

2005 Chevrolet Astro

2005 ENGINE Engine Mechanical - 4.3L - Astro & Safari

2005 ENGINE

Engine Mechanical - 4.3L - Astro & Safari

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Control Cable Bracket Nut	12 N.m	106 lb in
Accelerator Control Cable Bracket Stud to Intake Manifold	6 N.m	53 lb in
Accelerator Control Cable Bracket Stud to Throttle Body	12 N.m	106 lb in
Air Cleaner Adapter Stud	10 N.m	89 lb in
Air Conditioning (A/C) Compressor Side Brace Bolt	25 N.m	18 lb ft
Air Conditioning (A/C) Hose Bracket Nut to Intake Manifold	5 N.m	44 lb in
Air Conditioning (A/C) Pipe Bracket Nut to Rear of Left Cylinder Head	35 N.m	26 lb ft
Balance Shaft Driven Gear Bolt		
• First Pass	20 N.m	15 lb ft
• Final Pass	35 degrees	
Balance Shaft Retainer Bolt	12 N.m	106 lb in
Belt Idler Pulley Bolt	50 N.m	37 lb ft
Body Bolt		
• First Pass in Sequence - All Bolts	35 N.m	26 lb ft
• Final Pass in Sequence - Center Bolts	155 N.m	114 lb ft
• Final Pass in Sequence - Front and Rear Bolts	90 N.m	66 lb ft
Camshaft Retainer Bolt	12 N.m	106 lb in
Camshaft Sprocket Bolt	25 N.m	18 lb ft
Connecting Rod Nut		
• First Pass	27 N.m	20 lb ft
• Final Pass	70 degrees	
Crankshaft Balancer Bolt	95 N.m	70 lb ft
Crankshaft Bearing Cap Bolt - Preferred Method		
• First Pass	20 N.m	15 lb ft
• Final Pass	73 degrees	
Crankshaft Bearing Cap Bolt - Optional Strategy	105 N.m	77 lb ft
Crankshaft Position Sensor Bolt	8 N.m	71 lb in

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Crankshaft Pulley Bolt	58 N.m	43 lb ft
Crankshaft Rear Oil Seal Housing Bolt and Nut	12 N.m	106 lb in
Crankshaft Rear Oil Seal Housing Retainer Stud	6 N.m	53 lb in
Cylinder Head Bolt - Preferred Method		
• All Bolts First Pass in Sequence	30 N.m	22 lb ft
• Long Bolts Final Pass in Sequence	75 degrees	
• Medium Bolts Final Pass in Sequence	65 degrees	
• Short Bolts Final Pass in Sequence	55 degrees	
Cylinder Head Bolt - Optional On-Vehicle Strategy		
• First Pass in Sequence	35 N.m	26 lb ft
• Second Pass in Sequence	60 N.m	44 lb ft
• Final Pass in Sequence	90 N.m	66 lb ft
Cylinder Head Core Hole Plug	20 N.m	15 lb ft
Distributor Cap Bolt	2.4 N.m	21 lb in
Distributor Clamp Bolt	25 N.m	18 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Coolant Drain Hole Plug	20 N.m	15 lb ft
Engine Block Left Rear Oil Gallery Plug	30 N.m	22 lb ft
Engine Block Left Side Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Oil Gallery Plug	20 N.m	15 lb ft
Engine Block Right Rear Oil Gallery Plug	20 N.m	15 lb ft
Engine Coolant Heater Bolt/Screw	2 N.m	18 lb in
Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
Engine Flywheel Bolt	100 N.m	74 lb ft
Engine Front Cover Bolt	12 N.m	106 lb in
Engine Lift Bracket Bolt for J 41427	15 N.m	11 lb ft
Engine Lift Front Bracket Stud	35 N.m	26 lb ft
Engine Mount Bolt to Frame (AWD)	59 N.m	44 lb ft
Engine Mount Bolt to Frame (RWD)	47 N.m	35 lb ft
Engine Mount Bracket Bolt to Engine	64 N.m	47 lb ft
Engine Mount Bracket to Frame Bolt (RWD)	47 N.m	35 lb ft
Engine Mount Bracket to Frame Nut (RWD)	42 N.m	31 lb ft
Engine Mount Frame Bracket Through-bolt	80 N.m	59 lb ft
Engine Mount Frame Bracket Through-bolt Nut	68 N.m	50 lb ft
Engine Mount Nut to Frame (RWD)	42 N.m	31 lb ft
Engine Oil Pressure Gage Sensor	30 N.m	22 lb ft
Engine Oil Pressure Gage Sensor Fitting - Plus Required Angle	15 N.m	11 lb ft
Engine Wiring Harness Bracket Bolt to Generator and Drive Belt Tensioner Bracket	25 N.m	18 lb ft

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Engine Wiring Harness Bracket Nut to Evaporative Emission (EVAP) Canister Purge Solenoid Valve	8 N.m	71 lb in
Engine Wiring Harness Bracket Nut to Intake Manifold	12 N.m	106 lb in
Engine Wiring Harness Retainer Bolt to Rear of Right Cylinder Head	36 N.m	27 lb ft
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Nut to Intake Manifold	10 N.m	89 lb in
Exhaust Manifold Bolt/Stud		
• First Pass	15 N.m	11 lb ft
• Final Pass	30 N.m	22 lb ft
Fan and Water Pump Pulley Bolt	25 N.m	18 lb ft
Fuel Meter Body Bracket Bolt	10 N.m	89 lb in
Fuel Pipe Bracket Bolt	6 N.m	53 lb in
Fuel Pipe Bracket Stud to Rear of Cylinder Head	33 N.m	24 lb ft
Fuel Pipe Retainer Nut	3 N.m	27 lb in
Fuel Supply Pipe Nut - Fuel Tank Side	30 N.m	22 lb ft
Generator and Drive Belt Tensioner Bracket Bolt to Engine	41 N.m	30 lb ft
Generator and Drive Belt Tensioner Bracket Stud Nut	41 N.m	30 lb ft
Generator and Drive Belt Tensioner Bracket Stud to Engine	20 N.m	15 lb ft
Ground Wire Bolt to Rear of Cylinder Head	35 N.m	26 lb ft
Ground Wire Nut to Water Outlet Stud	19 N.m	14 lb ft
Ignition Coil Stud	12 N.m	106 lb in
Knock Sensor	25 N.m	18 lb ft
Lower Intake Manifold Bolt		
• First Pass in Sequence	3 N.m	27 lb in
• Second Pass in Sequence	12 N.m	106 lb in
• Final Pass in Sequence	15 N.m	11 lb ft
Negative Battery Cable Stud	40 N.m	30 lb ft
Oil Cooler Pipe Bracket Bolt to Oil Pan	10 N.m	89 lb in
Oil Fill Tube Bolt	25 N.m	18 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Adapter Bolt	21 N.m	15 lb ft
Oil Filter Fitting	55 N.m	41 lb ft
Oil Level Indicator Tube Bolt	12 N.m	106 lb in
Oil Level Indicator Tube Bolt to Transmission Fluid Fill Tube	12 N.m	106 lb in
Oil Pan Baffle Bolt	12 N.m	106 lb in
Oil Pan Bolt and Nut	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pump Bolt to Rear Crankshaft Bearing Cap	90 N.m	66 lb ft

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Oil Pump Cover Bolt	12 N.m	106 lb in
Park Brake Bracket Bolt to Frame	24 N.m	18 lb ft
Power Steering Pump Bolt	50 N.m	37 lb ft
Power Steering Pump Bracket Bolt to Engine	41 N.m	30 lb ft
Power Steering Pump Bracket Stud Nut	41 N.m	30 lb ft
Power Steering Pump Bracket Stud to Engine	20 N.m	15 lb ft
Power Steering Pump Rear Bracket Nut to Engine	41 N.m	30 lb ft
Power Steering Pump Rear Bracket Nut to Power Steering Pump	41 N.m	30 lb ft
Spark Plug		
• Initial Installation - NEW Cylinder Head	30 N.m	22 lb ft
• All Subsequent Installations	15 N.m	11 lb ft
Spark Plug Wire Support Bolt	12 N.m	106 lb in
Starter Motor Wiring Harness/Transmission Cooler Pipe Bracket Bolt to Oil Pan	10 N.m	89 lb in
Throttle Body Stud	9 N.m	80 lb in
Timing Chain Tensioner Bolt	12 N.m	106 lb in
Transmission Bolt to Oil Pan	47 N.m	35 lb ft
Transmission Cover Bolt	12 N.m	106 lb in
Transmission Fluid Fill Tube Bolt to Accelerator Control Cable Bracket	6 N.m	53 lb in
Upper Intake Manifold Stud		
• First Pass	5 N.m	44 lb in
• Final Pass	9 N.m	80 lb in
Upper Radiator Hose Support Bracket Nut to Exhaust Manifold Stud	36 N.m	27 lb ft
Valve Lifter Pushrod Guide Bolt	16 N.m	12 lb ft
Valve Rocker Arm Bolt	30 N.m	22 lb ft
Water Outlet Stud	25 N.m	18 lb ft
Water Pump Bolt	45 N.m	33 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	90 degree V6	
• Displacement	4.3 L	262 CID
• RPO	LU3	

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• VIN	X	
• Bore	101.60 mm	4.012 in
• Stroke	88.39 mm	3.480 in
• Compression Ratio	9.2:1	
• Firing Order	1-6-5-4-3-2	
• Spark Plug Gap	1.52 mm	0.060 in
Balance Shaft		
• Bearing Journal Diameter - Rear	38.085-38.100 mm	1.4994-1.500 in
• Bushing Bore Diameter - Rear	0.050-0.088 mm	0.0020-0.0035 in
Block		
• Crankshaft Main Bearing Bore Out-of-Round	0.050 mm	0.002 in
• Cylinder Bore Diameter	101.618-101.643 mm	4.0007-4.0017 in
• Cylinder Bore Out-of-Round - Production	0.017 mm	0.0007 in
• Cylinder Bore Out-of-Round - Service	0.05 mm	0.002 in
• Cylinder Bore Taper - Production Relief Side	0.025 mm	0.0010 in
• Cylinder Bore Taper - Production Thrust Side	0.012 mm	0.0005 in
• Cylinder Bore Taper - Service	0.025 mm	0.0010 in
• Cylinder Head Deck Surface Flatness	0.050-0.152 mm	0.002-0.006 in
Camshaft		
• Camshaft End Play	0.0254-0.2286 mm	0.0010-0.0090 in
• Camshaft Journal Diameter	47.440-47.490 mm	1.8677-1.8696 in
• Camshaft Journal Out-of-Round	0.008 mm	0.0003 in
• Camshaft Lobe Lift - Exhaust	7.0953 mm	0.2793 in
• Camshaft Lobe Lift - Intake	6.8678 mm	0.2704 in
• Camshaft Runout	0.100 mm	0.0039 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.038-0.078 mm	0.0015-0.0031 in
• Connecting Rod Bearing Clearance - Service	0.025-0.063 mm	0.0010-0.0025 in
• Connecting Rod Side Clearance	0.15-0.44 mm	0.006-0.017 in
Crankshaft		
• Connecting Rod Journal Diameter	57.116-57.148 mm	2.2487-2.2497 in
• Connecting Rod Journal Out-of-Round - Production	0.008 mm	0.0003 in
• Connecting Rod Journal Out-of-Round - Service	0.025 mm	0.0010 in

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• Connecting Rod Journal Taper - Production	0.010 mm	0.0004 in
• Connecting Rod Journal Taper - Service	0.025 mm	0.0010 in
• Crankshaft End Play	0.050-0.20 mm	0.002-0.008 in
• Crankshaft Main Bearing Clearance #1 - Production	0.02-0.05 mm	0.0008-0.0020 in
• Crankshaft Main Bearing Clearance #2, #3, and #4 - Production	0.028-0.058 mm	0.0011-0.0023 in
• Crankshaft Main Bearing Clearance #1 - Service	0.0254-0.05 mm	0.0010-0.0020 in
• Crankshaft Main Bearing Clearance #2, #3, and #4 - Service	0.025-0.063 mm	0.0010-0.0025 in
• Crankshaft Main Journal Diameter #1	62.199-62.217 mm	2.4488-2.4495 in
• Crankshaft Main Journal Diameter #2 and #3	62.191-62.215 mm	2.4485-2.4494 in
• Crankshaft Main Journal Diameter #4	62.179-62.203 mm	2.4480-2.4489 in
• Crankshaft Main Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Crankshaft Main Journal Out-of-Round - Service	0.025 mm	0.0010 in
• Crankshaft Main Journal Taper	0.007 mm	0.0003 in
Exhaust Manifold		
• Surface Flatness - Flange to Flange	0.25 mm	0.010 in
• Surface Flatness - Individual Flange	0.05 mm	0.002 in
Intake Manifold		
• Surface Flatness	0.10 mm	0.004 in
Lubrication System		
• Oil Capacity for C/K, G/H with Filter	4.3 L	4.5 qt
• Oil Capacity for C/K, G/H without Filter	3.8 L	4 qt
• Oil Capacity for S/T, M/L with Filter	4.7 L	5 qt
• Oil Capacity for S/T, M/L without Filter	4.3 L	4.5 qt
• Oil Pressure - at 1,000 RPM	42 kPa	6 psi
• Oil Pressure - at 2,000 RPM	125 kPa	18 psi
• Oil Pressure - at 4,000 RPM	166 kPa	24 psi
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Production	0.25-0.40 mm	0.010-0.016 in
• Piston Ring End Gap - Second Compression Ring - Production	0.38-0.58 mm	0.015-0.023 in
• Piston Ring End Gap - Oil Control Ring - Production	0.25-0.76 mm	0.010-0.029 in
• Piston Ring End Gap - First Compression Ring -	0.25-0.50 mm	0.010-0.020 in

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Service		
• Piston Ring End Gap - Second Compression Ring - Service	0.38-0.80 mm	0.015-0.031 in
• Piston Ring End Gap - Oil Control Ring - Service	0.005-0.090 mm	0.0002-0.0035 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.030-0.070 mm	0.0012-0.0027 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.076-0.280 mm	0.0030-0.0110 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.046-0.196 mm	0.0018-0.0077 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.030-0.085 mm	0.0012-0.0033 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.030-0.085 mm	0.0012-0.0033 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.076-0.200 mm	0.0030-0.0079 in
Pistons and Pins		
• Piston - Piston to Bore Clearance - Production	0.018-0.061 mm	0.0007-0.0024 in
• Piston - Piston to Bore Clearance - Service	0.075 mm	0.0029 in
• Pin - Piston Pin Clearance to Connecting Rod Bore - Press Fit	0.012-0.048 mm	0.0005-0.0019 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Production	0.013-0.023 mm	0.0005-0.0009 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Service	0.025 mm	0.0010 in
• Pin - Piston Pin Diameter	23.545-23.548 mm	0.9270-0.9271 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Intake	1.016-1.651 mm	0.040-0.065 in
• Valves - Valve Seat Width - Exhaust	1.651-2.489 mm	0.065-0.098 in
• Valves - Valve Stem Oil Seal Installed Height	1-2 mm	0.03937-0.07874 in
• Valves - Valve Stem-to-Guide Clearance - Intake - Production	0.025-0.069 mm	0.0010-0.0027 in
• Valves - Valve Stem-to-Guide Clearance - Intake - Service	0.025-0.094 mm	0.0010-0.0037 in

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• Valves - Valve Stem-to-Guide Clearance - Exhaust - Production	0.025-0.069 mm	0.0010-0.0027 in
• Valves - Valve Stem-to-Guide Clearance - Exhaust - Service	0.025-0.094 mm	0.0010-0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.5:1	
• Valve Springs - Valve Spring Free Length	51.3 mm	2.02 in
• Valve Springs - Valve Spring Installed Height - Intake	42.92-43.43 mm	1.670-1.700 in
• Valve Springs - Valve Spring Installed Height - Exhaust	42.92-43.43 mm	1.670-1.700 in
• Valve Springs - Valve Spring Load - Closed	338-374 N @ 43.2 mm	76-84 lb @ 1.70 in
• Valve Springs - Valve Spring Load - Open	832-903 N @ 32.3 mm	187-203 lb @ 1.27 in

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Balancer Shaft Driven Gear Bolt	Threadlock	12345382	10953489
Camshaft Retainer Bolt	Threadlock	12345382	10953489
Crankshaft Balancer Keyway	Adhesive	12346141	10953433
Cylinder Head Bolt	Sealant	12346004	10953480
Engine Block to the Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141	10953433
Engine Block to the Engine Front Cover Junction at the Oil Pan Sealing Surfaces	Adhesive	12346141	10953433
Engine Block at the Lower Intake Manifold Sealing Surfaces	Adhesive	12346141	10953433
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480
Engine Block Core Hole Plug	Threadlock	12345382	10953489
Engine Block Oil Gallery Plug	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Gage Sensor	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004	10953480
Engine Oil	SAE 5W-30 Oil	12345610	993193
Engine Oil Pressure Sensor	Sealant	12346004	10953480
Engine Oil Pressure Sensor Fitting	Sealant	12346004	10953480
Engine Oil Supplement	Lubricant	1052367	992367
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Stud	Threadlock	12345382	10953489
Exhaust Manifold Bolt/Stud	Threadlock	12345493	10953488

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Expansion Cup Plug - Balance Shaft Rear Bearing Hole	Sealant	12346004	10953480
Expansion Cup Plug - Camshaft Rear Bearing Hole	Sealant	12346004	10953480
Fuel Meter Body Bracket Bolt	Threadlock	12345382	10953489
Fuel Pipe Bolt	Threadlock	12345382	10953489
Lower Intake Manifold Bolt	Threadlock	12345382	10953489
Oil Level Indicator Tube	Sealant	12346004	10953480
Oil Pump Screen Tube	Sealant	12346004	10953480
Throttle Body Stud	Threadlock	12345382	10953489
Upper Intake Manifold Stud	Threadlock	12345382	10953489
Valve Train Component Prelube	Lubricant	12345501	992704
Water Pump Bolt	Sealant	12346004	10953480

COMPONENT LOCATOR

DISASSEMBLED VIEWS

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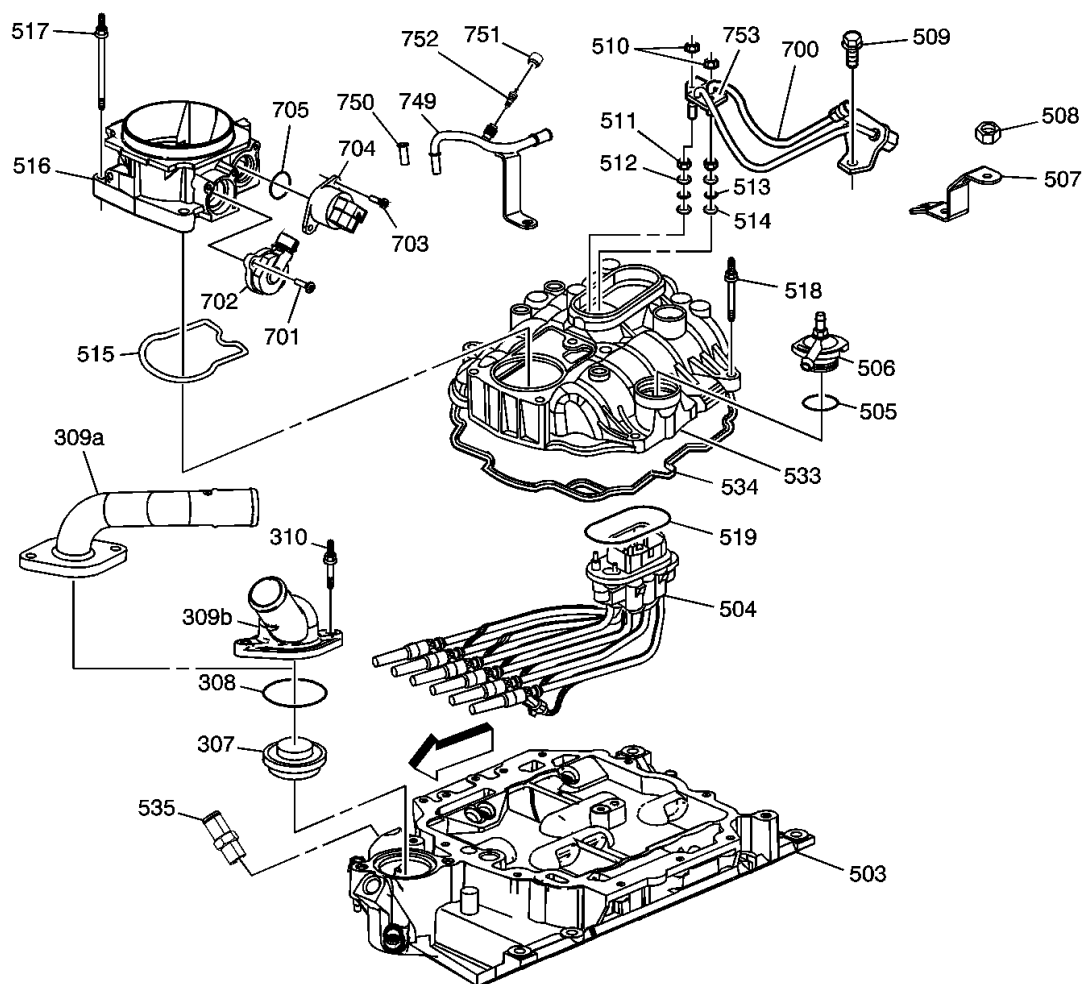


Fig. 1: Upper and Lower Intake Manifold View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
307	Thermostat
308	Thermostat Seal
309a	Thermostat Housing - S/T/C/K
309b	Thermostat Housing - M/L/G/H
310	Thermostat Housing Stud
503	Lower Intake Manifold
504	Fuel Meter Body
505	PCV Valve Cover Seal
506	PCV Valve Cover
507	Wire Harness Bracket
508	Wire Harness Bracket Nut

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509	Fuel Pipe Bolt
510	Fuel Pipe Nut
511	Fuel Pipe Seal Retainer
512	Upper Fuel Pipe Seal
513	Fuel Pipe Spacer
514	Lower Fuel Pipe Seal
515	Throttle Body Gasket
516	Throttle Body
517	Throttle Body Stud
518	Upper Intake Manifold Stud
519	Fuel Meter Body Seal
533	Upper Intake Manifold
534	Upper Intake Manifold Gasket
535	Heater Inlet Hose Fitting
700	Fuel Pipes
701	Throttle Position Sensor Bolt
702	Throttle Position Sensor
703	Idle Air Control Sensor Bolt
704	Idle Air Control Sensor
705	Idle Air Control Sensor Seal
749	Fuel Pipe - Returnless
750	Fuel Pipe Plug
751	Fuel Service Port Cap
752	Fuel Service Port Schrader Valve
753	Fuel Pipe Retainer

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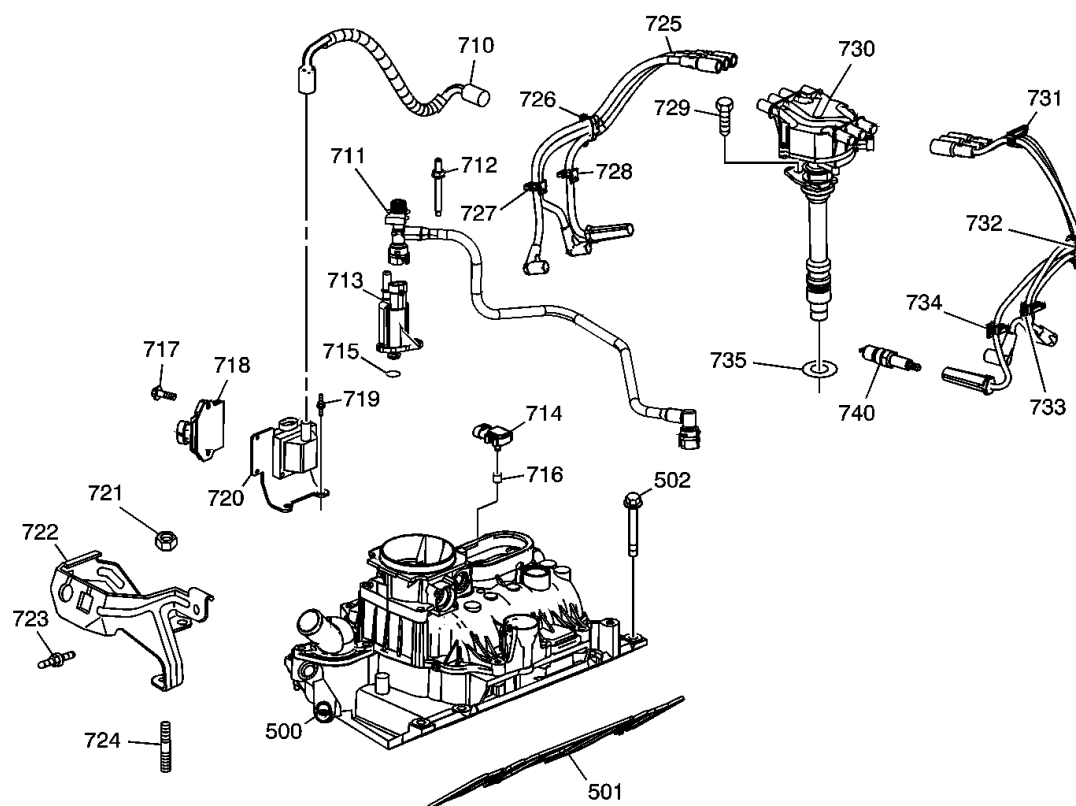


Fig. 2: Upper Engine View 1
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
500	Intake Manifold Assembly
501	Lower Intake Manifold Gasket
502	Lower Intake Manifold Bolt
710	Ignition Coil Wire
711	Evaporative Emission (EVAP) Purge Valve Hose
712	Evaporative Emission (EVAP) Purge Valve Bolt
713	Evaporative Emission (EVAP) Purge Valve
714	MAP Sensor
715	Evaporative Emission (EVAP) Purge Valve Seal
716	MAP Sensor Seal
717	Ignition Coil Module Bolt
718	Ignition Coil Module
719	Ignition Coil Bolt
720	Ignition Coil
721	Throttle Cable Bracket Nut

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722	Throttle Cable Bracket
723	Throttle Cable Bracket Bolt
724	Throttle Cable Bracket Stud
725	Ignition Wire Harness - Right
726	Ignition Wire Harness Retainer
727	Ignition Wire Harness Retainer
728	Ignition Wire Harness Retainer
729	Distributor Bolt
730	Distributor
731	Ignition Wire Harness - Left
732	Ignition Wire Harness Retainer
733	Ignition Wire Harness Retainer
734	Ignition Wire Harness Retainer
735	Distributor Gasket
740	Spark Plug

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212	Cylinder Head Bolt - Long
213	Cylinder Head Bolt - Medium
214	Cylinder Head Bolt - Short
215	Valve
216	Cylinder Head Gasket
217	Cylinder Head Locating Pin
414	Oil Fill Tube Grommet
415	Oil Fill Tube - G/H
415	Oil Fill Tube - S/T
415	Oil Fill Tube - M/L
415	Oil Fill Tube - C/K
416	Oil Fill Cap Seal
416	Oil Fill Cap Seal
416	Oil Fill Cap Seal
416	Oil Fill Cap Seal
417	Oil Fill Cap
417	Oil Fill Cap
417	Oil Fill Cap
417	Oil Fill Cap
421	Oil Fill Tube Seal
421	Oil Fill Tube Seal
523	Valve Rocker Arm Cover Bolt
524	Valve Rocker Arm Cover Bolt Grommet
525	Valve Rocker Arm Cover - Left
526	Valve Rocker Arm Cover Gasket
528	Valve Rocker Arm Cover - Right
529	Fresh Air Tube Grommet
600	Exhaust Manifold
601	Exhaust Manifold Gasket - Large
602	Exhaust Manifold Gasket - Small
603	Exhaust Manifold Heat Shield
604	Exhaust Manifold Heat Shield Bolt
605	Spark Plug Wire Heat Shield - Large
606	Exhaust Manifold Bolt
607	Exhaust Manifold Stud
608	Spark Plug Wire Heat Shield - Small
736	PCV Hose
738	Ignition Wire Bracket
739	Ignition Wire Bracket Bolt
741	Engine Coolant Temperature Sensor
748	Fresh Air Tube

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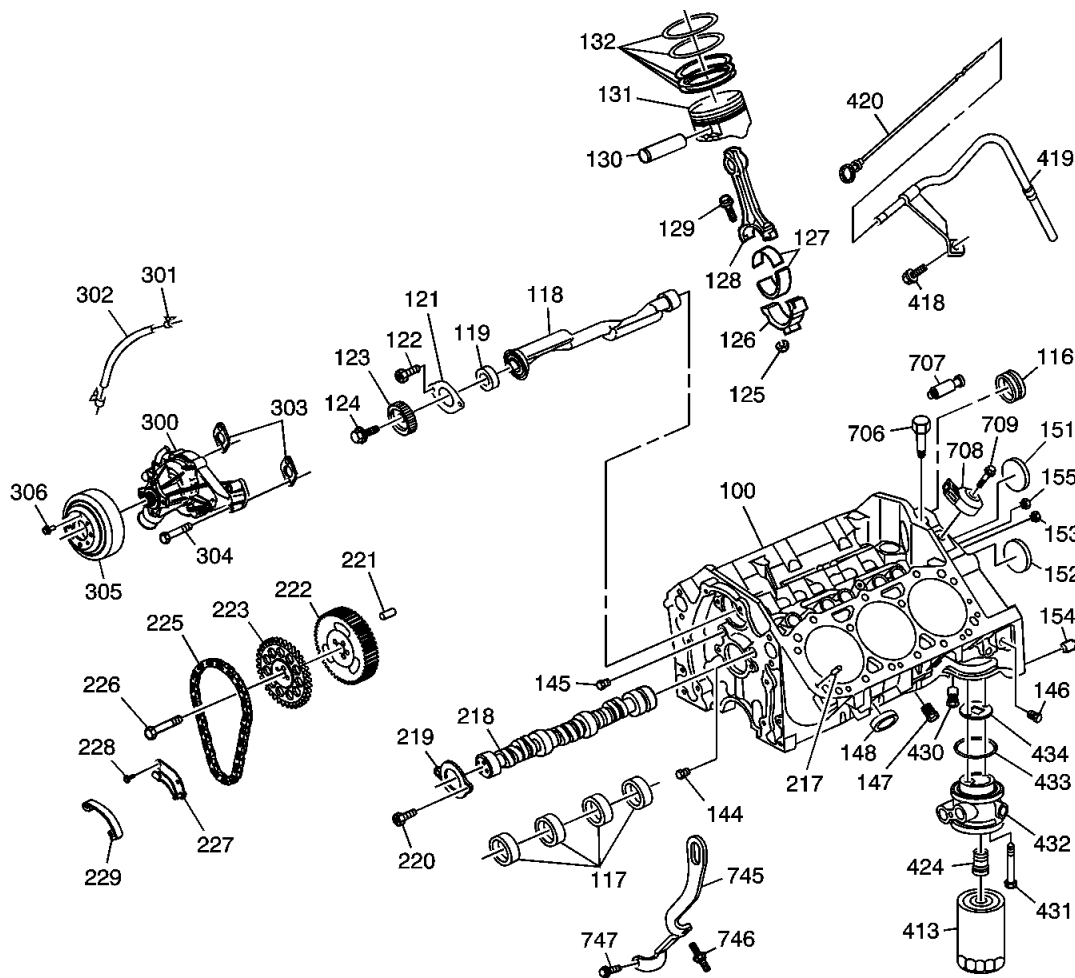


Fig. 4: Lower Engine Component View - 1 Of 2
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
116	Balance Shaft Bearing - Rear
117	Camshaft Bearing
118	Balance Shaft
119	Balance Shaft Bearing - Front
121	Balance Shaft Retainer Plate
122	Balance Shaft Retainer Plate Bolt
123	Balance Shaft Driven Gear
124	Balance Shaft Driven Gear Bolt
125	Connecting Rod Nut
126	Connecting Rod Cap

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127	Connecting Rod Bearing
128	Connecting Rod
129	Connecting Rod Bolt
130	Piston Pin
131	Piston
132	Piston Ring Set
144	Front Oil Gallery Plug - Left
145	Front Oil Gallery Plug - Right
146	Side Oil Gallery Plug - Left
147	Engine Block Coolant Drain Plug - Left
148	Engine Block Core Plug
151	Balance Shaft Rear Bearing Hole Plug
152	Camshaft Rear Bearing Hole Plug
153	Rear Oil Gallery Plug - Left
154	Transmission Locating Pin
155	Rear Oil Gallery Plug - Right
217	Cylinder Head Locating Pin
218	Camshaft
219	Camshaft Retainer Plate
220	Camshaft Retaining Plate Bolt
221	Camshaft Drive Gear Locating Pin
222	Camshaft Drive Gear
223	Camshaft Timing Gear
225	Timing Chain
226	Camshaft Timing Gear Bolt
227	Timing Chain Tensioner Bracket
228	Timing Chain Tensioner Bracket Bolt
229	Timing Chain Tensioner Shoe
300	Water Pump
301	Water Pump Bypass Hose Clamp
302	Water Pump Bypass Hose
303	Water Pump Gasket
304	Water Pump Bolt
305	Water Pump Pulley
306	Water Pump Pulley Bolt
413	Oil Filter
418	Oil Level Indicator Tube Bolt
419	Oil Level Indicator Tube
420	Oil Level Indicator
424	Oil Pressure Relief Valve O-Ring Seal
430	Oil Filter Bypass Valve

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	Oil Cooler Adapter Bolt
432	Oil Cooler Adapter
433	Oil Cooler Adapter Seal
434	Oil Cooler Adapter Gasket
706	Oil Pressure Sensor Fitting
707	Oil Pressure Sensor
708	Knock Sensor
709	Knock Sensor Bolt
745	Engine Lift Bracket - Front
746	Engine Lift Bracket Stud - Front
747	Engine Lift Bracket Bolt - Front

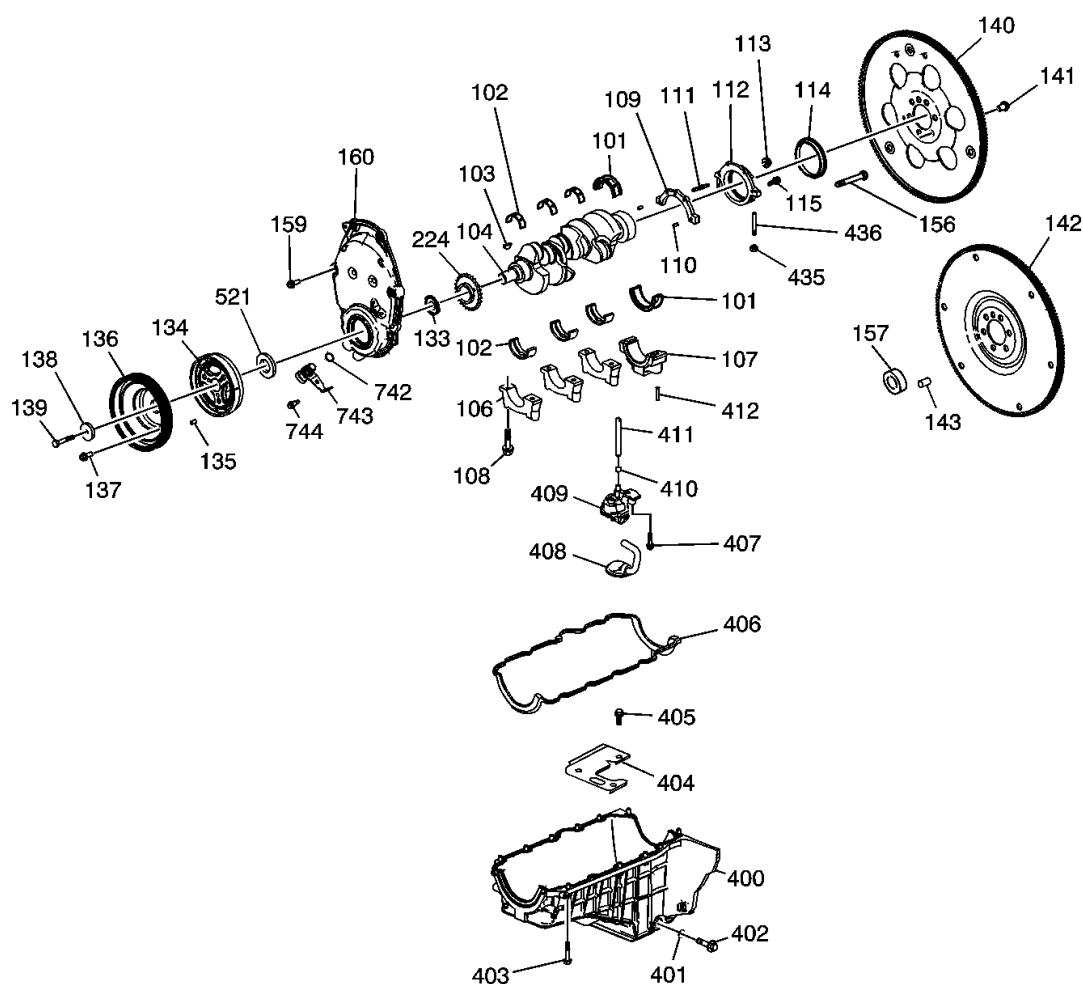


Fig. 5: Lower Engine View 2

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Callout	Component Name
101	Crankshaft Main Bearing - Thrust
101	Crankshaft Main Bearing - Thrust
102	Crankshaft Main Bearing
102	Crankshaft Main Bearing
103	Crankshaft Balancer Key
104	Crankshaft
106	Crankshaft Main Bearing Cap
107	Crankshaft Main Bearing Cap - Thrust
108	Crankshaft Main Bearing Cap Bolt
109	Crankshaft Rear Oil Seal Housing Gasket
110	Crankshaft Rear Oil Seal Housing Locating Pin
111	Crankshaft Rear Oil Seal Housing Stud
112	Crankshaft Rear Oil Seal Housing
113	Crankshaft Rear Oil Seal Housing Nut
114	Crankshaft Rear Oil Seal
115	Crankshaft Rear Oil Seal Housing Bolt
133	Crankshaft Position (CKP) Sensor Reluctor Ring
134	Crankshaft Balancer
135	Crankshaft Balancer Weight
136	Crankshaft Drive Belt Pulley
137	Crankshaft Drive Belt Pulley Bolt
138	Crankshaft Balancer Washer
139	Crankshaft Balancer Bolt
140	Flywheel - Auto Transmission
141	Flywheel Bolt
142	Flywheel - Manual Transmission
143	Flywheel Weight - Manual Transmission
156	Rear Oil Seal Housing Bolt - Large
157	Clutch Pilot Bearing
159	Front Cover Bolt
160	Front Cover
224	Crankshaft Timing Sprocket
400	Oil Pan
401	Oil Pan Drain Plug Seal
402	Oil Pan Drain Plug
403	Oil Pan Bolt
404	Oil Pan Baffle
405	Oil Pan Baffle Bolt
406	Oil Pan Gasket
407	Oil Pump Bolt

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	Oil Pump Pick Up Screen
409	Oil Pump
410	Oil Pump Drive Retainer
411	Oil Pump Drive Shaft
412	Oil Pump Locating Pin
435	Oil Pan Nut
436	Crankshaft Rear Oil Seal Housing Stud
521	Crankshaft Front Oil Seal
742	Crankshaft Position Sensor Seal
743	Crankshaft Position Sensor
744	Crankshaft Position Sensor Bolt

ENGINE IDENTIFICATION

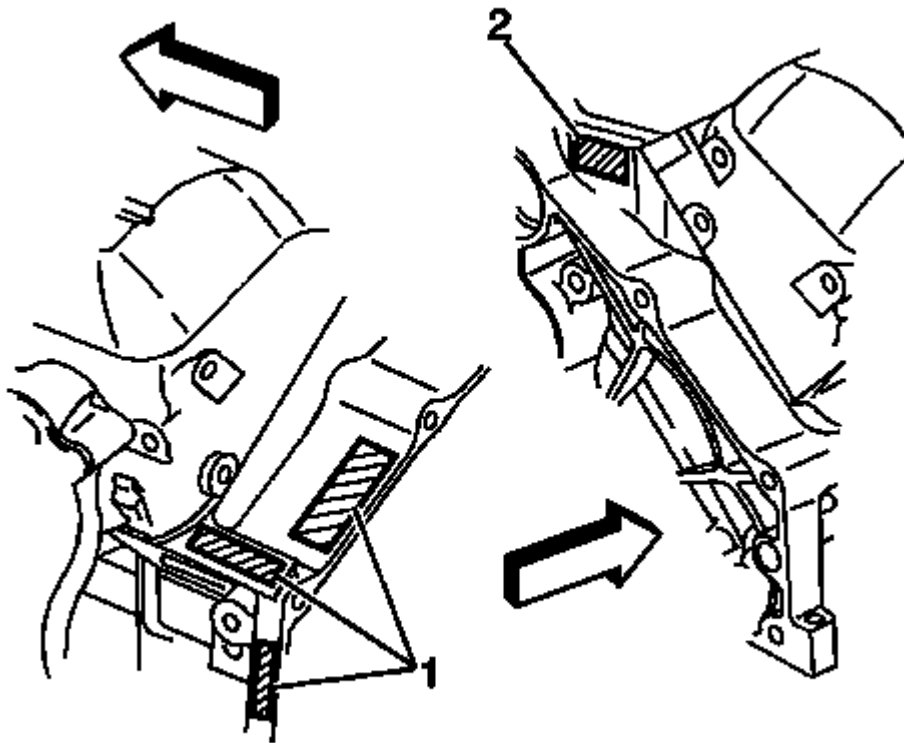


Fig. 6: Engine VIN Locations

Courtesy of GENERAL MOTORS CORP.

- The Vehicle Identification Number (VIN) Derivative is located on the left side rear of the engine block (1) or on the right side rear (2) and typically is a 9 digit number stamped or laser etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the VIN.

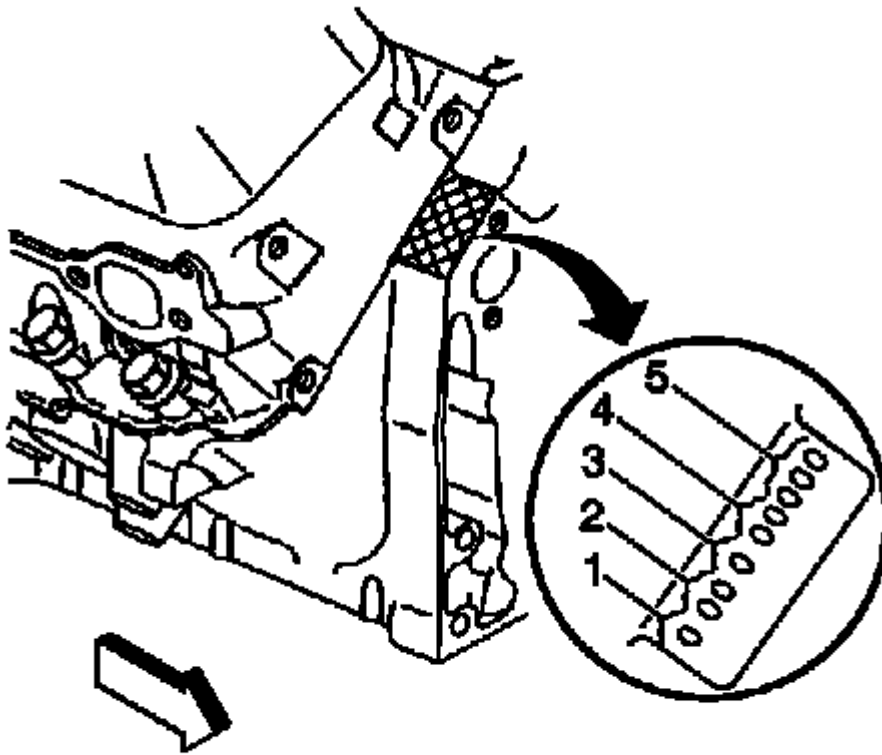


Fig. 7: Engine VIN Numerical Positions
Courtesy of GENERAL MOTORS CORP.

- Engines built at the Romulus engine plant have the engine identification number located at the right front top of the engine block.
 - The first digit (1) is the source code.
 - The second and third digits (2) are the month of build.
 - The fourth digit (3) is the hour of the build.
 - The fifth and sixth digits (4) are the date of build.
 - The seventh, eighth, and ninth digits (5) are the broadcast code.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL**Strategy Based Diagnostics**

1. Perform the **Diagnostic System Check - Vehicle** in Vehicle DTC Information 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**, **Lubrication Description**, **New Product Information** and **Drive Belt System Description**.

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
High oil pressure	• Verify oil pressure. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to <u>Drive Belt Replacement</u>.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Damaged, loose or improperly installed crankshaft balancer A misfire DTC may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to <u>Crankshaft Balancer Replacement</u>.
Worn, damaged, or improperly installed crankshaft reluctor wheel A worn or damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the wear or damage.	• Inspect the crankshaft position sensor. • Inspect the crankshaft reluctor wheel. • Inspect the crankshaft. • Repair or replace damaged components as required.
• Systems with electronic communications, DIS	

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or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery. A DTC P0300 or P0336 may be set.	
Damaged, loose or improperly installed engine flywheel A misfire DTC may be present without an actual misfire condition.	• Inspect the flywheel. • Repair or replace damaged components as required. Refer to <u>Engine Flywheel Replacement</u>.
Damaged, improperly installed or restricted exhaust system, collapsed or dented pipes, plugged mufflers or malfunctioning catalytic converters A DTC may be present without an actual fault condition.	• Inspect the exhaust system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed vacuum hoses	• Inspect the vacuum system components. • Repair or replace damaged components as required.
Damaged or improperly installed MAP sensor, sealing grommet nicked, torn or missing	• Inspect the MAP sensor. • Repair or replace damaged components as required.
Damaged or improperly installed throttle body	• Inspect the throttle body. • Repair or replace damaged components as required.
Damaged or improperly installed intake manifold	• Inspect the intake manifold. • Repair or replace damaged components as required.
Damaged or improperly installed cylinder head Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as

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	required.
Worn, damaged or loose valve rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn, damaged or loose valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Worn, damaged, loose or broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.
Worn, damaged or improperly installed piston 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. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins.

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- Inspect the connecting rods.
- Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to <u>Drive Belt Replacement</u>.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Worn, damaged, improperly installed or loose crankshaft balancer A misfire code may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to <u>Crankshaft Balancer Replacement</u>.
Worn, damaged, improperly installed or loose engine flywheel A misfire code may be present without an actual misfire condition.	• Inspect the engine flywheel. • Repair or replace damaged components as required. Refer to <u>Engine Flywheel Replacement</u>.
Worn, damaged or improperly installed piston 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. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft thrust bearing A misfire code may be present without an actual misfire condition.	• Inspect the crankshaft. • Inspect the crankshaft thrust bearing. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

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Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn, damaged or loose rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Damaged or improperly installed cylinder head Coolant consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

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Cause	Correction
Worn or damaged valve	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn, damaged or improperly installed piston rings Piston rings must be installed with the mark, or dimple, on the top of the piston ring, facing up.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components 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 engine oil, viscosity	Install the correct engine oil and oil filter. Refer to <u>Engine Oil and Oil Filter Replacement</u> .
Incorrect oil filter, without anti-drainback feature	Install the correct engine oil and oil filter. Refer to <u>Engine Oil and Oil Filter Replacement</u> .
Worn, damaged or improperly installed oil filter by-pass valve	• Inspect the oil filter by-pass valve. • Repair or replace damaged components as required.
High valve lifter leak down rate	• Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft thrust bearing	• Inspect the crankshaft. • Inspect the crankshaft thrust bearing. • Repair or replace damaged components as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Verify oil pressure. Refer to <u>Oil Pressure Diagnosis and Testing</u>.

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	• Repair or replace damaged components as required.
Improper lubrication of the valve train components	• Verify oil pressure. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Inspect the valve rocker arms. • Inspect the valve push rods. • Inspect the valve lifters. • Inspect the oil filter bypass valve. • Inspect the oil pump and pump screen. • Inspect the engine block oil galleries. • Repair or replace damaged components as required.
Worn, damaged or improperly installed valve rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn or damaged valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valves, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged or bent valve push rod	• Inspect the valve rocker arms. • Inspect the valve push rods. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Repair or replace damaged components as required.
Worn or damaged camshaft lobes	• Inspect the engine camshaft lobes.

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	• Repair or replace damaged components as required.
Worn, damaged, improperly installed or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.
Worn, damaged or improperly installed timing chain tensioner, if equipped	• Inspect the timing chain tensioner. • Repair or replace damaged components as required.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Verify oil pressure. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace damaged components as required.
Detonation or spark knock	• Verify the operation of the ignition controls system. Refer to <u>Diagnostic System Check - Vehicle</u> in Vehicle DTC Information. • Repair or replace damaged components as required.
Worn, damaged or improperly installed accessory drive belt - severe cracking, bumps or missing segments in the accessory drive belt	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed accessory drive system components	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft balancer	• Inspect the crankshaft balancer. • Inspect the crankshaft. • Repair or replace damaged components as required.
Worn, damaged or improperly installed engine flywheel	• Inspect the engine flywheel. • Inspect the engine flywheel bolts. • Inspect the torque converter. • Inspect the torque converter bolts. • Inspect the crankshaft. • Repair or replace damaged components as required.

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	required.
Worn, damaged or improperly installed torque converter	• Inspect the torque converter. • Inspect the torque converter bolts. • Inspect the engine flywheel. • Repair or replace damaged components as required.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged may loosen, improperly position or restrict oil flow at the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen. • Repair or replace damaged components as required.
Worn, damaged, improperly installed or restricted oil pump screen An oil pan that has been damaged may loosen, improperly position or restrict oil flow at the oil pump screen, preventing proper oil flow to the oil pump.	• Inspect the oil pan. • Inspect the oil pump screen. • Repair or replace damaged components as required.
Worn, damaged or improperly installed piston 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.	• Inspect the spark plugs. Refer to <u>Spark Plug Inspection</u> in Engine Controls. • Verify engine compression. Refer to <u>Engine Compression Test</u>. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.
Worn, damaged or improperly installed connecting rod bearing	• Inspect the connecting rods. • Inspect the connecting rod bearings. • Inspect the crankshaft connecting rod journals. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft bearing	• Inspect the crankshaft bearings. • Inspect the crankshaft journals. • Repair or replace damaged components as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

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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 ignition controls. Refer to <u>Diagnostic System Check - Vehicle</u> in Vehicle DTC Information. • Repair or replace damaged components as required.
Worn, damaged or improperly installed engine flywheel	• Inspect the engine flywheel. • Inspect the engine flywheel bolts. • Inspect the torque converter. • Inspect the torque converter bolts. • Inspect the crankshaft. • Repair or replace damaged components as required.
Worn, damaged or improperly installed torque converter	• Inspect the torque converter. • Inspect the torque converter bolts. • Inspect the engine flywheel. • Repair or replace damaged components as required.
Worn, damaged or improperly installed pistons 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.	• Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.
Worn, damaged or improperly installed connecting rod bearing	• Inspect the connecting rods. • Inspect the connecting rod bearings. • Inspect the crankshaft connecting rod journals. • Repair or replace damaged components as required.
Worn, damaged or improperly installed crankshaft bearing	• Inspect the crankshaft bearings. • Inspect the crankshaft journals. • Repair or replace damaged components as required.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

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Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive 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. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location. Refer to Unit Repair Manual - Manual Transmission.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material	• Inspect cylinder for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

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Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage.	
1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to <u>Engine Will Not Crank - Crankshaft Will Not Rotate</u>. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to <u>Engine Compression Test</u>.	
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 or 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 Cleaning and Inspection</u> .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed.	
1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to <u>Lower Engine Noise, Regardless of Engine Speed</u>. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to <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 Cleaning and Inspection</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

1. Ensure that the vehicle batteries are in good condition, and fully charged.
2. Operate the vehicle until the engine is at normal operating temperature.
3. Disconnect the positive ignition coil wire plug from the ignition coil.
4. Disconnect the fuel injector electrical connector.
5. Remove all of the spark plugs.

NOTE: Do not insert objects into the throttle plate opening. Damage to the throttle body can result, requiring replacement of the throttle body assembly.

6. Block the throttle linkage wide open.
7. Install the engine cylinder compression gage to the cylinder being tested.
8. Using the vehicle starter motor, rotate, or crank the engine for 4 compression strokes, or puffs, for the cylinder being tested. If the engine rotates for more than 4 compression strokes, test the cylinder again.
9. Record the compression reading.
10. Remove the engine cylinder compression gage from the cylinder being tested.
11. Repeat steps 8-11 for each additional cylinder. All cylinders must be tested to obtain valid test results.
12. If any cylinders have low compression, inject approximately 15 ml (1 oz) of engine oil into the cylinder through the spark plug hole.
13. Repeat steps 8-11 for all low compression cylinders.
14. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). Multiply the highest cylinder pressure by 70 percent, 1035 kPa x 70 percent = 725 kPa (150 psi x 70 percent = 105 psi), in order to determine the lowest allowable pressure in any other cylinder.

- Normal

The compression builds up quickly and evenly to the specified compression.

- Piston rings leaking

Compression is low on the first compression stroke. The compression builds up on the following strokes, but does not reach normal. Compression improves considerably when you add oil.

- Valves leaking

Compression is low on the first compression stroke. The compression does not build up on the following strokes, and does not reach normal. Compression does not improve much, if at all, when you add oil.

- Head gasket leaking

Compression is low on the first stroke. The compression does not build up on the following strokes, and does not reach normal. Compression does not improve much, if at all, when you add oil. Adjacent cylinders have the same, or similar, low compression readings.

15. If one or more cylinders fails to meet the minimum specified compression, repair or replace all damaged or worn components and test the engine again.

CYLINDER LEAKAGE TEST

Tools Required

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

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

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

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement in Engine Controls - 4.3L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke, with both valves closed.
4. Install the **J 35667-A**. See Special Tools.

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

5. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturer instructions. See Special Tools.

IMPORTANT: Perform the leakage test on all cylinders and record the values before doing any repairs.

6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
 1. Air leakage from the intake or exhaust system may indicate a worn or burnt valve or a broken valve spring.
 1. Remove the valve rocker arm cover of the suspect cylinder head. Refer to **Valve Rocker Arm Cover Replacement - Left** or **Valve Rocker Arm Cover Replacement - Right** .
 2. Ensure that both valves are closed.
 3. Inspect the cylinder head for a broken valve spring.
 4. Remove and inspect the suspect cylinder head. Refer to **Cylinder Head Replacement - Left** or **Cylinder Head Replacement - Right** .
 2. Air leakage from the crankcase, oil level indicator, or oil fill tube may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
 1. Remove the piston from the suspect cylinder. Refer to **Piston, Connecting Rod, and Bearing Removal** or **Piston, Connecting Rod, and Bearing Installation** .
 2. Inspect the piston and connecting rod assembly. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection** .
 3. Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .
 4. Inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .
 3. Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
 1. Remove both cylinder heads. Refer to **Cylinder Head Replacement - Left** or **Cylinder Head Replacement - Right** .
 2. Inspect both cylinder heads. Refer to **Cylinder Head Cleaning and Inspection** .
 3. Inspect the engine block. Refer to **Engine Block Cleaning and Inspection** .
7. Remove the **J 35667-A** . See **Special Tools**.
8. Install the spark plugs. Refer to **Spark Plug Replacement** .
9. Connect the battery ground negative cable.

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 1 liter (1 quart) of engine oil within 3 200 kilometers (2,000 miles). However, during initial engine break-in periods 4 828-6 437 kilometers (3,000-4,000 miles), oil consumption may exceed 1 liter (1 quart) or more. The causes of excessive oil consumption include the following conditions:

- External oil leaks

Tighten the bolts and/or replace gaskets and oil seals as necessary.

- Incorrect oil level or improper reading of oil level indicator

With the vehicle on a level surface, allow adequate drain down time and check for the correct oil level.

- Improper oil viscosity

Use recommended SAE viscosity for the prevailing temperatures.

- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, damaged, or the seal omitted

Ream the valve guides and install oversize service valves and/or new valve stem oil seals.

- Piston rings broken, improperly installed, worn, or not seated properly

Allow adequate time for the piston rings to seat. Replace broken or worn piston rings as necessary.

- Piston improperly installed or miss-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

1. With the vehicle on a level surface, allow adequate drain down time, 2-3 minutes, and measure for a low engine oil level.

Add the recommended grade engine oil, and fill the crankcase until the oil level measures FULL on the oil level indicator.

2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gage or the oil indicator light.

Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
 - Engine oil diluted by moisture or unburned fuel mixtures
 - Improper engine oil viscosity for the expected temperature
 - Incorrect or faulty oil pressure gage sensor
 - Incorrect or faulty oil pressure gage
 - Plugged oil filter
 - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gage sensor or another engine block oil gallery plug.
5. Install an oil pressure gage.
6. Start the engine and then allow the engine to reach normal operation temperature.
7. Measure the engine oil pressure at the following RPM:

Specification:

1. 42 kPa (6 psig) minimum, at 1,000 RPM

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2. 125 kPa (18 psig) minimum, at 2,000 RPM
 3. 166 kPa (24 psig) minimum, at 4,000 RPM
8. If the engine oil pressure is below minimum specifications, inspect the engine for one or more of the following:
- Oil pump worn or dirty
 - Malfunctioning oil pump pressure relief valve
 - Oil pump screen loose, plugged, or damaged
 - Excessive bearing clearance
 - Cracked, porous or restricted oil galleries
 - Engine block oil gallery plugs missing or incorrectly installed
 - Broken valve lifters

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		

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4	surrounding components. 2. Operate the vehicle for several kilometers - miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. 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	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 6
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers (miles) at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	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		

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	location of the leak?	Go to Step 10	Go to Step 8
8	Use J 28428-E High Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. See Special Tools . 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

Results Of Incorrect Operation

- A plugged positive crankcase ventilation (PCV) orifice or hose may cause the following conditions:
 - Rough idle
 - Stalling or slow idle speed
 - Oil leaks
 - Oil in air cleaner
 - Sludge in engine
- A leaking PCV orifice or hose may cause the following conditions:
 - Rough idle
 - Stalling
 - High idle speed

Functional Check

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

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

If an engine is idling rough, inspect for a clogged PCV orifice, a dirty vent filter, air cleaner element, or plugged hose. Replace as required. Use the following procedure:

1. Remove the PCV hose from the rocker arm cover.
2. Operate the engine at idle.
3. Place your thumb over the end of the hose in order to check for a vacuum. If there is no vacuum at the hose, inspect for the following items:
 - Plugged hoses
 - The manifold port
4. Turn OFF the engine.
5. Inspect the PCV orifice in the valve cover for debris or blockage.

DRIVE BELT CHIRPING DIAGNOSIS**Diagnostic Aids**

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

A loose or incorrect 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 verifies 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 verifies the noise is related to the drive belt. When removing the drive belt(s) the water pump may not be operating and cause the engine to overheat. Also DTCs may set if the engine is operating with the drive belt removed.
- 4:** Inspect all drive belt pulleys for pilling. Pilling is the small balls or strings in the drive belt grooves. Pilling occurs from the accumulation of rubber dust.
- 6:** Misalignment of the pulleys may be caused from incorrect 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 an incorrectly aligned pulley. Use a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found, refer to that accessory drive component for the correct installation procedure.
- 10:** Inspection of the fasteners eliminates the installment of incorrect: bolts, nuts, spacers, or washers.
- 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 correctly 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 if there is no excessive pilling will 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 up conditions and will subside once the vehicle reaches normal operating temperature. - It usually occurs on cold damp mornings.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to 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
	Inspect for severe pilling exceeding 1/3 of the belt groove		

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

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

A loose or incorrect 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. Ensure the accessory components are operated to their maximum capacity. An overcharged A/C system or power steering system with: a pinched hose, an incorrect fluid, or a failed generator 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 verifies the noise is related to the drive belt or an accessory drive component. If the drive belt is removed, the water pump may not operate. Without the water pump the engine may overheat. DTCs may set when the engine is operating with the drive belt removed.

4: This test verifies that an accessory drive component does not have a seized bearing. Remove the belt and test the bearings for smooth turning in the accessory drive components. Test the accessory drive components with the engine operating, vary the load on the components to verify that the components operate correctly.

5: This test is to verify that the drive belt tensioner operates correctly. If the drive belt tensioner is not operating correctly, correct 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(s) is not too long, which would prevent the drive belt tensioner from working correctly. Also if an incorrect length drive belt was installed, it may not be routed correctly and may be turning an accessory drive component in the wrong direction.

7: Misalignment of the pulleys may be caused from incorrect 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 pulley that is incorrectly aligned using a straight edge in the pulley grooves across two or three pulleys. If an incorrectly aligned pulley is found refer to that accessory drive component for the correct 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(s). 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

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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 correct operation. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Did you find and correct the condition?	Go to Step 9	Go to Step 6
6	Inspect for the correct drive belt length. Refer to <u>Drive Belt Replacement</u> . Did you find and correct the condition?	Go to Step 9	Go to Step 7
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 9	Go to Step 8
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 9	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT WHINE DIAGNOSIS

Diagnostic Aids

The drive belt(s) 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(s) or the accessory drive components. When removing the drive belt the water pump may not be operating and the engine may overheat. DTCs may set if 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(s) 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 correct 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.			
	Did you review the Drive Belt Symptom operation and		Go to <u>Symptoms</u> -

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1	perform the necessary inspections?	Go to Step 2	<u>Engine Mechanical</u>
2	Verify that there is a whine noise. Does the engine make the whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt(s). 2. Operate the engine for no longer than 30 to 40 seconds. Does the whine noise still exist?	Go to <u>Symptoms - Engine Mechanical</u>	Go to Step 4
4	Inspect for a failed accessory drive component bearing. Did you find and repair the condition?	Go to Step 5	Go to Diagnostic Aids
5	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

The drive belt(s) 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(s), completing the diagnostic table, and the noise is only heard when the drive belt(s) 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(s) 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(s) 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 correct operation.

Drive Belt Rumbling Diagnosis

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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 (pills) or strings in the drive belt pulley groove ○ 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(s). 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(s) 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(s) 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(s) may cause a vibration. While the drive belt(s) 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 fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness, ease of turning. Inspect for a bent fan shaft or bent mounting flange.

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

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: Refer to 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
	1. Remove the drive belt.	Go to Symptoms - Vibration	

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3	2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	<u>Diagnosis and Correction</u> in Vibration and Diagnosis	Go to Step 4
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to Step 5	Go to Step 6
5	Install a new drive belt. Refer to <u>Drive Belt Replacement</u>. Did you complete the replacement?	Go to Step 11	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 7	Go to Step 8
7	1. Tighten any loose fasteners. 2. Replace improper or missing fasteners. Refer to <u>Fastener Tightening Specifications</u>. Did you complete the repair?	Go to Step 11	-
8	Inspect for damaged fan blades or bent fan clutch shaft, if the fan is belt driven. Refer to <u>Fan Replacement</u> in Engine Cooling. Did you find and correct the condition?	Go to Step 11	Go to Step 9
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to <u>Water Pump Replacement</u> in Engine Cooling. Did you find and correct the condition?	Go to Step 11	Go to Step 10
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 11	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

If the drive belt(s) 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 correctly.

If the drive belt(s) is the incorrect length, the drive belt tensioner may not keep the correct tension on the drive belt.

Test Description

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

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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 incorrect 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 an incorrectly aligned pulley using a straight edge in the pulley grooves across two or three pulleys. If an incorrectly aligned pulley is found refer to that accessory drive component for the correct 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 correctly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

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

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

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: Refer to 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 incorrect, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	1. Tighten any loose fasteners. 2. Replace incorrect or missing fasteners. Refer to Fastener Tightening Specifications . Does the drive belt continue to fall off?	Go to Step 9	System OK
	Test the drive belt tensioner for operating correctly. Refer		

2005 Chevrolet Astro

2005 ENGINE Engine Mechanical - 4.3L - Astro & Safari

9	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**

Excessive wear on a drive belt(s) 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(s) 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(s) 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(s) is correctly installed on all of the drive belt pulleys. Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one groove on a pulley.

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

4: This inspection is to verify the drive belt(s) 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(s) 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 <u>Drive Belt Replacement</u> . Did you find this condition?	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . Did you complete the replacement?	Go to Step 6	-
6	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

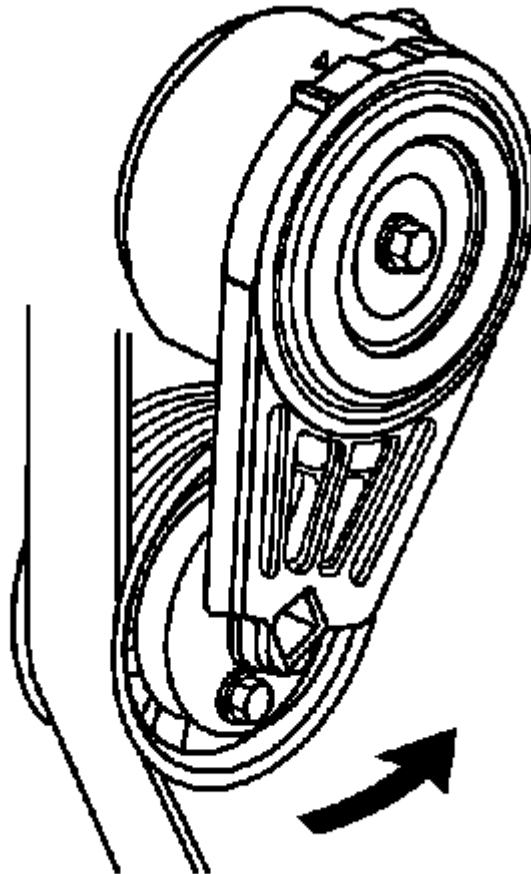


Fig. 8: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

NOTE: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

IMPORTANT: When the engine is operating the belt tensioner arm will move. Do not replace the belt tensioner because of movement in the belt tensioner arm.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Position a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise
3. Move the drive belt tensioner through it's full travel.
 - The movement should feel smooth.
 - There should be no binding.
 - The tensioner should return freely.
4. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
5. Install the drive belt. Refer to **Drive Belt Replacement**.

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement

Removal Procedure

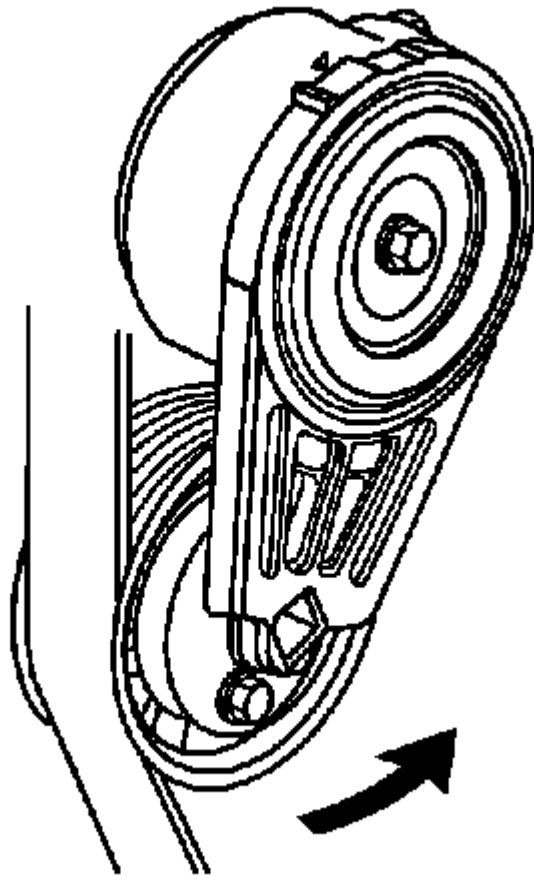


Fig. 9: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls-4.3 L.
2. Remove the air cleaner outlet duct from the throttle body. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-4.3 L.
3. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
4. Remove the drive belt.
5. Slowly release the tension on the drive belt tensioner arm.

Installation Procedure

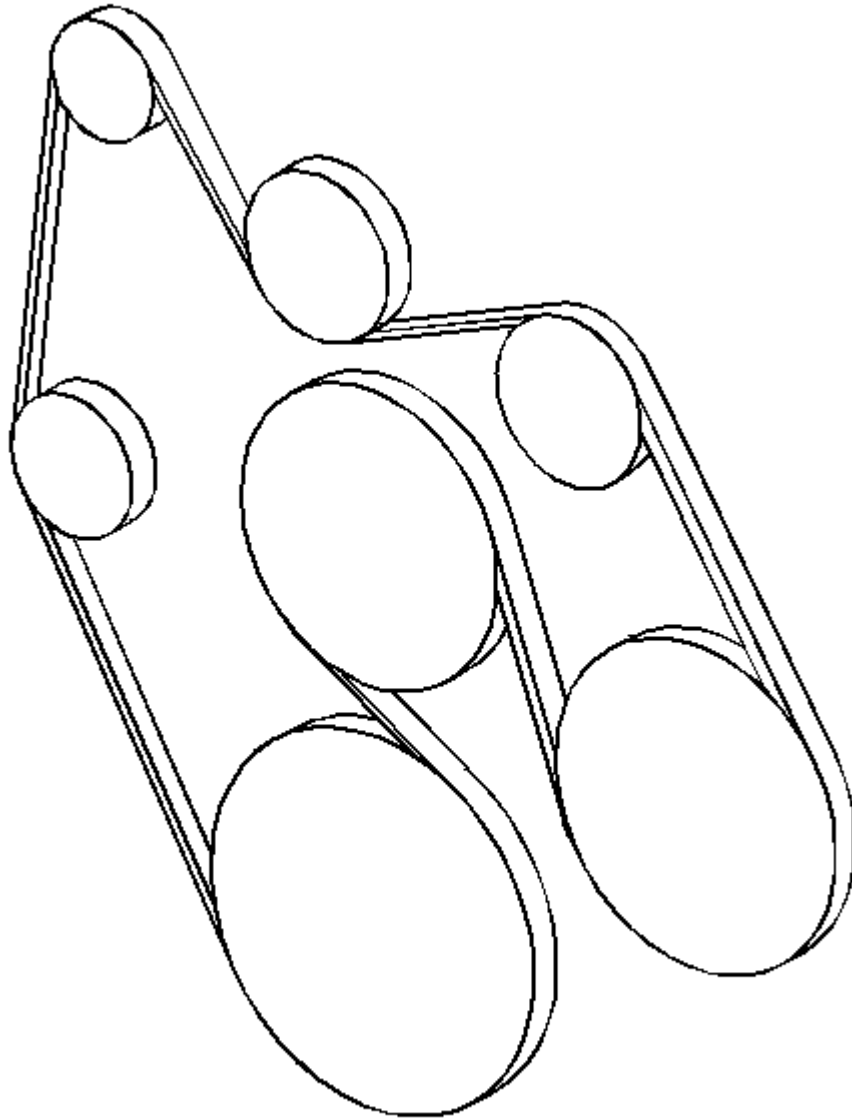


Fig. 10: Illustrating Drive Belt Routing (W/O Air Conditioning)
Courtesy of GENERAL MOTORS CORP.

1. Route the belt over all the pulleys except the tensioner arm.
2. Observe drive belt routing for vehicles without air conditioning.

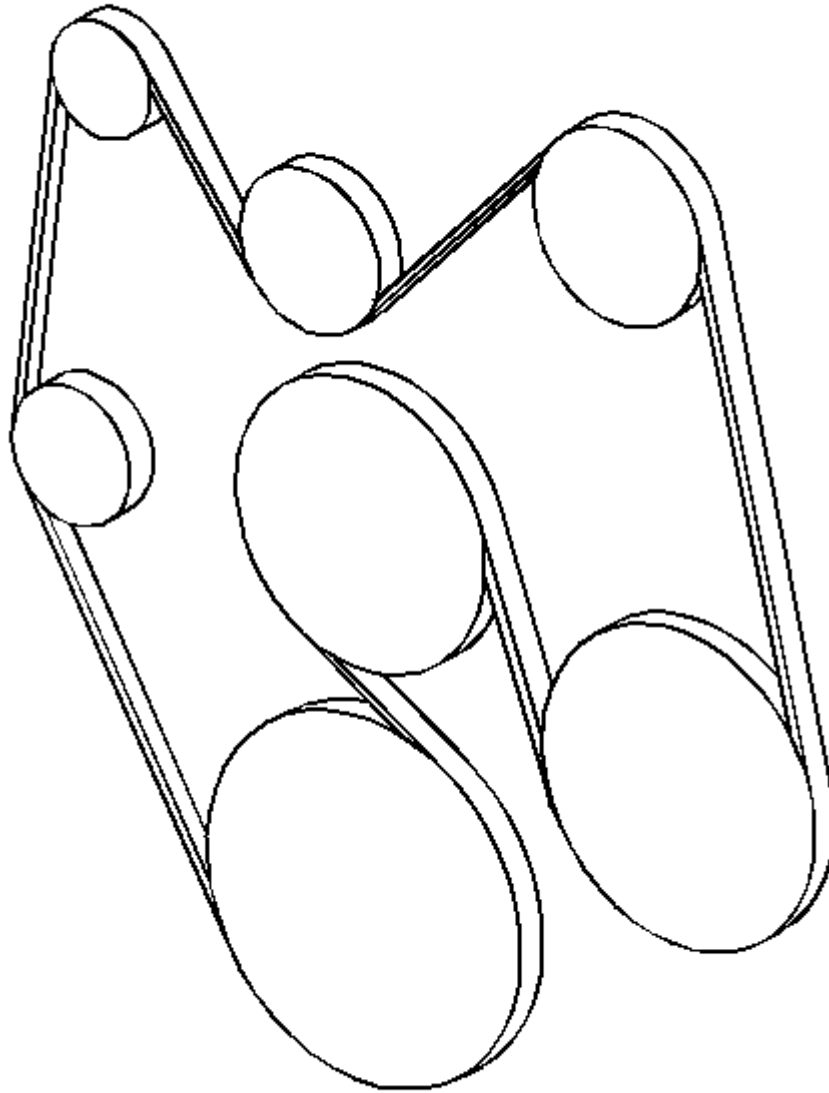


Fig. 11: View Of Drive Belt Routing (W/Air Conditioning)
Courtesy of GENERAL MOTORS CORP.

3. Observe drive belt routing for vehicles with air conditioning.

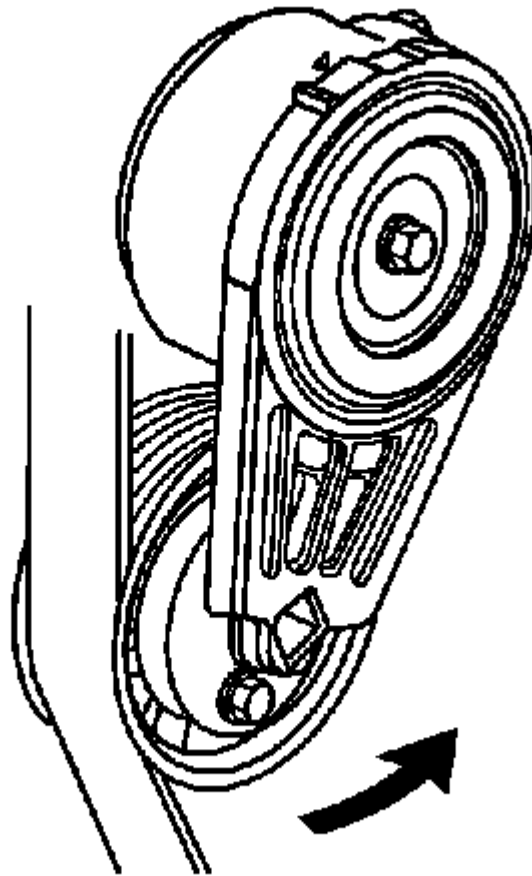


Fig. 12: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

4. Install a 3/8 inch drive wrench on the drive belt tensioner arm and rotate the arm counterclockwise.
5. Install the drive belt over the drive belt tensioner pulley.
6. Slowly release the tension on the tensioner arm.

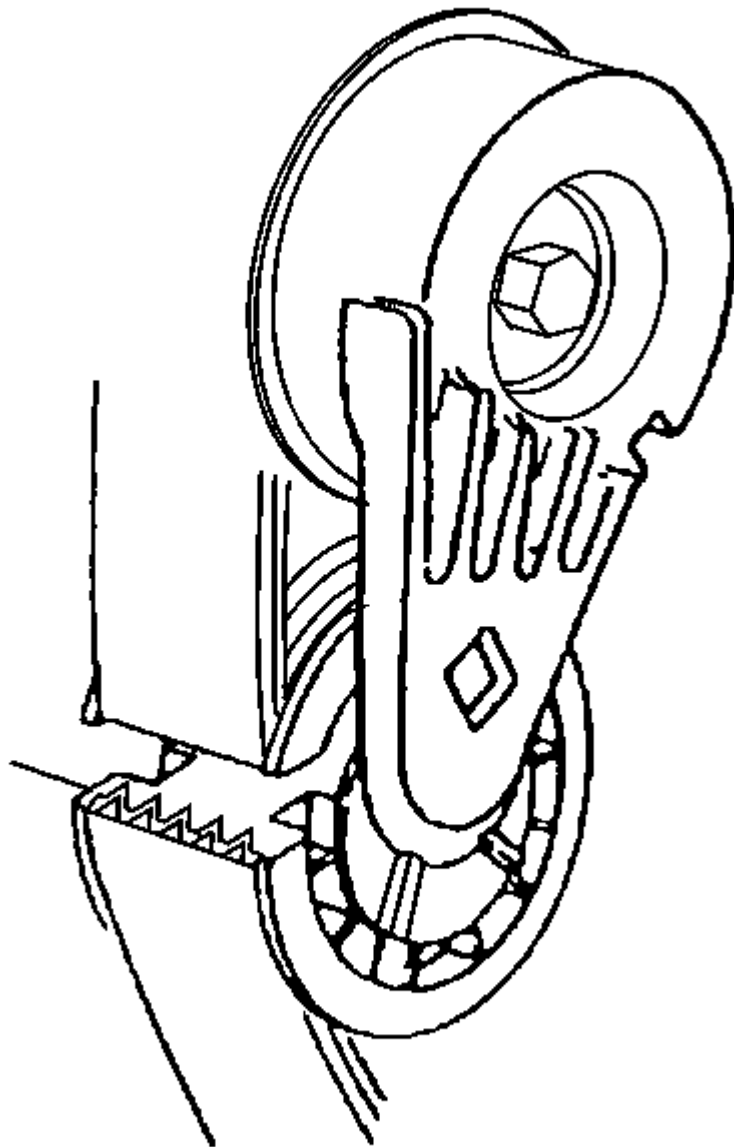


Fig. 13: Inspecting Drive Belt Pulley
Courtesy of GENERAL MOTORS CORP.

7. Inspect for the drive belt being properly installed on the pulleys.

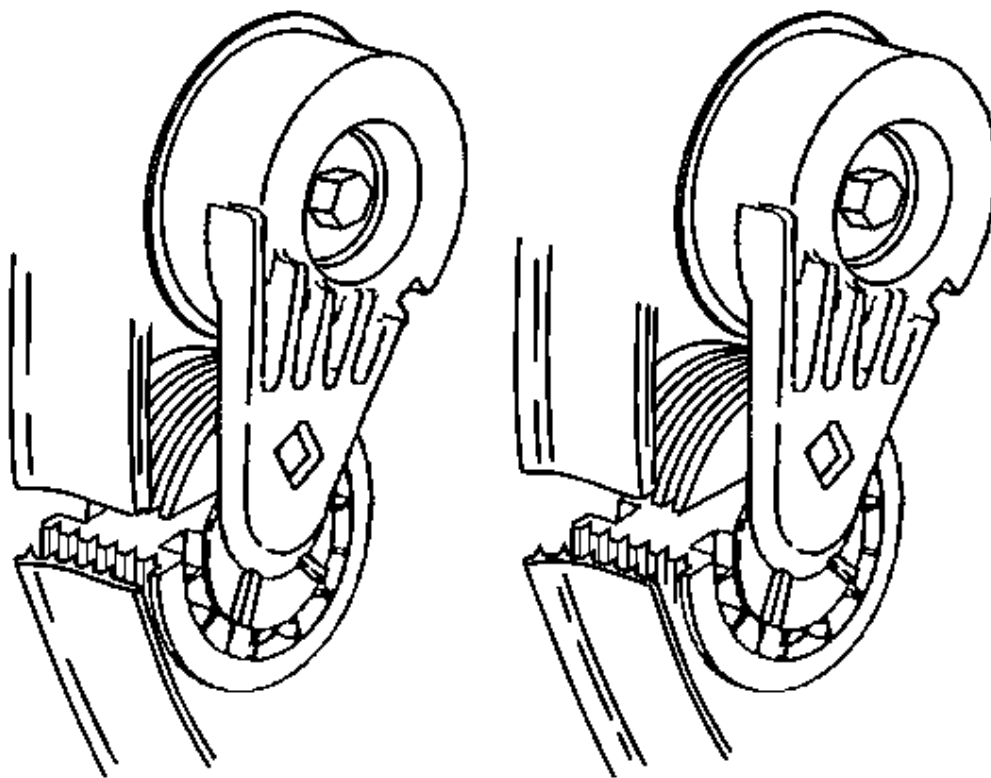


Fig. 14: Illustrating Incorrect Drive Belt Positions
Courtesy of GENERAL MOTORS CORP.

8. Avoid mis-positioning the drive belt by one or more grooves.

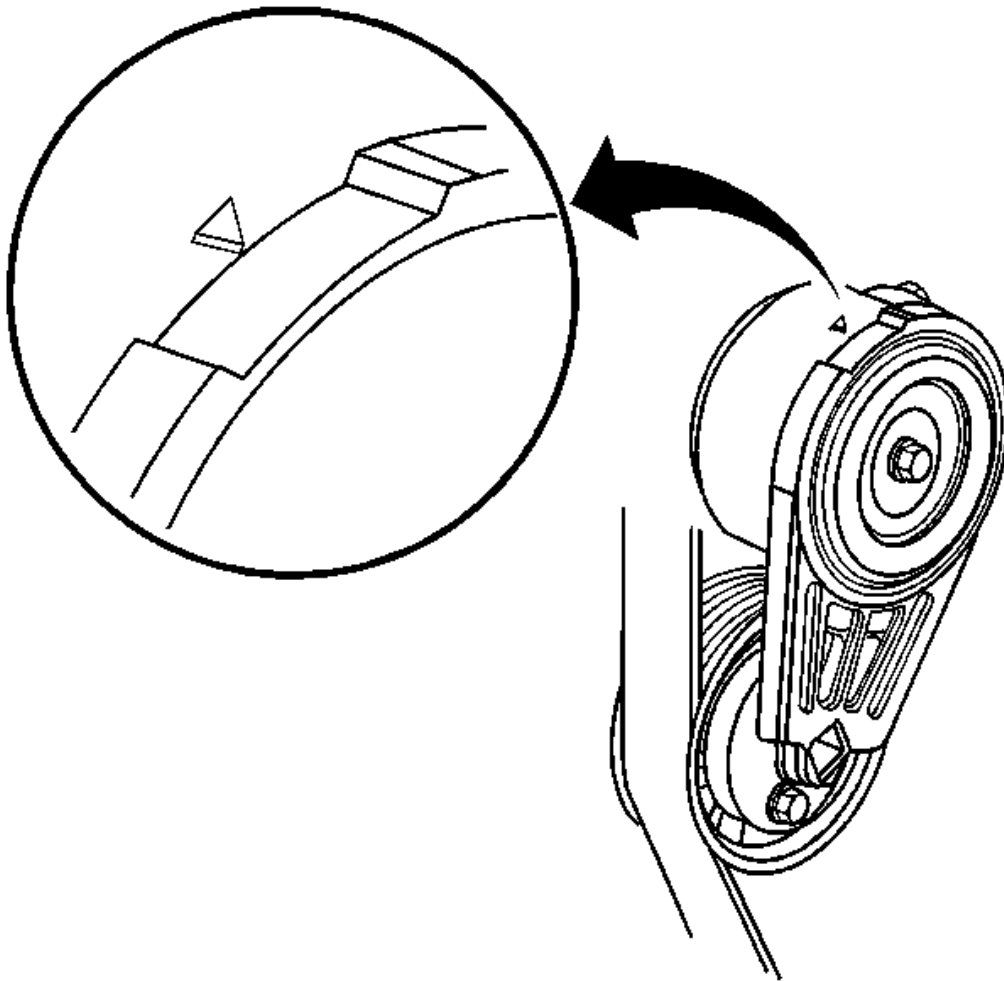


Fig. 15: Aligning Drive Belt Tensioner Fix Pointer & Index Mark
Courtesy of GENERAL MOTORS CORP.

9. Confirm for the proper drive belt size and the correct drive belt routing by observing the location of the fix pointer and the index marks on the drive belt tensioner. With a new drive belt installed, the fix pointer should align within the indentation on the drive belt tensioner.

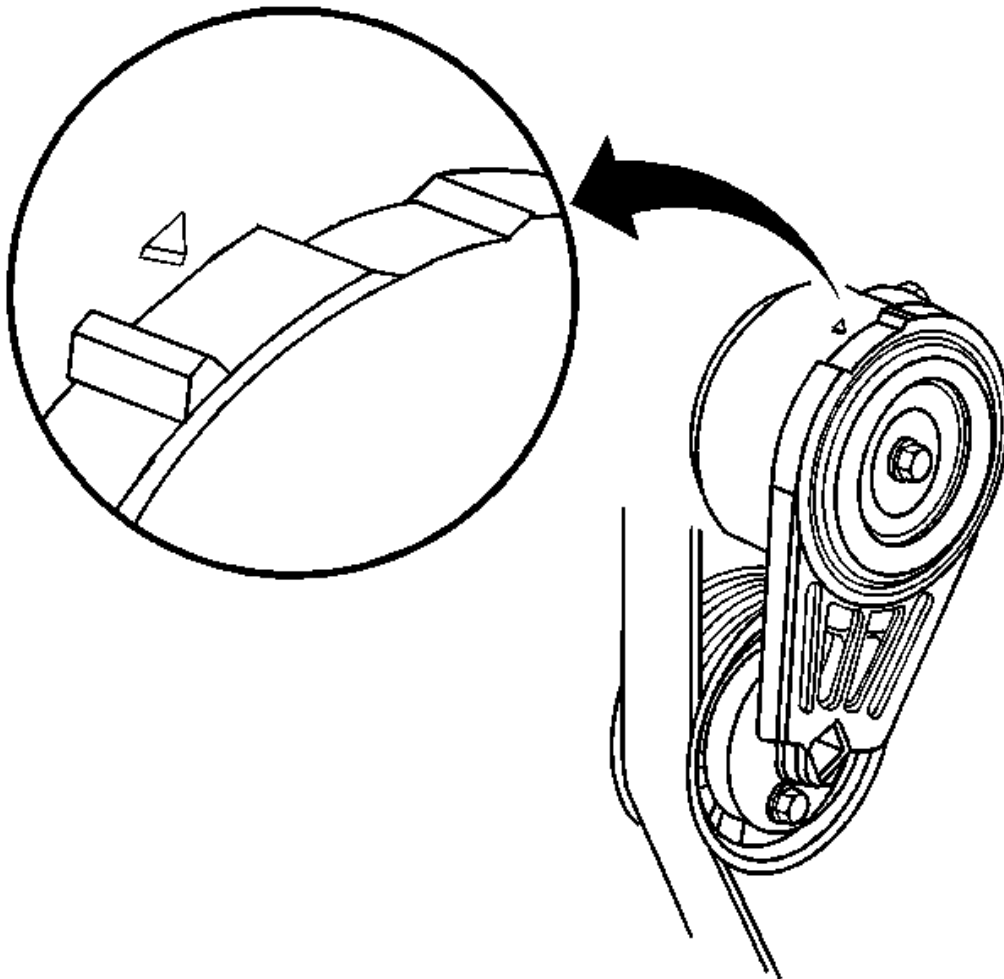


Fig. 16: Identifying Incorrect Index Mark Alignment
Courtesy of GENERAL MOTORS CORP.

10. With a used drive belt installed, the fix pointer should not align past the index mark.
11. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-4.3 L.
12. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls-4.3 L.

Drive Belt Tensioner Replacement

Removal Procedure

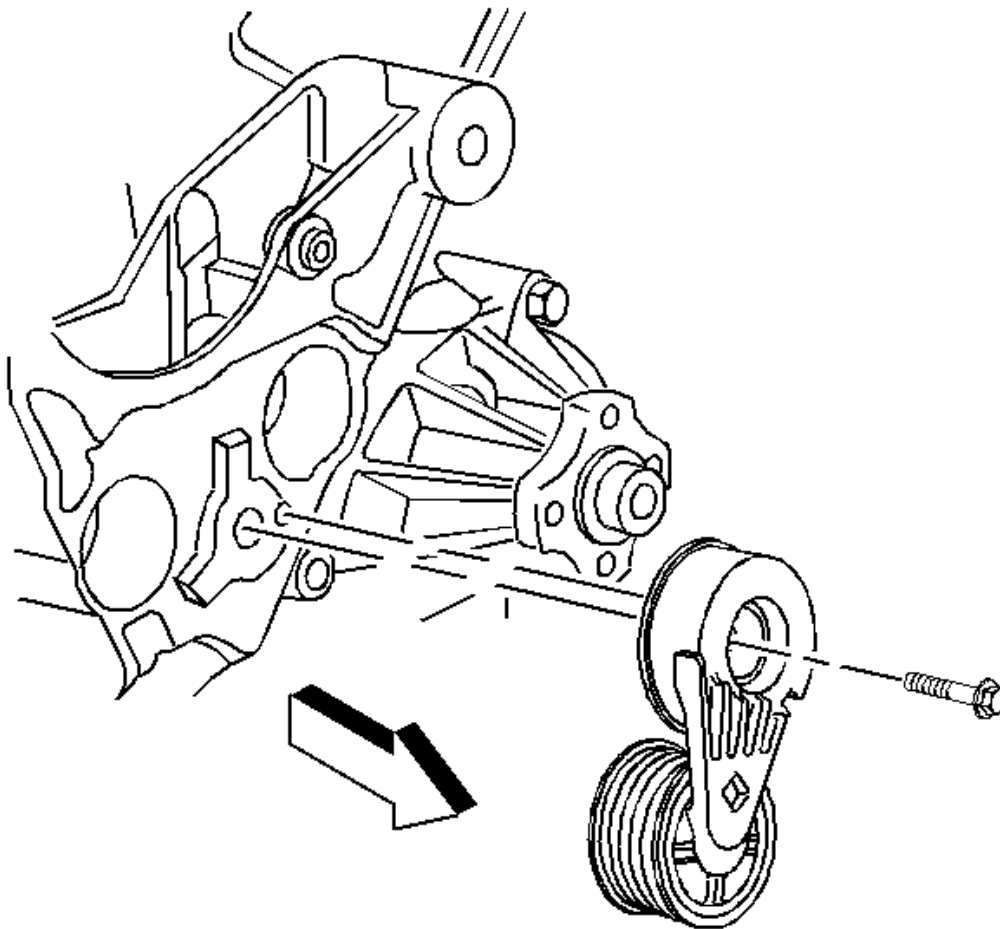


Fig. 17: View Of Drive Belt Tensioner Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

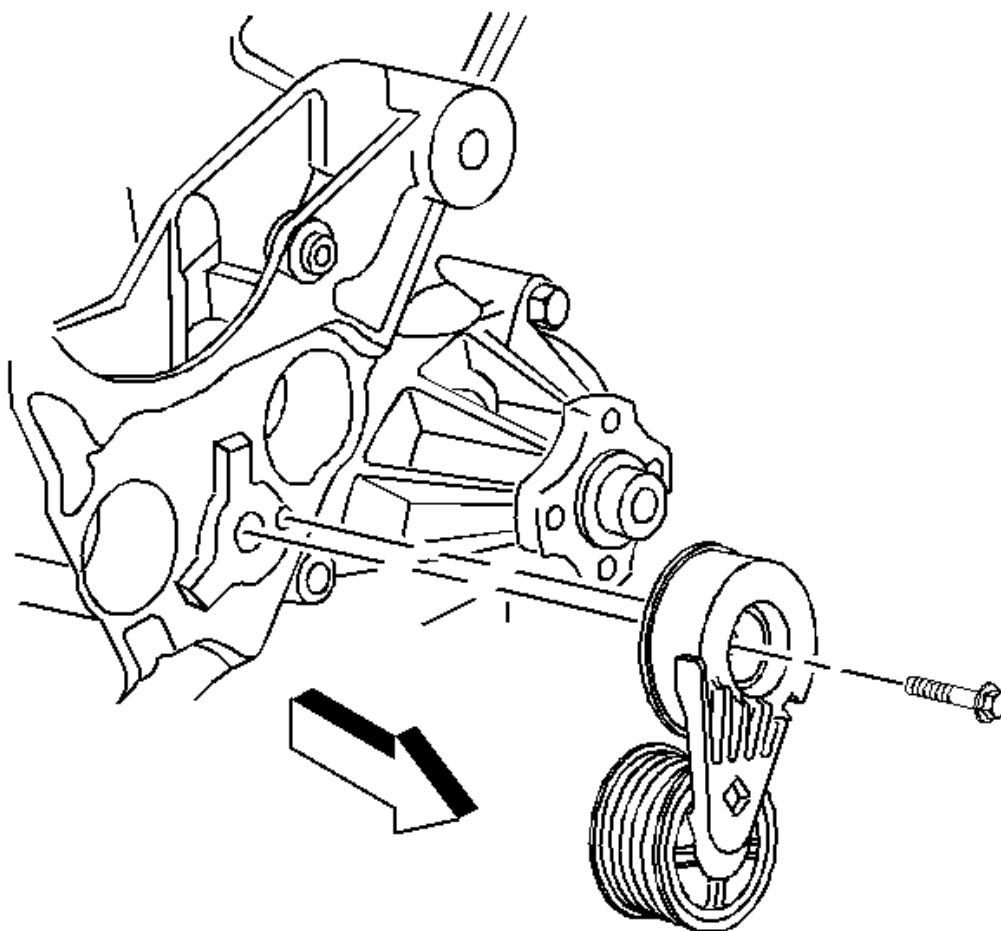


Fig. 18: View Of Drive Belt Tensioner Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the attaching bolt.

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

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

Drive Belt Idler Pulley Replacement - Right

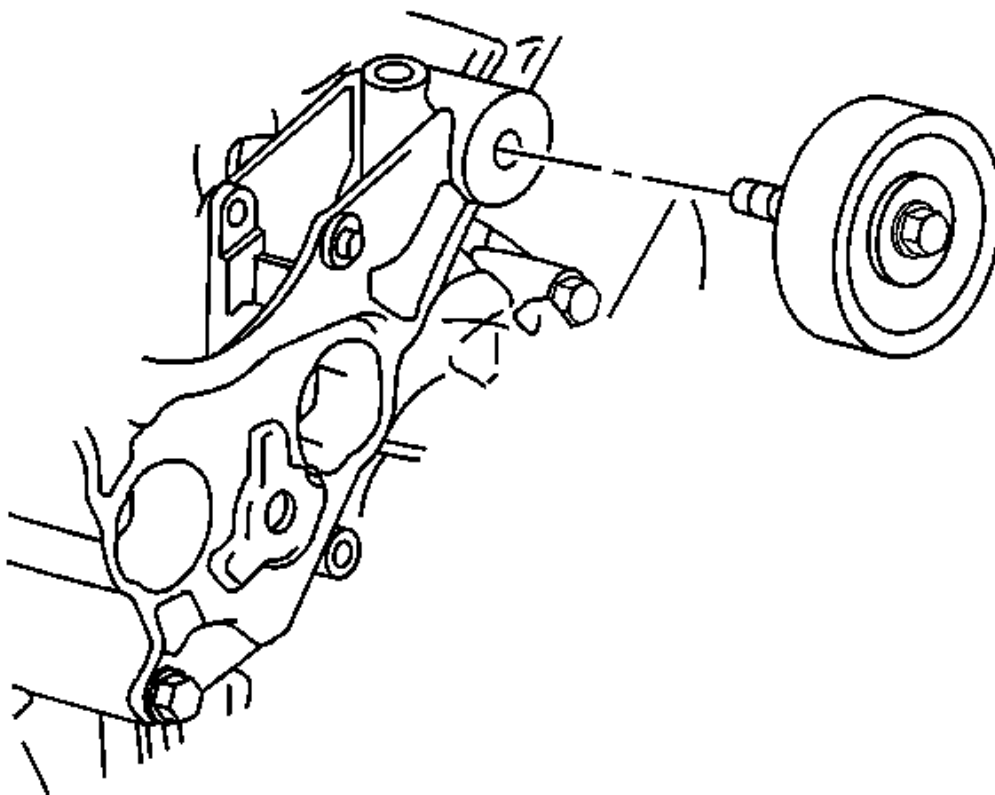
Removal Procedure

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

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley from the generator mounting bracket.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

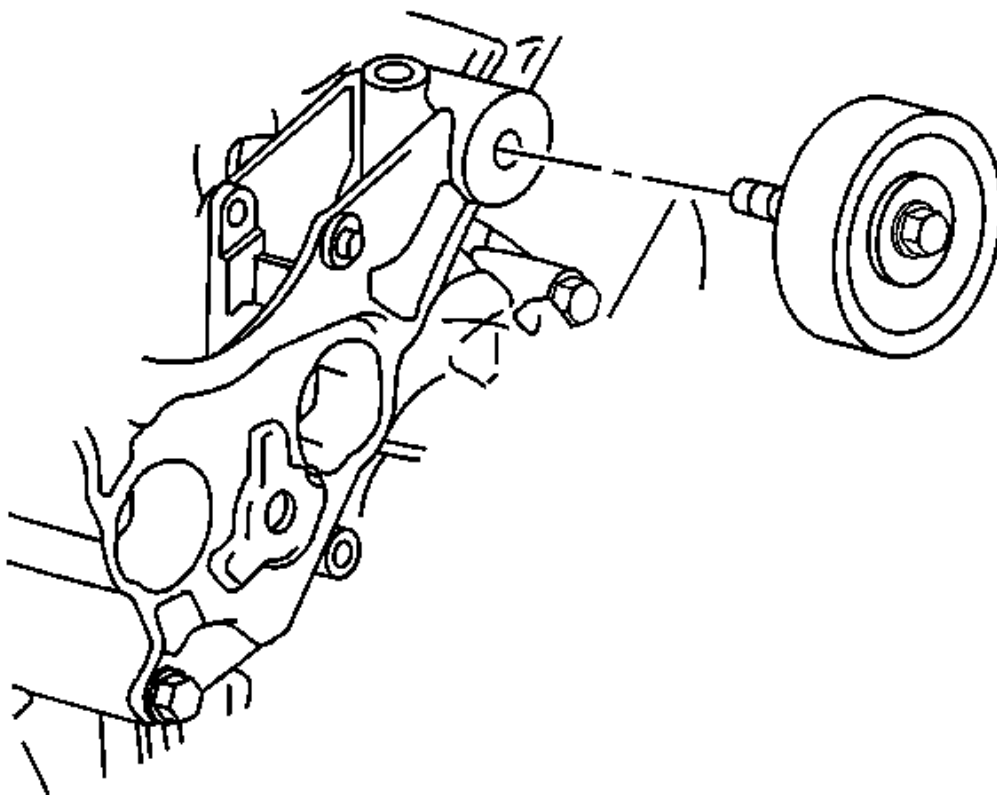


Fig. 20: Identifying Drive Belt Idler Pulley Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley and bolt to the generator mounting bracket.

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

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

Drive Belt Idler Pulley Replacement - without Air Conditioning

Removal Procedure

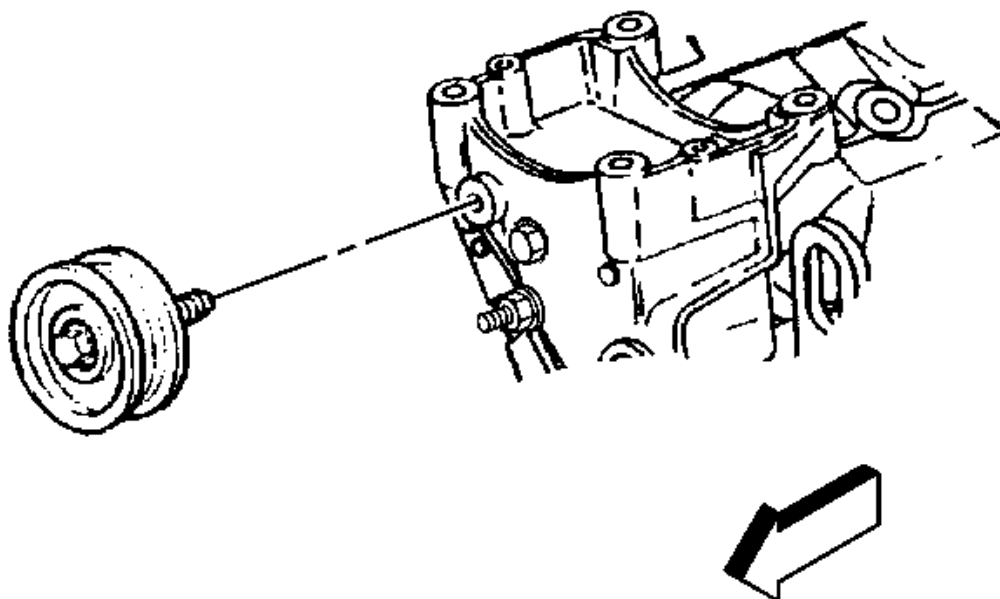


Fig. 21: Locating Drive Belt Idler Pulley Bolt (W/O Air Conditioning)
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley from the power steering pump mounting bracket.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

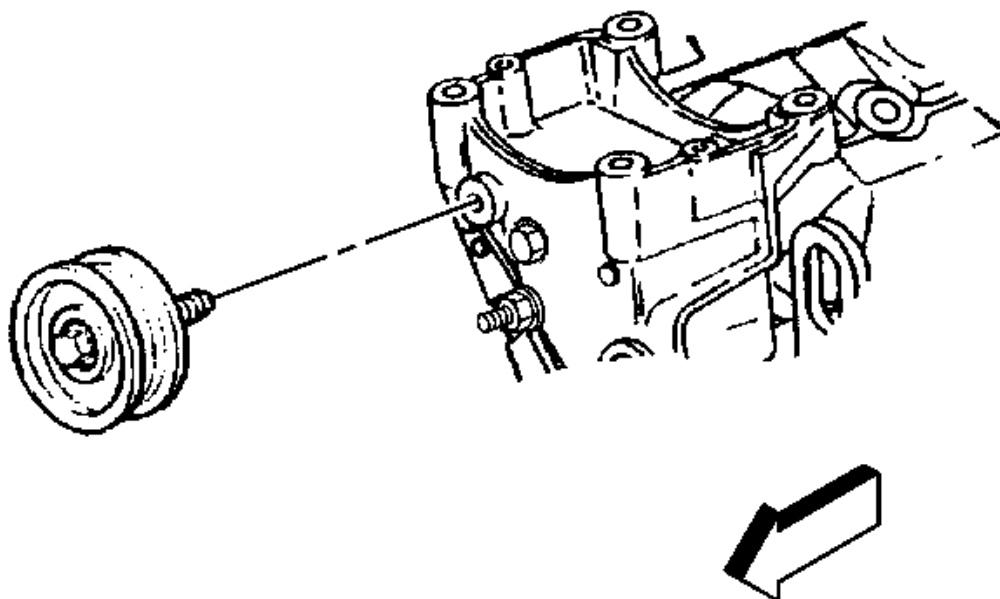


Fig. 22: Locating Drive Belt Idler Pulley Bolt (W/O Air Conditioning)
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley and bolt to the power steering pump mounting bracket.

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

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

Engine Mount Inspection

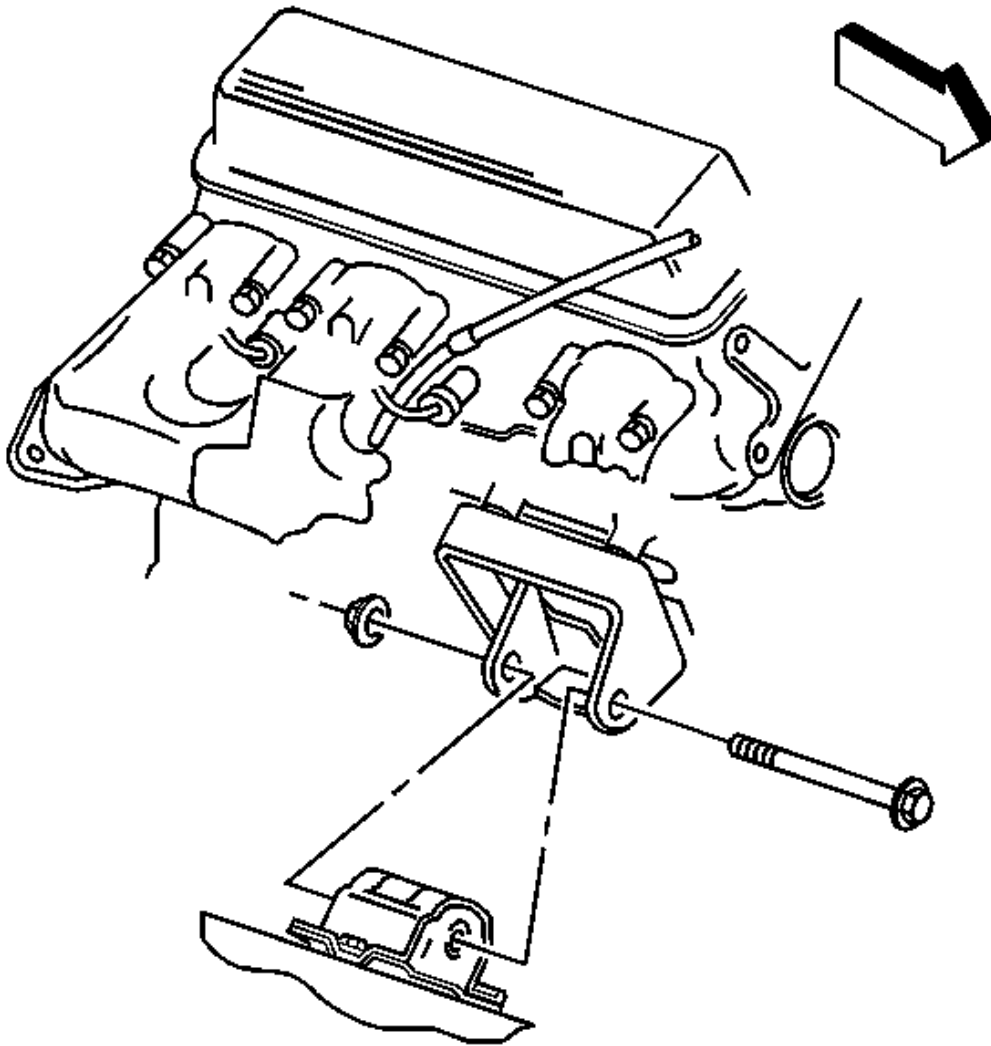


Fig. 23: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

NOTE: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

1. Raise the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Inspect for loose or missing bolts at the following locations:
 - The engine mount bracket to the engine

- The engine mount to the engine bracket through-bolts
 - The engine mount to frame bracket bolts
3. Replace loose or missing bolts.

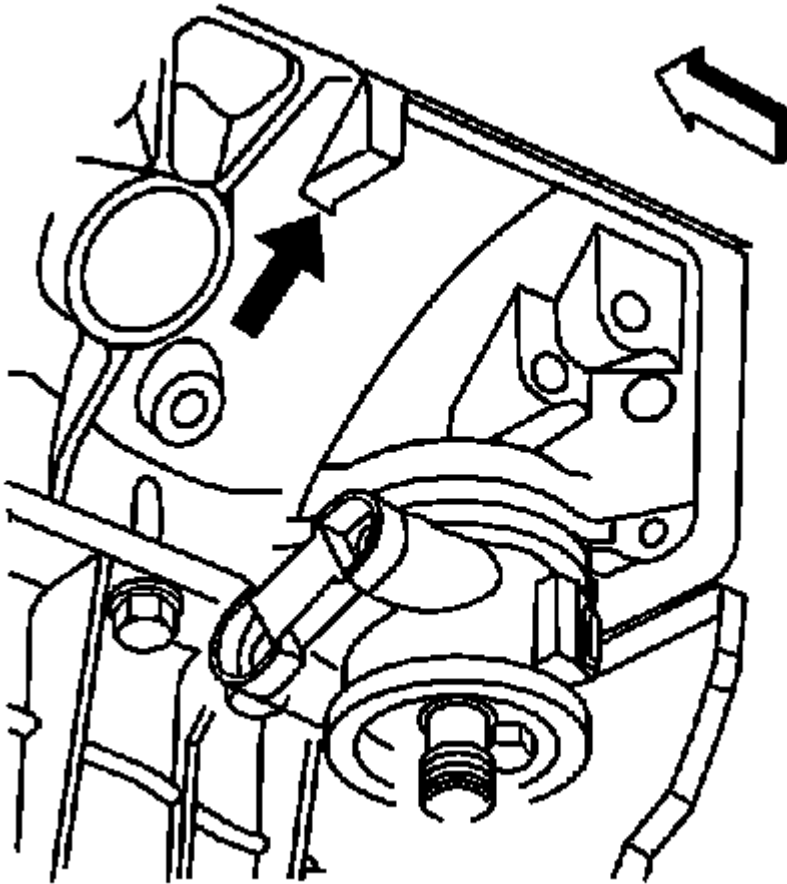


Fig. 24: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Lifting the engine in an unapproved manner may cause component damage.

4. In order to access the square tab on the left side of the engine remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
5. In order to access the square tab on the right side of the engine remove the starter. Refer to **Starter Motor Replacement** in Engine Electrical.
6. Using a jack on the square tab at the rear of the engine block (left side shown) raise the engine in order to complete the following tasks:
 - Remove weight from the engine mount.
 - Place a slight tension on the rubber cushion.

- Observe the engine mount while raising the engine.
7. Replace the engine mount if the following conditions exist:
 - Heat check cracks cover the hard rubber surface.
 - The rubber cushion is separated from the metal plate of the engine mount.
 - There is a split through the rubber cushion.
 8. Replace the starter, if removed. Refer to **Starter Motor Replacement** in Engine Electrical.
 9. Replace the oil filter adapter, if removed. Refer to **Oil Filter Adapter Replacement**.
 10. Lower the vehicle.

Engine Mount Replacement - Left**Removal Procedure**

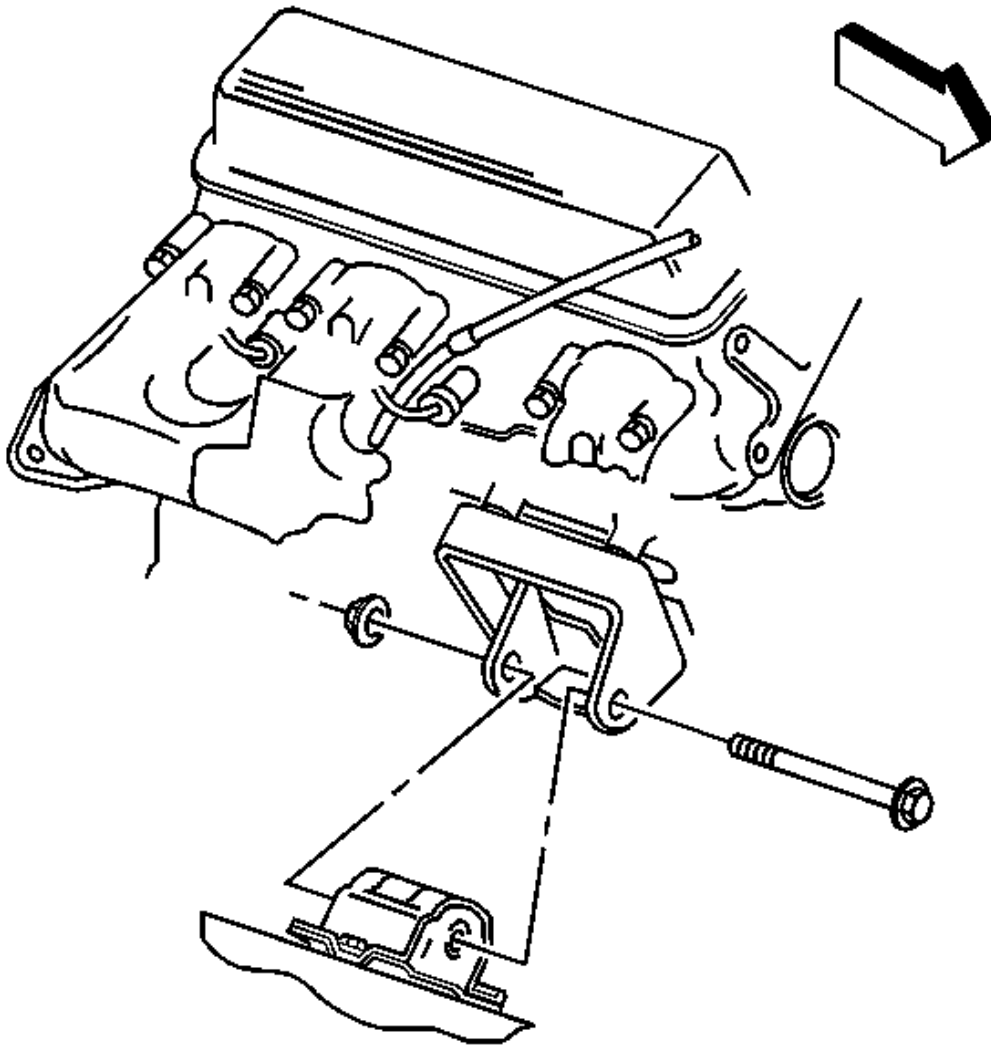


Fig. 25: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Engine Mounting Notice in Cautions and Notices.

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
4. Remove the engine mount through-bolt and nut for the side being replaced.

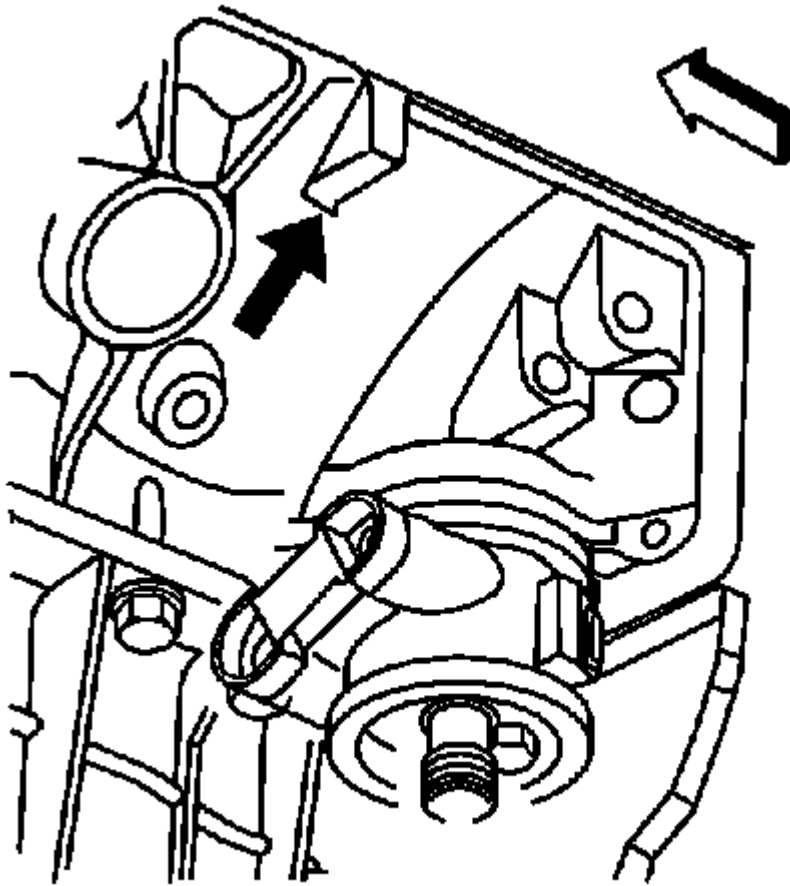


Fig. 26: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Engine Lifting Notice in Cautions and Notices.

5. Using a jack on the square tab (left side shown) at the rear of the engine block, raise the engine only enough to remove the engine mount.

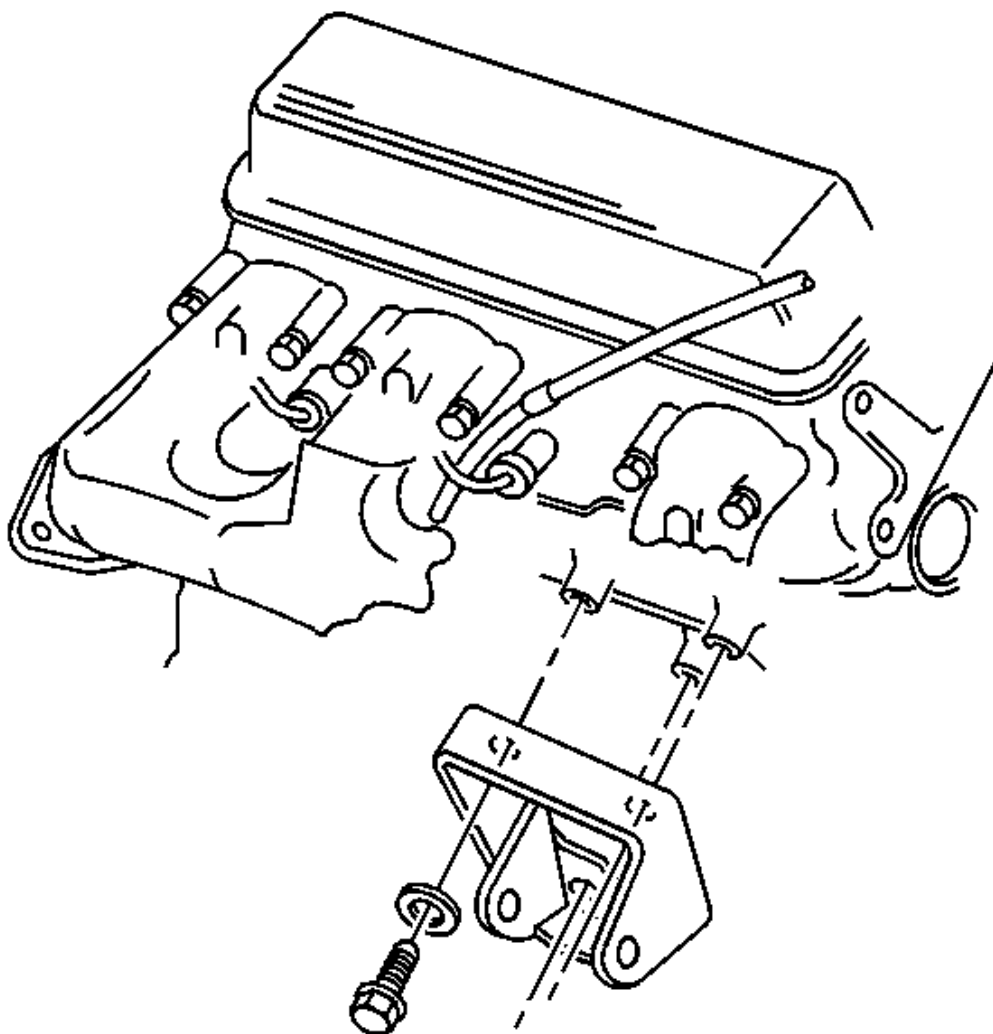


Fig. 27: View Of Engine Mount Bracket To Engine
Courtesy of GENERAL MOTORS CORP.

6. Remove the bolts for the engine mount bracket to the engine.

Access the upper two bolts for the right engine mount bracket through the fender wheelhouse.

7. Remove the engine mount bracket.

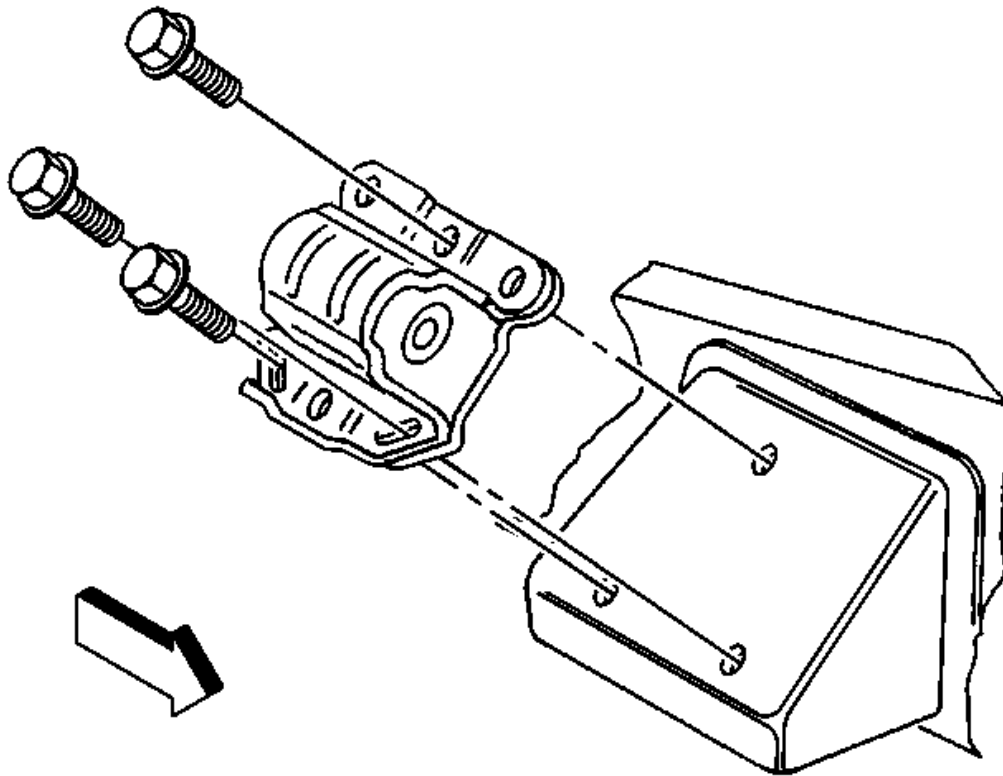


Fig. 28: Identifying Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS CORP.

8. For AWD vehicle remove the bolts for the engine mount to the frame (left side shown).
9. Remove the engine mount.

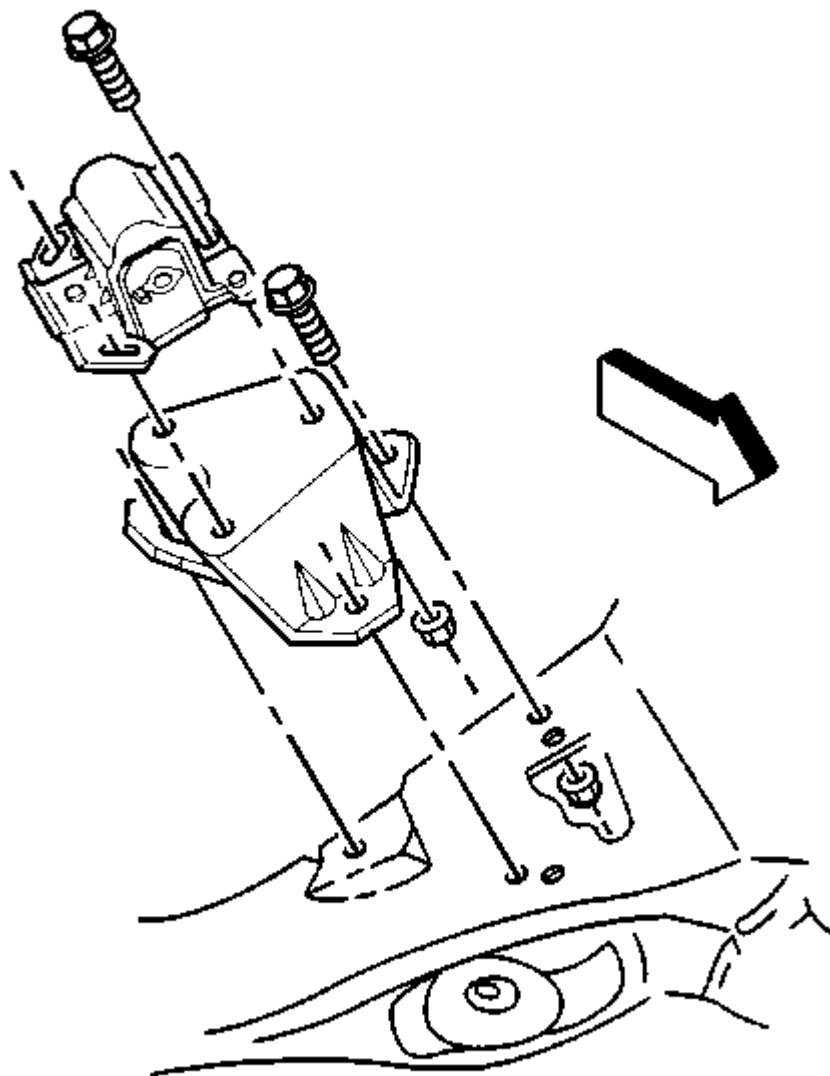


Fig. 29: Locating Engine Mount To Frame Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

10. For a RWD vehicle left side remove the bolts and the nuts for the engine mount to the frame bracket (left side shown).
11. If necessary, remove the left side engine mount frame bracket from the frame.

Installation Procedure

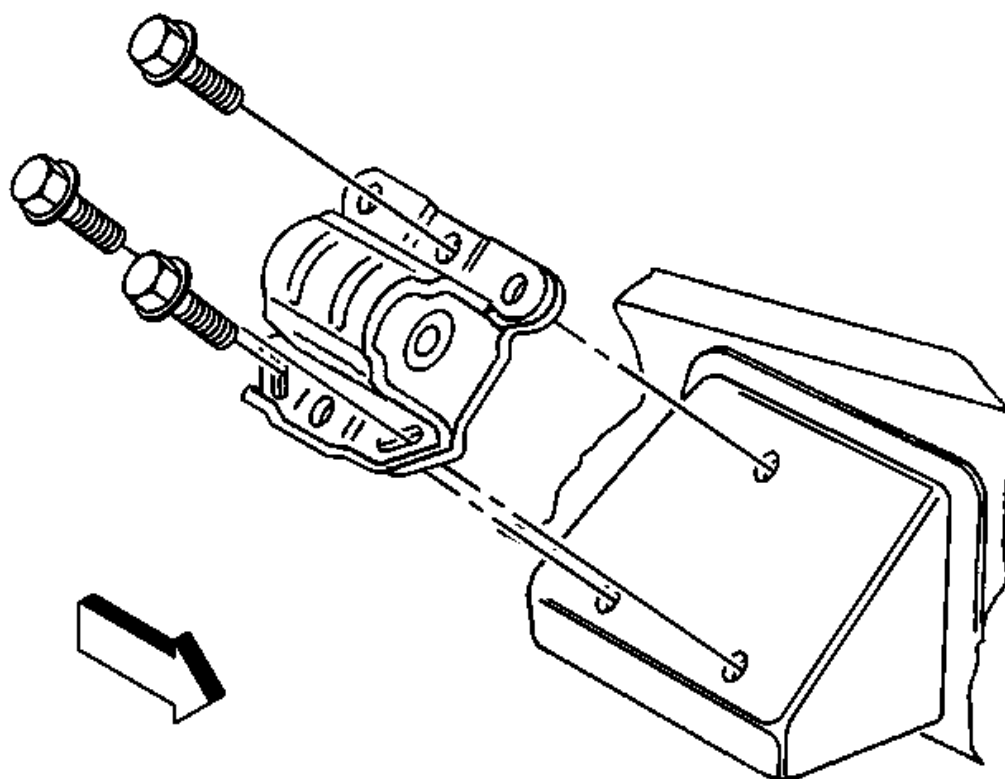


Fig. 30: Identifying Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS CORP.

1. For AWD vehicle install the engine mount to the frame (left side shown).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the AWD vehicle engine mount to the frame bolts.

Tighten: Tighten the AWD vehicle engine mount to frame bolts to 59 N.m (44 lb ft).

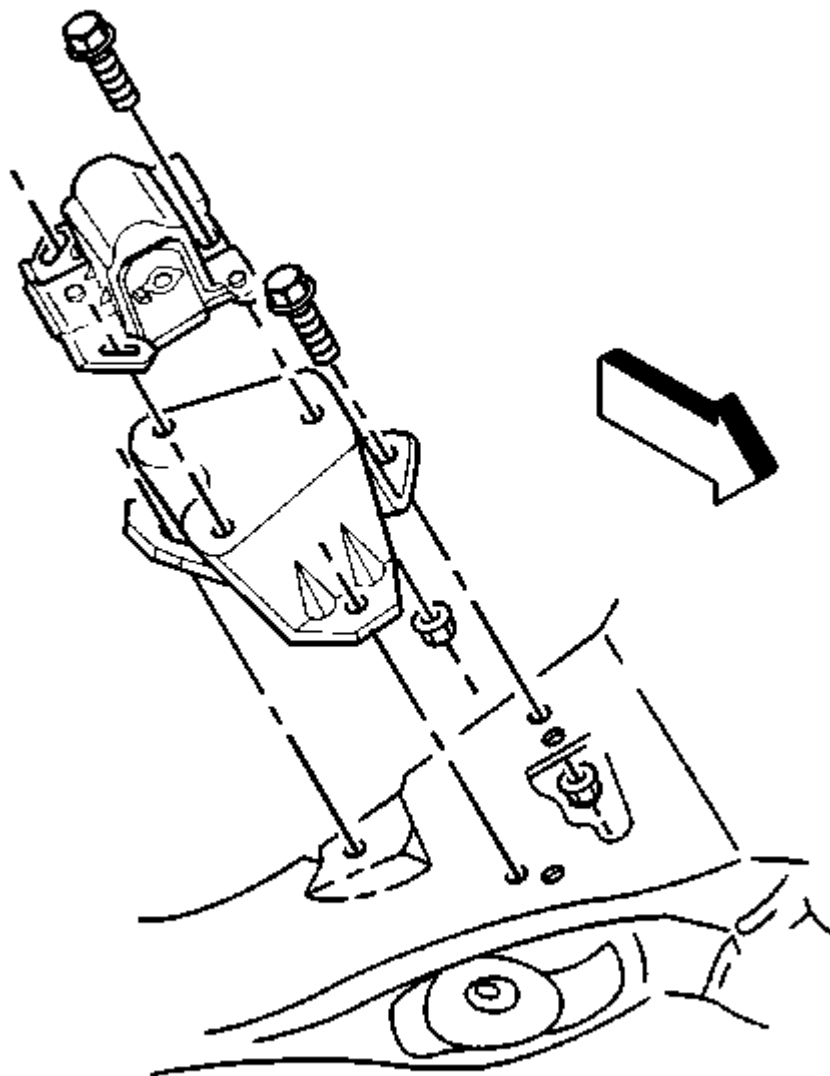


Fig. 31: Locating Engine Mount To Frame Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

3. If removed, install the RWD vehicle left side bolts, nuts and engine mount frame bracket to the frame.

Tighten:

- Tighten the engine mount frame bracket bolts to 47 N.m (35 lb ft).
- Tighten the engine mount frame bracket nuts to 42 N.m (31 lb ft).

4. Install the RWD vehicle left side engine mount, the bolts, and the nuts to the frame bracket.

Tighten:

- Tighten the engine mount to frame bolts to 47 N.m (35 lb ft).
- Tighten the engine mount to frame nuts to 42 N.m (31 lb ft).

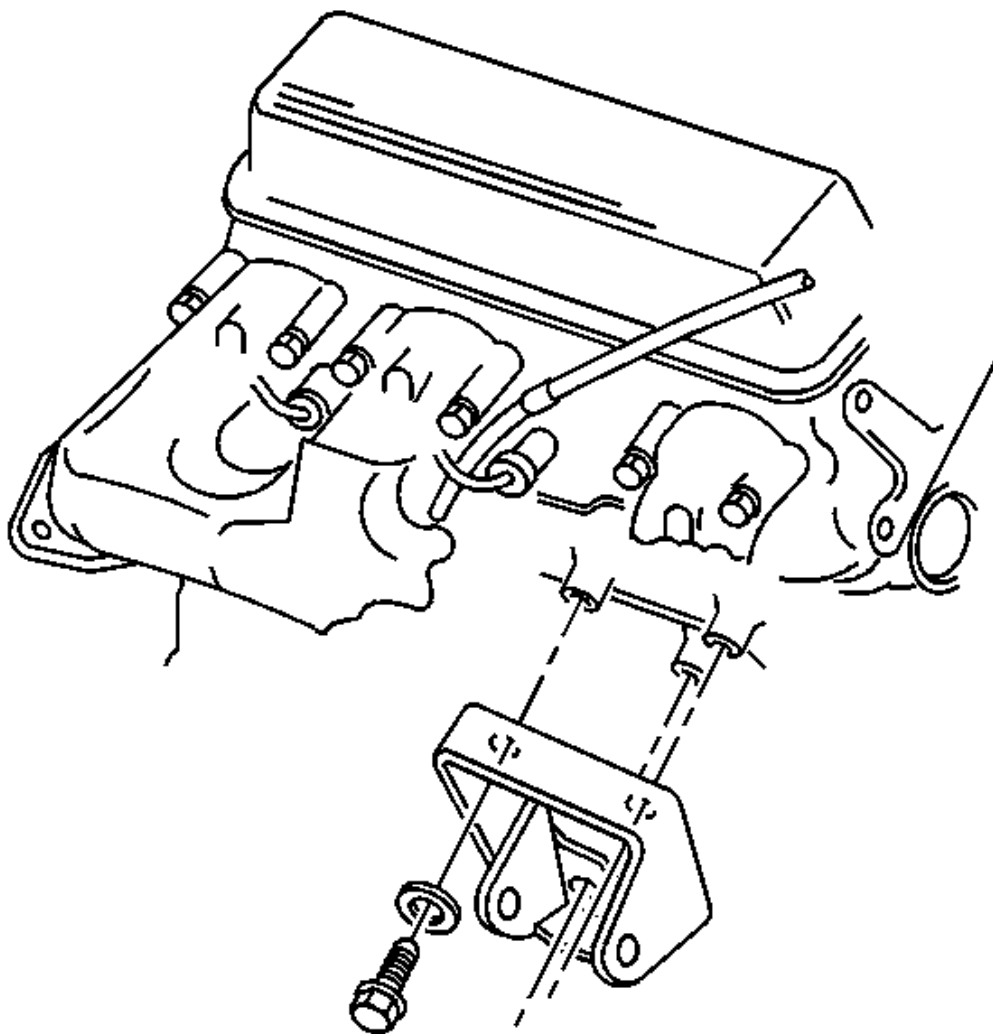


Fig. 32: View Of Engine Mount Bracket To Engine
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount bracket to the engine.

6. Install the engine mount bracket bolts.

Tighten: Tighten the engine mount bracket bolts to 64 N.m (47 lb ft).

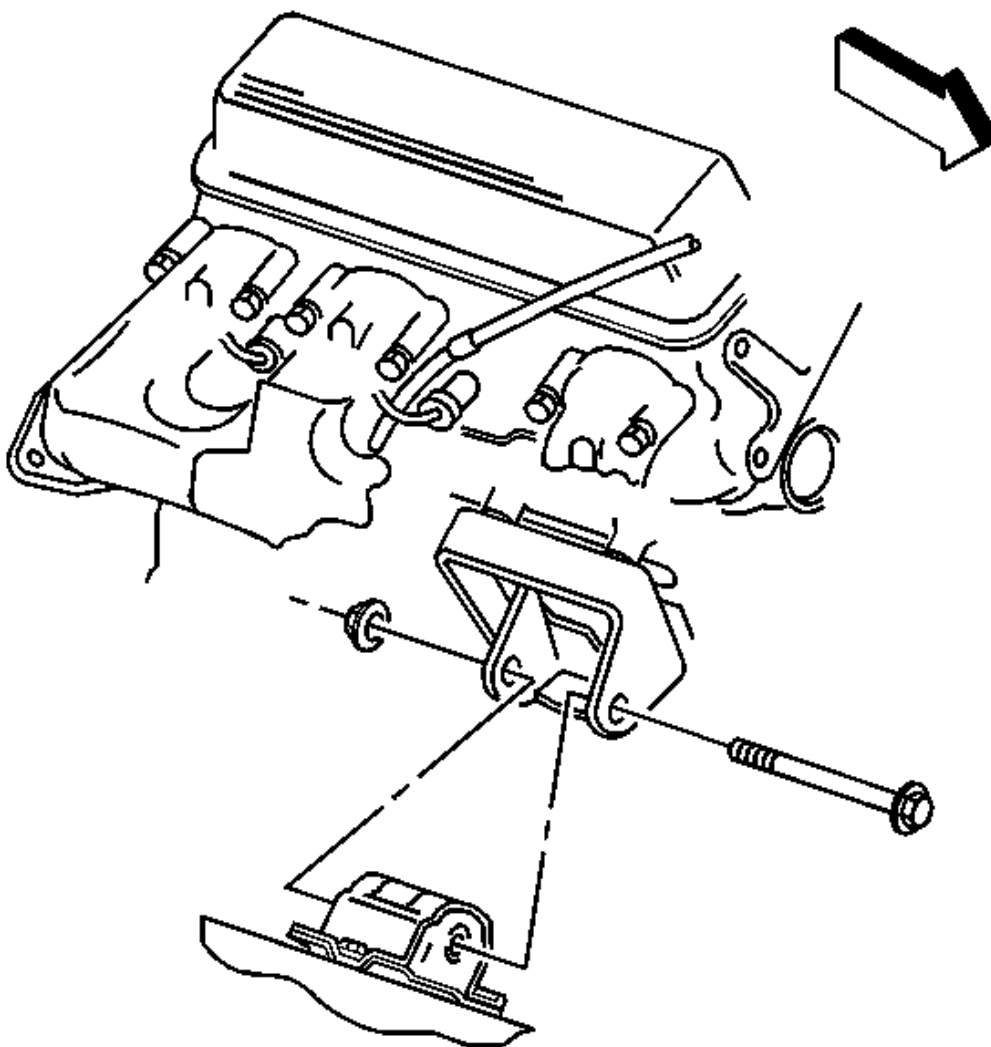


Fig. 33: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

7. Lower the engine.
8. Install the engine mount through-bolt and the nut.

Tighten: Tighten the engine mount through-bolt nuts to 68 N.m (50 lb ft).

9. Install the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
10. Lower the vehicle.
11. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Mount Replacement - Right

Removal Procedure

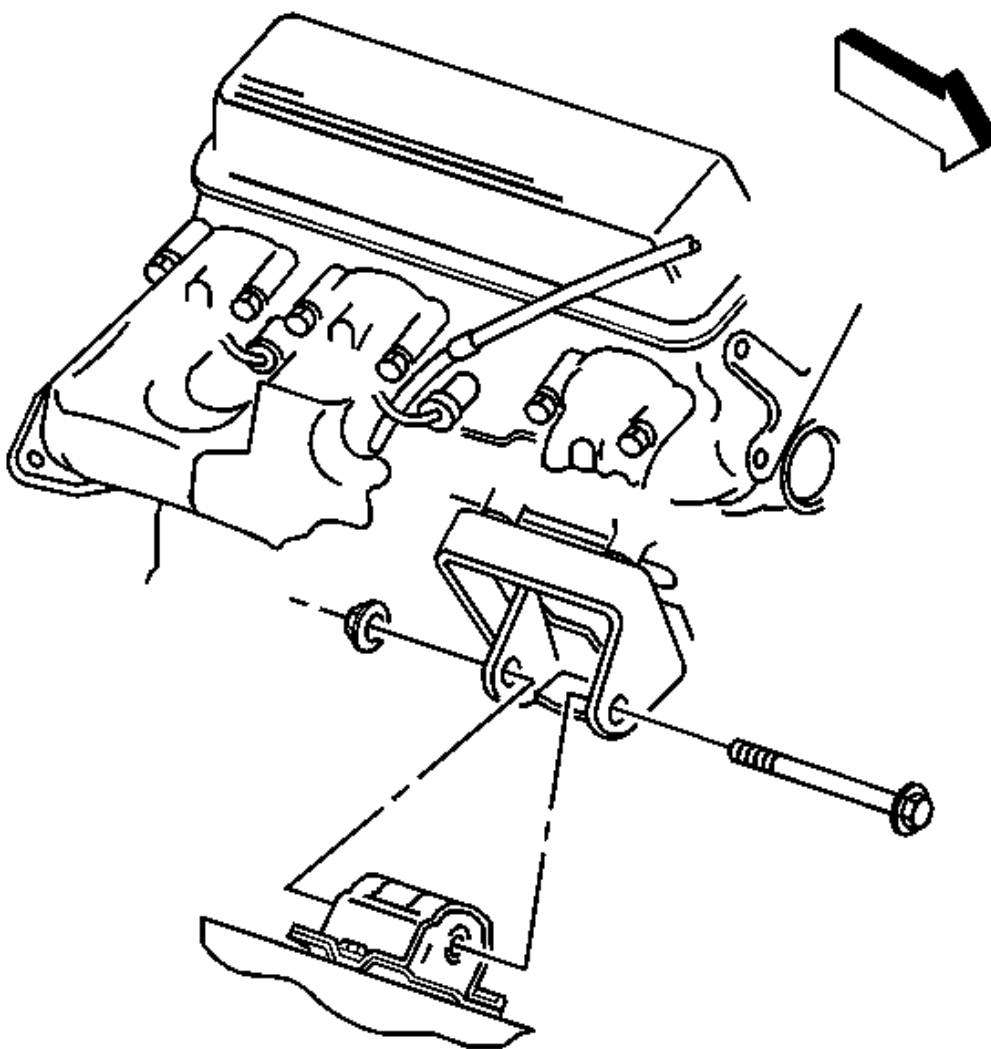


Fig. 34: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Engine Mounting Notice in Cautions and Notices.

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnect/Connect Procedure in Engine Electrical.
2. Raise the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
3. Remove the right front tire. Refer to Tire and Wheel Removal and Installation in Tires and Wheels.
4. Remove the right fender wheelhouse extension. Refer to Wheelhouse Extension Replacement in Body Front End.
5. Remove the starter. Refer to Starter Motor Replacement in Engine Electrical.
6. Remove the engine mount through-bolt and nut.

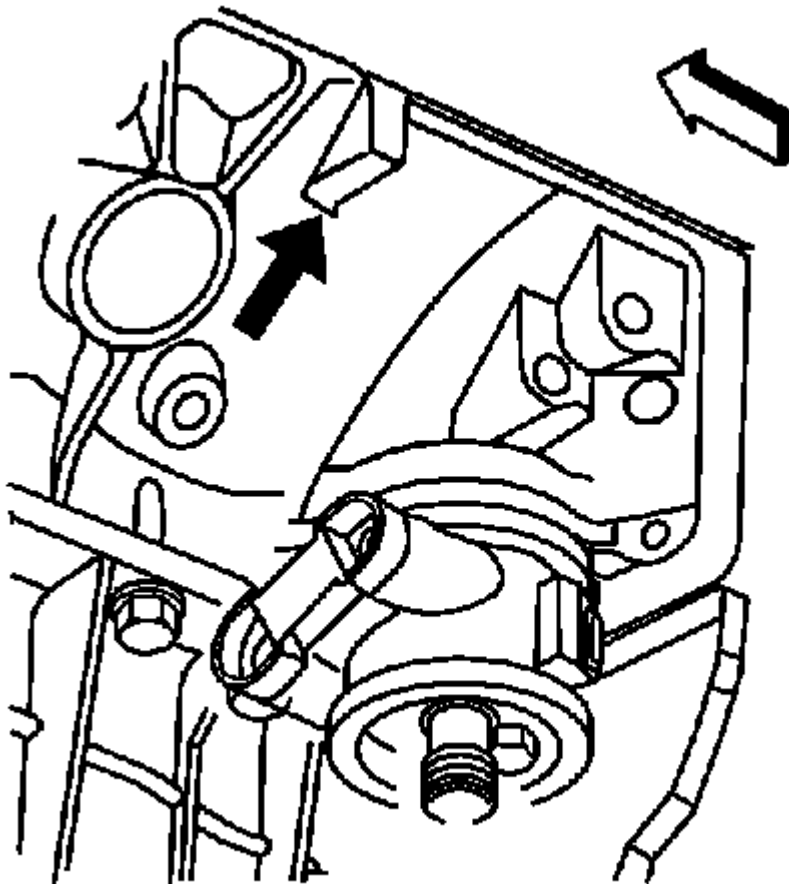


Fig. 35: View Of Square Tab At Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Engine Lifting Notice in Cautions and Notices.

7. Using a jack on the square tab (left side shown) at the rear of the engine block, raise the engine only enough to remove the engine mount.

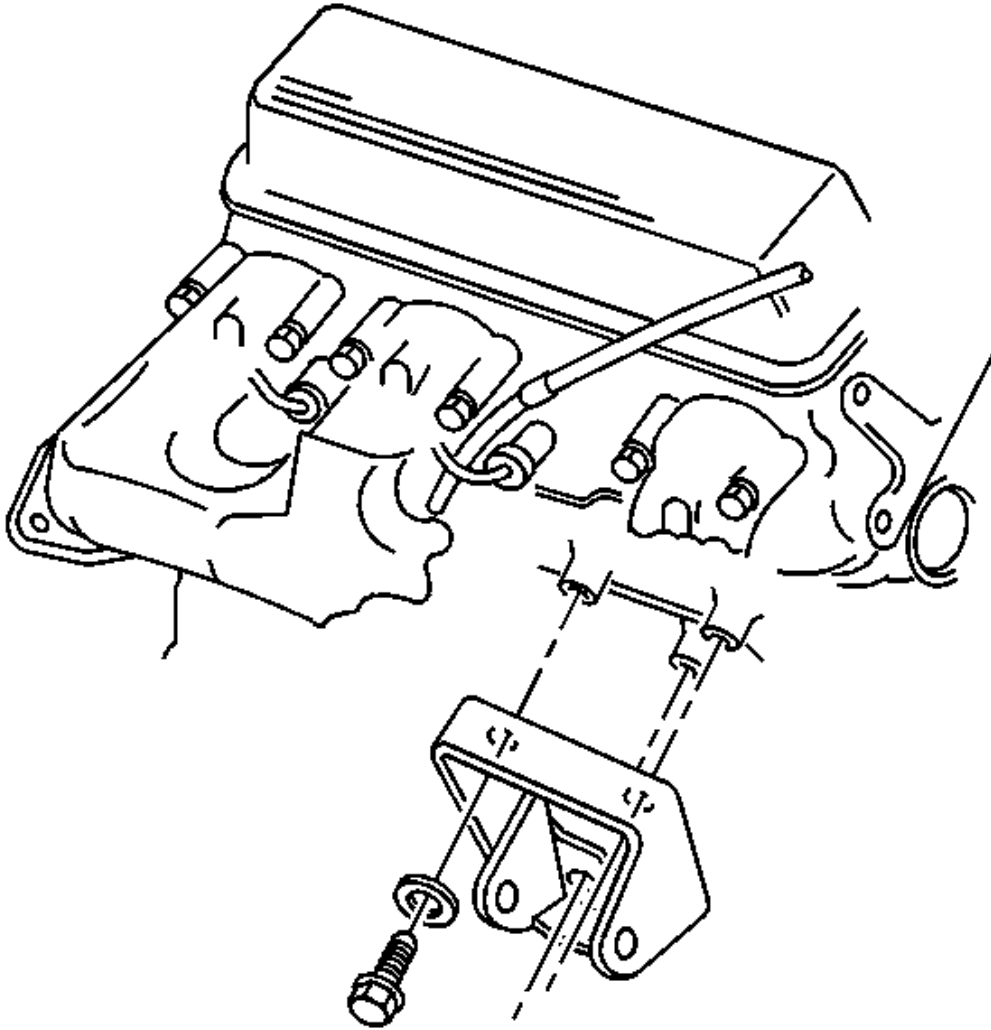


Fig. 36: View Of Engine Mount Bracket To Engine
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolts for the engine mount bracket to the engine.

Access the upper two bolts for the right engine mount bracket through the fender wheelhouse.

9. Remove the engine mount bracket.

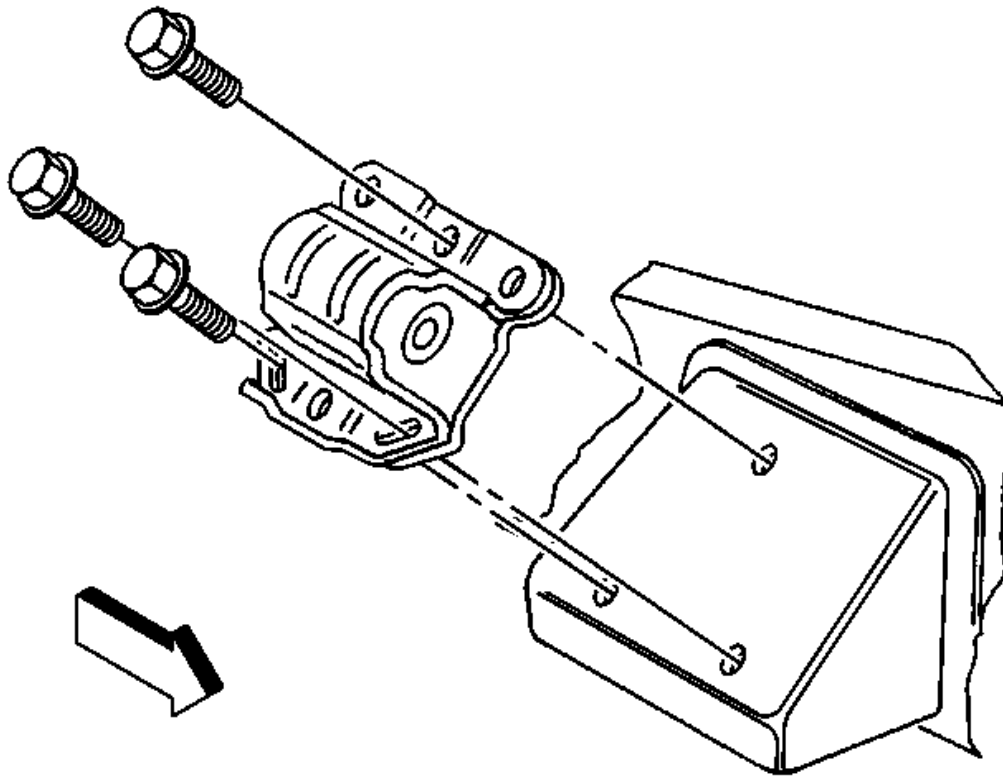


Fig. 37: Identifying Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS CORP.

10. For AWD vehicle remove the bolts for the engine mount to the frame (left side shown).
11. Remove the engine mount.

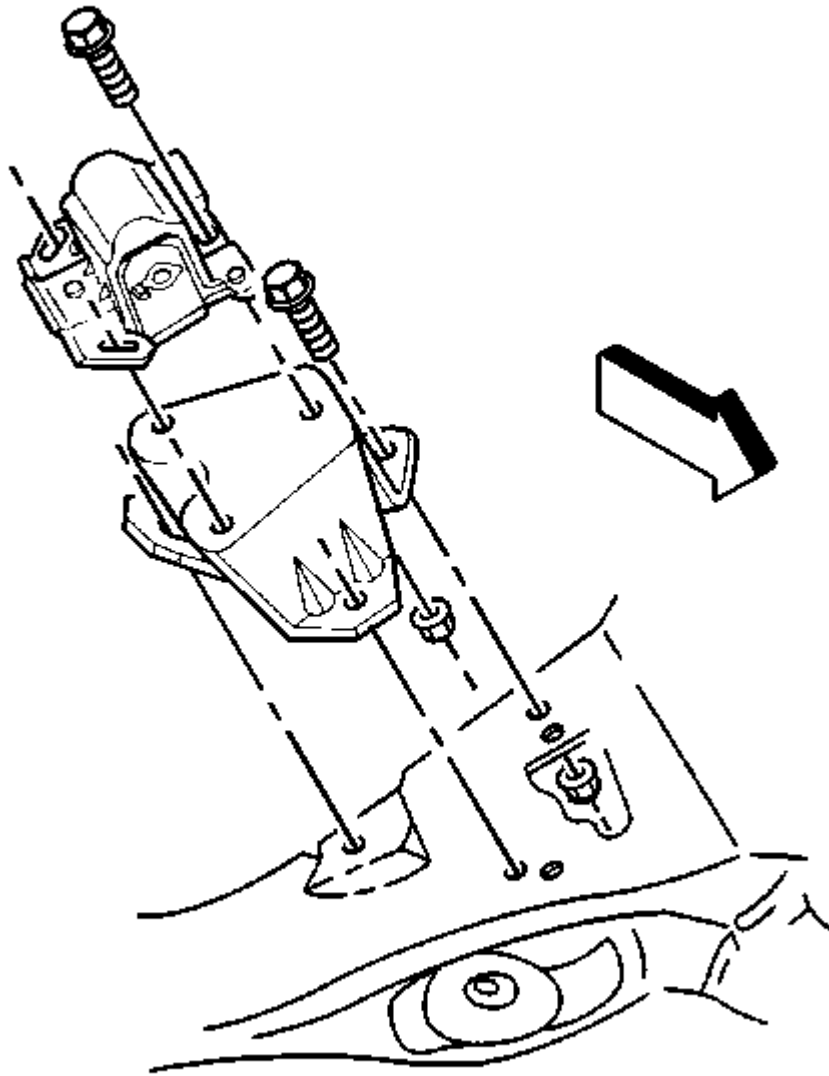


Fig. 38: Locating Engine Mount To Frame Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

12. For a RWD vehicle right side remove the bolts and the nuts for the engine mount to the frame.

Installation Procedure

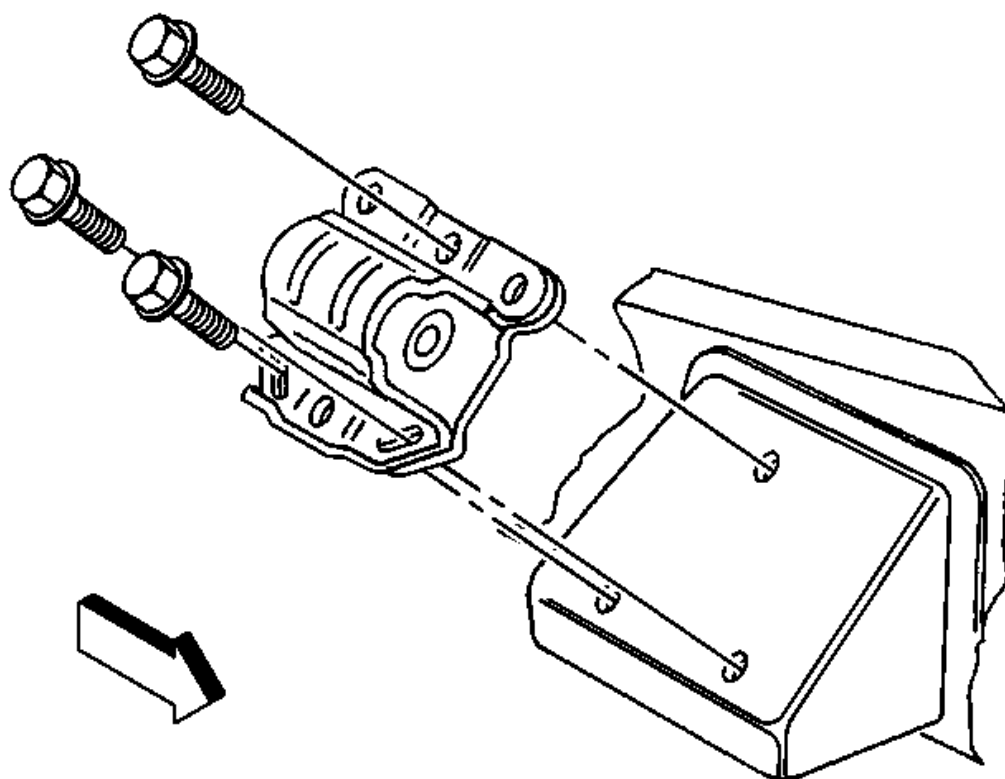


Fig. 39: Identifying Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the AWD vehicle engine mount to the frame bolts.

Tighten: Tighten the AWD vehicle engine mount to frame bolts to 59 N.m (44 lb ft).

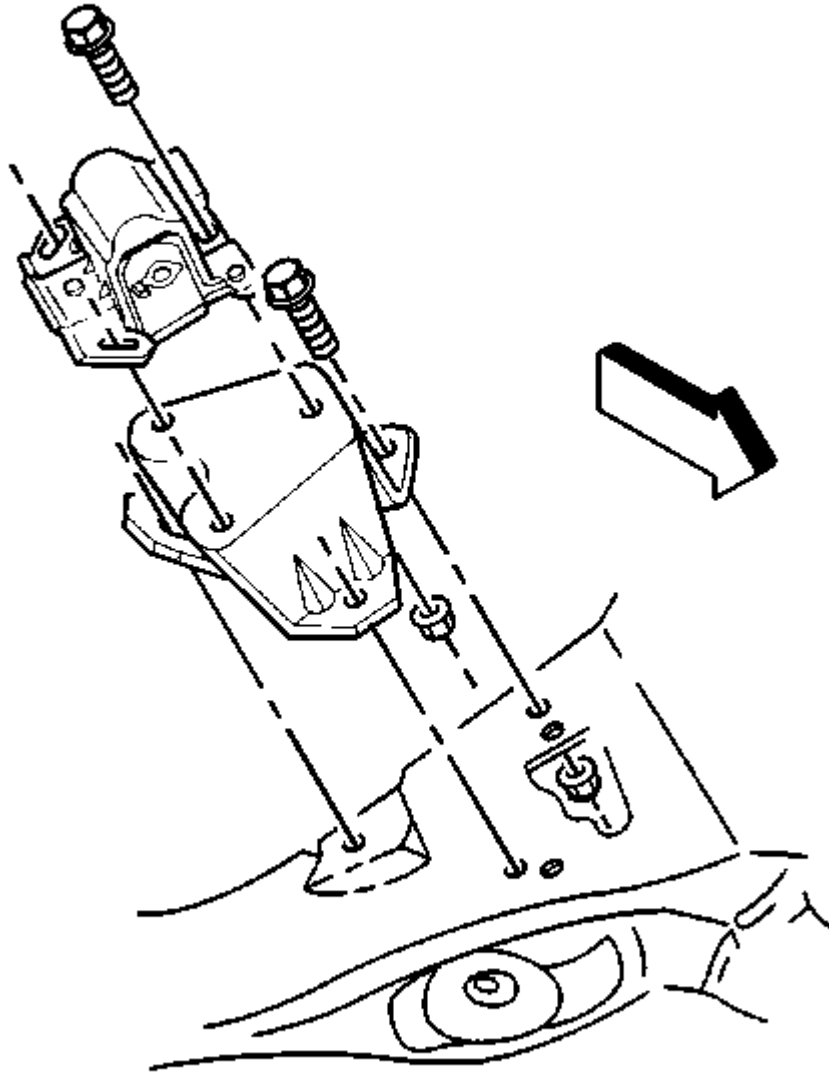


Fig. 40: Locating Engine Mount To Frame Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the RWD vehicle right side engine mount, the bolts, and the nuts to the frame.

Tighten:

- Tighten the engine mount to frame bolts to 47 N.m (35 lb ft).
- Tighten the engine mount to frame nuts to 42 N.m (31 lb ft).

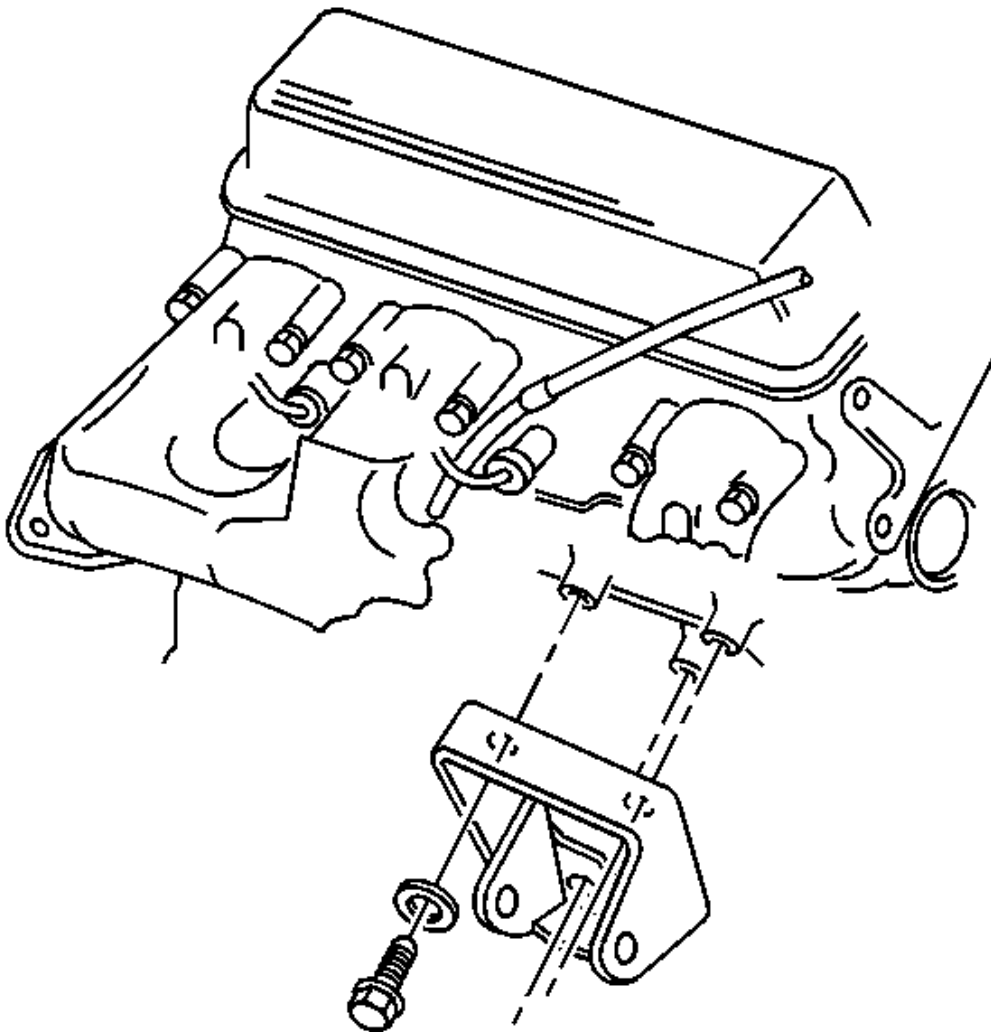


Fig. 41: View Of Engine Mount Bracket To Engine
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount bracket to the engine.
4. Install the engine mount bracket bolts.

Tighten: Tighten the engine mount bracket bolts to 64 N.m (47 lb ft).

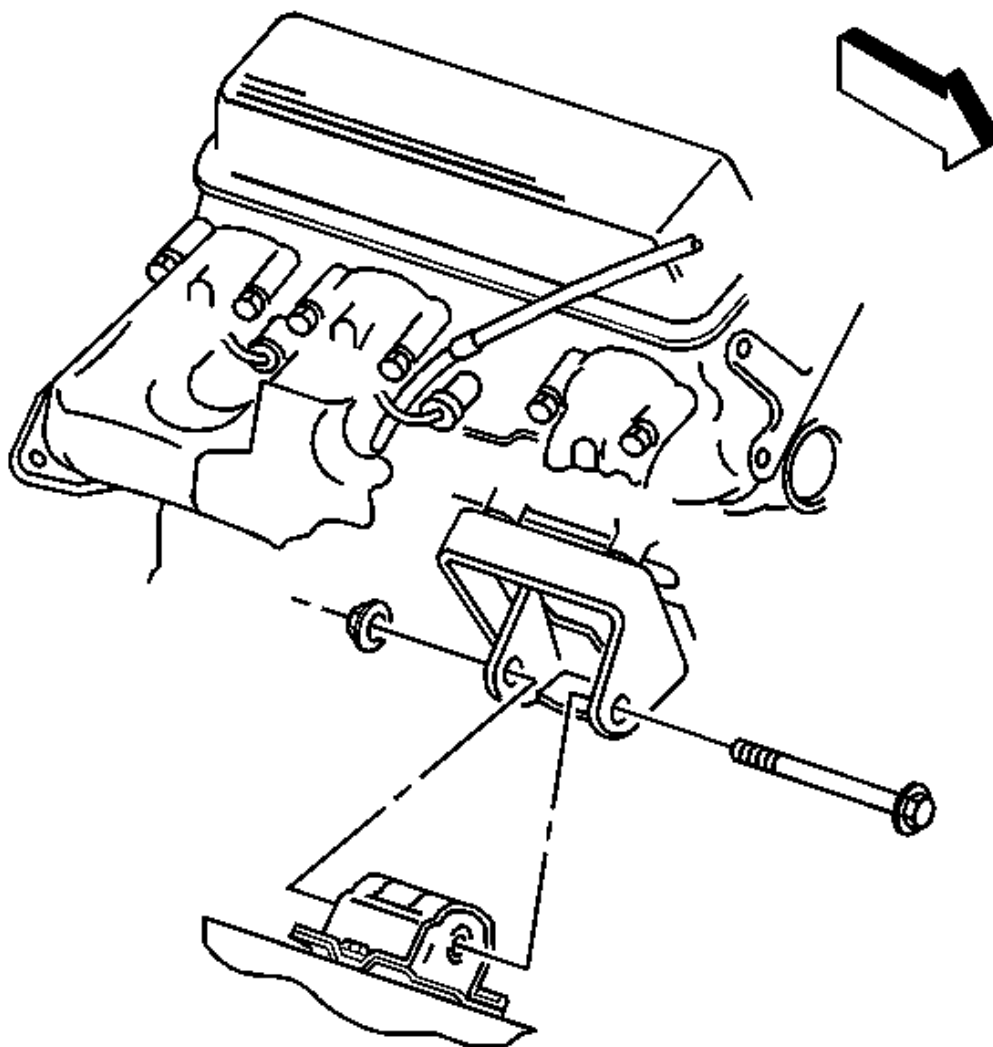


Fig. 42: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

5. Lower the engine.
6. Install the engine mount through- bolt and the nut.

Tighten: Tighten the engine mount through-bolt nuts to 68 N.m (50 lb ft).

7. Install the starter. Refer to **Starter Motor Replacement** in Engine Electrical.
8. Install the right fender wheelhouse extension. Refer to **Wheelhouse Extension Replacement** in Body

Front End.

9. Install the right front tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
10. Lower the vehicle.
11. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Intake Manifold Replacement - Upper

Removal Procedure

IMPORTANT: You do not have to remove the upper intake manifold in order to remove the lower intake manifold.

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Remove the air cleaner outlet duct from the throttle body. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-4.3 L.
3. Remove the throttle body assembly. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 4.3L.
4. Disconnect the accelerator control cable from the throttle shaft and the accelerator control cable bracket. Refer to **Accelerator Controls Cable Replacement** in Engine Controls-4.3 L.
5. Disconnect the cruise control cable, if equipped from the throttle shaft and the accelerator control cable bracket. Refer to **Cruise Control Cable Replacement** in Cruise Control.

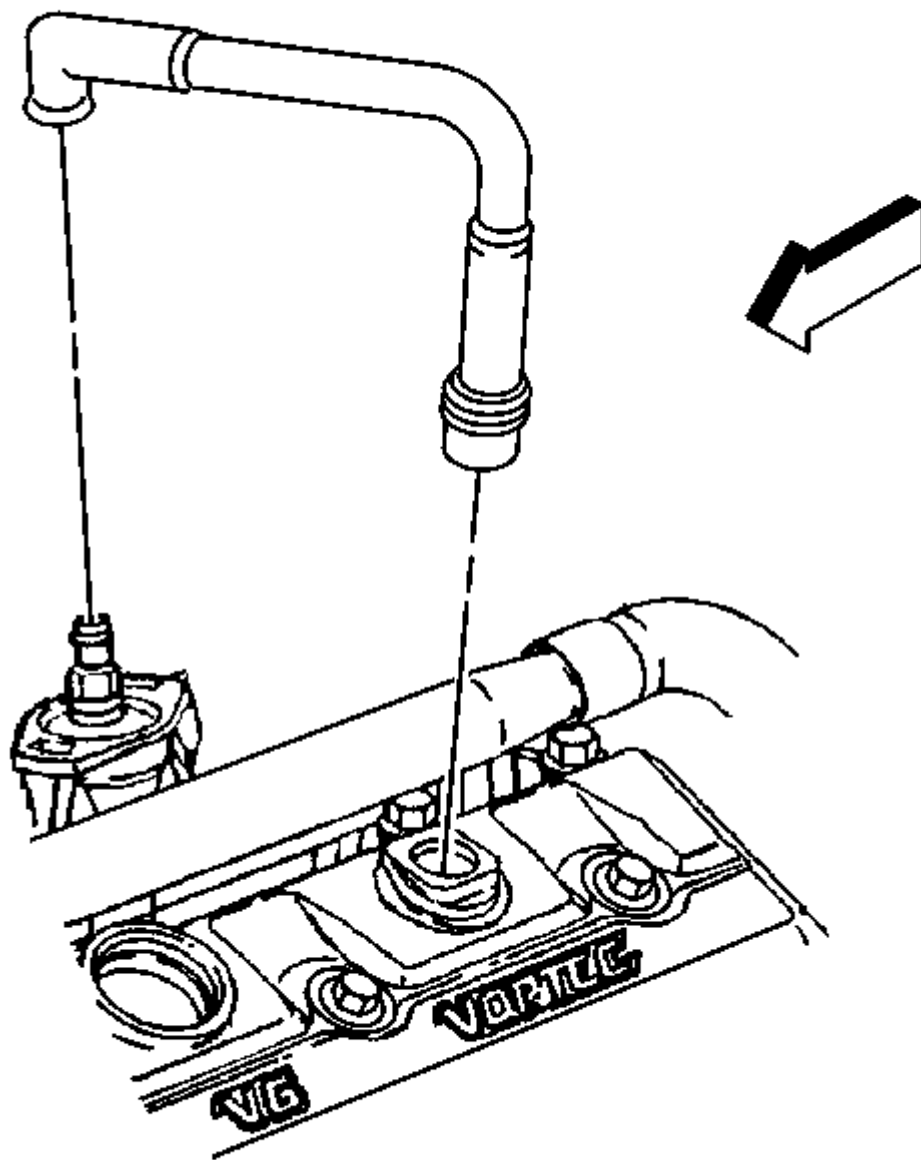


Fig. 43: Identifying Breather Tube
Courtesy of GENERAL MOTORS CORP.

6. Remove the PCV valve hose assembly from the intake manifold and the valve rocker arm cover.
7. Remove the nut holding the engine wiring harness bracket to the intake manifold stud.
8. Remove the engine wiring harness bracket from the stud.

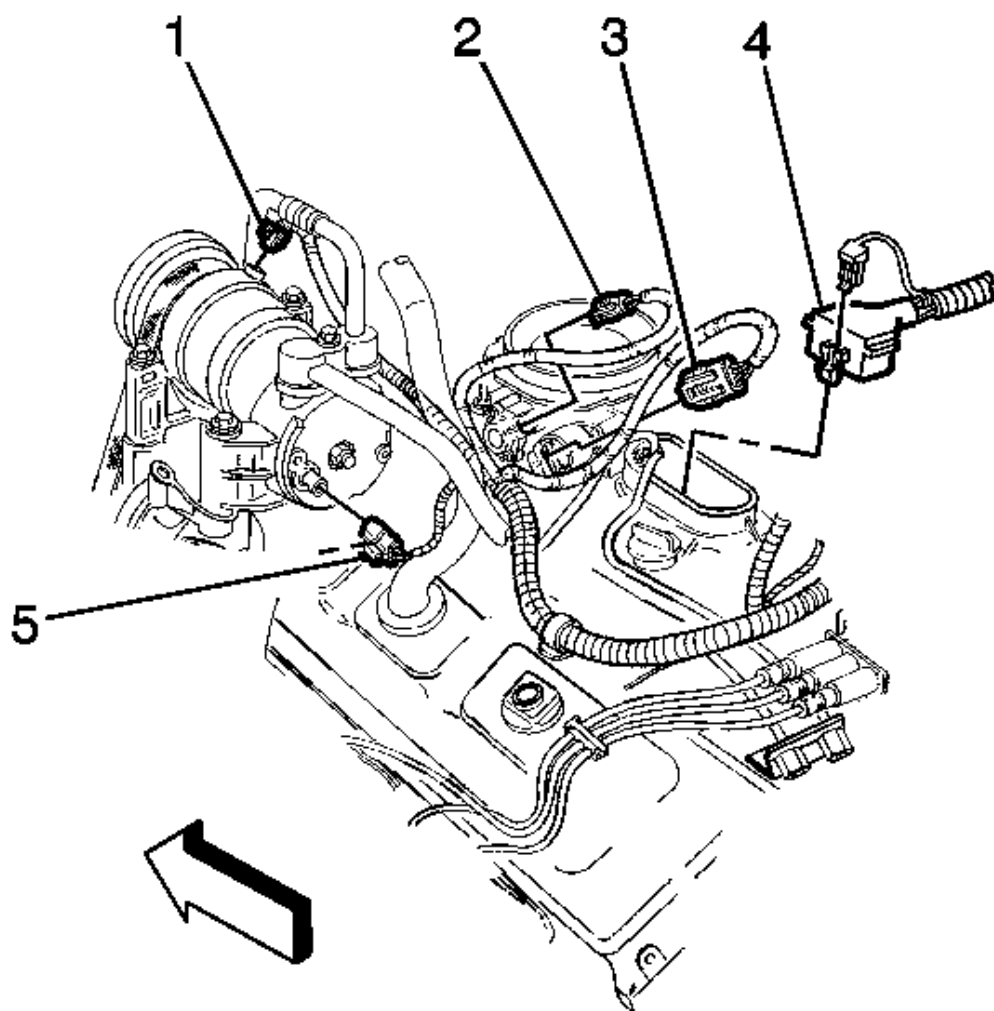


Fig. 44: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the following electrical connectors:
- The A/C compressor clutch, if equipped (1)
 - The A/C high pressure cutoff switch, if equipped (5)
 - The throttle position (TP) sensor (2)
 - The idle air control (IAC) motor (3)
 - The fuel meter body assembly connector (4)

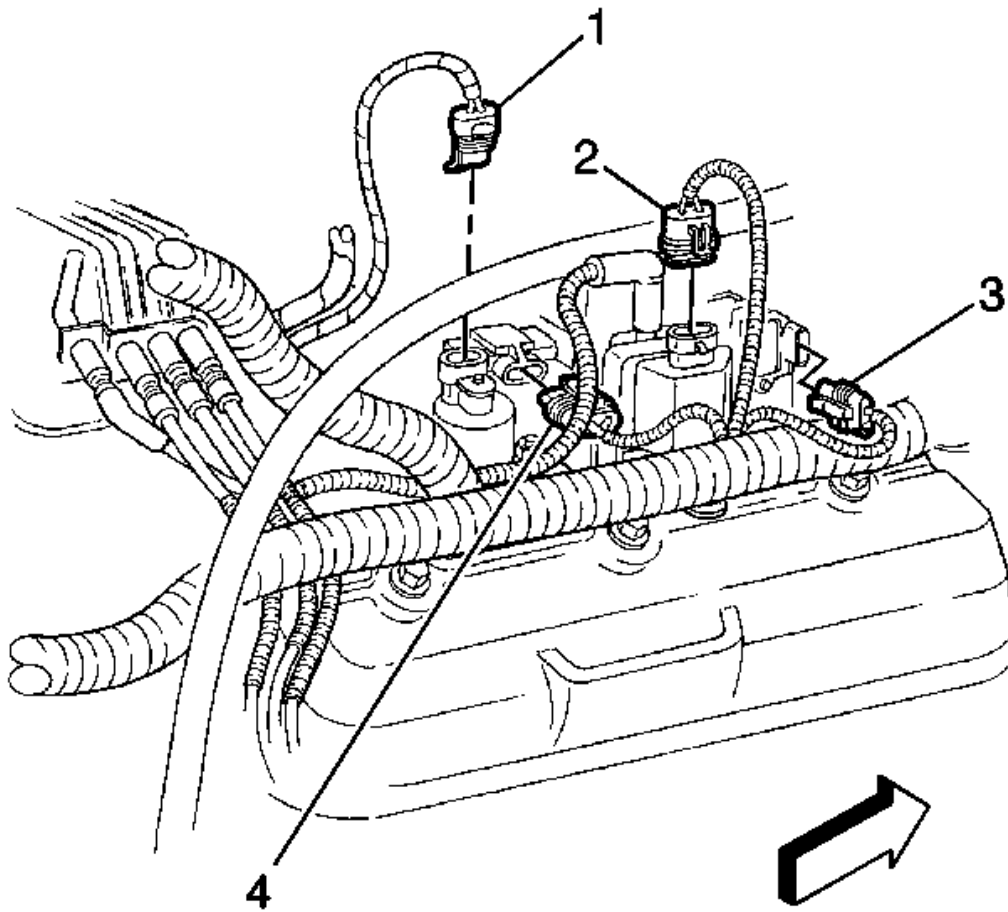


Fig. 45: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the following electrical connectors:
- The manifold absolute pressure (MAP) sensor (4)
 - The EVAP canister purge solenoid valve (1)

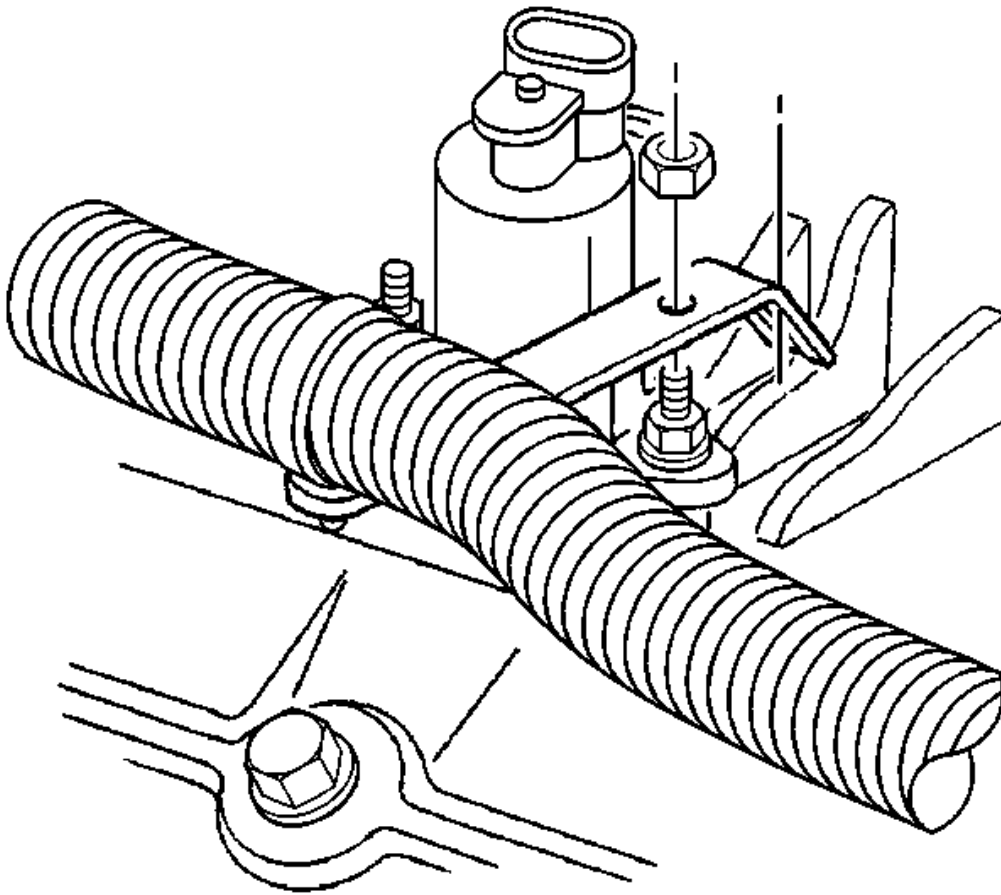


Fig. 46: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine wiring harness bracket from the stud at the EVAP canister purge solenoid valve.
12. Move and secure the engine wiring harness out of the way.
13. Remove the EVAP canister purge valve to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls-4.3 L.

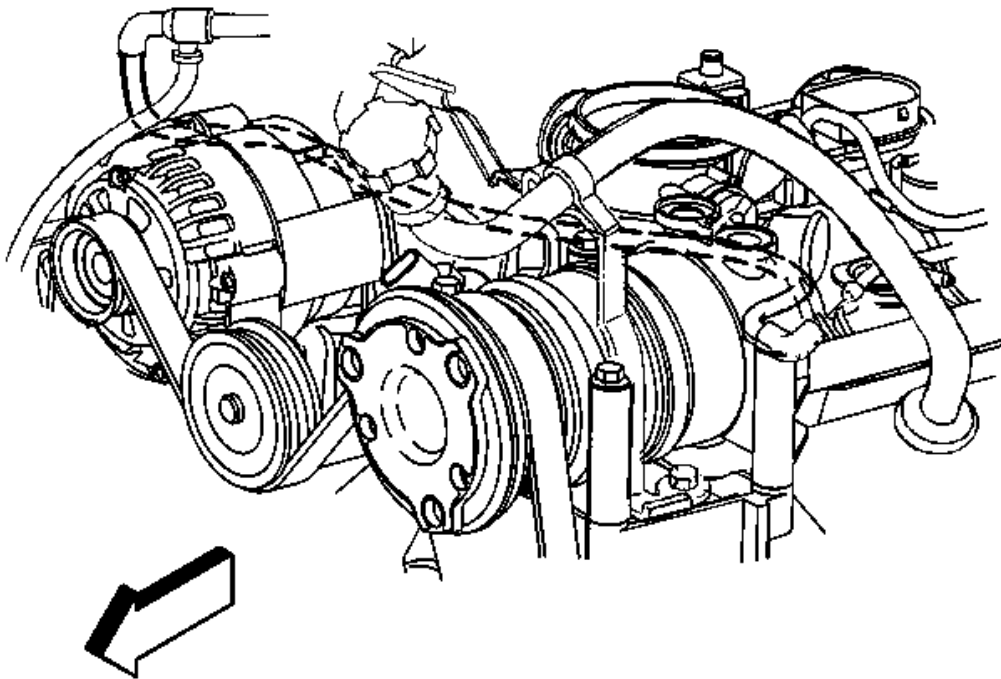


Fig. 47: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the vacuum hose from the intake manifold.

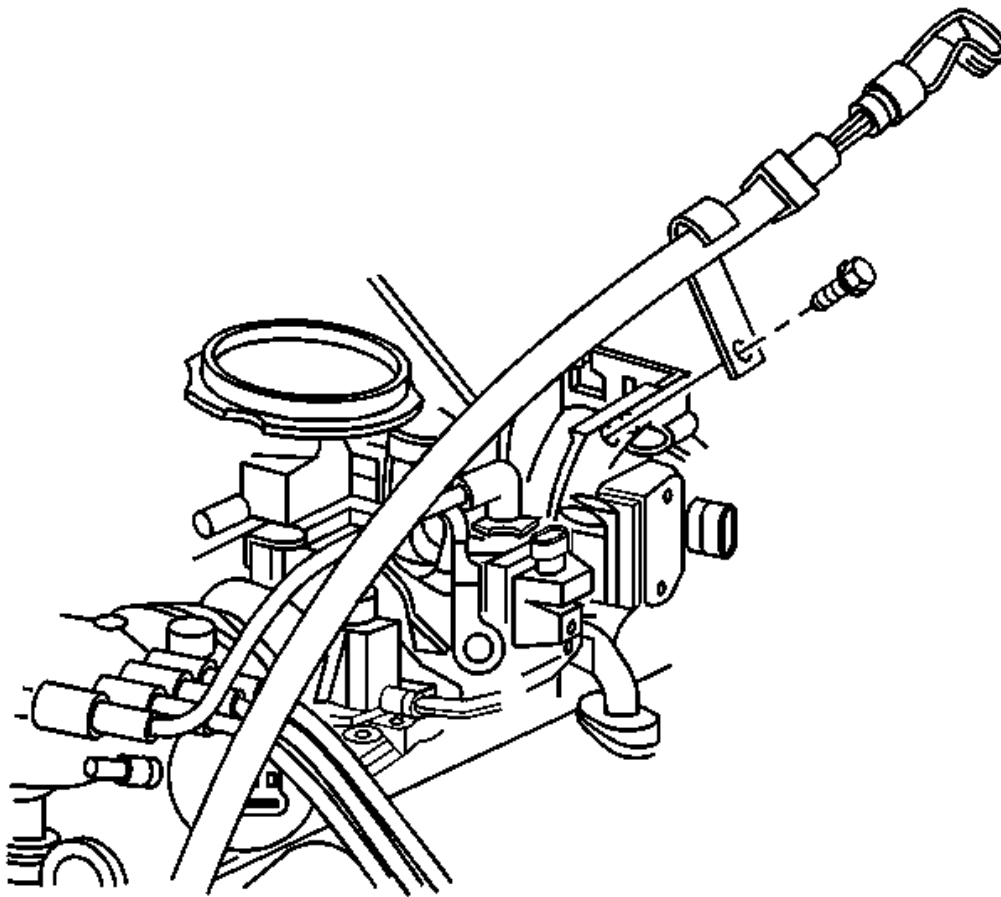


Fig. 48: Locating Accelerator Control Cable Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

15. Remove the bolt holding the transmission fluid filler tube to the accelerator control cable bracket.

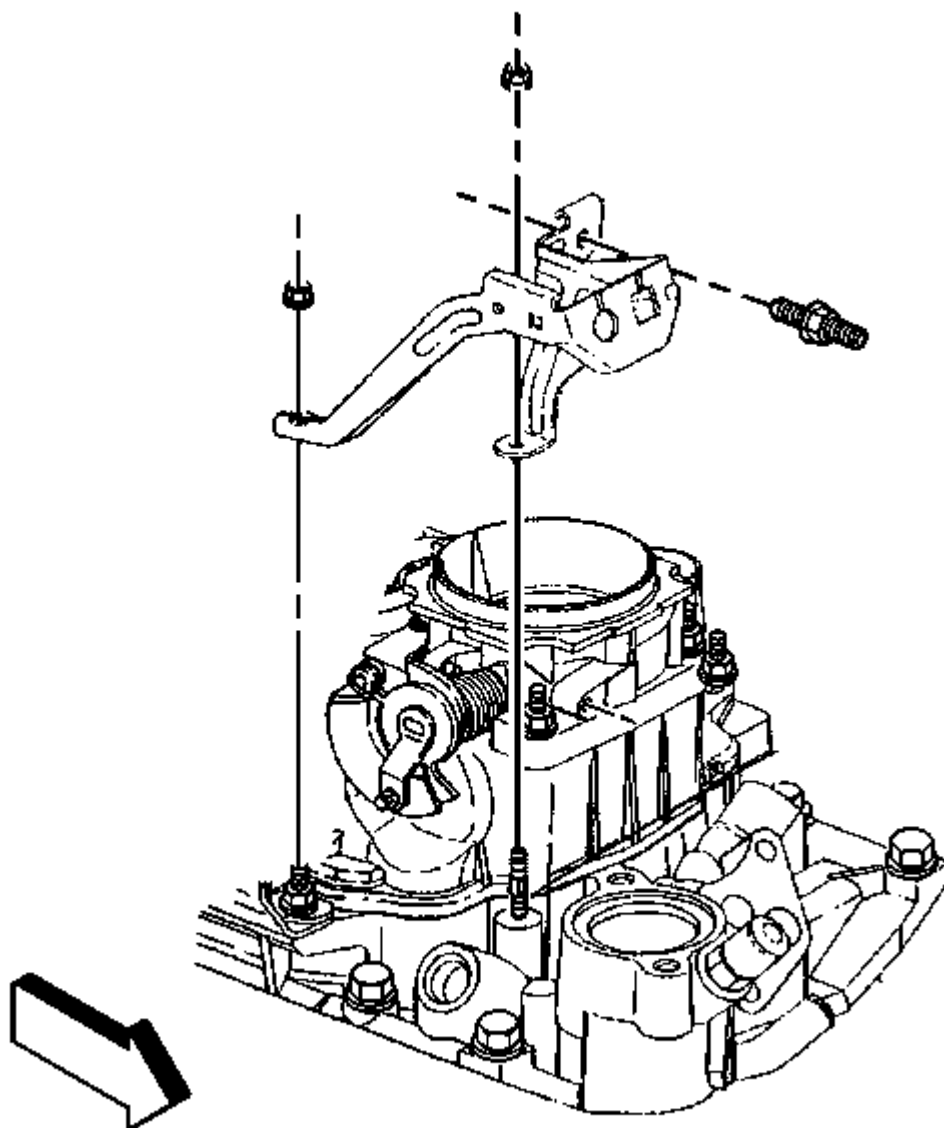


Fig. 49: View Of Accelerator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

16. Remove the accelerator control cable bracket from the throttle body and the intake manifold.
17. Remove the fuel lines from the fuel meter body assembly. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** in Engine Controls-4.3 L.

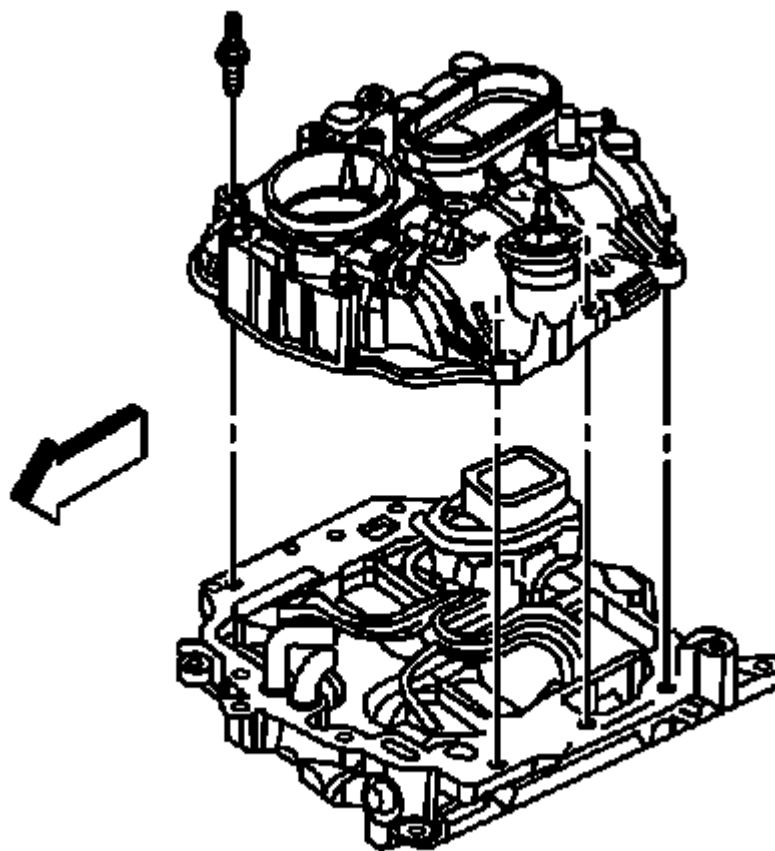


Fig. 50: Removing Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

18. Remove the studs for the upper intake manifold.
19. Remove the upper intake manifold.

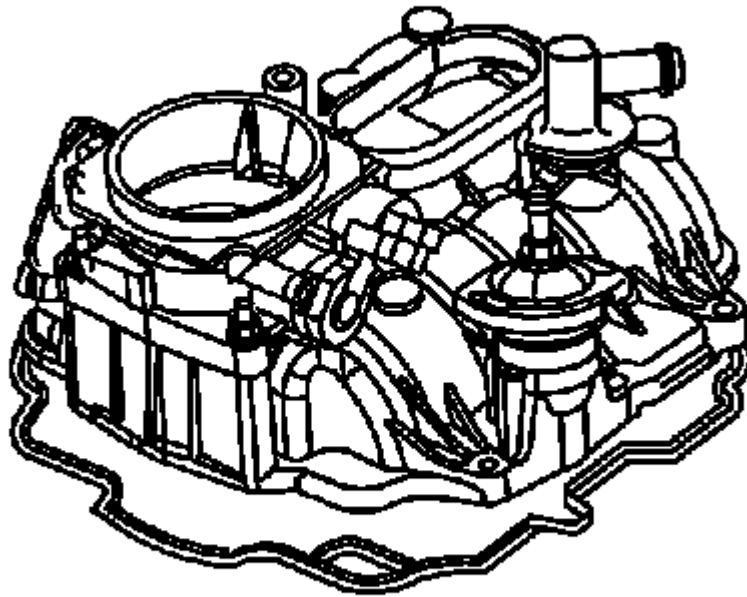


Fig. 51: Removing Intake Manifold Upper Gasket
Courtesy of GENERAL MOTORS CORP.

20. Remove the upper intake manifold gasket from the groove.
21. Discard the gasket.

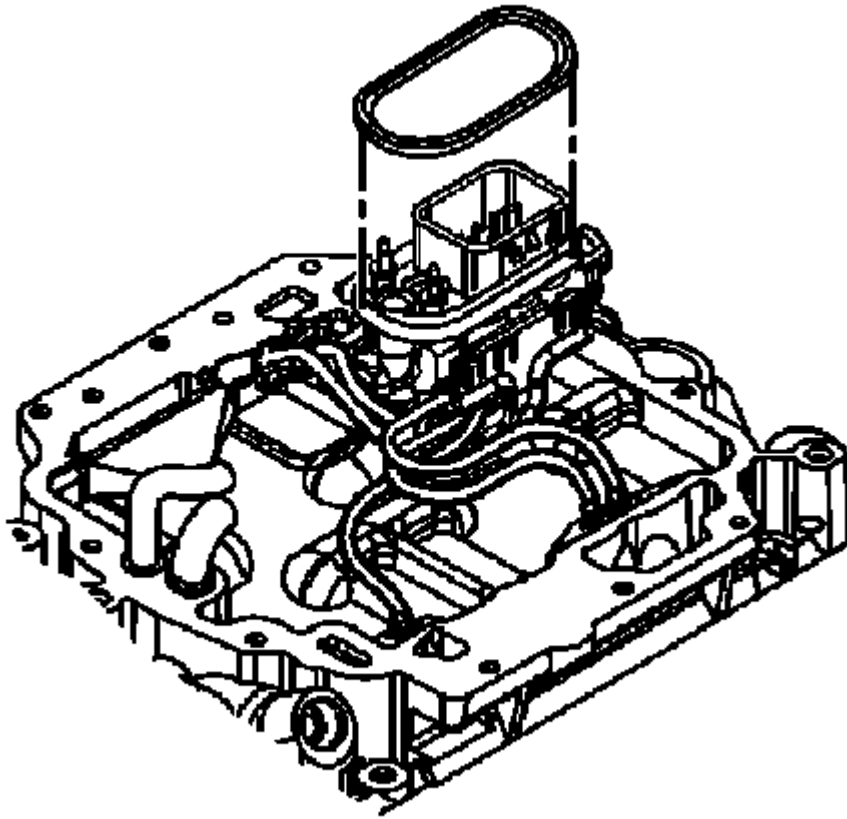


Fig. 52: Removing Fuel Meter Body O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

22. Remove the seal from the fuel meter body assembly.
23. Discard the seal.

IMPORTANT: Do not immerse the assembled upper intake manifold in cleaning solvent.

