2008 ENGINE

Engine Mechanical - 5.3L - LaCrosse

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Camshaft Position (CMP) Sensor Bolt	12 N.m	106 lb in
Camshaft Retainer Bolts - Hex Head Bolts	25 N.m	18 lb ft
Camshaft Retainer Bolts - TORX® Head Bolts	15 N.m	11 lb ft
Camshaft Sprocket Bolt - 1-Bolt Sprocket - First Pass	75 N.m	55 lb ft
Camshaft Sprocket Bolt - 1-Bolt Sprocket - Final Pass	50 degrees	
Connecting Rod Bolts - First Pass	20 N.m	15 lb ft
Connecting Rod Bolts - Final Pass	85 degrees	
Coolant Air Bleed Pipe and Cover Bolts	12 N.m	106 lb in
Coolant Temperature Sensor	20 N.m	15 lb ft
Crankshaft Balancer Bolt - Installation Pass to Ensure the Balancer is Completely Installed	330 N.m	240 lb ft
Crankshaft Balancer Bolt - First Pass - Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	50 N.m	37 lb ft
Crankshaft Balancer Bolt - Final Pass	140 degrees	
Crankshaft Bearing Cap M8 Bolts	25 N.m	18 lb ft
Crankshaft Bearing Cap M10 Bolts - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Bolts - Final Pass in Sequence	80 degrees	

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Crankshaft Bearing Cap M10 Studs - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Studs - Final Pass in Sequence	51 degrees	
Crankshaft Oil Deflector Nuts	25 N.m	18 lb ft
Crankshaft Position (CKP) Sensor Bolt	25 N.m	18 lb ft
Crankshaft Rear Oil Seal Housing Bolts	30 N.m	22 lb ft
Cylinder Head M8 Bolts - in Sequence	30 N.m	22 lb ft
Cylinder Head M11 Bolts - First Pass in Sequence	30 N.m	22 lb ft
Cylinder Head M11 Bolts - Second Pass in Sequence	90 degrees	
Cylinder Head M11 Bolts - Final Pass in Sequence	70 degrees	
Cylinder Head Coolant Plug	20 N.m	15 lb ft
EN 47699 Bolt	60 N.m	44 lb ft
Engine Block Coolant Drain Hole Plug	60 N.m	44 lb ft
Engine Block Coolant Heater	50 N.m	37 lb ft
Engine Block Oil Gallery Plugs	60 N.m	44 lb ft
Exhaust Crossover Pipe Nuts	25 N.m	18 lb ft
Exhaust Manifold Bolts - First Pass	15 N.m	11 lb ft
Exhaust Manifold Bolts - Final Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolts	9 N.m	80 lb in
Exhaust Manifold Studs	20 N.m	15 lb ft
Flex Plate Bolts - First Pass	20 N.m	15 lb ft
Flex Plate Bolts - Second Pass	50 N.m	37 lb ft
Flex Plate Bolts - Final Pass	100 N.m	74 lb ft
Front Cover Bolts	25 N.m	18 lb ft
Fuel Rail Bolts	10 N.m	89 lb in
Ignition Coil Bracket-to-Valve Rocker Arm Cover Studs	12 N.m	106 lb in
Ignition Coil-to-Bracket Bolts	10 N.m	89 lb in

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Intake Manifold Bolts - First Pass in Sequence	5 N.m	44 lb in
Intake Manifold Bolts - Final Pass in Sequence	10 N.m	89 lb in
J 41798 M8 Bolt	25 N.m	18 lb ft
J 41798 M10 Bolts	50 N.m	37 lb ft
Knock Sensor Bolts	20 N.m	15 lb ft
Manifold Absolute Pressure (MAP) Sensor Bolt	5 N.m	44 lb in
Oil Filter	30 N.m	22 lb ft
Oil Filter Fitting	55 N.m	40 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Pan Closeout Cover Bolt - Left Side	9 N.m	80 lb in
Oil Pan Closeout Cover Bolt - Right Side	9 N.m	80 lb in
Oil Pan Cover Bolts	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan M6 Bolts - Oil Pan-to-Rear Housing	12 N.m	106 lb in
Oil Pan M8 Bolts - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pressure Sensor	35 N.m	26 lb ft
Oil Pump Cover Bolts	12 N.m	106 lb in
Oil Pump Relief Valve Plug	12 N.m	106 lb in
Oil Pump Screen Nuts	25 N.m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N.m	106 lb in
Oil Pump-to-Engine Block Bolts	25 N.m	18 lb ft
Sight Shield Studs	12 N.m	106 lb in
Spark Plugs	15 N.m	11 lb ft
Throttle Body Bolts	10 N.m	89 lb in
Timing Chain Tensioner Bolts	25 N.m	18 lb ft
Valve Lifter Guide Bolts	12 N.m	106 lb in
Valve Lifter Oil Manifold Bolts	25 N.m	18 lb ft
Valve Rocker Arm Bolts	30 N.m	22 lb ft

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Valve Rocker Arm Cover Bolts	12 N.m	106 lb in
Water Inlet Housing Bolts	15 N.m	11 lb ft
Water Manifold - M8 Bolts	30 N.m	22 lb ft
Water Manifold - M10 Bolts	60 N.m	44 lb ft
Water Pump Bolts	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	**English**
General		
• Engine Type	V8	
• Displacement	5.3L	325 CID
• RPO	LS4	
• VIN	C	
• Bore	96.0-96.018 mm	3.779-3.78 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	9.9:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Active Fuel Management Cylinders	1-4-6-7	
• Spark Plug Gap	1.02 mm	0.04 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.58-59.63 mm	2.345-2.347 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 3 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.871-69.889 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-		

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Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	96.0-96.018 mm	3.779-3.78 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.57-234.82 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.99-55.04 mm	2.164-2.166 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Intake - Non Active Fuel Management Cylinders	7.2 mm	0.283 in
• Camshaft Lobe Lift - Intake - Active Fuel Management Cylinders	7.33 mm	0.289 in
• Camshaft Lobe Lift - Exhaust - Non Active Fuel Management Cylinders	7.2 mm	0.283 in
• Camshaft Lobe Lift - Exhaust - Active Fuel Management Cylinders	7.33 mm	0.289 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.023-0.065 mm	0.0009-0.0025 in

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• Connecting Rod Bearing Clearance - Service	0.023-0.076 mm	0.0009-0.003 in
• Connecting Rod Bore Diameter - Bearing End	56.505-56.525 mm	2.224-2.225 in
• Connecting Rod Bore Out-of-Round - Bearing End - Production	0.004-0.008 mm	0.00015-0.0003 in
• Connecting Rod Bore Out-of-Round - Bearing End - Service	0.004-0.008 mm	0.00015-0.0003 in
• Connecting Rod Side Clearance	0.11-0.51 mm	0.00433-0.02 in
Crankshaft		
• Connecting Rod Journal Diameter - Production	53.318-53.338 mm	2.0991-2.0999 in
• Connecting Rod Journal Diameter - Service	53.308 mm	2.0987 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service	0.02 mm	0.00078 in
• Crankshaft End Play	0.04-0.2 mm	0.0015-0.0078 in
• Crankshaft Main Bearing Clearance - Production	0.02-0.052 mm	0.0008-0.0021 in
• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in
• Crankshaft Main Journal Diameter -	64.992-65.008	

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Production	mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.003 mm	0.000118 in
• Crankshaft Main Journal Out-of-Round - Service	0.008 mm	0.0003 in
• Crankshaft Main Journal Taper - Production	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Service	0.02 mm	0.00078 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in
• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in
• Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
• Surface Flatness - Block Deck - Measured Within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.13 mm	0.005 in

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• Surface Flatness - Intake Manifold Deck	0.08 mm	0.0031 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured Within a 200 mm (7.87 in) Area that Includes 2 Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Capacity - with Filter	5.7 liters	6.0 quarts
• Oil Capacity - without Filter	5.2 liters	5.5 quarts
• Oil Pressure - Minimum - Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM
• Active Fuel Management Relief Valve Oil Pressure - as Measured at Oil Pressure Sensor Location	379-517 kPa Maximum	55-75 psig Maximum
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Crankshaft Rear Oil Seal Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.1 mm	0.0-0.004 in
Piston Rings		

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• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.23-0.44 mm	0.009-0.017 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.23-0.5 mm	0.009-0.0196 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.44-0.7 mm	0.017-0.027 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.44-0.76 mm	0.0173-0.03 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.18-0.75 mm	0.007-0.029 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.18-0.81 mm	0.007-0.032 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.012-0.2 mm	0.0005-0.0078 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.012-0.2 mm	0.0005-0.0078 in
Pistons and Pins		
• Piston - Piston Diameter - Measured	96.002-96.036	3.779-3.78 in

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Over Skirt Coating	mm	
• Piston - Piston to Bore Clearance - Production	-0.036 to +0.016 mm	-0.0014 to +0.0006 in
• Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.071 mm	0.0028 in
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.00004 in
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.00006 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Pin - Piston Pin Diameter	23.997-24.0 mm	0.9447-0.9448 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in
• Valves - Valve Lash	Net Lash - No Adjustment	
• Valves - Valve Lift - Intake - Non Active Fuel Management	12.24 mm	0.482 in
• Valves - Valve Lift - Exhaust - Non Active Fuel Management	12.24 mm	0.482 in
• Valves - Valve Lift - Intake - Active Fuel Management	12.46 mm	0.49 in
• Valves - Valve Lift - Exhaust - Active Fuel Management	12.46 mm	0.49 in
• Valves - Valve Lift - Exhaust	11.85 mm	0.466 in
• Valves - Valve Seat Angle	46 degrees	

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• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
• Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Valve Spring Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

SEALERS, ADHESIVES, AND LUBRICANTS

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Temperature Sensor Threads	Sealant	12346004	10953480

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Cylinder Head Core Hole Plugs	Threadlock	12345382	10953489
Cylinder Head Plug	Threadlock	12345382	10953489
Engine Block Coolant Drain Hole Plug Washer	Sealant	12346004	10953480
Engine Block Oil Gallery Plug - Front	Threadlock	12345382	10953489
Engine Block Oil Gallery Plug Washers	Sealant	12346004	10953480
Engine Oil	5W-30 Oil	12345610	729389
Engine Oil Pressure Sensor Threads	Sealant	12346004	10953480
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolts	Threadlock	12345493	10953488
Flexplate/Flywheel Bolts	Threadlock	12345382	10953489
Fuel Injection Fuel Rail Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket-to-Valve Cover Studs	Threadlock	12345382	10953489
Ignition Coil-to-Bracket Bolts	Threadlock	12345382	10953489
Intake Manifold Bolts	Threadlock	12345382	10953489
Oil Pan Surface at Front Cover and Rear Housing	Sealant	12378521	88901148
Thread Repair Component Cleaner	Cleaner	12346139	10953463
Thread Repair Component Cleaner	Cleaner	12377981	10953463
Thread Repair Cutting Oil	Lubricant	1052864	992881

THREAD REPAIR SPECIFICATIONS

Engine Block - Front/Rear Views

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Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front/Rear Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M10 x 1.5	215	211	212	213	214	33.5 (1.32)	27 (1.06)
3	M8 x 1.25	210	206	207	208	209	Thru	Thru
4	M10 x 1.5	215	211	212	213	214	Thru	Thru

Engine Block - Left/Right Side Views

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Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left/Right Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M8 x 1.25	210	206	207	208	209	28.5 (1.122)	23.0 (0.905)
3	M8 x 1.25	210	206	207	208	209	21.5 (0.846)	16.0 (0.629)
4	M10 x 1.5	215	211	212	213	214	29.0 (1.141)	23.0 (0.905)
5	M10 x 1.5	215	211	212	213	214	27.0 (1.062)	21.5 (0.846)
6	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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7	M11 x 2.0	108	105	N/A	106	107	69.0 (2.72)	60.0 (2.36)
8	M28 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	M6 x 1.0	205	201	202	203	204	22.5 (0.886)	15.0 (0.591)
Bolt hole 7 has a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.								

Engine Block - Top/Bottom Views

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Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top/Bottom Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				

1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	M10 x 2.0	104	101	N/A	102	103	31.0 (1.22)	25.5 (1.0)
4	M10 x 2.0	104	101	N/A	102	103	53.5 (2.10)	44.0 (1.73)
5	M8 x 1.25	210	206	207	208	209	26.5 (1.043)	19.0 (0.748)

- Bolt hole 3 has a 1.5 mm (0.059 in) counterbore included in the 31.0 mm (1.22 in) drill depth. Use sleeve J 42385-316 with the drill and tap.
- Bolt hole 4 has a 20.5 mm (0.807 in) counterbore included in the 53.5 mm (2.10 in) drill depth.

Cylinder Head - Top/End Views

Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top/End Views

	Thread			Counterbore			Drill Depth - Maximum	Tap Depth - Maximum

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Hole	Size	Insert	Drill	Tool	Tap	Driver	mm (in)	mm (in)
				J 42385-				
1	M8 x 1.25	210	206	207	208	209	26.5 (1.04)	19.0 (0.784)
2	M6 x 1.0	205	201	202	203	204	20.05 (0.789)	16.05 (0.632)
3	M10 x 1.5	215	211	212	213	214	28.0 (1.10)	20.0 (0.787)
4	M6 x 1.0	205	201	202	203	204	22.5 (0.885)	15.0 (0.688)

Cylinder Head - Intake/Exhaust Side Views

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Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake/Exhaust Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M6 x 1.0	205	201	202	203	204	Thru	Thru
2	M10 x 1.5	215	211	212	213	214	28.0 (1.10)	20.0 (0.787)
3	M8 x 1.25	210	206	207	208	209	21.0 (0.826)	16.0 (0.629)
4	M14 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	M12 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A

COMPONENT LOCATOR

DISASSEMBLED VIEWS

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Fig. 6: Disassembled View Of Intake Manifold/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
307	Engine Coolant Air Bleed Pipe
308	Seal
308	Seal
309	Bolt
311	Coolant Hose
312	Bolt
313	Engine Coolant Air Bleed Cover
322	Clamp
451	Valve Lifter Oil Manifold
452	Valve Lifter Oil Filter
454	O-ring
500	Intake Manifold
506	Bolt
508	Throttle Body
509	Throttle Body Gasket
510	Fuel Rail with Injectors
511	Bolt
512	Bolt
513	Seal
514	Intake Manifold Gasket
538	Bolt
556	Valve Lifter Oil Manifold Gasket
557	Fuel Rail Ground Strap
560	Bolt/Stud
706	Oil Pressure Sensor
707	Washer
714	Manifold Absolute Pressure (MAP) Sensor

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715	O-ring
729	Evaporative Emission (EVAP) Canister Purge Tube
730	EVAP Canister Purge Solenoid Valve
736	MAP Sensor Bolt
741	EVAP Canister Purge Solenoid Valve Bracket

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Fig. 7: Disassembled View Of Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
209	Valve Lifter - Non Active Fuel Management

210	Valve Lifter Guide
211	Bolt
212	Pushrod
213	Rocker Arm
214	Bolt
215	Rocker Arm Pivot Support
216	Core Hole Plug
217	Cylinder Head Gasket
218	Cylinder Head
219	Valve Lifter - Active Fuel Management
220	Bolt - M11
221	Bolt - M8
222	Valve Stem Oil Seal
223	Valve Spring
224	Valve Spring Cap
225	Valve Stem Key
226	Core Hole Plug
227	Intake Valve
228	Exhaust Valve
229	Cylinder Head Coolant Plug
230	Cylinder Head Locating Pin
422	Oil Fill Tube O-ring
423	Oil Fill Tube
424	Oil Fill Cap
450	Oil Fill Cap O-ring
504	Valve Cover Gasket
504	Valve Cover Gasket
505	Valve Cover
505	Valve Cover
515	Valve Cover Bolt Grommet
515	Valve Cover Bolt Grommet

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516	Bolt
516	Bolt
600	Exhaust Manifold
601	Exhaust Manifold Gasket
602	Bolt
603	Exhaust Manifold Heat Shield
604	Bolt
605	Stud
606	Exhaust Pipe
607	Nut
608	Bolt
609	Heat Shield
700	Positive Crankcase Ventilation (PCV) Hose - Fresh Air
716	PCV Hose - Dirty Air
719	Ignition Coil Bracket
720	Bolt
721	Ignition Coil Wire Harness
722	Ignition Coil
723	Bolt
724	Spark Plug Wire
725	Coolant Temperature Sensor (CTS)
726	Spark Plug

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Fig. 8: Disassembled View Of Front Of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Bolt
2	Water Pump
3	Water Pump Gasket
4	Bolt
5	Water Manifold
6	O-Ring
7	Coolant Cap
8	Water Manifold Gasket

9	O-Ring
10	Thermostat
11	Water Inlet Housing
12	Bolt
13	Engine Block
14	Camshaft Bearings
15	Camshaft
16	Camshaft Sprocket Locating Pin
17	Camshaft Retainer
18	Bolt
19	Camshaft Sprocket
20	Bolt
21	Crankshaft Sprocket
22	Timing Chain
23	Timing Chain Tensioner
24	Bolt
25	Front Cover Gasket
26	Front Cover
27	O-Ring
28	Camshaft Position (CMP) Sensor
29	Bolt
30	Crankshaft Front Oil Seal
31	Bolt
32	Crankshaft Balancer
33	Bolt
34	Bolt
35	Oil Pump Assembly
36	Bolt
37	Oil Pump Cover
38	Drive Gear
39	Driven Gear

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40	Plug
41	Pressure Relief Valve Spring
42	Pressure Relief Valve
43	O-Ring
44	Bolt
45	Nut
46	Oil Pump Screen

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Fig. 9: Disassembled View Of Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
132	Flex Plate - Automatic Transmission
133	Bolt
141	Crankshaft Rear Oil Seal
517	Bolt
518	Crankshaft Rear Oil Seal Housing
519	Crankshaft Rear Oil Seal Housing Gasket

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Fig. 10: Disassembled View Of Lower Engine Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Engine Block
2	Piston Pin

3	Retainer
4	Piston Rings
5	Piston
6	Connecting Rod
7	Connecting Rod Bearings
8	Connecting Rod Cap
9	Bolt
10	Crankshaft Main Bearing
10	Crankshaft Main Bearing
11	Crankshaft Thrust Bearing
11	Crankshaft Thrust Bearing
12	Crankshaft Sprocket Key
13	Crankshaft
14	Crankshaft Bearing Cap
15	Bolt - M8
16	Bolt
17	Oil Level Indicator
18	O-Ring
19	Oil Level Indicator Tube
20	O-Ring
21	Crankshaft Oil Deflector
22	Bolt - M10
23	Stud - M10
24	Nut
25	Oil Pump Screen
26	Nut
27	O-Ring
28	Bolt
29	Oil Pan Gasket
30	Cover - Right
31	Bolt

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32	Oil Pan
33	Oil Pressure Relief Valve - Active Fuel Management
34	Oil Pan Cover Gasket
35	Cover
36	Cover - Left
37	Bolt
38	Bolt
39	Oil Filter Fitting
40	Bolt
41	Oil Filter
42	O-Ring
43	Oil Pan Drain Plug
44	Bolt

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Fig. 11: View Of Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
100	Engine Block
101	Oil Gallery Plug - Front
110	O-Ring
111	Oil Gallery Plug - Rear
112	Oil Gallery Plug - Side
113	Washer
114	Coolant Heater

115	Washer
116	Oil Gallery Plug - Side
117	Washer
130	Transmission Housing Locating Pin
145	Washer
146	Engine Block Coolant Drain Hole Plug
701	Crankshaft Position (CKP) Sensor
702	O-Ring
718	Knock Sensor
718	Knock Sensor
739	Bolt
739	Bolt
750	Bolt

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Fig. 12: Oil Pump Assembly Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
408	Bolt
409	Oil Pump Housing Cover
410	Oil Pump Drive Gear
412	Oil Pump Driven Gear
413	Oil Pump
414	Oil Pump Pressure Relief Valve
415	Oil Pump Pressure Relief Valve Spring
416	Oil Pump Housing Plug

ENGINE IDENTIFICATION

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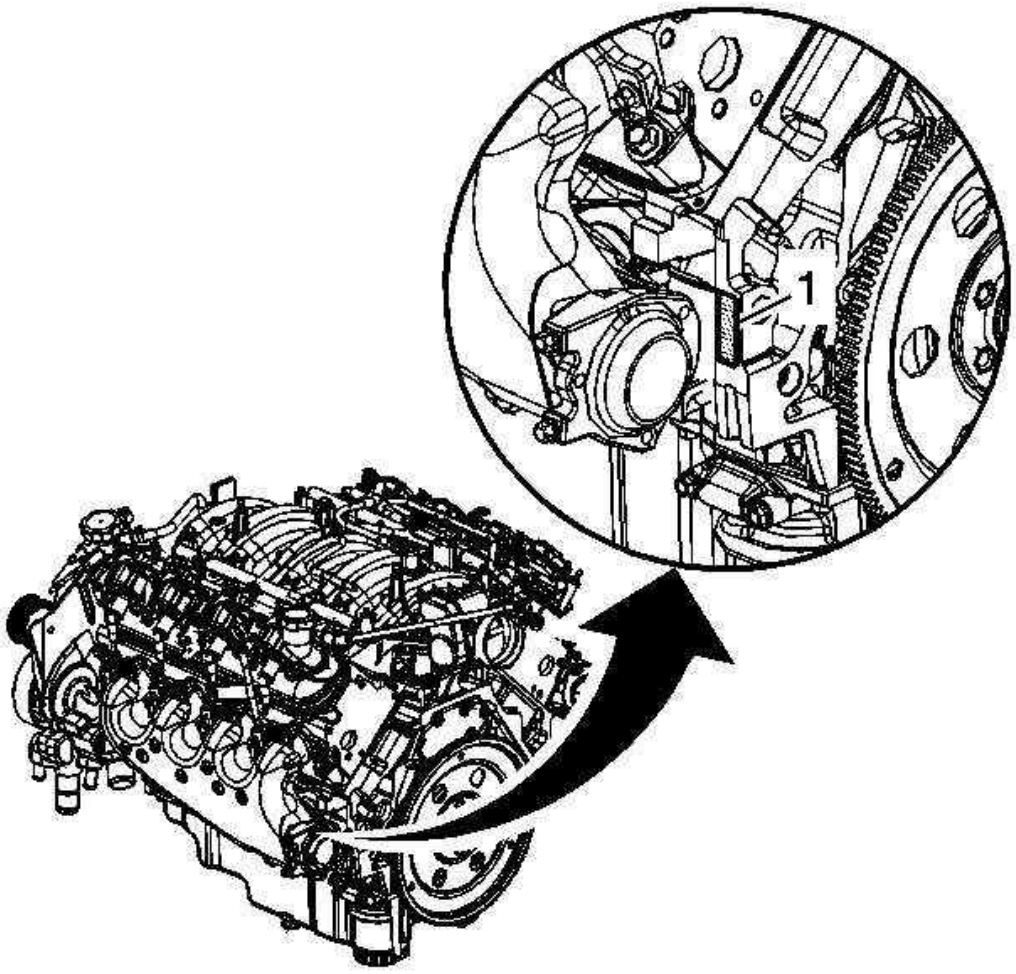


Fig. 13: Locating Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically 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.

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- The fourth through ninth digits are the last 6 digits of the VIN.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the:

- **Disassembled Views**
- **Engine Component Description**
- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Cylinder Deactivation (Active Fuel Management) System Description**
- **Drive Belt System Description**

Reviewing the description and operation information helps you determine the correct symptom diagnostic procedure when a condition exists. Reviewing the description and operation information also helps 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** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to:

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- **Disassembled Views**
- **Engine Component Description**
- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Cylinder Deactivation (Active Fuel Management) System Description**
- **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 condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Strategy Based Diagnosis** .

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect 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

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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**
- **Coolant in Combustion Chamber**
- **Coolant in Engine Oil**
- **Cylinder Deactivation (Active Fuel Management) System Diagnosis**
- **Engine Compression Test**
- **Cylinder Deactivation (Active Fuel Management) System Compression Test**
- **Cylinder Leakage Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Cylinder Deactivation (Active Fuel Management) Oil Pressure Relief Valve Diagnosis and Testing**
- **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing (5.3L)**
- **Oil Leak Diagnosis**

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- **Crankcase Ventilation System Inspection/Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Fuel injector harness connectors are connected to the incorrect fuel injectors/cylinders	Relocate the fuel injector harness connectors, as necessary.
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer, as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine	Repair or replace, as required.

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performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	
Improperly installed or damaged vacuum hoses	Repair or replace, as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body, as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor, as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and the rocker arms in the proper position.	Replace the valve rocker arms, as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the valves and piston and pin assembly.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets, as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**.

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compression.	• Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Inspect the cylinder heads, engine block, and/or head gaskets. Refer to **Coolant in Combustion Chamber**. 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to identify the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then sync the crankshaft position.	Replace the sensor and/or crankshaft, as required.

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• 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 P0300 DTC 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 to the point of generating a DTC P0300 or P0336.	

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine flywheel or crankshaft balancer	Repair or replace the flywheel and/or balancer, as required.

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A misfire code may be present without an actual misfire condition.	Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. • Repair or replace, as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings, as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms, as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.

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Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets, as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace, as required.
Improper operation of the active fuel management system	Inspect the system for proper operation. Refer to **Diagnostic Starting Point - Engine Mechanical**.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . • Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to **Coolant in Combustion Chamber**. • Repair or replace, as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace, as required.
Worn piston rings	1. Inspect the spark plugs for oil

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Oil consumption may or may not cause the engine to misfire.	deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters, as required.
Worn crankshaft thrust bearing	1. Check the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace, as required.
Damaged or faulty oil filter bypass valve The bypass valve is now internal to the oil filter	1. Inspect the oil filter bypass valve for proper operation. 2. Repair or replace, as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and**

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	Testing. 2. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm, bolt, and pedestal. 2. Repair or replace, as required.
Worn or damaged valve rocker arm	1. Inspect the rocker arm for wear or missing needle bearings 2. Replace the valve rocker arms, as required.
Bent or damaged push rod	Inspect the following components and replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The valve lifter guide • The piston Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • Improper operation of the active fuel management oil pressure

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	relief valve • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
Active fuel management valve lifter with a broken spring	Replace, as required.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft and valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components and repair, as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components and repair, as required: • The valves • The valve guides
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair, as required. Refer to **Oil Pressure Diagnosis and Testing**.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components, as required.

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Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace, as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair or replace, as required.
Loose or damaged flywheel/flex plate	Repair or replace the flywheel/flex plate.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace, as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair, as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, pin, and connecting rod. 2. Replace the piston and pin as an assembly, as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair, as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components and

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	repair, as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. Refer to **Piston, Connecting Rod, and Bearing Installation**. 2. Repair, as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair, as required.
Cracked flex plate - automatic transmission	1. Inspect the flex plate bolts and flex plate. 2. Repair, as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair, as required: • The connecting rod bearings • The connecting rods

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	• The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components and repair, as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flex plate location. 3. Repair or replace the components, as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flex plate bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flex plate location. 3. Repair or replace the components, as required.
Broken timing chain	1. Inspect the timing chain and sprockets. 2. Repair or replace the components, as required.
Seized timing chain or timing sprockets	1. Inspect the timing chain and sprockets for foreign material or a

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	seized chain. 2. Repair or replace the components, as required.
Seized or broken camshaft	1. Inspect the camshaft and the camshaft bearings. 2. Repair or replace the components, as required.
Bent valve in the cylinder head	1. Inspect the valves and the cylinder heads. 2. Repair or replace the components, as required.
Seized oil pump	1. Inspect the oil pump assembly. 2. Repair or replace, as required.
Hydraulically locked cylinder • Coolant/antifreeze in the cylinder • Oil in the cylinder • Fuel in the cylinder	1. Remove spark plugs and check for fluid in the cylinder. When rotating the engine with the spark plugs removed, the piston, on compression stroke, will push fluid from the combustion chamber. Refer to **Coolant in Combustion Chamber**. 2. Inspect for failed/broken head gaskets. 3. Inspect for a cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace the components, as required.
Material in the cylinder • Broken valve • Broken piston rings	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace the components,

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• Piston material • Foreign material	as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Repair or replace the components, as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Replace the piston, pin and connecting rod as an assembly, as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair or replace the components, as required.

COOLANT IN COMBUSTION CHAMBER

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

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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 **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
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

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil overfill condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. 2. Inspect by performing a cylinder 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. 2 cylinders side-by-side on the engine block with low compression may indicate a failed	

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cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty external engine oil cooler	Replace the components, as required.
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components, as required.
Cylinder head or block porosity	Replace the components, as required.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS

1. Measure the engine oil level and fill, as required.
2. Using the scan tool, inspect for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** . Repair, as required.
3. Verify proper engine oil pressure and operation of the active fuel management oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Verify proper operation of the active fuel management system components. Refer to **Cylinder Deactivation (Active Fuel Management) System Compression Test**.
5. Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.
6. Verify proper operation of the valve lifter oil manifold. Refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing (5.3L)**.
7. Replace the active fuel management valve lifters, as required. Both intake and

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exhaust lifters should be replaced in pairs. Refer to **Valve Lifter Replacement**.

ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gage at zero and crank the engine through 4 compression strokes, 4 puffs.
8. Measure the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Measure the compression again and record the reading.
10. The minimum compression in any 1 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 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1 035 x 70% = 725) (150 x 70% = 105).
    - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
    - Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
    - Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
    - If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM COMPRESSION TEST

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The Cylinder Deactivation (Active Fuel Management) System Compression Test is a functional test of the valve lifter oil manifold and valve lifters. Using a compression gage, the technician can monitor the specific cylinders ability to go into and out of active fuel management, as commanded by the scan tool. The actual pressure values on the compression gage are not as critical as is observing the on-off switching action of the solenoid and valve lifters.

1. Measure the engine oil level. Fill, as required.
2. Perform the Diagnostic System Check - Vehicle. Refer to **Diagnostic System Check - Vehicle** .
3. Disable the ignition system for the cylinder to be tested, by disconnecting the electrical wire harness to the ignition coil.
4. Disable the fuel injection system for the cylinder to be tested, by disconnecting the electrical wire harness to the fuel injector.
5. Remove the spark plug and wire for the cylinder to be tested.
6. Install a 0-1378 kPa (0-200 psi) compression gage.
7. Start the engine.
8. Using the scan tool output controls, command the solenoid ON, for the cylinder to be deactivated.
9. Depress the Schrader valve on the compression gage in order to release the pressure and zero the gage. With the engine running and the cylinder in active fuel management mode, the compression reading should be less than 172 kPa (25 psi).
10. Using the scan tool, de-energize the solenoid while observing the reading on the compression gage. With the engine running and the cylinder NOT in active fuel management mode, the compression gage reading should increase quickly to greater than 345 kPa (50 psi).

IMPORTANT: Only one cylinder can be tested at a time. When testing has been completed on a specific cylinder, the wire harness electrical connectors, spark plug, and spark plug wire must be installed prior to testing of each additional cylinder.

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11. Test each of the 4 active fuel management cylinders, one at a time. If the readings are not within specifications, remove and test the valve lifter oil manifold, as required. Refer to **Valve Lifter Oil Manifold Replacement** and **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing (5.3L)**.
12. If the compression test has been performed and all active fuel management cylinders are operating within specifications, the active fuel management system is performing as designed and no repairs are required.
13. Clear the diagnostic trouble codes (DTCs) with a scan tool.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester, or equivalent

IMPORTANT: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate one or more of the following conditions:

- **Worn or burnt valves**
- **Broken valve springs**
- **Stuck valve lifters**
- **Incorrect valve lash**
- **Damaged piston**
- **Worn piston rings**
- **Worn or scored cylinder bore**
- **Damaged cylinder head gasket**
- **Cracked or damaged cylinder head**
- **Cracked or damaged engine block**

Testing Procedure

CAUTION: Refer to Battery Disconnect Caution .

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1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **J 35667-A** , or equivalent.

IMPORTANT: It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.

5. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturers instructions.
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:
   - Air leakage noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
   - Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or greater of engine oil within 3 200 kilometers (2,000 miles).	
Preliminary	The causes of excessive oil consumption may include the following conditions:

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	• External oil leaks Refer to **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes. Allow adequate drain down time, 2-3 minutes, and inspect for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings, as necessary. • Piston and rings improperly installed or not fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

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- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **J 21867** Pressure Gage

Diagnosis and Testing

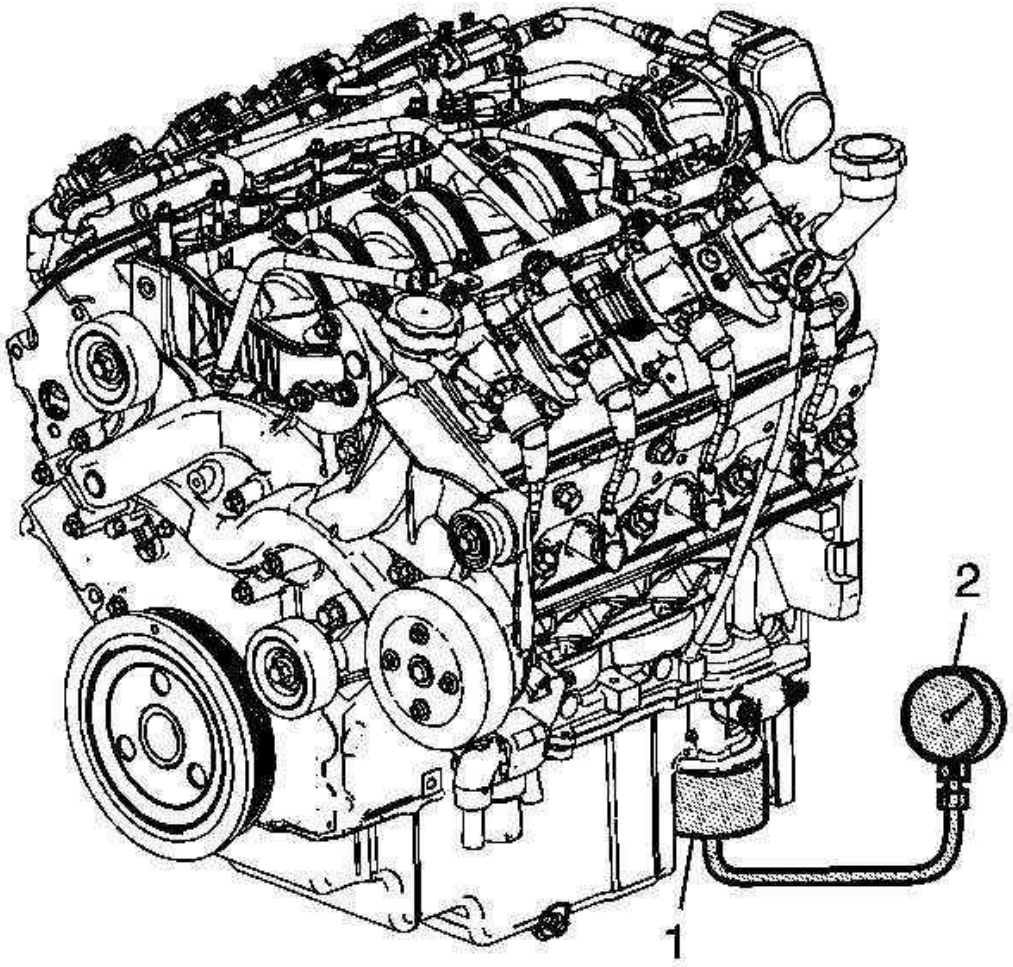


Fig. 14: Measuring Engine Oil Pressure
Courtesy of GENERAL MOTORS CORP.

1. With the vehicle on a level surface, run the vehicle for a few minutes. Allow adequate drain down time, 2-3 minutes, and measure the oil level.

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2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
   - Oil diluted by water or glycol antifreeze

     Refer to **Coolant in Engine Oil** .

   - Foamy oil, which may be caused by a cut or damaged oil pump screen O-ring seal
6. Remove the oil filter and install the **EN-47971** (1). See **Special Tools**.
7. Install **J 21867** (2), or equivalent to the **EN-47971** (1). See **Special Tools**.
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to **Engine Mechanical Specifications**.
10. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
    - Oil pump worn or dirty

      Refer to **Oil Pump Cleaning and Inspection** .

    - Oil pump-to-engine block bolts loose

      Refer to **Oil Pump, Screen and Crankshaft Oil Deflector Installation** .

    - Oil pump screen loose, plugged, or damaged
    - Oil pump screen O-ring seal missing or damaged
    - Malfunctioning oil pump pressure relief valve
    - Excessive bearing clearance
    - Cracked, porous, or restricted oil galleries
    - Oil gallery plugs missing or incorrectly installed

      Refer to **Engine Block Plug Installation** .

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- Improper operation of the active fuel management oil pressure relief valve

  Refer to **Cylinder Deactivation (Active Fuel Management) Oil Pressure Relief Valve Diagnosis and Testing** .

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) OIL PRESSURE RELIEF VALVE DIAGNOSIS AND TESTING

Tools Required

- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **J 21867** Pressure Gage
- **J-21867-16** Oil Pressure Adapter. See **Special Tools**.

Diagnosis and Testing

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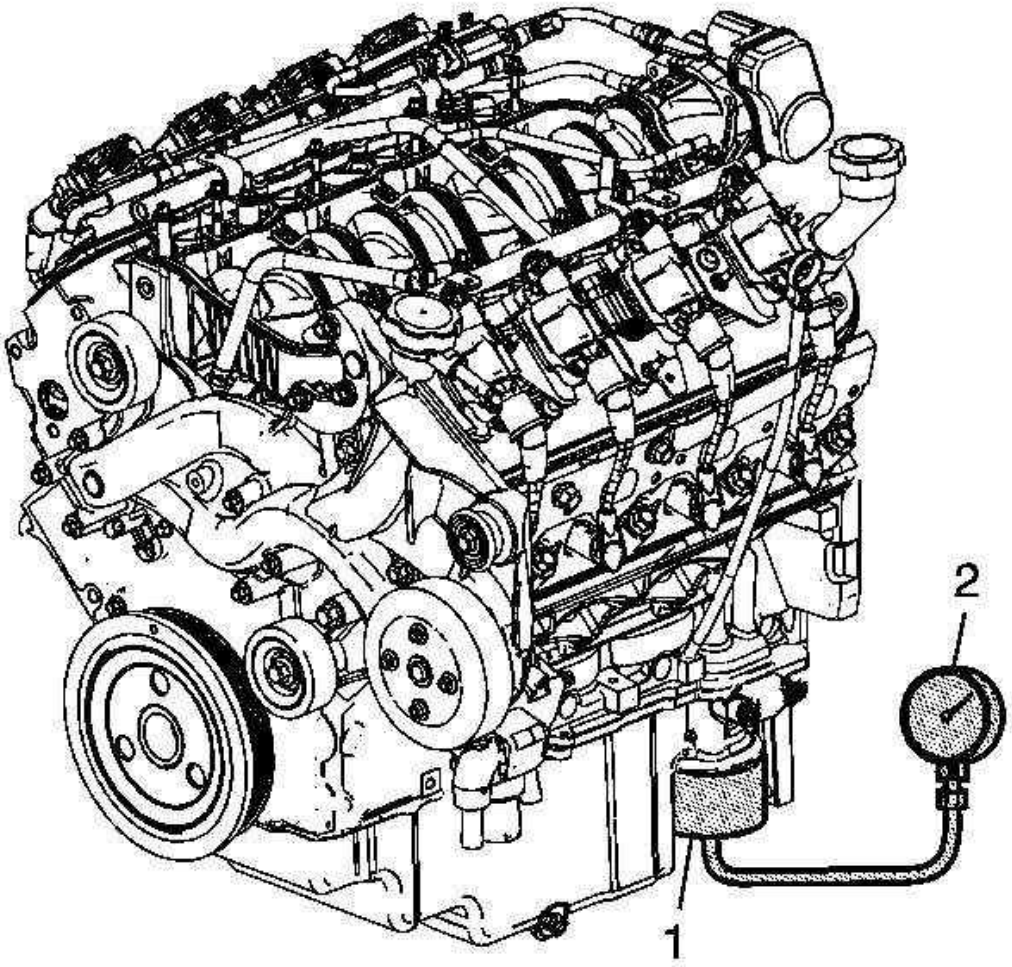


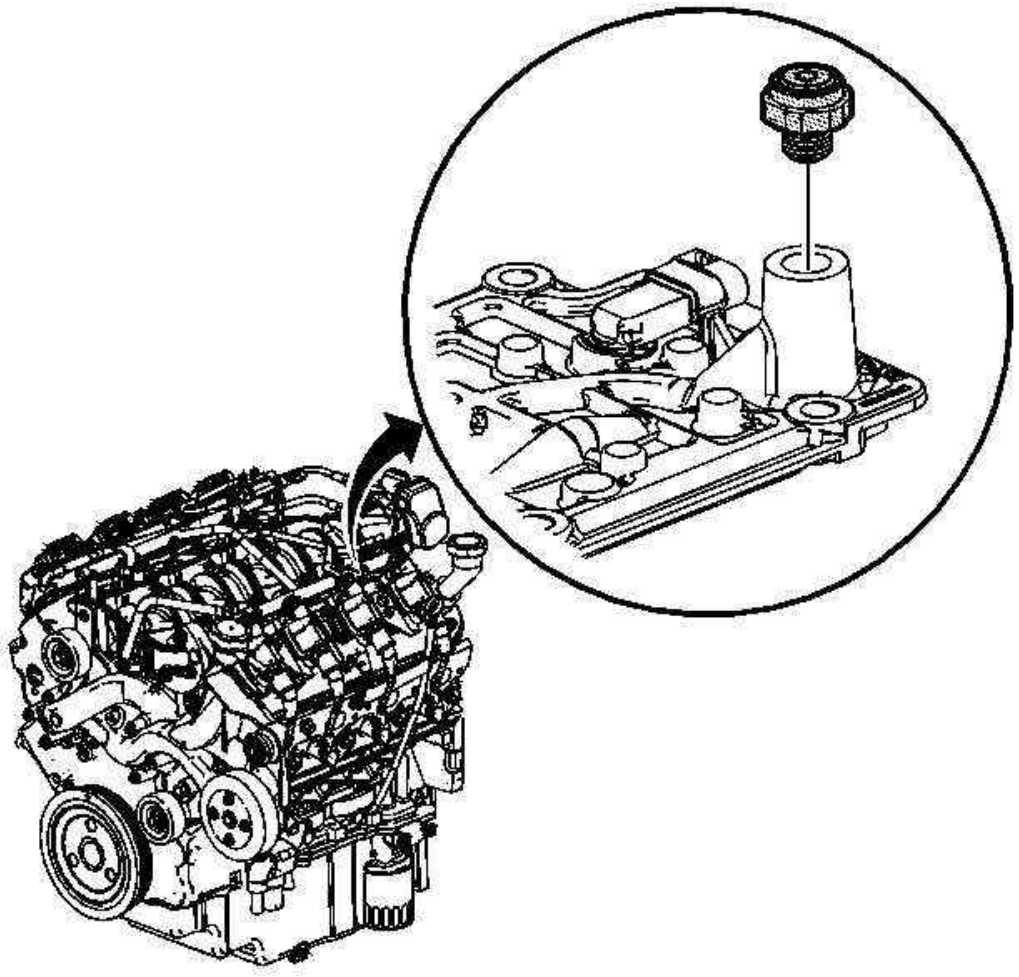
Fig. 15: Measuring Engine Oil Pressure
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This test is performed to verify the operation of the oil pressure relief valve. Refer to Cylinder Deactivation (Active Fuel Management) System Description, Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) Off, Lubrication Description - Main Pressure Above 55 psi with

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Cylinder Deactivation (Active Fuel Management) Off, Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) On, and Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) On.

1. Remove the oil filter and install the **EN-47971** (1). See **Special Tools**.
2. Install the **J 21867** (2), or equivalent to the **EN-47971** (1). See **Special Tools**.



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Fig. 16: View Of Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pressure sensor and install the **J-21867-16** . See **Special Tools**.

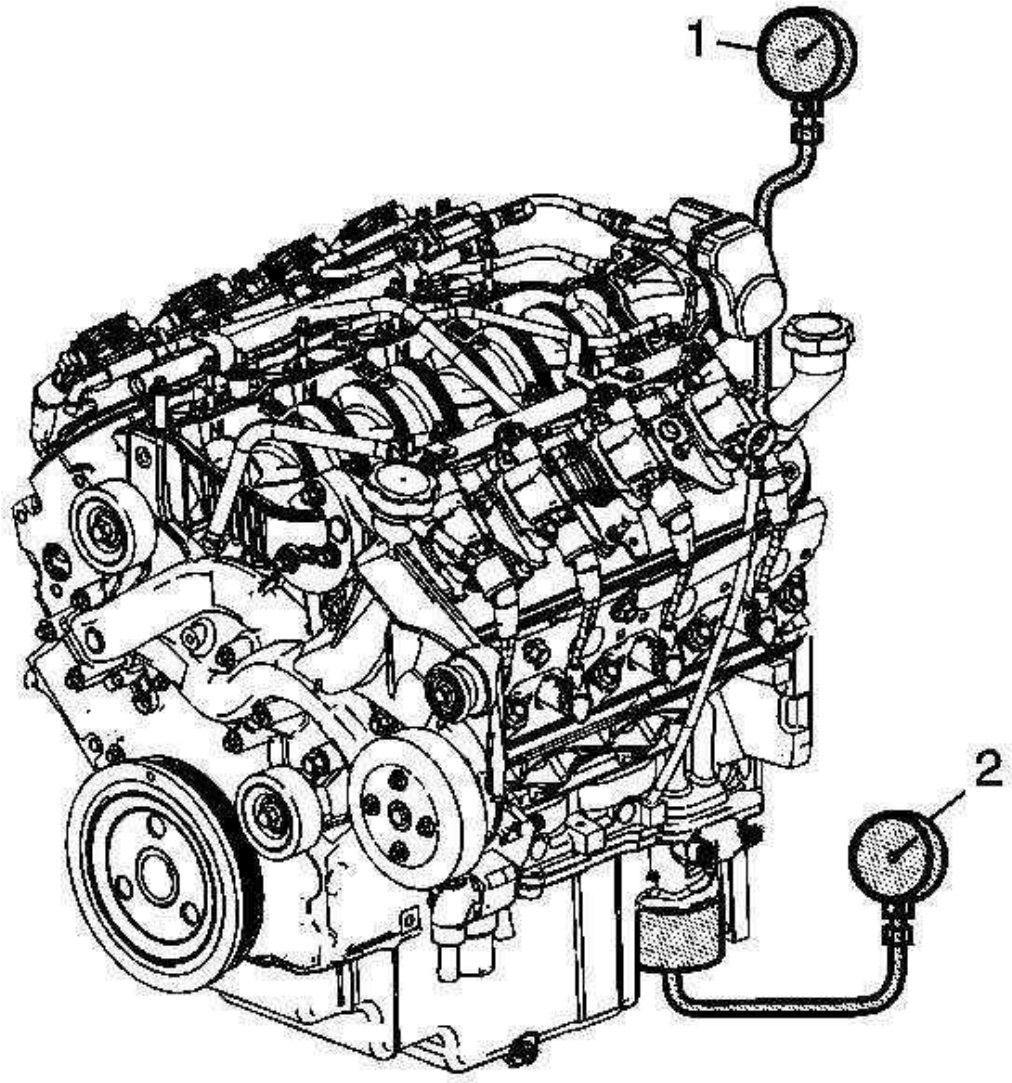


Fig. 17: Measuring Engine Oil Pressure While Observing Both Gages
Courtesy of GENERAL MOTORS CORP.

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4. Install the **J 21867** (1), or equivalent to the **J-21867-16** . See **Special Tools**.
5. Run the engine and measure the engine oil pressure while observing both gages.

   Operate the throttle as required to increase and decrease the engine oil pressure.

   - With the engine running and the lower pressure gage (2) measuring below 448 kPa (65 psi), both gages should display the same pressure reading. If the readings are not the same and the lower pressure gage (2) has a higher reading, the oil pressure relief valve is stuck in the open position or the valve lifter oil manifold filter is plugged.
   - With the engine running and the lower pressure gage (2) measuring above 448 kPa (65 psi), the upper gage (1) should display no greater than 448 kPa (65 psi). If the reading on the upper pressure gage (1) is greater than 448 kPa (65 psi), the oil pressure relief valve is stuck in the closed position.
6. Repair, as required.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) VALVE LIFTER OIL MANIFOLD DIAGNOSIS AND TESTING (5.3L)

Tools Required

- **EN-46999** Active Fuel Management Tester
- **EN-46999-1** Active Fuel Management Tester Air Adapter. See **Special Tools**.
- **EN-46999-5** Active Fuel Management Tester Harness - Small Block V8. See **Special Tools**.

IMPORTANT:

- **This component test applies only to vehicles with functional active fuel management.**
- **A minimum shop air source of 206 kPa (30 psi) is required for manifold testing.**
- **A water bleed is located on the EN-46999 . Occasionally, depress the valve in order to remove**

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excess water from the tool.

Diagnosis and Testing

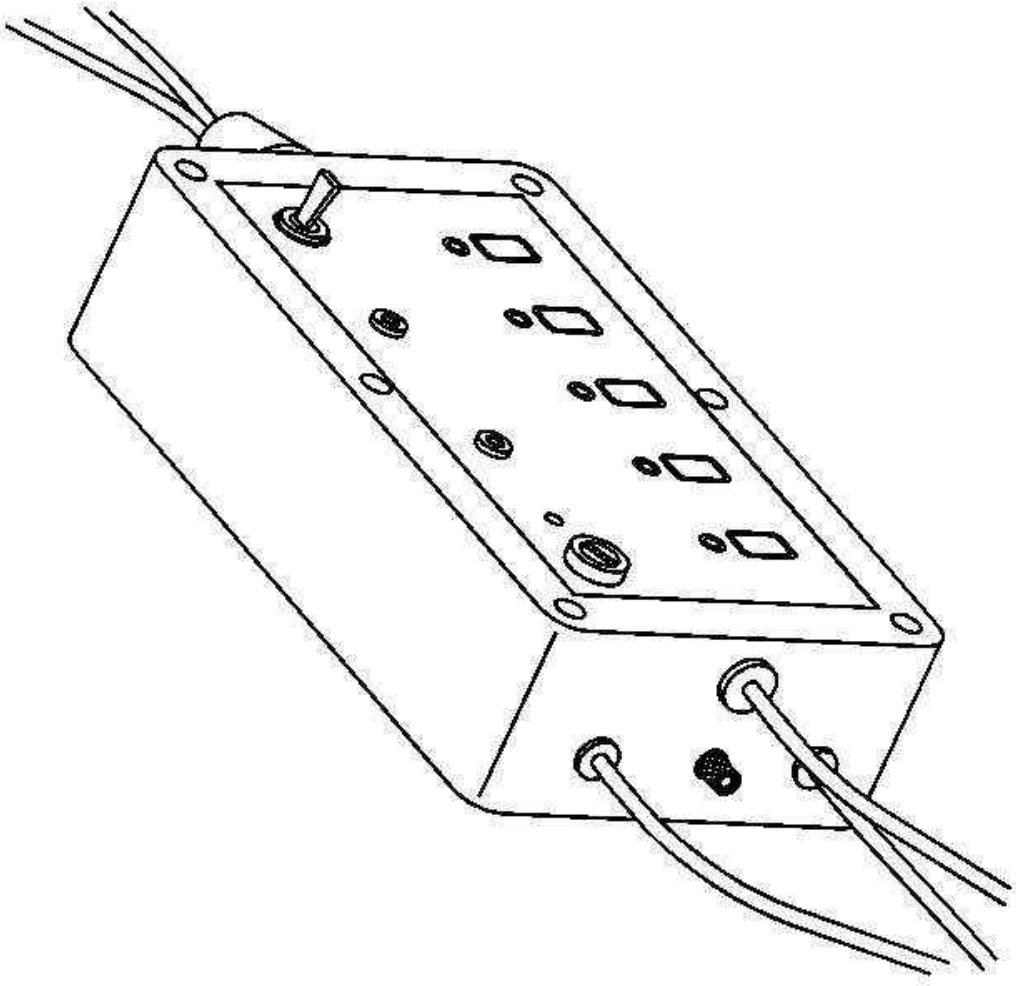


Fig. 18: Identifying Displacement On-Demand Tester
Courtesy of GENERAL MOTORS CORP.

The manifold bench test provides a maximum 206 kPa (30 psi) of filtered shop air to the manifold and will test each solenoid/valve for the following conditions:

- Proper operation

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- A stuck open condition - constant air flow
- A stuck closed condition - no air flow
- A flow restriction within the manifold

1. Individually depress each of the buttons 1-4 on the **EN-46999** in order to activate each of the solenoid/valves. When activating each solenoid/valve, a loud click should be heard from the solenoid and an increased amount of air will exit the outlet ports.
    - Button 1 will energize the solenoid/valve 1 for engine cylinder number 1.
    - Button 2 will energize the solenoid/valve 2 for engine cylinder number 4.
    - Button 3 will energize the solenoid/valve 3 for engine cylinder number 6.
    - Button 4 will energize the solenoid/valve 4 for engine cylinder number 7.

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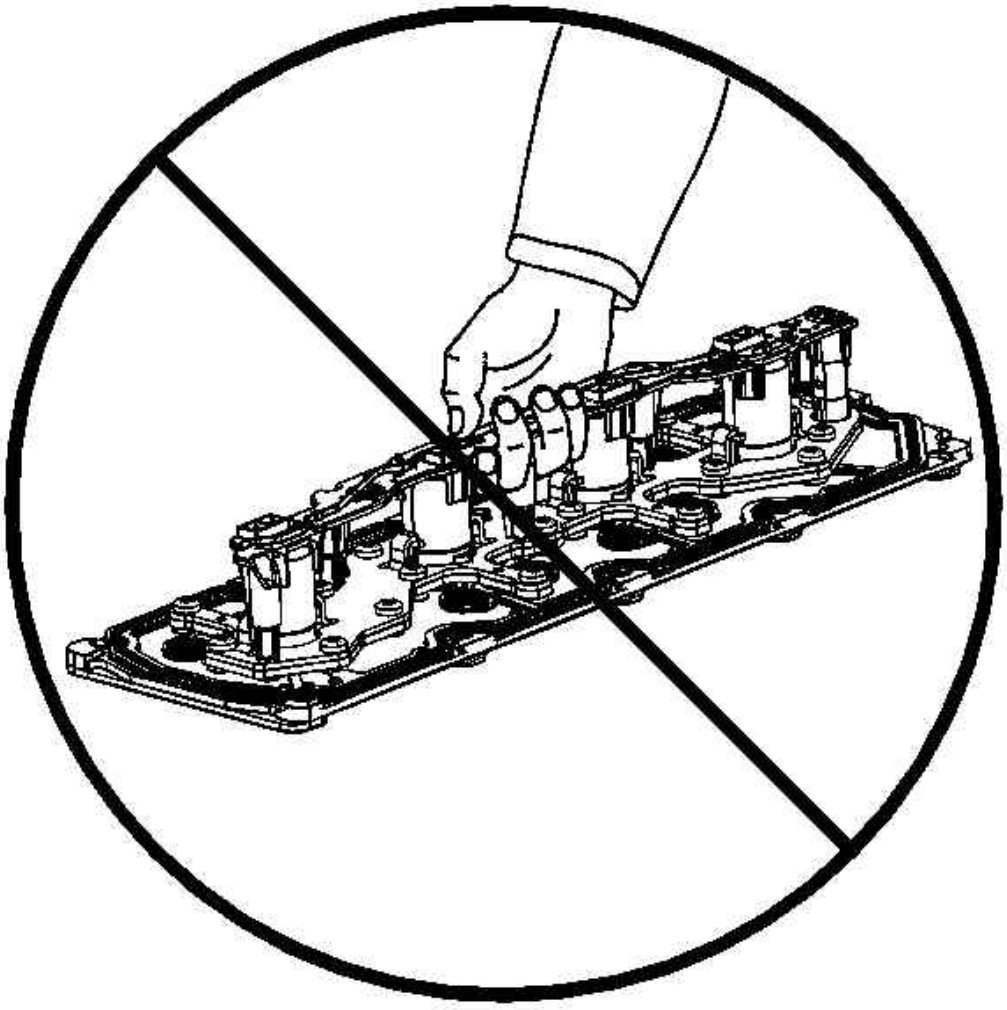


Fig. 19: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

2. Do not lift the manifold assembly by the electrical lead frame.

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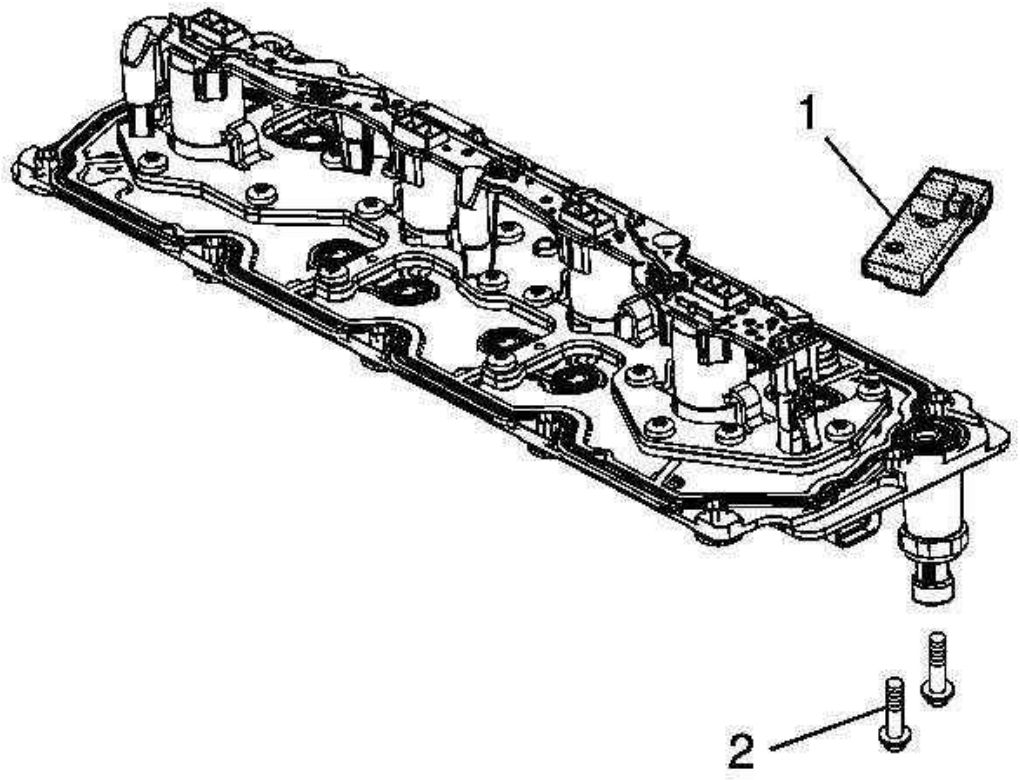


Fig. 20: Identifying Displacement On-Demand Tester Air Adapter
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN-46999-1** (1) to the manifold. See **Special Tools**.

NOTE: Refer to Fastener Notice .

4. Install 2 of the manifold bolts (2) to the **EN-46999-1** . See **Special Tools**.

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

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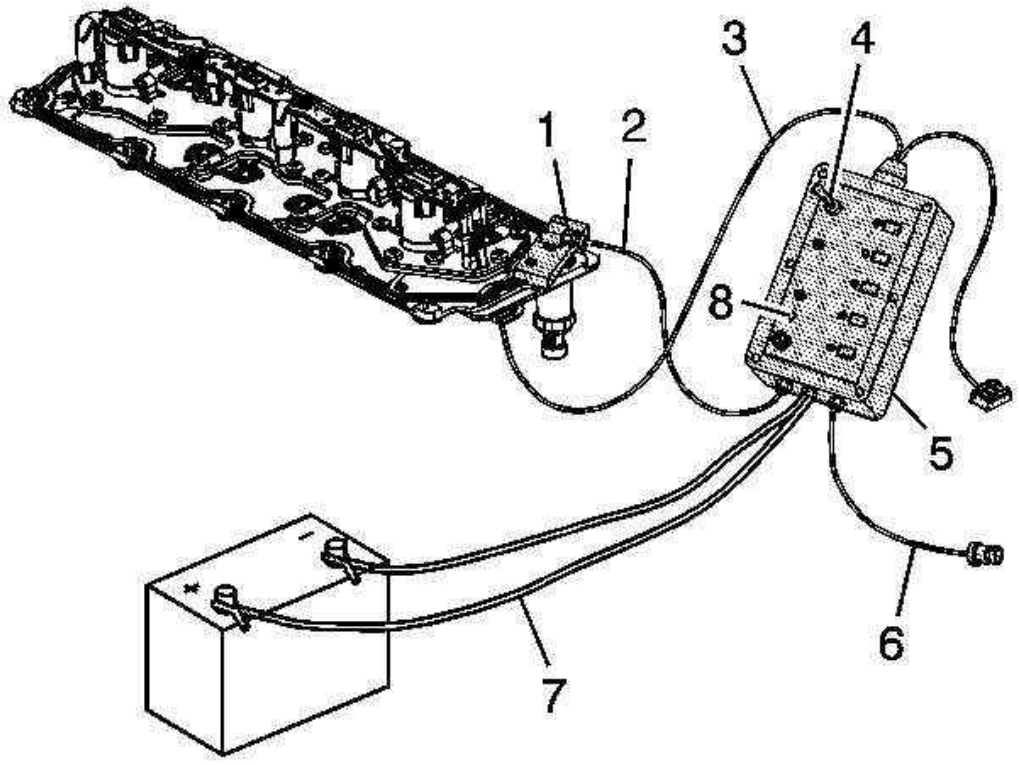


Fig. 21: View Of Connecting Of Tester
Courtesy of GENERAL MOTORS CORP.

5. Connect the air out hose (2) of the **EN-46999** (5) to the **EN-46999-1** (1). See **Special Tools**. Verify the air supply switch (4) is in the off position.
6. Connect the air in hose (6) of the **EN-46999** (5) to a shop air source.
7. Connect the 12-volt power supply connectors (7) of the **EN-46999** (5) to a 12-volt power supply. Verify the Power light (8) on the tool is illuminated. If the light on the tool is not illuminated when connected to a 12-volt power supply, test and/or replace the 3 amp fuse.
8. Connect the **EN-46999-5** power cable (3) to the electrical connector of the manifold. See **Special Tools**.

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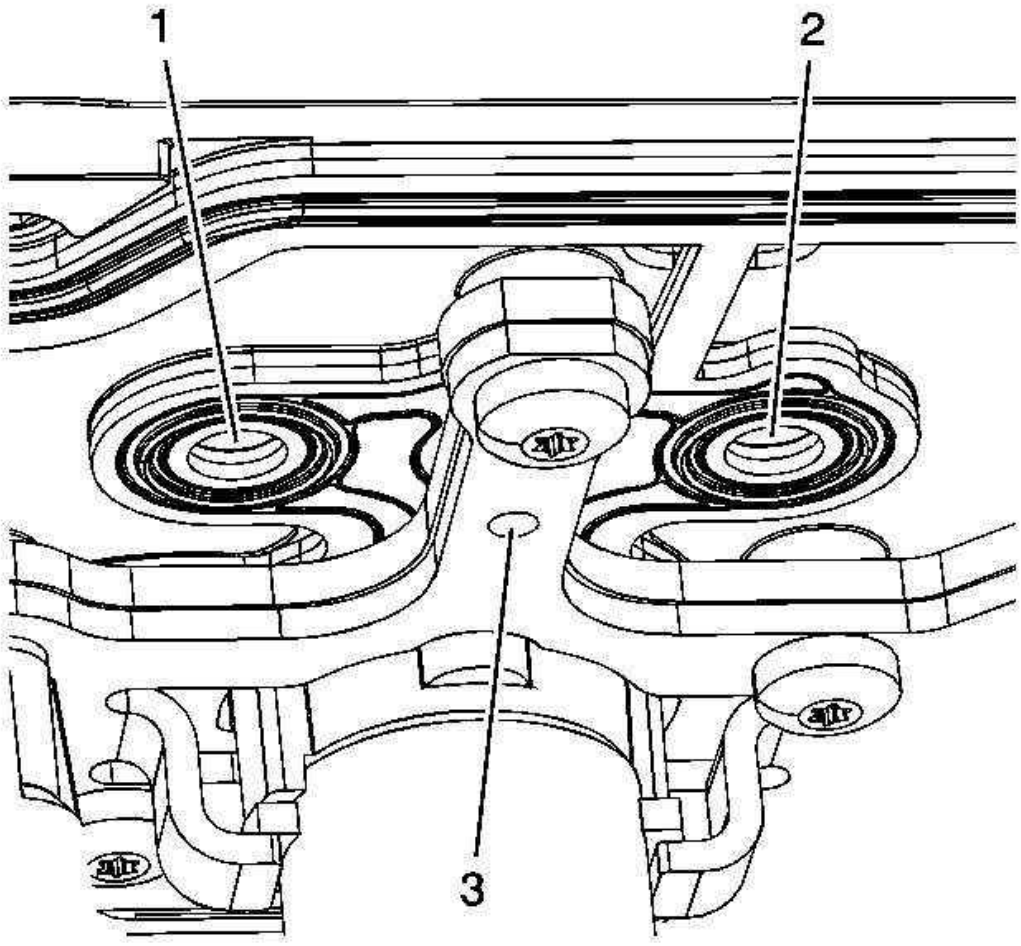


Fig. 22: View Of Bleed Holes & Outlet Ports
Courtesy of GENERAL MOTORS CORP.

9. Turn the air supply switch of the **EN-46999** to the ON position. With the air supply connected to the manifold assembly and the solenoid/valves in the closed position, a limited amount of air will exit each of the bleed holes (3) and outlet ports (1, 2) of the manifold.

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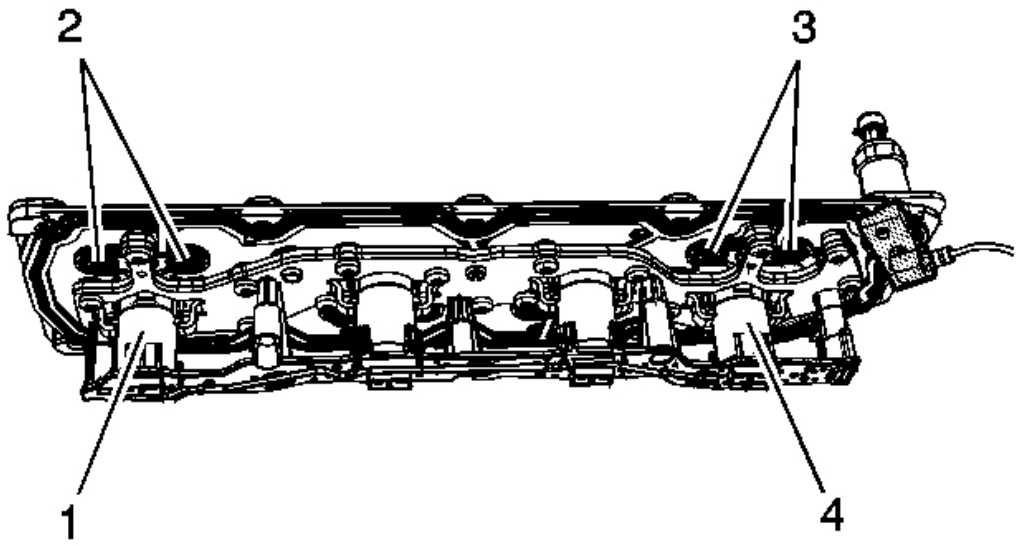


Fig. 23: View Of Solenoid/Valves 1 & 4
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The manifold must be tested in the proper position to ensure the solenoid/valves operate as designed.

10. Position the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 1 and 4.
11. Depress button number 1 on the tool to activate solenoid/valve 1. With button 1 depressed, the solenoid/valve (1) should open, allowing an increased amount of air to exit the outlet ports (2) of the manifold.
12. Depress button number 4 on the tool to activate solenoid/valve 4. With button 4 depressed, the solenoid/valve (4) should open, allowing an increased amount of air to exit the outlet ports (3) of the manifold.

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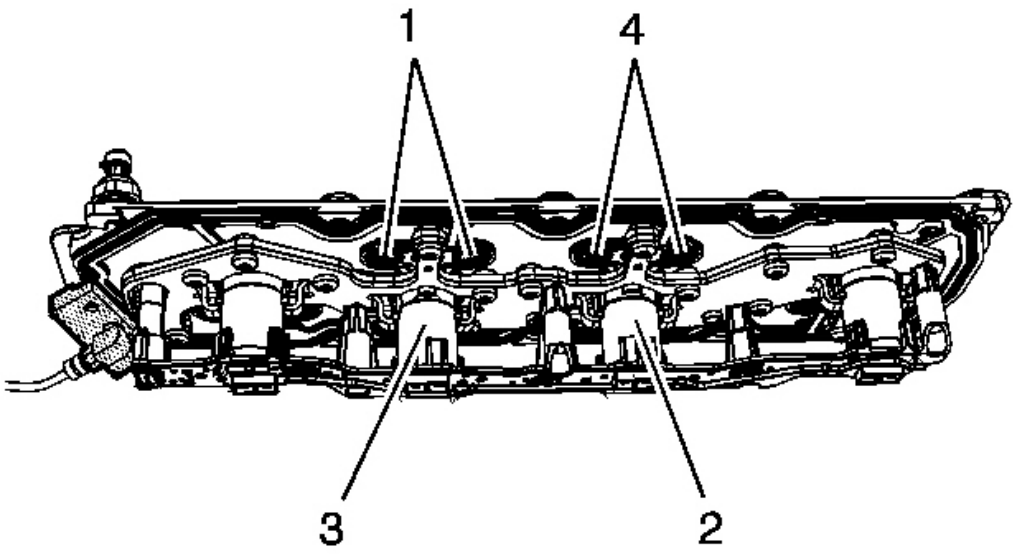


Fig. 24: View Of Solenoid/Valves 2 & 3
Courtesy of GENERAL MOTORS CORP.

13. Reposition the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 2 and 3.
14. Depress button number 2 on the tool to activate solenoid/valve 2. With button 2 depressed, the solenoid/valve (2) should open, allowing an increased amount of air to exit the outlet ports (4) of the manifold.
15. Depress button number 3 on the tool to activate solenoid/valve 3. With button 3 depressed, the solenoid/valve (3) should open, allowing an increased amount of air to exit the outlet ports (1) of the manifold.
16. When the test is completed, turn the air source switch on the **EN-46999** to the off position and disconnect the tool from the 12-volt power supply, shop air source and manifold assembly.
17. If after testing, it has been determined that 1 or more of the solenoid/valves is not functioning properly, replace the manifold as an assembly.
18. If after testing, it has been determined that the solenoid/valves are functioning properly, replace the valve lifters, as required. Both intake and exhaust lifters

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should be replaced in pairs.

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. Inspect 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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
	1. Completely clean the entire engine and surrounding components.		

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4	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. Inspect 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		

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	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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use the **J 28428-E** high-intensity black light kit in order to identify the type of fluid, and the approximate location of the leak. 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. Inspect for leaks at the following locations: • Sealing surfaces		

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	• 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

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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

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted positive crankcase ventilation (PCV) orifice • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV orifice or hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted PCV orifice • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV orifice or hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted PCV valve • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV valve or hose
High idle speed	Inspect for a leaking (damaged) PCV orifice or hose
Sludge in the engine	Inspect for any of the following conditions: • Restricted PCV orifice • Restricted or kinked PCV hose or engine vent

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	hose

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

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

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

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

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

6: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive

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component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

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

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

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

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

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a			

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pulley

- Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp.

DEFINITION: The following items are indications of drive belt squeal:

- A loud screeching noise that is caused by a slipping drive belt-This is unusual for a drive belt with multiple ribs.
- The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.

DEFINITION: The following items are indications of drive belt whine:

- A high pitched continuous noise
- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to **Diagnostic Aids**
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s).	Go to	

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	Does the chirping, squeal or whine noise still exist?	**Symptoms - Engine Mechanical**	Go to **Step 4**
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**

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12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 19**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still exist, proceed to **Diagnostic Aids**.	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to **Diagnostic Aids**
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**. Did you complete the repair?	Go to **Step 20**	Go to **Diagnostic Aids**
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the

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A/C system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

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

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

Test Description

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

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

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

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

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

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

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

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with a known good water pump.

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

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: ○ 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 DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to **Diagnostic Aids**
	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time		

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

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10	1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to or **Water Pump Replacement (LS4)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to **Diagnostic Aids**
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will

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probably cause the drive belt to make a noise or to fall off.

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

Test Description

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

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

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

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

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

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

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

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

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all of the pulleys.

15: This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	1. If diagnosing excessive wear, proceed to step 13. 2. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners.		

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	Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to **Diagnostic Aids**
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**
13	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement - Accessory**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to **Diagnostic Aids**

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16	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Inspection Procedure

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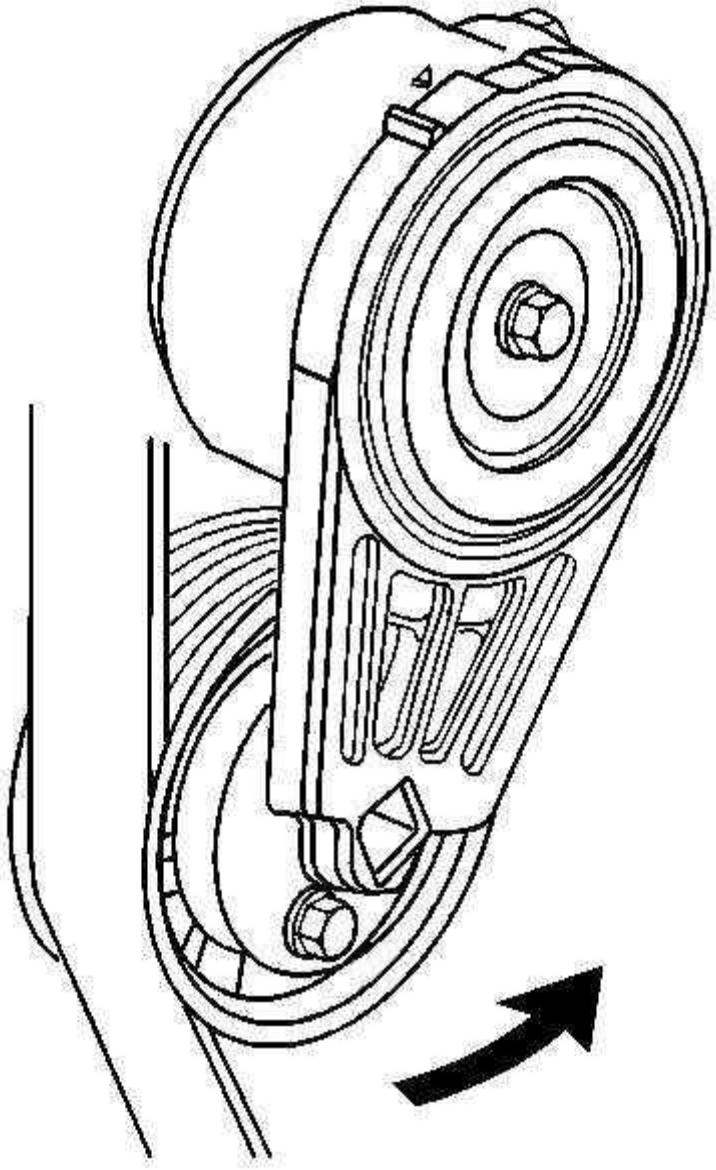


Fig. 25: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

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

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

1. Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Move the drive belt tensioner through its full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
3. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Replacement - Accessory**.
4. Install the drive belt. Refer to of **Drive Belt Replacement - Accessory**.

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT - ACCESSORY

Tools Required

EN-47988 Serpentine Belt Tension Unloader. See **Special Tools**.

Removal Procedure

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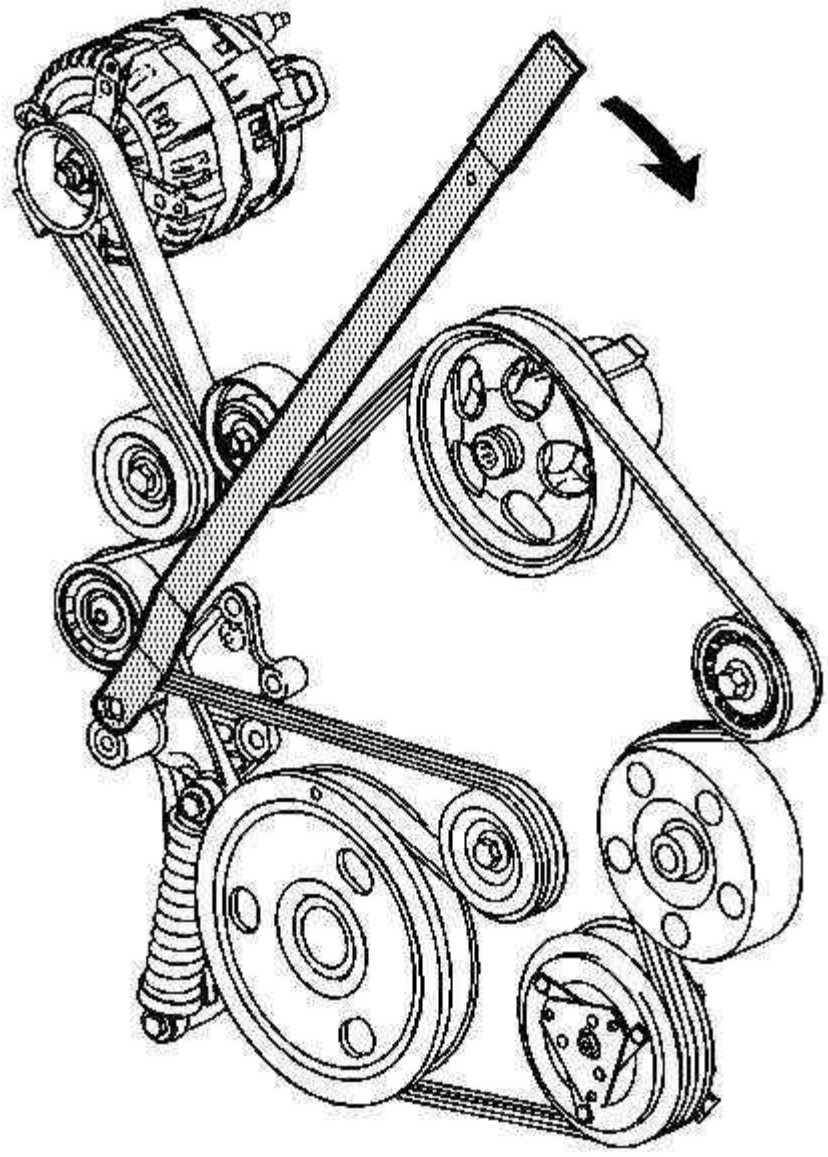
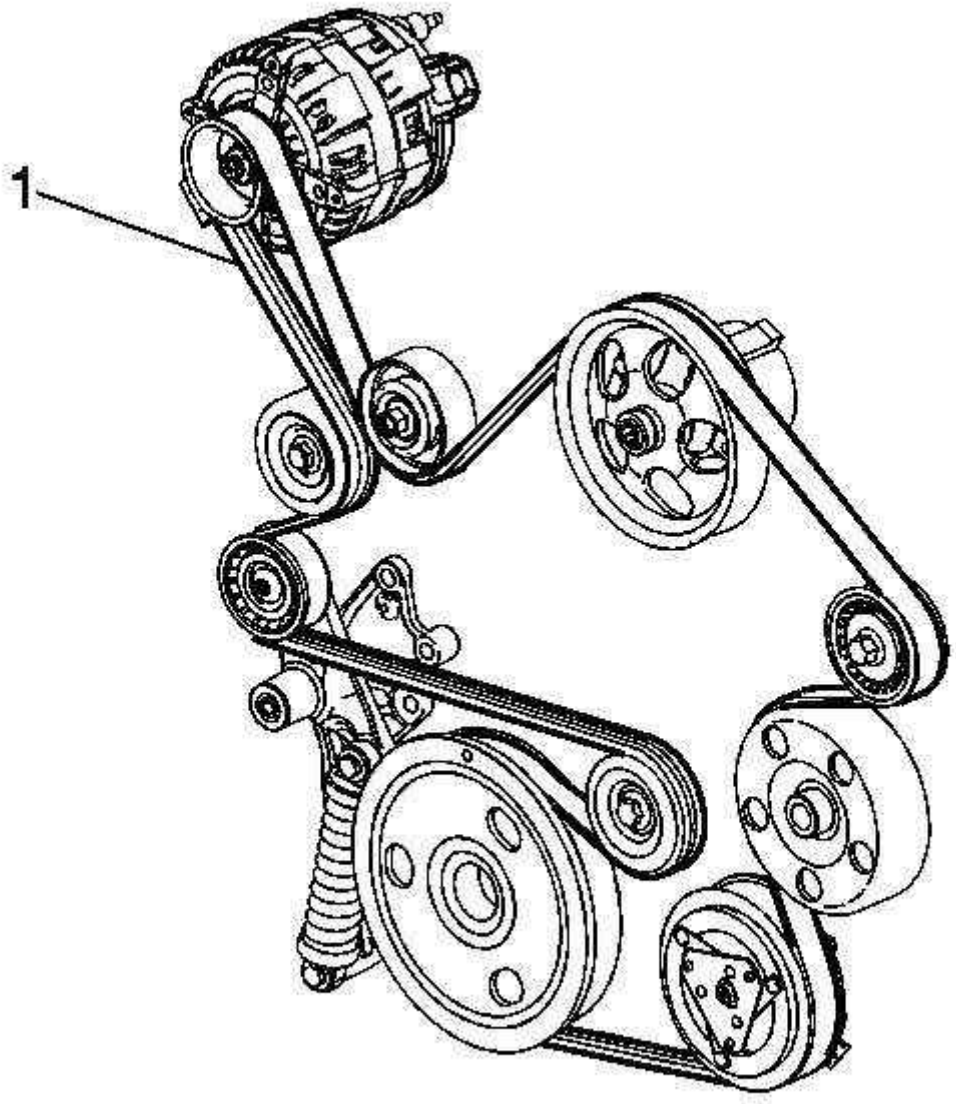


Fig. 26: Rotating Drive Belt Tensioner Clockwise
Courtesy of GENERAL MOTORS CORP.

1. Remove the passenger side diagonal brace, if more clearance is required. Refer to **Front Fender Upper Diagonal Brace Replacement** .

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2. Reposition the underhood bussed electrical center (UBEC), if more clearance is required.
3. Install the **EN-47988** , to the drive belt tensioner. See **Special Tools**.
4. Rotate the **EN-47988** clockwise in order to relieve the tension on the belt tensioner. See **Special Tools**.



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Fig. 27: View Of Drive Belt, Drive Belt Tensioner & Pulleys
Courtesy of GENERAL MOTORS CORP.

5. Remove the drive belt (1) from over the power steering pump pulley.
6. Slowly release the **EN-47988** . See **Special Tools**.
7. Remove the **EN-47988** from the belt tensioner. See **Special Tools**.
8. Remove the drive belt (1) from around all the other pulleys.
9. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

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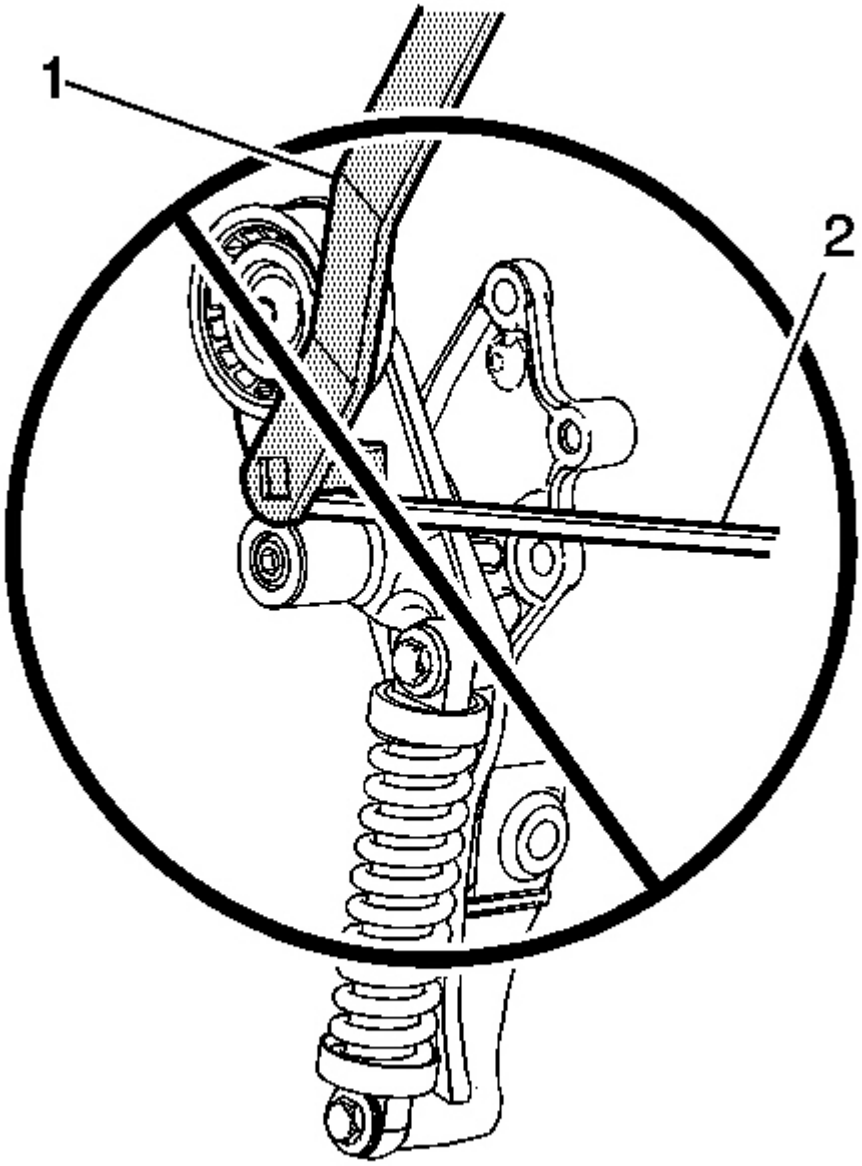


Fig. 28: Identifying Improper Use Of EN-47988 To Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install and route the drive belt around all the pulleys except for the power steering pump pulley.

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2. Ensure that when installing the **EN-47988** (1), to the belt tensioner that the **EN-47988** is NOT installed above the drive belt (2). See **Special Tools**.

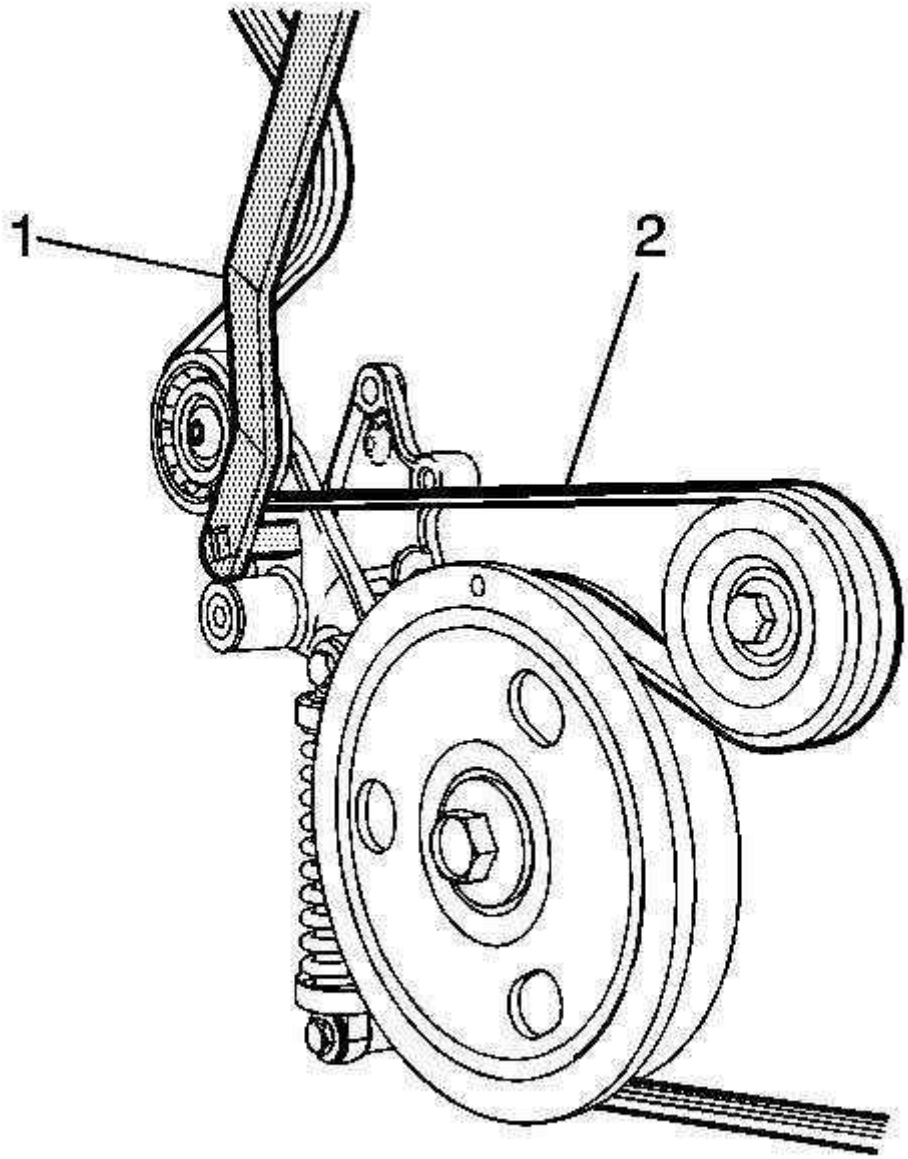


Fig. 29: Identifying Proper Use Of EN-47988 To Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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3. Ensure that when installing the **EN-47988** (1), to the belt tensioner that the **EN-47988** is installed below the drive belt (2). See **Special Tools**.
4. Rotate the **EN-47988** clockwise in order to relieve the tension on the belt tensioner. See **Special Tools**.
5. Ensure that the drive belt is still properly routed around all the other pulleys, then install the drive belt over the power steering pump pulley.
6. Slowly release the **EN-47988** . See **Special Tools**.
7. Remove the **EN-47988** from the belt tensioner. See **Special Tools**.
8. Inspect the drive belt for proper installation and alignment.
9. Position the UBEC, if required.
10. Install the passenger side diagonal brace, if required. Refer to **Front Fender Upper Diagonal Brace Replacement** .

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

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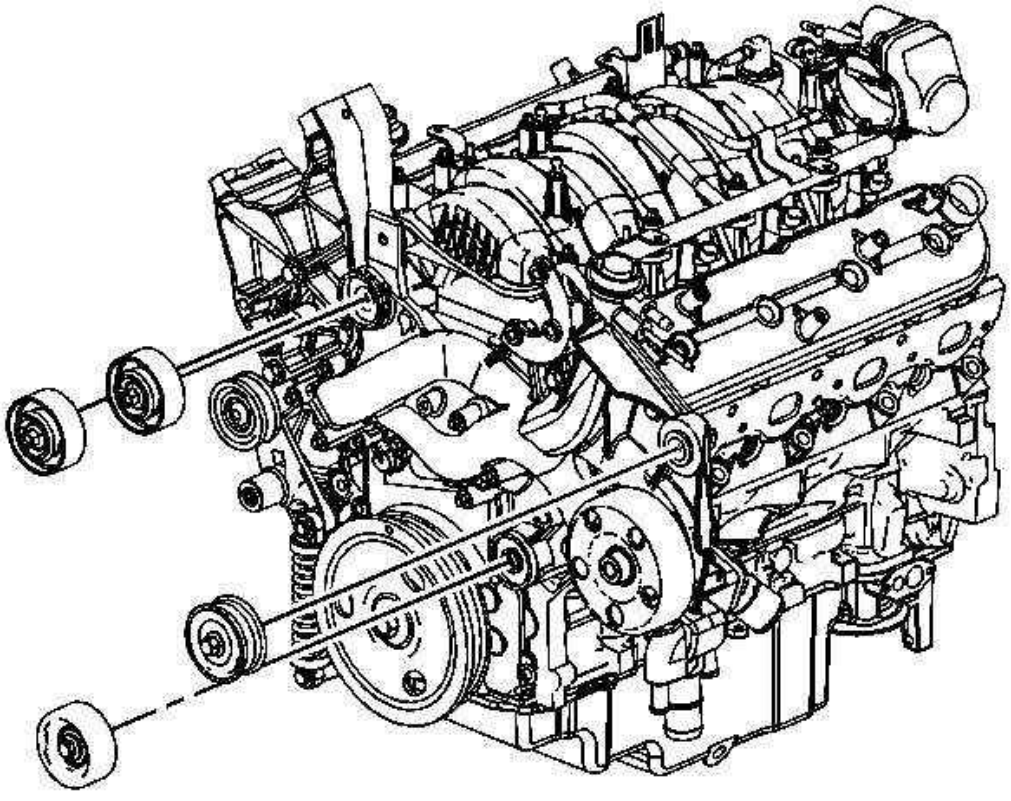


Fig. 30: Identifying Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Loosen the necessary drive belt idler pulley bolt.
3. Remove the necessary drive belt idler pulley.

Installation Procedure

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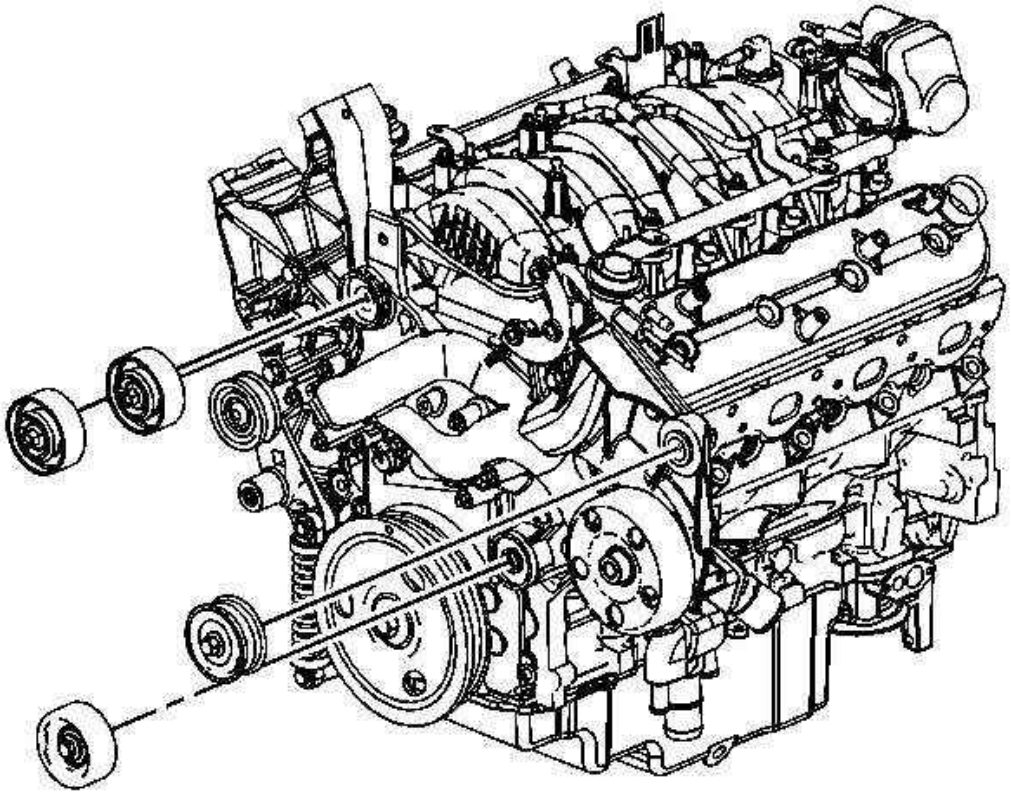


Fig. 31: Identifying Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Position the necessary drive belt idler pulley to the coolant manifold and/or generator bracket.

NOTE: Refer to Fastener Notice .

2. Tighten the necessary drive belt idler pulley bolt.

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

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

DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY

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Removal Procedure

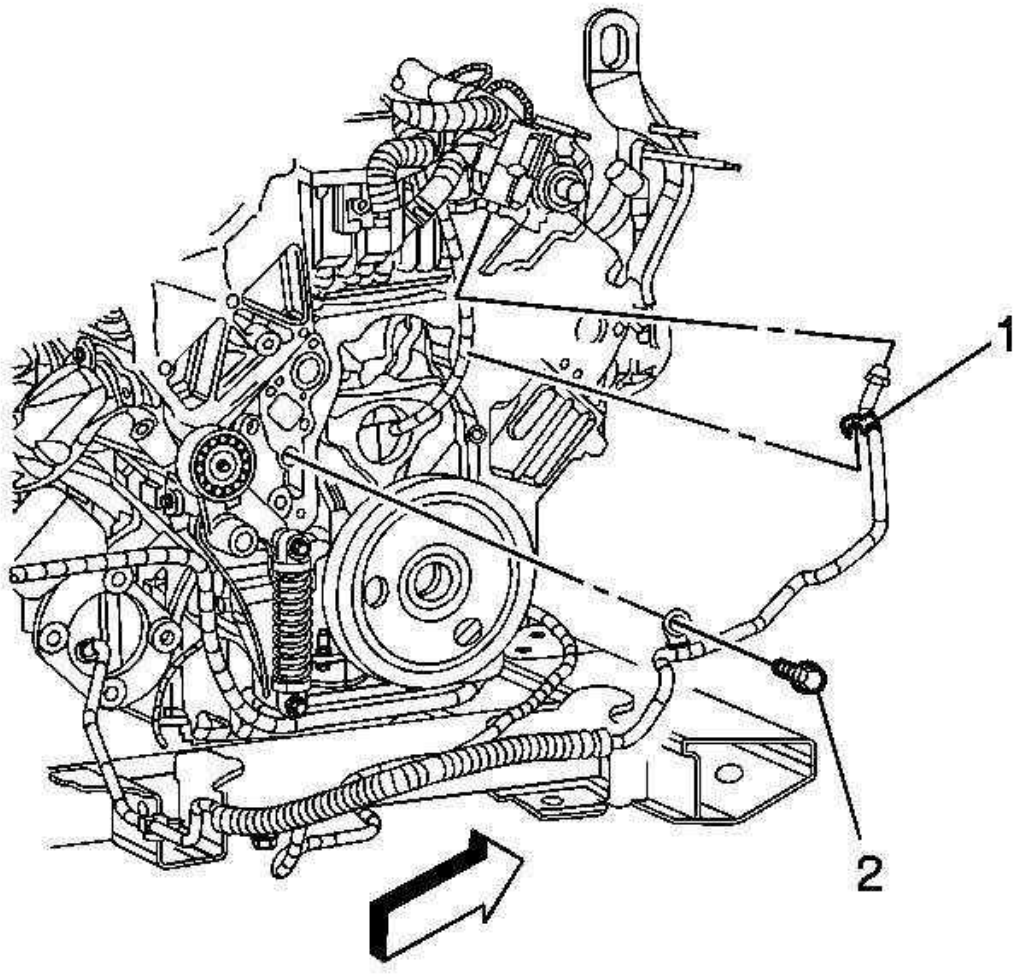


Fig. 32: Locating Power Steering Gear Inlet Hose Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the right wheel and tire. Refer to **Tire and Wheel Removal and Installation** .

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4. Remove the right engine splash shield.
5. Remove the power steering gear inlet hose retainer bolt (2).

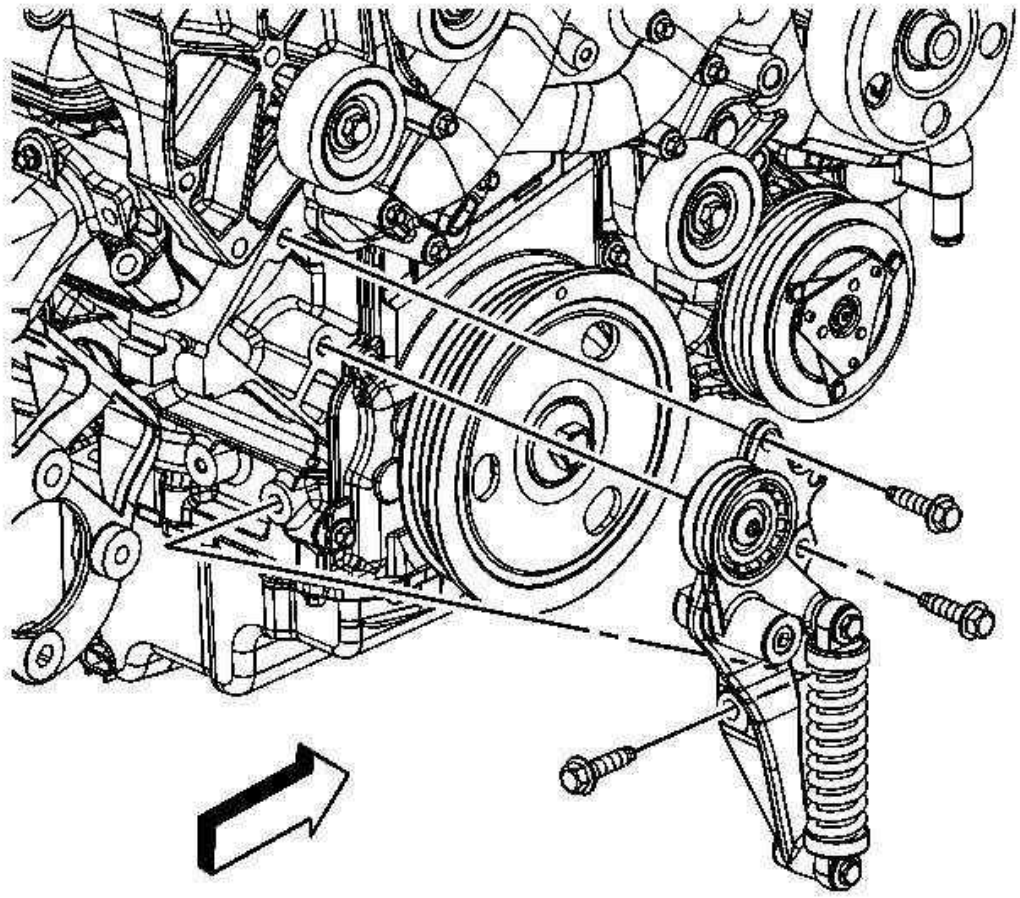


Fig. 33: Identifying Drive Belt Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the drive belt tensioner bolts.
7. Remove the drive belt tensioner.

Installation Procedure

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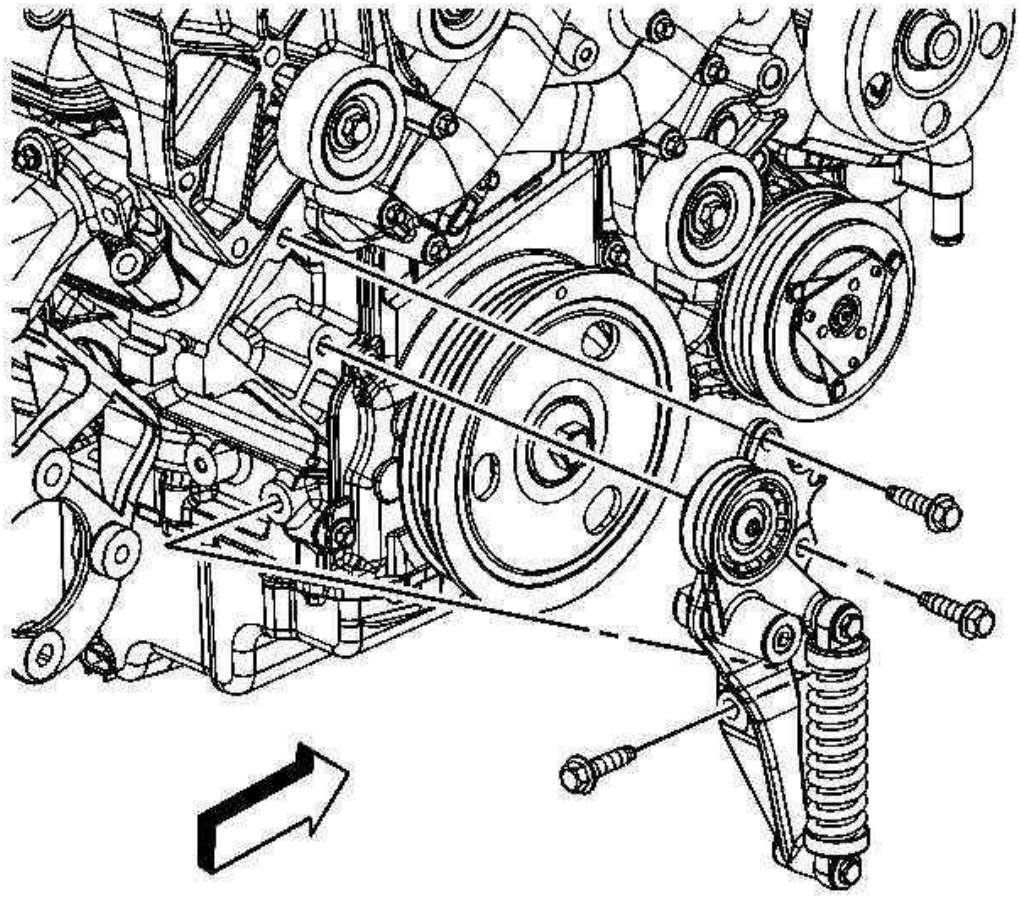


Fig. 34: Identifying Drive Belt Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.

   NOTE: Refer to Fastener Notice .

2. Install the drive belt tensioner bolts.

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

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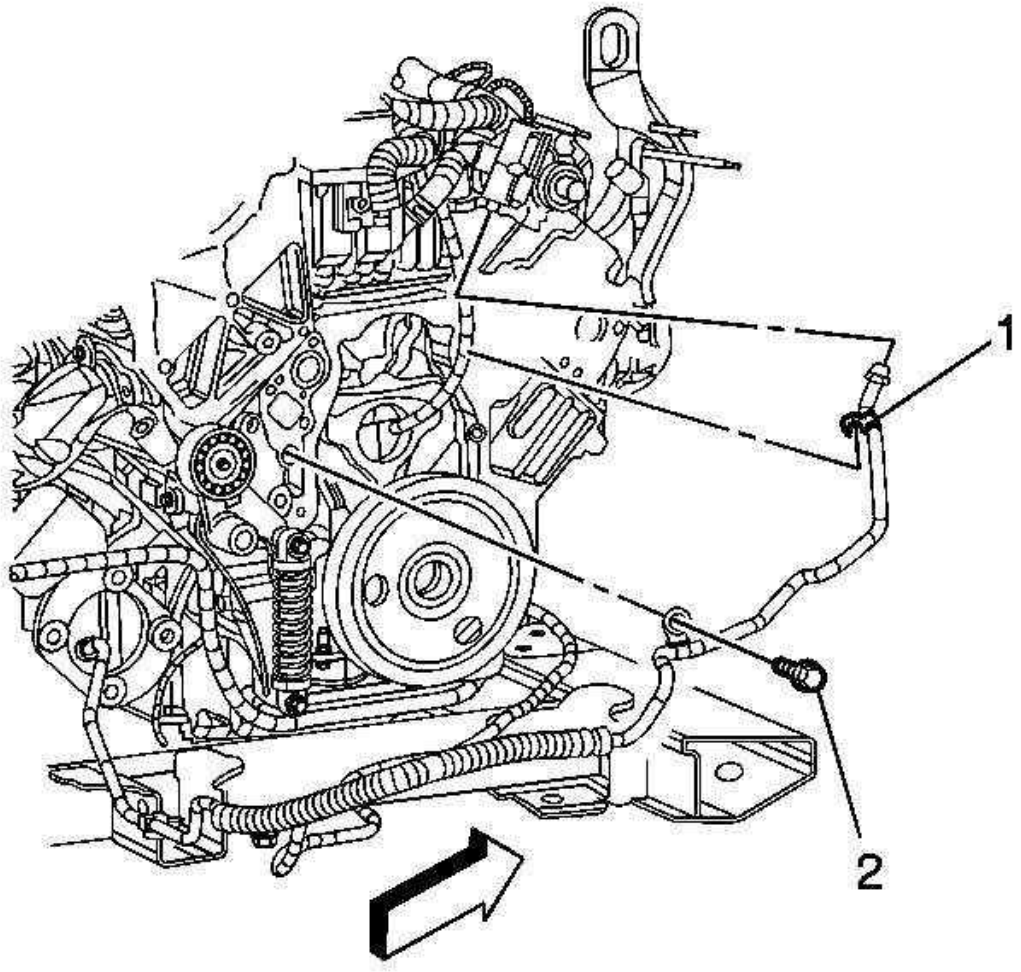


Fig. 35: Locating Power Steering Gear Inlet Hose Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the power steering gear inlet hose retainer bolt (2).

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

4. Install the right engine splash shield.
5. Install the right wheel and tire. Refer to **Tire and Wheel Removal and Installation** .

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6. Lower the vehicle.
7. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.

ENGINE SUPPORT FIXTURE

Tools Required

- **J 28467-B** Universal Engine Support Fixture
- **J 28467-501** Engine Support Fixture Adapters
- **J 42451-1** Engine Support Adapter. See **Special Tools**.

Installation Procedure

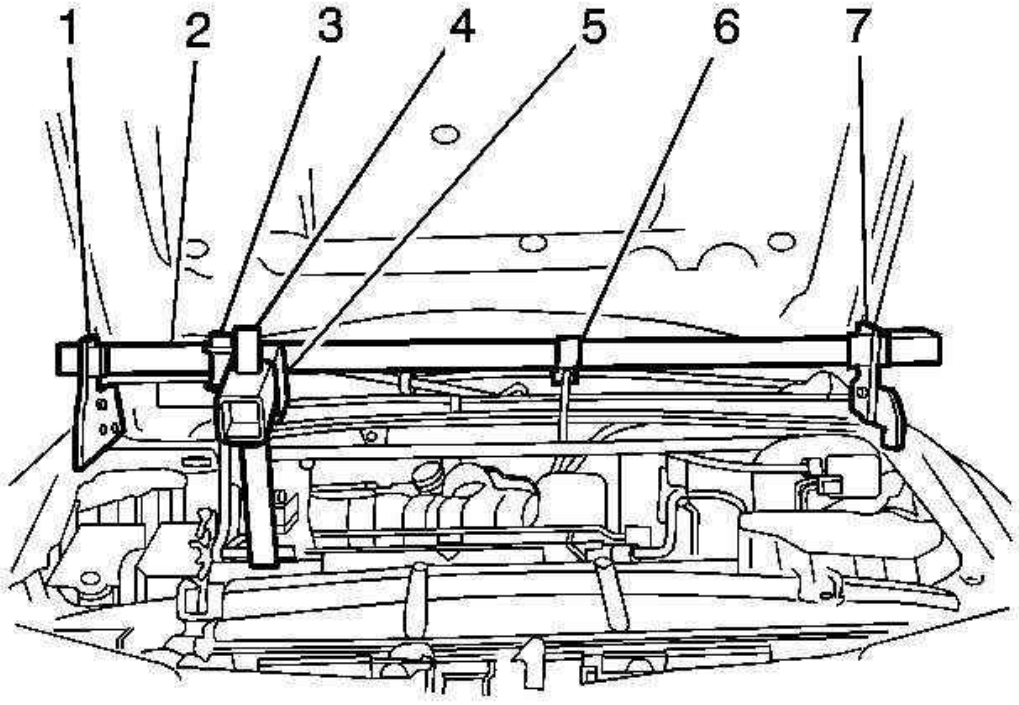


Fig. 36: Identifying Engine Support Adapter
Courtesy of GENERAL MOTORS CORP.

1. Remove the left bank ignition coils.

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2. Install **J 42451-1** bracket onto the left front of engine. See **Special Tools**.
3. Install the **J 28467-501** (1, 7) onto fender rails near the strut towers.
4. Install the J 28467-3 cross car tube (2) to the **J 28467-501** (1, 7).
5. Install the J 28467-2A radiator shelf tube on top of the J 28467-3 cross car tube (2).
6. Install the round tube of the J 28467-4A front support assembly (4) through the large hole in the J 28467-2A radiator shelf tube. The hole used in the J 28467-2A radiator shelf tube (5) depends on the vehicle application.
7. Place the rubber padded foot of the J 28467-4A front support assembly on the upper tie bar.
8. Install the J 28467-9 7/16-inch x 2.0-inch quick release pin through the hole in the J 28467-4A front support assembly in order to level the J 28467-2A radiator shelf tube.
9. Install the J 28467-7A lift hook through the J 28467-6A lift hook bracket (5).
10. Install the J 28467-6A assembled lift hook bracket (6) over the J 28467-3 strut tower tube (2).

ENGINE MOUNT STRUT REPLACEMENT

Removal Procedure

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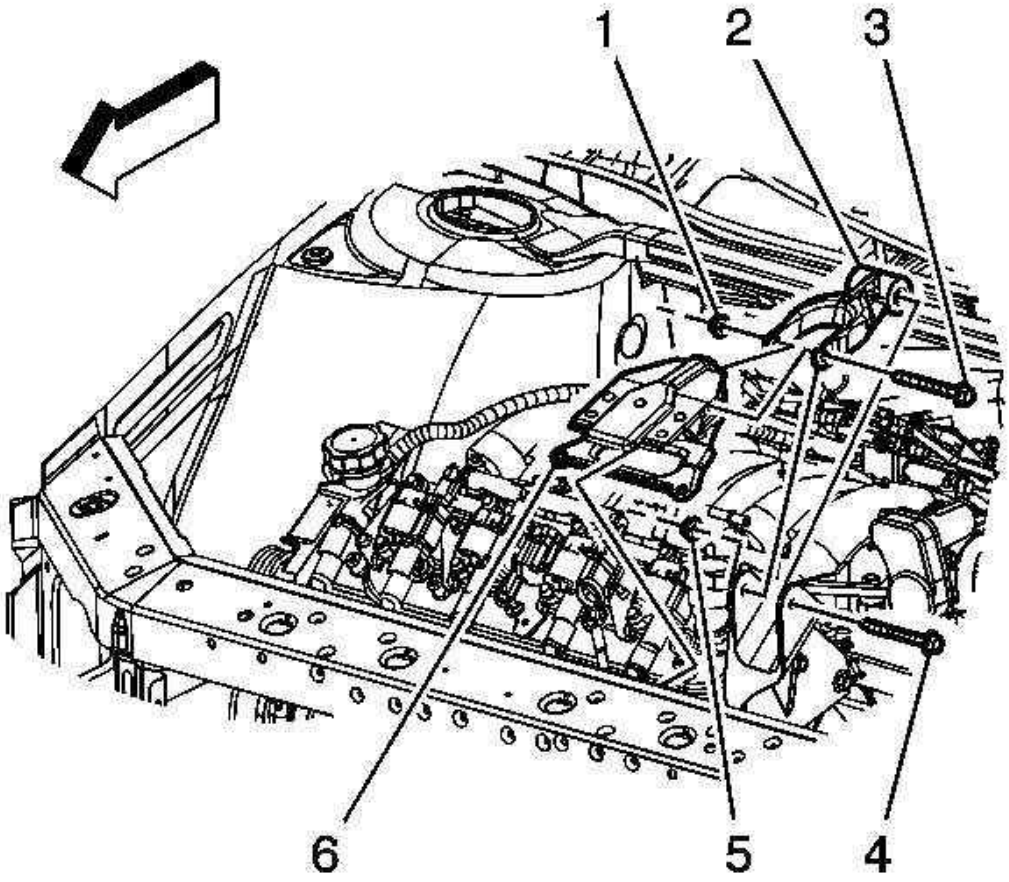


Fig. 37: View Of Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

1. Remove the forward engine mount strut bolt (3) and nut (1).
2. Remove the rear engine mount strut bolt (4) and nut (5).
3. Remove the engine mount strut (2).
4. Inspect the rubber in the engine mount strut for the following conditions:
    - Hardness
    - Splitting
    - Cracking

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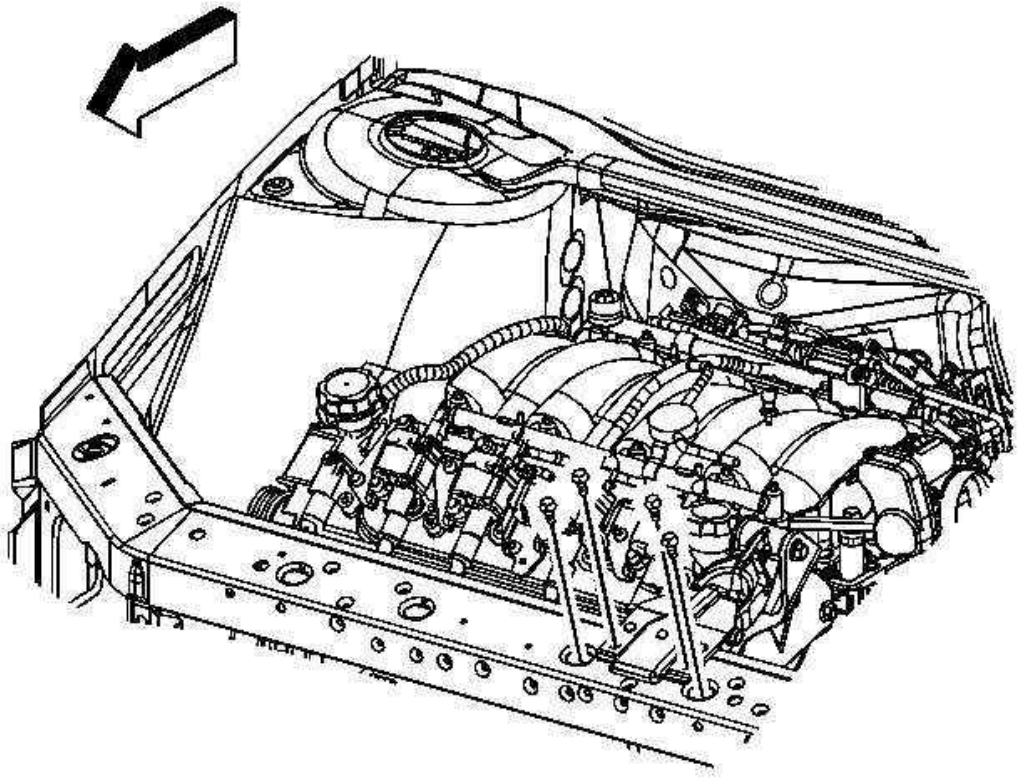


Fig. 38: View Of Engine Mount Strut Bracket (Body Side)
Courtesy of GENERAL MOTORS CORP.

5. If necessary, remove the engine mount strut bracket bolts (body side).
6. If necessary, remove the engine mount strut bracket (body side).

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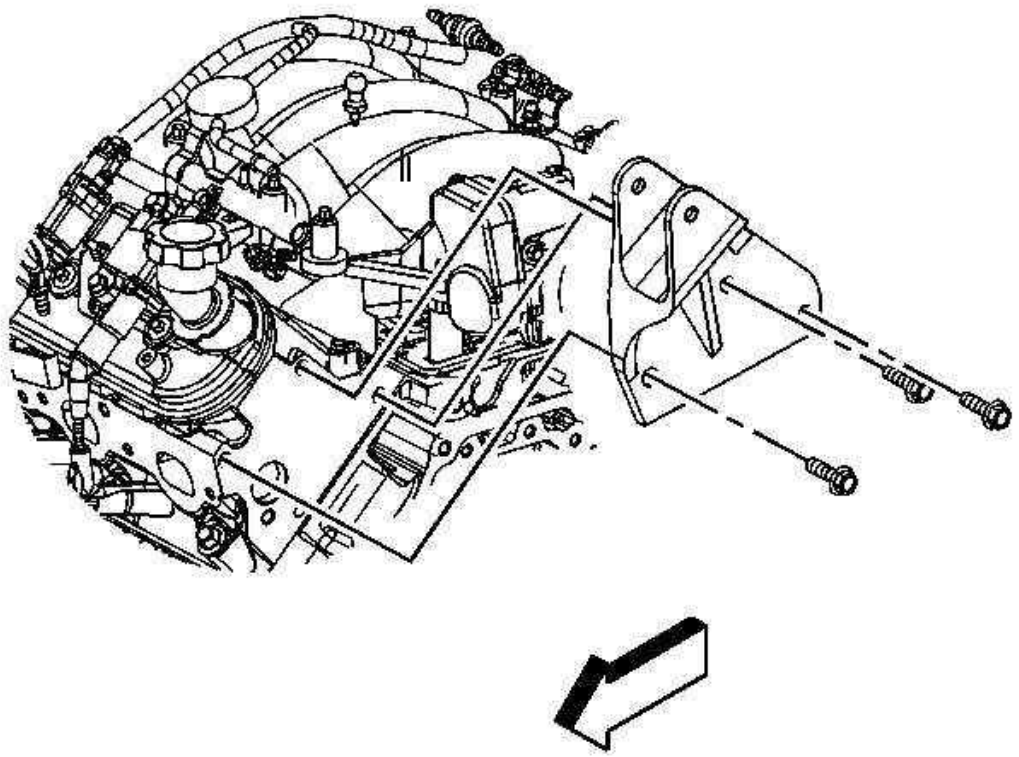


Fig. 39: View Of Engine Mount Strut Bracket (Engine Side)
Courtesy of GENERAL MOTORS CORP.

7. Remove the heater pipe bracket bolt from the engine mount.
8. If necessary, remove the engine mount strut bracket bolts (engine side).
9. If necessary, remove the engine mount strut bracket (engine side).

Installation Procedure

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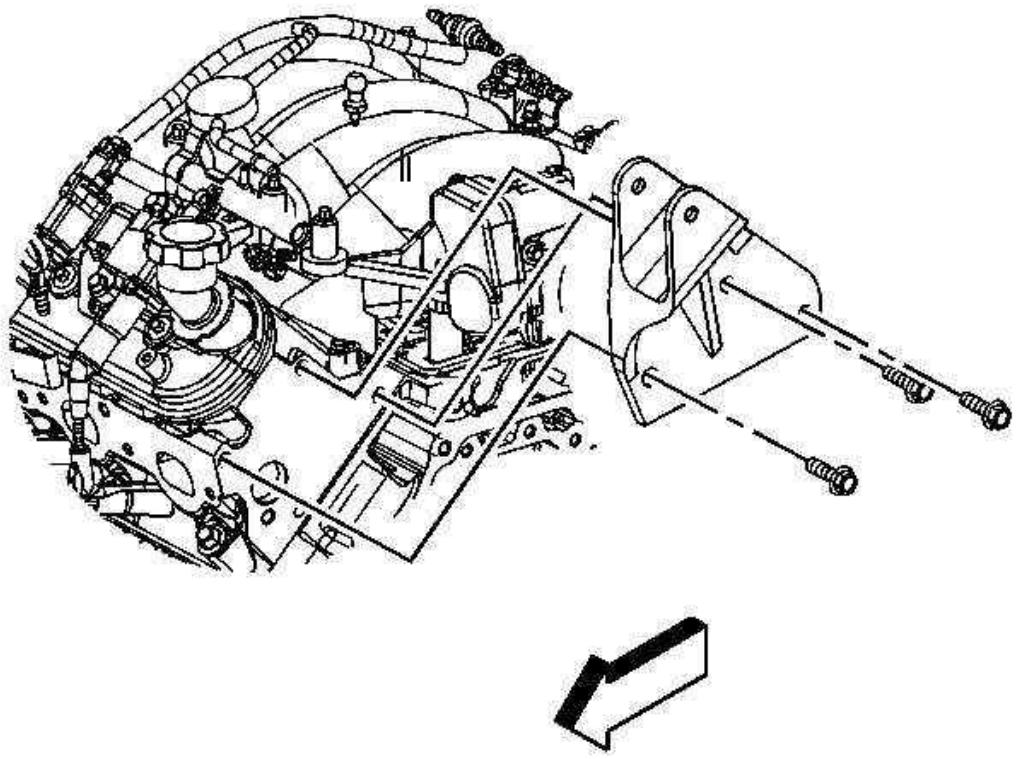


Fig. 40: View Of Engine Mount Strut Bracket (Engine Side)
Courtesy of GENERAL MOTORS CORP.

1. If necessary, position the engine mount strut bracket (engine side) to the cylinder head.

NOTE: Refer to Fastener Notice .

2. If necessary, install the engine mount strut bracket bolts (engine side).

   Tighten: Tighten the bolts to 48 N.m (35 lb ft).

3. Install the heater pipe bracket bolt.

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

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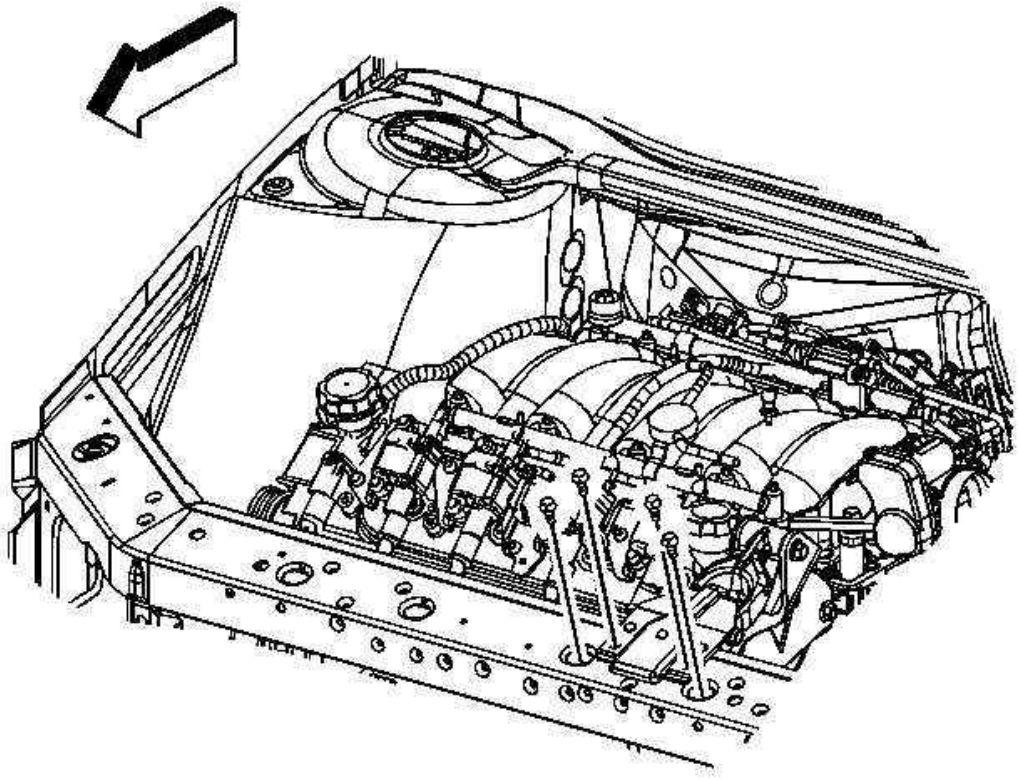


Fig. 41: View Of Engine Mount Strut Bracket (Body Side)
Courtesy of GENERAL MOTORS CORP.

4. If necessary, position the engine mount strut bracket (body side) to the vehicle.
5. If necessary, install the engine mount strut bracket bolts (body side).

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

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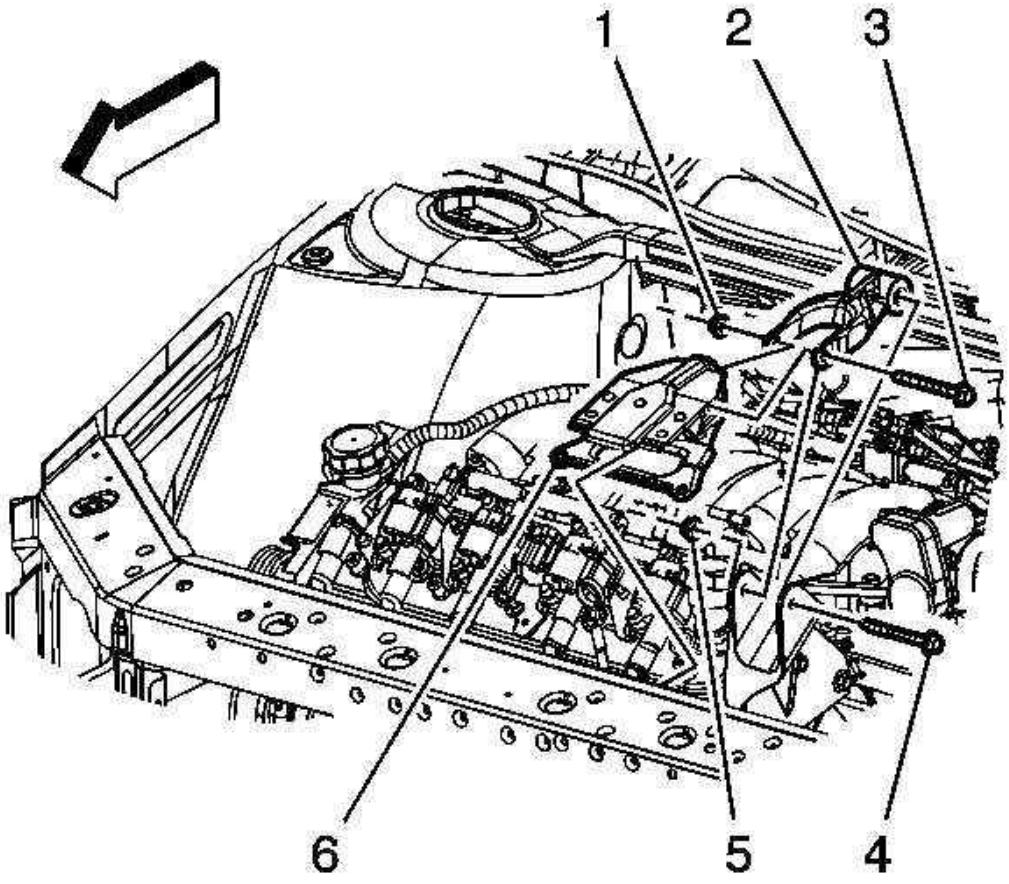


Fig. 42: View Of Engine Mount Strut
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount strut (2).
7. Install the rear engine mount strut bolt (4) and nut (5).

   Tighten: Tighten the bolt/nut to 48 N.m (35 lb ft).

8. Install the forward engine mount strut bolt (3) and nut (1).

   Tighten: Tighten the bolt/nut to 48 N.m (35 lb ft).

ENGINE MOUNT INSPECTION

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Inspection Procedure

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

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Raise the engine in order to remove the weight from the engine mount and to create slight tension in the rubber.
3. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber surface is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
4. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket.
5. For information on the transaxle mount, refer to **Transmission Mount Inspection** .

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

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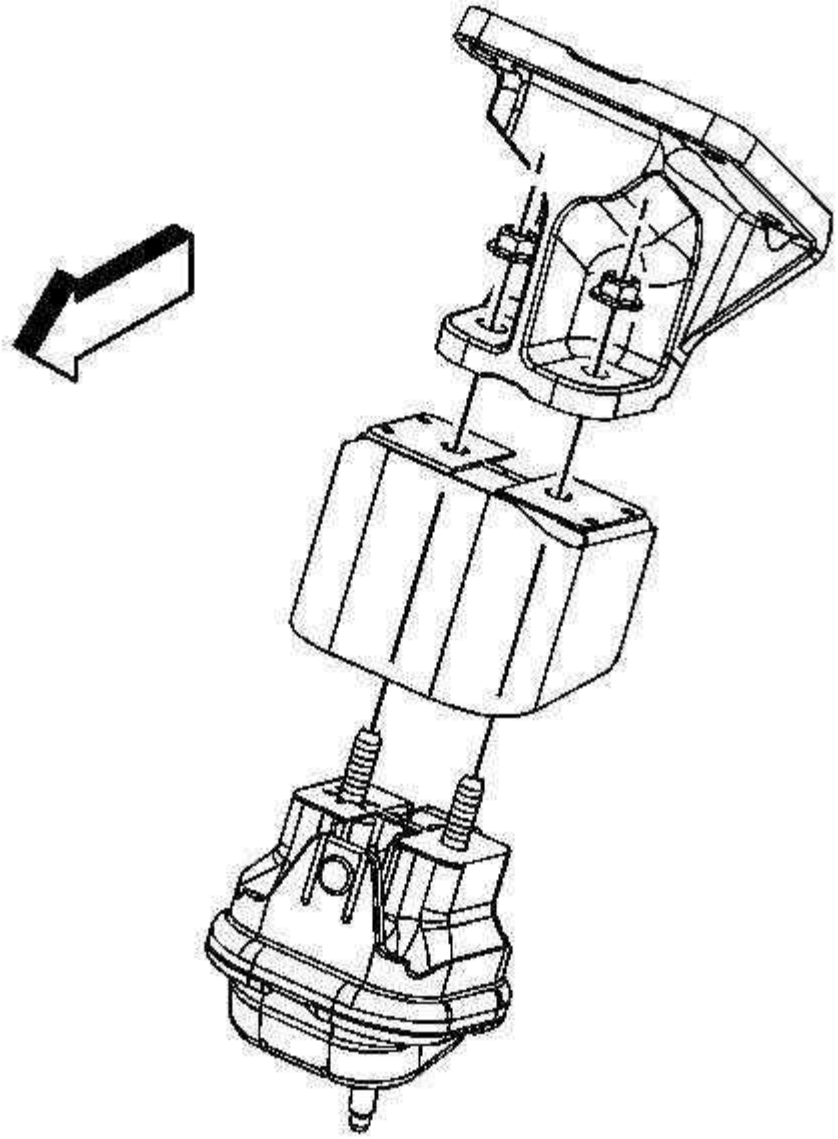


Fig. 43: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
2. Remove the left exhaust manifold. Refer to **Exhaust Manifold Removal -**

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Left Side.

3. Remove the upper engine mount nuts.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Using the engine support fixture, raise the engine.

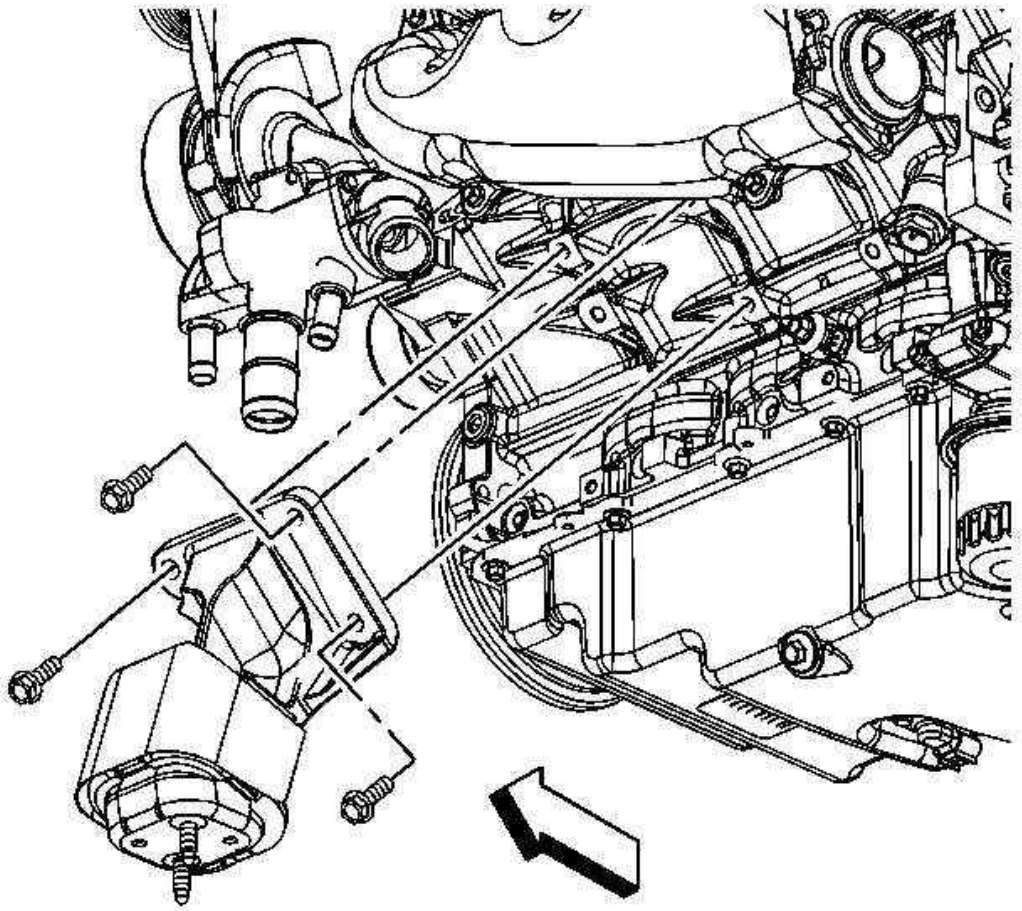


Fig. 44: View Of Lower Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bracket bolts.
7. Remove the engine mount bracket.
8. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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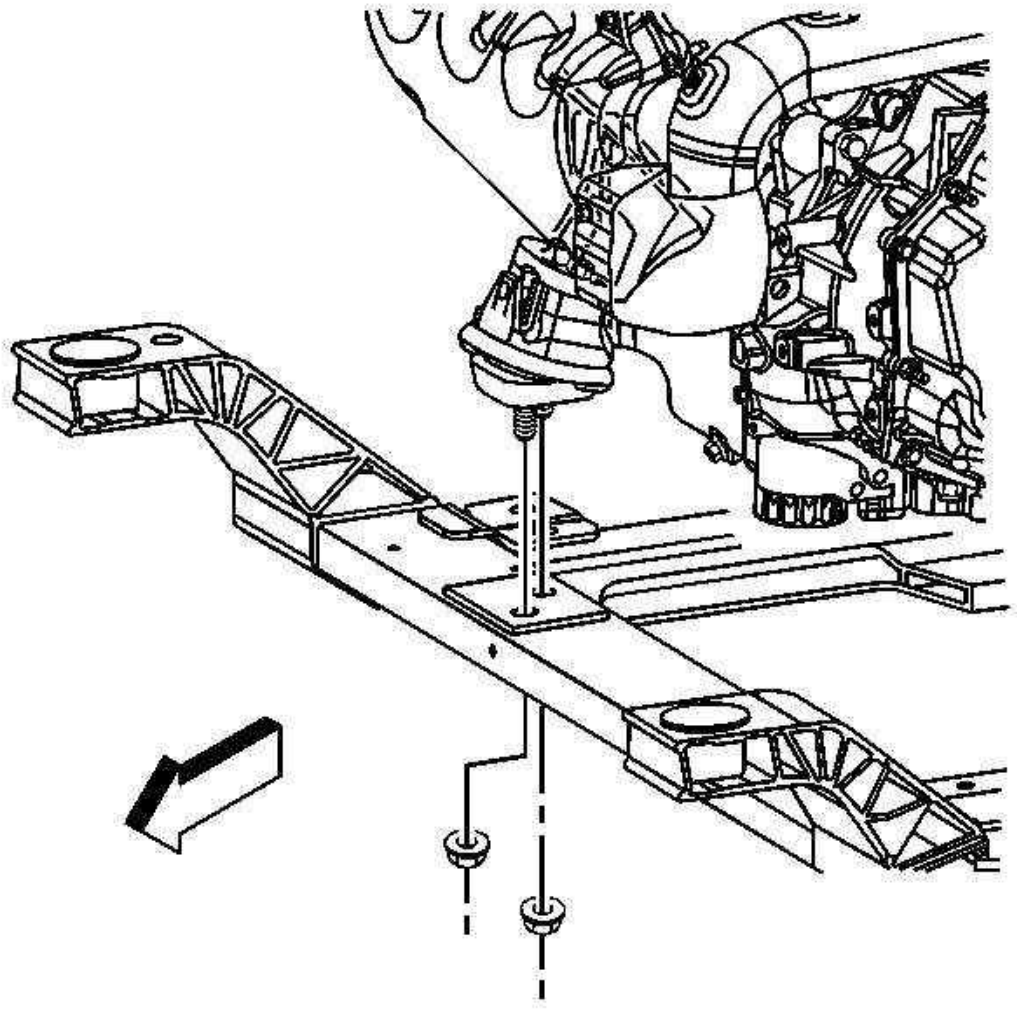


Fig. 45: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Remove the lower engine mount nuts.
10. Remove the engine mount.
11. Remove the engine mount heat shield, if necessary.

Installation Procedure

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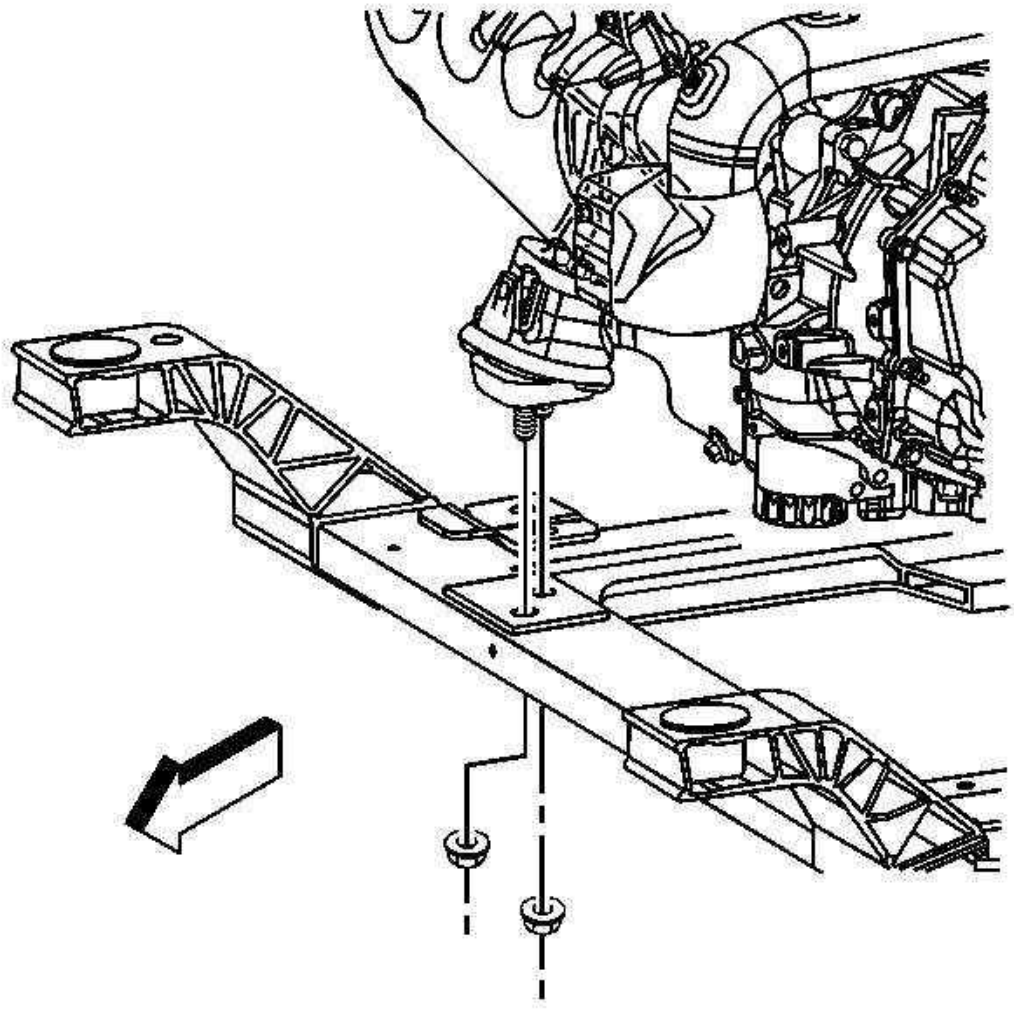


Fig. 46: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount heat shield, if necessary.
2. Install the engine mount to the engine.

NOTE: Refer to Fastener Notice .

3. Install the lower engine mount nuts.

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

4. Lower the vehicle.

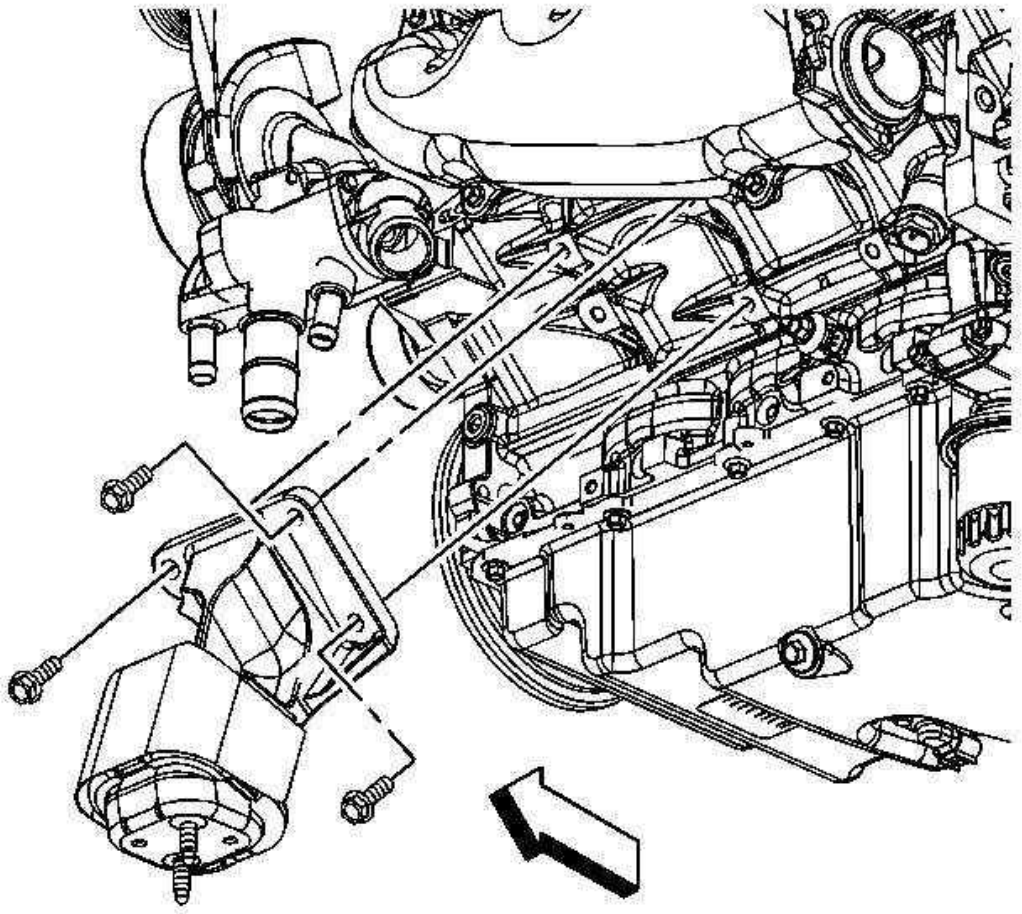


Fig. 47: View Of Lower Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount bracket.
6. Install the engine mount bracket bolts.

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

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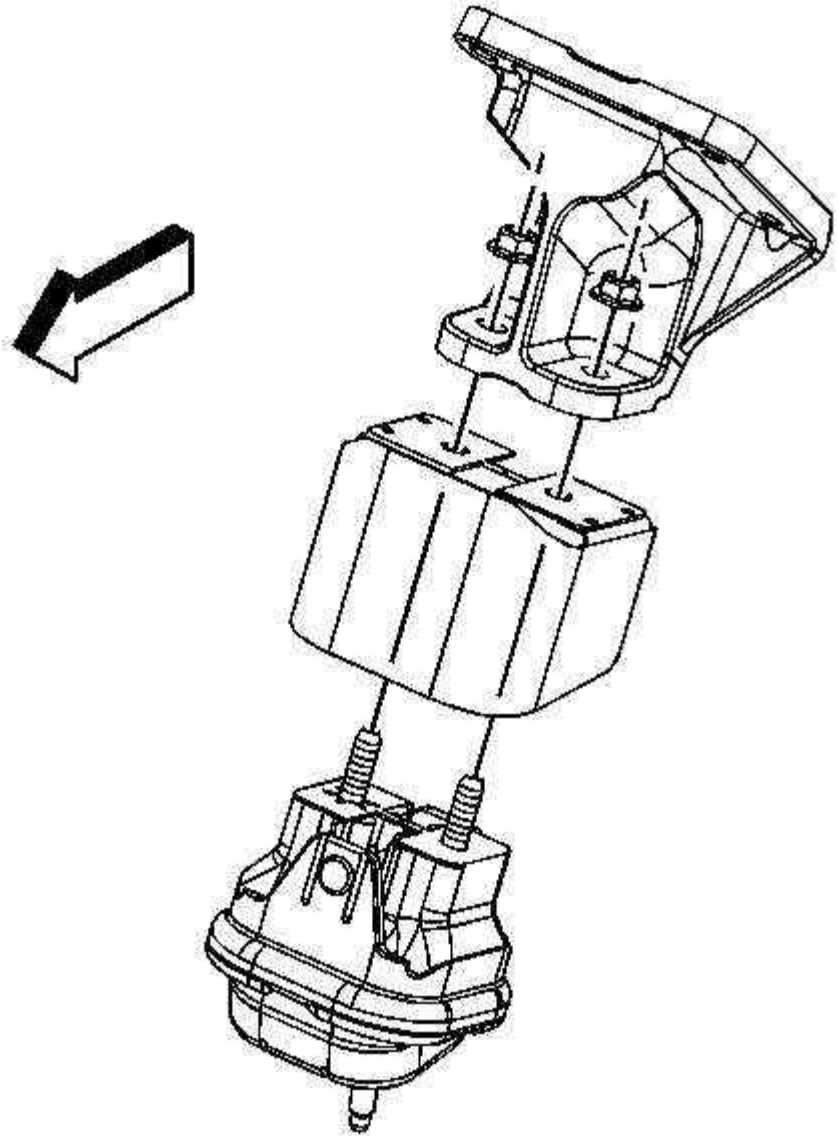


Fig. 48: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

7. Using the engine support fixture, lower the engine.
8. Remove the engine support fixture.

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9. Install the upper engine mount nuts.

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

10. Install the left exhaust manifold. Refer to **Exhaust Manifold Installation - Left Side**.
11. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE

Removal Procedure

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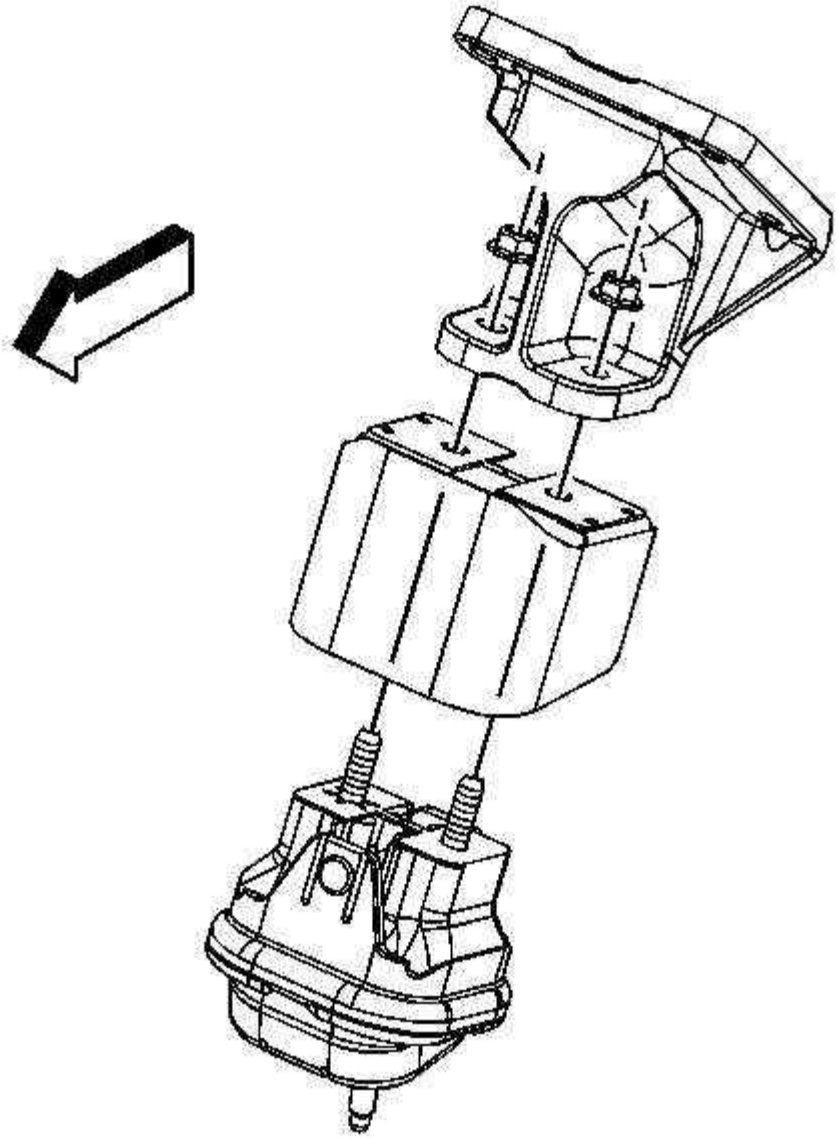


Fig. 49: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
2. Remove the left exhaust manifold. Refer to **Exhaust Manifold Removal -**

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Left Side.

3. Remove the upper engine mount nuts.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Using the engine support fixture, raise the engine.

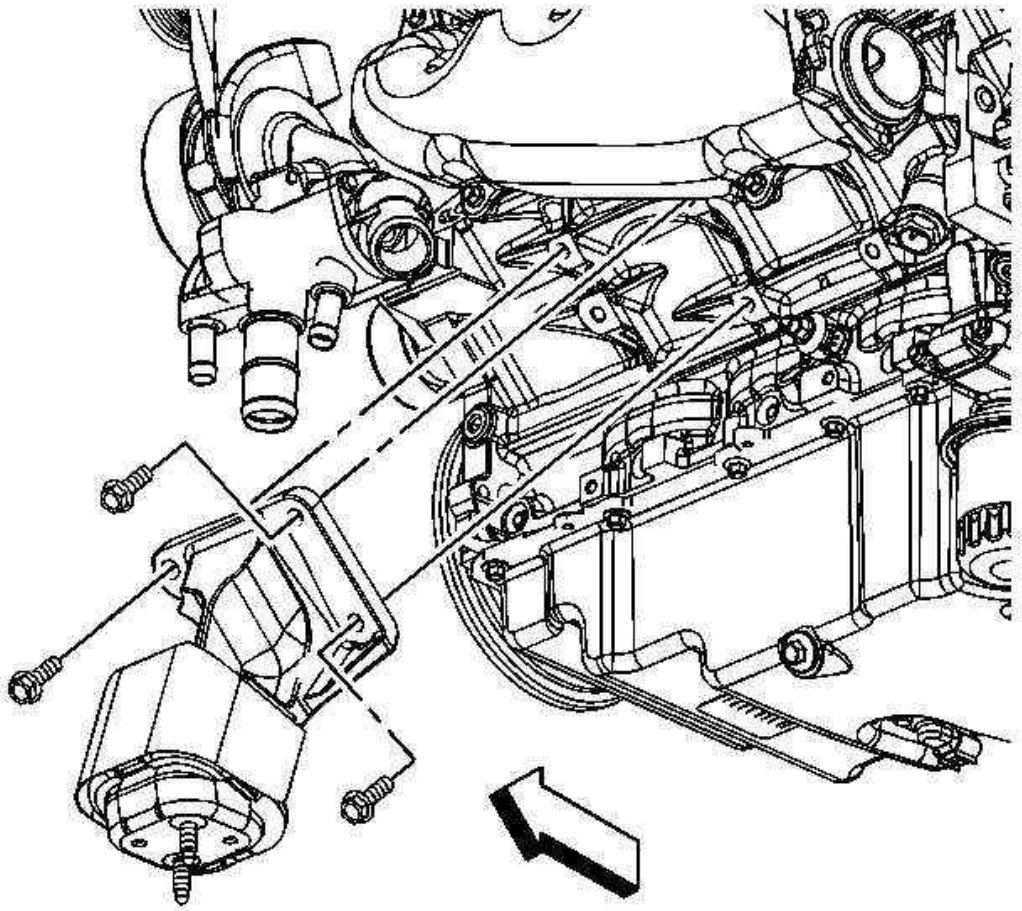


Fig. 50: View Of Lower Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bracket bolts.
7. Remove the engine mount bracket.

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Installation Procedure

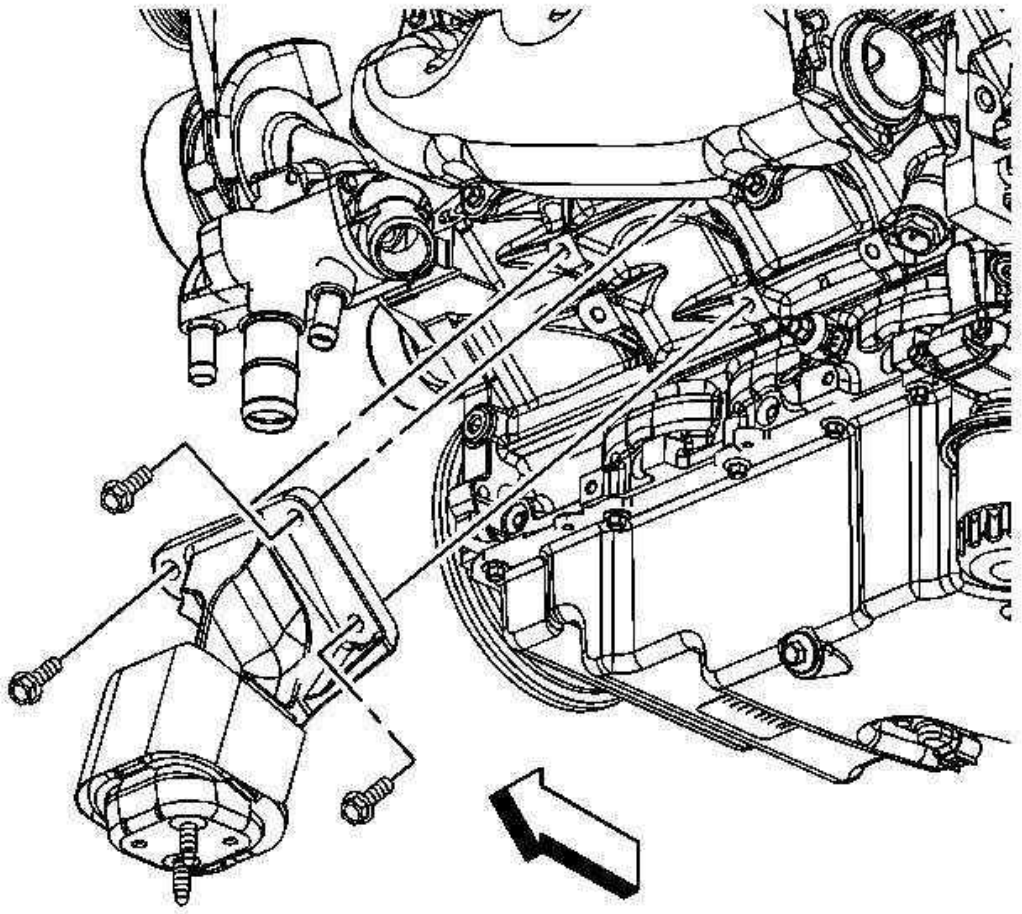


Fig. 51: View Of Lower Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.

   NOTE: Refer to Fastener Notice .

2. Install the engine mount bracket bolts.

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

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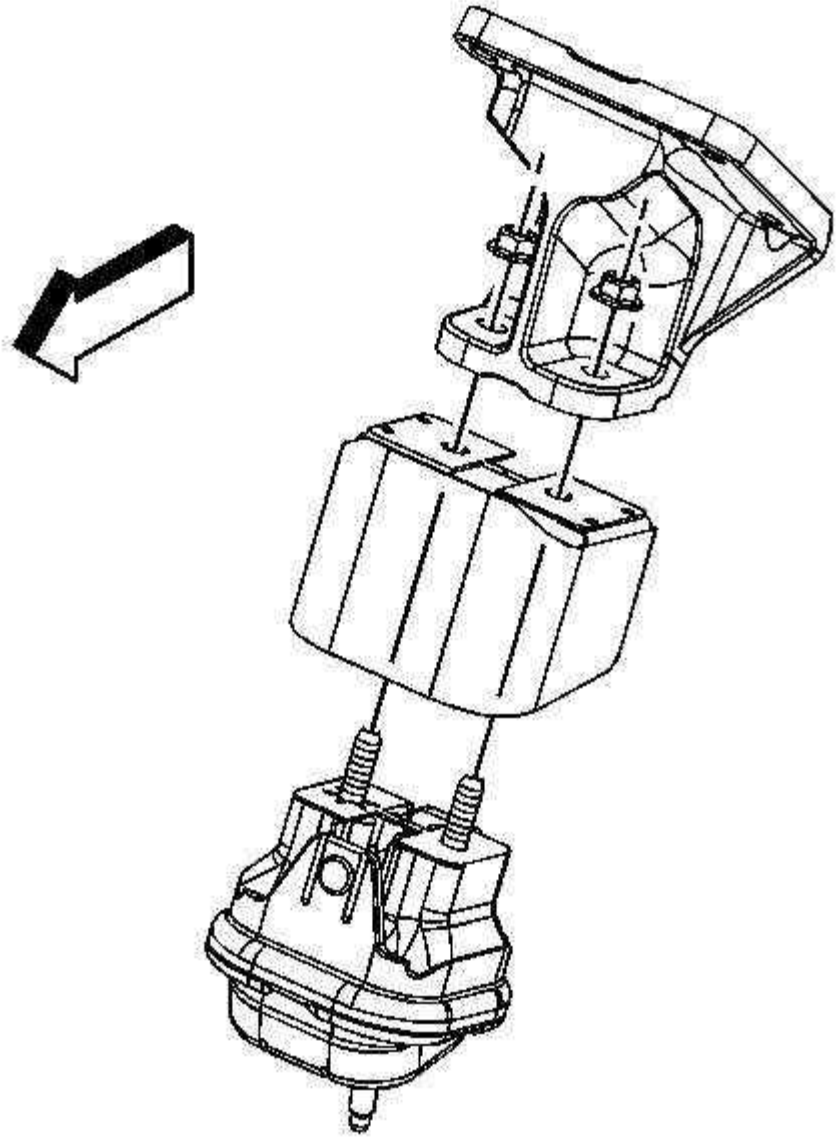


Fig. 52: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Using the engine support fixture, lower the engine.
4. Remove the engine support fixture.

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5. Install the upper engine mount nuts.

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

6. Install the left exhaust manifold. Refer to **Exhaust Manifold Installation - Left Side**.
7. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

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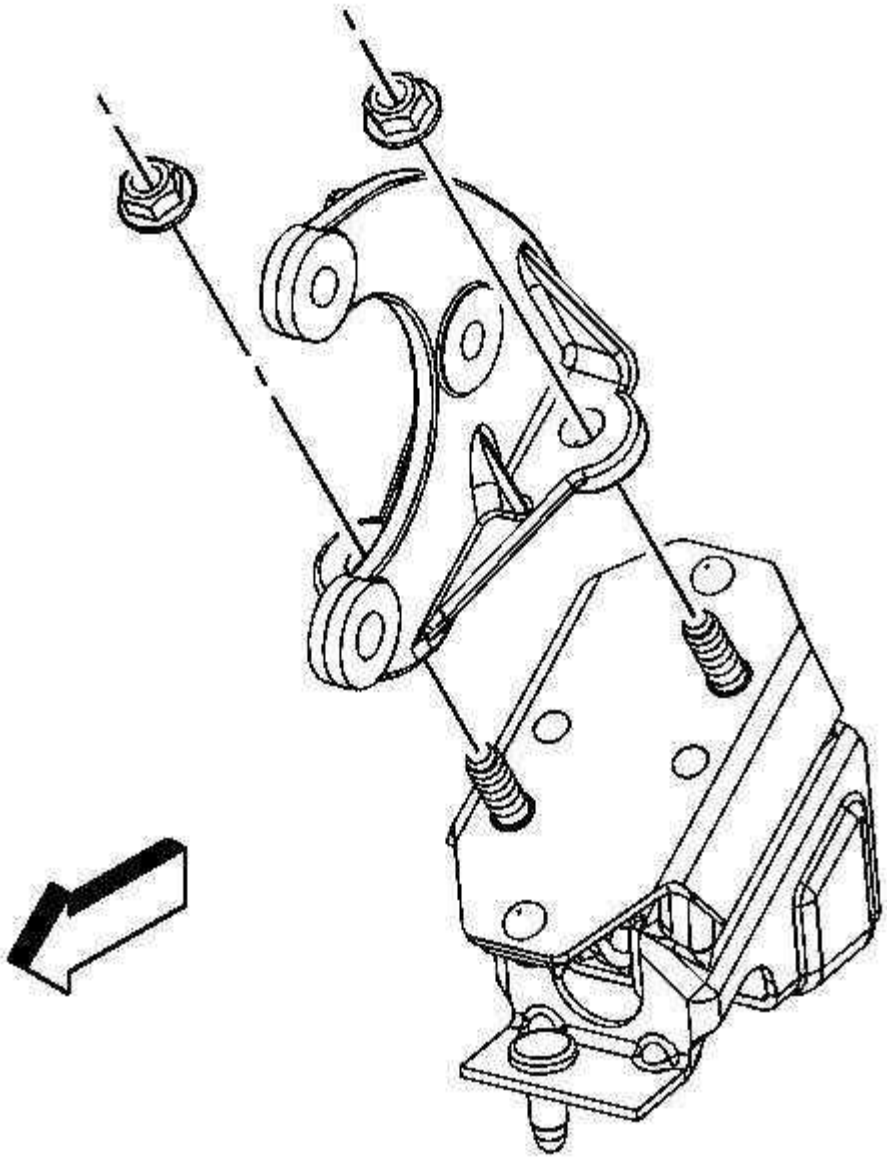


Fig. 53: View Of Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
2. Remove the right exhaust manifold. Refer to **Exhaust Manifold Removal -**

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Right Side.

3. Remove the upper engine mount nuts.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Using the engine support fixture, raise the engine.

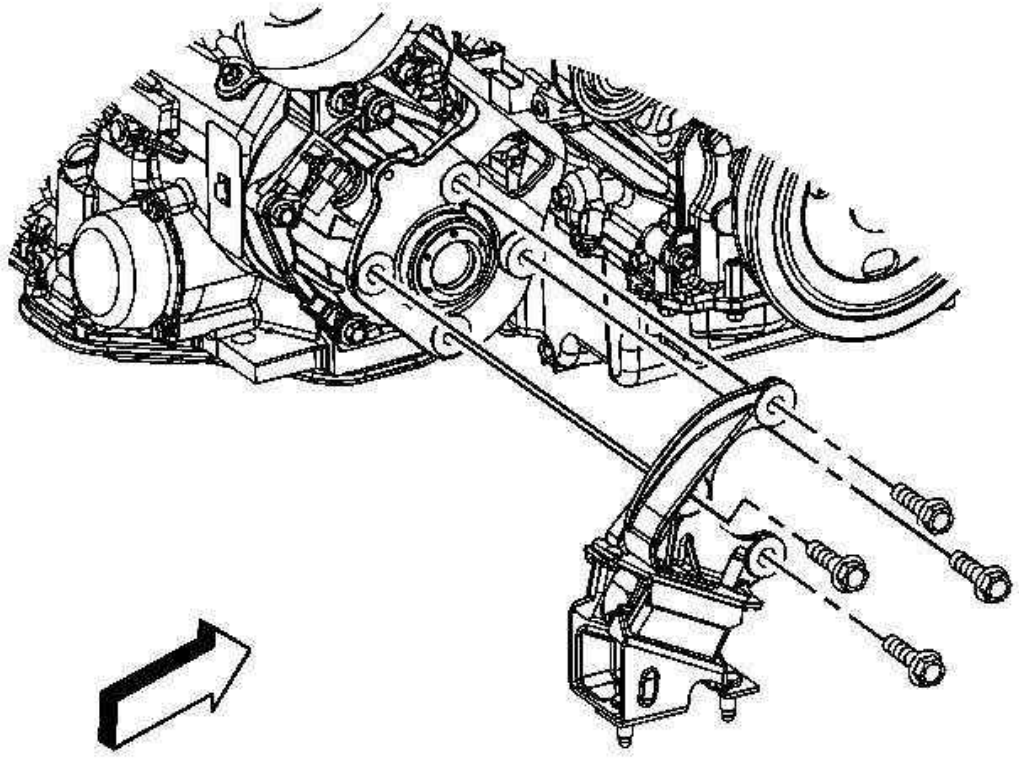


Fig. 54: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bracket bolts.
7. Remove the engine mount bracket.
8. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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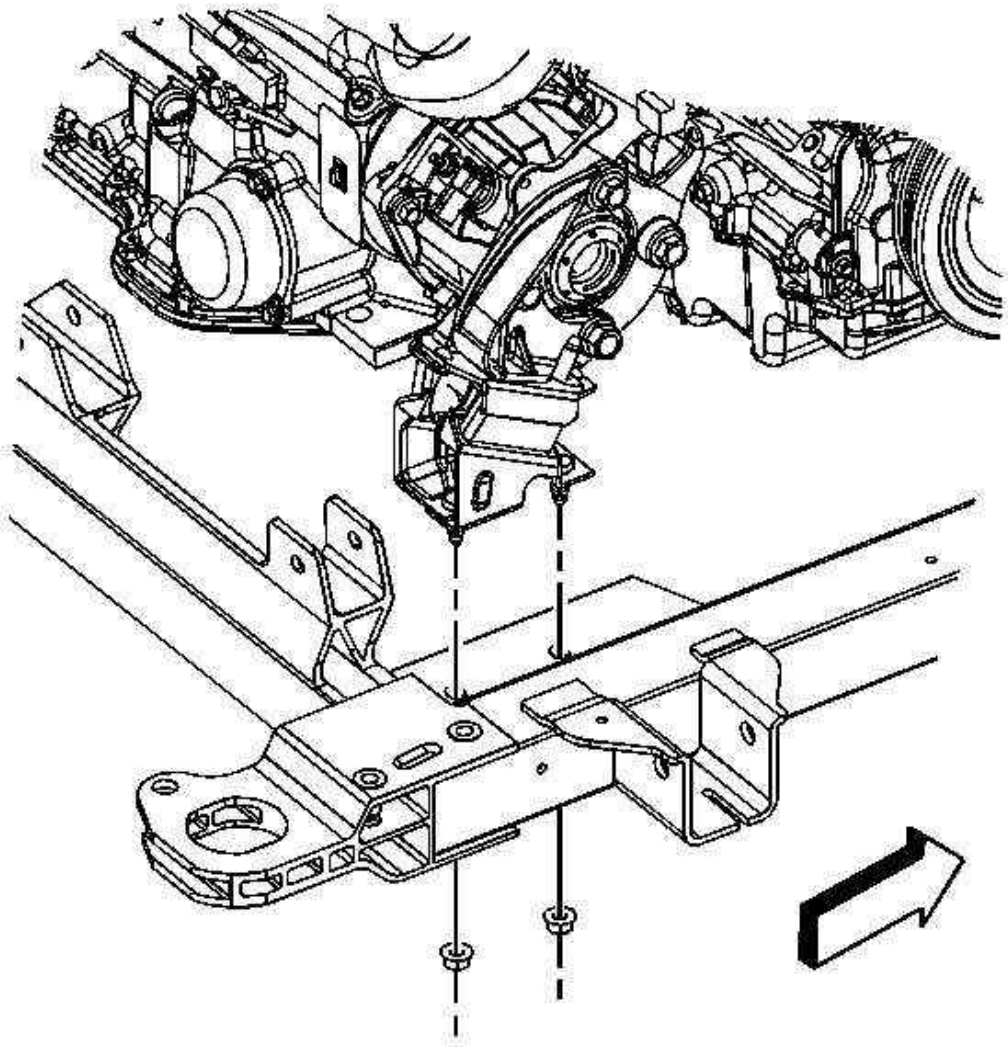


Fig. 55: View Of Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

9. Remove the lower engine mount nuts.
10. Remove the engine mount.

Installation Procedure

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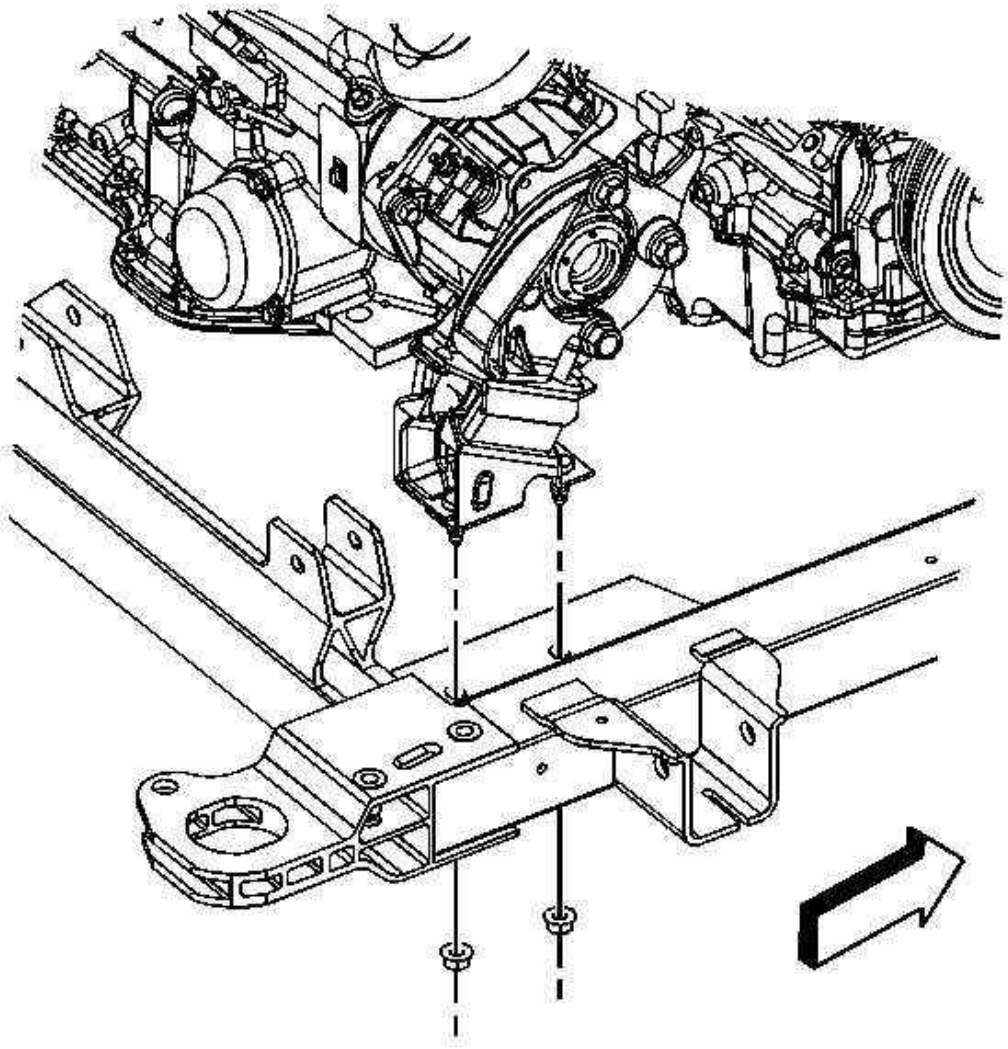


Fig. 56: View Of Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount.

NOTE: Refer to Fastener Notice .

2. Install the lower engine mount nuts.

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

3. Lower the vehicle.

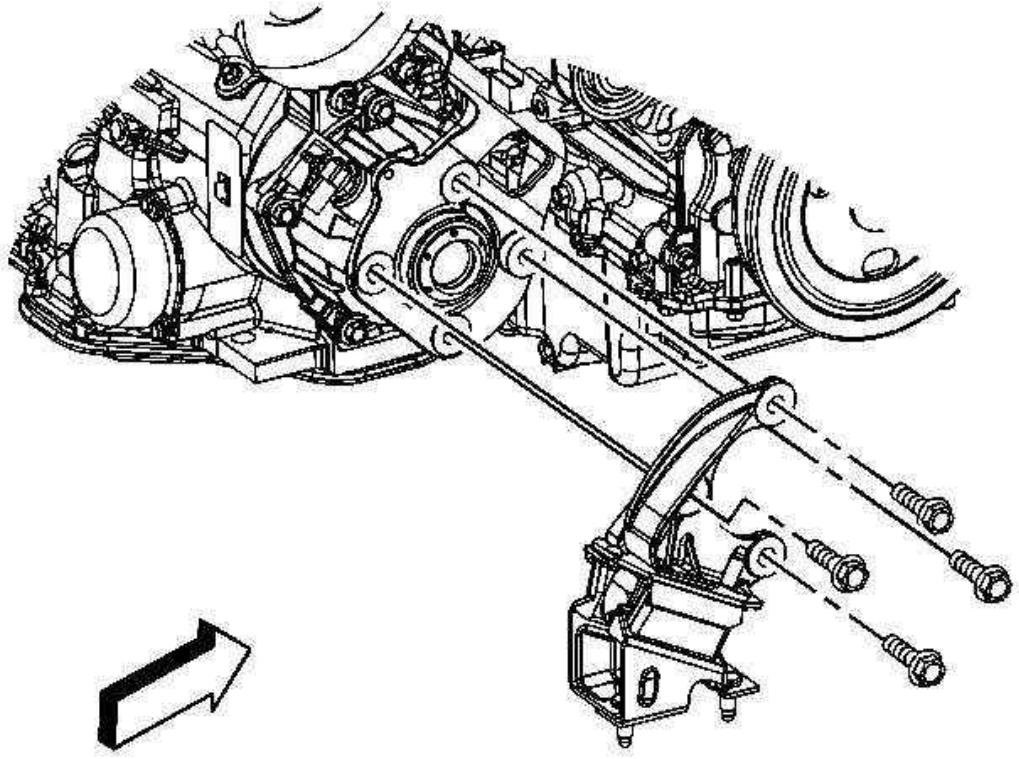


Fig. 57: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

4. Install the engine mount bracket.
5. Install the engine mount bracket bolts.

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

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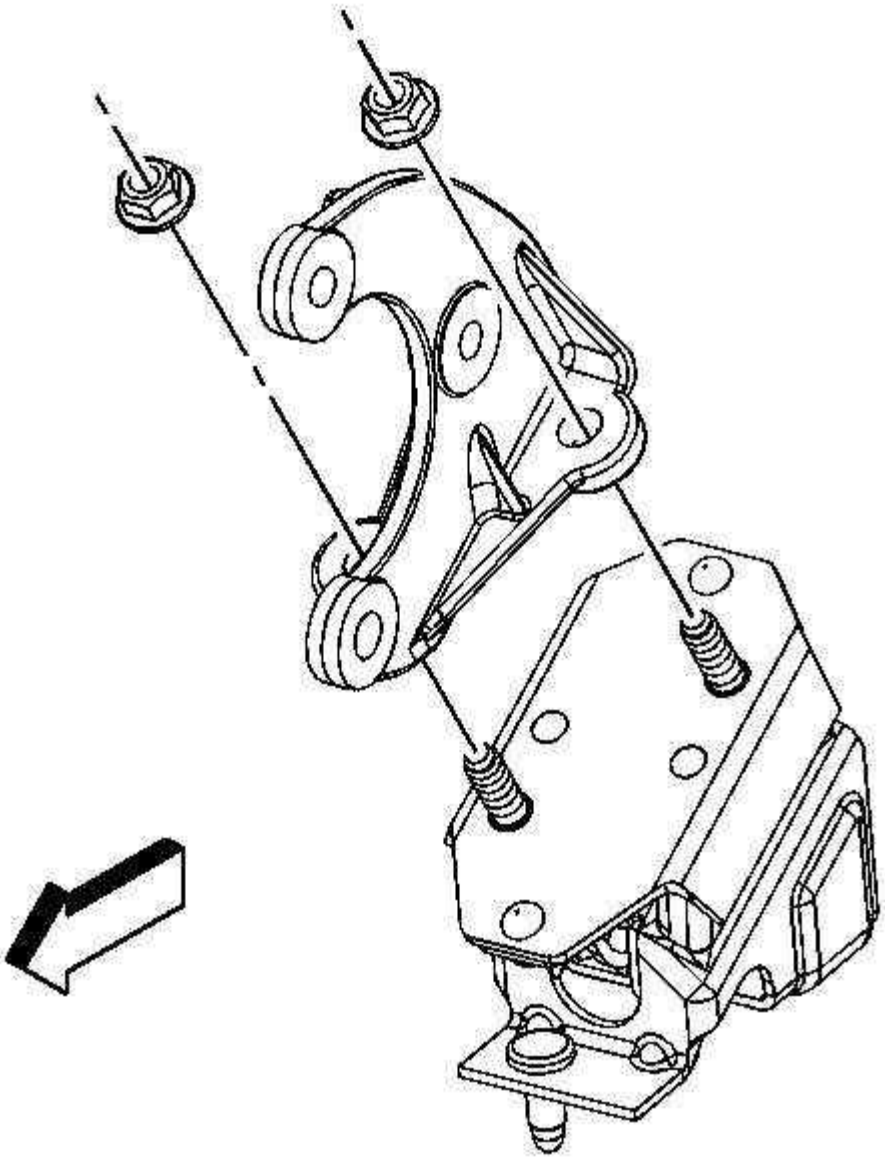


Fig. 58: View Of Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

6. Using the engine support fixture, lower the engine.
7. Remove the engine support fixture.

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8. Install the upper engine mount nuts.

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

9. Install the right exhaust manifold. Refer to **Exhaust Manifold Removal - Right Side**.
10. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

Removal Procedure

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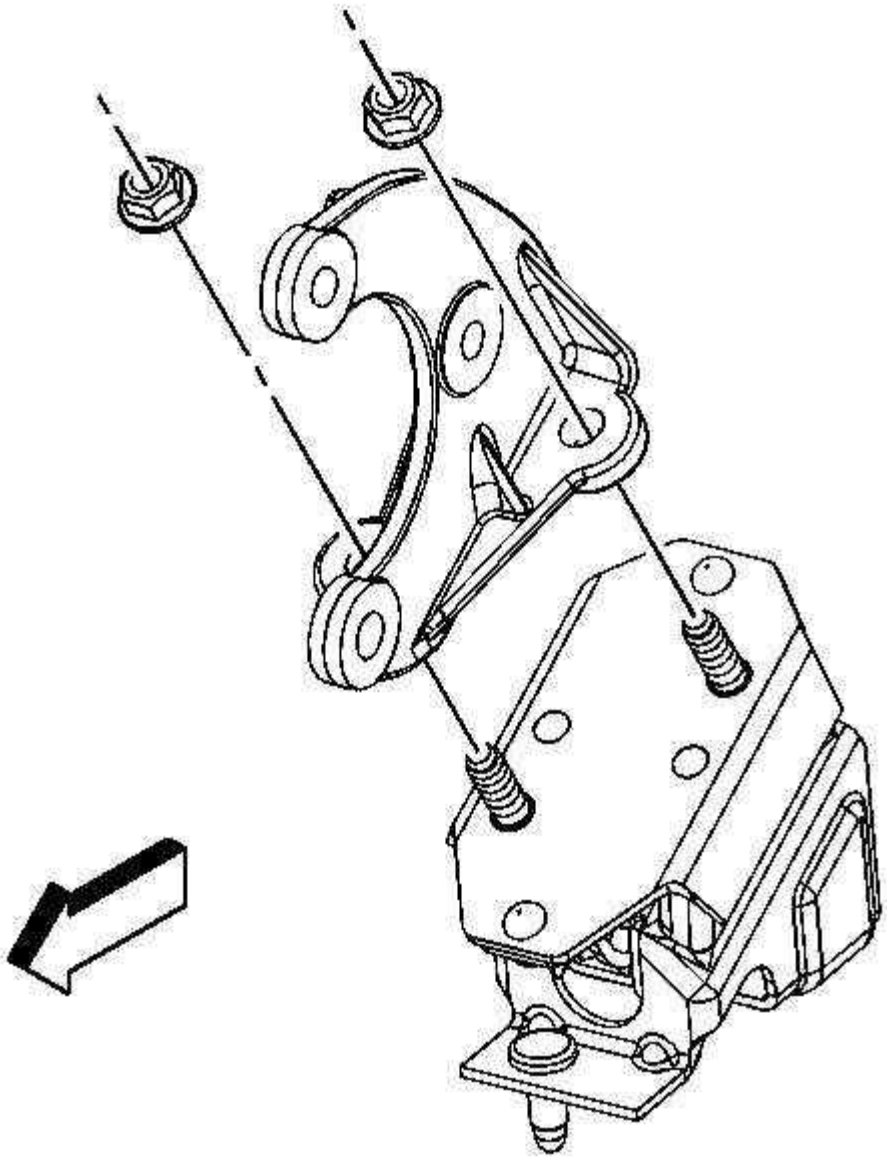


Fig. 59: View Of Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
2. Remove the right exhaust manifold. Refer to **Exhaust Manifold Removal -**

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Right Side.

3. Remove the upper engine mount nuts.
4. Install the engine support fixture. Refer to **Engine Support Fixture**.
5. Using the engine support fixture, raise the engine.

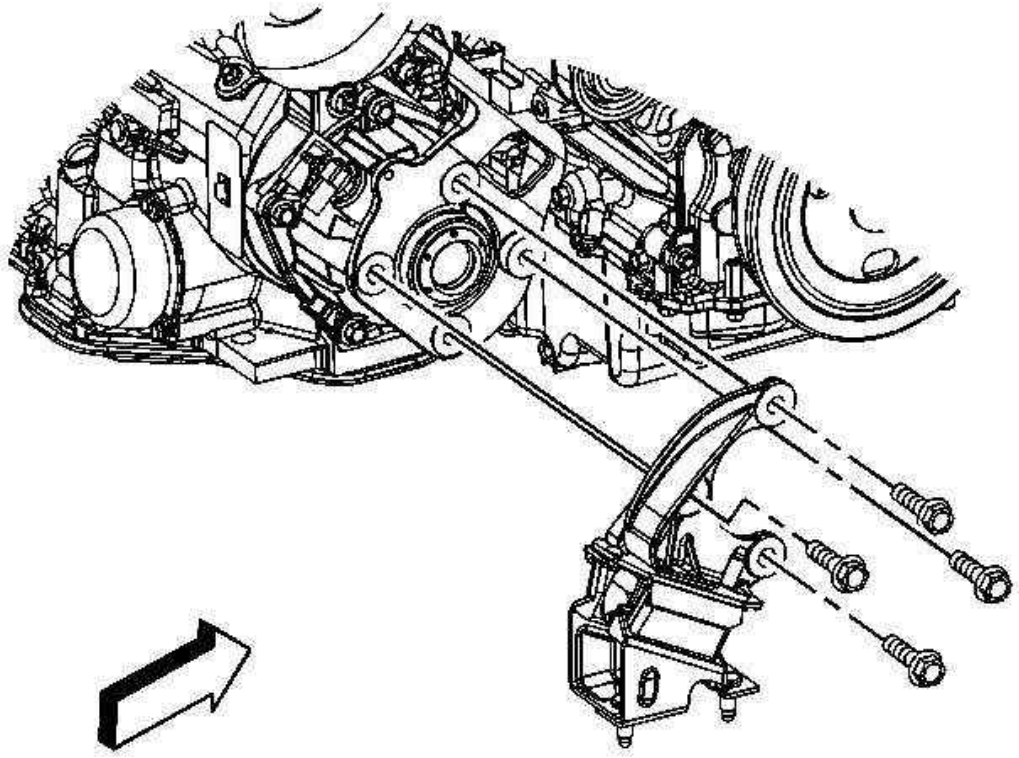


Fig. 60: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bracket bolts.
7. Remove the engine mount bracket.

Installation Procedure

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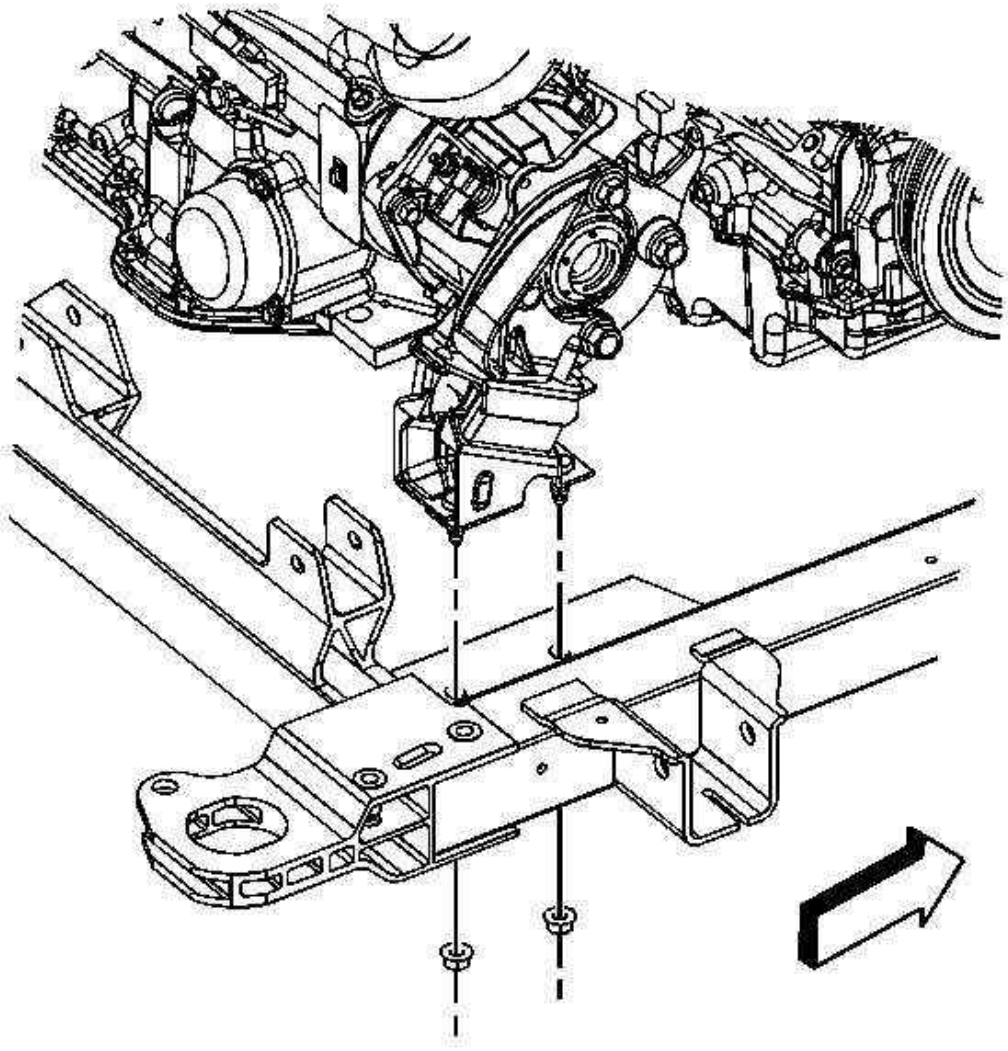


Fig. 61: View Of Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount.

NOTE: Refer to Fastener Notice .

2. Install the lower engine mount nuts.

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

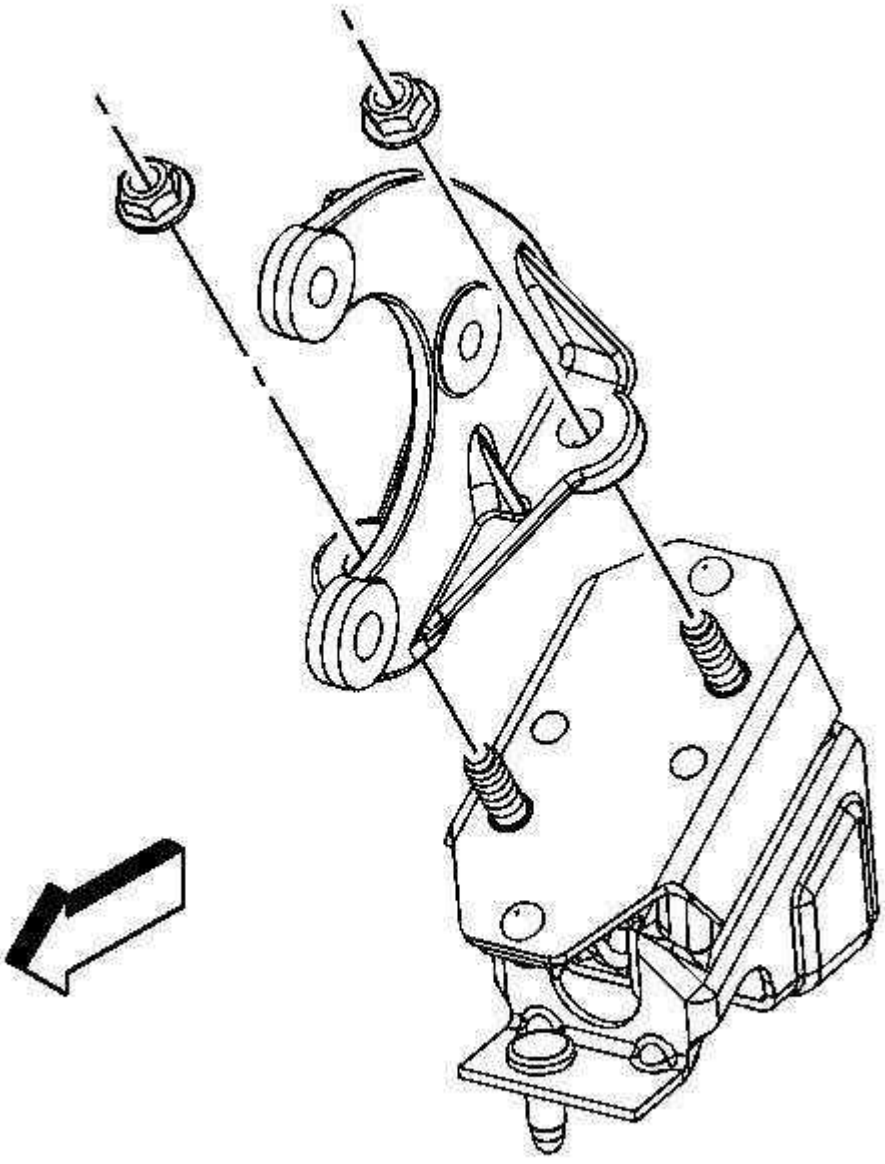


Fig. 62: View Of Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

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3. Using the engine support fixture, lower the engine.
4. Remove the engine support fixture.
5. Install the upper engine mount nuts.

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

6. Install the right exhaust manifold. Refer to **Exhaust Manifold Installation - Right Side**.
7. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.

UPPER INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT

Removal Procedure

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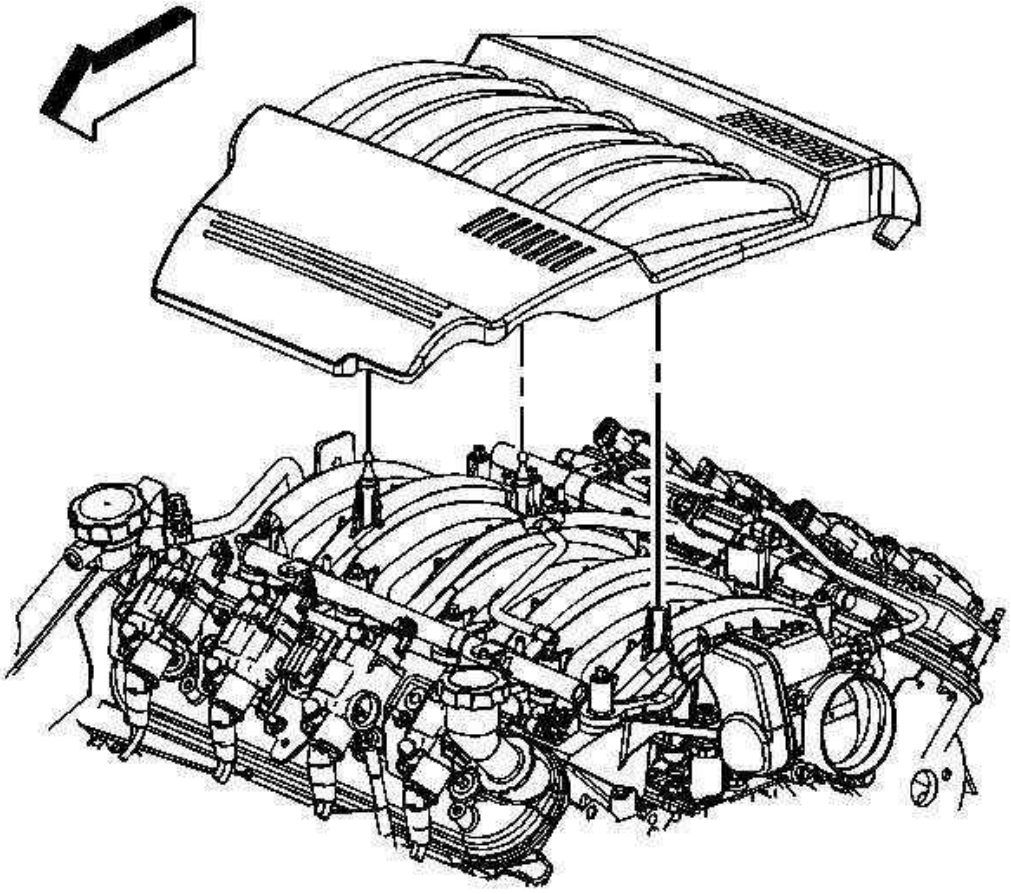


Fig. 63: View Of Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Pull up on the front and rear of the sight shield in order to disengage sight shield from the studs.
2. Remove the engine sight shield from the vehicle.

Installation Procedure

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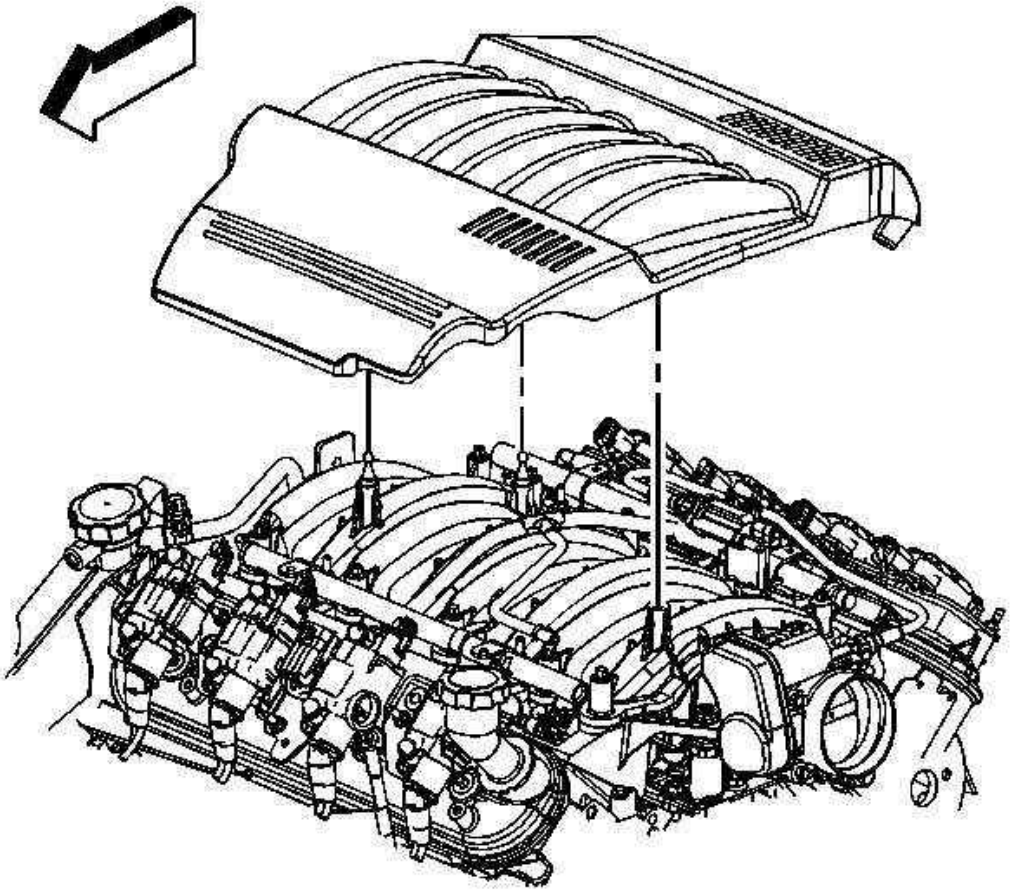


Fig. 64: View Of Sight Shield
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing the engine sight shield, ensure the heater hoses sit on top of the shield to prevent wear over time.

1. Align the sight shield to the studs on the intake manifold.
2. Push down in the 3 locations in order to secure the sight shield to the studs.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

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Removal Procedure

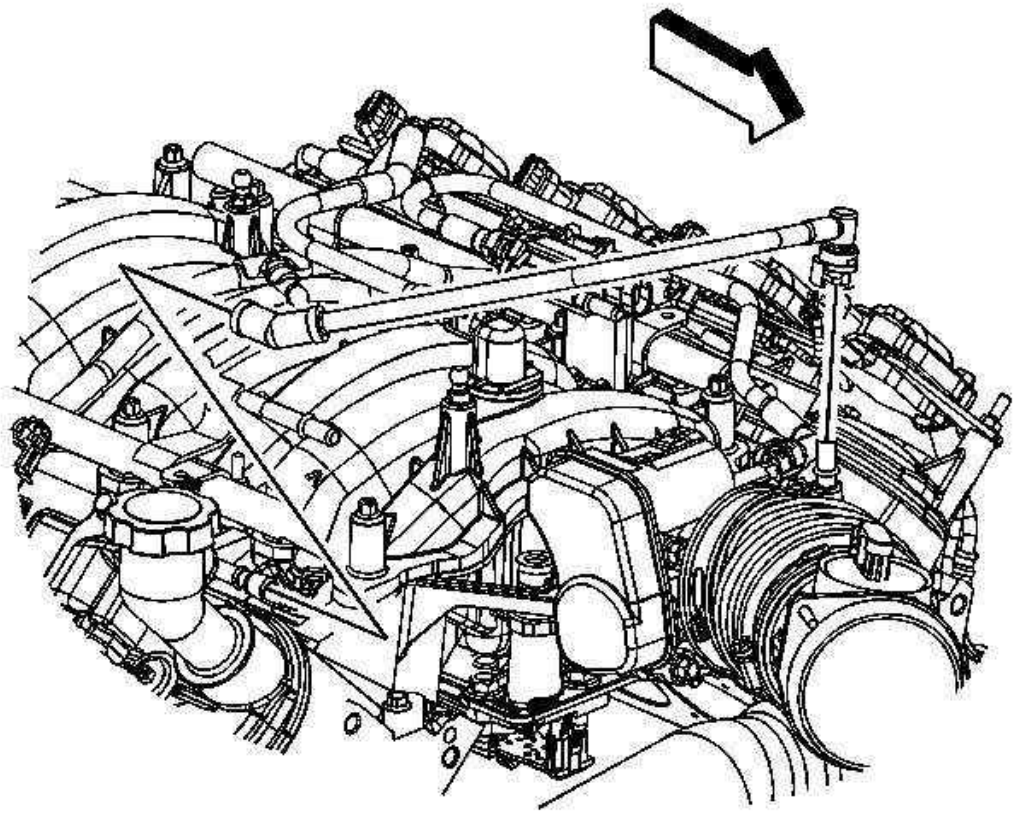


Fig. 65: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. If removing the positive crankcase ventilation (PCV) clean air tube perform the following:
    1. Remove the PCV clean air tube from the air intake duct.
    2. Remove the PCV clean air tube from the rocker arm cover.
    3. Remove the PCV clean air tube.

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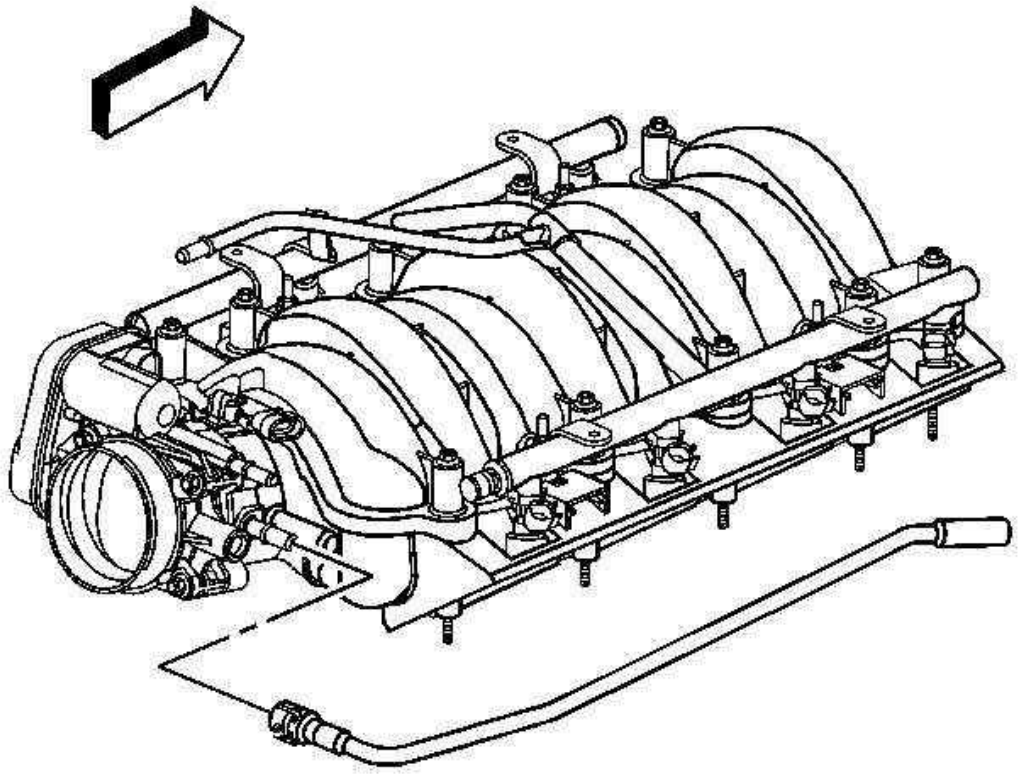


Fig. 66: View Of Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

3. If removing the PCV foul air tube perform the following:
    1. Remove the PCV foul air tube from the intake manifold.
    2. Remove the PCV foul air tube from the rocker arm cover.
    3. Remove the PCV foul air tube.

Installation Procedure

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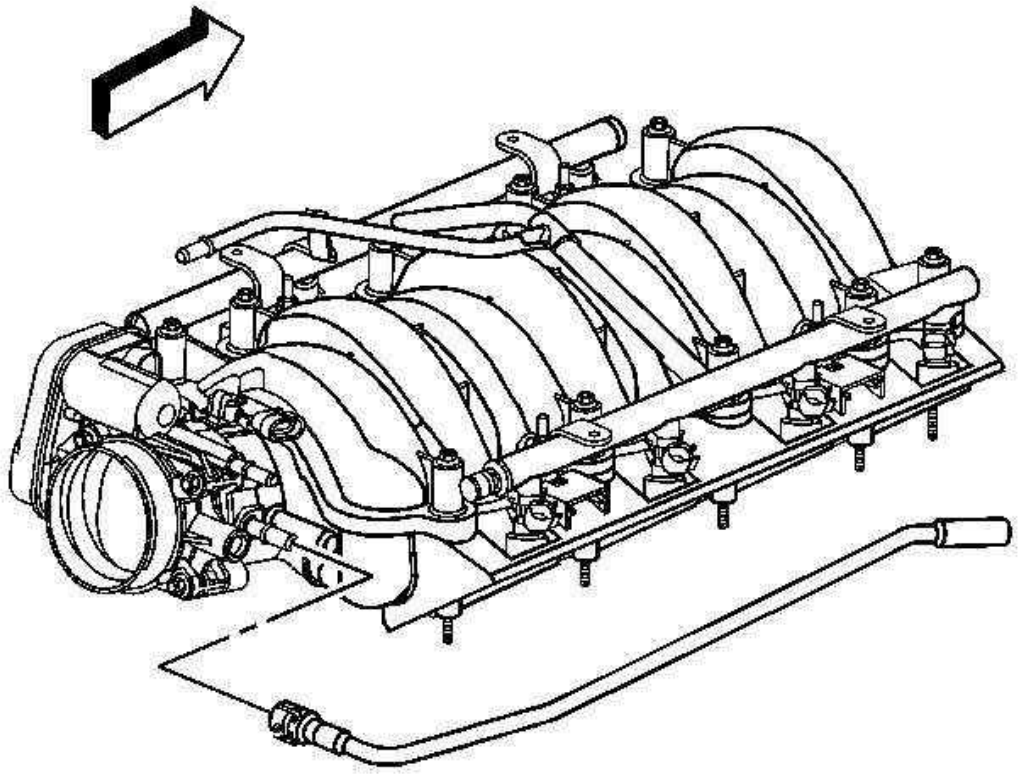


Fig. 67: View Of Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

1. If installing the PCV foul air tube perform the following:
    1. Install the PCV foul air tube.
    2. Install the PCV foul air tube to the rocker arm cover.
    3. Install the PCV foul air tube to the intake manifold.

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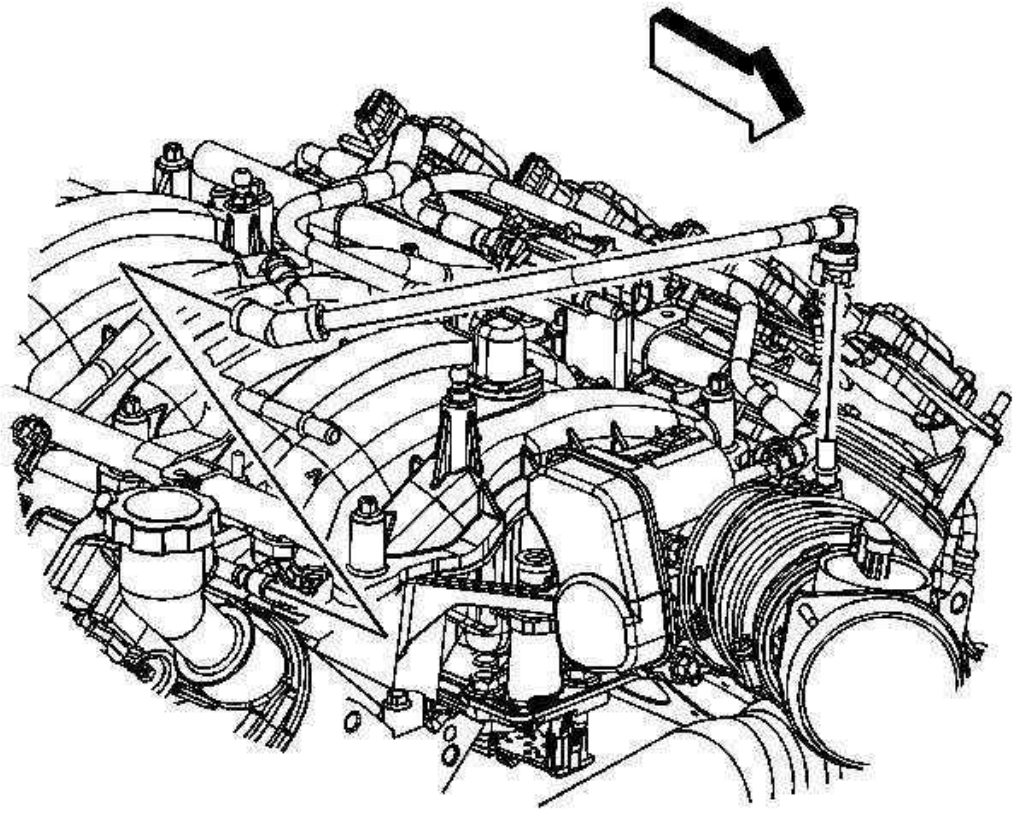


Fig. 68: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

2. If installing the PCV clean air tube perform the following:
    1. Install the PCV clean air tube.
    2. Install the PCV clean air tube to the rocker arm cover.
    3. Install the PCV clean air tube to the air intake duct.
3. Install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

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IMPORTANT: The intake manifold, throttle body, fuel rail, and injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

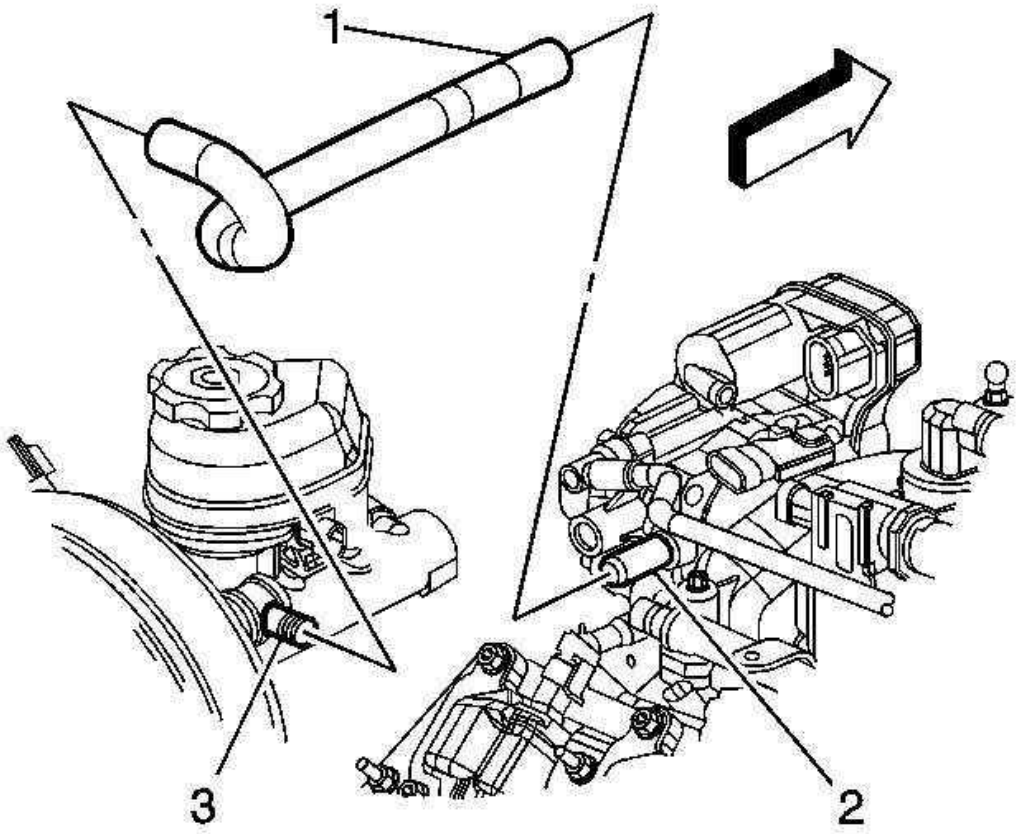


Fig. 69: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
2. Remove the fuel injectors. Refer to **Fuel Injector Replacement** .
3. Remove the brake booster vacuum hose (1) from the intake manifold (2) and the booster check valve (3).

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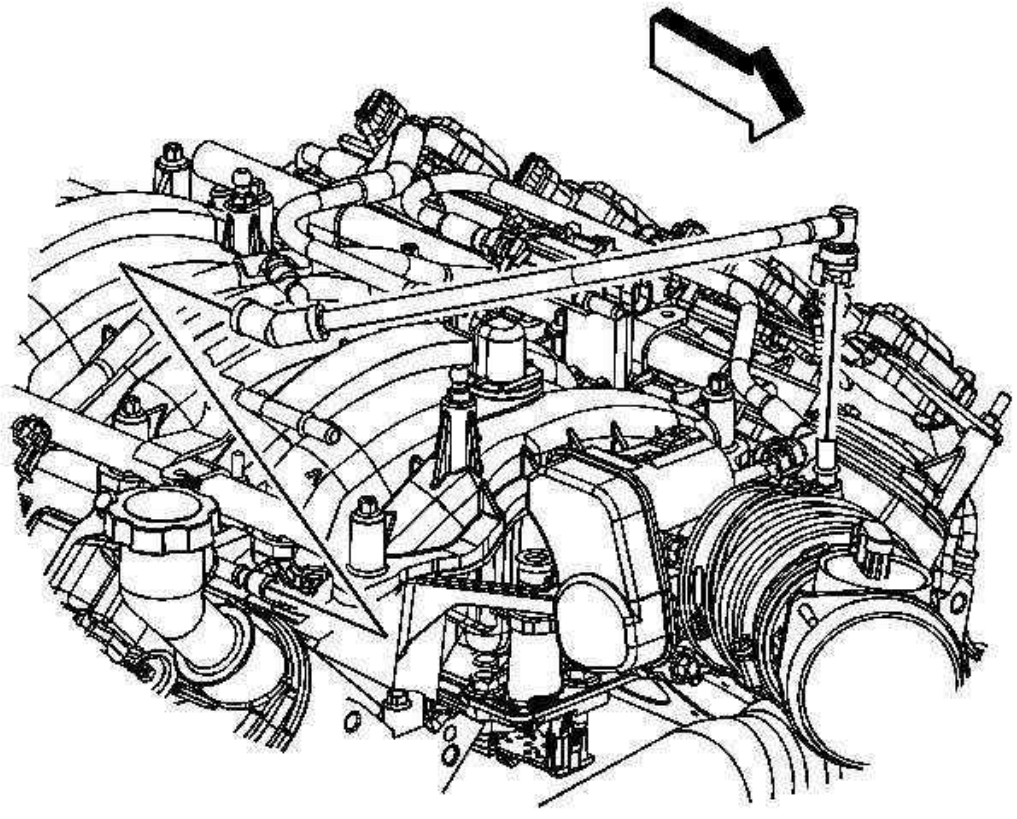


Fig. 70: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the positive crankcase ventilation (PCV) clean air tube from the air intake duct and valve rocker arm cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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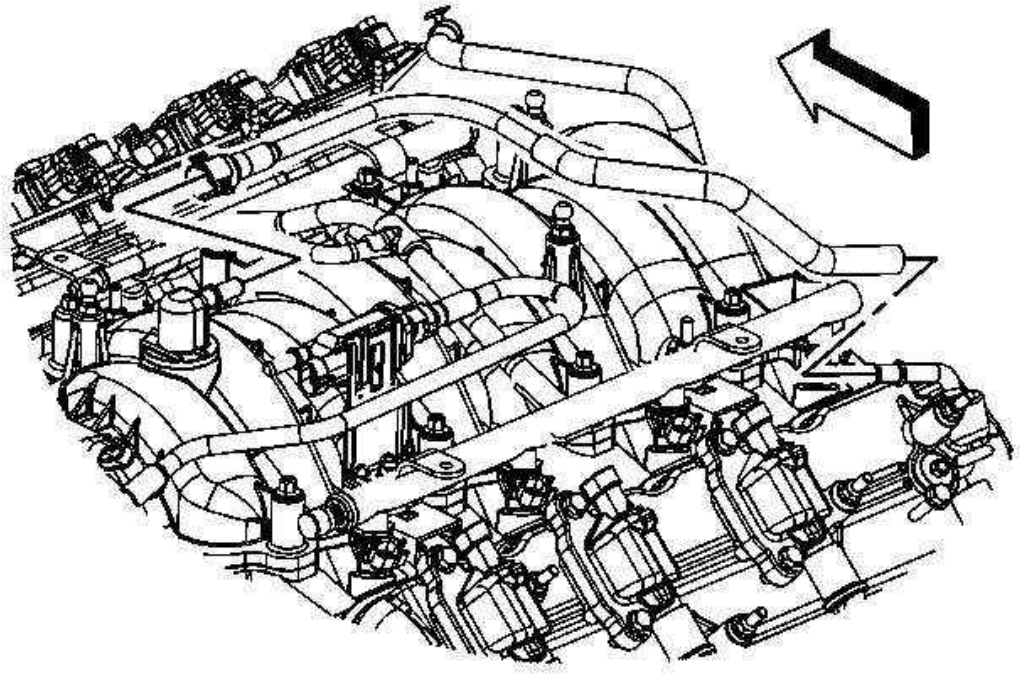


Fig. 71: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Remove the PCV foul air tube from the intake manifold and valve rocker arm cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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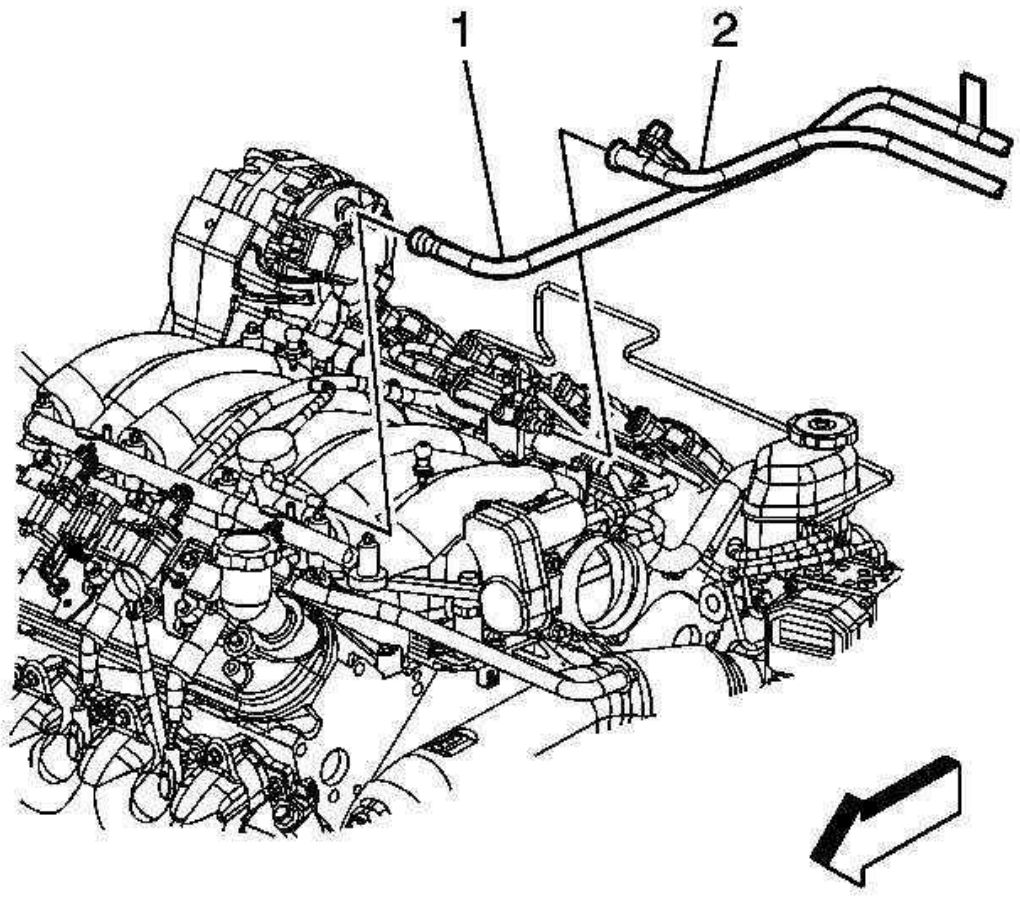


Fig. 72: View Of Fuel Feed Line & Evaporative Emission (EVAP) Line
Courtesy of GENERAL MOTORS CORP.

6. Remove the evaporative emission (EVAP) purge solenoid tube (2) from the solenoid and reposition. Refer to **Plastic Collar Quick Connect Fitting Service** .

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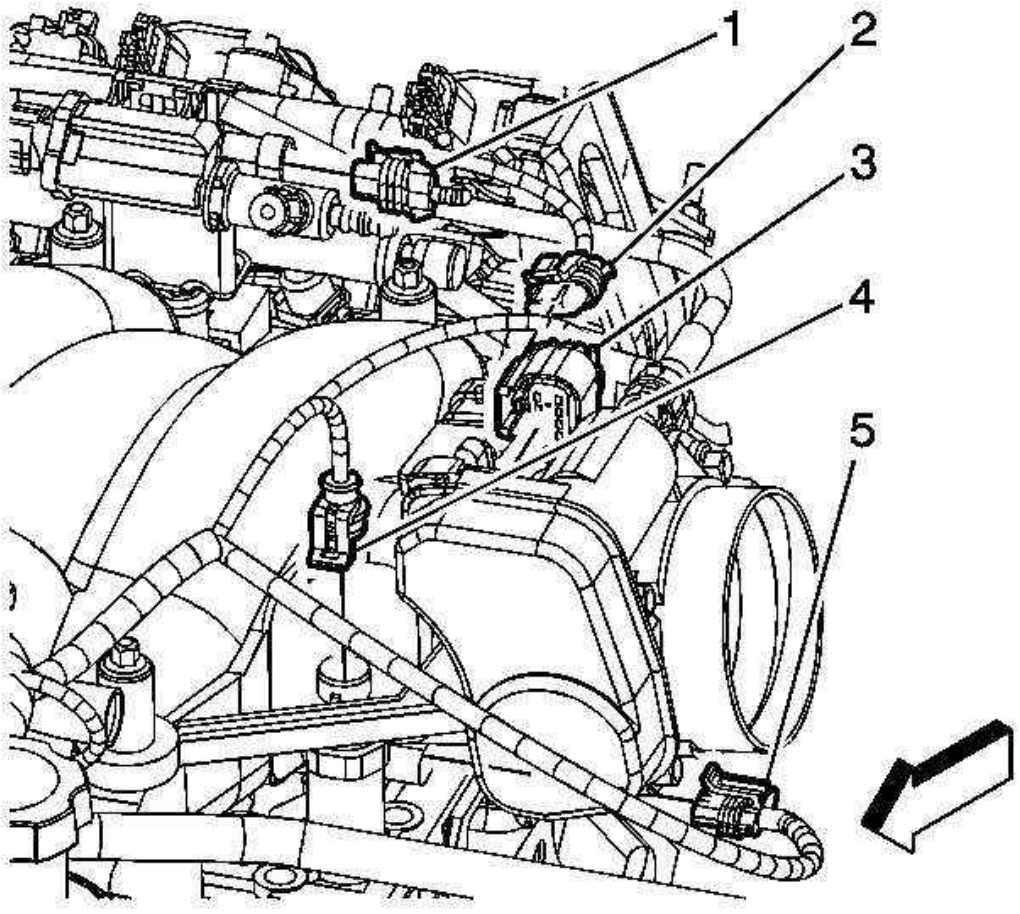


Fig. 73: View Of Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the following electrical connectors:
   - EVAP purge solenoid (1)
   - Manifold absolute pressure (MAP) sensor (2)
   - Oil pressure sensor (4)
   - Valve lifter oil manifold (5)

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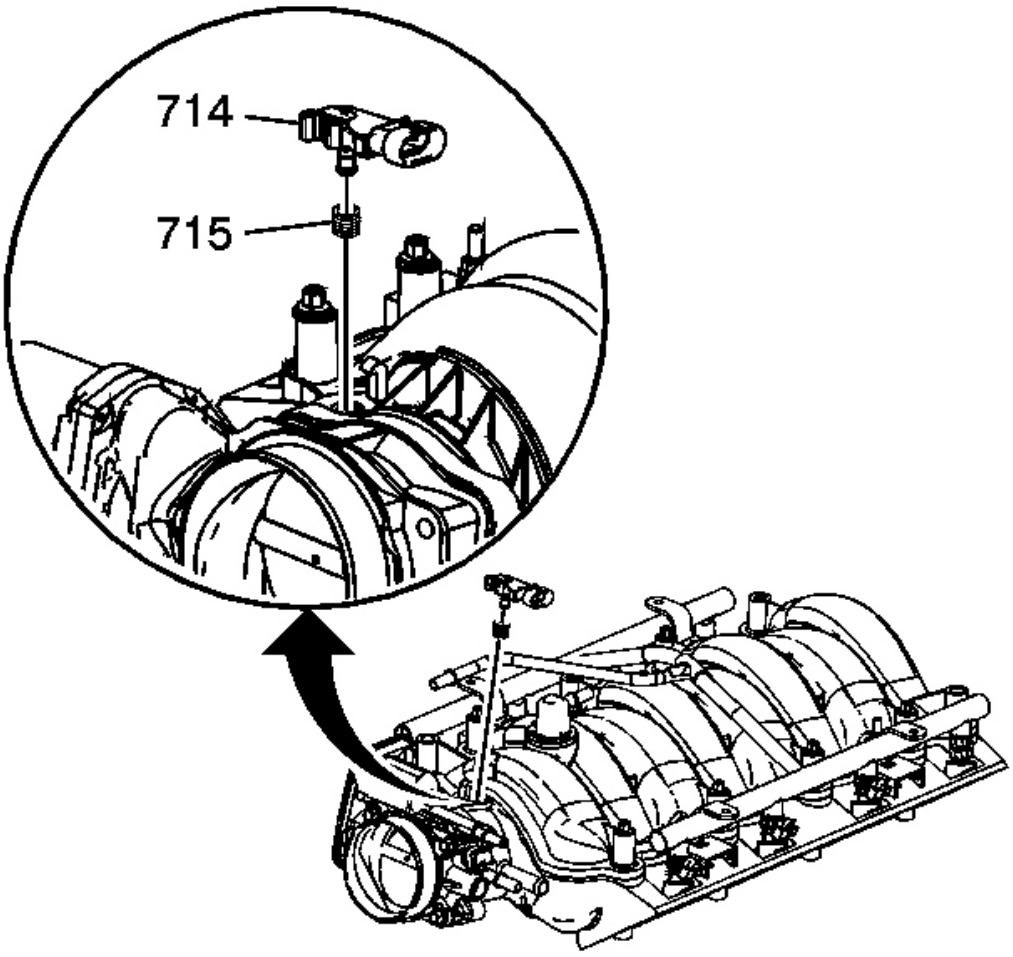


Fig. 74: View Of MAP Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the MAP sensor (714) from the intake manifold.

