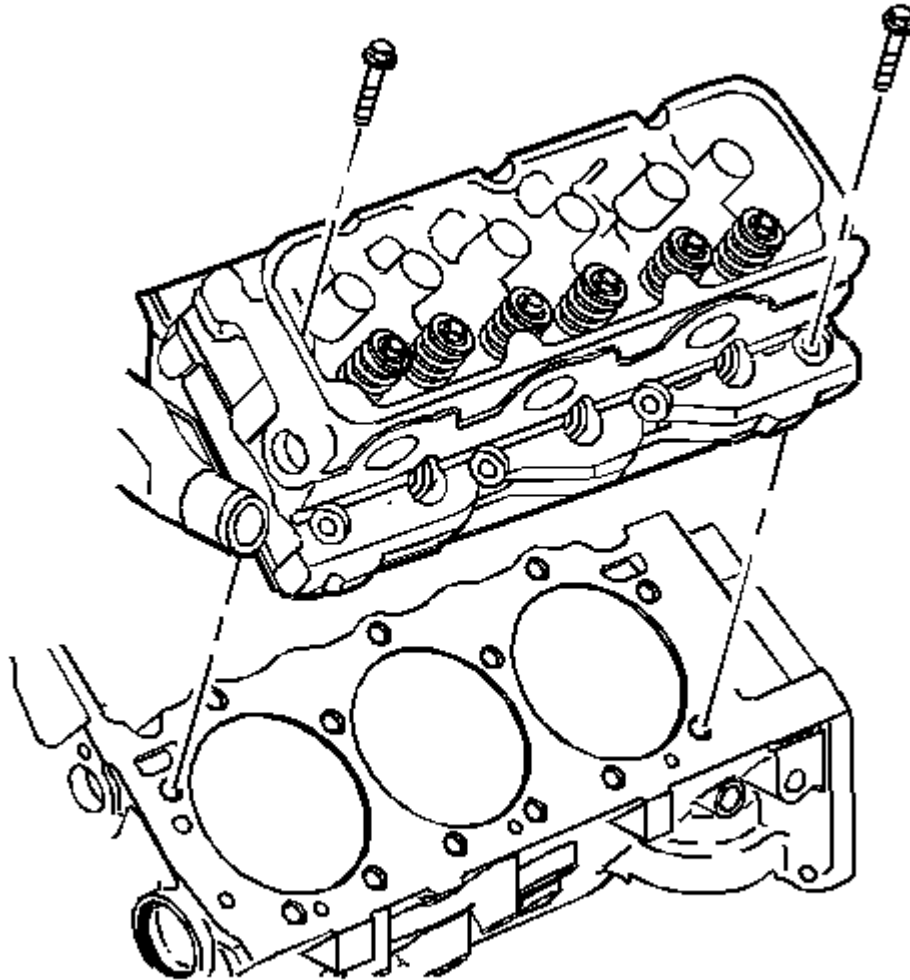


Fig. 325: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the cylinder head gasket. Ensure the arrows point towards the front of the engine. The right cylinder head gasket has the letter R stamped next to the arrow.
2. Install the cylinder head.

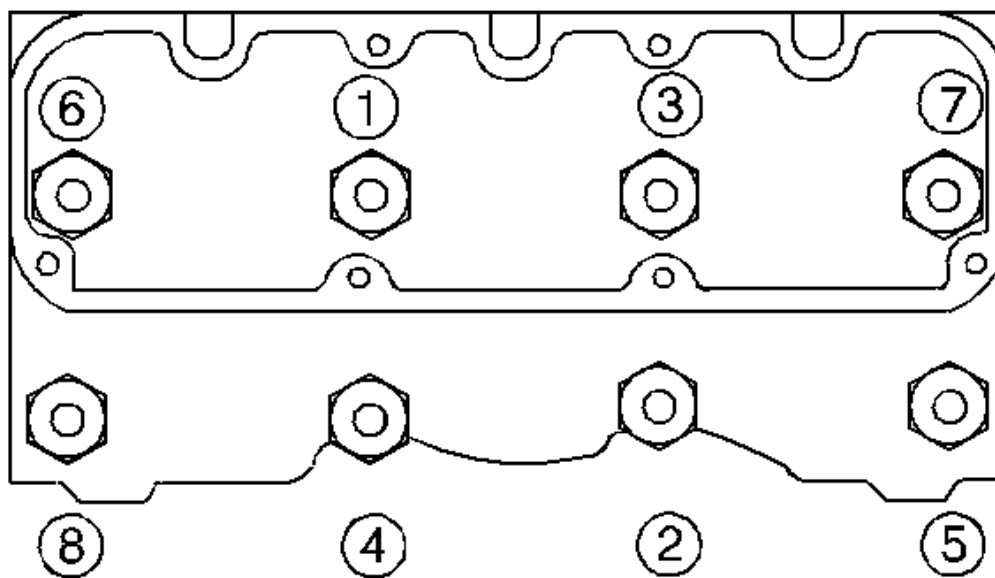


Fig. 326: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install new cylinder head bolts.

Tighten: Tighten the cylinder head bolts to 50 N.m (37 lb ft) in sequence. Using **J 45059** rotate each cylinder head bolt an additional 120 degrees. See Special Tools and Equipment.

Cylinder Head Installation - Left

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

Installation Procedure

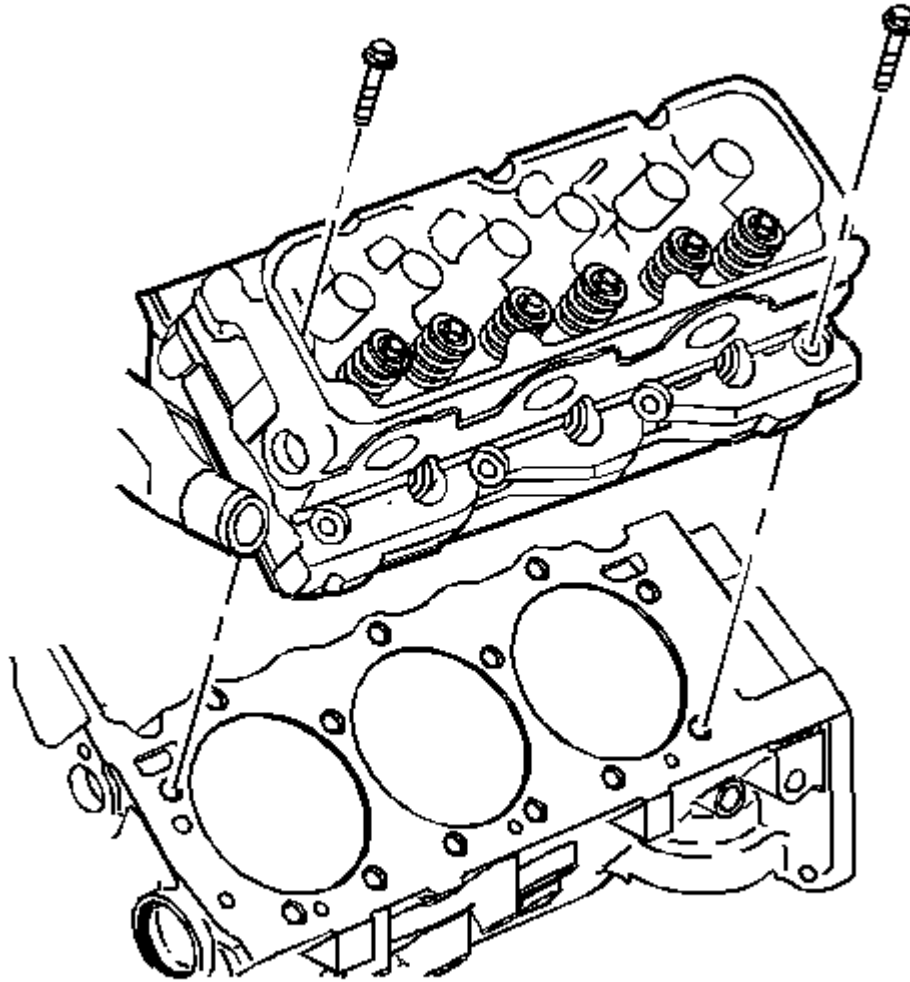


Fig. 327: Identifying Cylinder Head & Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the cylinder head gasket. Ensure the arrows point towards the front of the engine. The left cylinder head gasket has the letter L stamped next to the arrow.
2. Install the cylinder head.

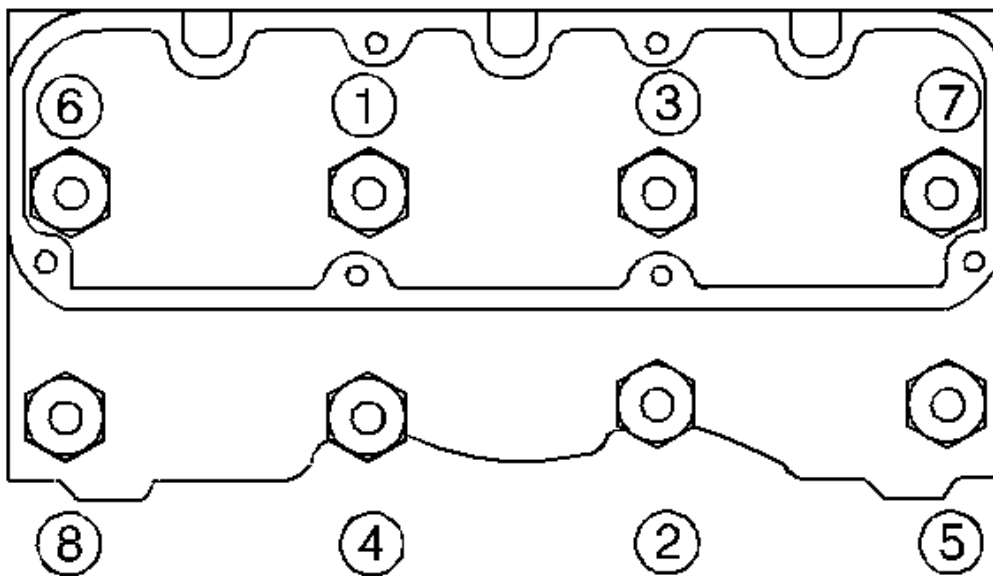


Fig. 328: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install new cylinder head bolts.

Tighten: Tighten the cylinder head bolts to 50 N.m (37 lb ft) in sequence. Using **J 45059** rotate each cylinder head bolt an additional 120 degrees. See Special Tools and Equipment.

Valve Rocker Arm and Push Rod Installation

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

Installation Procedure

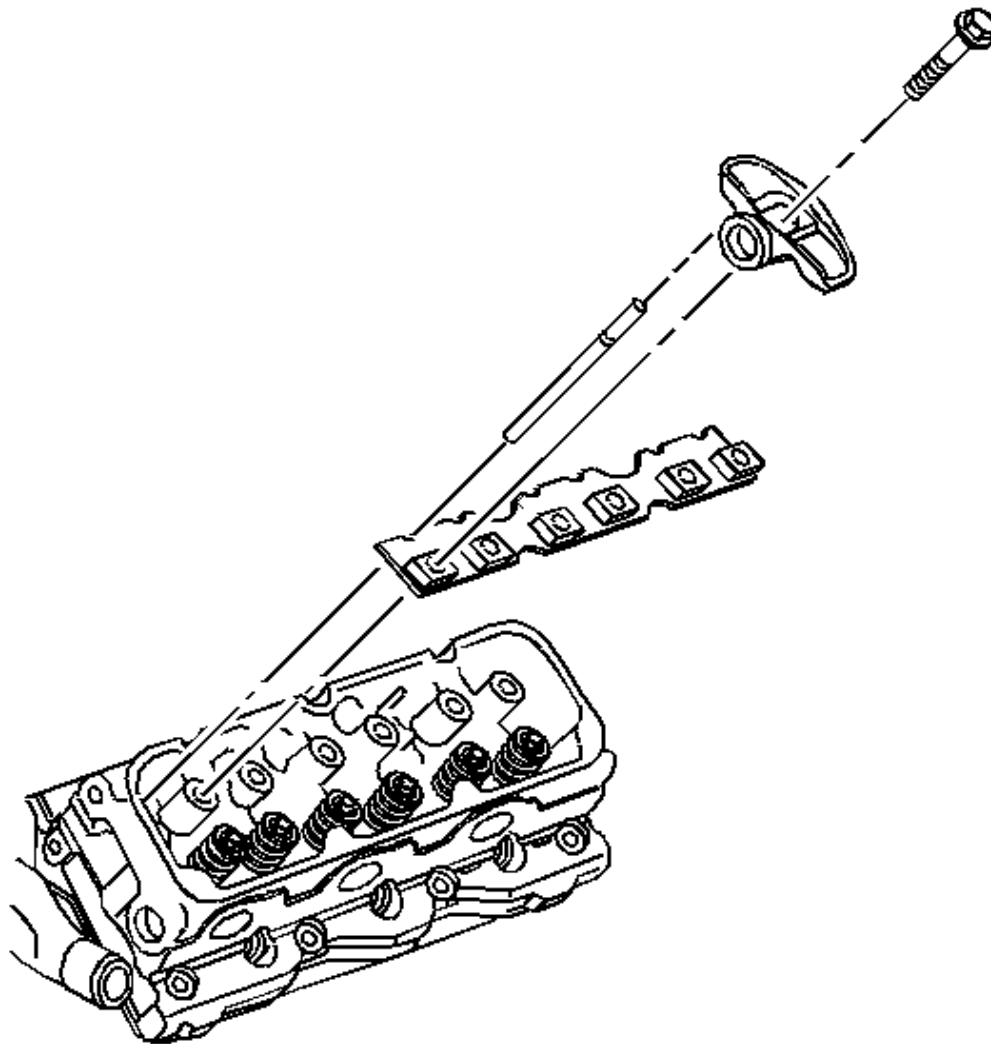


Fig. 329: View Of Valve Rocker Arm, Bolt, Push Rod & Push Rod Guide Plate
Courtesy of GENERAL MOTORS CORP.

1. Install the pushrod guide plate.
2. Install the push rods.
3. Install the valve rocker arm bearing retainer.
4. Coat the valve stem tip and pushrod tip with prelube GM P/N 1052367 (Canadian P/N 992869) or equivalent.
5. Install the valve rocker arms.

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

6. Apply threadlocker GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the valve rocker arm bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the valve rocker arm bolts.

Tighten: Tighten the valve rocker arm bolts to 15 N.m (11 lb ft) plus 90 degrees using **J 45059** . See Special Tools and Equipment.