24. Clean all sealing surfaces and the inside of the upper intake manifold with a shop towel and cleaning solvent.
25. Inspect the upper intake manifold for the following:
 - Cracks or other damage to the exterior
 - Cracking or damage to the gasket grooves
 - Loose or damaged bolt hole thread inserts

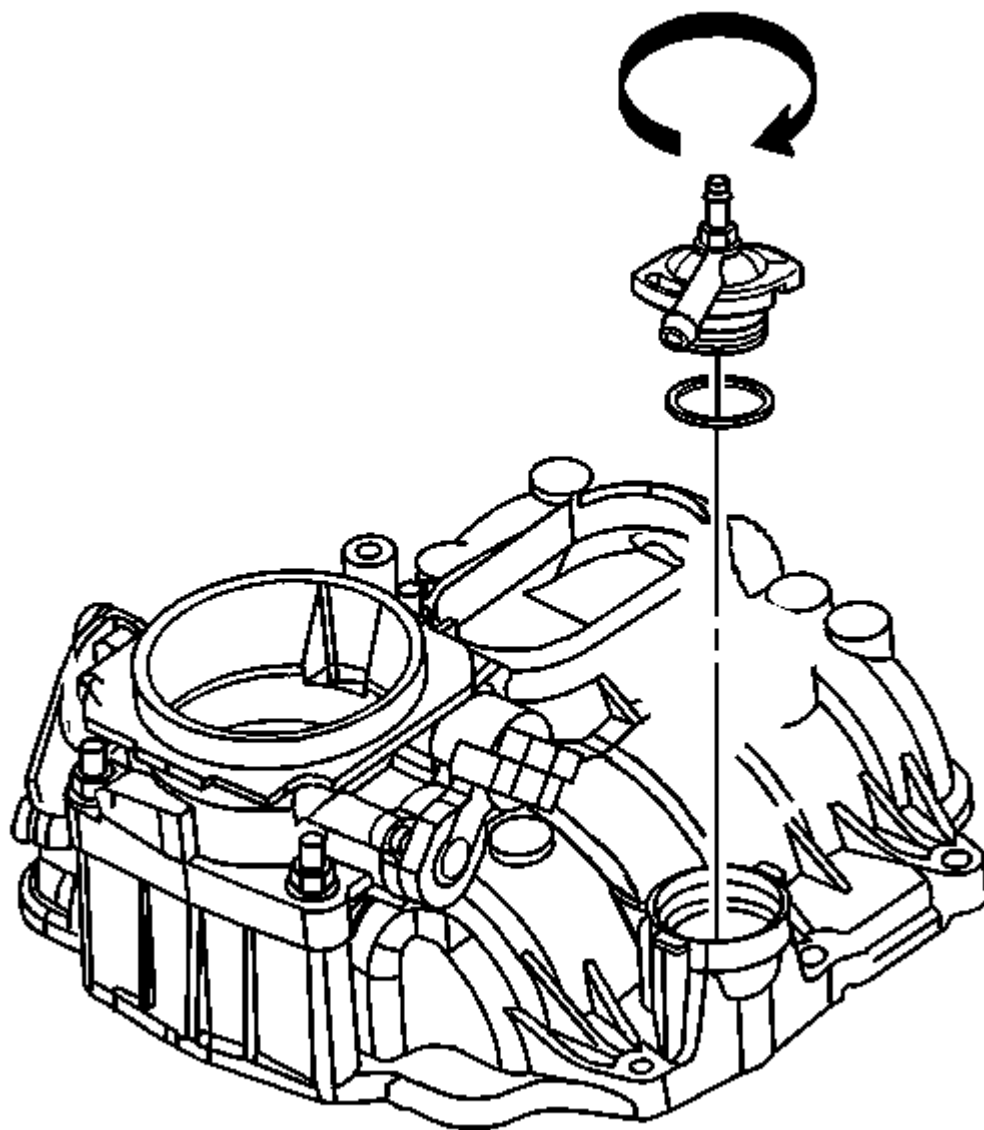


Fig. 53: Locating PCV Valve Cover
Courtesy of GENERAL MOTORS CORP.

26. If replacing the upper intake manifold, turn and remove the PCV valve cover from the upper intake manifold.
27. Remove and discard the seal.
28. Remove the throttle body if replacing the upper intake manifold. Refer to **Throttle Body Assembly**

Replacement in Engine Controls-4.3 L.

29. Remove the MAP sensor if replacing the upper intake manifold. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls-4.3 L.

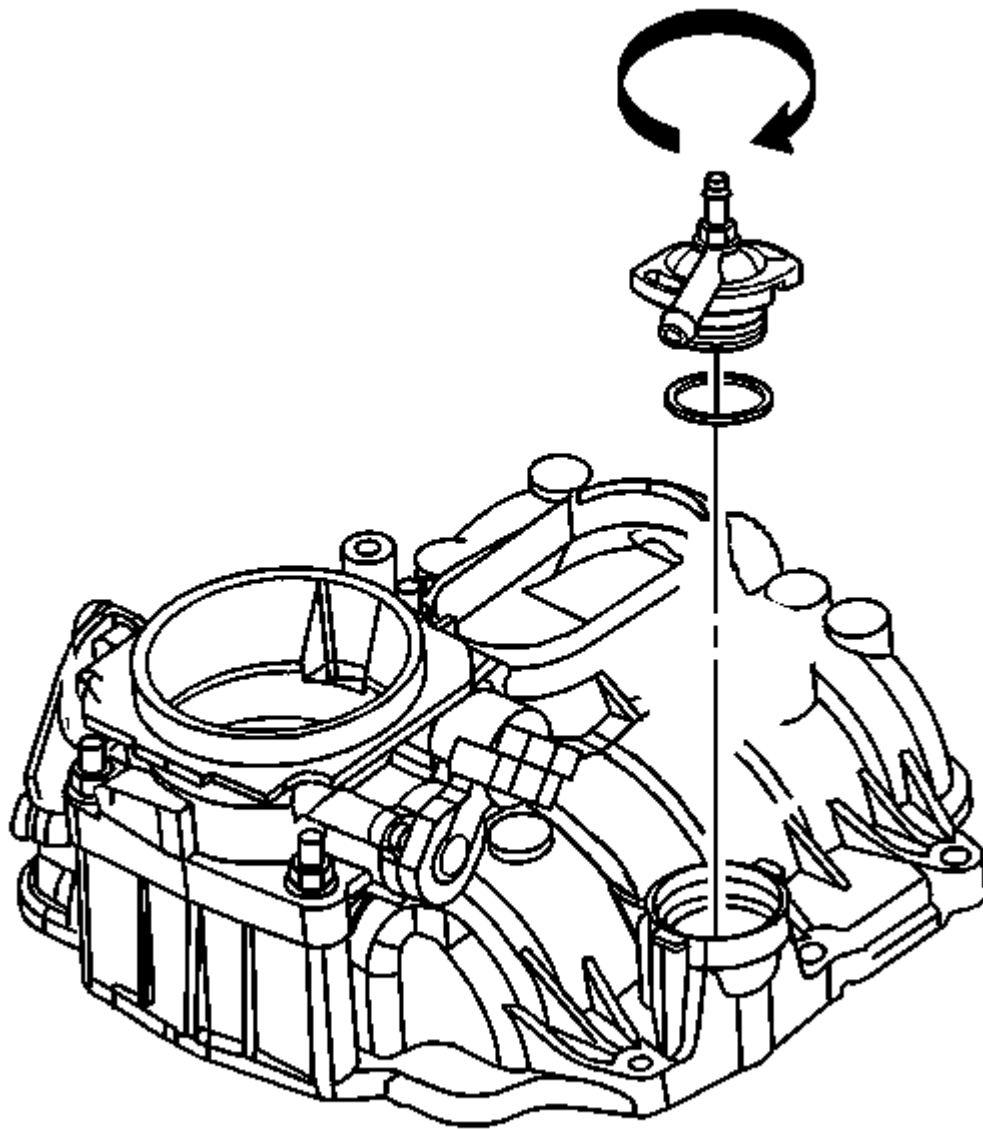
Installation Procedure

Fig. 54: Locating PCV Valve Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the throttle body, if removed. Refer to **Throttle Body Assembly Replacement** in Engine Controls-4.3 L.
2. Install the MAP sensor, if removed. Refer to **Manifold Absolute Pressure (MAP) Sensor Replacement** in Engine Controls-4.3 L.
3. Install the PCV valve cover, if removed, using the following procedure:
 1. Install a NEW seal (O-ring) on the PCV valve cover.
 2. Lubricate the seal with clean engine oil.
 3. Install the PCV valve cover in the upper intake manifold.
 4. Turn and lock the PCV valve cover in position.

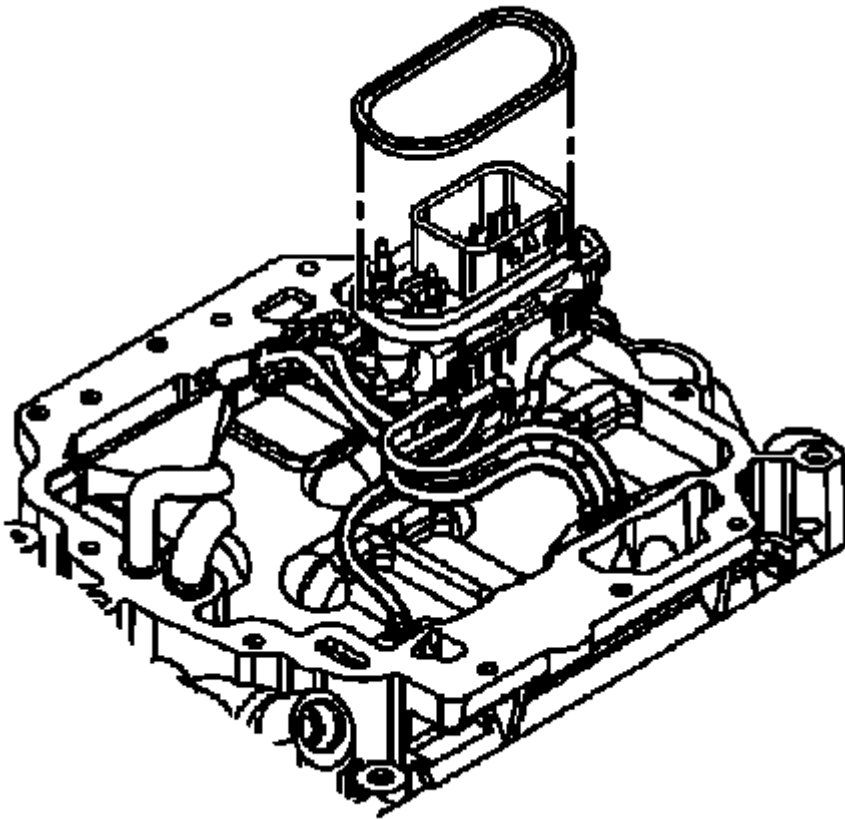


Fig. 55: Removing Fuel Meter Body O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW seal on the fuel meter body assembly.
5. Lubricate the seal with clean engine oil.

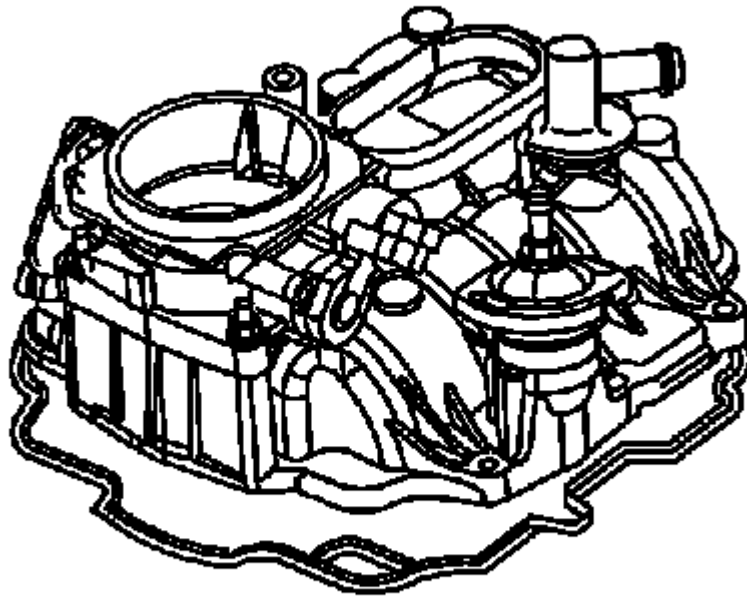


Fig. 56: Removing Intake Manifold Upper Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install a NEW upper intake manifold to lower intake manifold gasket in the groove of the upper intake manifold.

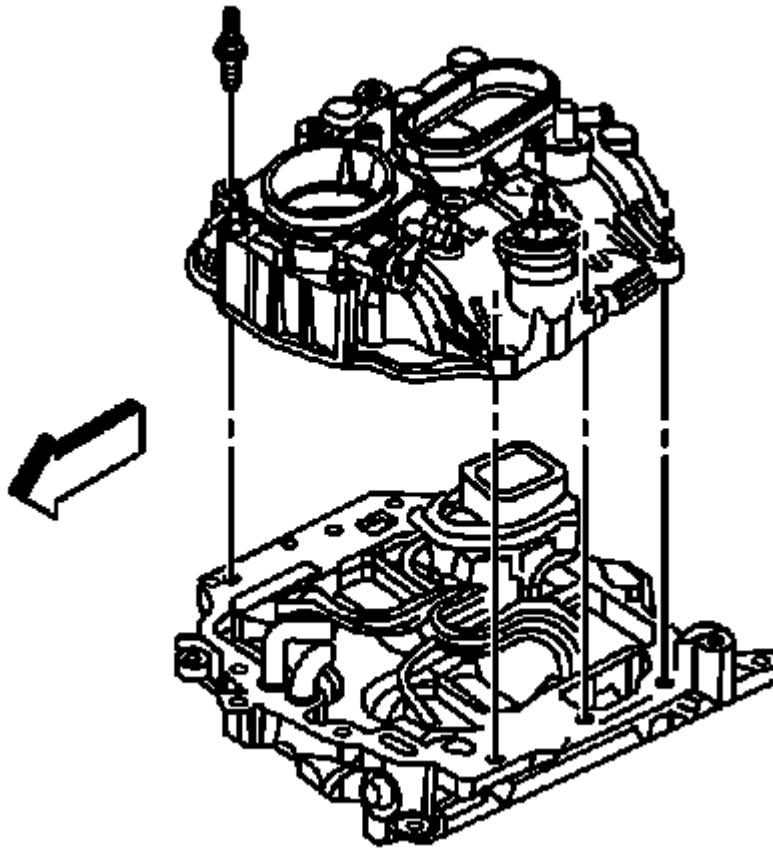


Fig. 57: Removing Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. Install the upper intake manifold onto the lower intake manifold.
8. If reusing the fasteners, apply threadlock GM P/N 12345382 or equivalent to the threads of the upper intake manifold attaching bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the upper intake manifold attaching studs.

Tighten:

1. Tighten the upper intake manifold attaching studs on the first pass to 5 N.m (44 lb in).
 2. Tighten the upper intake manifold attaching studs on the final pass to 9 N.m (80 lb in).
10. Install the fuel lines to the fuel meter body assembly. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** in Engine Controls-4.3 L.
 11. Install the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls-4.3 L.

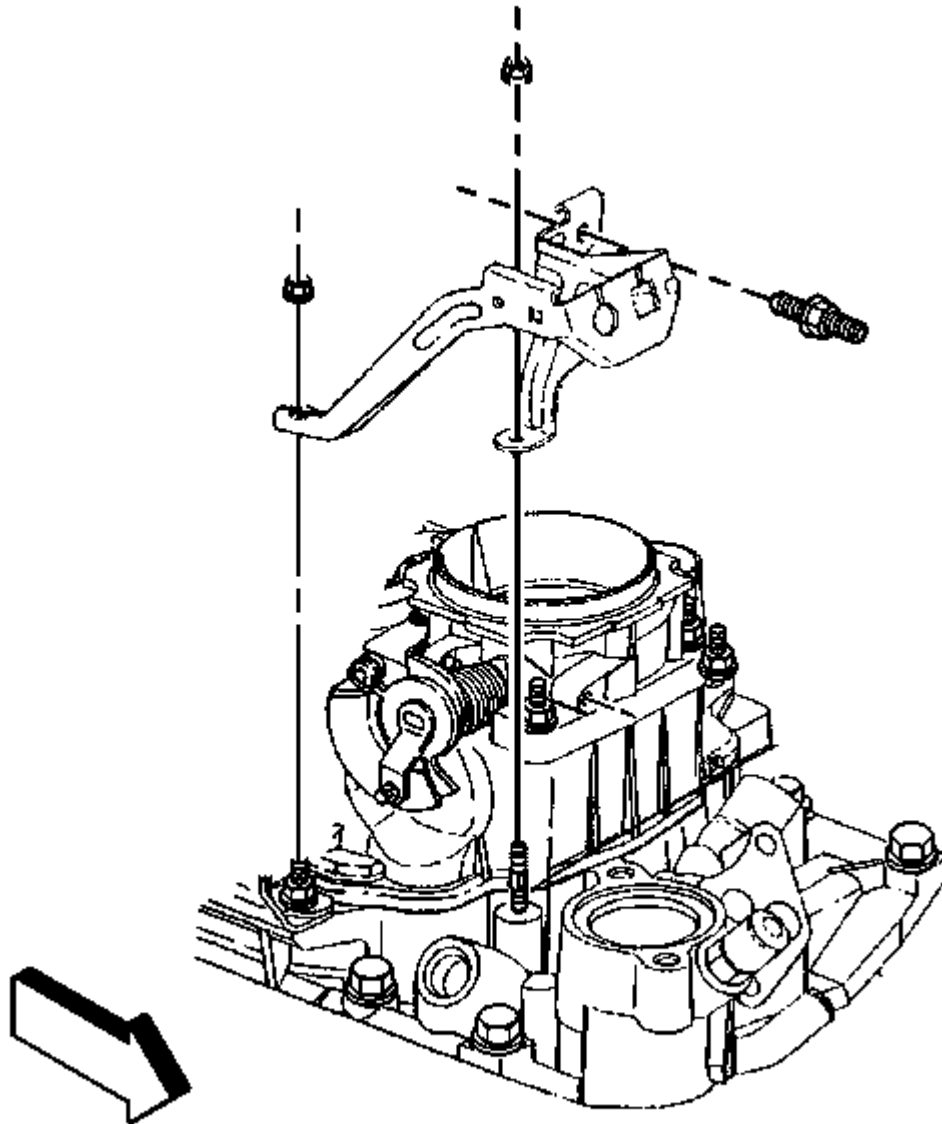


Fig. 58: View Of Accelerator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

12. Install the accelerator control cable bracket, studs, and nuts to the intake manifold and the throttle body.

Tighten: Tighten the accelerator control cable bracket nuts and studs to 12 N.m (106 lb in).

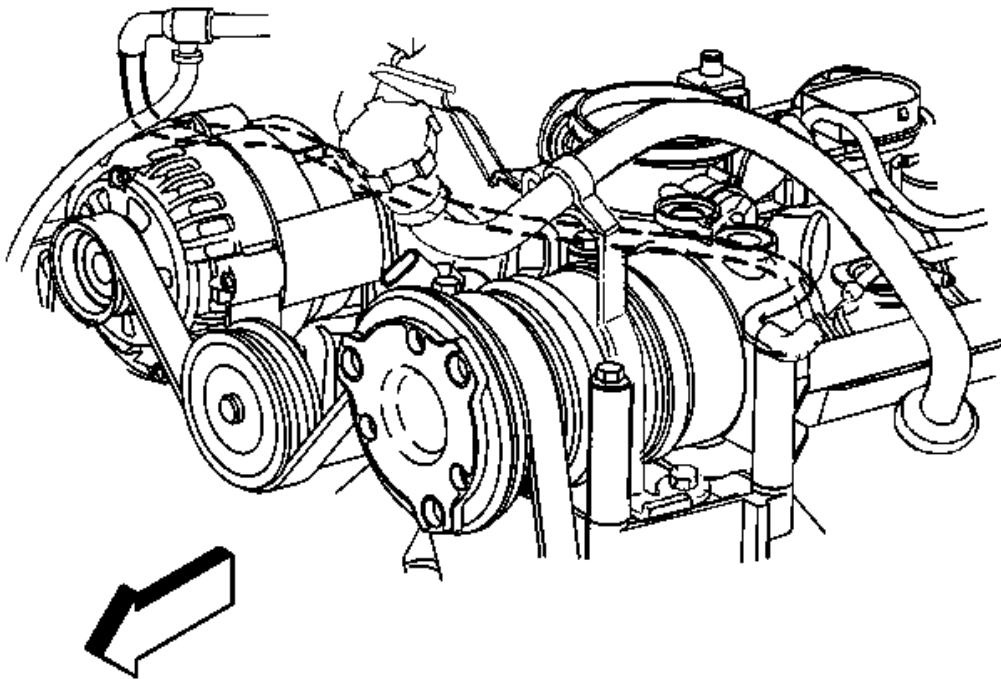


Fig. 59: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

13. Connect the vacuum hose to the intake manifold.

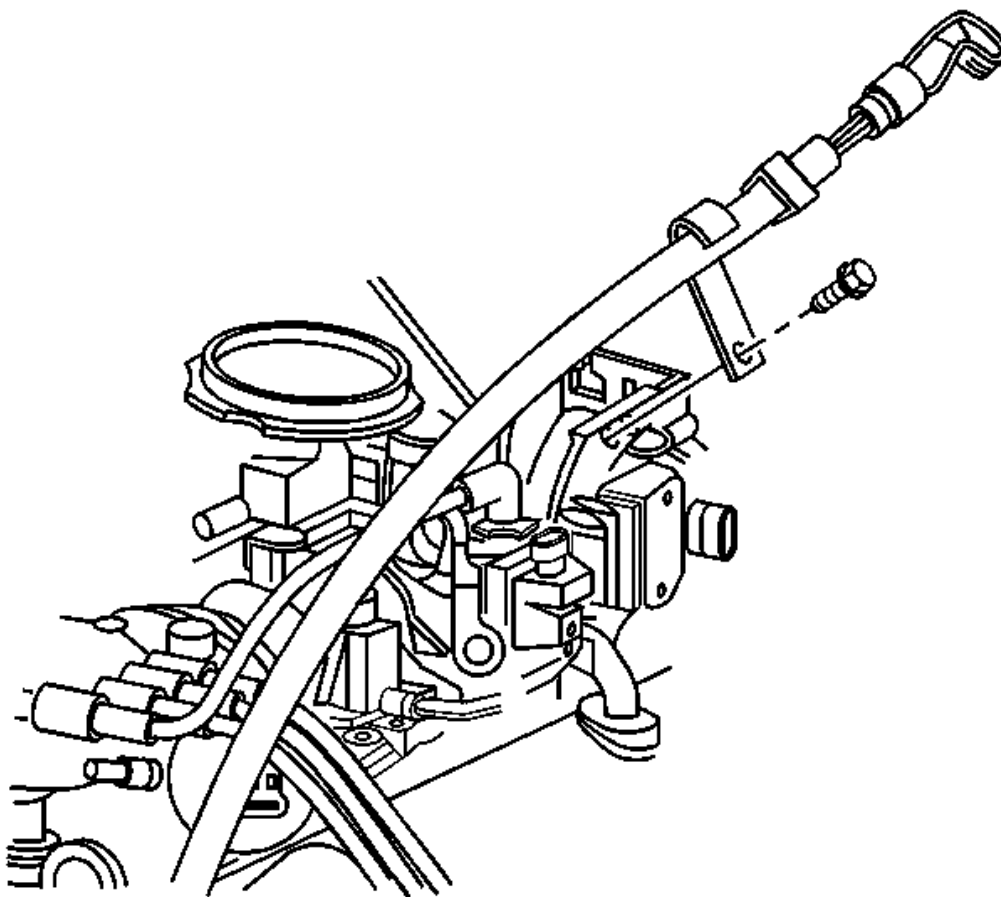


Fig. 60: Locating Accelerator Control Cable Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the transmission fluid fill tube and bolt to the accelerator control cable bracket.

Tighten: Tighten the transmission fluid fill tube bolt 6 N.m (53 lb in).

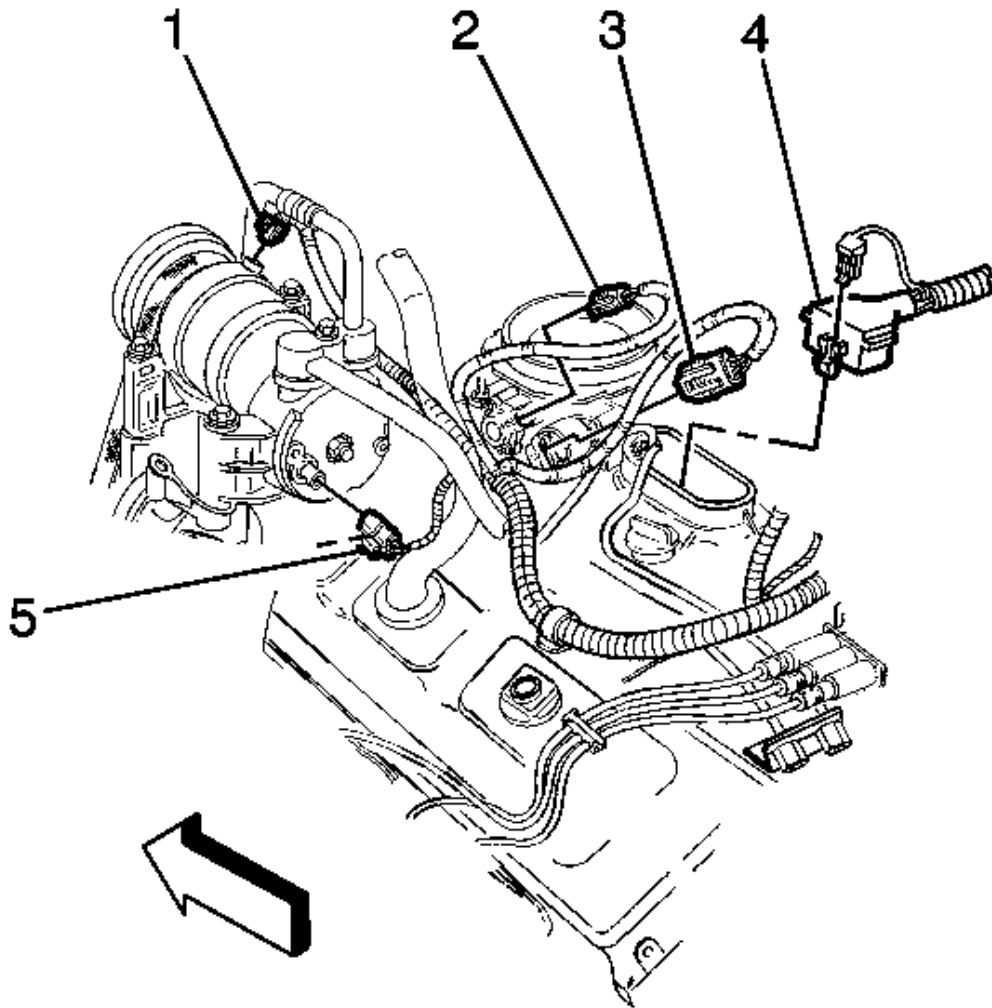


Fig. 61: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

15. Position the engine wiring harness.
16. Connect the following electrical connectors:
 - The A/C compressor clutch, if equipped (1)
 - The A/C high pressure cutoff switch, if equipped (5)
 - The throttle position (TP) sensor (2)
 - The idle air control (IAC) motor (3)
 - The fuel meter body assembly connector (4)

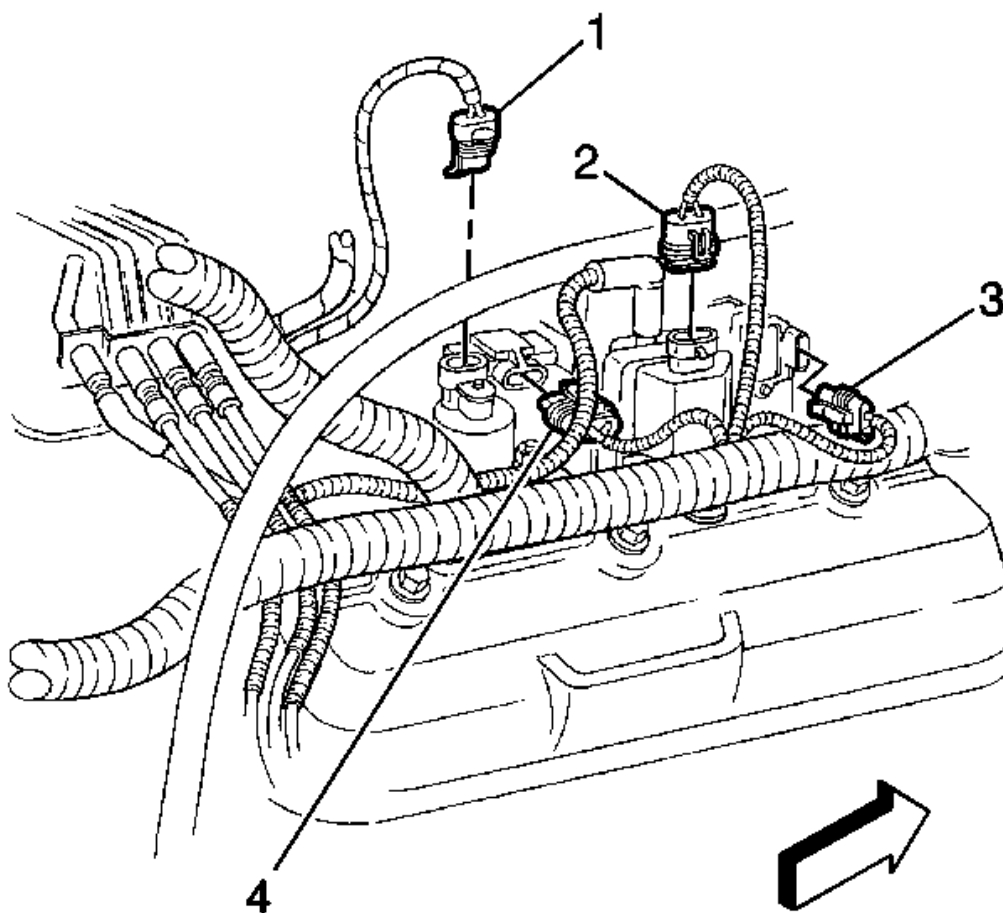


Fig. 62: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

17. Connect the following electrical connectors:
 - The manifold absolute pressure (MAP) sensor (4)
 - The EVAP canister purge solenoid valve (1)
18. Install the engine wiring harness bracket and nut to the intake manifold stud.

Tighten: Tighten the engine wiring harness bracket nut to 12 N.m (106 lb in).

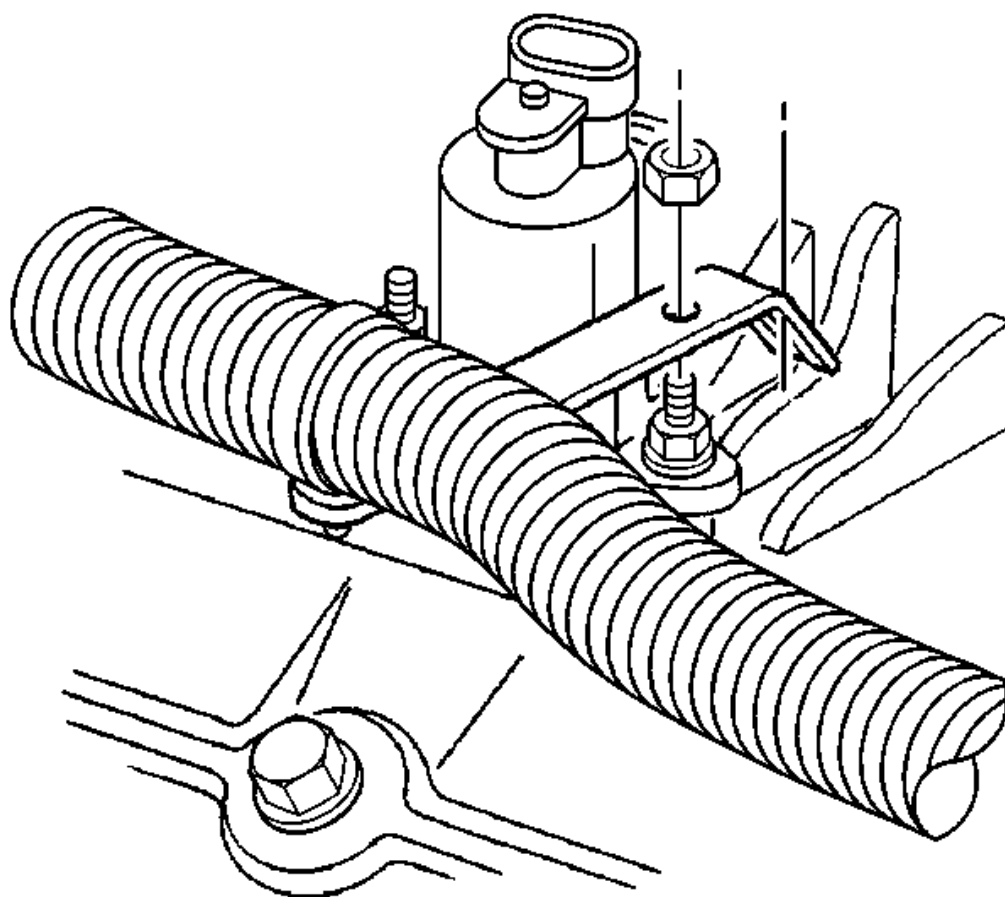


Fig. 63: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

19. Install the engine wiring harness bracket and the nut onto the stud at the EVAP canister purge solenoid valve.

Tighten: Tighten the engine wiring harness bracket nut to 8 N.m (71 lb in).

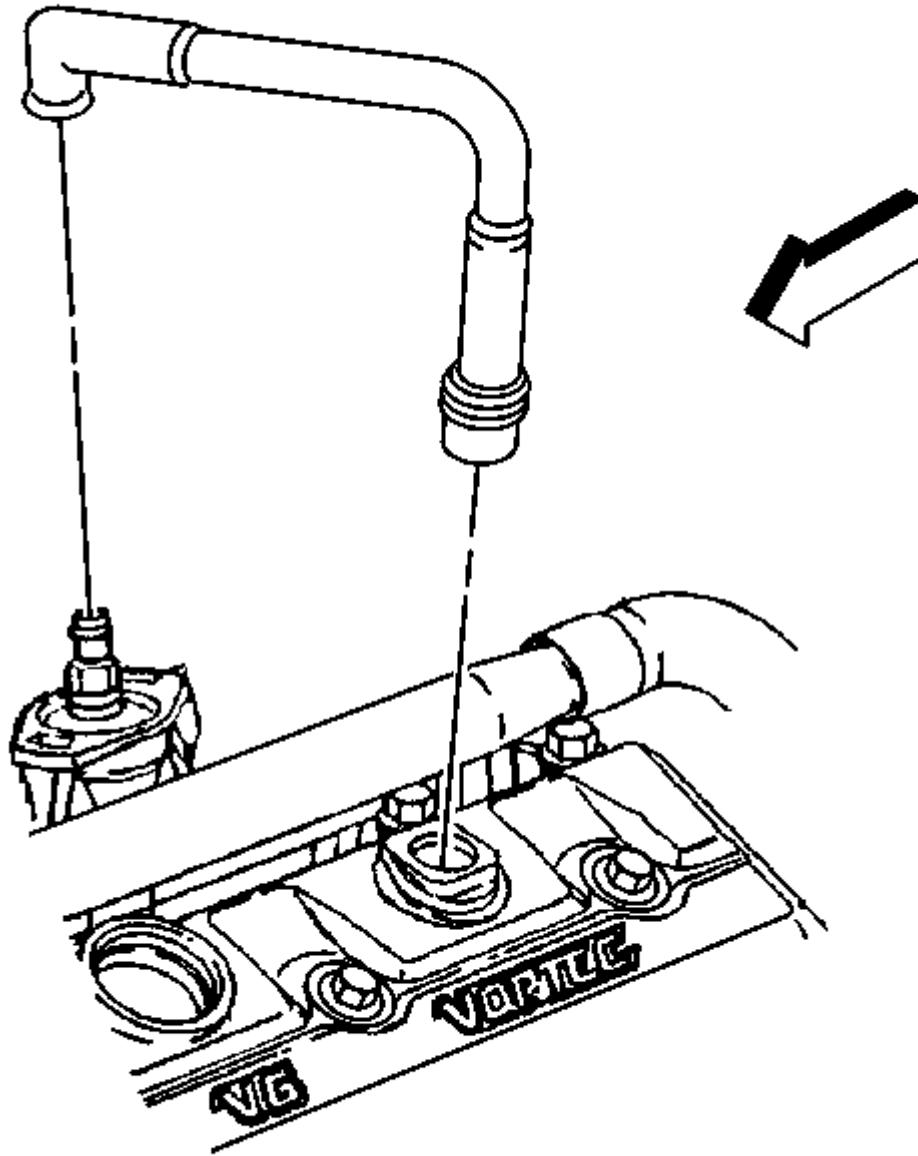


Fig. 64: Identifying Breather Tube
Courtesy of GENERAL MOTORS CORP.

20. Connect the PCV valve hose assembly to the intake manifold and the valve rocker arm cover.
21. Install the cruise control cable, if equipped to the throttle shaft and the accelerator control cable bracket. Refer to **Cruise Control Cable Replacement** in Cruise Control.
22. Install the accelerator control cable to the throttle shaft and the accelerator control cable bracket. Refer to

Accelerator Controls Cable Replacement in Engine Controls-4.3 L.

23. Install the throttle body assembly. Refer to **Throttle Body Assembly Replacement** in Engine Controls - 4.3L.
24. Install the air cleaner outlet duct to the throttle body assembly. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls-4.3 L.
25. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Intake Manifold Replacement - Lower**Removal Procedure**

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
3. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
4. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 4.3L.
5. Remove the air cleaner outlet duct from the throttle body assembly. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls - 4.3L.
6. Disconnect the accelerator control cable from the throttle shaft and the accelerator control cable bracket. Refer to **Accelerator Controls Cable Replacement** in Engine Controls - 4.3L.
7. Perform this step if the vehicle is equipped with a cruise control. Disconnect the cruise control cable from the throttle shaft, and from the accelerator control cable bracket. Refer to **Cruise Control Cable Replacement** in Cruise Control.

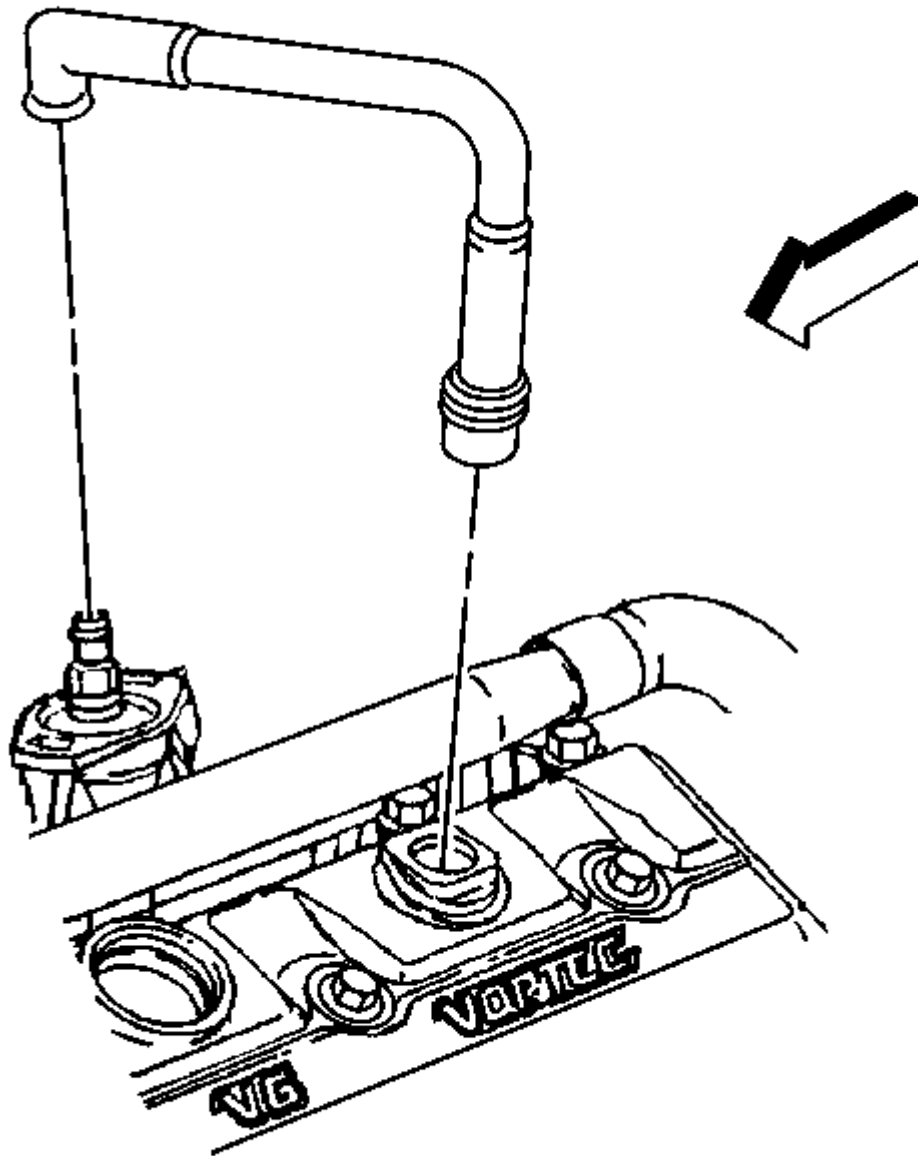


Fig. 65: Identifying Breather Tube

Courtesy of GENERAL MOTORS CORP.

8. Disconnect PCV valve hose assembly from the intake manifold and the valve rocker arm cover.

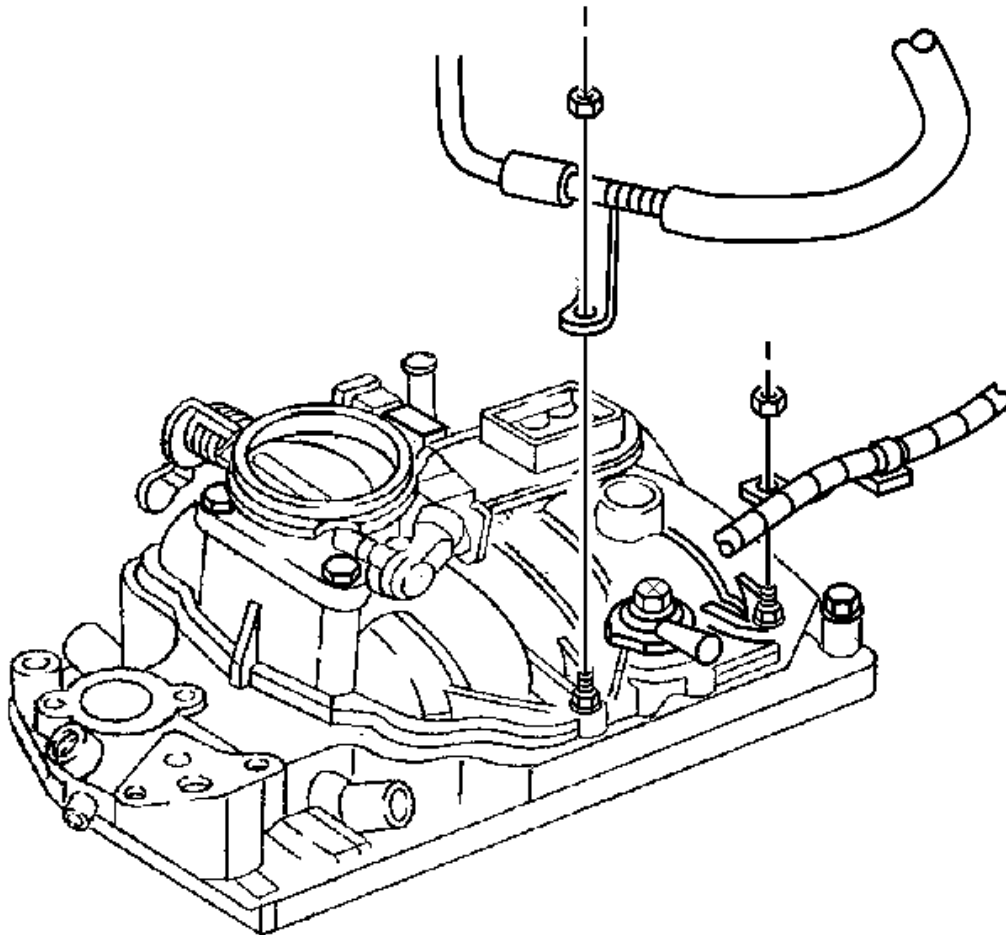


Fig. 66: View Of A/C Hose Bracket Nut
Courtesy of GENERAL MOTORS CORP.

9. Remove the nut holding the A/C hose bracket to the intake manifold stud, if equipped.
10. Remove the nut holding the engine wiring harness bracket to the intake manifold stud.

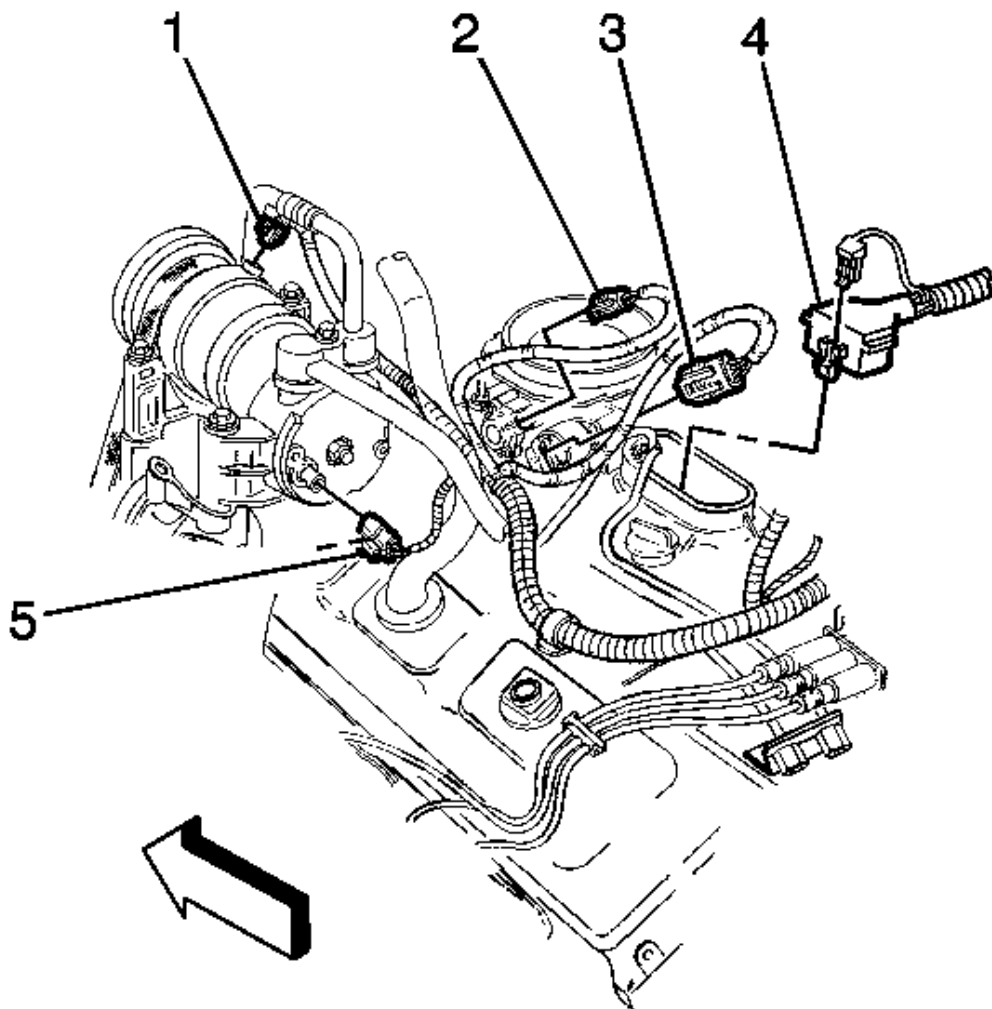


Fig. 67: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the following electrical connectors:
- The A/C compressor clutch, if equipped (1)
 - The A/C high pressure cutoff switch, if equipped (5)
 - The throttle position (TP) sensor (2)
 - The idle air control (IAC) motor (3)
 - The fuel meter body assembly connector (4)

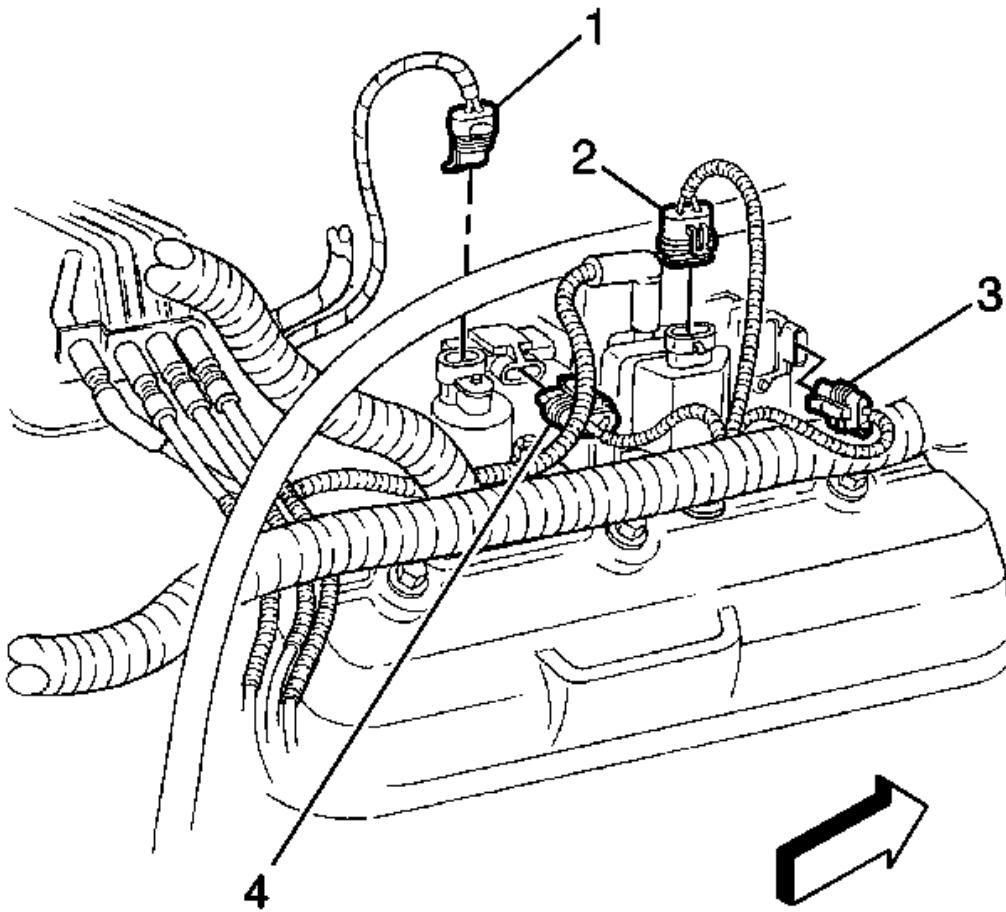


Fig. 68: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the following electrical connectors:
 - The manifold absolute pressure (MAP) sensor (4)
 - The EVAP canister purge solenoid valve (1)
13. Remove the ground wire from the stud at the water outlet.

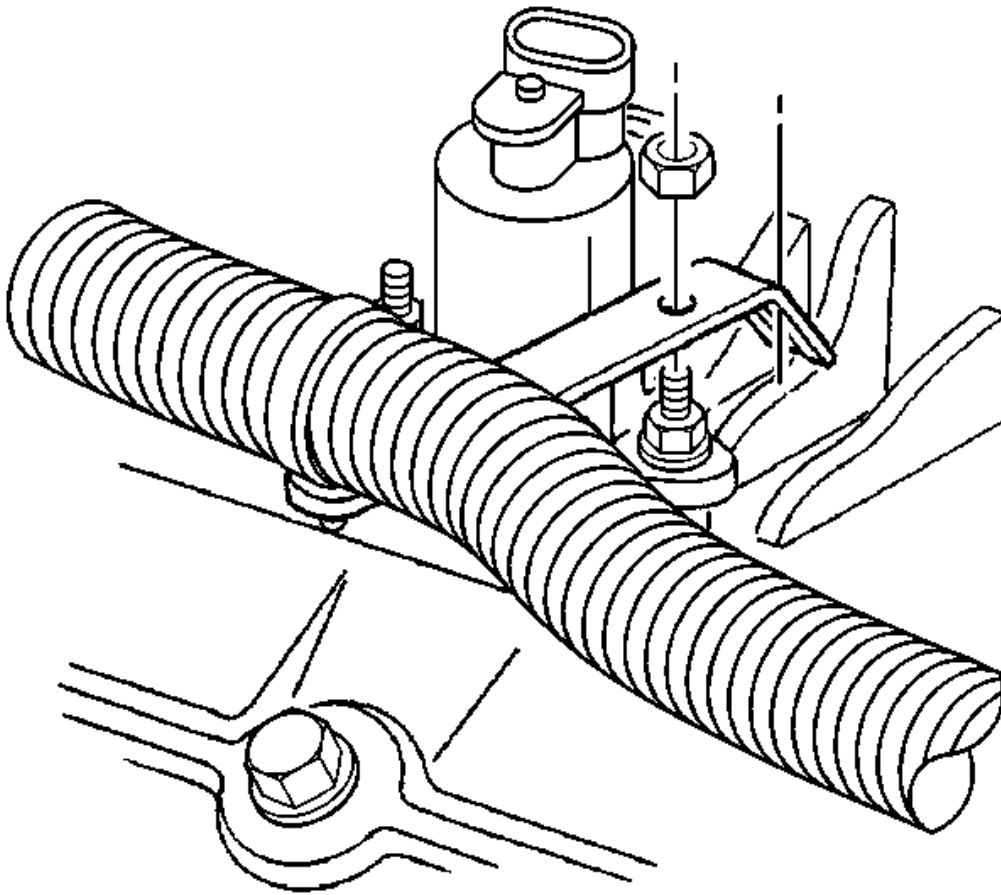


Fig. 69: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

14. Remove the nut, and remove the engine wiring harness bracket from the stud, at the EVAP canister purge solenoid valve.
15. Move and secure the engine wire harness out of the way.
16. Remove the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 4.3L.

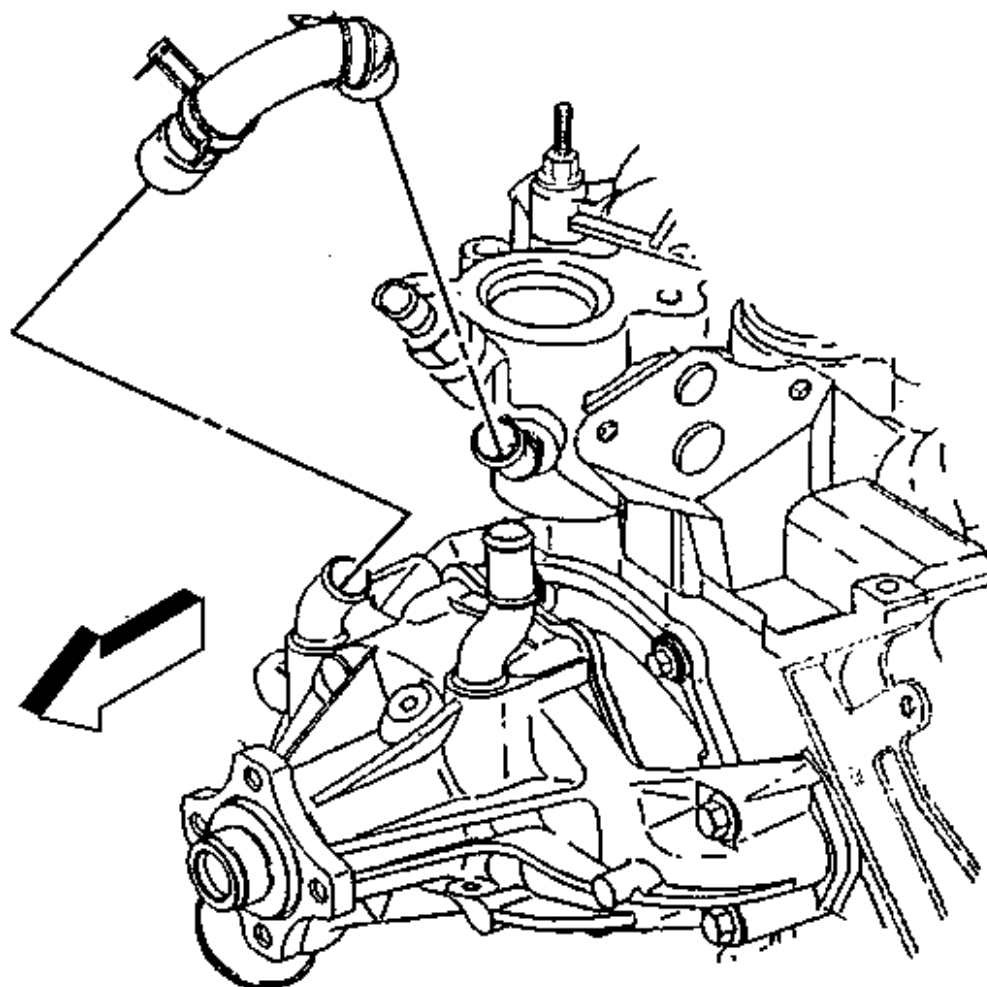


Fig. 70: Identifying Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

17. Remove the radiator inlet hose at the water outlet. Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.
18. Remove the heater hose from the intake manifold. Refer to **Heater Hose Replacement - Inlet** in Heating Ventilation and Air Conditioning.
19. Remove the water pump inlet hose from the intake manifold.

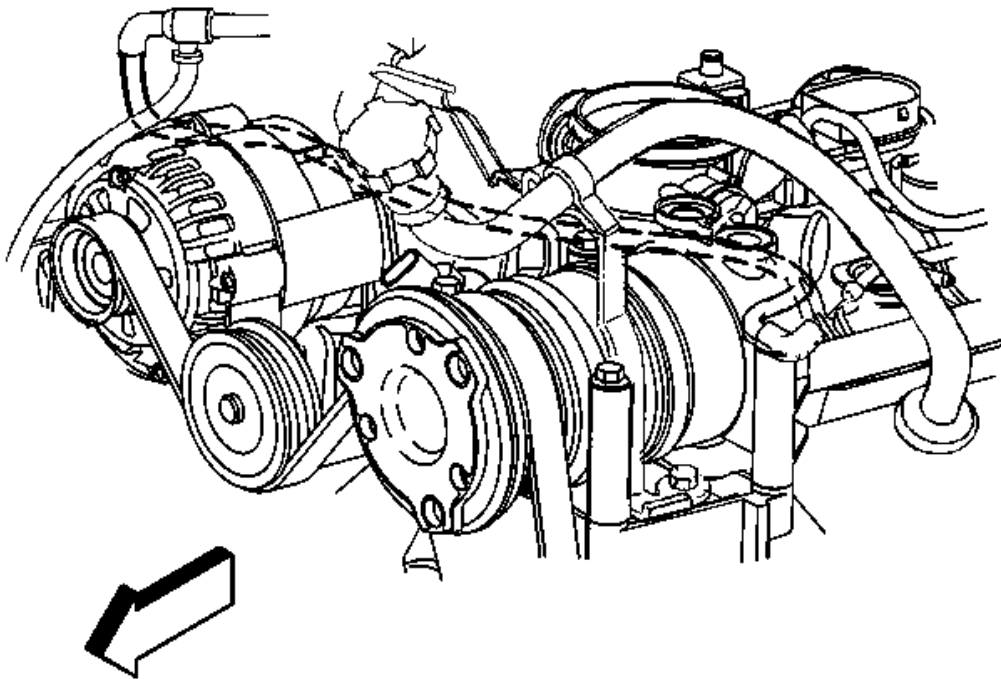


Fig. 71: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

20. Disconnect the vacuum hose from the intake manifold.

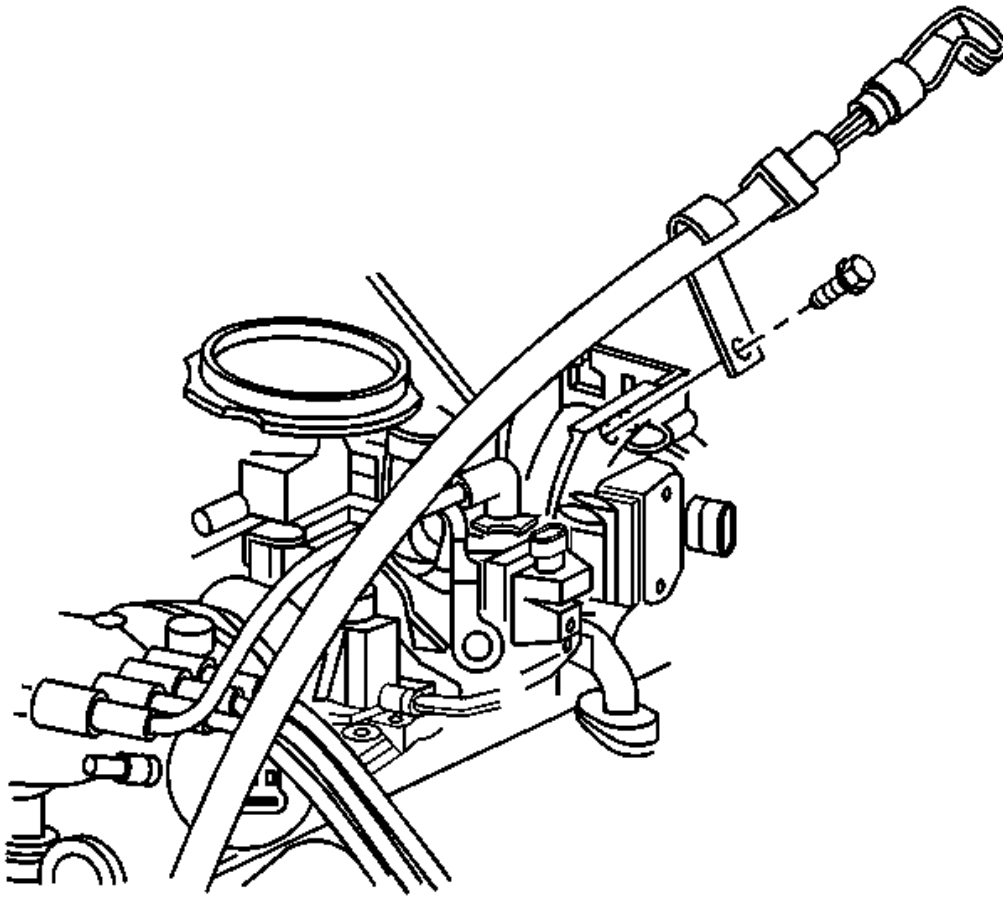


Fig. 72: Locating Accelerator Control Cable Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

21. Remove the bolt holding the transmission fluid filler tube to the accelerator control cable bracket.

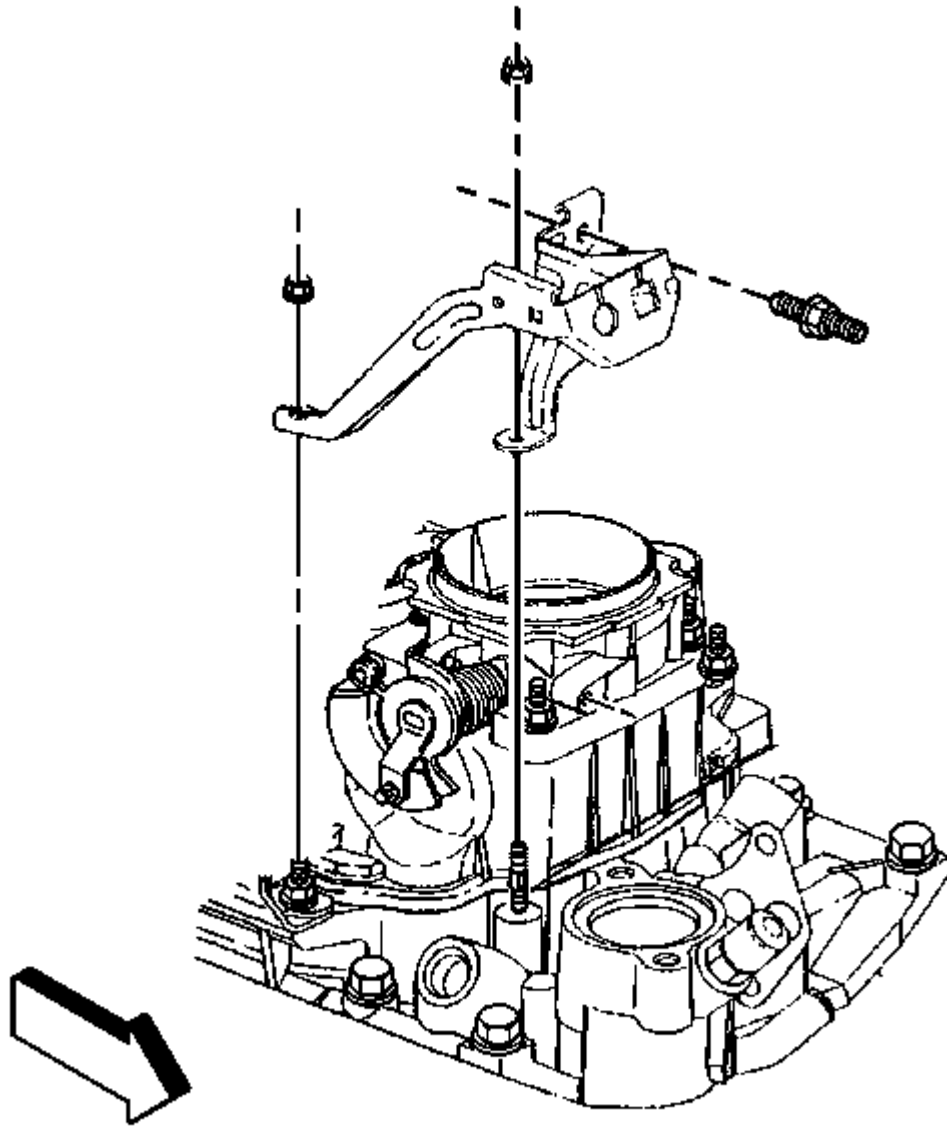


Fig. 73: View Of Accelerator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

22. Remove the accelerator control cable bracket from the throttle body and the intake manifold.
23. Remove the distributor. Refer to **Distributor Replacement** in Engine Controls - 4.3L.
24. Disconnect the fuel supply, and disconnect the return pipes, at the rear of the intake manifold. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** in Engine Controls - 4.3L.

25. Remove the ignition control module (ICM). Refer to **Ignition Control Module Replacement** in Engine Controls - 4.3L.

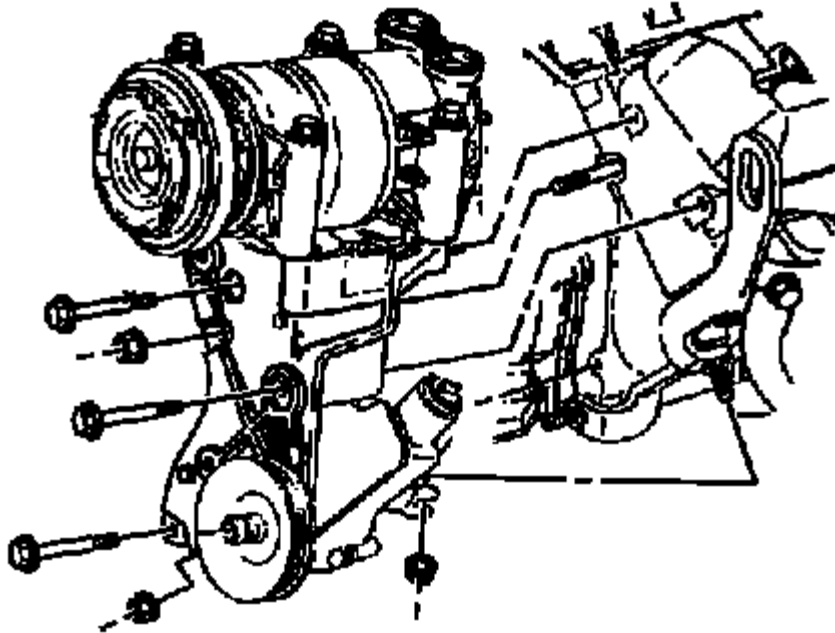


Fig. 74: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

26. In order to remove the front intake manifold bolt, perform the following steps:
1. Remove the drive belt. Refer to **Drive Belt Replacement**.
 2. Remove the A/C compressor side brace.
 3. Loosen the nut for the power steering pump rear bracket.
 4. Remove the oil filler tube bracket bolt and the oil filler tube.
 5. Remove the bolts and the nut for the power steering pump mounting bracket.
 6. Leave the A/C compressor, if equipped, and the power steering pump on the bracket.
 7. Slide the power steering pump bracket forward to access the bolt at the front of the intake manifold.
27. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
28. Clean all sealing surfaces and the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.
29. If the intake manifold requires replacement, refer to **Intake Manifold Disassemble (LU3)**, and to **Intake Manifold Assemble (LU3)**.

Installation Procedure

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

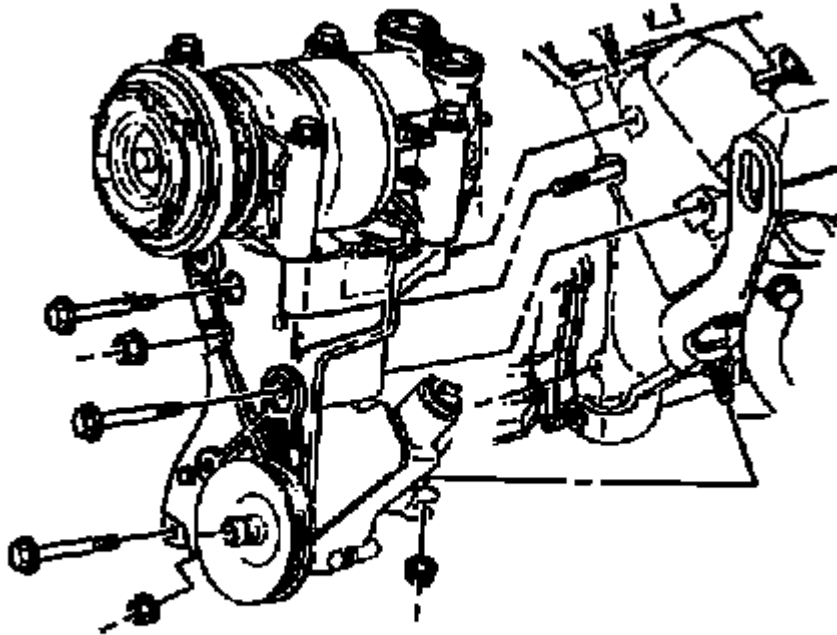


Fig. 75: View Of Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

2. Reposition the power steering pump mounting bracket.

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

3. Install the power steering pump mounting bracket three bolts and the nut.

Tighten: Tighten the power steering pump mounting bracket bolts and the nut and the power steering pump rear bracket nut to 41 N.m (30 lb ft).

4. Install A/C compressor side brace and bolts.

Tighten:

1. Tighten the A/C compressor side brace bolt to 25 N.m (18 lb ft).
2. Tighten the side brace bolt to the generator bracket to 25 N.m (18 lb ft).
5. Install the oil filler tube and bolt.

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

6. Install the drive belt. Refer to **Drive Belt Replacement**.
7. Install the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 4.3L.
8. Install the fuel supply and return pipes to the rear of the intake manifold. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** in Engine Controls - 4.3L.

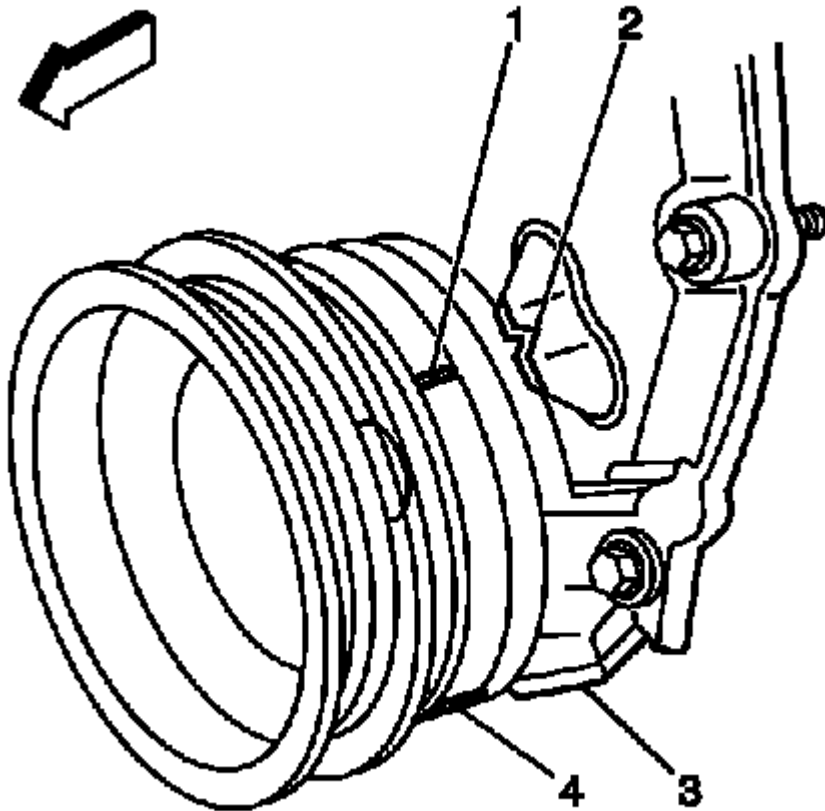


Fig. 76: View Of Crankshaft Balancer Alignment Mark & Engine Front Cover Alignment Tab
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to install the distributor for the correct engine timing, position the engine to number one cylinder top dead center.

9. Remove the spark plug for number one cylinder.

10. Rotate the crankshaft until number one cylinder is in the compression stroke.
11. Align the 2 reference marks on the crankshaft balancer (1, 4) with the 2 alignment marks (2, 3) on the front cover.
12. Install the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 4.3L.
13. Install the distributor. Refer to **Distributor Replacement** in Engine Controls - 4.3L.
14. Install the ICM. Refer to **Ignition Control Module Replacement** in Engine Controls - 4.3L.

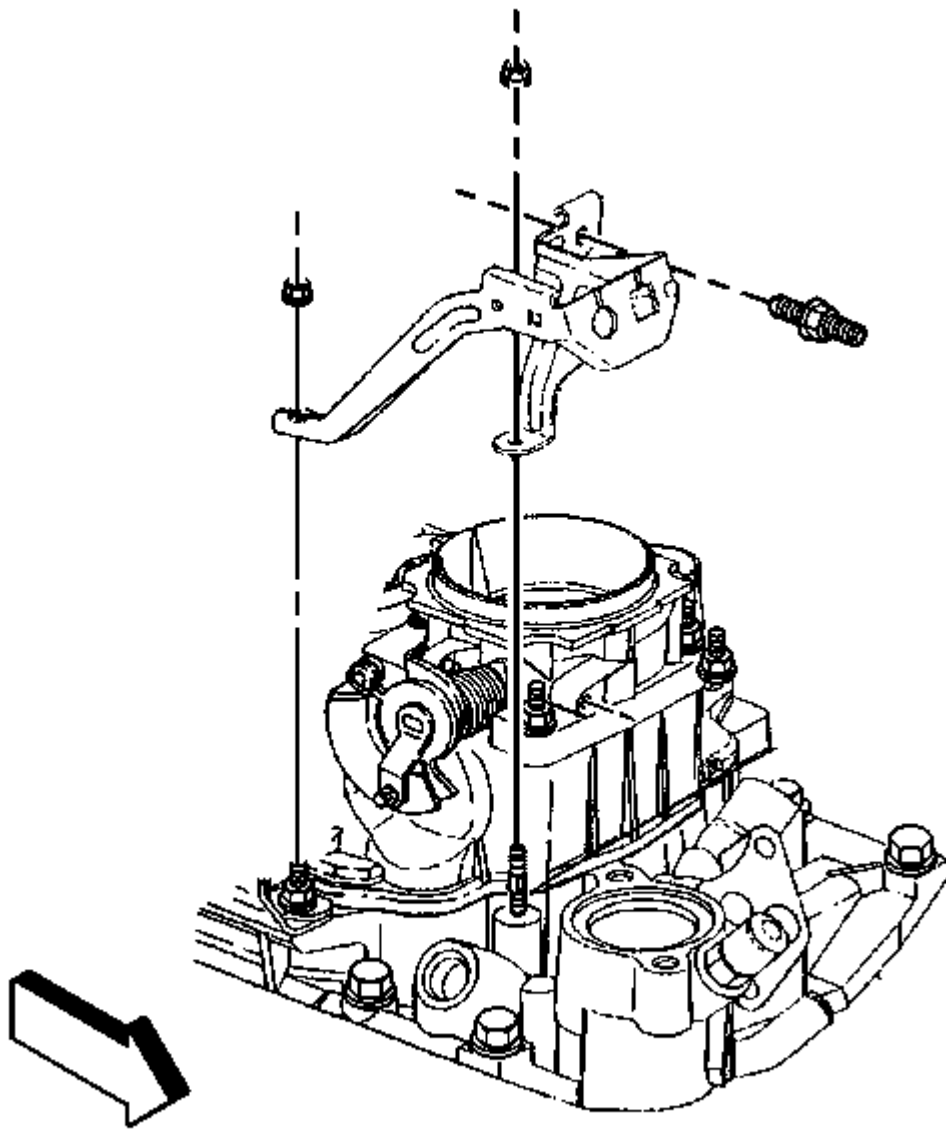


Fig. 77: View Of Accelerator Cable Bracket
Courtesy of GENERAL MOTORS CORP.

15. Install the accelerator control cable bracket, studs, and nuts to the intake manifold and the throttle body.

Tighten: Tighten the accelerator control cable bracket nuts and studs to 12 N.m (106 lb in).

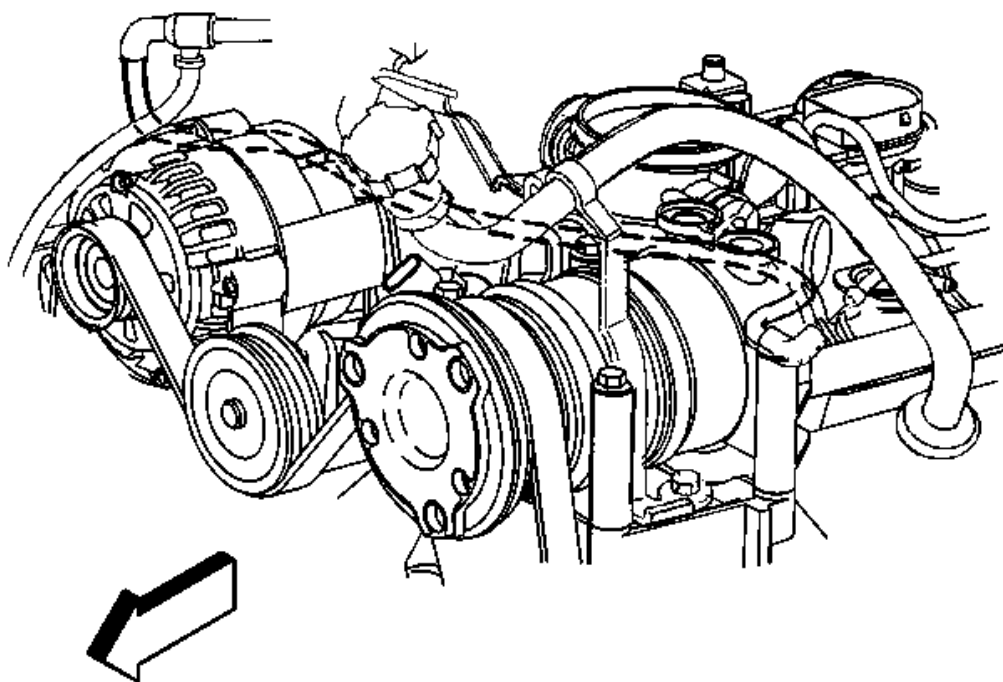


Fig. 78: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

16. Install the vacuum hose to the intake manifold.

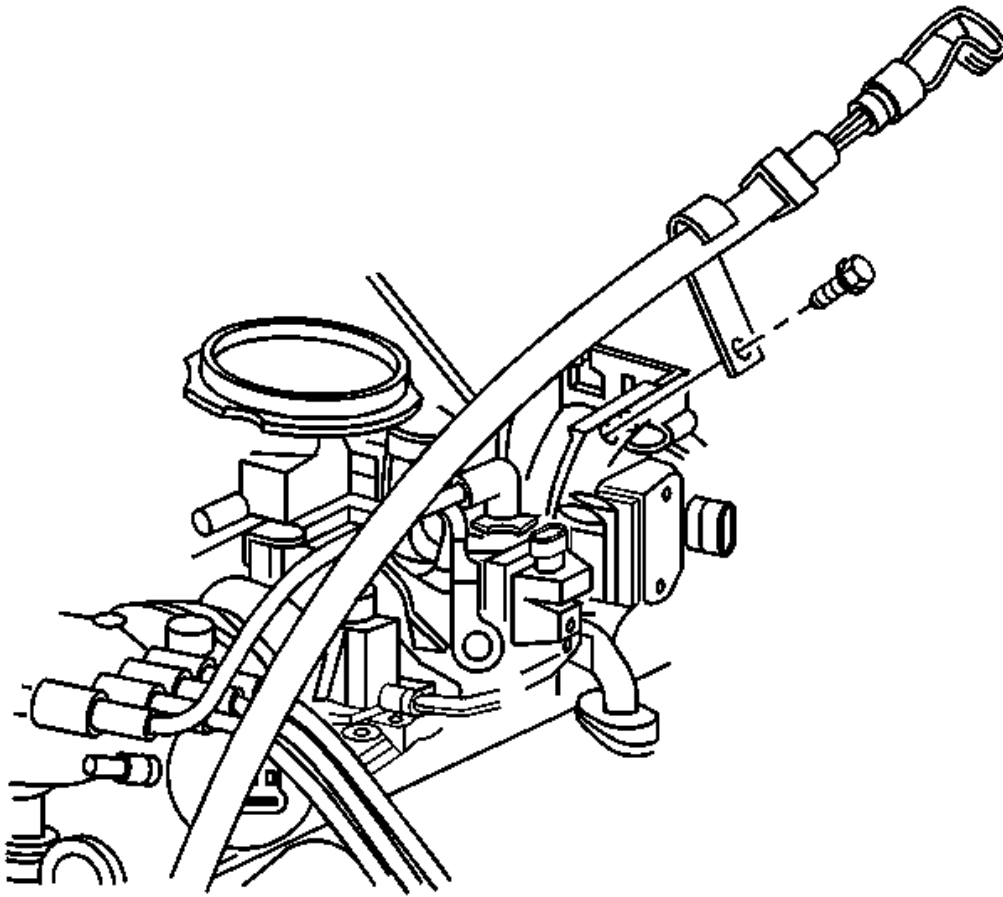


Fig. 79: Locating Accelerator Control Cable Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

17. Install the transmission fluid fill tube and bolt to the accelerator control cable bracket.

Tighten: Tighten the transmission fluid fill tube bolt 6 N.m (53 lb in).

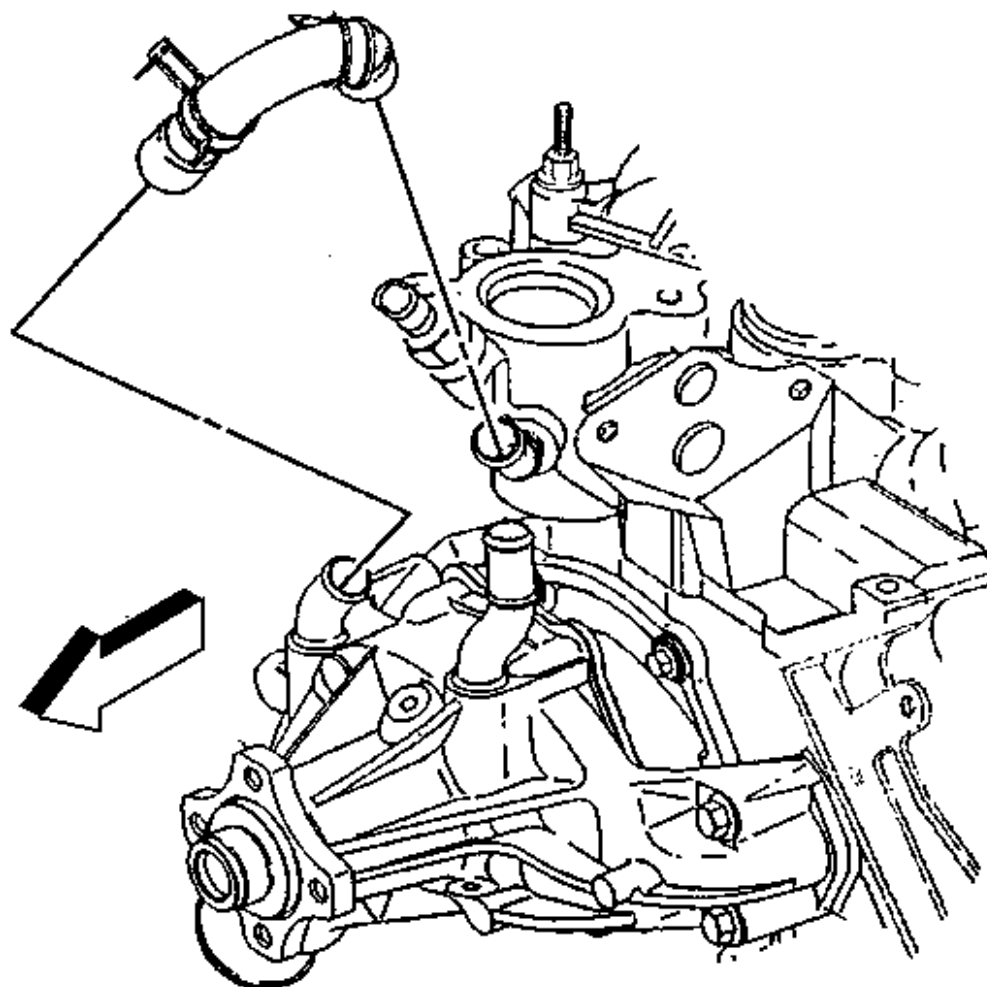


Fig. 80: Identifying Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

18. Install the water pump inlet hose to the intake manifold.
19. Install the heater hoses. Refer to **Heater Hose Replacement - Inlet** in Heating, Ventilation and Air Conditioning.
20. Install the radiator inlet hose to the water outlet. Refer to **Radiator Hose Replacement - Inlet** in Engine Cooling.

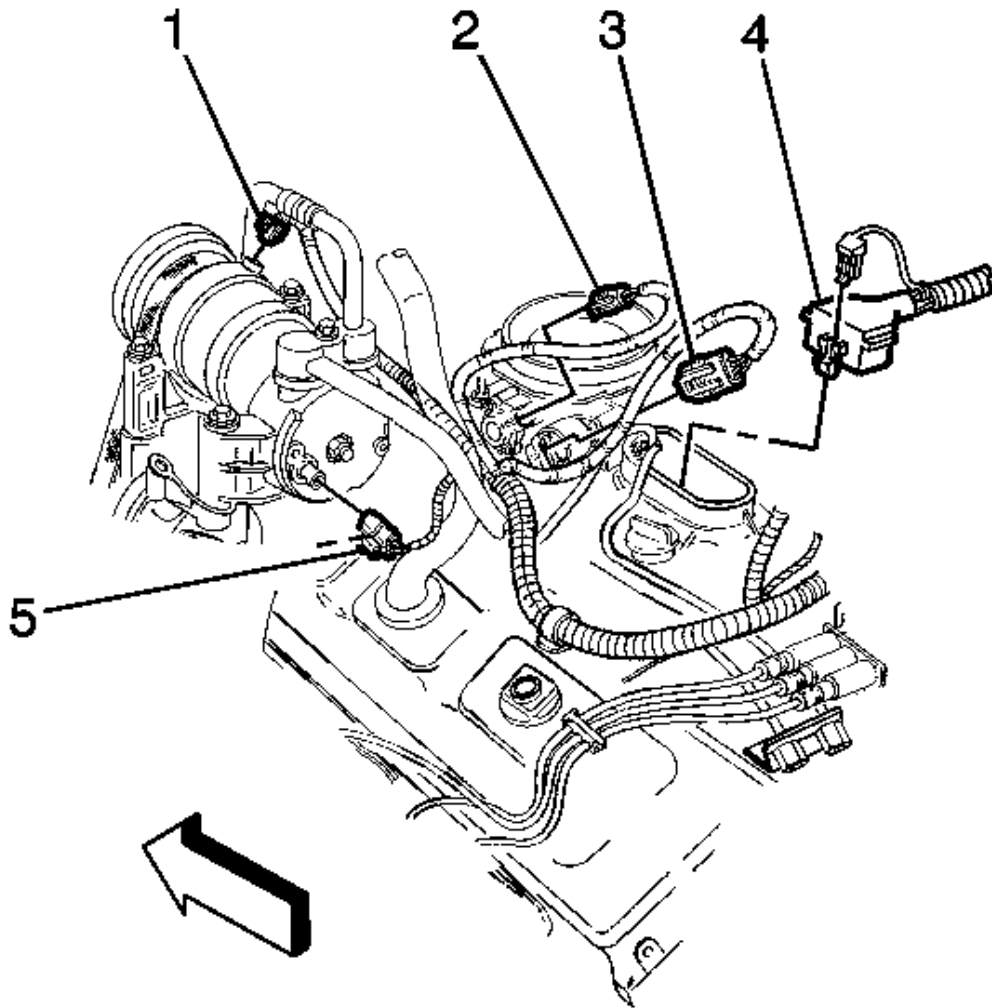


Fig. 81: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

21. Position the engine wiring harness.
22. Connect the following electrical connectors:
 - The A/C compressor clutch, if equipped (1)
 - The A/C high pressure cutoff switch, if equipped (5)
 - The throttle position (TP) sensor (2)
 - The idle air control (IAC) motor (3)
 - The fuel meter body assembly connector (4)

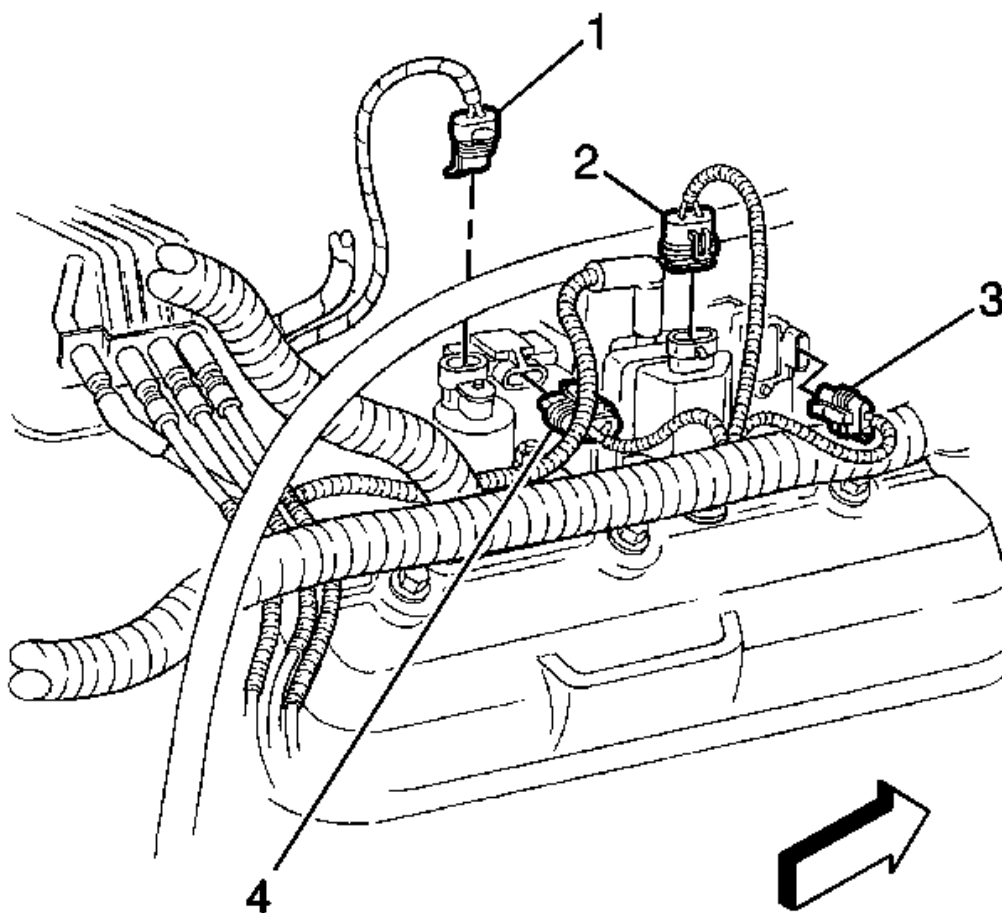


Fig. 82: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

23. Connect the following electrical connectors:
- The manifold absolute pressure (MAP) sensor (4)
 - The EVAP canister purge solenoid valve (1)
24. Install the ground wire and the nut to the water outlet stud.

Tighten: Tighten the ground wire nut to 19 N.m (14 lb ft).

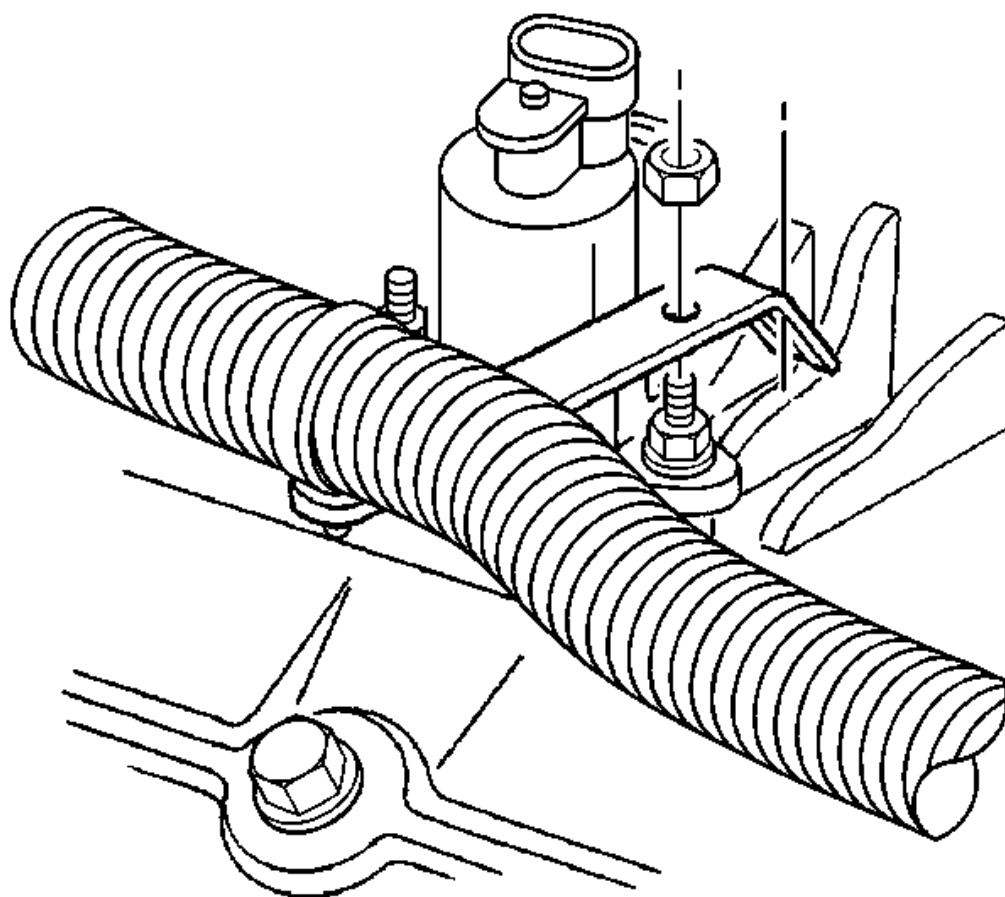


Fig. 83: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

25. Install the nut and the engine wiring harness bracket to the stud for the EVAP canister purge valve.

Tighten: Tighten the engine wiring harness bracket nut to 8 N.m (71 lb in).

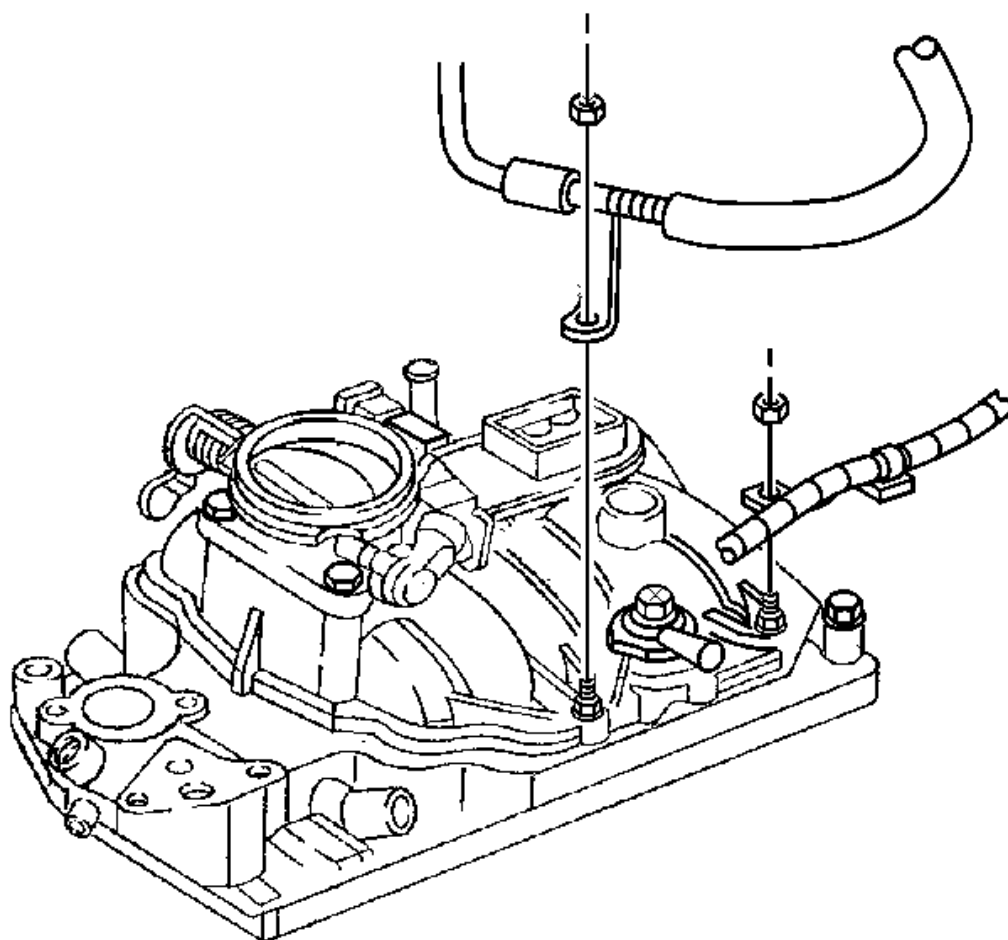


Fig. 84: View Of A/C Hose Bracket Nut
Courtesy of GENERAL MOTORS CORP.

26. Install the nut and the engine wiring harness bracket to the intake manifold stud.

Tighten: Tighten the engine wiring harness bracket nut to 12 N.m (106 lb in).

27. Install the nut and the A/C hose bracket to the intake manifold stud, if equipped.

Tighten: Tighten the A/C hose bracket nut to 5 N.m (44 lb in).

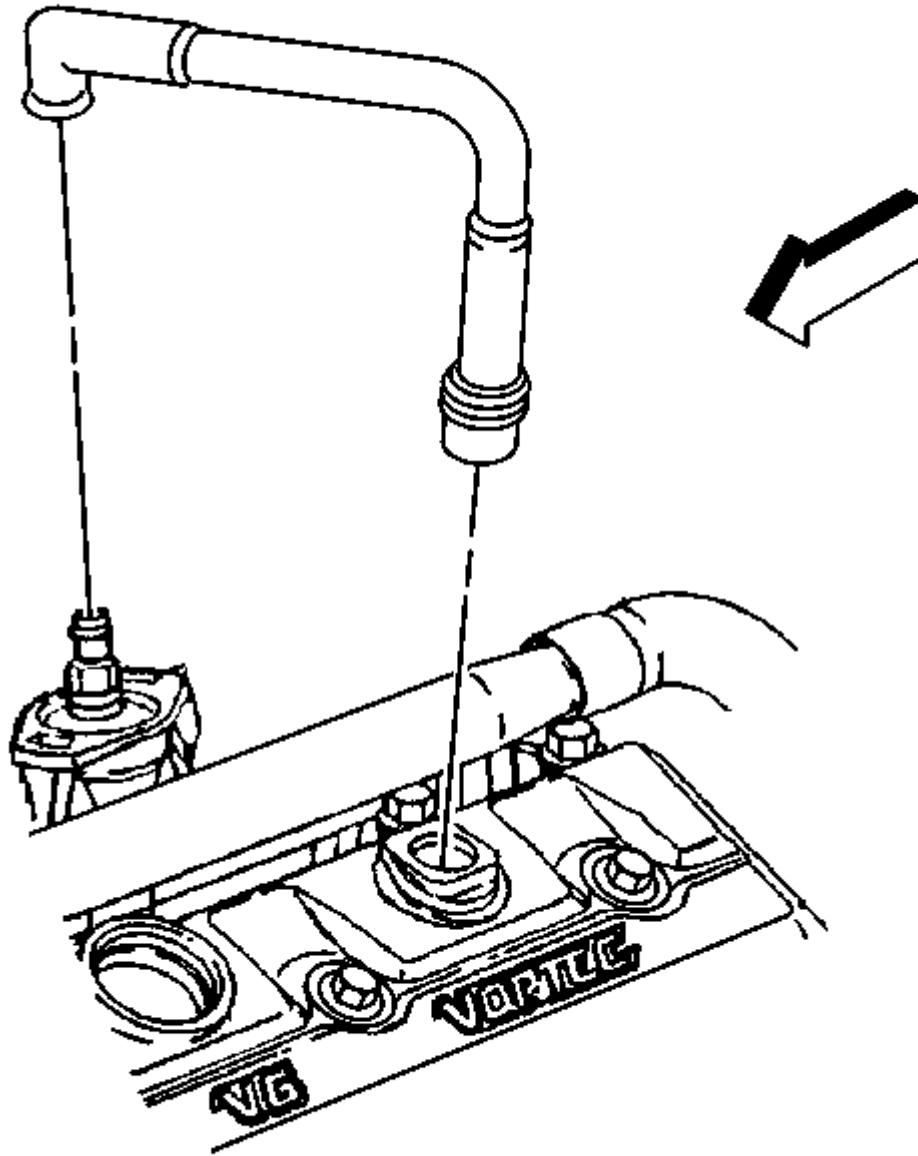


Fig. 85: Identifying Breather Tube
Courtesy of GENERAL MOTORS CORP.

28. Install the PCV valve hose assembly to the intake manifold and the valve rocker arm cover.
29. Install the cruise control cable, if equipped to the throttle shaft and the accelerator control cable bracket. Refer to **Cruise Control Cable Replacement** in Cruise Control.
30. Install the accelerator control cable to the throttle shaft and the accelerator control cable bracket. Refer to

Accelerator Controls Cable Replacement in Engine Controls - 4.3L.

31. Refill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
32. Install air cleaner outlet duct to the throttle body. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls - 4.3L.
33. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 4.3L.
34. Connect the battery negative cable. Refer to **Battery Replacement** in Engine Electrical.
35. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

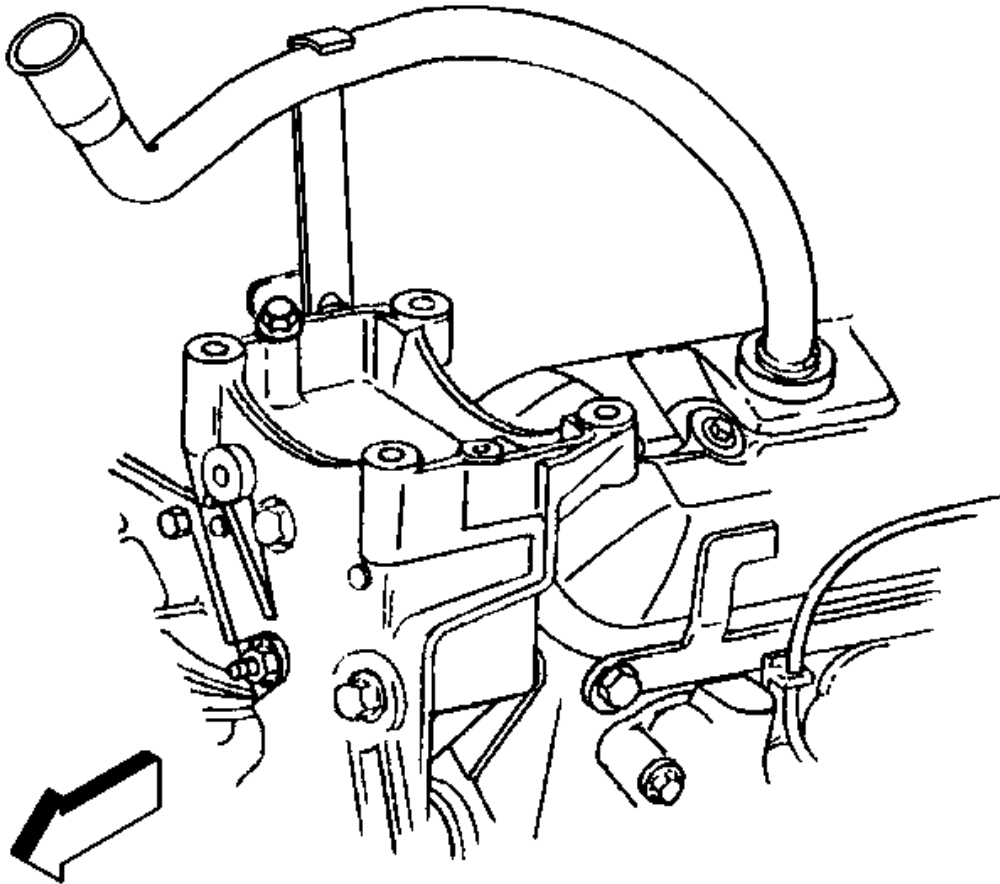
Valve Rocker Arm Cover Replacement - Left**Removal Procedure**

Fig. 86: View Of Oil Filler Tube Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Remove the oil filler tube and bolt.

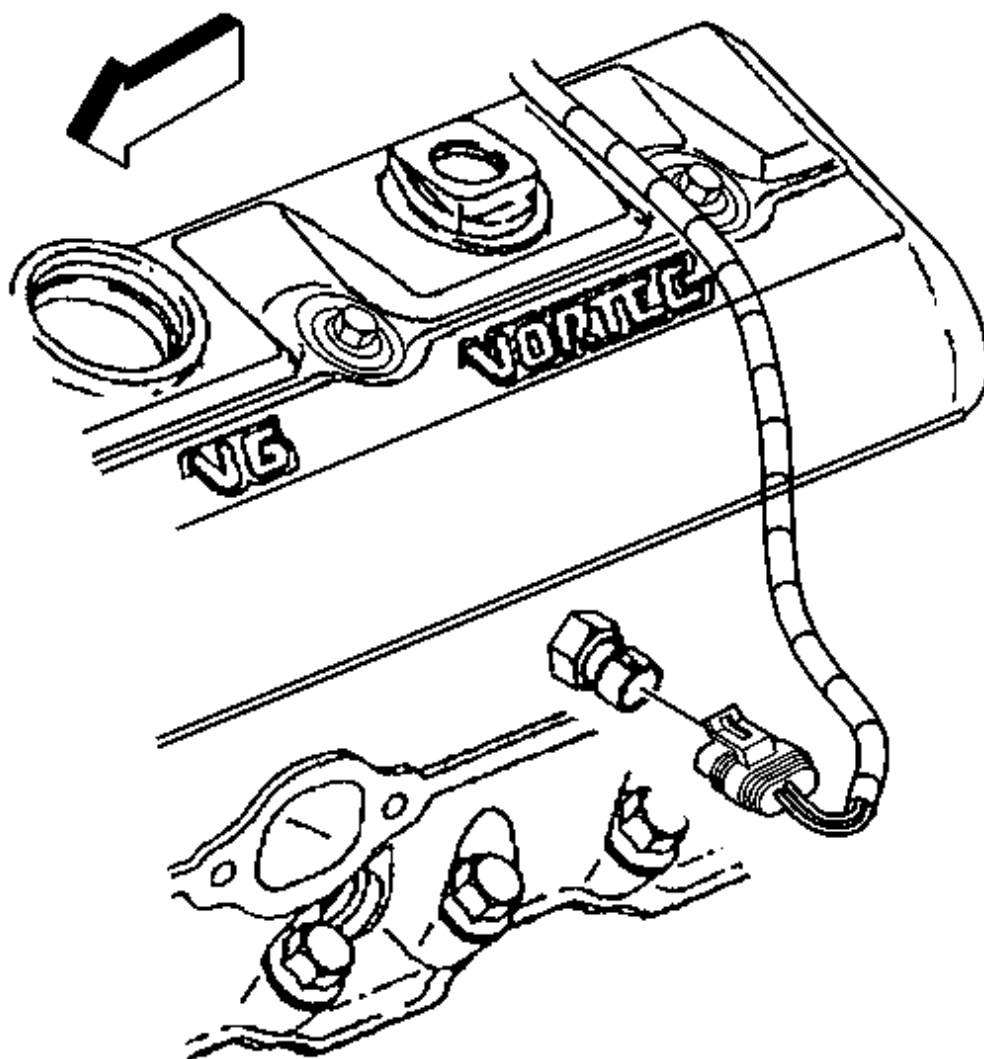


Fig. 87: Locating Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

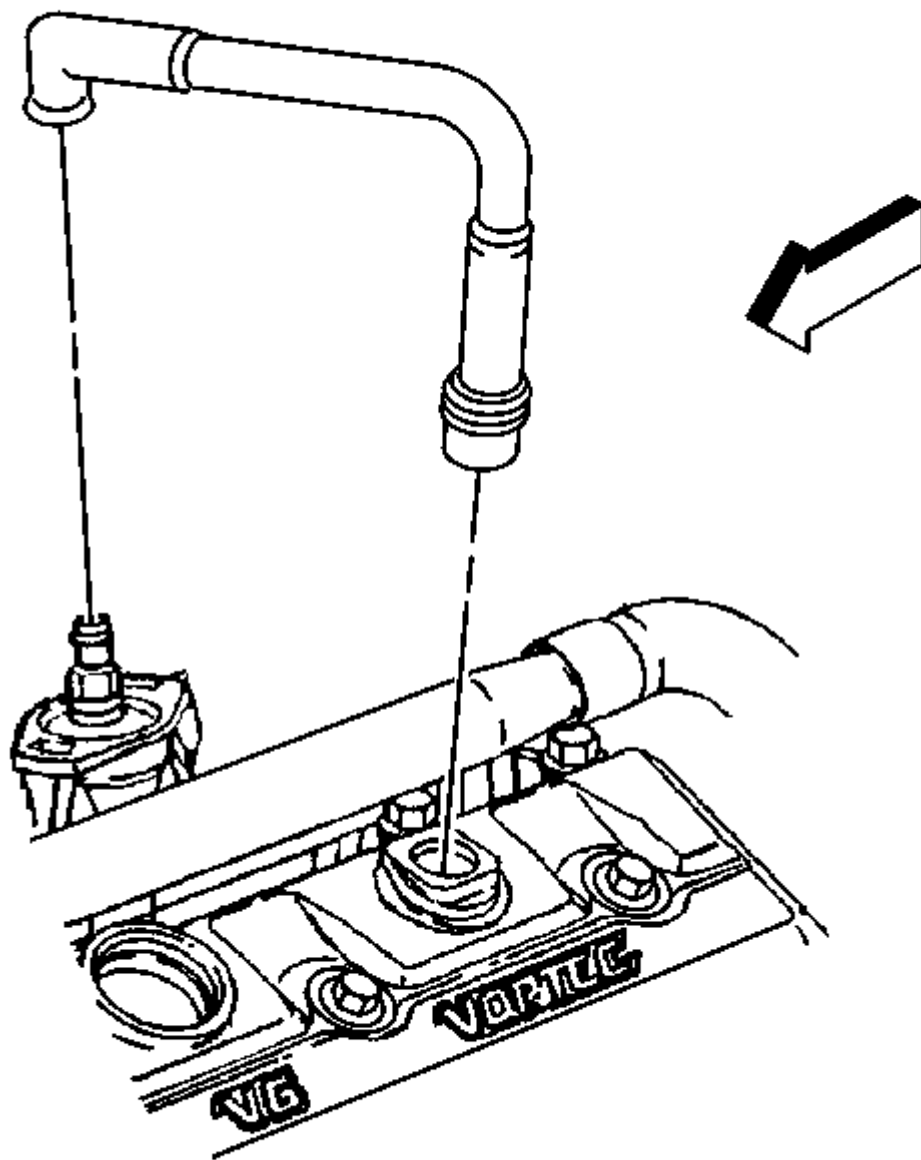


Fig. 88: Identifying Breather Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the PCV valve hose assembly from the intake manifold and the valve rocker arm cover.
5. Remove the rear spark plug wire retainer from the support.
6. Remove the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Removal - Left**.

7. Clean all sealing surfaces and the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

1. Install the valve rocker arm cover and bolts. Refer to **Valve Rocker Arm Cover Installation - Left**.

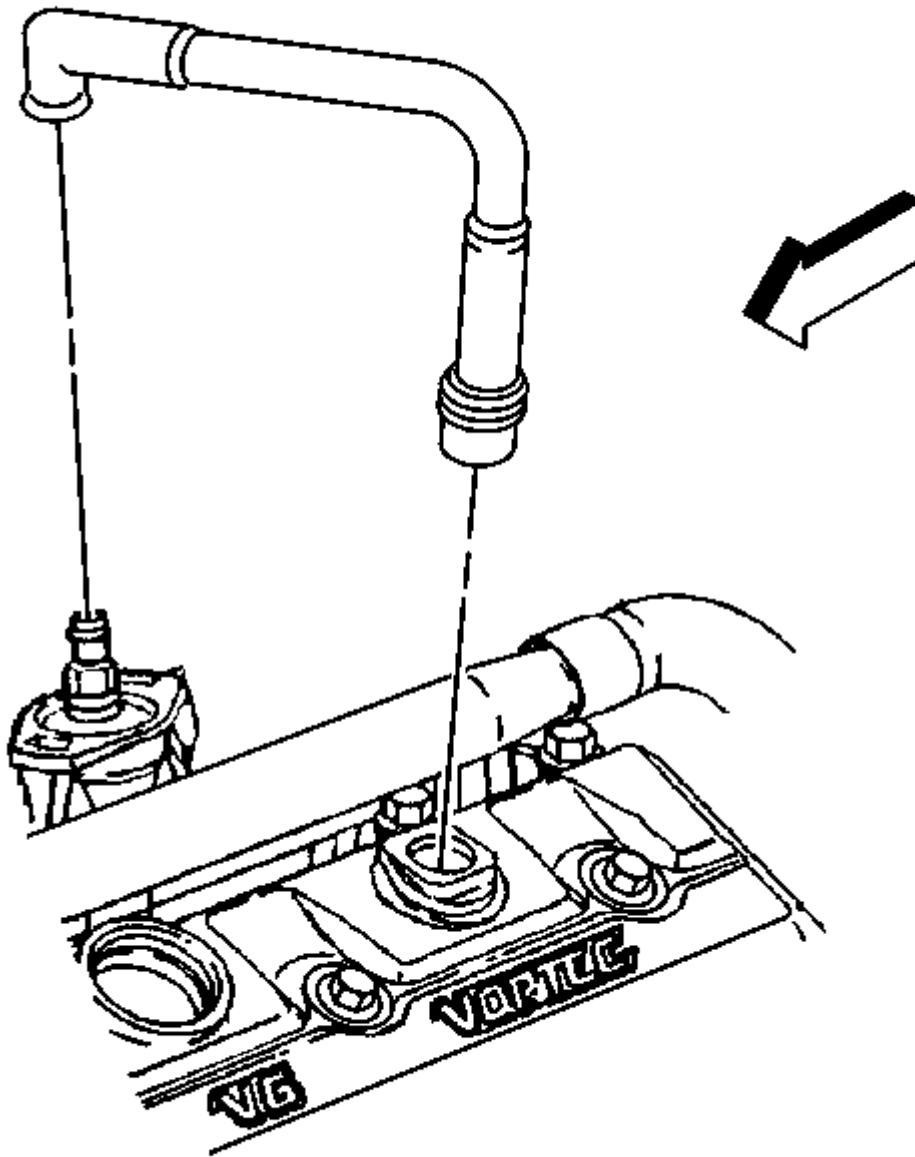


Fig. 89: Identifying Breather Tube
Courtesy of GENERAL MOTORS CORP.

2. Install the PCV valve hose assembly to the intake manifold and in the valve rocker arm cover.
3. Install the rear spark plug wire retainer to the support.

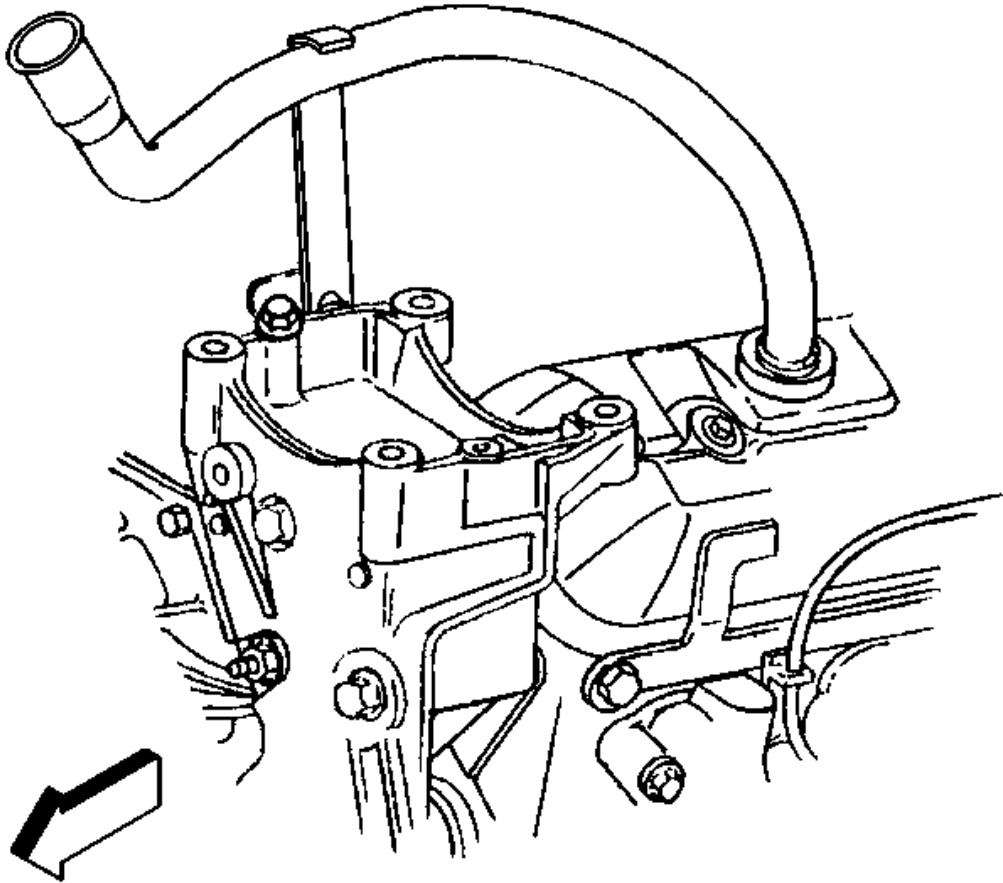


Fig. 90: View Of Oil Filler Tube Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil filler tube and bolt.

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

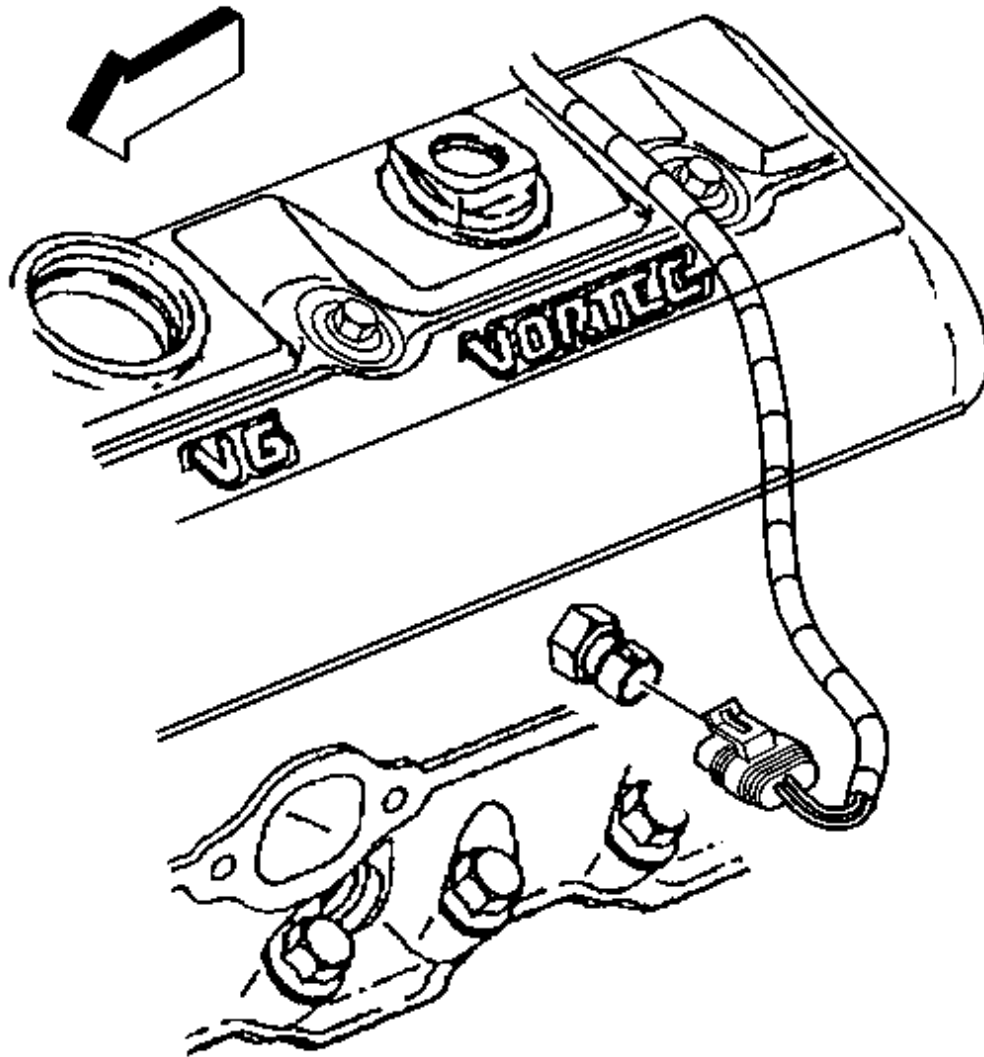


Fig. 91: Locating Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Connect the ECT sensor electrical connector.
6. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

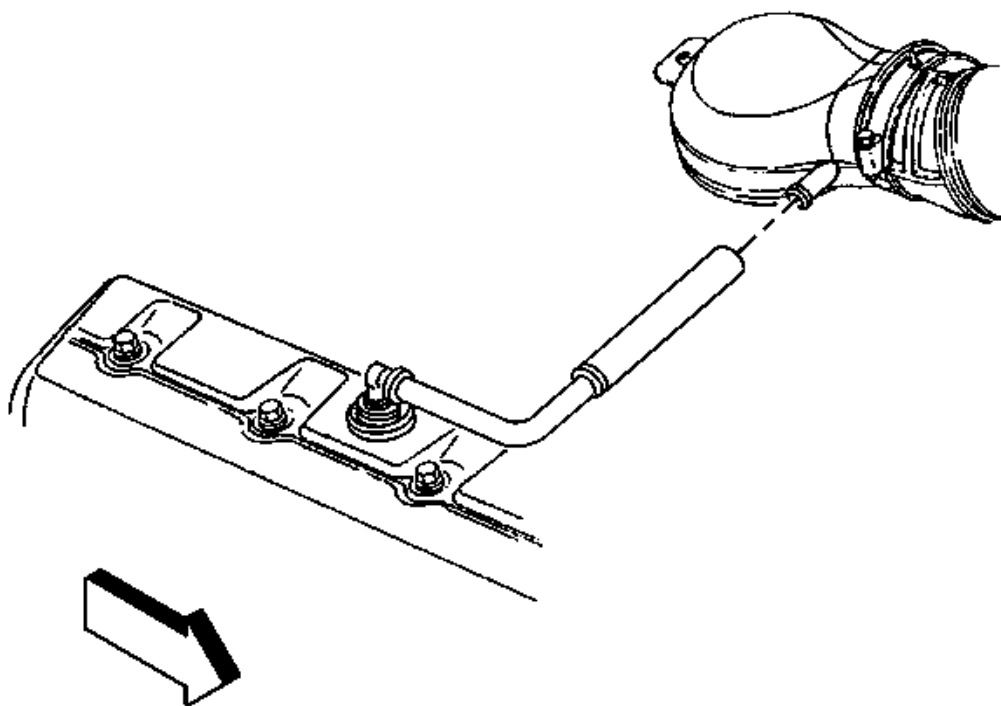


Fig. 92: View Of PCV Tube To Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Disconnect the spark plug wires for the right side of the engine from the distributor cap. Refer to **Spark Plug Wire Replacement** in Engine Controls-4.3L.
3. Remove the PCV tube from the valve rocker arm cover and the air cleaner outlet duct.

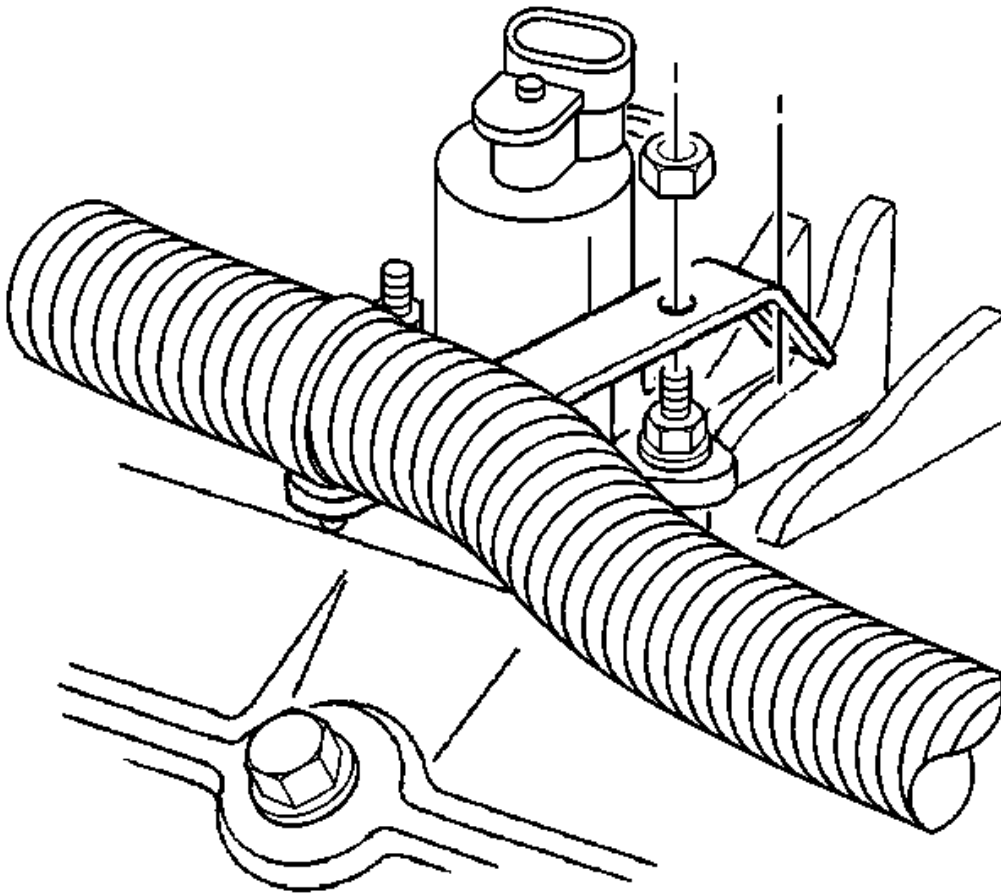


Fig. 93: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine wiring harness bracket from the EVAP canister purge solenoid valve stud.
5. Move the engine wiring harness aside.
6. Remove the right valve rocker arm cover. Refer to **Valve Rocker Arm Cover Removal - Right**.
7. Clean all sealing surfaces and the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

1. Install the right valve rocker arm cover and bolts. Refer to **Valve Rocker Arm Cover Installation - Right**.

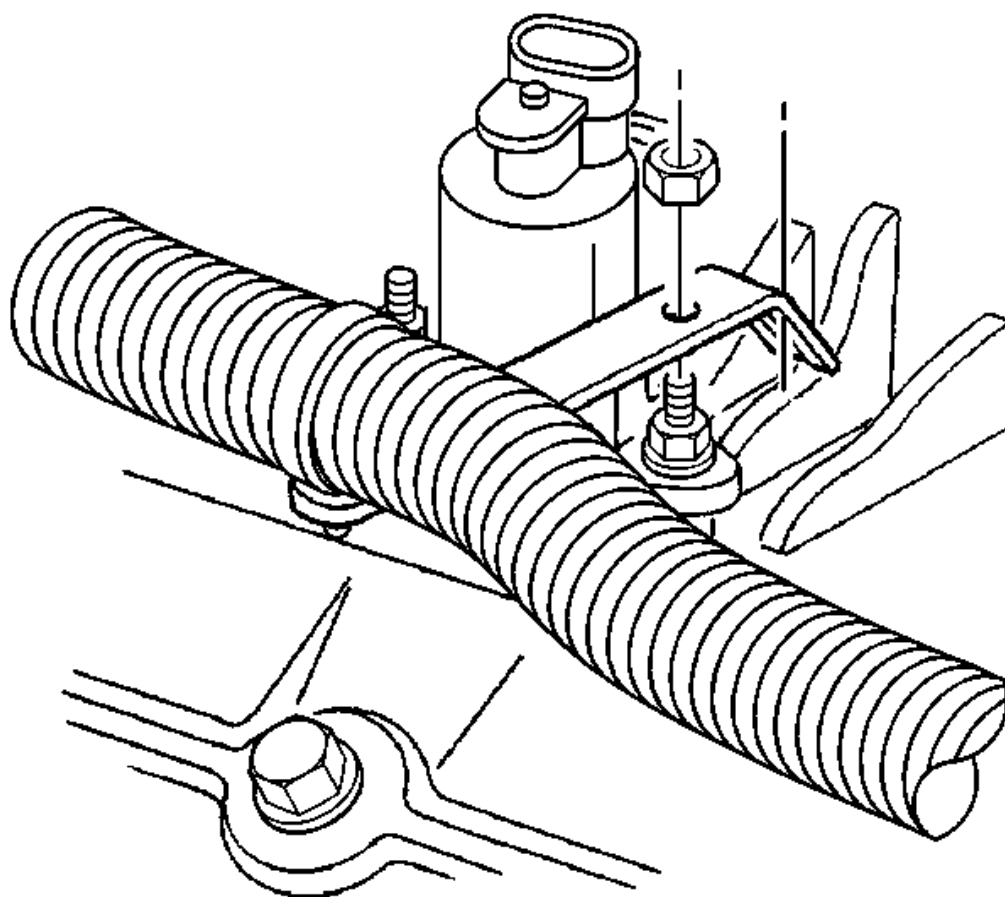


Fig. 94: Identifying Engine Wiring Harness Bracket On EVAP Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine wiring harness bracket and nut to EVAP canister purge solenoid valve stud.

Tighten: Tighten the engine wiring harness bracket nut to 8 N.m (71 lb in).

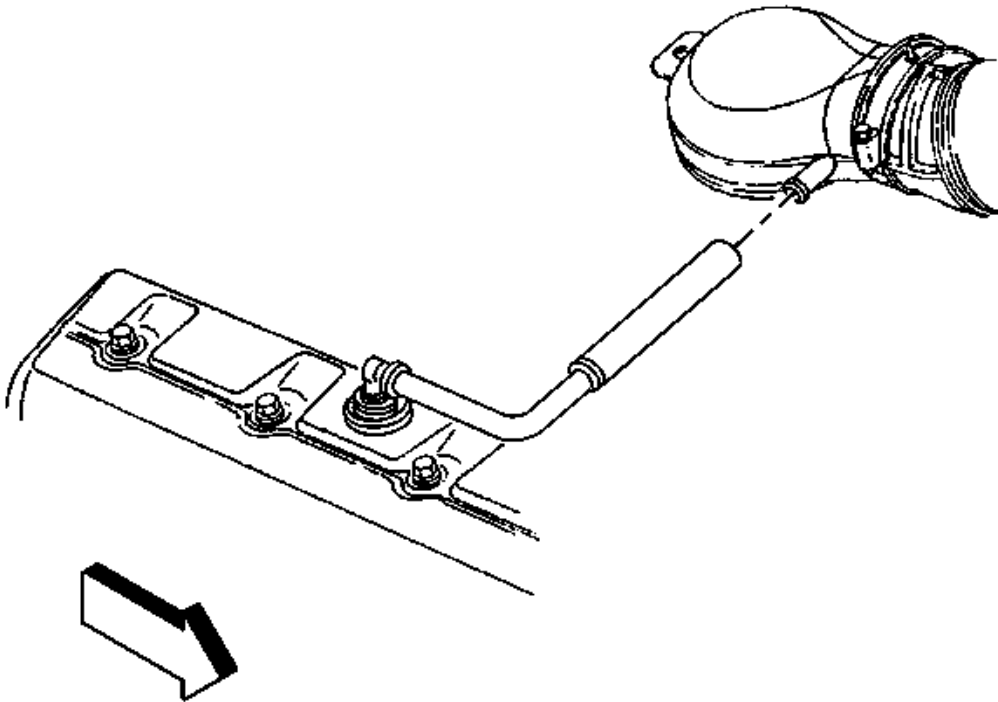


Fig. 95: View Of PCV Tube To Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

3. Install the PCV hose in the valve rocker arm cover and the air cleaner outlet duct.
4. Connect the spark plug wires to the distributor cap. Refer to **Spark Plug Wire Replacement** in Engine Controls-4.3L.
5. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

1. Remove the valve rocker arm cover.
 - Refer to **Valve Rocker Arm Cover Replacement - Right**.
 - Refer to **Valve Rocker Arm Cover Replacement - Left**.
2. Remove the valve rocker arm and the valve pushrod. Refer to **Valve Rocker Arm and Push Rod Removal**.
3. Clean and inspect the valve rocker arm and the valve pushrod. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection**.

Installation Procedure

1. Install the valve rocker arm and the valve pushrod. Refer to **Valve Rocker Arm and Push Rod Installation**.
2. Install the valve rocker arm cover.
 - Refer to **Valve Rocker Arm Cover Replacement - Left**.
 - Refer to **Valve Rocker Arm Cover Replacement - Right**.

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

- **J 22794** Spark Plug Port Adapter. See **Special Tools**.
- **J 38606** Valve Spring Compressor. See **Special Tools**.
- **J 5892-D** Valve Spring Compressor. See **Special Tools**.

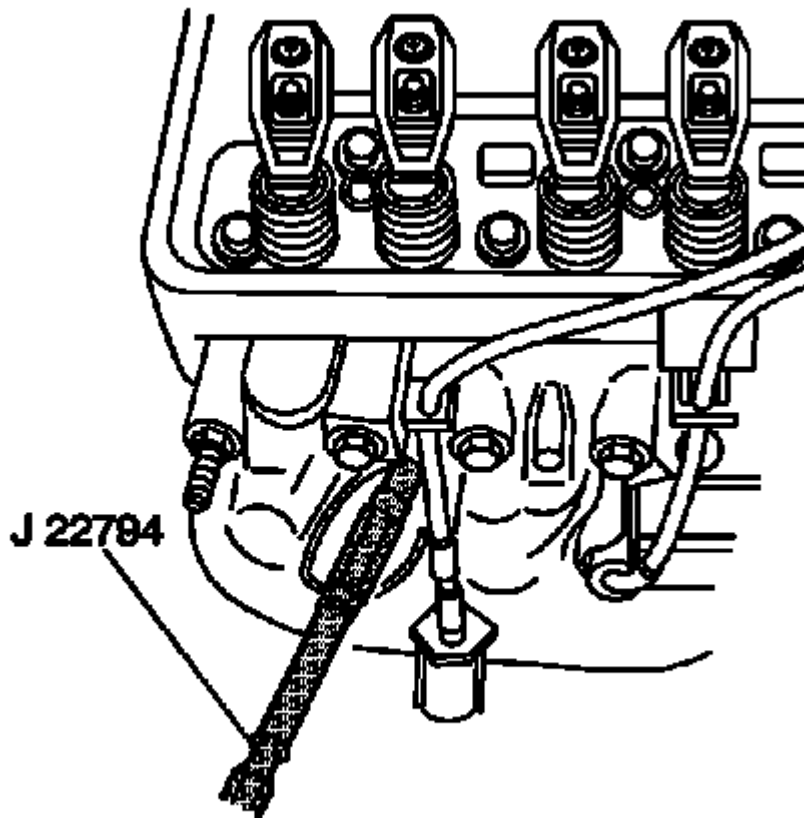
Removal Procedure

Fig. 96: Installing J 22794 Into Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover.
 - Refer to Valve Rocker Arm Cover Replacement - Left.
 - Refer to Valve Rocker Arm Cover Replacement - Right.
2. Remove the required valve rocker arms. Refer to Valve Rocker Arm and Push Rod Replacement.
3. Remove the required spark plugs. Refer to Spark Plug Replacement in Engine Controls-4.3 L.
4. Install the **J 22794** into the spark plug hole. See Special Tools.
5. Connect a shop air supply hose and apply compressed air in order to hold the valves in place.

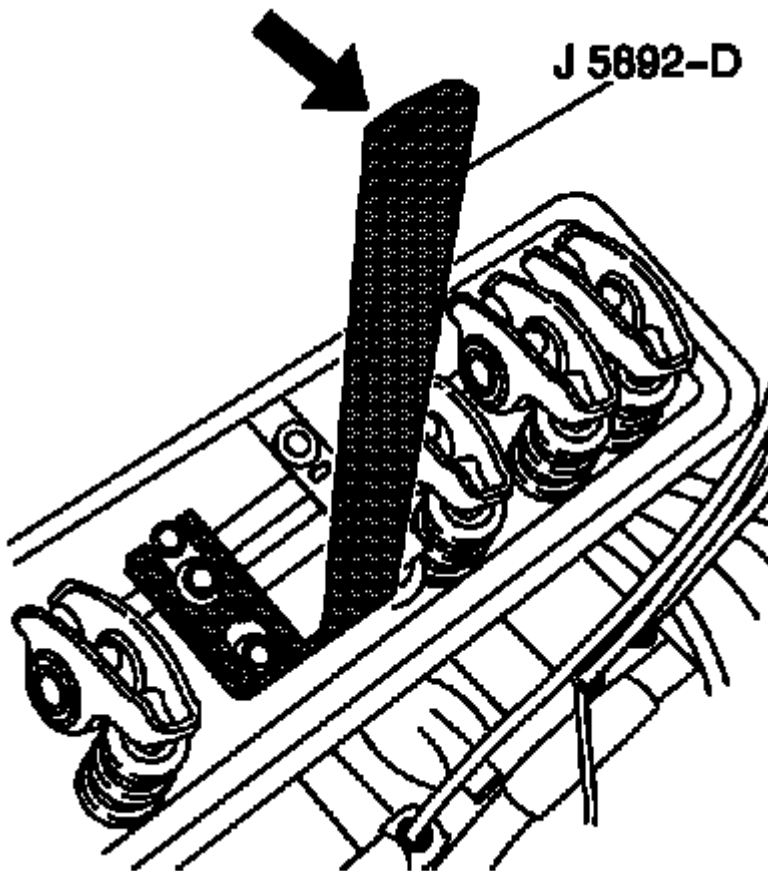


Fig. 97: Installing J 5892-D Under The Washer On The Rocker Arm Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove a bolt from a valve rocker arm.
7. Install a flat washer on the bolt.
8. Install the bolt in the valve rocker arm bolt hole for the valve spring requiring removal.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when

compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

9. Use the **J 5892-D** in order to compress the valve spring. See Special Tools.
 1. Hook the slotted end of **J 5892-D** under the washer on the valve rocker arm bolt. See Special Tools.
 2. Apply steady pressure on the valve spring cap until the valve keys are accessible.

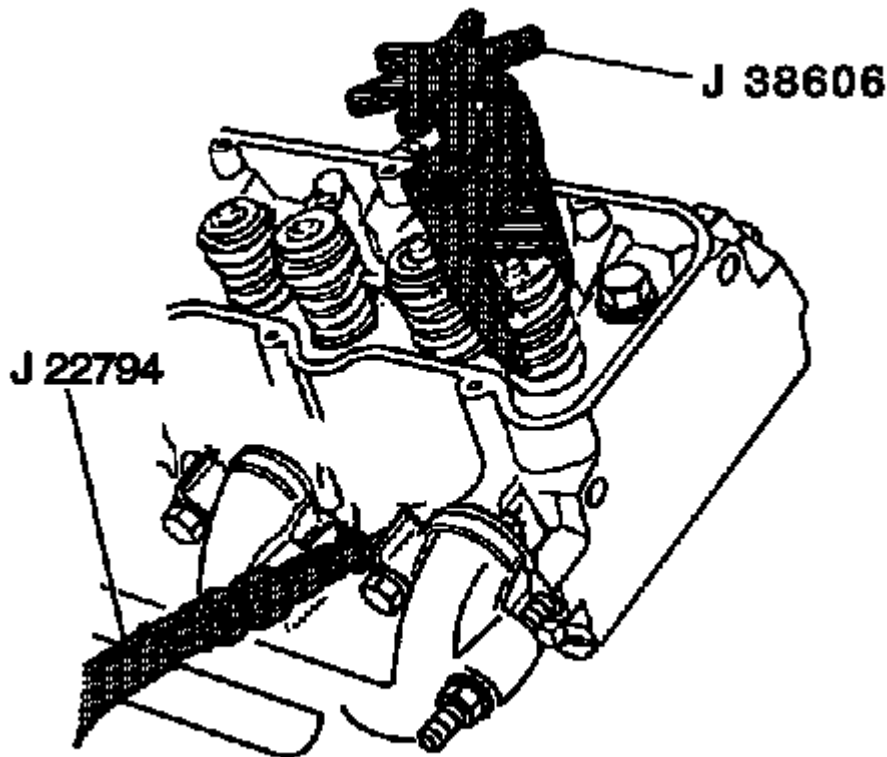


Fig. 98: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

NOTE: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

10. Use **J 38606** when **J 5892-D** will not fit. See Special Tools.

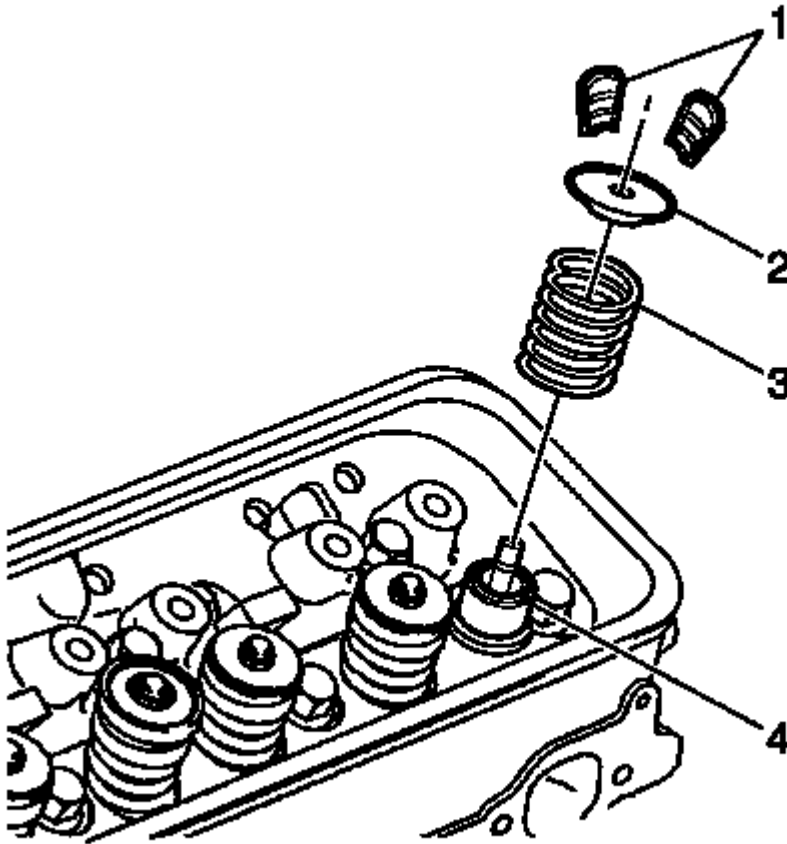


Fig. 99: Identifying Valve Components
 Courtesy of GENERAL MOTORS CORP.

11. Remove the valve keys (1).
12. Carefully release the valve spring tension.
13. Remove the **J 5892-D** or **J 38606** . See **Special Tools**.
14. Remove the valve spring cap (2) and valve spring (3).
15. Remove the valve stem oil seal (4).

Installation Procedure

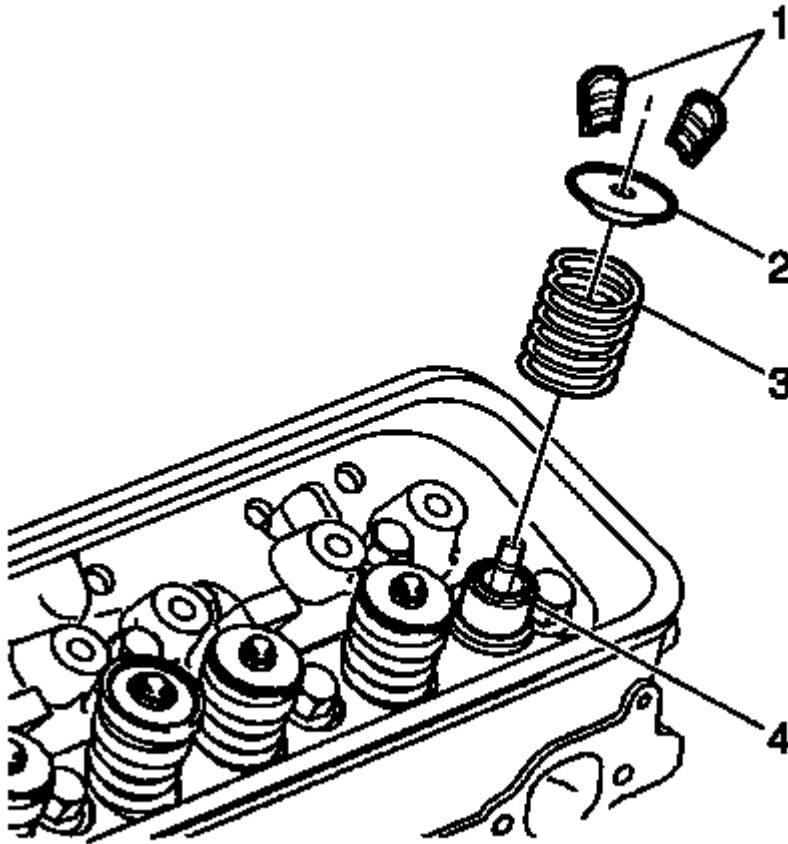


Fig. 100: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

1. Install the valve seals (4). Refer to Cylinder Head Assemble.
2. Install the valve spring (3).
3. Install the valve spring cap (2) on the valve stem.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

4. To press the valve spring (3) use the J 5892-D . See Special Tools.

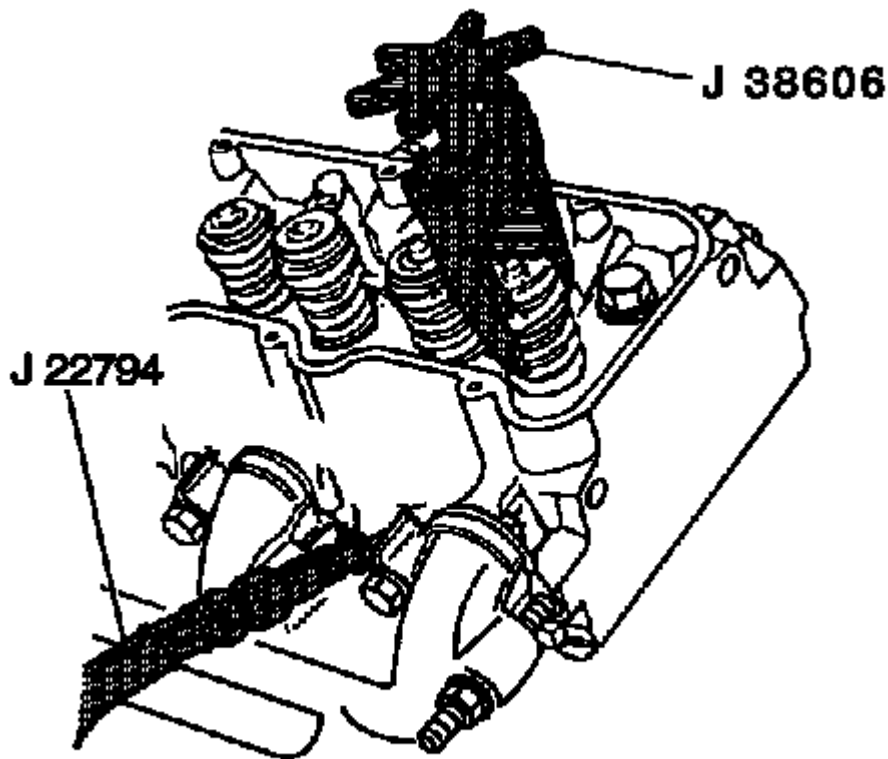


Fig. 101: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

NOTE: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratch.

5. Use the J 38606 if the clearance does not permit use of the J 5892-D . See Special Tools.
6. Install the valve stem keys. Use grease in order to hold the valve stem keys in place.

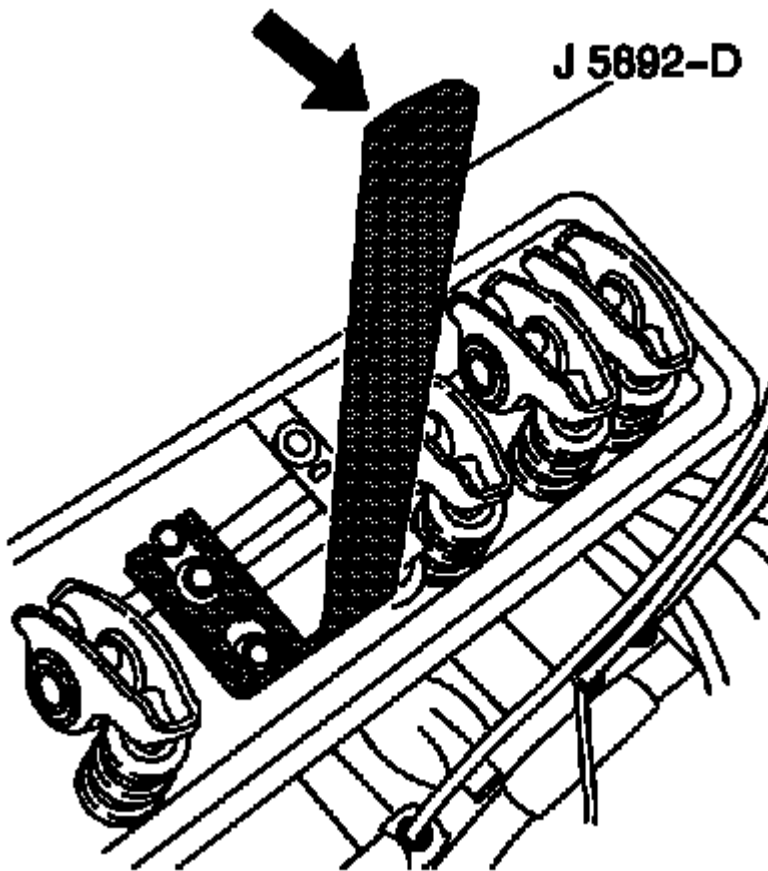


Fig. 102: Installing J 5892-D Under The Washer On The Rocker Arm Bolt
Courtesy of GENERAL MOTORS CORP.

7. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.

NOTE: The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

8. Remove the **J 5892-D** or the **J 38606** . See Special Tools.
 1. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
 2. Tap the end of the valve stem with a plastic faced hammer in to seat the valve stem keys, if necessary.
9. Remove the **J 22794** . See Special Tools.
10. Install the spark plugs. Refer to Spark Plug Replacement in Engine Controls-4.3L.
11. Install the valve rocker arms to the cylinder head. Refer to Valve Rocker Arm and Push Rod Installation.
12. Install the valve rocker arm cover. Refer to Valve Rocker Arm Cover Replacement - Left or Valve Rocker Arm Cover Replacement - Right.

Valve Lifter Replacement

Removal Procedure

1. Remove the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.
2. Remove the valve rocker arms and the valve push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
3. Remove the valve lifters. Refer to **Valve Lifter Removal**.
4. Use a cleaning solvent and a shop towel to clean any varnish from the valve lifter bores.
5. Inspect the valve lifter bores for excessive wear or scoring. Replace the engine block if there is excessive wear or deep scoring.
6. Inspect the camshaft for wear or damage. If the wear is questionable remove the camshaft and inspect. Refer to **Camshaft and Bearings Cleaning and Inspection**.
7. Clean and inspect the valve lifters and the valve pushrod guide. Refer to **Valve Lifters and Guides Cleaning and Inspection**.

Installation Procedure

IMPORTANT: It is normal for NEW lifters to make a slight ticking noise when the engine is first started. Increasing the engine RPMs slightly to raise oil pressure should stop the noise.

1. Install the valve lifters. Refer to **Valve Lifter Installation**.
2. Install the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
3. Install the lower intake manifold. Refer to **Intake Manifold Replacement - Lower**.

Cylinder Head Replacement - Left**Removal Procedure**

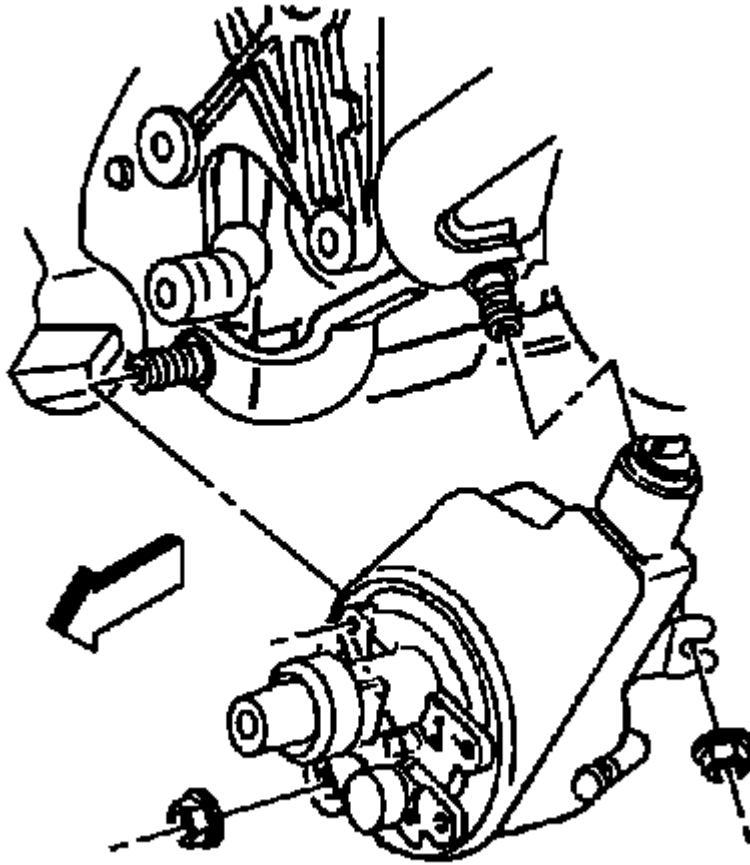


Fig. 103: Removing Power Steering Rear Mounting Bracket Nut From Engine Stud (4.3L)
 Courtesy of GENERAL MOTORS CORP.

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
3. Remove the engine cooling fan. Refer to **Fan Replacement** in Engine Cooling.
4. Remove the air conditioning compressor, if equipped. Refer to **Compressor Replacement** in Heating, Ventilation and Air Conditioning.
5. Remove the nut holding the power steering pump rear bracket to the engine front bracket stud.

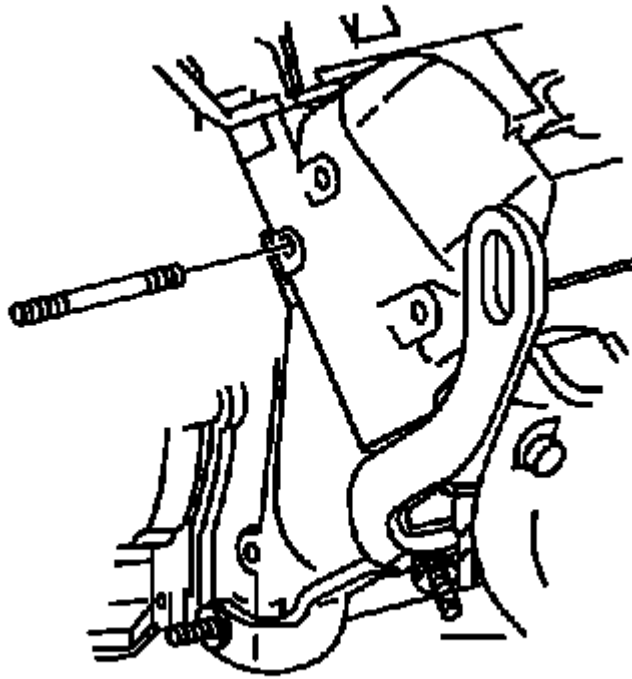


Fig. 104: Removing Power Steering Pump Bracket Stud
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The power steering pump can remain on the power steering pump mounting bracket. The pump hoses can remain attached to the pump.

6. Remove the power steering pump mounting bracket and set aside.
7. Remove the power steering pump mounting bracket stud from the cylinder head.
8. Remove the intake manifold. Refer to **Intake Manifold Replacement - Lower**.
9. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.

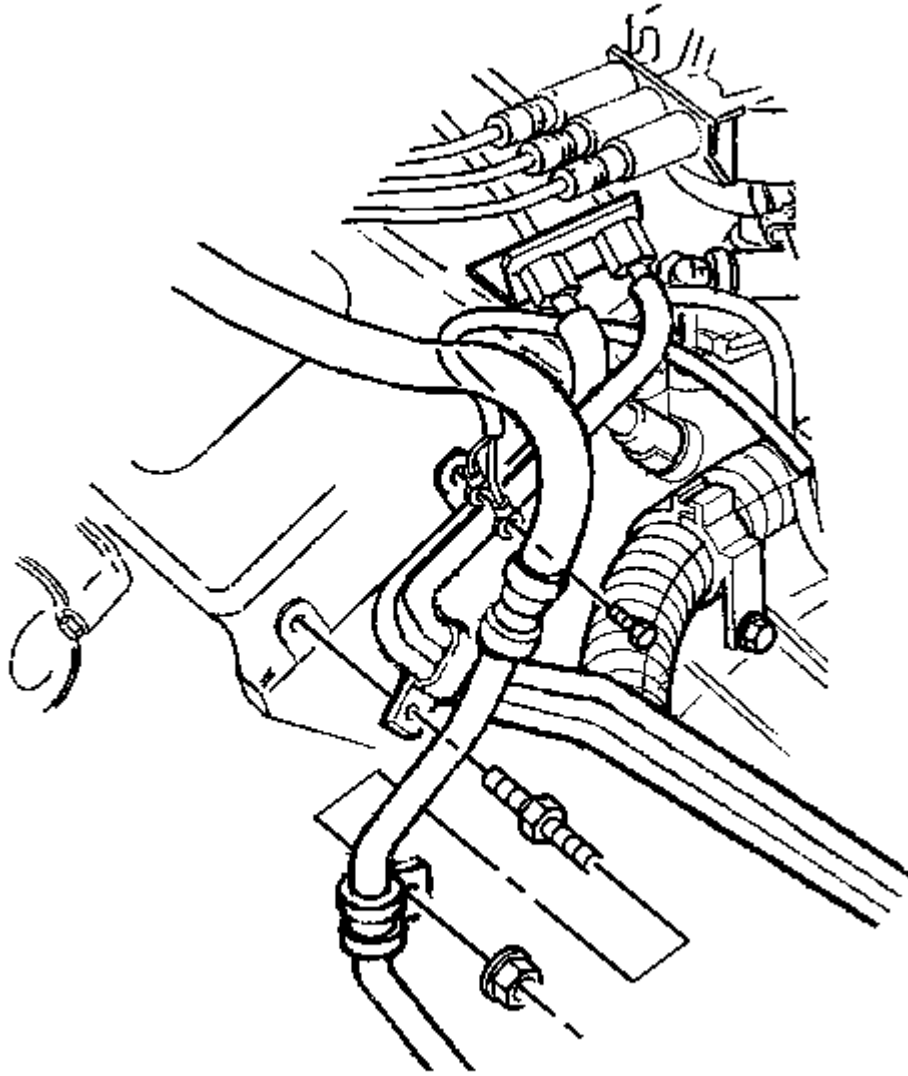


Fig. 105: Identifying A/C Pipe Bracket Nut
Courtesy of GENERAL MOTORS CORP.

10. Remove the ground wires at the rear of the left cylinder head.
11. Remove the A/C pipe bracket nut, if equipped.
12. Remove the fuel pipe bracket bolt at the rear of the cylinder head.
13. Remove the valve push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
14. Remove the cylinder head and the gasket. Refer to **Cylinder Head Removal - Left**.

15. Clean the engine block and the cylinder head sealing surfaces.

NOTE: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

16. Clean the cylinder head bolts and the engine block bolt holes.

17. For further service to the cylinder head refer to the following:

- Cylinder Head Disassemble.
- Cylinder Head Cleaning and Inspection.
- Valve Guide Reaming/Valve and Seat Grinding.
- Cylinder Head Assemble.

Installation Procedure

1. Install the cylinder head. Refer to Cylinder Head Installation - Left.
2. Install the valve push rods. Refer to Valve Rocker Arm and Push Rod Replacement.

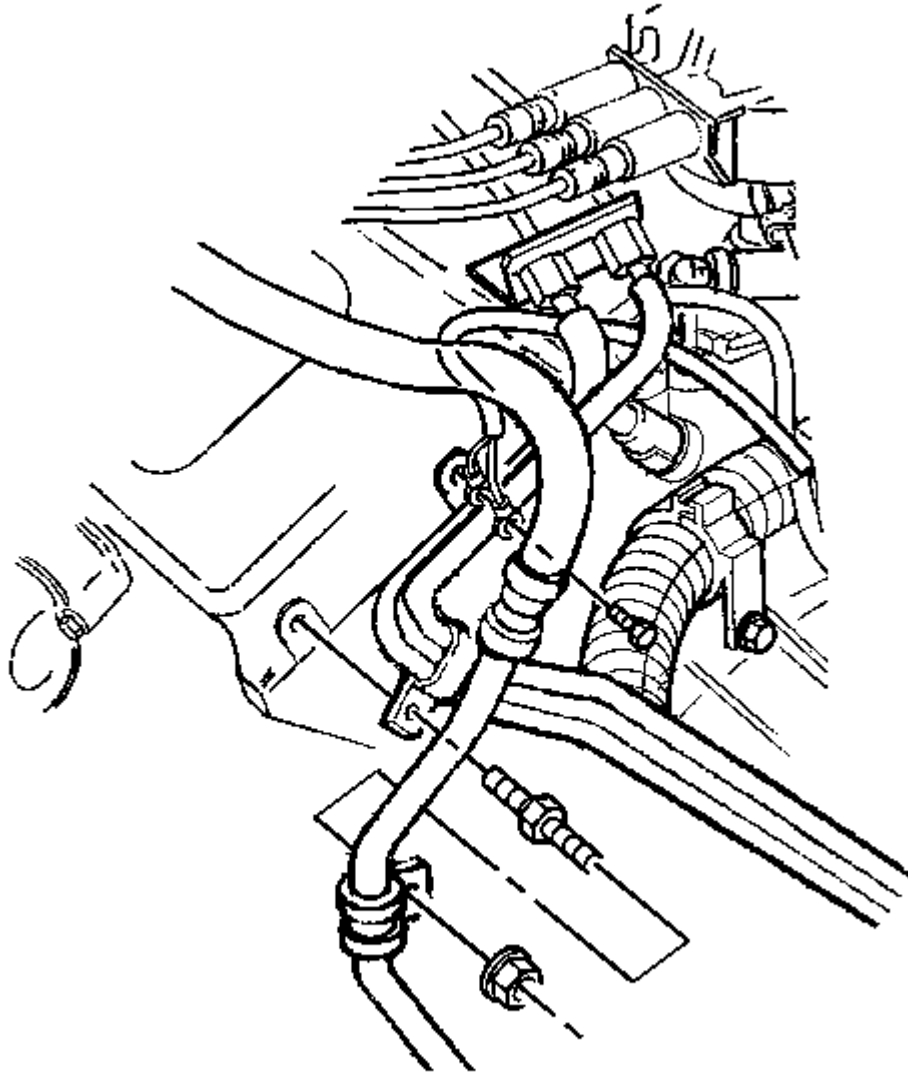


Fig. 106: Identifying A/C Pipe Bracket Nut
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the ground wires and bolt at the rear of the left cylinder head.

Tighten: Tighten the ground wire bolt to 35 N.m (26 lb ft).

4. Install the fuel pipe bracket and stud at the rear of the cylinder head.

Tighten: Tighten the fuel pipe bracket stud to 33 N.m (24 lb ft).

5. Install the A/C pipe bracket and nut, if equipped.

Tighten: Tighten the A/C pipe bracket nut to 35 N.m (26 lb ft).

6. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
7. Install the intake manifold. Refer to **Intake Manifold Replacement - Lower**.

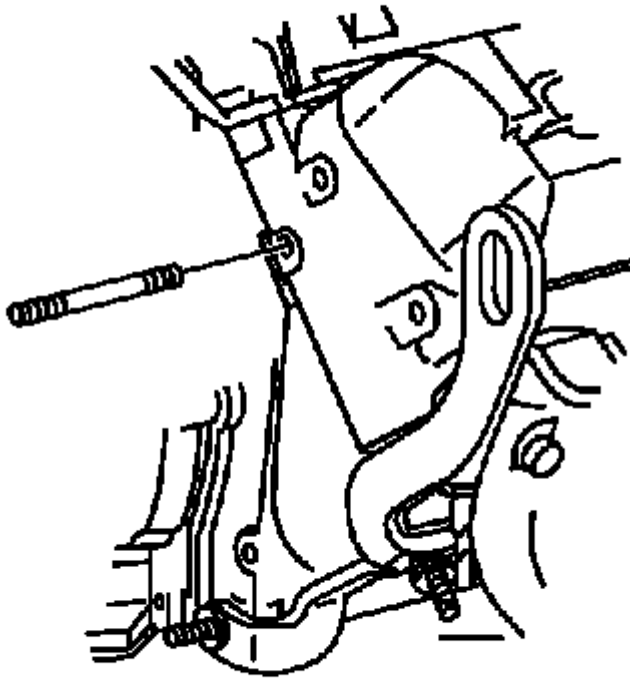


Fig. 107: Removing Power Steering Pump Bracket Stud
Courtesy of GENERAL MOTORS CORP.

8. Install the stud for the power steering pump mounting bracket to the cylinder head.

Tighten: Tighten the power steering pump mounting bracket stud to 20 N.m (15 lb ft).

9. Install the power steering pump mounting bracket.

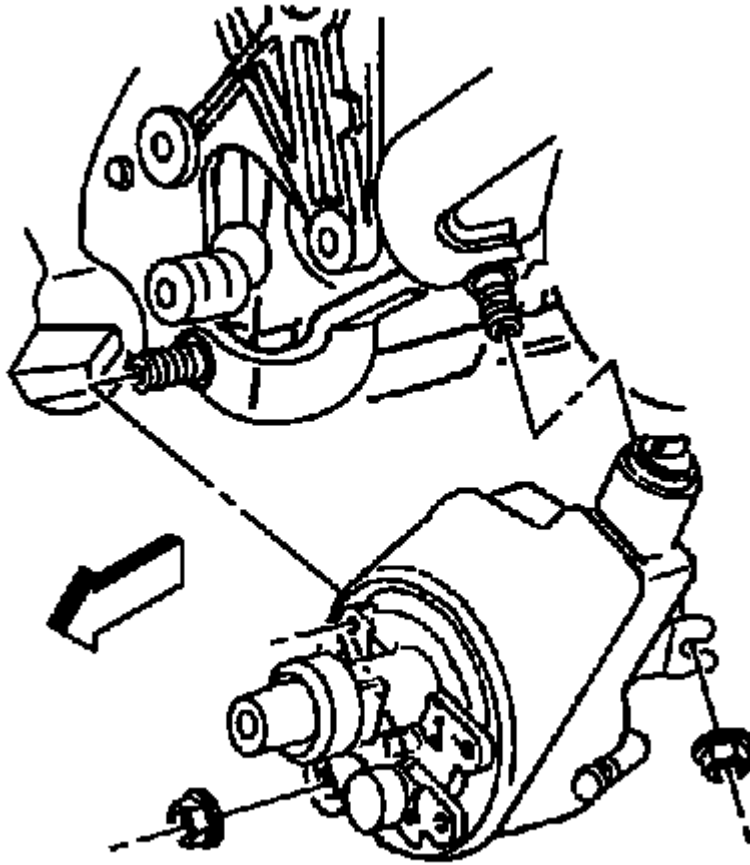


Fig. 108: Removing Power Steering Rear Mounting Bracket Nut From Engine Stud (4.3L)
Courtesy of GENERAL MOTORS CORP.

10. Install the nut holding the power steering pump rear bracket to the engine front bracket stud.

Tighten: Tighten the power steering pump rear bracket nut to 41 N.m (30 lb ft).

11. Install the air conditioning compressor. Refer to **Compressor Replacement** in Heating, Ventilation and Air Conditioning.
12. Install the engine cooling fan. Refer to **Fan Replacement** in Engine Cooling.
13. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
14. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Cylinder Head Replacement - Right

Removal Procedure

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

2. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
3. Remove the engine cooling fan. Refer to **Fan Replacement** in Engine Cooling.
4. Remove the intake manifold. Refer to **Intake Manifold Replacement - Lower**.

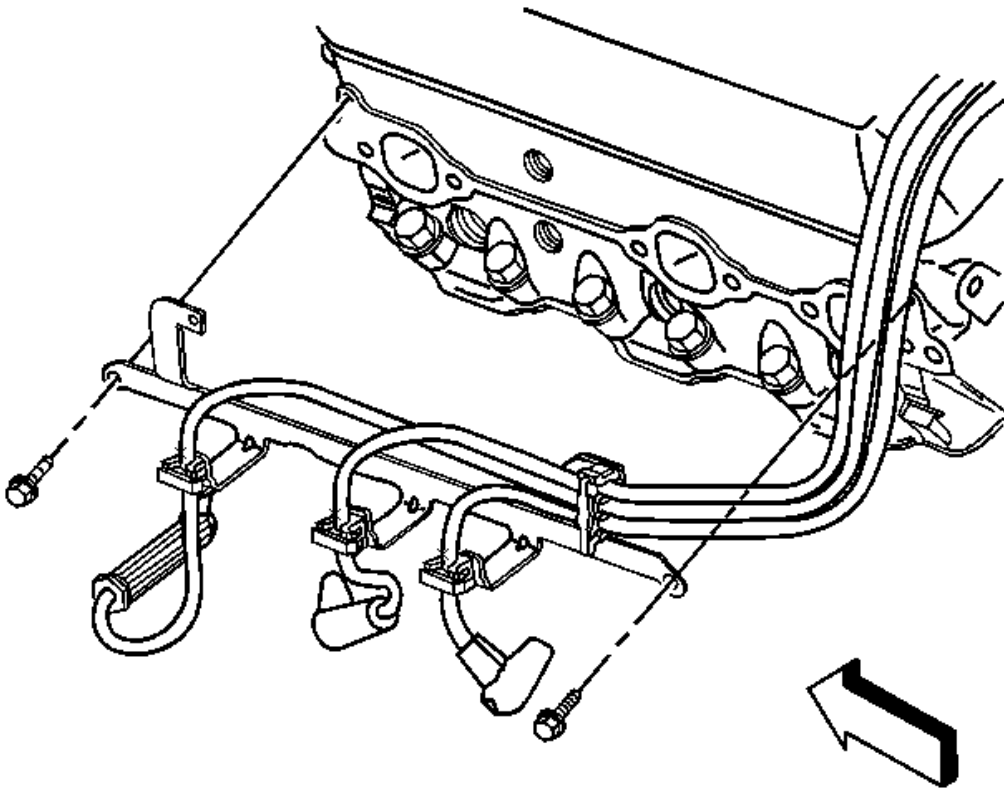


Fig. 109: View Of Spark Plug Wire Retaining Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the spark plug wire harness support.
6. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.

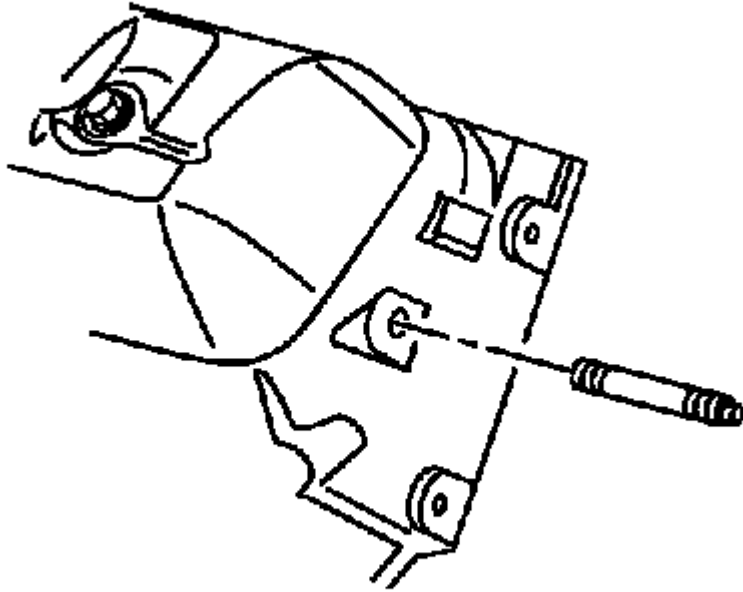


Fig. 110: Removing Generator Bracket Stud
Courtesy of GENERAL MOTORS CORP.

7. Remove the generator mounting bracket. Refer to **Generator Replacement** in Engine Electrical.
8. Remove the generator mounting bracket stud from the cylinder head.
9. Remove the engine wiring harness bolt from the rear of the right cylinder head.
10. Remove the valve push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
11. Remove the cylinder head and the gasket. Refer to **Cylinder Head Removal - Right**.
12. Clean the engine block and the cylinder head sealing surfaces.

NOTE: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

13. Clean the cylinder head bolts and the engine block bolt holes.
14. For further service to the cylinder head refer to the following:
 - **Cylinder Head Disassemble.**
 - **Cylinder Head Cleaning and Inspection.**
 - **Valve Guide Reaming/Valve and Seat Grinding.**

- **Cylinder Head Assemble.**

Installation Procedure

1. Install the cylinder head. Refer to **Cylinder Head Installation - Right.**
2. Install the valve push rods. Refer to **Valve Rocker Arm and Push Rod Replacement.**
3. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.

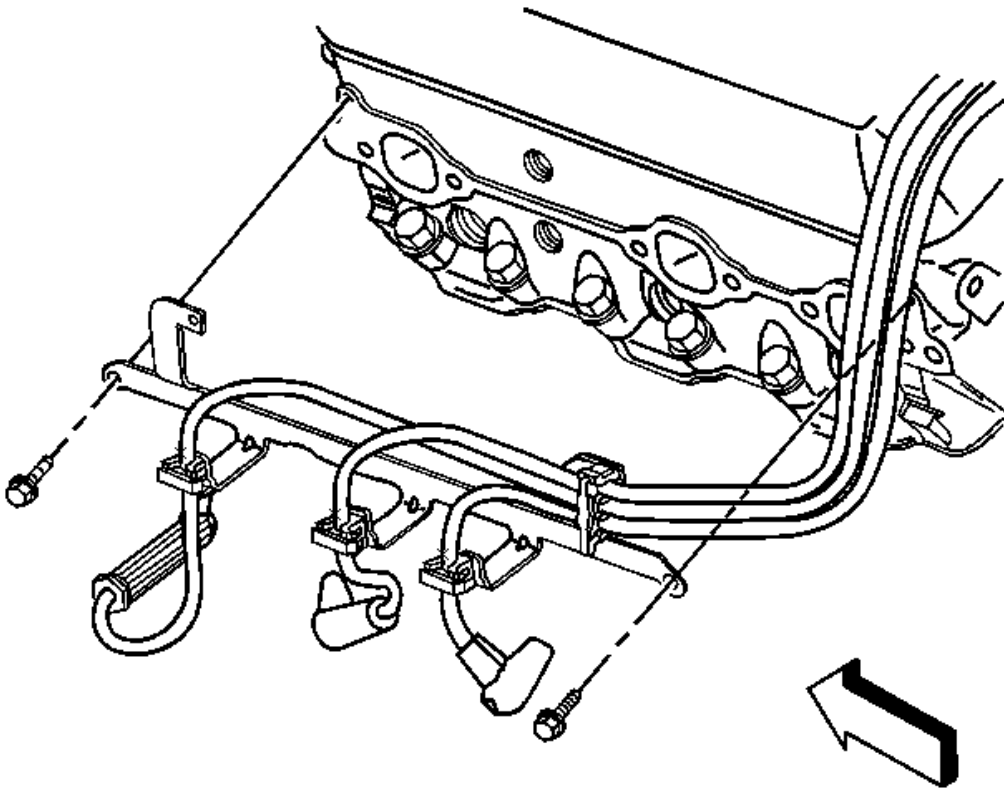


Fig. 111: View Of Spark Plug Wire Retaining Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the spark plug wire harness and support.

Tighten: Tighten the spark plug wire support bolts to 12 N.m (106 lb in).

5. Install the intake manifold. Refer to **Intake Manifold Replacement - Lower.**

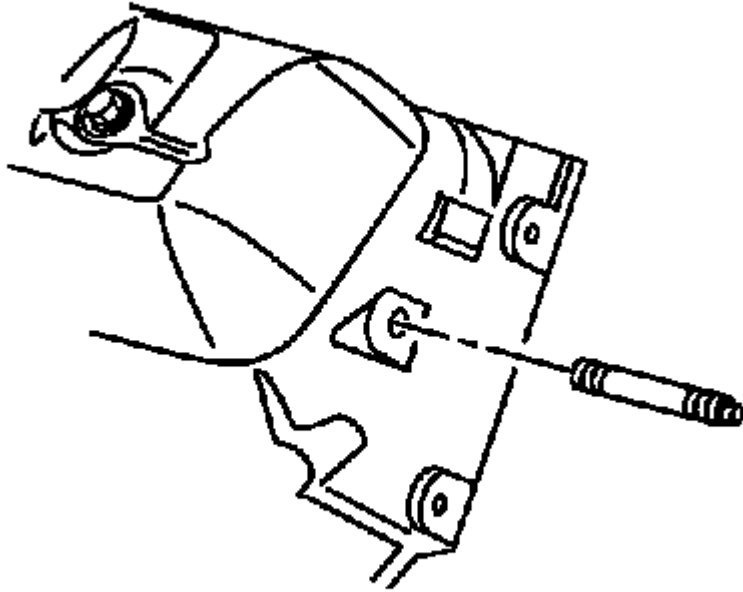


Fig. 112: Removing Generator Bracket Stud
Courtesy of GENERAL MOTORS CORP.

6. Install the stud for the generator mounting bracket.

Tighten: Tighten the generator mounting bracket stud to 20 N.m (15 lb ft).

7. Install the generator mounting bracket. Refer to **Generator Replacement** in Engine Electrical.
8. Install the bolt holding the engine wiring harness to the rear of the right cylinder head.

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

9. Install the engine cooling fan. Refer to **Fan Replacement** in Engine Cooling.
10. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
11. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Crankshaft Balancer Replacement

Removal Procedure

1. Remove the fan shroud assembly.
 - Refer to **Fan Shroud Replacement - Upper** in Engine Cooling.
 - Refer to **Fan Shroud Replacement - Lower** in Engine Cooling.
2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal**.
4. Clean and inspect all parts. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

1. Apply a small amount of grease to the crankshaft front cover oil seal sealing surface if reusing the seal.
2. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation**.
3. Install the drive belt. Refer to **Drive Belt Replacement**.
4. Install the fan shroud assembly.
 - Refer to **Fan Shroud Replacement - Upper** in Engine Cooling.
 - Refer to **Fan Shroud Replacement - Lower** in Engine Cooling.

Crankshaft Front Oil Seal Replacement**Tools Required**

J 35468 Crankshaft Aligner/Seal Installer. See **Special Tools**.

Removal Procedure

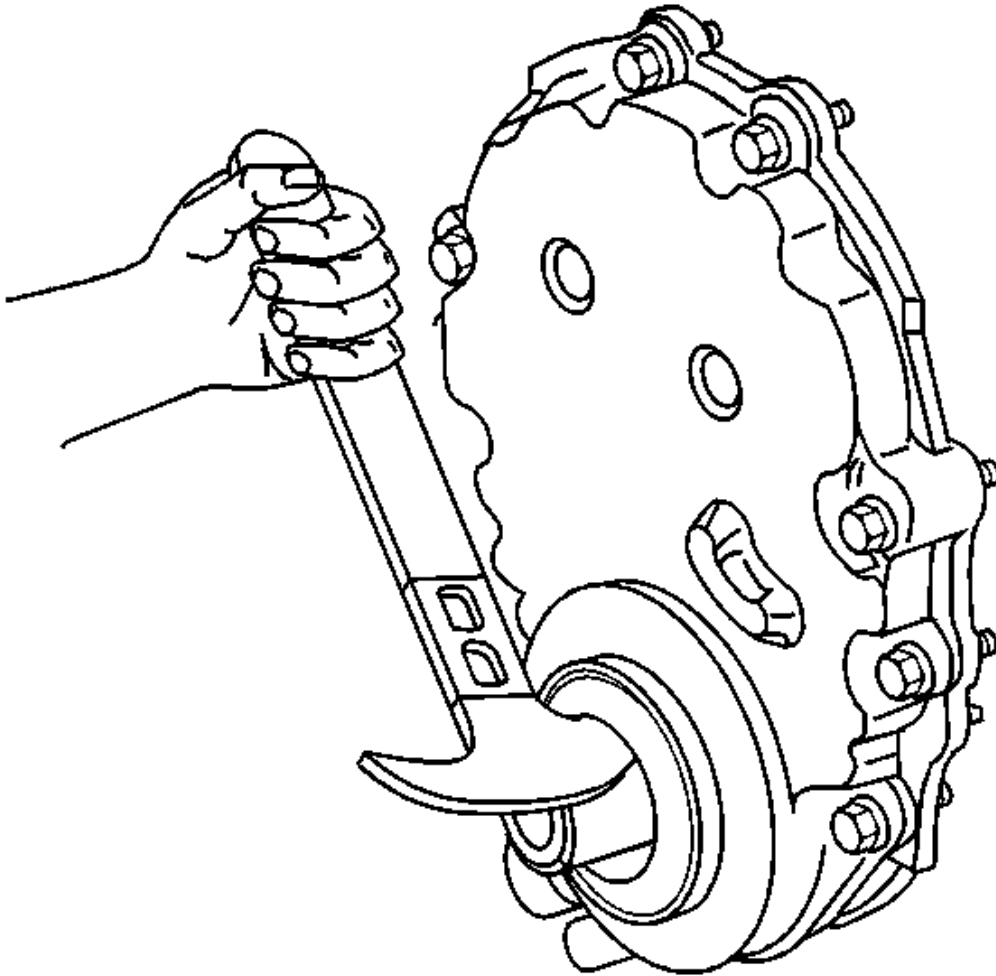


Fig. 113: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Use a suitable prying tool to remove the crankshaft front oil seal.
3. Inspect the engine front cover seal bore for damage.
4. Inspect the crankshaft balancer seal area. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

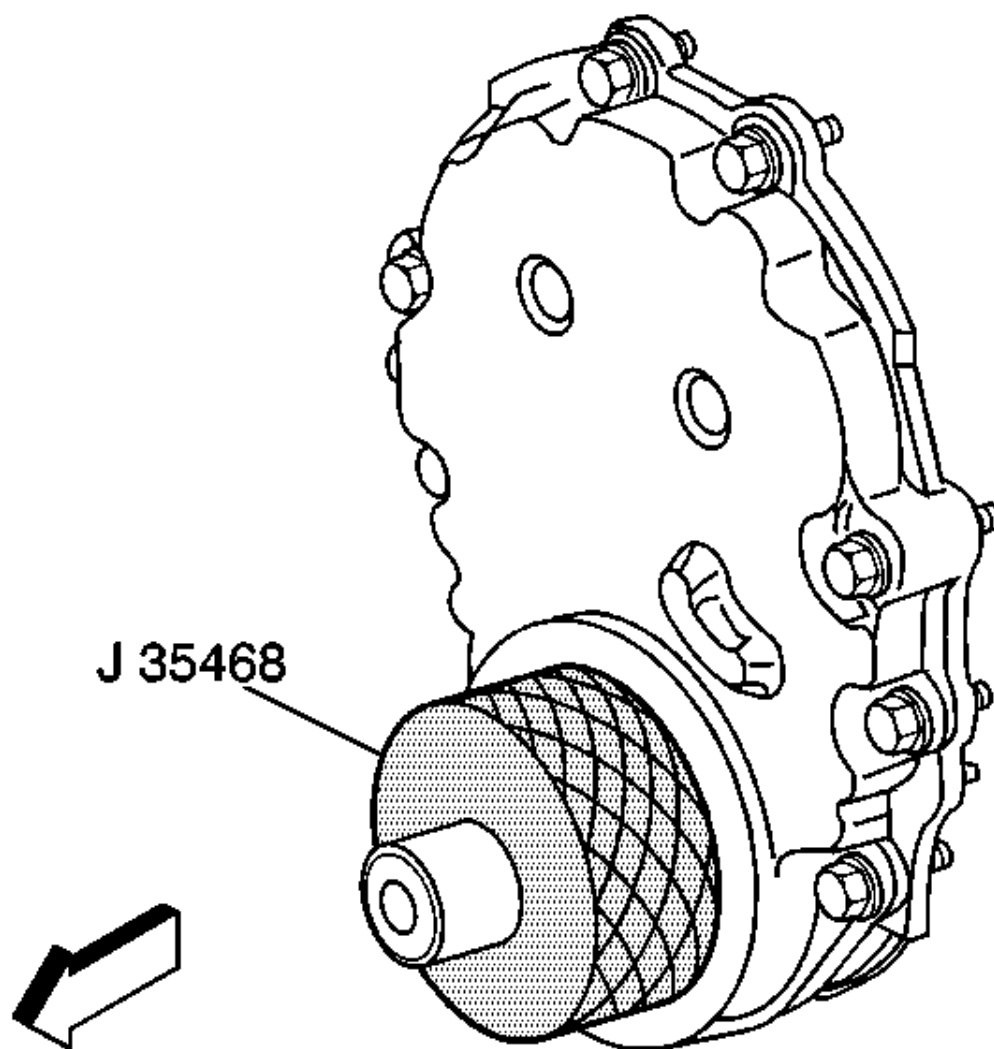


Fig. 114: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the exterior of the crankshaft front oil seal with clean engine oil.
2. Use the **J 35468** with a hammer in order to install the crankshaft front oil seal. See **Special Tools**.
3. Inspect to ensure the crankshaft front oil seal is flush and square to the engine front cover.
4. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Engine Front Cover Replacement

Removal Procedure

1. Remove the engine oil pan. Refer to **Oil Pan Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the water pump. Refer to **Water Pump Replacement** in Engine Cooling.
4. Remove the crankshaft position (CKP) sensor. Refer to **Crankshaft Position (CKP) Reluctor Ring Replacement** in Engine Controls-4.3L.

NOTE: Do not reuse the engine front cover. Oil leaks may result.

5. Remove the engine front cover. Refer to **Engine Front Cover Removal**.
6. Discard the engine front cover.
7. Clean all sealing surfaces.

Installation Procedure

NOTE: Do not reuse the engine front cover. Oil leaks may result.

1. Install the engine front cover. Refer to **Engine Front Cover Installation**.
2. Install the engine oil pan. Refer to **Oil Pan Replacement**.

IMPORTANT: Do not reuse the original seal (O-ring) when installing the crankshaft position sensor to the engine front cover. Erratic engine operation may result.

3. Install the CKP sensor. Refer to **Crankshaft Position (CKP) Reluctor Ring Replacement** in Engine Controls-4.3L.
4. Install the water pump. Refer to **Water Pump Replacement** in Engine Cooling.
5. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Crankshaft Position (CKP) Reluctor Ring Replacement**Removal Procedure**

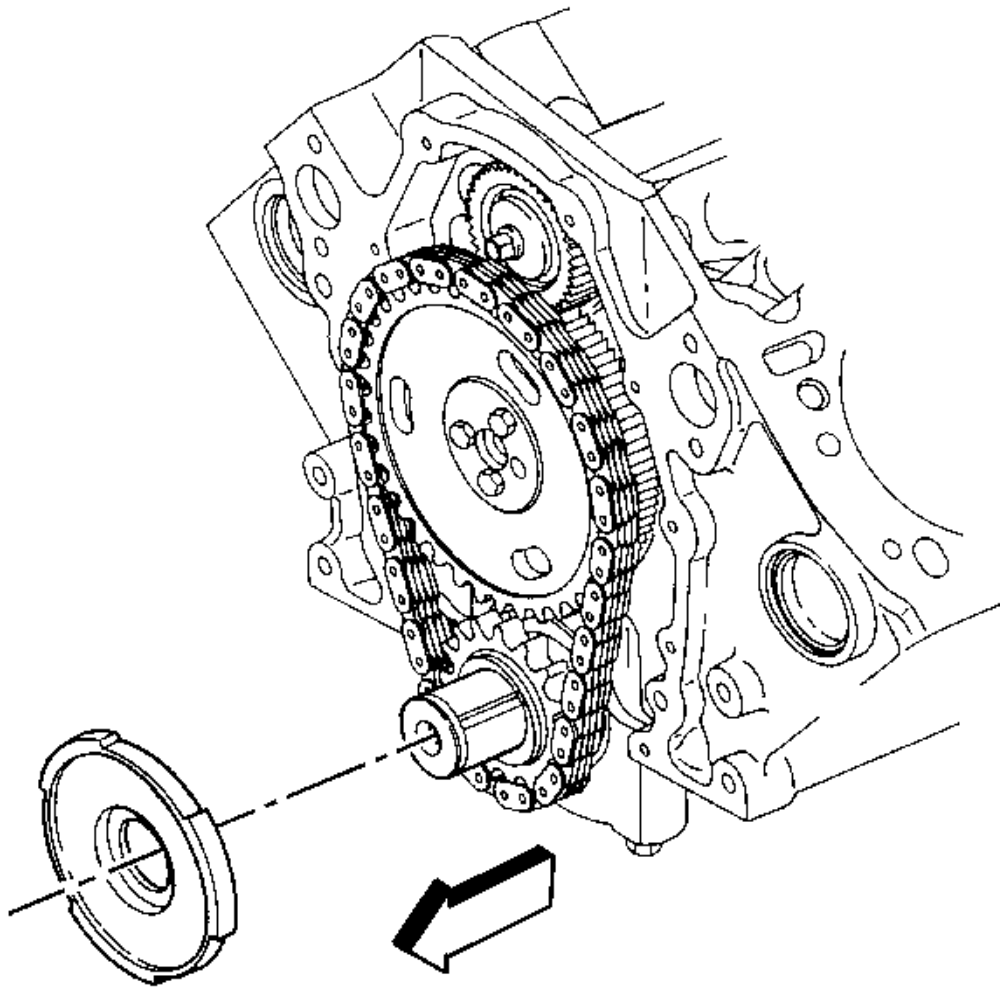


Fig. 115: View Of Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the crankshaft position sensor reluctor ring.