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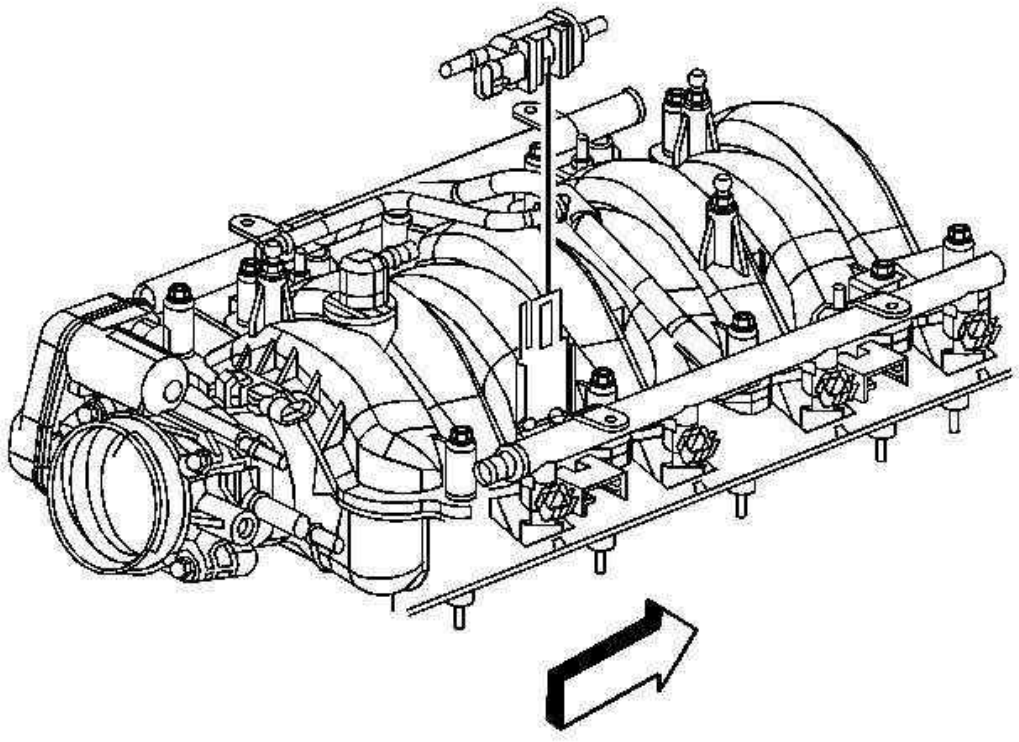


Fig. 75: Identifying EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

9. Remove the EVAP purge solenoid valve and bracket.

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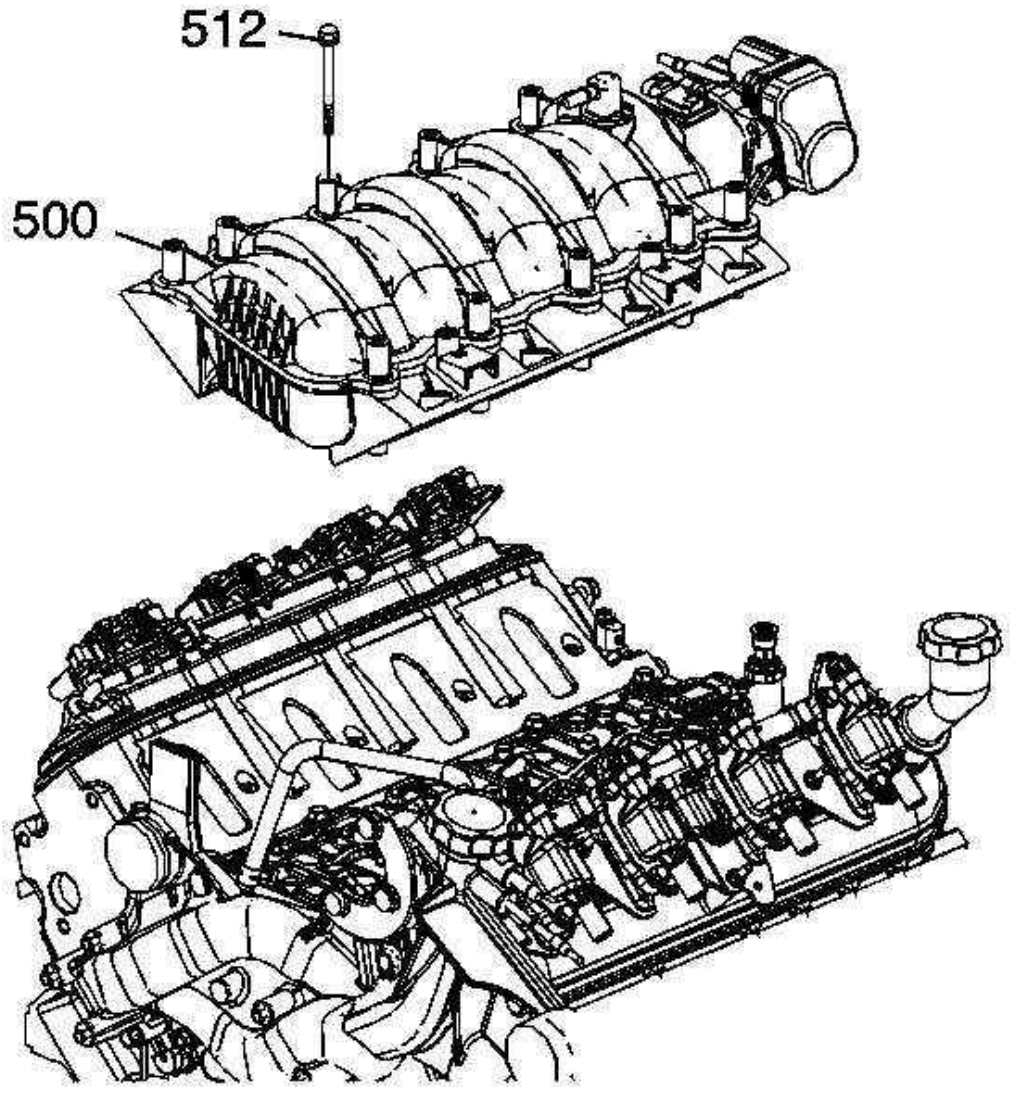


Fig. 76: View Of The Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the intake manifold bolts (512).
11. Remove the intake manifold (500).

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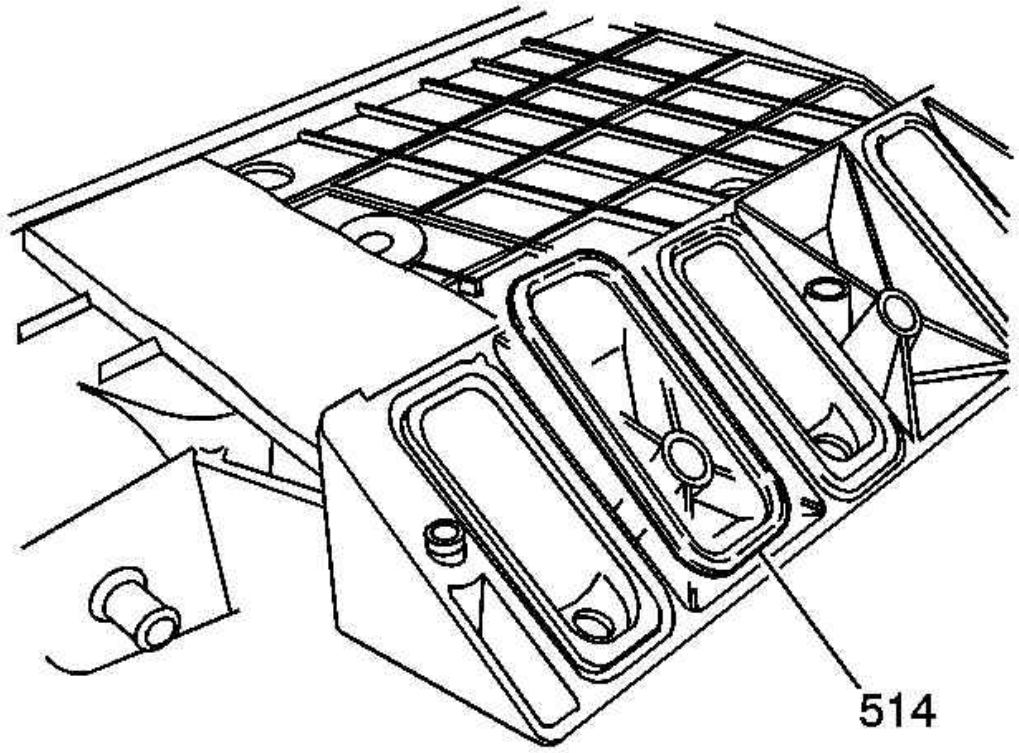


Fig. 77: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

12. Remove and discard the intake manifold gaskets (514).

Installation Procedure

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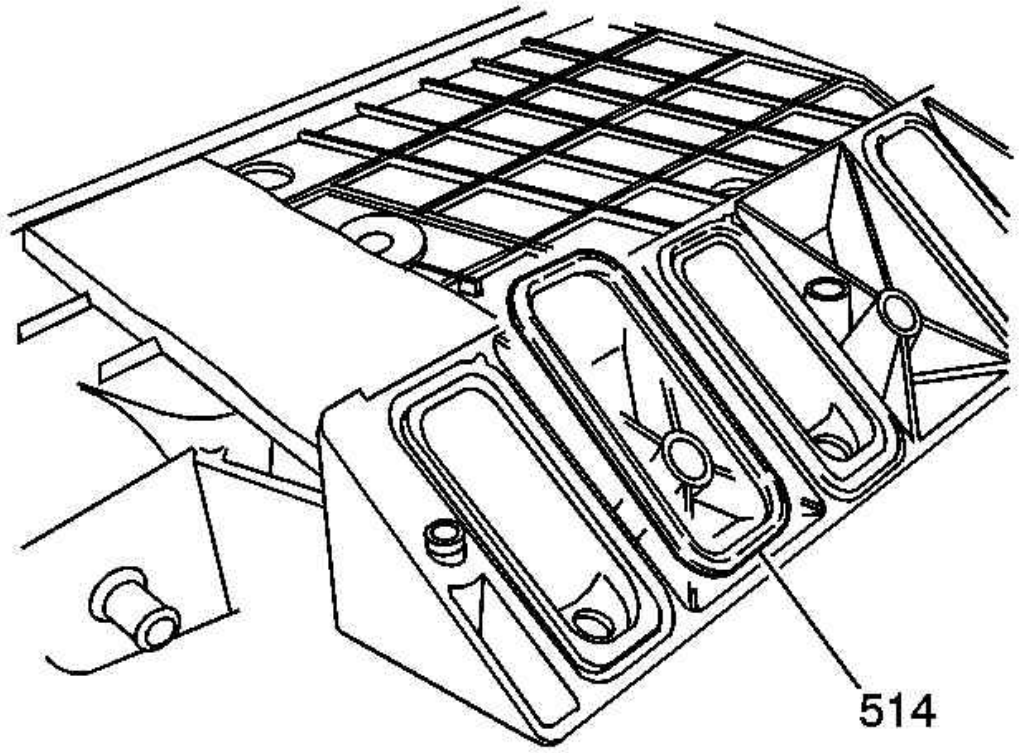


Fig. 78: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW intake manifold gaskets (514).

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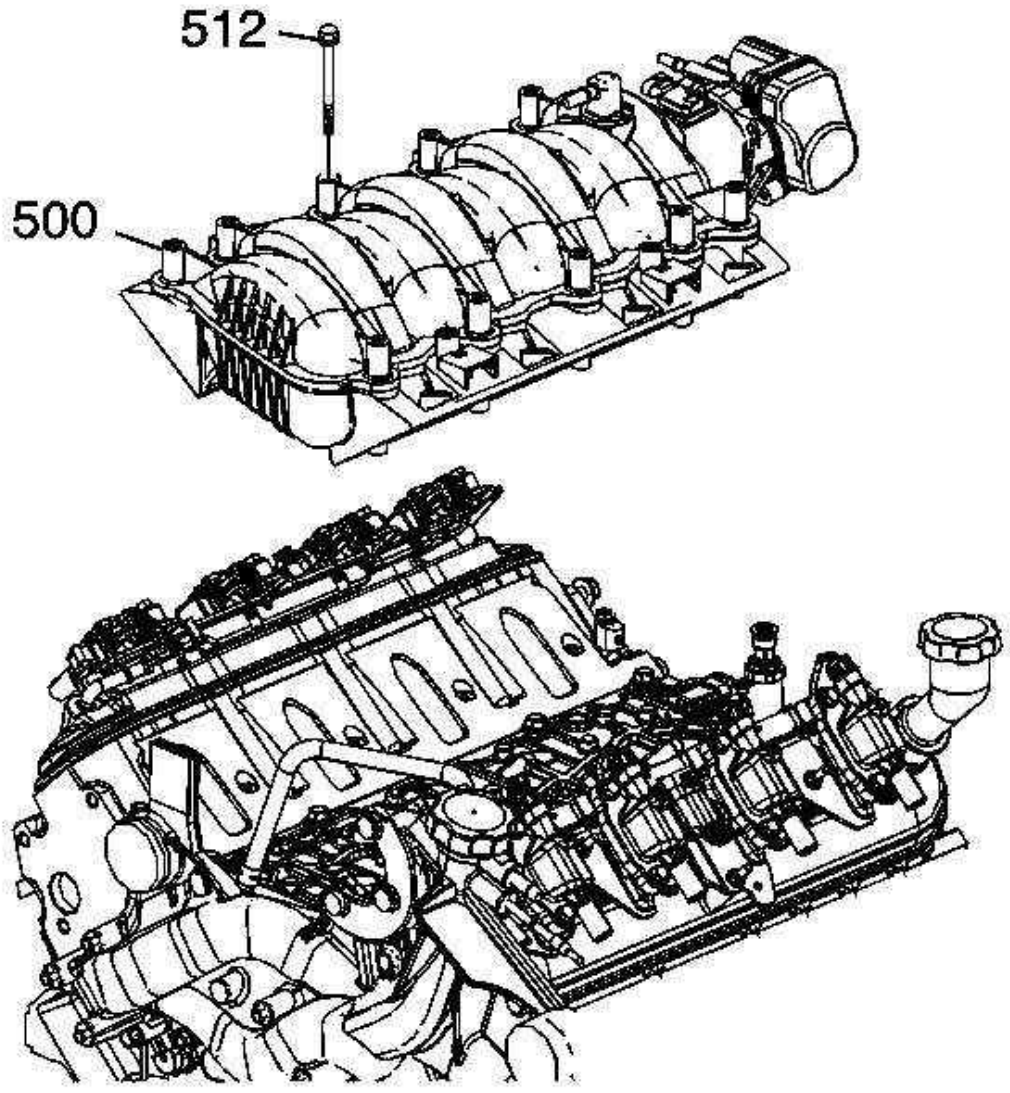


Fig. 79: View Of The Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold (500).
3. Apply a band of threadlock to the threads of the intake manifold bolts (512).

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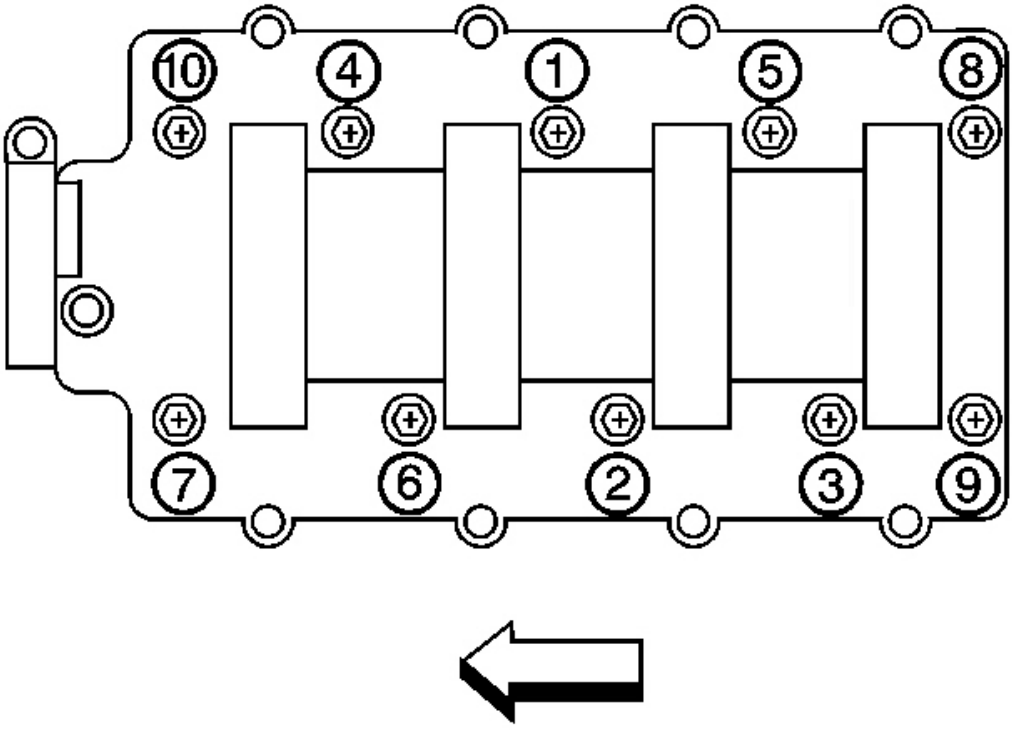


Fig. 80: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the intake manifold bolts.

Tighten:

- Tighten the bolts a first pass in sequence to 5 N.m (44 lb in).
- Tighten the bolts a first pass in sequence to 10 N.m (89 lb in).

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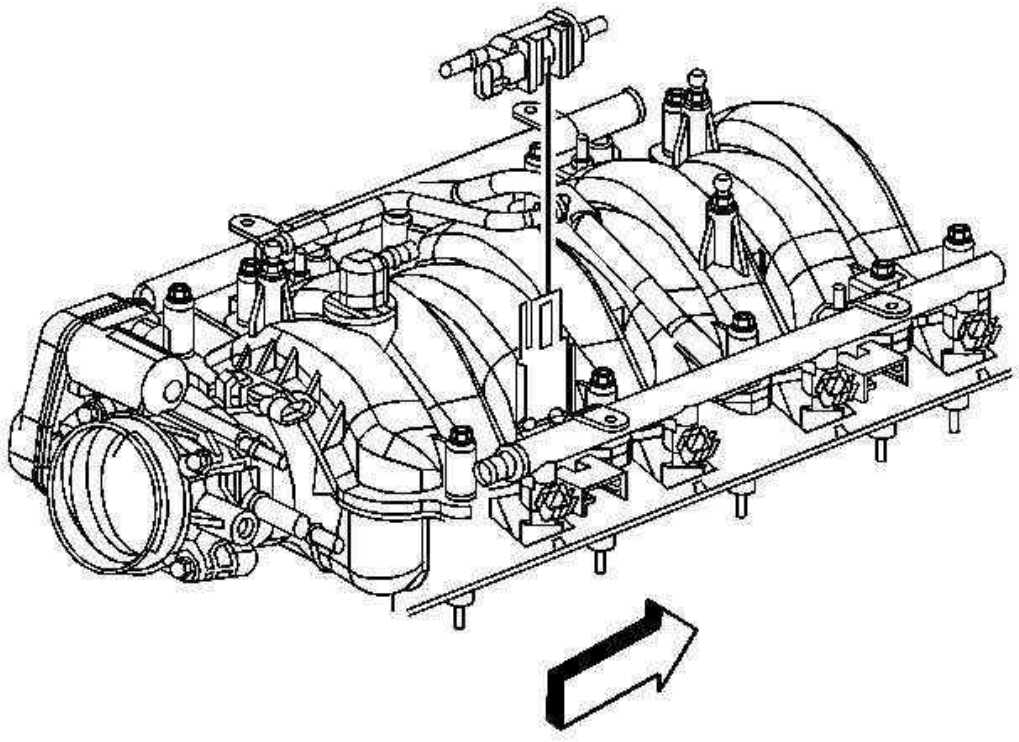


Fig. 81: Identifying EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the EVAP purge solenoid bracket and solenoid.

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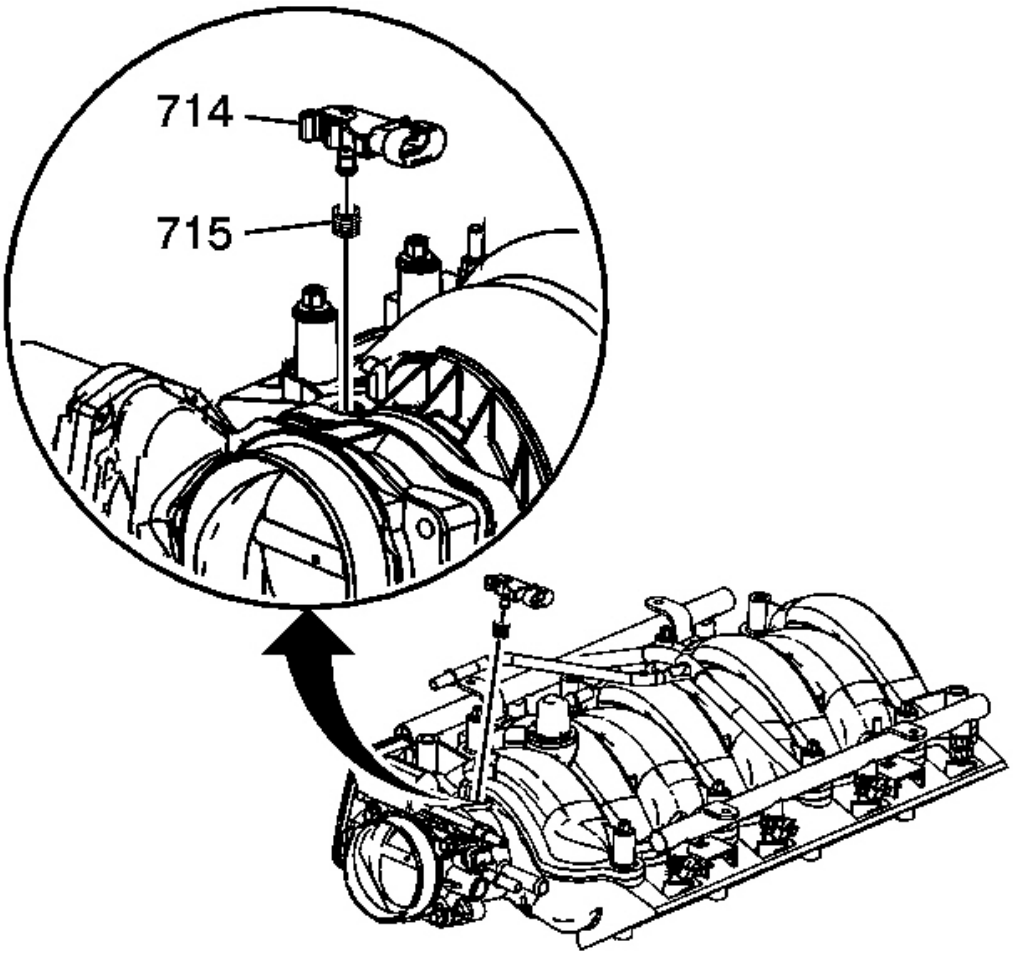


Fig. 82: View Of MAP Sensor
Courtesy of GENERAL MOTORS CORP.

6. Install the MAP sensor (714) to the intake manifold.

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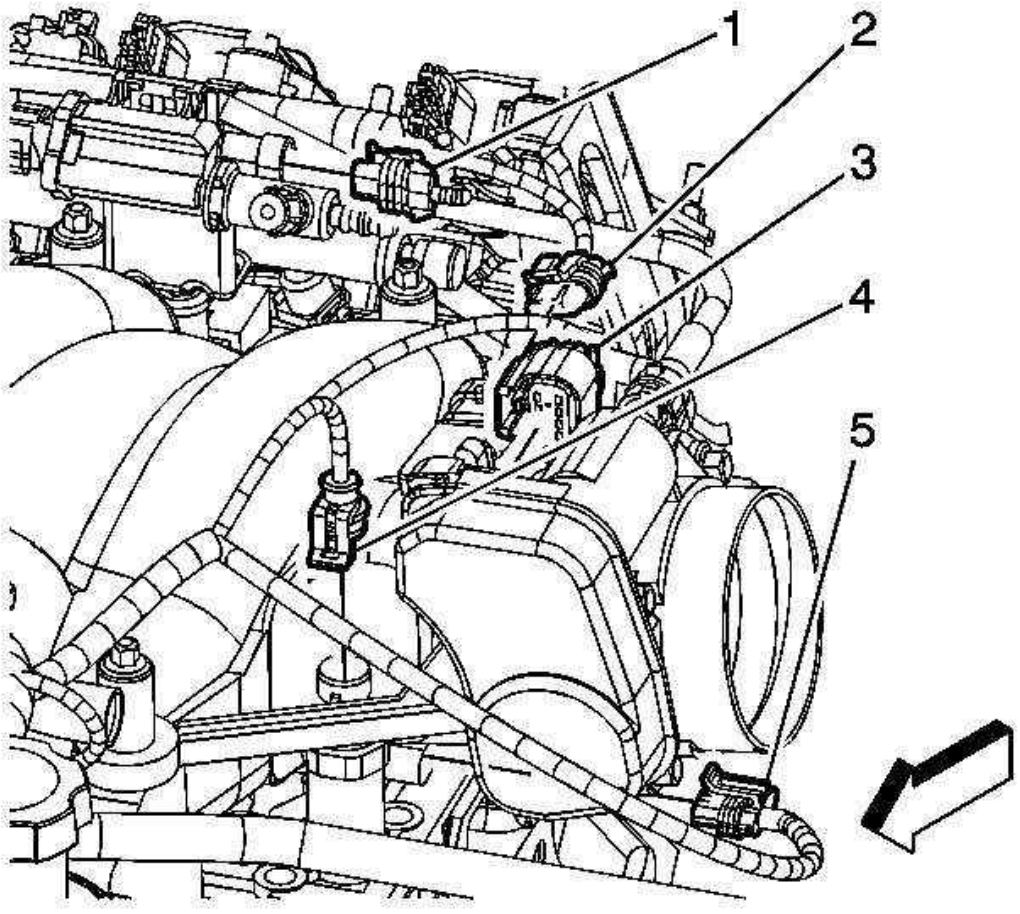


Fig. 83: View Of Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Connect the following electrical connectors:
   - EVAP purge solenoid (1)
   - MAP sensor (2)
   - Oil pressure sensor (4)
   - Valve lifter oil manifold (5)

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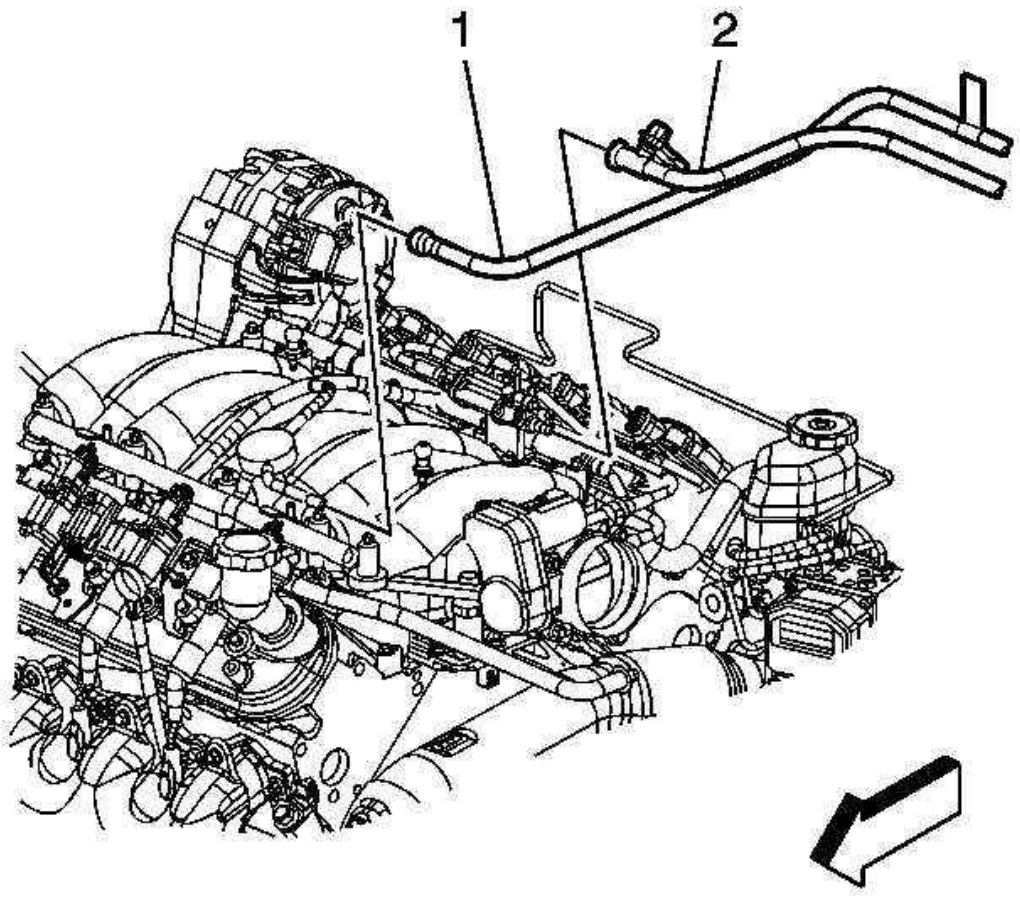


Fig. 84: View Of Fuel Feed Line & Evaporative Emission (EVAP) Line
Courtesy of GENERAL MOTORS CORP.

8. Position and install the EVAP purge solenoid tube (2) to the solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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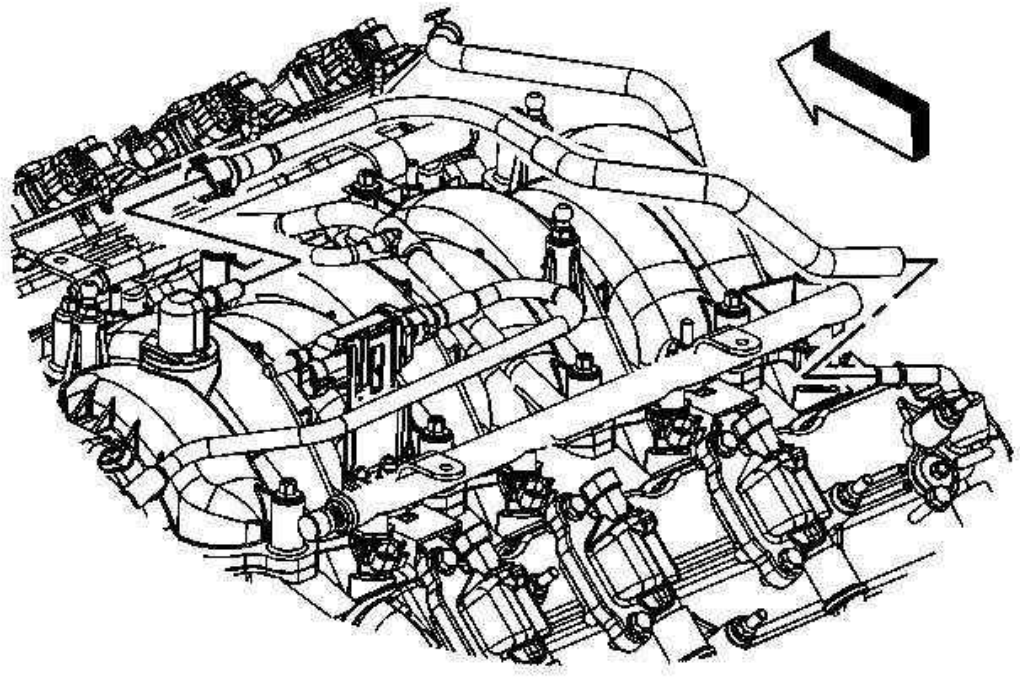


Fig. 85: Identifying PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

9. Install the PCV foul air tube to the intake manifold and valve rocker arm cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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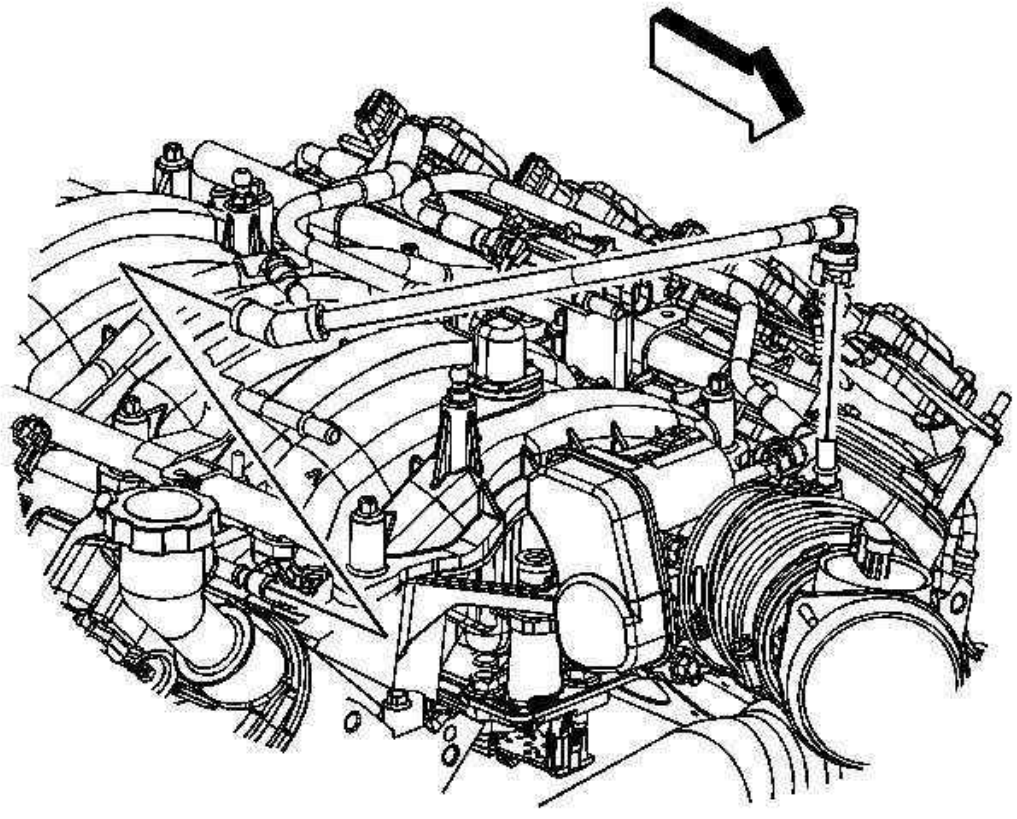


Fig. 86: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

10. Install the PCV clean air tube to the air intake duct and valve rocker arm cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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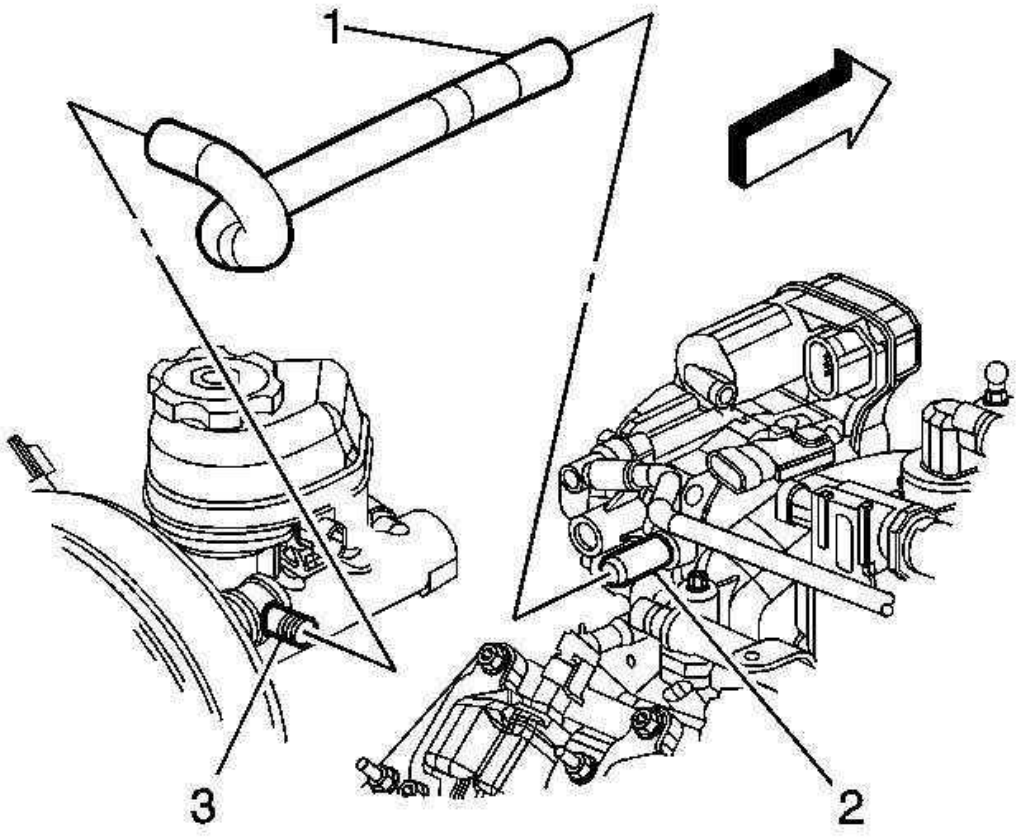


Fig. 87: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

11. Install the brake booster vacuum hose (1) to the intake manifold (2) and the booster check valve (3).
12. Install the fuel injectors. Refer to **Fuel Injector Replacement** .
13. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .

VALVE LIFTER OIL MANIFOLD REPLACEMENT

Removal Procedure

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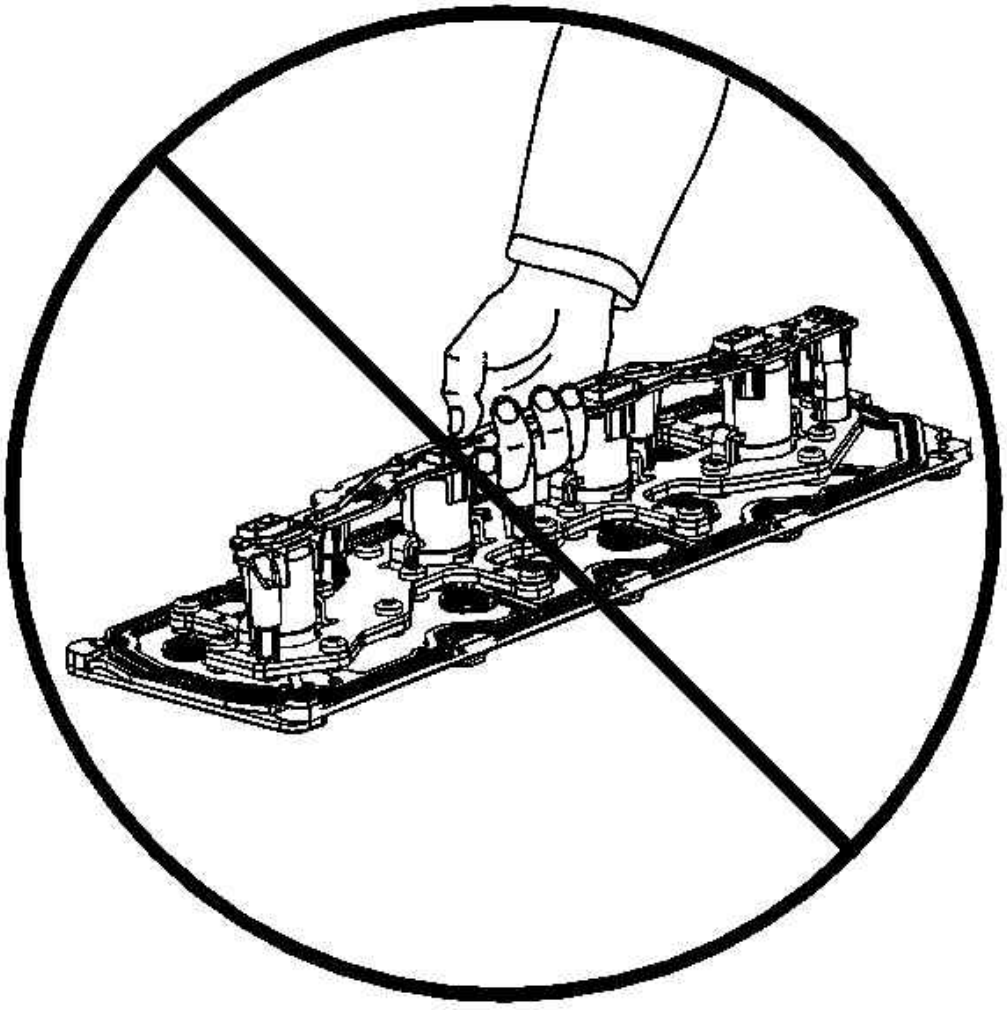


Fig. 88: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Do not lift the manifold assembly by the electrical lead frame.

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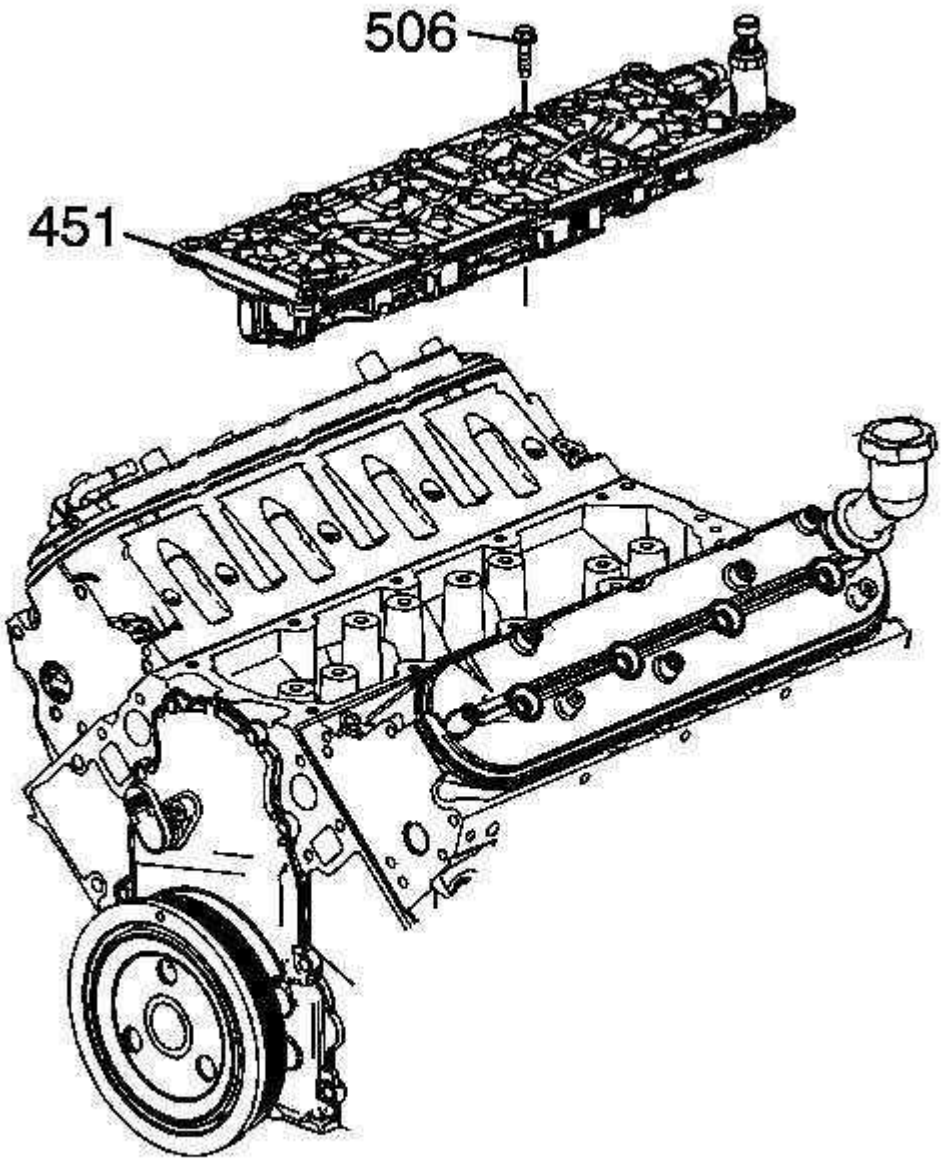


Fig. 89: View Of Valve Lifter Oil Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifter oil manifold bolts (506).

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IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.

4. Remove the valve lifter oil manifold (451).

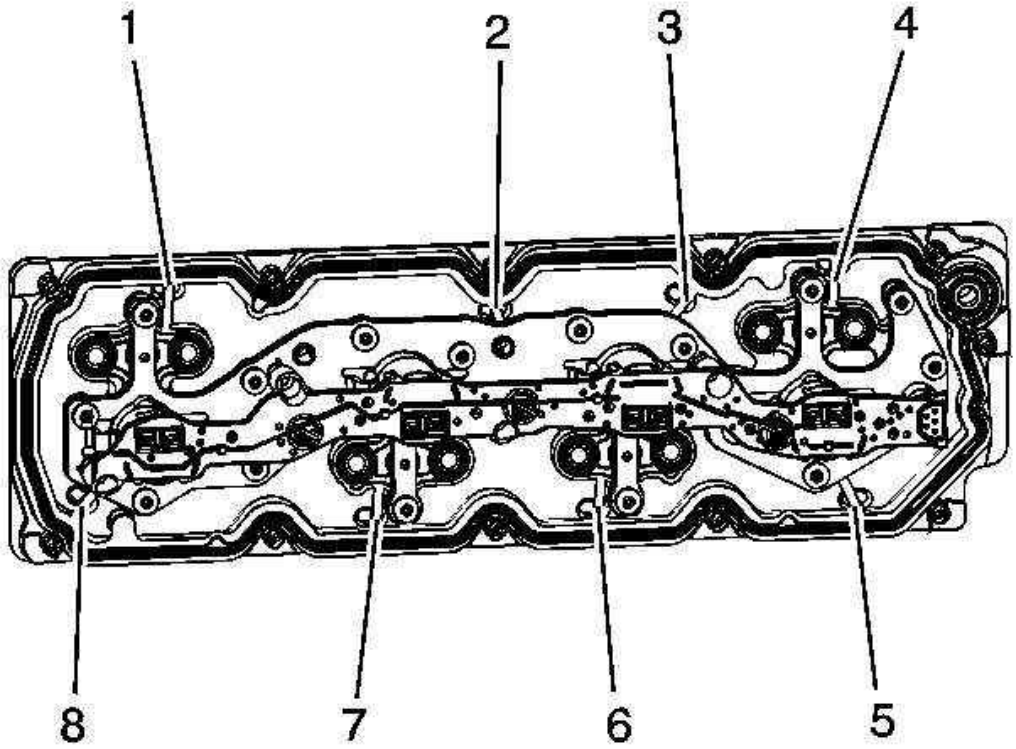


Fig. 90: View Of Eight Gasket Retaining Straps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove only the outer gasket from the manifold. Do not disassemble any of the internal components of the manifold in an attempt to remove the eight inner sealing gaskets. If the inner gaskets are cut or damaged, replace the manifold as an assembly. Only use a wire-cutter type tool in order to minimize the amount of debris. Do not use a rotary-type

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cutting tool on the retaining straps.

5. Identify the 8 gasket retaining strap locations (1-8).

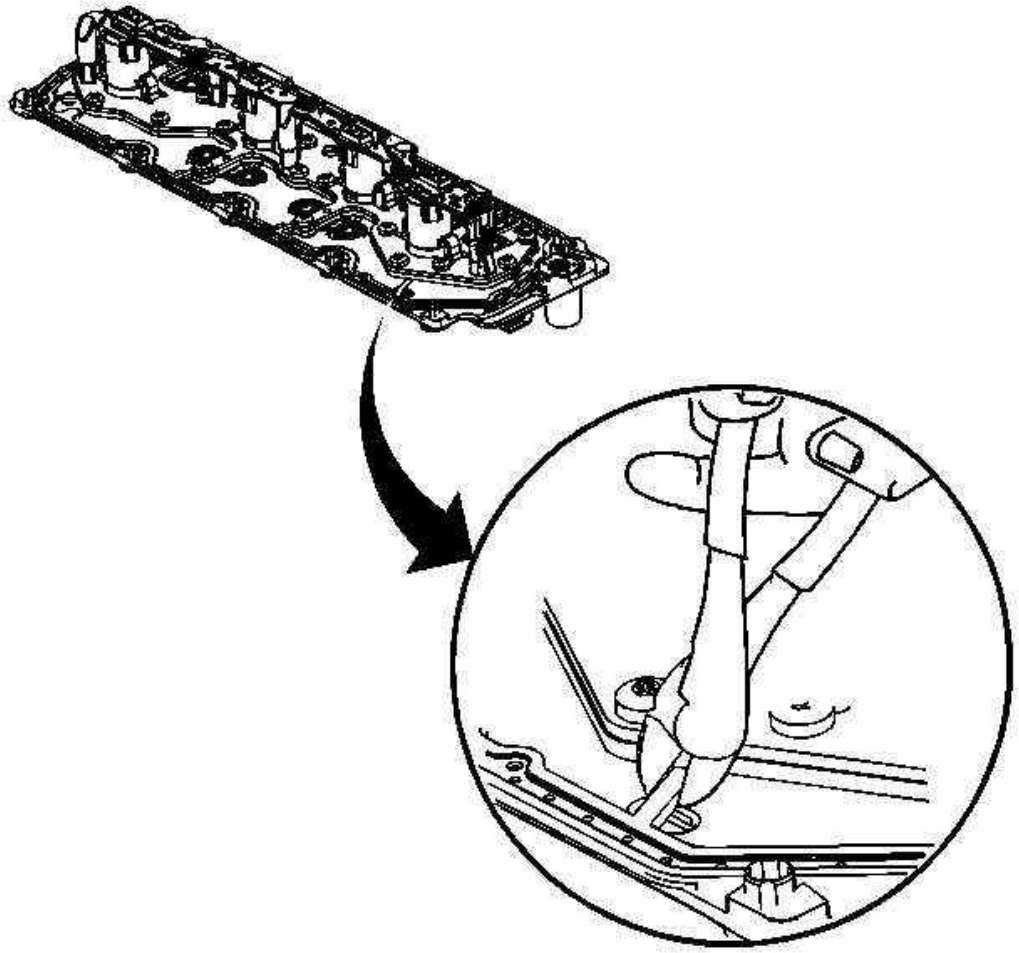


Fig. 91: Cutting Retaining Straps
Courtesy of GENERAL MOTORS CORP.

6. Using a wire-cutter type tool, snip the 8 retaining straps of the outer gasket.

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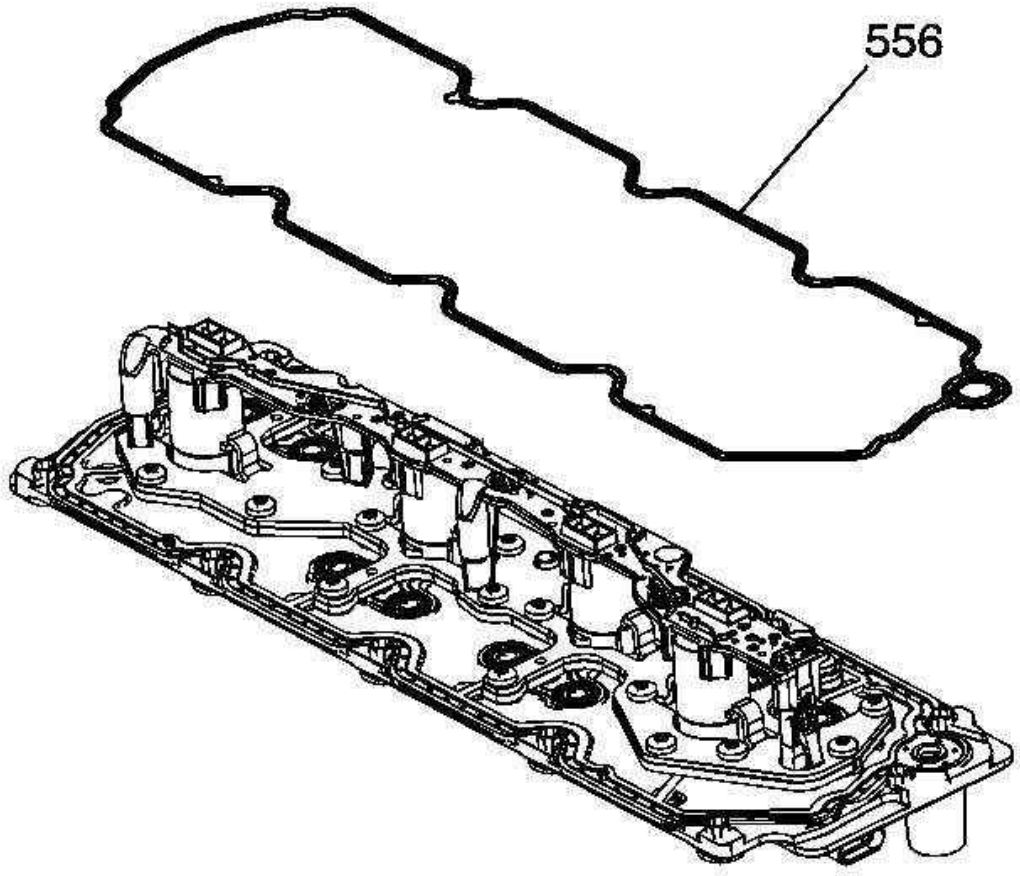


Fig. 92: Valve Lifter Oil Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the outer gasket (556) from the manifold.

Installation Procedure

IMPORTANT: All gasket surfaces should be free of oil or other foreign material during assembly.

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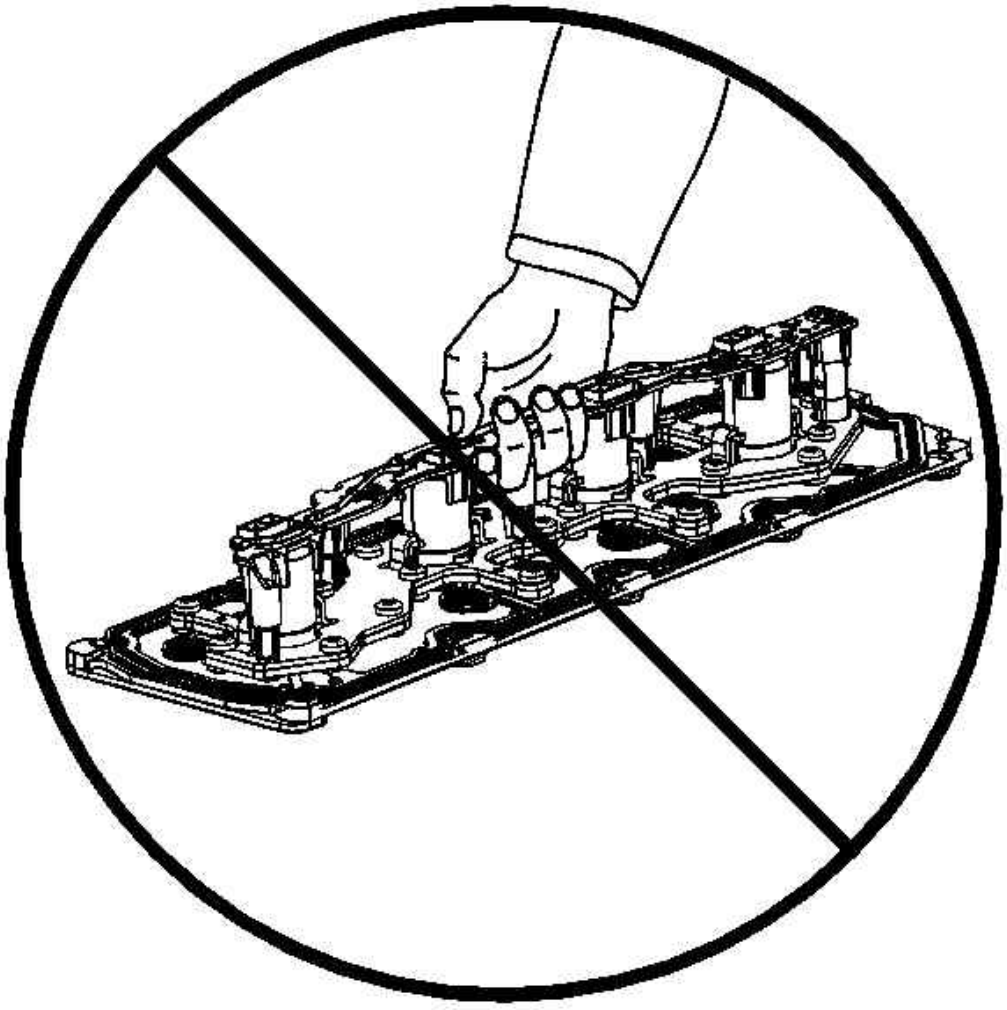


Fig. 93: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

1. Do not lift the manifold assembly by the electrical lead frame.

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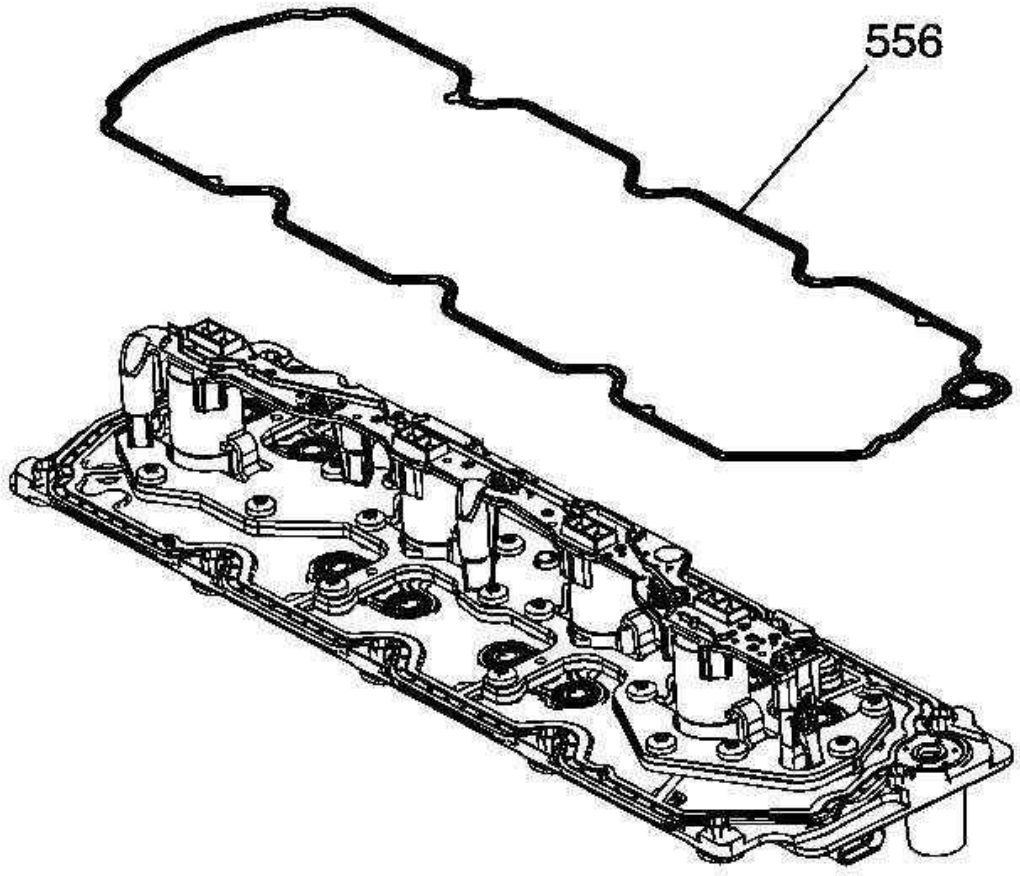


Fig. 94: Valve Lifter Oil Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the outer gasket (556) onto the manifold.

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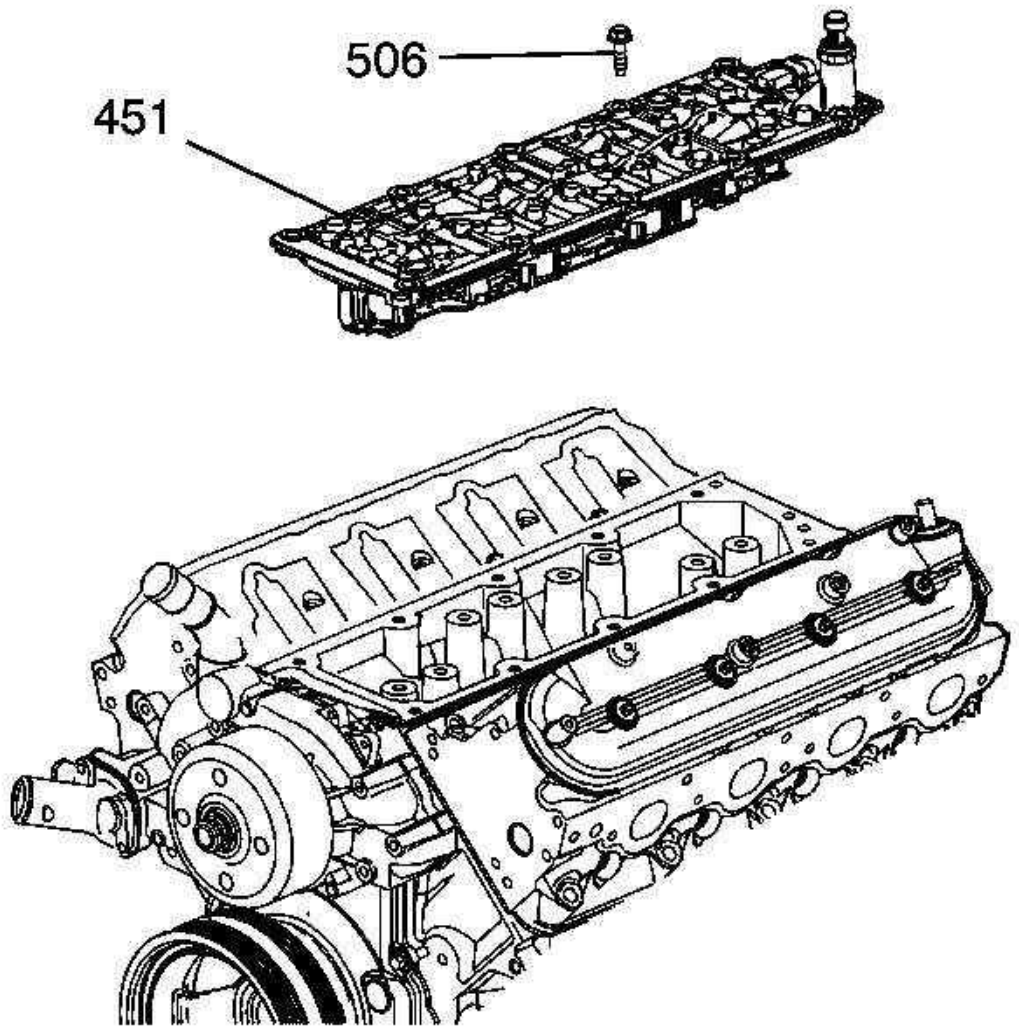


Fig. 95: View Of Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifter oil manifold (451).

NOTE: Refer to Fastener Notice .

4. Install the valve lifter oil manifold bolts (506).

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

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

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

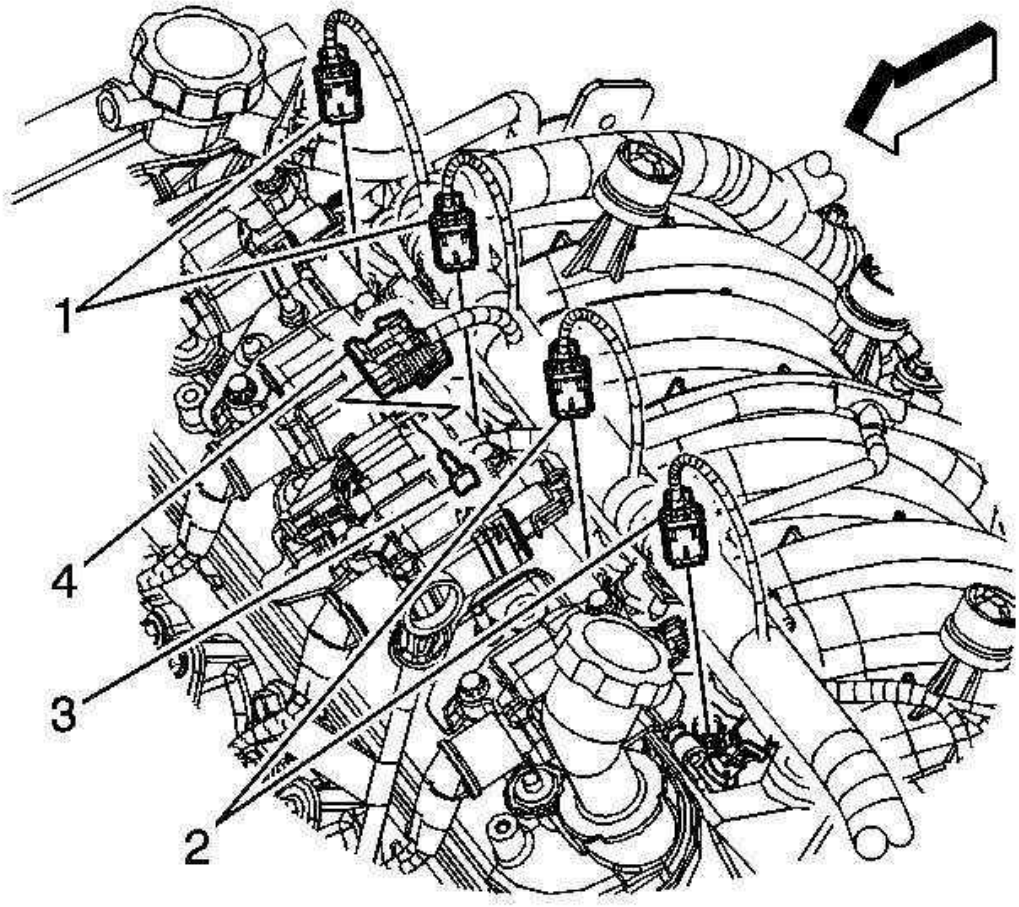


Fig. 96: View Of Ignition Coil Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield, if required. Refer to **Upper Intake Manifold Sight Shield Replacement**.

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2. Remove the connector position assurance (CPA) retainer (3).
3. Disconnect the ignition coil main electrical connector (4).
4. Reposition the engine harness, as necessary.

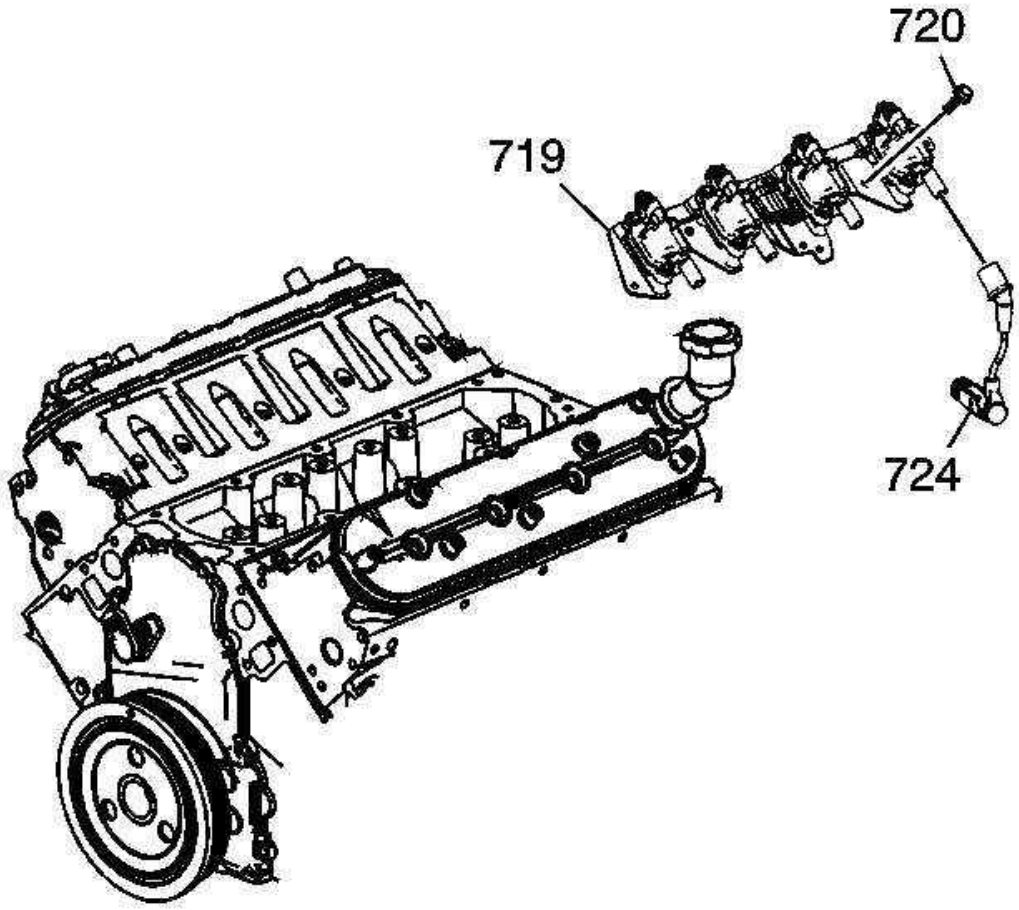


Fig. 97: View Of Ignition Coil & Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the spark plug wires (724) from the ignition coils.
    1. Twist each plug wire 1/2 turn.
    2. Pull only on the boot in order to remove the wire from the ignition coil.

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6. Remove the ignition coil bracket bolts (720).
7. Remove the ignition coil and bracket assembly (719).

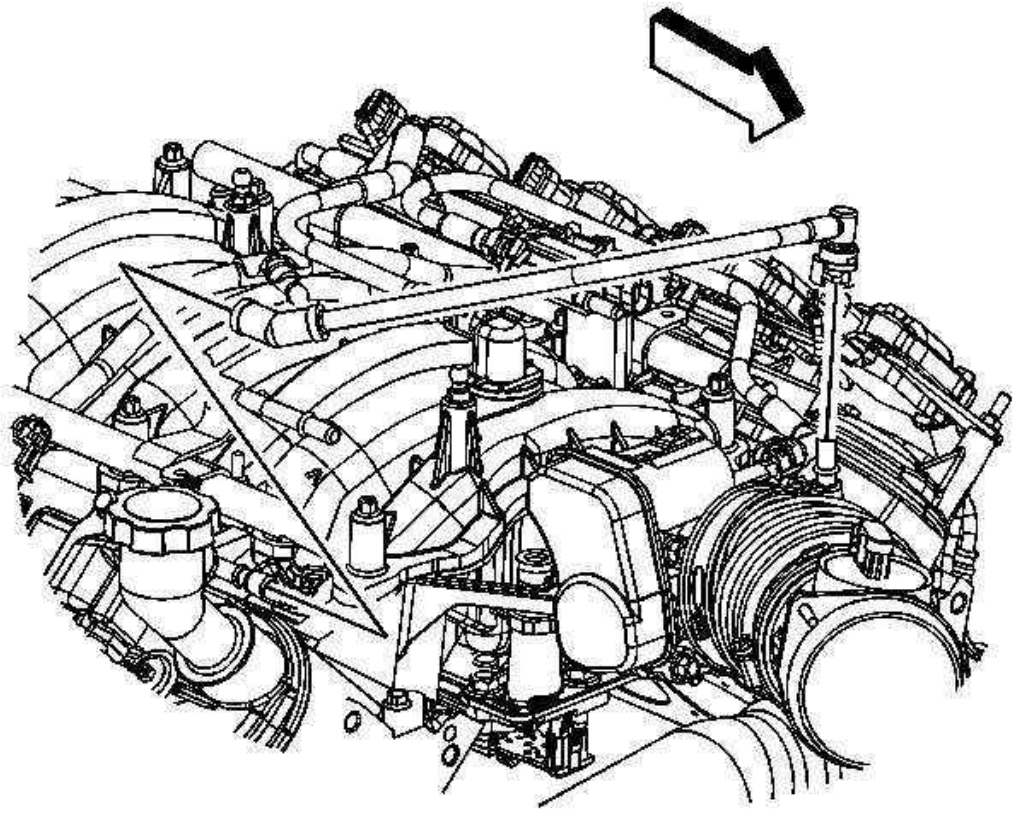


Fig. 98: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the positive crankcase ventilation (PCV) clean air tube from the valve rocker arm cover.

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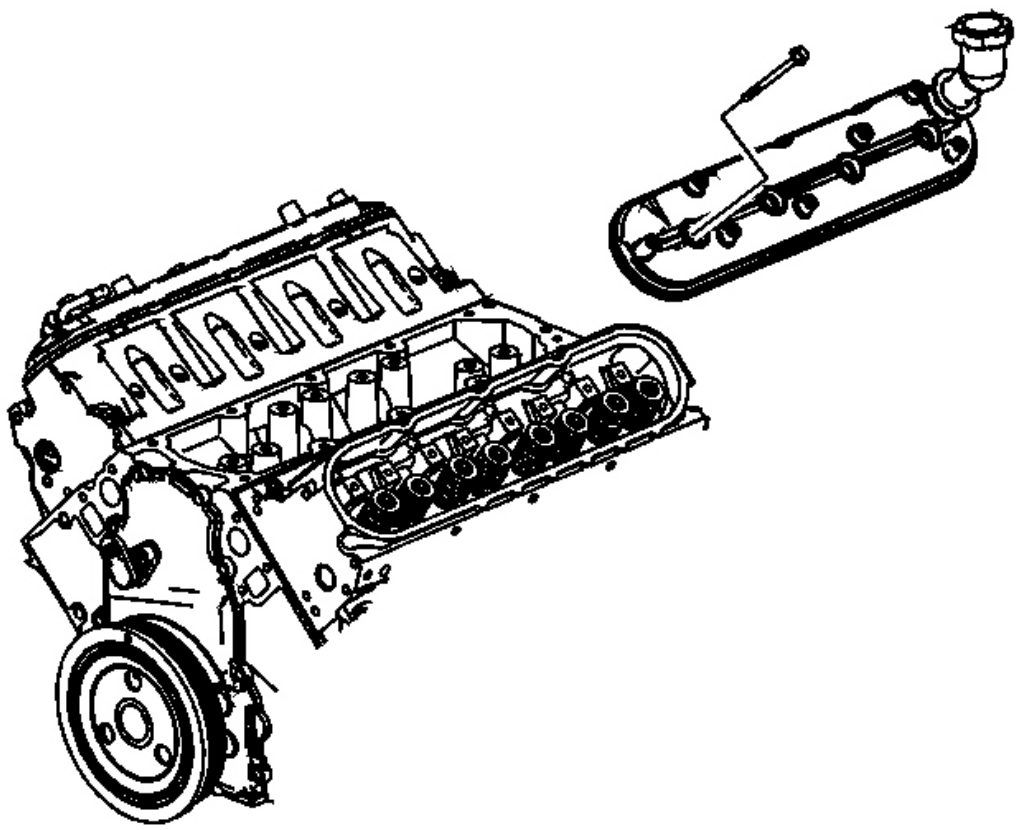


Fig. 99: View Of Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve rocker arm cover bolts and cover.

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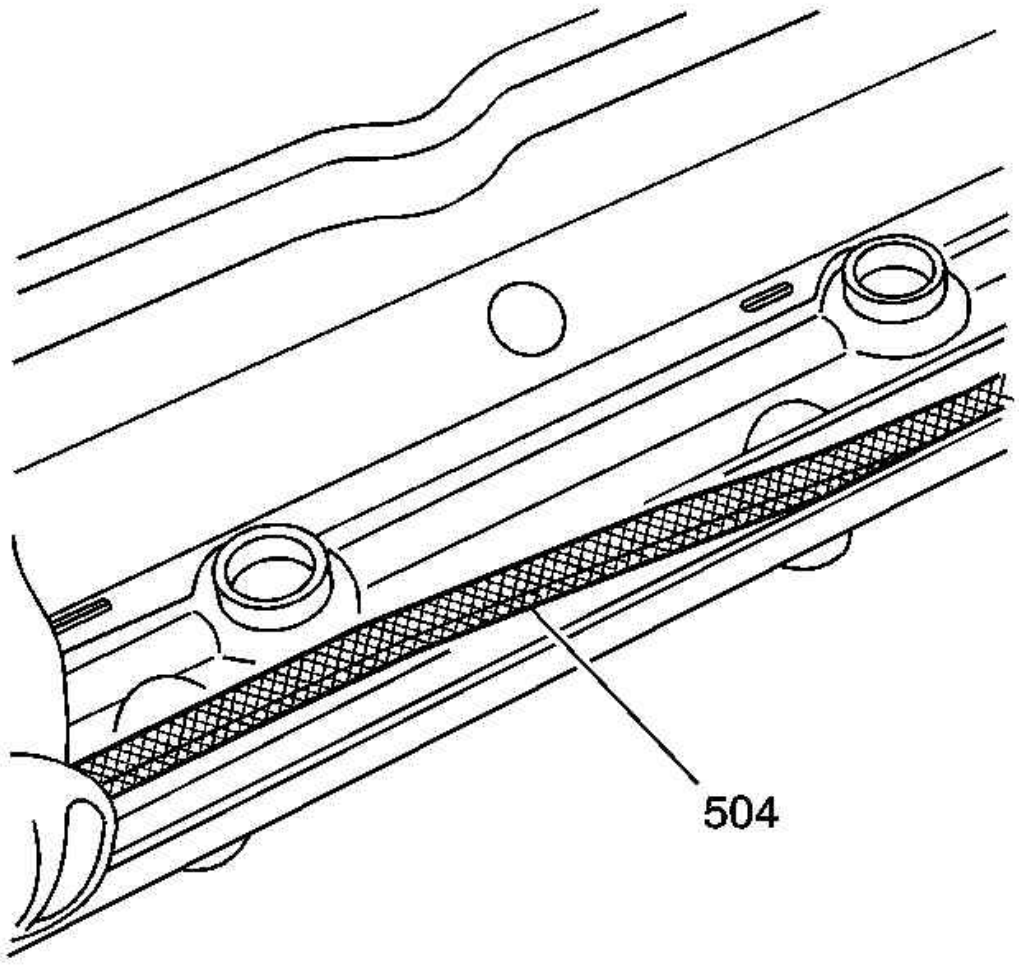


Fig. 100: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the old the gasket (504) from the valve rocker arm cover.
11. Remove the valve rocker arm cover bolt grommets, if cut or damaged.

IMPORTANT: Do not remove the oil fill tube from the rocker cover unless service is required. If the oil fill tube has been removed, install a NEW tube during assembly.

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12. Remove the oil fill cap from the oil fill tube, if necessary.
13. Remove the oil fill tube, if necessary.
14. Discard the oil fill tube, if necessary.

Installation Procedure

IMPORTANT:

- **All gasket surfaces should be free of oil an/or other foreign material during assembly.**
- **DO NOT reuse the valve rocker arm cover gasket.**
- **The valve rocker arm cover bolt grommets may be reused.**

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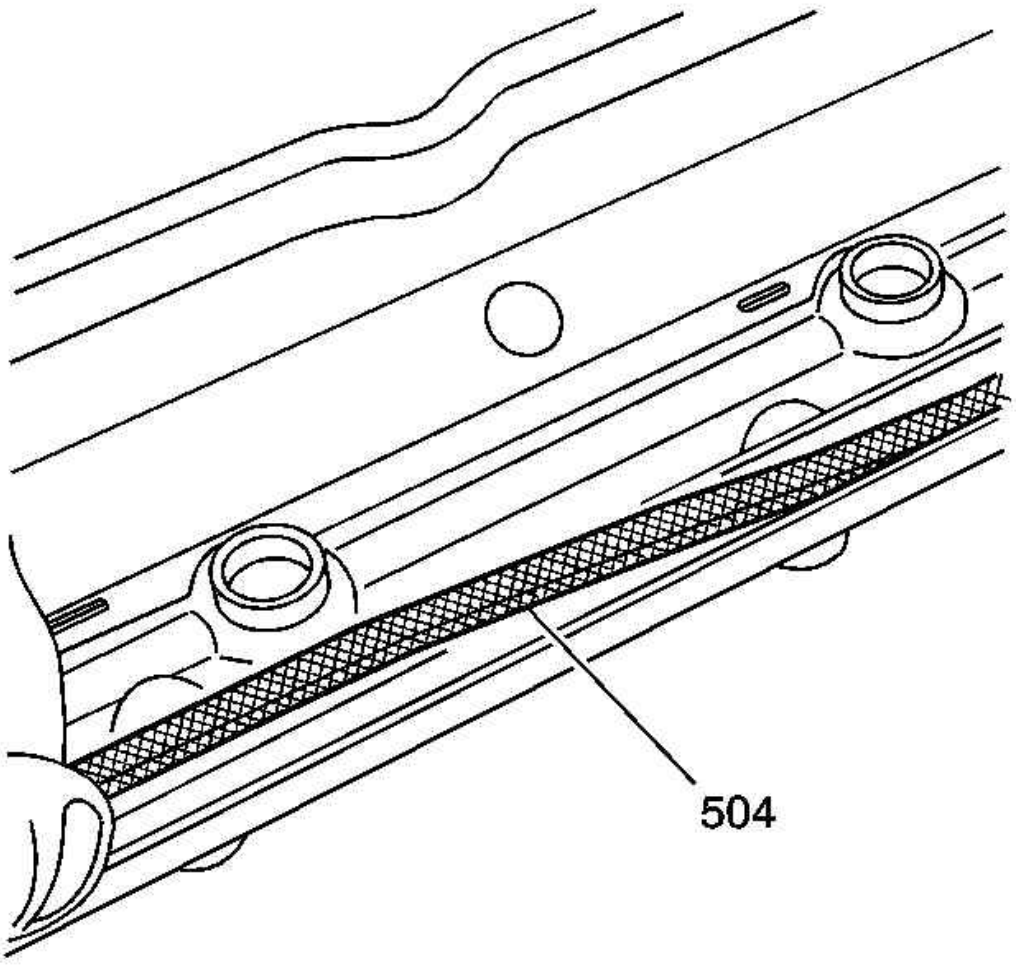


Fig. 101: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket (504) into the groove of the valve rocker arm cover.

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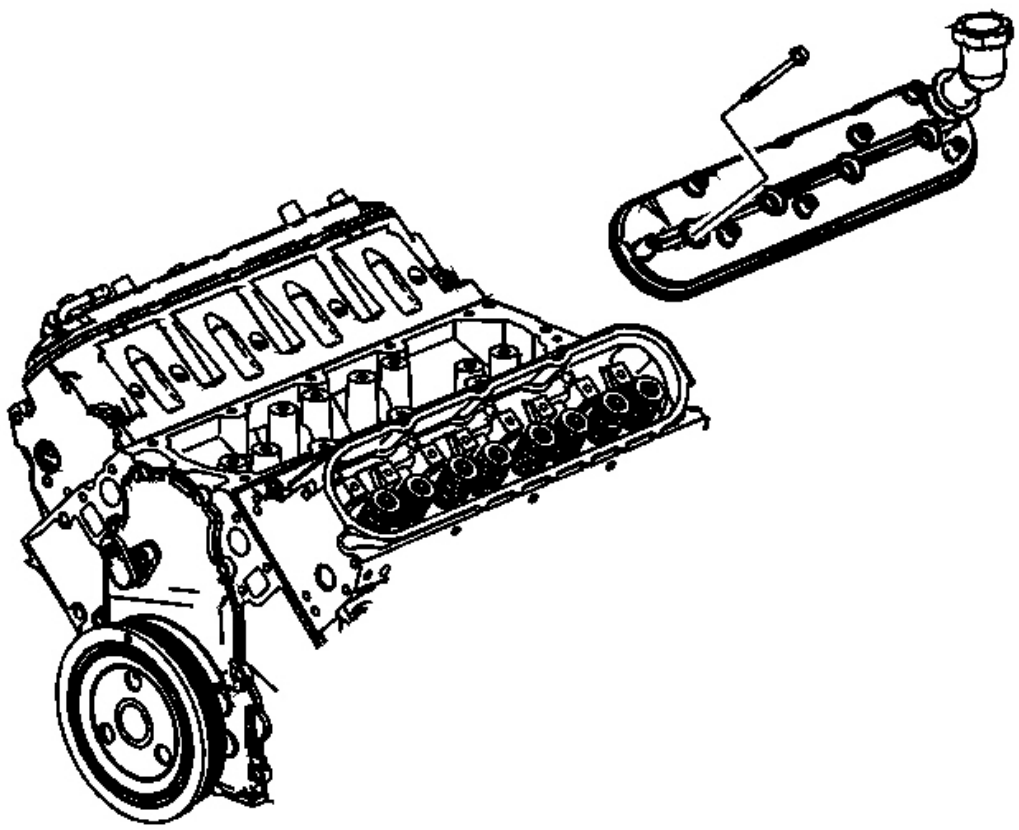


Fig. 102: View Of Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW oil fill tube to the valve rocker arm cover, if necessary.
3. Install NEW valve rocker arm cover bolt grommets, if necessary.

NOTE: Refer to Fastener Notice .

4. Install the valve rocker arm cover and bolts.

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

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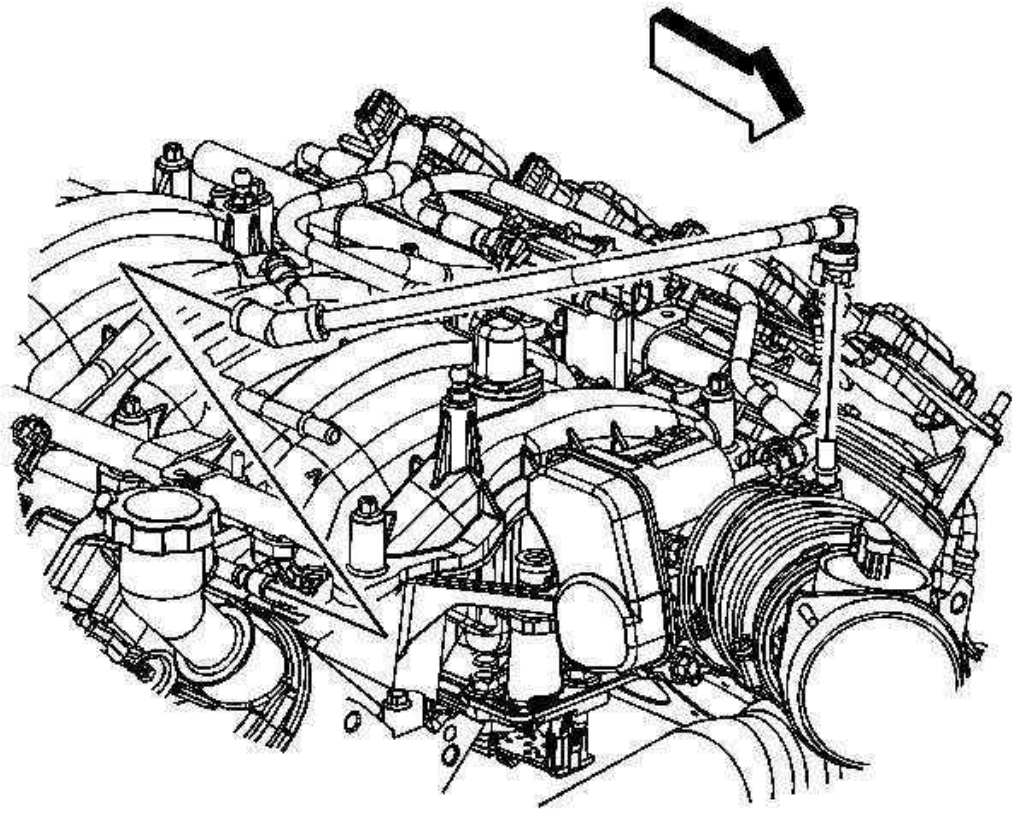


Fig. 103: View Of Positive Crankcase Ventilation (PCV) Clean Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Remove the positive crankcase ventilation (PCV) clean air tube from the valve rocker arm cover.

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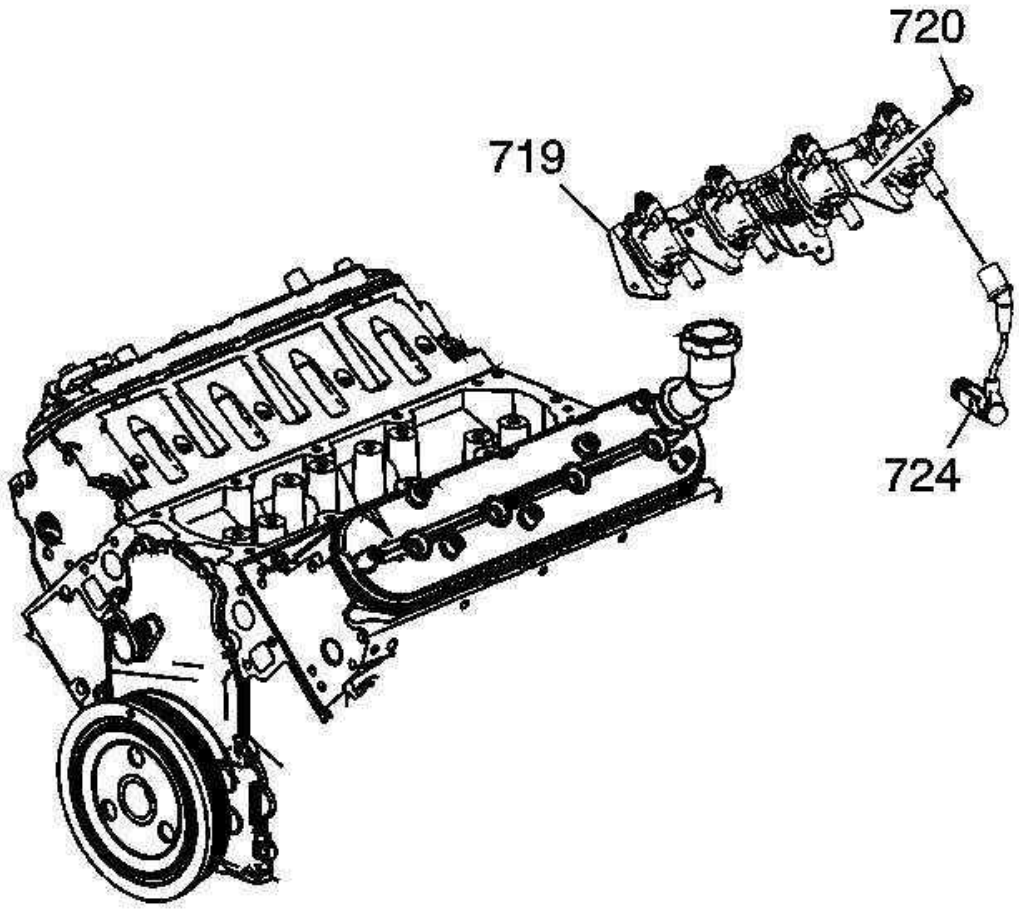


Fig. 104: View Of Ignition Coil & Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock to the threads of the ignition coil bracket bolts. Refer to **Sealers, Adhesives, and Lubricants**.
7. Install the ignition coil and bracket assembly.
8. Install the ignition coil bracket bolts.

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

9. Install the spark plug wires (724) to the ignition coils.

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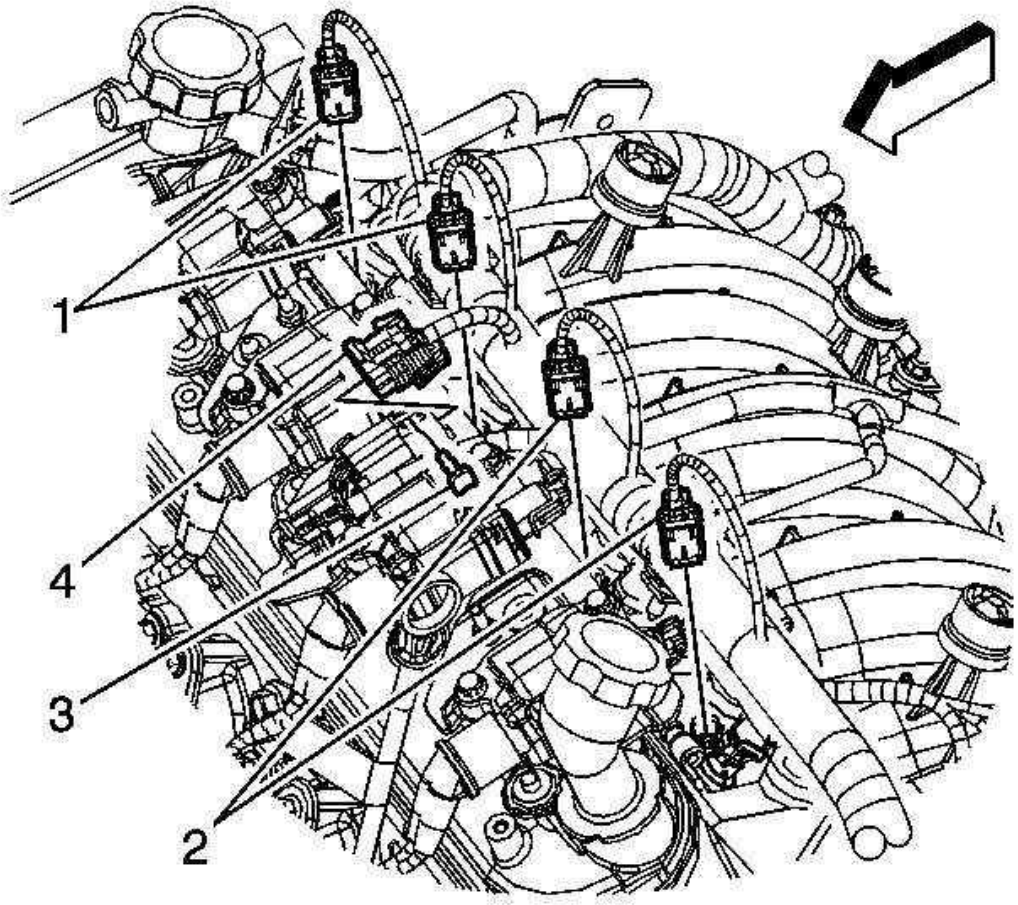


Fig. 105: View Of Ignition Coil Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

10. Position the engine harness, as necessary.
11. Connect the ignition coil main electrical connector (4).
12. Install the CPA retainer (3).
13. Install the engine sight shield, if required. Refer to **Upper Intake Manifold Sight Shield Replacement**.

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

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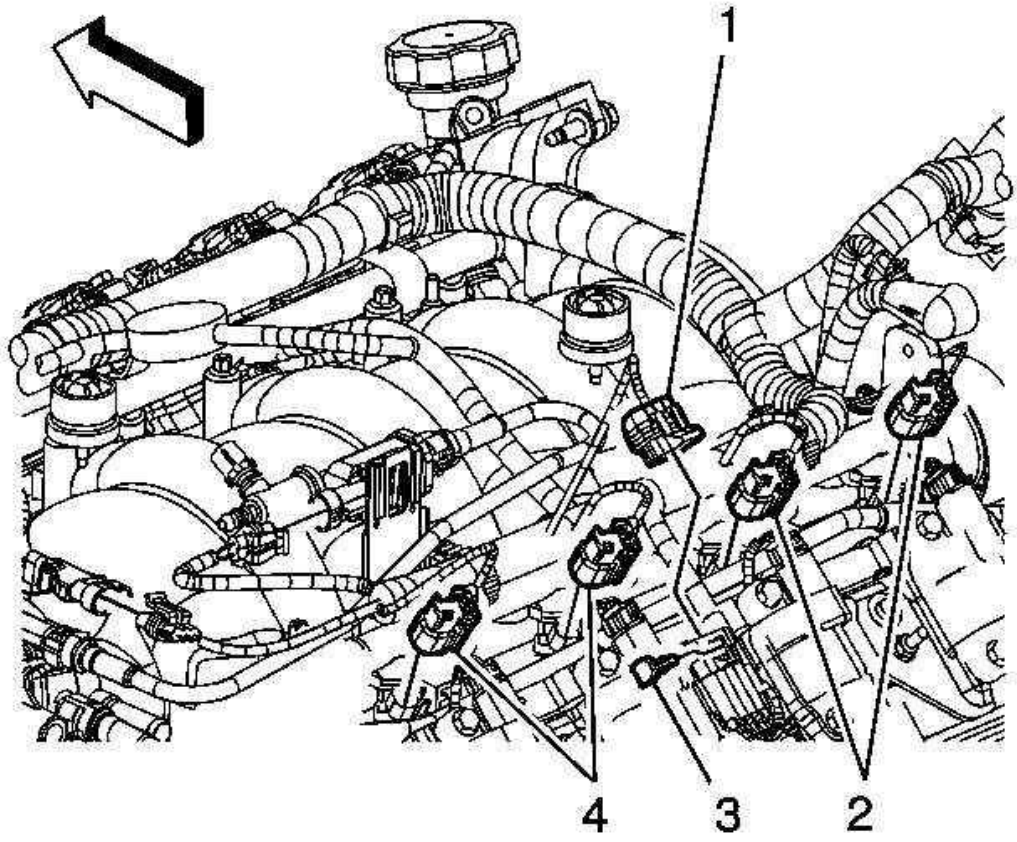


Fig. 106: View Of Ignition Coil Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield, if required. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. Remove the connector position assurance (CPA) retainer (3).
3. Disconnect the ignition coil main electrical connector (4).
4. Reposition the engine harness, if necessary.

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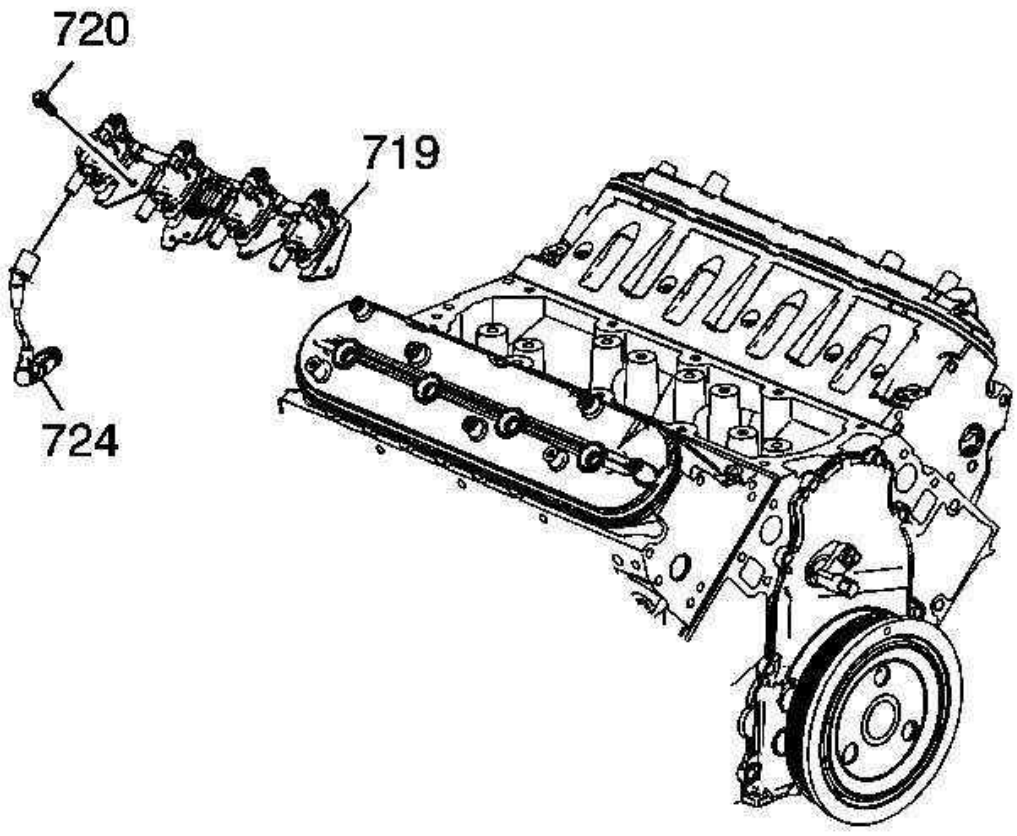


Fig. 107: View Of Ignition Coil And Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the spark plug wires (724) from the ignition coils.
    1. Twist each plug wire 1/2 turn.
    2. Pull only on the boot in order to remove the wire from the ignition coil.
6. Remove the ignition coil bracket bolts (720).
7. Remove the ignition coil and bracket assembly (719).

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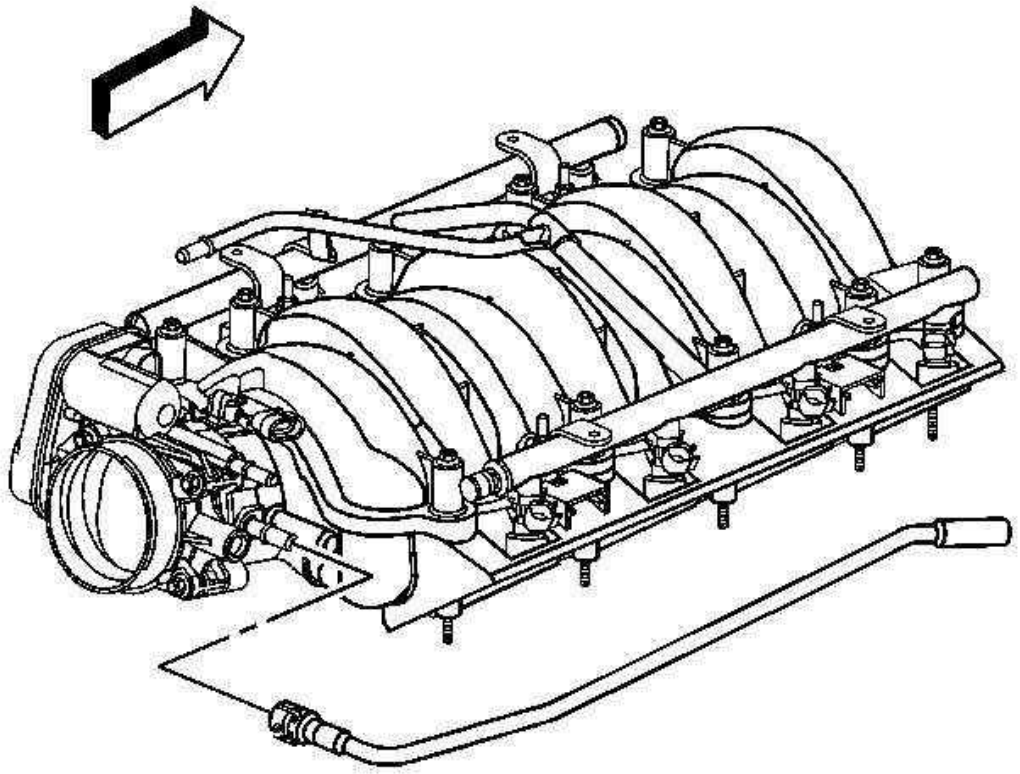


Fig. 108: View Of Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the positive crankcase ventilation (PCV) foul air hose from the intake manifold and valve rocker arm cover.

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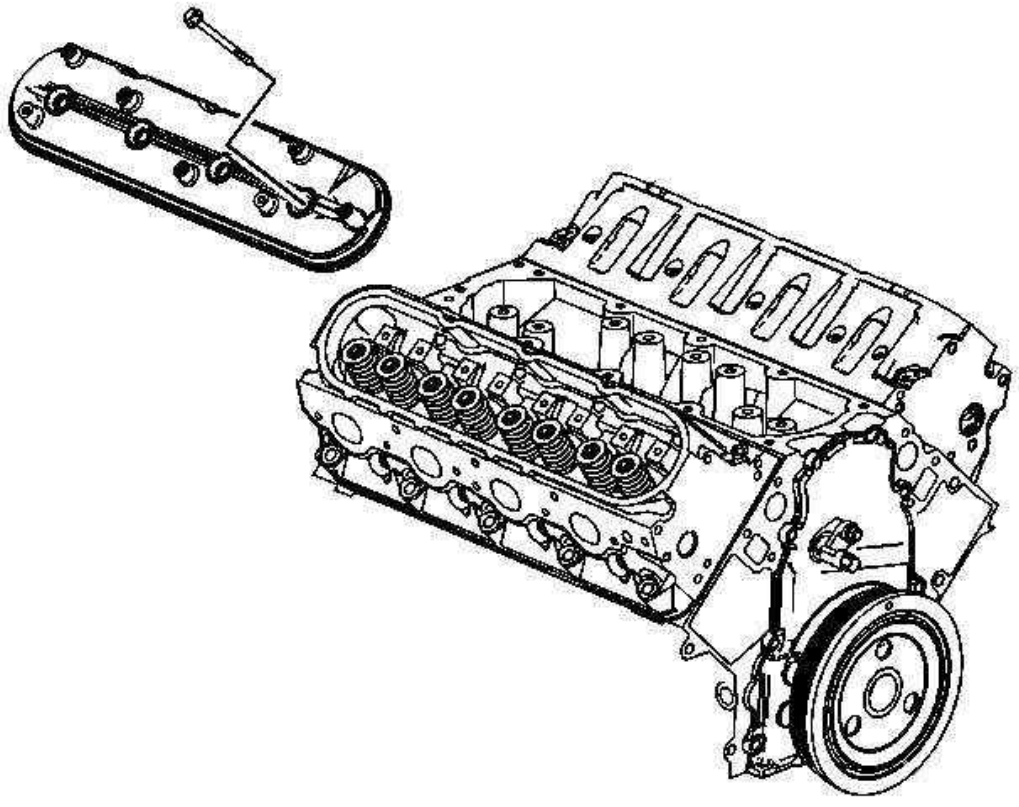


Fig. 109: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve rocker arm cover bolts and cover.

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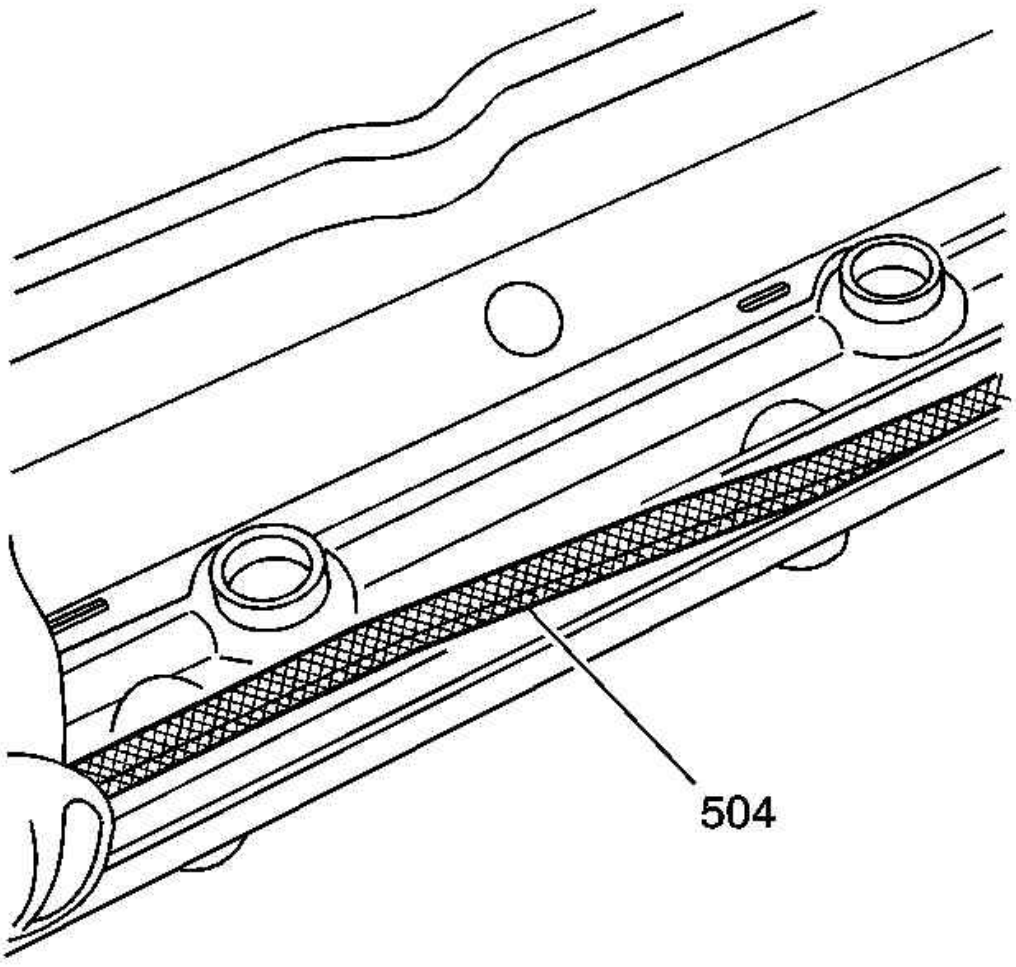


Fig. 110: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the old the gasket (504) from the valve rocker arm cover.
11. Remove the valve rocker arm cover bolt grommets, if cut or damaged.

Installation Procedure

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**

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- **DO NOT reuse the valve rocker arm cover gasket.**
- **The valve rocker arm cover bolt grommets may be reused.**

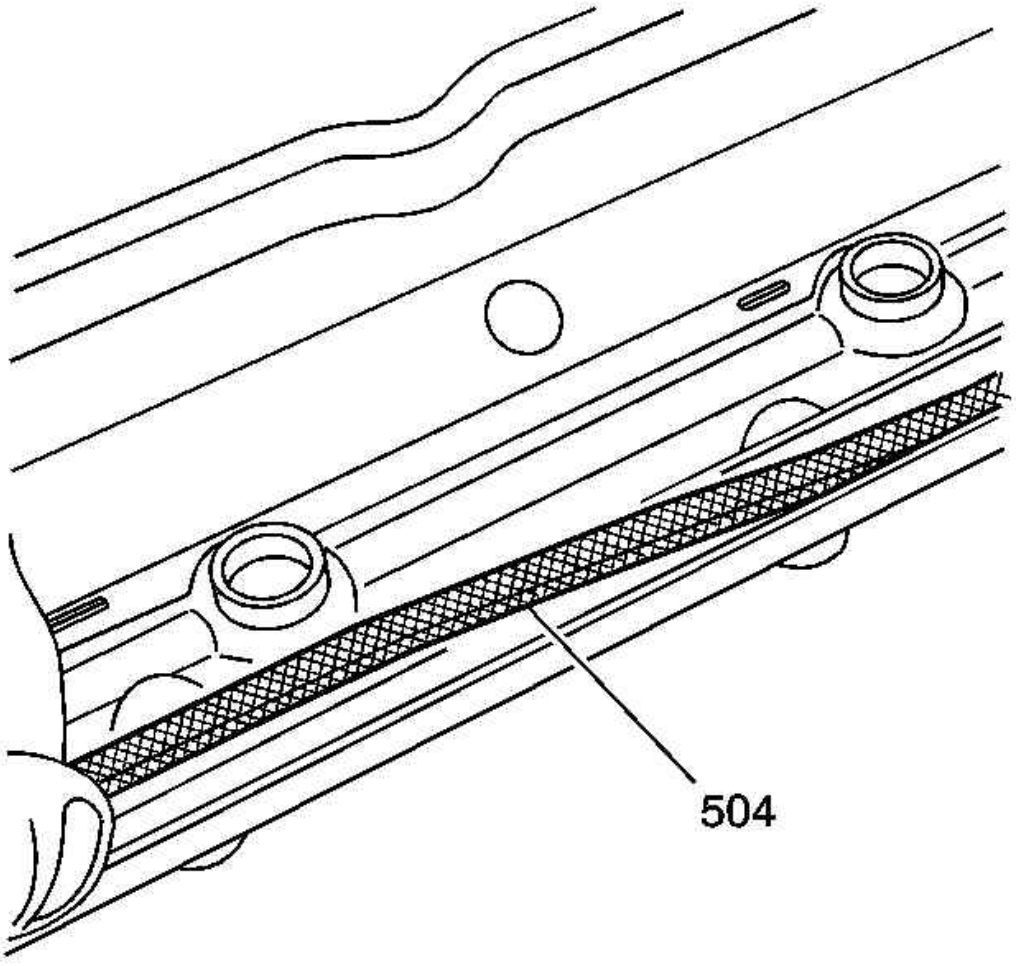


Fig. 111: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket (504) into the groove of the valve rocker arm cover.

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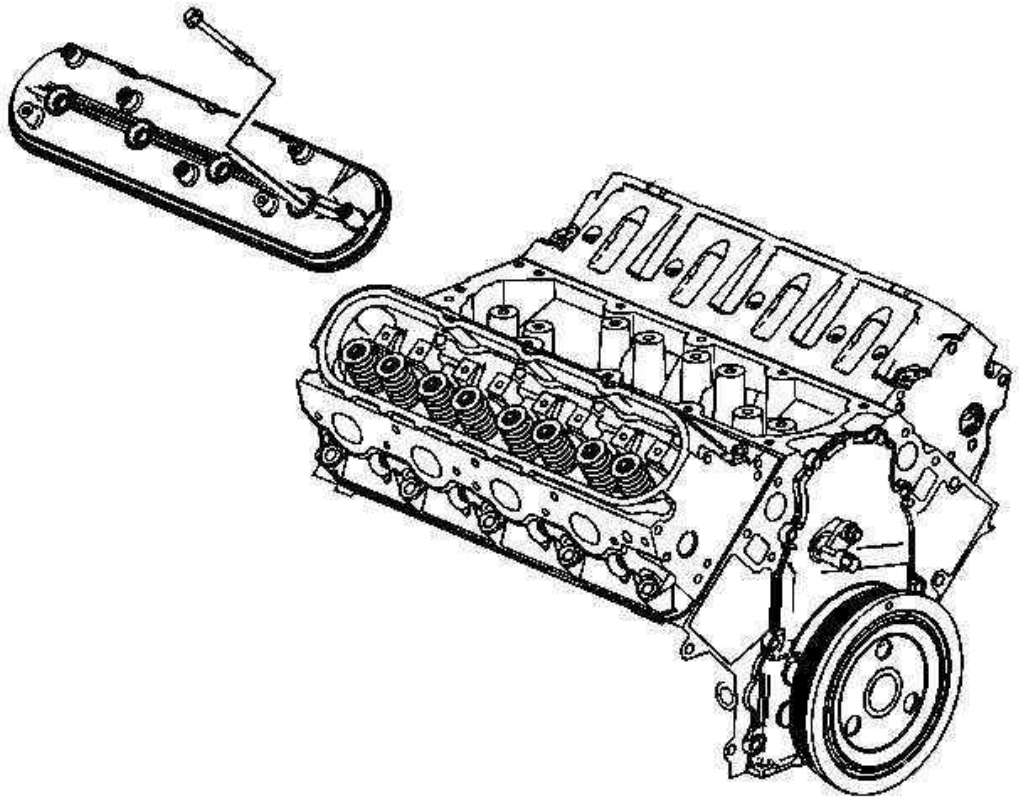


Fig. 112: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Install NEW valve rocker arm cover bolt grommets, if necessary.
3. Install the valve rocker arm cover and bolts.

NOTE: Refer to Fastener Notice .

4. Install the rocker arm cover bolts and grommets.

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

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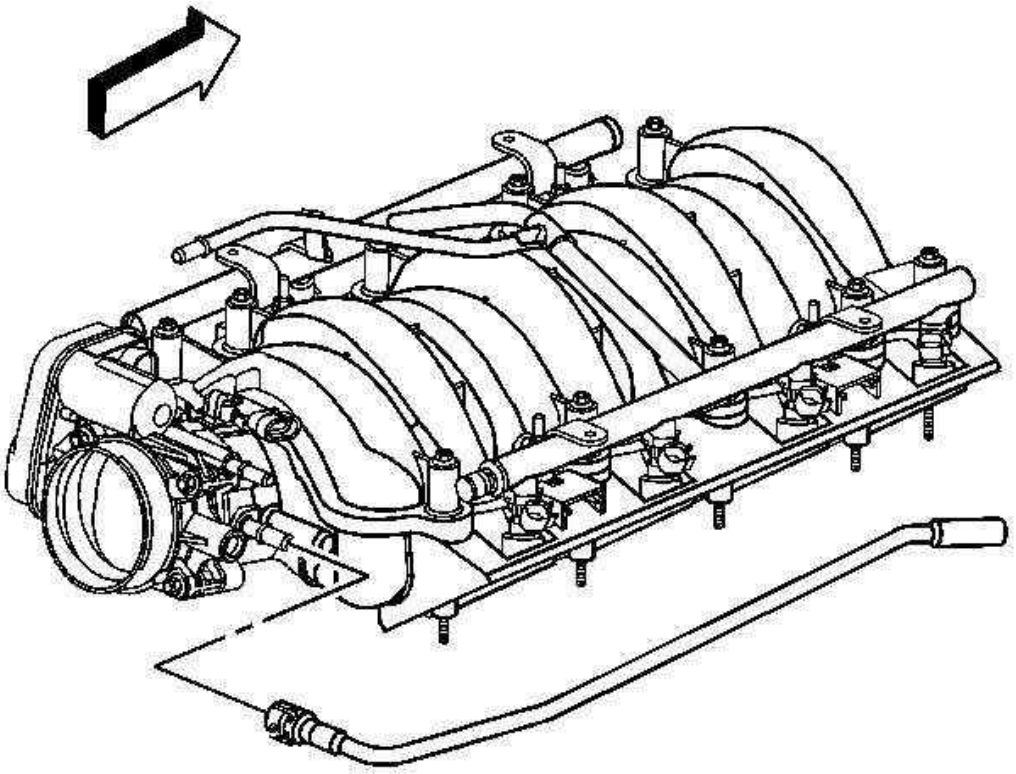


Fig. 113: View Of Positive Crankcase Ventilation (PCV) Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the PCV foul air hose to the intake manifold and valve rocker arm cover.

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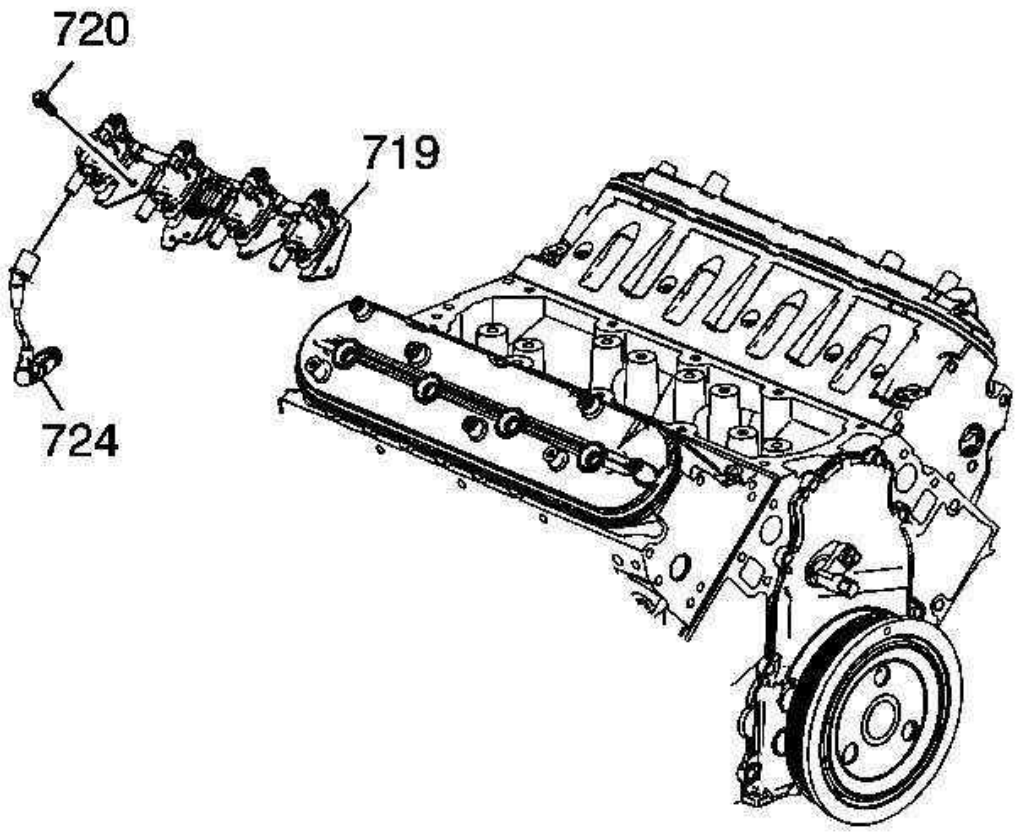


Fig. 114: View Of Ignition Coil And Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock to the threads of the ignition coil bracket bolts. Refer to **Sealers, Adhesives, and Lubricants**.
7. Install the ignition coil and bracket assembly (719).
8. Install the ignition coil bracket bolts (720).

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

9. Install the spark plug wires (724) from the ignition coils.

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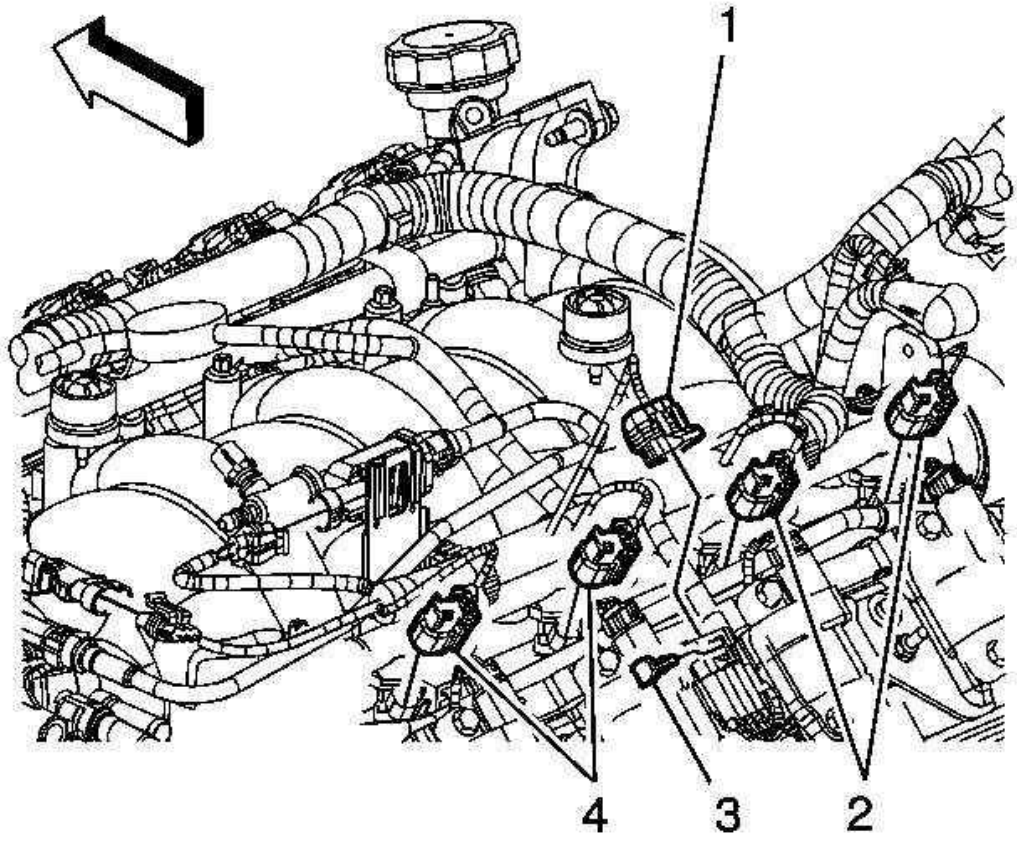


Fig. 115: View Of Ignition Coil Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

10. Position the engine harness, if necessary.
11. Connect the ignition coil main electrical connector (4).
12. Install the CPA retainer (3).
13. Install the engine sight shield, if required. Refer to **Upper Intake Manifold Sight Shield Replacement**.

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

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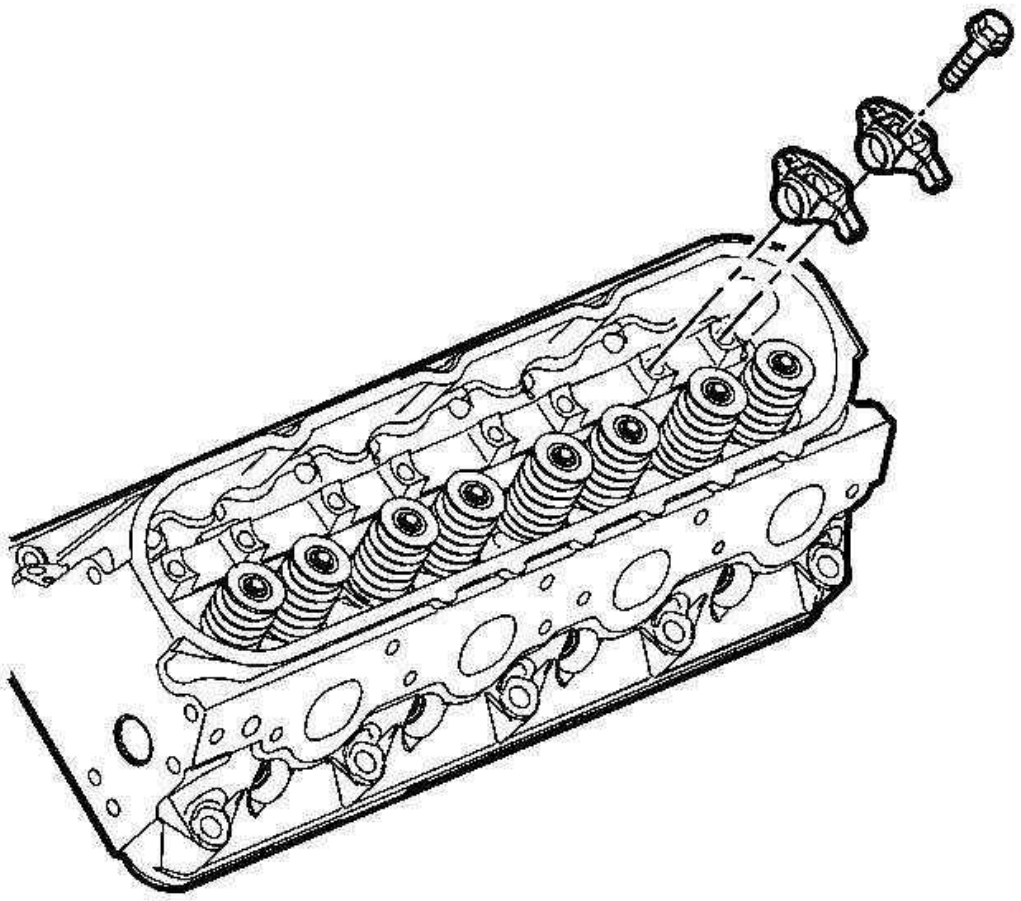


Fig. 116: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side** and/or **Valve Rocker Arm Cover Replacement - Right Side**.

IMPORTANT: Place the valve rocker arm, pushrod, and pivot support, in a rack so that the can be installed in the same location from which they were removed.

2. Remove the valve rocker arm bolt.

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3. Remove the valve rocker arm.

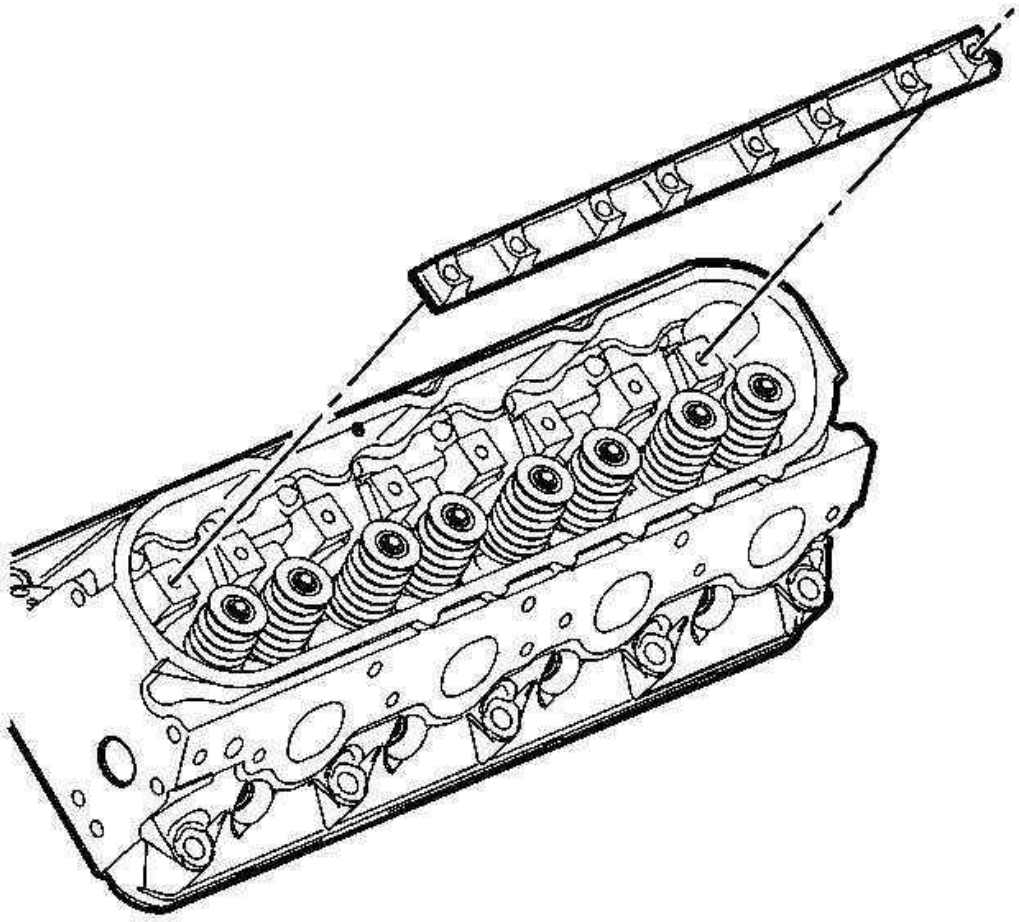


Fig. 117: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm pivot support.

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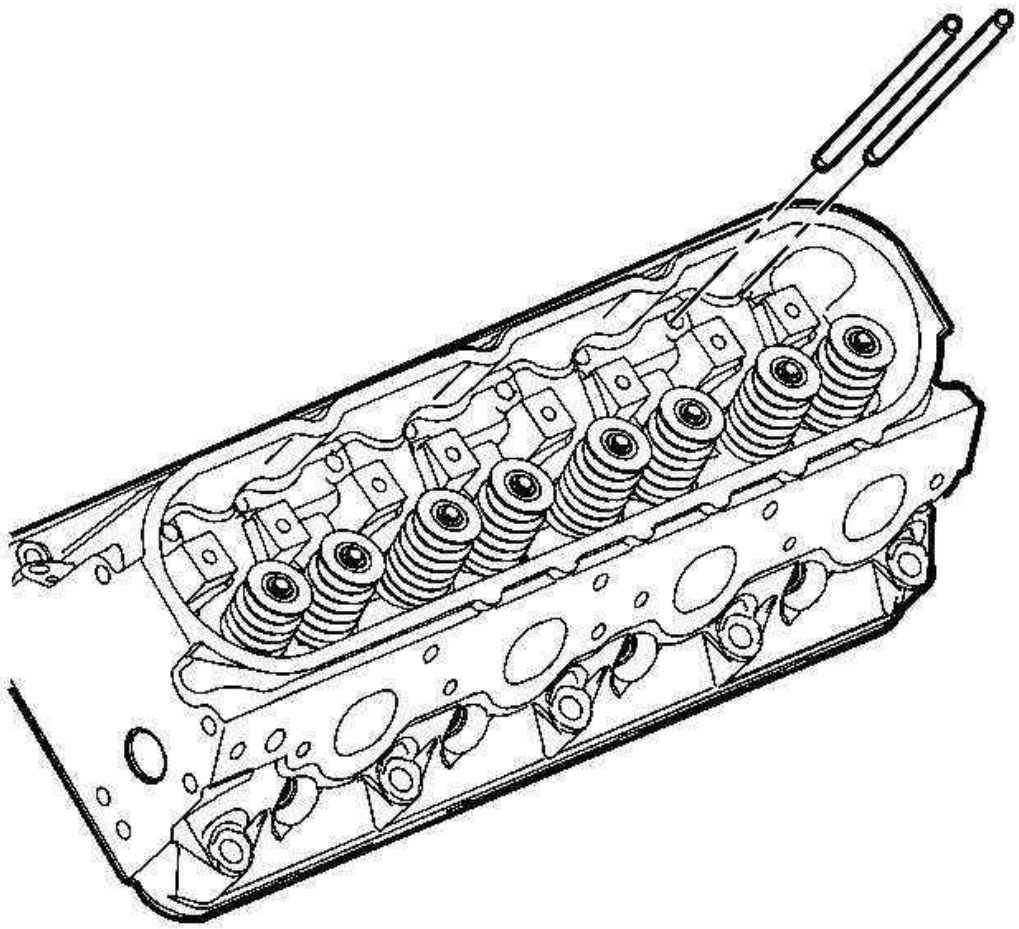


Fig. 118: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

5. Remove the pushrod.
6. Clean and inspect the valve rocker arm and pushrod. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

IMPORTANT:

- **When reusing the valve train components, always install the components to their original location and**

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position.

- **Valve lash is net build, no valve adjustment is required.**

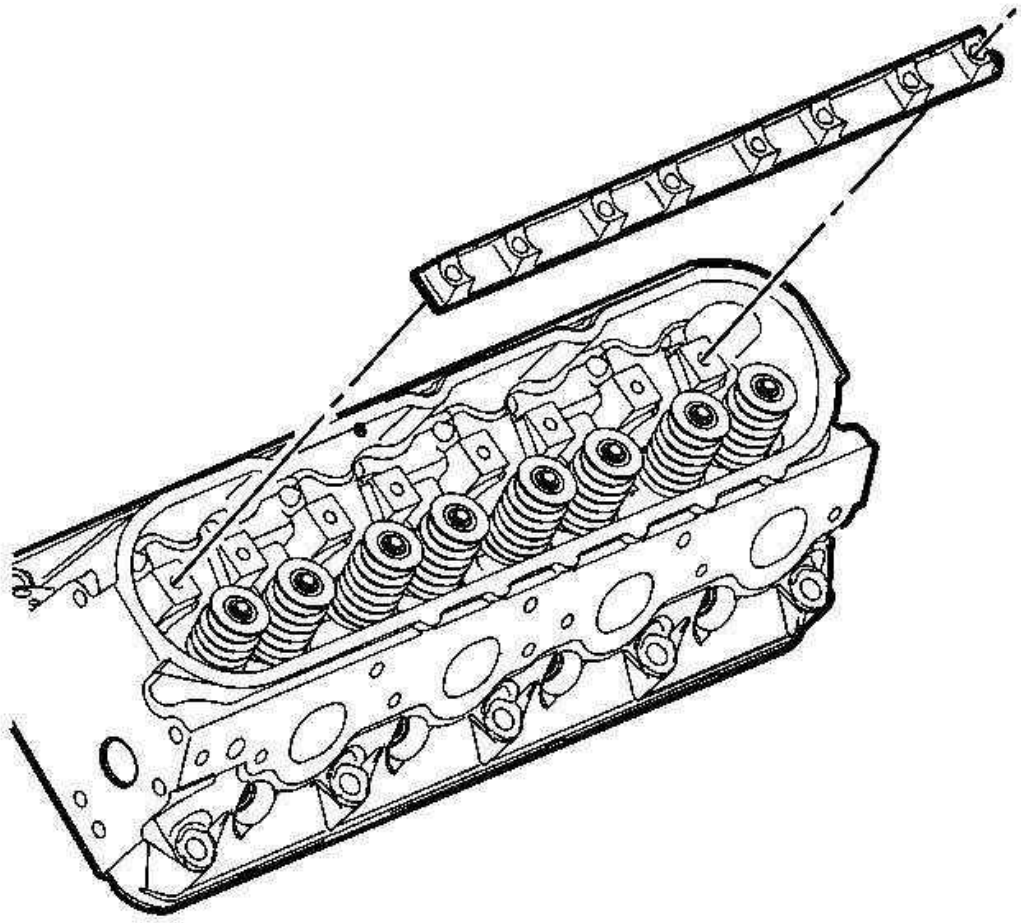


Fig. 119: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve rocker arm and pushrod with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolt with clean engine oil.
3. Install the valve rocker arm pivot support.

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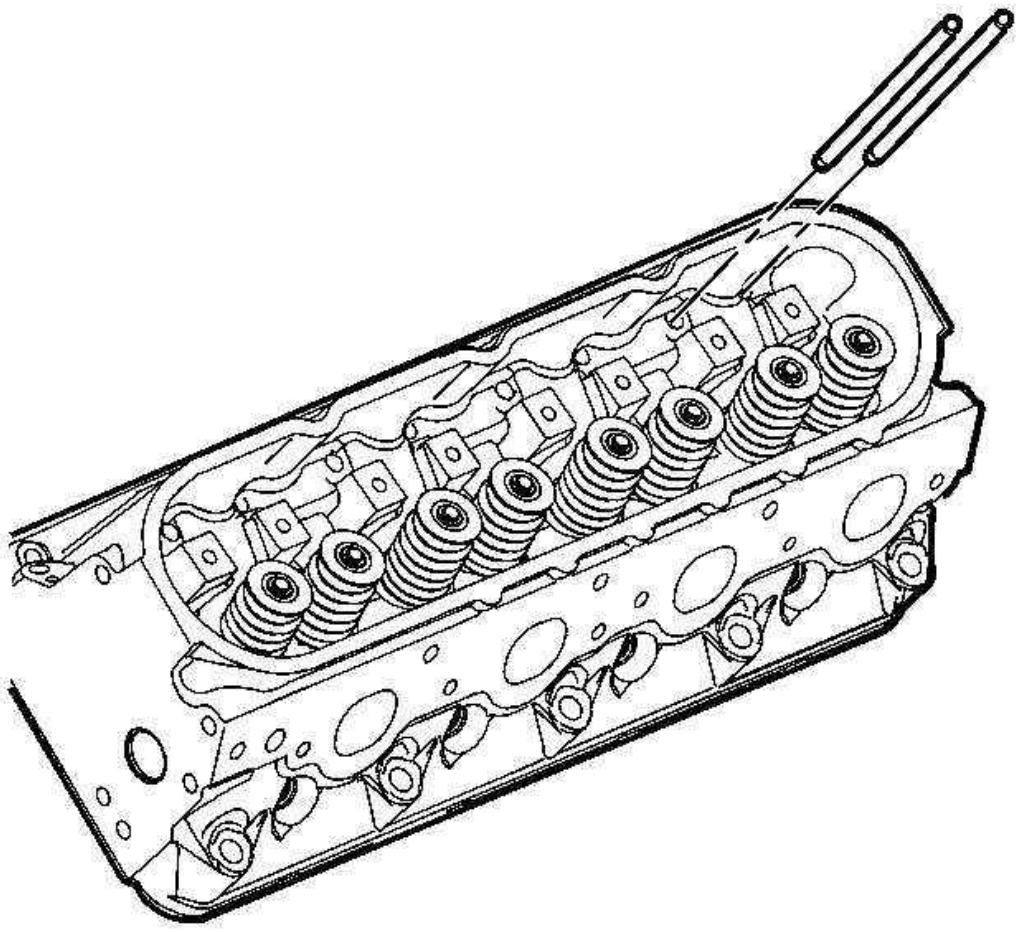


Fig. 120: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that the pushrod seats properly to the valve lifter socket.

4. Install the pushrod.

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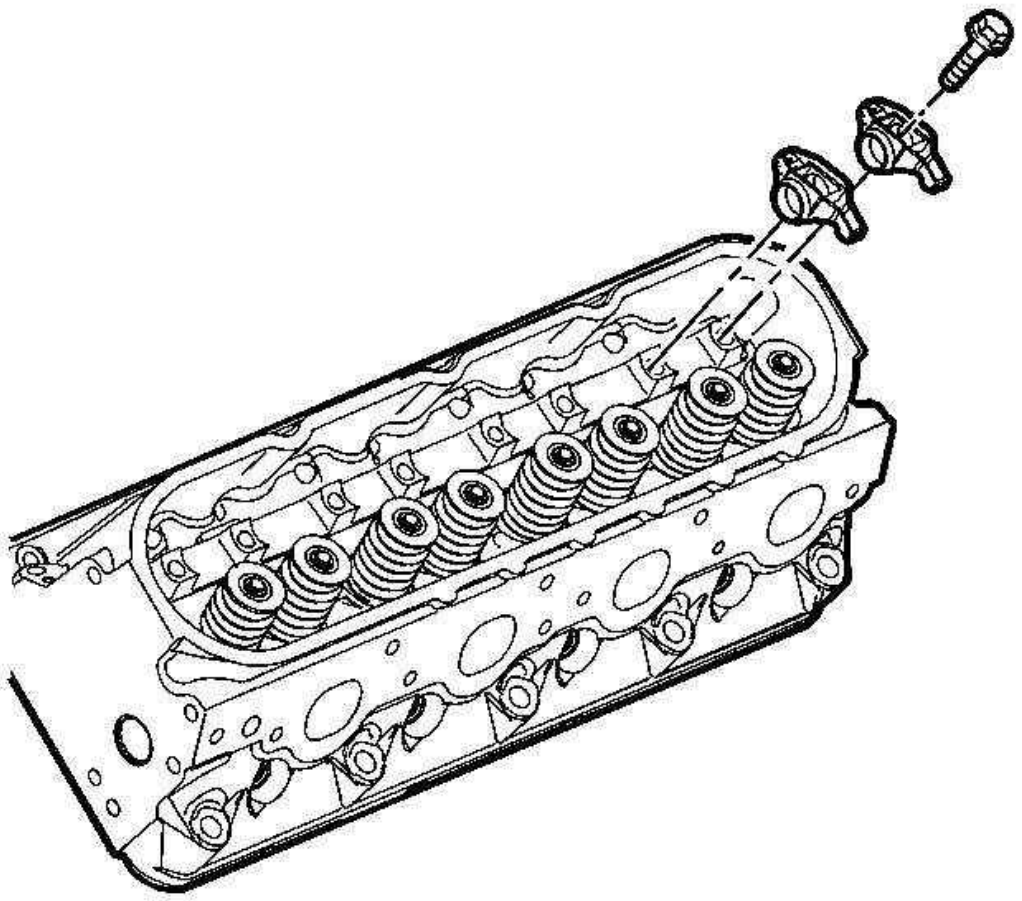


Fig. 121: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the pushrod seat properly to the ends of the rocker arm. DO NOT tighten the rocker arm bolt at this time.

5. Install the rocker arm and bolt.
6. Rotate the crankshaft until the number one piston is at top dead center (TDC) of the compression stroke. In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30

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position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

Cylinders 1, 3, 5, and 7 are the left bank.

Cylinder 2, 4, 6, and 8 are the right bank.

NOTE: Refer to Fastener Notice .

7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

   Tighten:
   - Tighten cylinders 1, 2, 7, and 8 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
   - Tighten cylinders 1, 3, 4, and 5 intake valve rocker arm bolts to 30 N.m (22 lb ft).

8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

   Tighten:
   - Tighten cylinders 3, 4, 5, and 6 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
   - Tighten cylinders 2, 6, 7, and 8 intake valve rocker arm bolts to 30 N.m (22 lb ft).

10. Install the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side** and/or **Valve Rocker Arm Cover Replacement - Right Side**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **J 22794** Spark Plug Port Adapter. See **Special Tools**.

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- **J 38606** Valve Spring Compressor. See **Special Tools**.

Removal Procedure

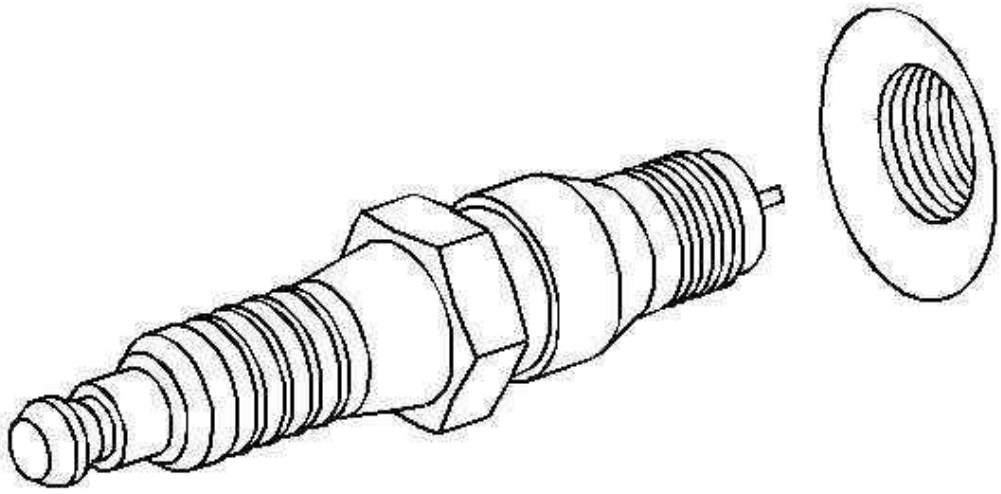


Fig. 122: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.

IMPORTANT: Remove the spark plugs from the cylinder head with the engine at room temperature.

2. Loosen the spark plug 1 or 2 turns.
3. Brush or air blast away any dirt or debris from around the spark plug.
4. Remove the spark plug.

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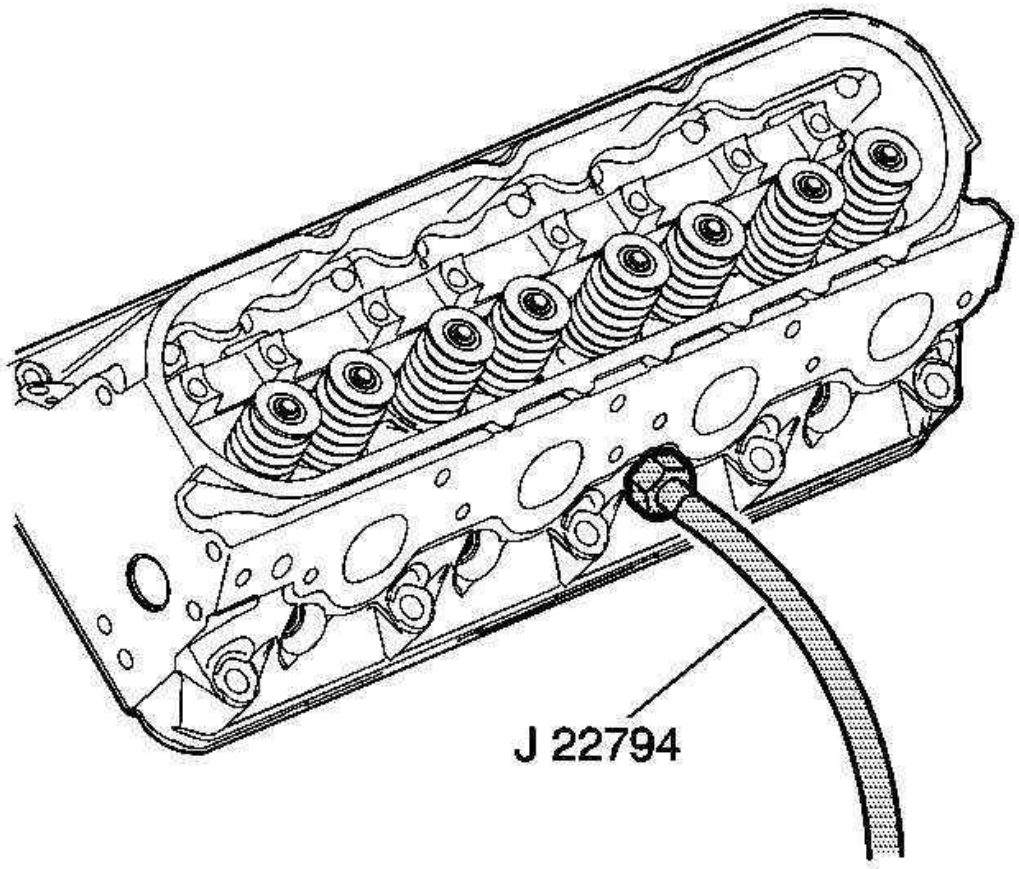


Fig. 123: Applying Compressed Air To J 22794
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 22794** into the spark plug hole. See **Special Tools**.
6. Attach an air hose to the **J 22794** . See **Special Tools**.
7. Apply compressed air to the **J 22794** in order to hold the valves in place. See **Special Tools**.

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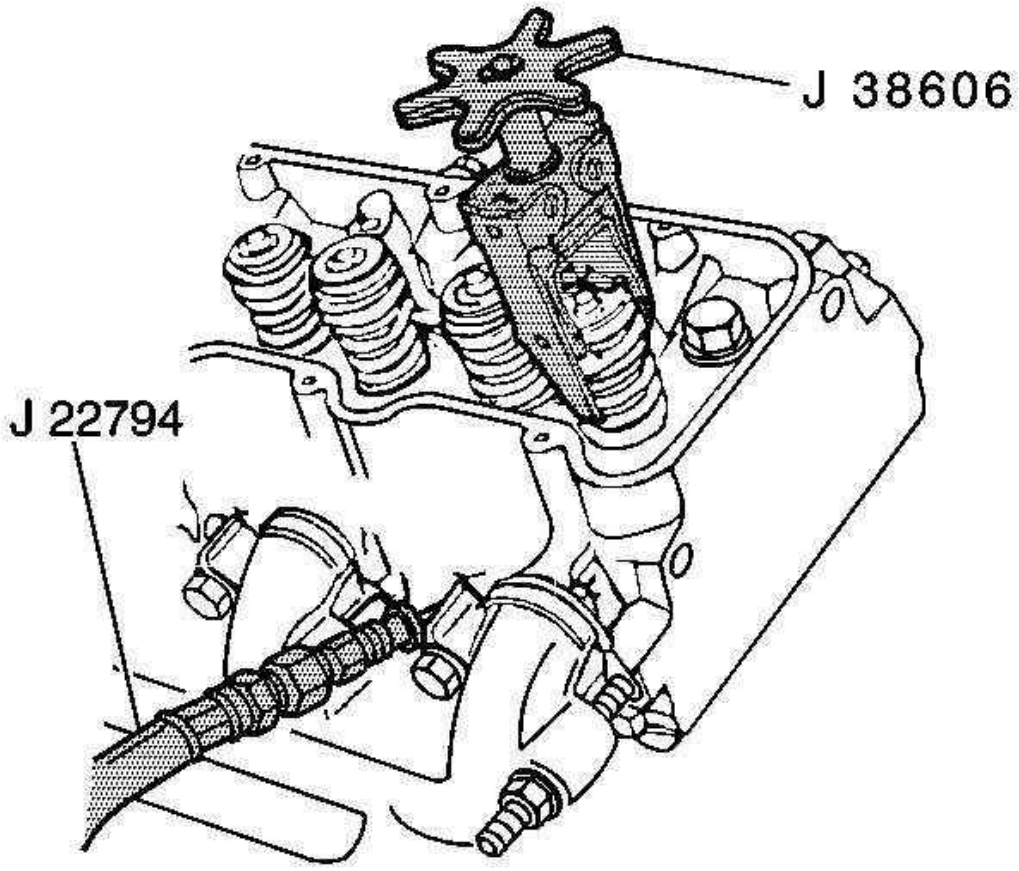


Fig. 124: Using J 38606 & J 5892-D To Remove Valve Spring
Courtesy of GENERAL MOTORS CORP.

8. Using the **J 38606** compress the valve spring. See **Special Tools**.

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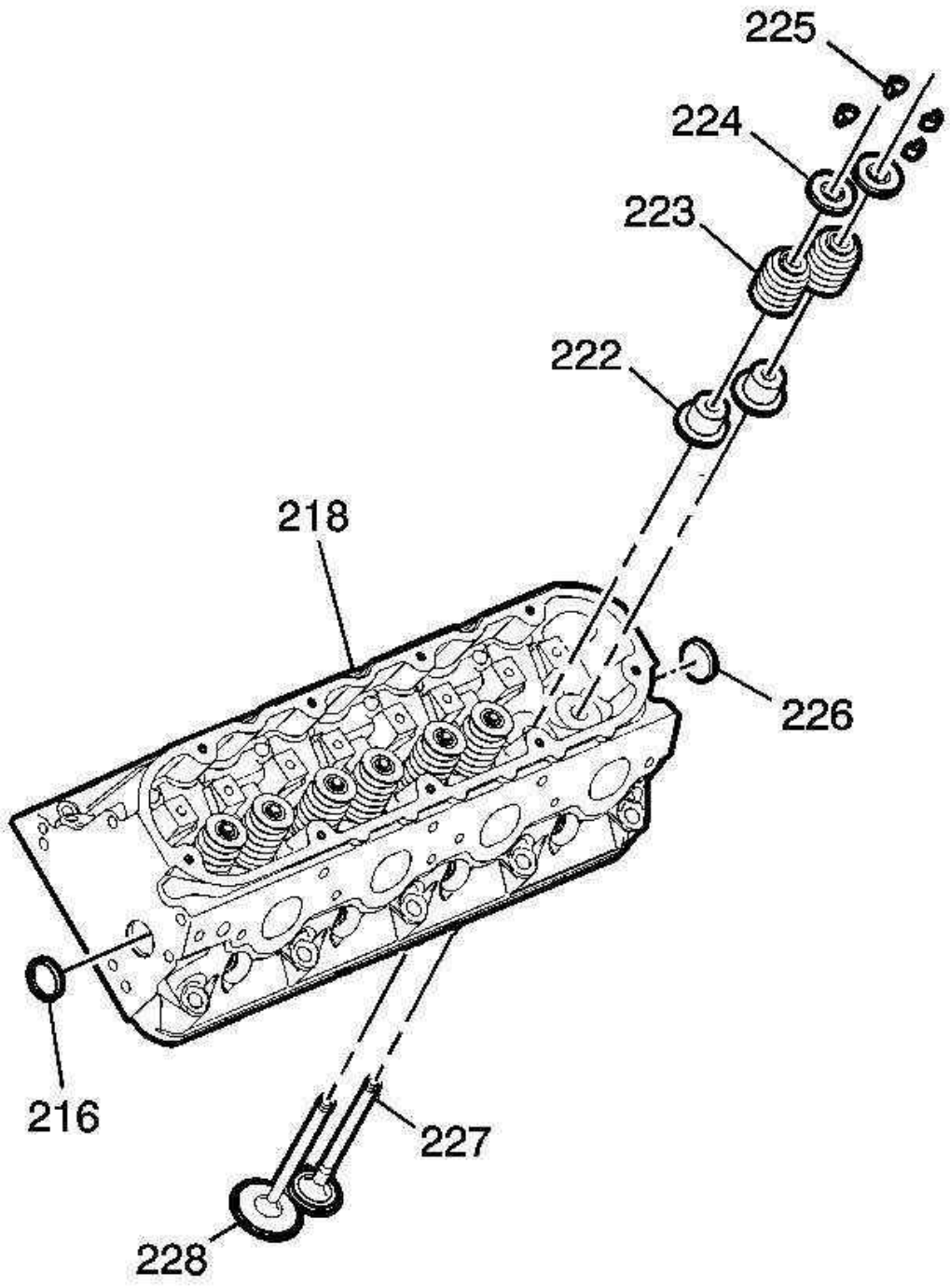


Fig. 125: View Of Cylinder Head Components

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Courtesy of GENERAL MOTORS CORP.

9. Remove the valve stem keys (225).
10. Using the **J 38606** carefully release the valve spring tension. See **Special Tools**.
11. Remove the **J 38606** . See **Special Tools**.
12. Remove the valve spring cap (224).
13. Remove the valve spring (223).
14. Remove the valve stem oil seal (222).

Installation Procedure

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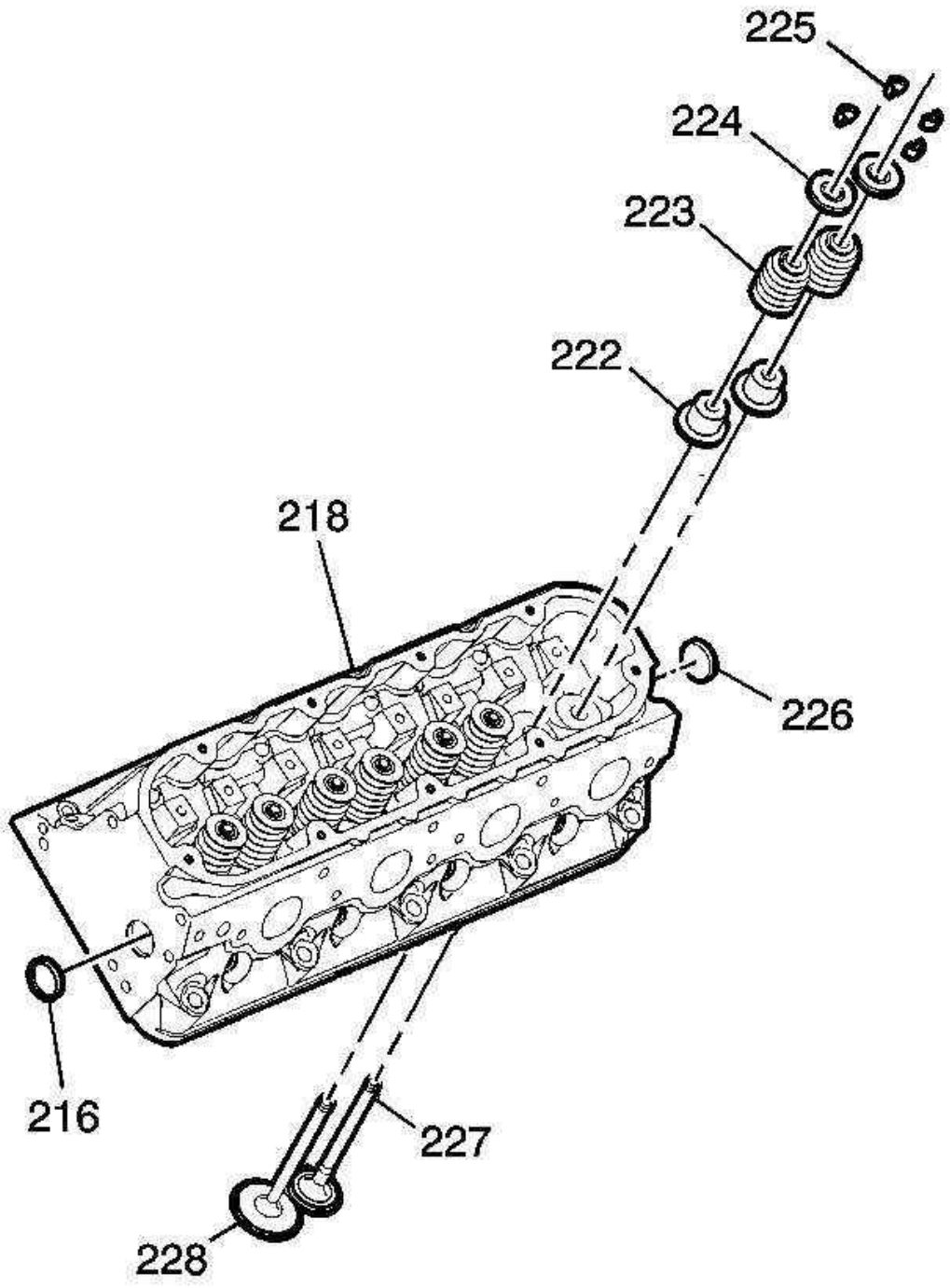


Fig. 126: View Of Cylinder Head Components

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Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring seat and area.
2. Install the valve stem oil seal (222).
3. Install the valve spring (223).
4. Install the valve spring cap (224).

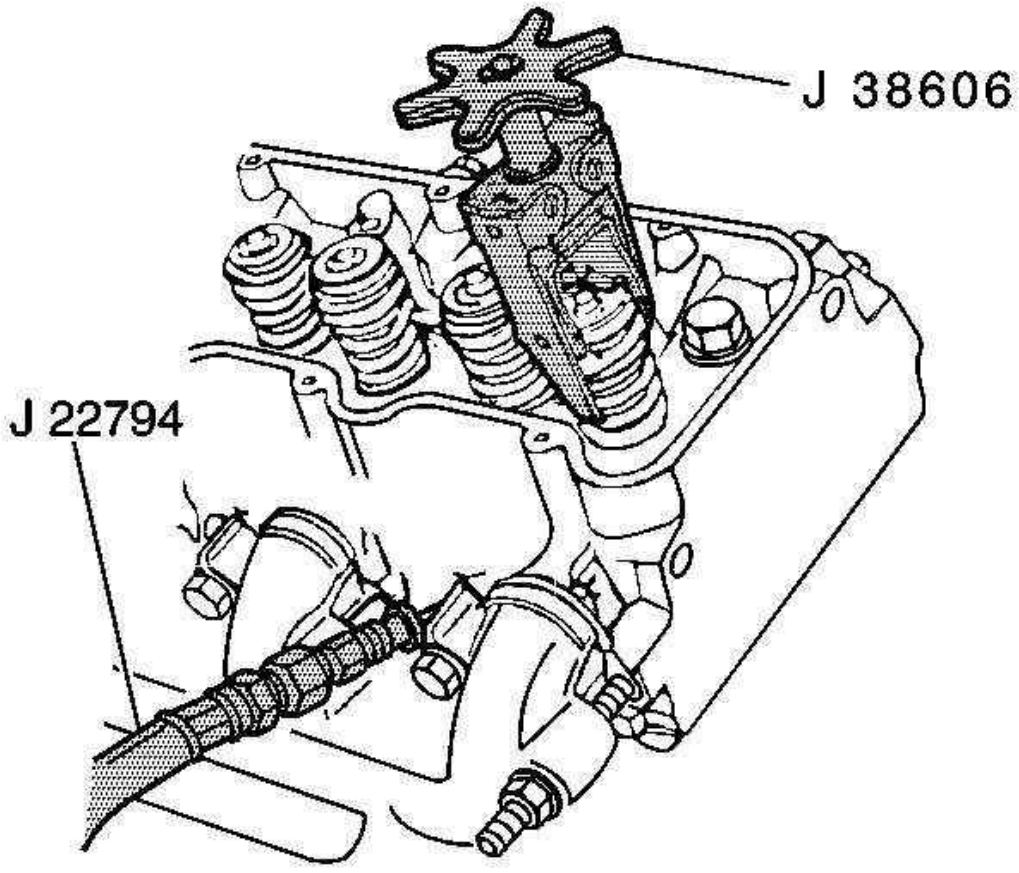


Fig. 127: Using J 38606 & J 5892-D To Remove Valve Spring
Courtesy of GENERAL MOTORS CORP.

5. Compress the valve spring using the **J 38606** . See **Special Tools**.
6. Install the valve stem keys.

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1. Use grease in order to hold the valve stem keys in place.
2. Make sure the keys seat properly in the groove of the valve stem.
3. Using the **J 38606** carefully release the valve spring tension, making sure the valve stem keys stay in place. See **Special Tools**.
4. Remove the **J 38606** . See **Special Tools**.
5. Tap the end of the valve stem with a plastic faced hammer to seat the keys, if necessary.

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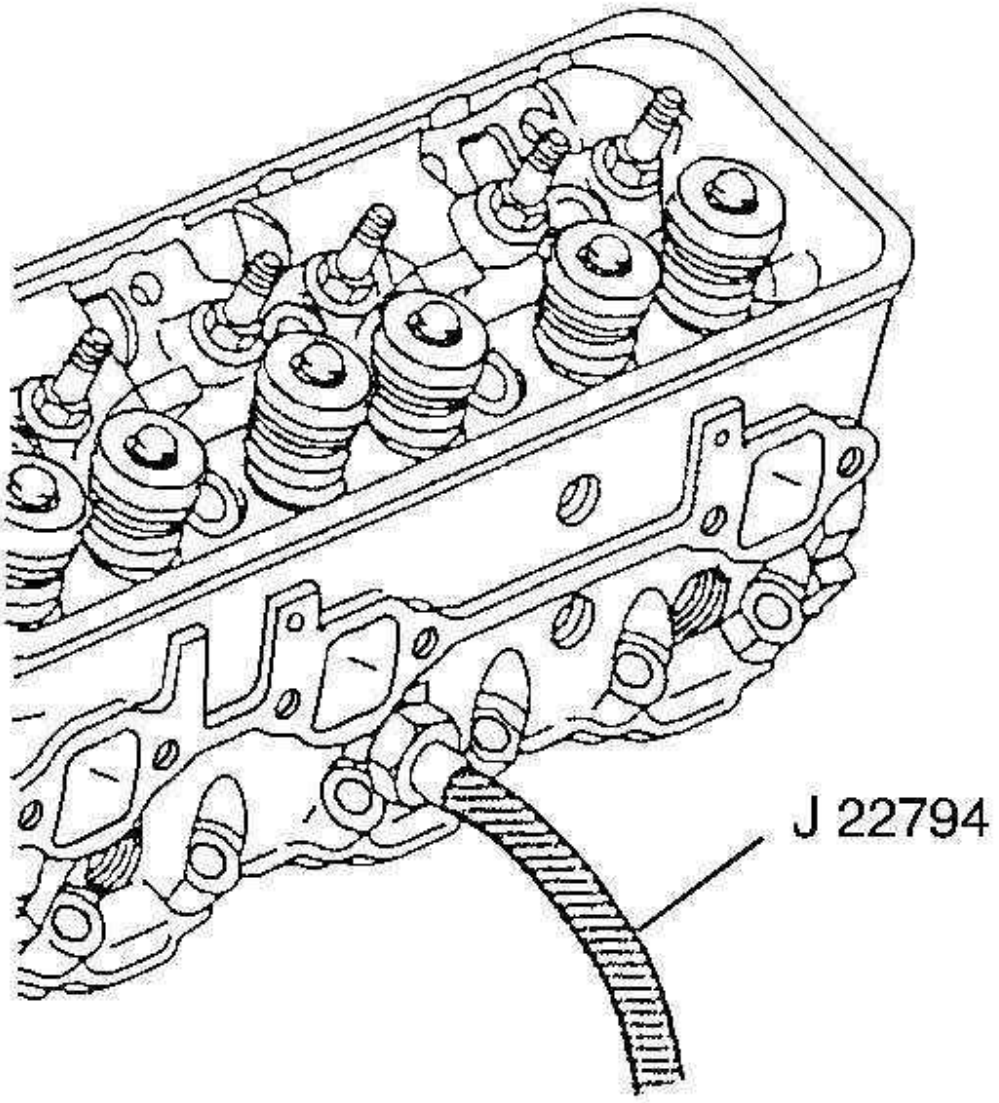


Fig. 128: View Of J 22794
Courtesy of GENERAL MOTORS CORP.

7. Remove the compressed air supply from the **J 22794** . See **Special Tools**.
8. Remove the **J 22794** from the spark plug port. See **Special Tools**.

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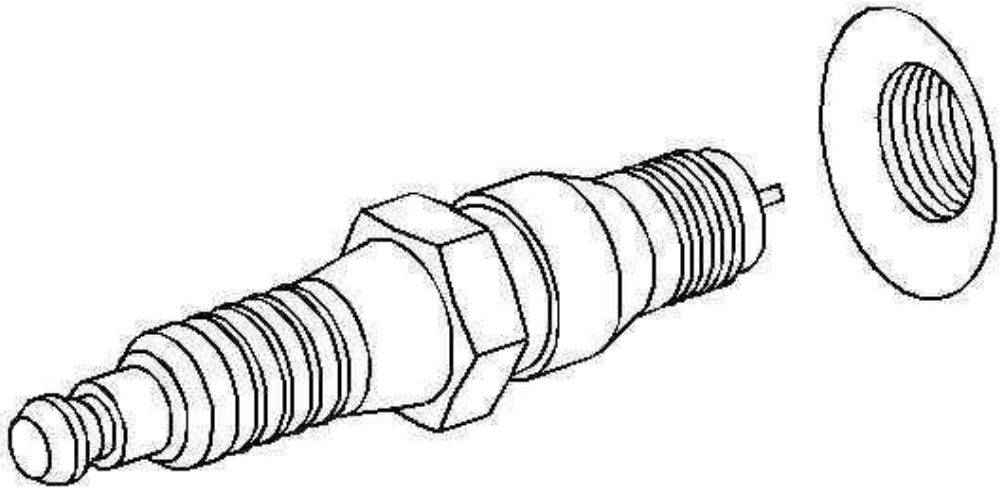


Fig. 129: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Hand start the spark plug.

   Tighten: Tighten the spark plug to 15 N.m (11 lb ft).

10. Install the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure

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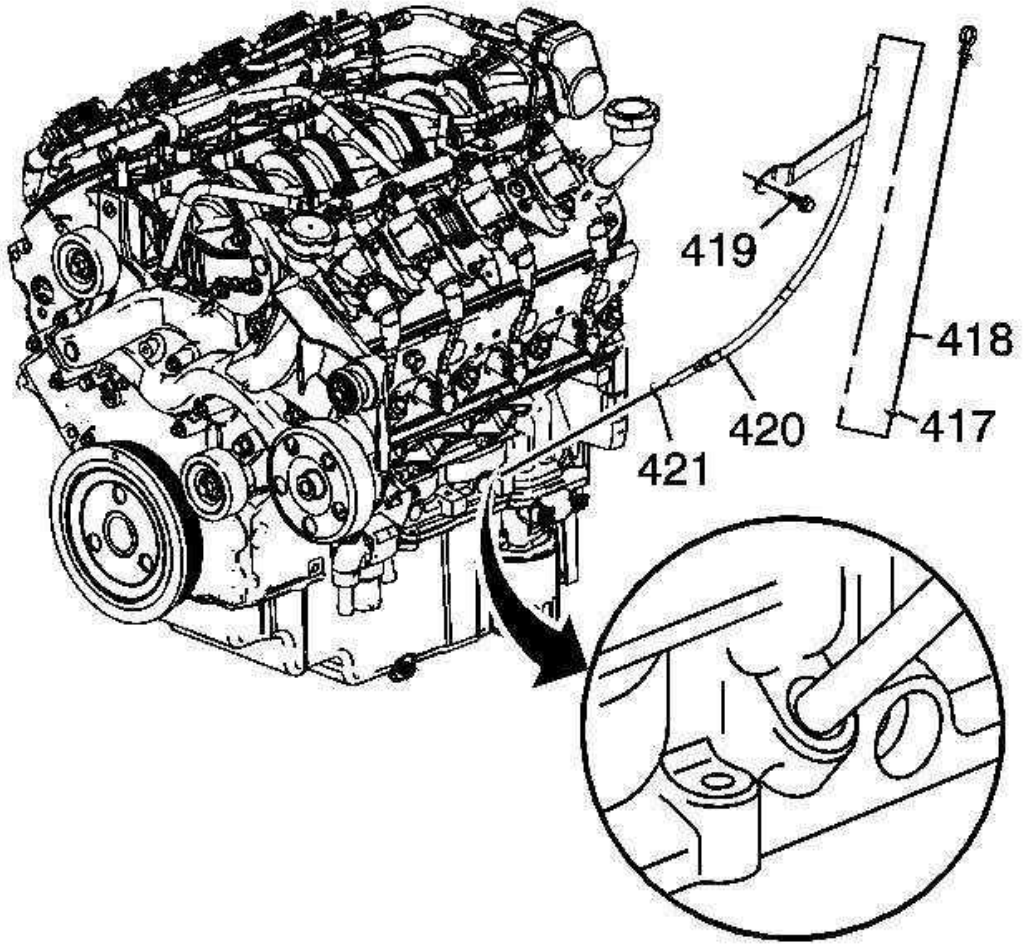


Fig. 130: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator (418) from the tube.
2. Remove the oil level indicator tube bolt (419).
3. Remove the oil level indicator tube (420) from the engine block.

IMPORTANT: Inspect the O-ring for cuts or damage. The seal may be reused if it is not cut or damaged.

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4. Remove the O-ring seal from the tube, if necessary.

Installation Procedure

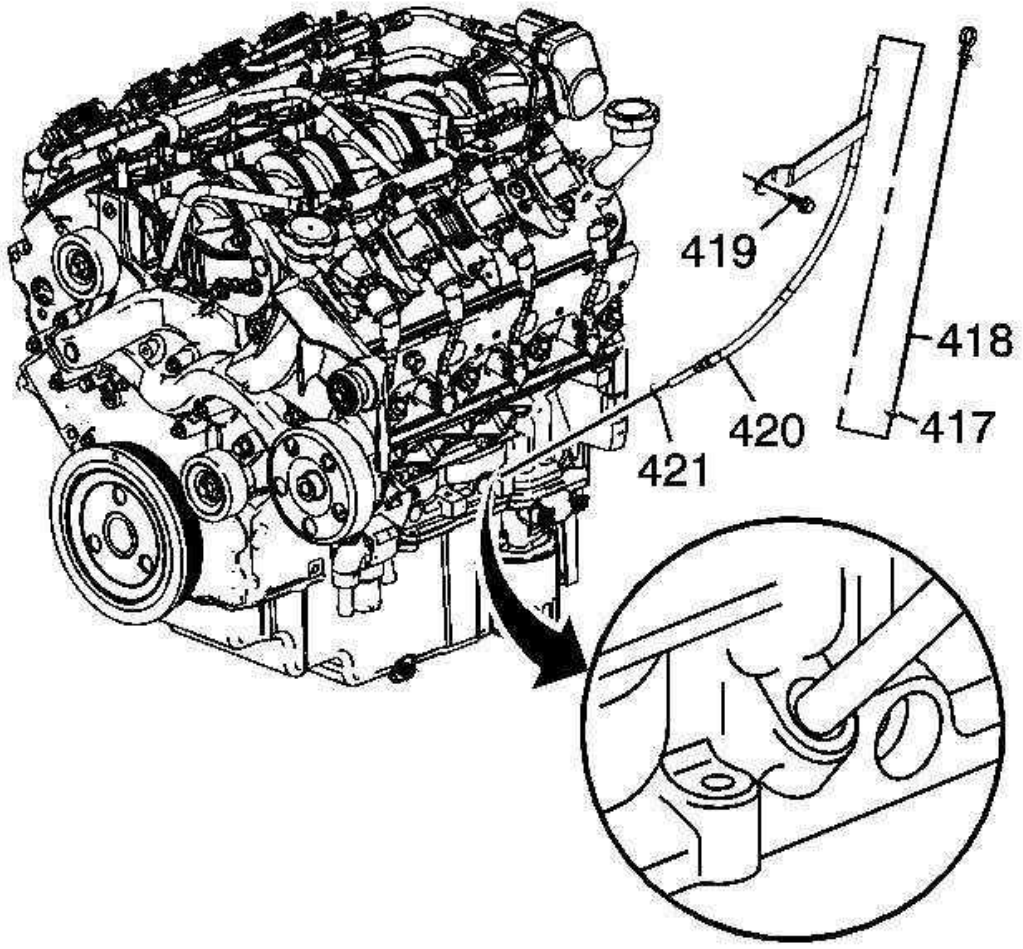


Fig. 131: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the O-ring seal with clean engine oil.
2. Install the O-ring seal onto the oil level indicator tube, if necessary.
3. Install the oil level indicator tube (420) to the engine block. The tube must be installed with the collar flush to the block.

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NOTE: Refer to Fastener Notice .

4. Install the oil level indicator tube bolt (419)

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

5. Install the oil level indicator (418) to the tube.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Tools Required

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 42385-200** Common Threads Repair Kit. See **Special Tools**.
- **J 45059** Torque Angle Meter

Removal Procedure

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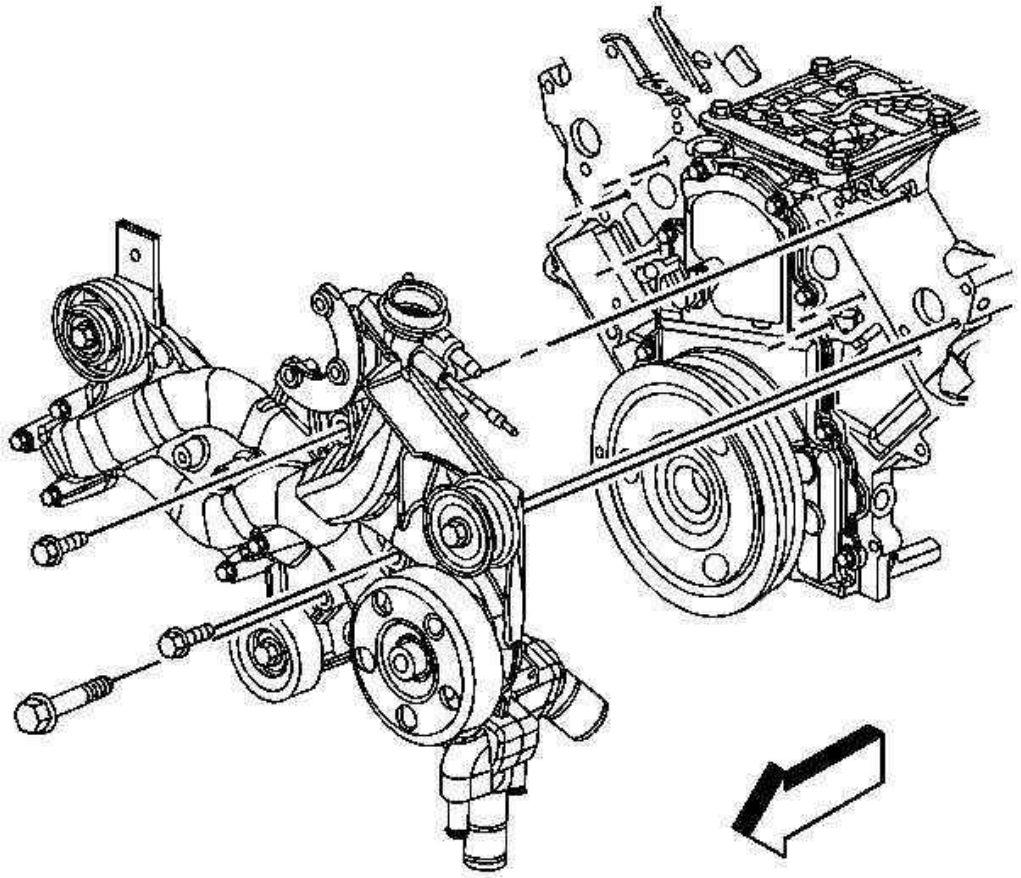


Fig. 132: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
3. Remove the left exhaust manifold. Refer to **Exhaust Manifold Removal - Left Side**.
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. Remove the power steering pump pulley. Refer to **Power Steering Pump**

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Pulley Replacement (LS4) .

6. Remove the 3 coolant manifold bolts to the cylinder head.

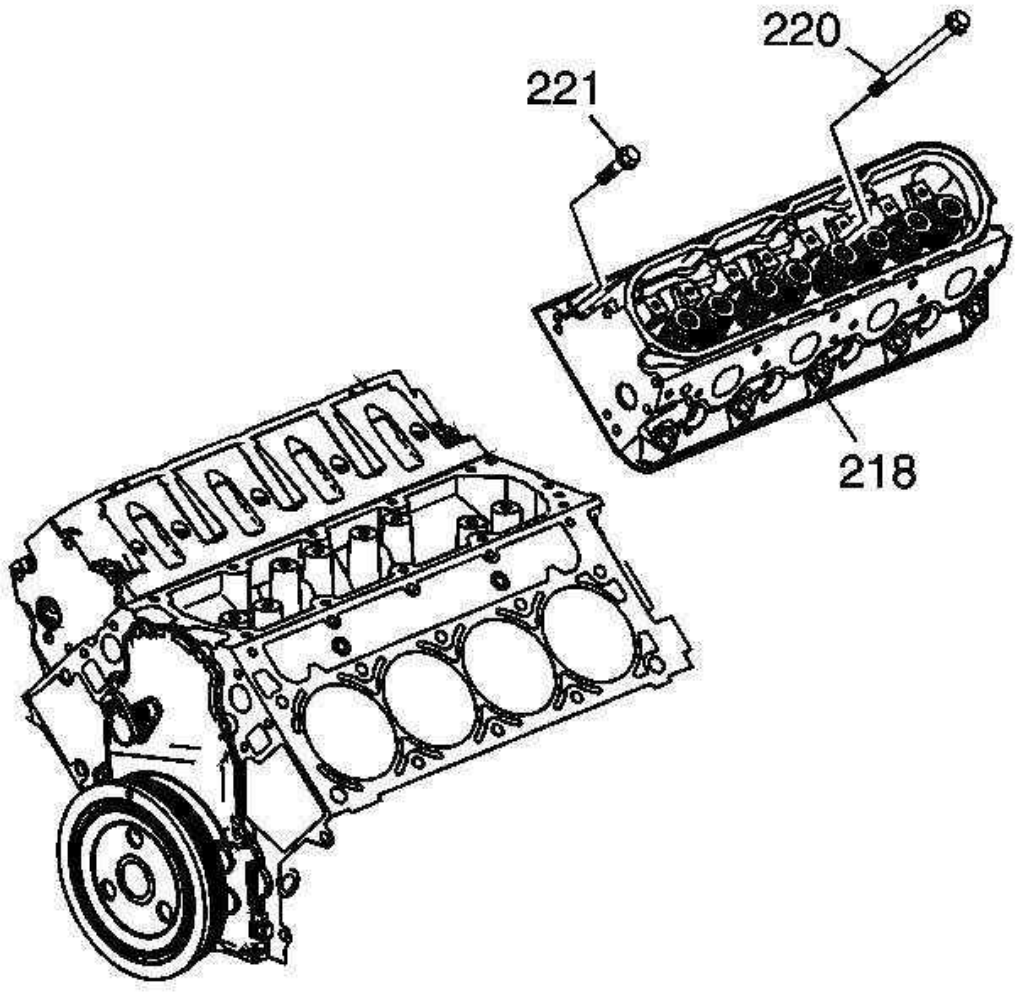


Fig. 133: View Of Cylinder Head & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine mount strut and bracket. Refer to **Engine Mount Strut Replacement**.

IMPORTANT: The cylinder head bolts are of a torque to yield

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design and are NOT to be used again.

8. Remove and discard the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

9. Remove the cylinder head.

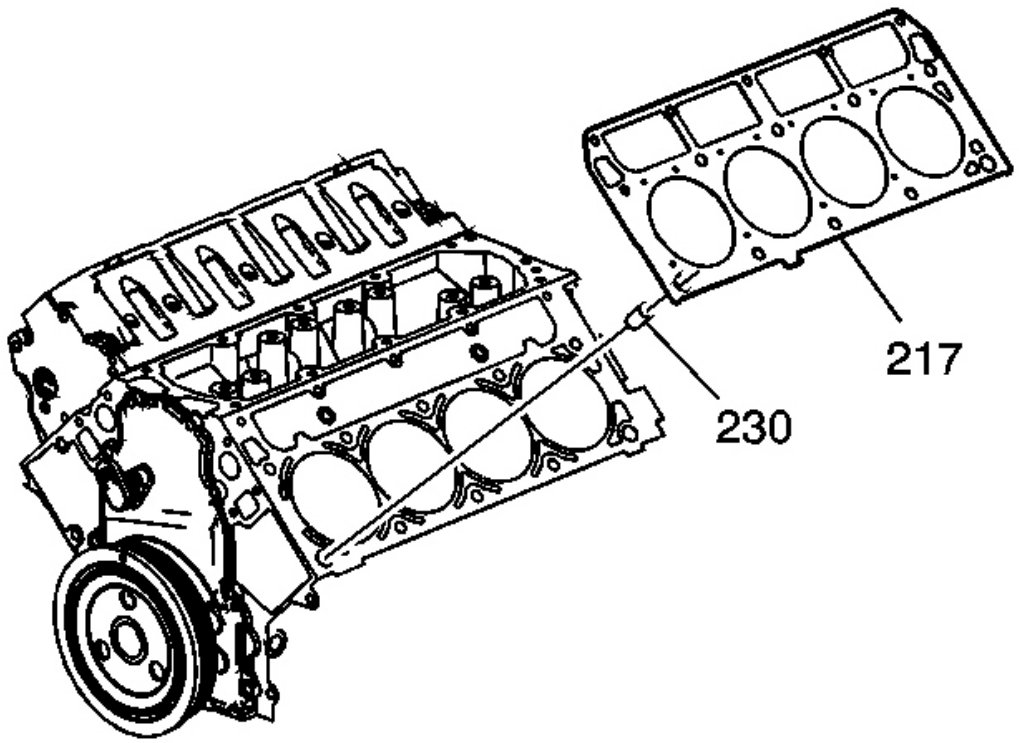


Fig. 134: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the cylinder head gasket (217).
11. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and**

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Inspection.

Installation Procedure

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

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.

IMPORTANT:

- **Do not reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket (unless specified).**
- **The cylinder head gaskets must be installed in the proper direction and position.**

1. Clean the cylinder head bolt holes, if required. **J 42385-100** can be used to clean the threads of old threadlocking material. See **Special Tools**.
2. Clean the engine block bolt holes, if required. **J 42385-200** can be used to clean the threads of old threadlocking material. See **Special Tools**.
3. Use spray cleaner to clean out the hole. Refer to **Sealers, Adhesives, and Lubricants**.
4. Clean the cylinder head bolt holes with compressed air.
5. Check the cylinder head locating pins for proper installation.

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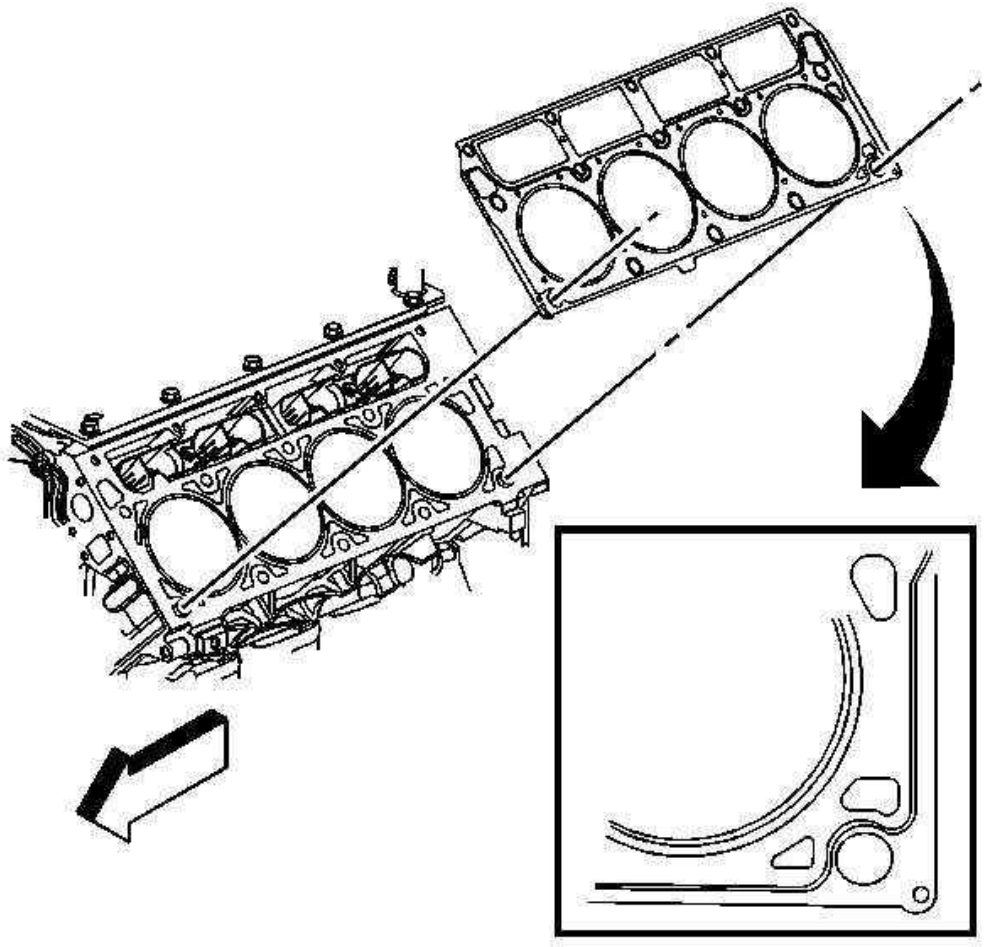


Fig. 135: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the cylinder head gasket, for the proper usage.

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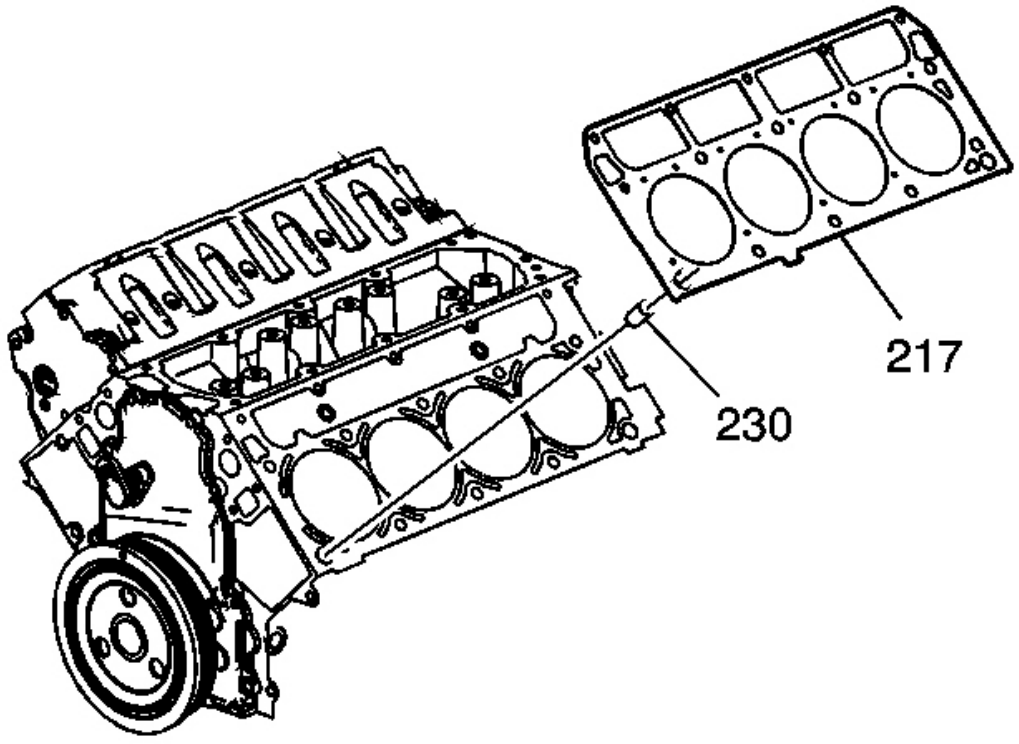


Fig. 136: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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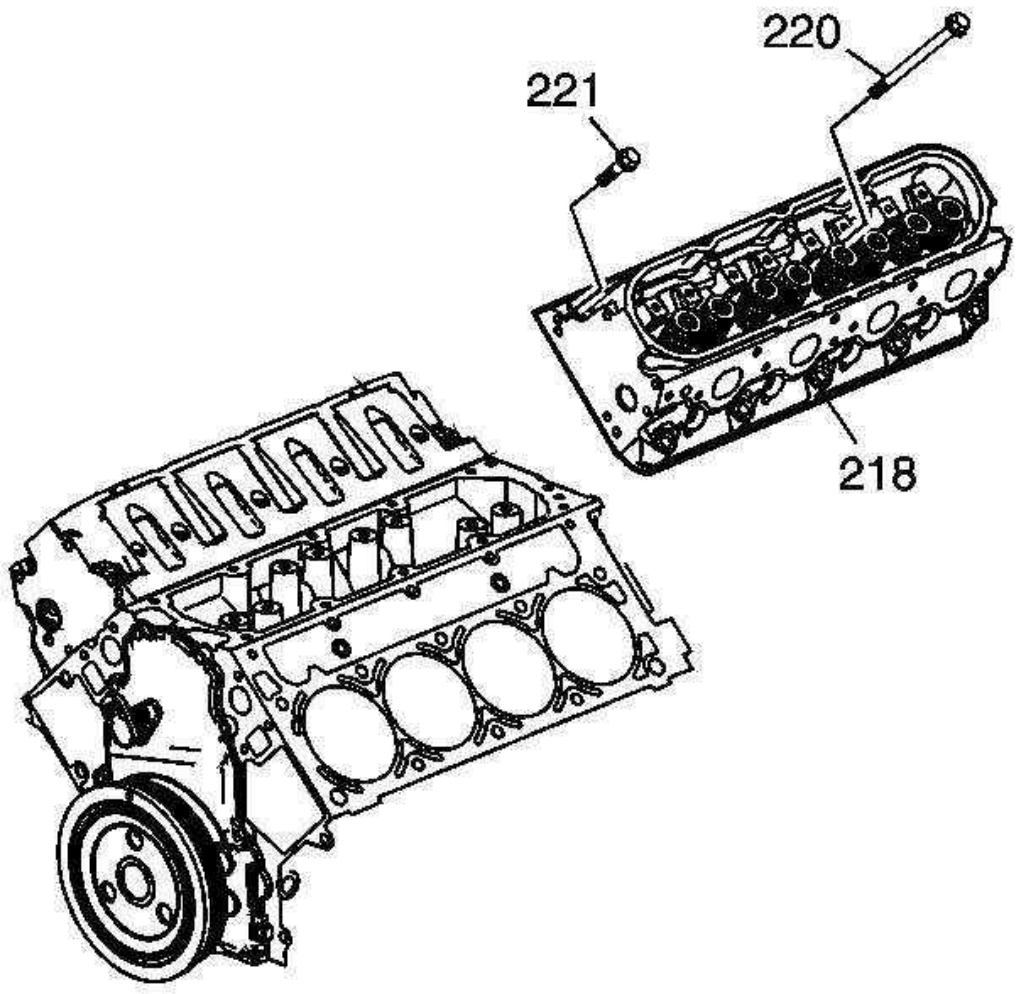


Fig. 137: View Of Cylinder Head & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head onto the locating pins.
9. Install the NEW cylinder head bolts (220, 221).

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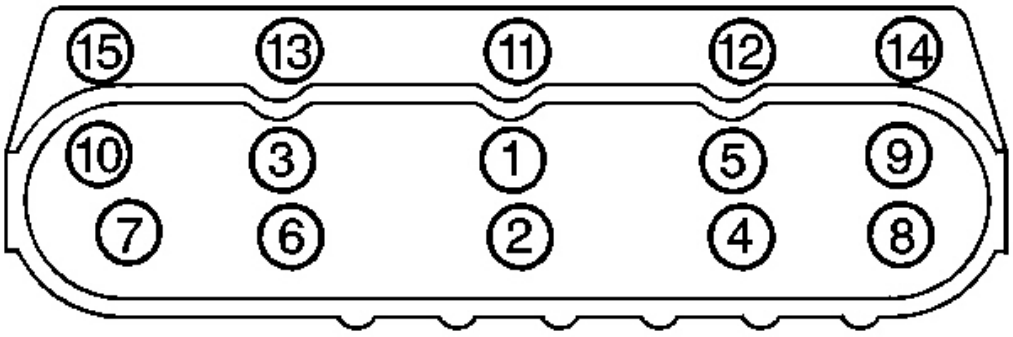


Fig. 138: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

10. Tighten the cylinder head bolts.

    Tighten:

    1. Tighten the M11 bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
    2. Tighten the M11 bolts (1-10) a second pass in sequence to 90 degrees using **J 45059** .
    3. Tighten the M11 bolts (1-10) a final pass in sequence to 70 degrees using **J 45059** .
    4. Tighten the M8 bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

11. Install the engine mount strut and bracket. Refer to **Engine Mount Strut Replacement**.

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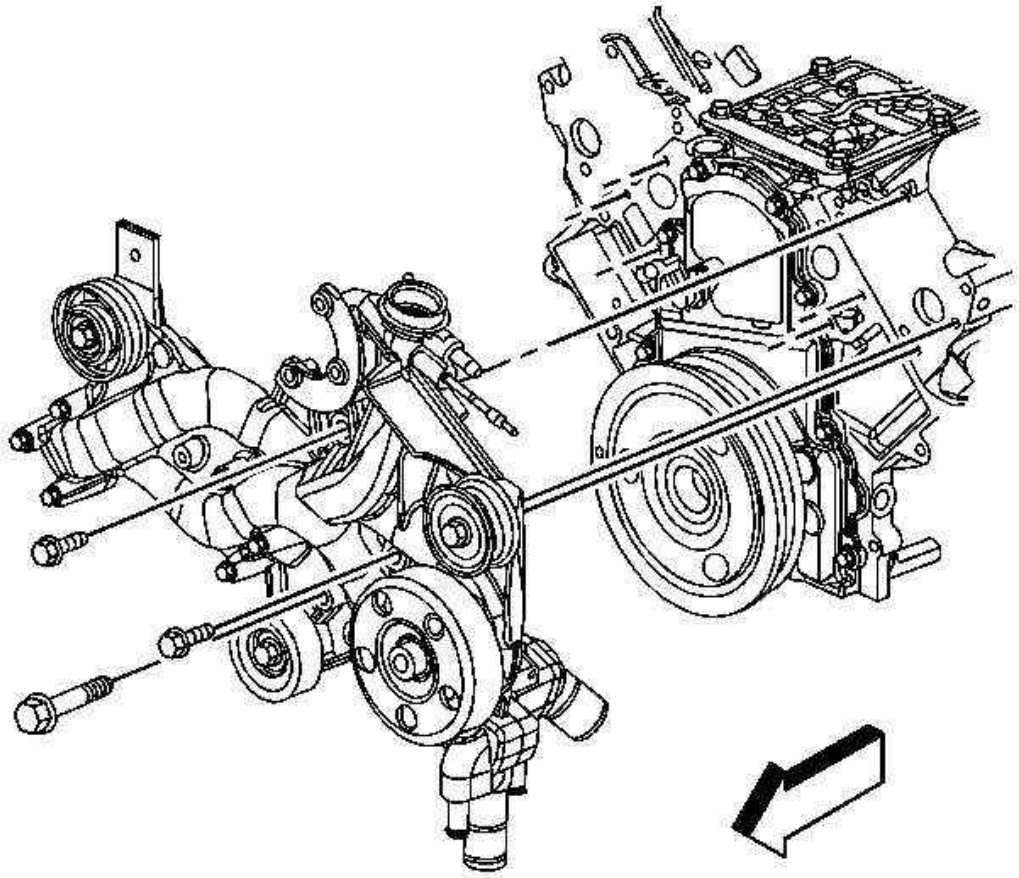


Fig. 139: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

12. Install the 3 coolant manifold bolts to the cylinder head.

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

13. Install the power steering pump pulley. Refer to or **Power Steering Pump Pulley Replacement (LS4)** .
14. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
15. Install the left exhaust manifold. Refer to **Exhaust Manifold Removal - Left**

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Side.

16. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
17. Install the intake manifold. Refer to **Intake Manifold Replacement**.

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Tools Required

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 42385-200** Common Threads Repair Kit. See **Special Tools**.
- **J 45059** Torque Angle Meter

Removal Procedure

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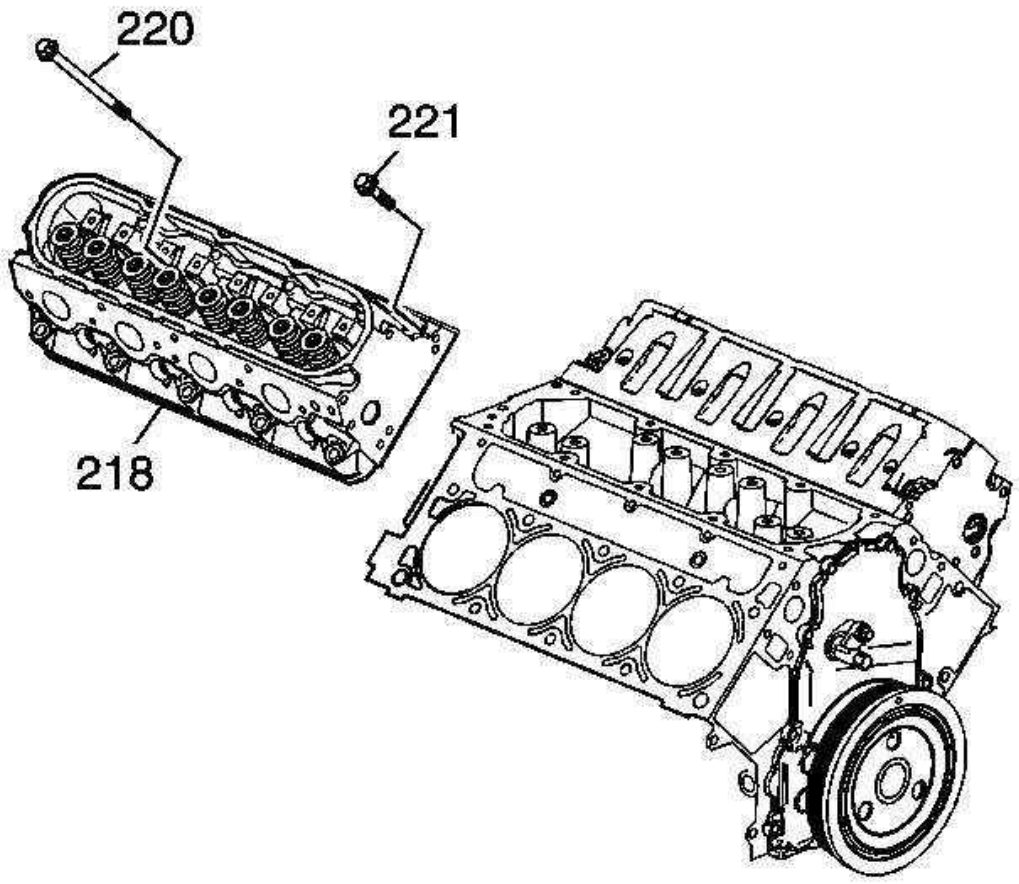


Fig. 140: View Of Cylinder Head & Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
3. Remove the generator bracket. Refer to **Generator Bracket Replacement (LS4)** .
4. Remove the right exhaust manifold. Refer to **Exhaust Manifold Removal - Right Side**.
5. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod**

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Replacement.

IMPORTANT: The cylinder head bolts are of a torque to yield design and are NOT to be used again.

6. Remove and discard the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

7. Remove the cylinder head (218).

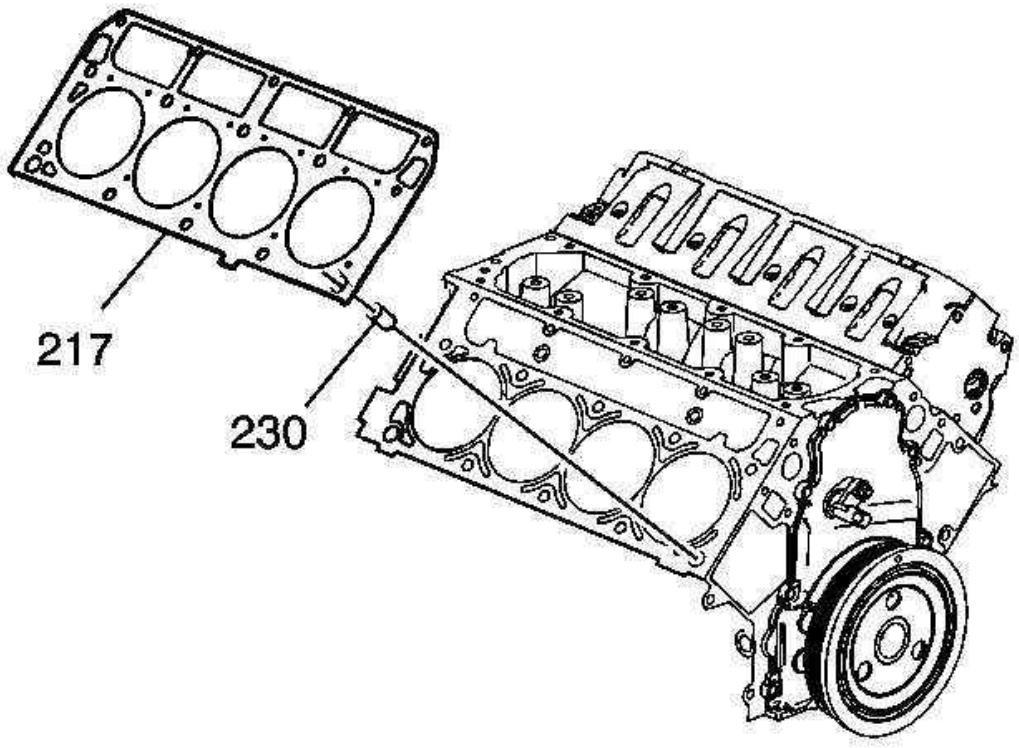


Fig. 141: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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8. Remove and discard the cylinder head gasket (217).
9. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

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

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.

IMPORTANT:

- **Do not reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket (unless specified).**
- **The cylinder head gaskets must be installed in the proper direction and position.**

1. Clean the cylinder head bolt holes, if required. **J 42385-100** can be used to clean the threads of old threadlocking material. See **Special Tools**.
2. Clean the engine block bolt holes, if required. **J 42385-200** can be used to clean the threads of old threadlocking material. See **Special Tools**.
3. Use spray cleaner to clean out the hole.
4. Clean the cylinder head bolt holes with compressed air.
5. Check the cylinder head locating pins for proper installation.

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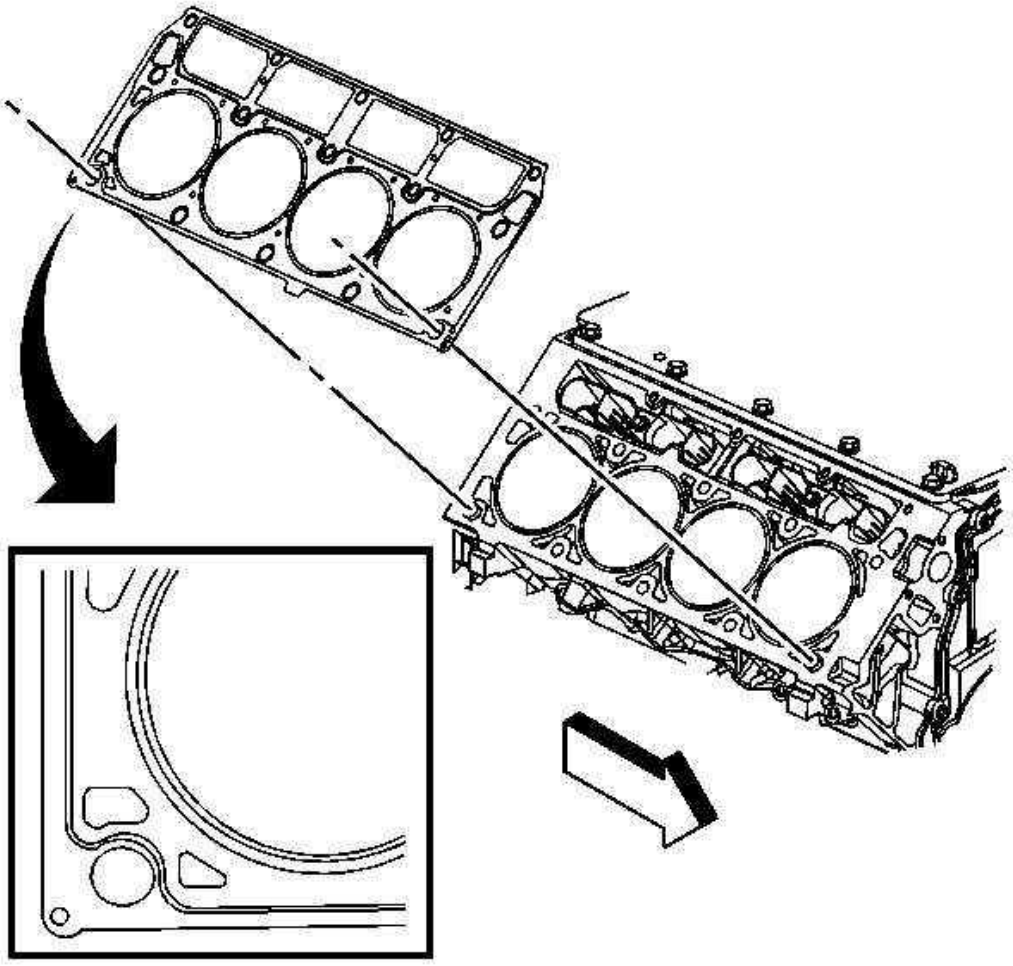


Fig. 142: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the cylinder head gasket, for the proper usage.

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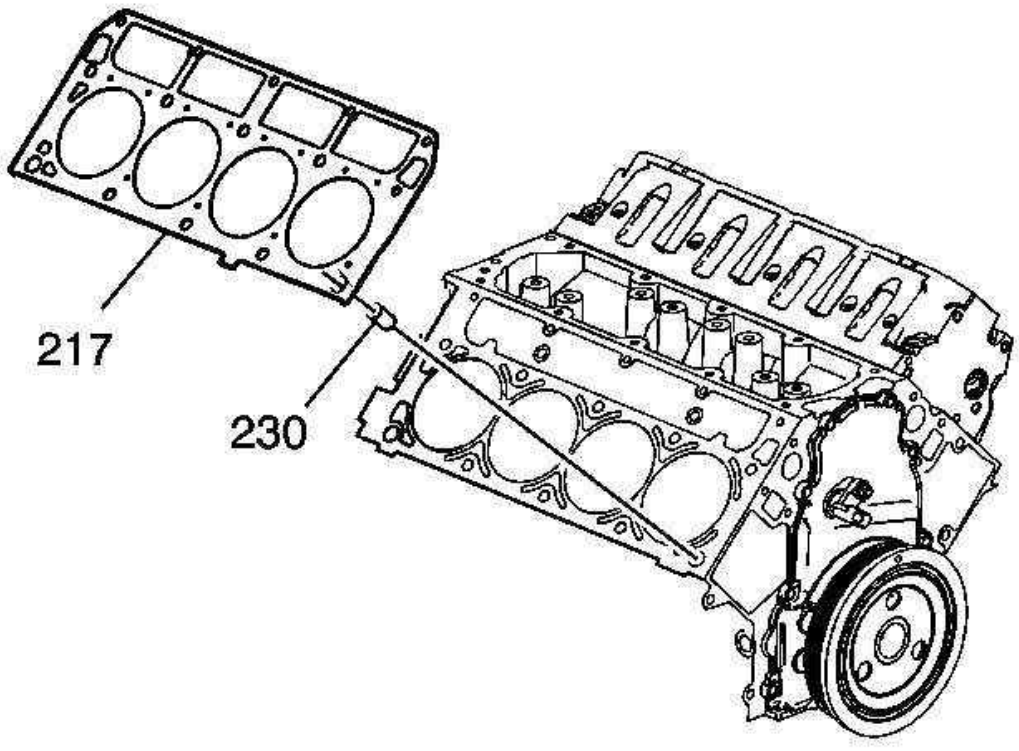


Fig. 143: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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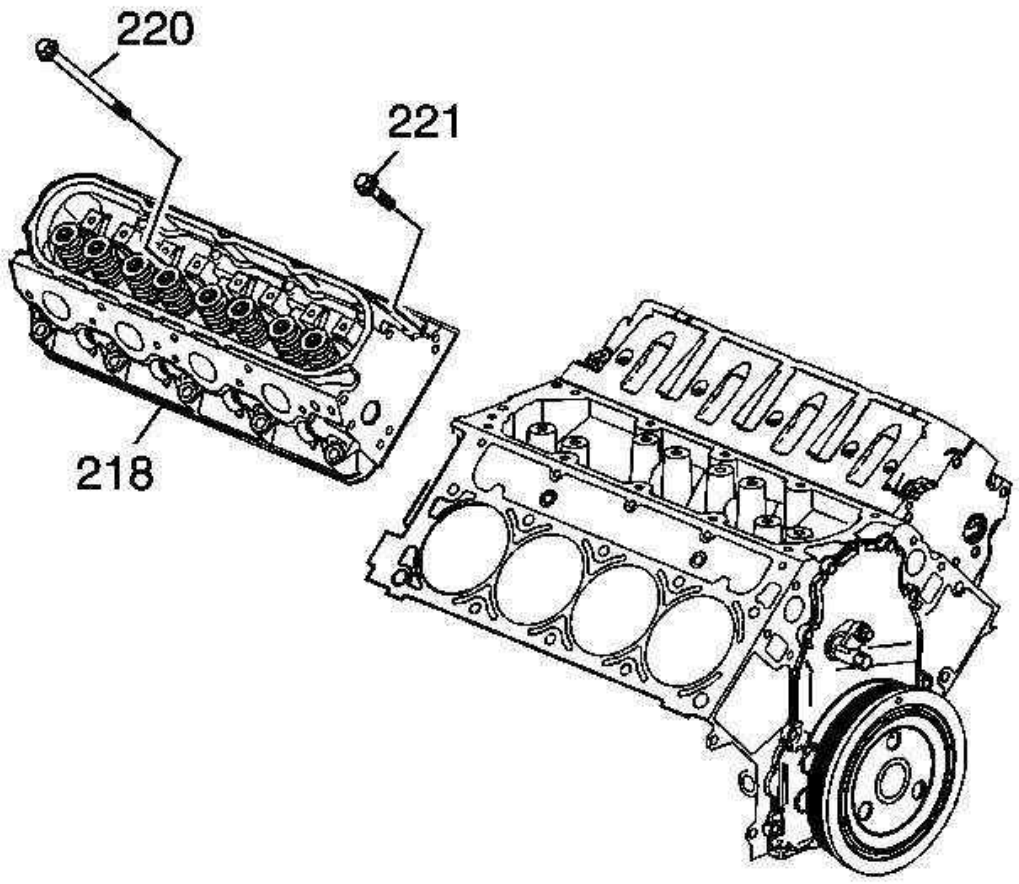


Fig. 144: View Of Cylinder Head & Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins.
9. Install the NEW cylinder head bolts (220, 221).

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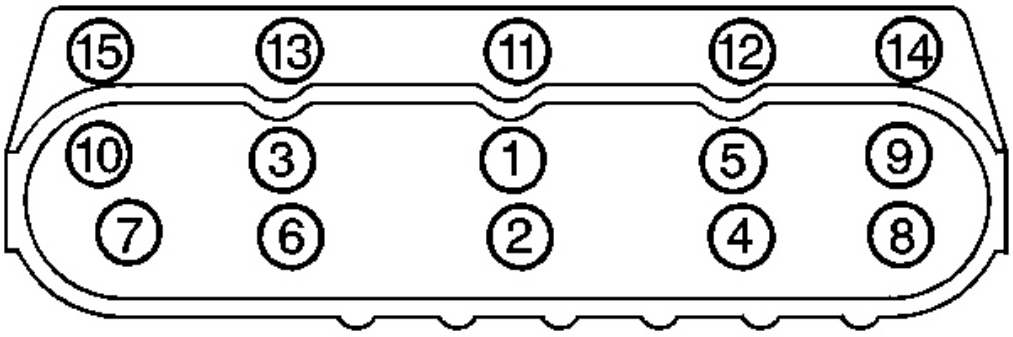


Fig. 145: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

10. Tighten the cylinder head bolts.

    Tighten:

    1. Tighten the M11 bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
    2. Tighten the M11 bolts (1-10) a second pass in sequence to 90 degrees using **J 45059** .
    3. Tighten the M11 bolts (1-10) a final pass in sequence to 70 degrees using **J 45059** .
    4. Tighten the M8 bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

11. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
12. Install the right exhaust manifold. Refer to **Exhaust Manifold Installation - Right Side**.
13. Install the generator bracket. Refer to **Generator Bracket Replacement (LS4)** .

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14. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
15. Install the intake manifold. Refer to **Intake Manifold Replacement**.

VALVE LIFTER REPLACEMENT

Special Tools

J 3049-A Valve Lifter Remover. See **Special Tools**.

Removal Procedure

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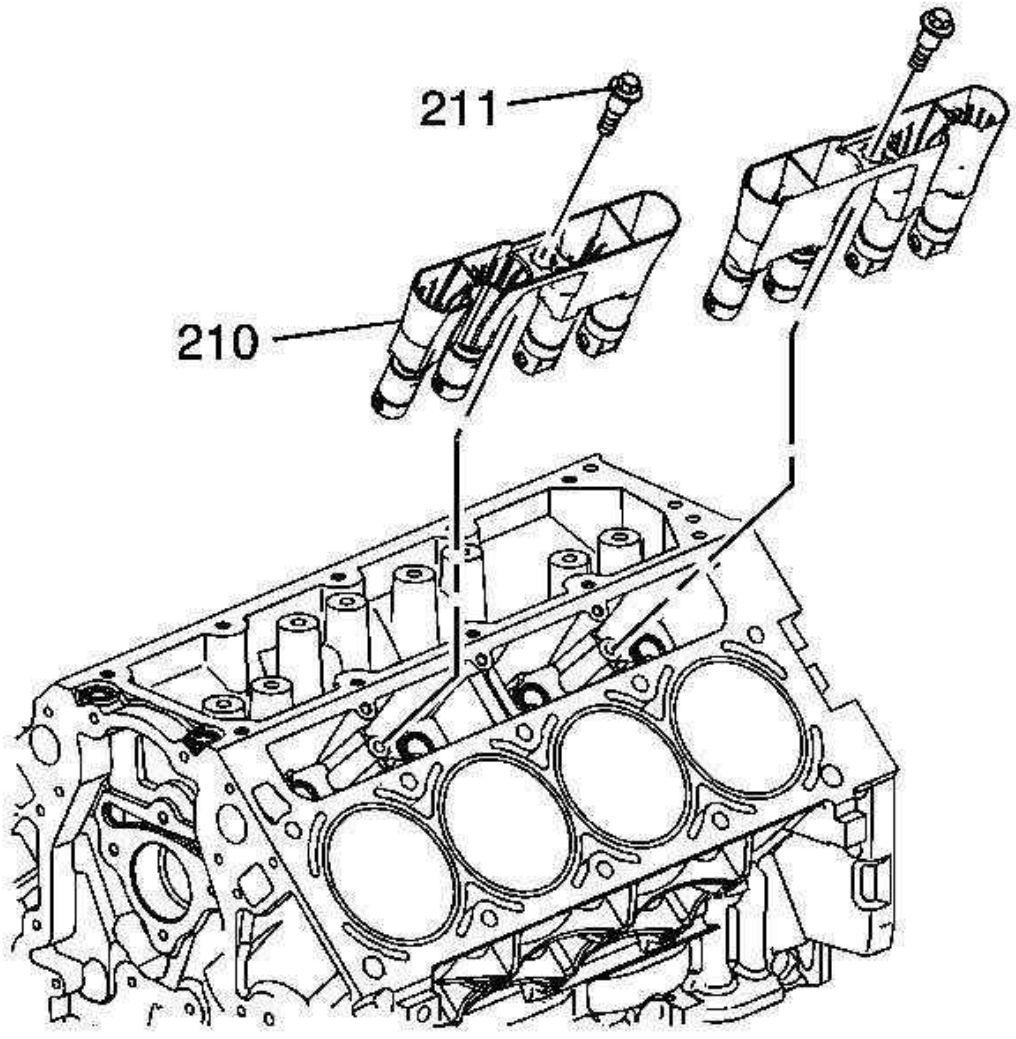


Fig. 146: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head. Refer to **Cylinder Head Replacement - Left Side** and/or **Cylinder Head Replacement - Right Side**.
2. Remove the lifter guide bolts (211).

IMPORTANT: Note the installed position of the guides. The

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notched area of the guide is to align with the locating tab of the block.

3. Remove the lifter guides (210) with lifters.

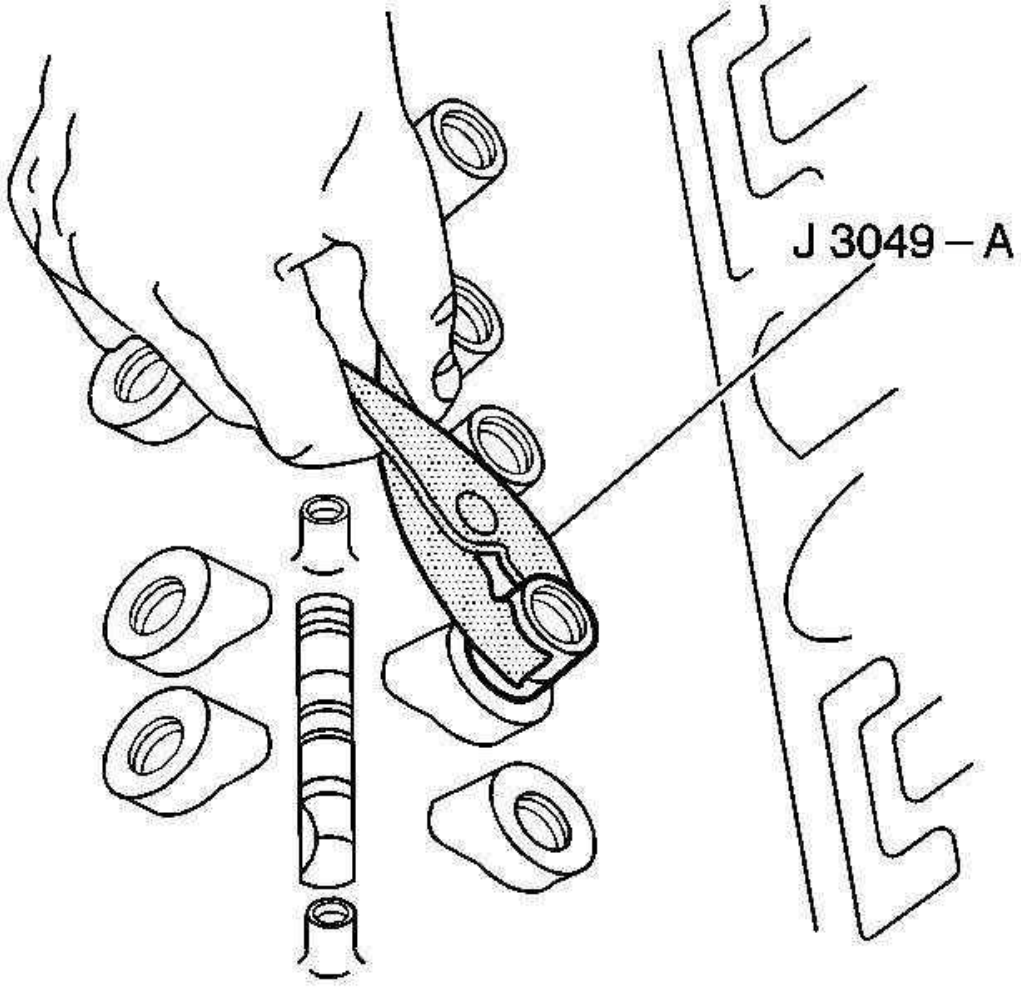


Fig. 147: Using J 3049-A To Remove Sticking Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some valve lifters may be stuck in their bores because of gum or varnish deposits.

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4. Use the **J 3049-A** or equivalent in order to remove the valve lifters, if necessary. See **Special Tools**.

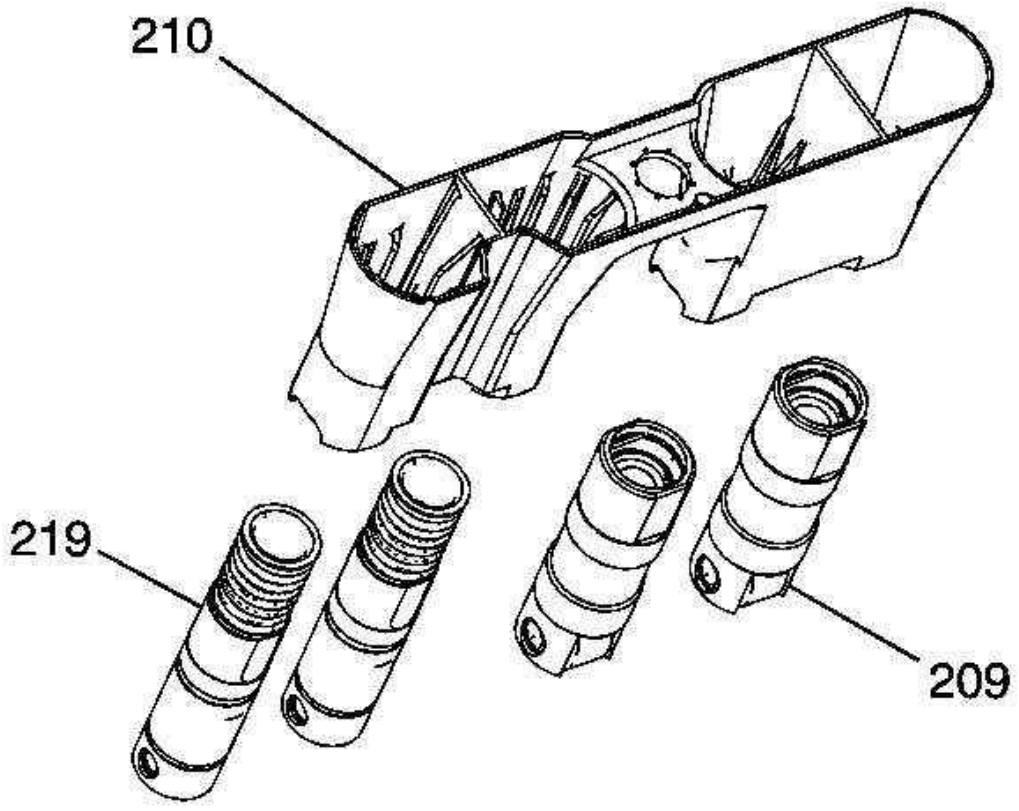


Fig. 148: View Of Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve lifters (209, 219) from the guide (210).

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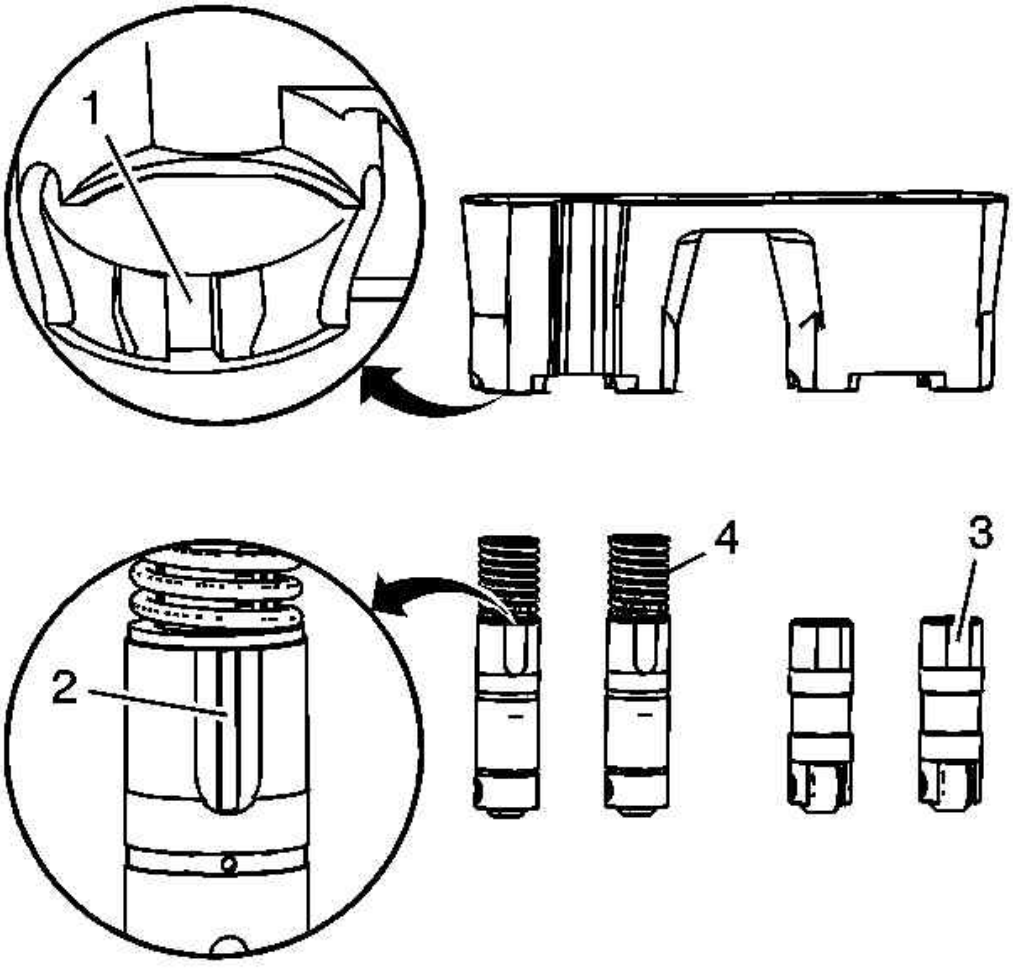


Fig. 149: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS CORP.

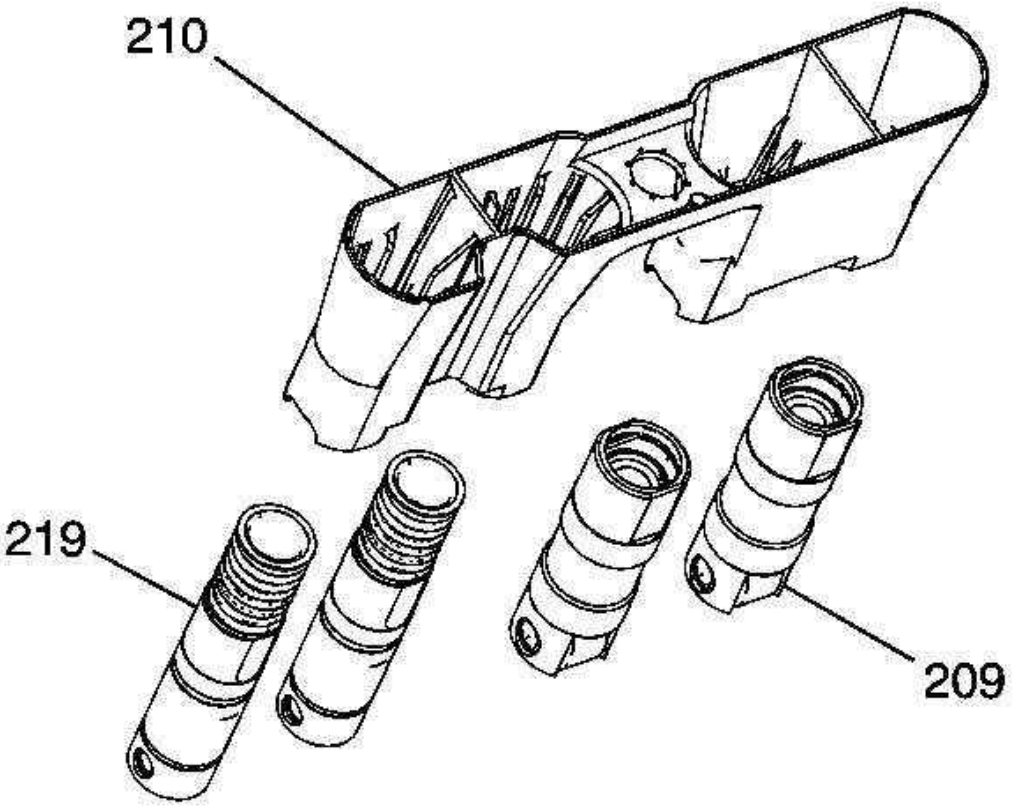
6. Organize or mark the components so that they can be installed in the same location from which they were removed. The displacement on demand lifters are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2).
7. Clean and inspect the valve lifters. Refer to **Valve Lifters and Guides Cleaning and Inspection (5.3L)**.