Valve Rocker Arm Cover Installation - Right

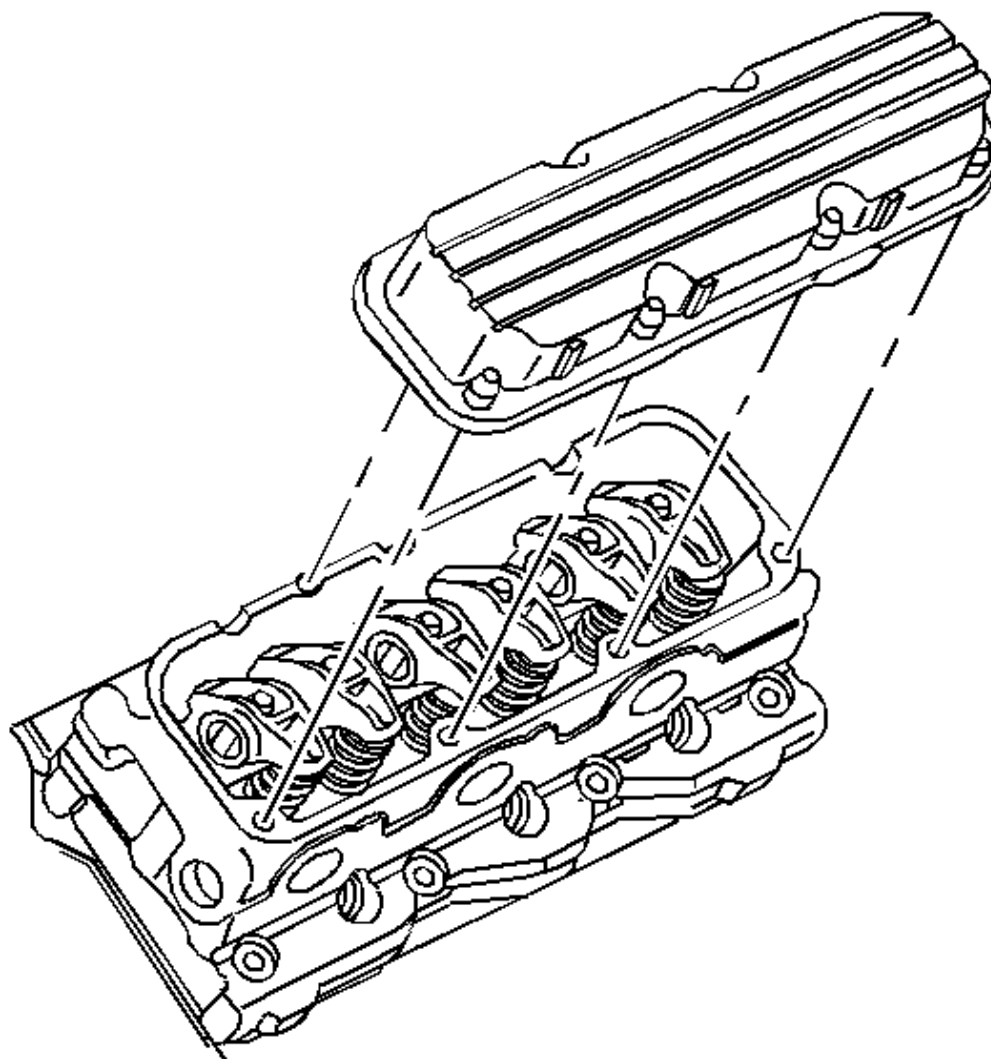


Fig. 330: Locating Right Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the valve rocker arm cover.
2. Apply GM P/N 12345382 (Canadian P/N 10953489) threadlocker or the equivalent to the threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

Valve Rocker Arm Cover Installation - Left

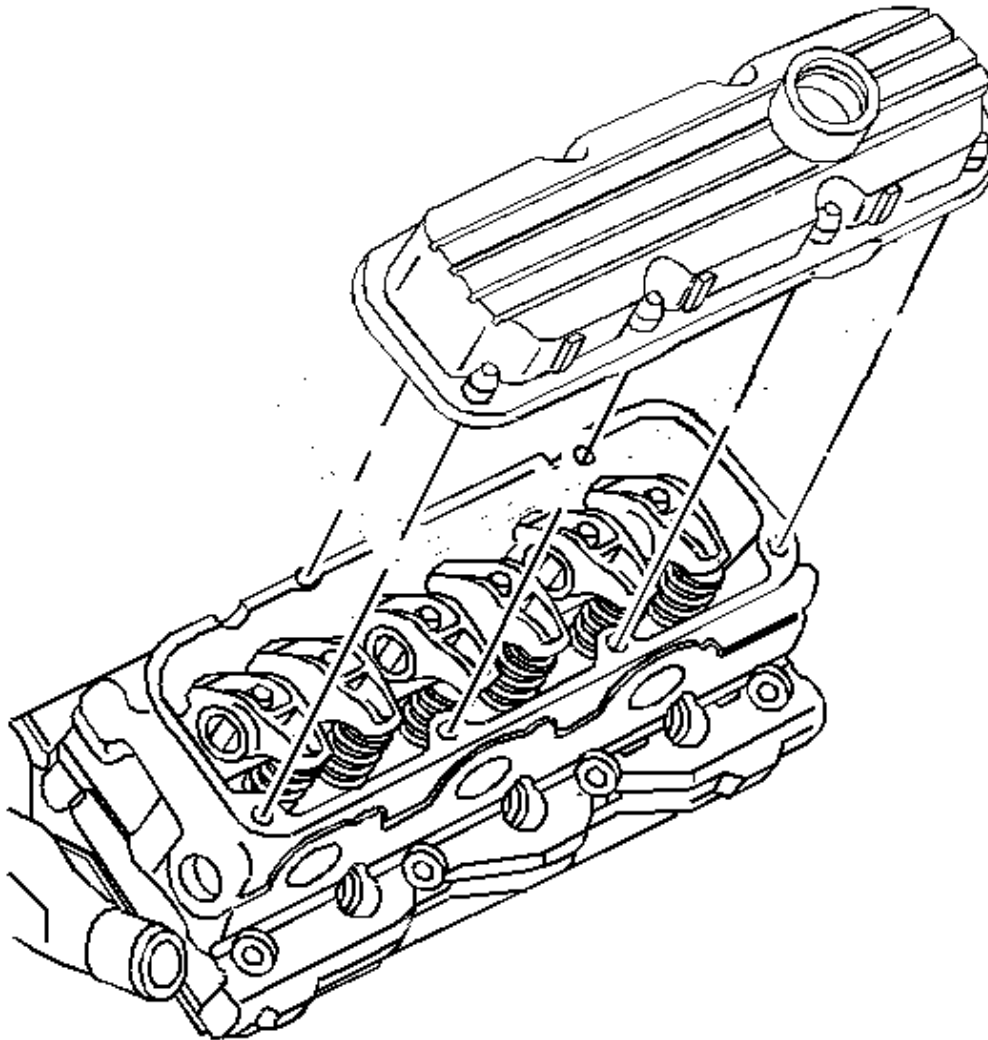


Fig. 331: Locating Left Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the valve rocker arm cover.
2. Apply GM P/N 12345382 (Canadian P/N 10953489) threadlocker or the equivalent to threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 10 N.m (89 lb in).

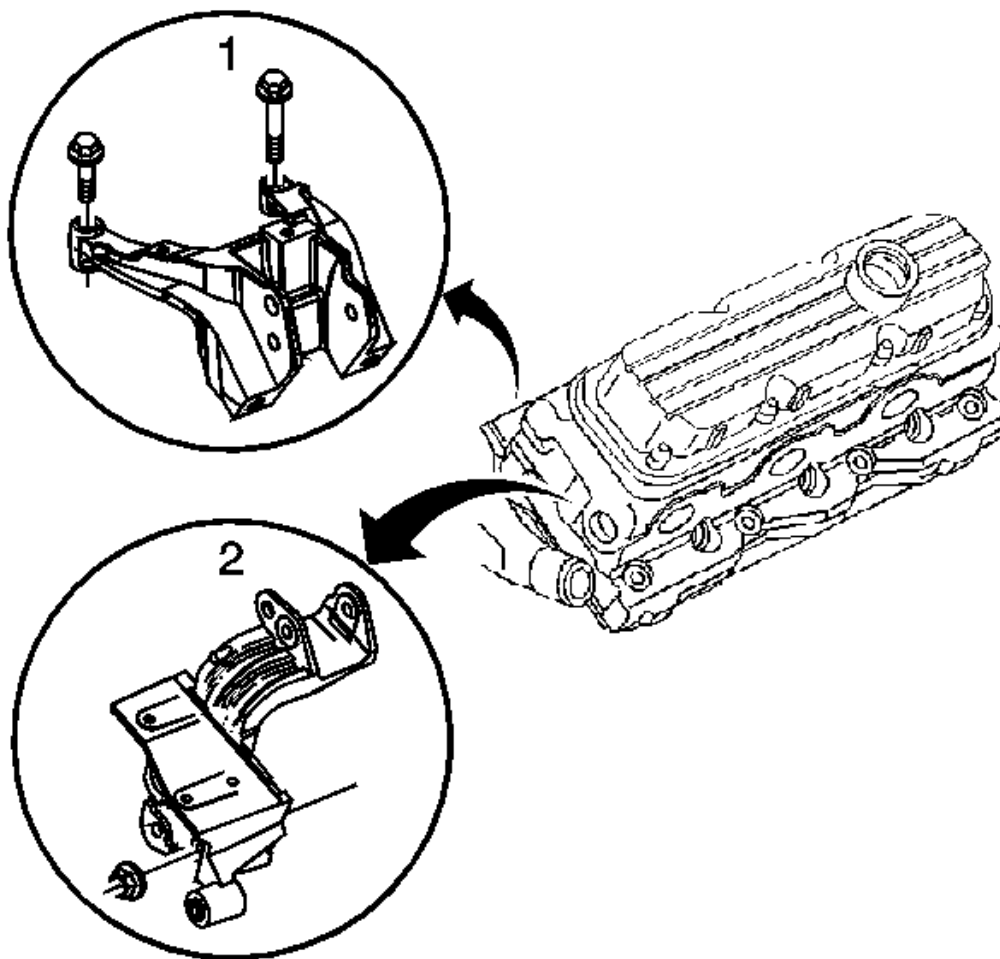


Fig. 332: Installing Engine Mount Strut Upper Bracket & Engine Mount Strut Bracket & Nuts & Bolts

Courtesy of GENERAL MOTORS CORP.

4. Install the engine mount strut upper bracket bolts (1) if applicable.

Tighten: Tighten the engine mount strut upper bracket bolts (1) to 50 N.m (37 lb ft).

5. Install the engine mount strut bracket and nuts (2), if applicable.

Tighten: Tighten the engine mount strut bracket and nuts (2) to 50 N.m (37 lb ft).

Exhaust Manifold Installation - Right

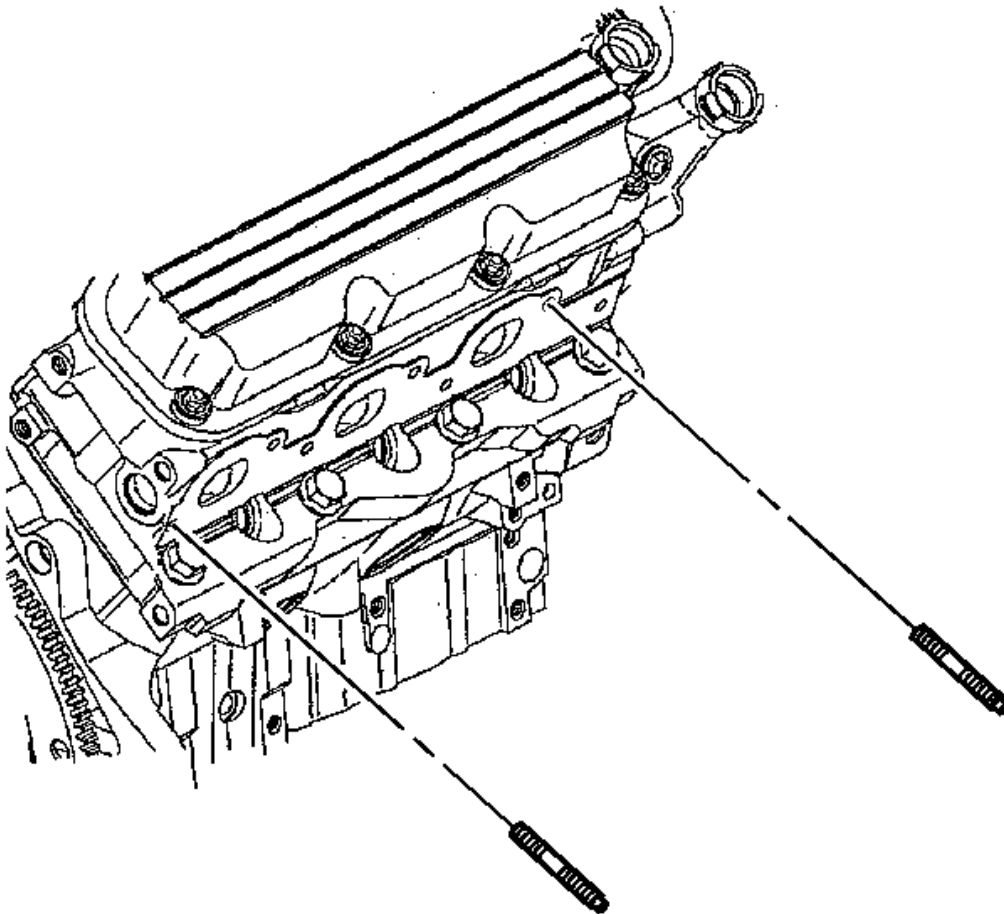


Fig. 333: Removing/Installing Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs.

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

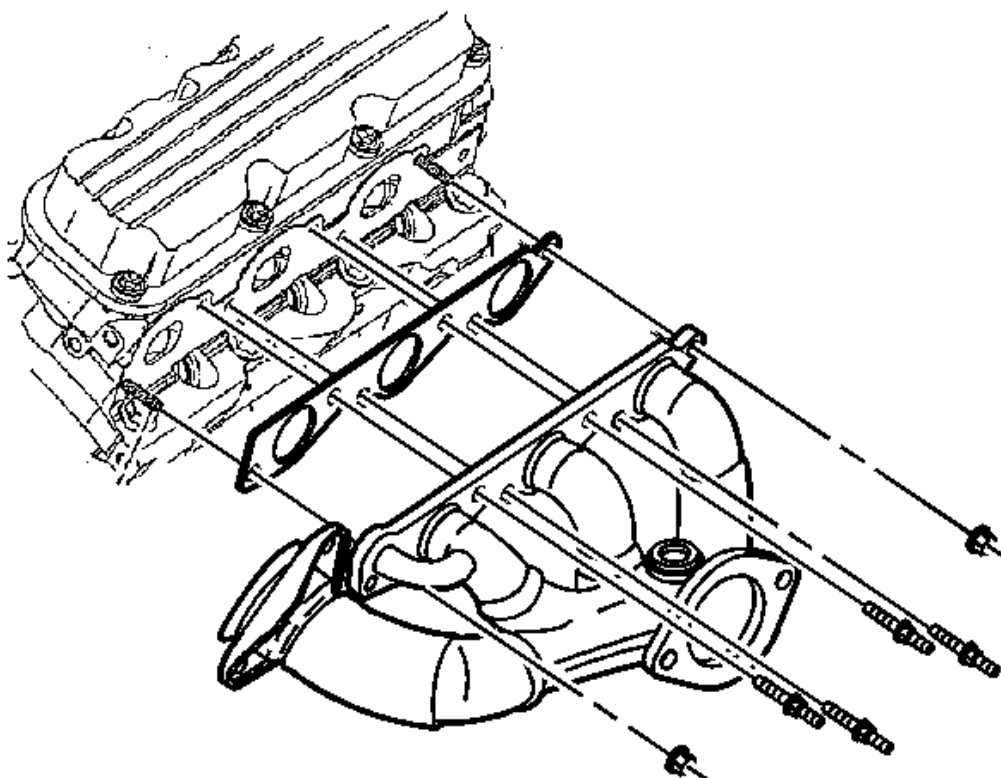


Fig. 334: Locating Right Exhaust Manifold Components (Without A.I.R.)
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold.
4. Install the exhaust manifold bolts and nuts.

Tighten: Tighten the exhaust manifold bolts and nuts to 30 N.m (22 lb ft).

5. Install the right side spark plugs.

Tighten:

- Tighten the spark plugs to 27 N.m (20 lb ft) when installing the spark plugs in to a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when re-installing the spark plugs after initial installation.

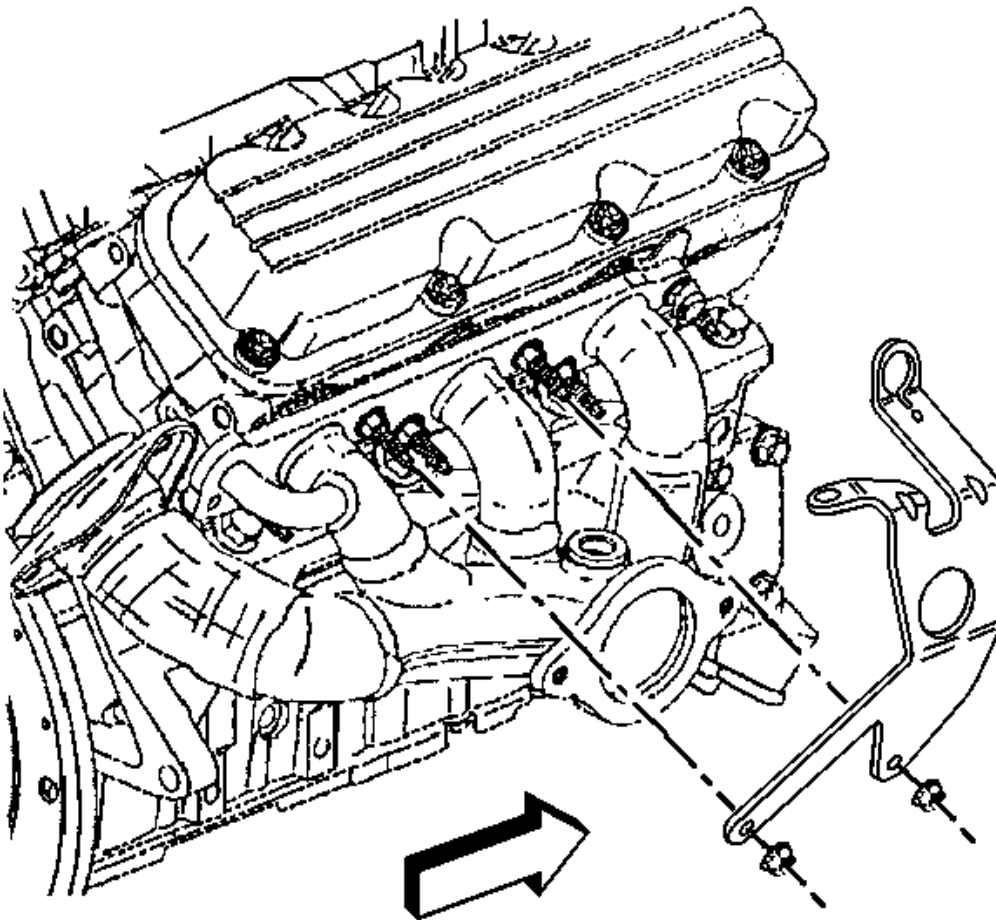


Fig. 335: Locating Fuel Injector Sight Shield Cover Bracket
Courtesy of GENERAL MOTORS CORP.