Installation Procedure

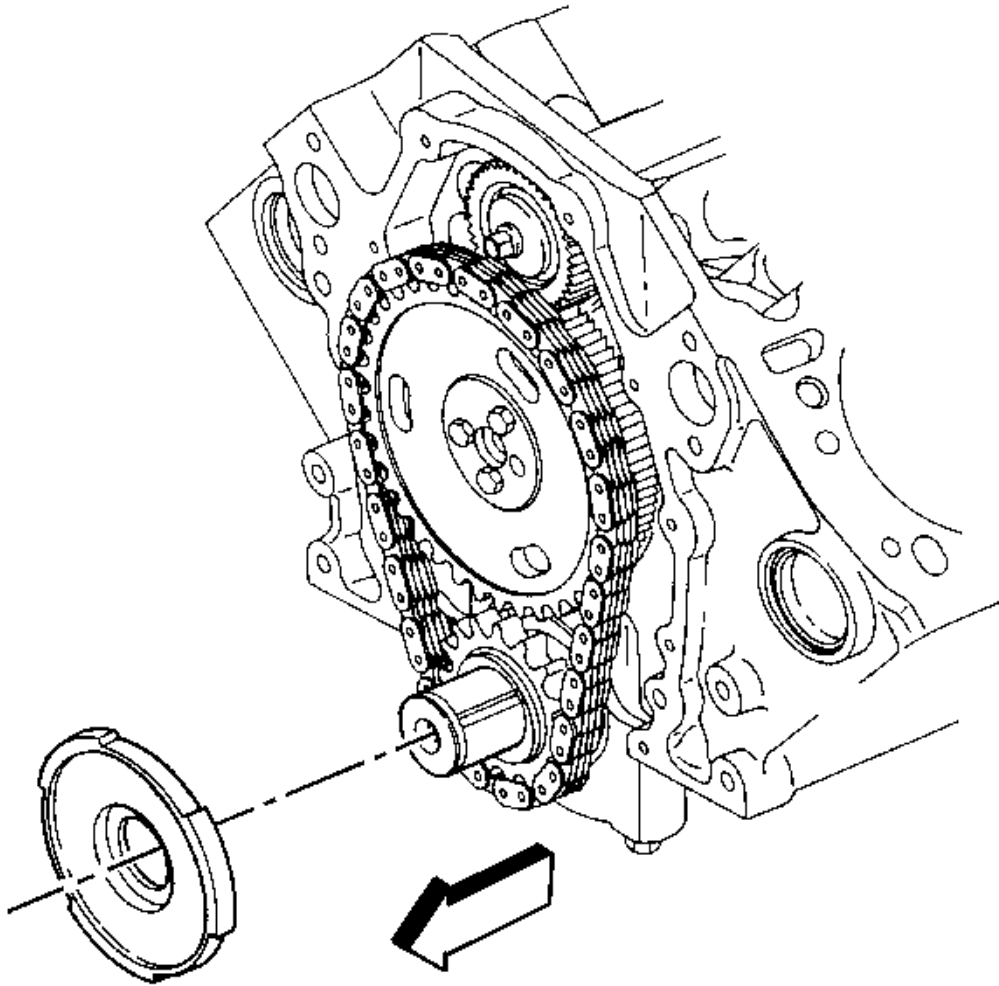


Fig. 116: View Of Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

NOTE: Failure to properly align the crankshaft position sensor reluctor ring may result in component damage and effect OBD II system performance.

IMPORTANT: The reluctor ring is shaped like a dish. The dish must face towards the engine front cover.

1. Install the crankshaft position sensor reluctor ring.
2. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

Timing Chain, Sprockets, and/or Tensioner Replacement**Tools Required**

- **J 5590** Rear Pinion Bearing Race Installer
- **J 5825-A** Crankshaft Gear Remover. See Special Tools.

Removal Procedure

NOTE: In order to rotate the engine install a bolt with the same threads as the crankshaft, but do not use the crankshaft balancer bolt or a bolt longer than 1 inch, in the crankshaft. Failing to do so will cause damage to the bolt threads and the crankshaft threaded hole when removing the bolt.

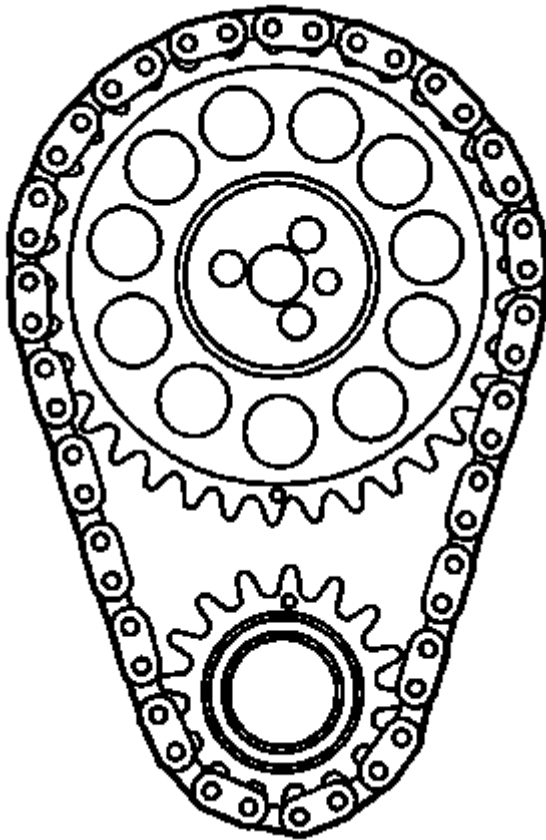


Fig. 117: View Of Camshaft & Crankshaft Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position (CKP) sensor reluctor ring. Refer to Crankshaft Position (CKP) Reluctor Ring Replacement.
2. Install a 7/16-20 x 1 inch bolt into the end of the crankshaft.

NOTE: Align the timing marks before removing the timing chain. If it is necessary

to turn either the camshaft or the crankshaft with the timing chain removed, loosen or remove the valve rocker arms. Turning either the crankshaft or camshaft with the timing chain removed may cause the pistons to contact the valves, resulting in damage.

3. Rotate the crankshaft until:

- The timing marks on both sprockets line up.
- The number 4 cylinder is at top dead center (TDC) of the compression stroke.

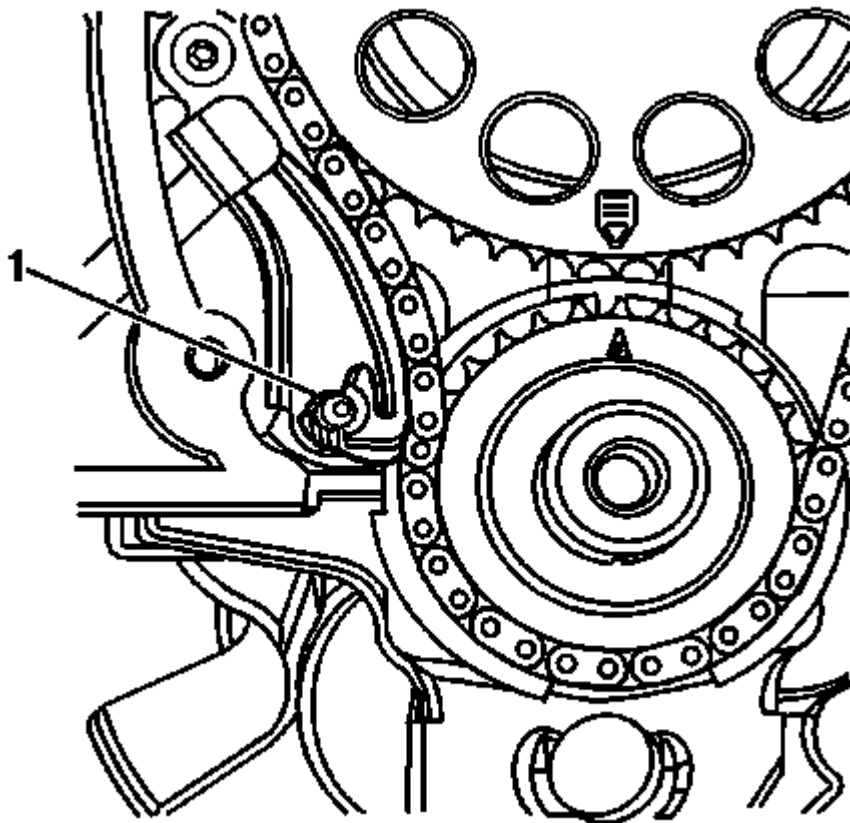


Fig. 118: Timing Chain Tensioner Shoe
Courtesy of GENERAL MOTORS CORP.

4. Unsnap the timing chain tensioner shoe from the pin (1).

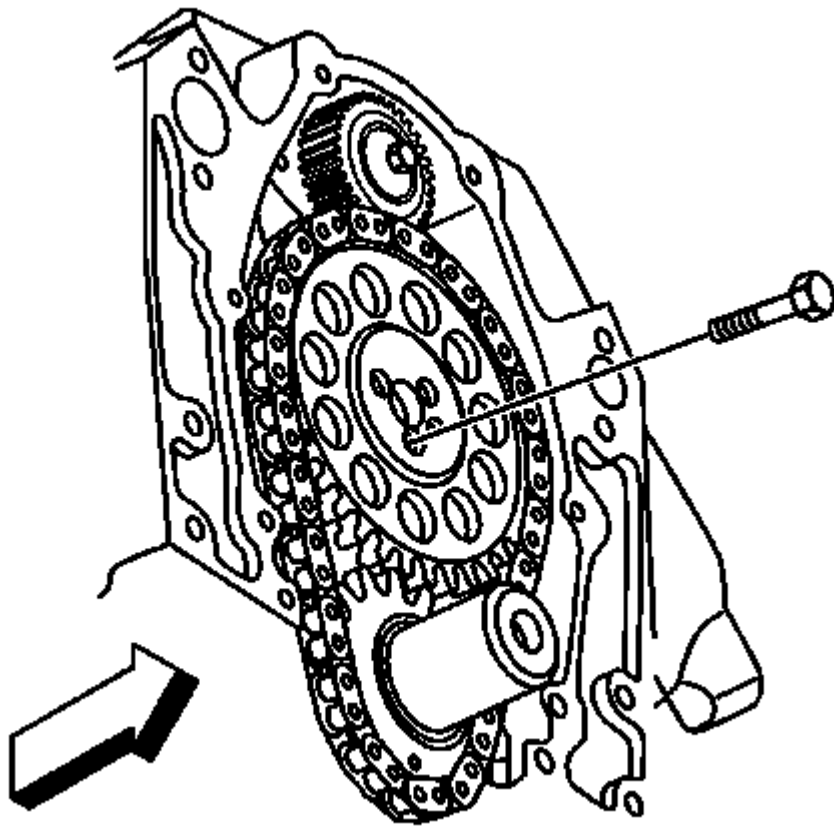


Fig. 119: Removing Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft sprocket bolts.

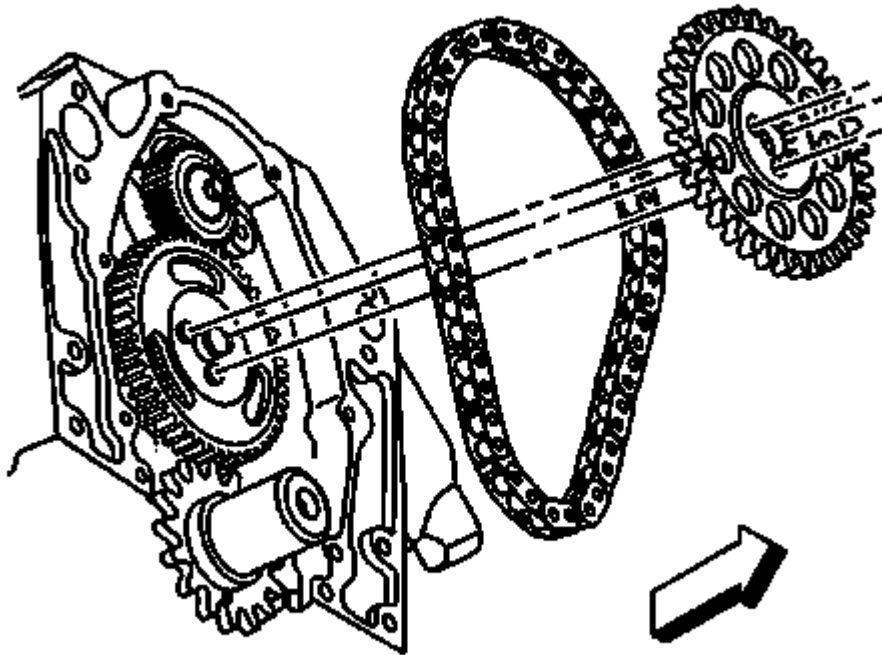


Fig. 120: Removing Camshaft Sprocket & Camshaft Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft sprocket and the camshaft timing chain.

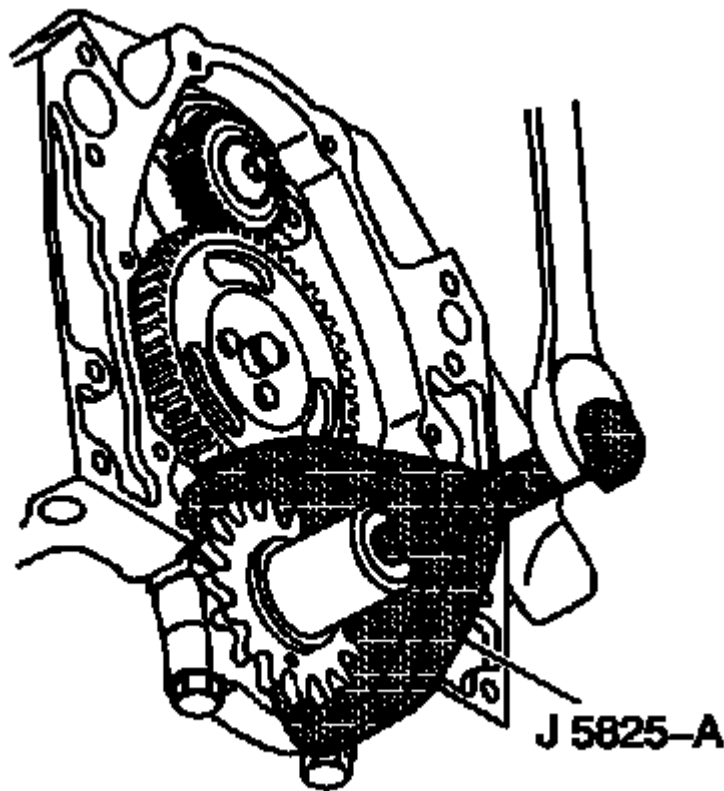


Fig. 121: Removing Crankshaft Sprocket Using J 5825-A
Courtesy of GENERAL MOTORS CORP.

7. Using **J 5825-A** and an open end wrench, remove the crankshaft sprocket. See **Special Tools**.

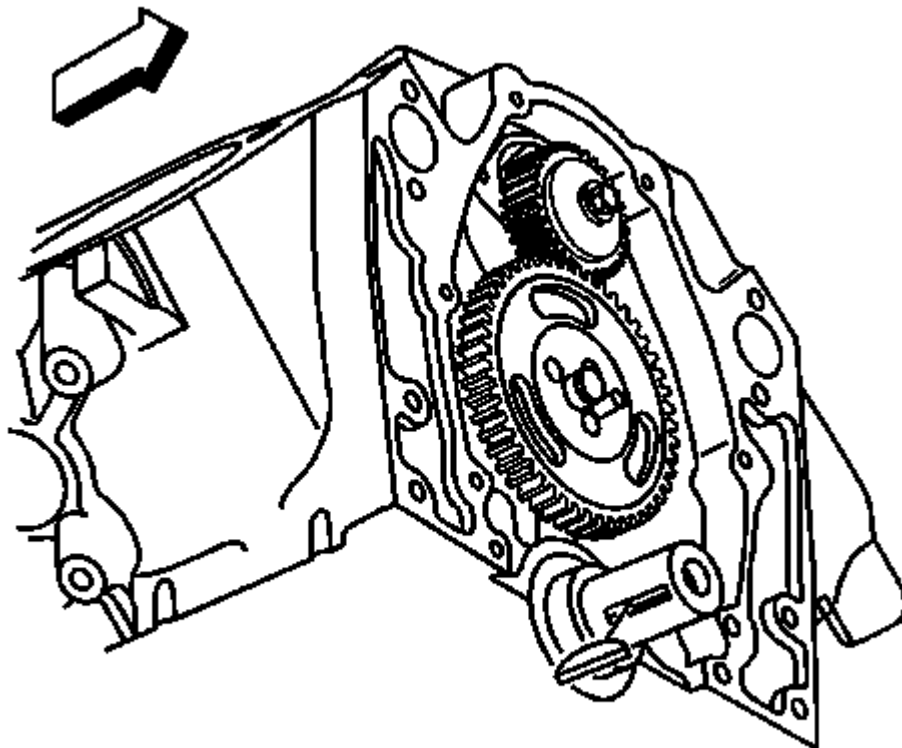


Fig. 122: Removing Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer key.

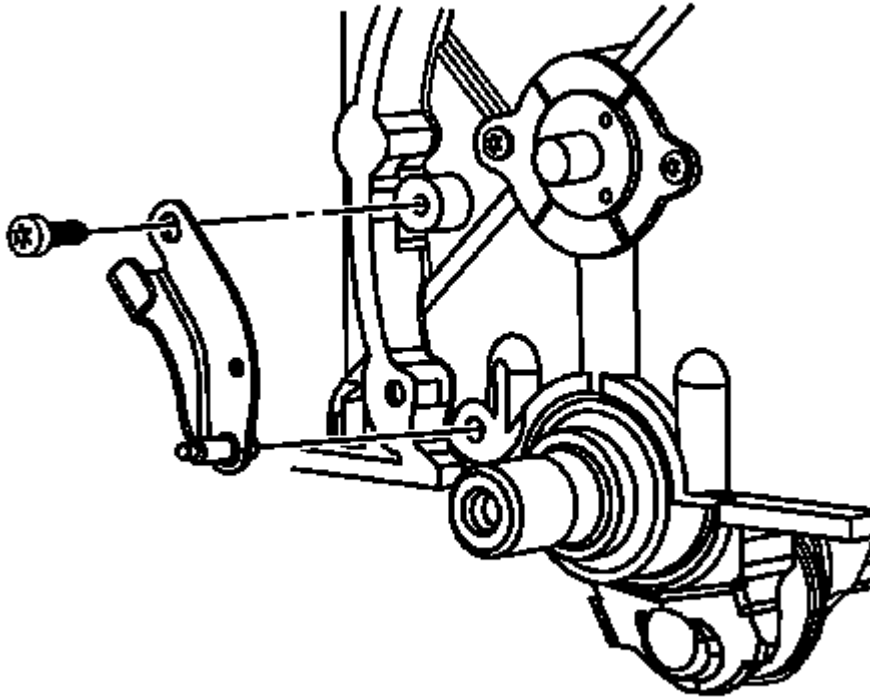


Fig. 123: Removing Timing Chain Tensioner Bracket
Courtesy of GENERAL MOTORS CORP.

9. If necessary, remove the timing chain tensioner bracket bolt and bracket.
10. Clean and inspect the timing chain and sprockets, if necessary. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

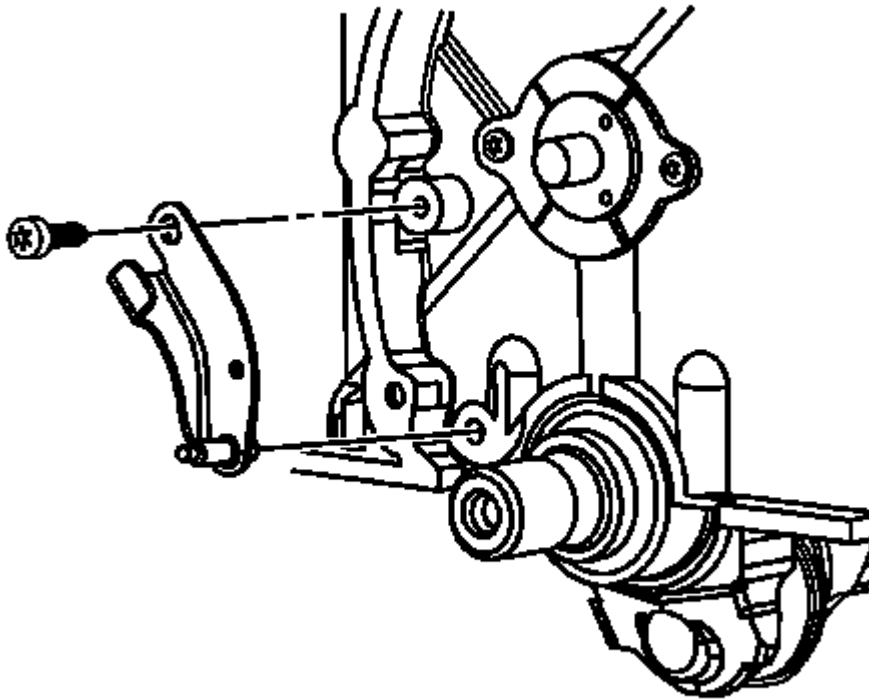


Fig. 124: Removing Timing Chain Tensioner Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. If necessary, install the timing chain tensioner bracket and bolt.

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

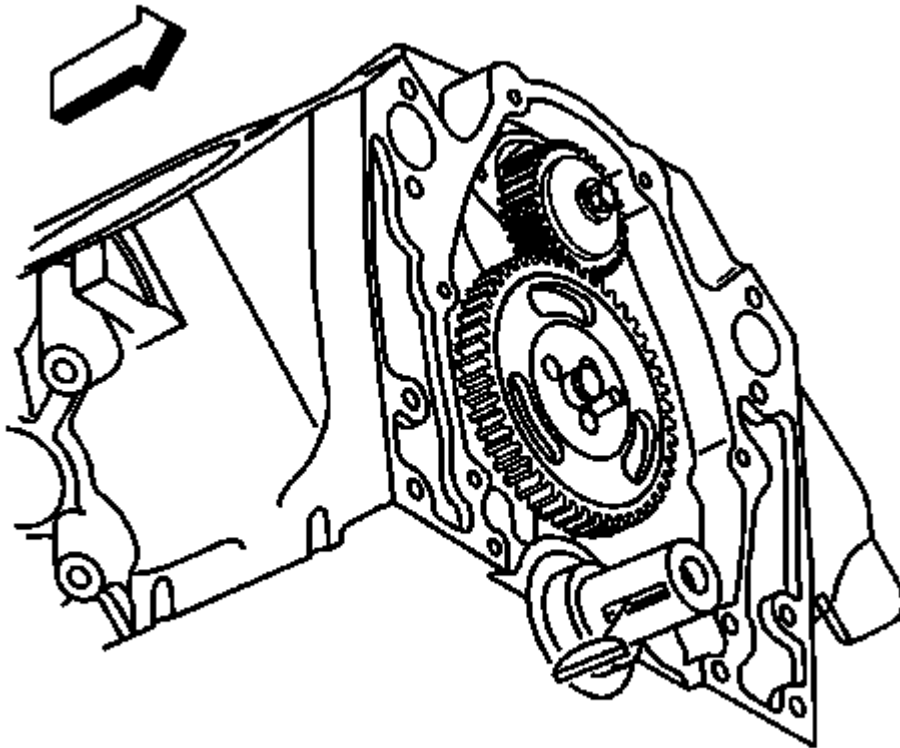


Fig. 125: Removing Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

2. Install the key into the crankshaft keyway.

The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.

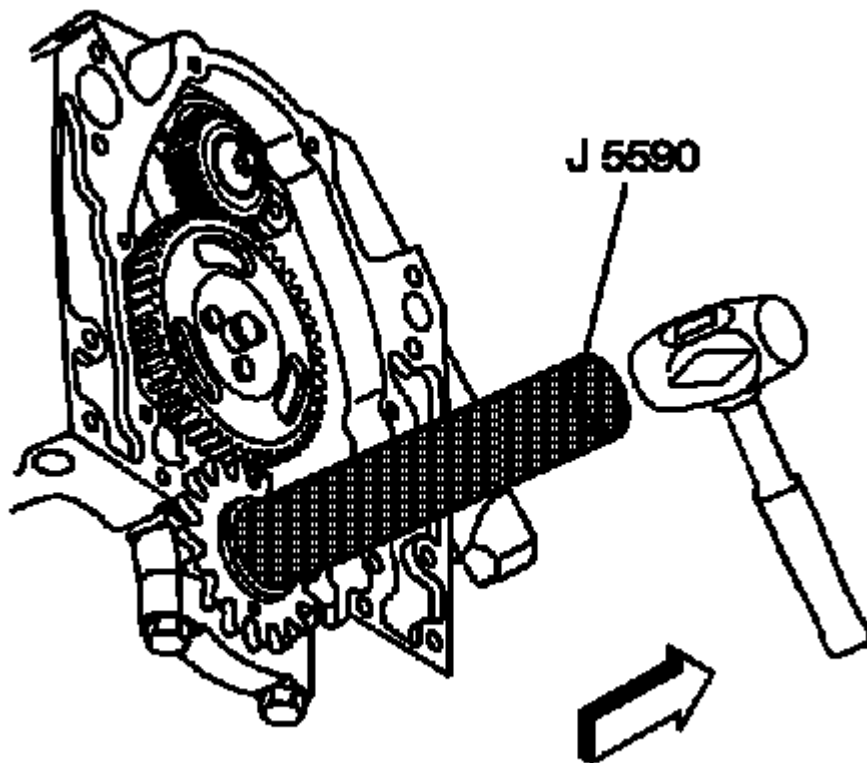


Fig. 126: Installing Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.
4. Using **J 5590** , install the crankshaft sprocket.

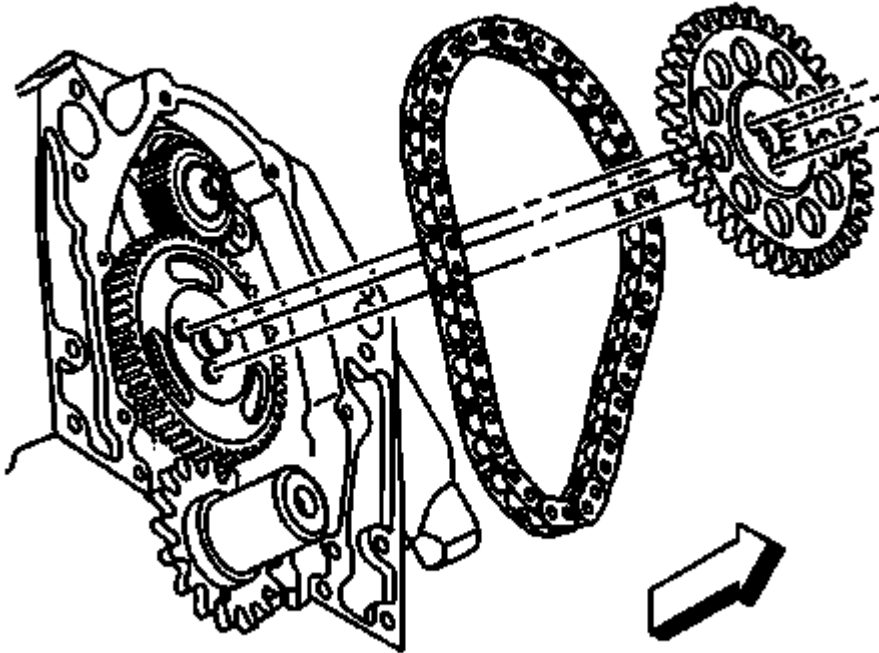


Fig. 127: Removing Camshaft Sprocket & Camshaft Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the camshaft sprocket with the alignment mark at the 6 o'clock position.

5. Install the camshaft sprocket and the camshaft timing chain. Wrap the timing chain around the crankshaft sprocket and position to the driver's side of the engine.

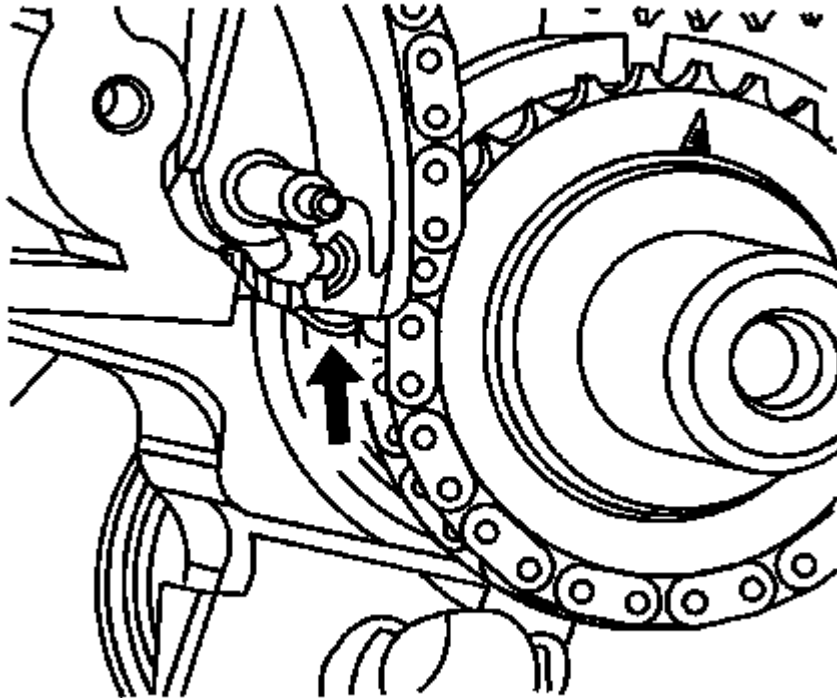


Fig. 128: Timing Chain Tensioner Shoe
Courtesy of GENERAL MOTORS CORP.

6. Install the timing chain tensioner shoe onto the bracket and position the top of the shoe under the tab at the top of the bracket.

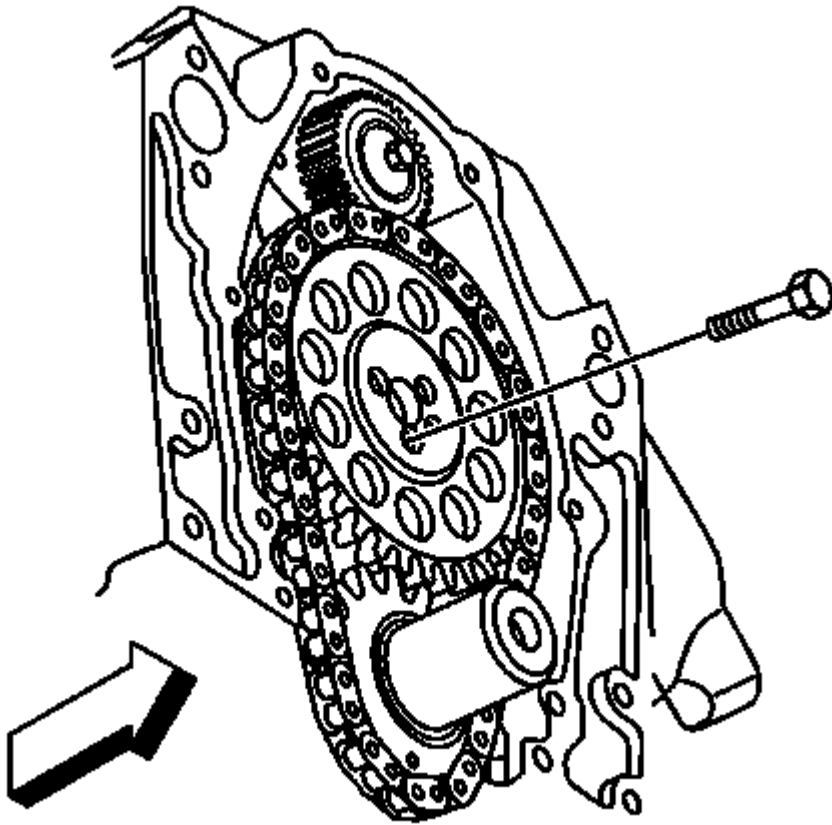


Fig. 129: Removing Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use a hammer to install the camshaft sprocket onto the camshaft.
To do so may dislodge the expansion cup plug.

7. Insert the camshaft timing chain sprocket into the timing chain and position so when the camshaft timing chain sprocket is installed on the camshaft, the camshaft timing marks will line up.
8. Install the camshaft sprocket bolts.

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

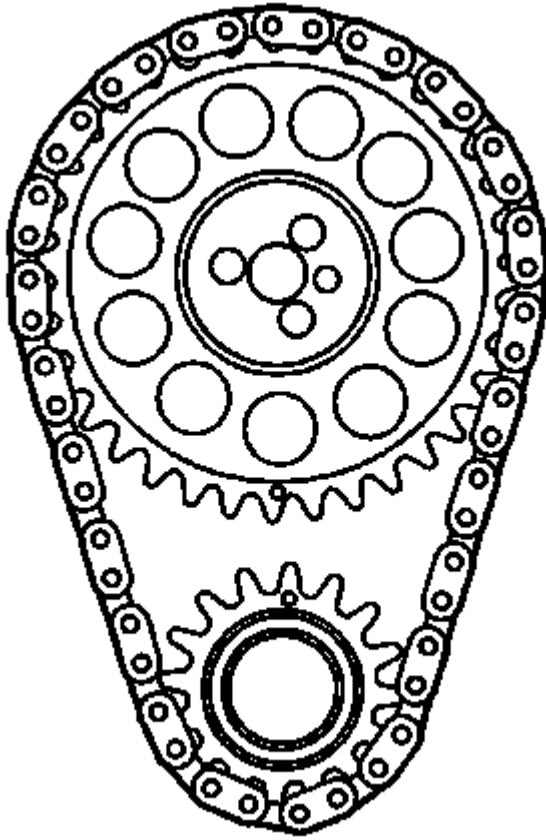


Fig. 130: View Of Camshaft & Crankshaft Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

9. Ensure that the crankshaft sprocket is aligned at the 12 o'clock position and camshaft sprocket is aligned at the 6 o'clock position.
10. Remove the bolt that was installed in the end of the crankshaft.
11. Install the CKP sensor reluctor ring. Refer to **Crankshaft Position (CKP) Reluctor Ring Replacement**.

Balance Shaft Replacement

Removal Procedure

1. Remove the radiator. Refer to **Radiator Replacement** in Engine Cooling.
2. Remove the A/C condenser, if equipped. Refer to **Condenser Replacement** in Heating Ventilation and Air Conditioning.
3. Remove the valve lifter pushrod guide. Refer to **Valve Lifter Replacement**.
4. Remove the camshaft timing chain and sprockets. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.

IMPORTANT: The balance shaft and the front bearing are serviced only as a package.
Do not remove the bearing from the balance shaft.

5. Remove the balance shaft. Refer to **Balance Shaft Removal**.
6. Clean and inspect the balance shaft. Refer to **Balance Shaft Cleaning and Inspection**.

Installation Procedure

1. Install the balance shaft. Refer to **Balance Shaft Installation**.
2. Install the camshaft timing chain and the camshaft sprocket. Refer to **Timing Chain and Sprockets Installation**.
3. Install the crankshaft position reluctor ring and the engine front cover. Refer to **Crankshaft Position (CKP) Reluctor Ring Replacement**.
4. Install the valve lifter pushrod guide. Refer to **Valve Lifter Replacement**.
5. Install the A/C condenser, if equipped. Refer to **Condenser Replacement** in Heating Ventilation and Air Conditioning.
6. Install the radiator. Refer to **Radiator Replacement** in Engine Cooling.

Camshaft Replacement**Removal Procedure**

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls-4.3L.
3. Remove the radiator. Refer to **Radiator Replacement** in Engine Cooling.
4. Remove the A/C condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.
5. Remove the radiator grille. Refer to **Grille Replacement** in Body Front End.
6. Remove the valve lifters. Refer to **Valve Lifter Replacement**.

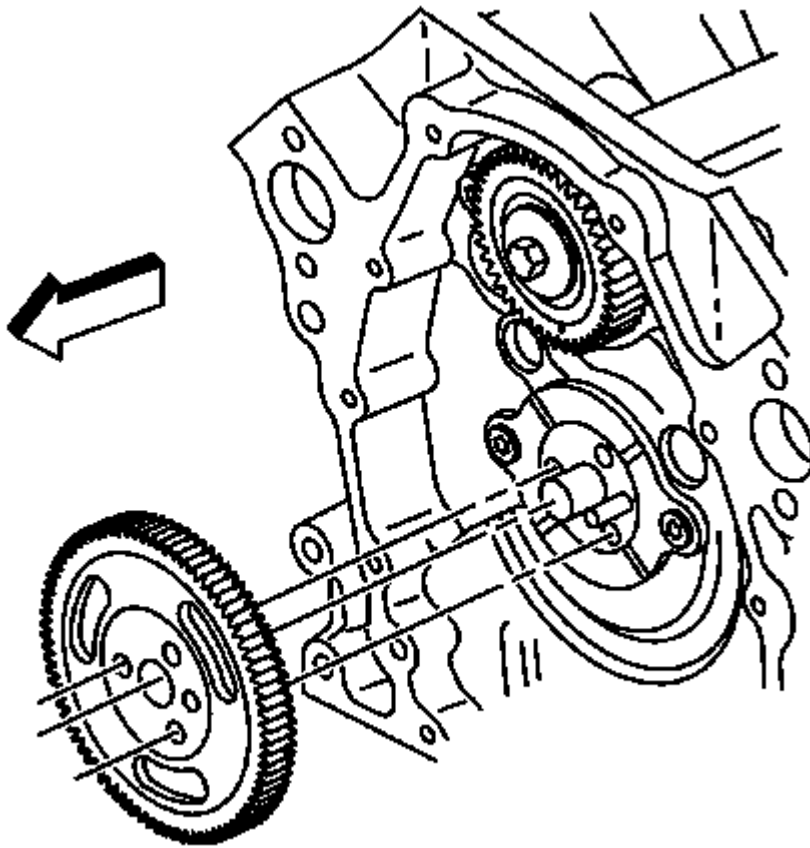


Fig. 131: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

7. Remove the timing chain and the camshaft sprocket. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.
8. Remove the balance shaft drive gear.
9. Remove the camshaft. Refer to **Camshaft Removal**.
10. Clean and inspect the camshaft and the bearings. Refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Whenever a new camshaft is installed, do the following procedures:

- Change the engine oil.
- Change the engine oil filter.
- Add GM Engine Oil Supplement GM P/N 1052367 (Canadian P/N 992869) or the equivalent to the engine oil.

1. Install the camshaft into the engine block. Refer to **Camshaft Installation**.
2. Install the balance shaft drive gear. Refer to **Balance Shaft Installation** for alignment of the balance

shaft drive gear and the driven gear.

3. Install the timing chain and camshaft sprocket. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.
4. Install the valve lifters. Refer to **Valve Lifter Replacement**.
5. Install the A/C condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.
6. Install the radiator grille. Refer to **Grille Replacement** in Body Front End.
7. Install the radiator. Refer to **Radiator Replacement** in Engine Cooling.
8. Fill the engine cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
9. Recharge the air conditioning system. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
10. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls-4.3L.
11. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

Oil Filter Adapter Replacement

Removal Procedure

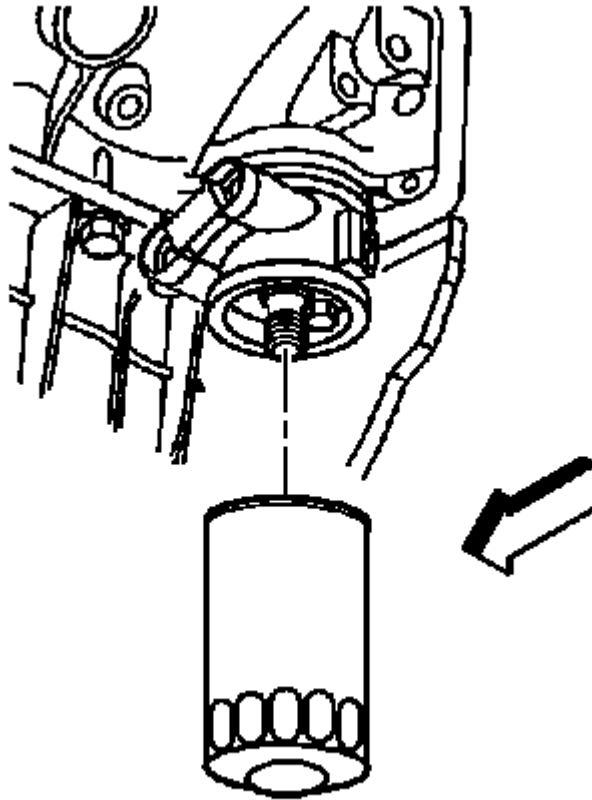


Fig. 132: Removing Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position a suitable container to catch the engine oil.
3. Remove the oil filter.
4. Disconnect the engine oil cooler pipes from the oil filter adapter. Refer to **Engine Oil Cooler Hose/Pipe Replacement** in Engine Cooling.
5. Remove the oil filter adapter. Refer to **Oil Filter Adapter Removal**.

Installation Procedure

1. Install the oil filter adapter with a NEW gasket. Refer to **Oil Filter Adapter Installation**.
2. Install the engine oil cooler pipes to the oil filter adapter. Refer to **Engine Oil Cooler Hose/Pipe Replacement** in Engine Cooling.
3. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
4. Lower the vehicle.
5. Operate the vehicle and check for leaks.
6. Check the oil level and add as required.

Oil Filter Bypass Valve Replacement**Removal Procedure**

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position a suitable container to catch the engine oil.
3. Remove the oil filter.
4. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.

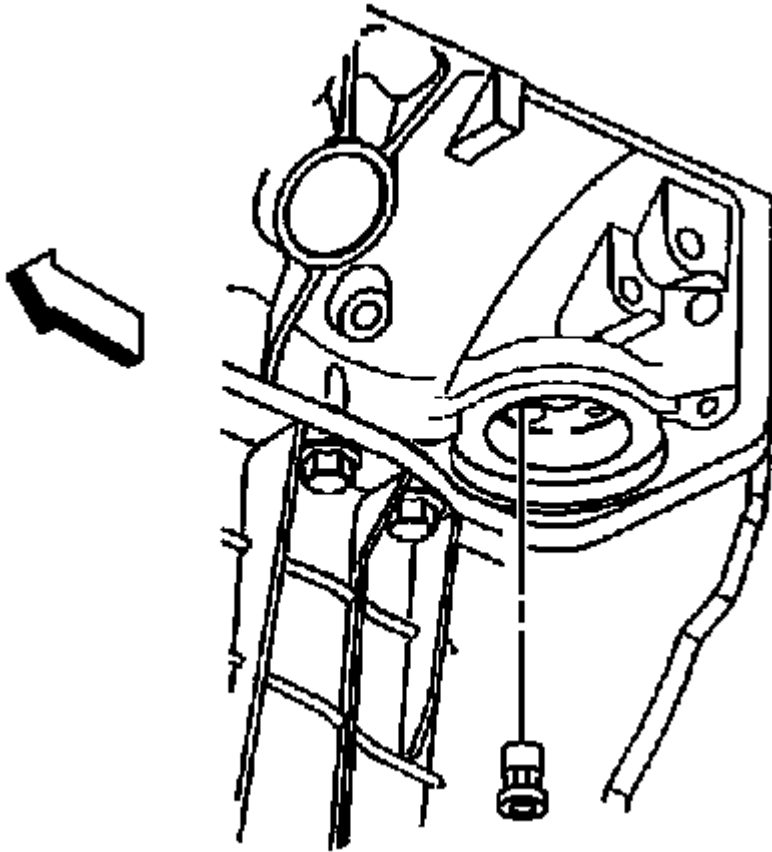


Fig. 133: Removing Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

5. Using a suitable prying tool remove the oil filter bypass valve.
6. Clean and inspect valve bore for damage.

Installation Procedure

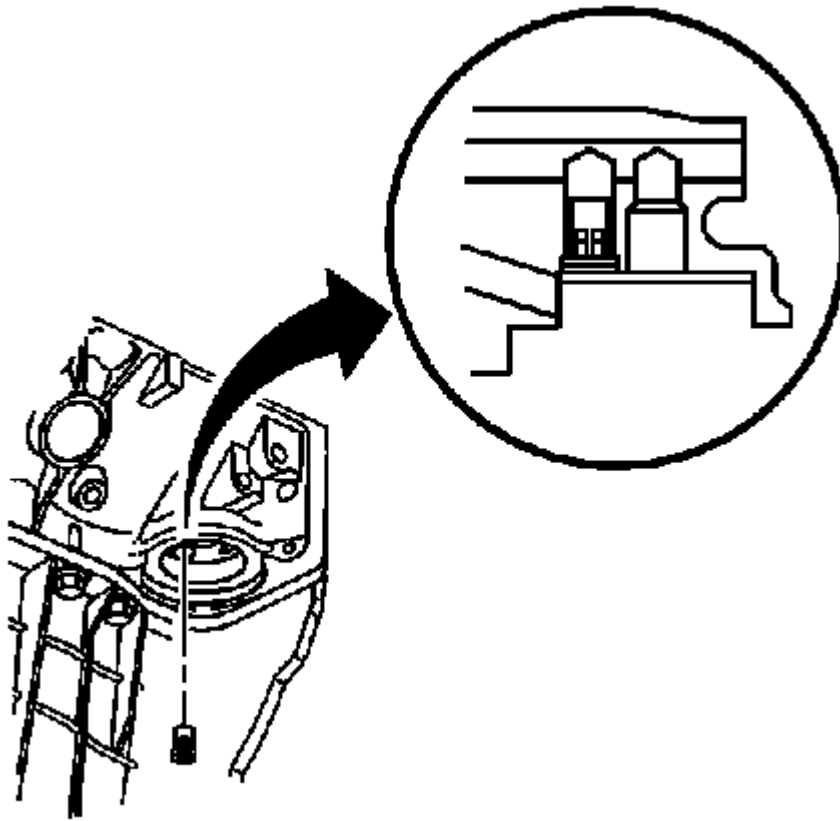


Fig. 134: Installing Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

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

1. Install a NEW oil filter bypass valve using the following procedure:
 1. Use a brass drift that is the same diameter as the outside diameter of the oil filter bypass valve.
 2. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 3. Using a pointed punch, stake the engine block area around the oil filter bypass valve.

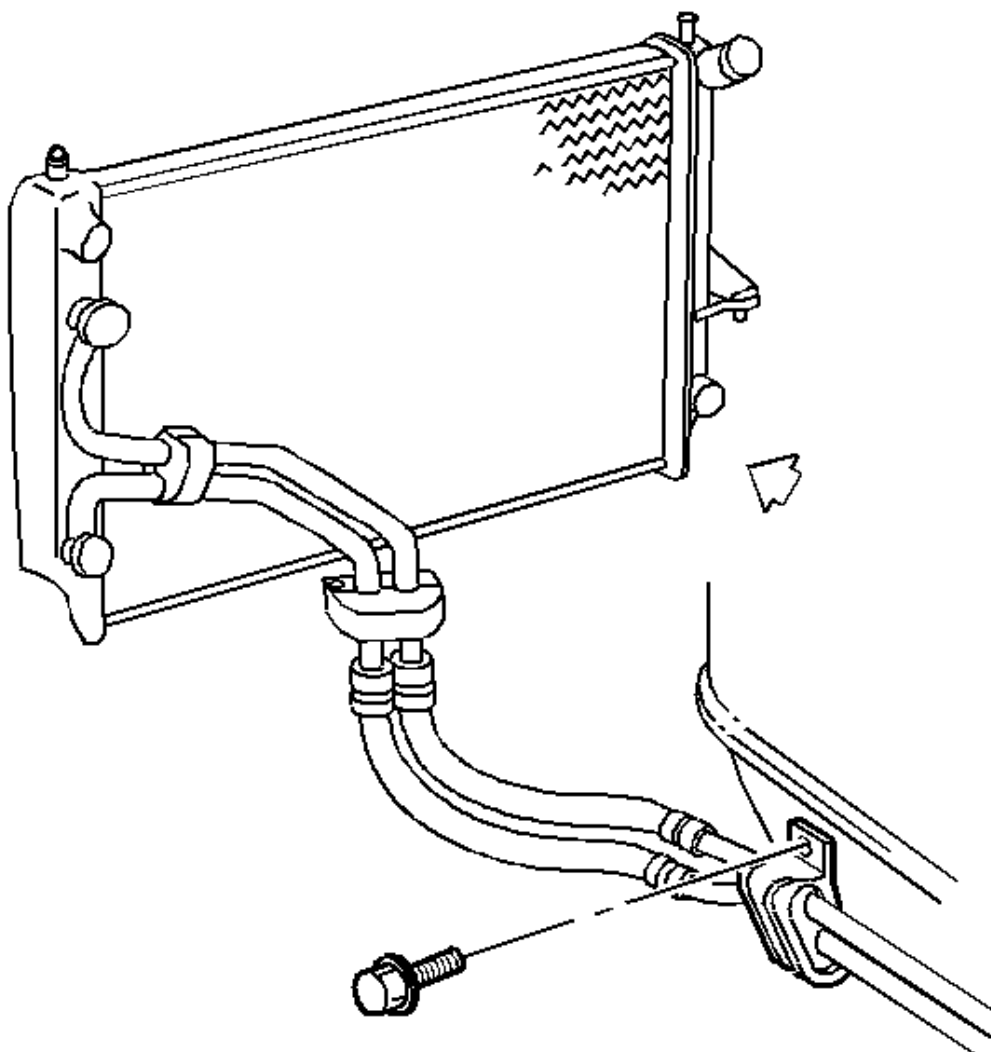
Stake in 3 locations 120 degrees apart.

2. Install the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
3. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
4. Lower the vehicle.

Oil Pan Replacement

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the oil level indicator.
3. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Remove the oil pan drain plug and drain the engine oil into a suitable container.
5. Remove the oil filter.

**Fig. 135: Locating Oil Cooler Pipes Bracket Retaining Bolt**

Courtesy of GENERAL MOTORS CORP.

6. Remove the bolt holding the oil cooler pipes bracket to the oil pan.
7. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.

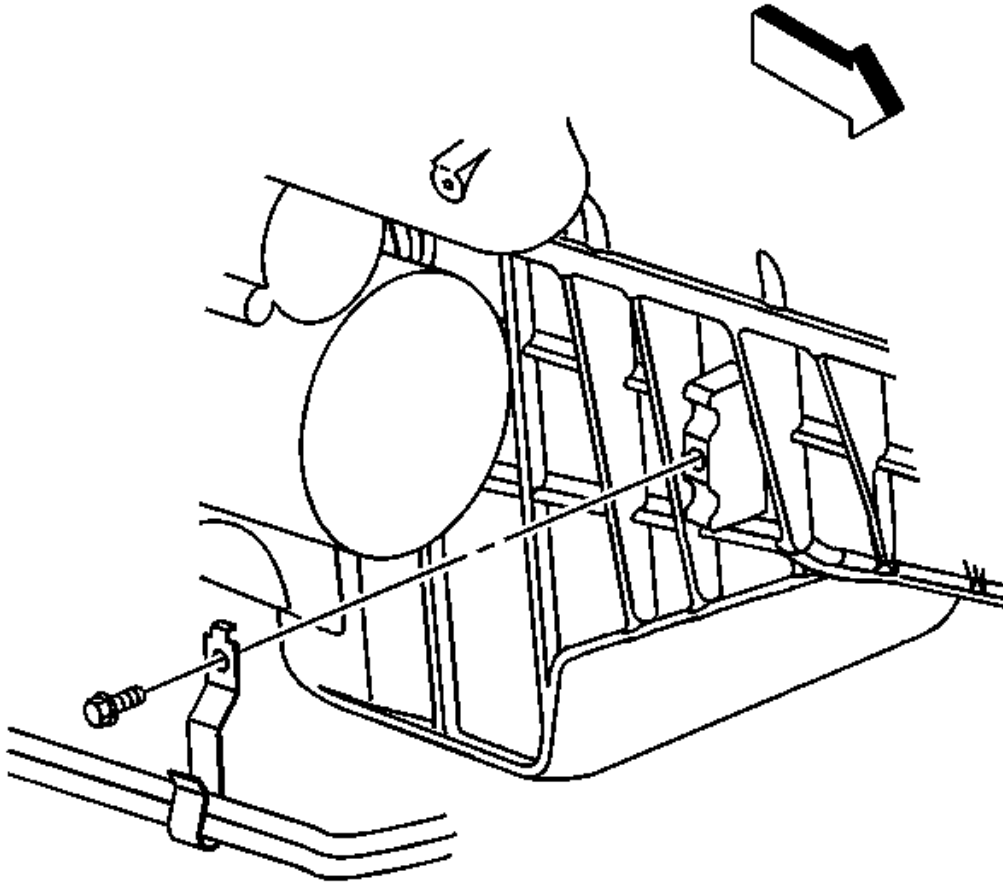


Fig. 136: Identifying Starter Wiring Harness & Transmission Cooler Pipes Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolt holding the bracket for the starter wiring harness and the transmission cooler pipes.
9. Remove the crankcase position (CKP) sensor wiring harness from the retainer.
10. Remove the starter. Refer to **Starter Motor Replacement** in Engine Electrical.

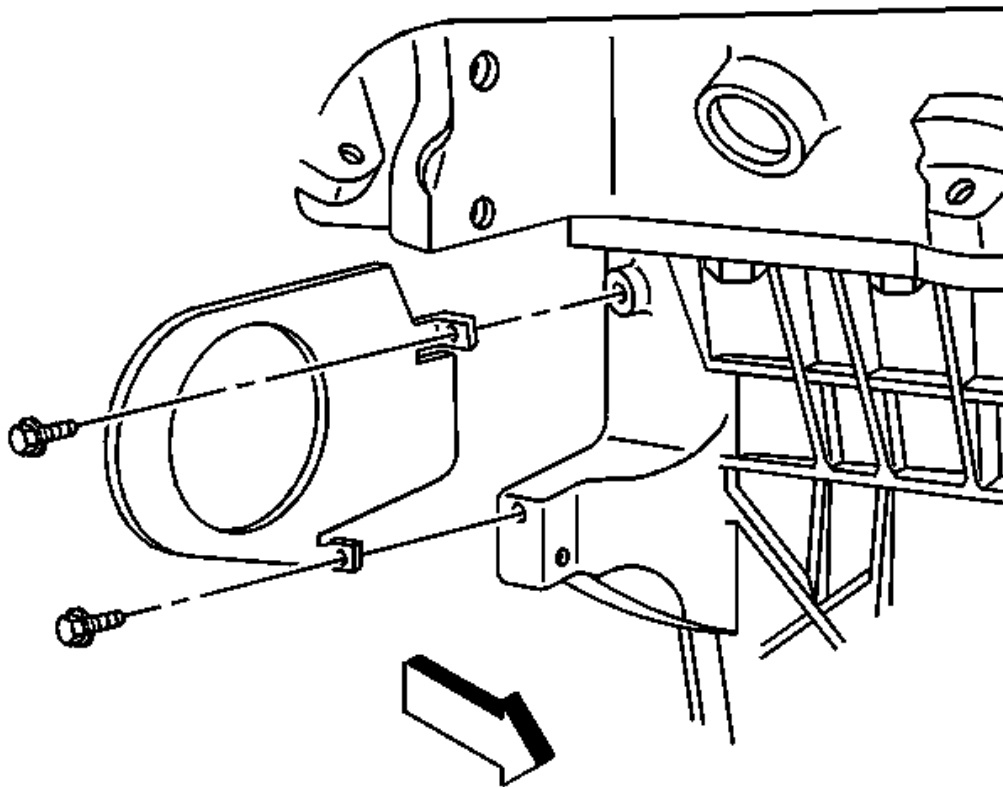


Fig. 137: View Of Transmission Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure NOT to break the cover rails.

11. Remove the transmission cover.

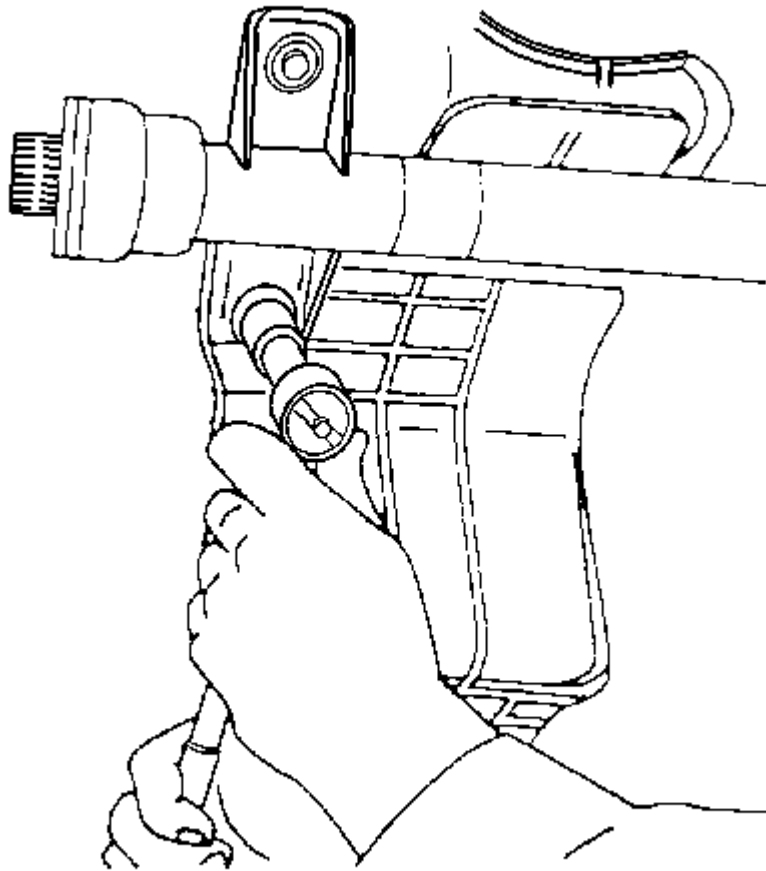


Fig. 138: View Of Inner Axle Shaft Housing
Courtesy of GENERAL MOTORS CORP.

12. Remove the inner axle shaft housing support bracket to the frame nuts and the washers (AWD only).

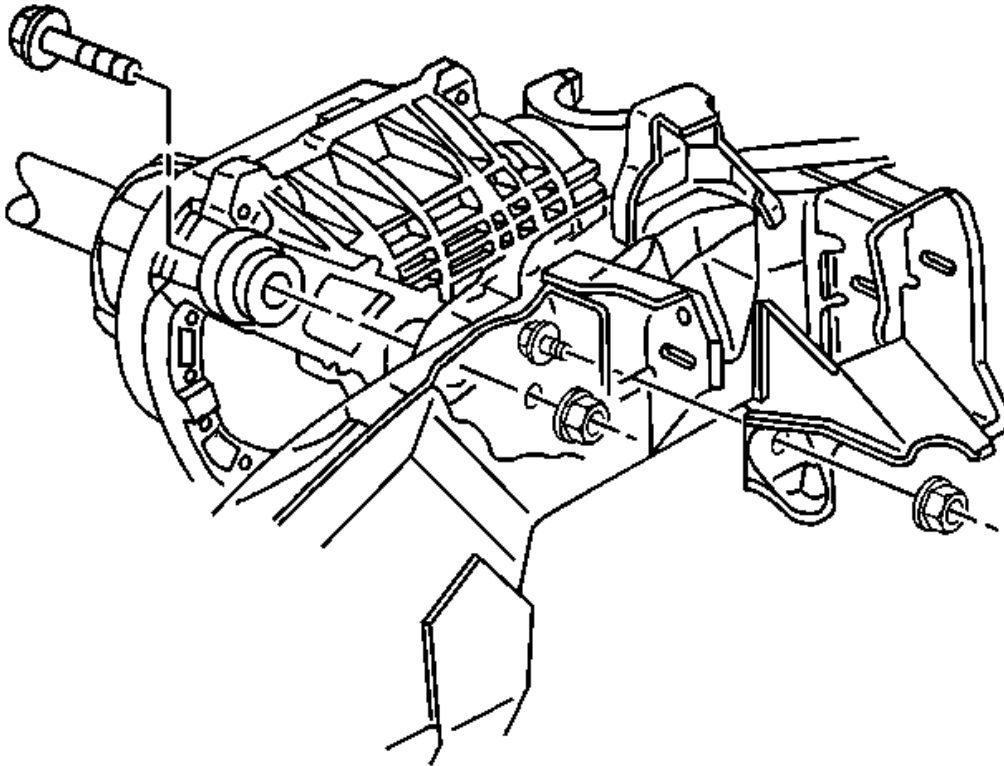


Fig. 139: Locating Upper & Lower Front Differential Carrier Mounting Nuts
Courtesy of GENERAL MOTORS CORP.

13. Remove the front differential carrier upper and lower mounting nuts and bolts (AWD only).
14. Lower the front differential carrier assembly only enough for removal of the oil pan.

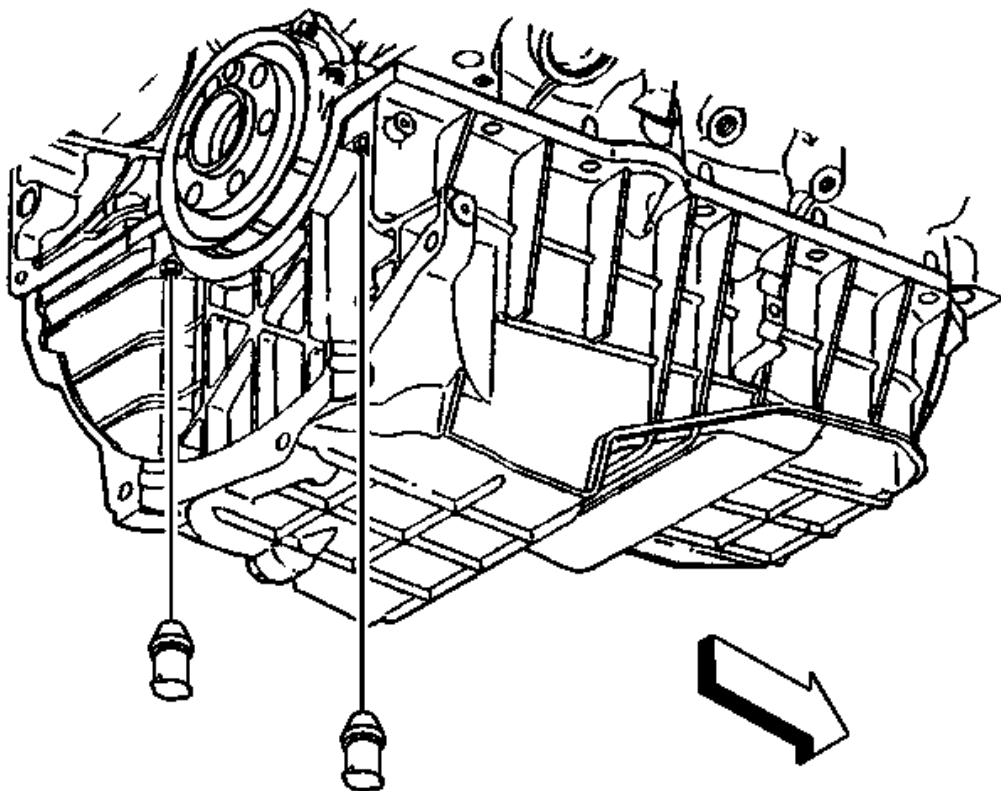


Fig. 140: Expanded View Of Oil Pan Rear Nuts Access Plugs
Courtesy of GENERAL MOTORS CORP.

15. Remove the access plugs for the oil pan rear nuts.

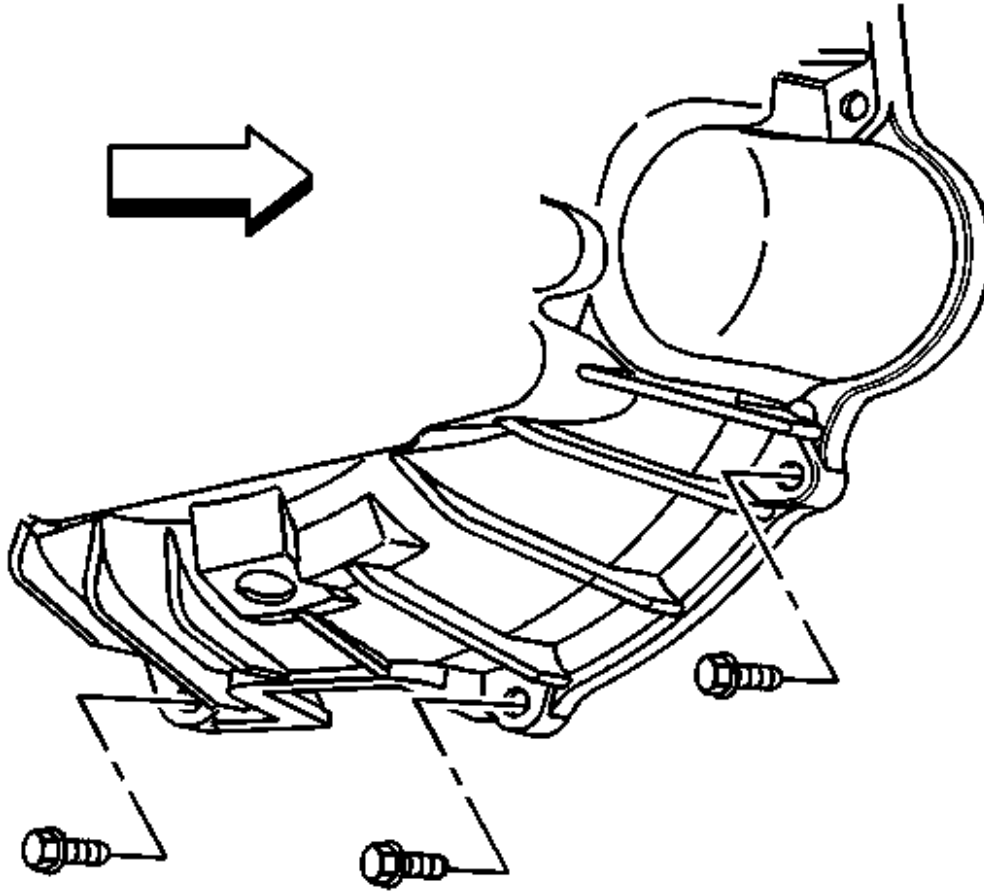


Fig. 141: Identifying Transmission To Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the transmission to oil pan bolts.
17. Remove the oil pan from the engine. Refer to **Oil Pan Removal**.
18. Clean all sealing surfaces on the engine and the oil pan. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

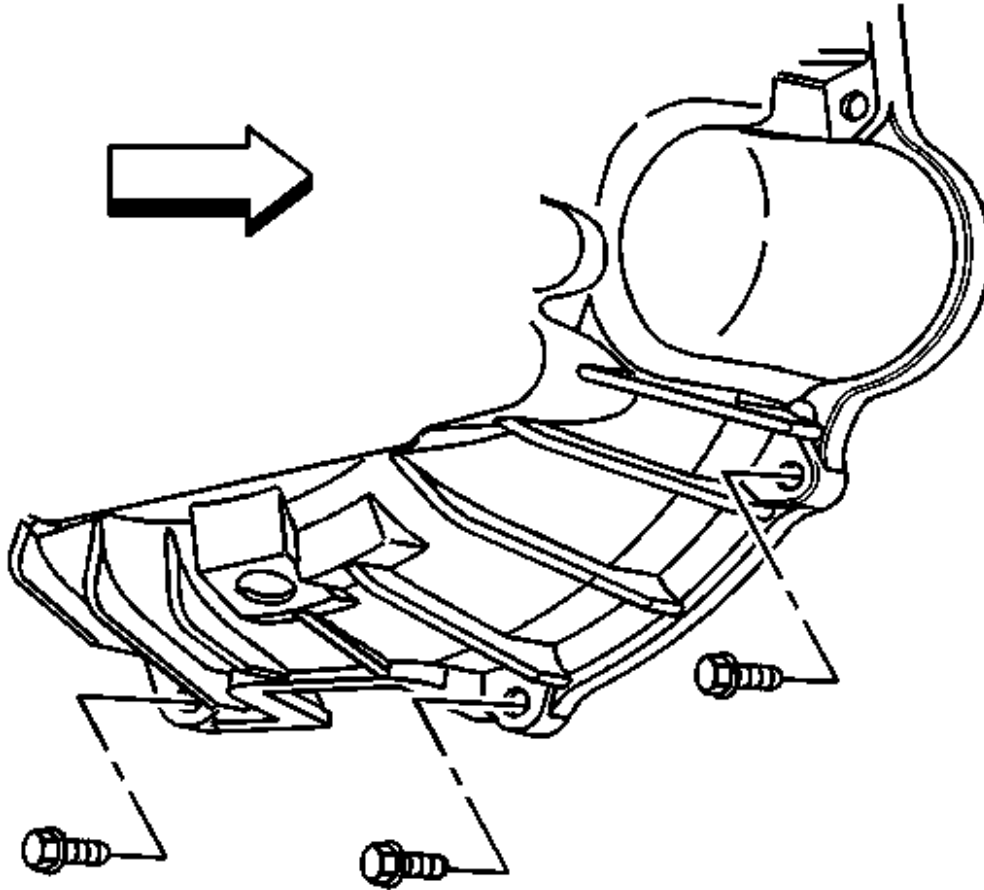


Fig. 142: Identifying Transmission To Oil Pan Bolts

Courtesy of GENERAL MOTORS CORP.

NOTE: Any time the transmission and the engine oil pan are off of the engine at the same time, install the transmission before the oil pan. This is to allow for the proper oil pan alignment. Failure to achieve the correct oil pan alignment can result in transmission failure.

1. Install the oil pan to the engine. Refer to **Oil Pan Installation**.

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

2. Install the transmission to oil pan bolts and nuts.

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

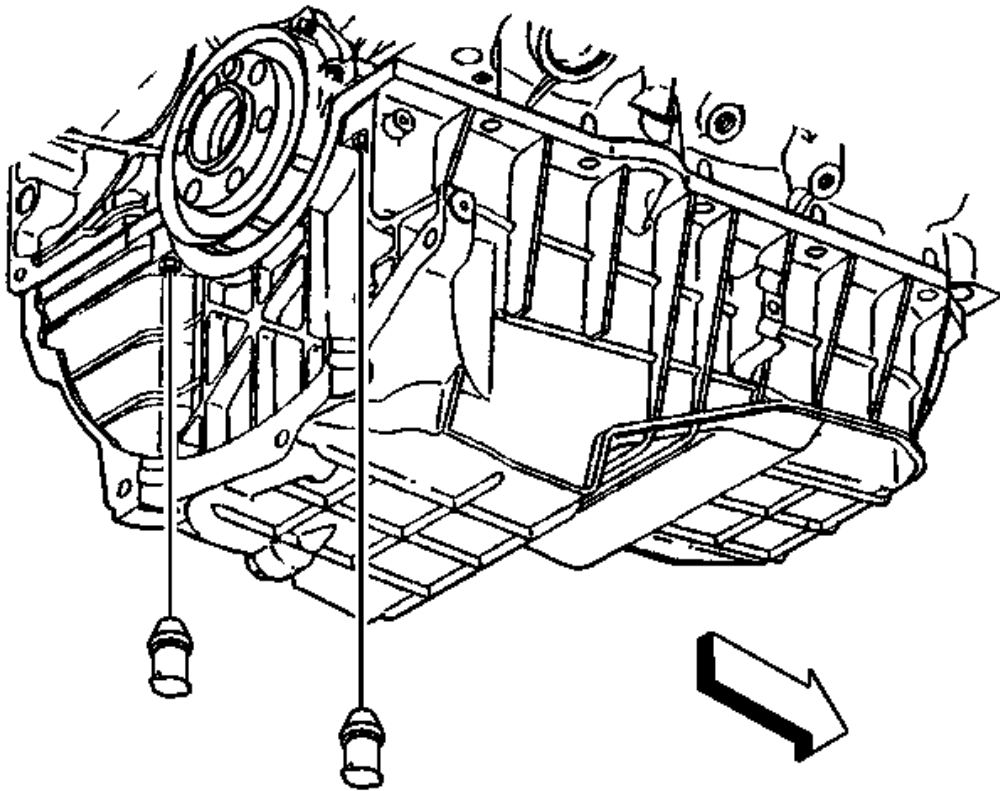


Fig. 143: Expanded View Of Oil Pan Rear Nuts Access Plugs
Courtesy of GENERAL MOTORS CORP.

3. Install the access plugs for the oil pan rear nuts.
4. Position the front differential carrier assembly.
5. Install the carrier upper and lower mounting bolts and nuts (AWD only). Refer to **Differential Carrier Assembly Replacement** in Front Drive Axle.
6. Install the inner axle shaft housing support bracket to frame washers and nuts (AWD only). Refer to **Differential Carrier Assembly Replacement** in Front Drive Axle.

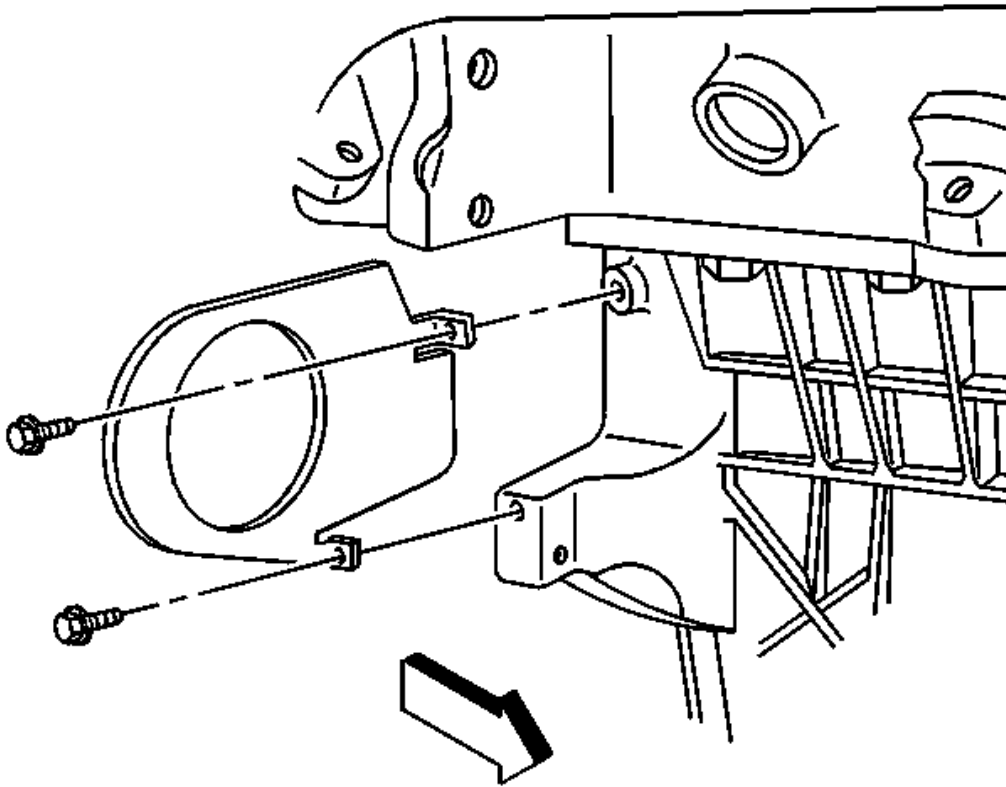


Fig. 144: View Of Transmission Cover
Courtesy of GENERAL MOTORS CORP.

7. Install the transmission cover.

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

8. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.

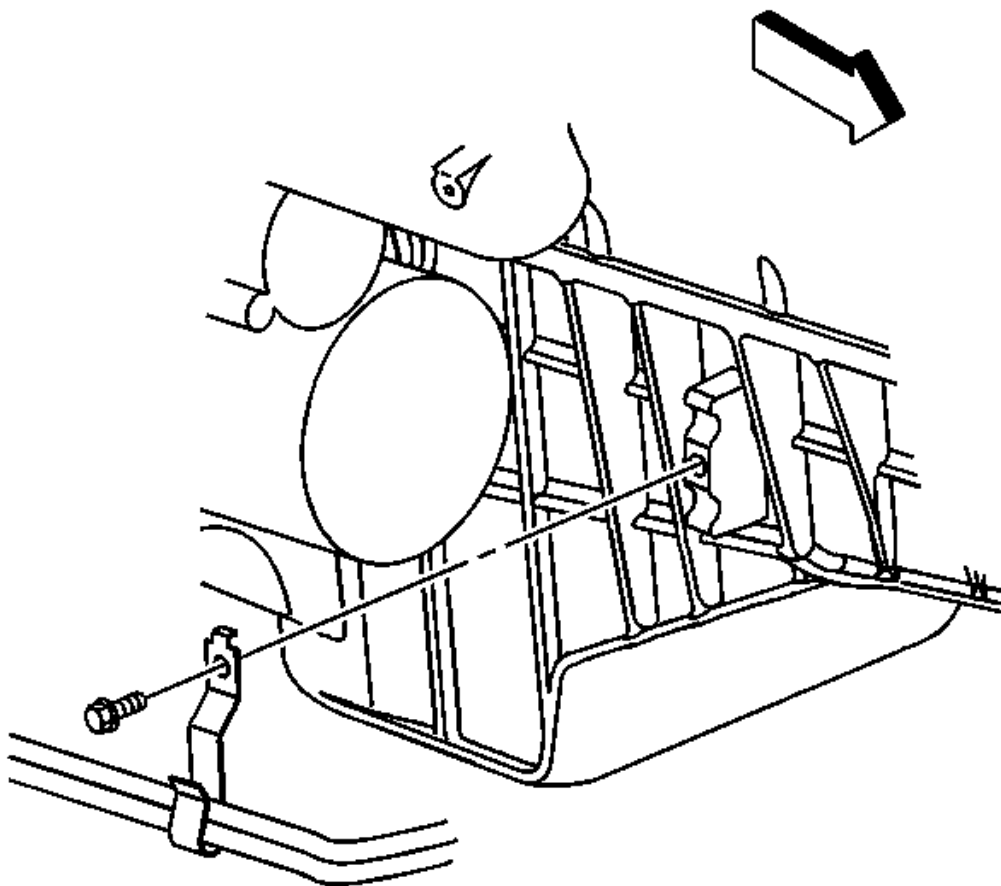


Fig. 145: Identifying Starter Wiring Harness & Transmission Cooler Pipes Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the bolt holding the bracket for the starter wiring harness and the transmission cooler pipes.

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

10. Install the CKP sensor wiring harness in the retainer.
11. Install the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.

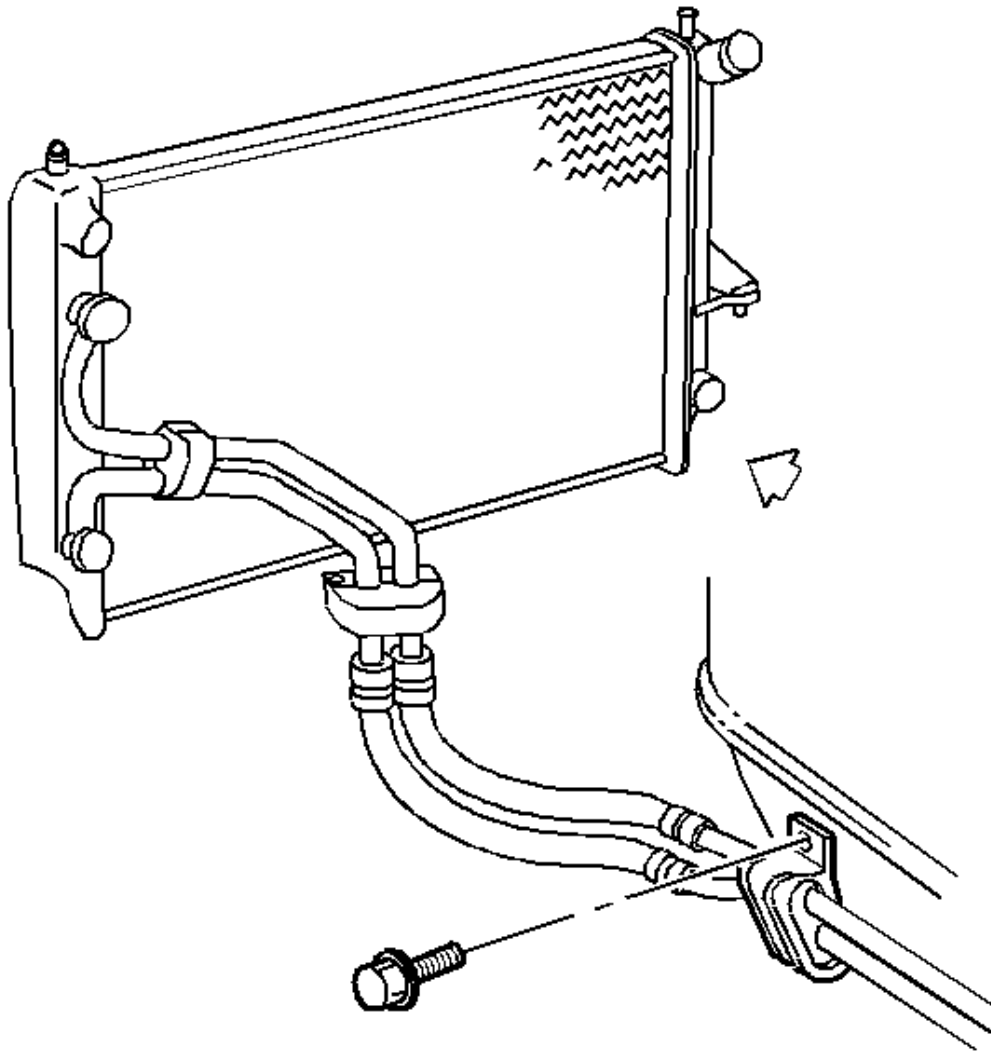


Fig. 146: Locating Oil Cooler Pipes Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

12. Install the oil cooler pipes bracket bolt.

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

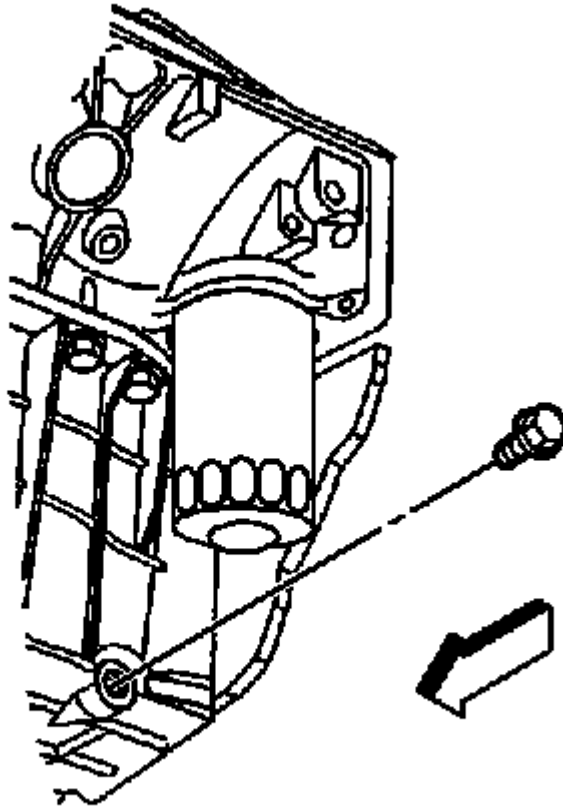


Fig. 147: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

13. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
14. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

15. Lower the vehicle.
16. Fill the crankcase with engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
17. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

J 41712 Oil Pressure Switch Socket. See **Special Tools**.

Removal Procedure

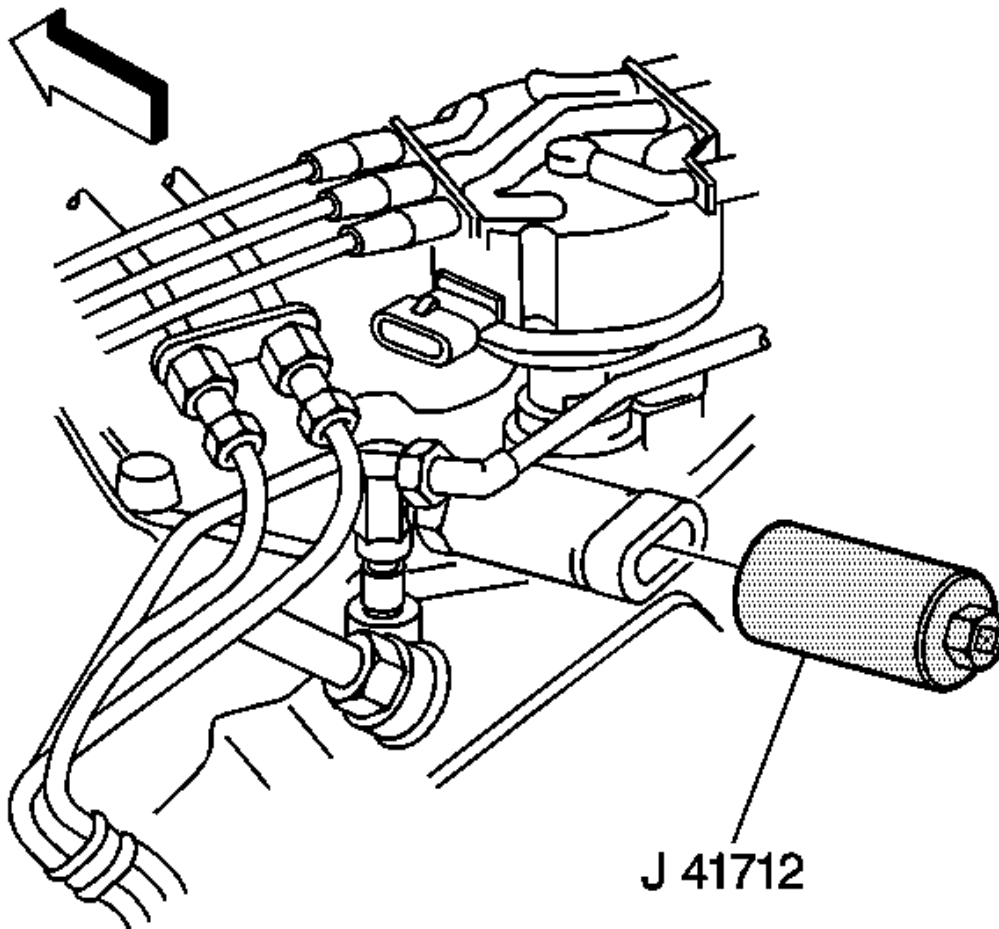


Fig. 148: Identifying J 41712

Courtesy of GENERAL MOTORS CORP.

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Disconnect the engine oil pressure sensor gage electrical connector.
3. Hold the engine oil pressure gage sensor fitting with a wrench.
4. Remove the engine oil pressure gage sensor using **J 41712** . See **Special Tools**.

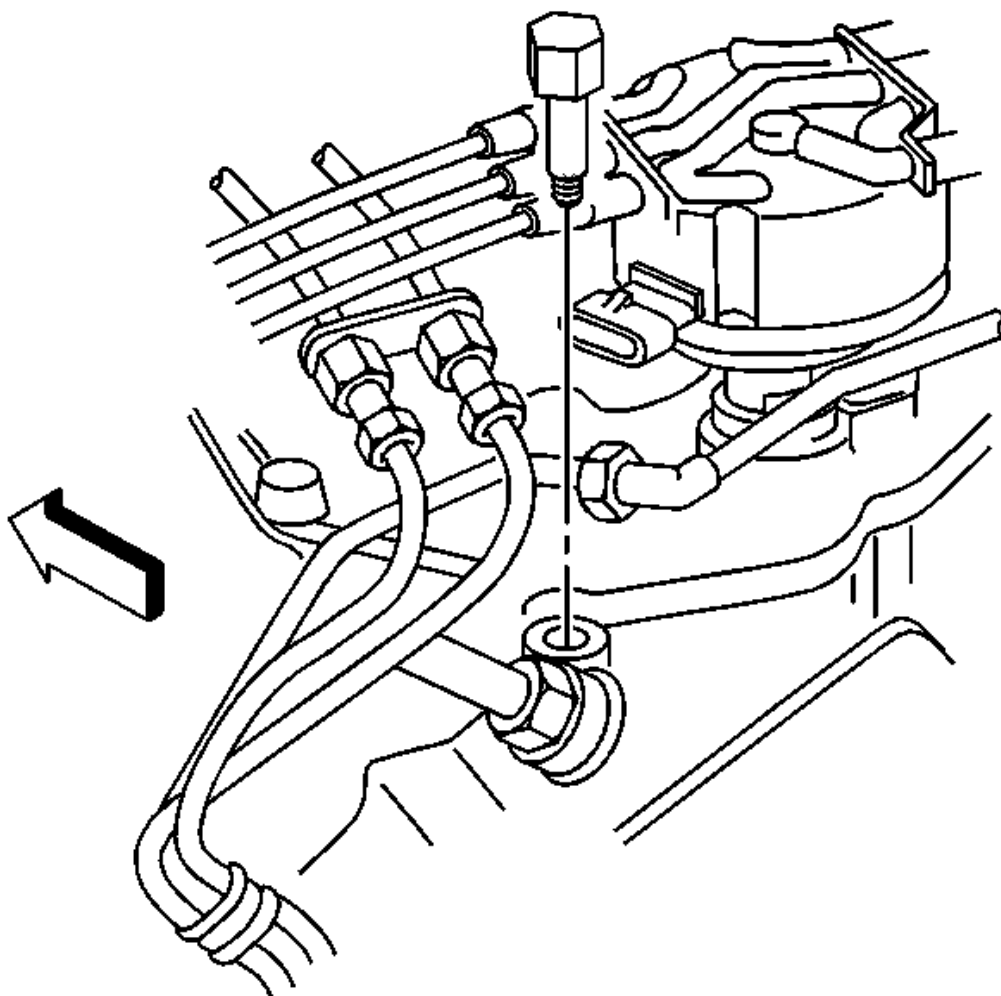


Fig. 149: View Of Engine Oil Pressure Gage Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the alignment of the engine oil pressure gage sensor fitting prior to removal.

5. Remove the engine oil pressure gage sensor fitting, if necessary.

Installation Procedure

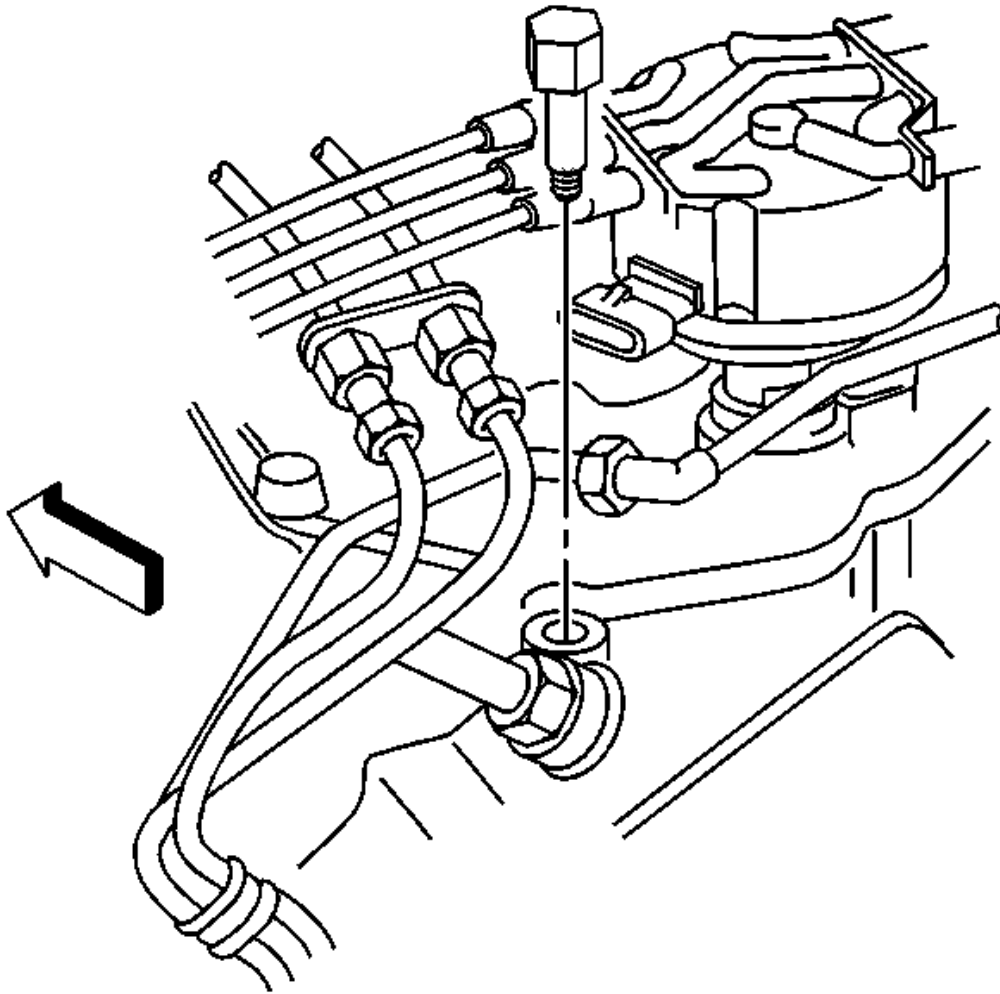


Fig. 150: View Of Engine Oil Pressure Gage Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine oil pressure gage sensor fitting, if removed.

Tighten:

1. Tighten the engine oil pressure gage sensor fitting to 15 N.m (11 lb ft).

IMPORTANT: Do not loosen the sensor fitting. Do not tighten the sensor fitting more than one turn to align.

2. Tighten the sensor fitting until properly aligned.

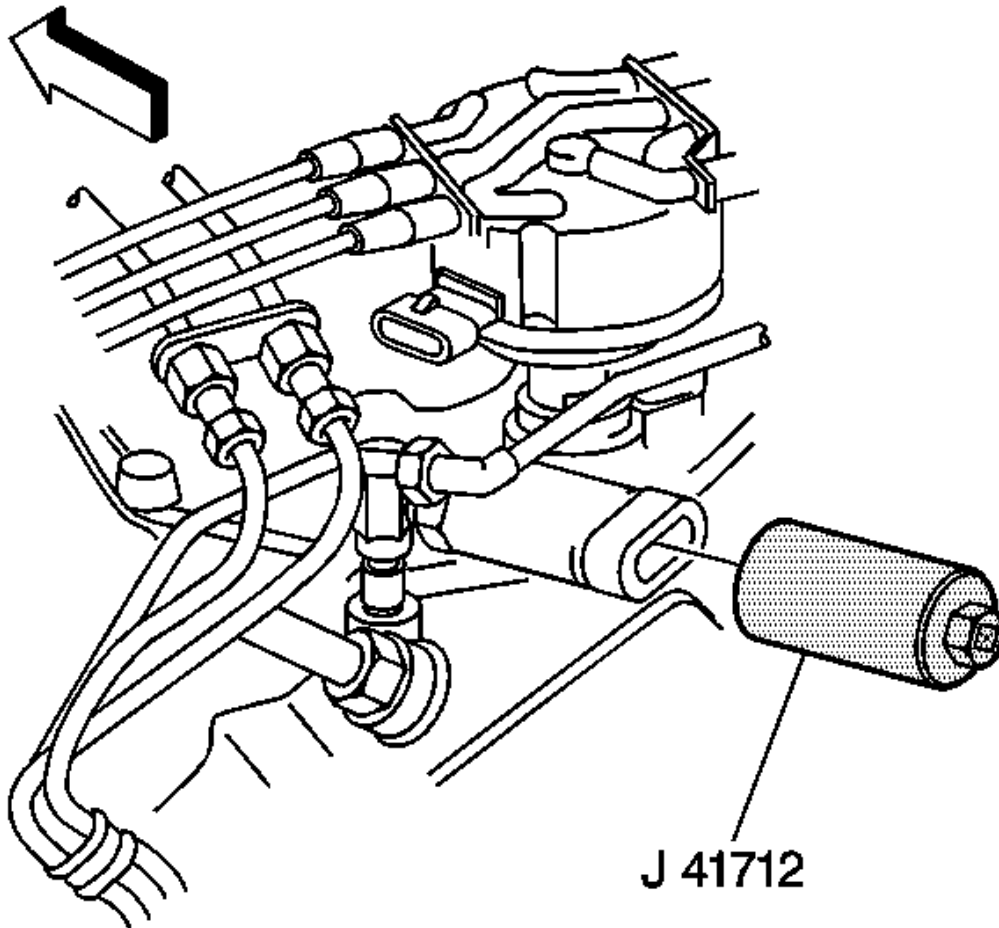


Fig. 151: Identifying J 41712

Courtesy of GENERAL MOTORS CORP.

2. Install the engine oil pressure gage sensor.
3. Hold the engine oil pressure gage sensor fitting with a wrench to prevent from turning.

Tighten: Using **J 41712** tighten the engine oil pressure gage sensor to 30 N. See **Special Tools.m** (22 lb ft).

4. Install the engine oil pressure gage sensor electrical connector.
5. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.

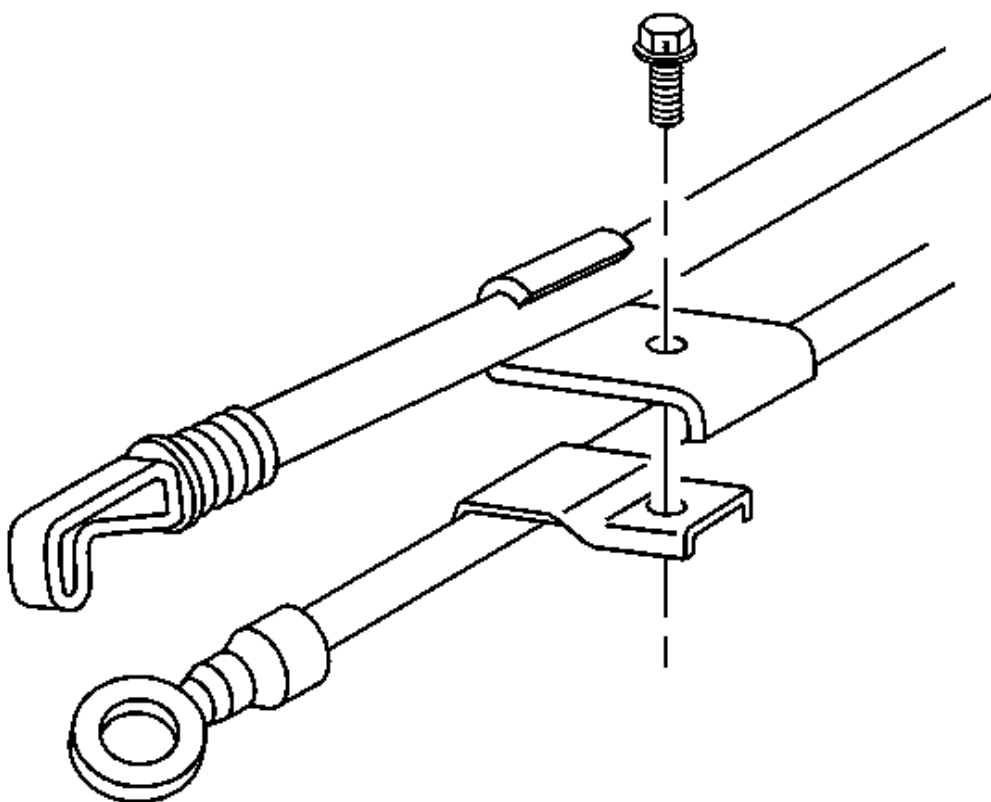
Oil Level Indicator and Tube Replacement**Removal Procedure**

Fig. 152: View Of Oil Level Indicator Tube To Transmission Fluid Fill Tube Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
2. Remove the oil level indicator.
3. Remove the bolt holding the oil level indicator tube to the transmission fluid fill tube.

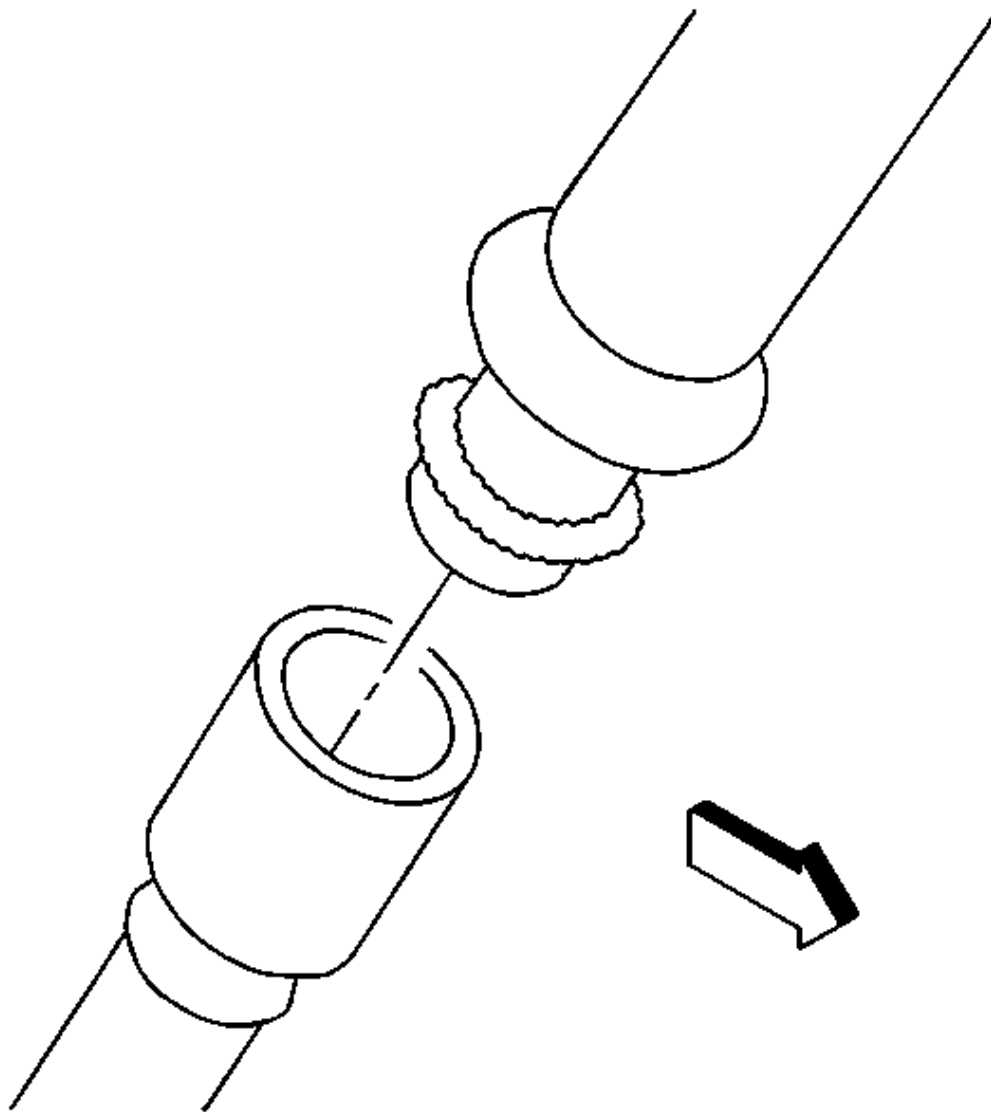


Fig. 153: Upper & Lower Oil Level Indicator Tubes
Courtesy of GENERAL MOTORS CORP.

4. Remove the upper half of the oil level indicator tube from the lower half.
5. Clean the old sealer from the tube.

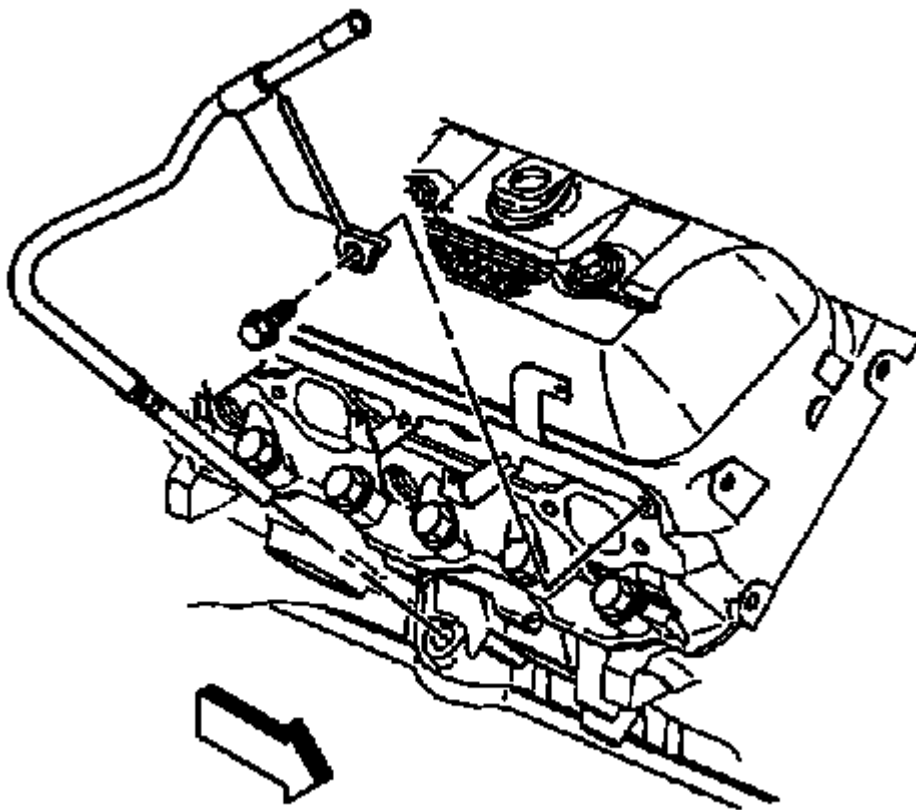


Fig. 154: Removing Oil Level Indicator Tube & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil level indicator tube bolt.
7. Remove the oil level indicator tube from the engine using a twisting motion.
8. Clean the old sealer from the oil level indicator tube and the engine block.

Installation Procedure

1. Install the lower half of the oil level indicator tube to the engine. Refer to **Oil Level Indicator and Tube Installation**.

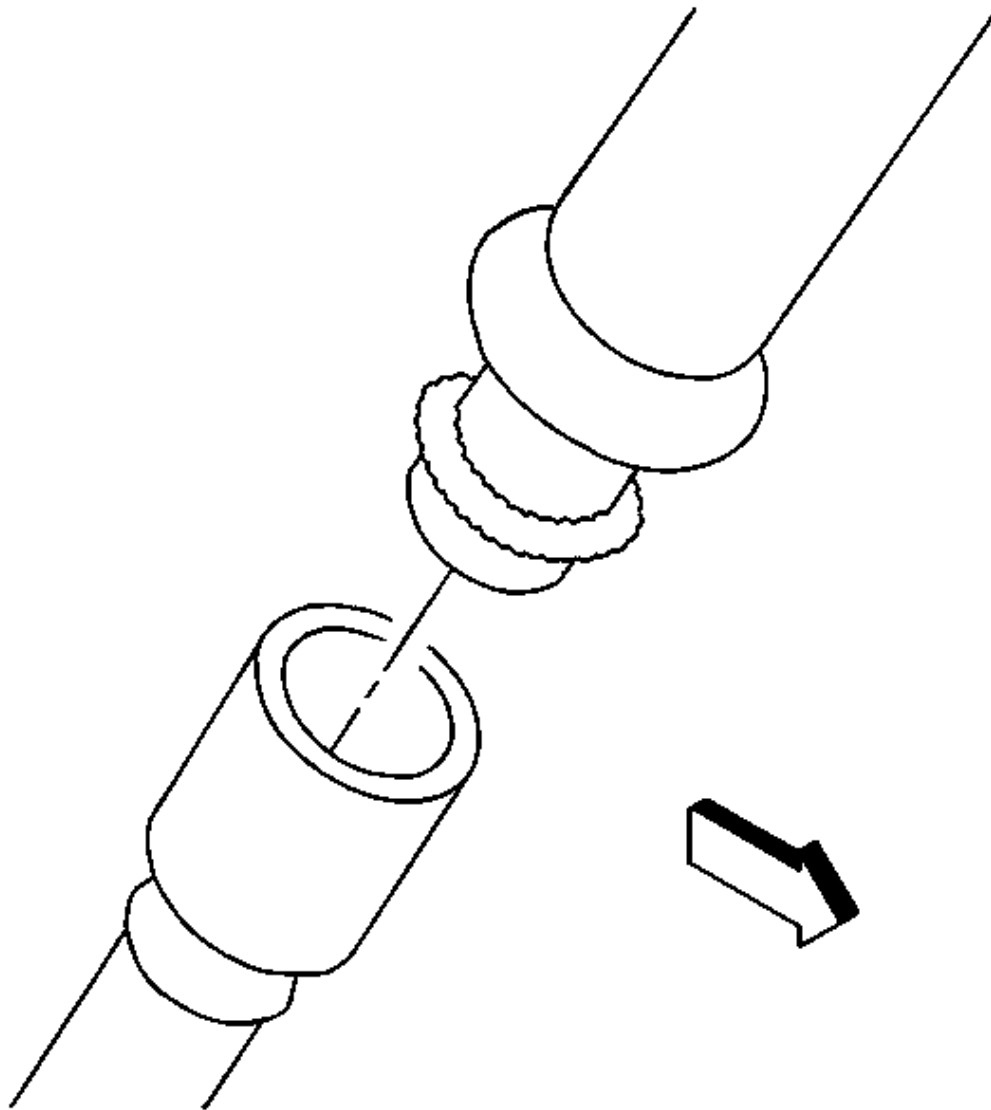


Fig. 155: Upper & Lower Oil Level Indicator Tubes
Courtesy of GENERAL MOTORS CORP.

2. Apply sealer, GM P/N 12346004 (Canadian P/N 10953480) or equivalent, on the upper oil level indicator tube to the area where the tube fits into the lower half.
3. Install the oil level indicator tube upper half to the lower half.

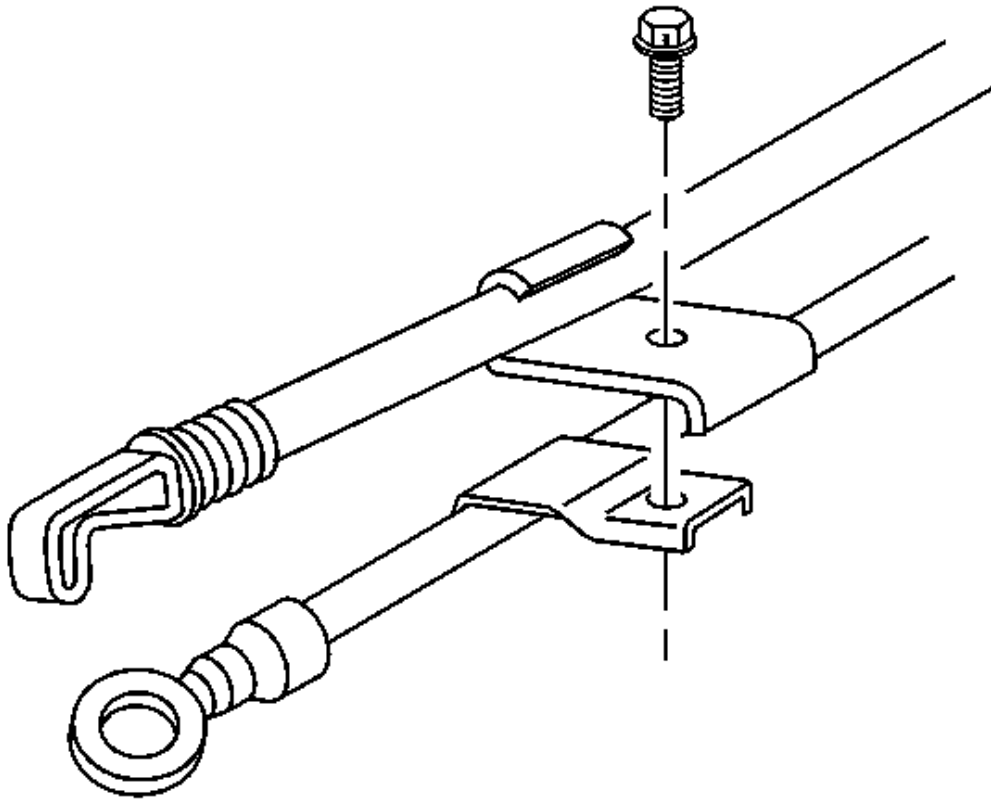


Fig. 156: View Of Oil Level Indicator Tube To Transmission Fluid Fill Tube Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Secure the engine oil level indicator tube to the transmission fluid fill tube with the bolt.

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

5. Install the oil level indicator.
6. Install the engine cover. Refer to Engine Cover Replacement in Interior Trim.

Oil Pump Replacement

Removal Procedure

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

2. Remove the oil pump. Refer to **Oil Pump Removal**.
3. Clean and inspect all parts. Refer to **Oil Pump Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Use a NEW oil pump driveshaft retainer.

1. Install the oil pump. Refer to **Oil Pump Installation**.
2. Install the oil pan. Refer to **Oil Pan Replacement**.

Crankshaft Rear Oil Seal Replacement**Tools Required**

J 35621-B Rear Main Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.
2. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

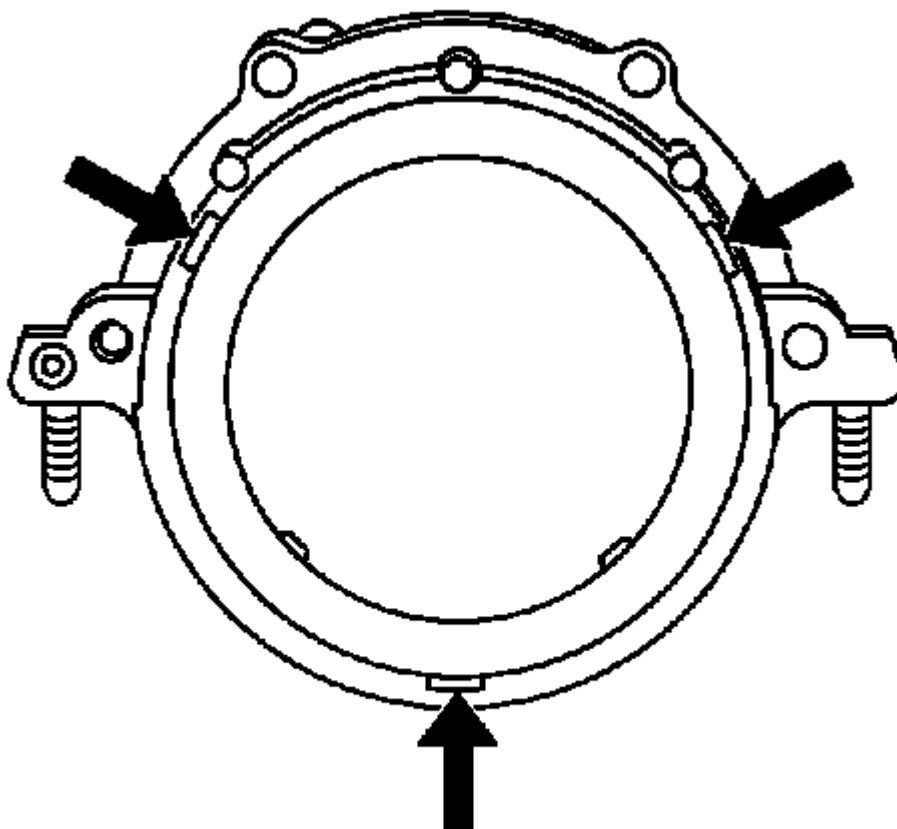


Fig. 157: Crankshaft Rear Oil Seal Notches
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.

4. Discard the crankshaft rear oil seal.
5. Clean off any dirt or rust in the area.

Installation Procedure

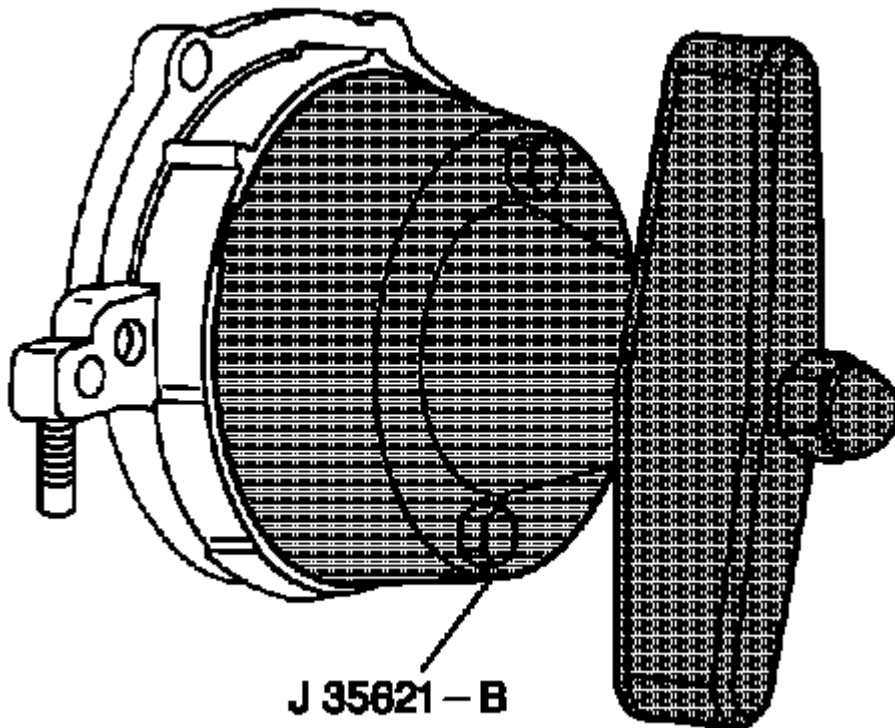


Fig. 158: Installing Crankshaft Rear Oil Seal Using J 35621-B
Courtesy of GENERAL MOTORS CORP.

1. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
2. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
3. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
4. Apply a small amount (2 to 3 drops) of clean engine oil to the crankshaft seal surface.
5. Inspect the **J 35621-B** flange for imperfections that may damage the crankshaft rear oil seal. See **Special Tools**.

Minor imperfections may be removed with a fine grade emery cloth.

IMPORTANT: DO NOT allow oil or any other lubricants to contact the seal lip surface of the crankshaft rear oil seal.

6. Remove the sleeve from the crankshaft rear oil seal.
7. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil seal.

8. Install the crankshaft rear oil seal onto the **J 35621-B**. See **Special Tools**.
9. Install the **J 35621-B** onto the rear of the crankshaft and hand tighten the tool bolts until snug. See **Special Tools**.

NOTE: Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

10. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 1. Turn the **J 35621-B** wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing. See **Special Tools**.

Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.
 2. Turn the **J 35621-B** wing nut counterclockwise to release the **J 35621-B** from the crankshaft rear oil seal. See **Special Tools**.
11. Remove the **J 35621-B** from the crankshaft. See **Special Tools**.
12. Wipe off any excess engine oil with a clean rag.
13. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.
14. Install the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.

Crankshaft Rear Oil Seal Housing Replacement

Removal Procedure

IMPORTANT: Do not remove the crankshaft rear oil seal housing if only replacing the crankshaft rear oil seal.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.
3. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.

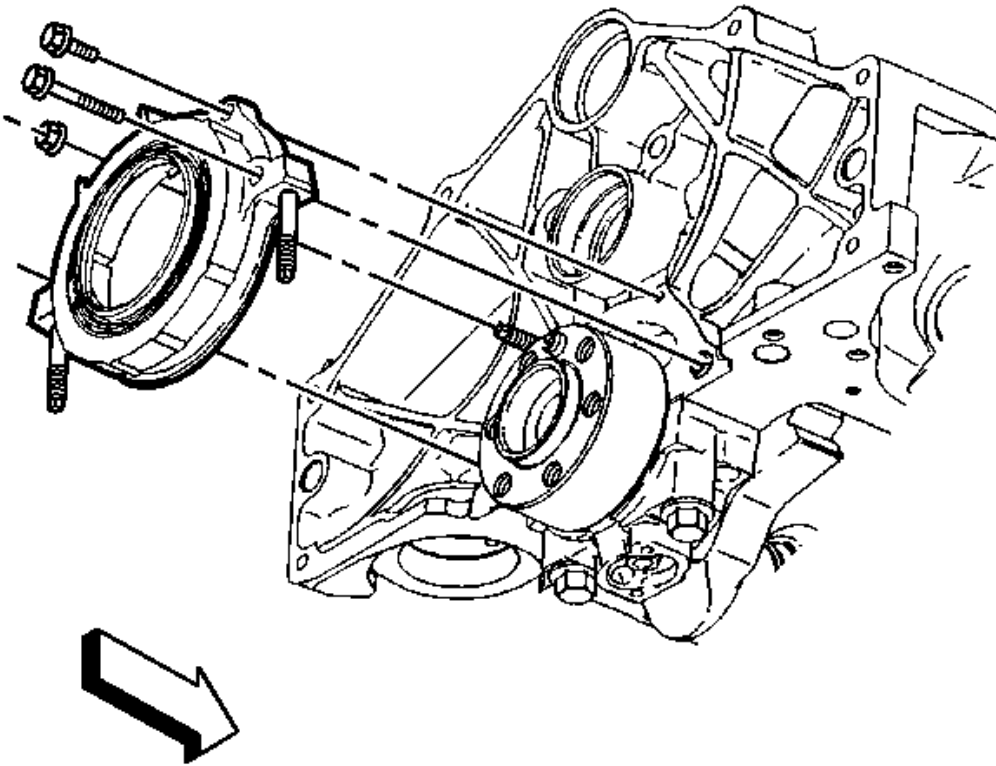


Fig. 159: Removing Crankshaft Rear Oil Seal Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and the nut holding the crankshaft rear oil seal housing to the engine.
5. Remove the crankshaft rear oil seal housing.

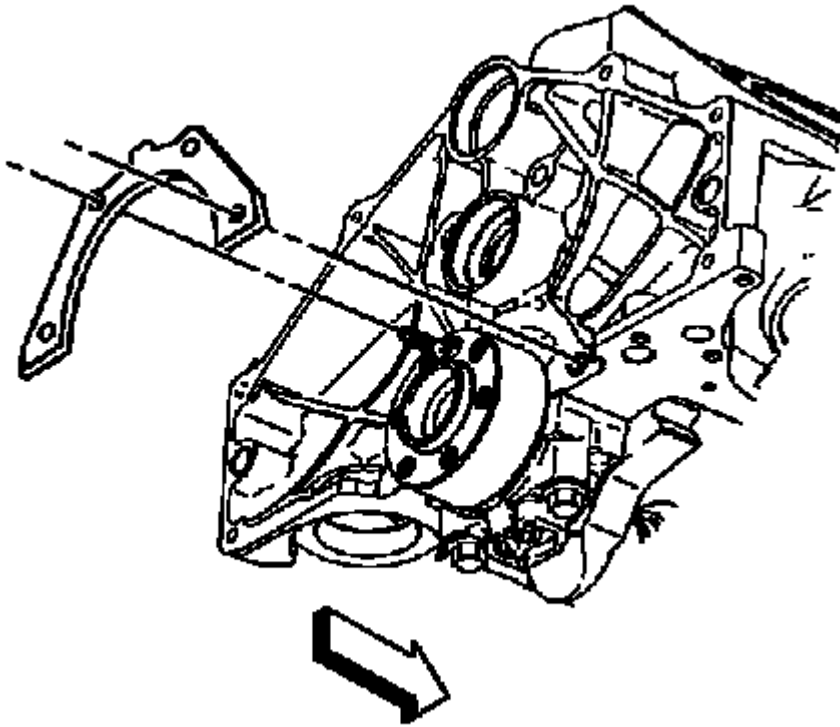


Fig. 160: Removing Housing Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the crankshaft rear oil seal housing gasket.
7. Clean all the sealing surfaces.
8. Inspect and replace the crankshaft rear oil seal housing for warping, cracks, wear, or damage.

Installation Procedure

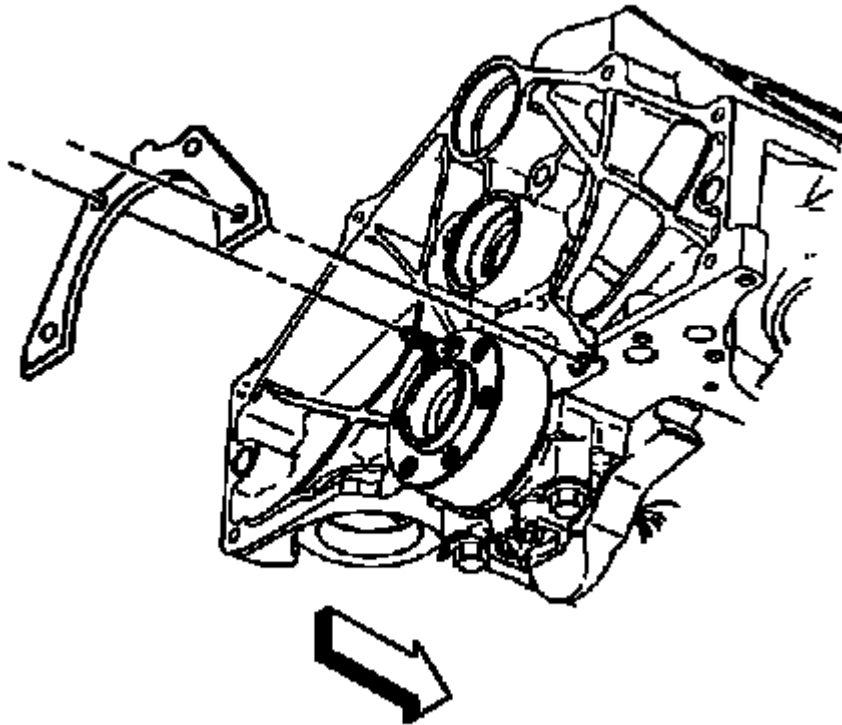


Fig. 161: Removing Housing Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing a NEW crankshaft rear oil seal housing the crankshaft rear oil seal will come with the housing. If reusing the housing and then installing a NEW seal follow the instructions for installing the housing and then refer to Crankshaft Rear Oil Seal Replacement to install the seal.

1. Install a NEW crankshaft rear oil seal housing gasket.

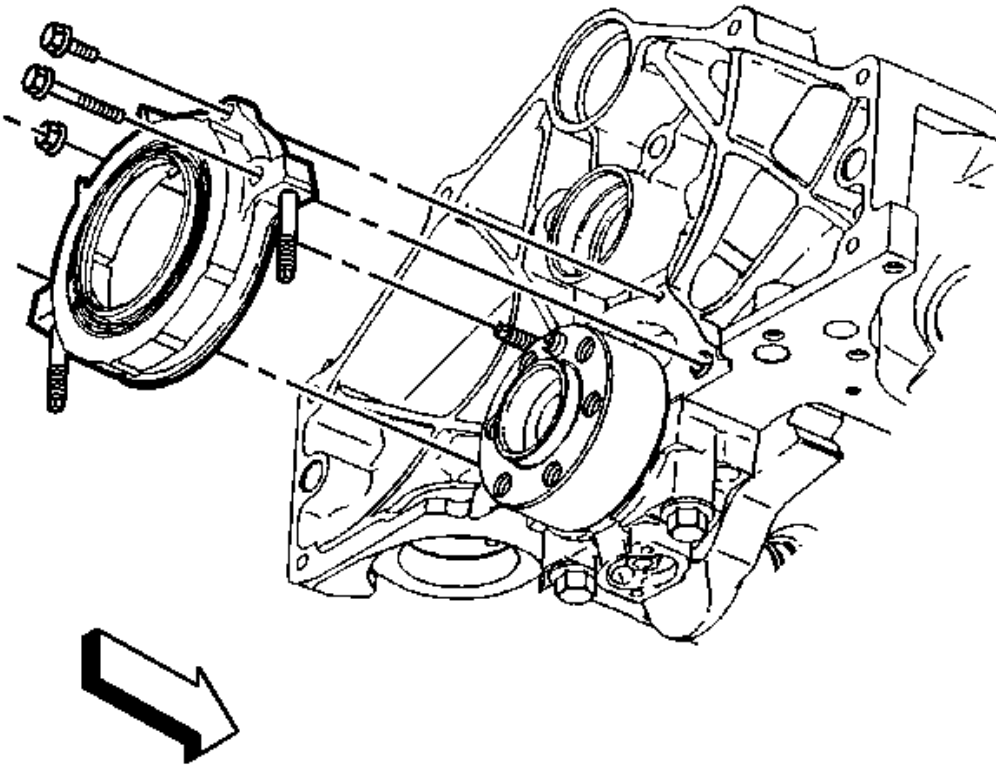


Fig. 162: Removing Crankshaft Rear Oil Seal Housing & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW crankshaft rear oil seal housing with the oil seal to the engine block using the following procedure.

IMPORTANT: Do not oil or grease the seal lip or the crankshaft seal area.

1. Leave the sleeve in the crankshaft rear oil seal and use the sleeve as a guide to ease the seal lip over the end of the crankshaft.
2. Push the crankshaft rear oil seal housing fully onto the crankshaft until the crankshaft rear oil seal housing is against the crankshaft rear oil seal gasket and the engine.
3. Remove the sleeve.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts and the nut to the crankshaft rear oil seal housing.

Tighten: Tighten the crankshaft rear oil seal housing bolts and nut to 12 N.m (106 lb in).

4. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

NOTE: Any time the transmission and the engine oil pan are off of the engine at the same time, install the transmission before the oil pan. This is to allow for the proper oil pan alignment. Failure to achieve the correct oil pan alignment can result in transmission failure.

5. Install the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.
6. Install the oil pan. Refer to **Oil Pan Replacement**.

Engine Flywheel Replacement

Removal Procedure

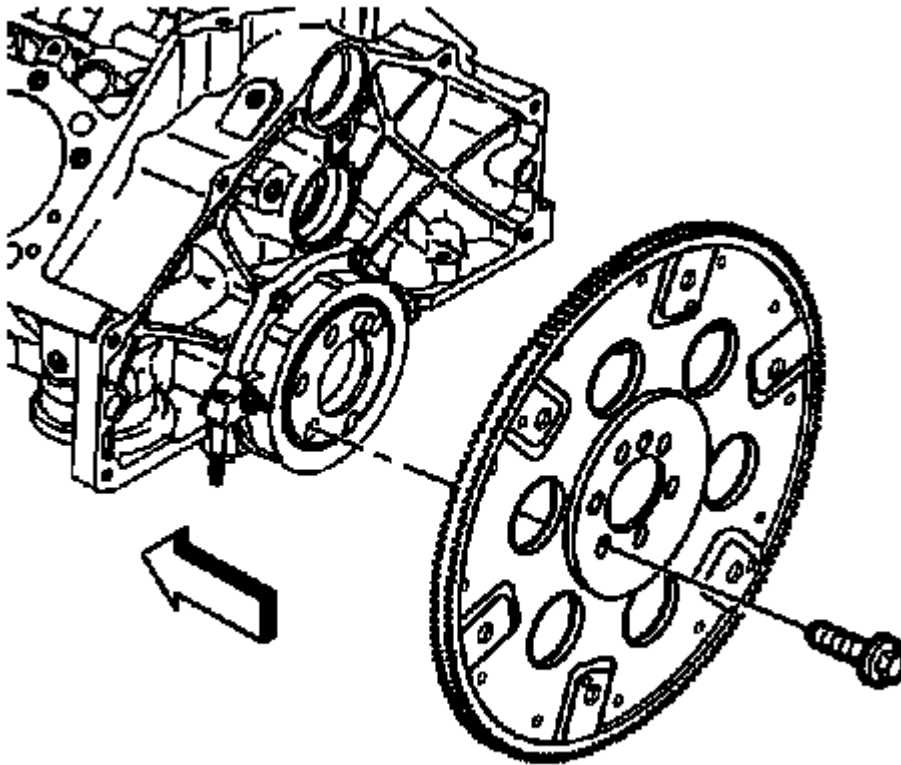


Fig. 163: Expanded View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.
2. Remove the bolts and the engine flywheel.
3. Clean and inspect all parts. Refer to **Engine Flywheel Cleaning and Inspection**.

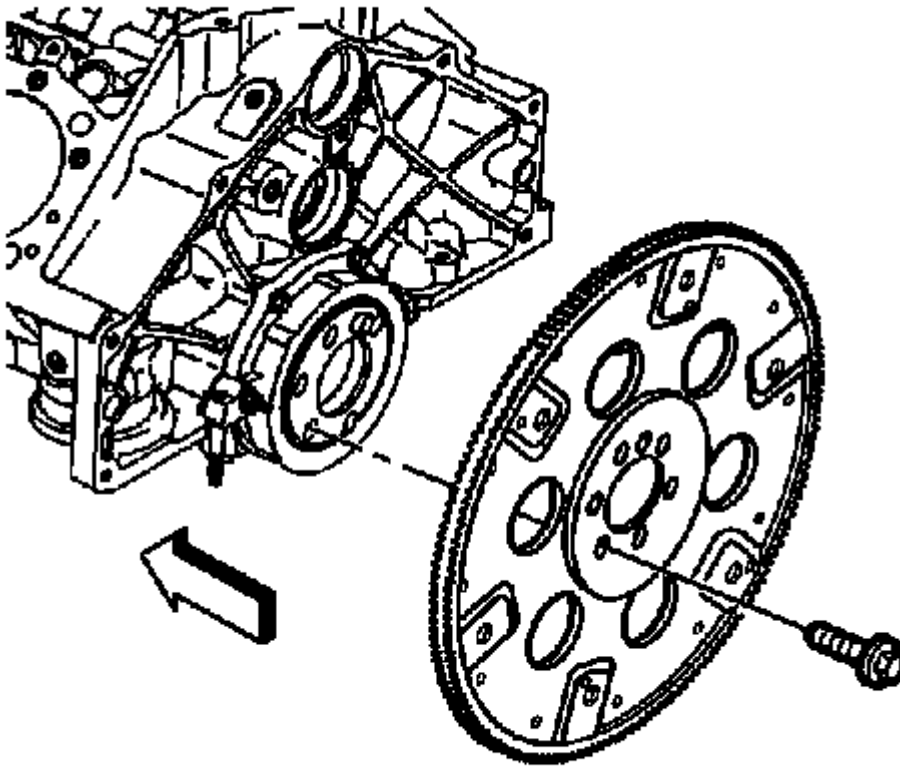
Installation Procedure

Fig. 164: Expanded View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the engine flywheel to the crankshaft.
2. Align the locator hole to the pin.

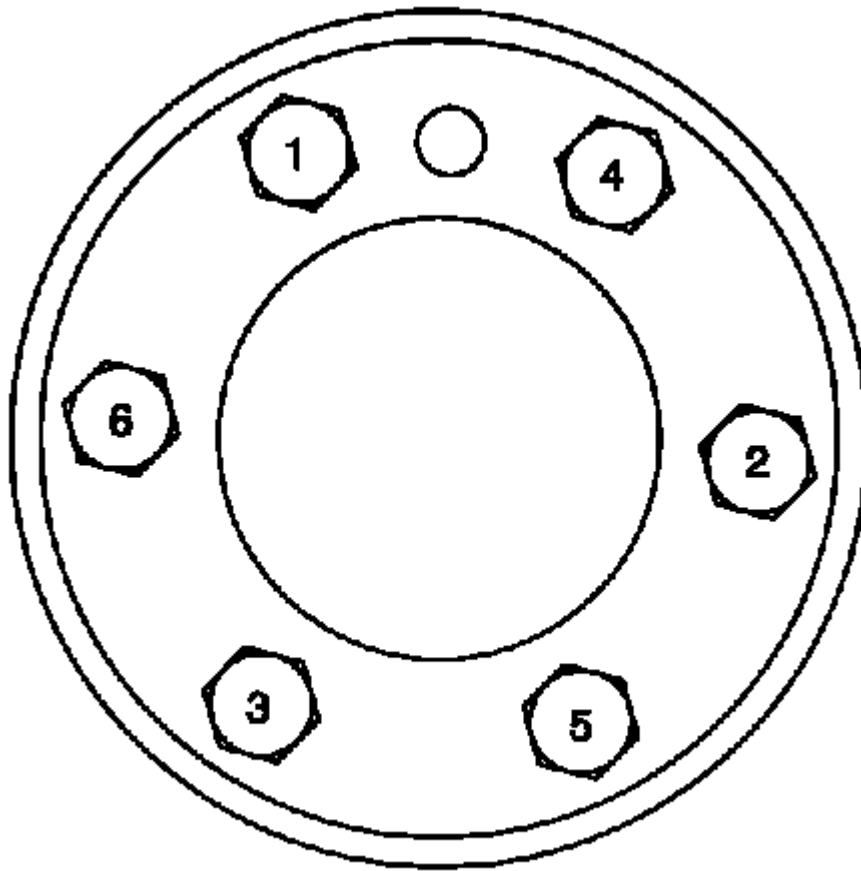


Fig. 165: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine flywheel bolts.

Tighten: Tighten the engine flywheel bolts in sequence to 100 N.m (74 lb ft).

4. Install the transmission assembly. Refer to **Transmission Replacement** in Automatic Transmission-4L60-E.

Engine Replacement

Tools Required

- J 41427 Engine Lift Bracket
- J 41602 Body Protection Hoist Adapter Set
- J 39580 Universal Engine Support Table. See **Special Tools**.

NOTE: Failure to flush out the oil cooling system or the engine cooling system may result in premature failure of the replacement engine.
If the engine is damaged internally and a new engine is installed, make sure that all foreign material is completely flushed out of the cooling system.
The oil cooler system should be also be flushed out, if equipped.

IMPORTANT: This procedure must be performed on a side lift hoist. The engine and front frame assembly will be removed out of the bottom of the vehicle. A single post hoist or a twin post hoist cannot be used to perform this procedure.

Removal Procedure

1. Disconnect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
3. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 4.3L.
4. Remove the air cleaner outlet duct from the throttle body. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls - 4.3L.
5. Remove the following components:
 - The upper fan shroud
 - The fan
 - The fan clutch
 - The lower fan shroud
 - Both radiator hoses
 - The oil cooler lines
 - The transmission cooler lines
6. Disconnect the air conditioning hose at the accumulator and the condenser, if equipped. Refer to **Compressor/Condenser Hose Replacement - Auxiliary** in Heating, Ventilation and Air Conditioning.
7. Remove the bolts holding the condenser to the radiator.
8. Remove the radiator. Refer to **Radiator Replacement** in Engine Cooling.

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.

9. Remove the accelerator control cable. Refer to **Accelerator Controls Cable Replacement** in Engine Controls - 4.3L.
10. Remove the cruise control cable, if equipped, from the throttle shaft. Refer to **Cruise Control Cable**

Replacement in Cruise Control.

11. Remove the cruise control cable from the accelerator control cable bracket.
12. Remove the power steering reservoir and drain the fluid. Refer to **Remote Power Steering Fluid Reservoir Replacement** in Power Steering Systems.
13. Disconnect the pipes from the hydro boost unit. Refer to **Hydraulic Brake Booster Replacement** in Hydraulic Brakes.
14. Disconnect the master cylinder from the hydro boost unit. Refer to **Master Cylinder Replacement** in Hydraulic Brakes.
15. Tie the master cylinder to the oil fill tube.
16. Disconnect the steering shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.
17. Disconnect the heater hoses from the engine. Refer to **Heater Hose Replacement - Inlet** in Heating, Ventilation and Air Conditioning.

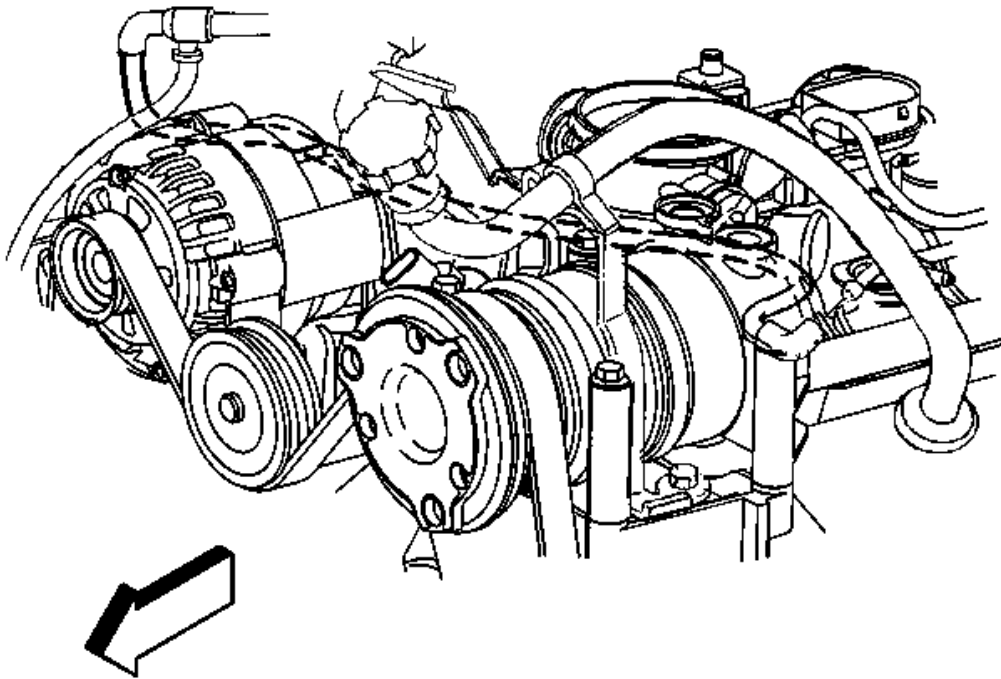


Fig. 166: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the vacuum hose to the vacuum tank from the intake manifold.
19. Disconnect the engine wiring harness from the VCM.

20. Disconnect the fuse box and the wiring harness from the bulkhead connector.
21. Disconnect the negative battery cable from the battery. Disconnect the battery cable assembly from the fender and the radiator support. Refer to **Battery Negative Cable Replacement** in Engine Electrical.
22. Secure the battery cable assembly to the engine.
23. Disconnect all related electrical connectors that connect the wiring harness to the body under the hood including the following:
 - The ground wires
 - The A/C module
 - The differential pressure input switch
24. Remove the wiring harness from the retainers and lay the harness on the engine.

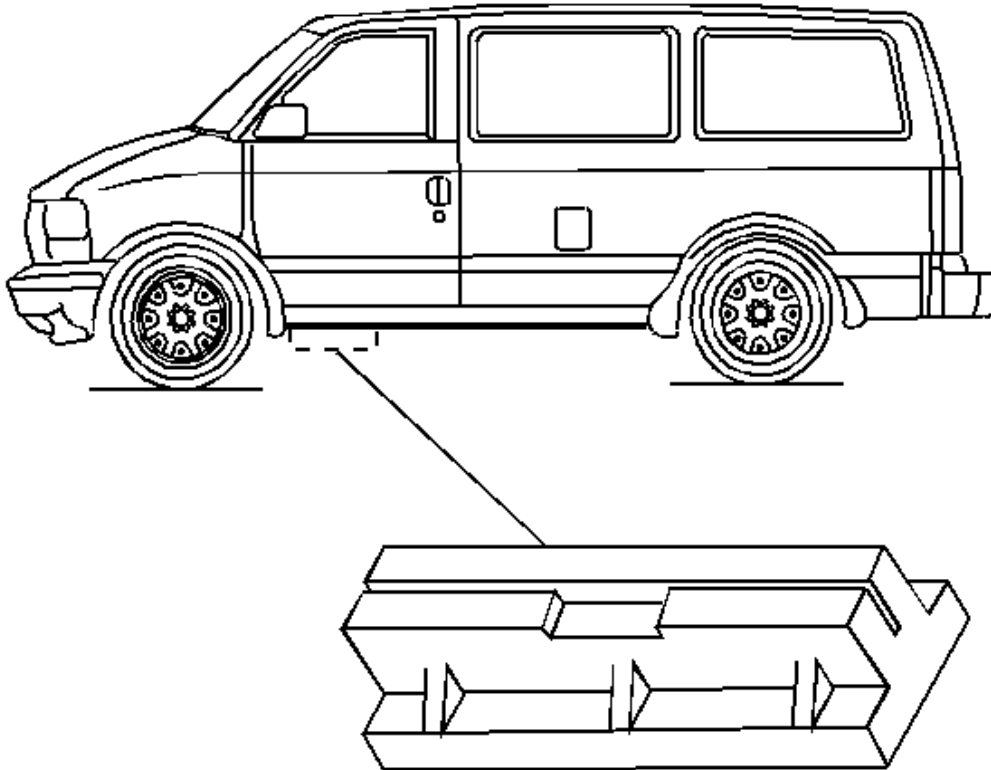


Fig. 167: Identifying J 41602

Courtesy of GENERAL MOTORS CORP.

25. Remove the front section of the running boards, if equipped. Refer to **Assist Step Extension Replacement - Front** in Frame and Underbody.

26. Install the **J 41602** to the pinch weld area on both sides of the vehicle.
27. Position the front hoist arms under the **J 41602** . Refer to **Lifting and Jacking the Vehicle** in General Information for correct position of the rear hoist arms.
28. Make sure the rear of the vehicle is slightly higher than the front.
29. Raise the vehicle.

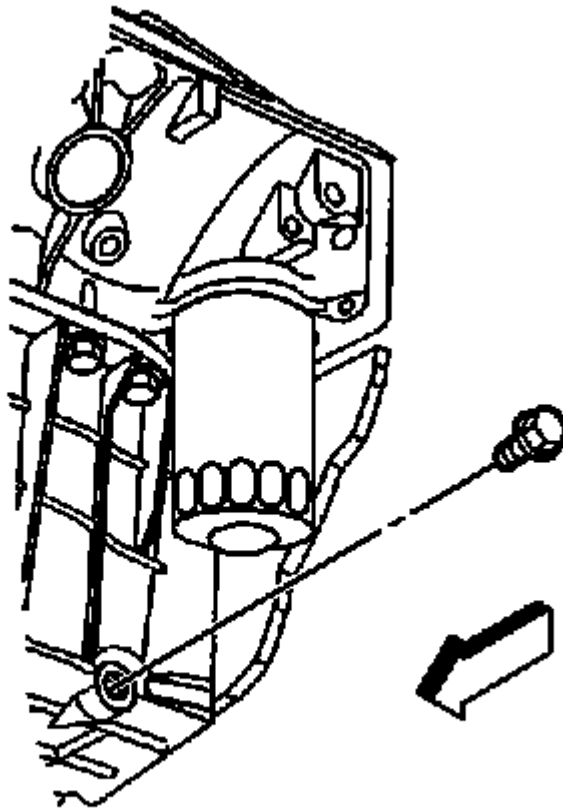


Fig. 168: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

30. Remove the oil pan drain plug and drain the engine oil into a suitable container.
31. Remove the engine oil cooler pipes from the oil filter adapter. Refer to **Engine Oil Cooler Hose/Pipe Replacement** in Engine Cooling.
32. Remove the rear propeller shaft. Refer to **Propeller Shaft Replacement - Rear** in Propeller Shaft.

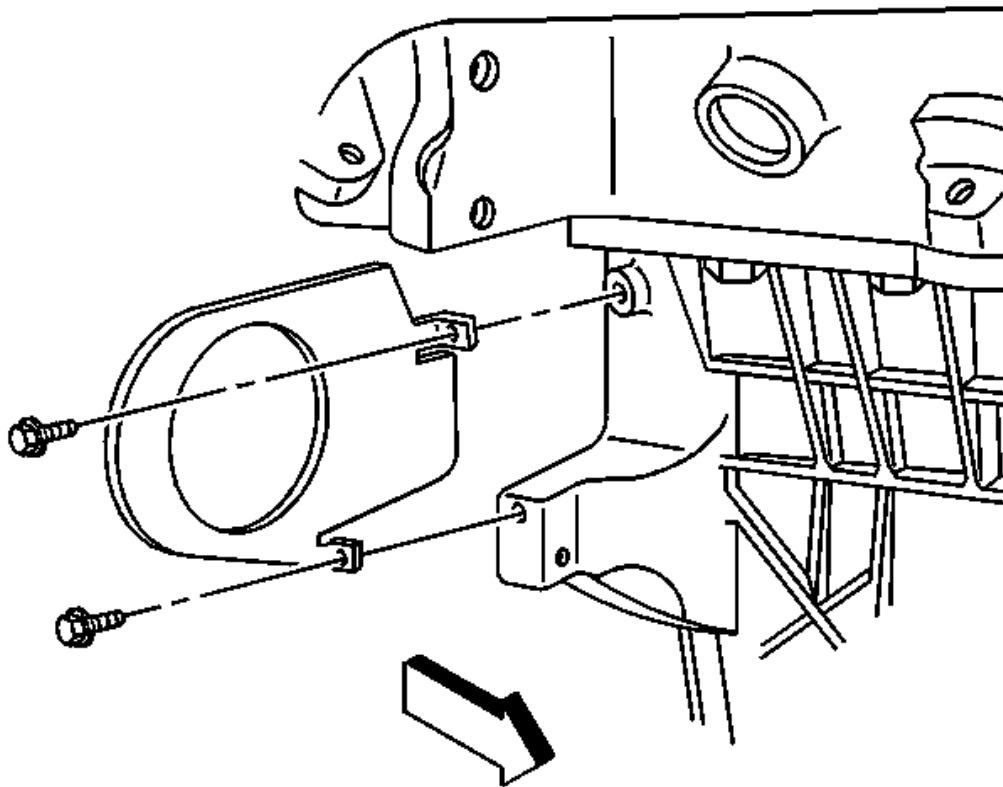


Fig. 169: View Of Transmission Cover
Courtesy of GENERAL MOTORS CORP.

33. Remove the starter. Refer to **Starter Motor Replacement** in Engine Electrical.

IMPORTANT: Make sure NOT to break the cover rails.

34. Remove the transmission cover.

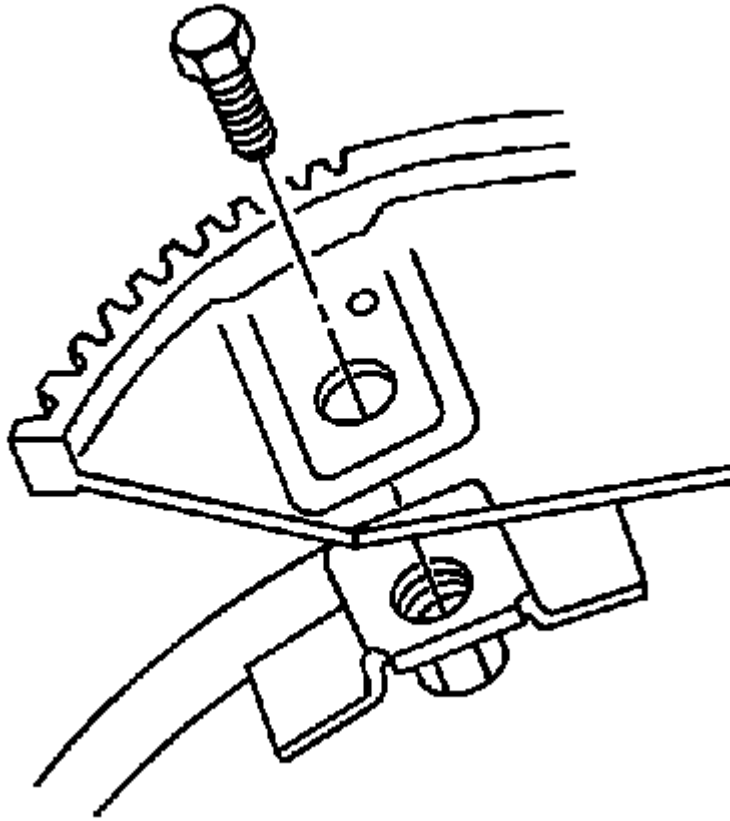


Fig. 170: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

35. Remove the torque converter bolts through the starter opening.
36. Disconnect the shift cable from the transmission. Refer to **Automatic Transmission Range Selector Cable Replacement** in Automatic Transmission - 4L60-E.
37. Remove the heat shield.
38. Disconnect the exhaust system at the main flange behind the catalytic converter. Refer to **Catalytic Converter Replacement (RWD)** or **Catalytic Converter Replacement (A4WD)** in Engine Exhaust.
39. Remove the muffler and tail pipe section from the hangers and remove from the vehicle.

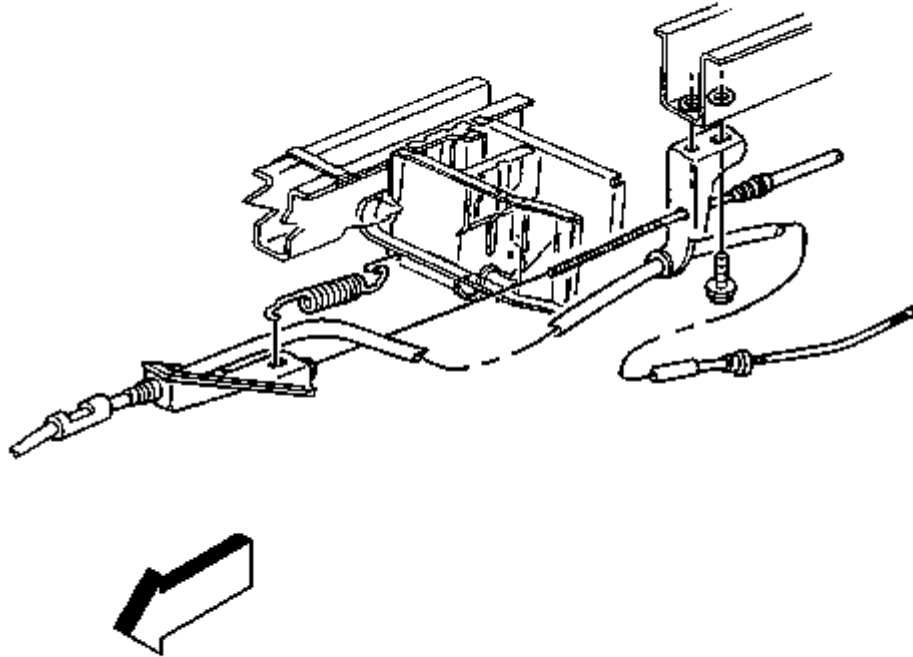


Fig. 171: View Of Park Brake Bracket
Courtesy of GENERAL MOTORS CORP.

40. Remove the park brake bracket from the frame.
41. Disconnect the rear brake pipe from the brake pressure modulator valve (BPMV). Refer to **Brake Pressure Modulator Valve (BPMV) Replacement** in Antilock Brake System.
42. Remove the front bumper. Refer to **Impact Bar Replacement - Front Bumper** in Bumpers.
43. Disconnect the power steering cooler from the front air deflector. Refer to **Power Steering Cooler Pipe/Hose Replacement** in Power Steering Systems.
44. Disconnect the inflatable restraint front end discriminating sensor electrical connector. Refer to **Inflatable Restraint Front End Discriminating Sensor Replacement** in SIR.
45. Disconnect the fender wheelhouse extensions from the chassis to the frame. Refer to **Wheelhouse Extension Replacement** in Body Front End.
46. Disconnect the rear air conditioning pipes at the rear crossmember, if equipped.

Leave the air conditioning pipes attached to the powertrain assembly. Refer to **Accumulator Tube Replacement - Auxiliary Side** in Heating, Ventilation and Air Conditioning.

47. Disconnect the fuel pipes at the fuel filter. Refer to **Fuel Hose/Pipes Assembly Replacement** in Engine

Controls - 4.3L.

48. Pull the fuel pipes through the crossmember (forward). Lay the fuel pipes on the transmission.
49. Disconnect the fuel tank electrical connector.
50. Disconnect the EVAP vent valve electrical connector.
51. Remove the bolt and the ground wire at the chassis by the EVAP vent valve.
52. Make sure all the connections are disconnected between the chassis and the frame.
53. Remove the engine wiring harness clips from the frame and the cross sills.

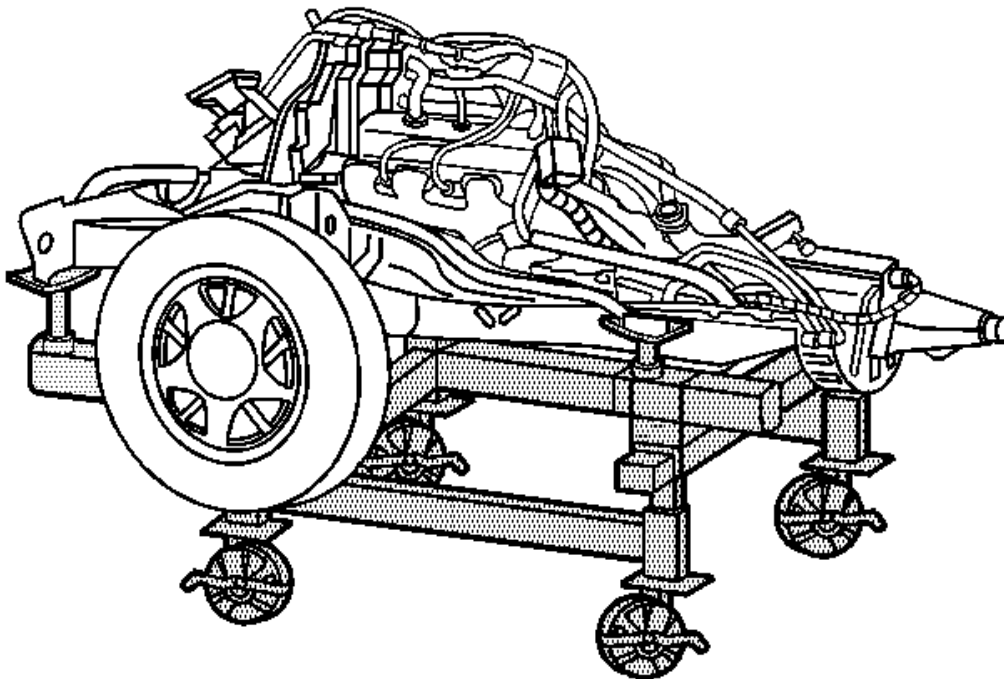


Fig. 172: Supporting Engine With J 39580
Courtesy of GENERAL MOTORS CORP.

54. Position the **J 39580** under the engine/frame assembly. See **Special Tools**.
55. Lower the vehicle.
56. Adjust **J 39580** in order to correctly support the frame assembly with the following components: See **Special Tools**.
 - The engine
 - The transmission
 - The front suspension components
 - The front differential carrier assembly, if equipped

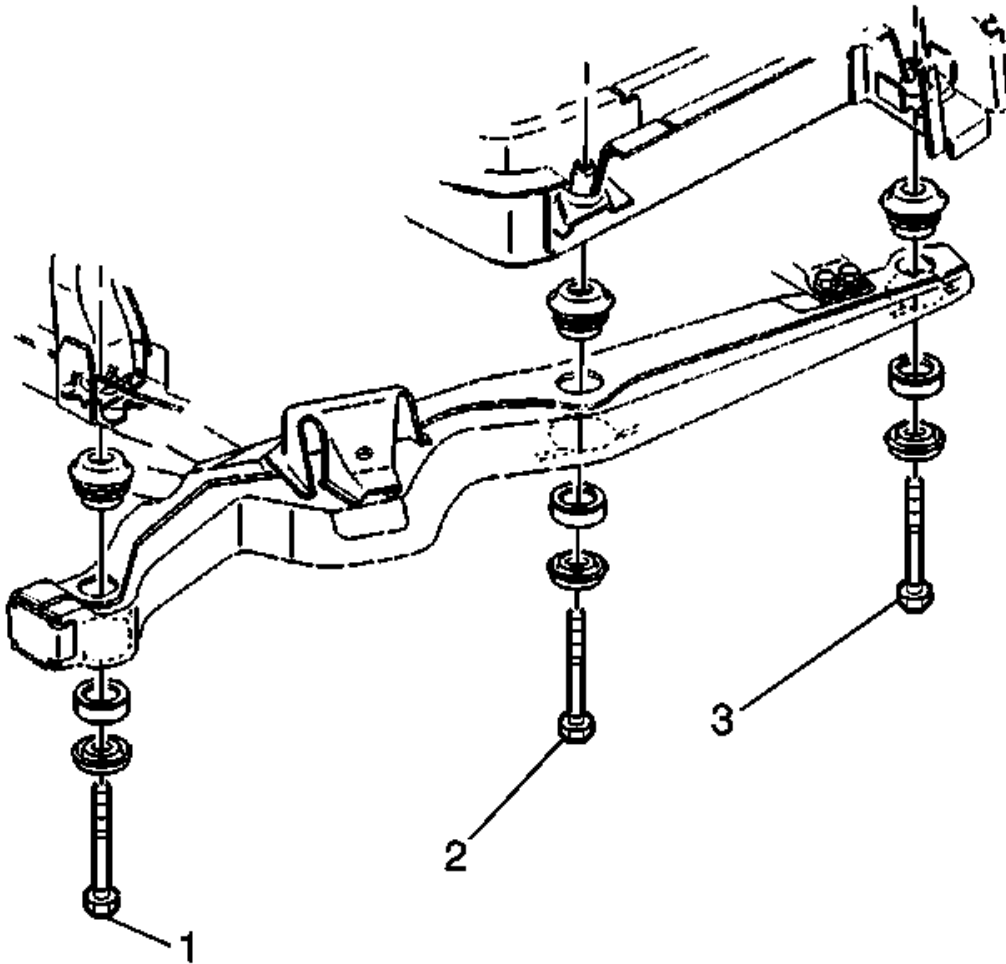


Fig. 173: Expanded View Of Body Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

57. Remove the body mount bolts (1,2,3). Refer to **Frame Cushion or Insulator Replacement** in Frame and Underbody.
58. Place a jack stand under the transmission crossmember to prevent the engine/frame assembly from tipping off of the **J 39580** . See **Special Tools**.
59. Raise the hoist in order to separate the body from the engine/frame assembly.
60. Install support stands under the rear axle.
61. Move the engine/frame assembly from under the vehicle.

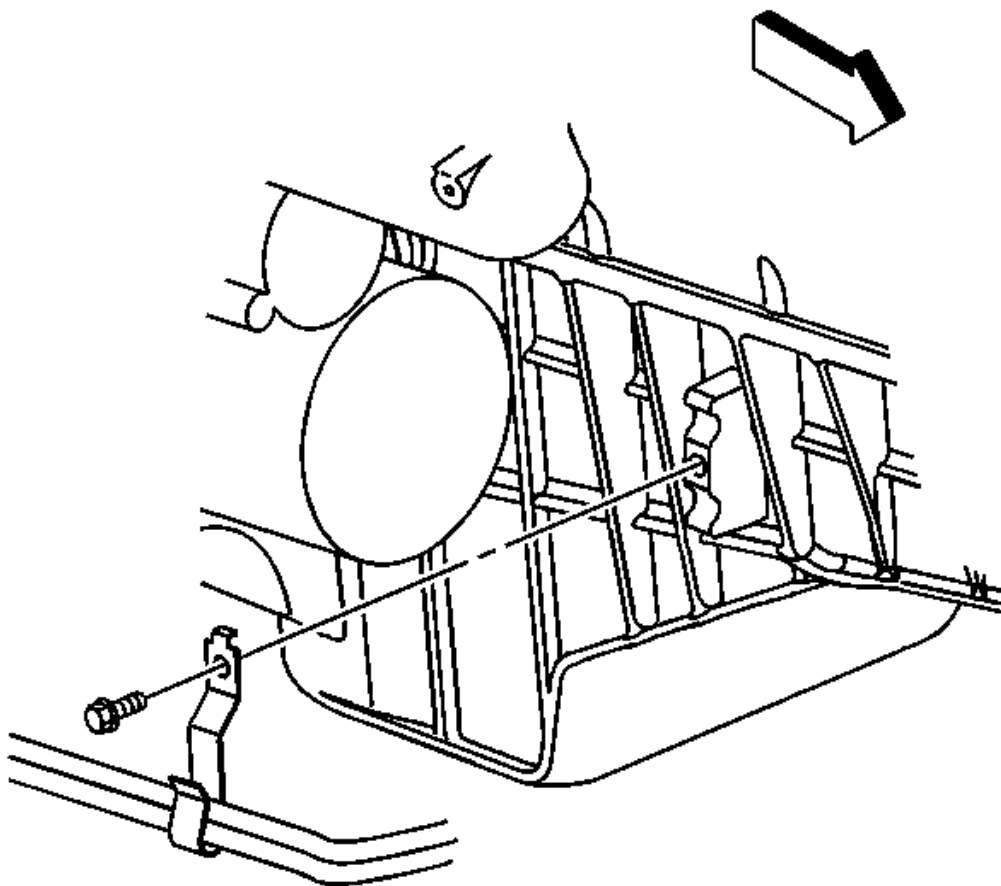


Fig. 174: Identifying Starter Wiring Harness & Transmission Cooler Pipes Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

62. Remove the bolt holding the starter wiring harness and the transmission oil cooler pipe bracket to the oil pan.
63. Remove the generator. Refer to **Generator Replacement** in Engine Electrical.

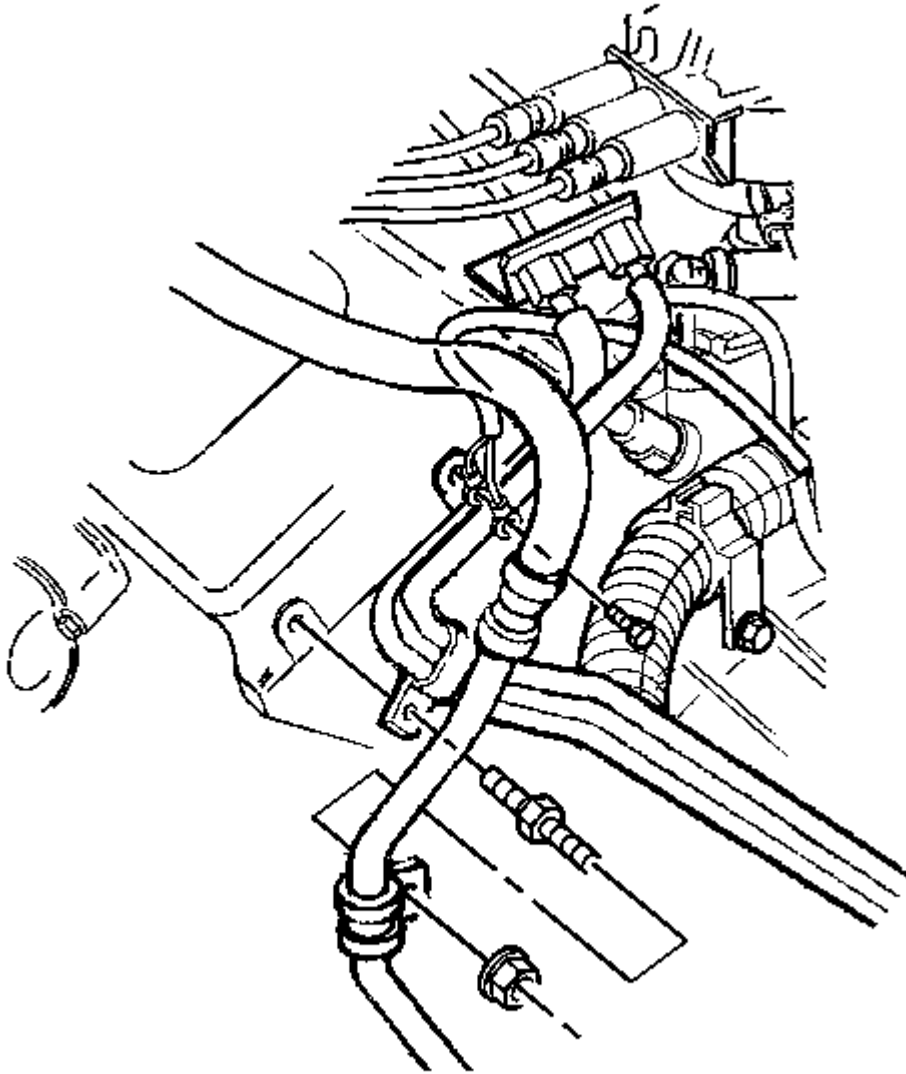


Fig. 175: Identifying A/C Pipe Bracket Nut
Courtesy of GENERAL MOTORS CORP.

64. Remove the nut and the A/C pipe bracket, if equipped from the fuel pipe bracket stud.
65. Remove the stud holding the fuel pipe bracket to the rear of the left cylinder head.
66. Remove the fuel pipe stud nut on the side of the transmission.
67. Move the fuel pipes back to clear the engine.
68. Disconnect the fuel pipes at the rear of the engine. Refer to **Fuel Hose/Pipes Replacement - Engine**

Compartment in Engine Controls - 4.3L.

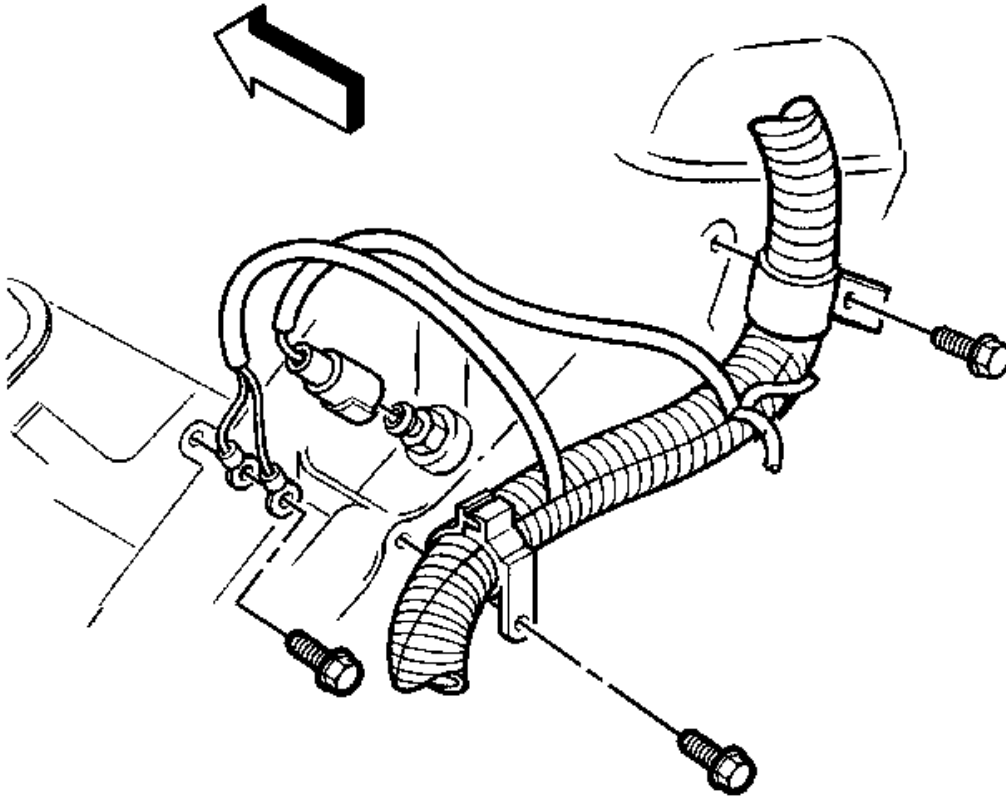


Fig. 176: Identifying Ground Wire Bolt & Engine Wiring Harness Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

69. Remove the ground wire bolt and ground wire from the rear of the left cylinder head.
70. Remove the bolt holding the engine wiring harness clip to the rear of the right cylinder head.

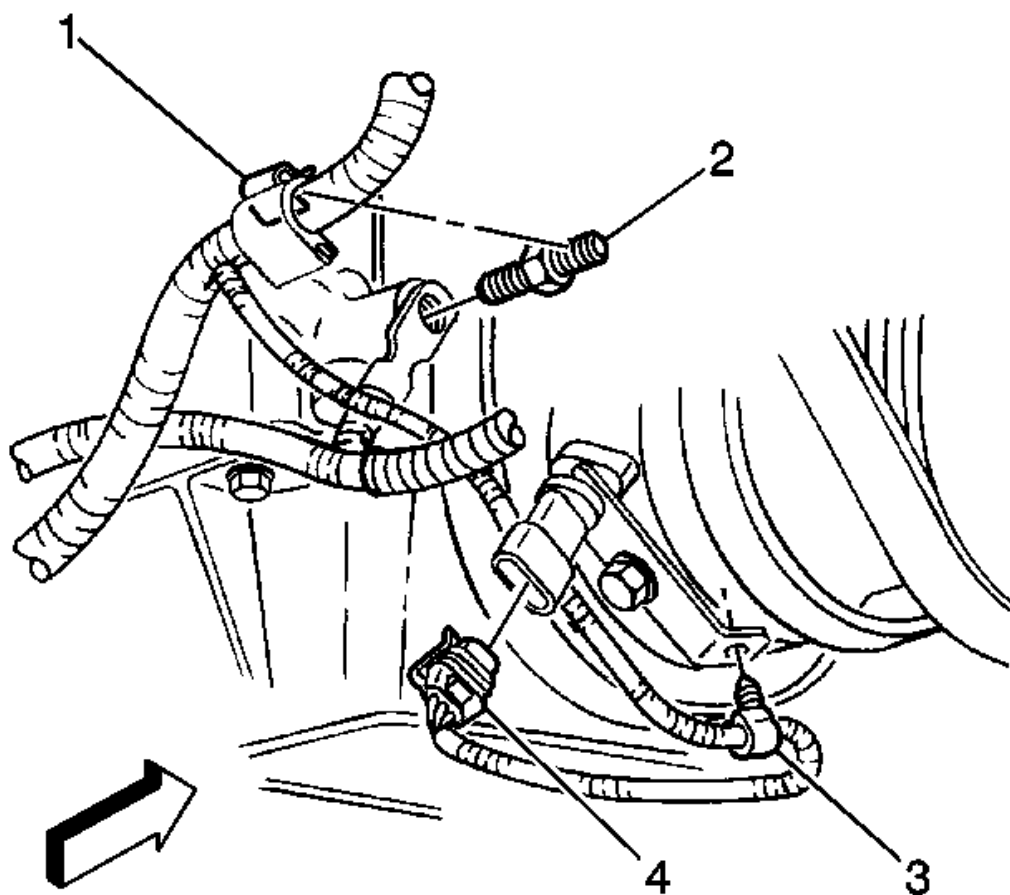


Fig. 177: Locating Crankcase Position (CKP) Sensor Electrical Connector & Clip
Courtesy of GENERAL MOTORS CORP.

71. Disconnect the crankcase position (CKP) sensor electrical connector (4).
72. Remove the CKP sensor wiring harness clip (3) from the bracket.
73. Remove the engine wiring harness clip (1) from the negative battery cable stud (2).
74. Remove the negative battery cable stud (1) and the cable.

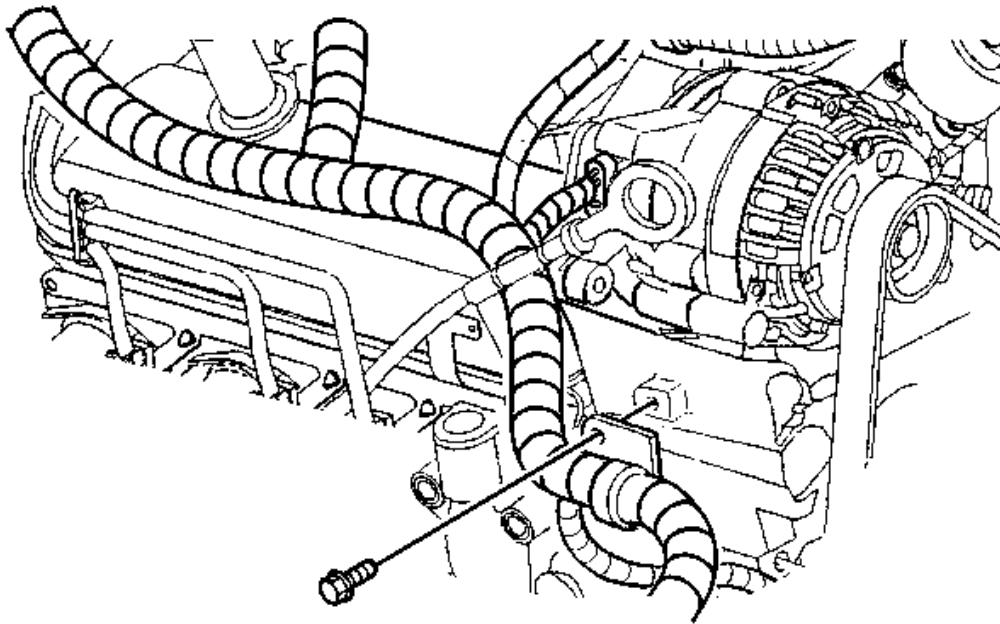


Fig. 178: View Of Engine Wiring Harness Bracket To Generator Mounting Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

75. Remove the bolt holding the engine wiring harness bracket to the generator mounting bracket.
76. Remove the ground wire from the stud at the water outlet.

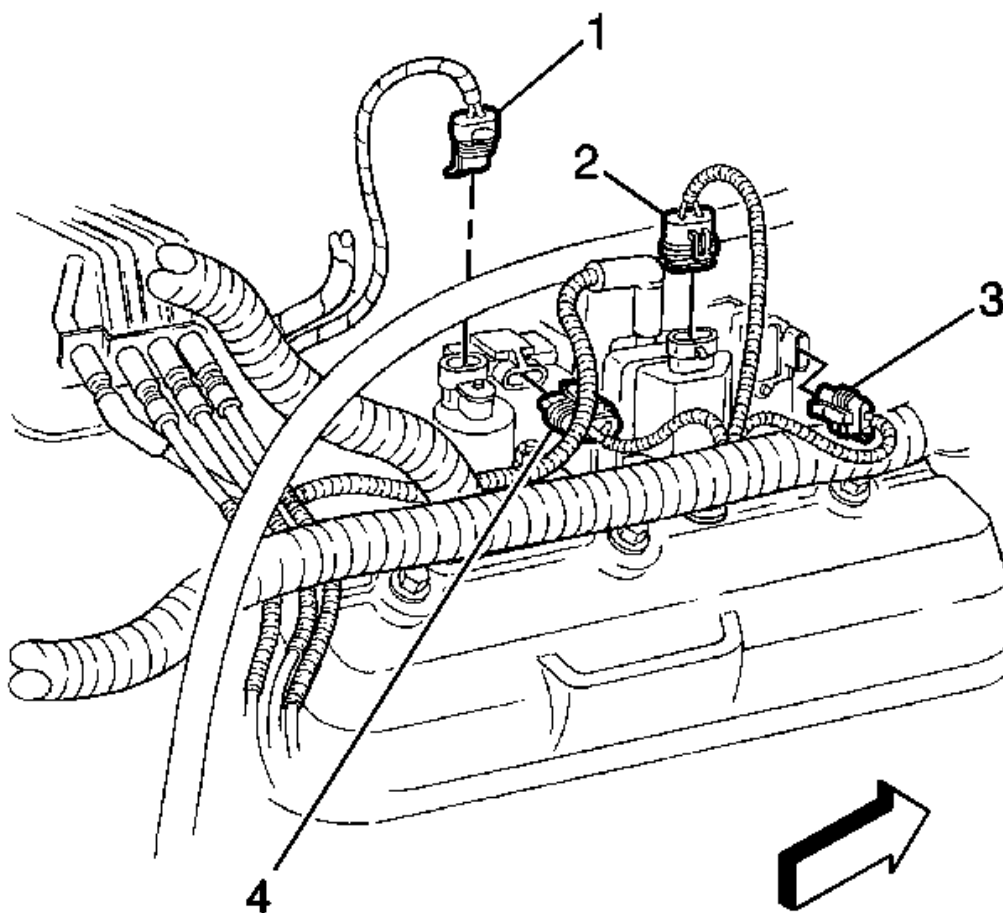


Fig. 179: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

77. Disconnect the following electrical connectors:

- The manifold absolute pressure (MAP) sensor (4)
- The EVAP canister purge solenoid valve (1)
- The ignition coil (2)
- The ignition coil module (ICM) (3)

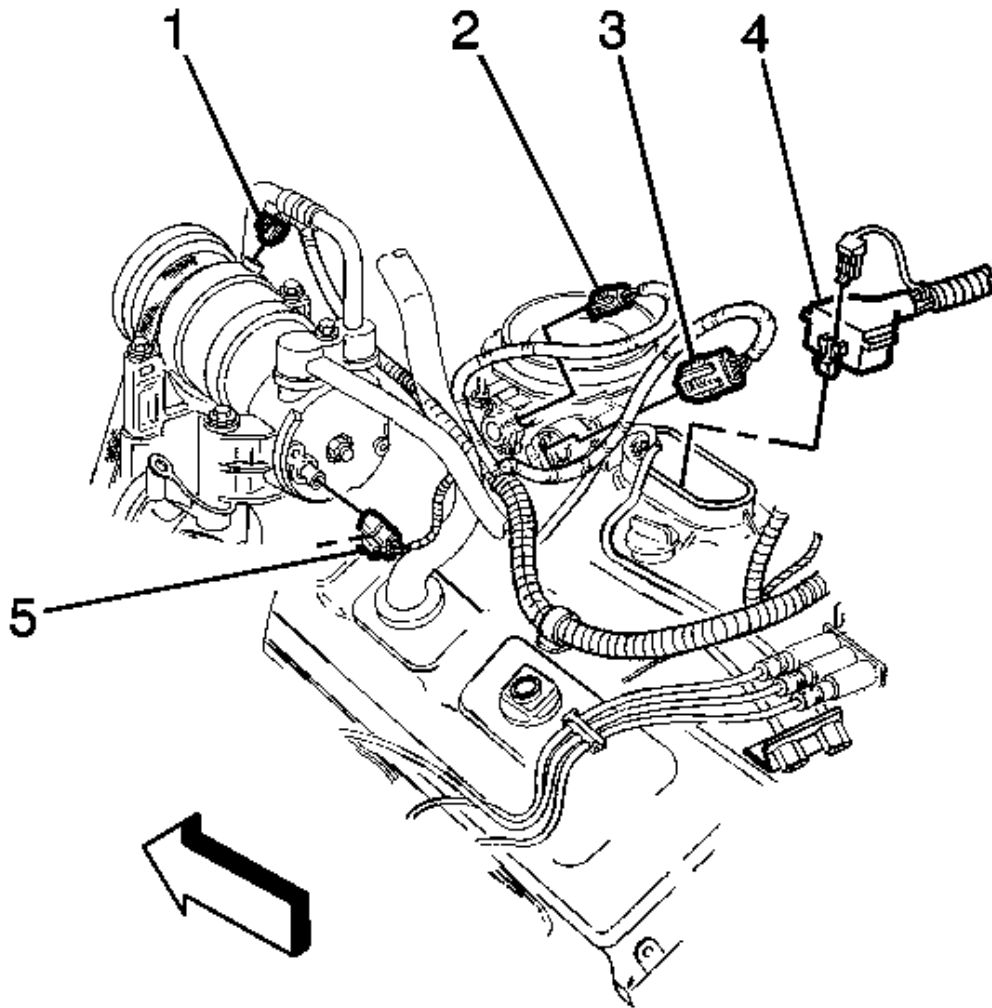


Fig. 180: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

78. Disconnect the following electrical connectors:

- The A/C compressor clutch (1), if equipped
- The A/C high pressure cutoff switch (5), if equipped
- The throttle position (TP) sensor (2)
- The idle air control (IAC) motor (3)
- The fuel meter body assembly connector (4)

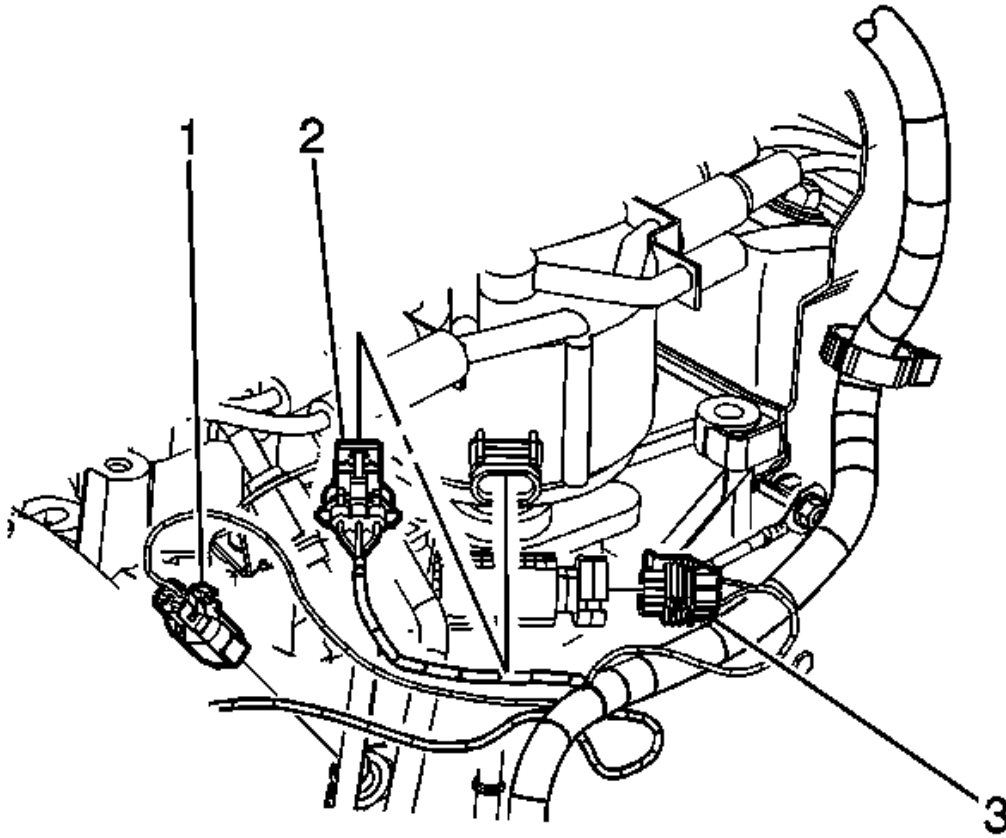


Fig. 181: Locating Knock Sensor & Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

79. Disconnect the following electrical connectors:
 - The knock sensor (KS) (1)
 - The distributor (2)
 - The engine oil pressure sensor (3)
80. Remove the engine wiring harness from the brackets.
81. Remove the bolts holding the transmission fluid fill tube from the oil indicator and the bell housing bolt.
82. Move the transmission fluid tube to the side.
83. Position the engine wiring harness out of the way.
84. Remove the transfer case to engine block brace, if equipped.
85. Remove the exhaust pipe from the exhaust manifolds. Refer to **Catalytic Converter Replacement (RWD)** or **Catalytic Converter Replacement (A4WD)** in Engine Exhaust.
86. Disconnect the spark plug wires from the spark plugs. Refer to **Spark Plug Wire Replacement** in Engine

Controls - 4.3L.

87. Remove the distributor cap with the spark plug wire harness. Refer to **Distributor Replacement** in Engine Controls - 4.3L.
88. Remove the air conditioning pipe bracket nut from the intake manifold stud.
89. Remove the air conditioning compressor and the power steering pump, leaving the pump and the compressor on the bracket.

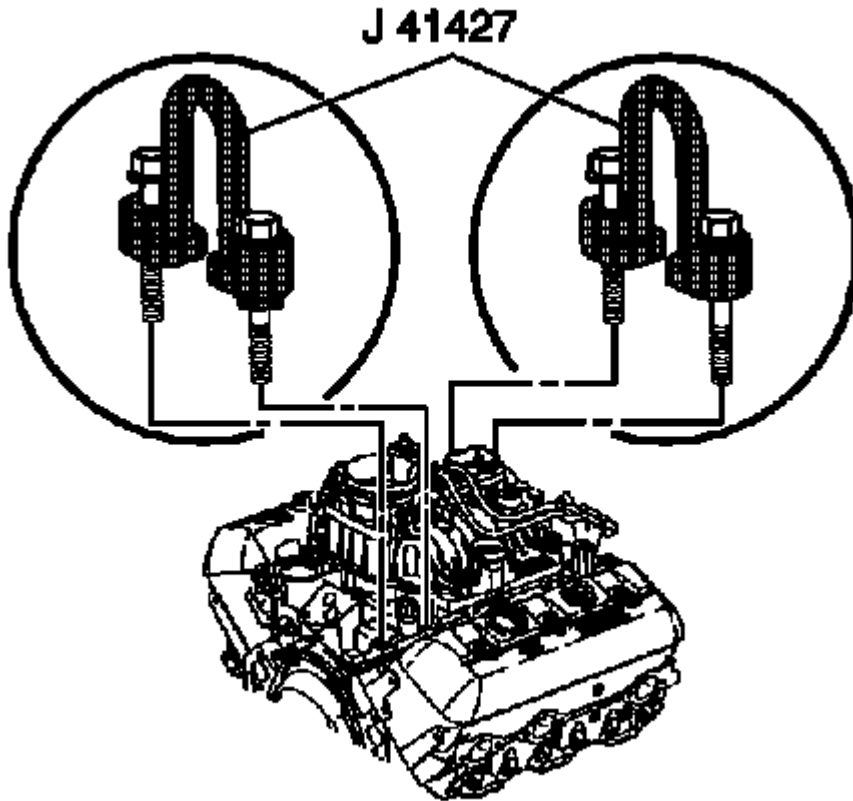


Fig. 182: Engine Lift Brackets J 41427
Courtesy of GENERAL MOTORS CORP.

90. Install the J 41427 using the following procedure:
 1. Remove the 2 right rear lower intake manifold bolts.
 2. Install the J 41427 marked RIGHT REAR.

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

3. Install the retaining bolts.

Tighten: Tighten the retaining bolts to 15 N.m (11 lb ft).

4. Remove the 2 left front lower intake manifold bolts.
5. Install the J 41427 marked LEFT FRONT with the arrow pointing to the front of the engine.
6. Install the retaining bolts

Tighten: Tighten the retaining bolts to 15 N.m (11 lb ft).

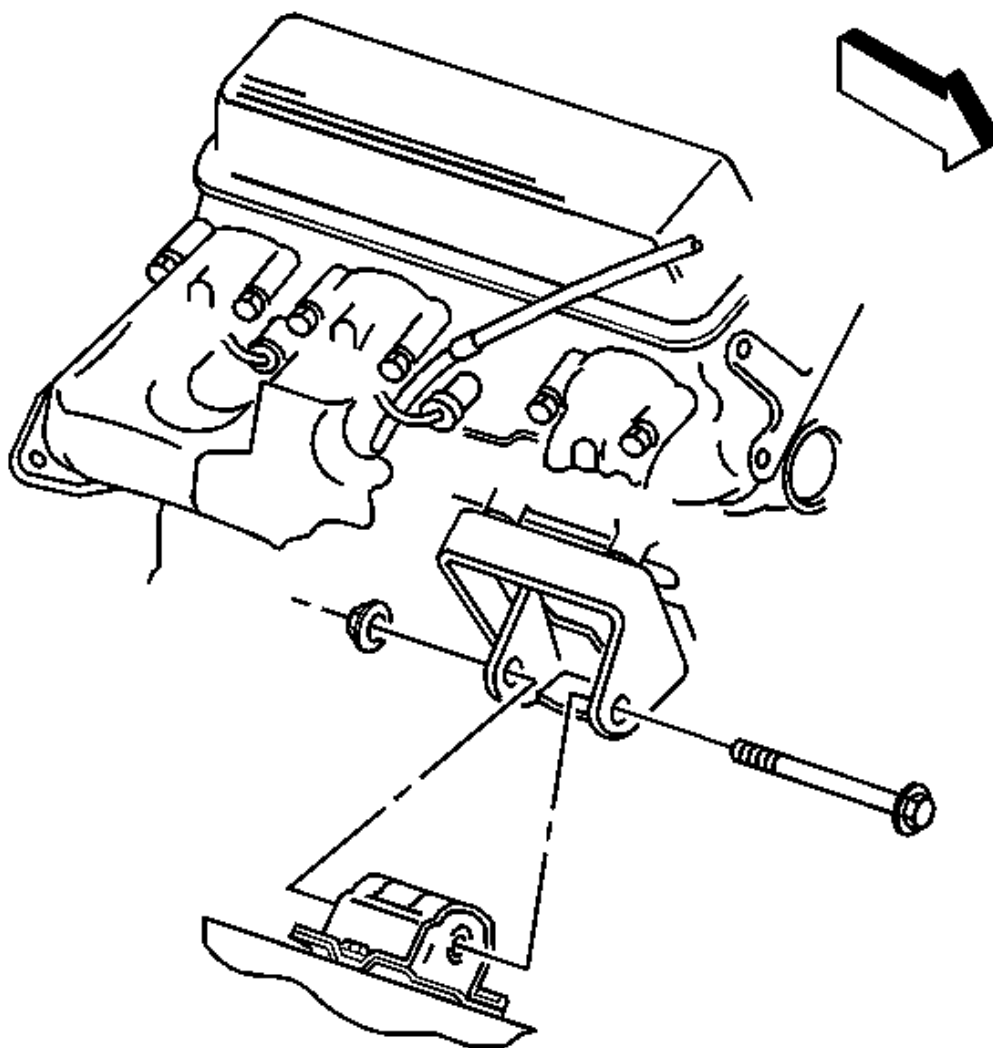


Fig. 183: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

91. Remove the engine mount through bolts.

92. Raise the engine slightly. Support the front of the transmission with suitable floor stand and a block of wood. Do not support the transmission under the oil pan.

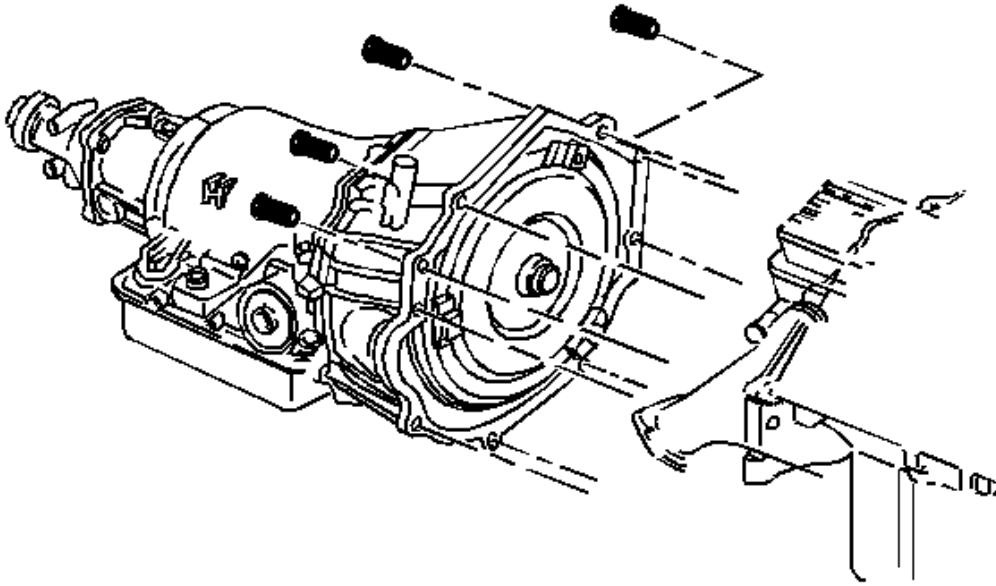


Fig. 184: View Of Transmission To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

93. Remove the transmission to engine bolts.
94. Disconnect the engine from the transmission.
95. Remove the engine from the frame.

Installation Procedure

IMPORTANT: If you install a new engine, make sure any remaining components, brackets, or accessories are transferred to the new engine.

1. Install the engine into the frame.
2. Connect the engine to the transmission. Refer to Transmission Replacement in Automatic Transmission - 4L60-E.
3. Remove the support from under the transmission.
4. Lower the engine and the transmission onto the engine mounts.