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Installation Procedure

IMPORTANT:

- **When reusing the valve lifters, install the lifters in their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the four valve guide assemblies will contain two displacement on demand valve lifters and two non-displacement on demand valve lifters.**
- **With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain two displacement on demand valve lifters.**



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Fig. 150: View Of Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve lifters (209, 219) and engine block valve lifter bores with clean engine oil.

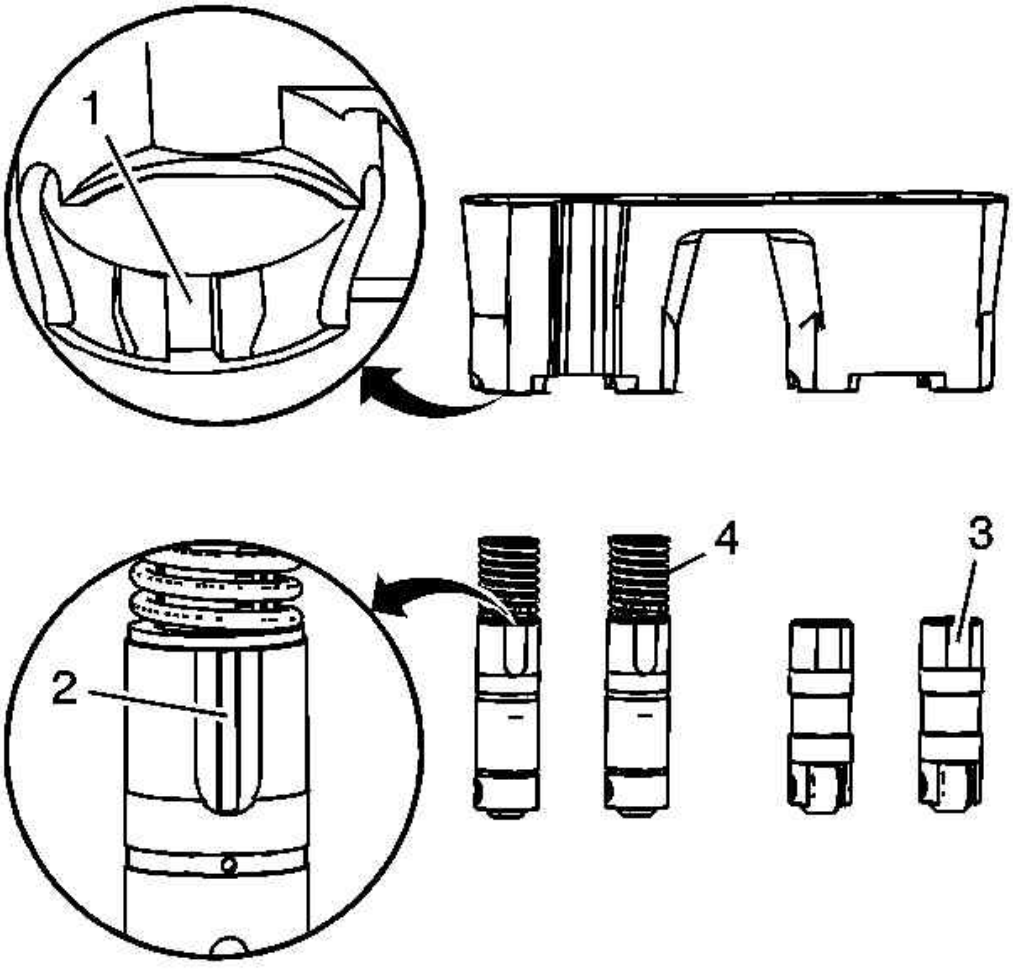


Fig. 151: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS CORP.

2. Insert the valve lifters into the lifter guides.

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- Align the flat area (3) on the top of the non-displacement on demand lifter with the flat area in the lifter guide bore.
- The displacement on demand lifters are to be installed into the guide, with the notch in the guide (2) of the lifter.

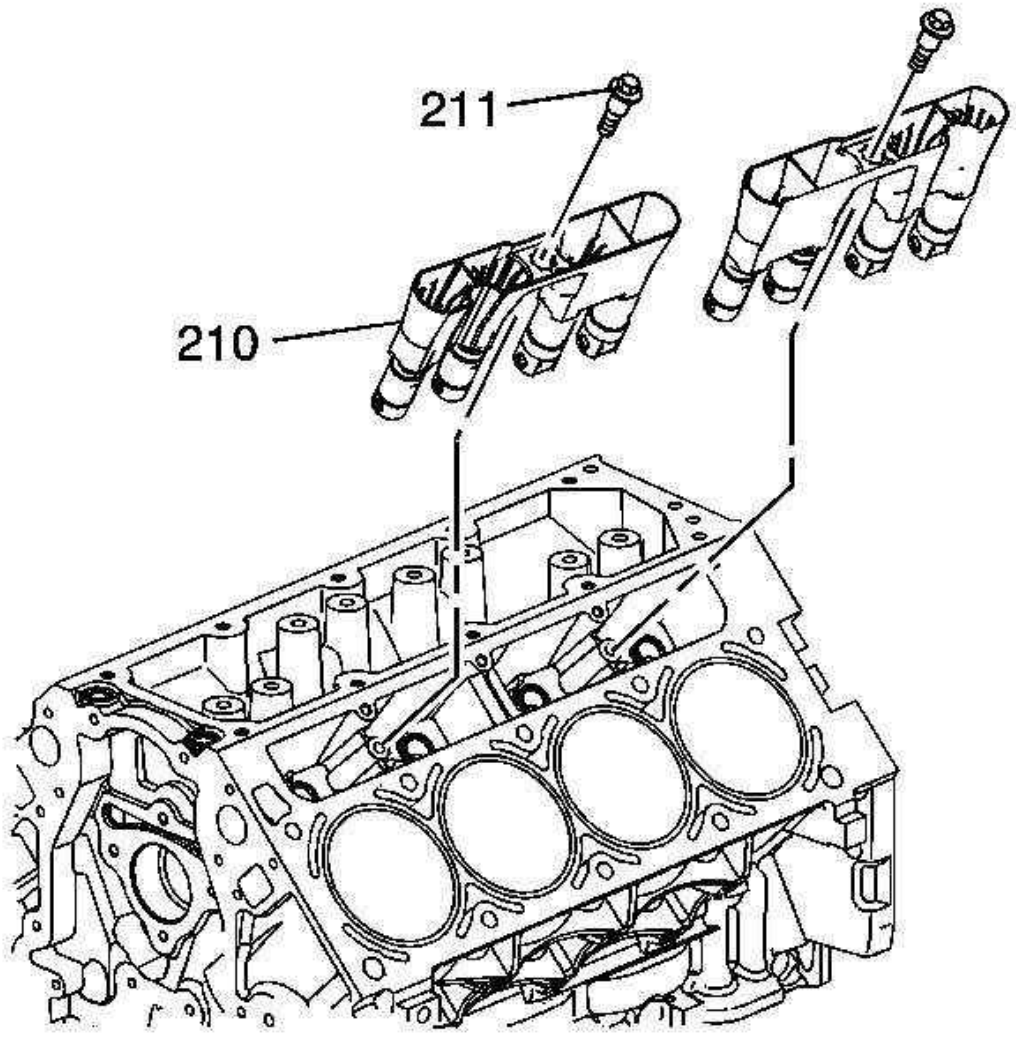


Fig. 152: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

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3. Install the valve lifter guides (210) with lifters to the engine block.

NOTE: Refer to Fastener Notice .

4. Install the valve lifter guide bolts (211).

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

5. Install the cylinder head. Refer to **Cylinder Head Replacement - Left Side** and/or **Cylinder Head Replacement - Right Side**.

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

- **EN 47699** Flywheel Holding Tool. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 41816** Crankshaft Balancer Remover
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 42640** Steering Column Anti-Rotation Pin
- **J 45059** Torque Angle Meter

Removal Procedure

1. Install a **J 42640** . Refer to **Steering Column Replacement** .
2. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
3. Remove the air cleaner upper housing. Refer to **Air Cleaner Assembly Replacement** .
4. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement**.
5. Remove the starter motor. Refer to **Starter Motor Replacement (LS4)** .
6. Remove the front fender splash shield.
7. Disconnect the transaxle cooler lines at the transaxle. Refer to **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .

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8. Remove the stabilizer shaft link lower nuts. Refer to **Stabilizer Shaft Link Replacement** .
9. Remove the intermediate steering shaft pinch bolt and separate the shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
10. Remove the front lower air deflector braces and the deflector. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .
11. Remove the radiator to frame braces.
12. Install the engine support fixture. Refer to **Engine Support Fixture**.
13. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
14. Remove the frame-to-body bolts.
15. Remove the transmission-to-engine bolt located at approximately the 10 o'clock position when looking from the rear of the engine.

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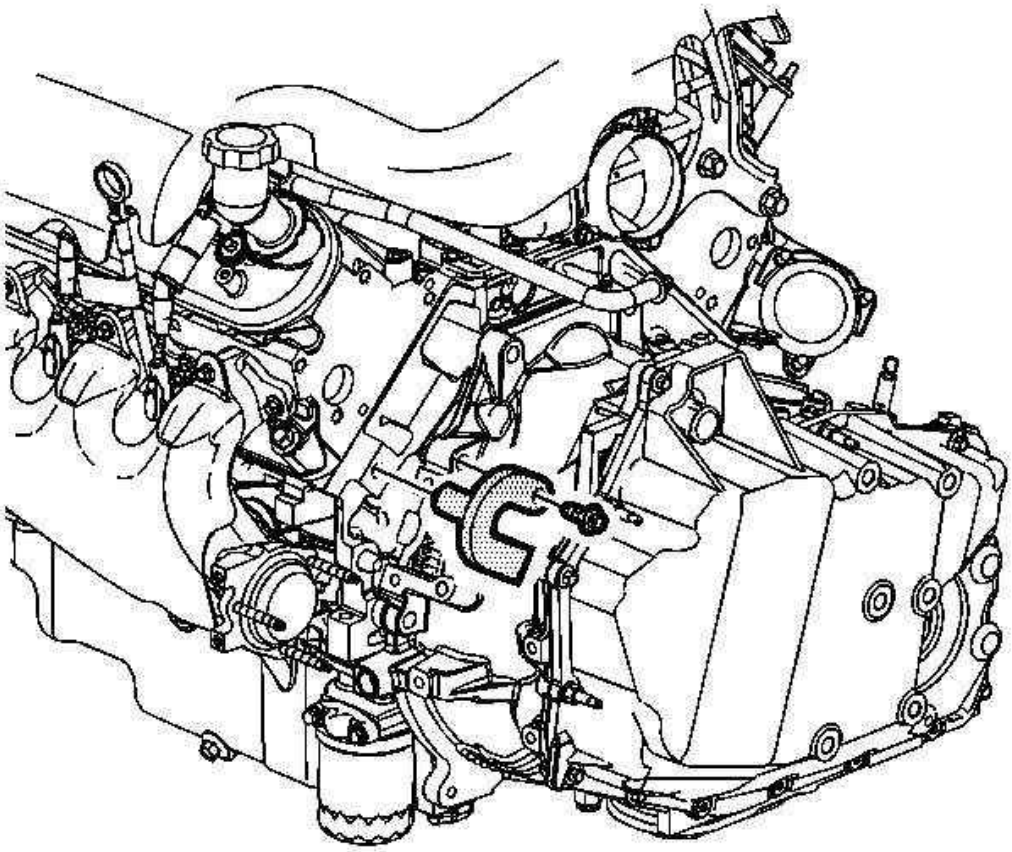


Fig. 153: Installing EN 47699 & Bolt To Block & Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

16. Install the **EN 47699** and bolt to the block and flywheel. See **Special Tools**.

    Tighten: Tighten the bolt to 60 N.m (44 lb ft).

17. Remove the right front tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .
18. Lower the engine approximately 100 mm (4 in).

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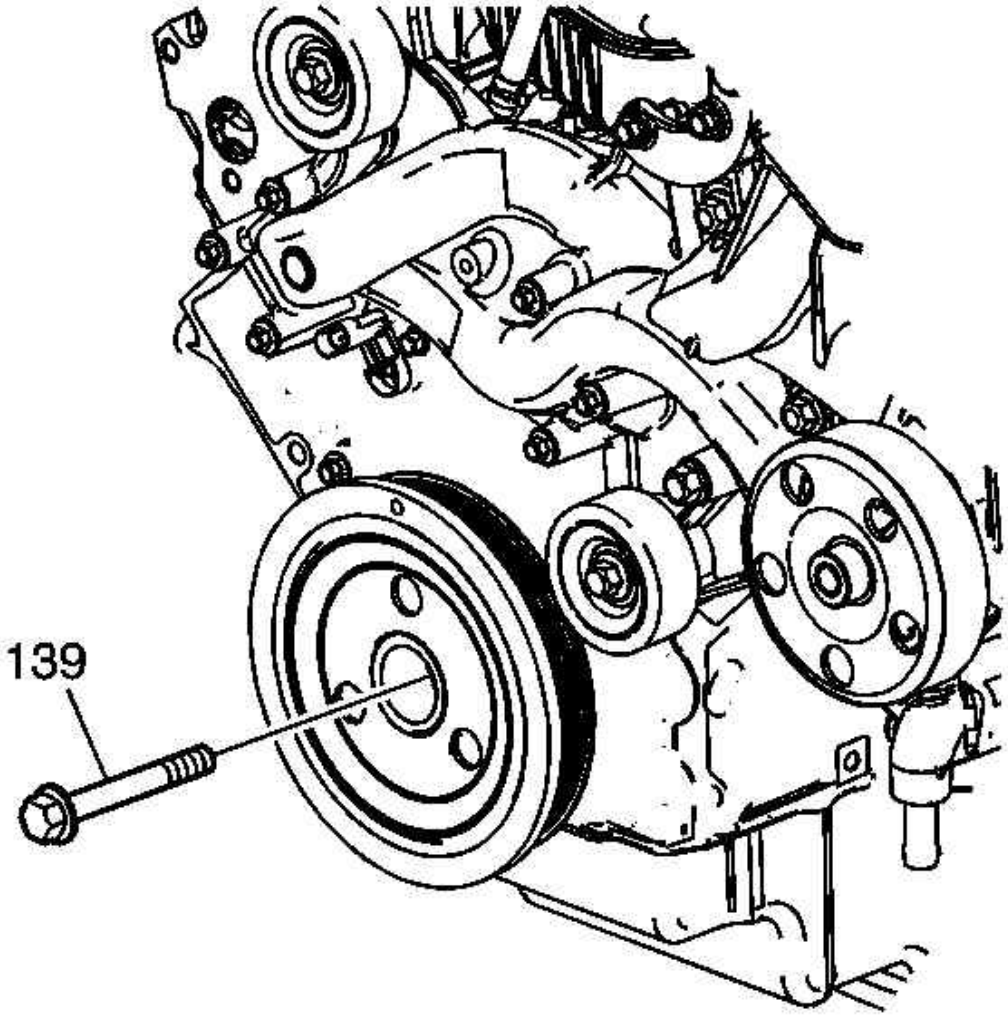


Fig. 154: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

19. Remove the crankshaft balancer bolt (139).

    Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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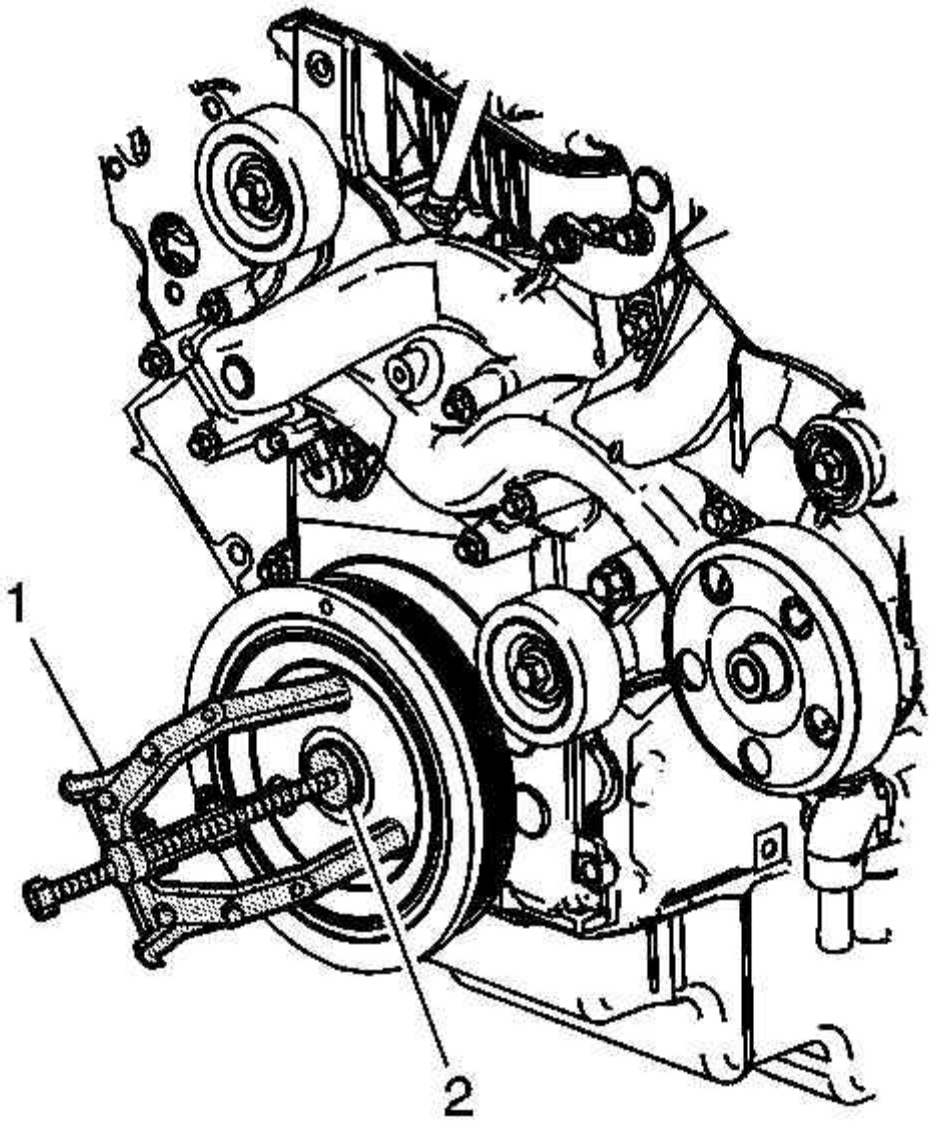


Fig. 155: View Of Special Tools & Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

20. Install the **J 41816** (1) and the **J 41816-2** (2), to the crankshaft balancer. See **Special Tools**.

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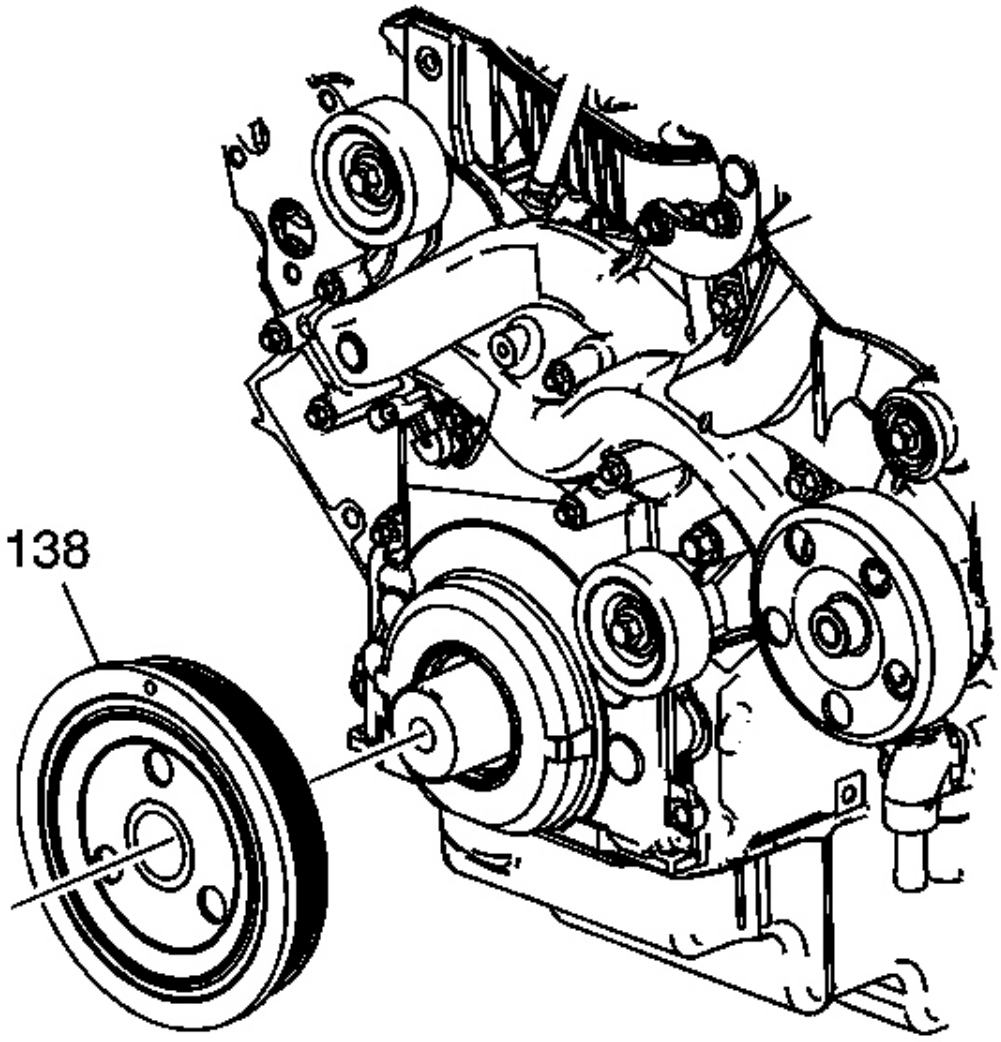


Fig. 156: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

21. Remove the crankshaft balancer (138).
22. Remove the **J 41816** and the **J 41816-2** from the crankshaft balancer. See **Special Tools**.

Installation Procedure

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IMPORTANT:

- **The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW bolt and tighten as described in the second, third and forth passes of the balancer bolt tightening procedure.**
- **The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and forth passes tighten the new bolt to the proper torque.**
- **The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.**

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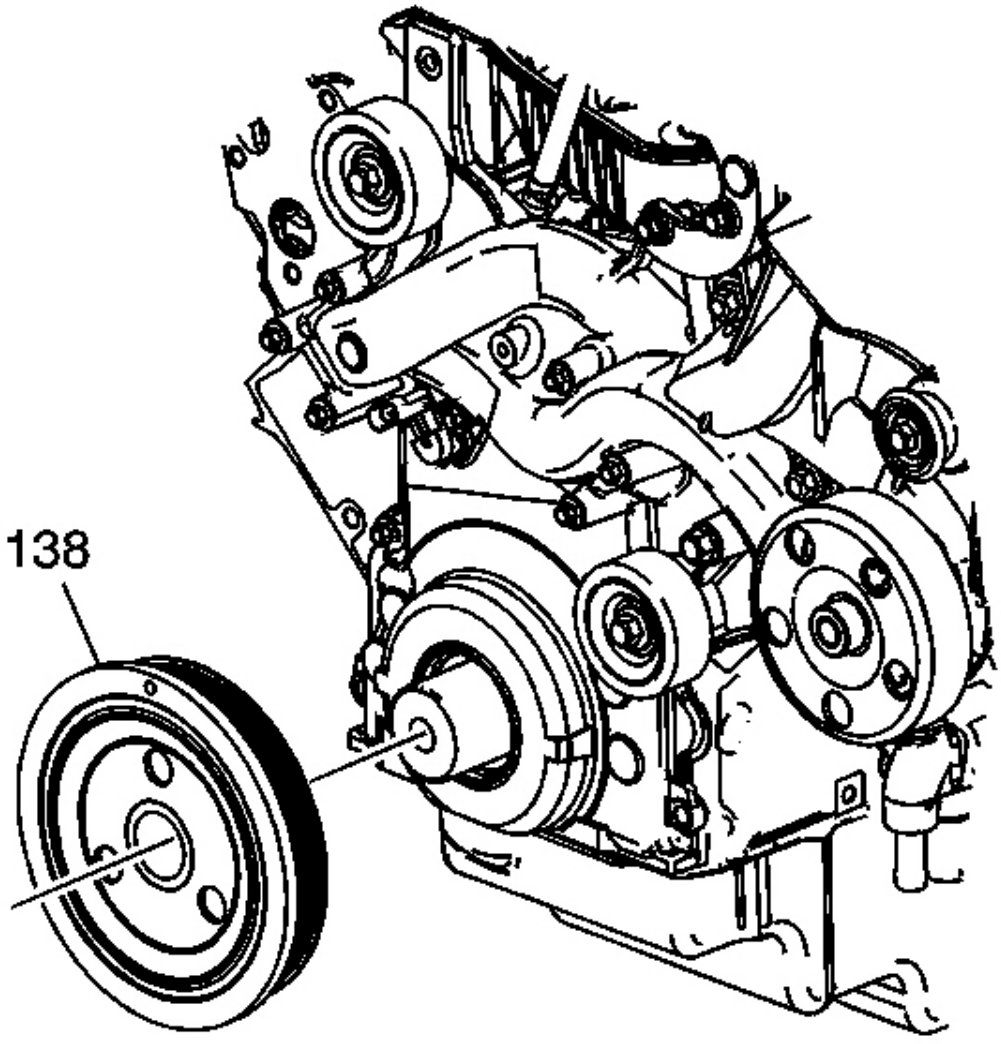


Fig. 157: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer (138) onto the end of the crankshaft.

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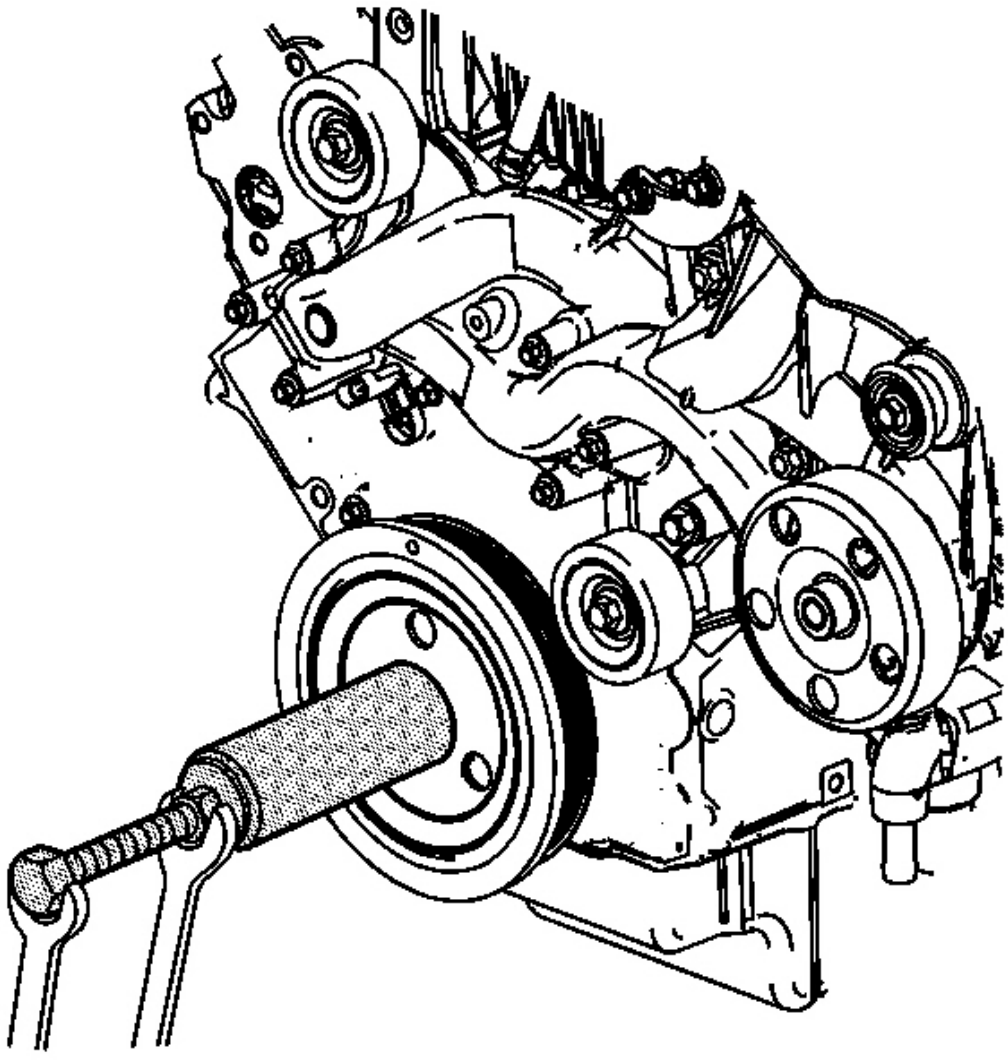


Fig. 158: Using Special Tools To Install Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

2. Using the **J 41665** , install the crankshaft balancer. See **Special Tools**.
    1. Assemble the threaded rod, nut, washer and installer. Insert the smaller end of the installer into the front of the balancer.
    2. Use a wrench and hold the hex end of the threaded rod.

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3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
4. Remove the tool and reverse the installation tool. Position the larger end of the installer against the front of the balancer.
5. Use a wrench and hold the hex end of the threaded rod.
6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
7. Remove the balancer installation tool.

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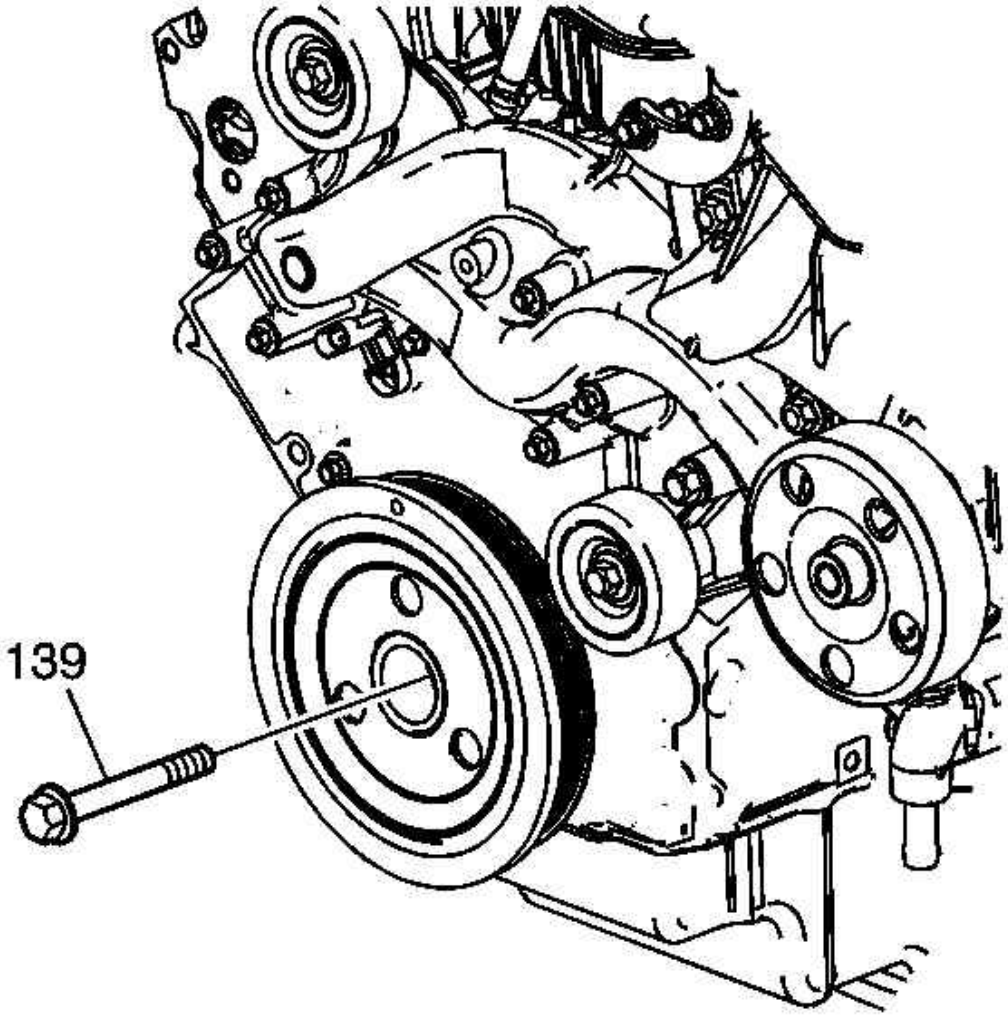


Fig. 159: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the USED crankshaft balancer bolt (139).

   Tighten: Tighten the USED bolt to 330 N.m (240 lb ft).

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4. Remove the USED crankshaft balancer bolt.

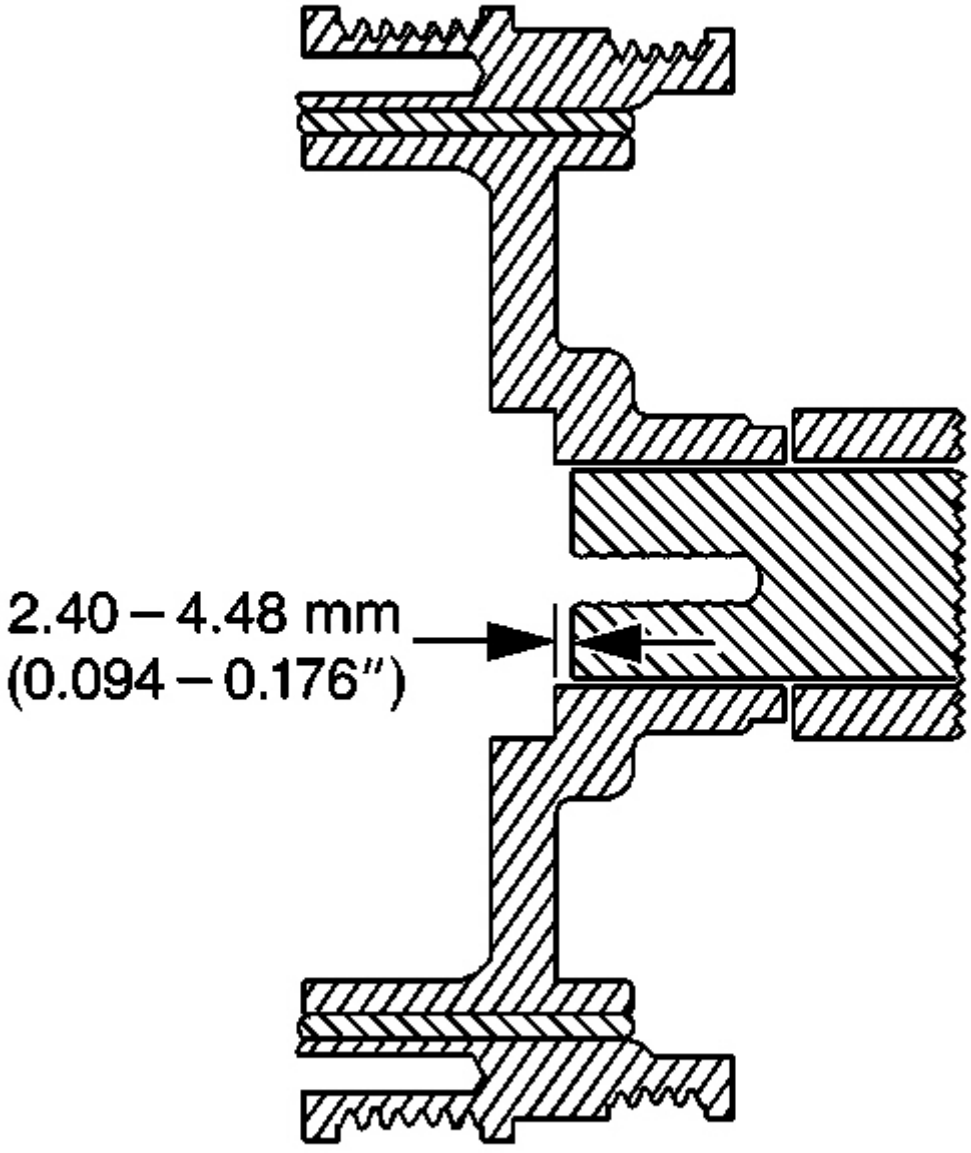


Fig. 160: View Of Balancer Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.

5. Measure for a correctly installed balancer. If the balancer is not installed to the proper dimensions, install the **J 41665** and repeat the installation procedure. See **Special Tools**.

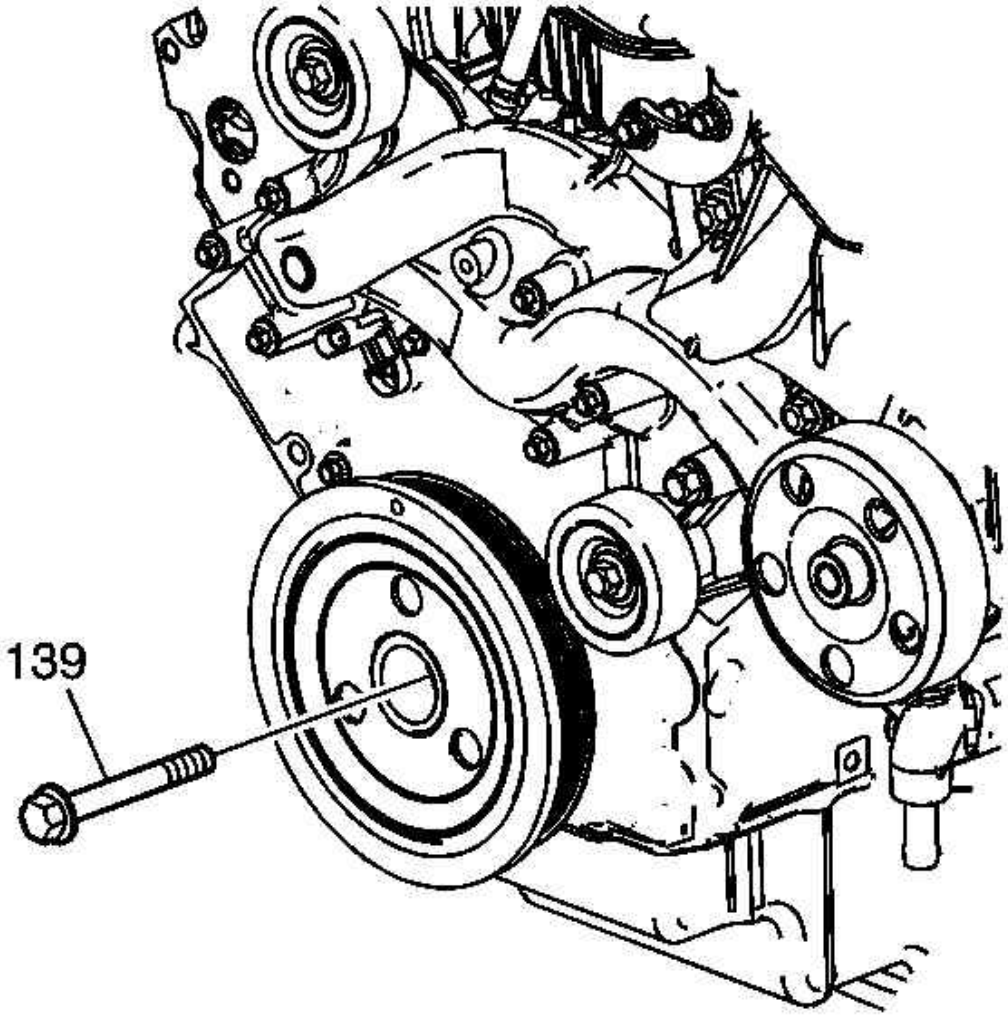


Fig. 161: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

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6. Install a NEW crankshaft balancer bolt (139).

   Tighten:
   - Tighten the bolt a first pass to 50 N.m (37 lb ft).
   - Tighten the bolt a second pass to 140 degrees using **J 45059** .

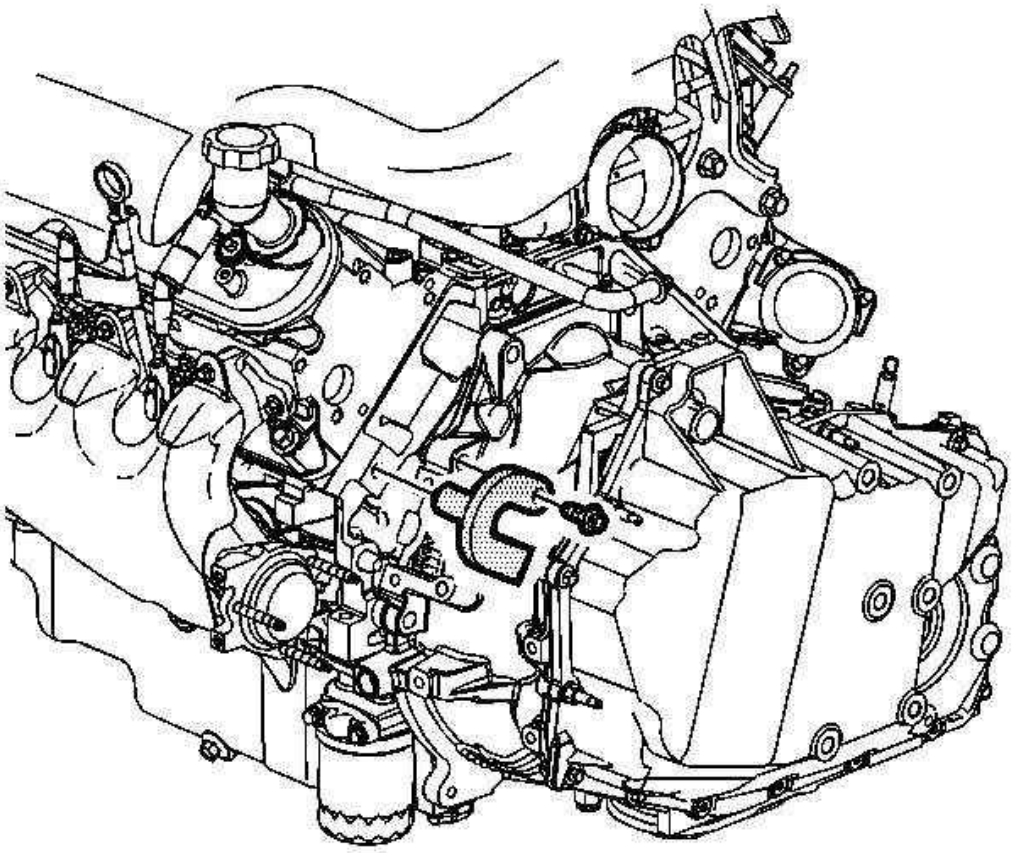


Fig. 162: Installing EN 47699 & Bolt To Block & Flywheel
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 47699** and bolt from the block and flywheel. See **Special Tools**.
8. Install the transmission bellhousing bolt located at approximately the 10

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o'clock position when looking from the rear of the engine.

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

9. Raise and properly position the frame and install the frame to body bolts. Refer to **Frame Replacement** .
10. Install the frame to radiator braces.
11. Install the front lower air deflector. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .
12. Connect the intermediate steering shaft to the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
13. Install the stabilizer shaft link lower nuts. Refer to **Stabilizer Shaft Link Replacement** .
14. Connect the transaxle cooler lines to the transaxle. Refer to **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .
15. Remove the engine support fixture.
16. Install the front fender splash shield.
17. Install the starter motor. Refer to **Starter Motor Replacement (LS4)** .
18. Install the air cleaner upper housing. Refer to **Air Cleaner Assembly Replacement** .
19. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
20. Install the engine mount strut. Refer to **Engine Mount Strut Replacement**.
21. Install the right front tire and wheel assembly. Refer to **Tire and Wheel Removal and Installation** .
22. Perform the crankshaft position (CKP) system variation learn procedure.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

J 41478 Crankshaft Front Oil Seal Installer. See **Special Tools**.

Removal Procedure

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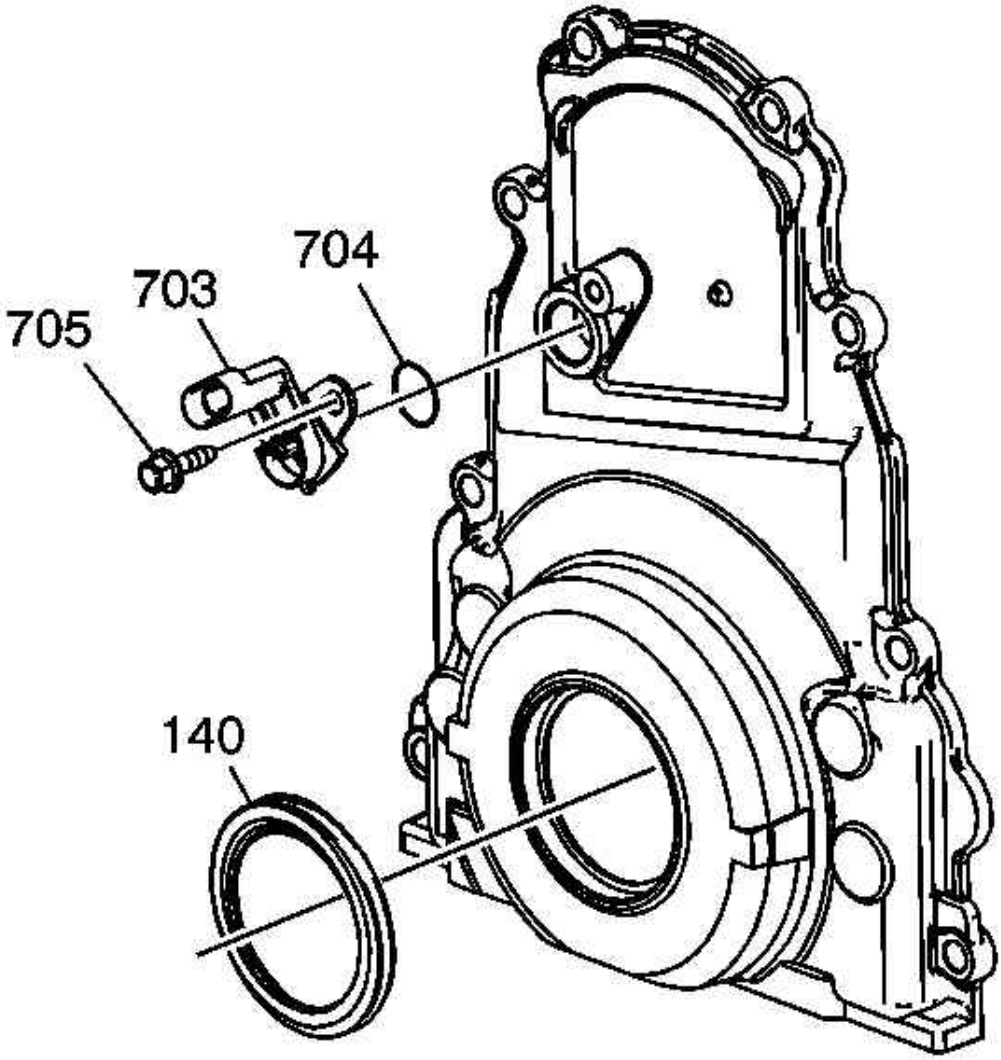


Fig. 163: View Of Crankshaft Oil Seal & Camshaft Position (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Remove and discard the crankshaft oil seal (140).

Installation Procedure

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IMPORTANT:

- **Do not lubricate the oil seal sealing surface.**
- **Do not reuse the crankshaft oil seal.**

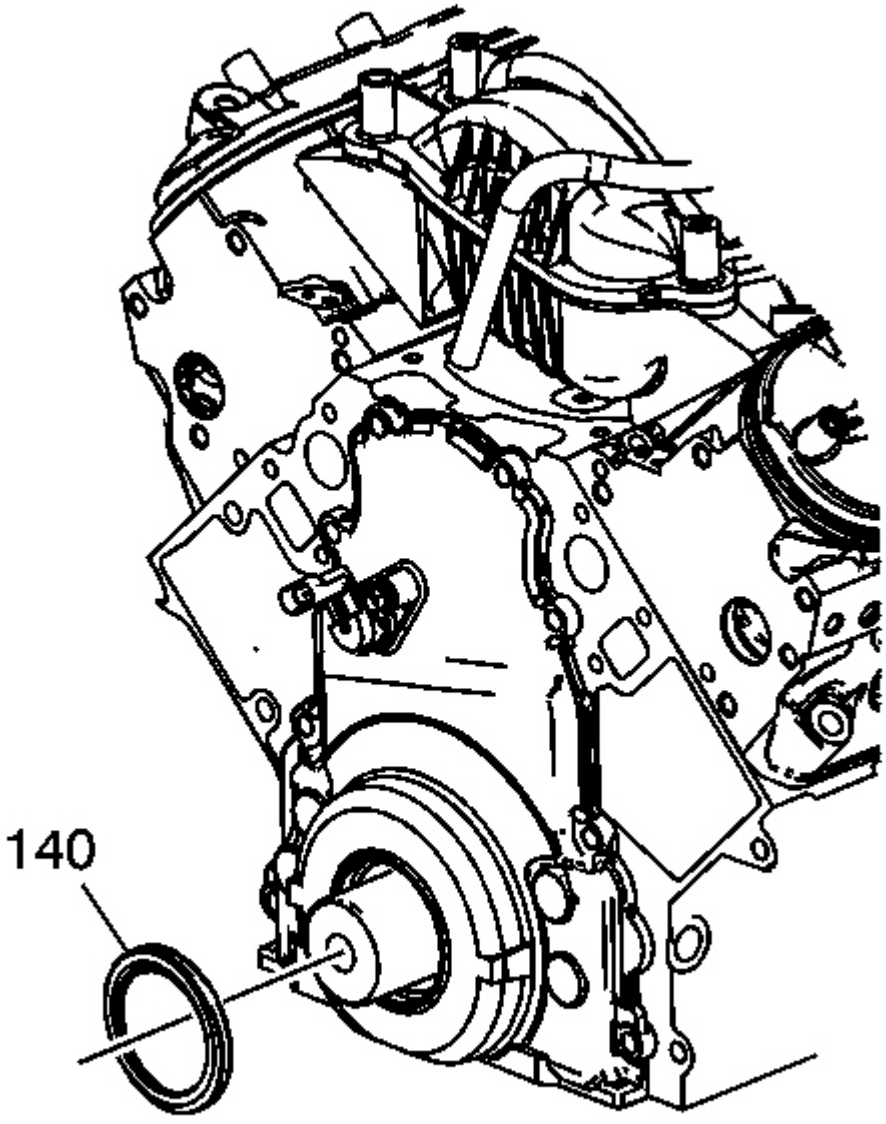


Fig. 164: Aligning Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

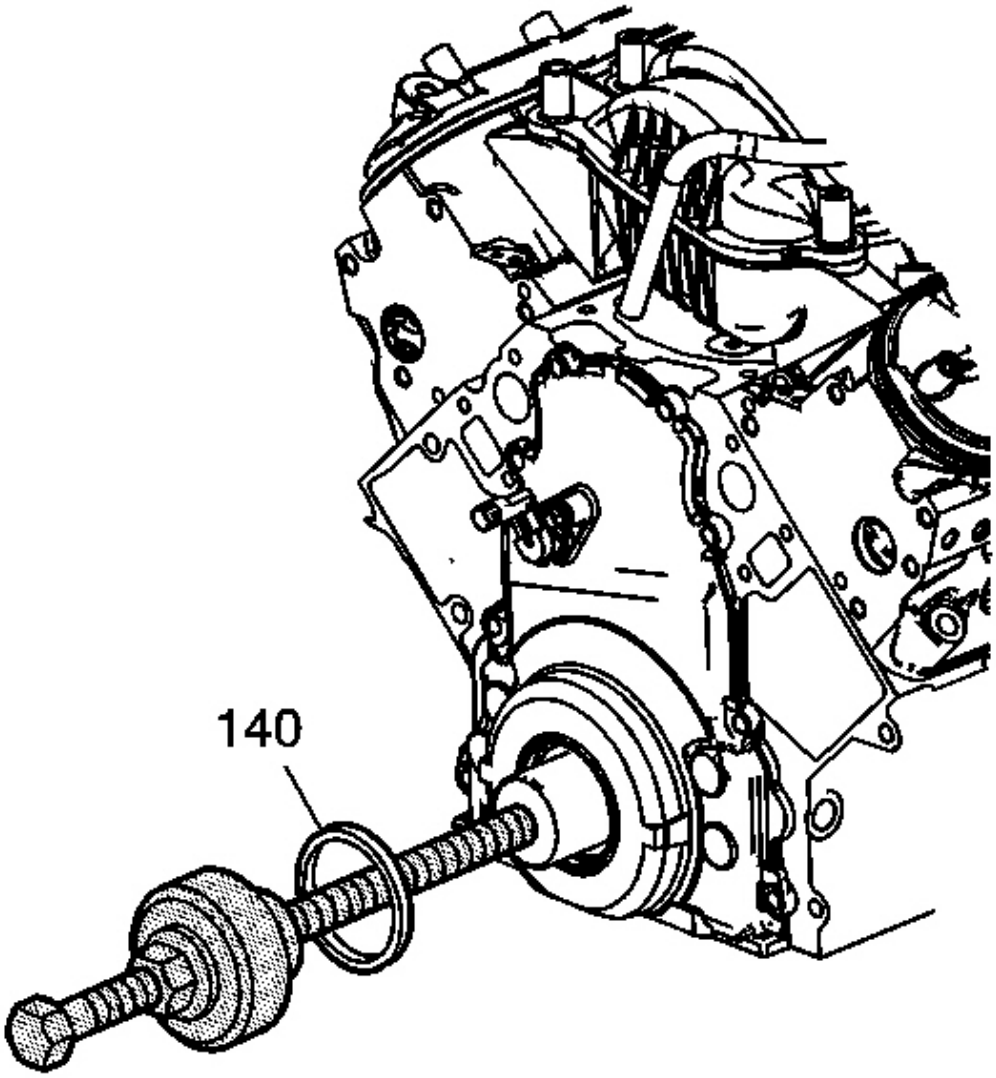


Fig. 165: Using Special Tools To Install Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) onto the **J 41478** . See **Special Tools**.

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4. Install the **J 41478** threaded rod with nut, washer, guide, and oil seal into the end of the crankshaft. See **Special Tools**.
5. Using the **J 41478** , install the oil seal into the cover bore. See **Special Tools**.
    1. Use a wrench and hold the hex on the installer bolt.
    2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
    3. Remove the **J 41478** . See **Special Tools**.
    4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Tools Required

J 41476 Front and Rear Cover Alignment Tool (at crankshaft seal area). See **Special Tools**.

Removal Procedure

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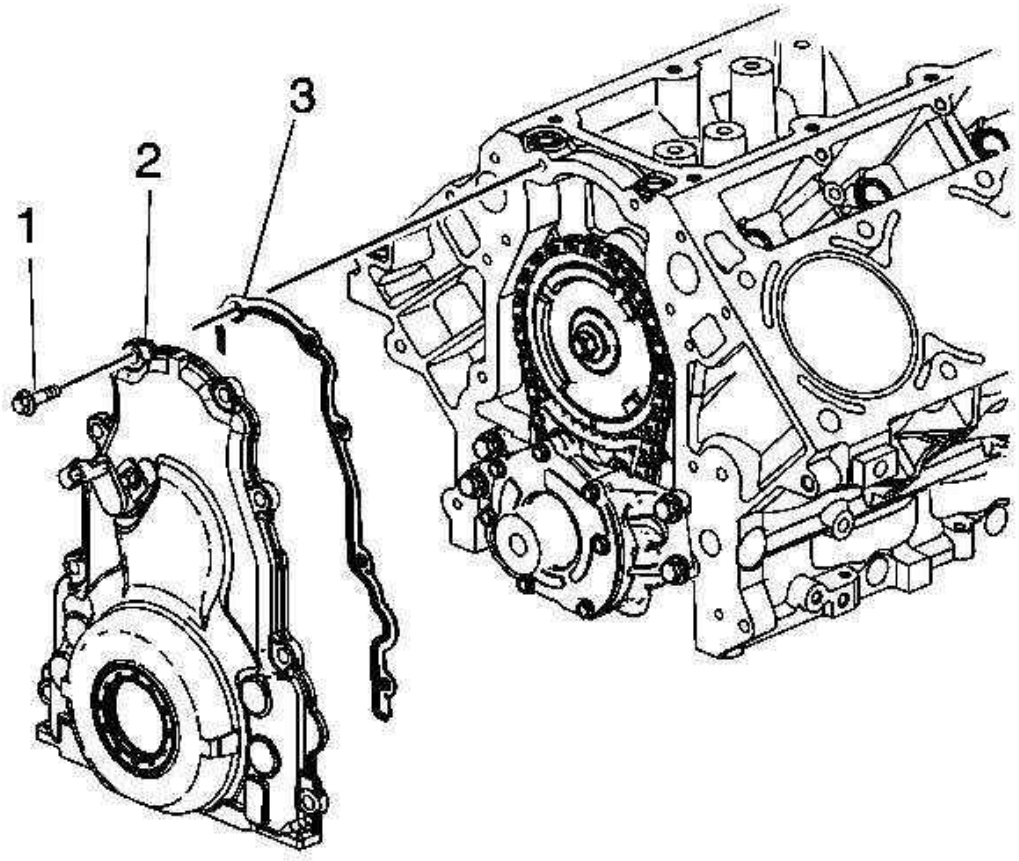


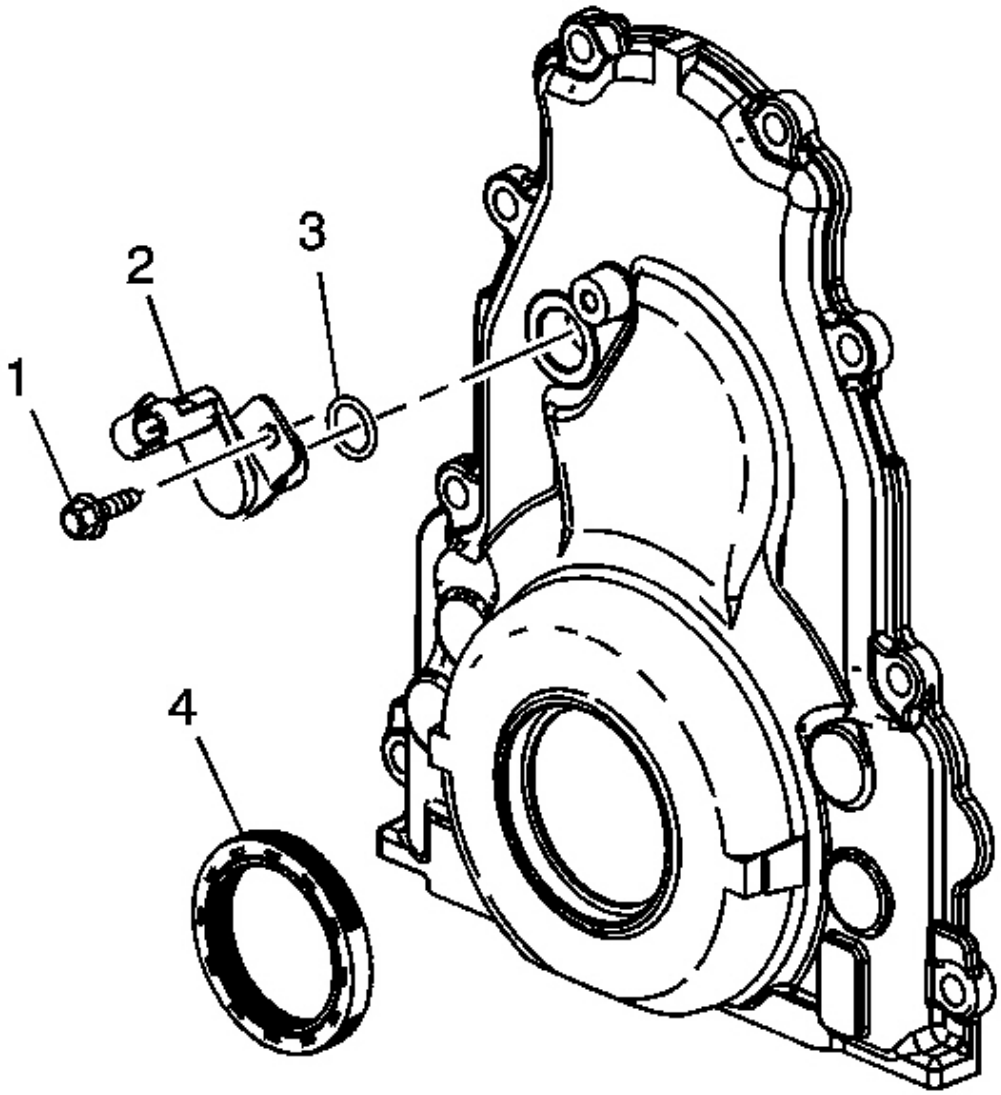
Fig. 166: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the generator. Refer to **Generator Replacement (LS4)** .
2. Remove the power steering pump. Refer to **Power Steering Pump Replacement (LS4)** .
3. Remove the coolant pump manifold. Refer to **Coolant Pump Manifold Replacement** .
4. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
5. Remove the belt tensioner bolt and reposition the tensioner (which blocks the

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front cover bolt).

6. Remove the oil pan-to-front cover bolts.
7. Remove the front cover bolts (1).
8. Remove the front cover (2) and gasket (3).
9. Discard the front cover gasket.



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Fig. 167: Identifying CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Remove the oil seal (4).
11. Remove the bolt (1) and camshaft position (CMP) sensor (2).
12. Remove the O-ring (3) from the sensor, as required.

Installation Procedure

IMPORTANT:

- **Do not reuse the crankshaft oil seal or front cover gasket.**
- **Do not apply any type of sealant to the front cover gasket (unless specified).**
- **The special tool in this procedure is used to properly center the front crankshaft front oil seal.**
  - **All gasket surfaces should be free of oil or other foreign material during assembly.**
  - **The crankshaft front oil seal MUST be centered in relation to the crankshaft.**
  - **An improperly aligned front cover may cause premature front oil seal wear and/or engine oil leaks.**

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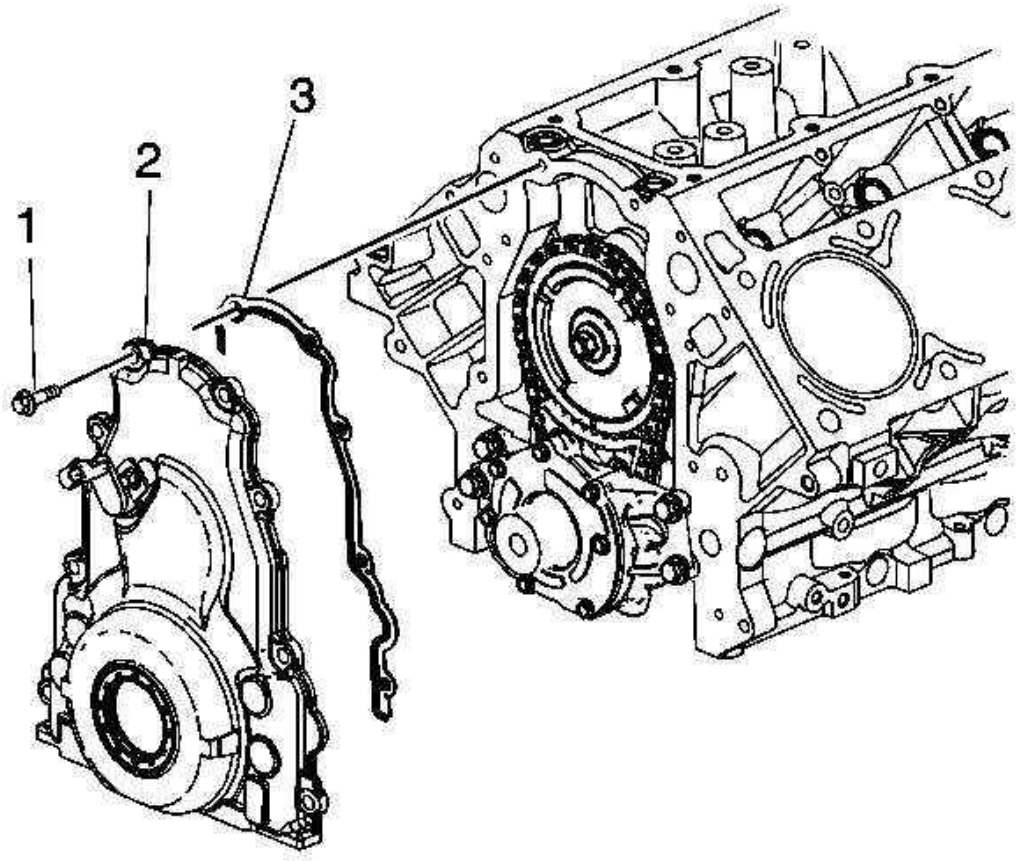


Fig. 168: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the front cover gasket (3), front cover (2), and bolts (1).
2. Tighten the cover bolts finger tight. Do not overtighten.

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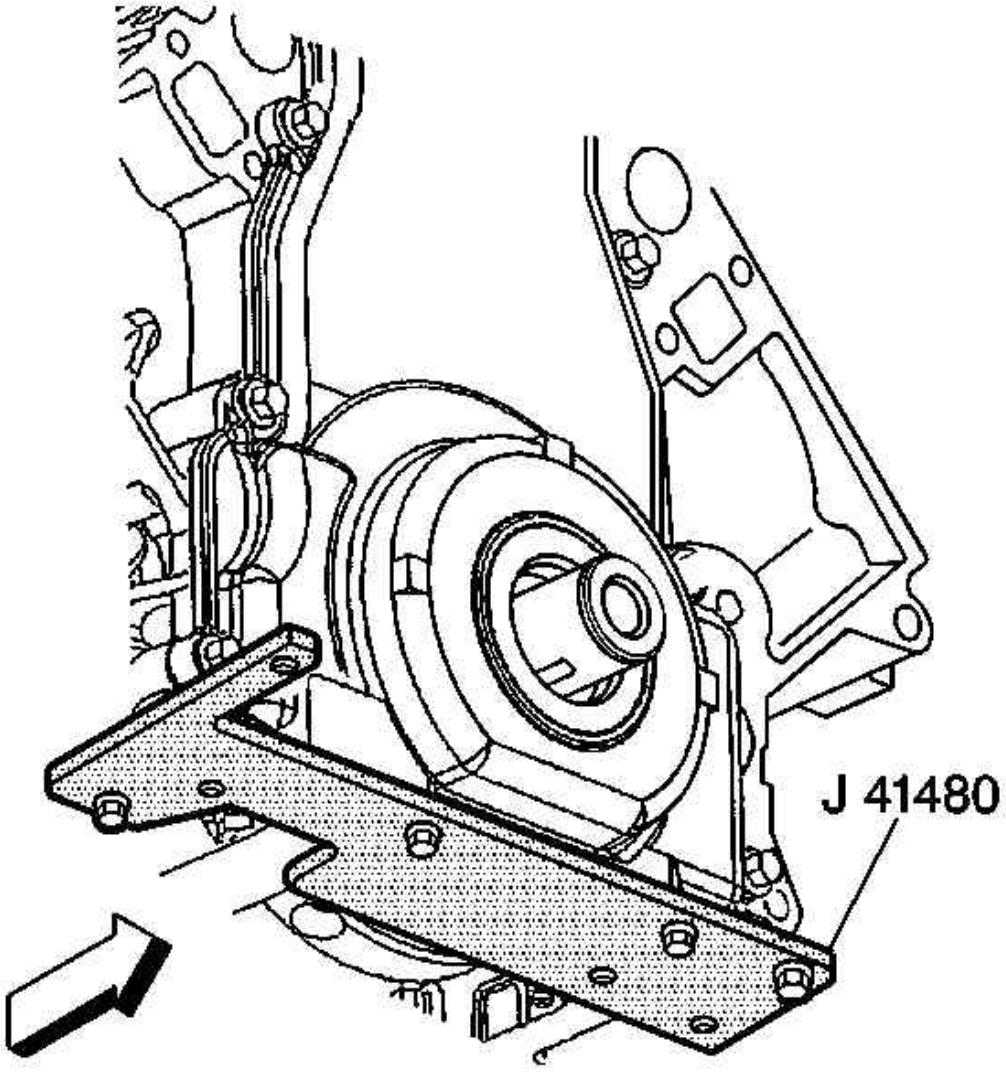


Fig. 169: View Of J 41480 Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

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3. Install the **J 41480** . See **Special Tools**.

   Tighten: Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

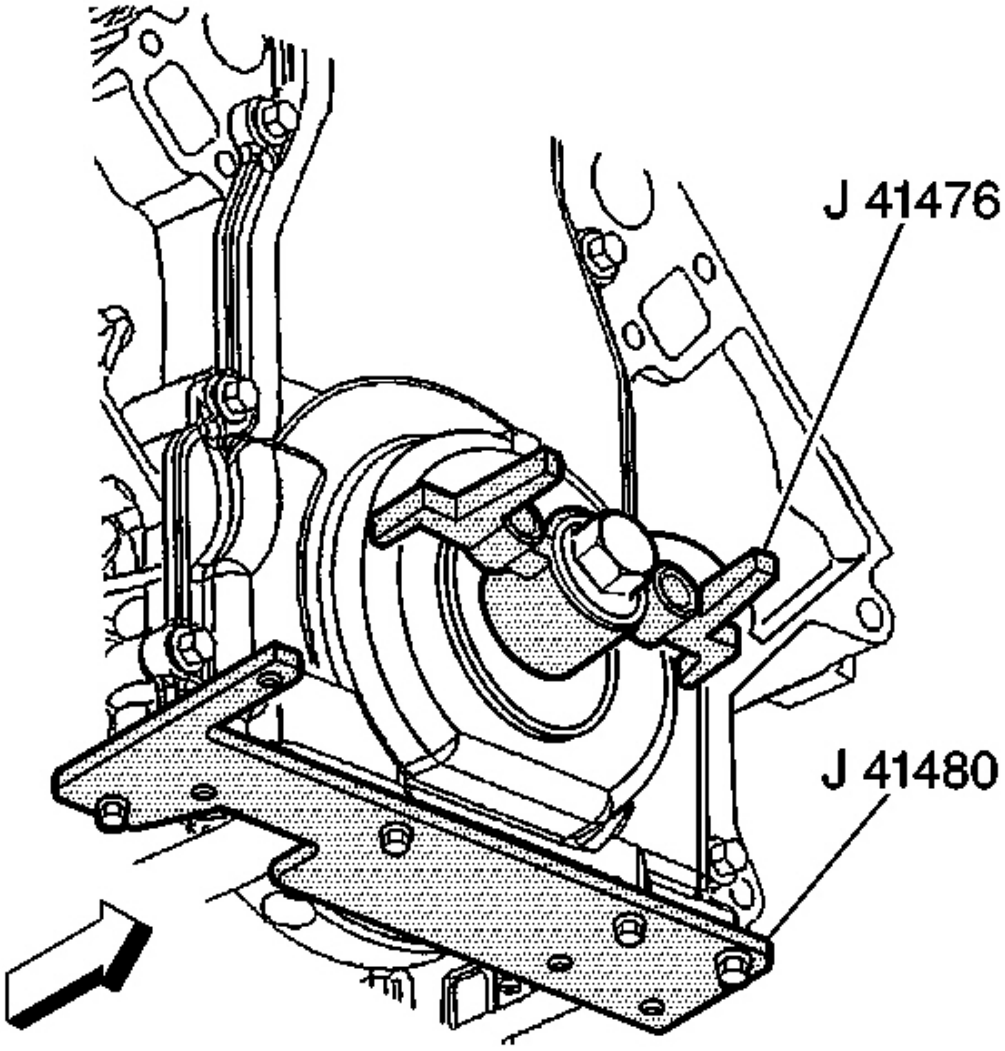


Fig. 170: View Of J 41476 & J 41480 Installed On Engine
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the tapered legs of the tool with the machined

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alignment surfaces on the front cover.

4. Install the **J 41476** . See **Special Tools**.
5. Install the crankshaft balancer bolt.

   Tighten:

   1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
   2. Tighten the **J 41480** . See **Special Tools**.
   3. Tighten the engine front cover bolts to 25 N.m (18 lb ft).

6. Remove the tools.

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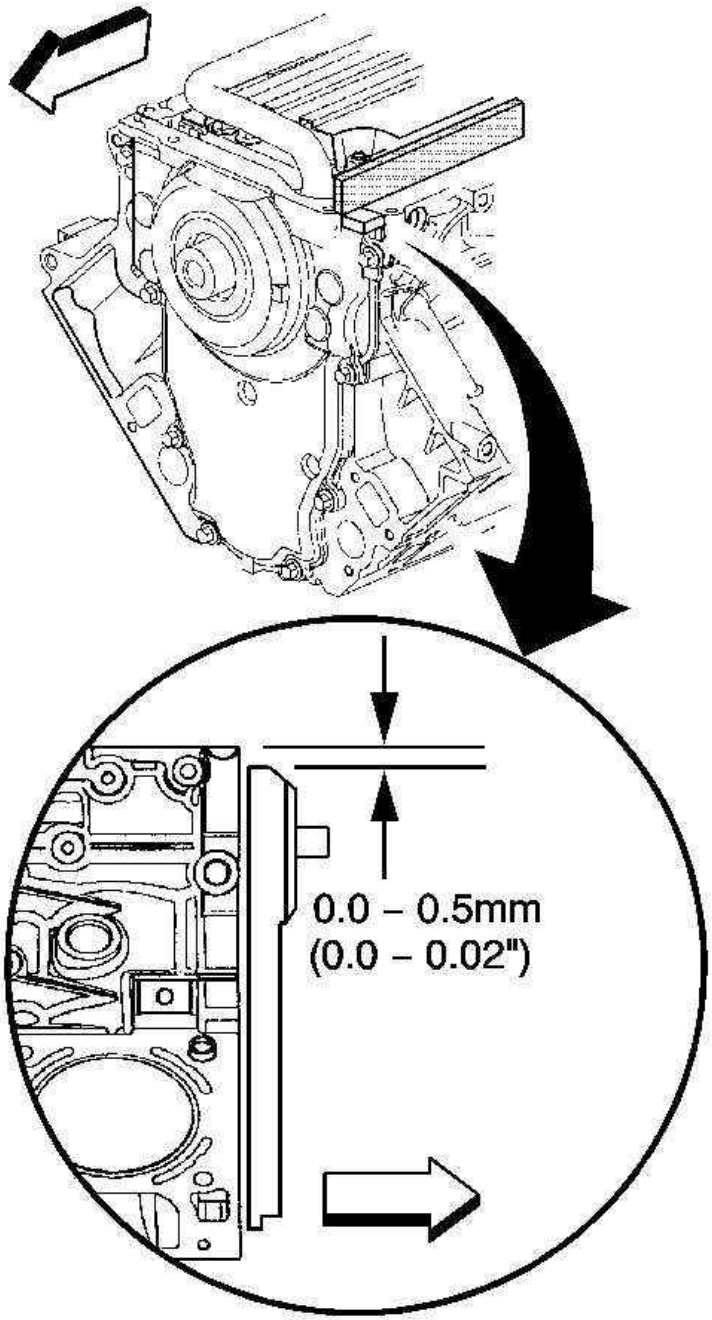


Fig. 171: View Of Front Cover-To-Engine Block Proper Installation Position

Courtesy of GENERAL MOTORS CORP.

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7. Measure the oil pan surface flatness, front cover-to-engine block.
    1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

       Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

    2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface, or no greater than 0.5 mm (0.02 in) below flush.
8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.

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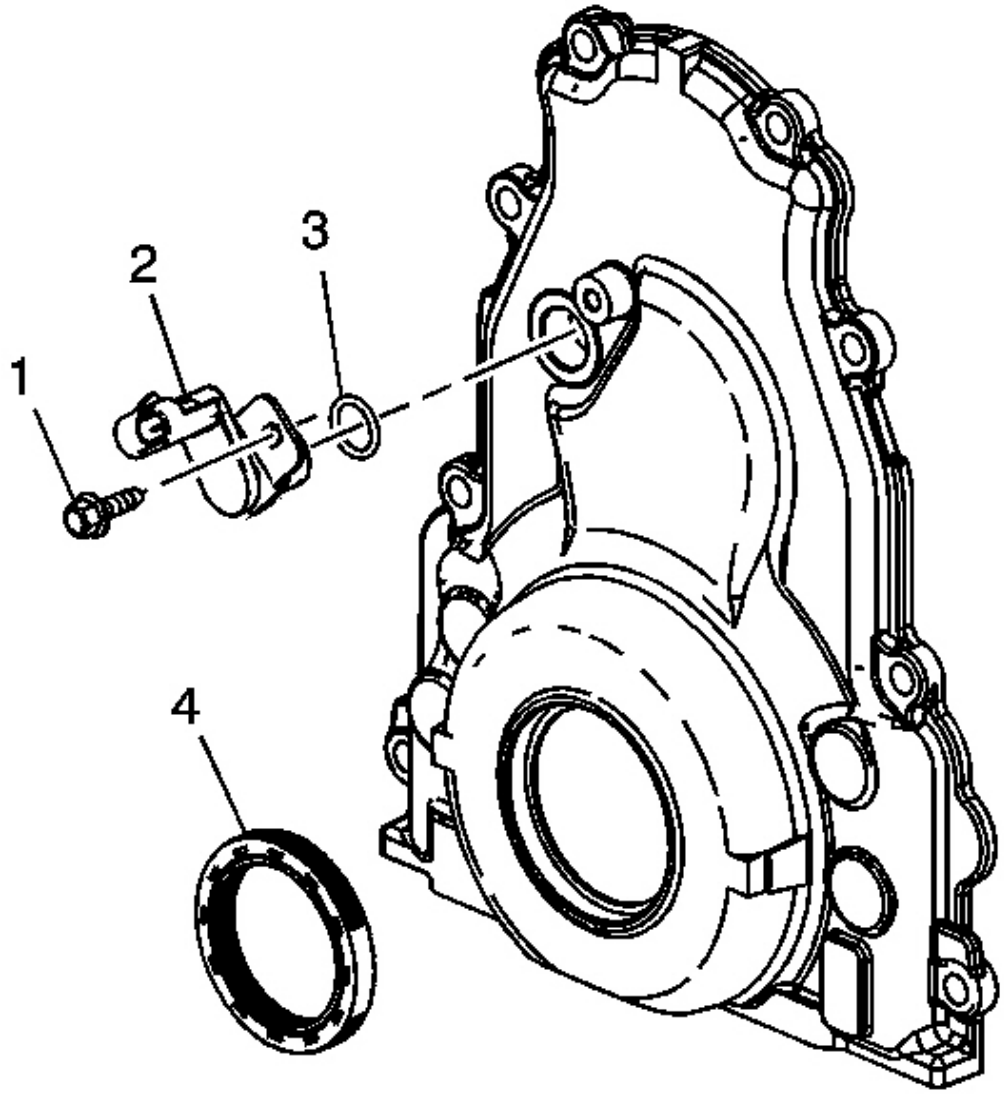


Fig. 172: Identifying CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position (CMP) sensor O-ring seal (3) for cuts or damage. If the seal is not cut or damaged, it may be used again.
11. Lubricate the O-ring seal with clean engine oil.

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12. Install the O-ring seal onto the sensor (2).
13. Install the sensor to the cover.
14. Install the bolt (1).

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

15. Install the coolant pump manifold. Refer to **Coolant Pump Manifold Replacement** .
16. Inspect the CMP sensor O-ring seal (3) for cuts or damage. If the seal is not cut or damaged, it may be reused.
17. Lubricate the O-ring seal with clean engine oil.
18. Install the O-ring seal (3) onto the CMP sensor.
19. Install the CMP sensor (2) and bolt (1) from the front cover.

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

20. Position the belt tensioner and install the bolt.

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

21. Install the power steering pump. Refer to **Power Steering Pump Replacement (LS4)** .
22. Install the generator. Refer to **Generator Replacement (LS4)** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

- **J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools**.
- **J 41479-2A** Crankshaft Rear Oil Seal Installation Guide. See **Special Tools**.

Removal Procedure

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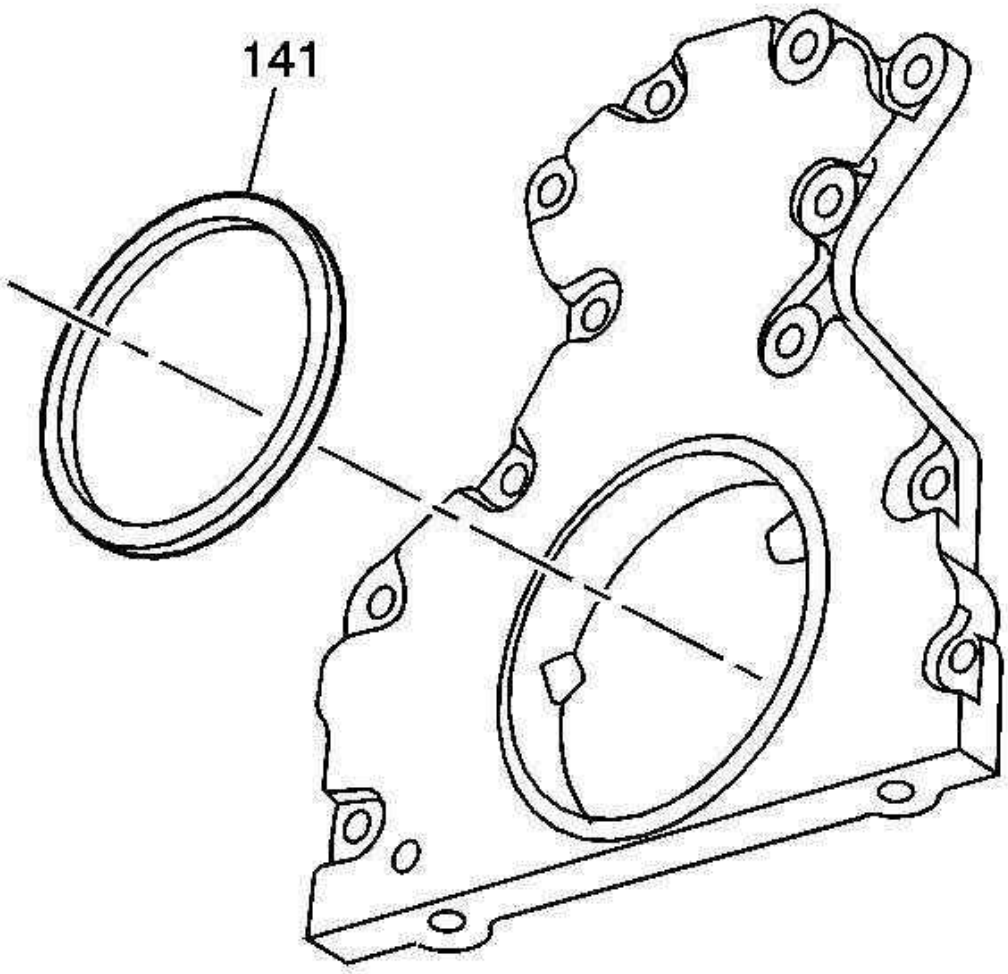


Fig. 173: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove and discard the crankshaft rear oil seal (141).

Installation Procedure

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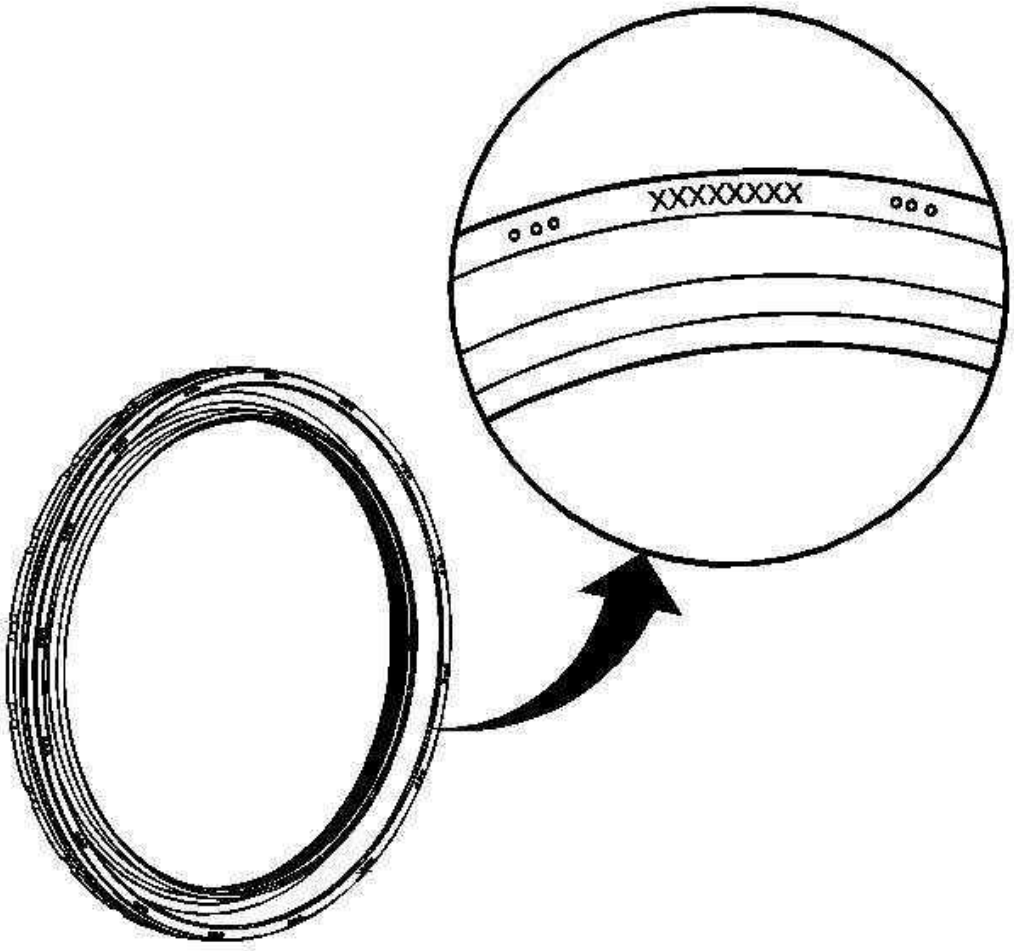


Fig. 174: Identifying Oil Seal Orientation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. The part number is applied to the outside face of the seal, as shown.

1. Inspect the seal and identify the part number markings for proper orientation.

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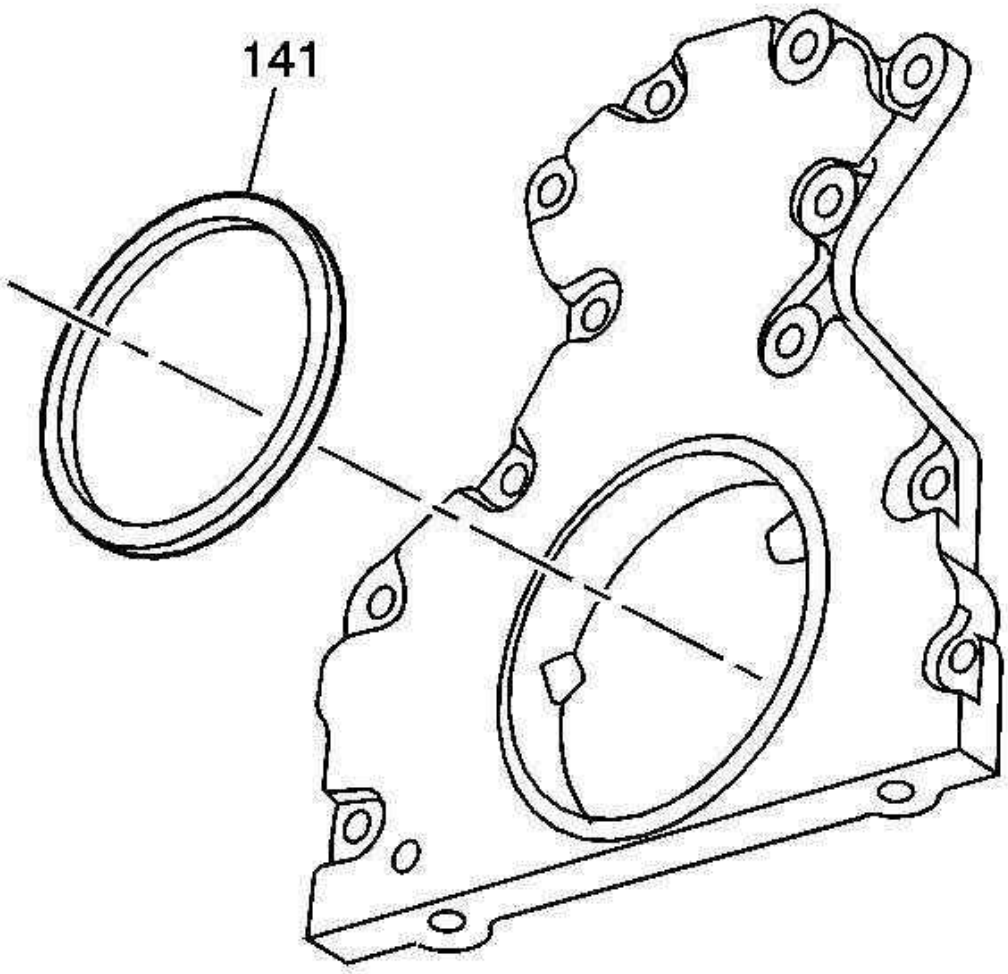


Fig. 175: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.**
- **Do not reuse the crankshaft rear oil seal.**

2. Lubricate the outside diameter (OD) of the oil seal (141) with clean engine oil. DO NOT allow oil or other lubricants to contact the seal surface.

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3. Lubricate the rear cover oil seal bore with clean engine oil. DO NOT allow oil or other lubricants to contact the crankshaft surface.

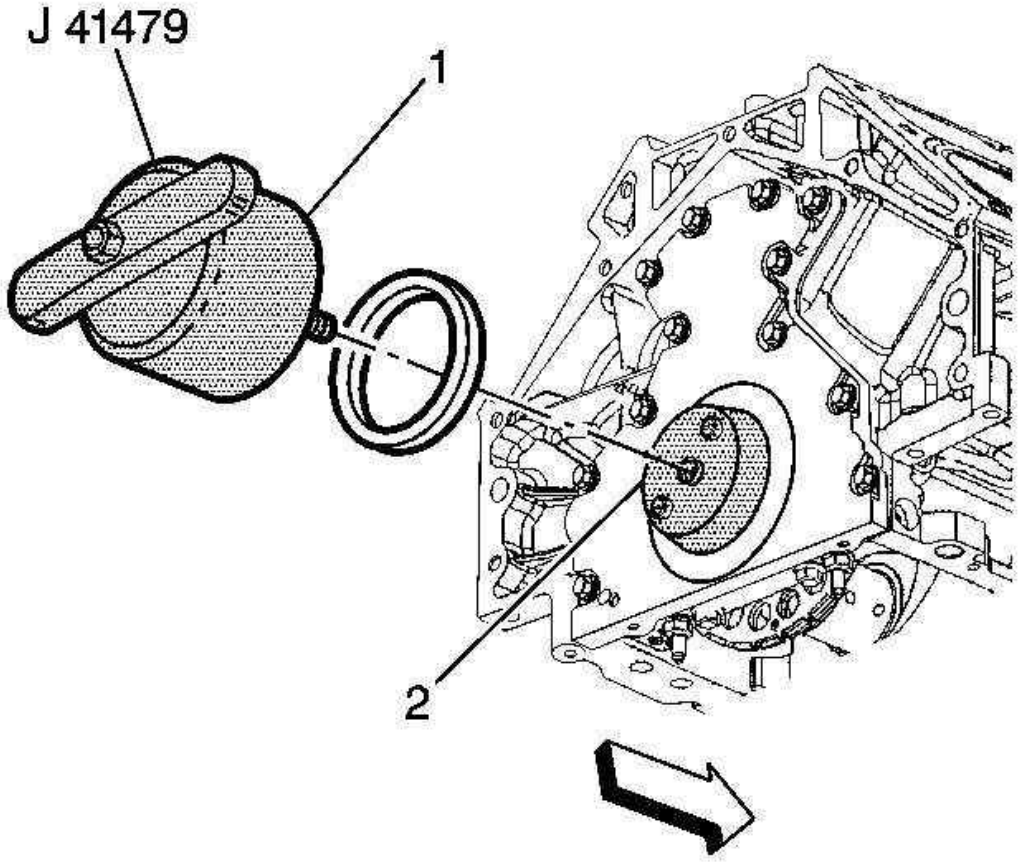


Fig. 176: View Of J 41479 Cone & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41479** tapered cone (2) with the **J 41479-2A** and bolts onto the rear of the crankshaft. See **Special Tools**.
5. Tighten the bolts until snug. Do not overtighten.
6. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
7. Install the oil seal with the part number markings facing away from the engine.

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8. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.
9. Align the oil seal into the tool (1).
10. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
11. Remove the **J 41479** and the **J 41479-2A** . See **Special Tools**.
12. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

ENGINE REAR COVER REPLACEMENT

Tools Required

J 41476 Front and Rear Cover Alignment Tool (at crankshaft seal area). See **Special Tools**.

Removal Procedure

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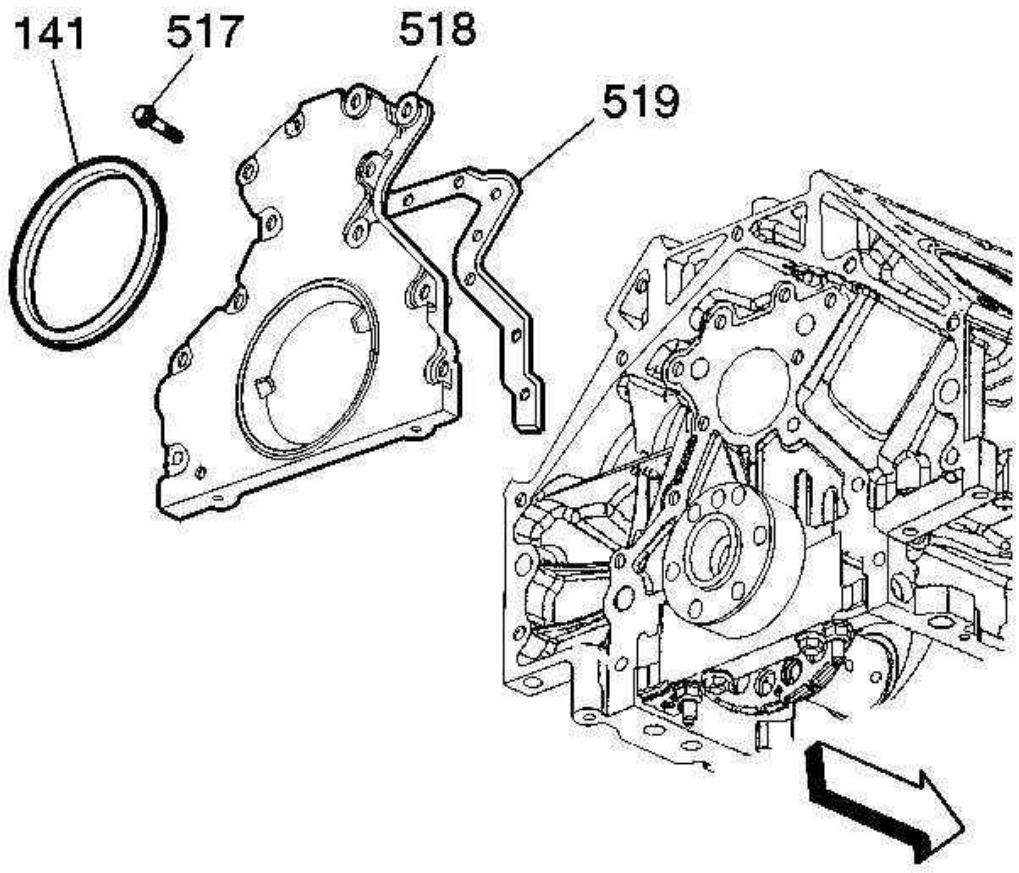


Fig. 177: View Of Engine Rear Cover, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the oil pan-to-rear cover bolts.
3. Remove the rear cover bolts (517).
4. Remove the rear cover (518) and gasket (519). Discard the gasket.
5. Remove and discard the rear oil seal (141).

Installation Procedure

IMPORTANT:

- **Do not reuse the crankshaft oil seal or rear cover**

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gasket.

- **Do not apply any type of sealant to the rear cover gasket, unless specified.**
- **The special tool in this procedure is used to properly center the crankshaft rear oil seal.**
- **The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned.**

Install the rear cover without the crankshaft oil seal.

  - **All gasket surfaces should be free of oil or other foreign material during assembly.**
  - **The crankshaft rear oil seal MUST be centered in relation to the crankshaft.**
  - **An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.**

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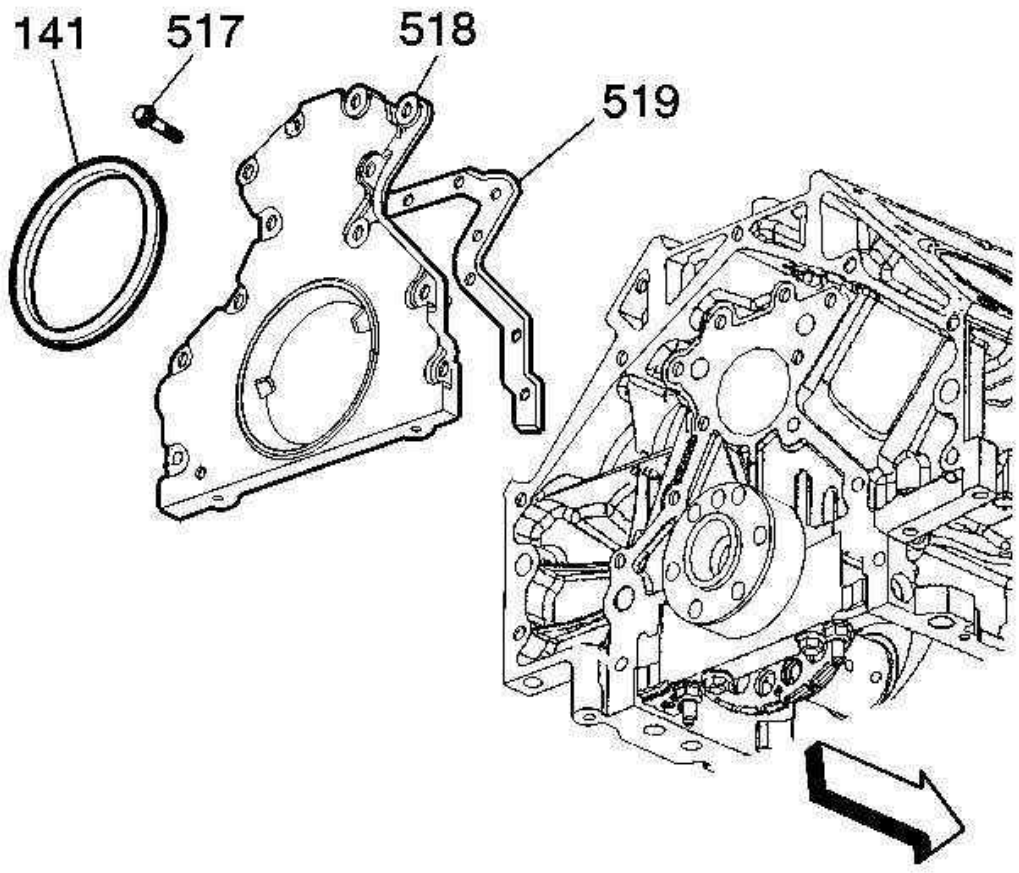


Fig. 178: View Of Engine Rear Cover, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant or equivalent 20 mm (0.80 in) long, to the oil pan to engine block junction. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install the rear cover gasket (519) and cover (518).
3. Install the rear cover bolts (517) until snug. Do not overtighten.
4. Install the oil pan-to-rear cover bolts until snug. Do not overtighten.

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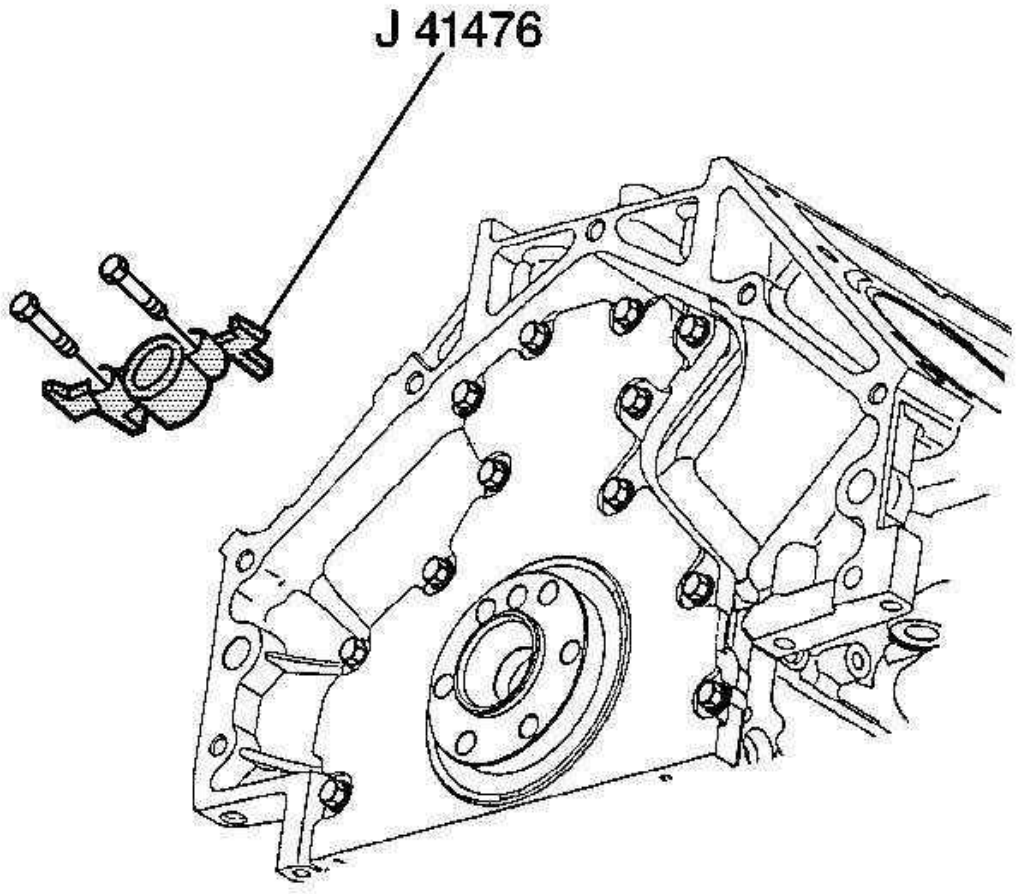


Fig. 179: View Of J 41476 & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The tapered legs of the alignment tool must enter the rear cover oil seal bore.

5. Rotate the crankshaft until two opposing flywheel bolt holes are parallel to the oil pan surface.
6. Install the **J 41476** and bolts onto the rear of the crankshaft. See **Special Tools**.

NOTE: Refer to Fastener Notice .

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7. Tighten the **J 41476** mounting bolts until snug. See **Special Tools**. Do not overtighten.

   Tighten:

   1. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
   2. Tighten the engine rear cover bolts to 30 N.m (22 lb ft).

8. Remove the **J 41476** . See **Special Tools**.
9. Install a NEW crankshaft rear oil seal. Refer to **Crankshaft Rear Oil Seal Replacement**.
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

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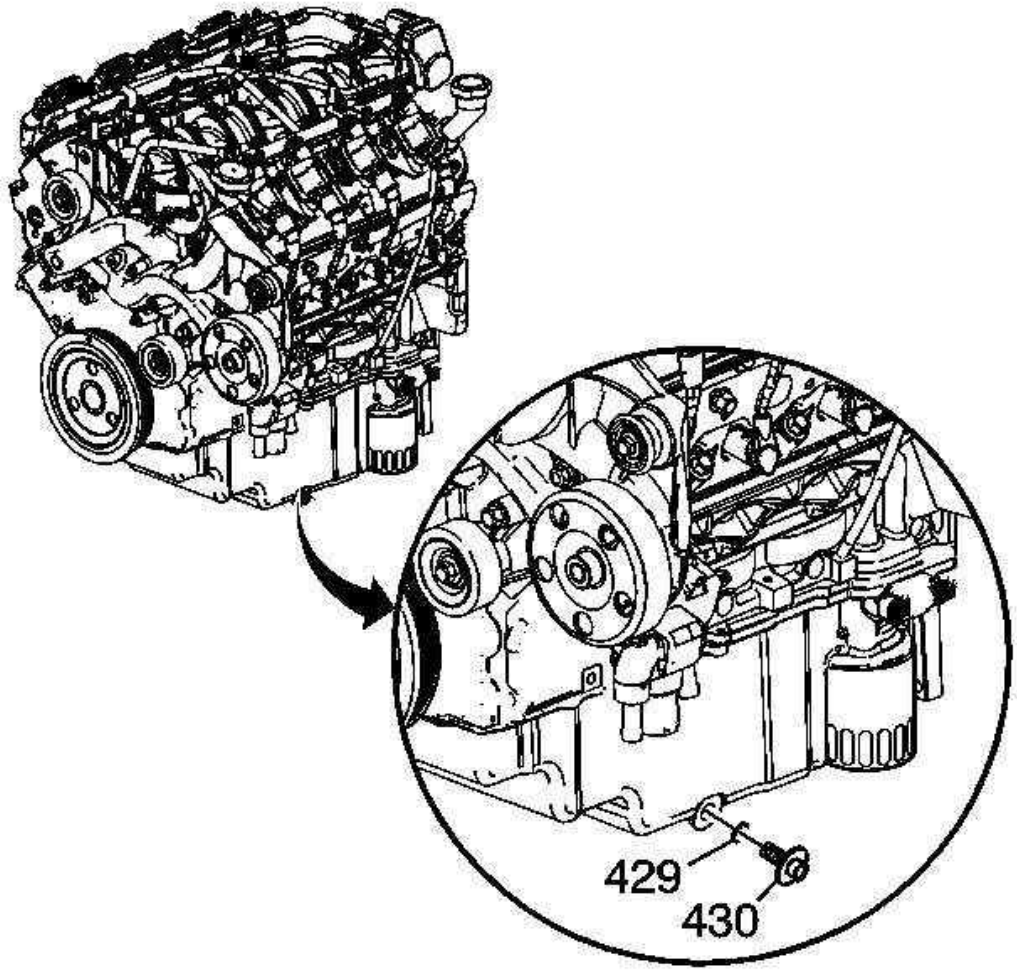


Fig. 180: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the oil pan drain plug (430) and O-ring (429).
5. Allow the oil to drain into an appropriate container.

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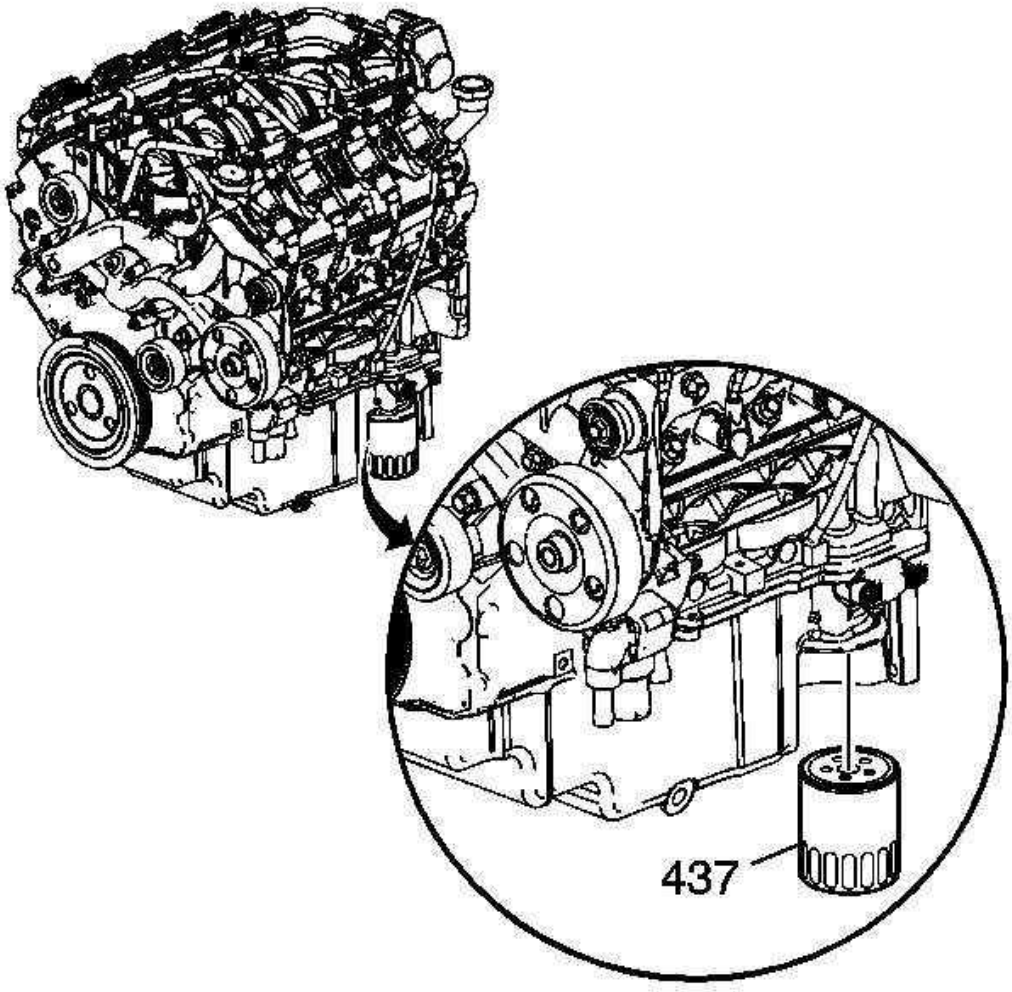


Fig. 181: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil filter (437). Allow the rest of the engine oil to drain into an appropriate container.

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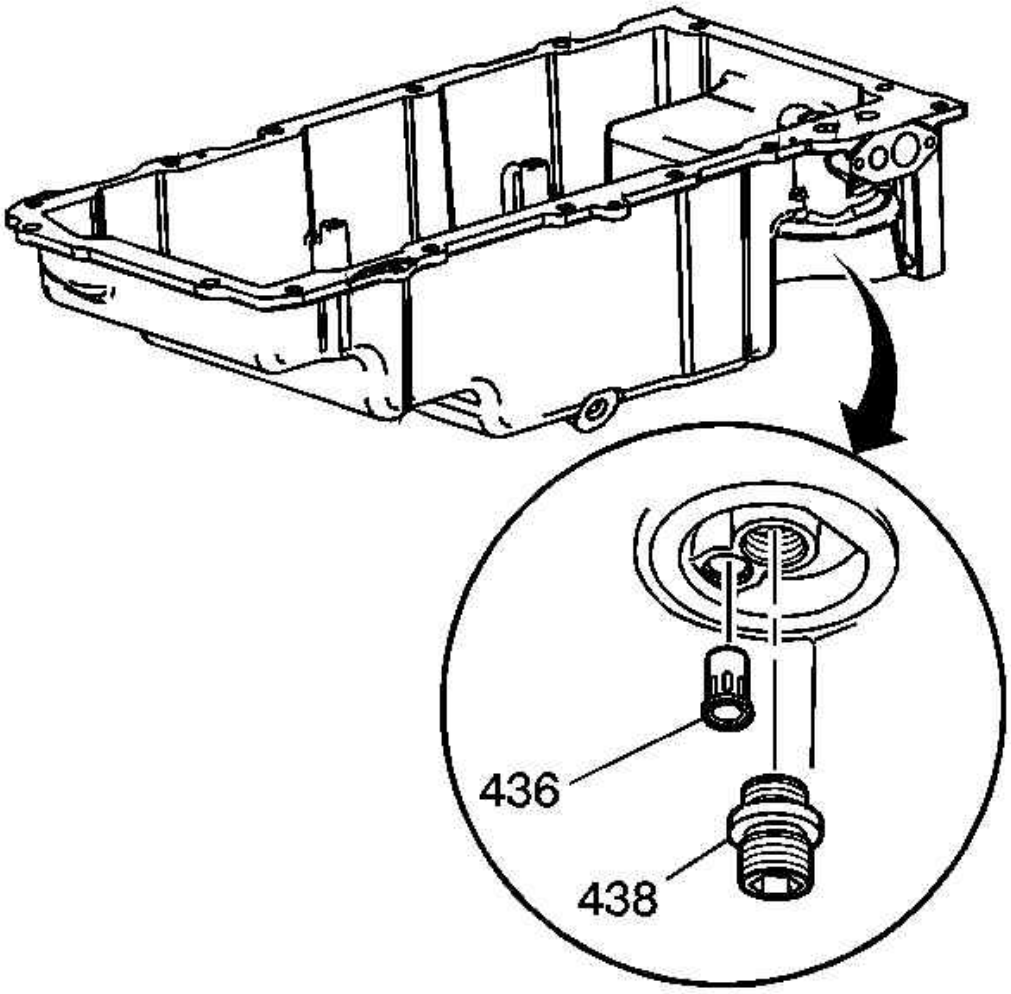


Fig. 182: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil filter adapter (438).

Installation Procedure

NOTE: Refer to Fastener Notice .

IMPORTANT: Prior to installing a NEW oil filter, ensure that the old oil

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filter gasket has been removed from the engine block. If not, remove the old gasket.

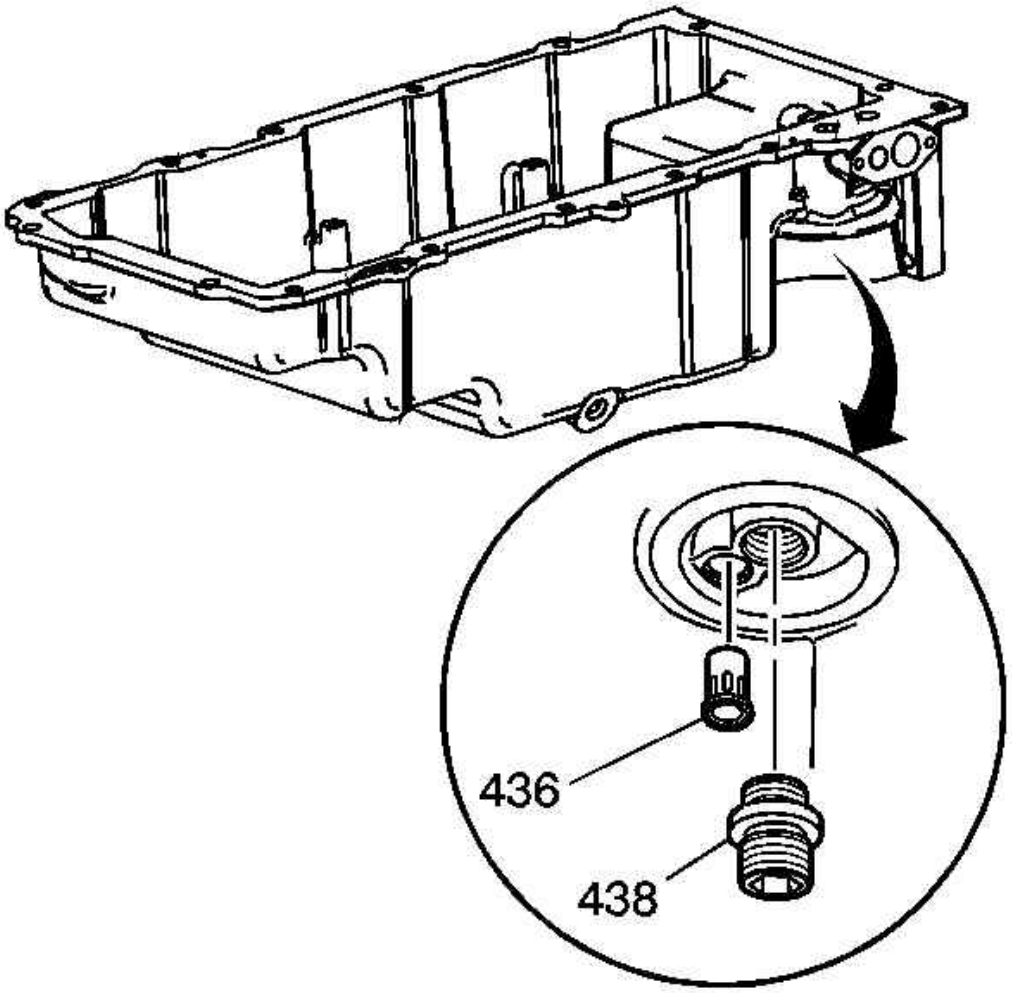


Fig. 183: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil filter adapter (438).

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

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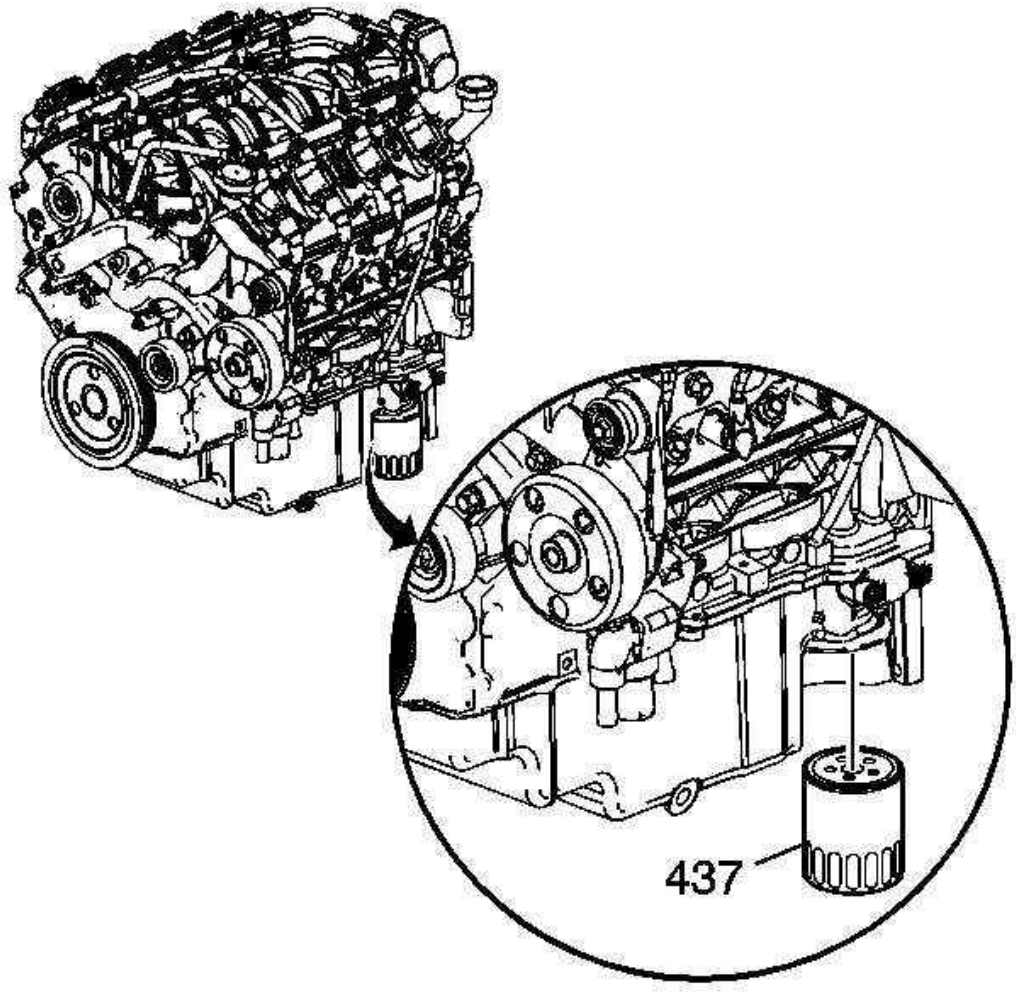


Fig. 184: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW engine oil filter (437).

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

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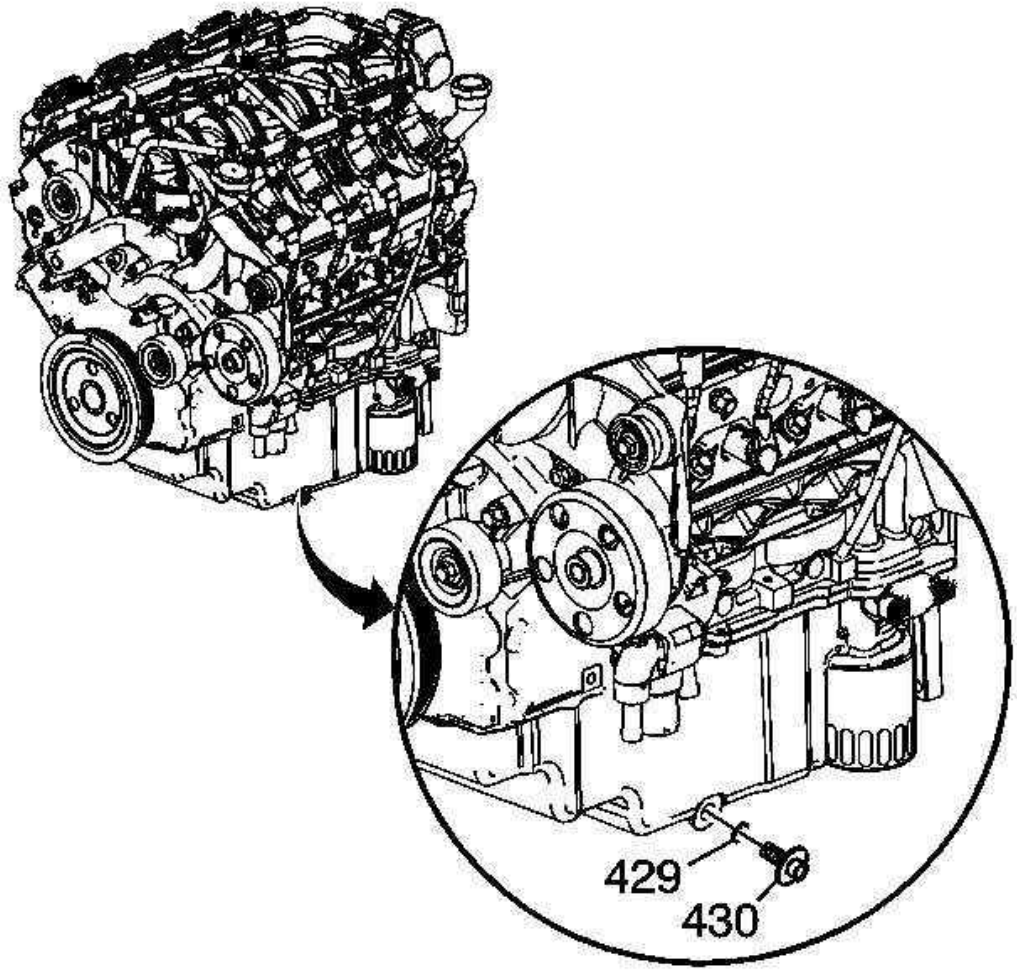


Fig. 185: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan drain plug (430) and O-ring (429).

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

4. Lower the vehicle.
5. Fill the engine with the appropriate amount and type of NEW engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant**

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Recommendations .

6. Check the oil level.
7. Install the oil fill cap.
8. Close the hood.
9. Reset the engine oil life monitor, if necessary. Refer to **GM Oil Life System Resetting** .

OIL FILTER BYPASS VALVE REPLACEMENT

Removal Procedure

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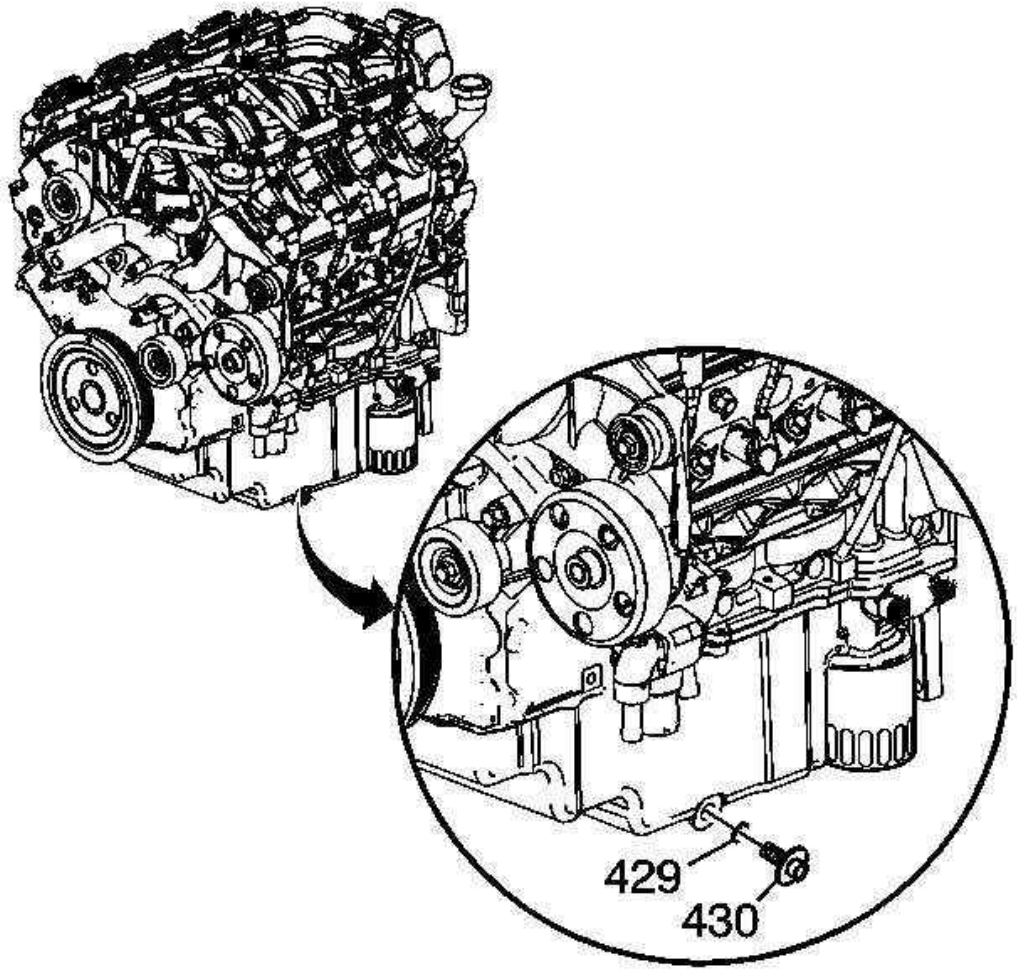


Fig. 186: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the oil pan drain plug (430) and O-ring (429).
5. Allow the oil to drain into an appropriate container.

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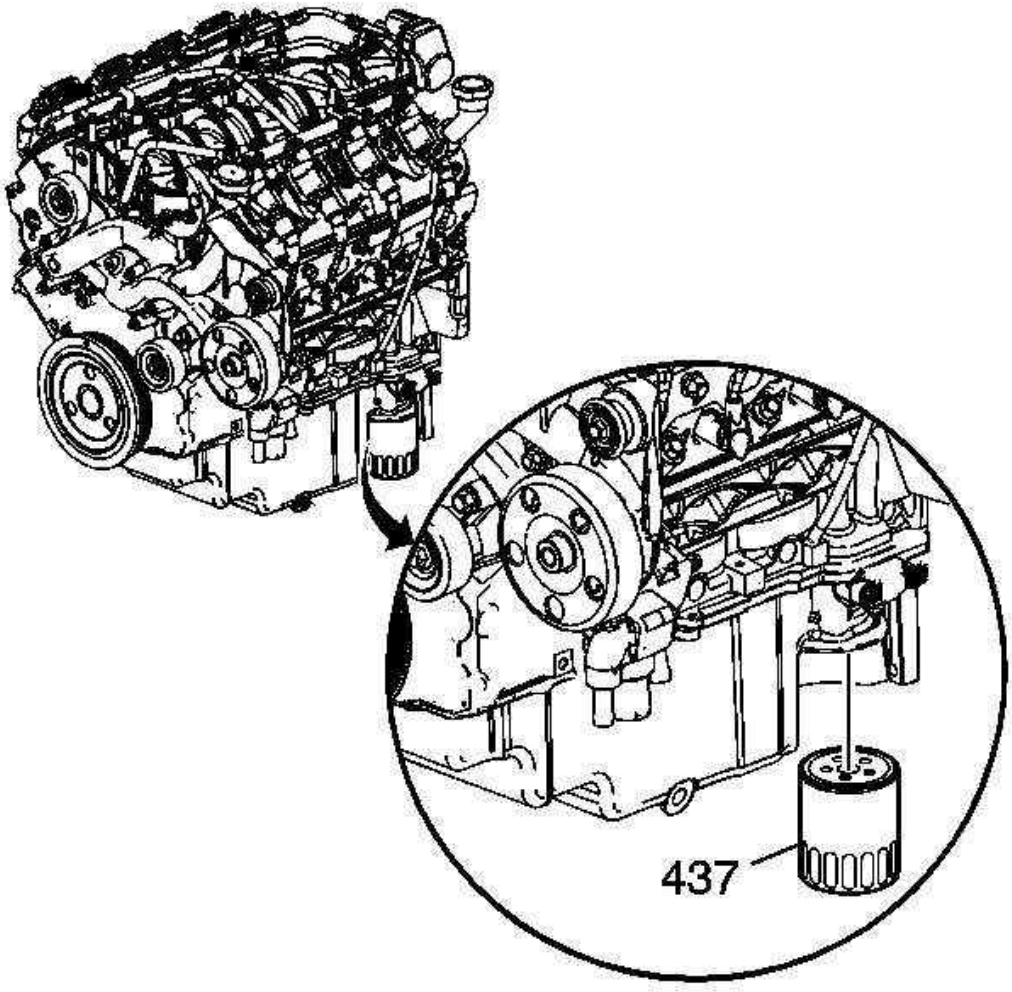


Fig. 187: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil filter (437). Allow the rest of the engine oil to drain into an appropriate container.

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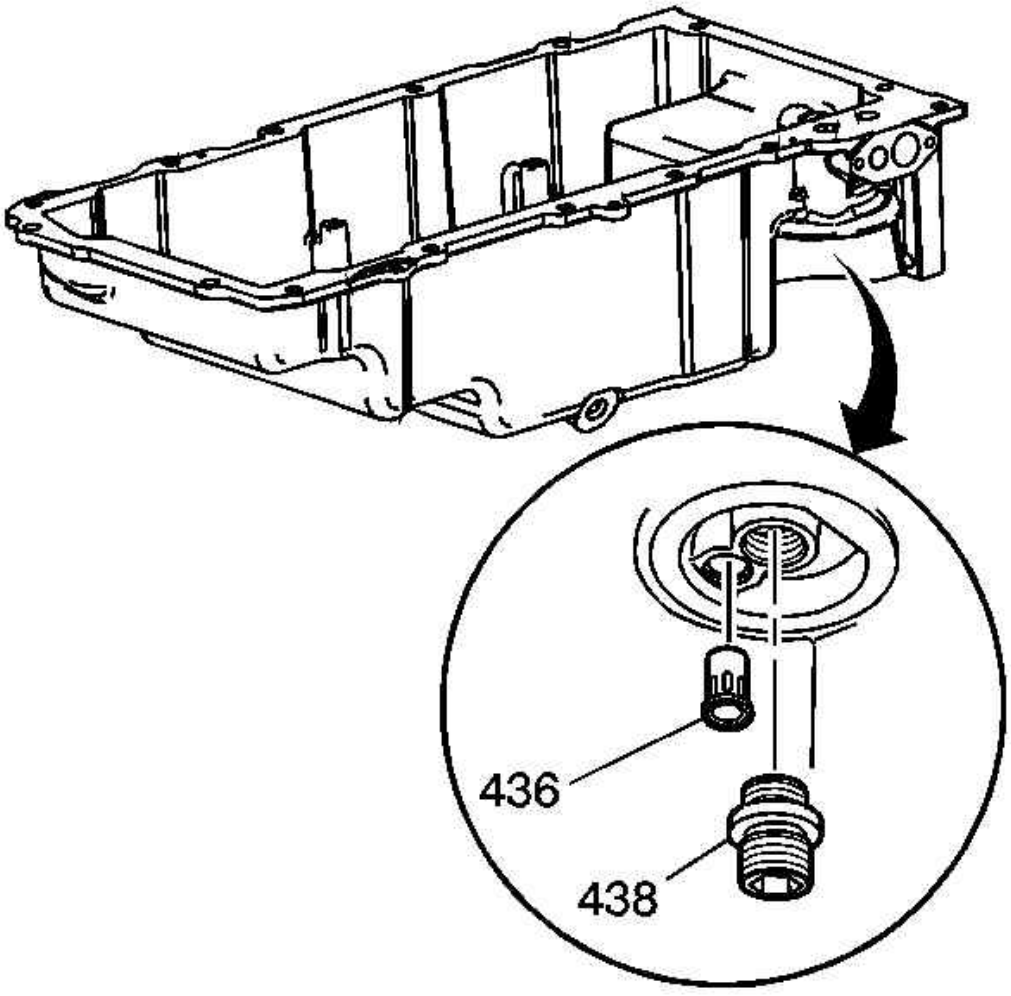


Fig. 188: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil filter adapter (438).
8. Remove the bypass valve (436).

Installation Procedure

IMPORTANT: Prior to installing a NEW oil filter, ensure that the old oil filter gasket has been removed from the engine block. If

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not, remove the old gasket.

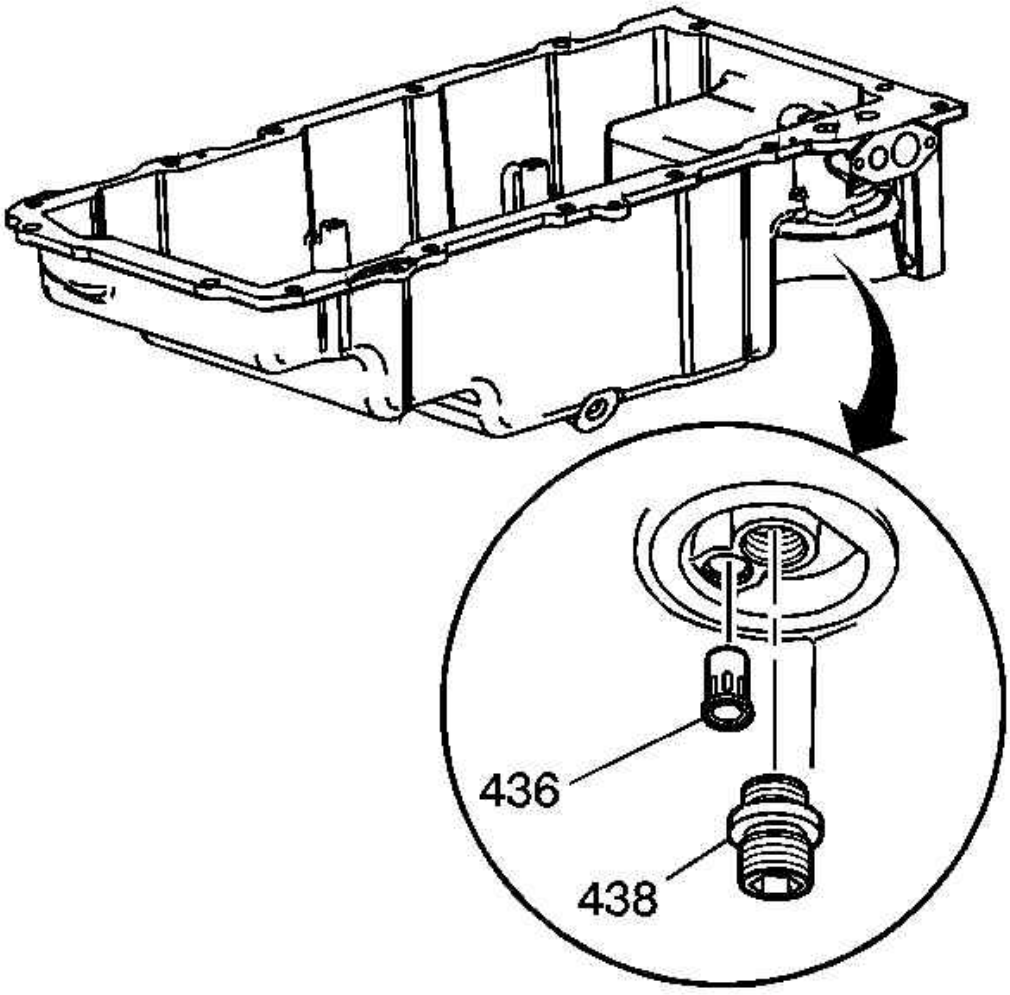


Fig. 189: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW bypass valve (436).

NOTE: Refer to Fastener Notice .

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2. Install a NEW oil filter adapter (438).

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

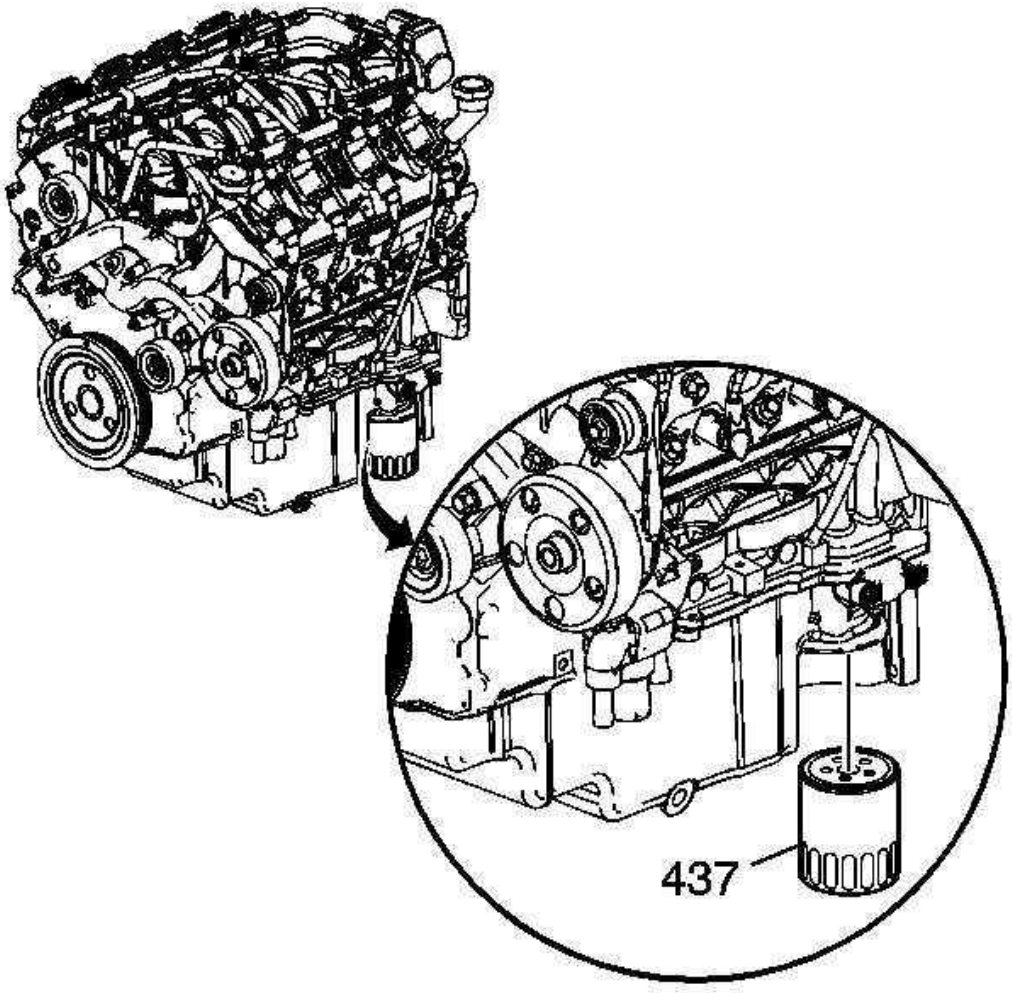


Fig. 190: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW engine oil filter (437).

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

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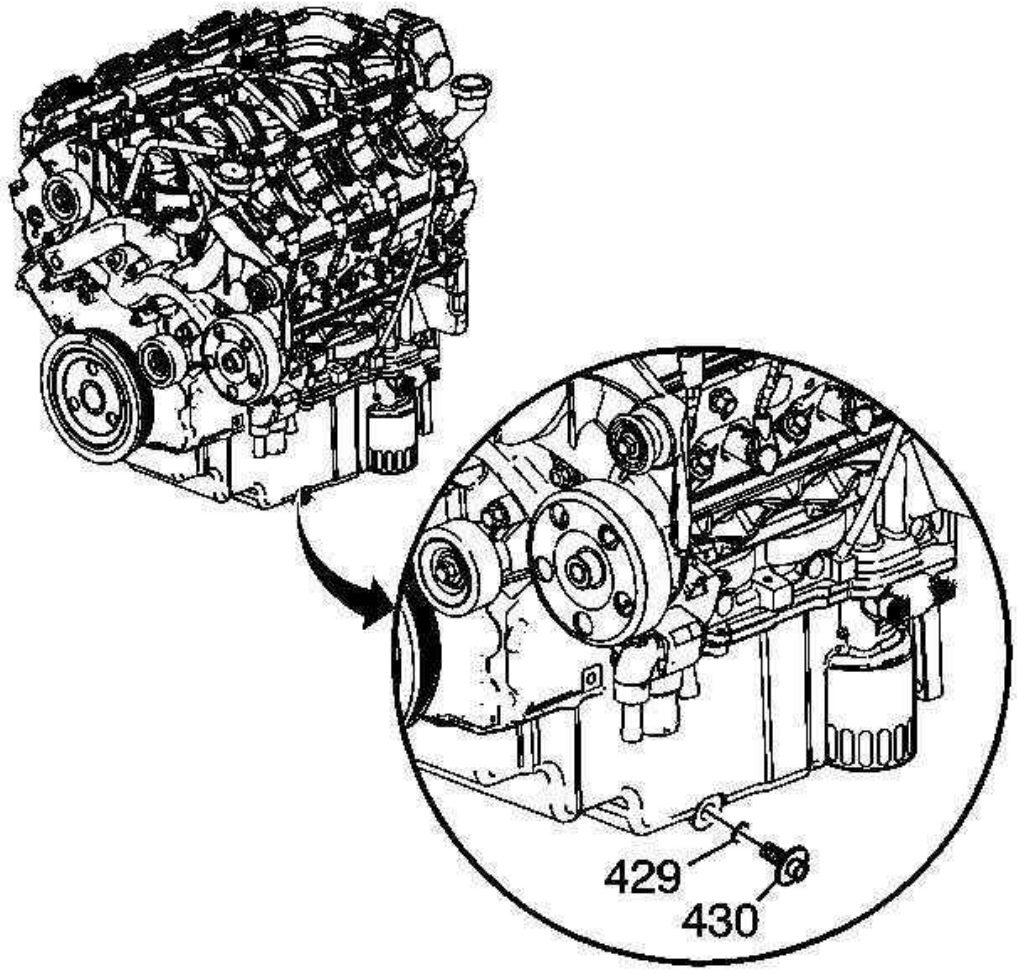


Fig. 191: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan drain plug (430) and O-ring (429).

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

5. Lower the vehicle.
6. Fill the engine with the appropriate amount and type of NEW engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant**

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Recommendations .

7. Check the oil level.
8. Install the oil fill cap.
9. Close the hood.
10. Reset the engine oil life monitor, if necessary. Refer to **GM Oil Life System Resetting** .

OIL PAN REPLACEMENT

Removal Procedure

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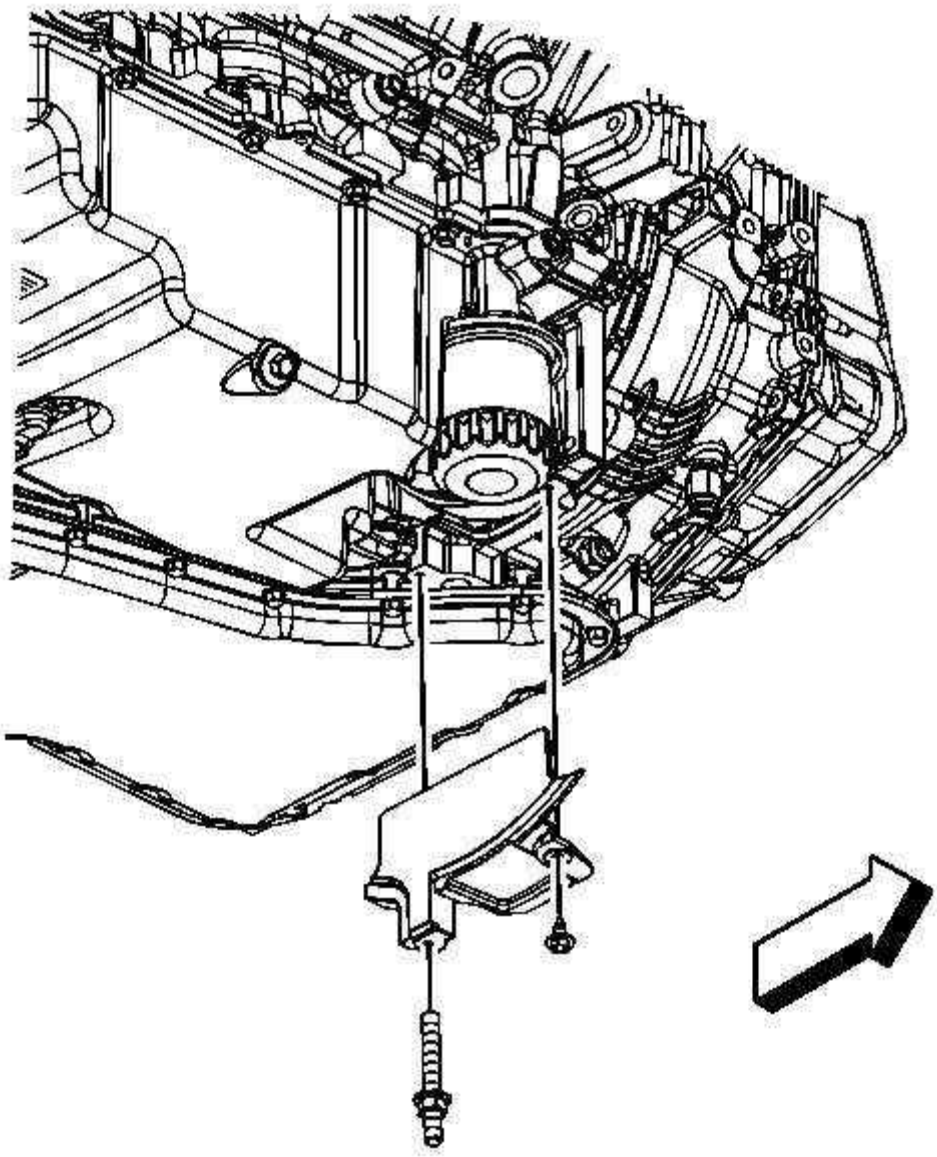


Fig. 192: View Of Transaxle Converter Cover Bolt/Stud & Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine frame. Refer to **Frame Replacement** .
2. Drain the engine oil and remove the engine oil filter.

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3. Reinstall the drain plug and oil filter until snug.
4. Remove the transaxle converter cover bolt/stud and cover.

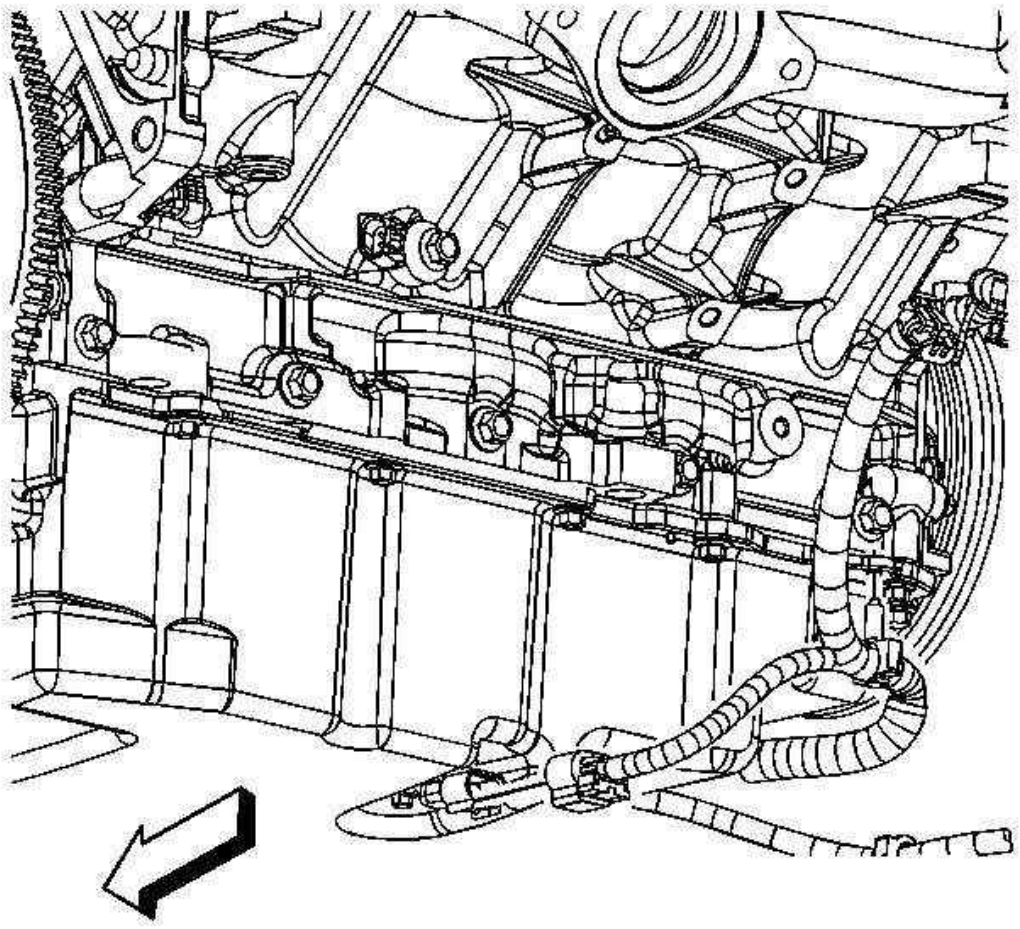


Fig. 193: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the oil level sensor electrical connector.
6. Remove engine harness retainer from the front of oil pan.

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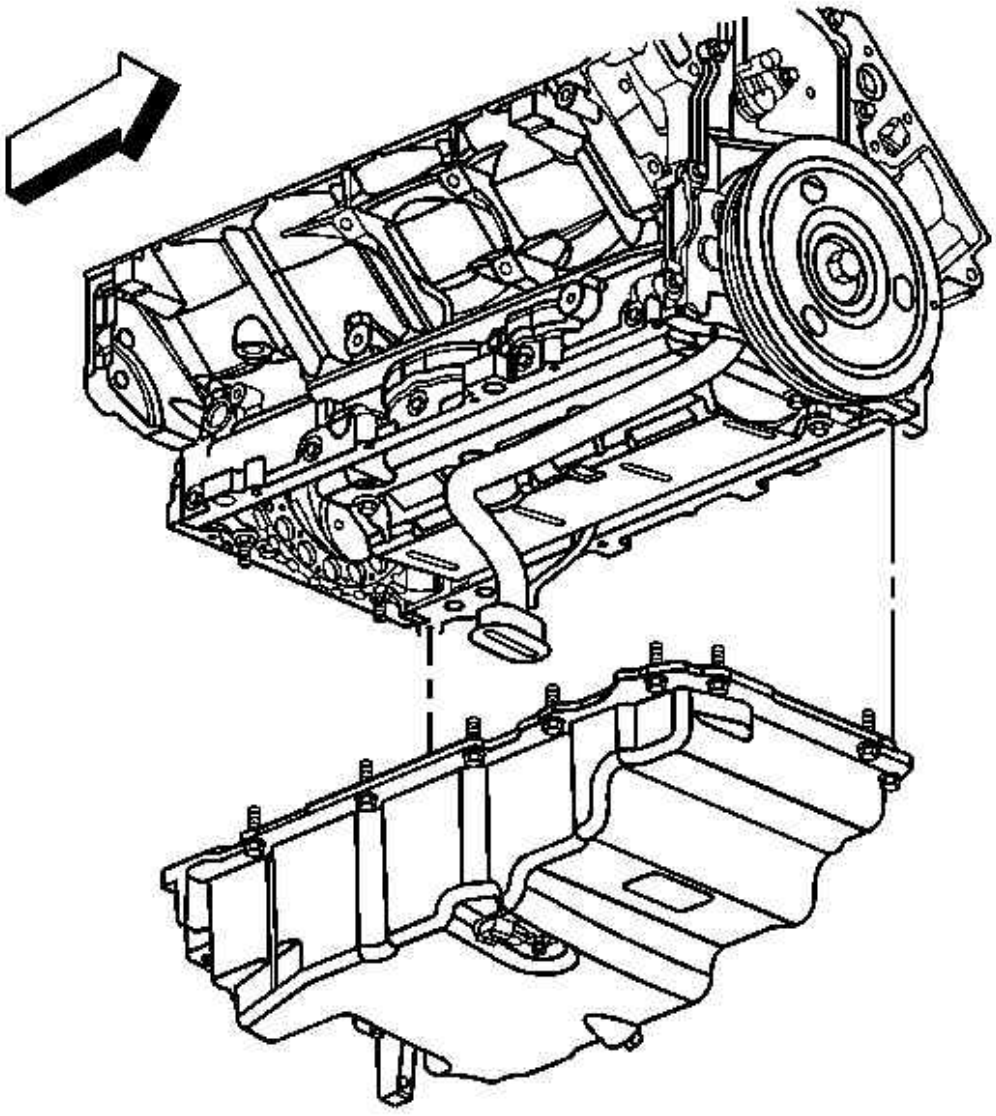


Fig. 194: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Position the drive belt tensioner aside in order to access the oil pan bolt. Refer to **Drive Belt Tensioner Replacement - Accessory**.
8. Remove the oil pan bolts.

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9. Remove the oil pan.

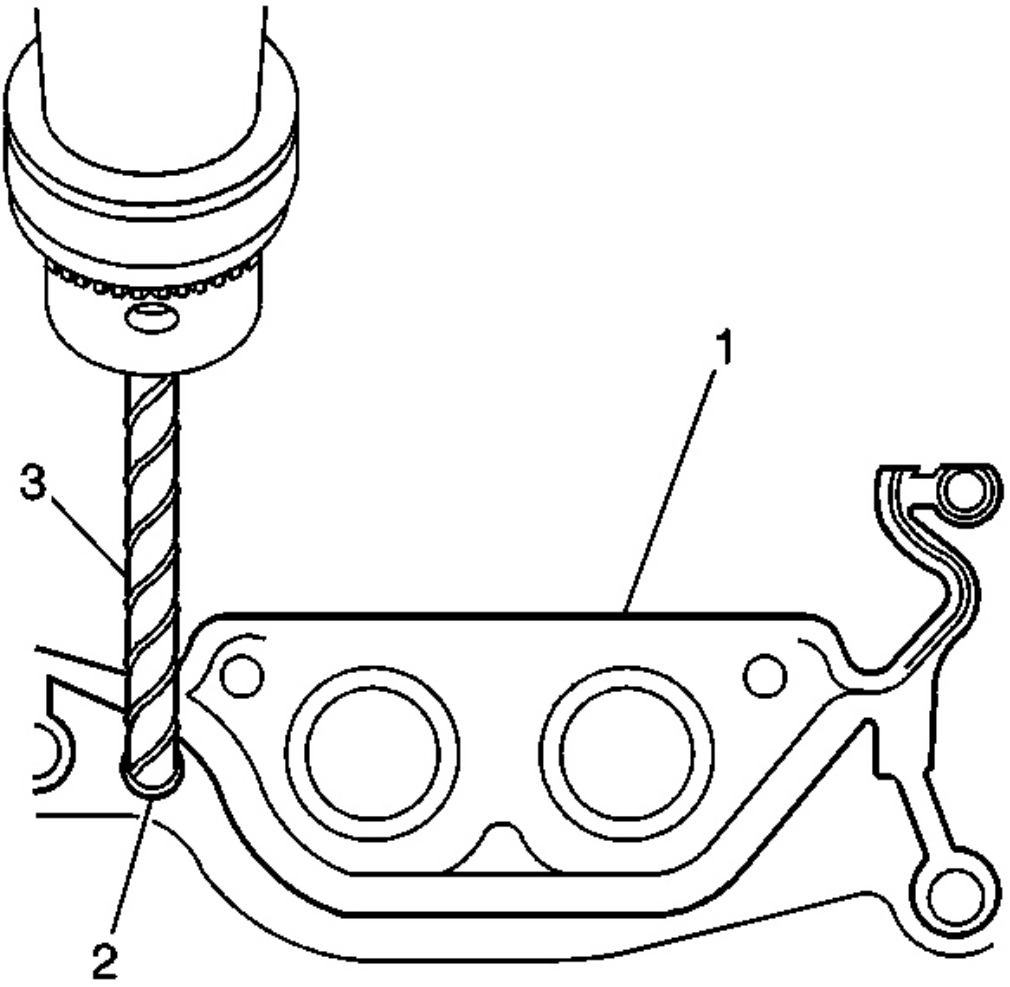


Fig. 195: Drilling Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.

10. Drill (3) out the oil pan gasket retaining rivets (2), if required.

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11. Remove the gasket (1) from the pan.
12. Discard the gasket and rivets.
13. Clean and inspect the engine oil pan. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

IMPORTANT:

- **The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush, or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.**
- **Do NOT reuse the oil pan gasket.**
- **It is NOT necessary to rivet the NEW gasket to the oil pan.**

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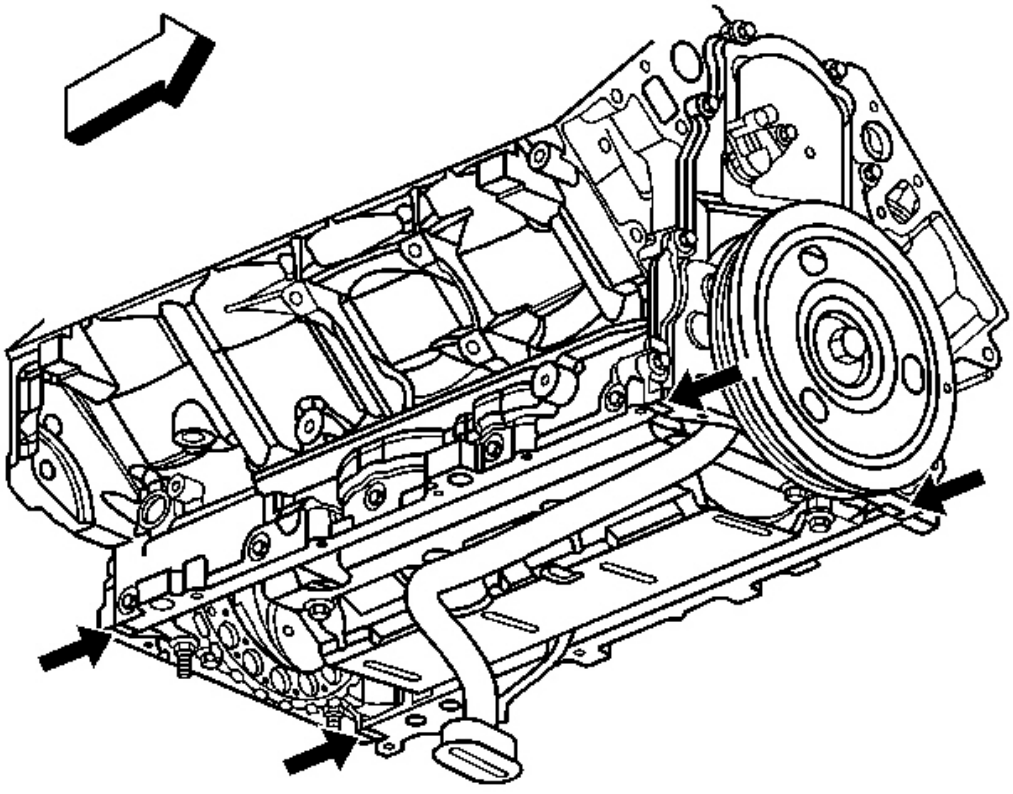


Fig. 196: Applying Bead Of Sealant
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant, or equivalent 20 mm (0.80 in) long to the engine block. Apply the sealant directly onto the tabs of the front/rear cover gasket that protrudes into the oil pan surface. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

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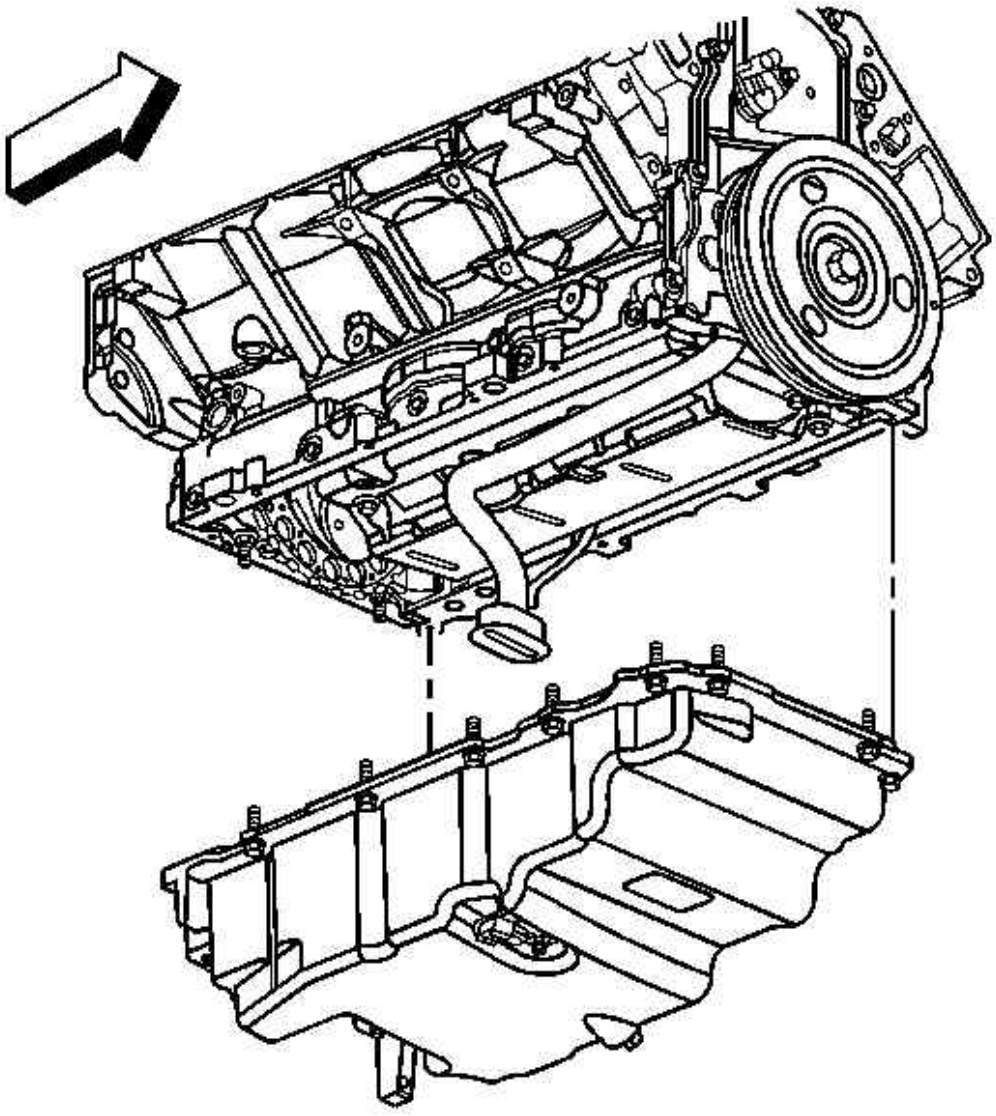


Fig. 197: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

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2. Pre-assemble the oil pan gasket to the pan.
    1. Install the gasket onto the pan.
    2. Install the oil pan bolts to the pan and through the gasket.

NOTE: Refer to Fastener Notice .

3. Install the oil pan, gasket, and bolts to the engine block.

Tighten:

- Tighten the oil pan and oil pan-to-front cover bolts to 25 N.m (18 lb ft).
- Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
- Tighten the transmission housing, converter cover, and transmission bolts/stud to 50 N.m (37 lb ft).

4. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**.

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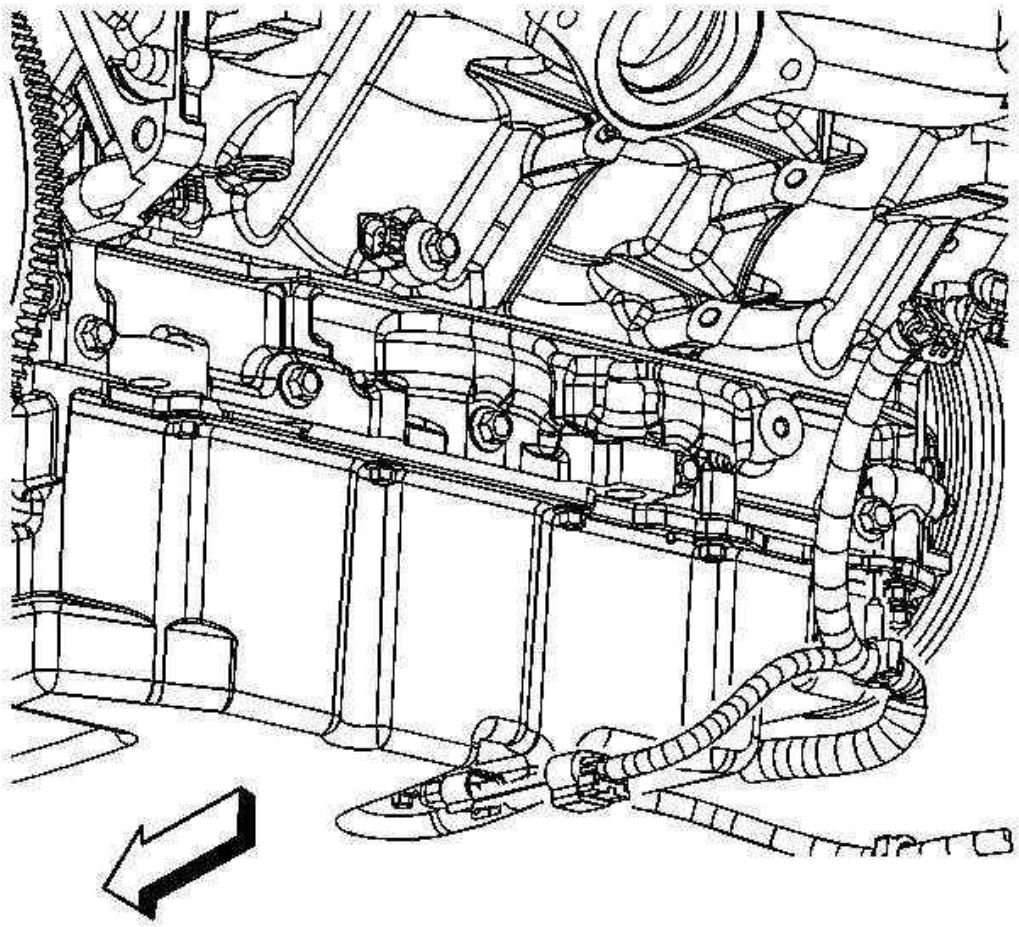


Fig. 198: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

5. Install engine harness to front of oil pan.
6. Connect the oil level sensor electrical connector.

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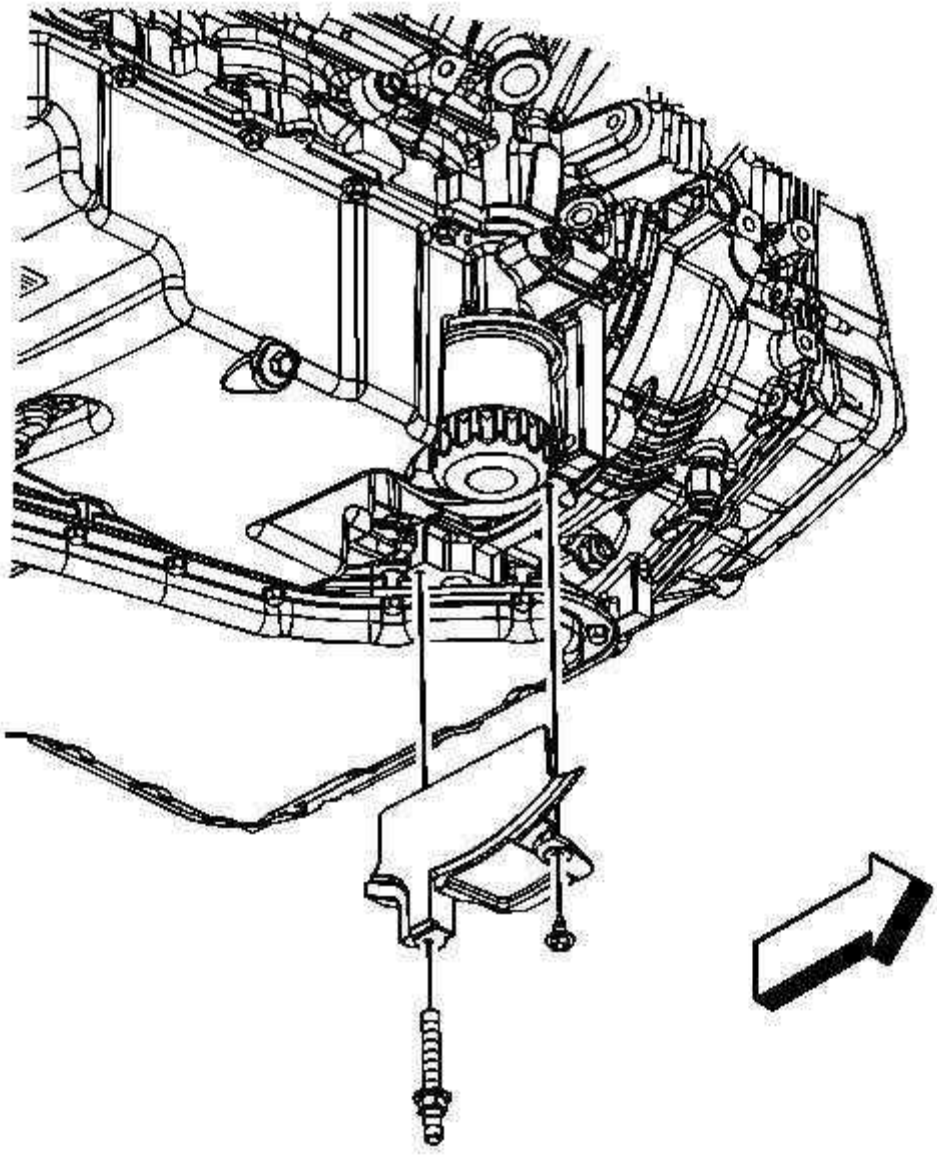


Fig. 199: View Of Transaxle Converter Cover Bolt/Stud & Cover
Courtesy of GENERAL MOTORS CORP.

7. Install the transaxle converter cover and bolt/stud.

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

8. Install new engine oil and a new oil filter. Refer to **Engine Oil and Oil Filter Replacement**.
9. Install the engine frame. Refer to **Frame Replacement** .

OIL PRESSURE RELIEF VALVE REPLACEMENT

Removal Procedure

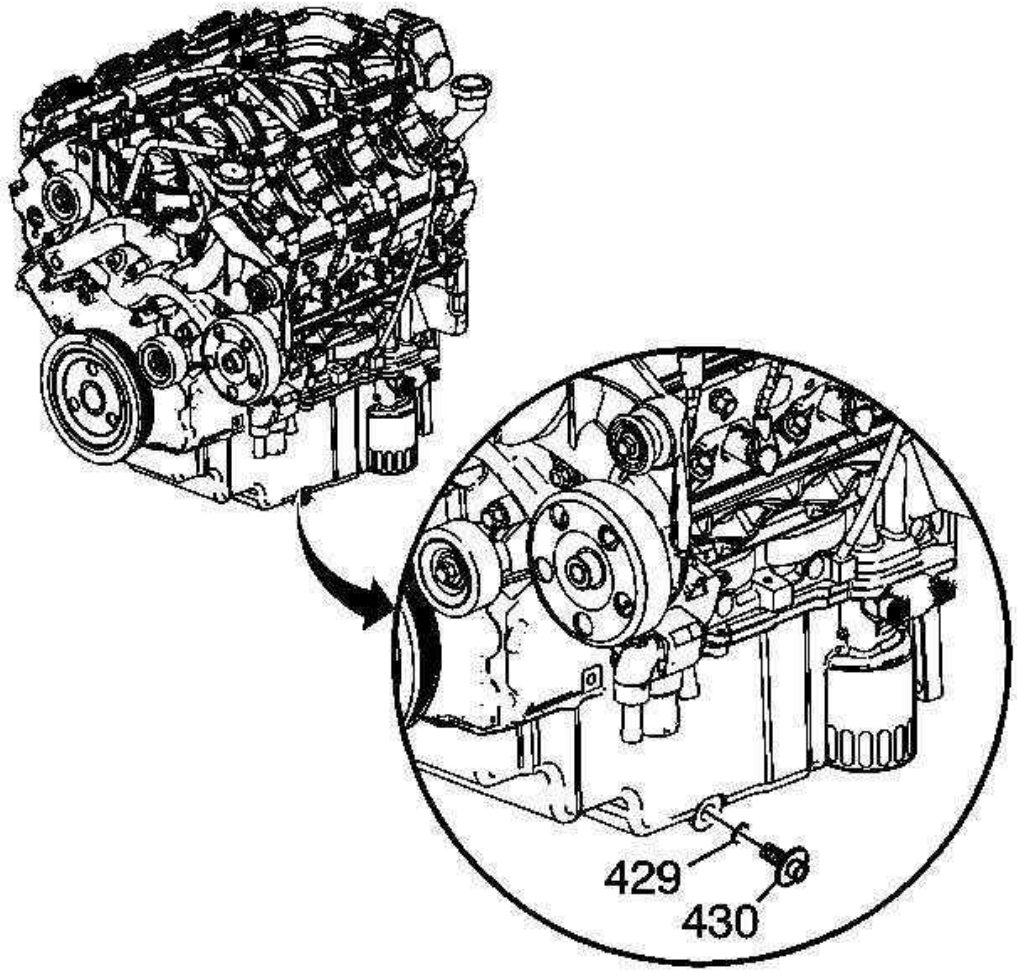


Fig. 200: View Of Oil Pan Drain Plug & O-Ring

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Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the oil pan drain plug (430) and O-ring (429).
5. Allow the oil to drain into an appropriate container.

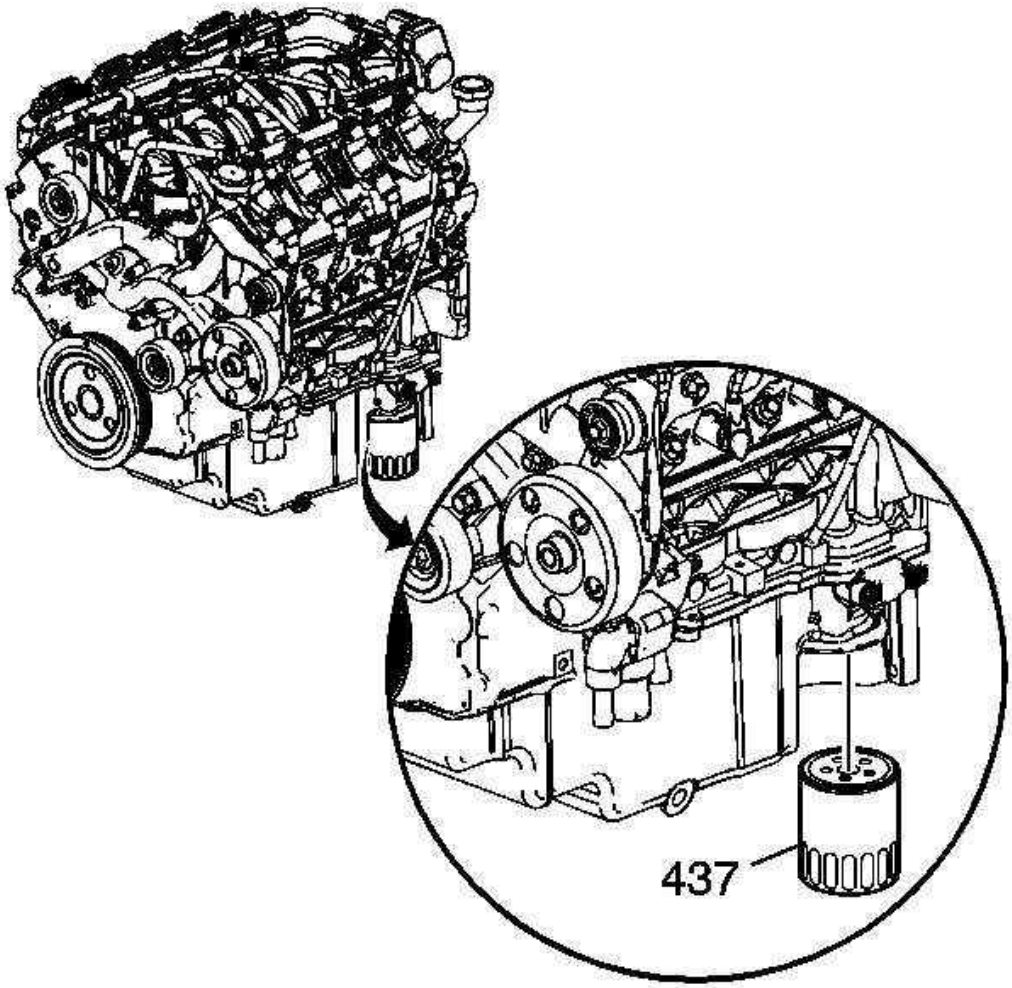


Fig. 201: View Of Engine Oil Filter

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Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil filter (437). Allow the rest of the engine oil to drain into an appropriate container.

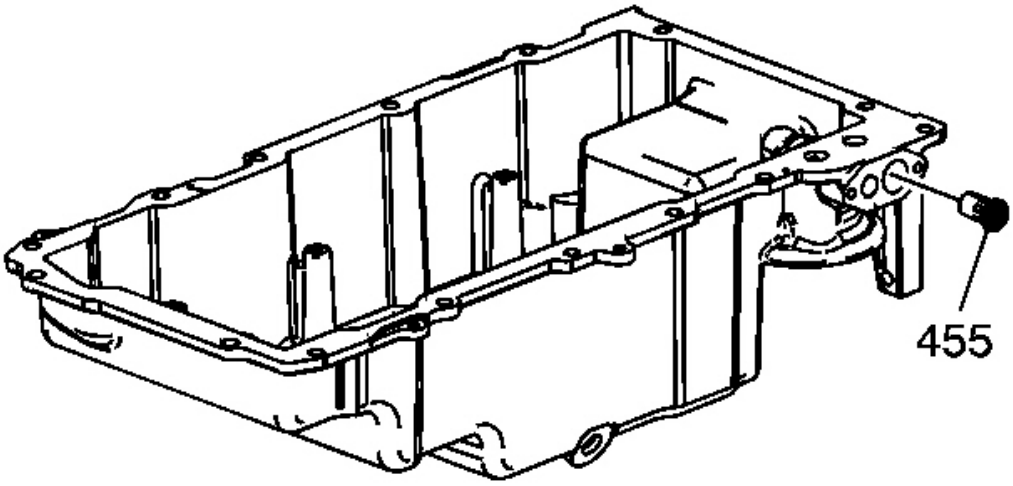


Fig. 202: Locating Valve Lifter Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pan cover bolts.
8. Remove the valve lifter oil pressure relief valve (455).

Installation Procedure

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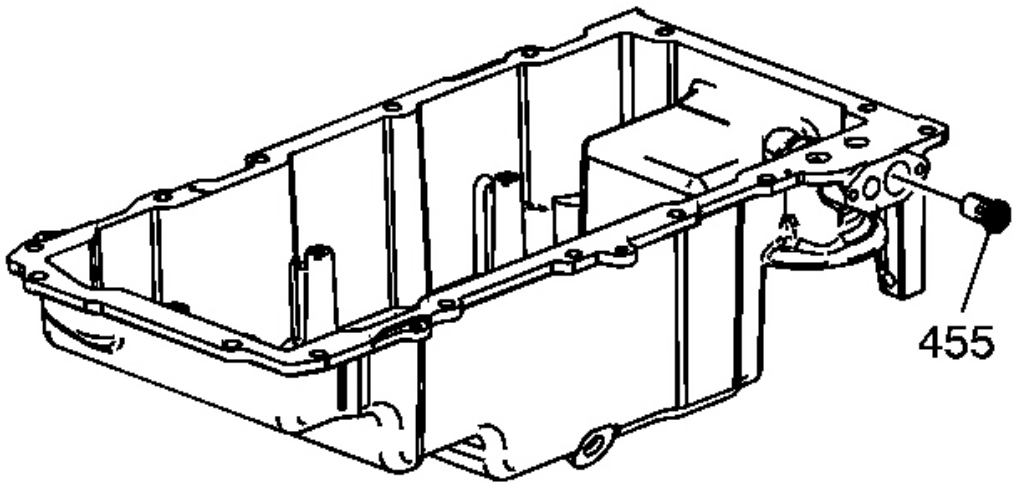


Fig. 203: Locating Valve Lifter Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the valve lifter oil pressure relief valve (455).

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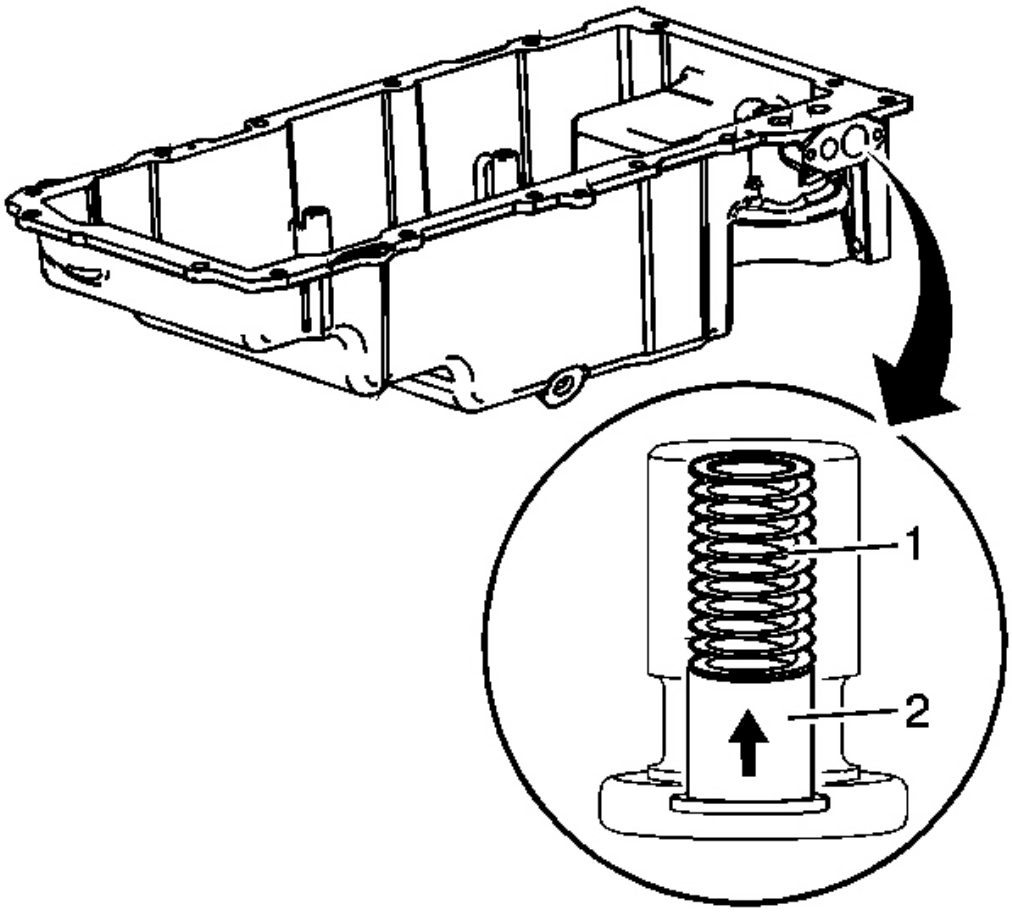


Fig. 204: View Of Valve Lifter Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve lifter oil pressure relief valve for proper operation. Lightly depress the valve (2). The valve spring (1) should seat the valve to the proper closed position.

NOTE: Refer to Fastener Notice .

3. Install the oil pan cover bolts and cover.

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

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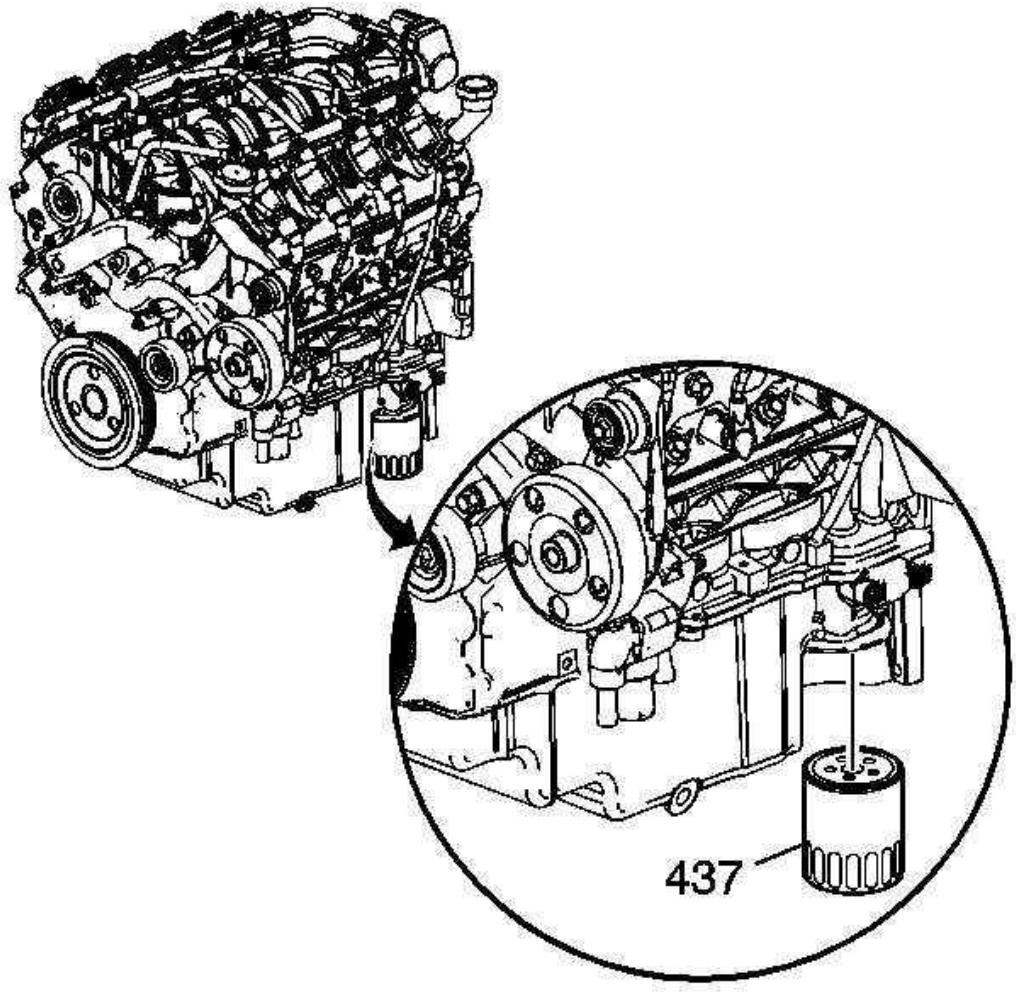


Fig. 205: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW engine oil filter (437).

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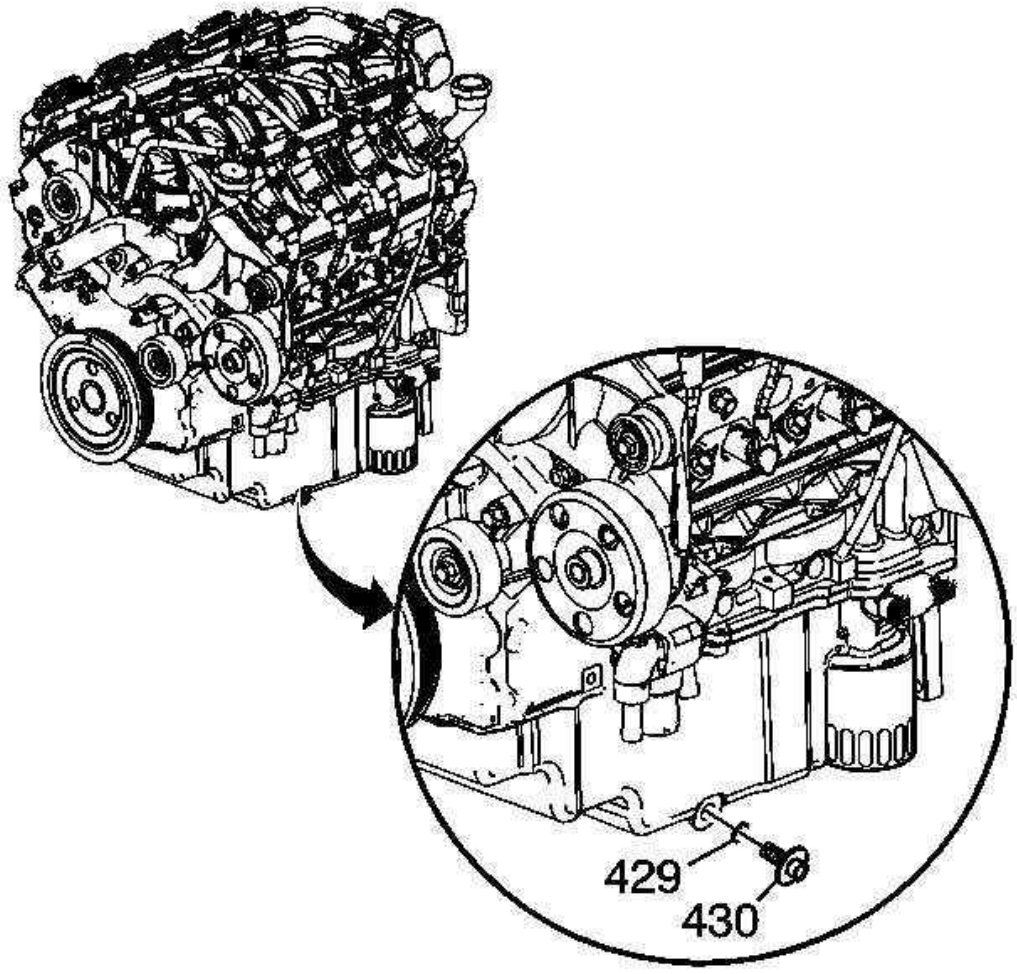


Fig. 206: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pan drain plug (430) and O-ring (429).
6. Lower the vehicle.
7. Fill the engine with the appropriate amount and type of NEW engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations** .
8. Check the oil level.

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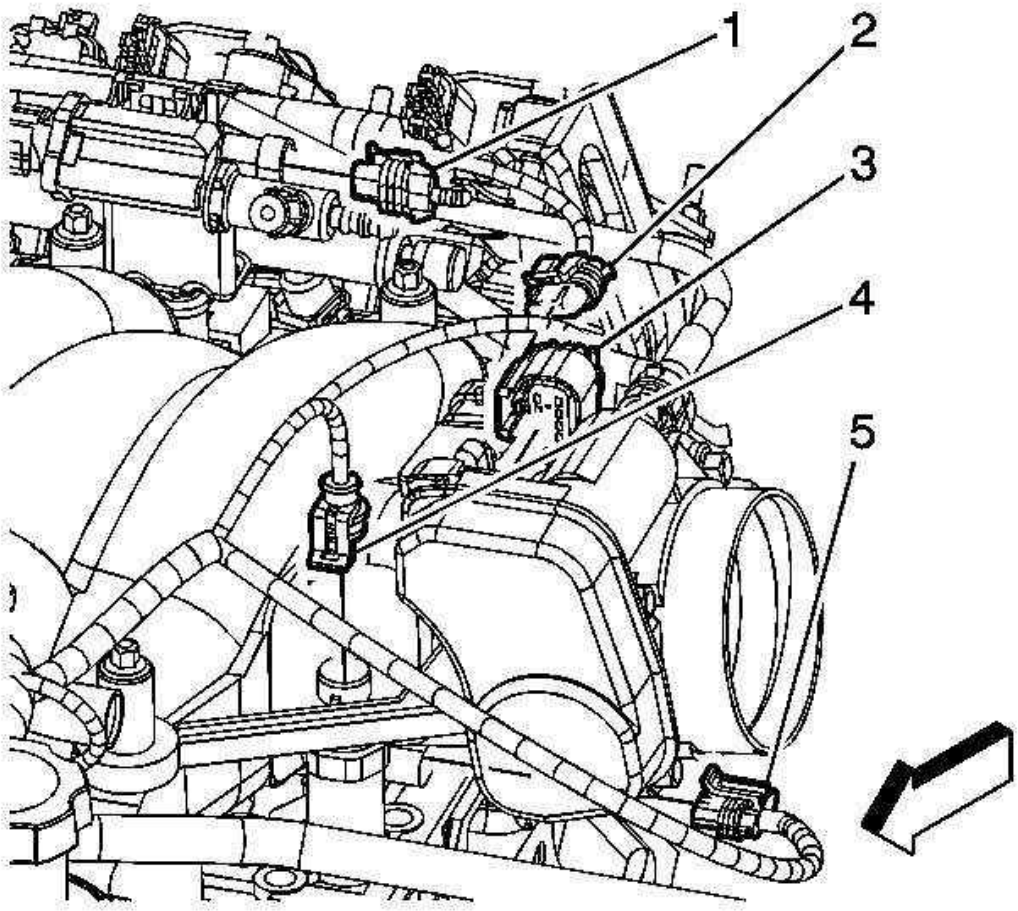
9. Install the oil fill cap.
10. Open the hood.
11. Reset the engine oil lift monitor, if necessary. Refer to **GM Oil Life System Resetting** .

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Tools Required

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

Removal Procedure



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Fig. 207: View Of Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. If necessary, remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. Disconnect the oil pressure sensor electrical connector (4).

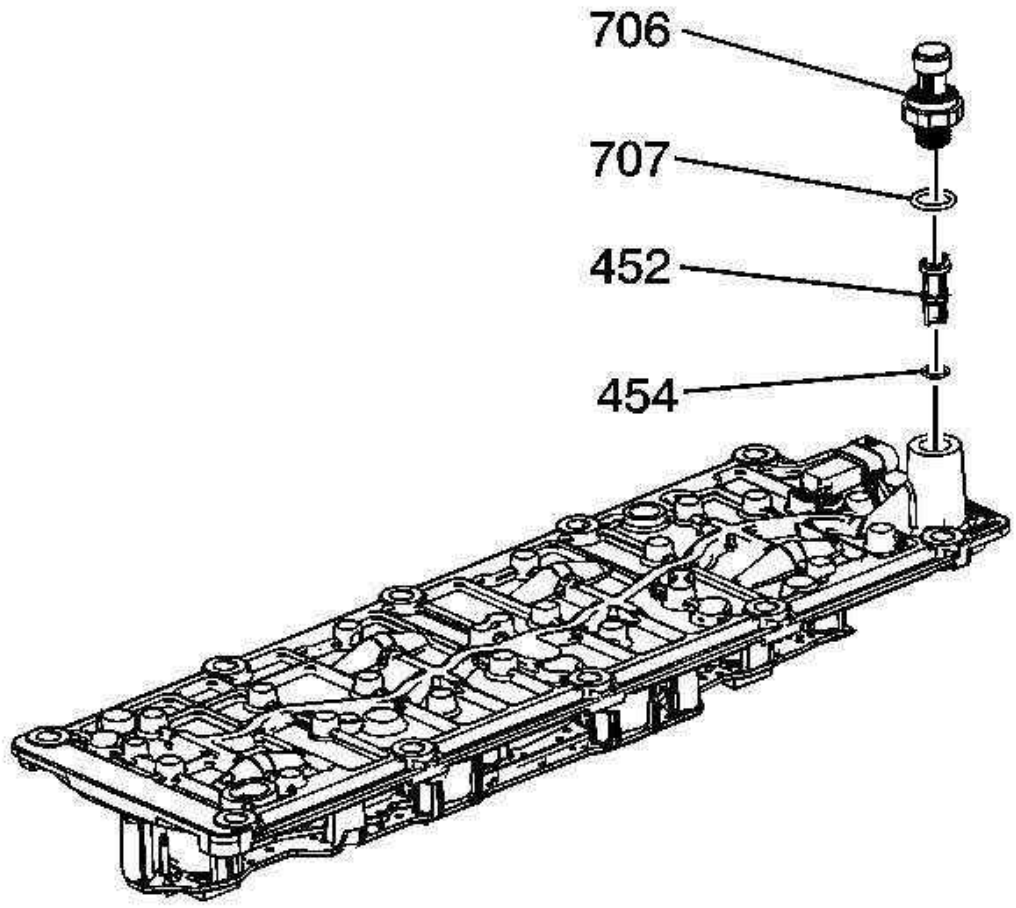


Fig. 208: View Of Oil Pressure Sensor, Washer & Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Using **J 41712** , remove the oil pressure sensor (706) and washer (707). See

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Special Tools.

Installation Procedure

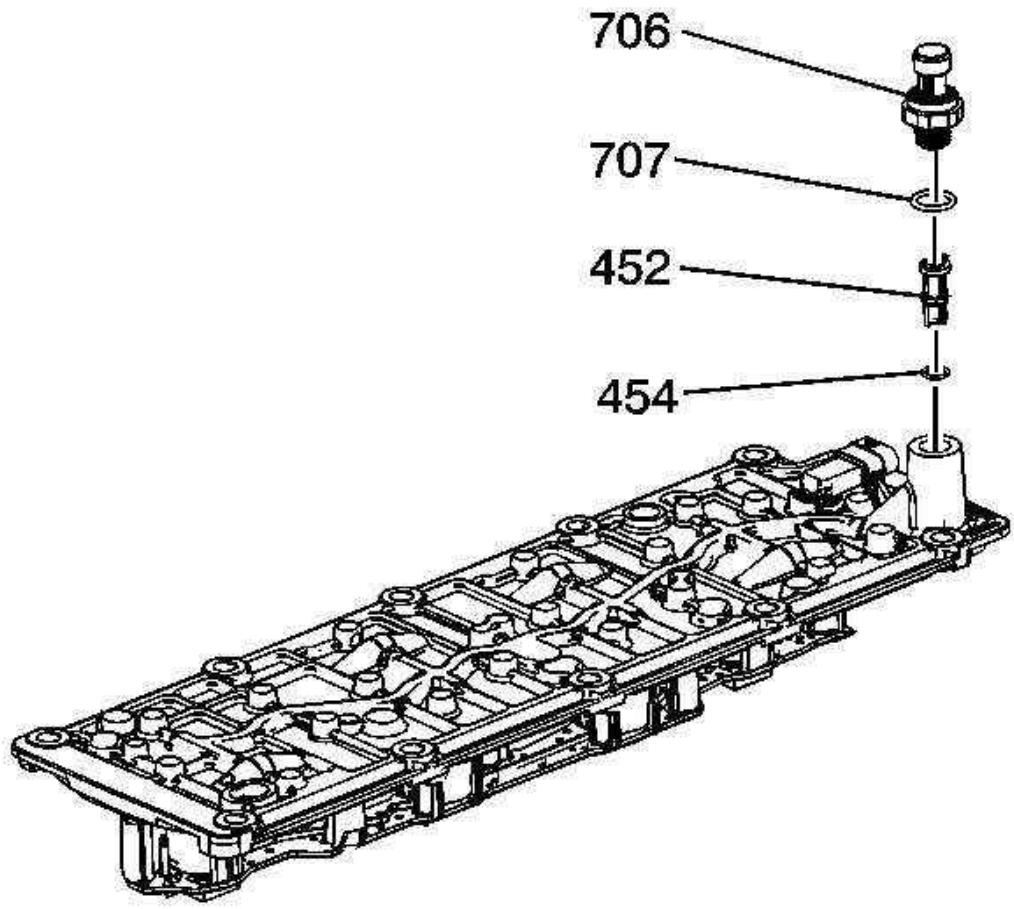


Fig. 209: View Of Oil Pressure Sensor, Washer & Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant to the threads of the oil pressure sensor. Refer to **Sealers, Adhesives, and Lubricants**.

NOTE: Refer to Fastener Notice .

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2. Using **J 41712** , install the oil pressure sensor (706) and washer (707). See **Special Tools**.

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

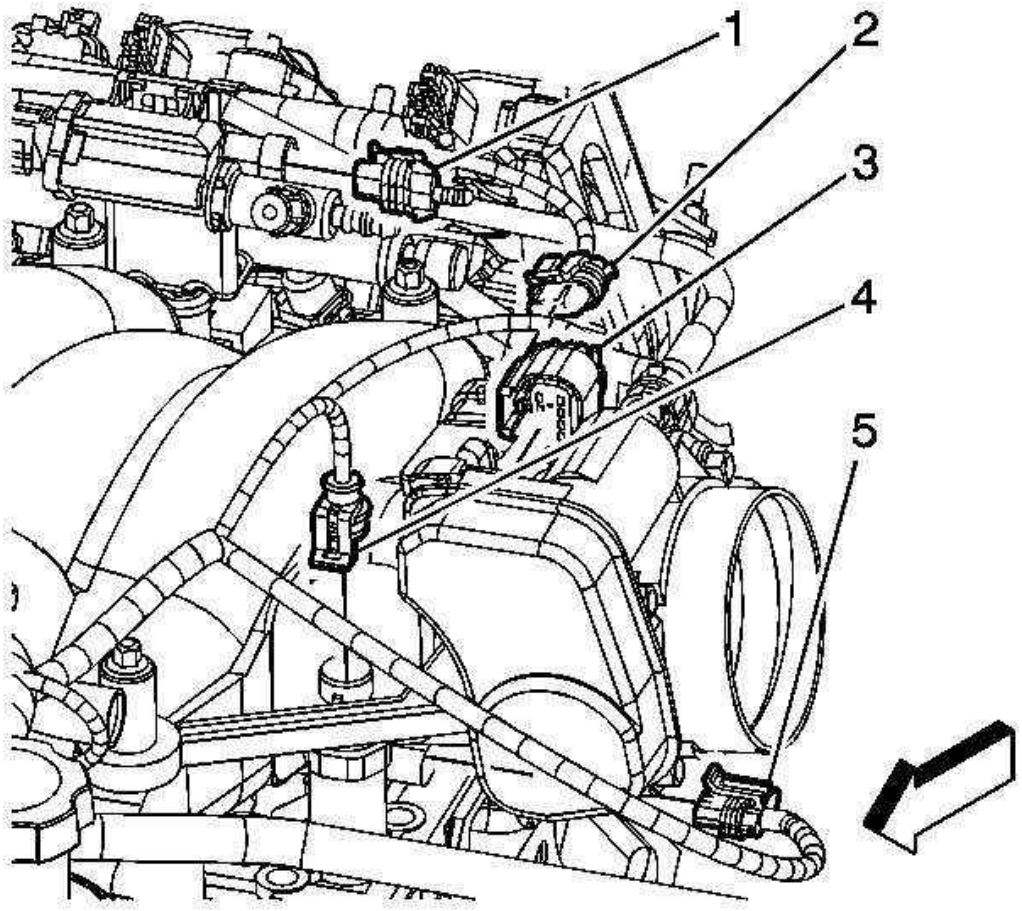


Fig. 210: View Of Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (4).
4. If necessary, install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.

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ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

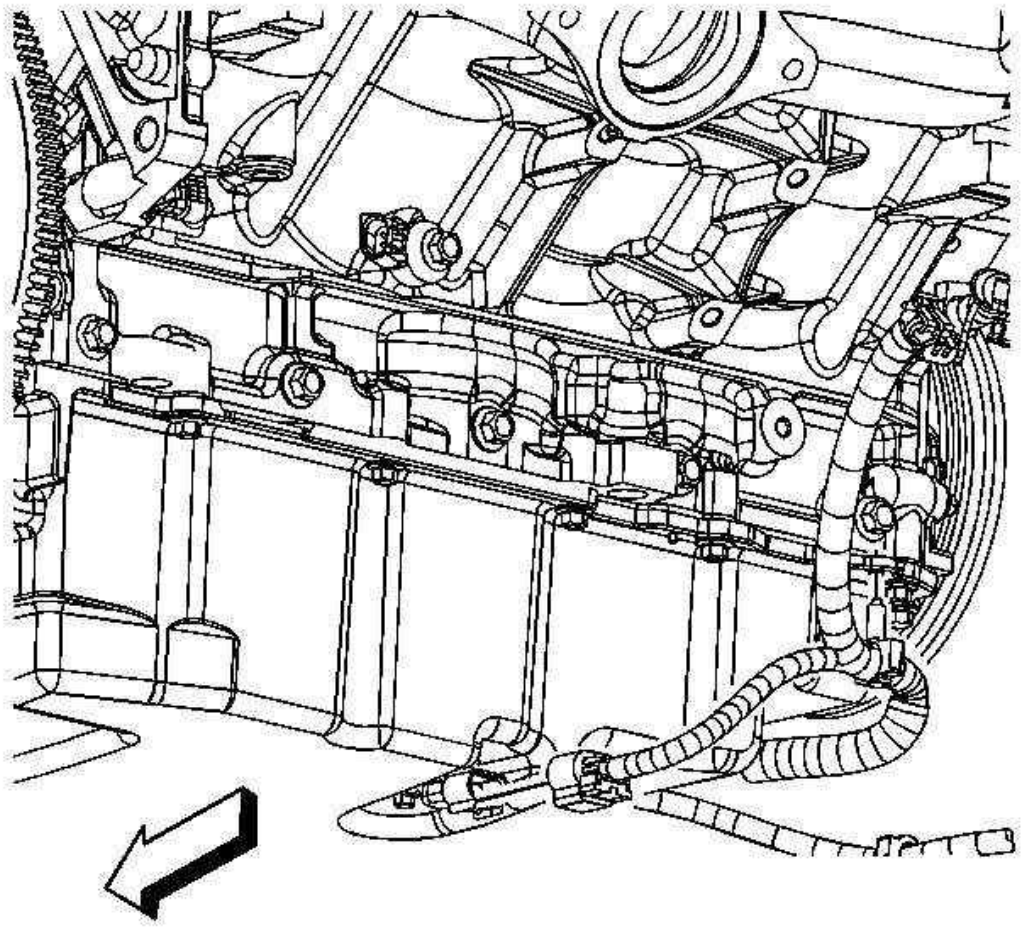


Fig. 211: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Drain the oil from the oil pan.
3. Disconnect the oil level sensor electrical connector.

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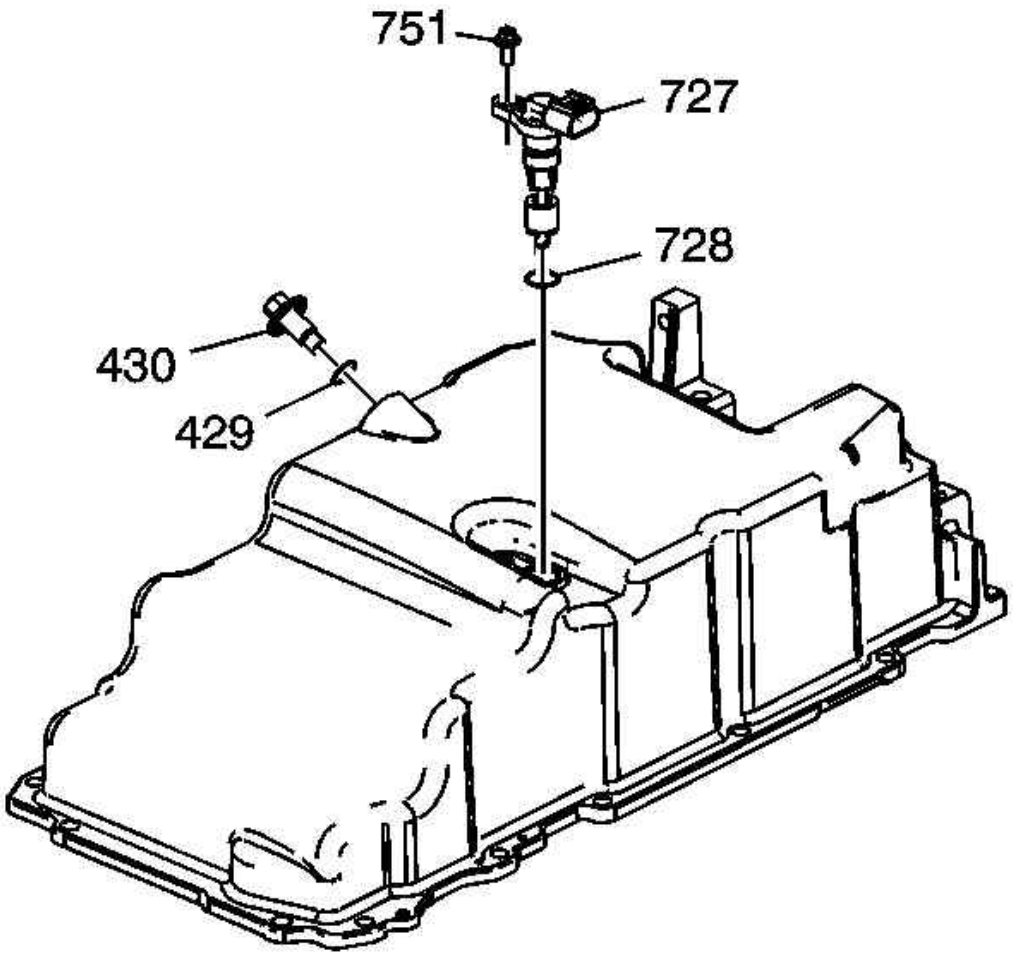


Fig. 212: View Of Oil Pan, Drain Plug & O-Ring, Oil Level Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level sensor bolt (751).
5. Remove the oil level sensor (727) and O-ring (728) from the oil pan.

Installation Procedure

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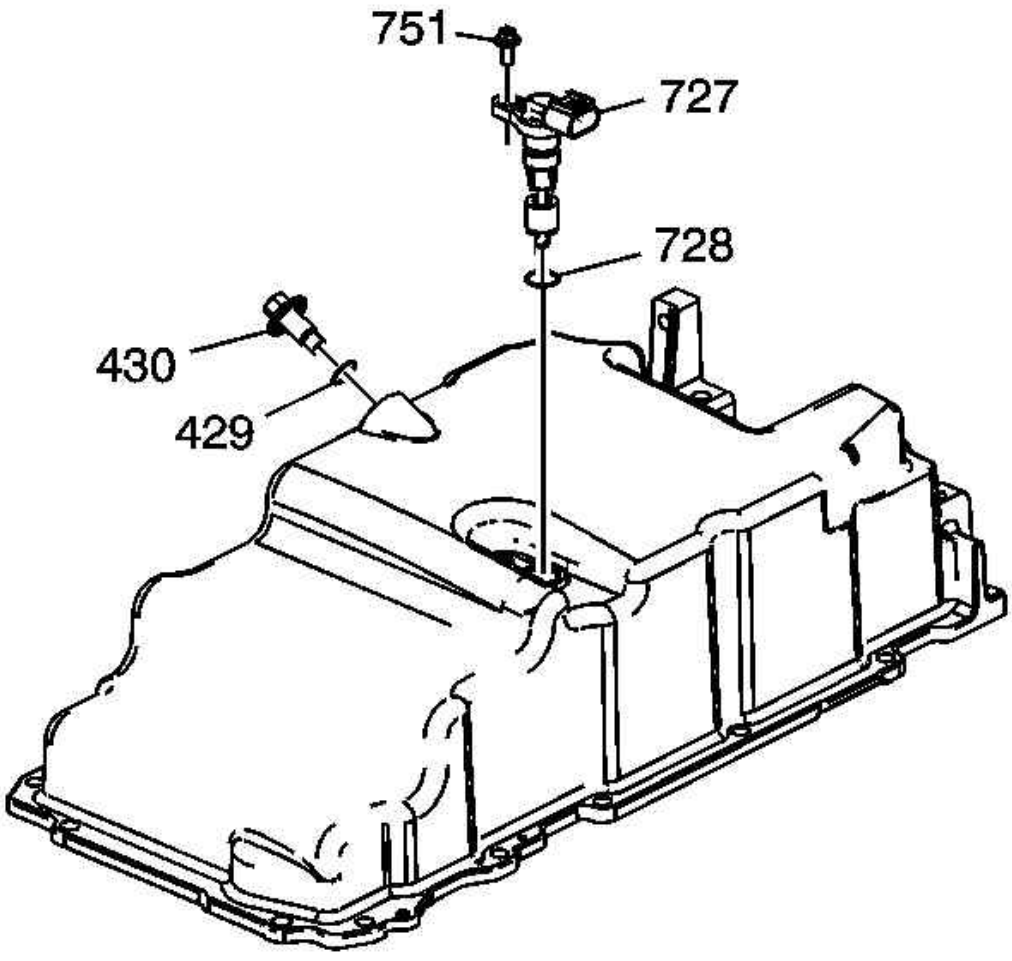


Fig. 213: View Of Oil Pan, Drain Plug & O-Ring, Oil Level Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level sensor (727) and O-ring (728) to the oil pan.

NOTE: Refer to Fastener Notice .

2. Install the oil level sensor bolt (751).

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

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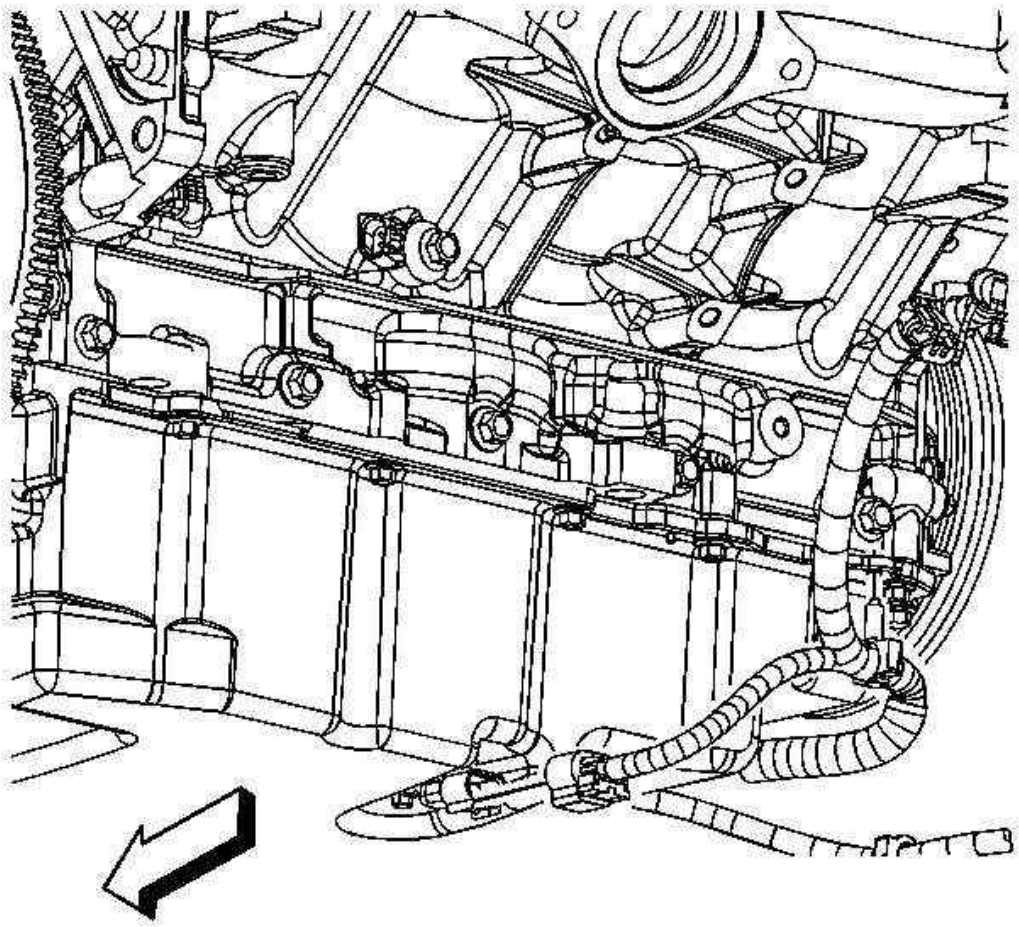


Fig. 214: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil level sensor electrical connector.
4. Lower the vehicle.
5. Refill the engine oil to the proper level.

OIL PUMP, SCREEN, AND CRANKSHAFT OIL DEFLECTOR REPLACEMENT

Removal Procedure

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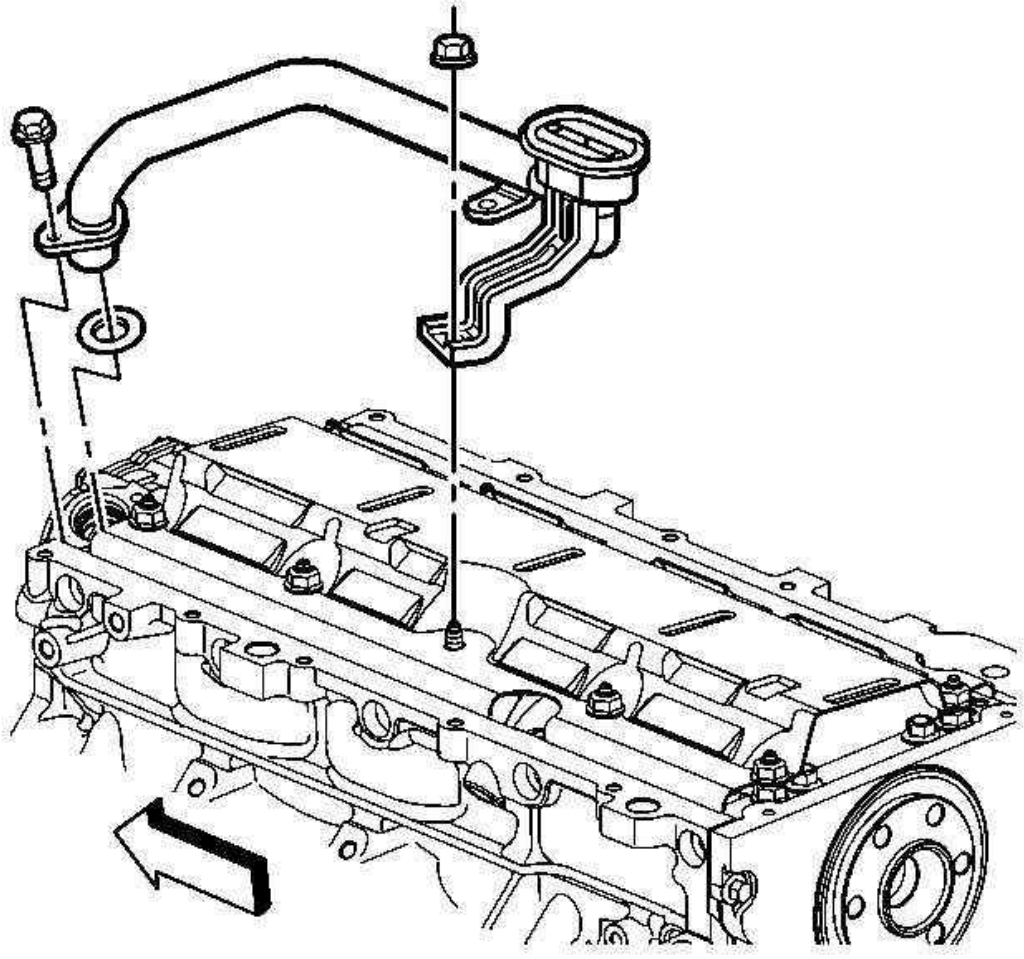


Fig. 215: View Of Oil Pump Screen, Nuts & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
3. Remove the oil pump screen bolt and nuts.
4. Remove the oil pump screen with O-ring seal.
5. Remove the O-ring seal from the pump screen.
6. Discard the O-ring seal.

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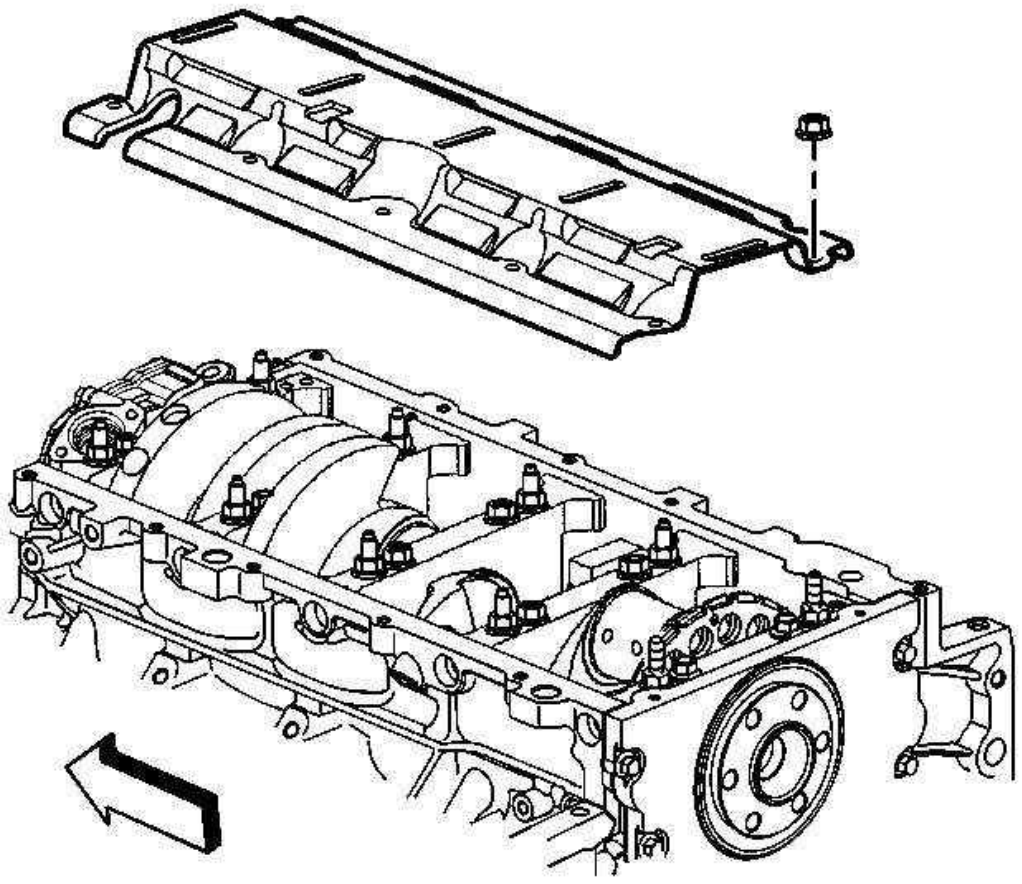


Fig. 216: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft oil deflector nuts.
8. Remove the crankshaft oil deflector.

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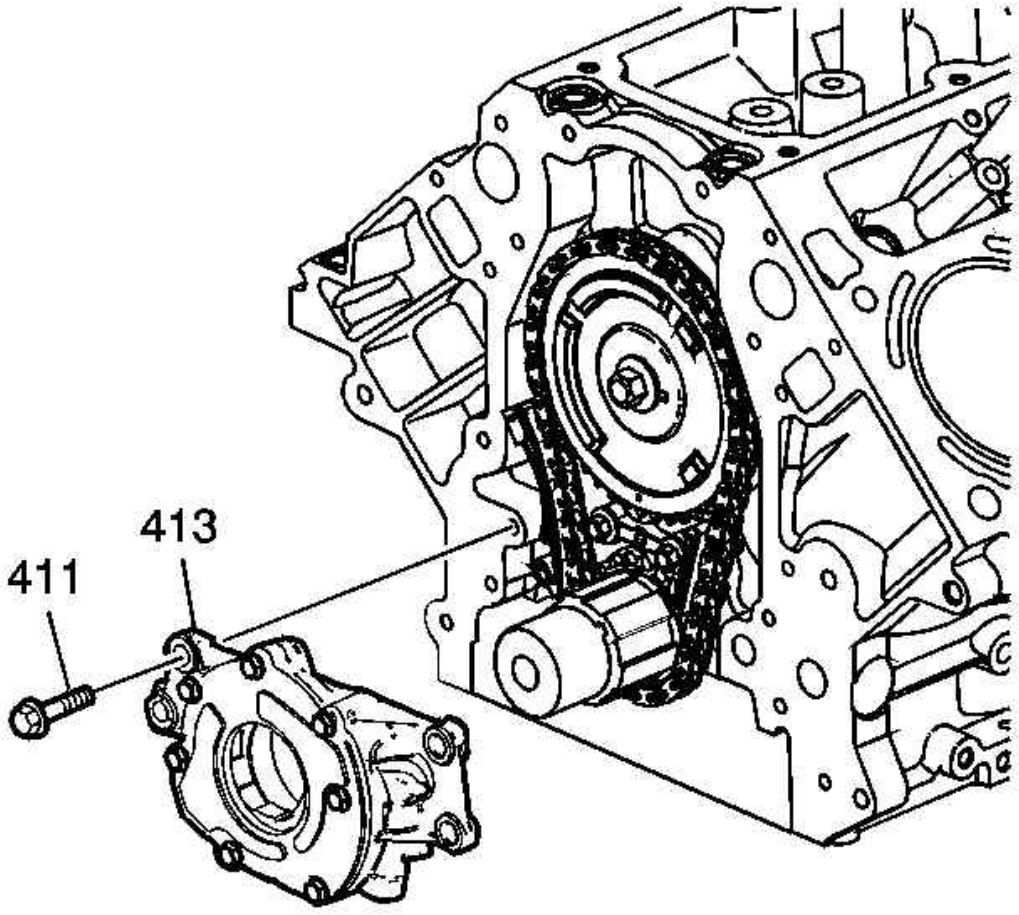


Fig. 217: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pump bolts (411).

IMPORTANT: Do not allow dirt or debris to enter the oil pump assembly. Cap ends, as necessary.

10. Remove the oil pump (413).

Installation Procedure

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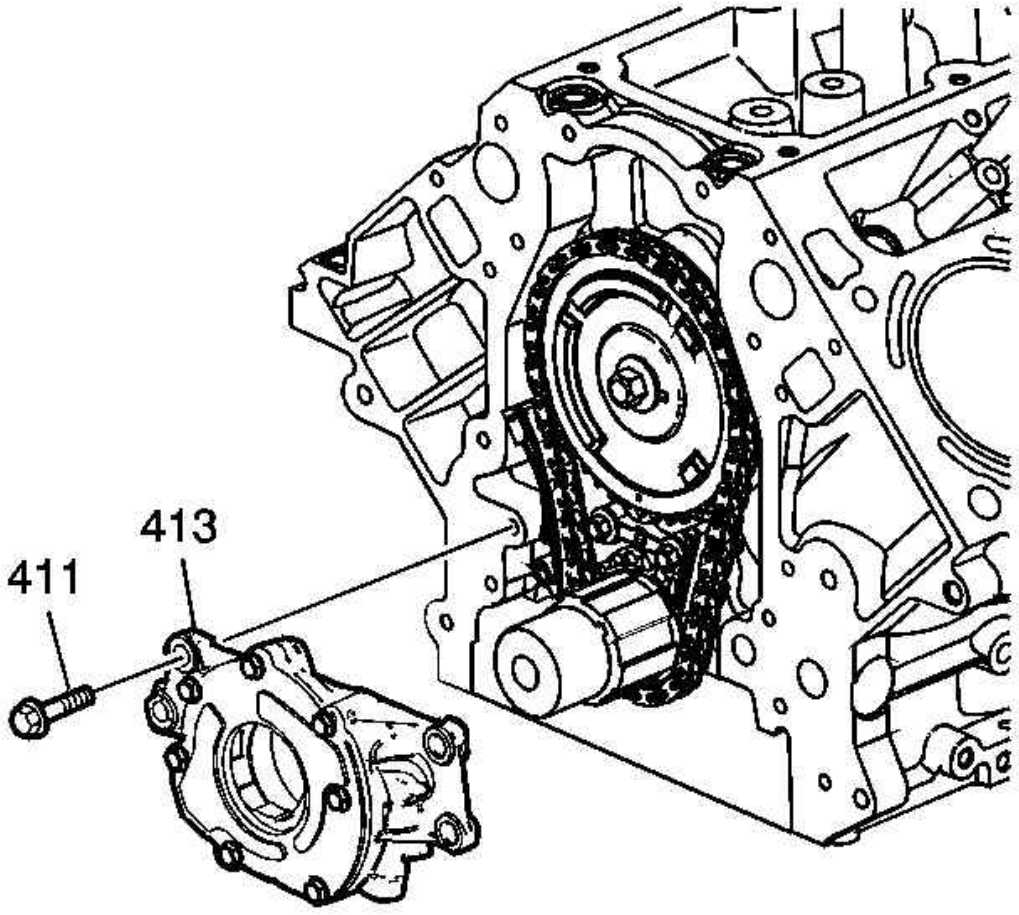


Fig. 218: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

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NOTE: Refer to Fastener Notice .