6. Install the fuel injector sight shield cover bracket.
7. Install the fuel injector sight shield cover bracket nuts.

Tighten: Tighten the fuel injector sight shield bracket nuts to 30 N.m (22 lb ft).

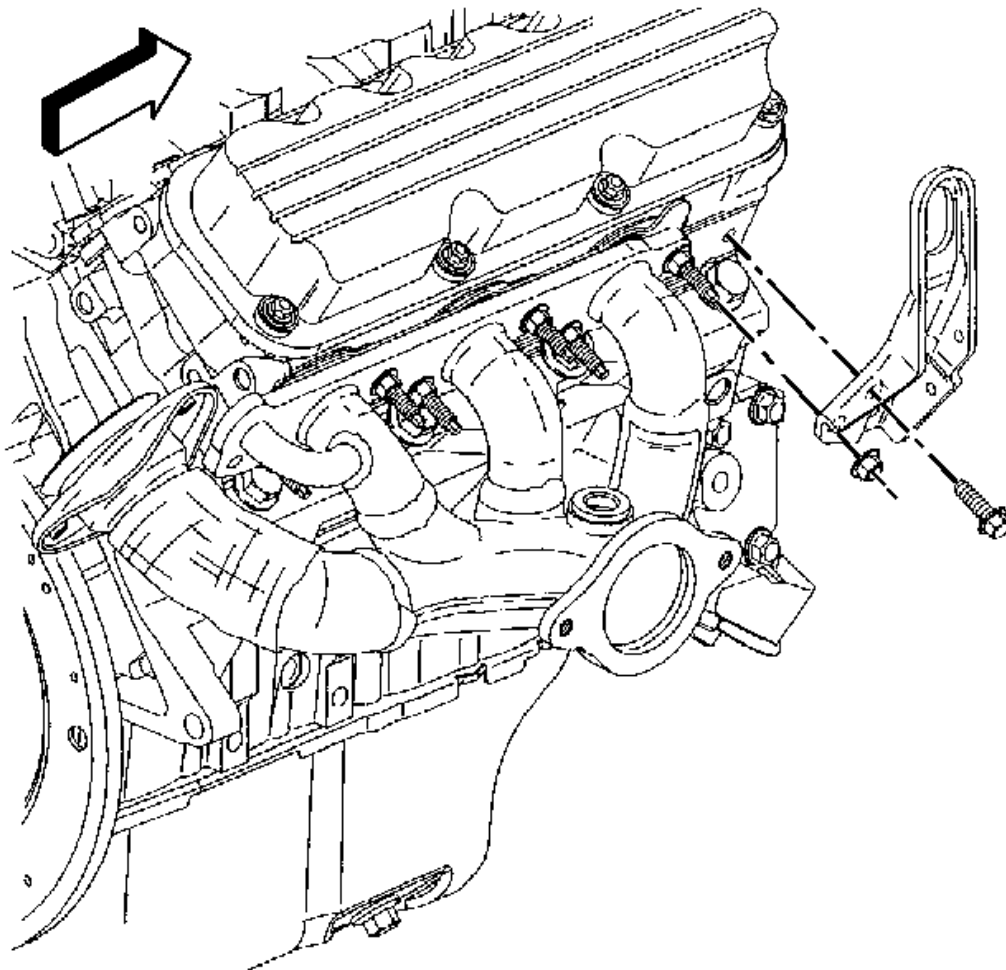


Fig. 336: Removing/Installing Right Engine Lift Hook Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the right engine lift hook.
9. Install the right engine lift hook nut and bolt.

Tighten: Tighten the right engine lift hook nut and bolt to 30 N.m (22 lb ft).

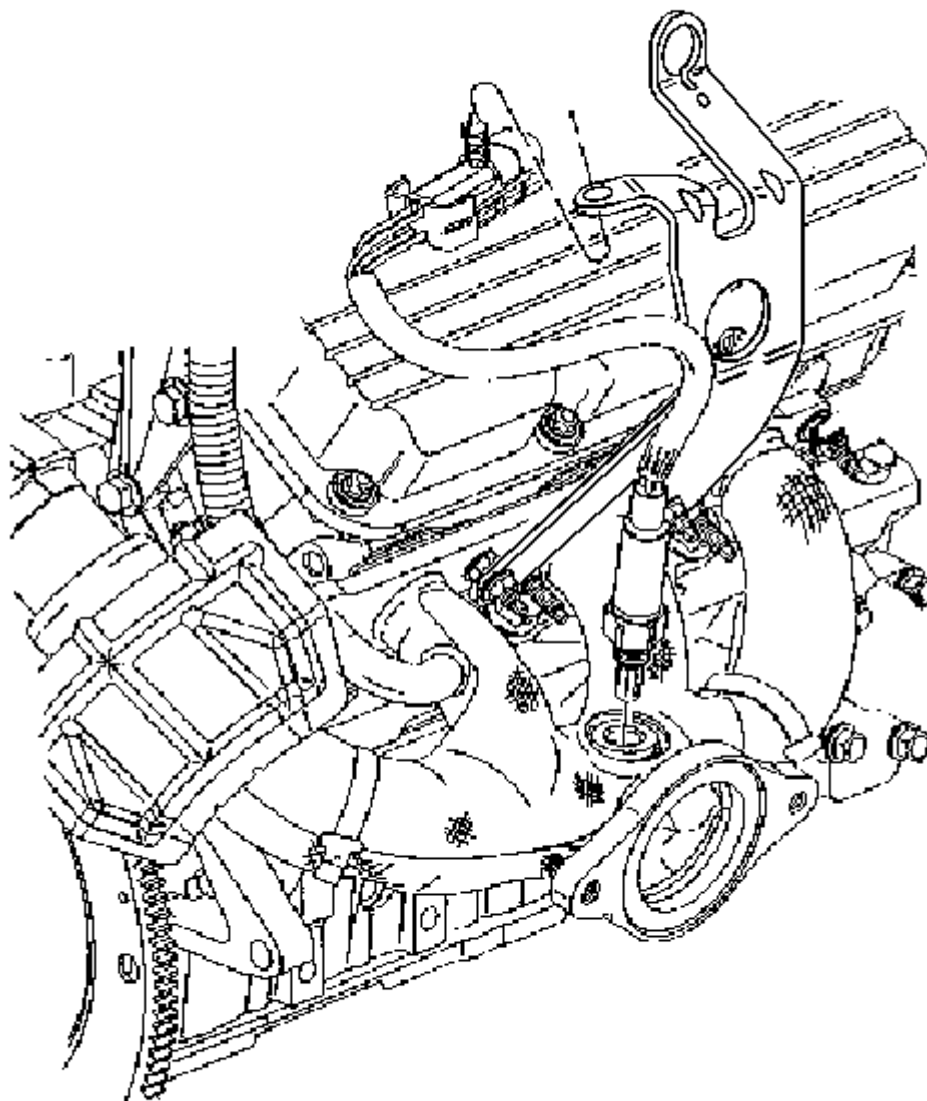


Fig. 337: Locating Heated Oxygen Sensor Lead
Courtesy of GENERAL MOTORS CORP.

10. Coat the threads of the heated oxygen sensor with anti seize compound.
11. Install the heated oxygen sensor.

Tighten: Tighten the heated oxygen sensor to 42 N.m (31 lb ft).

12. Install the heated oxygen sensor lead.

Exhaust Manifold Installation - Left

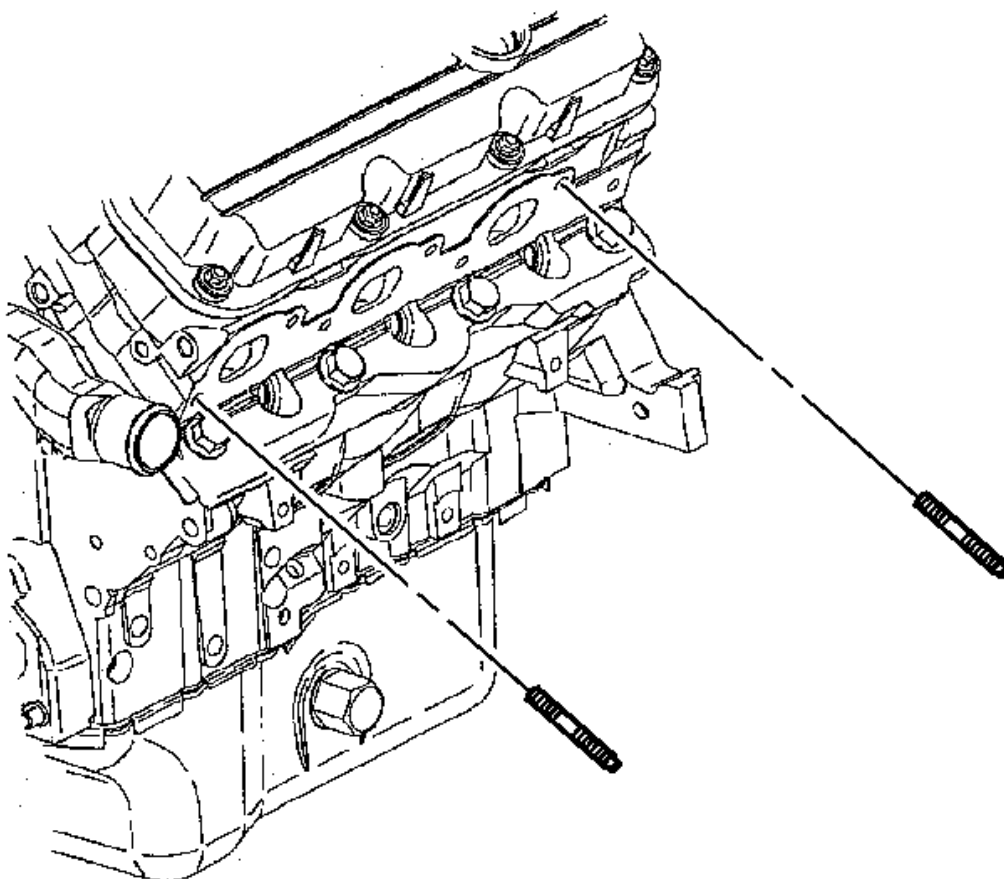


Fig. 338: Identifying Left Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs.

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

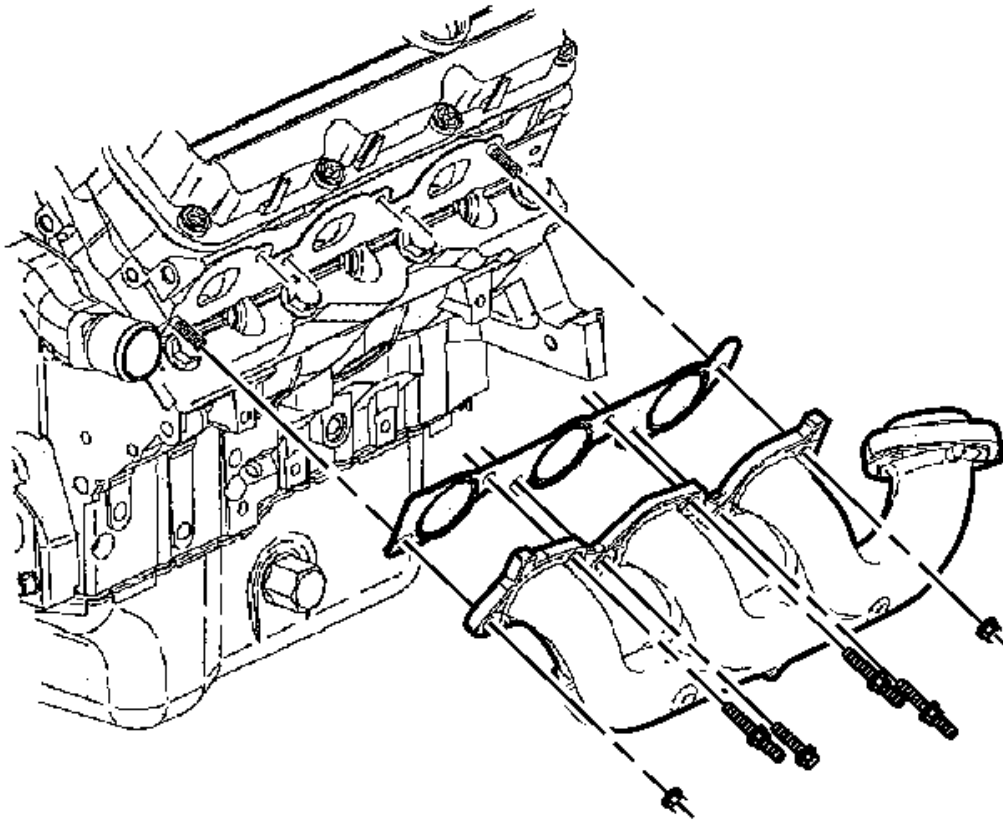


Fig. 339: Removing/Installing Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold.
4. Install the exhaust manifold bolts and nuts.

Tighten: Tighten the exhaust manifold bolts and nuts to 30 N.m (22 lb ft).

5. Install the left side spark plugs.

Tighten:

- Tighten the spark plugs to 27 N.m (20 lb ft) when installing the spark plugs in to a new cylinder head.
- Tighten the spark plugs to 15 N.m (13 lb ft) when re-installing the spark plugs after initial installation.

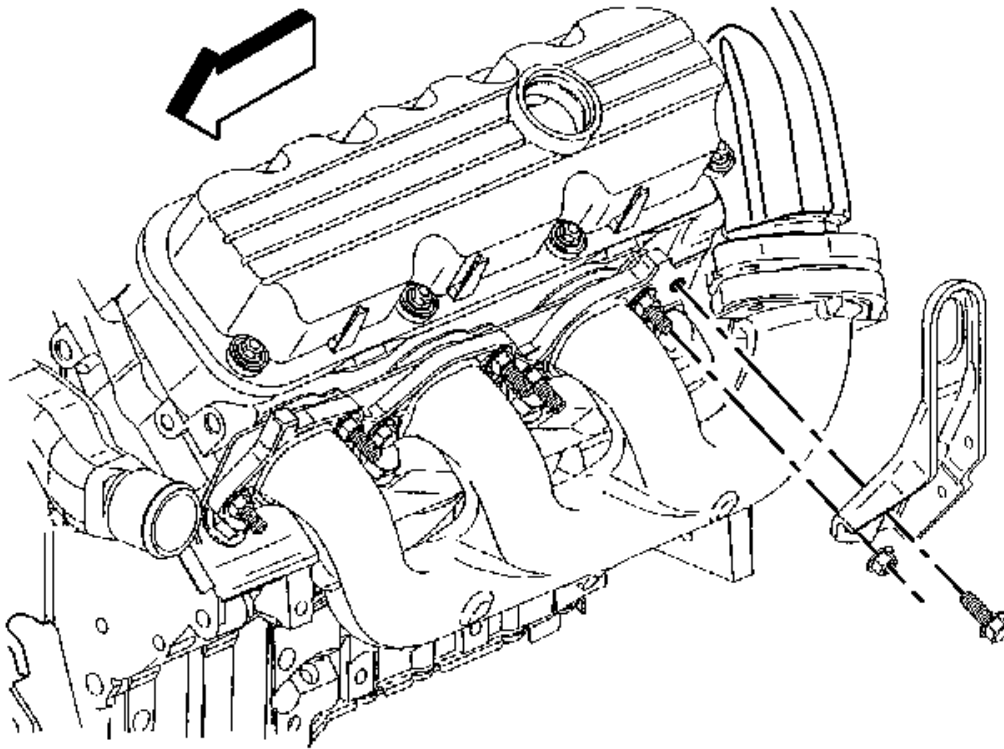


Fig. 340: Locating Left Engine Lift Hook
Courtesy of GENERAL MOTORS CORP.