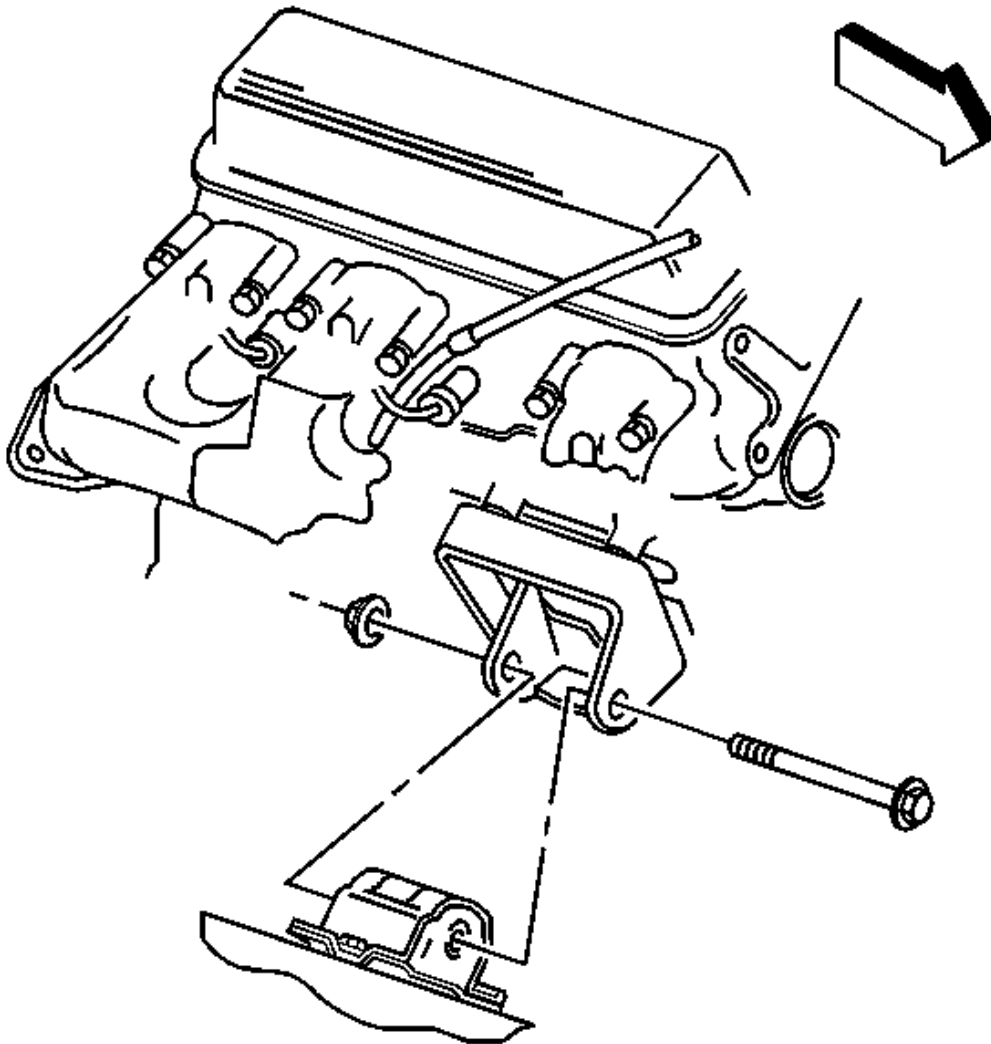


Fig. 185: Expanded View Of Engine Mounts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the engine mount through-bolts and nuts.

Tighten: Tighten the engine mount through-bolt nuts to 68 N.m (50 lb ft).

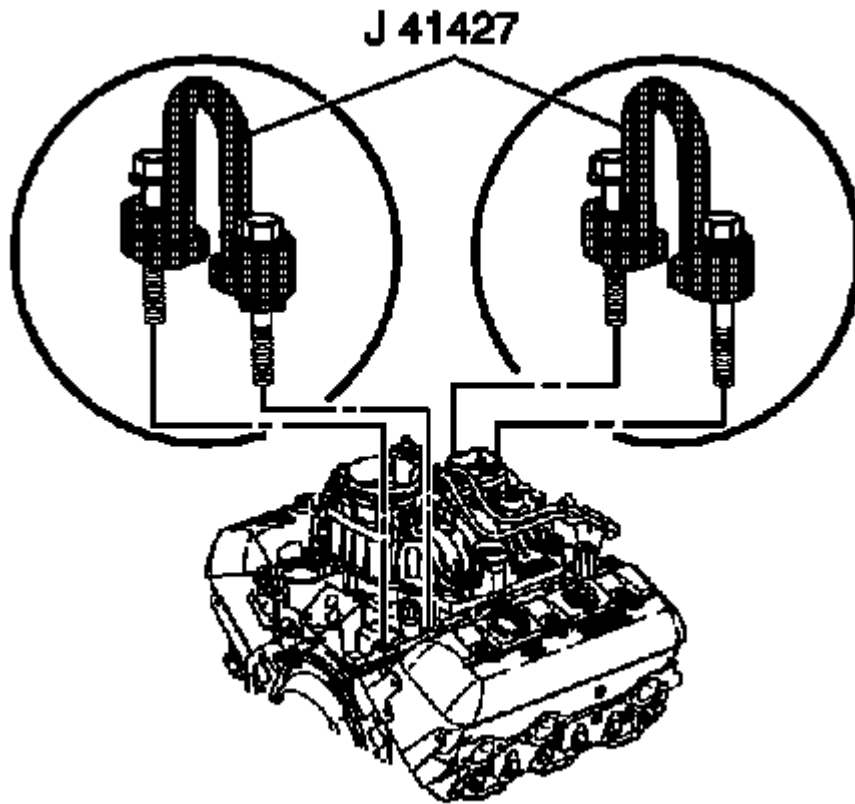


Fig. 186: Engine Lift Brackets J 41427
 Courtesy of GENERAL MOTORS CORP.

6. Remove the J 41427 from the engine.
7. Apply thread lock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the lower intake manifold bolts.
8. Install the intake manifold bolts.

Tighten:

1. Tighten each of the bolts to 3 N.m (27 lb in).
 2. Tighten each of the bolts to 12 N.m (106 lb in).
 3. Tighten each of the bolts to 15 N.m (11 lb ft).
9. Install the air conditioning compressor, if equipped, and the power steering pump mounting bracket.
 10. Install the distributor cap.
 11. Install the spark plug wires.
 12. Install the exhaust pipe to the exhaust manifolds. Refer to **Catalytic Converter Replacement (RWD)** or **Catalytic Converter Replacement (A4WD)** in Engine Exhaust.
 13. Connect the fuel pipes at the rear of the engine. Refer to **Fuel Hose/Pipes Replacement - Engine**

Compartment in Engine Controls - 4.3L.

14. Install the transfer case to engine block brace, if equipped.

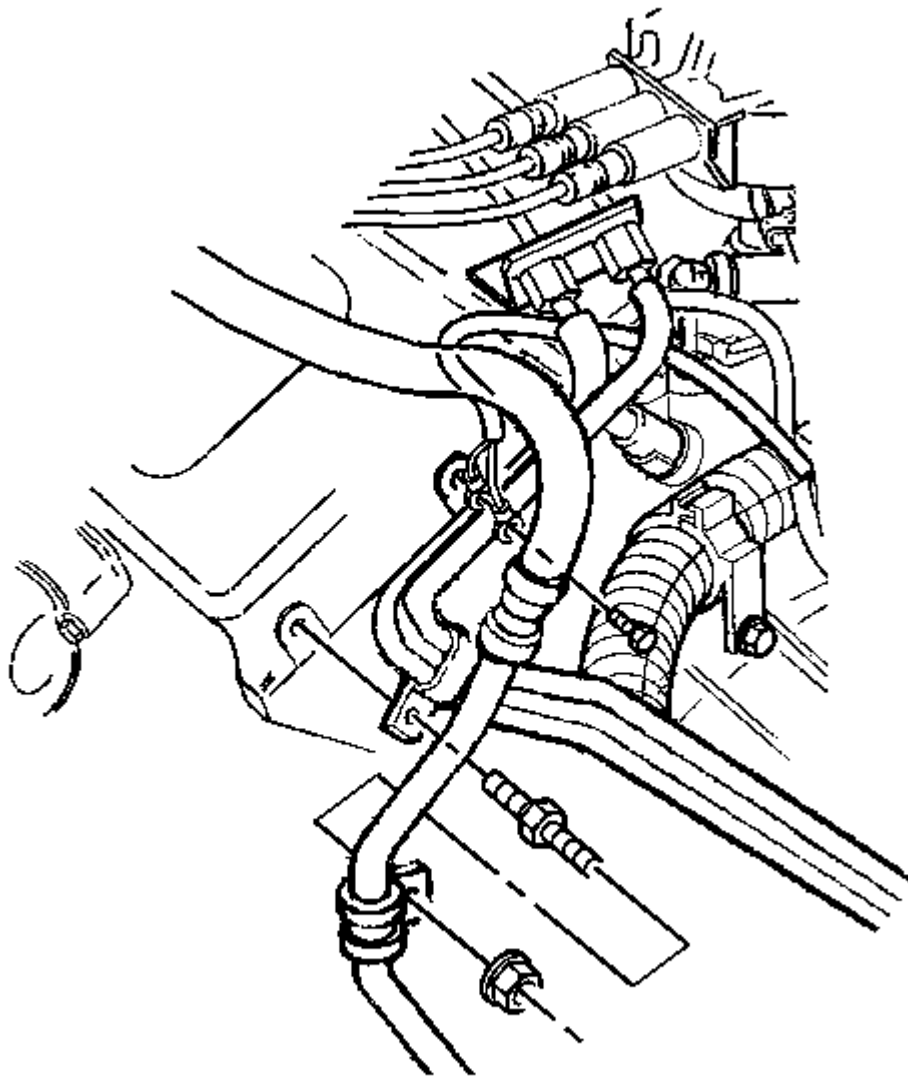


Fig. 187: Identifying A/C Pipe Bracket Nut
Courtesy of GENERAL MOTORS CORP.

15. Install the fuel pipe bracket and stud to the rear of the left cylinder head.

Tighten: Tighten the fuel pipe bracket stud to 33 N.m (24 lb ft).

16. Install the A/C pipe bracket and nut, if equipped, to the fuel pipe bracket stud.

Tighten: Tighten the A/C pipe bracket nut to 35 N.m (26 lb ft).

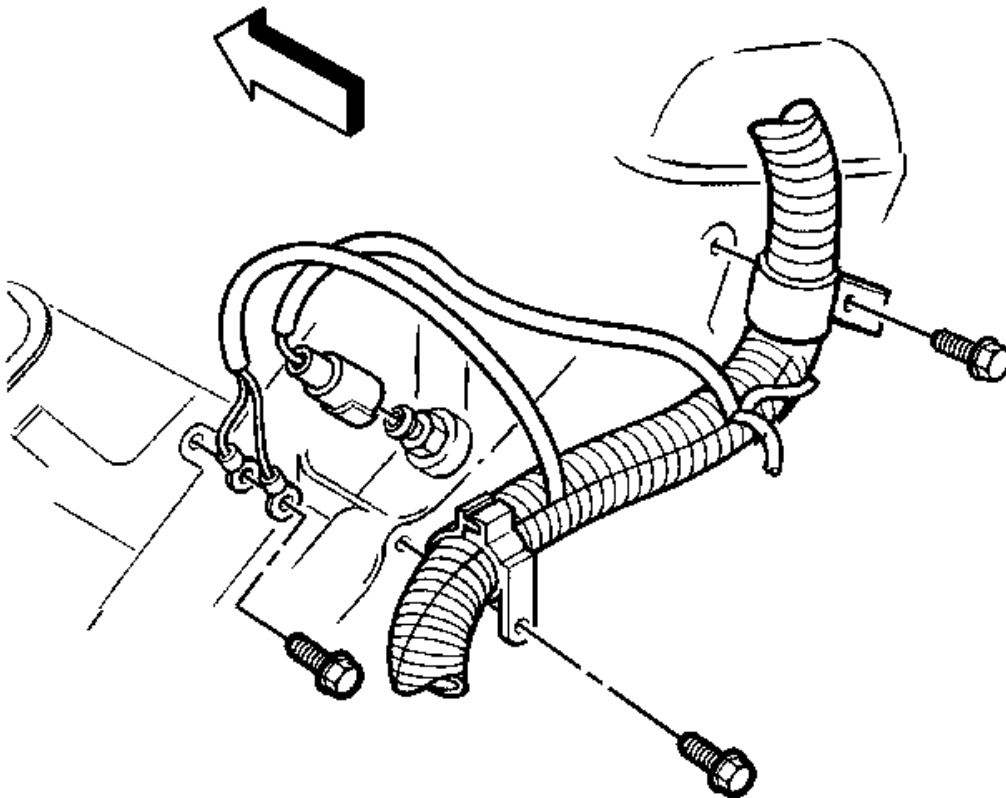


Fig. 188: Identifying Ground Wire Bolt & Engine Wiring Harness Clip Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

17. Position the engine wiring harness.
18. Install the engine wiring harness clips in the brackets.
19. Install the engine wiring harness clip bolt to the rear of the right cylinder head.

Tighten: Tighten the engine wiring harness clip bolt to 36 N.m (27 lb ft).

20. Install the ground wire and bolt at the rear of the left cylinder head.

Tighten: Tighten the ground wire bolt to 35 N.m (26 lb ft).

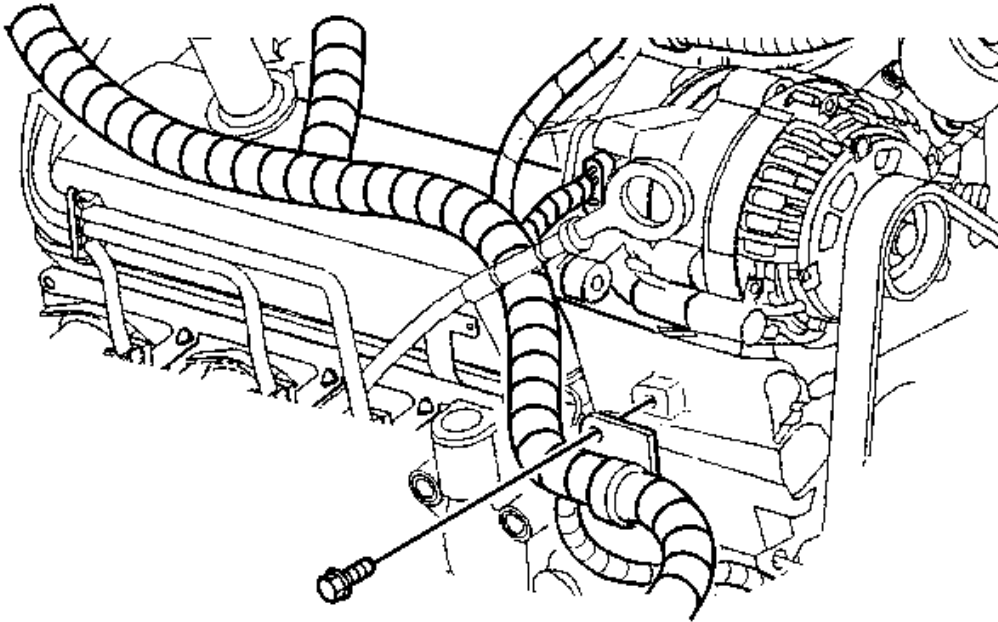


Fig. 189: View Of Engine Wiring Harness Bracket To Generator Mounting Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

21. Install the engine wiring harness bracket and bolt to the generator mounting bracket.

Tighten: Tighten the engine wiring harness bolt to 35 N.m (26 lb ft).

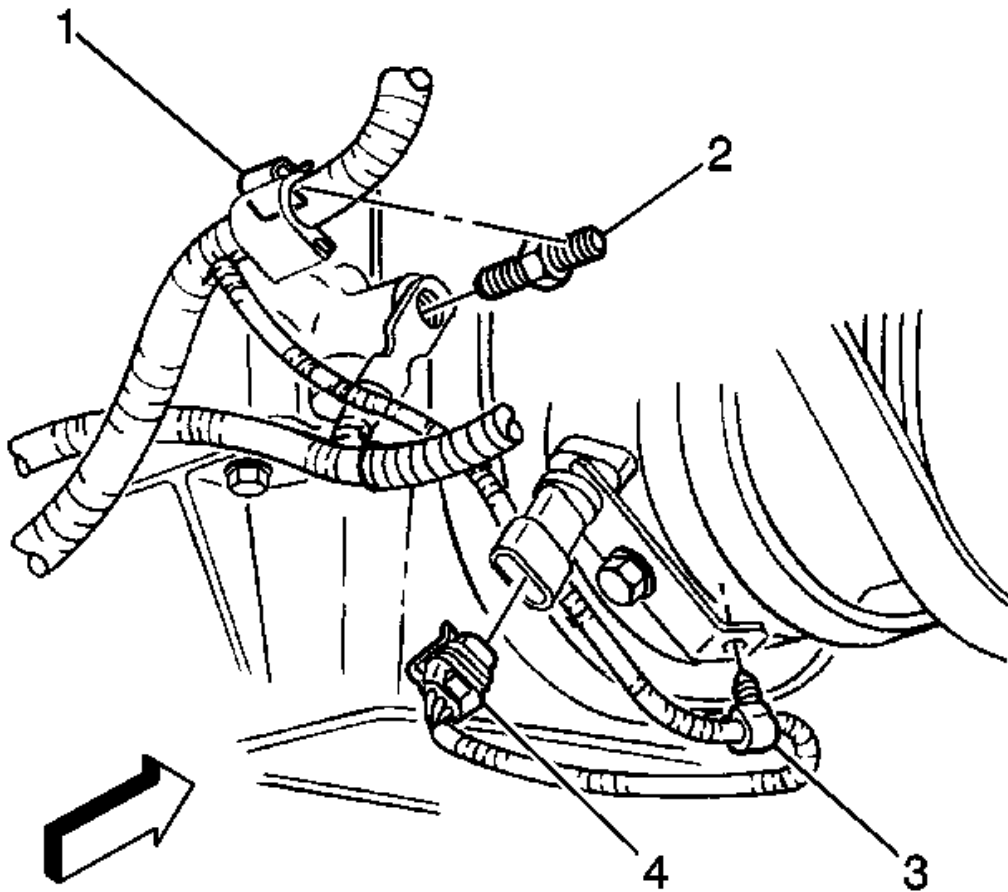


Fig. 190: Locating Crankcase Position (CKP) Sensor Electrical Connector & Clip
 Courtesy of GENERAL MOTORS CORP.

22. Install the negative battery cable and stud (2).

Tighten: Tighten the negative battery cable stud to 40 N.m (30 lb ft).

23. Install the CKP sensor wiring harness clip (3) in the bracket.
24. Connect the CKP sensor electrical connector (4).
25. Install the engine wiring harness clip (1) on the negative battery cable stud (2).

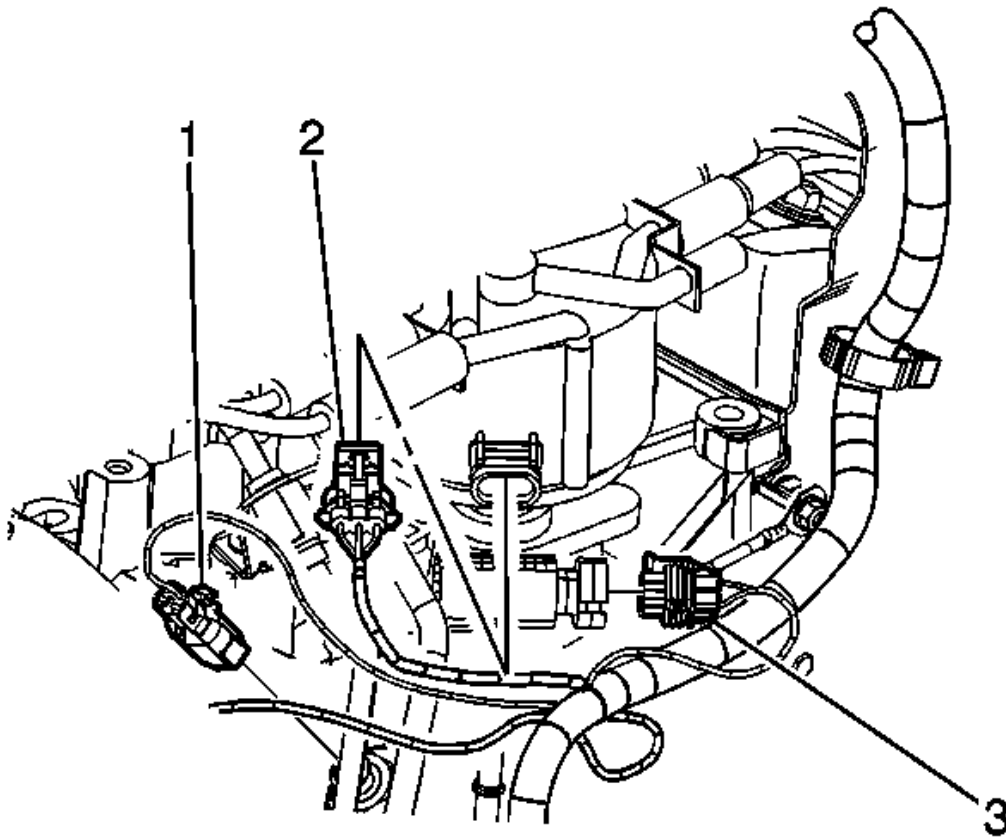


Fig. 191: Locating Knock Sensor & Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

26. Connect the following electrical connectors:

- The knock sensor (KS) (1)
- The distributor (2)
- The engine oil pressure sensor (3)

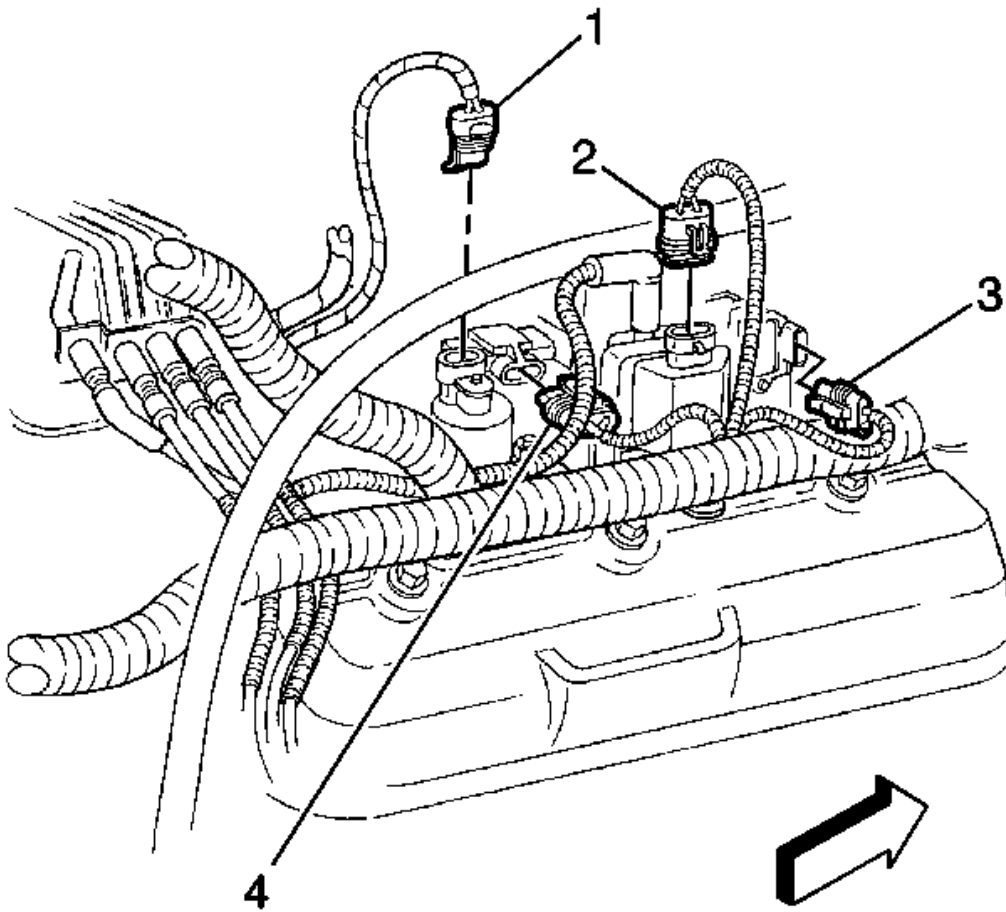


Fig. 192: Locating Manifold Absolute Pressure (Map) Sensor
Courtesy of GENERAL MOTORS CORP.

27. Connect the following electrical connectors:

- The manifold absolute pressure (MAP) sensor (4)
- The EVAP canister purge solenoid valve (1)
- The ignition coil (2)
- The ICM (3)

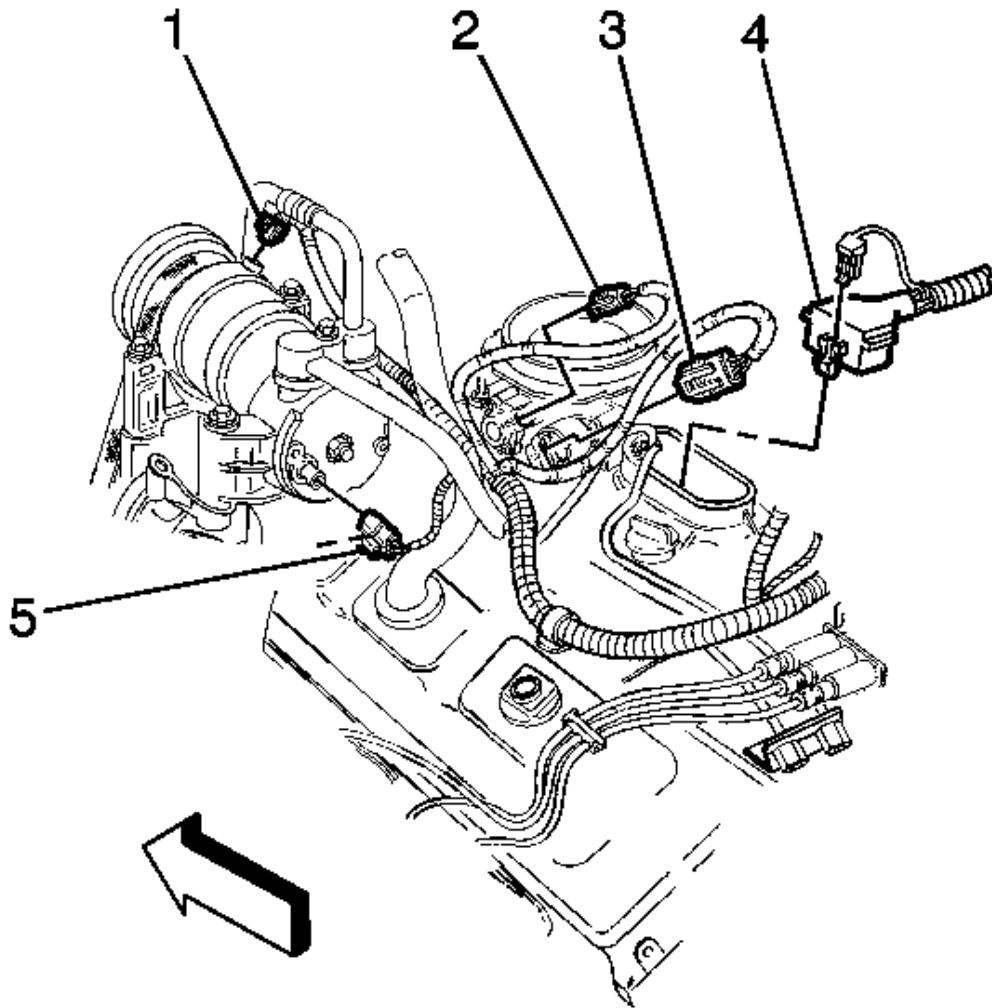


Fig. 193: Identifying Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

28. Connect the following electrical connectors:
- The A/C compressor clutch (1), if equipped
 - The A/C high pressure cutoff switch (5), if equipped
 - The throttle position (TP) sensor (2)
 - The idle air control (IAC) motor (3)
 - The fuel meter body assembly connector (4)
29. Install the ground wire and the nut to the water outlet stud.

Tighten: Tighten the ground wire nut to 19 N.m (14 lb ft).

30. Install the generator. Refer to **Generator Replacement** in Engine Electrical.

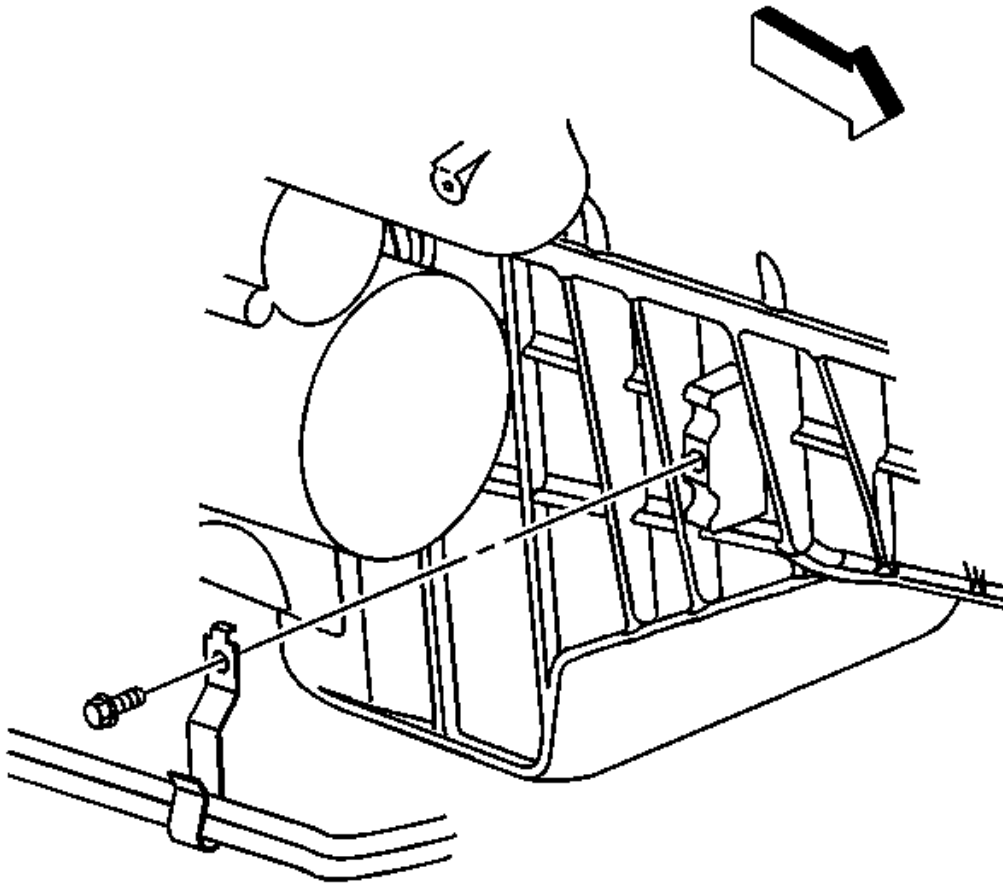


Fig. 194: Identifying Starter Wiring Harness & Transmission Cooler Pipes Bracket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

31. Install the bolt for the starter wiring harness and the transmission oil cooler pipe bracket.

Tighten: Tighten the starter wiring harness bracket bolt to 10 N.m (89 lb in).

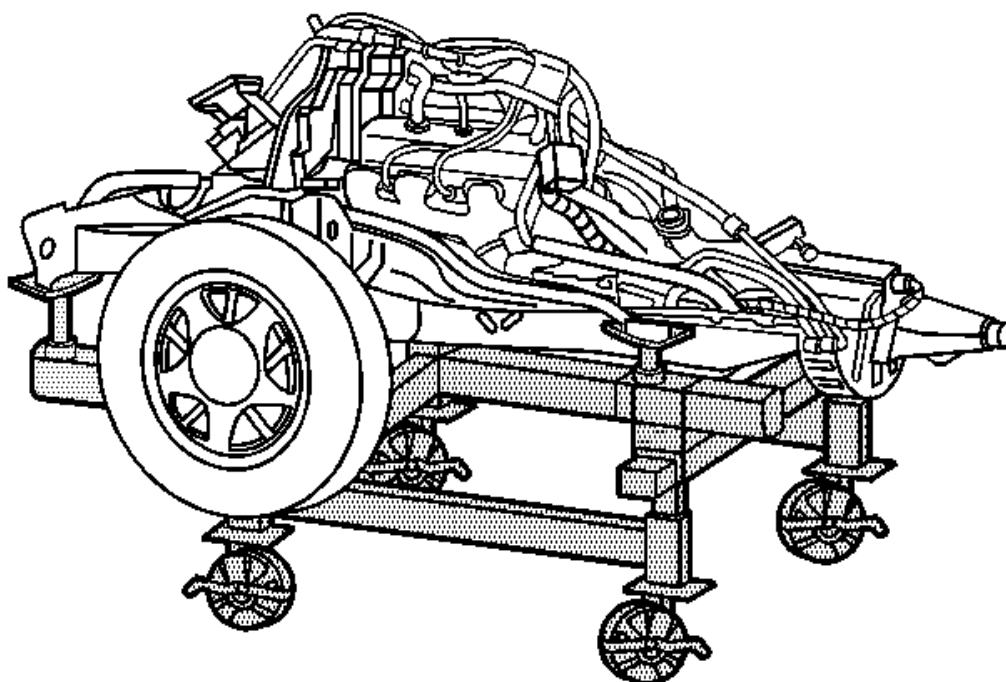


Fig. 195: Supporting Engine With J 39580
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the frame using the 2 alignment holes in the frame and the body.
Use a pry bar or dowel pin in order to align the holes as the vehicle is
being lowered onto the engine/frame assembly.

32. Lower the vehicle onto the engine/frame assembly and the **J 39580** . See **Special Tools**.

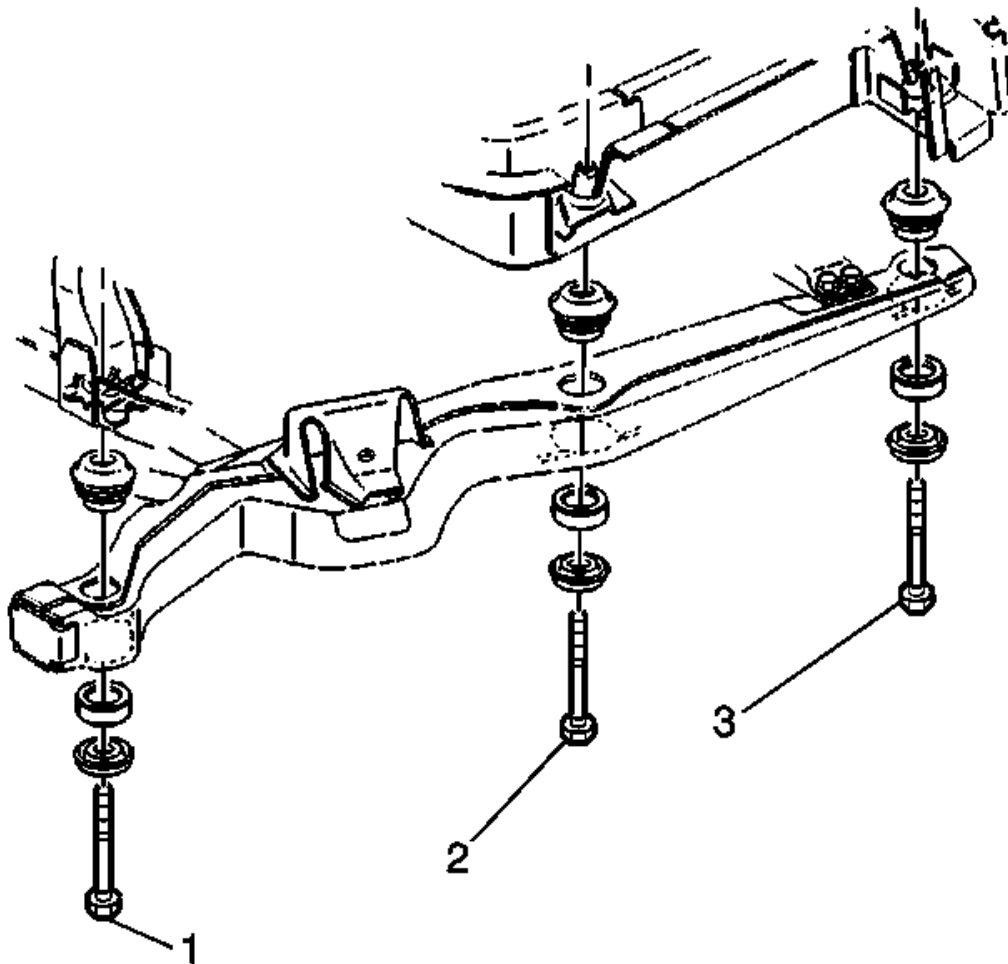


Fig. 196: Expanded View Of Body Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The 6 frame-to-body bolts must be tightened in sequence in order to ensure correct alignment of the frame to the chassis.

33. Install the bolts (1, 2, 3).

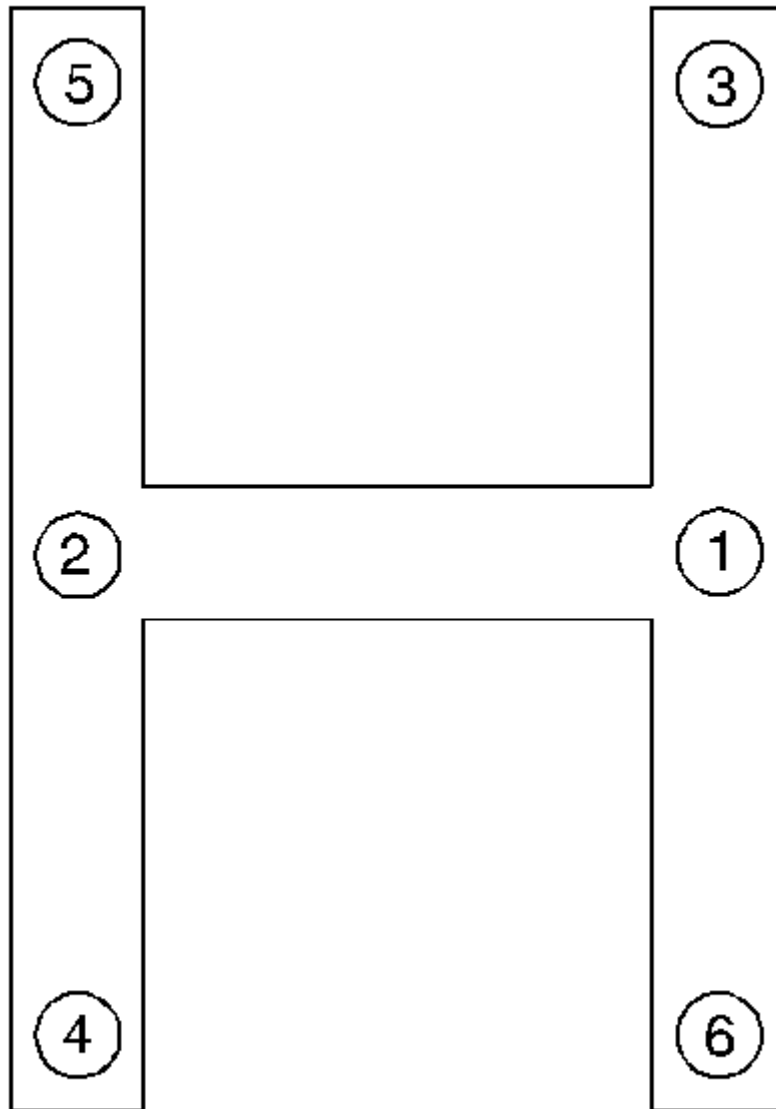


Fig. 197: Illustrating Body Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

34. Tighten the body bolts using the following sequence:

Tighten:

1. Tighten all of the body bolts in the sequence shown to 35 N.m (26 lb ft).
2. Tighten the right center body bolt to 155 N.m (114 lb ft).

3. Tighten the left center body bolt to 155 N.m (114 lb ft).
4. Tighten the right front body bolt to 90 N.m (66 lb ft).
5. Tighten the left rear body bolt to 90 N.m (66 lb ft).
6. Tighten the left front body bolt to 90 N.m (66 lb ft).
7. Tighten the right rear body bolt to 90 N.m (66 lb ft).

35. Raise the vehicle.

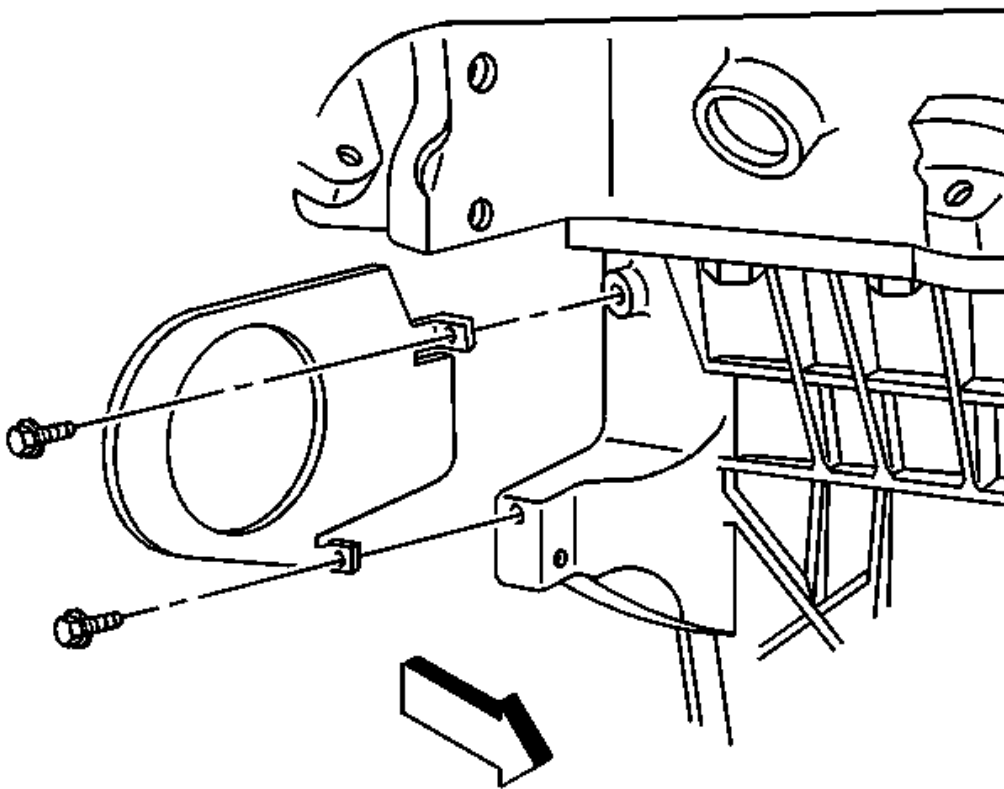


Fig. 198: View Of Transmission Cover
Courtesy of GENERAL MOTORS CORP.

36. Install the transfer case vent tube, if equipped.
37. Connect the wire connector to the wiring harness above the transmission.
38. Connect the shift cable to the transmission. Refer to **Automatic Transmission Range Selector Cable Replacement** in Automatic Transmission - 4L60-E.
39. Install the torque converter bolts.

Tighten: Tighten the bolts to 62 N.m (46 lb ft).

40. Install the transmission cover.

Tighten: Tighten the transmission cover bolts to 12 N.m (106 lb in).

41. Install the starter. Refer to **Starter Motor Replacement** in Engine Electrical.
42. Install the oil cooler pipes to the oil filter adapter. Refer to **Engine Oil Cooler Hose/Pipe Replacement** in Engine Cooling.
43. Install the rear propeller shaft. Refer to **Propeller Shaft Replacement - Rear** in Propeller Shaft.
44. Connect the power steering cooler. Refer to **Power Steering Cooler Pipe/Hose Replacement** in Power Steering Systems.
45. Connect the inflatable restraint front end discriminating sensor electrical connector. Refer to **Inflatable Restraint Front End Discriminating Sensor Replacement** in SIR.
46. Connect the fender wheelhouse extensions from chassis to the frame. Refer to **Wheelhouse Extension Replacement** in Body Front End.
47. Install the front bumper. Refer to **Impact Bar Replacement - Front Bumper** in Bumpers.
48. Install the muffler and the tail pipe section to the hangers and install it to the converter assembly. Refer to **Catalytic Converter Replacement (RWD)** or **Catalytic Converter Replacement (A4WD)** in Engine Exhaust.
49. Connect the fuel pipes at the fuel filter. Refer to **Fuel Hose/Pipes Assembly Replacement** in Engine Controls - 4.3L.
50. Position the engine wiring harness in the clips on the frame and the cross sills.
51. Connect the fuel tank electrical connector.
52. Connect the EVAP vent valve electrical connector.
53. Install the bolt and the ground wire at the chassis by the EVAP vent valve.

Tighten: Tighten the ground wire bolt to 9 N.m (80 lb in).

54. Ensure that all of the electrical connections are connected between the chassis and the frame.

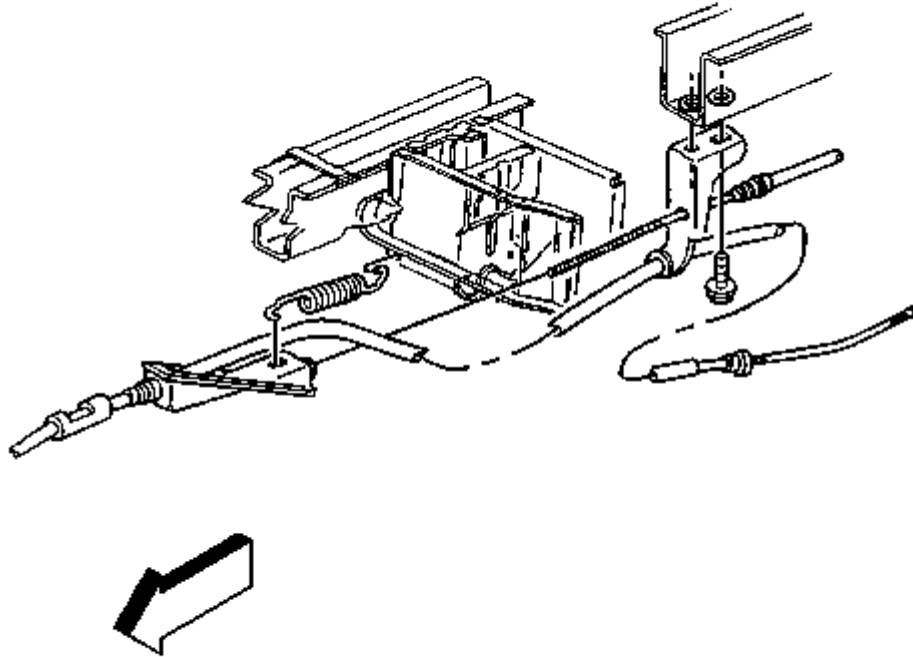


Fig. 199: View Of Park Brake Bracket
Courtesy of GENERAL MOTORS CORP.

55. Install the bolt and the park brake bracket to the frame.

Tighten: Tighten the park brake bracket bolt to 24 N.m (18 lb ft).

56. Connect the rear air conditioning pipes at the rear crossmember by the fuel tank fill hoses, if equipped.
 - Refer to **Accumulator Tube Replacement - Auxiliary Side** in Heating, Ventilation and Air Conditioning.
 - Refer to **Evaporator Tube Replacement - Auxiliary Side** in Heating, Ventilation and Air Conditioning.
57. Connect the rear brake pipe to the BPMV. Refer to **Brake Pressure Modulator Valve (BPMV) Replacement** in Antilock Brake System.
58. Remove the bell housing to transmission bolt.
59. Lower the vehicle.

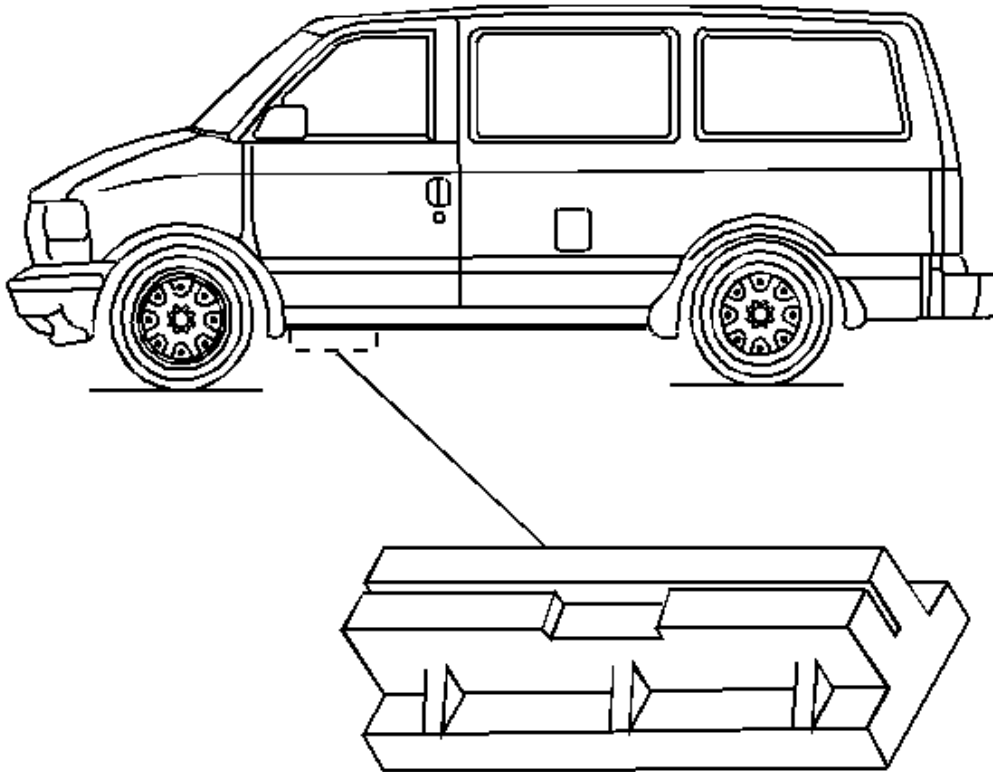


Fig. 200: Identifying J 41602

Courtesy of GENERAL MOTORS CORP.

60. Remove both of the **J 41602** .
61. Install the front section of the running boards. Refer to **Assist Step Extension Replacement - Front** in Frame and Underbody.
62. Install the battery cable assembly to the fender and the radiator support. Refer to **Battery Negative Cable Replacement** in Engine Electrical.
63. Install the battery positive cable but do not install the battery negative cable.
64. Install the wiring harness in the retainers clips along the bulkhead.
65. Connect the fuse box and the wiring harness to the bulkhead connector.
66. Connect all related connectors including the following:
 - The ground wires
 - The A/C module
 - The cruise control module
 - The wiper motor

- The differential pressure input switch
67. Connect the steering shaft to the steering gear. Refer to **Intermediate Steering Shaft Replacement** in Steering Wheel and Column.
 68. Connect the heater hoses to the engine. Refer to **Heater Hose Replacement - Inlet** in Heating, Ventilation and Air Conditioning.

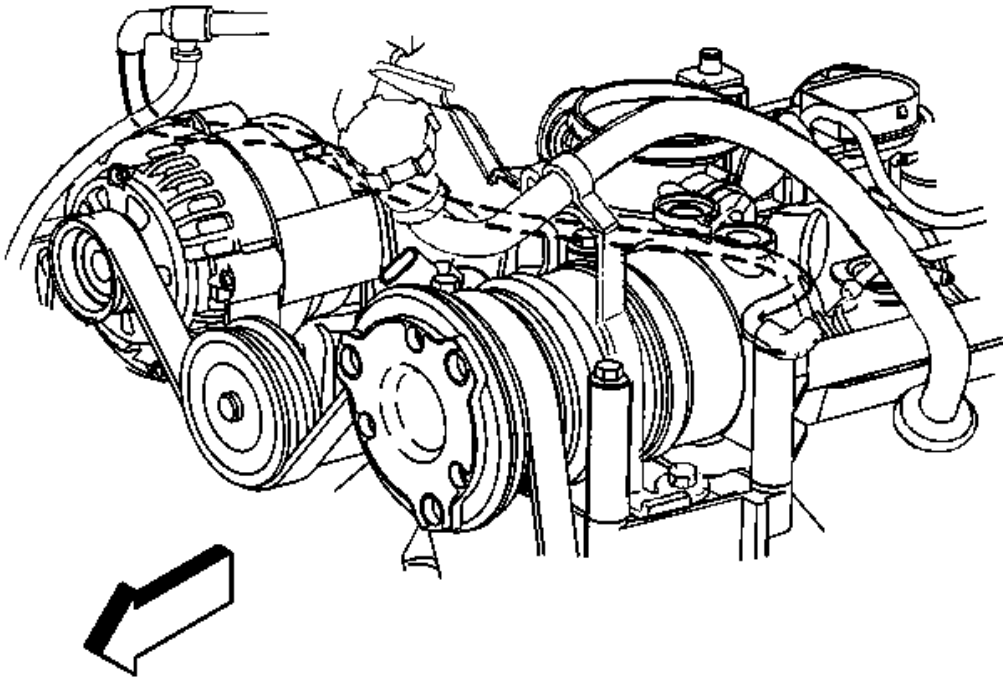


Fig. 201: View Of Intake Manifold Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

69. Connect the vacuum hose for the vacuum tank to the intake manifold.
70. Connect the pipes to the hydro boost. Refer to **Hydraulic Brake Booster Replacement** in Hydraulic Brakes.
71. Install the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement** in Power Steering System.
72. Install the master cylinder to the hydro boost. Refer to **Master Cylinder Replacement** in Hydraulic Brakes.

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.

73. Install the NEW accelerator control cable. Refer to **Accelerator Controls Cable Replacement** in Engine Controls - 4.3L.
74. Connect the cruise control cable to the throttle shaft and the accelerator control cable bracket. Refer to **Cruise Control Cable Replacement** in Cruise Control.
75. Connect the air conditioning pipes at the accumulator and the condenser, if equipped. Refer to **Compressor/Condenser Hose Replacement - Auxiliary** in Heating, Ventilation and Air Conditioning.
76. Install the radiator. Refer to **Radiator Replacement** in Engine Cooling.
77. Fill the cooling system with the correct grade of engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
78. Install the air cleaner outlet duct to the throttle body. Refer to **Air Cleaner Outlet Resonator Replacement** in Engine Controls - 4.3L.
79. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls-4.3L.
80. Fill the crankcase with the correct grade of engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
81. Fill and bleed the brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)** in Hydraulic Brakes.
82. Fill the transmission with the correct grade and quantity of transmission fluid. Refer to **Automatic Transmission Fluid/Filter Replacement** in Automatic Transmission - 4L60-E.
83. Fill the power steering system with the correct grade and quantity of power steering fluid. Refer to **Checking and Adding Power Steering Fluid** in Power Steering System.
84. Connect the battery negative cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
85. Recharge the air conditioning system and check for correct operation, if equipped. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
86. Install the engine cover. Refer to **Engine Cover Replacement** in Interior Trim.
87. Perform a crankshaft variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls.
88. Operate the engine and check for correct operation.

Engine Oil and Oil Filter Replacement

Removal Procedure

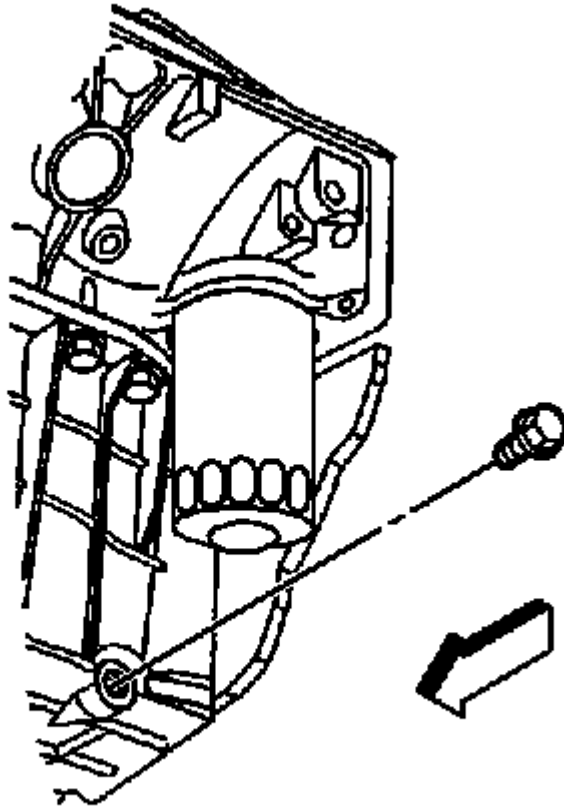


Fig. 202: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle and support with safety stands. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil pan drain plug and drain the engine oil in a suitable container.

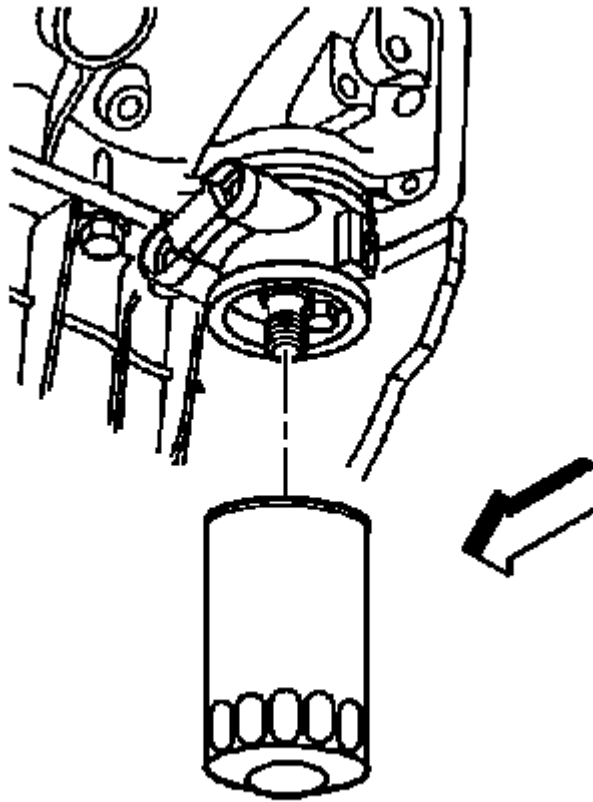


Fig. 203: Removing Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil filter.
4. Inspect to ensure the engine oil filter gasket is removed.

Installation Procedure

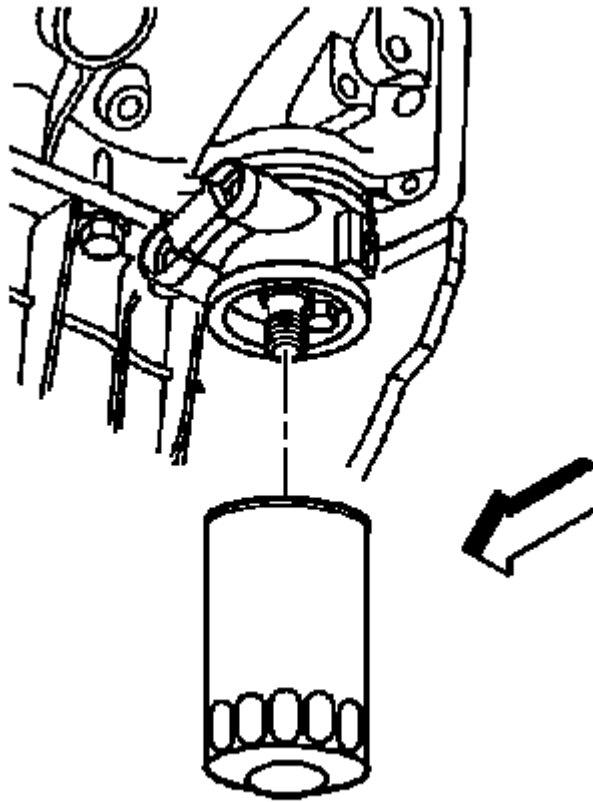


Fig. 204: Removing Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the engine oil filter gasket with clean engine oil.
2. Install the engine oil filter.
3. Follow the tightening instructions on the oil filter.

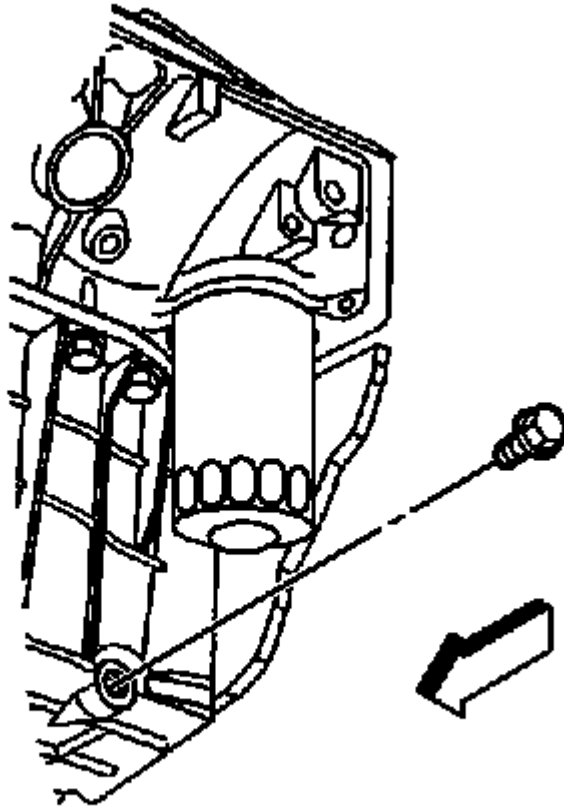


Fig. 205: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the drain plug to the oil pan.

Tighten: Tighten the oil pan plug to 25 N.m (18 lb ft).

5. Remove the safety stands and lower the vehicle.
6. Fill the engine with the proper capacity and quality of engine oil.
 - Refer to Capacities - Approximate Fluid in Maintenance and Lubrication.
 - Refer to Maintenance Schedule in Maintenance and Lubrication.
7. Operate the engine, check for leaks and oil pressure.
8. Check the oil level and add as required.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

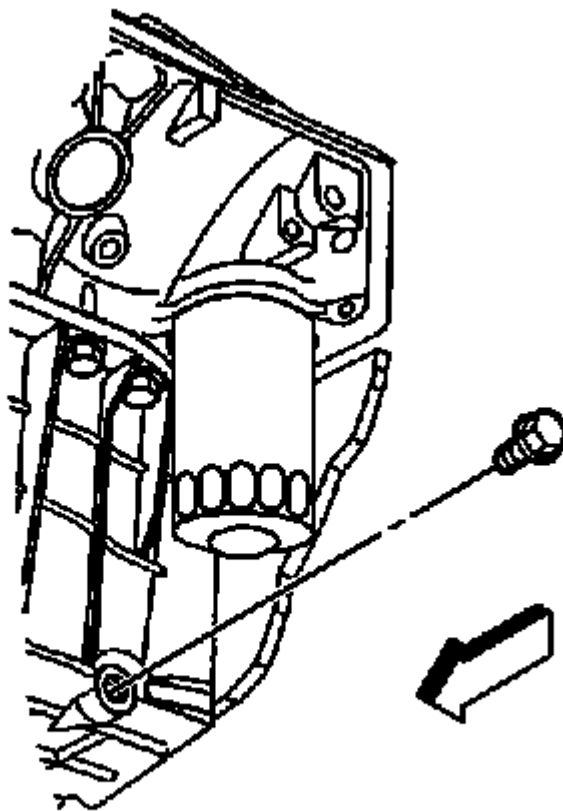


Fig. 206: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug and allow the engine oil to drain into a suitable container.

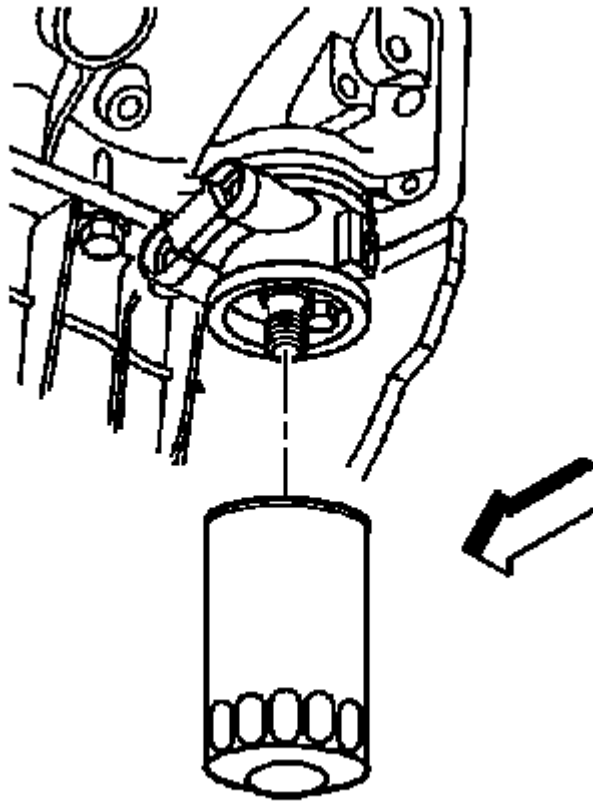


Fig. 207: Removing Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter.
3. Discard the oil filter.

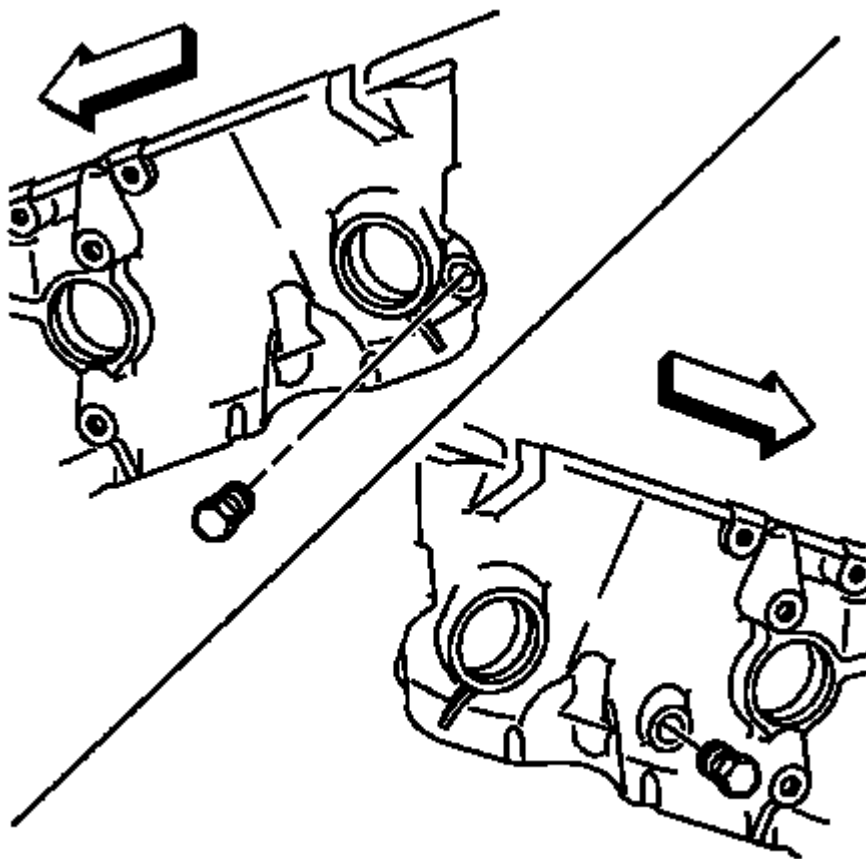


Fig. 208: Removing Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS CORP.

4. Remove both the engine block coolant drain hole plugs and allow the coolant to drain into a suitable container.

Engine Flywheel Removal

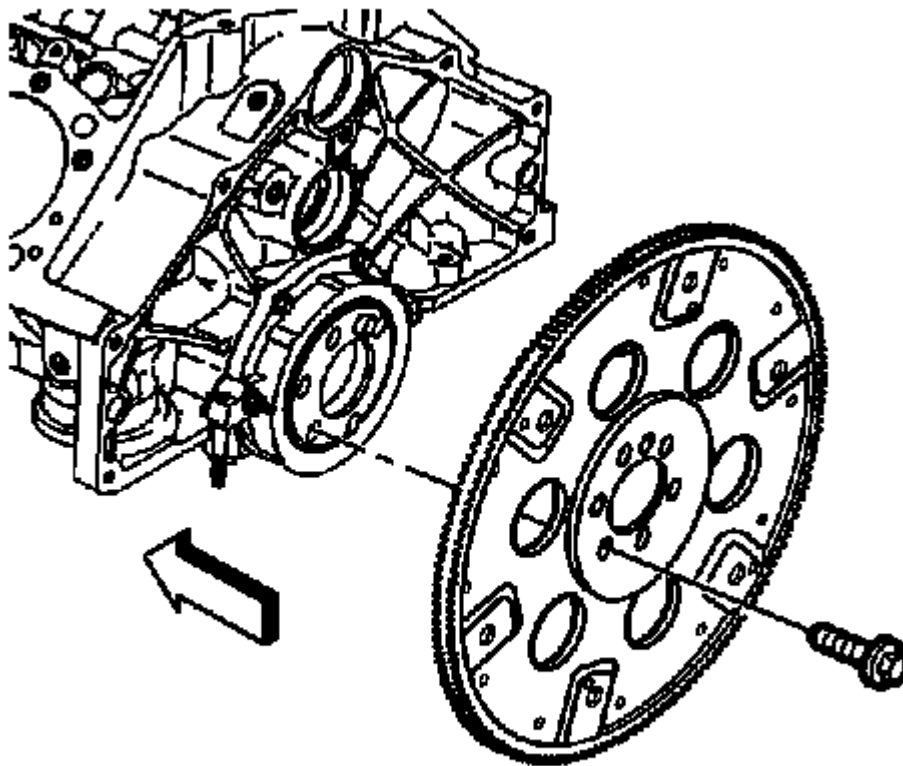


Fig. 209: Expanded View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

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

Exhaust Manifold Removal - Left

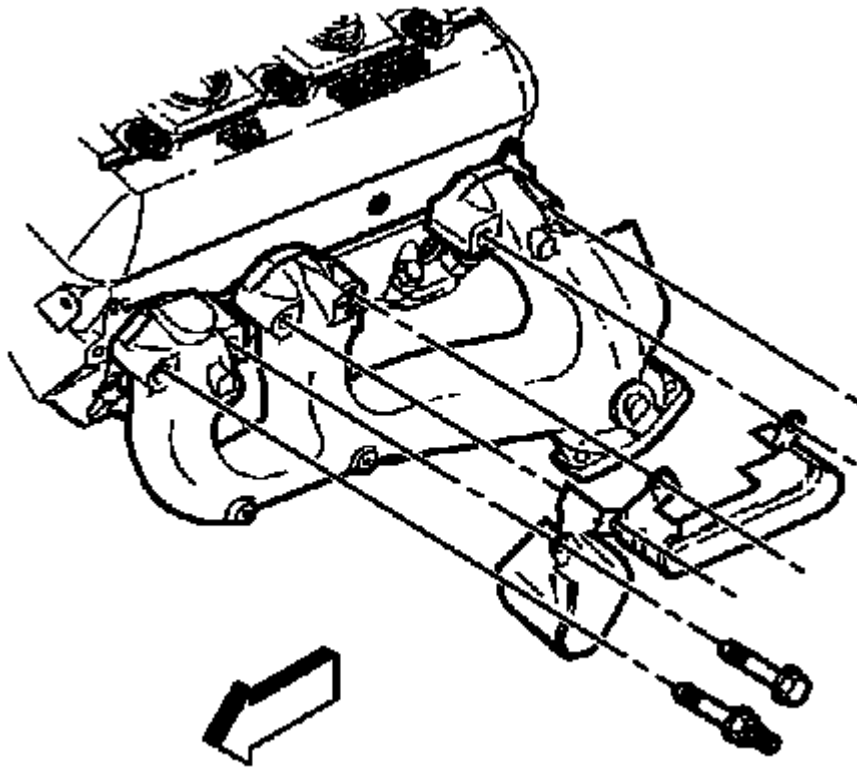


Fig. 210: Removing Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 1. Rotate the spark plug wire boot one half turn.
 2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the spark plug wires from the spark plug wire retainers.
3. Remove the exhaust manifold bolts and the stud.
4. Remove the spark plug wire shields, if applicable, and the exhaust manifold.

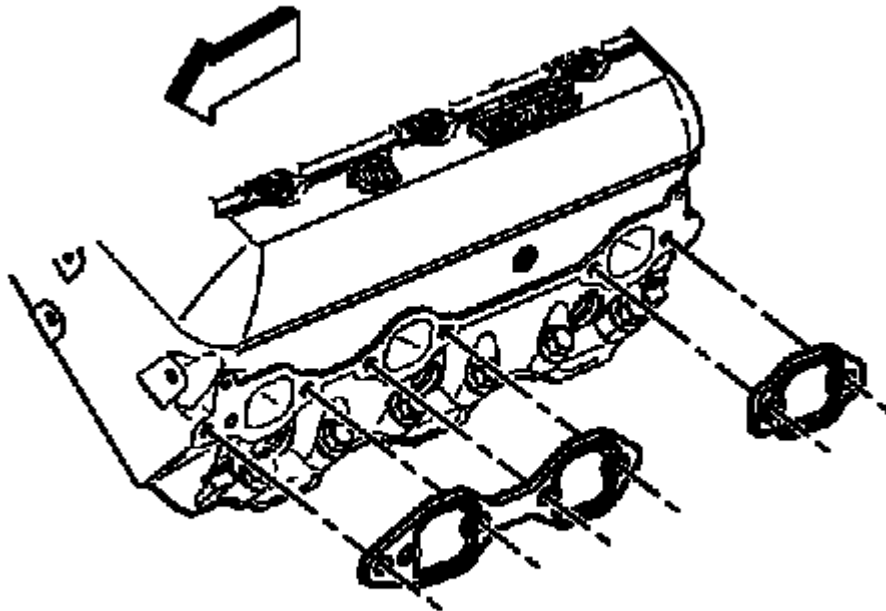


Fig. 211: Removing Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the exhaust manifold gaskets.

Exhaust Manifold Removal - Right

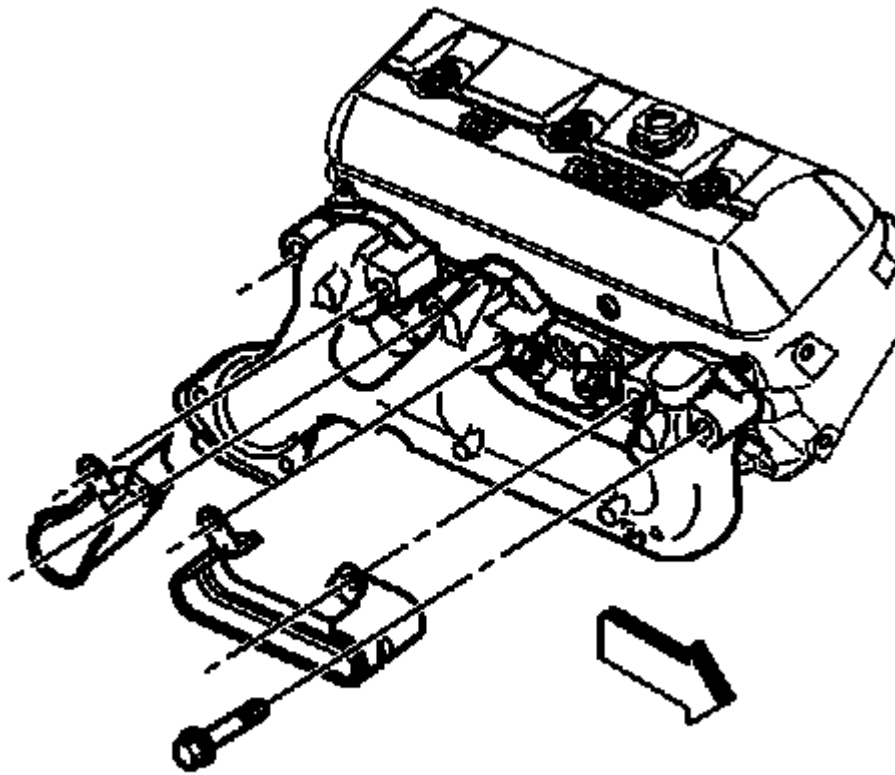


Fig. 212: Removing Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs.
 1. Rotate the spark plug wire boot one half turn.
 2. Pull outward on the spark plug wire boot to release from the spark plug.
2. Remove the spark plug wires from the spark plug wire retainers.
3. Remove the exhaust manifold bolts.
4. Remove the spark plug wire shields and the exhaust manifold.

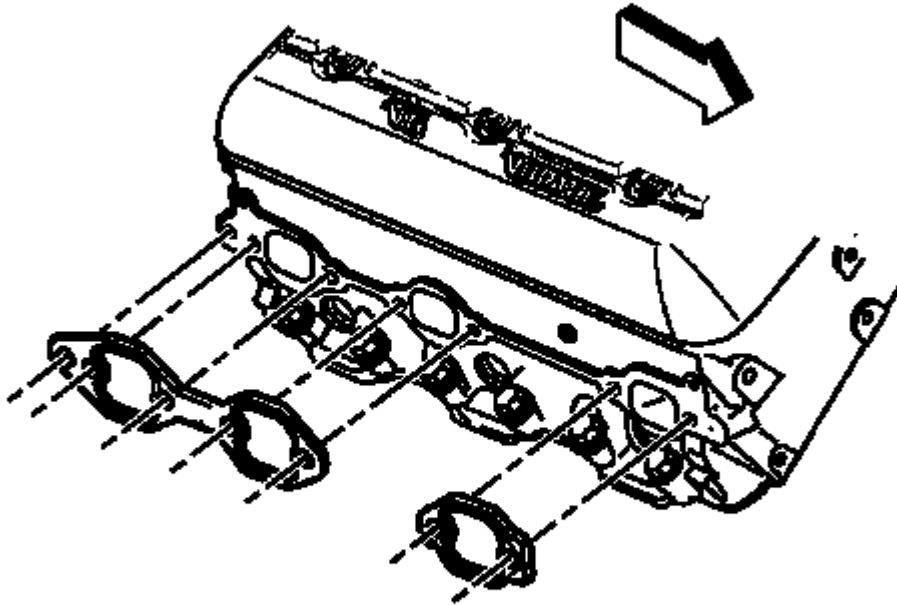


Fig. 213: Removing Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the exhaust manifold gaskets.

Oil Level Indicator and Tube Removal

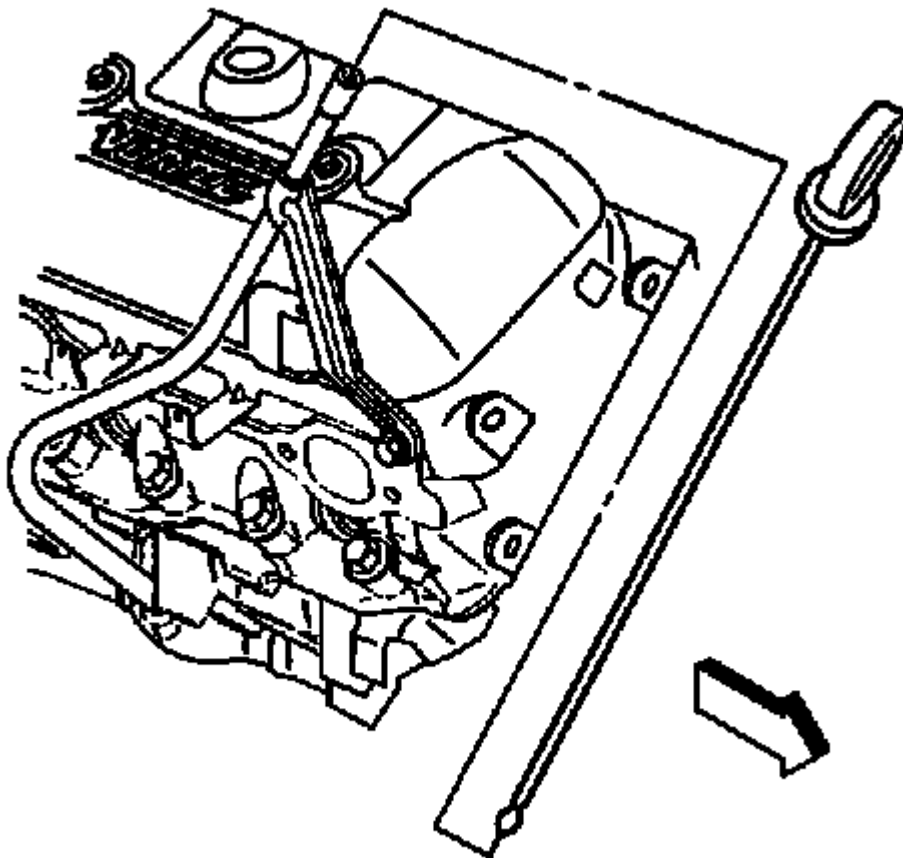


Fig. 214: Removing Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the oil level indicator tube, if required.

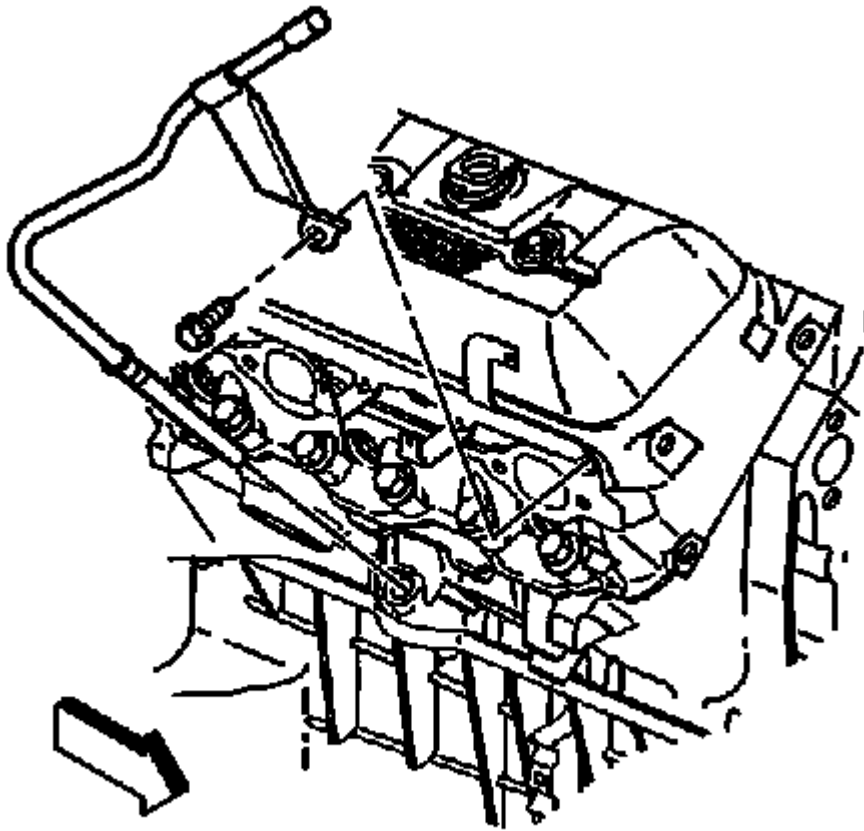


Fig. 215: Removing Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

Water Pump Removal

Tools Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools**.

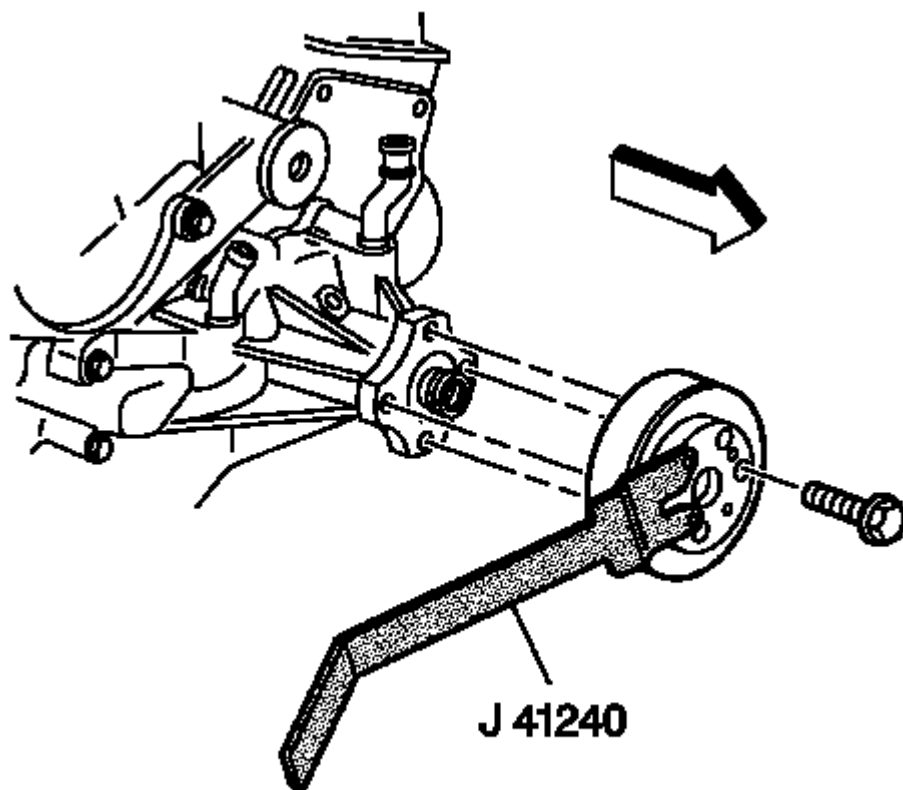


Fig. 216: Removing Water Pump Pulley, Fan & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts and the fan and water pump pulley using the **J 41240** . See **Special Tools**.

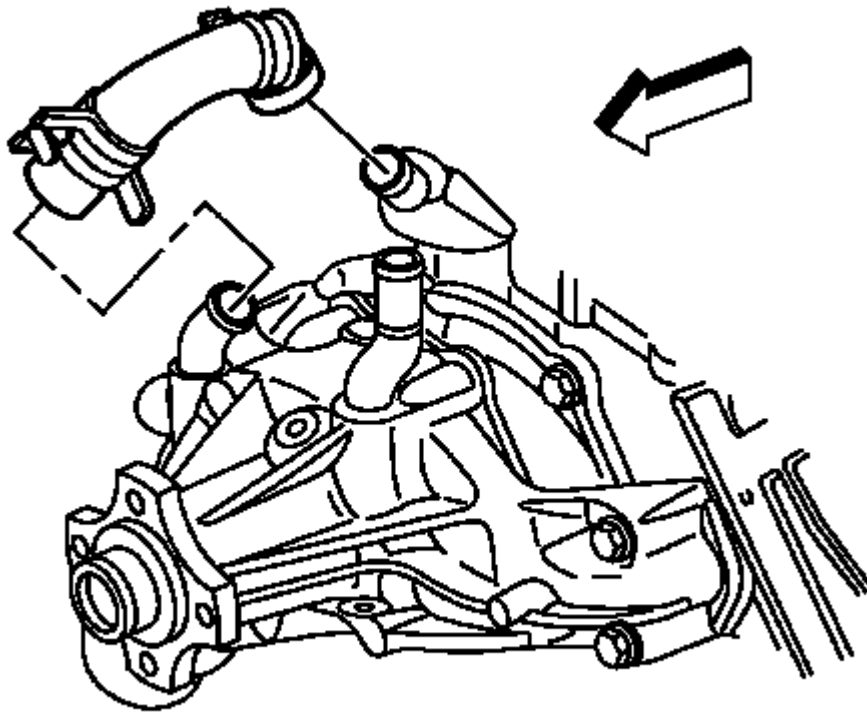


Fig. 217: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

2. Remove the clamps and the water pump inlet hose.

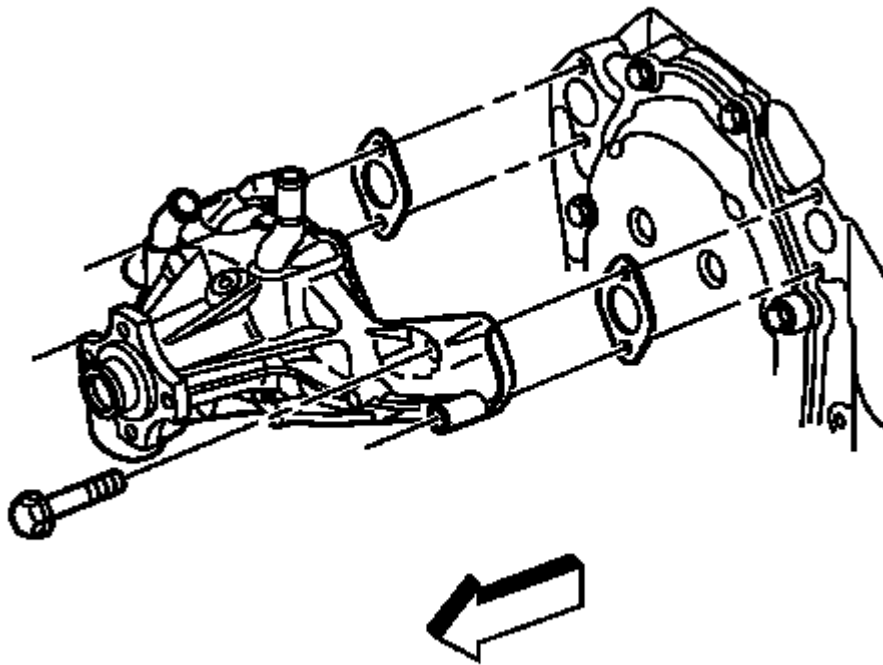


Fig. 218: Removing Water Pump
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gaskets.
6. Discard the water pump gaskets.

Crankshaft Balancer Removal

Tools Required

J 23523-F Balancer Remover and Installer

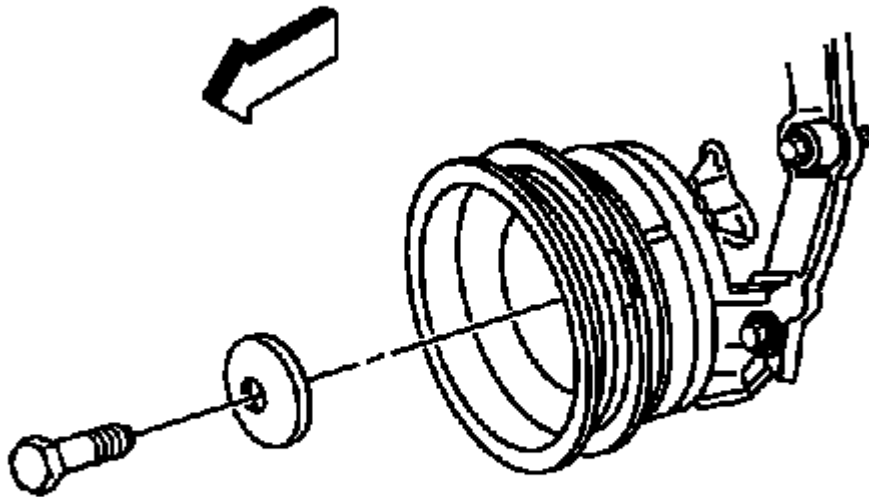


Fig. 219: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer bolt and washer.

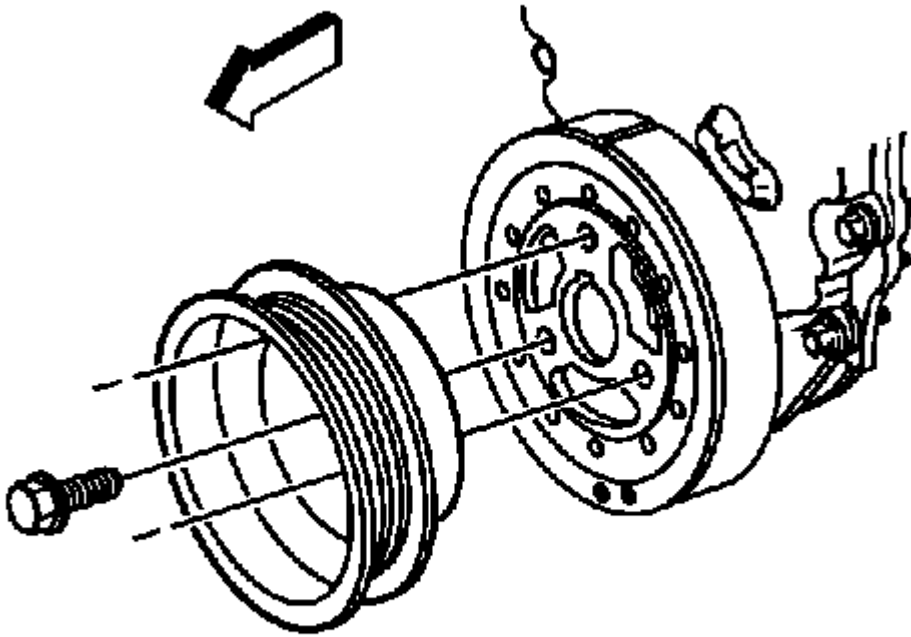


Fig. 220: View Of Crankshaft Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts and the crankshaft pulley.

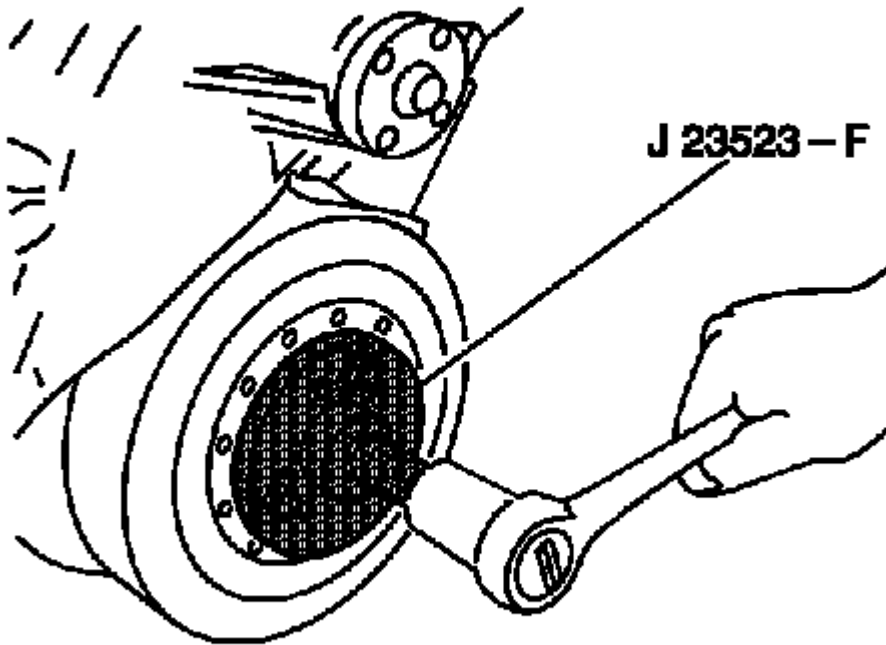


Fig. 221: Removing Crankshaft Balancer Using J 23523-F
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Use the J 23523-F in order to remove the crankshaft balancer.
 1. Install the J 23523-F plate and bolts onto the crankshaft balancer.
 - Tighten:** Tighten the bolts to 25 N.m (18 lb ft).
 2. Install the J 23523-F forcing screw into the plate.
 3. Rotate the J 23523-F forcing screw clockwise in order to remove the crankshaft balancer.
4. Remove the J 23523-F from the crankshaft balancer.

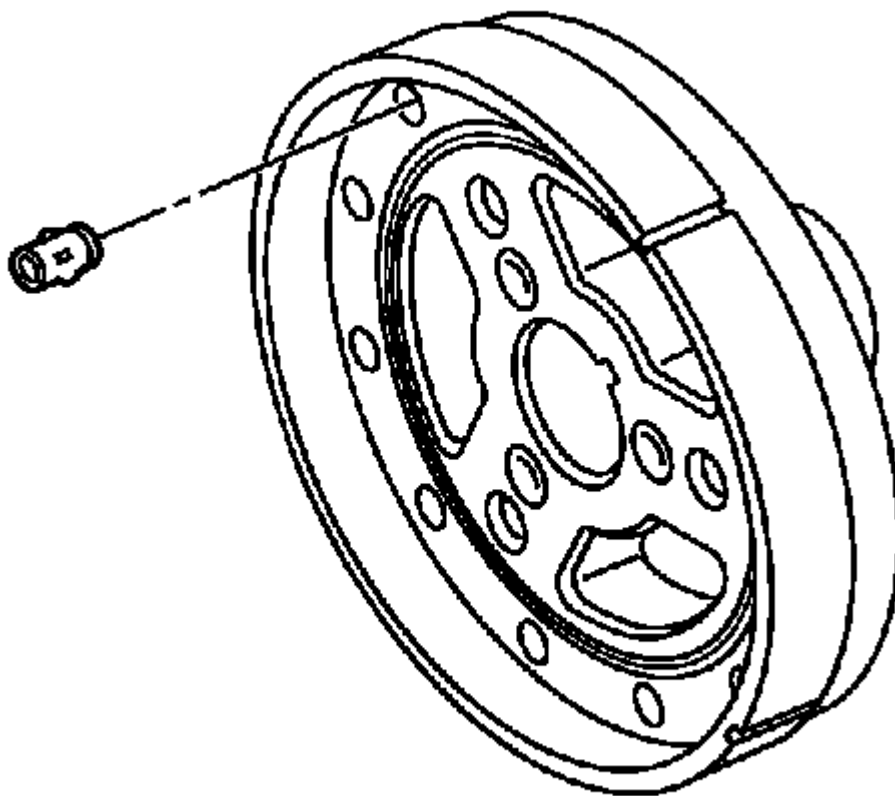


Fig. 222: View Of Crankshaft Balancer Weights
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If replacing the crankshaft balancer, **NEW** weights must be installed into the **NEW** crankshaft balancer, in the same location as the old weights in the old balancer.

5. Note the position and length of any crankshaft balancer front groove pins, if applicable.

Valve Rocker Arm Cover Removal - Left

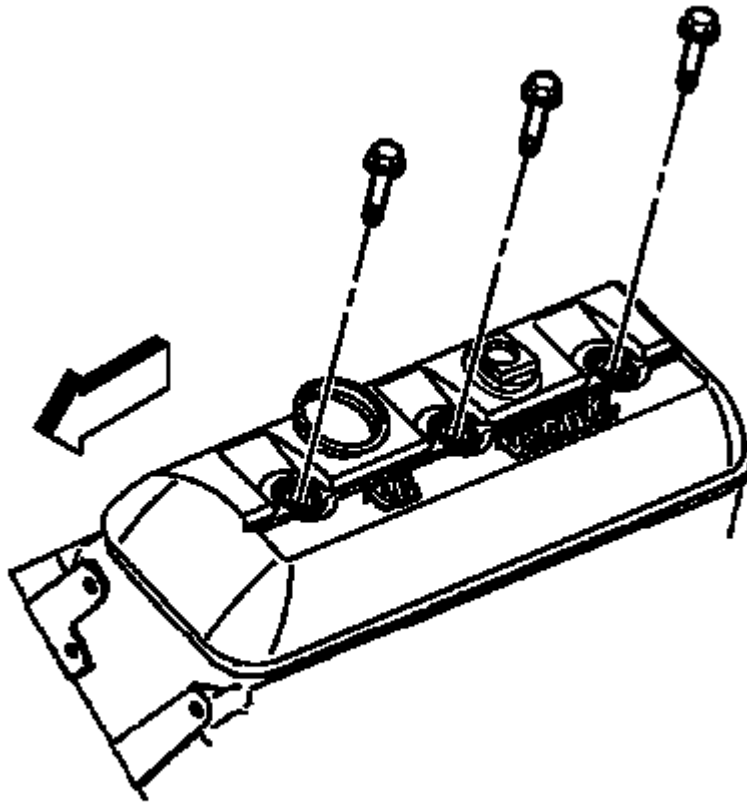


Fig. 223: Removing Valve Rocker Arm Cover Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

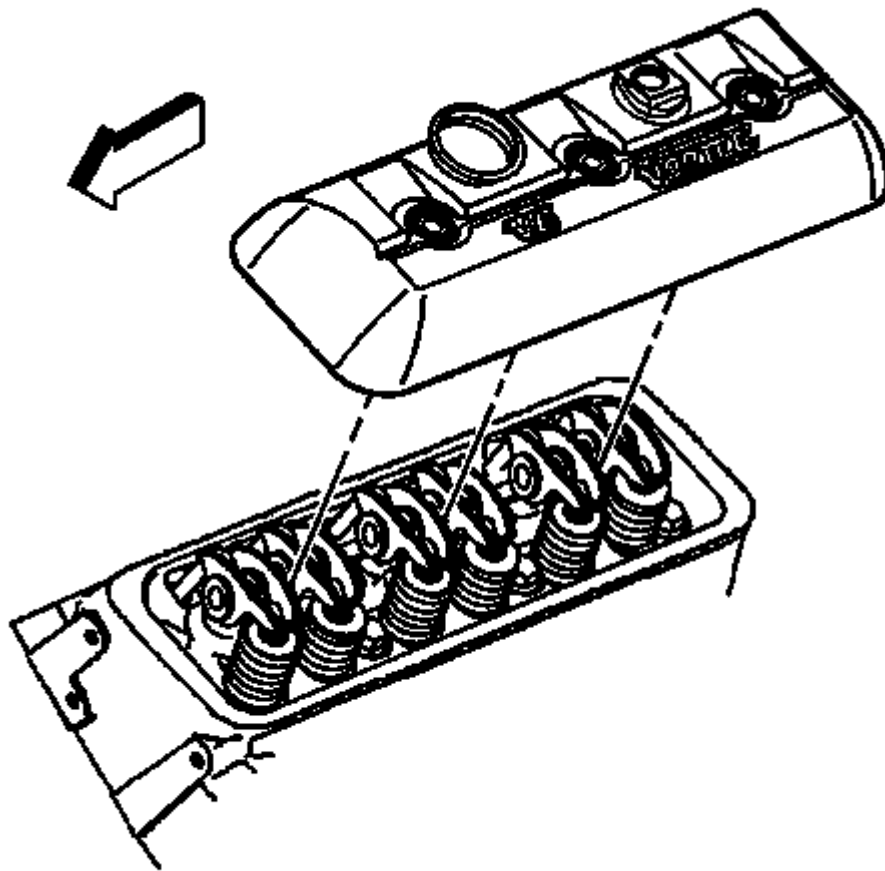


Fig. 224: Remove Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm cover.

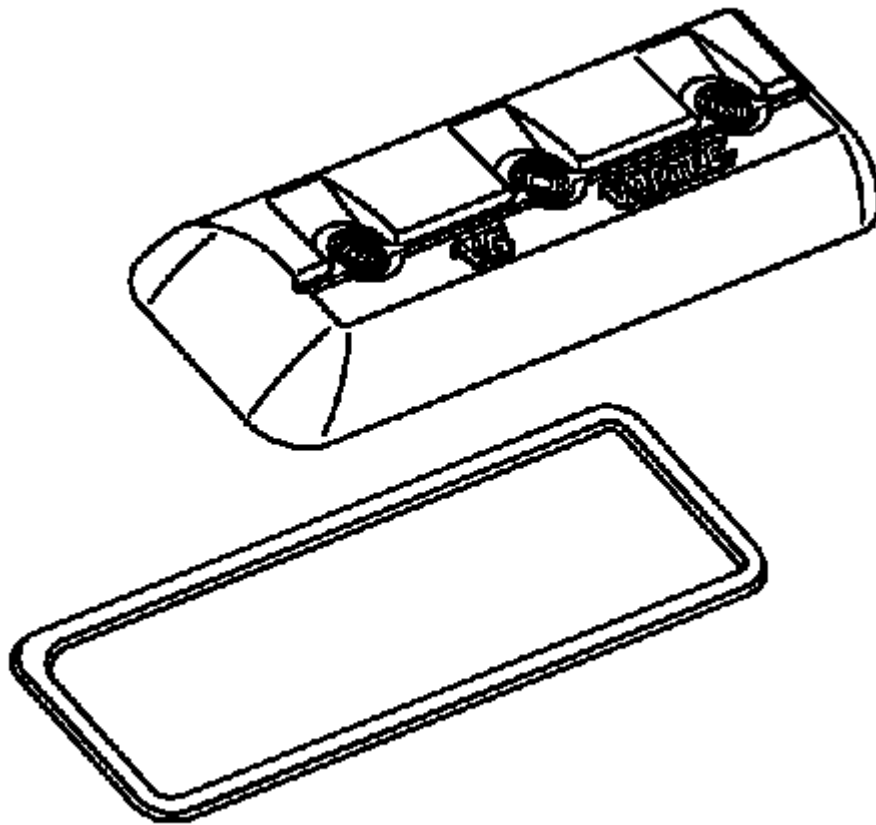


Fig. 225: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

Valve Rocker Arm Cover Removal - Right

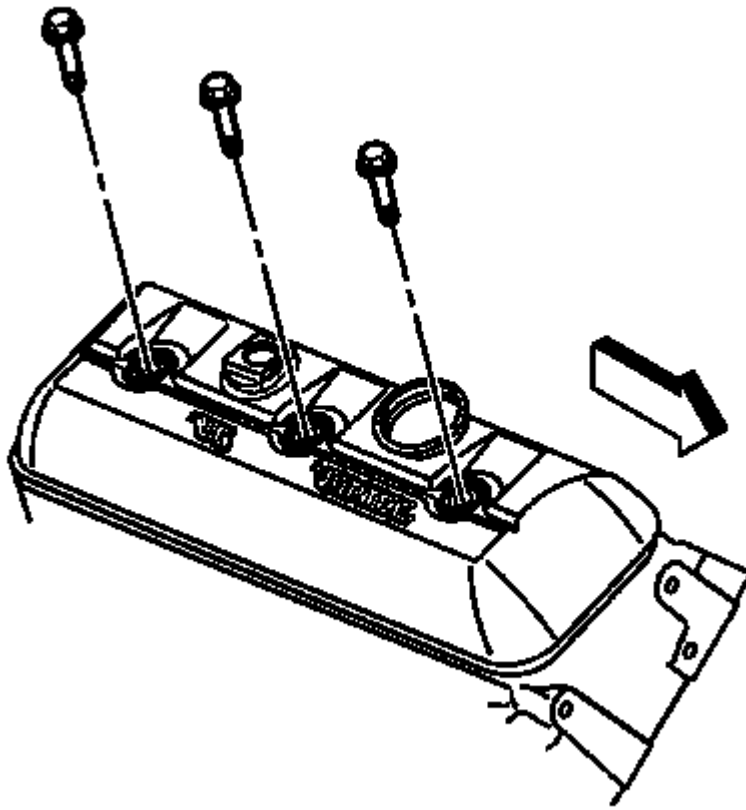


Fig. 226: Removing Valve Rocker Arm Cover Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover bolt grommets.
3. Discard the valve rocker arm cover bolt grommets.

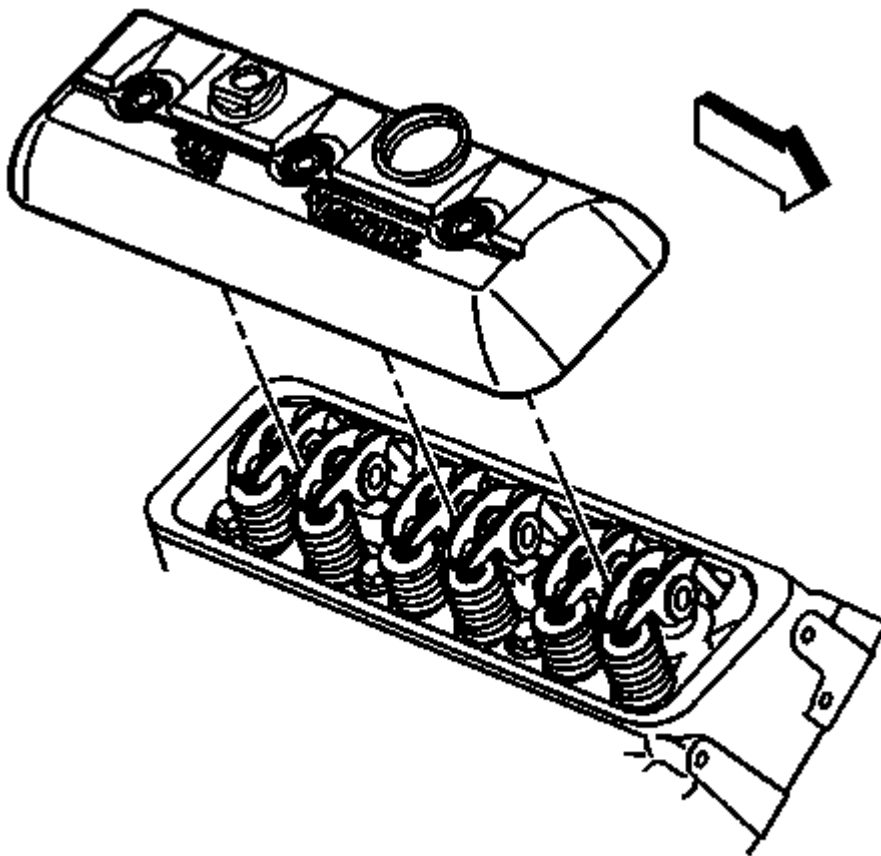


Fig. 227: Removing Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm cover.

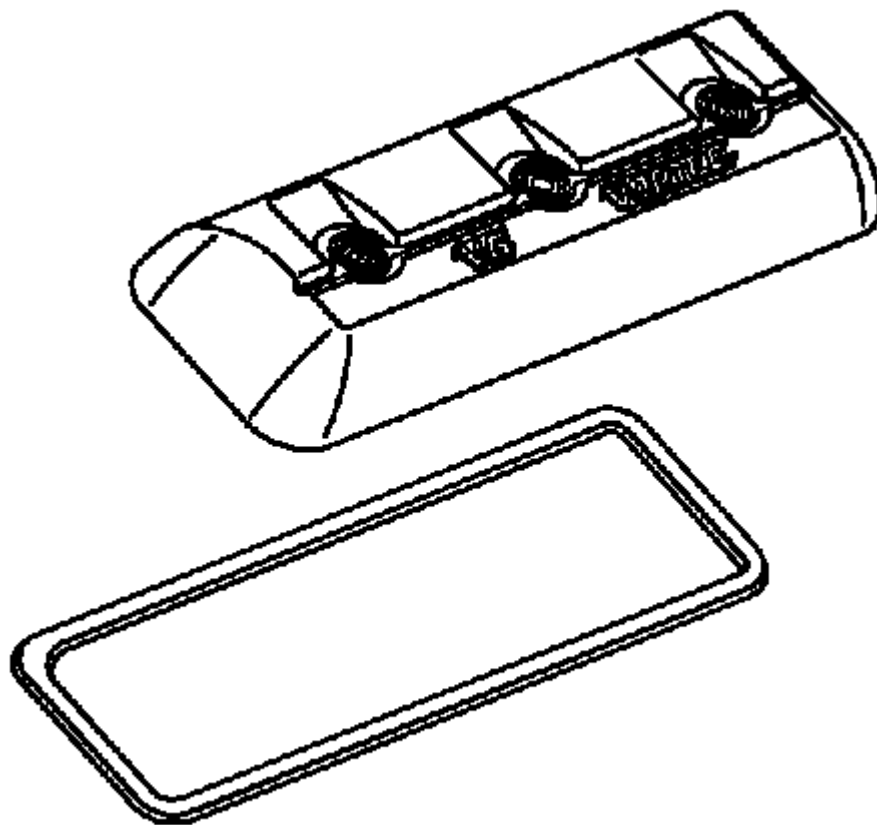


Fig. 228: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover gasket.
6. Discard the valve rocker arm cover gasket.

Distributor Removal

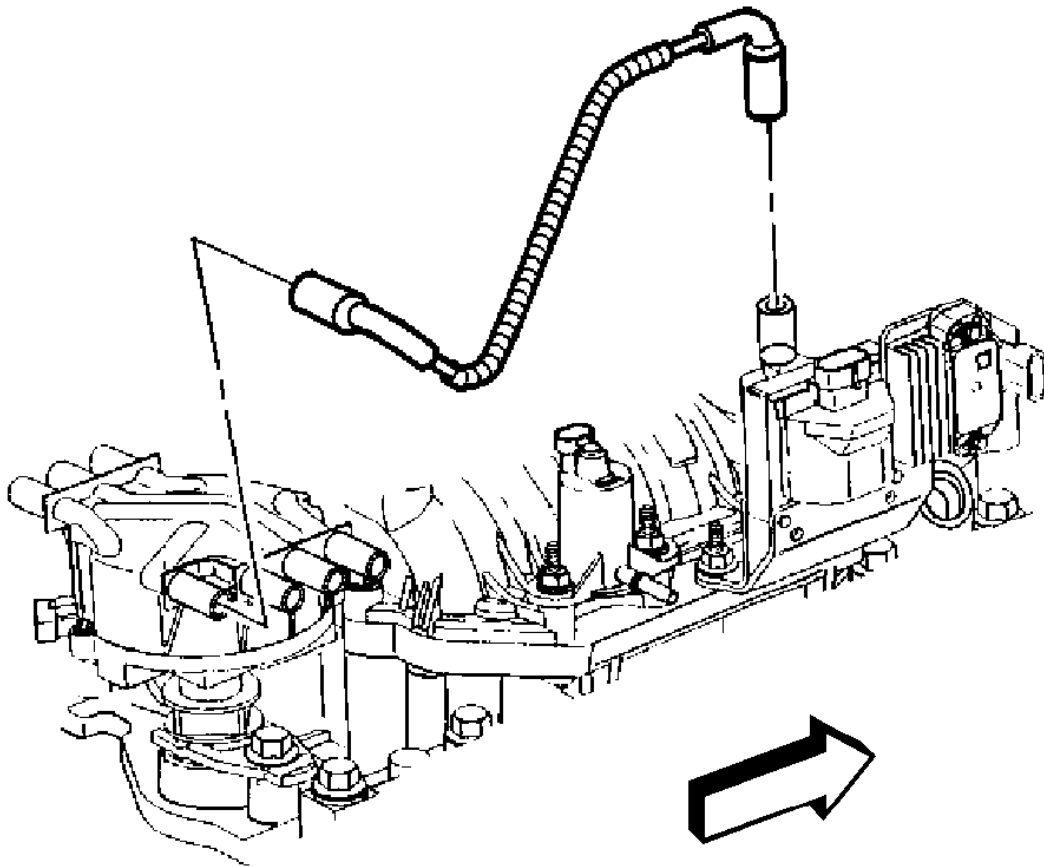


Fig. 229: Removing Ignition Coil Wire Harness
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coil wire harness from the ignition coil and distributor cap.

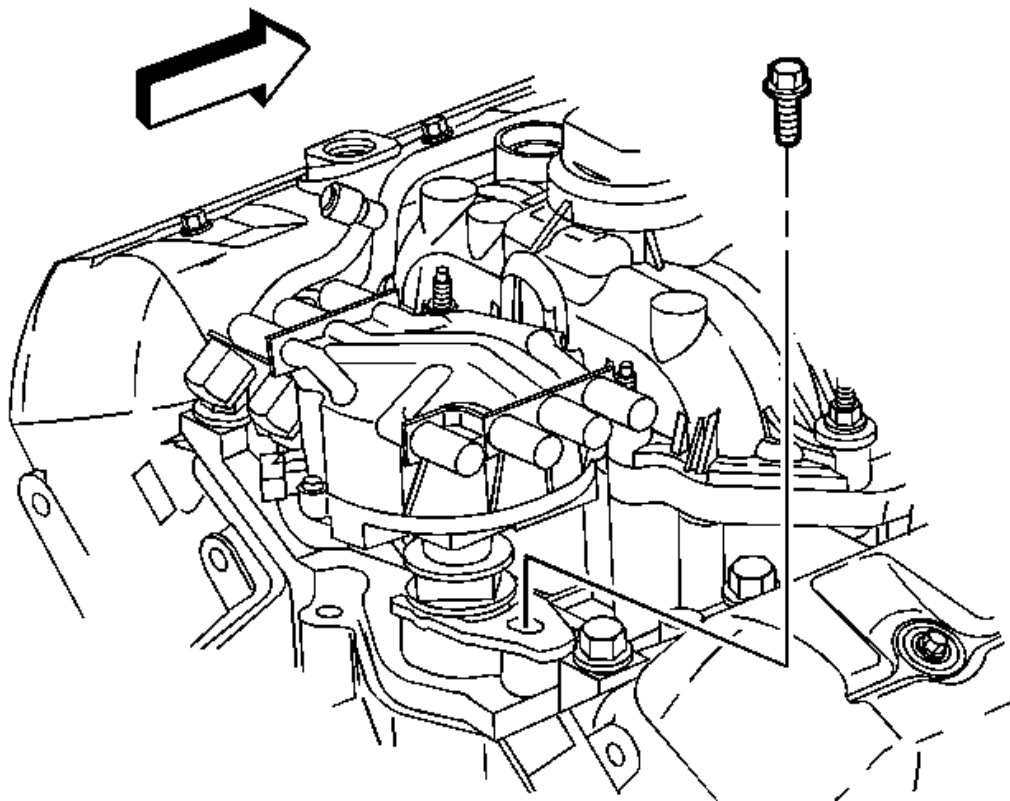


Fig. 230: Removing Distributor Clamp Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the distributor clamp bolt.
3. Remove the distributor and the distributor clamp.

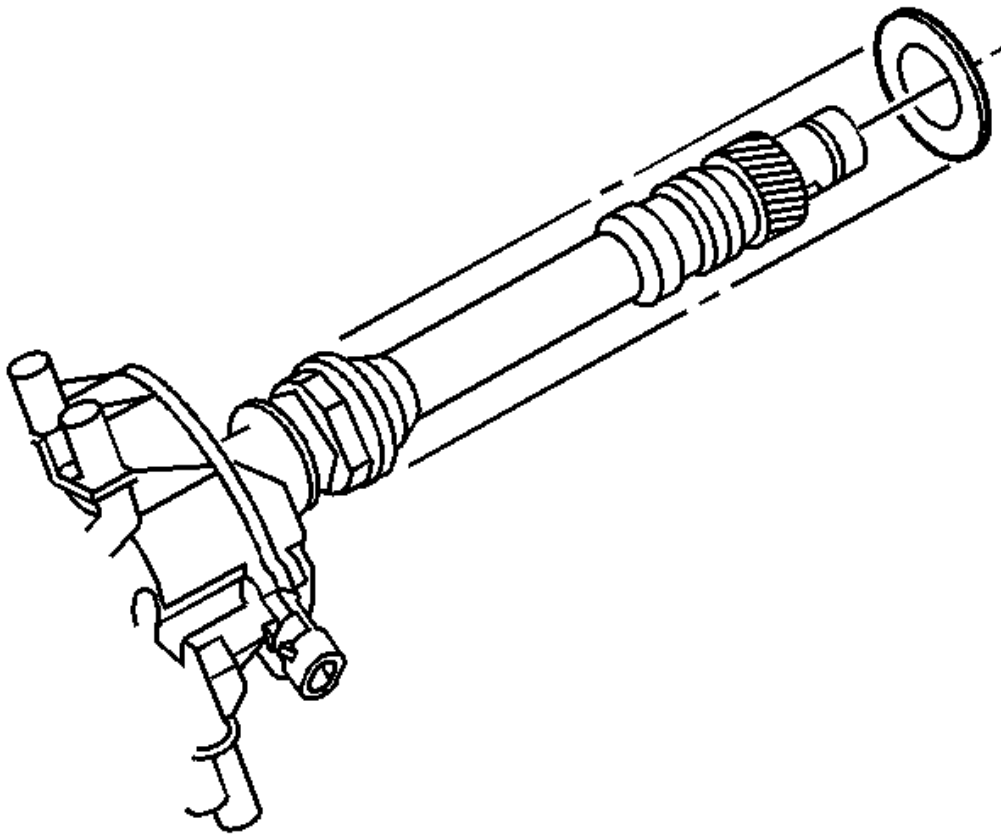


Fig. 231: Removing Distributor Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove the distributor gasket and discard.

Intake Manifold Removal

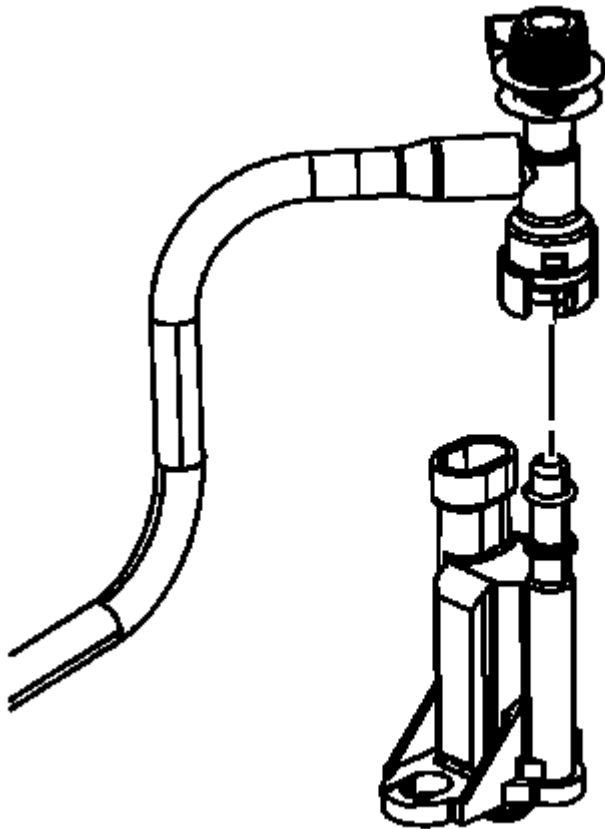


Fig. 232: Removing Evaporative Emission Canister Purge Solenoid Valve Harness
Courtesy of GENERAL MOTORS CORP.

1. Remove the evaporative emission (EVAP) canister purge solenoid valve harness.
 1. Push the quick disconnect clip and hold in place.
 2. Pull outward on the harness elbow.

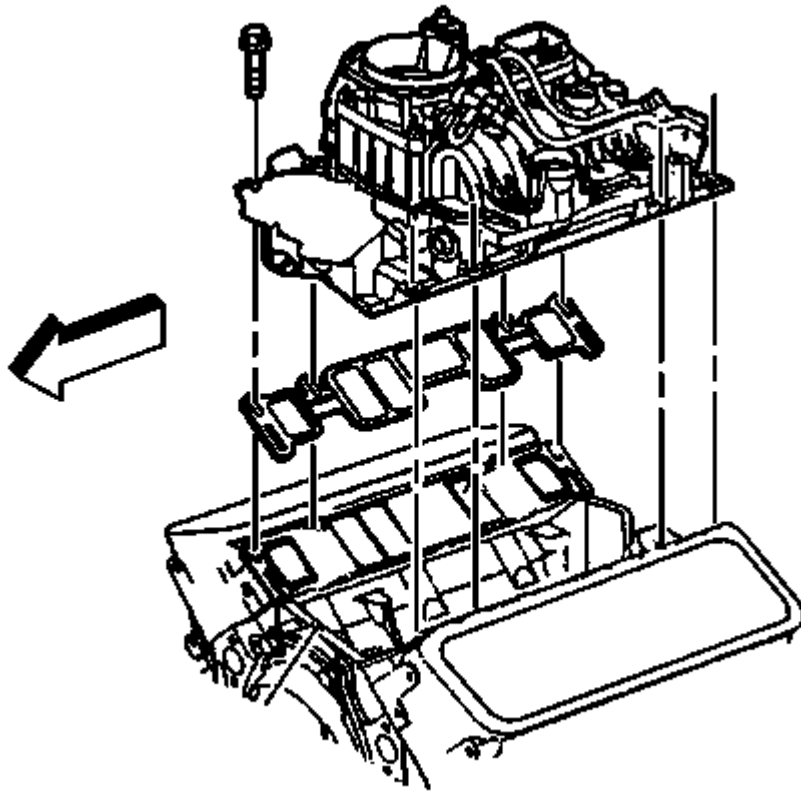


Fig. 233: Removing Intake Manifold Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine coolant temperature (ECT) sensor wire connector, if equipped, from the engine wiring harness bracket.
3. Remove the lower intake manifold bolts.

IMPORTANT:

- The intake manifold may be removed as an assembly. Do not remove the specific intake manifold components unless component service is required.
- Do not allow dirt or debris to enter the fuel system. Ensure that the ends of the fuel system are properly sealed.

4. Remove the intake manifold assembly.
5. Remove and discard the lower intake manifold gaskets.

Valve Rocker Arm and Push Rod Removal

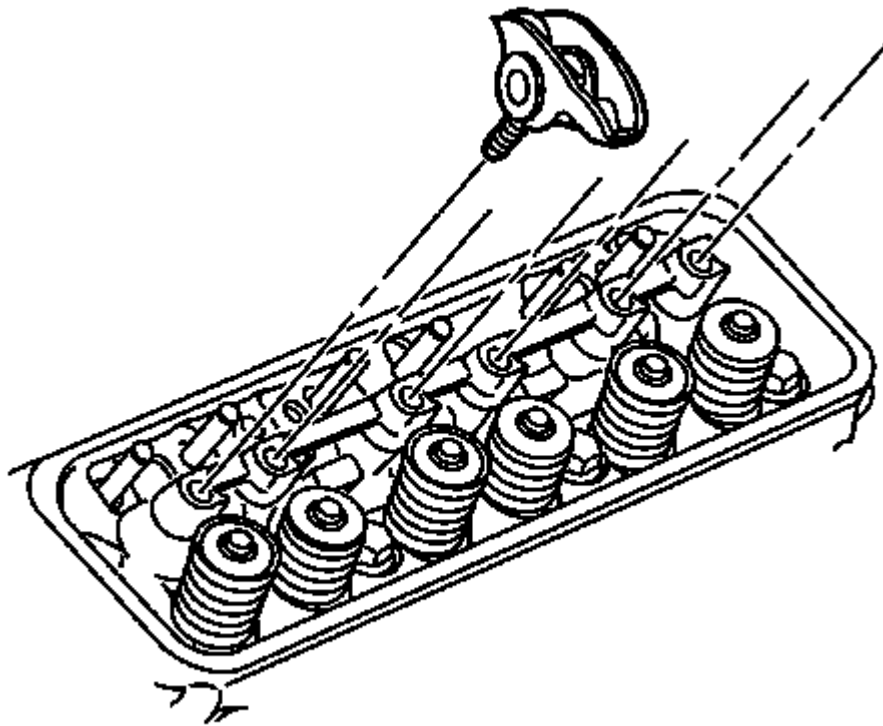


Fig. 234: Removing Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, and organize all the components for assembly.

1. Remove the valve rocker arms.

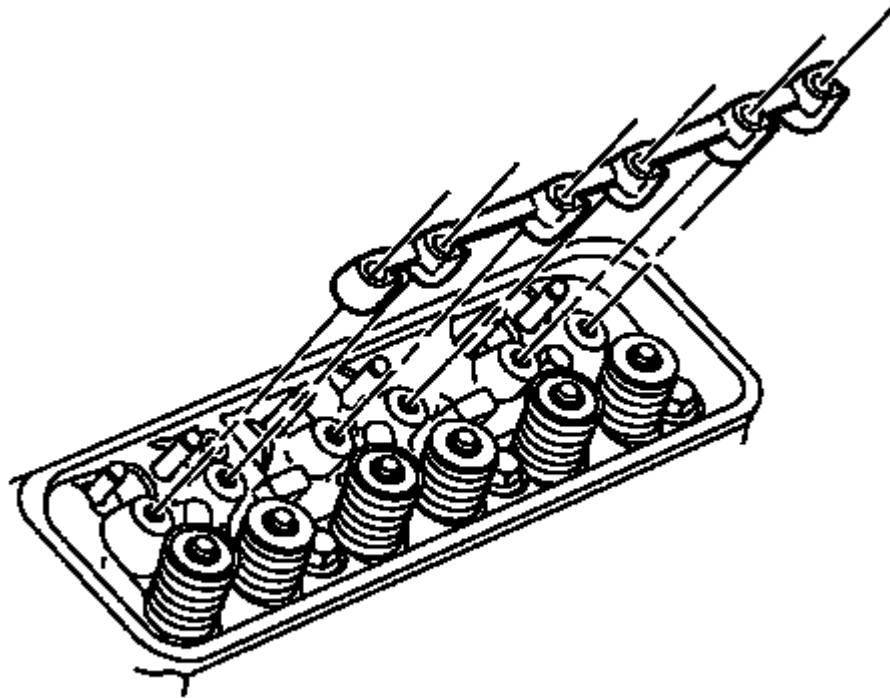


Fig. 235: Removing Rocker Arm Supports
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve rocker arm supports.

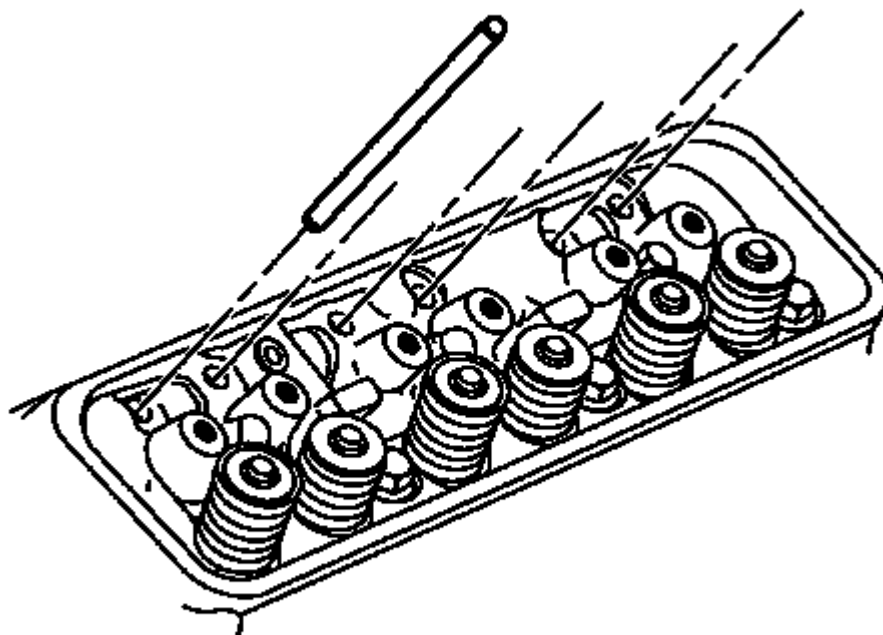


Fig. 236: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve pushrods.

Cylinder Head Removal - Left

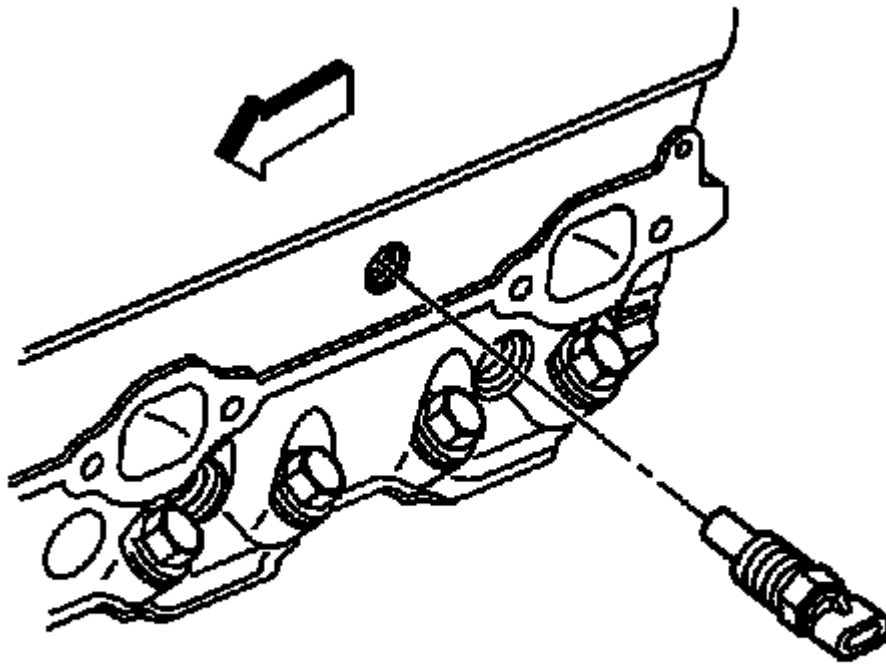


Fig. 237: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor, if applicable.

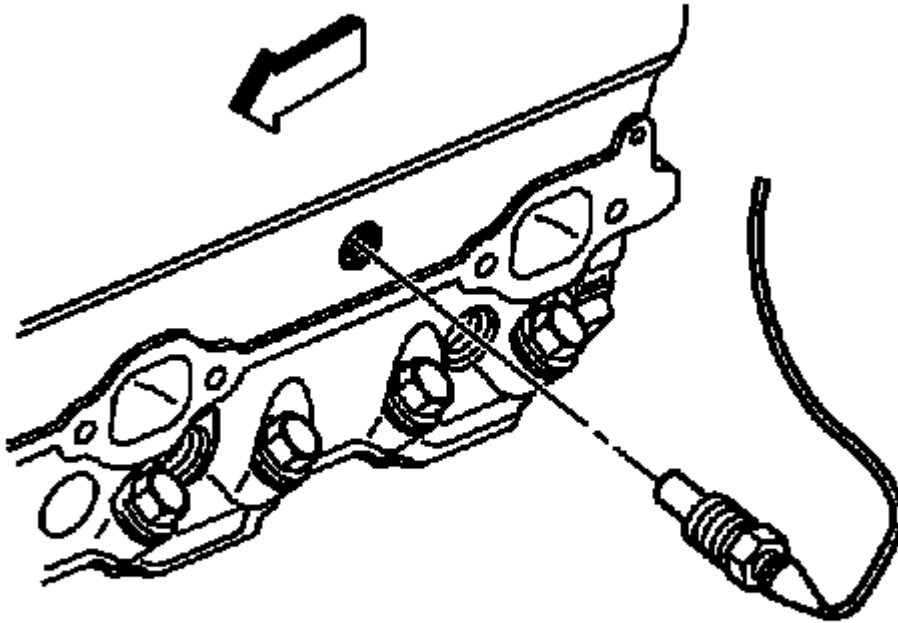


Fig. 238: Removing Engine Coolant Temperature Gage Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine coolant temperature gage sensor, if applicable.

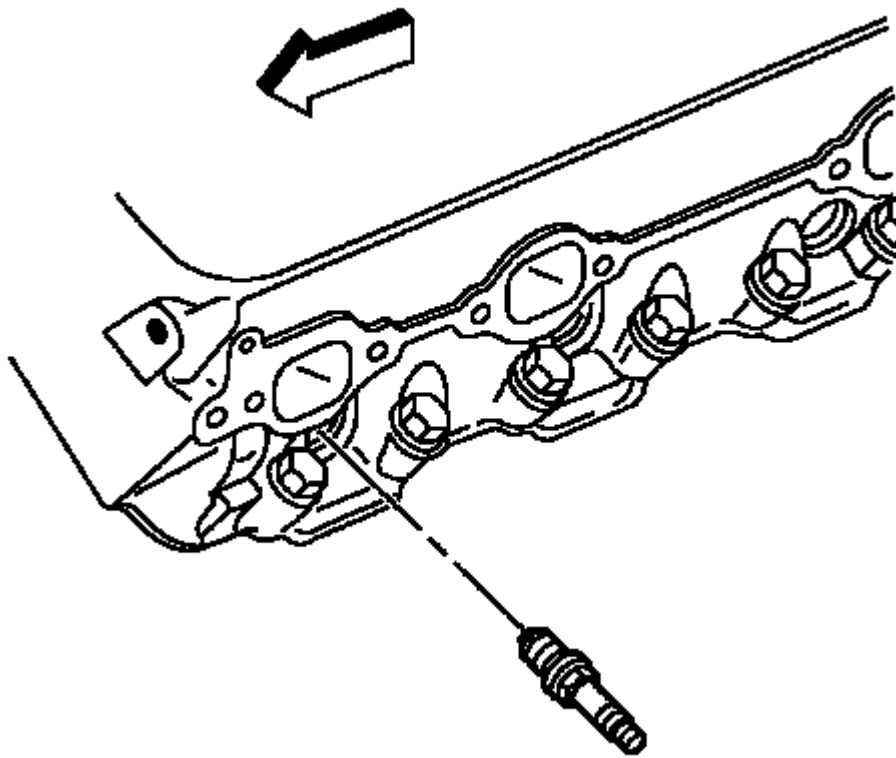


Fig. 239: Removing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

3. Remove the spark plugs.

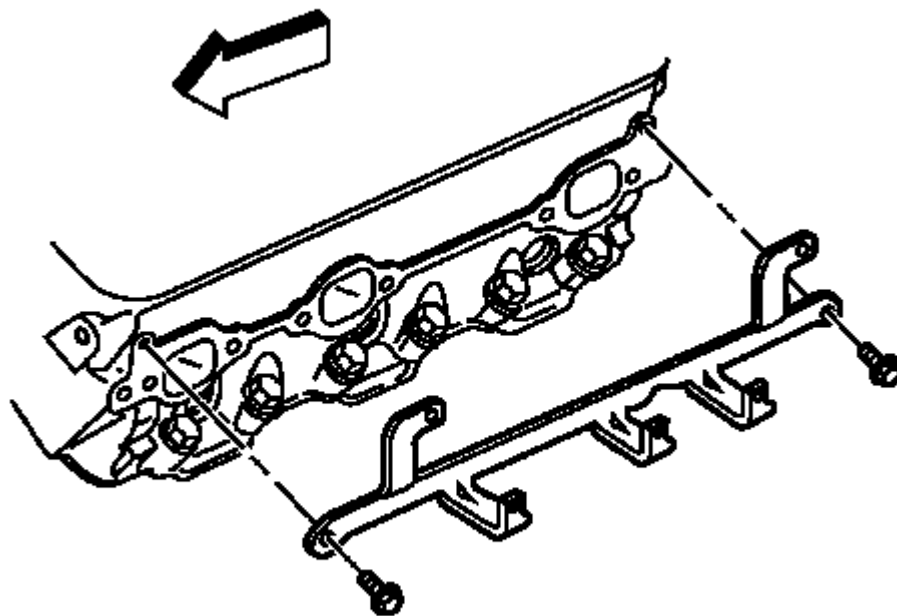


Fig. 240: Removing Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and the spark plug wire support.

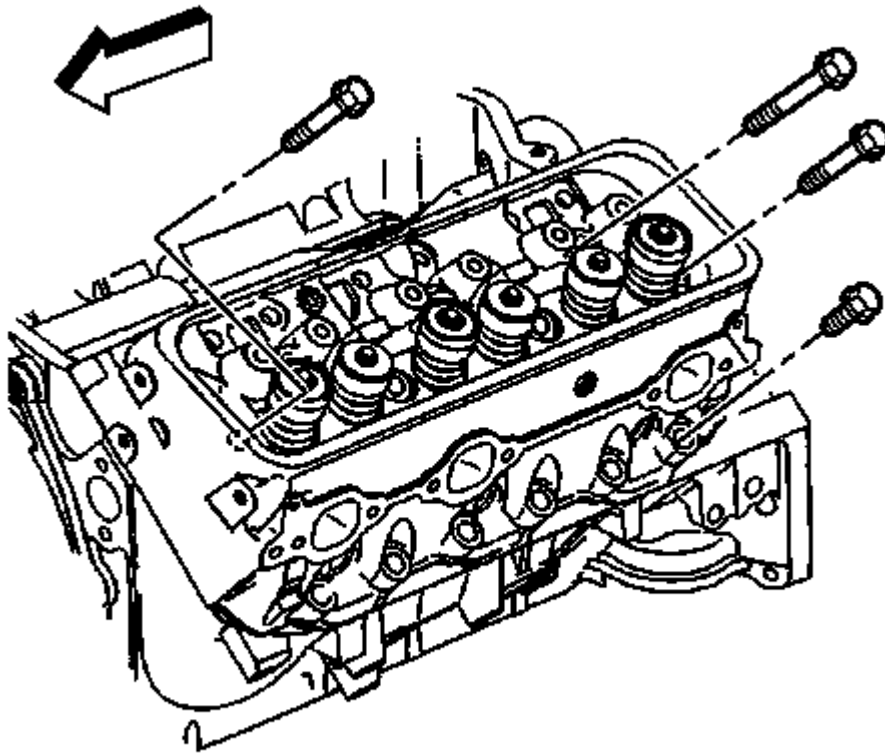


Fig. 241: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

5. Remove the cylinder head bolts and discard.

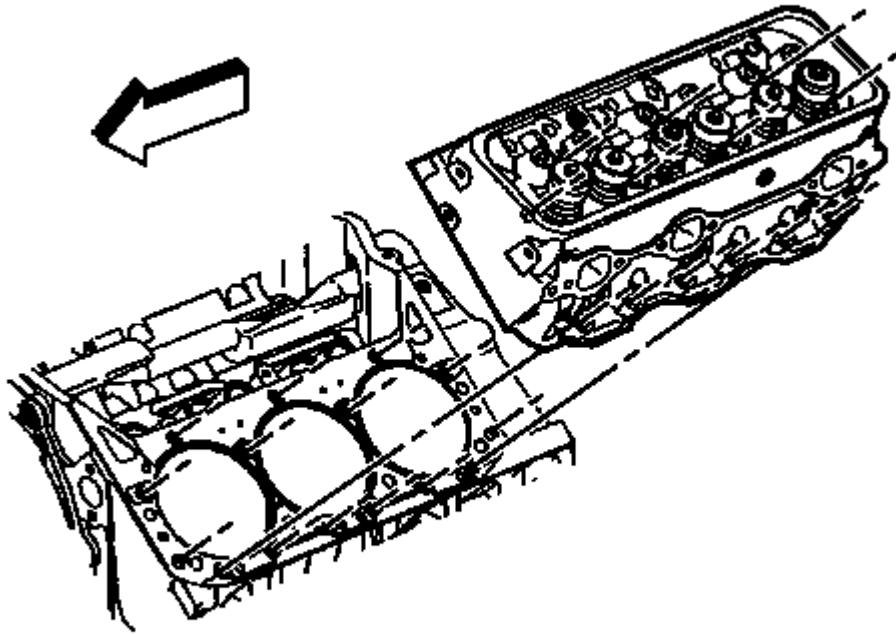


Fig. 242: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

6. Remove the cylinder head.

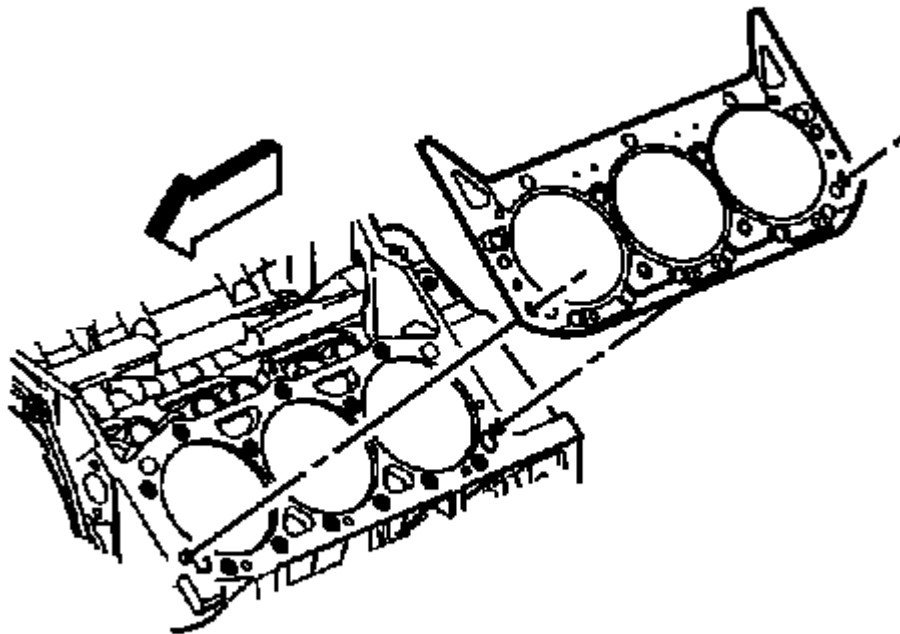


Fig. 243: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the cylinder head gasket.

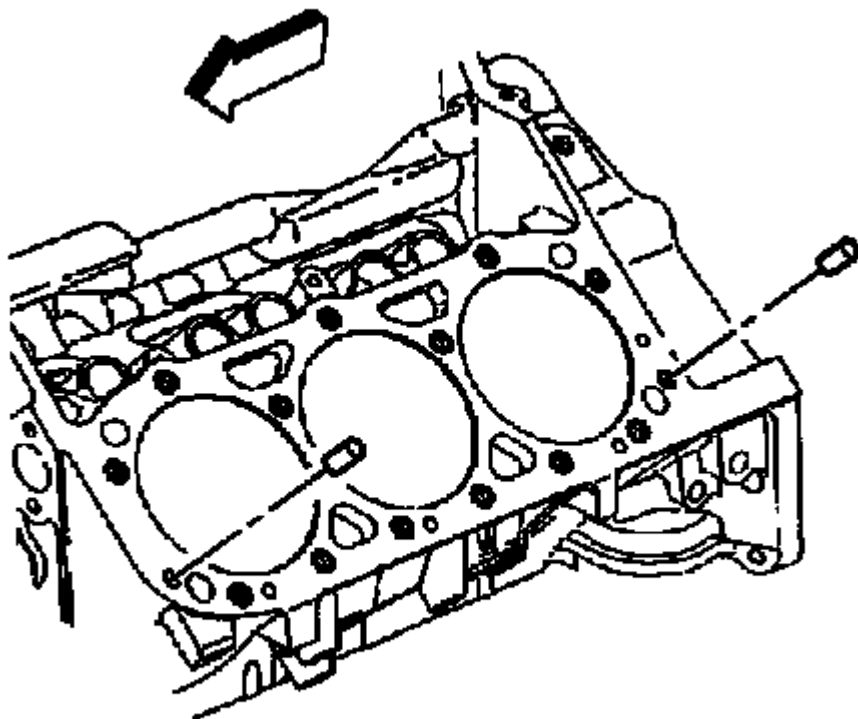


Fig. 244: Removing Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head locator dowel pins, if required.

Cylinder Head Removal - Right

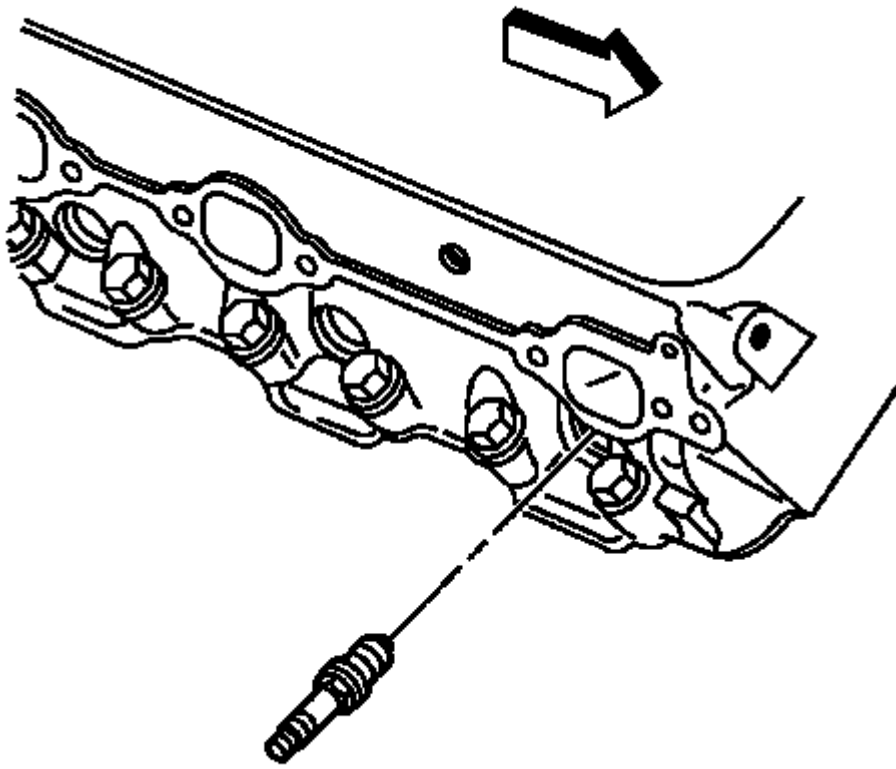


Fig. 245: Locating Spark Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.

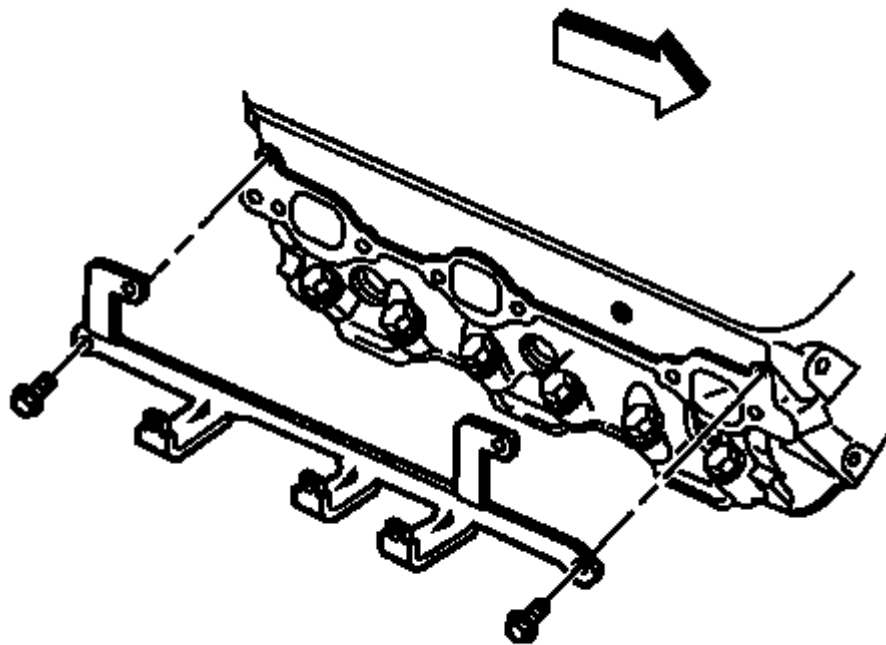


Fig. 246: Removing Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear bolt and the spark plug wire support.

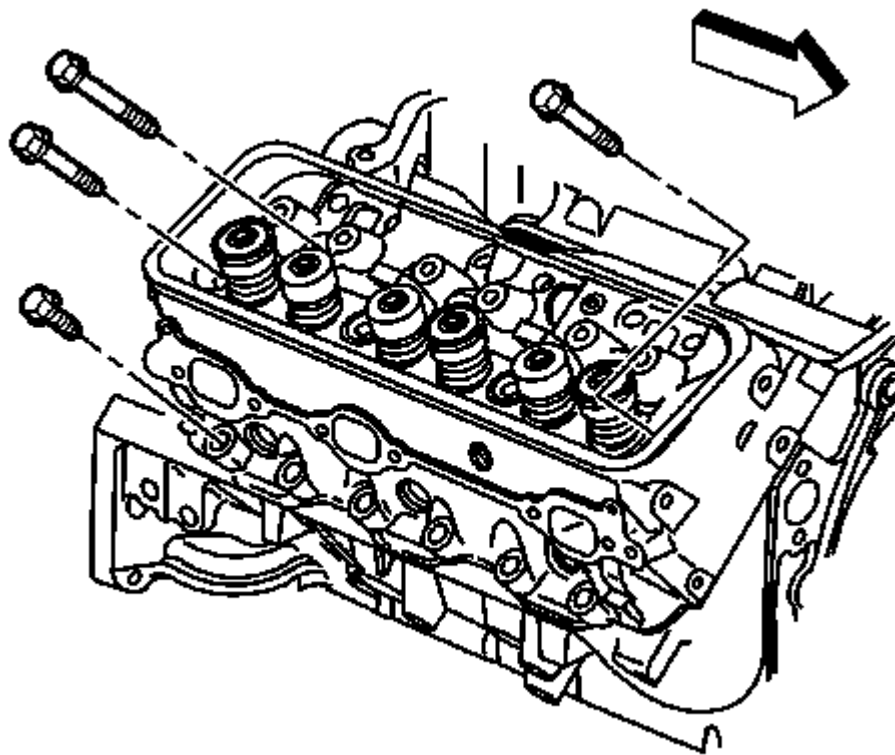


Fig. 247: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head bolts and discard.

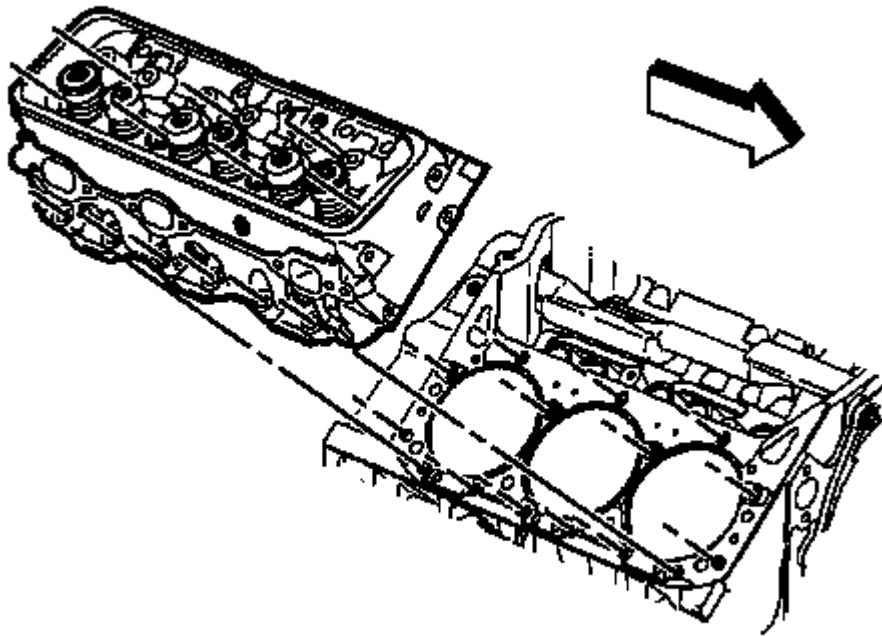


Fig. 248: Removing/Installing Cylinder Head (Right)

Courtesy of GENERAL MOTORS CORP.

NOTE: After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

4. Remove the cylinder head.

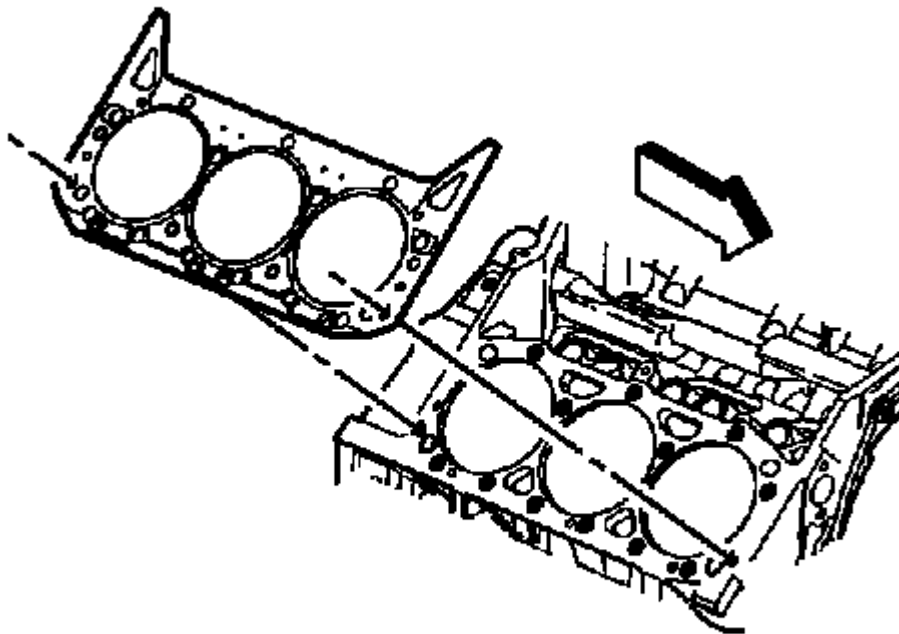


Fig. 249: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the cylinder head gasket.

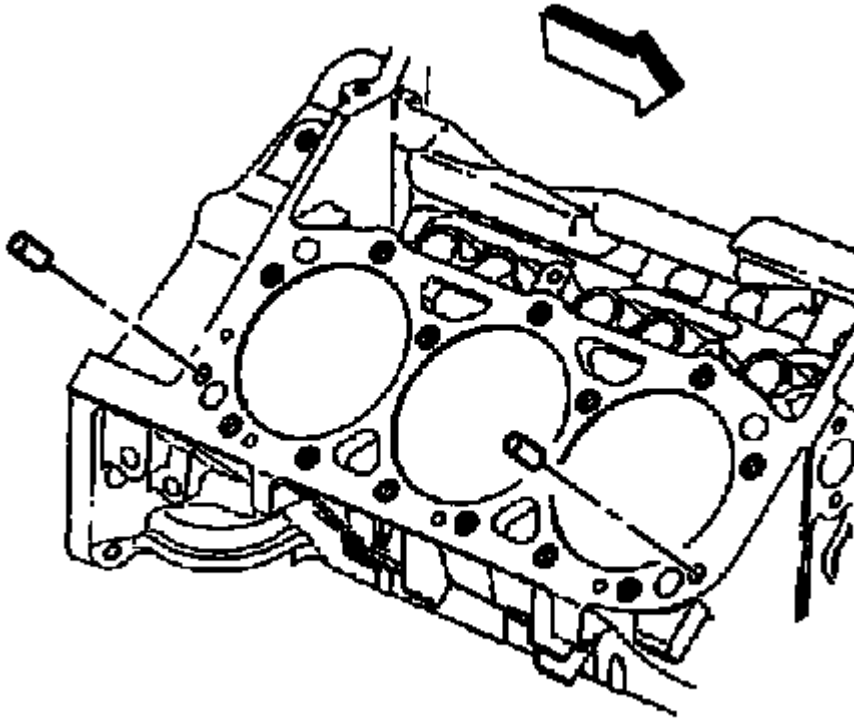


Fig. 250: Removing Cylinder Head Locator Pins
Courtesy of GENERAL MOTORS CORP.

6. Remove the cylinder head locator dowel pins, if required.

Valve Lifter Removal

Tools Required

J 3049-A Valve Lifter Remover. See **Special Tools**.

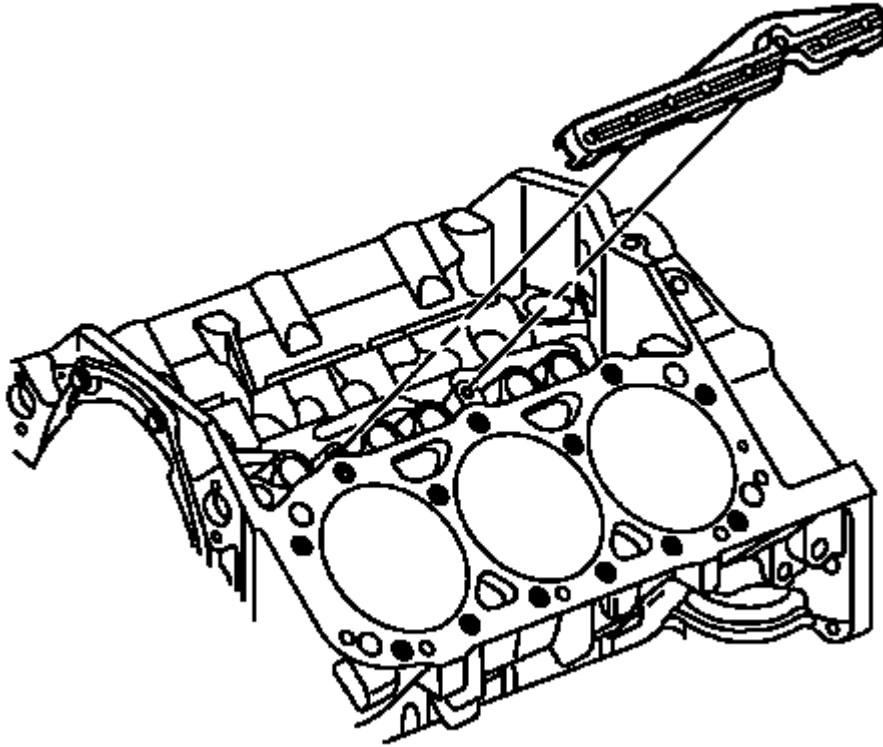


Fig. 251: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the components in a rack so that the components can be reinstalled to their original location.

1. Remove the bolts and valve lifter pushrod guide.

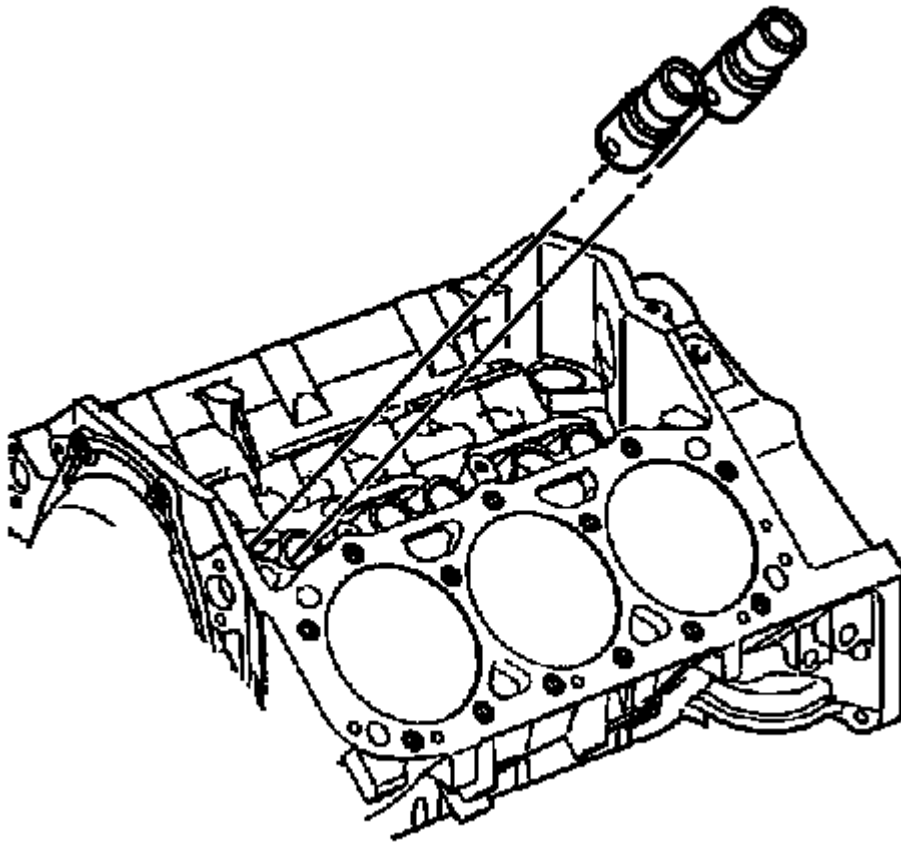


Fig. 252: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve lifters in the rack in the upright position in order to maintain the oil inside the valve lifters.

2. Remove the valve lifters.

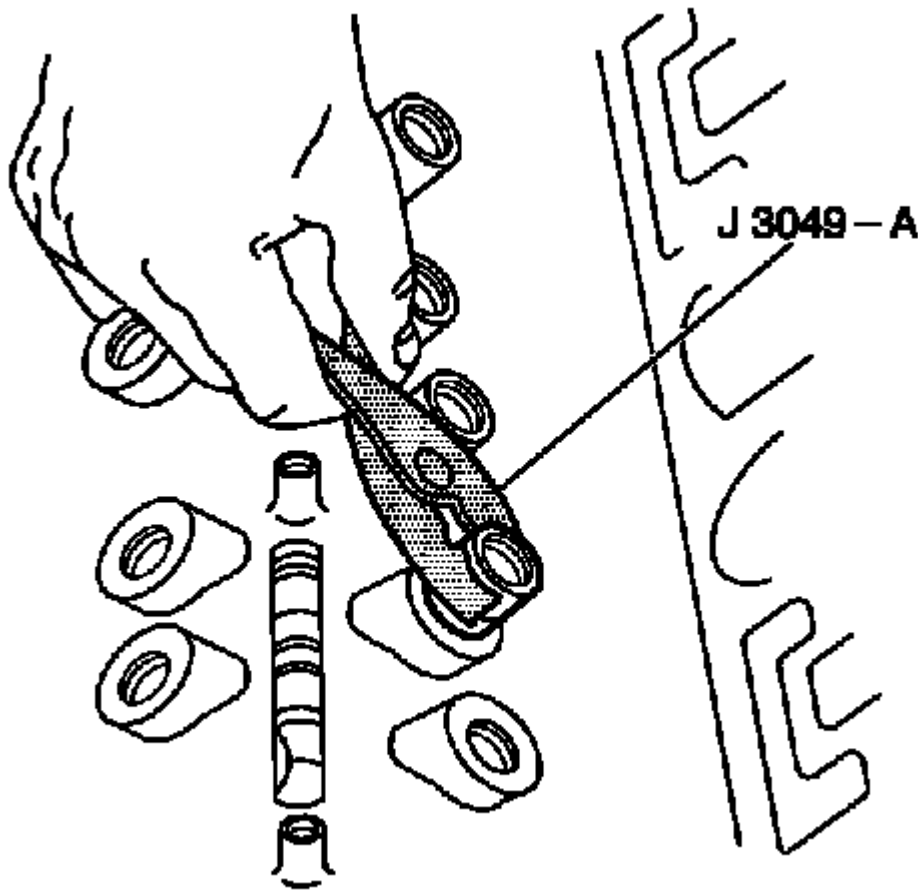


Fig. 253: Using J 3049-A To Remove The Stuck Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some valve lifters may be stuck in the valve lifter bores because of gum or varnish deposits and may require the use of J 3049-A for removal. See Special Tools.

3. Use the **J 3049-A** in order to remove the stuck valve lifters. See Special Tools.

Oil Filter Adapter Removal

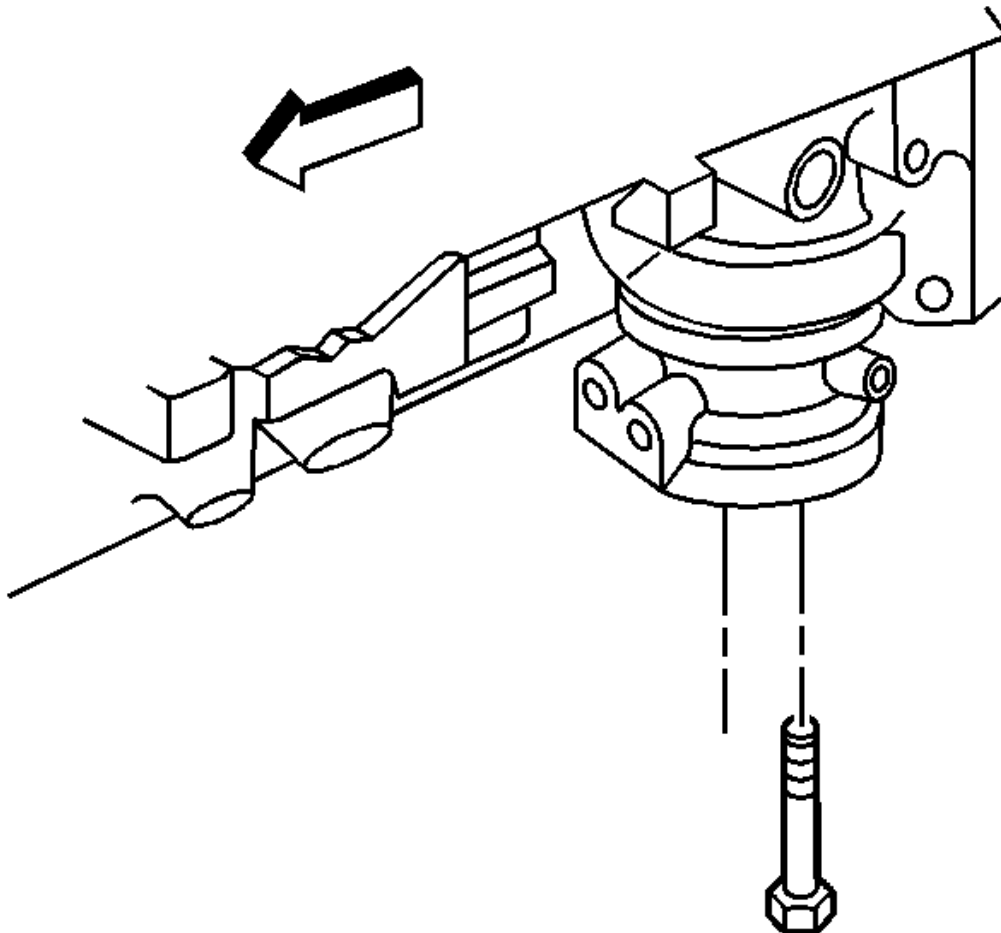


Fig. 254: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter bolts.

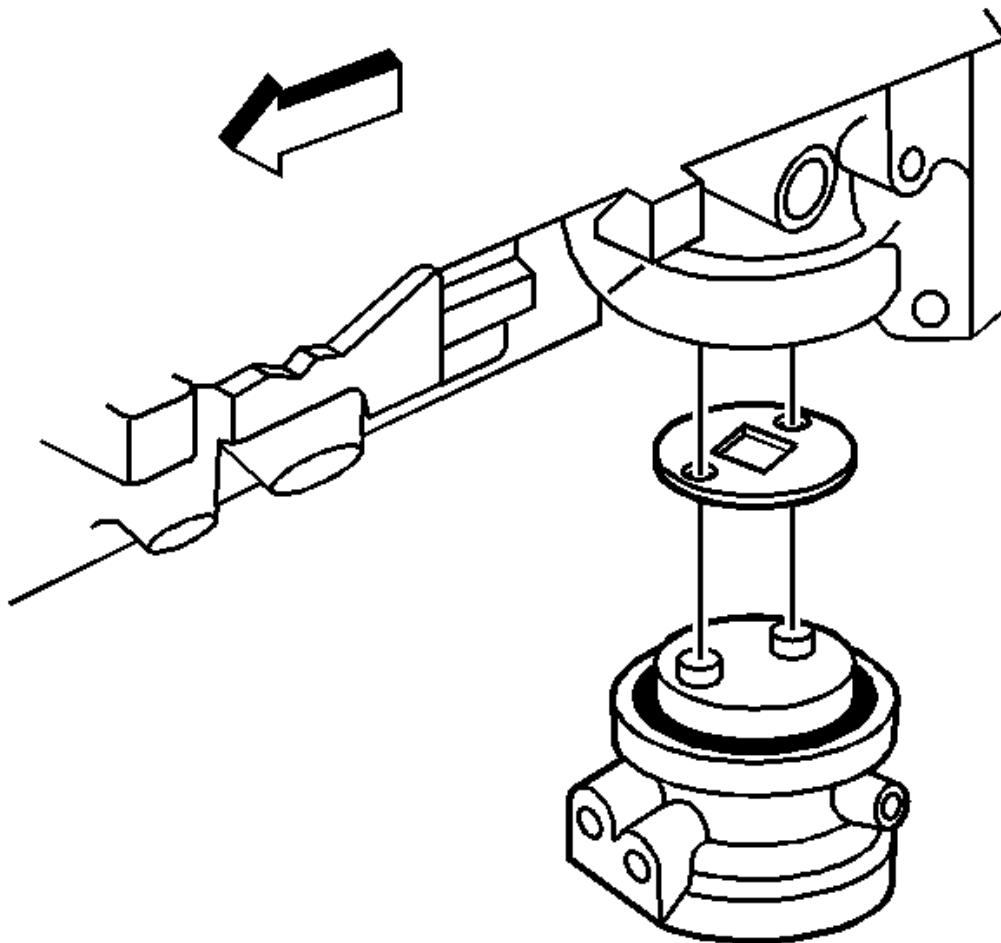


Fig. 255: Identifying Oil Filter Adapter & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter adapter and the oil filter adapter gasket.
3. Discard the oil filter adapter gasket.

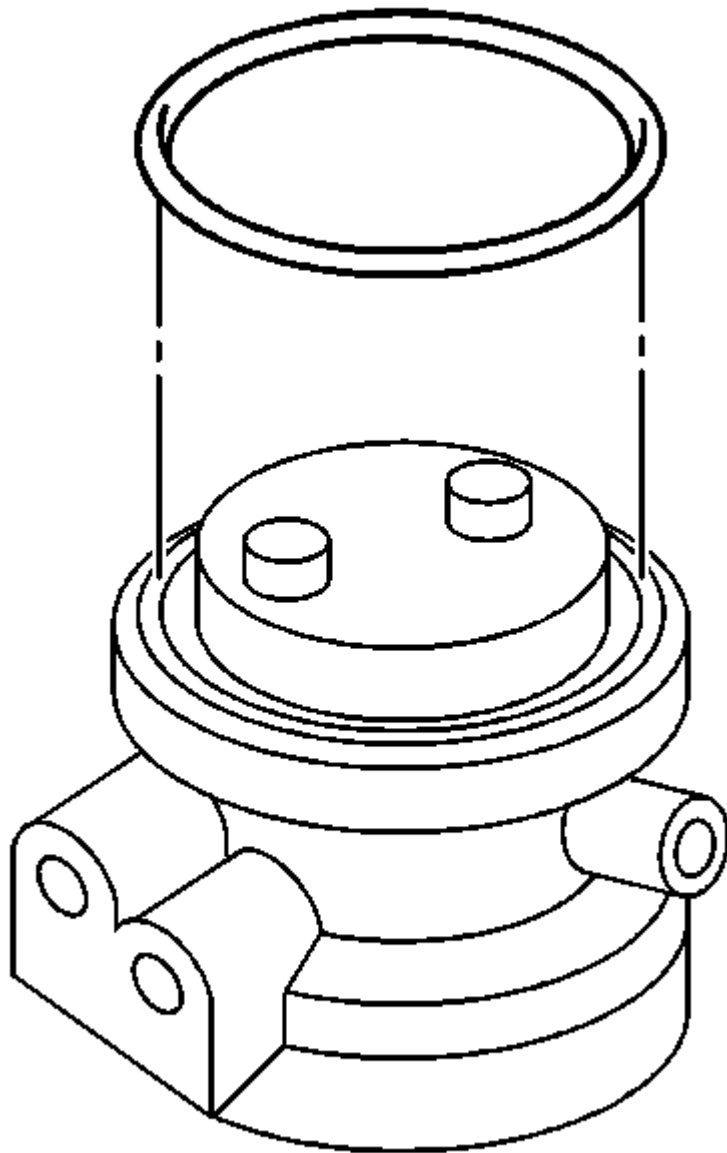


Fig. 256: Locating Oil Filter Adapter Seal - O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter adapter seal - O-ring.
5. Discard the oil filter adapter seal - O-ring.

Oil Pan Removal

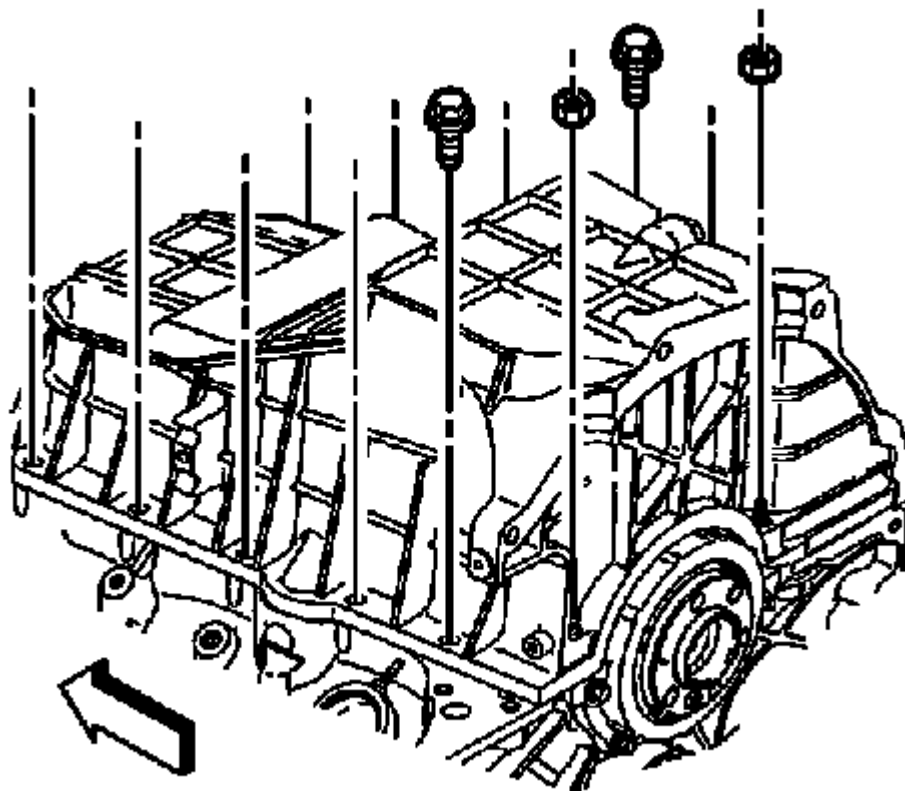


Fig. 257: Removing Oil Pan Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts and nuts.

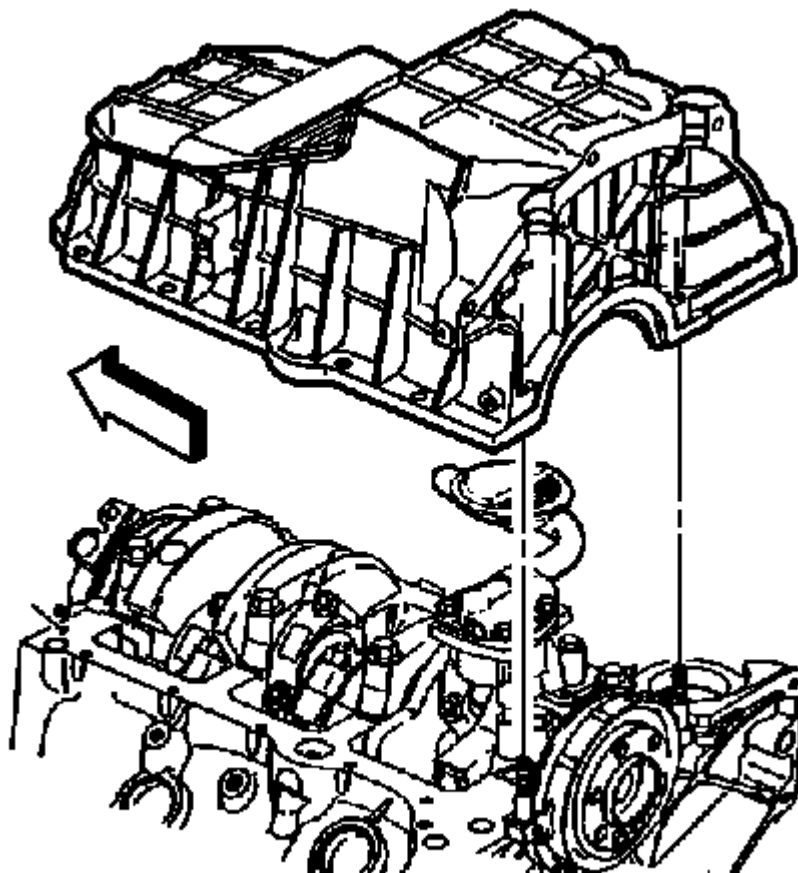


Fig. 258: Removing Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan.

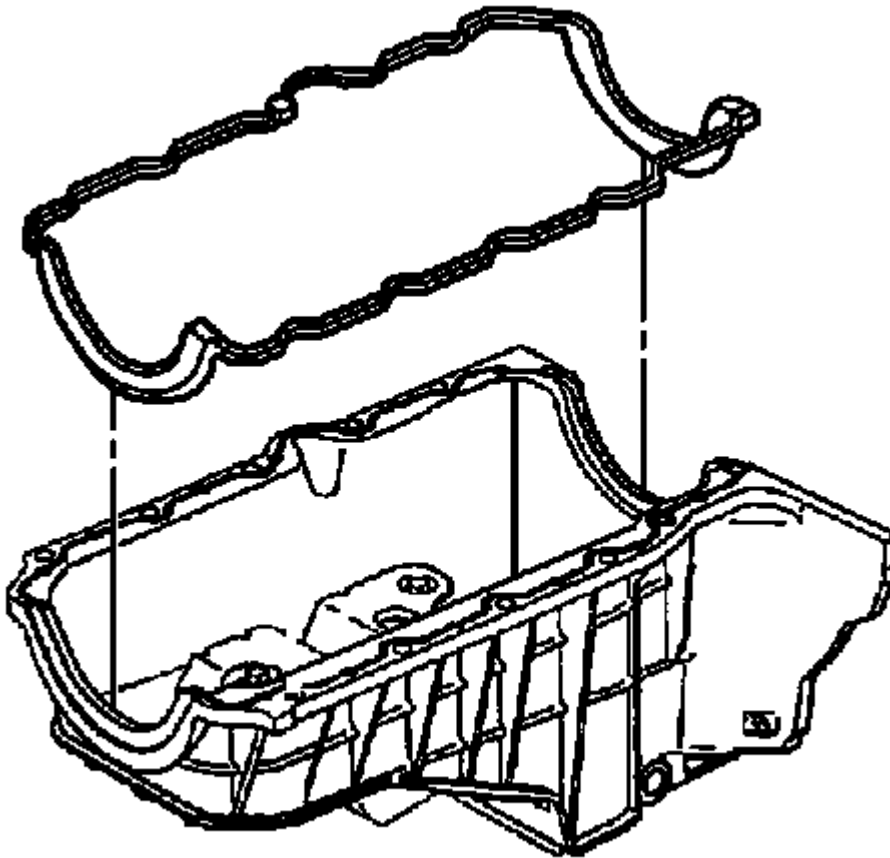


Fig. 259: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan gasket.
4. Discard the oil pan gasket.

Oil Pump Removal

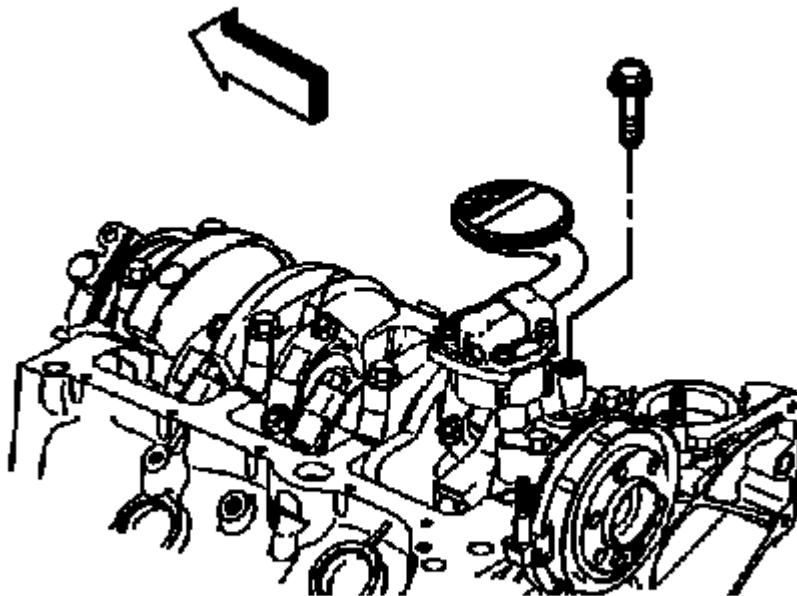


Fig. 260: Removing Oil Pump Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolt.

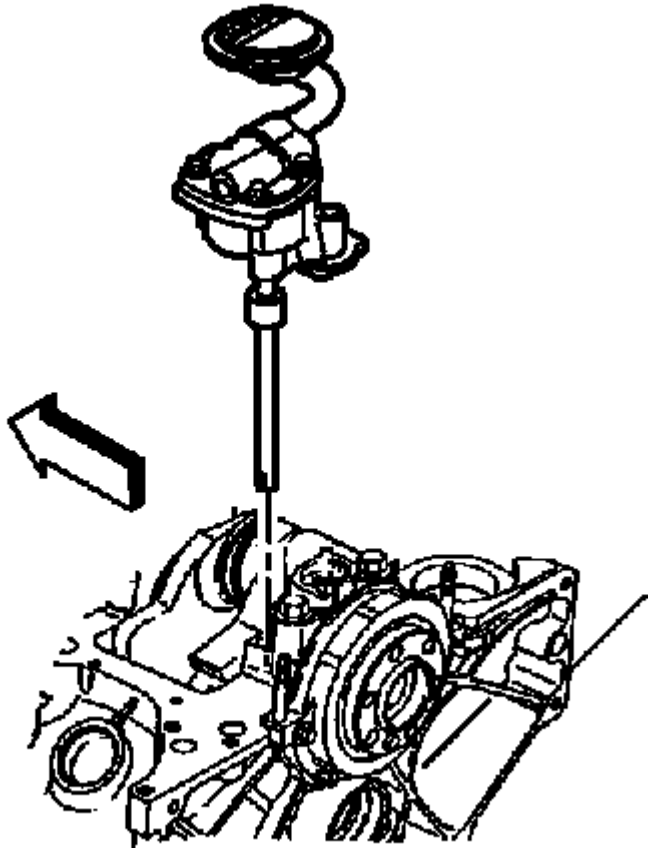


Fig. 261: Removing Oil Pump
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump.

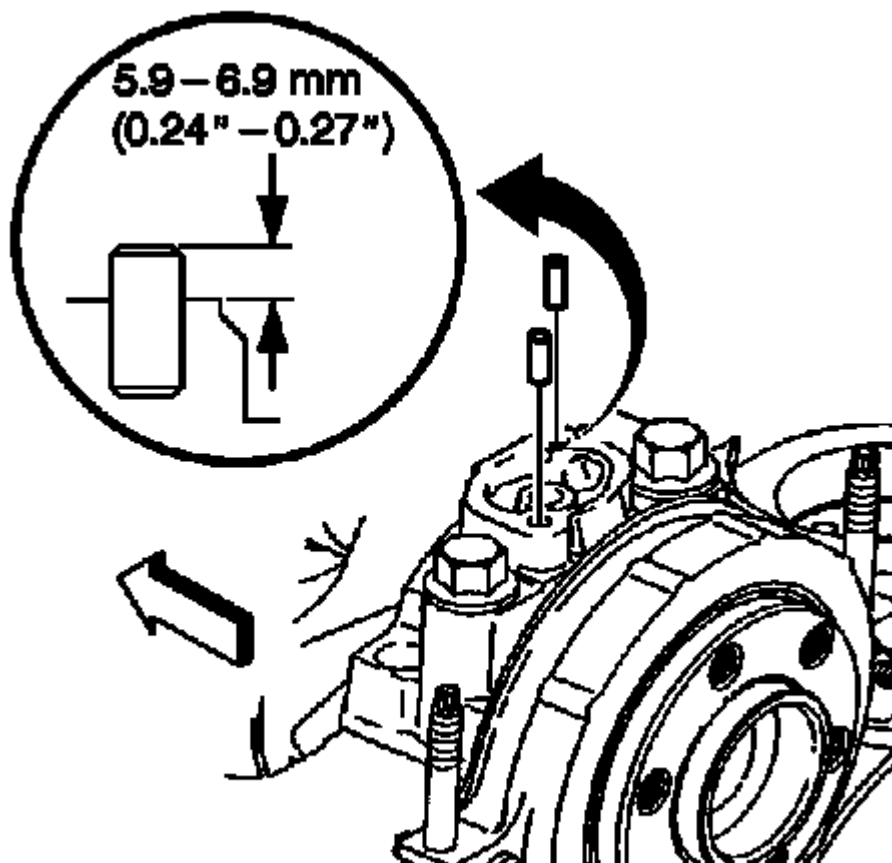


Fig. 262: Oil Pump Locator Pins
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil pump locator pins for damage, and replace the pins if required.

Engine Front Cover Removal

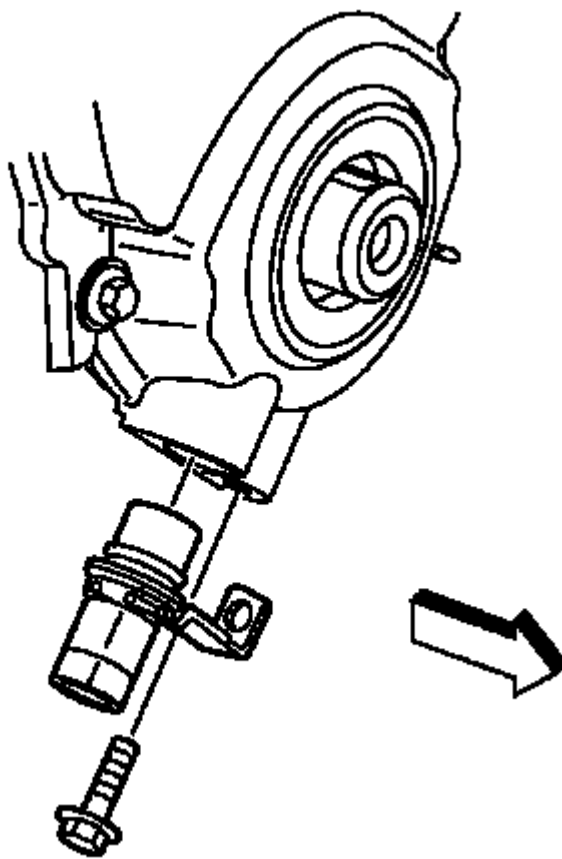


Fig. 263: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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

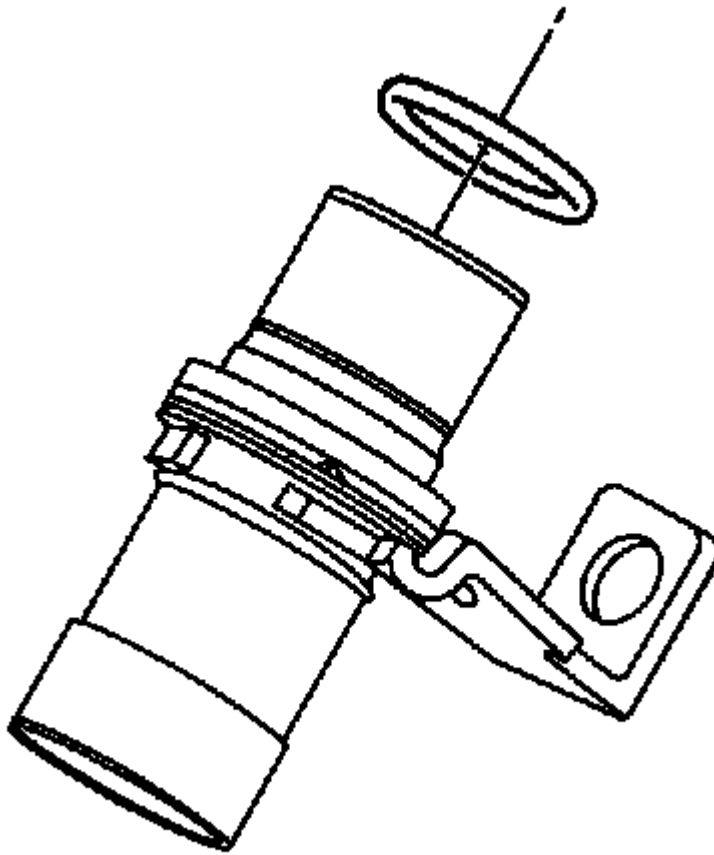


Fig. 264: View Of Crankshaft Position Sensor Seal O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft position sensor seal, O-ring.
4. Discard the crankshaft position sensor seal, O-ring.

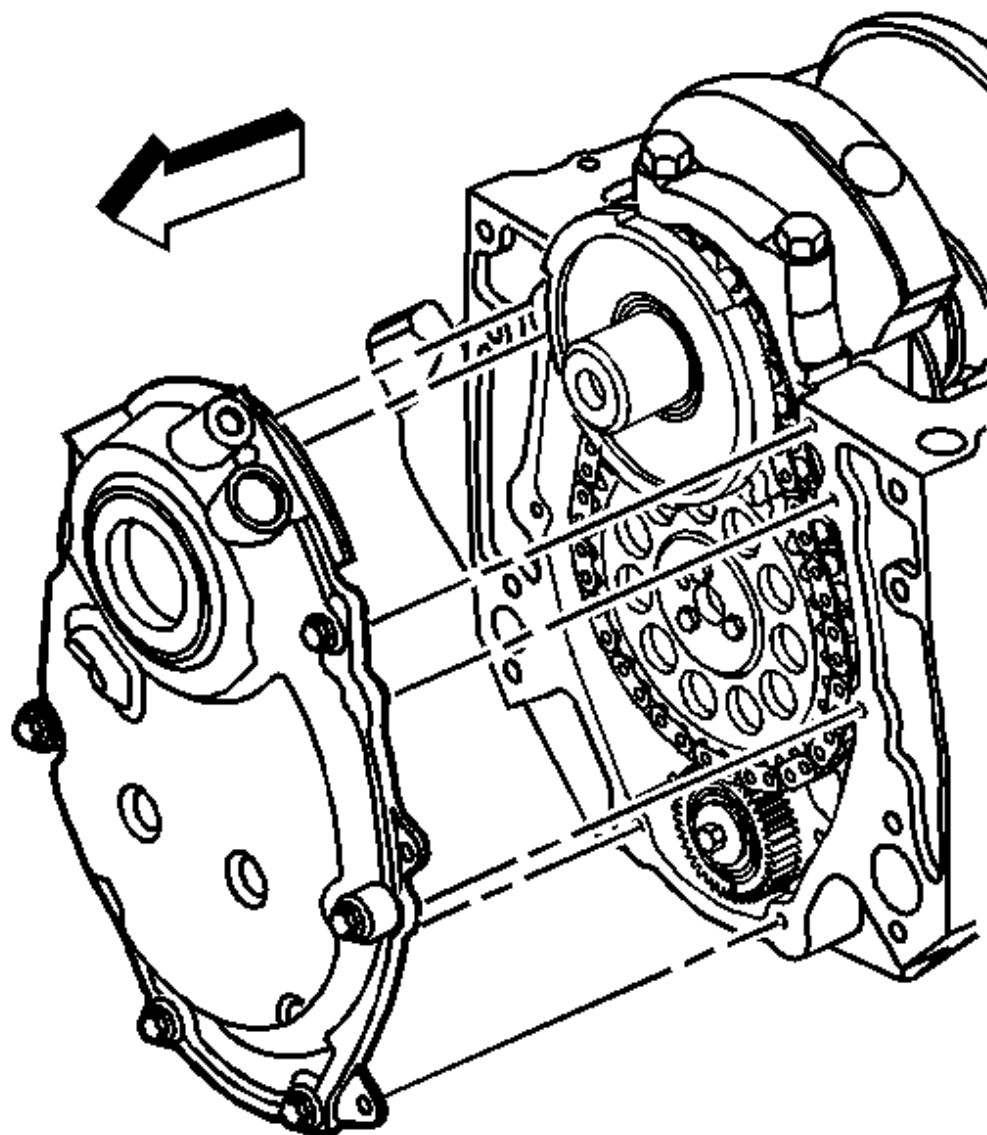


Fig. 265: Removing Engine Front Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine front cover bolts.

IMPORTANT: After the composite engine front cover is removed do not reinstall the engine front cover. Always install a NEW engine front cover.

6. Remove the engine front cover.
7. Discard the engine front cover.

Timing Chain and Sprockets Removal**Tools Required**

J 5825-A Crankshaft Gear Remover. See **Special Tools**.