3. Install the oil pump bolts (411).

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

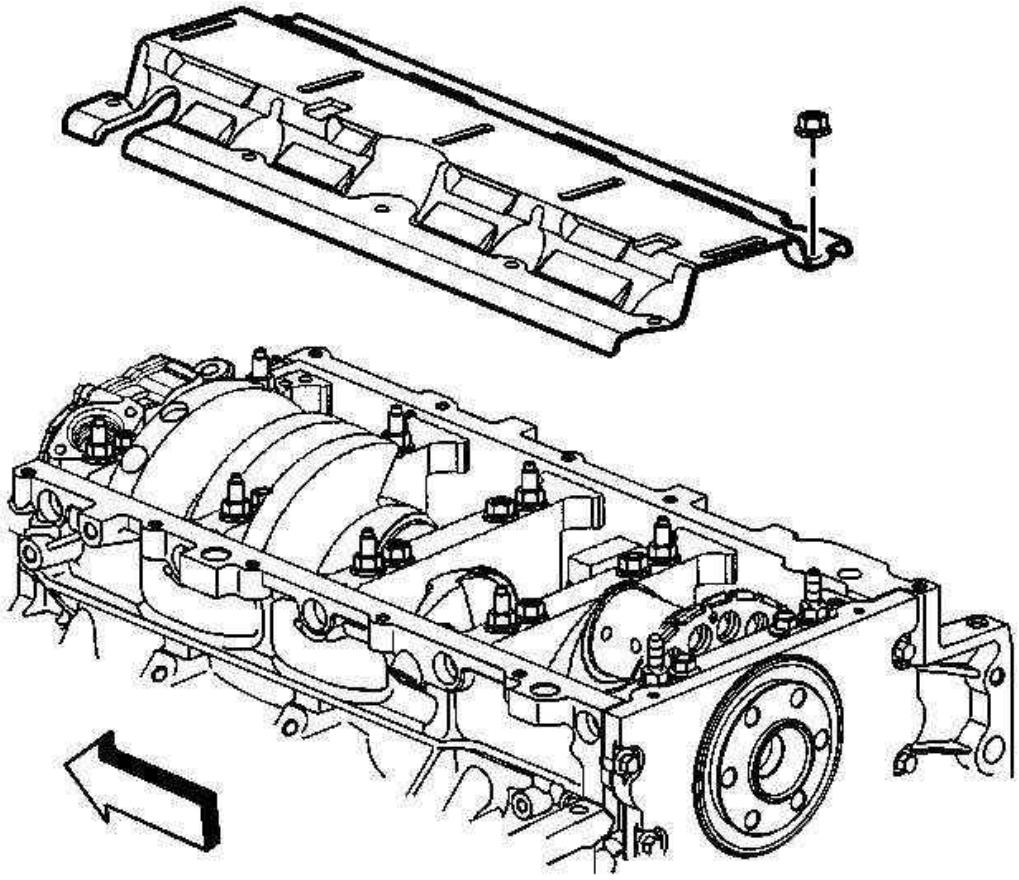


Fig. 219: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.

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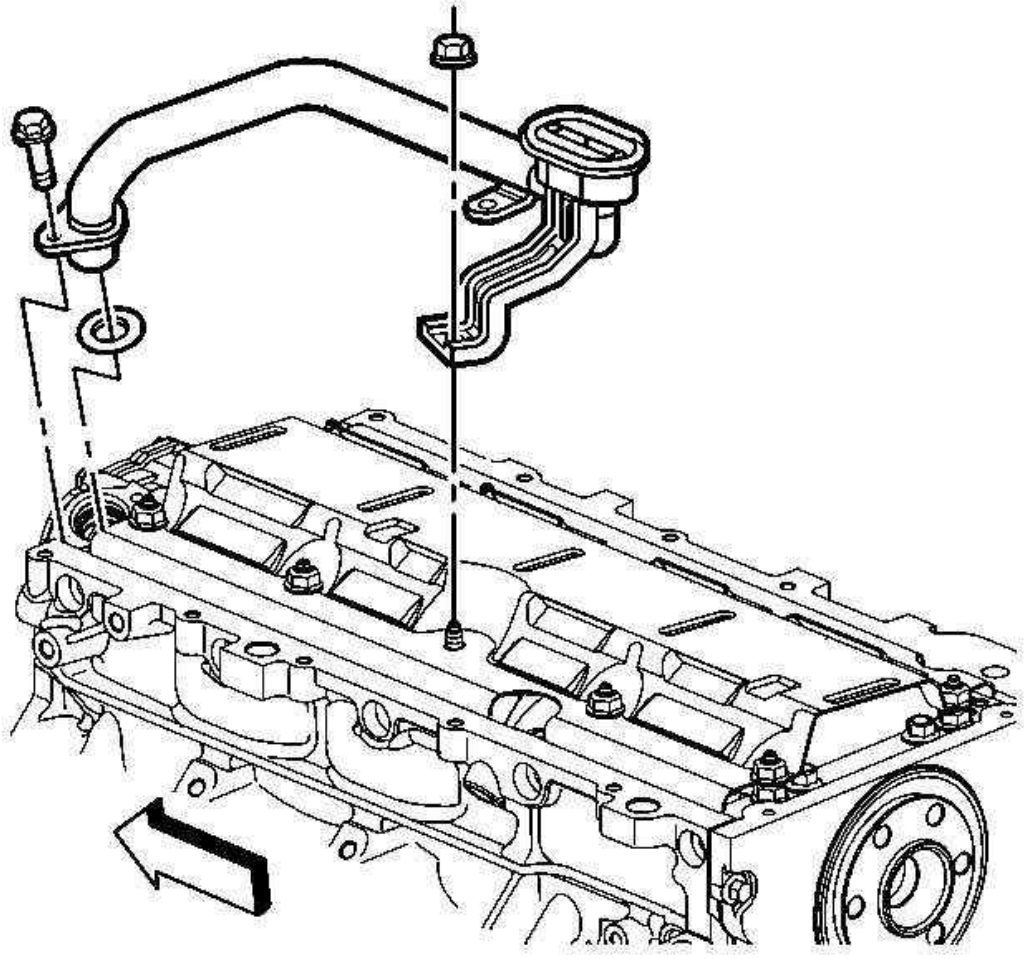


Fig. 220: View Of Oil Pump Screen, Nuts & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

IMPORTANT:

- **Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.**
- **Align the oil pump screen mounting brackets**

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with the correct crankshaft bearing cap bolt/studs.

7. Install the oil pump screen.
8. Install the oil pump screen bolt and the deflector nuts.

Tighten:

1. Tighten the oil pump screen bolt to 12 N.m (106 lb in).
2. Tighten the crankshaft oil deflector nut to 25 N.m (18 lb ft).

9. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
10. Install the oil pan. Refer to **Oil Pan Replacement**.

TIMING CHAIN AND SPROCKET REPLACEMENT

Tools Required

- **J 8433** Two Jaw Puller
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.

Removal Procedure

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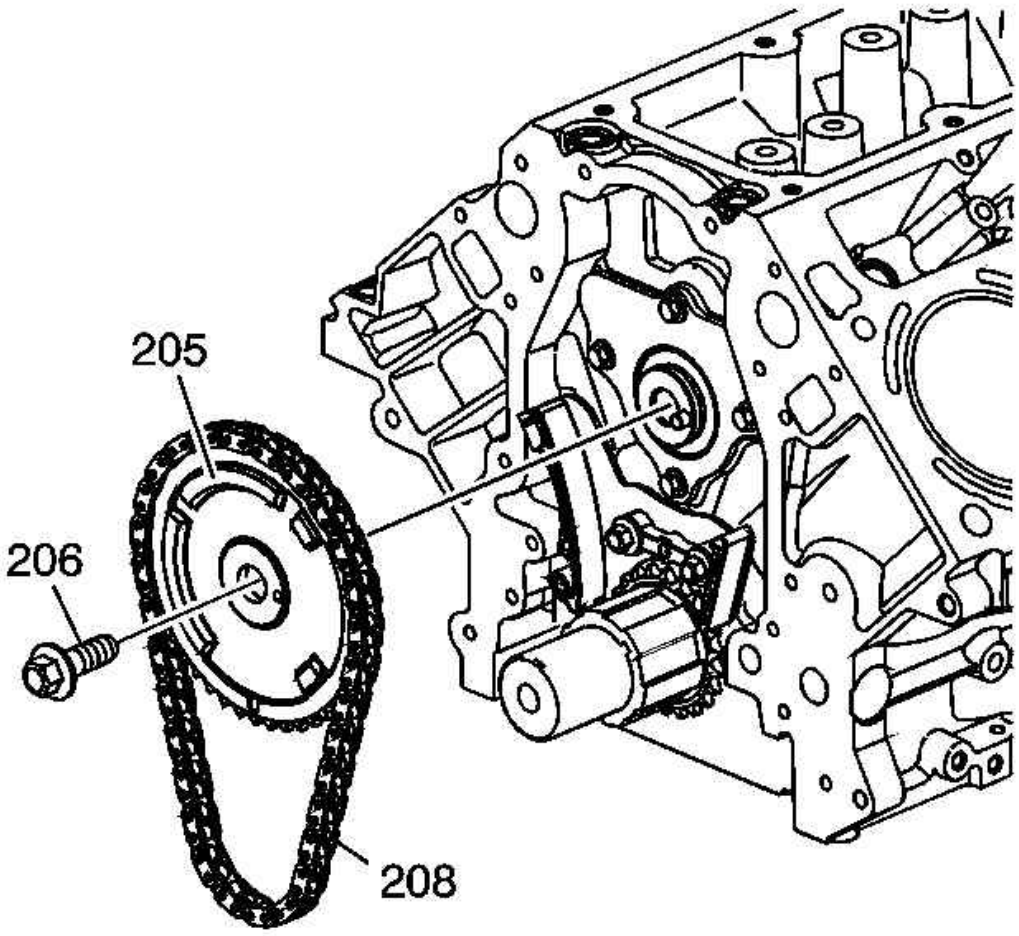


Fig. 221: View Of Camshaft Sprocket, Timing Chain & Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

1. Remove the oil pump. Refer to **Oil Pump, Screen, and Crankshaft Oil Deflector Replacement**.
2. Remove and discard the camshaft sprocket bolt (206).

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3. Remove the camshaft sprocket (205) and timing chain (208).

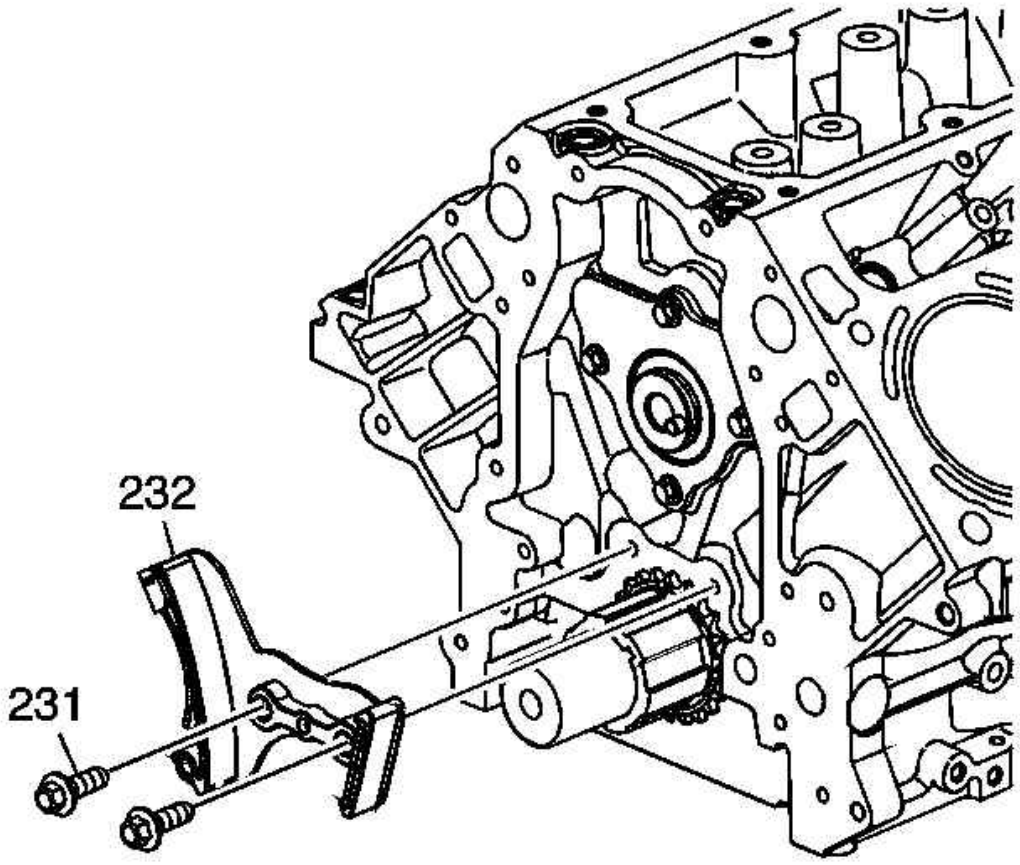


Fig. 222: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts (231) and timing chain tensioner (232).

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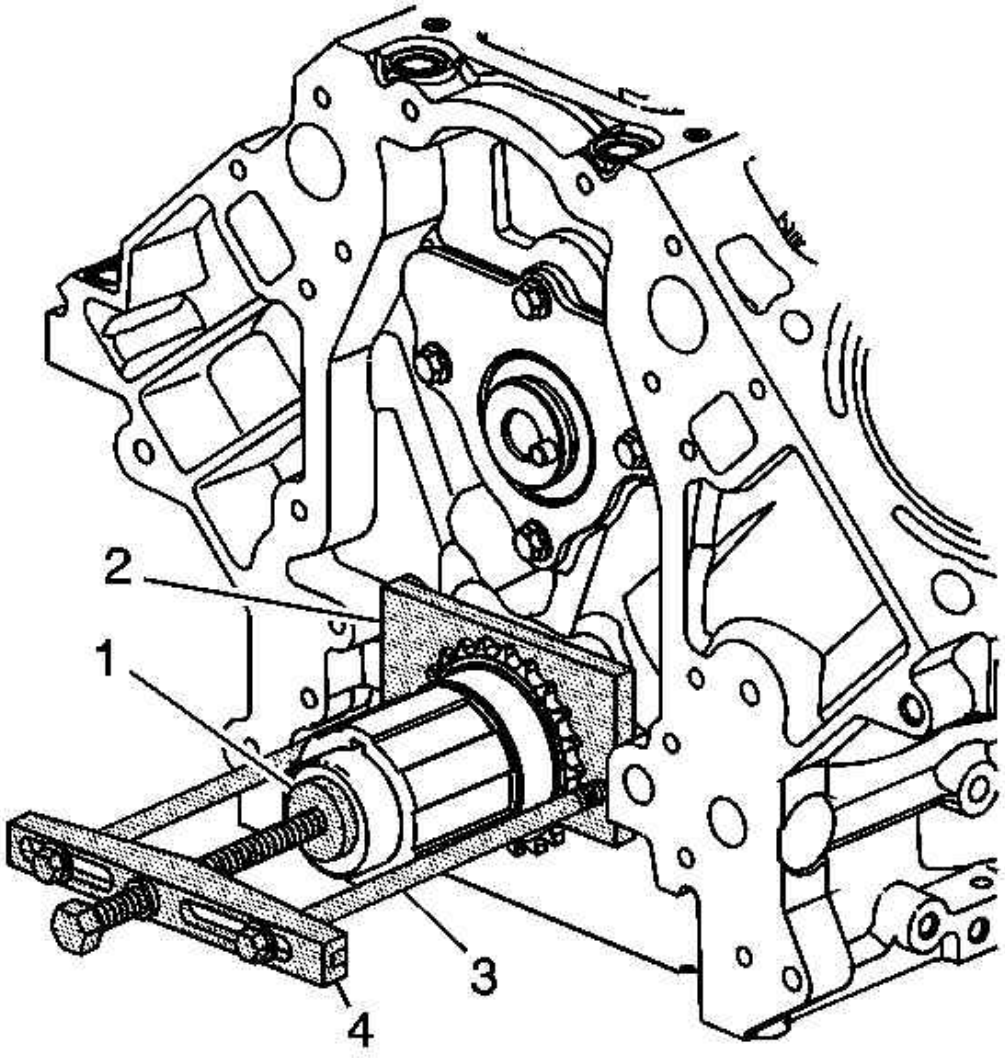


Fig. 223: View Of Crankshaft Sprocket Special Tools
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 41816-2** (1), the **J 41558** (2), bolts (3), and the **J 8433** (4) in order to remove the crankshaft sprocket. See **Special Tools**.

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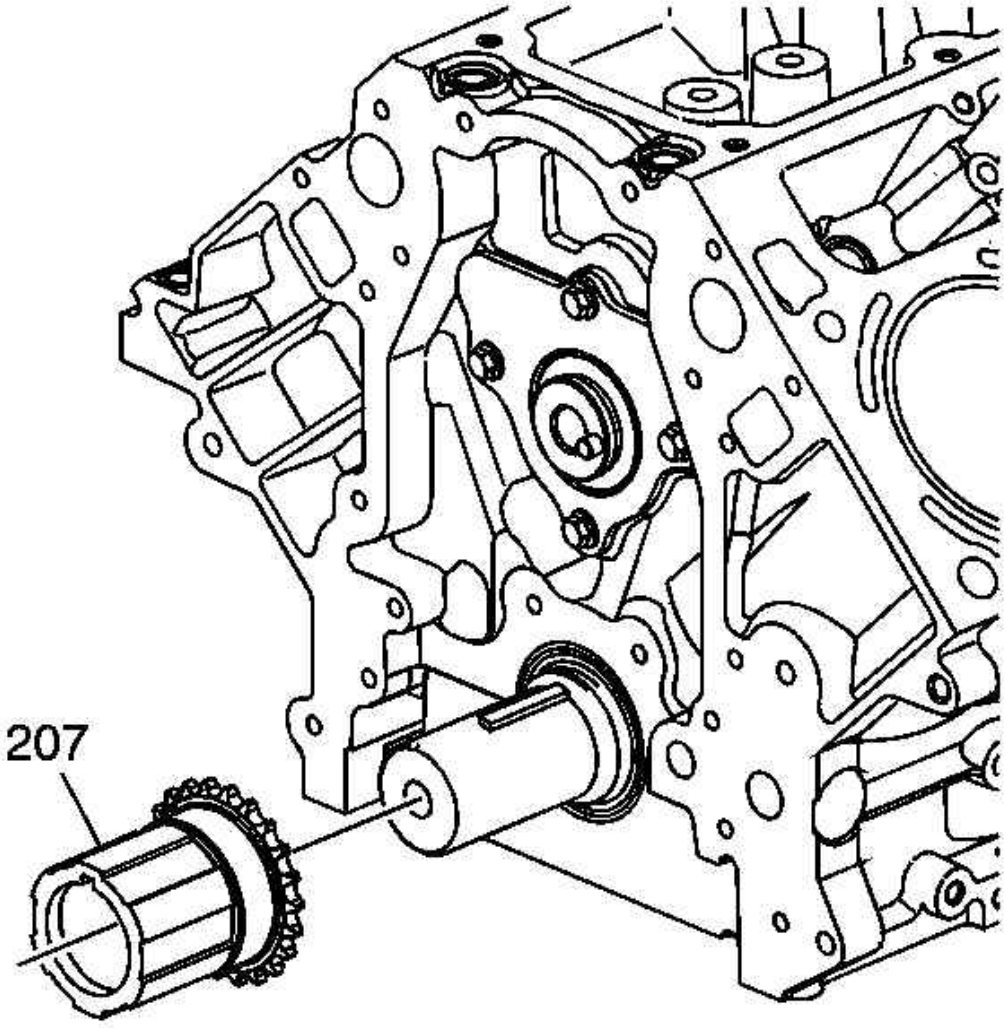


Fig. 224: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket (207).

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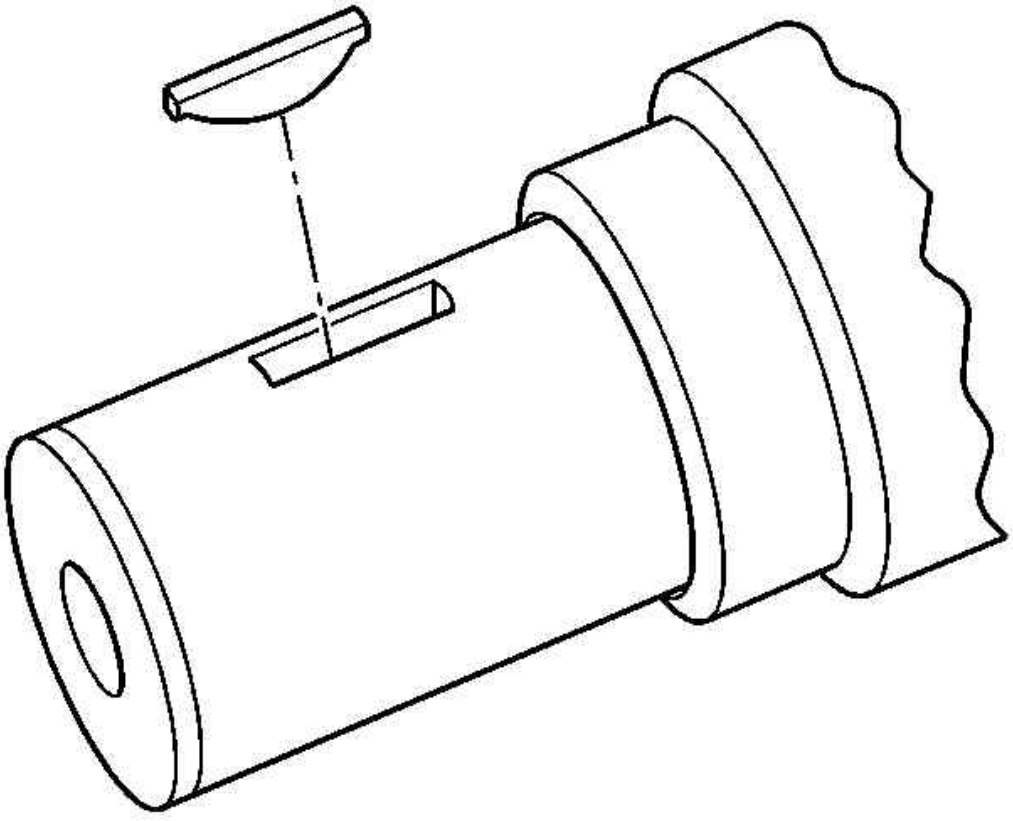


Fig. 225: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket key, as required.

Installation Procedure

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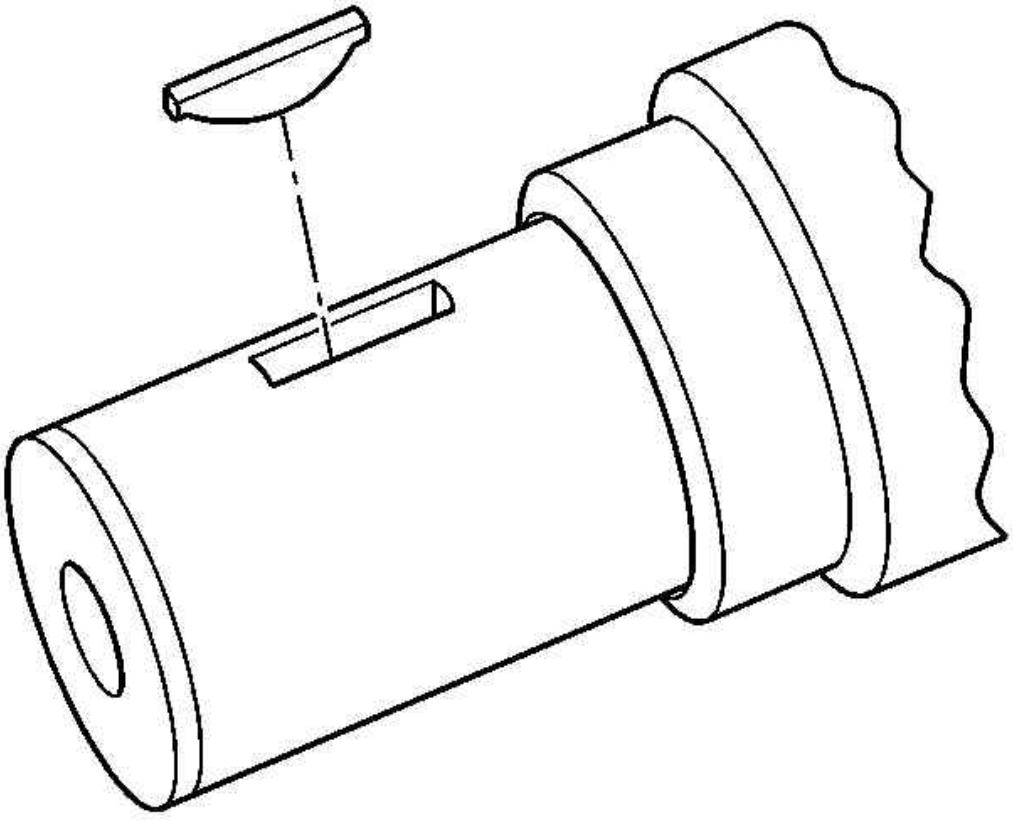


Fig. 226: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.

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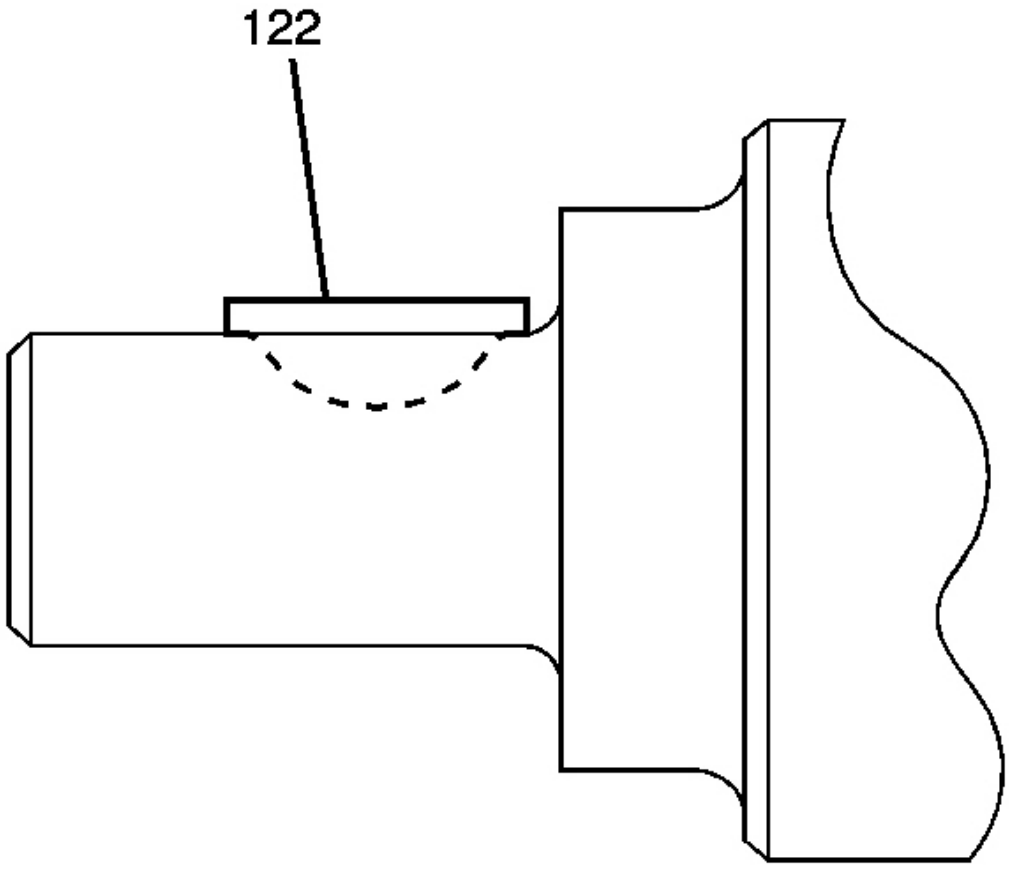


Fig. 227: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.

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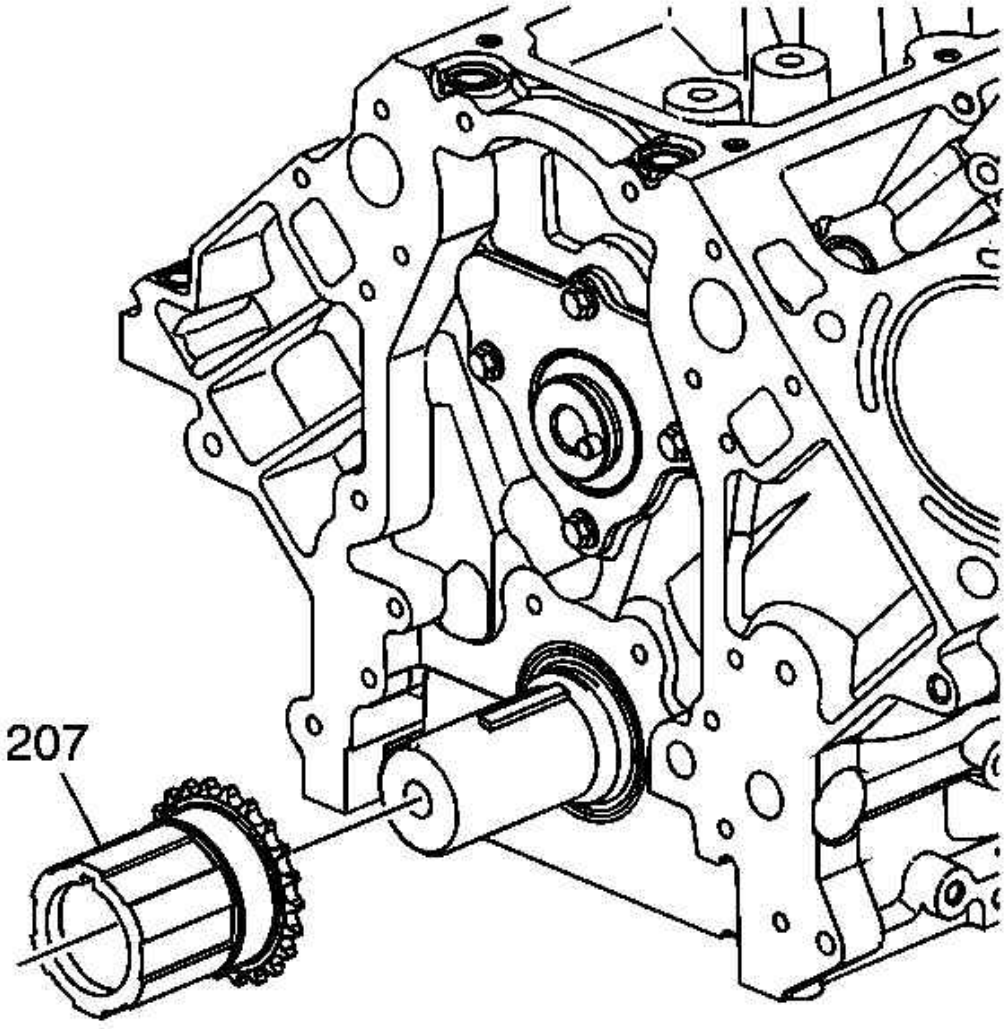


Fig. 228: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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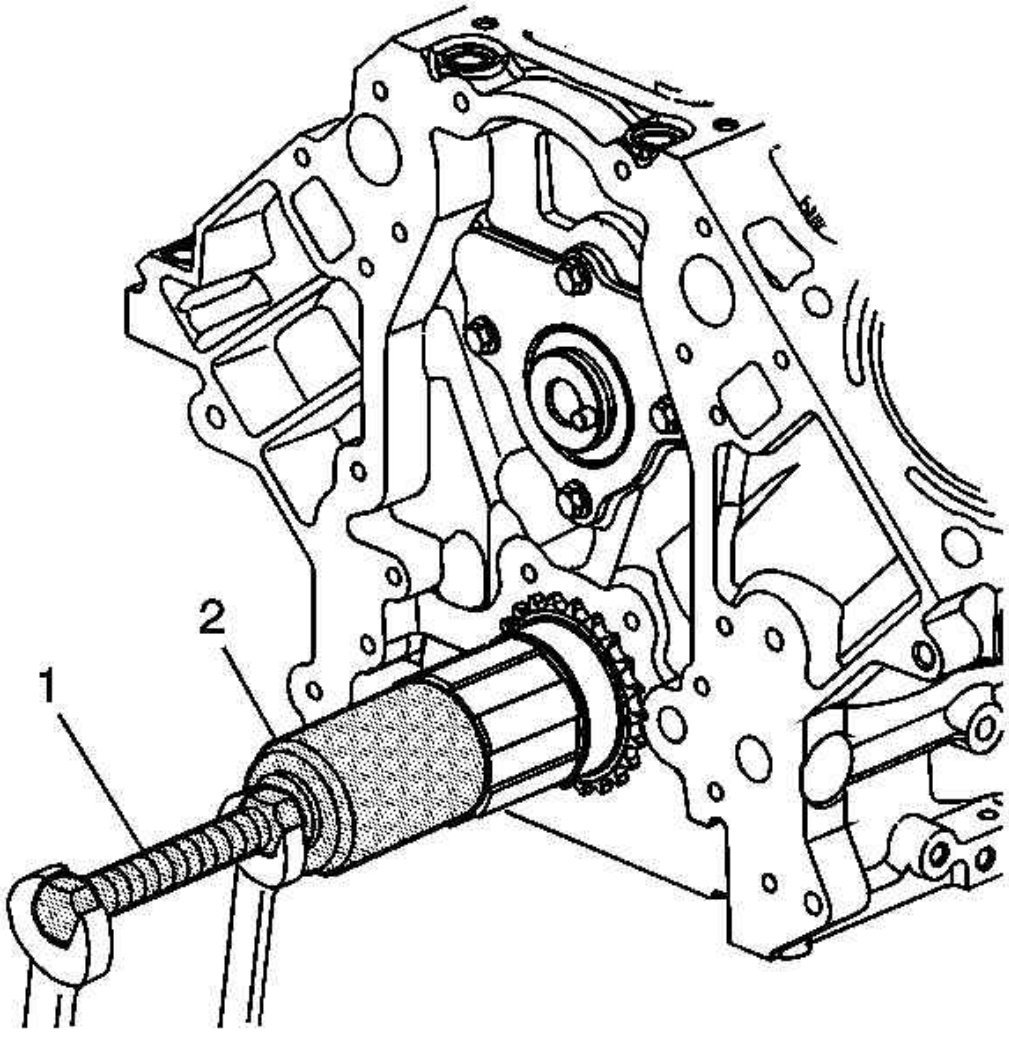


Fig. 229: View Of Crankshaft Sprocket & Installer
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41478** (1) and the **J 41665** (2) in order to install the crankshaft sprocket. See **Special Tools**.

   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

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5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.

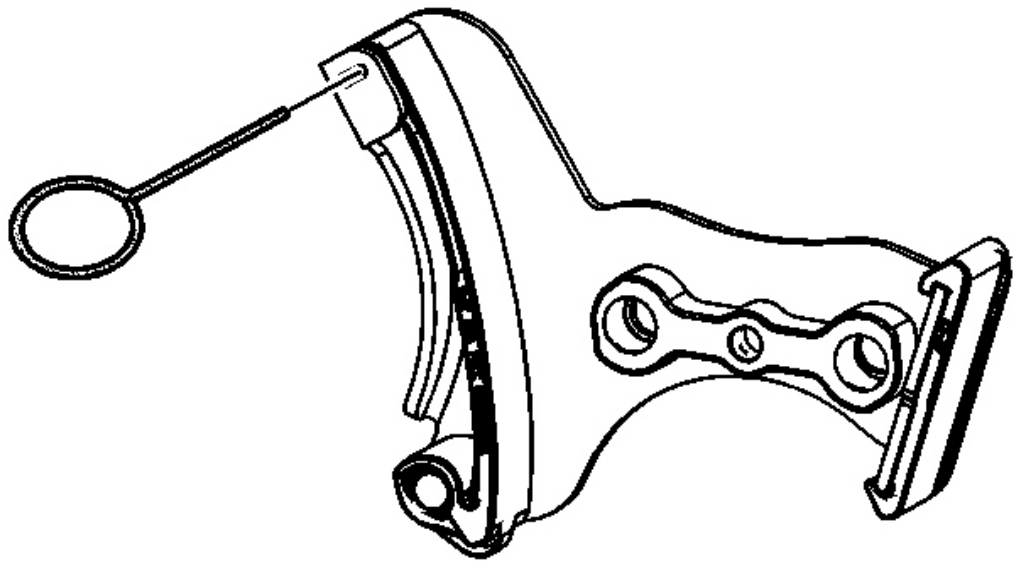


Fig. 230: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Compress the timing chain tensioner guide and install the **EN 46330** . See **Special Tools**.

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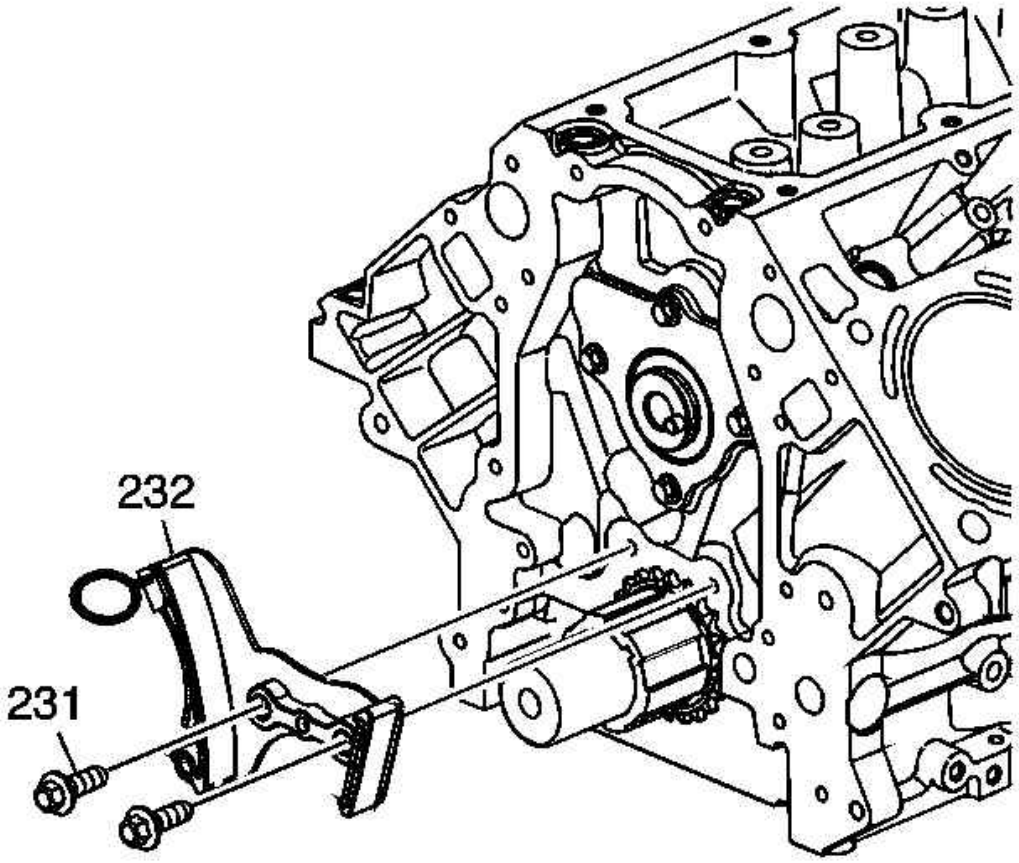


Fig. 231: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Install the timing chain tensioner (232) and bolts (231).

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

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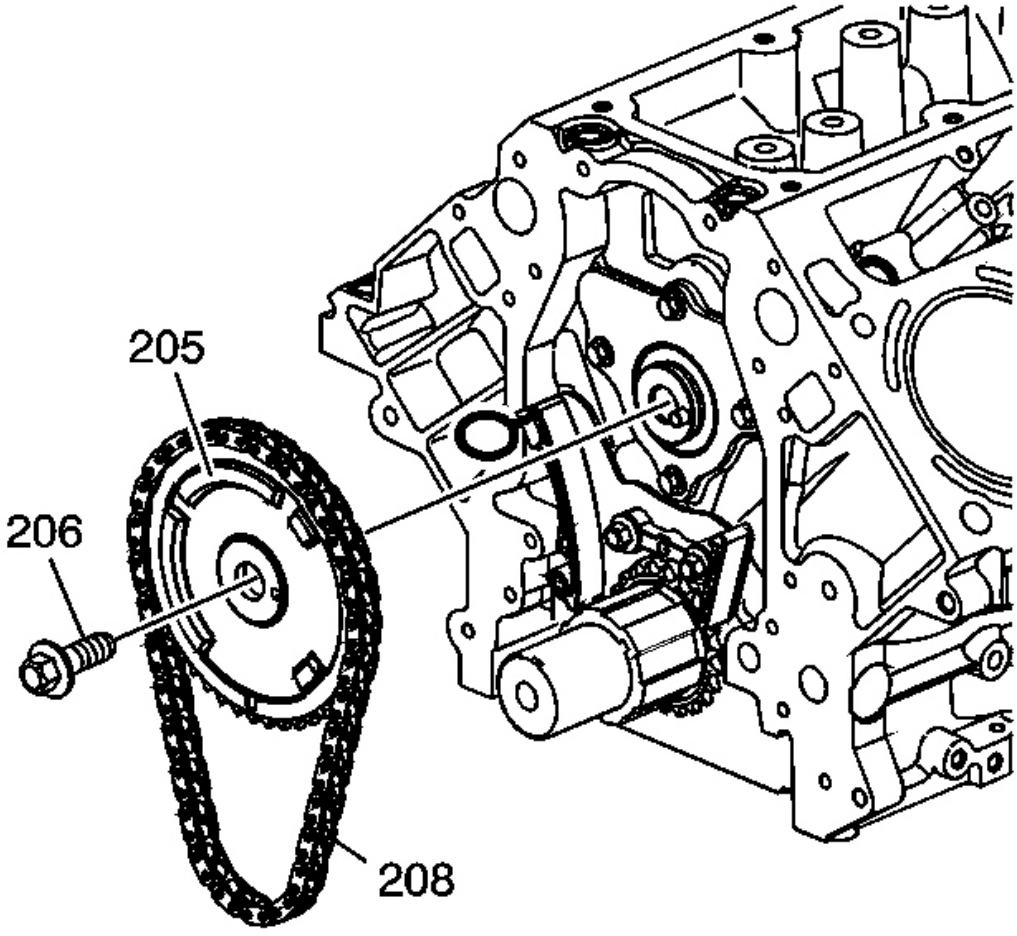


Fig. 232: View Of Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the camshaft sprocket bolt again. Install a NEW bolt during assembly.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**

8. Install the camshaft sprocket (205), timing chain (208), and NEW bolt (206).

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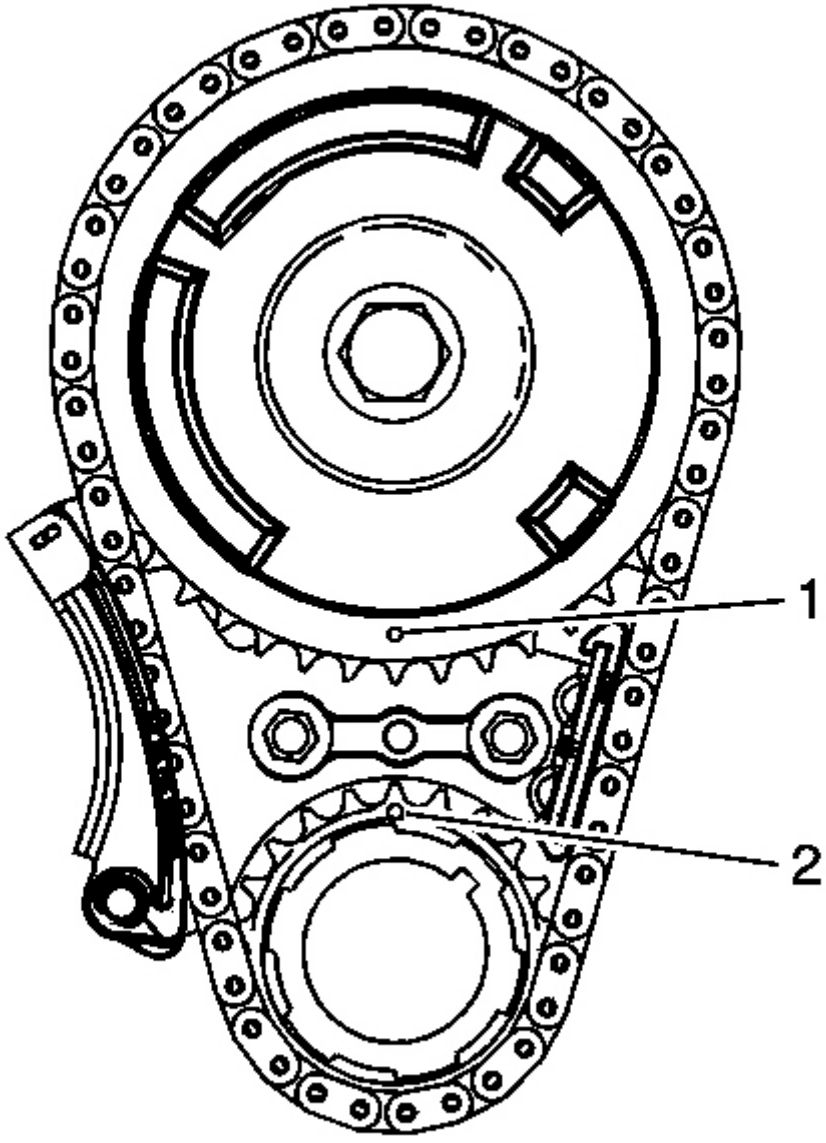


Fig. 233: Identifying Camshaft & Crankshaft Marks
Courtesy of GENERAL MOTORS CORP.

9. Inspect the sprockets for proper alignment. The mark on the camshaft sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft

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sprocket (2) should be located in the 12 o'clock position.

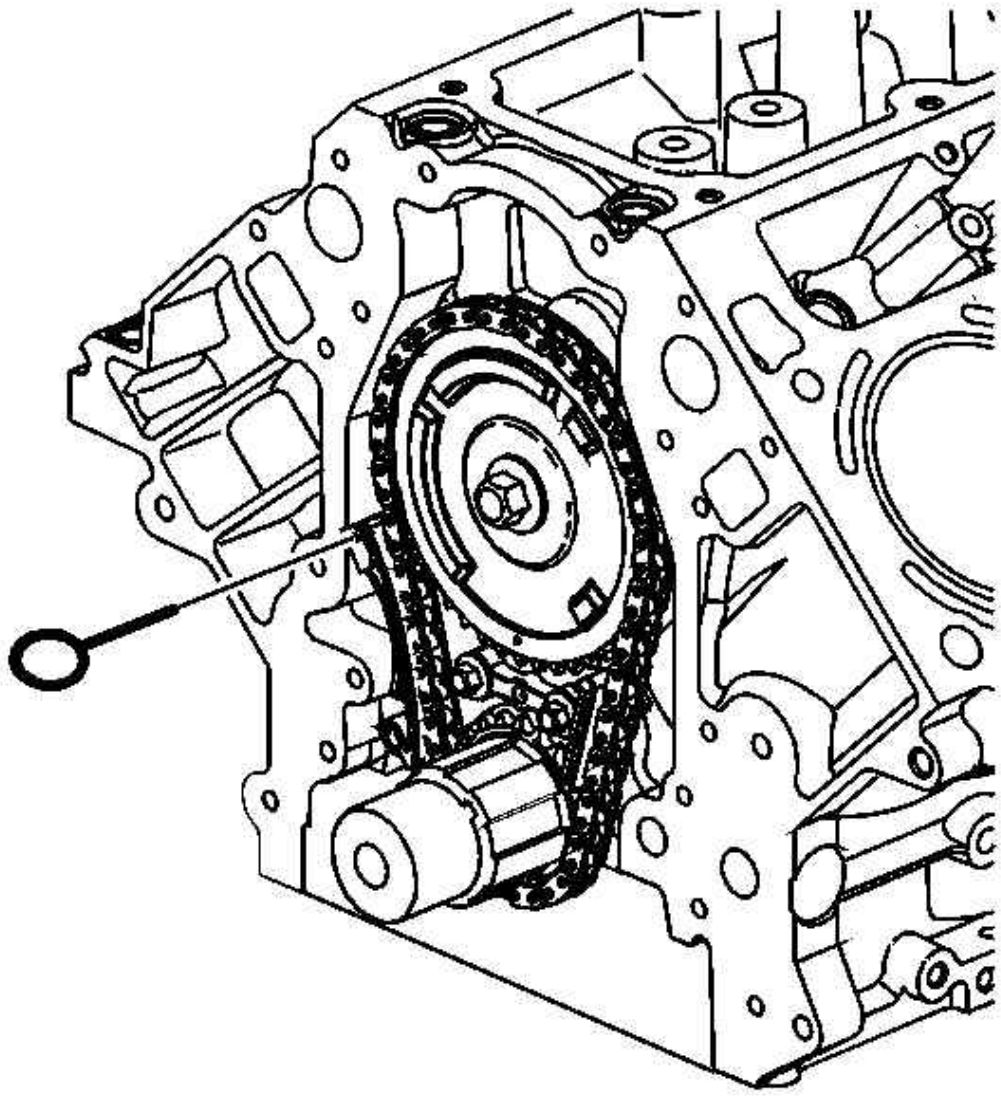


Fig. 234: Locating Tensioner Pin
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN 46330** . See **Special Tools**.

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IMPORTANT: Do not apply threadlock to the flex plate bolts at this time.

11. Temporarily install the automatic transmission flex plate and bolts. Refer to **Engine Flywheel Replacement**.

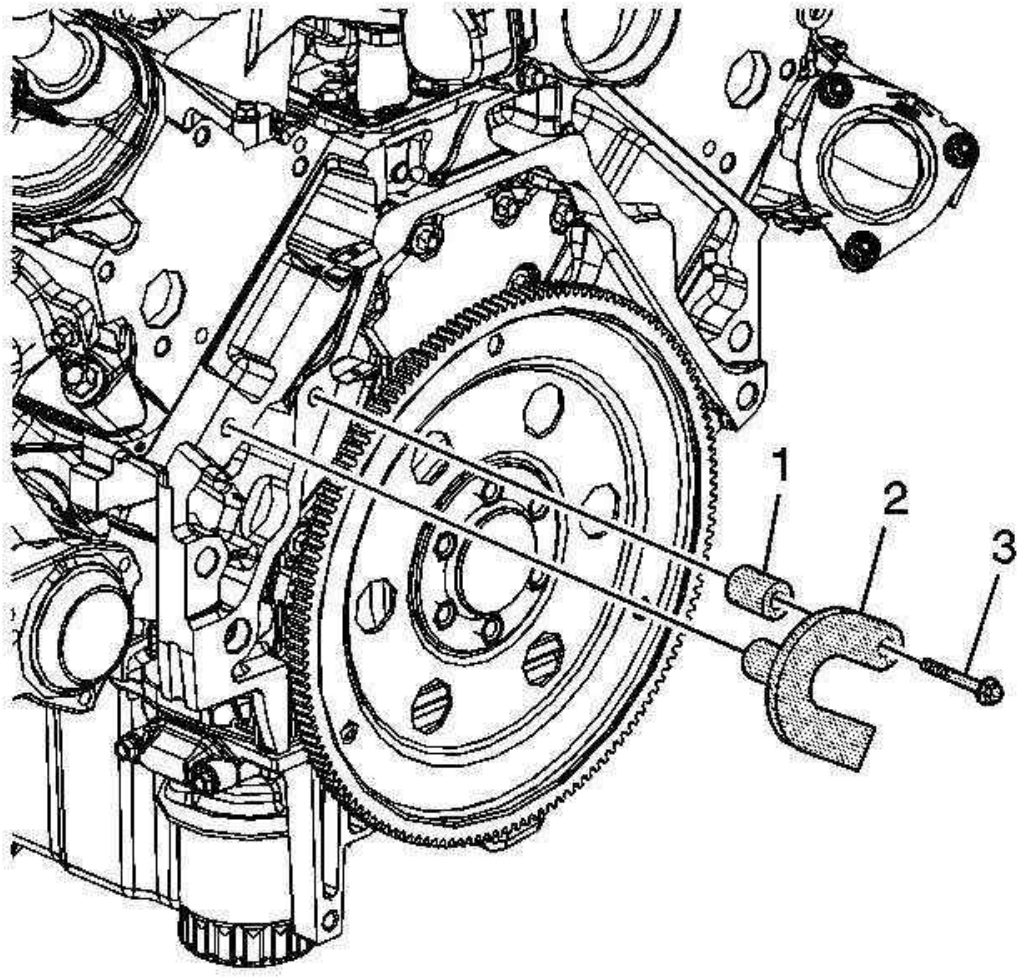


Fig. 235: View Of Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN 47699** (2), spacer (1), and bolts (3) to the block and flex plate.

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See **Special Tools**.

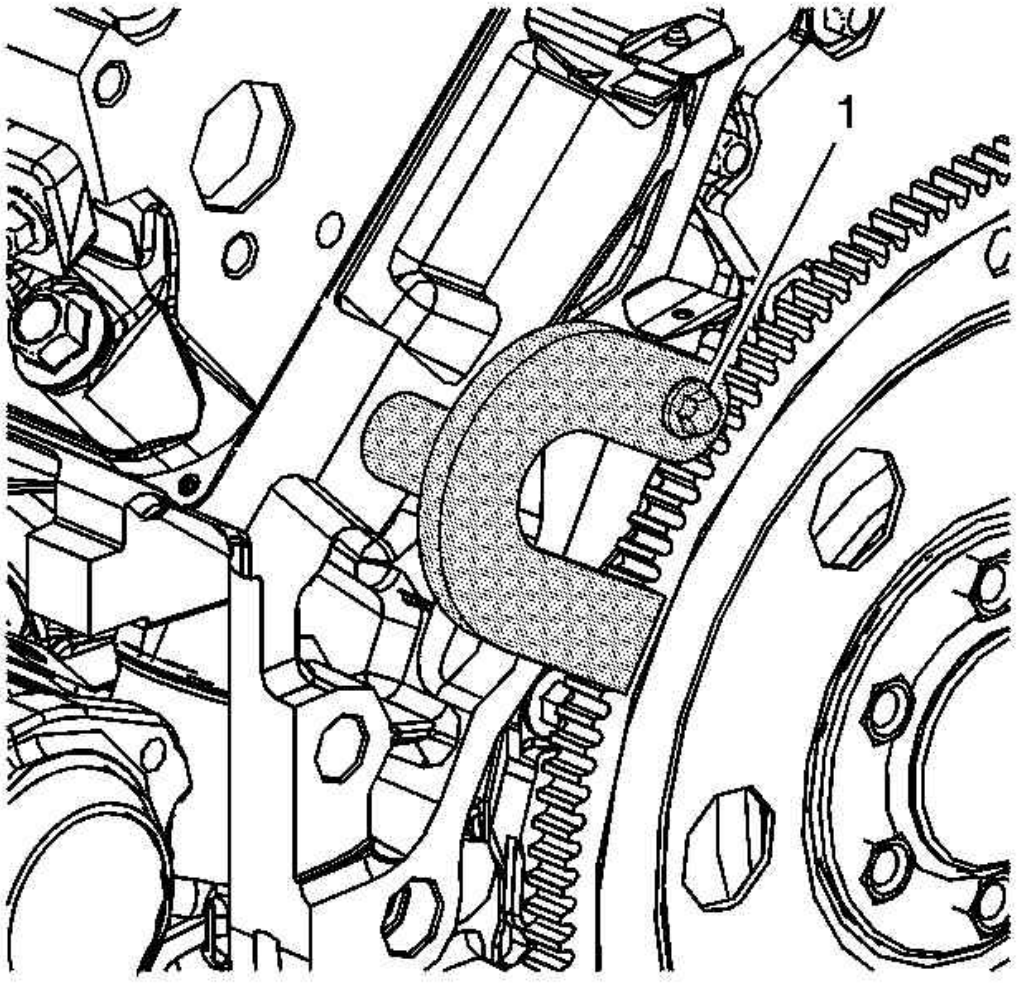


Fig. 236: Identifying Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

13. Tighten the **EN 47699** bolt (1). See **Special Tools**.

    Tighten: Tighten the bolt to 60 N.m (44 lb ft).

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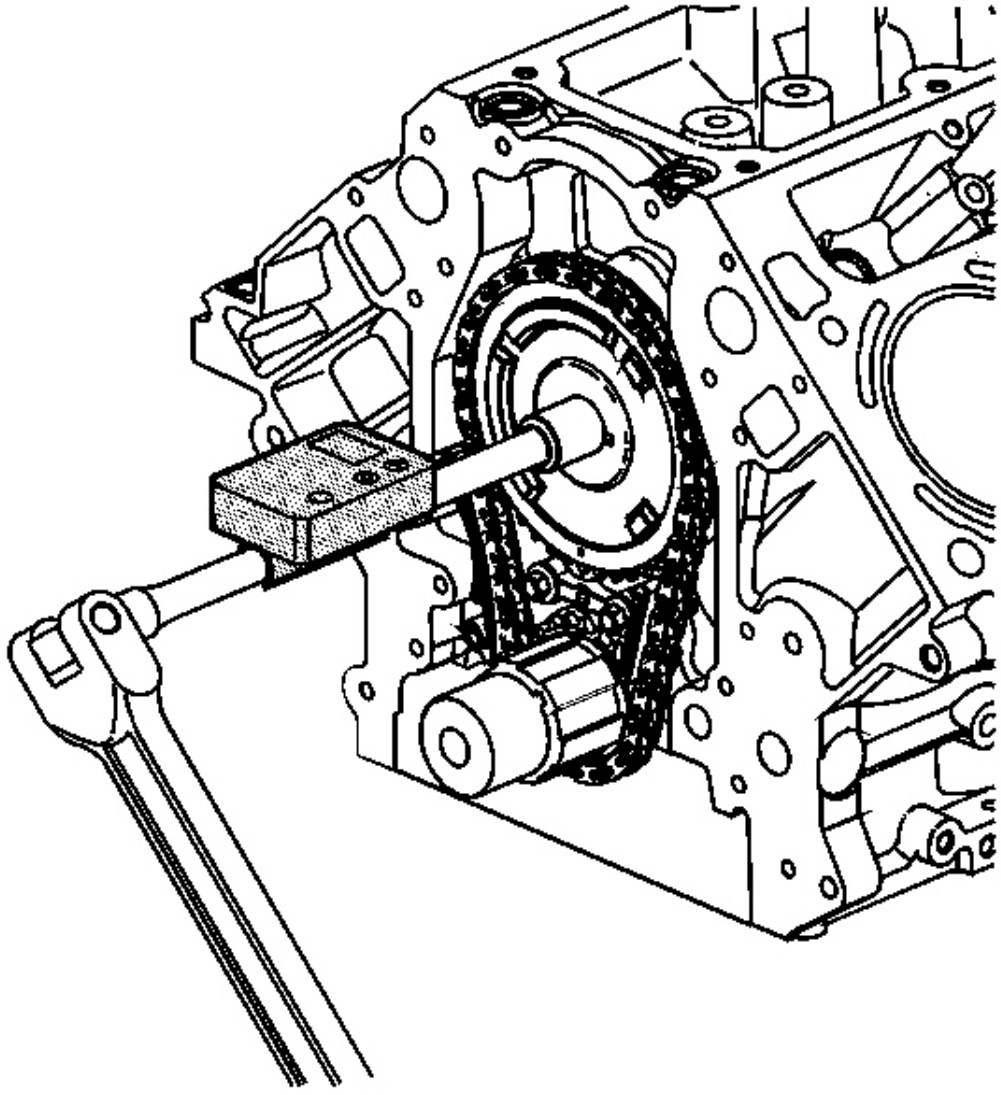


Fig. 237: Identifying Camshaft Sprocket Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

14. Tighten the camshaft sprocket bolt.

Tighten:

1. Tighten the camshaft sprocket bolt a first pass to 75 N.m (55 lb ft).

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2. Tighten the camshaft sprocket bolt a final pass an additional 50 degrees using the **J 45059** .

15. Remove the **J 42386-A** and bolts.
16. Remove the automatic transmission flex plate and bolt. Refer to **Engine Flywheel Removal**.
17. Install the oil pump. Refer to **Oil Pump, Screen, and Crankshaft Oil Deflector Replacement**.

CAMSHAFT REPLACEMENT

Removal Procedure

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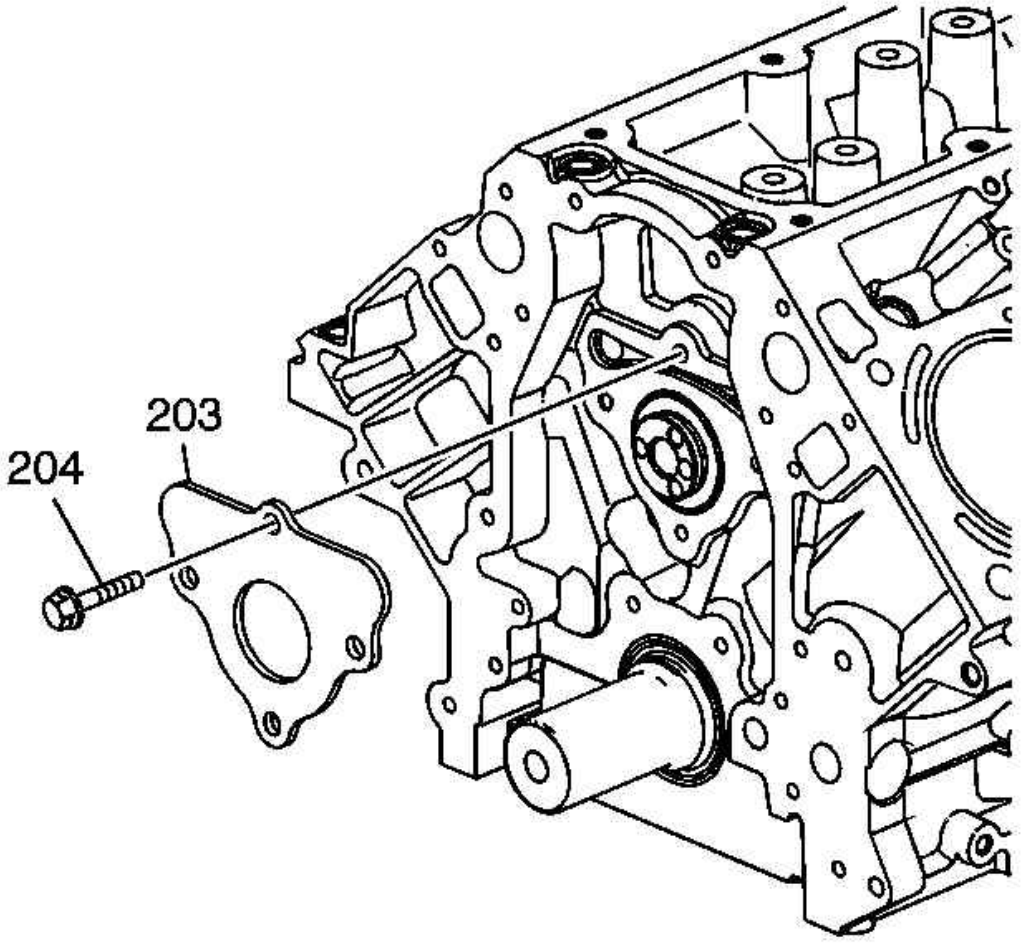


Fig. 238: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine. Refer to **Engine Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal**.
3. Remove the oil level indicator. Refer to **Oil Level Indicator and Tube Removal**.
4. Remove the left and right exhaust manifolds. Refer to **Exhaust Manifold Removal - Left Side** and **Exhaust Manifold Removal - Right Side**.
5. Remove the water pump. Refer to **Water Pump Removal**.

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6. Remove the coolant pump manifold. Refer to **Coolant Pump Manifold Replacement** .
7. Remove the intake manifold. Refer to **Intake Manifold Removal**.
8. Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Removal**.
9. Remove the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe and Hole Cover Removal**.
10. Remove the left and right valve rocker arm covers. Refer to **Valve Rocker Arm Cover Removal - Left Side** and **Valve Rocker Arm Cover Removal - Right Side**.
11. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Removal**.
12. Remove the valve lifters. Refer to **Valve Lifter Removal**.
13. Remove the oil pan-to-front cover bolts.
14. Remove the front cover. Refer to **Engine Front Cover Removal**.
15. Remove the camshaft retainer bolts (204) and retainer (203).

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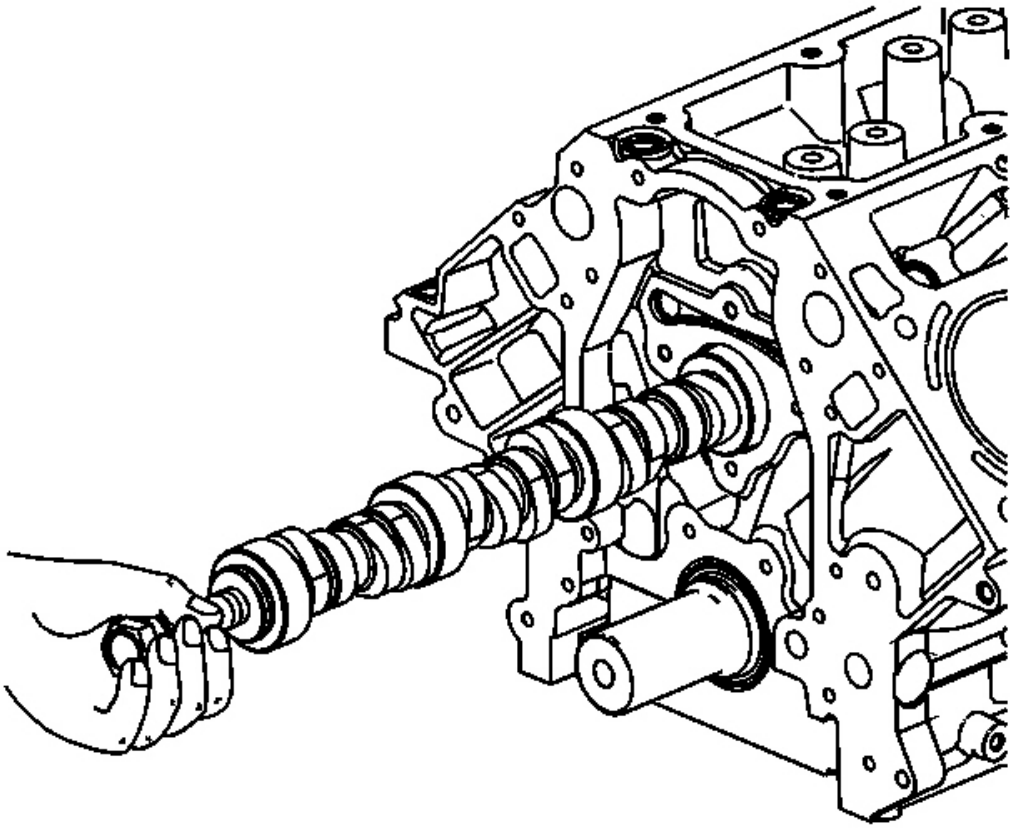


Fig. 239: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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

16. Remove the camshaft.
    1. Install the camshaft sprocket bolt into the camshaft front bolt hole.
    2. Using the bolt as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the bolt from the front of the camshaft.

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Installation Procedure

IMPORTANT: If camshaft replacement is required, the valve lifters must also be replaced.

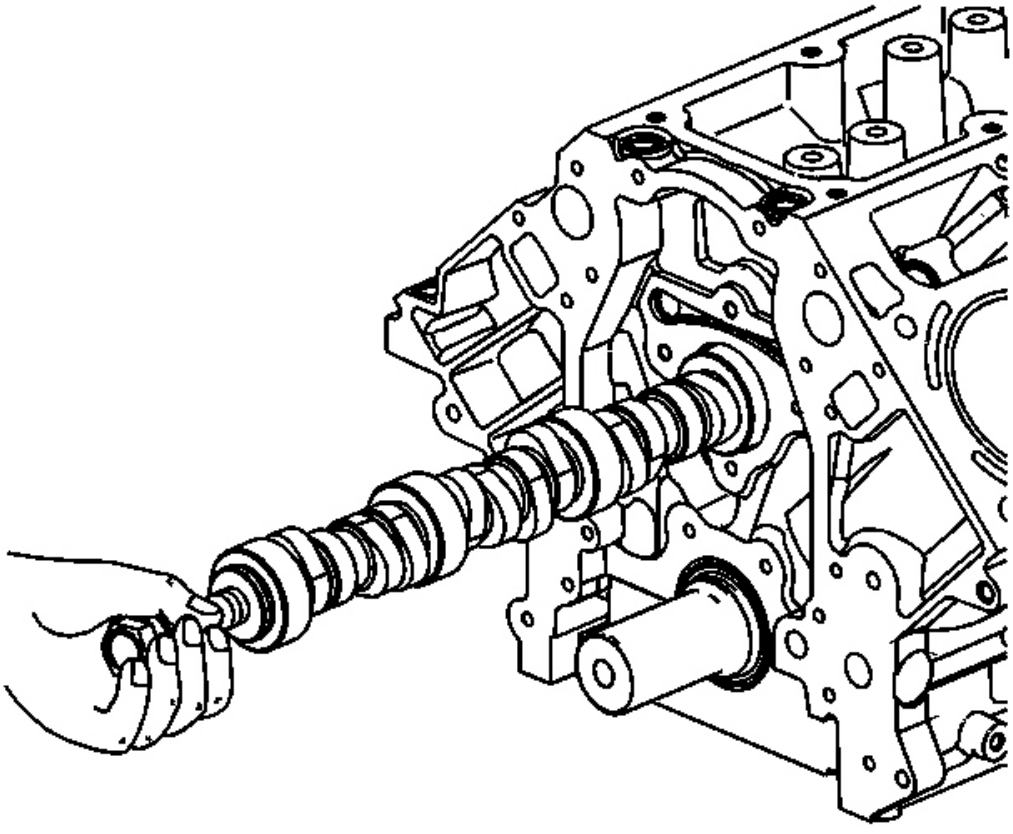


Fig. 240: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install the camshaft sprocket bolt into the camshaft front bolt hole.

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

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avoid damage to the camshaft bearings.

3. Using the bolt as a handle, carefully install the camshaft into the engine block.
4. Remove the bolt from the front of the camshaft.

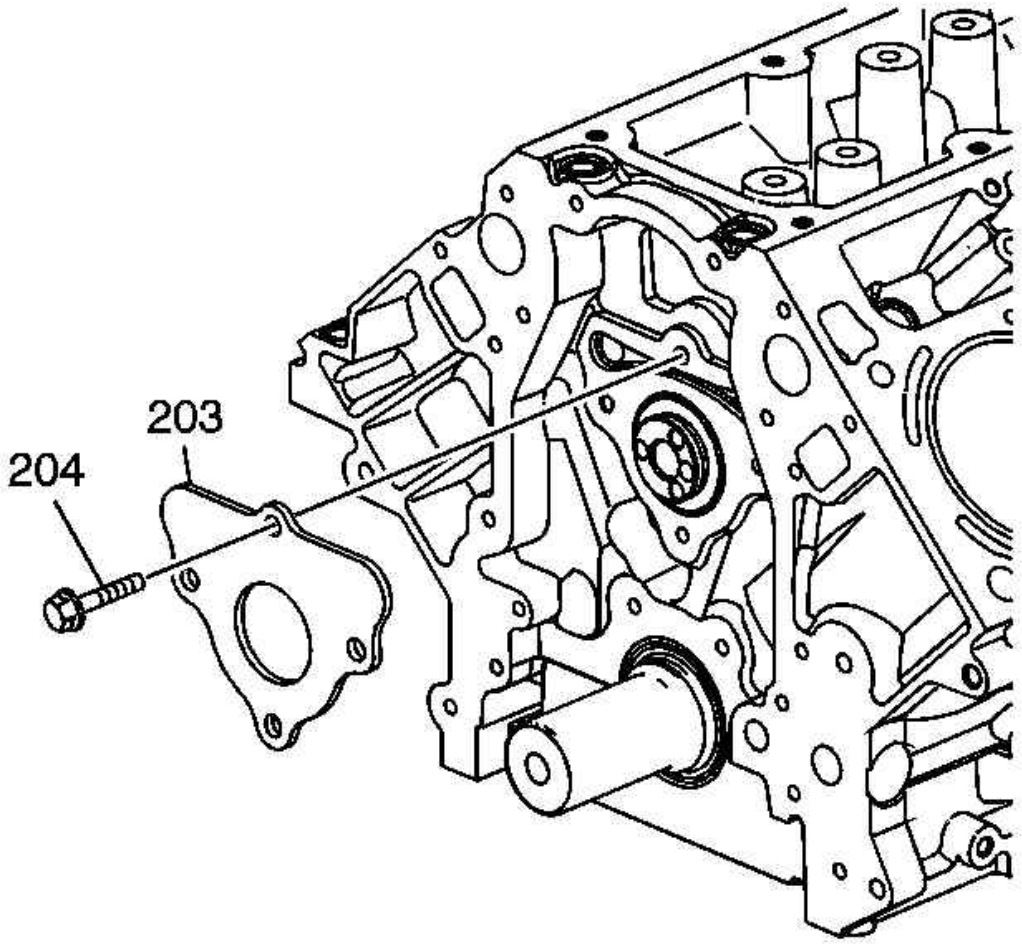


Fig. 241: View Of Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The gasket surface on the engine block should be clean and free of dirt or debris.

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5. Install the camshaft retainer (203) and the bolts (204). Install the retainer with the sealing gasket facing the front of the engine block.

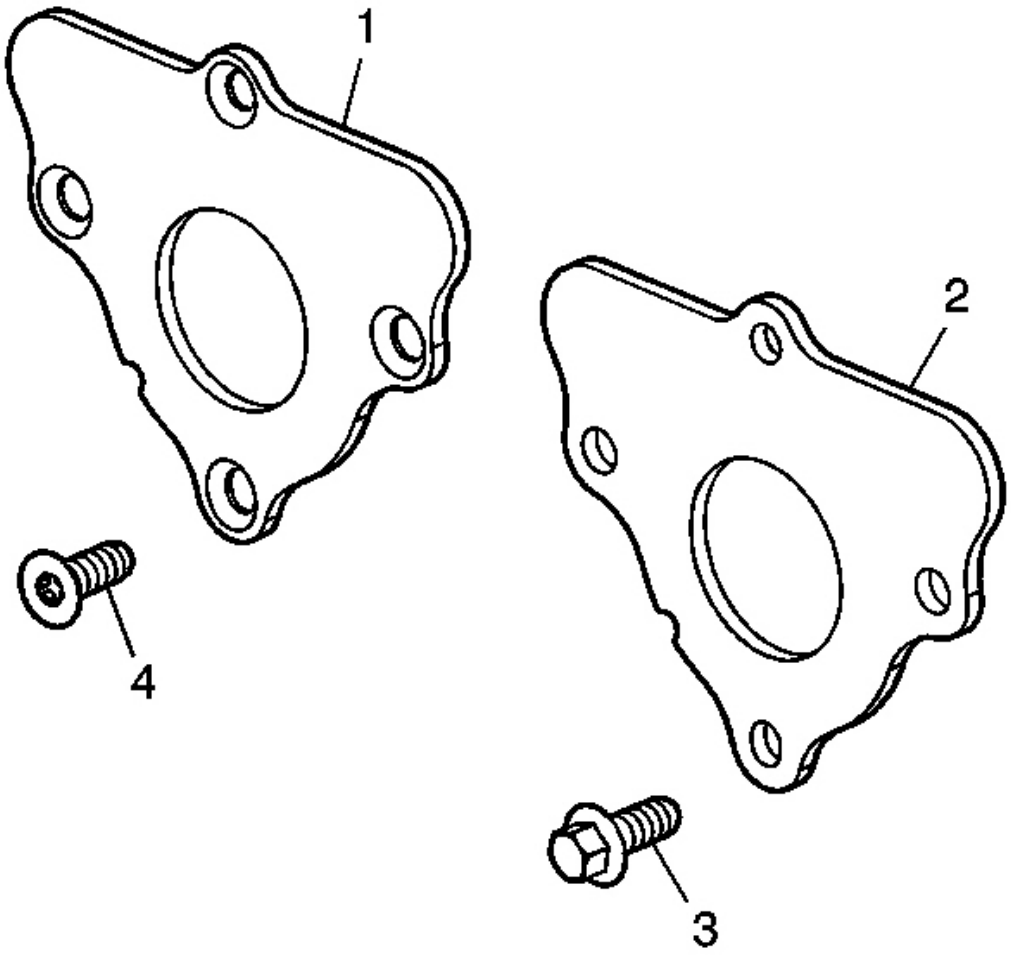


Fig. 242: Identifying Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Tighten the camshaft retainer bolts.

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Tighten:

- Tighten the first design hex head bolts (3) to 25 N.m (18 lb ft).
- Tighten the second design TORX® head bolts (4) to 15 N.m (11 lb ft).

7. Install the front cover. Refer to **Engine Front Cover Installation**.
8. Install the oil pan-to-front cover bolts.

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

9. Install the valve lifters. Refer to **Valve Lifter Installation (5.3L)**.
10. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Installation**.
11. Install the left and right valve rocker arm covers. Refer to **Valve Rocker Arm Cover Installation - Left Side** and **Valve Rocker Arm Cover Installation - Right Side**.
12. Install the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe and Hole Cover Installation**.
13. Install the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Installation**.
14. Install the intake manifold. Refer to **Intake Manifold Installation**.
15. Install the coolant pump manifold. Refer to **Coolant Pump Manifold Replacement** .
16. Install the water pump. Refer to **Water Pump Installation**.
17. Install the left and right exhaust manifolds. Refer to **Exhaust Manifold Installation - Left Side** and **Exhaust Manifold Installation - Right Side**.
18. Install the oil level indicator. Refer to **Oil Level Indicator and Tube Installation**.
19. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation**.
20. Install the engine. Refer to **Engine Replacement**.

ENGINE FLYWHEEL REPLACEMENT

Removal Procedure

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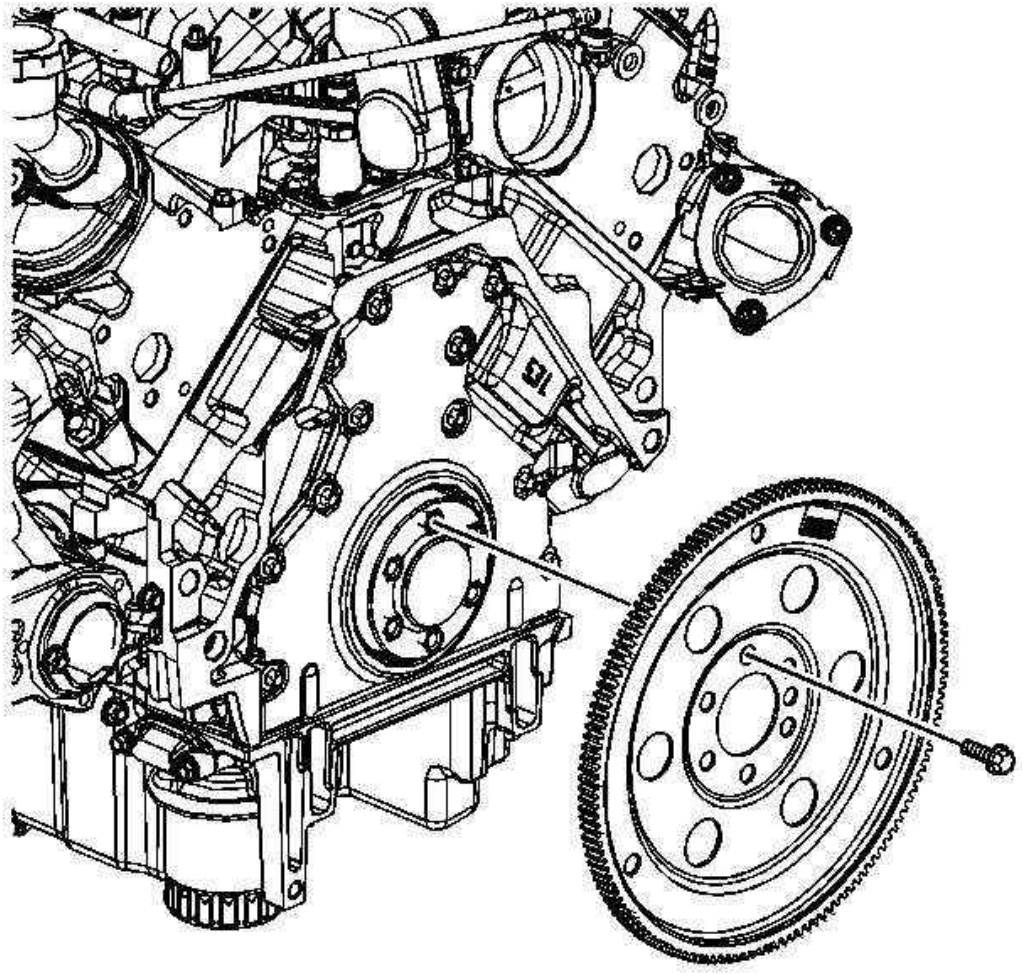


Fig. 243: Identifying Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transmission. Refer to **Transmission Replacement** .
2. Remove the flywheel bolts and flywheel.
3. Clean and inspect the engine flywheel. Refer to **Engine Flywheel Cleaning and Inspection**.

Installation Procedure

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IMPORTANT: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer if applicable, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a 3-stage tightening process.

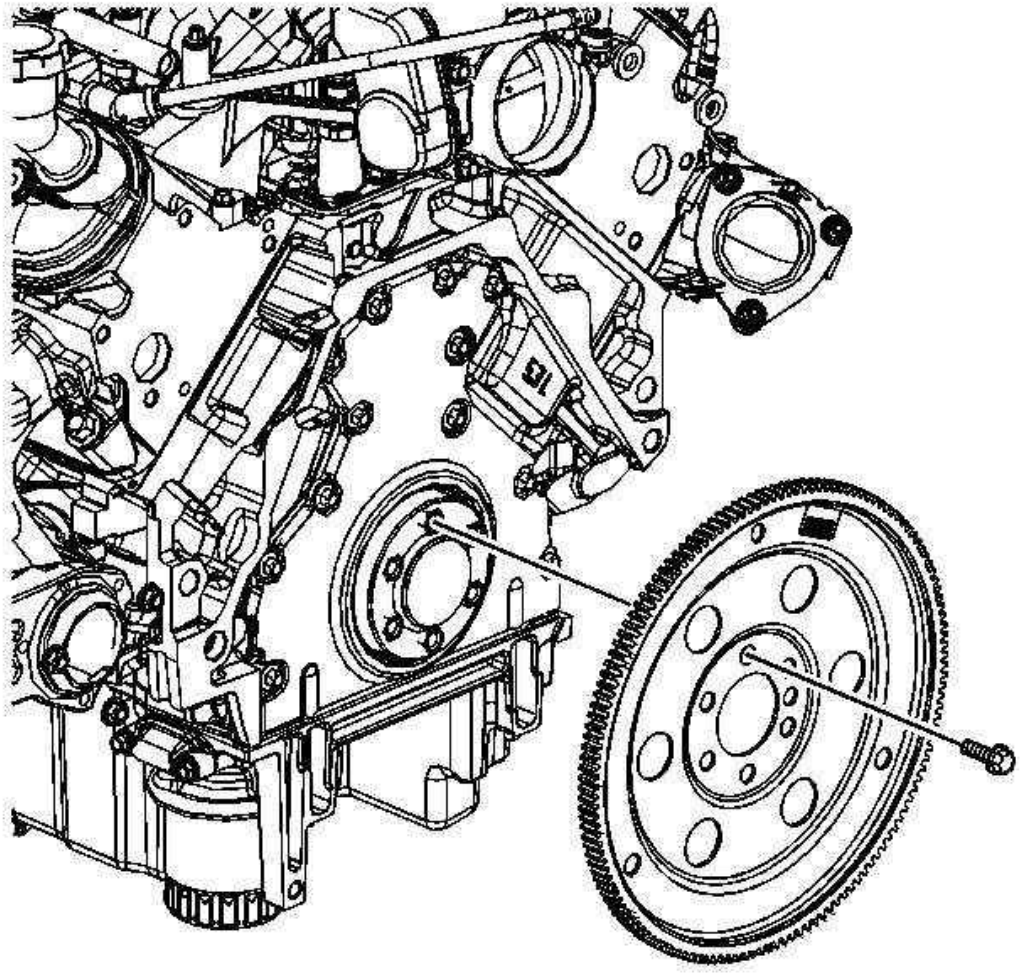


Fig. 244: Identifying Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel to the crankshaft.

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2. Apply threadlock to the threads of the flywheel bolts. Refer to **Sealers, Adhesives, and Lubricants**.

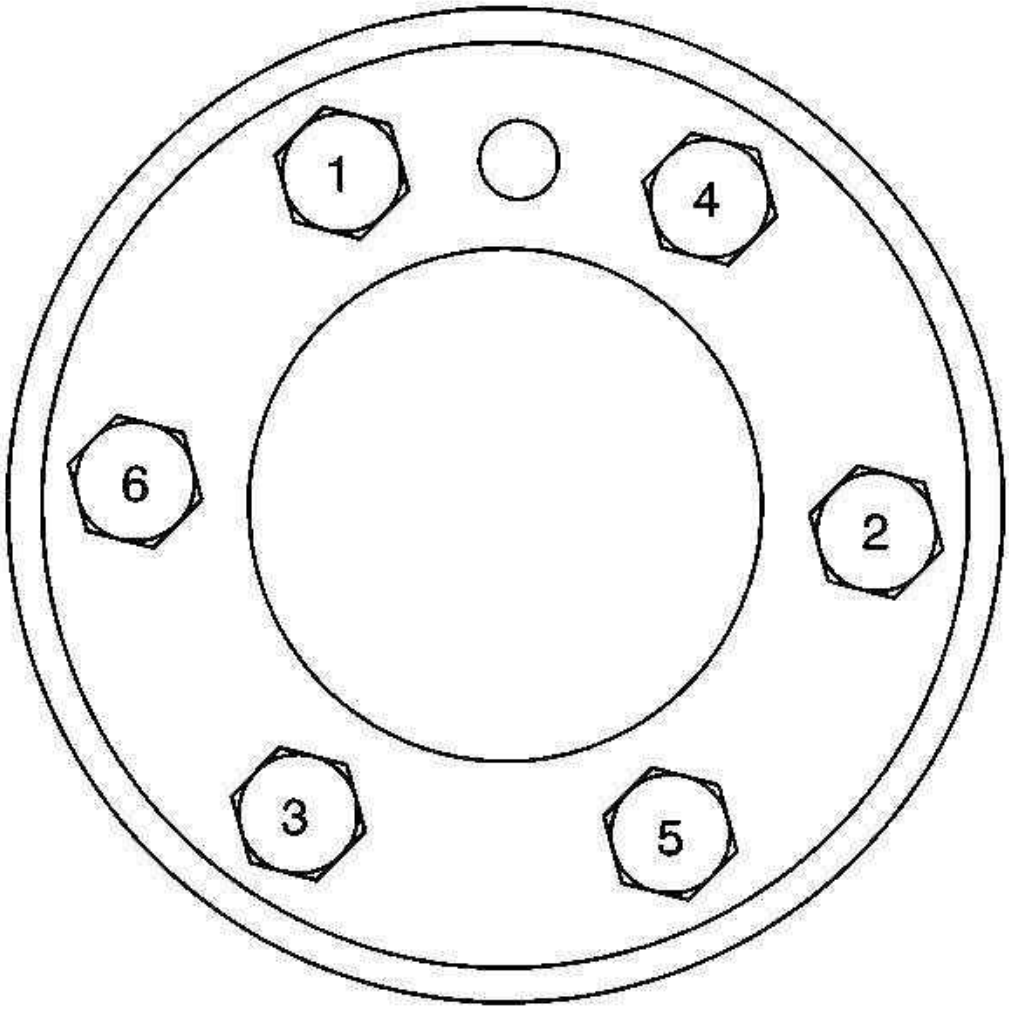


Fig. 245: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the engine flywheel bolts.

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Tighten:

- Tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
- Tighten the bolts a second pass in sequence to 50 N.m (37 lb ft).
- Tighten the bolts a final pass in sequence to 100 N.m (74 lb ft).

4. Install the automatic transmission. Refer to **Transmission Replacement** .

ENGINE REPLACEMENT

Tools Required

- **J 38185** Hose Clamp Pliers
- **J 39580** Universal Engine Support Table

Removal Procedure

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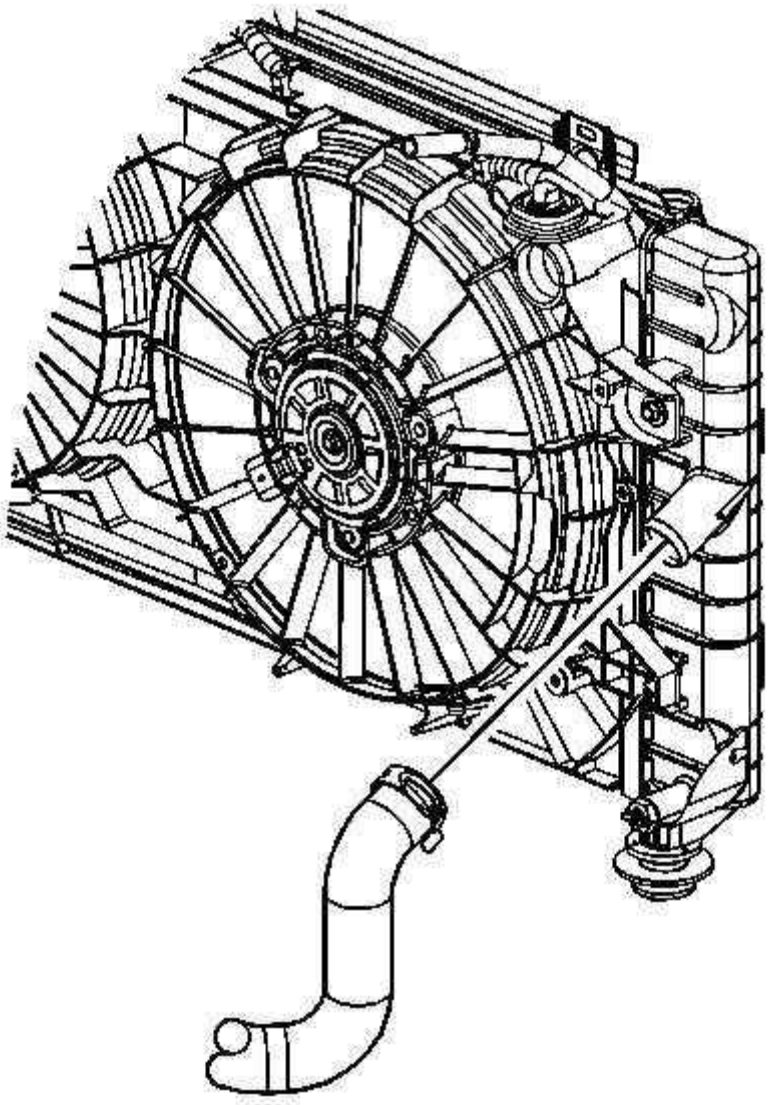


Fig. 246: View Of Inlet Hose & Radiator
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (LS4)** .
2. Remove the engine sight shield. Refer to **Upper Intake Manifold Sight**

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Shield Replacement.

3. Evacuate the air conditioning (A/C) system. Refer to **Refrigerant Recovery and Recharging** .
4. Remove the front tires and wheels. Refer to **Tire and Wheel Removal and Installation** .
5. Drain the cooling system. Refer to **Cooling System Draining and Filling (LS4 GE47716 Fill)** or **Cooling System Draining and Filling (LS4 Static Fill)** .
6. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
7. Lower the vehicle.
8. Using the **J 38185** reposition the inlet hose clamp at the radiator.
9. Remove the inlet hose from the radiator.

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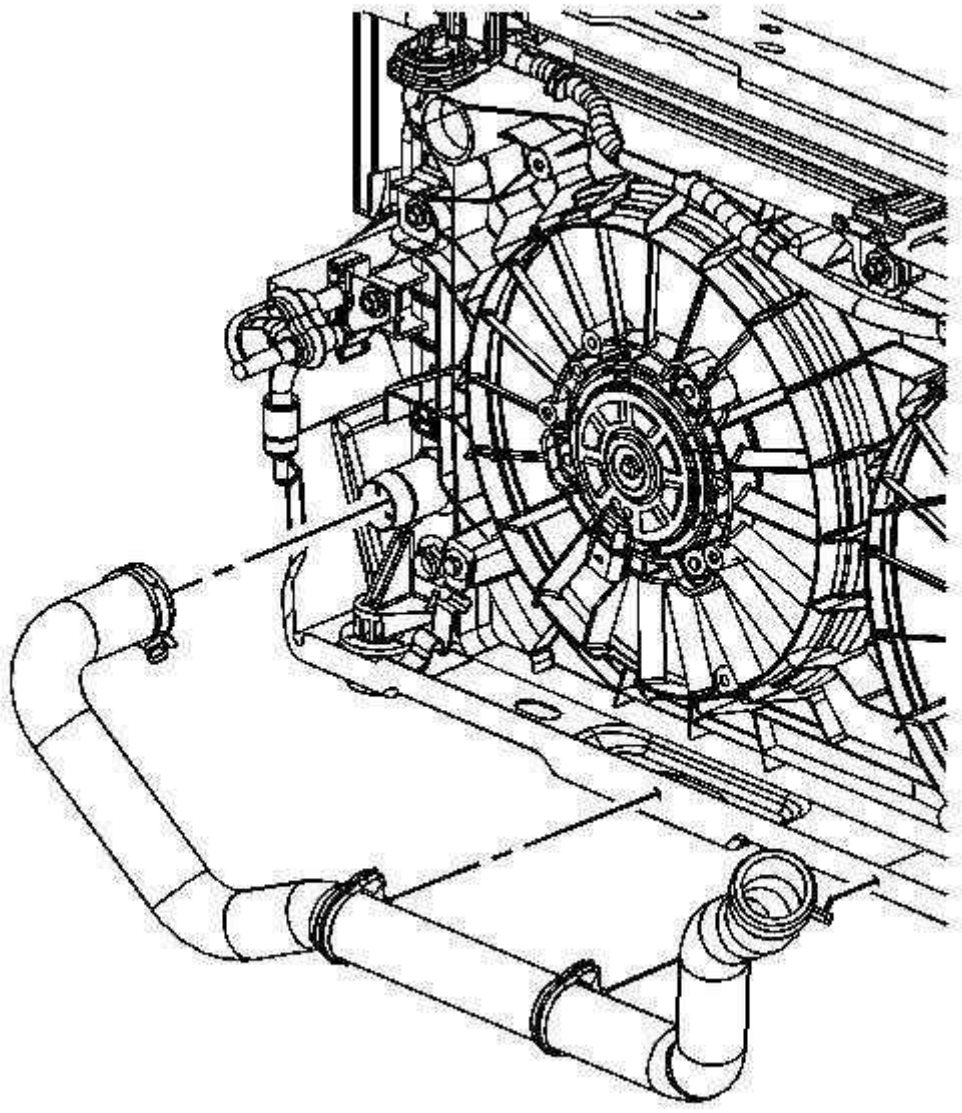


Fig. 247: View Of Outlet Hose & Radiator
Courtesy of GENERAL MOTORS CORP.

10. Using the **J 38185** reposition the outlet hose clamp at the radiator.
11. Disengage the outlet hose clips from the fan shroud.
12. Remove the outlet hose from the radiator.

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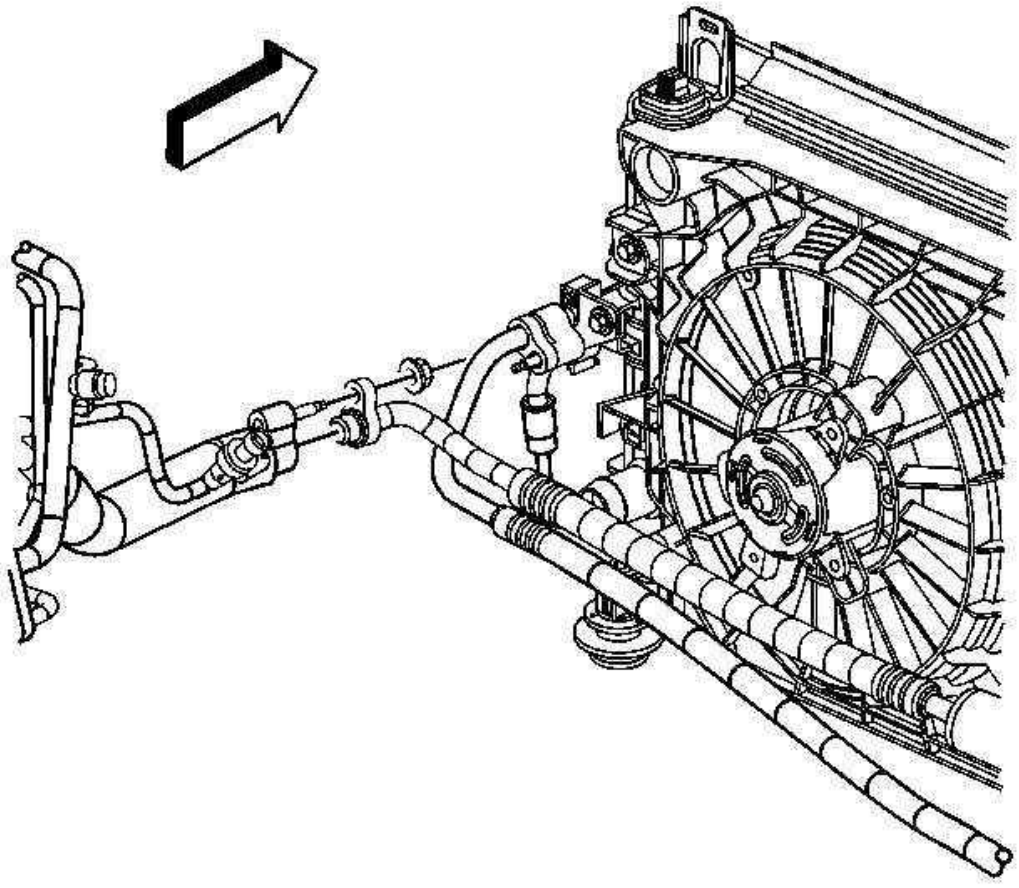


Fig. 248: View Of A/C Compressor Hose Nut & A/C Receiver/Dehydrator Tube
Courtesy of GENERAL MOTORS CORP.

13. Remove the A/C compressor hose nut at the A/C receiver/dehydrator tube.
14. Remove the A/C compressor hose.

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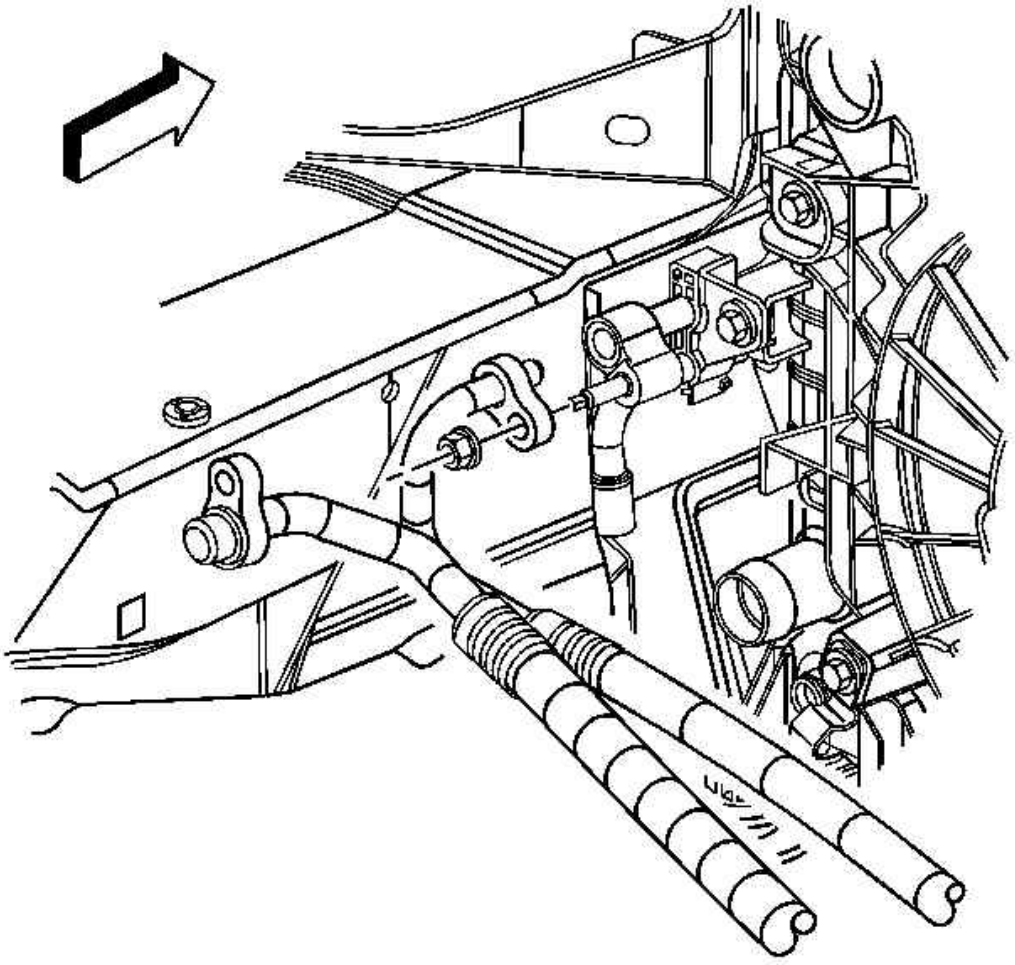


Fig. 249: View Of A/C Compressor Hose & Nut At A/C Condenser
Courtesy of GENERAL MOTORS CORP.

15. Remove the A/C compressor hose nut at the A/C condenser.
16. Remove the A/C compressor hose.

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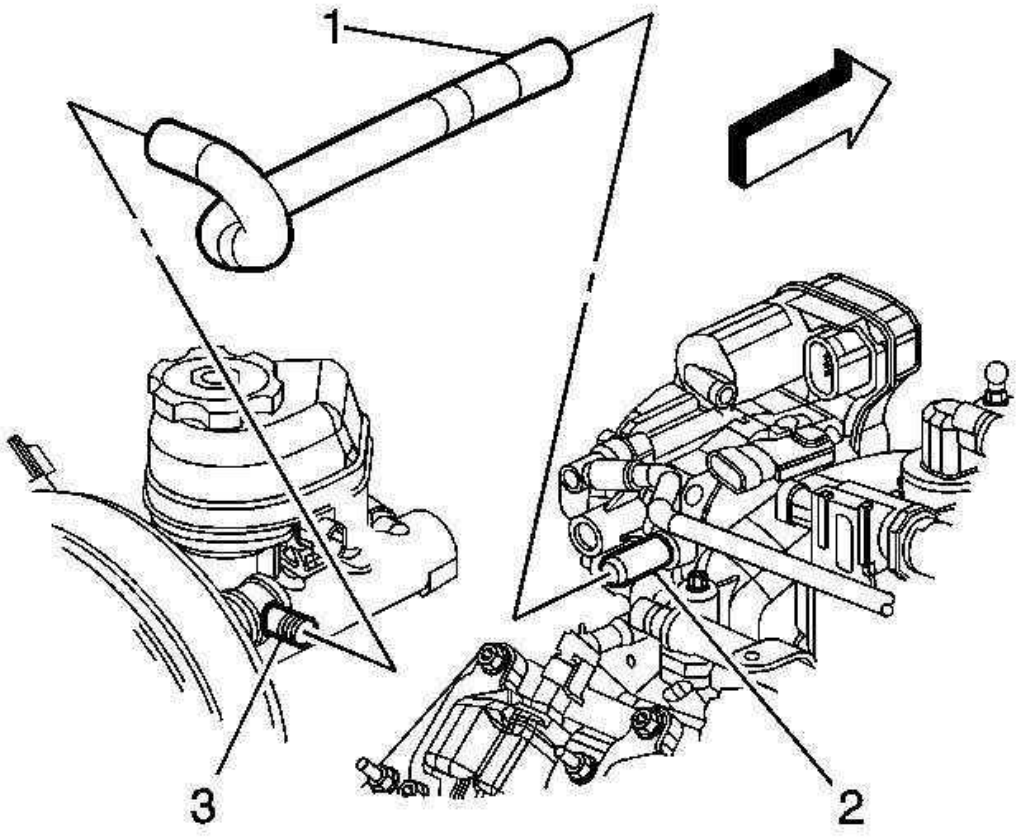


Fig. 250: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

17. Remove the brake booster vacuum hose from the brake booster (3).
18. Remove the brake booster vacuum hose (1) from the intake manifold (2).

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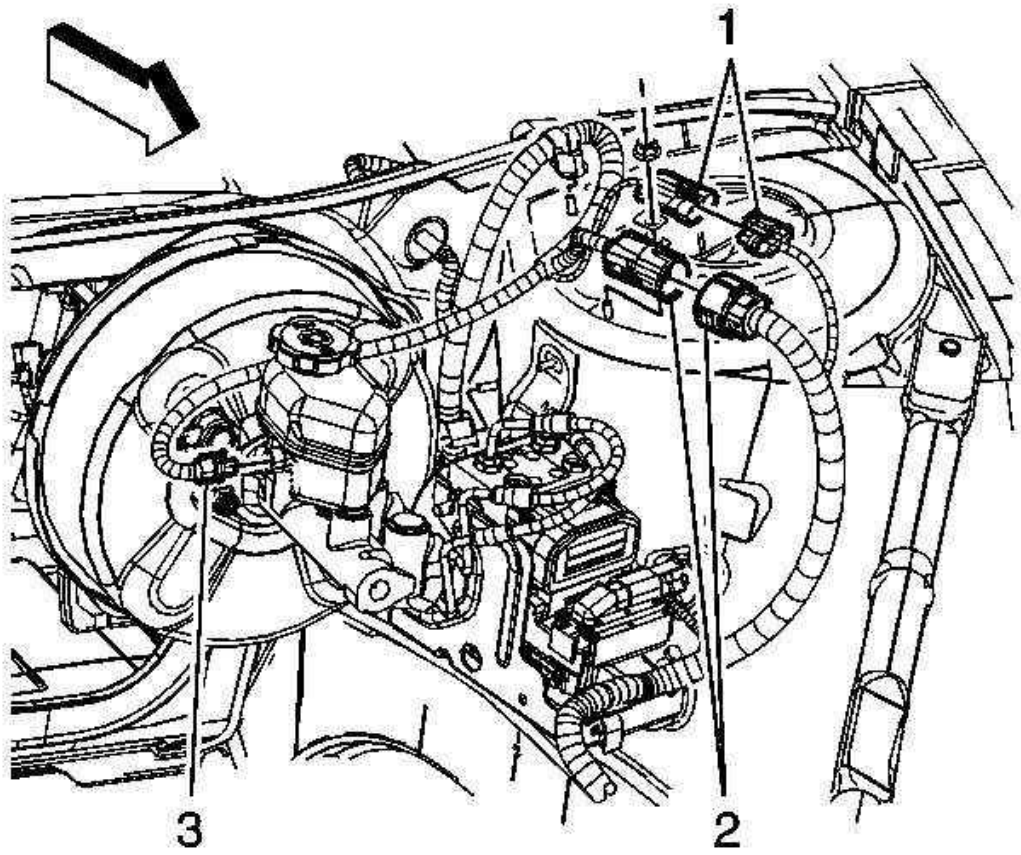


Fig. 251: View Of Engine Harness Electrical Connectors & Brake Fluid Level Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

19. Disconnect the engine harness electrical connectors (1, 2) from the instrument panel (I/P) harness electrical connectors.
20. Disconnect the brake fluid level switch electrical connector (3) from the master cylinder.

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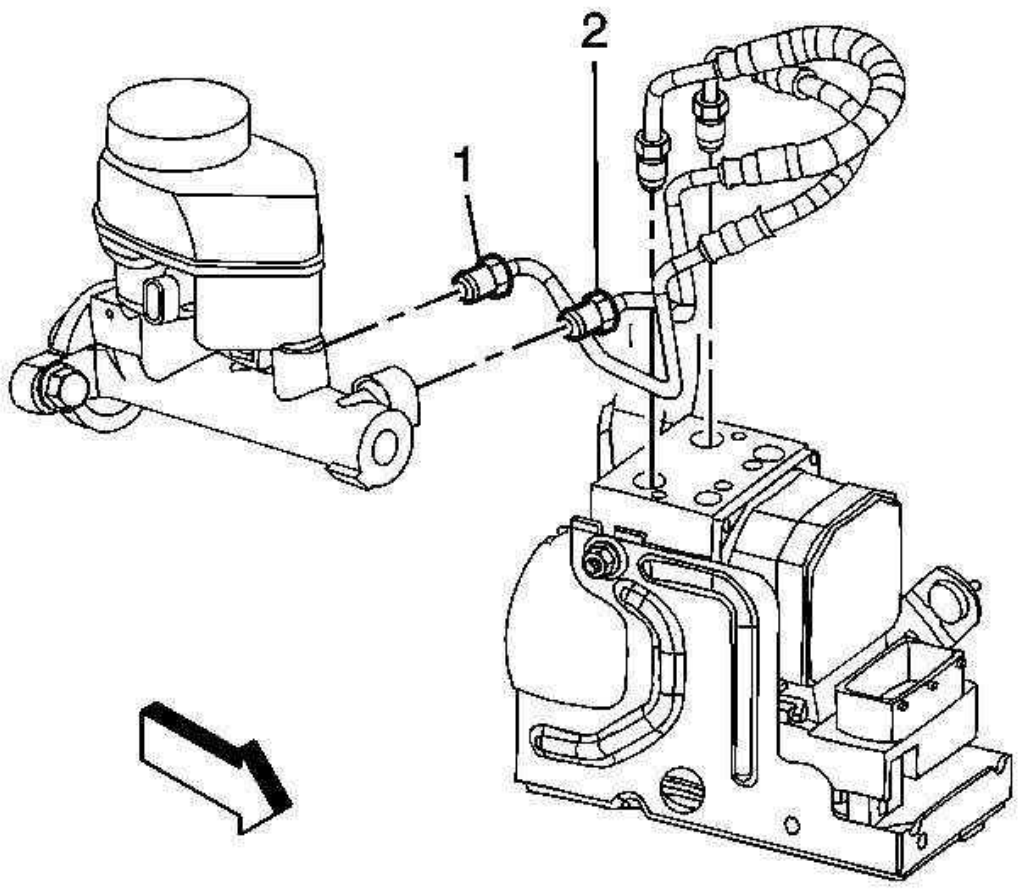


Fig. 252: View Of Master Cylinder Brake Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

21. Remove brake fluid from the master cylinder.
22. Disconnect the from brake pipe fittings (1, 2) from the master cylinder.

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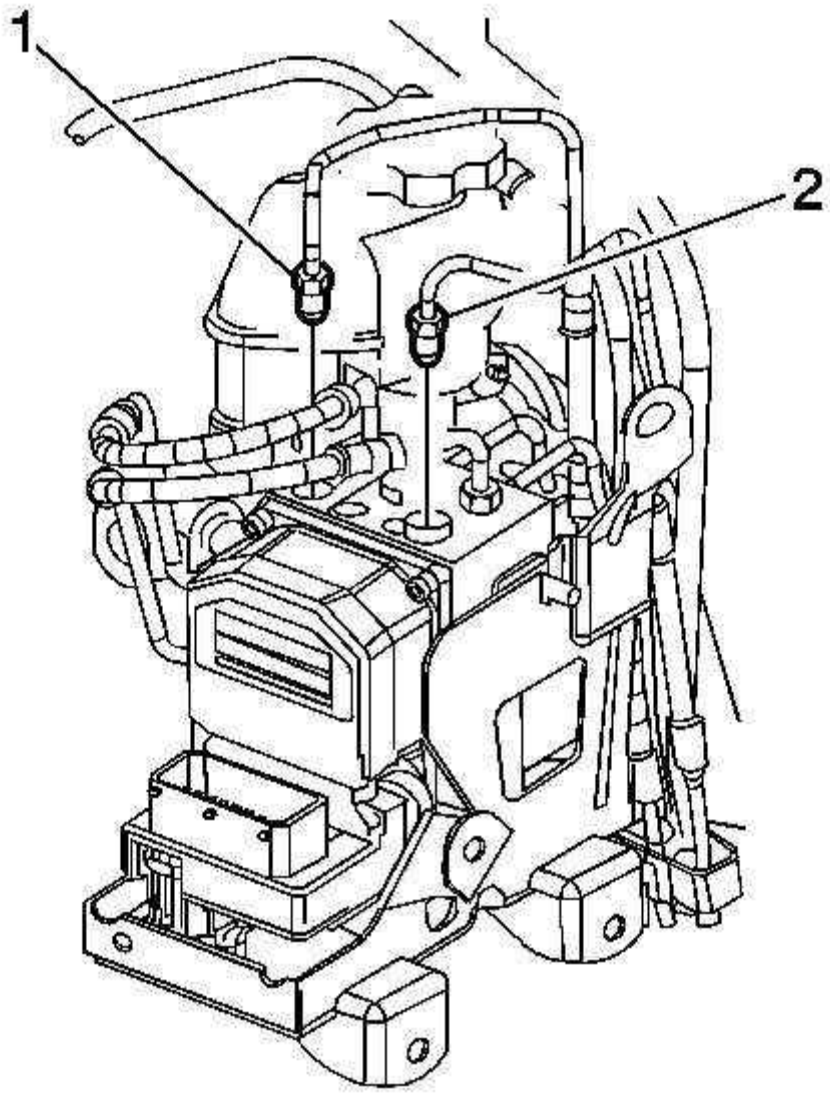


Fig. 253: View Of Anti Lock Brake (ABS) Module Brake Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

23. Disconnect the brake pipe fittings (1, 2) from the antilock brake (ABS) module.

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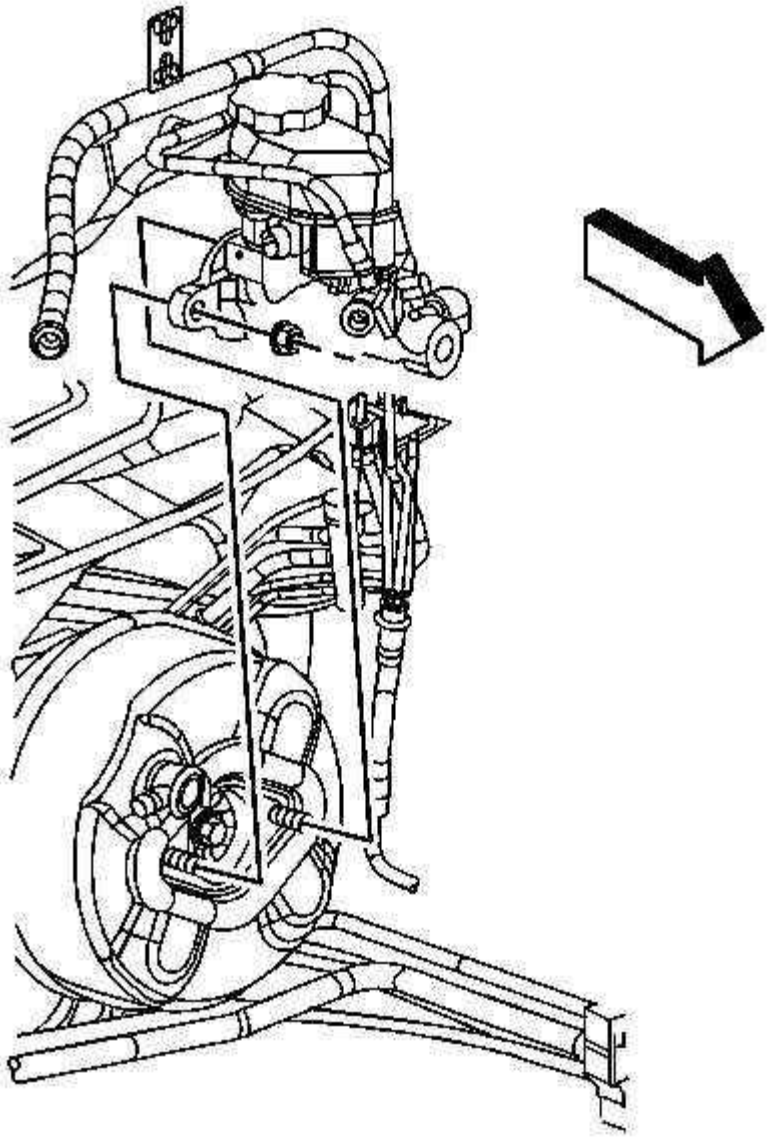


Fig. 254: View Of Master Cylinder & Nuts
Courtesy of GENERAL MOTORS CORP.

24. Remove the master cylinder nuts.
25. Position the master cylinder to the engine. Hold the master cylinder in place

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using mechanic's wire.

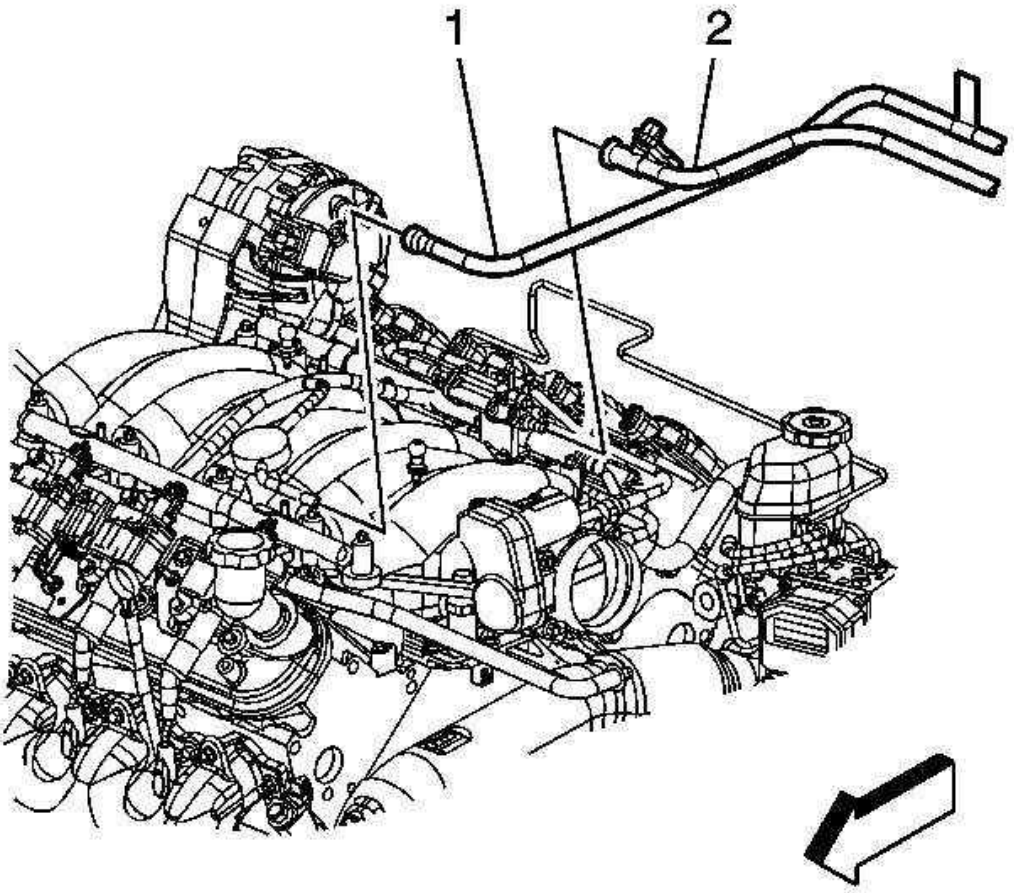


Fig. 255: View Of Fuel Feed Line & Evaporative Emission (EVAP) Line
Courtesy of GENERAL MOTORS CORP.

26. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief (With CH 48027)** or **Fuel Pressure Relief (Without CH 48027)** .
27. Disconnect the fuel feed line (1) from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
28. Disconnect the evaporative emission (EVAP) line (2) from the purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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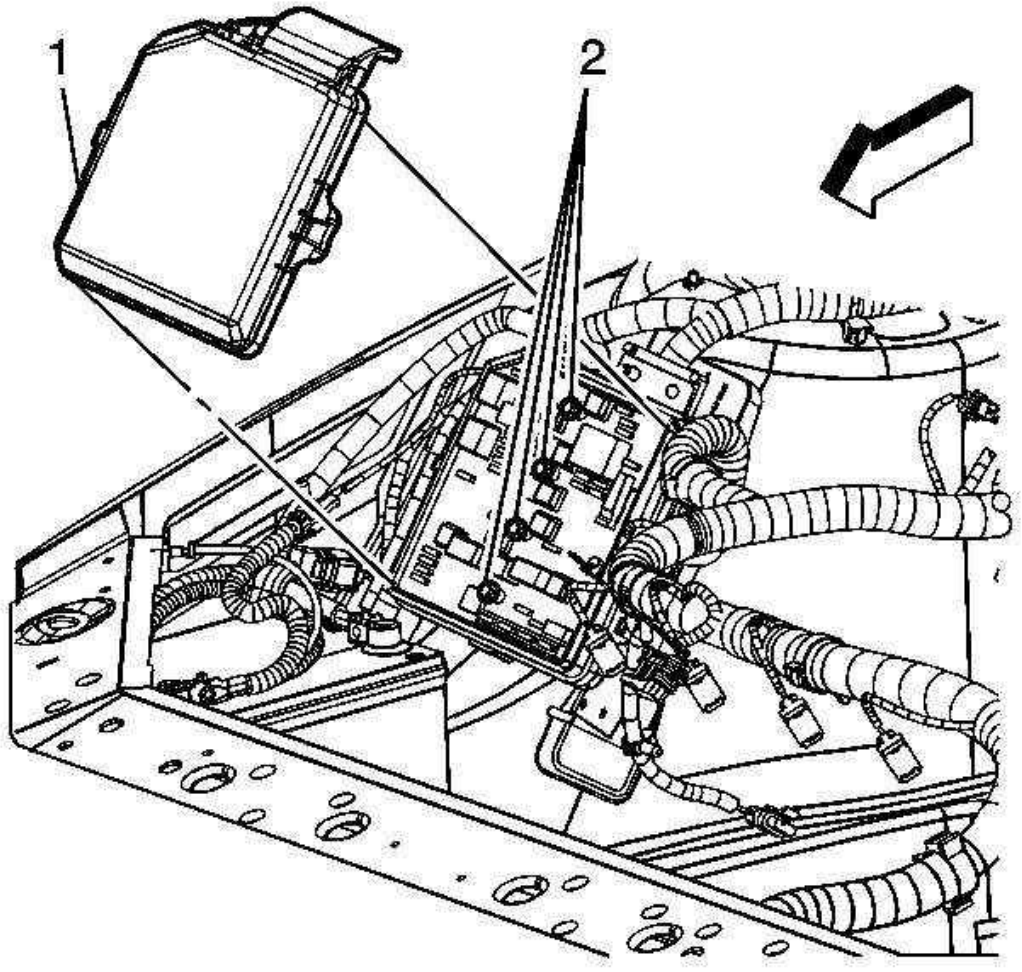


Fig. 256: View Of Bussed Electrical Center (BEC) Cover & Fuse Block
Courtesy of GENERAL MOTORS CORP.

29. Remove the right front fender diagonal brace. Refer to **Front Fender Upper Diagonal Brace Replacement** .
30. Remove the underhood electrical center cover (1).
31. Loosen the 4 integral bolts (2) attaching the fuse block. Reposition the fuse block.

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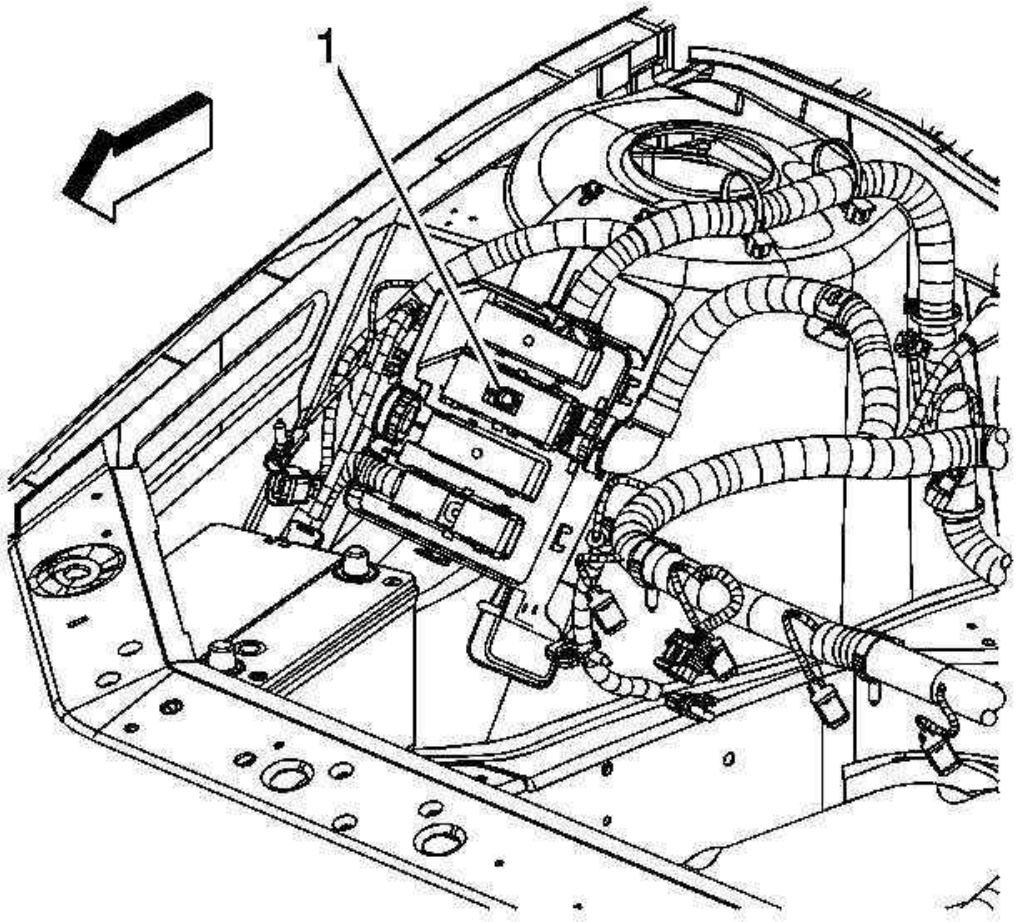


Fig. 257: View Of Engine Harness Connector Bracket
Courtesy of GENERAL MOTORS CORP.

32. Loosen the engine harness connector bolt (1). Remove the engine harness connector from the bracket.

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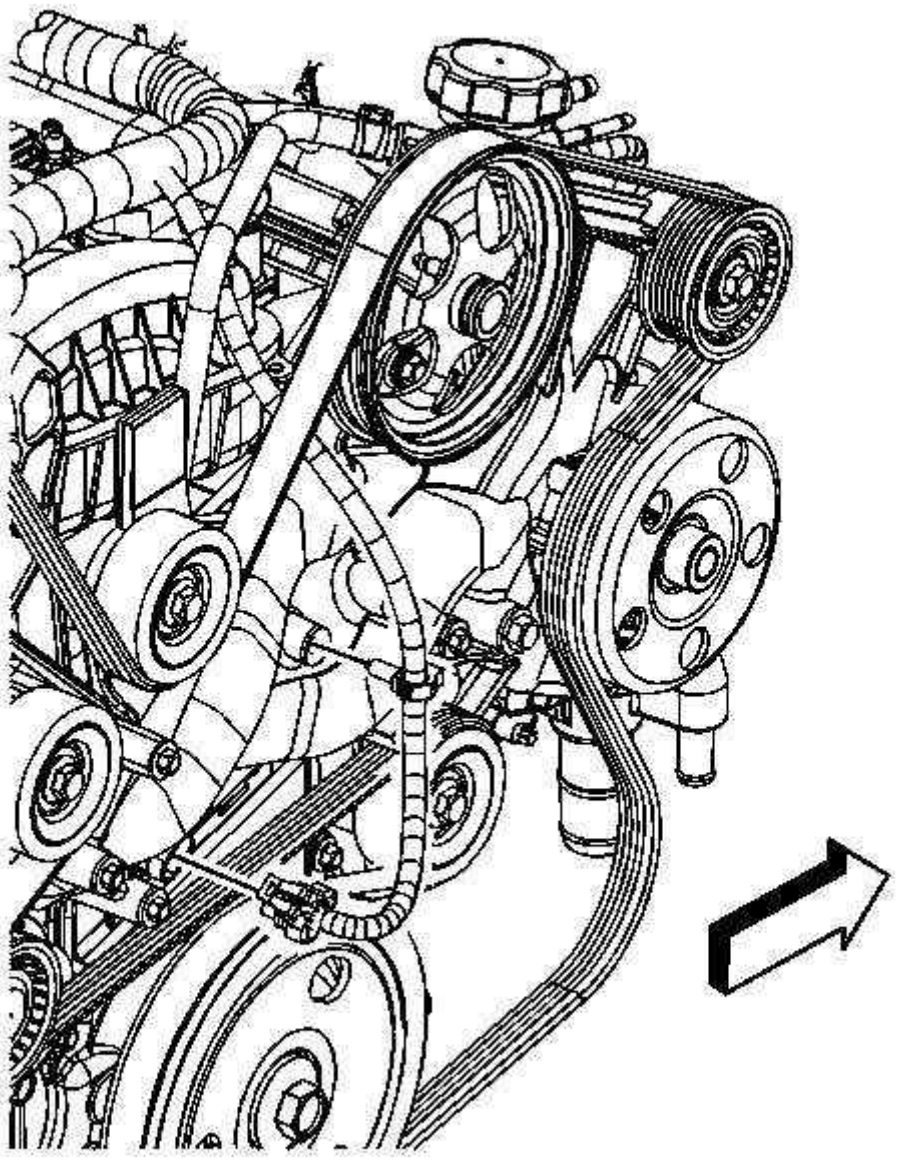


Fig. 258: Locating Camshaft Position (CMP) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

33. Disconnect the camshaft position sensor lead.

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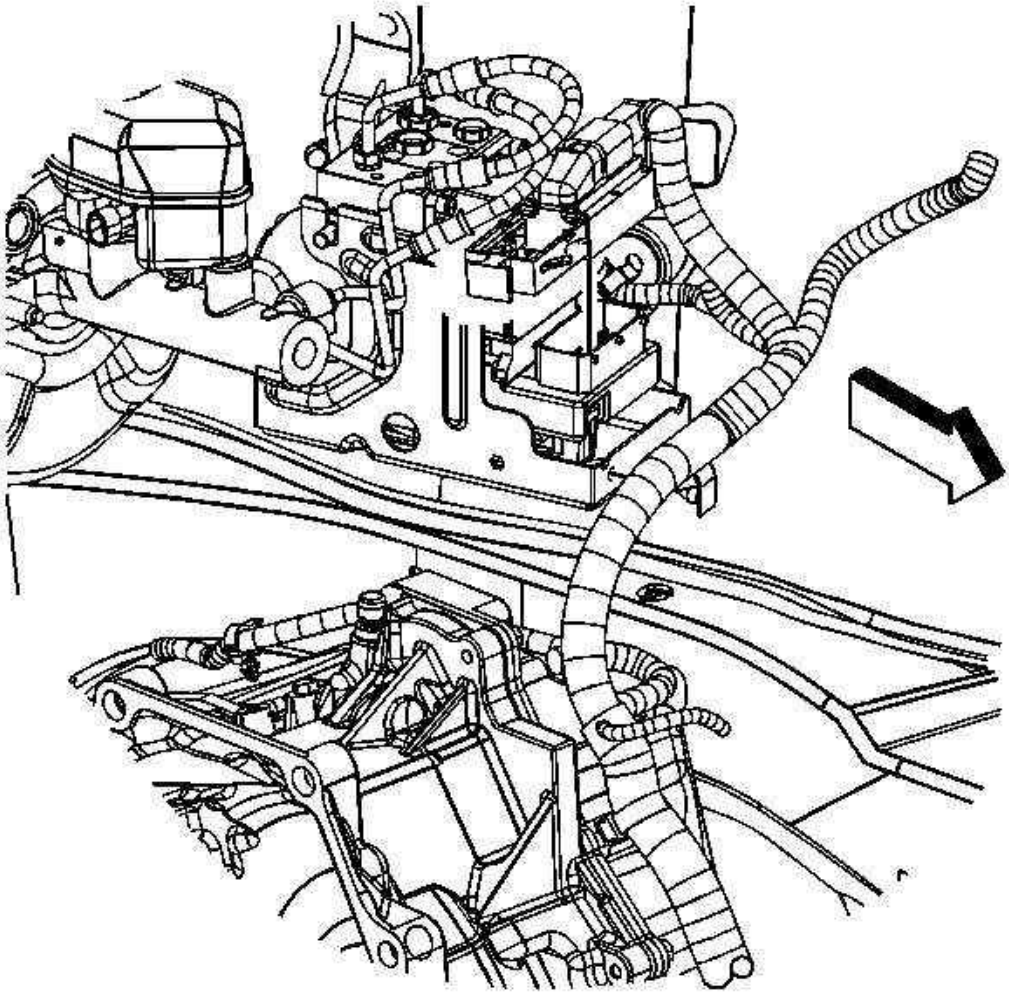


Fig. 259: View Of Engine Harness Electrical Connector & ABS Module
Courtesy of GENERAL MOTORS CORP.

34. Disconnect the engine harness electrical connector from the ABS module.

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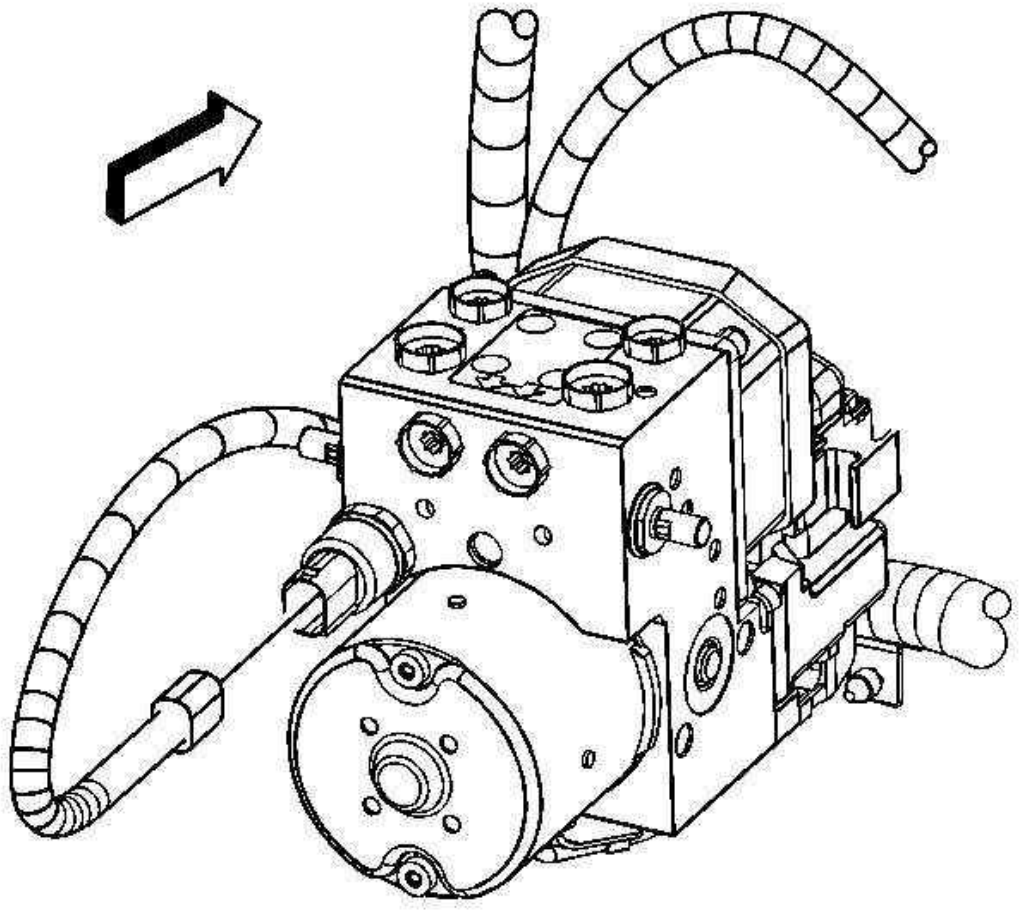


Fig. 260: View Of Engine Harness Electrical Connector & Electronic Brake Control Module (EBCM)
Courtesy of GENERAL MOTORS CORP.

35. Disconnect the engine harness electrical connector from the electronic brake control module (EBCM).

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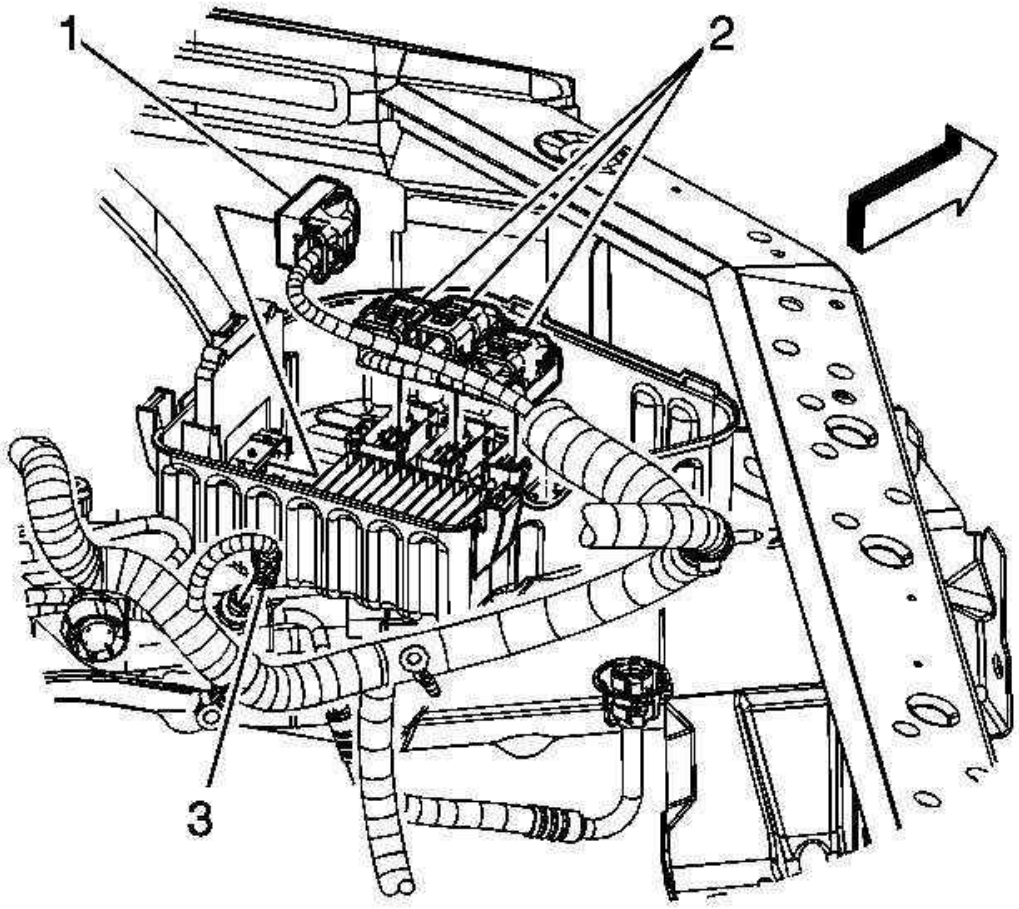


Fig. 261: View Of Transmission Control Module, Engine Control Module & A/C Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

36. Remove the air cleaner assembly. Refer to **Air Cleaner Element Replacement** .
37. Disconnect the following electrical connectors:
    - Transmission control module (TCM) (1)
    - Engine control module (ECM) (2)
    - A/C pressure sensor (3)

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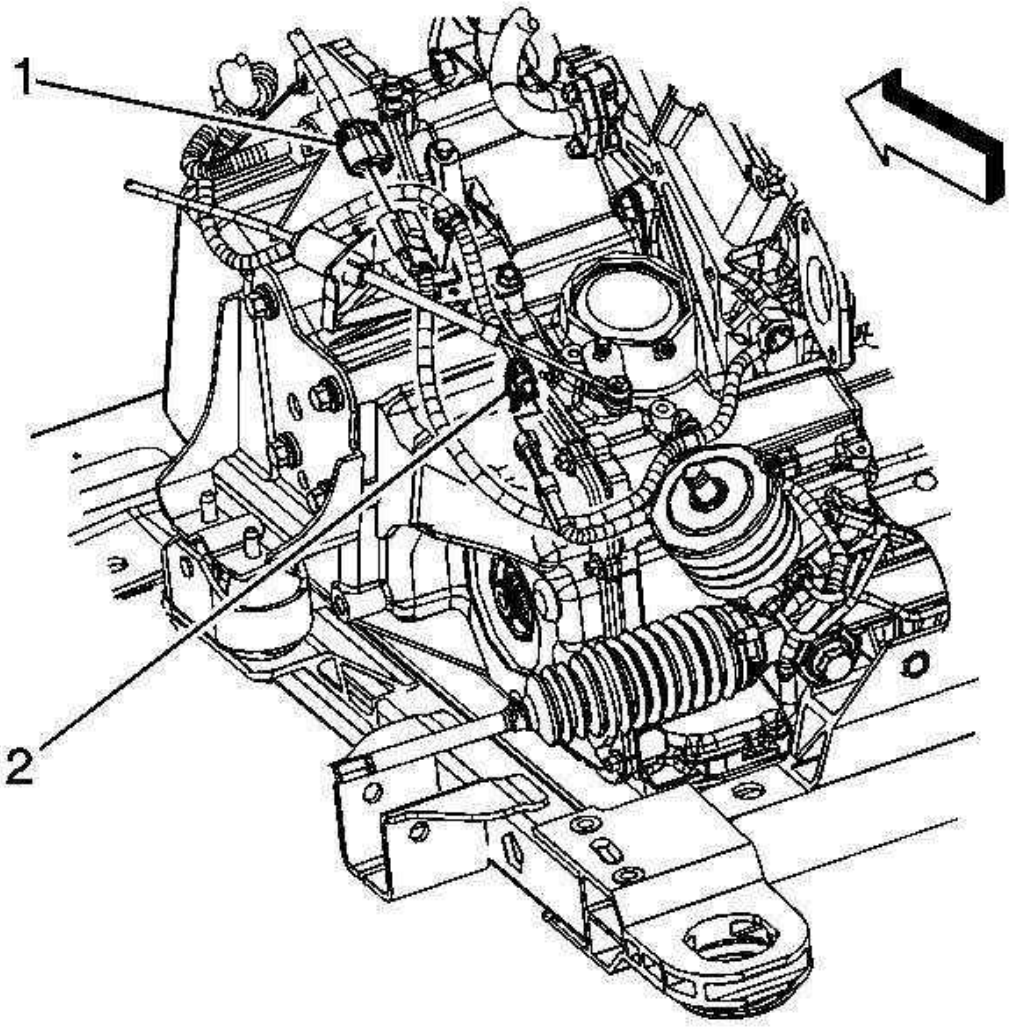


Fig. 262: View Of Crankshaft Position (CKP) Sensor Harness & Power Steering Gear Harness To Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

38. Disconnect the engine harness electrical connector (1) from the crankshaft position (CKP) sensor harness.
39. Disconnect the engine harness electrical connector (2) from the power steering gear harness.

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40. Remove the clip attaching the power steering gear harness to the bracket.

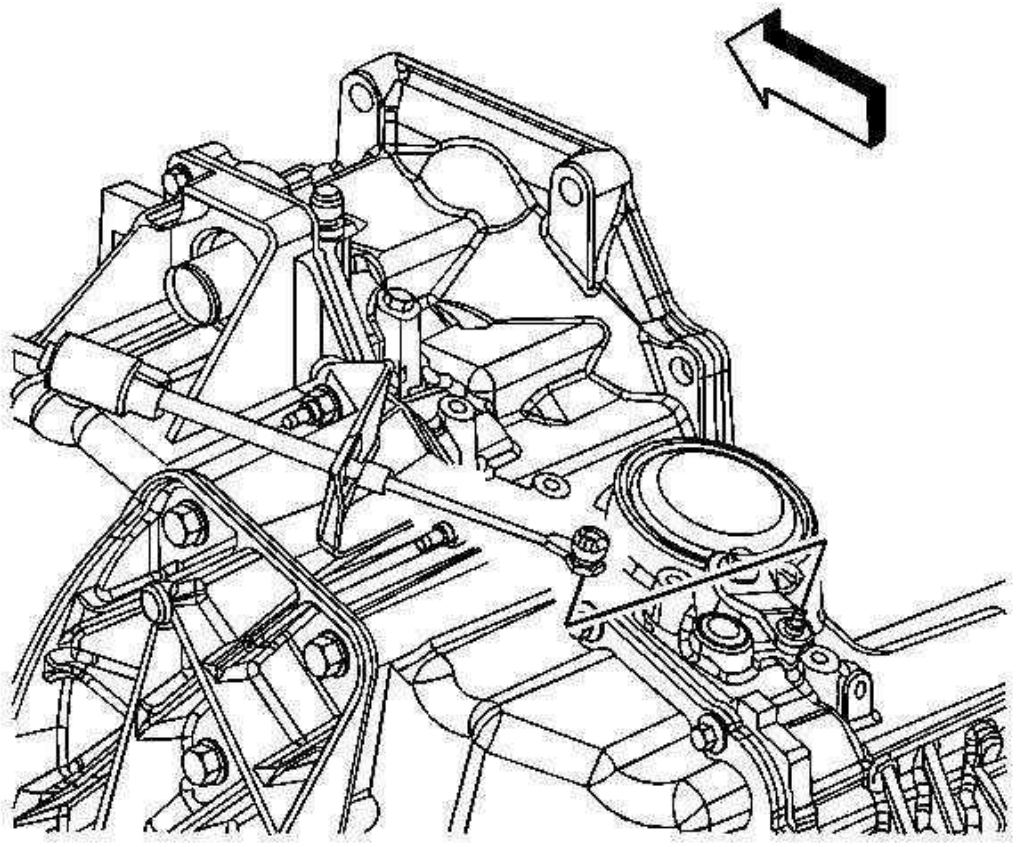


Fig. 263: View Of Shift Cable At Transaxle
Courtesy of GENERAL MOTORS CORP.

41. Remove the shift cable clip.
42. Disconnect the shift cable from the transaxle selector lever stud.
43. Remove the shift cable from the bracket.

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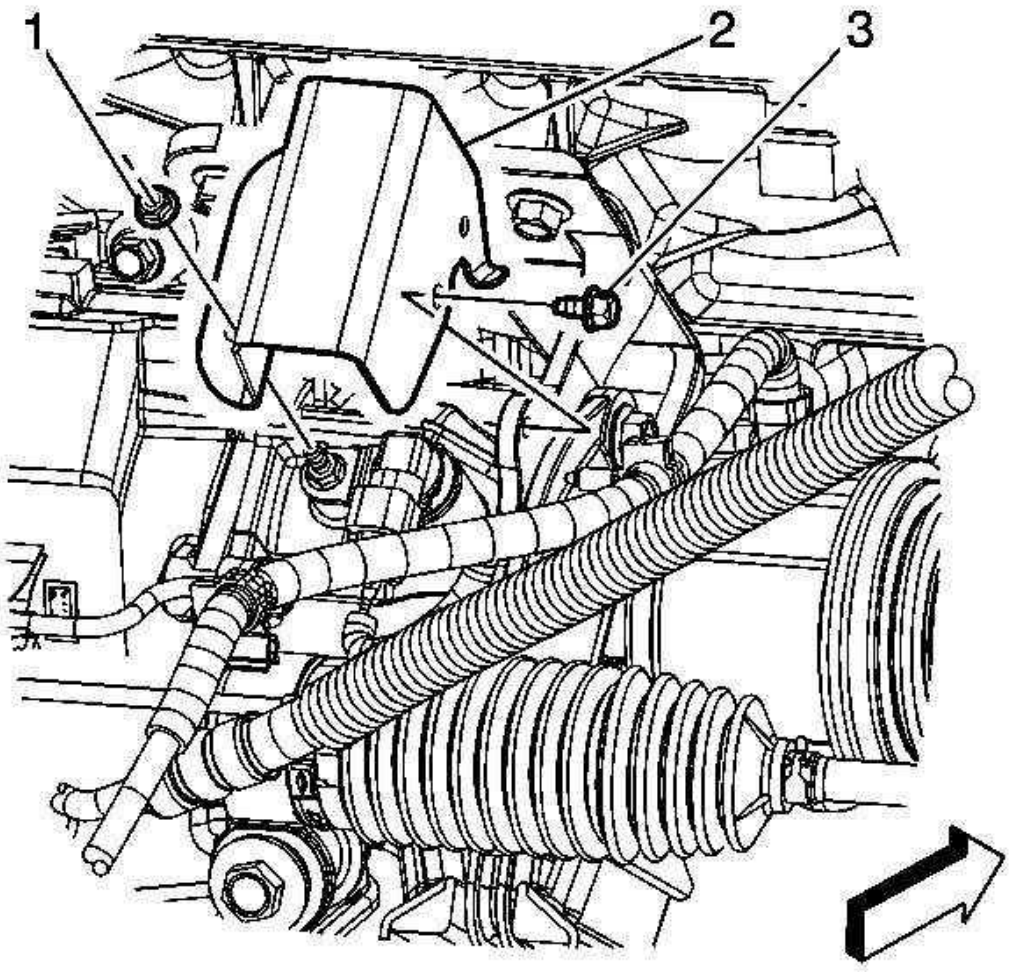


Fig. 264: View Of Vehicle Speed Sensor (VSS) Shield, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

44. Remove the vehicle speed sensor (VSS) shield nut (1) and bolt (3). Remove the shield (2).

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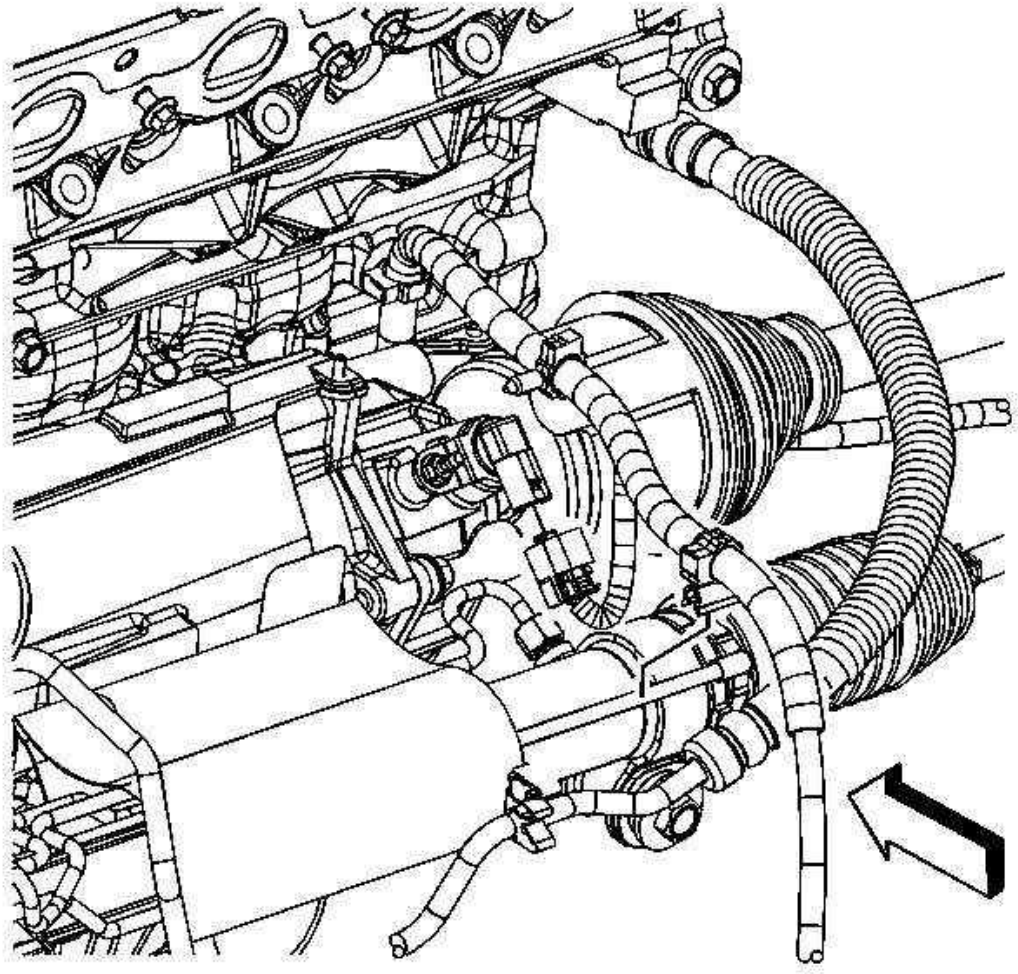


Fig. 265: View Of Engine Harness Electrical Connector For VSS
Courtesy of GENERAL MOTORS CORP.

45. Disconnect the engine harness electrical connector from the VSS.
46. Set all branches of the engine wiring harness on top of the engine.

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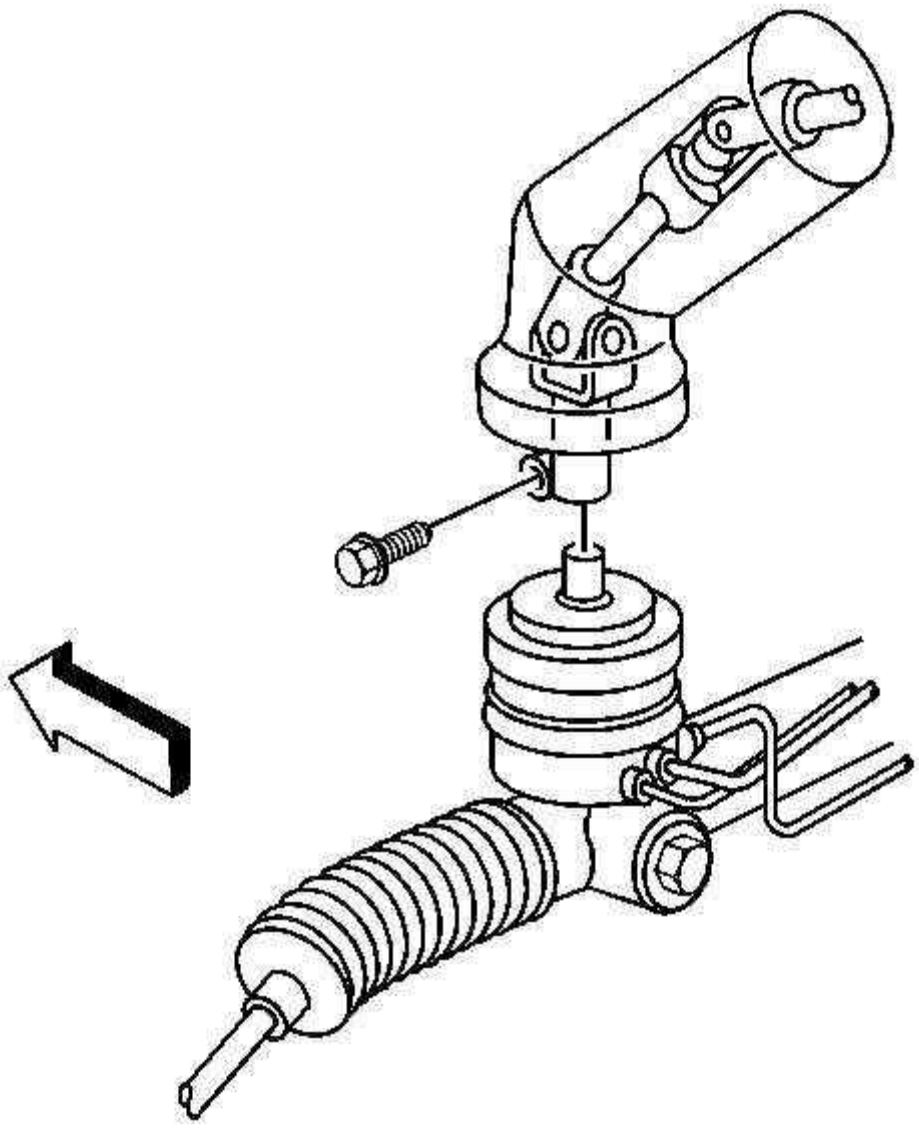


Fig. 266: View Of Intermediate Shaft, Bolt & Steering Gear
Courtesy of GENERAL MOTORS CORP.

47. Reposition the intermediate shaft lower boot.
48. Remove the intermediate shaft to steering gear bolt.

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49. Separate the intermediate shaft from the steering gear.
50. Disconnect both front wheel speed sensors. Refer to **Front Wheel Bearing and Hub Replacement** .
51. Unclip the ABS wire harness from the lower control arm.

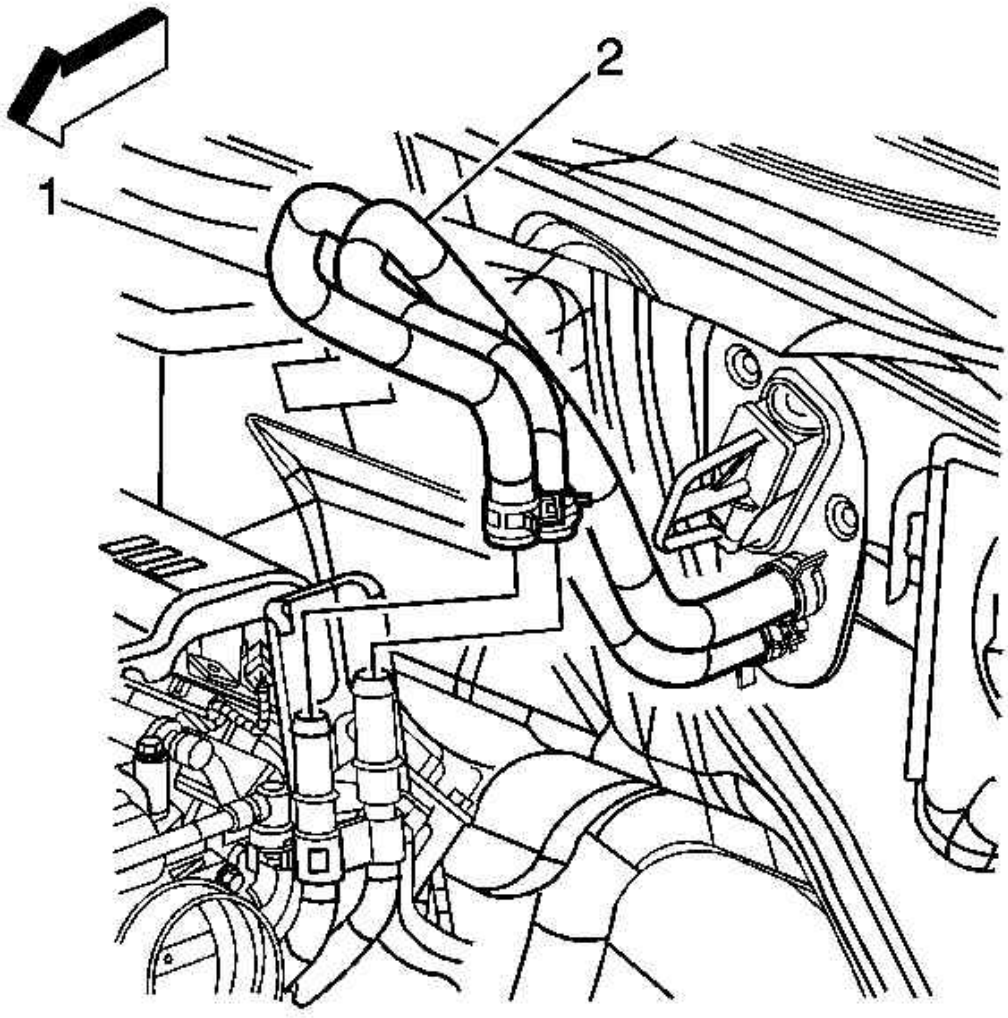


Fig. 267: View Of Heater Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

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52. Using the **J 38185** reposition the heater inlet and outlet hose clamps.
53. Remove the heater inlet (2) and outlet (1) hoses from the heater inlet/outlet pipe.
54. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
55. Disconnect the stabilizer links from the stabilizer shaft.
56. Disconnect the ball joints from the steering knuckles. Refer to **Lower Control Arm Ball Joint Replacement** .
57. Disconnect the power steering pressure hose from the steering gear.
58. Disconnect the power steering pressure line clips from the frame.
59. Disconnect the outer tie rod ends from the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod End Replacement** .

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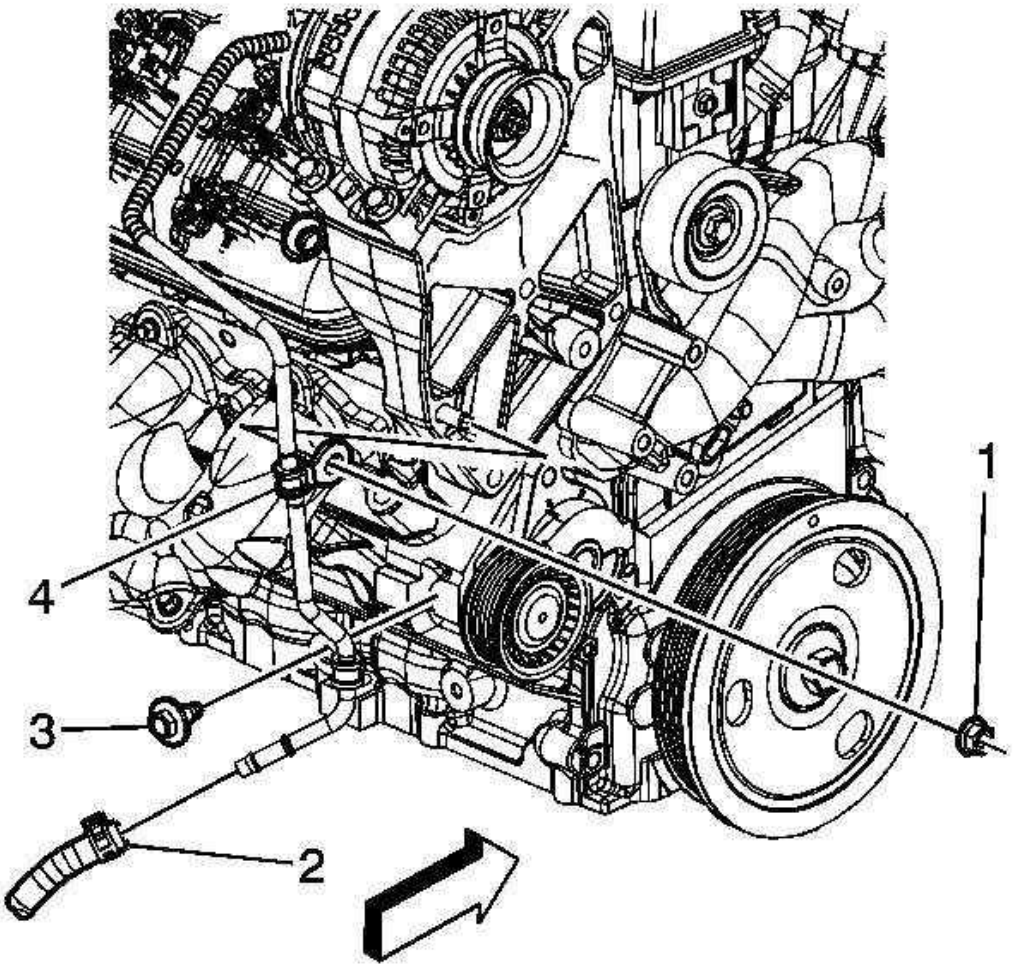


Fig. 268: View Of Power Steering Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

60. Loosen the power steering hose clamp at the inlet pipe.
61. Remove the power steering hose (2) from the inlet pipe.
62. Remove the left and right wheel drive shafts from the transaxle. Refer to **Wheel Drive Shaft Replacement** .
63. Support the wheel drive shafts using mechanic's wire.

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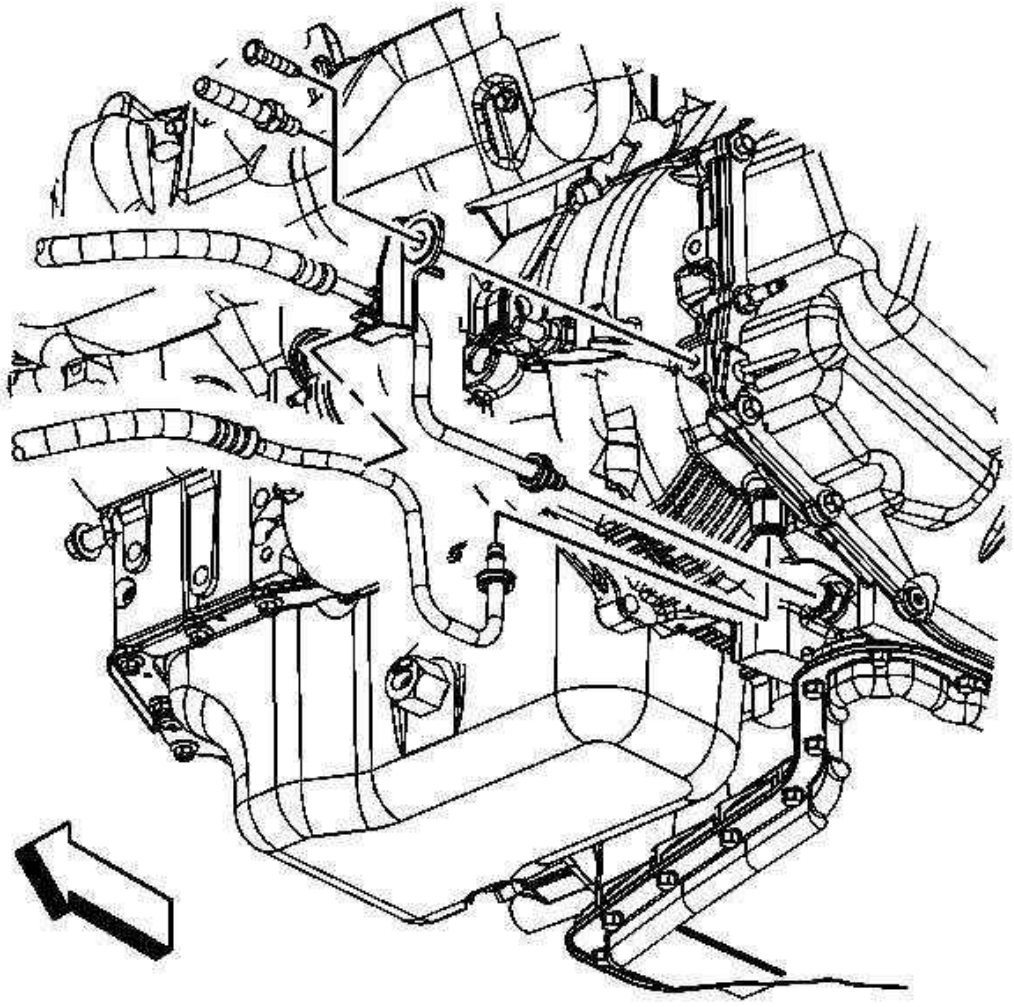


Fig. 269: View Of Transaxle Oil Cooler Lines
Courtesy of GENERAL MOTORS CORP.

64. Remove the transaxle oil cooler line bracket bolt/stud.
65. Disconnect the transaxle oil cooler lines from the transaxle. Refer to **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and Connection** .

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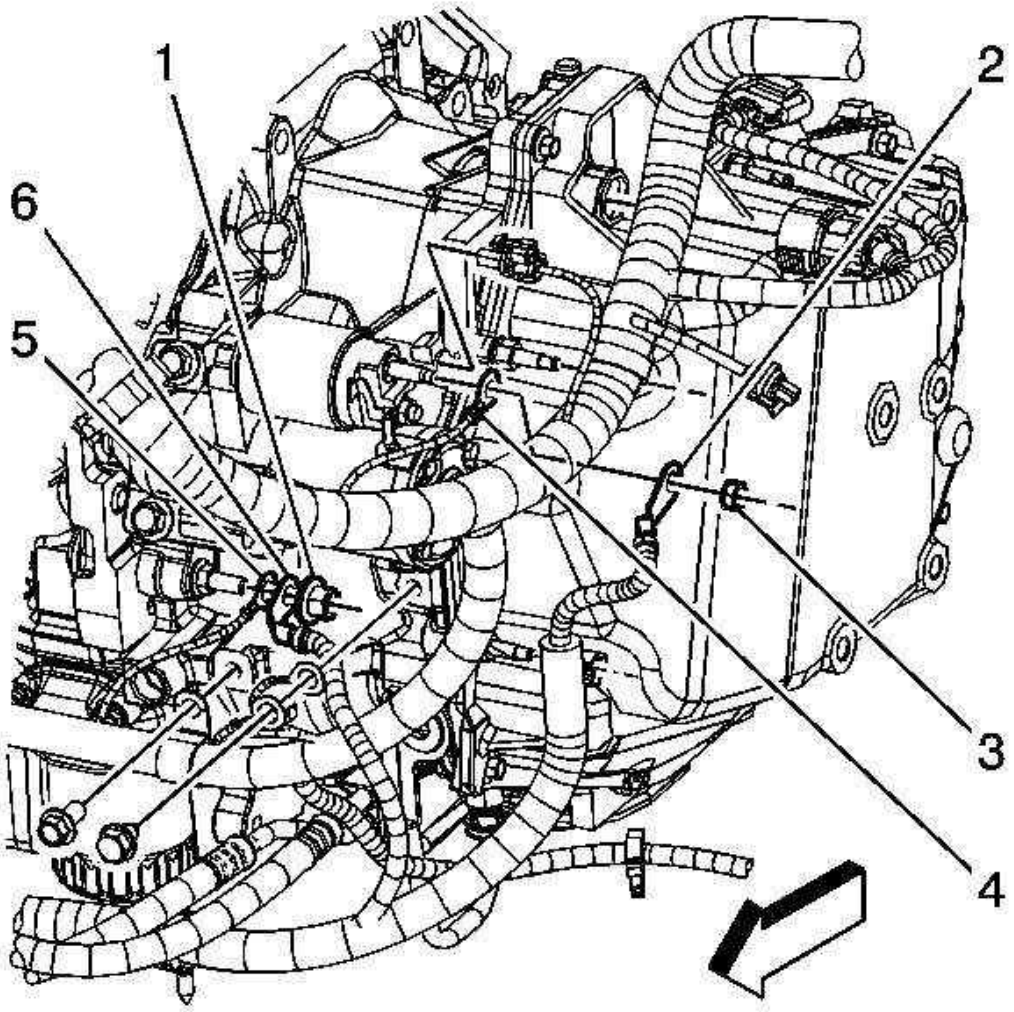


Fig. 270: View Of Battery Positive & Negative Cables
Courtesy of GENERAL MOTORS CORP.

66. Remove the positive battery cable nut (3) from the starter.
67. Remove the cable terminal (2) from the starter.
68. Remove the battery cable ground nut (1).
69. Remove the cable ground terminal (6) from the stud.

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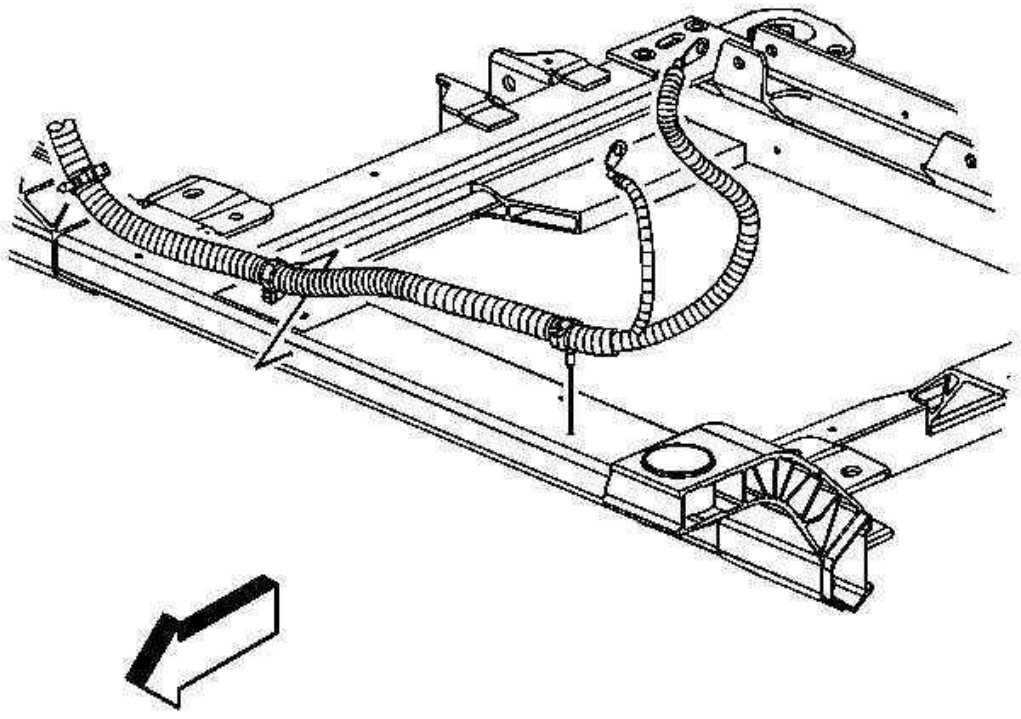


Fig. 271: View Of Battery Cable Harness Retainers
Courtesy of GENERAL MOTORS CORP.

70. Remove the battery cable retainers from the engine frame.
71. Disconnect the exhaust system. Refer to **Catalytic Converter Replacement** .
72. Disconnect the O2 sensor harness pigtail.

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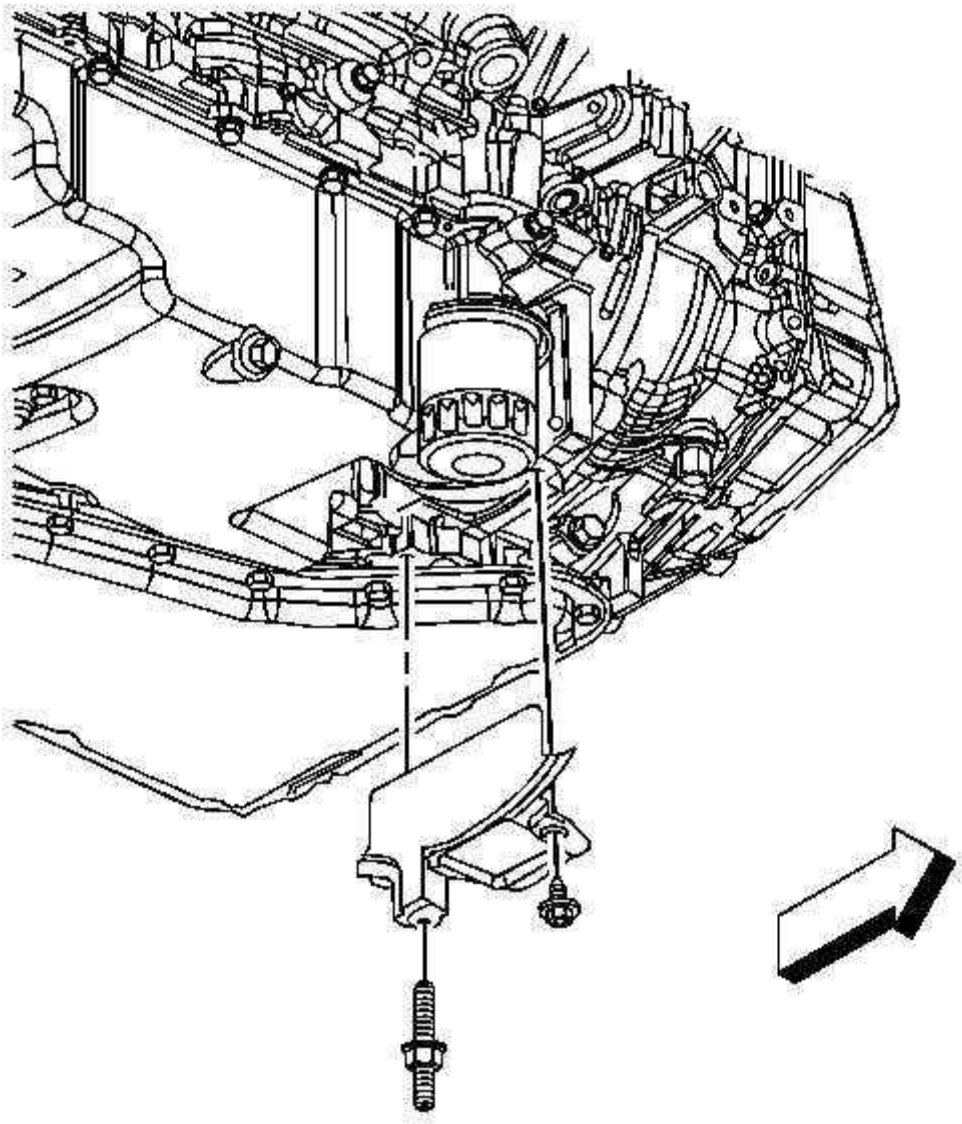


Fig. 272: View Of Transaxle Converter Cover & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

73. Remove the transaxle converter cover bolt/stud.
74. Remove the converter cover.

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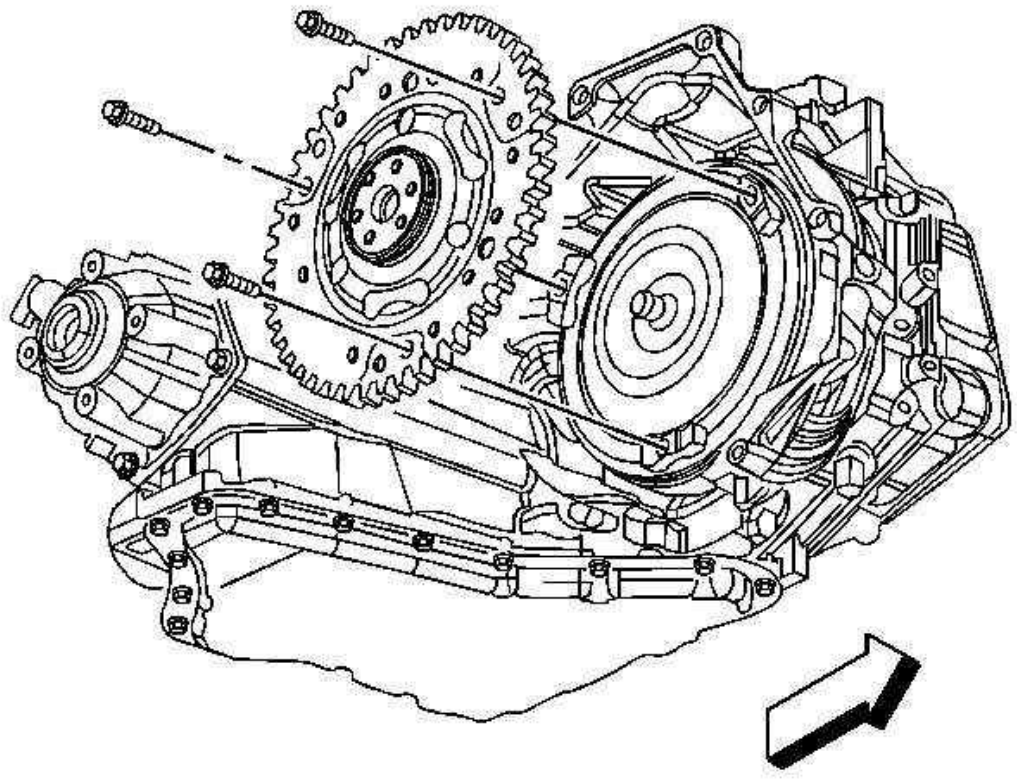


Fig. 273: View Of Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

75. Remove the flywheel bolts.
76. Remove the front air deflectors. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .

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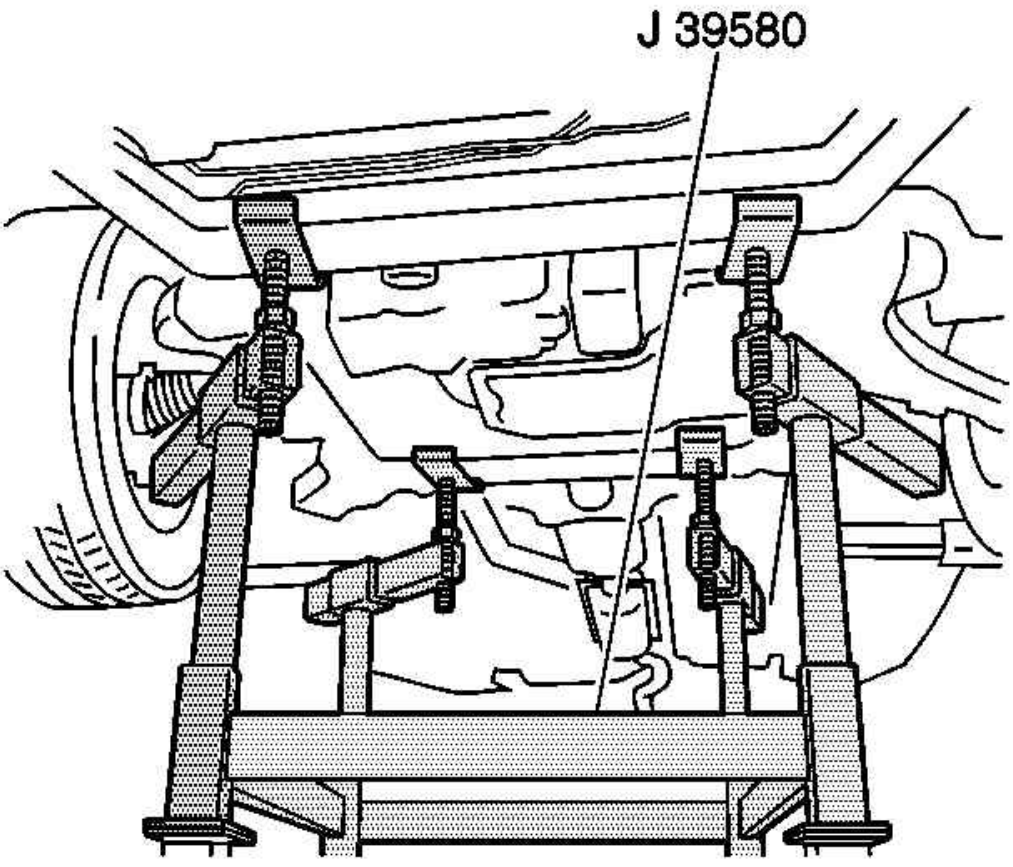


Fig. 274: Identifying Utility Stand
Courtesy of GENERAL MOTORS CORP.

77. Raise the vehicle enough to place **J 39580** under the engine, frame, and front suspension.
78. Support the rear of the vehicle with suitable jackstand.
79. Strap the front of the vehicle to the hoist.
80. Raise the **J 39580** , or lower the vehicle to preload the weight of the engine, frame, and front suspension.
81. Remove the radiator to frame brackets.

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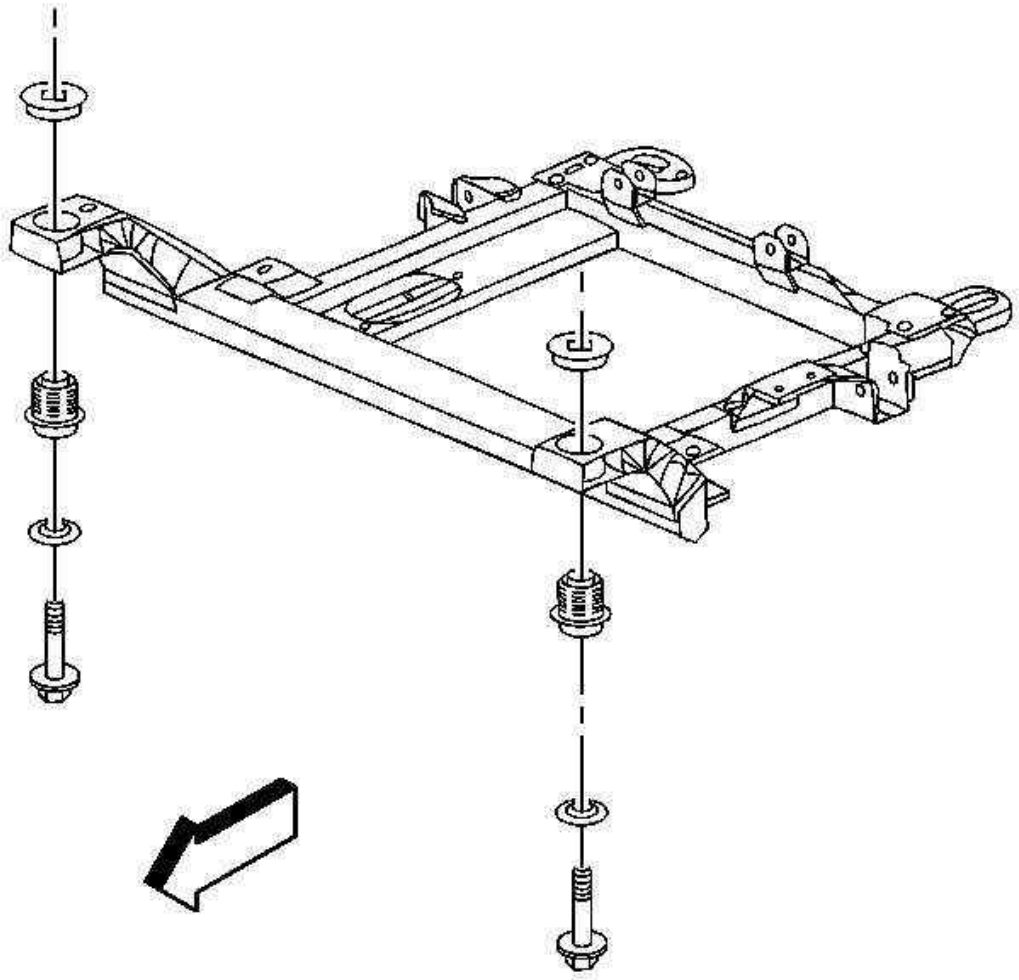


Fig. 275: View Of Engine Frame Front Bolts
Courtesy of GENERAL MOTORS CORP.

82. Remove the engine frame front bolts.

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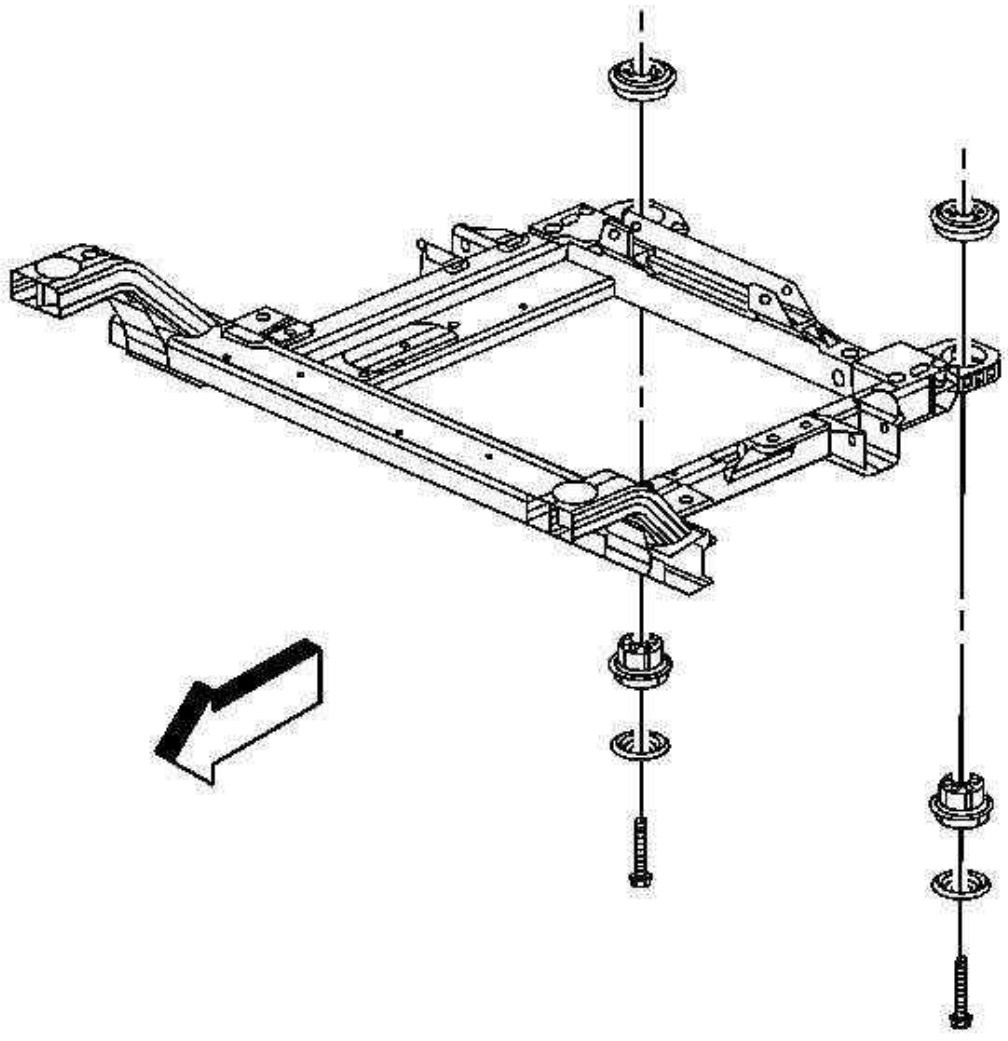


Fig. 276: View Of Engine Frame Rear Bolts
Courtesy of GENERAL MOTORS CORP.

83. Remove the engine frame rear bolts.
84. With the aid of an assistant, lower the **J 39580** and/or raise the vehicle to remove the engine and the frame from the vehicle.
85. Ensure that all hoses, wires, and pipes clear the vehicle during the removal process.

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86. Use a suitable engine lift to support the engine.

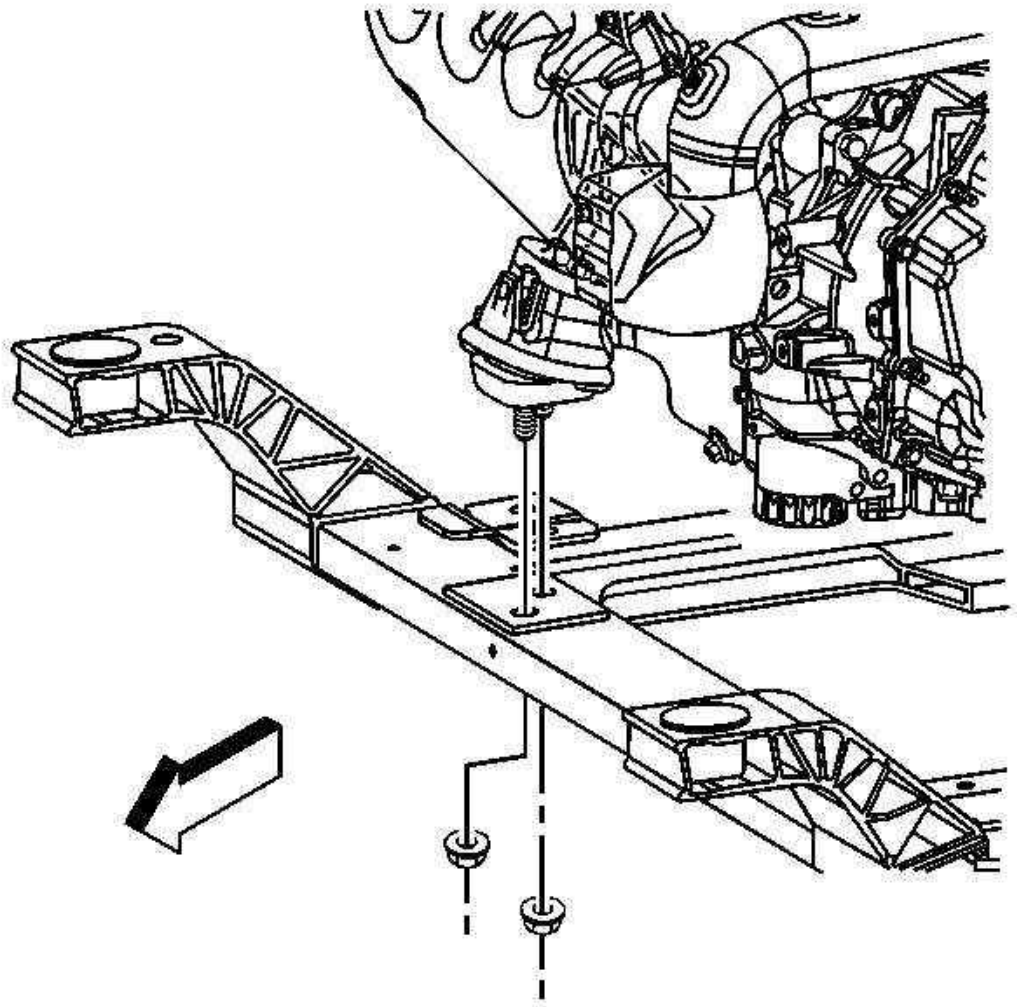


Fig. 277: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

87. Remove the front engine mount to frame nuts.

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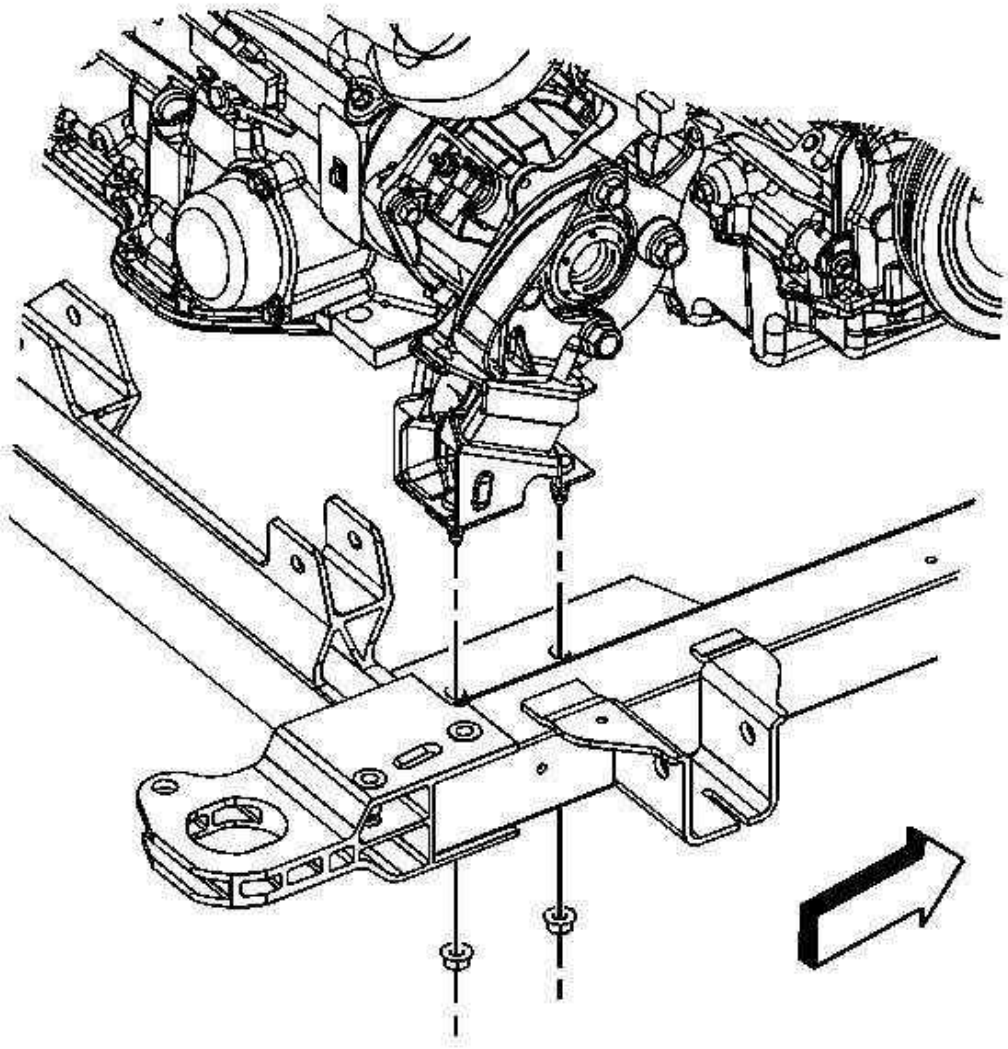
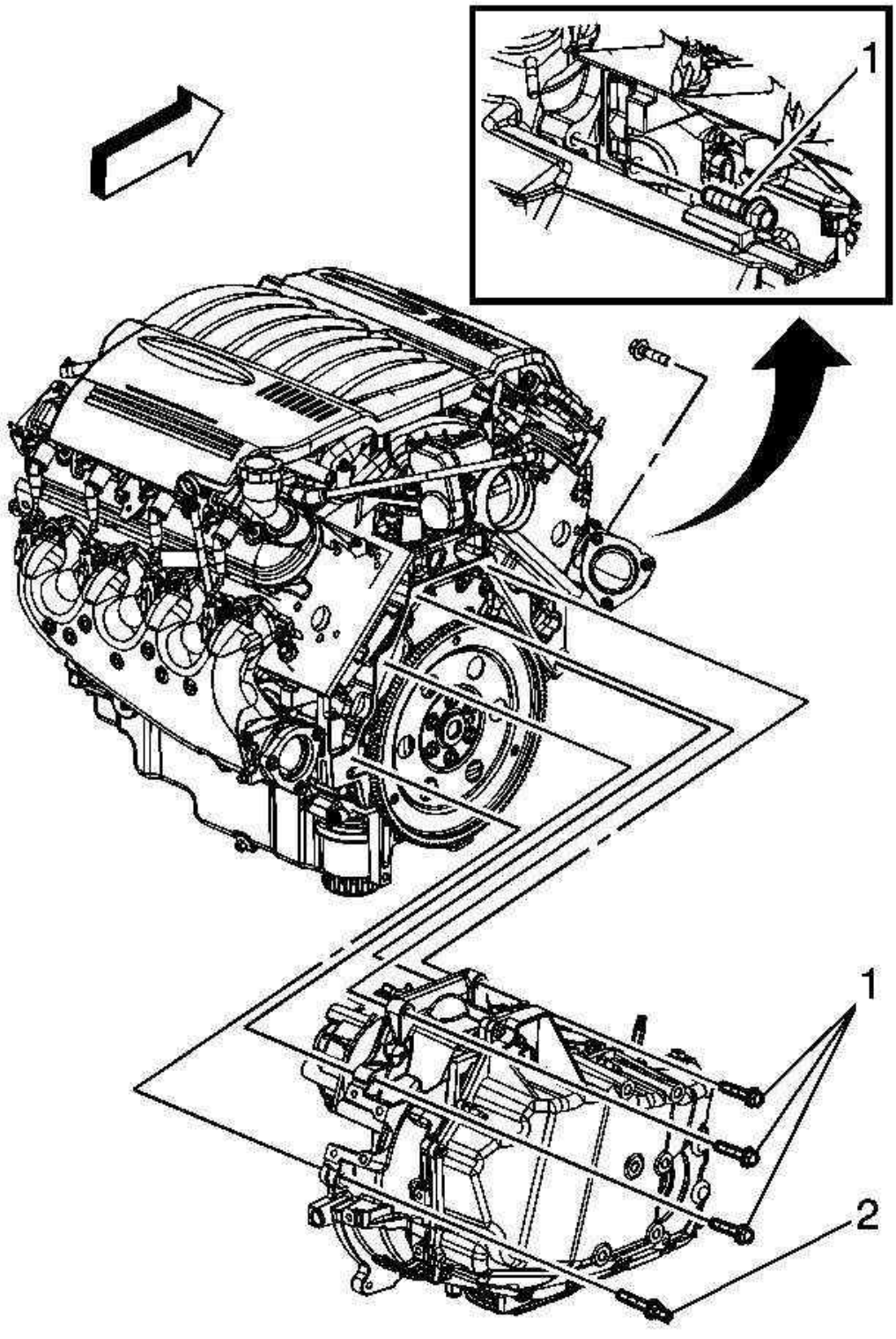


Fig. 278: View Of Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

88. Remove the rear engine mount to frame nuts.

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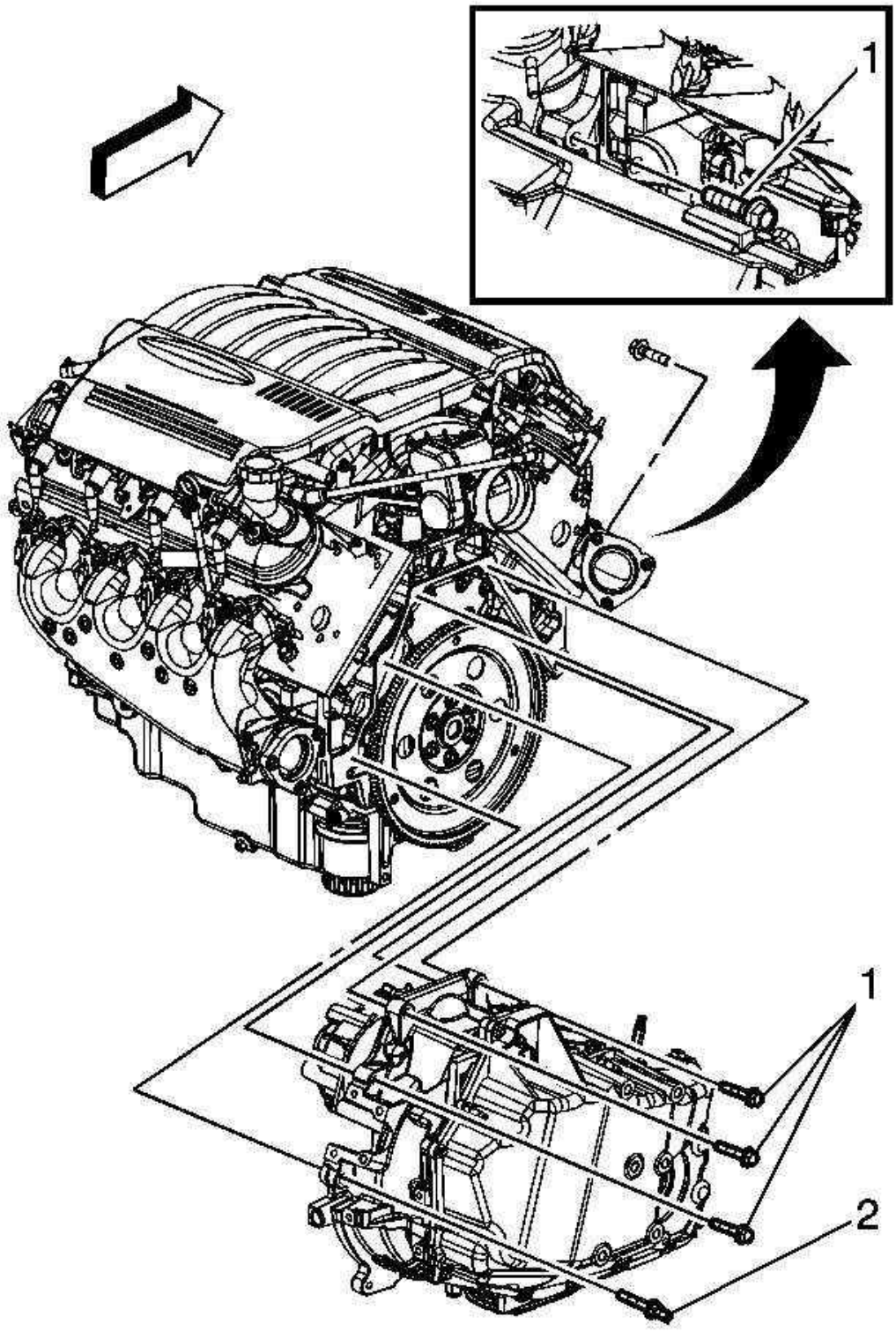
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Fig. 279: View Of Transaxle To Engine Bolts & Stud
Courtesy of GENERAL MOTORS CORP.

89. Remove the transaxle to engine bolts (1) and stud (2).
90. Separate the engine from the transaxle.
91. Using a suitable engine lift, remove the engine from the frame.
92. Install the engine onto a suitable engine stand.

Installation Procedure

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Fig. 280: View Of Transaxle To Engine Bolts & Stud
Courtesy of GENERAL MOTORS CORP.

1. Using a suitable engine lift, remove the engine from the engine stand.
2. Position and install the engine to the frame and the transaxle.

NOTE: Refer to Fastener Notice .

3. Install the transaxle to engine bolts (1) and stud (2).

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

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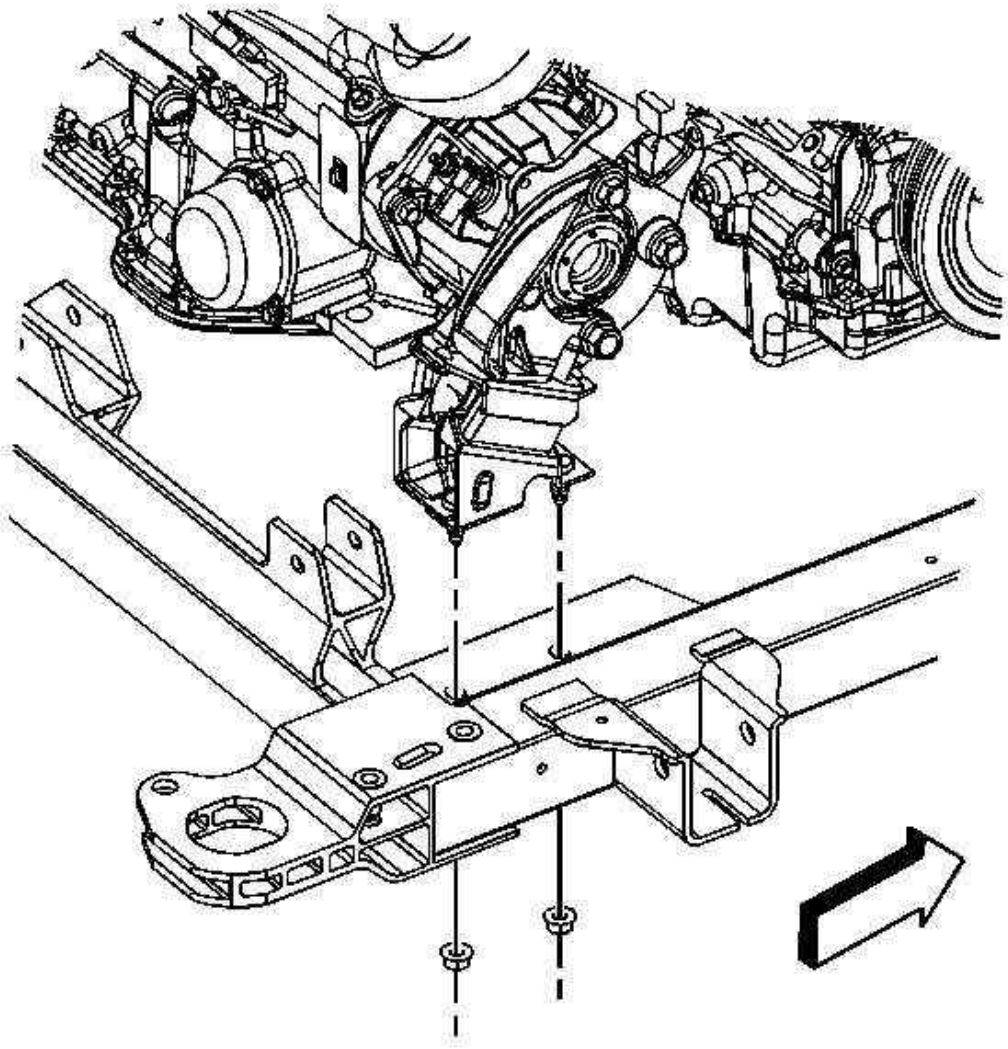


Fig. 281: View Of Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the rear engine mount to frame nuts.

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

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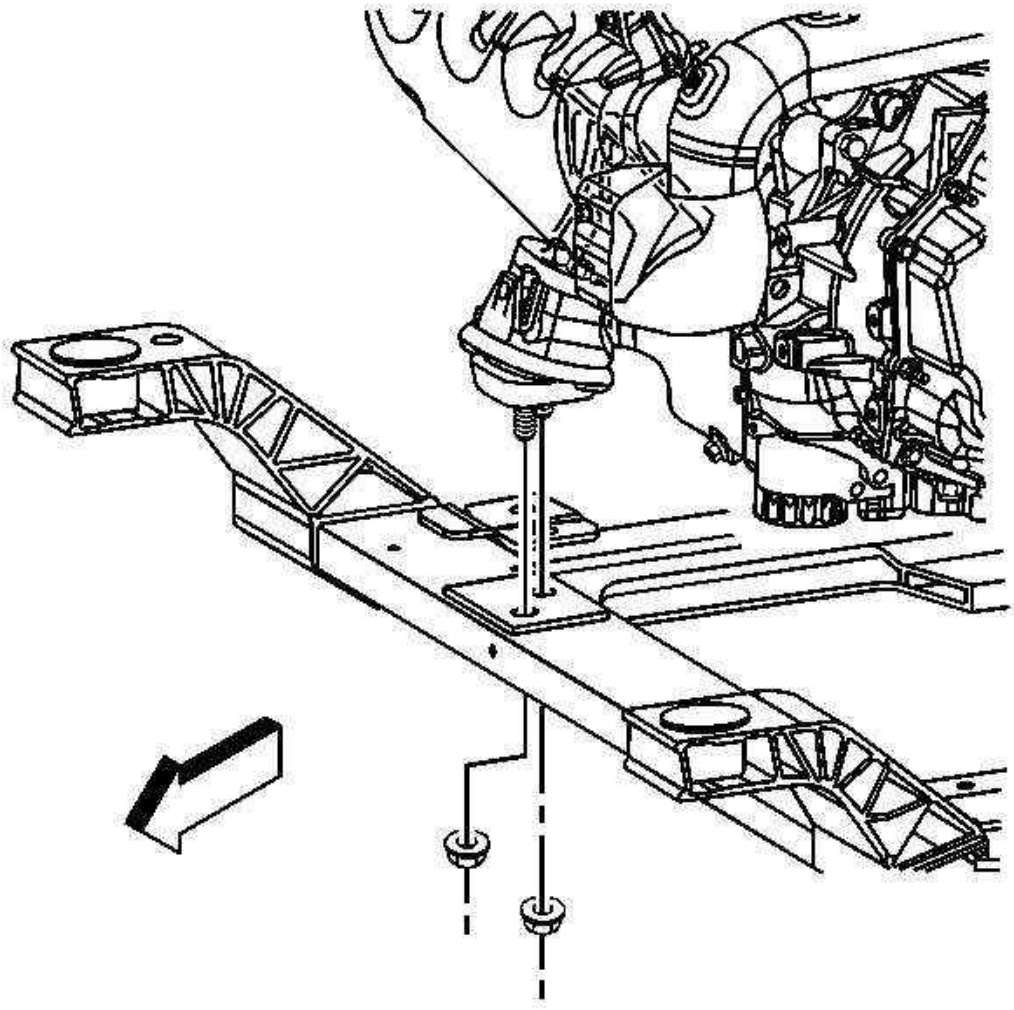


Fig. 282: View Of Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

5. Install the front engine mount to frame nuts.

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

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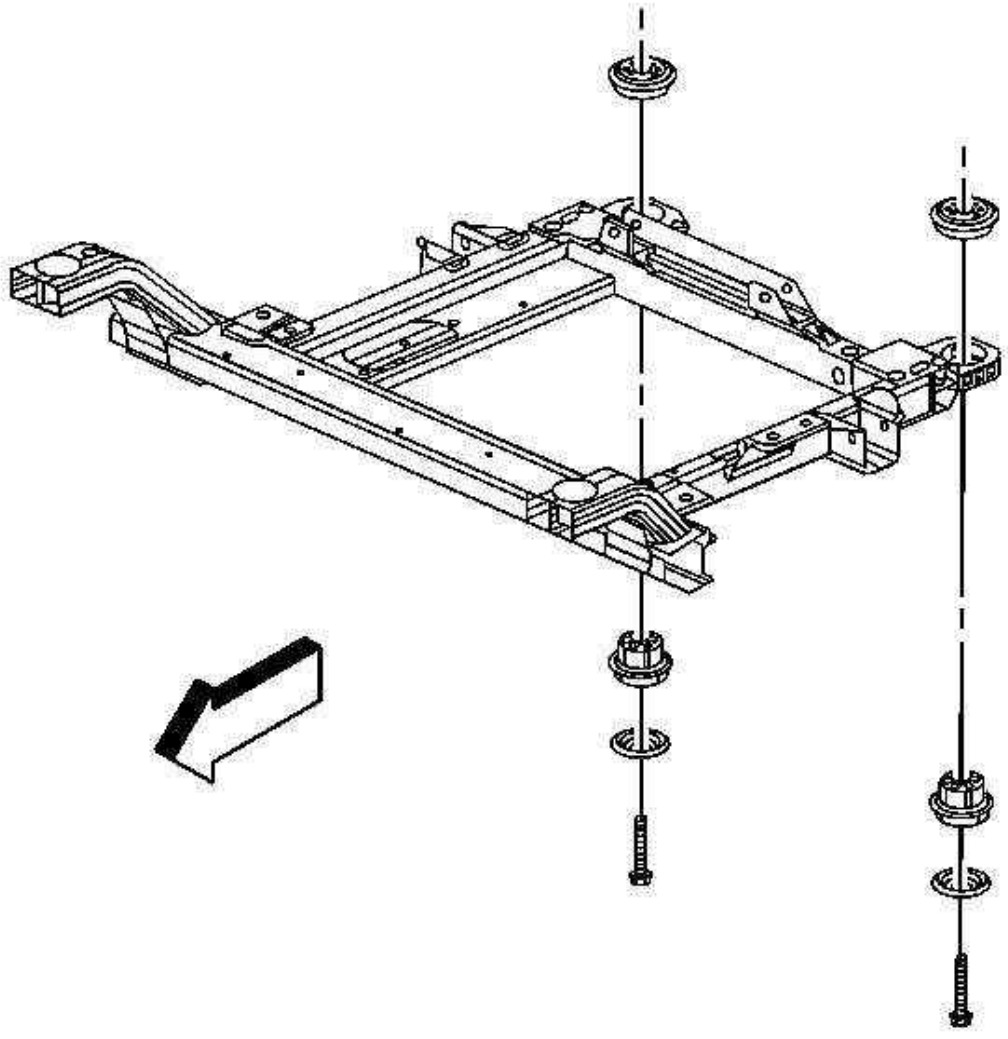


Fig. 283: View Of Engine Frame Rear Bolts
Courtesy of GENERAL MOTORS CORP.

6. Ensure that all hoses, wires, and pipes clear the vehicle during the installation process.
7. With the aid of an assistant, raise the **J 39580** and/or lower the vehicle to install the engine and frame to the vehicle.
8. Install the engine frame rear bolts.

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Tighten: Tighten the bolts to 160 N.m (118 lb ft).

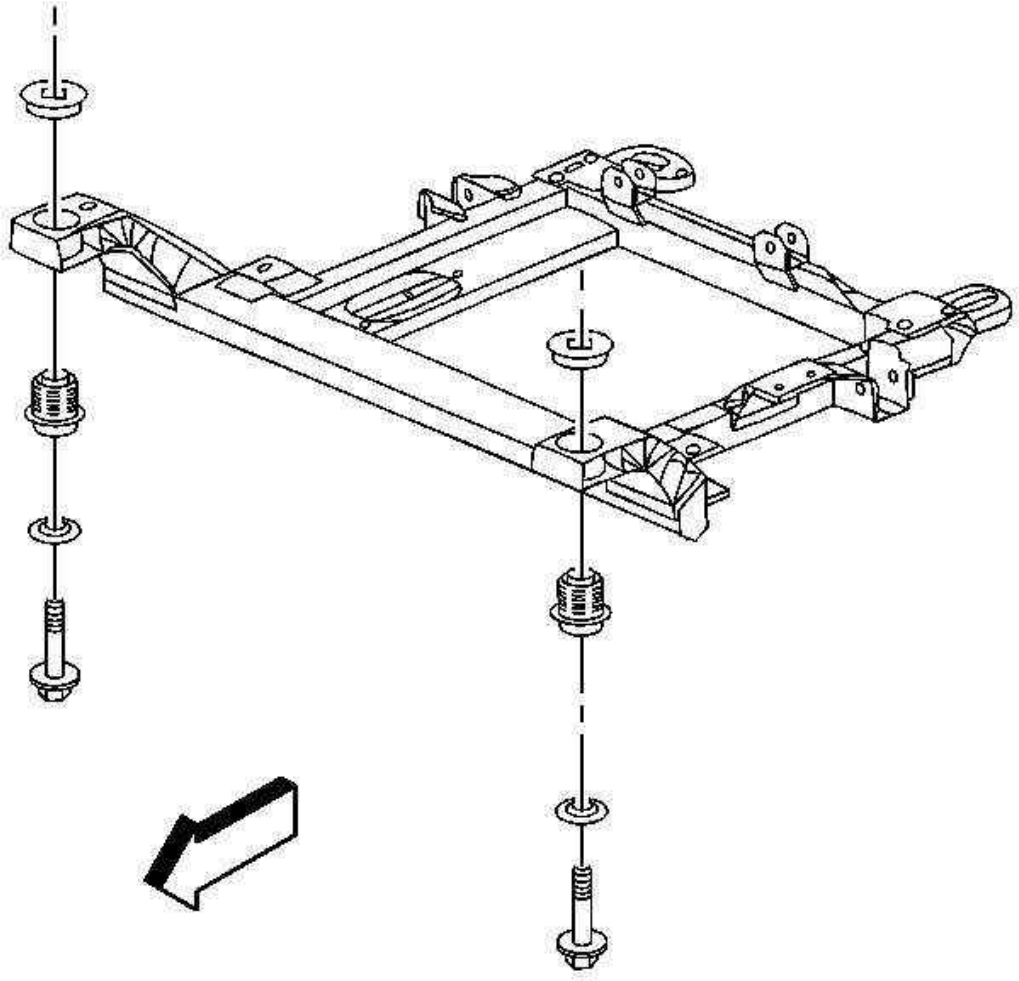


Fig. 284: View Of Engine Frame Front Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the engine frame front bolts.

   Tighten: Tighten the bolts to 145 N.m (107 lb ft).

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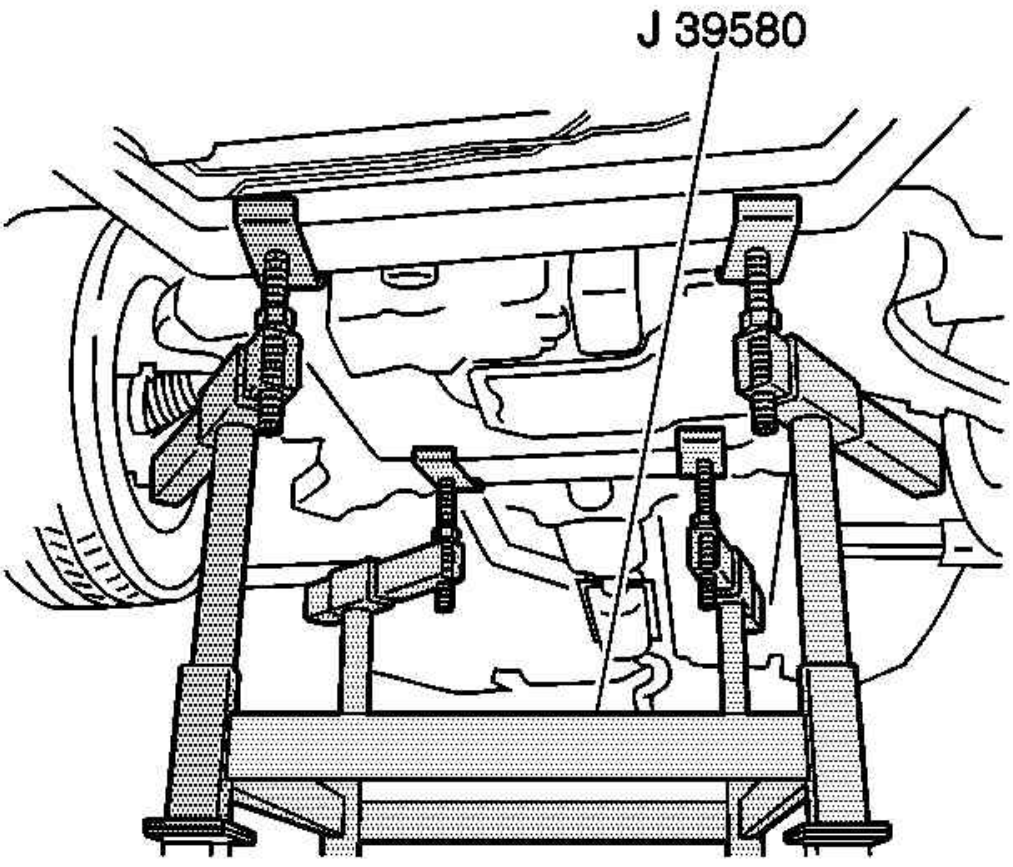


Fig. 285: Identifying Utility Stand
Courtesy of GENERAL MOTORS CORP.

10. Install radiator to front frame brackets.
11. Lower the **J 39580** , or raise the vehicle to preload the weight of the engine, frame, and front suspension.
12. Remove the support from under the rear of the vehicle.
13. Raise the vehicle enough to remove the **J 39580** from under the engine, frame, and front suspension.

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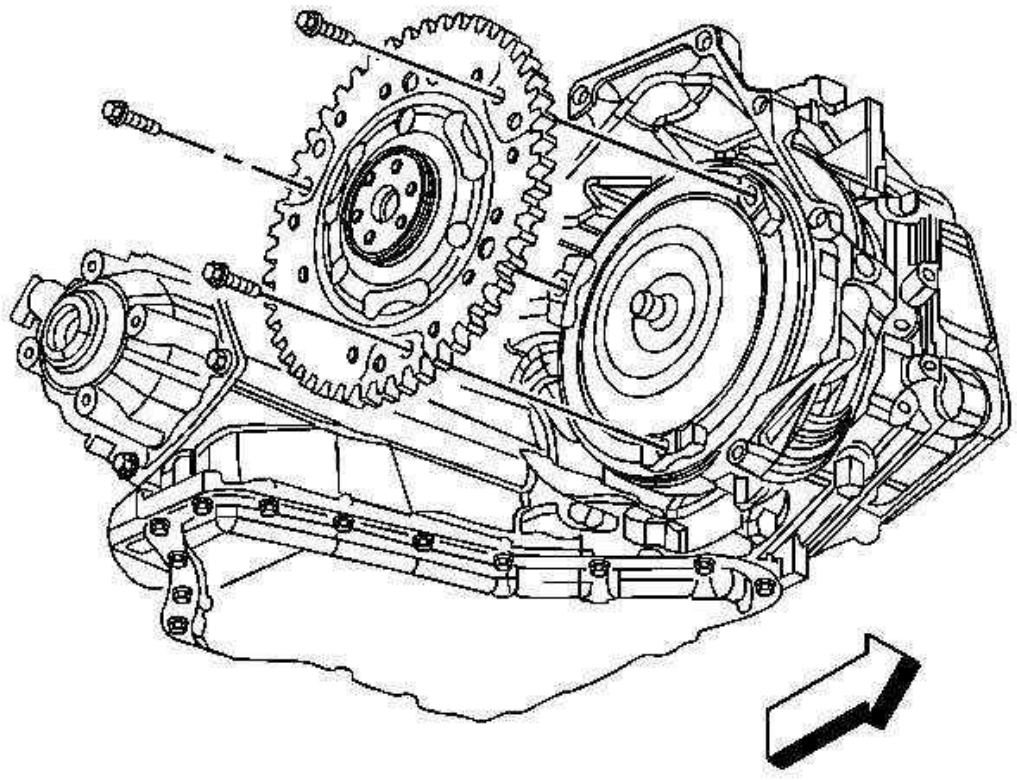


Fig. 286: View Of Flywheel Bolts
Courtesy of GENERAL MOTORS CORP.

14. Connect the exhaust system and connect the O2 sensor harness pigtail. Refer to **Catalytic Converter Replacement** .
15. Install the flywheel bolts.

    Tighten: Tighten the bolts to 63 N.m (47 lb ft).

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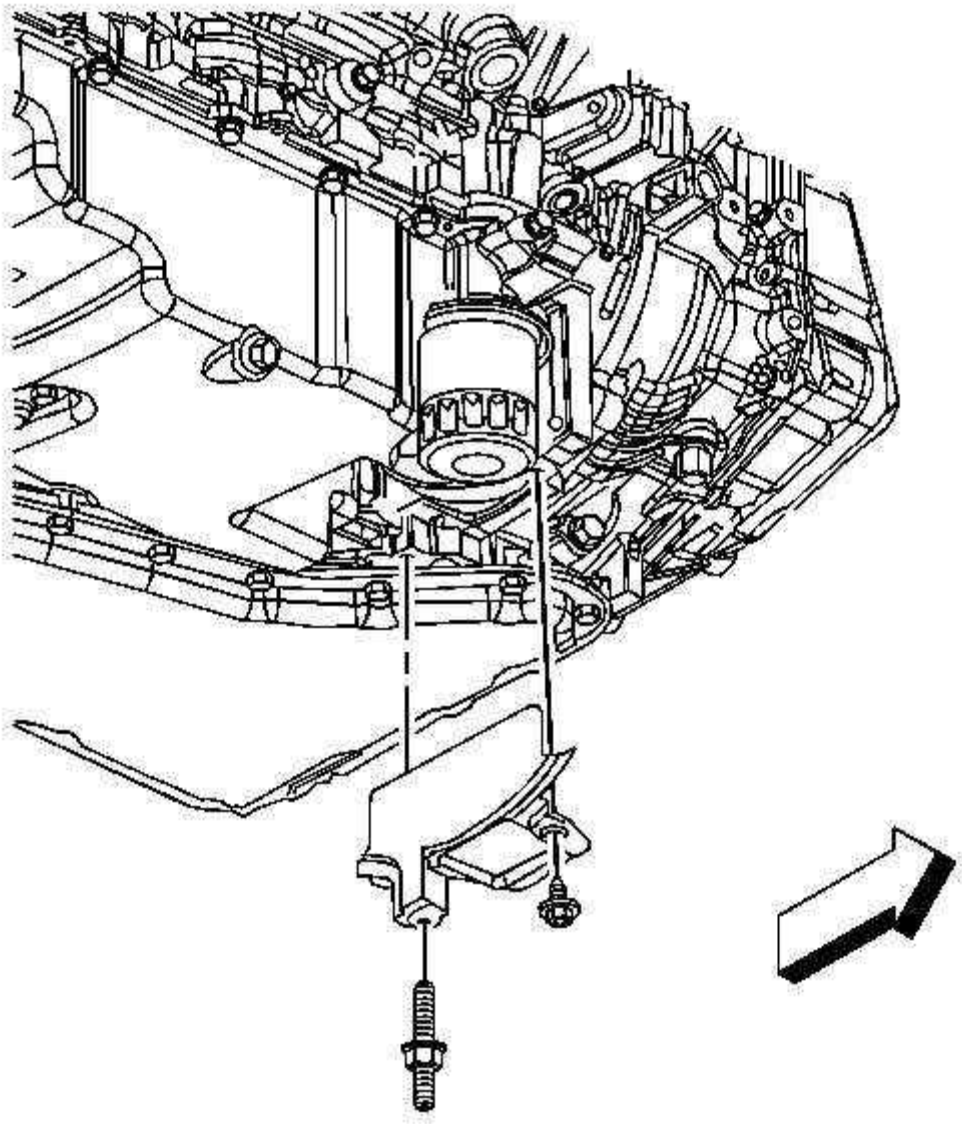


Fig. 287: View Of Transaxle Converter Cover & Bolt/Stud
Courtesy of GENERAL MOTORS CORP.

16. Install the converter cover.
17. Install the transaxle converter cover bolt/stud.

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

18. Install the left and right wheel drive shafts into the transaxle. Refer to **Wheel Drive Shaft Replacement** .

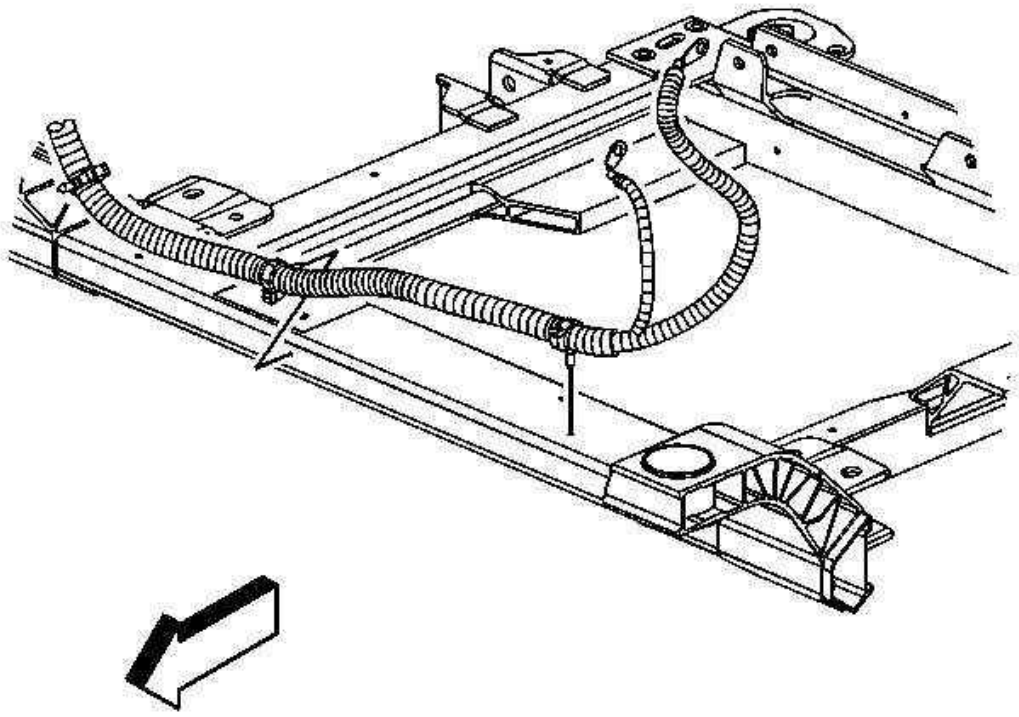


Fig. 288: View Of Battery Cable Harness Retainers
Courtesy of GENERAL MOTORS CORP.