6. Install the left engine lift hook.
7. Install the left engine lift hook nut and bolt.

Tighten: Tighten the left engine lift hook nut and bolt to 30 N.m (22 lb ft).

Intake Manifold Installation - Lower

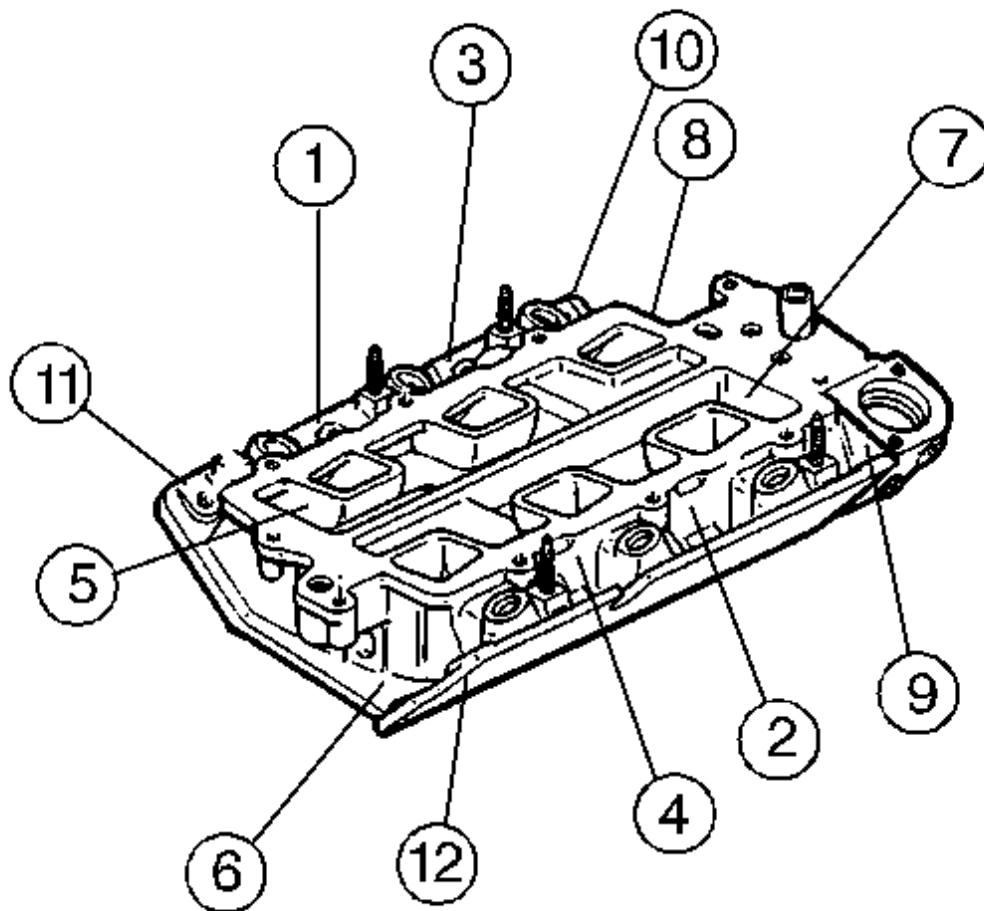


Fig. 341: Lower Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Clean the lower intake manifold sealing surface using GM P/N 12346139 (Canadian P/N 10953463) or equivalent prior to installing any seals or gaskets.
2. Install the lower intake manifold gaskets and seals.
3. Apply a drop of RTV GM P/N 12378479 (Canadian P/N 10953472) or equivalent to the four corners where the gaskets and seals meet.
4. Install the lower intake manifold.
5. Apply threadlocker 272 GM P/N 12345493 (Canadian P/N 10953488) or the equivalent to the bolt threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the lower intake manifold bolts.

Tighten: Tighten the lower intake manifold bolts in sequence to 15 N.m (11 lb ft).

Exhaust Gas Recirculation (EGR) and EGR Pipe Installation

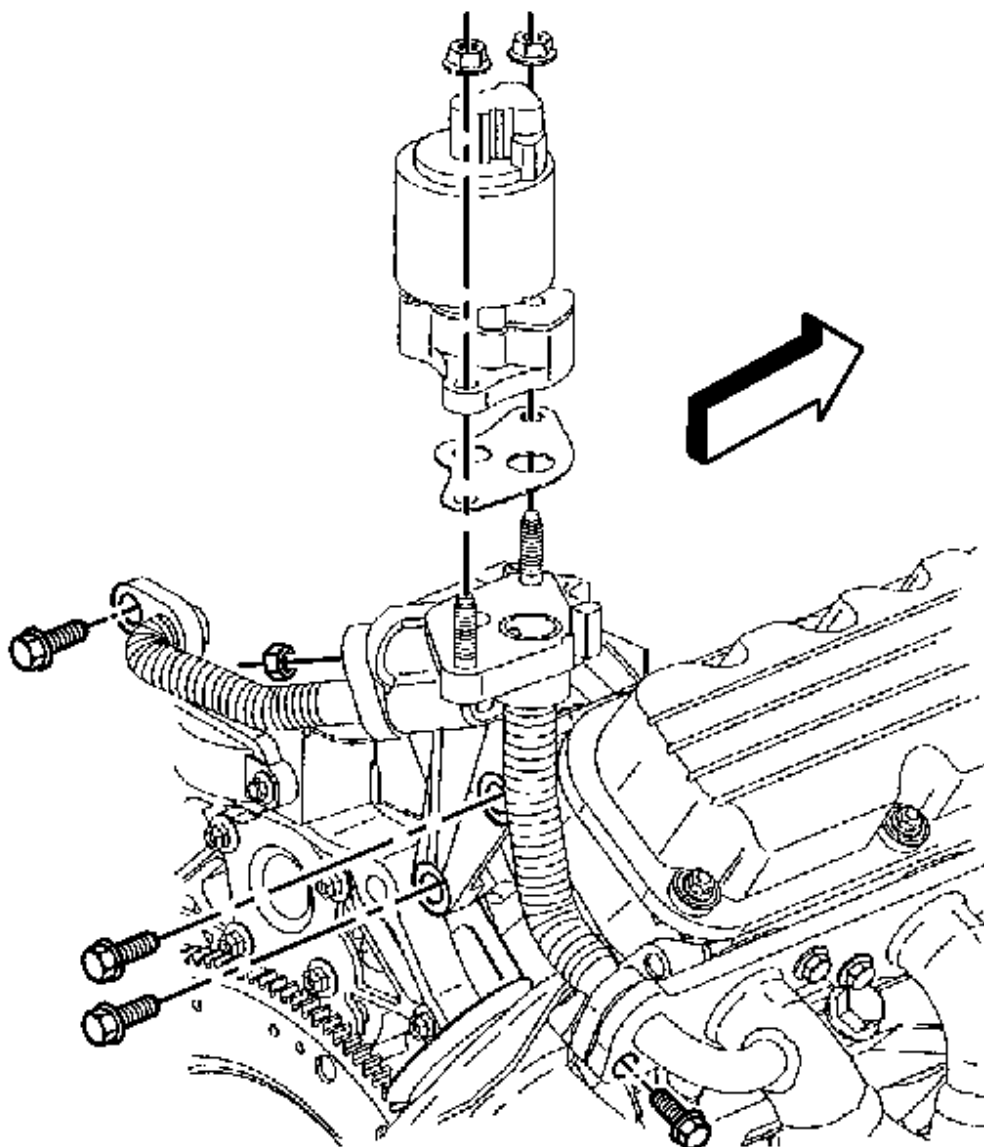


Fig. 342: View Of EGR Valve Adapter Assembly

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Inspect the EGR inlet/outlet pipes for leaks before installation. If cracks, deformations or any visible signs of leaking are present, replace the appropriate part.

1. Install the EGR inlet pipe into the RH exhaust manifold as the EGR valve adapter assembly is installed onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the EGR valve adapter assembly to cylinder head bolts and the EGR inlet pipe to RH exhaust manifold bolt.

Tighten:

- Tighten the EGR valve adapter assembly to cylinder head bolts to 50 N.m (37 lb ft).
- Tighten the EGR inlet pipe to RH exhaust manifold bolt to 29 N.m (21 lb ft).

3. Install the EGR valve outlet pipe to the lower intake and the EGR valve adapter assembly.
4. Install the EGR valve outlet pipe bolt and nut.

Tighten: Tighten the EGR valve outlet pipe bolt and nut to 29 N.m (21 lb ft).

5. Install the EGR valve gasket and EGR valve.
6. Install the EGR valve nuts.

Tighten: Tighten the EGR valve nuts to 29 N.m (21 lb ft).

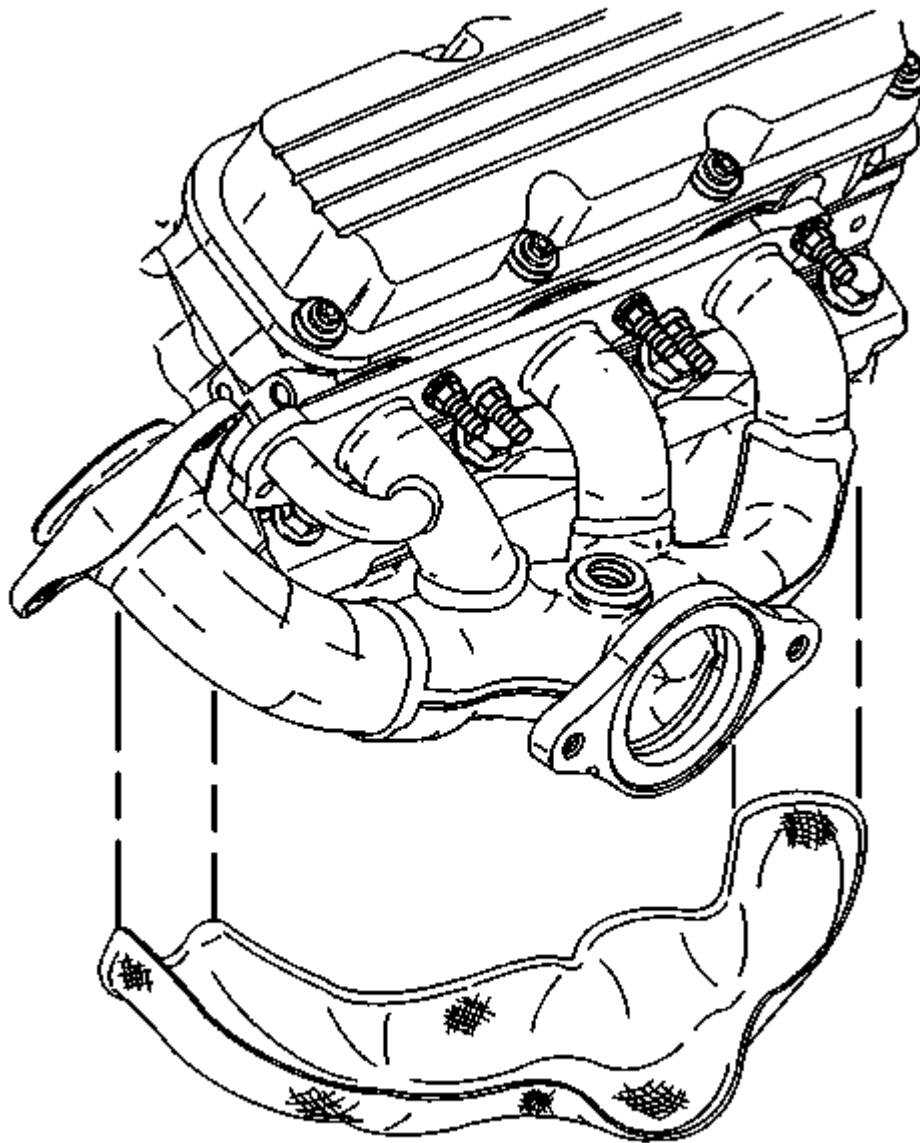


Fig. 343: Lower Right Exhaust Manifold Heat Shield (3.8L)
Courtesy of GENERAL MOTORS CORP.

7. Install the lower right exhaust manifold heat shield.
8. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 10 N.m (89 lb in).

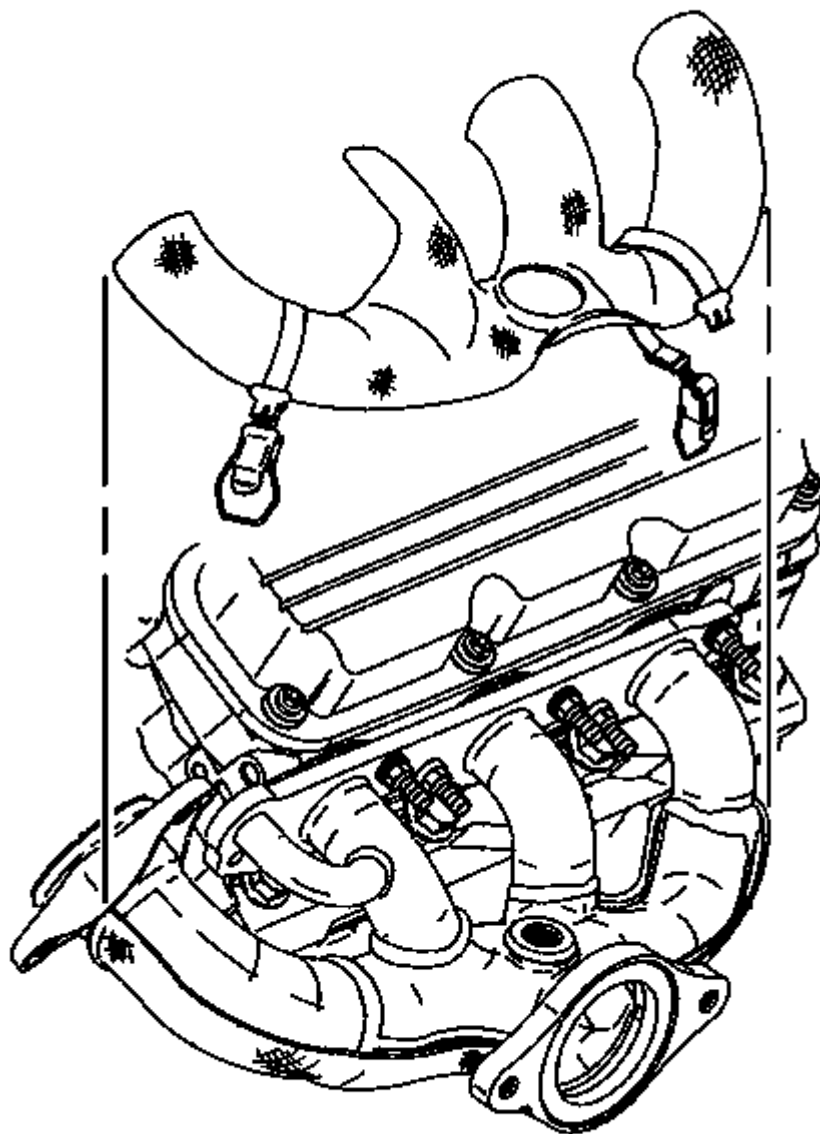


Fig. 344: Upper Right Exhaust Manifold Heat Shield (3.8L)
Courtesy of GENERAL MOTORS CORP.