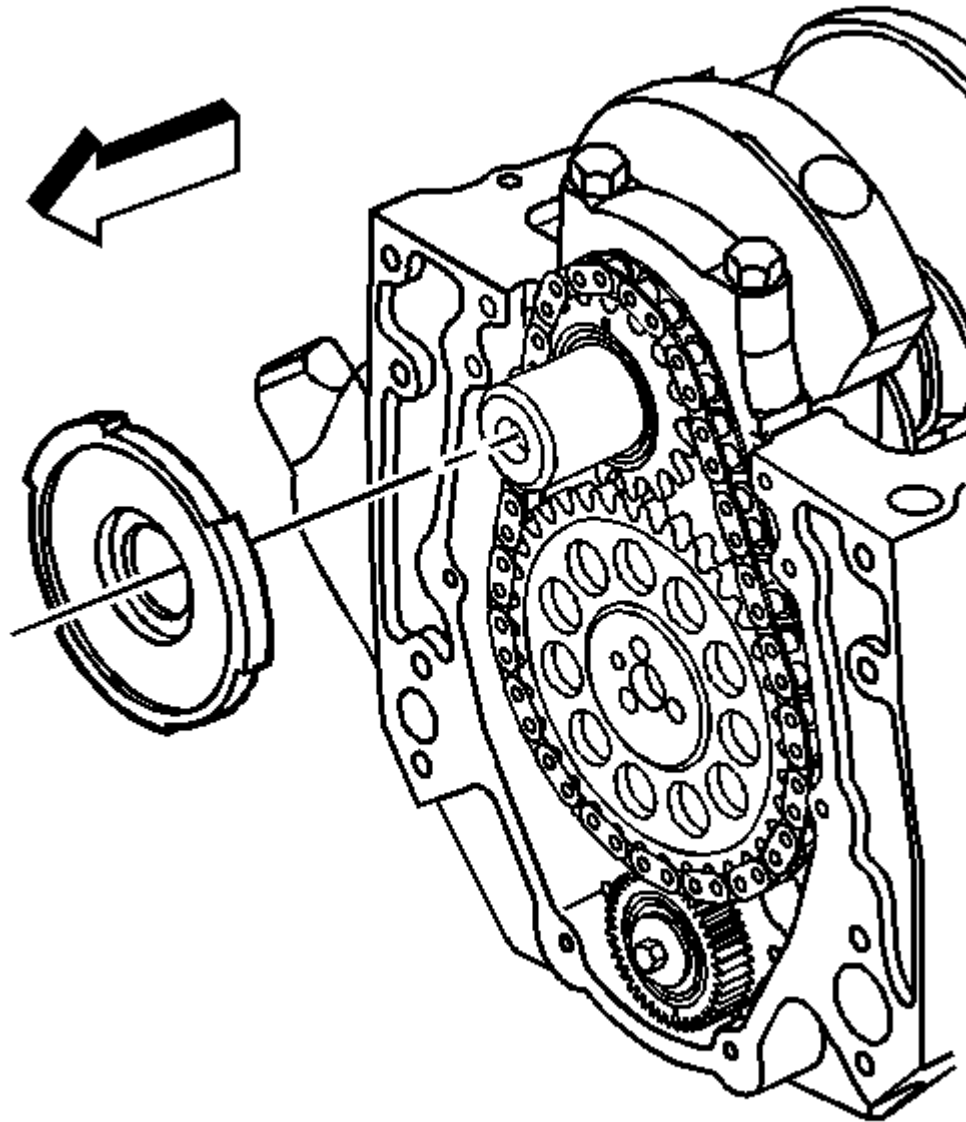


Fig. 266: Removing Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor reluctor ring.

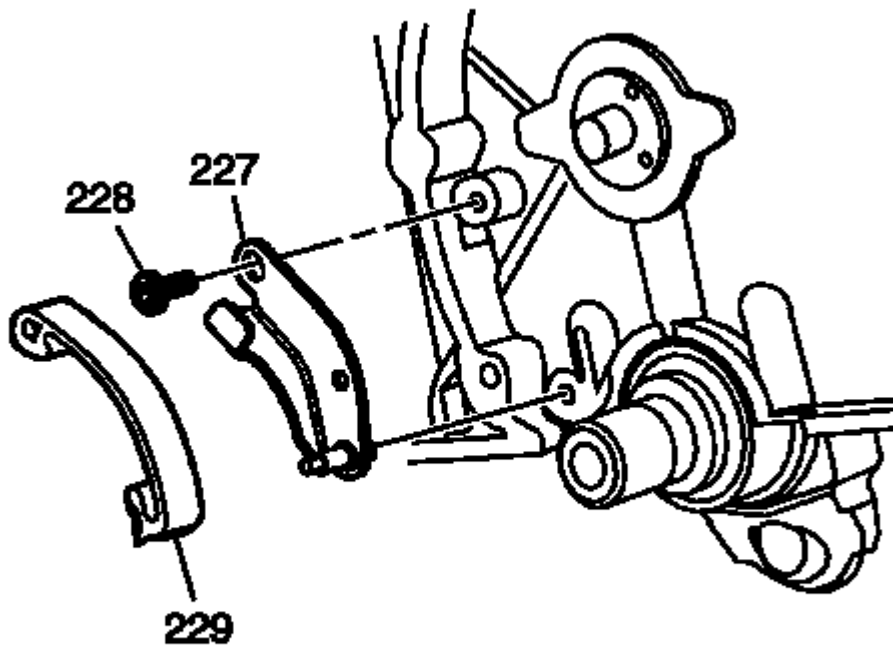


Fig. 267: Removing Timing Chain Tensioner Shoe, Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing chain tensioner shoe (229) using a downward motion.
3. Remove the timing chain tensioner bracket bolt and bracket (227 and 228).

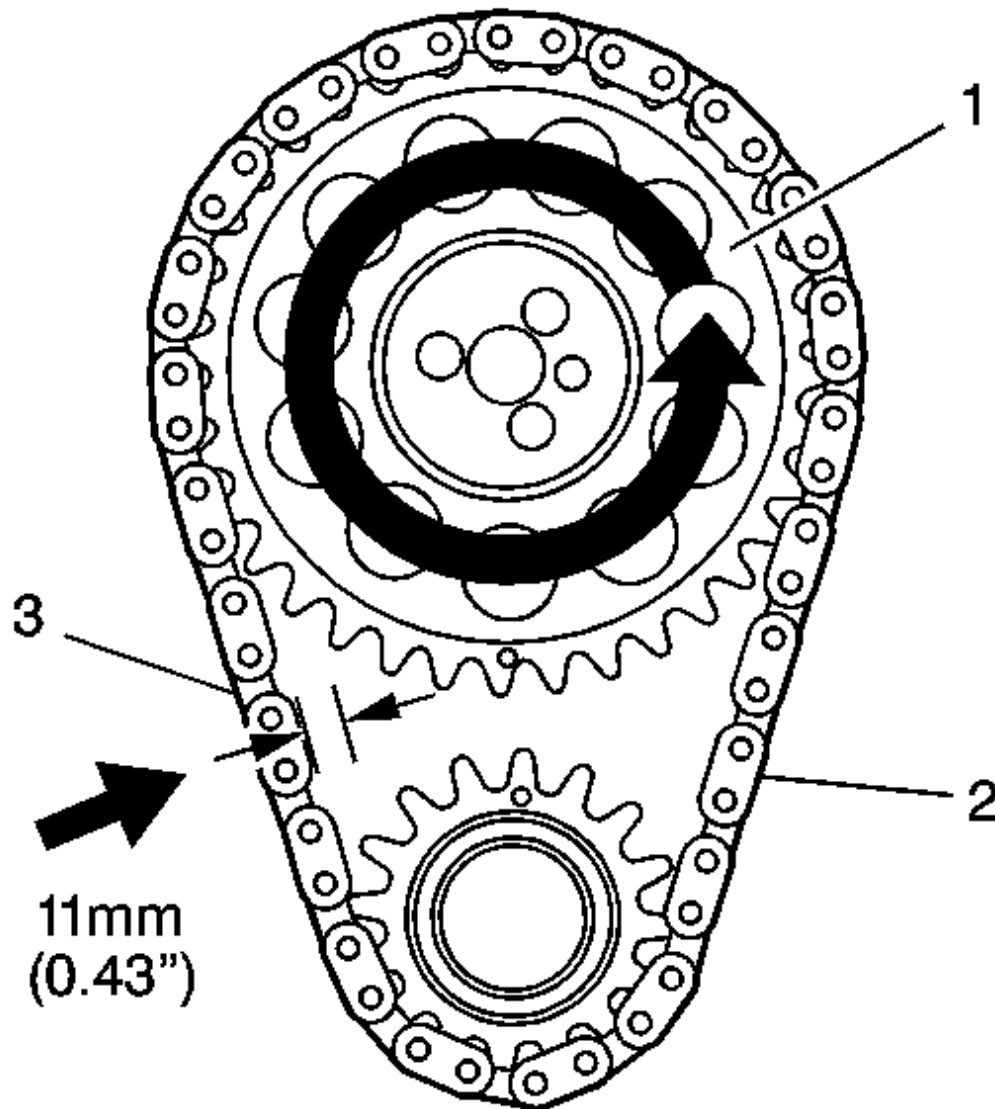


Fig. 268: Camshaft Sprocket, Timing Chain & Slack Side
Courtesy of GENERAL MOTORS CORP.

4. Check the camshaft timing chain free play.
 1. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).
 2. Measure the free play on the slack side (3) of the camshaft timing chain.

If the camshaft timing chain can be moved side to side in excess of 11 mm (0.43 in), replacement of the camshaft timing chain and the sprockets is recommended during assembly.

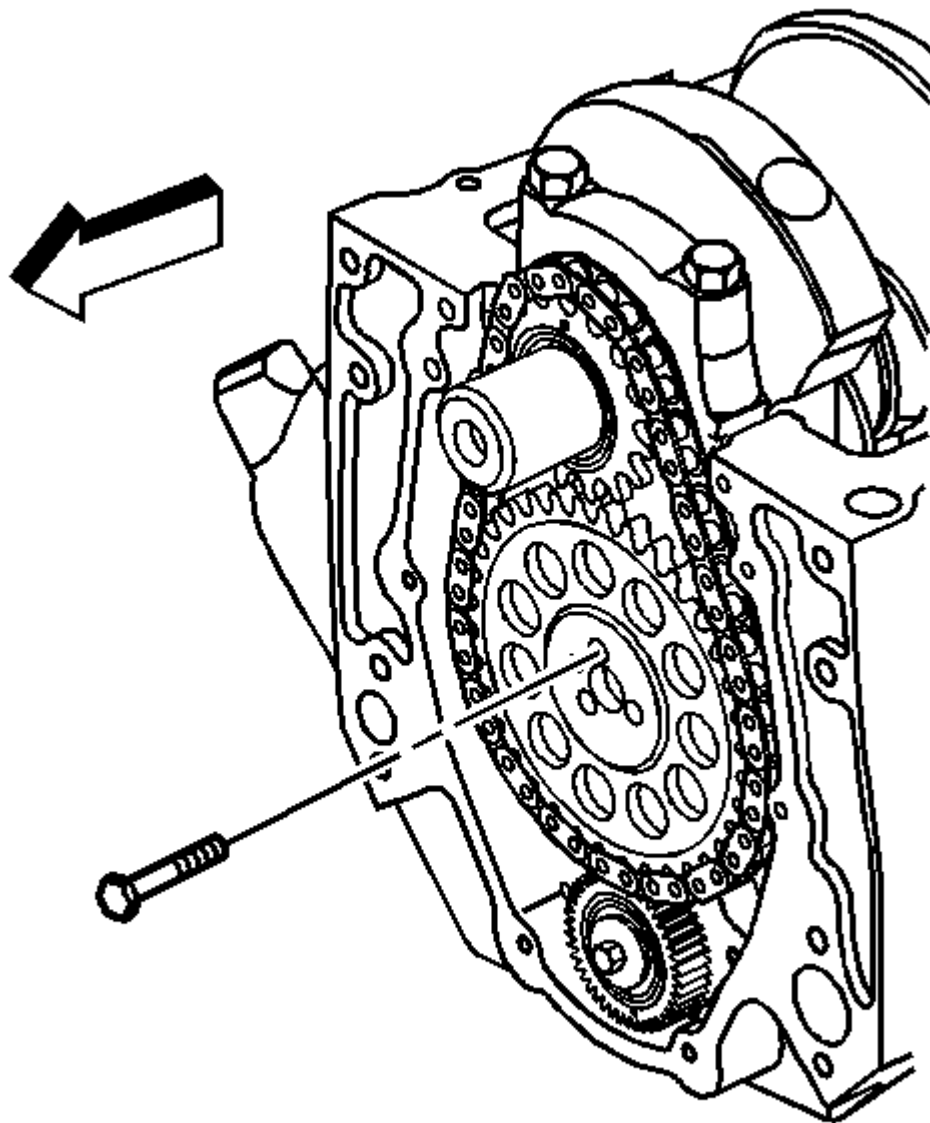


Fig. 269: Removing Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft sprocket bolts.

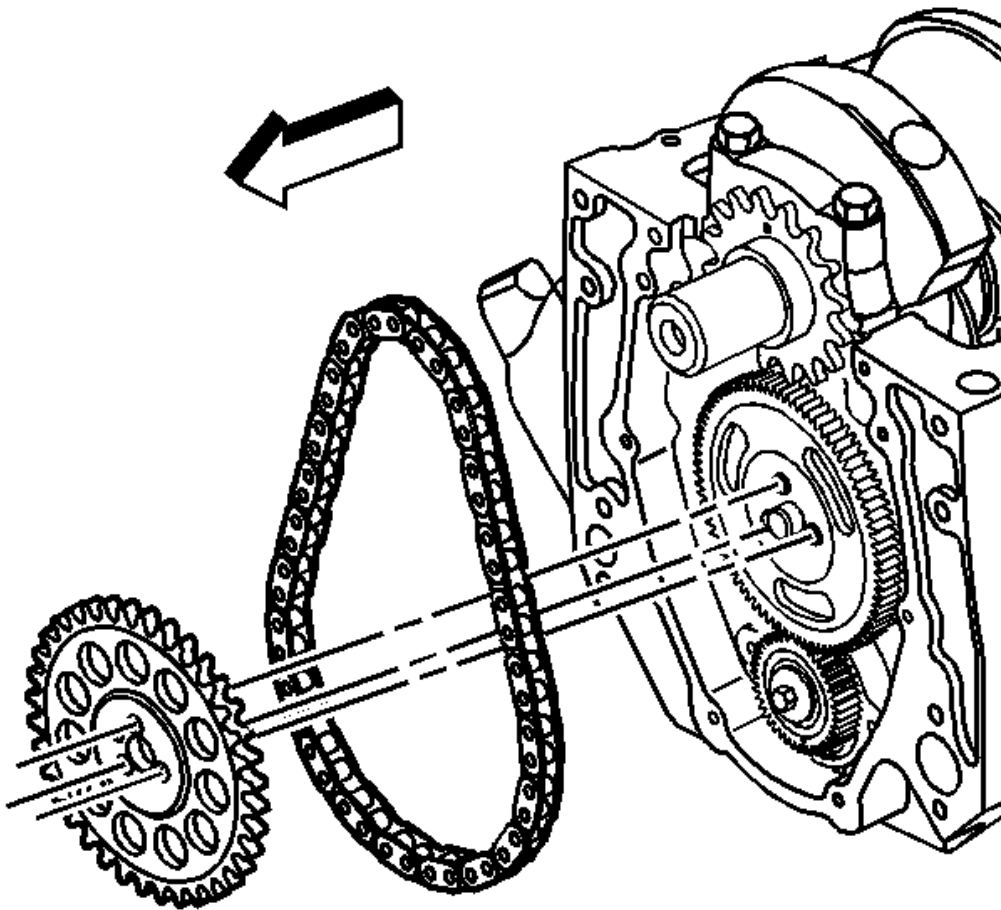


Fig. 270: Removing Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft sprocket and the camshaft timing chain.

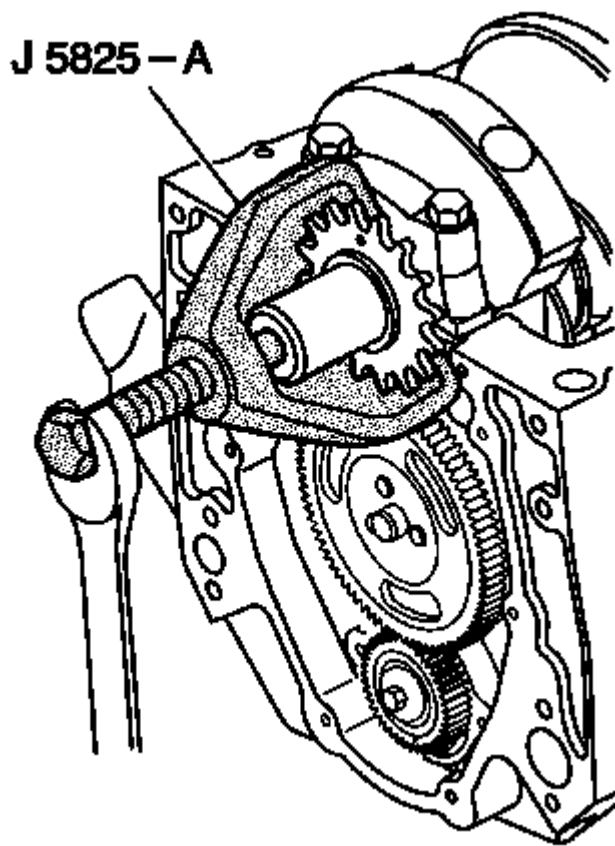


Fig. 271: J 5825-A

Courtesy of GENERAL MOTORS CORP.

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

7. Remove the crankshaft sprocket using the **J 5825-A** . See Special Tools.

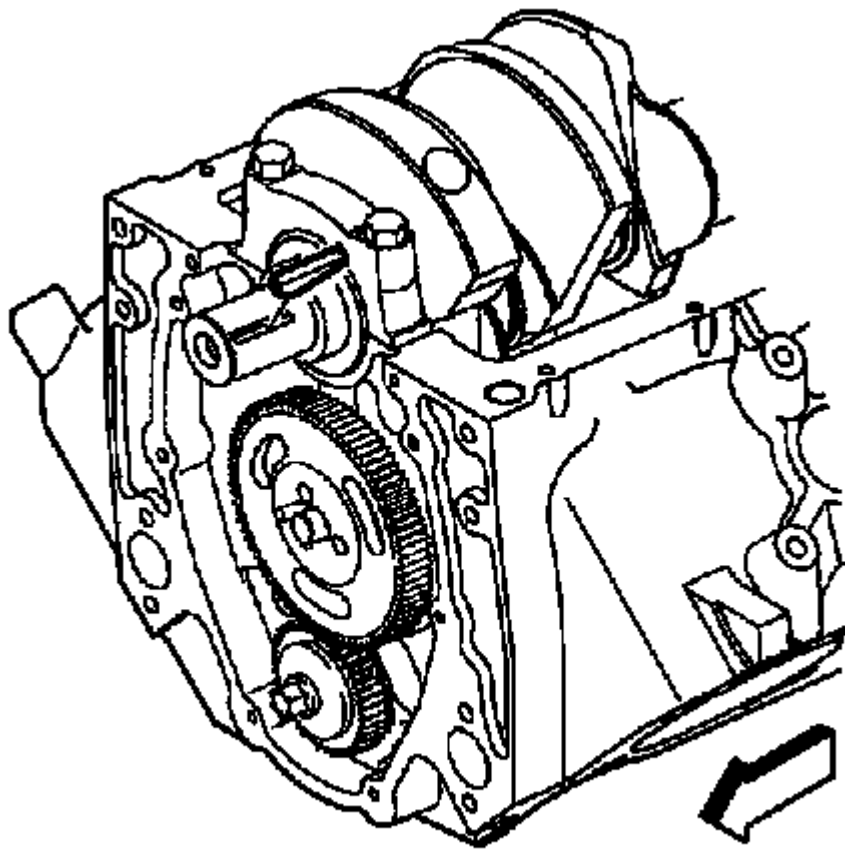


Fig. 272: Removing Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer key.

Balance Shaft Removal

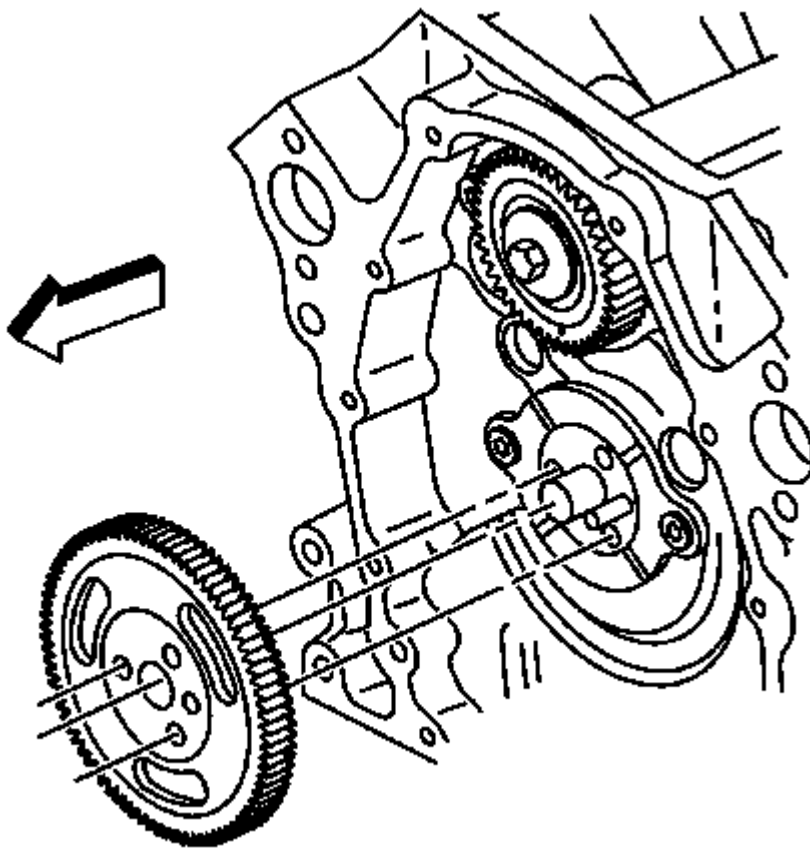


Fig. 273: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft drive gear.

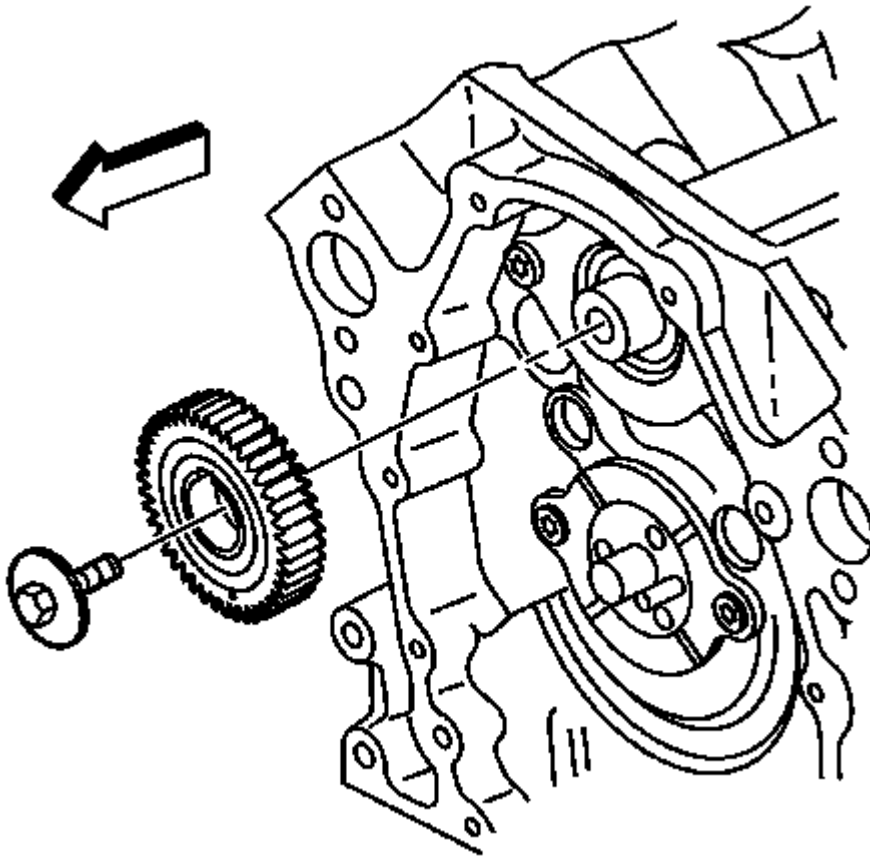


Fig. 274: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft drive and balance shaft driven gears are serviced as a set. The set includes the balance shaft driven gear bolt.

2. Remove the balance shaft driven gear bolt from the balance shaft.
 1. Use a wrench in order to secure the balance shaft.

Place the wrench onto the balance shaft near to the balance shaft front bearing.

2. Remove the balance shaft bolt.
 3. Remove the wrench from the balance shaft.
3. Remove the balance shaft driven gear from the balance shaft.

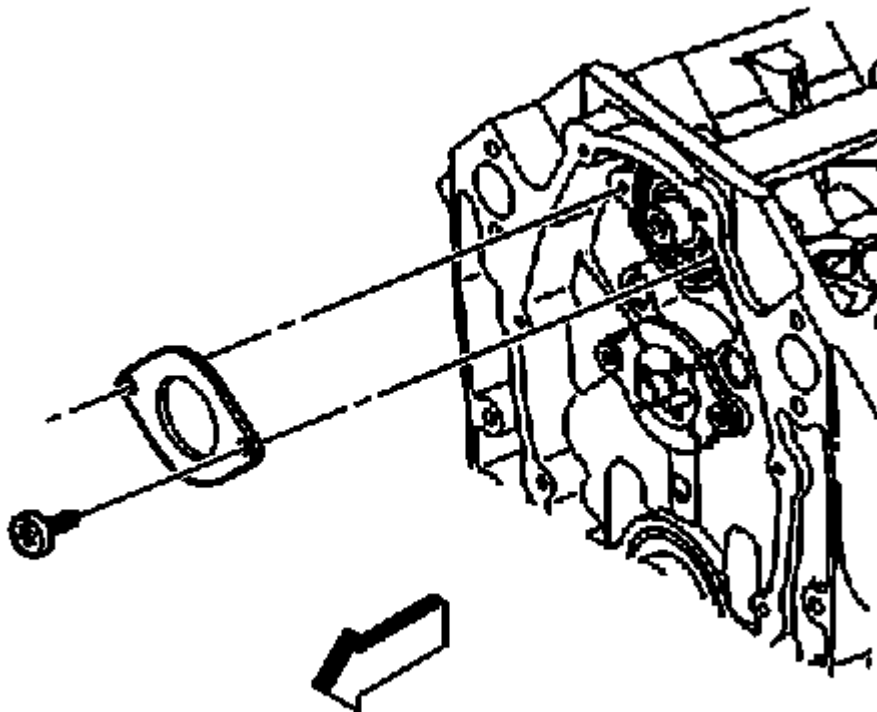


Fig. 275: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and the balance shaft retainer.

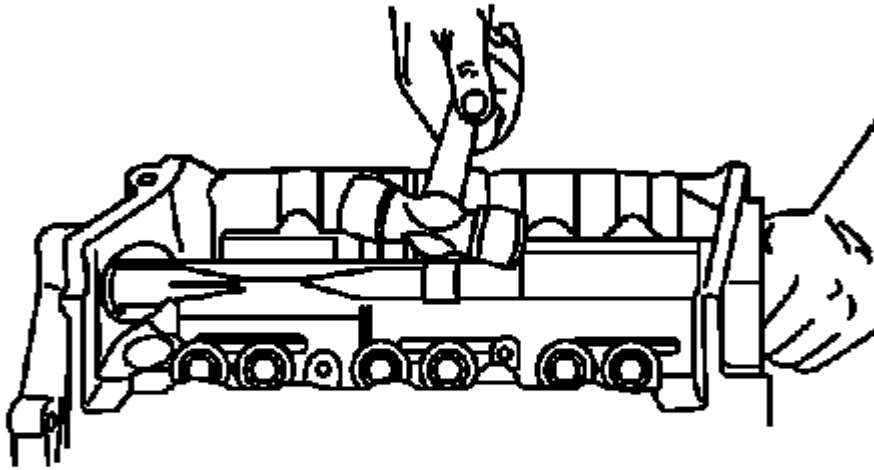


Fig. 276: Removing Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as a package. Do not remove the balance shaft front bearing from the balance shaft.

5. Use a soft-faced hammer in order to remove the balance shaft from the engine block.

Camshaft Removal

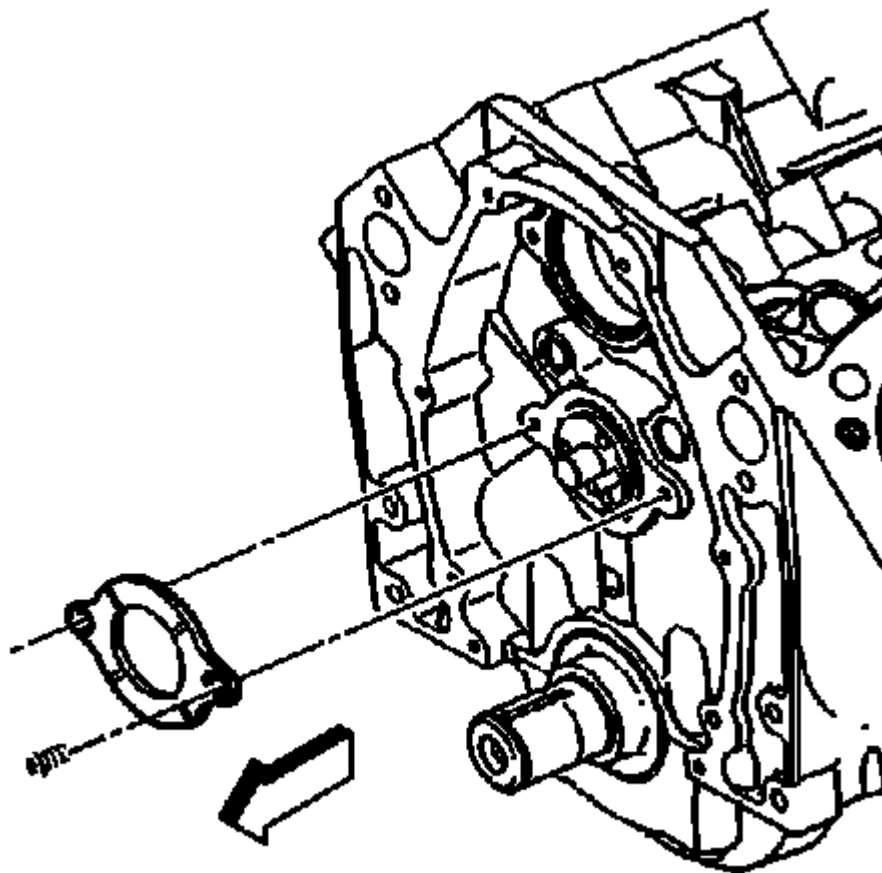


Fig. 277: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts and retainer.

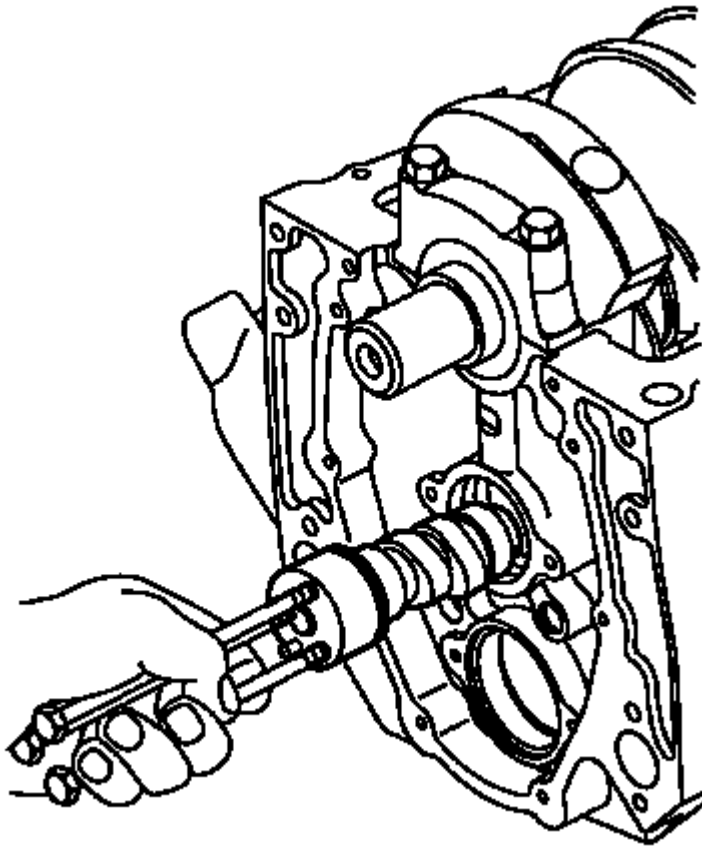


Fig. 278: Installing & Removing Engine Camshaft Front Bolts
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the engine camshaft.
 1. Install the three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.
 2. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
 3. Remove the bolts from the front of the engine camshaft.

Piston, Connecting Rod, and Bearing Removal

Tools Required

- **J 5239** Connecting Rod Bolt Guide Set. See **Special Tools**.
- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools**.

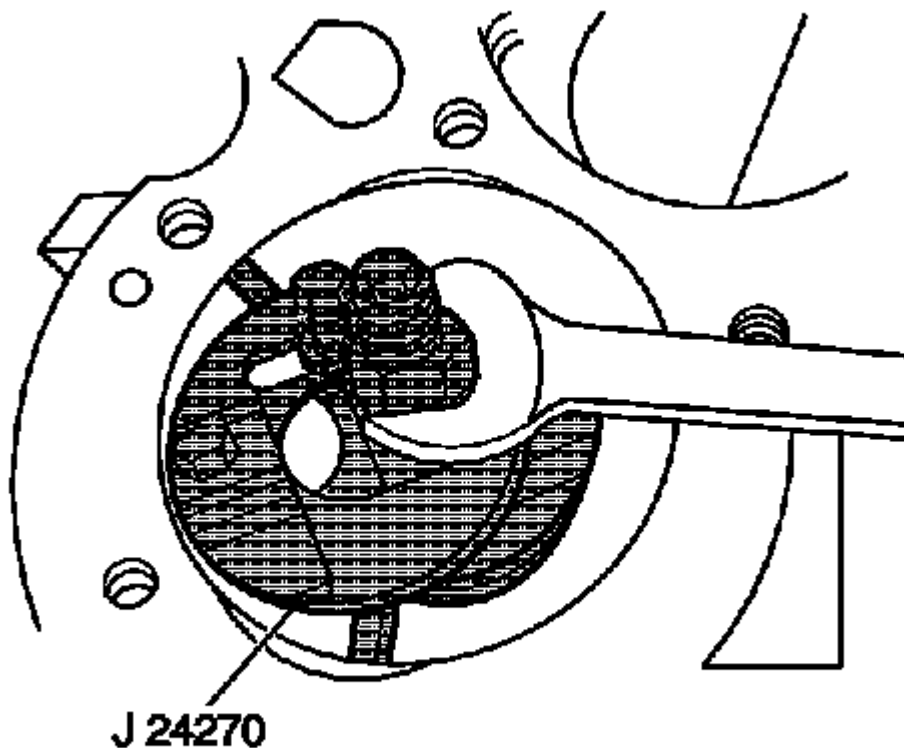


Fig. 279: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 24270** in order to remove the cylinder ring ridge. See **Special Tools**.
 1. Turn the crankshaft until the piston is at the bottom of the stroke.
 2. Place a cloth on top of the piston.
 3. Use the **J 24270** to remove all of the cylinder ring ridge. See **Special Tools**.
 4. Turn the crankshaft so the piston is at the top of the stroke.
 5. Remove the cloth.
 6. Remove the cutting debris.

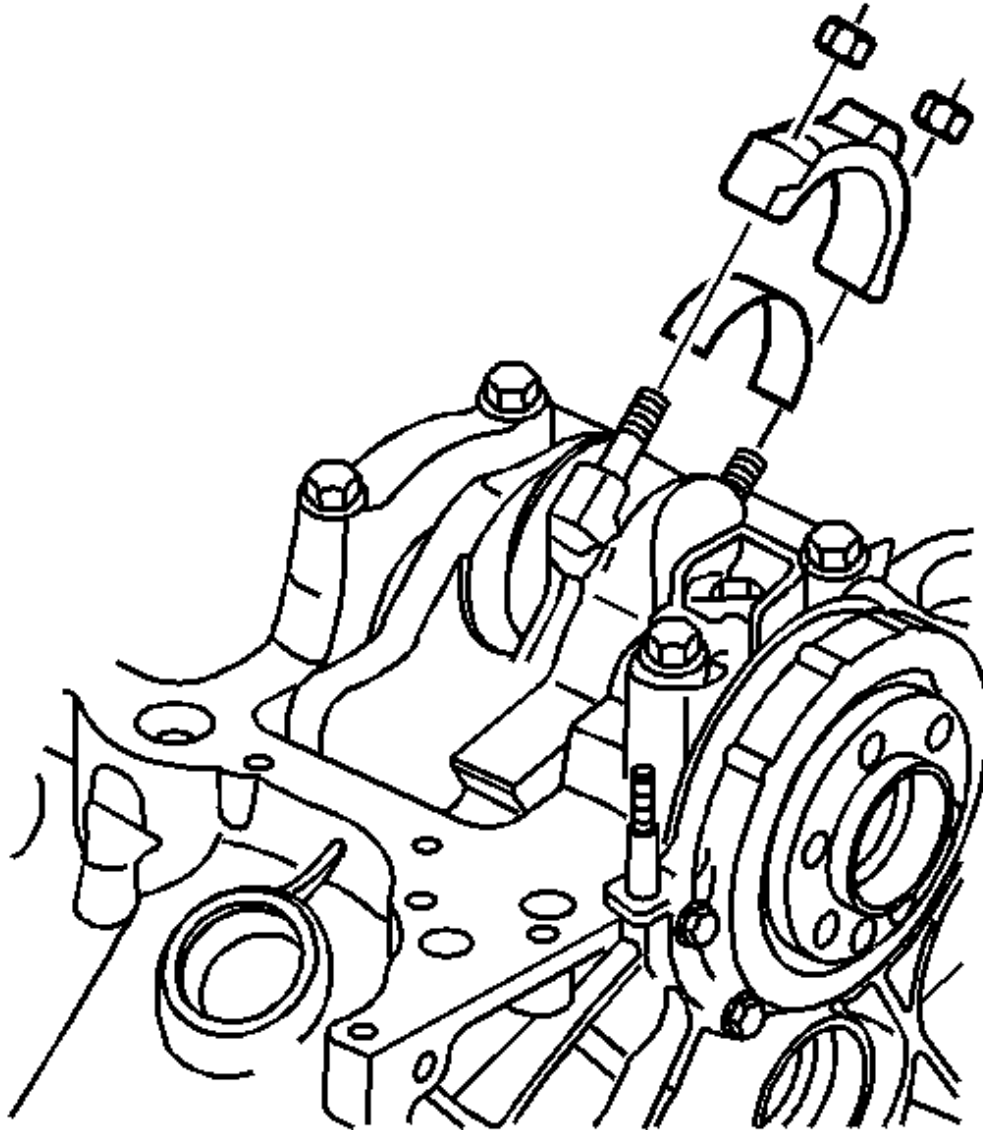


Fig. 280: Removing Connecting Rod Nut & Cap
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place matchmarks or numbers on the connecting rods and the connecting rod caps.

2. Remove the connecting rod nuts.

3. Remove the connecting rod cap.

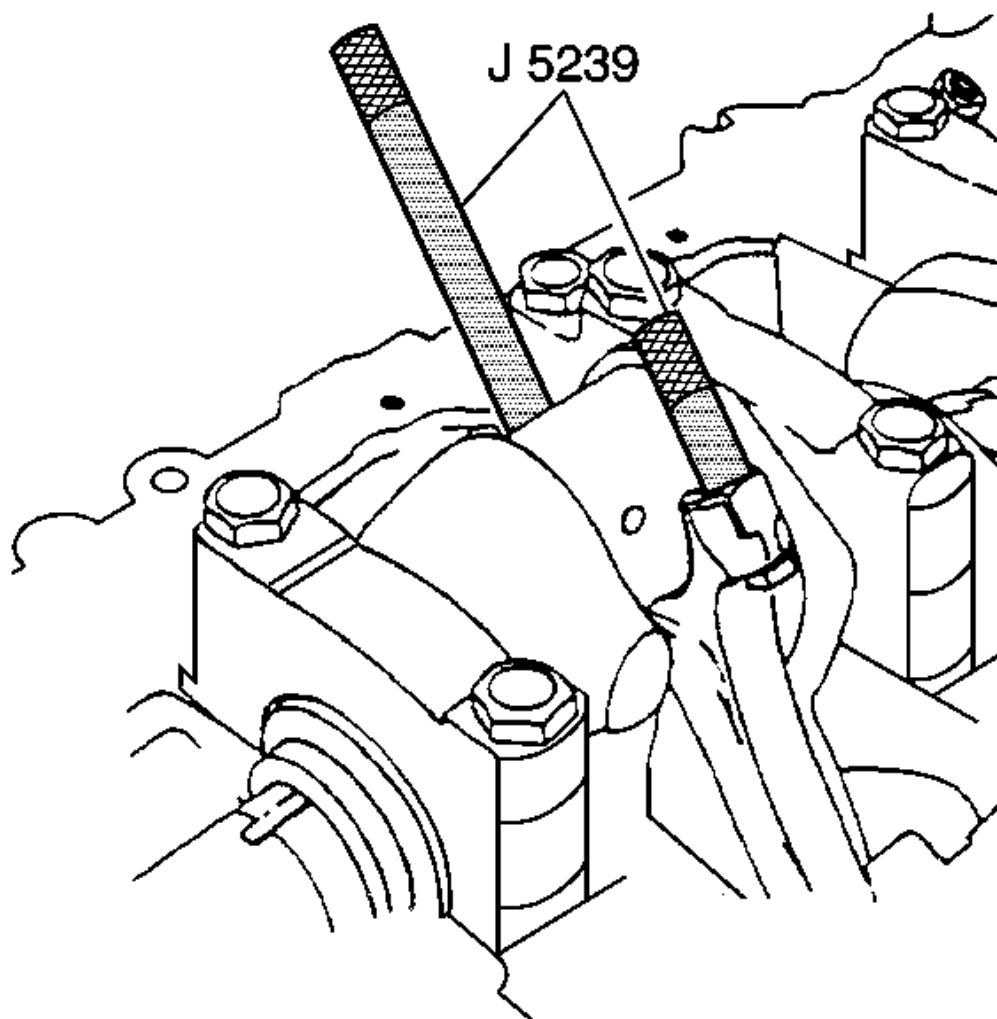


Fig. 281: Protecting Crankshaft Journals Using J 5239
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 5239** in order to protect the crankshaft journals and remove the connecting rod and the piston out of the top of the engine block. See **Special Tools**.

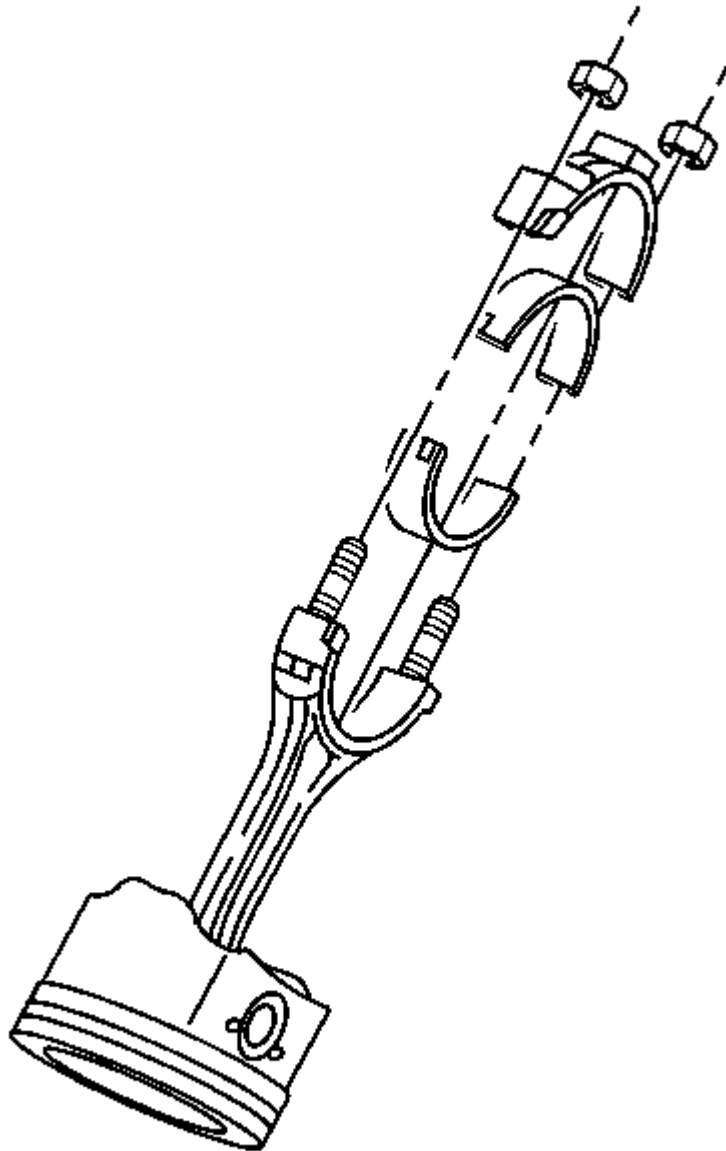


Fig. 282: Connecting Rods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always assemble the connecting rod caps to the matching connecting rods.

5. Remove the connecting rod bearings.

- Keep the connecting rod bearings with the original connecting rod and connecting rod cap.
- Wipe the oil from the connecting rod bearings.
- Wipe the oil from the crankpins.

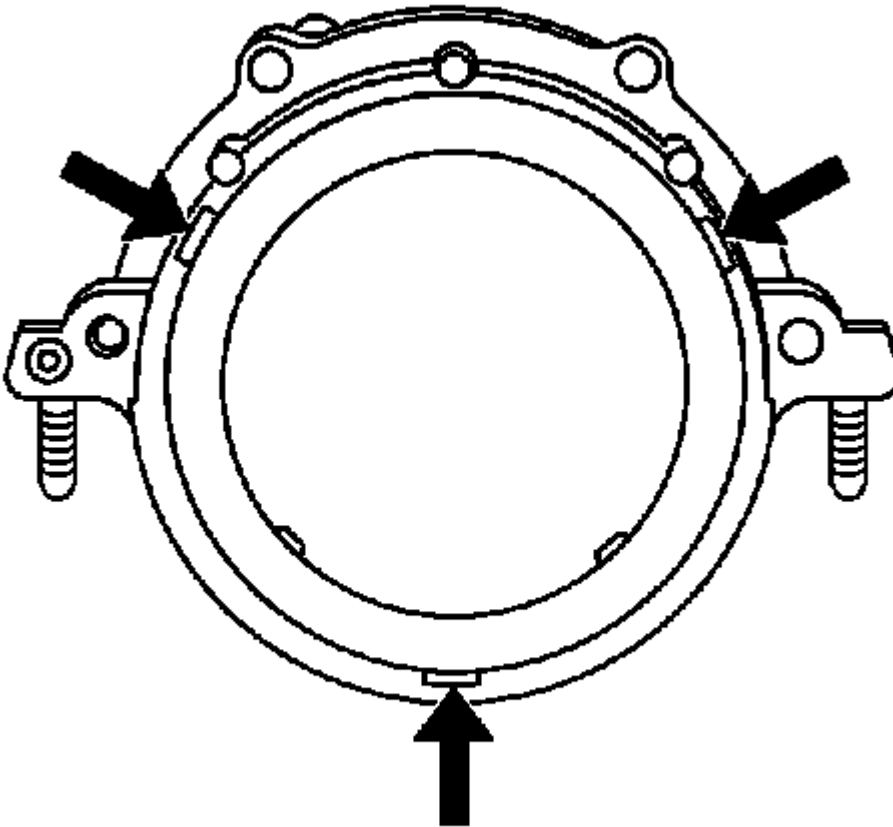
Crankshaft Rear Oil Seal and Housing Removal

Fig. 283: Crankshaft Rear Oil Seal Notches
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.

2. Discard the crankshaft rear oil seal.

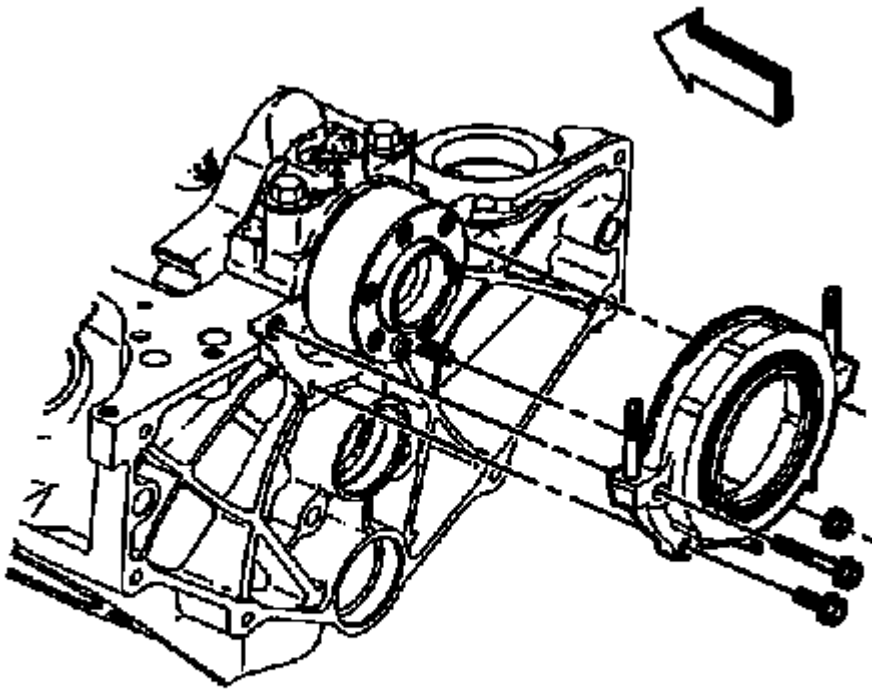


Fig. 284: Removing Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft rear oil seal housing nut and bolts.
4. Remove the crankshaft rear oil seal housing.

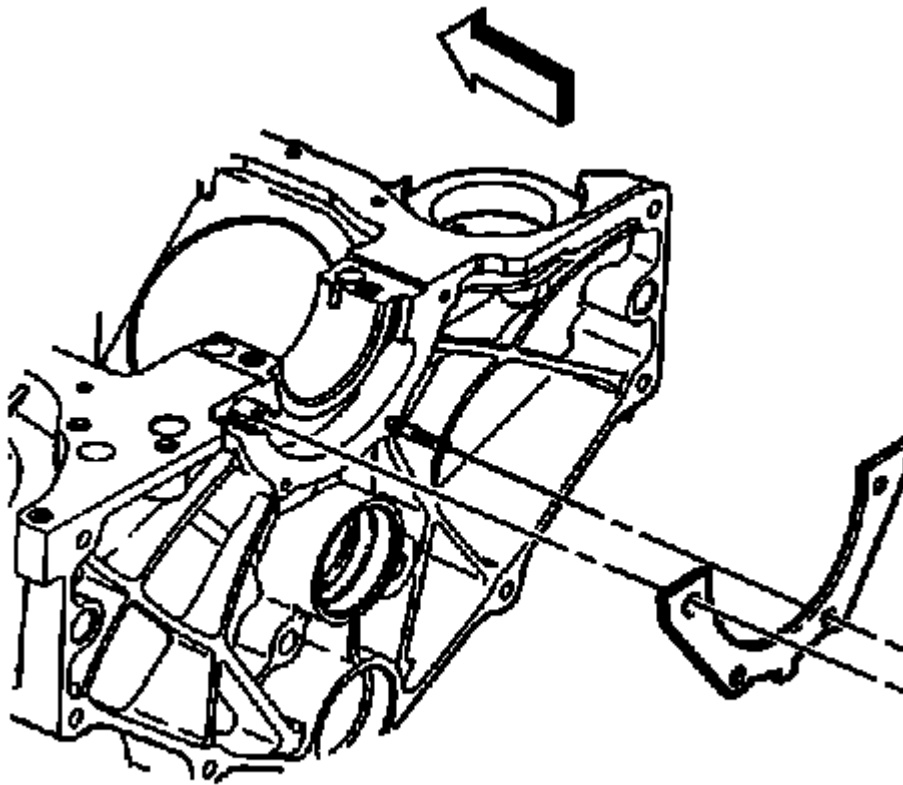


Fig. 285: Removing Crankshaft Rear Oil seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft rear oil seal housing gasket.
6. Discard the crankshaft rear oil seal housing gasket.

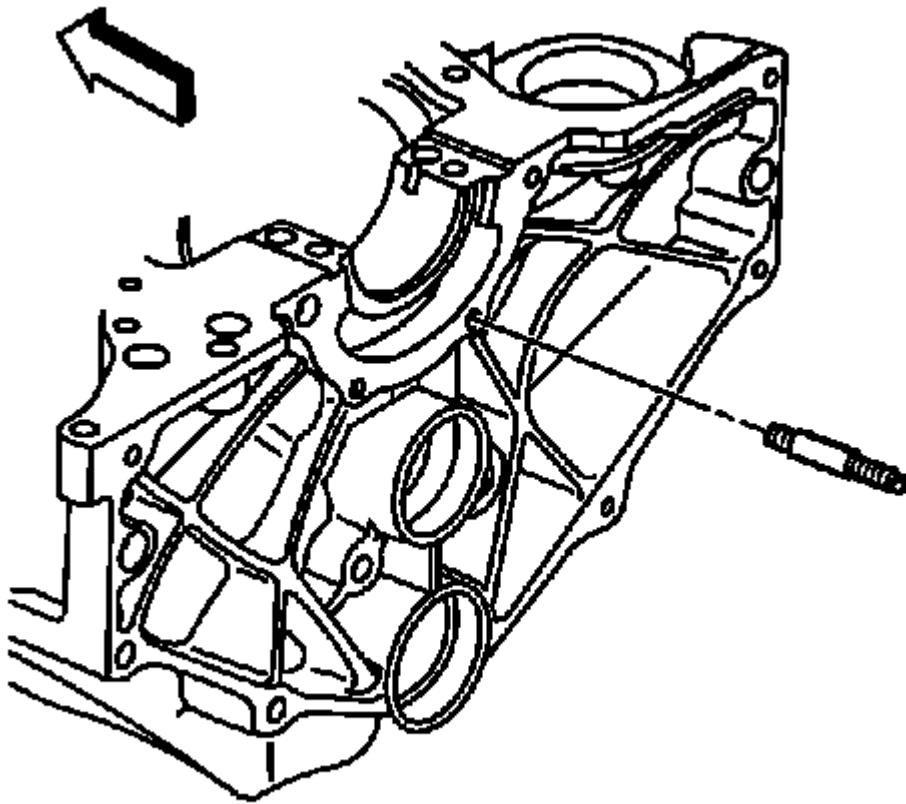


Fig. 286: Removing Crankshaft Rear Oil Seal Housing Retainer Stud
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft rear oil seal housing retainer stud from the engine block.

Crankshaft and Bearings Removal

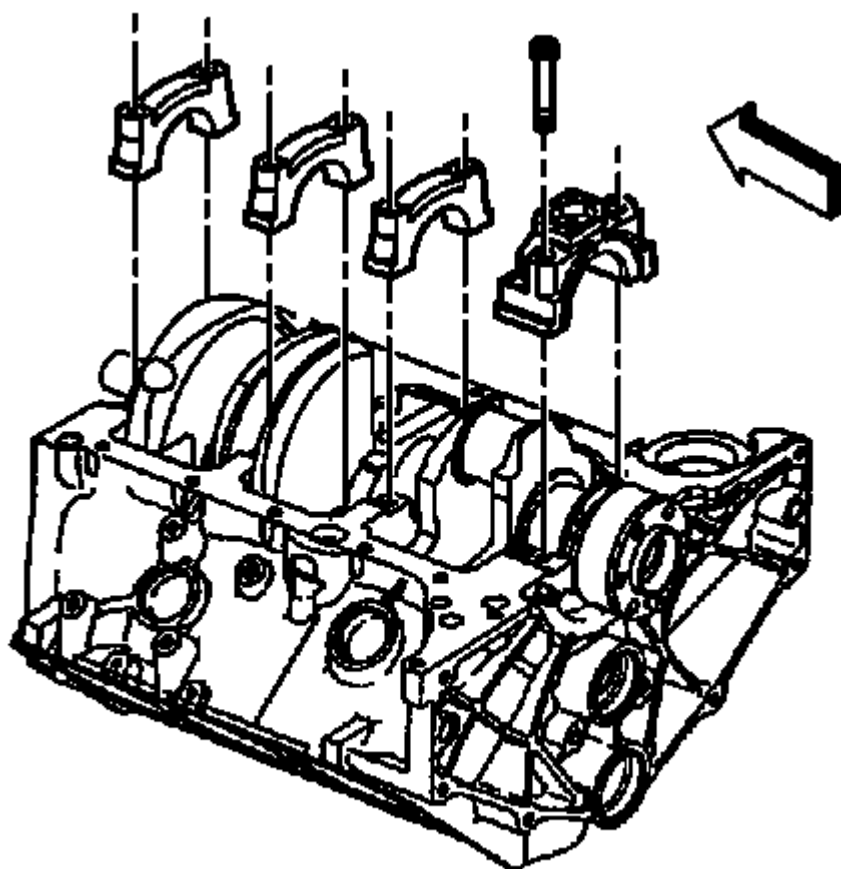


Fig. 287: Removing Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Mark or identify the crankshaft bearing cap locations, direction, and positions for assembly.
2. Remove the crankshaft bearing cap bolts and discard.
3. Remove the crankshaft bearing caps.

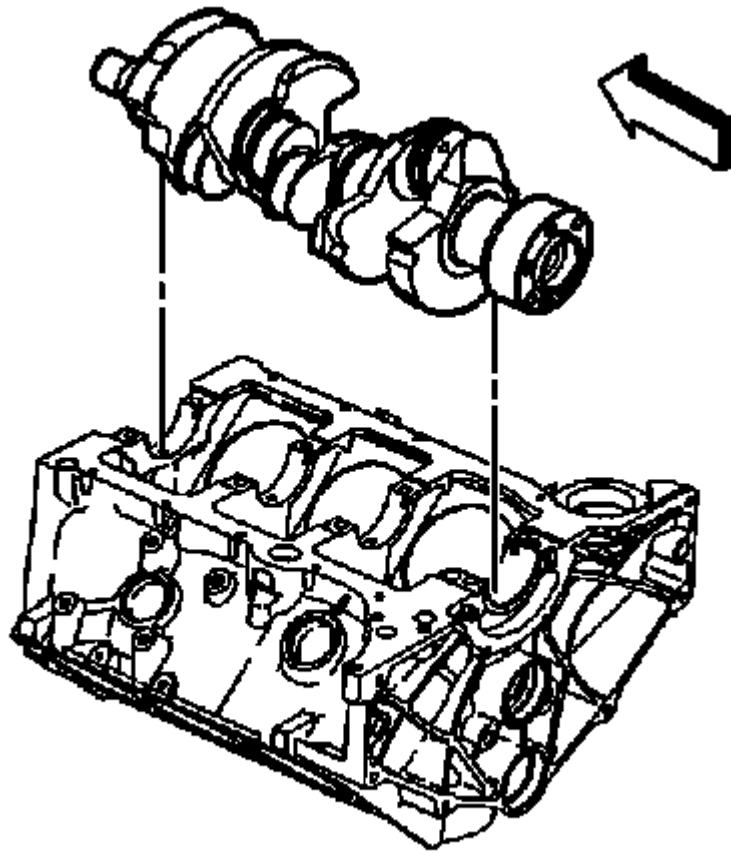


Fig. 288: Removing Crankshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft.

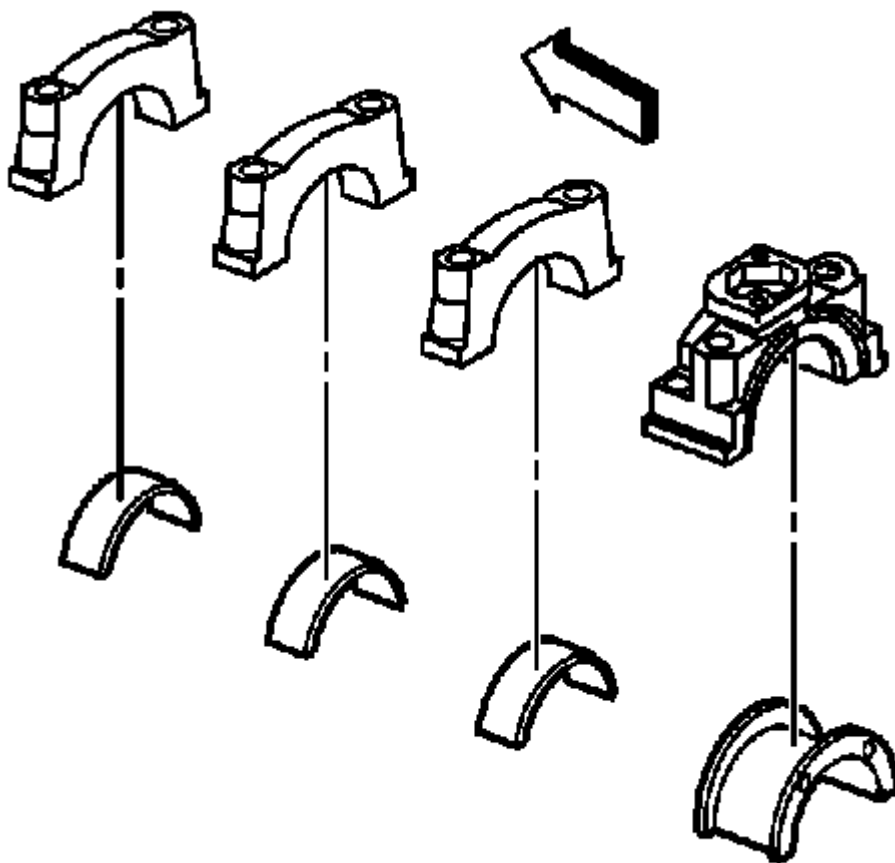


Fig. 289: Removing Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft bearings from the crankshaft bearing caps.

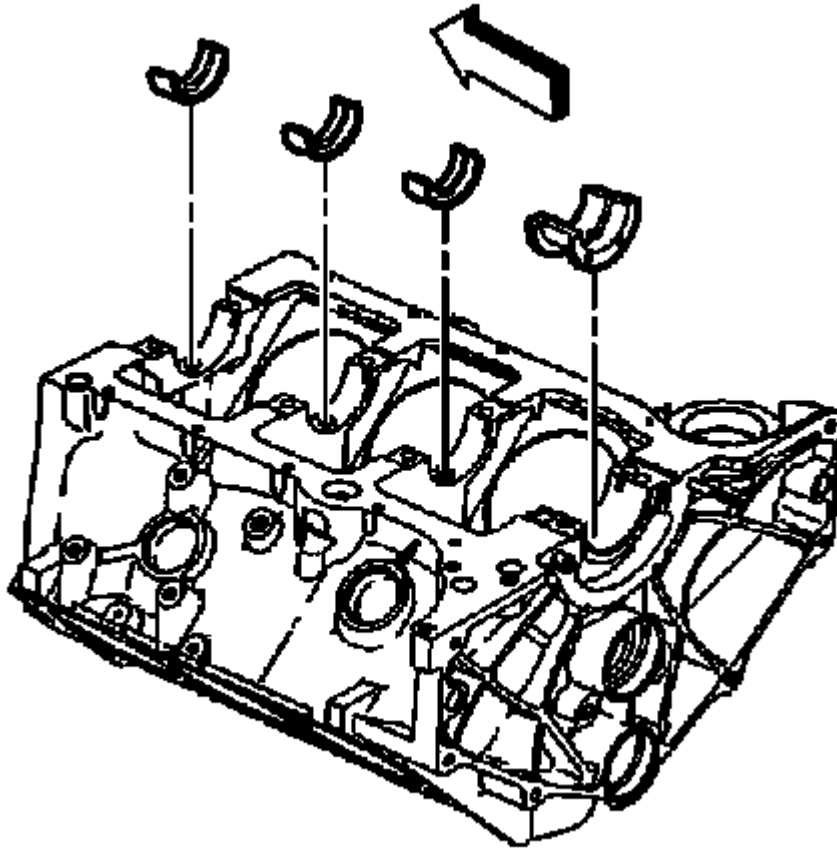


Fig. 290: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft bearings from the engine block.

Engine Block Plug Removal

Tools Required

J 41712 Oil Pressure Switch Socket. See Special Tools.

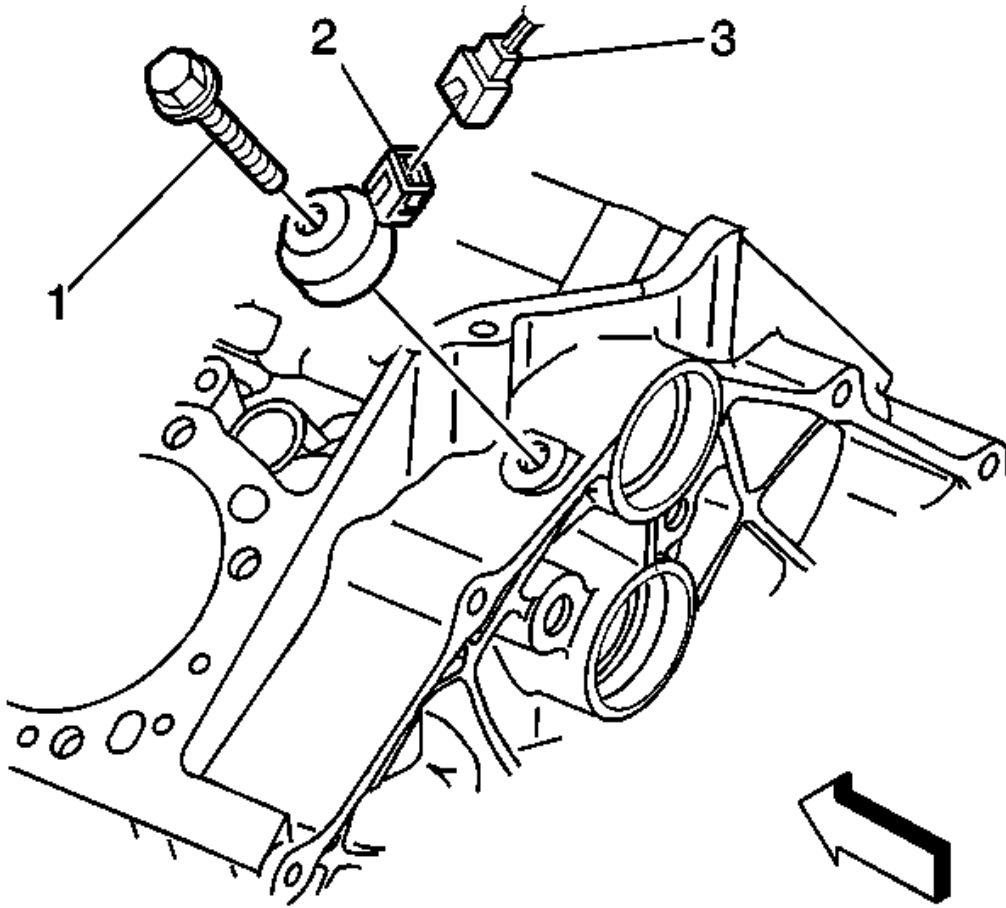


Fig. 291: Locating Knock Sensor & Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the knock sensor retaining bolt (1).
2. Remove the knock sensor (2).

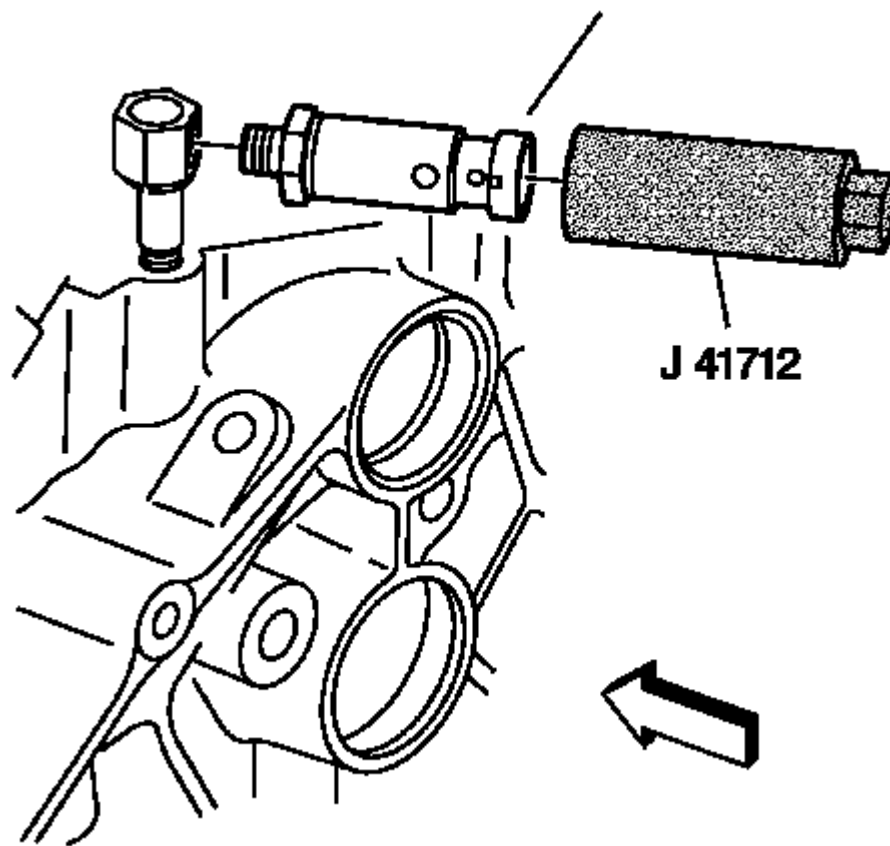


Fig. 292: Removing Engine Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure gage sensor using the J 41712 . See **Special Tools**.

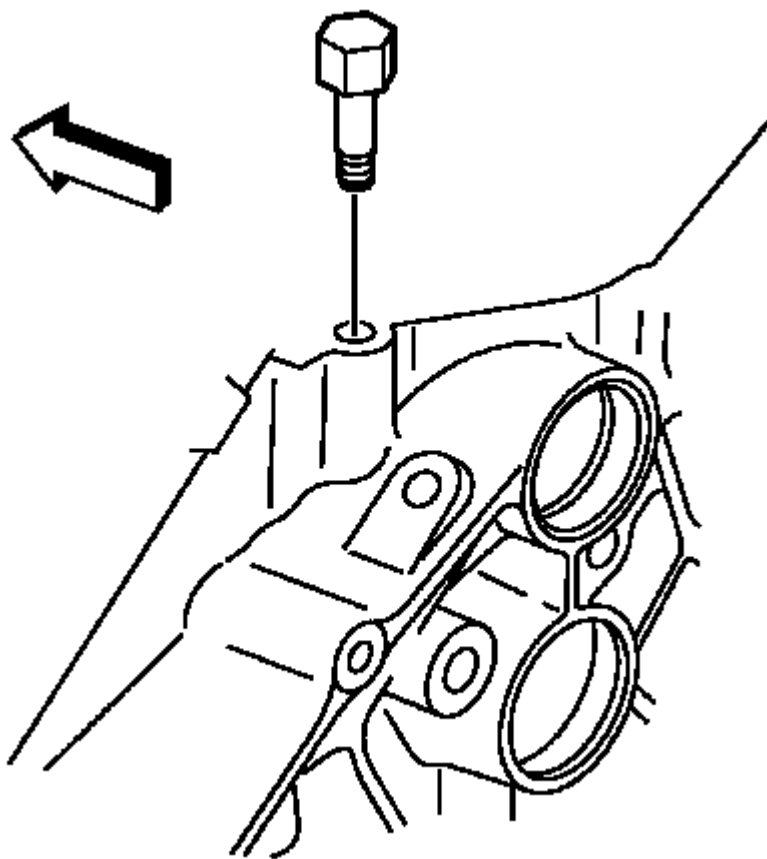


Fig. 293: Removing Engine Oil Pressure Sensor Fitting
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine oil pressure sensor fitting.

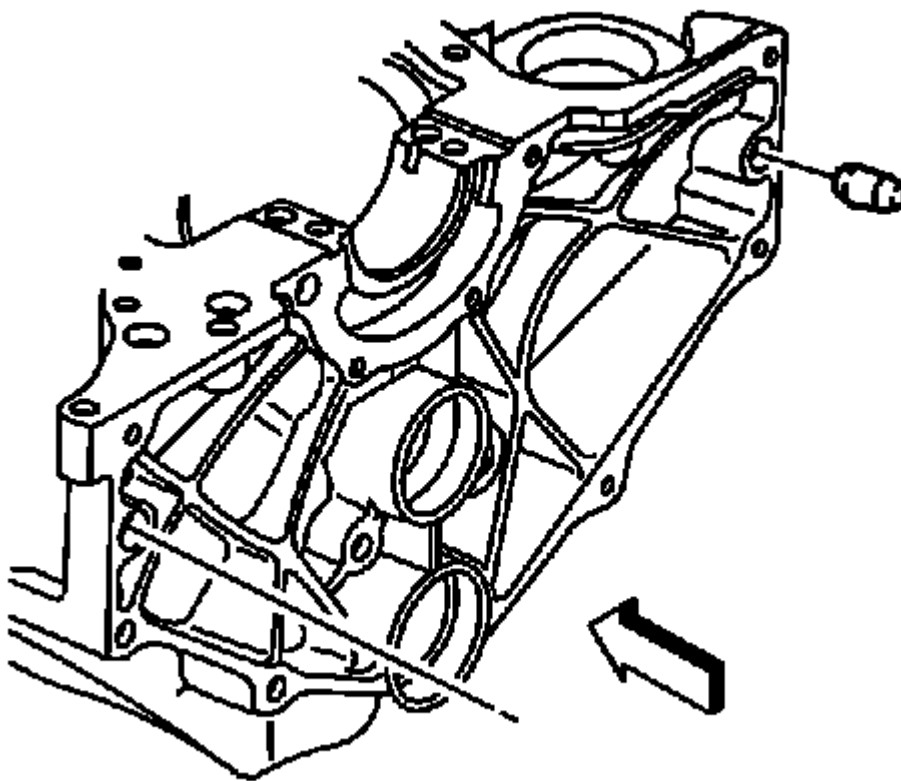


Fig. 294: Removing Transmission Locator Dowel Straight Pins
Courtesy of GENERAL MOTORS CORP.

5. Remove the transmission locator dowel straight pins, if required.

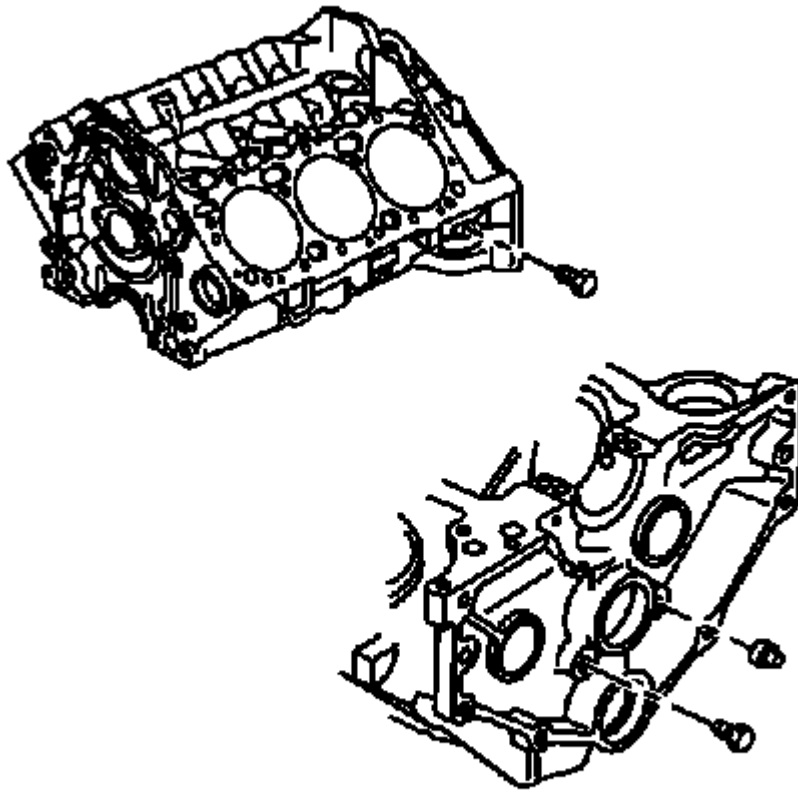


Fig. 295: Removing Engine Block Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine block left side oil gallery plug.
7. Remove the engine block left rear oil gallery plug.
8. Remove the engine block right rear oil gallery plug.

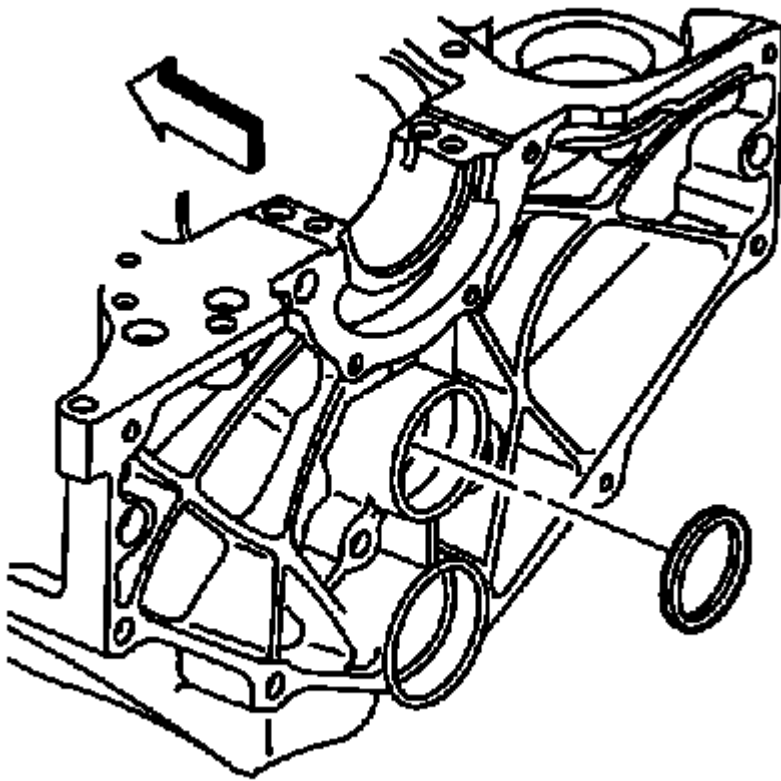


Fig. 296: Removing Expansion Cup Plug From Camshaft Rear Bearing Hole
Courtesy of GENERAL MOTORS CORP.

9. Remove the expansion cup plug from the camshaft rear bearing hole and discard.

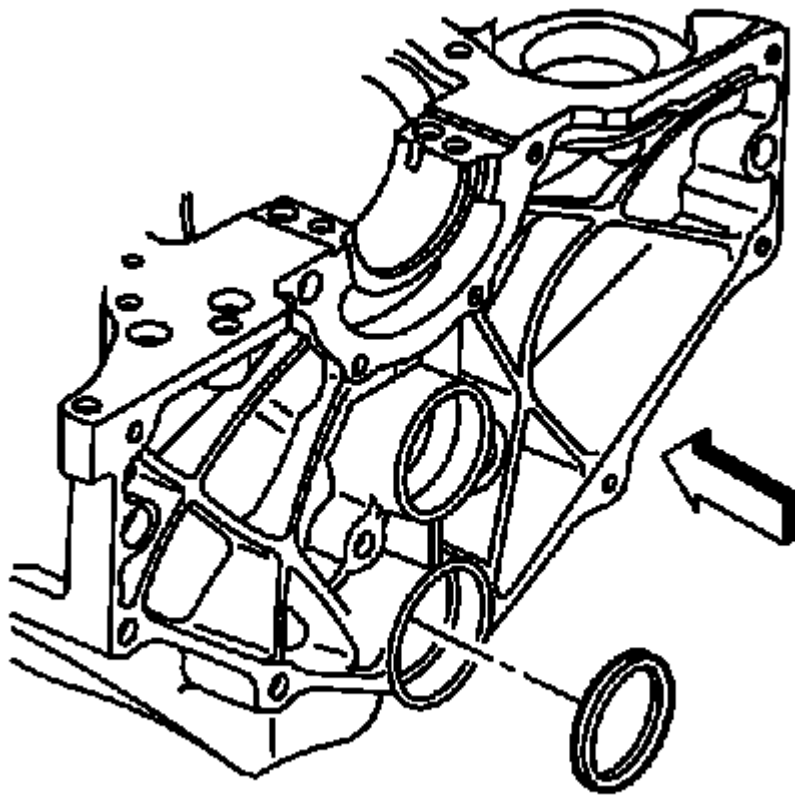


Fig. 297: Removing Expansion Cup Plug From Balance Shaft Rear Bearing Hole
Courtesy of GENERAL MOTORS CORP.

10. Remove the expansion cup plug from the balance shaft rear bearing hole and discard.

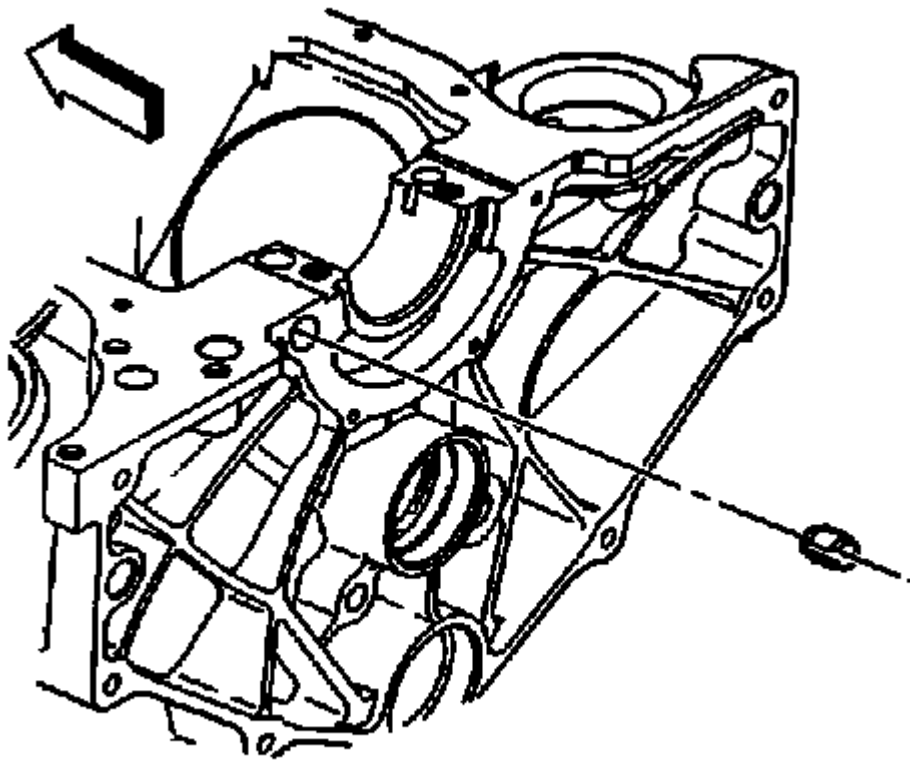


Fig. 298: Removing Crankshaft Rear Oil Seal Housing Locator Spring
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft rear oil seal housing locator spring type S pin, if required.

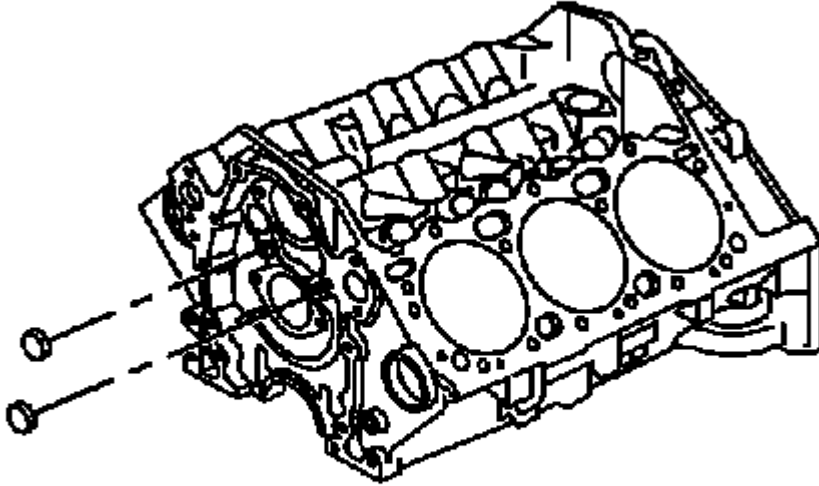


Fig. 299: Removing Front Oil Gallery Plugs From Engine Block
Courtesy of GENERAL MOTORS CORP.

12. Remove the front oil gallery plugs or balls from the front of the engine block and discard.

Insert a 3/8 x 26 inch rod into the rear oil gallery holes in order to drive out the front oil gallery plugs or balls.

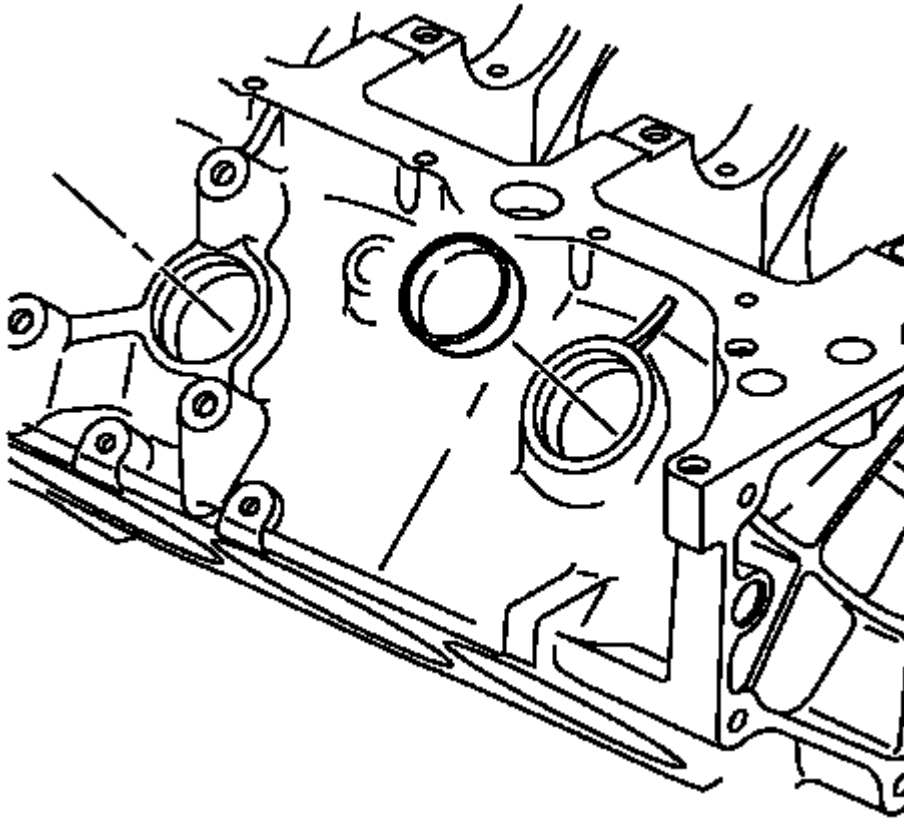


Fig. 300: Removing Engine Block Core Hole Plugs
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine block core hole plugs.
 1. Use a suitable tool in order to drive the engine block core hole plugs into the coolant jacket.
 2. Use a suitable tool in order to pull the engine block core hole plugs from the coolant jacket.
 3. Discard the engine block core hole plugs.

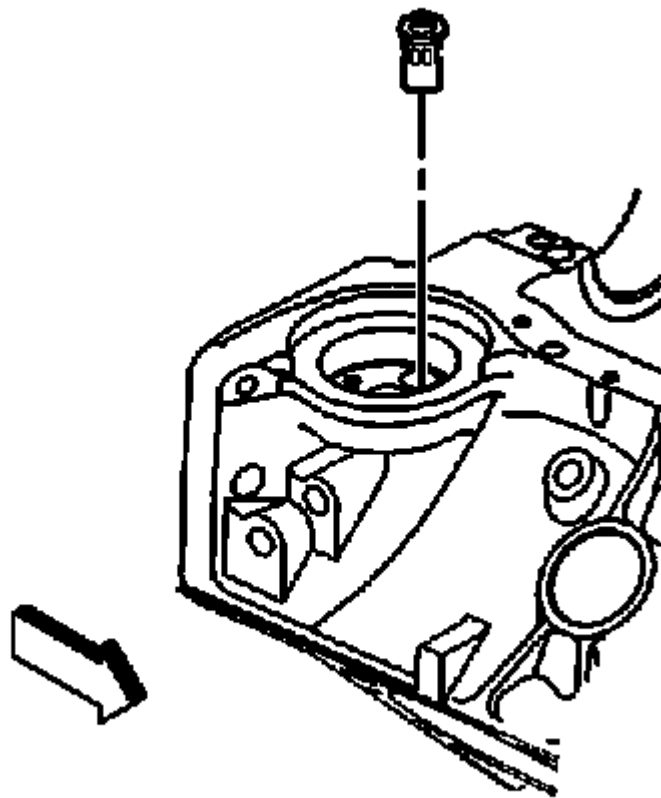


Fig. 301: Removing Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil filter bypass valve and discard.

Engine Block Cleaning and Inspection

Tools Required

J 8087 Cylinder Bore Gage

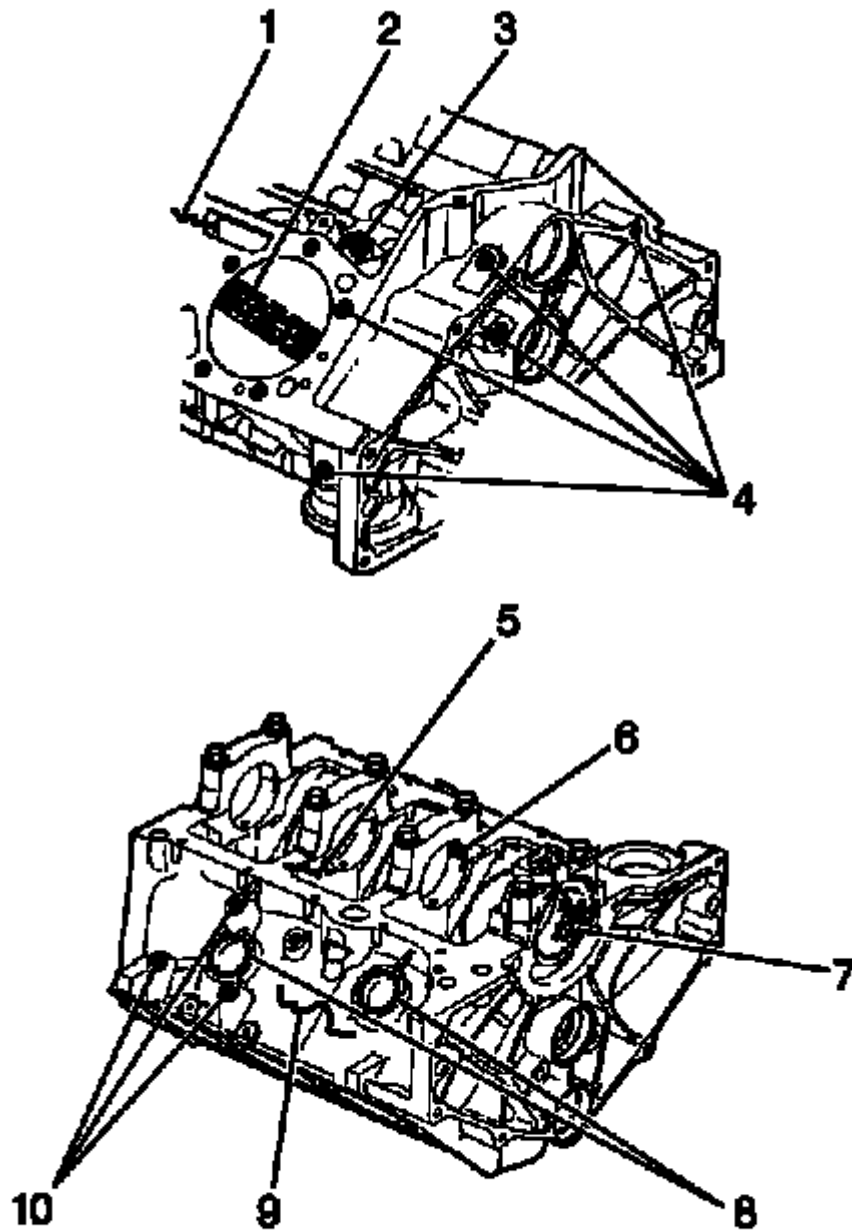


Fig. 302: Engine Inspection Areas
 Courtesy of GENERAL MOTORS CORP.

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

1. Clean all the remaining sealing or gasket material from the sealing surfaces.

2. Clean the engine block with cleaning solvent.
3. Flush the engine block with clean water or steam.
4. Clean the cylinder bores.
5. Clean the oil galleries and the oil passages.
6. Clean the scale and the deposits from the coolant passages.

NOTE: **Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.**

7. Clean the engine block cylinder head bolt holes.
8. After cleaning the engine block, spray or wipe the cylinder bores and the machined surfaces with clean engine oil.
9. Inspect the following areas:
 - Coolant jackets (1) for cracks
 - Cylinder bores (2) for scratches or gouging
 - Valve lifter bores (3) for excessive scoring or wear
 - Threaded holes (4) for damage
 - Crankshaft bearing webs (5) for cracks
 - Crankshaft bearing caps (6) and the crankshaft bearing bores (7) for damage
 - The crankshaft bearing bores should be round and uniform when measuring the inside diameter (ID).
 - The surface where the crankshaft bearings contact the crankshaft bearing bore should be smooth.
 - If a crankshaft bearing cap is damaged and requires replacement, replace the crankshaft bearing cap first, then rebore the engine block crankshaft bearing bores and check for the proper alignment. Finally, check the crankshaft for the proper clearances.
 - Engine block core hole plug bores (8) for damage
 - Engine block (9) for cracks or damage
 - Engine mount bosses (10) for damage

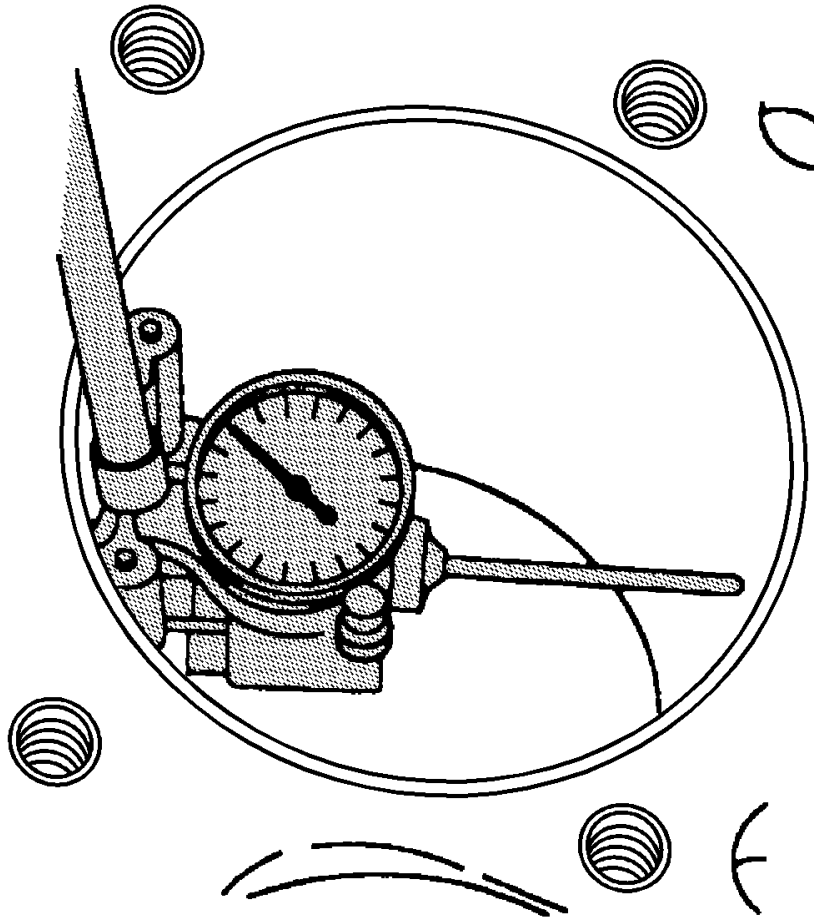


Fig. 303: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

10. Measure the cylinder bores for taper and out-of-round.
 1. Depress the plunger on the J 8087 to 7 mm (0.275 in) or until the J 8087 enters the cylinder bore.
 2. Center the J 8087 in the cylinder bore and turn the indicator dial to 0.
 3. Move the J 8087 up and down the cylinder bore to determine the cylinder bore taper. Refer to **Engine Mechanical Specifications** .
 4. Turn the J 8087 to different points around the cylinder bore to determine the cylinder bore out-of-round condition. Refer to **Engine Mechanical Specifications** .

Cylinder Boring and Honing

Honing Procedure

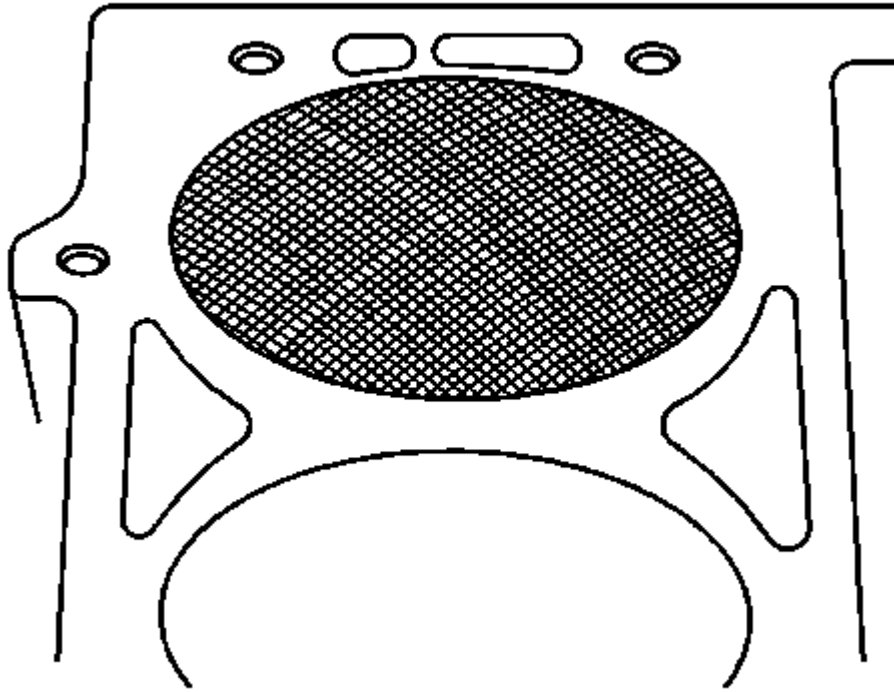


Fig. 304: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

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

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
 - 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.
 - DO NOT hone to a final grade with a coarse or medium-grade stone.
 - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
 - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45-65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
 - Repeatedly check the cylinder bore fit with the selected piston.
 - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.

Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

- The finish marks should be clean but not sharp.
 - The finish marks should be free from imbedded particles or torn or folded metal.
4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
 5. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
 1. Scrub the cylinder bores with a stiff bristle brush.
 2. Rinse the cylinder bores thoroughly with clean hot water.
 3. Dry the cylinder bores with a clean rag.
 4. Do not allow any abrasive material to remain in the cylinder bores.
 - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
 - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
 6. Perform final measurements of the piston and the cylinder bore.
 7. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
 8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Boring Procedure

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

1. Before starting the honing or reboring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. File the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding use of the boring equipment.
4. When reboring the cylinders, make sure all the crankshaft bearing caps are installed in the original position and direction.
5. Tighten the crankshaft bearing caps to the proper torque specifications in order to avoid distortion of the cylinder bores in the final assembly.
6. When making the final cut with the boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. Carefully perform the honing and boring operation in order to maintain the specified clearances between the pistons, the piston rings, and the cylinder bores.

Piston and Connecting Rod Disassemble

Tools Required

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



Fig. 305: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the piston rings from the pistons.

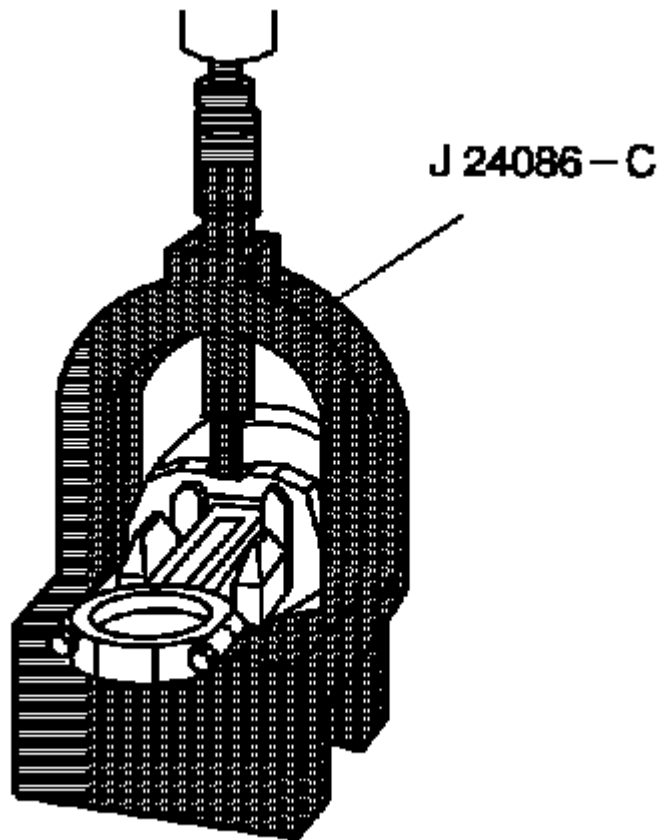


Fig. 306: Pressing The Piston Pin From The Connecting Rod Using J 24086-C
Courtesy of GENERAL MOTORS CORP.

2. Press the piston pin from the connecting rod using the **J 24086-C** . See **Special Tools**.

The piston pin has an interference fit into the connecting rod, and is full floating in the piston.

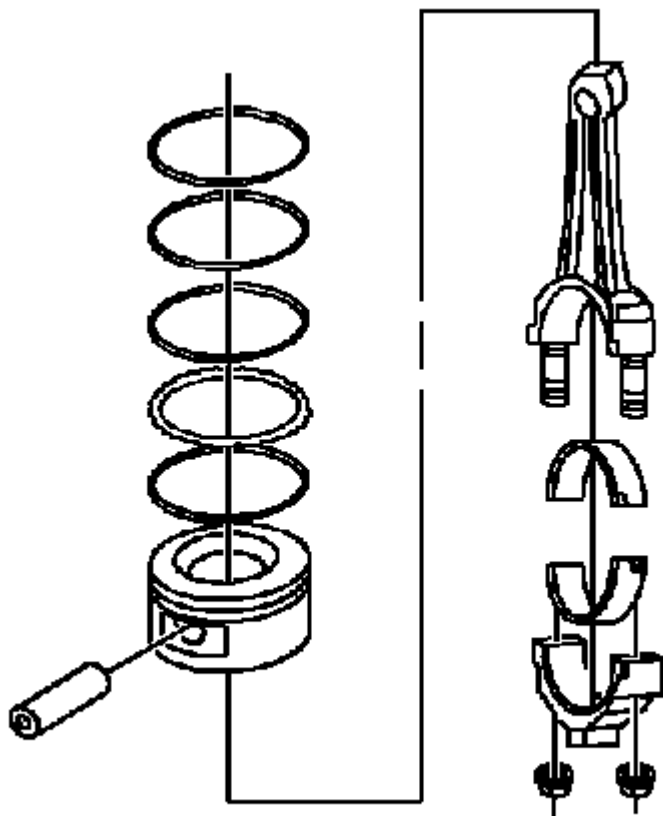


Fig. 307: Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

3. Mark, separate, and organize the parts for assembly.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

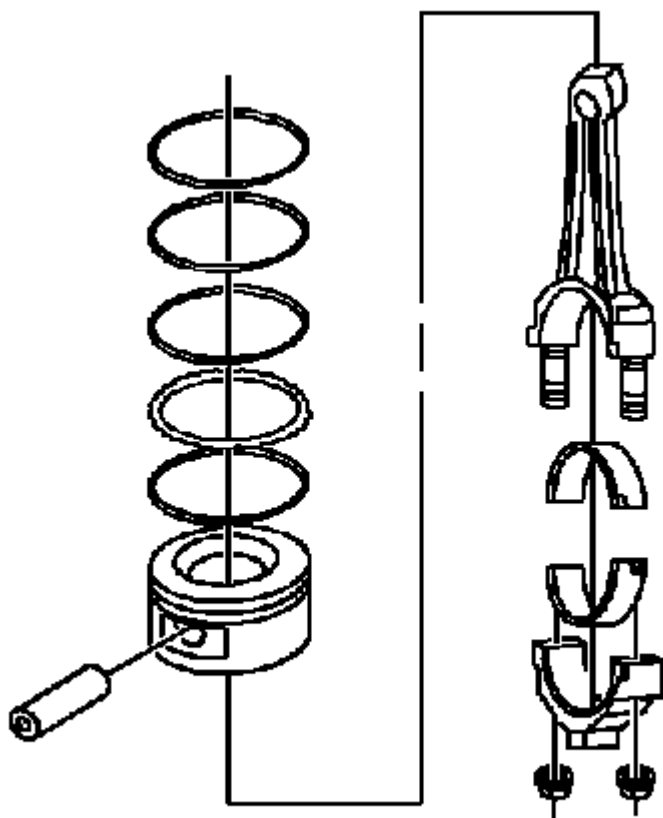


Fig. 308: Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the piston and connecting rod in solvent.

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

2. Dry the components with compressed air.

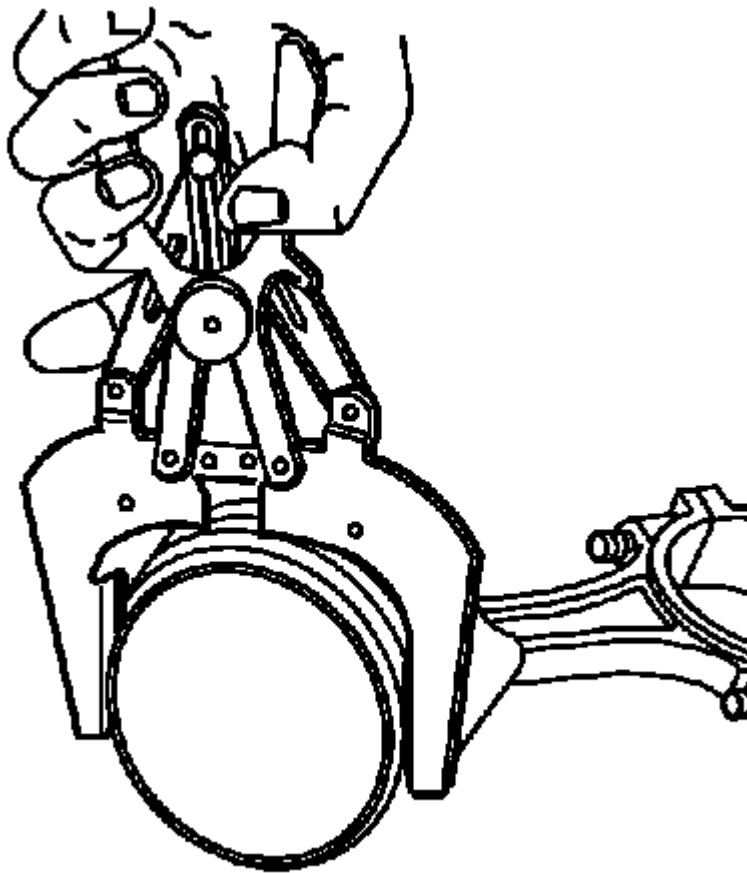


Fig. 309: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.

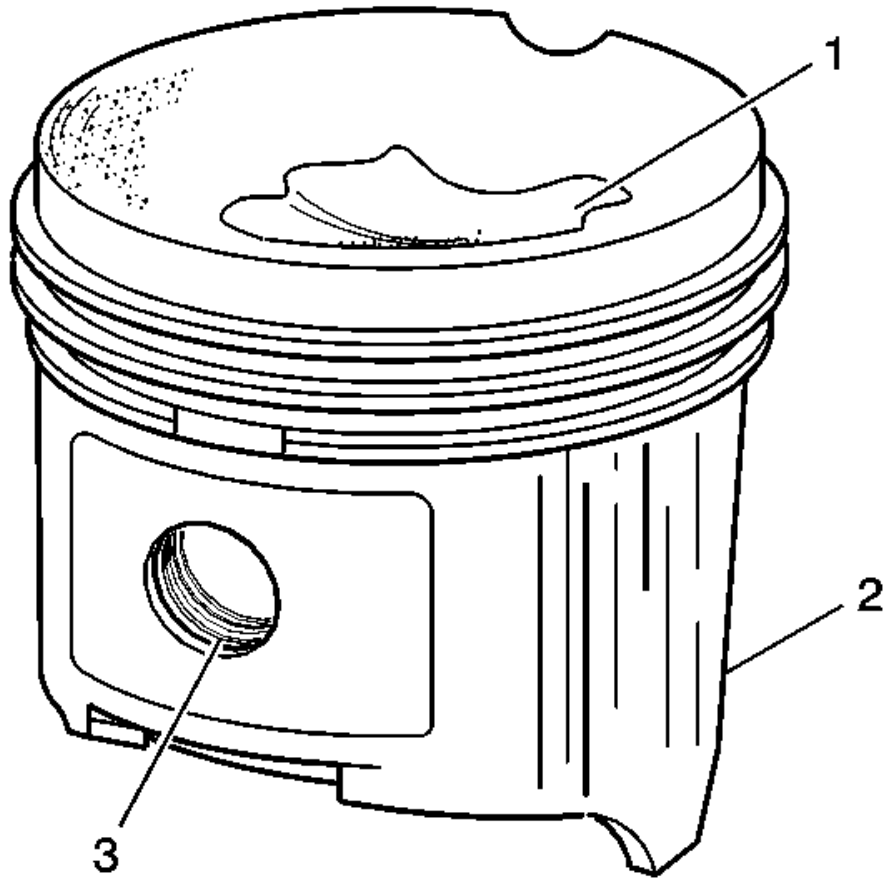


Fig. 310: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

4. Clean the piston oil lubrication holes and slots.
5. Inspect the piston for the following:
 - Eroded areas (1) on the top of the piston
 - Scuffed or damaged skirt (2)
 - Damage to the pin bore (3)
 - Cracks in the piston ring lands, the piston skirt, or the pin bosses
 - Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind
6. Inspect the piston pin for scoring, wear or other damage.

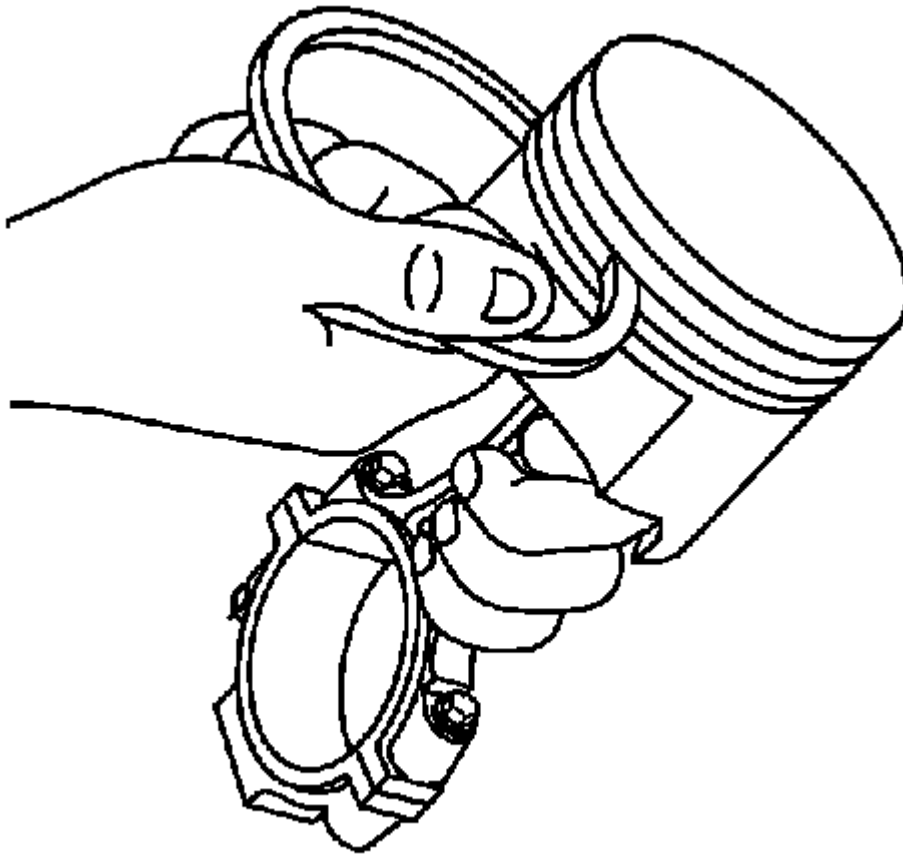


Fig. 311: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring-to-piston ring groove side clearance.
 1. Insert the edge of the piston ring into the piston ring groove.
 2. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, replace the piston ring.

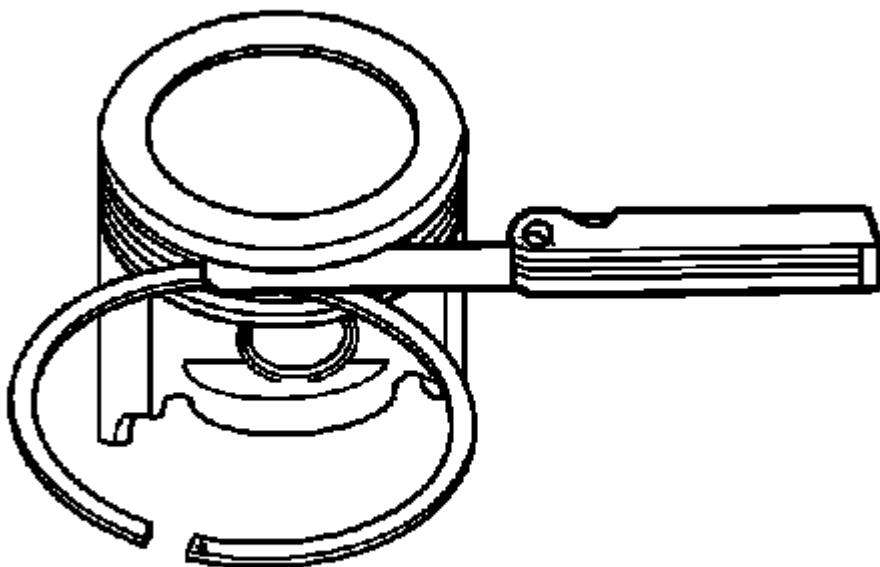


Fig. 312: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gauge.
9. If the side clearance is too small, try another piston ring set.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
11. To determine the proper piston ring side clearance, refer to **Engine Mechanical Specifications**.

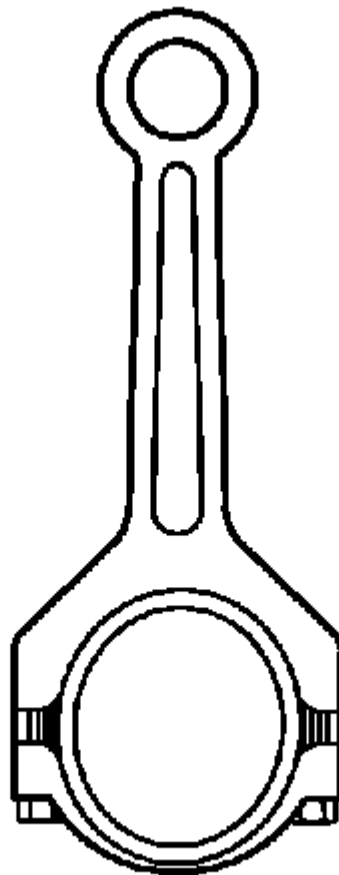


Fig. 313: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

12. Inspect the connecting rod for an out-of-round bearing bore. Refer to **Engine Mechanical Specifications**.

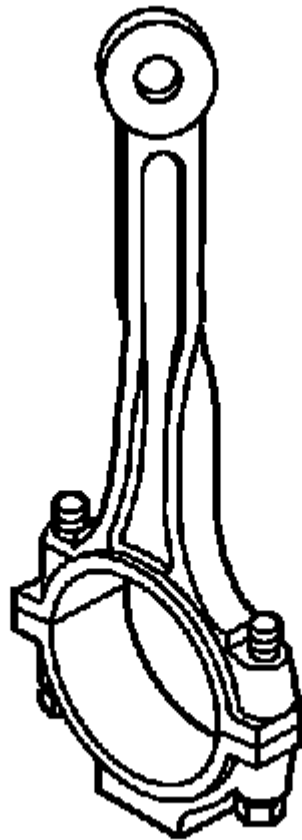


Fig. 314: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

13. Inspect the connecting rod for twisting.
14. Inspect the connecting rod for damage to the bearing cap and bolt threads.

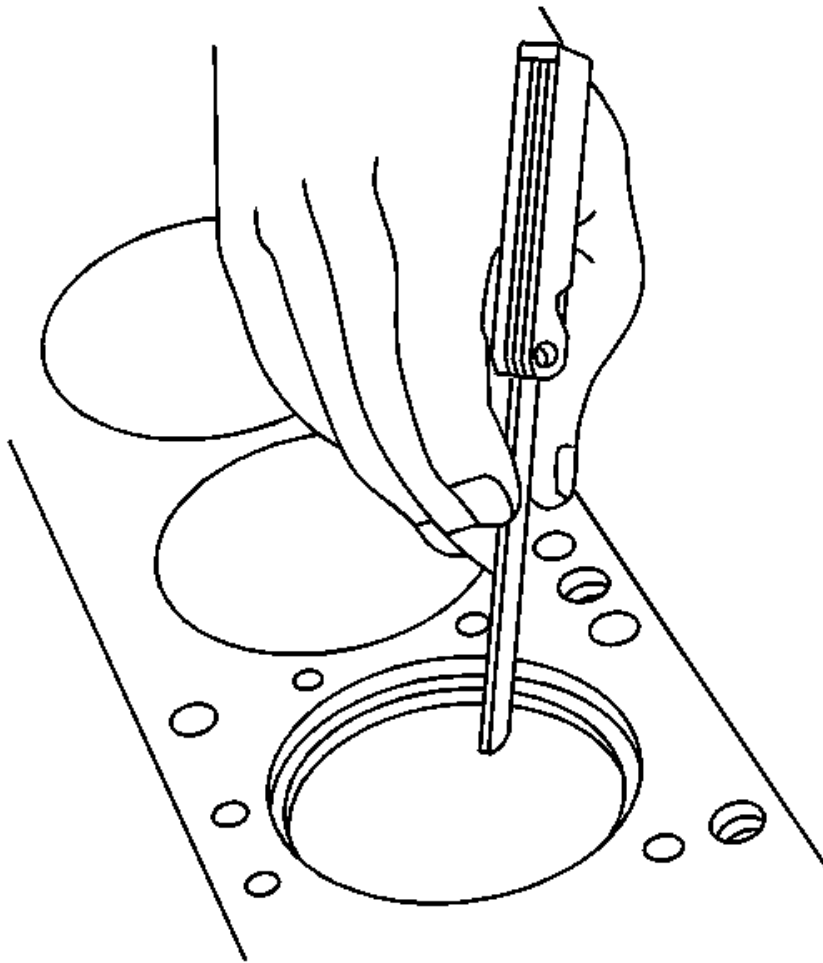


Fig. 315: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

15. Measure the piston compression ring end gap.

IMPORTANT: Fit each compression ring to the cylinder in which it will be used.

1. Place the compression ring into the cylinder bore.
2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.

The ring must be square to the cylinder wall.

3. Use a feeler gage in order to measure the end gap.
4. Select another size ring set if the end gap exceeds specifications. Refer to **Engine Mechanical Specifications** .

Piston and Connecting Rod Assemble

Tools Required

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

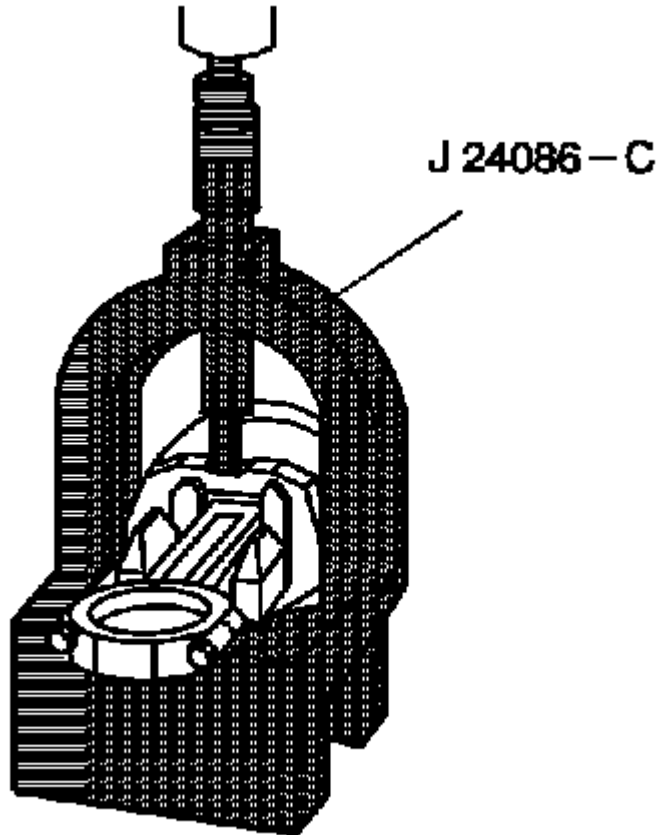


Fig. 316: Pressing The Piston Pin From The Connecting Rod Using J 24086-C
Courtesy of GENERAL MOTORS CORP.

CAUTION: Avoid contact with HOT components. Wear safety glasses and protective gloves to avoid personal injury.

NOTE: Applying excessive heat to the connecting rod may damage or distort the rod. Rod temperature **SHOULD NOT** exceed 315°C (600°F). At this temperature the end of the connecting rod will turn a straw color upon visual inspection.

NOTE: After the J 24086-C installer hub bottoms on the support assembly, **DO NOT** exceed 35,000 kPa (5,000 psi) or the tool may be damaged.

IMPORTANT: When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.
The new piston pin has an interference fit into the connecting rod and is full floating in the piston.

1. Install the new piston pin and connecting rod assembly.
 1. Lubricate the piston pin bores with clean engine oil.
 2. Use a torch and apply MILD heat to the piston pin end of the connecting rod.
 3. Use the **J 24086-C** in order to press the new piston pin into the piston and connecting rod assembly. See **Special Tools**.
 4. Inspect for the proper installation of the piston and piston pin.

The piston must move freely on the new piston pin with no binding or interference.

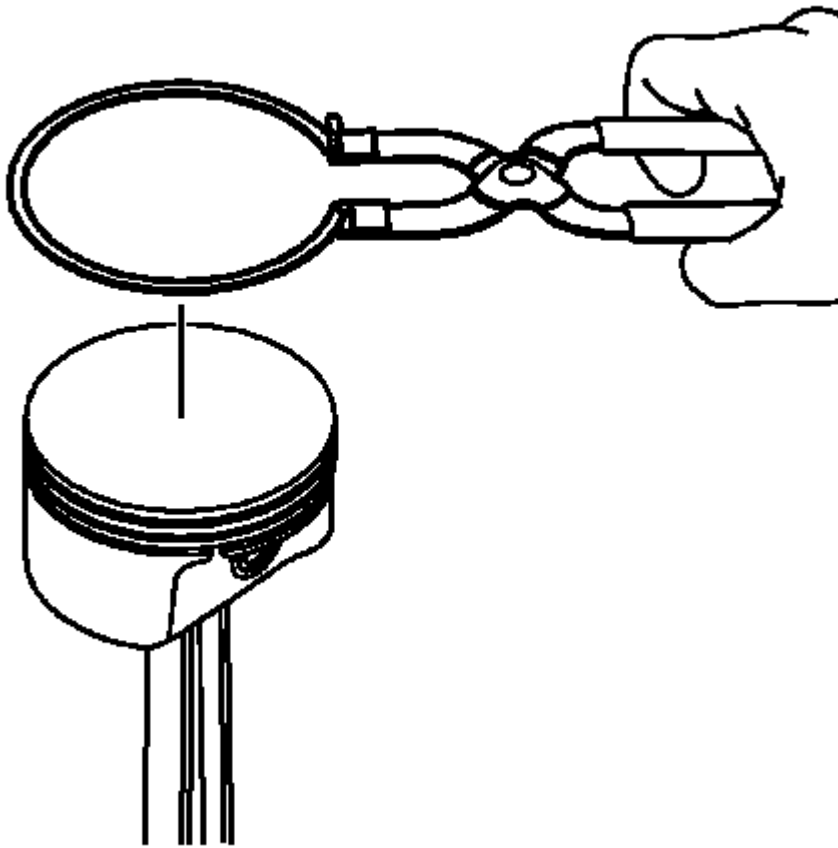


Fig. 317: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

2. Install the piston rings onto the piston.
 1. Install the oil control piston ring spacer.
 2. Install the lower oil control piston ring.
 3. Install the upper oil control piston ring.
 4. Install the lower compression piston ring.

The mark on the side of the piston ring should face the top of the piston.

5. Install the upper compression piston ring.

The mark on the side of the piston ring should face the top of the piston.

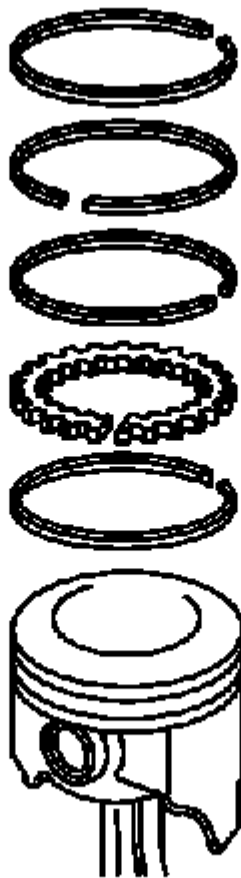


Fig. 318: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

3. Space the compression piston ring end gaps 120 degrees apart.

4. Space the oil control piston ring end gaps a minimum of 90 degrees apart.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator
- **J 43690** Rod Bearing Clearance Checking Tool. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

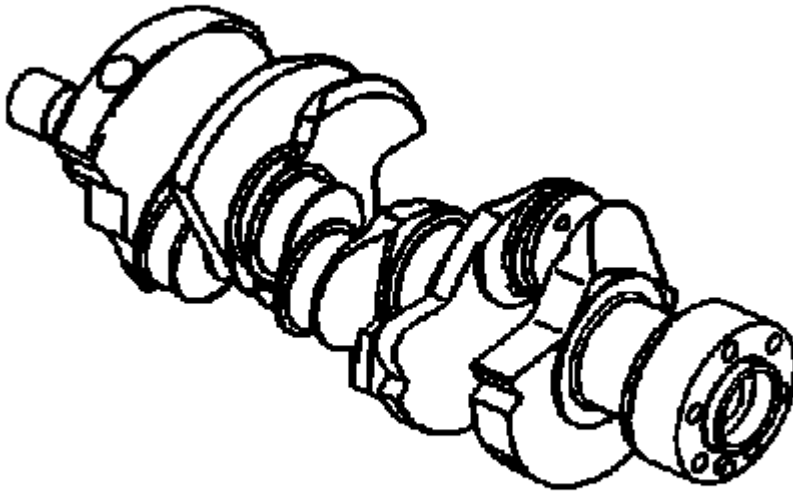


Fig. 319: Crankshaft

Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the crankshaft bearing surfaces.

1. Clean the crankshaft in cleaning solvent. Remove all sludge or restrictions from the oil passages.
2. Dry the crankshaft with compressed air.

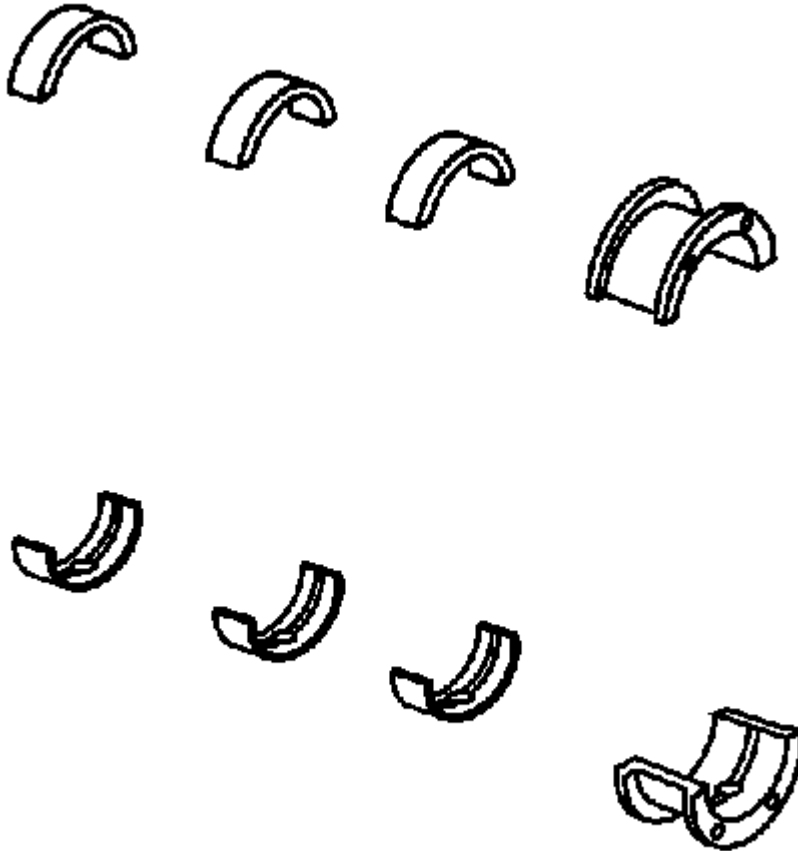


Fig. 320: Crankshaft Bearings

Courtesy of GENERAL MOTORS CORP.

3. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a soft cloth, do not scratch the crankshaft bearing surfaces.
4. Dry the crankshaft bearings with compressed air.

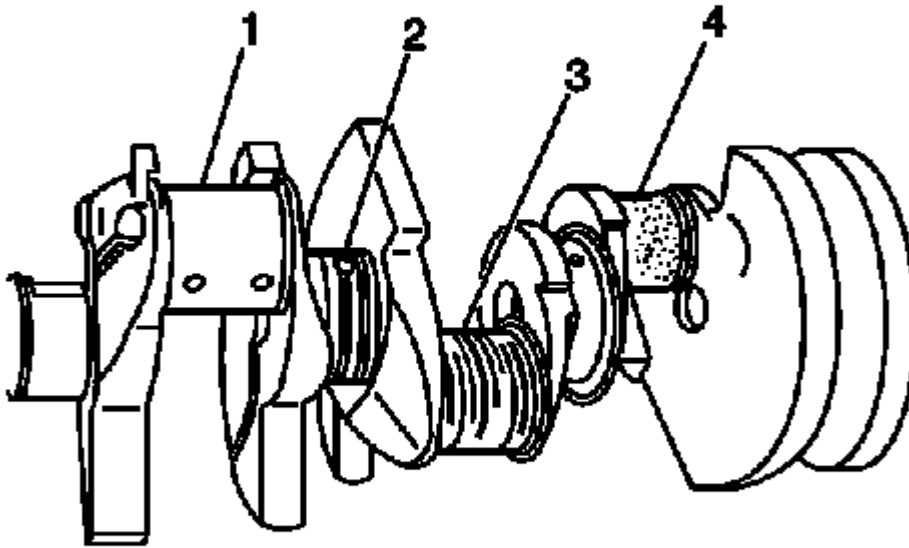


Fig. 321: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

5. Inspect the crankshaft for the following:
- Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
 - Deep grooves (2)
 - Scratches or uneven wear (3)
 - Pitted surfaces (4)
 - Wear or damage to the thrust journal surfaces
 - Scoring or damage to the rear seal surface
 - Restrictions to the oil passages
 - Damage to the threaded bolt holes

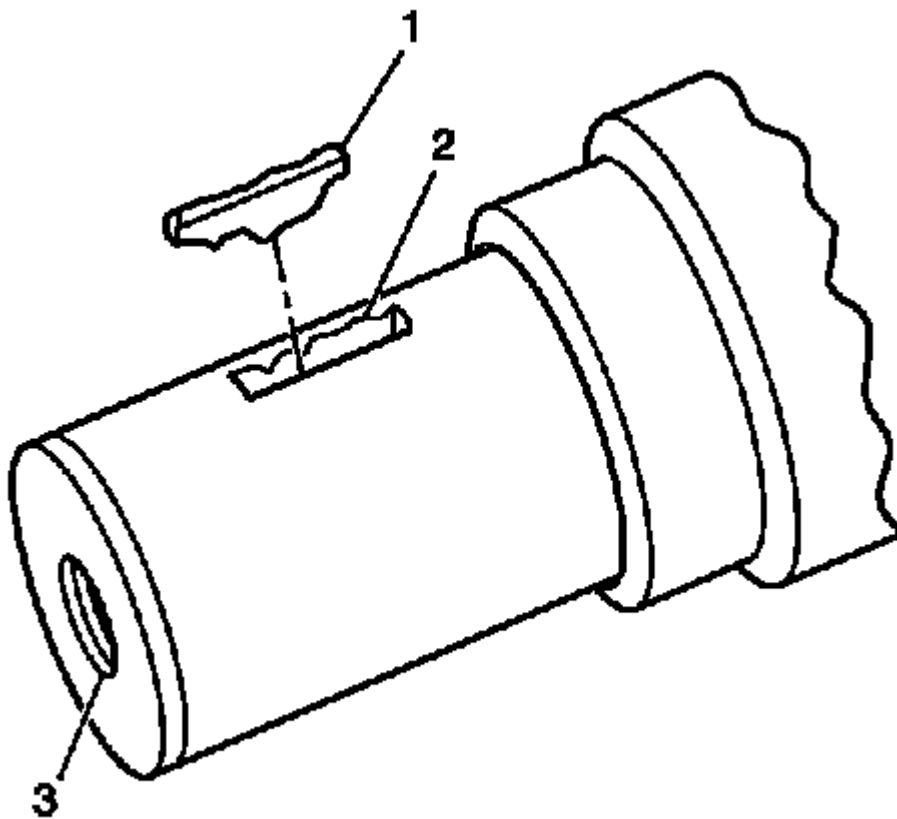


Fig. 322: Crankshaft Balancer Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

6. Inspect the crankshaft balancer key (1), the keyway (2), and the threaded hole (3) for damage.
Repair or replace the crankshaft as necessary.

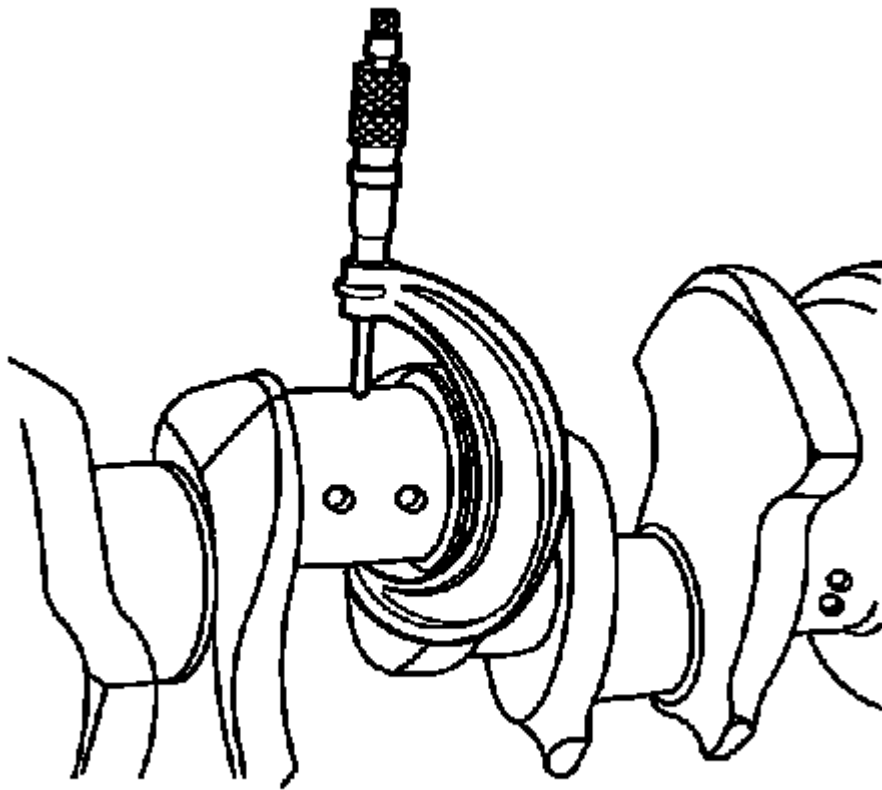


Fig. 323: Measuring Crankpins For Out-Of-Round & Taper
Courtesy of GENERAL MOTORS CORP.

7. Measure the crankpins for out-of-round and taper. Refer to **Engine Mechanical Specifications**.

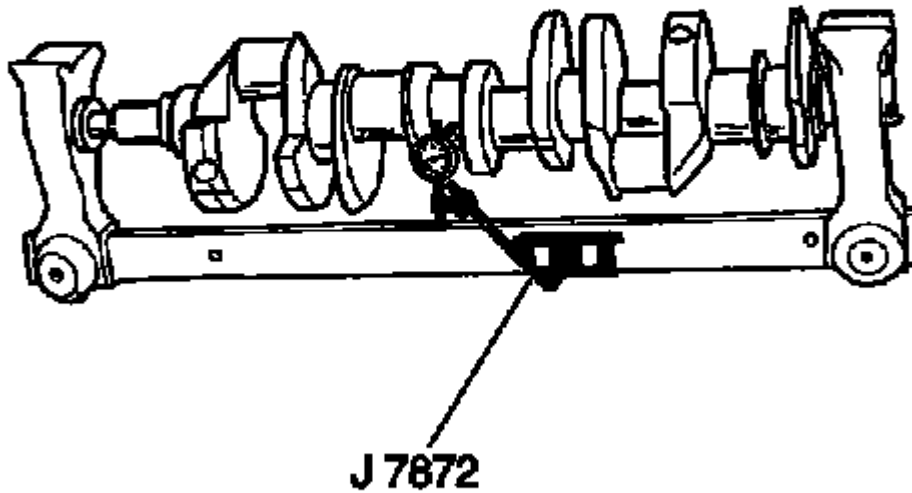


Fig. 324: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

8. Use a suitable support to support the crankshaft on the front and rear journals.
9. Use the **J 7872** in order to measure the crankshaft journal runout. The proper crankshaft journal runout is 0.025 mm maximum (0.0010 in maximum).

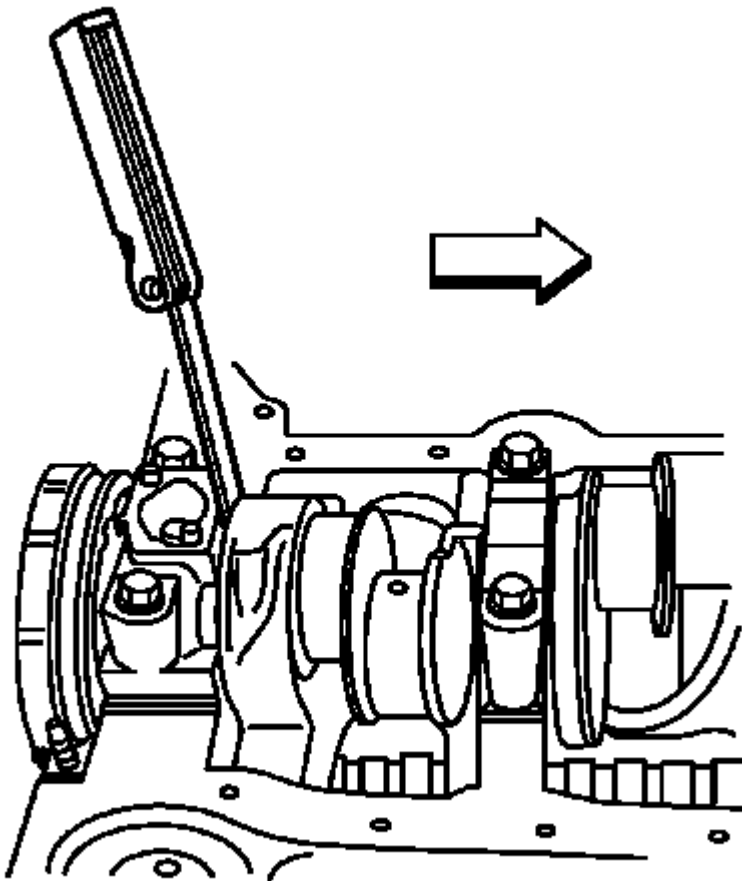


Fig. 325: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft end play.

IMPORTANT: In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings, the crankshaft bearing caps, and the crankshaft bearing cap bolts must be installed into the engine block and the bolts tightened using J 45059 . See Special Tools. The proper crankshaft bearing cap bolt tightening specification first pass is 20 N.m (15 lb ft), final pass is 73 degrees.

1. Firmly thrust the crankshaft first rearward, then forward. This will align the crankshaft rear bearings and the crankshaft thrust surfaces.
2. With the crankshaft pushed forward, insert a feeler gage between the crankshaft and the crankshaft bearing surface and then measure the clearance. The proper crankshaft end play clearance specification is 0.050-0.20 mm (0.002-0.008 in).
3. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, then loosen the crankshaft bearing cap bolts, one crankshaft bearing cap at a time, until the tight crankshaft bearing is located.

Burrs on the crankshaft bearing cap or engine block, foreign matter between the crankshaft bearing and the crankshaft bearing cap or the engine block, or a faulty crankshaft bearing could cause a lack of clearance between the crankshaft and crankshaft bearing.

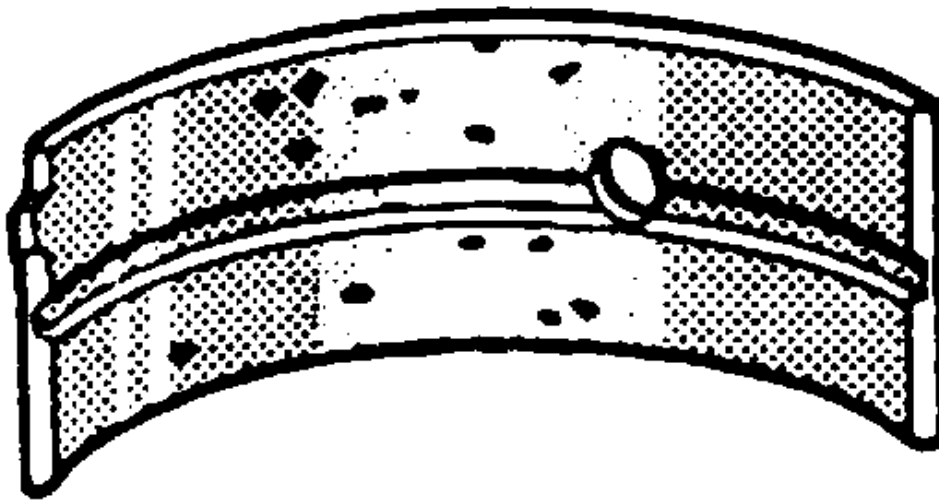


Fig. 326: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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

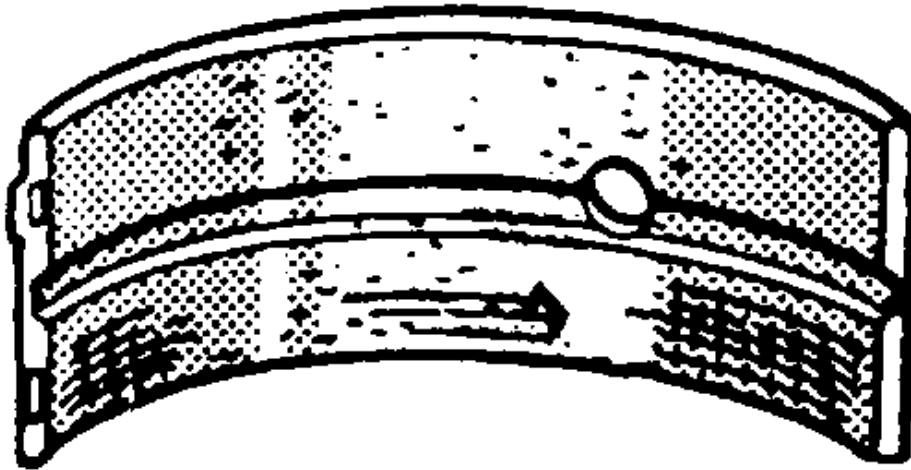


Fig. 327: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

12. Inspect the crankshaft bearings for excessive scoring or discoloration.
13. Inspect the crankshaft bearings for dirt or debris imbedded into the crankshaft bearing material.

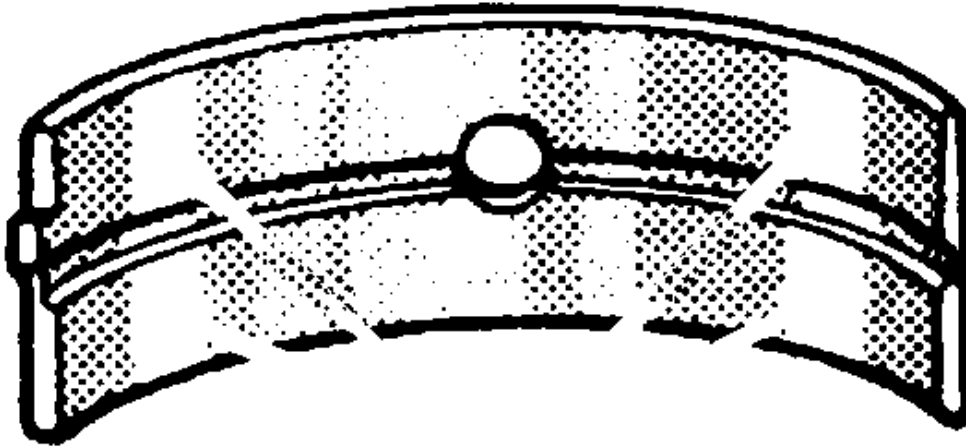


Fig. 328: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

14. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the crankshaft bearings.
 - If the lower half of the crankshaft bearing is worn or damaged, both the upper and lower halves of the crankshaft bearing should be replaced.
 - Generally, if the lower half of the crankshaft bearing is suitable for use, the upper half of the crankshaft bearing should also be suitable for use.

Measuring Crankshaft Bearing Clearances

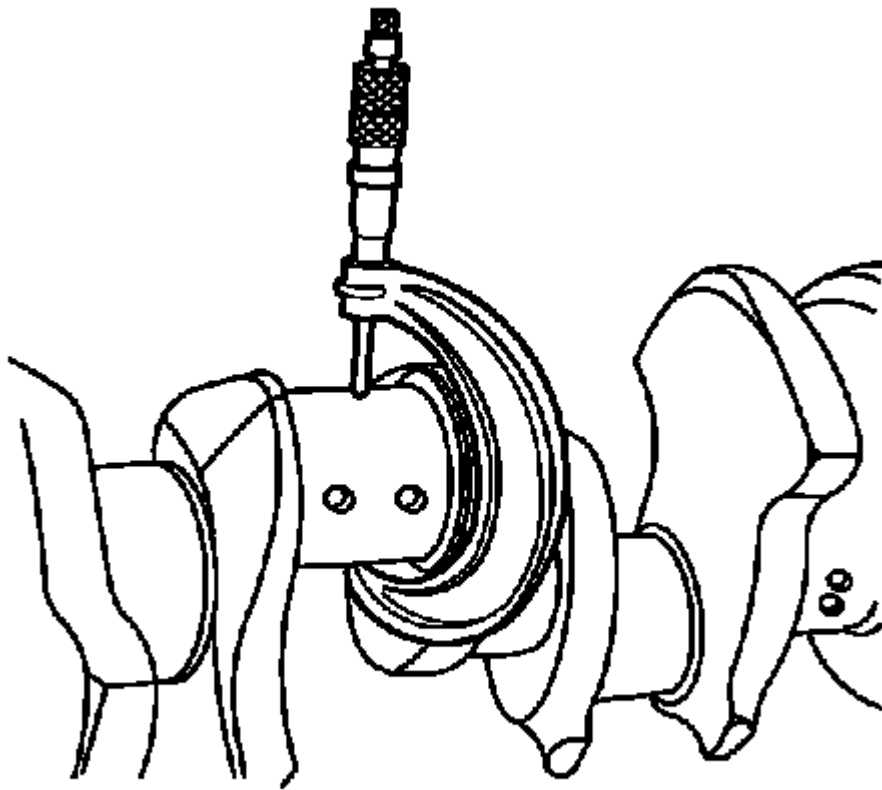


Fig. 329: Measuring Crankpins For Out-Of-Round & Taper
Courtesy of GENERAL MOTORS CORP.

- The crankshaft bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, then new upper and lower crankshaft bearings will be required. The service crankshaft bearings are available in the standard size and an undersize.
- The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of an undersize crankshaft bearing.
- In order to determine the correct replacement bearing size, the bearing clearance must be measured accurately. When checking main bearing clearances, either the micrometer or plastic gage method may be used; however, the micrometer method gives more reliable results and is preferred. When checking connecting rod bearing clearances, the plastic gage method will result in unreliable measurements. The use of **J 43690** is preferred. See **Special Tools**.
- Normally the crankshaft bearing journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round crankshaft bearing journal, be sure to fit to the maximum diameter of the crankshaft bearing journal. If the crankshaft bearing is fitted to the minimum diameter and the crankshaft bearing journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft bearing journal will result in rapid crankshaft bearing failure.
- If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory. If the

clearance is not within specifications, replace the crankshaft bearing. Always replace both the upper and lower crankshaft bearings as a set.

- A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.

Measuring Crankshaft Bearing Clearances - Micrometer Method

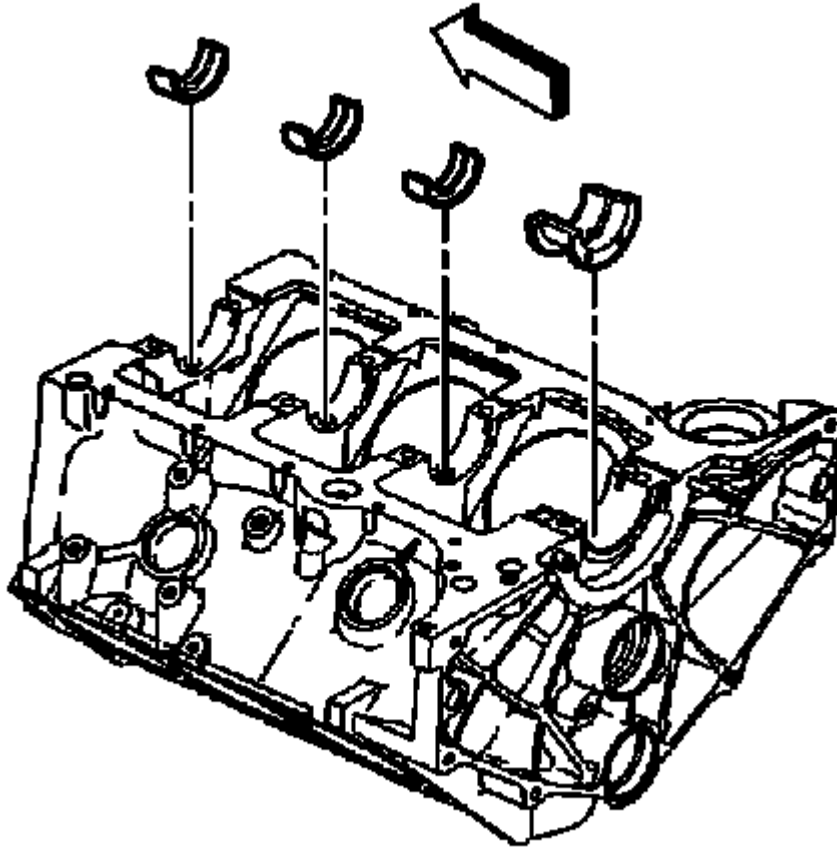


Fig. 330: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Measure the crankshaft journal diameter with a micrometer in several places, approximately 90 degrees apart. Average the measurements.
2. Determine the taper and out-of-round of the journal. Refer to **Engine Mechanical Specifications**.
3. Install the bearings into the engine block or connecting rod assembly.

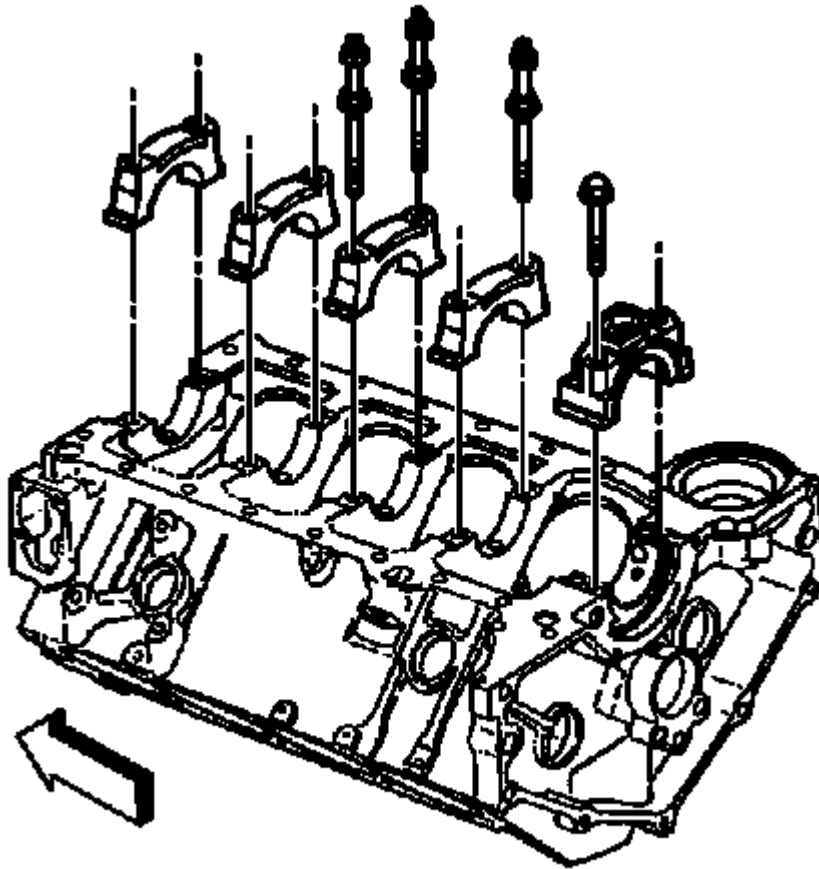


Fig. 331: Installing Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the bearing cap bolts and tighten to specifications. Refer to **Fastener Tightening Specifications**.
5. Measure the bearing inside diameter (ID) at two points 90 degrees apart. Average the measurements.
6. In order to determine the bearing clearance, subtract the average journal diameter from the average bearing inside diameter.
7. Compare the readings to specifications. Refer to **Engine Mechanical Specifications**.
8. Replace bearing halves as required to obtain the proper bearing clearances.

Measuring Connecting Rod Bearing Clearances - J 43690 Method

1. Remove the oil pan and other necessary components to gain access to the connecting rods. Remove the oil pump assembly.
2. Rotate the crankshaft until the crankshaft journal/connecting rod to be measured is in the 10 o'clock position.

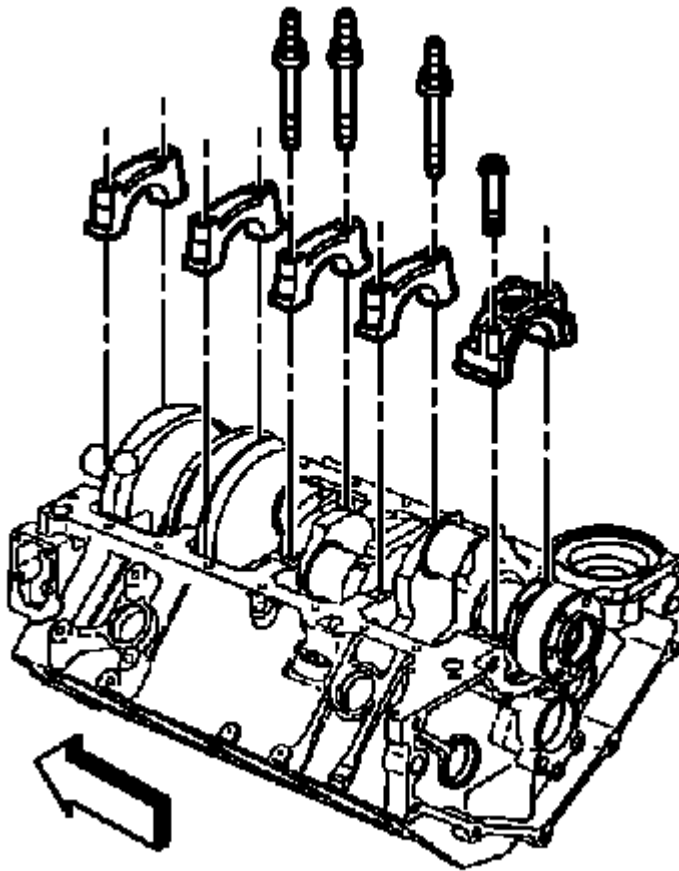


Fig. 332: Removing Bearing Cap Bolts, Cap & Bearing Half
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading. Remove an intermediate bearing cap, as required, in order to secure the crankshaft and allow measurement of connecting rod bearing clearances.

3. Remove the bearing cap bolts, cap and bearing half.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Insert a piece of paper card stock onto the crankshaft journal. Install the bearing half, bearing cap, and bolts. Refer to **Fastener Tightening Specifications**.

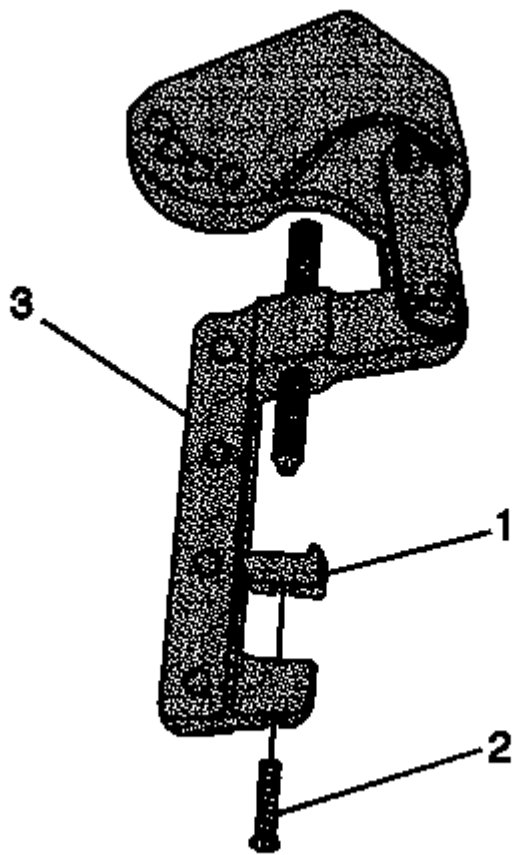


Fig. 333: Installing Foot & Bolt To Pivot Arm Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the foot (1) and bolt (2) to the pivot arm assembly (3). Tighten the bolt until snug.

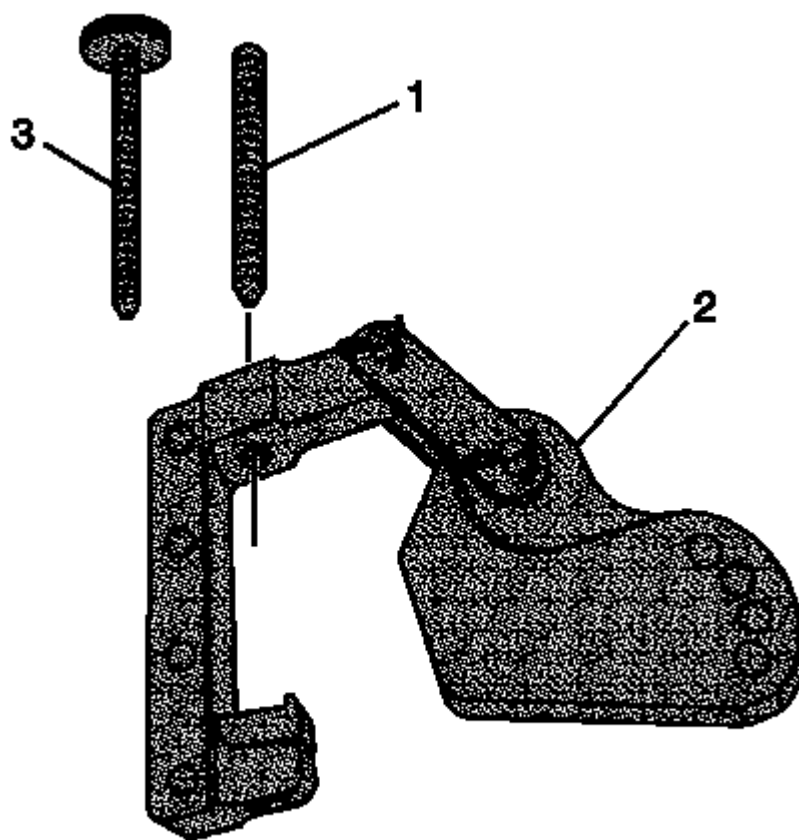


Fig. 334: Installing Screw To Pivot Arm Assembly
Courtesy of GENERAL MOTORS CORP.

6. Install the screw (1 or 3) to the pivot arm assembly (2).

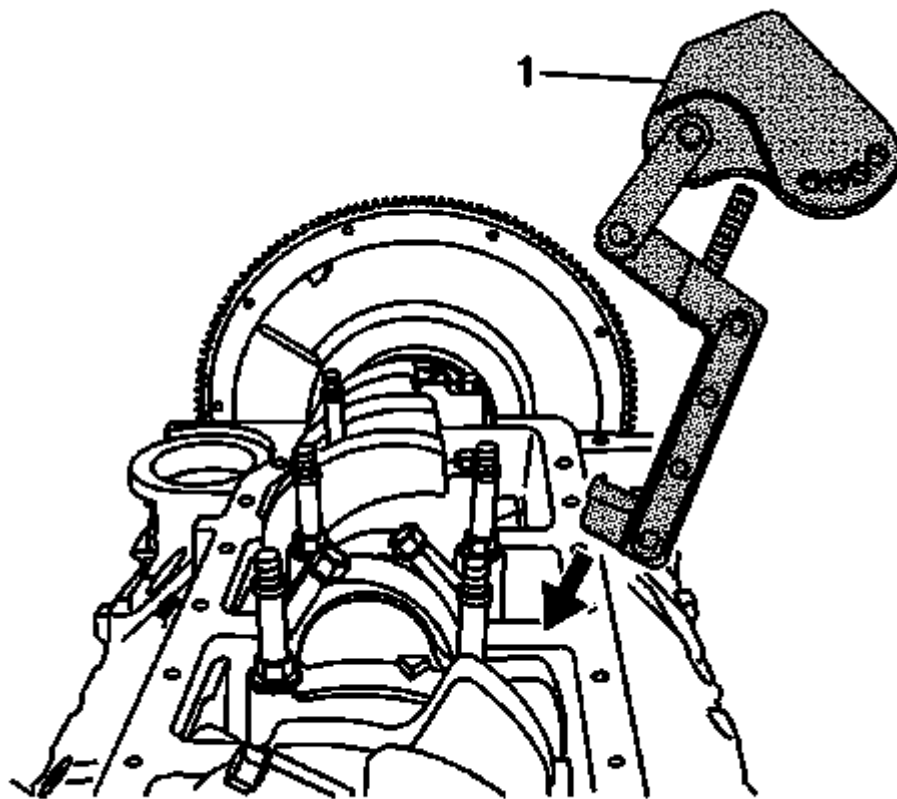


Fig. 335: Installing Pivot Arm Assembly Onto Connecting Rod
Courtesy of GENERAL MOTORS CORP.

7. Install the pivot arm assembly (1) onto the connecting rod.

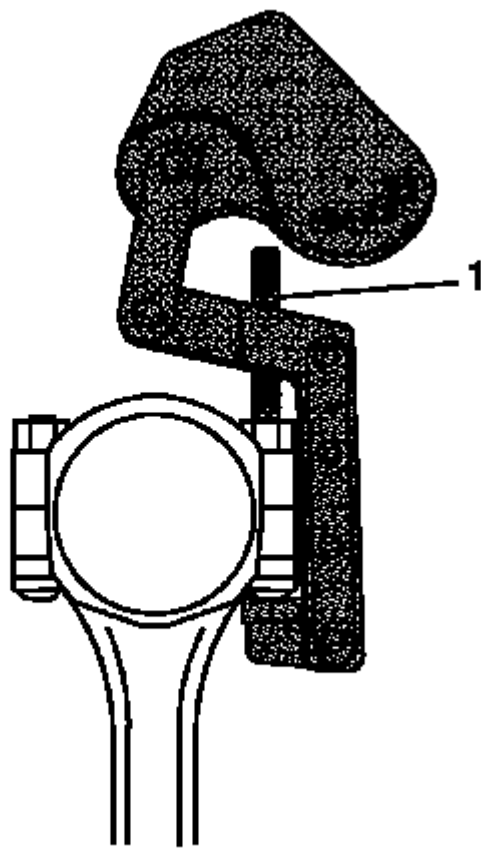


Fig. 336: Positioning Screw Onto Small End Of Connecting Rod Bolt
Courtesy of GENERAL MOTORS CORP.

8. Position the foot of the pivot arm assembly over the large end of the connecting rod bolt.
9. Position the screw (1) onto the small end of the connecting rod bolt and tighten securely.

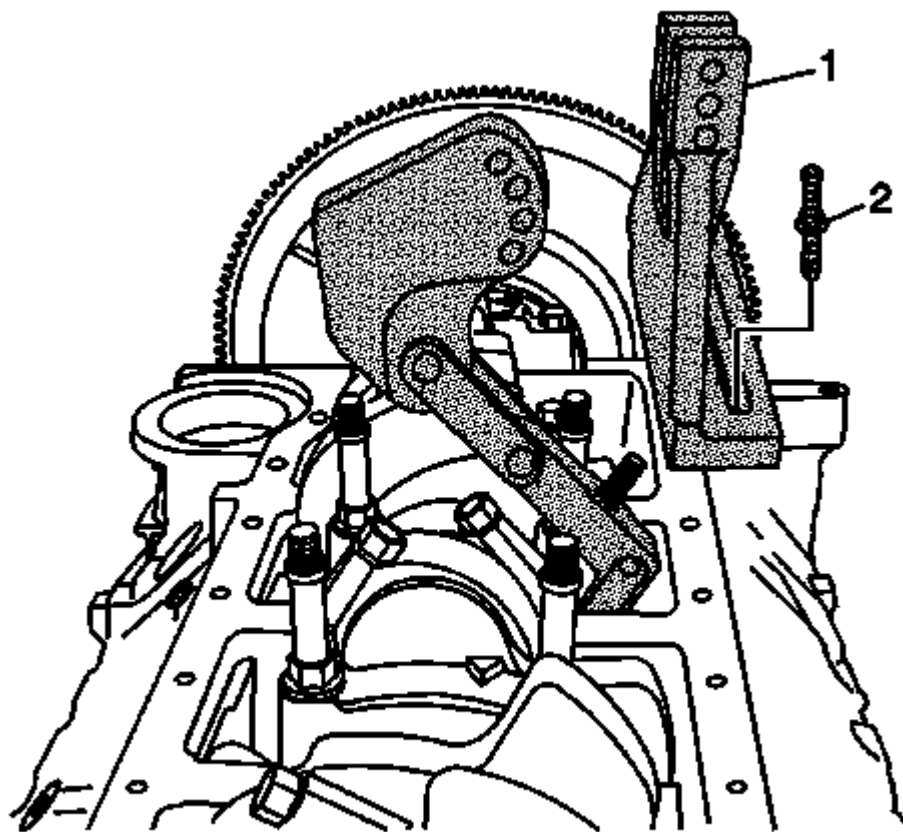


Fig. 337: Installing Base & Bolt To Oil Pan Rail
Courtesy of GENERAL MOTORS CORP.

10. Install the base (1) and bolt (2) to the oil pan rail.

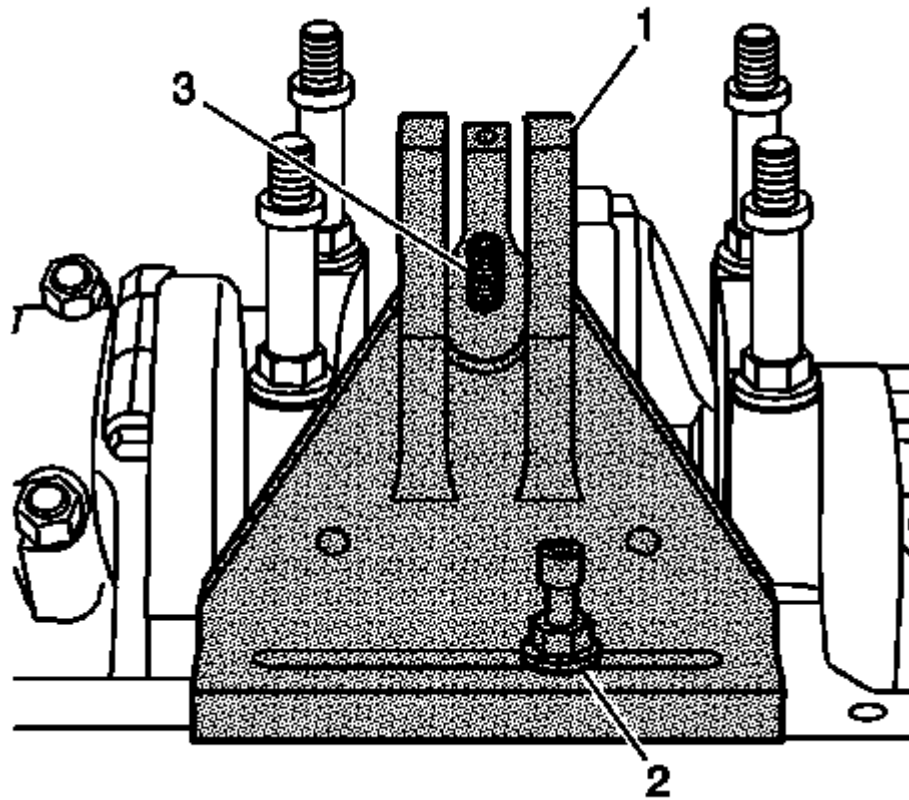


Fig. 338: Aligning Center Of Base W/Pivot Arm Assembly Screw
Courtesy of GENERAL MOTORS CORP.

11. Align the center of the base (1) with the screw (3) of the pivot arm assembly. Tighten the bolt (2) until snug.

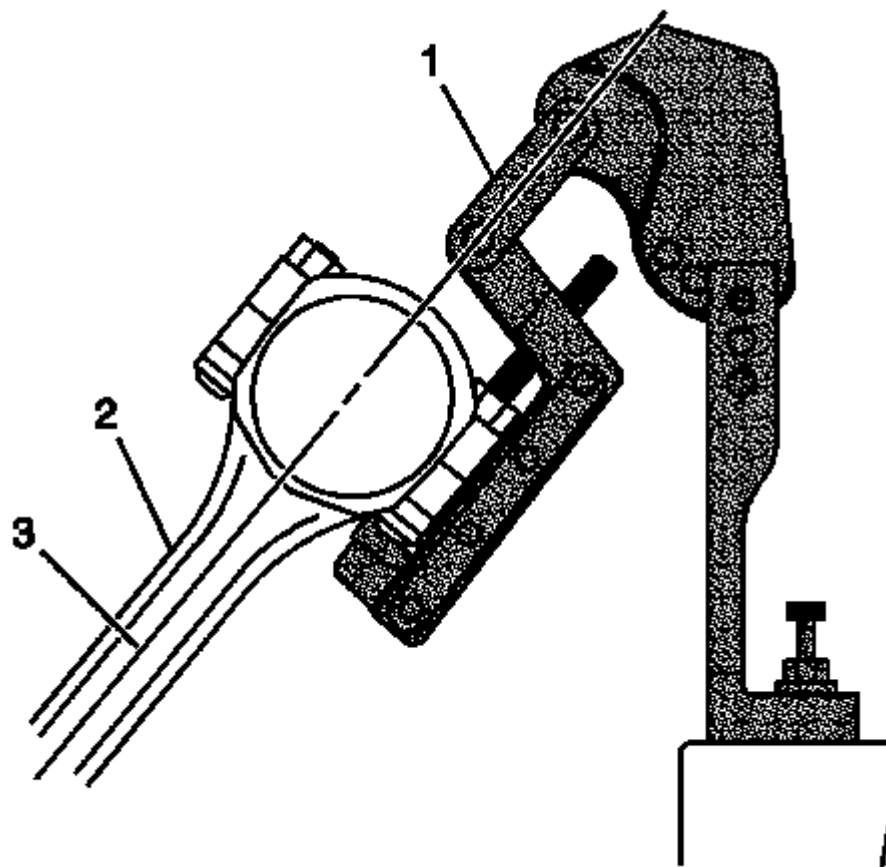


Fig. 339: Aligning Pivot Arm Assembly Link On Connecting Rod Beam Plane
Courtesy of GENERAL MOTORS CORP.

12. Align the link (1) of the pivot arm assembly on a plane (3) equal to that of the connecting rod beam (2).

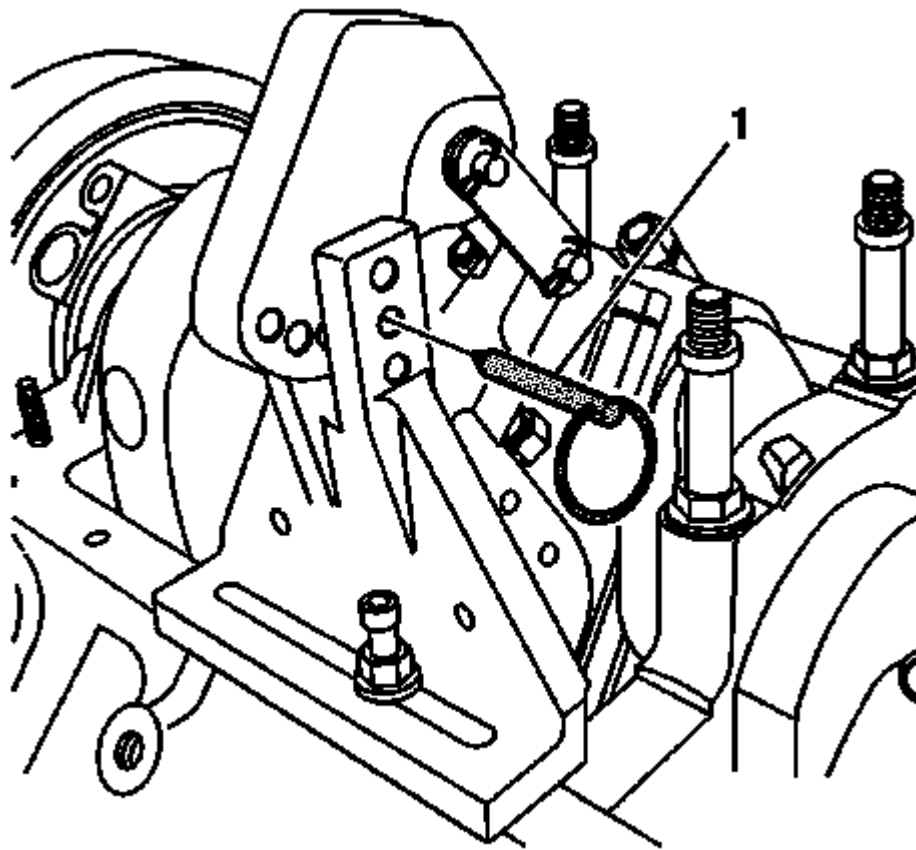


Fig. 340: Positioning Pivot Arm To Base & Inserting Pin
Courtesy of GENERAL MOTORS CORP.

13. With the link of the pivot arm assembly aligned to the beam of the connecting rod, position the pivot arm to the base and insert the pin (1).

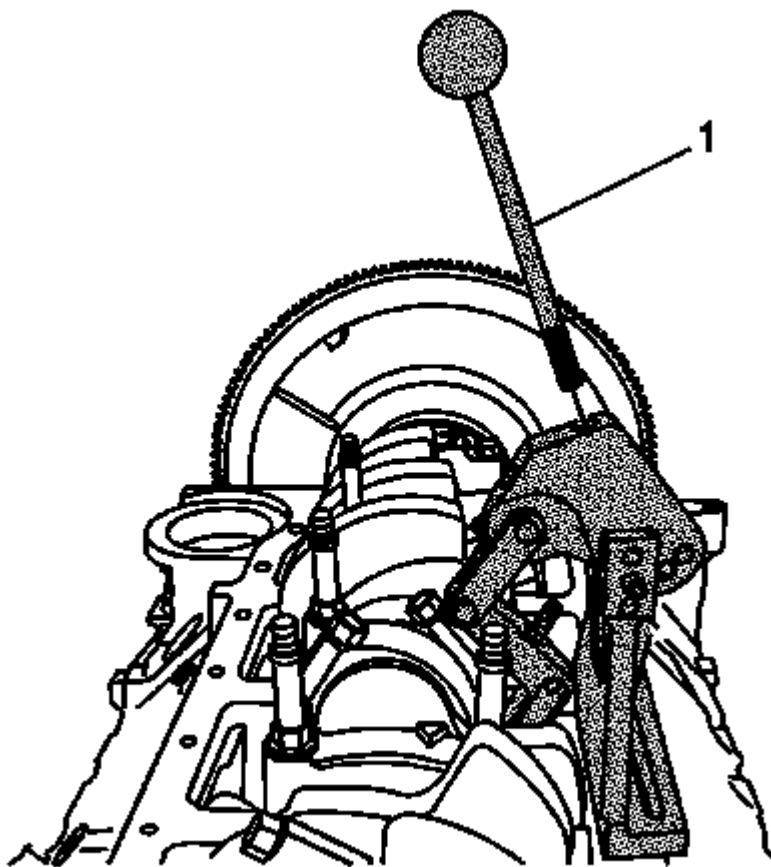


Fig. 341: Pivot Arm Assembly Handle
Courtesy of GENERAL MOTORS CORP.

14. Insert the handle (1) to the pivot arm assembly.

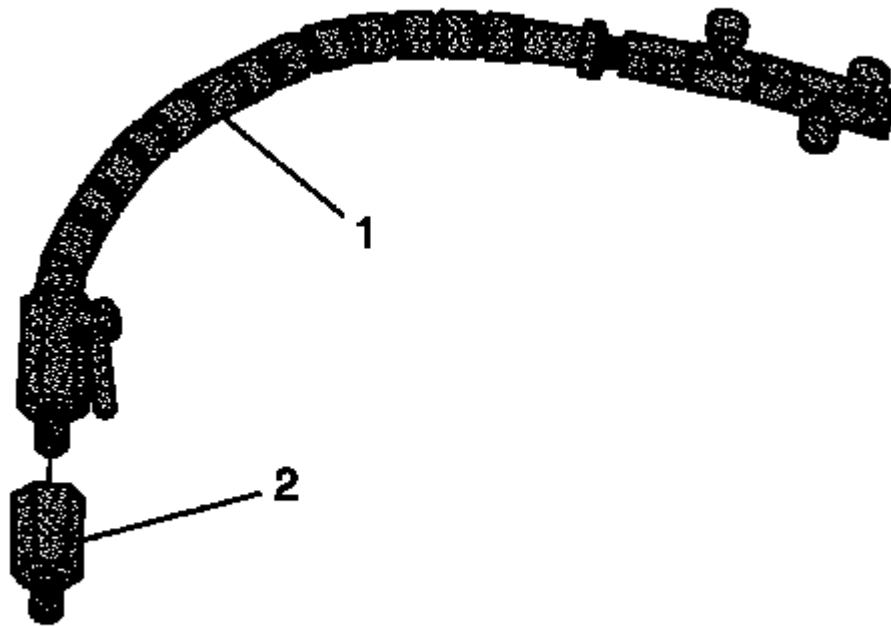


Fig. 342: Installing Swivel Base & Adapter
Courtesy of GENERAL MOTORS CORP.

15. Select the adapter (2), as required, and install to the swivel base (1). Tighten until snug.

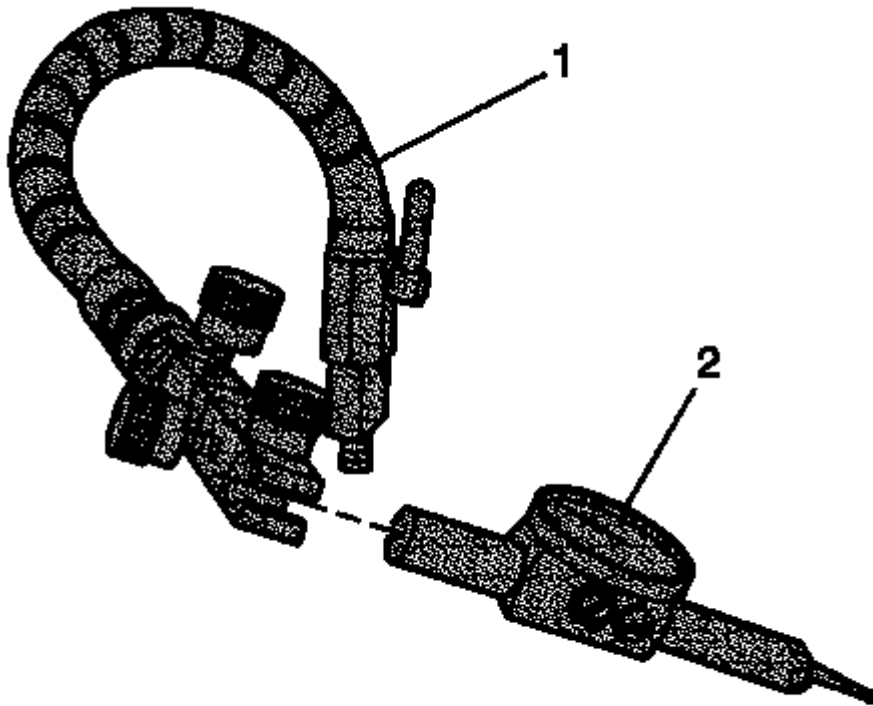


Fig. 343: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The clamp of the swivel base and the shaft of the indicator should be free of oil or other debris. A loose or improperly clamped indicator may indicate incorrect readings.

16. Install the indicator (2) to the swivel base (1). Tighten the clamp of the base until snug.

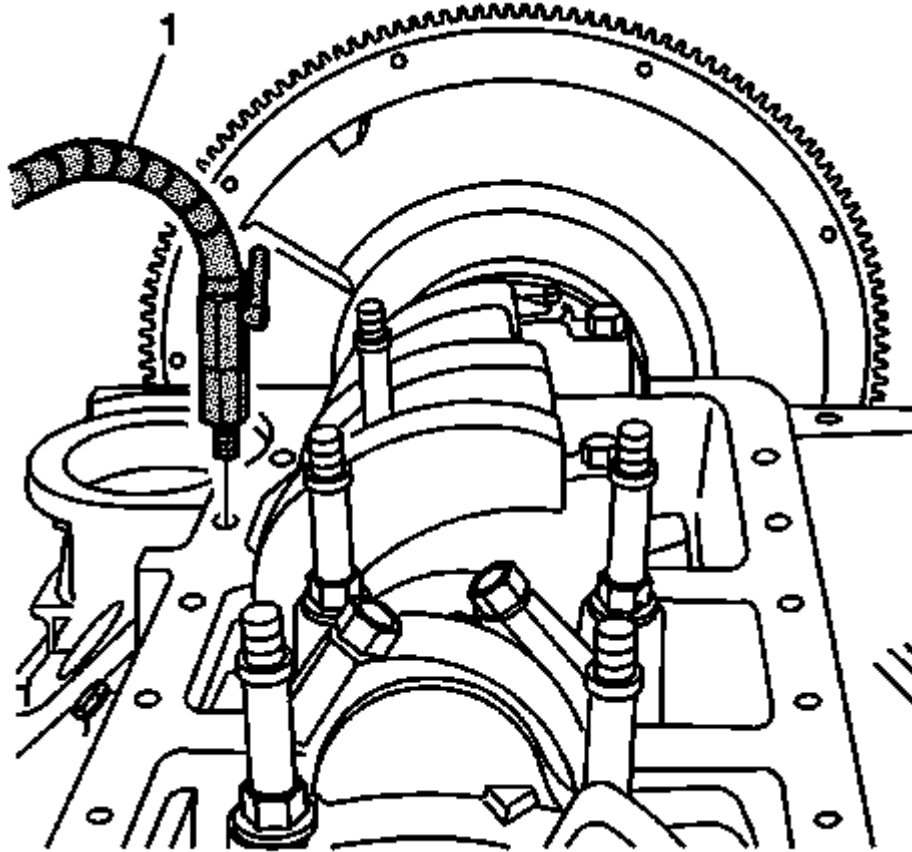


Fig. 344: Installing Swivel Base To Oil Pan Rail
Courtesy of GENERAL MOTORS CORP.

17. Install the swivel base (1) to the oil pan rail of the engine block. Tighten until snug.

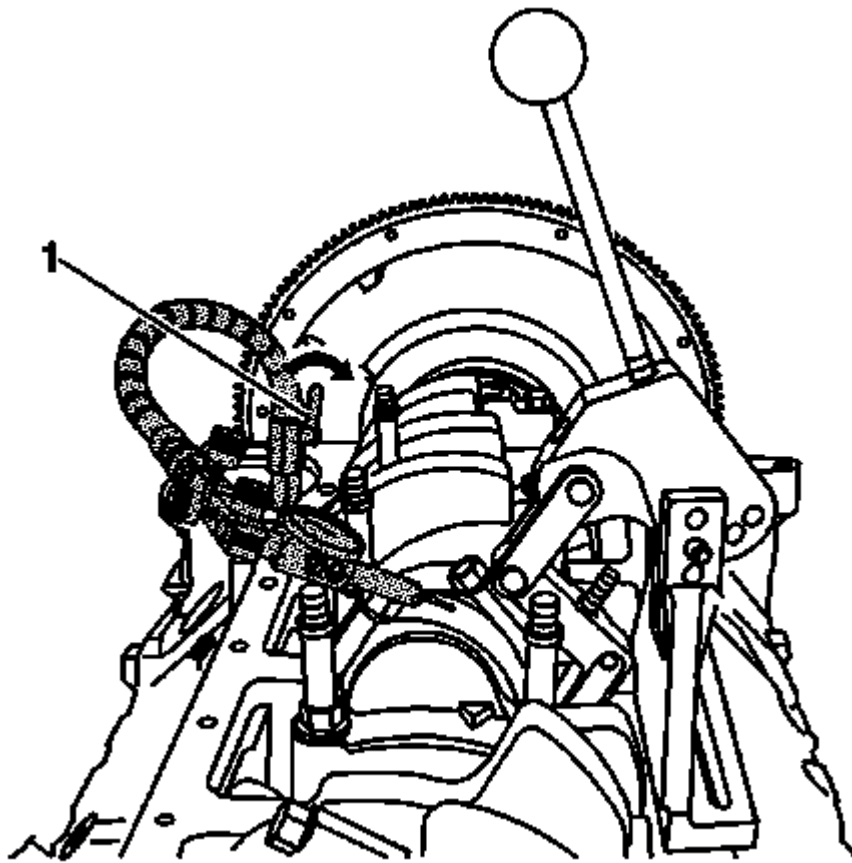


Fig. 345: Swivel Base Locking Lever
Courtesy of GENERAL MOTORS CORP.

18. Adjust the swivel base as required and position the indicator tip slightly above the connecting rod cap. Lock the swivel base in position by rotating the locking lever (1). Do not allow the tip of the indicator to contact the connecting rod at this time.

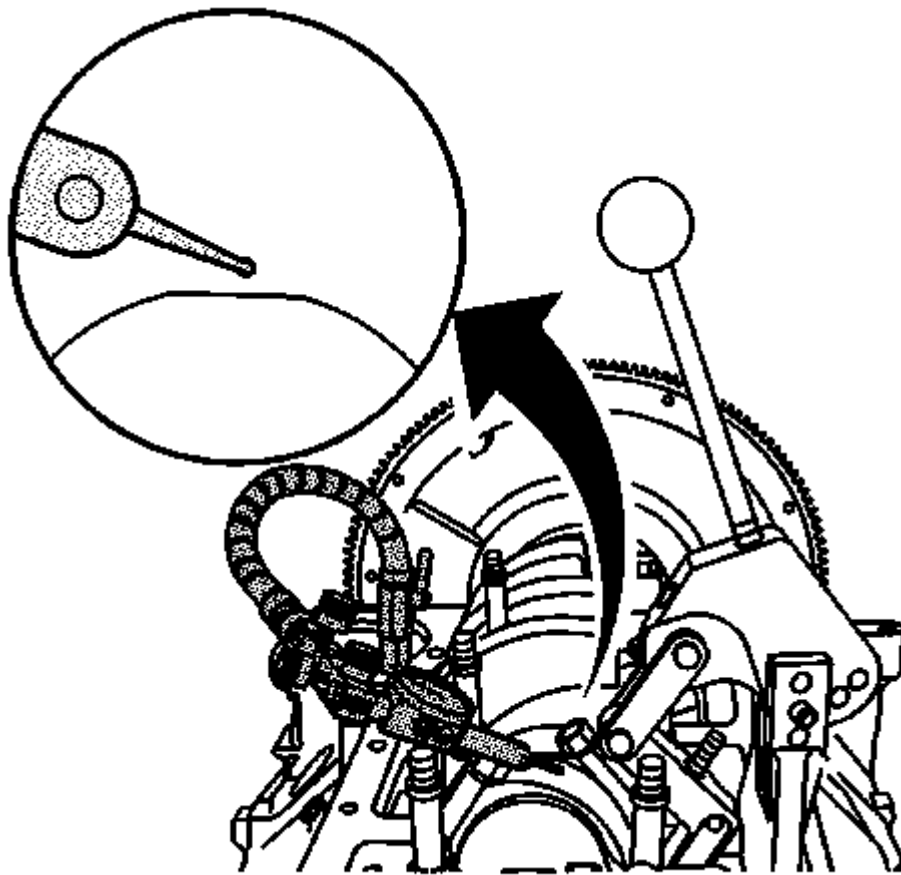


Fig. 346: Proper Indicator Positioning
Courtesy of GENERAL MOTORS CORP.

19. The tip of the indicator should be positioned above and NOT in contact with the cap end of the connecting rod.

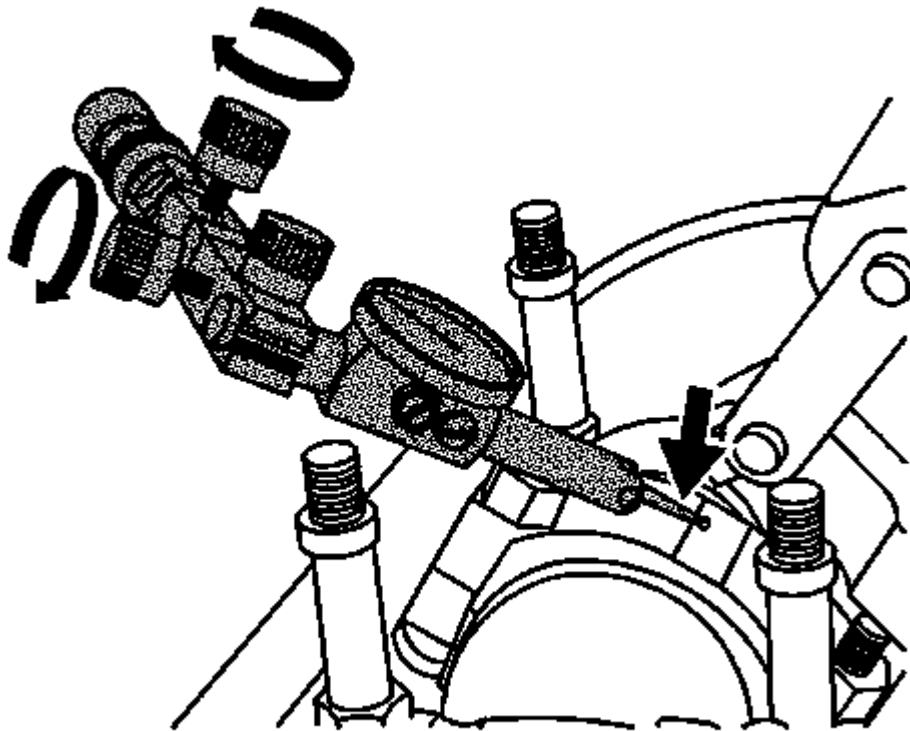


Fig. 347: Swivel Base Fine Adjustment Knobs
Courtesy of GENERAL MOTORS CORP.

20. Rotate the fine adjustment knobs on the dial indicator end of the swivel base to position the tip of the indicator in contact with the connecting rod.