19. Install the battery cable retainers to the engine frame.
20. Install the front air deflector. Refer to **Radiator Air Lower Baffle and Deflector Replacement** .

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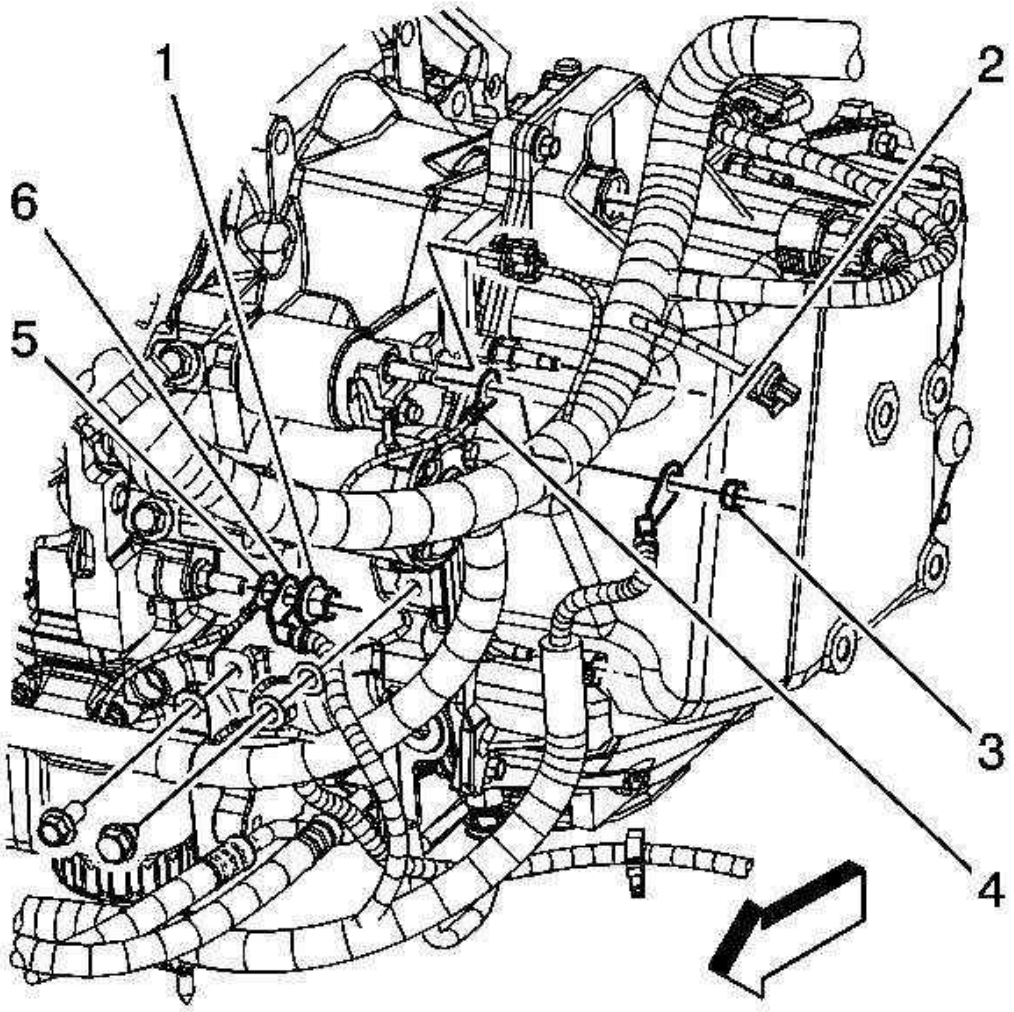


Fig. 289: View Of Battery Positive & Negative Cables
Courtesy of GENERAL MOTORS CORP.

21. Install the cable ground terminal (6) to the stud.
22. Install the battery cable ground nut (1).

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

23. Install the cable terminal (2) to the starter.

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24. Install the positive battery cable nut (3) to the starter.

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

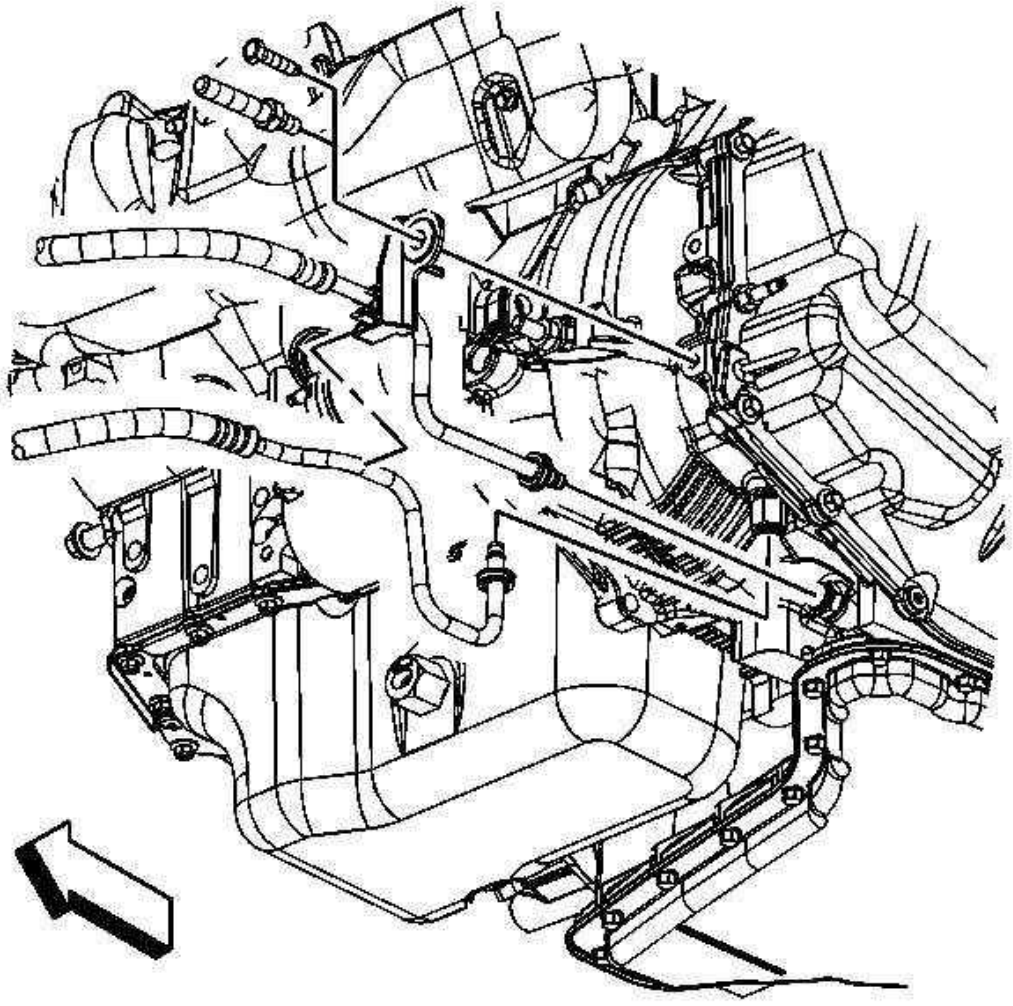


Fig. 290: View Of Transaxle Oil Cooler Lines
Courtesy of GENERAL MOTORS CORP.

25. Connect the transaxle oil cooler lines to the transaxle. Refer to **Transmission Fluid Cooler Hose/Pipe Quick-Connect Fitting Disconnection and**

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Connection .

26. Install the transaxle oil cooler line bracket bolt/stud.

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

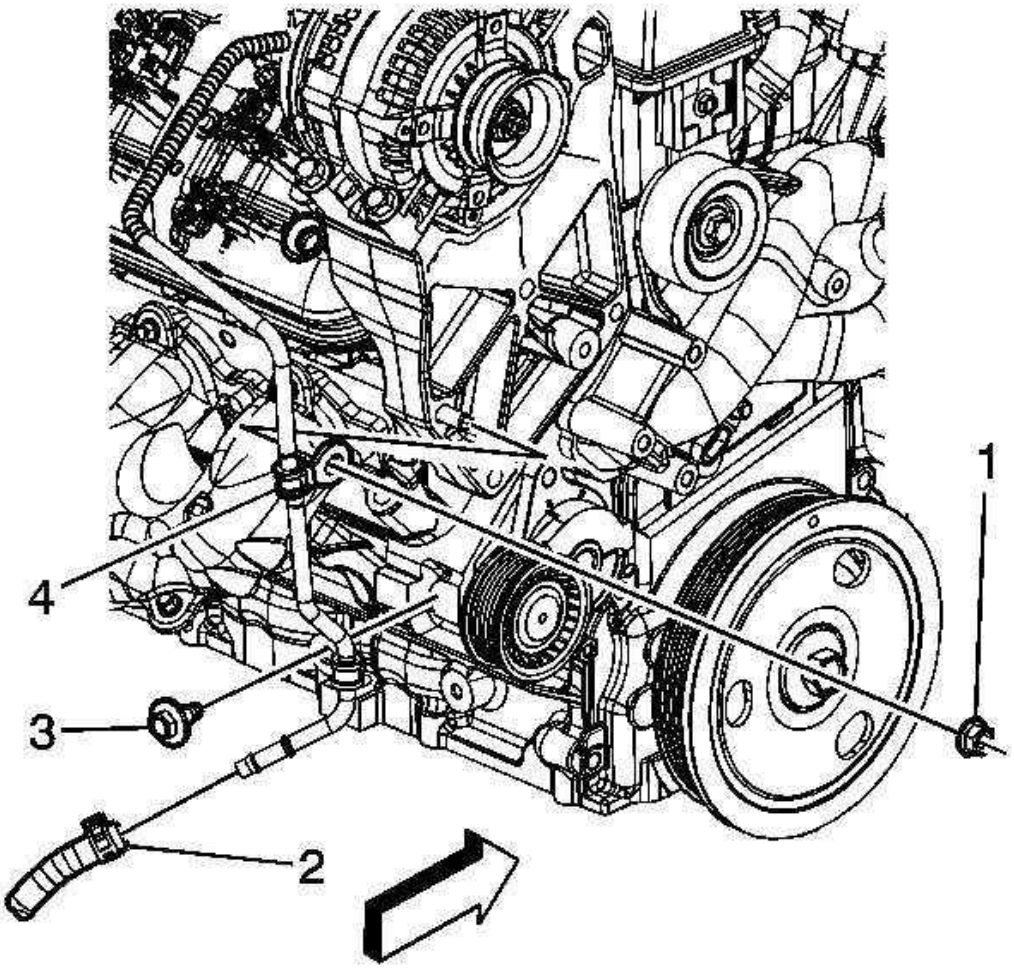


Fig. 291: View Of Power Steering Hose & Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

27. Install the power steering hose (2) to the inlet pipe.
28. Tighten the power steering hose clamp at the inlet pipe.

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Tighten: Tighten the clamp to 6 N.m (53 lb in).

29. Connect the power steering pipe to the steering gear. Refer to **Power Steering Pressure Pipe/Hose Replacement (LS4)** .
30. Connect the power steering pipe to the frame clips.
31. Lower the vehicle.

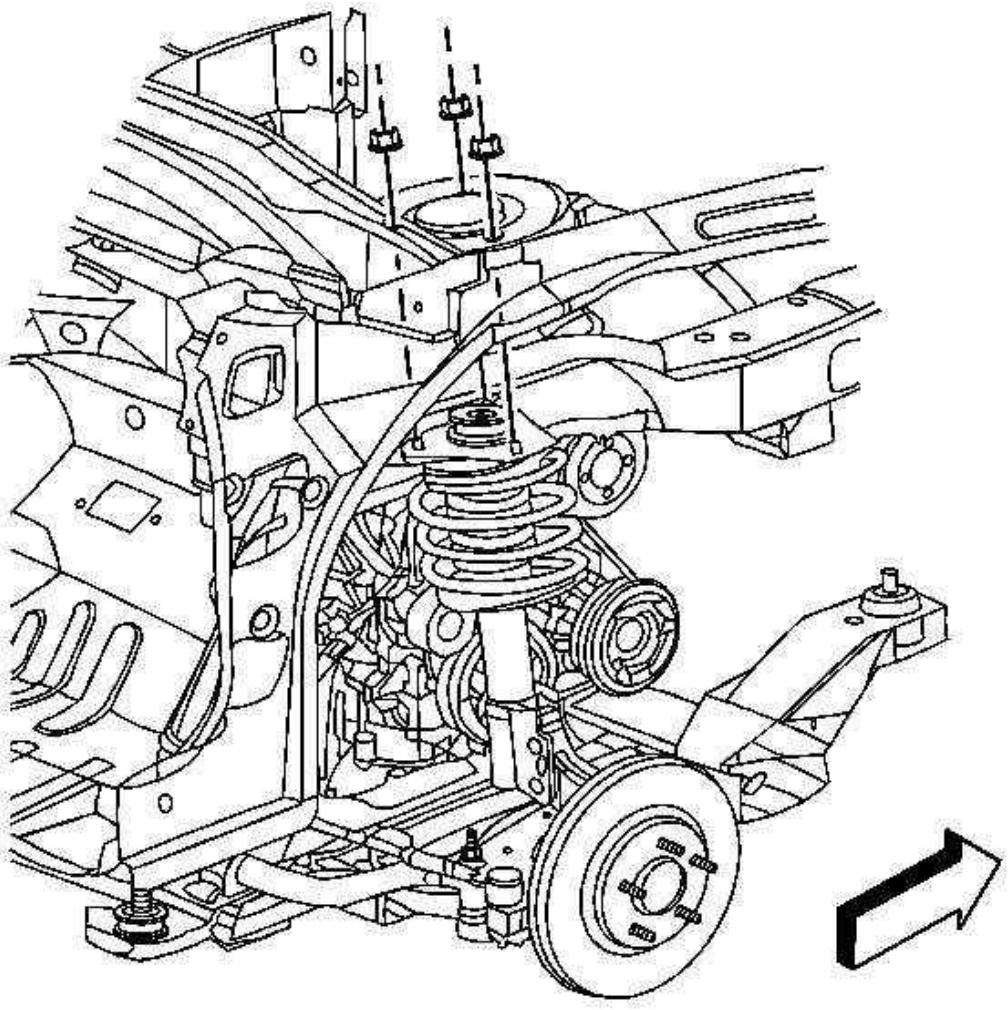


Fig. 292: View Of Upper Strut Nuts
Courtesy of GENERAL MOTORS CORP.

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32. Position and install the ball joint nuts. Refer to **Lower Control Arm Ball Joint Replacement** .
33. Install the sway links to the stabilizer shaft. Refer to **Stabilizer Shaft Link Replacement** .
34. Install the tie rod ends to the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod End Replacement** .
35. Connect the wheel speed sensor electrical connectors.
36. Connect the wheel speed sensor wiring harness to the lower control arm.

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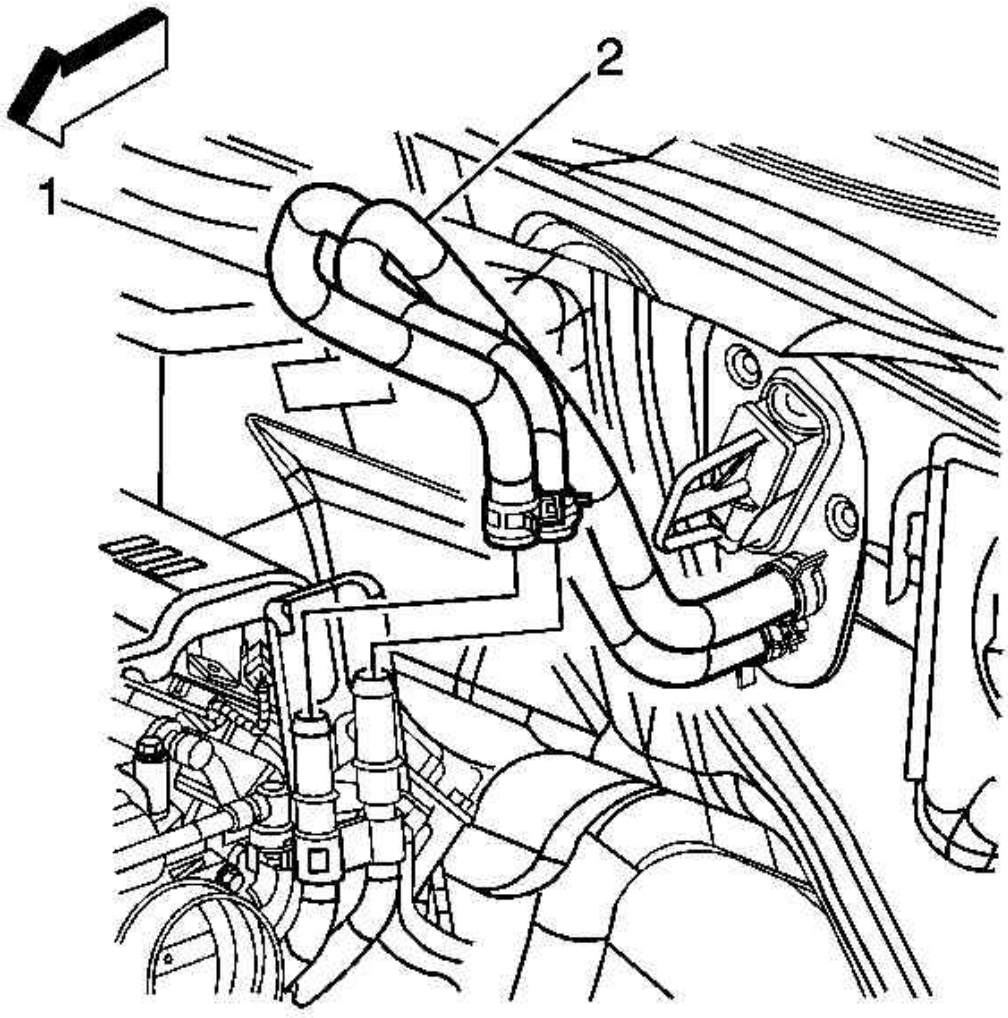


Fig. 293: View Of Heater Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

37. Install the heater inlet (2) and outlet (1) hoses to the heater inlet/outlet pipe.
38. Using the **J 38185** position the heater inlet and outlet hose clamps.

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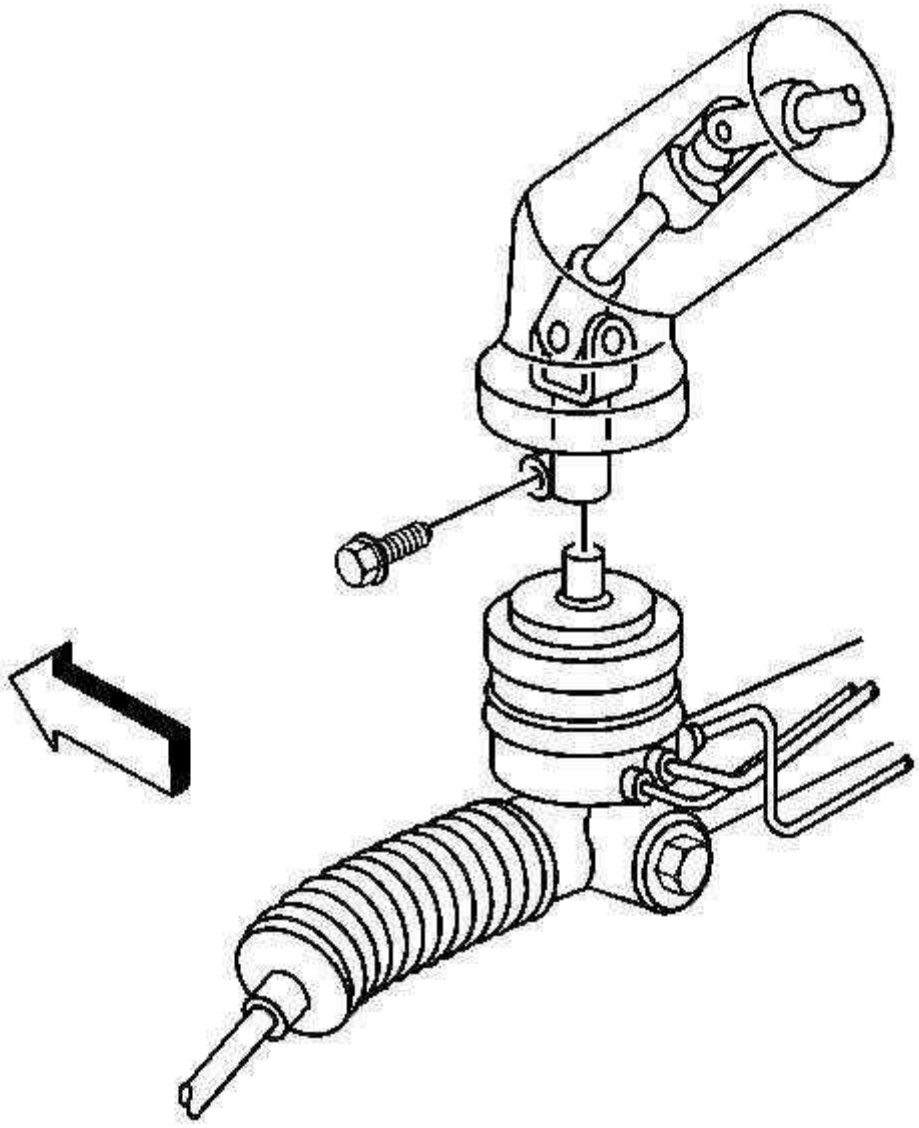


Fig. 294: View Of Intermediate Shaft, Bolt & Steering Gear
Courtesy of GENERAL MOTORS CORP.

39. Install the intermediate shaft to the steering gear.
40. Install the intermediate shaft to steering gear bolt.

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

41. Position the intermediate shaft lower boot.

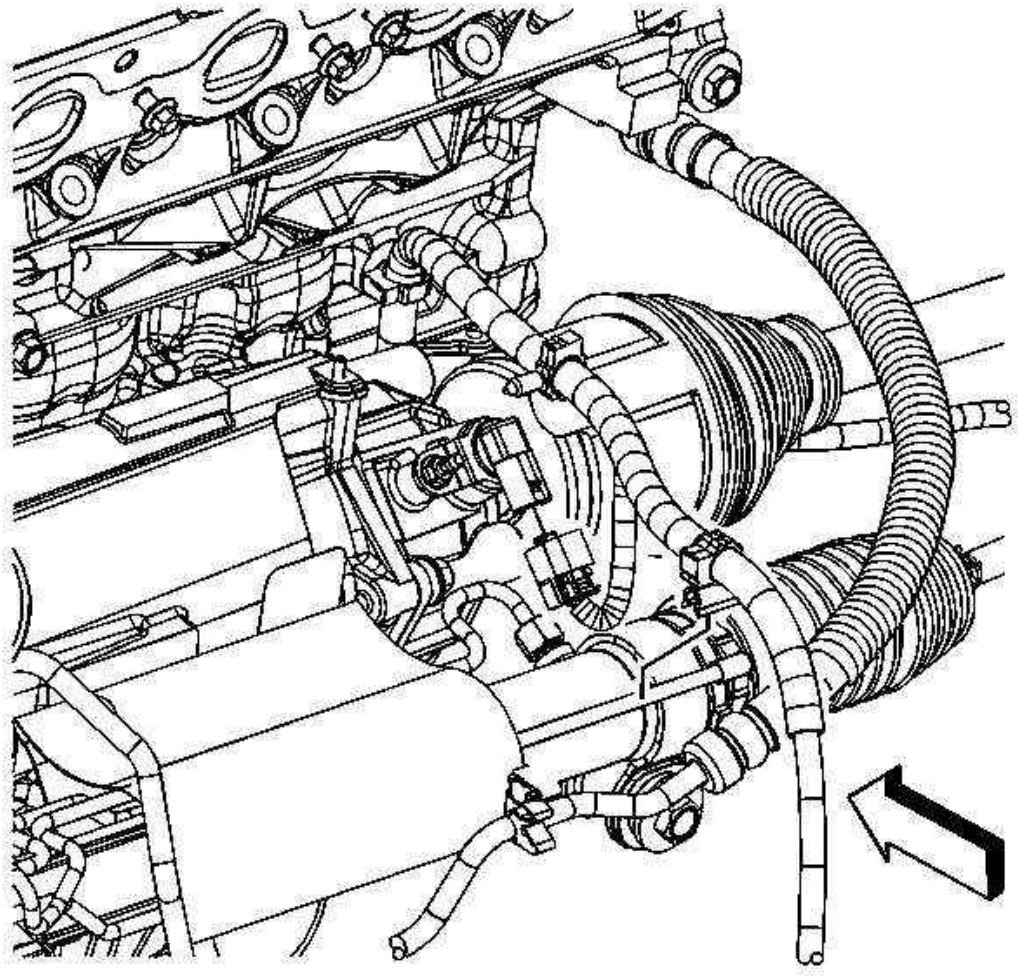


Fig. 295: View Of Engine Harness Electrical Connector For VSS
Courtesy of GENERAL MOTORS CORP.

42. Route all branches of the engine wiring harness to their correct locations.
43. Connect the engine harness electrical connector to the VSS.

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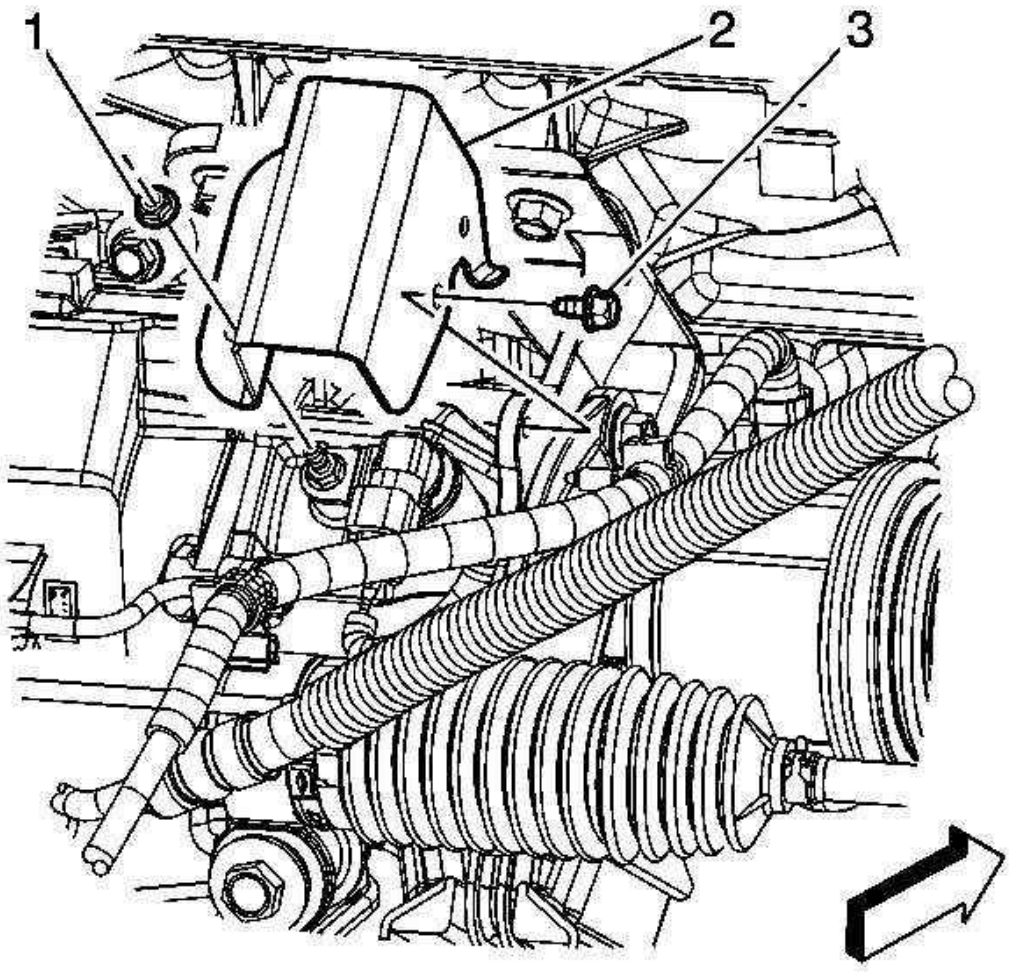


Fig. 296: View Of Vehicle Speed Sensor (VSS) Shield, Nut & Bolt
Courtesy of GENERAL MOTORS CORP.

44. Install the VSS shield (2). Install the VSS shield nut (1) and bolt (3).

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

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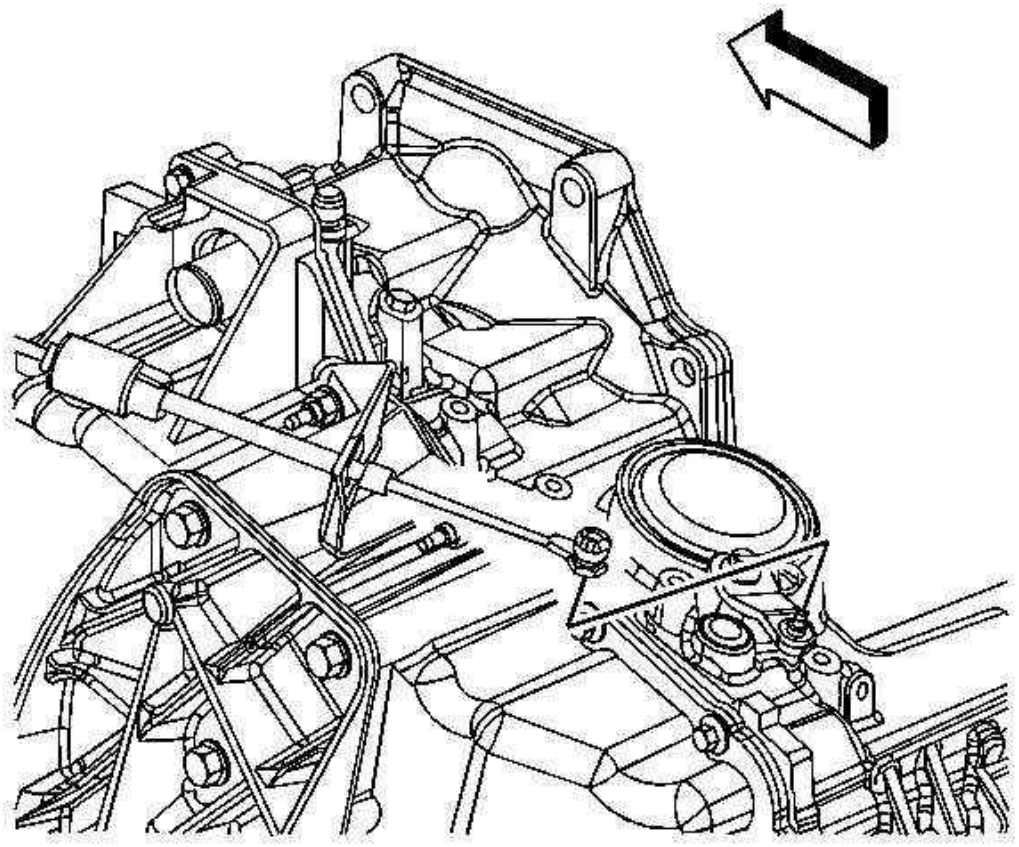


Fig. 297: View Of Shift Cable At Transaxle
Courtesy of GENERAL MOTORS CORP.

45. Install the shift cable to the bracket.
46. Connect the shift cable to the transaxle selector lever stud.
47. Install the shift cable clip.

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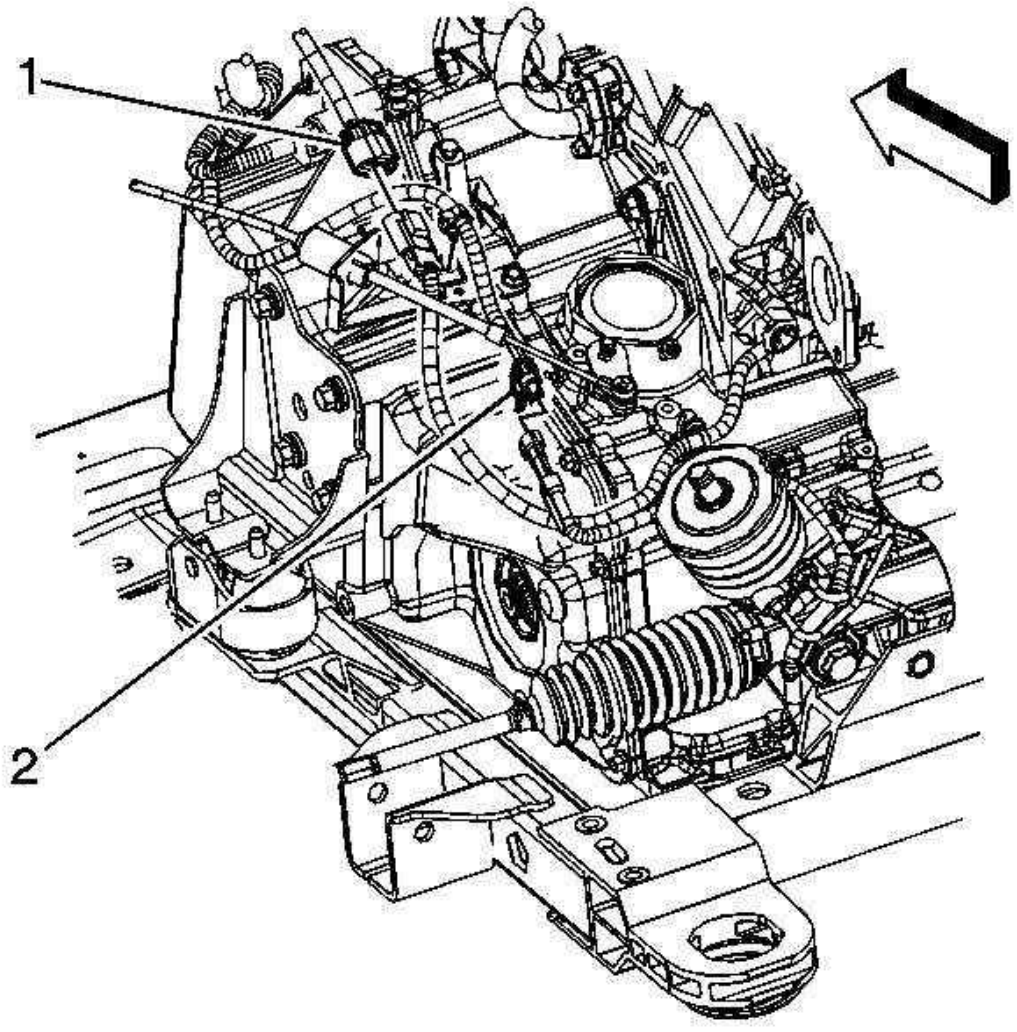


Fig. 298: View Of Crankshaft Position (CKP) Sensor Harness & Power Steering Gear Harness To Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

48. Install the clip attaching the power steering gear harness to the bracket.
49. Connect the engine harness electrical connector (1) to the CKP sensor harness.
50. Connect the engine harness electrical connector (2) to the power steering gear harness.

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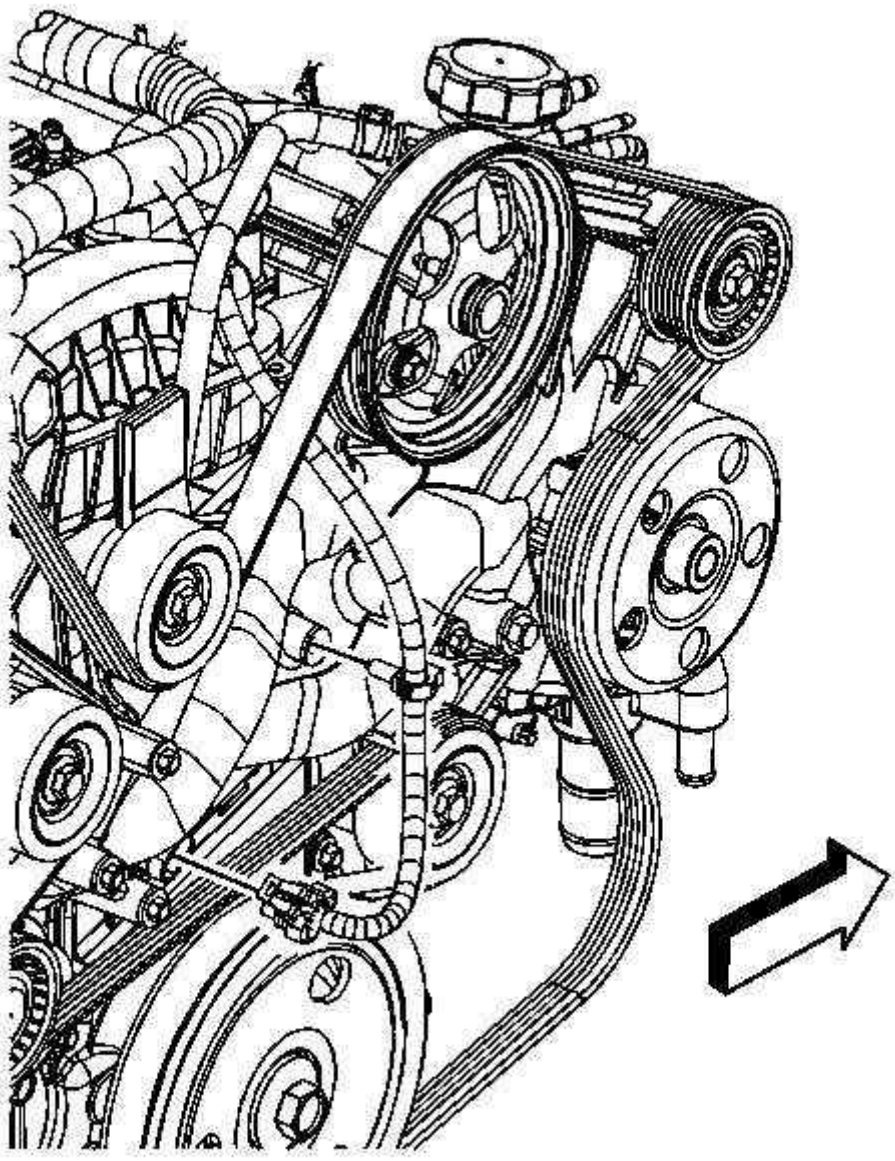


Fig. 299: Locating Camshaft Position (CMP) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

51. Connect the camshaft position sensor lead to the sensor.

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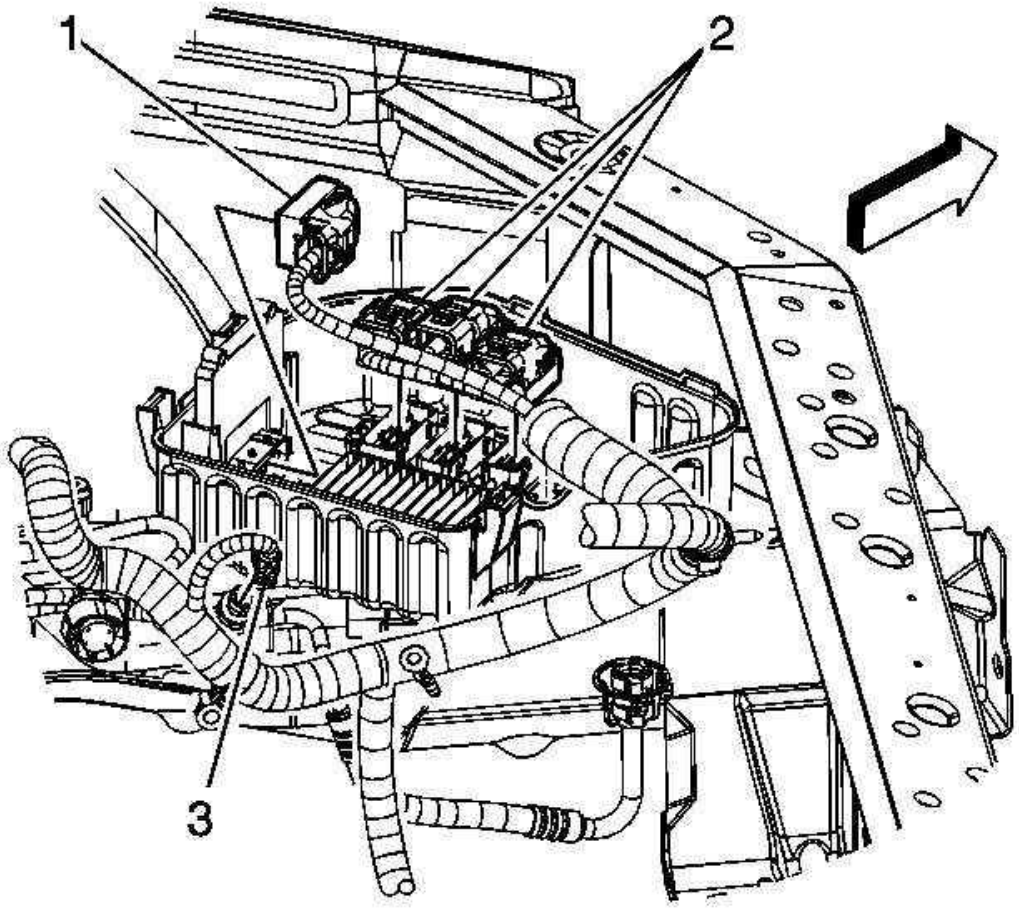


Fig. 300: View Of Transmission Control Module, Engine Control Module & A/C Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

52. Connect the following electrical connectors:
    - TCM (1)
    - ECM (2)
    - A/C pressure sensor (3)
53. Install the air cleaner assembly. Refer to **Air Cleaner Element Replacement** .

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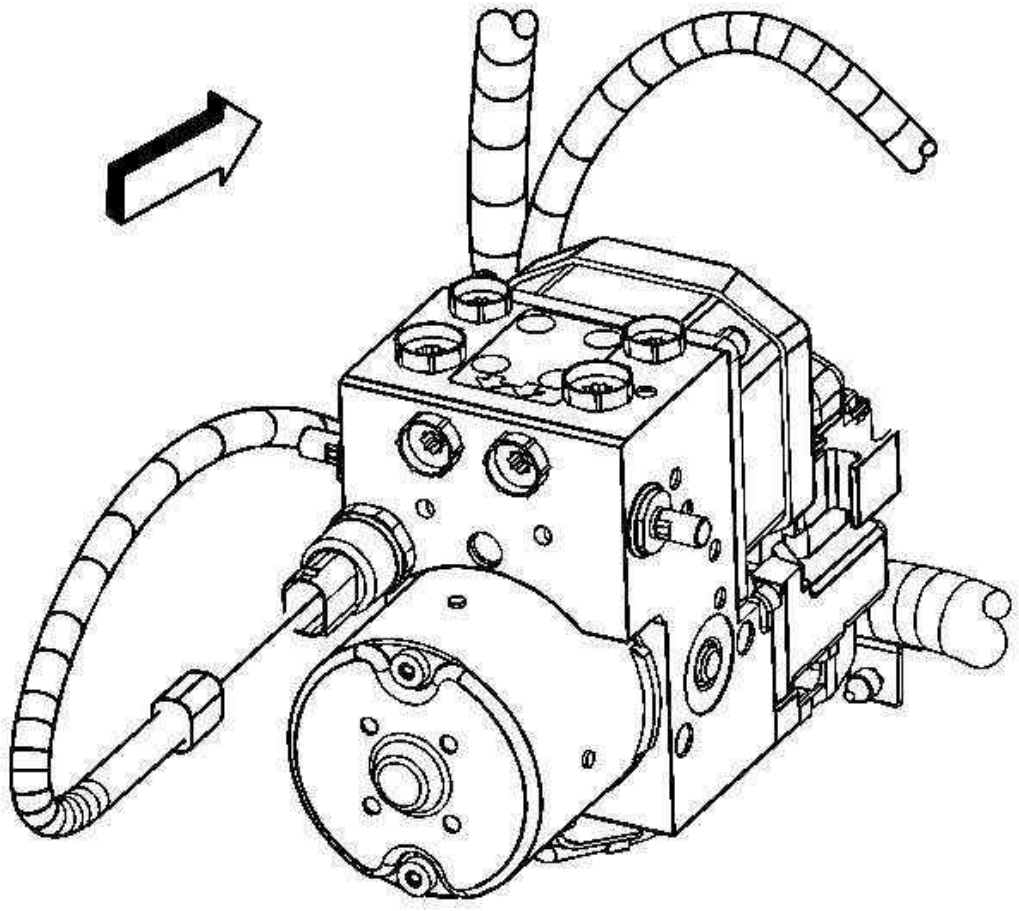


Fig. 301: View Of Engine Harness Electrical Connector & Electronic Brake Control Module (EBCM)
Courtesy of GENERAL MOTORS CORP.

54. Connect the engine harness electrical connector to the EBCM.

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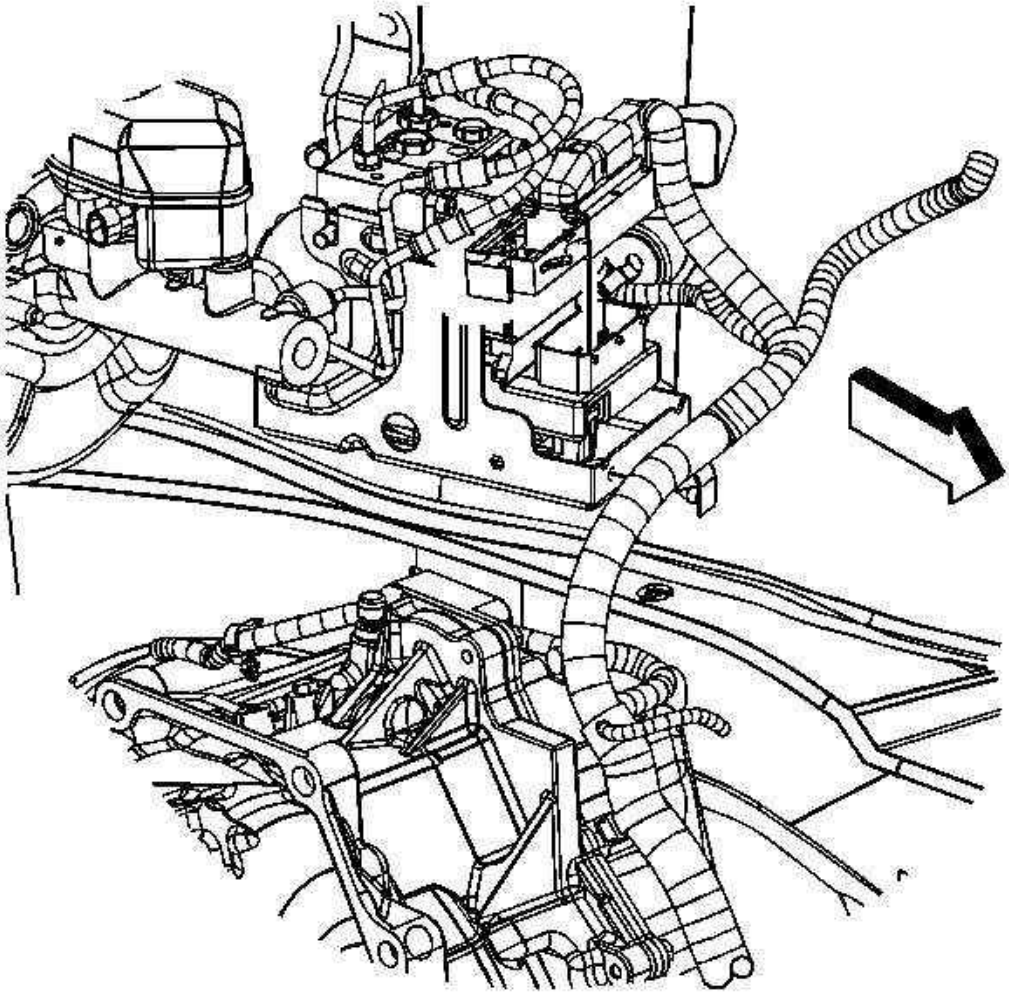


Fig. 302: View Of Engine Harness Electrical Connector & ABS Module
Courtesy of GENERAL MOTORS CORP.

55. Connect the engine harness electrical connector to the ABS module.

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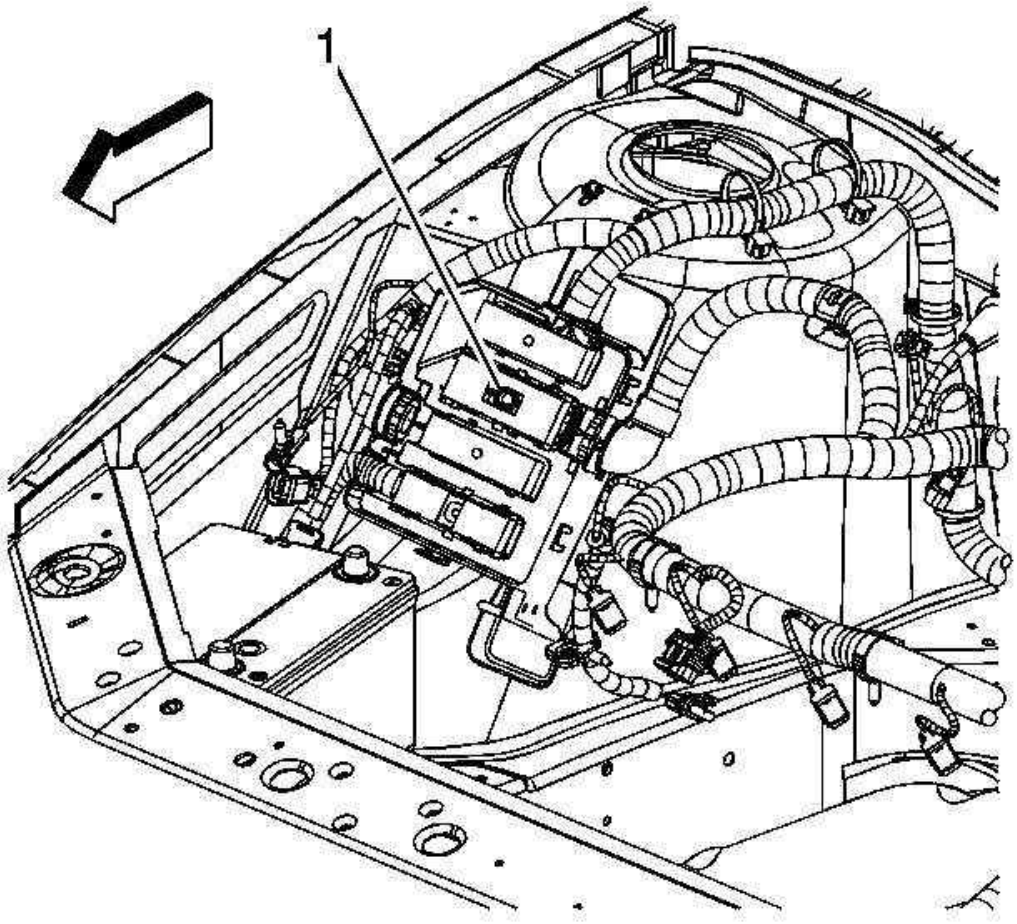


Fig. 303: View Of Engine Harness Connector Bracket
Courtesy of GENERAL MOTORS CORP.

56. Install the engine harness connector to the bracket. Tighten the engine harness connector bolt (1).

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

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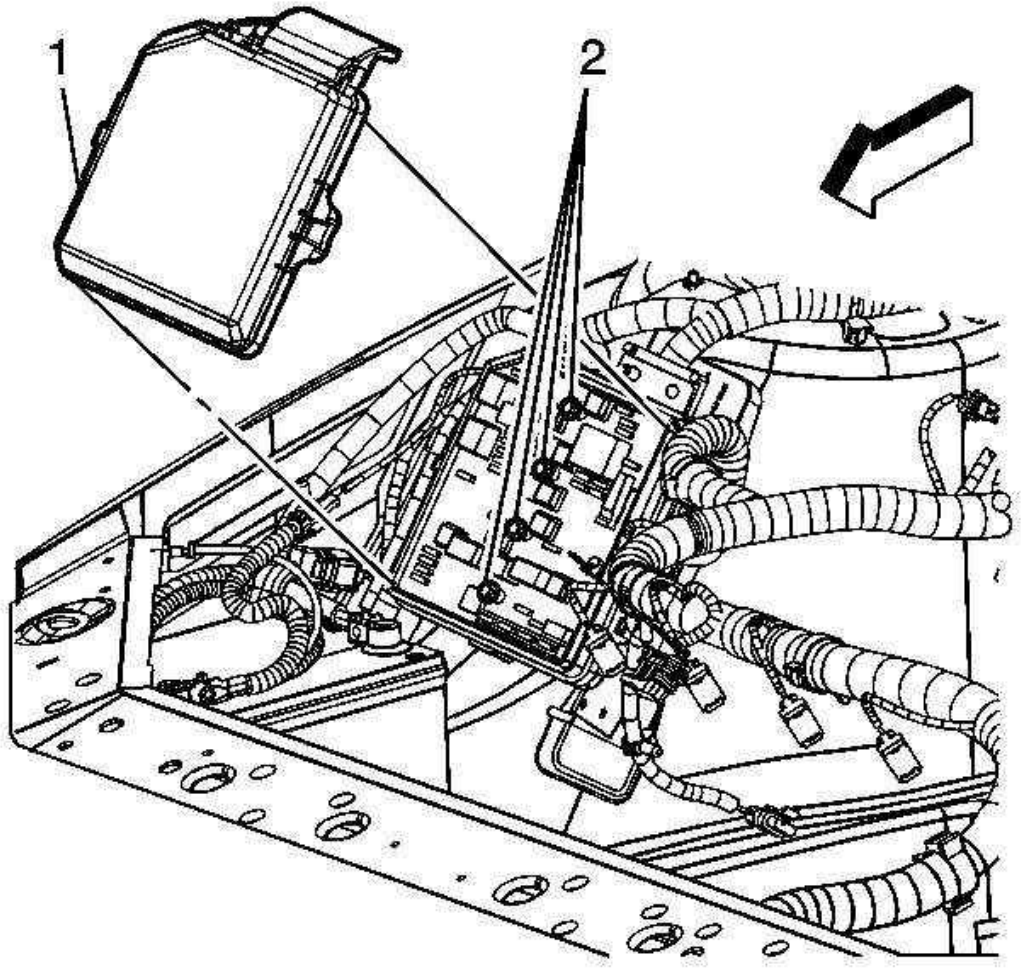


Fig. 304: View Of Bussed Electrical Center (BEC) Cover & Fuse Block
Courtesy of GENERAL MOTORS CORP.

57. Position the fuse block. Tighten the 4 integral bolts (2) attaching the fuse block.

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

58. Install the electrical center cover (1).

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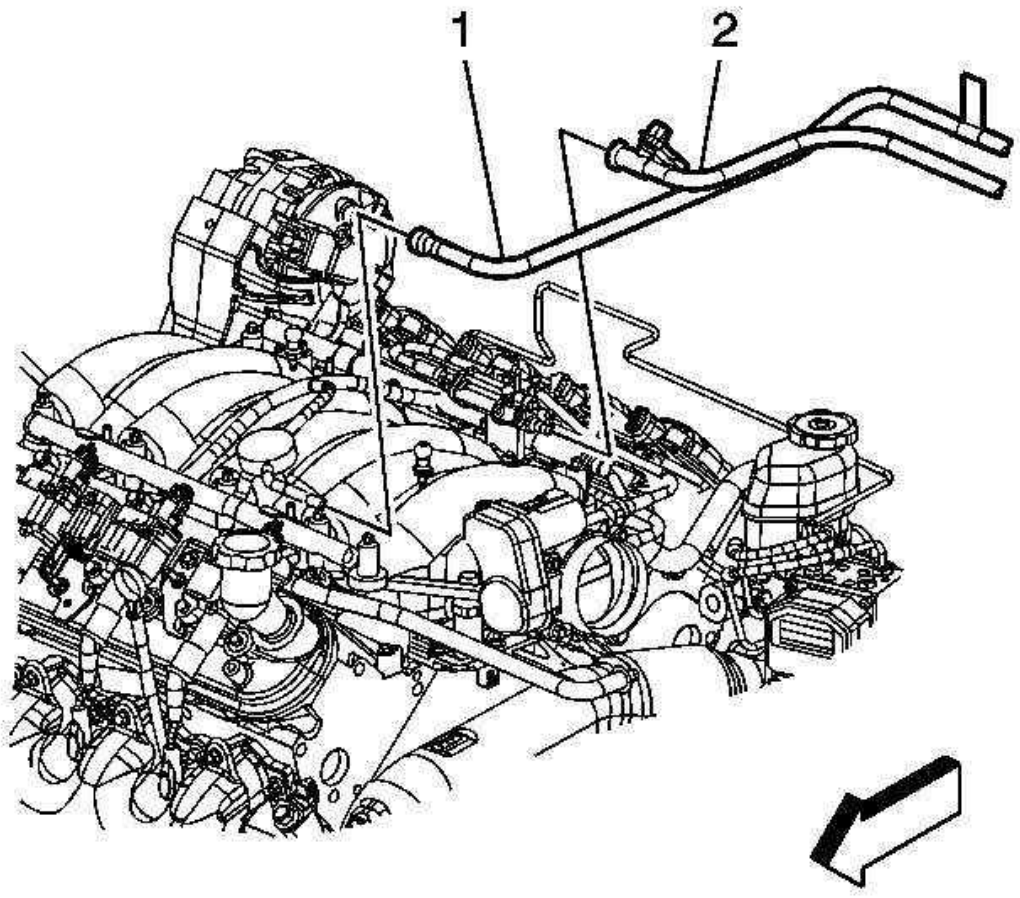


Fig. 305: View Of Fuel Feed Line & Evaporative Emission (EVAP) Line
Courtesy of GENERAL MOTORS CORP.

59. Connect the fuel feed line (1) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
60. Connect the EVAP line (2) to the purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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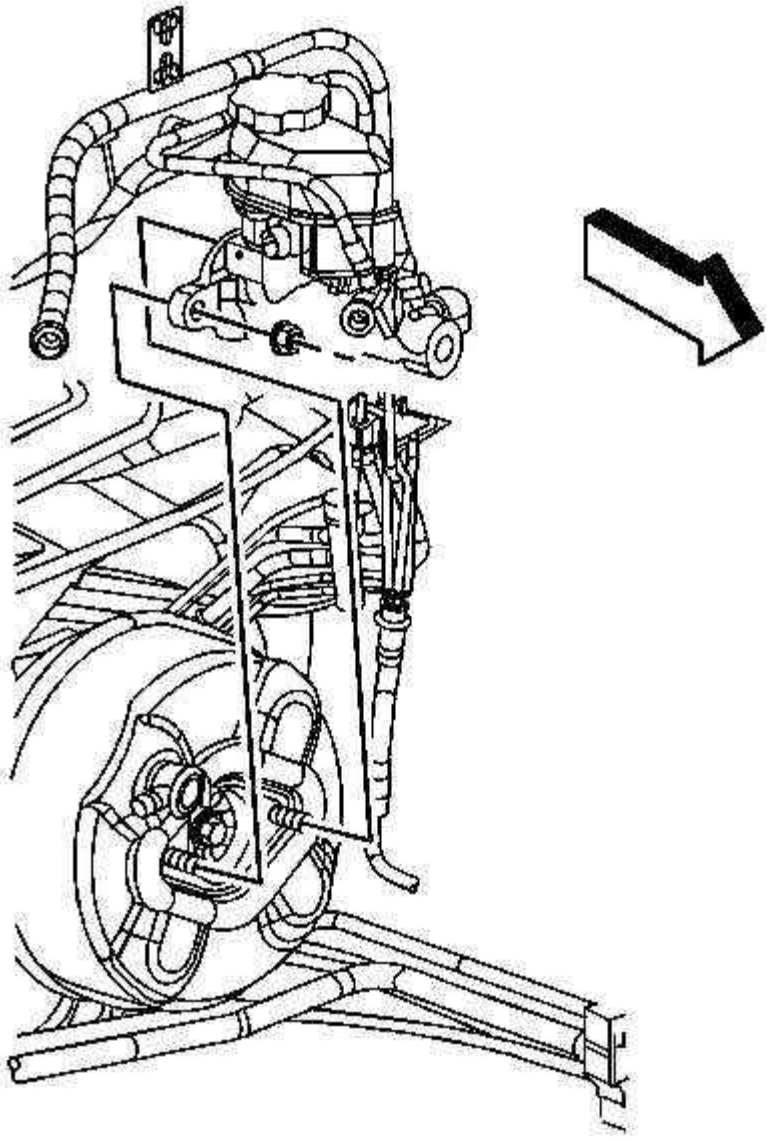


Fig. 306: View Of Master Cylinder & Nuts
Courtesy of GENERAL MOTORS CORP.

61. Remove the mechanic's wire holding the master cylinder. Position the master cylinder to the brake booster.

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62. Install the master cylinder nuts.

    Tighten: Tighten the nuts to 33 N.m (24 lb ft).

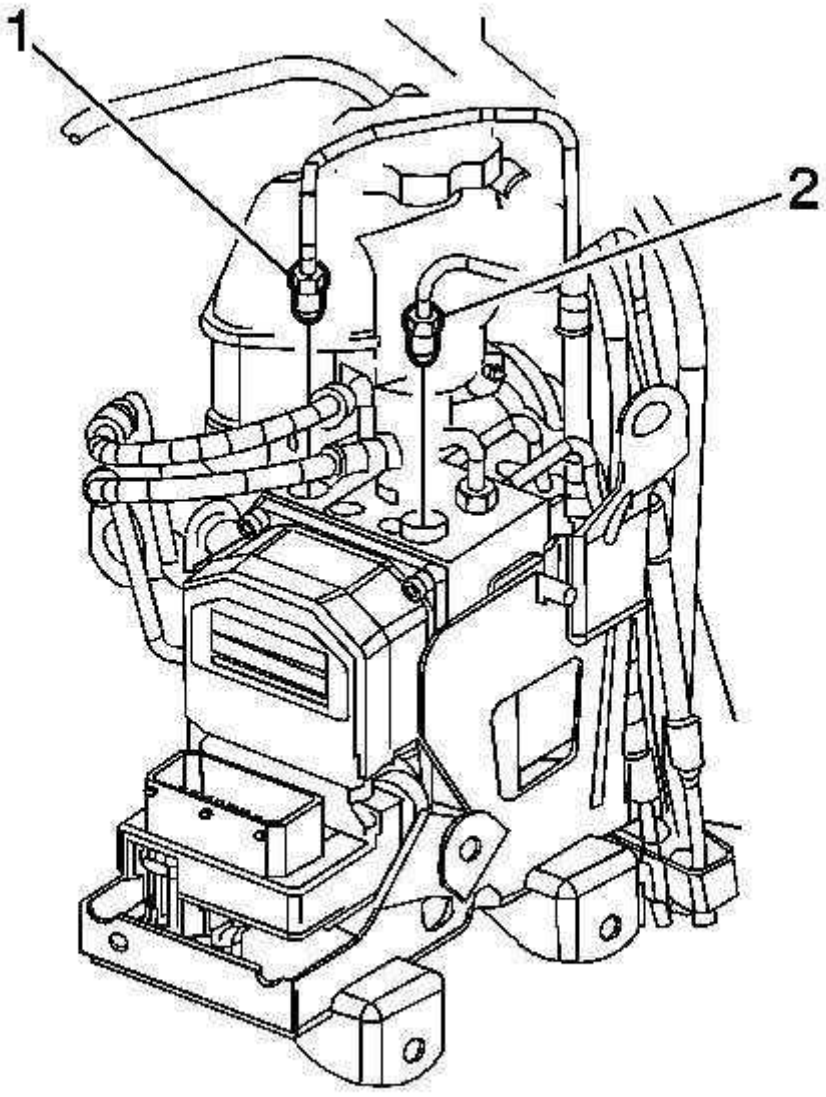


Fig. 307: View Of Anti Lock Brake (ABS) Module Brake Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

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63. Connect the brake pipe fittings (1, 2) to the ABS module.

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

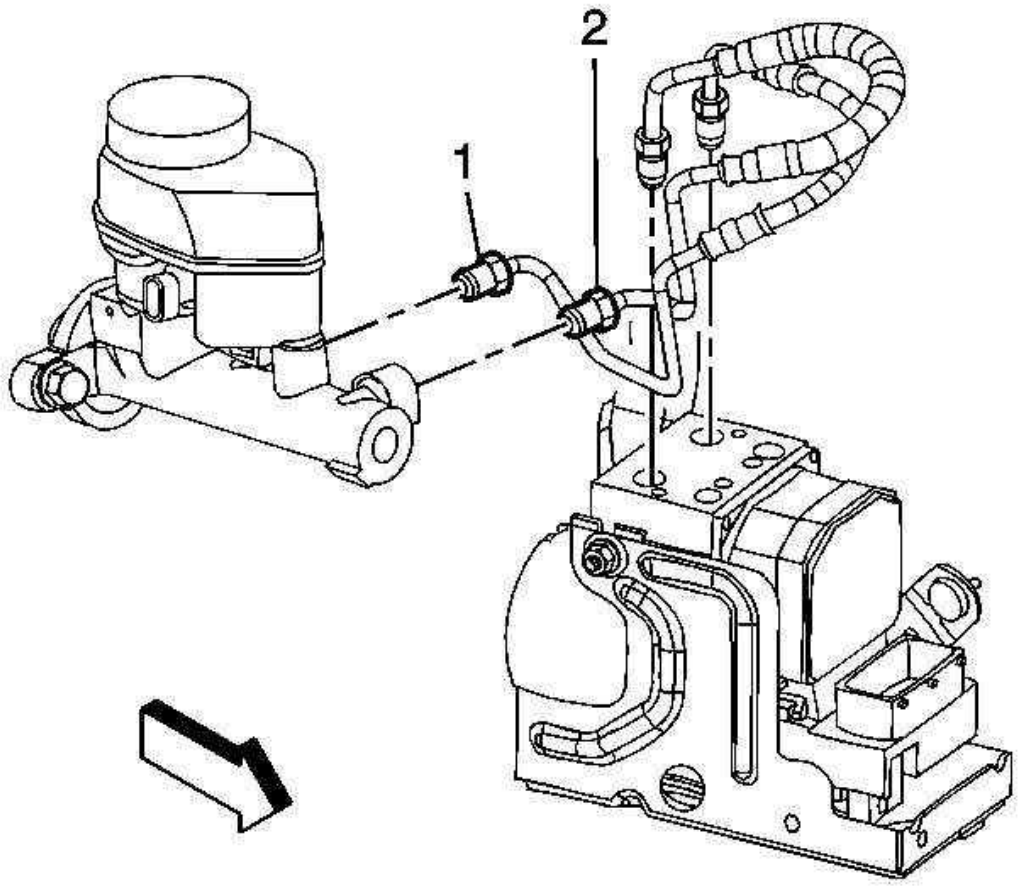


Fig. 308: View Of Master Cylinder Brake Pipe Fittings
Courtesy of GENERAL MOTORS CORP.

64. Connect the from brake pipe fittings (1, 2) to the master cylinder.

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

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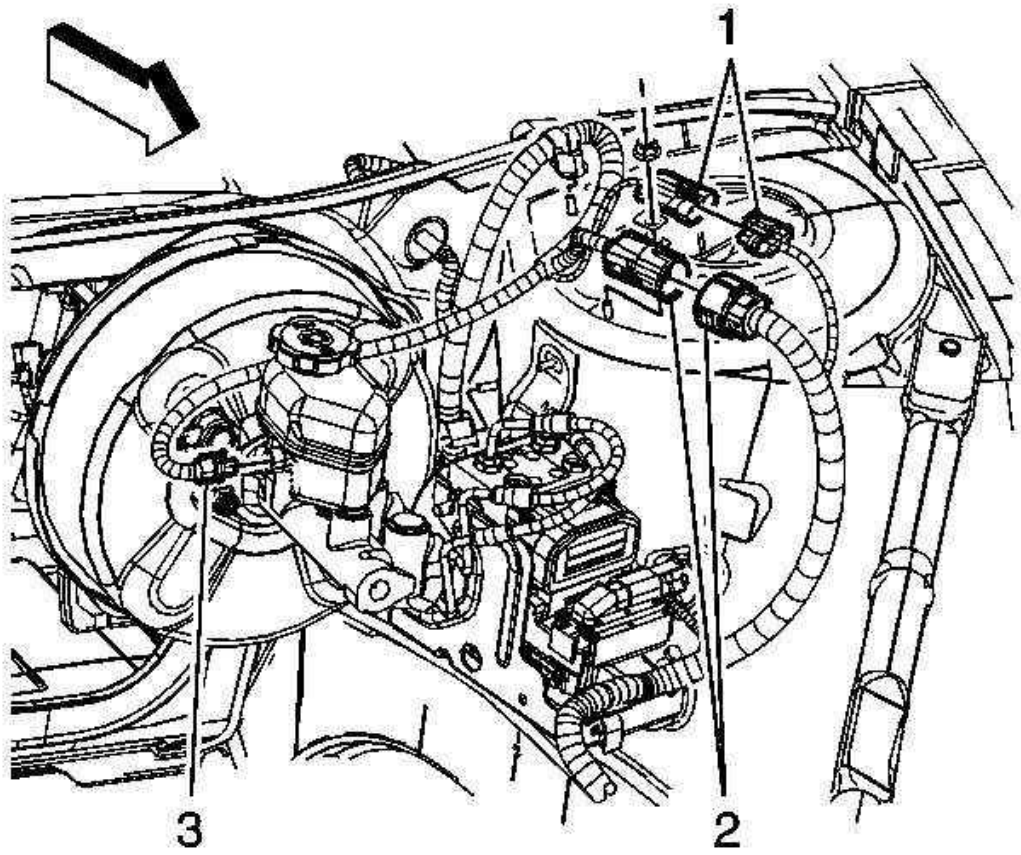


Fig. 309: View Of Engine Harness Electrical Connectors & Brake Fluid Level Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

65. Connect the brake fluid level switch electrical connector (3) to the master cylinder.
66. Connect the engine harness electrical connectors (1, 2) to the I/P harness electrical connectors.

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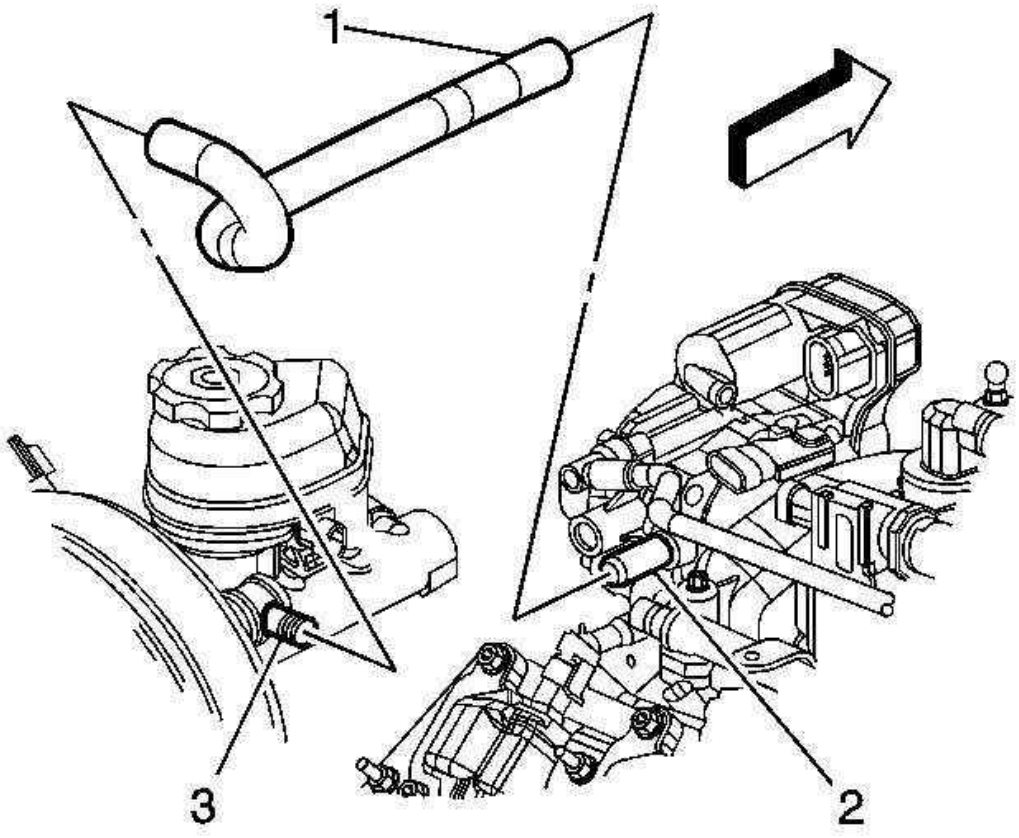


Fig. 310: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

67. Install the brake booster vacuum hose (1) to the intake manifold (2).
68. Install the brake booster vacuum hose to the brake booster (3).

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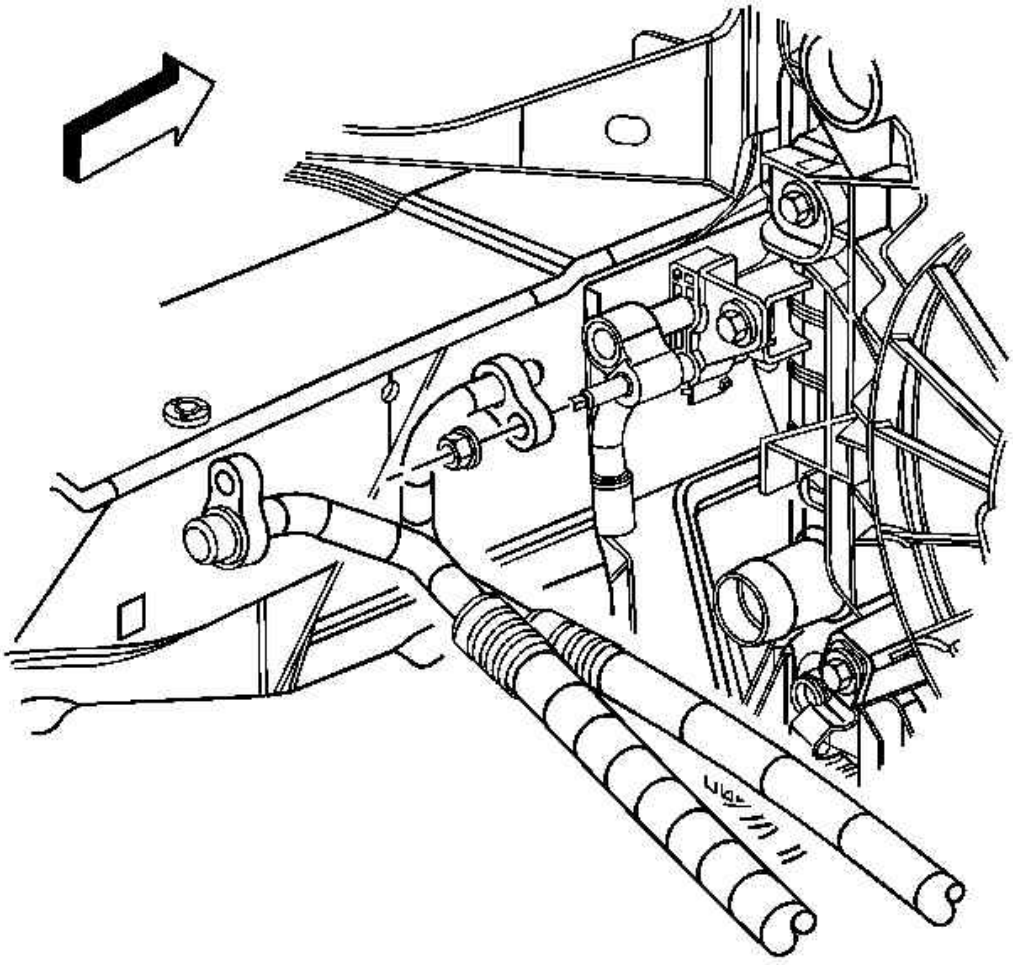


Fig. 311: View Of A/C Compressor Hose & Nut At A/C Condenser
Courtesy of GENERAL MOTORS CORP.

69. Install the A/C compressor hose.
70. Install the A/C compressor hose nut at the A/C condenser.

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

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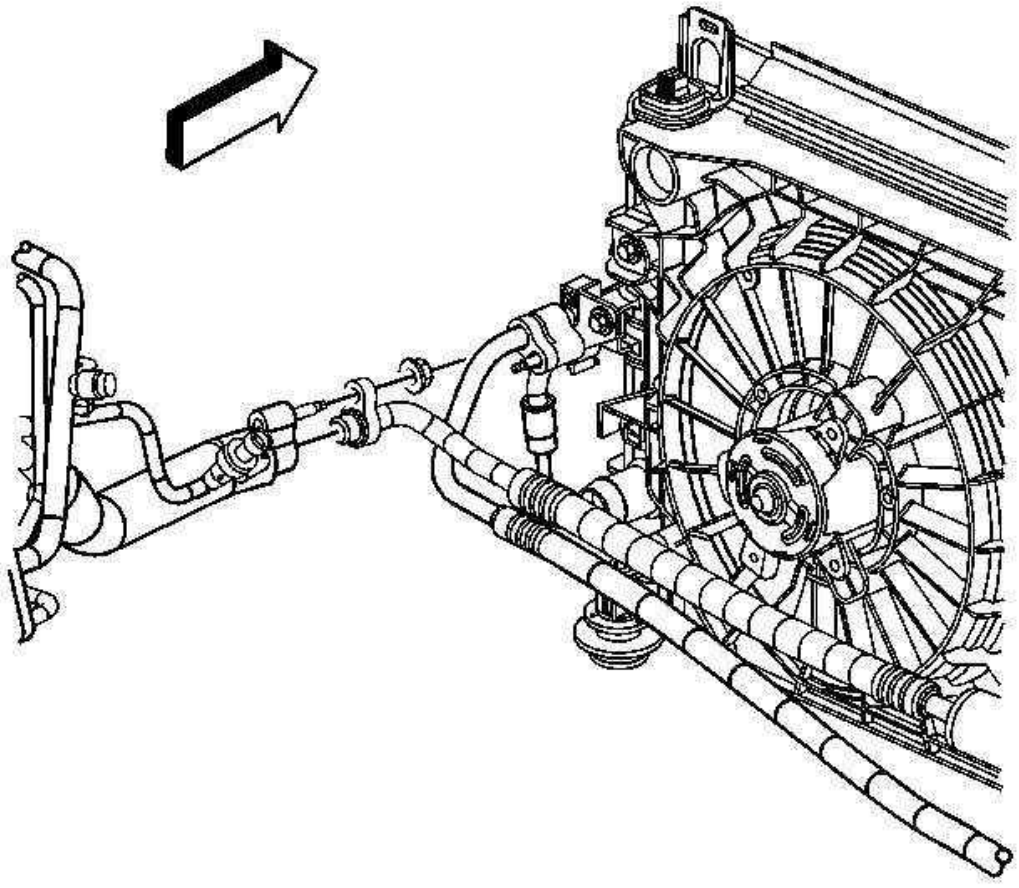


Fig. 312: View Of A/C Compressor Hose Nut & A/C Receiver/Dehydrator Tube
Courtesy of GENERAL MOTORS CORP.

71. Install the A/C compressor hose.
72. Install the A/C compressor hose nut at the A/C receiver/dehydrator tube.

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

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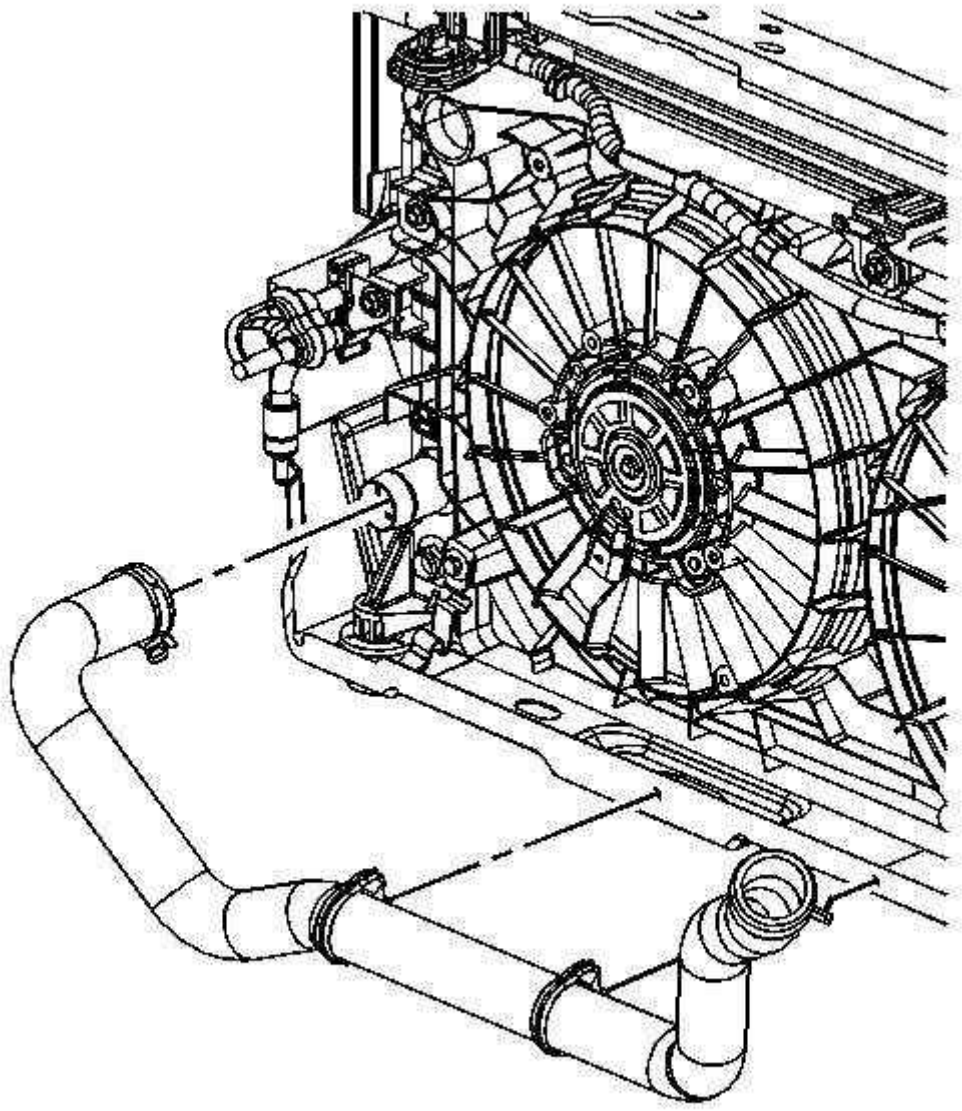


Fig. 313: View Of Outlet Hose & Radiator
Courtesy of GENERAL MOTORS CORP.

73. Install the outlet hose to the radiator.
74. Connect the outlet hose clips to the fan shroud.
75. Using the **J 38185** position the outlet hose clamp at the radiator.

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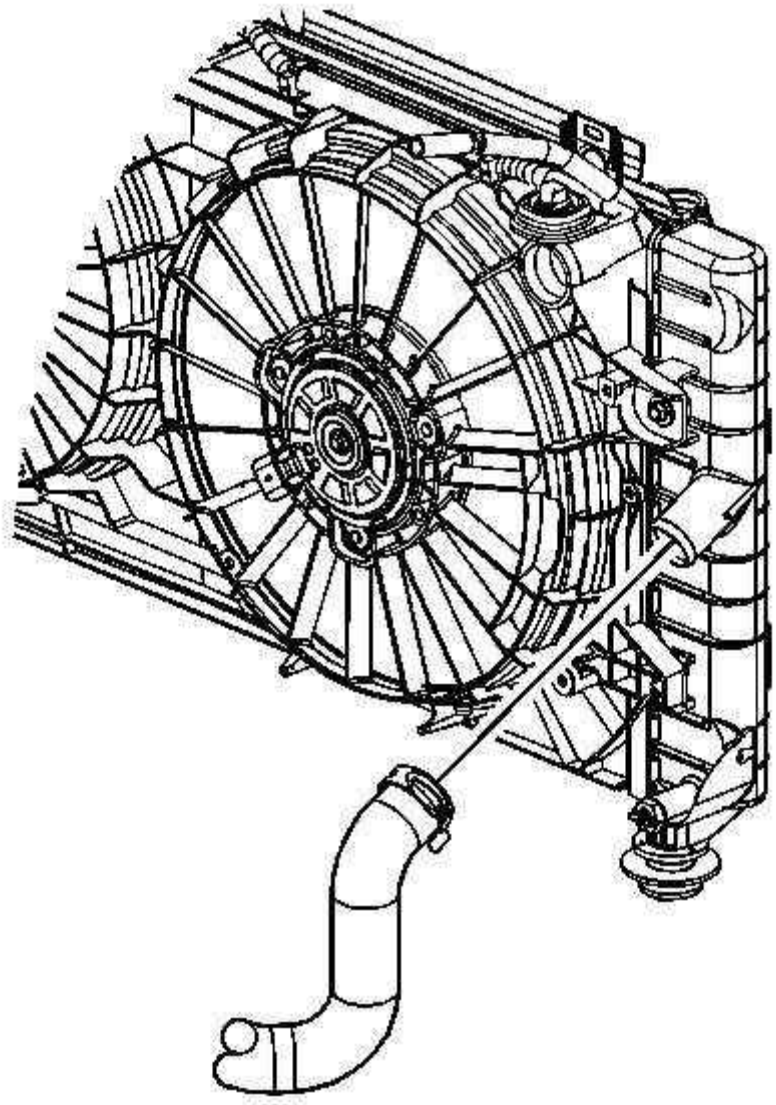


Fig. 314: View Of Inlet Hose & Radiator
Courtesy of GENERAL MOTORS CORP.

76. Install the inlet hose to the radiator.
77. Using the **J 38185** position the inlet hose clamp at the radiator.
78. Install the front tires and wheels. Refer to **Tire and Wheel Removal and**

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Installation .

79. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (LS4)** .
80. Install the right fender diagonal brace. Refer to **Front Fender Upper Diagonal Brace Replacement** .
81. Refill the engine with oil.
82. Recharge the A/C system. Refer to **Refrigerant Recovery and Recharging** .
83. Refill the cooling system. Refer to **Cooling System Draining and Filling (LS4 GE47716 Fill)** or **Cooling System Draining and Filling (LS4 Static Fill)** .
84. Bleed the brake system. Refer to **Hydraulic Brake System Bleeding (Manual)** or **Hydraulic Brake System Bleeding (Pressure)** .
85. Check the transaxle fluid level, add fluid if necessary. Refer to **Transmission Fluid Check** .
86. Install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.
87. Run the engine and inspect for leaks.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

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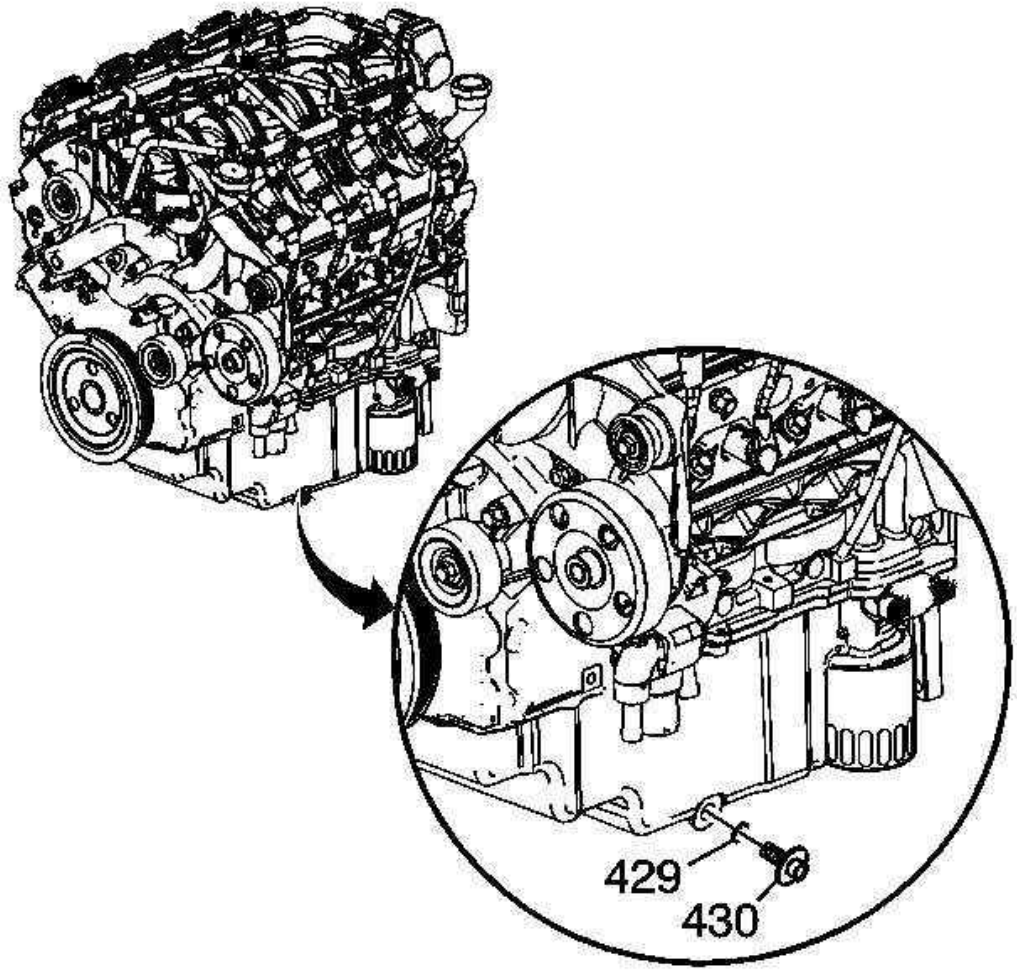


Fig. 315: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the oil pan drain plug (430) and O-ring (429).
5. Allow the oil to drain into an appropriate container.

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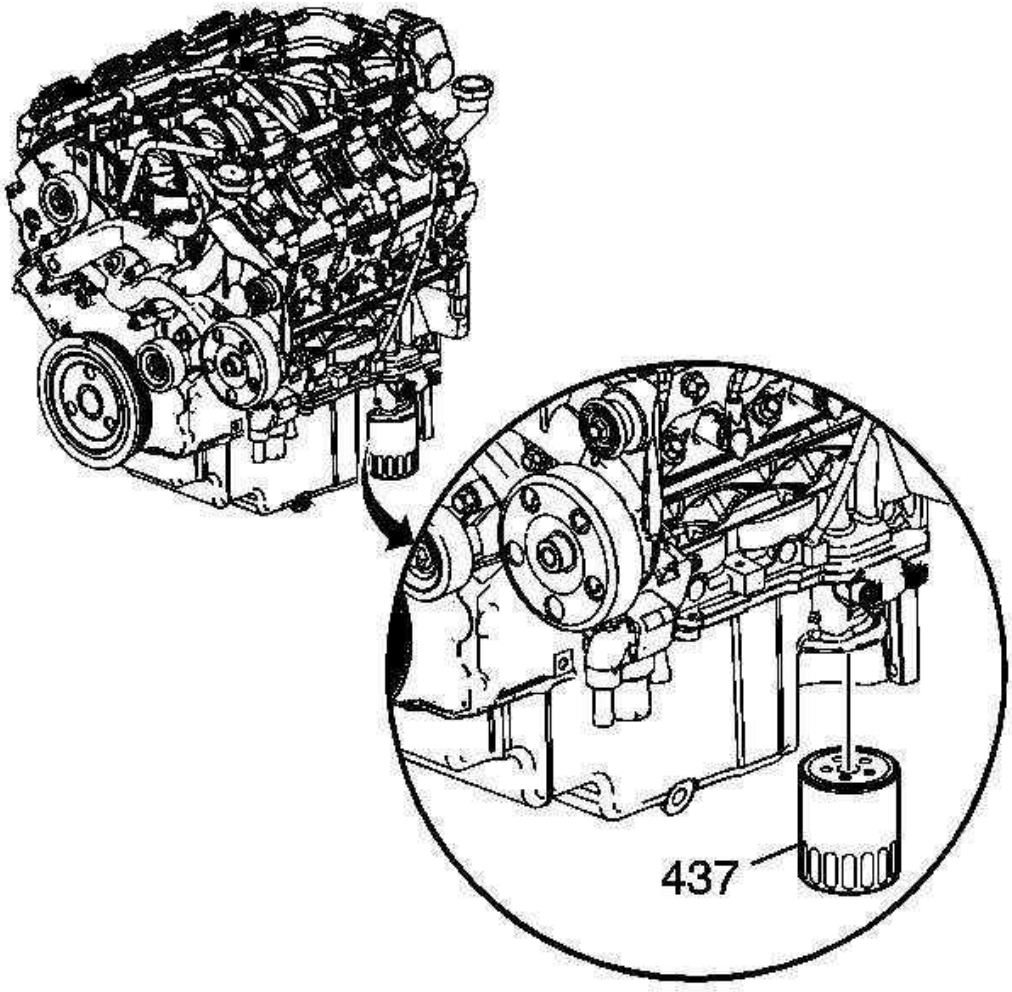


Fig. 316: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil filter (437). Allow the rest of the engine oil to drain into an appropriate container.

Installation Procedure

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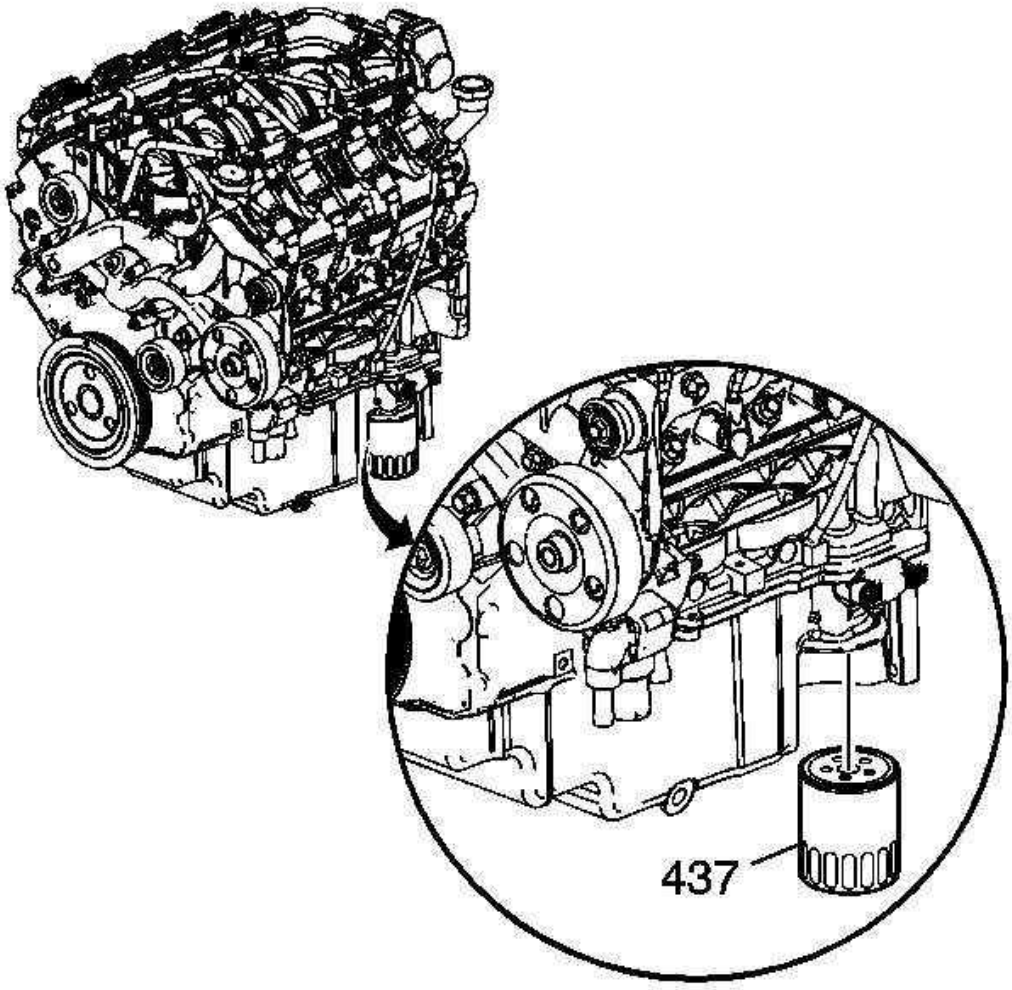


Fig. 317: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Prior to installing a NEW oil filter, ensure that the old oil filter gasket has been removed from the engine block. If not, remove the old gasket.

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1. Install a NEW engine oil filter (437).

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

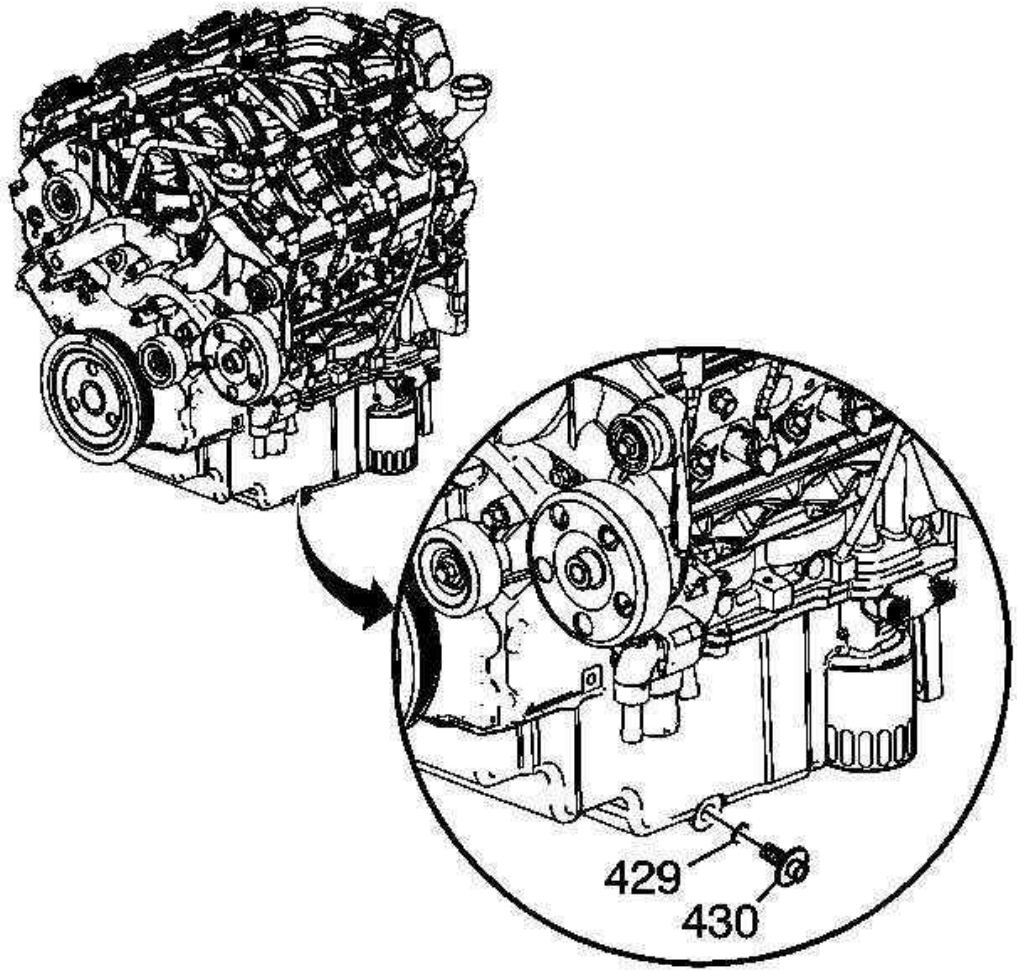


Fig. 318: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pan drain plug (430) and O-ring (429).

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

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3. Lower the vehicle.
4. Fill the engine with the appropriate amount and type of NEW engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations** .
5. Check the oil level.
6. Install the oil fill cap.
7. Close the hood.
8. Reset the engine oil life monitor, if necessary. Refer to **GM Oil Life System Resetting** .

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

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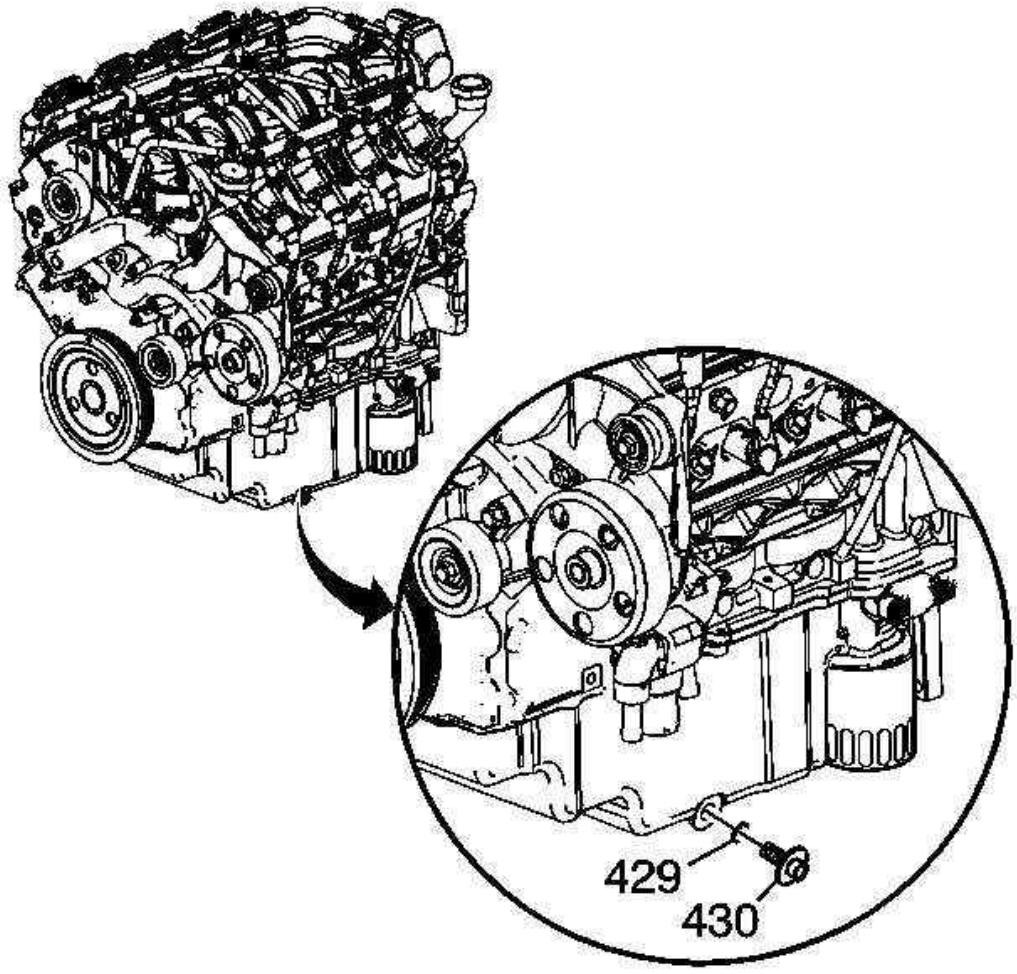


Fig. 319: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug (430) and O-ring (429).

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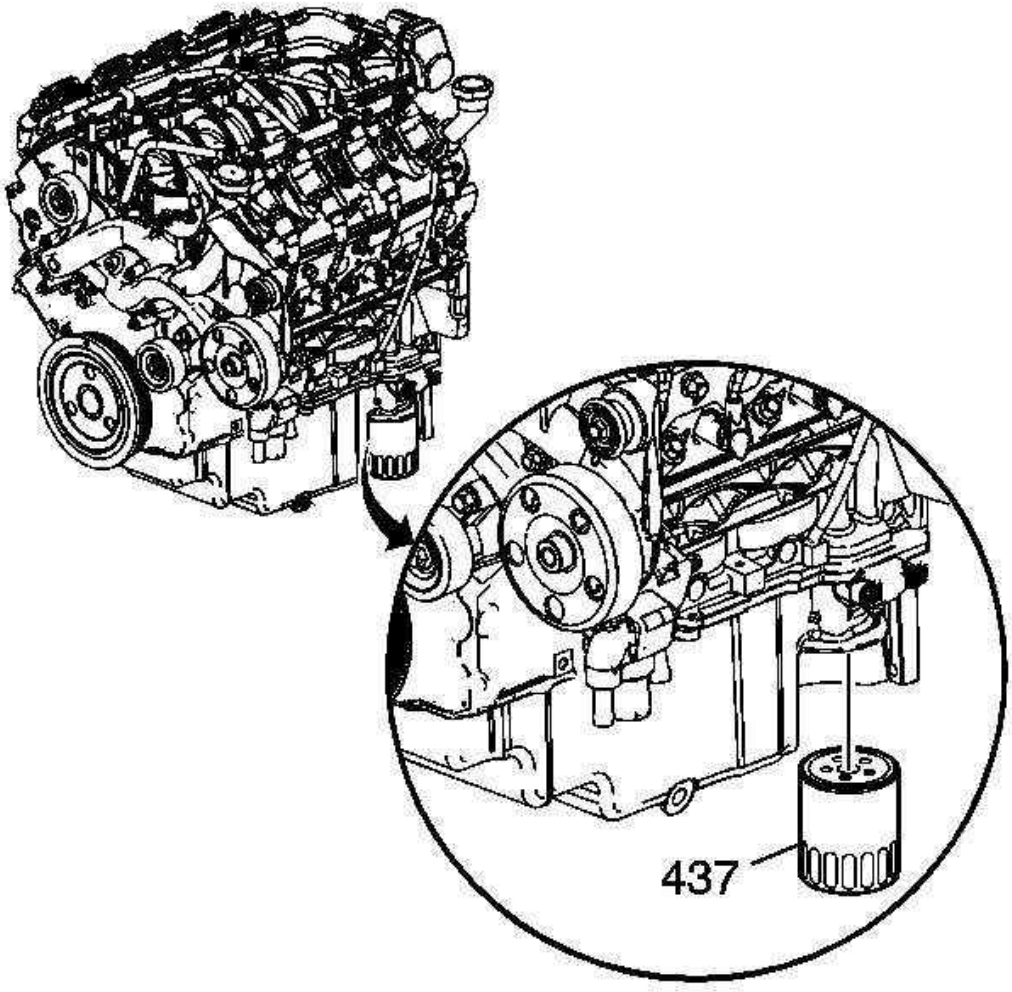


Fig. 320: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter (437).

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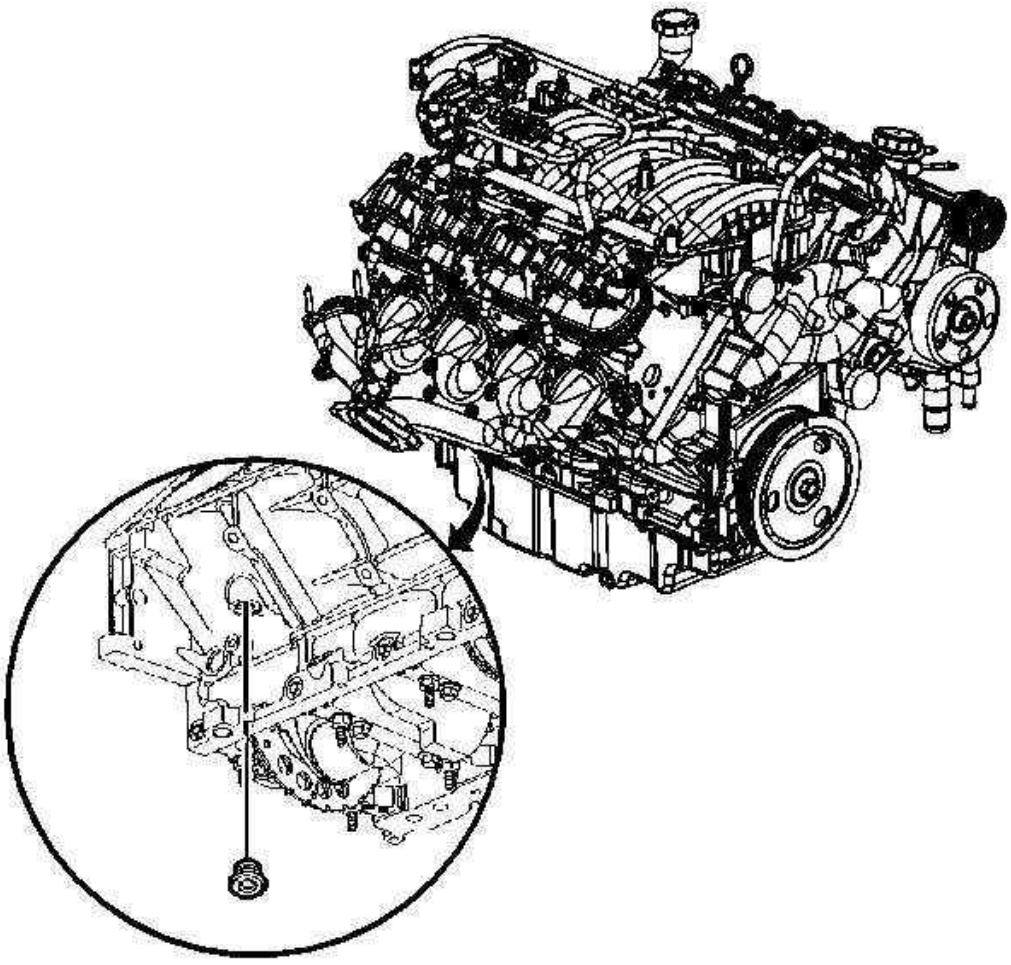


Fig. 321: View Of Right Side Rear Engine Block Coolant Drain Hole Plug & Washer
Courtesy of GENERAL MOTORS CORP.

3. Remove the right side rear engine block coolant drain hole plug and washer.

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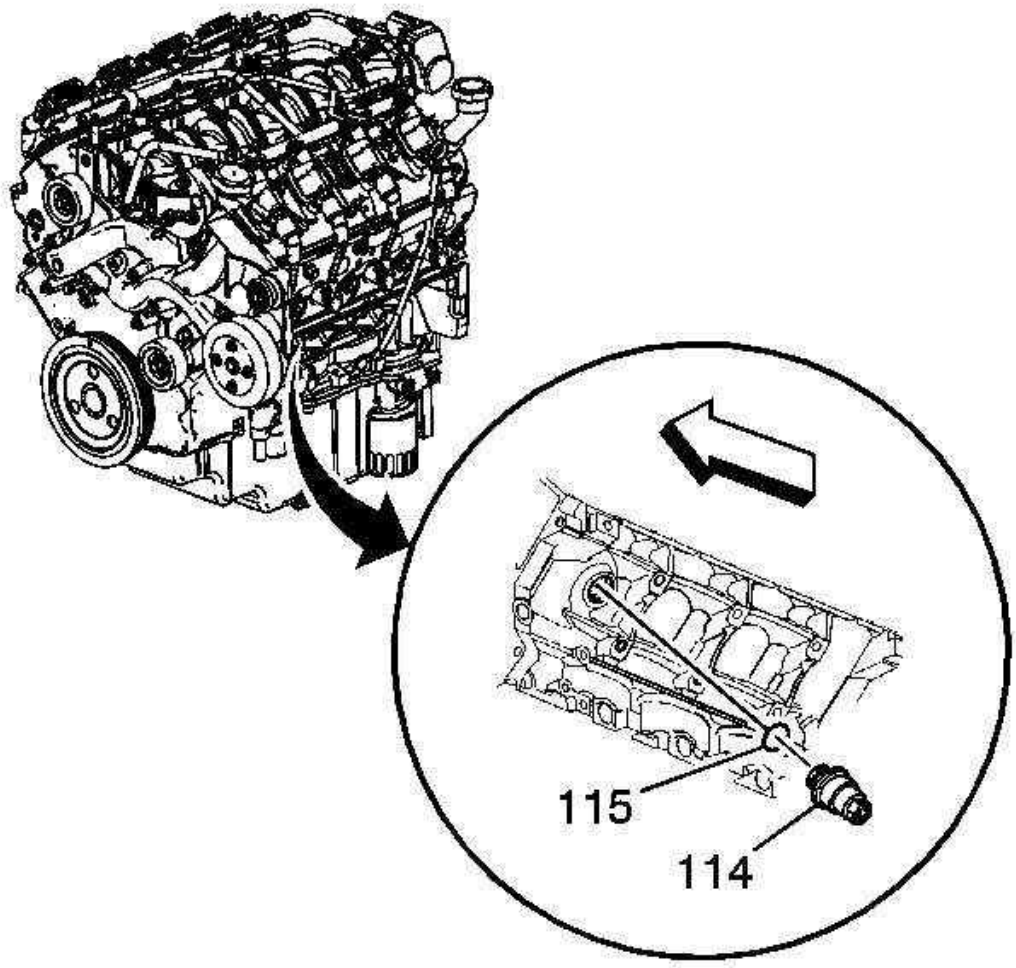


Fig. 322: View Of Engine Block Coolant Heater & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block coolant heater (114) and washer (115).

CRANKSHAFT BALANCER REMOVAL

Tools Required

- **EN 47699** Flywheel Holding Tool. See **Special Tools**.
- **J 41816** Crankshaft Balancer Remover

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- **J 41816-2** Crankshaft End Protector. See **Special Tools**.

Removal

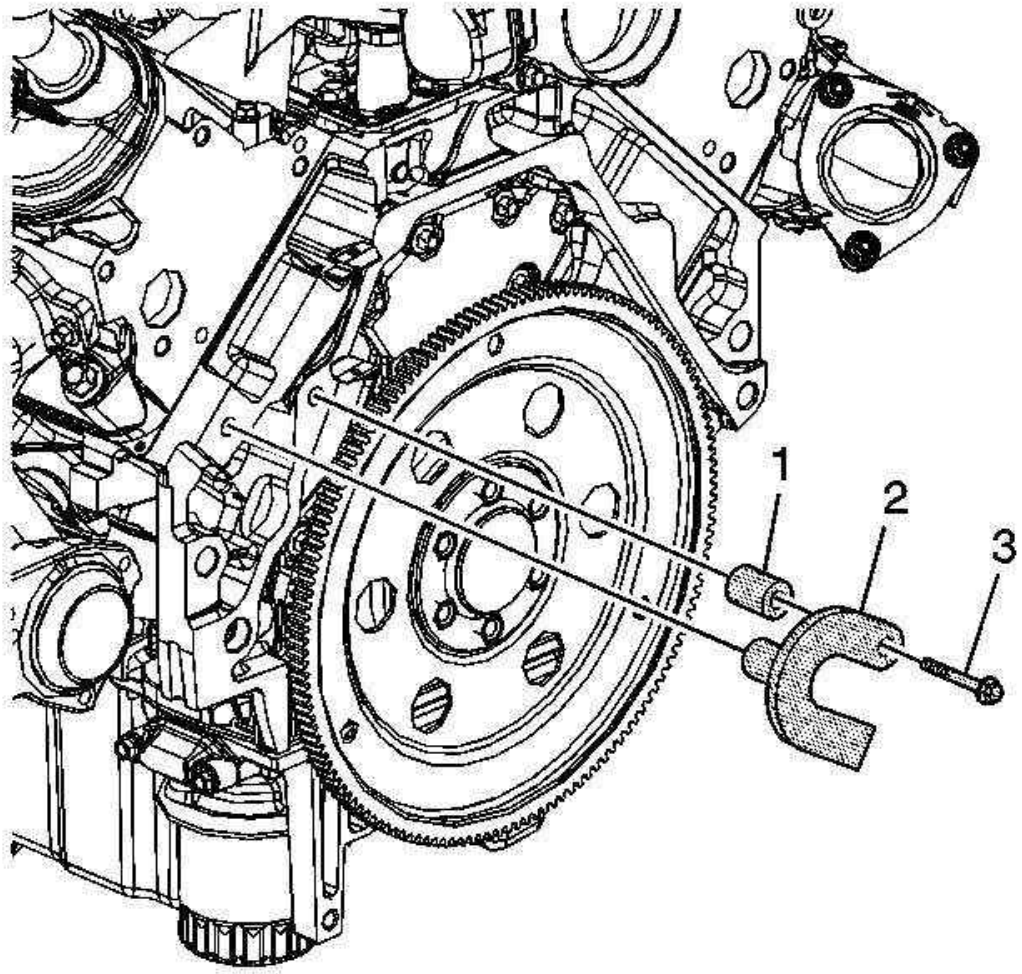


Fig. 323: View Of Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

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1. Install the **EN 47699** (2), spacer (1), and bolt (3) to the block and flex plate. See **Special Tools**.

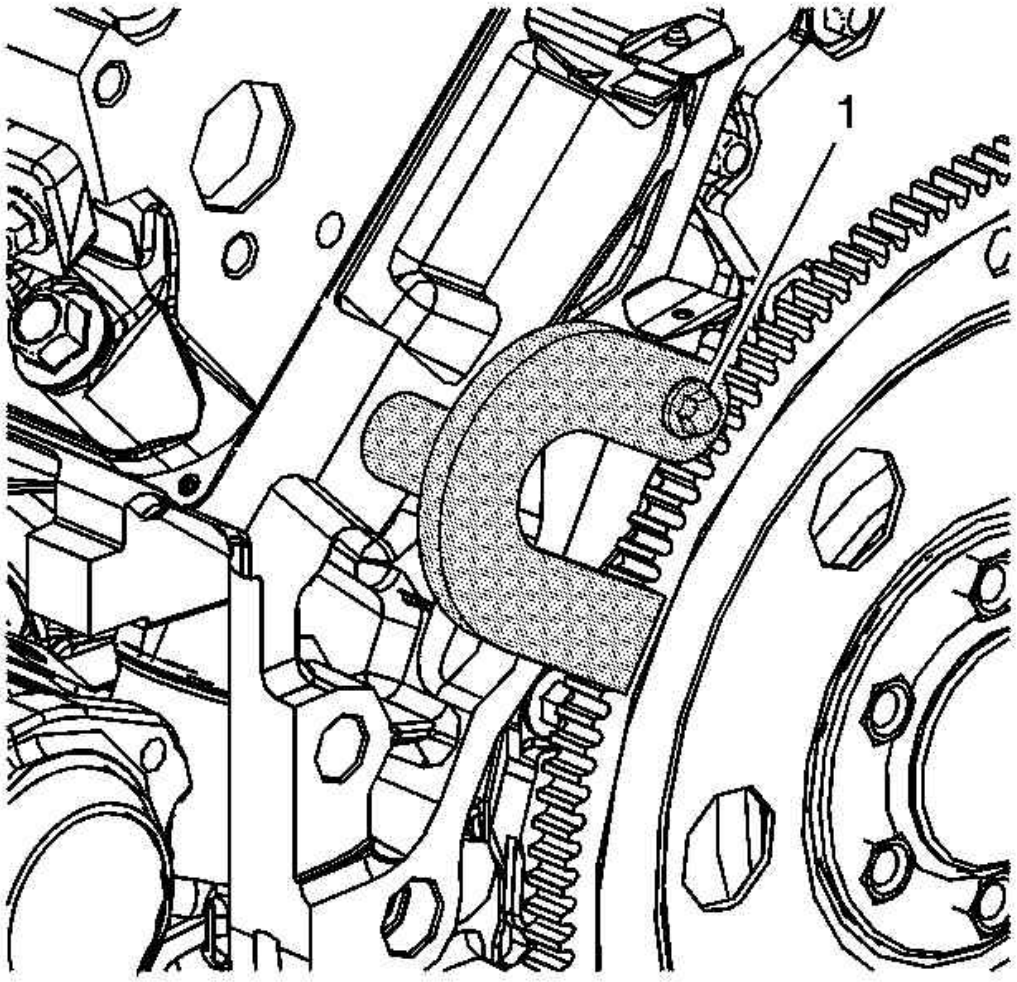


Fig. 324: Identifying Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Tighten the **EN 47699** bolt (1). See **Special Tools**.

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Tighten: Tighten the bolt to 60 N.m (44 lb ft).

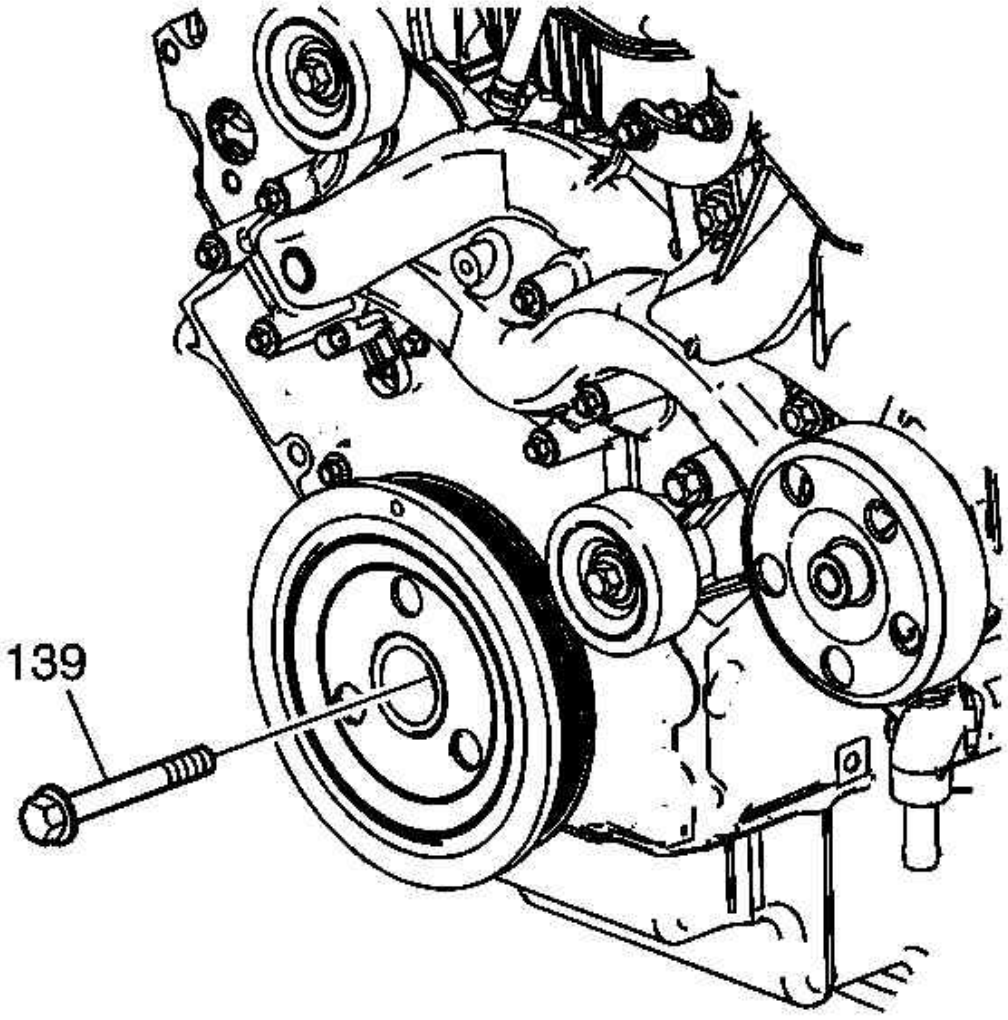


Fig. 325: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft balancer bolt (139).

   Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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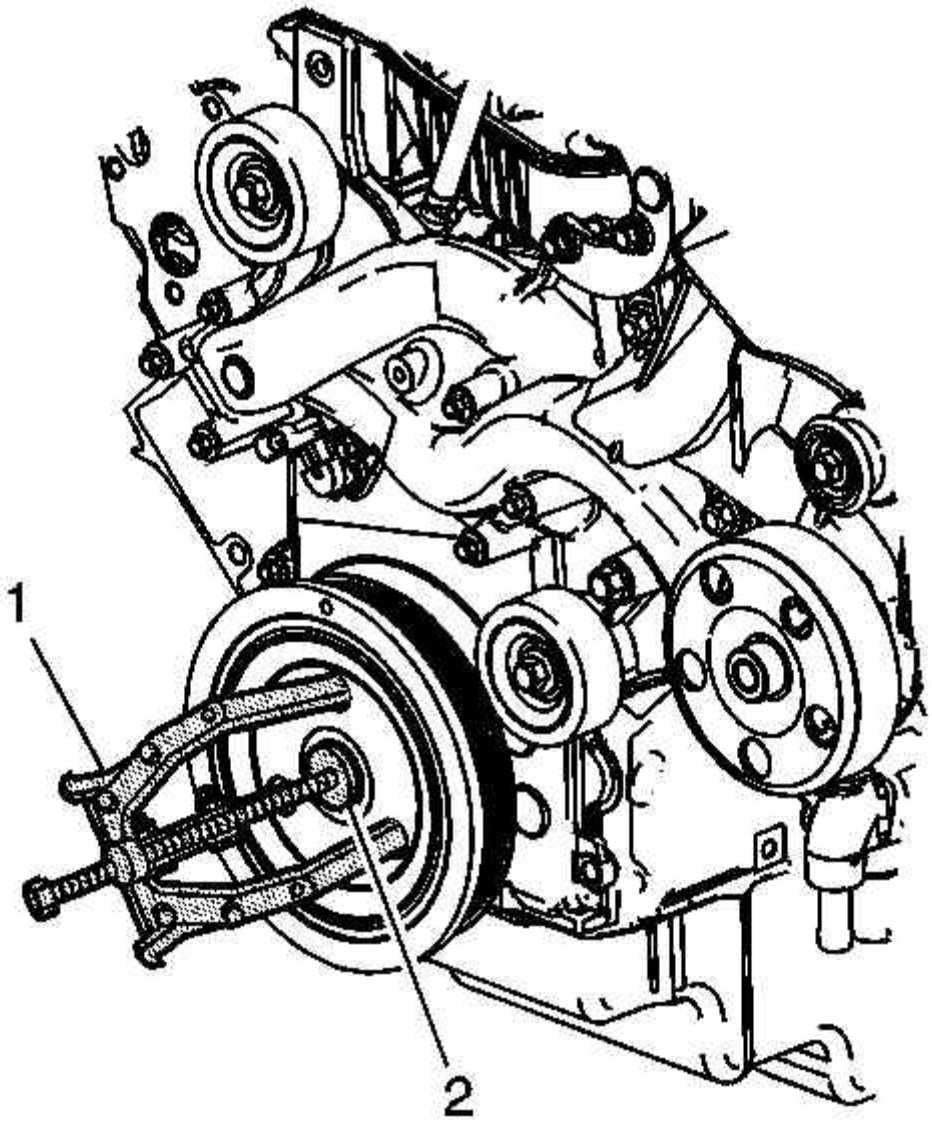


Fig. 326: View Of Special Tools & Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41816** (1) and the **J 41816-2** (2) in order to remove the crankshaft balancer. See **Special Tools**.

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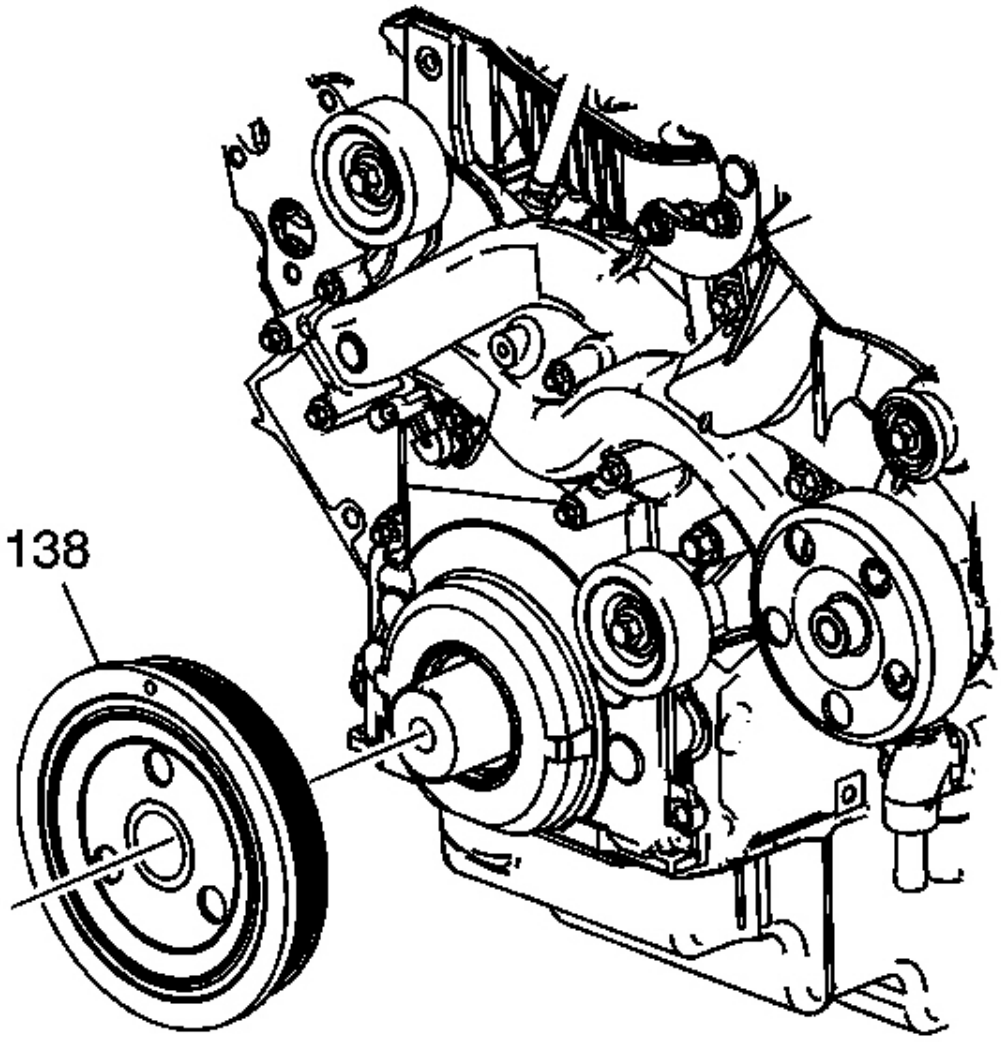


Fig. 327: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft balancer (138).
6. Remove the **EN 47699** , bolt, and spacer. See **Special Tools**.

ENGINE FLYWHEEL REMOVAL

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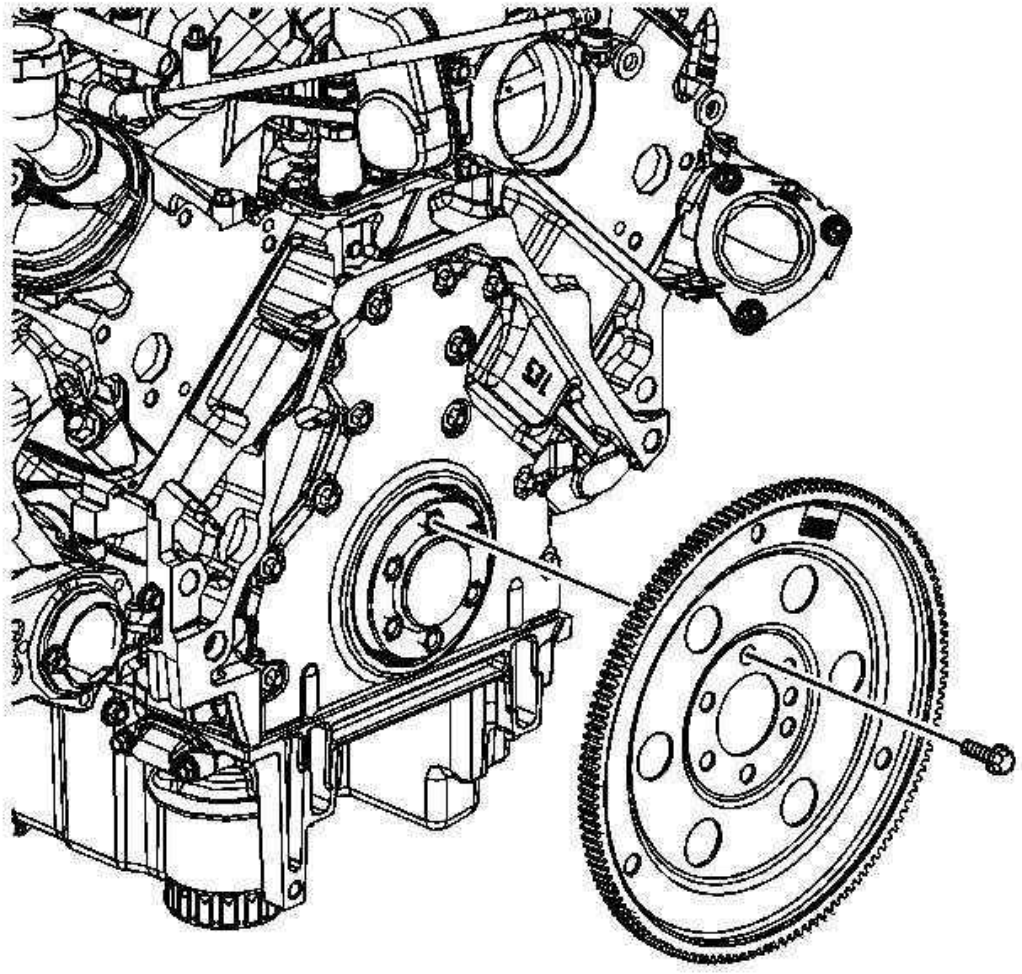


Fig. 328: Identifying Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.

1. Remove the engine flex plate bolts.

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2. Remove the flex plate.

OIL LEVEL INDICATOR AND TUBE REMOVAL

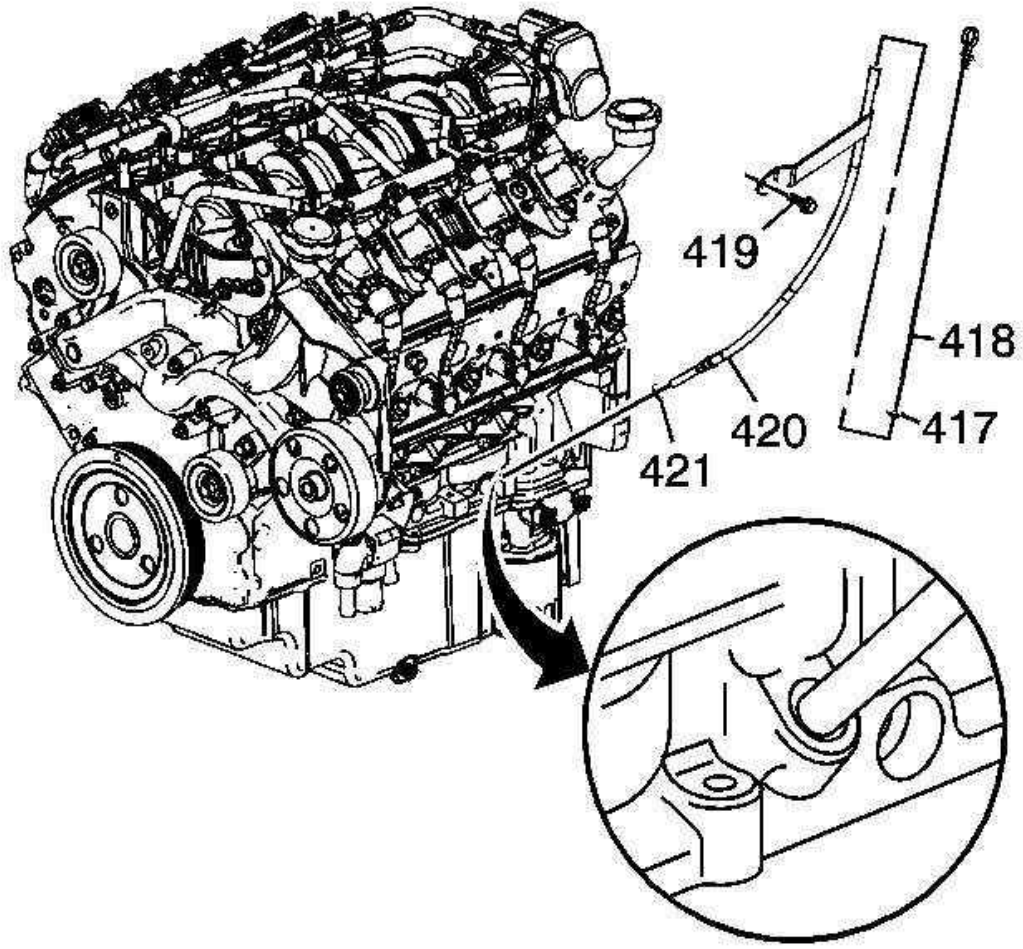


Fig. 329: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator (418) from the tube.
2. Remove the oil level indicator tube bolt (419).
3. Remove the oil level indicator tube (420).

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IMPORTANT: Inspect the O-ring for cuts or damage. The O-ring may be used again if it is not cut or damaged.

4. Remove the O-ring (421) from the tube, as required.

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

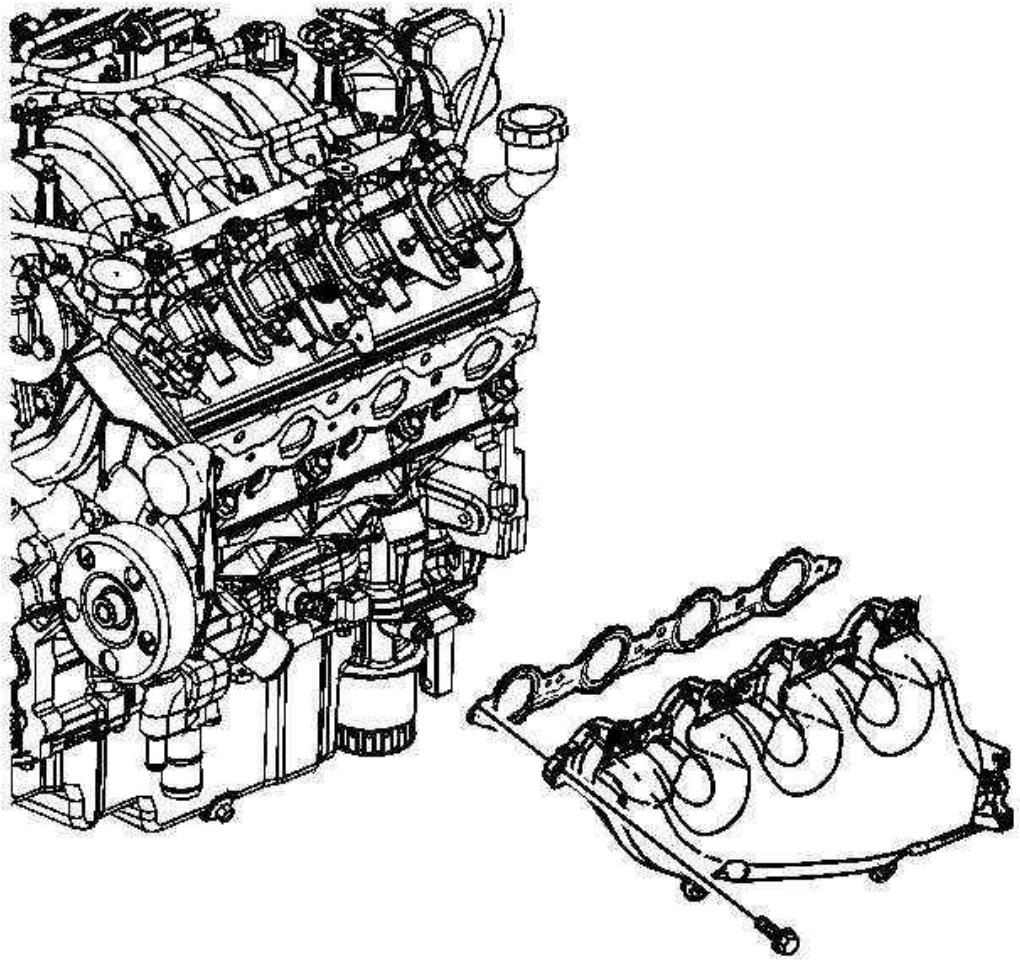


Fig. 330: View Of Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.

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2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

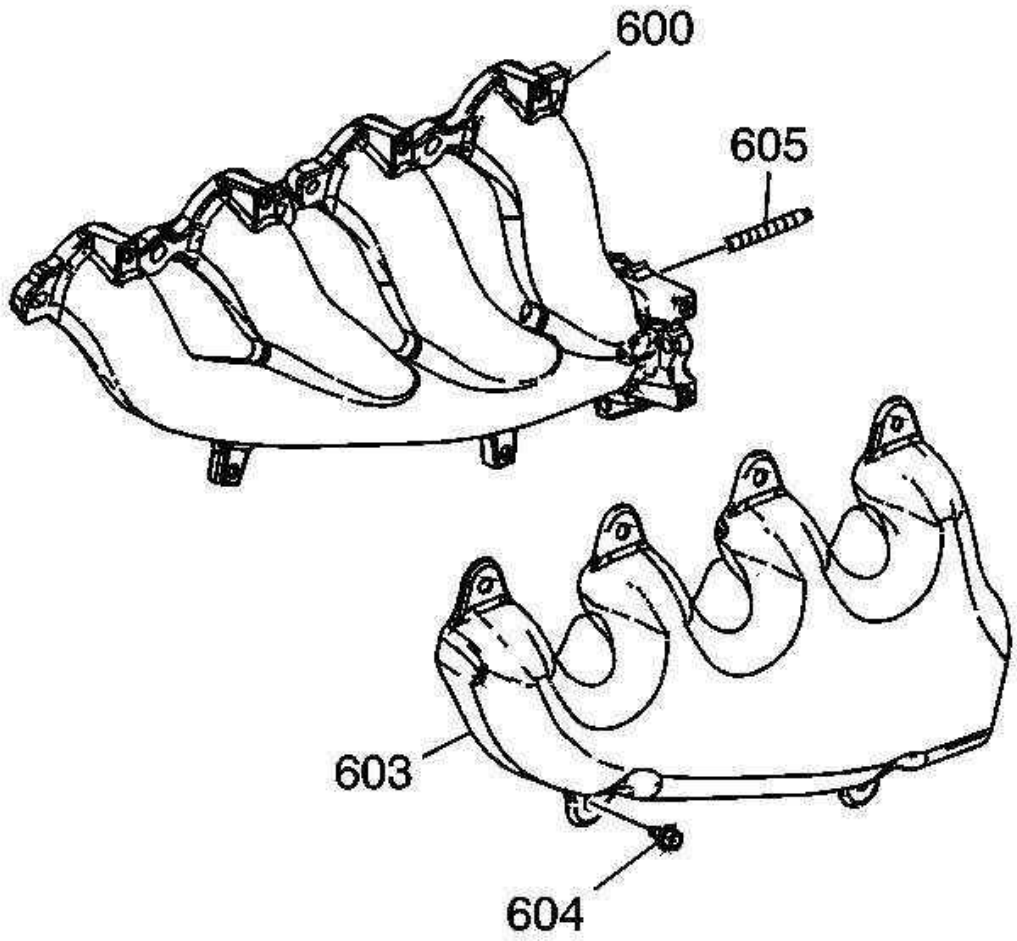


Fig. 331: Identifying Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600), as required.
5. Remove the studs (605), as required.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

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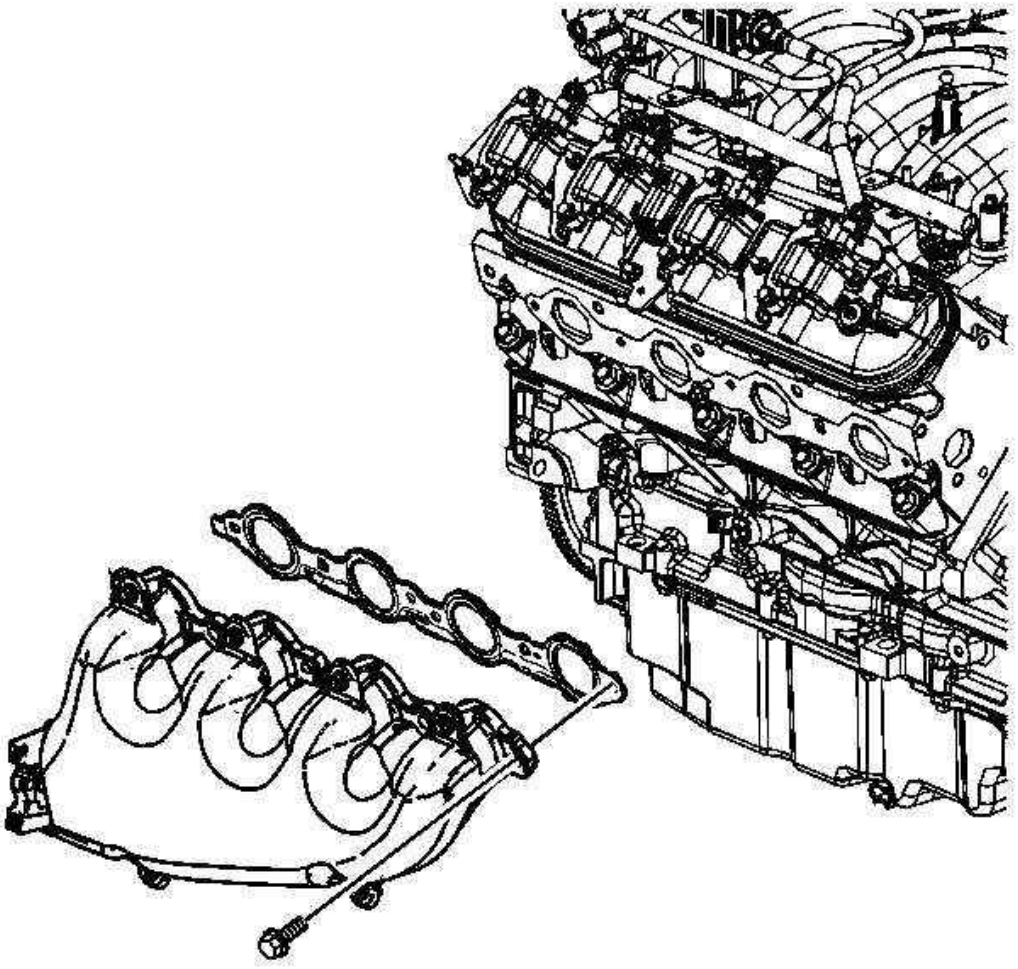


Fig. 332: View Of Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

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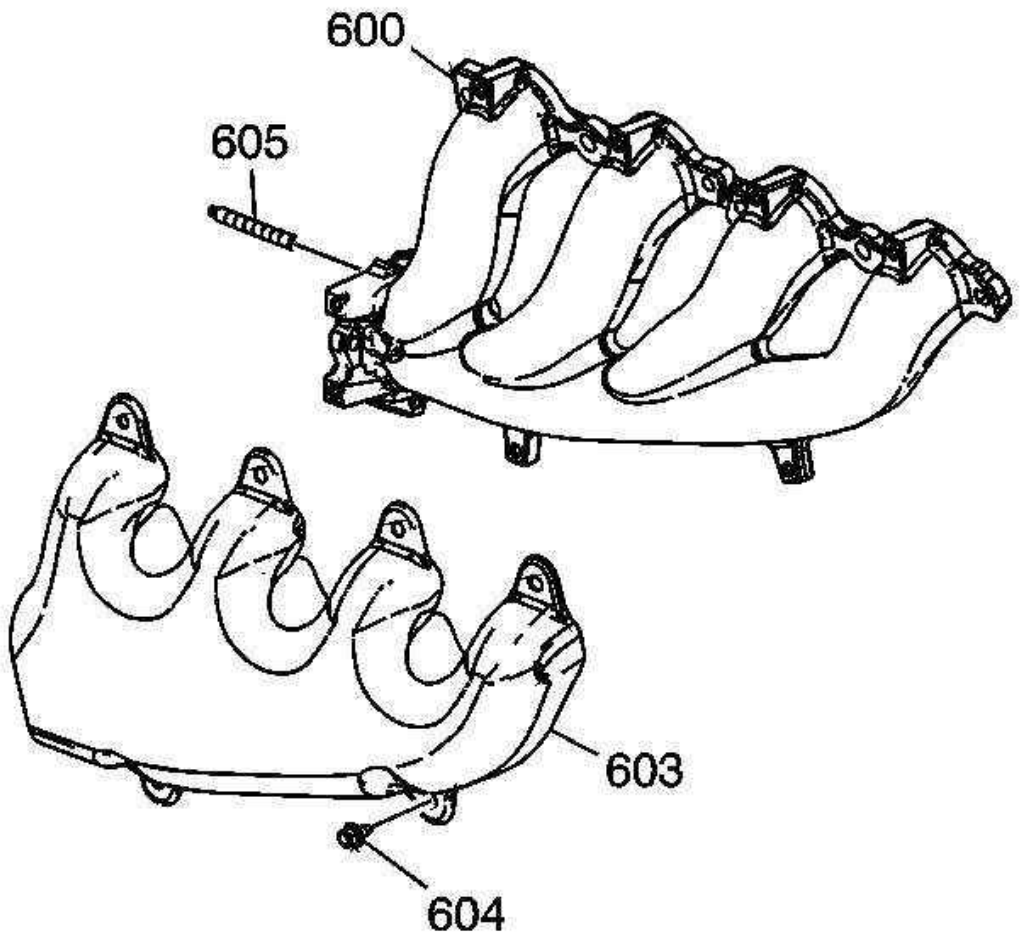


Fig. 333: View Of Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600), as required.
5. Remove the studs (605), as required.

WATER PUMP REMOVAL

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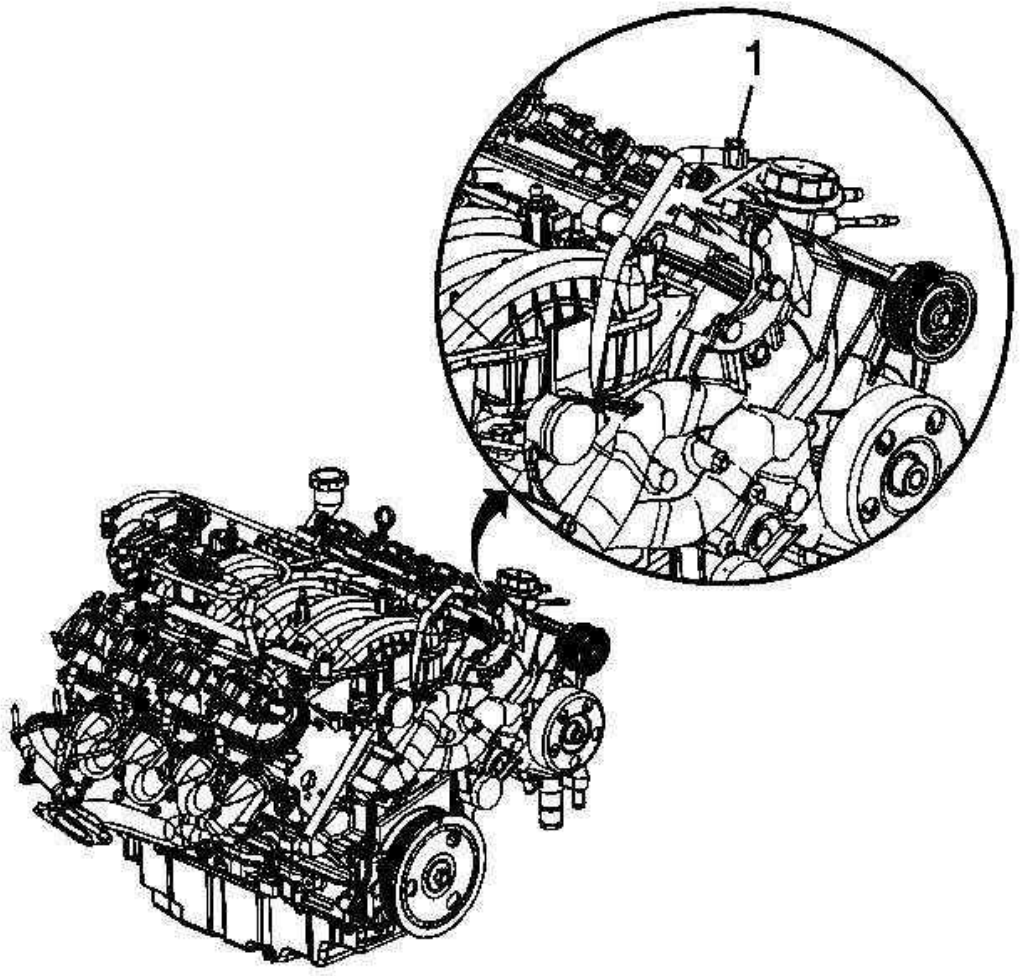


Fig. 334: Locating Engine Coolant Air Bleed Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the engine coolant air bleed hose and clamp (1).

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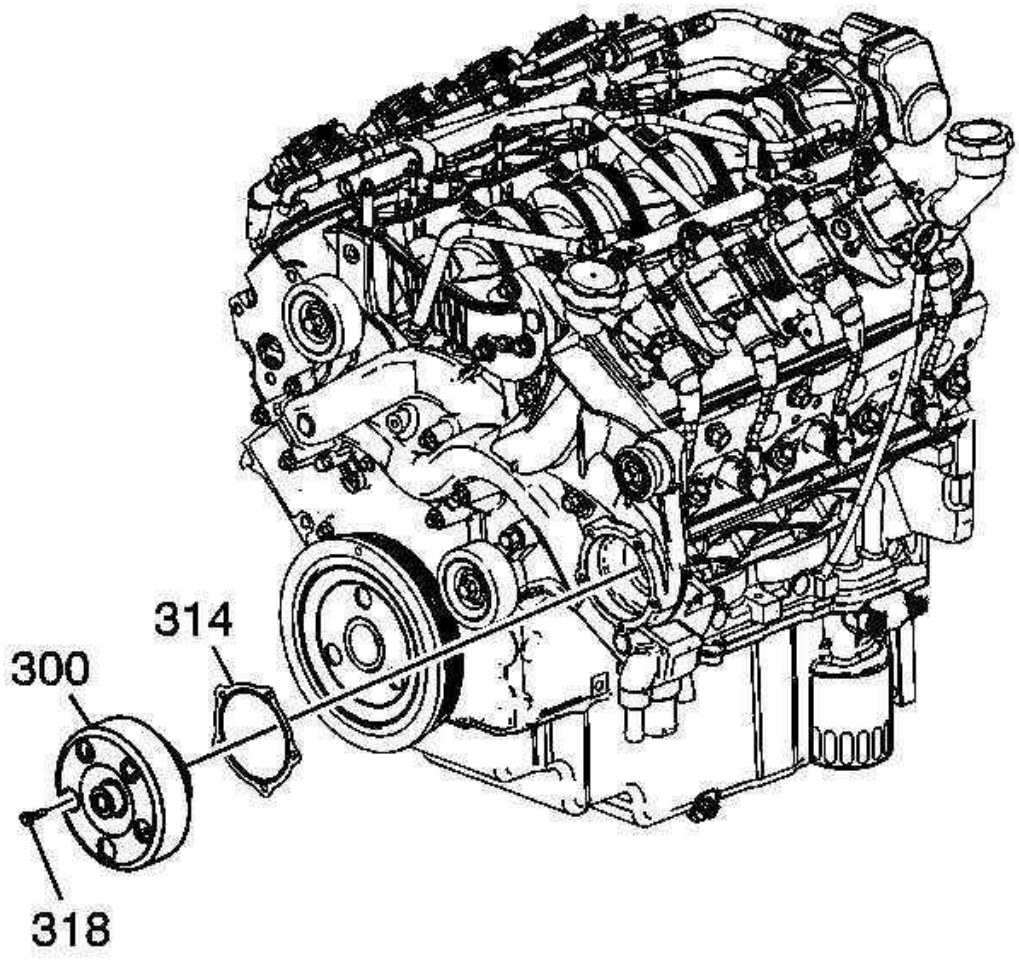


Fig. 335: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the water pump (300), bolts (318), and gasket (314).

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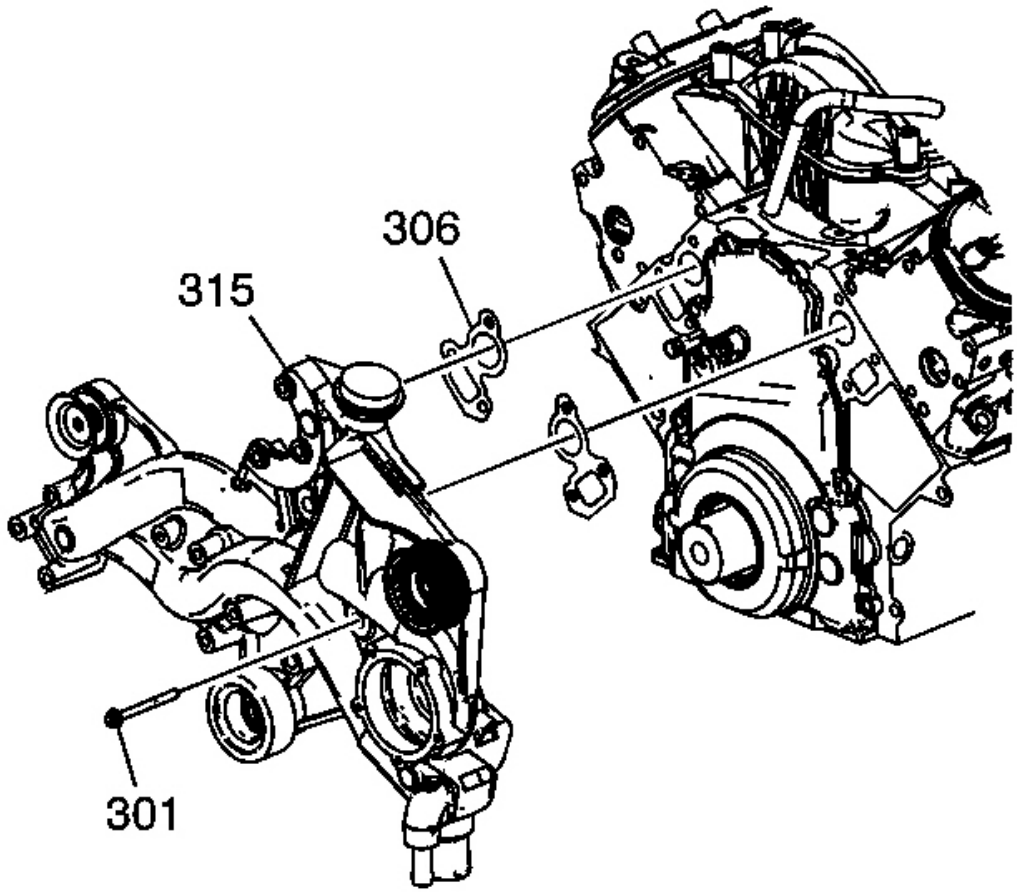


Fig. 336: View Of Water Manifold, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

3. Remove the water manifold (315), bolts (301), and gaskets (306).

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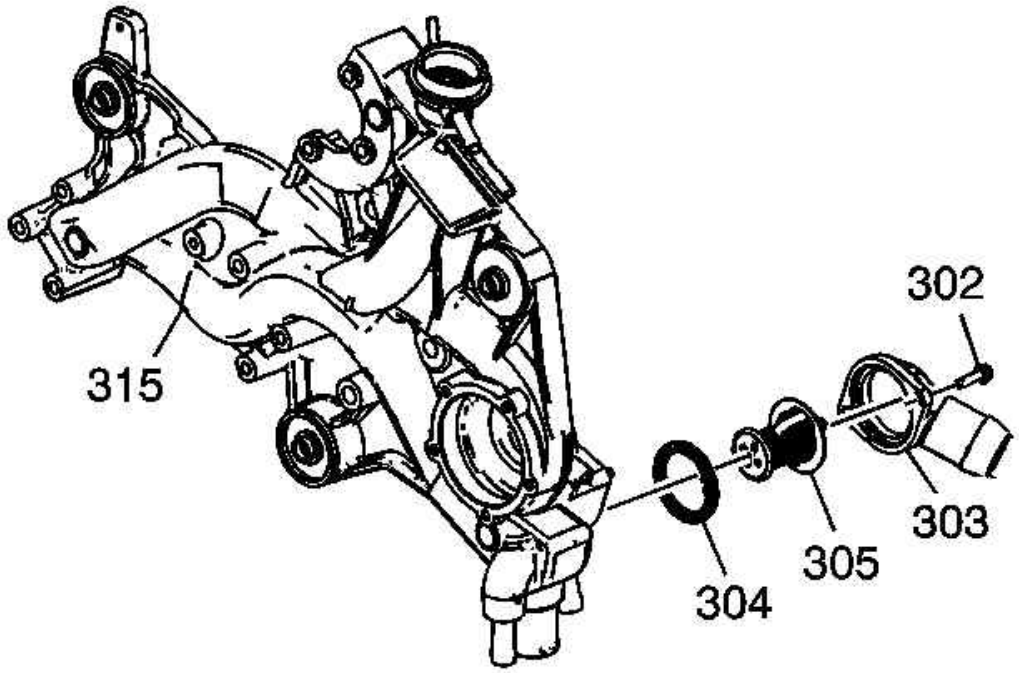


Fig. 337: View Of Thermostat Housing, Bolts, Thermostat & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Remove the water inlet housing (303), bolts (302), thermostat (305), and O-ring (304), as required.
5. Discard the gaskets.

THROTTLE BODY REMOVAL

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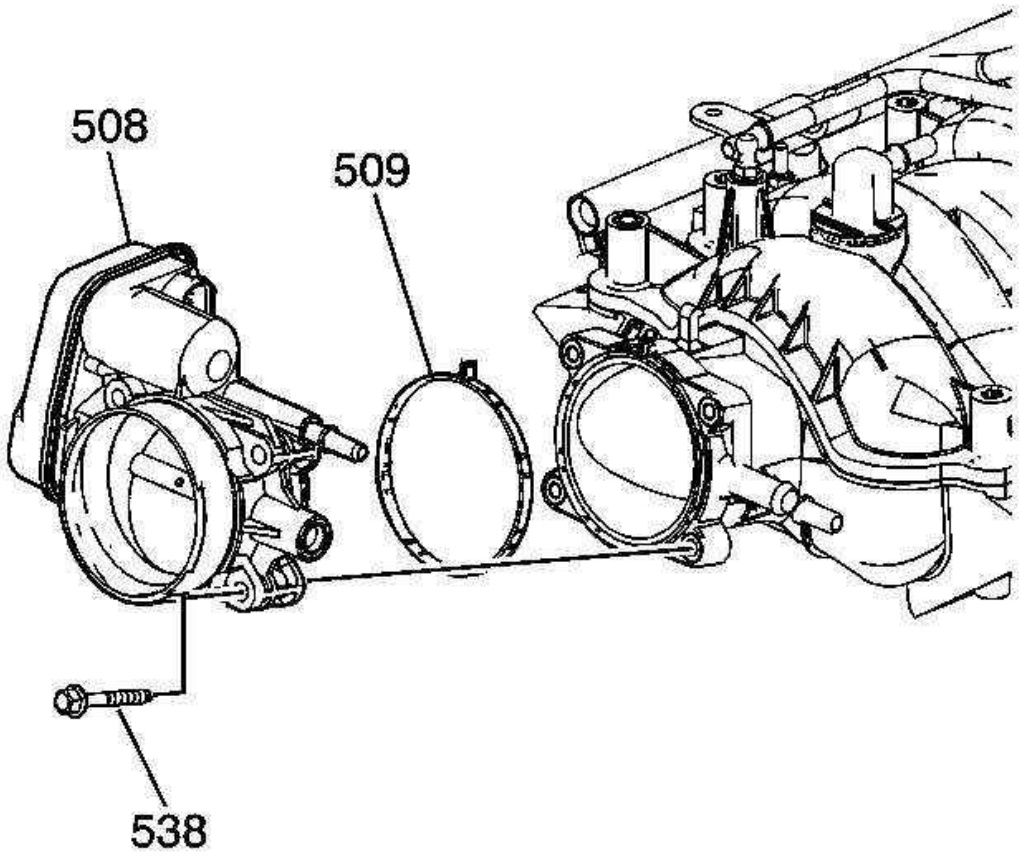


Fig. 338: Exploded View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the throttle body bolts (538).
3. Remove the throttle body (508).
4. Remove the throttle body gasket (509).

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5. Discard the gasket.

FUEL RAIL AND INJECTORS REMOVAL

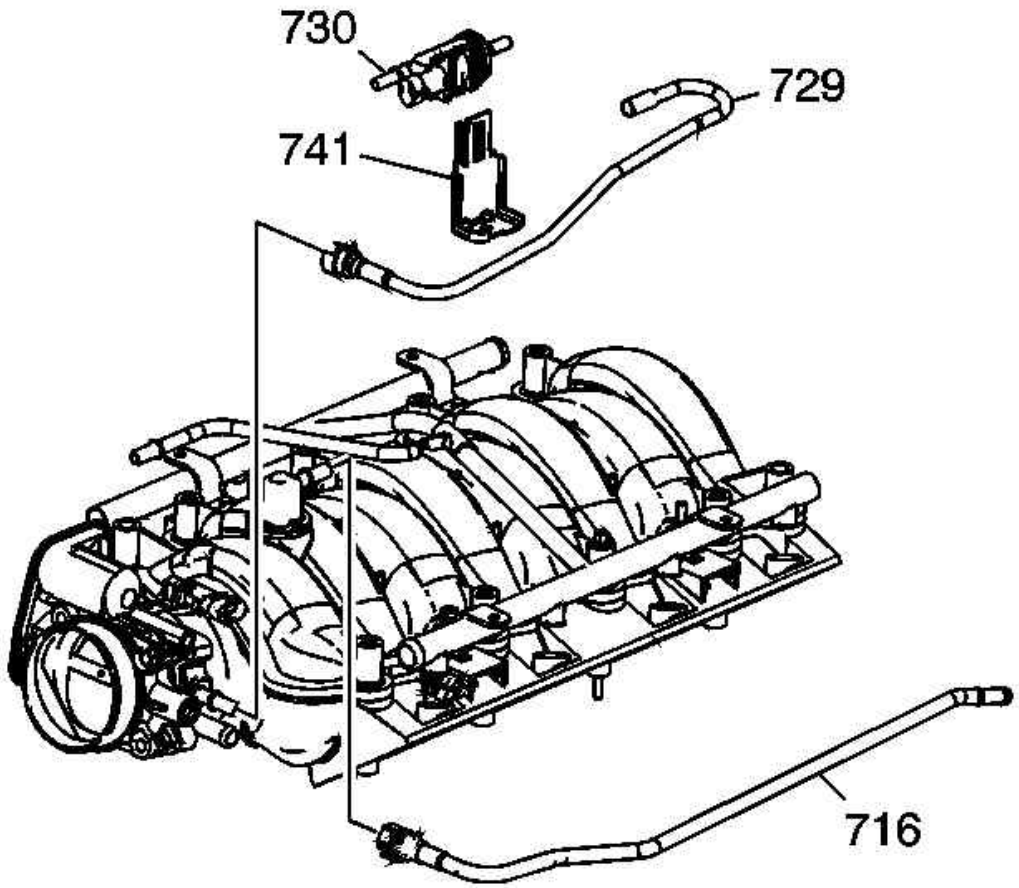


Fig. 339: View Of EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution .

NOTE:

- **Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector**

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terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.

- **Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.**

IMPORTANT: The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the intake manifold as a complete assembly.

1. Remove the positive crankcase ventilation (PCV) dirty air hose (716).
2. Remove the evaporative emission (EVAP) canister purge solenoid valve (730), bracket (741), and tube (729).

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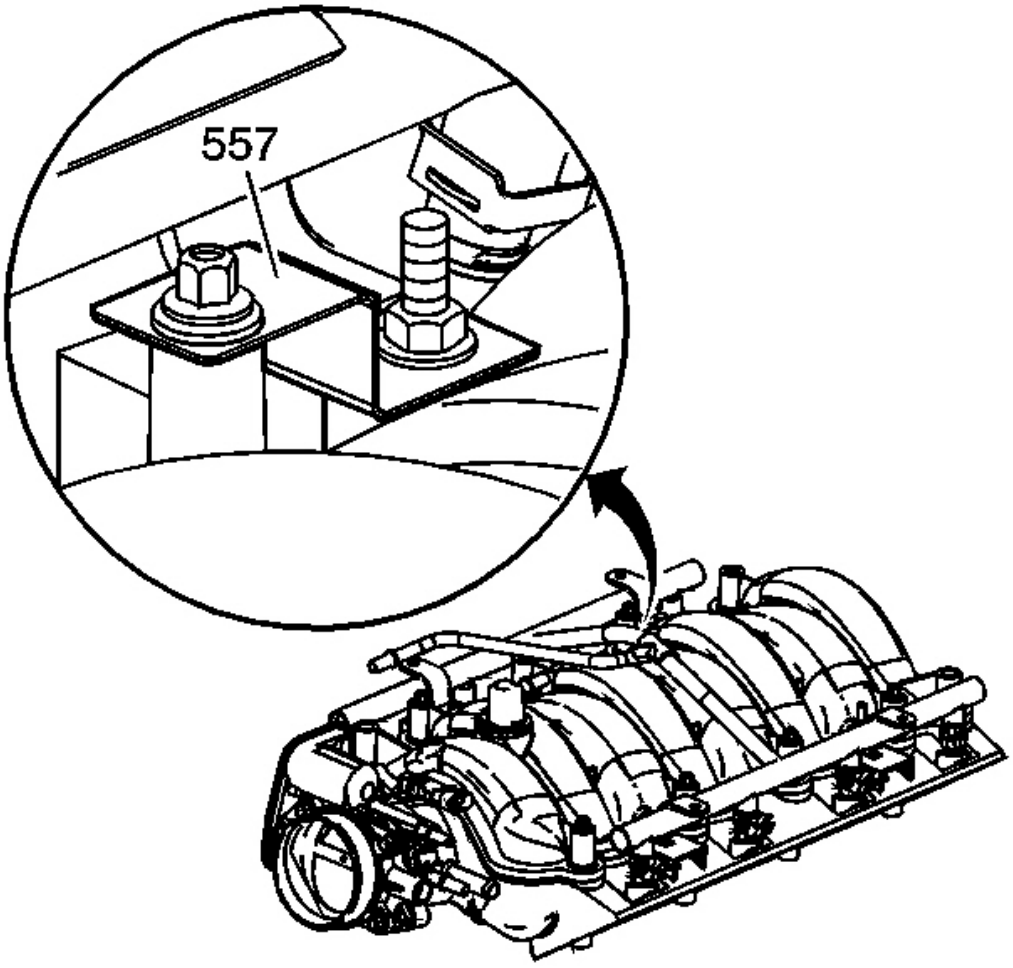


Fig. 340: View Of Fuel Rail Ground Strap
Courtesy of GENERAL MOTORS CORP.

3. Note the location of the fuel rail ground strap (557).

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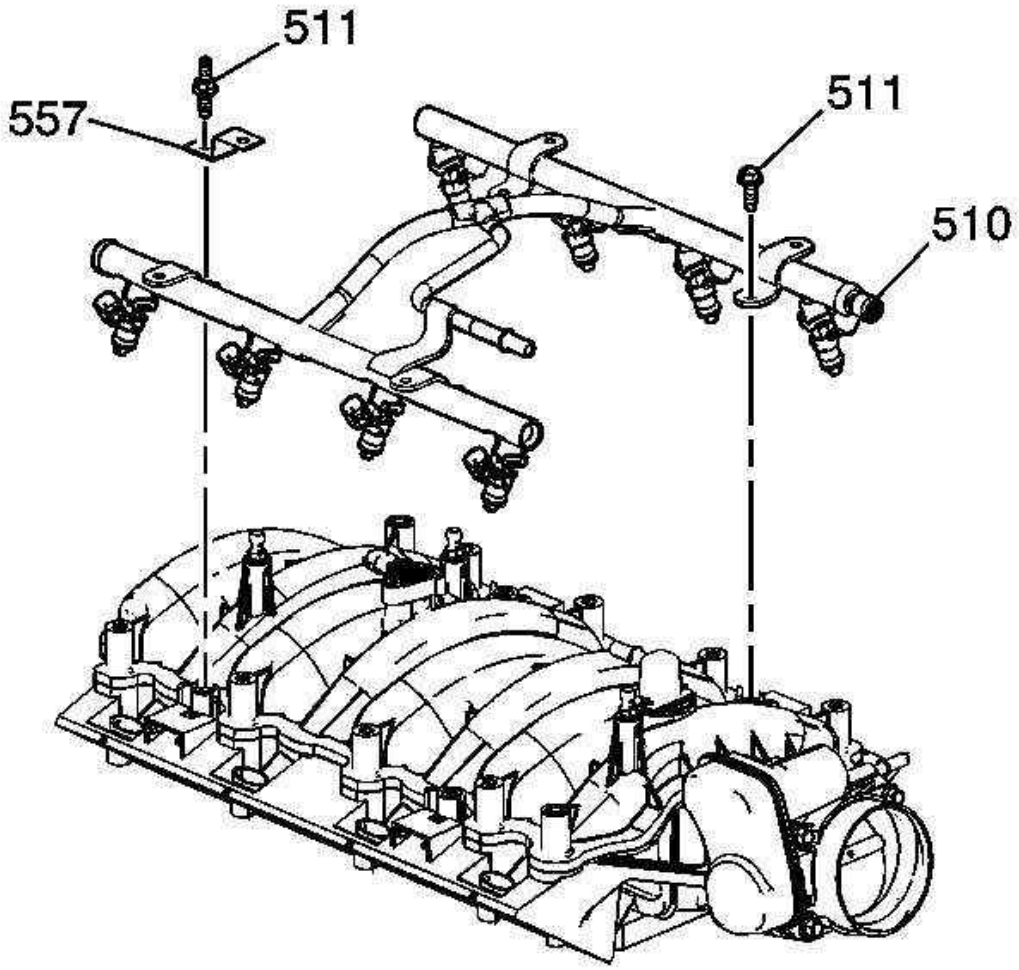


Fig. 341: View Of Fuel Rail Bolts & Ground Strap
Courtesy of GENERAL MOTORS CORP.

4. Remove the fuel rail bolts (511) and ground strap (557).

IMPORTANT:

- **Do not separate the fuel injectors from the fuel rail, unless component service is required.**
- **Use cleanliness and care when handling the fuel system components.**

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- **Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends, as necessary.**

5. Remove the fuel rail (510) with injectors. Lift evenly on both sides of the fuel rail until all injectors have left their bores.

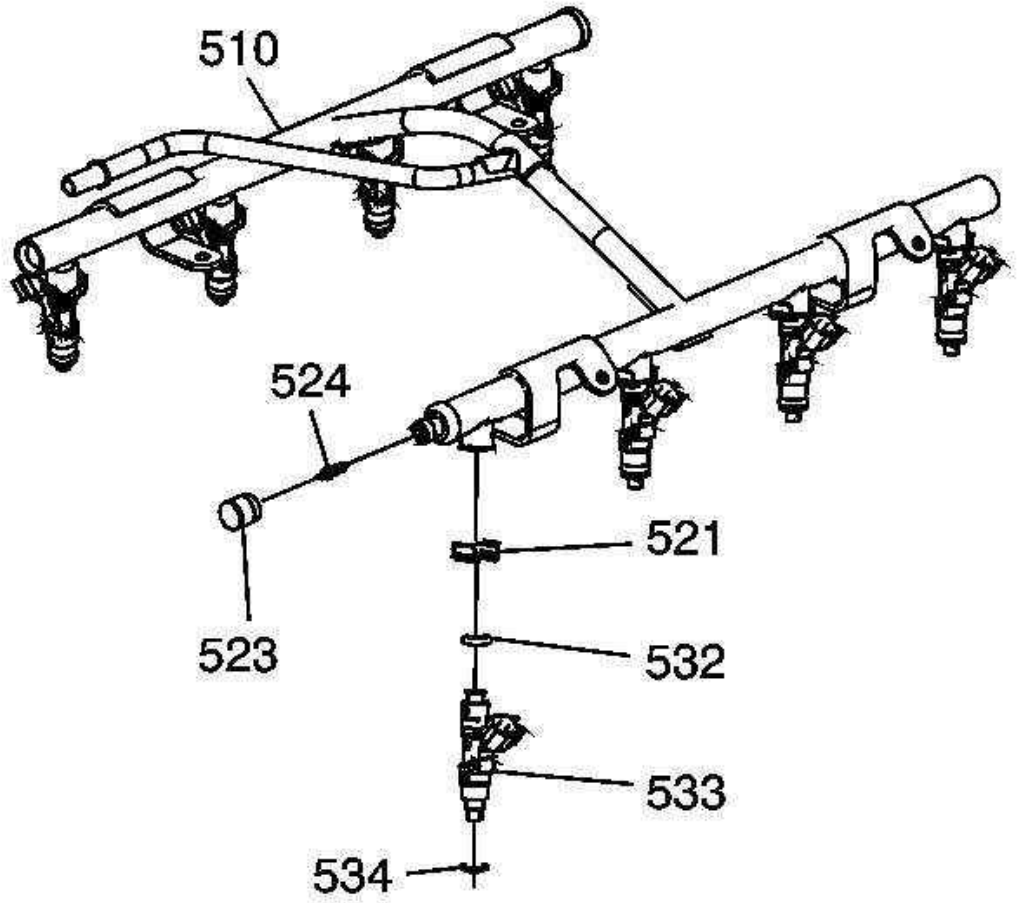


Fig. 342: View Of Fuel Rail With Injectors
Courtesy of GENERAL MOTORS CORP.

6. Remove the fuel injector retainers (521) and fuel injectors (533), as required.

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7. Remove the O-rings (532, 534) from the injectors, as required.

INTAKE MANIFOLD REMOVAL

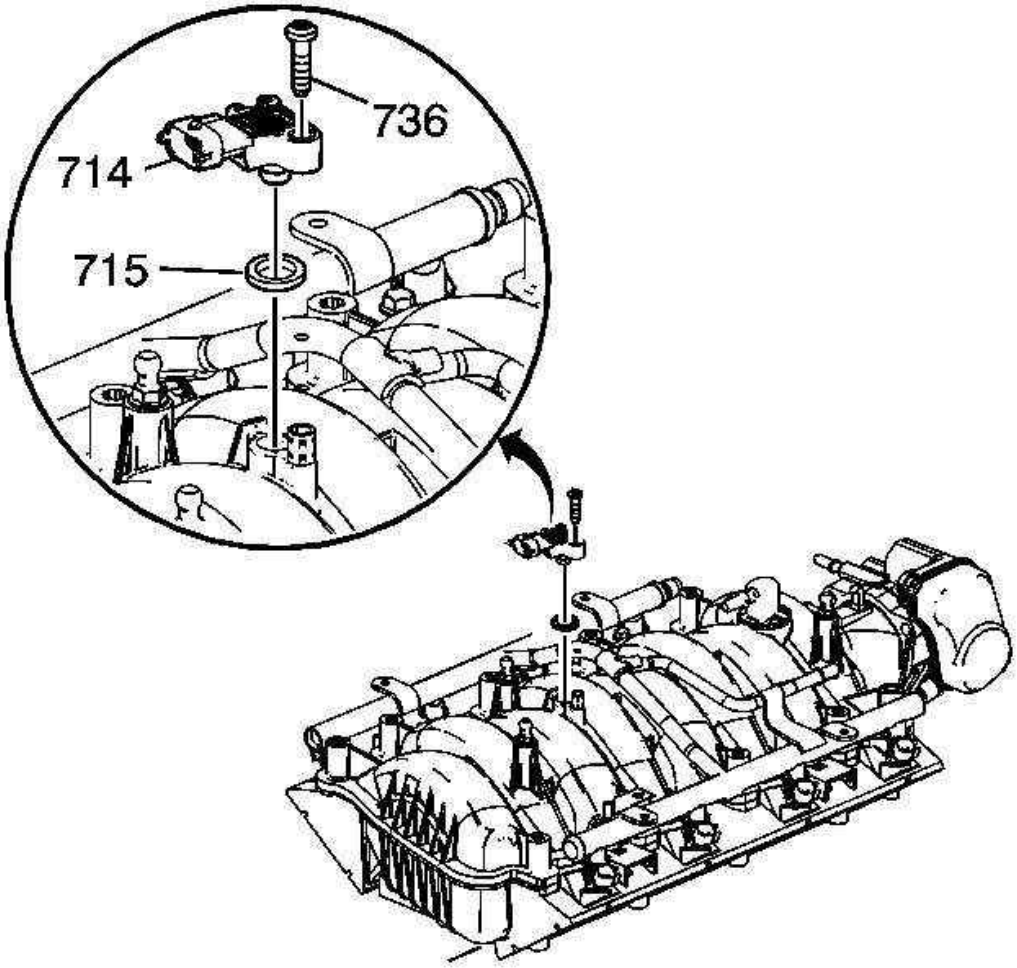


Fig. 343: Identifying MAP Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual**

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components, remove the manifold as a complete assembly.

- **DO NOT use the intake manifold-to-cylinder head gaskets again.**

1. Remove the manifold absolute pressure (MAP) sensor (714) and bolt (736).
2. Remove the seal (715) from the sensor, as required.

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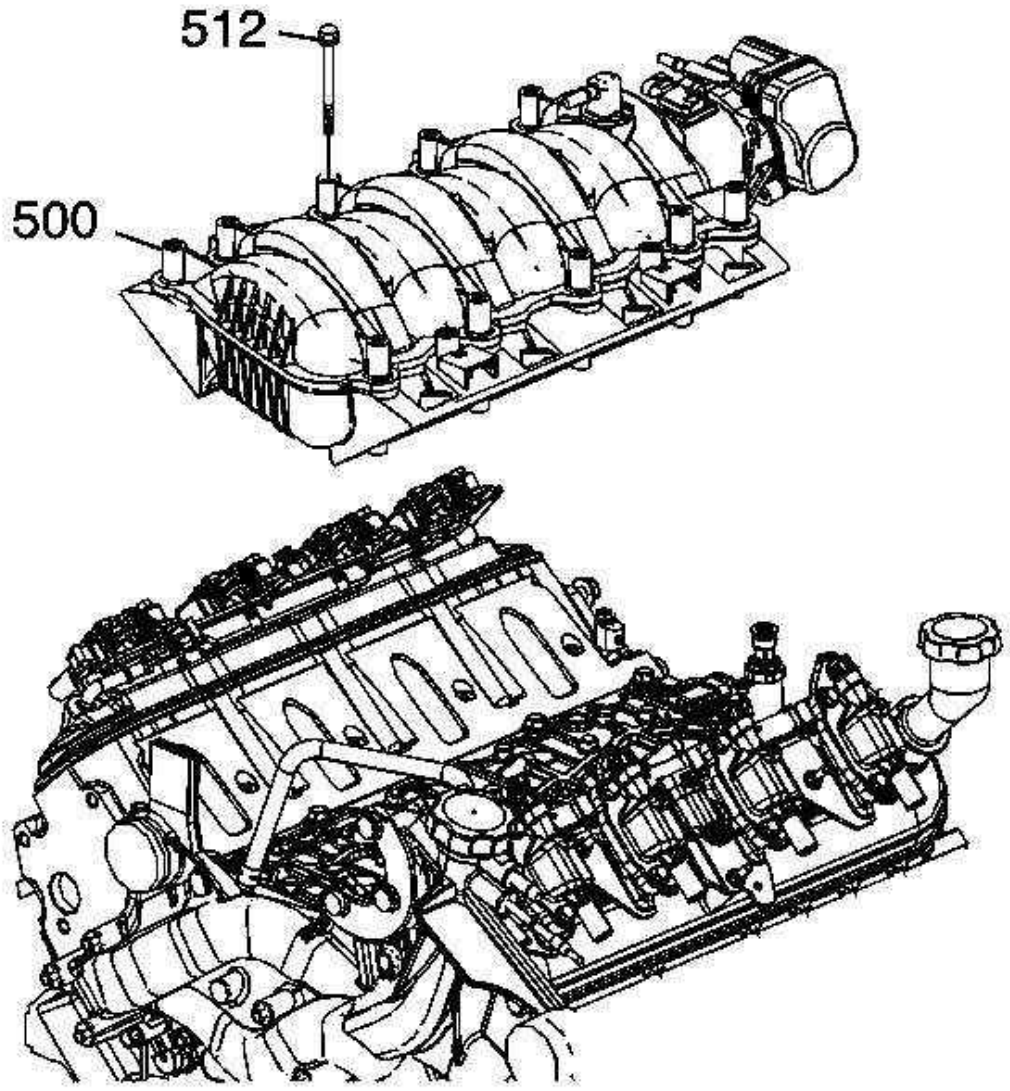


Fig. 344: View Of The Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake manifold bolts (512).
4. Remove the intake manifold (500).

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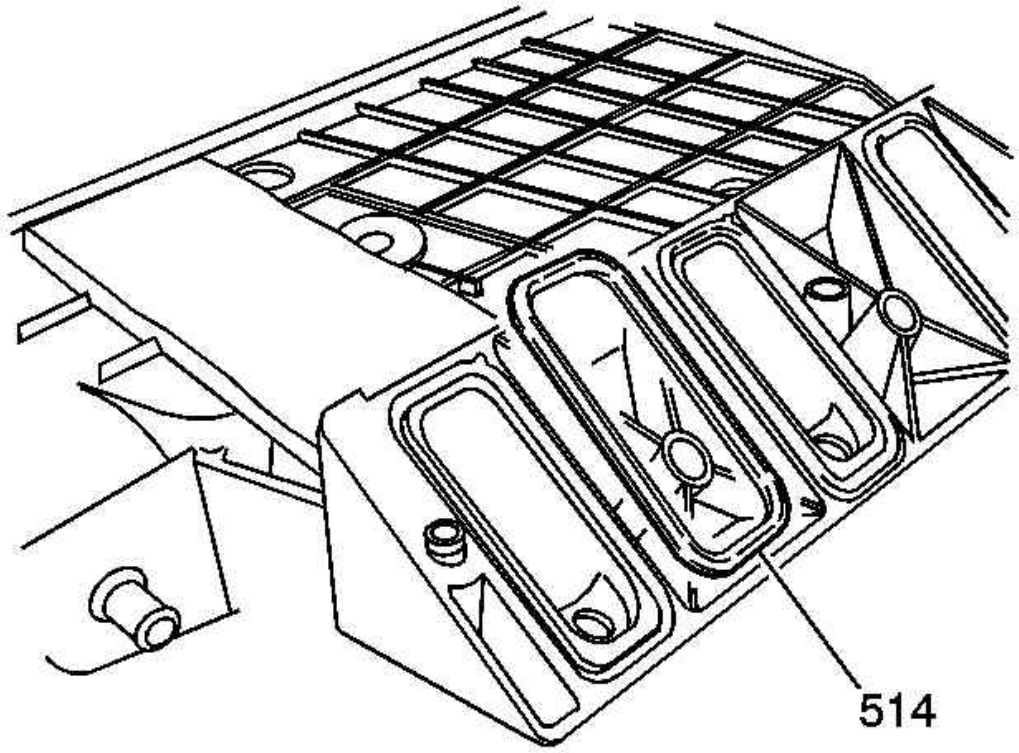


Fig. 345: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake manifold gaskets (514).
6. Discard the intake manifold gaskets.

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER REMOVAL

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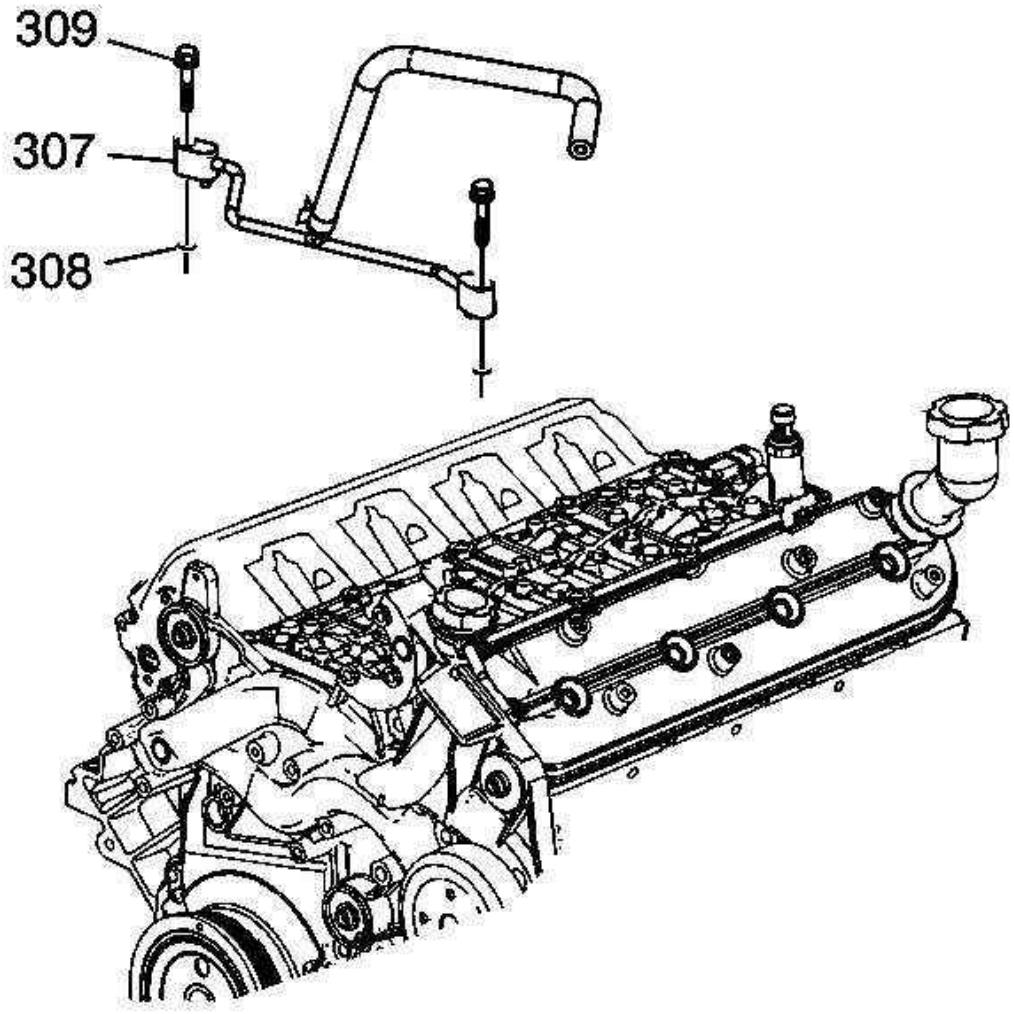


Fig. 346: View Of Coolant Air Bleed Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with hose and seals (308).

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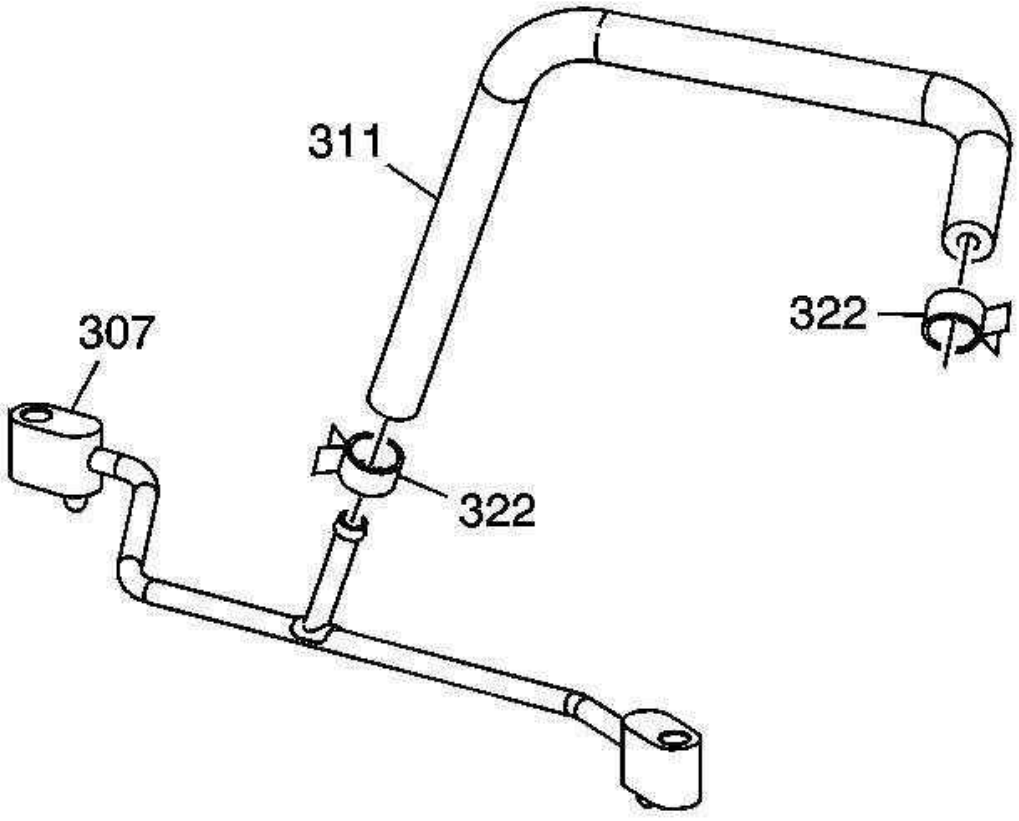


Fig. 347: View Of Coolant Air Bleed Pipe & Clamp
Courtesy of GENERAL MOTORS CORP.

3. Remove the hose (311) and clamps (322) from the pipe (307), as required.

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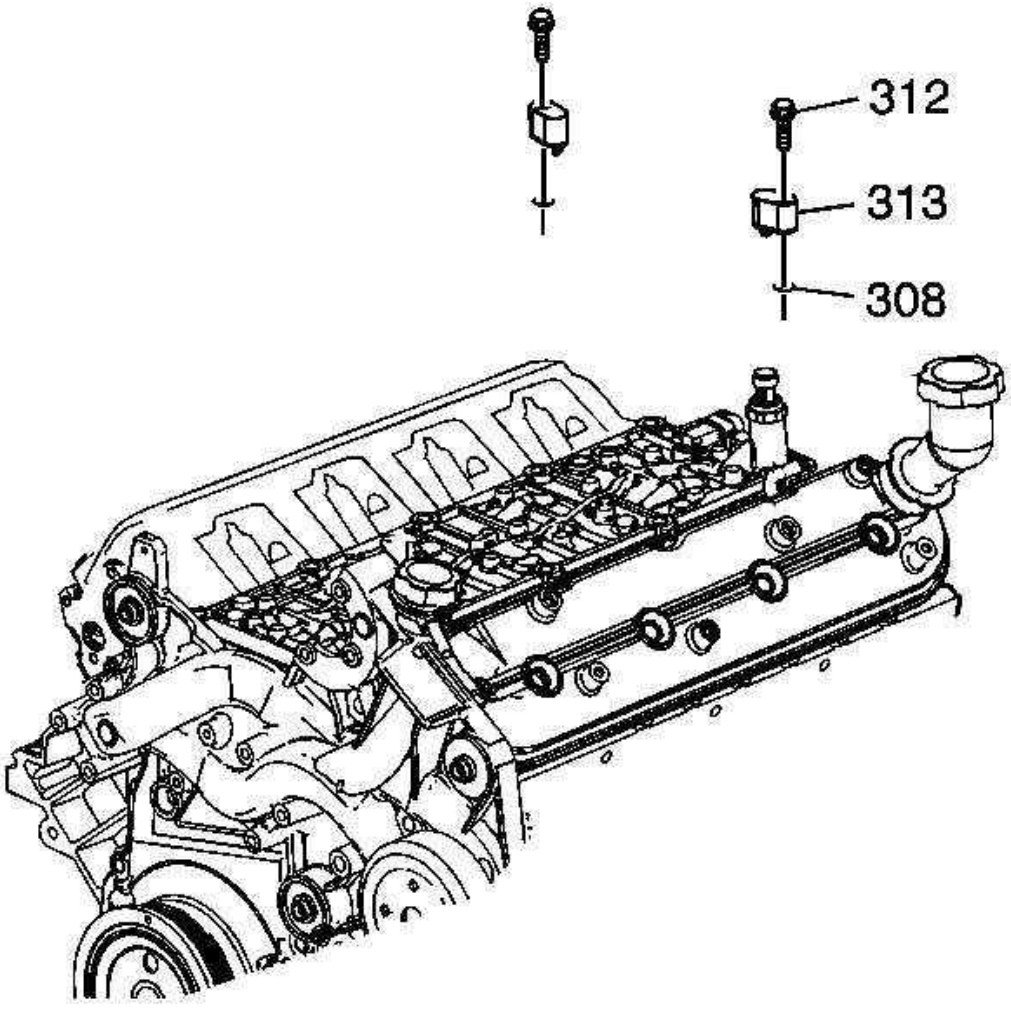


Fig. 348: View Of Engine Coolant Air Bleed Cover, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine coolant air bleed cover bolts (312).
5. Remove the covers (313) with seals (308).

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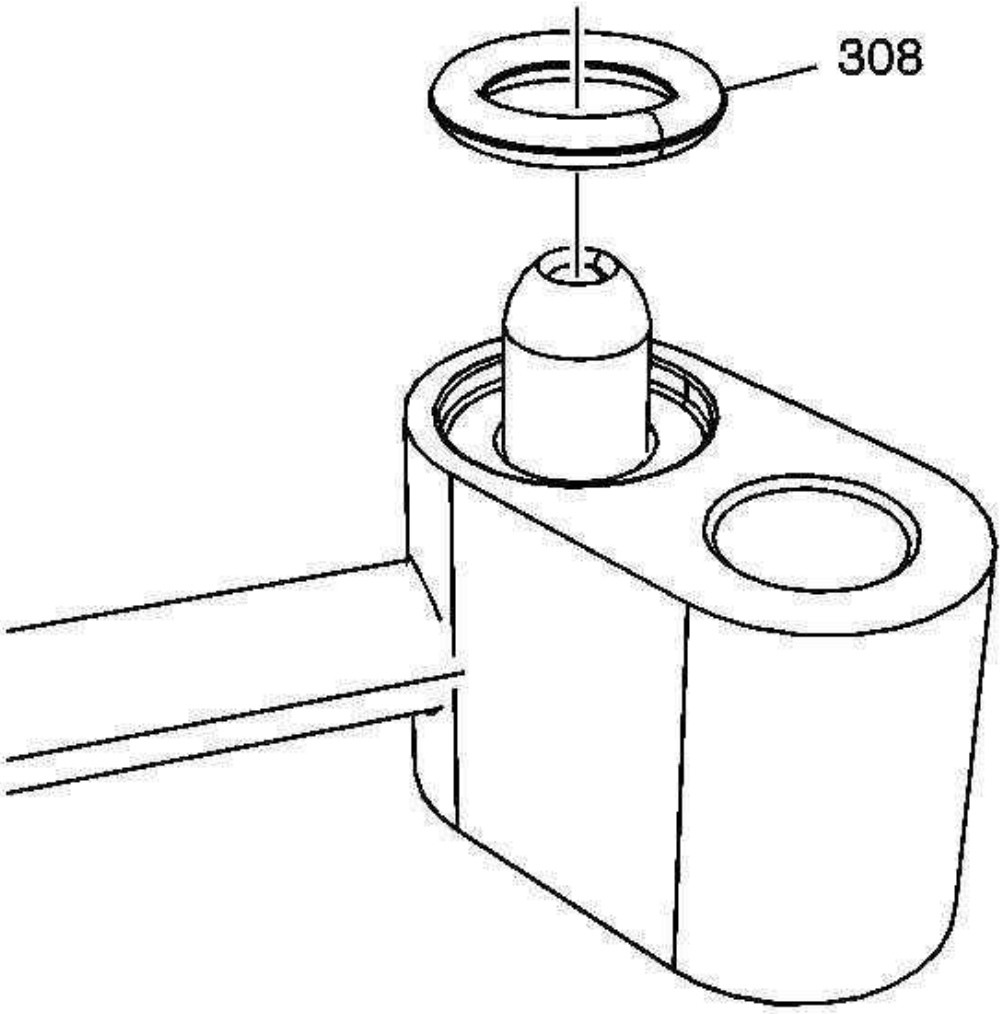


Fig. 349: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

6. Remove the seals (308) from the pipe and covers.
7. Discard the seals.

VALVE LIFTER OIL MANIFOLD REMOVAL

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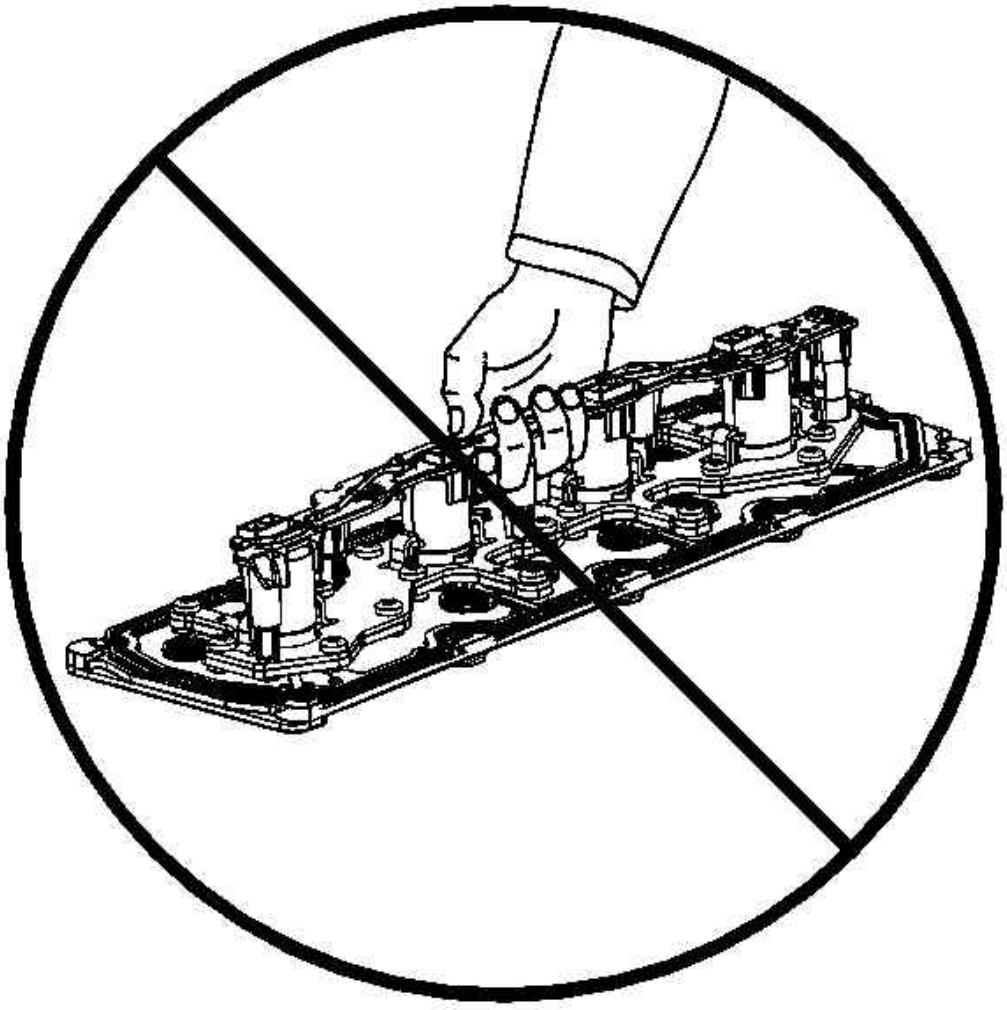


Fig. 350: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

1. Do not lift the manifold assembly by the electrical lead frame.

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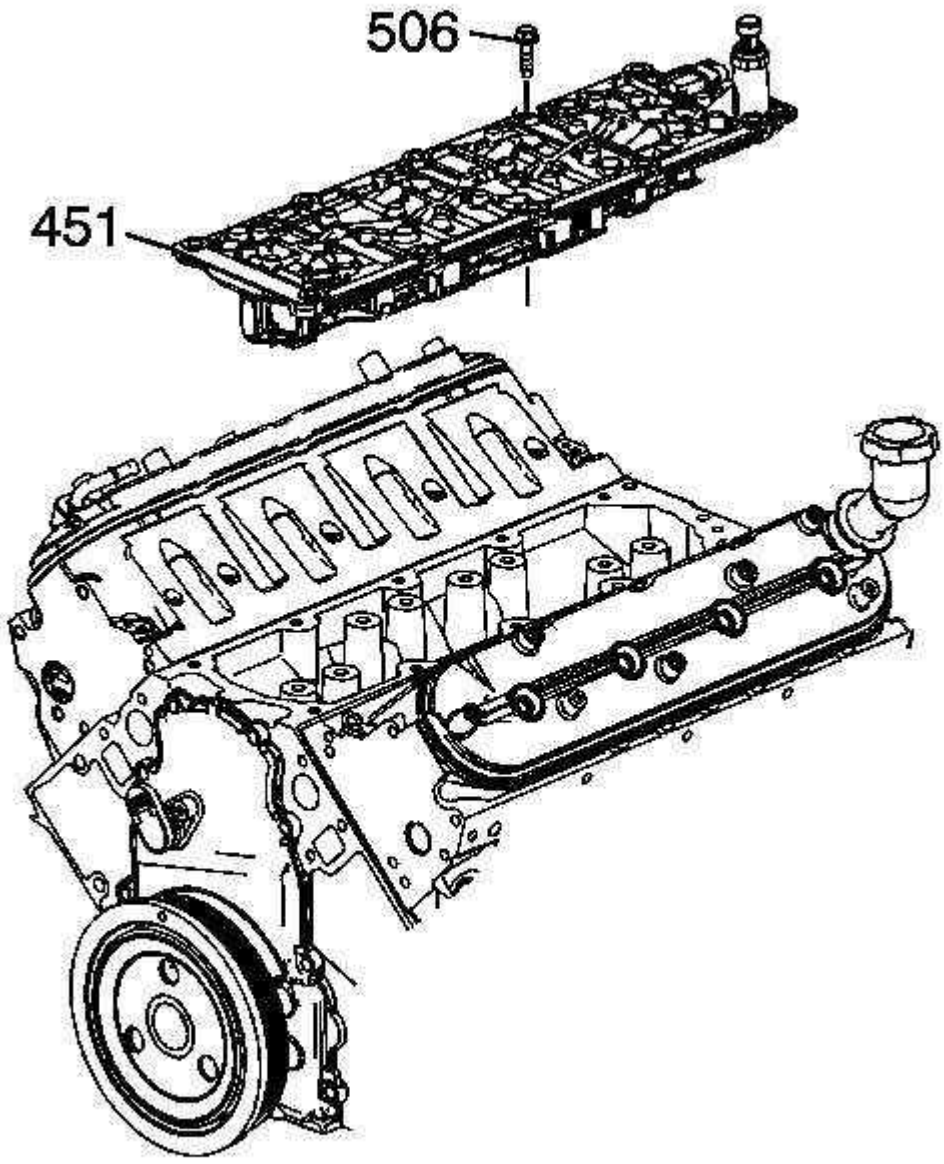


Fig. 351: View Of Valve Lifter Oil Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve lifter oil manifold bolts (506).

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IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

3. Remove the valve lifter oil manifold (451).

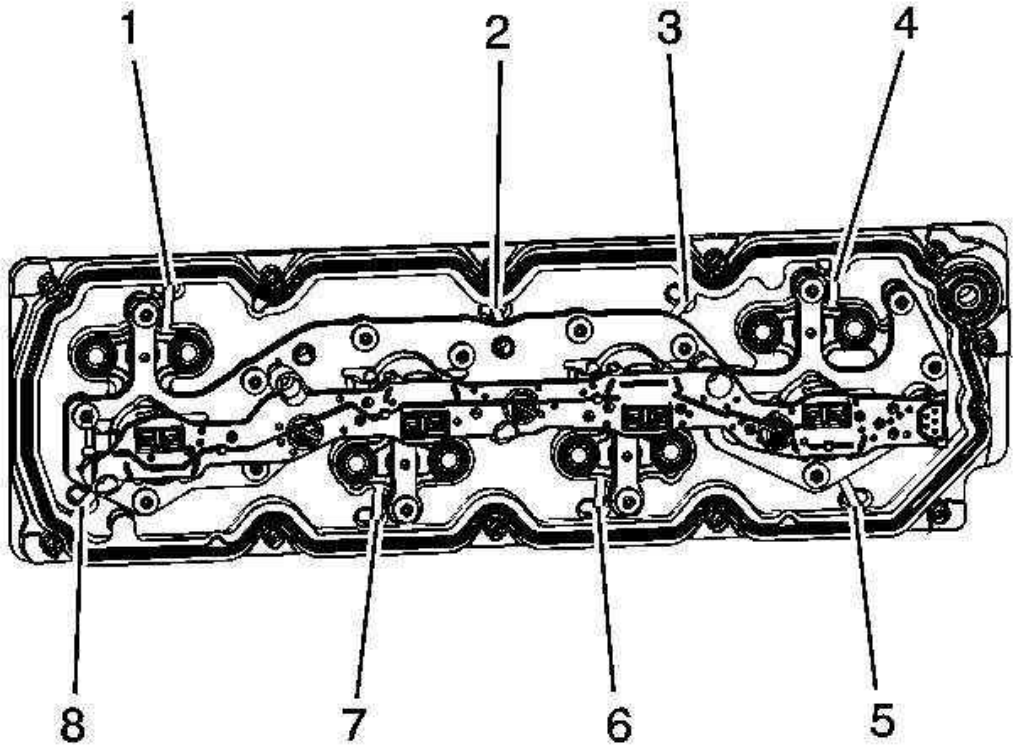


Fig. 352: View Of Eight Gasket Retaining Straps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove only the outer gasket from the manifold. Do not disassemble any of the internal components of the manifold in an attempt to remove the 8 inner sealing gaskets. If the inner gaskets are cut or damaged, replace the manifold as an assembly. Only use a wire-cutter type tool in order to minimize the amount of debris. Do not use a rotary-type

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cutting tool on the retaining straps.

4. Identify the 8 gasket retaining strap locations.

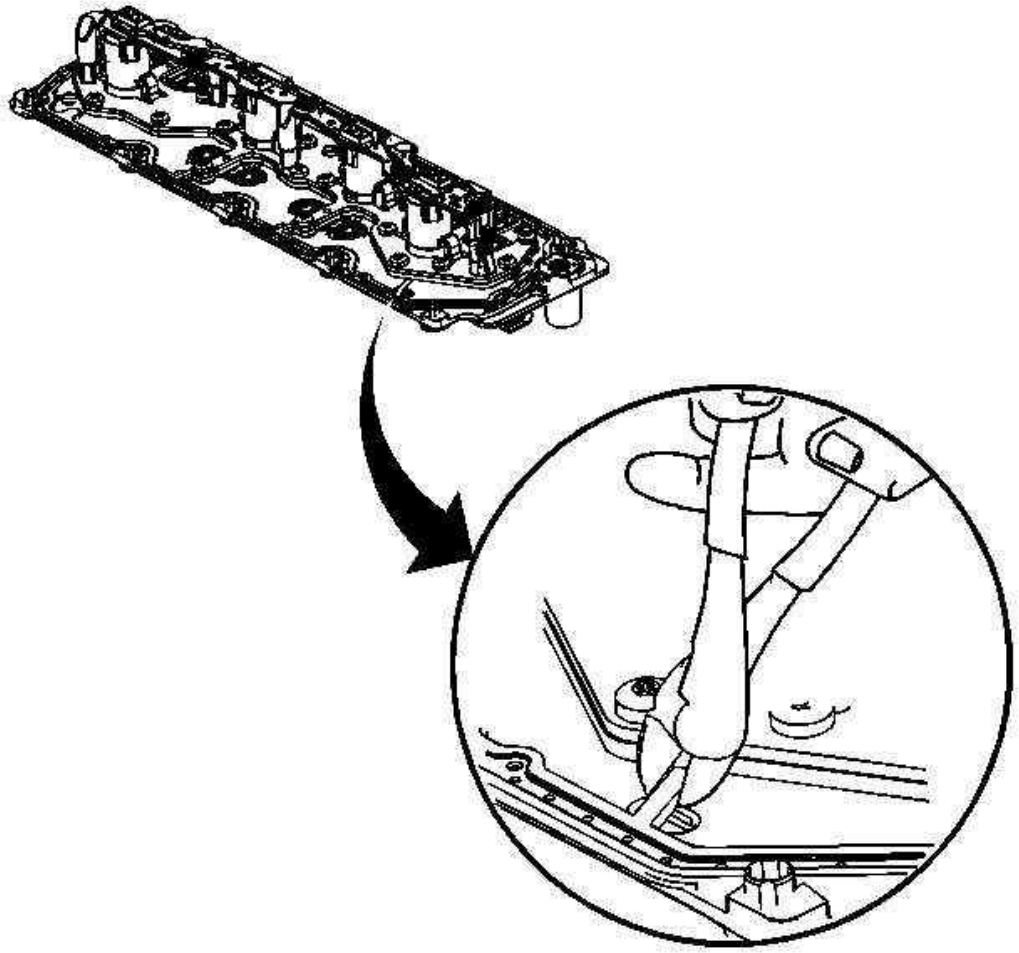


Fig. 353: Cutting Retaining Straps
Courtesy of GENERAL MOTORS CORP.

5. Using a wire-cutter type tool, snip the 8 retaining straps of the outer gasket.

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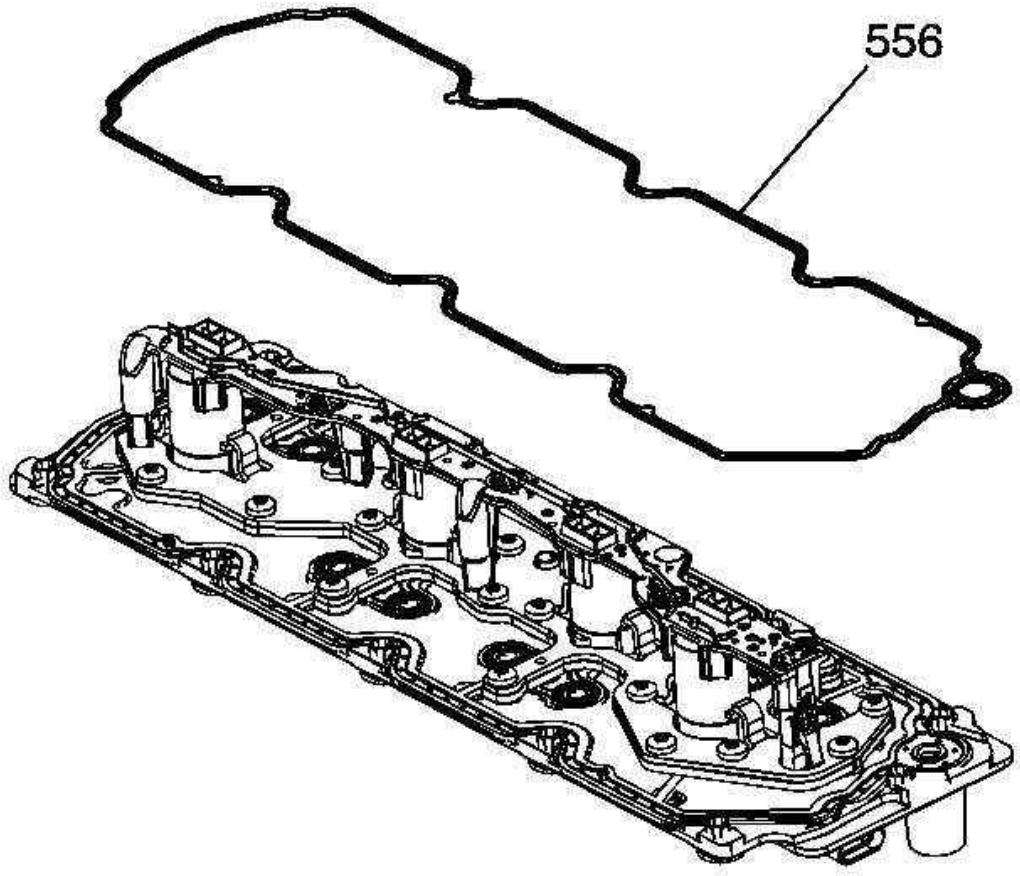


Fig. 354: Valve Lifter Oil Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the outer gasket (556) from the manifold.

VALVE LIFTER OIL FILTER REMOVAL

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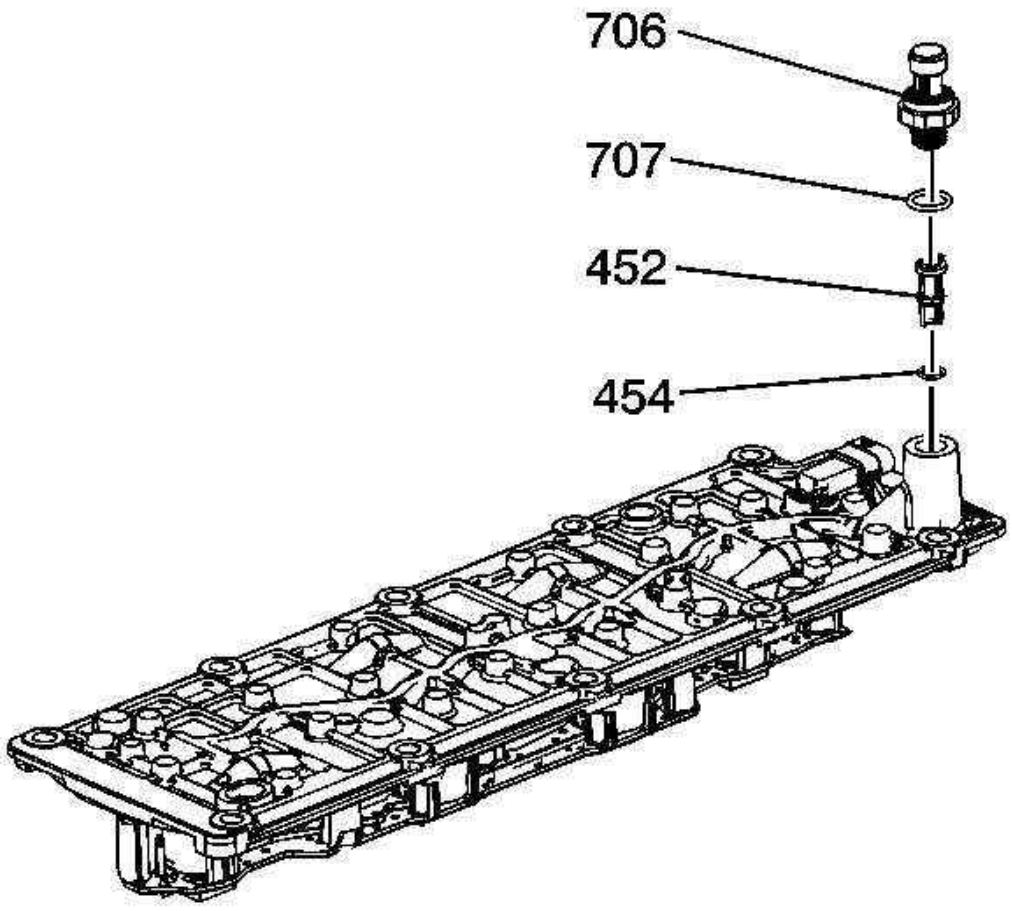


Fig. 355: View Of Oil Pressure Sensor, Washer & Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

1. Remove the oil pressure sensor (706).
2. Remove the oil filter (452).
3. Inspect the O-ring (454) for cuts or damage. If the filter is plugged or the O-ring is cut or damaged, replace the filter and O-ring as an assembly.

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VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

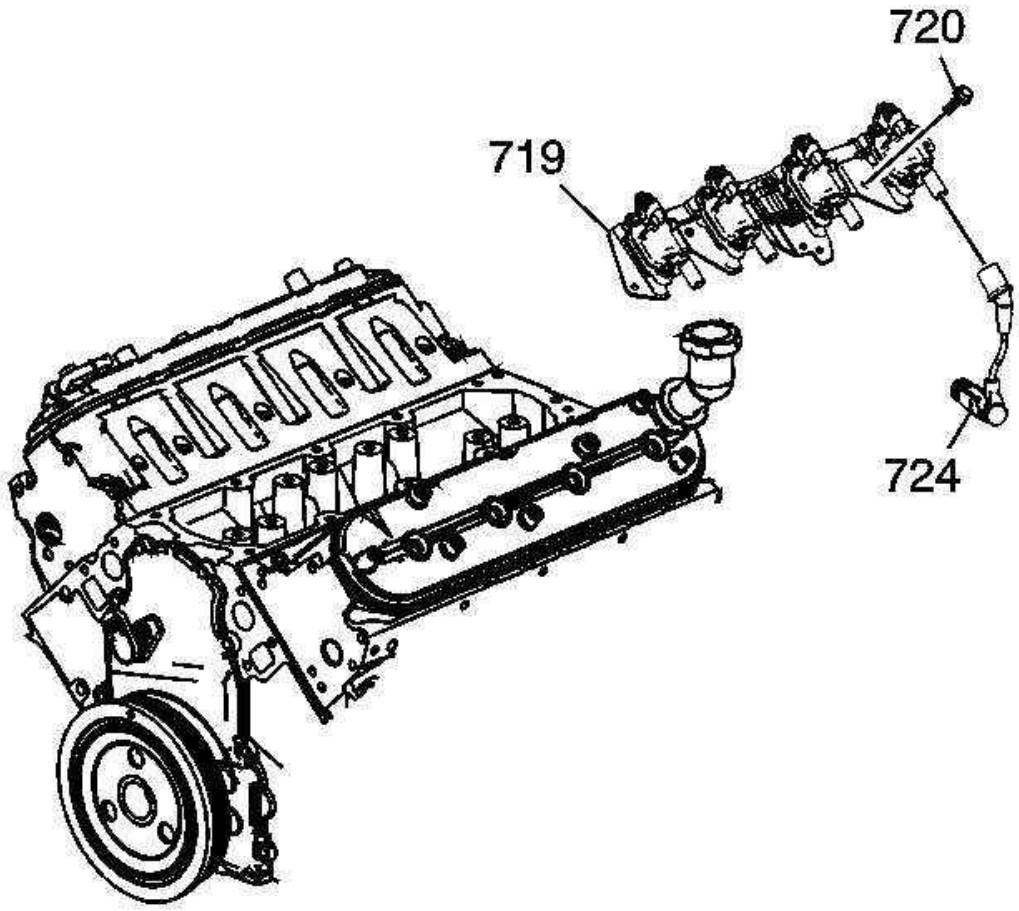


Fig. 356: View Of Ignition Coil & Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).

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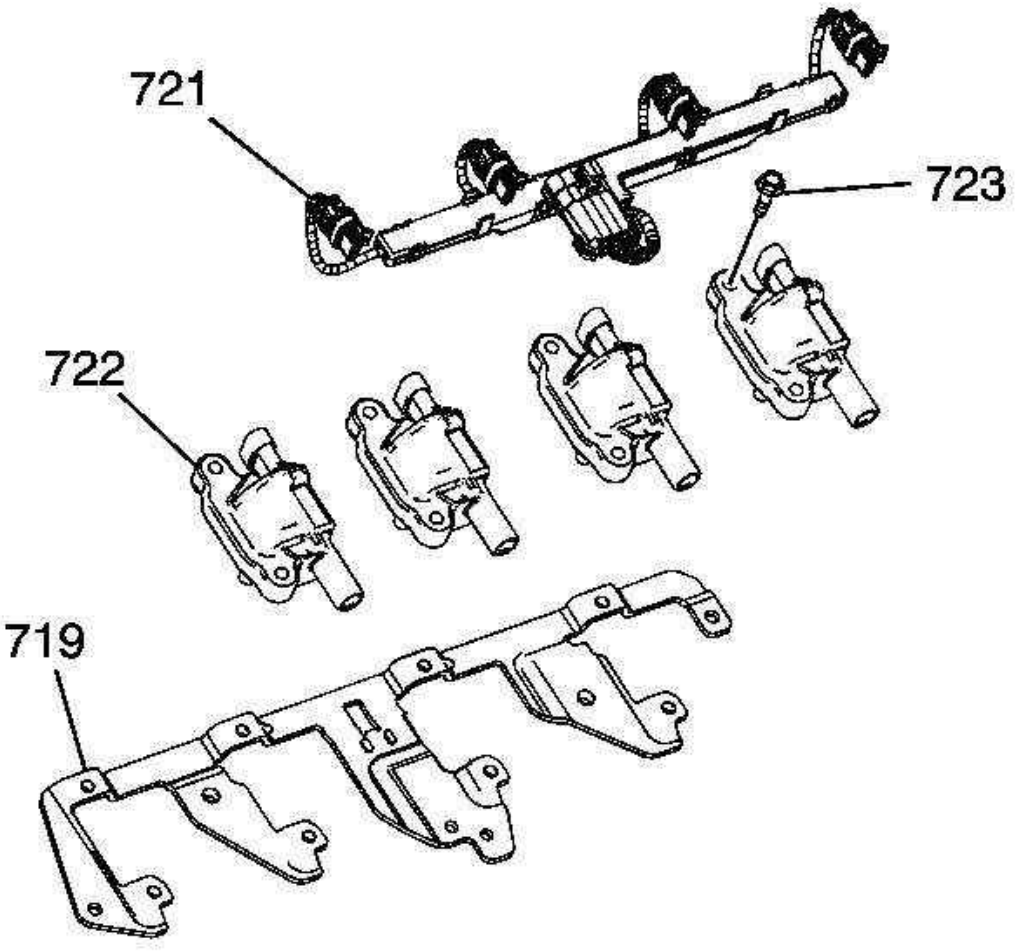


Fig. 357: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket, as required.

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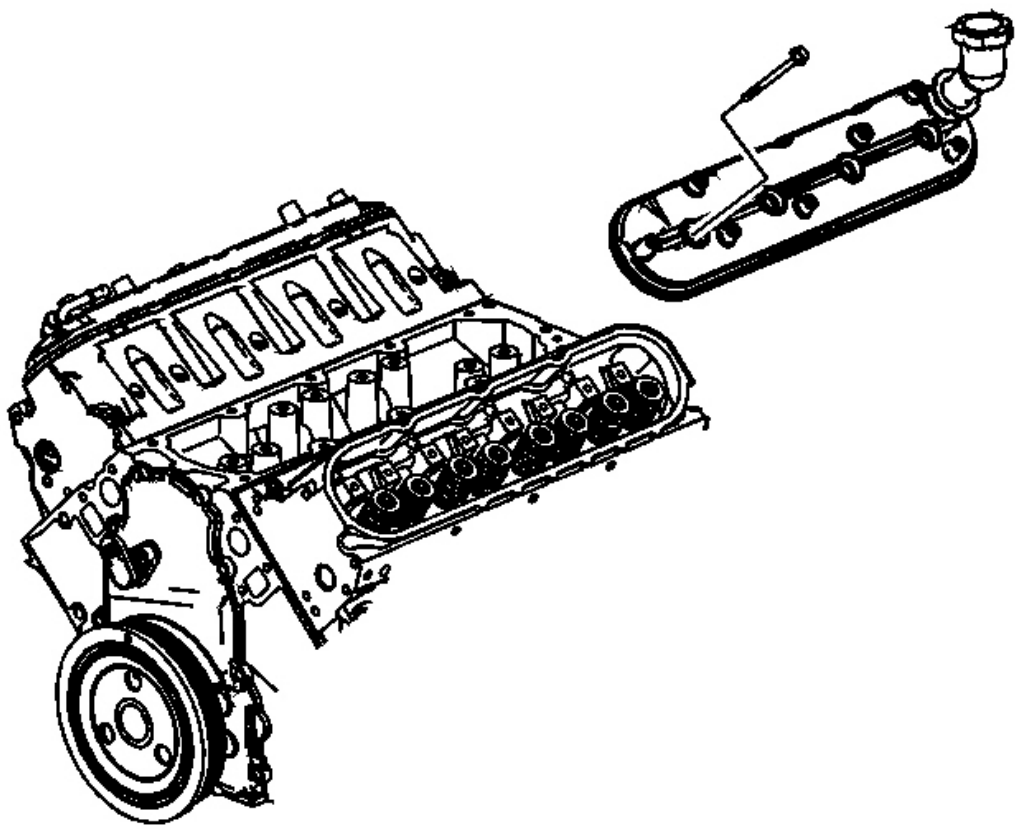


Fig. 358: View Of Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

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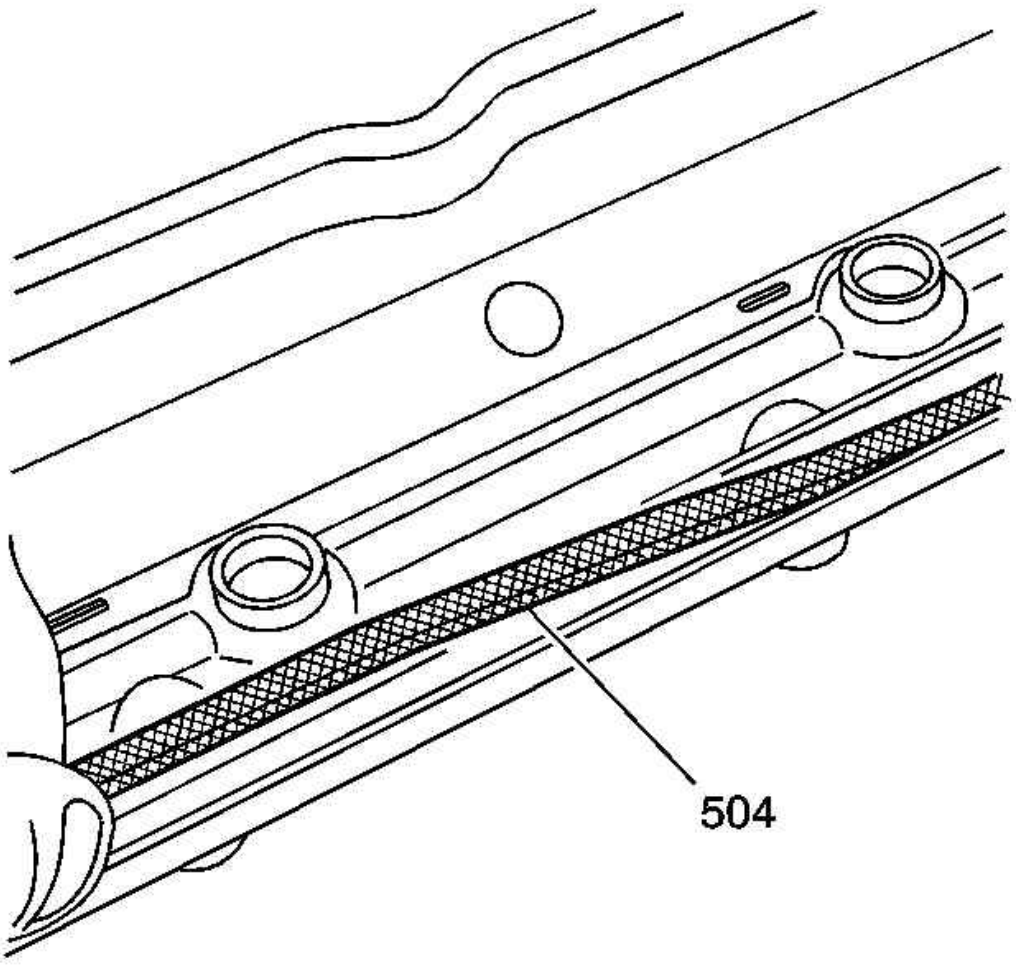


Fig. 359: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the oil fill tube from the cover, unless service is required. If the oil fill tube has been removed from the cover, install a NEW tube during assembly.