9. Install the upper right exhaust manifold heat shield.

Intake Manifold Installation - Upper

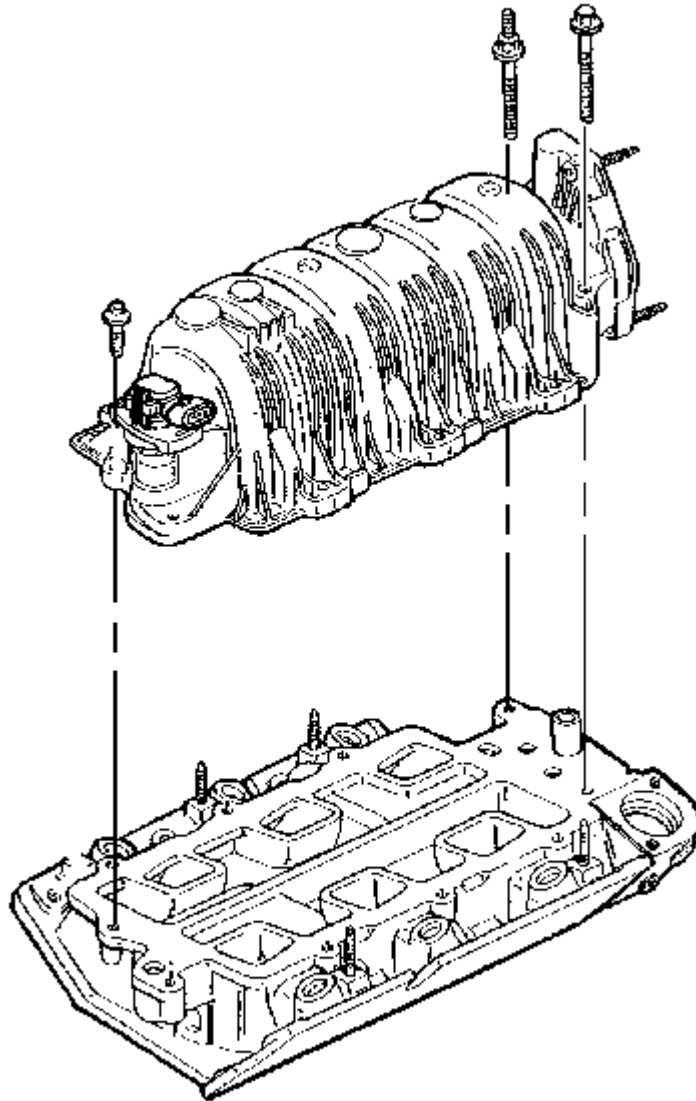


Fig. 345: Identifying Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the upper intake manifold gasket.
2. Install the upper intake manifold.

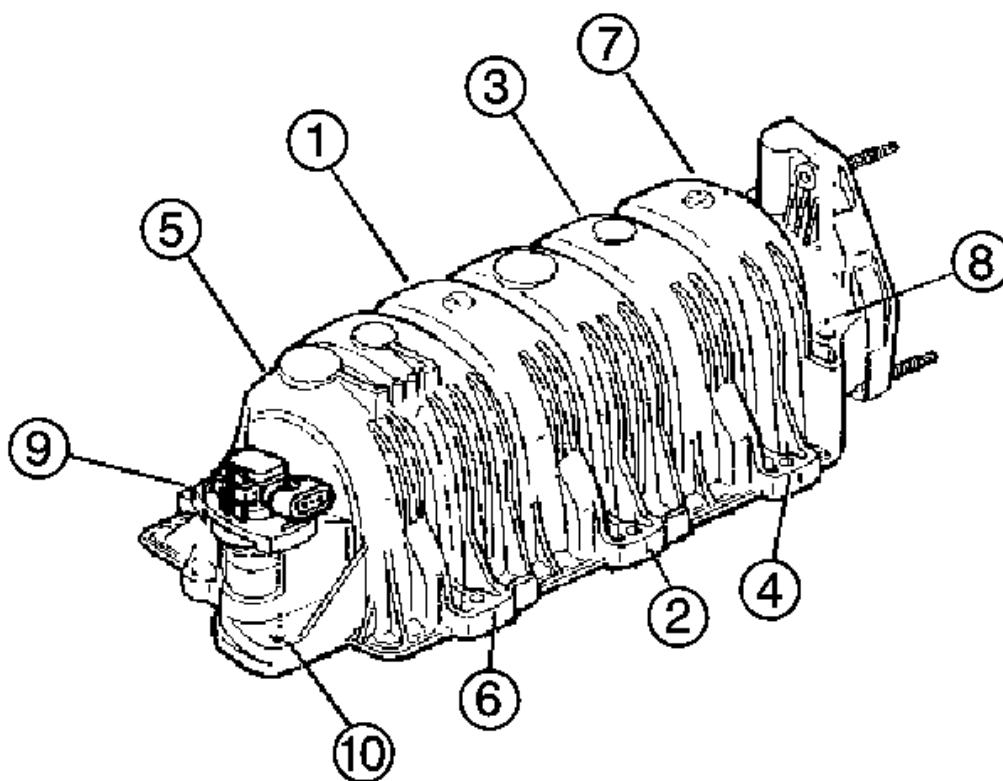


Fig. 346: Upper Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the upper intake manifold bolts.

Tighten: Tighten the upper intake manifold bolts in sequence to 10 N.m (89 lb in).

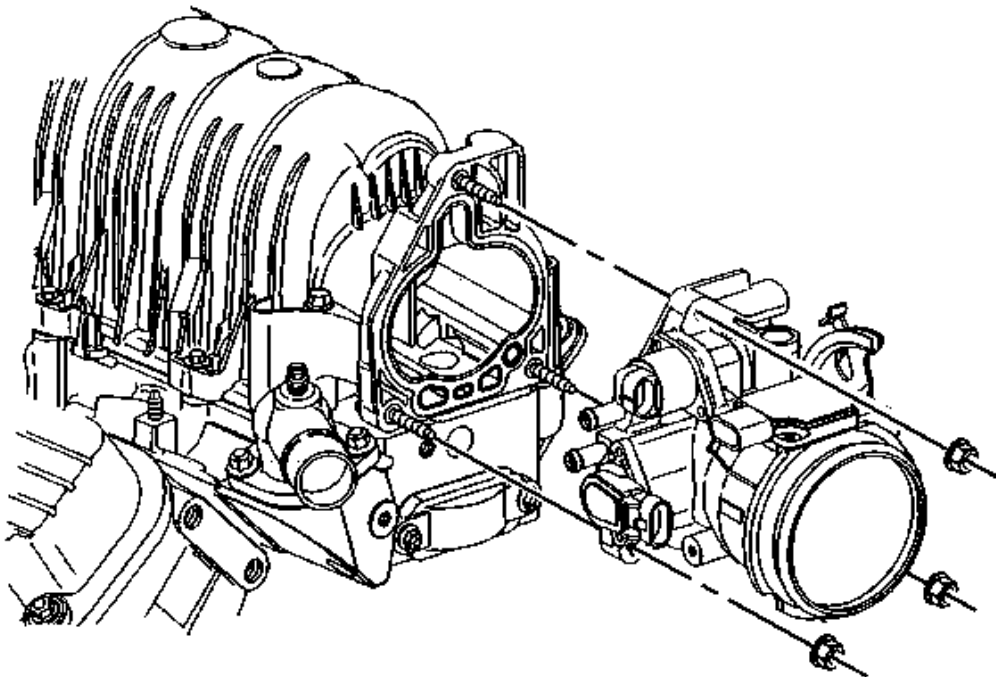


Fig. 347: Identifying Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Double check the cleanliness of the throttle body to upper intake surfaces prior to assembly.

4. Install the throttle body gasket.
5. Install the throttle body.
6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads.
7. Install the throttle body nuts.

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

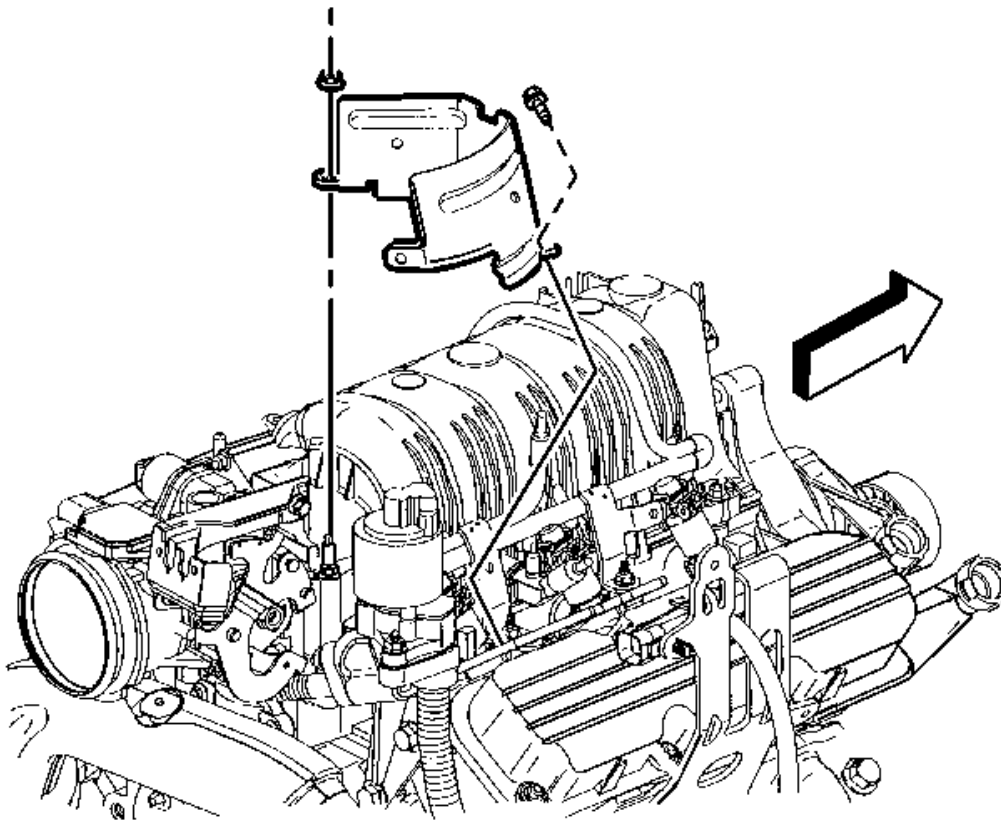


Fig. 348: Locating Engine Wiring Harness Heat Shield
Courtesy of GENERAL MOTORS CORP.

8. Install the engine wiring harness heat shield.
9. Install the engine wiring harness heat shield bolt and nut.

Tighten: Tighten the engine wiring harness heat shield bolt and nut to 10 N.m (89 lb in).

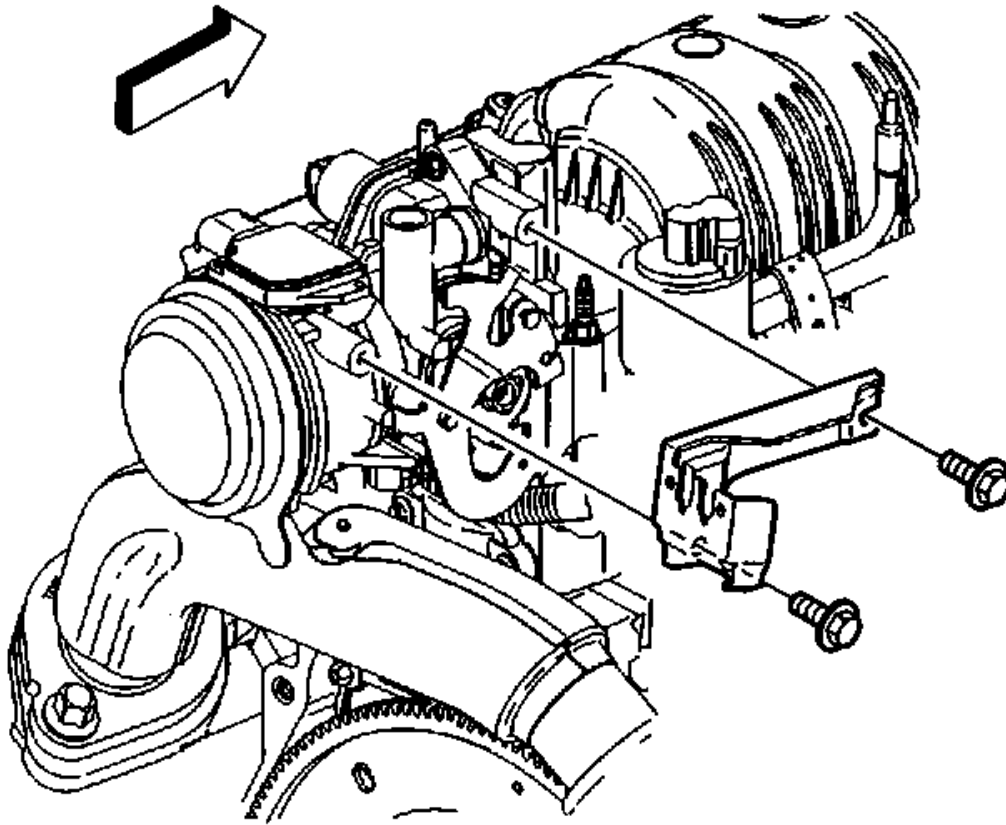


Fig. 349: Identifying Accelerator Control Cable Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the accelerator control cable bracket.
11. Install the accelerator control cable bracket bolts.

Tighten: Tighten the accelerator control cable bracket bolts to 16 N.m (12 lb ft).

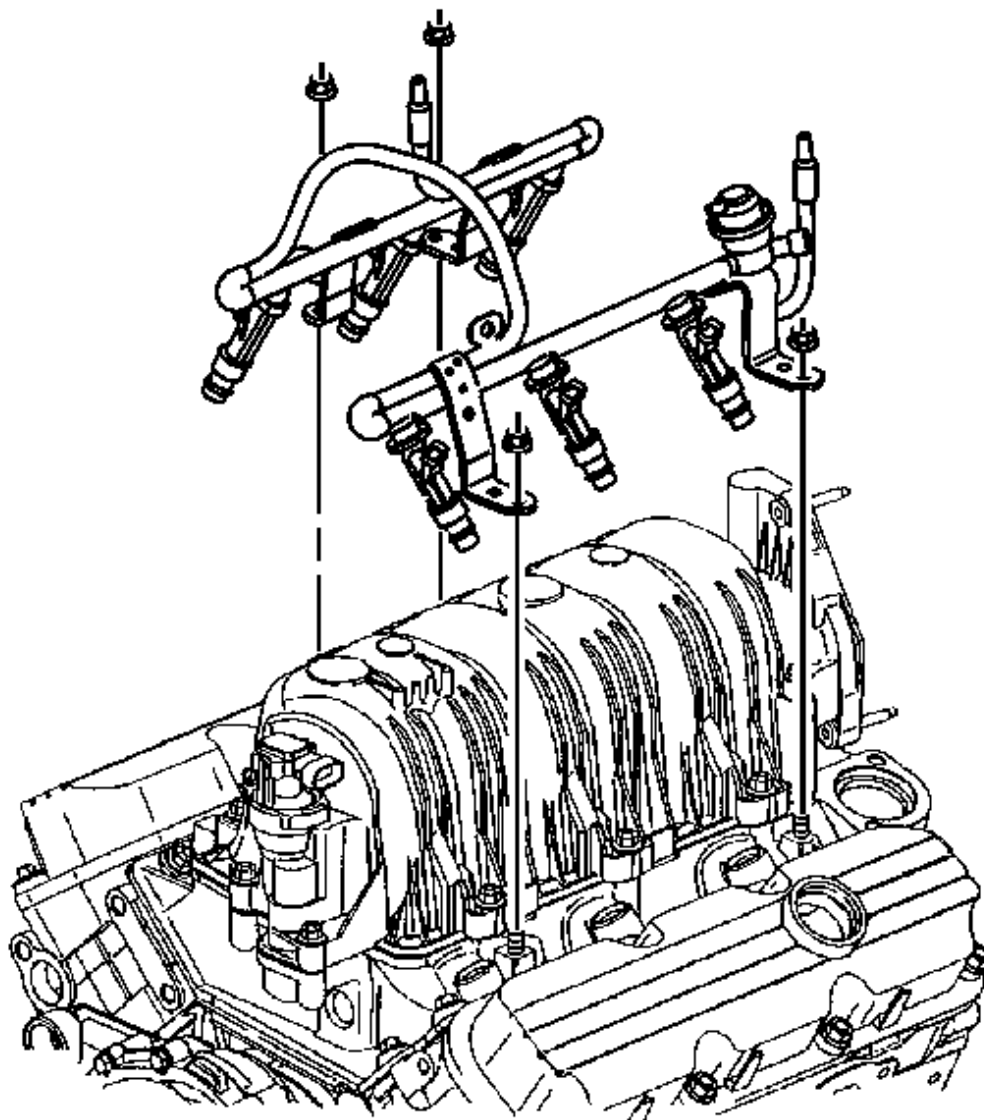


Fig. 350: Identifying Fuel Injector Rail Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the fuel injector O-ring seals twice. Install NEW fuel injector O-ring seals during assembly.