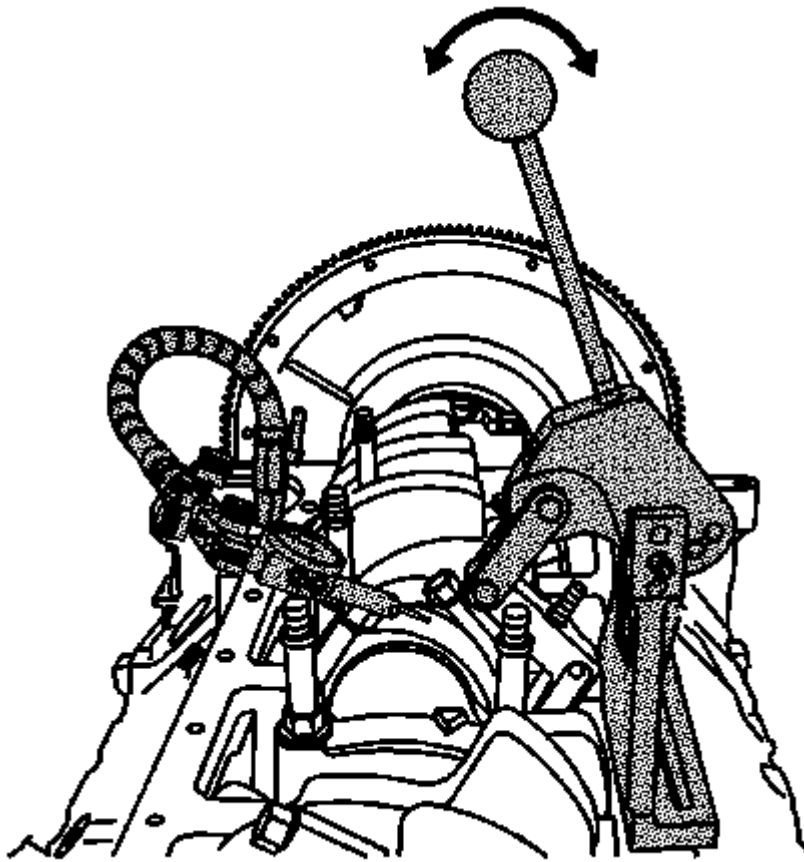


Fig. 348: Actuating Pivot Arm Assembly Handle
Courtesy of GENERAL MOTORS CORP.

21. Lightly actuate the handle of the pivot arm assembly, multiple times in both directions, to ensure the oil film is removed from the journal.

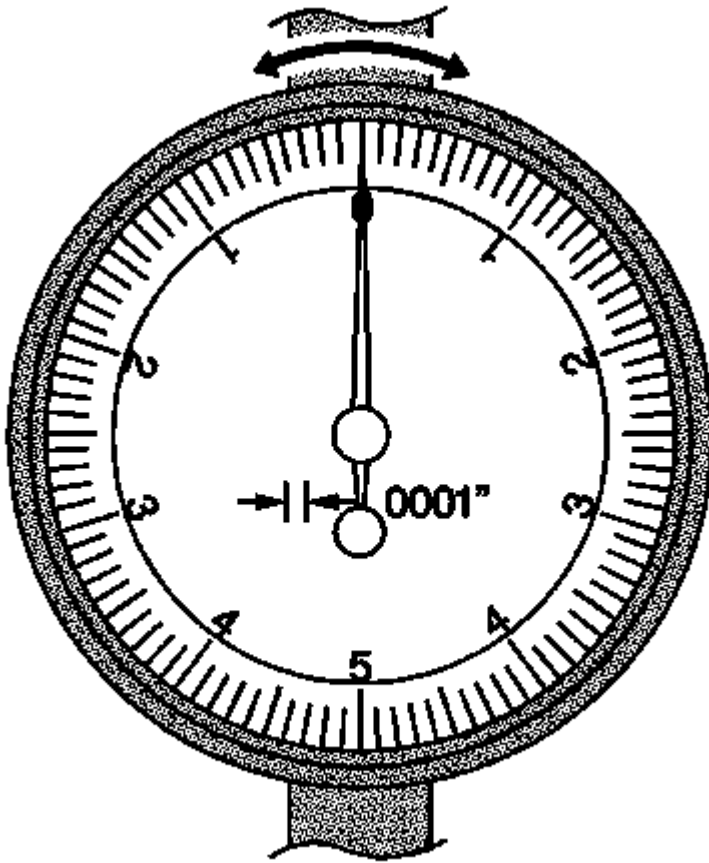


Fig. 349: Dial Indicator

Courtesy of GENERAL MOTORS CORP.

22. Load the handle in the forward position and zero the dial indicator. Load the handle multiple times in both directions and record the reading.

IMPORTANT: During this procedure, card stock may enter the crankshaft journal oil galleries. Be sure to remove all card stock from the bearing journal and oil galleries prior to reassembly.

23. Remove the bearing cap bolts, cap, and paper stock.
24. Replace bearing halves as required to obtain the proper bearing clearances.
25. Install the bearings, cap, and bolts. Refer to Fastener Tightening Specifications.

Measuring Crankshaft Bearing Clearances - Plastic Gage Method

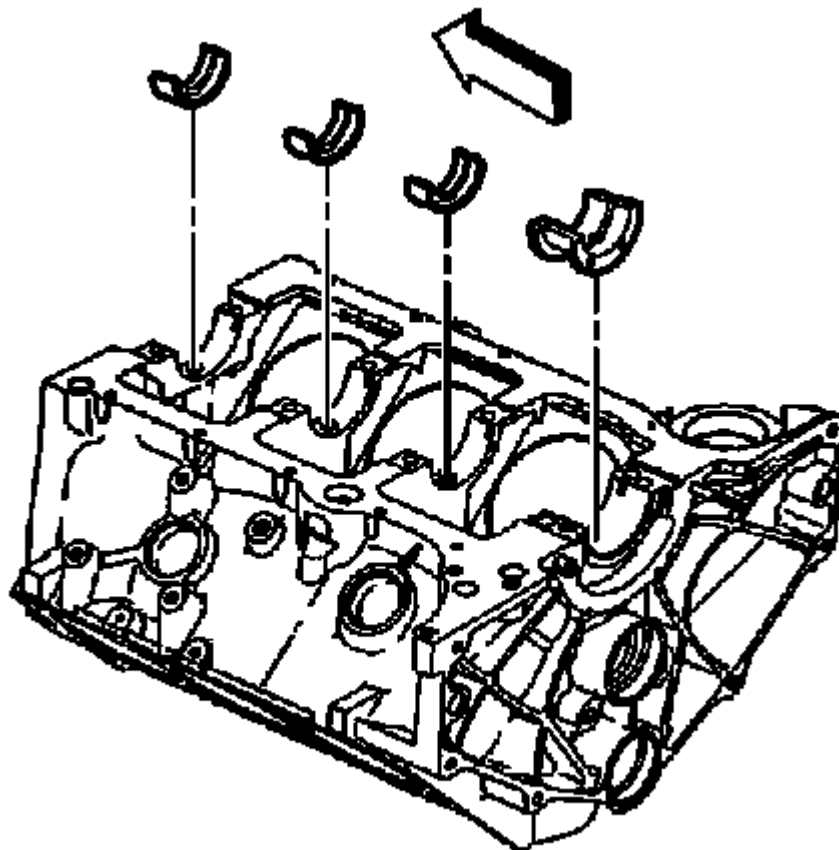


Fig. 350: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft bearings into the engine block.

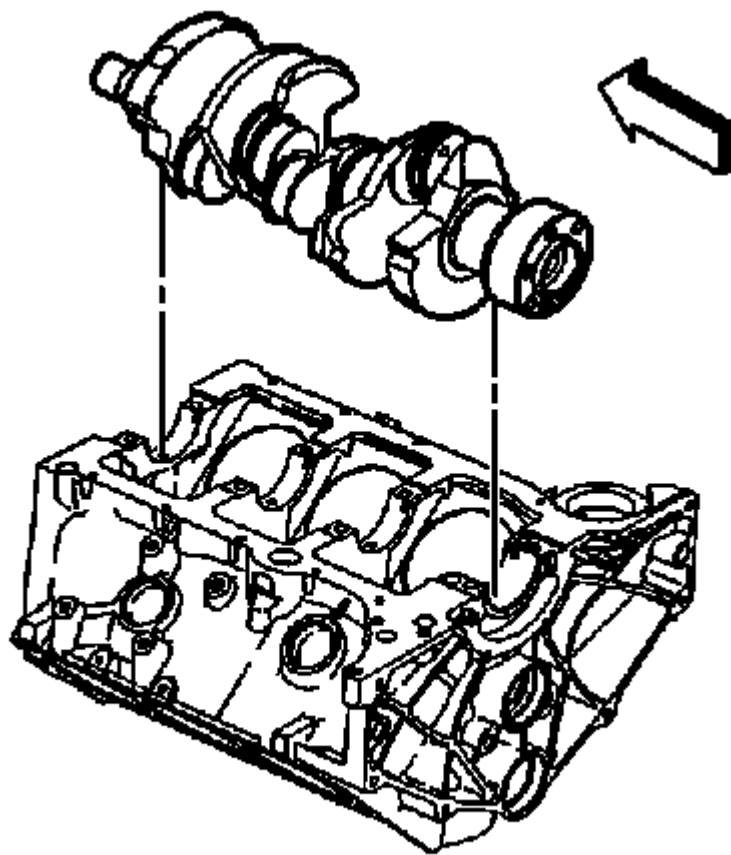


Fig. 351: Removing Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft.

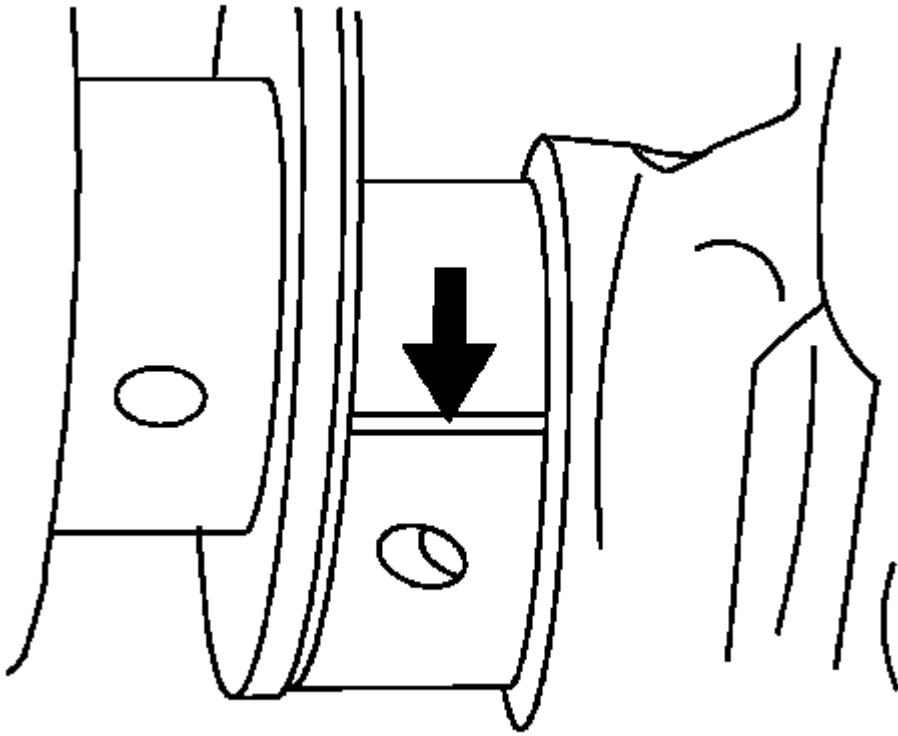


Fig. 352: Installing Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

3. Install the gaging plastic the full width of the journal.

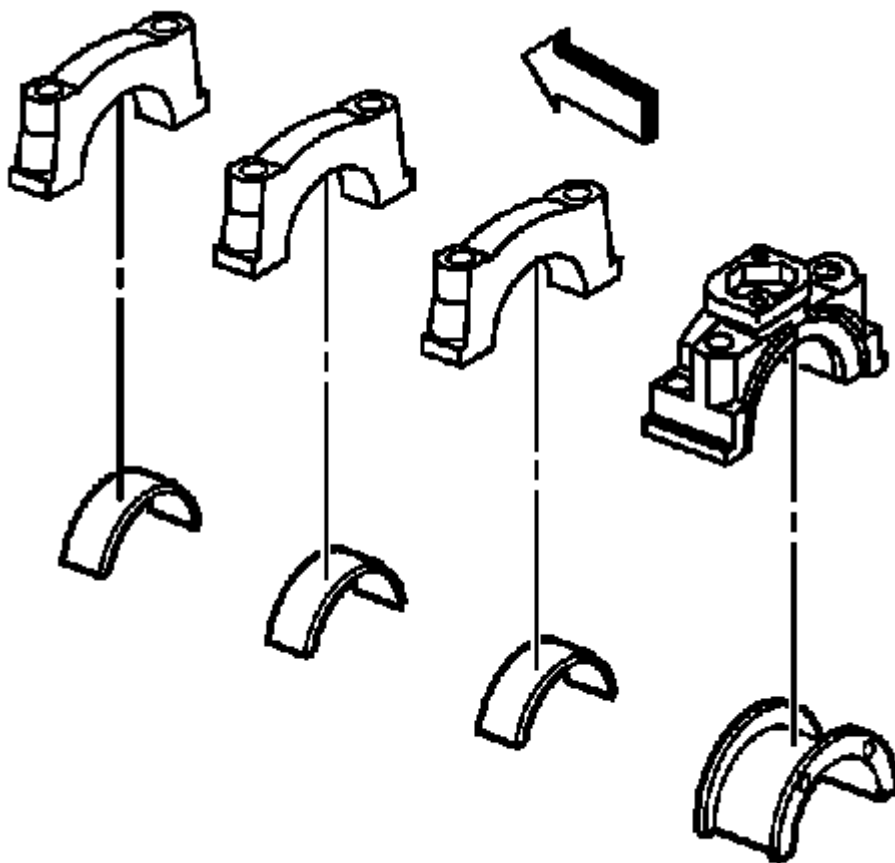


Fig. 353: Removing Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft bearings into the crankshaft bearing caps.

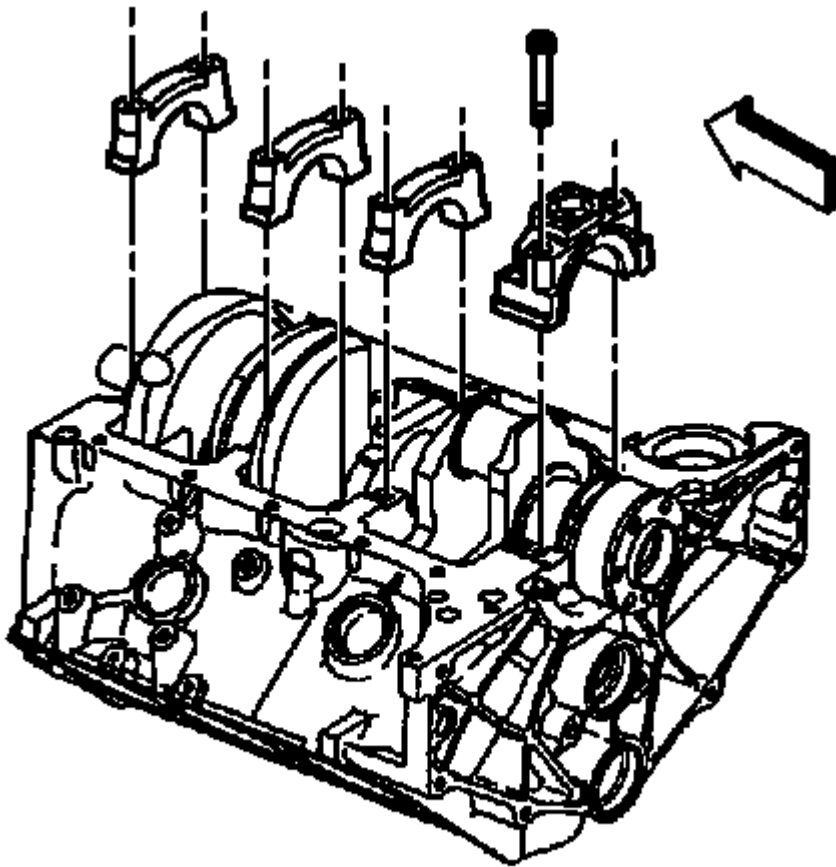


Fig. 354: Removing Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.

Tighten: Tighten the crankshaft bearing caps to 105 N.m (77 lb ft).

7. Remove the crankshaft bearing cap bolts.
8. Remove the crankshaft bearing caps. The gaging plastic may adhere to either the crankshaft bearing journal or the crankshaft bearing surface.

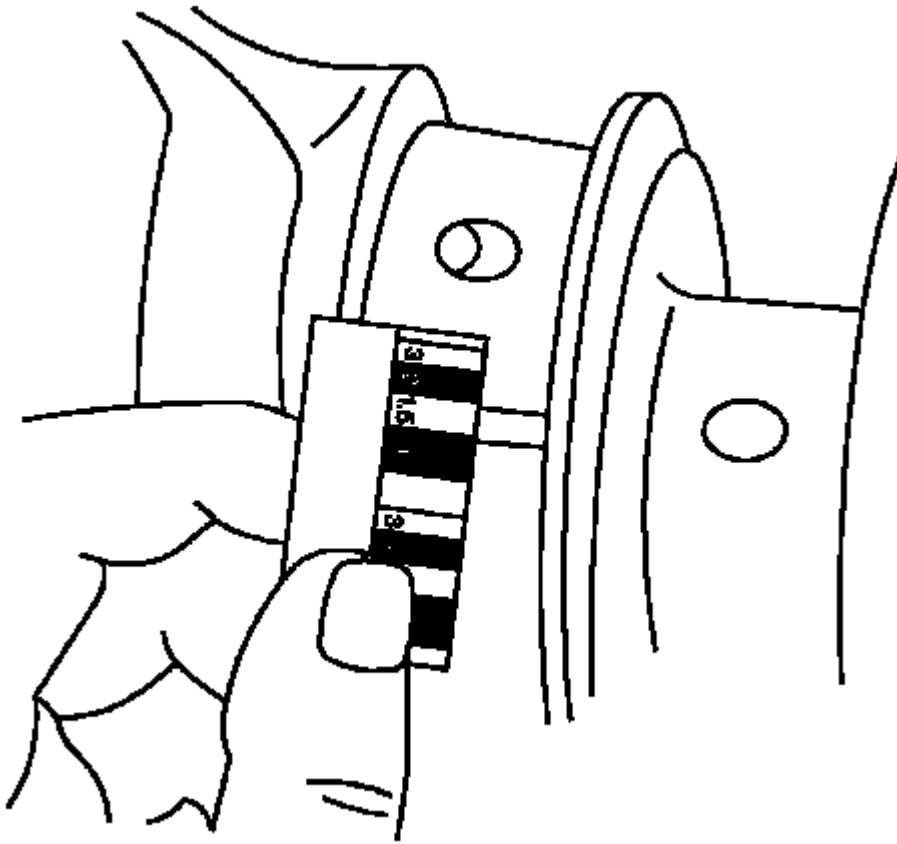


Fig. 355: Measuring Compressed Width
Courtesy of GENERAL MOTORS CORP.

9. Without removing the gaging plastic, measure the compressed width at the widest point using the graduated scale on the edge of the gaging plastic envelope.

If the flattened gaging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft bearing journal.

10. Remove the flattened gaging plastic.
11. Measure the remaining crankshaft bearing journals.

Measuring Connecting Rod Bearing Side Clearance

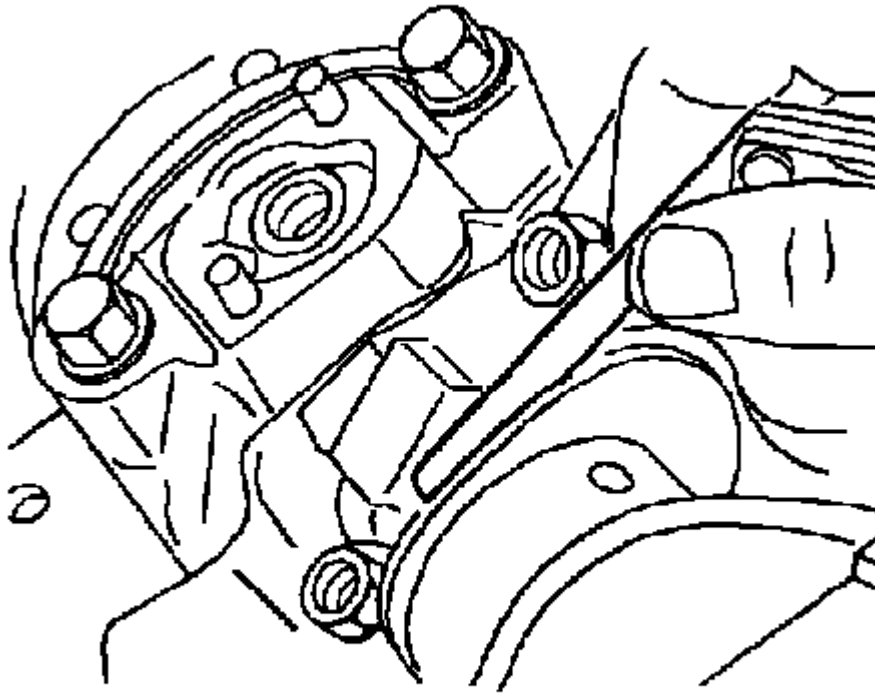


Fig. 356: Measuring Connecting Side Clearance
Courtesy of GENERAL MOTORS CORP.

1. Insert a feeler gage between the connecting rod caps and measure the connecting rod side clearance. The proper connecting rod side clearance specification is 0.15-0.44 mm (0.006-0.017 in).
2. Connecting rod side clearances may also be measured with a dial indicator set.

Crankshaft Balancer Cleaning and Inspection

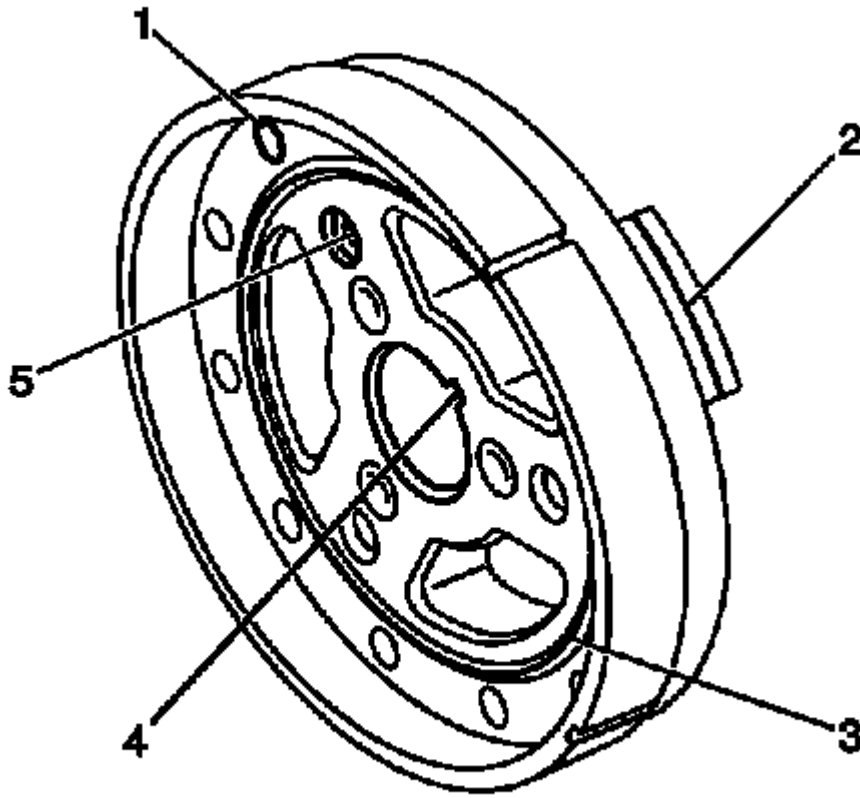


Fig. 357: Crankshaft Balancer Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the crankshaft balancer in cleaning solvent.
2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
 - Loose or improperly installed crankshaft balancer front groove pin (1)

A properly installed front groove pin should be installed until flush or below flush with the face of the crankshaft balancer.

IMPORTANT: A crankshaft front oil sealing surface with excessive scoring, grooves, rust, or other damage must be replaced.

- Worn, grooved, or damaged crankshaft front oil sealing surface (2)

Minor imperfections on the crankshaft balancer crankshaft front oil seal surface may be removed with a polishing compound or fine grade emery cloth.

- Worn, chunking, or deteriorated rubber (3) between the hub and the outer ring
- Worn or damaged keyway (4)
- Worn or damaged bolt hole threads (5)

Engine Flywheel Cleaning and Inspection

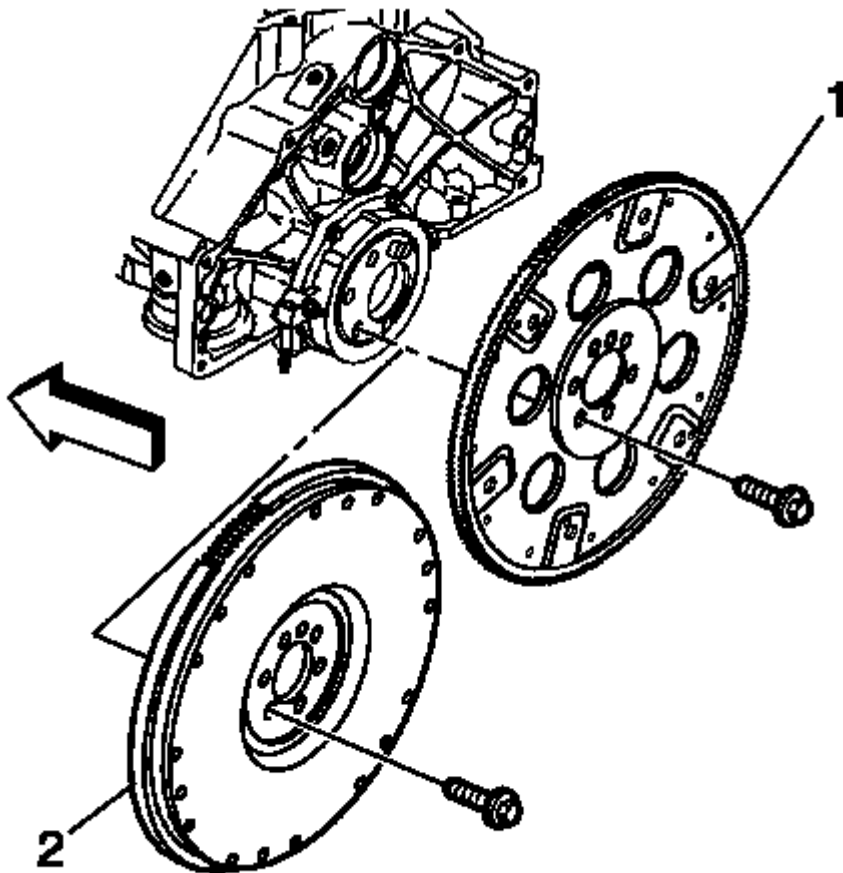


Fig. 358: Removing Flywheel

Courtesy of GENERAL MOTORS CORP.

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

1. Clean the engine flywheel (1 or 2) in cleaning solvent.
2. Dry the engine flywheel with compressed air.

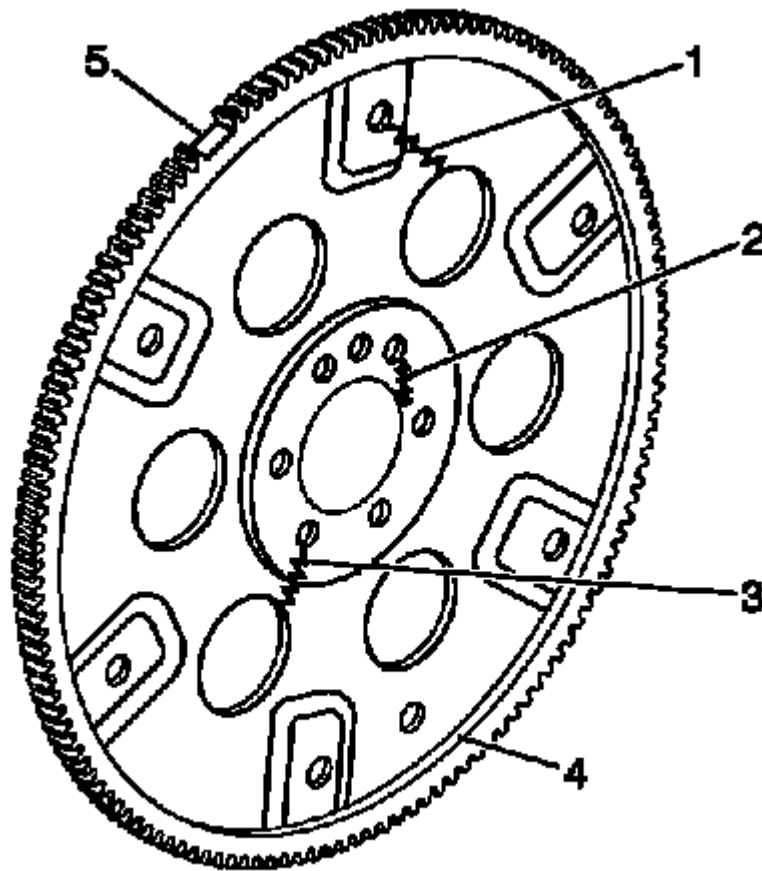


Fig. 359: Flywheel Inspection Areas (Automatic Transmission)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to repair the welded areas, if present, that retain the ring gear to the engine flywheel plate. Always install a **NEW** engine flywheel.

3. Inspect the engine flywheel, automatic transmission, if equipped, for the following:
 - Stress cracks around the engine flywheel-to-torque converter bolt hole locations (1)
 - Missing balance weights
 - Stress cracks around the engine flywheel-to-crankshaft bolt hole locations (2 or 3)
 - Welded areas that retain the ring gear onto the engine flywheel for cracking (4), if present
 - Damaged ring gear teeth (5)

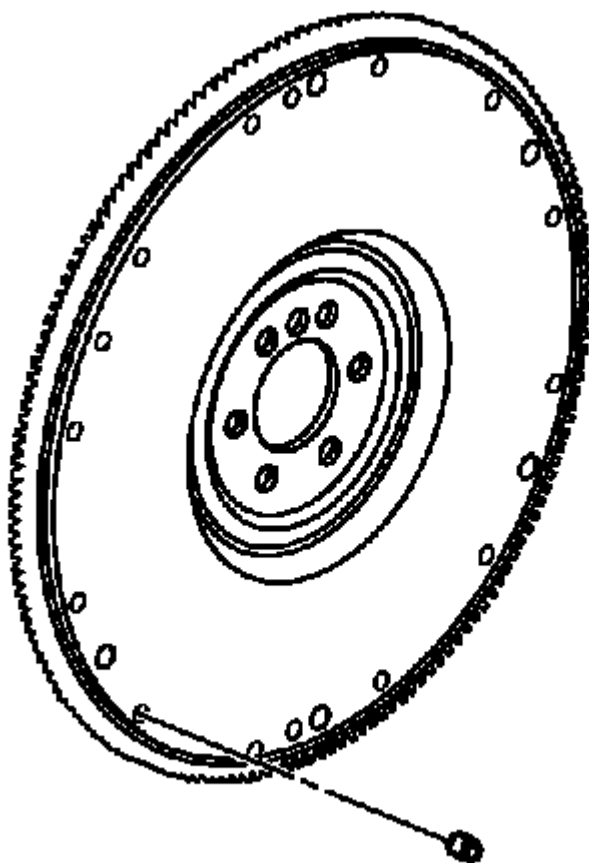


Fig. 360: Locating Flywheel Weights (Manual Transmission)
Courtesy of GENERAL MOTORS CORP.

4. Inspect the engine flywheel, manual transmission, if equipped, for loose or improperly installed flywheel weights, if applicable.

A properly installed flywheel weight should be installed until flush or below flush with the face of the engine flywheel.

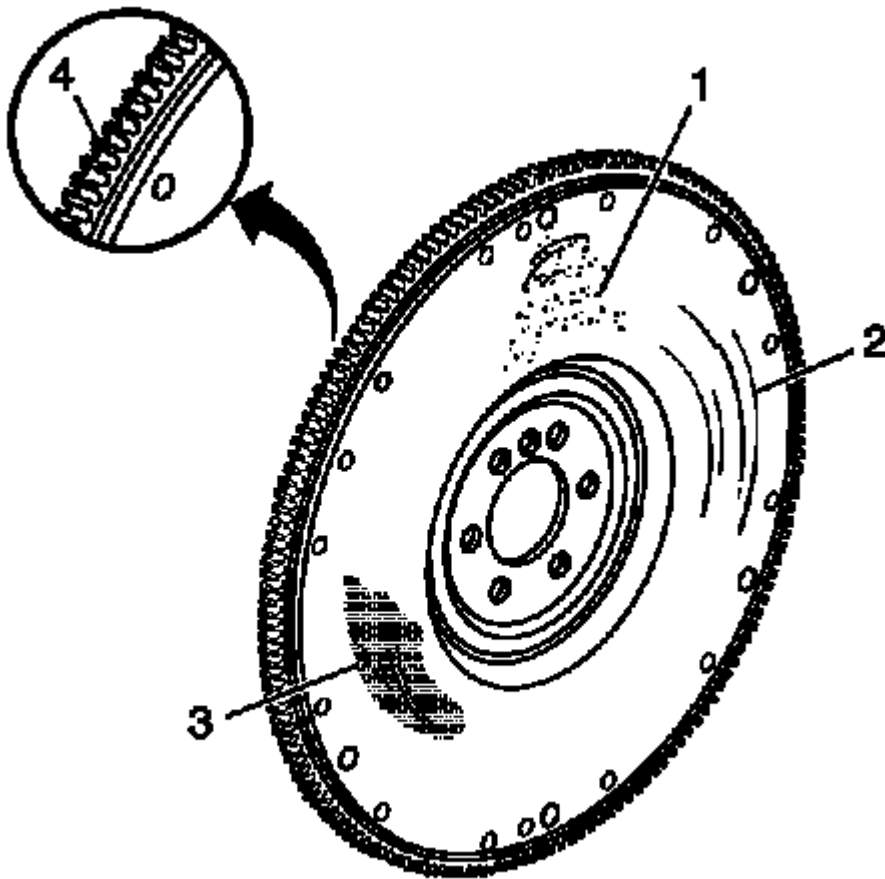


Fig. 361: Flywheel Inspection Areas (Manual Transmission)
Courtesy of GENERAL MOTORS CORP.

5. Inspect the engine flywheel, manual transmission, if equipped, for the following:

- Pitted friction surface (1)
- Scoring or grooves (2)
- Rust or other surface damage (3)
- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the engine flywheel and the ring gear should be positioned completely flat against the flange of the engine flywheel.

Camshaft and Bearings Cleaning and Inspection

Tools Required

J 7872 Magnetic Base Dial Indicator

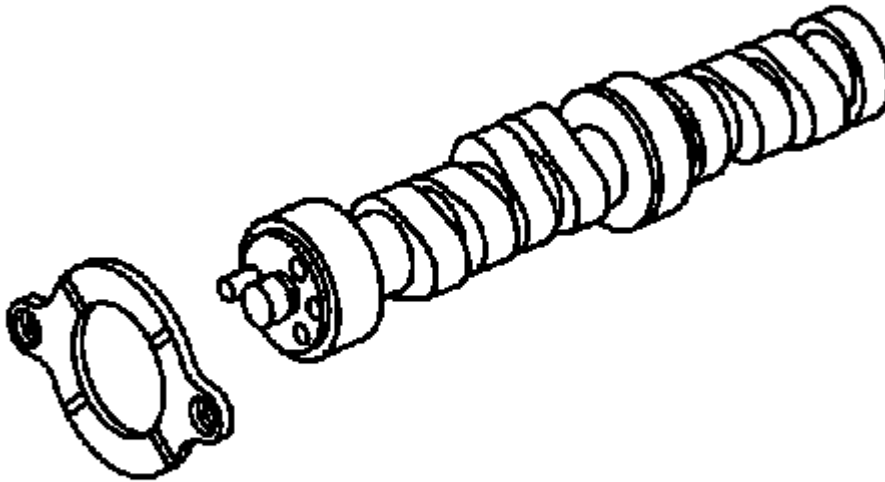


Fig. 362: Camshaft & Retainer Plate
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the engine camshaft in cleaning solvent.
2. Dry the engine camshaft with compressed air.
3. Inspect the camshaft retainer plate for damage.

If the camshaft retainer plate is damaged, replace as necessary.

4. Inspect the camshaft bearings for correct fit into the engine block camshaft bearing bores.

The camshaft bearings have an interference fit to the engine block camshaft bearing bores and must not be loose in the engine block camshaft bearing bores.

IMPORTANT: If any camshaft bearing is excessively worn or scored, replace all the camshaft bearings.

5. Inspect the camshaft bearings for excessive wear or scoring.

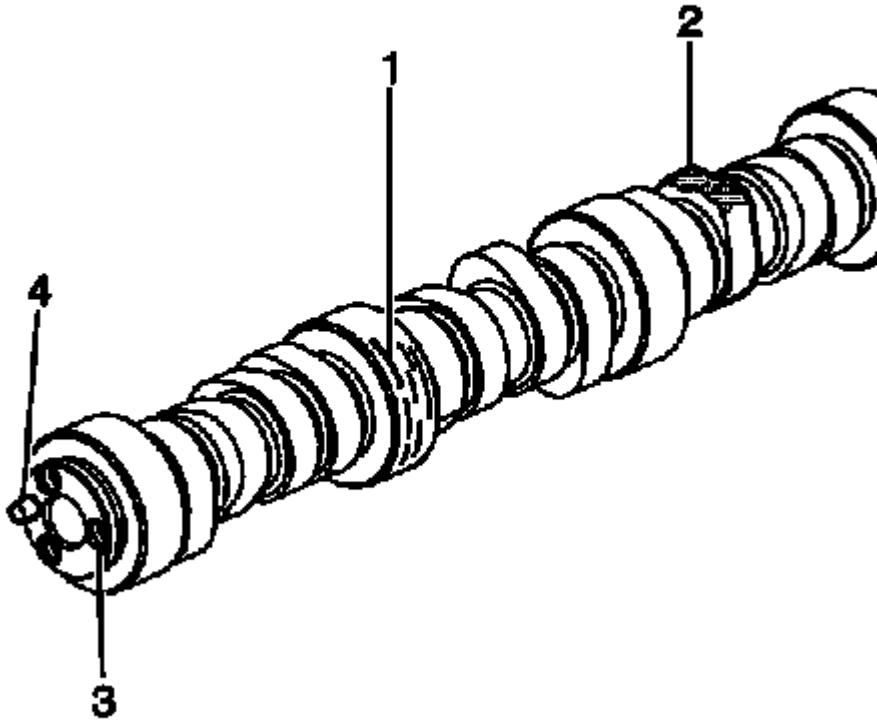


Fig. 363: Camshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

6. Inspect the engine camshaft for the following:
- Worn, scored, or damaged bearing journals (1)
 - Worn engine camshaft lobes (2)
 - Damaged bolt hole threads (3)
 - Damaged camshaft sprocket locator pin (4)

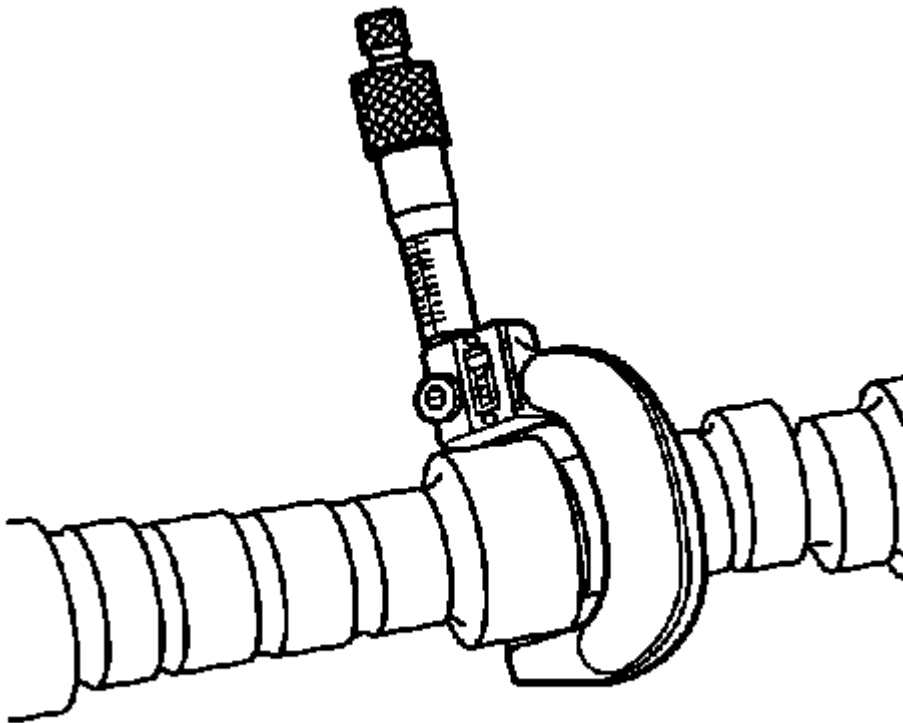


Fig. 364: Measuring Engine Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

7. Measure the engine camshaft journals with a micrometer.

If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.

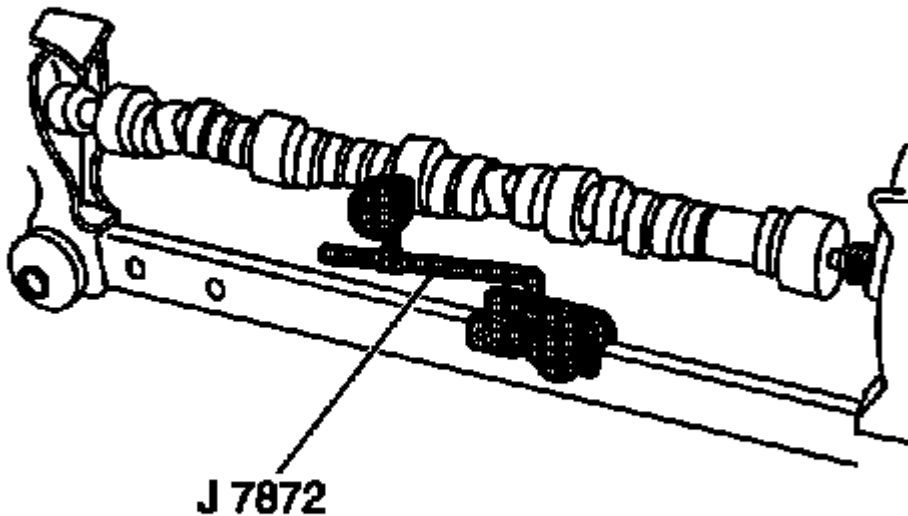


Fig. 365: Measuring The Engine Camshaft Lobe Lift Using 7872
Courtesy of GENERAL MOTORS CORP.

8. Measure for a bent engine camshaft or excessive engine camshaft runout using the **J 7872** .
 1. Mount the engine camshaft in a suitable stand between centers.
 2. Use the **J 7872** in order to check the intermediate engine camshaft journals.

If the runout exceeds 0.065 mm (0.0026 in), the engine camshaft is bent and must be replaced.

9. Measure the engine camshaft lobe lift using the **J 7872** .
 1. Place the engine camshaft on the V-blocks.
 2. Use the **J 7872** in order to measure the engine camshaft lobe lift.
10. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications. Refer to **Engine Mechanical Specifications**.

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Kit. See Special Tools.

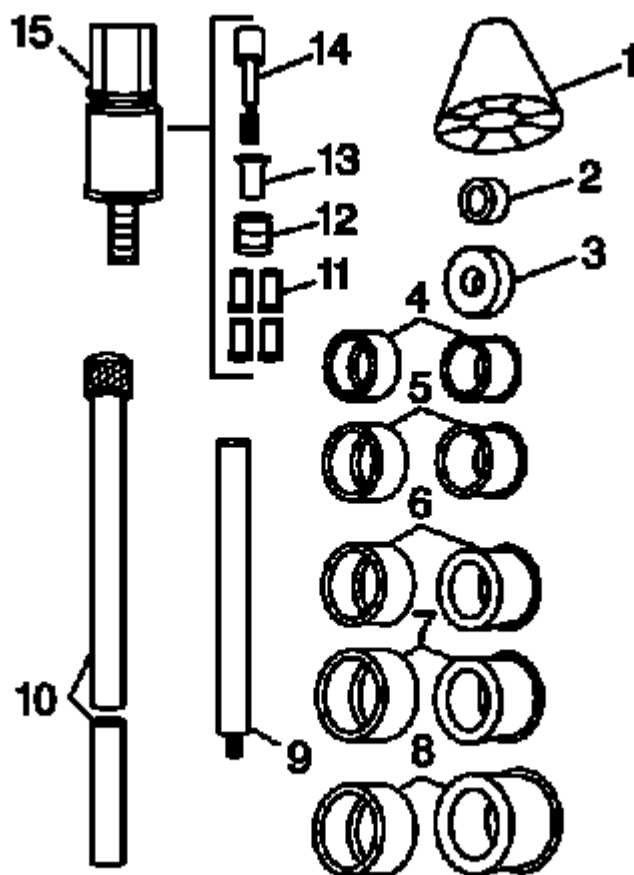


Fig. 366: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

1. Select the cone (1), the handle (10), the expanding driver (4-8), the washer (2 or 3), and the expander assembly (15) from the **J 33049** . See Special Tools.
2. Assemble the **J 33049** . See Special Tools.

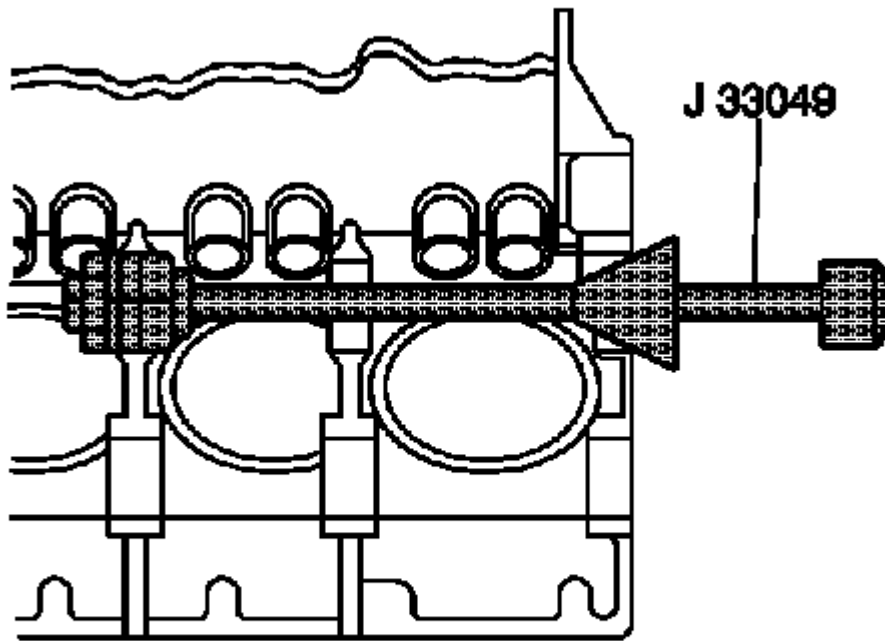


Fig. 367: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block camshaft bearing bore.
- Always remove the camshaft inner bearings #2 and #3 first. The camshaft outer bearings #1 and #4 serve as a guide for the J 33049 . See Special Tools.

3. Remove the camshaft inner bearings #2 and #3.

1. Insert the **J 33049** through the front of the engine block and into the camshaft inner bearing #2. See Special Tools.
2. Tighten the **J 33049** expander assembly nut until snug. See Special Tools.
3. Push the **J 33049** guide cone into the camshaft front bearing in order to align the **J 33049** . See Special Tools.

4. Drive the camshaft inner bearing #2 from the camshaft inner bearing bore #2.
5. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
6. Remove the camshaft inner bearing #2 from the **J 33049** expander assembly. See **Special Tools**.
7. Insert the **J 33049** expander assembly into the camshaft inner bearing #3. See **Special Tools**.
8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
9. Push the **J 33049** guide cone into the camshaft front bearing in order to align the **J 33049** . See **Special Tools**.
10. Drive the camshaft inner bearing #3 from the camshaft inner bearing bore #3.
11. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
12. Remove the camshaft inner bearing #3 from the **J 33049** expander assembly. See **Special Tools**.
4. Remove the **J 33049** from the engine block. See **Special Tools**.
5. Remove the camshaft outer bearings #1 and #4.
 1. Insert the **J 33049** into the camshaft outer bearing #1. See **Special Tools**.
 2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
 3. Drive the camshaft outer bearing #1 from the camshaft outer bearing bore #1.
 4. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
 5. Remove the camshaft outer bearing #1 from the **J 33049** expander assembly. See **Special Tools**.
 6. Remove the **J 33049** from the engine block. See **Special Tools**.
 7. Insert the **J 33049** into the camshaft outer bearing #4. See **Special Tools**.
 8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
 9. Drive the camshaft outer bearing #4 from the camshaft outer bearing bore #4.
 10. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
 11. Remove the camshaft outer bearing #4 from the **J 33049** expander assembly. See **Special Tools**.
6. Remove the **J 33049** from the engine block. See **Special Tools**.
7. Discard the camshaft bearings.

Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Service Kit. See **Special Tools**.

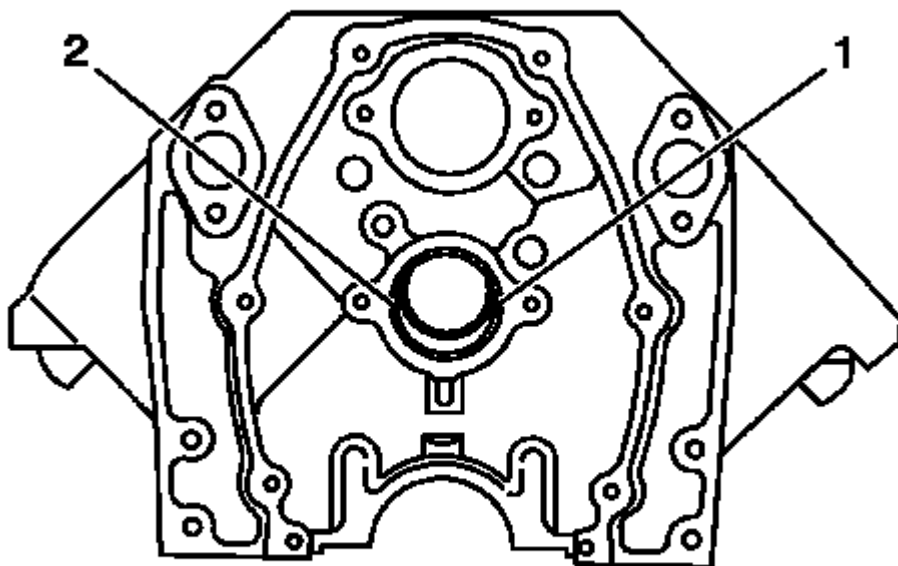


Fig. 368: Locating Camshaft Bearing Lubrication Hole At 3 & 9 O'clock Positions
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing the camshaft bearings, always look in order to ensure that the camshaft bearing lubrication hole is located above the 3 o'clock position (1) or the 9 o'clock position (2). The proper positioning of the camshaft bearing lubrication hole is in order to ensure the best lubrication of the engine camshaft journals.

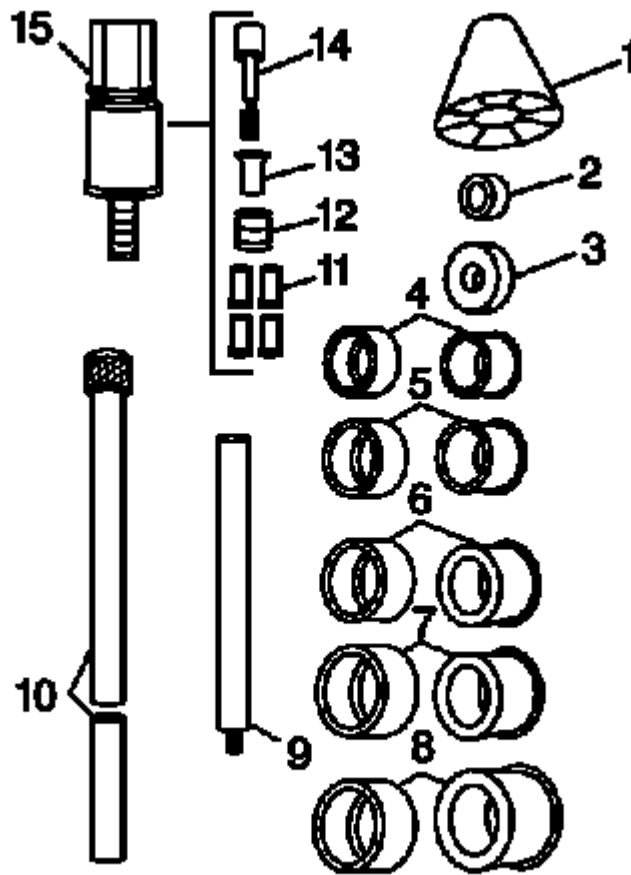


Fig. 369: View Of J 33049 Camshaft Bearing Service Kit Components
 Courtesy of GENERAL MOTORS CORP.

1. Assemble the **J 33049** handle (10), the expanding driver (4-8), the washer (2 or 3), and the expander assembly (15). See **Special Tools**.

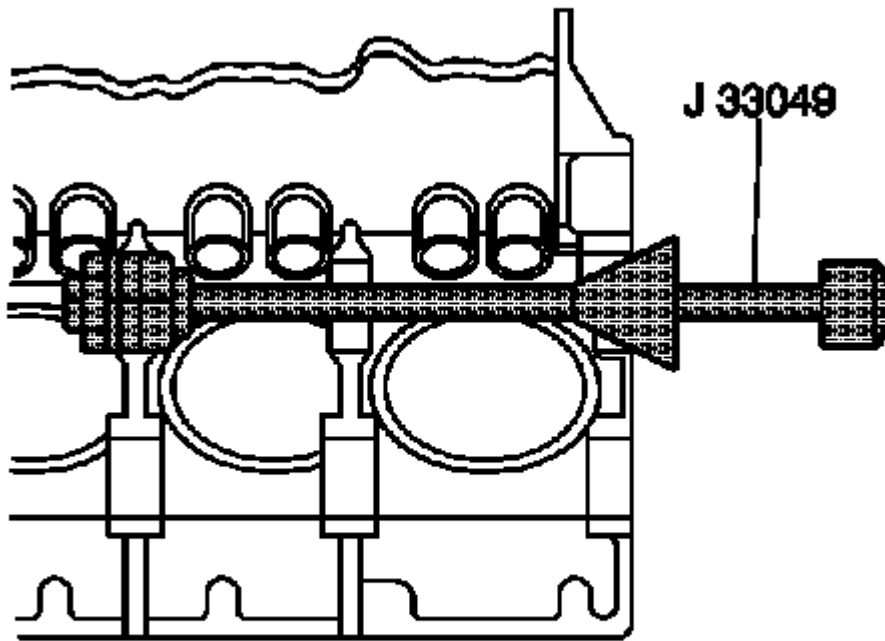


Fig. 370: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: The camshaft bearings vary in size. When ordering the new camshaft bearings, be sure to order the correct camshaft bearings for the application to be serviced.
Always install the camshaft outer bearings #1 and #4 first. The camshaft outer bearings serve as a guide for the J 33049 and help center the camshaft inner bearings during the installation process. See Special Tools.

2. Install the NEW camshaft outer bearings #4 and #1.
 1. Install the NEW camshaft outer bearing #4 onto the J 33049 expander assembly. See Special Tools.
 2. Tighten the J 33049 expander assembly nut until snug. See Special Tools.
 3. Align the lubrication hole of the camshaft outer bearing #4 above the 3 o'clock position or the 9

- o'clock position of the camshaft outer bearing bore #4 at the rear of the engine block.
4. Drive the camshaft outer bearing #4 into the camshaft outer bearing bore #4 at the rear of the engine block.
 5. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
 6. Remove the camshaft outer bearing #4 from the **J 33049** expander assembly. See **Special Tools**.
 7. Install the NEW camshaft outer bearing #1 onto the **J 33049** expander assembly. See **Special Tools**.
 8. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
 9. Align the lubrication hole of the camshaft outer bearing #1 above the 3 o'clock position or the 9 o'clock position of the camshaft outer bearing bore #1 at the front of the engine block.
 10. Drive the camshaft outer bearing #1 into the camshaft outer bearing bore #1 at the front of the engine block.
 11. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
 12. Carefully slide the **J 33049** into the engine block until the **J 33049** expander assembly is positioned between the camshaft inner bearing bores. See **Special Tools**.
3. Install the NEW camshaft inner bearings #3 and #2.
1. Install the NEW camshaft inner bearing #3 onto the **J 33049** expander assembly. See **Special Tools**.
 2. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
 3. Align the lubrication hole of the camshaft inner bearing #3 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #3 of the engine block.
 4. Push the **J 33049** guide cone into the camshaft front bearing bore #1 in order to align the **J 33049** . See **Special Tools**.
 5. Drive the camshaft inner bearing #3 into the camshaft inner bearing bore #3.
 6. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
 7. Carefully slide the **J 33049** until the **J 33049** expander assembly is positioned between the camshaft inner bearing bore #2 and the camshaft outer bearing bore #1. See **Special Tools**.
 8. Install the NEW camshaft inner bearing #2 onto the **J 33049** expander assembly. See **Special Tools**.
 9. Tighten the **J 33049** expander assembly nut until snug. See **Special Tools**.
 10. Align the lubrication hole of the camshaft inner bearing #2 above the 3 o'clock position or the 9 o'clock position of the camshaft inner bearing bore #2 of the engine block.
 11. Push the **J 33049** guide cone into the camshaft front bearing bore #1 in order to align the **J 33049** . See **Special Tools**.
 12. Drive the camshaft inner bearing #2 into the camshaft inner bearing bore #2.
 13. Loosen the **J 33049** expander assembly nut. See **Special Tools**.
4. Carefully remove the **J 33049** from the engine block. See **Special Tools**.

Balance Shaft Bearing and/or Bushing Removal

Tools Required

- **J 26941** Bushing/Bearing Remover. See Special Tools.
- **J 38834** Balance Shaft Service Kit. See Special Tools.

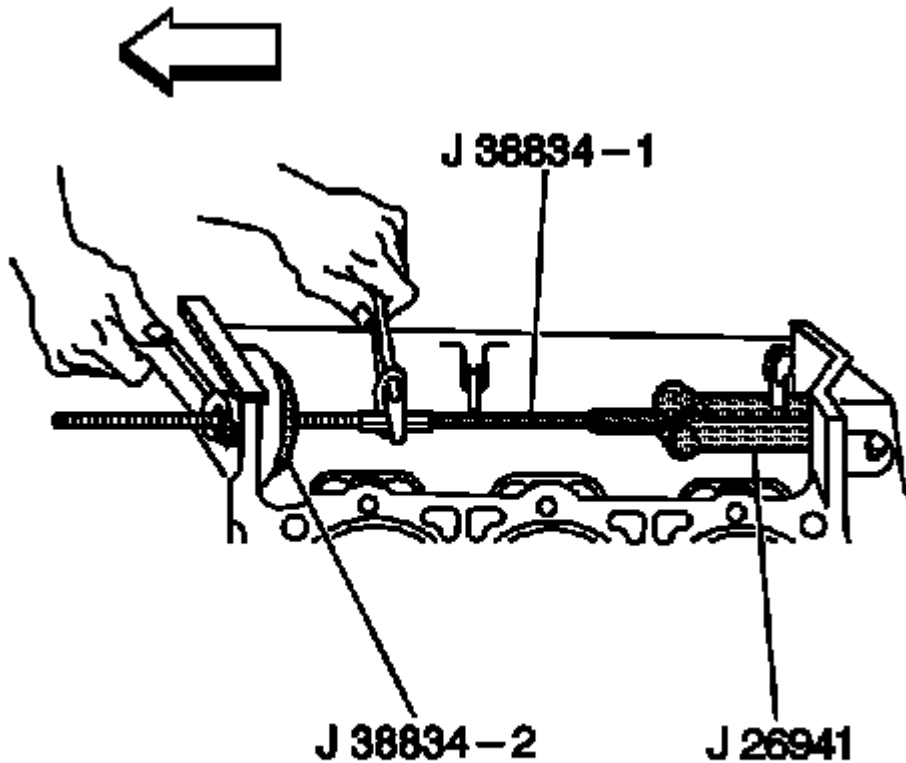


Fig. 371: Removing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

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

1. Use the **J 38834** and the **J 26941** in order to remove the balance shaft rear bearing. See Special Tools.
 1. Install **J 26941** legs behind the balance shaft rear bearing and secure. See Special Tools.
 2. Install the **J 38834-1** with the short threaded end through the balance shaft bore in the front of the engine block.
 3. Install the **J 38834-1** into **J 26941** . See Special Tools.
 4. Slide the **J 38834-2** onto the **J 38834-1** and into the balance shaft bore of the engine block.
 5. Install the **J 38834** bearing, washer, and nut onto the **J 38834-1**. See Special Tools.
 6. Using a wrench secure the **J 38834-1** and then rotate the **J 38834** nut clockwise until the balance shaft rear bearing is removed from the engine block. See Special Tools.

7. Remove the **J 26941** from the balance shaft rear bearing. See **Special Tools**.
2. Discard the balance shaft rear bearing.

Balance Shaft Cleaning and Inspection

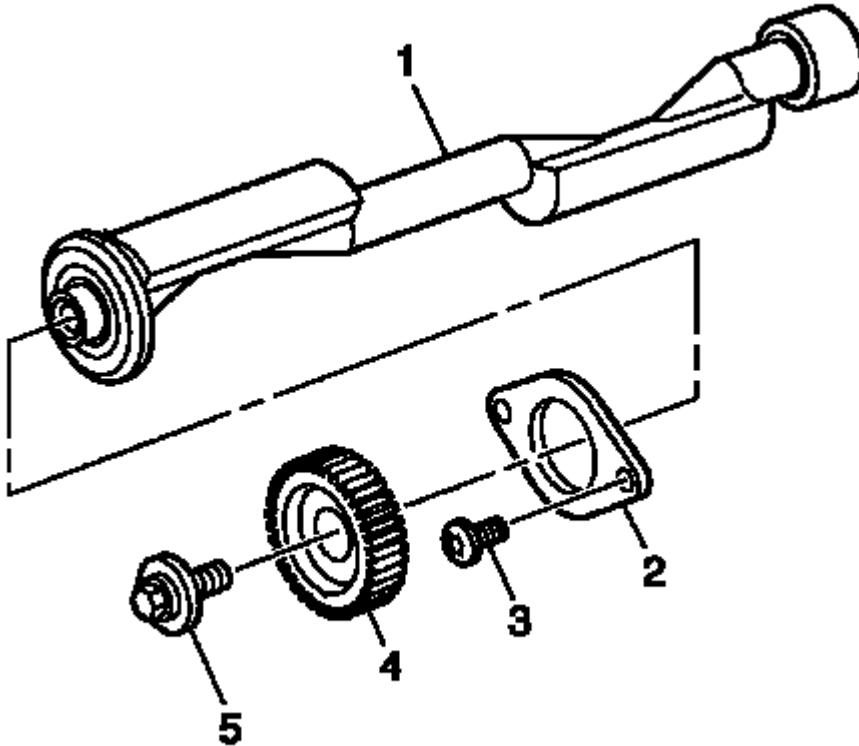


Fig. 372: Balance Shaft Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as an assembly. Do not remove the balance shaft front bearing from the balance shaft.

1. Clean the following components in cleaning solvent:
 - The balance shaft (1)
 - The balance shaft retainer (2)
 - The balance shaft rear bearing
 - The balance shaft driven gear (4)

- The balance shaft drive gear
2. Dry the following components with compressed air:
 - The balance shaft (1)
 - The balance shaft retainer (2)
 - The balance shaft rear bearing
 - The balance shaft driven gear (4)
 - The balance shaft drive gear
 3. Inspect the balance shaft bearings for the following:
 - Front ball bearing for damage or wear
 - Front ball bearing for smoothness of operation
 - Rear sleeve bearing for wear, scoring, or other damage
 4. Inspect the balance shaft (1) for the following:
 - Wear or scoring on the rear bearing journal
 - Damaged bolt hole threads
 - Damage to the balance shaft driven gear locator pin
 5. Inspect the balance shaft retainer (2) for wear or damage.
 6. Inspect the balance shaft retainer bolts (3) for damaged threads.
 7. Inspect the driven gear (4) for the following:
 - Excessive wear or damage
 - Nicks, burrs, or scoring
 8. Inspect the driven gear bolt (5) for damaged threads.

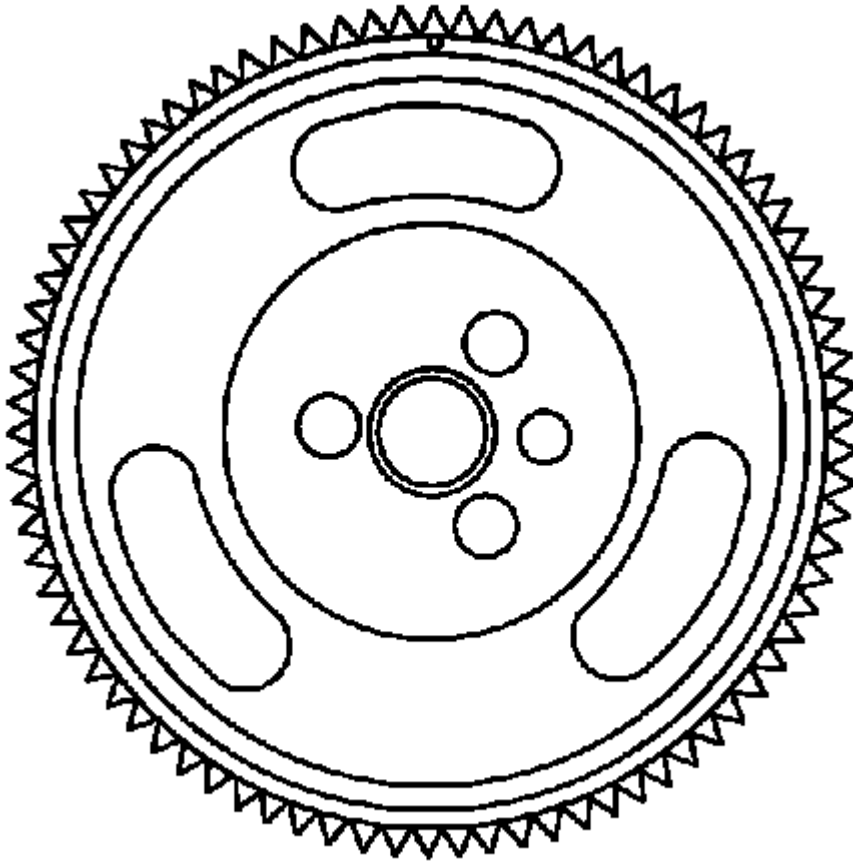


Fig. 373: Balance Shaft Drive Gear Camshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

9. Inspect the balance shaft drive gear for the following:
 - Excessive wear or damage
 - Nicks, burrs, or scoring

Balance Shaft Bearing and/or Bushing Installation

Tools Required

J 38834 Balance Shaft Service Kit. See **Special Tools**.

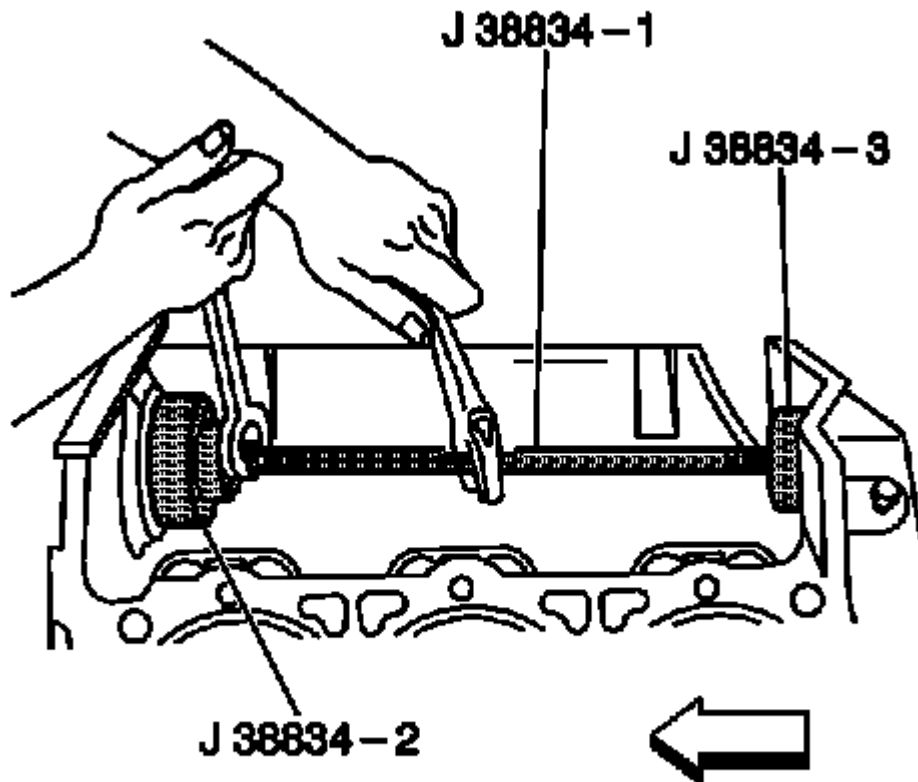


Fig. 374: Installing Balance Shaft Rear Bearing
Courtesy of GENERAL MOTORS CORP.

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

1. Use the **J 38834** in order to install the balance shaft rear bearing. See **Special Tools**.
 1. Install the J 38834-3 onto the short threaded end of the J 38834-1.
 2. Install the **J 38834** nut, the washer, and the bearing on the long threaded end of the J 38834-1. See **Special Tools**.
 3. Install the J 38834-2 onto the J 38834-1 so that the smaller diameter of the J 38834-2 will be facing the front of the engine block.
 4. Install the J 38834-2 on the inside of the balance shaft front bearing bore.
 5. Lubricate the NEW balance shaft rear bearing with clean engine oil.
 6. Install the balance shaft rear bearing onto the J 38834-2.
 7. Align the balance shaft rear bearing for installation.
 8. Using a wrench secure the J 38834-1 into place.
 9. Rotate the **J 38834** nut until the balance shaft rear bearing is properly and completely pushed into

the balance shaft rear bearing bore. See **Special Tools**.

2. Remove the **J 38834** . See **Special Tools**.

Timing Chain and Sprockets Cleaning and Inspection

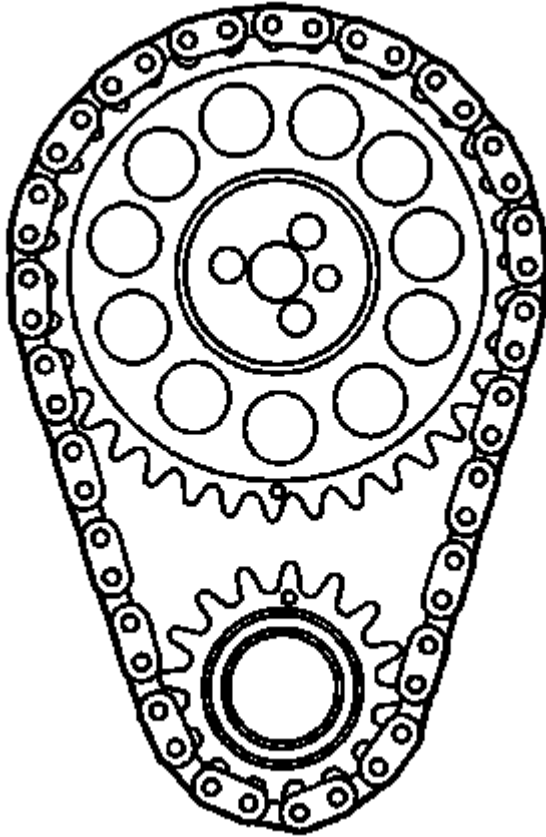


Fig. 375: View Of Camshaft & Crankshaft Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

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

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

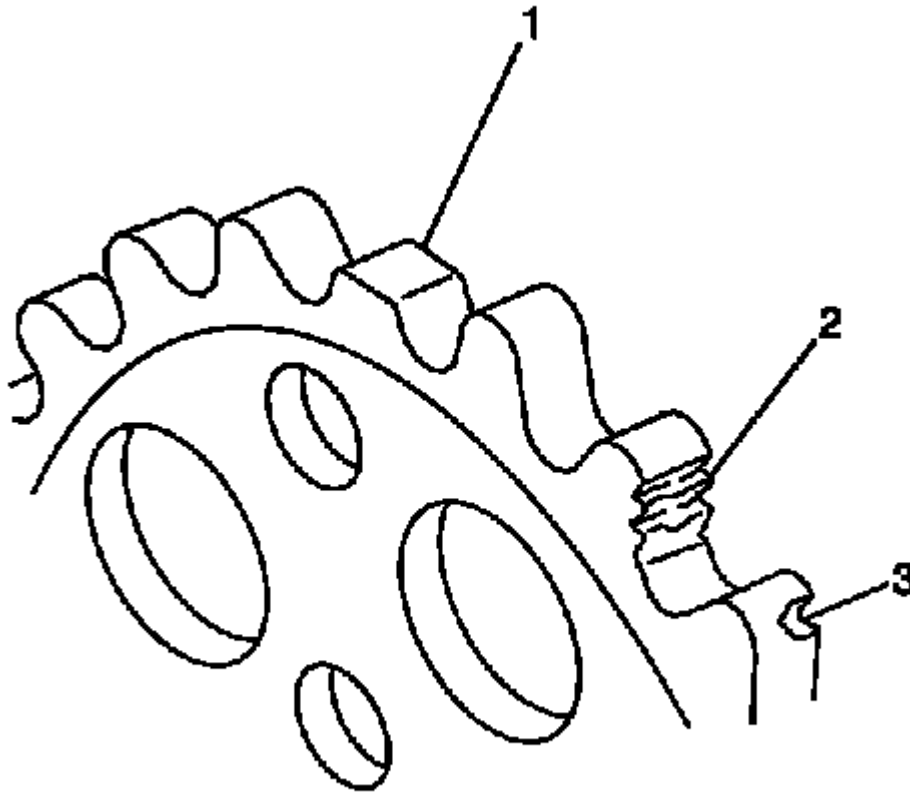


Fig. 376: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft sprocket and the crankshaft sprocket for:
 - Broken teeth (1)
 - Damaged teeth (2)
 - Chipped teeth (3)
 - Worn teeth
 - Uneven wear on the edge of the teeth
 - Worn valleys between the sprocket teeth
 - Crankshaft sprocket keyway for wear
5. Inspect the timing chain tensioner bracket and shoe for cracking and wear.

Valve Rocker Arm and Push Rods Cleaning and Inspection

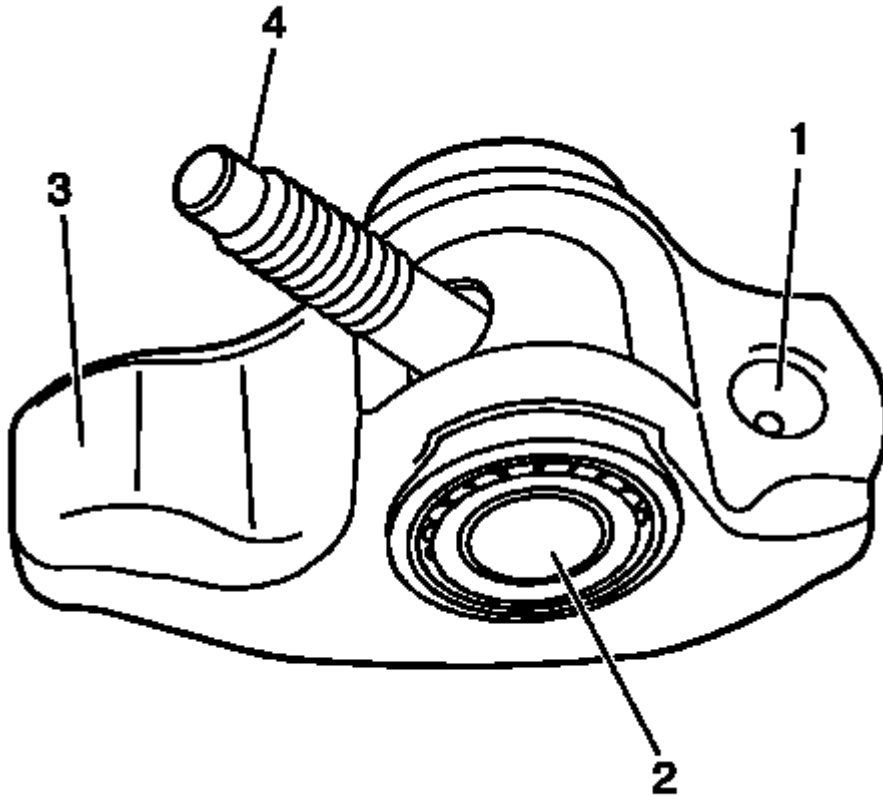


Fig. 377: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Parts that are to be reused must be marked, sorted, and organized for assembly.

1. Mark, sort, and organize the components for assembly.

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

2. Clean the components with cleaning solvent.
3. Dry the components with compressed air.
4. Inspect the valve rocker arm 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.

- Valve rocker arm bolt threads for damage (4)

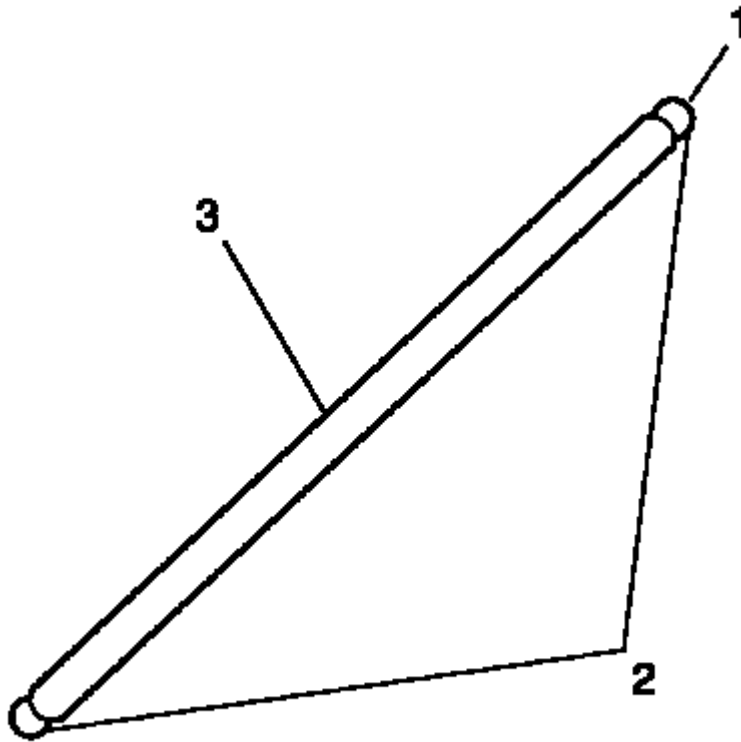


Fig. 378: Pushrod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. 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.

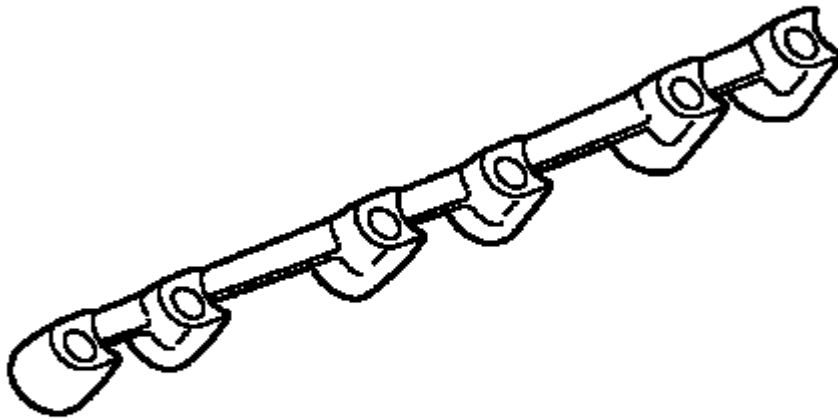


Fig. 379: Valve Rocker Support
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve rocker support for excessive wear or damage.

Valve Lifters and Guides Cleaning and Inspection

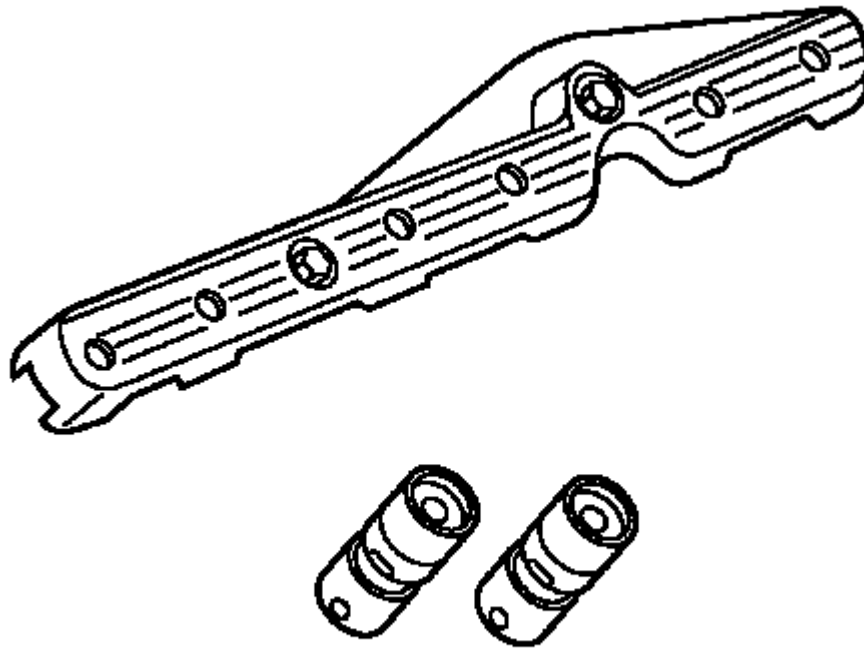


Fig. 380: Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Mark, sort, and organize the components for assembly.

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

2. Clean the components in cleaning solvent.
3. Dry the components with compressed air.

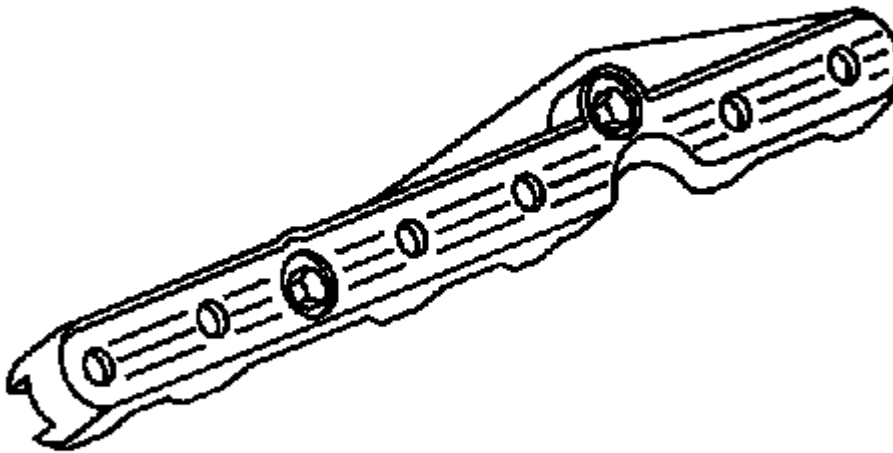


Fig. 381: Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter pushrod guides for excessive wear.
5. Inspect the valve lifter pushrod guides for cracks or damage.

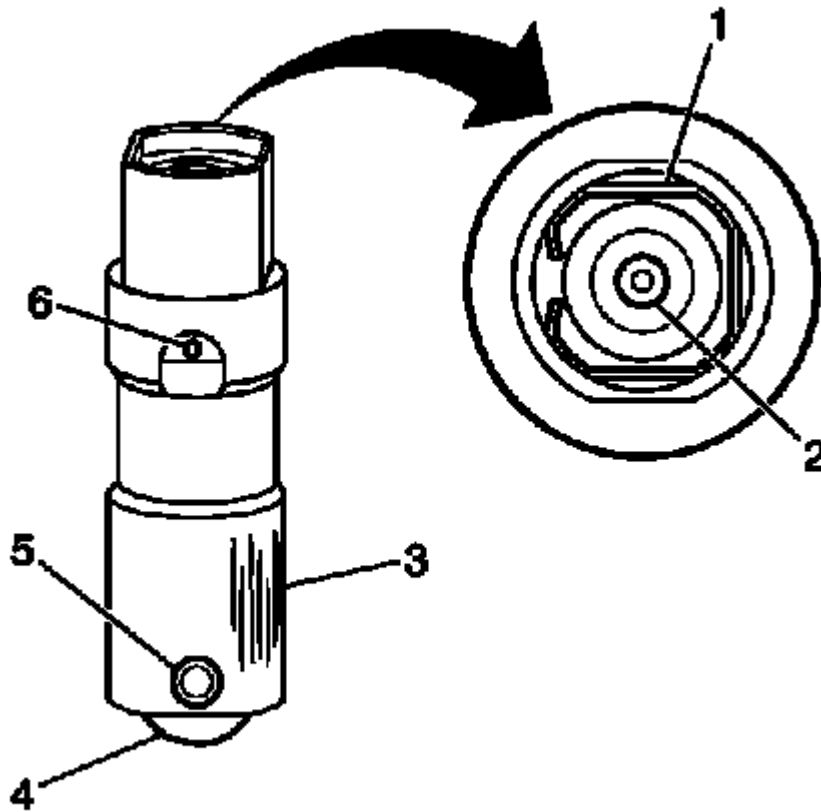


Fig. 382: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve lifter for the following:

- Broken or damaged clip (1)
- Worn pushrod socket (2)
- Scuffed or worn lifter body (3)

If the valve lifter shows scuffing or wear, inspect the engine block valve lifter bores for wear.

- Worn roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)

Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor. See **Special Tools**.

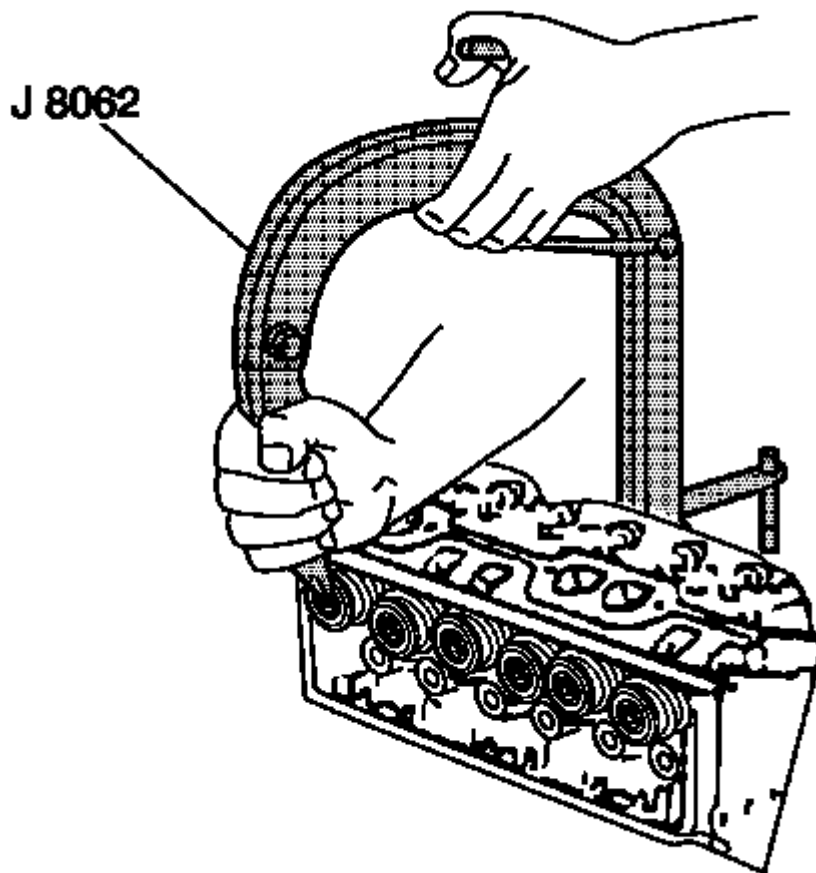


Fig. 383: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

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

1. Use the **J 8062** in order to compress the valve springs. See **Special Tools**.

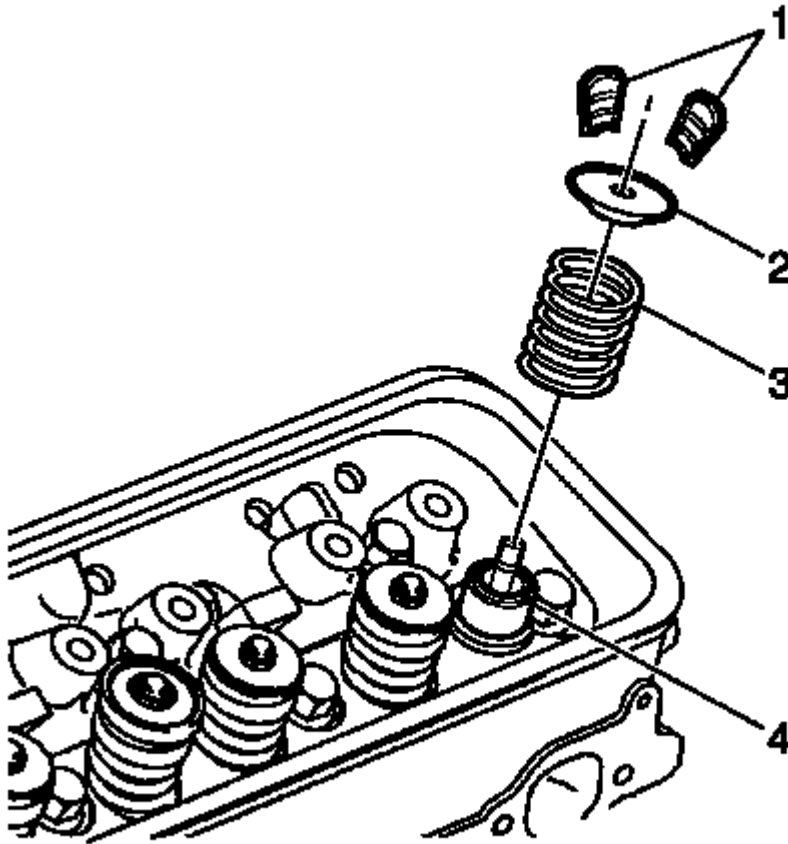


Fig. 384: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, and organize the components so that the components can be reinstalled in their original location and position.

2. Remove the valve stem keys (1).
3. Remove the **J 8062** from the cylinder head. See **Special Tools**.
4. Remove the valve spring cap (2).
5. Remove the valve spring (3).
6. Remove the valve stem oil seal (4).
7. Discard the valve stem oil seal.
8. Remove the valve.

Cylinder Head Cleaning and Inspection

Tools Required

- **J 8001** Dial Indicator Set
- **J 8089** Carbon Removing Brush
- **J 9666** Valve Spring Tester. See **Special Tools**.

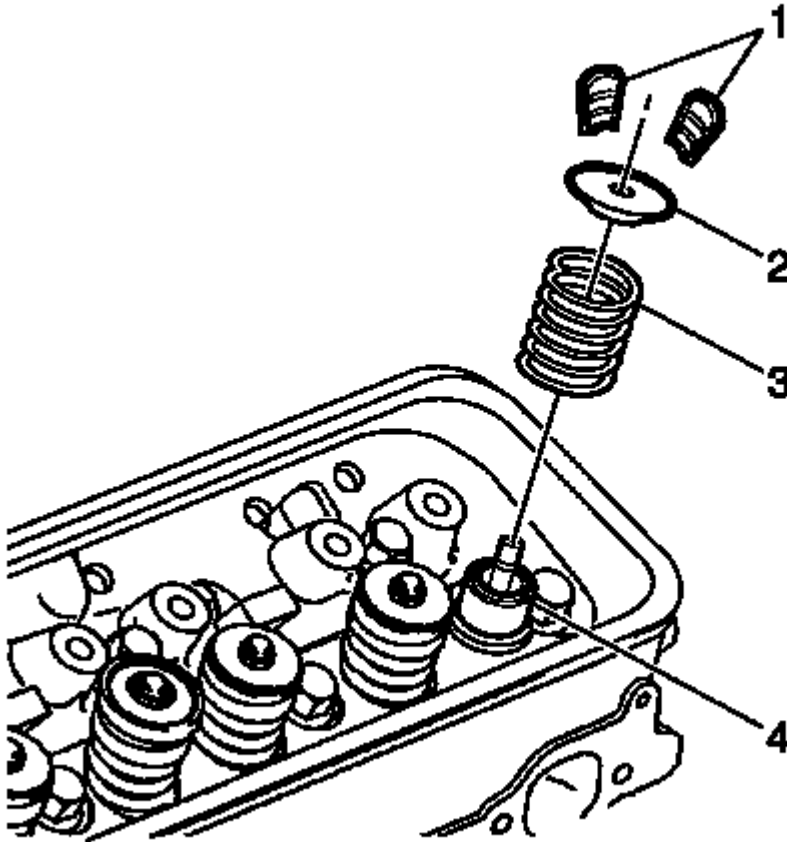


Fig. 385: Identifying Valve Components
 Courtesy of GENERAL MOTORS CORP.

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

1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:
 - Valve stem keys (1)
 - Valve spring cap (2)
 - Valve spring (3)
 - Cylinder head
3. Dry the components with compressed air.

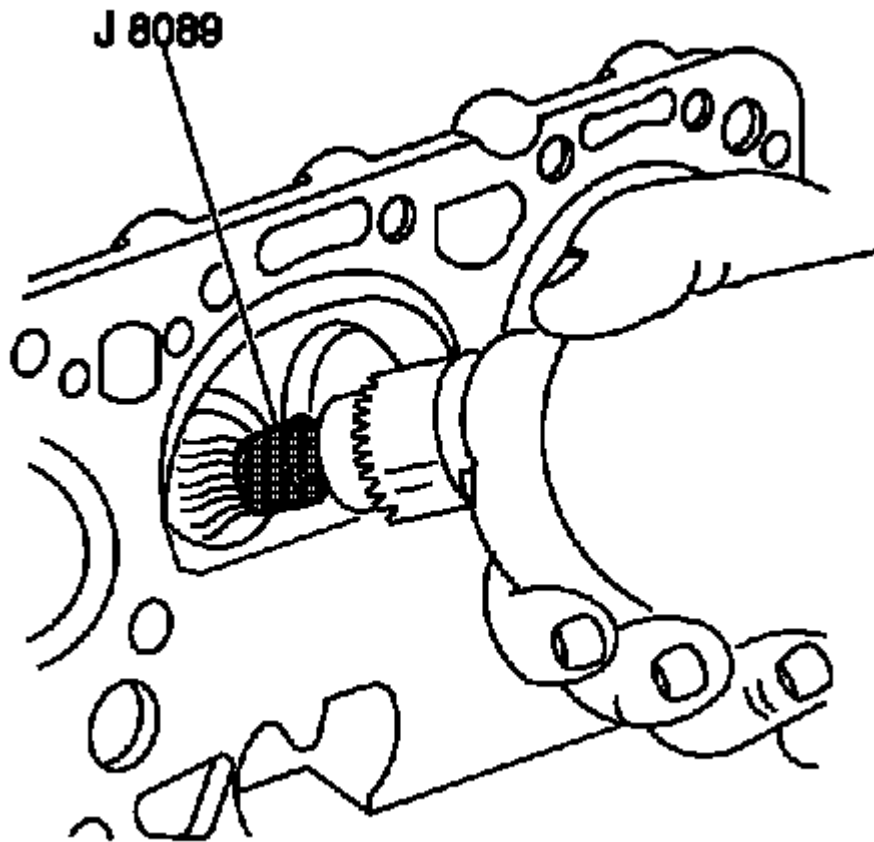


Fig. 386: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

4. Use the J 8089 to clean the carbon from the cylinder head combustion chambers.

Be careful not to scuff the combustion chambers.

5. Inspect the cylinder head for the following:
 - Damage to the gasket surfaces
 - Damage to the threaded bolt holes
 - Burnt or eroded areas in the combustion chamber
 - Cracks in the exhaust ports and combustion chambers
 - External cracks in the water chamber
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged, or leaking core plugs

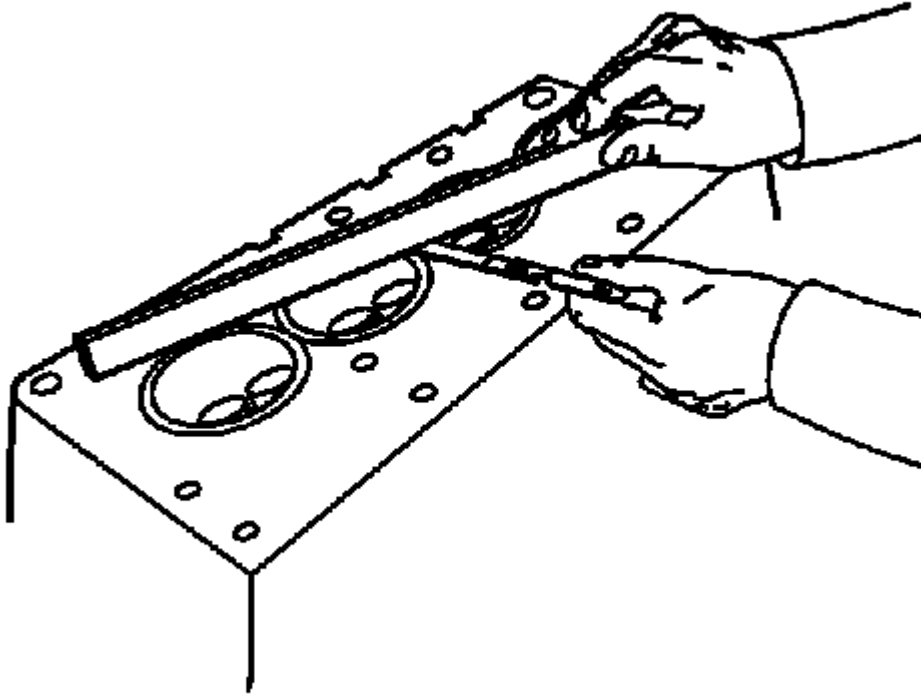


Fig. 387: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Measure the cylinder head for warpage with a straight edge and feeler gage.
 - A cylinder head block deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
 - A cylinder head exhaust manifold deck with warpage in excess of 0.05 mm (0.002 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
 - A cylinder head intake manifold deck with warpage in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.

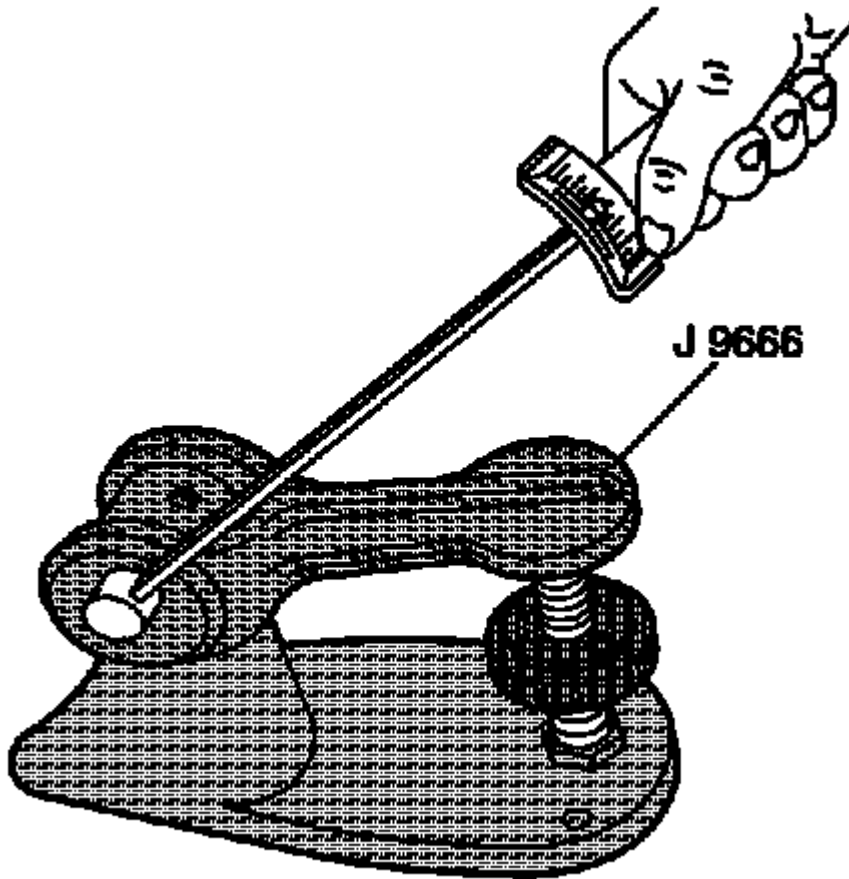


Fig. 388: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

7. Use the **J 9666** in order to measure the valve spring. See **Special Tools**.

Replace the valve spring if the valve spring tension is less than 338 N (76 lb) at 43.2 mm (1.70 in).

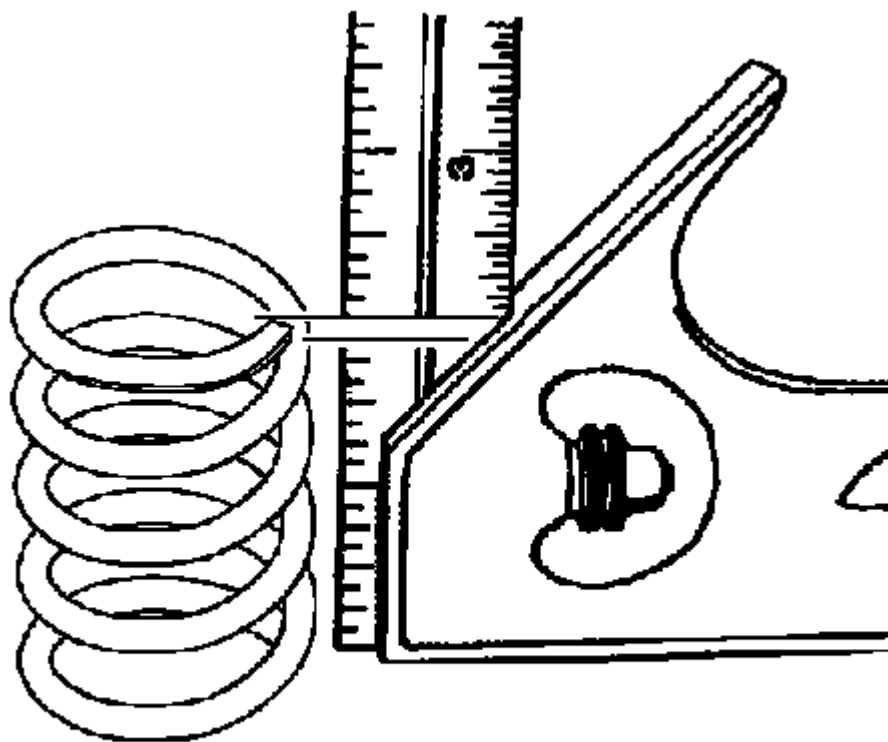


Fig. 389: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

8. Inspect the valve springs for squareness.

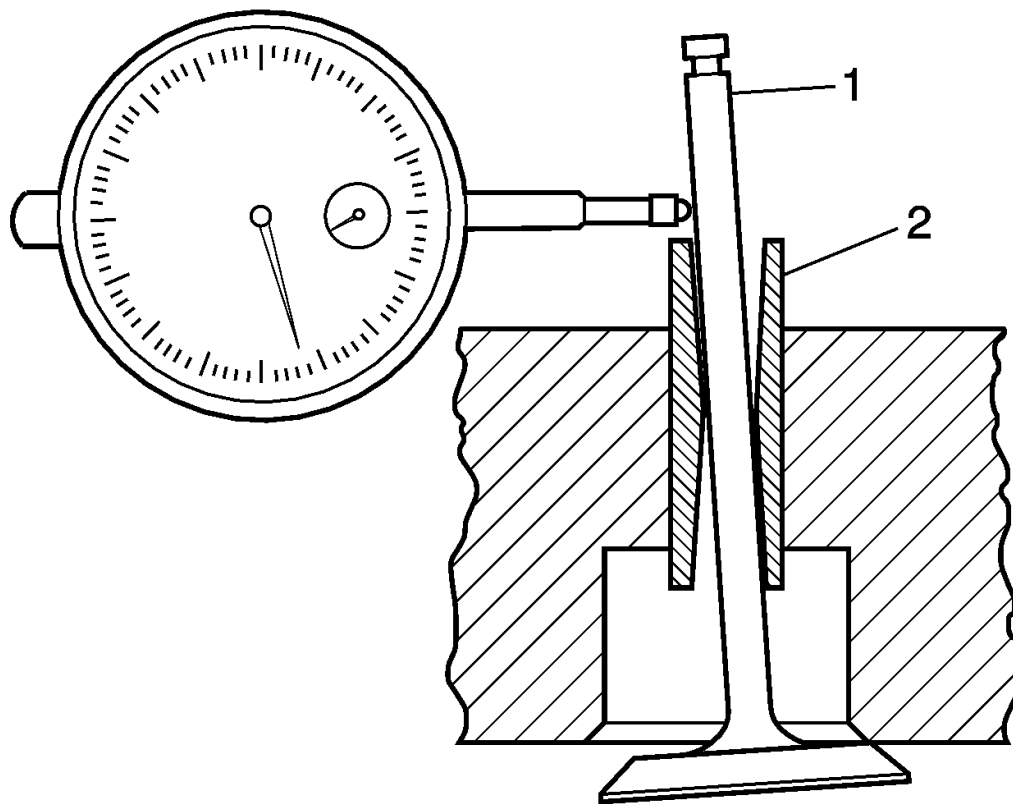


Fig. 390: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

9. Valve stems (1) with excessive valve guide (2) clearance must be repaired or the cylinder head replaced.

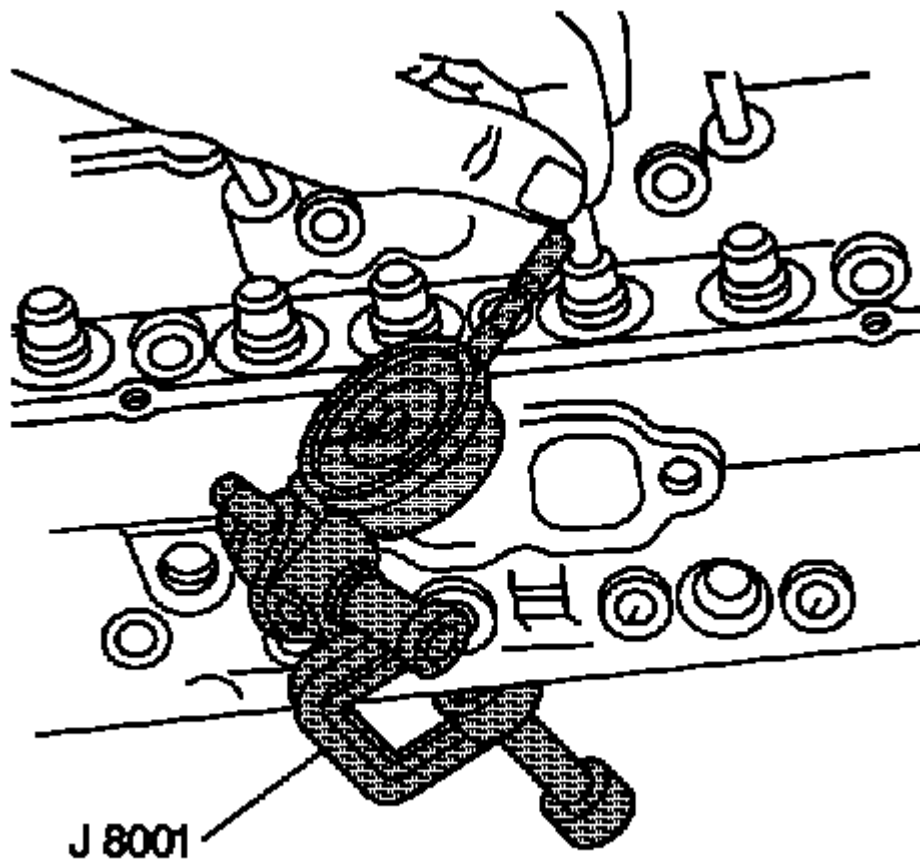


Fig. 391: Measuring Valve Stem-To-Guide Clearance Using J 8001
Courtesy of GENERAL MOTORS CORP.

10. Measure the valve stem-to-guide clearance.

Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

1. Clamp the **J 8001** on the exhaust port side of the cylinder head.
2. Position the dial indicator so that the movement of the valve stem from side to side, crosswise to the cylinder head, will cause a direct movement of the dial indicator stem.

The dial indicator stem must contact the side of the valve stem just above the valve guide.

3. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.
4. Use light pressure and move the valve stem from side to side in order to obtain a valve stem-to-guide clearance reading. Refer to **Engine Mechanical Specifications**.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

J 5830-02 Valve Guide Reamer Set. See **Special Tools**.

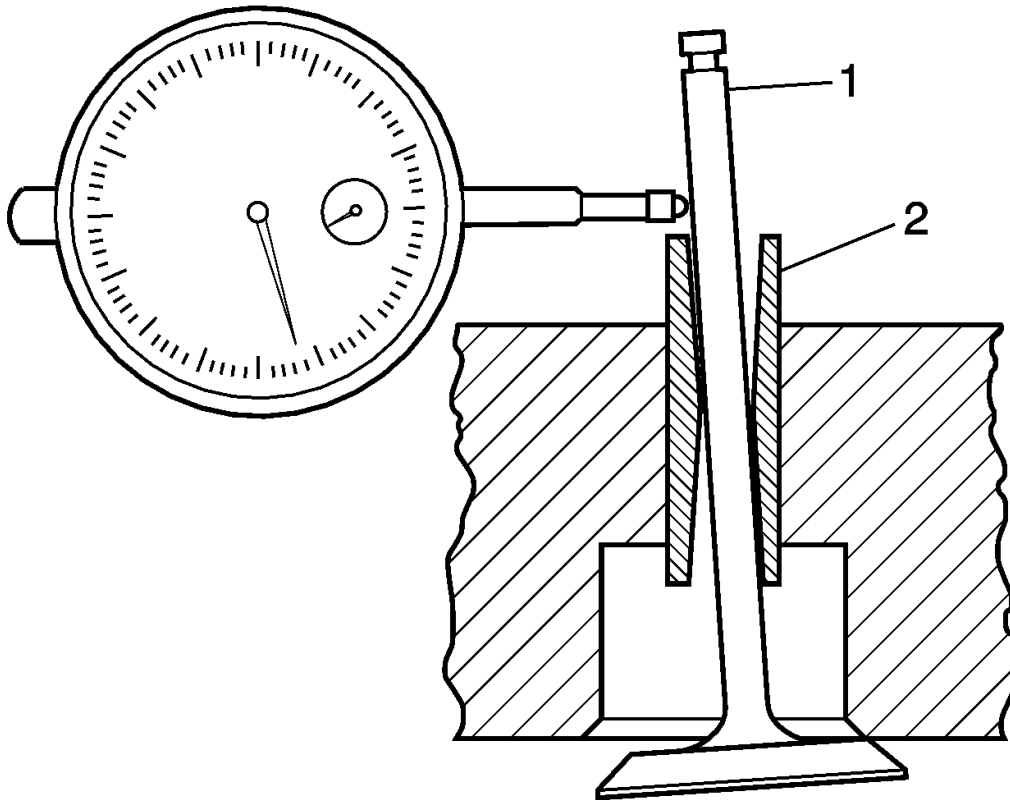


Fig. 392: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem-to-guide clearance. Refer to **Cylinder Head Cleaning and Inspection**.
2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.

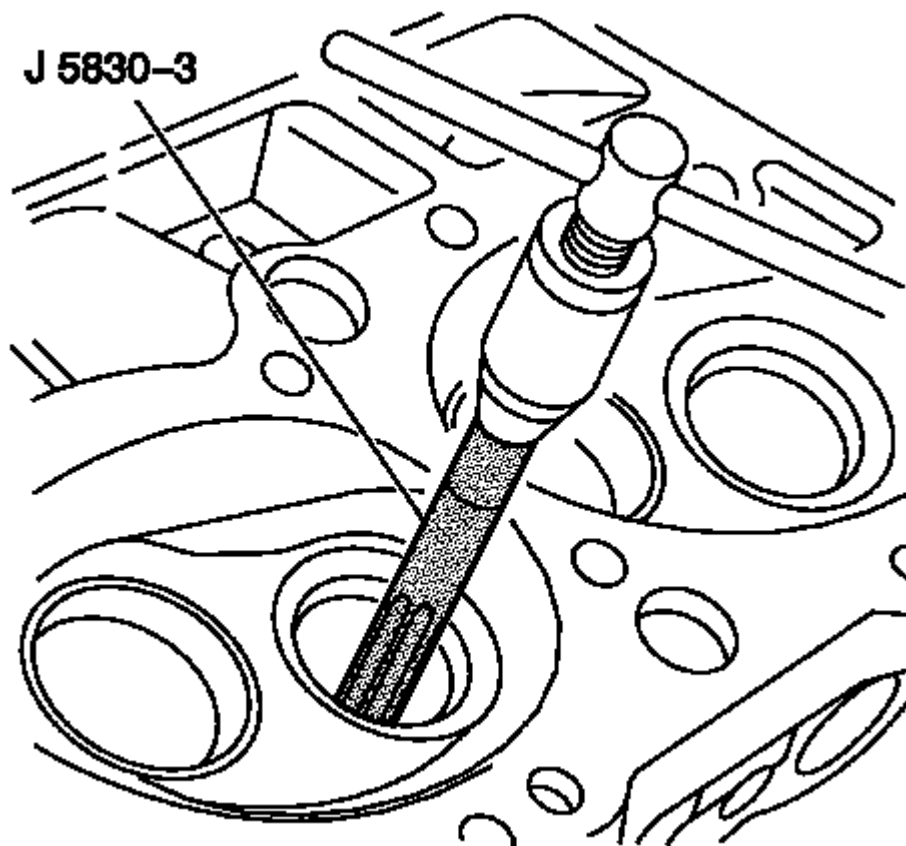


Fig. 393: Reaming Exhaust Valve Guide Using J 5830-3
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Exhaust valves with excessive valve stem-to-guide clearance must be replaced with the available service valve that has an 0.774 mm (0.0305 in) oversize valve stem. The intake valves are NOT available with oversize valve stems. Replace the cylinder head if after using a NEW intake valve in order to measure the valve stem-to-guide clearance, the valve stem-to-guide clearance is not within specifications.

3. Use the J 5830-3 in order to ream the exhaust valve guide in order to achieve the correct valve stem-to-guide clearance.
4. Always recondition the exhaust valve seat after reaming the exhaust valve guide bores and installing new exhaust valves.

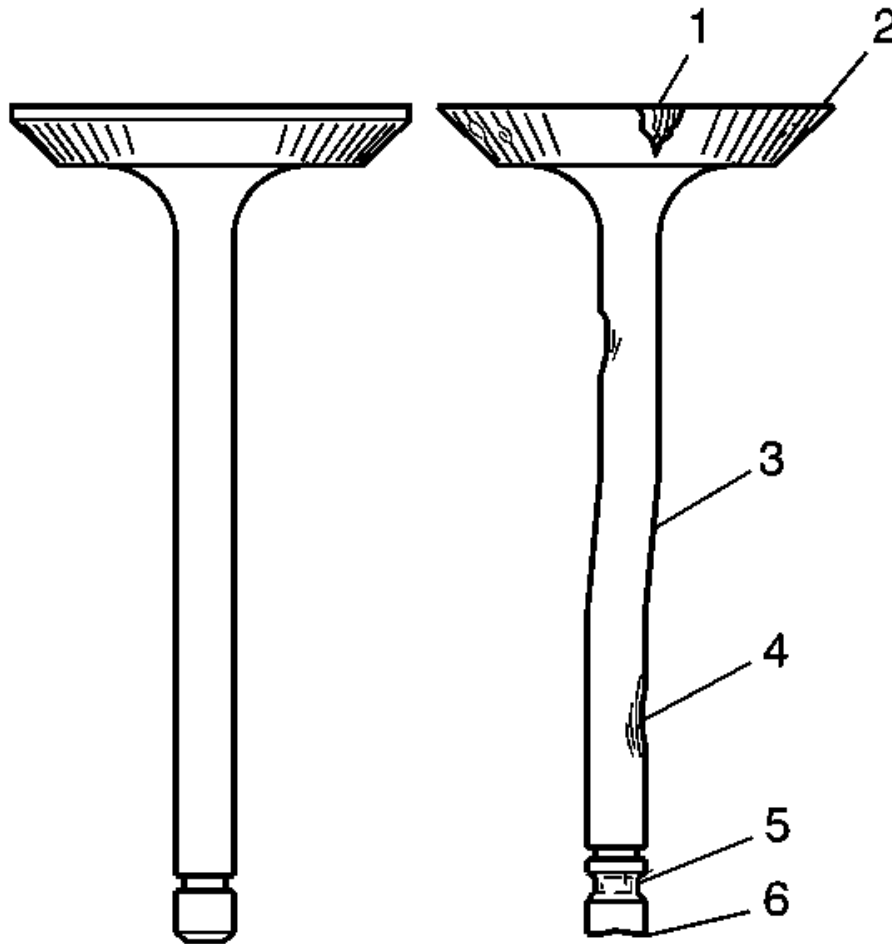


Fig. 394: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

5. Inspect the valves for the following:
- Burnt or damaged areas (1)
 - Undersized margin (2)
 - Bent stem (3)
 - Scoring or other damage to the stem (4)
 - Worn key groove (5)
 - Worn stem tip (6)

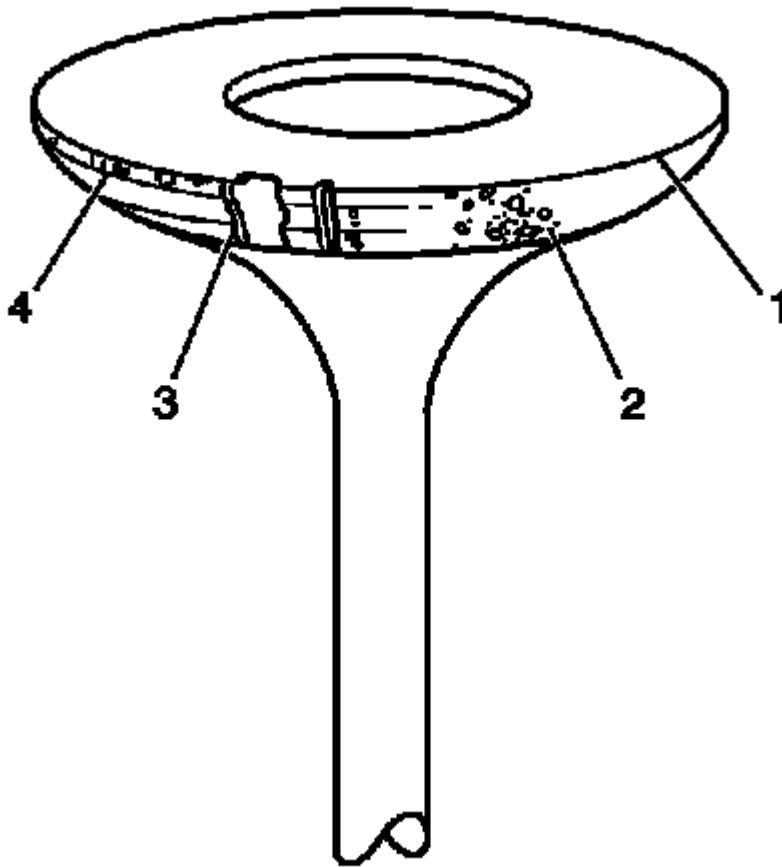


Fig. 395: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

6. Inspect the valve contact surface for the following:

- Undersized margin (1)
- Pitted surface (2)
- Burnt or eroded areas (3)
- Acceptable edge margin (4)

Valves with excessive damage must be replaced.

Minor imperfections of the valve or valve seat may be repaired.

7. Reconditioning of the valves and valve seats:

- The valves must seat perfectly for the engine to deliver optimum power and performance.
- Cooling the valve heads is another important factor. Good contact between each valve and valve seat in the cylinder head is necessary to insure that the heat in the valve head is properly carried away.
- Regardless of what type of equipment is used, it is essential that the valve guide bores are free from

carbon or dirt in order to ensure the proper centering of the pilot in the valve guide.

The valve seats should be concentric to within 0.05 mm (0.002 in) total indicator reading.

- Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the valve head and the valve stem.

Replace the valve if the valve stem is excessively worn or warped.

Replace the valve if the edge margin (4) of the valve head is less than 0.79 mm (0.031 in) thick after grinding.

- Several different types of equipment are available for reconditioning valves and valve seats. Follow the equipment manufacturer's recommendations for equipment use to attain the proper results.

Cylinder Head Assemble

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 42073** Valve Stem Seal Installer. See **Special Tools**.

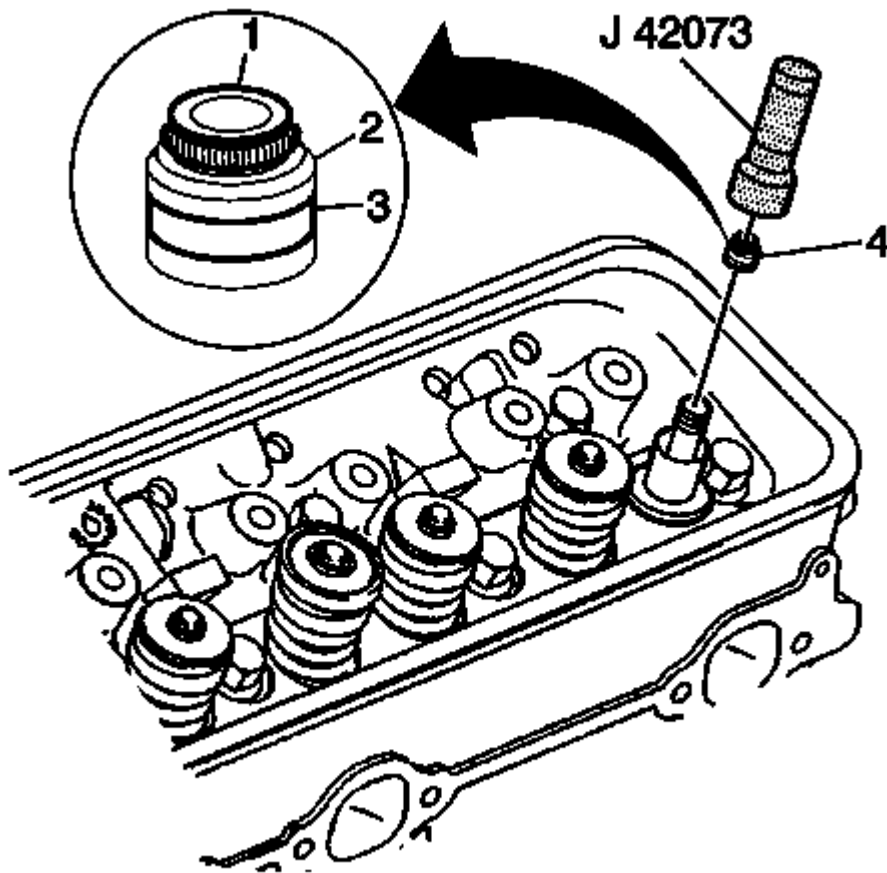


Fig. 396: Exhaust Valve Oil Stem Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal, or the material may be red in color (2) with no paint stripe. The intake valve oil seal is black in color.

1. Assemble the valve into the proper valve guide.
2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.
4. Assemble the valve stem oil seal onto the valve stem.

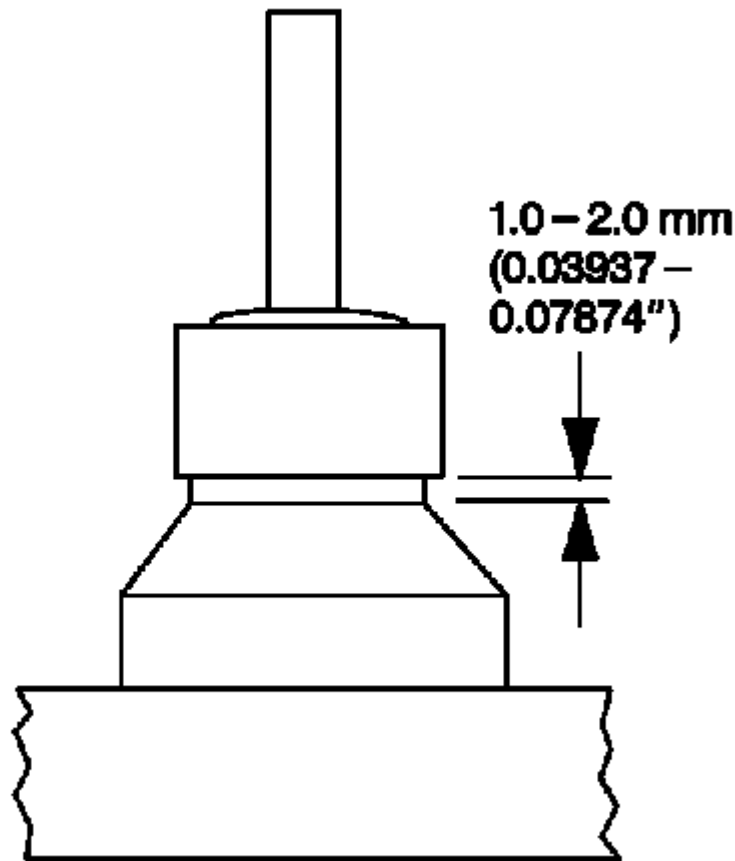


Fig. 397: Valve Stem Oil Seal Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

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

5. Using the **J 42073** , install the valve stem oil seal onto the valve guide. See **Special Tools**.
 1. Tap the valve stem oil seal onto the valve guide until the **J 42073** bottoms against the valve spring seat. See **Special Tools**.
 2. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

There should be a 1-2 mm (0.03937-0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

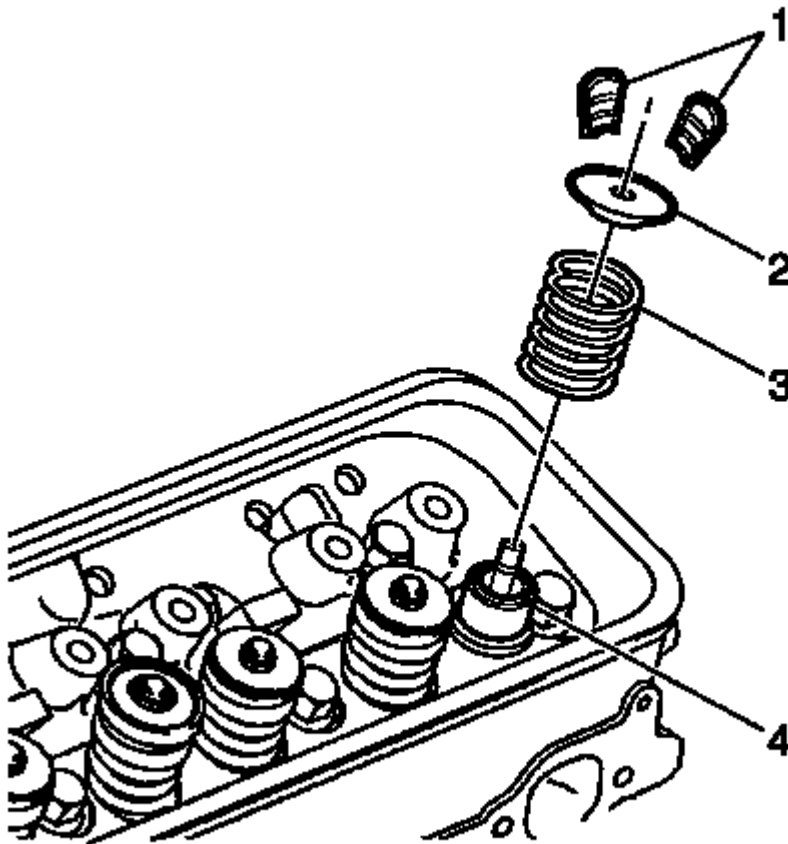


Fig. 398: Identifying Valve Components
Courtesy of GENERAL MOTORS CORP.

6. Install the valve spring (3).
7. Install the valve spring cap (2) onto the valve spring (3), over the valve stem.

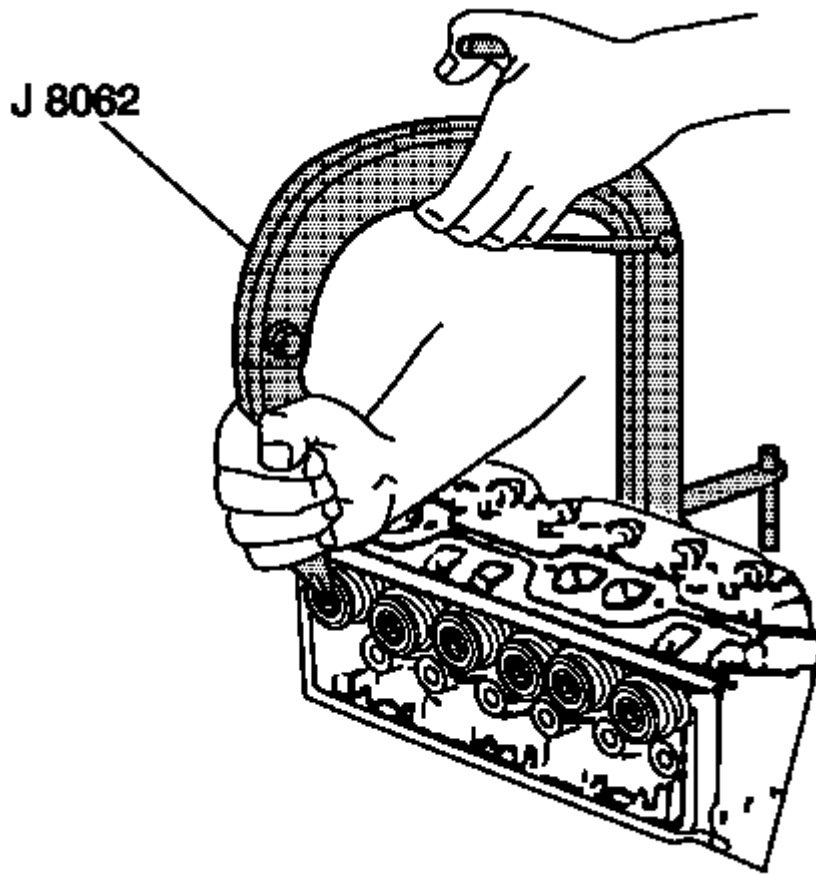


Fig. 399: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

8. Use the **J 8062** to compress the valve spring. See Special Tools.
9. Install the valve stem O-ring seal.
10. Install the valve stem keys.
 1. Use grease to hold the valve stem keys in place while disconnecting the **J 8062** . See Special Tools.
 2. Tap the end of the valve stem with a plastic-faced hammer to seat the valve stem keys.
 3. Inspect the valve stem keys to ensure that they are seated in the upper groove of the valve stem.

Oil Pump Disassemble

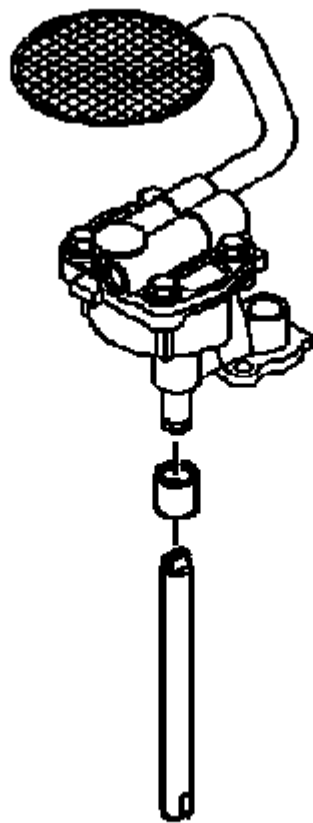


Fig. 400: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

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

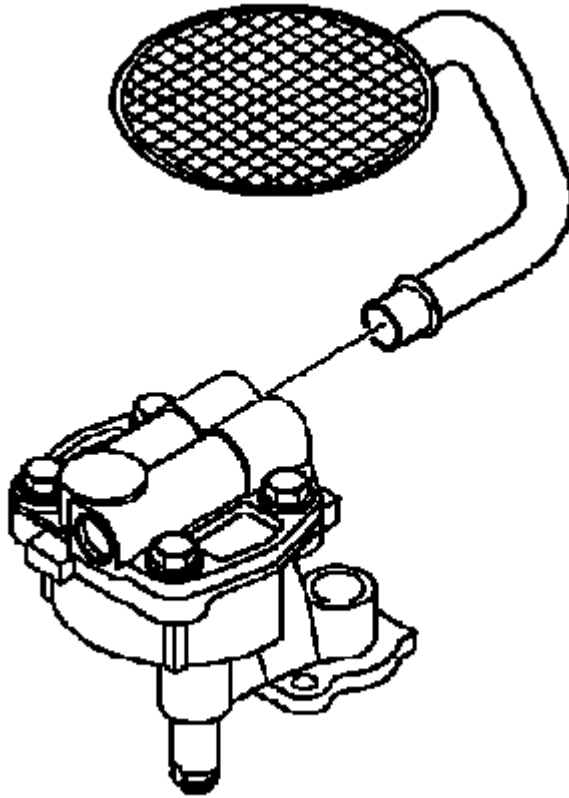


Fig. 401: Removing Oil Pump Pipe

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a complete assembly.

2. Remove the oil pump pipe, if necessary. The oil pump pipe has a press fit into the oil pump cover.

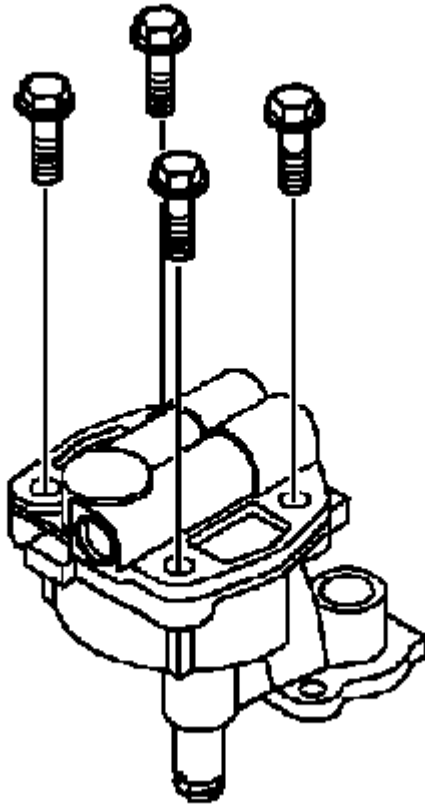


Fig. 402: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pump cover bolts.

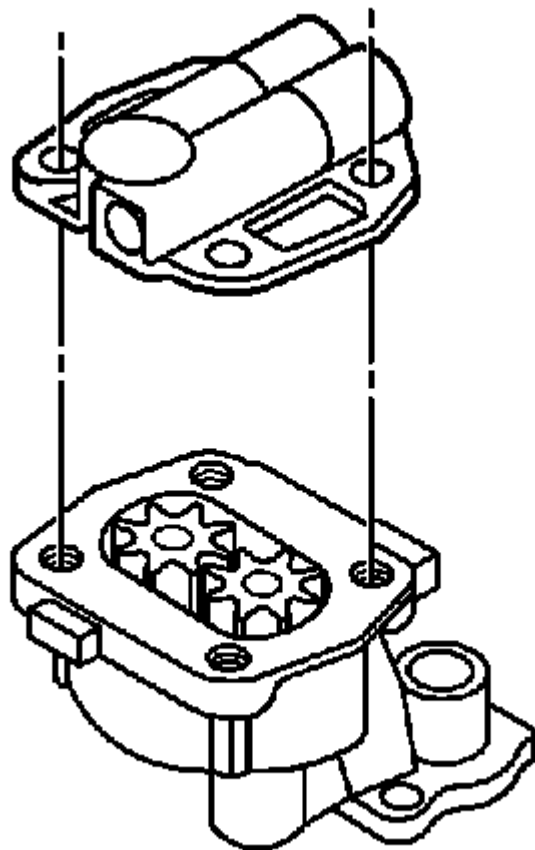


Fig. 403: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pump cover.

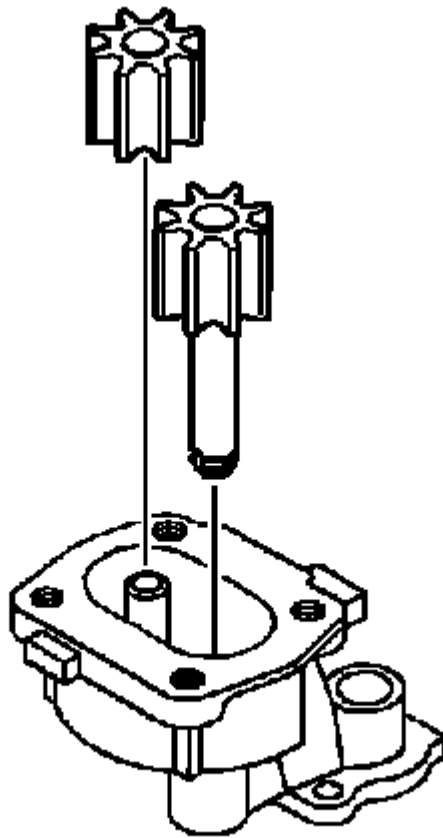


Fig. 404: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

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

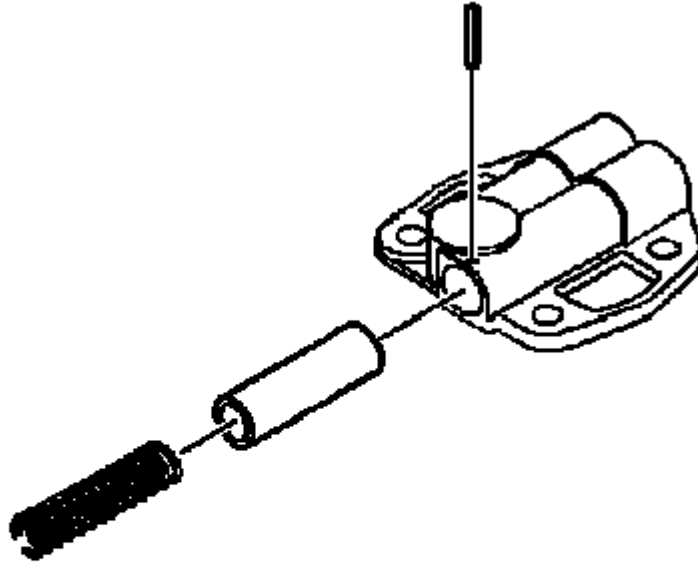


Fig. 405: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

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

7. Remove the following items:
 1. The oil pump pressure relief valve spring straight pin
 2. The oil pump pressure relief spring
 3. The oil pump pressure relief valve

Oil Pump Cleaning and Inspection

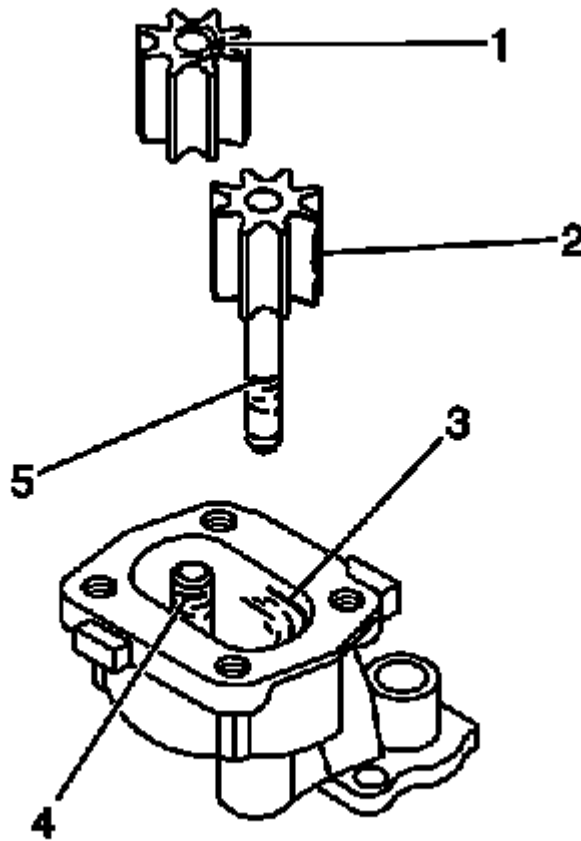


Fig. 406: Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the oil pump for the following conditions:
 - Scoring on the top of the gears (1)
 - Damaged gears (2) for the following:
 - Chipping
 - Galling
 - Wear
 - Scoring, damage or casting imperfections to the body (3)
 - Damaged or scored gear shaft (4)
 - Damaged or scored gear shaft (5)

- Damaged bolt hole threads
- Worn oil pump driveshaft bore
- Damaged or sticking oil pump pressure relief valve

Minor imperfections may be removed with a fine oil stone.

- Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
 5. During oil pump installation, install a NEW oil pump driveshaft retainer.

Oil Pump Assemble

Tools Required

J 21882 Oil Suction Pipe Installer. See Special Tools.

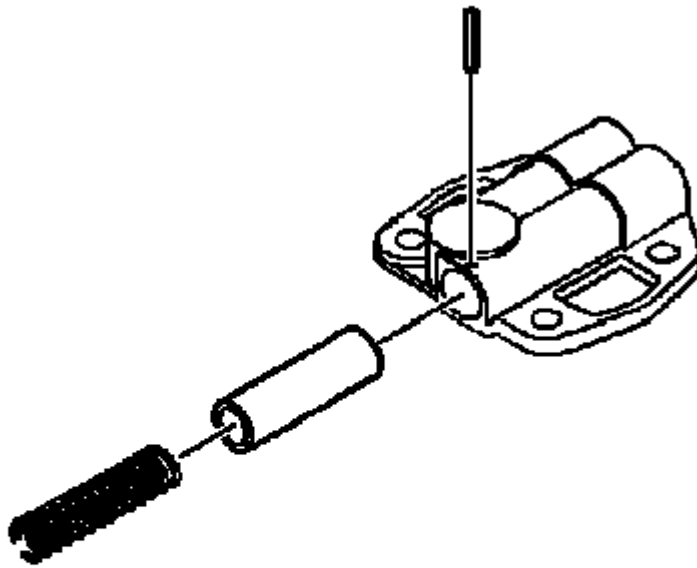


Fig. 407: View Of Oil Pump Pressure Relief Valve, Spring & Spring Straight Pin
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 9931930) or equivalent, to the oil pump pressure relief valve, oil pump pressure relief valve spring, and oil pump body.

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

IMPORTANT: Replace the oil pump pressure relief valve spring when you reuse the oil pump.

2. Install the following items:
 1. The oil pump pressure relief valve
 2. The oil pump pressure relief valve spring
 3. The oil pump pressure relief valve spring straight pin

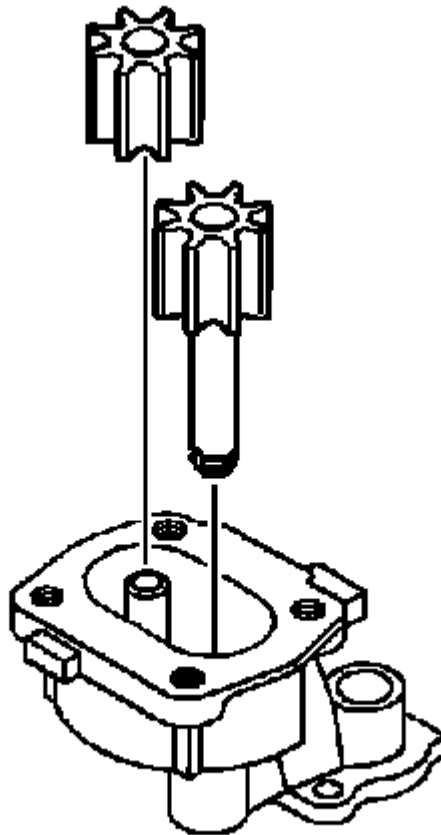


Fig. 408: View Of Oil Pump Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

3. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, to the oil pump drive gear, the oil pump driven gear, and the oil pump body internal surfaces.
4. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
 1. Align the matchmarks on the oil pump drive and driven gears.
 2. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.

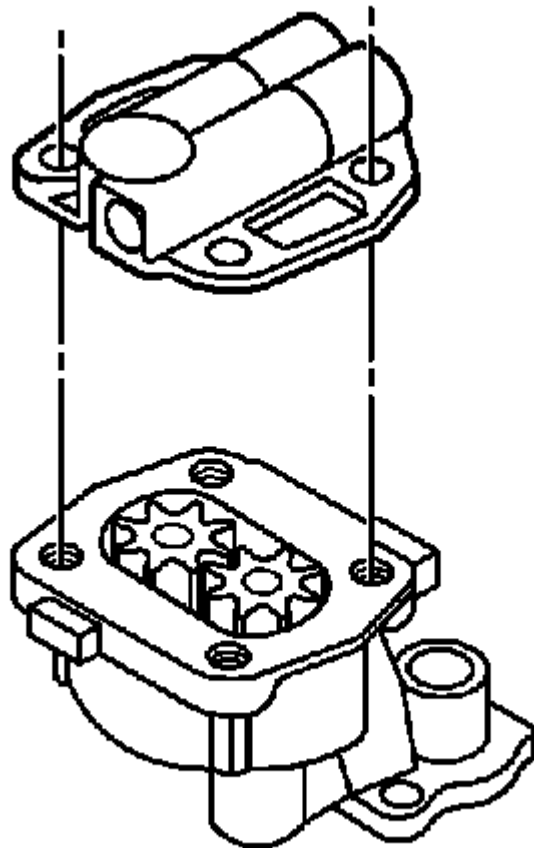


Fig. 409: View Of Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pump cover.

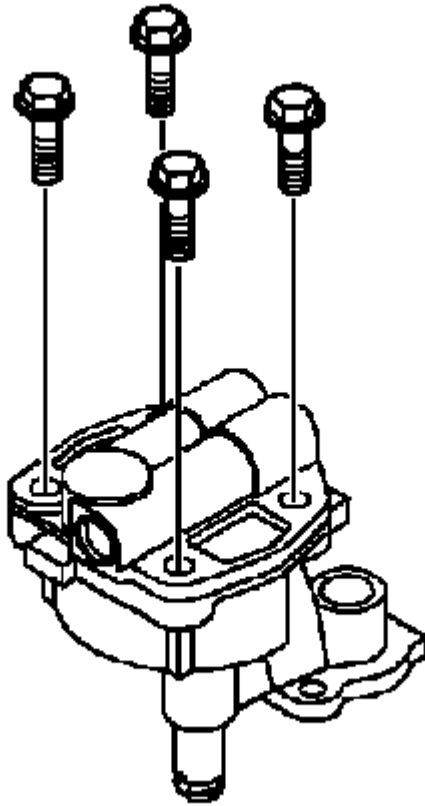


Fig. 410: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Caution and Notices.

6. Install the oil pump cover bolts.

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

7. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.

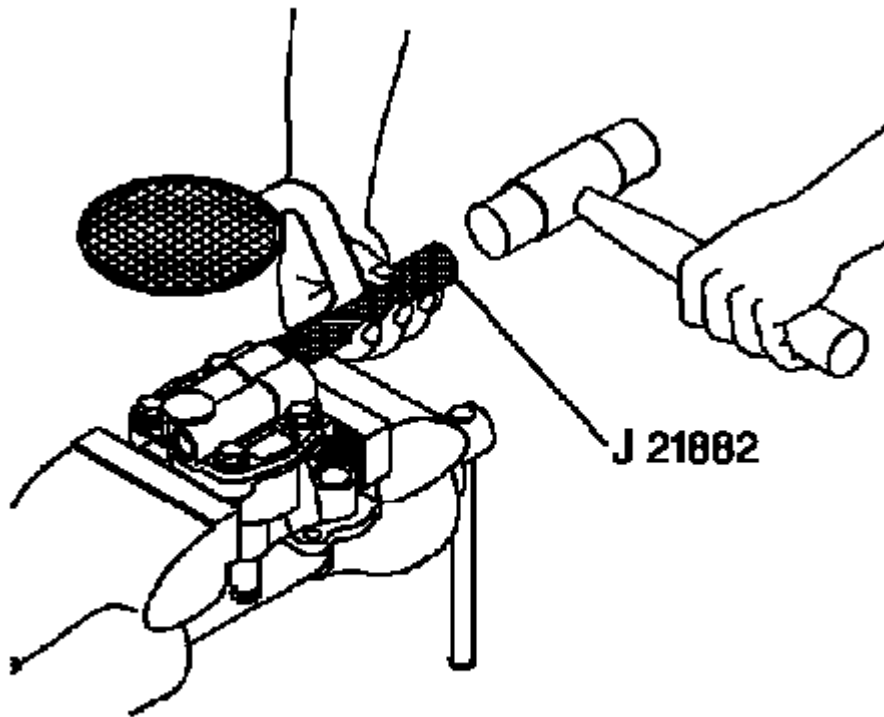


Fig. 411: Installing Oil Pump Screen Into Pump Body
Courtesy of GENERAL MOTORS CORP.

8. Install the oil pump screen.
 1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
 2. Mount the oil pump in a soft jawed vise.
 3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the end of the oil pump screen pipe.
 4. Use the **J 21882** and a soft-faced hammer in order to tap the oil pump screen into the pump body. See **Special Tools**.

The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.

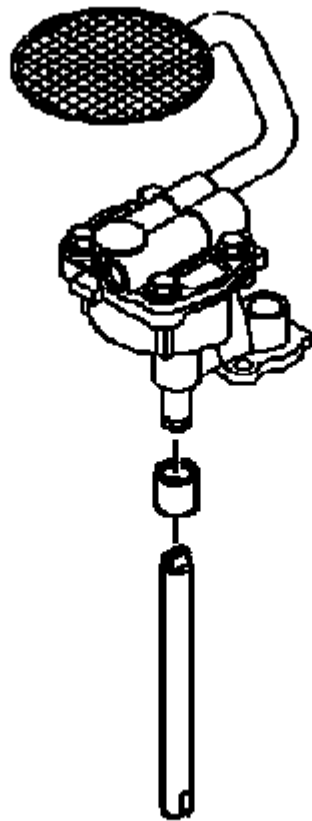


Fig. 412: View Of Oil Pump Driveshaft & Oil Pump Driveshaft Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install a NEW oil pump driveshaft retainer during assembly.

9. Install the oil pump driveshaft and the NEW oil pump driveshaft retainer.

Valve Rocker Arm Cover Cleaning and Inspection

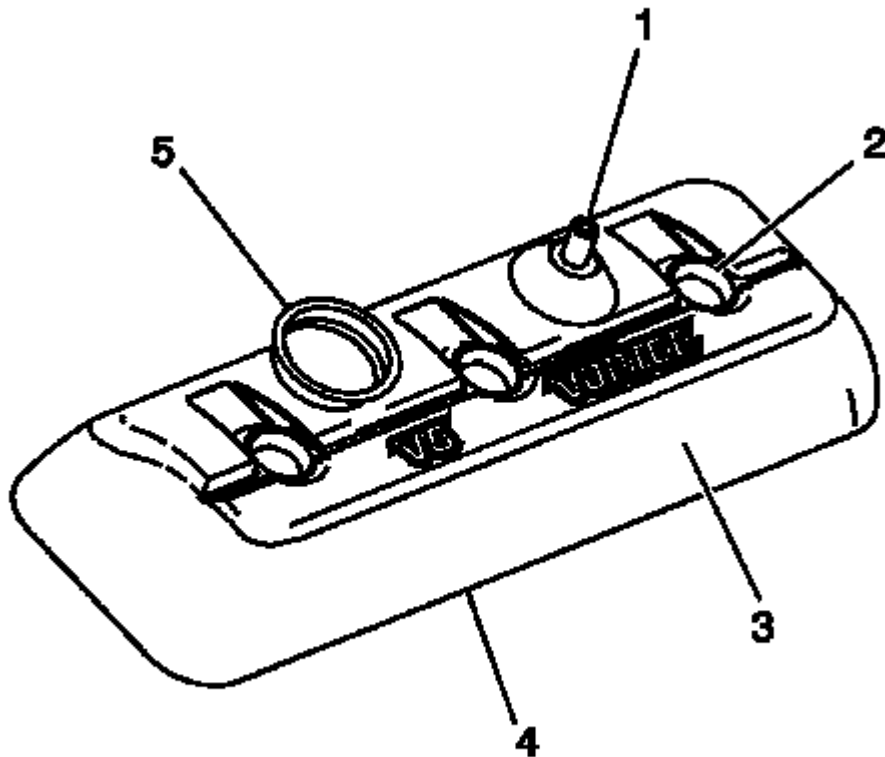


Fig. 413: View Of Valve Cover

Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: The positive crankcase ventilation (PCV) orifice is part of the valve cover and cannot be removed. If damaged, replace the valve cover.

1. Clean the valve rocker arm cover in cleaning solvent.
2. Dry the valve rocker arm cover with compressed air.
3. Inspect the valve rocker arm cover for the following:
 - Damage to the PCV orifice or grommet (1)
 - Damage to the bolt holes (2)

A damaged valve rocker arm cover may interfere with the valve rocker arms.

- Damage to the exterior of the valve rocker arm cover (3)
- Gouges or damage to the sealing surface (4)

- Damage to the oil fill tube grommet (5)
- Restrictions to the ventilation system passages

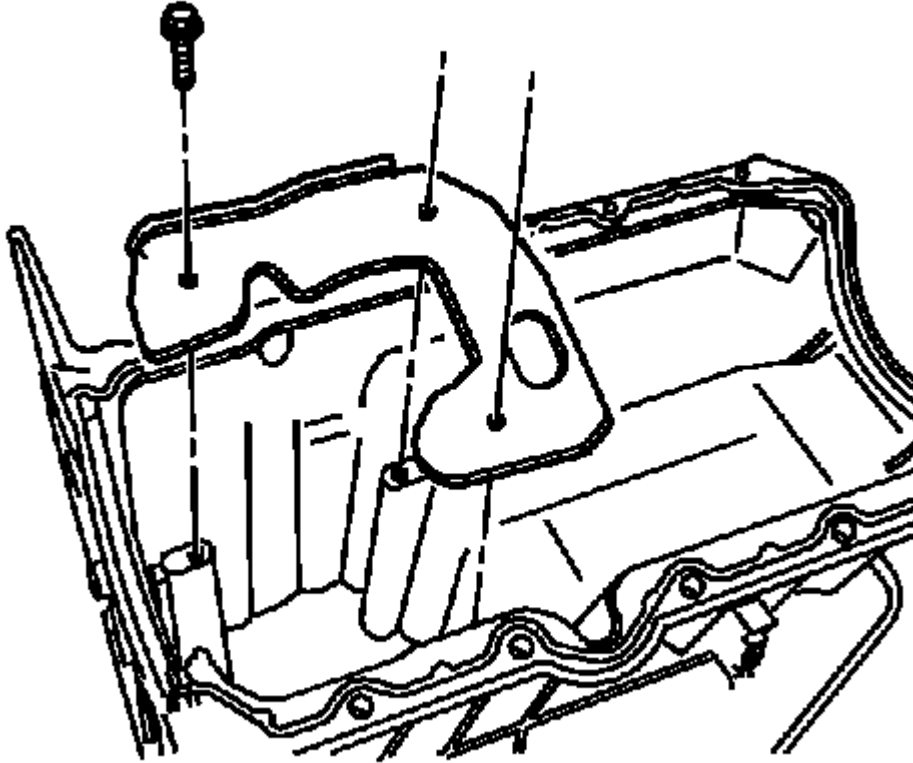
Oil Pan Cleaning and Inspection

Fig. 414: Removing Oil Pan Baffle Bolts & Oil Pan Baffle
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan baffle bolts and the oil pan baffle.

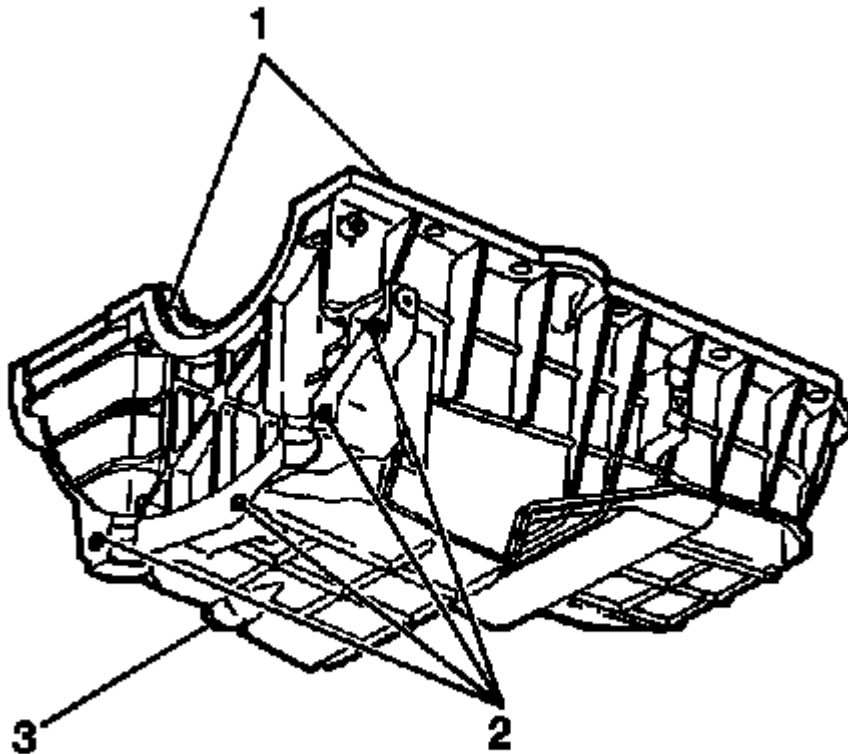


Fig. 415: Oil Pan Cleaning & Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

2. Clean the oil pan and oil pan baffle in cleaning solvent.
3. Dry the oil pan and oil pan baffle with compressed air.
4. Inspect the oil pan for the following:
 - Gouges or damage to the oil pan sealing surfaces (1)
 - Damage to the threaded holes (2)
 - Damaged oil pan drain hole threads (3)
 - Damage to the oil pan baffle
 - Damage to the exterior of the oil pan

A damaged oil pan may interfere with the proper position of the oil pump screen, or may not distribute oil properly in the oil pan sump area.

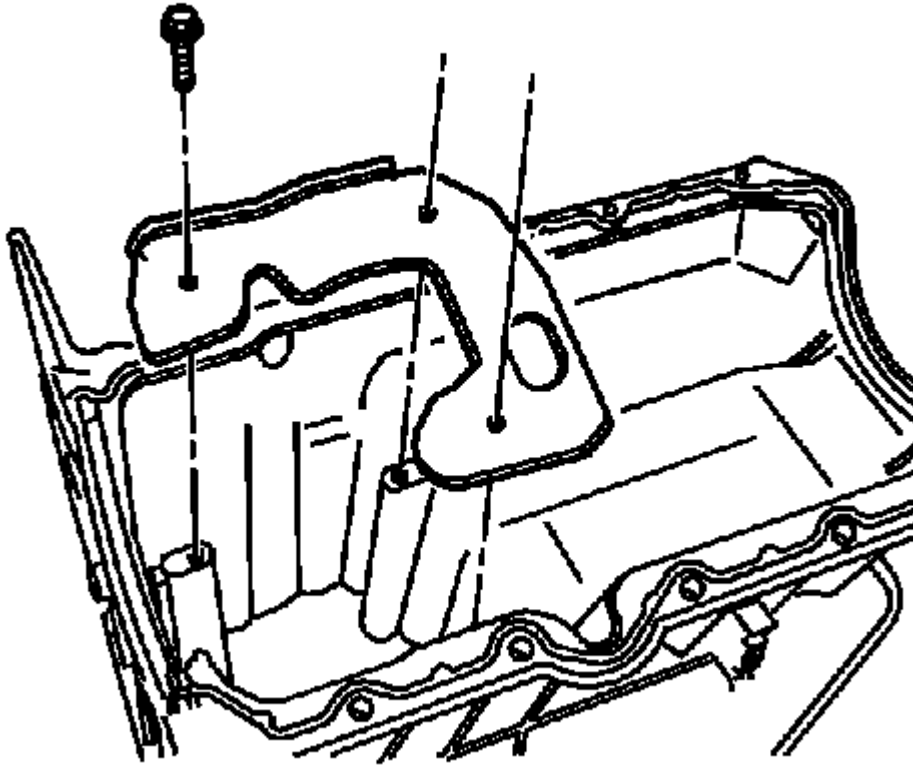


Fig. 416: Removing Oil Pan Baffle Bolts & Oil Pan Baffle
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pan baffle and the bolts.

Tighten: Tighten the oil pan baffle bolts to 12 N.m (106 lb in).

Intake Manifold Disassemble (LU3)

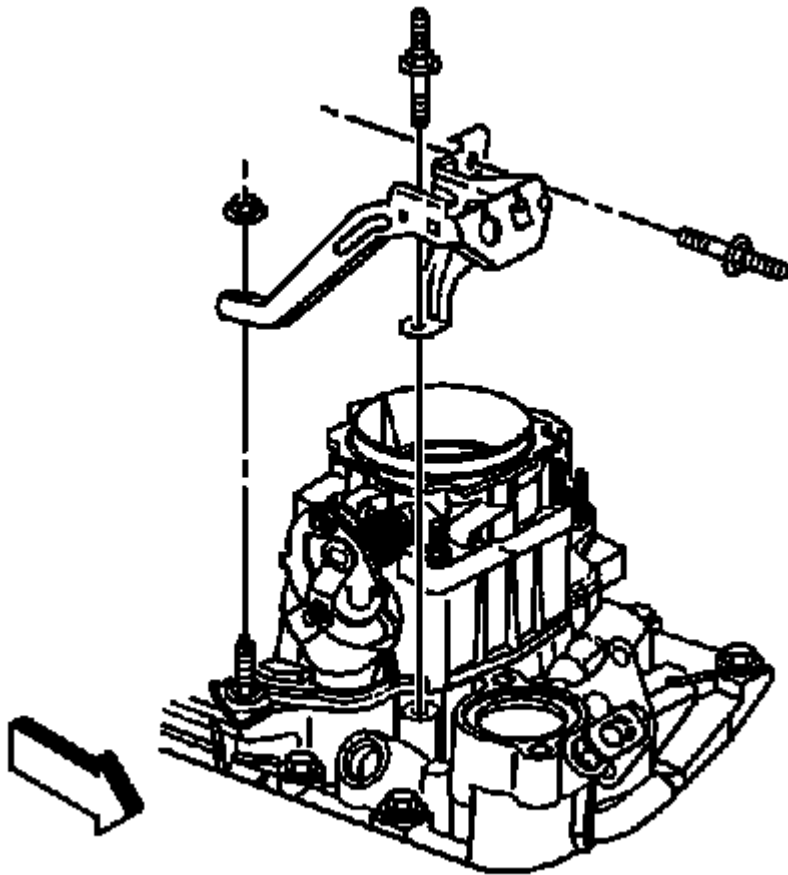


Fig. 417: Removing Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the nuts, the studs, and the accelerator control cable bracket.

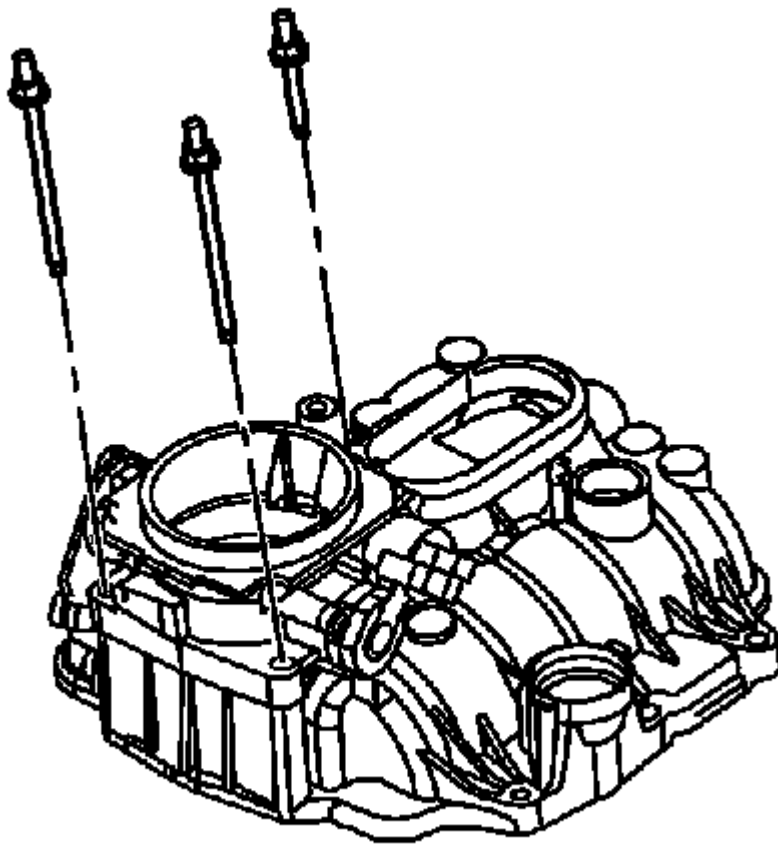


Fig. 418: View Of Throttle Body & Attaching Studs
Courtesy of GENERAL MOTORS CORP.

2. Remove the throttle body attaching studs.

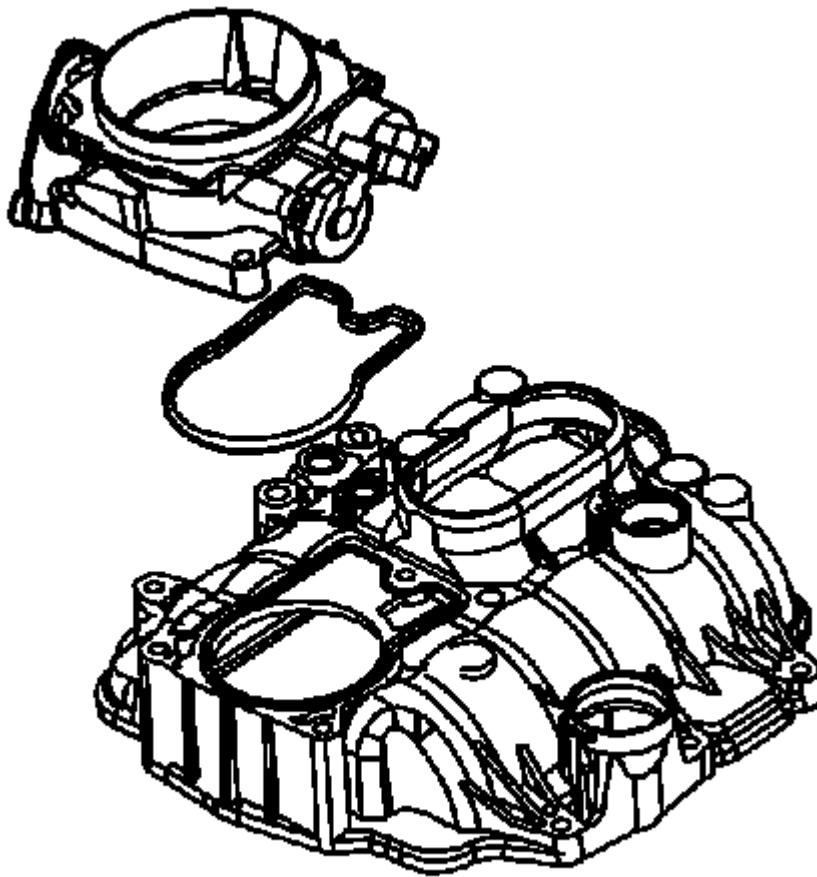


Fig. 419: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body.
4. Remove the throttle body to upper intake manifold gasket.
5. Discard the throttle body to upper intake manifold gasket.

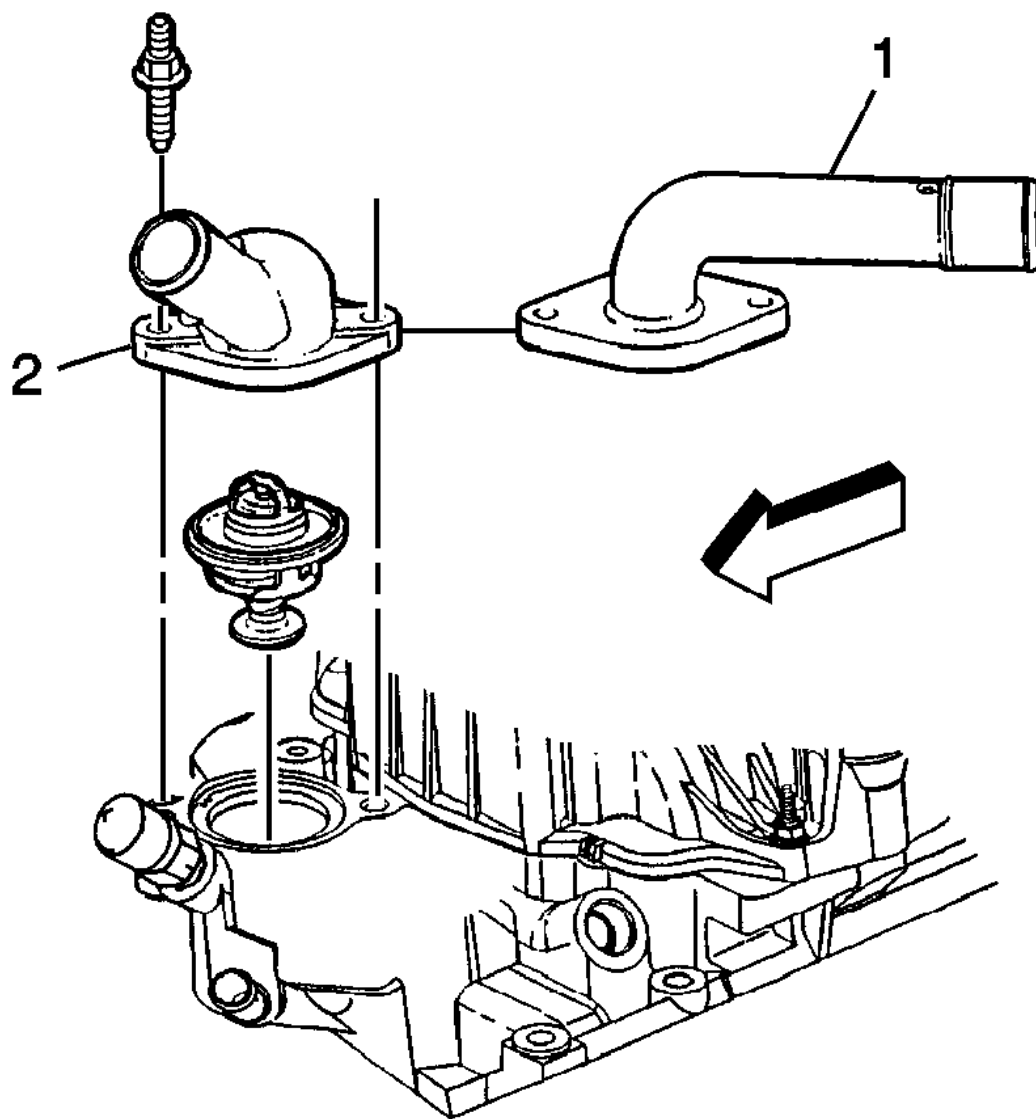


Fig. 420: Removing Water Outlet
Courtesy of GENERAL MOTORS CORP.

6. Remove the water outlet studs.
7. Remove the water outlet (1 or 2).
8. Remove the engine coolant thermostat.

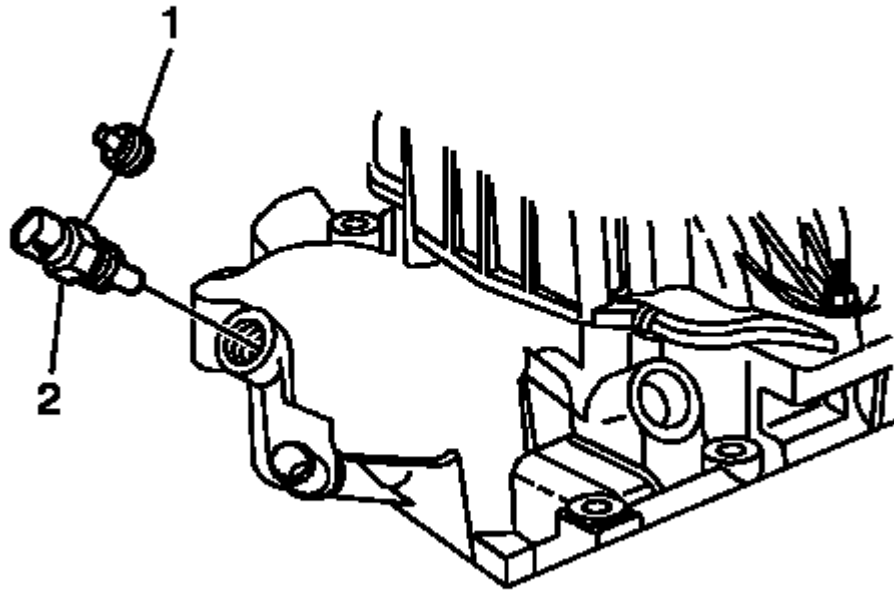


Fig. 421: ECT Sensor & Plug

Courtesy of GENERAL MOTORS CORP.

9. Remove the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2) from the front of the lower intake manifold, if equipped.

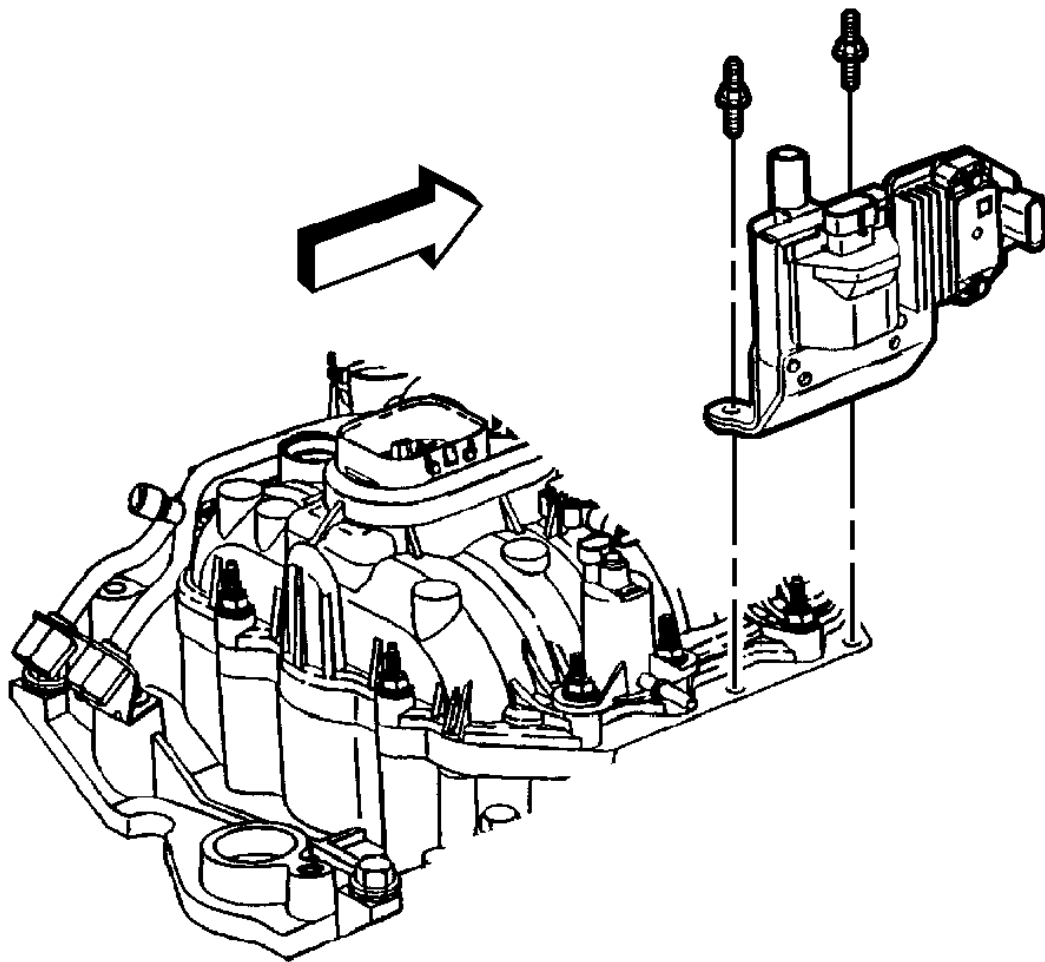


Fig. 422: Removing Ignition Coil & Studs
Courtesy of GENERAL MOTORS CORP.

10. Remove the studs and the ignition coil.

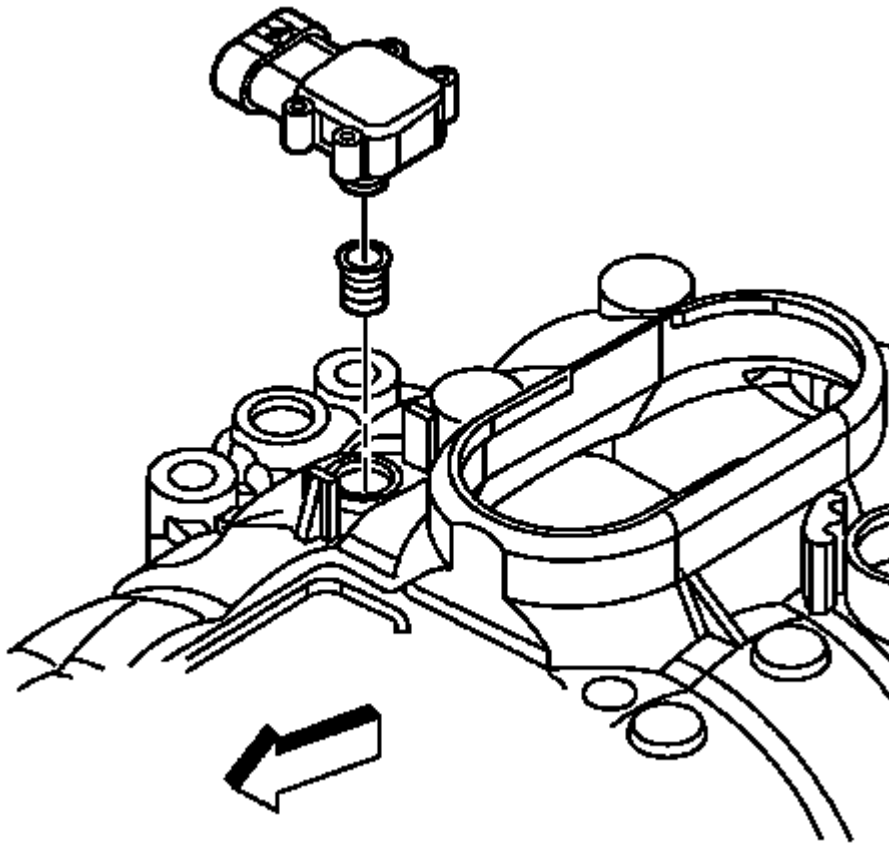


Fig. 423: Removing MAP Sensor
Courtesy of GENERAL MOTORS CORP.

11. Remove the manifold absolute pressure (MAP) sensor.
12. Remove the MAP sensor seal from the MAP sensor.
13. Discard the MAP sensor seal.

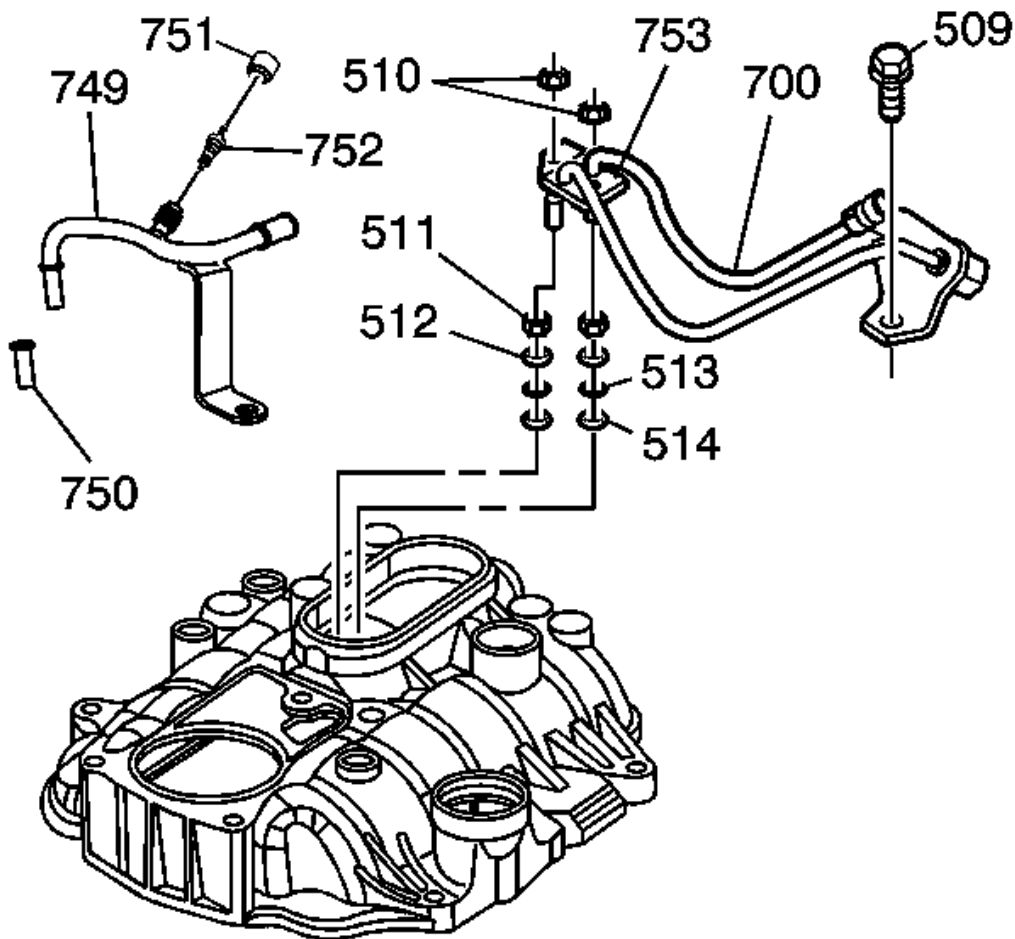


Fig. 424: Fuel Meter Body, Pipes & Brackets
Courtesy of GENERAL MOTORS CORP.

14. Remove the fuel pipe bolt (509).
15. Remove the fuel service port cap (751) and Schrader valve (752), if required.
16. Remove the fuel pipe retainer nuts (510).
17. Remove the fuel pipe retainer (753).
18. Remove the fuel pipe (700, 749).
19. Remove the fuel pipe plug (750), if required.
20. Remove and discard the fuel seal retainers (511).
21. Remove and discard the fuel seals (512), yellow O-rings.
22. Remove and discard the spacer rings (513), flat washers.

23. Remove and discard the fuel seals (514), black O-rings.

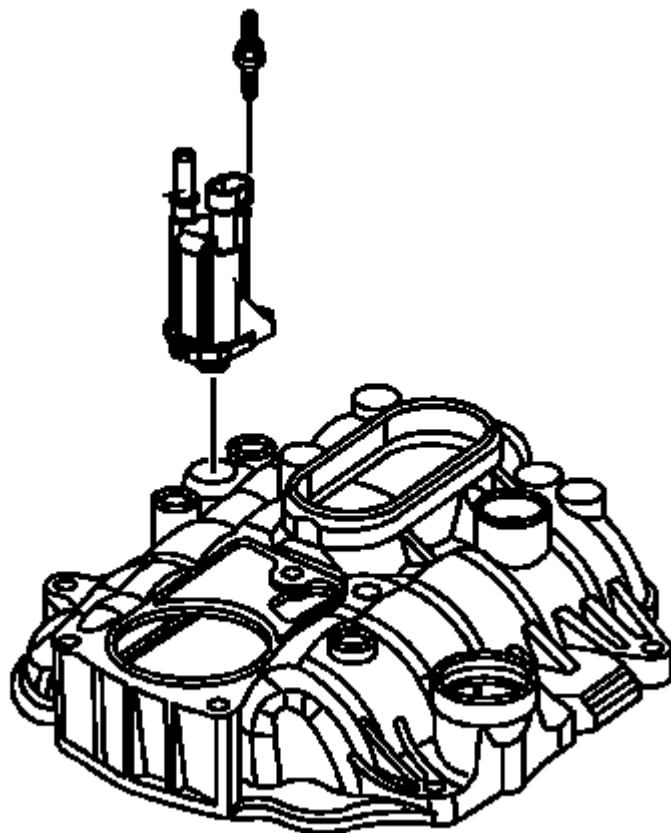


Fig. 425: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

24. Remove the studs and the evaporative emission (EVAP) canister purge solenoid valve.
25. Remove the nut and the engine wiring harness bracket.

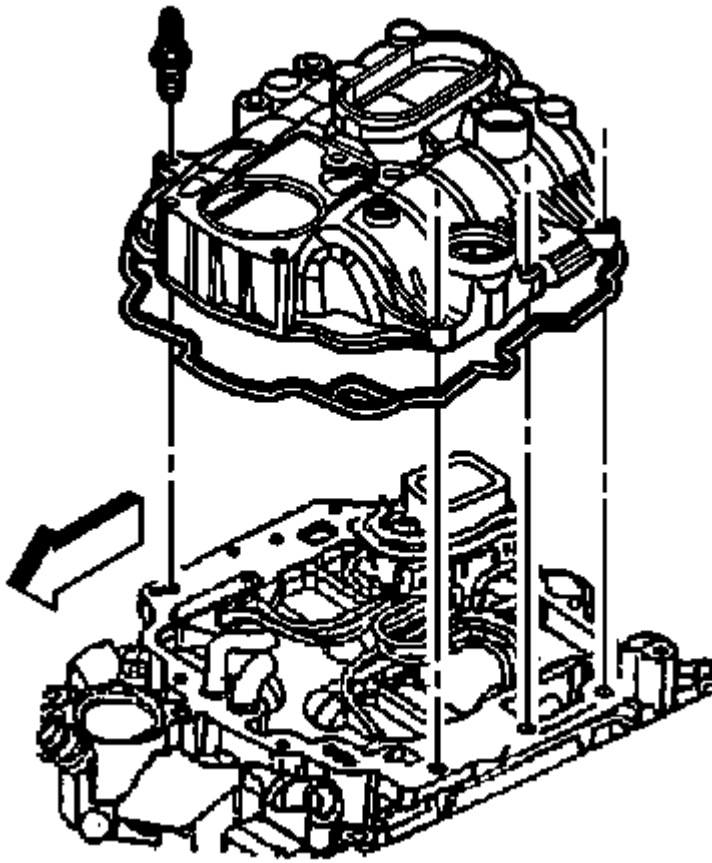


Fig. 426: Removing Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

26. Remove the upper intake manifold attaching studs.
27. Remove the upper intake manifold.
28. Remove the upper intake manifold to lower intake manifold gasket.
29. Discard the upper intake manifold to lower intake manifold gasket.

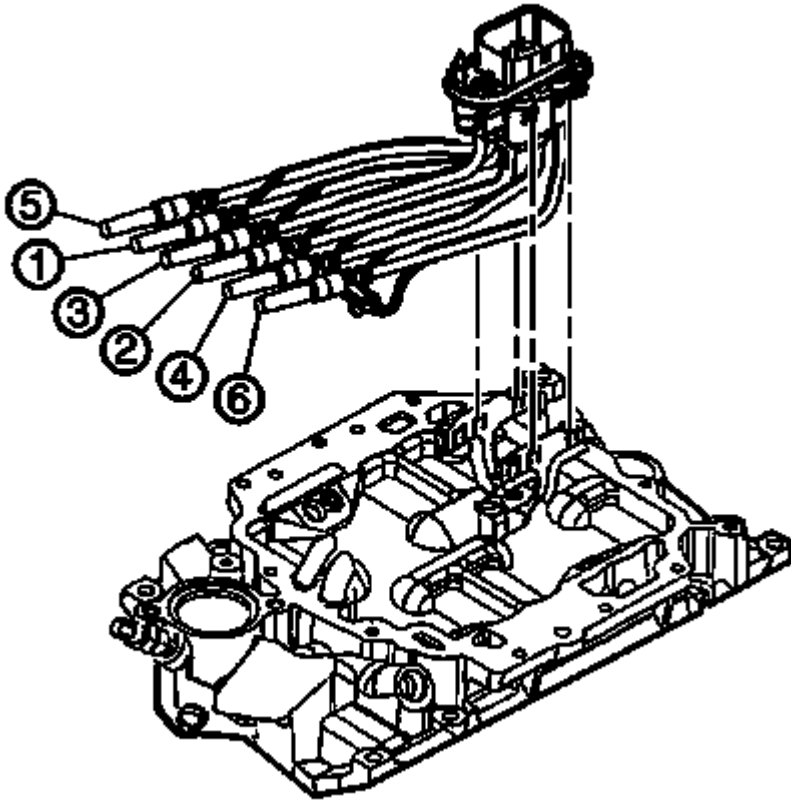


Fig. 427: Removing Injectors From Lower Intake Manifold Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the removal of the fuel injector assembly, the retainers that hold the injectors into the intake manifold may become worn. This is OK. Upon installation of the upper intake manifold, the injectors will be held fully seated, thus keeping them from backing out of the lower intake manifold.

30. Remove the fuel meter body seal and discard.
31. Remove the 6 injectors from the lower intake manifold bores.
32. Remove the fuel meter body.
33. Remove the bolt and the fuel meter body bracket.

Intake Manifold Cleaning and Inspection

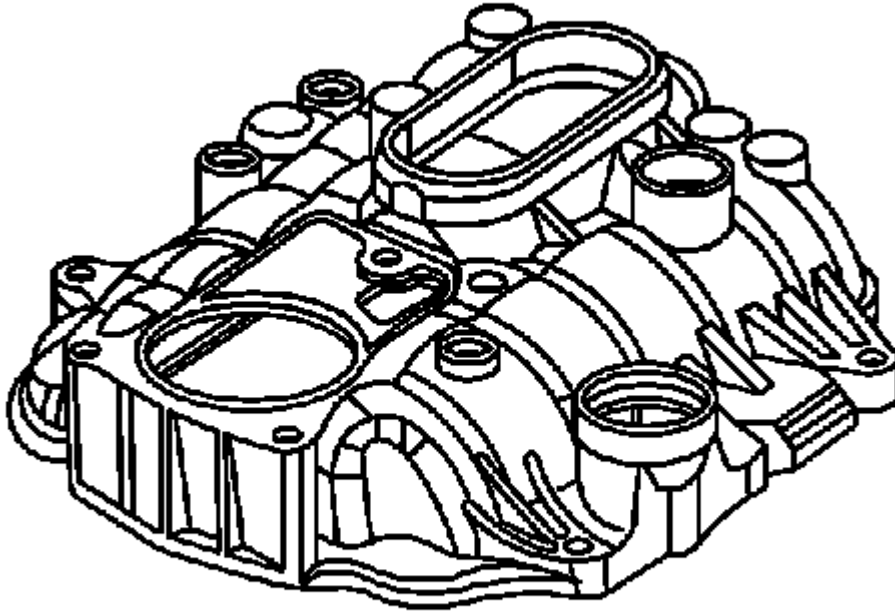


Fig. 428: Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the upper intake manifold in cleaning solvent.
2. Dry the upper intake manifold with compressed air.

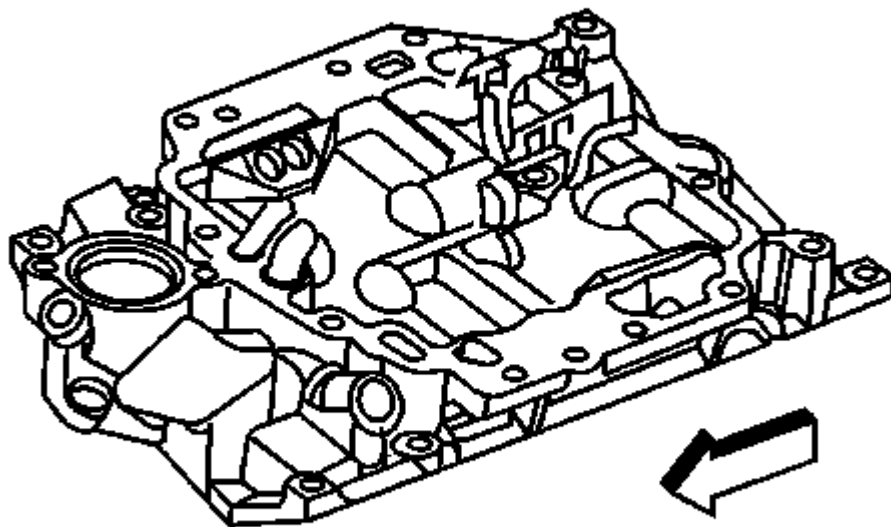


Fig. 429: Lower Intake Manifold
Courtesy of GENERAL MOTORS CORP.

3. Clean the lower intake manifold in cleaning solvent.
4. Dry the lower intake manifold with compressed air.

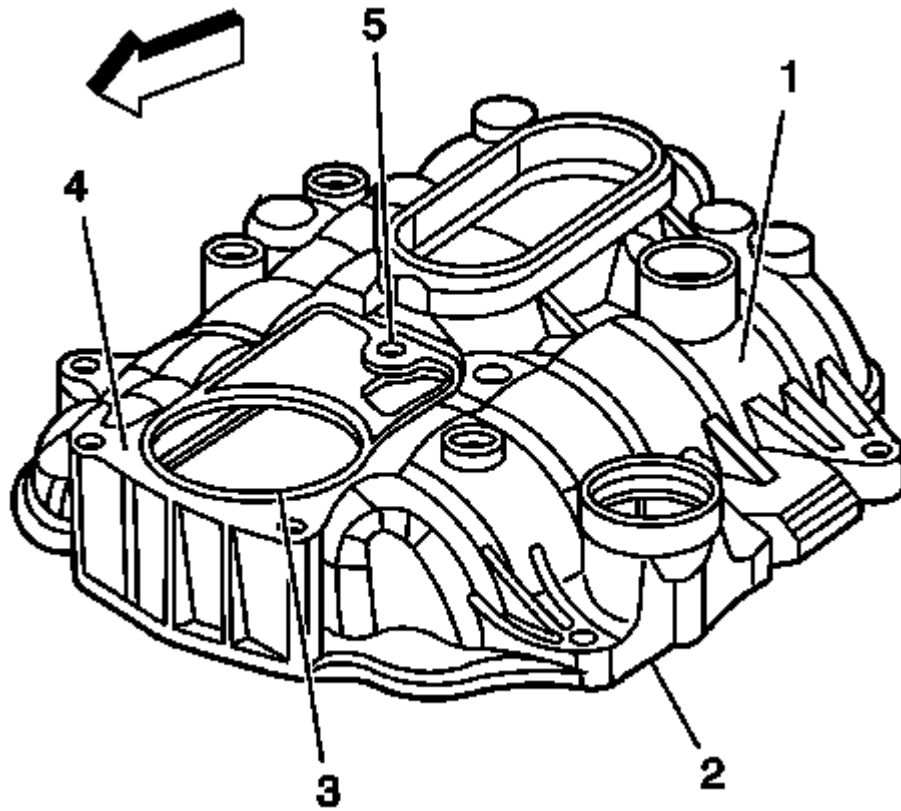


Fig. 430: Upper Intake Manifold Damage
Courtesy of GENERAL MOTORS CORP.