7. Remove the gasket (504) from the cover.

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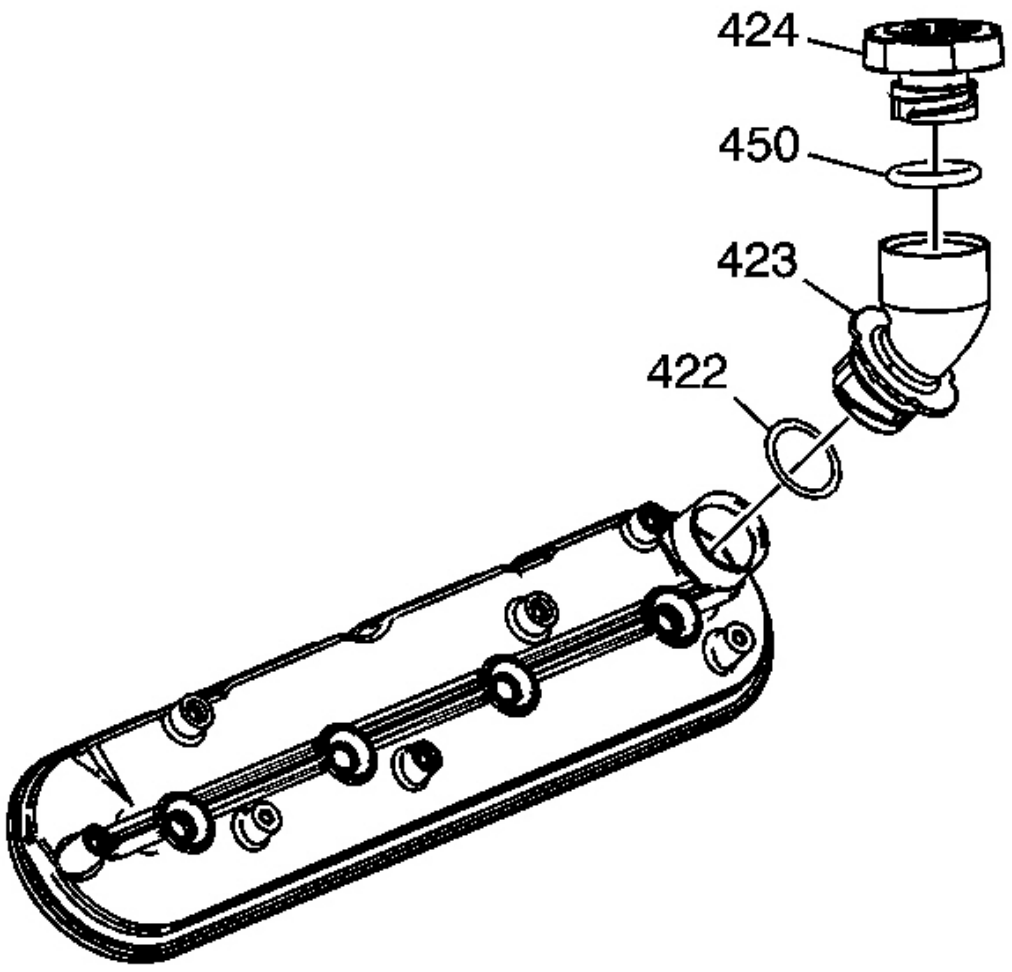


Fig. 360: Identifying Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil fill cap (424) from the oil fill tube, as required.
9. Remove the oil fill tube (423), as required.
10. Discard the oil fill tube.

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

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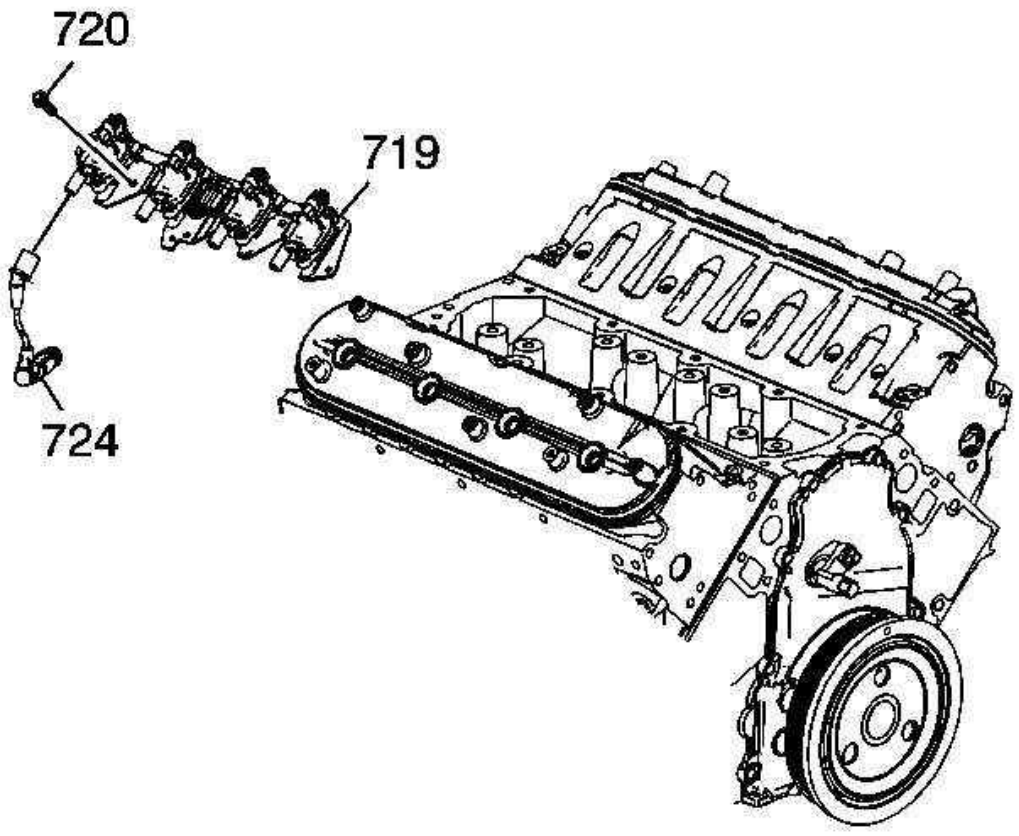


Fig. 361: View Of Ignition Coil And Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).

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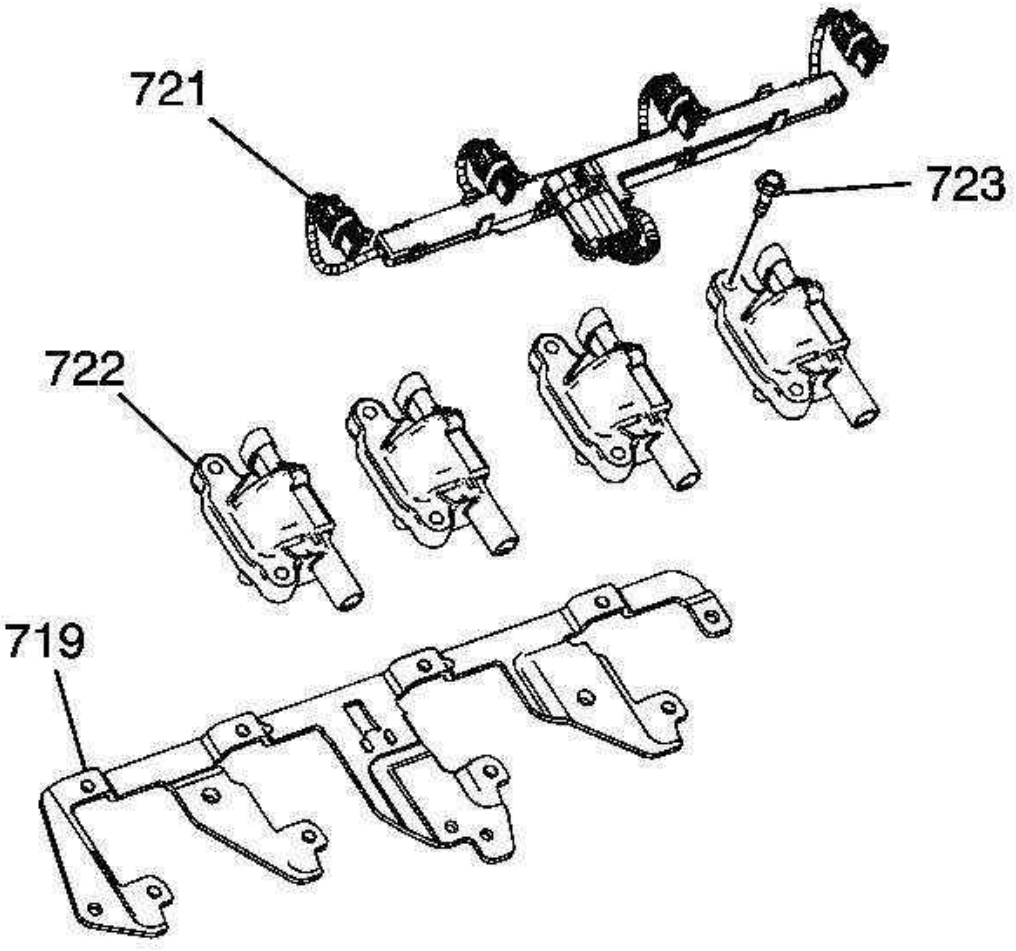


Fig. 362: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket, as required.

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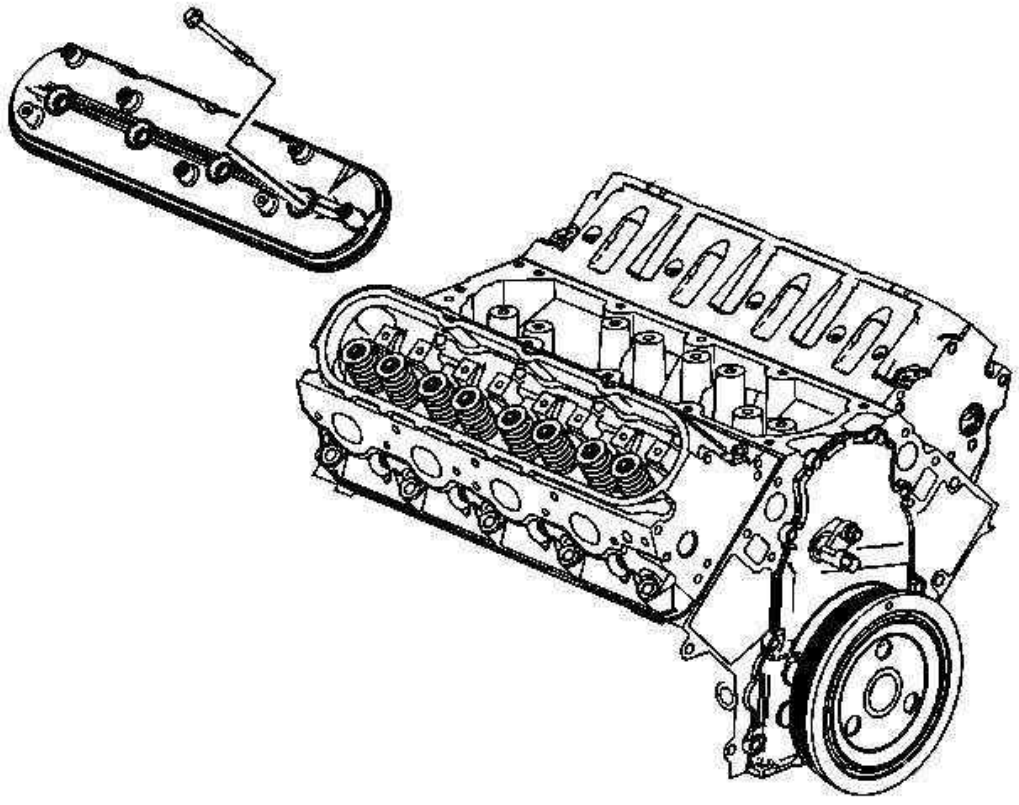


Fig. 363: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

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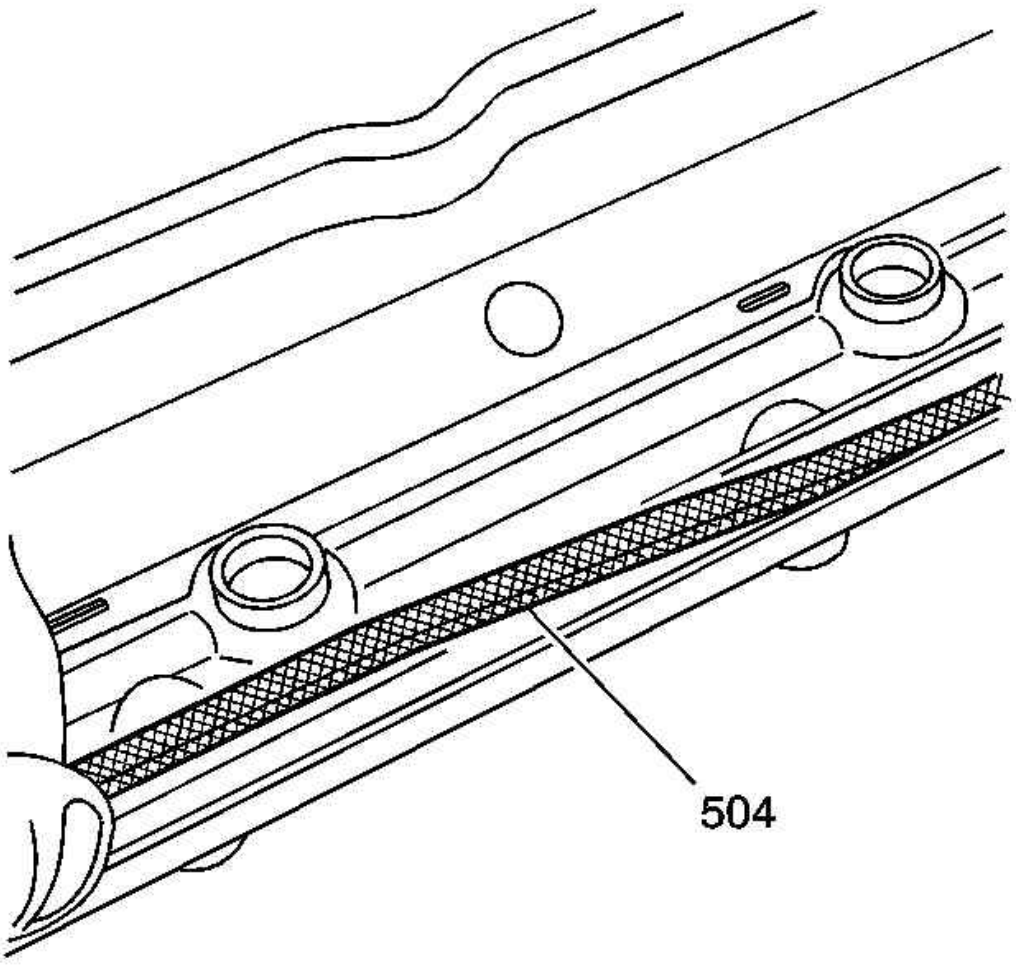


Fig. 364: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

VALVE ROCKER ARM AND PUSH ROD REMOVAL

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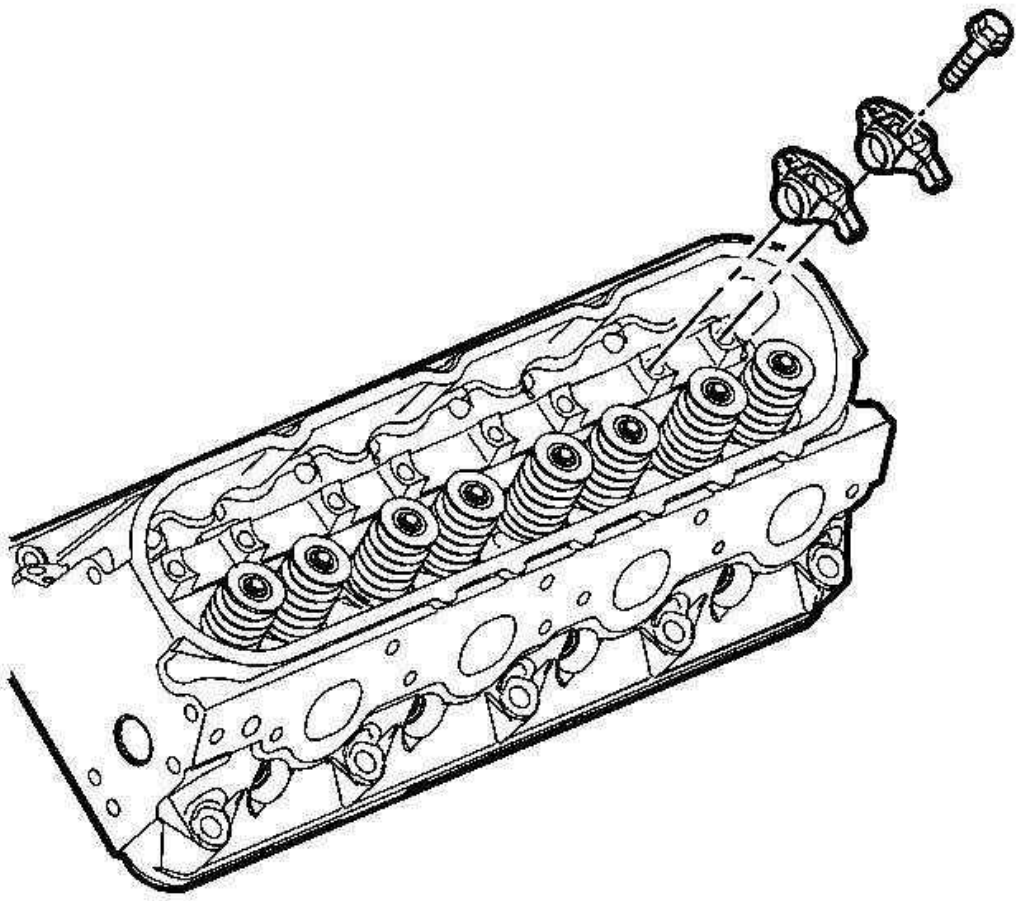


Fig. 365: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve rocker arms, valve pushrods, and pivot support, in a rack so they can be installed in the same location from which they were removed.

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

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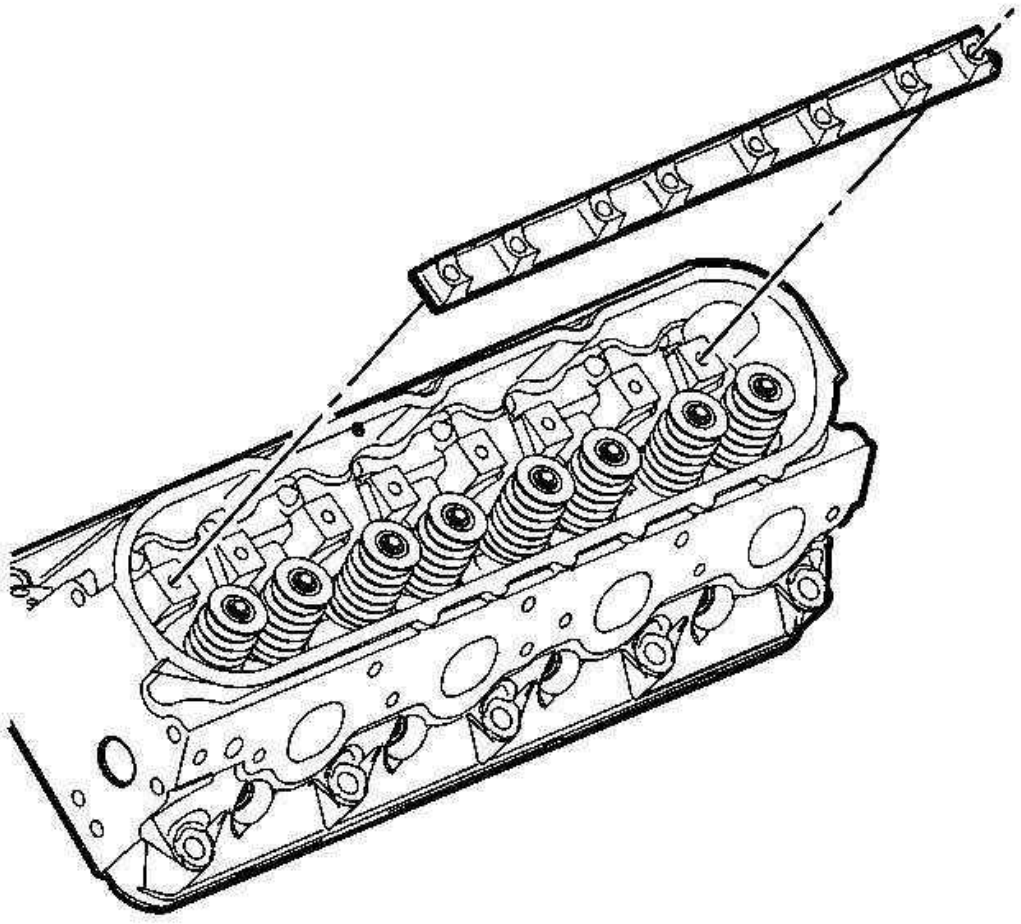


Fig. 366: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

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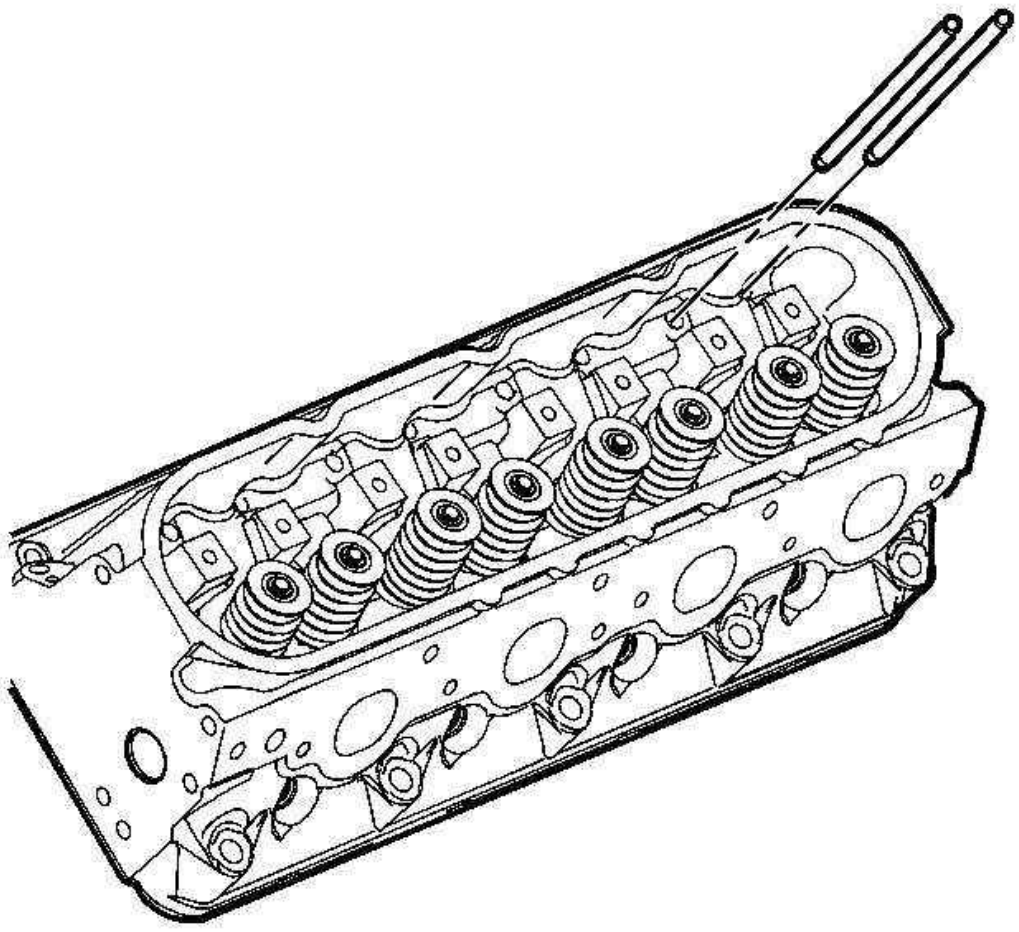


Fig. 367: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

CYLINDER HEAD REMOVAL - LEFT SIDE

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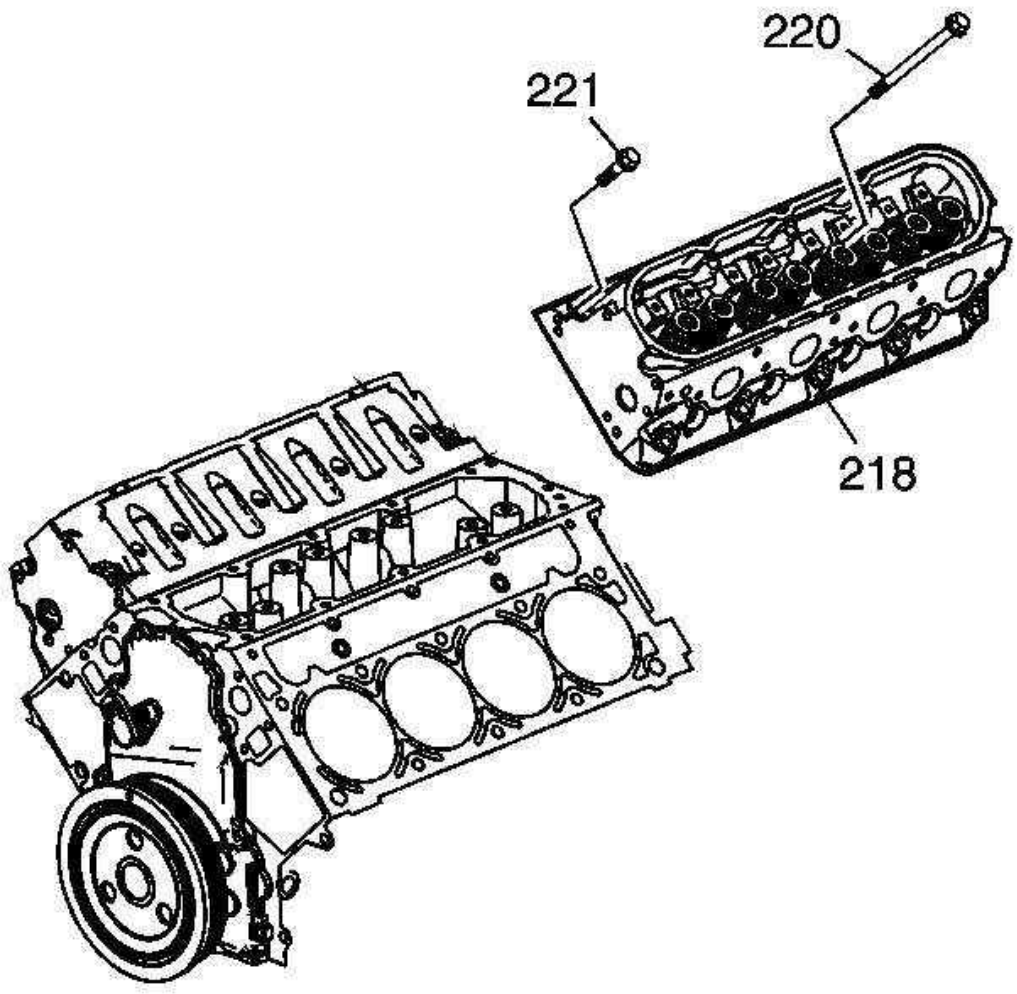


Fig. 368: View Of Cylinder Head & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on 2 wood

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blocks in order to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

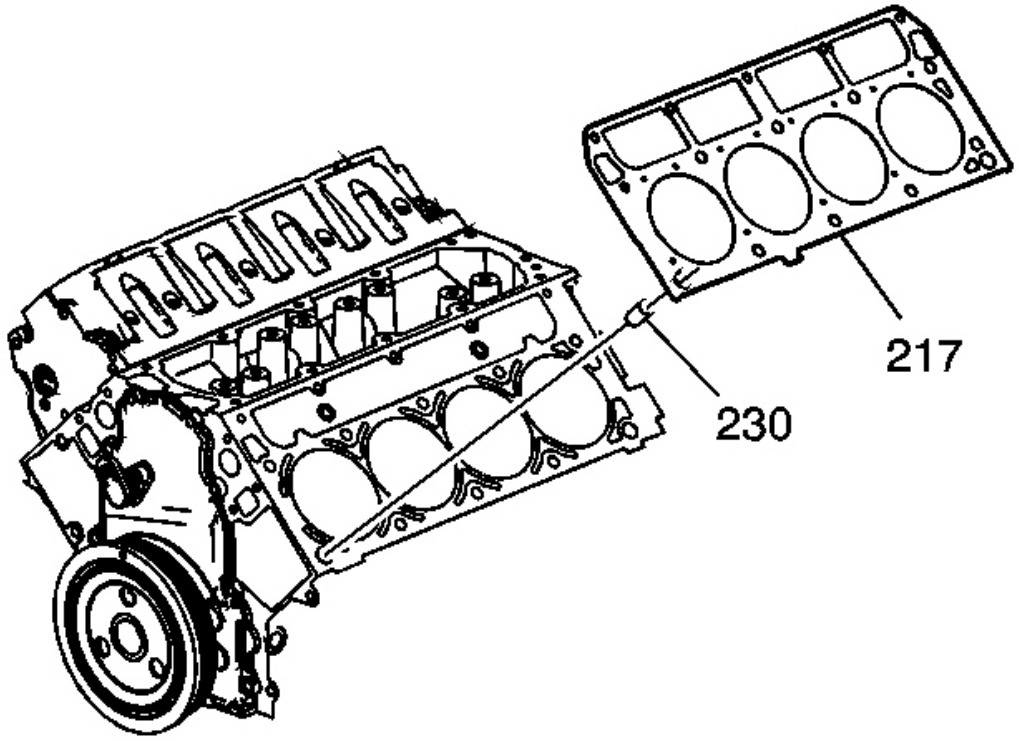


Fig. 369: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

CYLINDER HEAD REMOVAL - RIGHT SIDE

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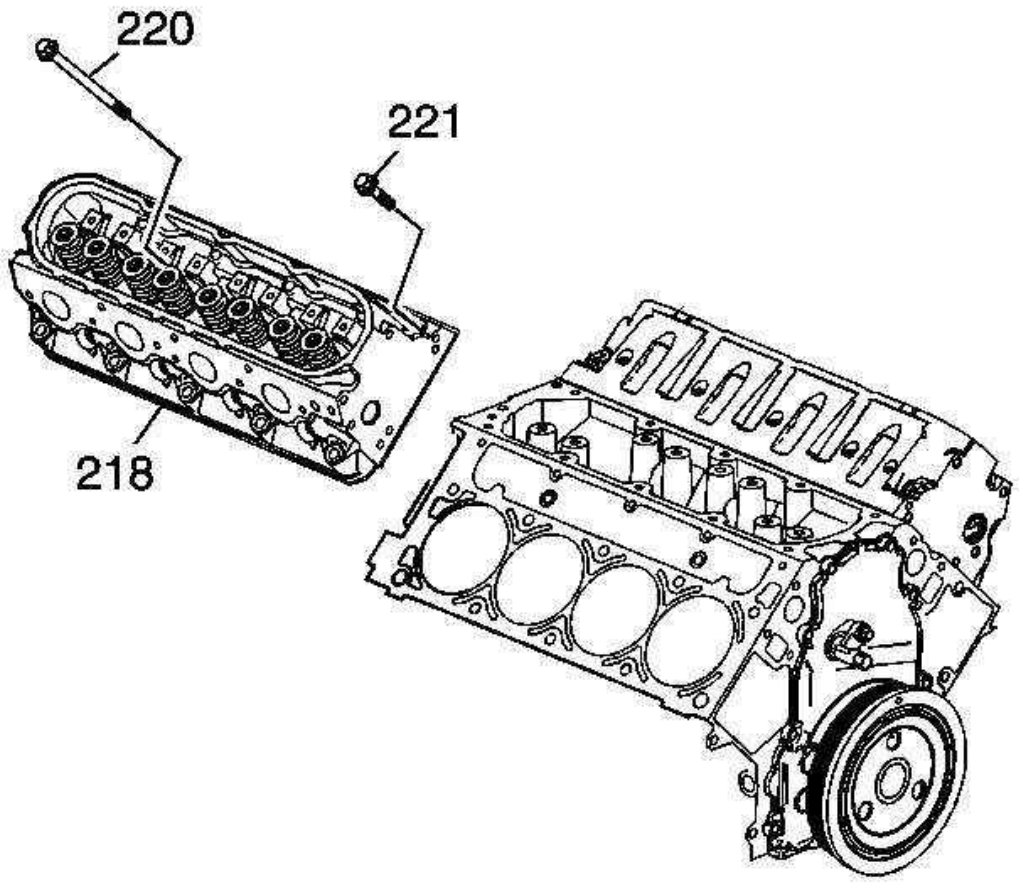


Fig. 370: View Of Cylinder Head & Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

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2. Remove the cylinder head (218).

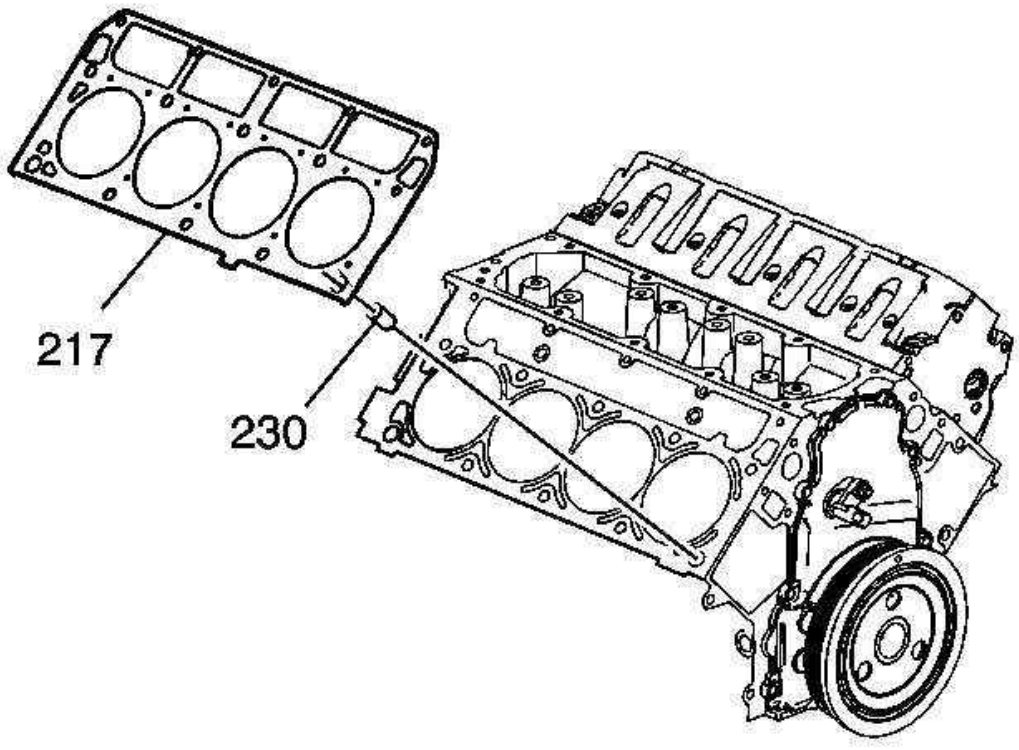


Fig. 371: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

VALVE LIFTER REMOVAL

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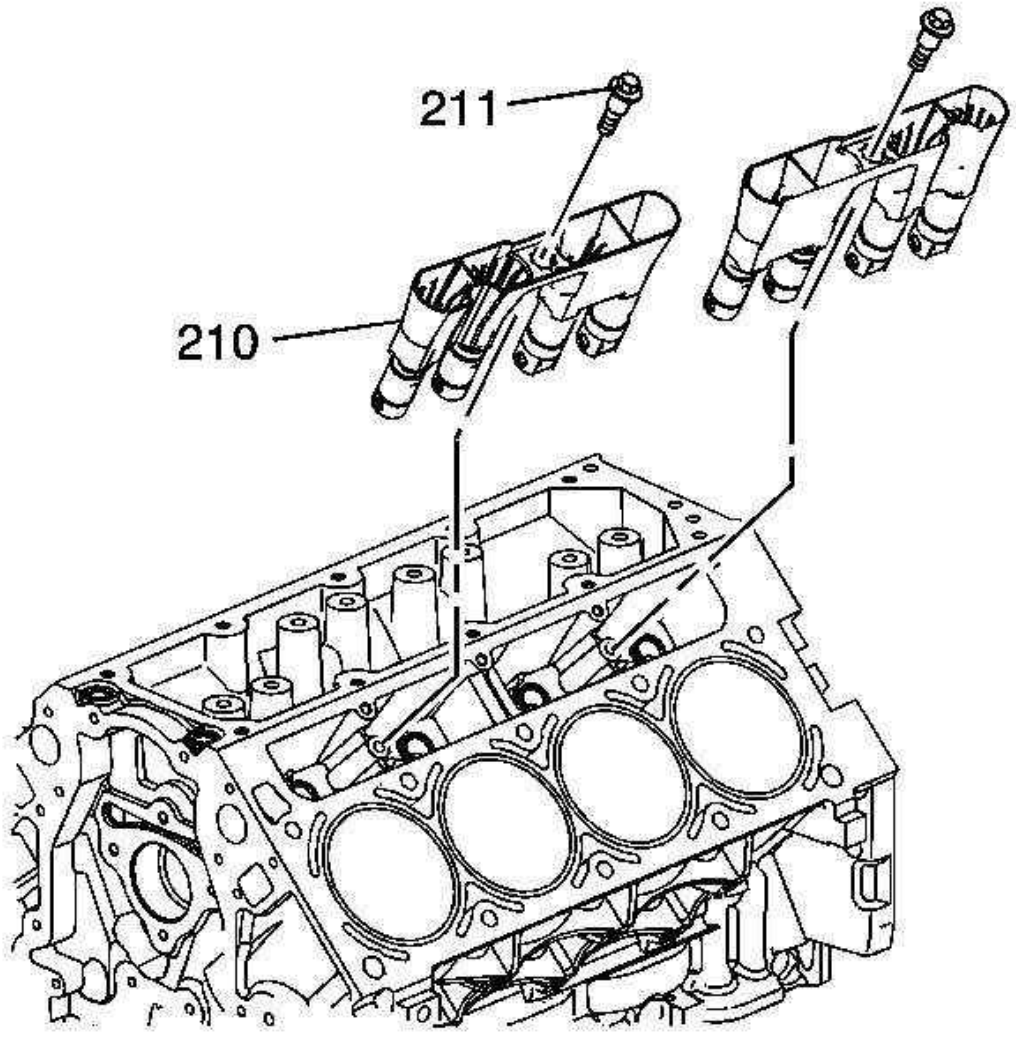


Fig. 372: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (211).
2. Remove the guides (210) with lifters.

Note the installed position of the guides. The notched area of the guide is to align with the locating tab of the block.

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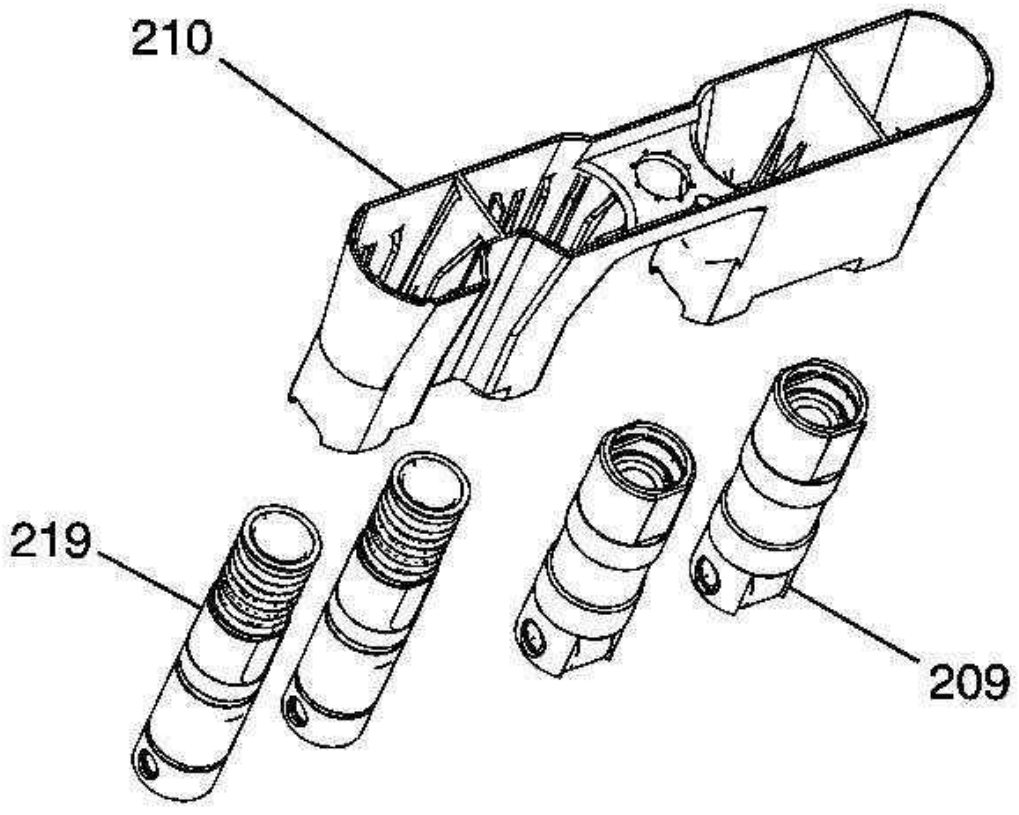


Fig. 373: View Of Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifters (209, 219) from the guide (210).

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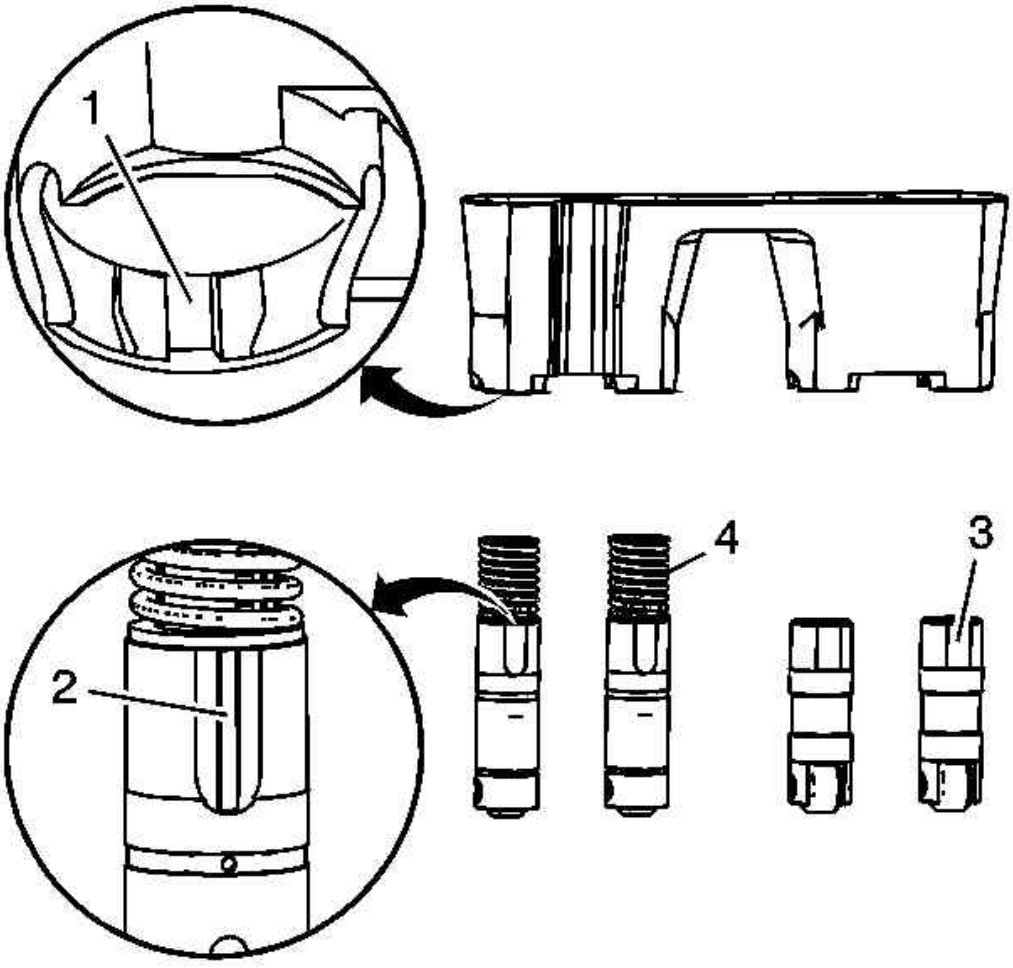


Fig. 374: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS CORP.

4. Organize or mark the components so they can be installed in the same location from which they were removed. The active fuel management lifters (4) are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to **Separating Parts**.

OIL FILTER REMOVAL

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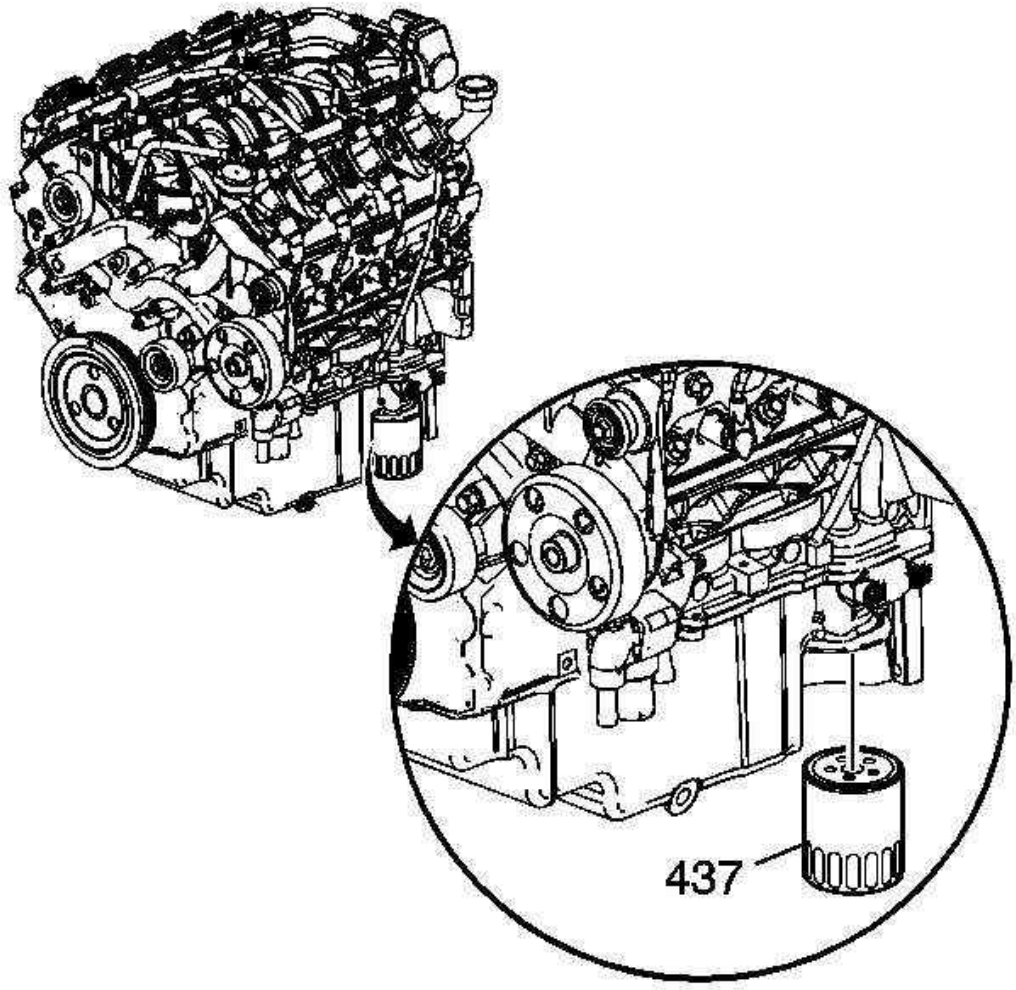


Fig. 375: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (437).

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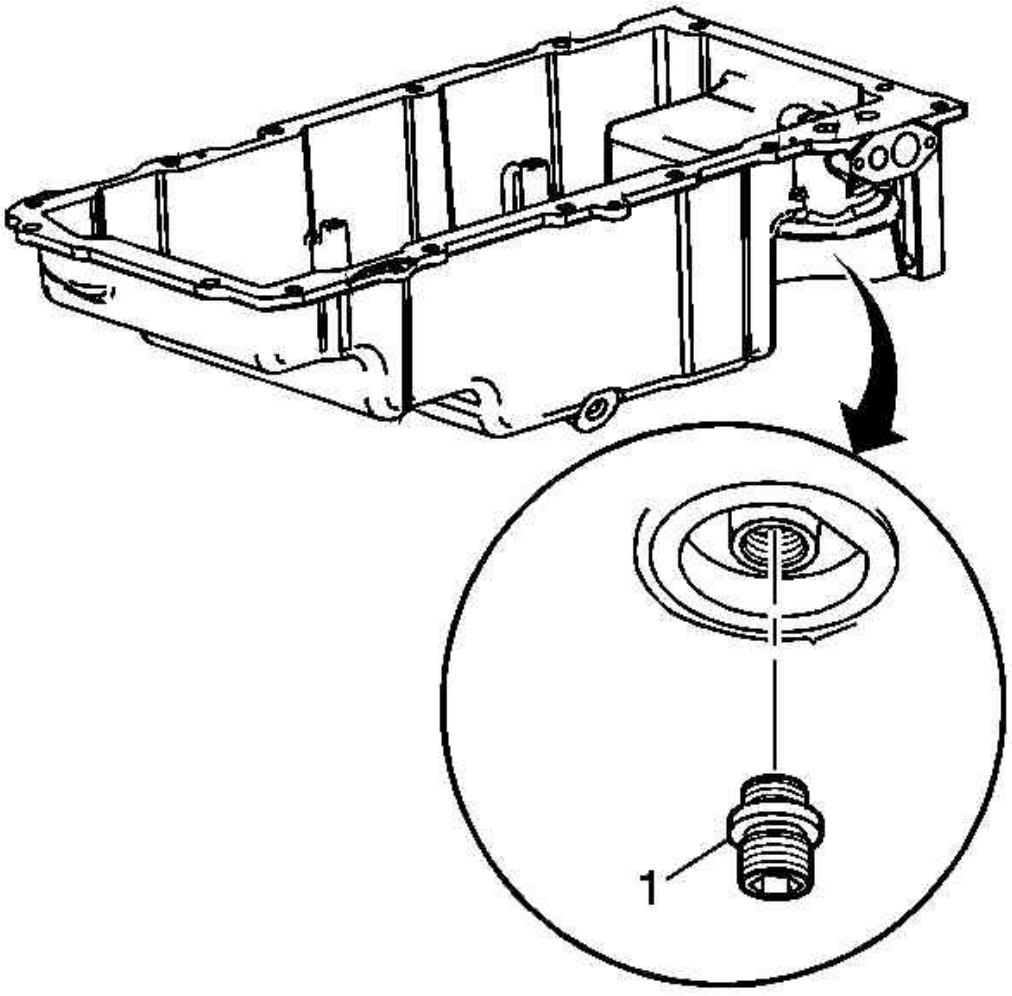


Fig. 376: Identifying Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting (1), as required.

OIL PAN REMOVAL

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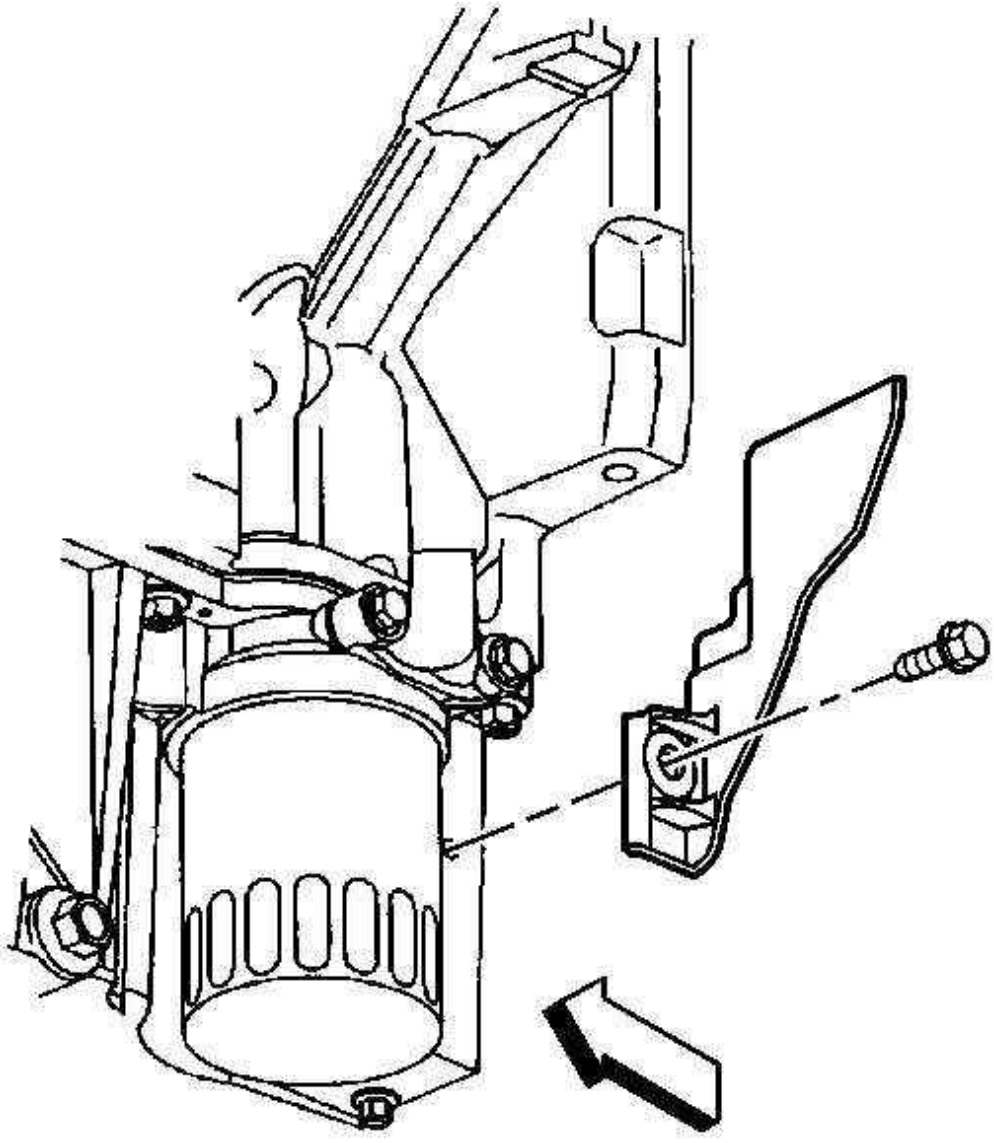


Fig. 377: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing**

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a new gasket, it is not necessary to install new oil pan gasket rivets.

- **DO NOT use the oil pan gasket again. When installing the oil pan, install a NEW oil pan gasket.**

1. Remove the left closeout cover and bolt.

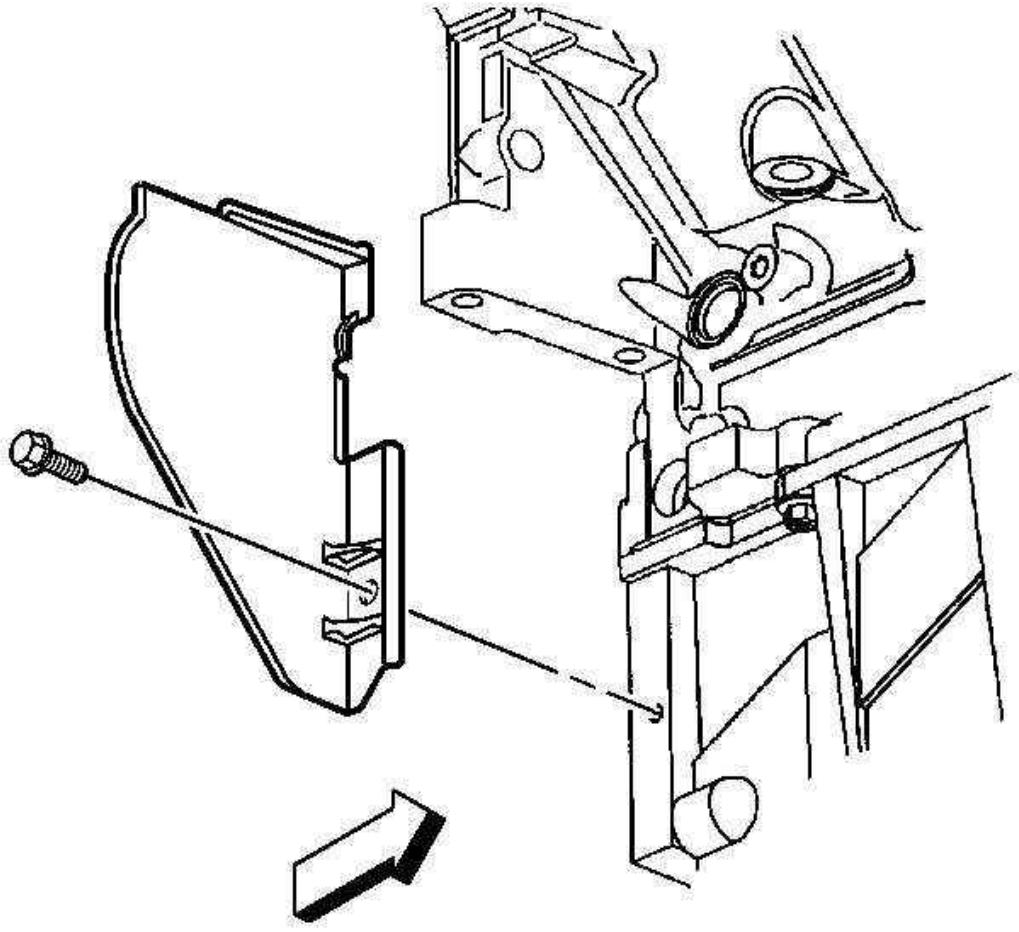


Fig. 378: View Of Right Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

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2. Remove the right closeout cover and bolt.

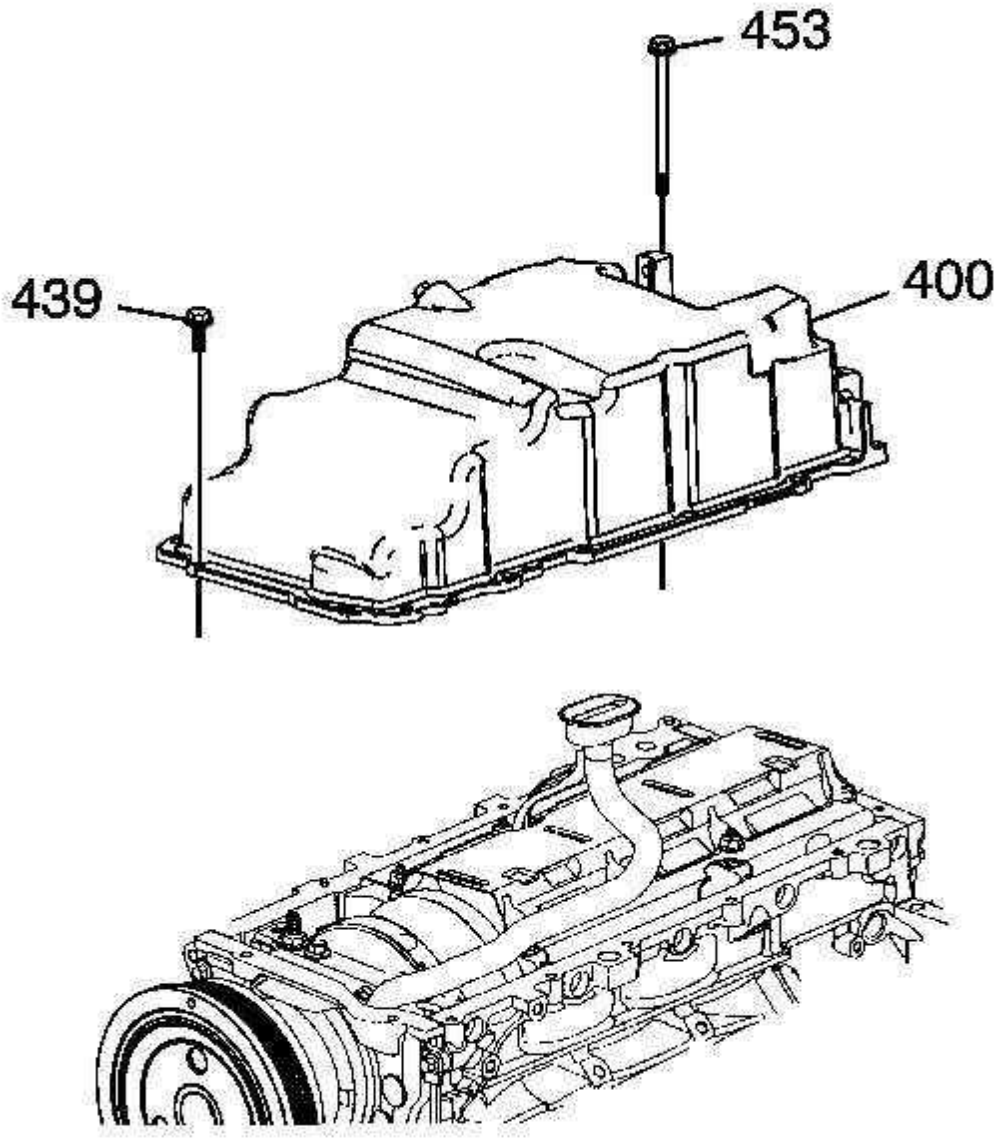


Fig. 379: Identifying Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan bolts (439, 453).

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4. Remove the oil pan (400).

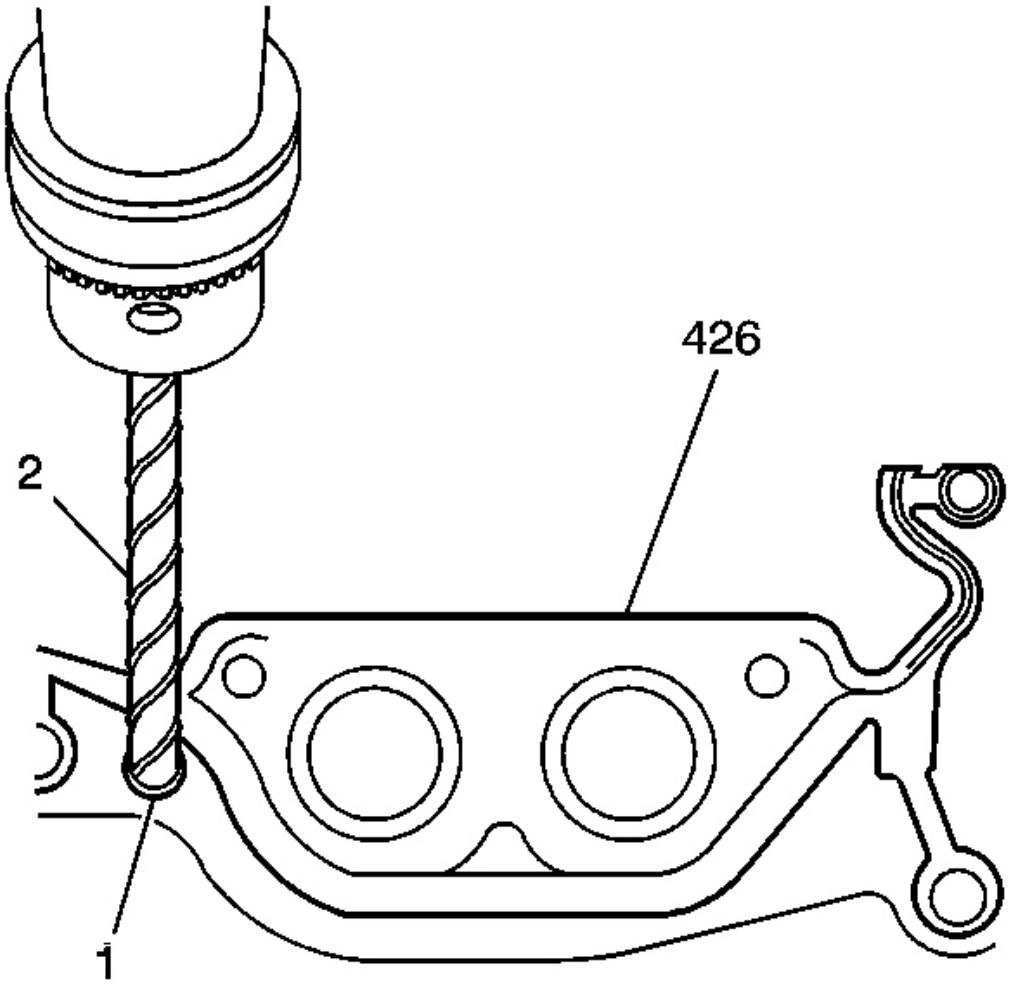


Fig. 380: Drilling Out Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **DO NOT allow foreign material to enter the oil passages of the oil pan. Cap or cover the openings, as required.**
- **Use care not to gouge, score, or damage the oil**

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pan sealing surface.

5. Drill (2) out the oil pan gasket retaining rivets (1), if required.
6. Remove the gasket (426) from the pan.
7. Discard the gasket and rivets.
8. Remove the baffle and other components, as required. Refer to **Oil Pan Cleaning and Inspection**.

ENGINE FRONT COVER REMOVAL

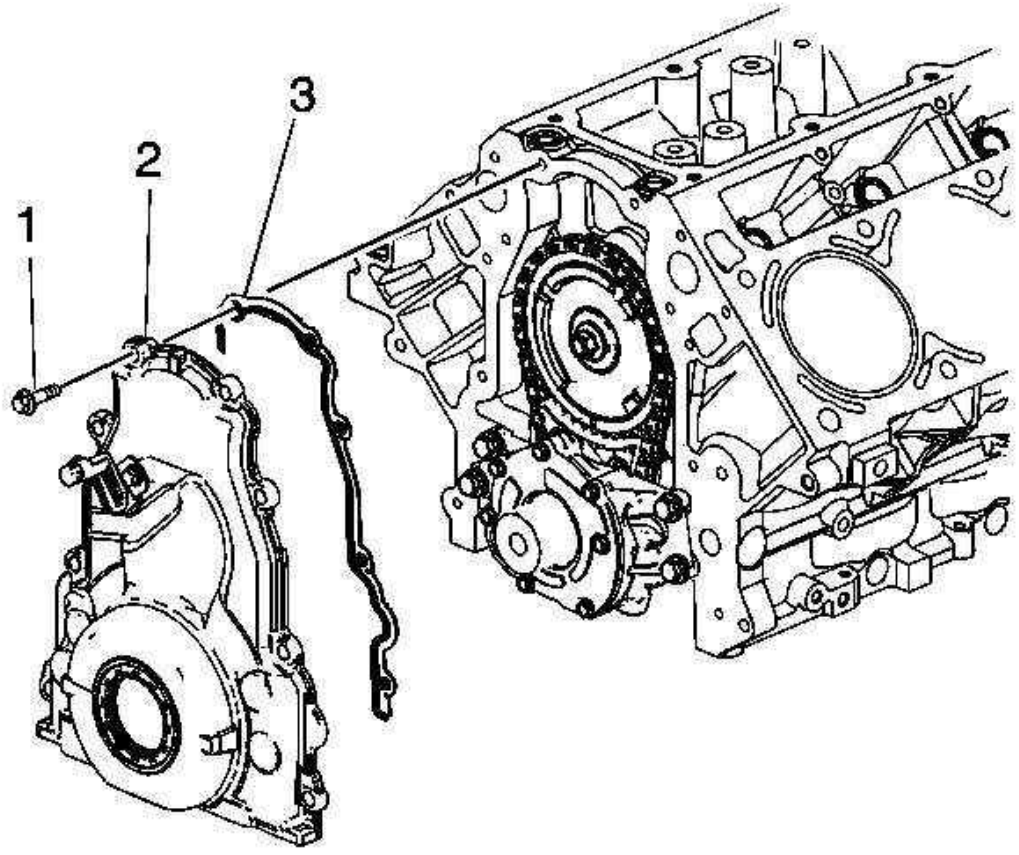


Fig. 381: View Of Engine Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

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1. Remove the front cover bolts (1).
2. Remove the front cover (2) and gasket (3).
3. Discard the front cover gasket.

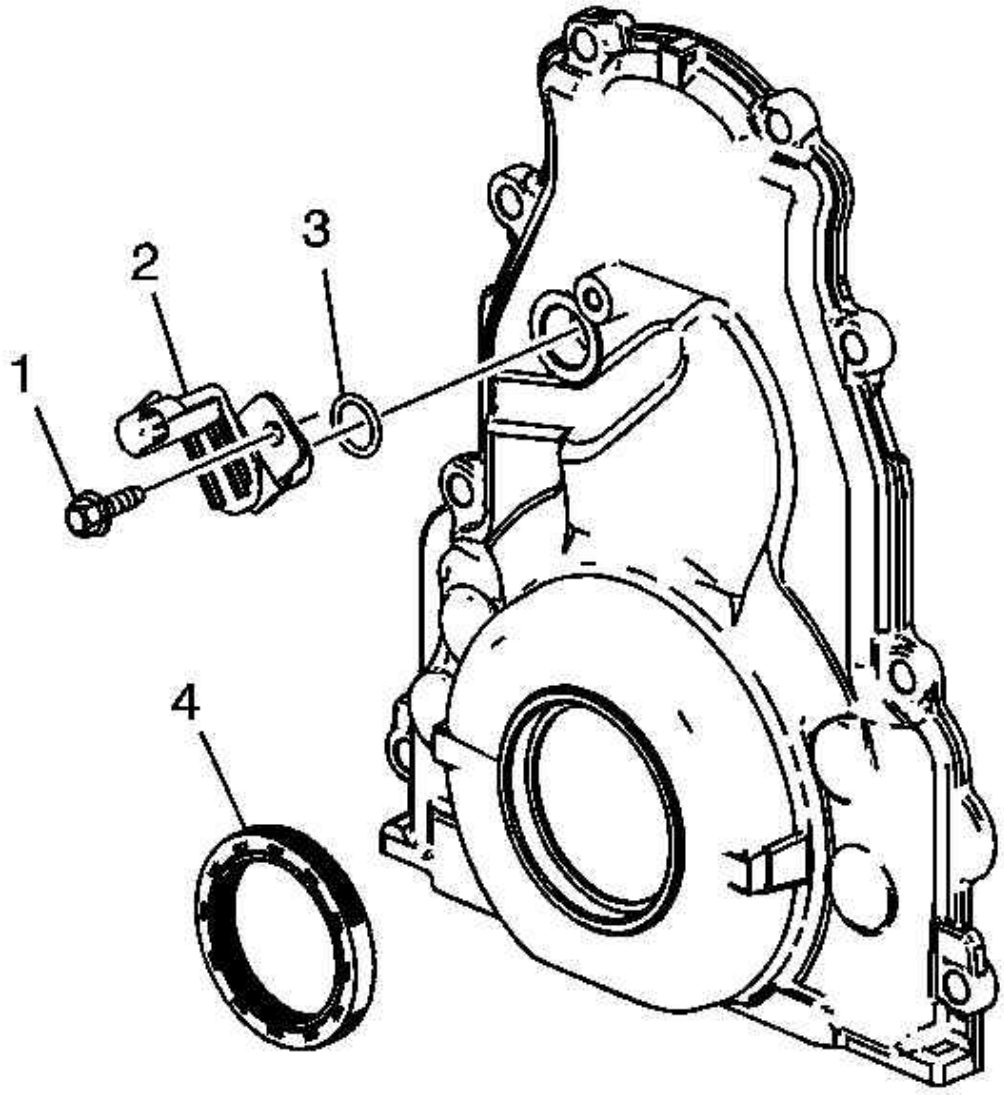


Fig. 382: View Of Engine Front Cover, Seal & CMP Sensor
Courtesy of GENERAL MOTORS CORP.

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4. Remove the oil seal (4).
5. Remove the bolt (1) and camshaft position (CMP) sensor (2).
6. Remove the O-ring (3) from the sensor, as required.

CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

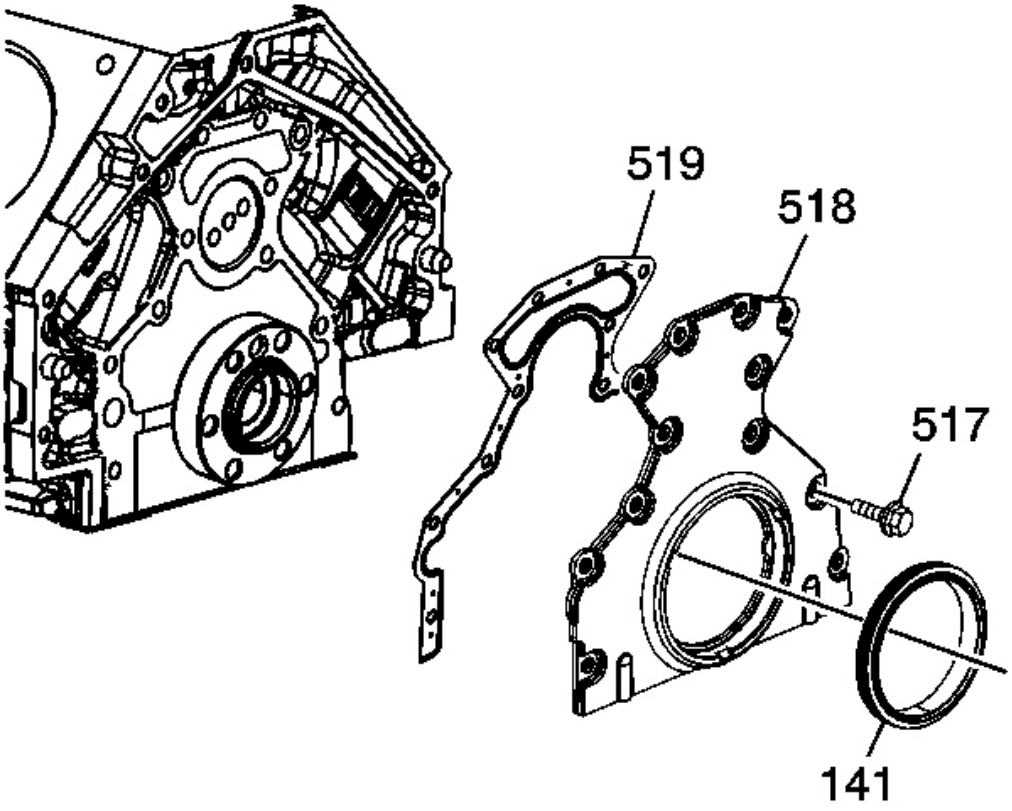


Fig. 383: View Of Rear Housing, Gasket & Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the rear oil seal housing bolts (517).
2. Remove the housing (518) and gasket (519).
3. Remove the rear oil seal (141).

OIL PUMP, SCREEN AND CRANKSHAFT OIL DEFLECTOR REMOVAL

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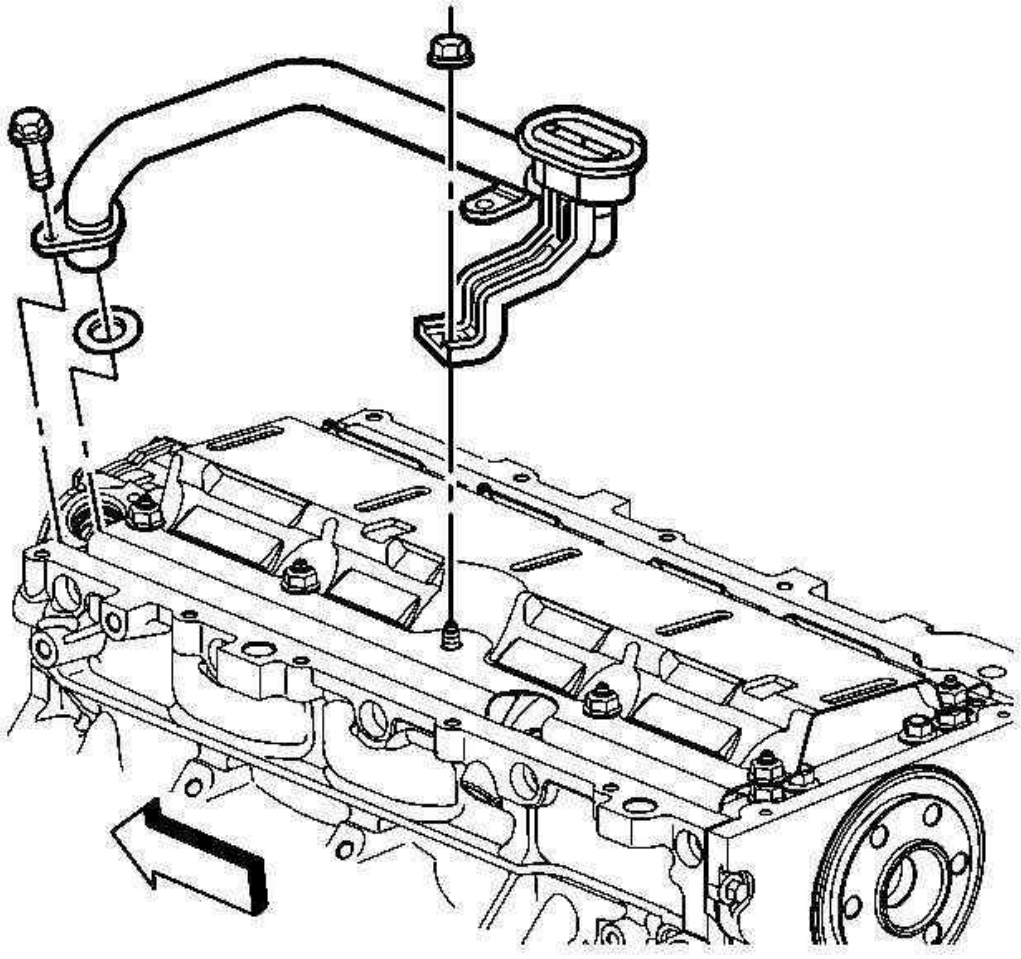


Fig. 384: View Of Oil Pump Screen, Nuts & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump screen bolt and nuts.
2. Remove the oil pump screen with O-ring seal.
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.

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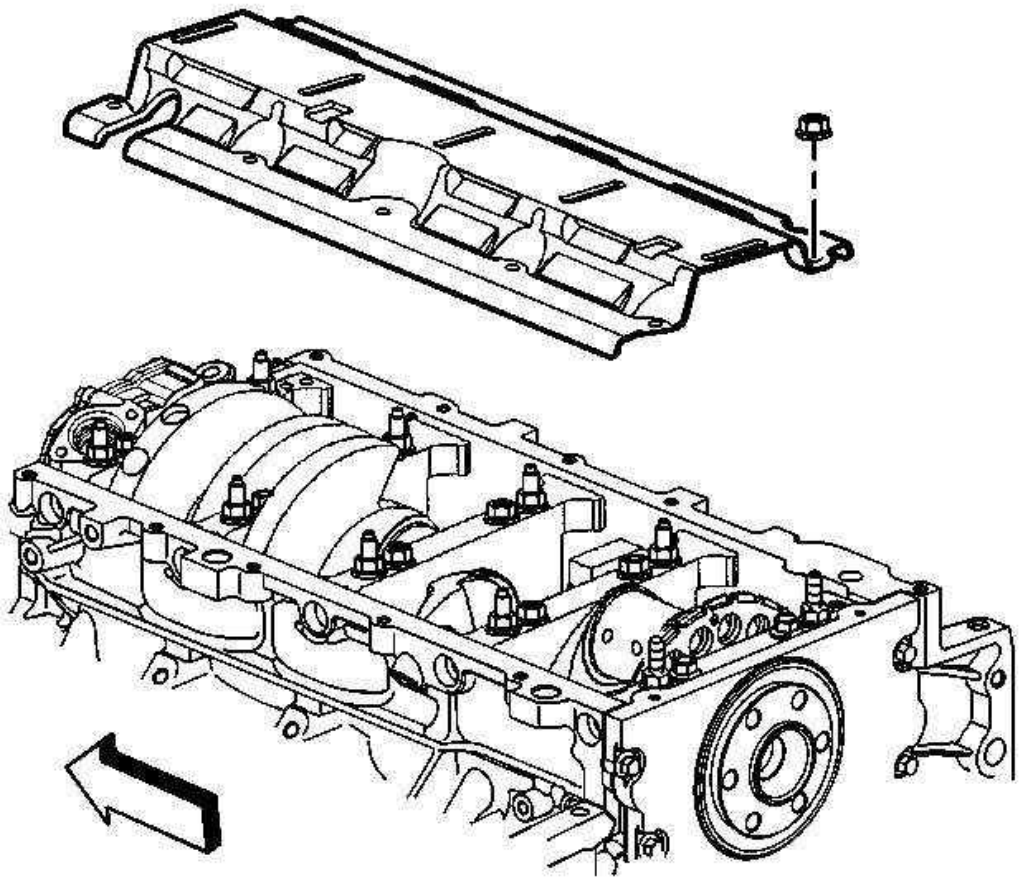


Fig. 385: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

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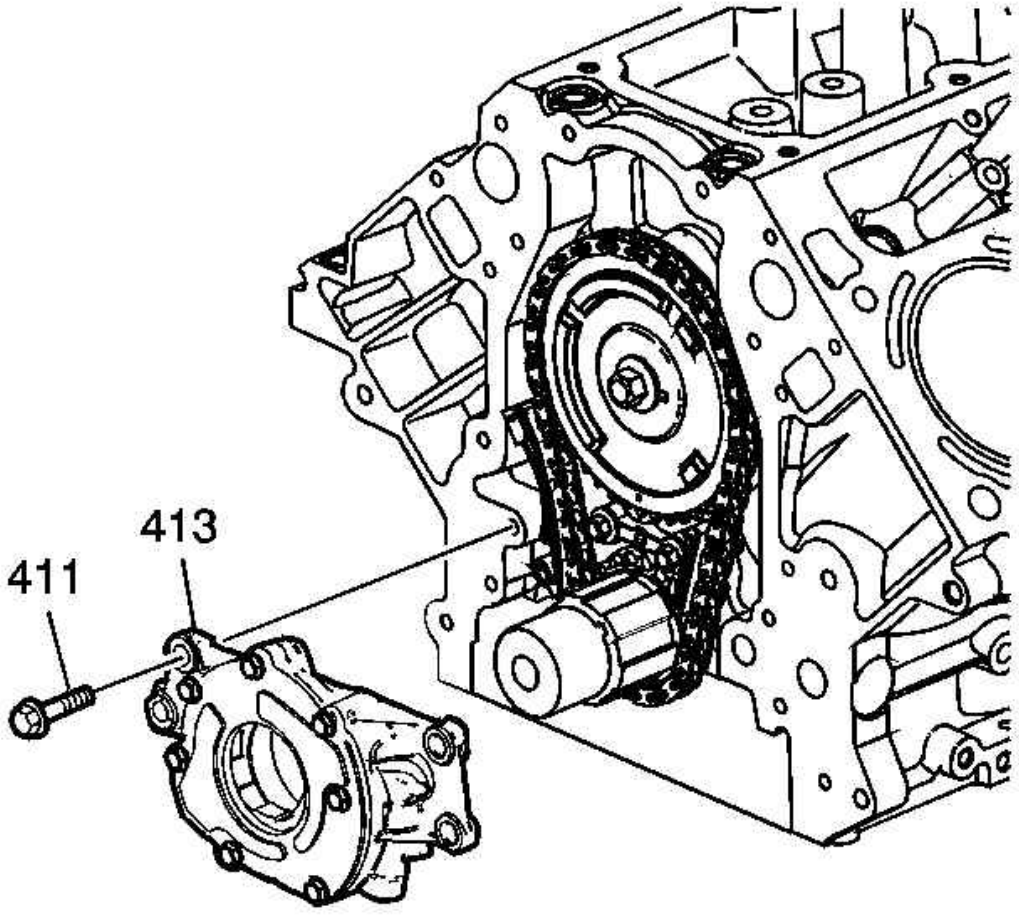


Fig. 386: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pump bolts (411).

IMPORTANT: Do not allow dirt or debris to enter the oil pump assembly. Cap ends, as necessary.

8. Remove the oil pump (413).

TIMING CHAIN AND SPROCKETS REMOVAL

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Tools Required

- **J 8433** Two Jaw Puller. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.

Removal

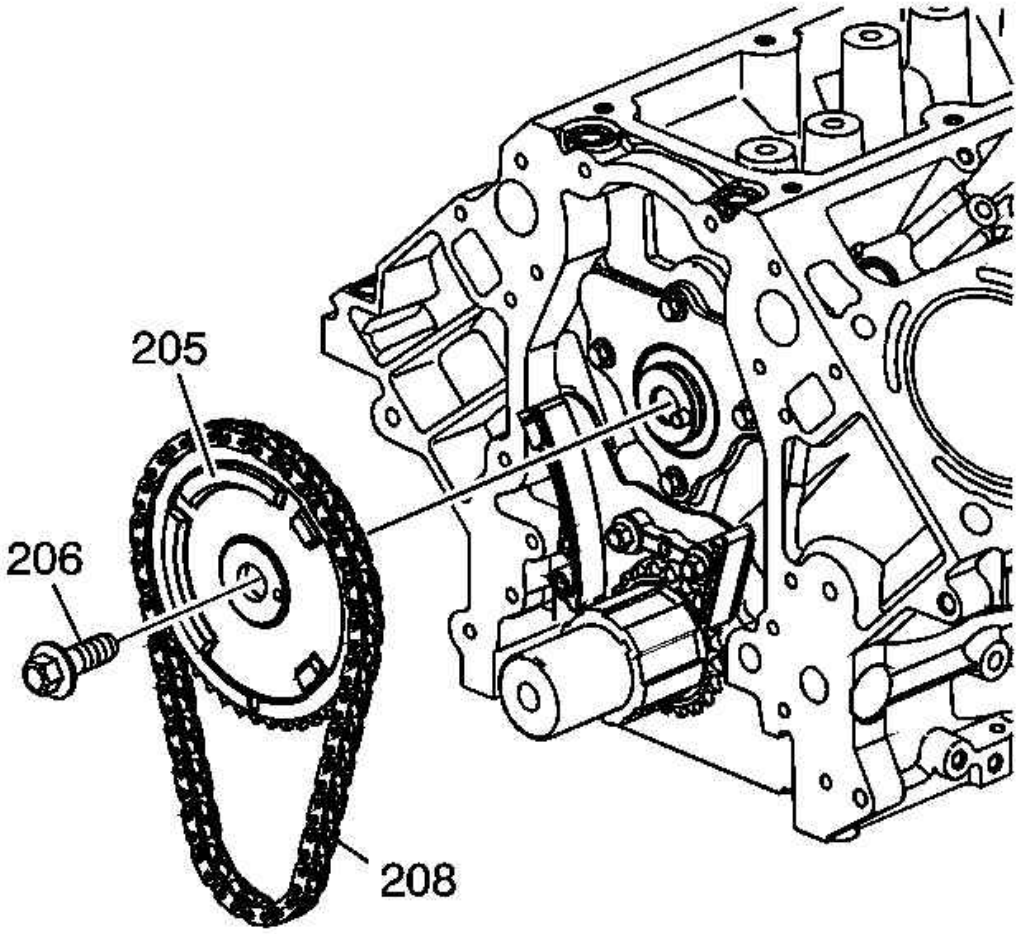


Fig. 387: View Of Camshaft Sprocket, Timing Chain & Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

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NOTE: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

1. Remove and discard the camshaft sprocket bolt (206).
2. Remove the camshaft sprocket (205) and timing chain (208).

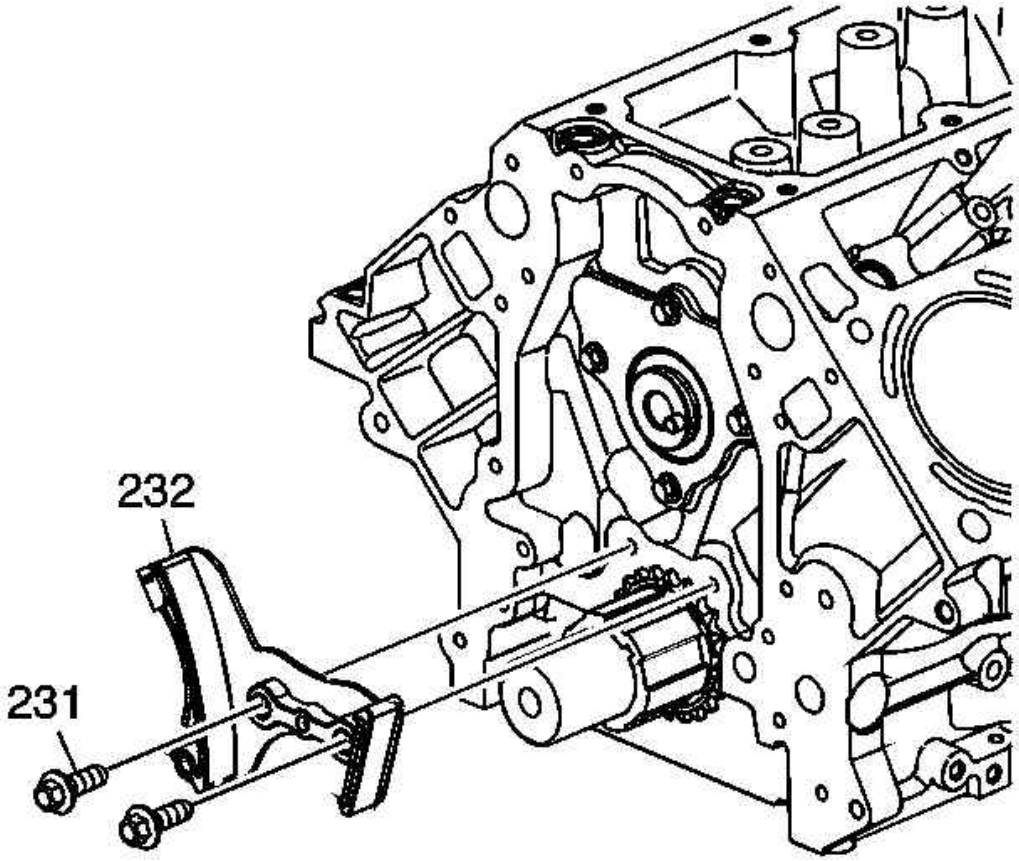


Fig. 388: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts (231) and timing chain tensioner (232).

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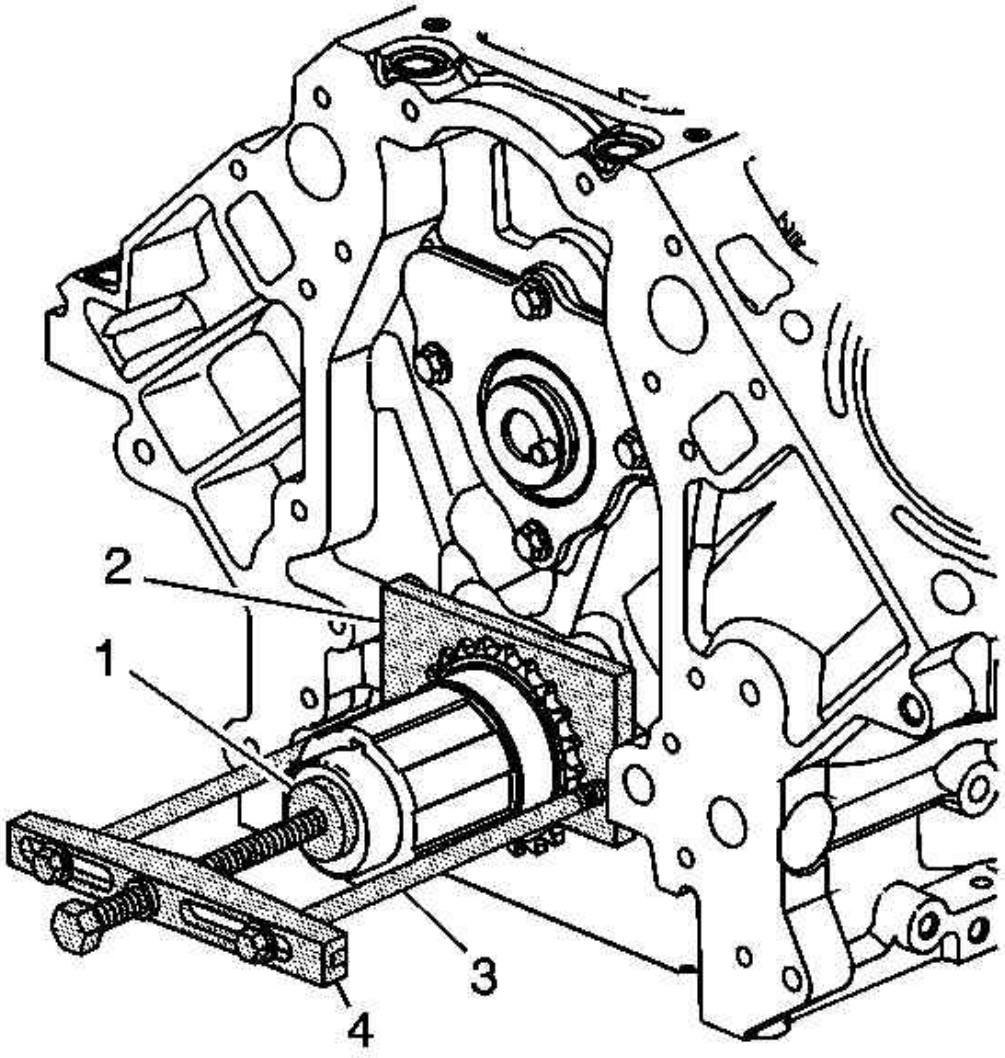


Fig. 389: View Of Crankshaft Sprocket Special Tools
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41816-2** (1), the **J 41558** (2), bolts (3), and the **J 8433** (4) in order to remove the crankshaft sprocket. See **Special Tools**.

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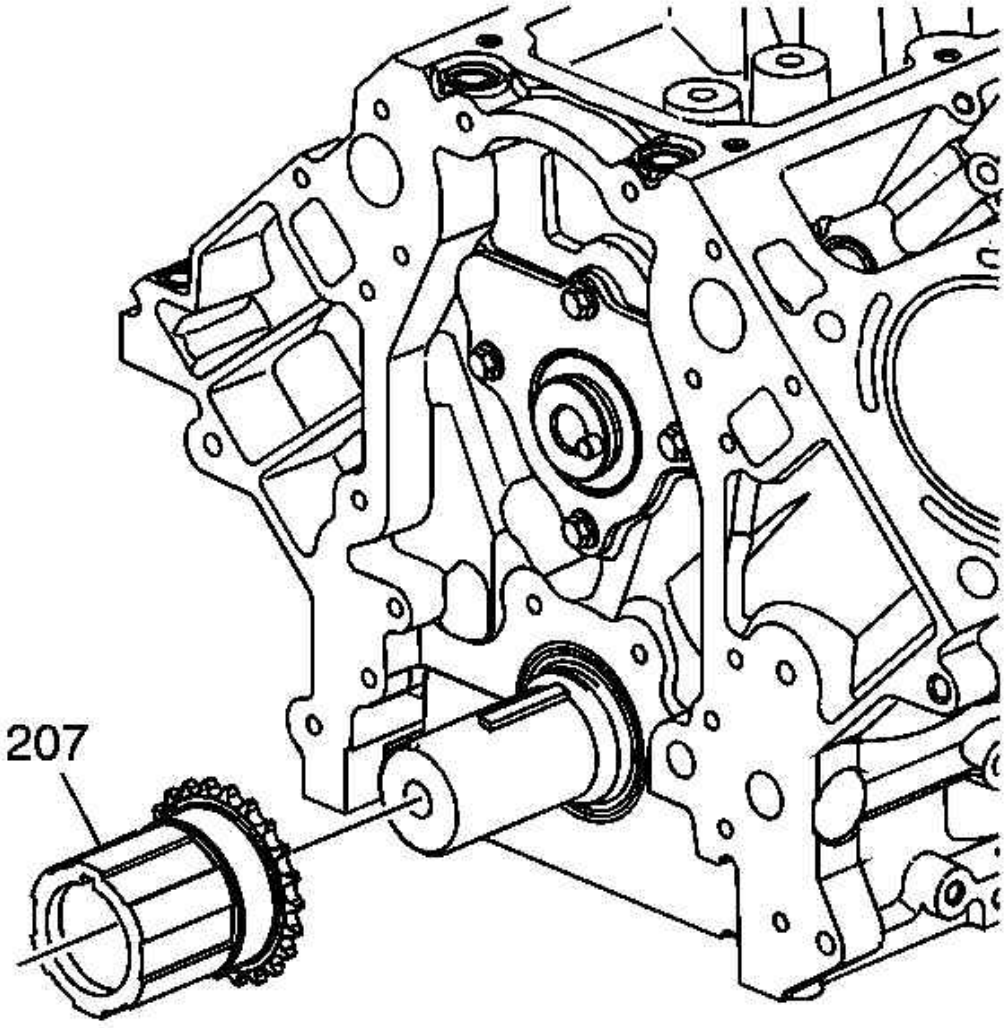


Fig. 390: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket (207).

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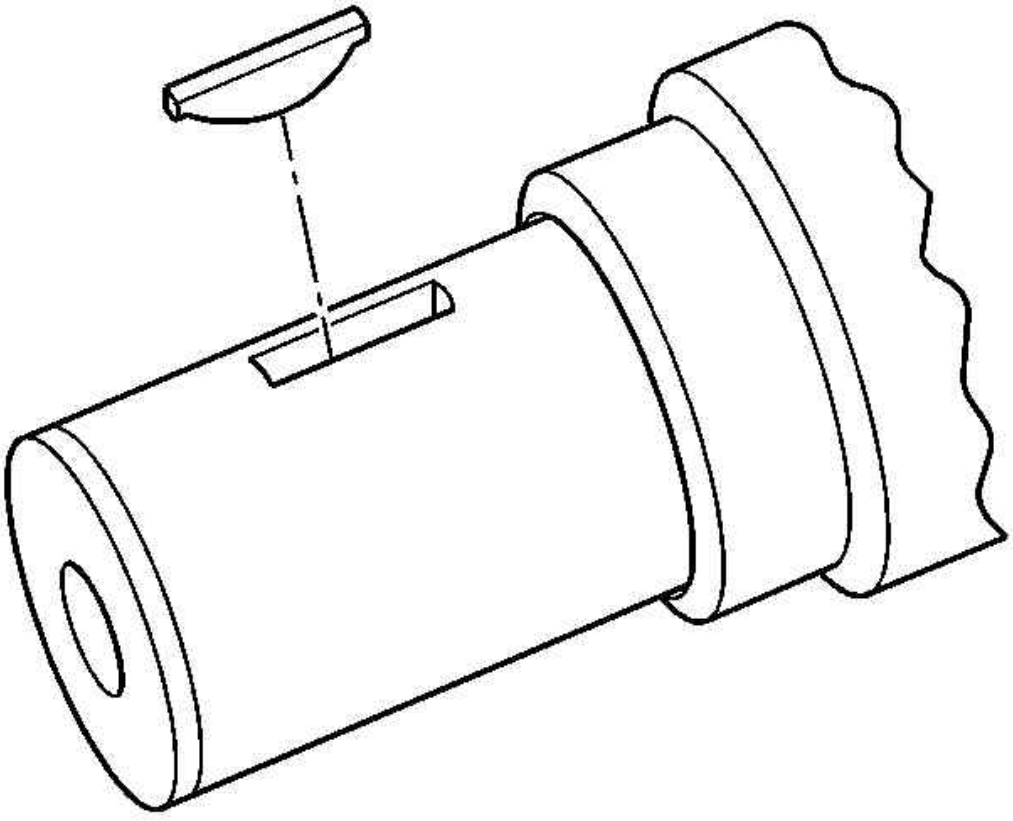


Fig. 391: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket key, as required.

CAMSHAFT REMOVAL

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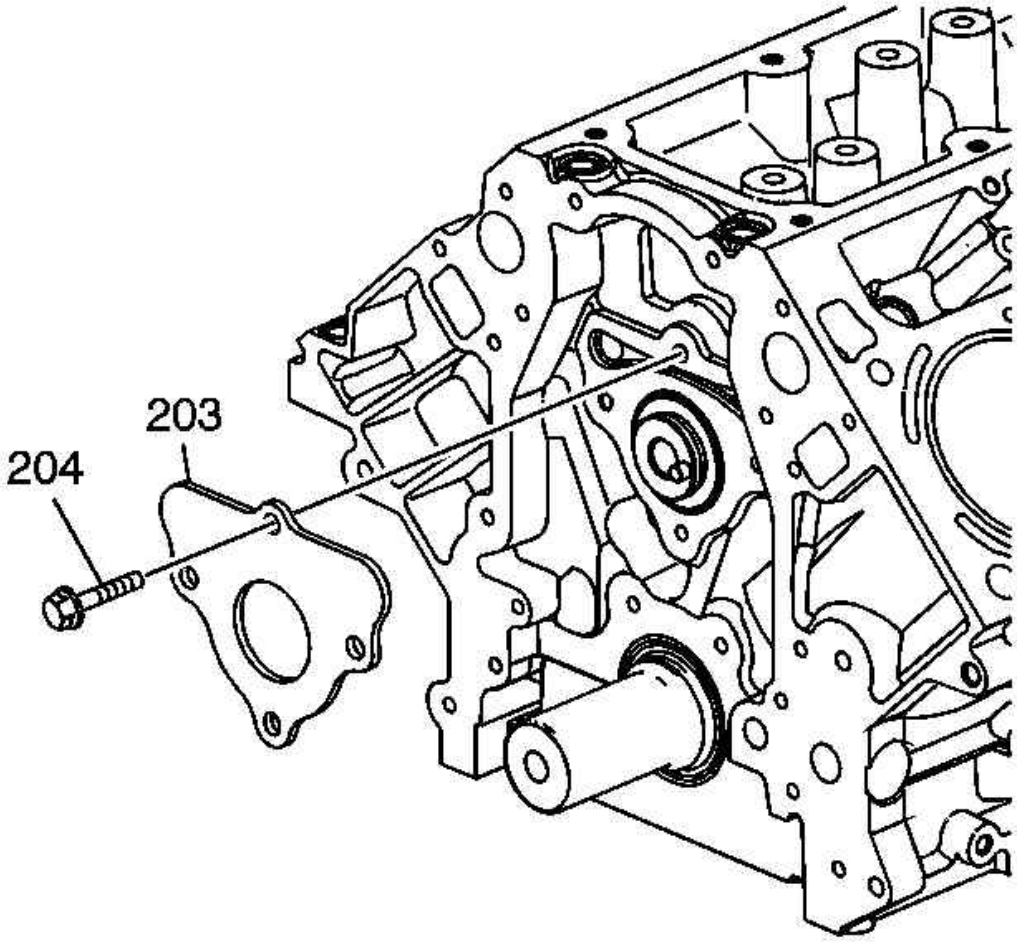


Fig. 392: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts (204) and retainer (203).

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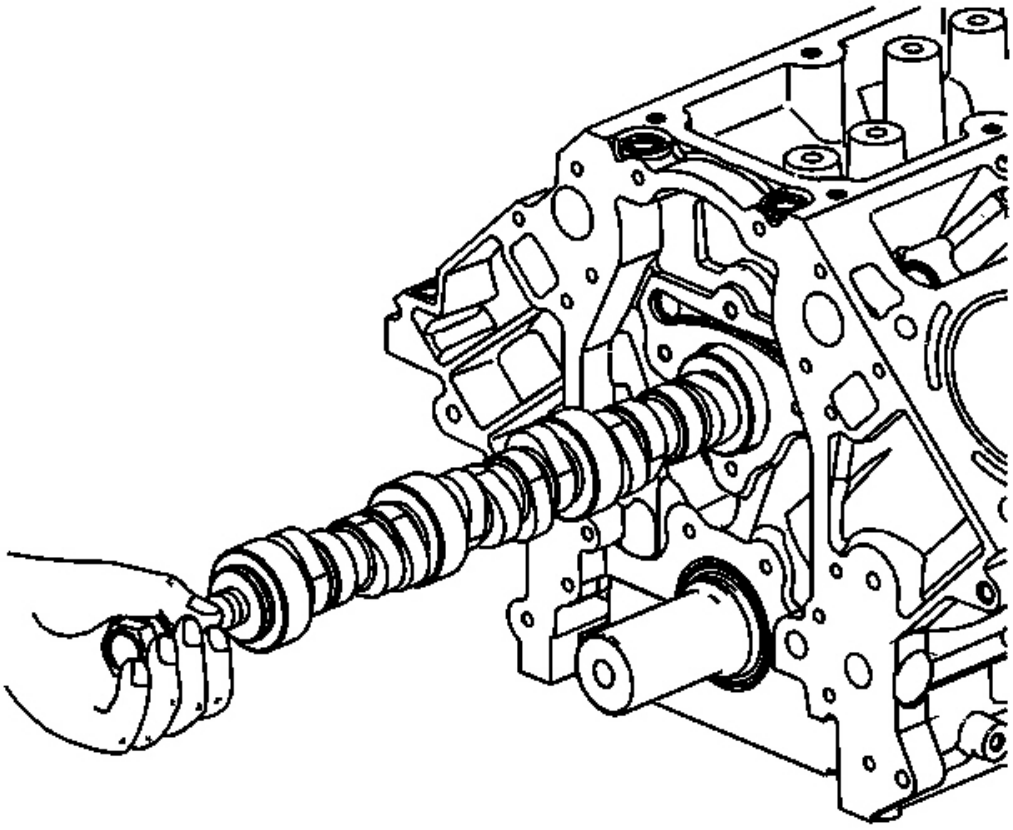


Fig. 393: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the camshaft.
    1. Install the camshaft sprocket bolt into the camshaft front bolt hole.
    2. Using the bolt as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the bolt from the front of the camshaft.

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PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

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

Removal

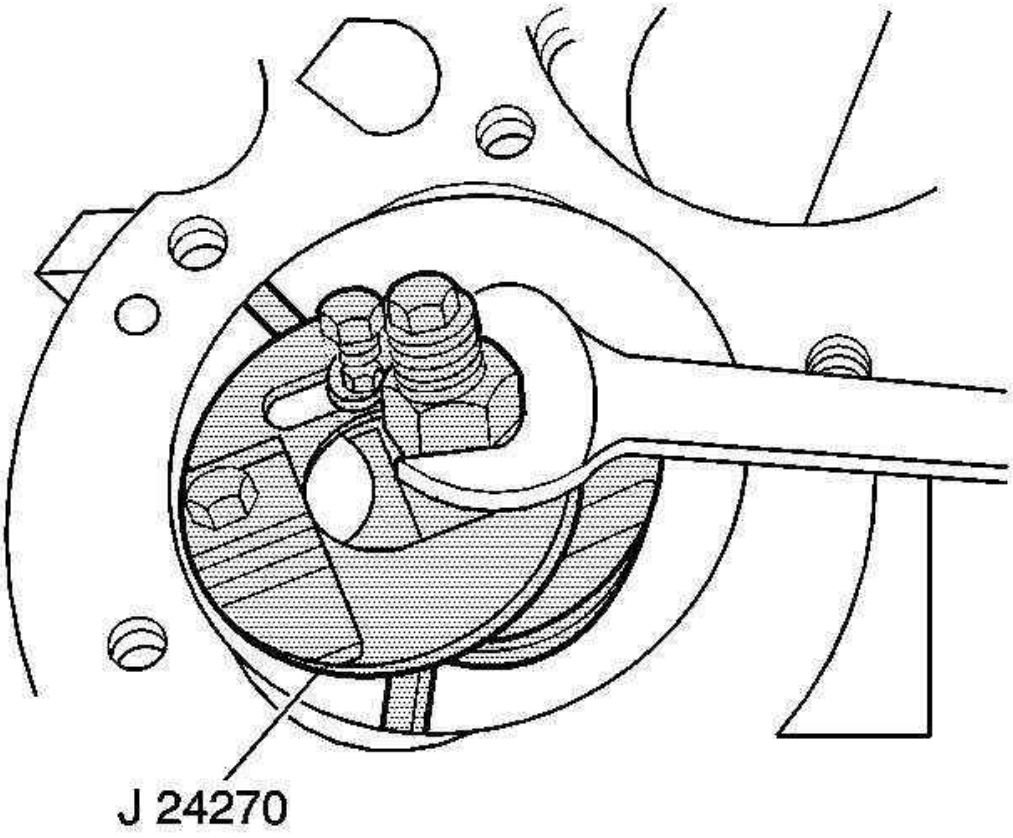


Fig. 394: View Of Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 24270** in order to remove the cylinder bore ring ridge, if required.
    1. Turn the crankshaft until the piston is at the bottom of the stroke.

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2. Place a cloth on top of the piston.
3. Use the **J 24270** , or equivalent, in order to remove a cylinder ring ridge.
4. Turn the crankshaft so the piston is at the top of the stroke.
5. Remove the cloth.
6. Remove the cutting debris from the cylinder and piston.

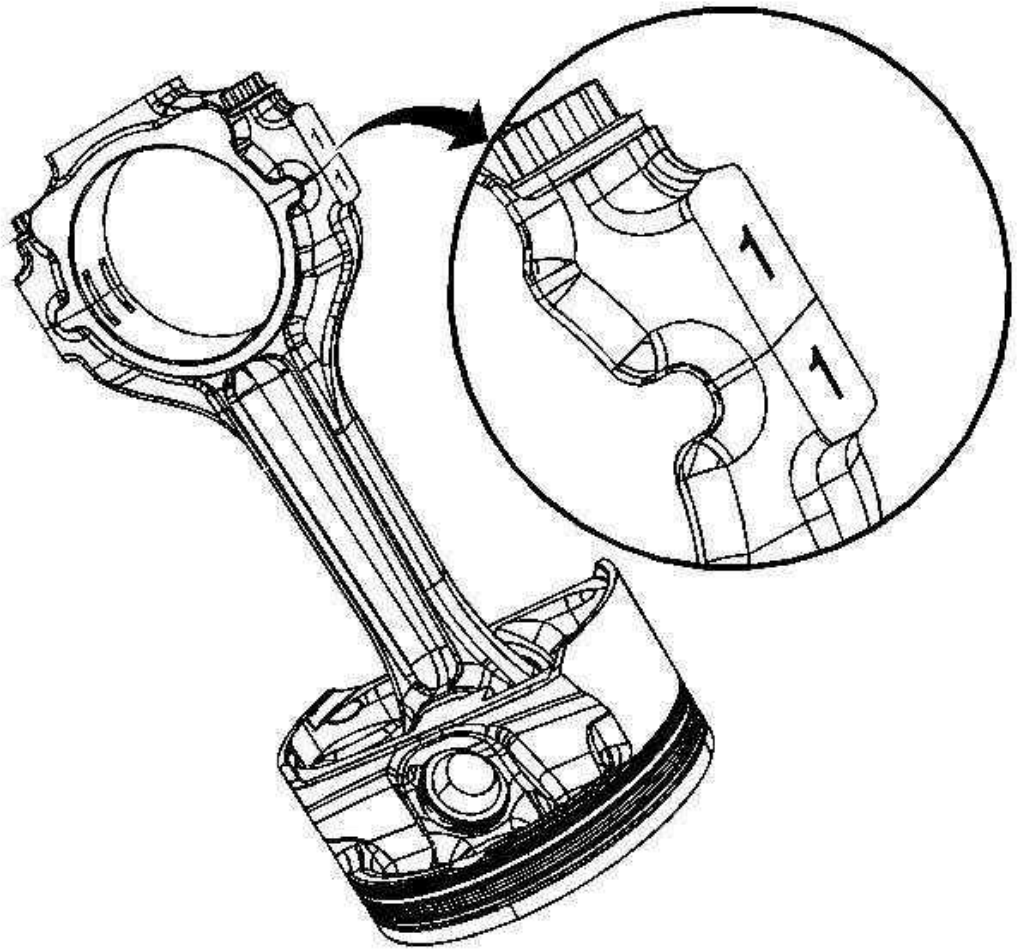


Fig. 395: Identifying Matchmarks On Connecting Rods & Caps
Courtesy of GENERAL MOTORS CORP.

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2. Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
   - A stamping mark on the side of the connecting rod, at the crankshaft journal, may affect component geometry.
   - Mark the top of the piston to the specific cylinder bore.

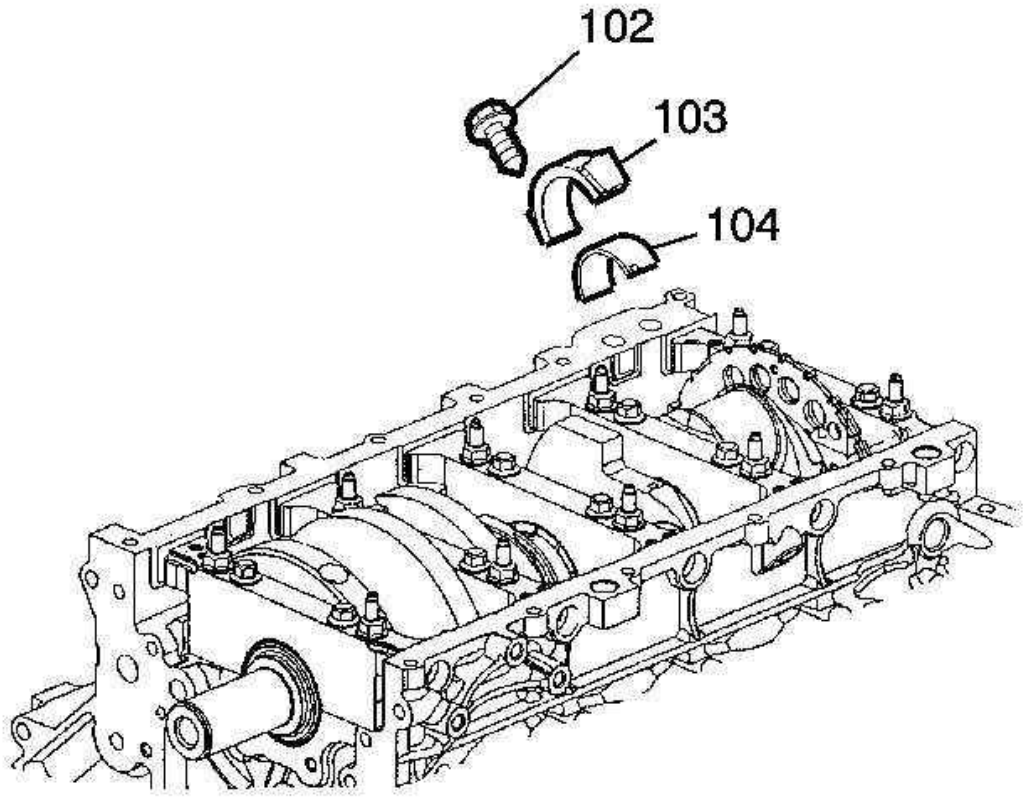


Fig. 396: View Of Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location. The connecting rods and the bearing

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caps are NOT interchangeable. Refer to Separating Parts.

3. Remove the connecting rod bolt (102), cap (103) and bearing (104).

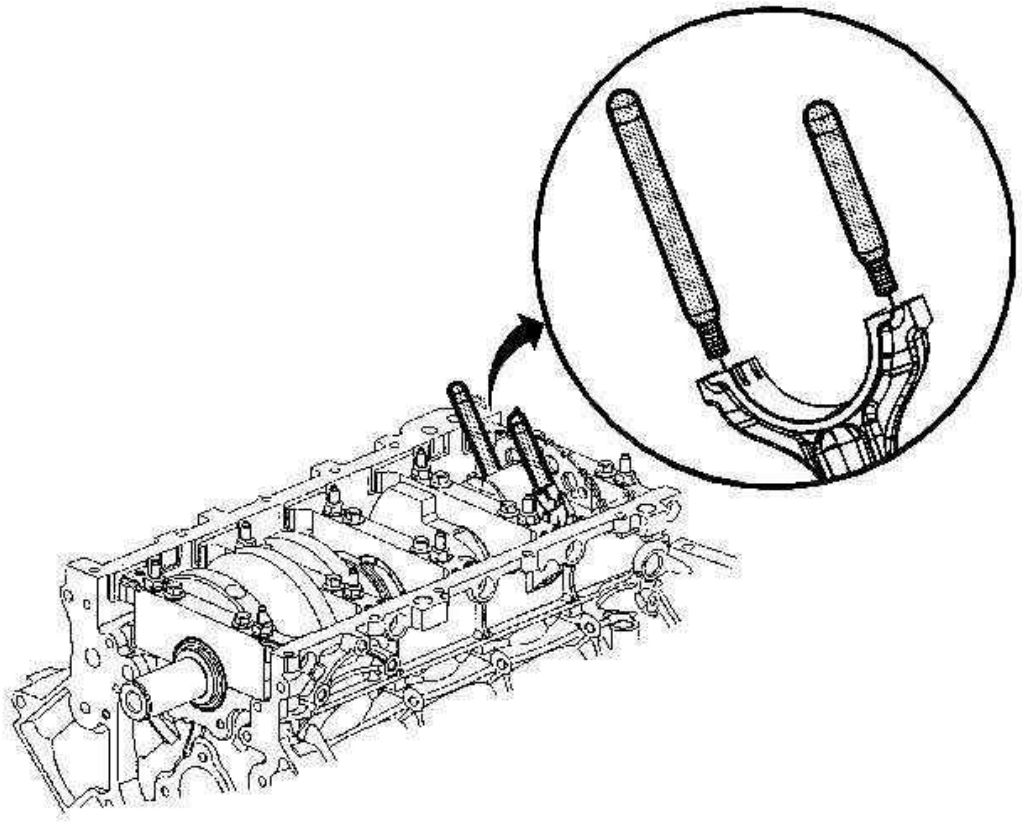


Fig. 397: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod. See **Special Tools**.

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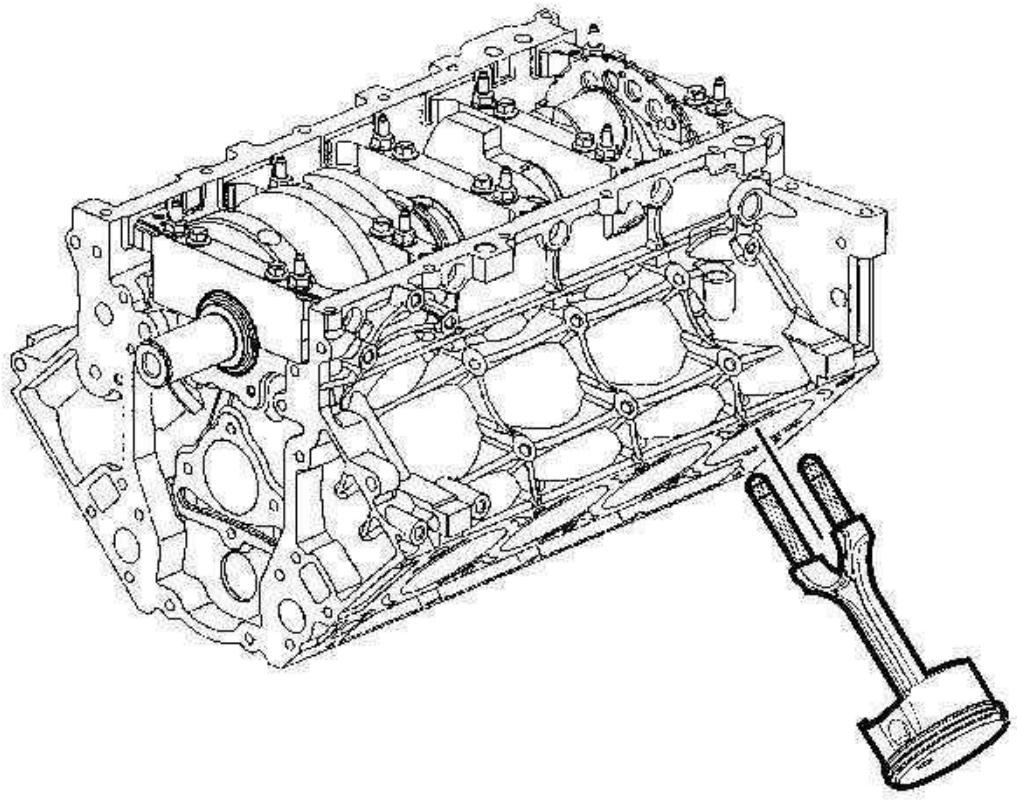


Fig. 398: Installing Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

5. Using a hammer, tap lightly on the end of the **J 41556** in order to remove the piston and connecting rod assembly from the cylinder bore. See **Special Tools**.

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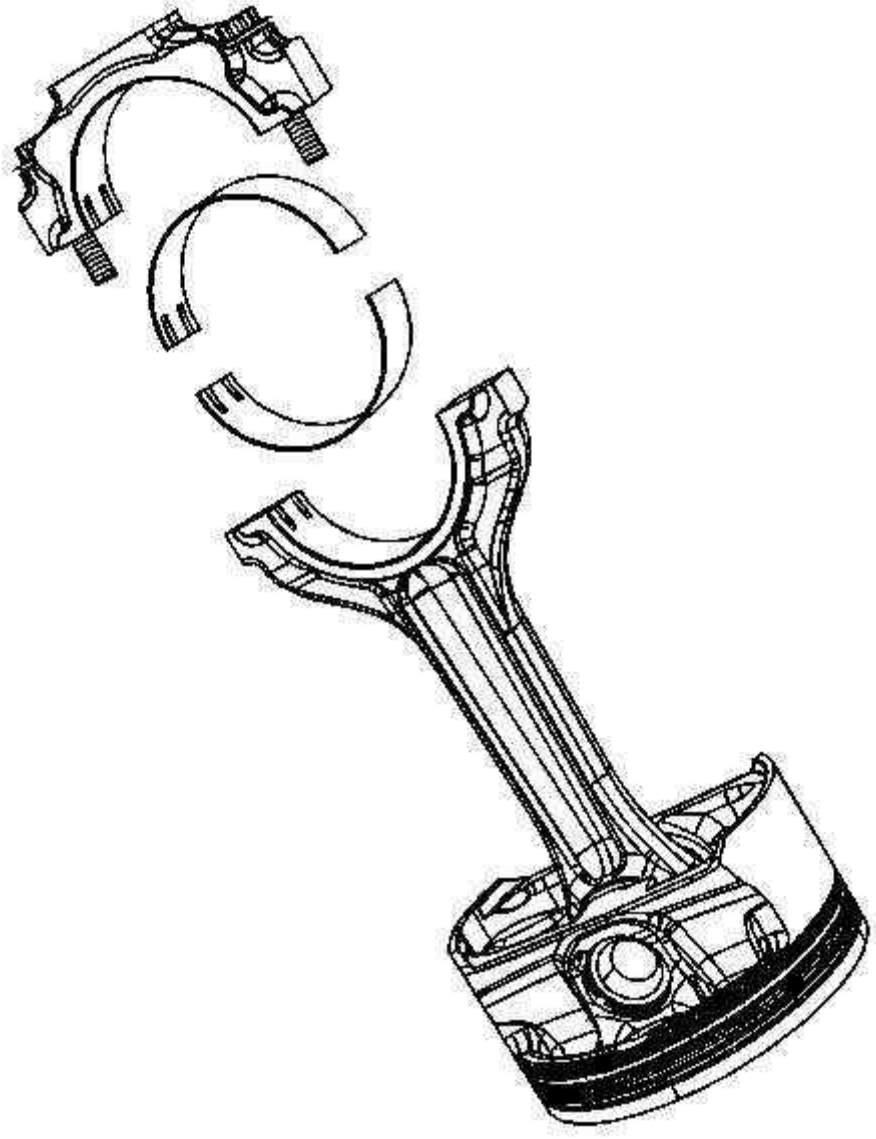


Fig. 399: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

6. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolt onto the matching connecting rod.

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CRANKSHAFT AND BEARING REMOVAL

Tools Required

- **J 6125-1B** Slide Hammer with Adapter
- **J 41818** Crankshaft Bearing Cap Remover

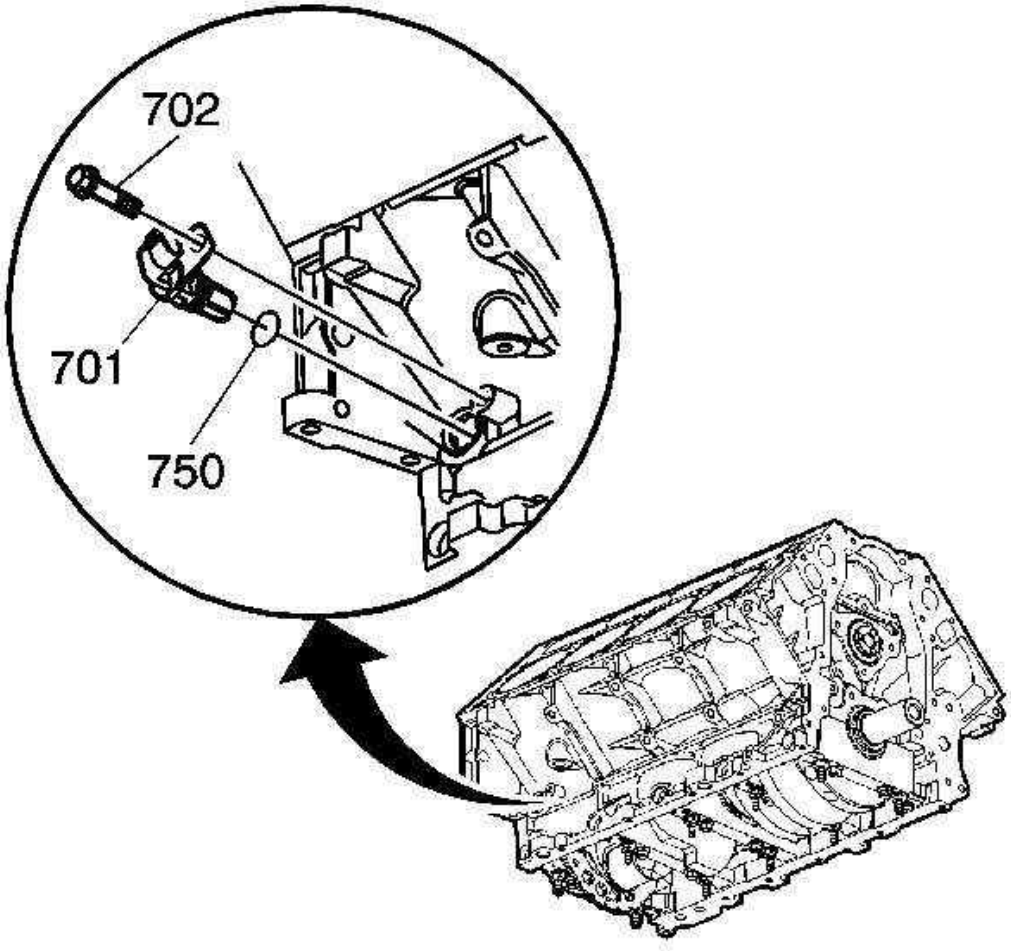


Fig. 400: View Of CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

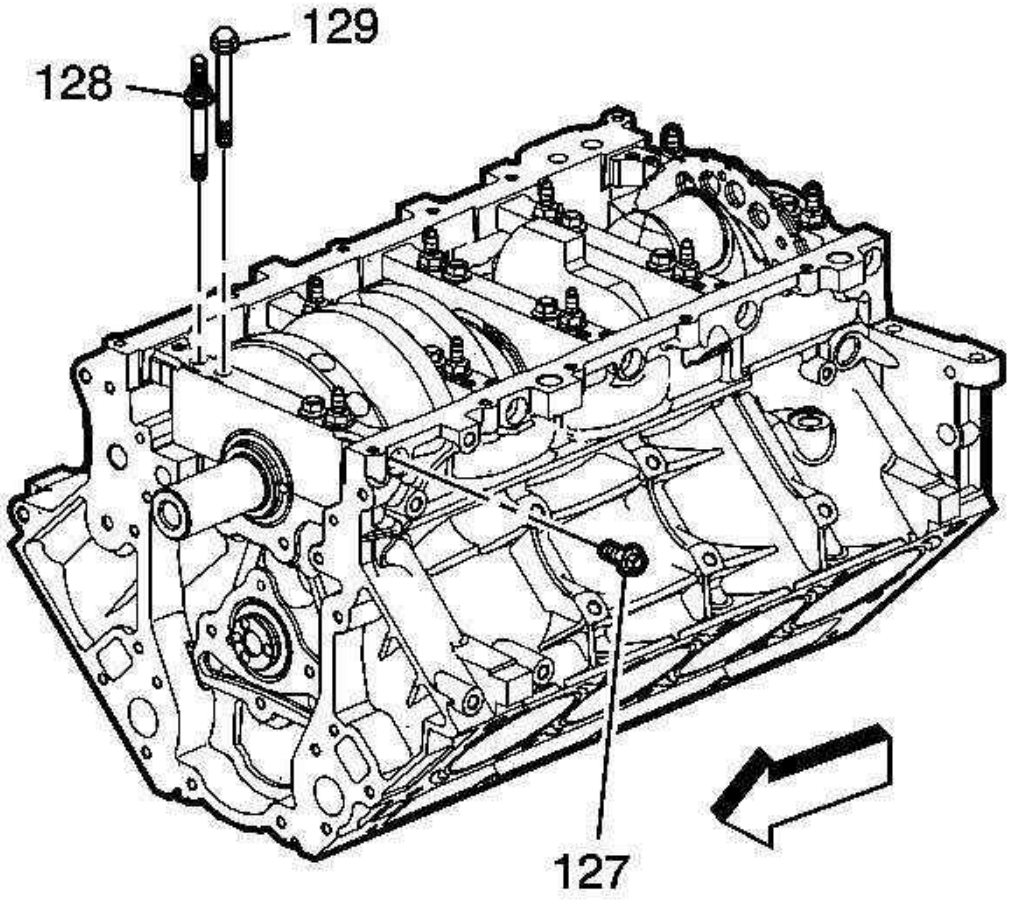
- **The crankshaft bearing caps are machined with**

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the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps MUST be installed to their original position and direction.

- **Do not use the bearing cap M8 side bolts again.**

1. Remove the crankshaft position (CKP) sensor bolt (702).
2. Remove the CKP sensor (701).
3. Remove the O-ring (750) from the sensor, as required.



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Fig. 401: View Of Crankshaft Bearing Caps & Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft bearing cap M8 bolts (127).
5. Remove the crankshaft bearing cap M10 bolts (129) and studs (128).

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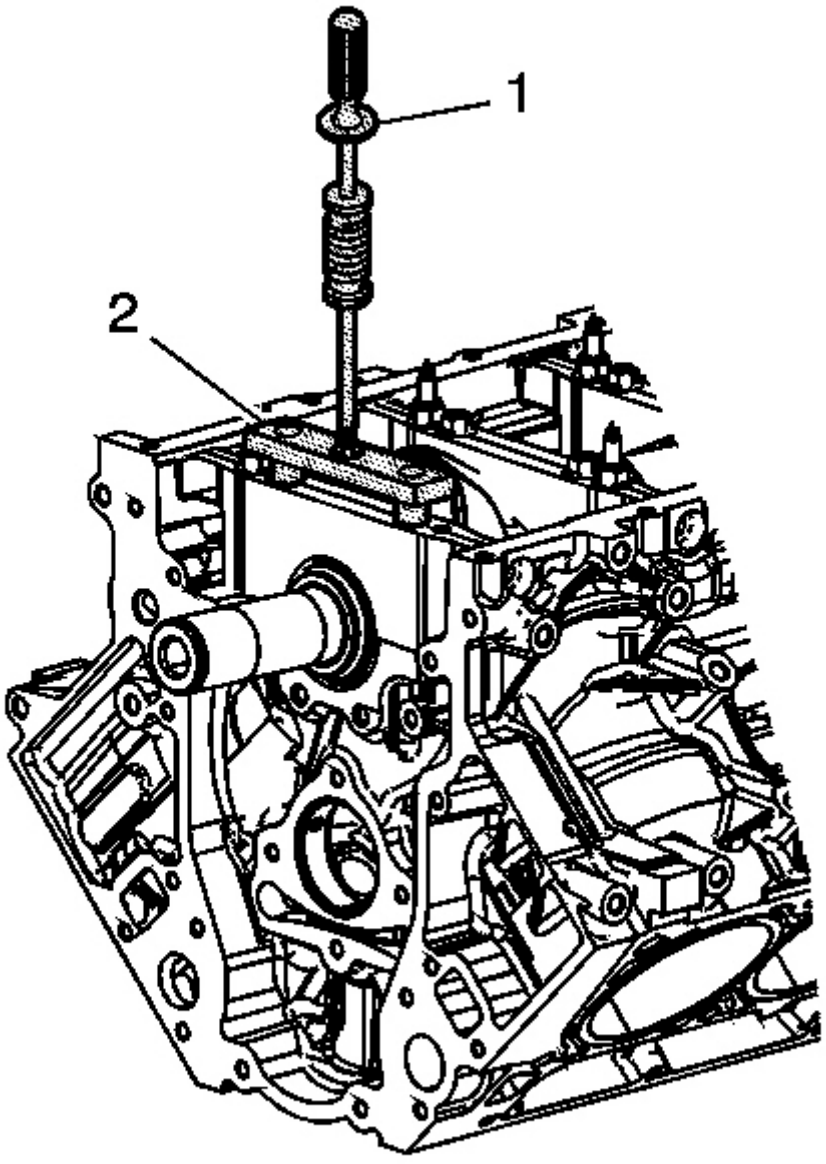


Fig. 402: View Of Crankshaft Bearing Cap Bolts (M10)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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6. Install the **J 41818** (2).

   Tighten: Tighten the **J 41818** bolts to 11 N.m (100 lb in).

7. Install the **J 6125-1B** (1) to the **J 41818** (2) in order to remove the crankshaft bearing caps.

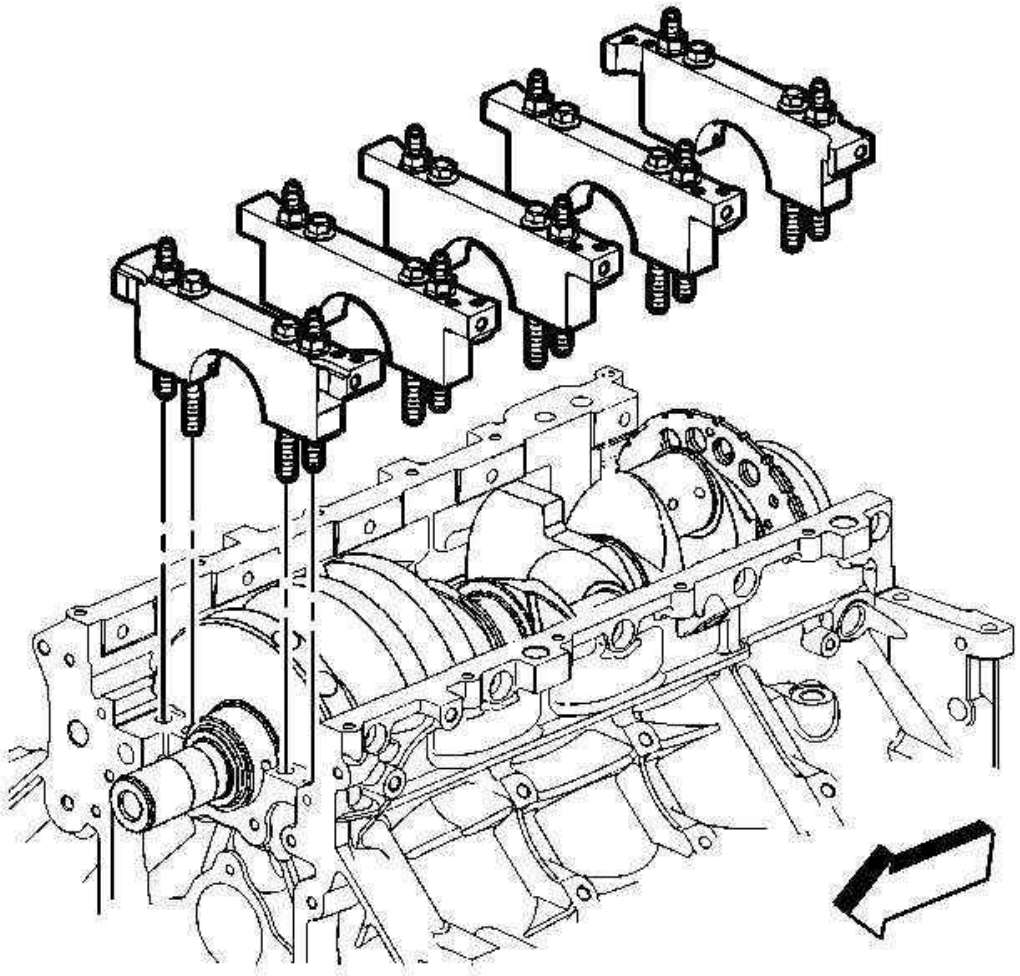


Fig. 403: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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8. Remove the bearing caps.

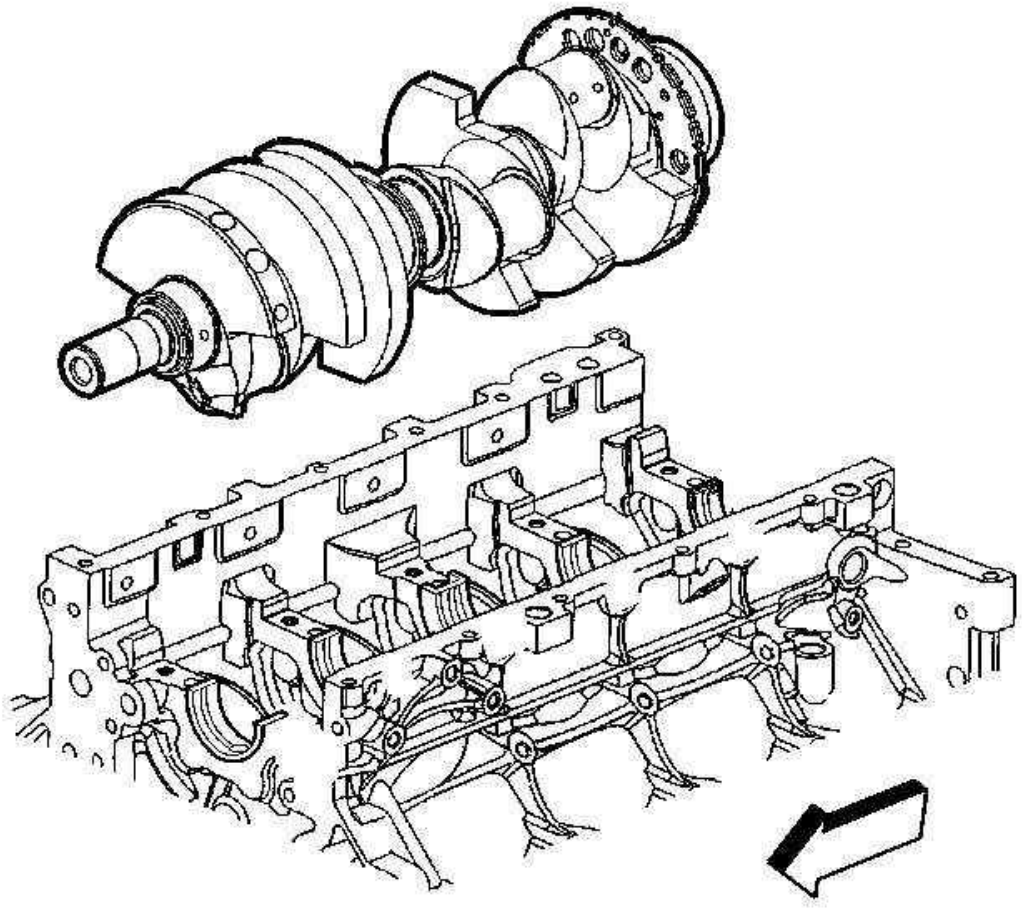


Fig. 404: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs, or other damage to the teeth may affect on-board diagnostics (OBD) II system performance.

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9. Remove the crankshaft.

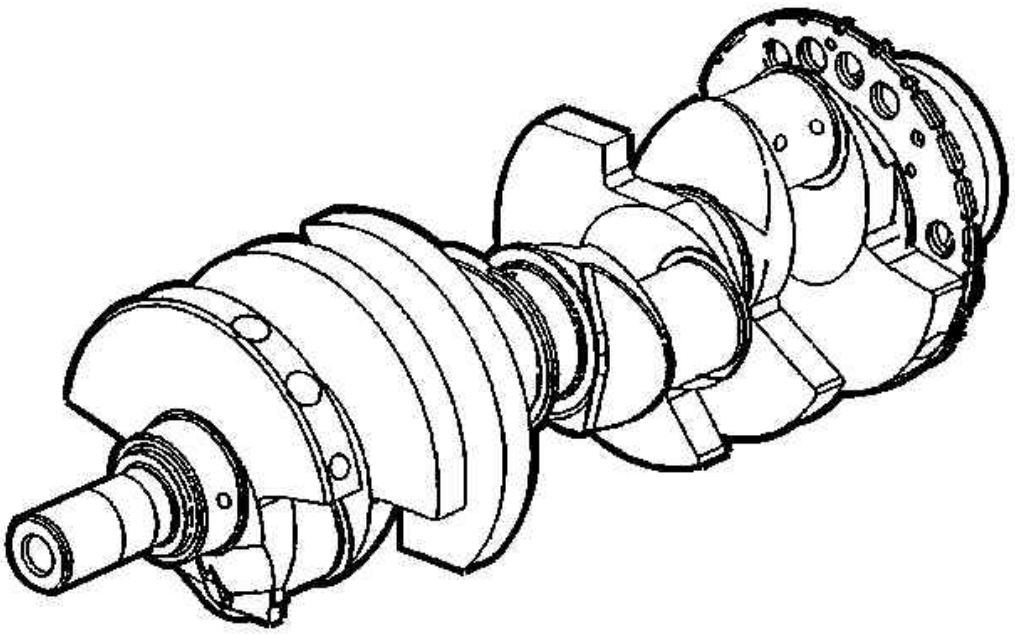


Fig. 405: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

10. Lay the crankshaft onto wooden V-blocks or other protective surface.

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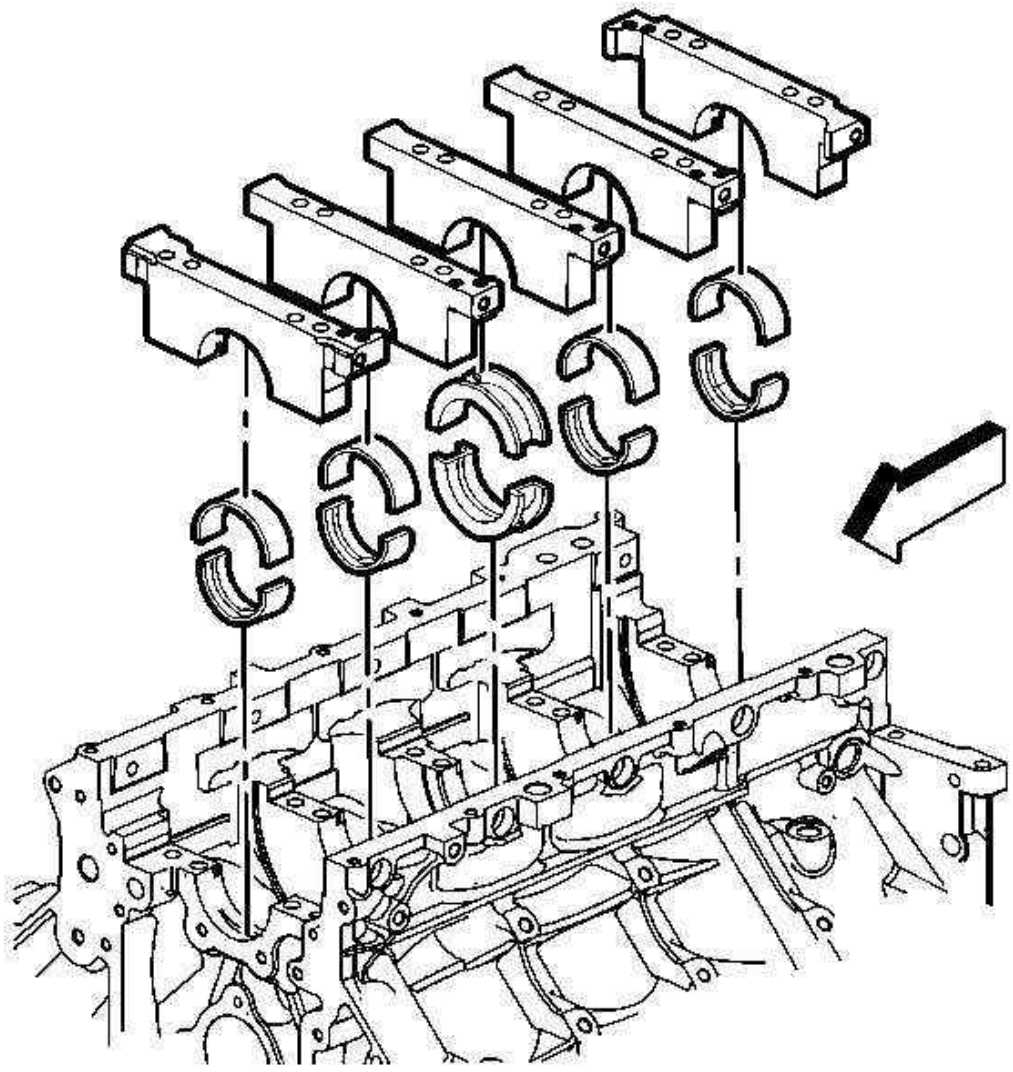


Fig. 406: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft bearings from the bearing caps and the engine block.
12. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to **Separating Parts**.

ENGINE BLOCK PLUG REMOVAL

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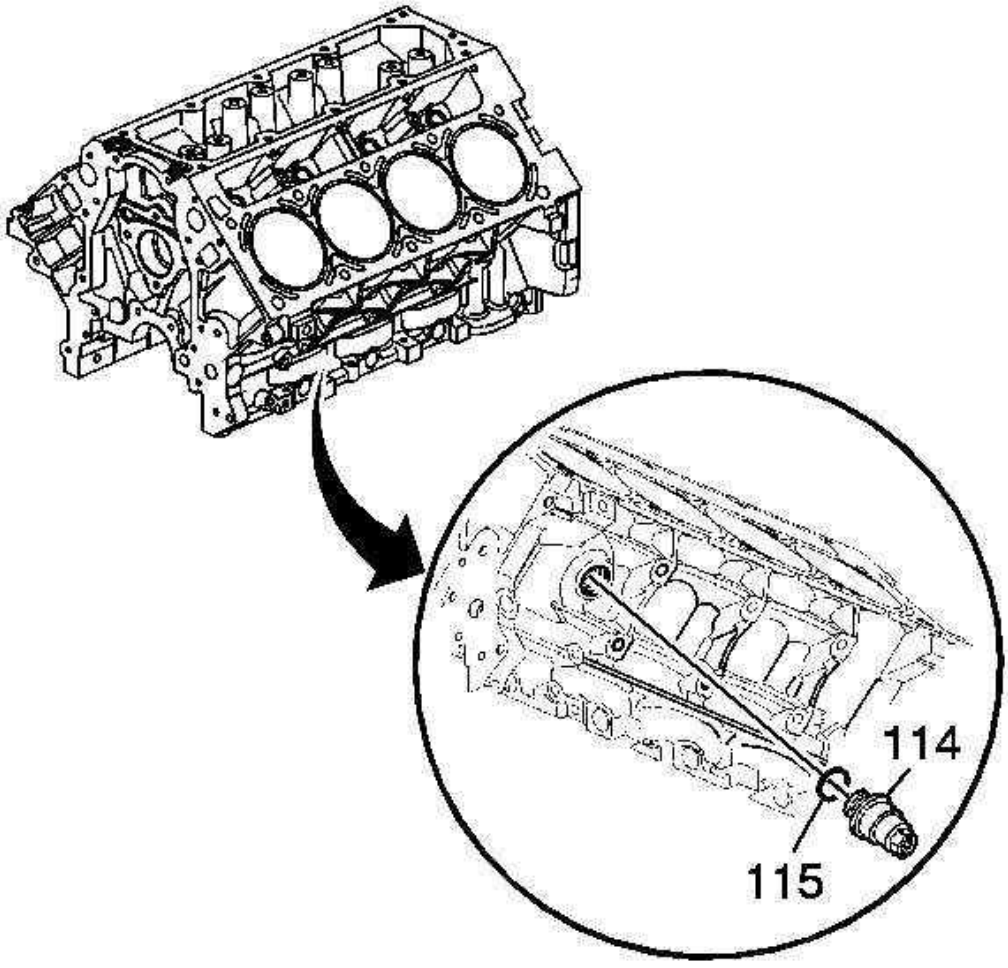


Fig. 407: Identifying Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block coolant heater (114).

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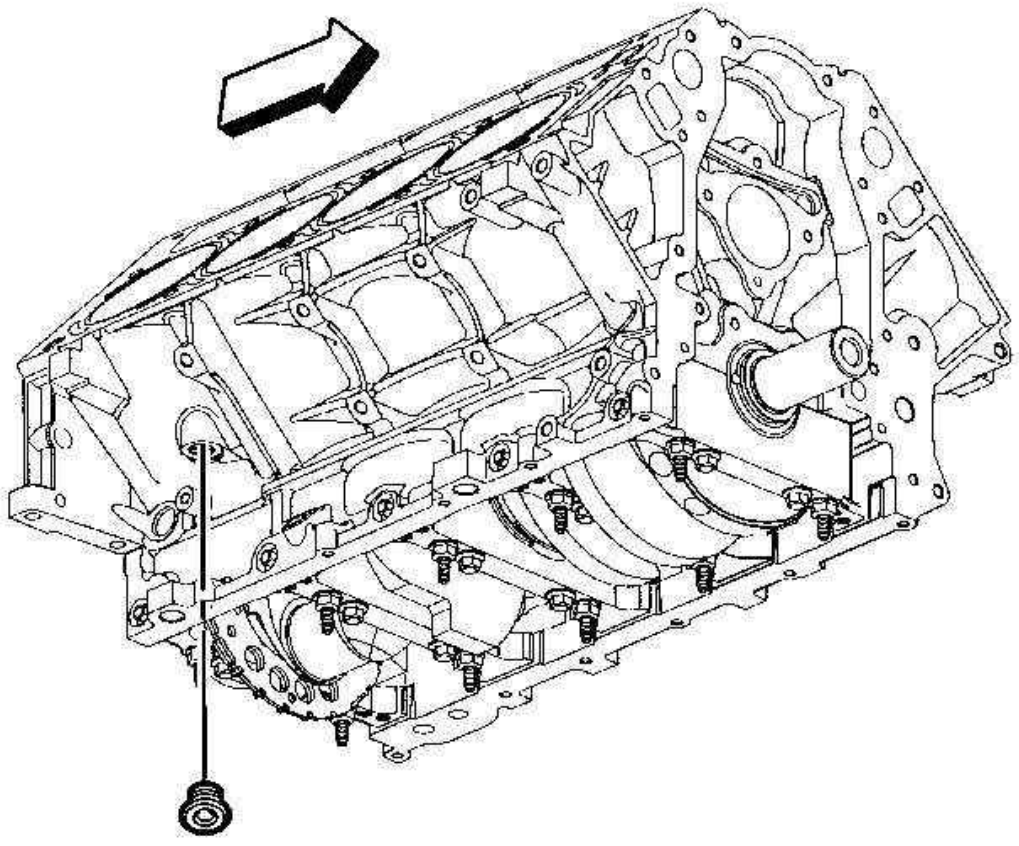


Fig. 408: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block coolant drain hole plug.

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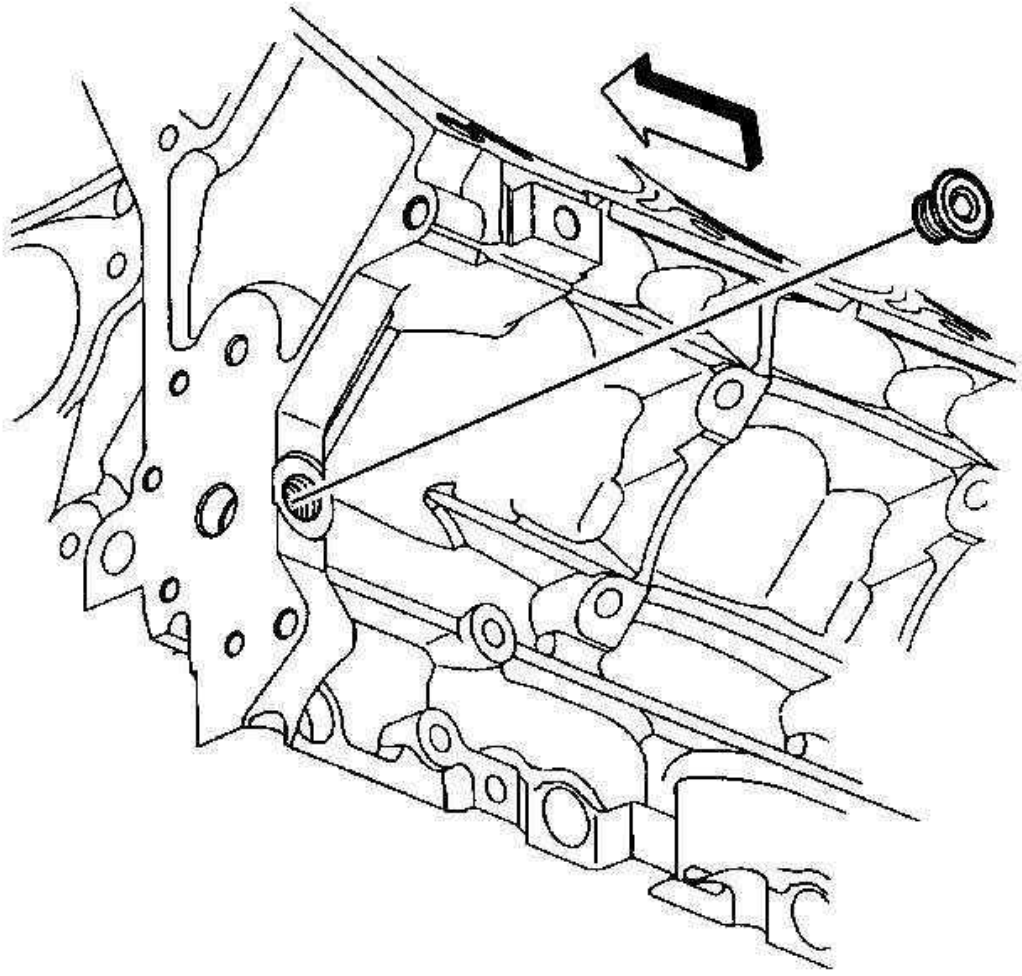


Fig. 409: Identifying Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block left front oil gallery plug.

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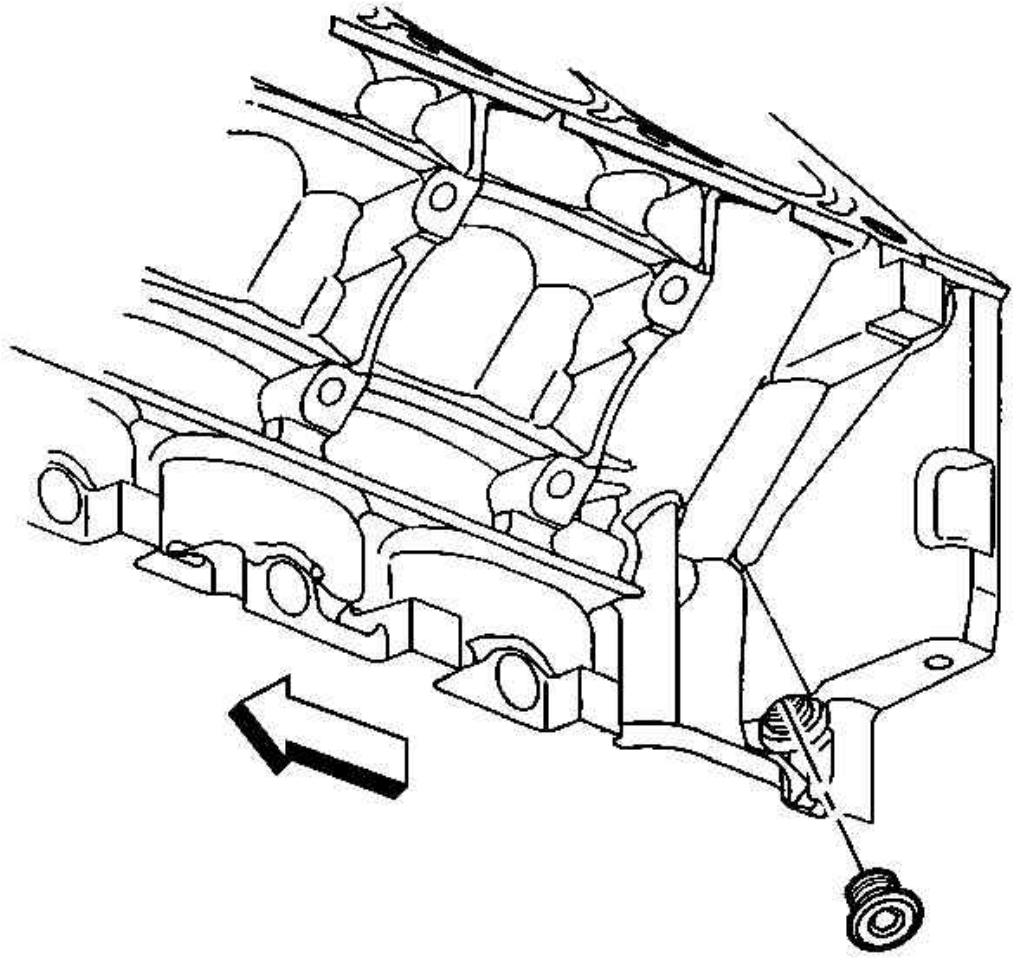
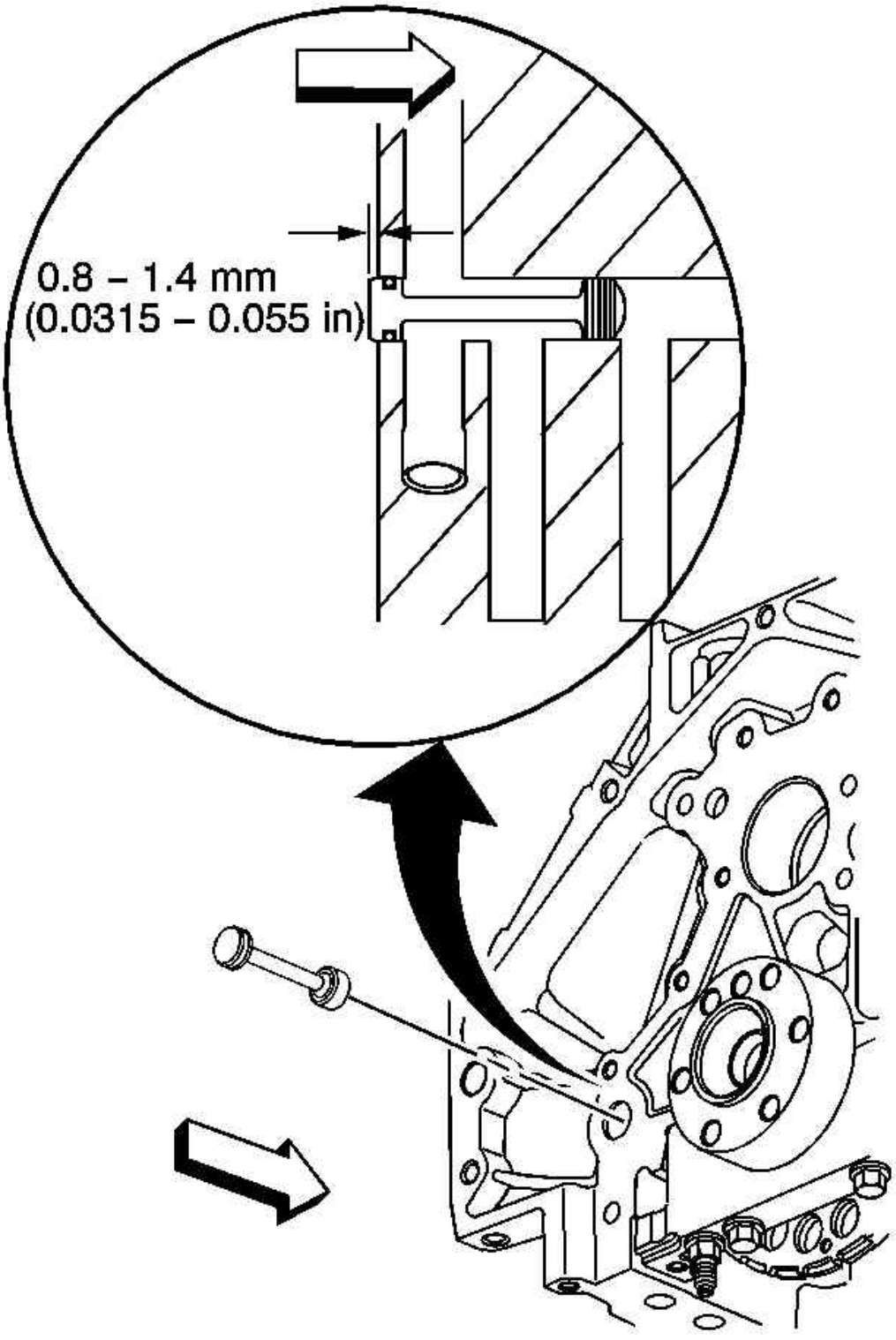


Fig. 410: View Of Engine Block Left Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block left rear oil gallery plug.
5. Inspect the block plug sealing washers.

   If the block plug and heater sealing washers are not damaged, they may be used during assembly.

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Fig. 411: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine block rear oil gallery plug.
7. Inspect the O-ring seal of the rear oil gallery plug.

   If the O-ring seal is not cut or damaged, the plug and O-ring seal may be used during assembly.

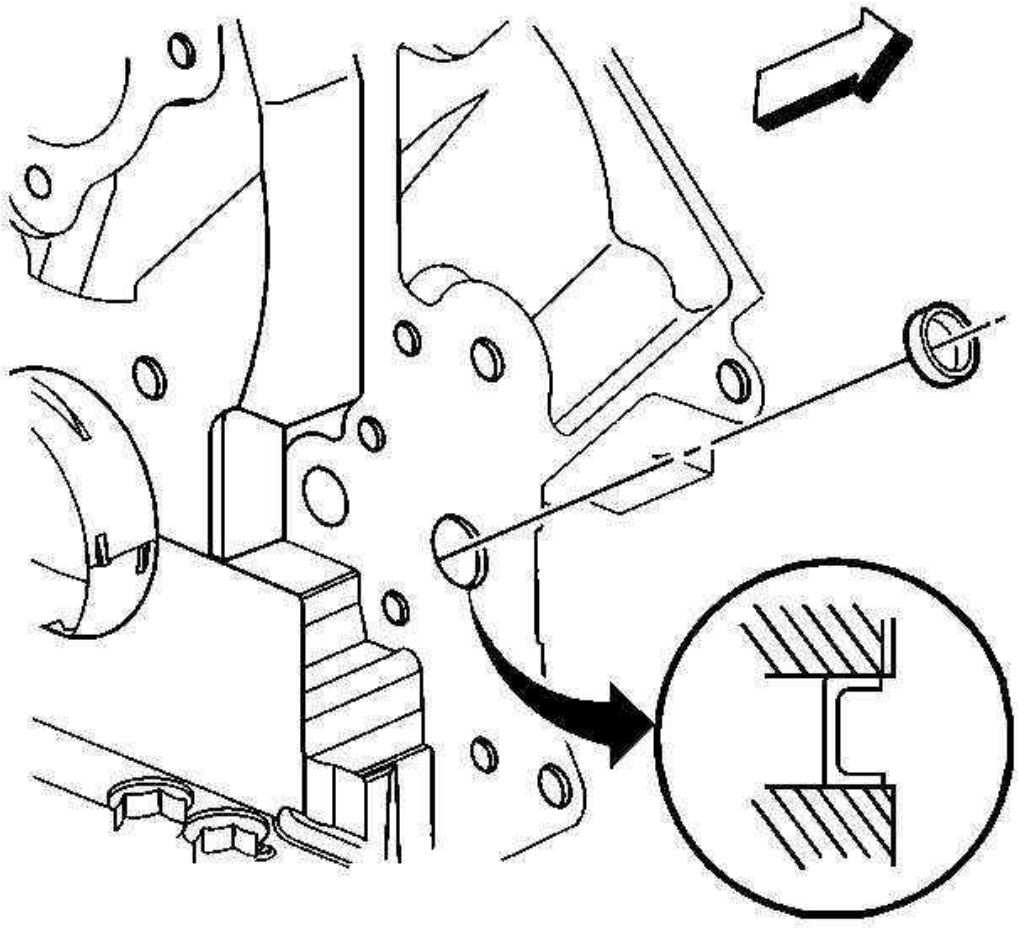


Fig. 412: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Remove the front oil gallery plug only if service is required. If the front oil gallery plug is removed, a NEW oil gallery plug must be installed.

8. Remove the engine block front oil gallery plug.

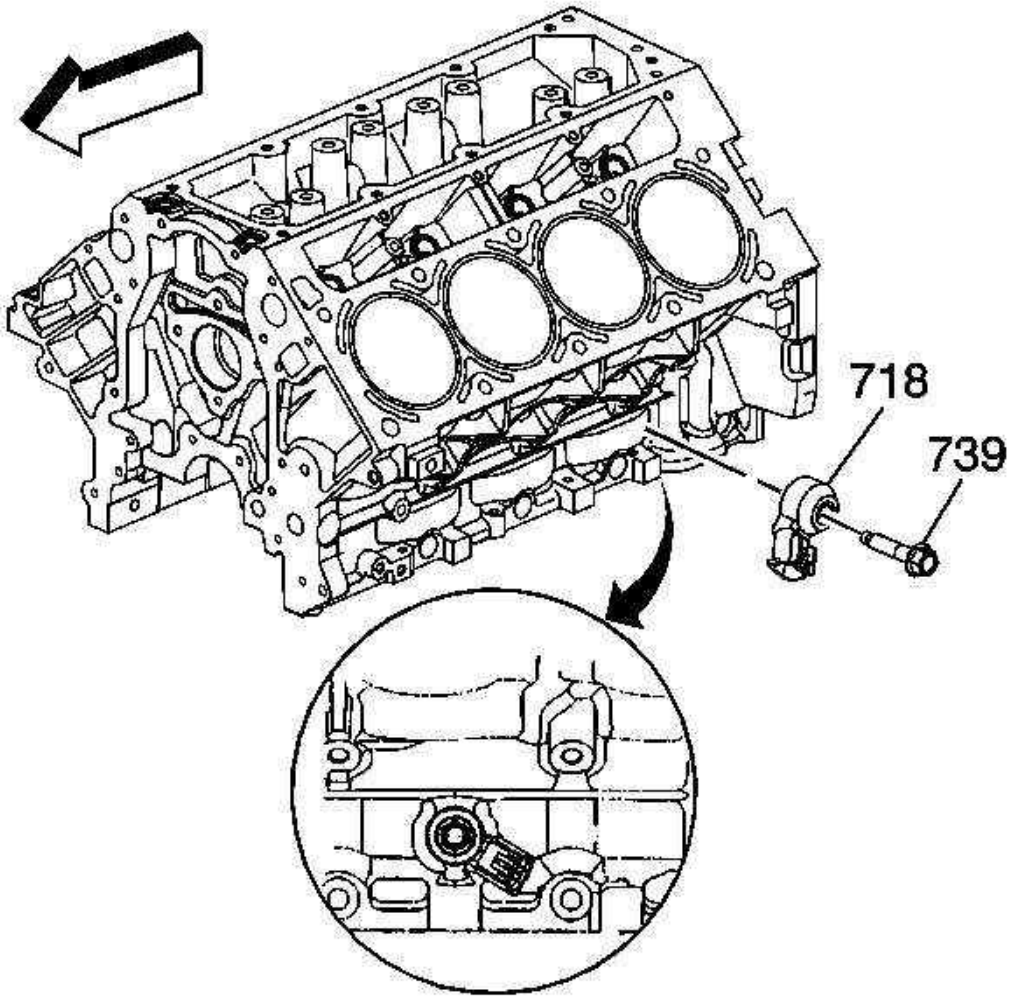


Fig. 413: View Of Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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9. Remove the left side knock sensor (718) and bolt (739).

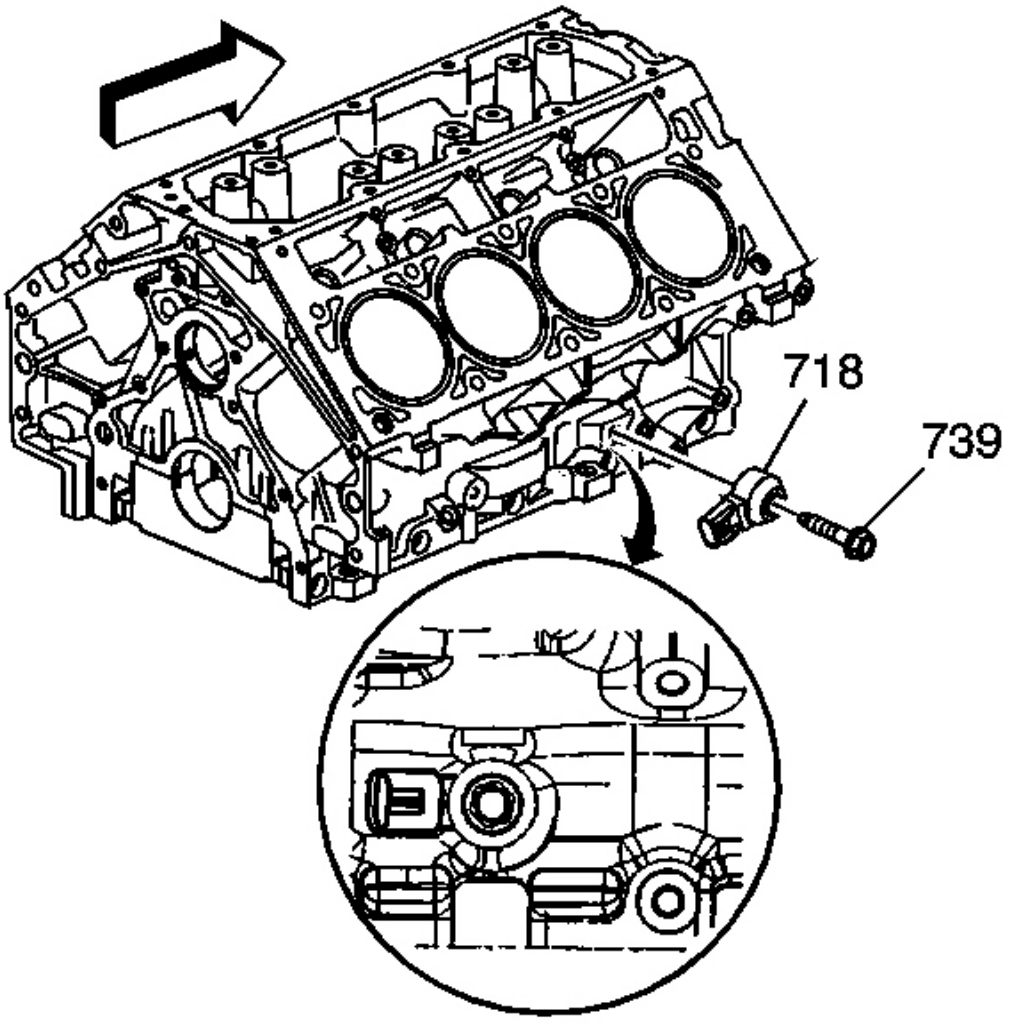


Fig. 414: Identifying Knock Sensor
Courtesy of GENERAL MOTORS CORP.

10. Remove the right side knock sensor (718) and bolt (739).

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

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- **J 8087** Cylinder Bore Gage
- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.

Cleaning Procedure

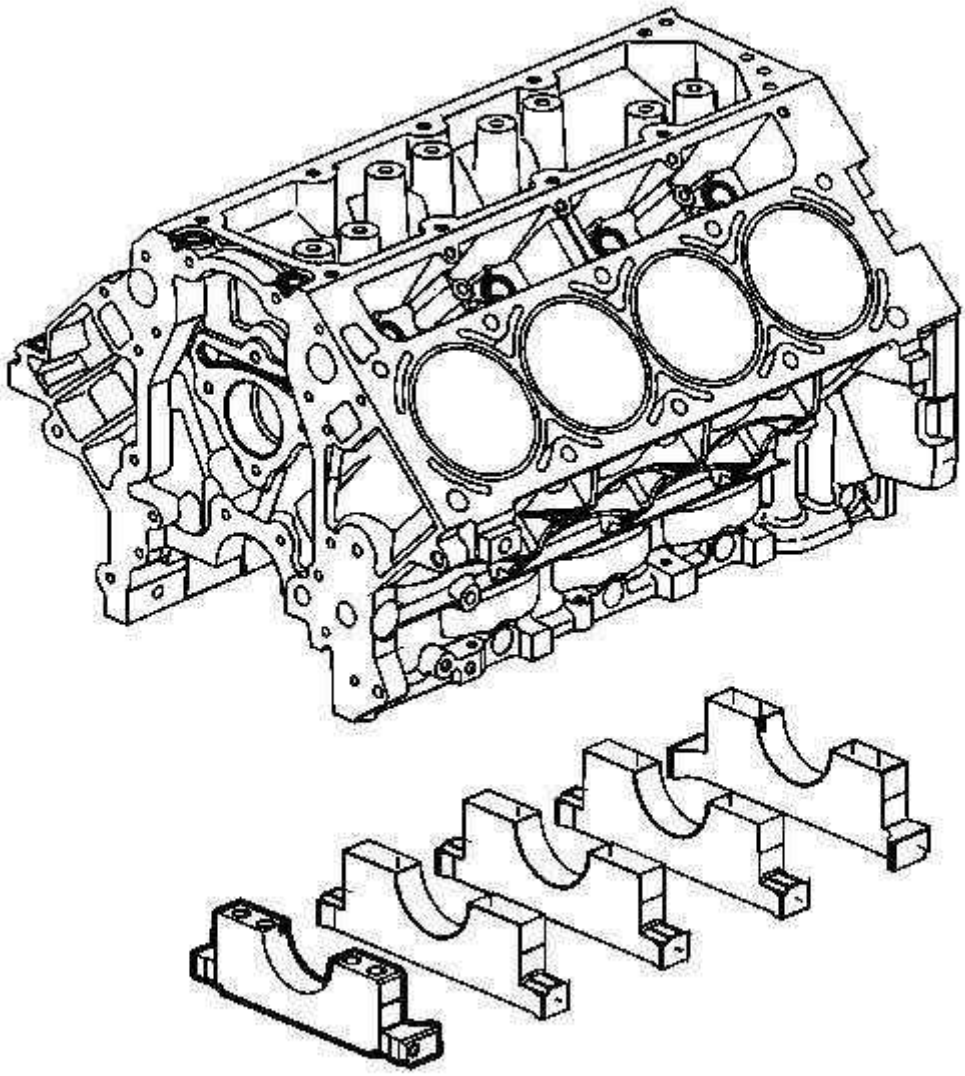


Fig. 415: View Of Engine Block & Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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NOTE: Do not use a caustic solution to clean the aluminum engine block.

IMPORTANT: When cleaning the engine block in a thermal type oven, do not exceed 232°C (450°F).

Clean the following components:

- Remove all sludge, dirt, or debris using a cleaning solvent or thermal type oven. Refer to **Cleanliness and Care**.
- Gasket surfaces

  Refer to **Replacing Engine Gaskets**.

- Coolant passages
- Oil galleries
- Main bearing caps
- Cylinder head bolt holes to remove threadlocking material

  Thread repair driver tool J 42385-107 may be used to clean the threads of old threadlocking material.

Inspection Procedure

1. Inspect the following components:
   - Cylinder walls for excessive scratches, gouging, or ring ridge
   - Cylinder bores for excessive ring ridge at the top of the cylinder
   - Coolant jacket for cracks
   - Valve lifter bores for excessive scoring or wear
   - Crankshaft bearing webs for cracks
   - Gasket sealing surfaces for excessive scratches or gouging

     Refer to **Replacing Engine Gaskets**.

   - Oil galleries for restrictions

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- Threaded bolt holes for damaged threads
- Scoring or damage to the displacement on demand oil passages or sealing surfaces

2. Measure the cylinder bores for excessive ring ridge at the top of the cylinder.

Measuring the Cylinder for Oversize

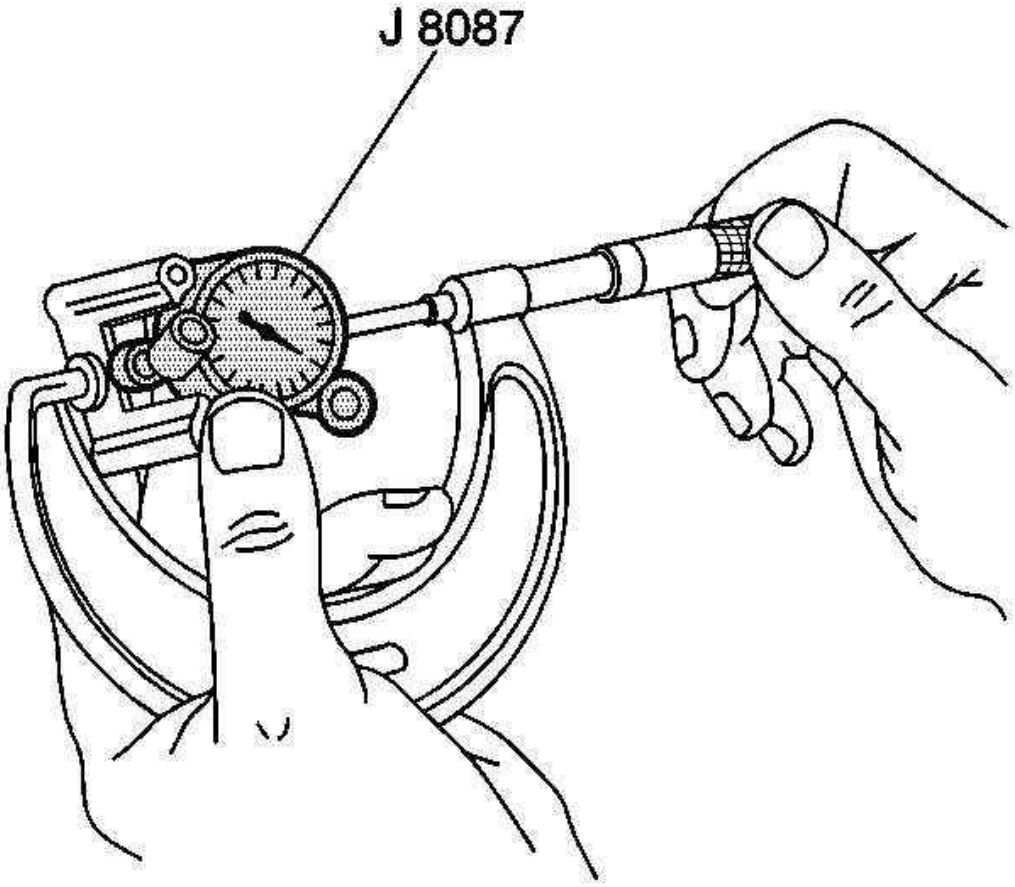


Fig. 416: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical Specifications**.

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2. Insert the **J 8087** bore gage into the micrometer and zero the bore gage dial.

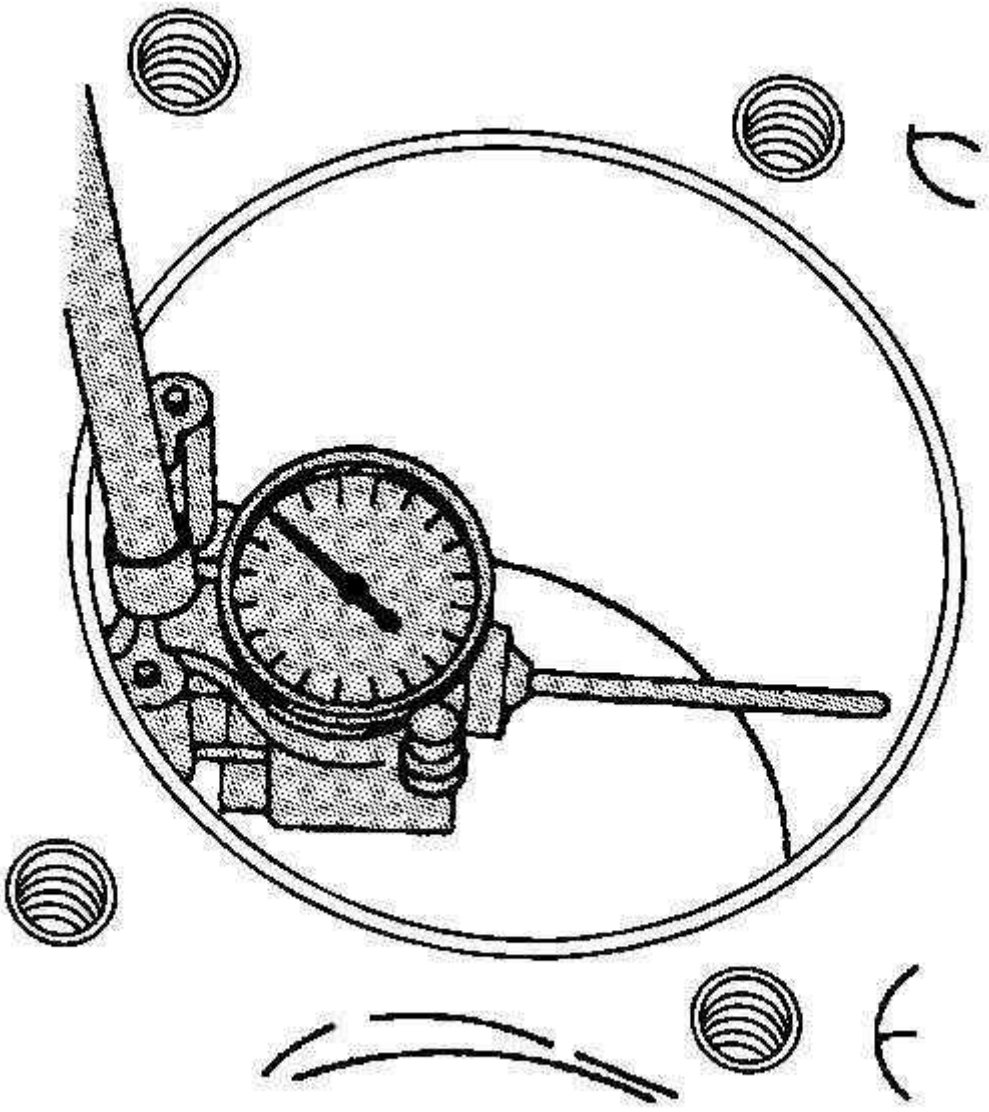


Fig. 417: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 8087** , measure the cylinder bore for oversize.

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Slide the bore gage up and down throughout the length of the cylinder bore. Measure the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center, and bottom of the bore. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston. Refer to **Engine Mechanical Specifications**.

CYLINDER BORING AND HONING

Boring Procedure

IMPORTANT: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available.

1. Measure all pistons with a micrometer to determine the cylinder bore diameter.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block, removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

Honing Procedure

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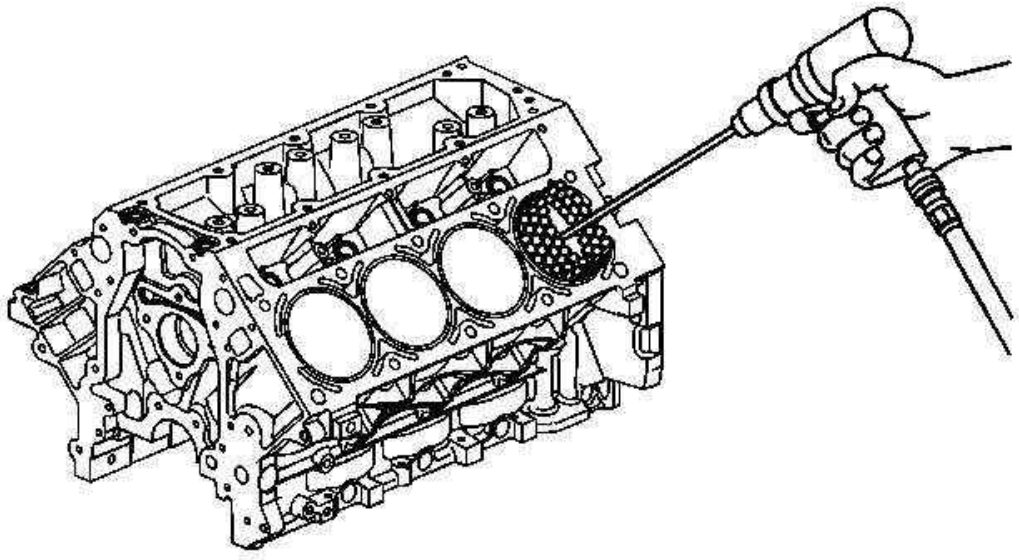


Fig. 418: Illustrating Honing Of Cylinders
Courtesy of GENERAL MOTORS CORP.

1. When honing the cylinders, 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 you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly check the cylinder bore for fit with the selected piston.

   All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100-grit stone.
4. Perform final cylinder honing with a 240-grit stone and obtain a 45 degree

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cross hatch pattern.

A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.

5. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
6. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
7. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.
8. Perform final measurements of the piston and the cylinder bore.
9. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure

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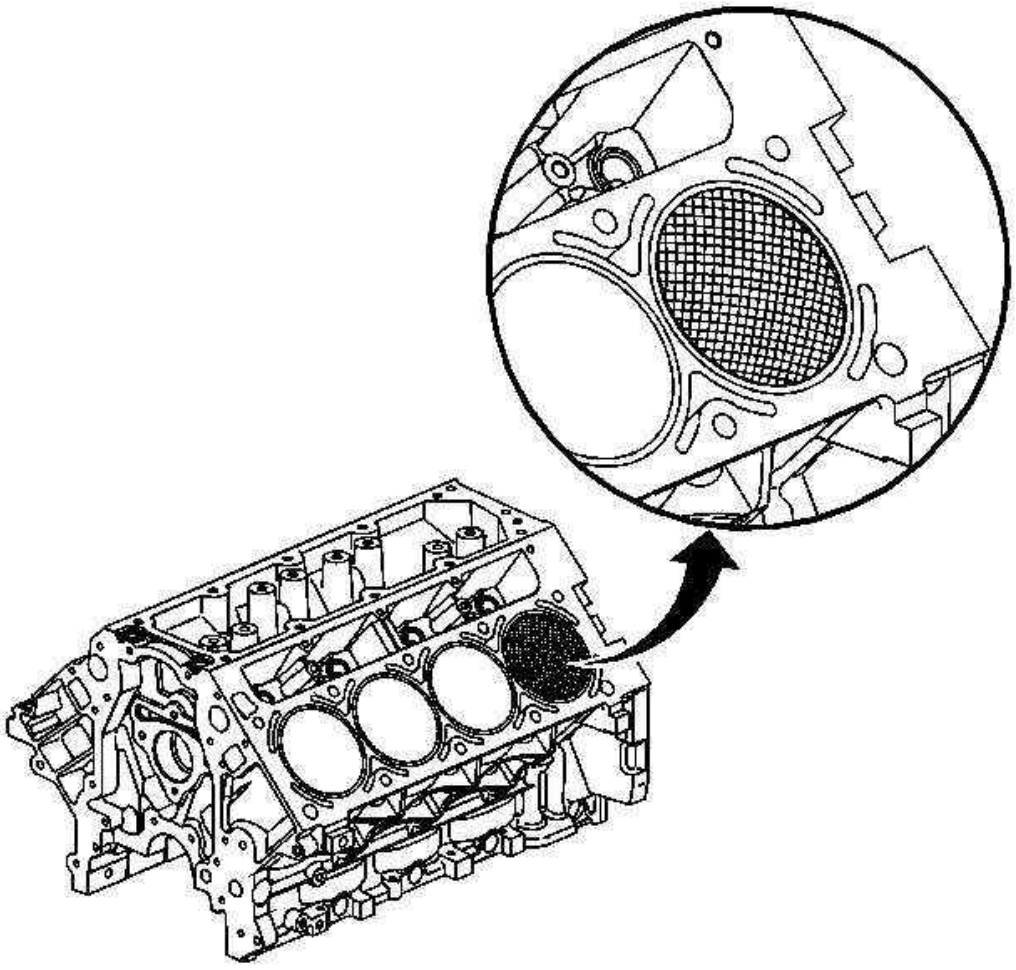


Fig. 419: Illustrating Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240-grit stone of silicone carbide, or equivalent, material when preforming the deglazing procedure.

A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.

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CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator Set
- **J 43690** Rod Bearing Checking Tool
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit

Cleaning Procedure

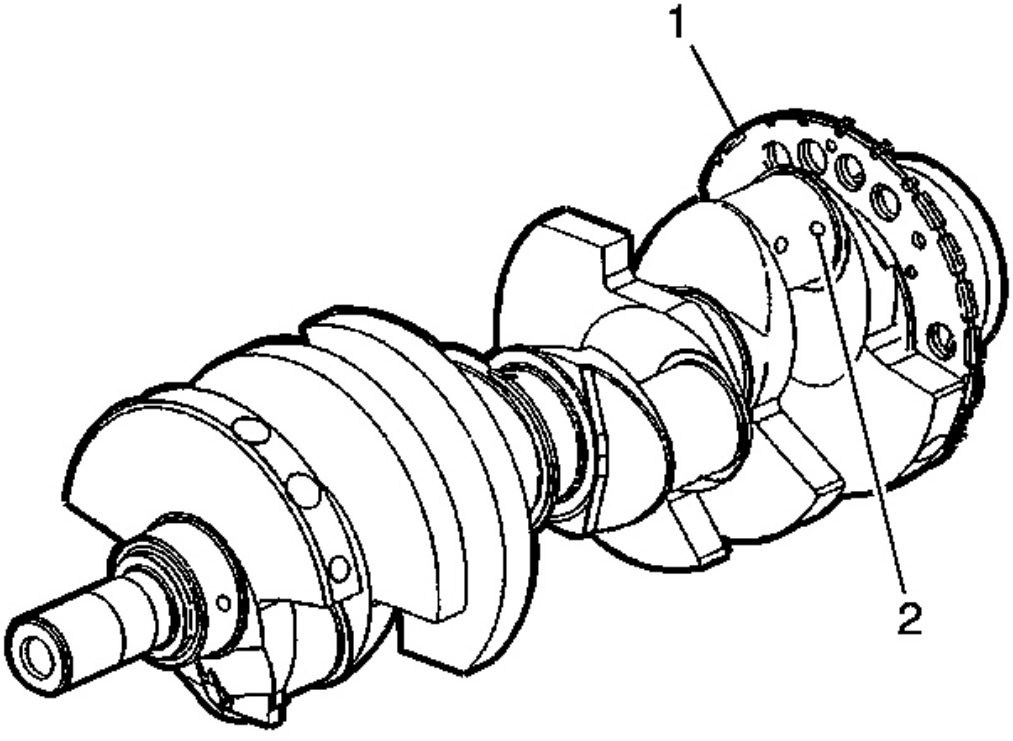


Fig. 420: View Of Oil Passages & Crankshaft Position (CKP) Sensor Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the crankshaft position (CKP) sensor

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reluctor ring teeth. Nicks, burrs, or other damage to the teeth may affect on-board diagnostics (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages (2) and inspect for restrictions or burrs.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the crankshaft with compressed air.

Inspection Procedure

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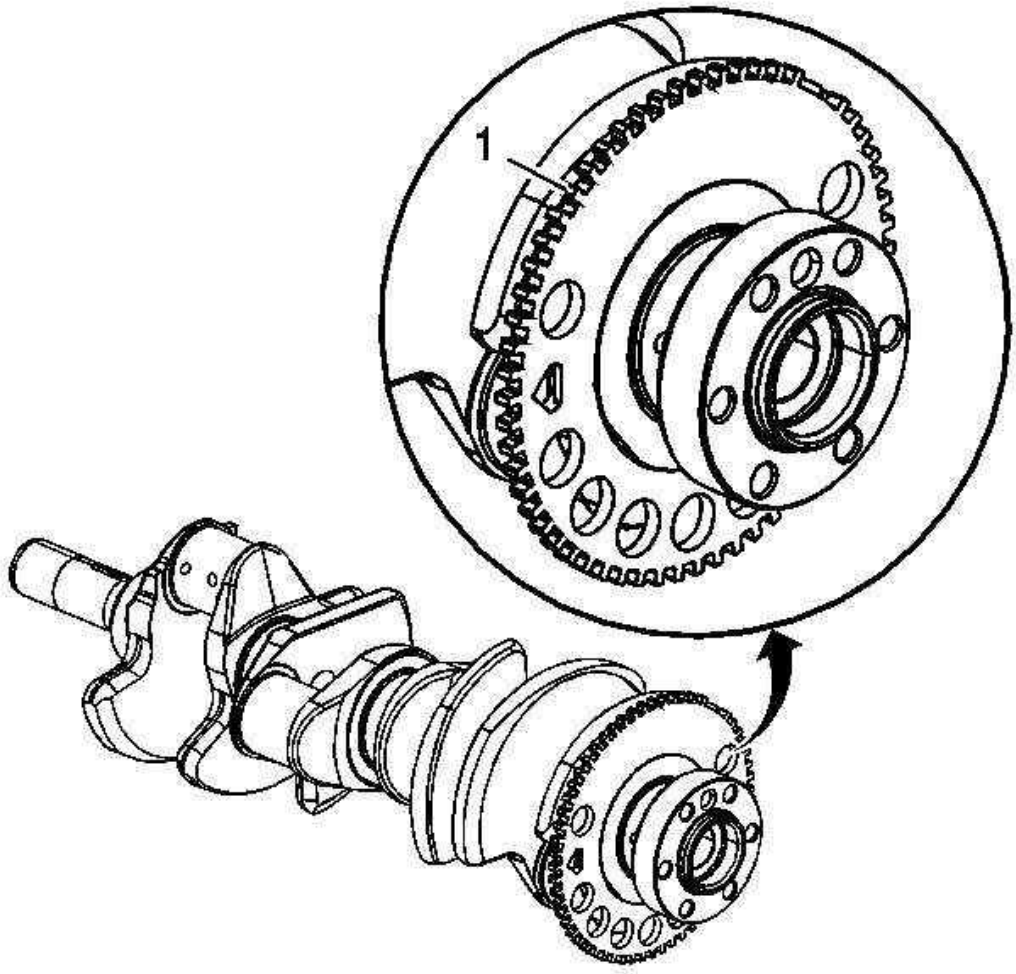


Fig. 421: View Of Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may affect OBD II system performance.

1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the CKP reluctor ring teeth (1) for damage.

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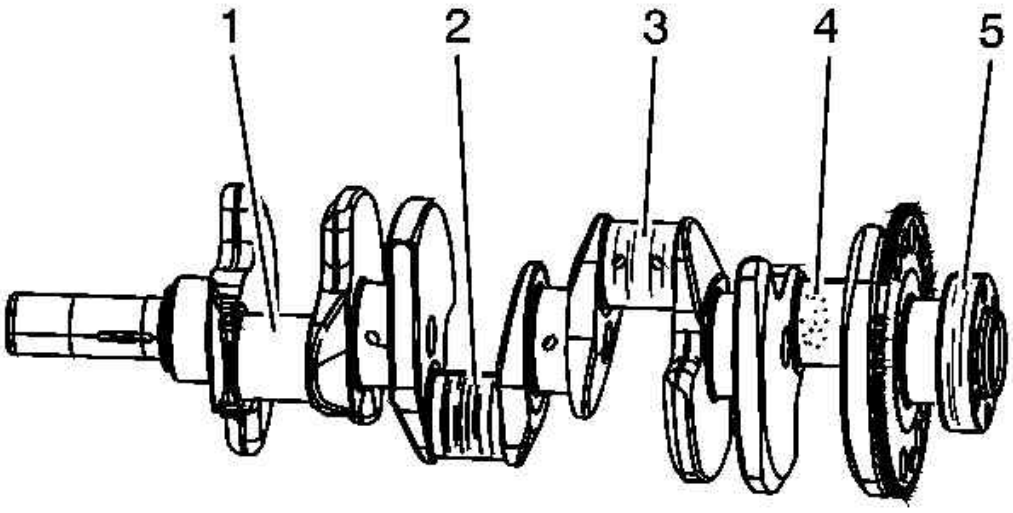


Fig. 422: Inspecting Crankshaft Journals For Wear
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft journals for wear (1).

   Journals should be smooth with no signs of scoring, wear, or damage.

4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded bearing material (4).
7. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.

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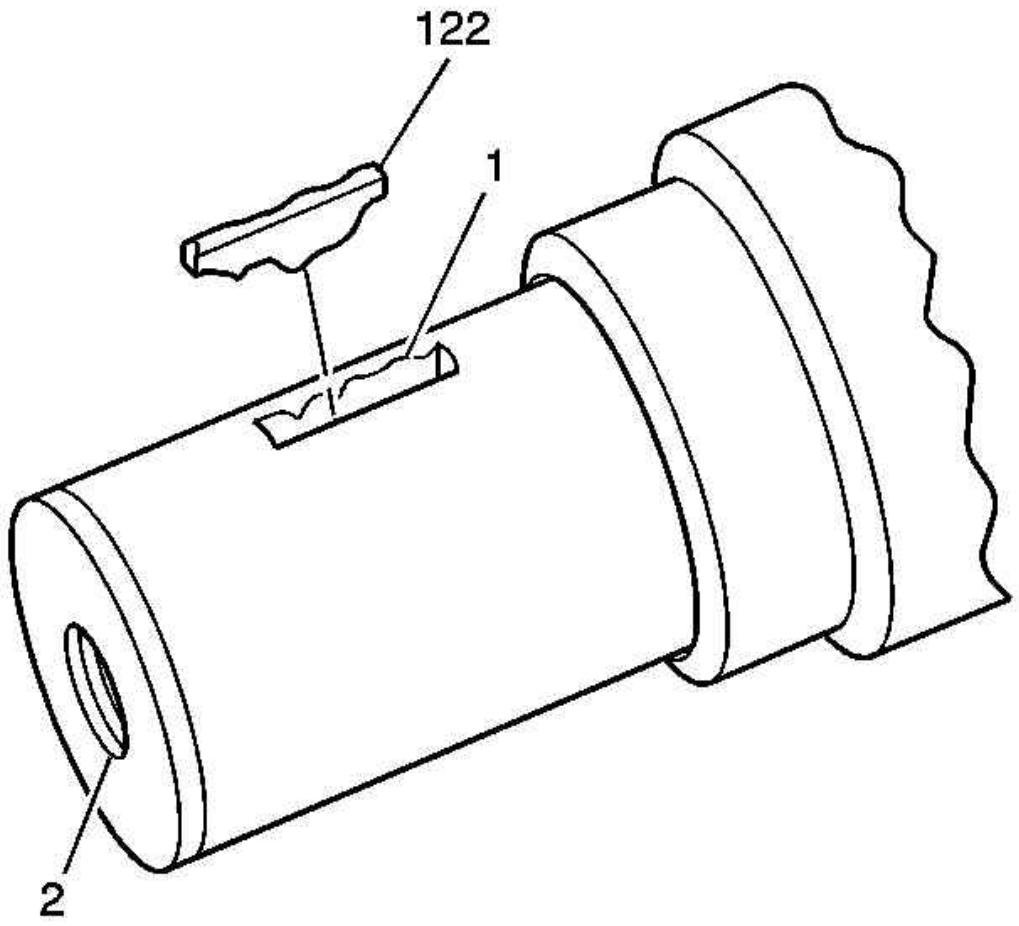


Fig. 423: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

8. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

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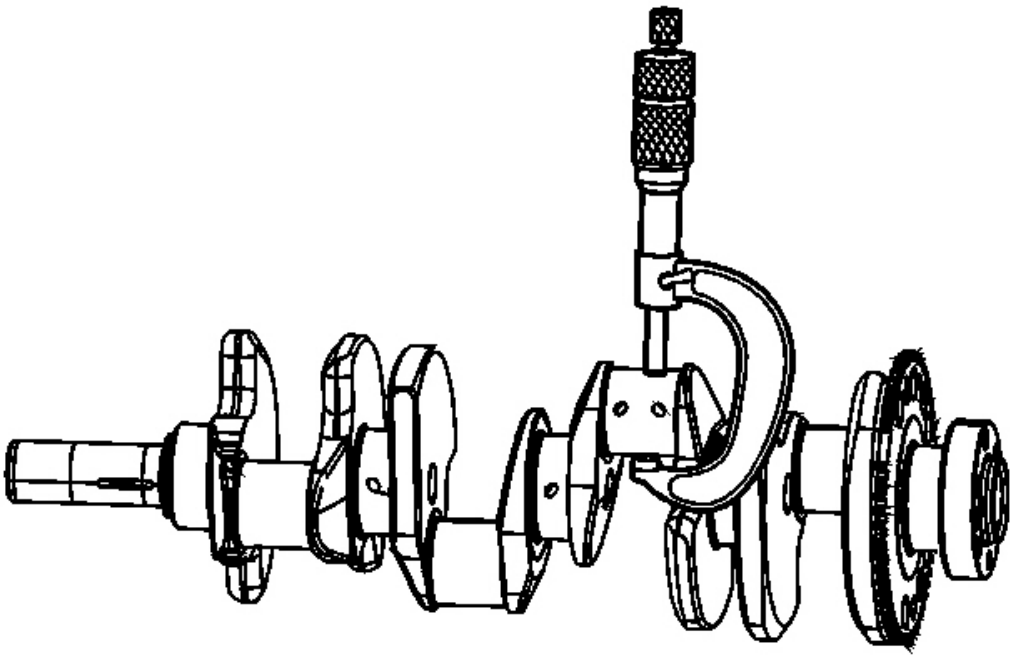


Fig. 424: Measuring Connecting Rod Journals For Out-Of-Round & Taper
Courtesy of GENERAL MOTORS CORP.

9. Measure the crankpins for the out-of-round.
10. Measure the crankpins for taper.

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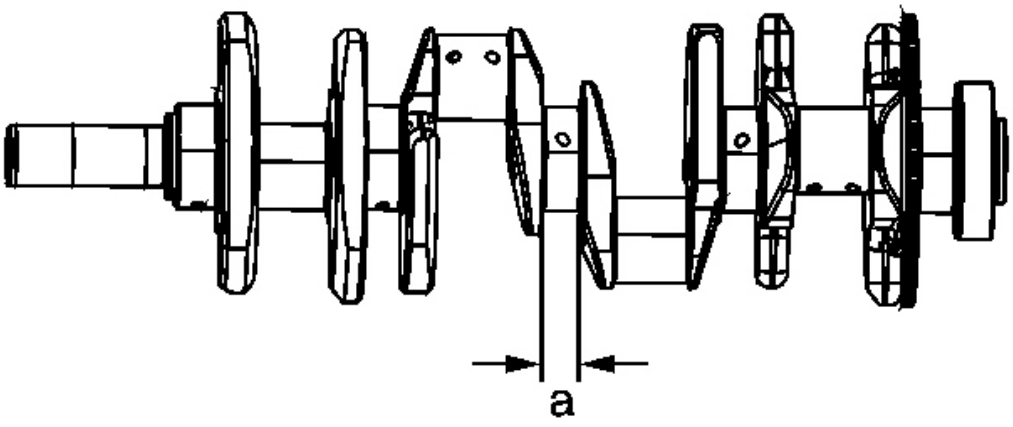
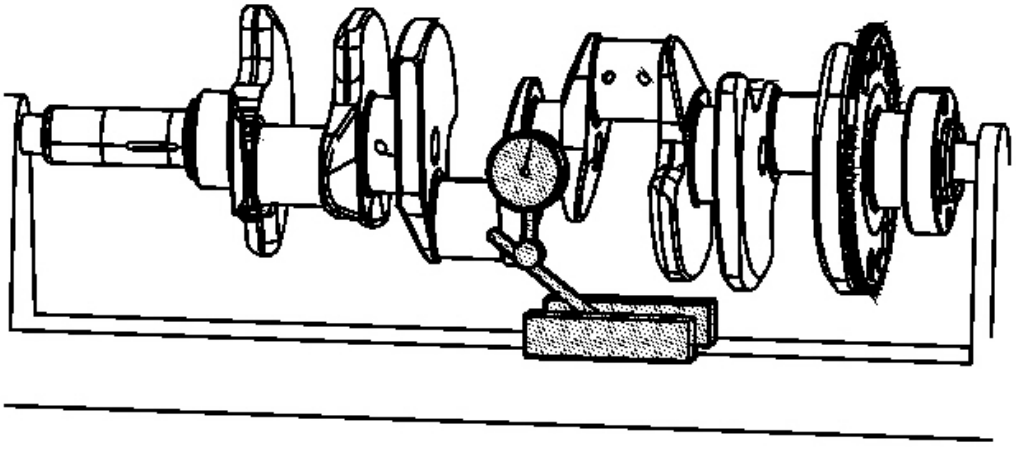


Fig. 425: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft thrust wall width (a).

    A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.



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Fig. 426: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

    Use wooden V-blocks or a fixture to support the crankshaft on the front and rear journals.

13. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
15. Use the **J 7872** in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

    If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.

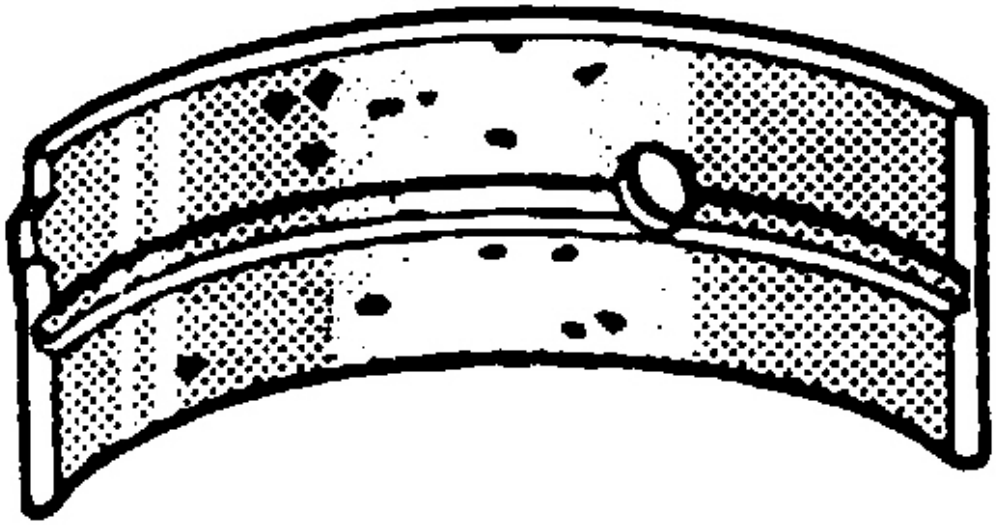


Fig. 427: Identifying Crankshaft Bearing Craters Or Pockets

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Courtesy of GENERAL MOTORS CORP.

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

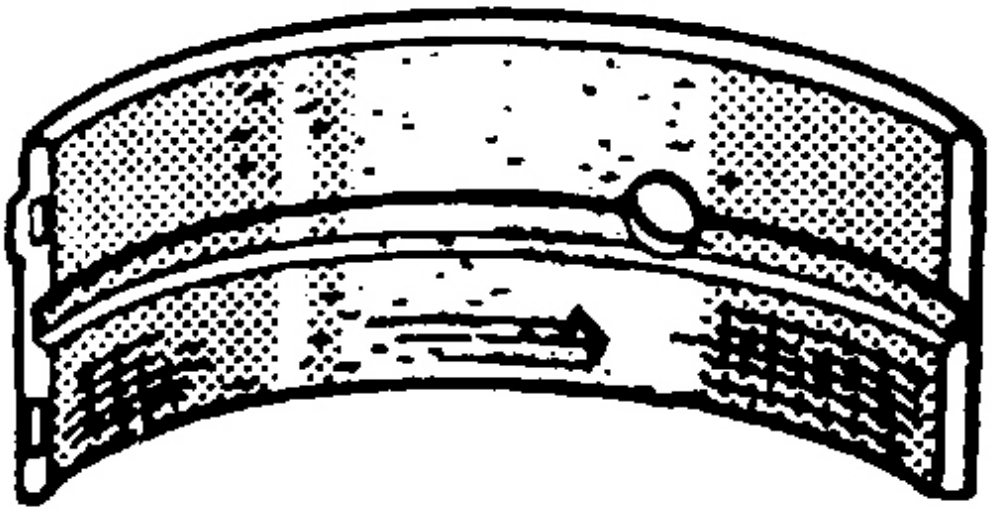


Fig. 428: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

17. Inspect the crankshaft bearings for excessive scoring or discoloration.
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

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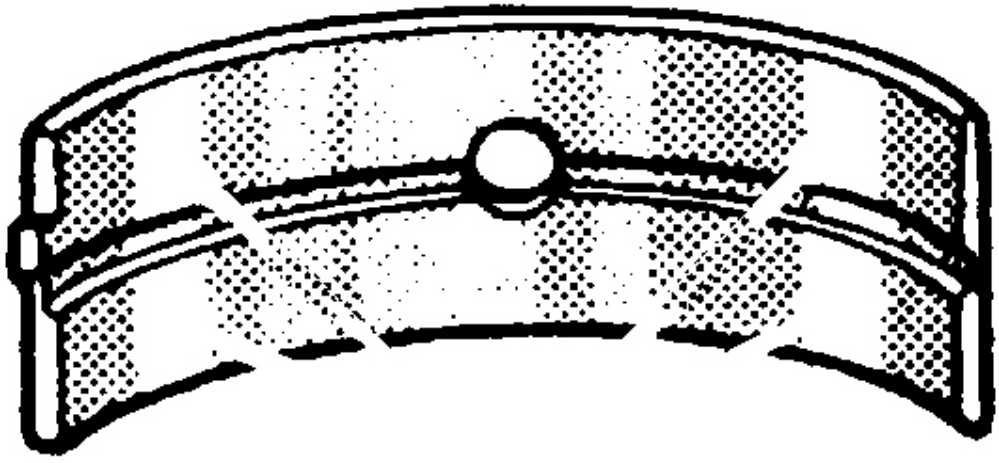


Fig. 429: View of Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Measuring Main Bearing Clearance - Gaging Plastic Method

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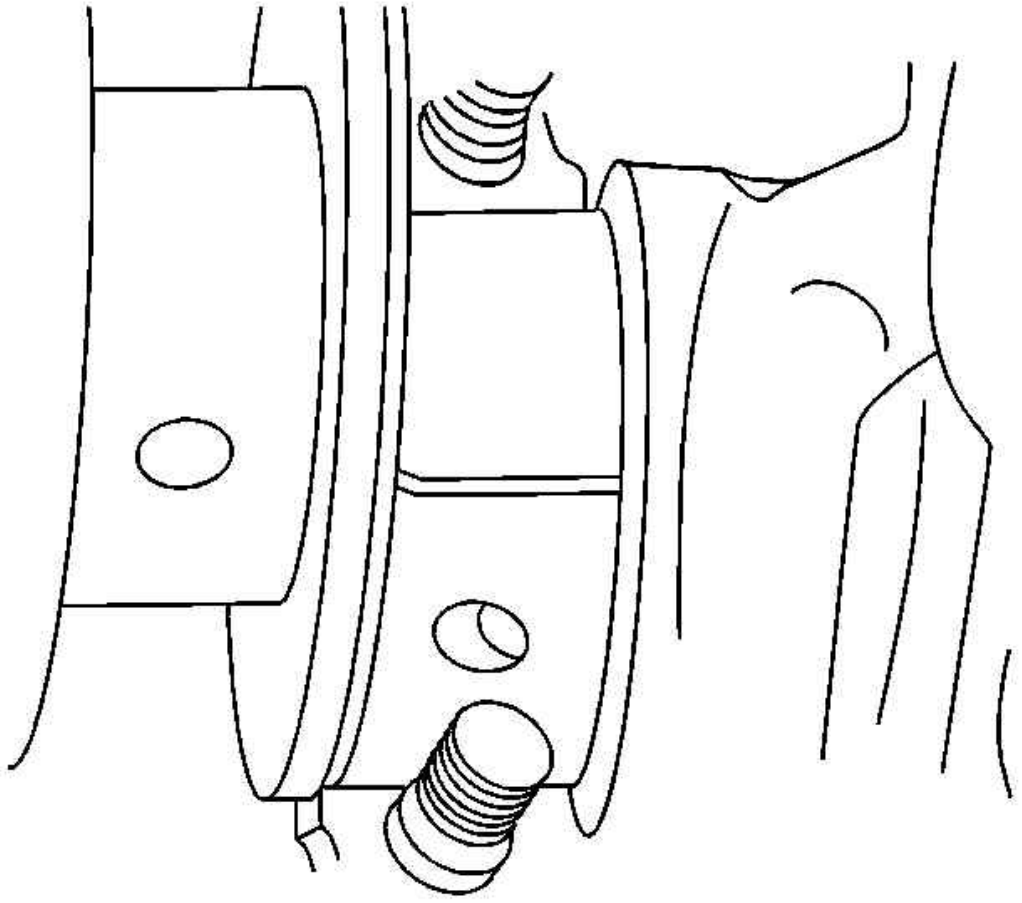


Fig. 430: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.**
- **Do not rotate the crankshaft while gaging**

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plastic is between the crankshaft journal and the bearing surface.

- **The crankshaft bearing clearances are critical. Excessive bearing clearance may effect CKP sensor signals and may affect OBD II system operation.**
- **Remove the bearing cap side bolts prior to cap removal.**

1. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.
2. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of the crankshaft bearing journal.
3. Install the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Installation**.
4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.

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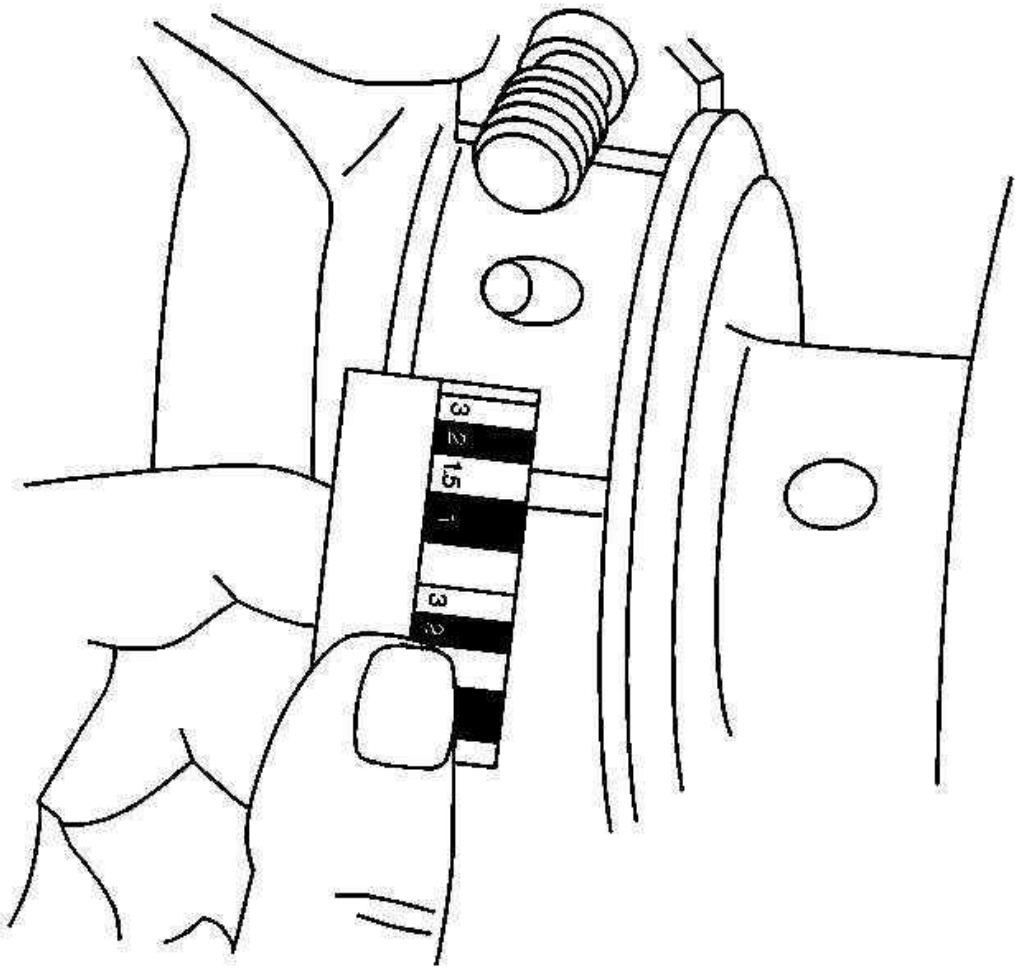


Fig. 431: Measuring Gaging Plastic On Crankshaft
Courtesy of GENERAL MOTORS CORP.

5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.
    - If the gaging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
    - If clearance cannot be brought to specifications, replace the crankshaft or engine block, as required. Refer to **Engine Mechanical Specifications**.

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Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method

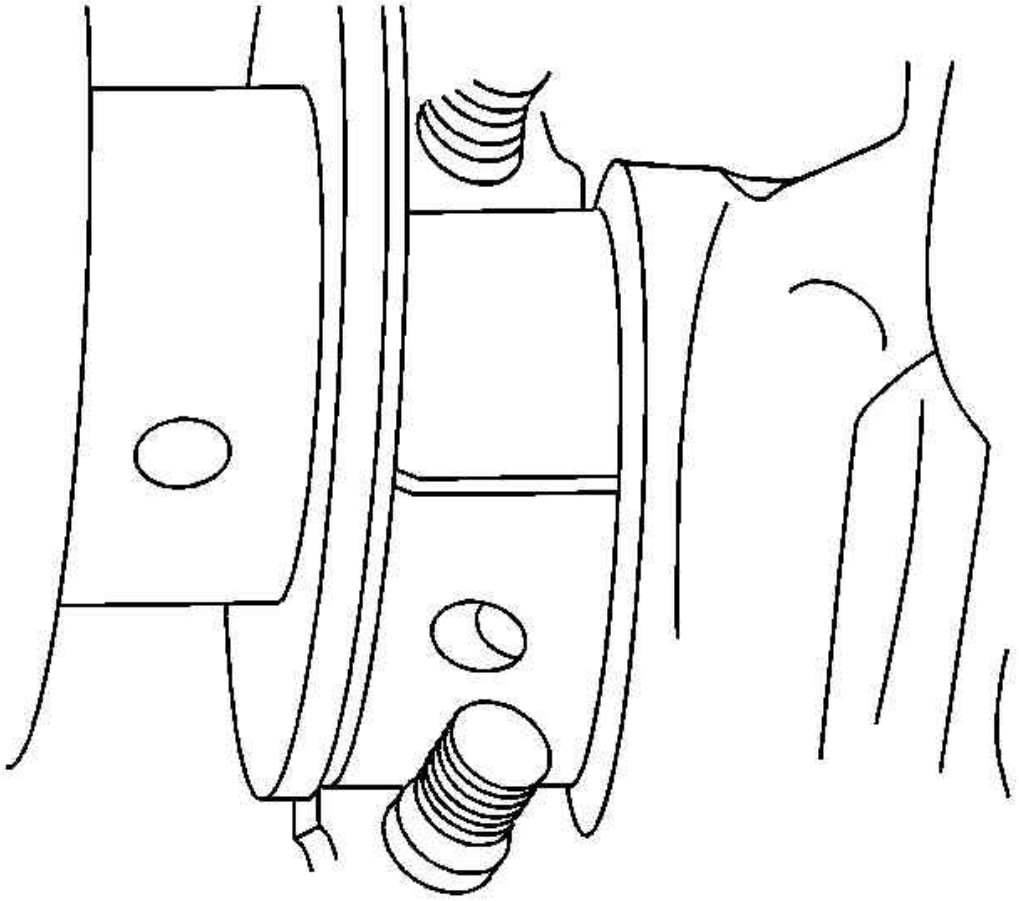


Fig. 432: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required.**

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- **Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.**

1. Remove the bearing cap, bearing half and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.
2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.
3. Install the bearing cap, bearing half, and bolts. Refer to **Piston, Connecting Rod, and Bearing Installation**.
4. Remove the bearing cap, bearing half and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.

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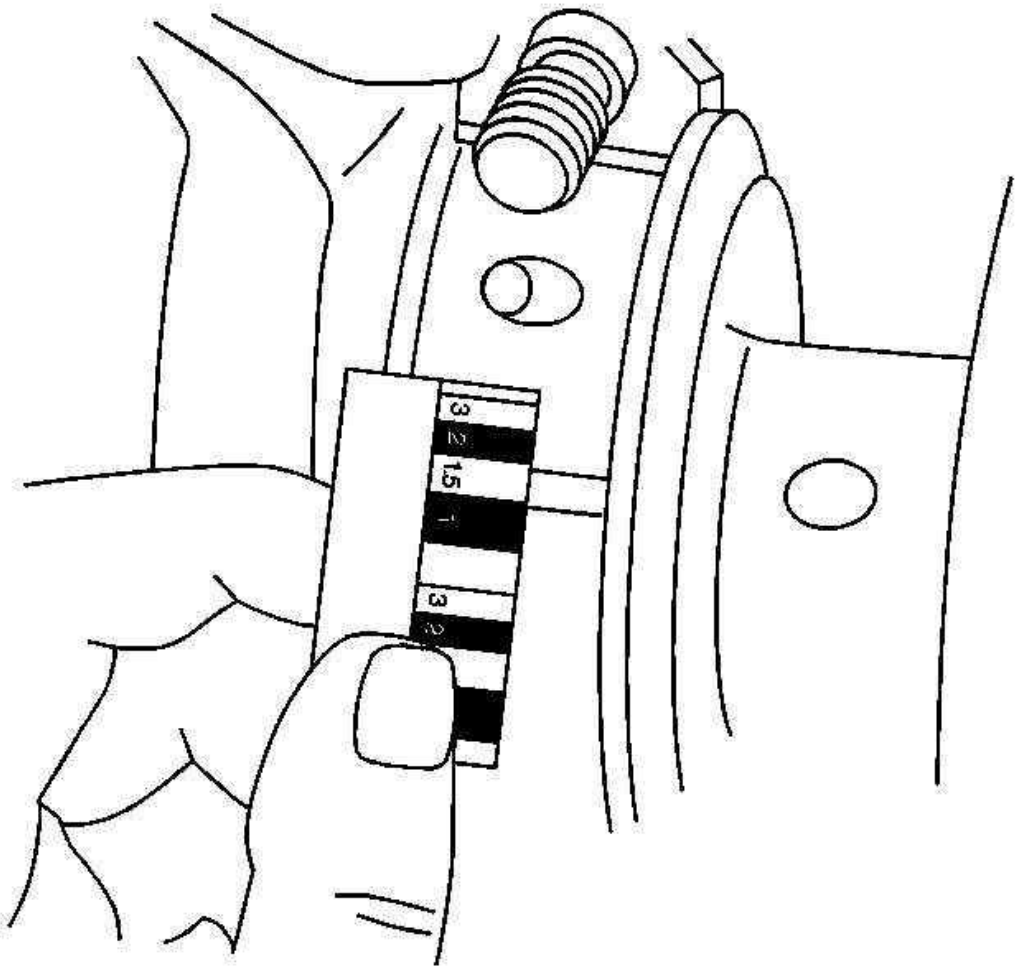


Fig. 433: Measuring Gaging Plastic On Crankshaft
Courtesy of GENERAL MOTORS CORP.

5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit. Refer to **Engine Mechanical Specifications**.

Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

J 43690 and **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool

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instruction sheets as supplied by the tool manufacturer.

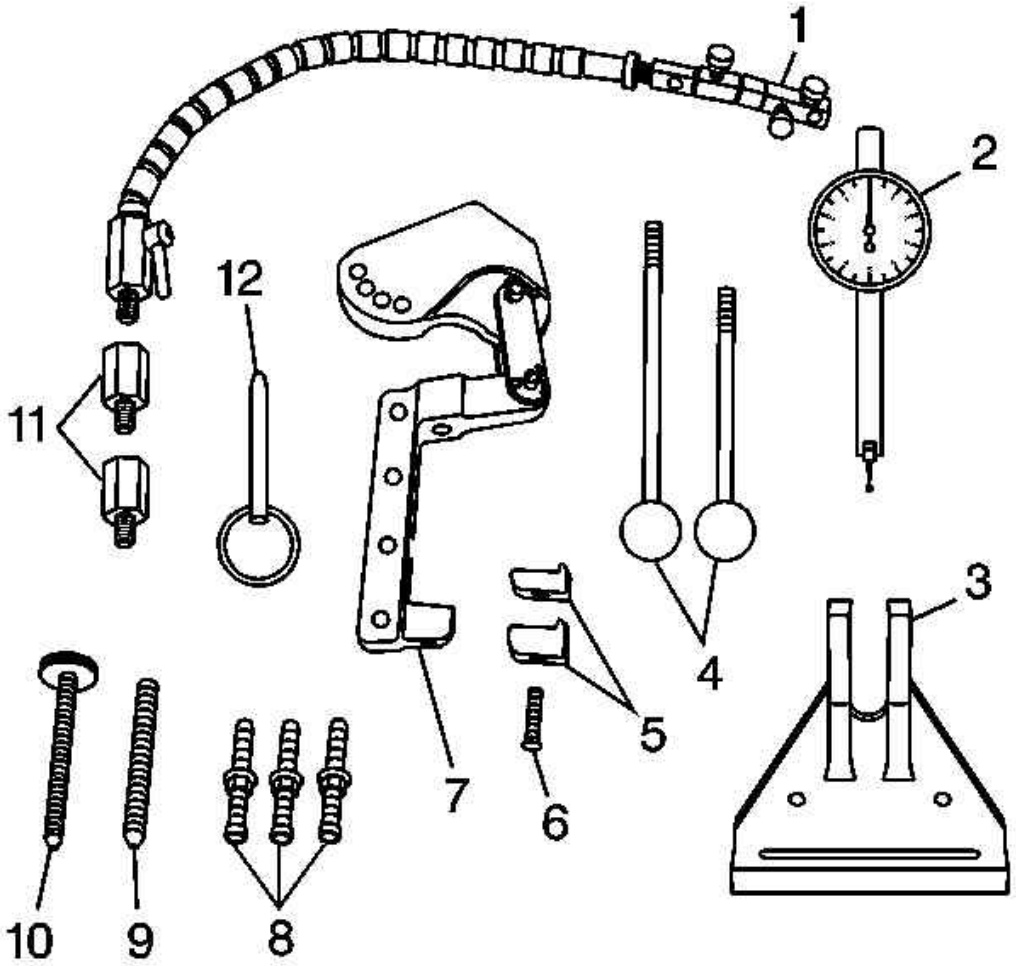


Fig. 434: Identifying Rod Bearing Clearance Checking Tool Set
Courtesy of GENERAL MOTORS CORP.

Rod Bearing Checking Tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)

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- J 43690-5, J 43690-6 Handle (4)
- J 43690-10, J 43690-11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, J 43690-7, J 43690-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

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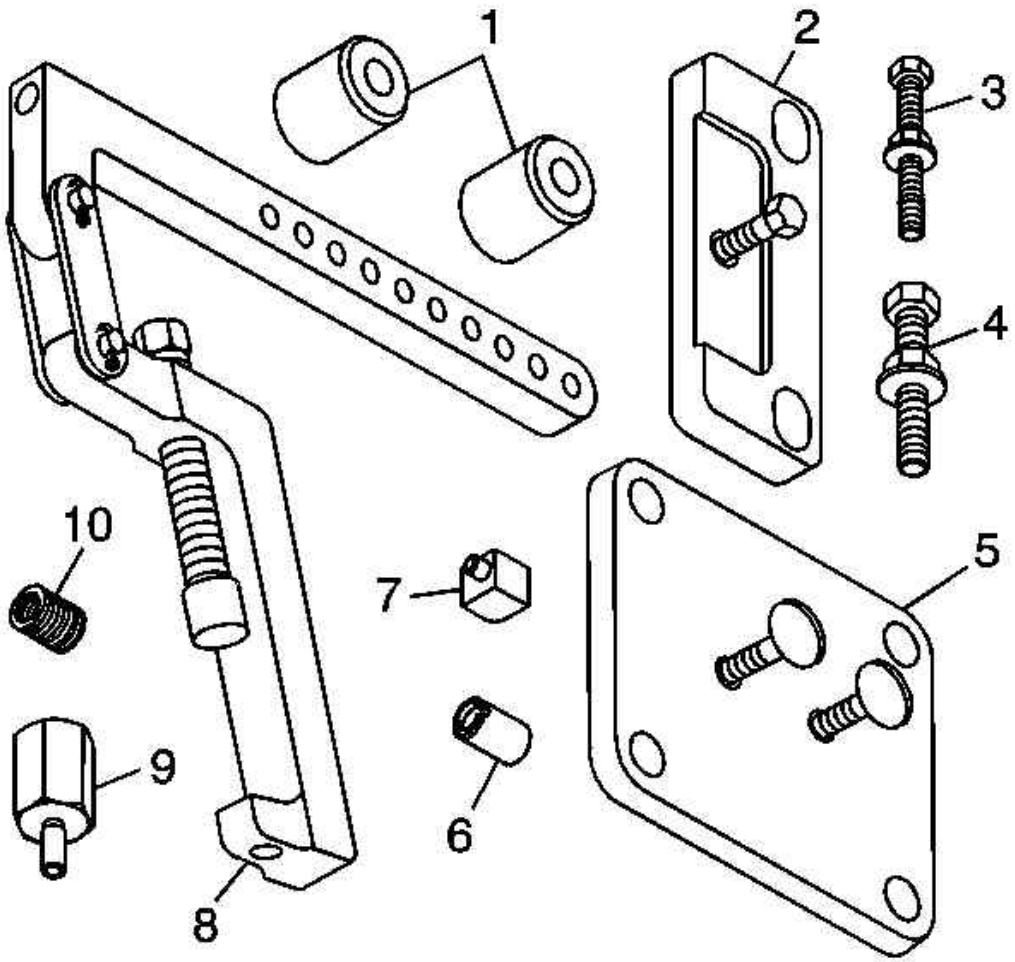


Fig. 435: Identifying Rod Bearing Clearance Checking Tool Adapter Kit
Courtesy of GENERAL MOTORS CORP.