12. Install the fuel injector rail.
13. Install the fuel injector rail nuts.

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

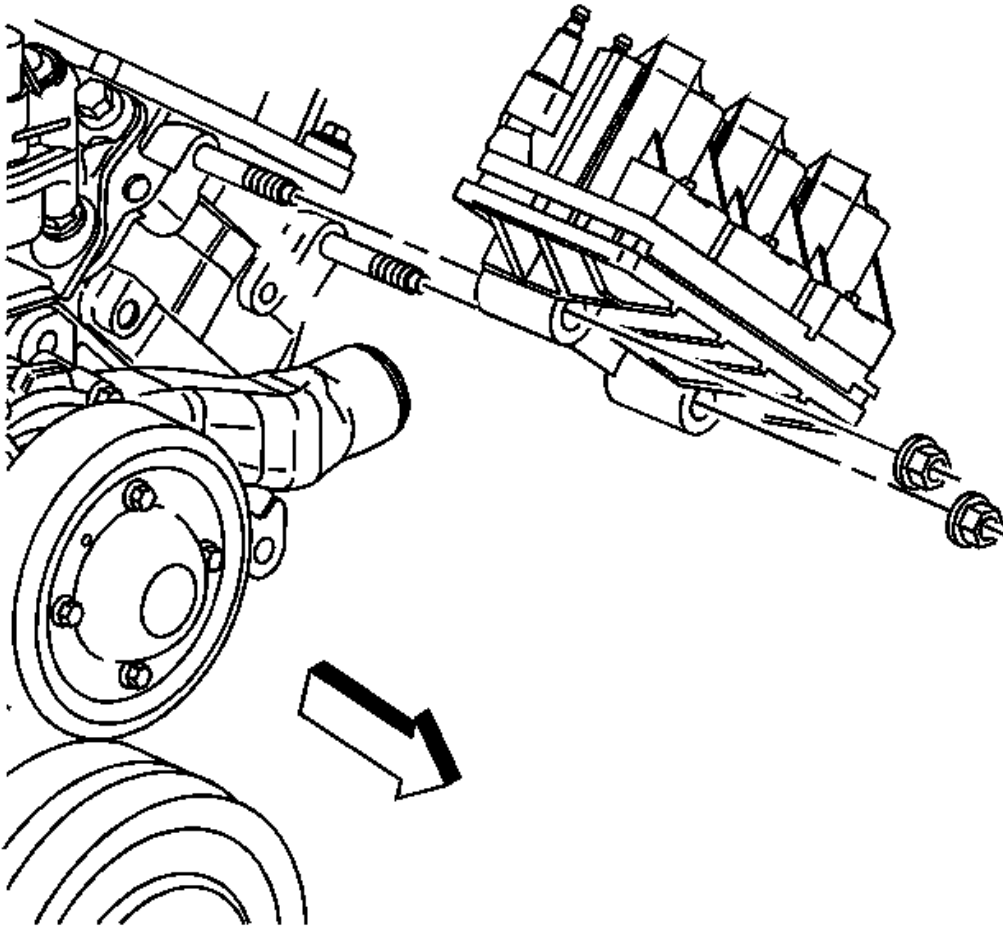


Fig. 351: Identifying Ignition Control Module Assembly
Courtesy of GENERAL MOTORS CORP.

14. Install the ignition control module assembly.
15. Install the ignition control module assembly bracket nuts.

Tighten: Tighten the ignition control module assembly bracket nuts to 50 N.m (37 lb ft).

16. Connect the ignition control module connector to the ignition control module assembly.
17. Connect the ignition wires to the fuel injector rail.
18. Install the spark plug wires.

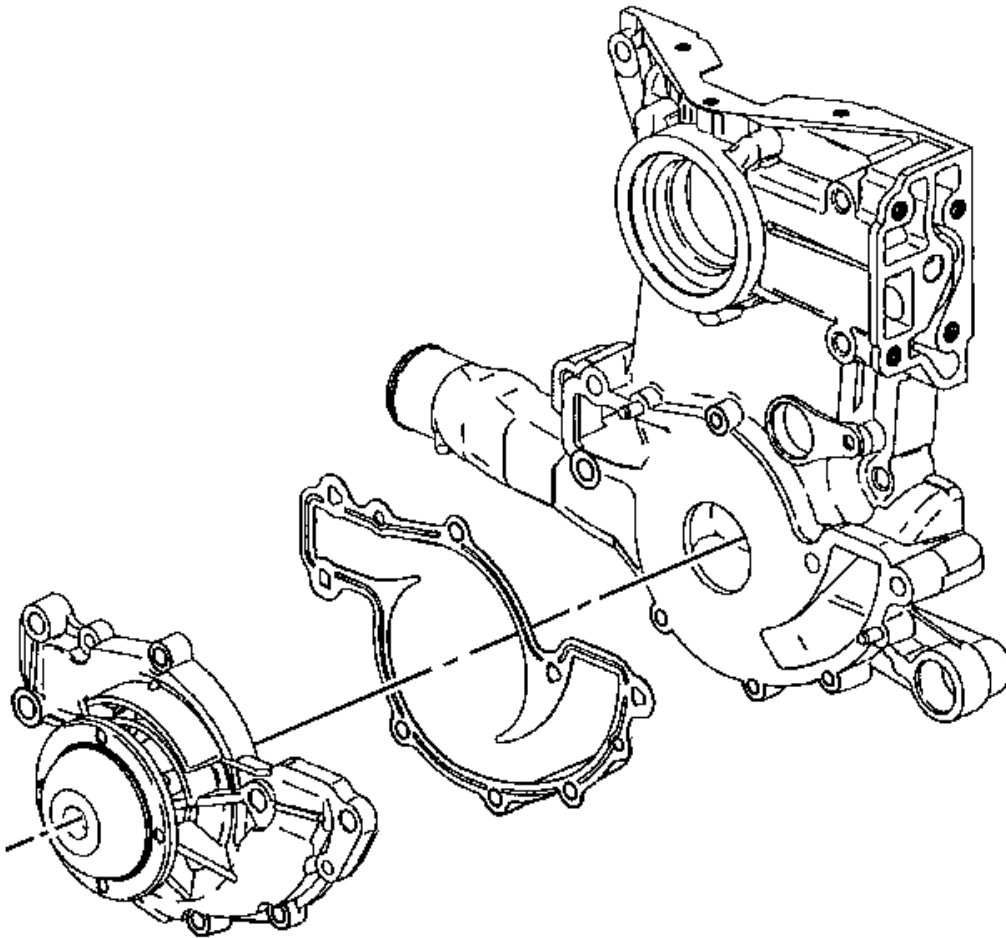
Water Pump Installation

Fig. 352: Water Pump & Components
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 small water pump bolts to 22 N.m (16 lb ft).

- Tighten the large water pump bolts to 34 N.m (25 lb ft).

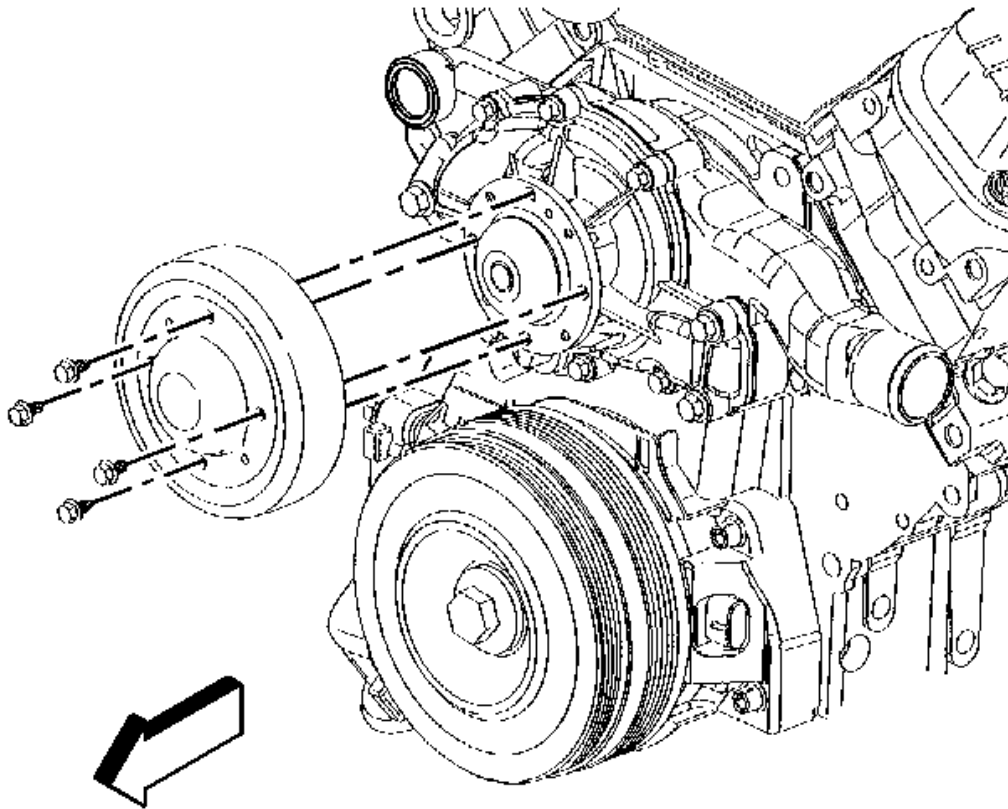


Fig. 353: Identifying Water Pump Pulley Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the water pump pulley.
5. Install the water pump pulley bolts.

Tighten: Tighten the water pump pulley bolts to 13 N.m (116 lb in).

Water Outlet and Thermostat Installation

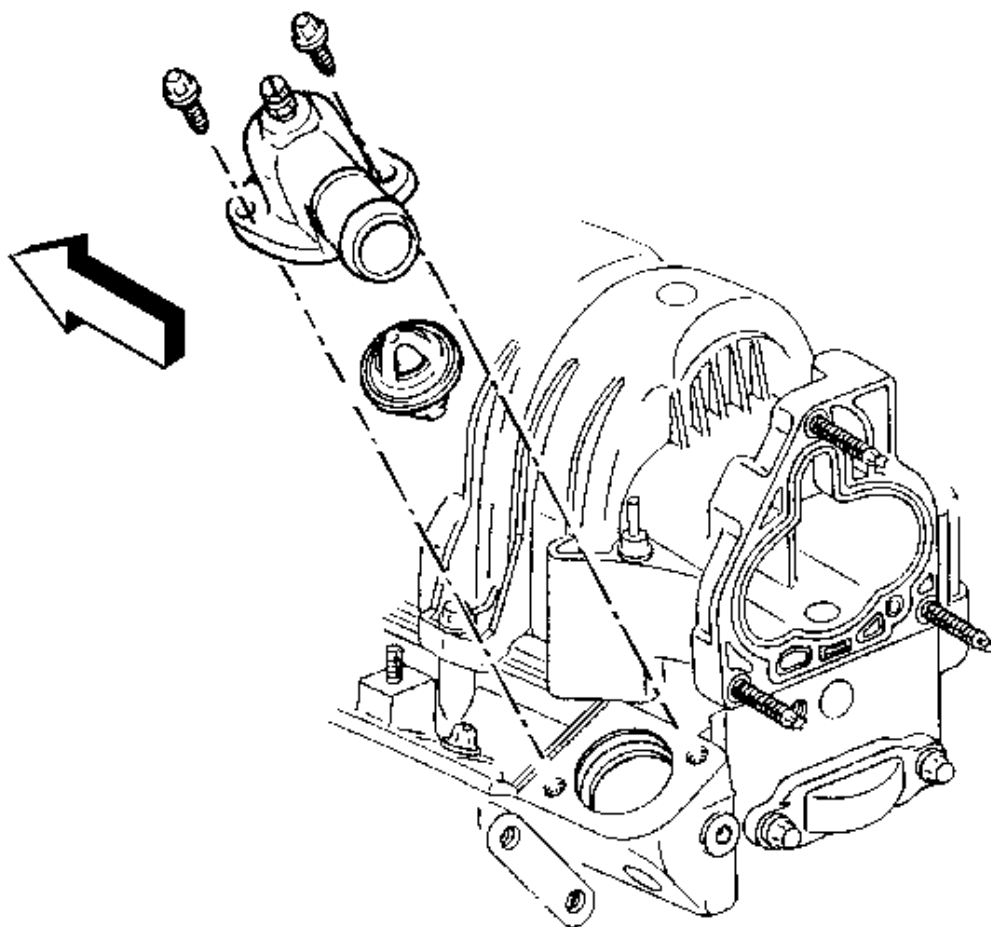


Fig. 354: Identifying Water Outlet & Thermostat
Courtesy of GENERAL MOTORS CORP.

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 27 N.m (20 lb ft).

Oil Level Indicator and Tube Installation

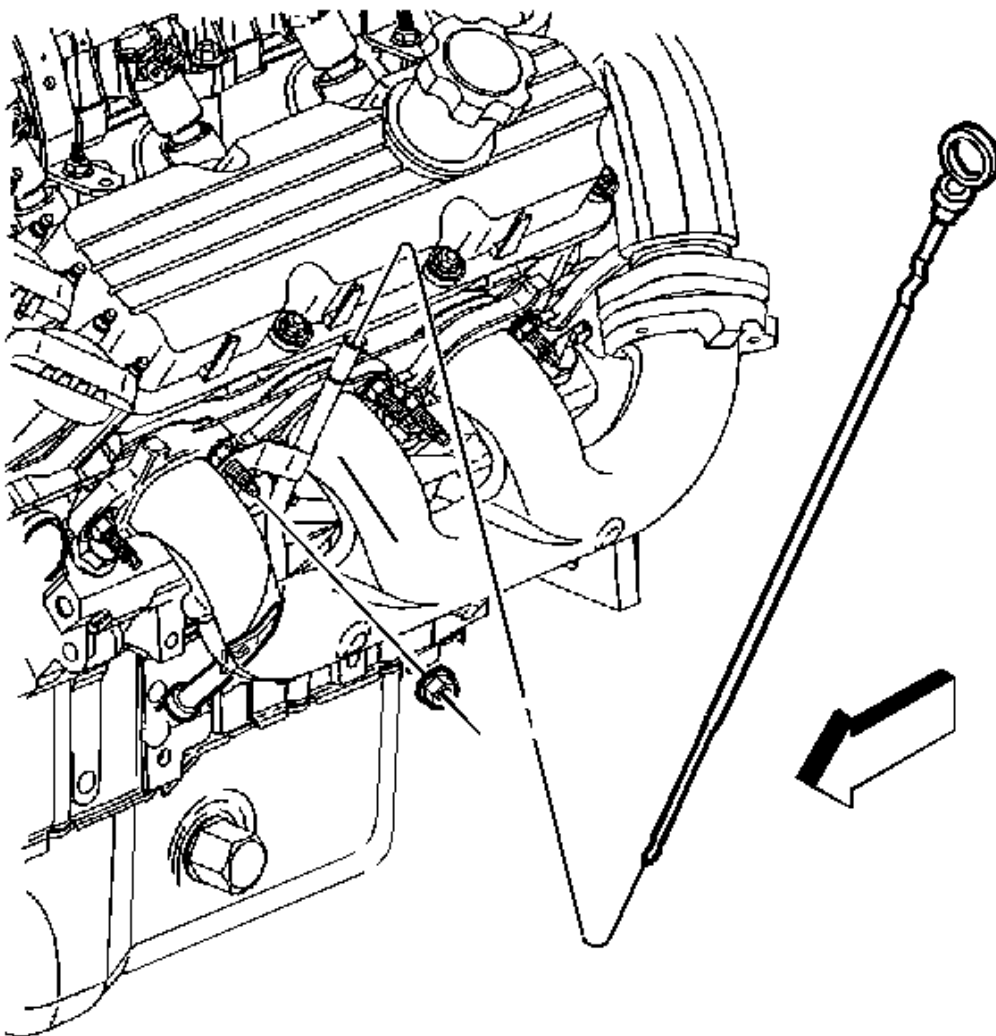


Fig. 355: Locating Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the Oil Level Indicator Tube.
 - Lubricate the O-ring with engine oil and make sure it is in place.
 - Ensure that the assembly is fully seated in the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil level indicator tube nut.