5. Inspect the upper intake manifold for the following:
- Cracks or other damage to the exterior (1)
 - Cracking or damage in the gasket grooves (2) and (3)
 - Damage to the throttle body mounting surface (4)
 - Loose or damaged bolt hole thread inserts (5)

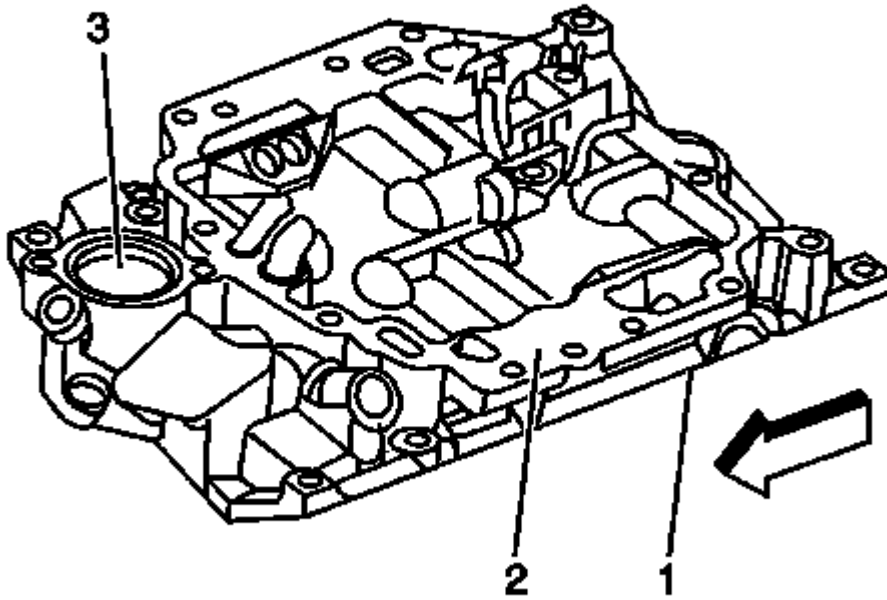


Fig. 431: Lower Intake Manifold Damage
Courtesy of GENERAL MOTORS CORP.

6. Inspect the lower intake manifold for the following:
- Damage to the gasket sealing surfaces (1) and (2)
 - Restricted cooling system passages (3)
 - Cracks or damage
 - Damage to the threaded bolt holes

Intake Manifold Assemble (LU3)

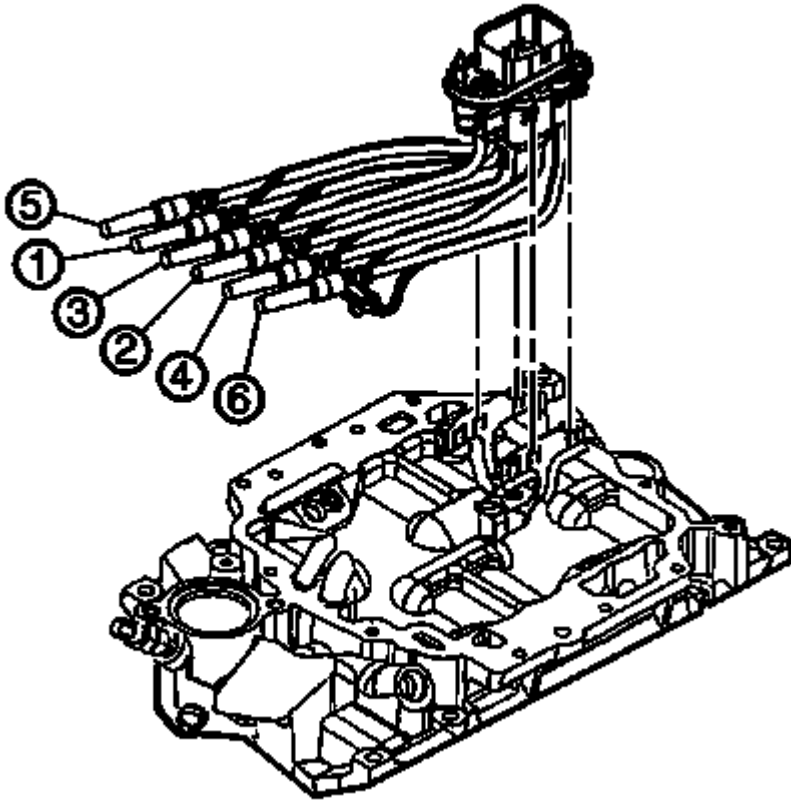


Fig. 432: Removing Injectors From Lower Intake Manifold Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the removal of the fuel injector assembly, the retainers that hold the injectors into the intake manifold may become worn. This is OK. Upon installation of the upper intake manifold, the injectors will be held fully seated, thus keeping them from backing out of the lower intake manifold.

1. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the fuel meter body bracket bolt.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the fuel meter body bracket and bolt.

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

IMPORTANT: All injector lines must face forward as the fuel meter body is snapped into the bracket. Also, the number three fuel tube must be positioned behind the number one fuel tube to eliminate interference with the upper intake manifold when installed.

3. Install the fuel meter body into the fuel meter body bracket.
4. Install the 6 injectors into the proper lower intake manifold bores in proper sequence (3, 5, 1, 2, 4, 6).
5. Inspect the injectors in order to ensure that they are firmly seated and locked in the lower intake manifold bores.
6. Ensure that the electrical connections of the injectors are positioned so that they do not interfere with each other, and are pointing towards the center of the intake manifold. Rotate the electrical connector inboard if necessary. Also, ensure there is no tension on the injector wires.

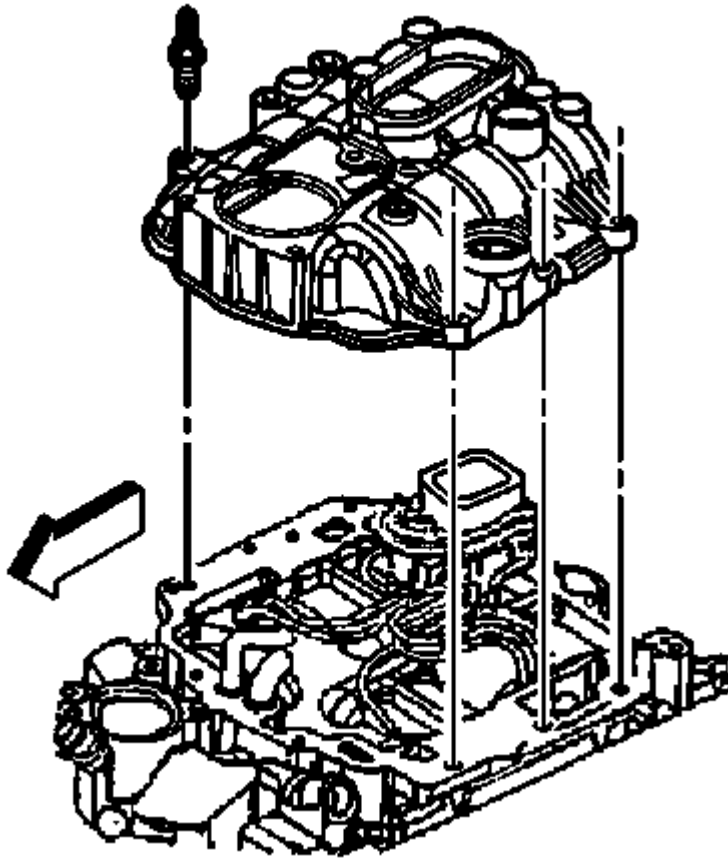


Fig. 433: Installing Upper Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. Install a NEW upper intake manifold to lower intake manifold gasket into the groove of the upper intake manifold.
8. Install the upper intake manifold onto the lower intake manifold.
9. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the upper intake manifold attaching studs.
10. Install the upper intake manifold attaching studs.

Tighten:

1. Tighten the upper intake manifold attaching studs on the first pass to 5 N.m (44 lb in).
2. Tighten the upper intake manifold attaching studs on the final pass to 9 N.m (80 lb in).

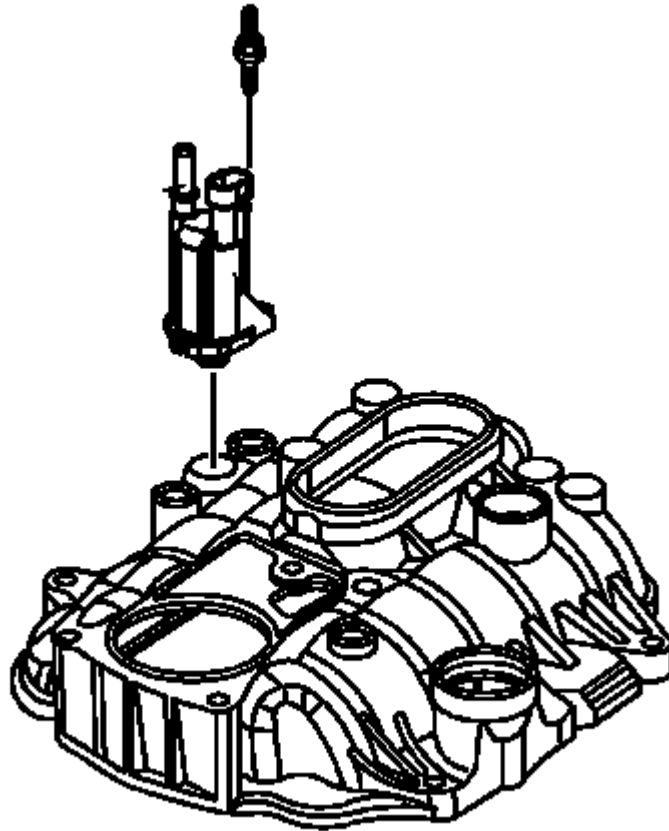


Fig. 434: Purge Solenoid & Nut
Courtesy of GENERAL MOTORS CORP.

11. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the evaporative emission (EVAP) canister purge solenoid valve studs.
12. Install the EVAP canister purge solenoid valve and studs.

Tighten: Tighten the EVAP canister purge solenoid valve studs to 10 N.m (89 lb in).

13. Install the engine wiring harness bracket and nut.

Tighten: Tighten the engine wiring harness bracket nut to 12 N.m (106 lb in).

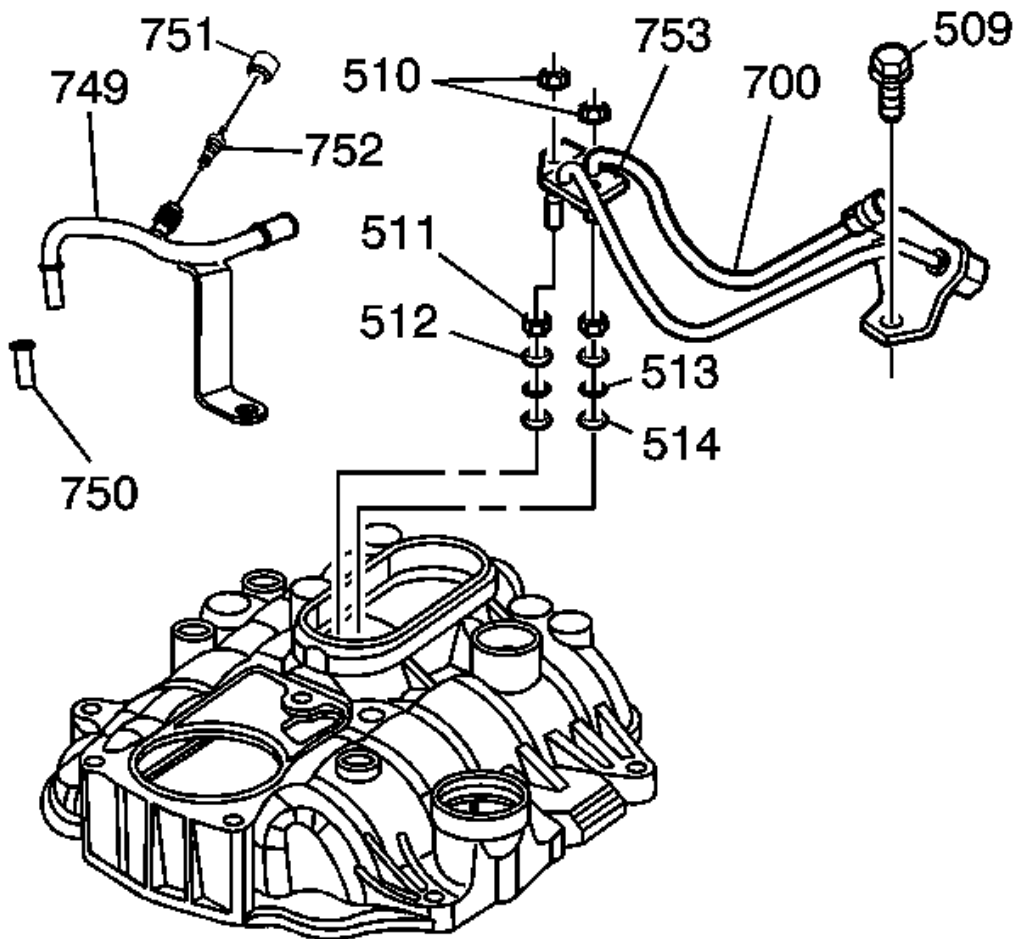


Fig. 435: Fuel Meter Body, Pipes & Brackets
Courtesy of GENERAL MOTORS CORP.

14. Install the NEW fuel seals (514), black O-rings, into the fuel meter body.
15. Install the NEW spacer rings (513), flat washers, into the fuel meter body.
16. Install the NEW fuel seals (512), yellow O-rings, into the fuel meter body.
17. Install the NEW fuel seal retainers (511) into the fuel meter body.
18. Install the fuel pipe plug (750), if required.
19. Install the fuel pipe (700, 749) into the fuel meter body.
20. Install the fuel pipe retainer bracket (753) onto the fuel pipe.
21. Install the fuel pipe retainer bracket nuts (510).
22. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to

the threads of the fuel pipe bolt.

23. Install the fuel service port cap (751) and Schrader valve (752), if required.
24. Install the fuel pipe bolt (509).

Tighten:

1. Tighten the fuel pipe bracket nuts to 3 N.m (27 lb in).
2. Tighten the fuel pipe bolt to 6 N.m (53 lb in).

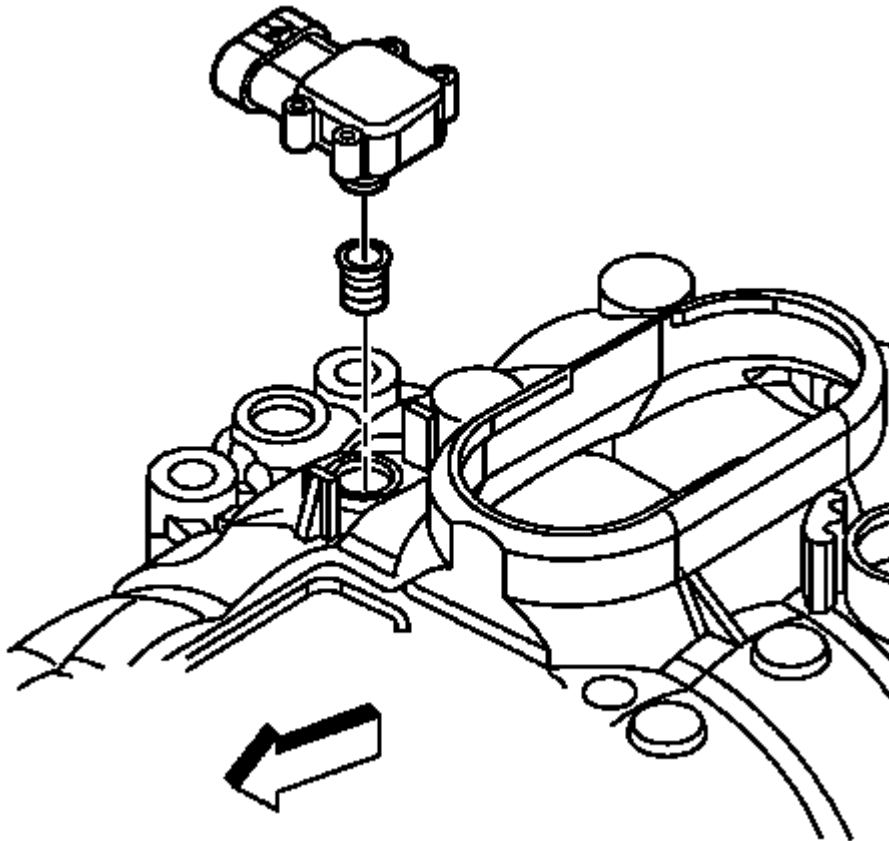


Fig. 436: Removing MAP Sensor
Courtesy of GENERAL MOTORS CORP.

25. Install a NEW manifold absolute pressure (MAP) sensor seal onto the MAP sensor.
26. Apply a small amount, approximately 1 drop, of clean engine oil to the MAP sensor seal.
27. Install the MAP sensor into the upper intake manifold.

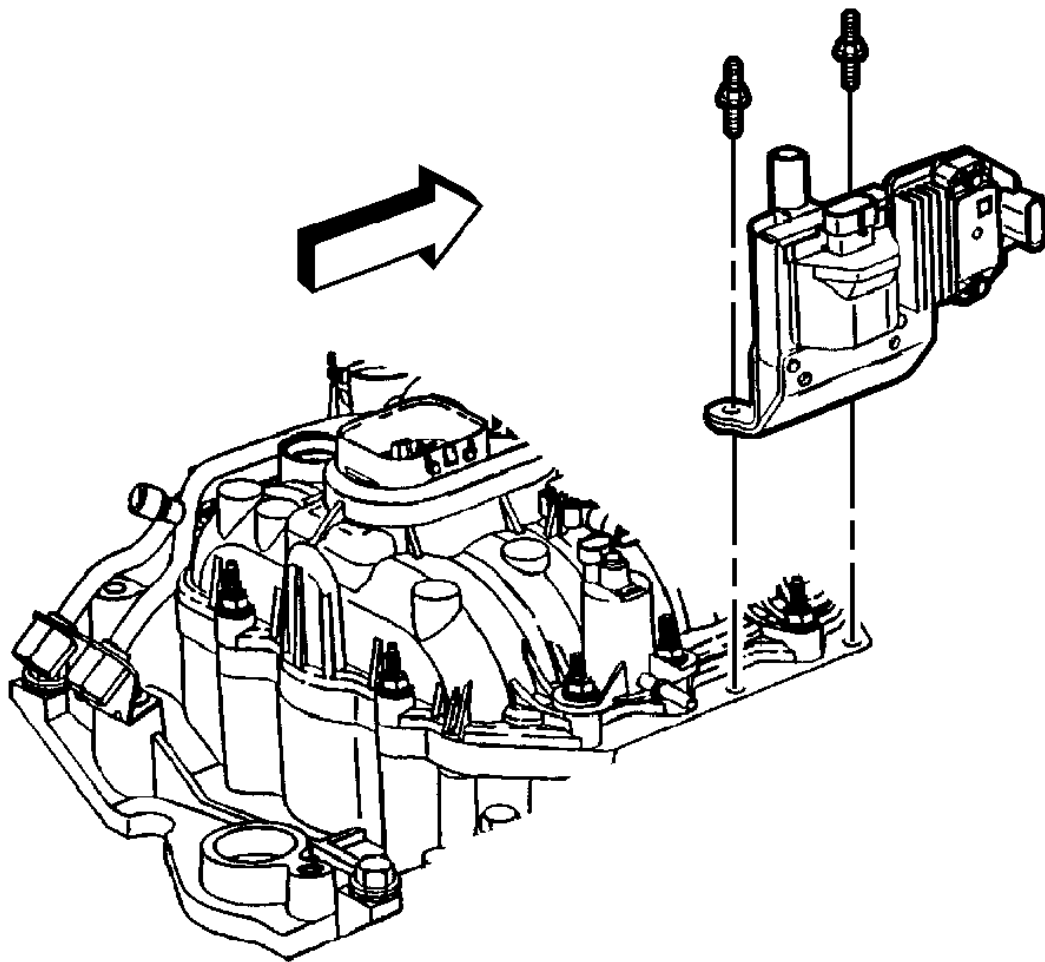


Fig. 437: Removing Ignition Coil & Studs
Courtesy of GENERAL MOTORS CORP.

28. Install the ignition coil and studs.

Tighten: Tighten the ignition coil studs to 12 N.m (106 lb in).

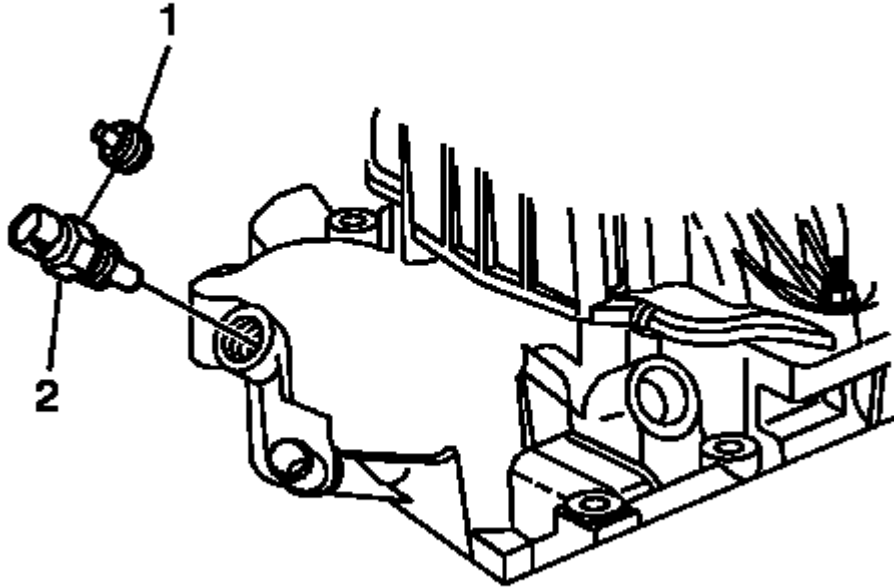


Fig. 438: ECT Sensor & Plug

Courtesy of GENERAL MOTORS CORP.

29. If reusing the engine coolant temperature (ECT) sensor plug (1) or the ECT sensor (2), if equipped, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the ECT sensor plug (1) or the ECT sensor (2).
30. Install the ECT sensor or plug, if equipped, into the front of the lower intake manifold.

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

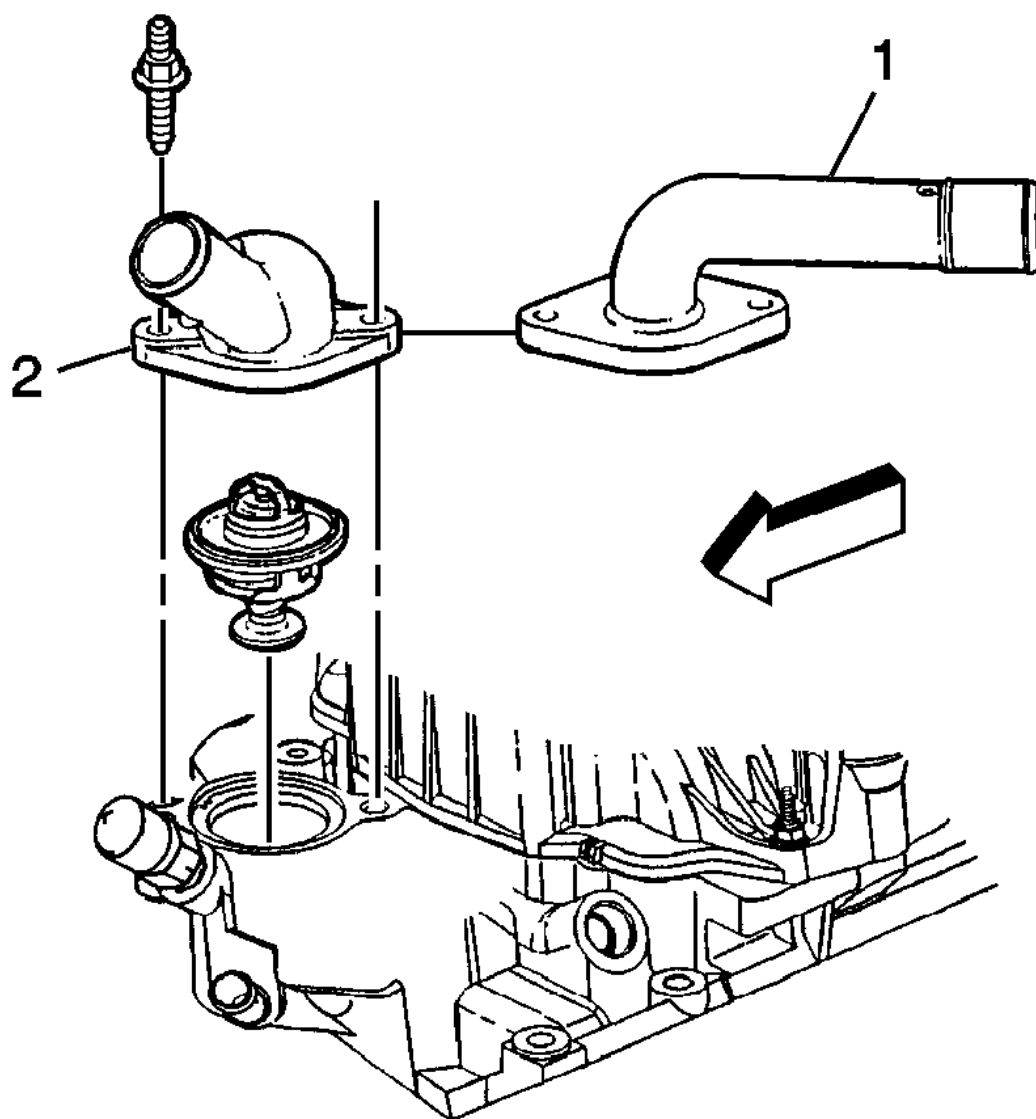


Fig. 439: Removing Water Outlet
Courtesy of GENERAL MOTORS CORP.

31. Install the engine coolant thermostat.
32. Install the water outlet (1 or 2).
33. Install the water outlet studs.

Tighten: Tighten the water outlet studs to 25 N.m (18 lb ft).

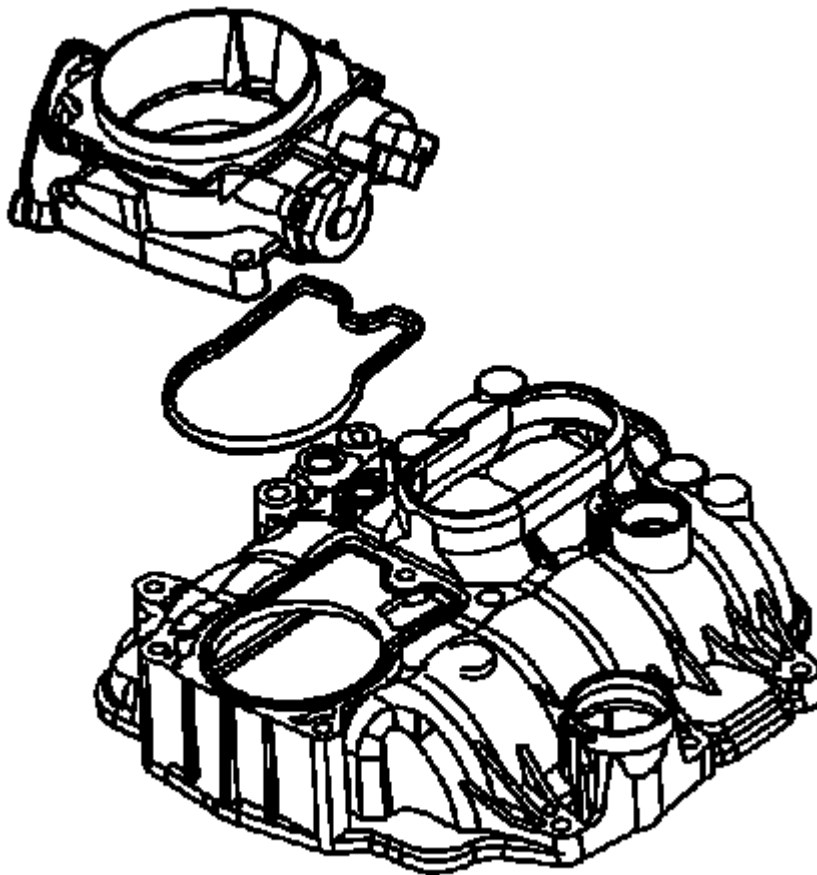


Fig. 440: View Of Throttle Body & Gasket
Courtesy of GENERAL MOTORS CORP.

34. Install a NEW throttle body gasket into the groove in the upper intake manifold.
35. Install the throttle body onto the upper intake manifold.

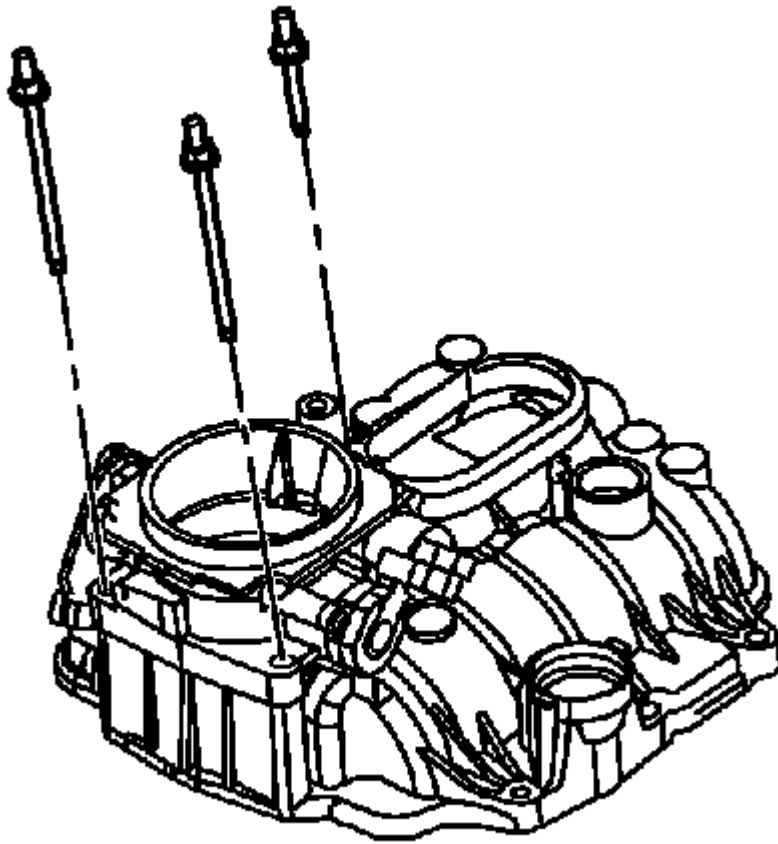


Fig. 441: View Of Throttle Body & Attaching Studs
Courtesy of GENERAL MOTORS CORP.

36. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the throttle body attaching studs.
37. Install the throttle body attaching studs.

Tighten: Tighten the throttle body attaching studs to 9 N.m (80 lb in).

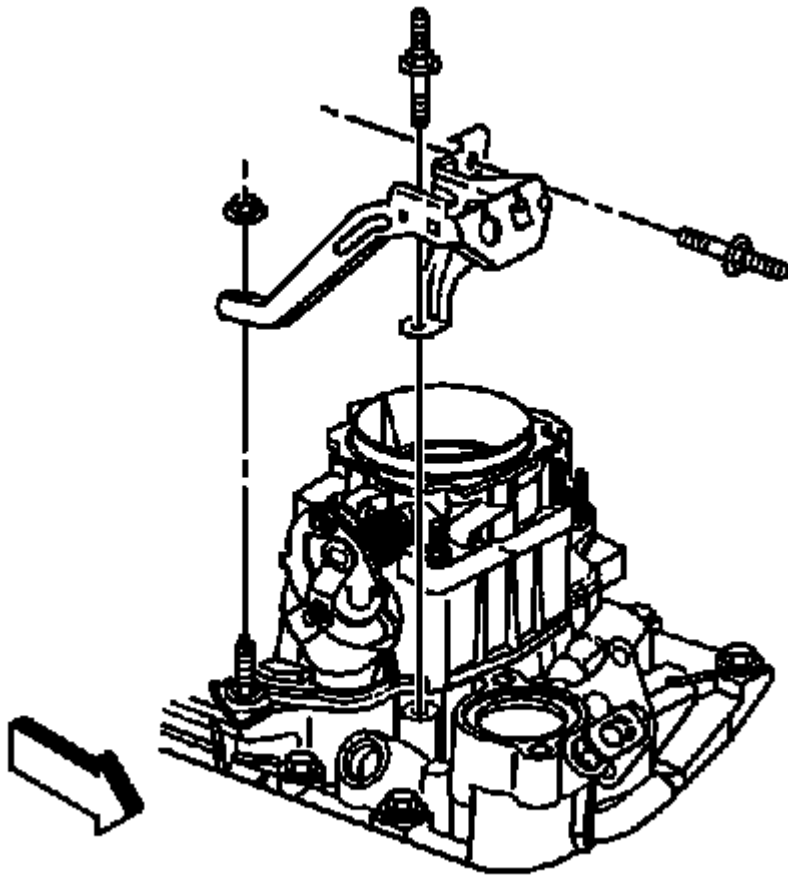


Fig. 442: Removing Accelerator Control Cable Bracket
Courtesy of GENERAL MOTORS CORP.

38. Install the accelerator control cable bracket, the studs, and the nuts.

Tighten:

1. Tighten the accelerator control cable bracket stud to the intake manifold to 6 N.m (53 lb in).
2. Tighten the accelerator control cable bracket nuts to 12 N.m (106 lb in).
3. Tighten the accelerator control cable bracket stud to the throttle body to 12 N.m (106 lb in).

Exhaust Manifold Cleaning and Inspection

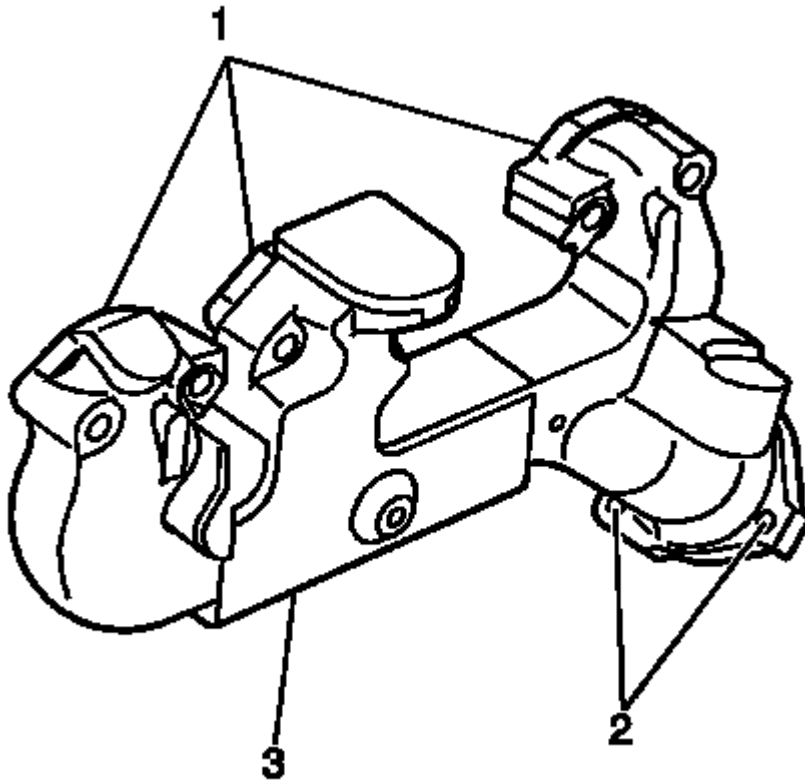


Fig. 443: Exhaust Manifold Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the exhaust manifolds in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
 - Damage to the gasket sealing surfaces (1)
 - Damage to the threaded holes (2)
 - Restrictions within exhaust passages
 - Broken or damaged exhaust manifold heat shields (3), if applicable
 - Broken or damaged exhaust manifold

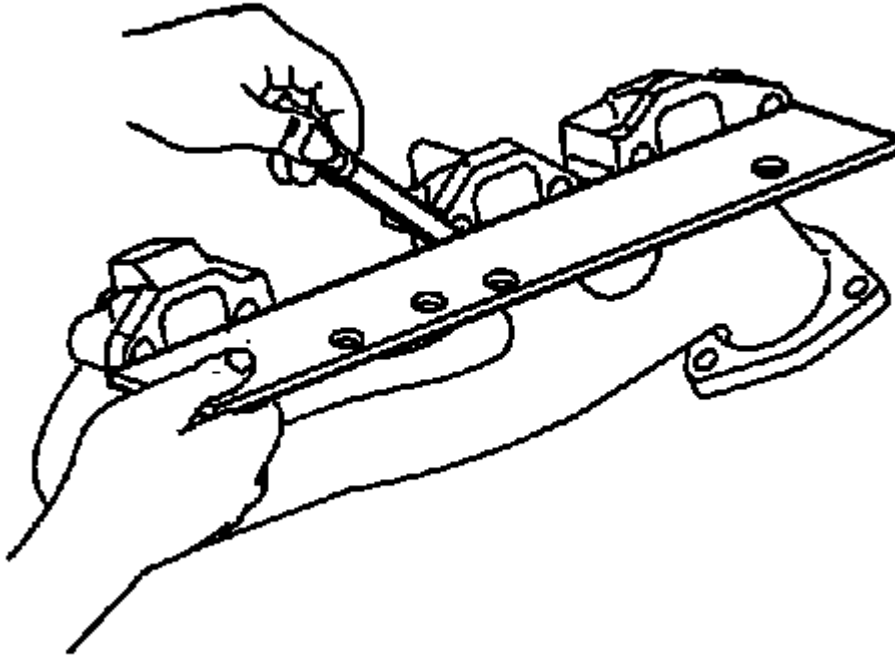


Fig. 444: Measuring Exhaust Manifold Flanges Alignment
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges using a straight edge and a feeler gage. Refer to **Engine Mechanical Specifications**.

If the surface flatness is not within the specifications, the exhaust manifold is warped and must be replaced.

Water Pump Cleaning and Inspection

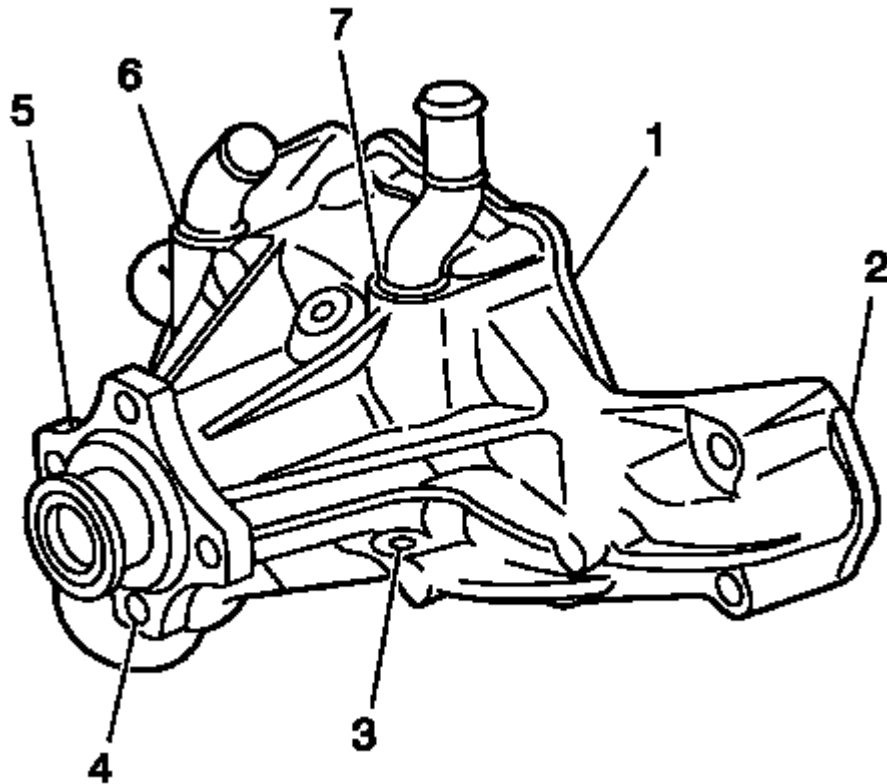


Fig. 445: Water Pump Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all the dirt and any debris from the water pump.
3. Inspect the water pump for the following:
 - Leakage or damage to the housing cover or gasket (1)
 - Excessive scratches or gouging to the gasket sealing surfaces (2)
 - Leakage from the water pump vent hole (3)

A stain around the vent hole is acceptable. If leakage occurred (dripping) with the engine operating and the cooling system pressurized, then replace the water pump.

- Damaged bolt hole threads (4)
- Excessive side-to-side movement of the water pump shaft (5)
- Leakage around the water inlet pipe (6)
- Leakage around the heater hose pipe (7)

- Restrictions within the internal coolant passages

Thread Repair

General purpose thread repair kits are available commercially.

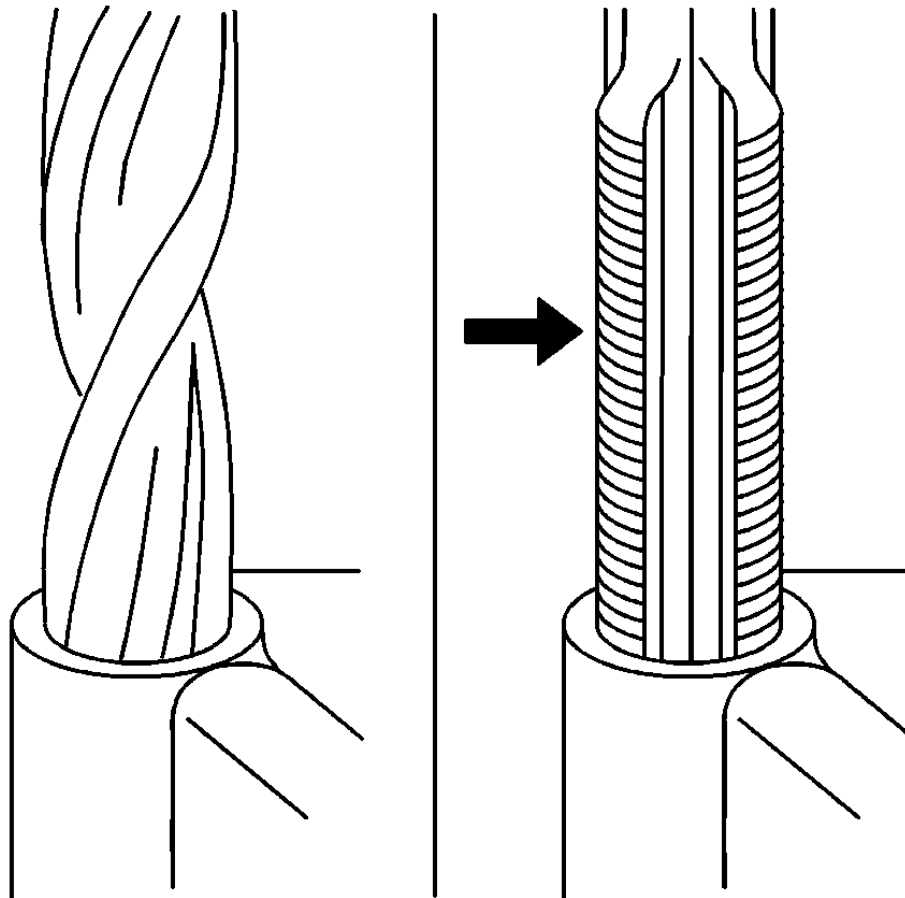


Fig. 446: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

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.

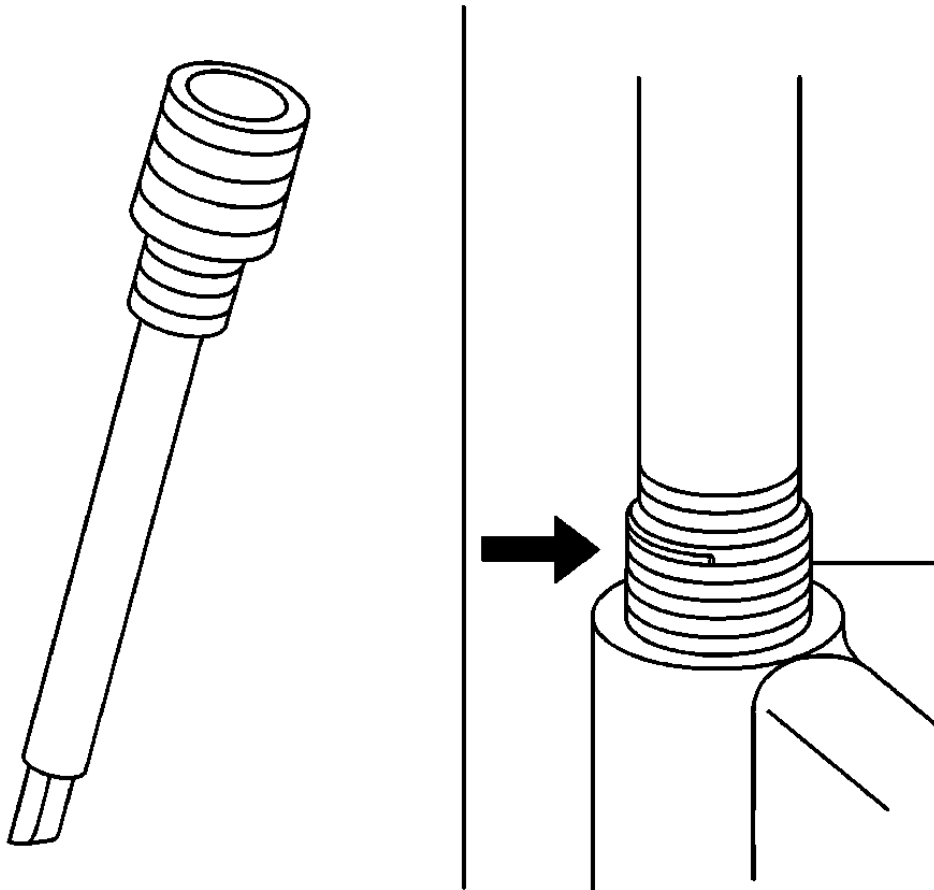


Fig. 447: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

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 the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are re-installed into an engine, return the components to the original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil, unless otherwise specified. The engine oil will provide the initial lubrication when the engine is first started.

Engine Block Plug Installation**Tools Required**

J 41712 Oil Pressure Switch Socket. See **Special Tools**.

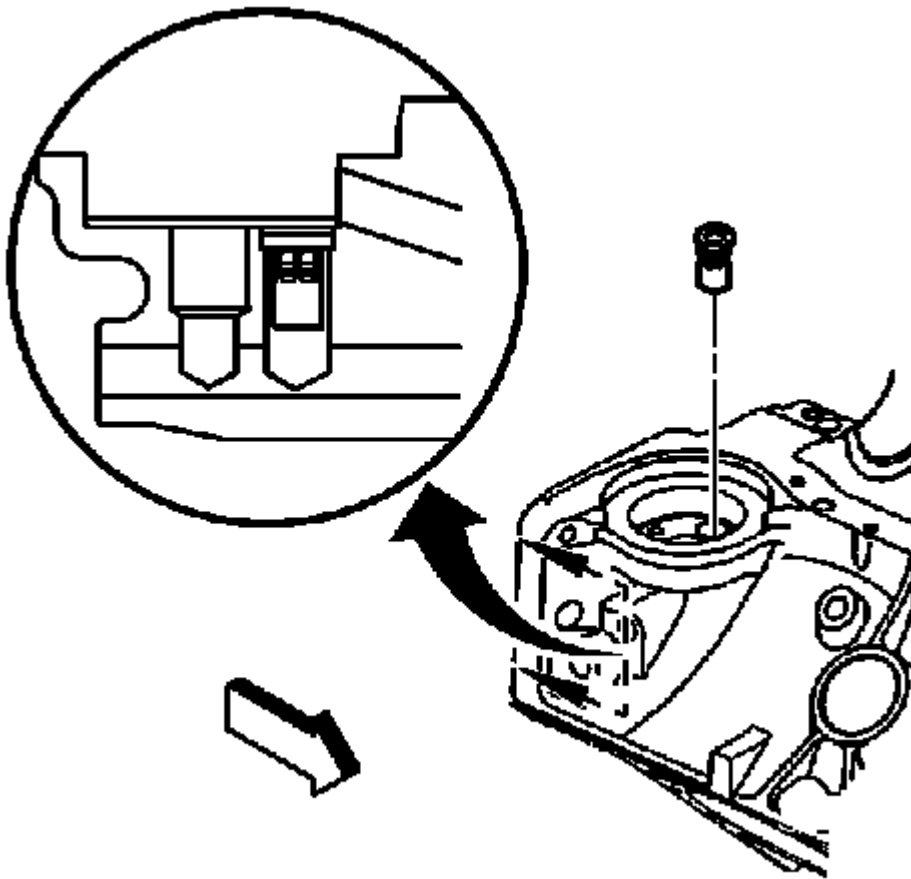


Fig. 448: Installing Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

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

1. Install a NEW oil filter bypass valve.
 1. Install the oil filter bypass valve into the oil gallery bore until slightly below flush with the surface of the engine block.
 2. Using a pointed punch, stake the engine block area around the oil filter bypass valve.

Stake in 3 locations 120 degrees apart.

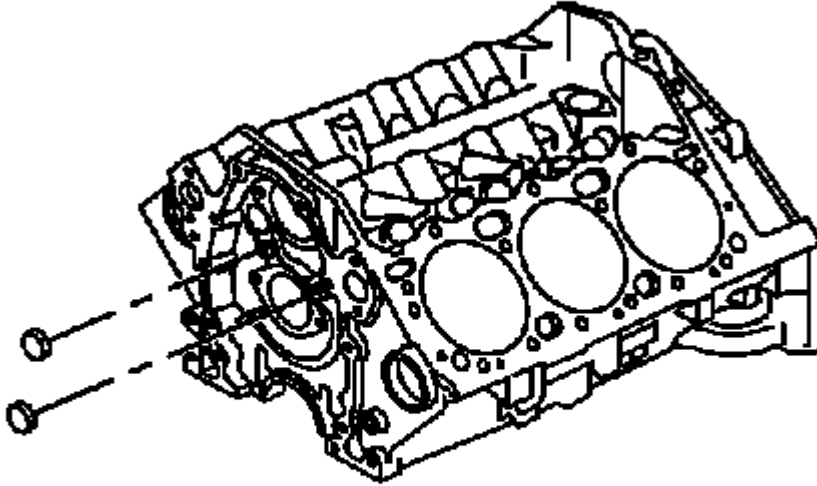


Fig. 449: Removing Front Oil Gallery Plugs From Engine Block
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW front engine oil gallery plugs.
3. Install the NEW front engine block oil gallery plugs.

A properly installed front engine oil gallery plug must be installed slightly below flush with the front face of the engine block.

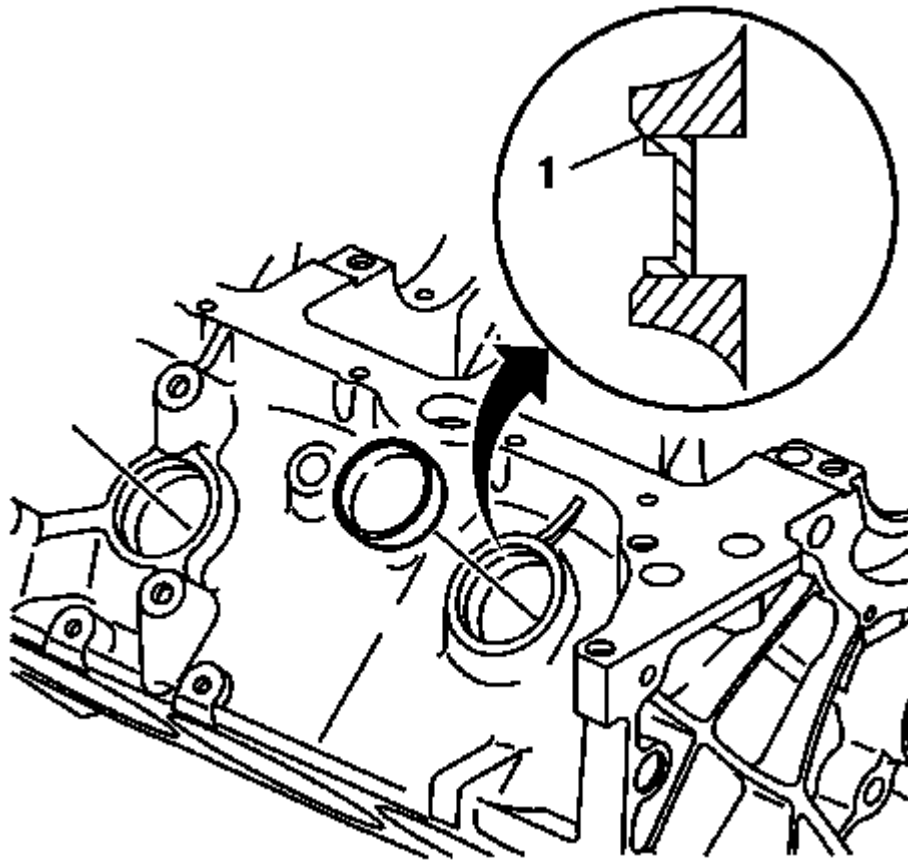


Fig. 450: Engine Block Core Hole Chamfer
Courtesy of GENERAL MOTORS CORP.

4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the outside diameter of the NEW engine block core hole plugs.
5. Install the NEW engine block core hole plugs.

A properly installed engine block core hole plug must be installed flush or below the bottom of the chamfer (1) of the engine block core hole.

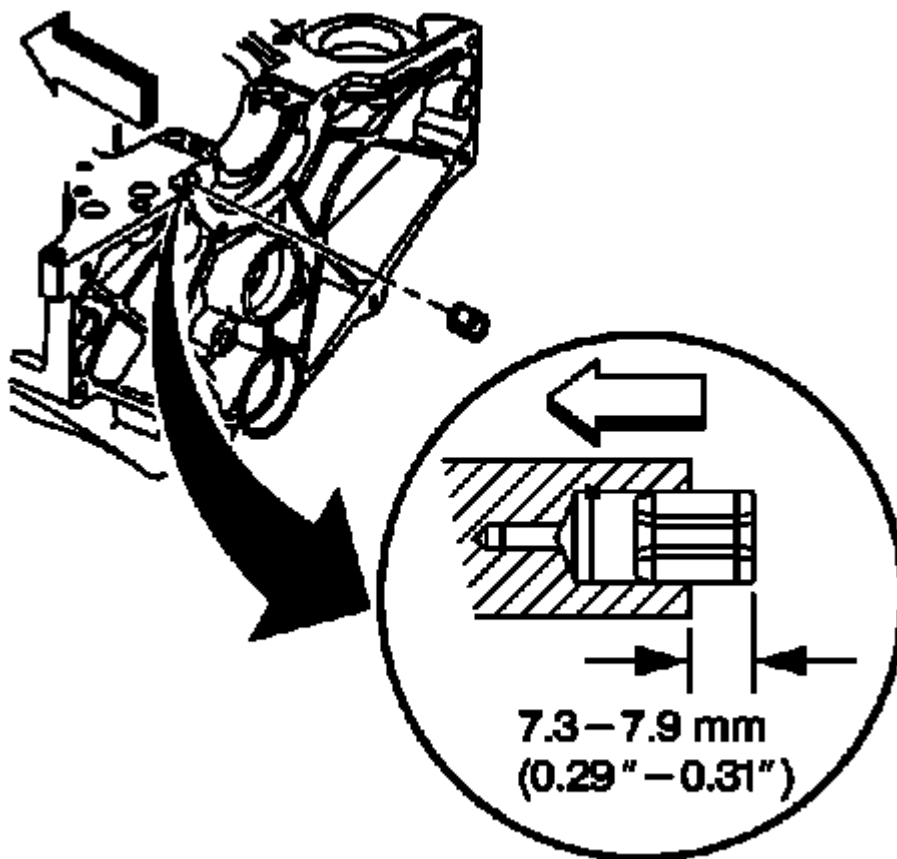


Fig. 451: Installing Crankshaft Rear Oil Seal Housing Locator Spring
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft rear oil seal housing locator spring type S pin, if required.

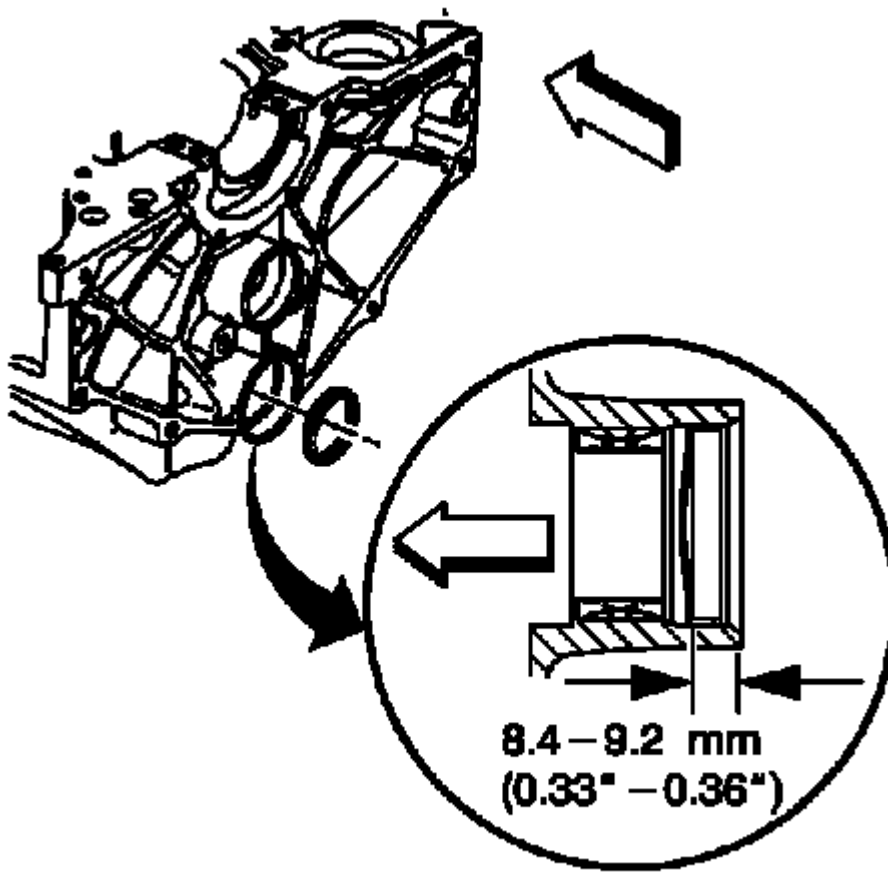


Fig. 452: Installing Expansion Cup Plug Into Balance Shaft Rear Bearing Bole
 Courtesy of GENERAL MOTORS CORP.

7. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW expansion cup plug.
8. Install the NEW expansion cup plug into the balance shaft rear bearing hole.

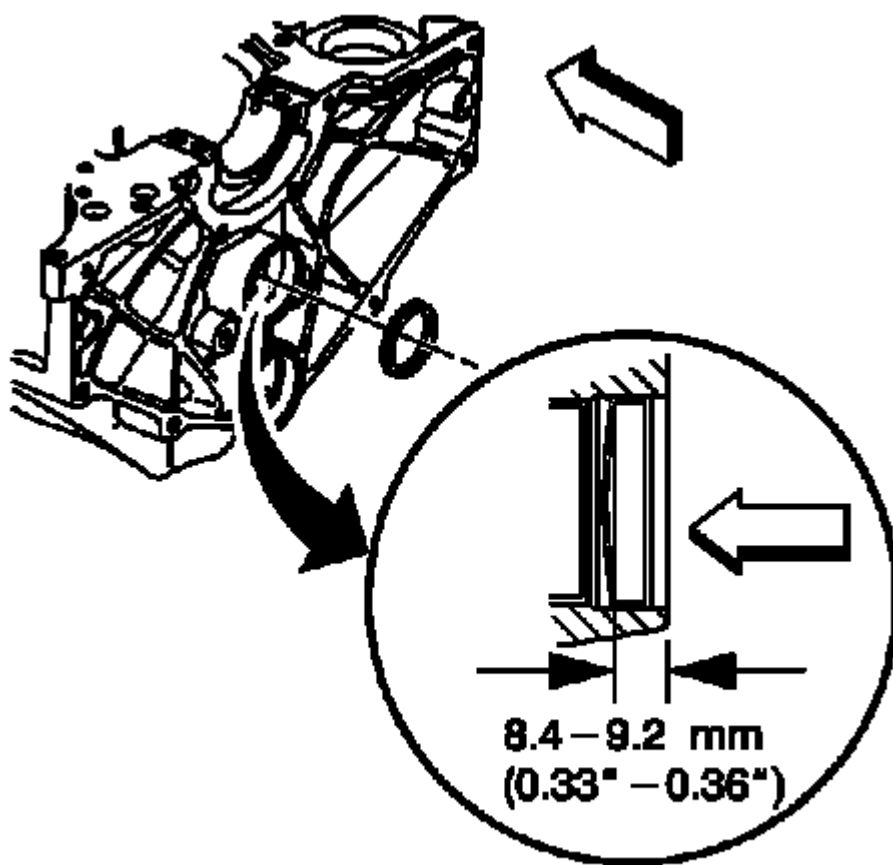


Fig. 453: Installing Expansion Cup Plug Into Camshaft Rear Bearing Hole
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the outside diameter of the NEW expansion cup plug.
10. Install the NEW expansion cup plug into the camshaft rear bearing hole.

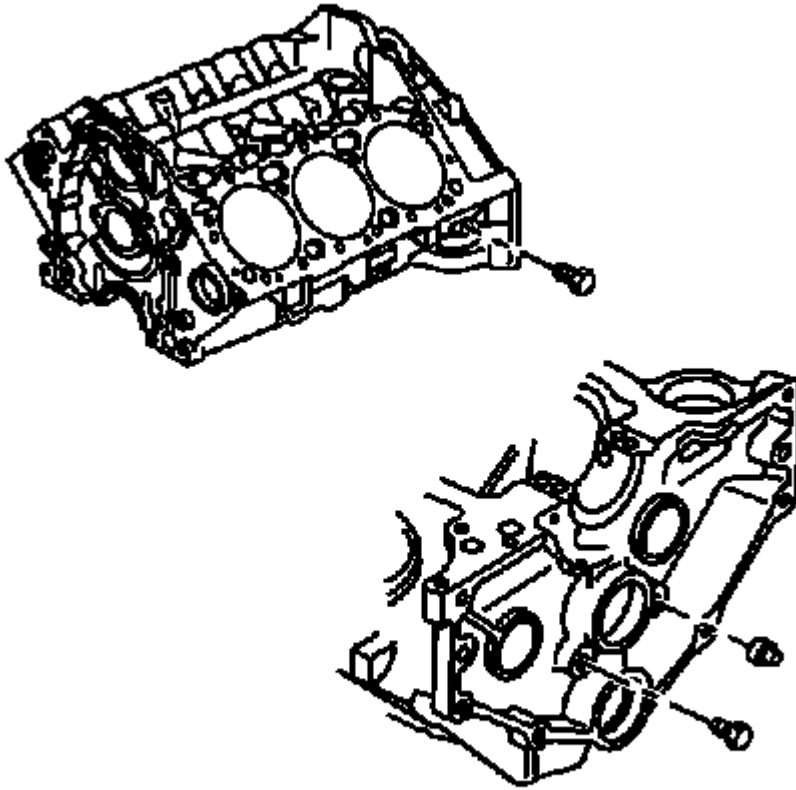


Fig. 454: Removing Engine Block Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

11. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

NOTE: Refer to Fastener Notice in Cautions and Notices.

12. Install the engine block right rear oil gallery plug, the engine block left rear oil gallery plug, and the engine block left side oil gallery plug.

Tighten:

- Tighten the engine block left side oil gallery plug and the engine block right rear oil gallery plug to 20 N.m (15 lb ft).
- Tighten the engine block left rear oil gallery plug to 30 N.m (22 lb ft).

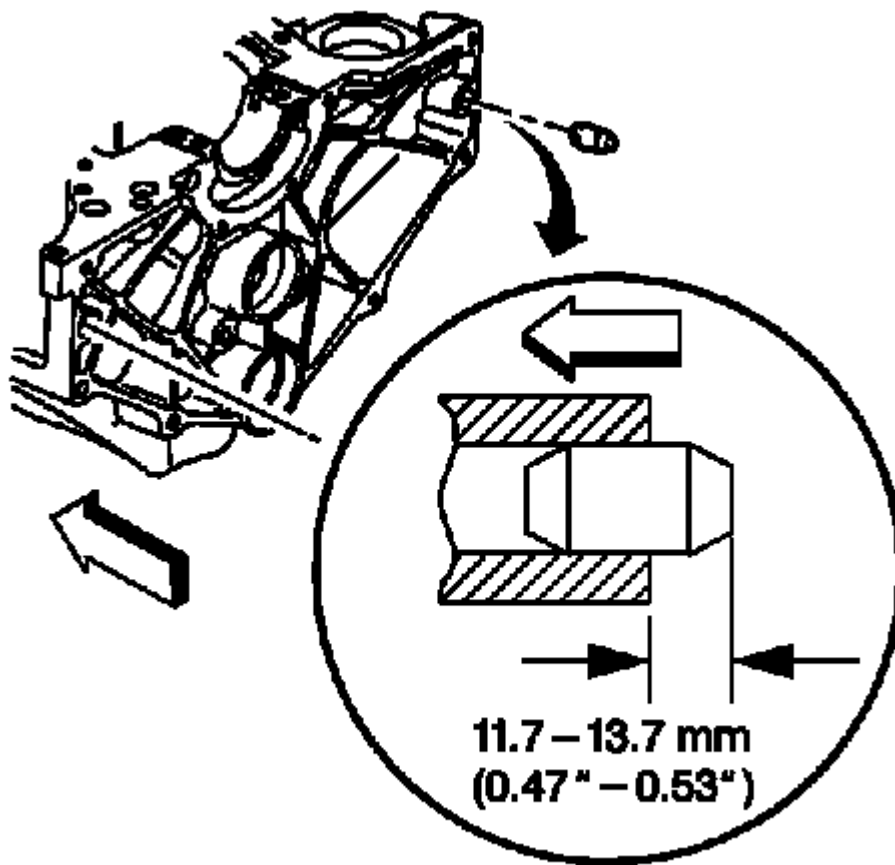


Fig. 455: Installing Transmission Locator Dowel Straight Pins
Courtesy of GENERAL MOTORS CORP.

13. Install the transmission locator dowel straight pins, if required.

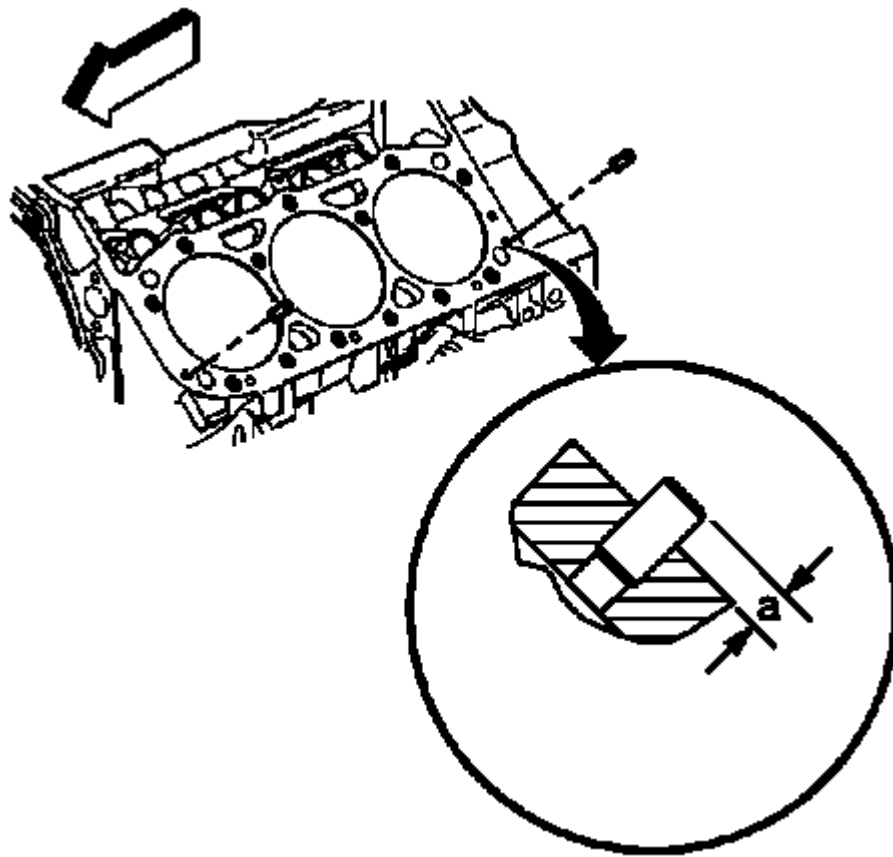


Fig. 456: Left Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

14. Install the left side cylinder head locator dowel pins, if required.

The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

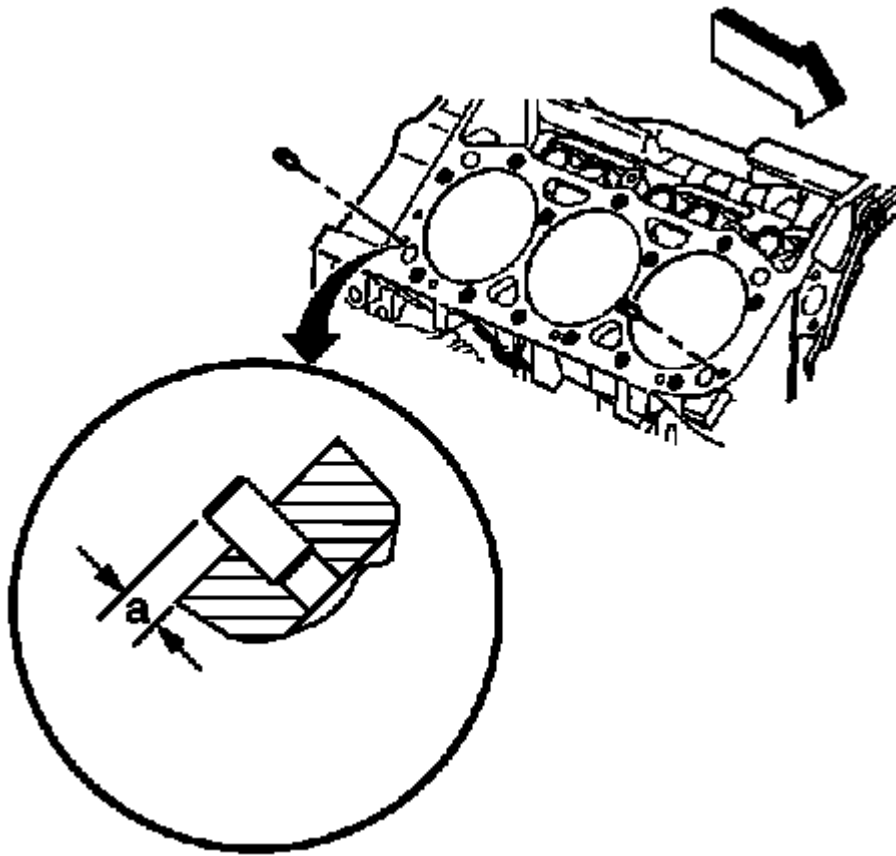


Fig. 457: Right Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

15. Install the right side cylinder head locator dowel pins, if required.

The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

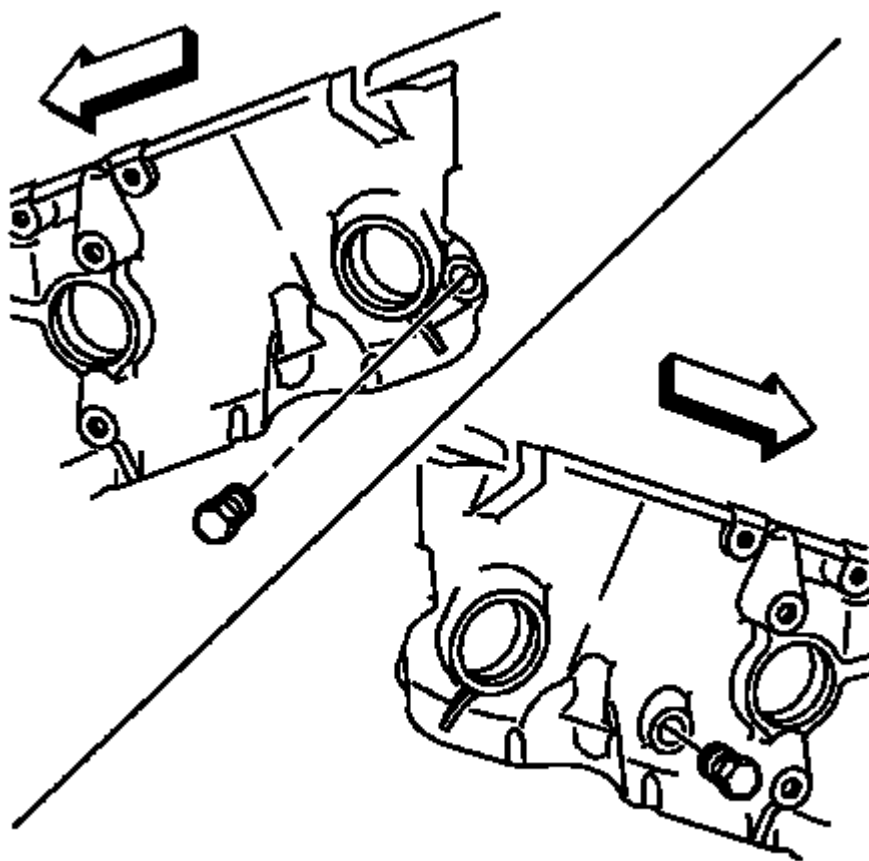


Fig. 458: Removing Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS CORP.

16. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine block coolant drain hole plugs.
17. Install the engine block coolant drain hole plugs.

Tighten: Tighten the engine block coolant hole plugs to 20 N.m (15 lb ft).

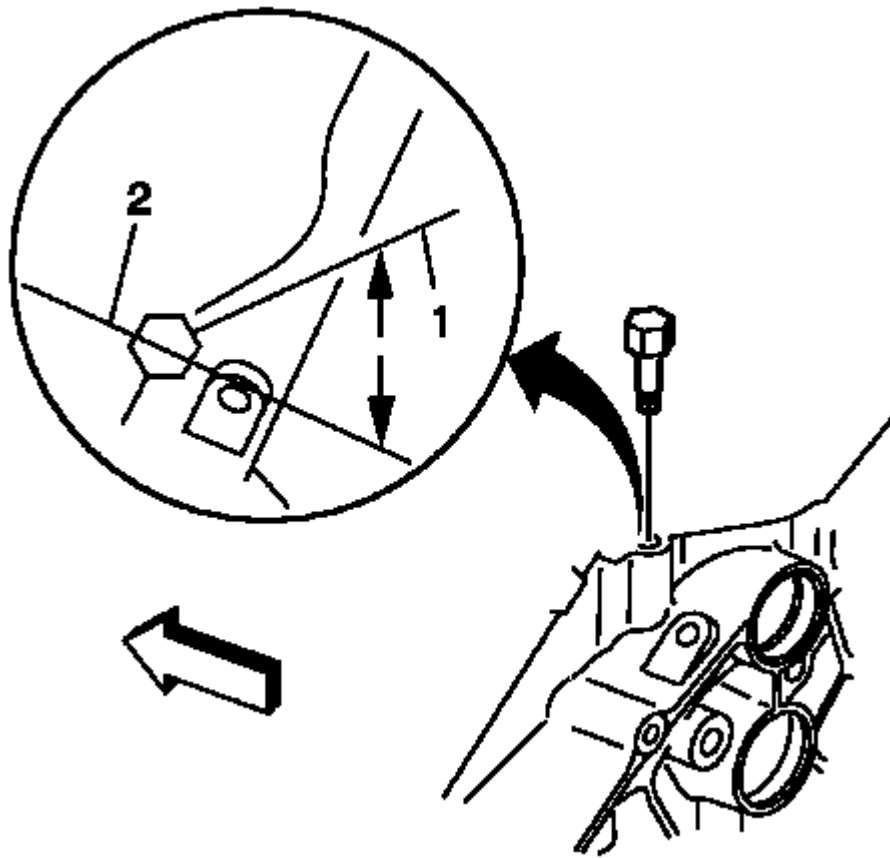


Fig. 459: Engine Oil Pressure Sensor Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

18. If reusing the engine oil pressure sensor fitting, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine oil pressure sensor fitting.

IMPORTANT: Do not loosen the engine oil pressure fitting after the initial torque has been obtained.

19. Install the engine oil pressure sensor fitting.

Tighten: Tighten the engine oil pressure sensor fitting to 15 N.m (11 lb ft).

IMPORTANT: Do not rotate the engine oil pressure fitting clockwise more than 359 degrees after the initial torque has been obtained.

20. Rotate the engine oil pressure sensor fitting clockwise to the proper position (1), 50 degrees from the centerline (2).

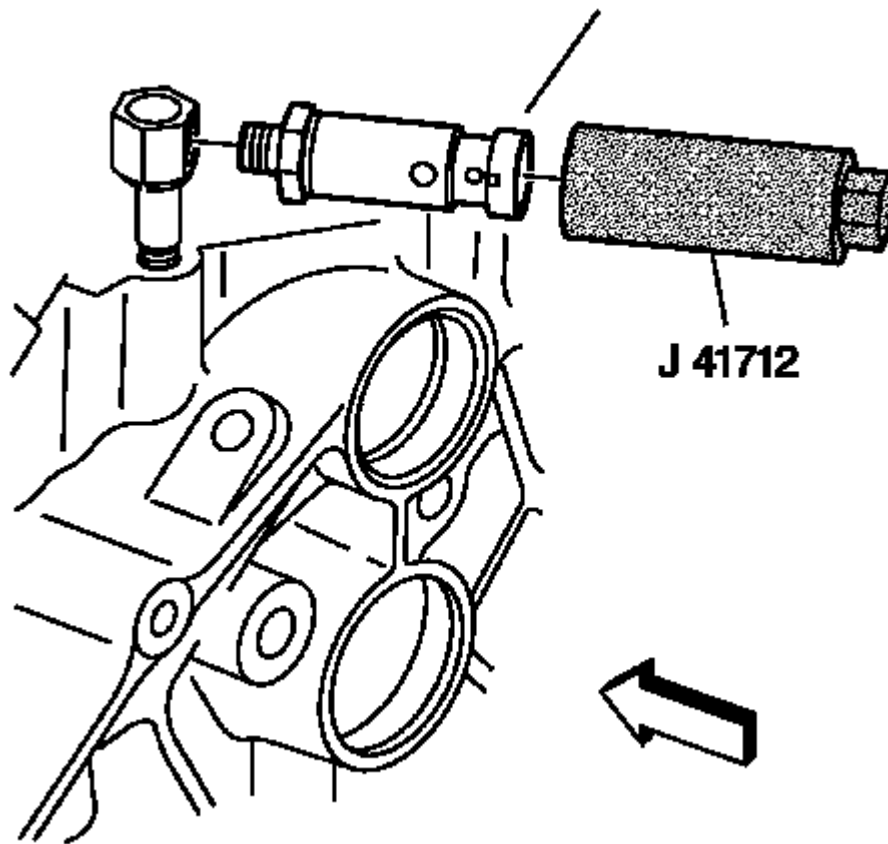


Fig. 460: Removing Engine Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

21. If reusing the engine oil pressure gage sensor, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine oil pressure gage sensor.
22. Install the engine oil pressure gage sensor using the **J 41712** . See **Special Tools**.

Tighten: Tighten the engine oil pressure gage sensor to 30 N.m (22 lb ft).

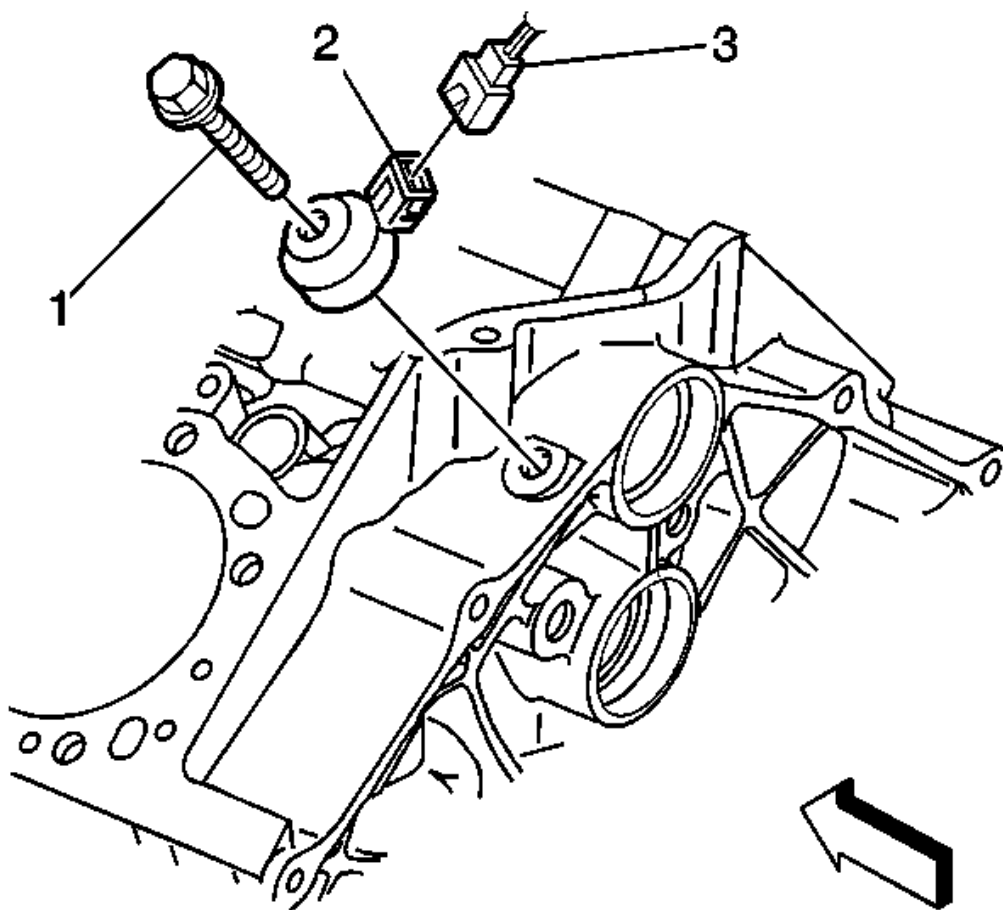


Fig. 461: Locating Knock Sensor & Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

23. Install the knock sensor (2).
24. Install the knock sensor retaining bolt (1).

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

Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter. See Special Tools.

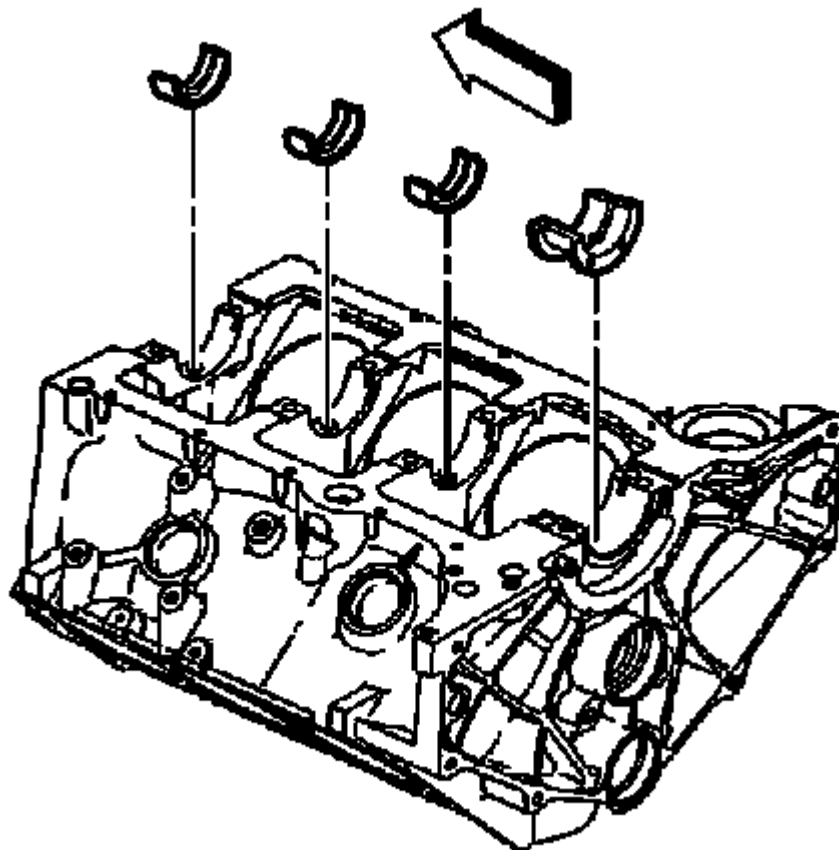


Fig. 462: View Of Crankshaft Bearings At Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil to the crankshaft bearings.

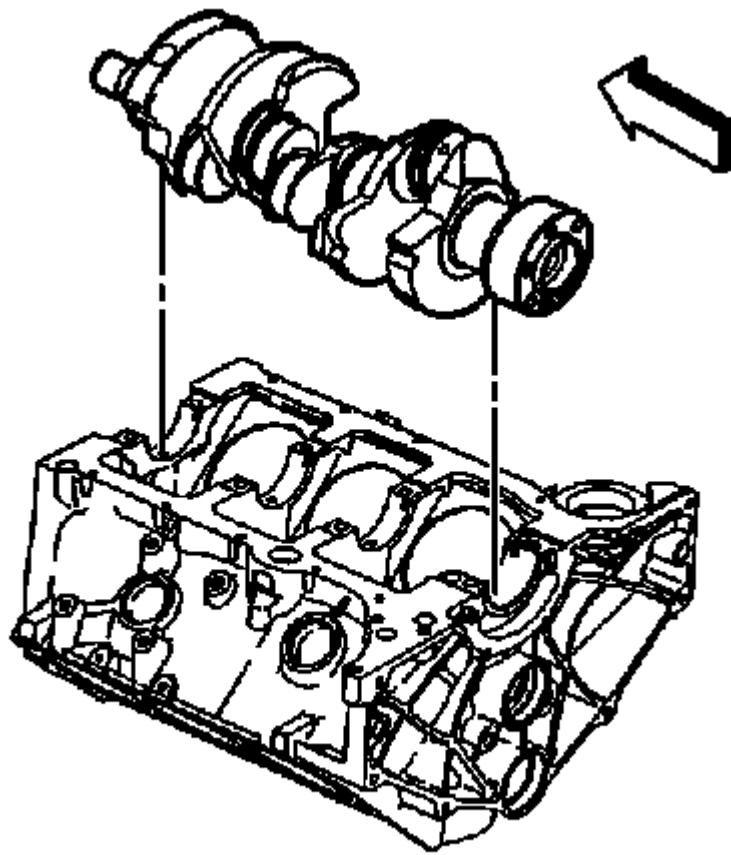


Fig. 463: Removing Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Apply clean engine oil to the crankshaft bearing journals.
4. Install the crankshaft.

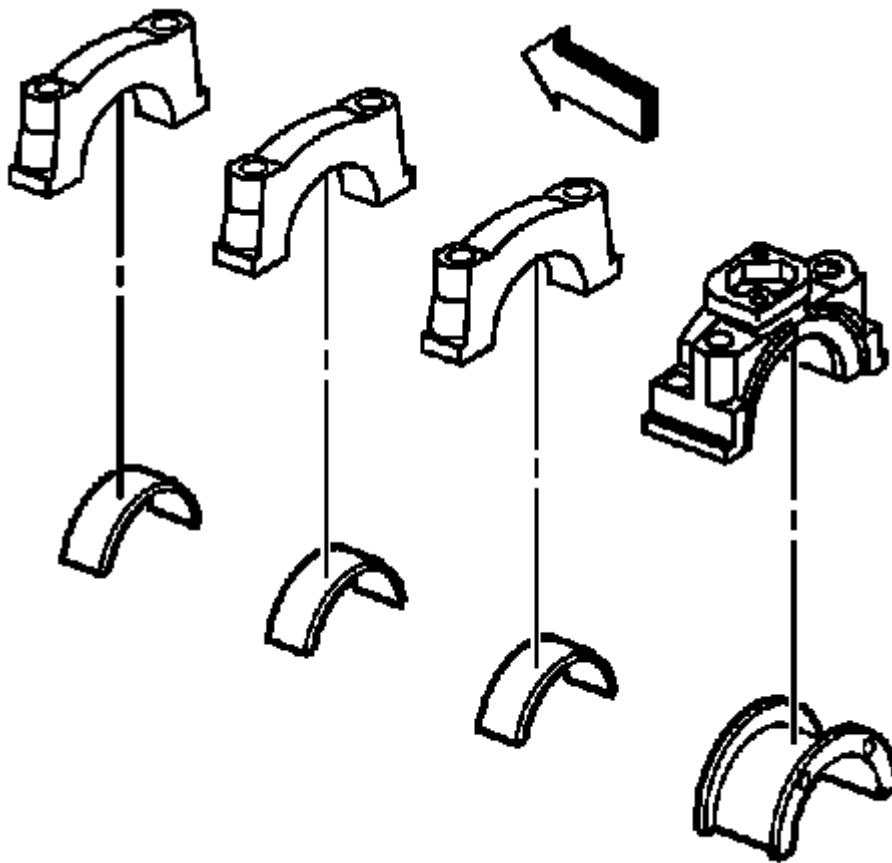


Fig. 464: Removing Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil to the crankshaft bearings.

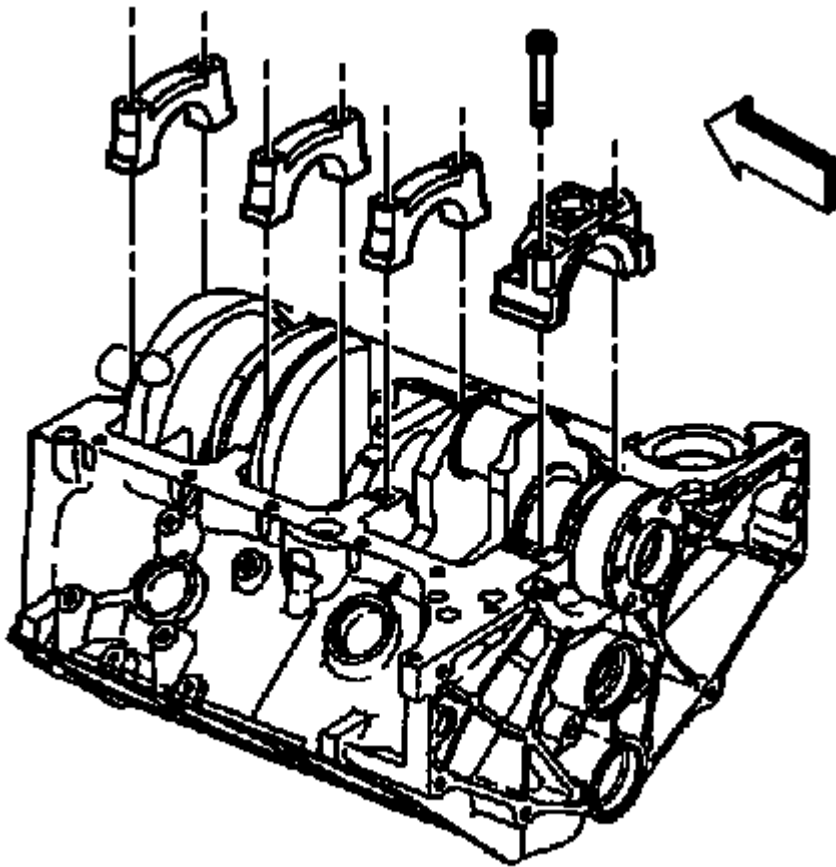


Fig. 465: Removing Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft bearing caps in the original position and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
8. Install the NEW crankshaft bearing cap bolts until snug.
9. Thrust the crankshaft rearward in order to set and align the crankshaft thrust bearings and the crankshaft bearing caps.
10. Thrust the crankshaft forward in order to align the rear faces of the crankshaft thrust bearings.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Tighten the crankshaft bearing cap bolts.

Tighten:

1. Tighten the crankshaft bearing cap bolts on the first pass to 20 N.m (15 lb ft).
2. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the **J 45059** . See Special Tools.

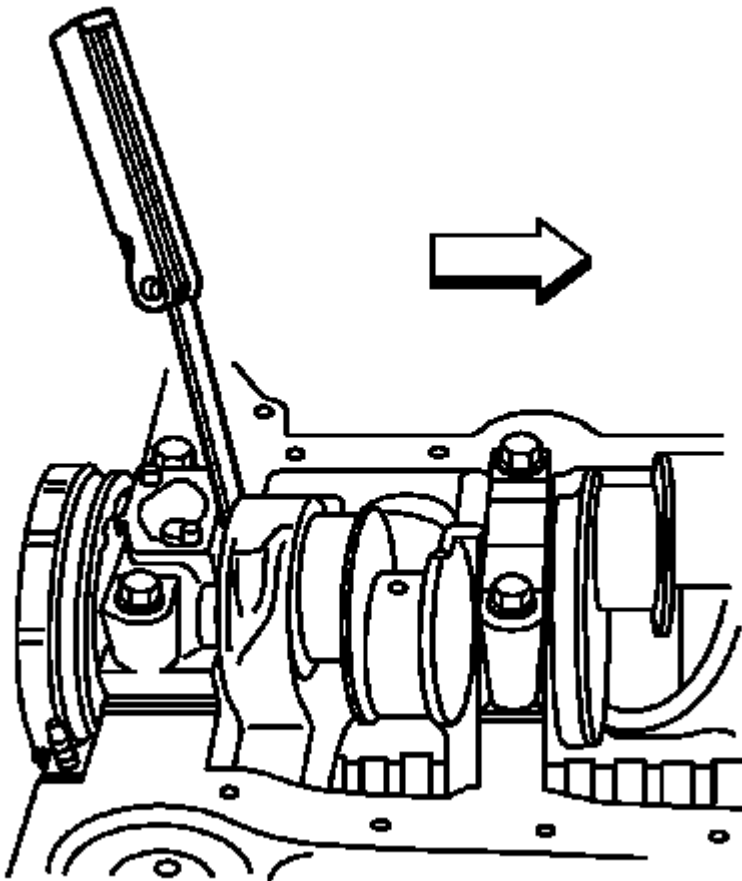


Fig. 466: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft end play.

1. Firmly thrust the crankshaft rearward, and then forward.

This will align the crankshaft rear bearing thrust surfaces.

2. With the crankshaft pushed forward, insert a feeler gage between the crankshaft and the crankshaft rear bearing thrust surface to measure the clearance.

Specification: Crankshaft end play 0.05-0.20 mm (0.002-0.008 in)

13. Rotate the crankshaft in order to check for binding.

A bent crankshaft or lack of proper crankshaft bearing clearance may cause binding.

14. If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts on 1 crankshaft bearing cap at a time in order to determine the location of the binding.

A lack of proper crankshaft bearing clearance may be caused by the following:

- Burrs on the crankshaft bearing cap
- Foreign material between the crankshaft bearing and the engine block
- Foreign material between the crankshaft bearing and the crankshaft bearing cap
- Damaged crankshaft bearing
- Improper size crankshaft bearing

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

J 35621-B Rear Main Seal Installer. See Special Tools.

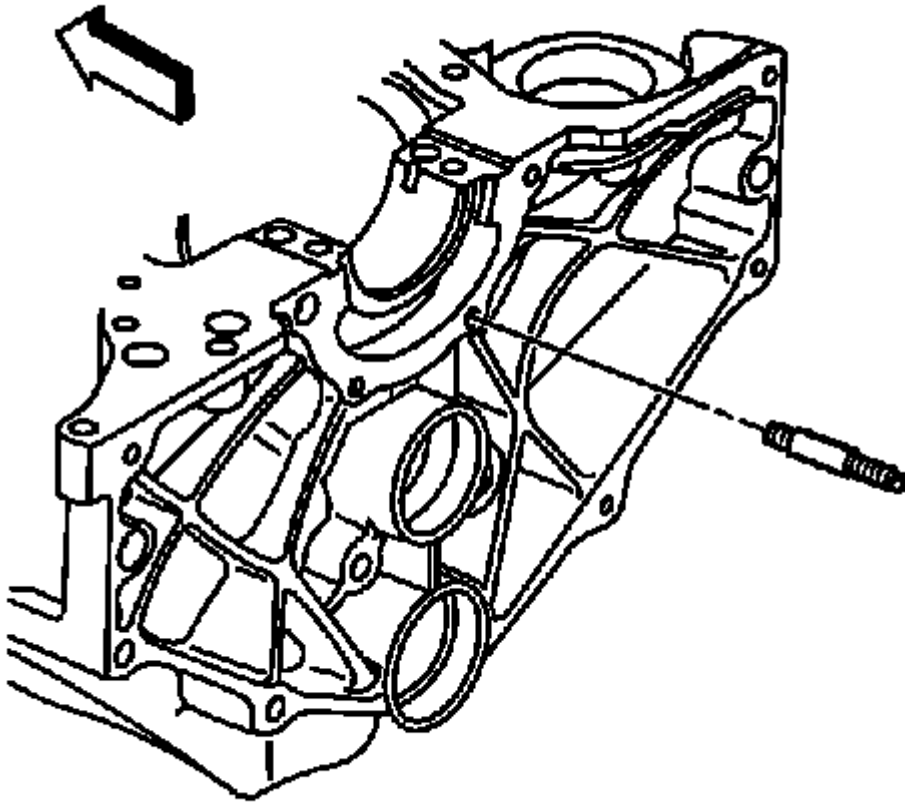


Fig. 467: Removing Crankshaft Rear Oil Seal Housing Retainer Stud
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the crankshaft rear oil seal housing retainer stud.

Tighten: Tighten the crankshaft rear oil seal housing retainer stud to 6 N.m (53 lb in).

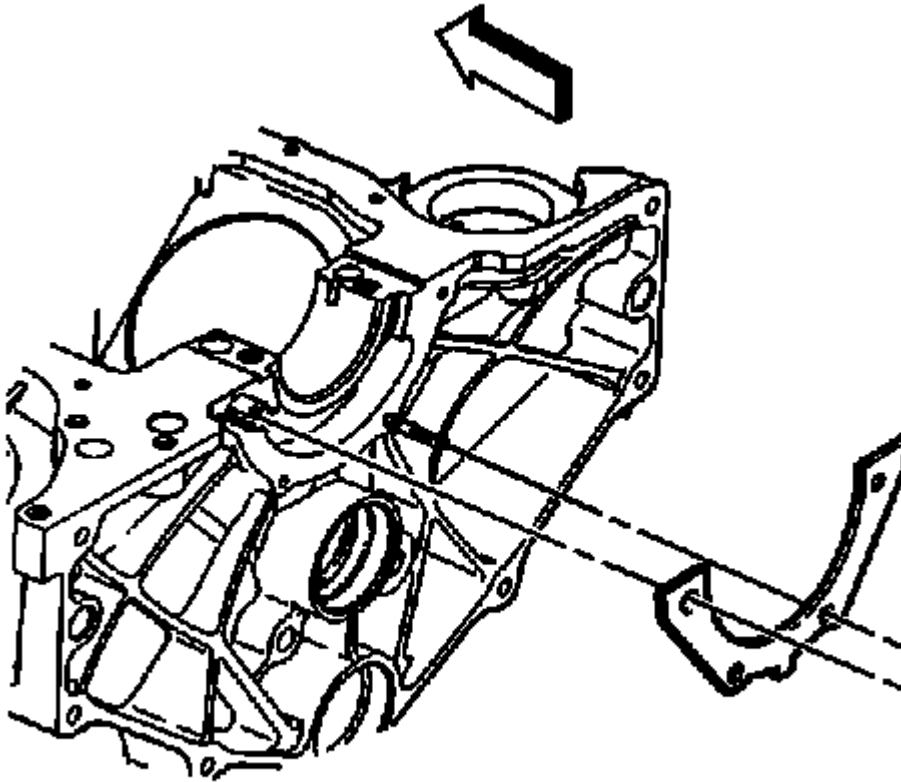


Fig. 468: Removing Crankshaft Rear Oil seal Housing Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always use a NEW crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

2. Install the NEW crankshaft rear oil seal housing gasket.

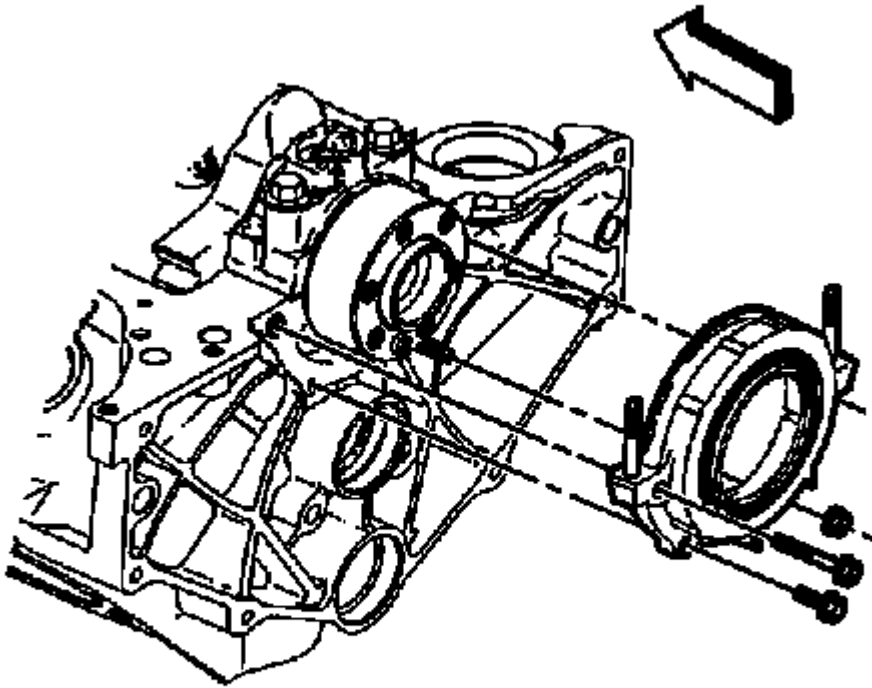


Fig. 469: Removing Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft rear oil housing onto the crankshaft rear oil seal housing retainer stud.
4. Install the crankshaft rear oil seal housing nut and bolts.

Tighten: Tighten the crankshaft rear oil seal housing nut and bolts to 12 N.m (106 lb in).

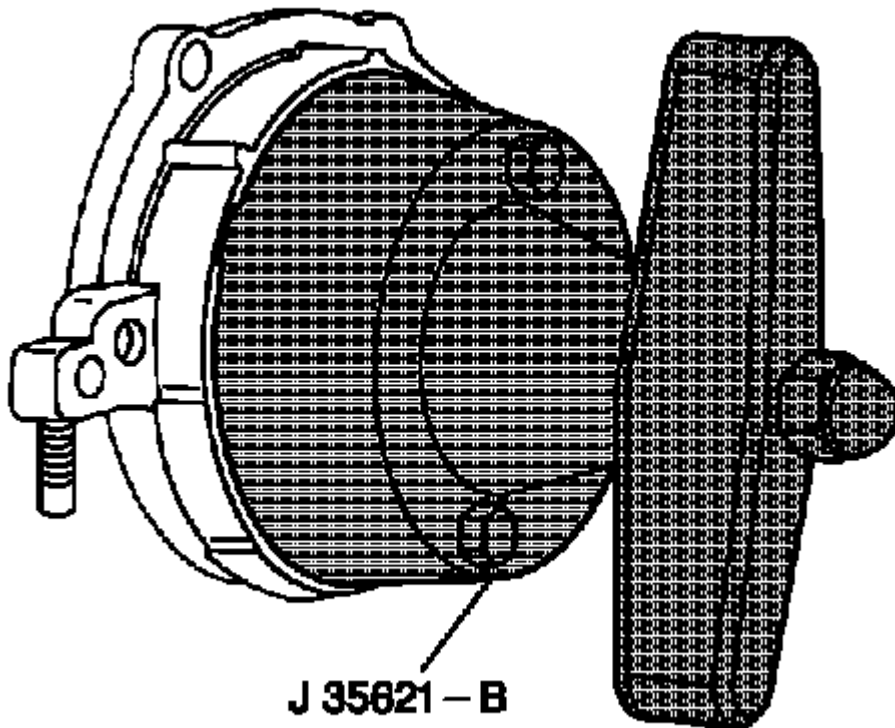


Fig. 470: Installing Crankshaft Rear Oil Seal Using J 35621-B
Courtesy of GENERAL MOTORS CORP.

5. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
6. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
7. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
8. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft seal surface.
9. Inspect the **J 35621-B** flange for imperfections that may damage the crankshaft rear oil seal. See **Special Tools**.

Minor imperfections may be removed with a fine grade emery cloth.

IMPORTANT: DO NOT allow oil or any other lubricants to contact the inner seal lip surface of the crankshaft rear oil seal.

10. Remove the sleeve from the crankshaft rear oil seal.
11. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil

seal.

12. Install the crankshaft rear oil seal onto the **J 35621-B**. See **Special Tools**.
13. Install the **J 35621-B** onto the rear of the crankshaft and hand tighten the tool bolts until snug. See **Special Tools**.

NOTE: Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

14. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 1. Turn the **J 35621-B** wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing. See **Special Tools**.

Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.

2. Turn the **J 35621-B** wing nut counterclockwise to release the **J 35621-B** from the crankshaft rear oil seal. See **Special Tools**.
15. Remove the **J 35621-B** from the crankshaft. See **Special Tools**.
16. Wipe off any excess engine oil with a clean rag.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 5239** Connecting Rod Bolt Guide Set. See **Special Tools**.
- **J 8037** Ring Compressor. See **Special Tools**.
- **J 8087** Cylinder Bore Gage
- **J 45059** Angle Meter. See **Special Tools**.

Piston Selection

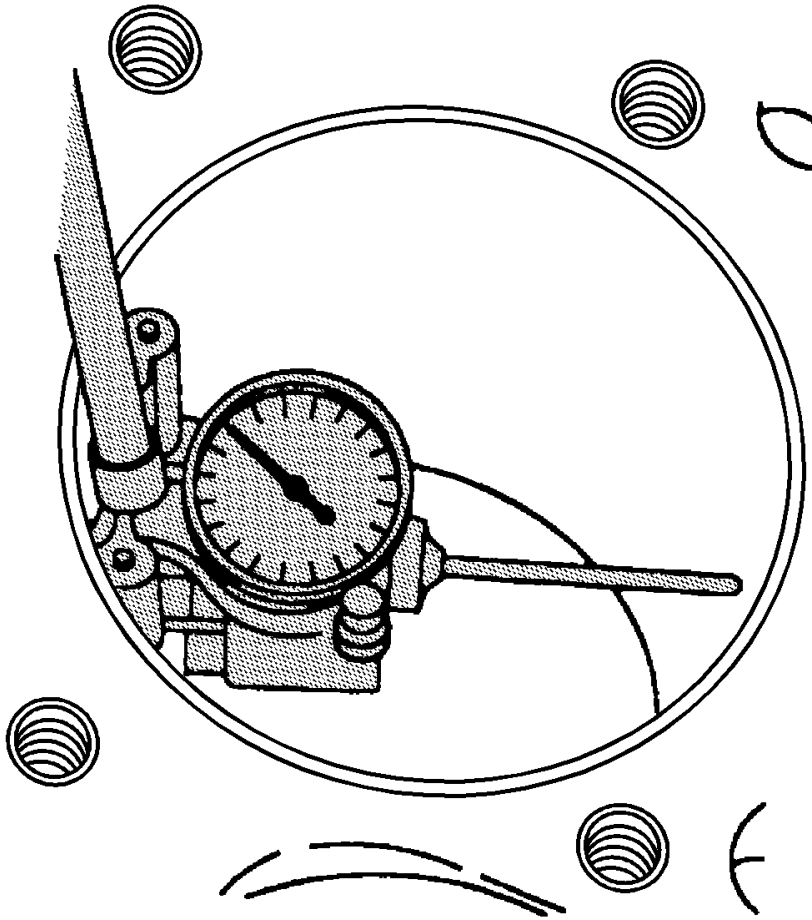


Fig. 471: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

A used piston and piston pin set may be reinstalled if, after cleaning and inspection, the piston and piston pin are within specifications.

1. Use the J 8087 in order to measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore and 90 degrees to the crankshaft centerline.

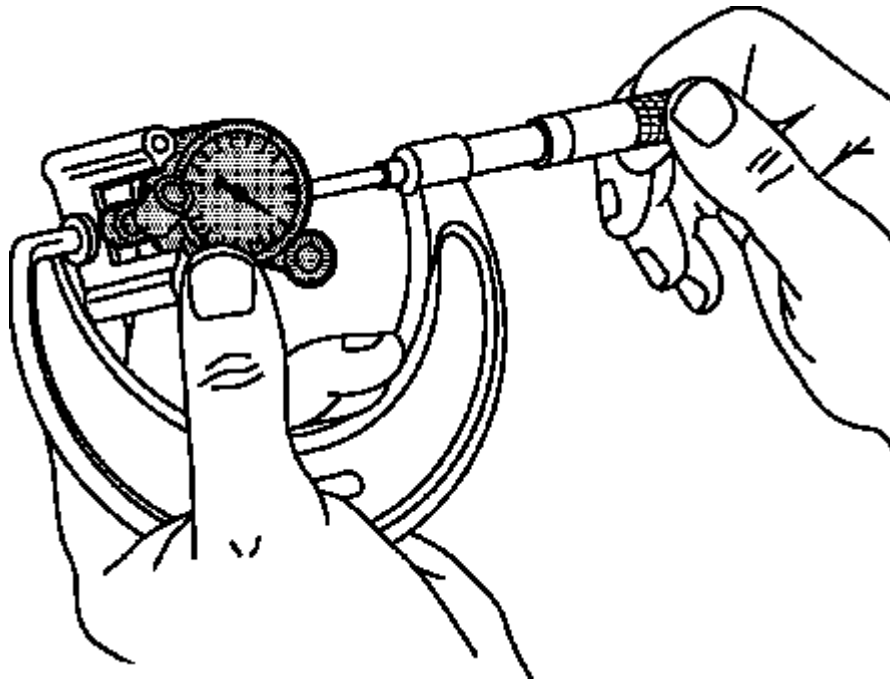


Fig. 472: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

2. Measure the J 8087 with a micrometer and record the reading.

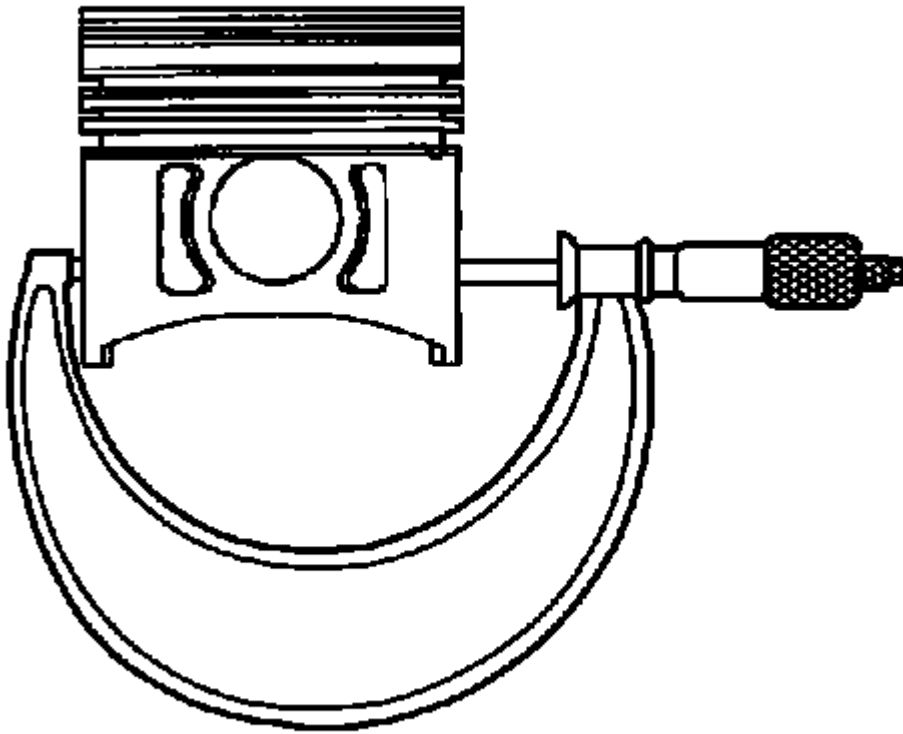


Fig. 473: Measuring Piston Outside Diameter Using Micrometer
Courtesy of GENERAL MOTORS CORP.

3. With a micrometer or caliper at a right angle to the piston pin bore, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
4. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
5. If the proper clearance cannot be obtained, then select another piston and measure the clearances.

If the proper fit cannot be obtained, the cylinder bore may require honing or boring.

6. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.

Installation Procedure

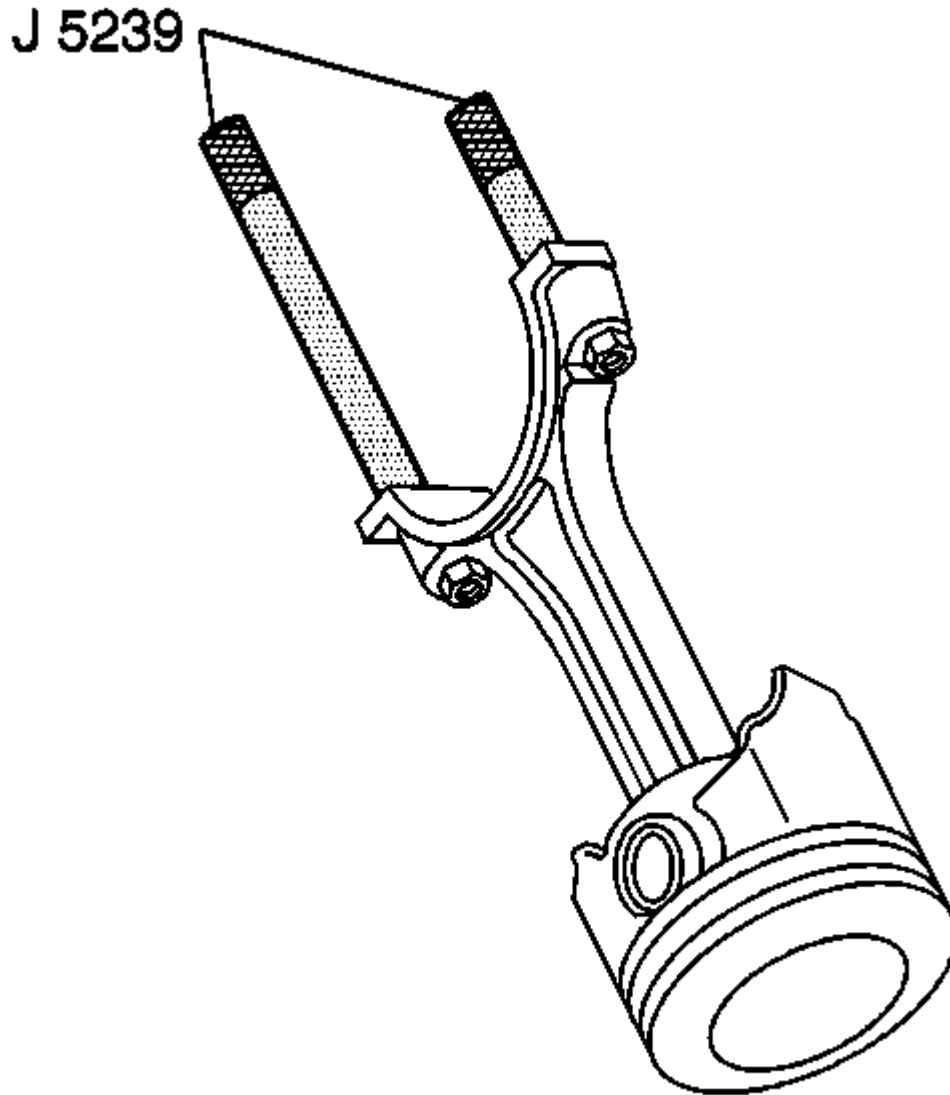


Fig. 474: Installing J 5239 Onto The Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the following components:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces

2. Install the **J 5239** onto the connecting rod bolts. See **Special Tools**.

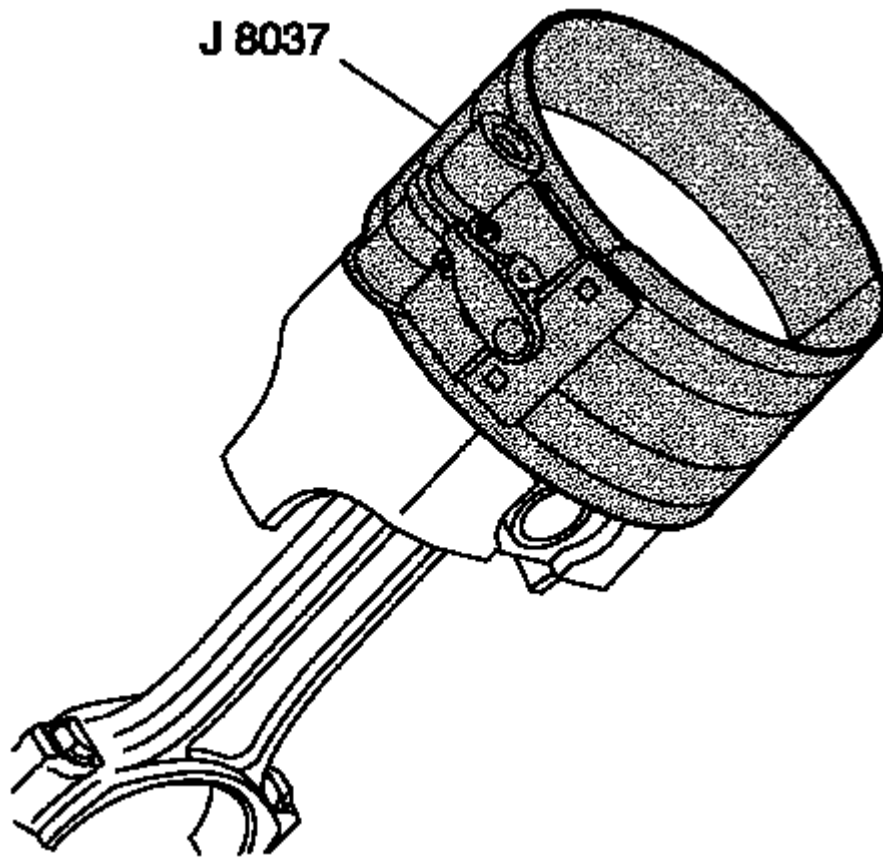


Fig. 475: Compressing The Piston Rings Using J 8037
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools**.

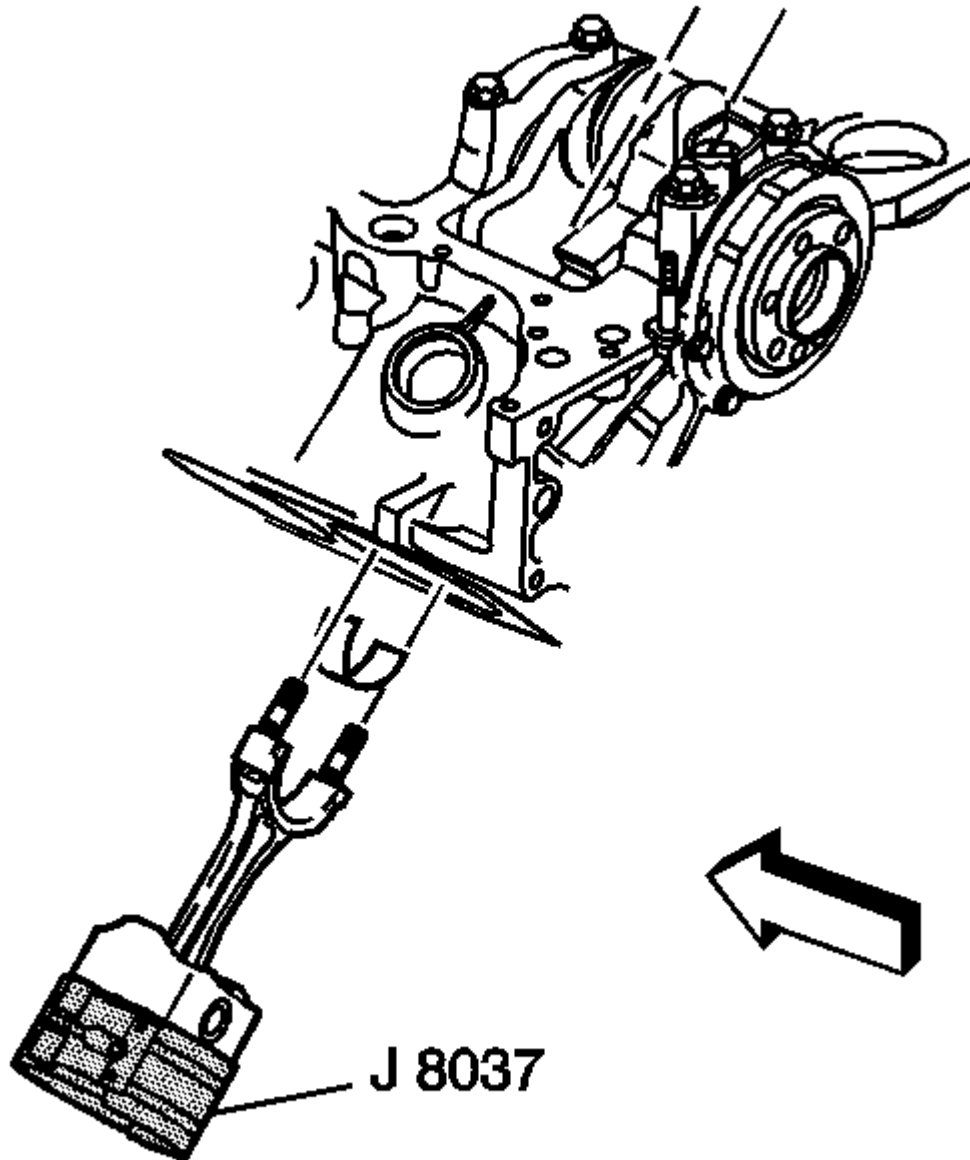


Fig. 476: Installing Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The mark on the top of the piston must face the front of the engine block. When assembled, the flanges on the connecting rod and connecting rod cap should face to the front of the engine block on the left bank, and to the rear of the engine block on the right bank.

4. Install the piston and connecting rod assembly, and the **J 8037** into the proper cylinder bore. See **Special Tools**.

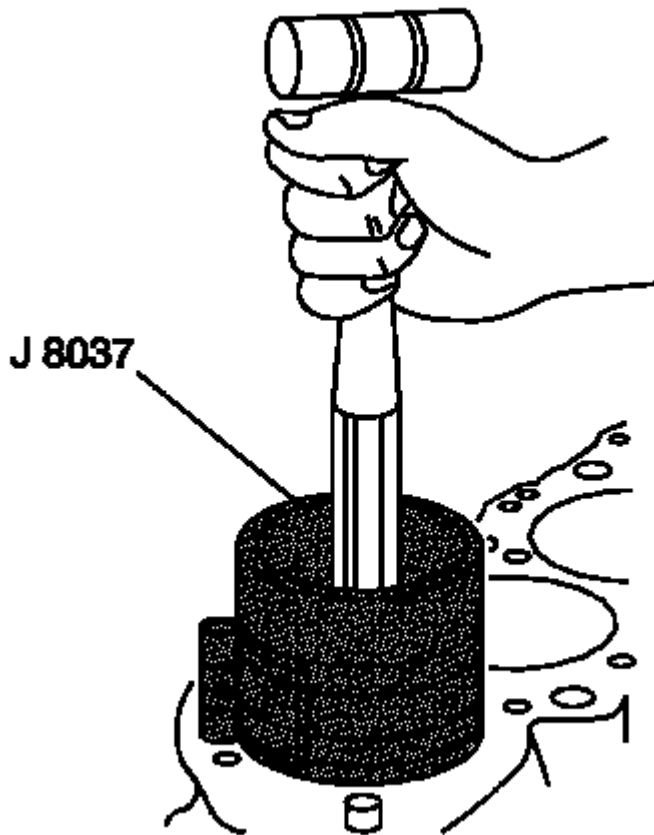


Fig. 477: Installing Piston & Connecting Rod Assembly Into Engine
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 8037** and the **J 5239** and lightly tap the top of the piston with a wooden hammer handle. See **Special Tools**.
 1. Hold the **J 8037** firmly against the engine block until all of the piston rings have entered the cylinder bore. See **Special Tools**.
 2. Use the **J 5239** in order to guide the connecting rod onto the crankshaft journal. See **Special Tools**.

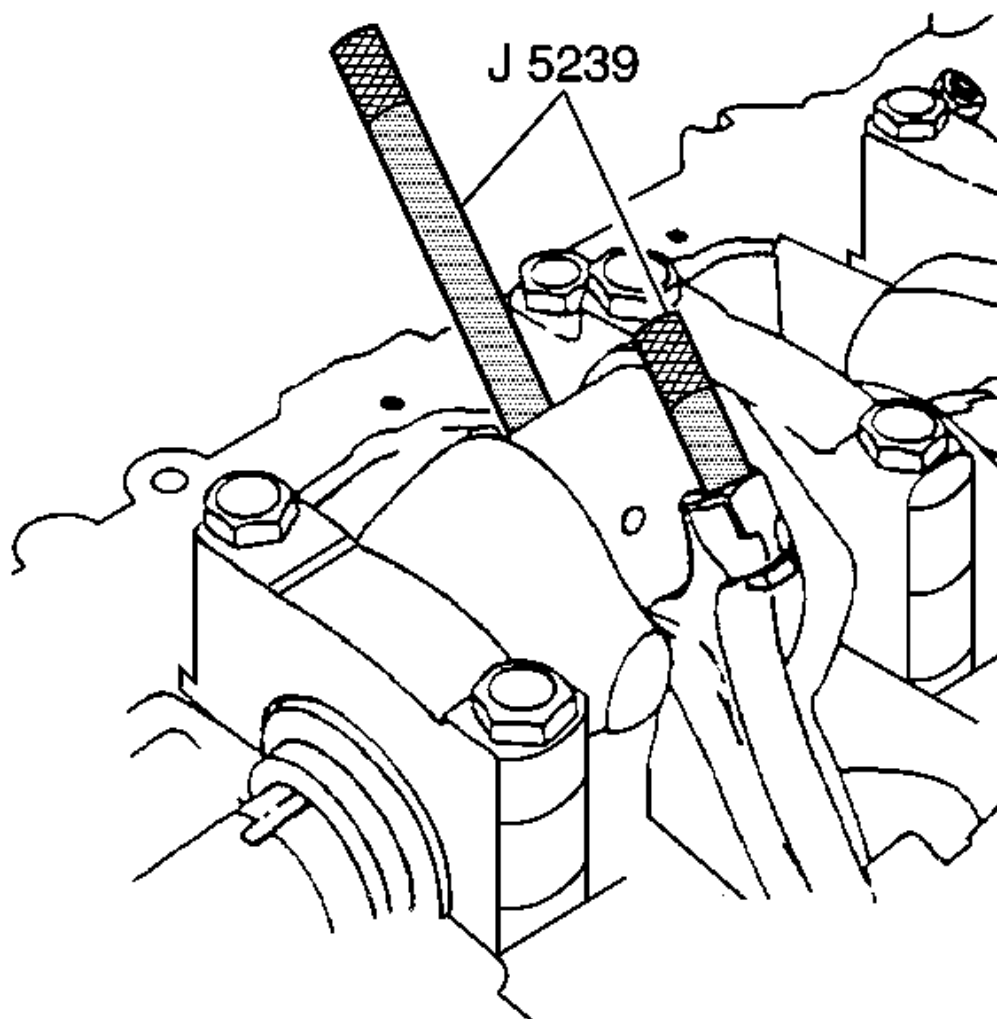


Fig. 478: Protecting Crankshaft Journals Using J 5239
Courtesy of GENERAL MOTORS CORP.

6. Remove the **J 5239** . See **Special Tools**.

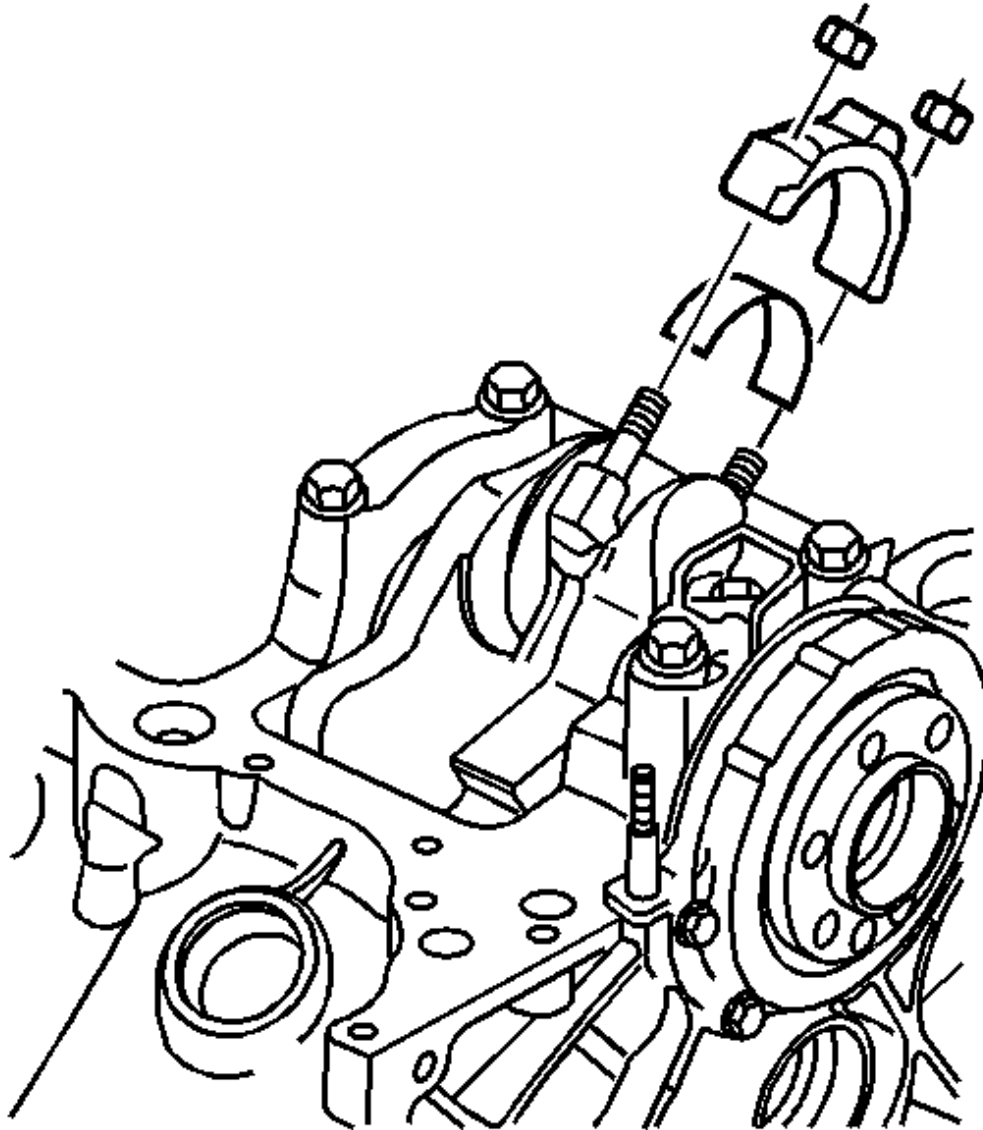


Fig. 479: Removing Connecting Rod Nut & Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the connecting rod caps, bearings, and nuts.

Tighten:

1. Tighten the nuts evenly on the first pass to 27 N.m (20 lb ft).
2. Use the **J 45059** in order to tighten the nuts on the final pass an additional 70 degrees. See **Special Tools**.

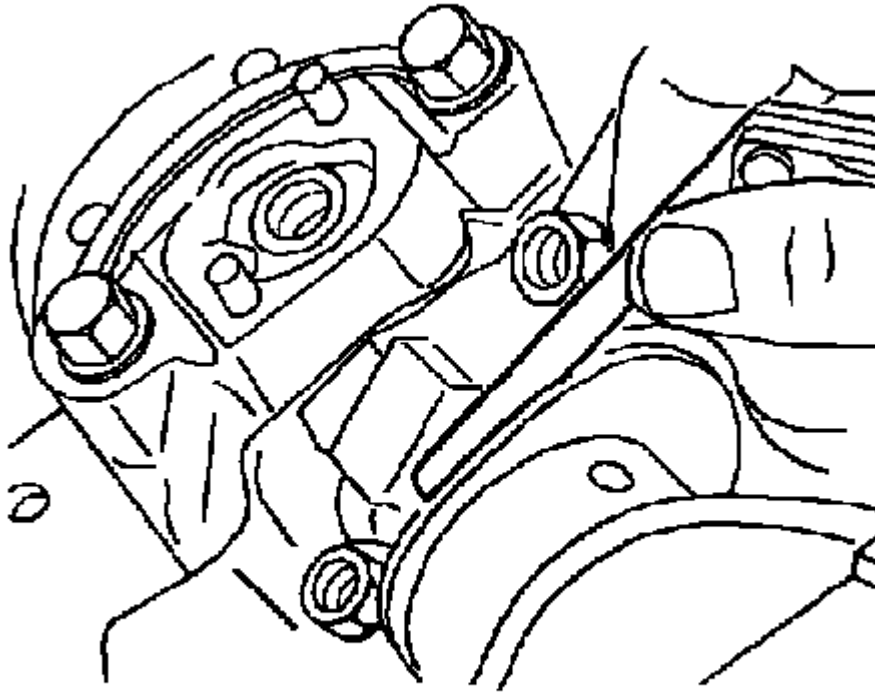


Fig. 480: Measuring Connecting Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. After the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly, parallel to the crankpin, in order to ensure that the connecting rods have side clearance.
9. Use a feeler gage or a dial indicator to measure the connecting rod side clearance between the connecting rod caps. The connecting rod side clearance should be 0.15-0.44 mm (0.006-0.017 in).

Camshaft Installation

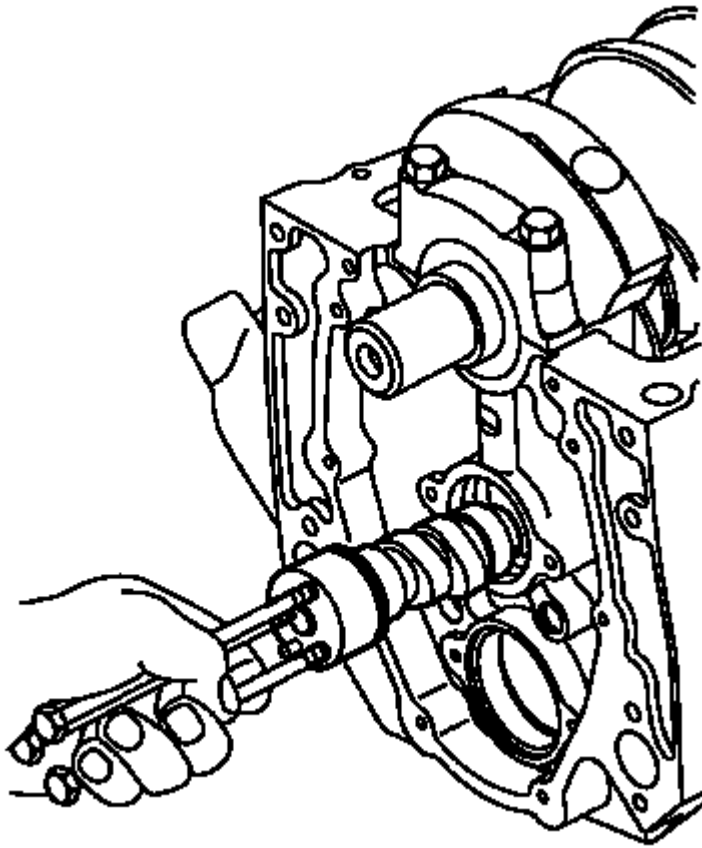


Fig. 481: Installing & Removing Engine Camshaft Front Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, or engine oil supplement GM P/N 1052367 (Canadian P/N 992367) or equivalent, to the following components:
 - The engine camshaft lobes
 - The camshaft bearing journals
 - The camshaft bearings
 - The distributor drive gear
2. Install three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.

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

3. Use the bolts as a handle in order to install the engine camshaft.
4. Remove the 3 bolts from the front of the engine camshaft.

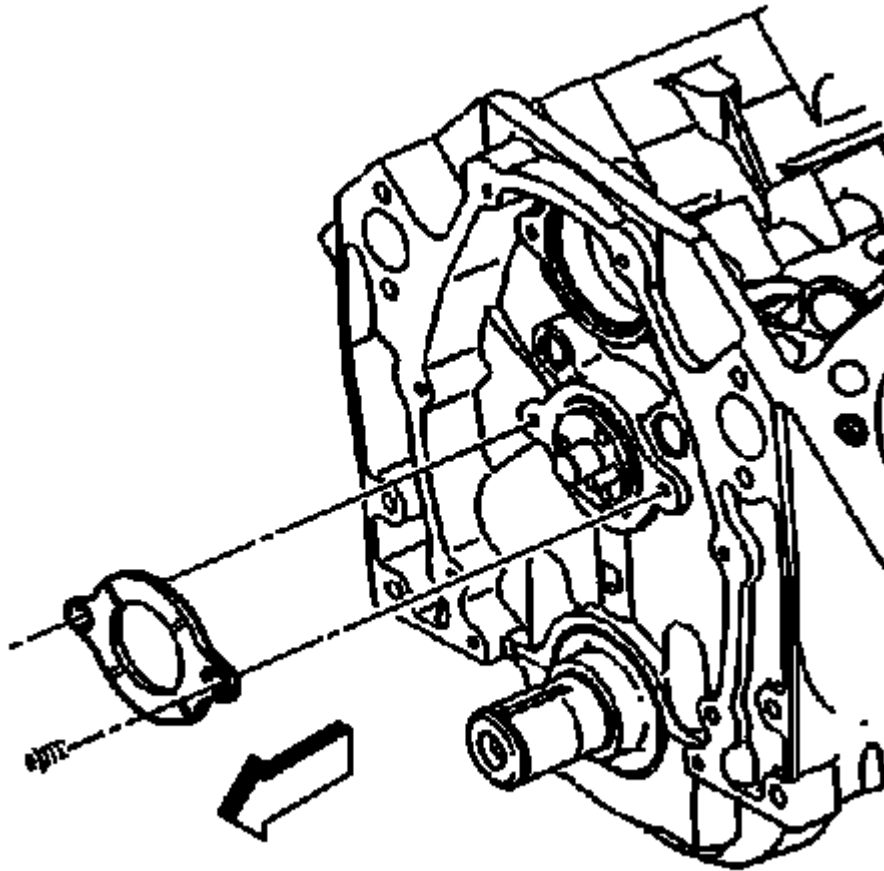


Fig. 482: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

5. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the camshaft retainer bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the camshaft retainer and bolts.

Tighten: Tighten the camshaft retainer bolts to 12 N.m (106 lb in).

Balance Shaft Installation

Tools Required

- J 8092 Universal Driver Handle
- J 36996 Balance Shaft Installer. See Special Tools.
- J 45059 Angle Meter. See Special Tools.

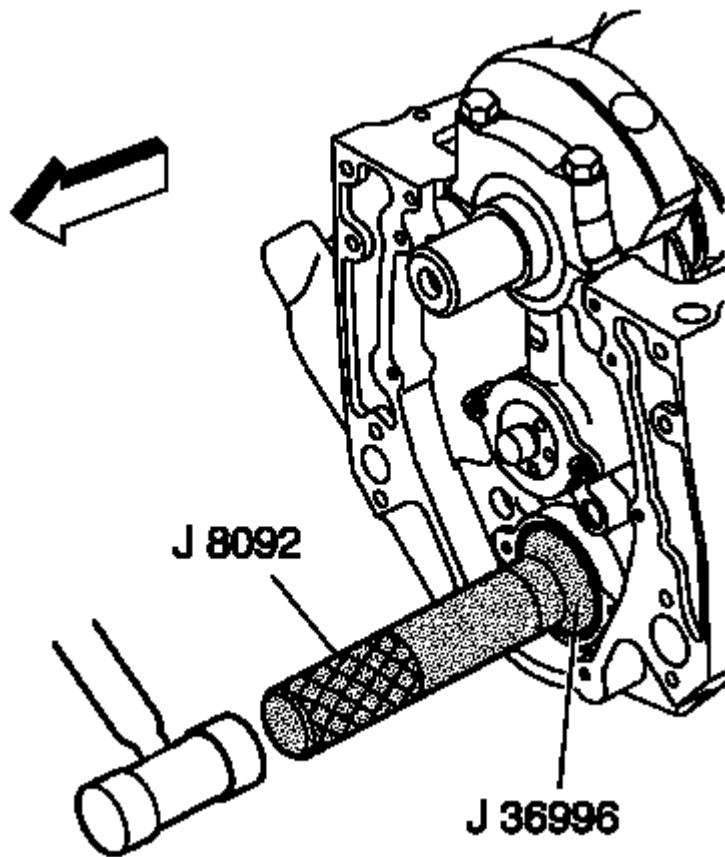


Fig. 483: Installing Balance Shaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balance shaft and the balance shaft front bearing are serviced only as an assembly. Do not remove the balance shaft front bearing from the balance shaft.

1. Apply clean engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent, to the balance shaft front bearing.

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

2. Use the **J 36996** and the J 8092 in order to install the balance shaft. See Special Tools.

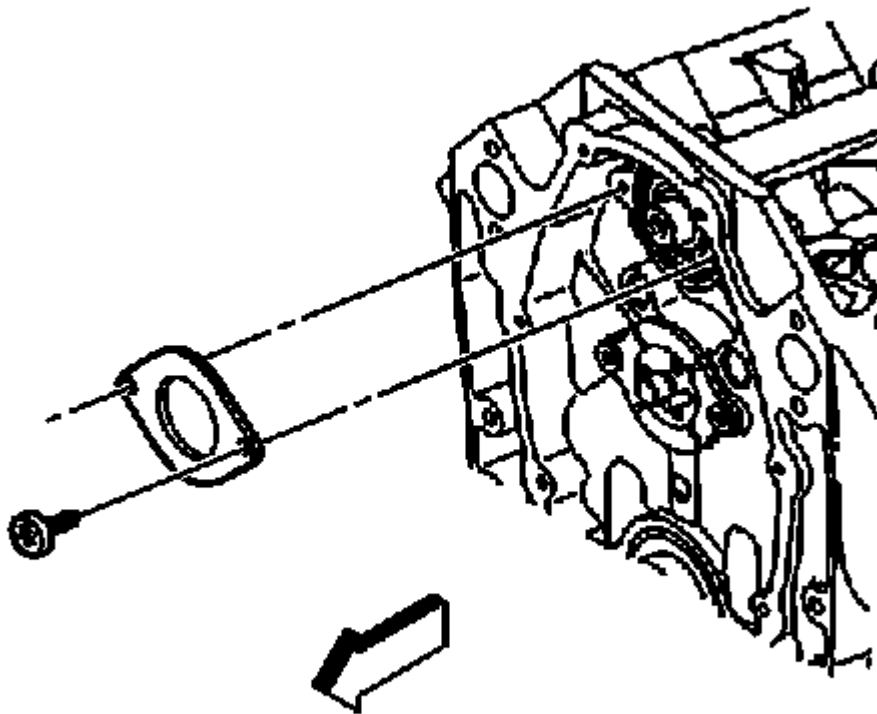


Fig. 484: View of Balance Shaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the balance shaft retainer and bolts.

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

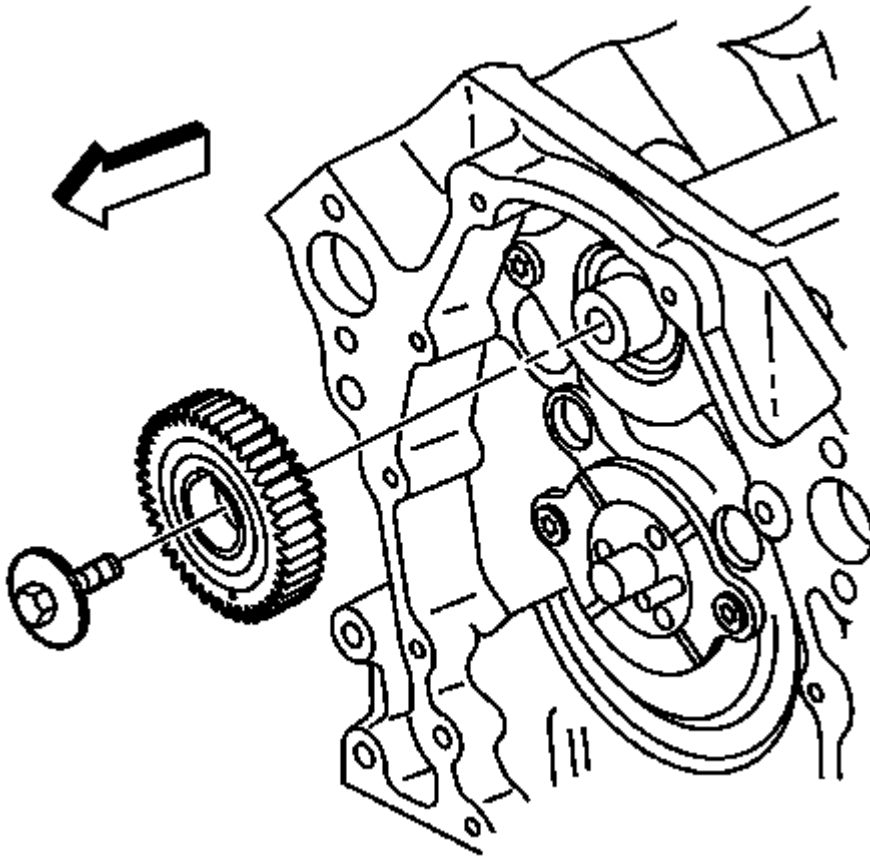


Fig. 485: Locating Balance Shaft Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Install the balance shaft driven gear onto the balance shaft.
5. If reusing the fastener, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the balance shaft driven gear bolt.
6. Install the balance shaft driven gear bolt.
 1. Use a wrench to secure the balance shaft.

Place the wrench onto the balance shaft near to the balance shaft front bearing.

2. Install the balance shaft driven gear bolt.

Tighten:

1. Tighten the balance shaft driven gear bolt on the first pass to 20 N.m (15 lb ft).
 2. Tighten the balance shaft driven gear bolt on the final pass using the **J 45059** an additional 35 degrees. See **Special Tools**.
7. Remove the wrench from the balance shaft.
 8. Rotate the balance shaft by hand in order to ensure that there is clearance between the balance shaft and the valve lifter pushrod guide. If the balance shaft does not rotate freely, check to ensure that the retaining

ring on the balance shaft front bearing is seated on the case.

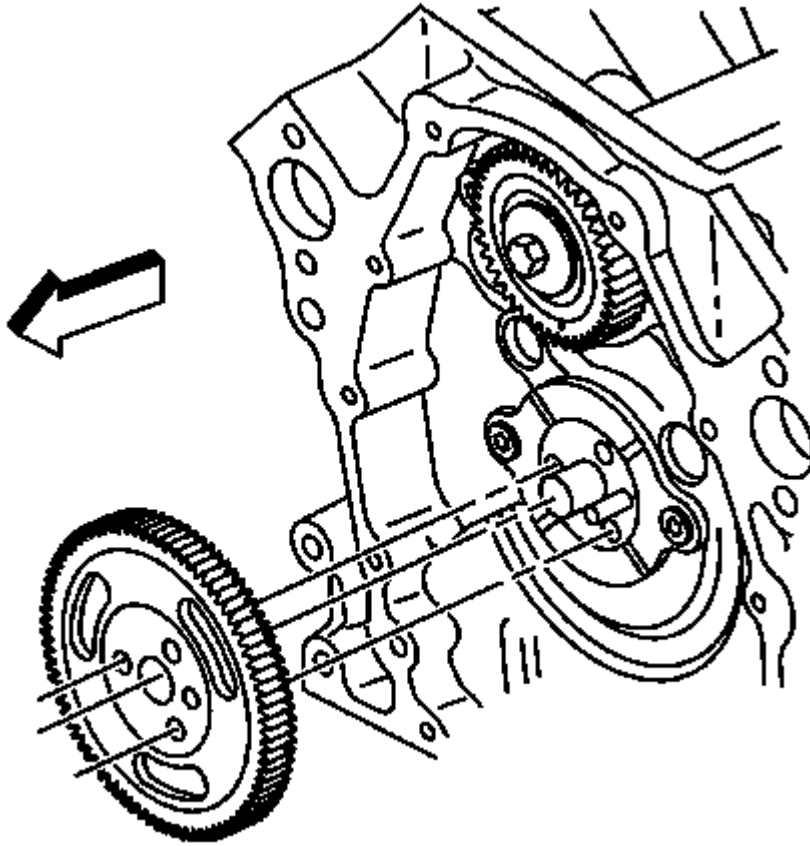


Fig. 486: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT install the camshaft sprocket bolts at this time.

9. Install the balance shaft drive gear.

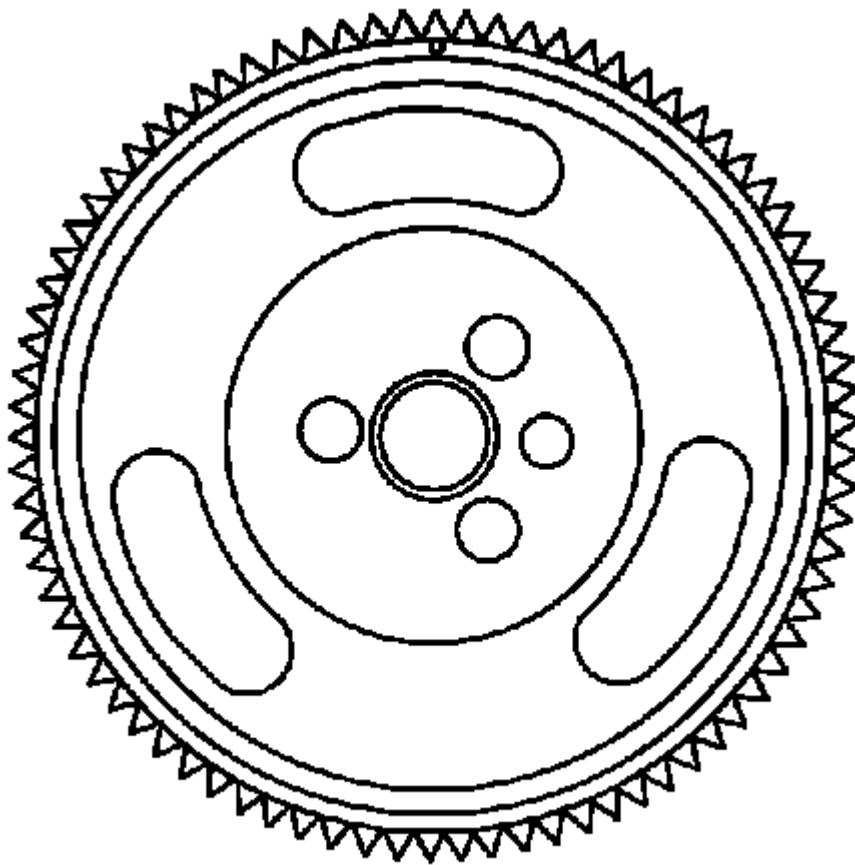


Fig. 487: Balance Shaft Drive Gear Camshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

10. Rotate the engine camshaft so that the timing mark on the balance shaft drive gear is in the 12 o'clock position.

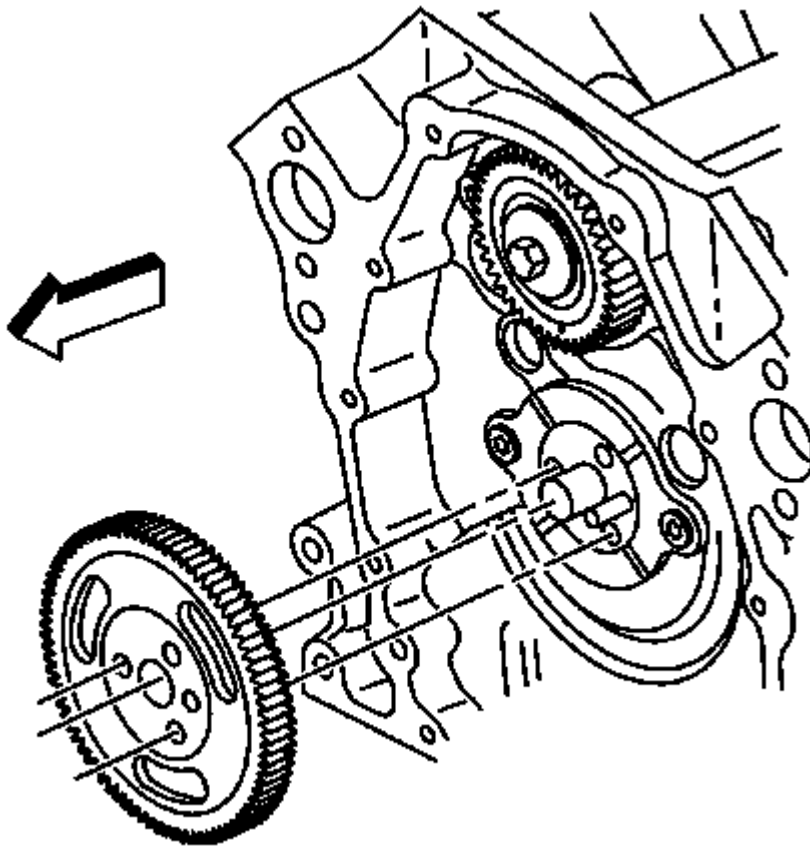


Fig. 488: View Of Balance Shaft Drive Gear
Courtesy of GENERAL MOTORS CORP.

11. Remove the balance shaft drive gear.

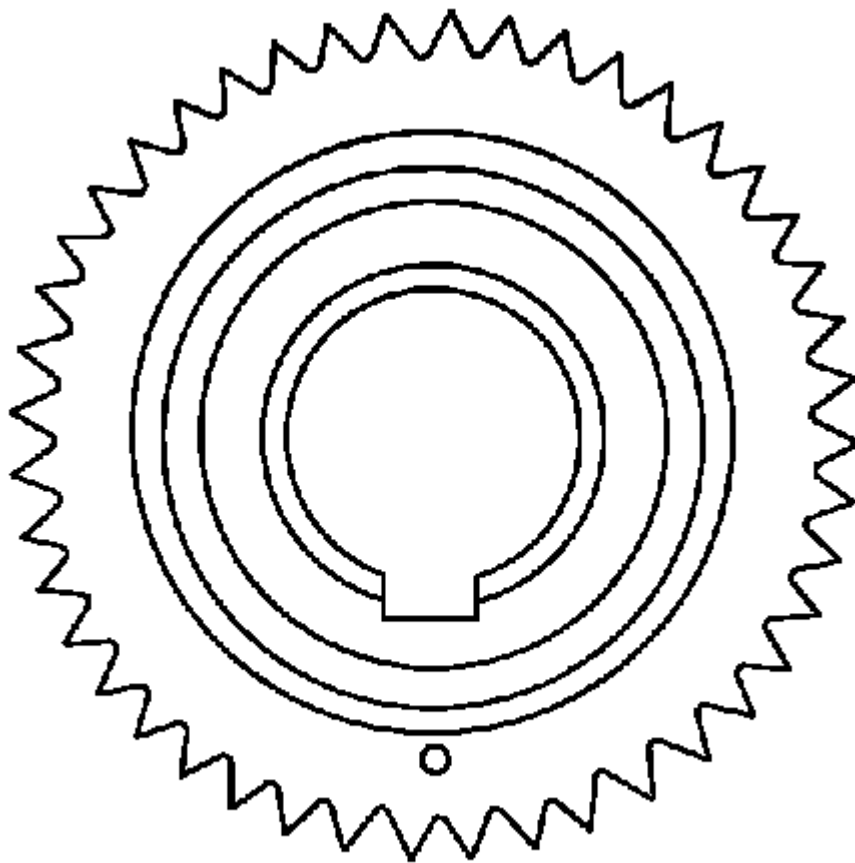


Fig. 489: Balance Shaft Driven Gear Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Rotate the balance shaft so that the timing mark on the balance shaft driven gear is in the 6 o'clock position.

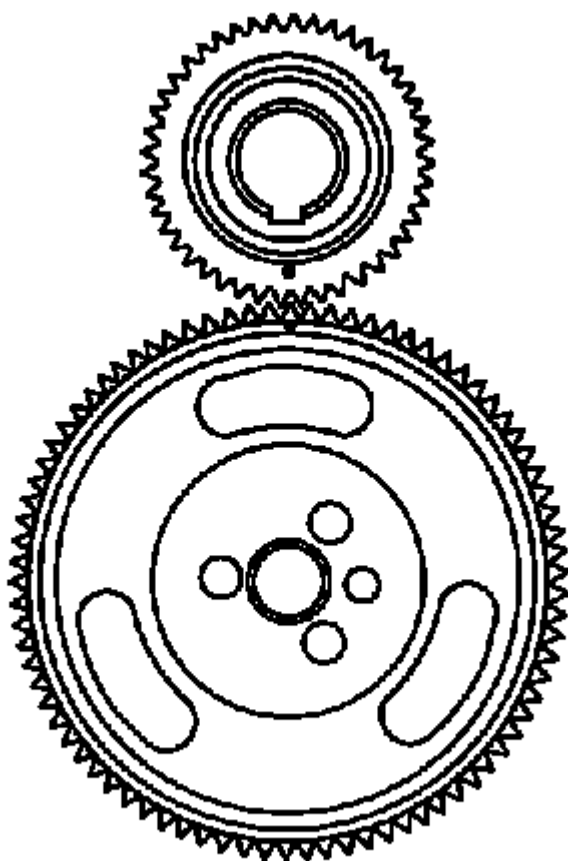


Fig. 490: Aligning Balance Shaft Drive Gear & Balance Shaft Driven Gear Timing Marks
Courtesy of GENERAL MOTORS CORP.

13. Position the balance shaft drive gear onto the engine camshaft.
14. Look to ensure that the balance shaft drive gear and the balance shaft driven gear timing marks are aligned.

Timing Chain and Sprockets Installation

Tools Required

J 5590 Pinion Bearing Race Installer - Rear

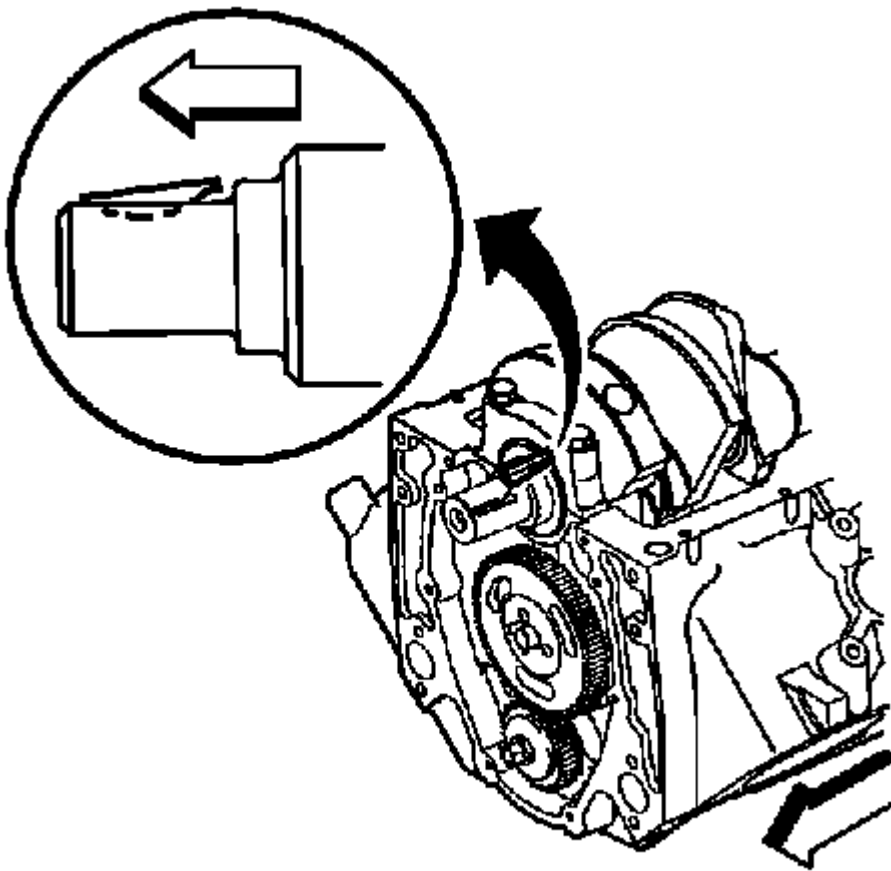


Fig. 491: Installing Crankshaft Balancer Key
Courtesy of GENERAL MOTORS CORP.

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.

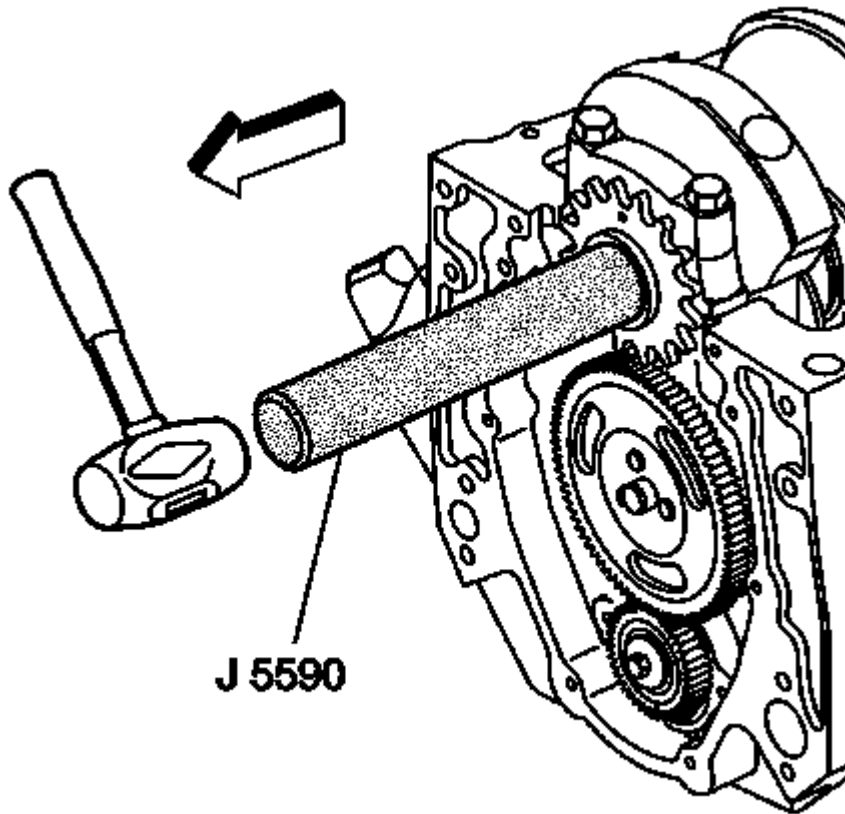


Fig. 492: Installing The Crankshaft Sprocket Using J 5590
Courtesy of GENERAL MOTORS CORP.

2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.

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

3. Use the **J 5590** in order to install the crankshaft sprocket.

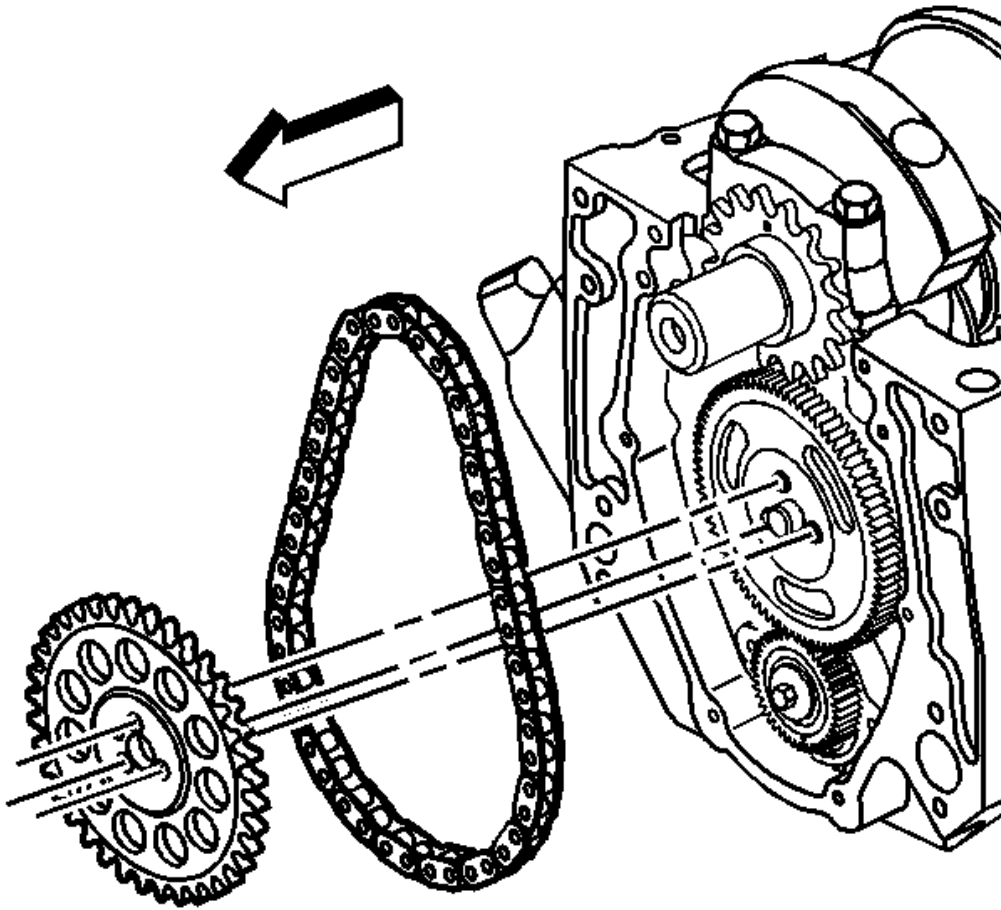


Fig. 493: Removing Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Rotate the crankshaft until the crankshaft sprocket alignment mark is at the 12 o'clock position.

IMPORTANT: Install the camshaft sprocket with the alignment mark at the 6 o'clock position.

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

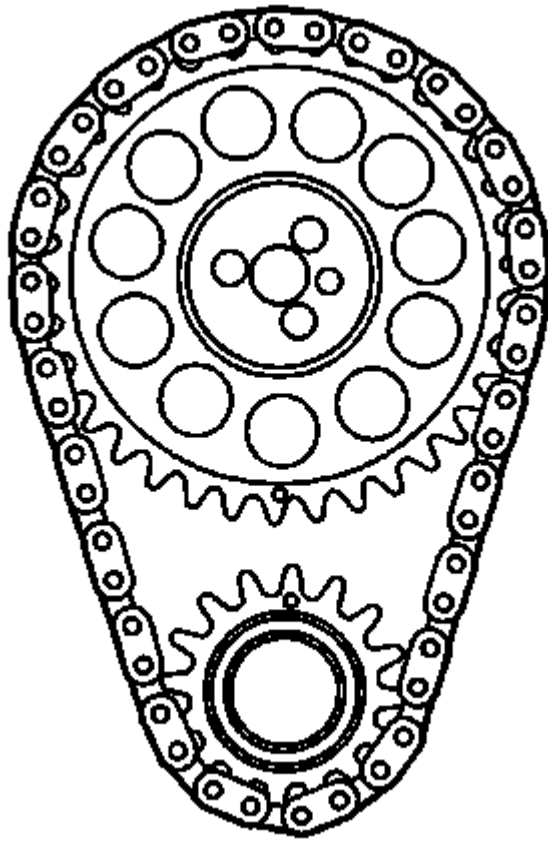


Fig. 494: View Of Camshaft & Crankshaft Sprocket Timing Marks
Courtesy of GENERAL MOTORS CORP.

6. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and camshaft sprocket is aligned at the 6 o'clock position.

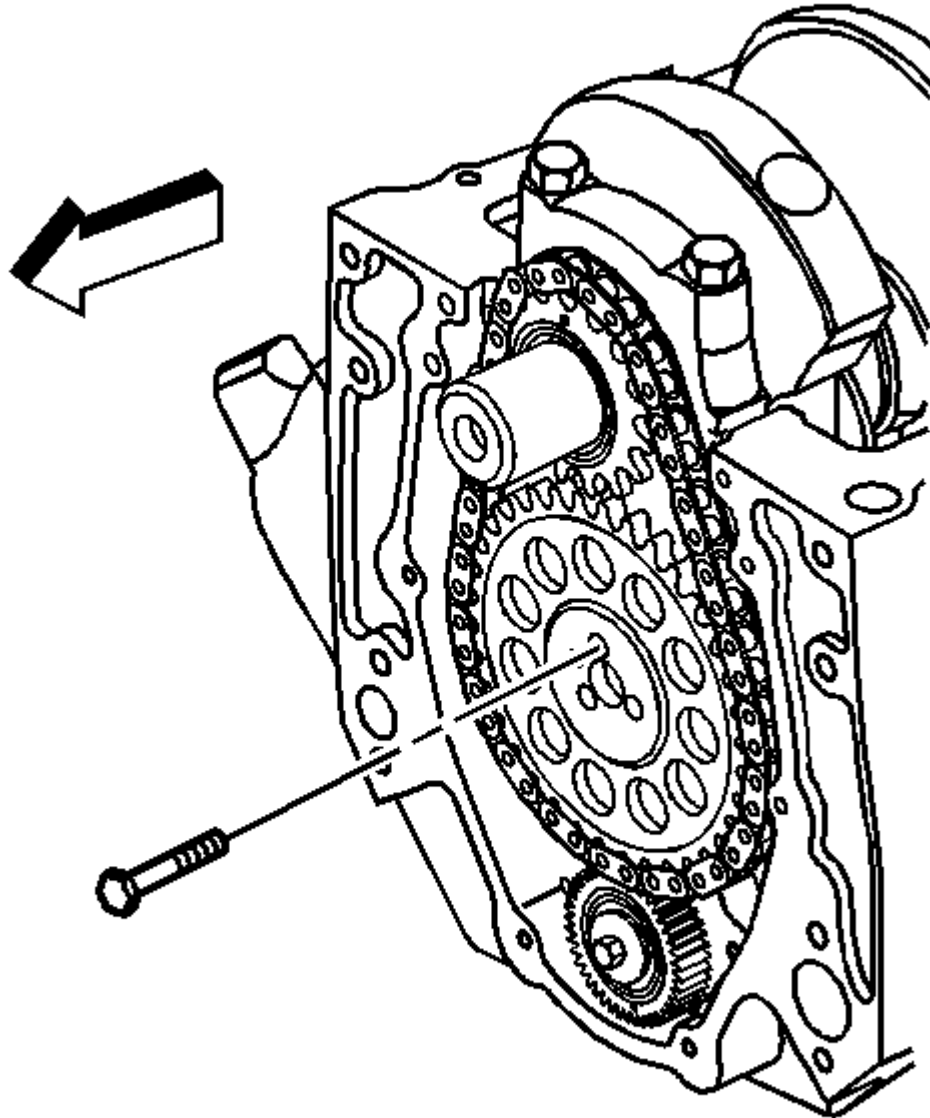


Fig. 495: Removing Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Do not use a hammer to install the camshaft sprocket onto the camshaft.
To do so may dislodge the expansion cup plug, camshaft rear bearing

hole.

7. Install camshaft sprocket bolts.

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

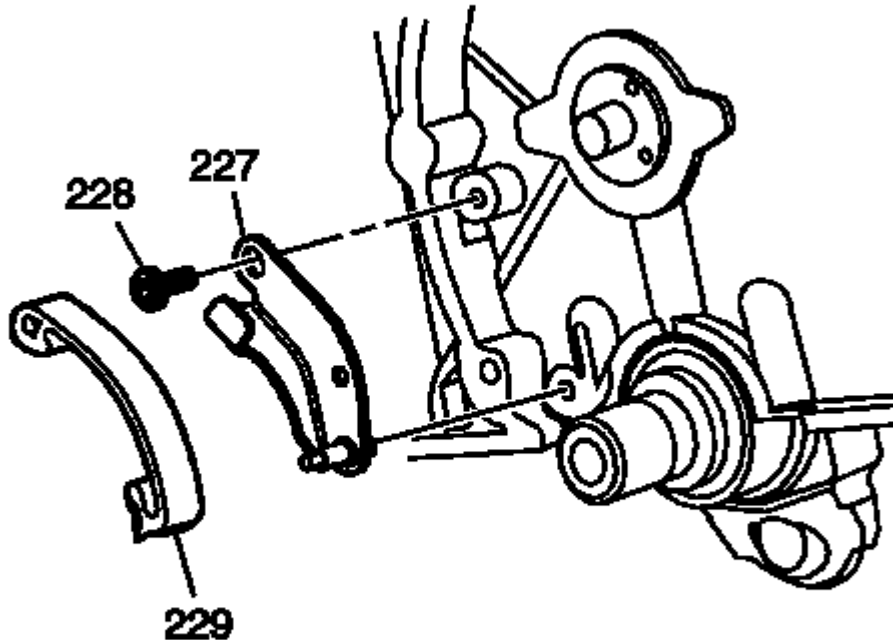


Fig. 496: Removing Timing Chain Tensioner Shoe, Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the timing chain tensioner bracket and bolt (227 and 228).

Tighten: Tighten the timing chain tensioner bracket bolt to 12 N.m (106 lb in).

IMPORTANT: The timing chain tensioner shoe snaps onto the tensioner bracket. Ensure that the shoe is fully seated before proceeding.

9. Install the timing chain tensioner shoe (229) using an upwards motion.

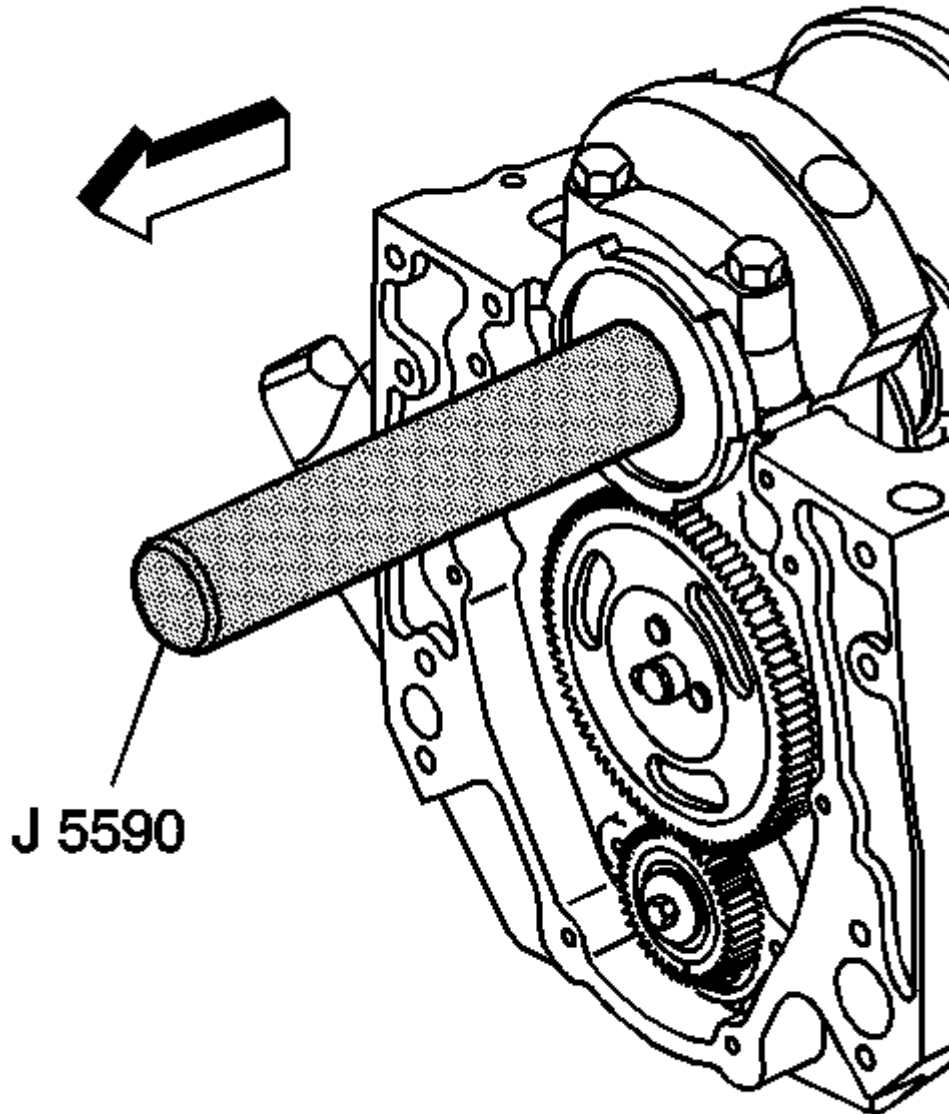


Fig. 497: Using J 5590 To Push The Crankshaft Position Sensor Reluctor Ring Onto The Crankshaft
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft position sensor reluctor ring.
 1. Align the keyway on the crankshaft position sensor reluctor ring with the crankshaft balancer key in the crankshaft.
 2. Use the **J 5590** in order to push the crankshaft position sensor reluctor ring onto the crankshaft until

completely seated against the crankshaft sprocket.

Engine Front Cover Installation

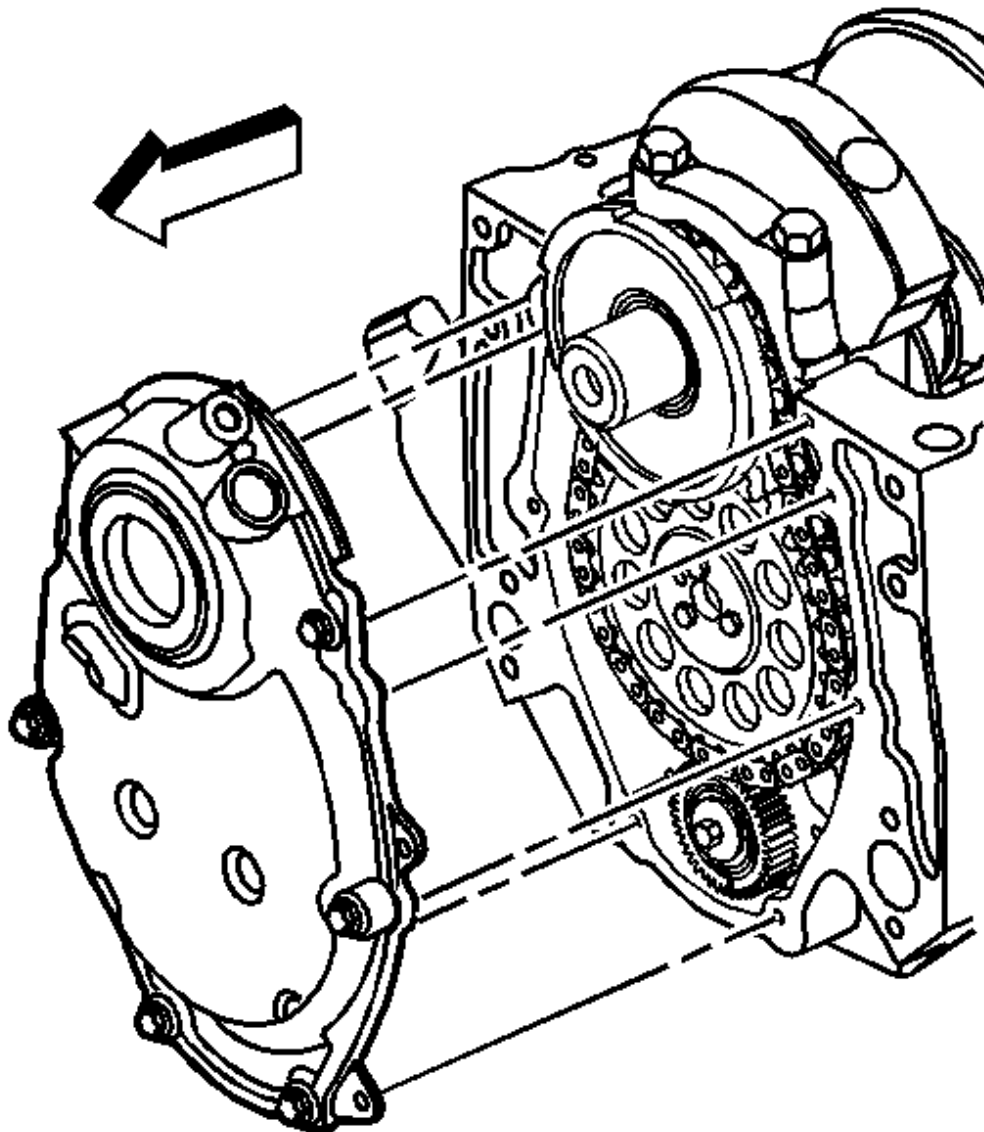


Fig. 498: Removing Engine Front Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Once the composite engine front cover is removed DO NOT reinstall the

engine front cover. Always install a NEW engine front cover.

1. Install the NEW engine front cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine front cover bolts.

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

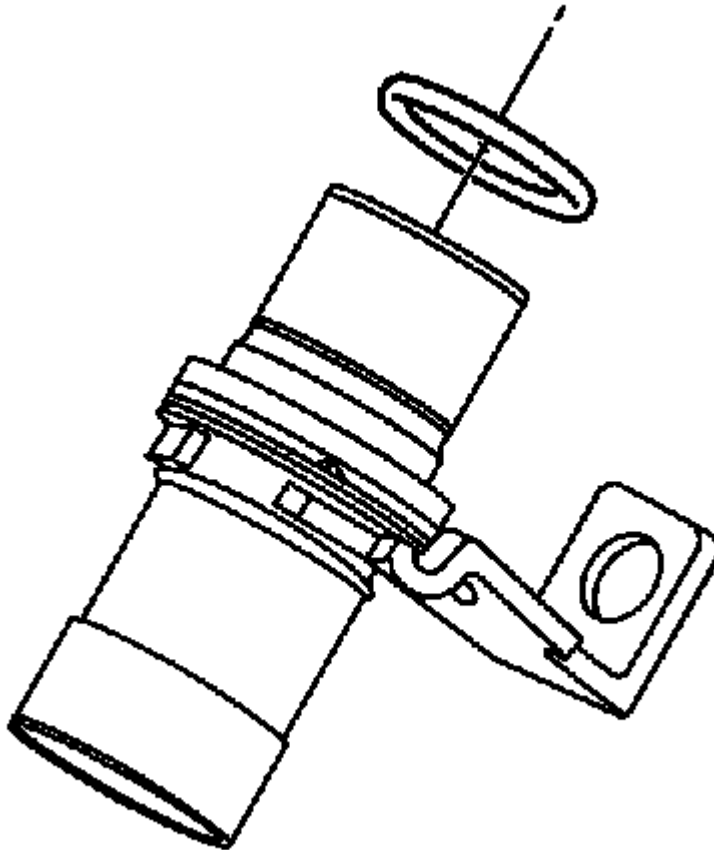


Fig. 499: View Of Crankshaft Position Sensor Seal O-Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the original crankshaft position sensor seal, O-ring. When installing the crankshaft position sensor be sure the crankshaft position sensor is fully seated and held stationary in the engine front cover crankshaft position sensor bore. A crankshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

3. Lubricate the NEW crankshaft position sensor seal, O-ring, with clean engine oil.
4. Install the NEW crankshaft position sensor seal, O-ring, onto the crankshaft position sensor.

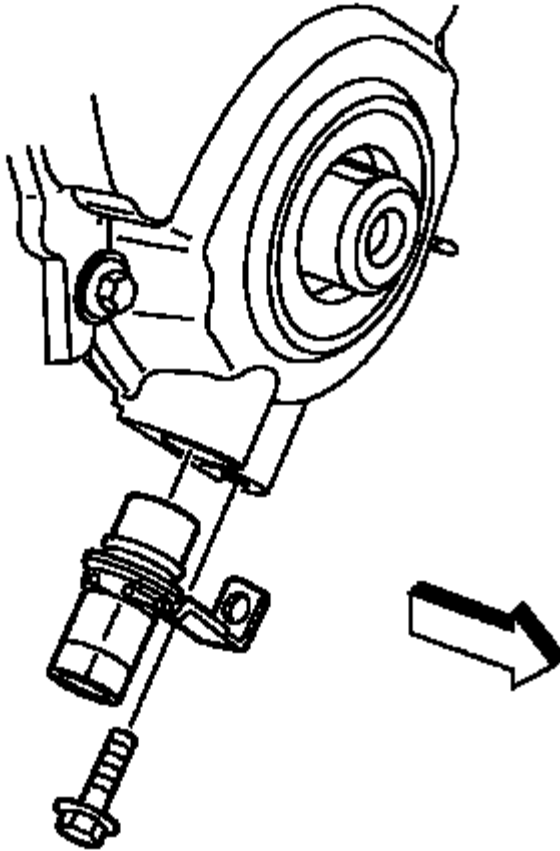


Fig. 500: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install crankshaft position sensor until fully seated into the engine front cover.
6. Install crankshaft position sensor bolt.

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

Oil Pump Installation

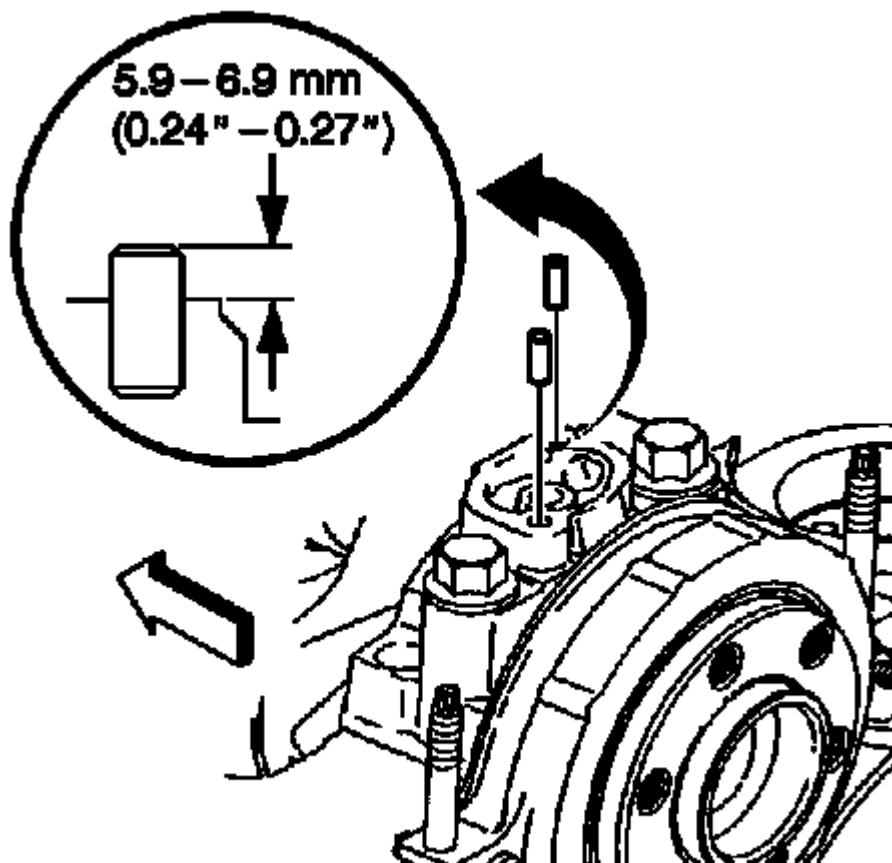


Fig. 501: Oil Pump Locator Pins
Courtesy of GENERAL MOTORS CORP.

1. Inspect for properly installed oil pump locator pins.

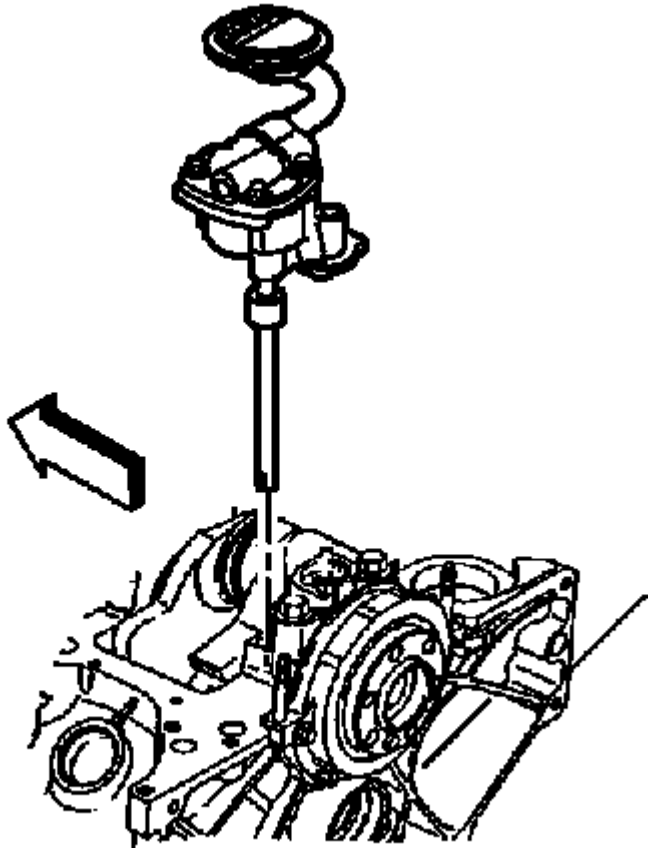


Fig. 502: Removing Oil Pump

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the oil pump driveshaft retainer.
During assembly, install a NEW oil pump driveshaft retainer.

2. Install the oil pump.
3. Position the oil pump onto the pins.

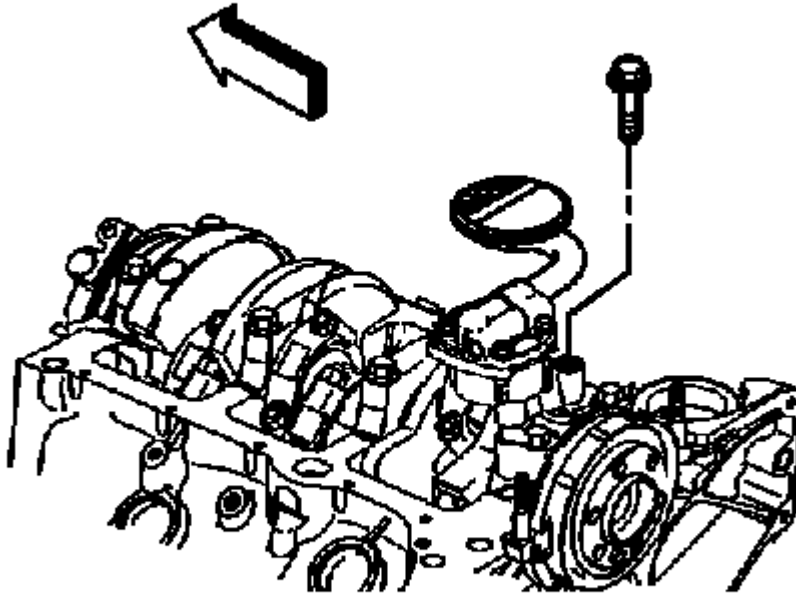


Fig. 503: Removing Oil Pump Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pump bolt attaching the oil pump to the rear crankshaft bearing cap.

Tighten: Tighten the oil pump bolt to 90 N.m (66 lb ft).

Oil Pan Installation

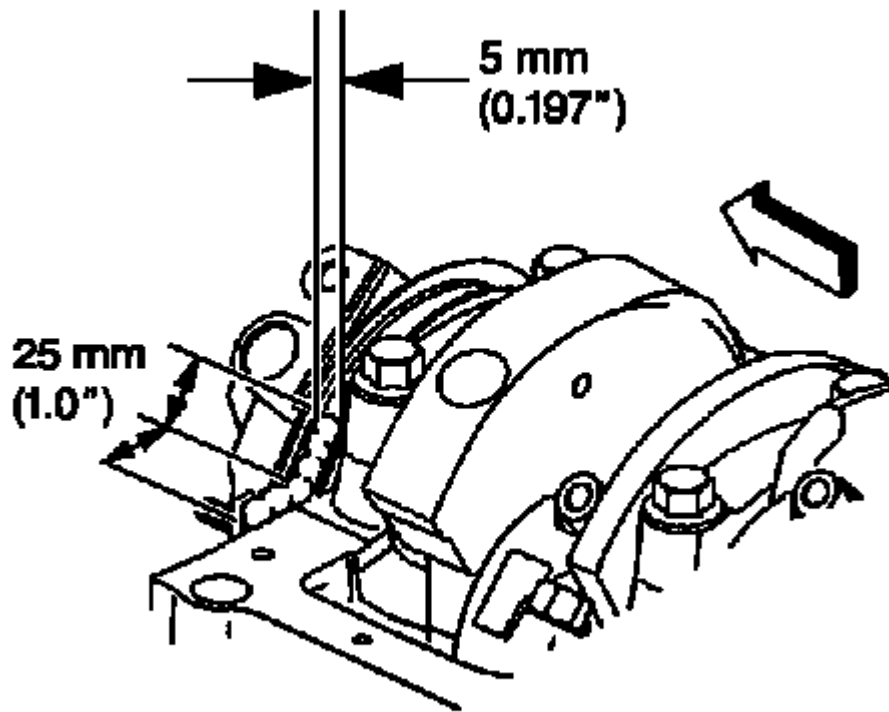


Fig. 504: Applying Adhesive To Engine Sides Front Cover To Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to both the right and left sides of the engine front cover to engine block junction at the oil pan sealing surfaces.