Rod Bearing Checking Tool - Adapter Kit

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)

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- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

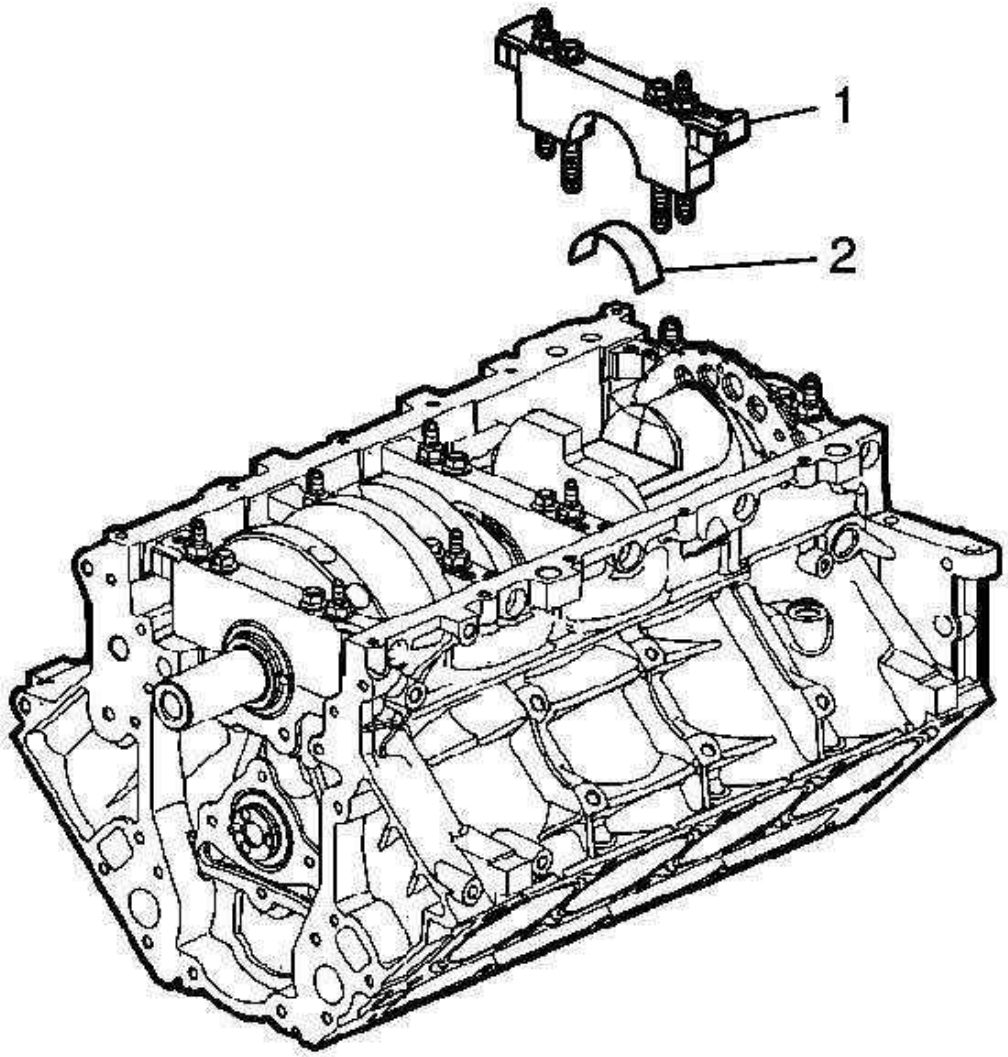


Fig. 436: View Of Bearing Cap, Bolt & Bearing Half

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Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to **Fastener Tightening Specifications**.

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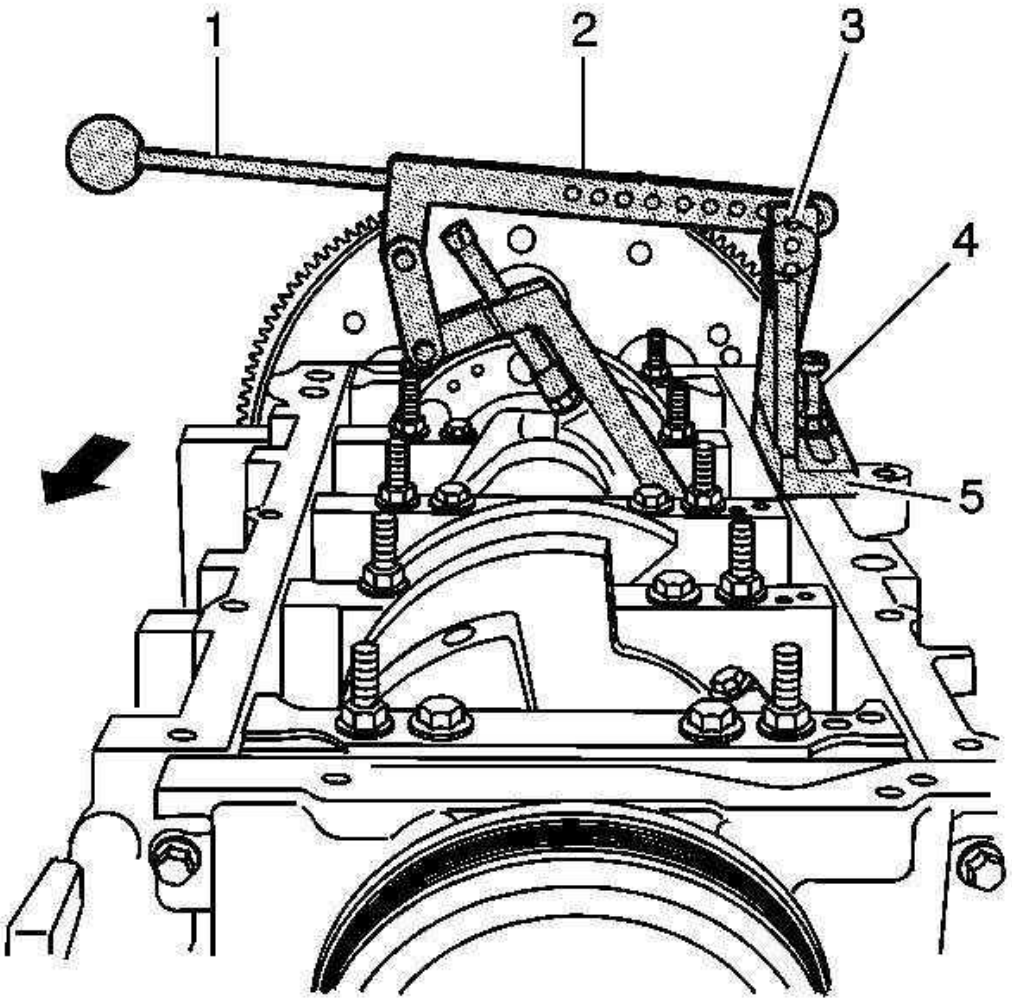


Fig. 437: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Install the following:
    1. J 43690-2 (5)
    2. J 43690-3 (4)
    3. J 43690-101 (2)
    4. 280310 (3)

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5. J 43690-5 (1)

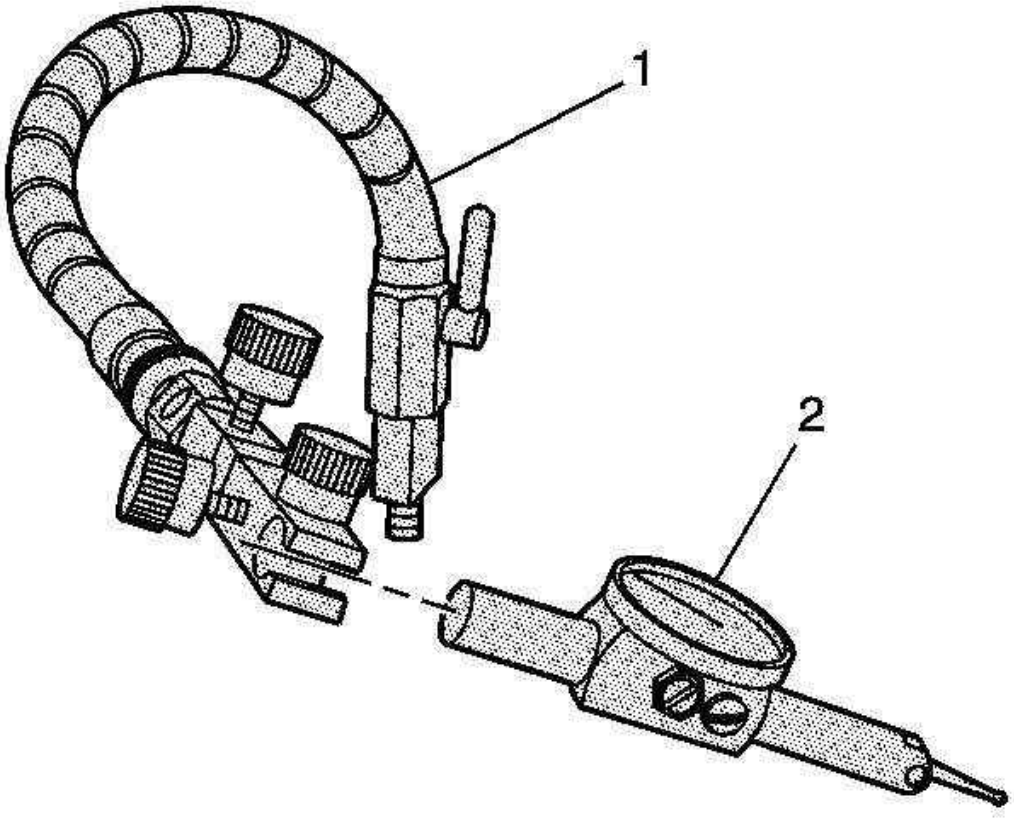


Fig. 438: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

   A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components, as required.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

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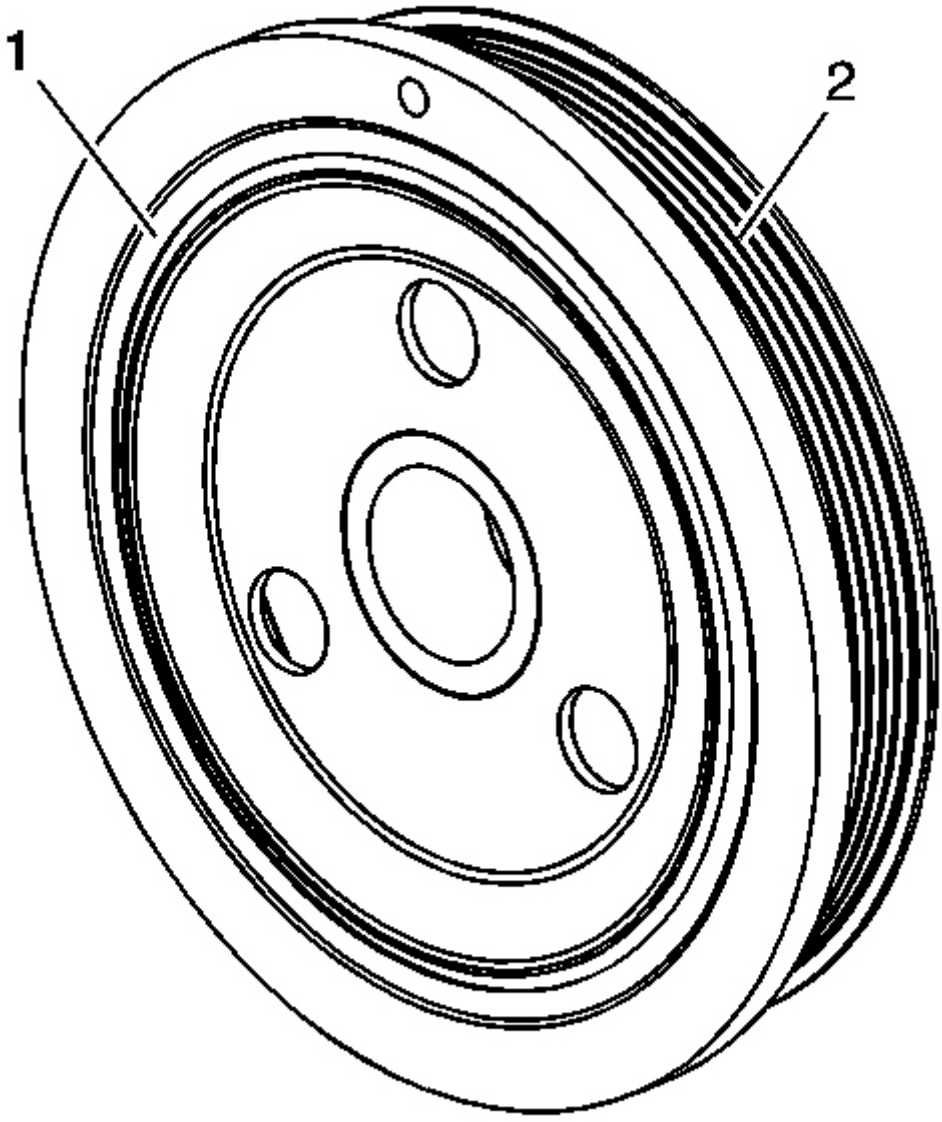


Fig. 439: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

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3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following conditions:
   - Worn, grooved, or damaged hub seal surface

     A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

     Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

     IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

   - Dirty or damaged belt grooves (2)

     The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

     Minor imperfections may be removed with a fine file.

   - Worn, chunking, or deteriorated rubber (1) between the hub and pulley

ENGINE FLYWHEEL CLEANING AND INSPECTION

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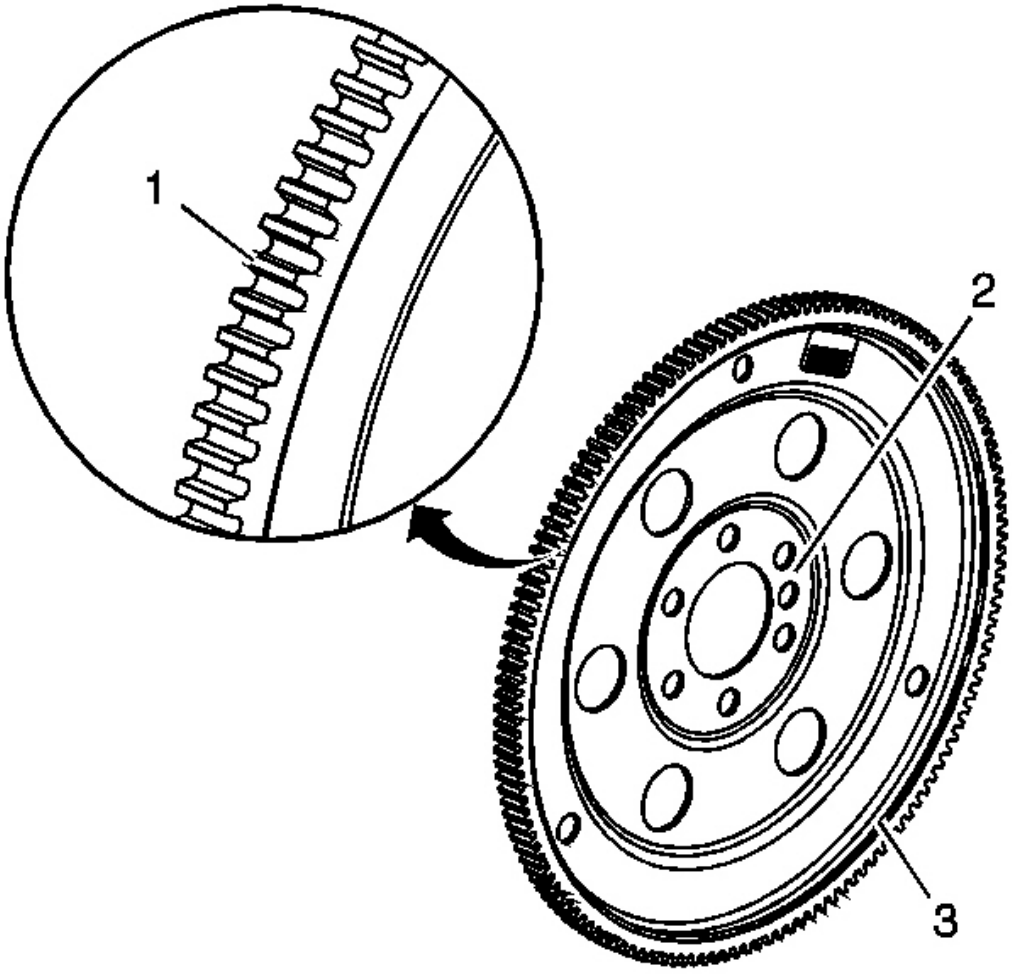


Fig. 440: Identifying Flex Plate
Courtesy of GENERAL MOTORS CORP.

1. Clean the flex plate in solvent.
2. Dry the flex plate with compressed air.
3. Inspect the flex plate for the following conditions:
   - Damaged ring gear teeth (1)
   - Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

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

- Welded areas (3) that retain the ring gear onto the flex plate for cracking

PISTON AND CONNECTING ROD DISASSEMBLE

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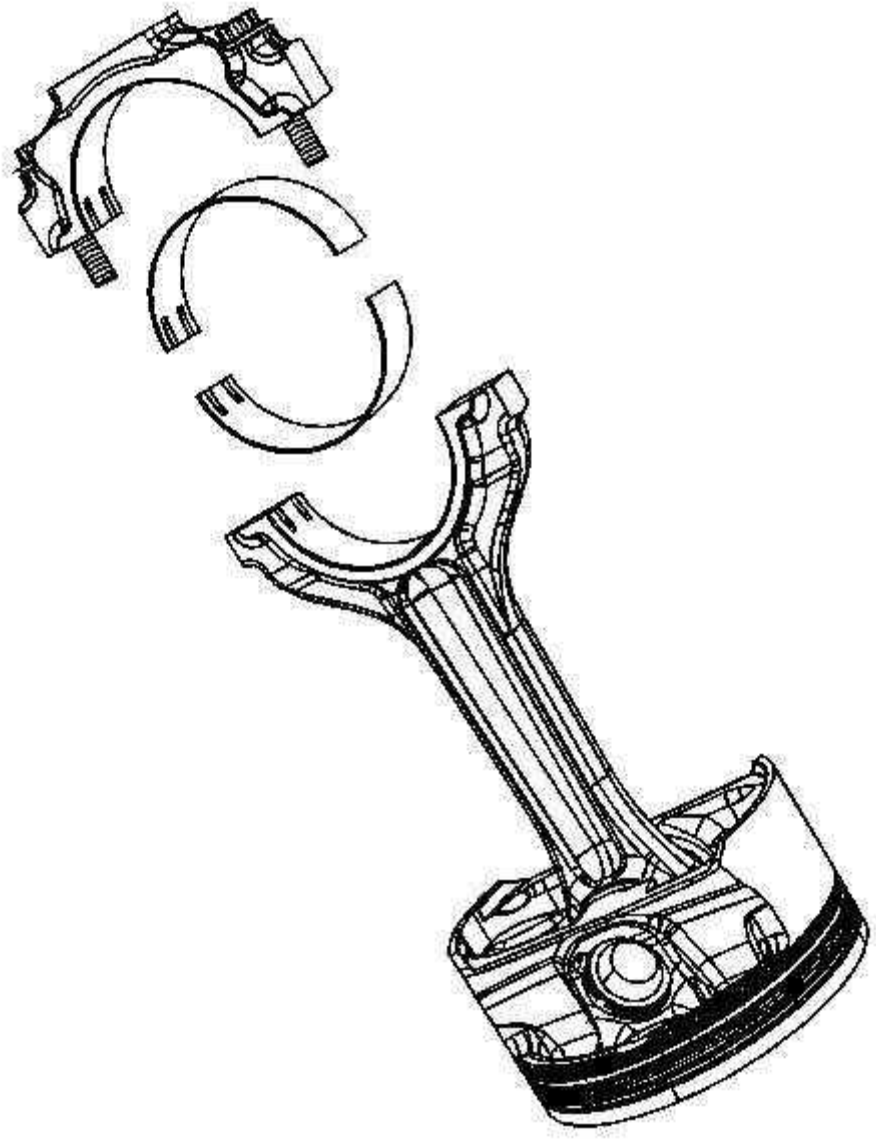


Fig. 441: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings from the rod and cap.

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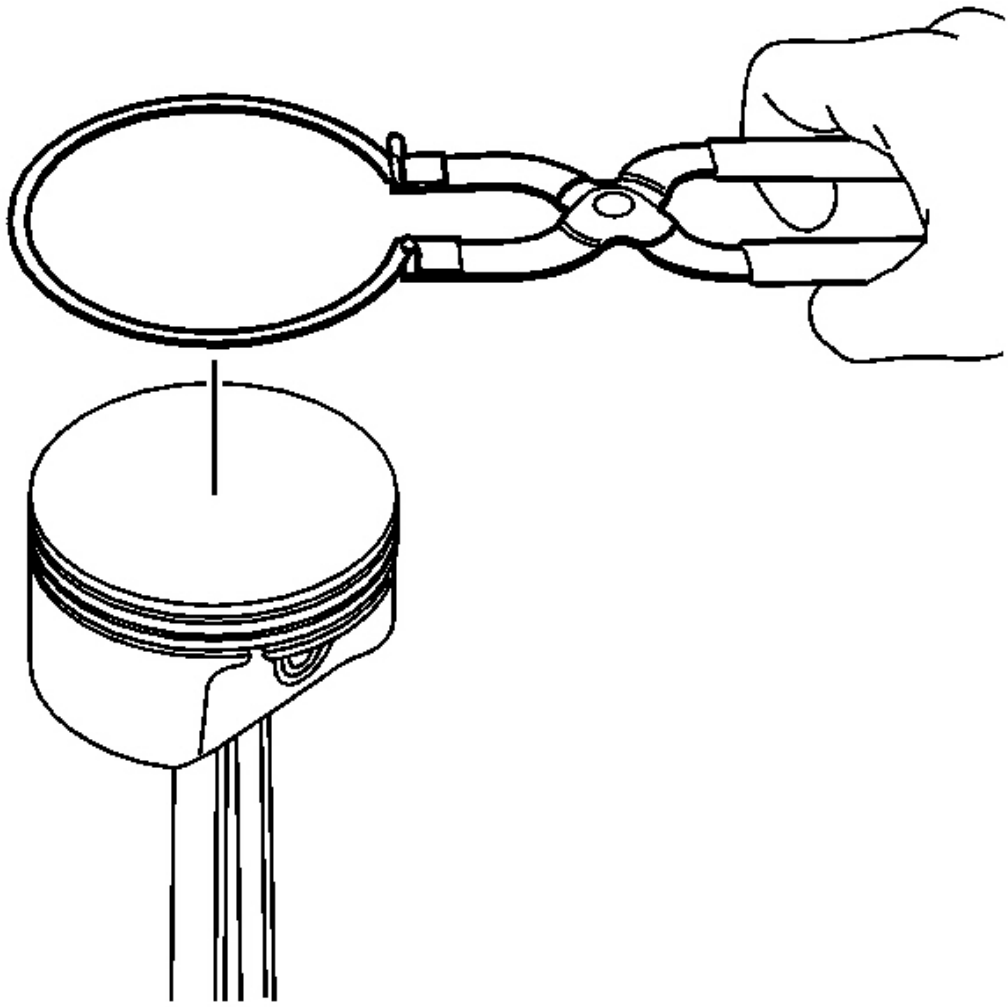


Fig. 442: Identifying Piston Ring Expander With Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

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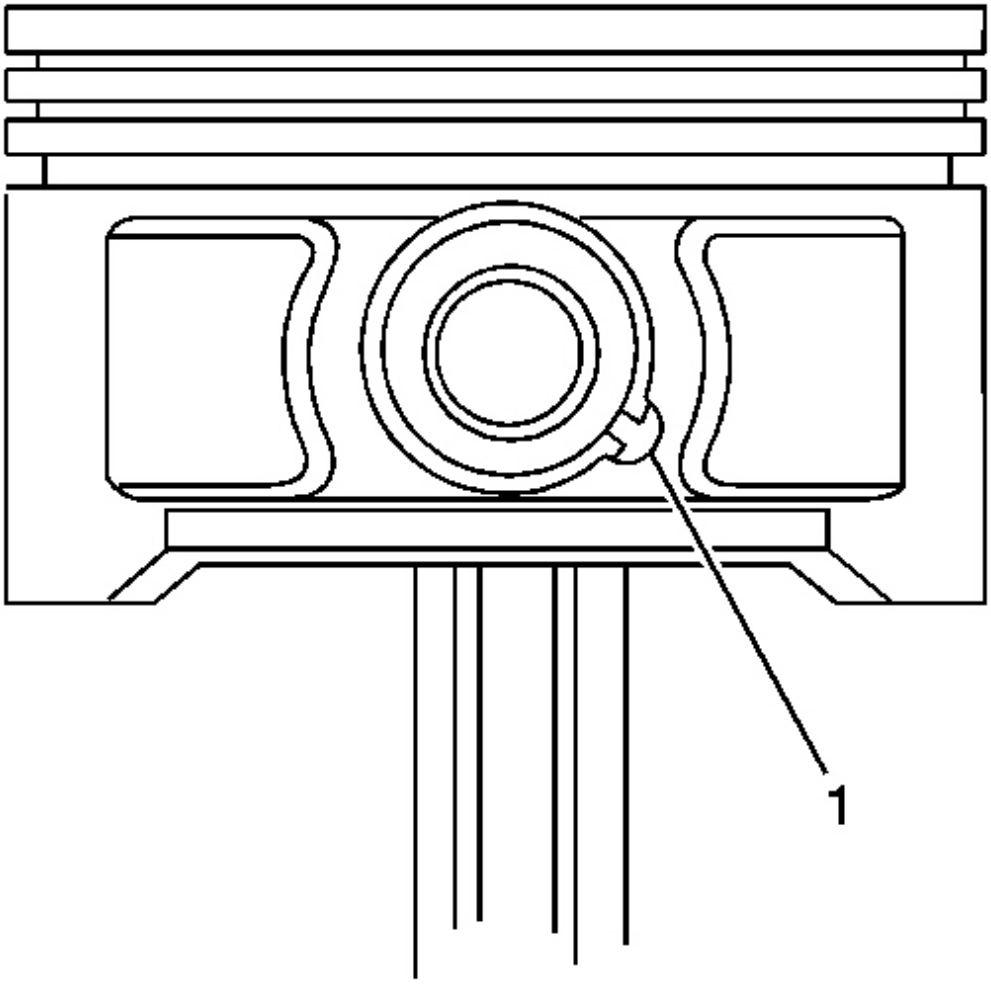


Fig. 443: View Of Piston Pin Retaining Clip & Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.

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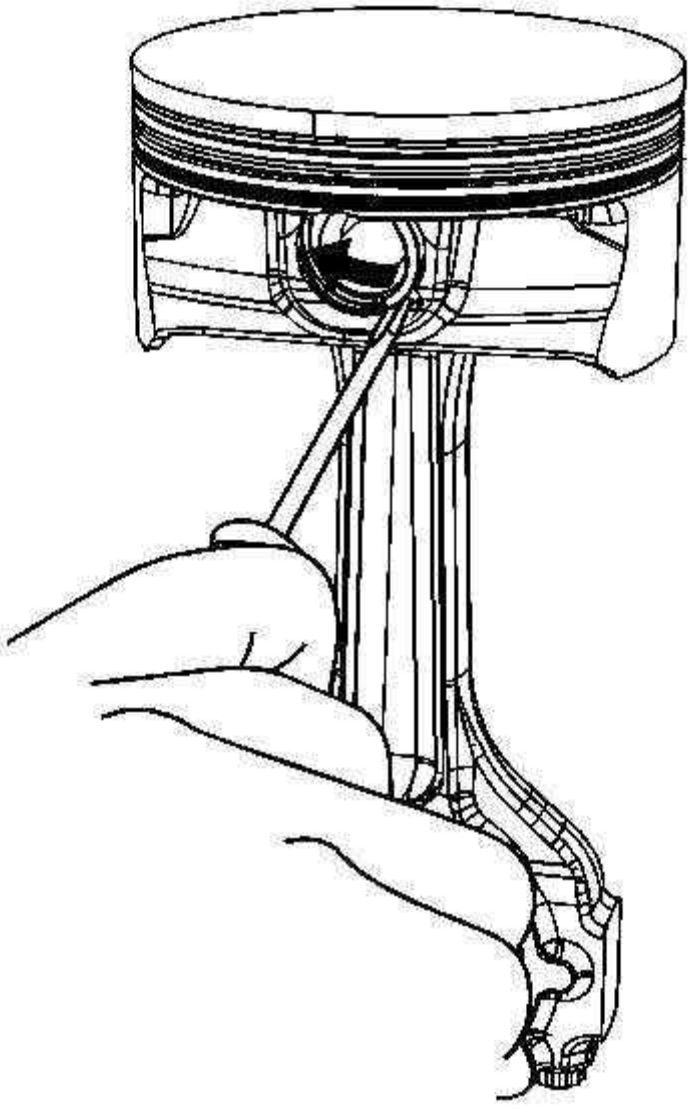


Fig. 444: Identifying Piston Pin Retainer
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainers starting in the cutout area of the pin bore.

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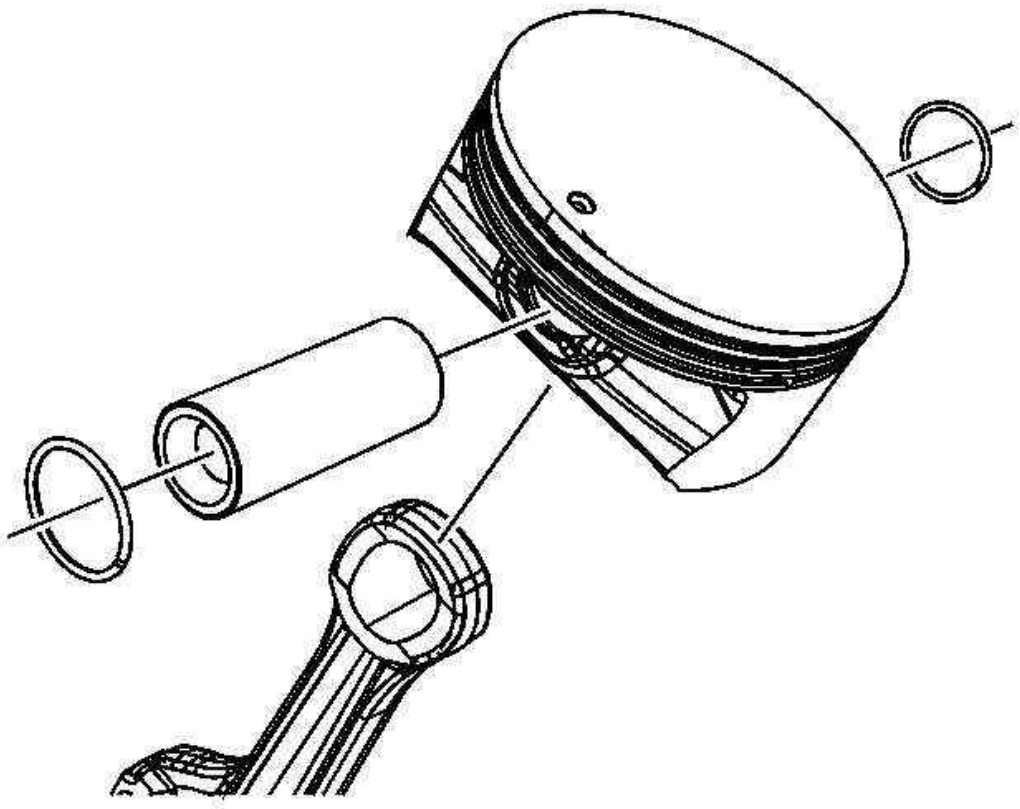


Fig. 445: View Of Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

Mark, sort, or organize the piston and the matching piston pin.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Piston, Pin, and Piston Rings

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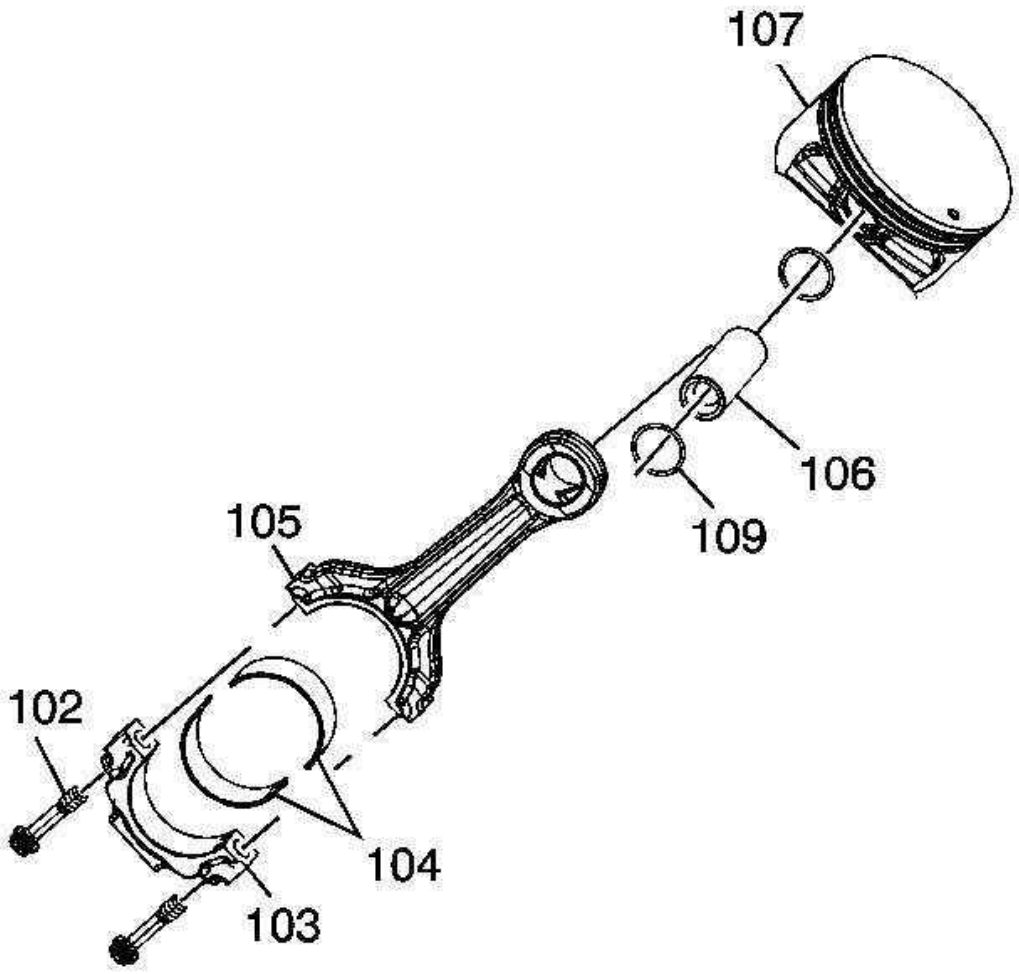


Fig. 446: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.**
- **The piston and pin are to be serviced as an assembly.**
- **Do not wire brush any part of the piston.**
- **Measurement of the components should be**

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taken with the components at normal room temperature.

1. Clean the varnish and carbon from the piston (107) using cleaning solvent.

   CAUTION: Refer to Safety Glasses Caution .

2. Dry the components with compressed air.

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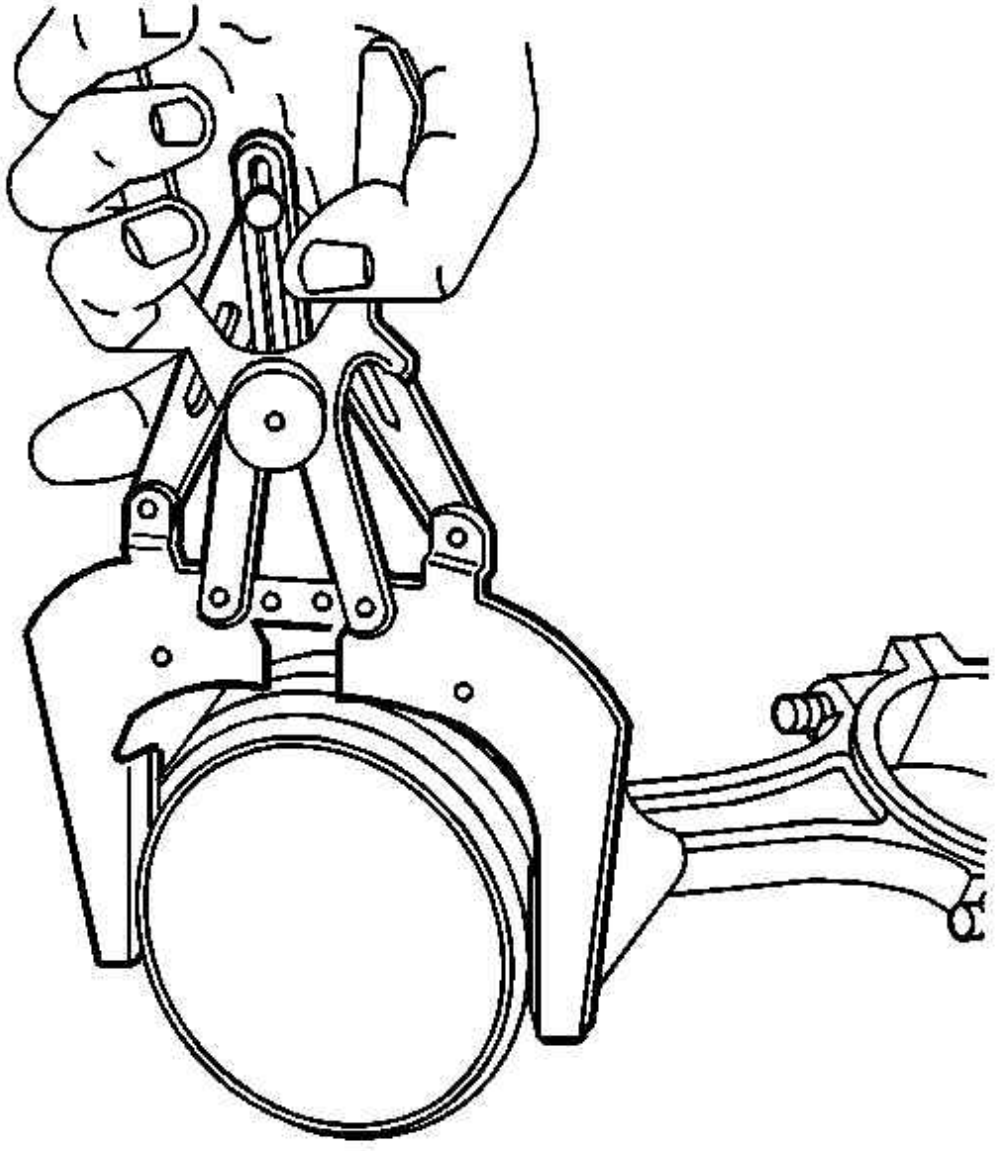


Fig. 447: Cleaning The Piston Ring Grooves
Courtesy of GENERAL MOTORS CORP.

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

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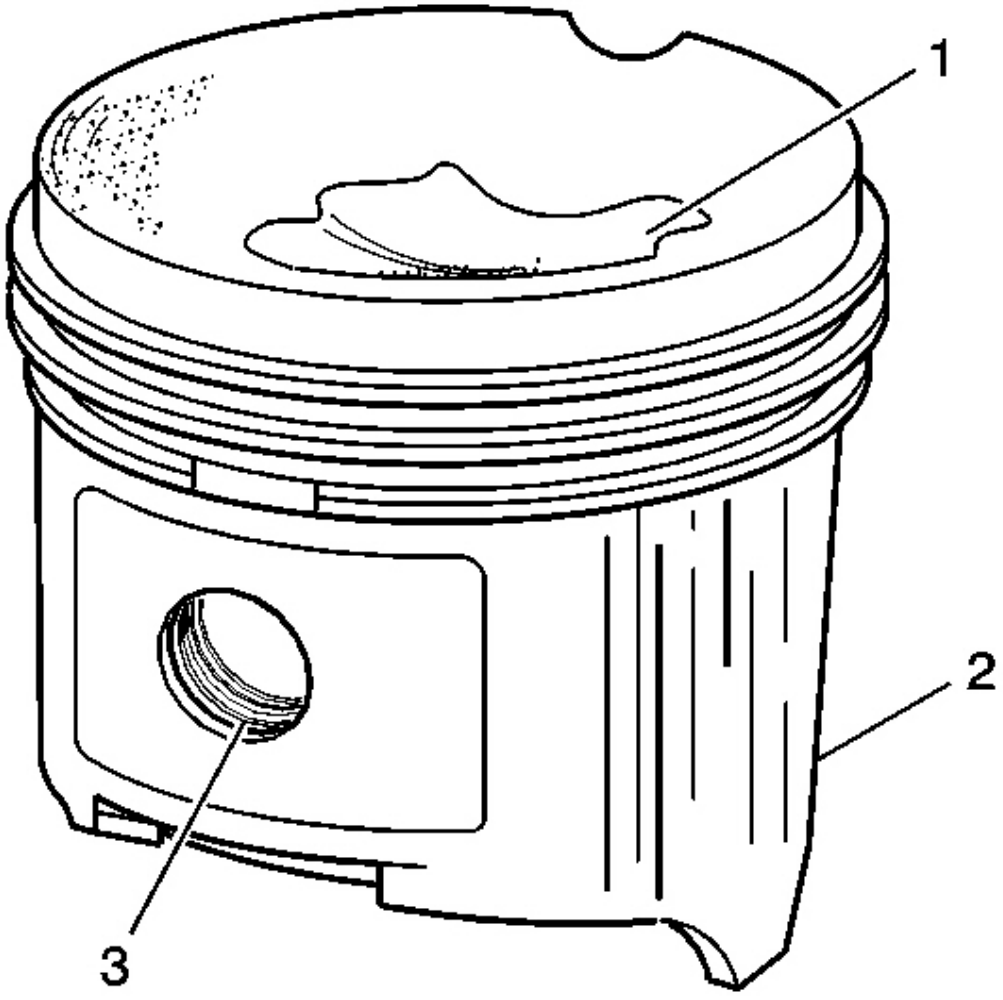


Fig. 448: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the piston for the following conditions:
   - Cracks in the piston ring lands, the piston skirt, or pin bosses
   - Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind

   MINOR imperfections may be removed from the piston with a fine file.

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- Scuffed or damaged skirts (2)
- Eroded areas at the top of the piston (1)
- Scoring to the full-floating design piston pin bore (3) or piston pin

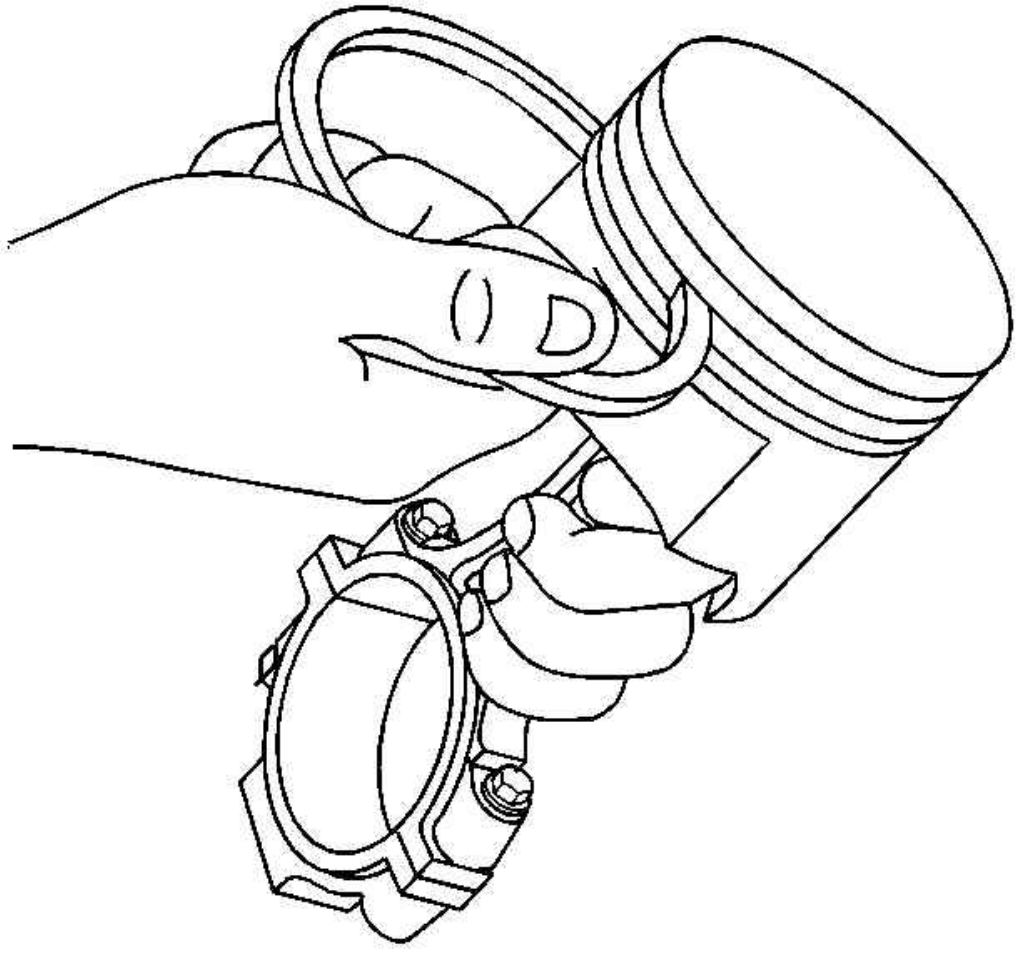


Fig. 449: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

6. Insert the edge of the piston ring into the piston ring groove.

   Roll the piston ring completely around the piston. If binding is caused by

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distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings, as required.

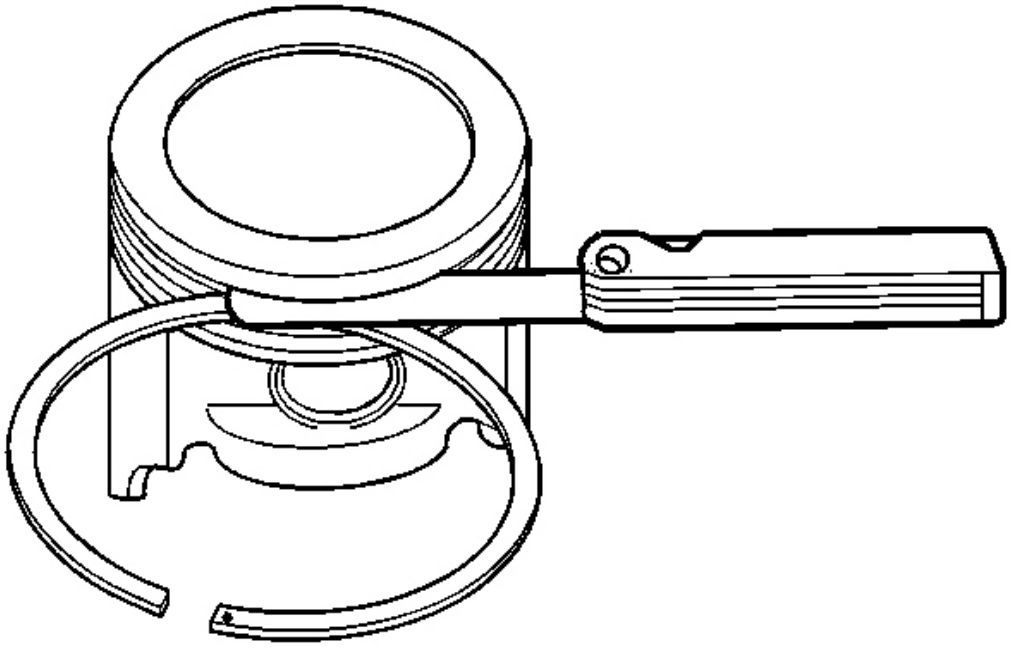


Fig. 450: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to- groove clearance cannot be obtained, replace the piston, pin, and connecting rod assembly. Refer to **Engine Mechanical Specifications**.

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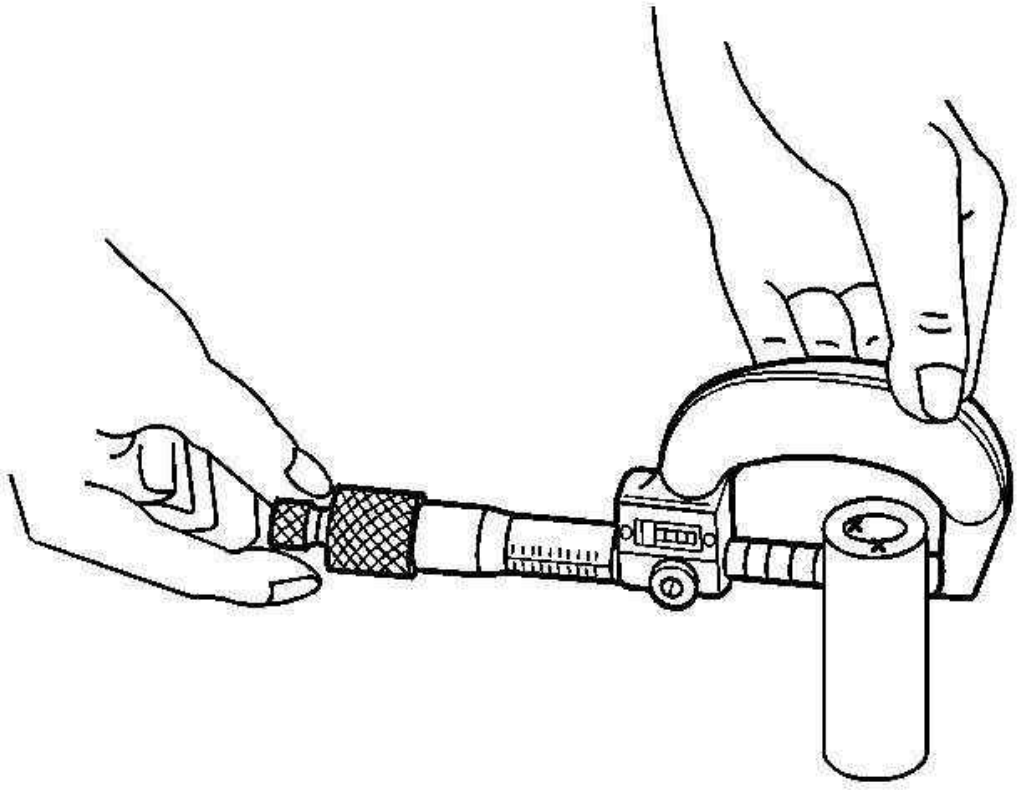


Fig. 451: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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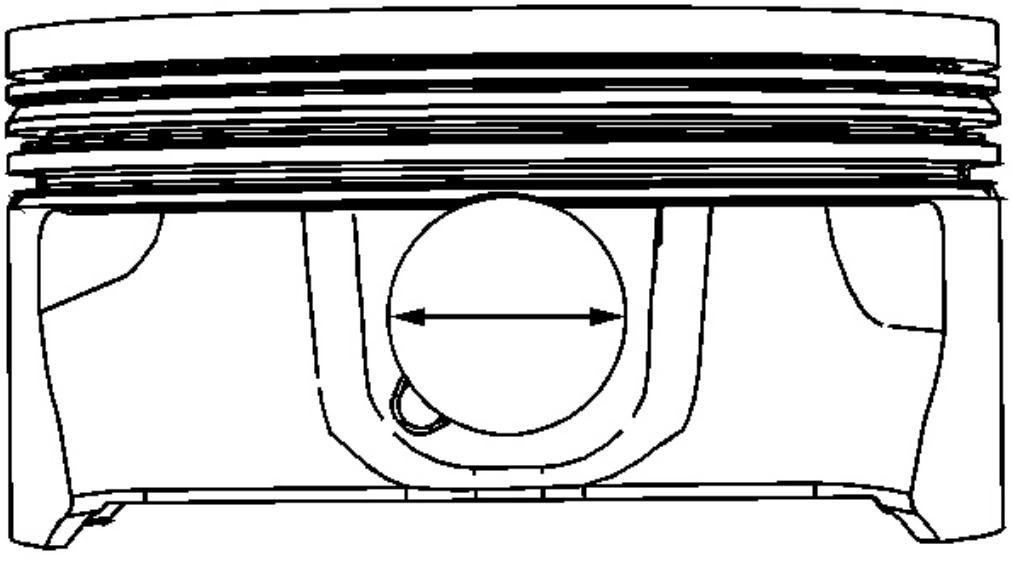


Fig. 452: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS CORP.

9. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
10. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications**.

Measuring Piston Ring End Gap

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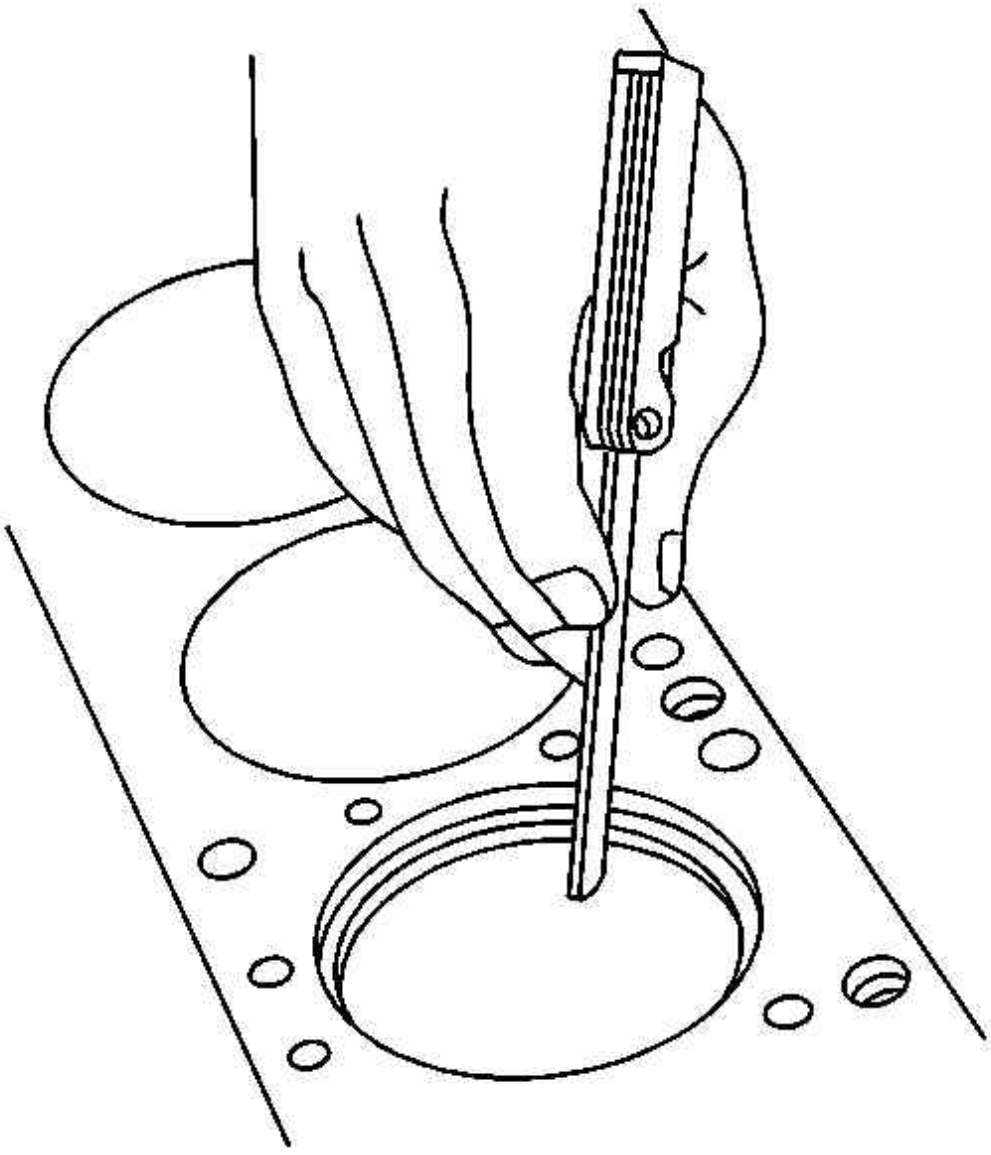


Fig. 453: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

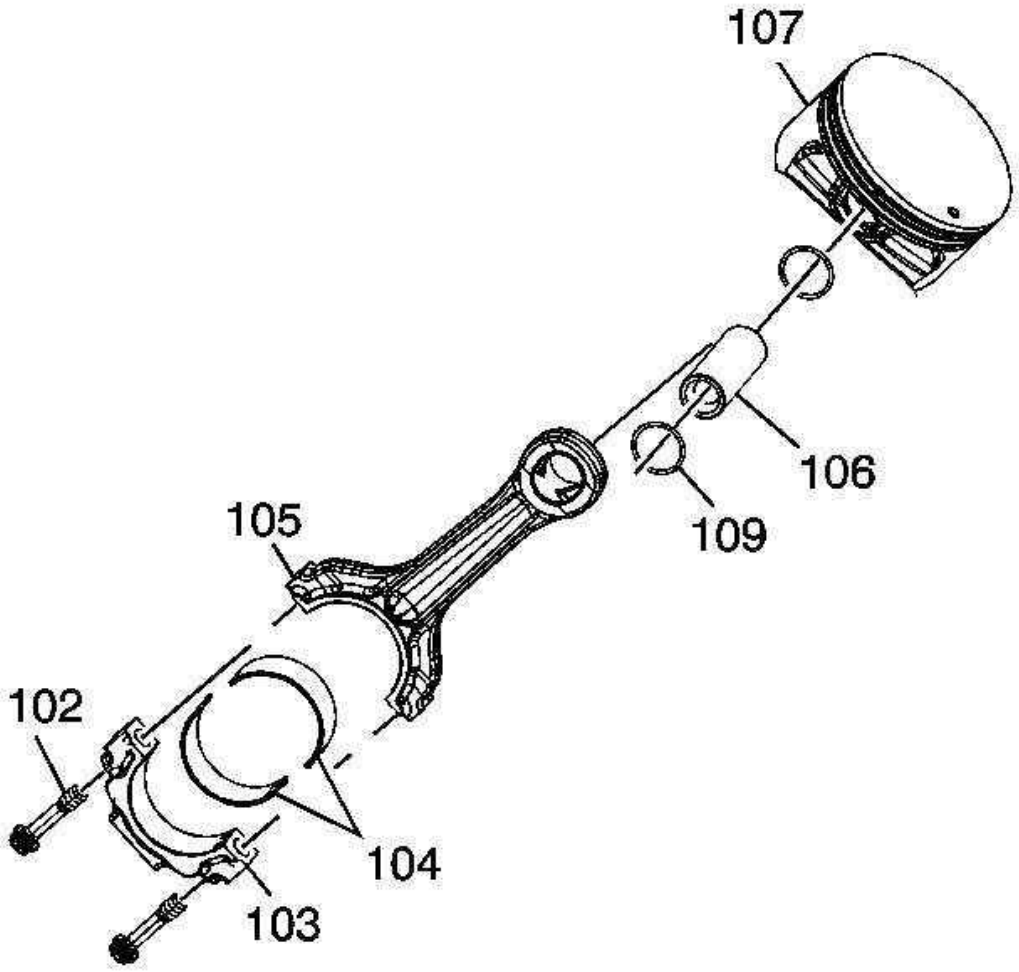
- **Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.**

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- **Measure the piston ring in the cylinder in which it will be used.**

1. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area.
2. Insert a feeler gage and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings



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Fig. 454: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the piston, pin, and connecting rod as an assembly.**
- **Do not attempt to repair the bolt hole threads of the connecting rod.**

1. Clean the connecting rod (105) and cap (103) in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the components with compressed air.

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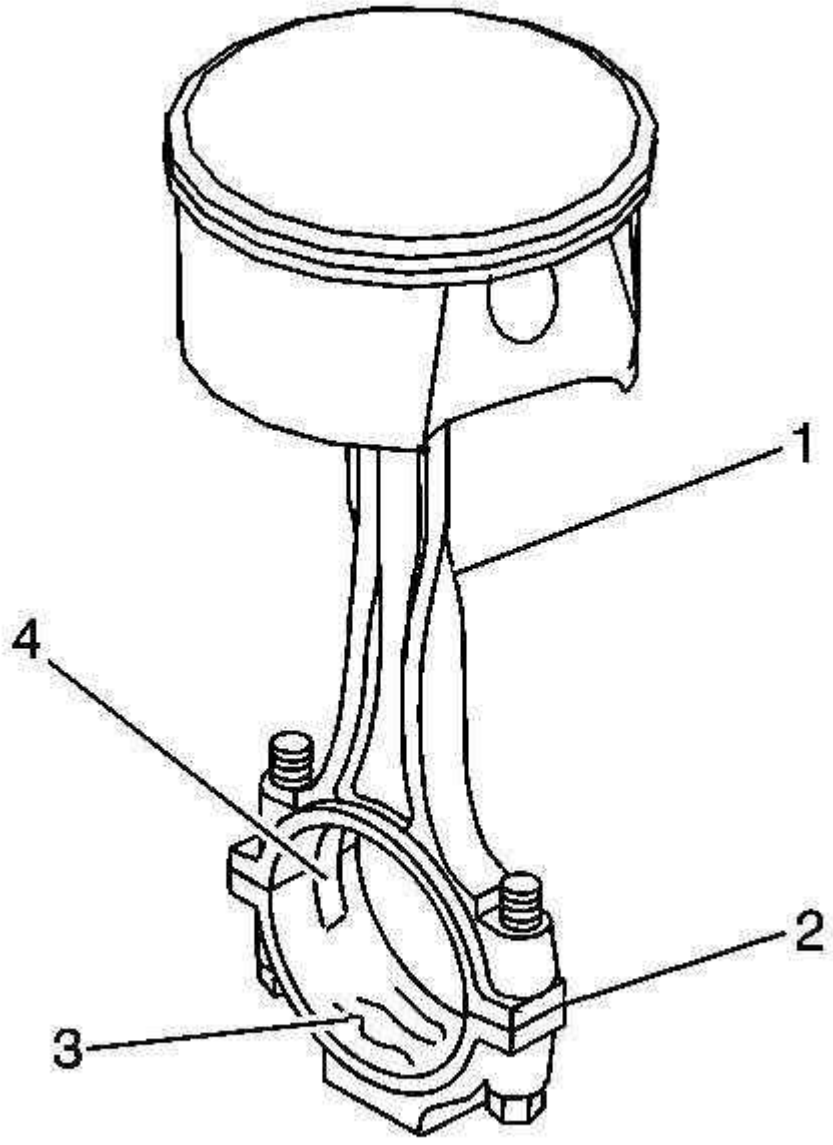


Fig. 455: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the connecting rod for the following conditions:
   - Twisting (1)

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- Proper fit of the connecting rod and cap mating surfaces (2)
- Nicks or gouges in the bearing bore (3)
- Damage to the bearing locating slots (4)

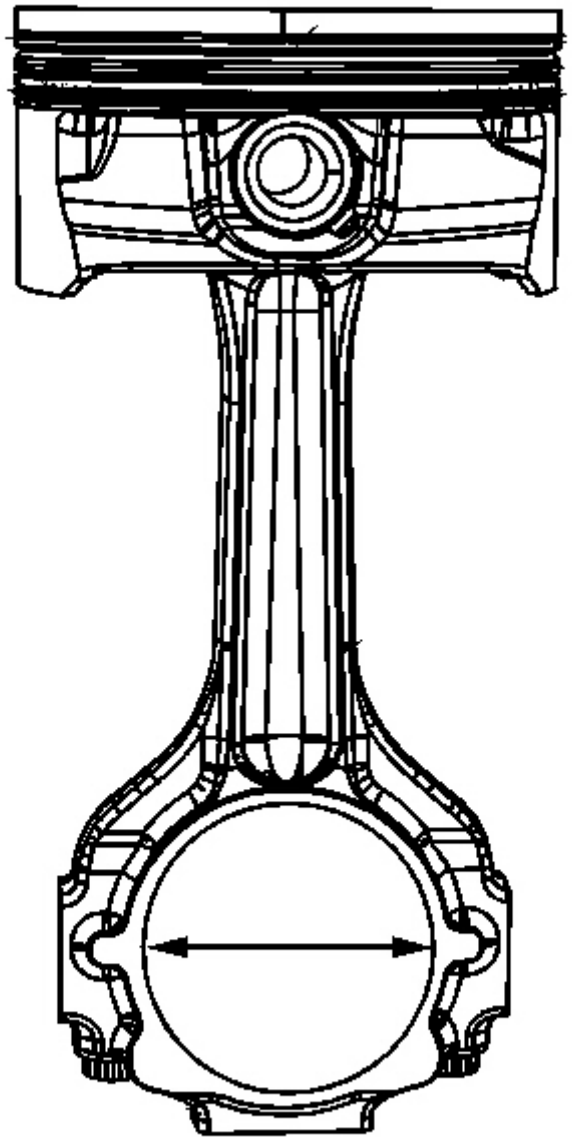


Fig. 456: Identifying Connecting Rod Bearing Bore

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Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

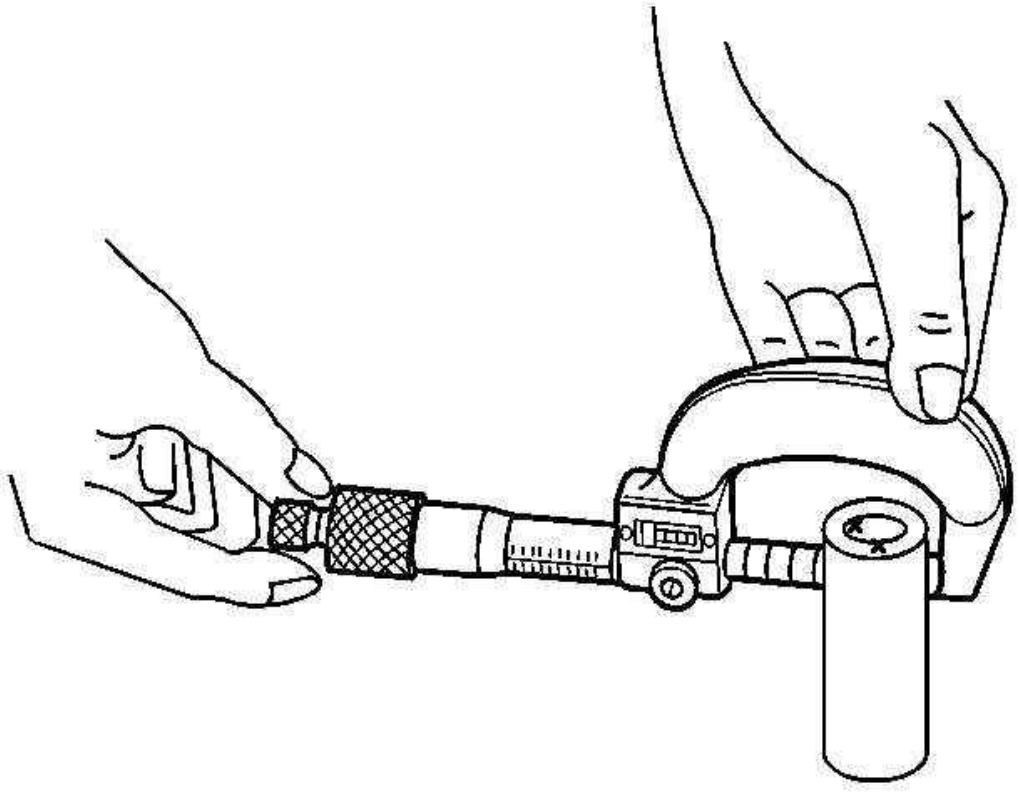


Fig. 457: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. To determine full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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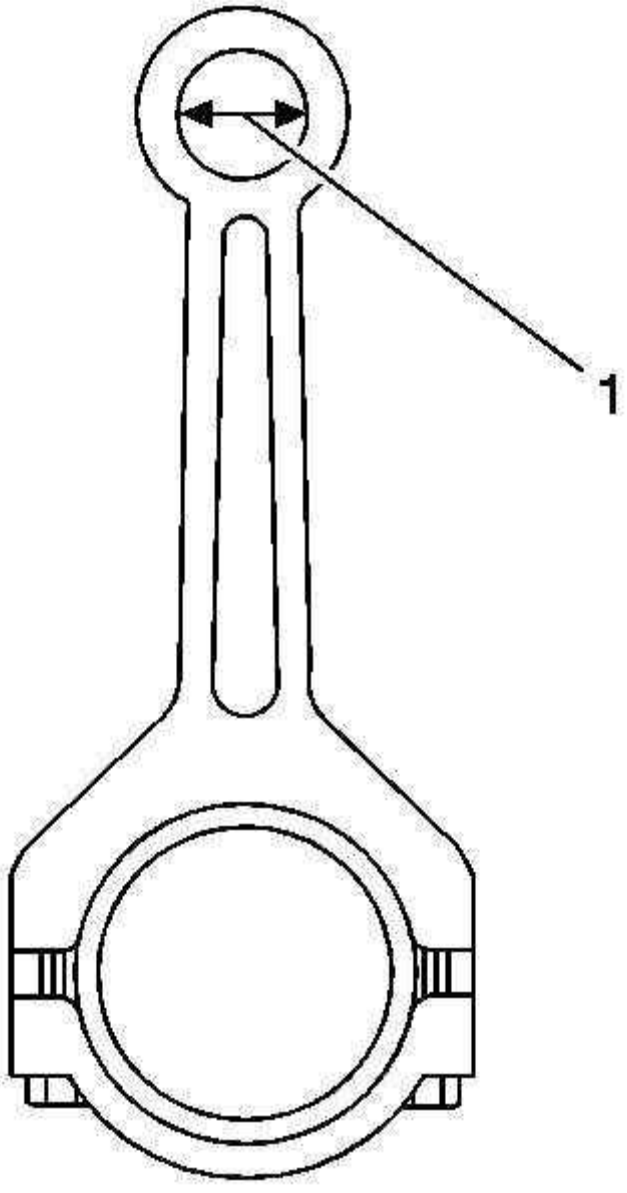


Fig. 458: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS CORP.

6. To determine the full-floating piston pin-to-connecting rod bore clearance, use

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a micrometer and measure the connecting rod pin bore (1) inside diameter (ID).

7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications**.

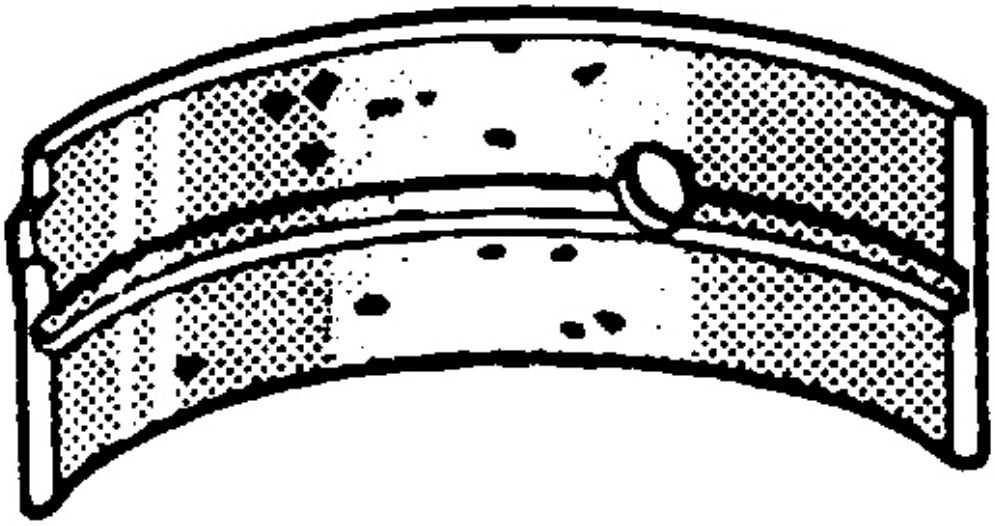


Fig. 459: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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

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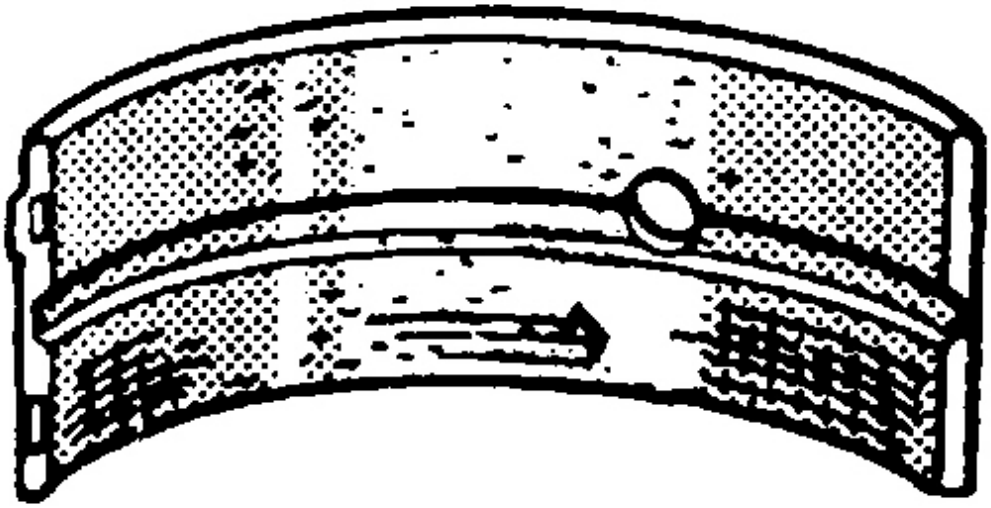


Fig. 460: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

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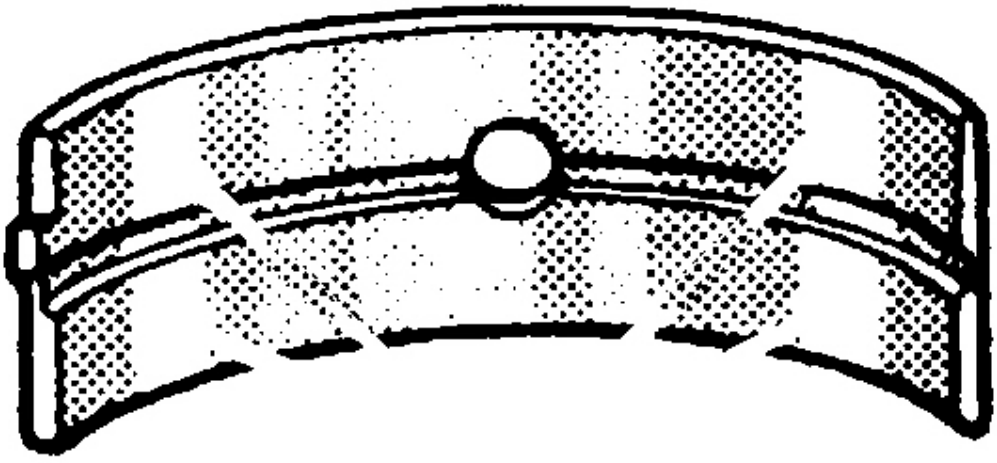


Fig. 461: View of Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.

PISTON AND CONNECTING ROD ASSEMBLE

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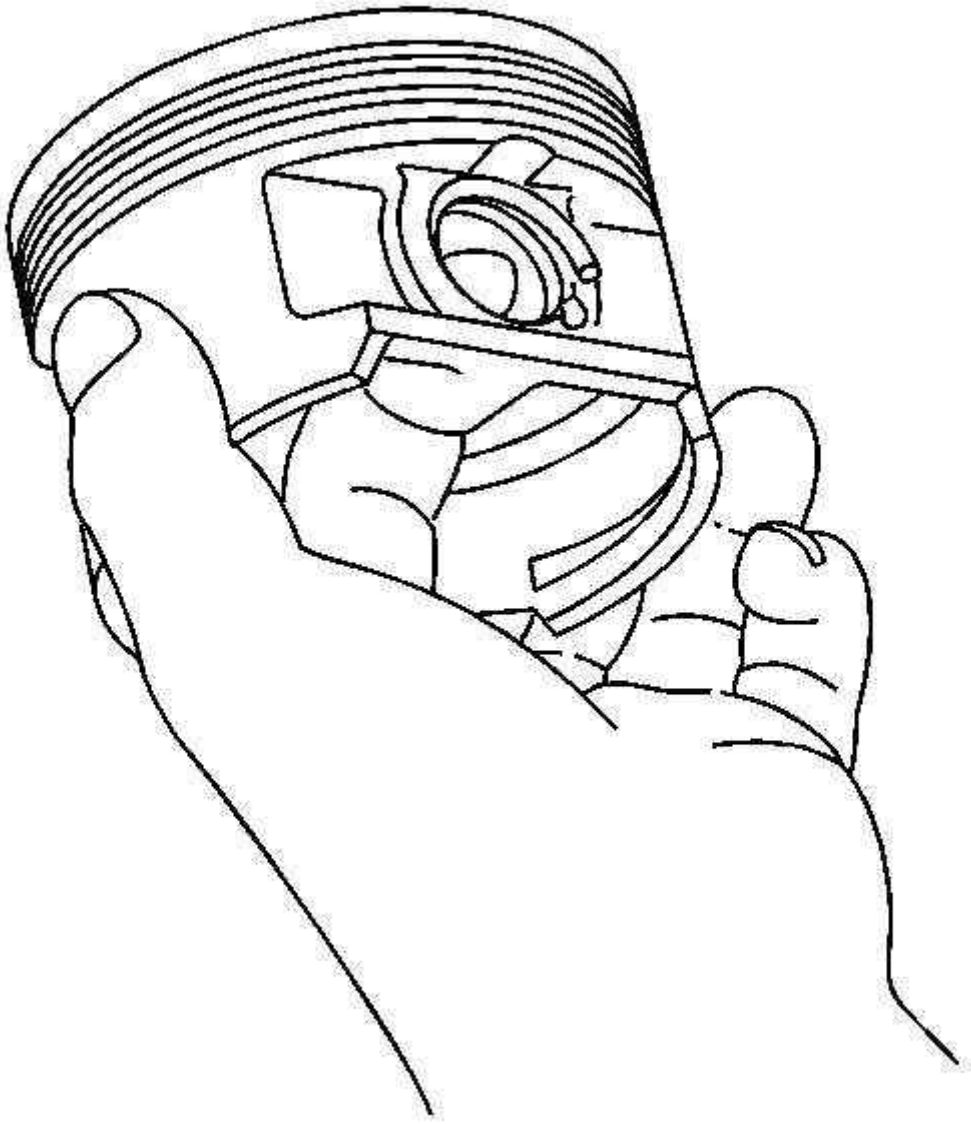


Fig. 462: View Of Retaining Clip In Pin Bore Groove
Courtesy of GENERAL MOTORS CORP.

1. Install the retainer. The retainer should be seated in the groove of the pin bore.

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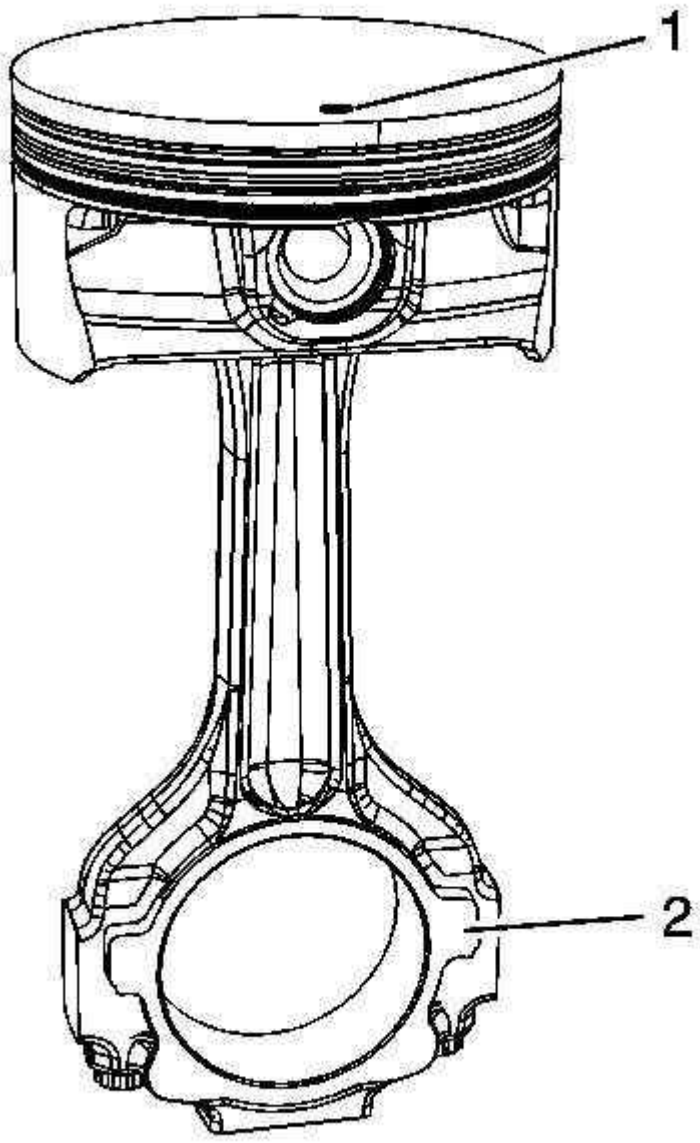


Fig. 463: Locating Mark On Top Of Piston & Connecting Rod Tab
Courtesy of GENERAL MOTORS CORP.

2. Assemble the piston and connecting rod. The mark (1) on the top of the piston and the tab (2) on the side of the connecting rod should be facing the same direction.

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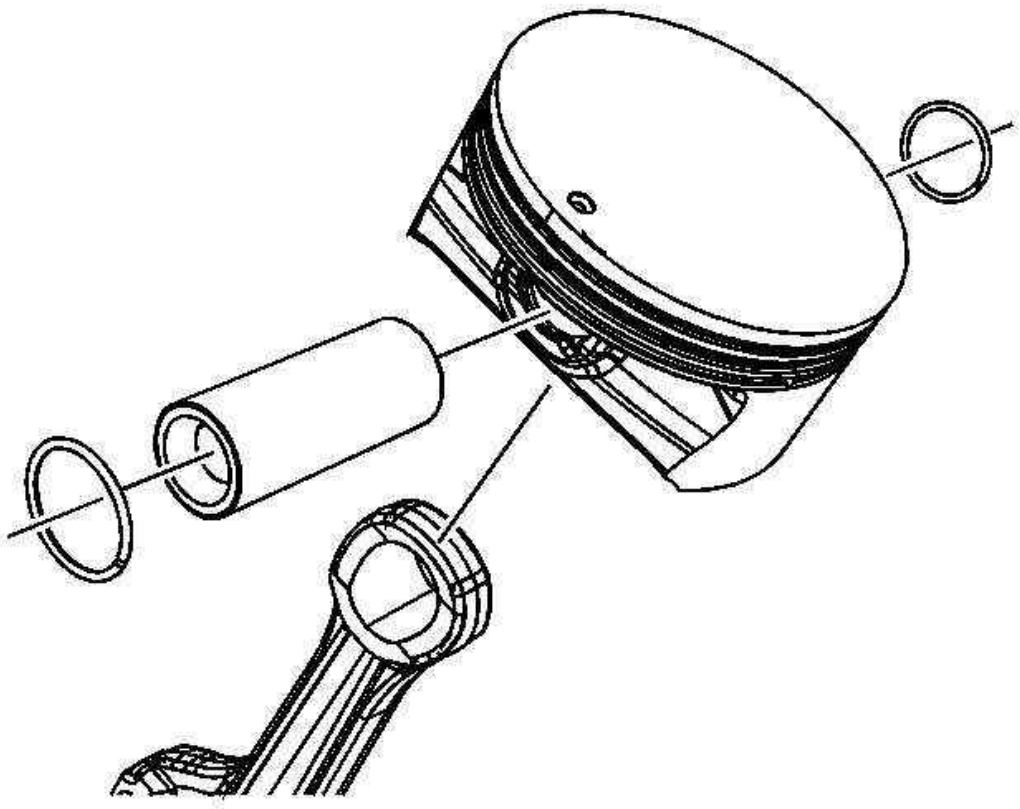


Fig. 464: View Of Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Install the piston pin to the piston and connecting rod.
4. Install the retainers. The retainers should be seated in the groove of the pin bore.

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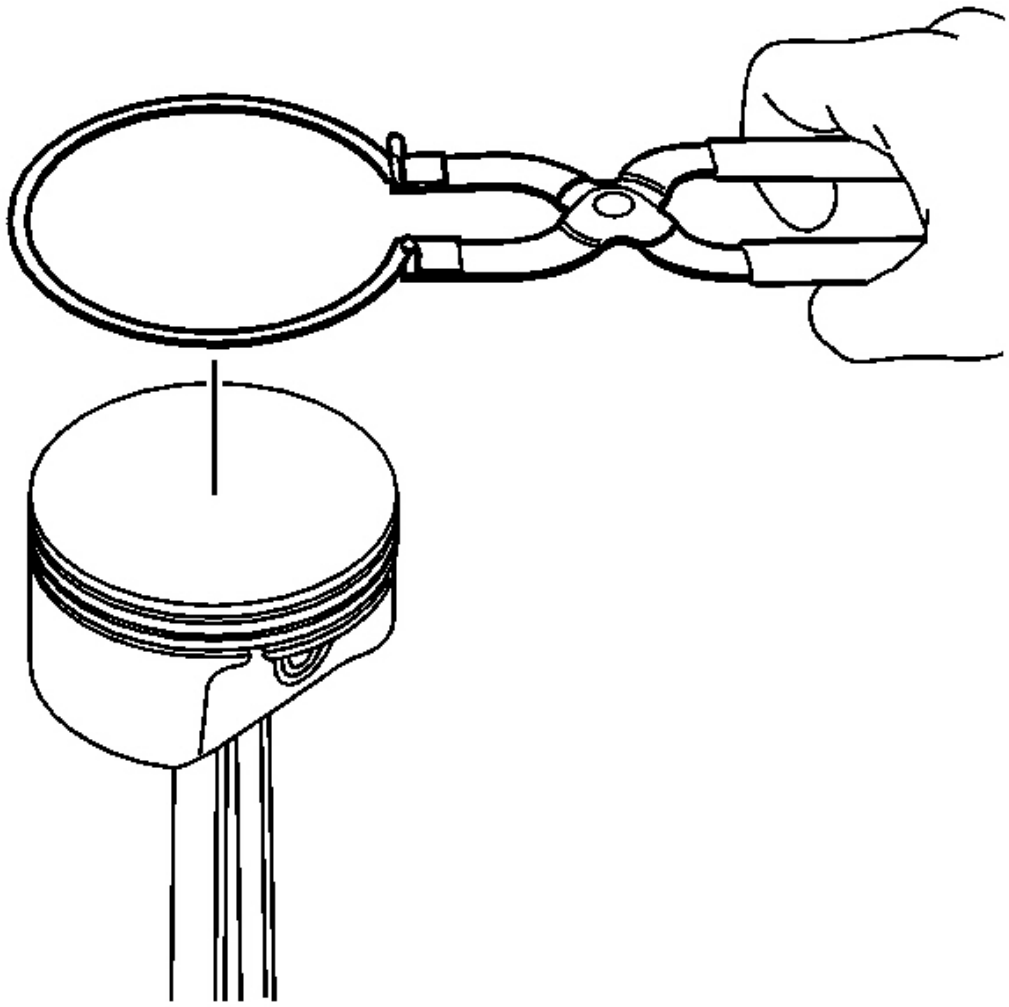


Fig. 465: Identifying Piston Ring Expander With Piston Rings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

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5. Using piston ring pliers, install the piston rings onto the piston. The dimple or mark on the piston ring should face the top of the piston. If no dimple or mark can be found on the top compression ring, it may be installed in either direction.
6. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
7. Position the compression ring end gaps 180 degrees opposite each other.

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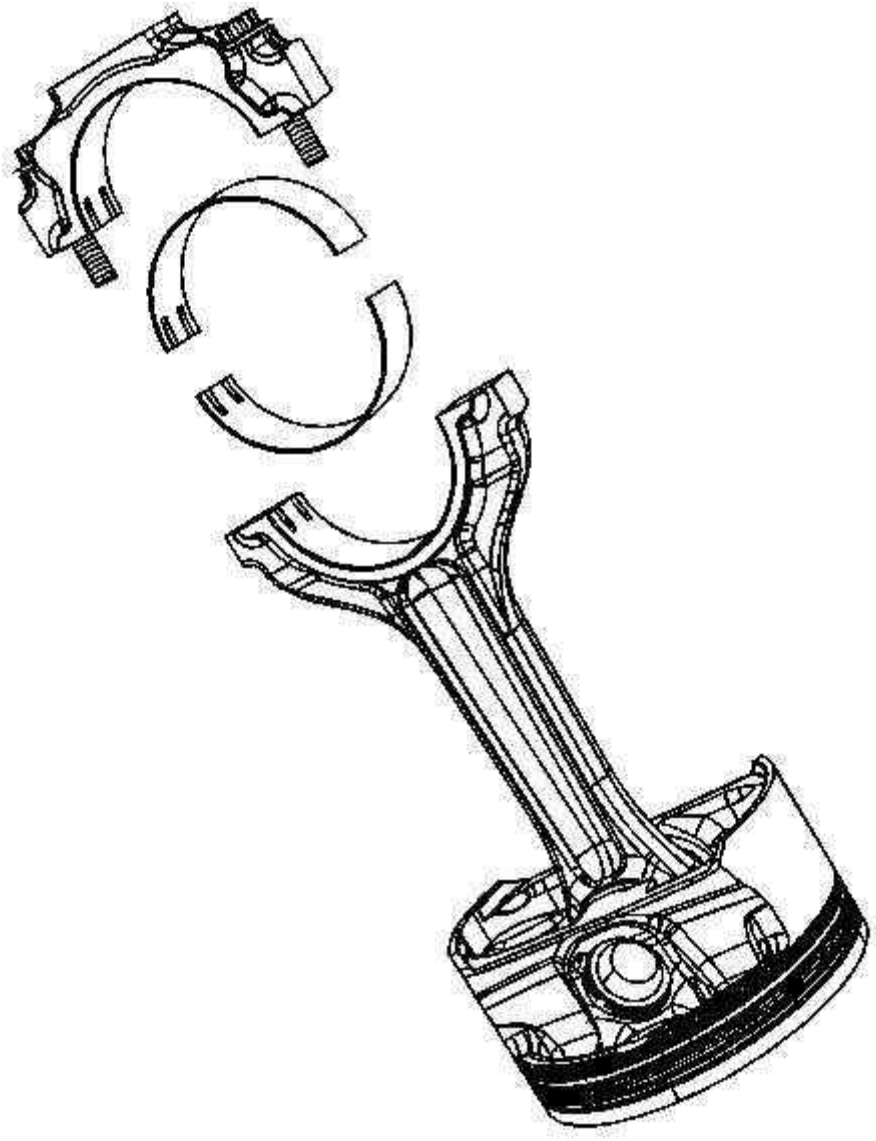


Fig. 466: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod bearings to the rod and cap.

CAMSHAFT BEARING REMOVAL

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Tools Required

J 33049 Camshaft Bearing Service Set

Removal Procedure

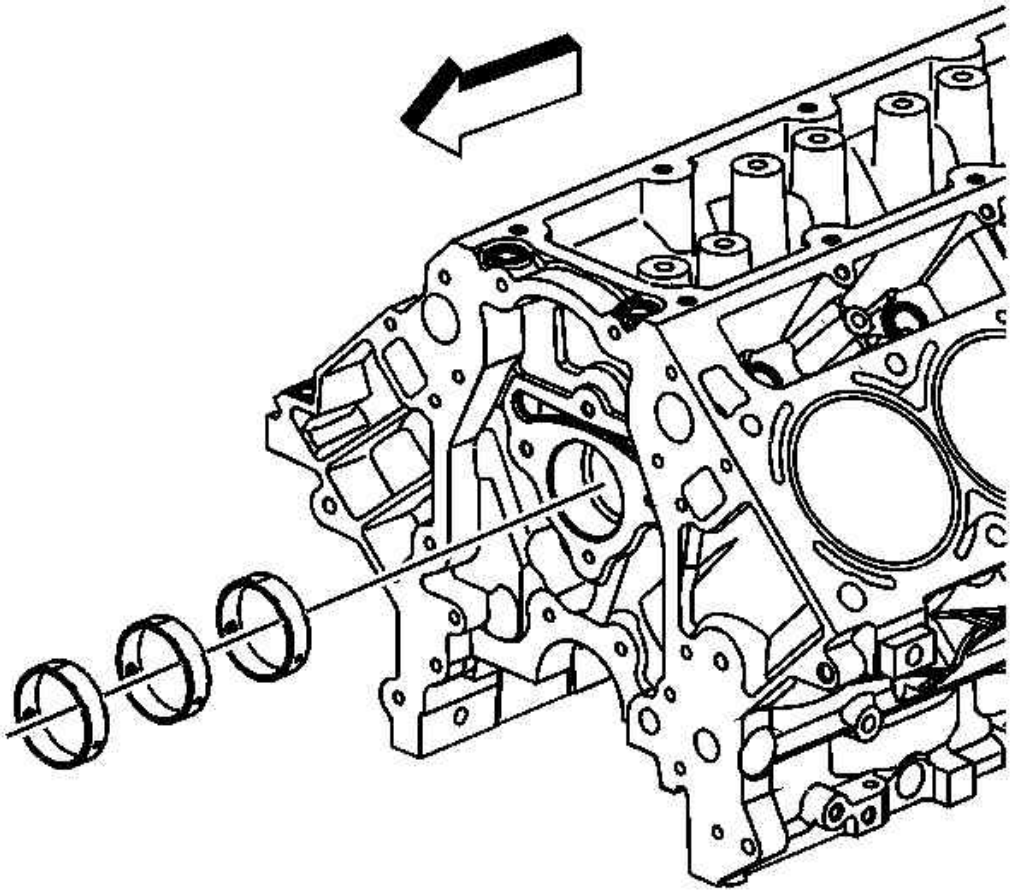
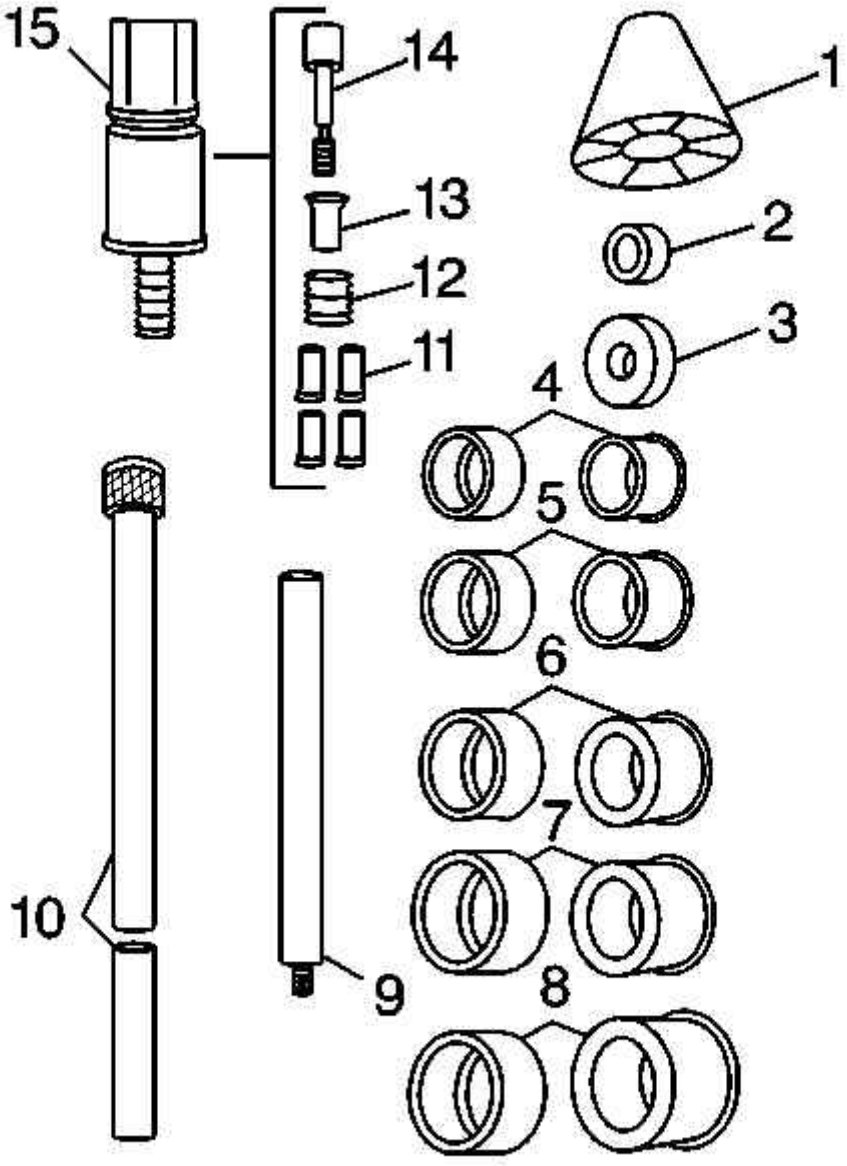


Fig. 467: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out of round, or damaged engine block bearing bore.

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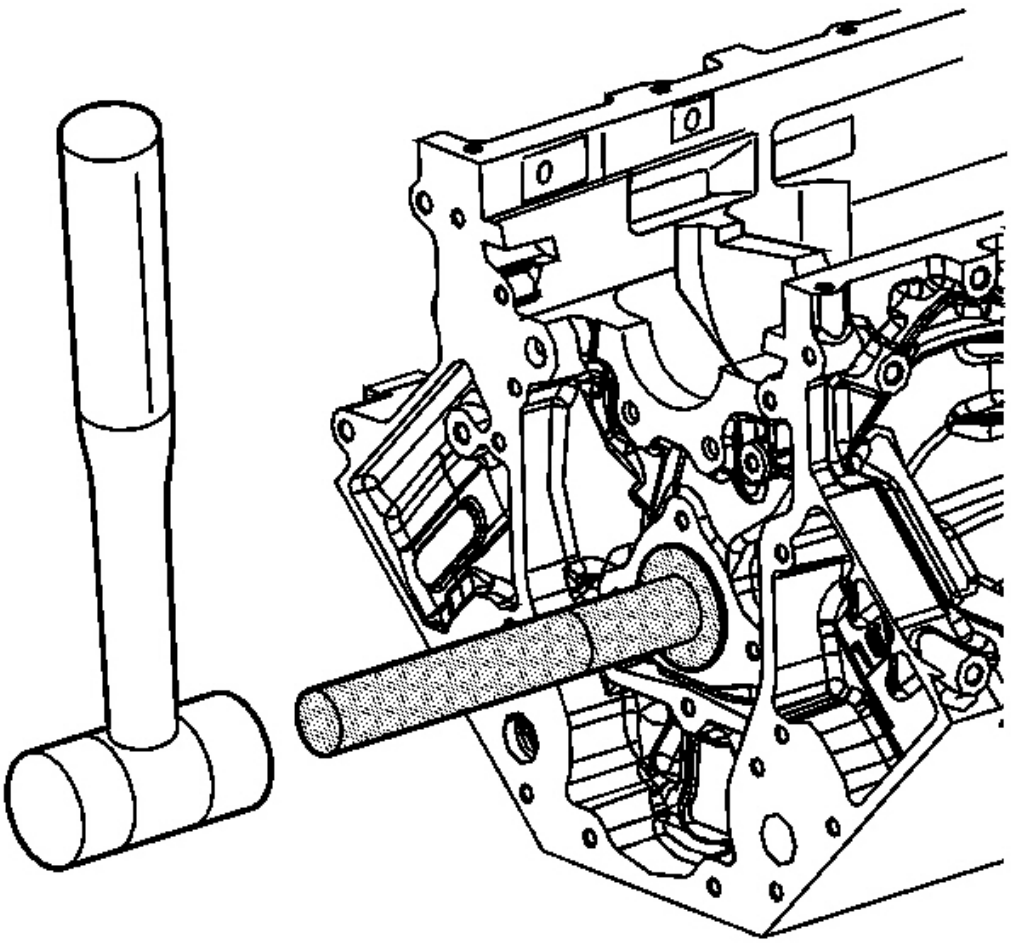
1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores. Refer to **Camshaft and Bearings Cleaning and Inspection**.
2. Repair or replace the components, as required.



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Fig. 468: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** .
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing location in order to align the tool.



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Fig. 469: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Drive the bearing from the block bore.

IMPORTANT: In order to remove the front camshaft bearing, operate the tool from the rear of the block, using the guide cone in the rear camshaft bearing bore location.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

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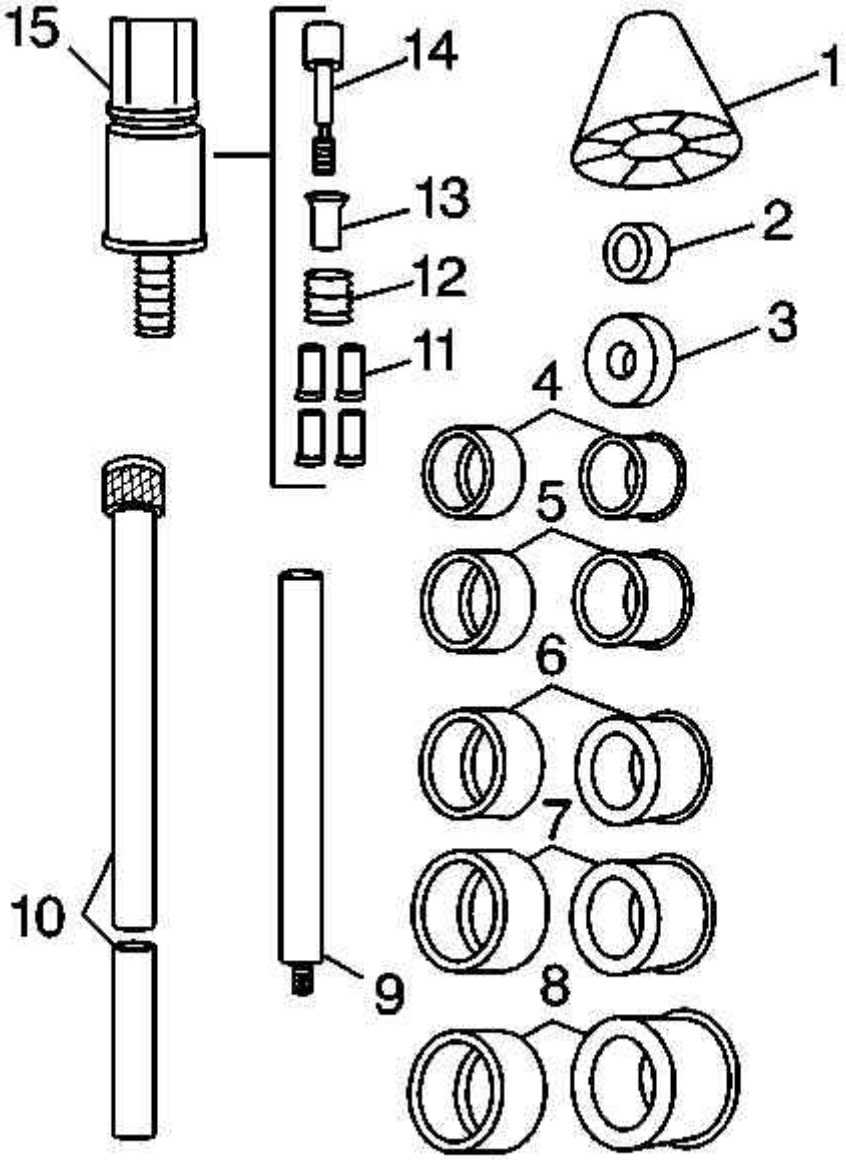


Fig. 470: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander

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sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).

- Expander bearing driver number 1 inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the expander assembly and the small washer.
- Expander bearing driver number 2 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number 1 expanding driver and the small washer.
- Expander bearing driver number 3 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number 2 expanding driver and the large washer.
- Expander bearing driver number 4 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number 3 expanding driver and the large washer.
- Expander bearing driver number 5 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with number 4 expanding driver and the large washer.
- Expander bearing driver number 6 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number 5 expanding driver and the large washer.

Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

IMPORTANT: To install or remove the expanding driver, always push on or pull from the ends.
Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Ensure the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. With the small end of the cone (2) facing the driver assembly, place the guide cone over the driving bar.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

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For removal of the inner bearings, it may be necessary to install the driver bar extension.

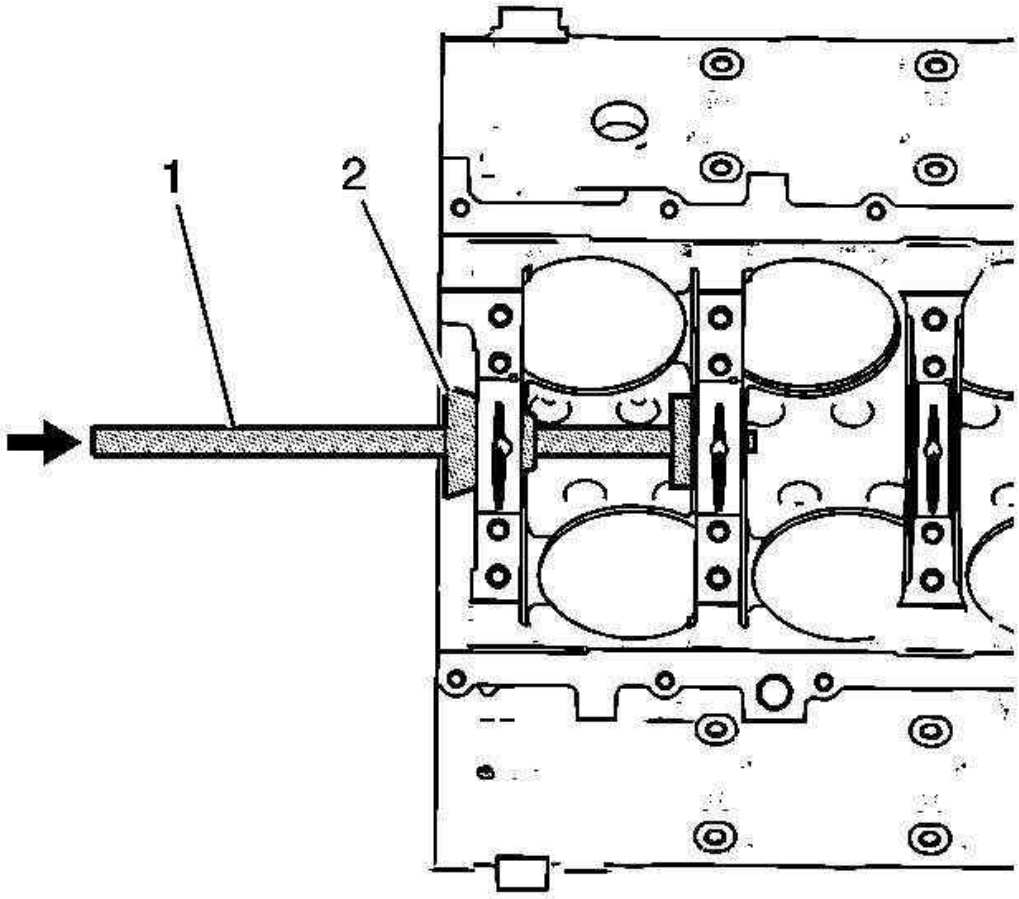


Fig. 471: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

7. Insert the tool into an inner camshaft bearing and tighten until snug.

   Operate the tool from the front or rear of the engine block.

   On some engine blocks, the nut on the expander assembly is inaccessible, except from either end. In this case, you must use a socket and extension to

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enlarge and reduce the expander assembly.

8. Slide the cone (2) into the front or rear camshaft bearing location. This will properly align the tool.
9. Drive the bearing out of the engine block.
10. Repeat the procedure for the additional inner bearings.

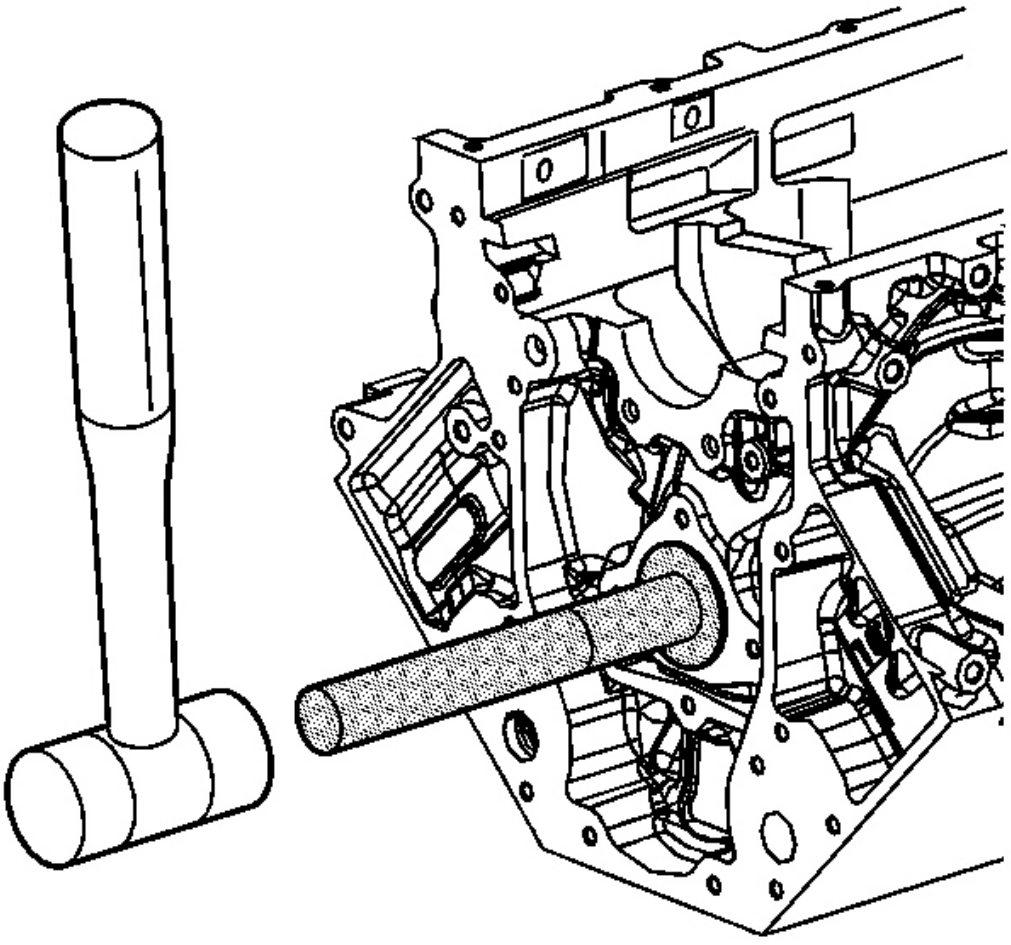


Fig. 472: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

11. For the 2 end bearings, front and rear, remove the nylon cone and driver bar

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extension.

12. Drive the bearings out of or into the engine block.

CAMSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Camshaft Lobe Lift Indicator. See **Special Tools**.

Cleaning

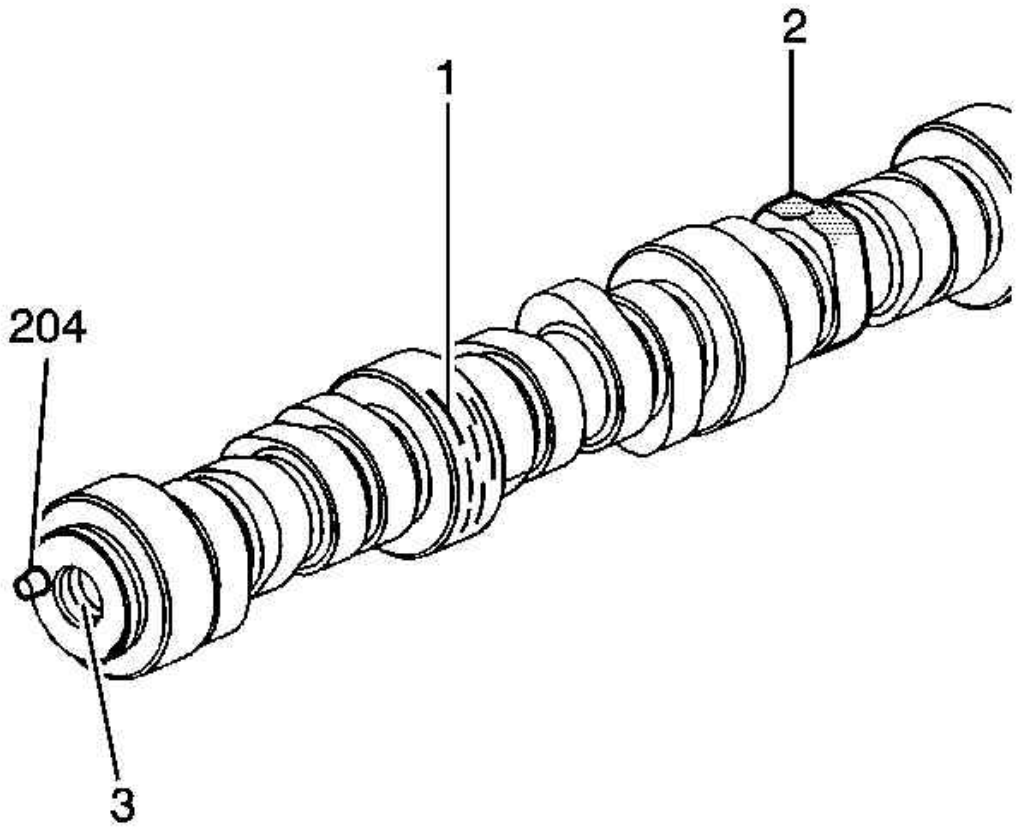


Fig. 473: Identifying Camshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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1. Clean the components in solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the threaded bolt hole (3) in the front of the camshaft for damaged threads or debris.
6. Inspect the camshaft sprocket pin (204) for damage.
7. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

   If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

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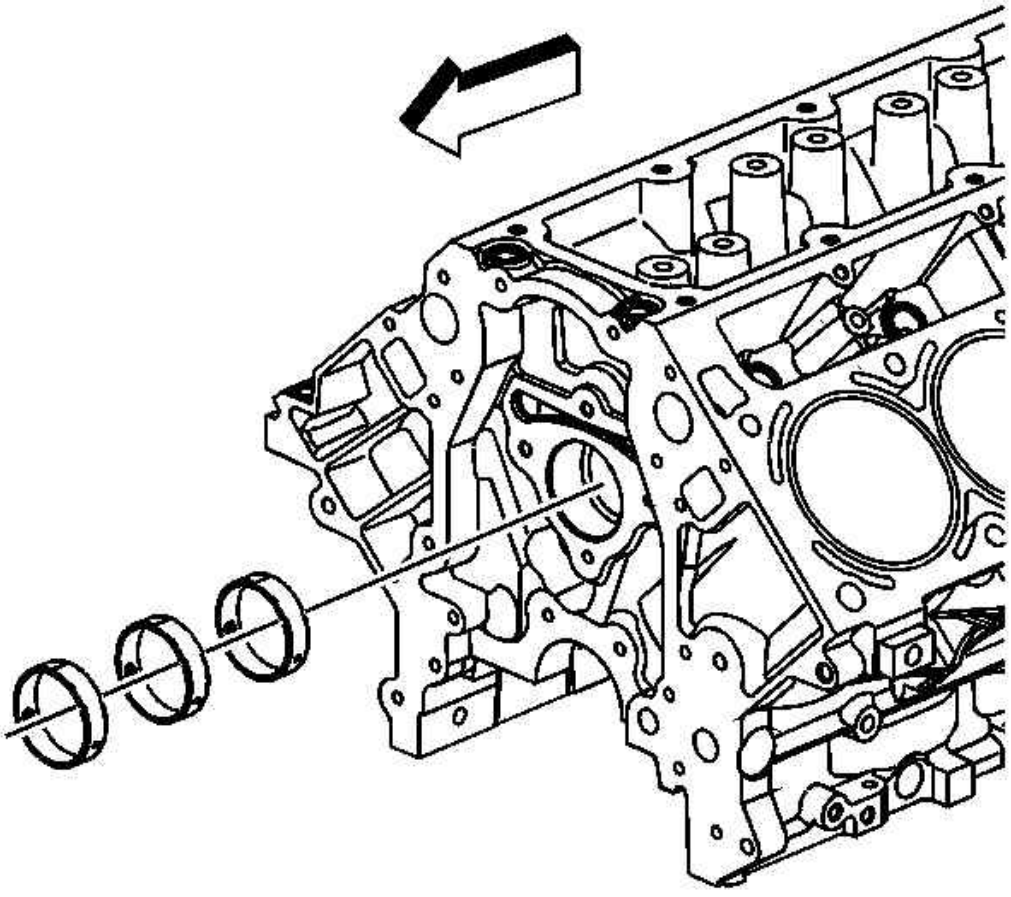


Fig. 474: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

8. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in the engine block bearing bores.
9. Inspect the camshaft bearings for excessive wear or scoring.

   Bearings with excessive scoring or wear must be replaced.

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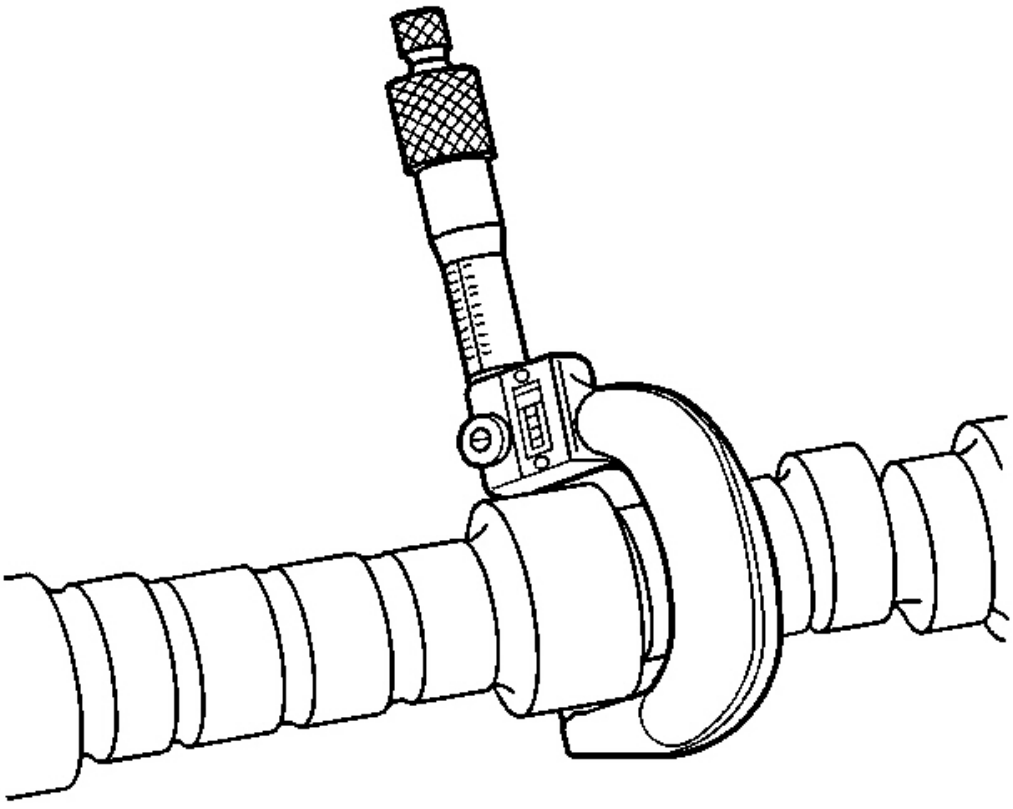


Fig. 475: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

10. Using a micrometer, measure the camshaft journals for wear and out-of-round.
    - If the camshaft bearing journals are greater than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
    - If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the camshaft.

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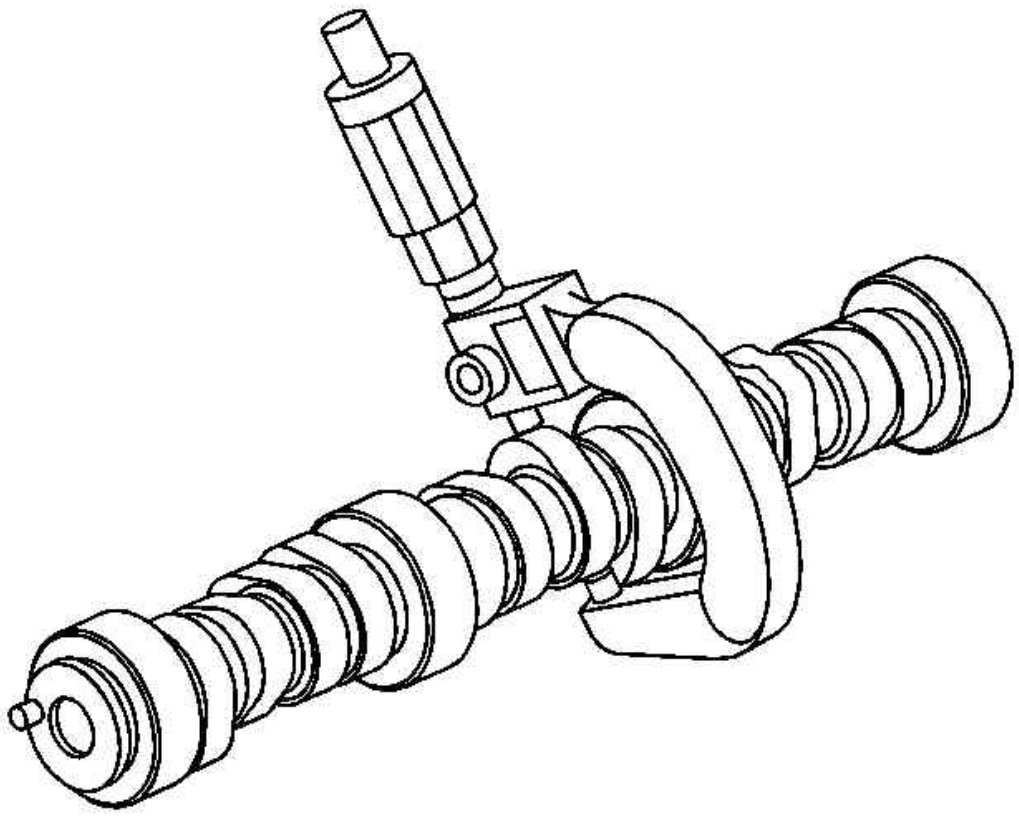


Fig. 476: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

11. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

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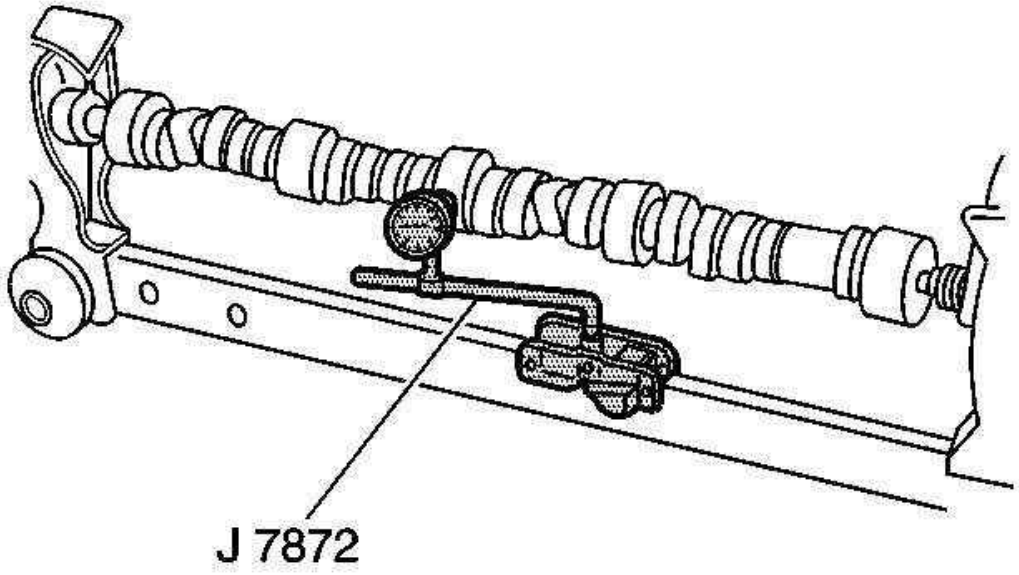
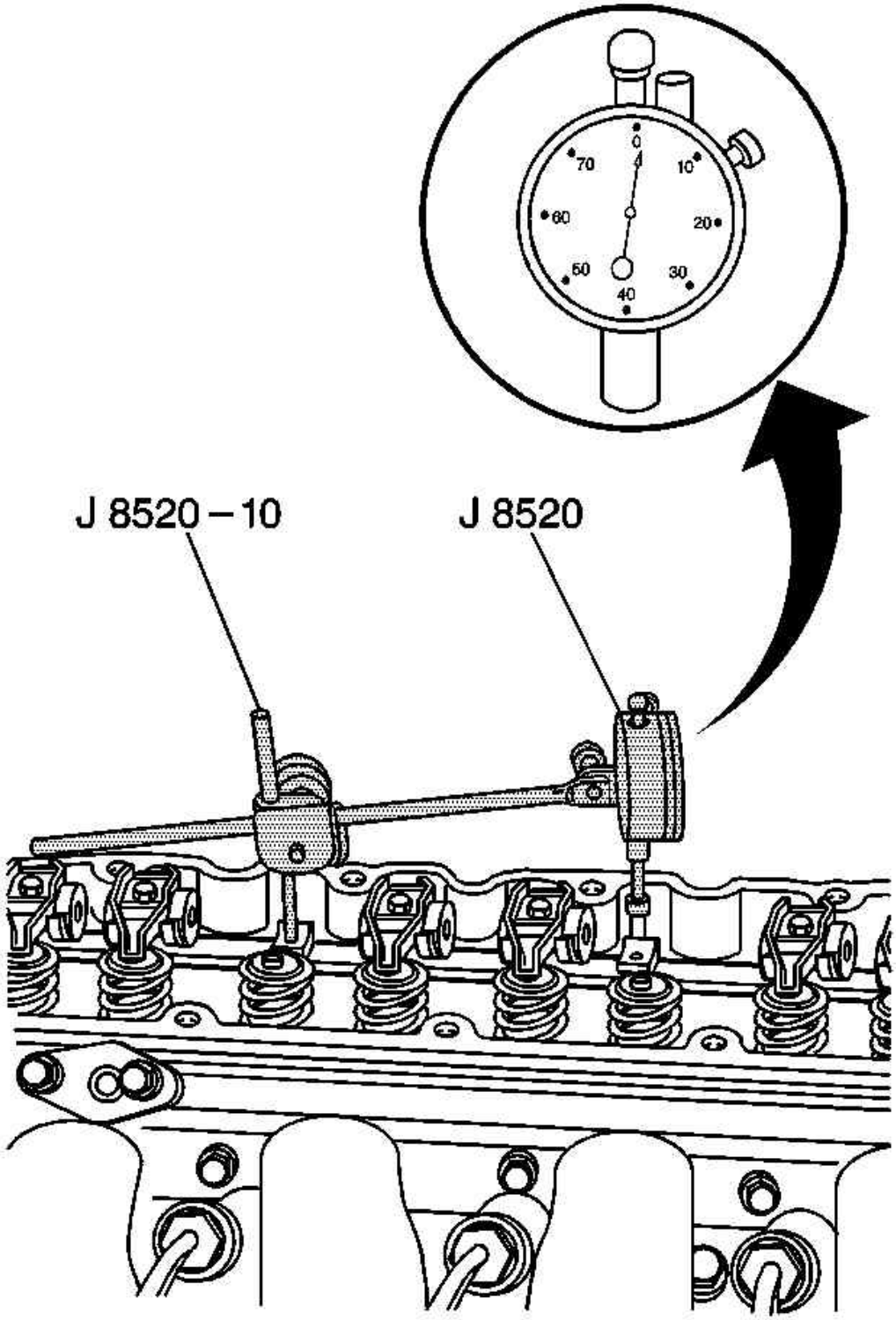


Fig. 477: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the camshaft runout.
    1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
    2. Using the **J 7872** , measure the runout of the intermediate camshaft bearing journals.
    3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift

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Fig. 478: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

1. Using the **J 8520** , measure camshaft lobe lift. See **Special Tools**.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the **J 8520** and position onto the stud. See **Special Tools**.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise, until the dial indicator obtains its highest and lowest readings.
8. Compare the total to specifications. Refer to **Engine Mechanical Specifications**.

CAMSHAFT BEARING INSTALLATION

Tools Required

J 33049 Camshaft Bearing Service Set

Installation Procedure

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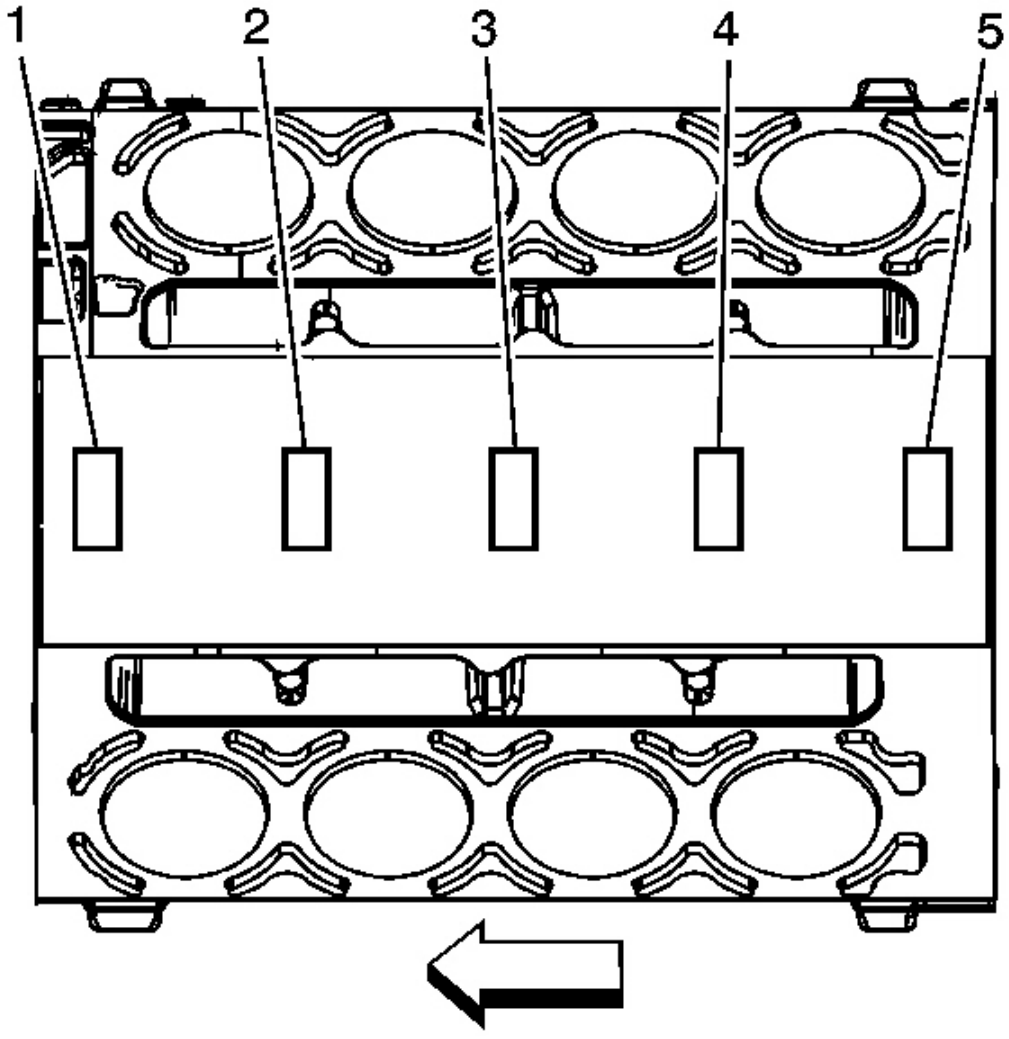


Fig. 479: Identifying Engine Block Camshaft Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Position 1 and 5 are the largest diameter bores. Position 3 is the smallest diameter bore. Position 2 and 4 are the intermediate size bores.

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The inside diameter (ID) for all camshaft bearings is the same size.

1. Measure the engine block camshaft bearing bores (1-5) in order to identify the correct OD size bearing for each position. Refer to **Engine Mechanical Specifications**.

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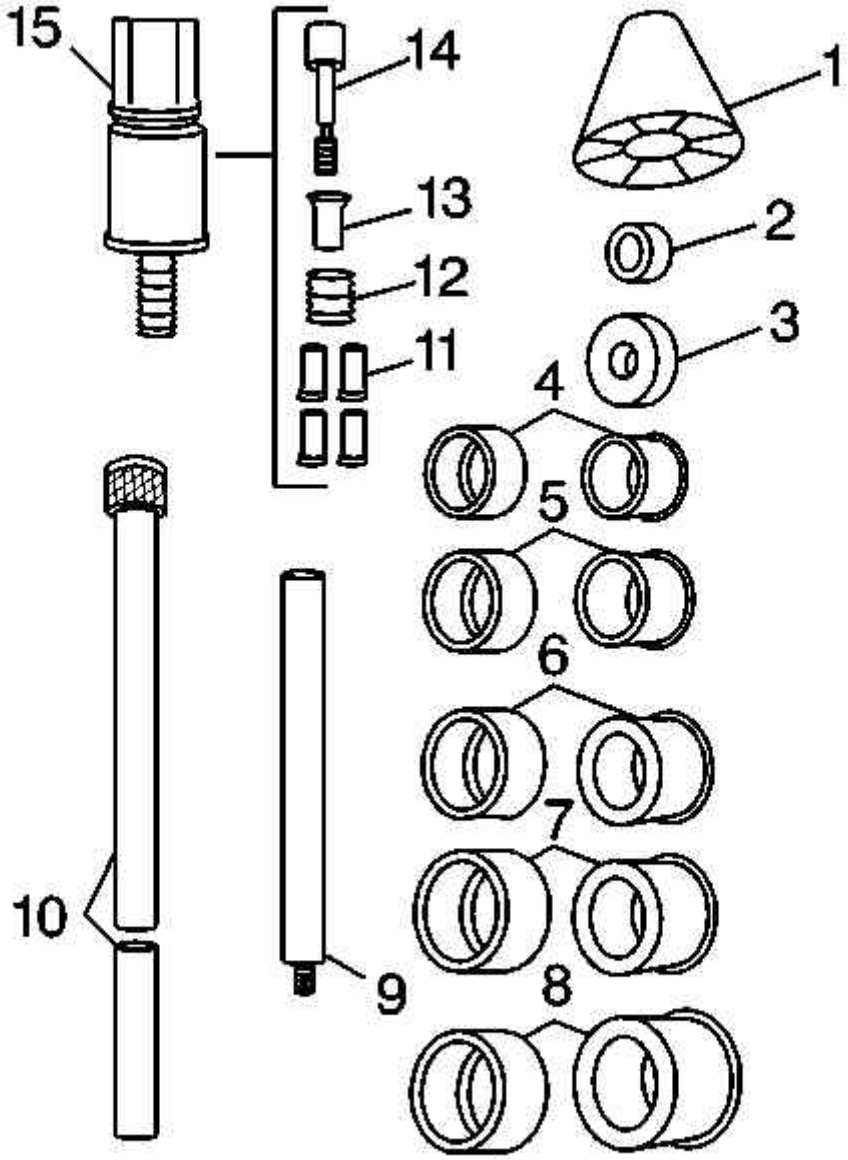


Fig. 480: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

2. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . Refer to **Piston and Connecting Rod Assemble**.

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3. Assemble the tool.

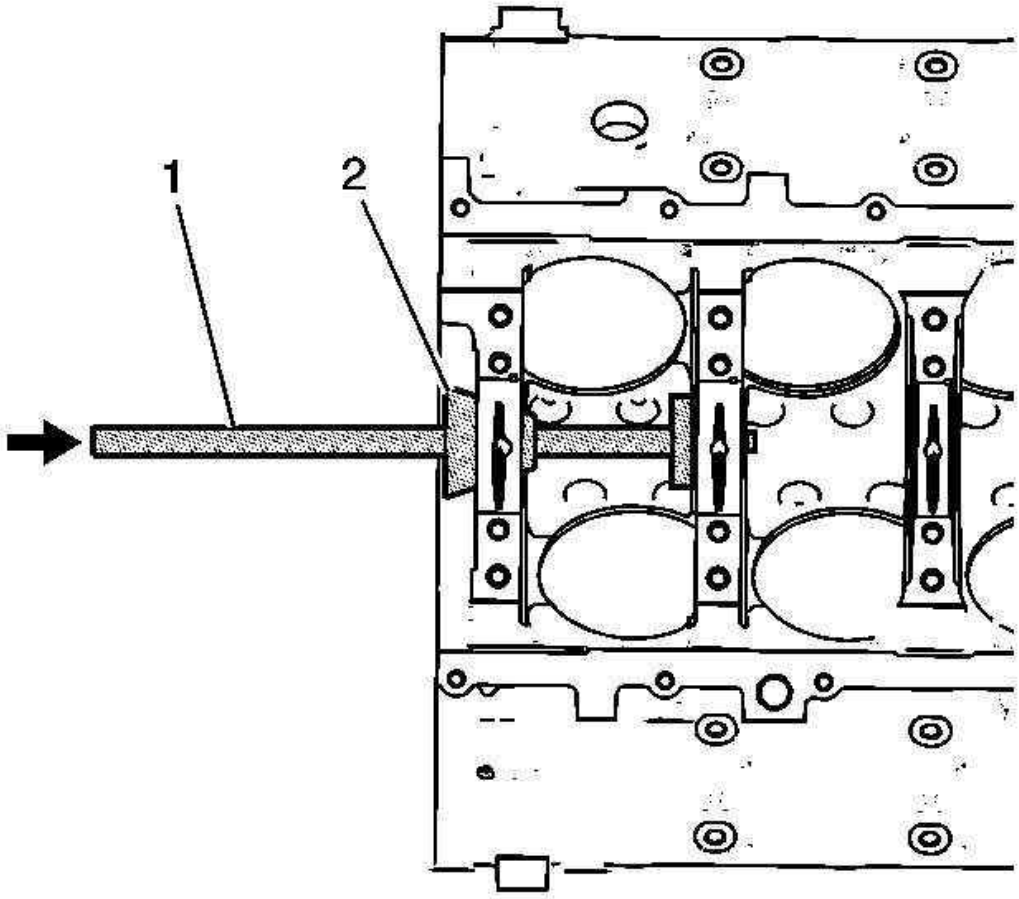


Fig. 481: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Insert the tool through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the cone (2) into the front camshaft bearing location in order to align the tool.
7. Drive the bearing into the block bore.

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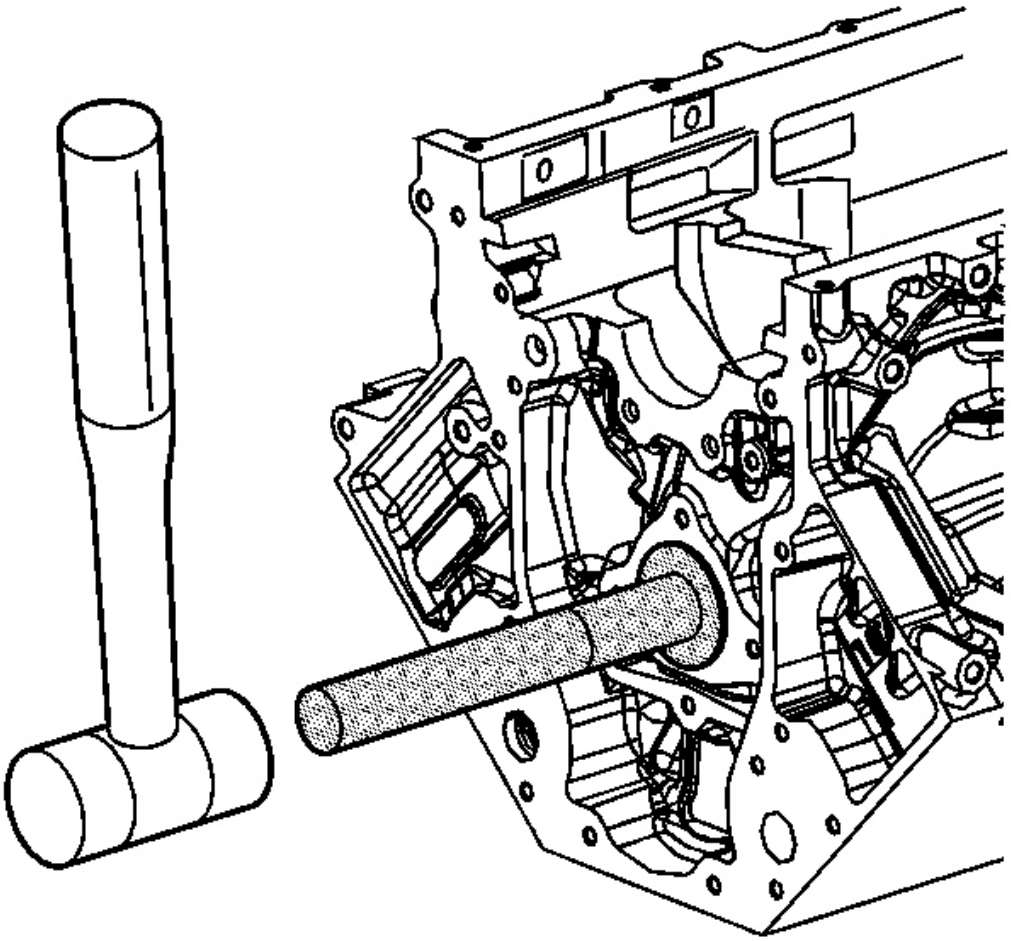


Fig. 482: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Install the front and rear bearings to the block.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

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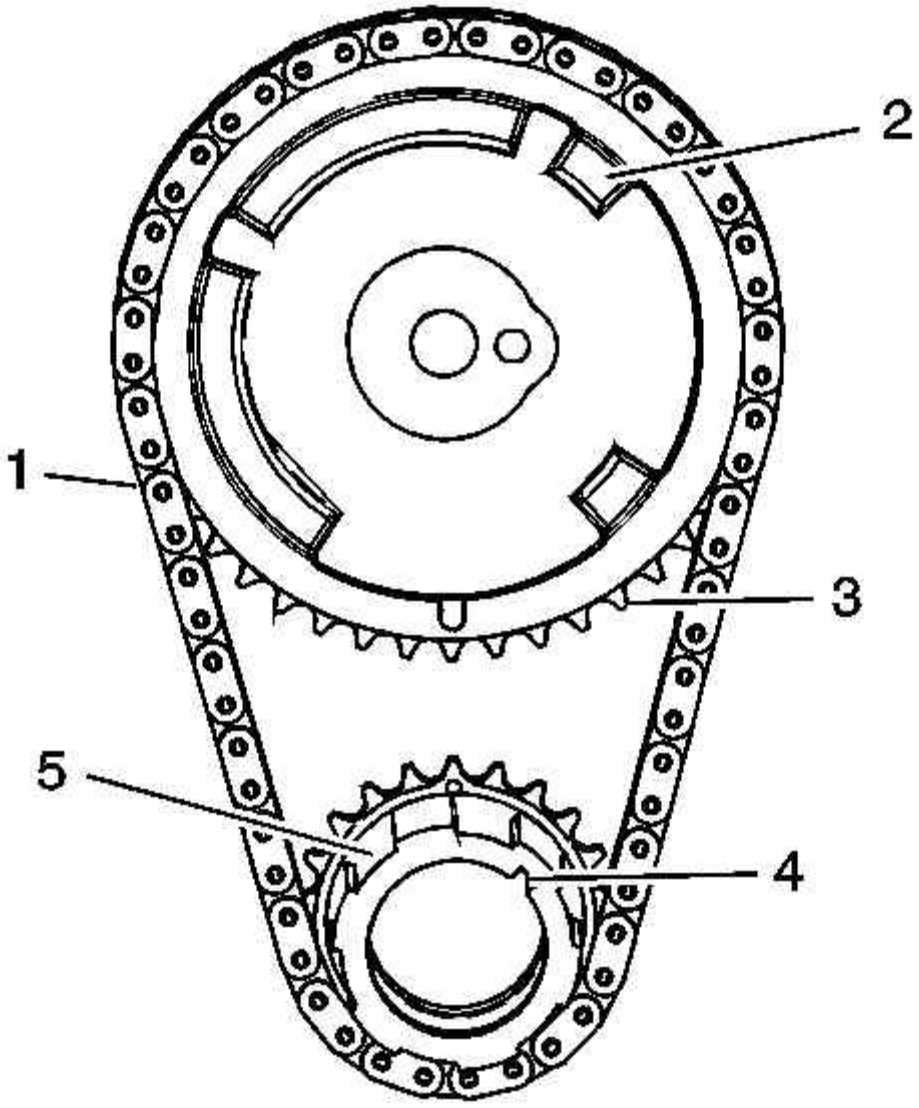


Fig. 483: Identifying Timing Chain & Sprockets Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Clean the components with cleaning solvent.

CAUTION: Refer to Safety Glasses Caution .

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2. Dry the components with compressed air.
3. Inspect the timing chain (1) for binding or wear.
4. Inspect the camshaft position (CMP) sensor raised areas (2) for nicks or damage.
5. Inspect for worn, damaged, or chipped teeth (3).
6. Inspect for a damaged keyway (4).
7. Inspect for worn oil pump drive splines (5).

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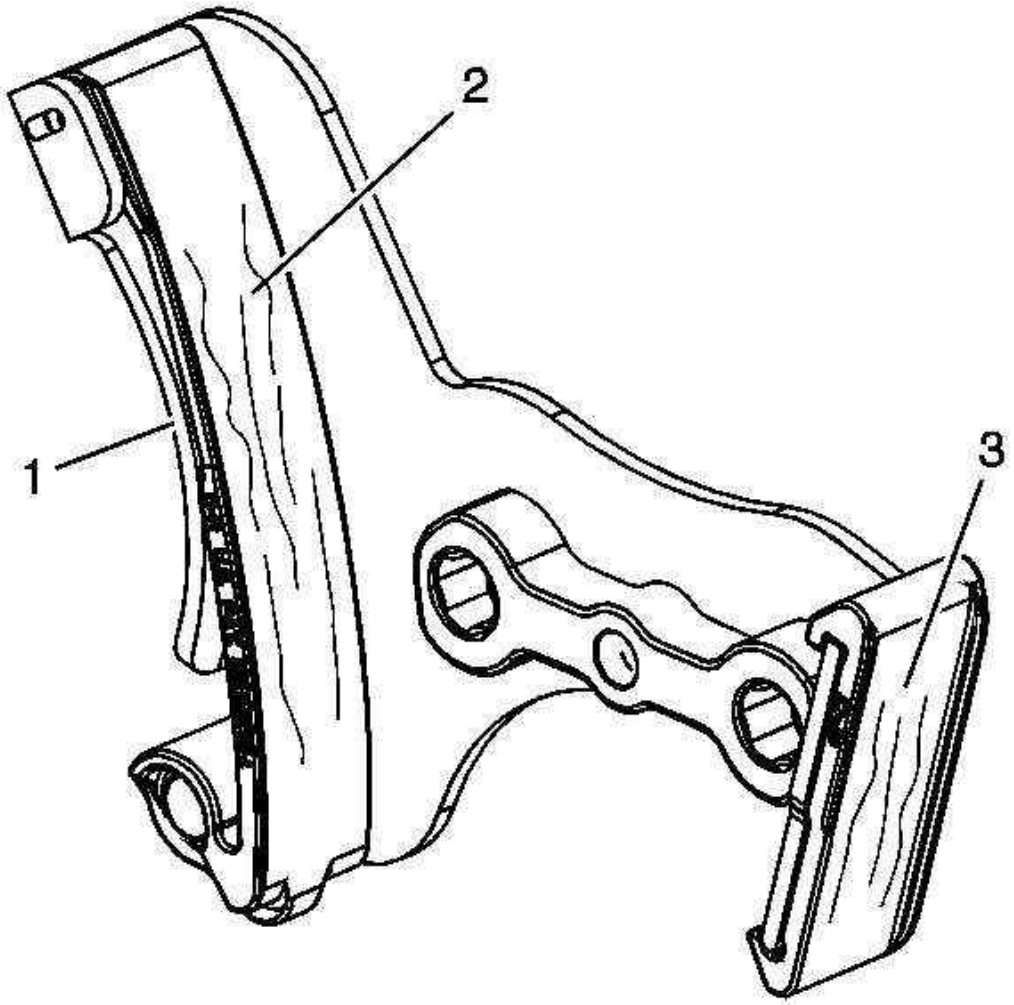


Fig. 484: View Of Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS CORP.

8. Inspect the timing chain tensioner for the following conditions:
   - Damaged or broken tension spring (1)
   - Excessive wear or scoring on the chain guide surfaces (2, 3)

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

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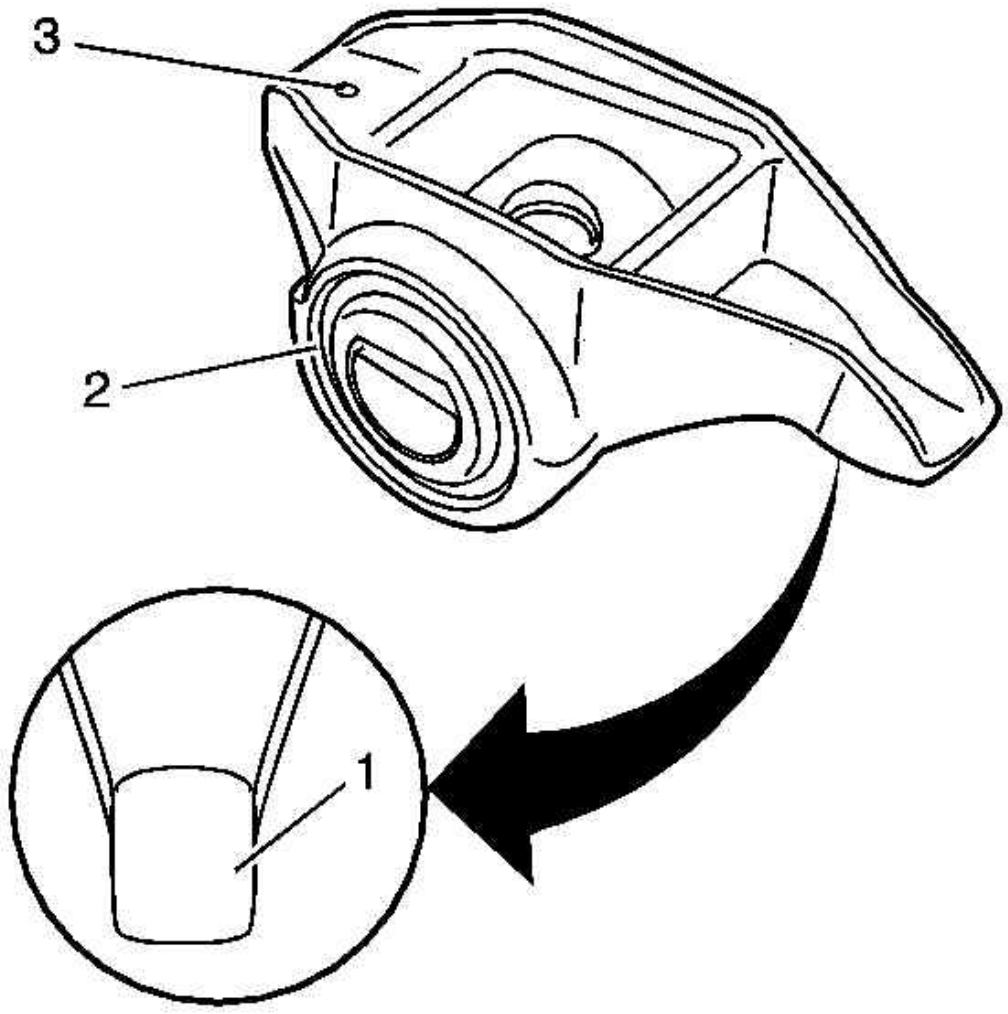


Fig. 485: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Parts that are to be used again must be marked, sorted or organized for assembly.

1. Mark, sort, or organize the components for assembly. Refer to **Separating Parts**.

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2. Clean the components with cleaning solvent.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.
6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.
9. Inspect the rocker arm pivot supports for cracks, wear, or other damage.

VALVE LIFTERS AND GUIDES CLEANING AND INSPECTION (5.3L)

Non Active Fuel Management Valve Lifters

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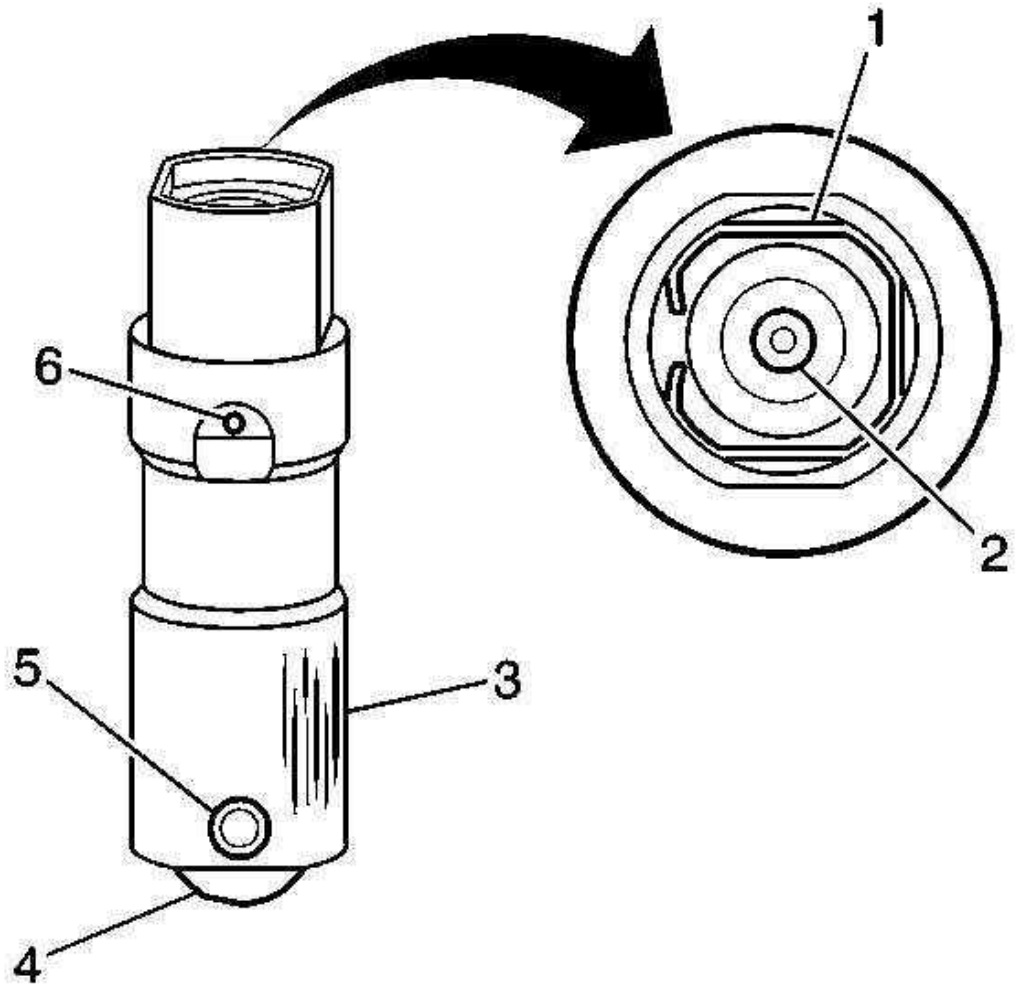


Fig. 486: Identifying Valve Lifter Inspection Areas
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

CAUTION: Refer to Safety Glasses Caution .

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2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
    - Bent or broken clip (1)
    - Worn pushrod socket (2)
    - Scuffed or worn sides (3)

      If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

    - Flat spots on the roller (4)
    - Loose or damaged pin (5)
    - Plugged oil hole (6)
    - Worn or damaged roller bearing

      The roller should rotate freely with no binding or roughness.

Active Fuel Management Valve Lifters

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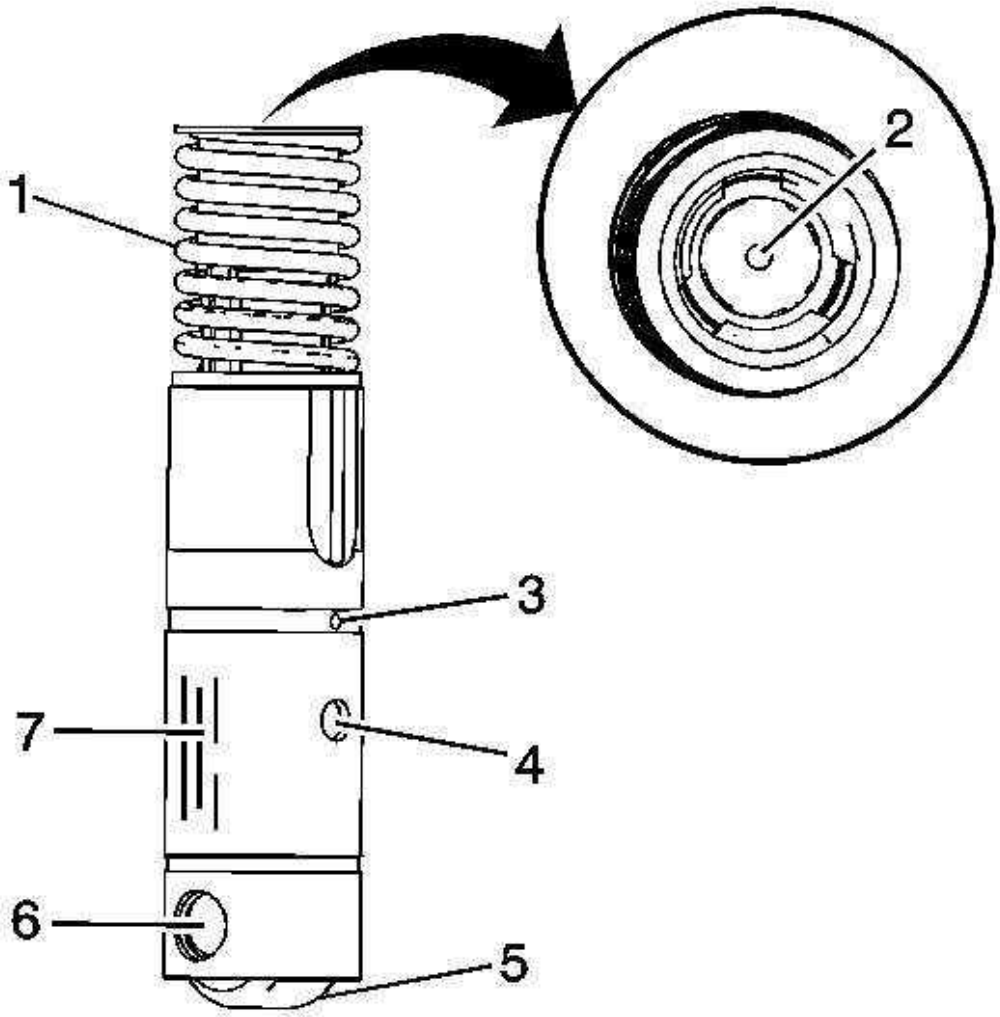


Fig. 487: View Of Displacement on Demand Valve Lifters Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

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CAUTION: Refer to Safety Glasses Caution .

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
   - Broken or collapsed spring (1)
   - Worn pushrod socket (2)
   - Plugged lubrication hole (3)
   - Plugged lifter oil-switching hole (4)
   - Flat spots on the roller (5)
   - Worn or damaged roller bearing (6)

     The roller should rotate freely with no binding or roughness.

   - Scuffed or worn sides (7)

Valve Guides

Inspect the valve lifter guides for the following conditions:

- Cracks or damage
- Excessive wear in the lifter mounting bores

CYLINDER HEAD DISASSEMBLE

Tools Required

J 8062 Valve Spring Compressor - Head Off

Disassembly Procedure

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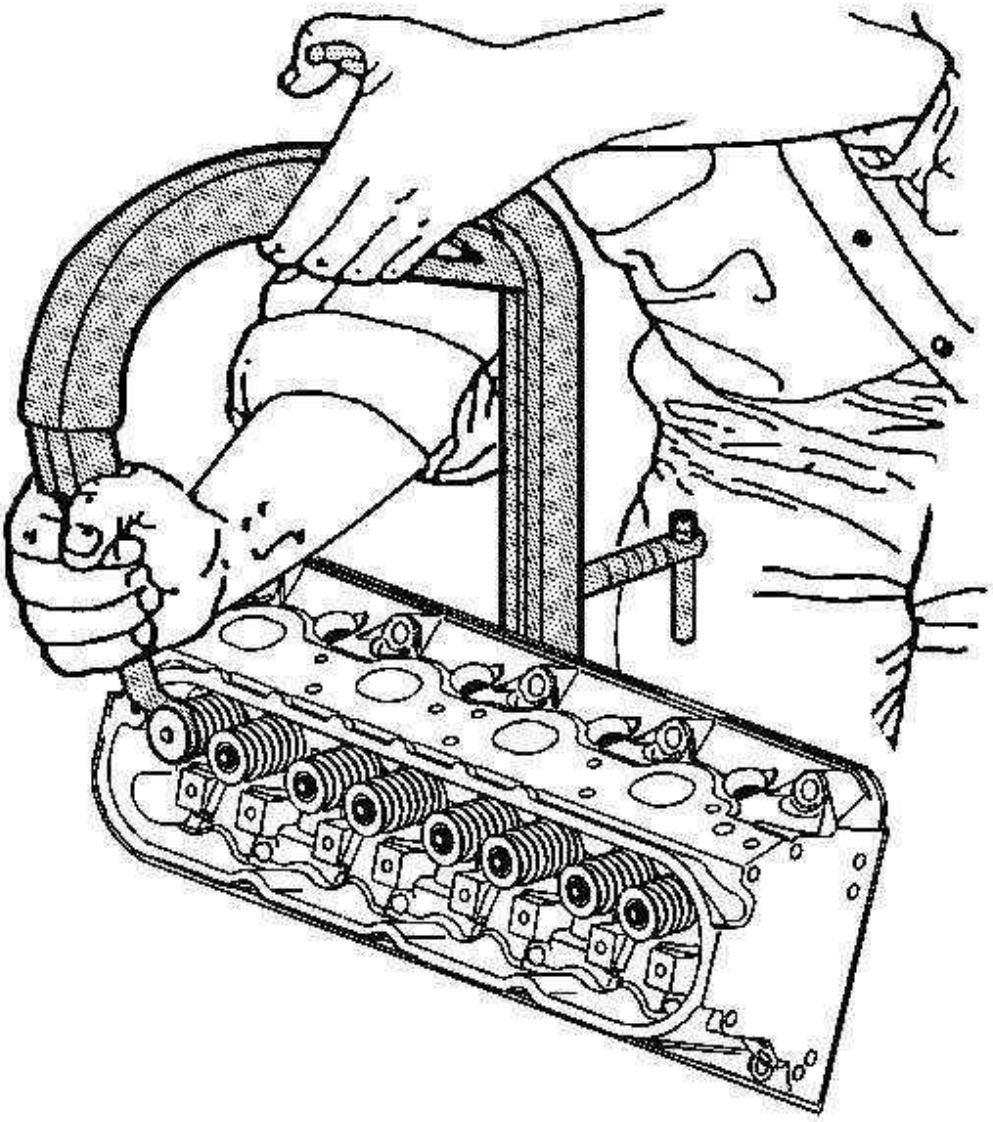


Fig. 488: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **With the components at room temperature, remove the spark plugs from the cylinder head.**

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- **Mark, organize, or sort the cylinder head components for assembly. Return the components to their original location during assembly.**

1. Remove the spark plugs from the cylinder heads.
2. Use the **J 8062** in order to compress the valve spring.

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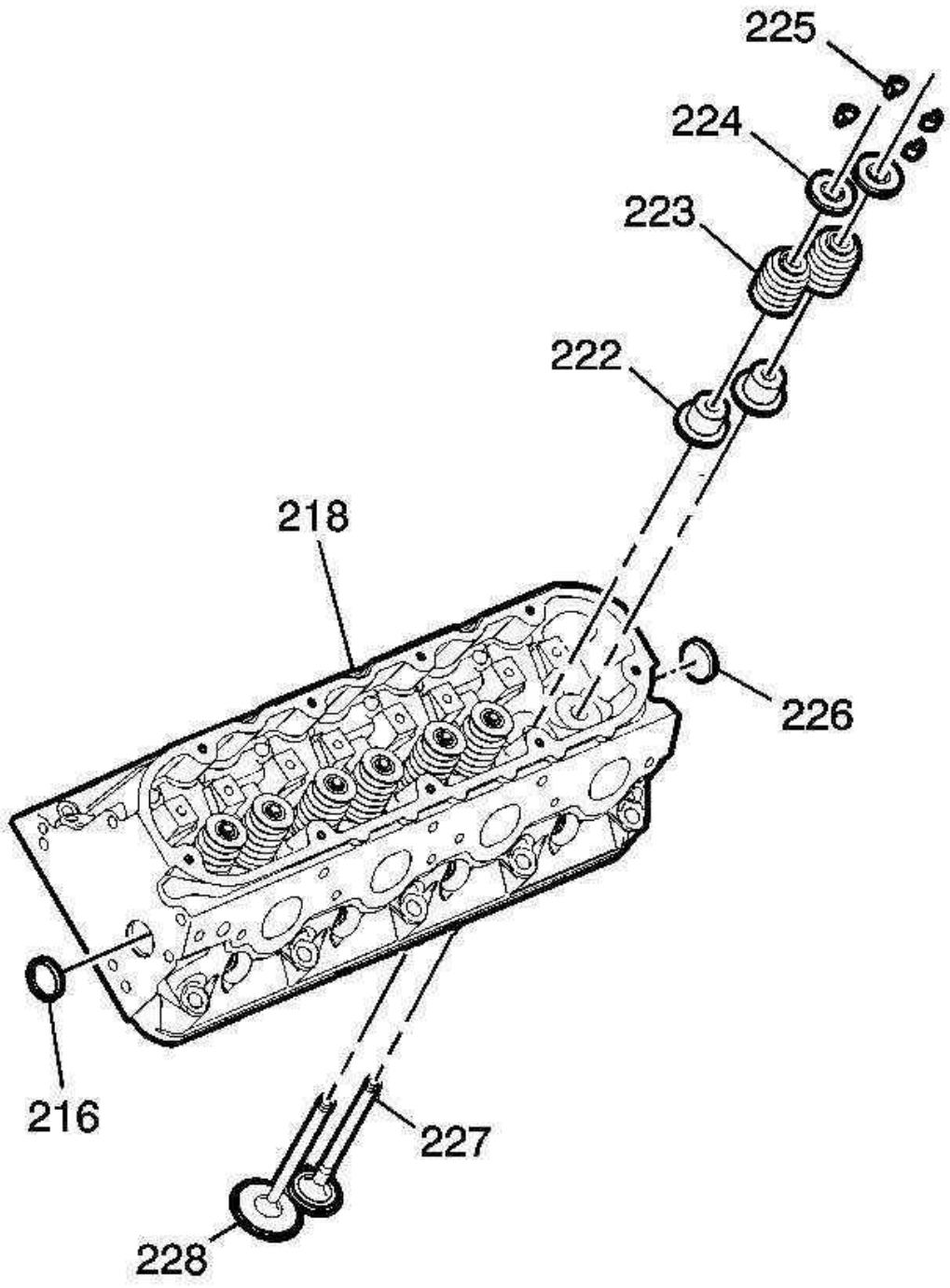


Fig. 489: View Of Cylinder Head Components

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Courtesy of GENERAL MOTORS CORP.

3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (227 and 228).
7. Remove the valve stem oil seal (222). Refer to **Separating Parts**.

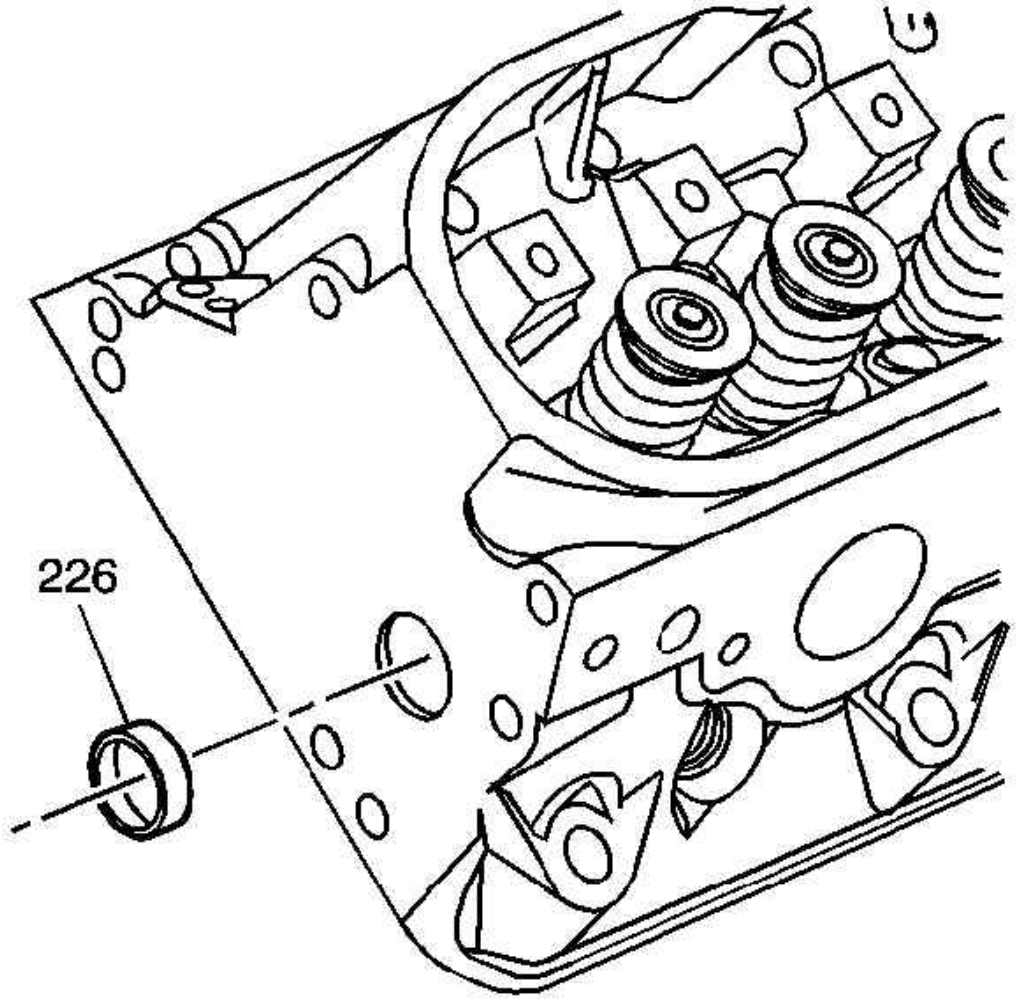


Fig. 490: View Of Cylinder Head Expansion Plugs

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Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head core hole plugs (226), as required.

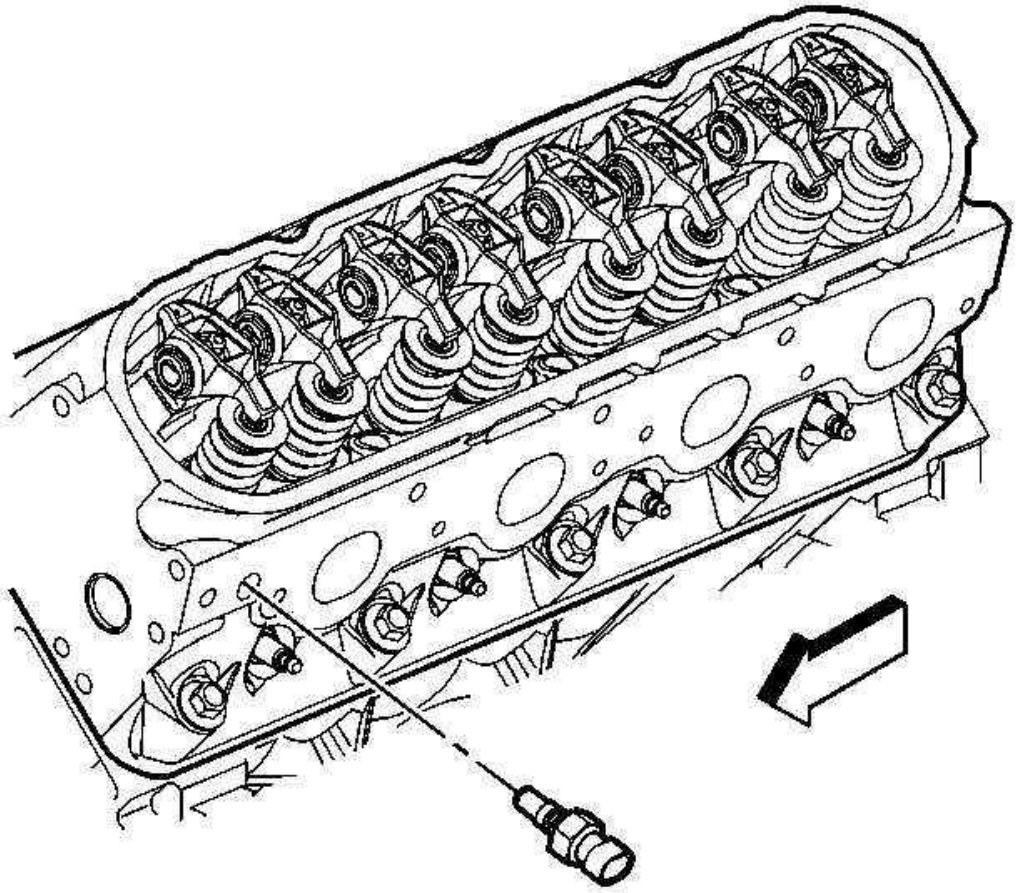


Fig. 491: View Of Coolant Temperature Sensor (Left Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor from the left cylinder head.

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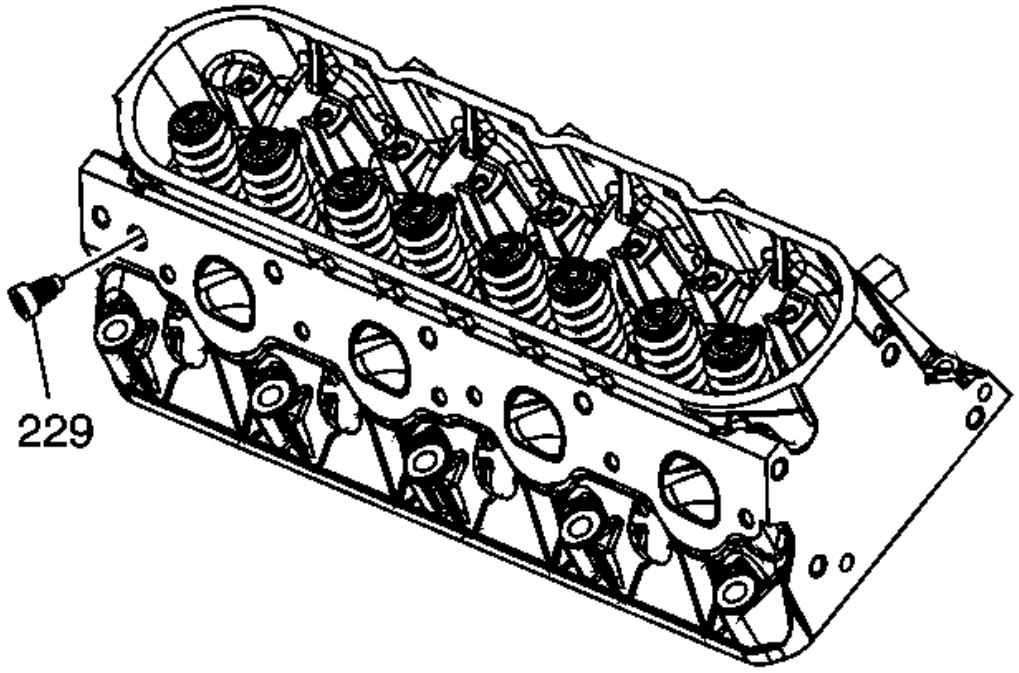


Fig. 492: Identifying Right Cylinder Head Coolant Plug
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant plug (229) from the right cylinder head.

CYLINDER HEAD CLEANING AND INSPECTION

Tools Required

- **J 8089** Carbon Removal Brush. See **Special Tools**.
- **J 9666** Valve Spring Tester

Cleaning and Inspection

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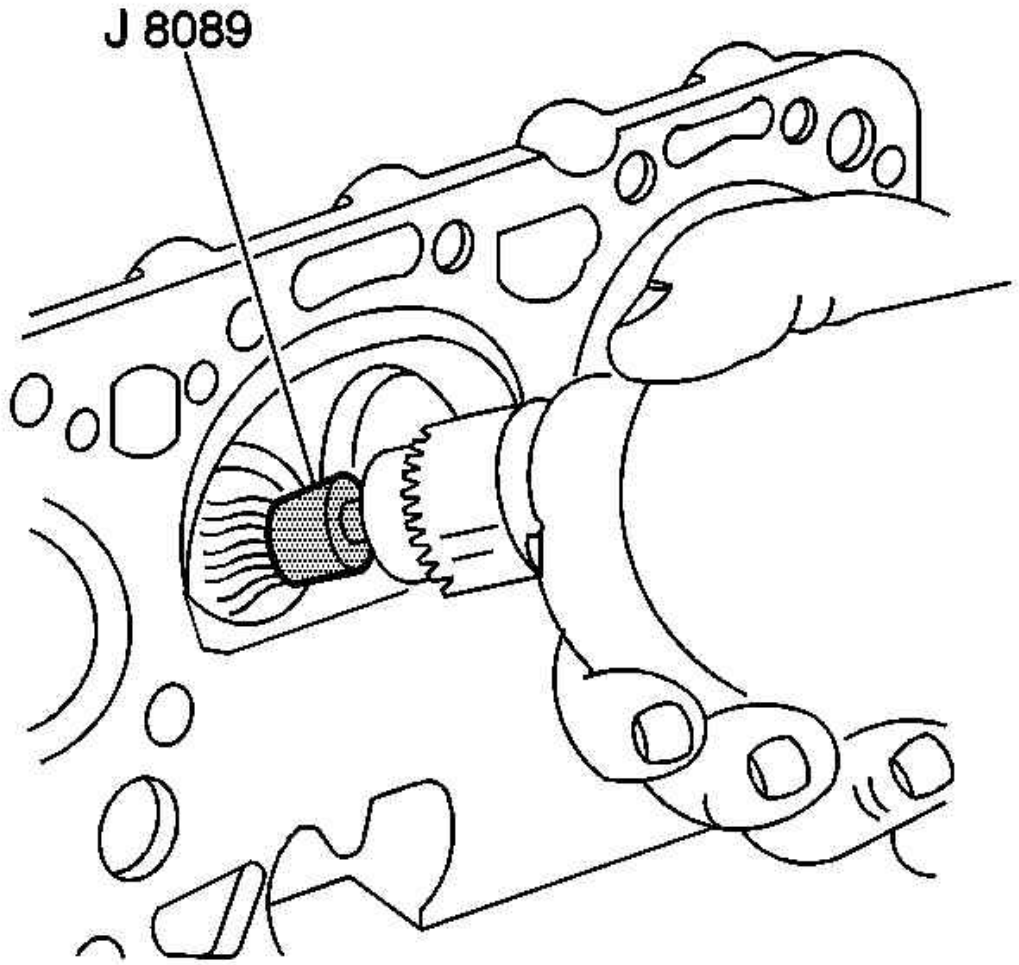


Fig. 493: View Of Carbon Removal Using J 8089
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **When cleaning a cylinder head in a thermal type oven, do not exceed 204°C (400°F).**
- **Be careful not to scuff the chamber.**

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1. Clean the following components:
   - Use the **J 8089** in order to remove the carbon from the combustion chambers. See **Special Tools**.
   - Gasket surfaces

     Refer to **Replacing Engine Gaskets** .

   - Valve stems and heads on a buffing wheel
   - Bolt hole threads

     Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:
   1. Cracks in the exhaust ports and combustion chambers
   2. External cracks in the water chambers
   3. Gasket surfaces for excessive scratches or gouging

      Refer to **Replacing Engine Gaskets** .

   4. Bolt hole threads for debris or damaged threads

      Refer to **Thread Repair** or **Thread Repair Specifications** .

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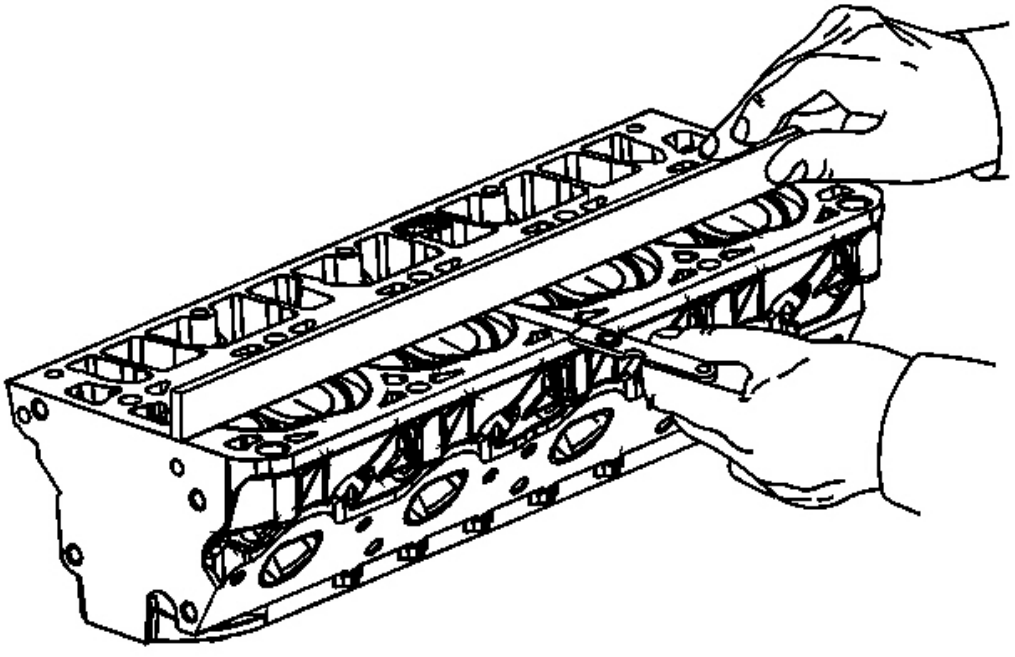


Fig. 494: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications**.

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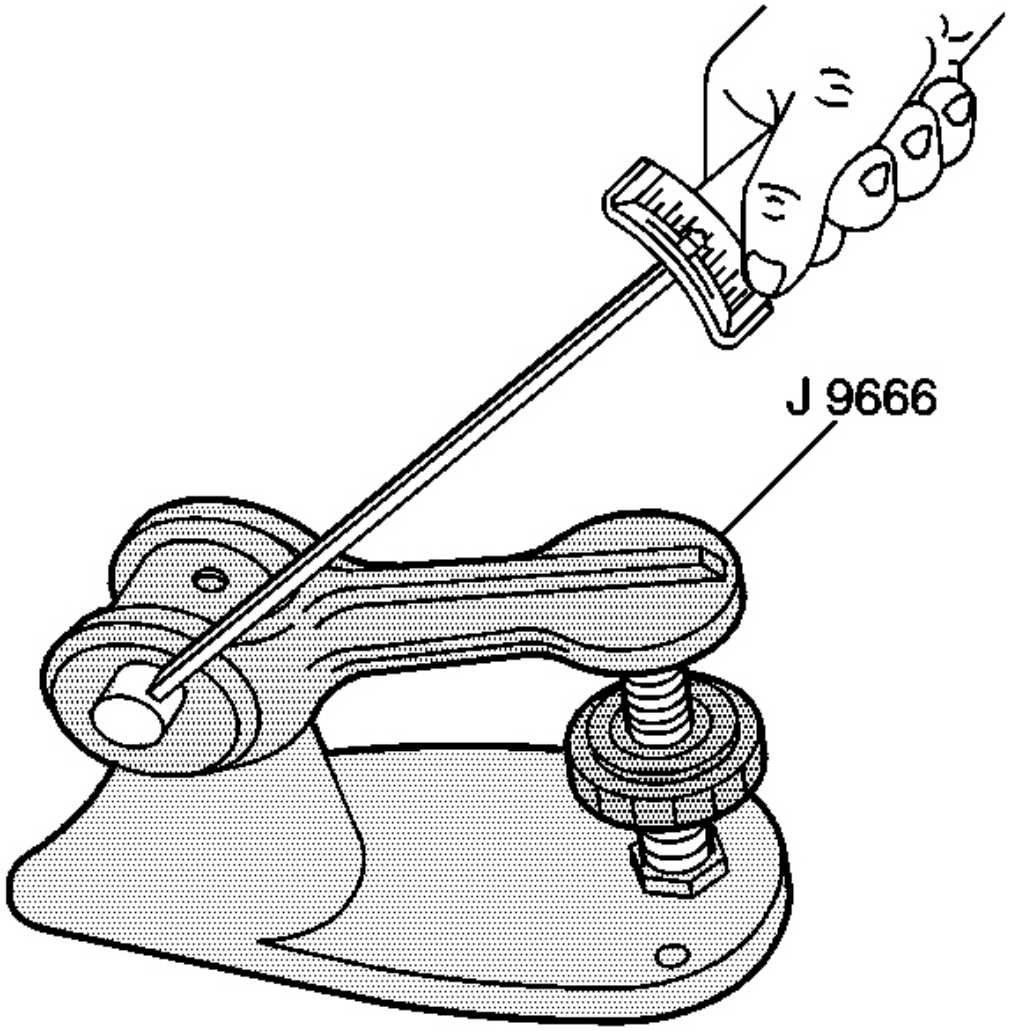


Fig. 495: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 9666** in order to measure the valve spring tension. Refer to **Engine Mechanical Specifications**.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Valve Guide Reaming

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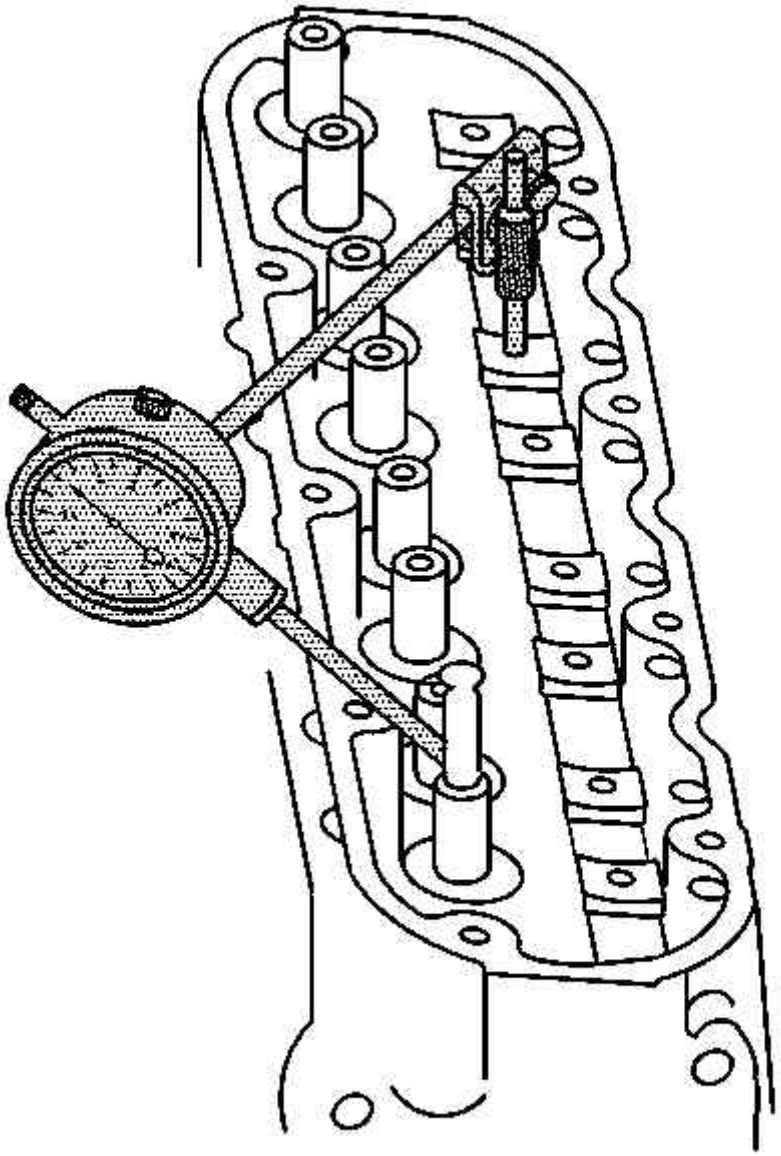


Fig. 496: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem**

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oil seal wear, component damage, and/or excessive engine oil consumption.

- **Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.**

1. Measure the valve stem-to-guide clearance using a dial indicator. Position the tip of the dial indicator at the top of the valve guide.

   Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gage to measure the guide bore.

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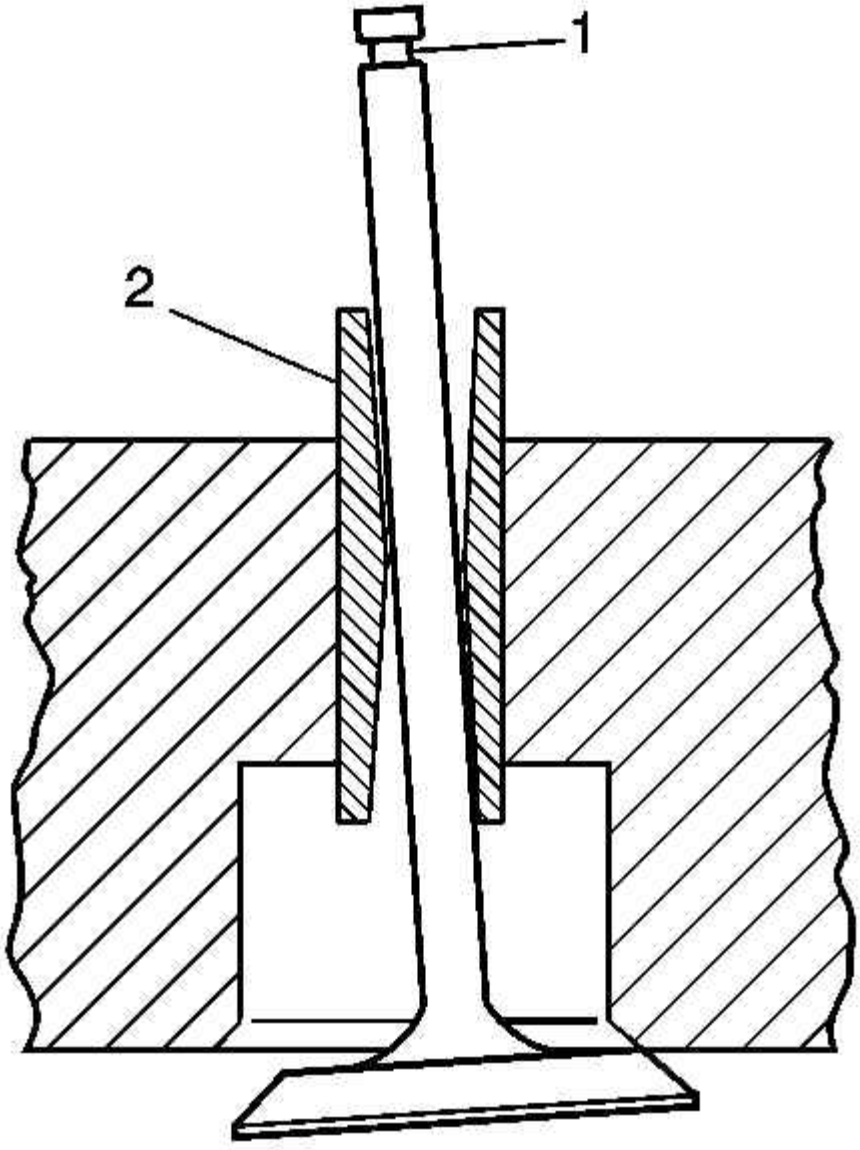


Fig. 497: View Of Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the components replaced. Refer to **Engine Mechanical Specifications**.

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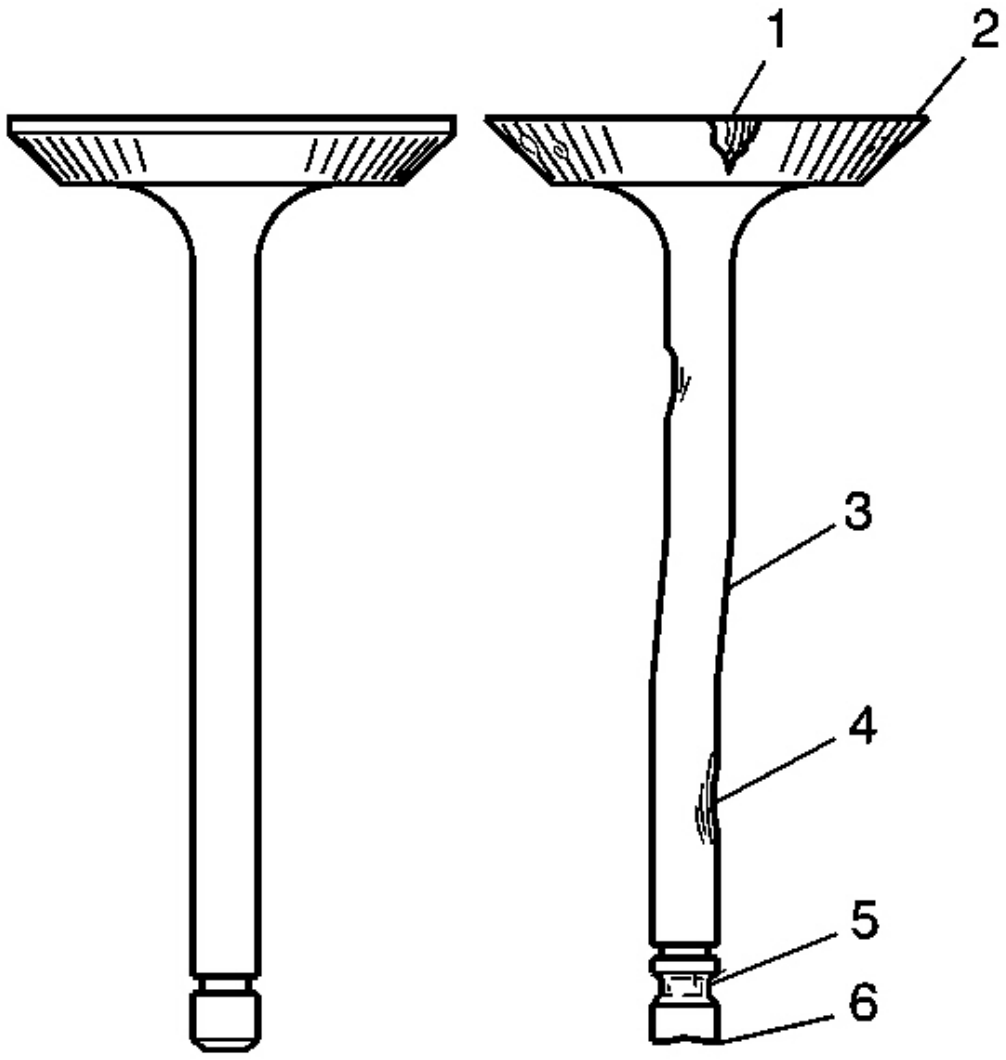


Fig. 498: Identifying Inspection Points For Valve Damage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve stems for excessive scoring, wear, or warpage.
   - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
   - If a valve guide is worn or has excessive stem-to-guide clearance, the

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cylinder head should be replaced.

4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

   If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the cylinder head must be replaced.

Valve and Seat Grinding

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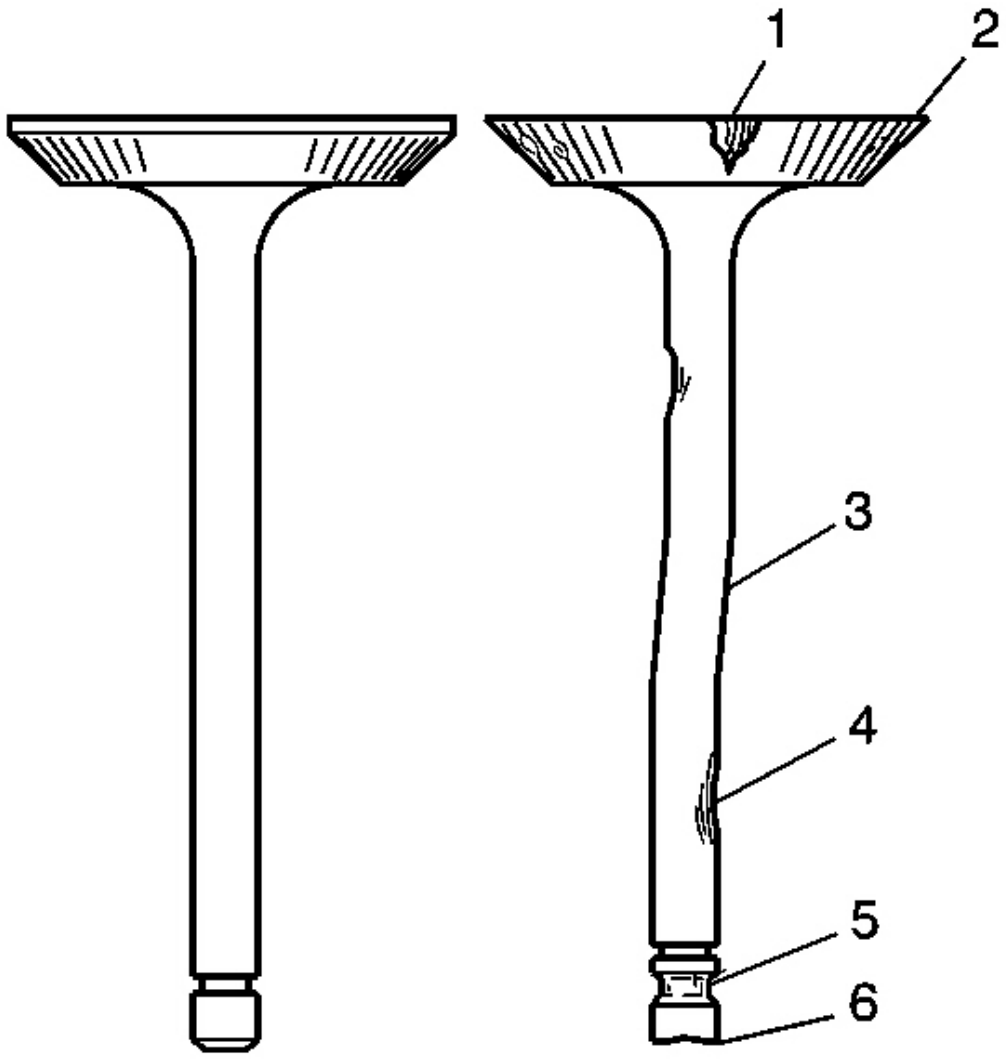


Fig. 499: Identifying Inspection Points For Valve Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of**

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equipment are available for grinding valve seats.

- **Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.**
- **The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.**
- **Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.**
- **Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment should be carefully followed to obtain the proper results.**
- **DO NOT reface intake valves. Intake valves with excessive wear or damage MUST be replaced.**

1. Inspect the valve for the following conditions:

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- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)

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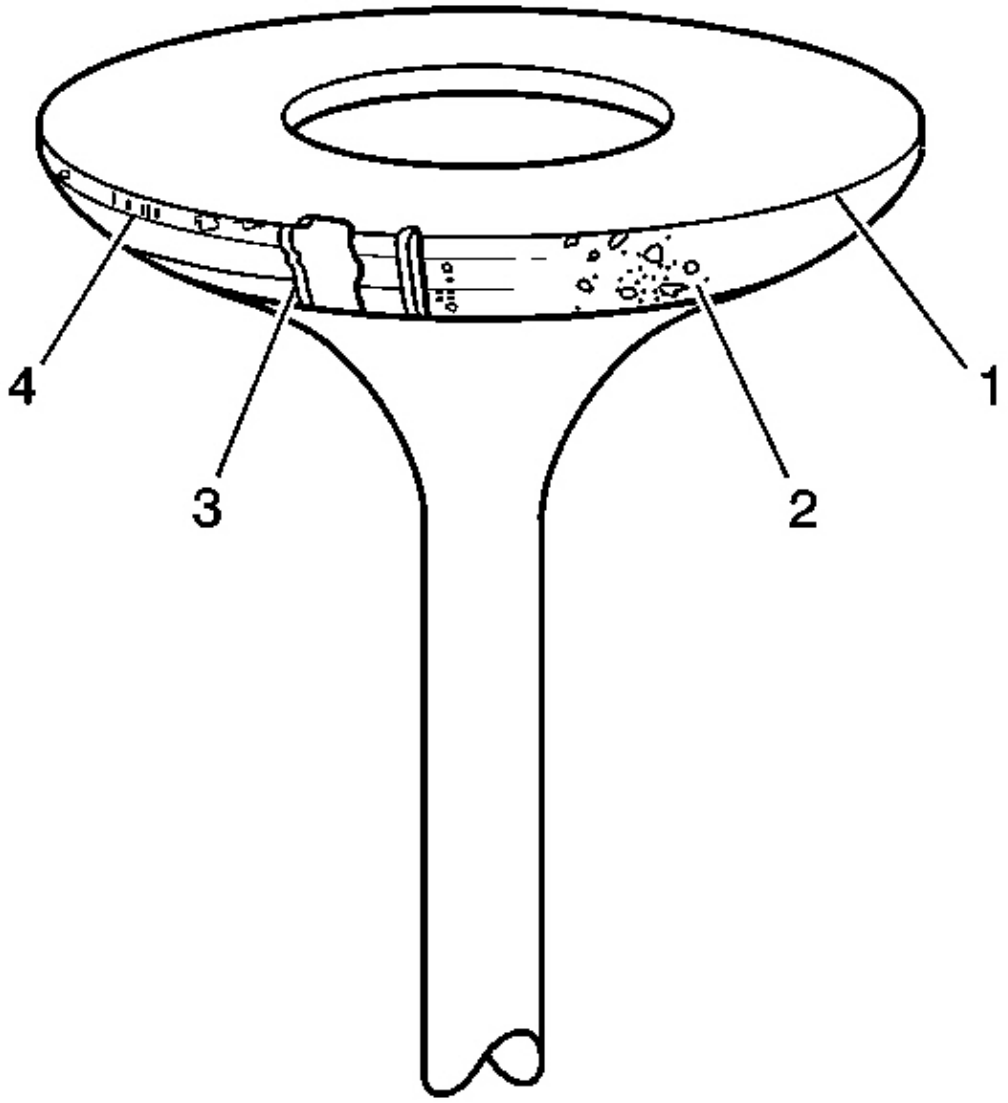


Fig. 500: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
   - Worn or no margin (1 or 4)
   - Pitted surfaces (2)

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- Burnt or eroded areas (3)

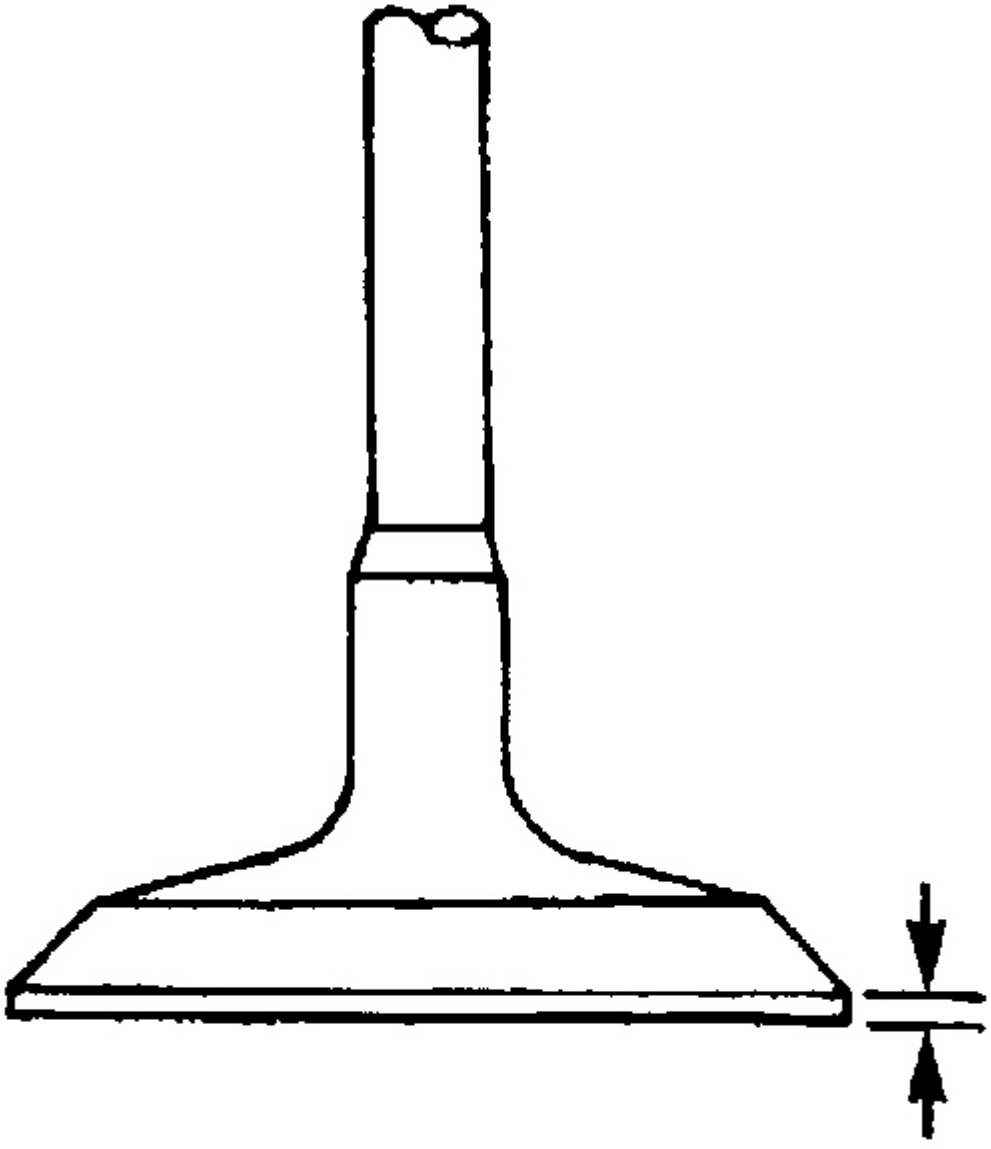


Fig. 501: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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3. Inspect the valve margin.

   The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.

4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring to obtain the proper spring installed height. Refer to **Cylinder Head Disassemble**.
7. Inspect for a loose valve seat in the cylinder head. The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

   The valve guide must be clean for the seat grinding tool to obtain proper results.

9. Grind the valve seat.

   The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.

10. Inspect the valve seats.
    - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
    - If the valve seat has been ground, it may be necessary to shim the valve spring to attain the proper spring installed height. Refer to **Cylinder Head Disassemble**.

CYLINDER HEAD ASSEMBLE

Tools Required

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J 8062 Valve Spring Compressor - Head Off

Assembly Procedure

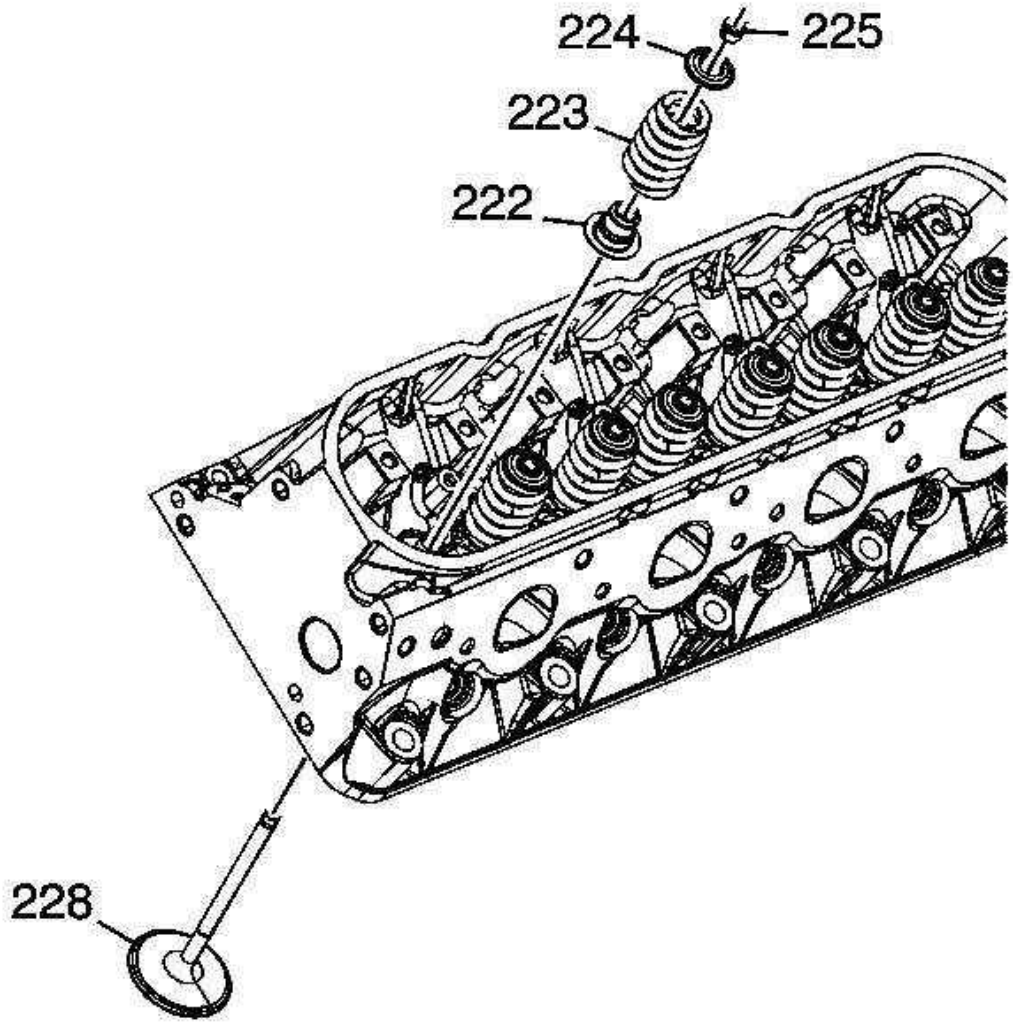


Fig. 502: View Of Valve Components
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring shim area.

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IMPORTANT: When using the valves and related components again, install the parts to their original location.

2. Install the valves (228) into the proper location. Refer to **Separating Parts**.

IMPORTANT: The valve stem oil seal alignment and position on the valve guide is critical.
An improperly installed valve stem oil seal may lead to excessive oil consumption, increased vehicle emissions, or component damage.

3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).

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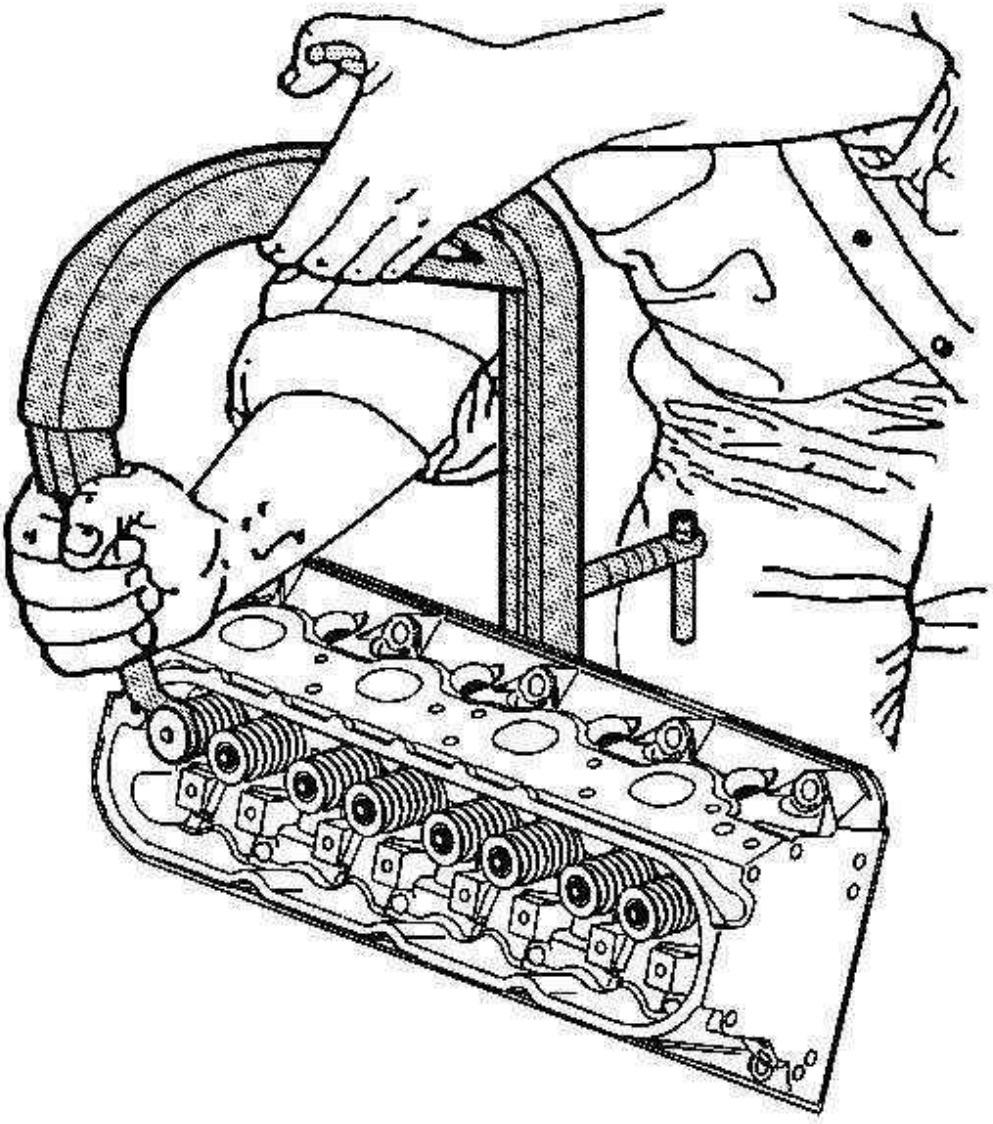


Fig. 503: Compressing Valve Spring
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve spring using the **J 8062** .
7. Install the valve stem keys.
    1. Use grease to hold the keys in place and remove the **J 8062** .

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2. Ensure the keys seat properly in the groove of the valve stem.
3. Tap the end to the valve stem with a plastic faced hammer to seat the keys, if necessary.

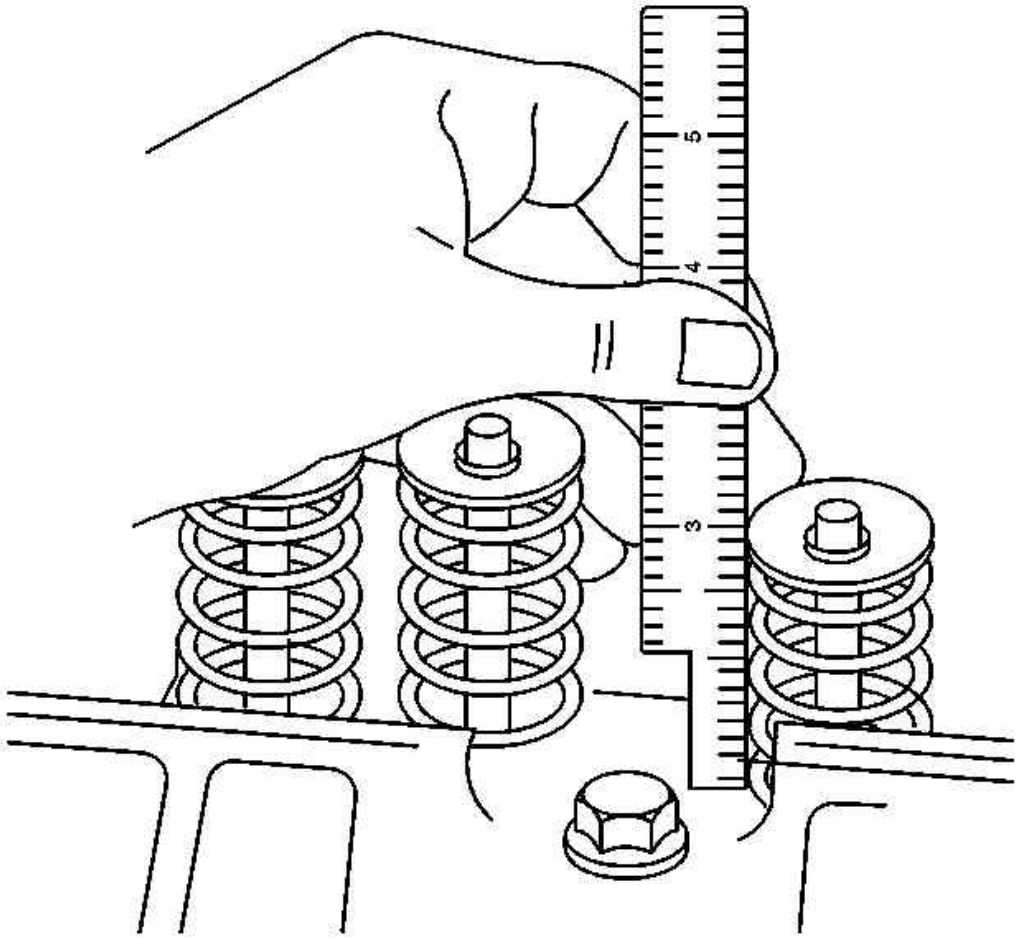


Fig. 504: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

8. Measure the valve spring installed height using a ruler.

   Measure from the base of the valve spring to the top of the valve spring.

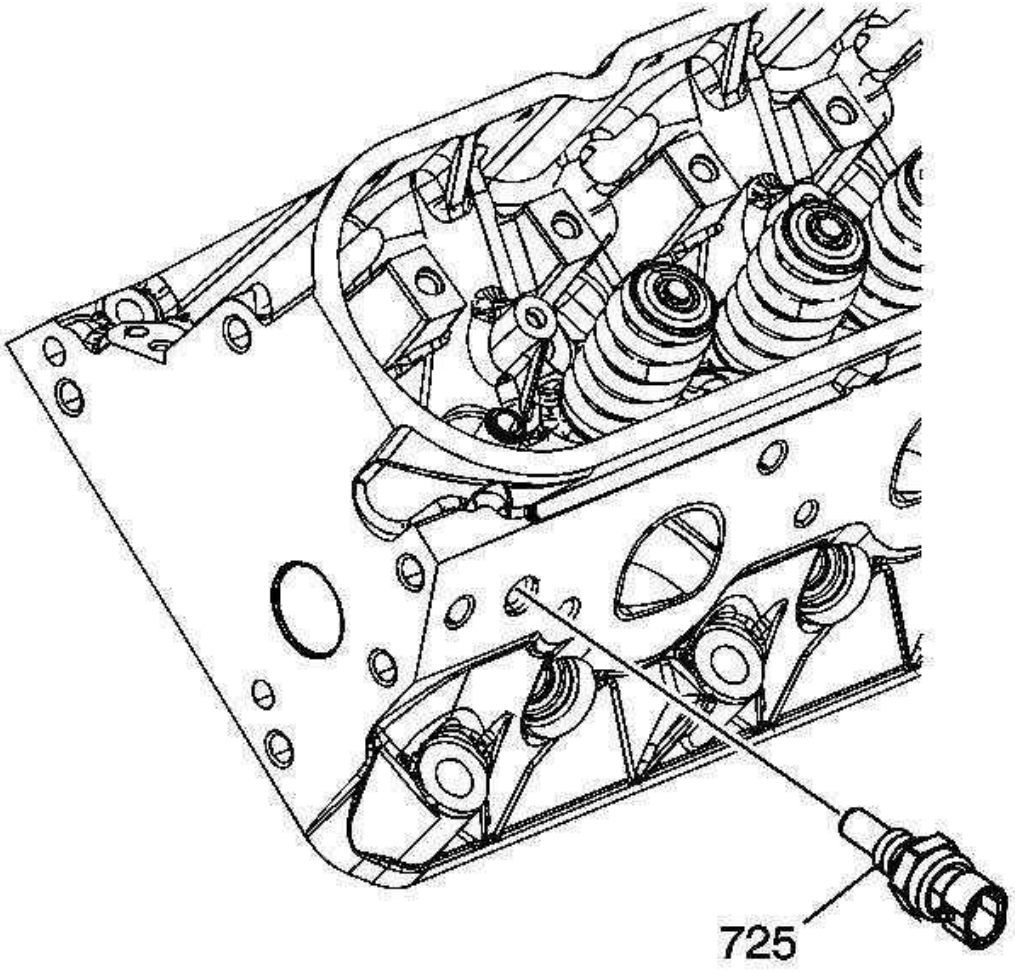
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Specification:

- If the installed height exceeds 46.25 mm (1.82 in), install a valve spring shim of approximately 0.5 mm (0.02 in) thick.
- Do not shim the valve spring to obtain less than the specified height.

  Do not assemble the components without a spring shim on the cylinder head.

9. Install the remaining valves, springs, and other components.



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Fig. 505: Locating Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the coolant sensor.

NOTE: Refer to Fastener Notice .

11. Install the coolant temperature sensor (725) into the left cylinder head.

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

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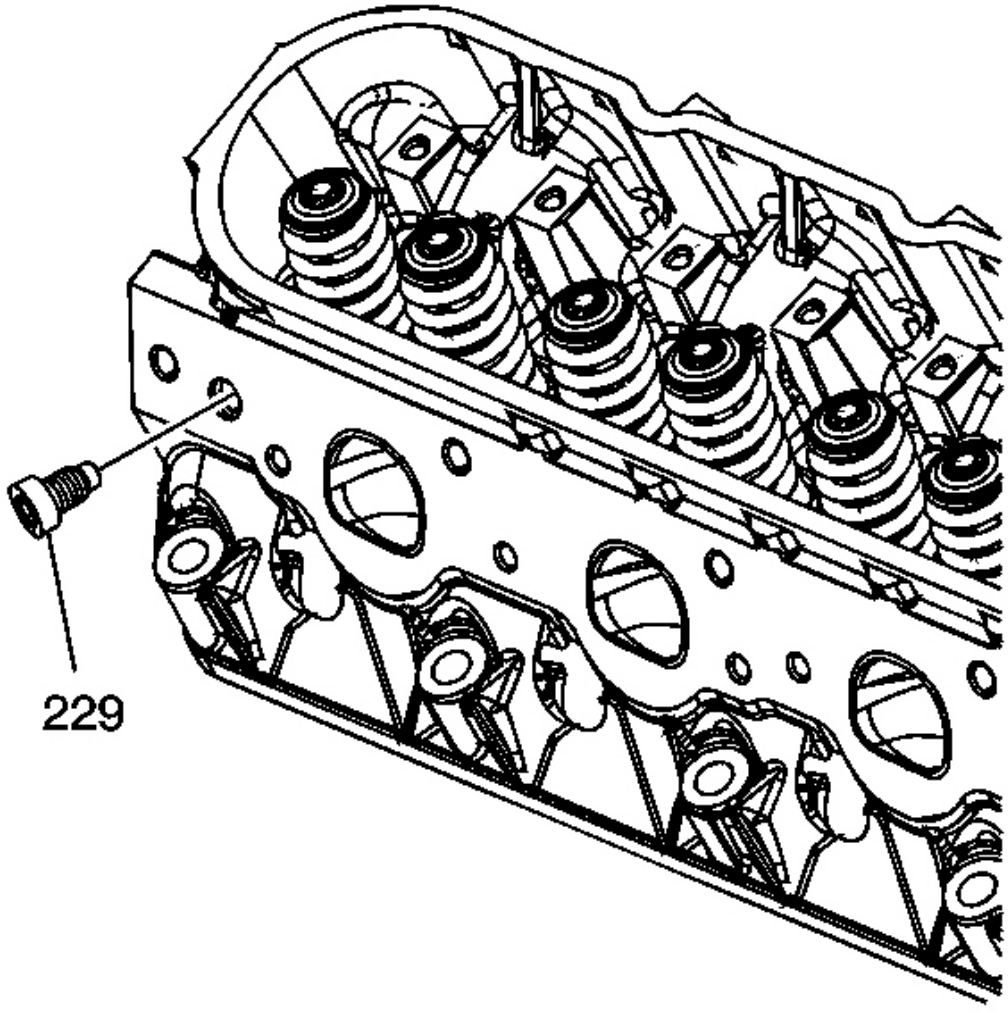


Fig. 506: Locating Coolant Plug
Courtesy of GENERAL MOTORS CORP.

12. Install threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the plug (229).
13. Install the coolant plug to the right cylinder head.

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

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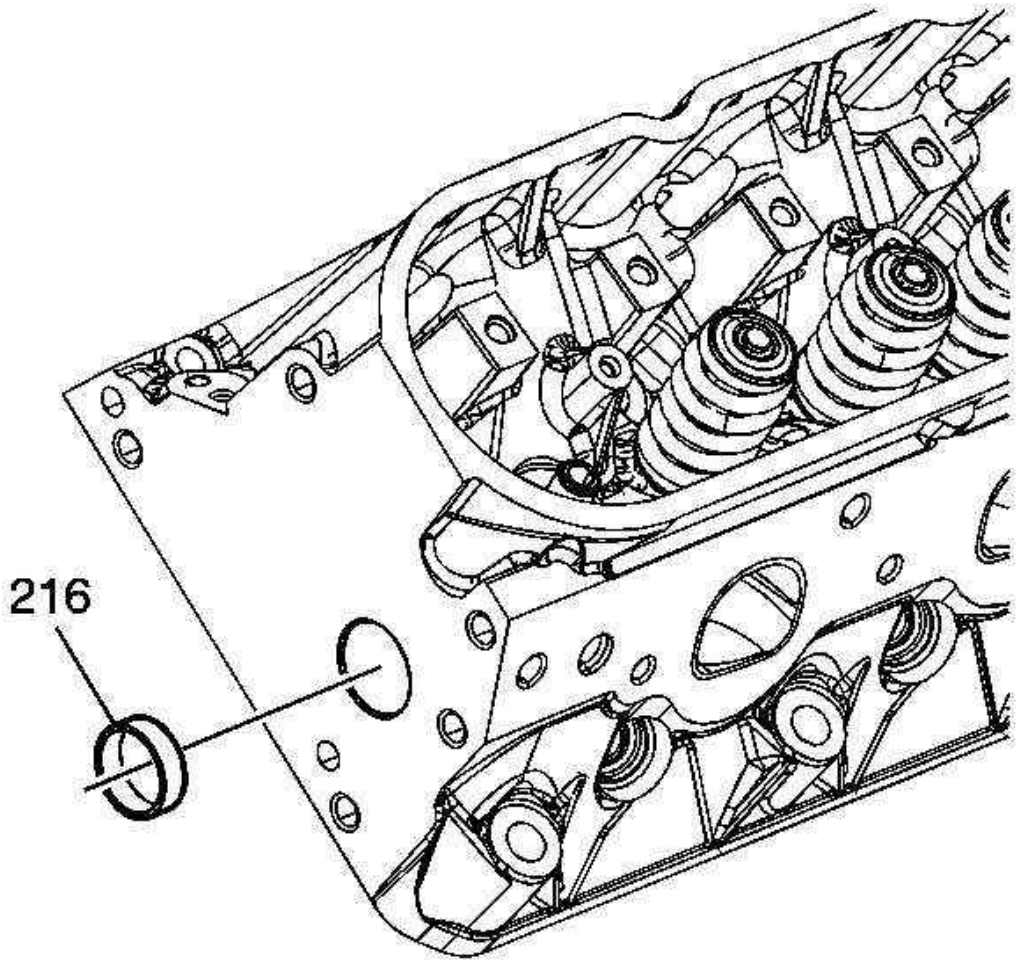


Fig. 507: Locating Cylinder Head Core Hole Plug
Courtesy of GENERAL MOTORS CORP.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the sides of the cylinder head core hole plugs (216).
15. Install the core hole plugs into the cylinder head.

    A properly installed plug should be installed 2.5 mm (0.1 in) below the end face of the head.