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

Drive Belt Tensioner Installation

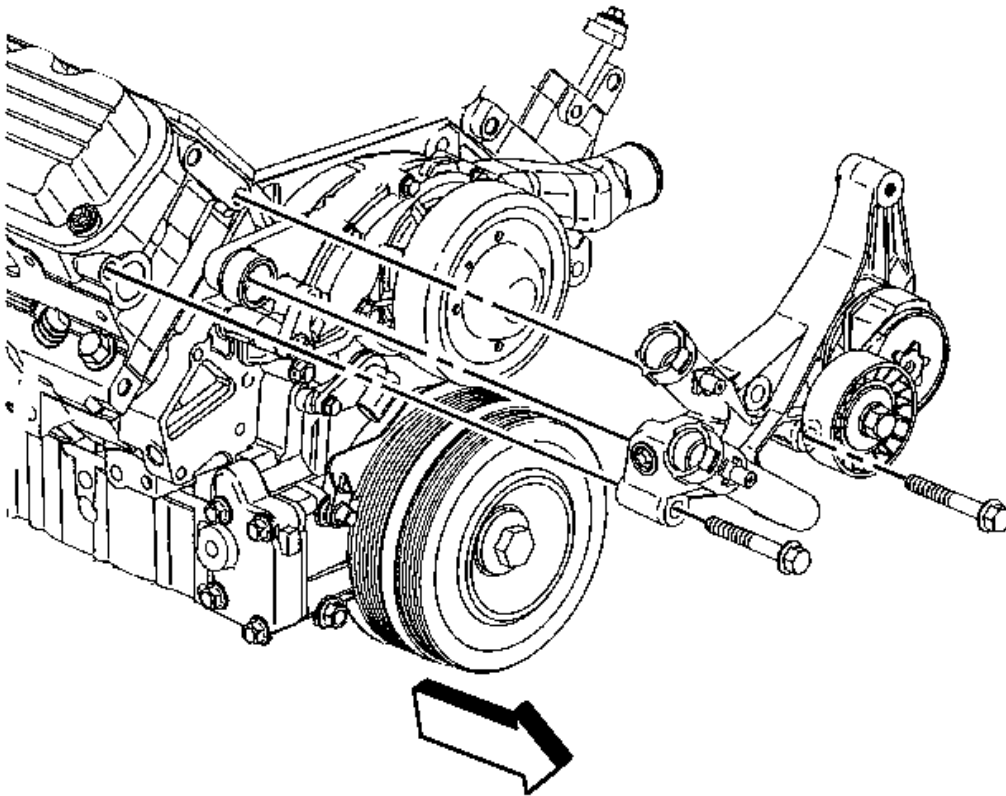


Fig. 356: Locating Drive Belt Tensioner Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner bracket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bracket bolts.

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

Engine Flywheel Installation

Tools Required

J 45059 Angle Meter. See Special Tools and Equipment.

Installation Procedure

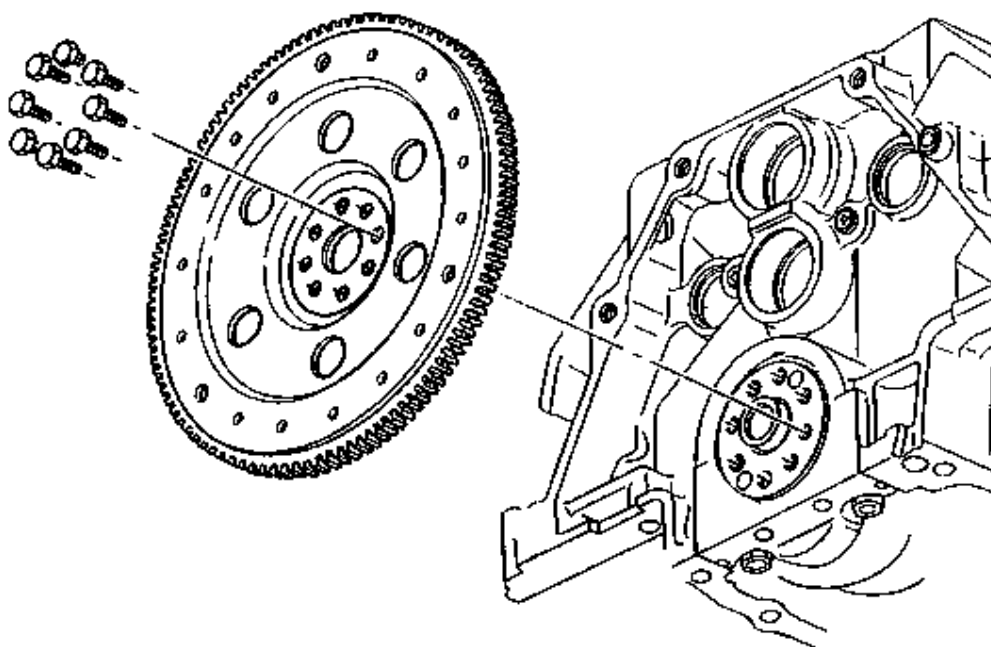


Fig. 357: Locating Engine Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the new flywheel bolts.

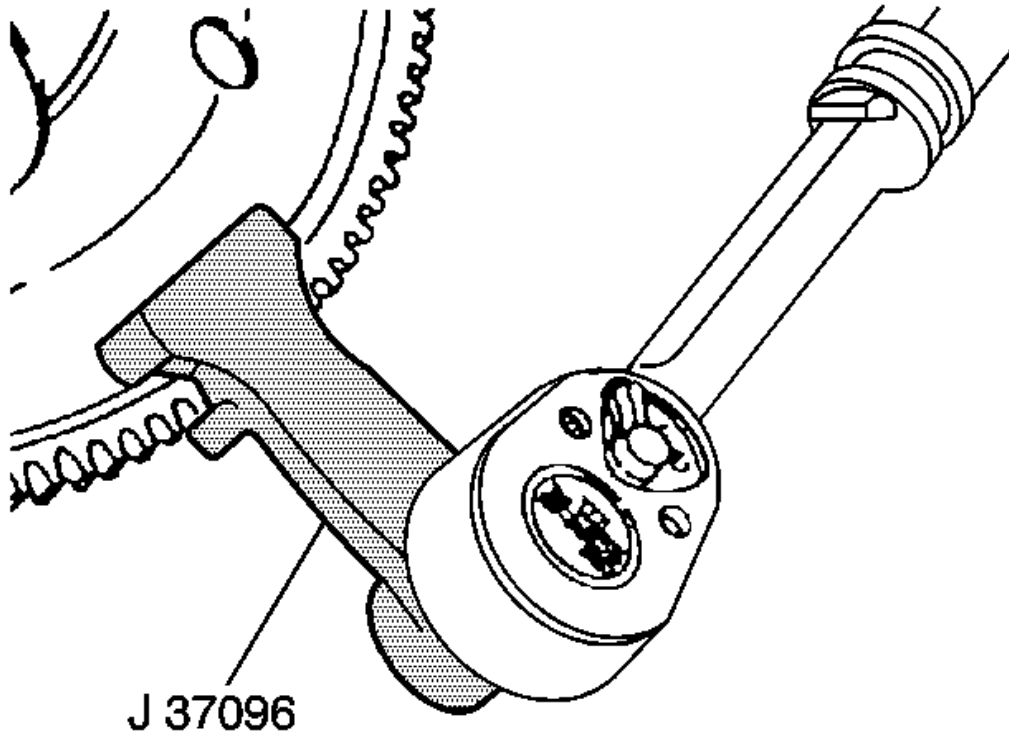
Tighten: Tighten the bolts to 15 N.m (11 lb ft). Use the **J 45059** to tighten the bolts an additional 50 degrees. See Special Tools and Equipment.

Crankshaft Balancer Installation

Tools Required

- **J 37096** Flywheel Holder. See Special Tools and Equipment.
- **J 45059** Angle Meter. See Special Tools and Equipment.

Installation Procedure

**Fig. 358: Holding Flywheel**

Courtesy of GENERAL MOTORS CORP.

1. Lubricate the seal surface of the crankshaft balancer with engine oil.

IMPORTANT: The crankshaft position sensor system variation learn procedure must be completed whenever the crankshaft is replaced.

2. Install the crankshaft balancer.
3. Use **J 37096** to hold the flywheel. See Special Tools and Equipment.

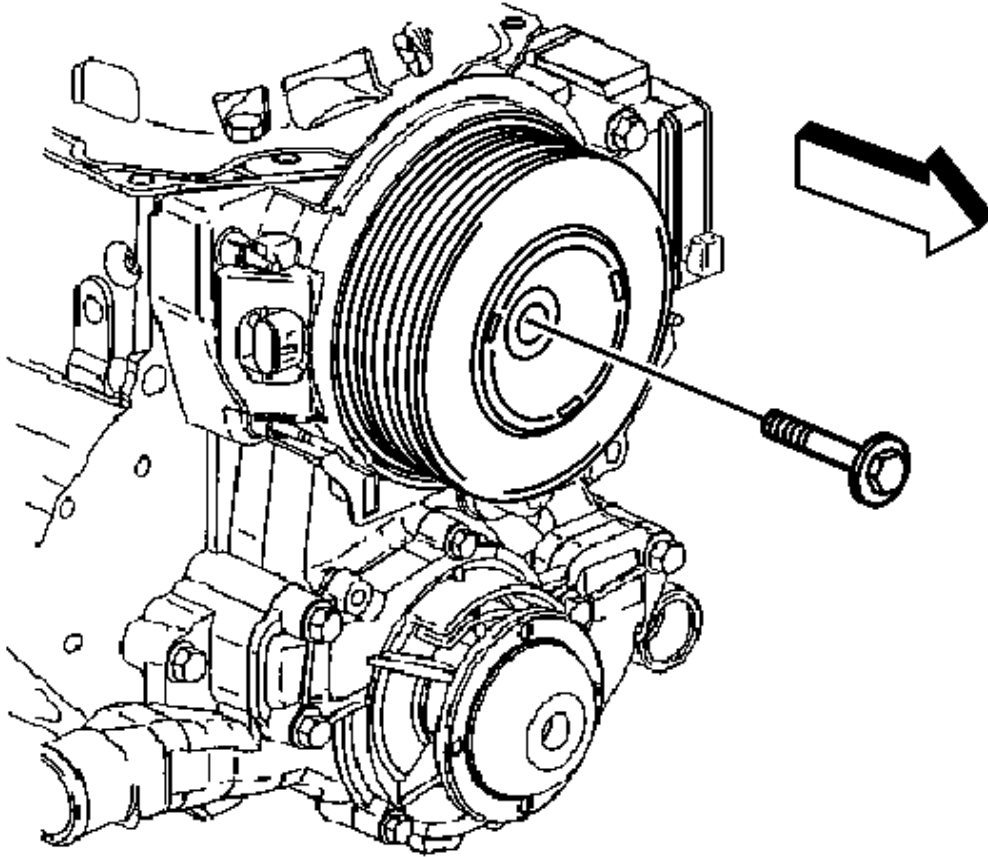


Fig. 359: Locating Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the crankshaft balancer bolt.

Tighten: Tighten the crankshaft balancer bolt to 150 N.m (111 lb ft). Use **J 45059** to tighten the crankshaft balancer bolt an additional 76 degrees. See Special Tools and Equipment.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

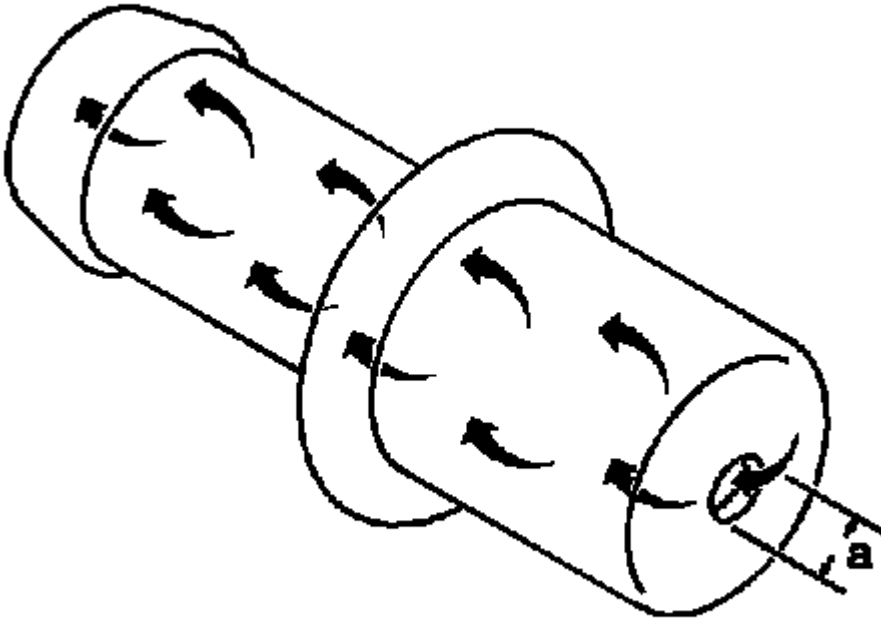


Fig. 360: Identifying PCV Orificed Tube
Courtesy of GENERAL MOTORS CORP.

A crankcase ventilation system is used to consume crankcase vapors created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using a 3 mm (0.118 in) (a) orifice located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley

- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped
 - The engine cooling fan, if belt driven
 - The water pump, if belt driven
 - The vacuum pump, if equipped
 - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers - chloroprene or EPDM - and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Construction

Starting at the front of the engine, the cylinders of the left bank are numbered 1-3-5 and the cylinders of the right bank are numbered 2-4-6. The crankshaft is supported in the engine block by four bearings. The crankshaft is counterbalanced by the flywheel, the crankshaft balancer, and the weights cast into the crankshaft. Additional counterbalancing is obtained from the balance shaft which rides in the engine block above the camshaft and is driven by the camshaft. All 3800 engines are even-firing, the cylinders fire at equal 120 degree intervals of crankshaft rotation. The location of the crankshaft journals has been offset by 30 degrees to fire the cylinders at 120 degree intervals of crankshaft rotation. The camshaft lobes and timing also reflect the 120 degree intervals. The even firing crankshaft provides an equal interval of 120 degrees between ignition of each of the cylinders throughout the firing order. The firing order is 1-6-5-4-3-2. The aluminum alloy pistons have slipper skirts and are cam turned. Four drilled holes or casted slots in the oil ring grooves permit drain back of the oil collected by the oil ring. The camshaft is supported by four bearings in the engine block and is driven by the crankshaft through sprockets and a timing chain. The cylinder heads are cast iron and incorporate integral valve stem guides. Right and left cylinder heads are identical and are interchangeable, but it is good practice to reinstall the

cylinder heads on the side from which they are removed. The intake manifold is bolted to the inner faces of both cylinder heads so it connects with all inlet ports.

Each exhaust and intake valve has a valve spring to insure positive seating throughout the operating speed range. The valve rocker arms for each bank of the cylinders pivot on pedestals bolted to the cylinder head. Hydraulic roller valve lifters and tubular push rods are used to operate overhead rocker arms and valves of both banks of the cylinders from a single camshaft. This system requires no lash adjustment at the time of assembly or service.

In addition to its normal function of a cam follower, each valve lifter also serves as an automatic adjuster which maintains zero lash in the valve train under all operating conditions. By eliminating all lash in the valve train and also providing a cushion of oil to absorb operating shocks, the valve lifter promotes quiet valve operation. It also eliminates the need for periodic valve adjustment to compensate for wear of parts. Oil is supplied to the valve lifter through a hole in the side of the valve lifter body which indexes with a groove and a hole in the valve lifter plunger. Oil is then metered past the oil metering valve in the valve lifter, through the push rods to the valve rocker arms. When the valve lifter begins to move up the camshaft lobe, the check ball is held against its seat in the plunger by the check ball spring which traps the oil in the base of the valve lifter body below the plunger.

The plunger and the valve lifter body then raise as a unit, pushing up the push rod to open the valve. The force of the valve spring which is exerted on the plunger through the valve rocker arm and push rod, causes a slight amount of leakage between the plunger and the valve lifter body. This leakage allows a slow escape of trapped oil in the base of the valve lifter body. As the valve lifter rolls down the other side of the camshaft lobe and reaches the base circle or valve closed position, the plunger spring quickly moves the plunger back (up) to its original position. This movement causes the check ball to open against the ball spring, and any oil inside the plunger is drawn into the base of the valve lifter. This restores the valve lifter to the zero lash.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight or indicate important product changes from the previous model year.