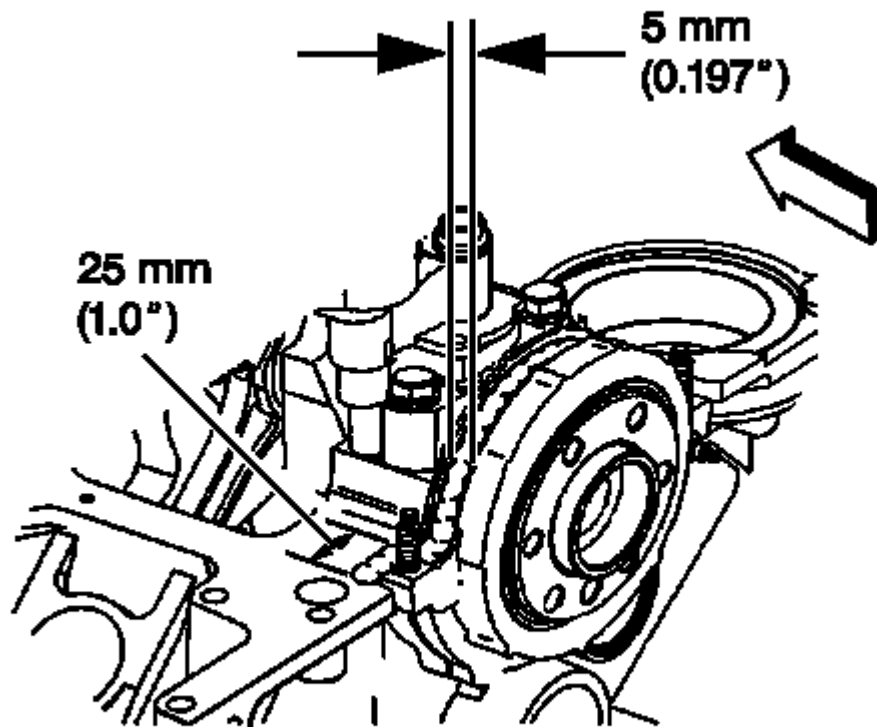


Fig. 505: Applying Adhesive To Entire Length Of Rear Oil Seal Housing To Engine Block Junction At Oil Pan Sealing Surfaces

Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the entire crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.

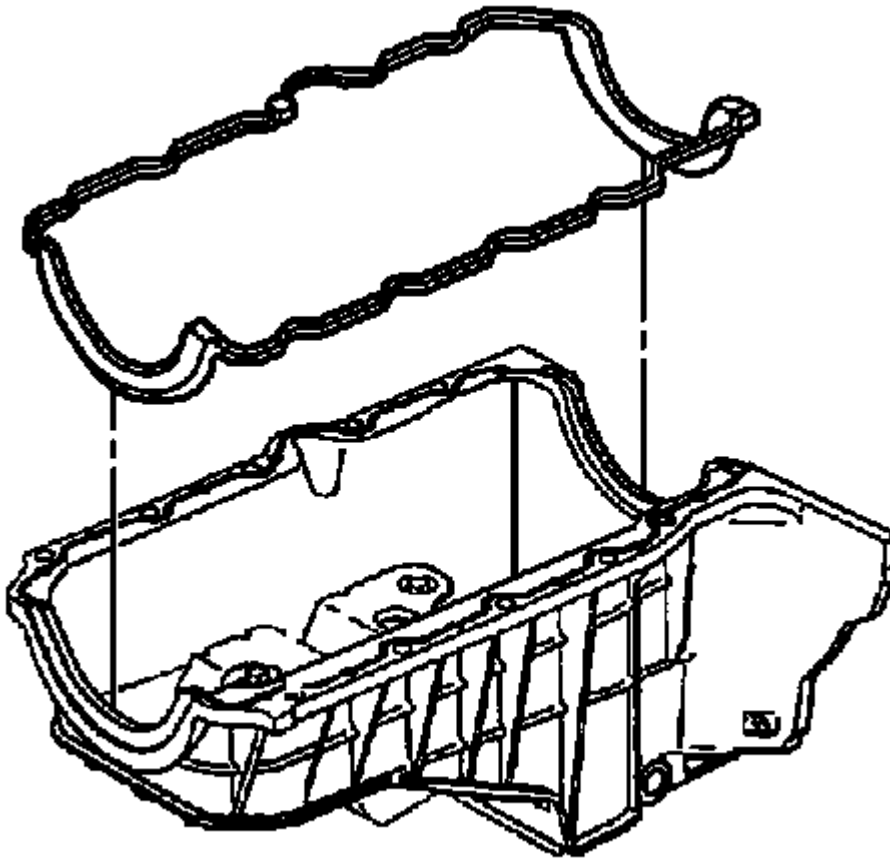


Fig. 506: View Of Oil Pan Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install a NEW oil pan gasket.
The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Install the NEW oil pan gasket into the groove in the oil pan.

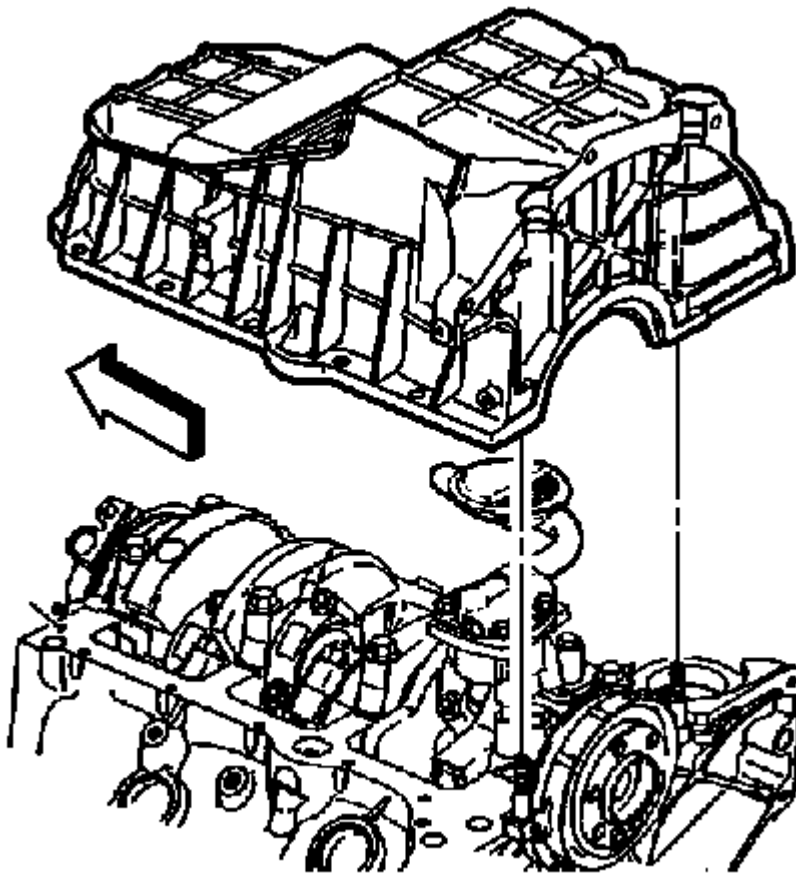


Fig. 507: Removing Oil Pan

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan alignment must always be flush or forward no more than 0.3 mm (0.011 in) from the rear face of the engine block.

4. Install the oil pan onto the engine block.

Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.

5. Slide the oil pan back against a suitable straight edge.

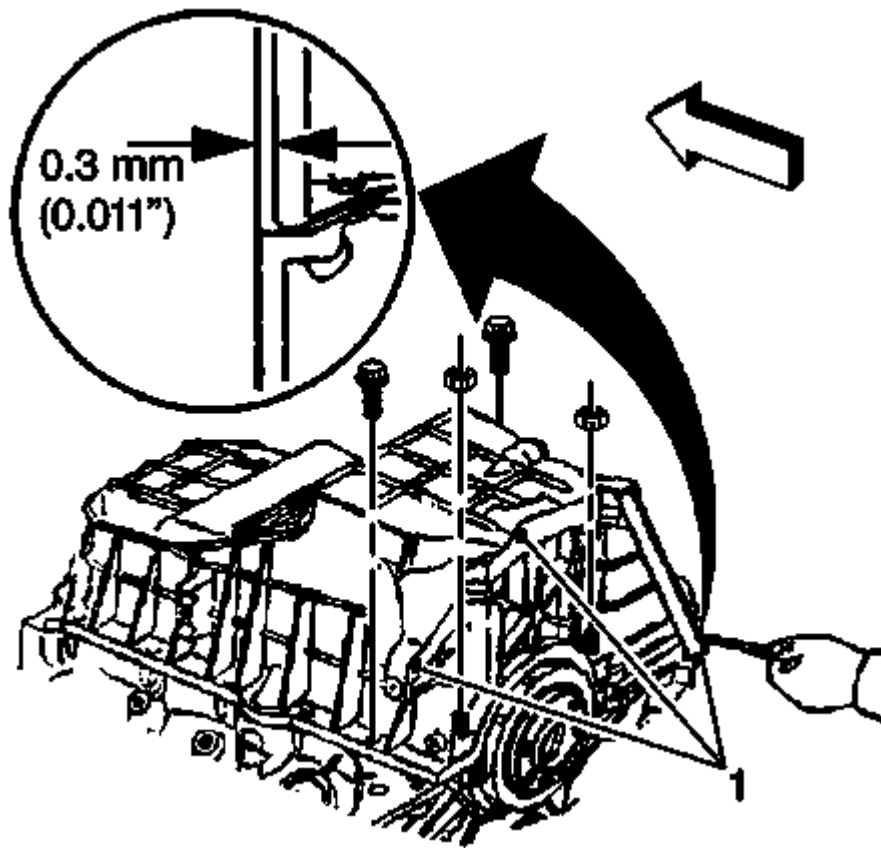


Fig. 508: Installing Oil Pan Bolts & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan bolts and nuts, but do not tighten.
7. Measure the pan-to-transmission housing clearance using a feeler gage and a straight edge.

Use a feeler gage to check the clearance between the oil pan-to-transmission housing measurement points. If the clearance exceeds 0.3 mm (0.011 in) at any of the 3 oil pan-to-transmission housing measurement points (1), then repeat the step until the oil pan-to-transmission housing clearance is within the specification. The oil pan must always be forward of the rear face of the engine block.

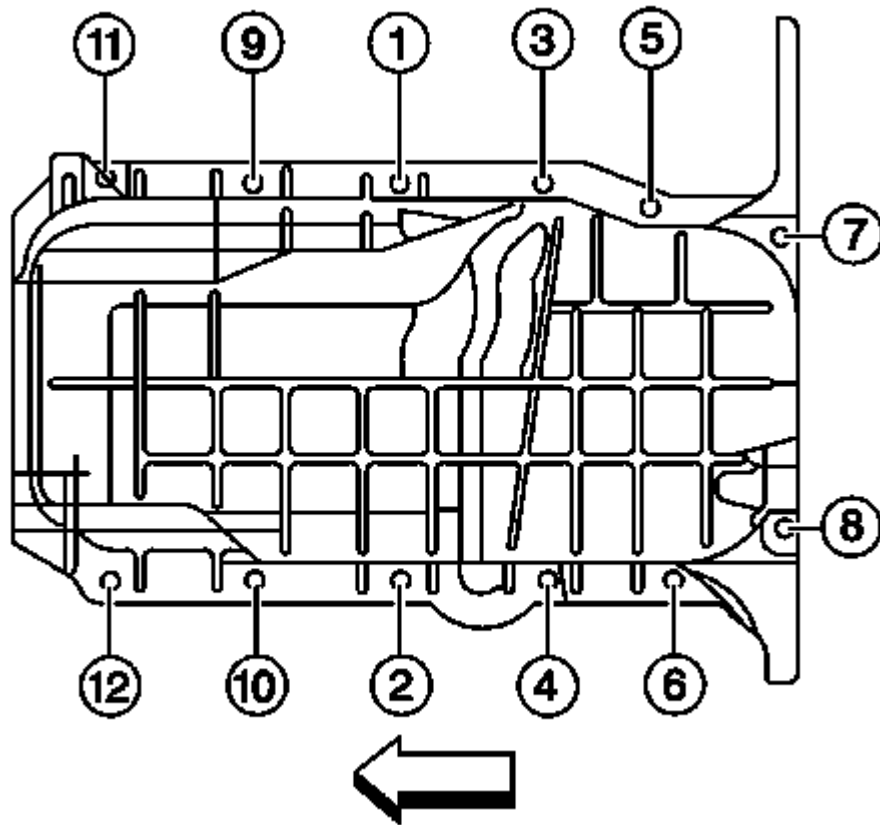


Fig. 509: Oil Pan Bolts & Nuts Proper Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

NOTE: The alignment of the mating components is crucial. An offset greater than 0.30 mm (0.011 in) between the rear faces of the oil pan and block is not acceptable. Offsets greater than 0.30 mm (0.011 in) will affect the alignment between the engine assembly and the transmission. Misalignment of the engine assembly to the transmission can lead to internal and external damage to the engine assembly and/or transmission.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the oil pan bolts and nuts in sequence (1-12).

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

9. Measure the clearance between the 3 oil pan-to-transmission housing measurement points in order to ensure proper alignment.

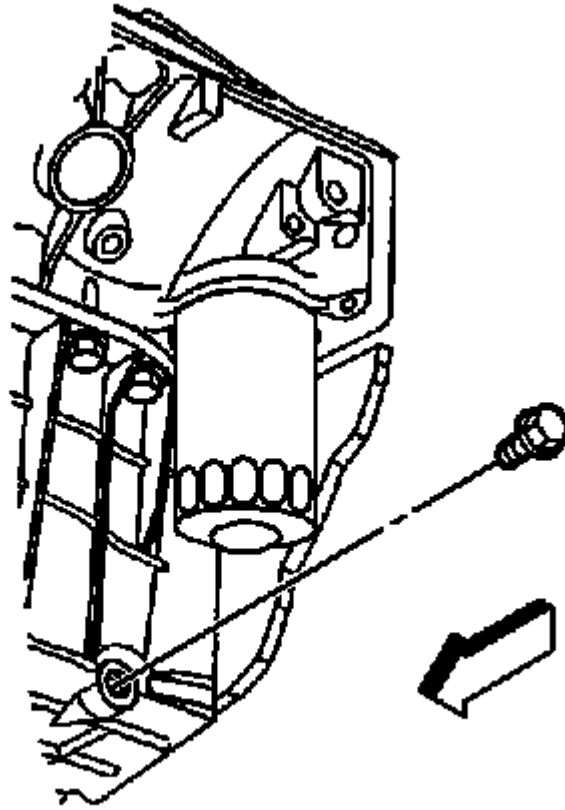


Fig. 510: Identifying Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

10. Install a NEW oil pan drain plug seal, O-ring, onto the oil pan drain plug.
11. Install the oil pan drain plug into the oil pan.

Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

Oil Filter Adapter Installation

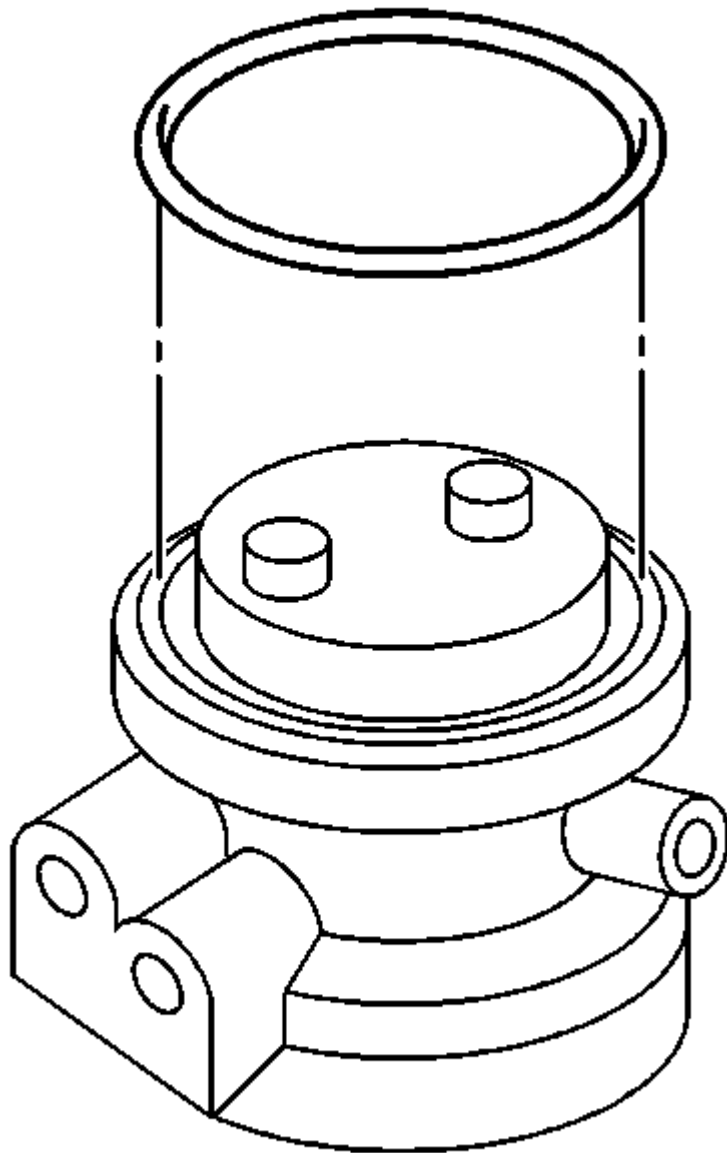


Fig. 511: Locating Oil Filter Adapter Seal - O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter adapter seal, O-ring, into the groove in the oil filter adapter.

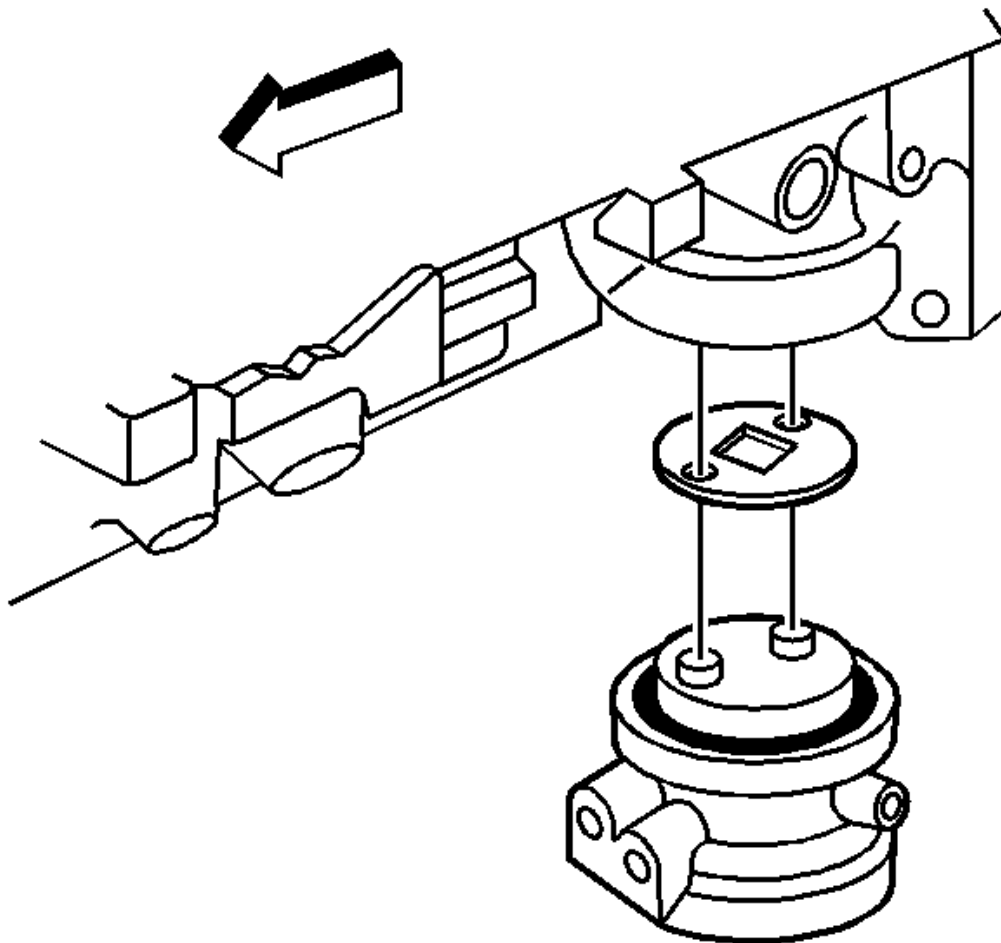


Fig. 512: Identifying Oil Filter Adapter & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter adapter and NEW oil filter adapter gasket.

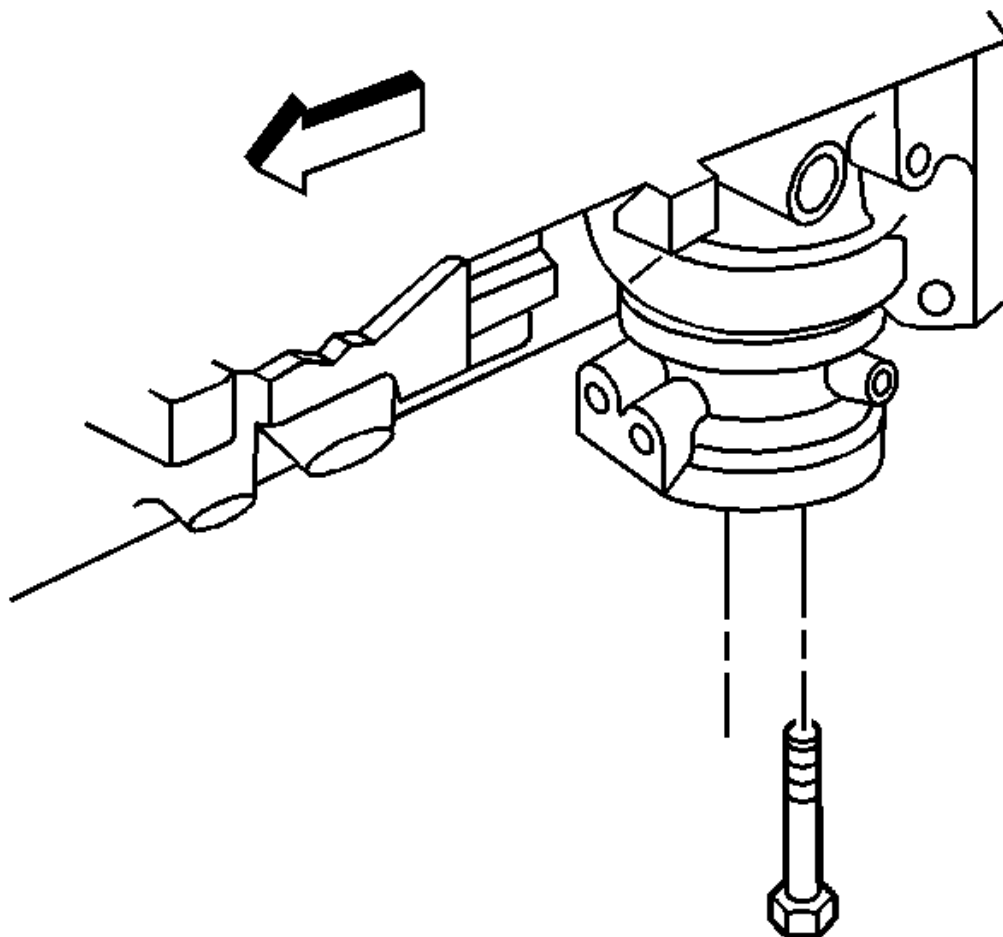


Fig. 513: View Of Oil Filter Adapter Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil filter adapter bolts.

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

Crankshaft Balancer Installation

Tools Required

J 23523-F Balancer Remover and Installer

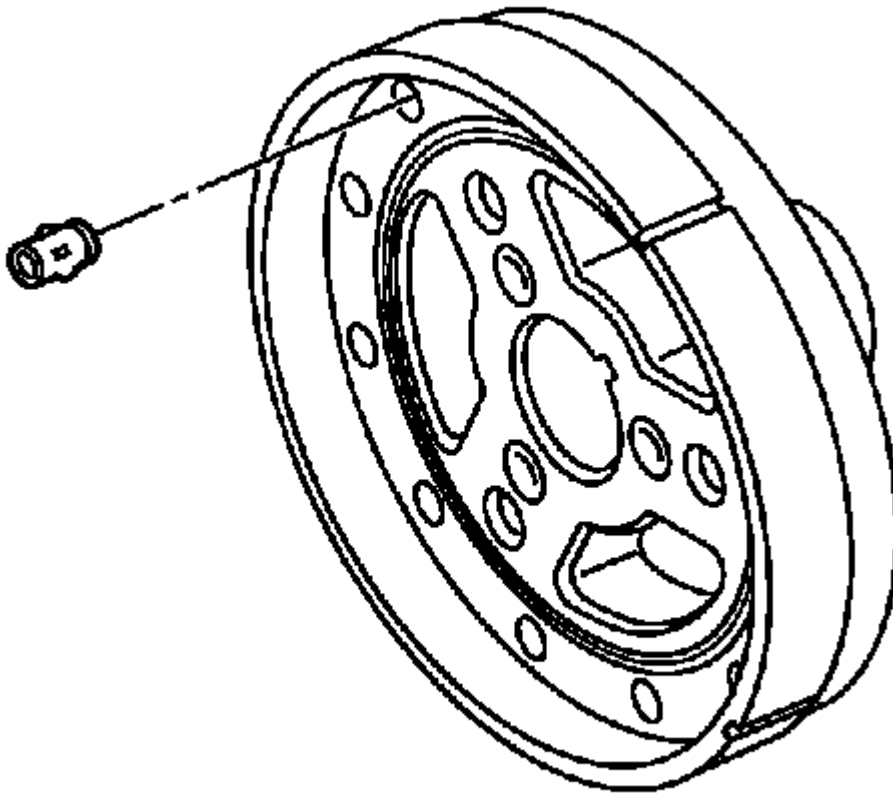


Fig. 514: View Of Crankshaft Balancer Weights

Courtesy of GENERAL MOTORS CORP.

1. Look to ensure that the crankshaft balancer front groove pin is installed in the proper location, if applicable.

The length and location of the pins must be the same as the original length and location.

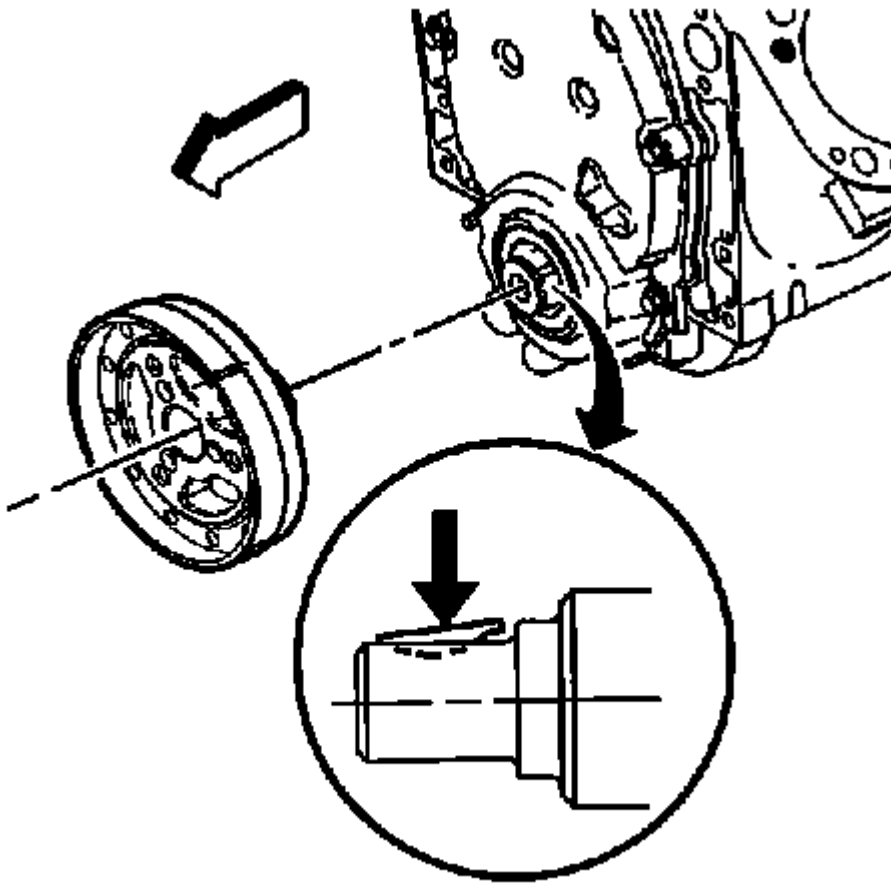


Fig. 515: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

2. Apply a small amount of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, onto the crankshaft balancer keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
3. Align the keyway of the crankshaft balancer with the crankshaft balancer key.
4. Install the crankshaft balancer onto the end of the crankshaft.

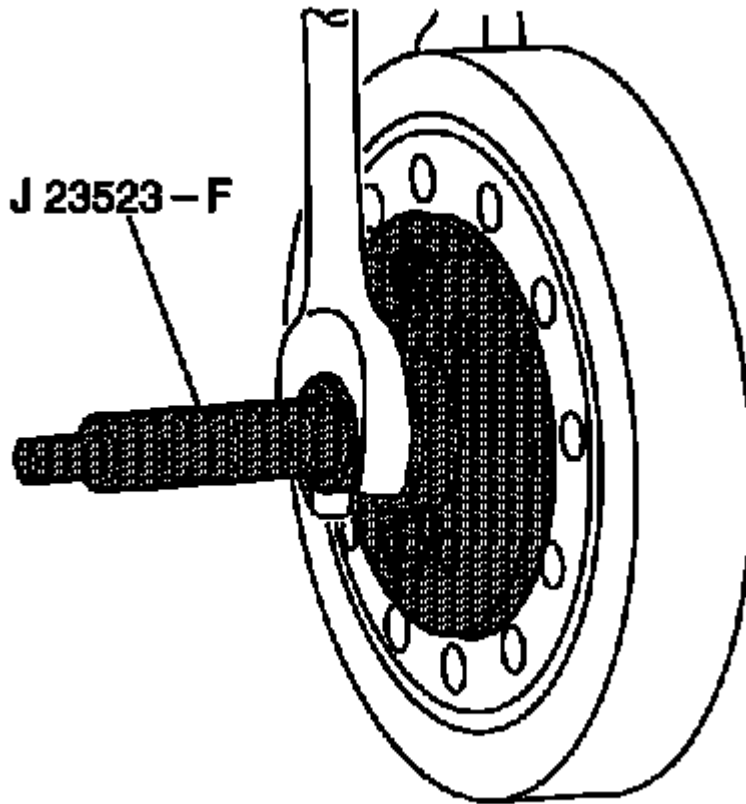


Fig. 516: Pressing The Crankshaft Balancer Onto The Crankshaft Using J 23523-F
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Use the J 23523-F in order to press the crankshaft balancer onto the crankshaft.
 1. Install the J 23523-F plate and bolts onto the front of the crankshaft balancer.

Tighten: Tighten the J 23523-F plate bolts to 25 N.m (18 lb ft).

 2. Install the J 23523-F screw into the end for the crankshaft.
 3. Install the J 23523-F bearing, the washer, and the nut onto the J 23523-F screw.
 4. Rotate the J 23523-F nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.
6. Remove the J 23523-F .

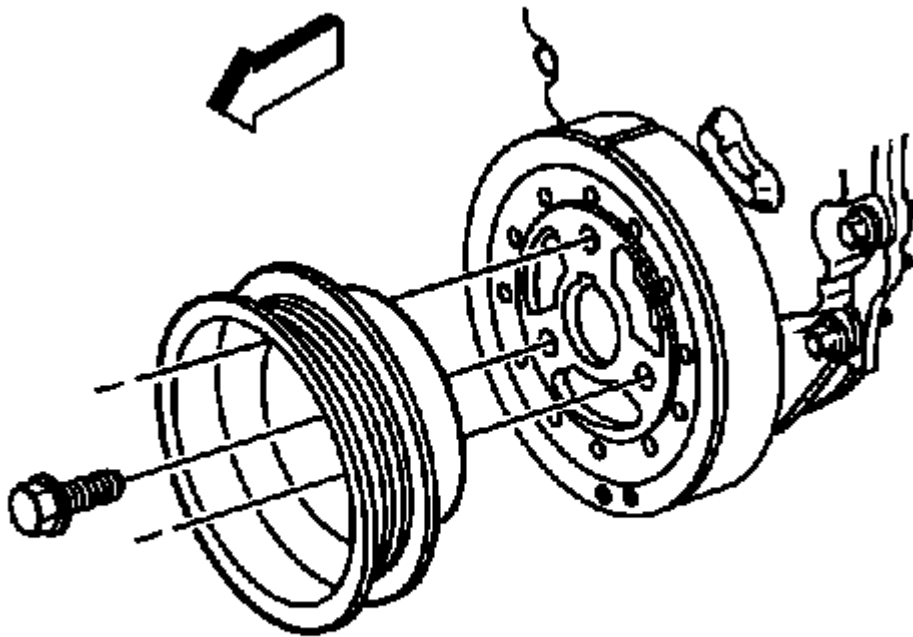


Fig. 517: View Of Crankshaft Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the crankshaft pulley and bolts. Finger tighten all bolts until snug.

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

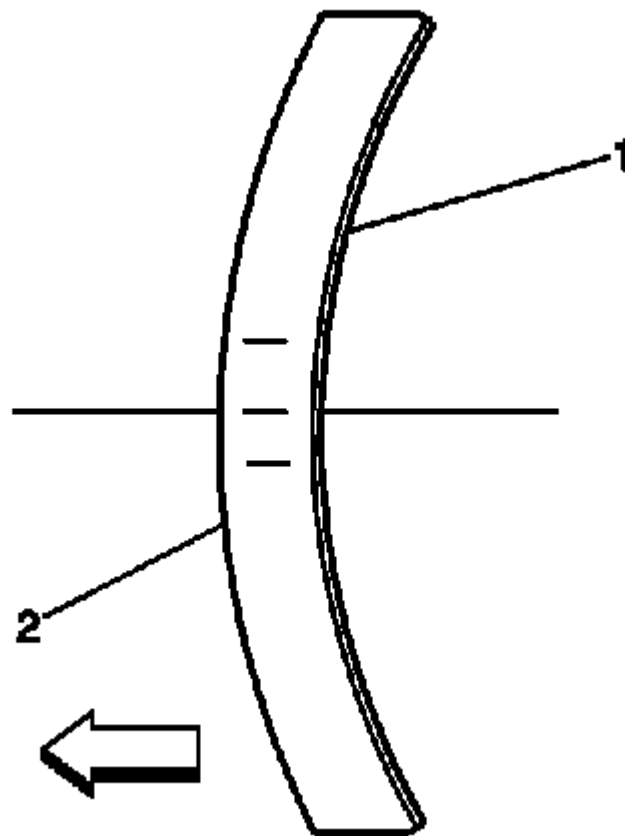


Fig. 518: Crankshaft Balancer Washer
Courtesy of GENERAL MOTORS CORP.

8. Ensure that the crown of the crankshaft balancer washer (2) is faced away from the engine.

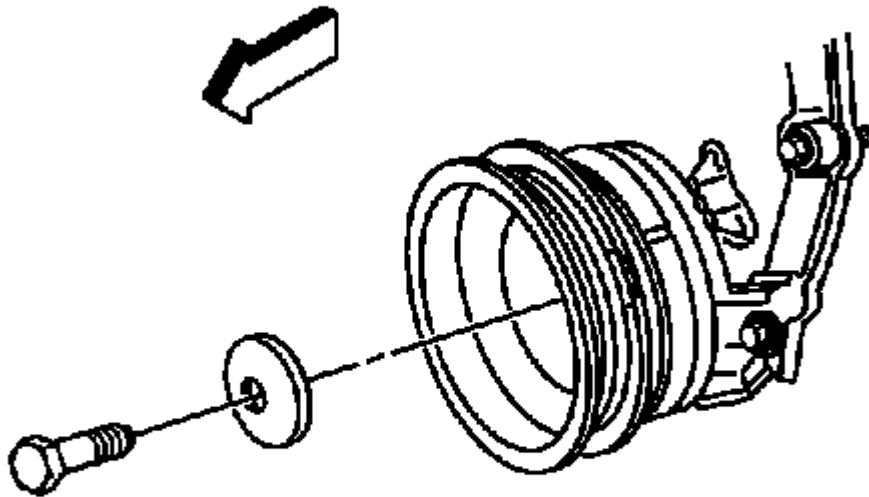


Fig. 519: View Of Crankshaft Balancer Washer & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the crankshaft balancer washer and the bolt.

Tighten: Tighten the crankshaft balancer bolt to 95 N.m (70 lb ft).

Valve Lifter Installation

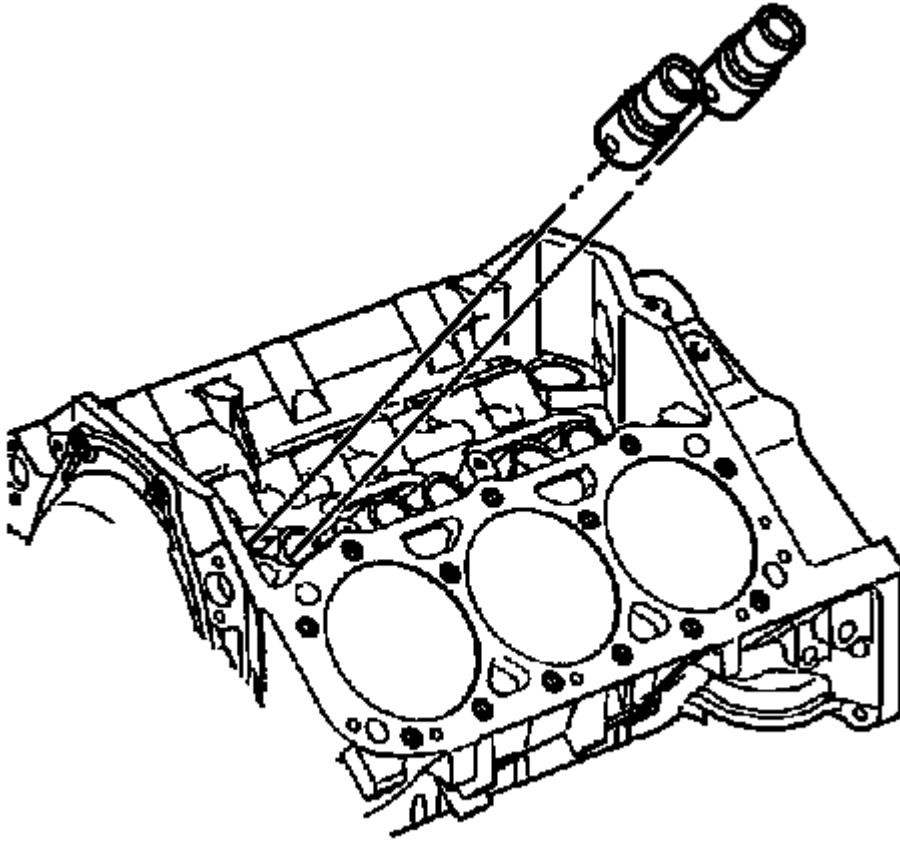


Fig. 520: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

1. Apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent, to the valve lifter rollers.

IMPORTANT: If reusing the valve lifters, install the valve lifters in the original positions.

2. Install the valve lifters.

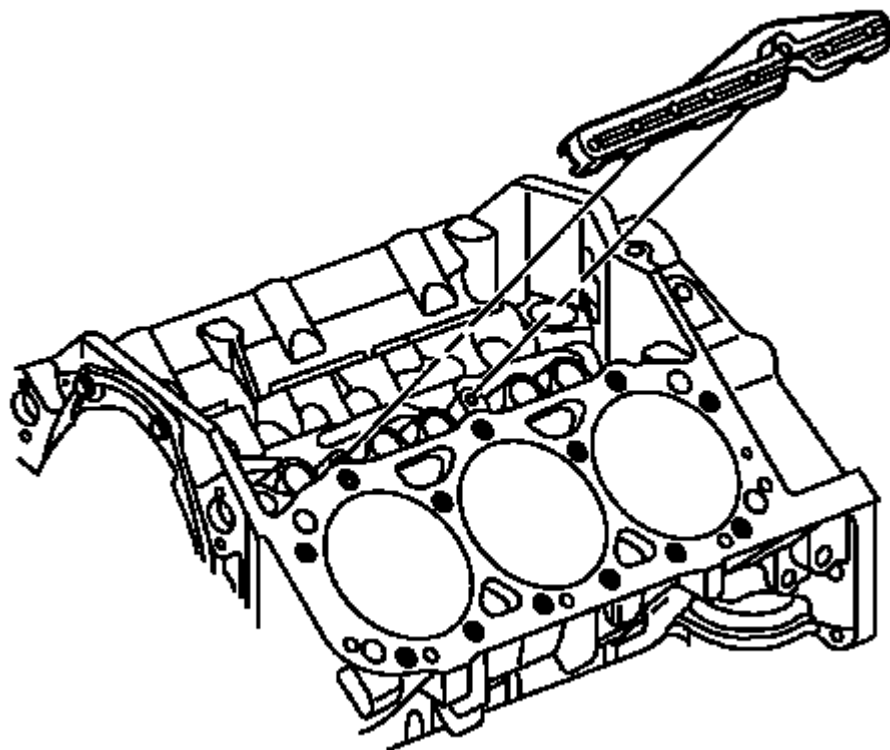


Fig. 521: View Of Valve Lifter Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the valve lifter pushrod guides.

Tighten: Tighten the valve lifter pushrod guide bolts to 16 N.m (12 lb ft).

Cylinder Head Installation - Left

Tools Required

J 45059 Angle Meter. See Special Tools.

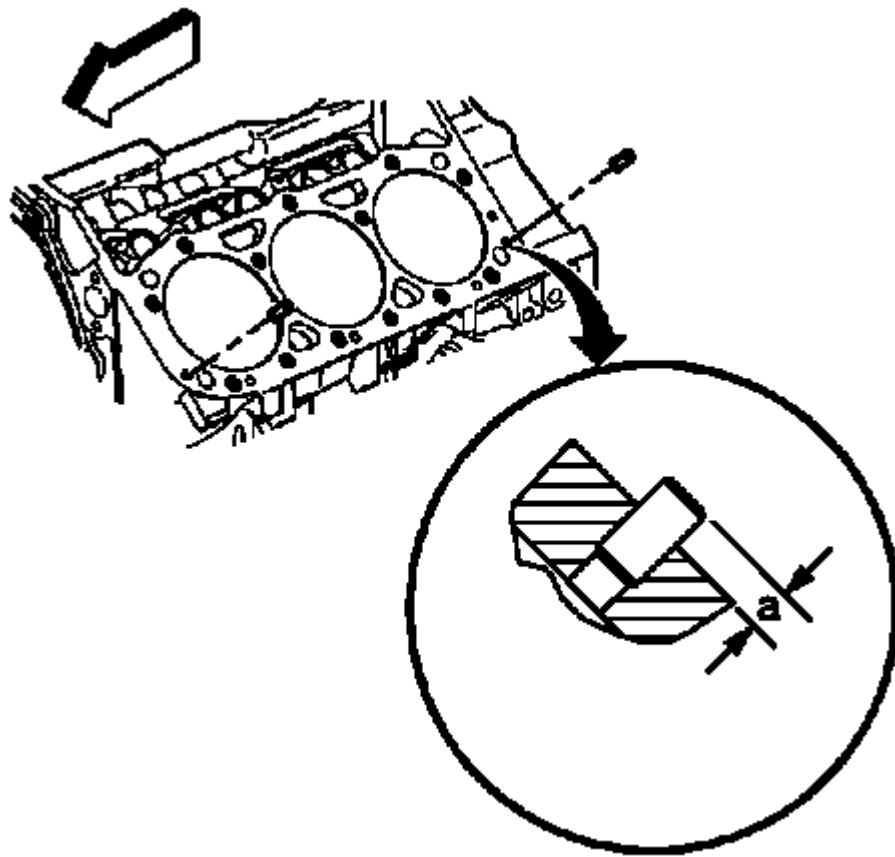


Fig. 522: Left Side Cylinder Head Locator Dowel Pins Proper Installation Position
 Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the cylinder head locator dowel pins for proper installation.

The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

3. Clean the cylinder head gasket surfaces on the cylinder head.

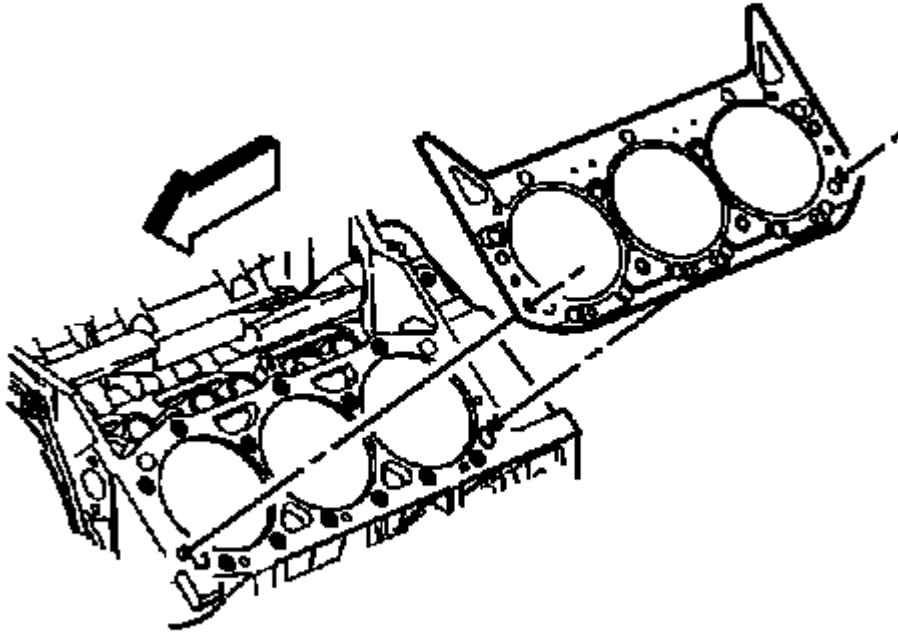


Fig. 523: View Of Cylinder Head Gasket And Alignment Pins - Left
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type sealer on the cylinder head gasket, unless specified.

4. Install the NEW cylinder head gasket in position over the cylinder head locator dowel pins.

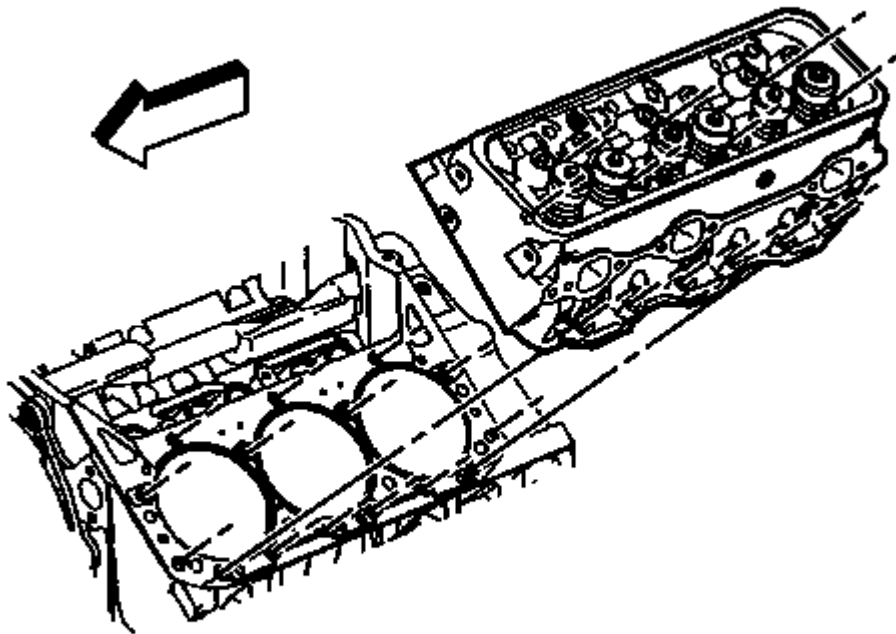


Fig. 524: Removing/Installing Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

5. Install the cylinder head onto the engine block.

Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

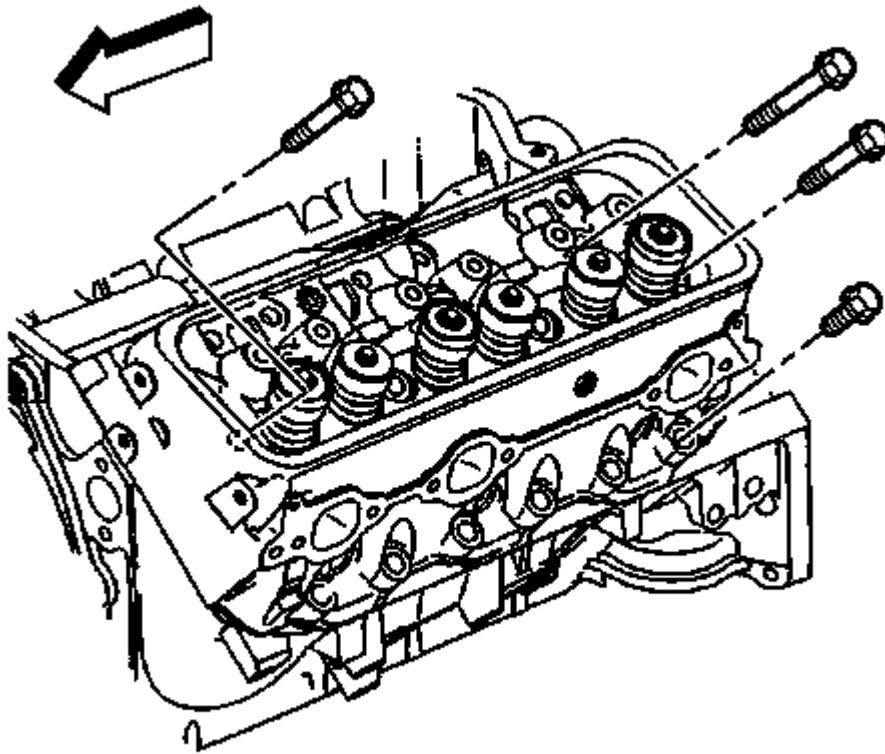


Fig. 525: Locating Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the NEW cylinder head bolts.
7. Install the NEW cylinder head bolts finger tight.

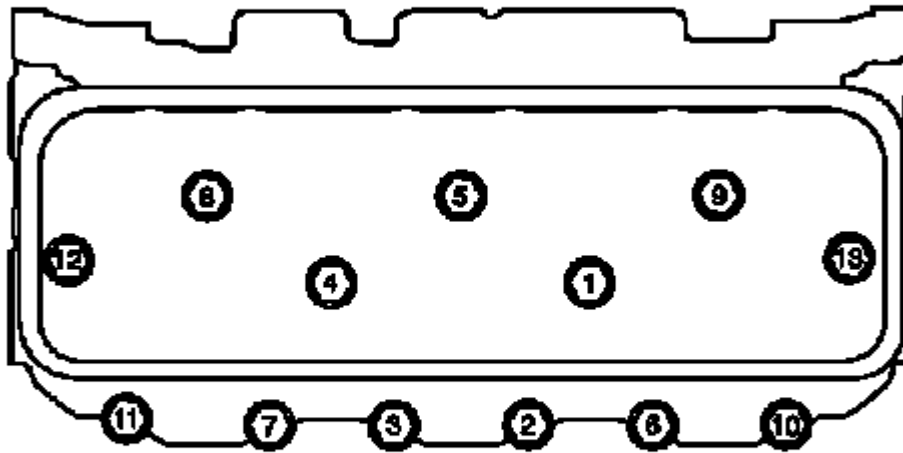


Fig. 526: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the cylinder head bolts in sequence on the first pass.

Tighten: Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the **J 45059** in order to tighten the cylinder head bolts in sequence on the final pass. See Special Tools.

Tighten:

- Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
- Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
- Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

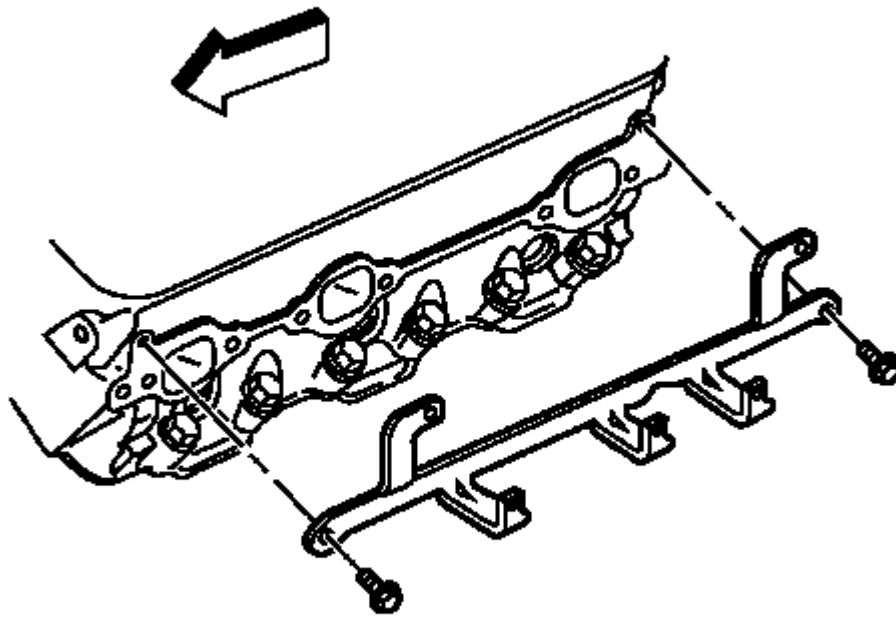


Fig. 527: Removing Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

10. Install the spark plug wire support and bolts.

Tighten: Tighten the spark plug wire support bolts to 12 N.m (106 lb in).

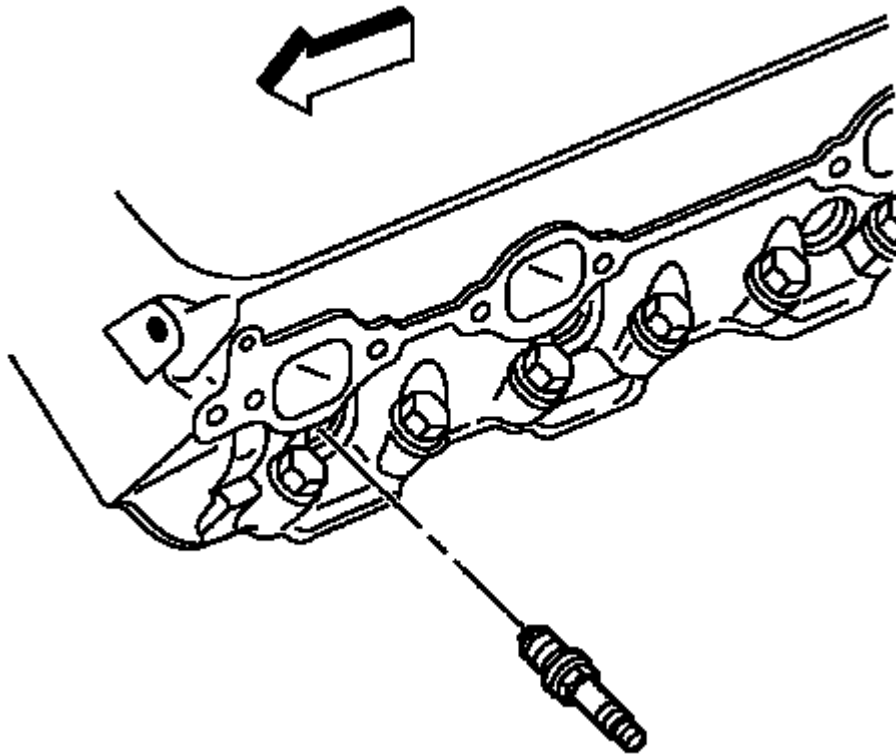


Fig. 528: Removing Spark Plugs
Courtesy of GENERAL MOTORS CORP.

11. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

Specification: Spark plug gap to 1.52 mm (0.060 in).

12. Install the spark plugs.

Tighten:

- Tighten the spark plugs for a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

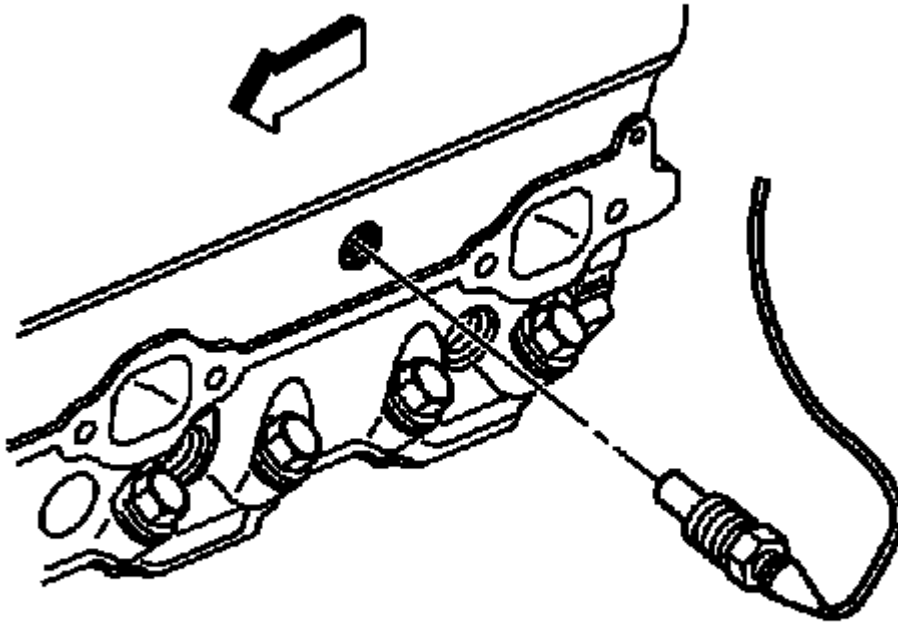


Fig. 529: Removing Engine Coolant Temperature Gage Sensor
Courtesy of GENERAL MOTORS CORP.

13. If reusing the engine coolant temperature gage sensor, if applicable, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine coolant temperature gage sensor.
14. Install the engine coolant temperature gage sensor, if applicable.

Tighten: Tighten the engine coolant temperature gage sensor to 20 N.m (15 lb ft).

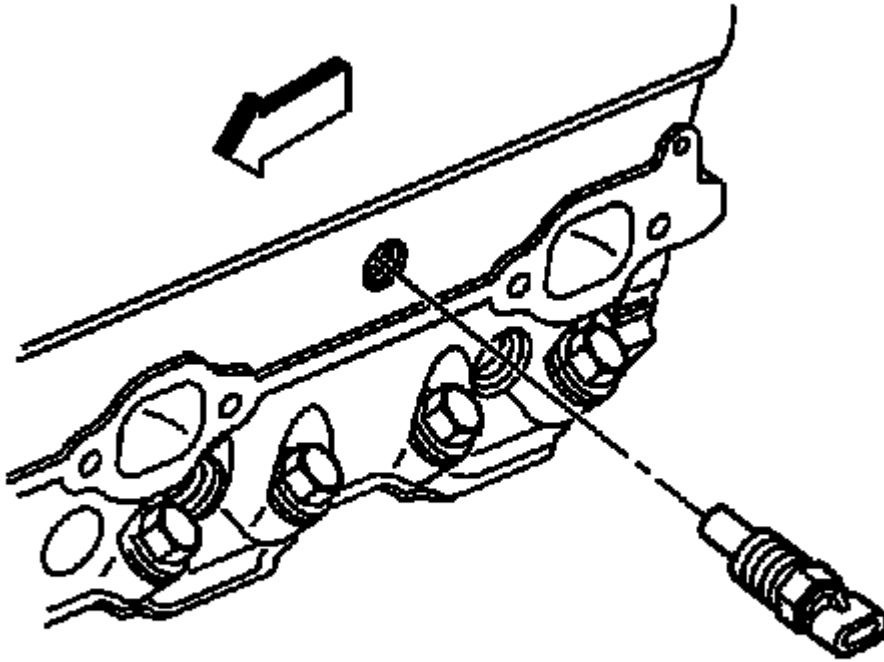


Fig. 530: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

15. If reusing the engine coolant temperature sensor, if applicable, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the engine coolant temperature gage sensor.
16. Install the engine coolant temperature sensor, if applicable.

Tighten: Tighten the engine coolant temperature sensor to 20 N.m (15 lb ft).

Cylinder Head Installation - Right

Tools Required

J 45059 Angle Meter. See Special Tools.

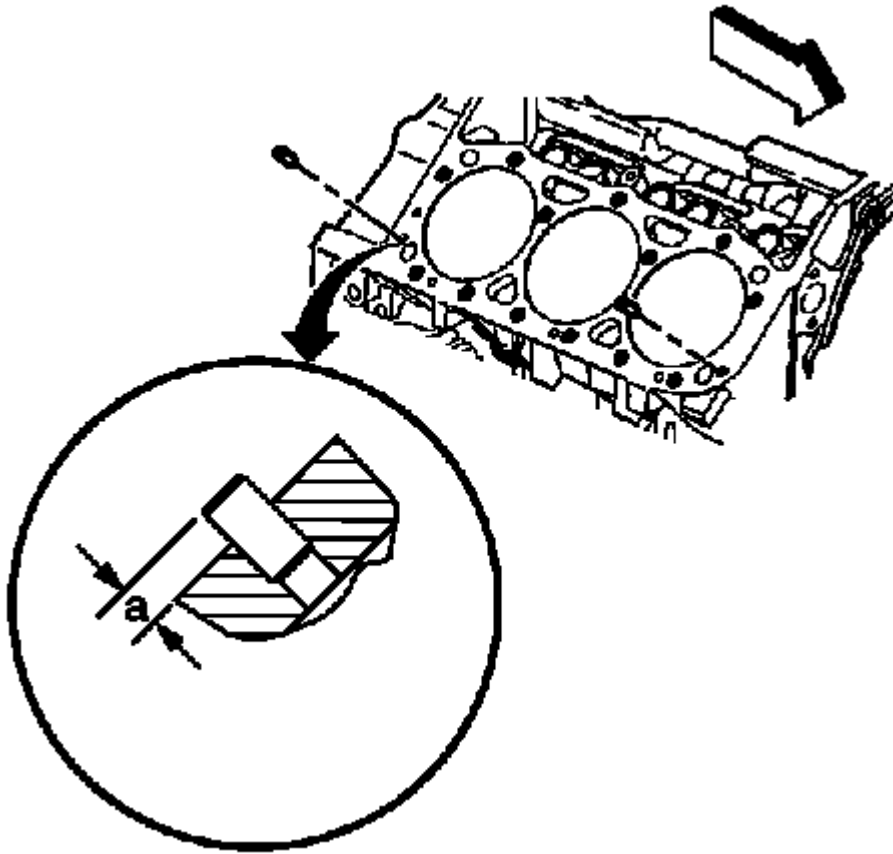


Fig. 531: Right Side Cylinder Head Locator Dowel Pins Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the cylinder head locator dowel pins for proper installation.

The installation height should be 6.3-6.5 mm (0.248-0.256 in) (a).

3. Clean the cylinder head gasket surfaces on the cylinder head.

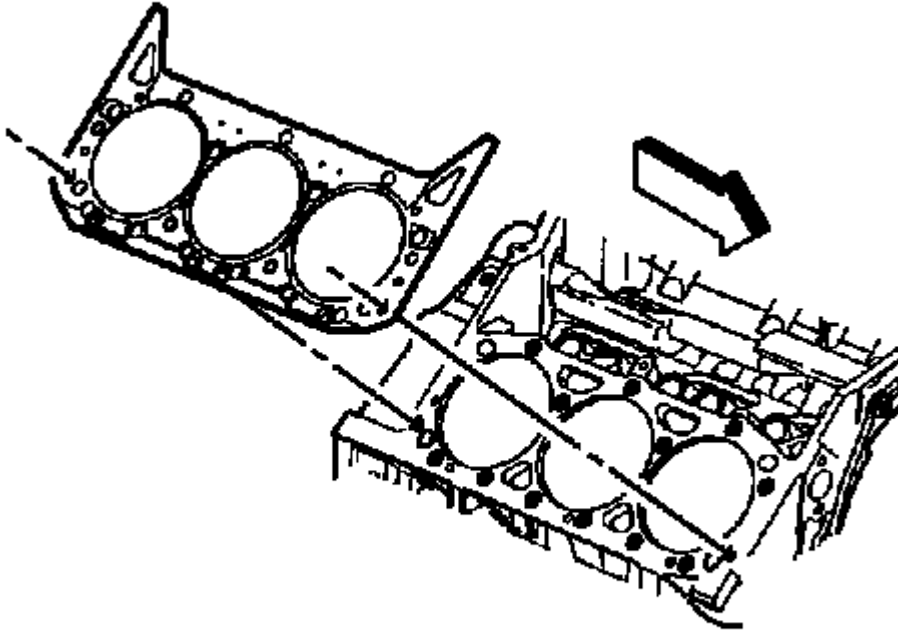


Fig. 532: View Of Cylinder Head Gasket And Alignment Pins - Right
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type sealer on the cylinder head gasket, unless specified.

4. Install the NEW cylinder head gasket in position over the cylinder head locator dowel pins.

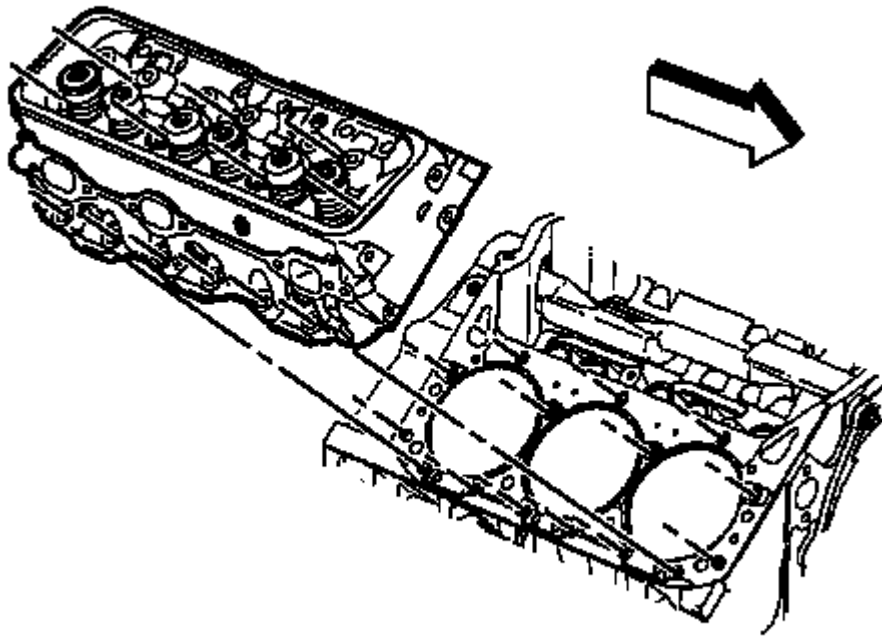


Fig. 533: Removing/Installing Cylinder Head (Right)
Courtesy of GENERAL MOTORS CORP.

5. Install the cylinder head onto the engine block.

Guide the cylinder head carefully into place over the dowel pins and the cylinder head gasket.

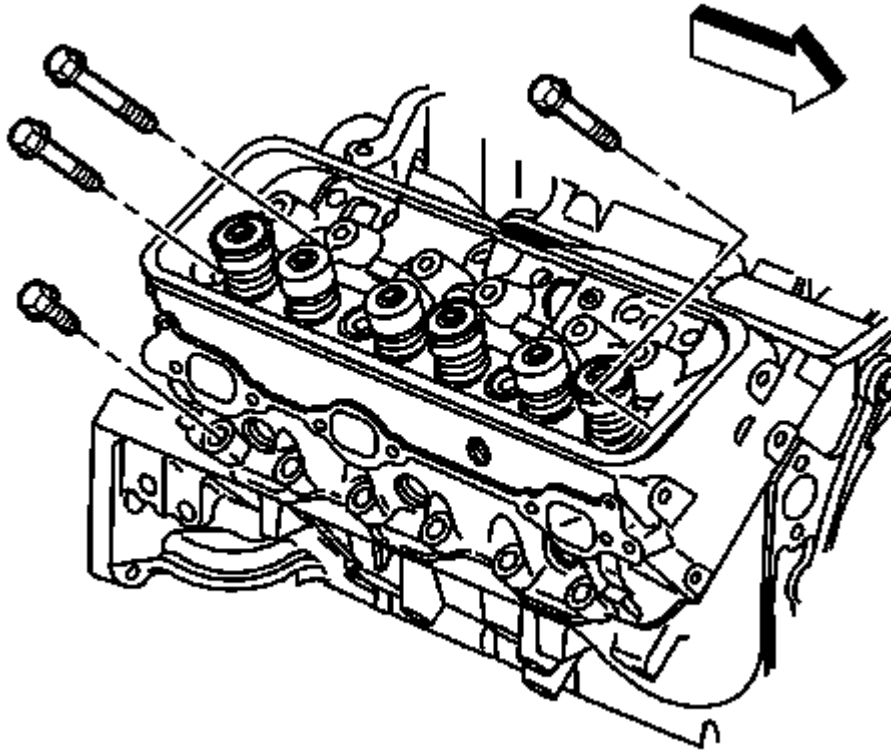


Fig. 534: Locating Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the NEW cylinder head bolts.
7. Install the NEW cylinder head bolts finger tight.

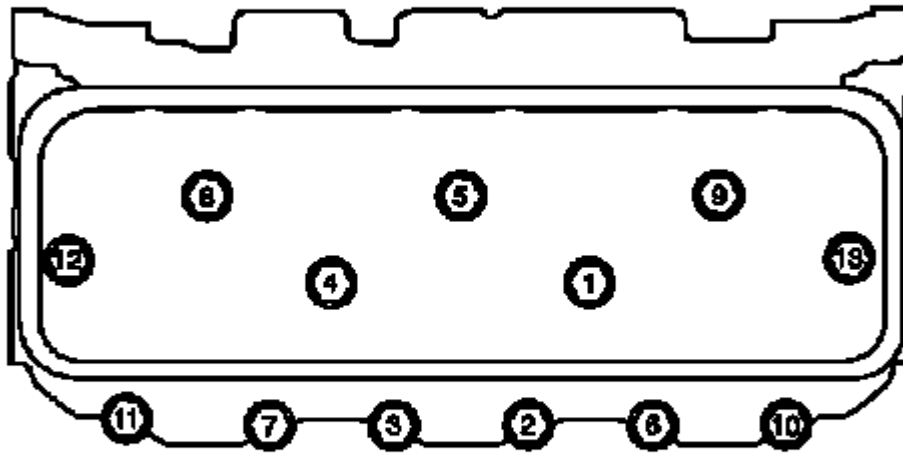


Fig. 535: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the cylinder head bolts in sequence on the first pass.

Tighten: Tighten the bolts in sequence on the first pass to 30 N.m (22 lb ft).

9. Use the **J 45059** in order to tighten the cylinder head bolts in sequence on the final pass. See Special Tools.

Tighten:

- Tighten the long bolts (1, 4, 5, 8, and 9) on the final pass in sequence to 75 degrees.
- Tighten the medium bolts (12 and 13) on the final pass in sequence to 65 degrees.
- Tighten the short bolts (2, 3, 6, 7, 10, and 11) on the final pass in sequence to 55 degrees.

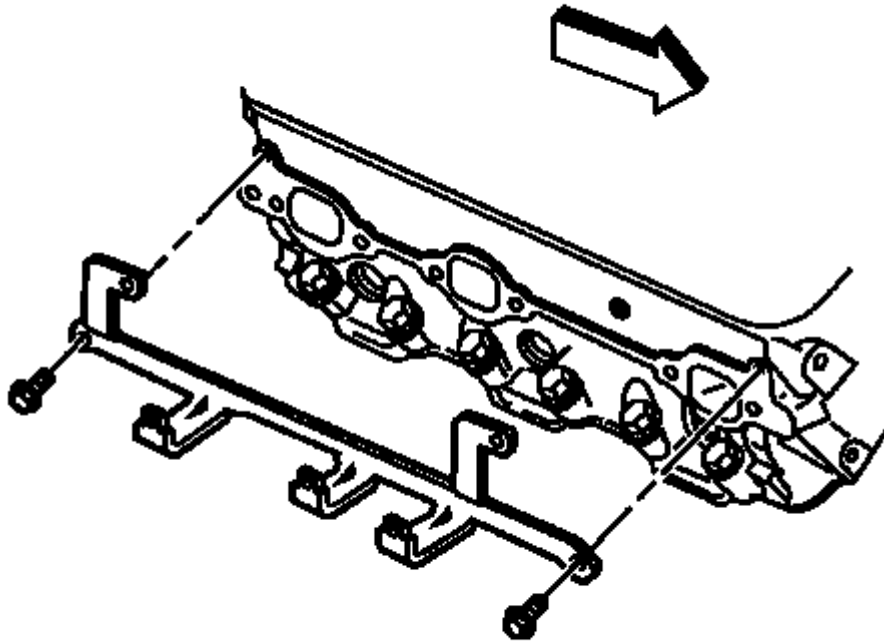


Fig. 536: Removing Spark Plug Wire Support
Courtesy of GENERAL MOTORS CORP.

10. Install the spark plug wire support and bolts.

Tighten: Tighten only the rear spark plug wire support bolt to 12 N.m (106 lb in).

11. Remove the front spark plug wire support bolt.

The front spark plug wire support bolt is used to fasten the oil level indicator tube, and will be installed within the oil level indicator tube installation procedure.

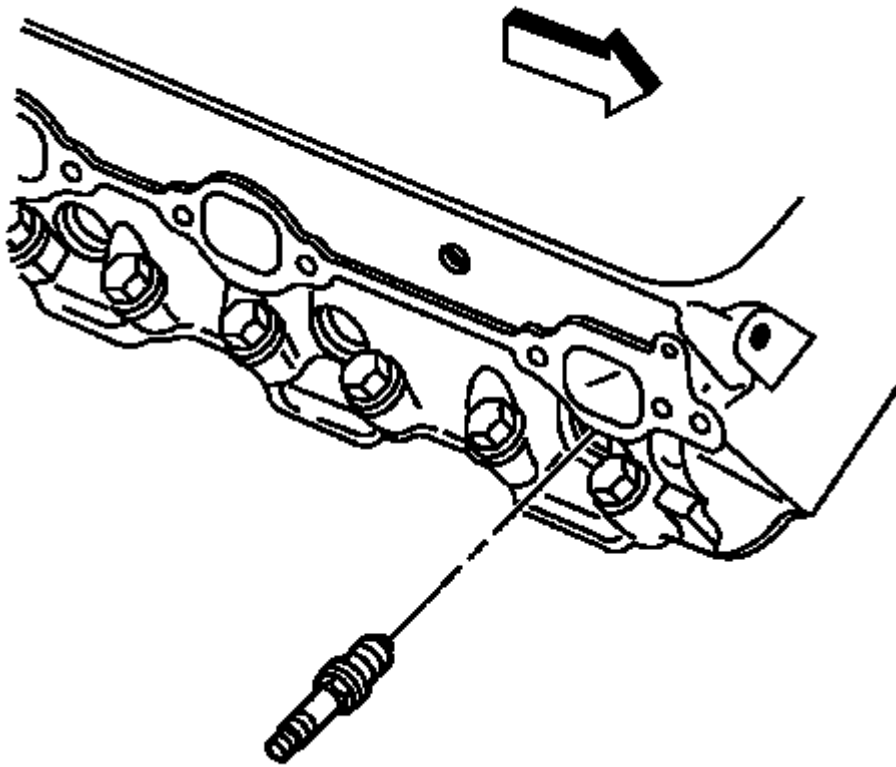


Fig. 537: Locating Spark Plugs

Courtesy of GENERAL MOTORS CORP.

12. Measure the NEW spark plugs for the proper gap.

Adjust the spark plug gap if necessary.

Specification: Spark plug gap to 1.52 mm (0.060 in).

13. Install the spark plugs.

Tighten:

- Tighten the spark plugs for a USED cylinder head to 15 N.m (11 lb ft).
- Tighten the spark plugs for the initial installation of a NEW cylinder head to 30 N.m (22 lb ft).

Valve Rocker Arm and Push Rod Installation

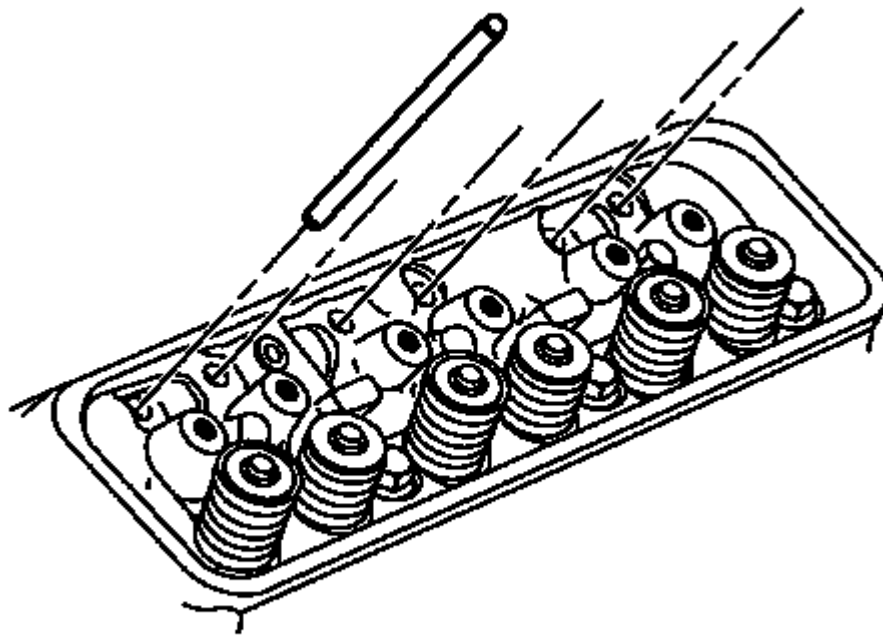


Fig. 538: View Of Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to keep parts in order. Parts must be reinstalled into the original location and position.

1. Install the valve pushrods.

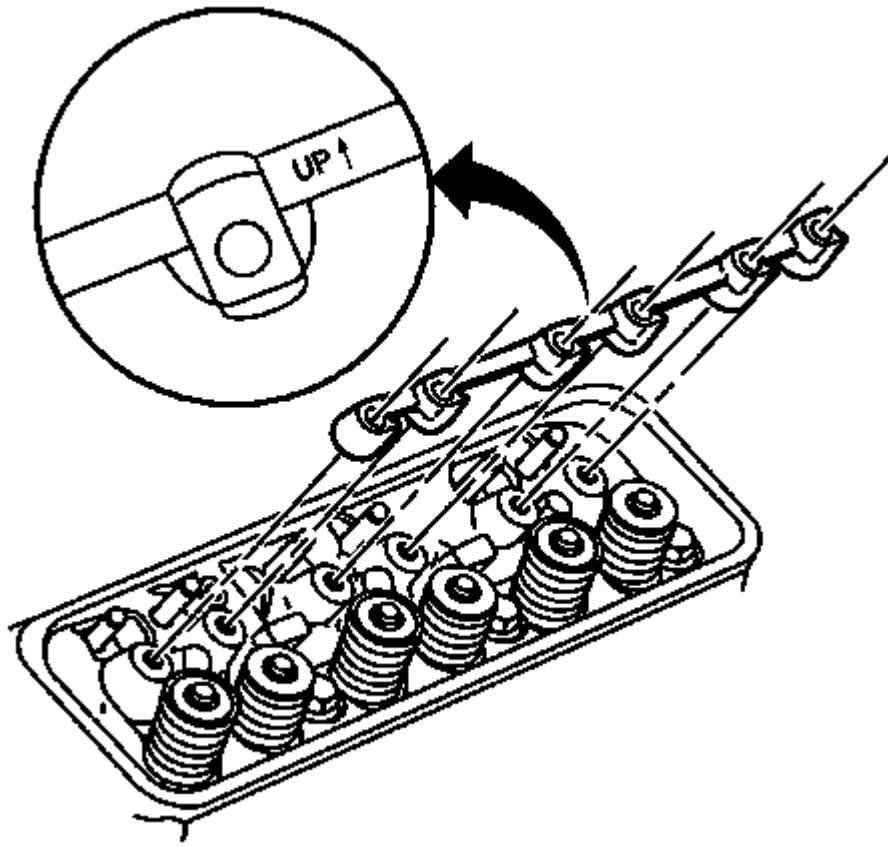


Fig. 539: Installing Rocker Arm Supports
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure that the arrow on the valve rocker arm support is in the up position.

2. Install the valve rocker arm supports.

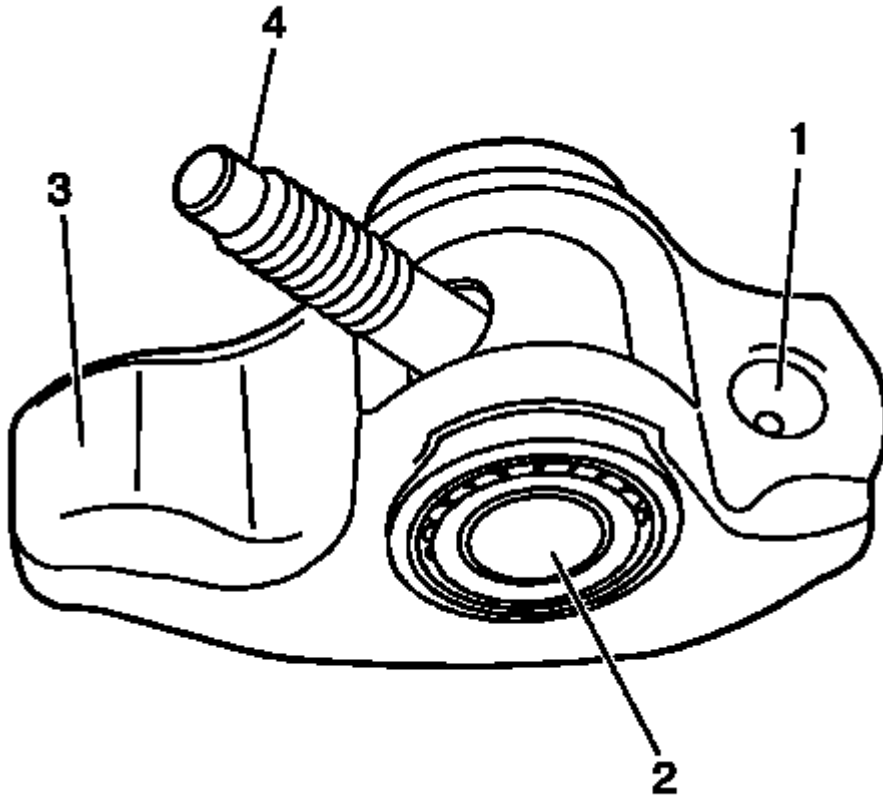


Fig. 540: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS CORP.

3. Apply prelube GM P/N 12345501 (Canadian P/N 992704) or equivalent, to the following valve rocker arm contact surfaces:
 - Valve pushrod socket (1)
 - Roller pivot (2)
 - Valve stem tip (3)

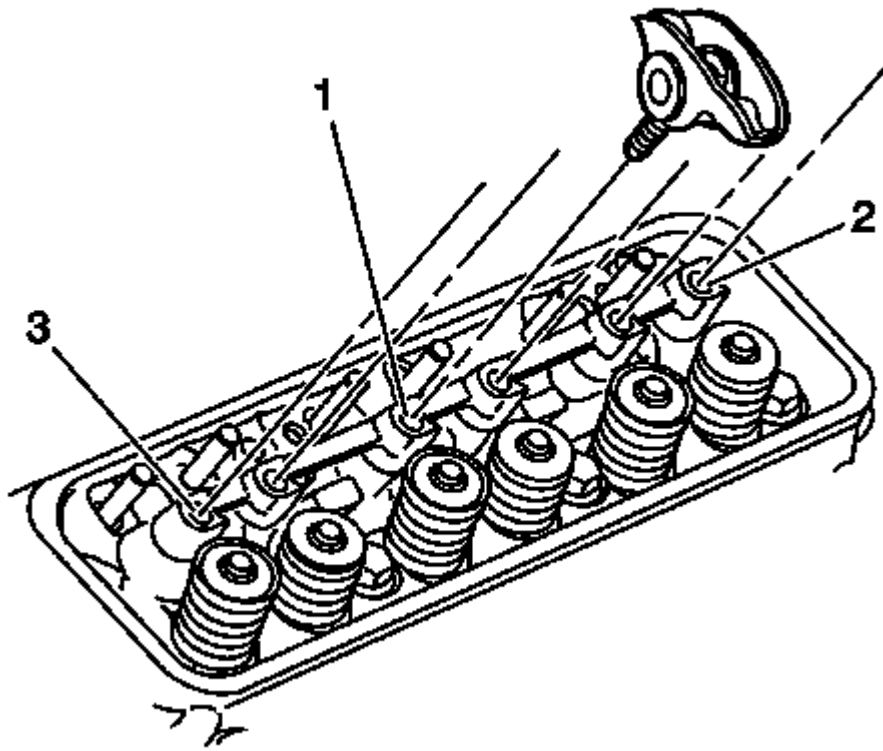


Fig. 541: Installing Rocker Arms
Courtesy of GENERAL MOTORS CORP.

4. Install the valve rocker arm assemblies as follows:
 1. Finger start the bolt at location (1)
 2. Finger start the bolt at location (2)
 3. Finger start the bolt at location (3)
 4. Finger start the remaining valve rocker arm bolts

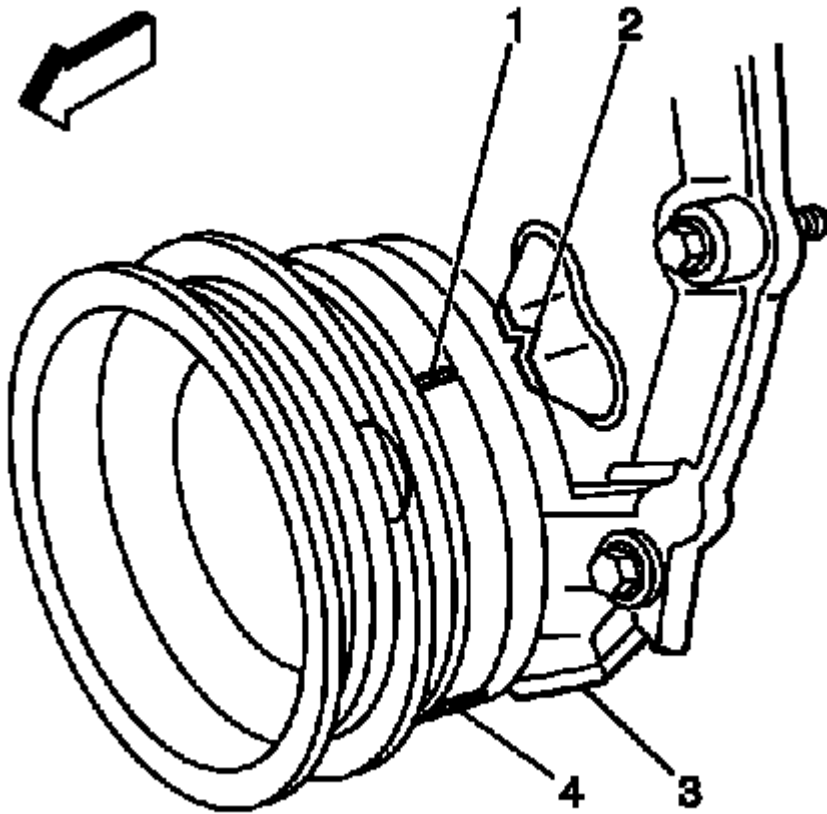


Fig. 542: View Of Crankshaft Balancer Alignment Mark & Engine Front Cover Alignment Tab
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rotate the number 1 cylinder to top dead center (TDC) of the compression stroke. The engine front cover has 2 alignment tabs and the crankshaft balancer has 2 alignment marks which are spaced 90 degrees apart that are used for positioning the number 1 piston at TDC.

5. Rotate the crankshaft balancer clockwise until the alignment marks on the crankshaft balancer are aligned with the tabs on the engine front cover, 1 with 2 and 3 with 4. At that point the number 1 piston should be at TDC of the compression stroke.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Once the valve rocker arm assemblies are installed and properly torqued, no additional valve lash adjustment is required.

6. Tighten the valve rocker arm bolts.

Tighten: Tighten valve rocker arm bolts to 30 N.m (22 lb ft).

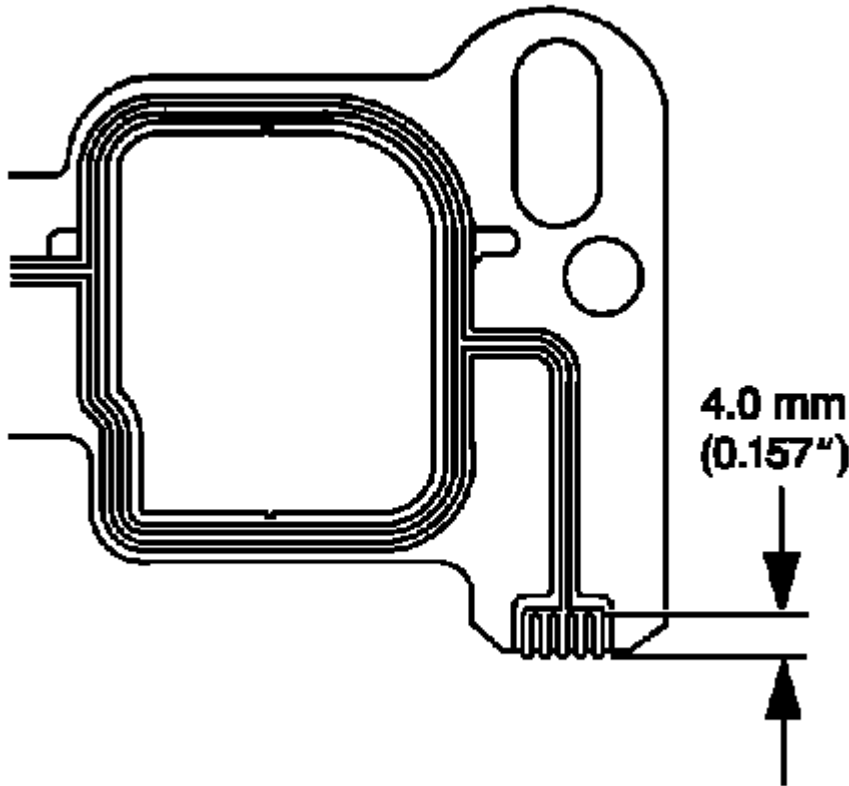
Intake Manifold Installation

Fig. 543: Applying Patch Of Adhesive To Cylinder Head Side Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: Apply the proper amount of the sealant when assembling this component. Excessive use of the sealant can prohibit the component from sealing properly. A component that is not sealed properly can leak leading to extensive engine damage.

1. Apply a 4.0 mm (0.157 in) patch of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the cylinder head side of the lower intake manifold gasket at each end.

IMPORTANT: The lower intake manifold gasket must be installed while the adhesive is still wet to the touch.

2. Install the lower intake manifold gasket onto the cylinder head.

Use the gasket locator pins in order to properly seat the lower intake manifold gasket on the cylinder head.

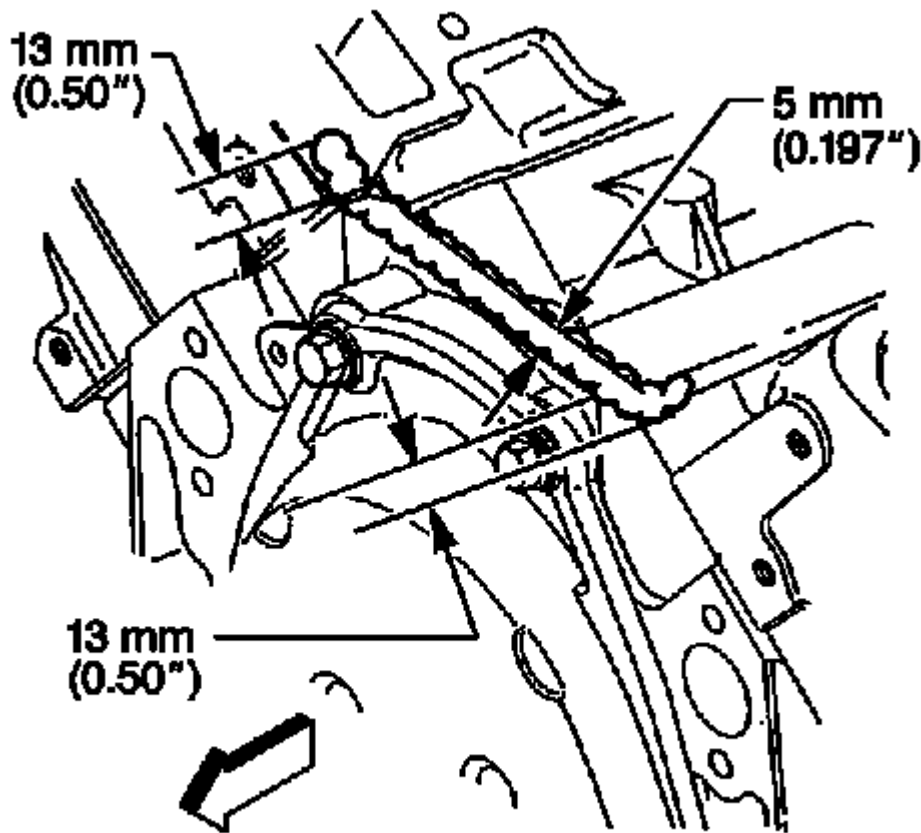


Fig. 544: Applying Adhesive To Front Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The lower intake manifold must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the front top of the engine block.
4. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

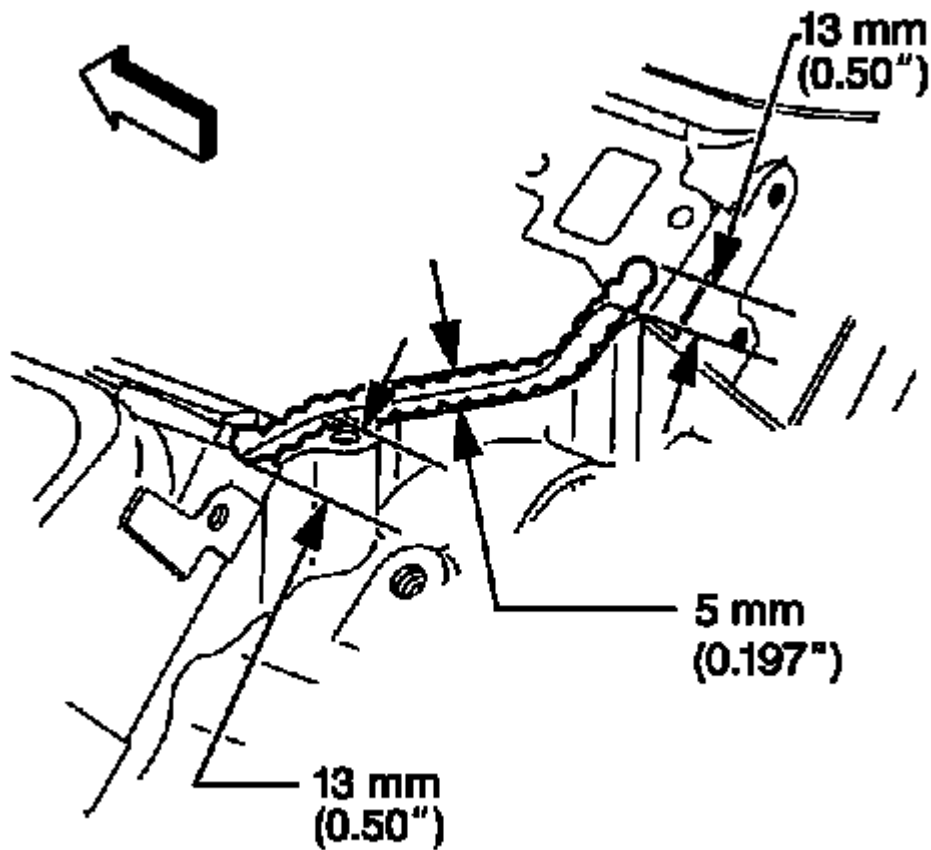


Fig. 545: Applying Adhesive To Rear Top Of Engine Block
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.197 in) bead of adhesive GM P/N 12346141 (Canadian P/N 10953433) or equivalent, to the rear top of the engine block.
6. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.

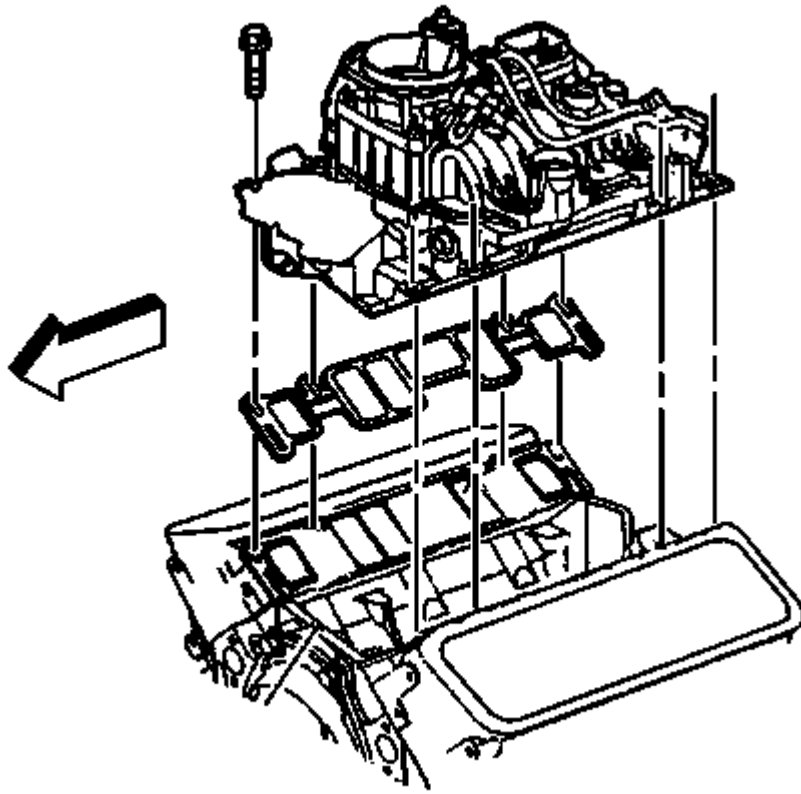


Fig. 546: Removing Intake Manifold Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the lower intake manifold onto the engine block.
8. If reusing the fasteners, apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent, to the threads of the lower intake manifold bolts.
9. Install the lower intake manifold bolts.

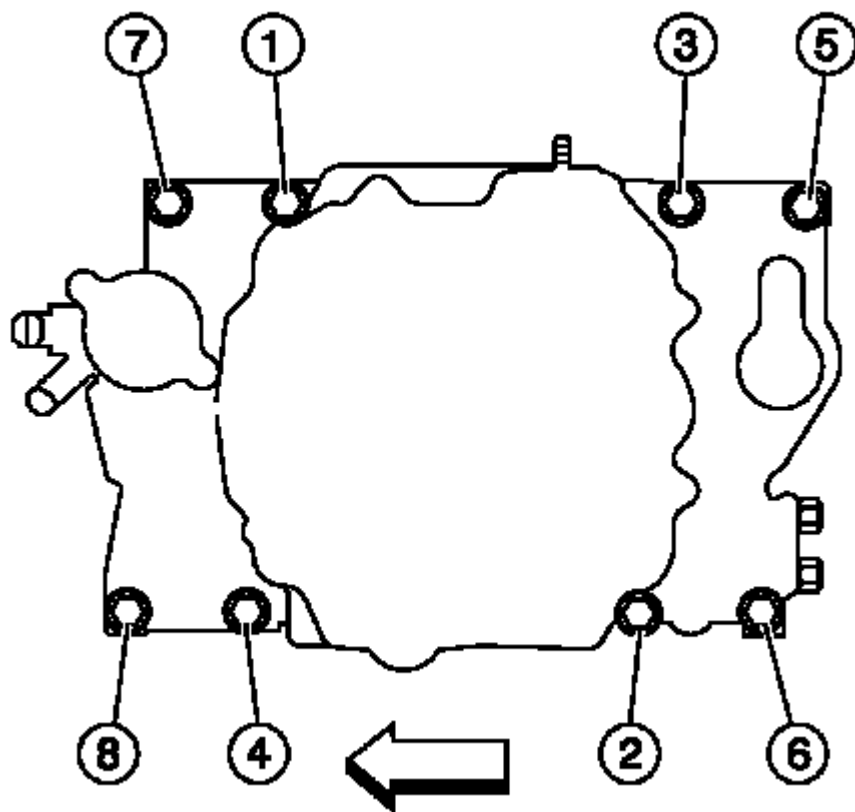


Fig. 547: Intake Manifold Lower Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Tighten the lower intake manifold bolts.

Tighten:

1. Tighten the bolts on the first pass in sequence (1-8) to 3 N.m (27 lb in).
2. Tighten the bolts on the second pass in sequence (1-8) to 12 N.m (106 lb in).
3. Tighten the bolts on the final pass in sequence (1-8) to 15 N.m (11 lb ft).

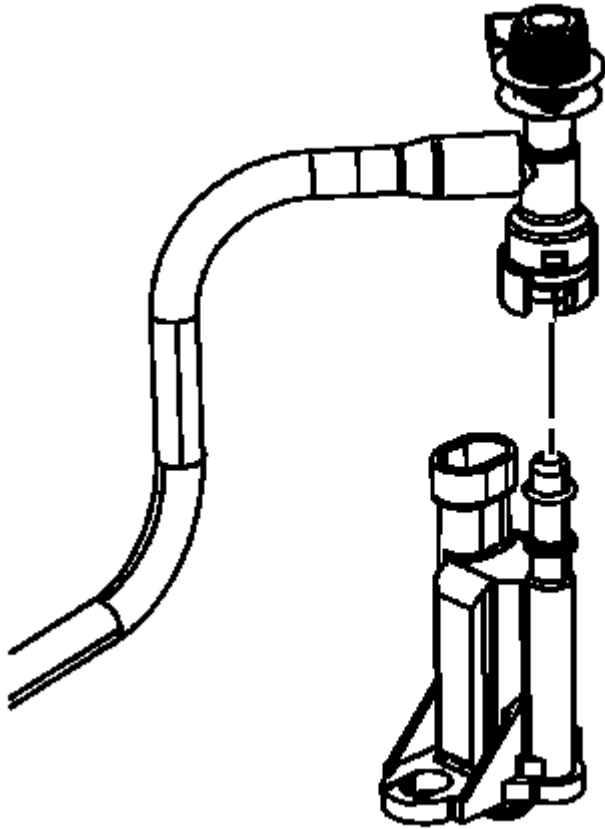


Fig. 548: View Of Evaporative Emission Canister Solenoid Valve Harness
Courtesy of GENERAL MOTORS CORP.

11. Connect the evaporative emission (EVAP) canister solenoid valve harness.
 1. Push the elbow inward until the quick connect snaps into place.
 2. Pull the elbow outward in order to ensure proper connection.

Distributor Installation

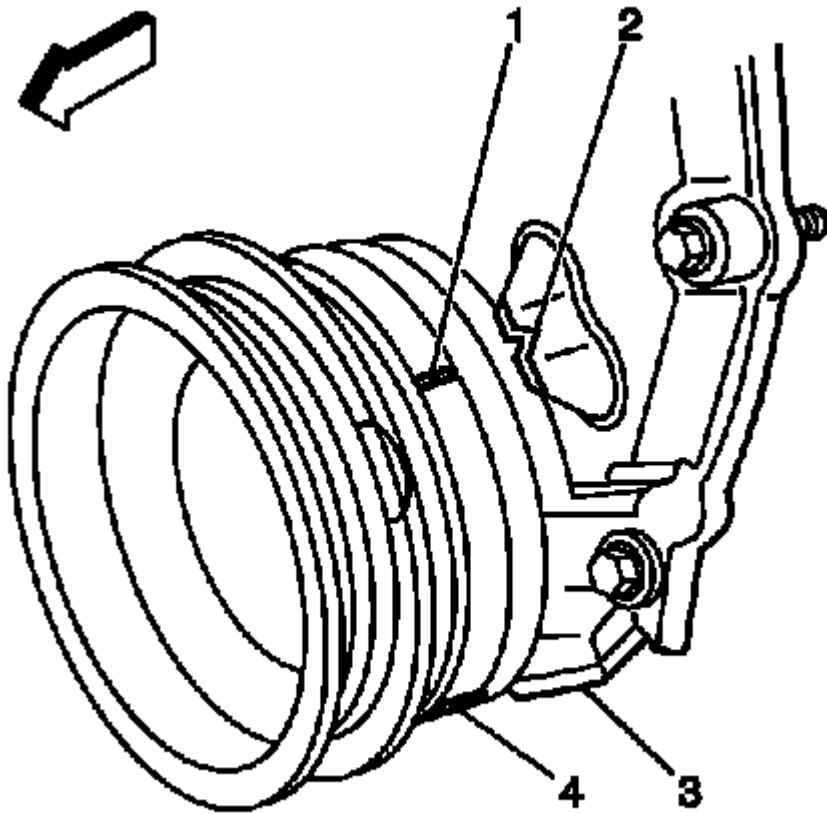


Fig. 549: View Of Crankshaft Balancer Alignment Mark & Engine Front Cover Alignment Tab
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine front cover has 2 alignment tabs and the crankshaft balancer has 2 alignment marks (spaced 90 degrees apart) which are used for positioning number 1 piston at top dead center (TDC). With the piston on the compression stroke and at top dead center, the crankshaft balancer alignment mark (1) must align with the engine front cover tab (2) and the crankshaft balancer alignment mark (4) must align with the engine front cover tab (3).

1. Rotate the crankshaft balancer clockwise until the alignment marks on the crankshaft balancer are aligned with the tabs on the engine front cover and the number 1 piston is at top dead center of the compression stroke.

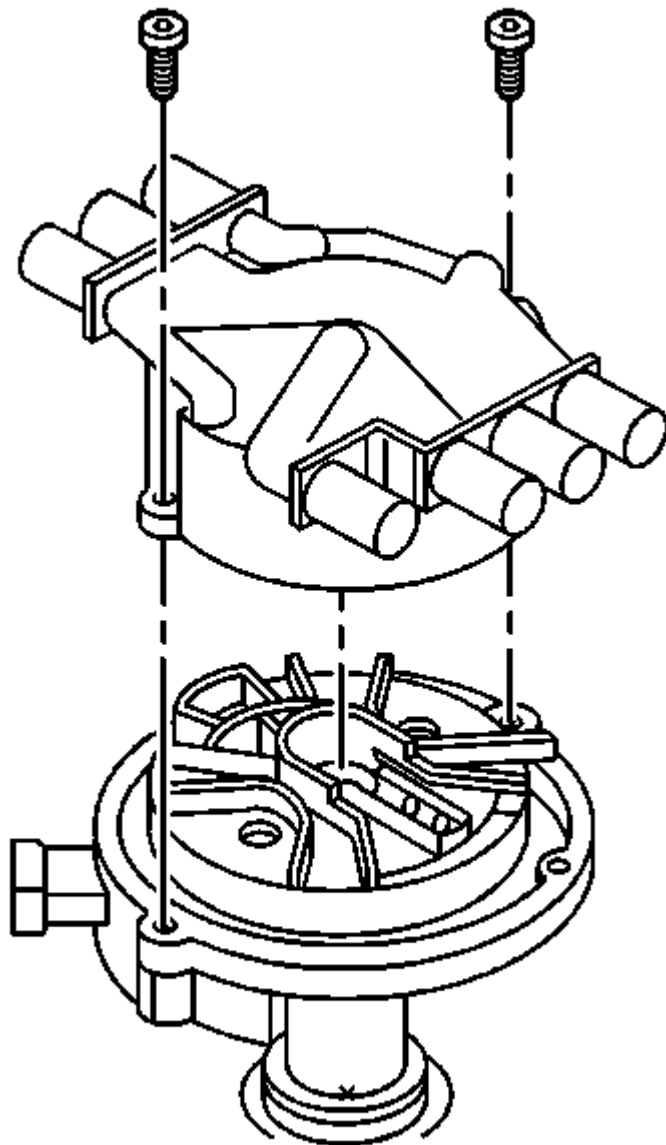


Fig. 550: View Of Distributor Cap
Courtesy of GENERAL MOTORS CORP.

2. Remove the distributor cap bolts and discard.
3. Remove the distributor cap.

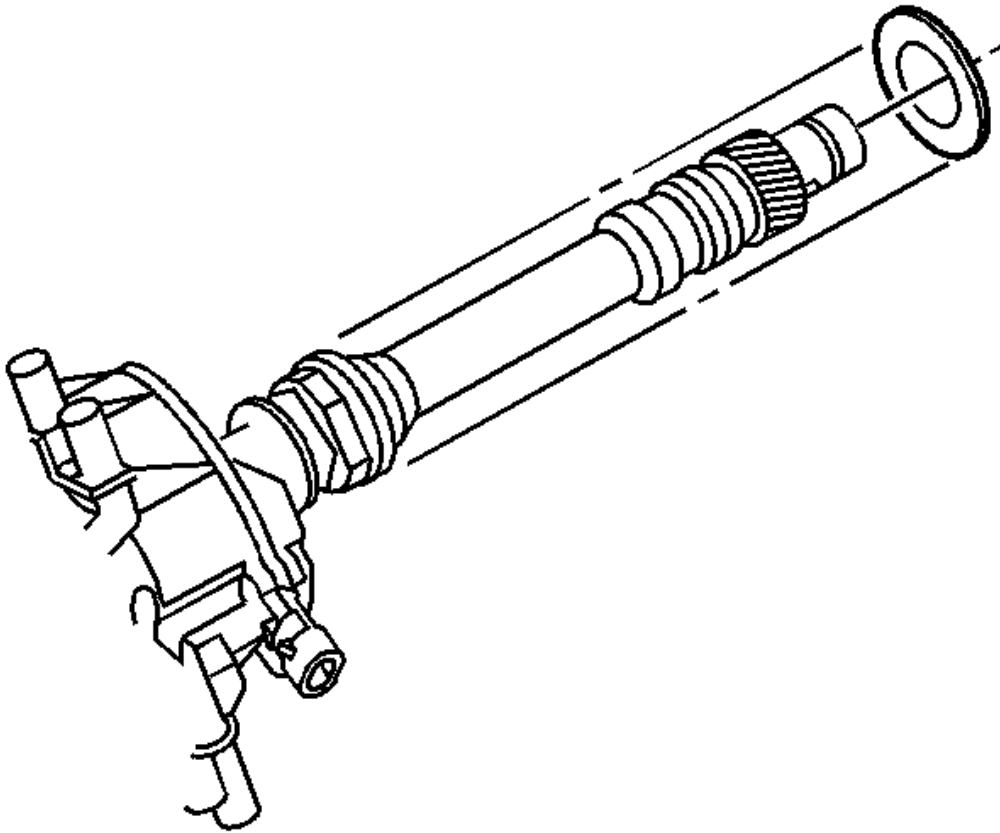


Fig. 551: Removing Distributor Gasket
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW distributor gasket onto the distributor.

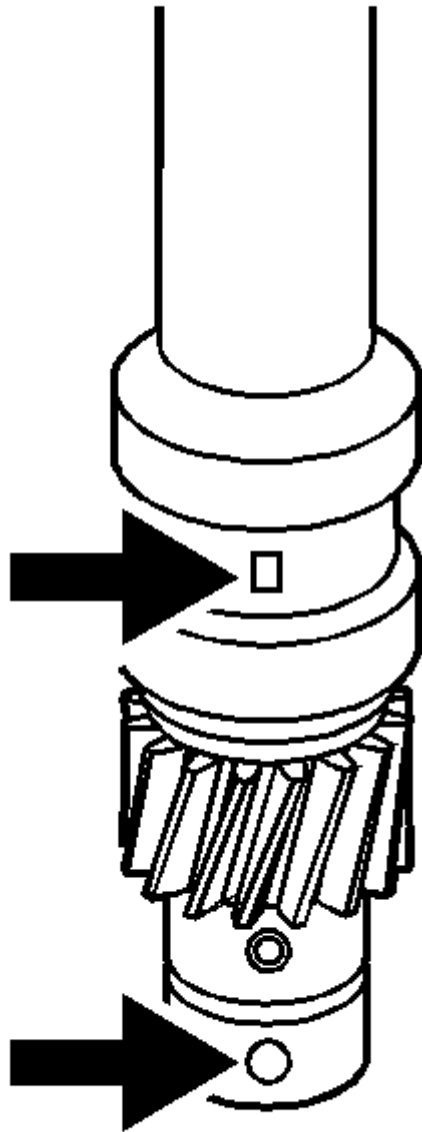


Fig. 552: Aligning Driven Gear Indent W/Distributor Housing Paint Mark
Courtesy of GENERAL MOTORS CORP.

5. Align the indent hole on the driven gear with the paint mark on the distributor housing.
6. Ensure that the distributor rotor segment points to the cap hold area.

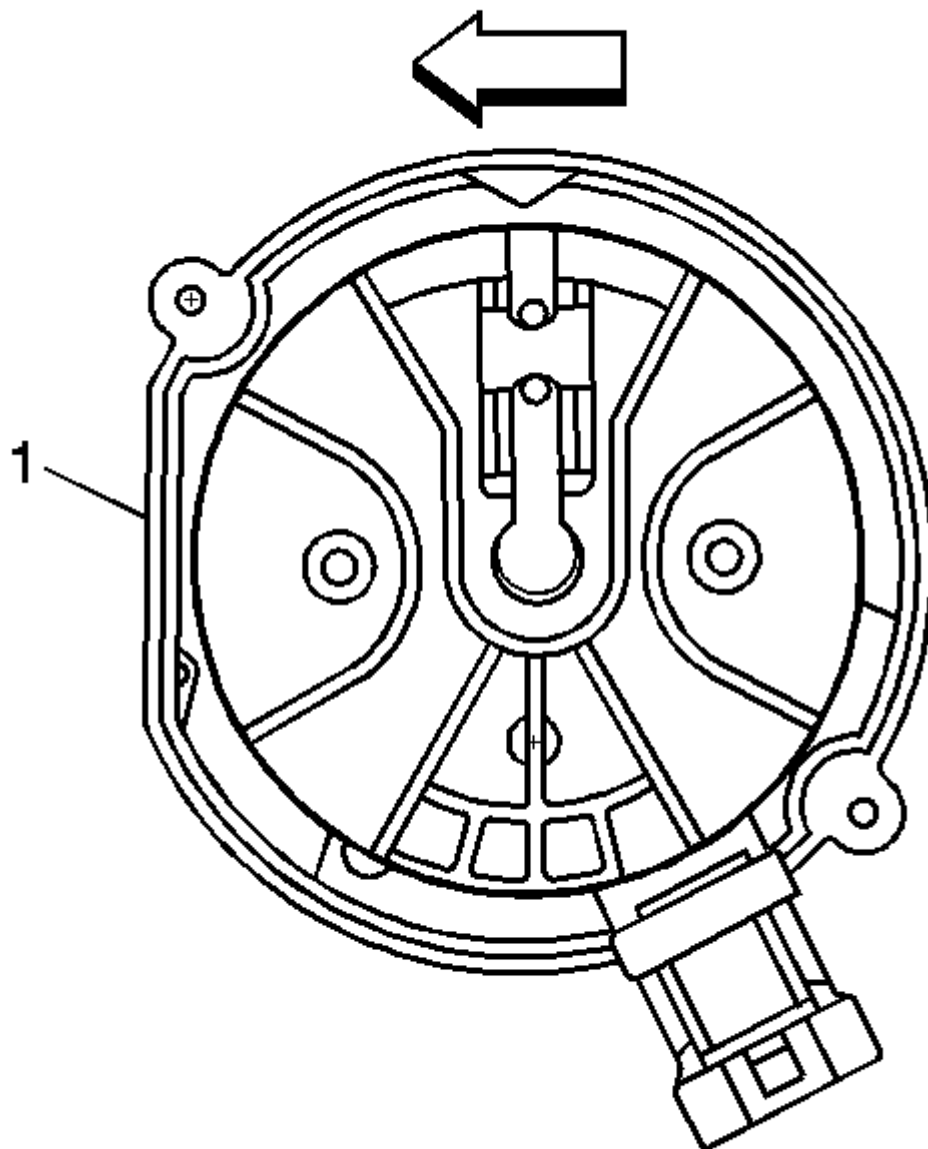


Fig. 553: Aligning Flat In Distributor Housing Toward Front Of Engine
Courtesy of GENERAL MOTORS CORP.

7. Align the slotted tang in the oil pump driveshaft with the distributor driveshaft.

Rotate the oil pump driveshaft with a screwdriver if necessary.

8. Align the flat (1) in the distributor housing toward the front of the engine.

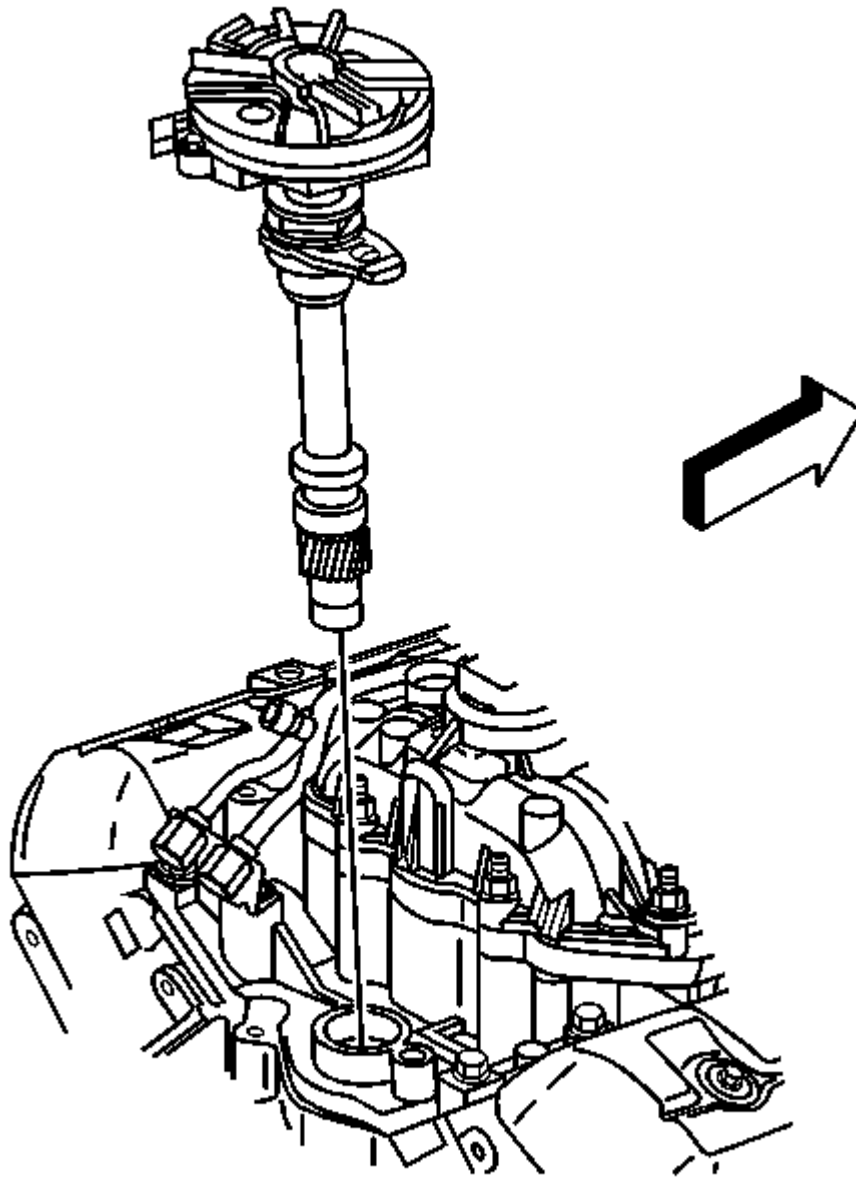


Fig. 554: Installing Distributor & Cap
Courtesy of GENERAL MOTORS CORP.

9. Install the distributor and distributor clamp.

The flat in the distributor housing must point toward the front of the engine.

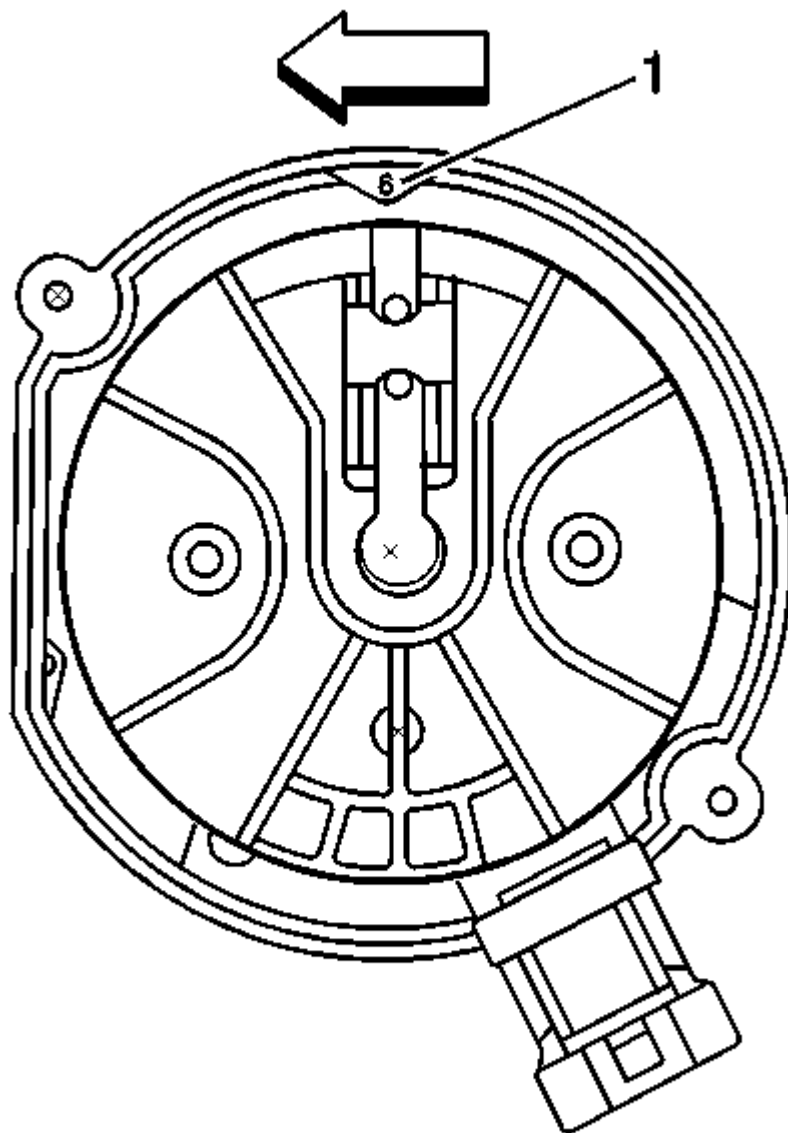


Fig. 555: Aligning Distributor Rotor Segment With Number 6 Pointer
Courtesy of GENERAL MOTORS CORP.

10. Once the distributor is fully seated, align the distributor rotor segment with the number 6 pointer (1) that is cast into the distributor base.

If the distributor rotor segment does not come within a few degrees of the number 6 pointer (1), the gear mesh between the distributor and camshaft may be off a tooth or more. Repeat the procedure again in order to achieve proper alignment.

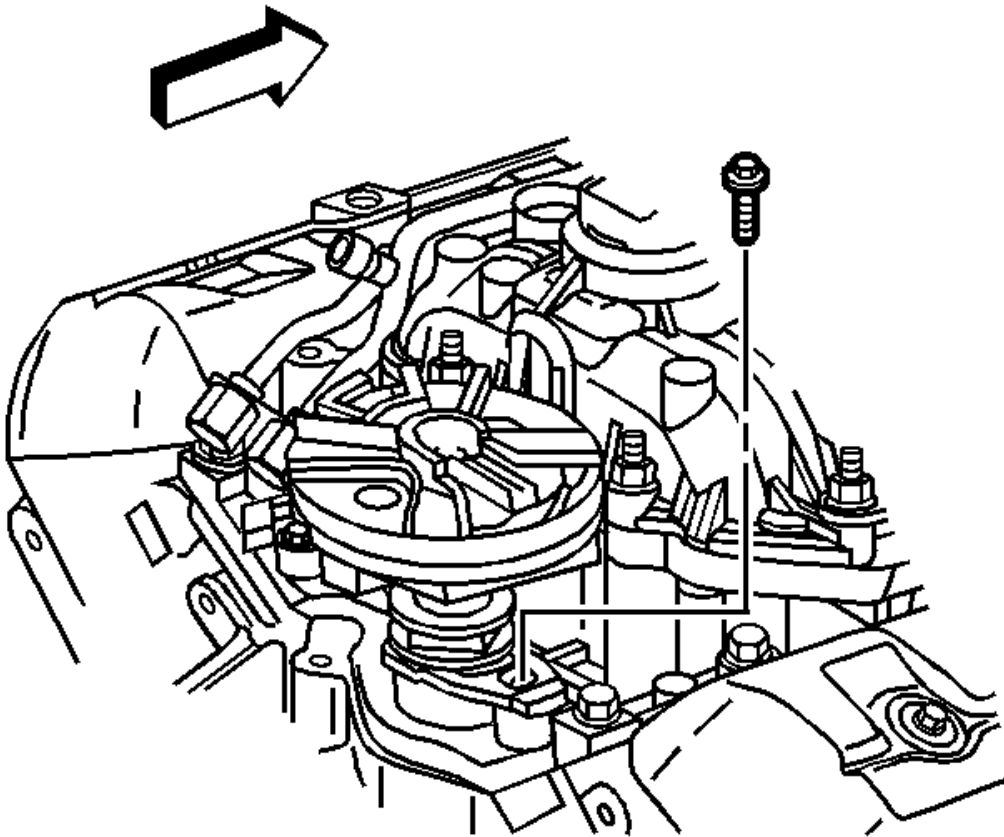


Fig. 556: Installing Distributor Clamp Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Install the distributor clamp bolt.

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

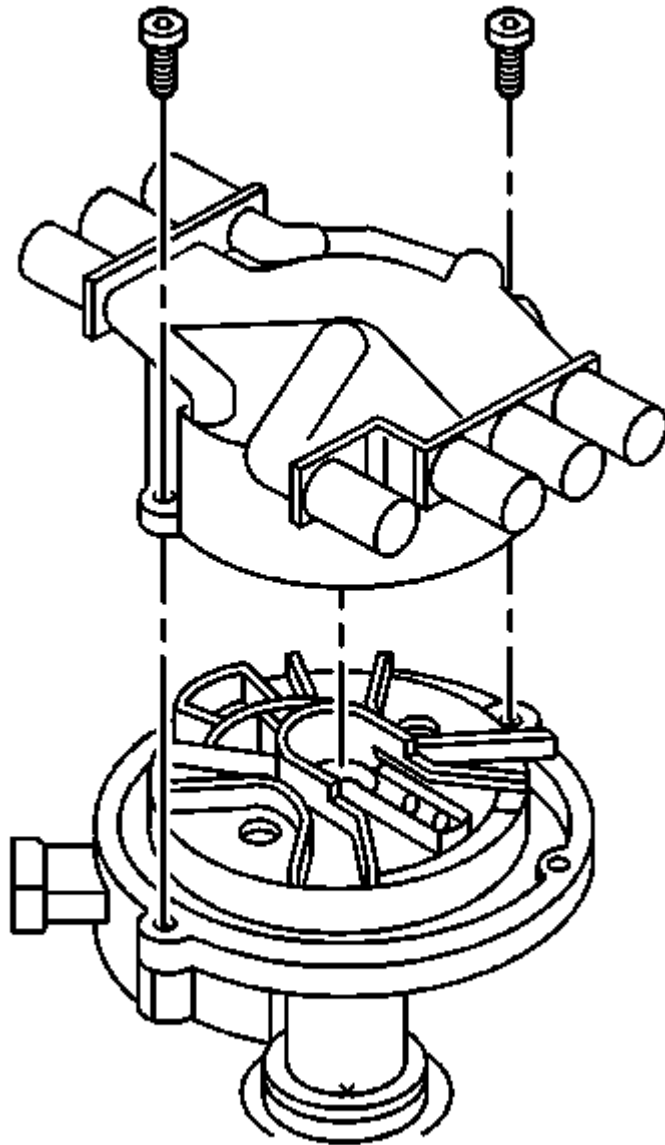


Fig. 557: View Of Distributor Cap
 Courtesy of GENERAL MOTORS CORP.

12. Install the distributor cap and NEW distributor cap bolts.

Tighten: Tighten the distributor cap bolts to 2.4 N.m (21 lb in).

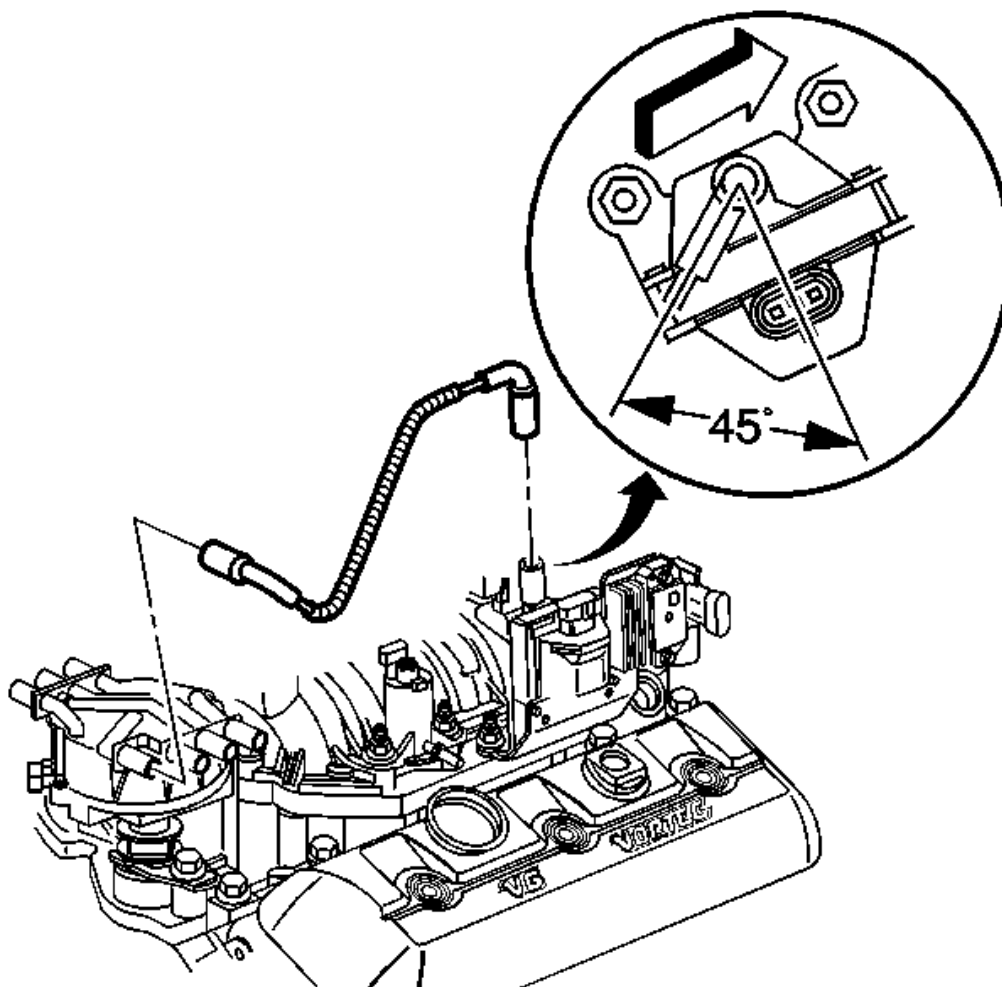


Fig. 558: View Of Ignition Coil Wire Harness
Courtesy of GENERAL MOTORS CORP.

13. Install the ignition coil wire harness.

Valve Rocker Arm Cover Installation - Left

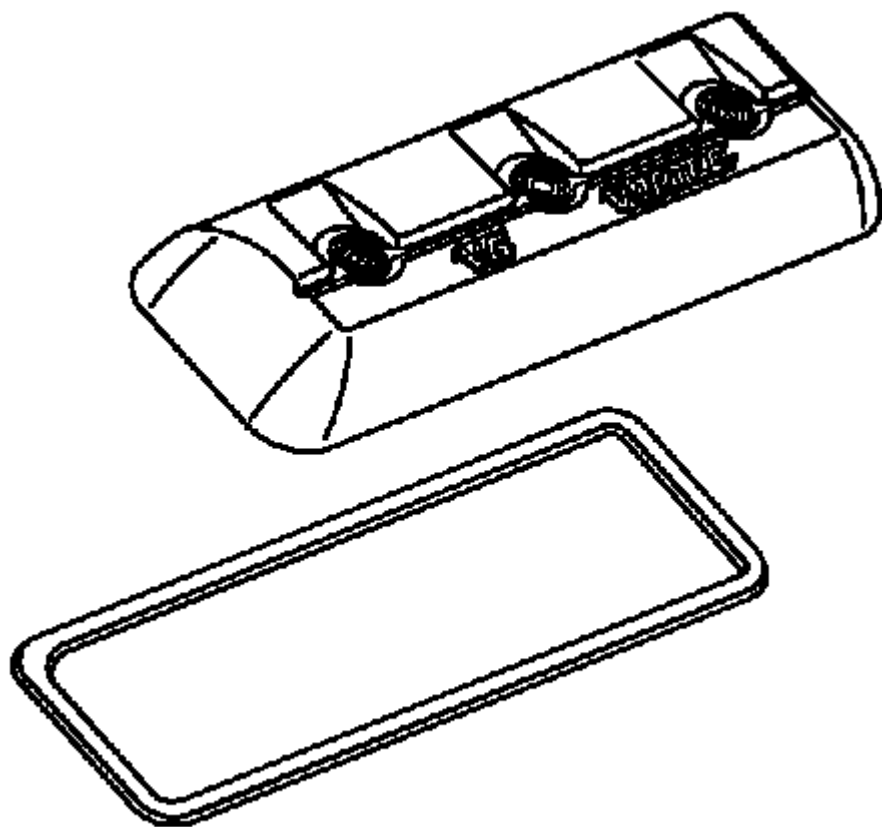


Fig. 559: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

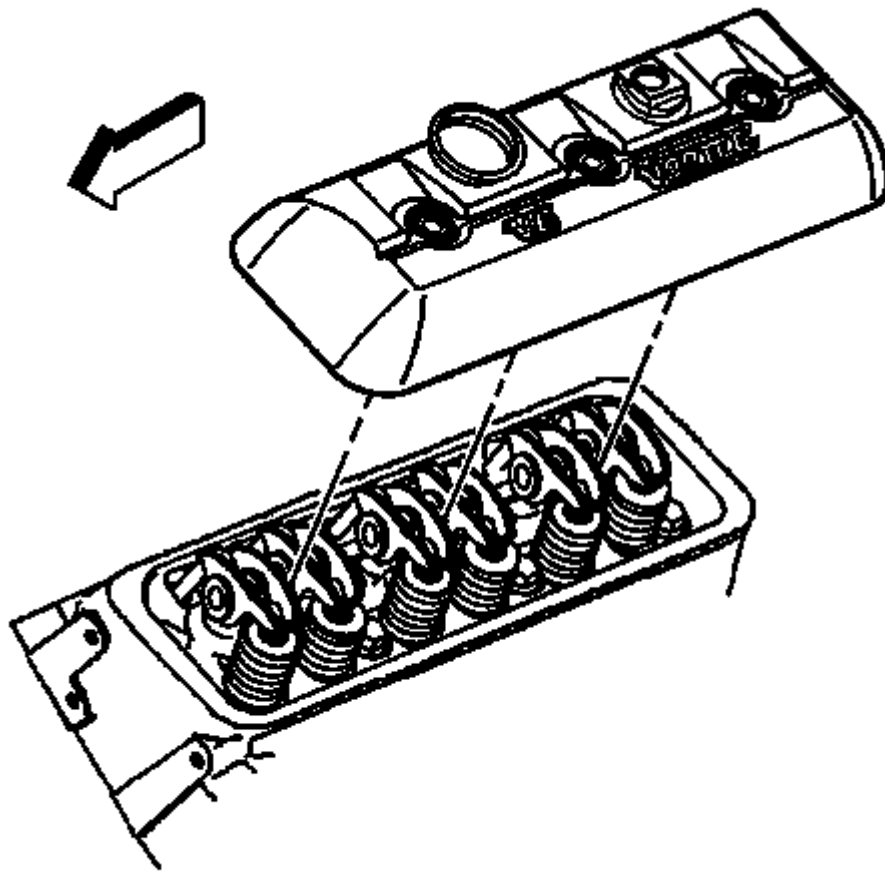


Fig. 560: Remove Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

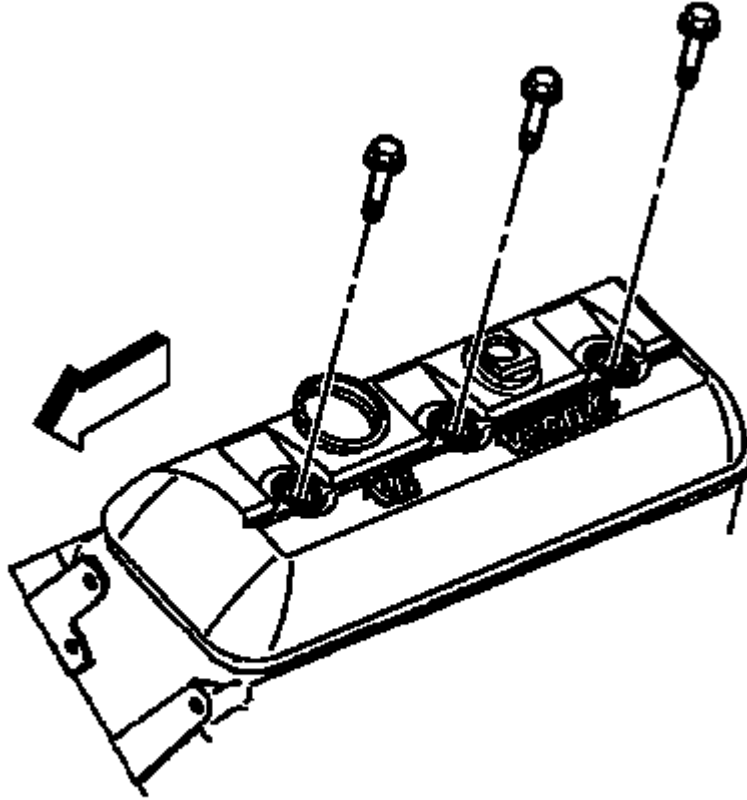


Fig. 561: Removing Valve Rocker Arm Cover Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

Valve Rocker Arm Cover Installation - Right

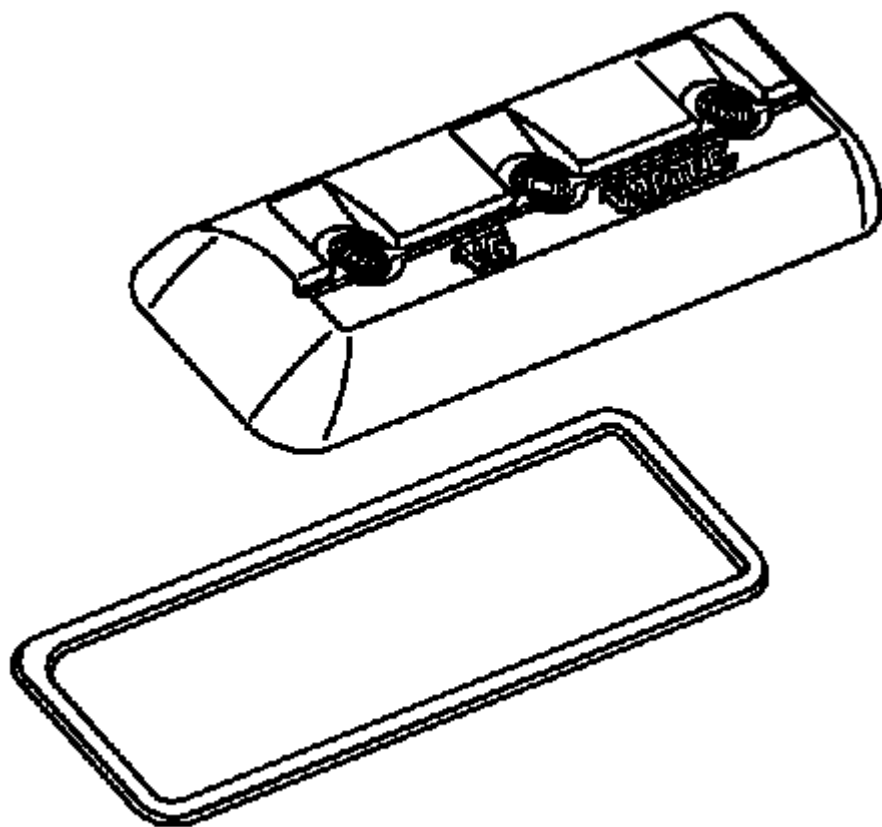


Fig. 562: View Of Rocker Arm Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the valve cover gasket or the valve rocker arm cover bolt grommets.

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.
2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.

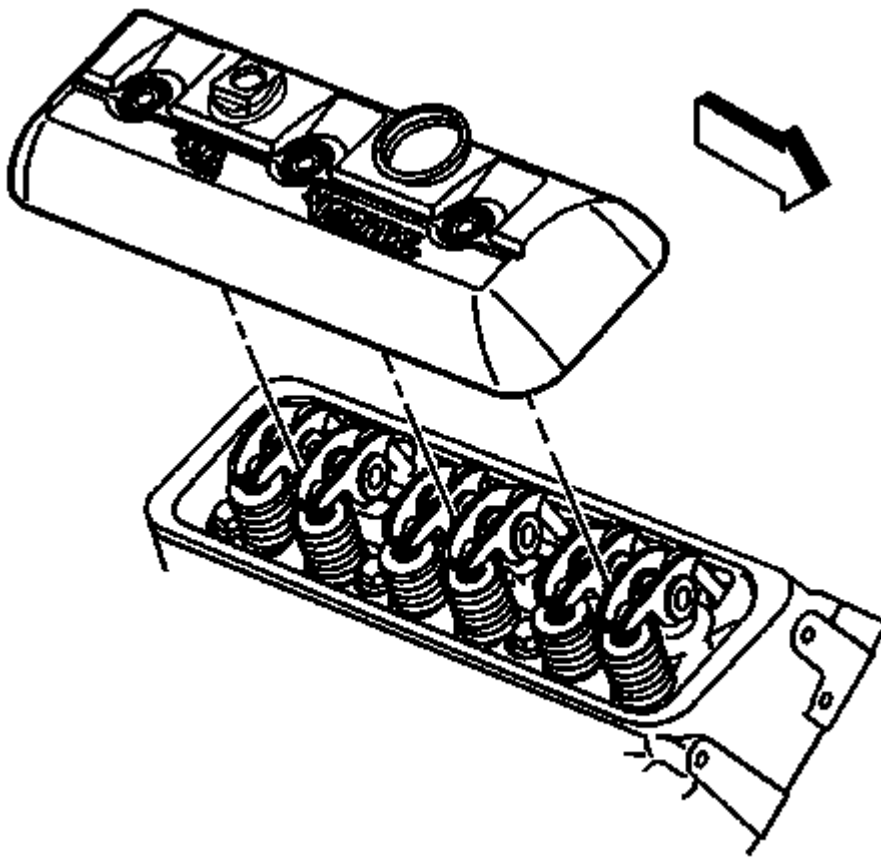


Fig. 563: Removing Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

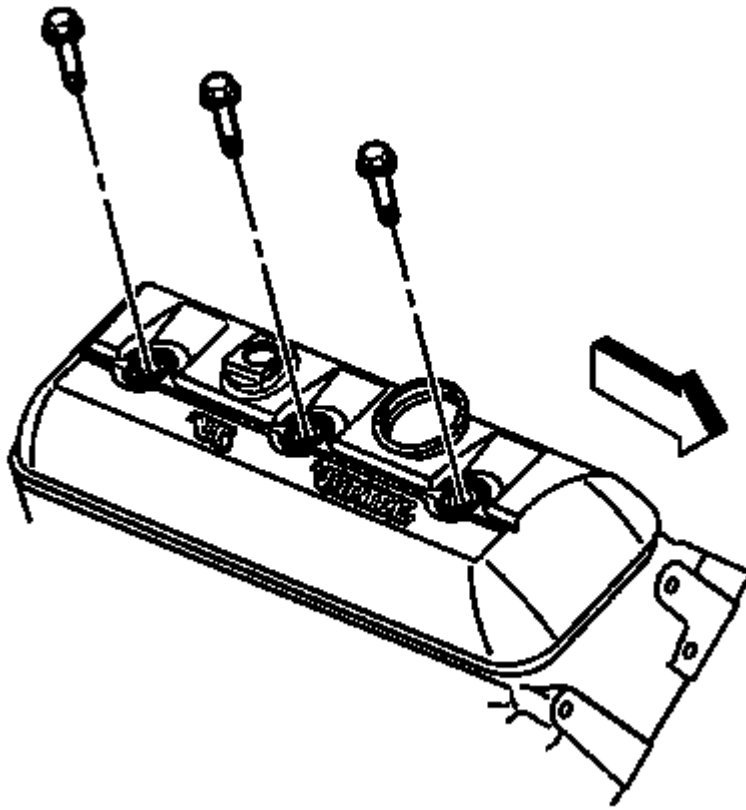


Fig. 564: Removing Valve Rocker Arm Cover Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

Oil Level Indicator and Tube Installation

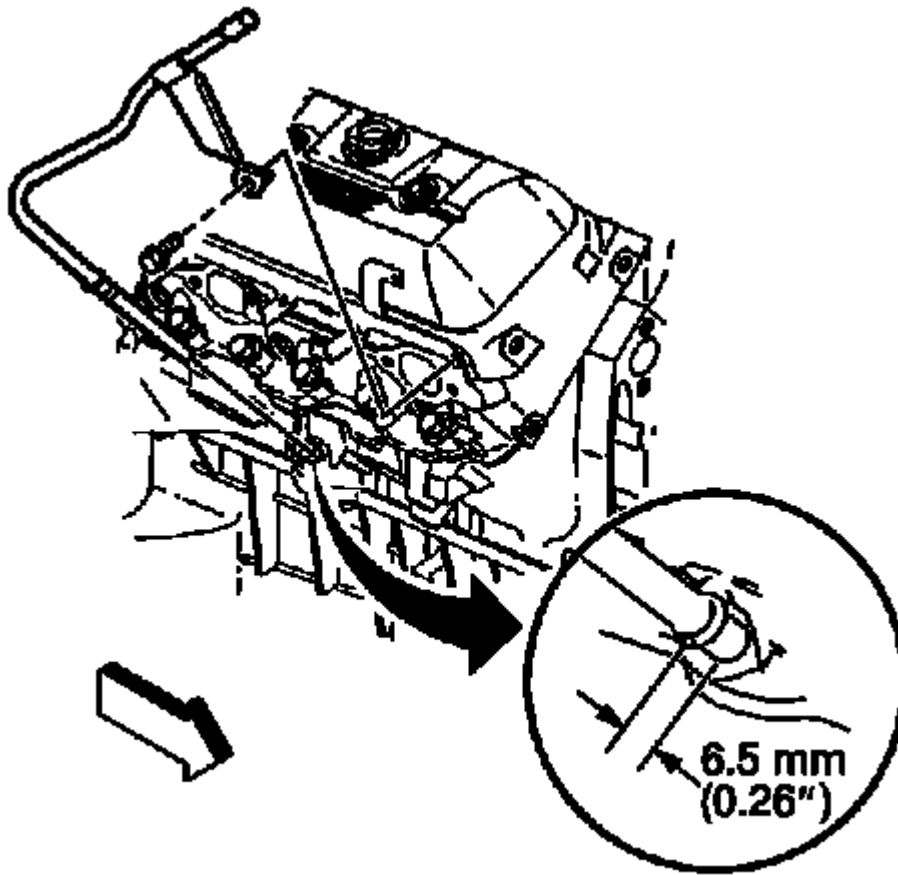


Fig. 565: Applying Sealant & Installing Oil Level Indicator Tube & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, around the oil level indicator tube 13 mm (0.5 in) below the tube bead.
2. Install the oil level indicator tube into the engine block. Rotate the oil level indicator tube into position.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil level indicator tube bolt.

Tighten: Tighten the oil level indicator tube bolt to 12 N.m (106 lb in).

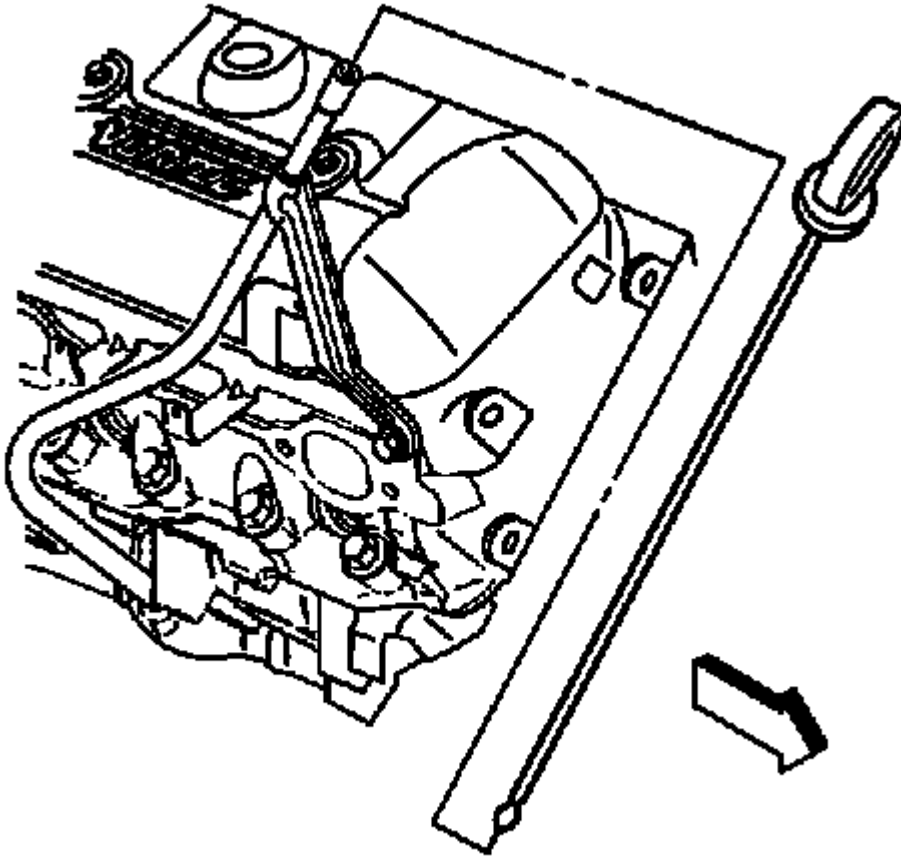


Fig. 566: Removing Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

4. Install the oil level indicator into the oil level indicator tube, if required.

Water Pump Installation

Tools Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools**.

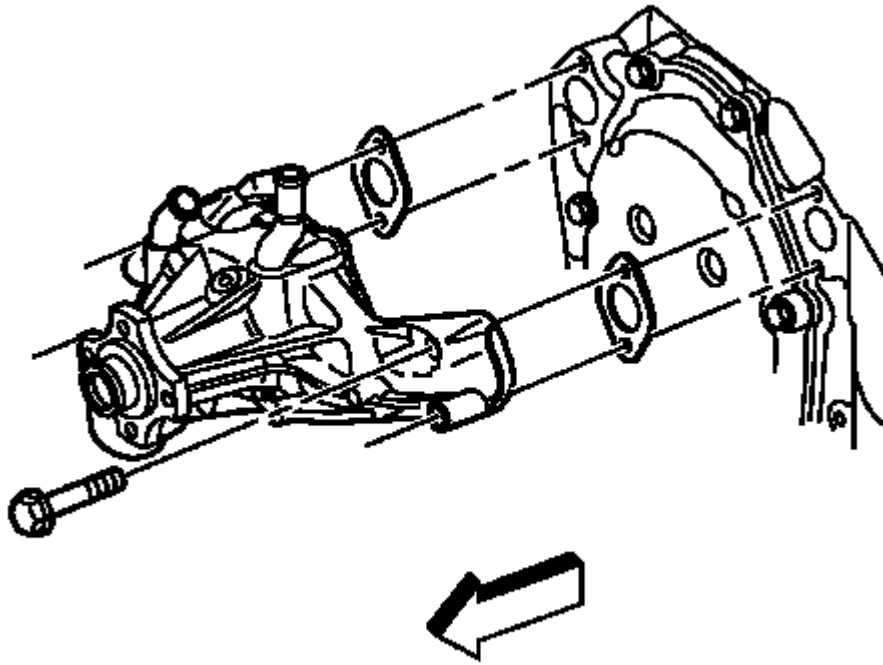


Fig. 567: Removing Water Pump
Courtesy of GENERAL MOTORS CORP.

1. If reusing the fasteners, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the water pump bolts.
2. Install the water pump and the NEW water pump gaskets.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water pump bolts.

Tighten: Tighten the water pump bolts to 45 N.m (33 lb ft).

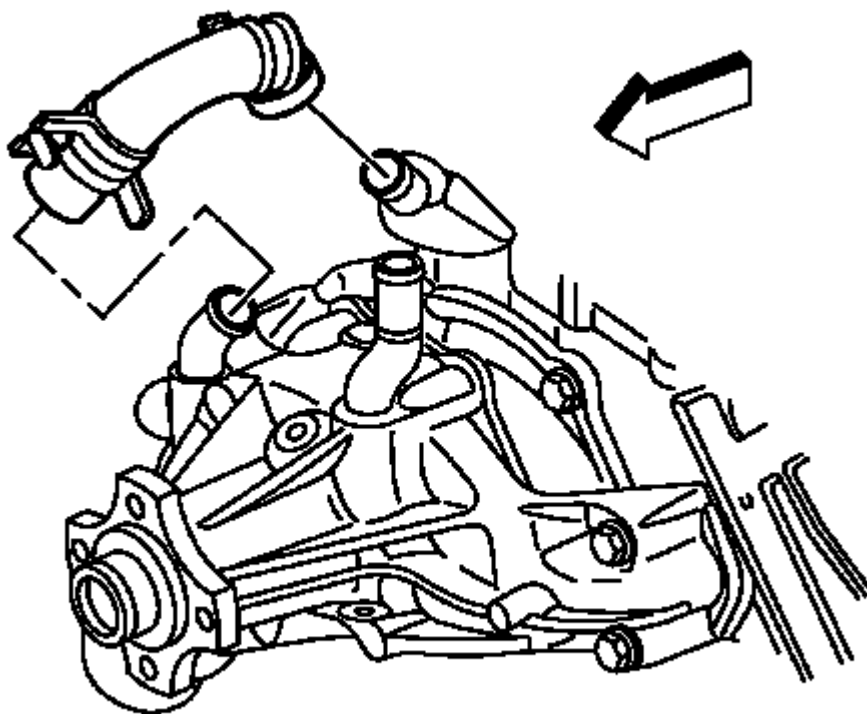


Fig. 568: View Of Water Pump Inlet Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: After final assembly, the water pump inlet hose clamp tangs, water pump end, must point forward and the upper tang should be level with the outside diameter of the water pump inlet hose.

4. Install the water pump inlet hose and the water pump inlet hose clamps.

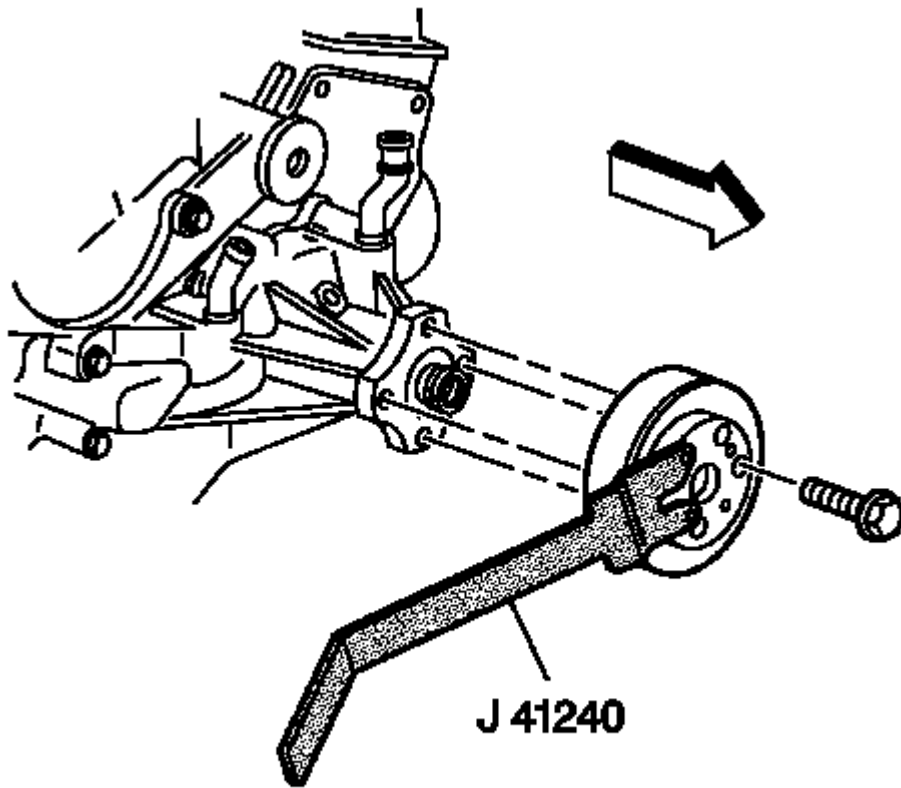


Fig. 569: Removing Water Pump Pulley, Fan & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the fan and water pump pulley and bolts using the **J 41240** . See **Special Tools**.

Tighten: Tighten the fan and water pump pulley bolts to 25 N.m (18 lb ft).

Exhaust Manifold Installation - Left

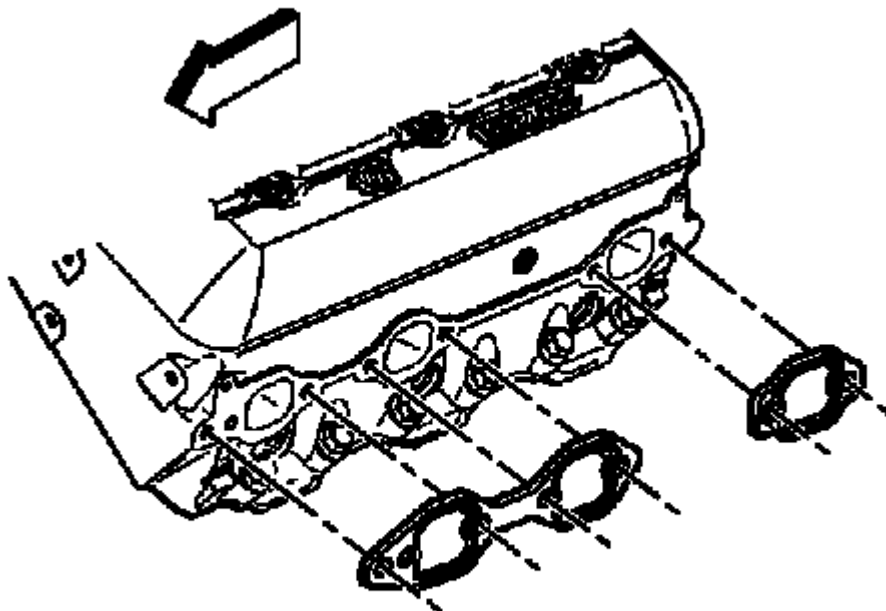


Fig. 570: Removing Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW exhaust manifold gaskets.

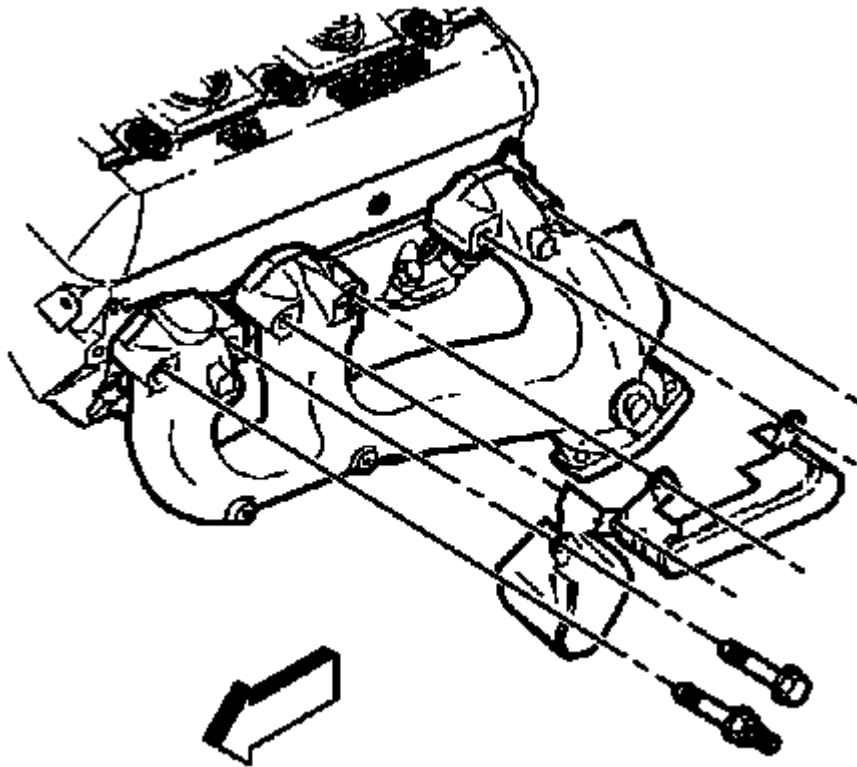


Fig. 571: Removing Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. If reusing the fasteners, apply threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the threads of the exhaust manifold bolts and stud.

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

5. Install the exhaust manifold bolts and stud.

Tighten:

1. Tighten the exhaust manifold bolts and stud on the first pass to 15 N.m (11 lb ft).
 2. Tighten the exhaust manifold bolts and stud on the final pass to 30 N.m (22 lb ft).
6. Install the spark plug wires to the spark plug wire retainers.
 7. Install the spark plug wires onto the spark plugs.

Exhaust Manifold Installation - Right

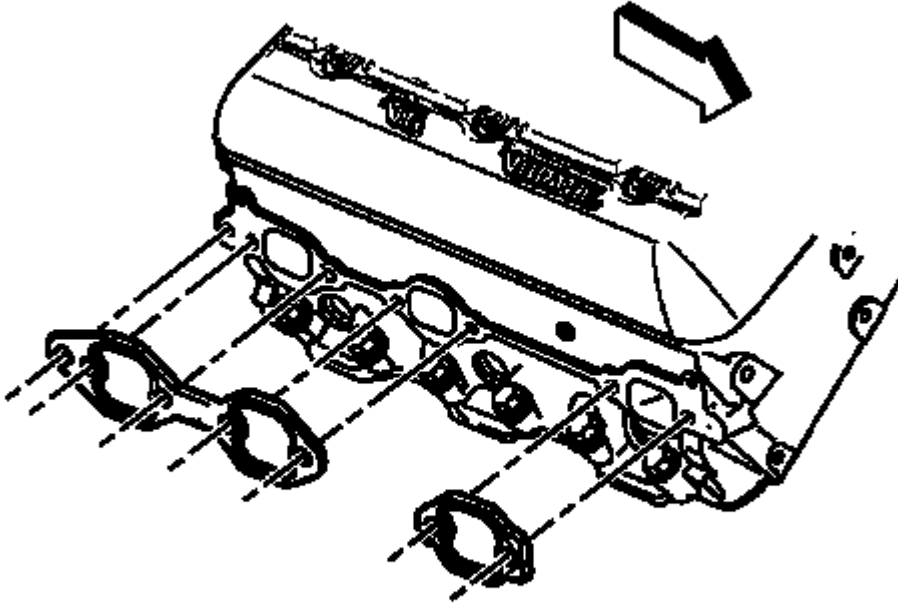


Fig. 572: Removing Exhaust Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW exhaust manifold gaskets.

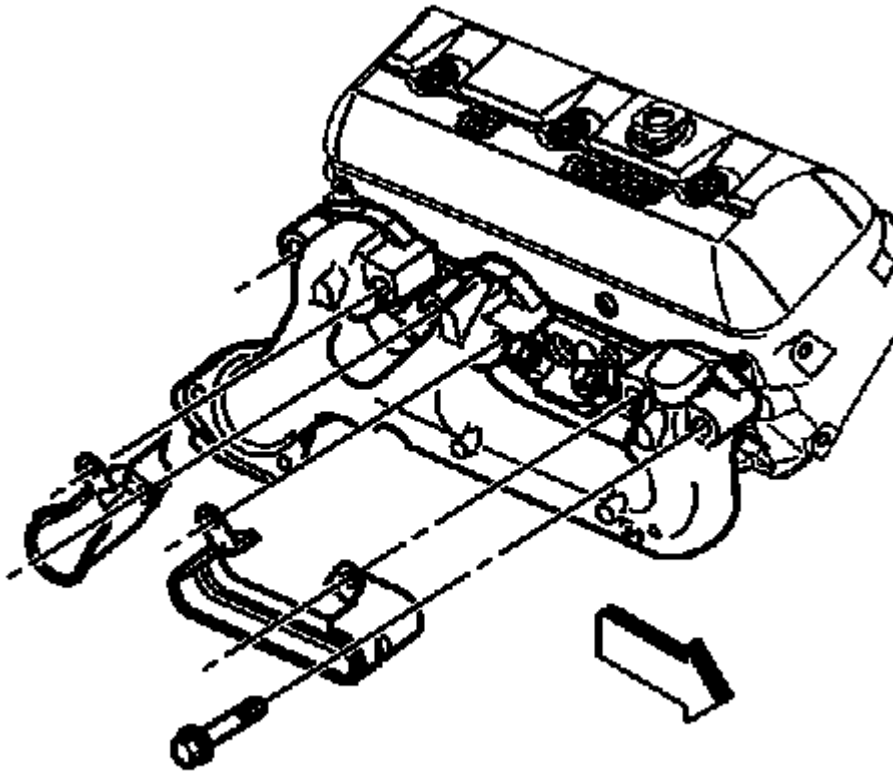


Fig. 573: Removing Exhaust Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold.
3. Install the spark plug wire shields.
4. If reusing the fasteners, apply threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent, to the threads of the exhaust manifold bolts.

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

5. Install the exhaust manifold bolts.

Tighten:

1. Tighten the exhaust manifold bolts on the first pass to 15 N.m (11 lb ft).
 2. Tighten the exhaust manifold bolts on the final pass to 30 N.m (22 lb ft).
6. Install the spark plug wires to the spark plug wire retainers.
 7. Install the spark plug wires onto the spark plugs.

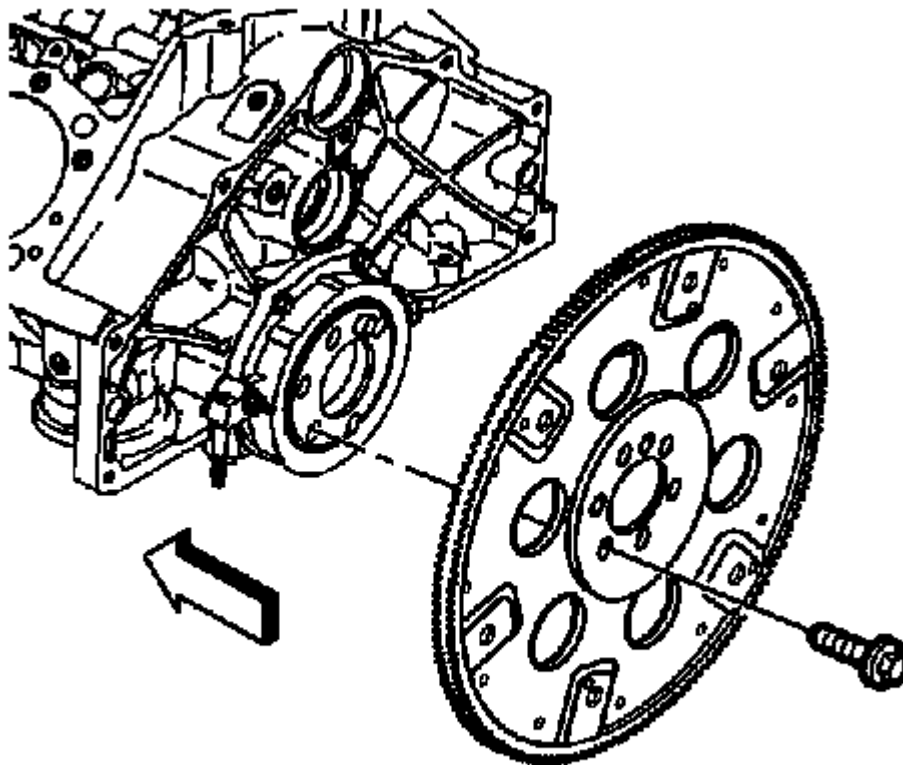
Engine Flywheel Installation

Fig. 574: Expanded View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the engine flywheel to the crankshaft.
2. Align the locator hole to the pin.

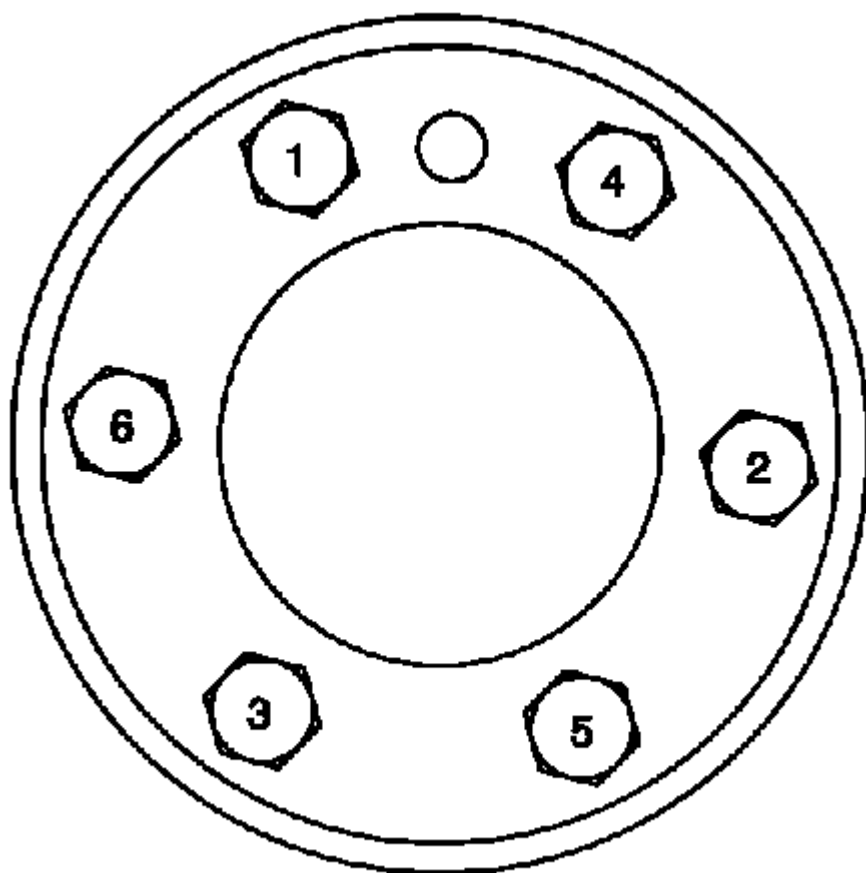


Fig. 575: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine flywheel bolts.

Tighten: Tighten the engine flywheel bolts in sequence to 100 N.m (74 lb ft).

Engine Prelubing

Tools Required

J 45299 Engine Preluber. See Special Tools.

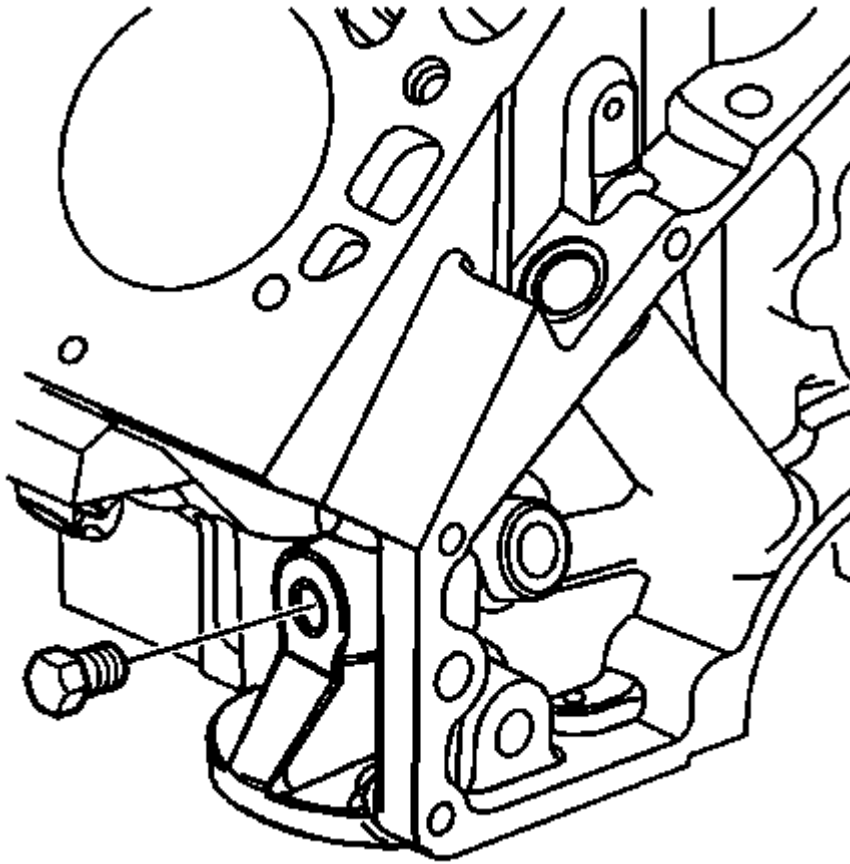


Fig. 576: View Of Engine Block Left Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and 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 engine block left oil gallery plug and remove.
4. Install the M16 x 1.5 adapter P/N 509375.

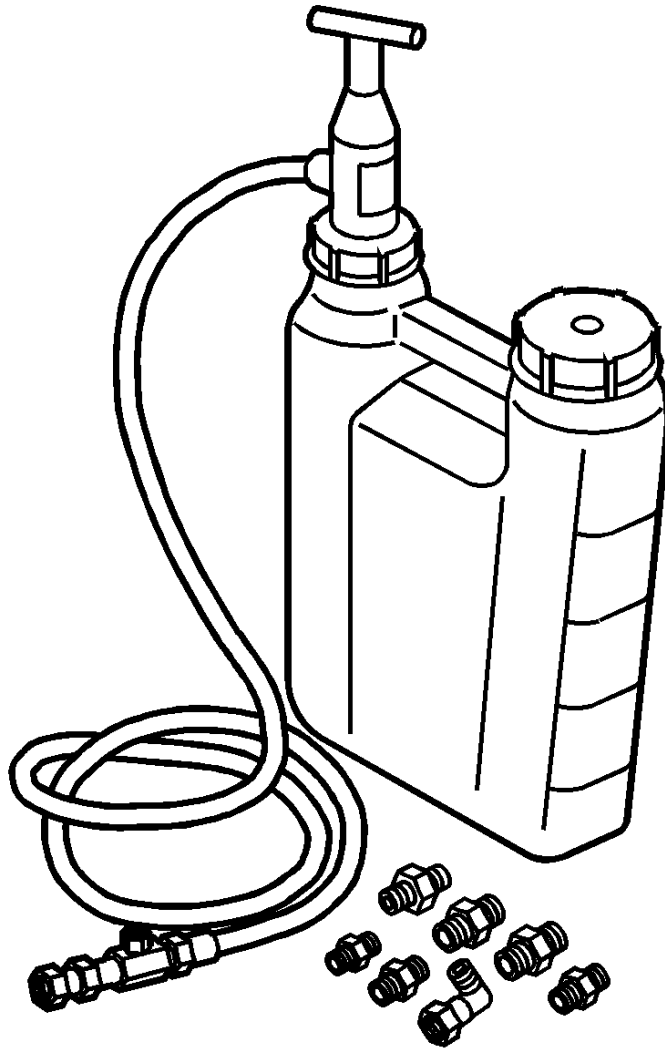


Fig. 577: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the **J 45299** in order to flow a minimum of 1-1. See **Special Tools**. 9 liters (1-2 quarts) 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 gallery plug to the engine.

Tighten: Tighten the oil gallery plug to 60 N.m (44 lb ft).

9. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

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

Operation

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the valve cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

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

Balance Shaft

The cast iron balance shaft is mounted in the crankcase above and in-line with the camshaft. A camshaft gear drives the gear attached to the balance shaft. The front end of the balance shaft is supported by a ball-type bearing. The rear end of the balance shaft uses a sleeve-type bearing.

Camshaft

The steel camshaft is supported by four bearings pressed into the engine block. The camshaft timing chain sprocket mounted to the front of the camshaft is driven by the crankshaft sprocket through a camshaft timing chain.

Crankshaft

The cast nodular iron crankshaft is supported by four crankshaft bearings. The number four crankshaft bearing at the rear of the engine is the end thrust bearing. The crankshaft bearings are retained by bearing caps that are machined with the engine block for proper alignment and clearances. The crankshaft position sensor reluctor ring has three lugs used for crankshaft timing and is constructed of powdered metal. The crankshaft position sensor reluctor ring has a slight interference fit onto the crankshaft and an internal keyway for correct positioning.

Cylinder Heads

The cast iron cylinder heads have one intake and one exhaust valve for each cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides and seats are integral to the cylinder head. The 4.3L heavy duty applications have pressed in exhaust valve seats. The valve rocker arms are positioned on the valve rocker arm supports and retained by a bolt.

Engine Block

The cast iron engine block has six cylinders arranged in a V shape with three cylinders in each bank. Starting at the front side of the engine block, the cylinders in the left bank are numbered 1-3-5 and cylinders in the right bank are numbered 2-4-6 when viewed from the rear. The firing order of the cylinders is 1-6-5-4-3-2. The cylinders are encircled by coolant jackets.

Exhaust Manifolds

The cast iron exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system.

Intake Manifold

The intake manifold is a two-piece design. The upper portion is made from a composite material and the lower portion is cast aluminum. The throttle body attaches to the upper manifold. The Central Multipoint Flexible Injection (MFI) system uses multiple fuel injectors to meter and distribute fuel to each engine cylinder. The MFI is retained by a bracket bolted to the lower intake manifold. The fuel meter body also houses the pressure regulator. Metal inlet and outlet fuel lines and nylon delivery tubes connect to the Central MFI unit. The delivery tubes independently distribute fuel to each cylinder through injectors located at the port entrance of each manifold runner where the fuel is atomized.

Piston and Connecting Rod Assemblies

The cast aluminum pistons use two compression rings and one oil control assembly. The piston is a low friction, lightweight design with a flat top and barrel shaped skirt. The piston pins are offset 0.9 mm (0.0354 in) toward the major thrust side (right side) to reduce piston slap as the connecting rod travels from one side of the piston to the other side after a stroke. The piston pins have a floating fit in the piston and are retained by a press fit in the connecting rod. The connecting rods are forged steel. The connecting rods are machined with the rod cap installed for proper clearances and alignments.

Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and the tubular valve pushrods to the roller type valve rocker arms. The roller type valve rocker arm pivots on a needle type bearing in order to open the valve. The valve rocker arms for each bank of cylinders are mounted to a one piece valve rocker arm support. Each valve rocker arm is retained on the valve rocker arm support and the cylinder head by a bolt. The hydraulic valve lifters keep all the parts of the valve train in constant contact. Each hydraulic valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

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

The timing chain tensioner has been added.

Returnless fuel has been added on C/K and G/H platforms.

Torque Values and/or Fastener Tightening Strategies

Addition of timing tensioner bolt torque

Changed Engine Specifications

No changes for 2005.

New Sealants and/or Adhesives

No new sealants or adhesives for 2005.

Disassembly and Assembly Procedure Revisions

Timing chain disassembly and assembly procedures changed due to the addition of the timing chain tensioner.

Engine Mechanical Diagnostic Procedure Revisions

No changes for 2005.

New Special Tools Required

No changes for 2005.

LUBRICATION DESCRIPTION

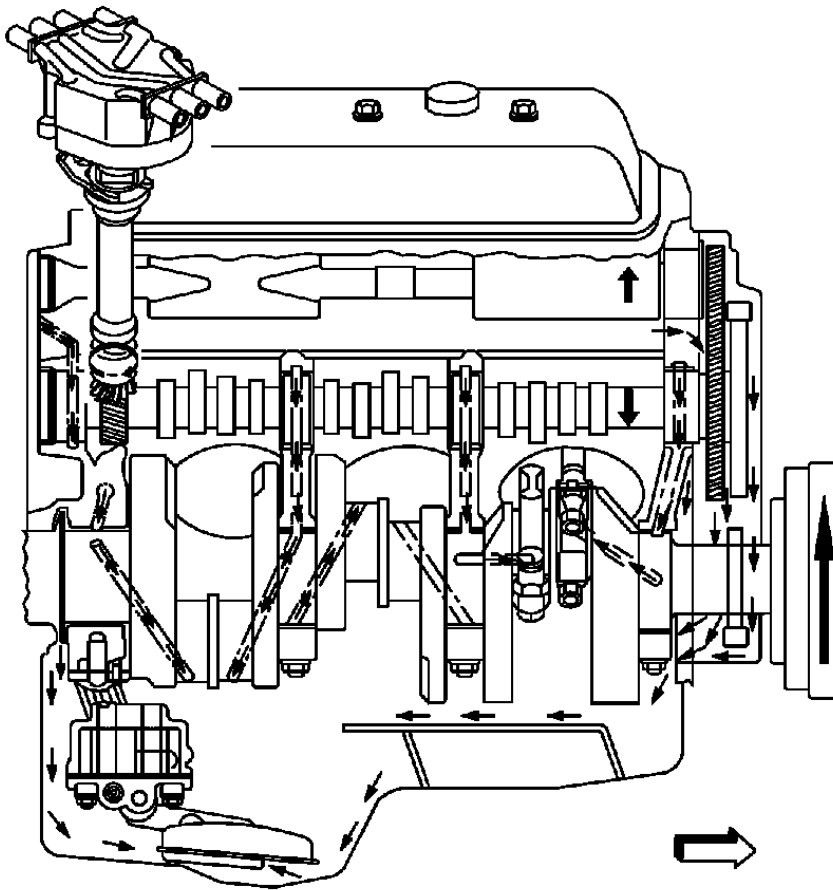


Fig. 578: Engine Lubrication
 Courtesy of GENERAL MOTORS CORP.

Full pressure lubrication, through a full-flow oil filter is supplied by a gear-type oil pump. Oil is drawn up through the oil pump screen and passes through the pump to the oil filter. The oil filter is a full-flow paper element unit with an anti-drain back valve. An oil filter bypass valve is used to ensure adequate oil supply, in the event the filter becomes plugged or develops excessive pressure drop. Filtered oil flows into the main gallery and then to the camshaft, the balance shaft, the rear bearing, and the crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the valve lifters through the hollow valve pushrods to the valve rocker arms. Oil drains back to the crankcase through the oil drain holes in the cylinder head. The camshaft timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

CLEANLINESS AND CARE

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.

- When components are removed for service, the components should be marked, organized or retained in a specific order for re-assembly.
- At the time of installation, the components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. The surfaces should be protected to avoid component damage.
- Apply a liberal amount of clean engine oil to friction areas during assembly.
- Proper lubrication will protect and lubricate friction areas during initial operation.

SEPARATING PARTS

IMPORTANT: Many internal engine components will develop specific wear patterns on their friction surfaces.
When disassembling the engine, internal components MUST be separated, marked and organized in a way to ensure reinstallation to original location and position.

Mark or identify the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the specific cylinder bore
- Connecting rod to the crankshaft journal
- Connecting rod to connecting rod cap
- Crankshaft bearings and connecting rod bearings
- Engine camshaft and valve lifters
- Valve lifters, valve rocker arms, and valve rocker arm supports
- Valve to the valve guide
- Valve spring to cylinder head location
- Engine block bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.

This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER**Sealant Types**

IMPORTANT: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Anaerobic sealant room temperature vulcanizing (RTV)
- Anaerobic sealant, which include the following:
 - Gasket eliminator
 - Pipe
 - Threadlock

Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant

Anaerobic type room temperature vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

NOTE: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

IMPORTANT: Do not wait for the RTV sealant to skin over.

- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.

The surfaces to be sealed must be clean and dry.

NOTE: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- IMPORTANT:**
- Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.
 - Do not overtighten the fasteners.
 - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
 - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
 - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

- IMPORTANT:**
- Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than 5 minutes, may result in incorrect clamp load of assembled components.
 - Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

NOTE: **Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.**

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. The tools (or the equivalents) are specially designed to quickly and safely accomplish the operations for which the tools are intended. The use of special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

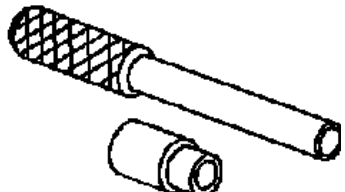
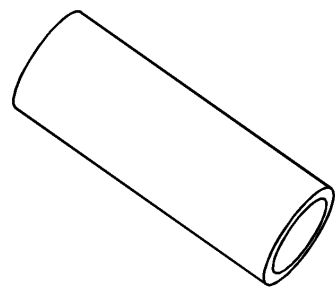
- Approved eye protection and safety gloves
- A clean, well-lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized

- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

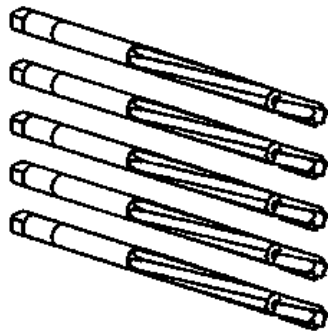
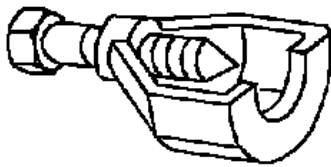
SPECIAL TOOLS

Special Tools

Illustration	Tool Number/ Description
	J 3049-A Valve Lifter Remover
	J 5239 Connecting Rod Bolt Guide Set
	J 5590 Pinion Bearing Race Installer-Rear
	J 5825-A Crankshaft Gear Remover

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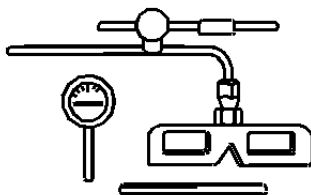
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J 5830-02
Valve Guide Reamer Set



J 5892-D
Valve Spring Compressor

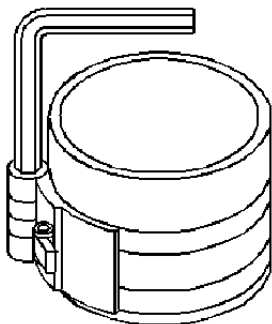
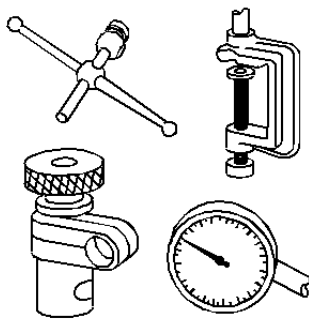


J 7872
Magnetic Base Dial Indicator

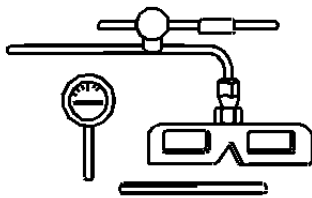
J 8001
Dial Indicator Set

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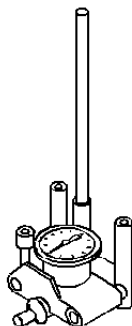
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J 8037
Ring Compressor



J 8062
Valve Spring Compressor

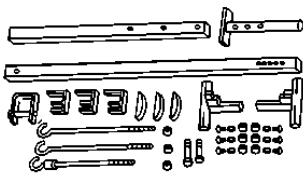
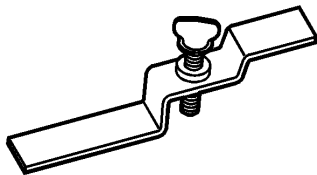


J 8087
Cylinder Bore Gage

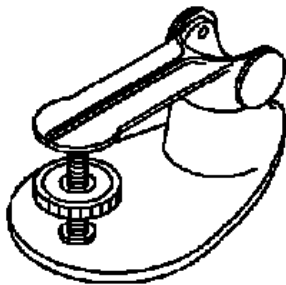
J 8089
Carbon Removing Brush

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J 8092
Universal Driver Handle



J 9666
Valve Spring Tester

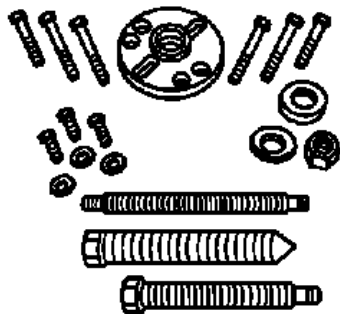


J 21882
Oil Suction Pipe Installer

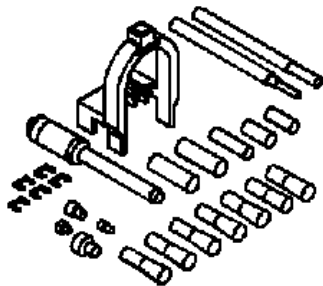
J 22794
Spark Plug Port Adapter

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J 23523-F
Balancer Remover and Installer



J 24086-C
Piston Pin Remover/Installer

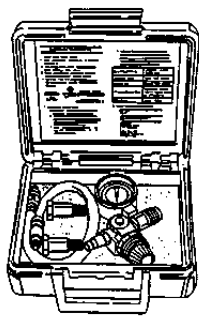
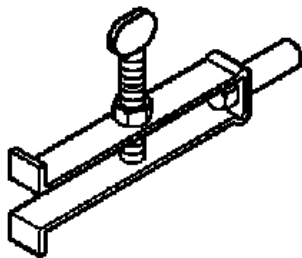


J 24270
Cylinder Bore Ridge Reamer

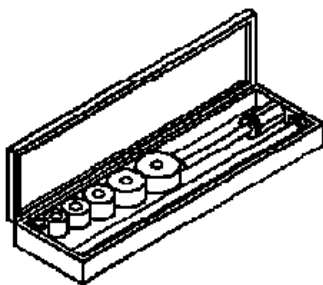
J 26941
Bushing/Bearing Remover

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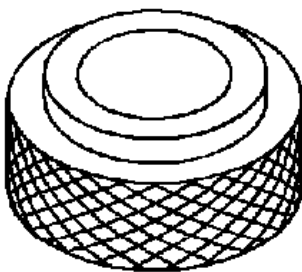
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J 28428-E
High Intensity Black Light Kit



J 33049
Camshaft Bearing Service Kit

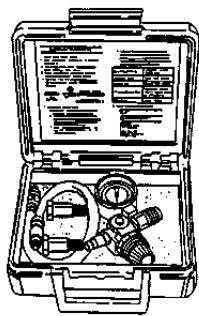
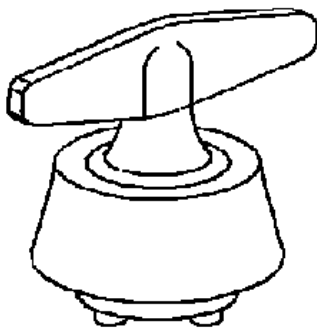


J 35468
Cover Aligner/Seal Installer

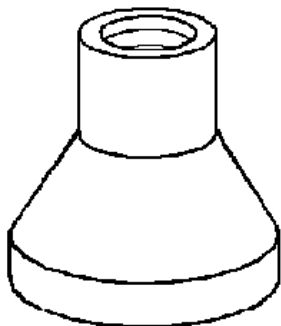
J 35621-B
Rear Main Seal Installer

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J 35667-A
Cylinder Head Leakdown Tester



J 36996
Balance Shaft Installer

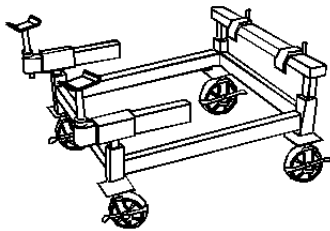


J 38606
Valve Spring Compressor

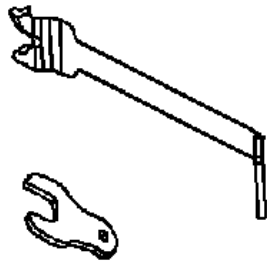
J 38834
Balance Shaft Service Kit

2005 Chevrolet Astro

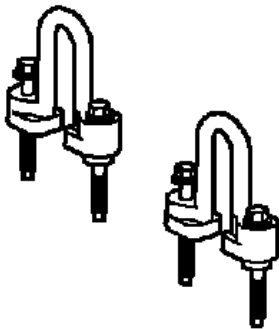
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J 39580
Universal Engine Support Table



J 41240
Fan Clutch Remover and Installer

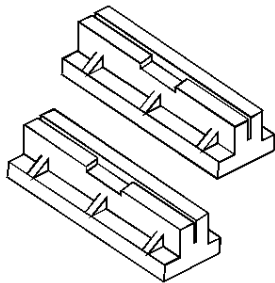


J 41427
Engine Lift Bracket

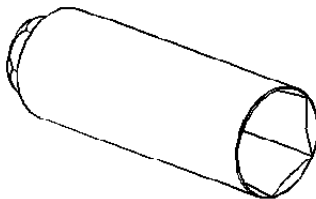
J 41602

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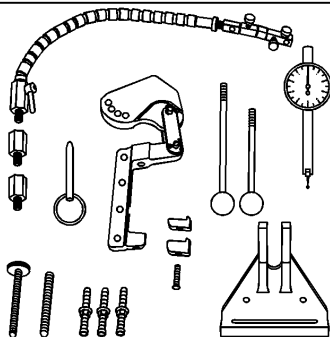
Body Protection Hoist Adapter Set



J 41712
Oil Pressure Switch Socket



J 42073
Valve Stem Seal Installer

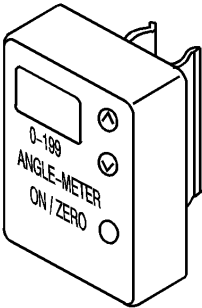


J 43690
Rod Bearing Clearance Checking Tool

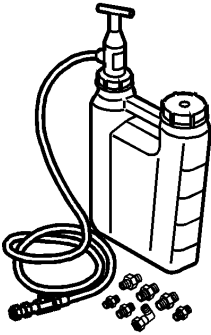
J 45059

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Angle Meter



J 45299
Engine Preluber