Changes may include one or more of the following items:

- A component comparison from the previous year
- Fastener changes
- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required

Component Comparison

New Manifold Absolute Pressure (MAP)/Barometric Pressure (BARO) sensors, retainer clips and bracket have

been added on L67 engines only.

Fastener Changes

No fastener changes for 2004.

Torque Values and/or Fastener Tightening Strategies

No torque value changes for 2004.

Changed Engine Specifications

No specification changes for 2004.

New Sealants and/or Adhesives

No new sealants and or adhesives for 2004.

Disassembly and Assembly Procedure Revisions

No changes for 2004

Engine Mechanical Diagnostic Procedure Revisions

No revisions for 2004

New Special Tools Required

J 45059 Angle Meter has replaced the J 36660-A Torque Angle Meter in 2004.

LUBRICATION DESCRIPTION

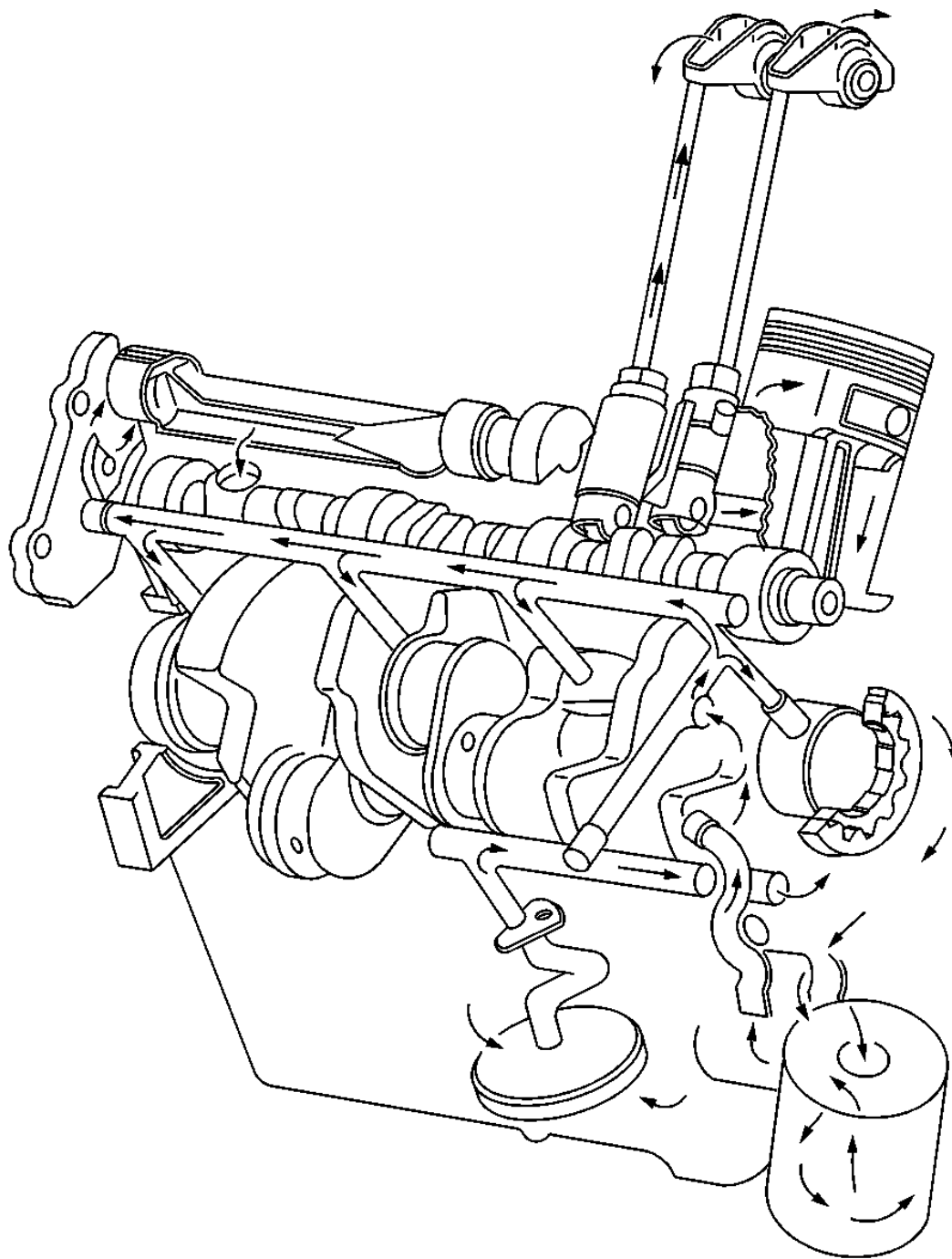


Fig. 361: Identifying Engine Lubrication System
Courtesy of GENERAL MOTORS CORP.

The engine lubrication system is of the force-feed type. The oil is supplied under full pressure to the crankshaft,

connecting rods, valve lifters, camshaft, and rear balance shaft bearing. A controlled volume of oil is supplied to the valve rocker arms and push rods. All other moving parts are lubricated by gravity flow or splash. The engine oil is stored in the lower crankcase (oil pan) which is filled through a filler opening in the valve rocker arm cover. A removable oil level indicator, on the left side of the engine block, is provided to check the oil level. The oil pump is located in the engine front cover and is driven by the crankshaft. It is a gerotor-style pump which is a combination of a gear and a rotor pump. It is connected by a passage in the cylinder block to an oil screen and pipe assembly. The screen is submerged in the oil supply and has ample volume for all operating conditions. If the screen becomes clogged, oil may be drawn into the system through the oil pressure relief valve in the oil filter adapter. Oil is drawn into the pump through the screen and pipe assembly, and a passage in the crankcase, connecting to the passages in the engine front cover. Oil is discharged from the oil pump to the oil filter adapter. The oil filter adapter consists of an oil filter bypass valve and a nipple for installation of an oil filter. The spring-loaded oil pressure relief valve, located in the engine front cover, limits the oil pressure. The oil filter bypass valve opens when the oil filter is restricted to approximately 68.95 kPa (10 psi) of pressure difference between the oil filter inlet and discharge. The oil will then bypass the oil filter and channel unfiltered oil directly to the main oil galleries of the engine. A full-flow oil filter is externally mounted to the oil filter adapter on the lower right front side of the engine. If the filter element becomes restricted, not allowing engine oil to pass through, a spring-loaded bypass valve opens. The main oil galleries run the full length of the engine block and cut into the valve lifter guide holes to supply oil at full pressure to the valve lifters. Holes, drilled from the crankshaft bearings to the main oil gallery, intersect the camshaft bearing bores to supply oil to the cam bearings.

Oil is transferred from the crankshaft bearings to the connecting rod bearings through holes drilled in the crankshaft. Pistons, piston pins, and cylinder walls are lubricated by oil splash from the crankshaft and connecting rods.

Each valve rocker arm and valve is supplied with oil through the tubular push rod. The oil comes from the inside of the valve lifter passing around the metering valve and through a hole in the push rod seat. Oil from the push rod passes through a hole in the push rod seat, and emerges on top of the push rod seat boss.

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

The components of an internal combustion engine develop wear patterns with their mating components. During disassembly of the engine, parts should be separated and kept in order so they may be reinstalled in the same location from which they were removed.

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 sealer. 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:

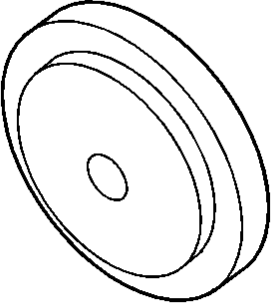
- A suitable parts cleaning tank
- A compressed air supply
- Trays, in order to keep the parts and the fasteners organized
- An adequate set of hand tools

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

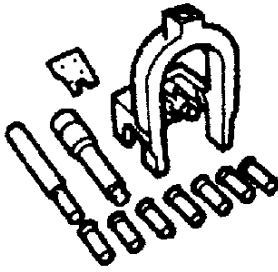
SPECIAL TOOLS

Special Tools

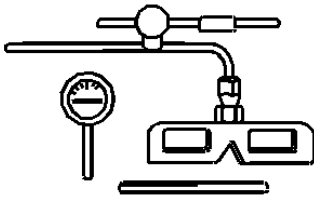
Illustration	Tool Number/Description
	EN 47623 Rear Main Seal Installer

2004 Pontiac Bonneville SLE

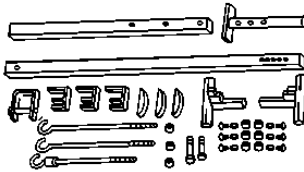
2004 ENGINE Engine Mechanical - 3.8L - Bonneville



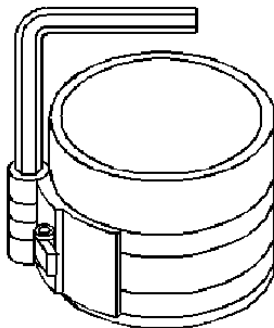
J 6125-1B
Slide Hammer



J 7872
Magnetic Base Indicator Set



J 8001
Dial Indicator Set

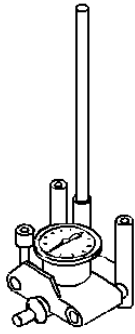


J 8037
Piston Ring Compressor

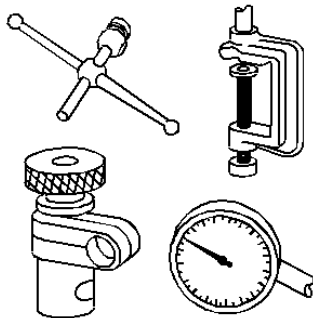
J 8087

2004 Pontiac Bonneville SLE

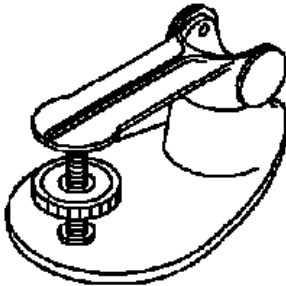
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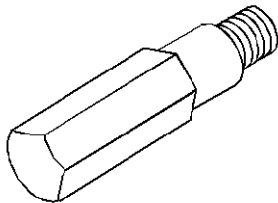
Cylinder Bore Gage



J 8092
Drive Handle



J 9666
Valve Spring Tester



J 21465-13
Drive Handle Extension

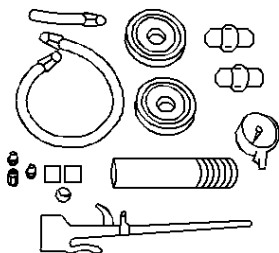
J 22794
Spark Plug Port Adapter

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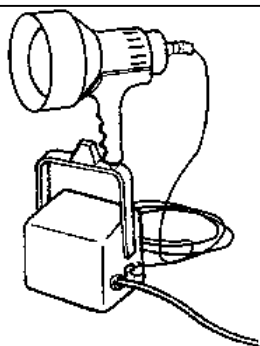
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J 24270
Cylinder Ridge Reamer



J 25087-C
Oil Pressure Tester and Pump Primer

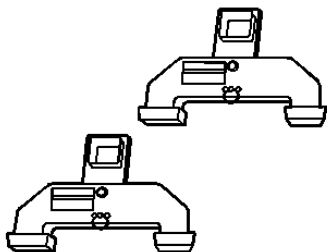


J 28428-E
High Intensity Black Light

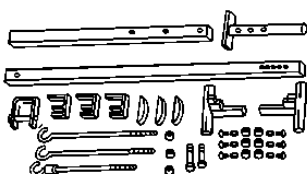
J 28467-501

2004 Pontiac Bonneville SLE

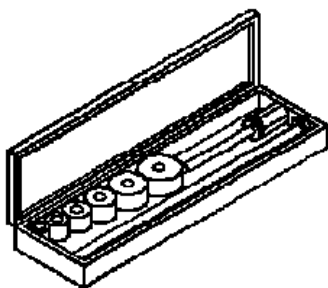
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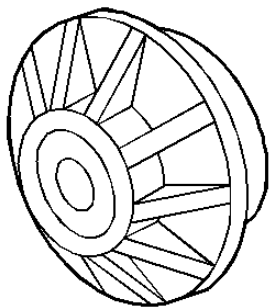
Engine Support Fixture Adapters



J 28467-B
Universal Engine Support Fixture



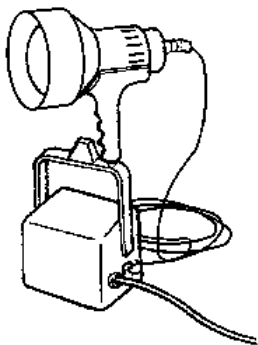
J 33049
Camshaft Bearing Service Set



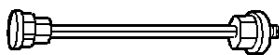
J 35354
Seal Installer

2004 Pontiac Bonneville SLE

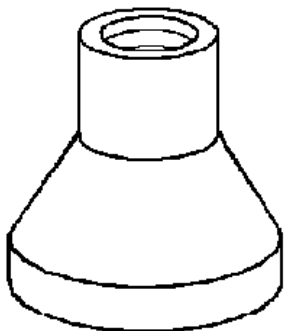
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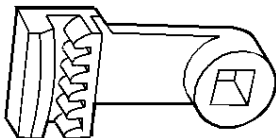
J 35667-A
Cylinder Head Leakdown Tester



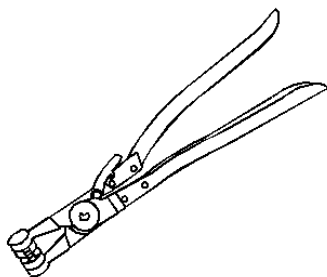
J 36995
Balance Shaft Bearing Remover/Installer



J 36996
Balance Shaft Installer



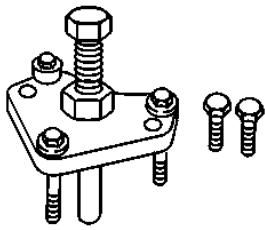
J 37096
Flywheel Holding Tool



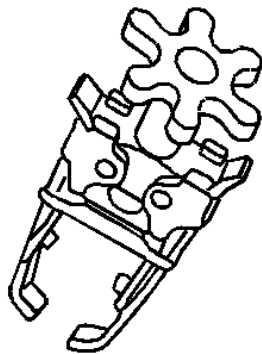
J 38185
Hose Clamp Pliers

2004 Pontiac Bonneville SLE

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J 38197-A
Crankshaft Balancer Remover



J 38606
Valve Spring Compressor

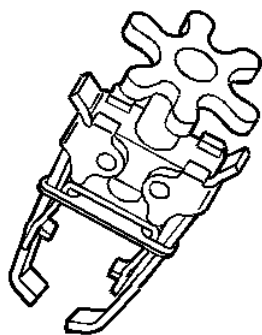
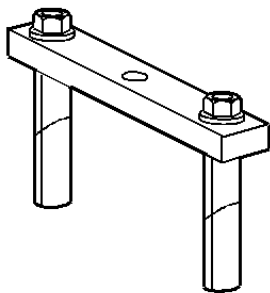


J 38722
Compression Tester

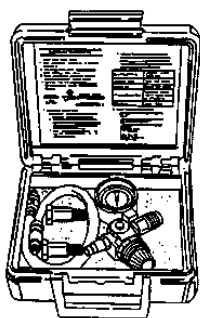
J 41348
Main Bearing Cap Puller

2004 Pontiac Bonneville SLE

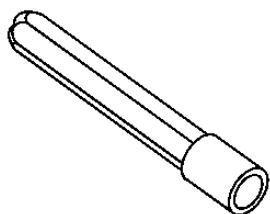
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J 41507
Connecting Rod Assembly Guide



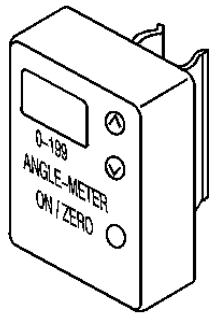
J 41712
Oil Pressure Switch Socket



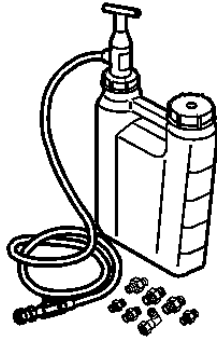
J 42863
Valve Stem Seal Installer

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J 45059
Angle Meter



J 45299
Engine Preluber