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OIL PUMP DISASSEMBLE

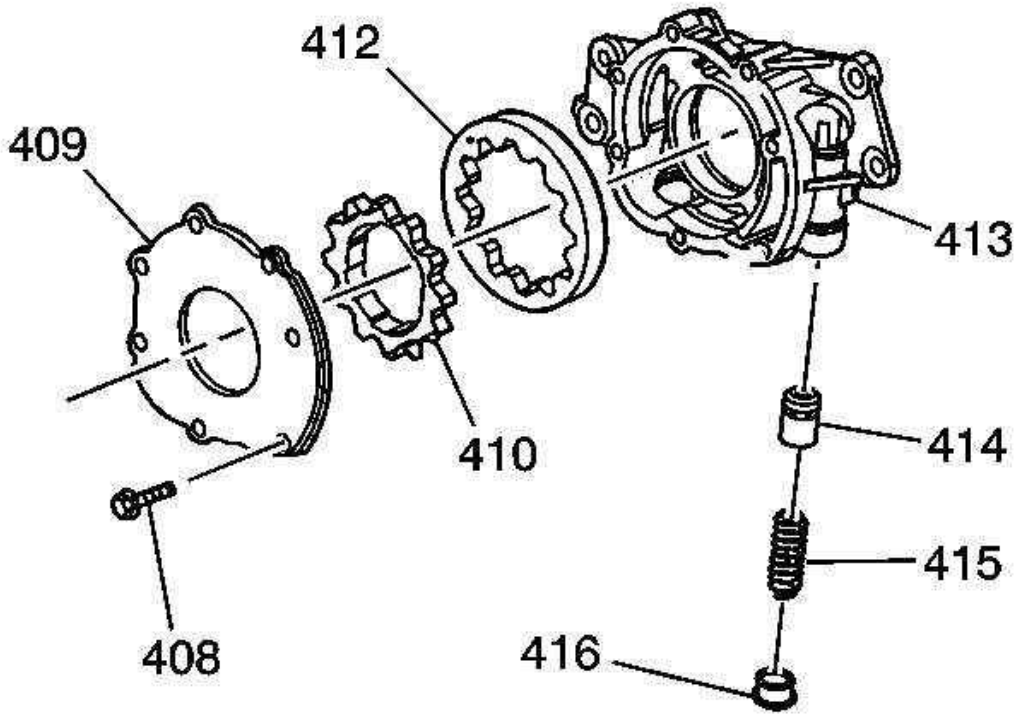


Fig. 508: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts (408).
2. Remove the oil pump cover (409).

IMPORTANT: Mark or identify the gears for assembly. Refer to Separating Parts.

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3. Remove the drive gear (410).
4. Remove the driven gear (412).
5. Remove the pressure relief valve plug (416).
6. Remove the pressure relief valve spring (415).
7. Remove the pressure relief valve (414).
8. Inspect the oil pump components. Refer to **Oil Pump Cleaning and Inspection**.

OIL PUMP CLEANING AND INSPECTION

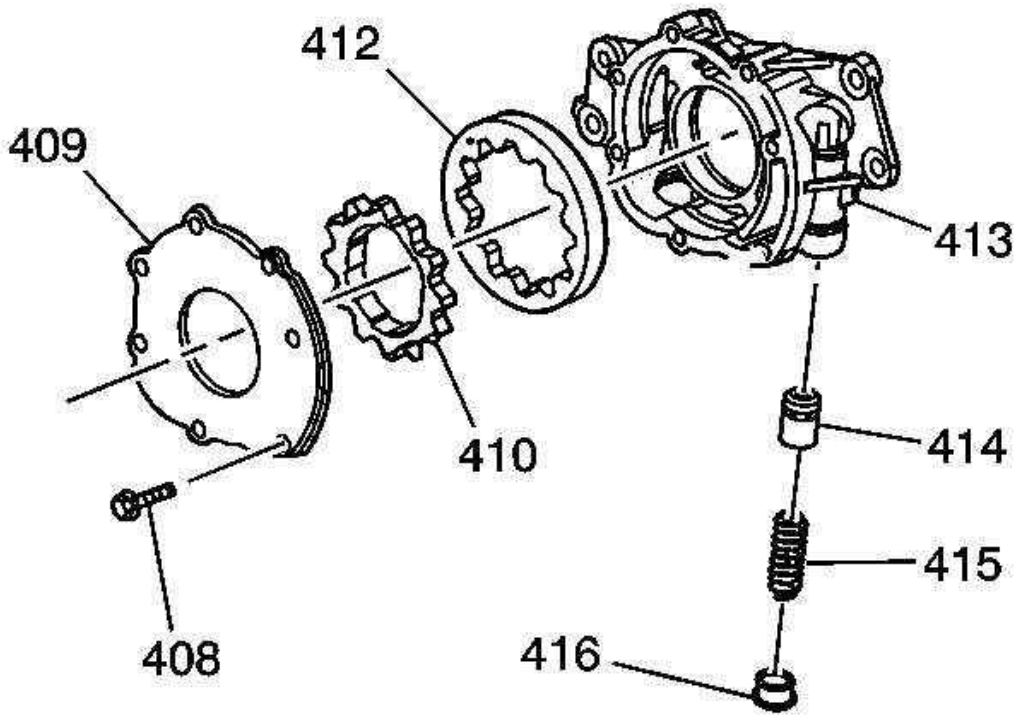


Fig. 509: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **The internal parts of the oil pump assembly are**

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not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

- **The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.**

1. Clean the parts in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the parts with compressed air.
3. Inspect the oil pump housing (413) and the cover (409) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.
5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug (416) and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
8. Inspect the drive gear (410) and driven gear (412) for chipping, galling or wear.

   Minor burrs or imperfections on the gears may be removed with a fine oil stone.

9. Inspect the drive gear splines for excessive wear.
10. Inspect the pressure relief valve (414) and bore for scoring or wear.

    The valve must move freely in the bore with no restrictions.

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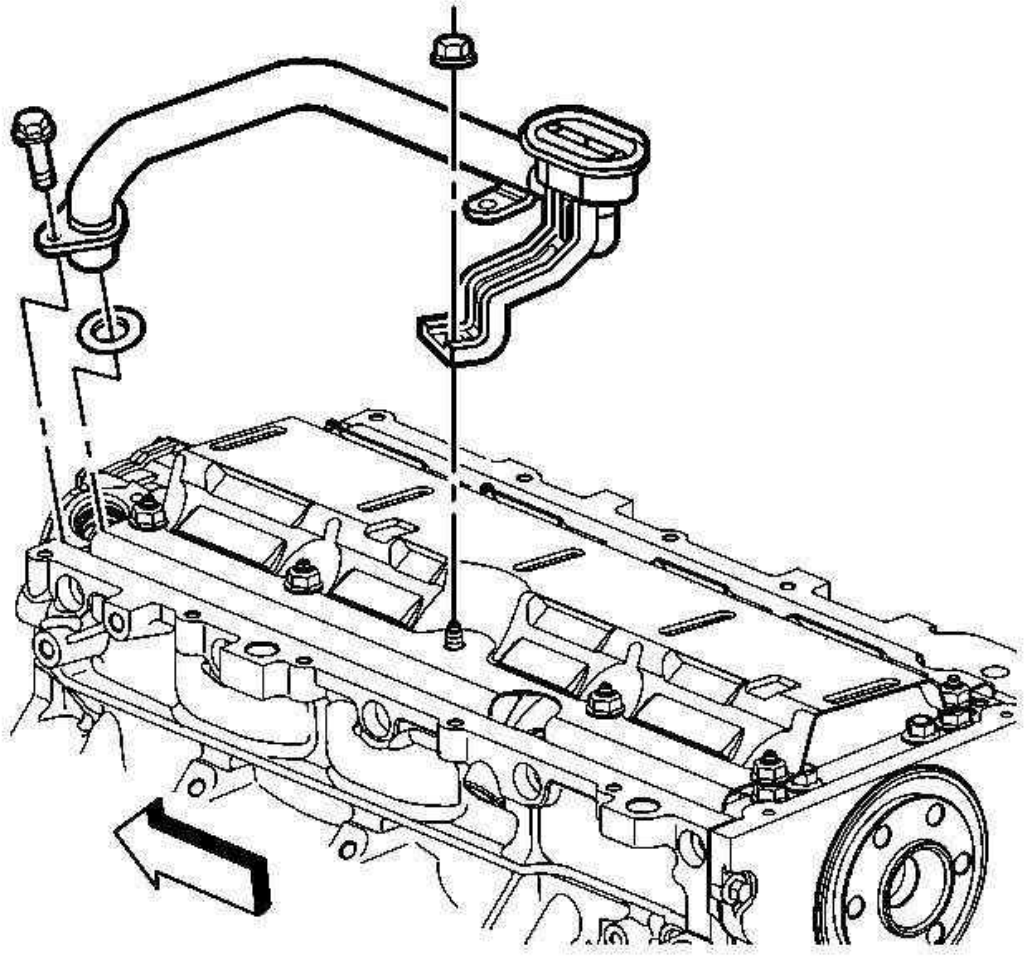


Fig. 510: View Of Oil Pump Screen, Nuts & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Inspect the oil pump screen for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.

OIL PUMP ASSEMBLE

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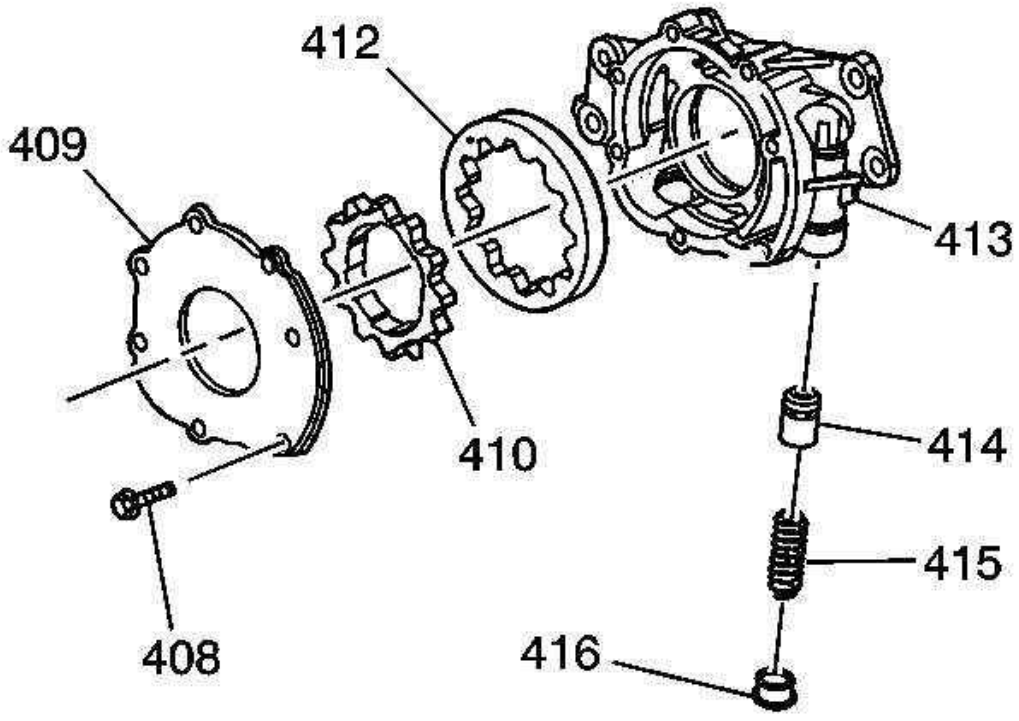


Fig. 511: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

1. Install the driven gear (412) into the pump housing (413).

   Install the driven gear with the orientation mark facing the pump cover.

2. Install the drive gear (410) into the pump housing.
3. Install the oil pump cover (409).

NOTE: Refer to Fastener Notice .

4. Install the pump cover bolts (408).

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

5. Install the relief valve (414).
6. Install a NEW relief valve spring (415).
7. Install the pressure relief valve plug (416).

Tighten: Tighten the pressure relief valve plug to 12 N.m (106 lb in).

8. Inspect the oil pump for smooth operation by rotating the drive gear.

ENGINE FRONT COVER CLEANING AND INSPECTION

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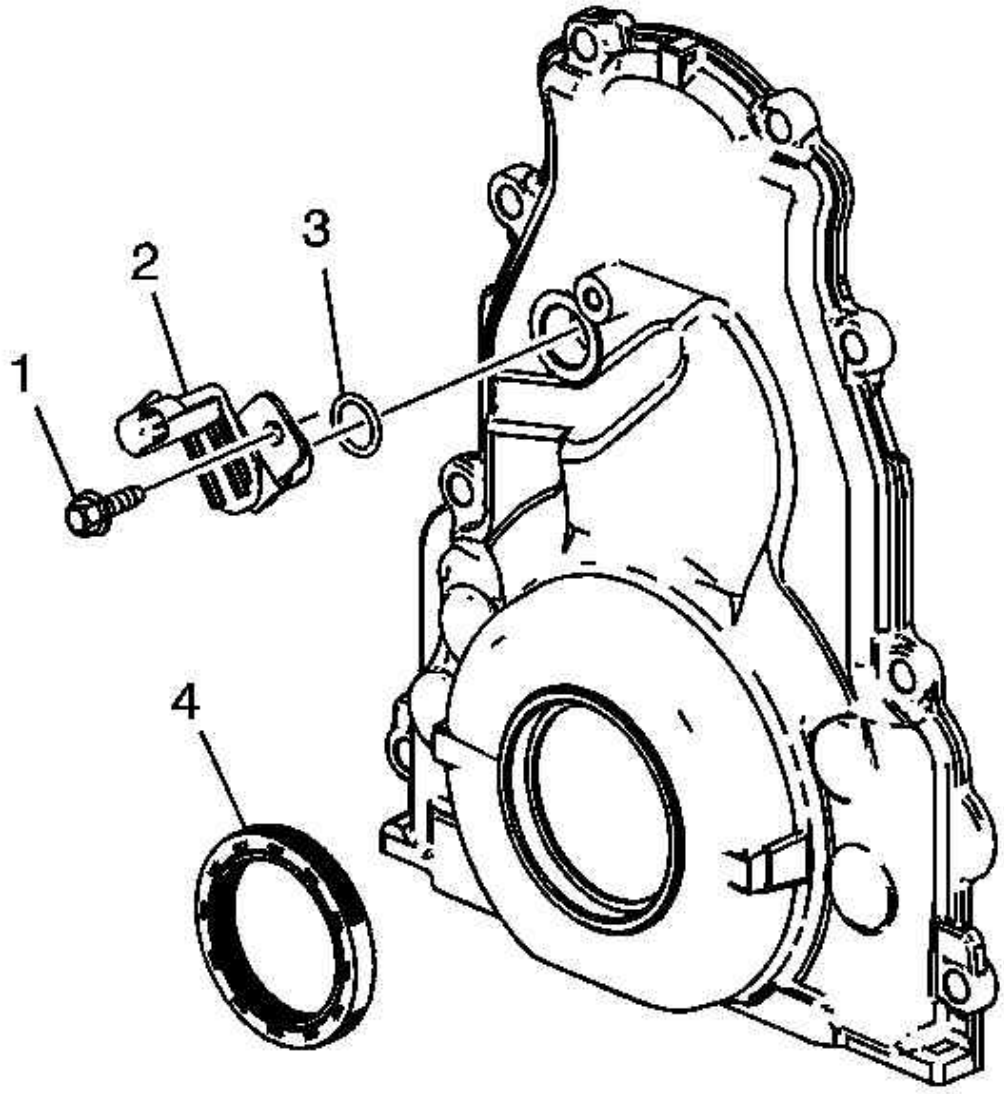


Fig. 512: View Of Engine Front Cover, Seal & CMP Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the front cover-to-engine block**

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gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (4) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal and camshaft position (CMP) sensor mounting bores for damage.

CRANKSHAFT REAR OIL SEAL HOUSING CLEANING AND INSPECTION

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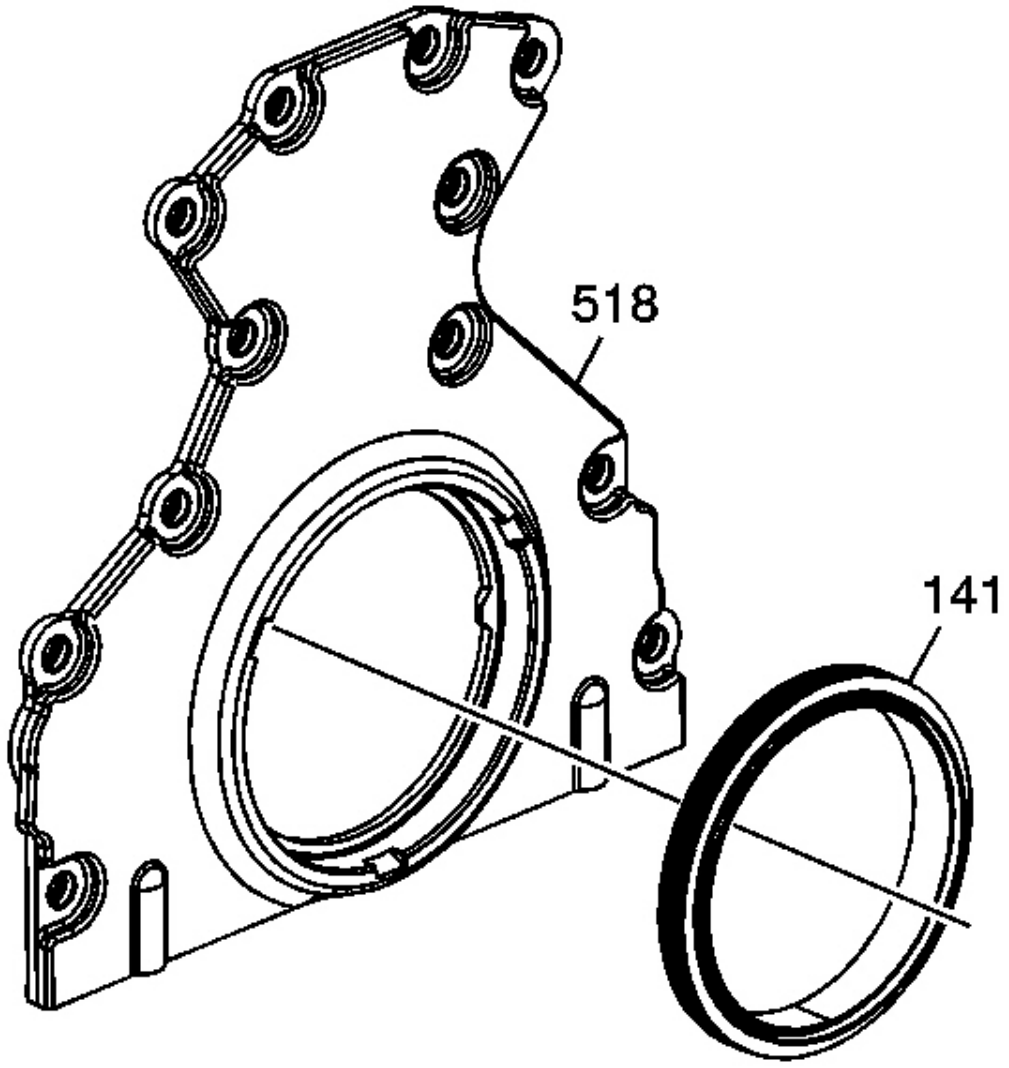


Fig. 513: View Of Crankshaft Rear Oil Seal & Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft rear oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the rear housing-to-engine block**

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gasket again. Install a NEW gasket during assembly.

1. Remove the crankshaft oil seal (141) from the rear housing.
2. Clean the housing in solvent. Remove the sealant from the housing oil pan surface. Refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the housing with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the housing-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

VALVE LIFTER OIL MANIFOLD CLEANING AND INSPECTION

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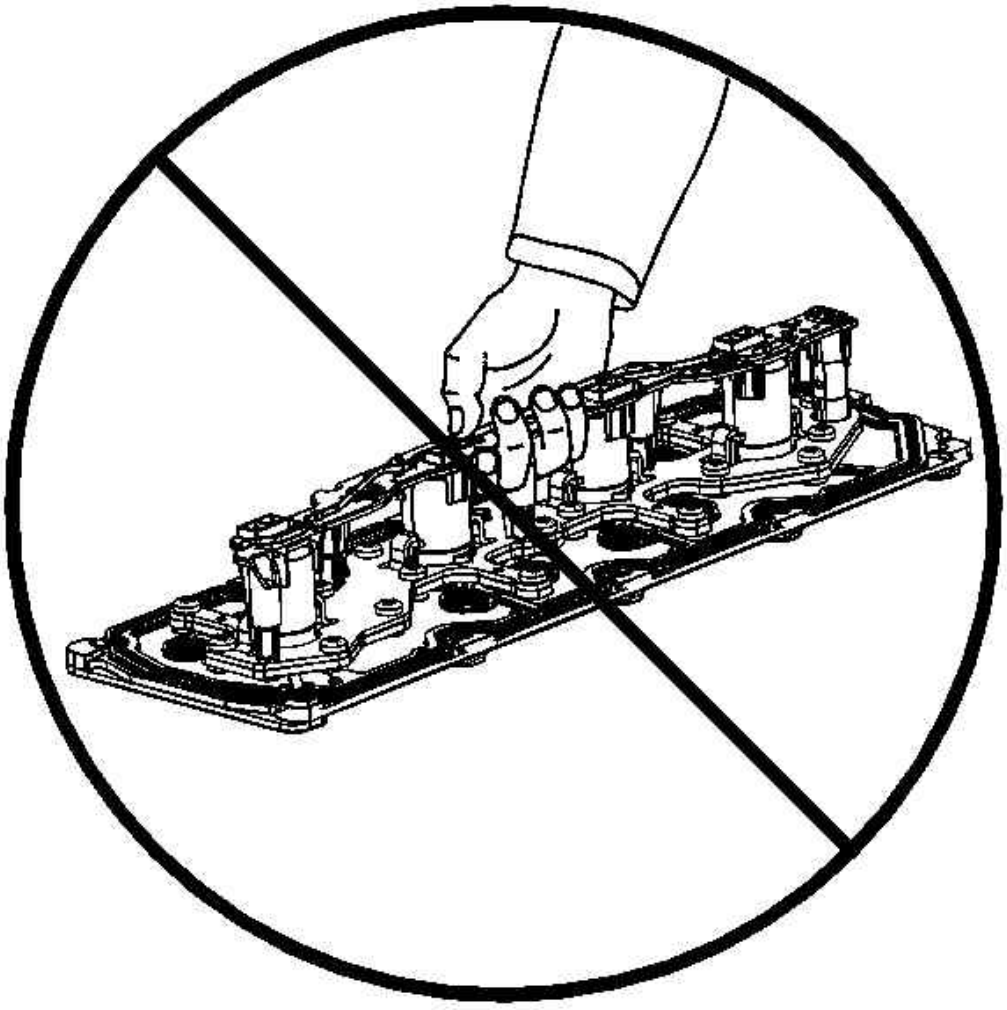


Fig. 514: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.**
- **Do not disassemble the electrical components from the manifold.**
- **Do not submerge the electrical components in**

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cleaning solvent.

- **Do not use the manifold exterior gasket again. Remove the exterior gasket and install a NEW service gasket during assembly.**

1. Do not lift the manifold assembly by the electrical lead frame.

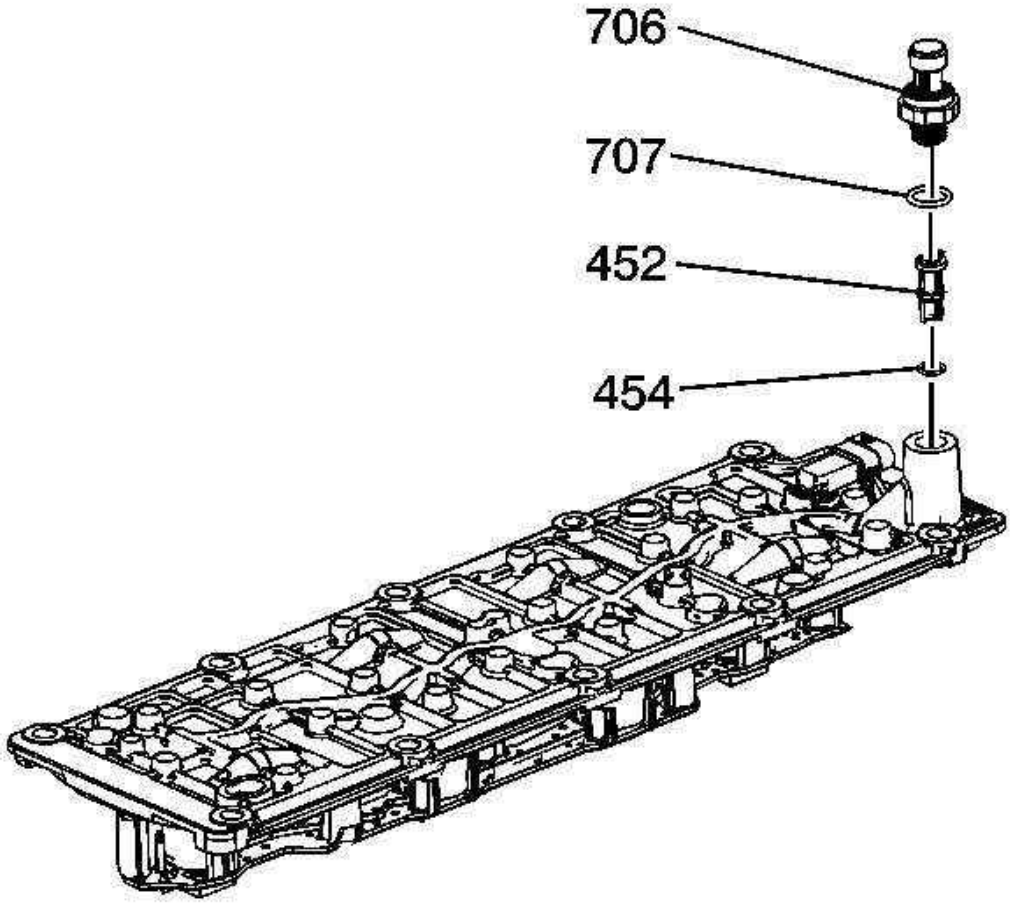


Fig. 515: View Of Oil Pressure Sensor, Washer & Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pressure sensor (706) and washer (707).

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3. Remove the oil screen (452) with O-ring (454).

CAUTION: Refer to Safety Glasses Caution .

4. Clean the manifold with compressed air.

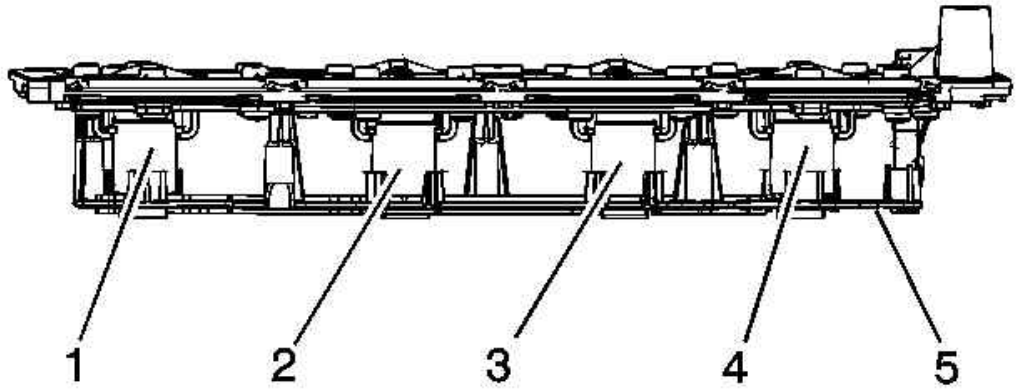


Fig. 516: View Of Electrical Solenoids
Courtesy of GENERAL MOTORS CORP.

5. Inspect for loose electrical solenoids (1-4) or loose or missing bolts.
6. Inspect for damage to the electrical lead frame (5).
7. Inspect for a damaged electrical connector, for bent or corroded pins.

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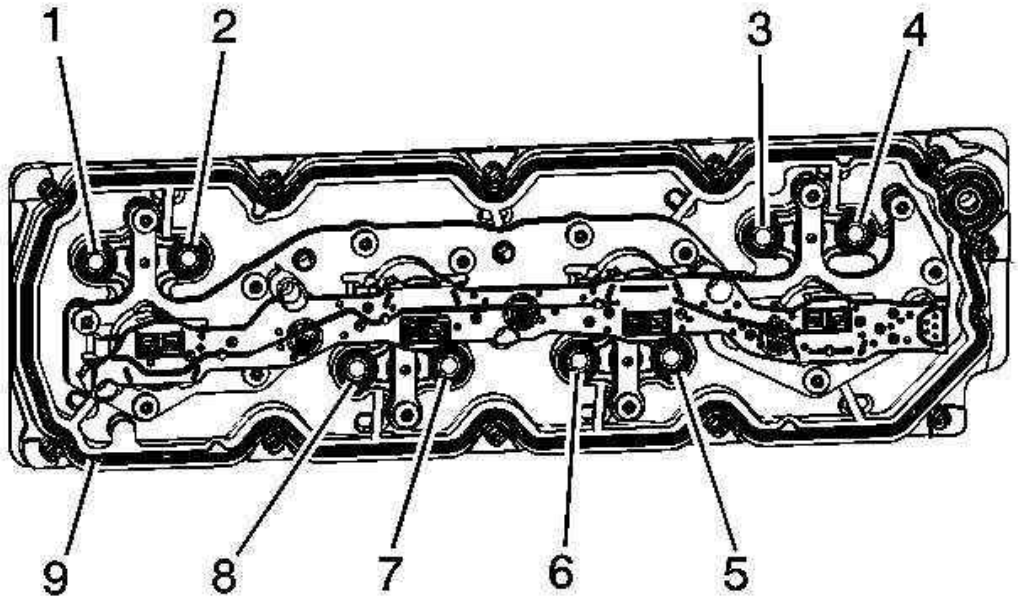


Fig. 517: Inspecting Manifold For Seal & Gasket Leaks
Courtesy of GENERAL MOTORS CORP.

8. Inspect for damaged interior sealing gaskets (1-8). If the interior sealing gaskets are damaged, the manifold must be replaced as an assembly.
9. Inspect for a damaged exterior sealing gasket (9) or scored gasket surfaces.
10. Inspect for debris or restrictions within the oil passages of the manifold.

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

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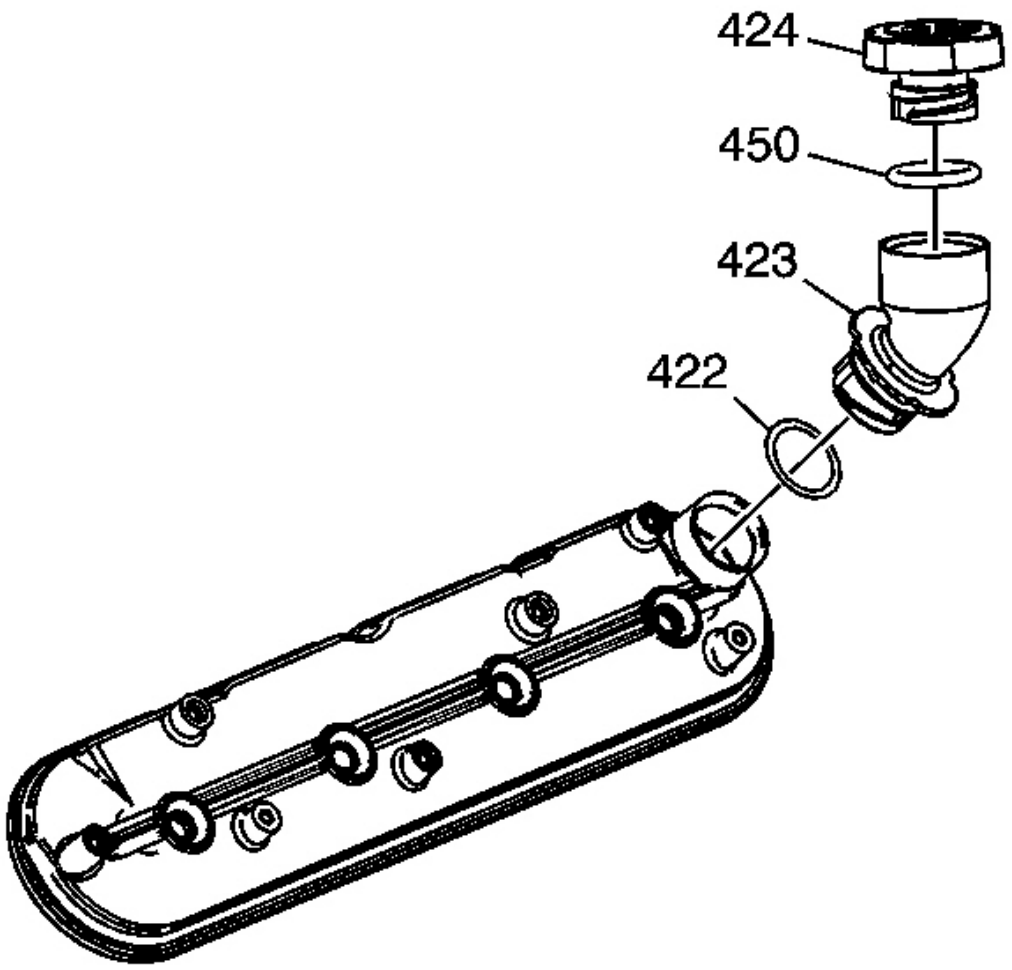


Fig. 518: Identifying Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.**
- **Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.**
- **Do not remove the oil fill tube from the covers**

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unless service is required.

- **If the oil fill tube has been removed from the rocker arm cover, install a NEW tube during assembly.**

1. Inspect the oil fill tube (423) for a loose fit or damage.

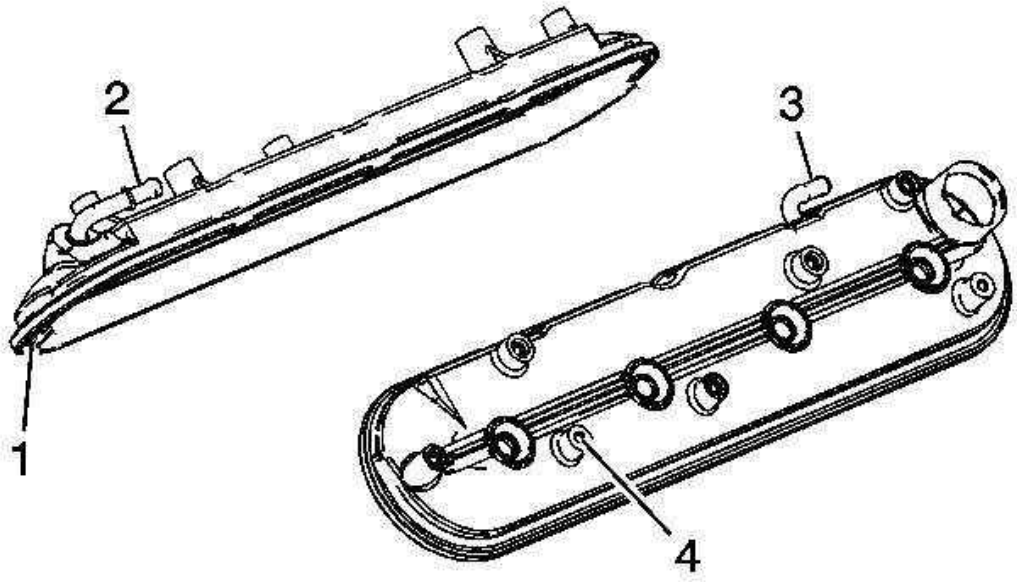


Fig. 519: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the covers for the following conditions:
   - Scoring or damage to the gasket surfaces (1)
   - Ventilation system passages (2, 3) for restrictions
   - Threaded bolt holes (4) for damage or debris

OIL PAN CLEANING AND INSPECTION

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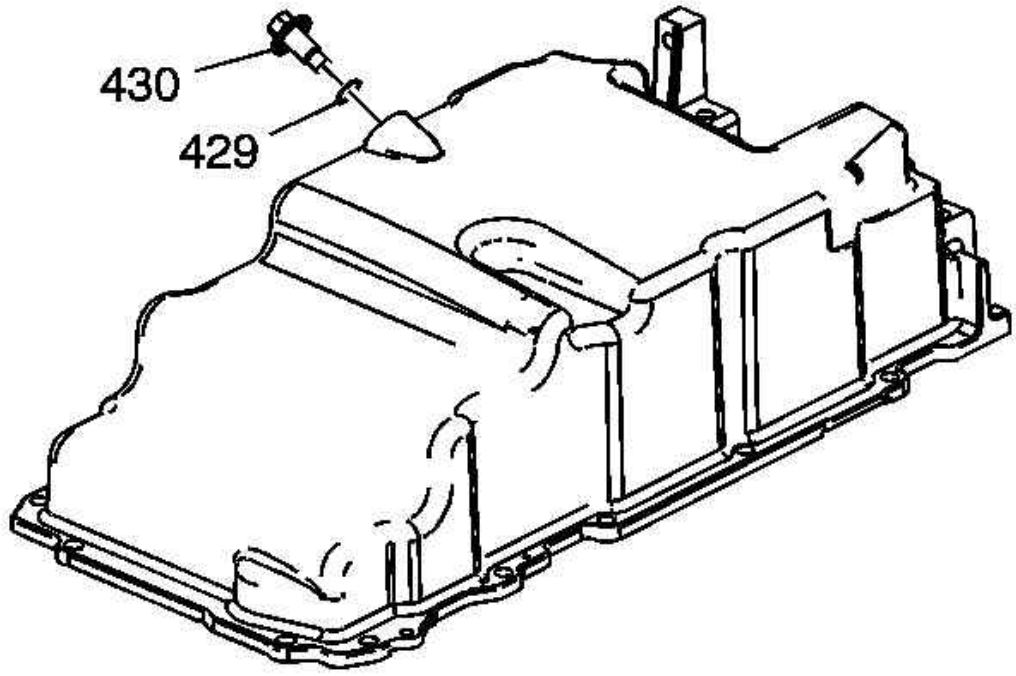


Fig. 520: View Of Oil Pan, Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing a NEW oil pan gasket, it is not necessary to install the rivets that retain the NEW gasket to the pan.

1. Remove the oil filter fitting and bypass valve, as required. Refer to **Oil Filter Removal**.
2. Remove the drain plug (430) and O-ring (429).

CAUTION: Refer to Safety Glasses Caution .

3. Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.

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4. Dry the oil pan with compressed air.
5. Inspect the oil pan for the following conditions:
   - Damaged gasket surfaces
   - Restrictions within the oil passages of the pan
   - Threaded bolt holes for damage

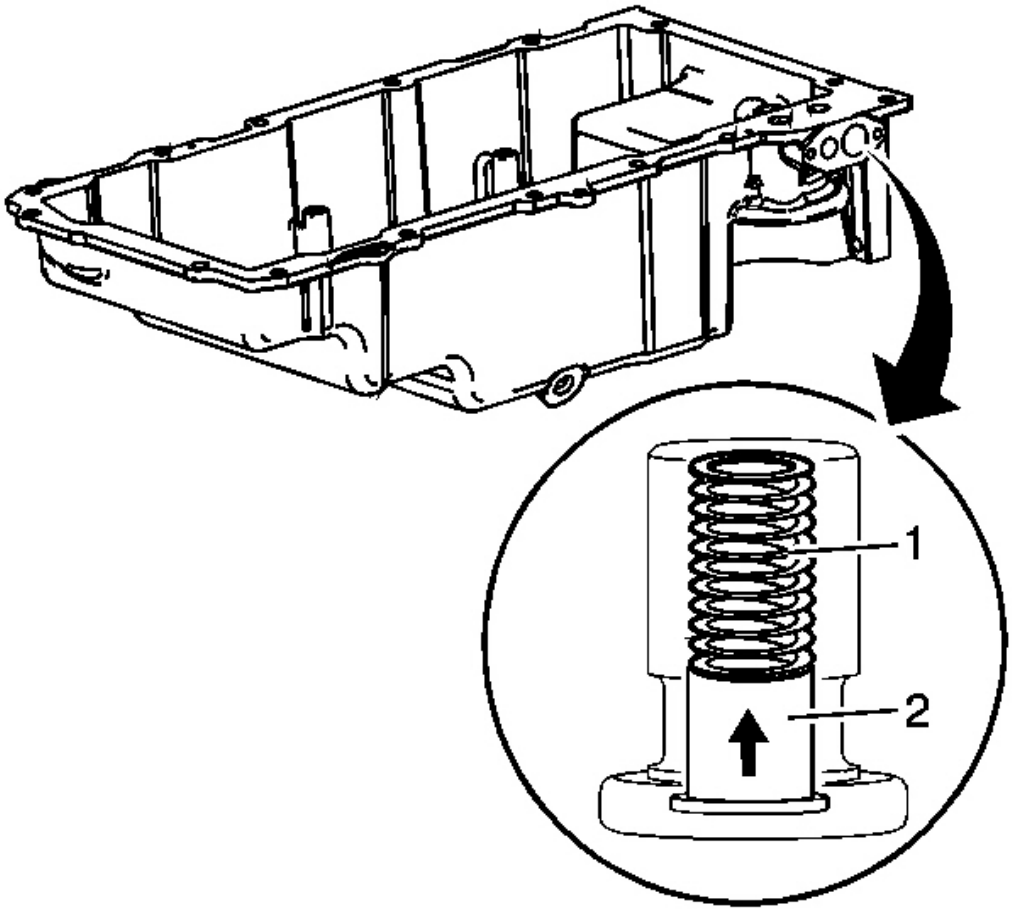


Fig. 521: View Of Valve Lifter Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

6. Inspect the active fuel management oil pressure relief valve for proper

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operation.

Lightly depress the valve (2). The valve spring (1) should seat the valve to the proper closed position.

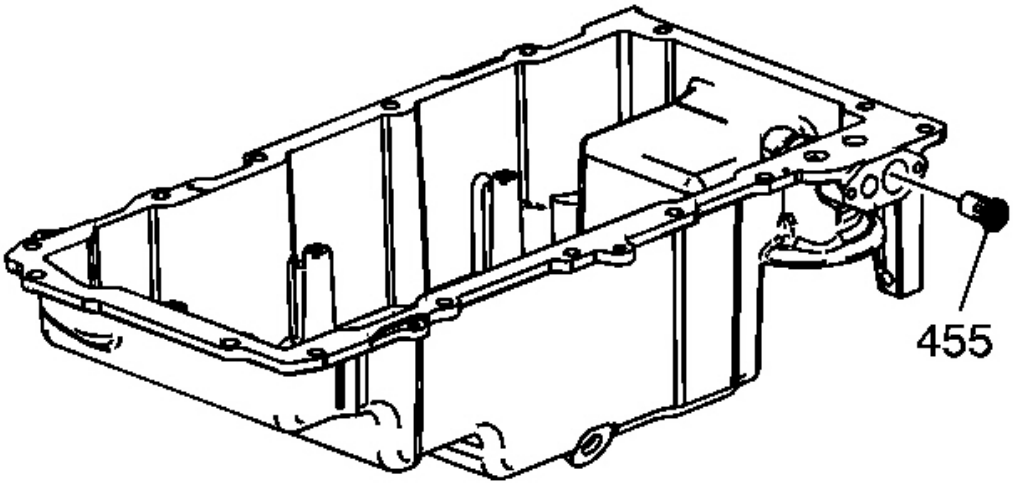


Fig. 522: Locating Valve Lifter Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

7. The valve (455) is press-fit in the oil pan and is serviceable separately.

INTAKE MANIFOLD CLEANING AND INSPECTION

Cleaning Procedure

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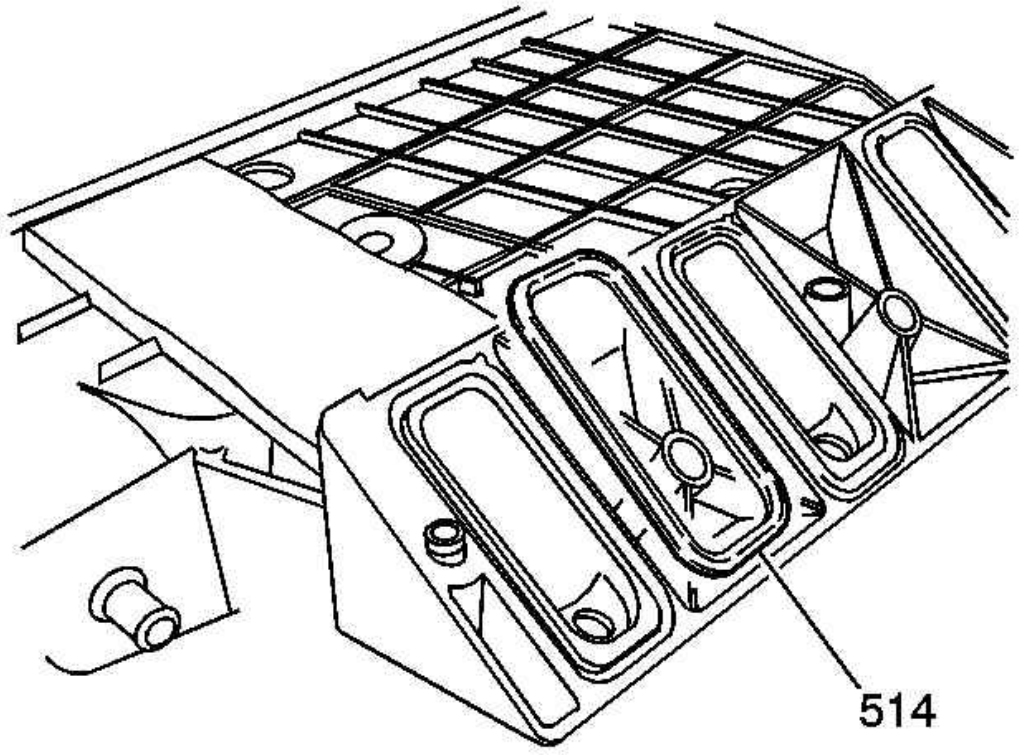


Fig. 523: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the intake manifold-to-cylinder head gaskets (514).

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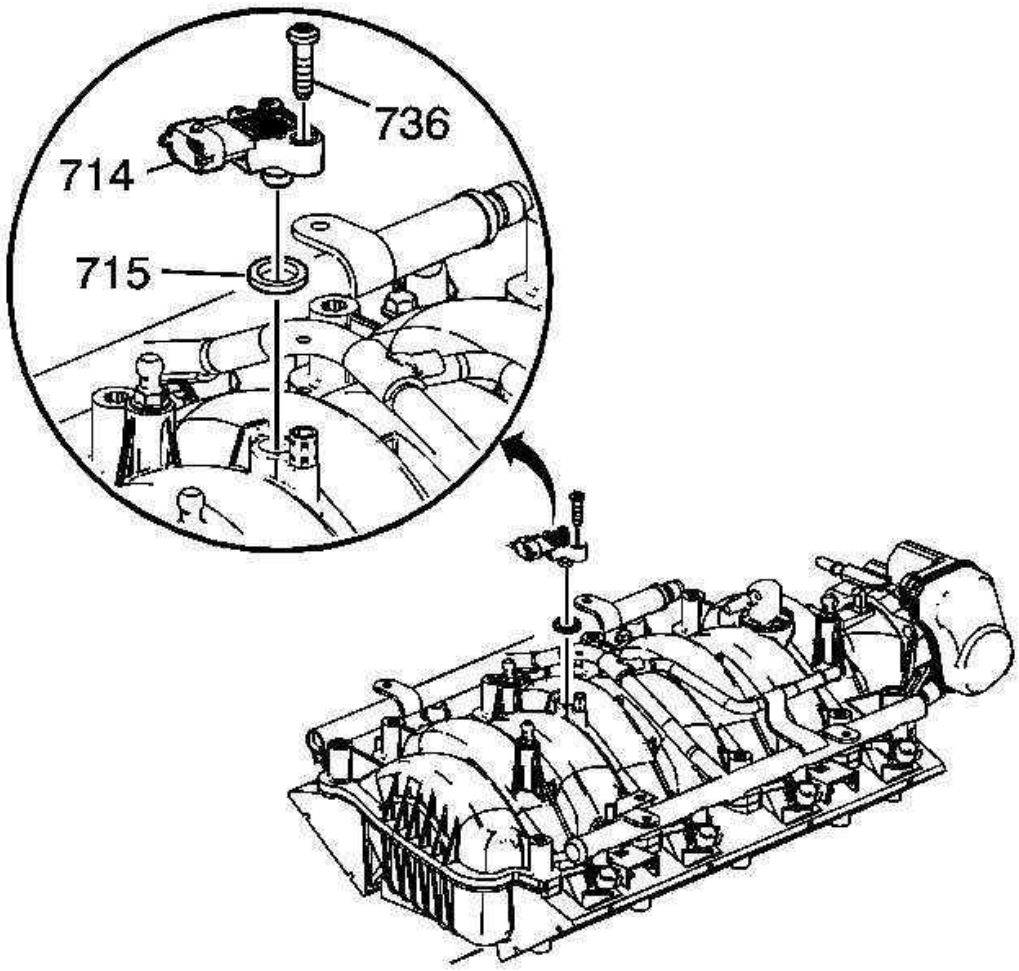


Fig. 524: Identifying MAP Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714). Refer to **Intake Manifold Removal**.

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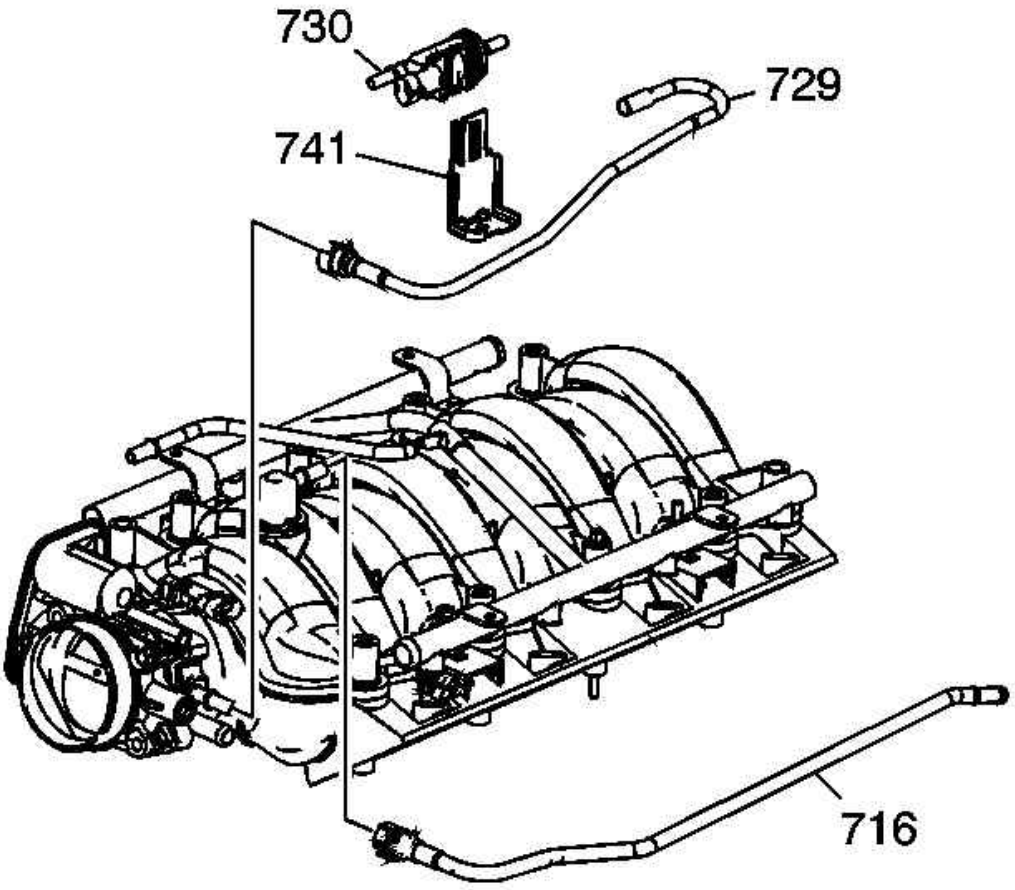


Fig. 525: View Of EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the evaporative emission (EVAP) canister purge solenoid valve (730), EVAP tube (729), and fuel rail with injectors. Refer to **Fuel Rail and Injectors Removal**.
4. Remove the throttle body and gasket. Refer to **Throttle Body Removal**.
5. Clean the intake manifold in solvent.

CAUTION: Refer to Safety Glasses Caution .

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6. Dry the intake manifold with compressed air.

Inspection Procedure

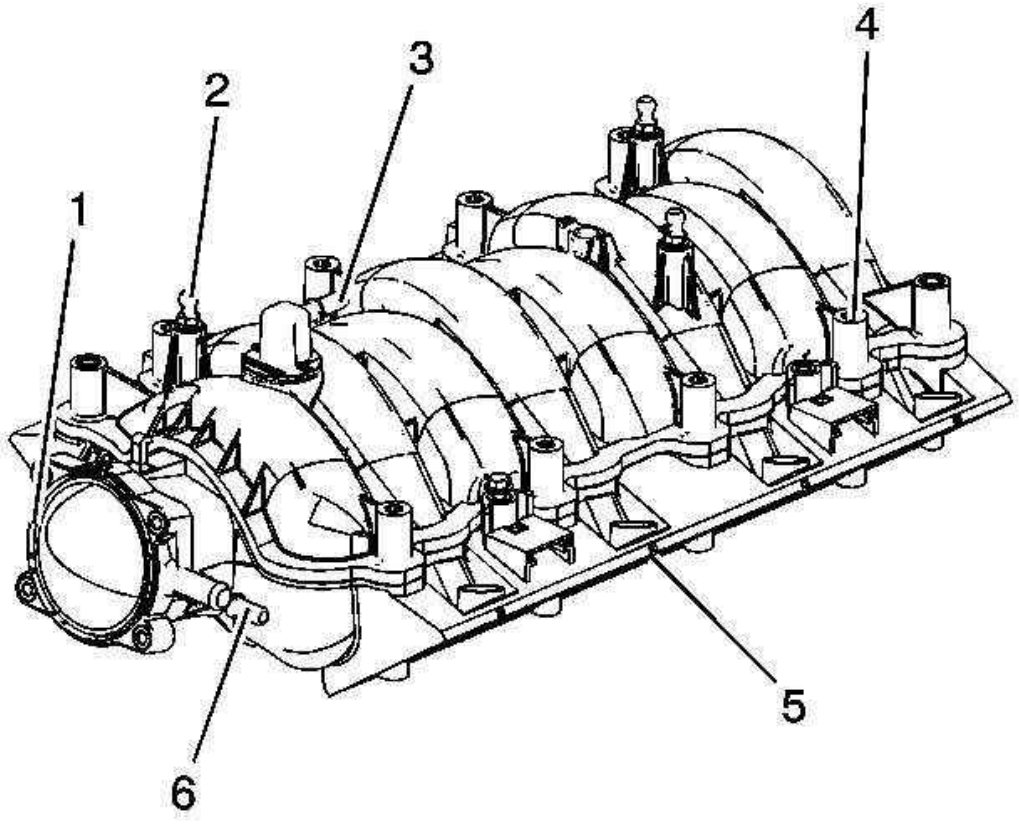


Fig. 526: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the manifold for the following conditions:
   - Damaged gasket or sealing surfaces (1, 5)
   - Loose threaded inserts or studs (2, 4)
   - Debris or restrictions within the passages of the manifold
   - Damaged or broken hose fittings (3, 6)
   - Inspect the composite intake manifold assembly for cracks or other

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damage.

2. Inspect the intake manifold cylinder head deck for warpage.
    1. Locate a straight edge across the intake manifold cylinder head deck surface.

       Position the straight edge across a minimum of 2 runner port openings.

    2. Insert a feeler gage between the intake manifold and the straight edge.

       An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION

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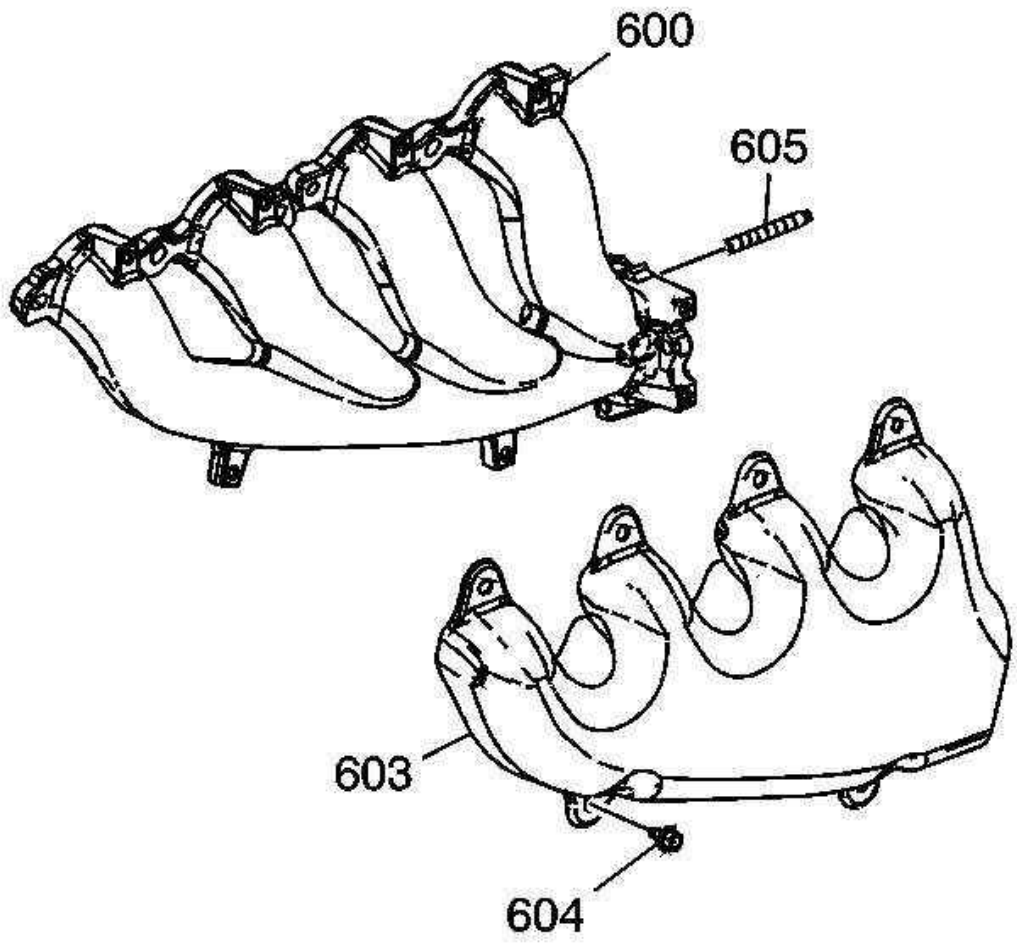


Fig. 527: Identifying Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may affect on-board diagnostics (OBD) II system performance.

1. Clean the exhaust manifold (600) and heat shield (603) in solvent.

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CAUTION: Refer to Safety Glasses Caution .

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose, damaged, or cracked heat shield (603).
5. Inspect the studs (605) for damaged threads.

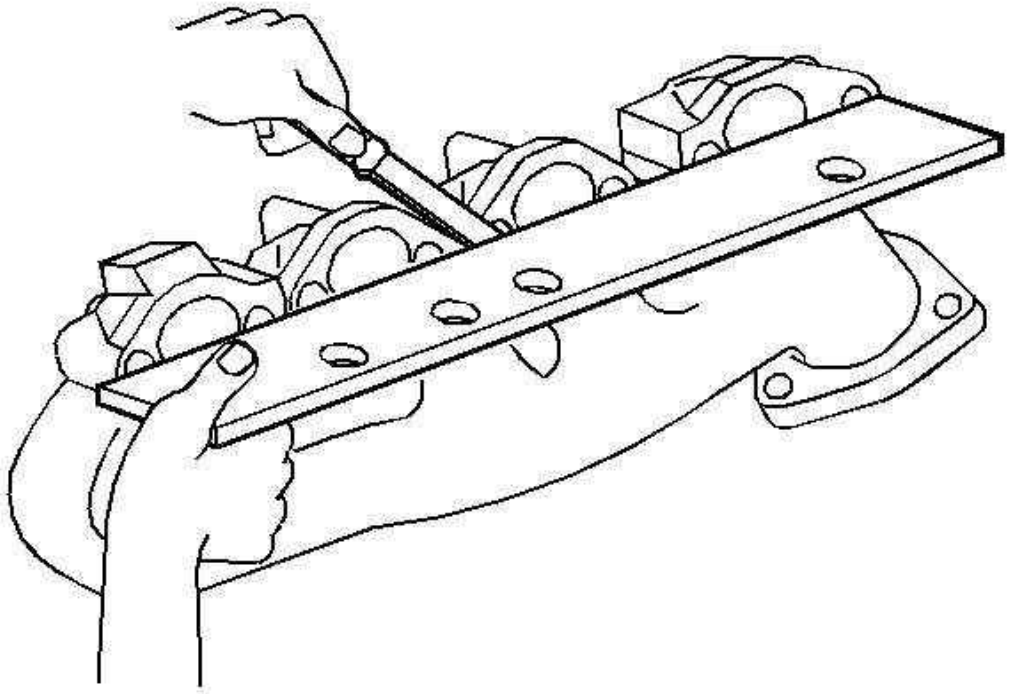


Fig. 528: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Use a straight edge and a feeler gage and measure the exhaust manifold cylinder head deck for warpage.

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An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the 2 front or 2 rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER CLEANING AND INSPECTION

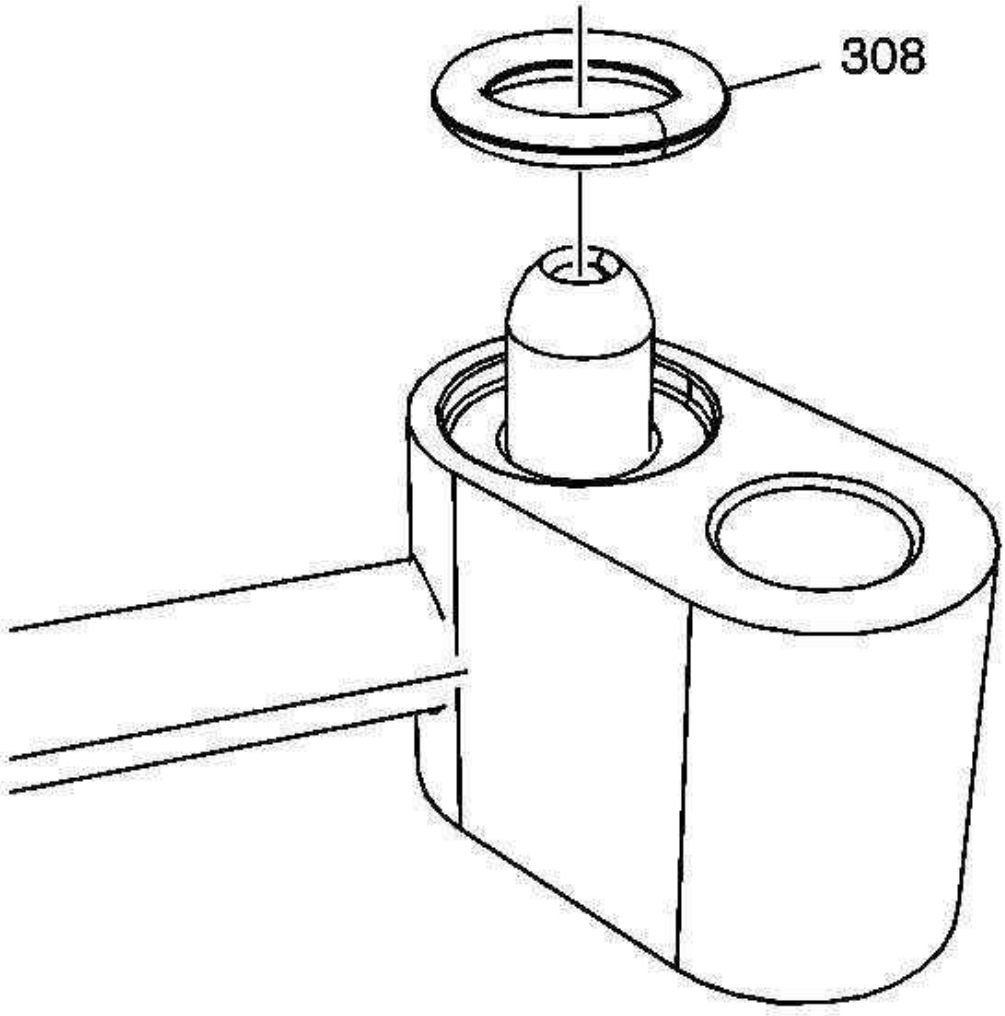


Fig. 529: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Do not use the engine coolant air bleed pipe and cover gaskets again. Upon installation of the pipe and covers, install NEW gaskets.

1. Remove the seals (308) from the pipe and covers.

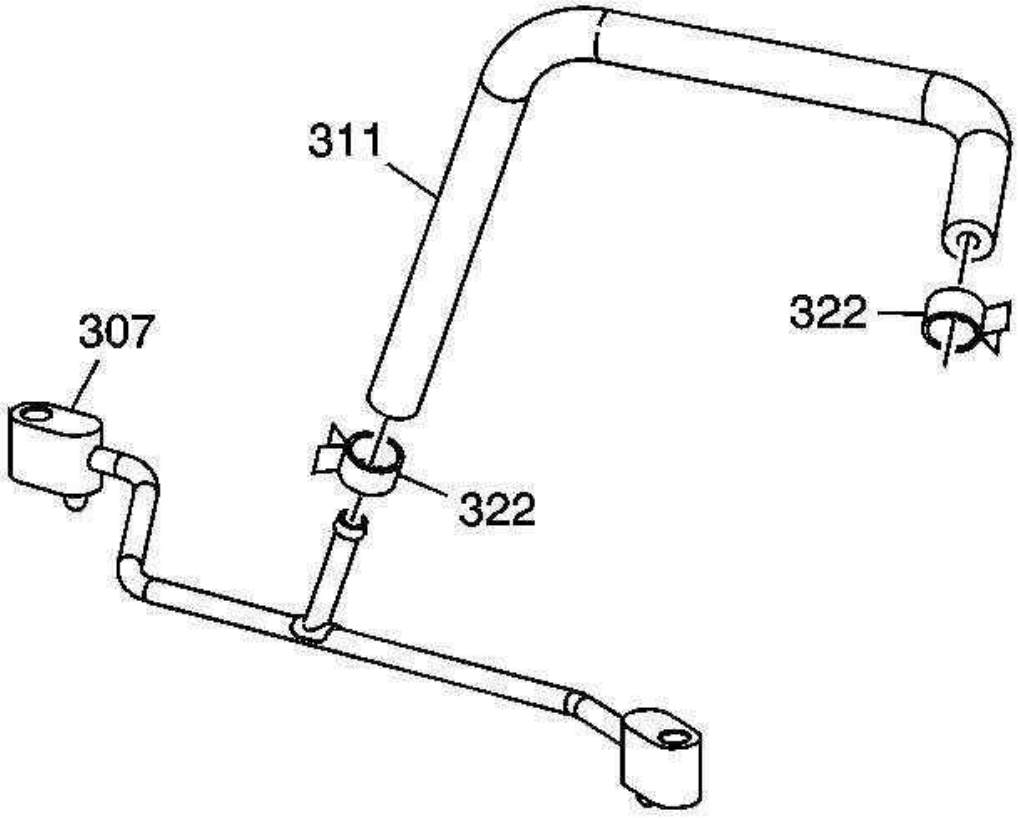


Fig. 530: View Of Coolant Air Bleed Pipe & Clamp
Courtesy of GENERAL MOTORS CORP.

2. Clean the pipe (307) and covers in solvent.

CAUTION: Refer to Safety Glasses Caution .

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3. Dry the pipe (307) and covers with compressed air.
4. Inspect the pipe and covers for damaged sealing surfaces or restrictions within the pipe.
5. Inspect the hose (311) for wear, restrictions, or damage.

WATER PUMP CLEANING AND INSPECTION

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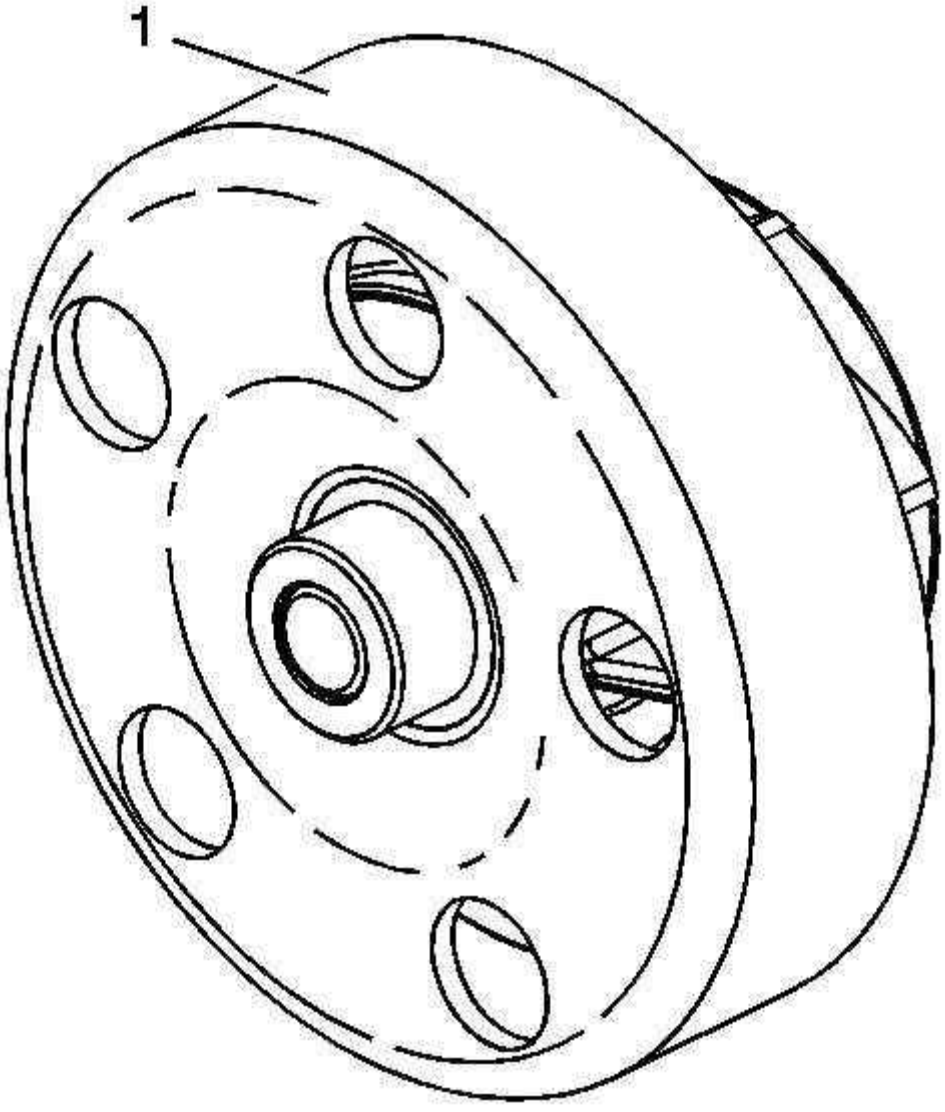


Fig. 531: Identifying Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

1. Clean all excess dirt and debris from the water pump housing.
2. Inspect the water pump for the following conditions:
   - Gasket sealing surfaces for excessive scratches or gouging

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- Excessive side-to-side play in the pulley shaft
- Leakage at the water pump vent hole

  A stain around the vent hole is acceptable. If leakage, dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.

- Wear or damage in the belt tracking area of the pulley (1)

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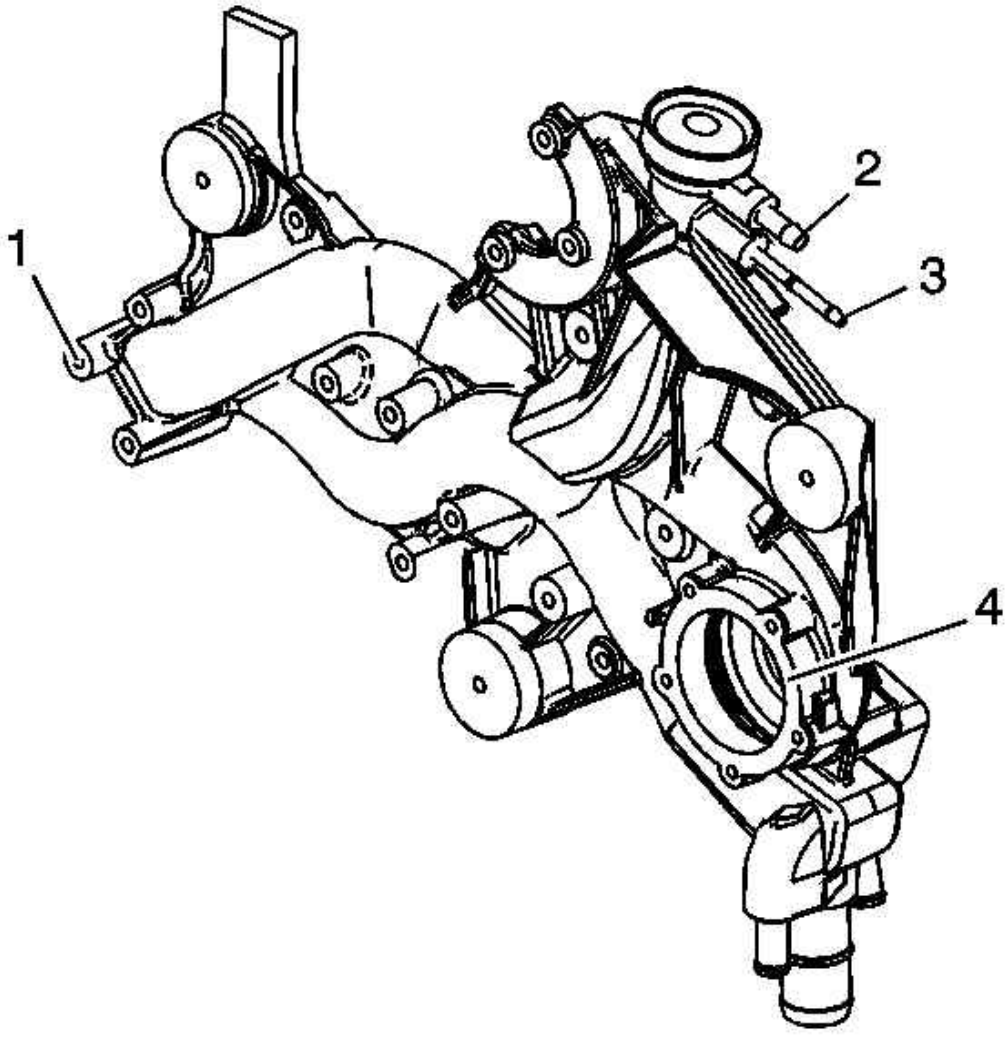


Fig. 532: Identifying Water Manifold
Courtesy of GENERAL MOTORS CORP.

3. Inspect the water manifold for the following conditions:
   - Damage to threaded bolt holes (1)
   - Restrictions within the internal passages (2, 3)
   - Gasket sealing surfaces (4) for excessive scratches or gouging

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THREAD REPAIR

Tools Required

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 42385-200** Common Thread Repair Kit. See **Special Tools**.
- **J 42385-300** Fixtures and Hardware Kit. See **Special Tools**.

General Thread Repair

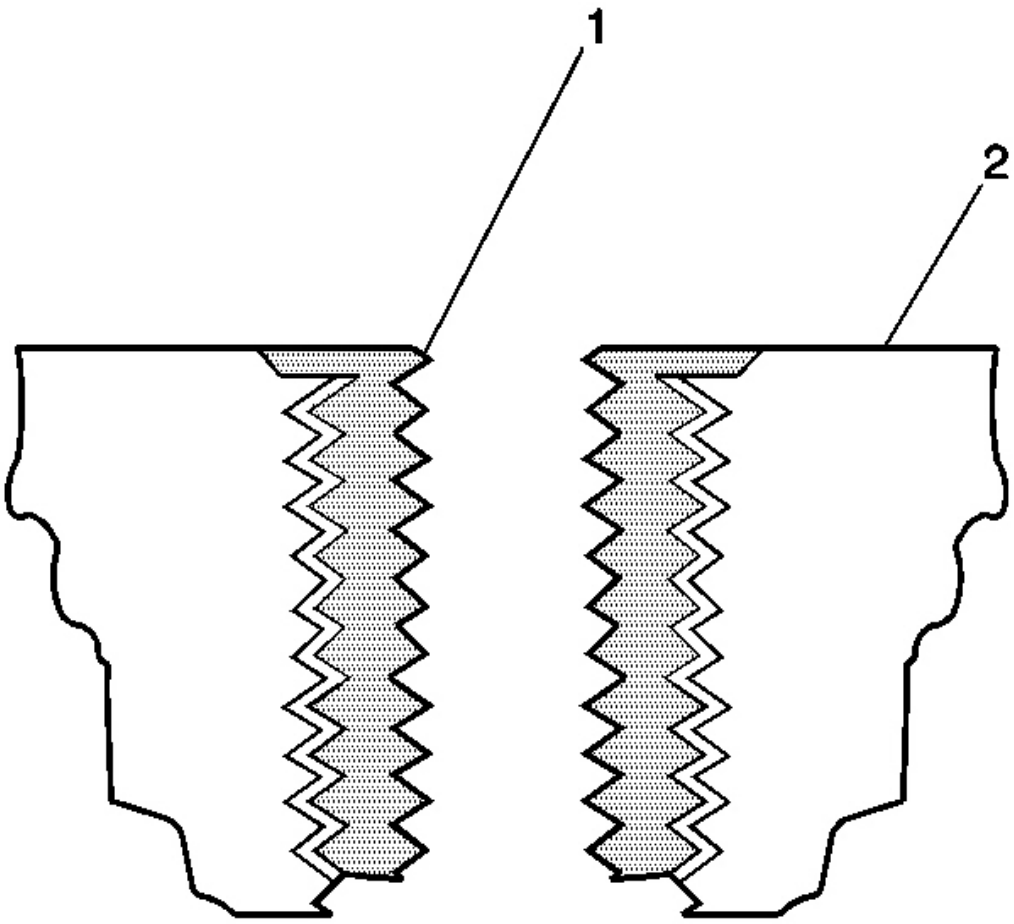


Fig. 533: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

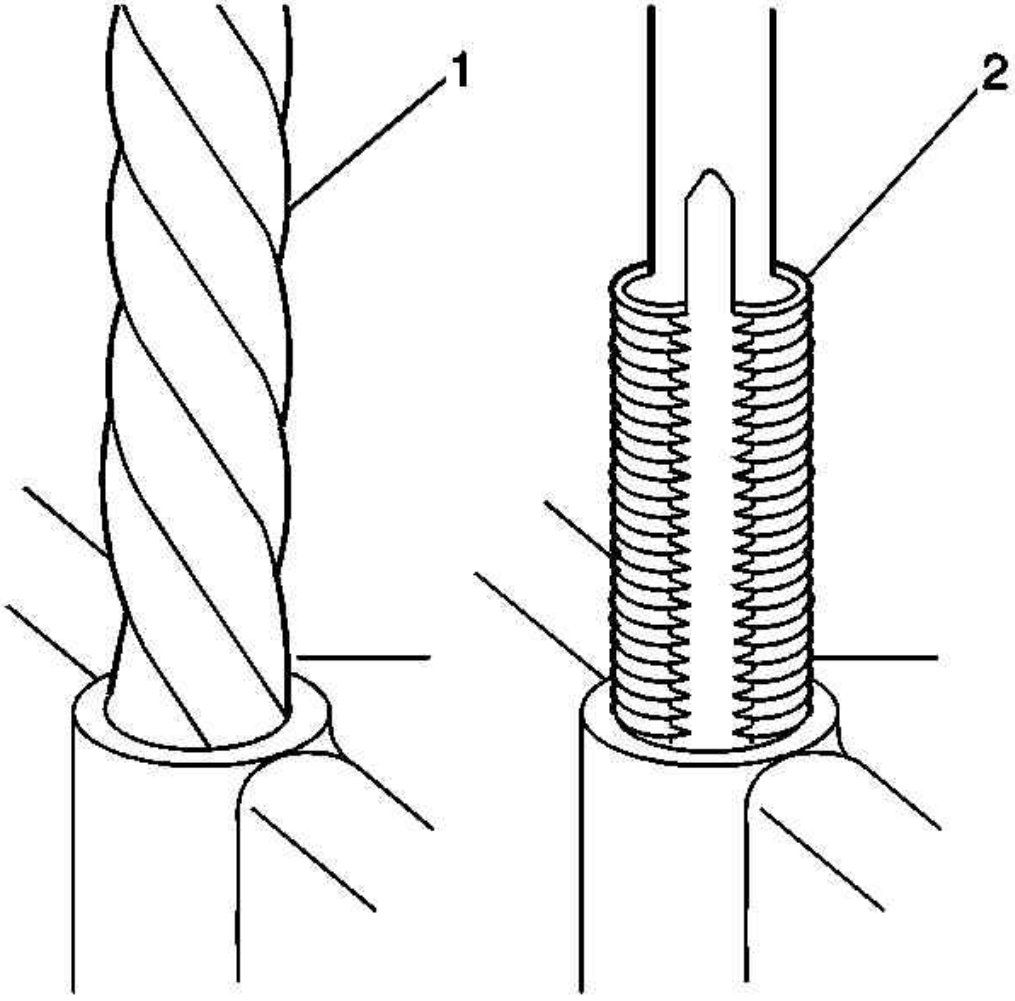


Fig. 534: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.**
- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

1. Drill out the threads of the damaged hole (1).
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

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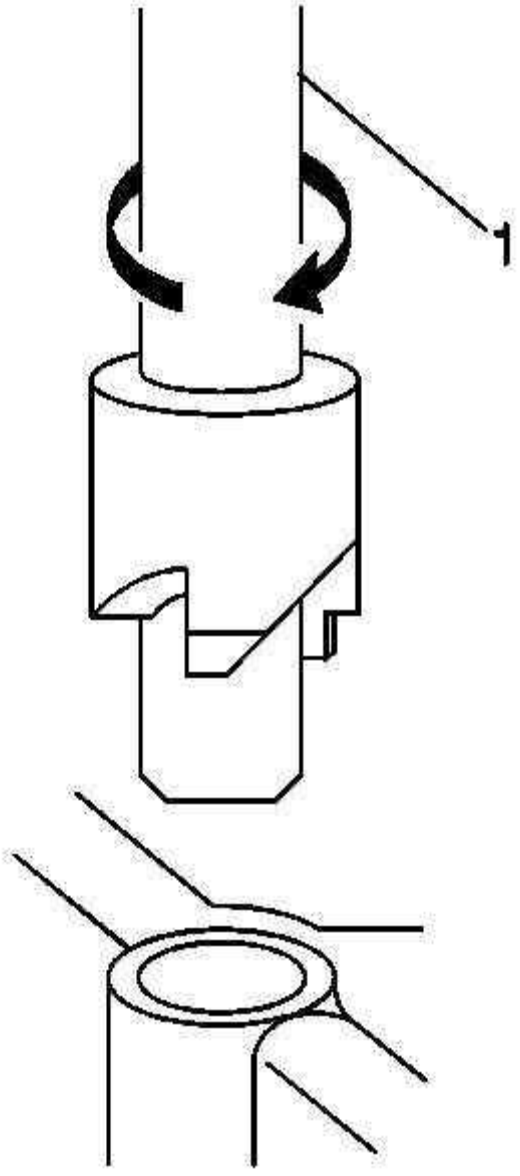


Fig. 535: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

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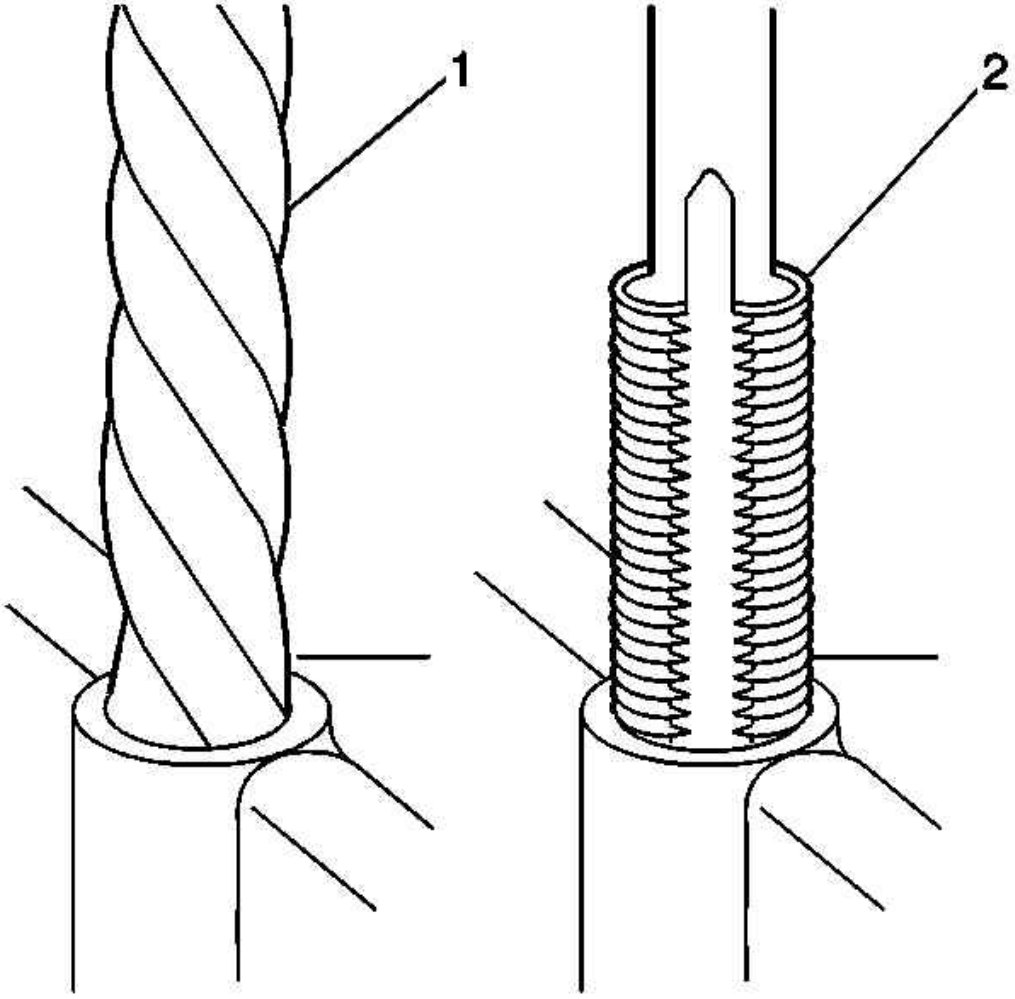


Fig. 536: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
   - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
   - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
   - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.

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7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

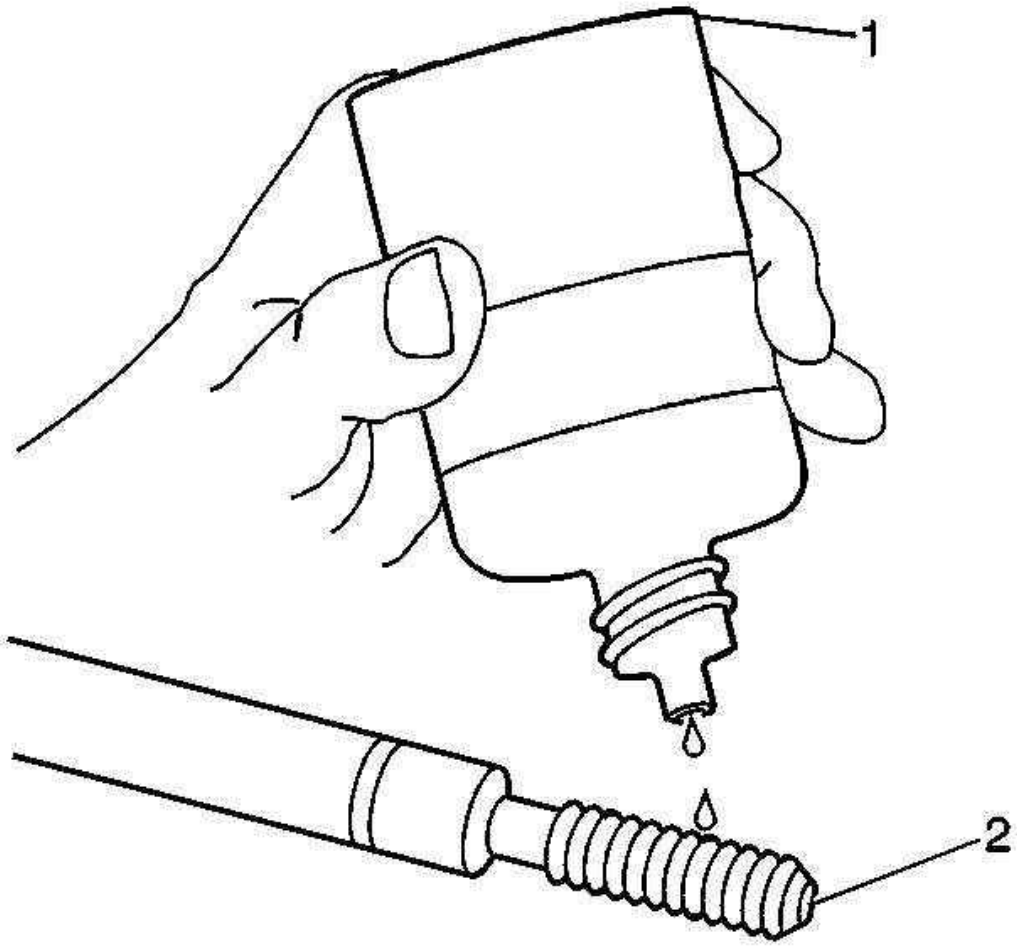


Fig. 537: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

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9. Lubricate the threads of the installer tool (2) with the driver oil (1).

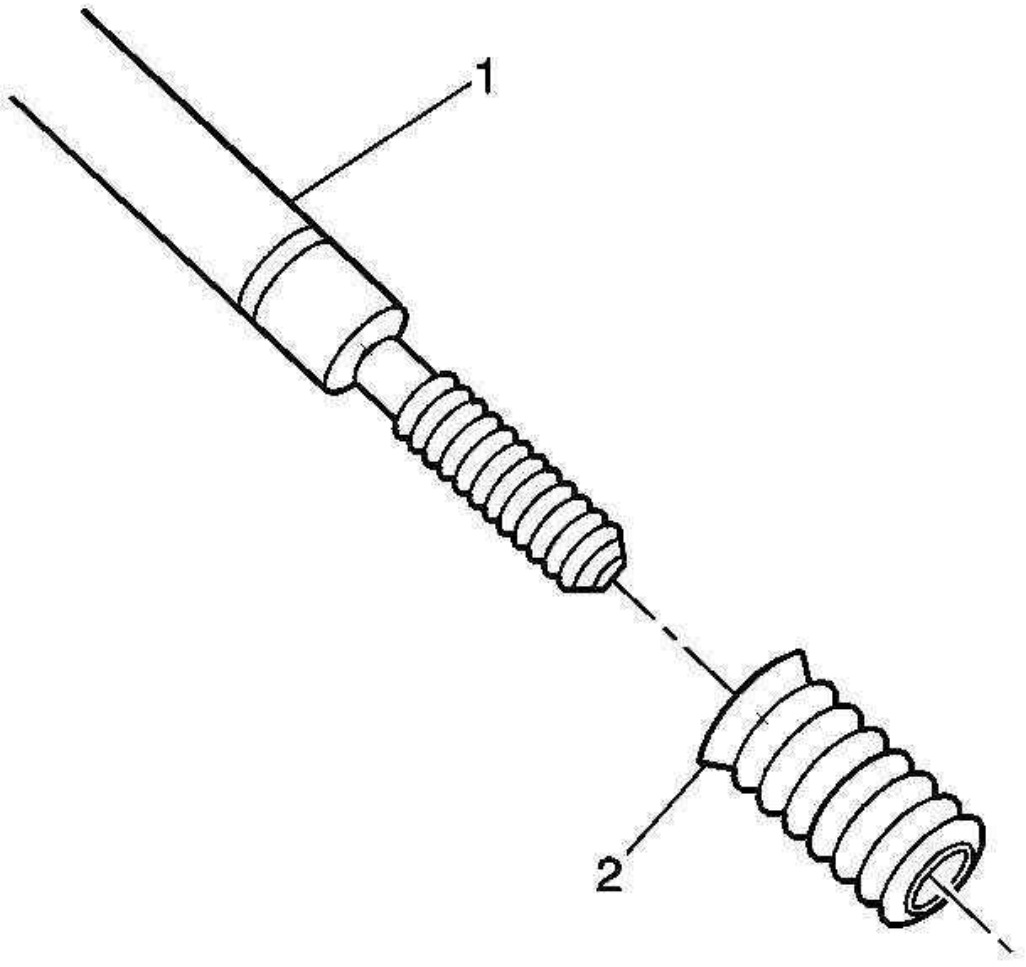


Fig. 538: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

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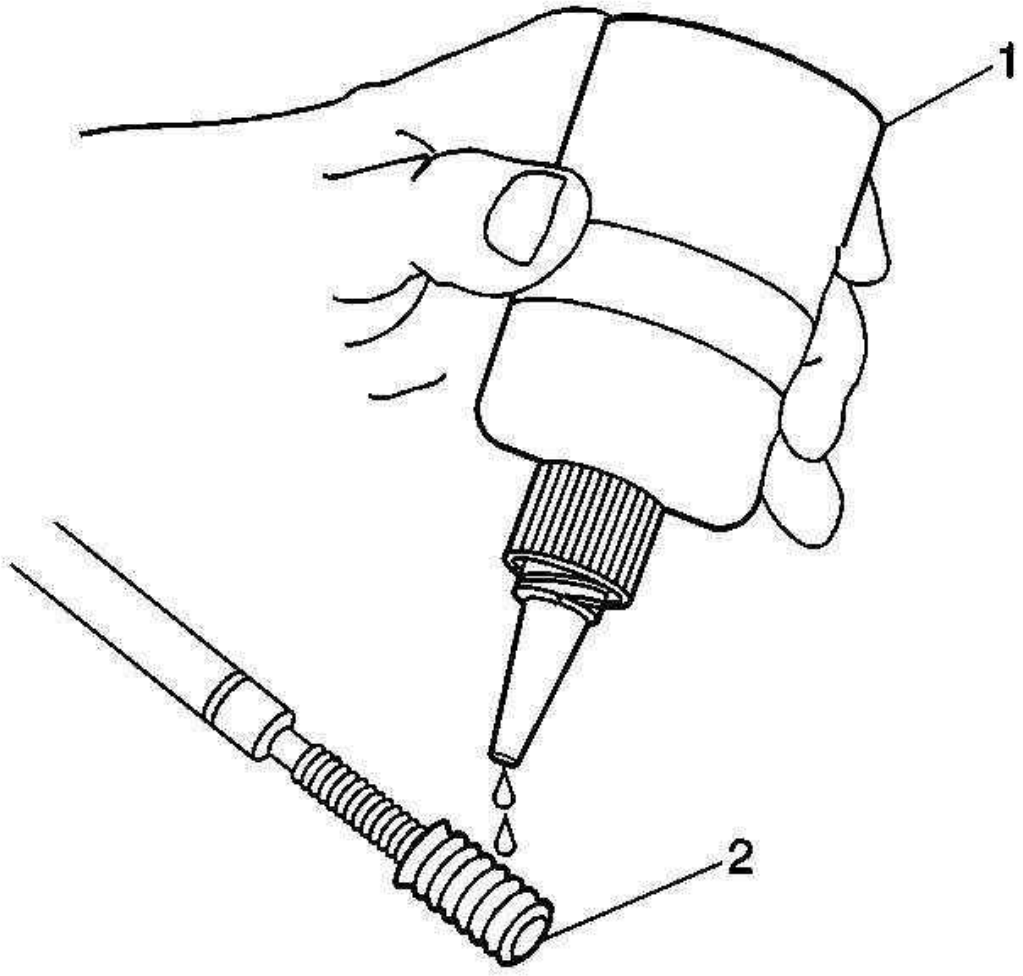


Fig. 539: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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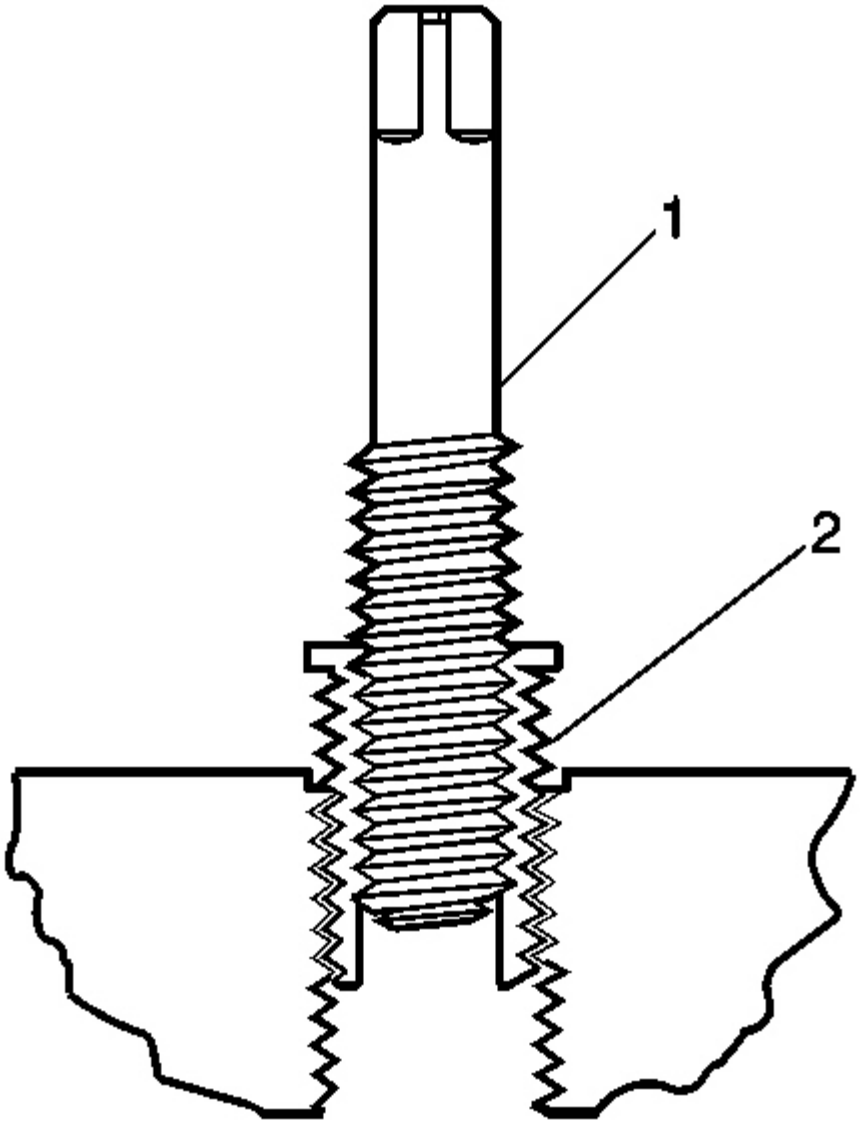


Fig. 540: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface.

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Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

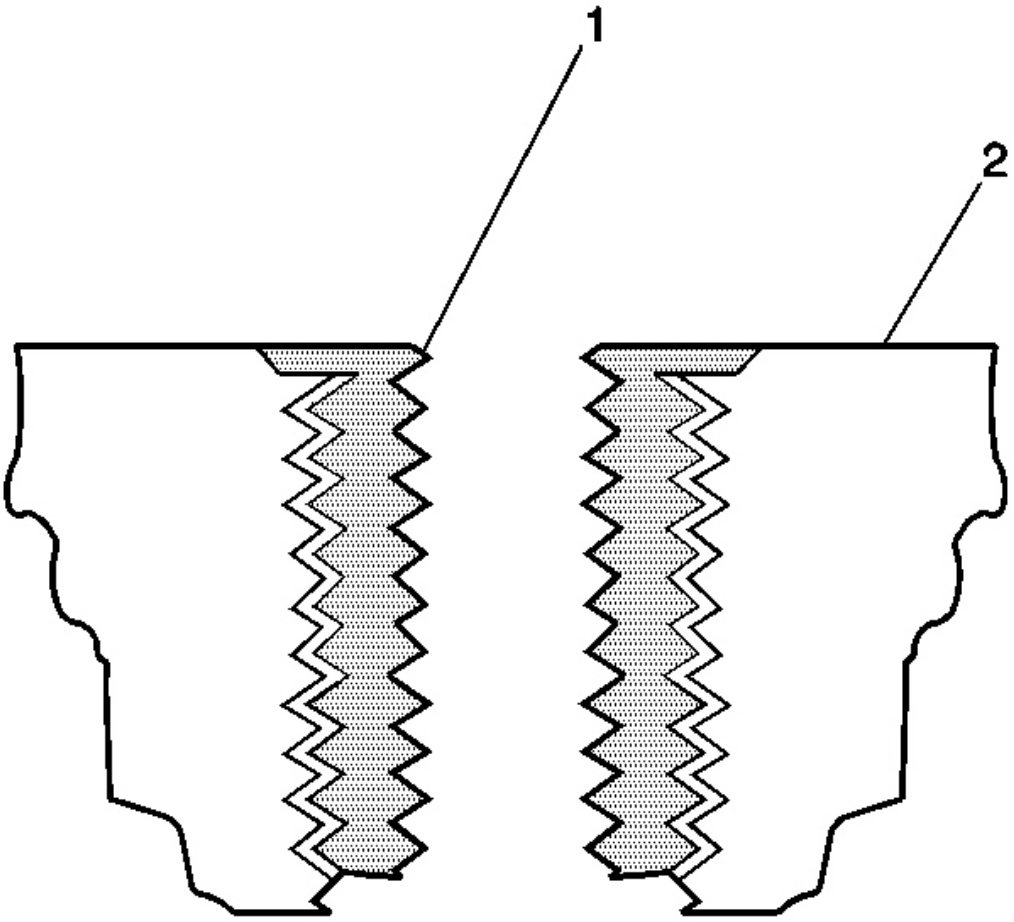


Fig. 541: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

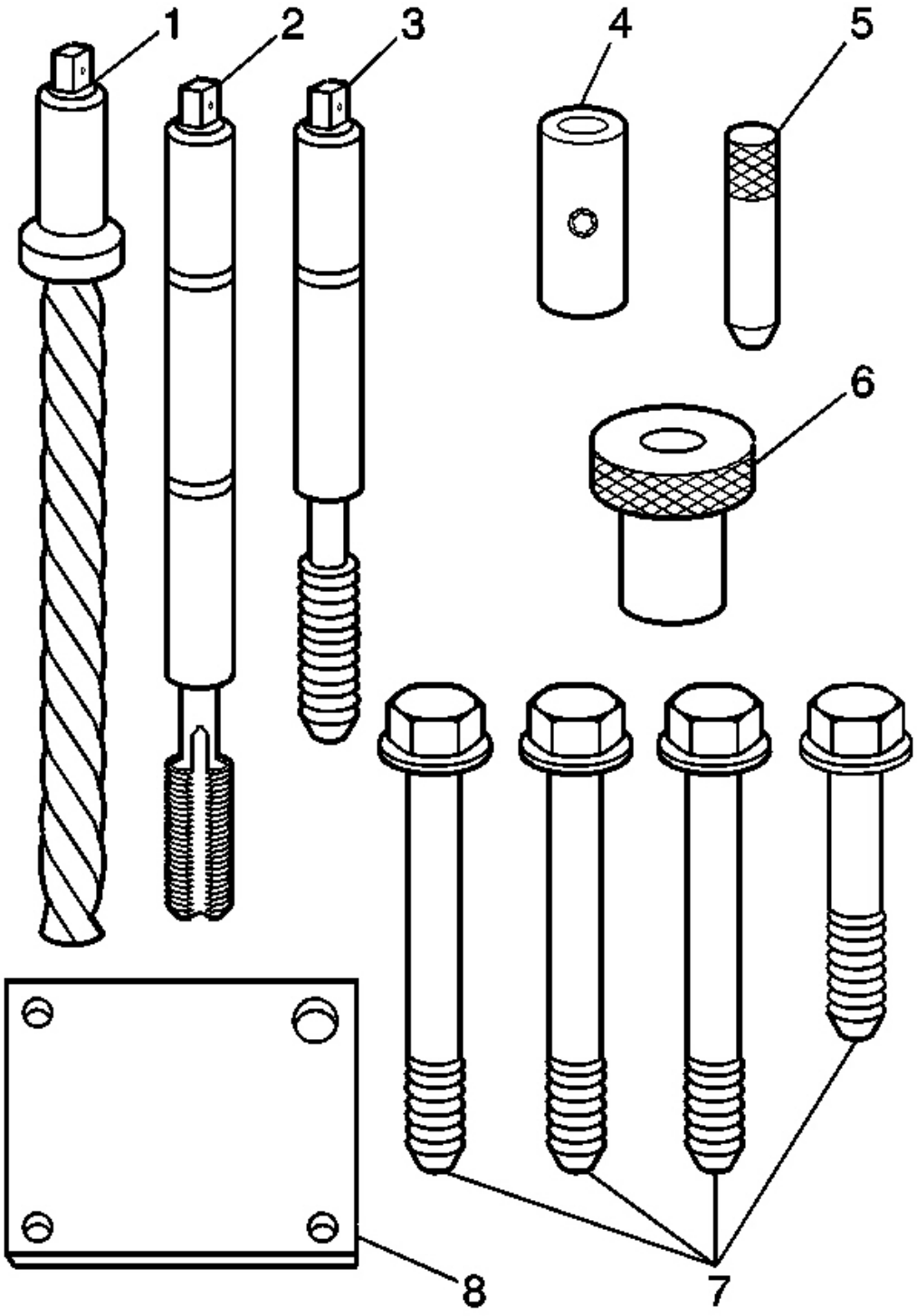
A properly installed insert (1) will be either flush or slightly below flush with

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the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

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Fig. 542: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The cylinder head bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The sleeve (4)
   - The alignment pin (5)
   - The bushing (6)
   - The bolts (7)
   - The fixture plate (8)

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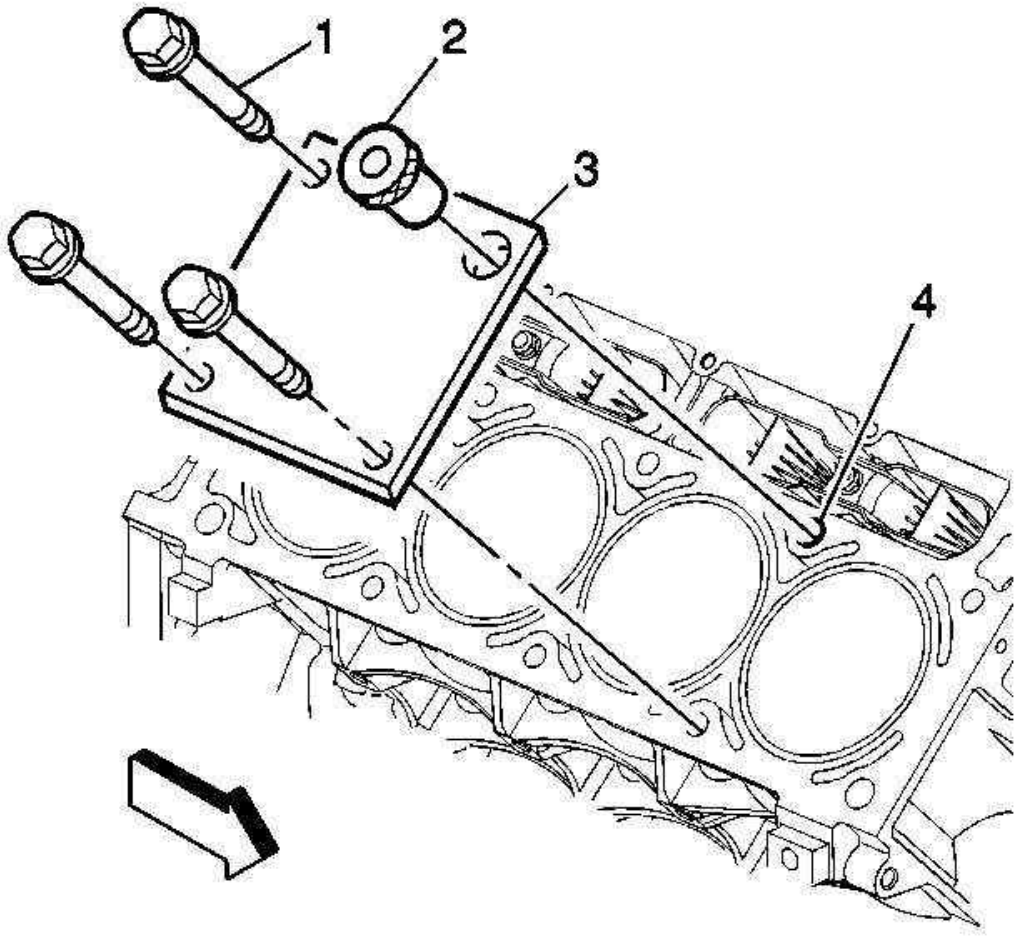


Fig. 543: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

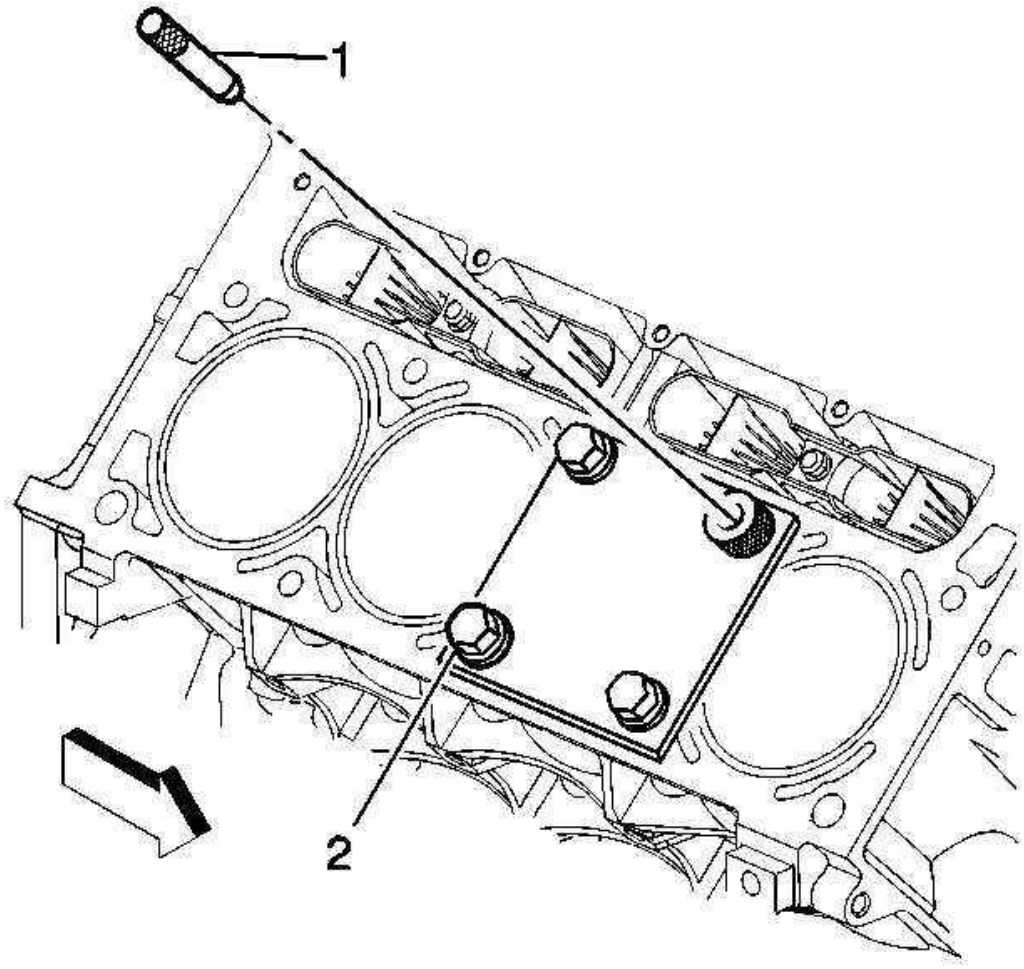
- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures.**

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- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

   Position the fixture plate and bushing over the hole that is to be repaired (4).



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Fig. 544: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

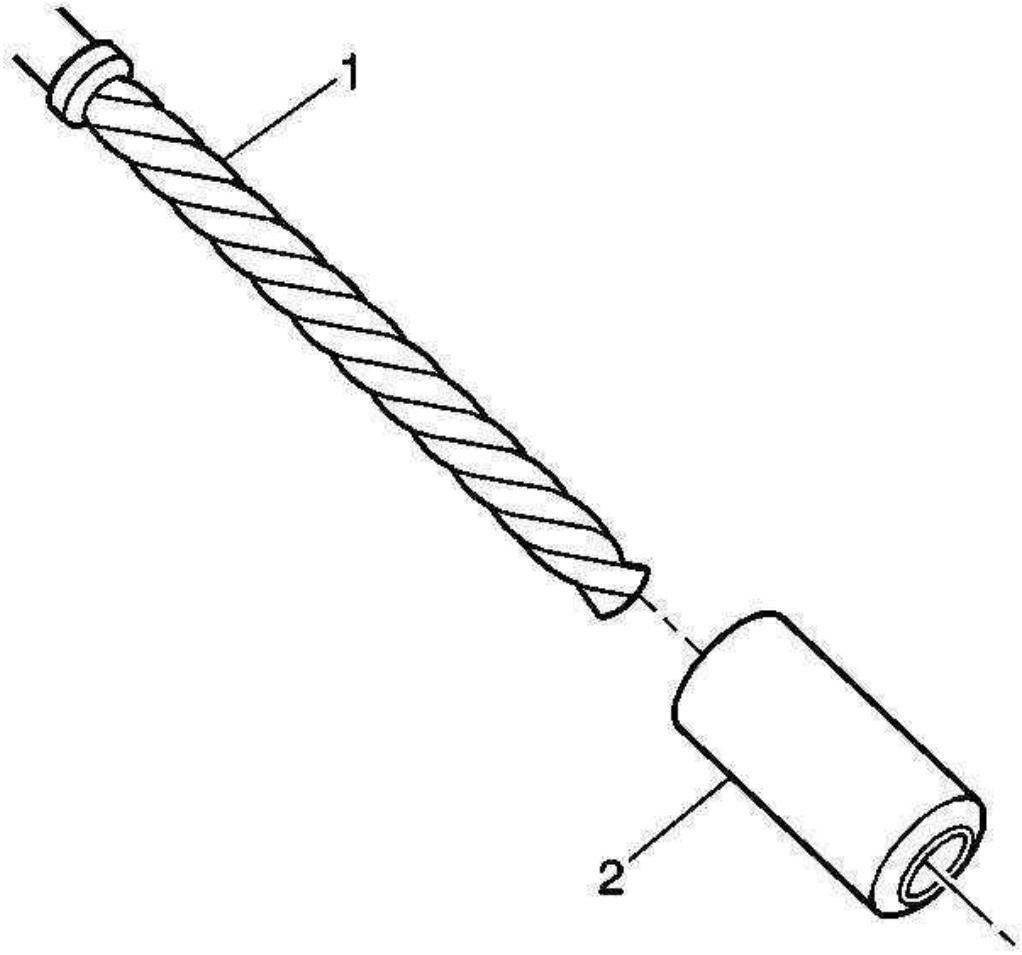


Fig. 545: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

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6. Install the sleeve (2) onto the drill (1).

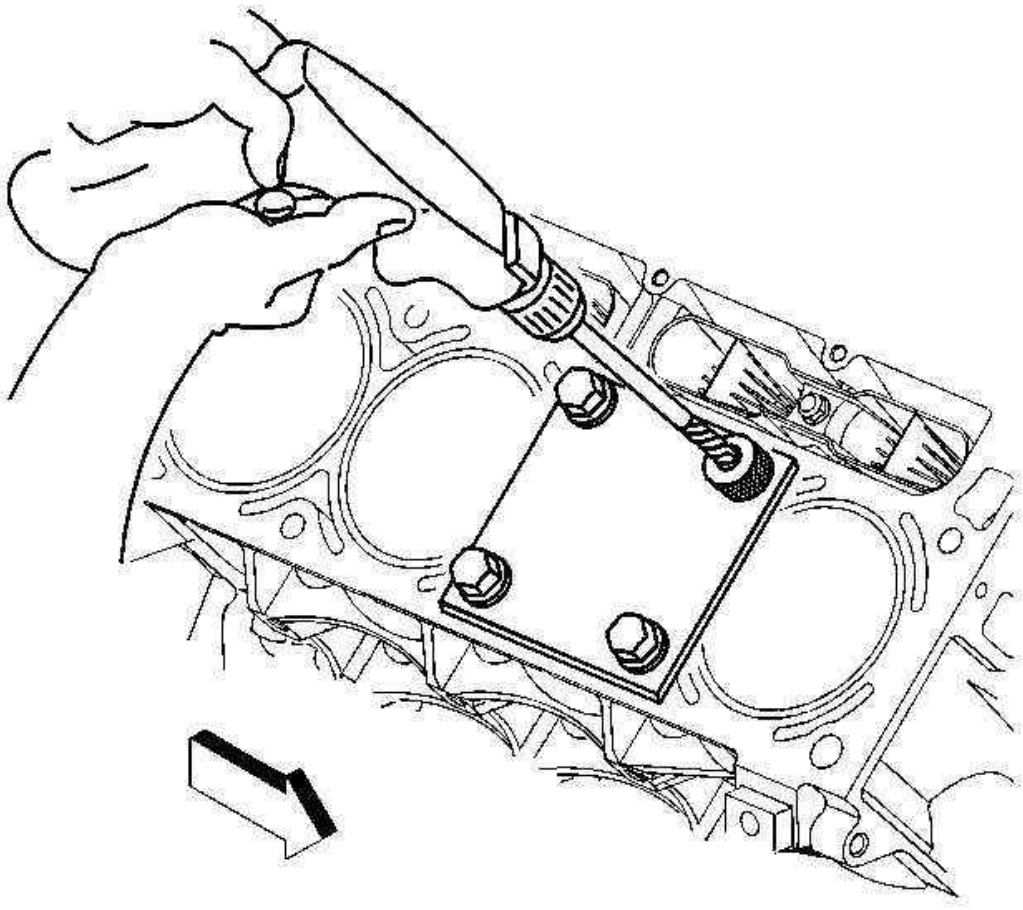


Fig. 546: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the

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bushing.

8. Using compressed air, clean out any chips.

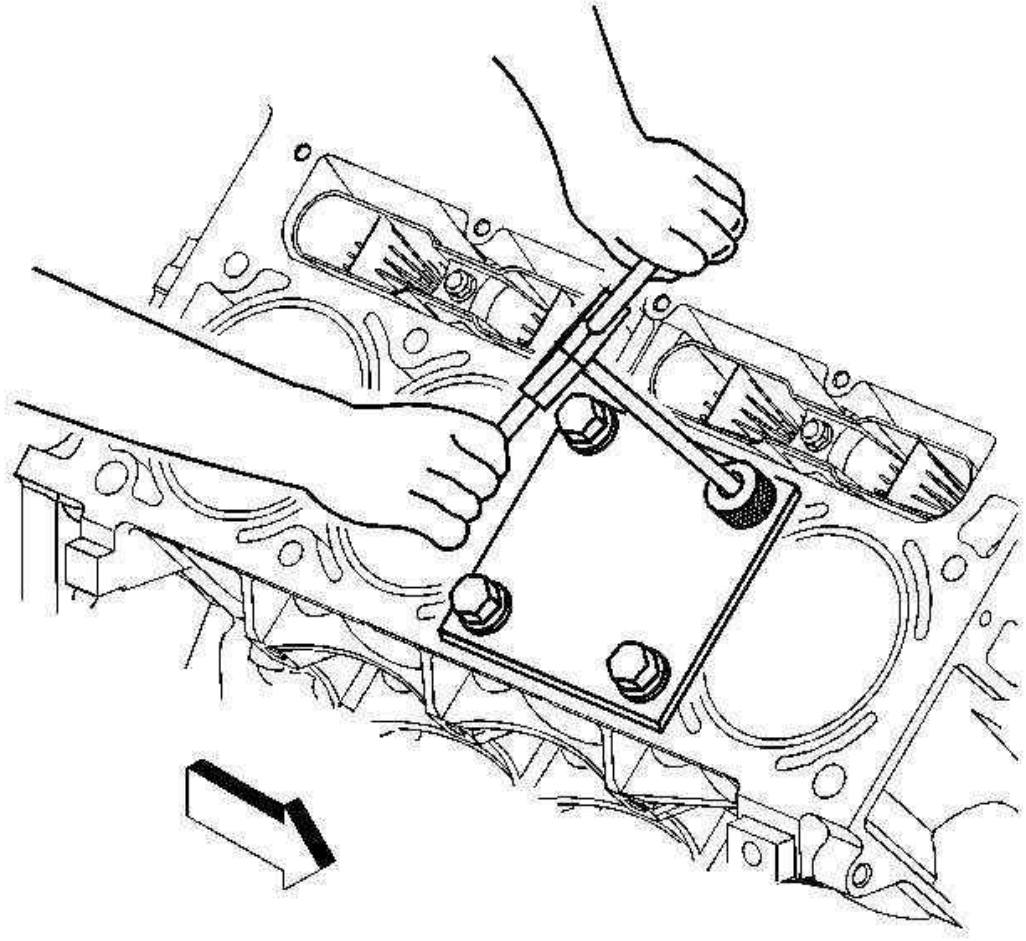


Fig. 547: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

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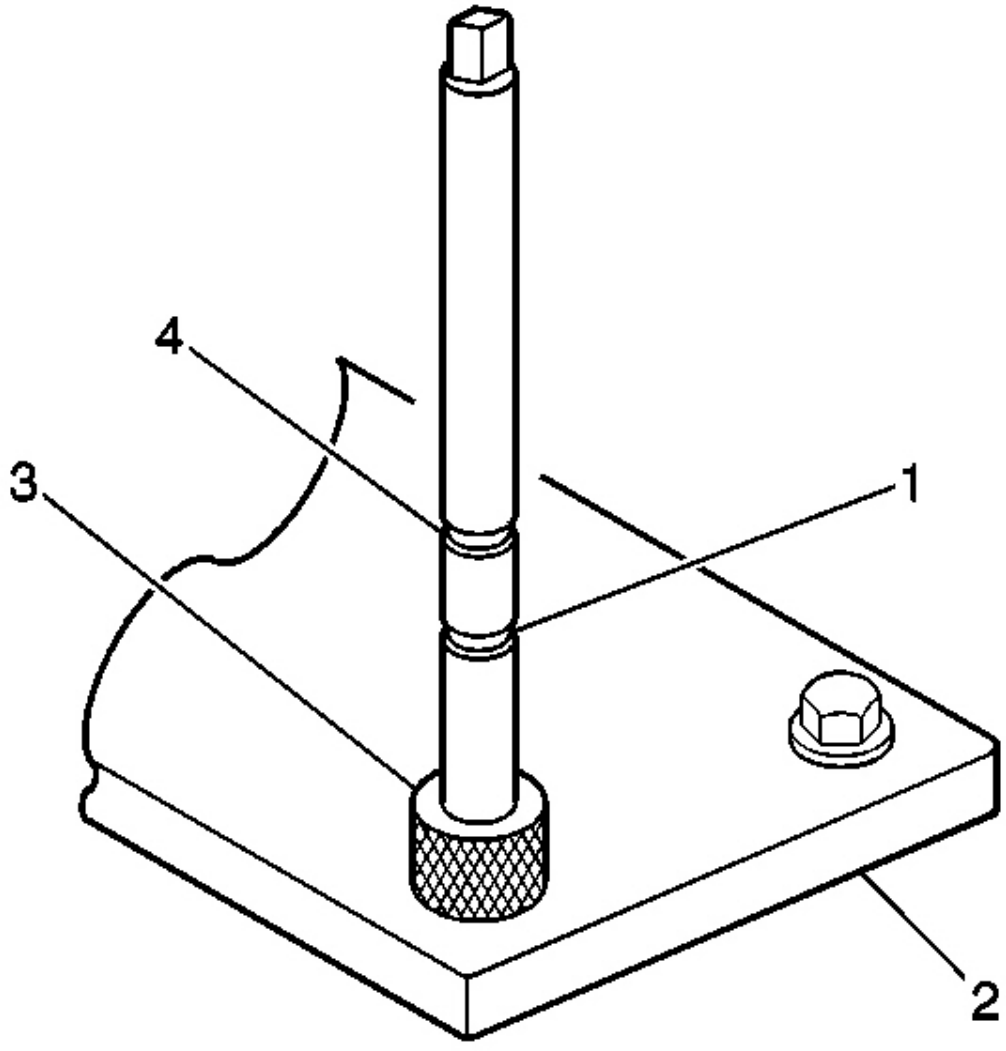


Fig. 548: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (1) on the tap aligns with the top of the drill bushing (3).
11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.

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13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

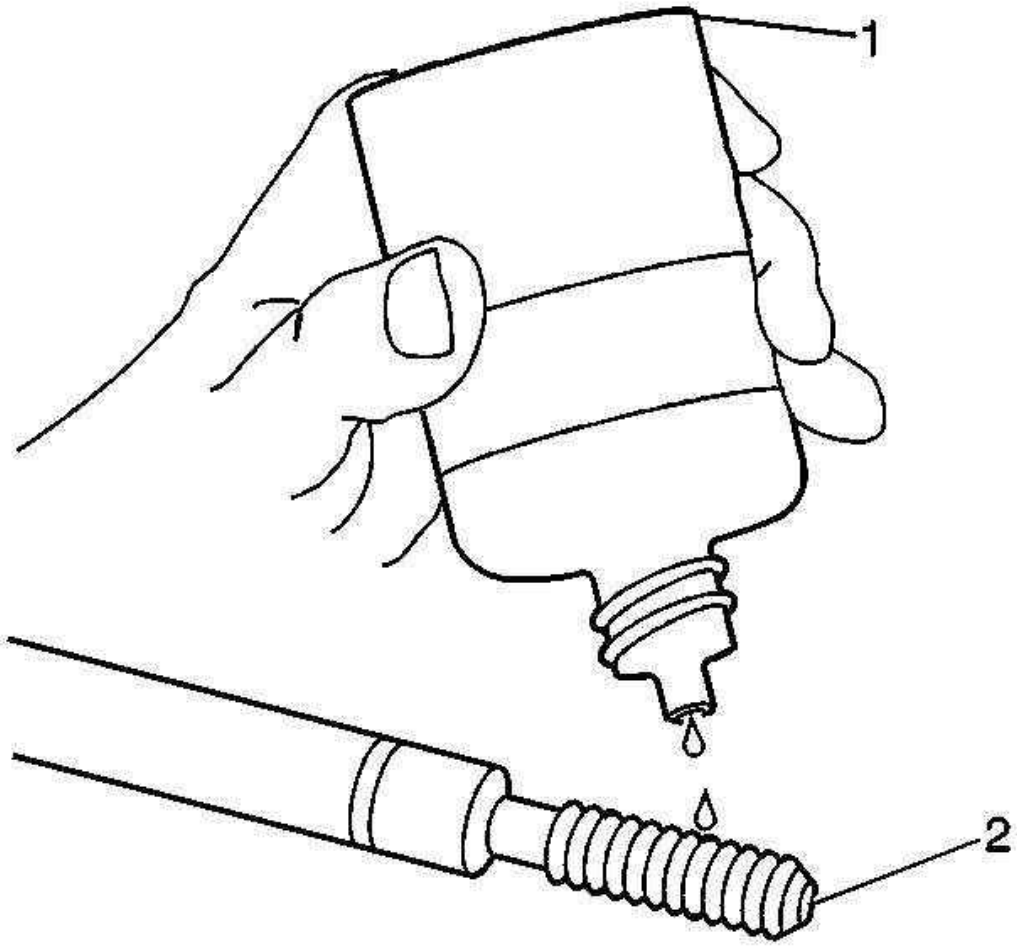


Fig. 549: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or foreign material to contact the OD of the insert.

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15. Lubricate the threads of the installer tool (2) with the driver oil (1).

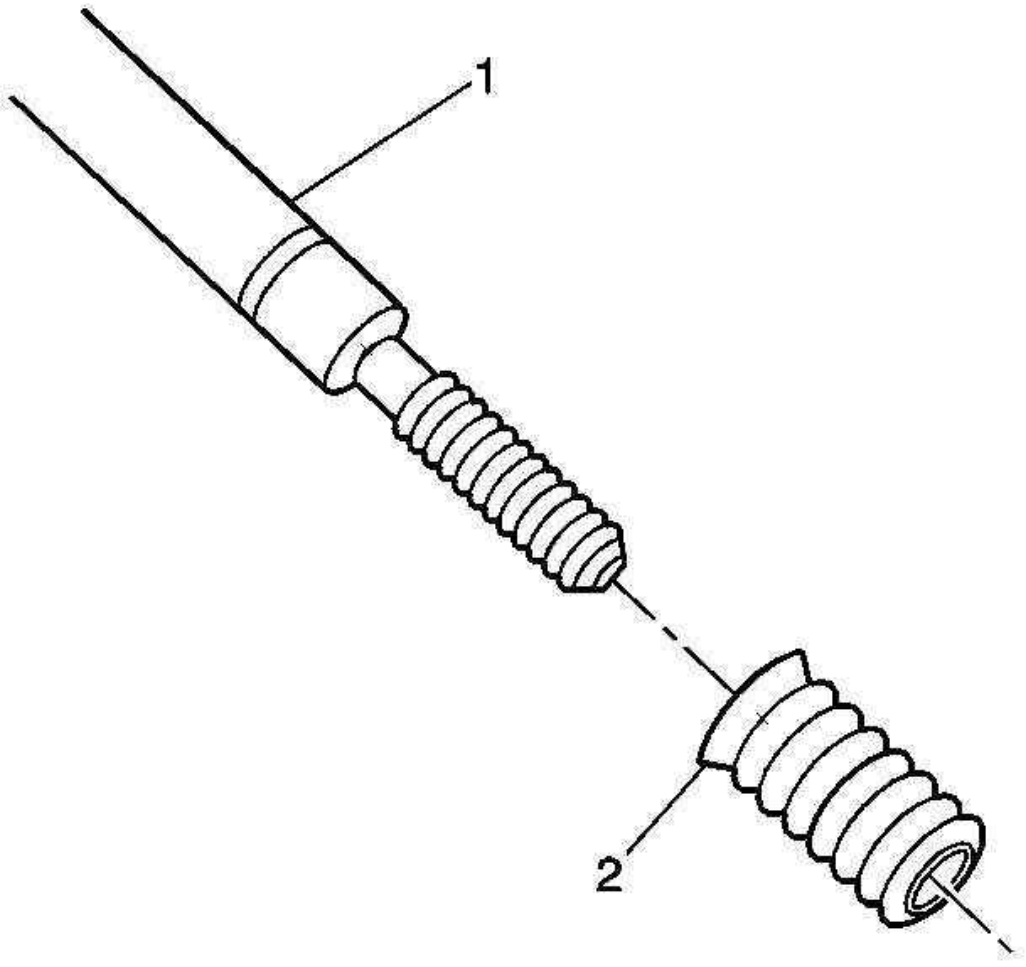


Fig. 550: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

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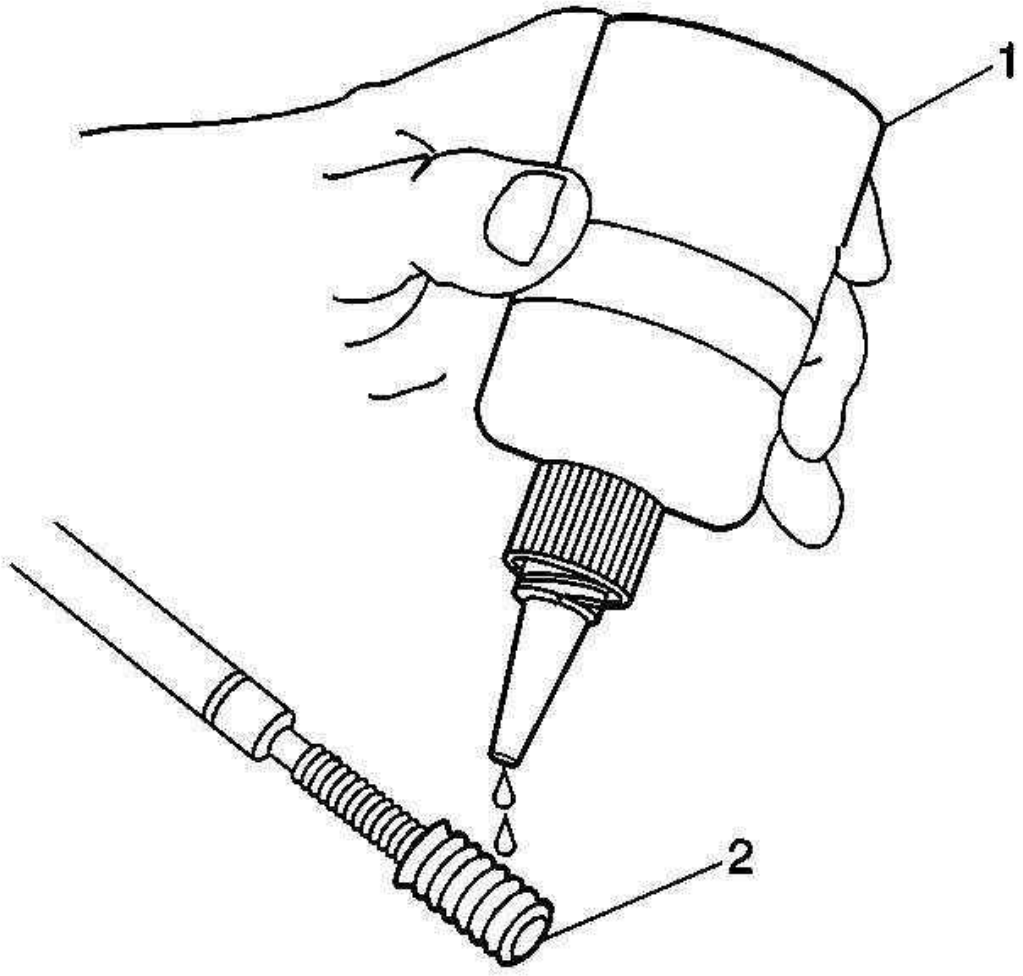


Fig. 551: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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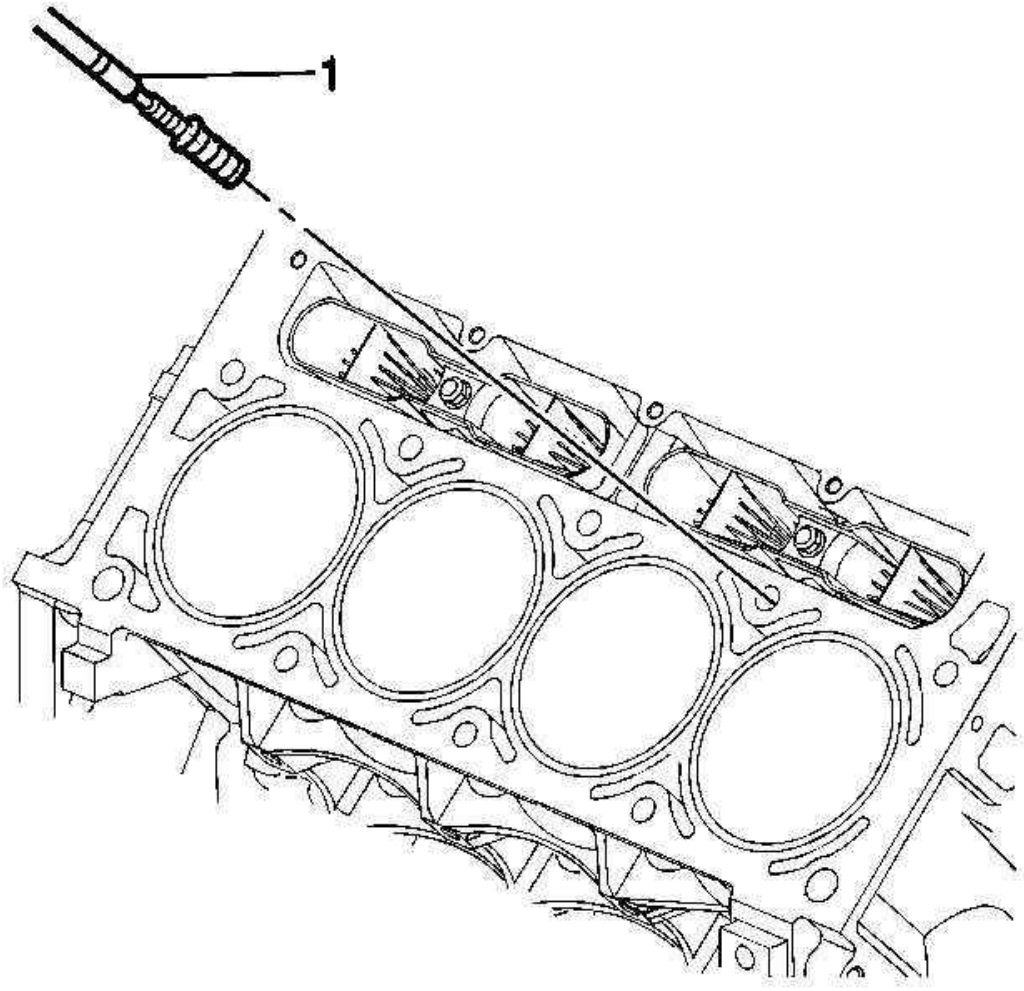


Fig. 552: Installing Insert & Driver Into Cylinder Bolt Hole
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

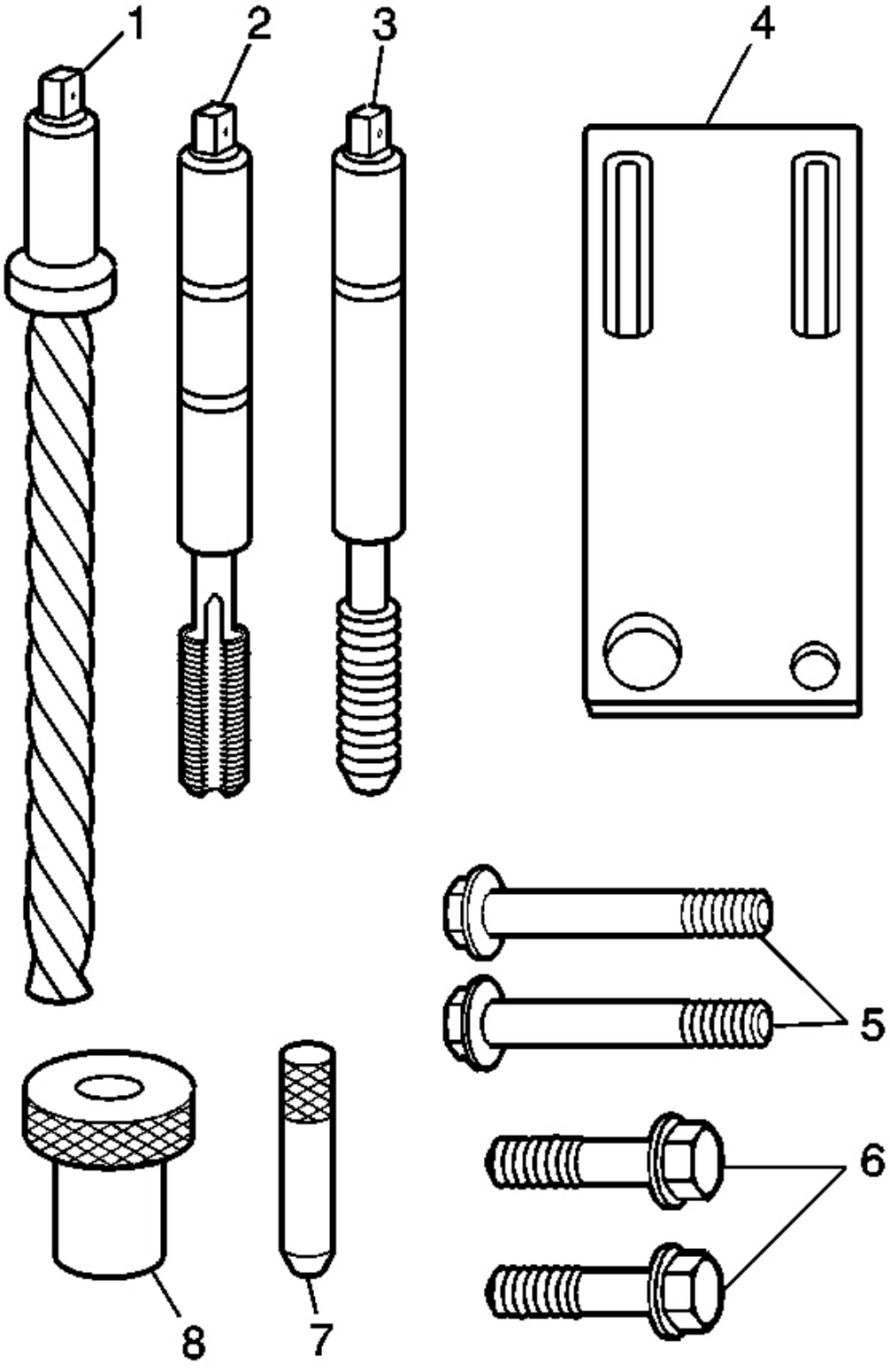
    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and

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mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

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Fig. 553: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The fixture plate (4)
   - The long bolts (5)
   - The short bolts (6)
   - The alignment pin (7)
   - The bushing (8)

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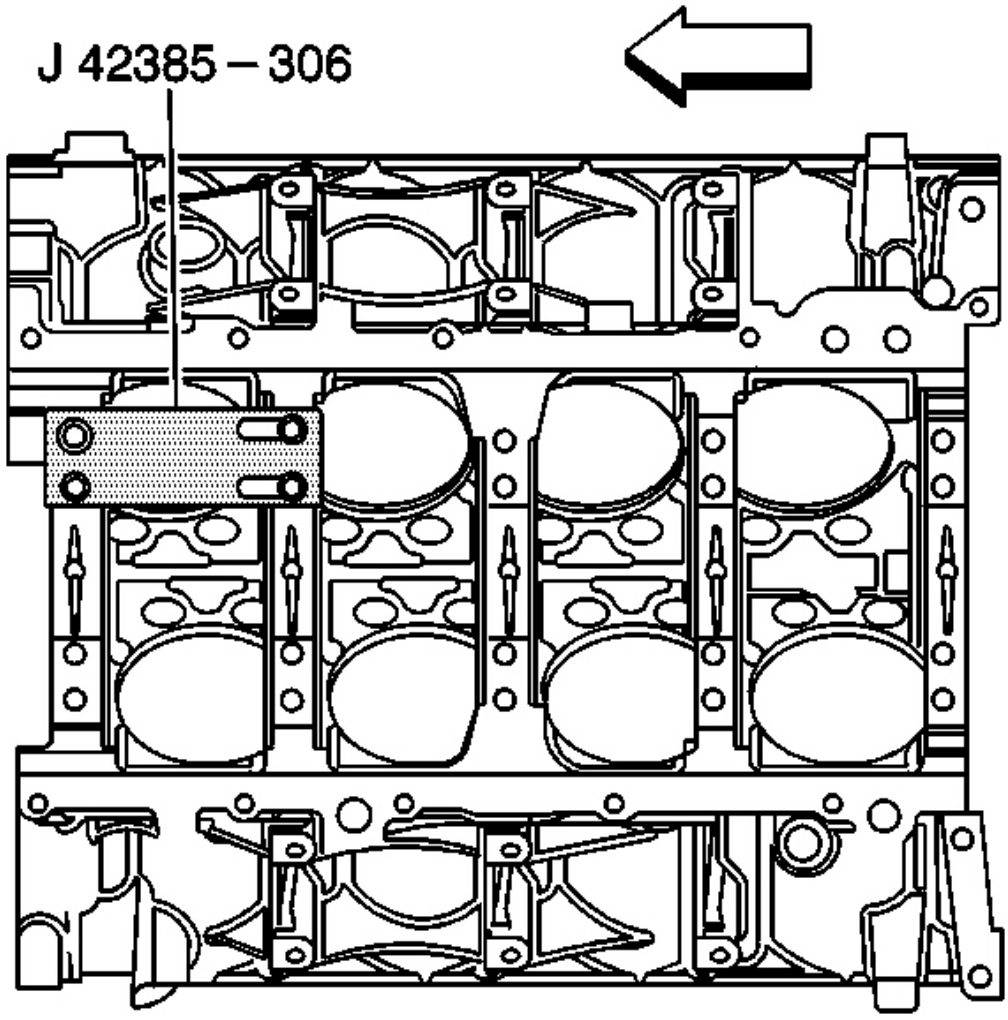


Fig. 554: View Of Fixture Plate, Bolt & Bushing
Courtesy of GENERAL MOTORS CORP.

2. Install the fixture plate, bolt, and bushing onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

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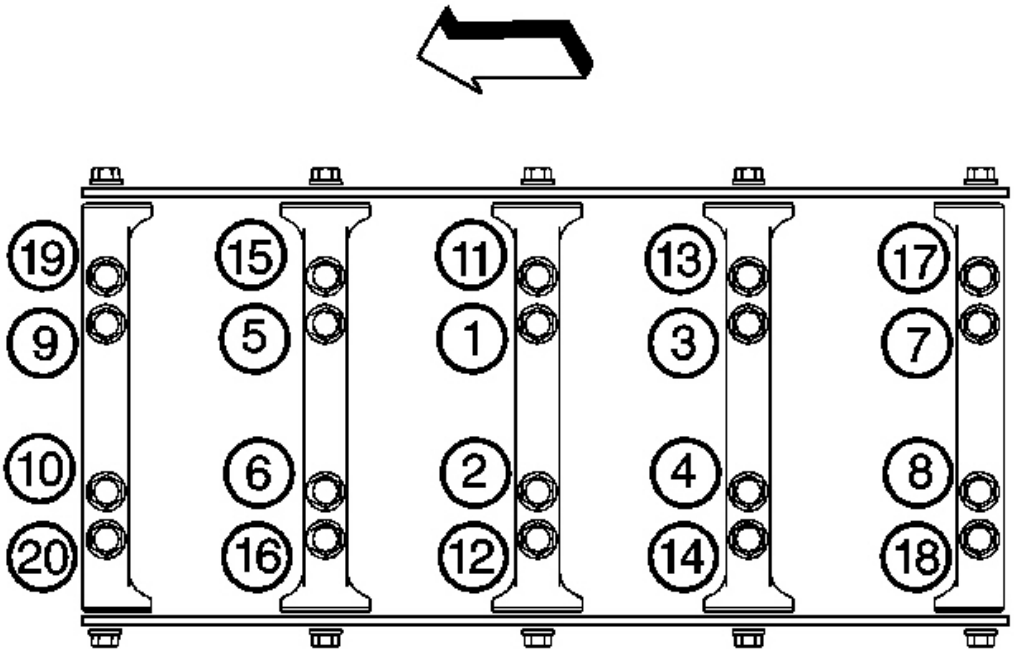


Fig. 555: Identifying Main Cap Bolt Hole Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Drill out the damaged hole.

   The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

   Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.

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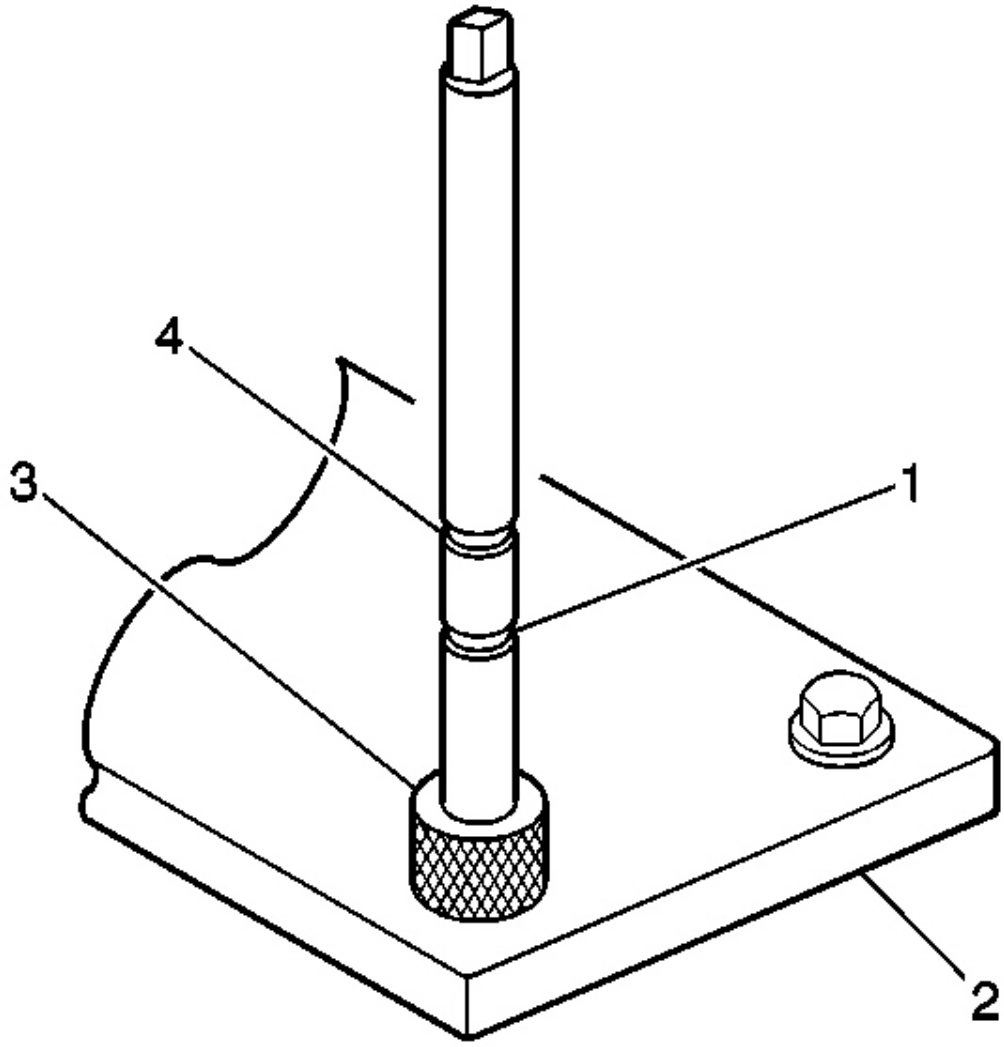


Fig. 556: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

6. Using a tap wrench, tap the threads of the drilled hole.

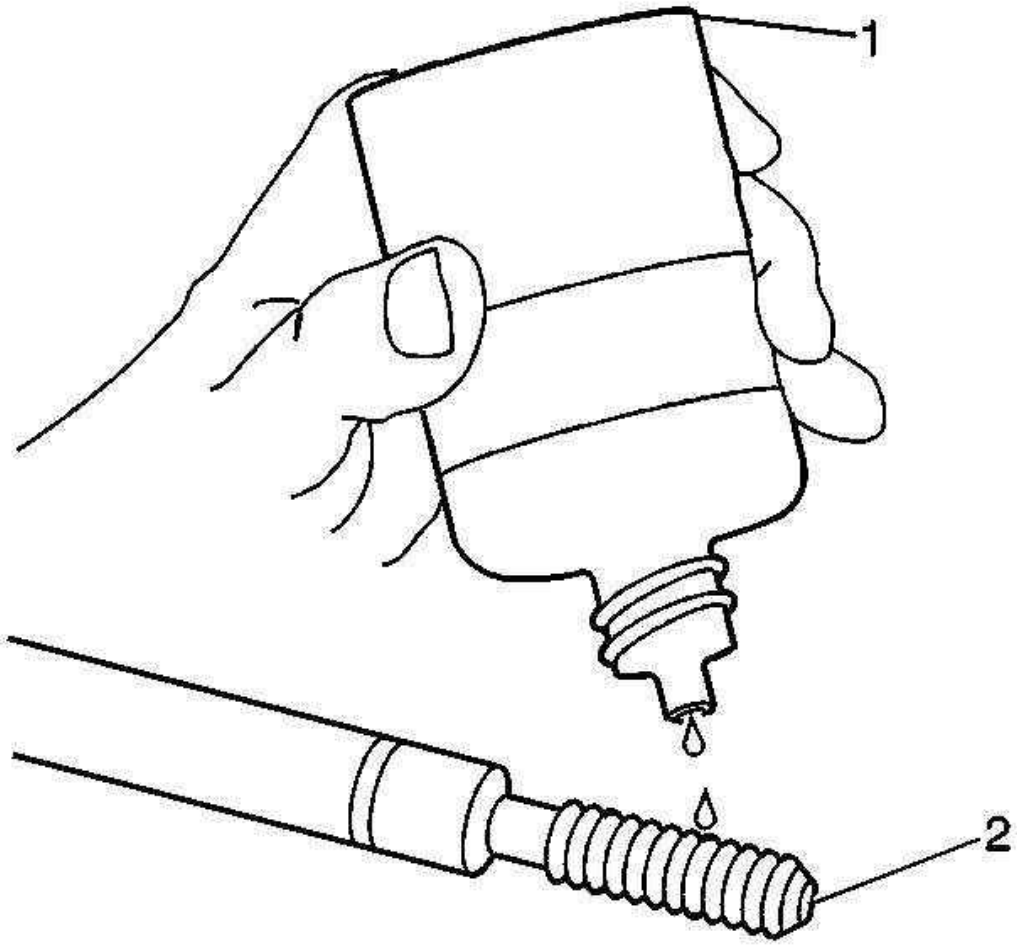
   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

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For the deeper main cap holes 1-10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

For the shallower main cap holes 11-20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), or equivalent, into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.



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Fig. 557: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or foreign material to contact the OD of the insert.

10. Lubricate the threads of the installer tool (2) with the driver oil (1).

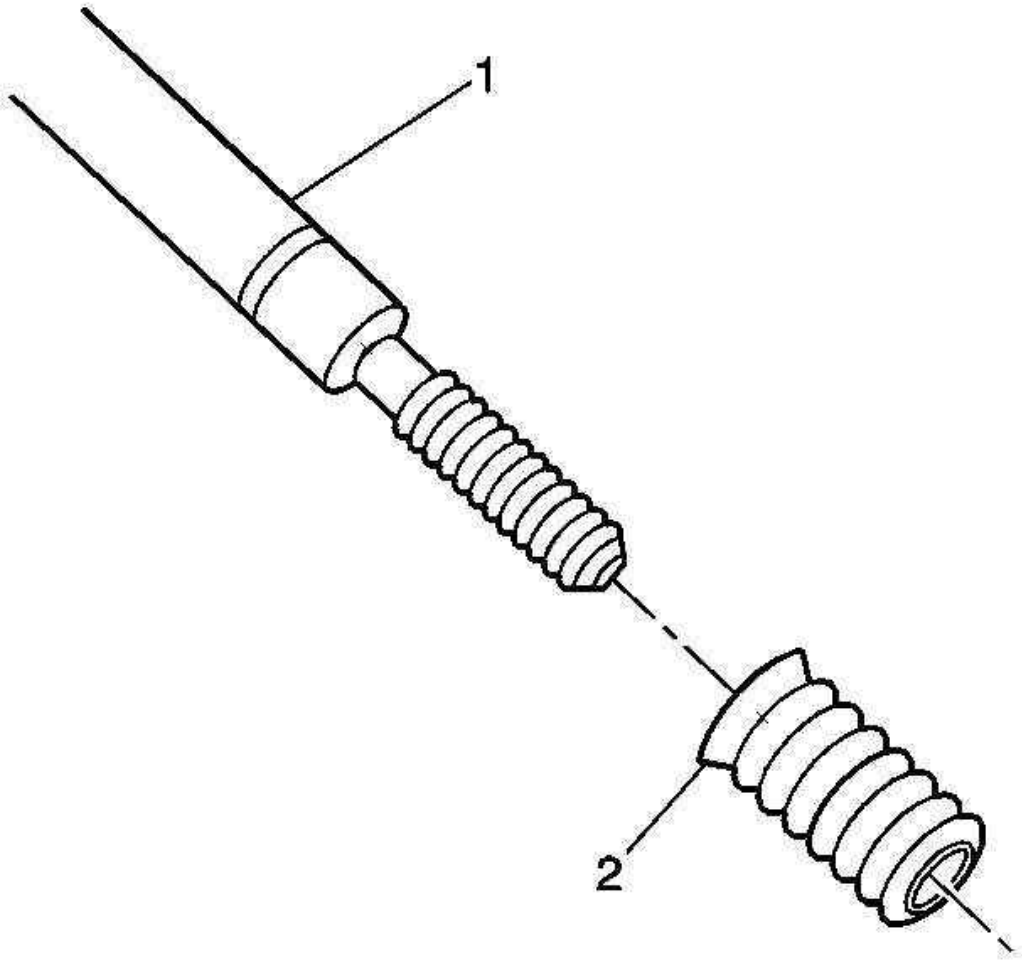


Fig. 558: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

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11. Install the insert (2) onto the driver tool (1).

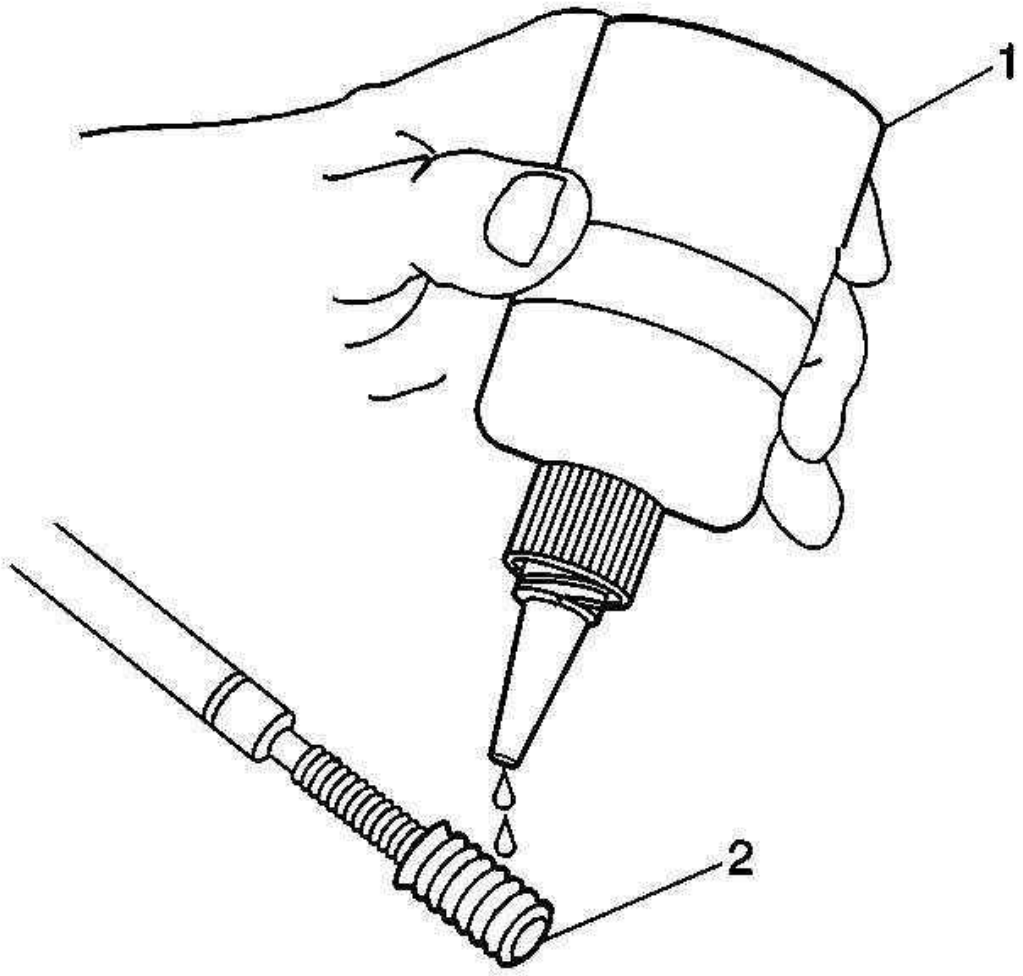


Fig. 559: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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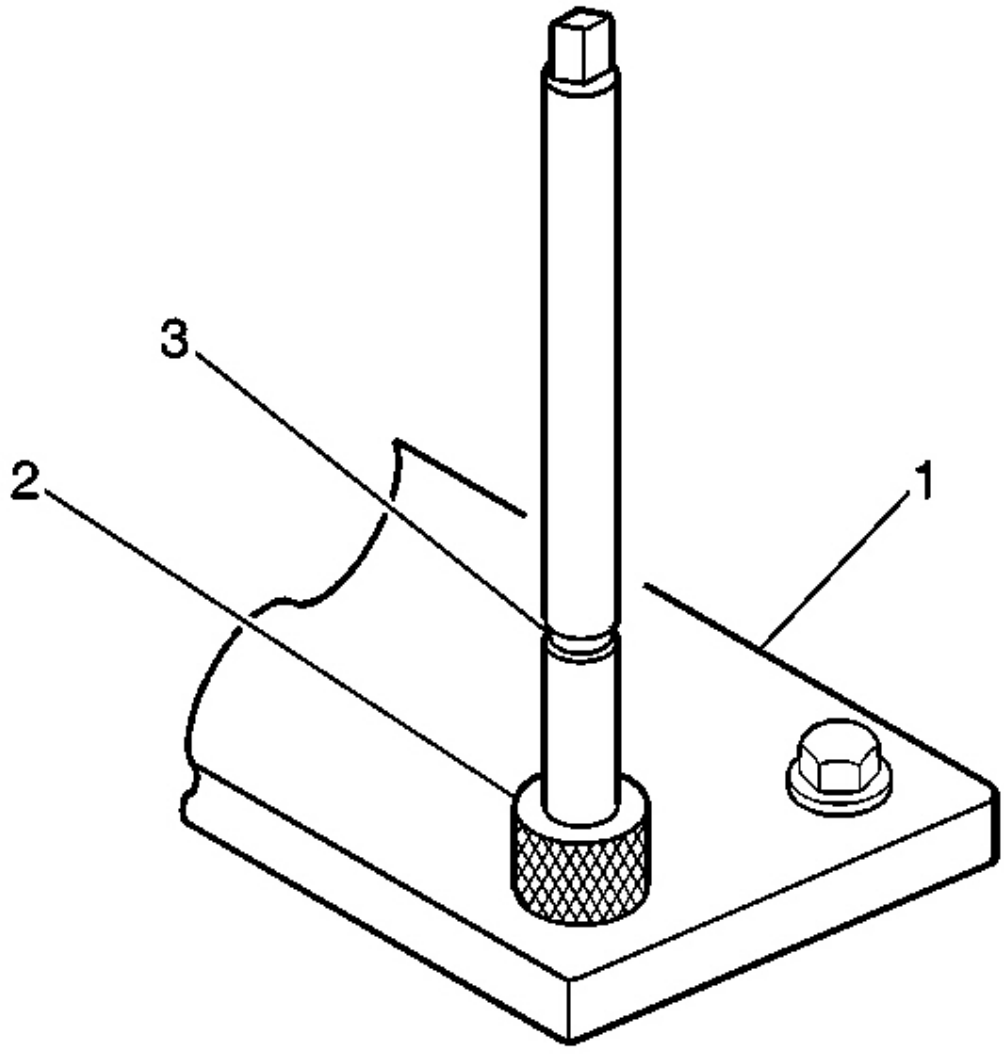


Fig. 560: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into

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the hole.

Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

SERVICE PRIOR TO ASSEMBLY

- Dirt or debris causes premature wear of the rebuilt engine. Clean all components. Refer to **Cleanliness and Care**.
- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position, and direction. Refer to **Separating Parts**.
- During assembly, lubricate all moving parts with clean engine oil. This provides initial lubrication when the engine is first started.

ENGINE BLOCK PLUG INSTALLATION

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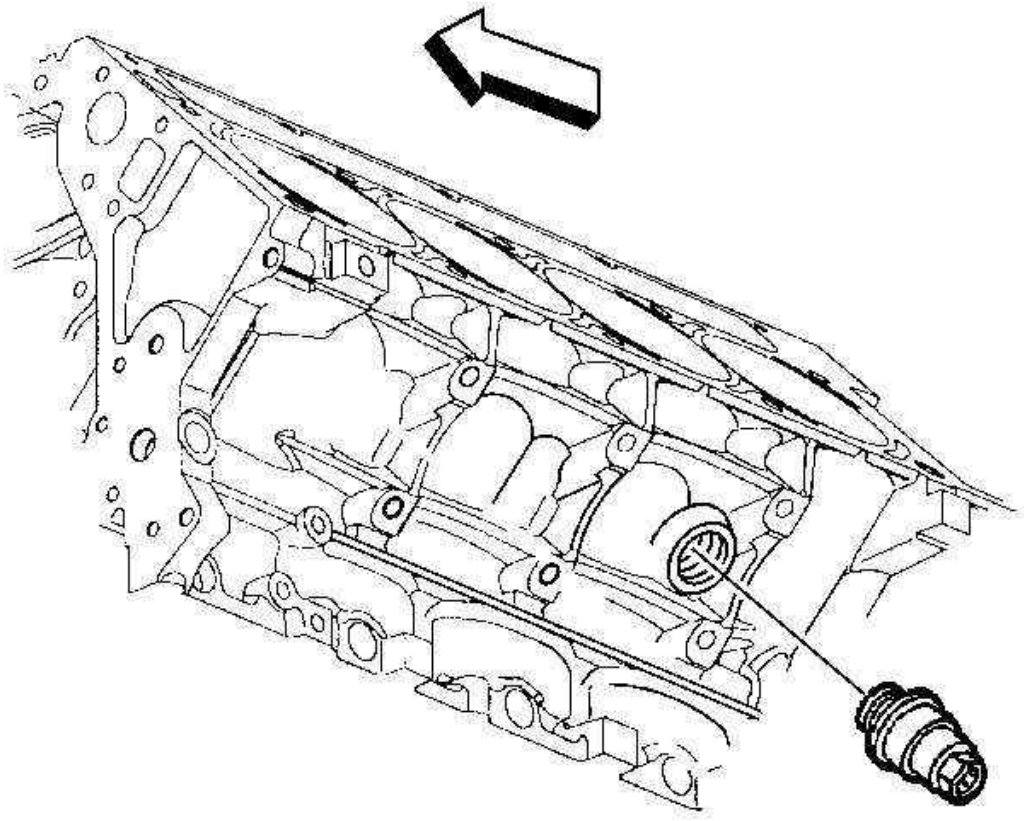


Fig. 561: Identifying Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Engine block plug, oil gallery, and coolant sealing washers may be used again if not bent, scored or otherwise damaged.

1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer, if applicable. Refer to **Sealers, Adhesives, and Lubricants**.

NOTE: Refer to Fastener Notice .

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2. Install the engine block coolant heater to the engine block.

   Tighten: Tighten the block coolant heater to 50 N.m (37 lb ft).

3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant drain hole plug sealing washer.

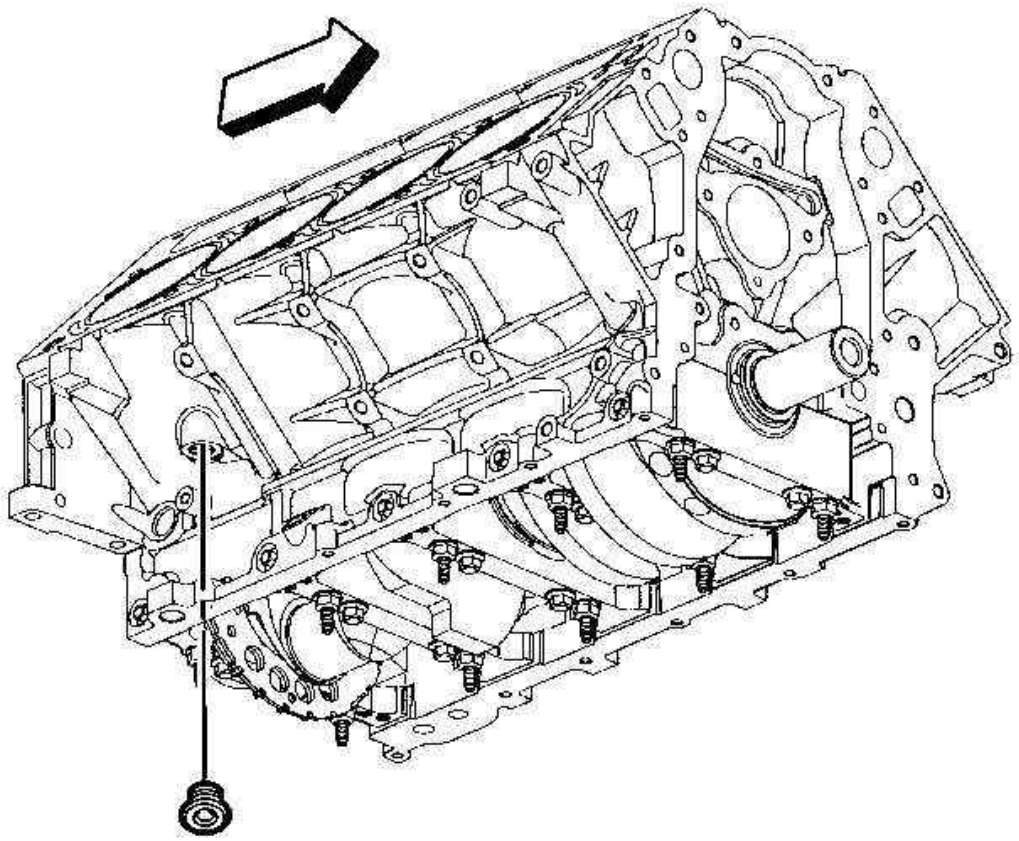


Fig. 562: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

4. Install the engine block coolant drain hole plug.

   Tighten: Tighten the coolant drain hole plug to 60 N.m (44 lb ft).

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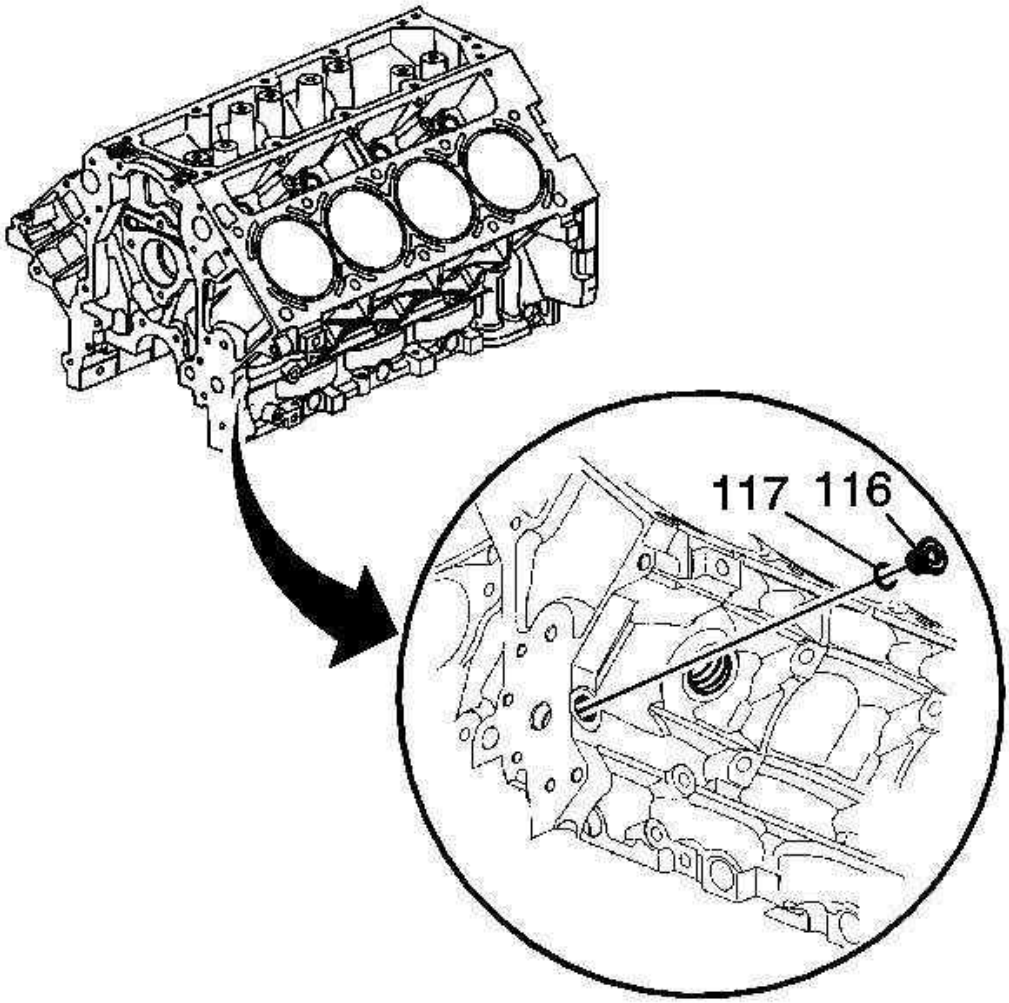


Fig. 563: Locating Engine Block Left Front Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer (117).
6. Install the engine block left front oil gallery plug (116).

   Tighten: Tighten the block left front oil gallery plug to 60 N.m (44 lb ft).

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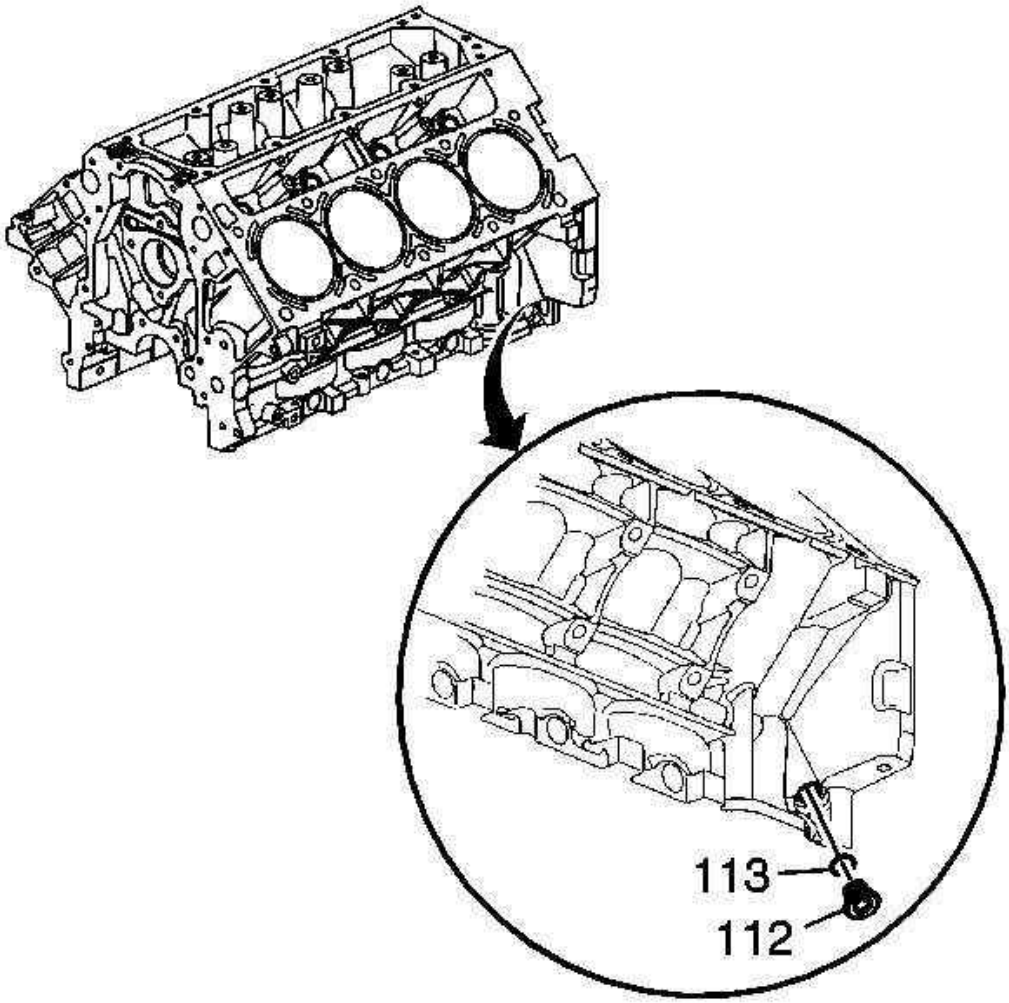
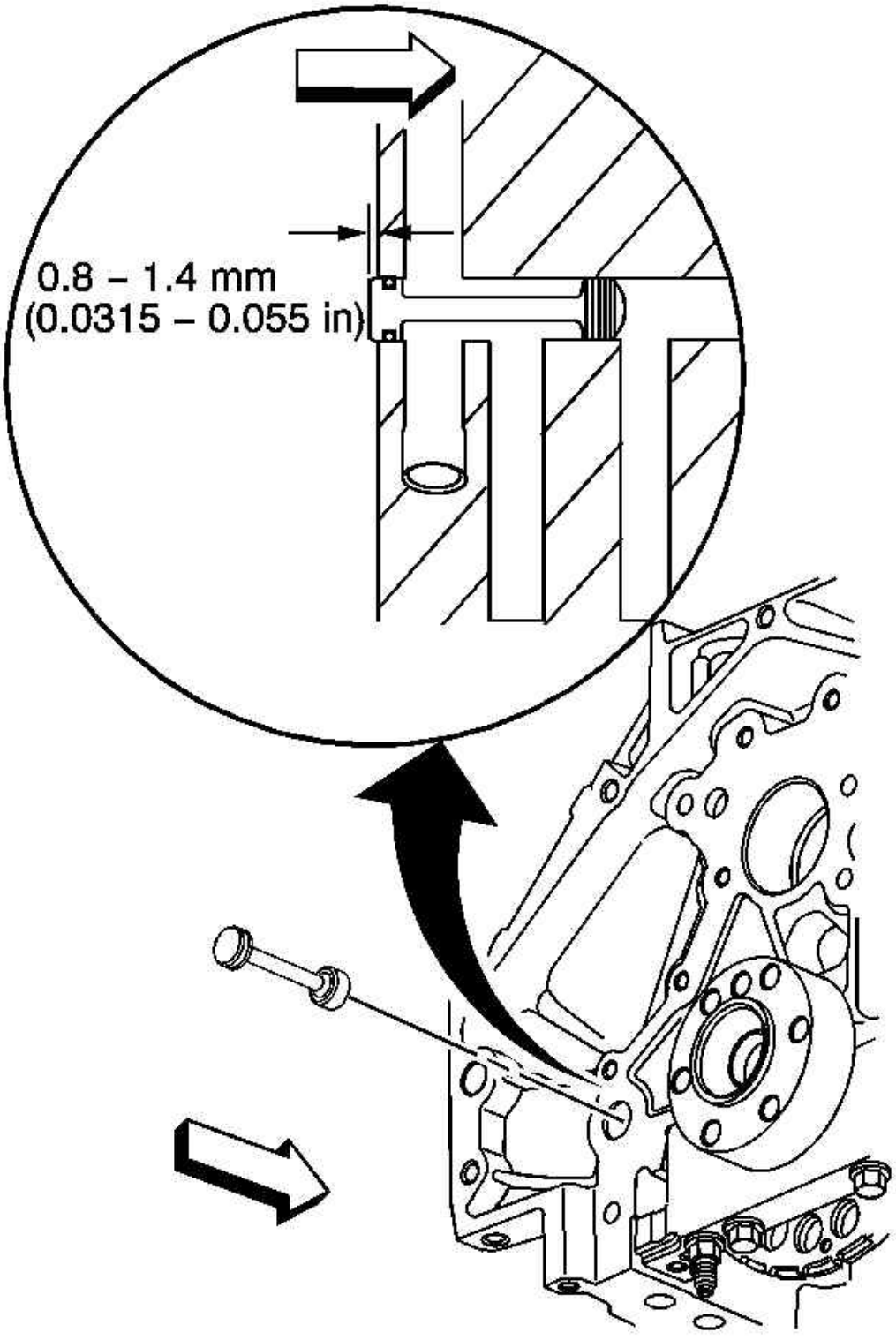


Fig. 564: Locating Engine Block Left Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer (113).
8. Install the engine block left rear oil gallery plug (112).

   Tighten: Tighten the block left rear oil gallery plug to 60 N.m (44 lb ft).

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Fig. 565: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

9. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be used again.
10. Lubricate the O-ring seal with clean engine oil.
11. Install the O-ring seal onto the plug.
12. Install the engine block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.

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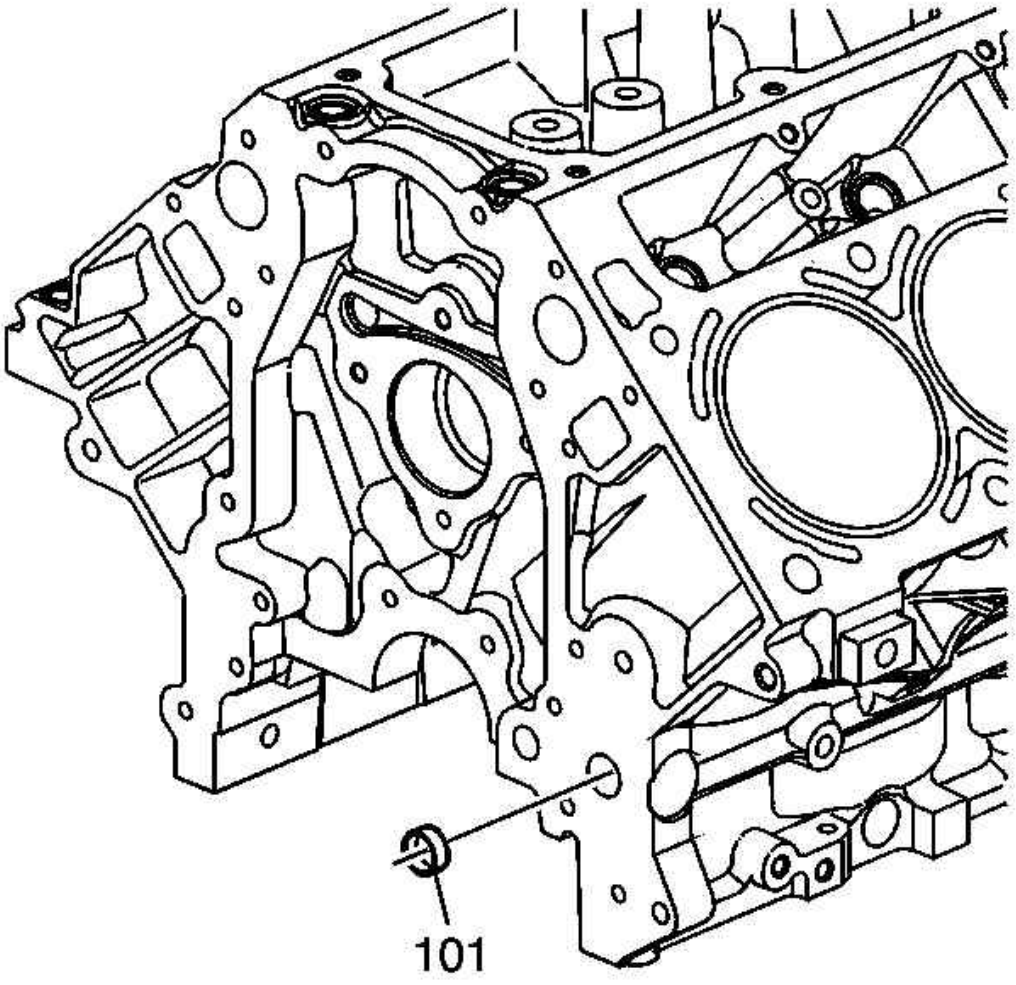


Fig. 566: Locating Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug (101).

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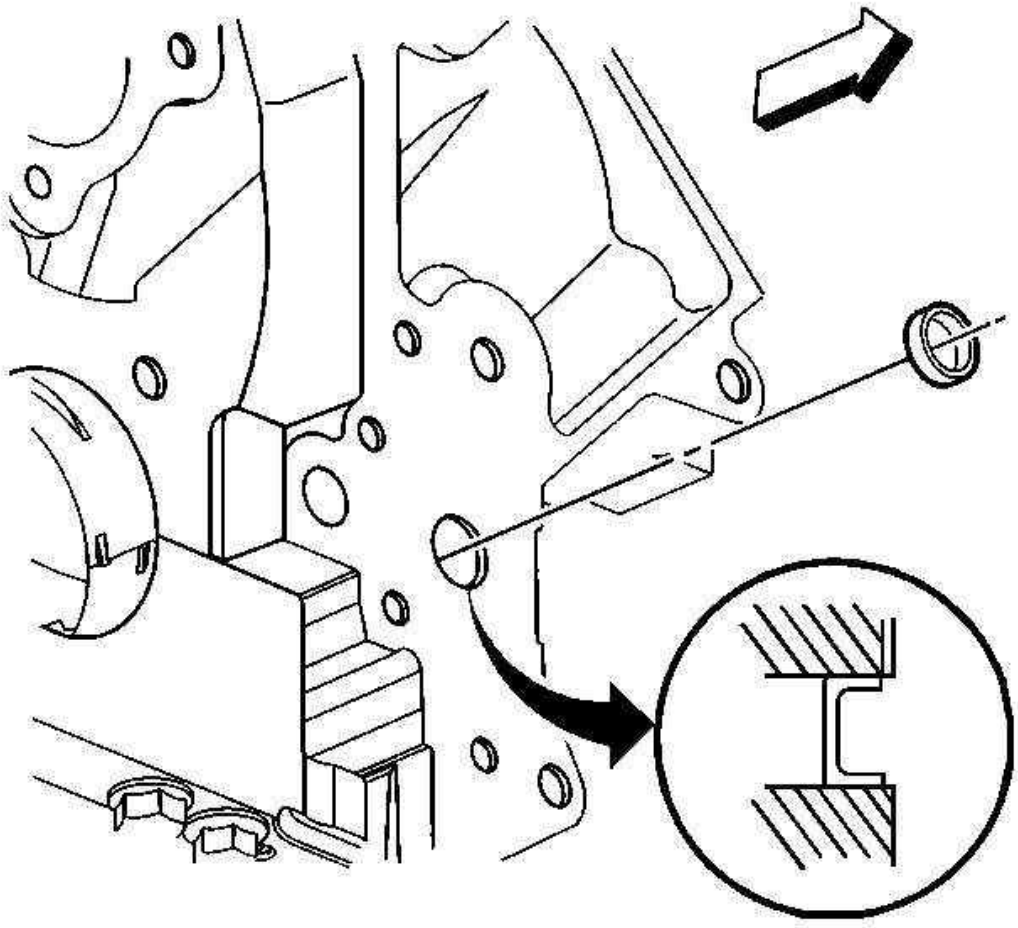


Fig. 567: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

14. Install a NEW engine block front oil gallery plug. Install the plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.

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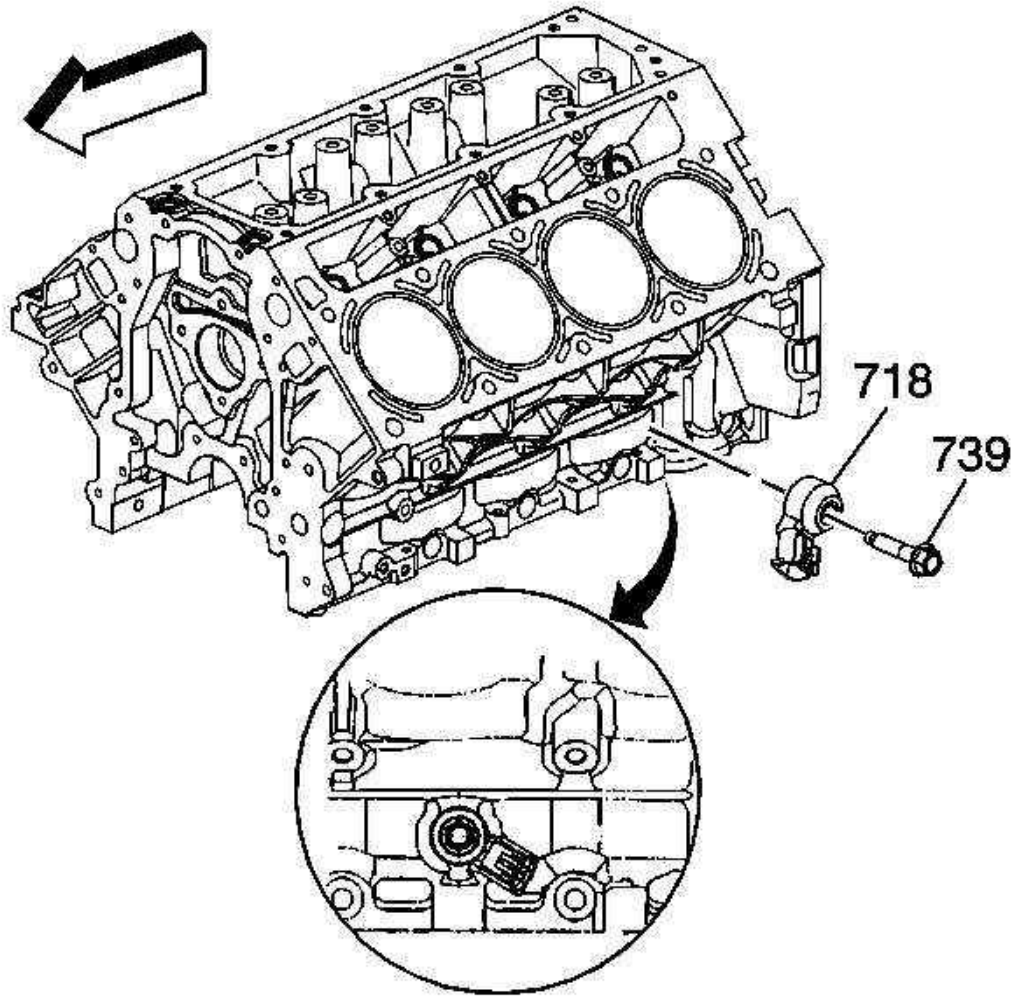


Fig. 568: View Of Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Install the left side knock sensor (718) and bolt (739).

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

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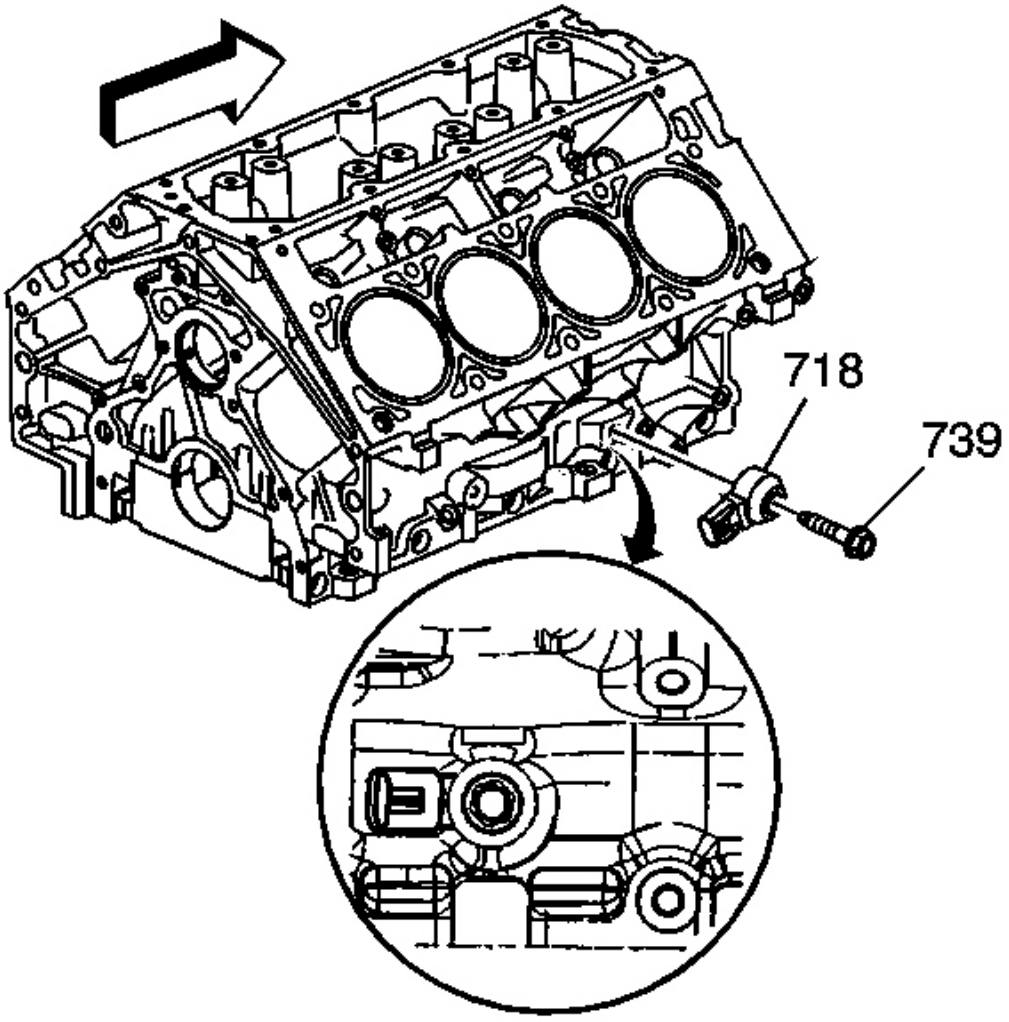


Fig. 569: Identifying Knock Sensor
Courtesy of GENERAL MOTORS CORP.

16. Install the right side knock sensor (718) and bolt (739).

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

CRANKSHAFT AND BEARING INSTALLATION

Tools Required

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J 45059 Angle Meter

Installation Procedure

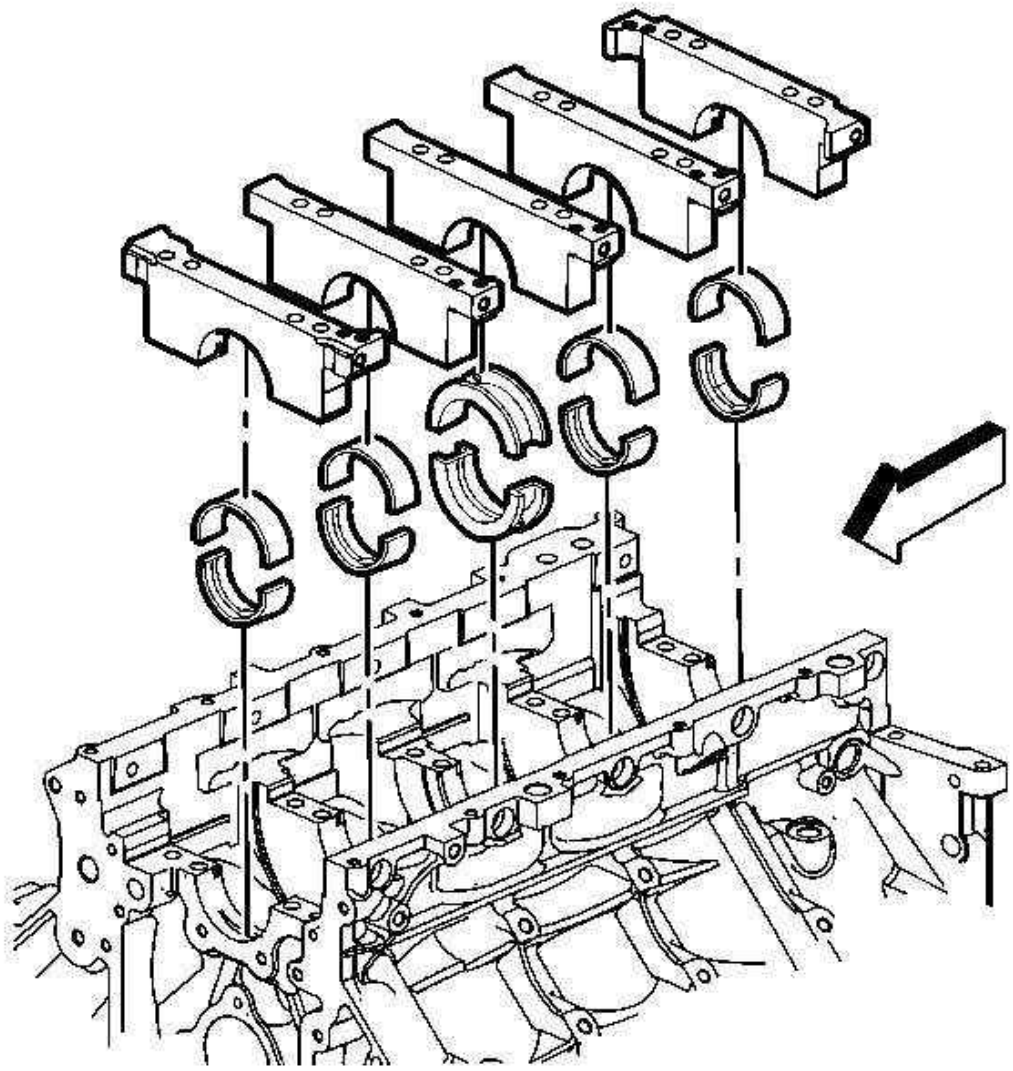


Fig. 570: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Crankshaft bearing clearances are critical.**

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Excessive crankshaft bearing clearance may affect crankshaft position sensor signals and/or on-board diagnostics (OBD) II system performance.

- **Crankshaft bearing caps must be installed to the proper location and direction.**
- **When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.**
- **Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.**
- **To prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.**

The crankshaft bearing cap M8 side bolts have a pre-applied sealant patch applied to the bolt flange.

1. Install the crankshaft bearings to the engine block and bearing caps. The thrust bearings are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

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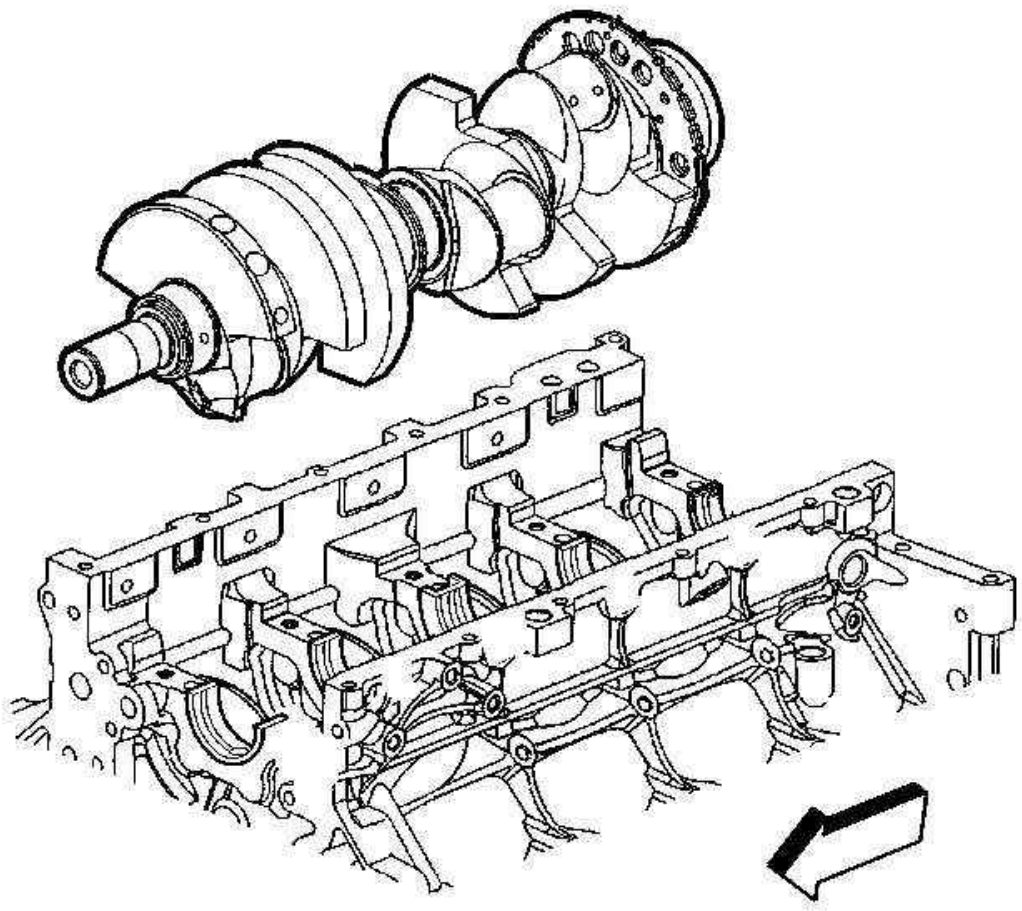


Fig. 571: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft.

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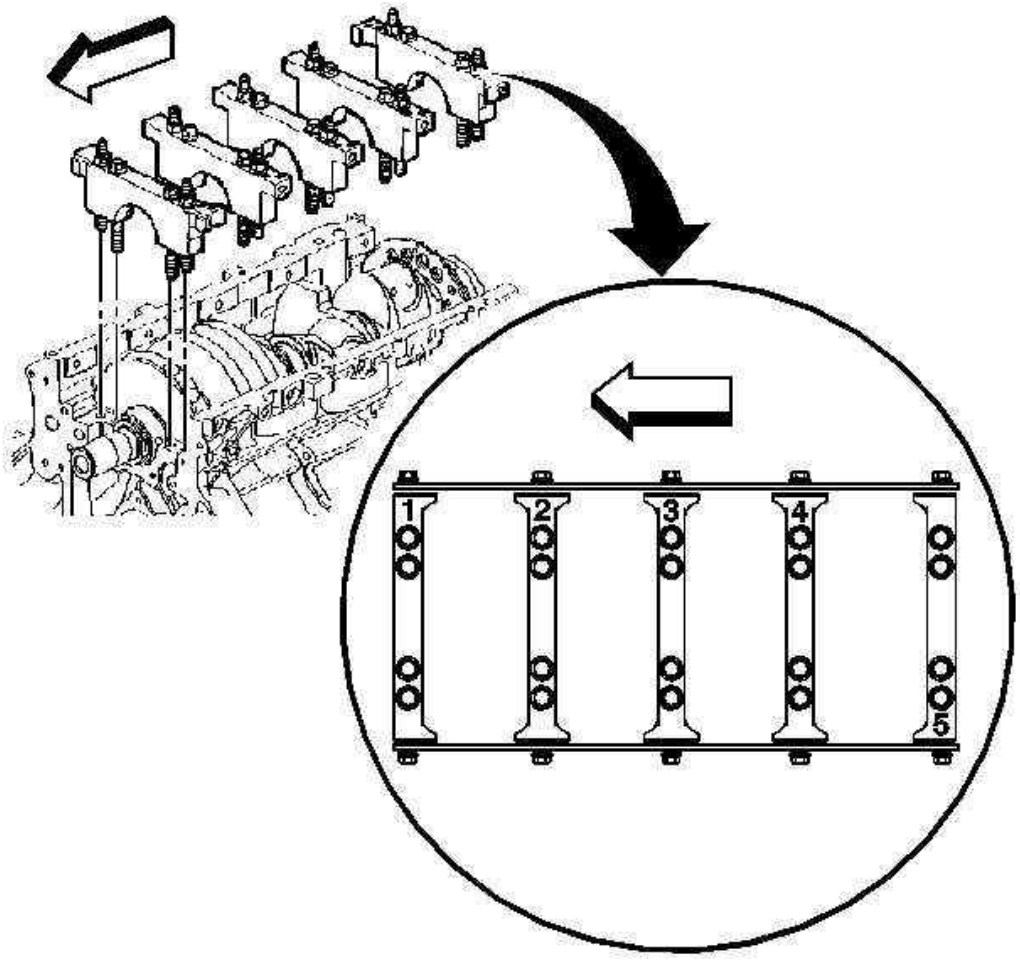


Fig. 572: View Of Proper Bearing Cap Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The bearing caps must be installed in the proper location and direction.

4. Install the crankshaft bearing caps, with bearings, into the engine block.

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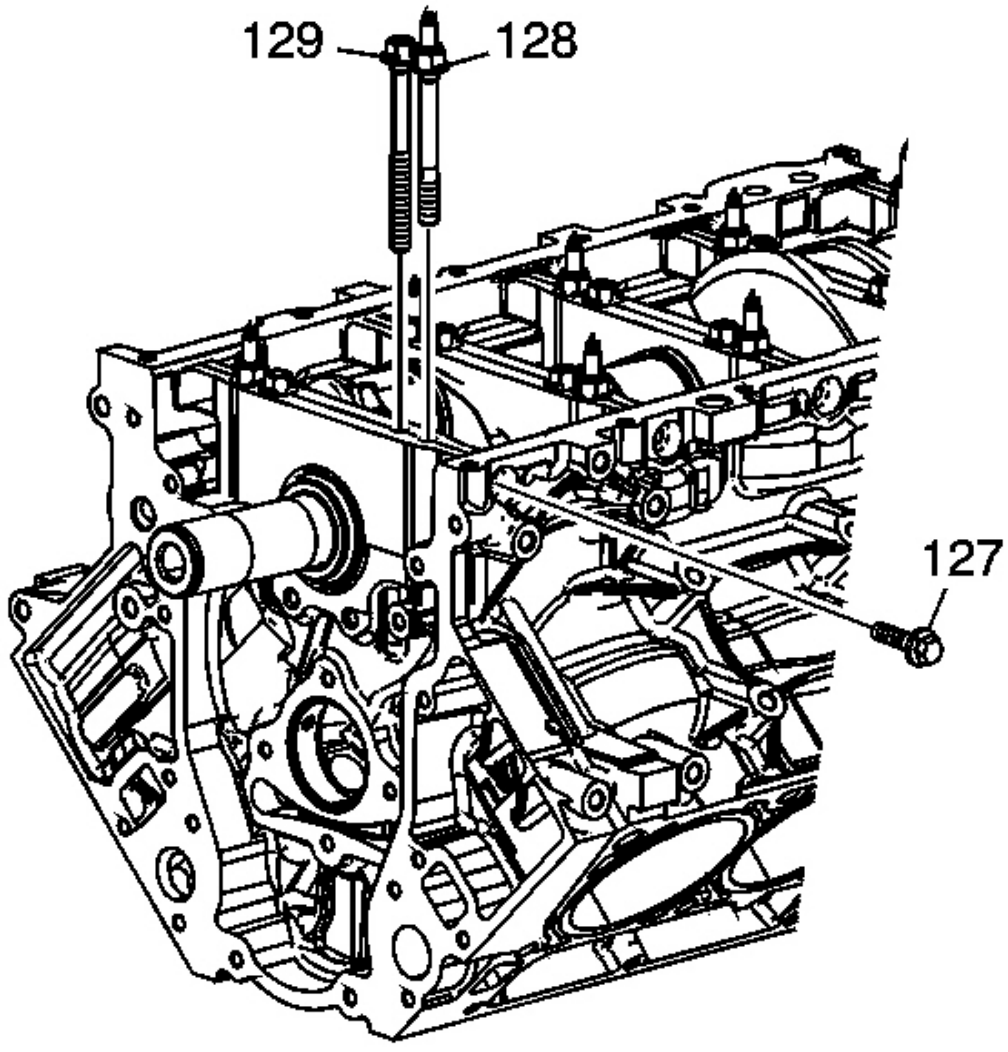


Fig. 573: Identifying Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

5. Install the M10 bolts (129) and M10 studs (128).
6. Tap the bearing caps into place with a plastic-face hammer.
7. Install the NEW M8 bearing cap side bolts (127).

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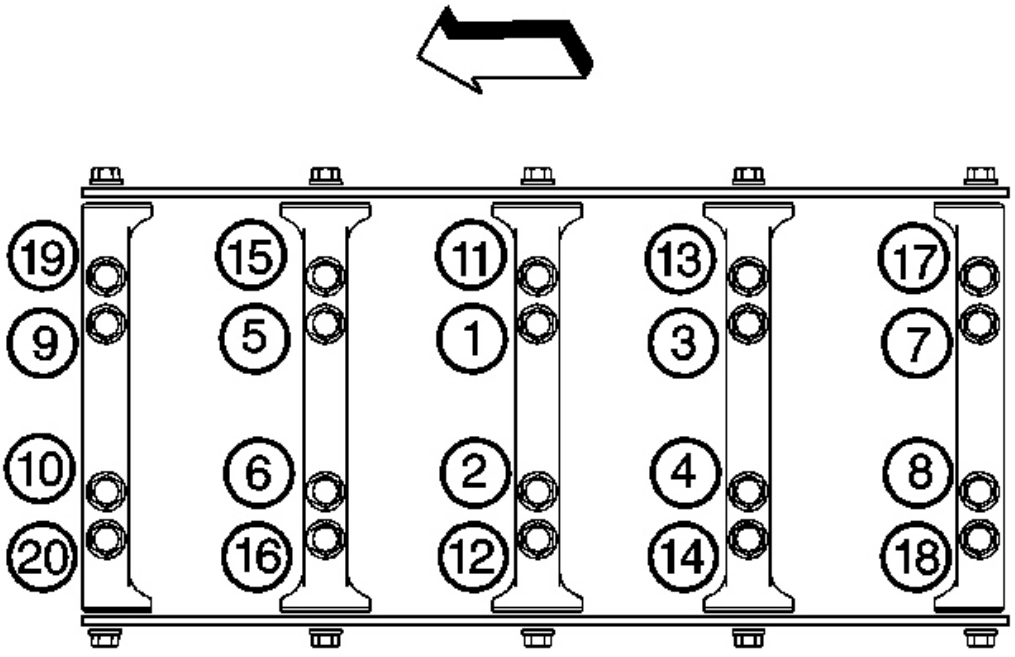


Fig. 574: Identifying Main Cap Bolt Hole Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the bearing cap M10 bolts (1-10).

   Tighten: Tighten the M10 bearing cap bolts (1-10) a first pass in sequence to 20 N.m (15 lb ft).

   IMPORTANT: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward direction.

9. Using a plastic-face hammer, tap the crankshaft rearward, then forward to align the thrust bearings.

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Tighten:

1. Tighten the M10 bolts (1-10) a final pass in sequence 80 degrees using the **J 45059** .
2. Tighten the M10 studs (11-20) a first pass in sequence to 20 N.m (15 lb ft).
3. Tighten the M10 studs (11-20) a final pass in sequence 51 degrees using the **J 45059** .
4. Tighten the bearing cap M8 bolts to 25 N.m (18 lb ft).

   Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the same bearing cap.

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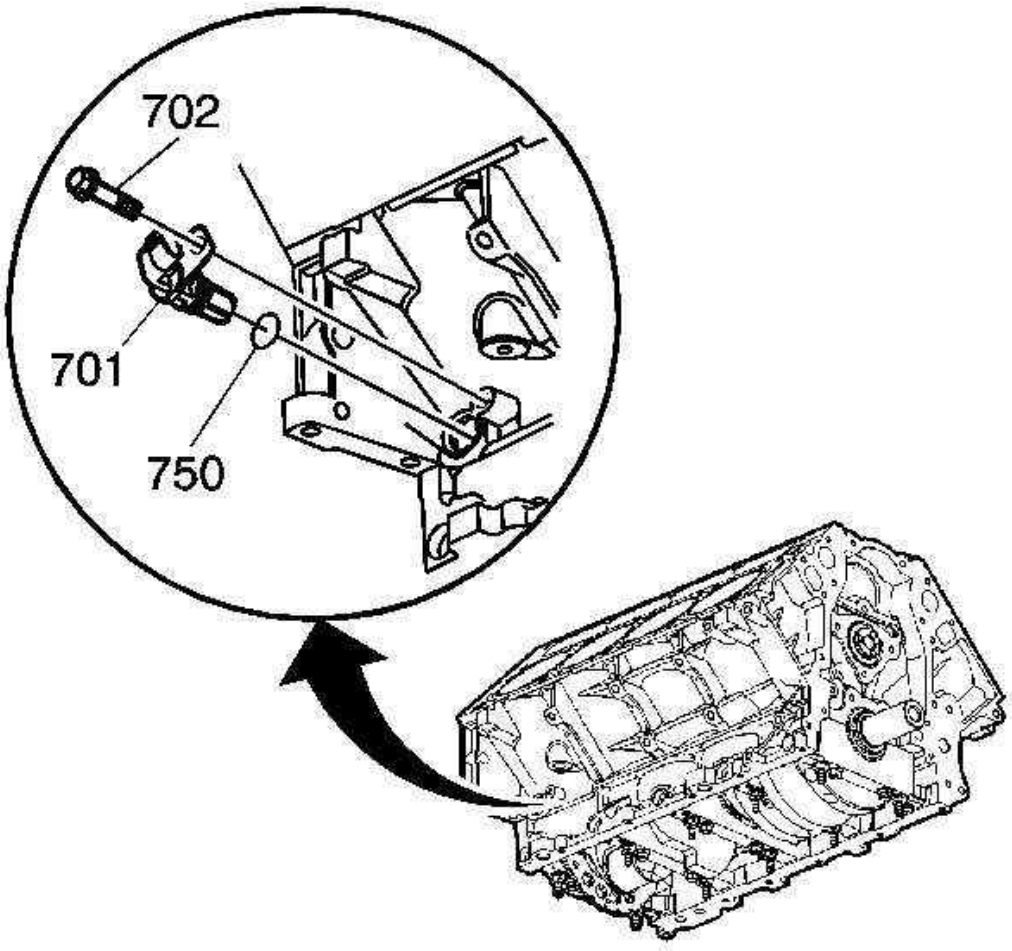


Fig. 575: View Of CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft position (CKP) sensor.
    1. Inspect the CKP sensor O-ring seal (750). If the O-ring seal is not cut or damaged, it may be used.
    2. Coat the O-ring seal with clean engine oil.
    3. Install the O-ring onto the sensor.
    4. Install the sensor (701). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.

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5. Install the sensor bolt (702).

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

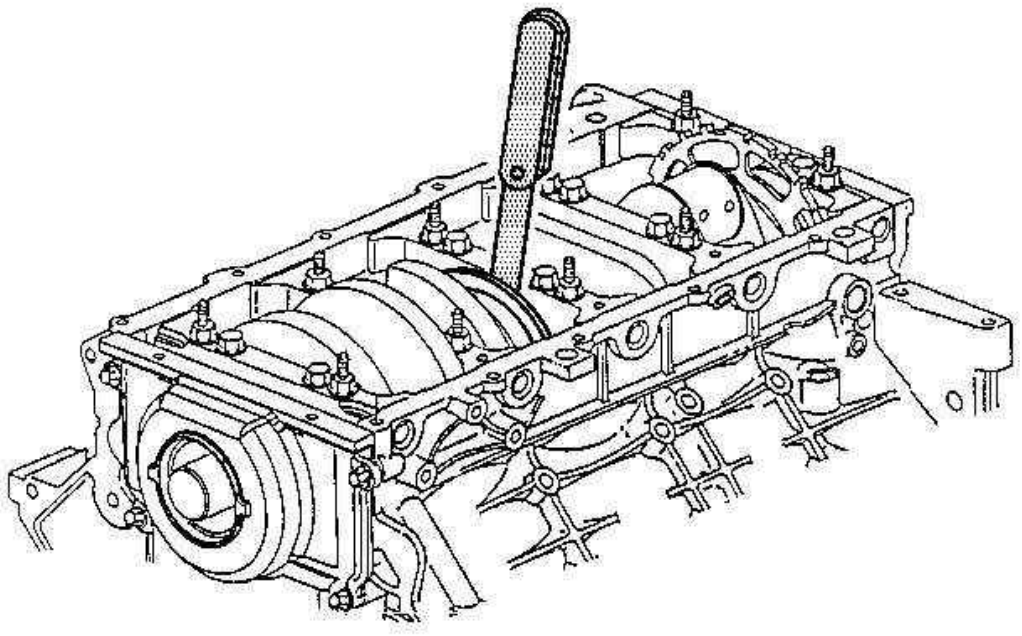


Fig. 576: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gage between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

       The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

    3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

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PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Tools Required

- **J 8037** Piston Ring Compressor
- **J 8087** Cylinder Bore Gage
- **J 41556** Connecting Rod Guide. See **Special Tools**.
- **J 45059** Angle Meter

Piston Selection

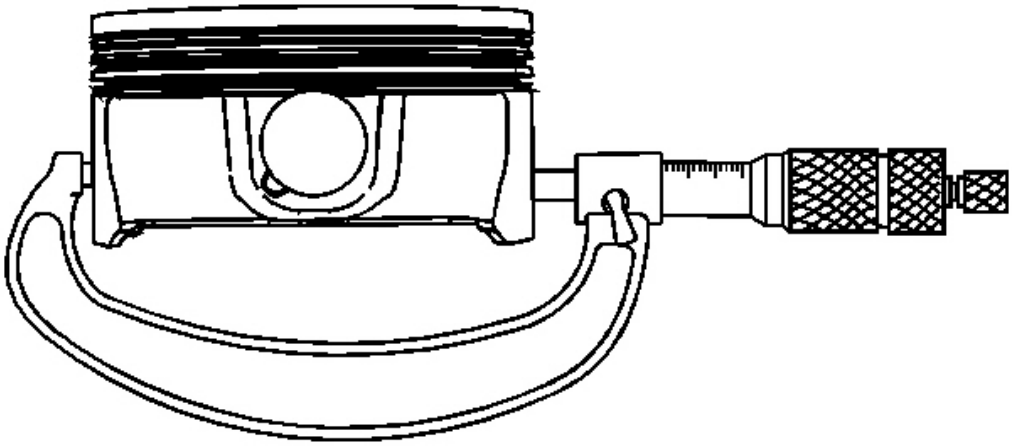


Fig. 577: Measuring Piston Outside Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.

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1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to **Engine Mechanical Specifications**.
2. Record the piston OD.

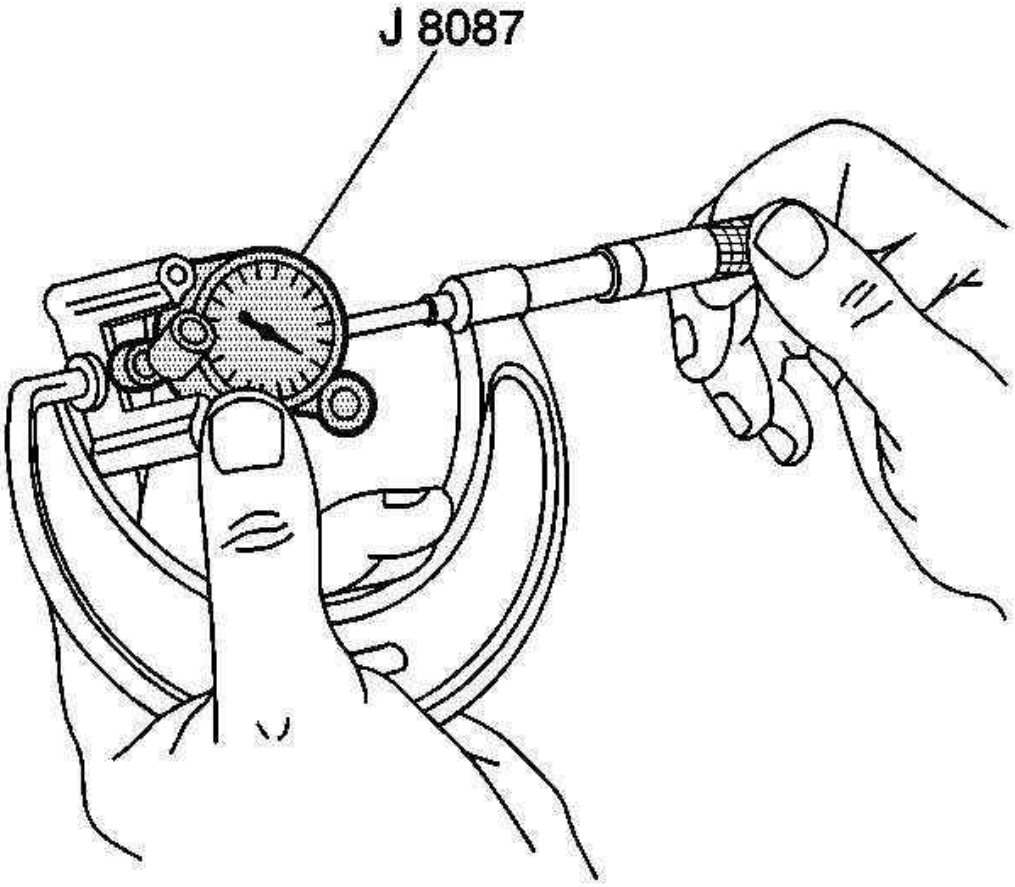


Fig. 578: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **J 8087** into the micrometer and zero the gage dial.

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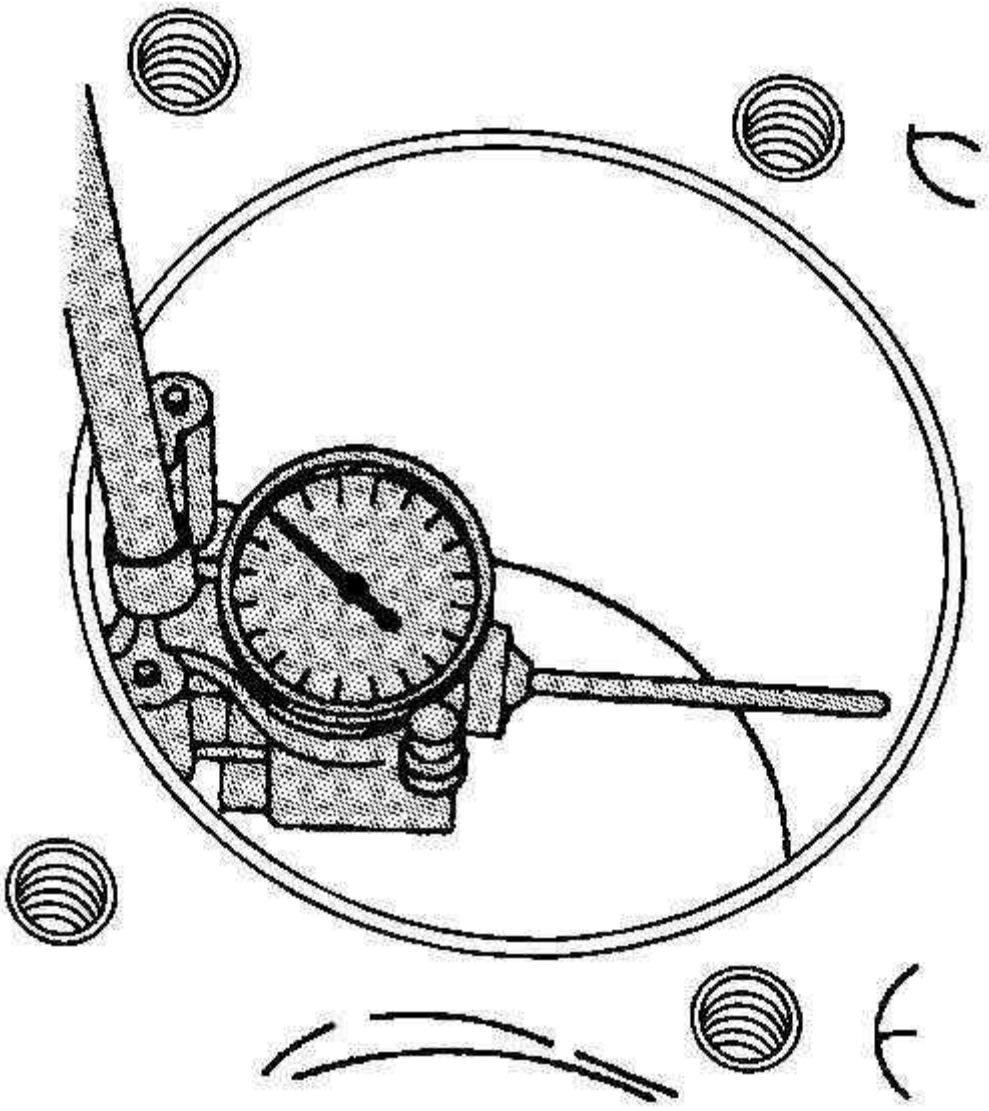


Fig. 579: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 8087** , measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.

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7. Subtract the piston OD from the cylinder bore ID in order to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston and pin assembly and measure the clearances again. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

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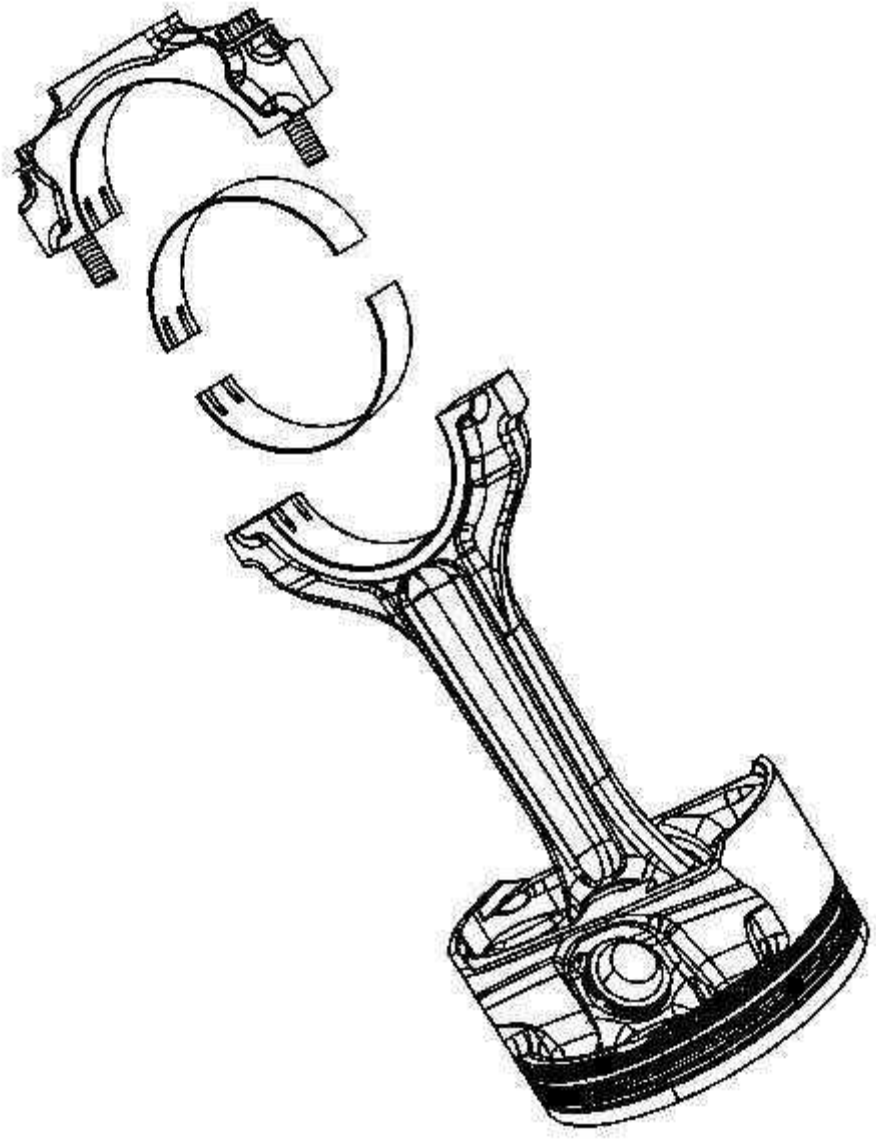


Fig. 580: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the following components with clean engine oil:
   - Piston

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- Piston rings
- Cylinder bore
- Bearings and bearing surfaces

2. Install the bearings to the connecting rod and cap.
3. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
4. Position the compression ring end gaps 180 degrees opposite each other.

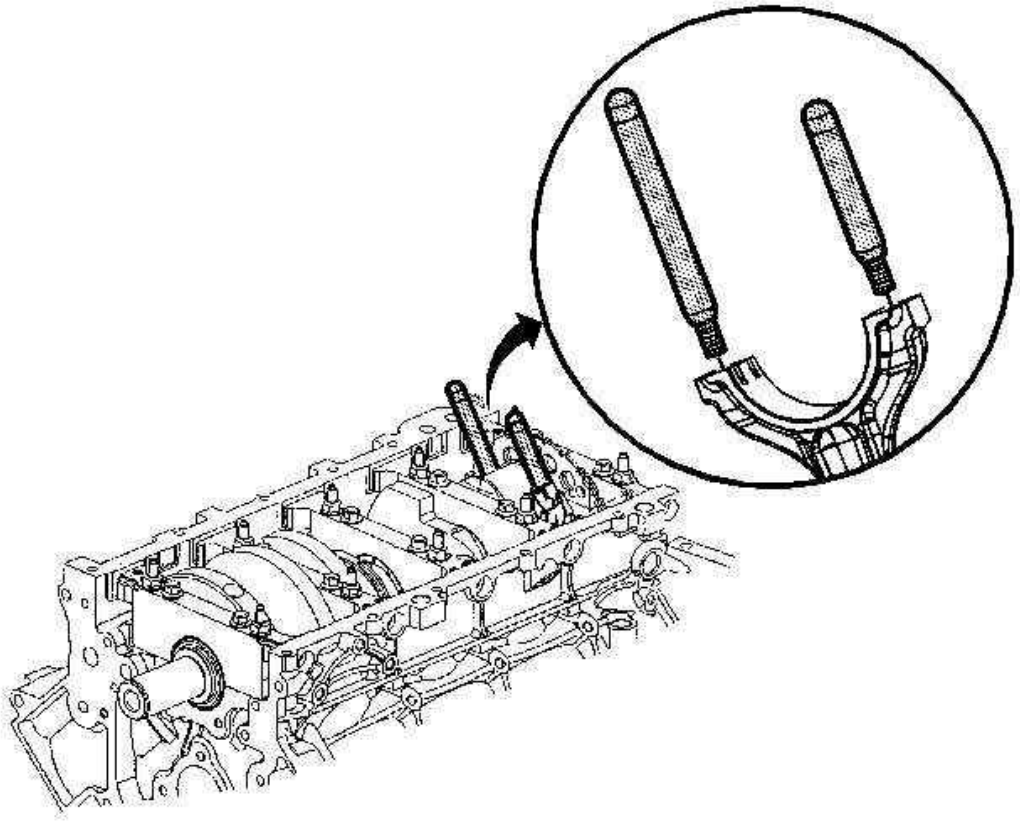


Fig. 581: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 41556** to the connecting rod. See **Special Tools**.

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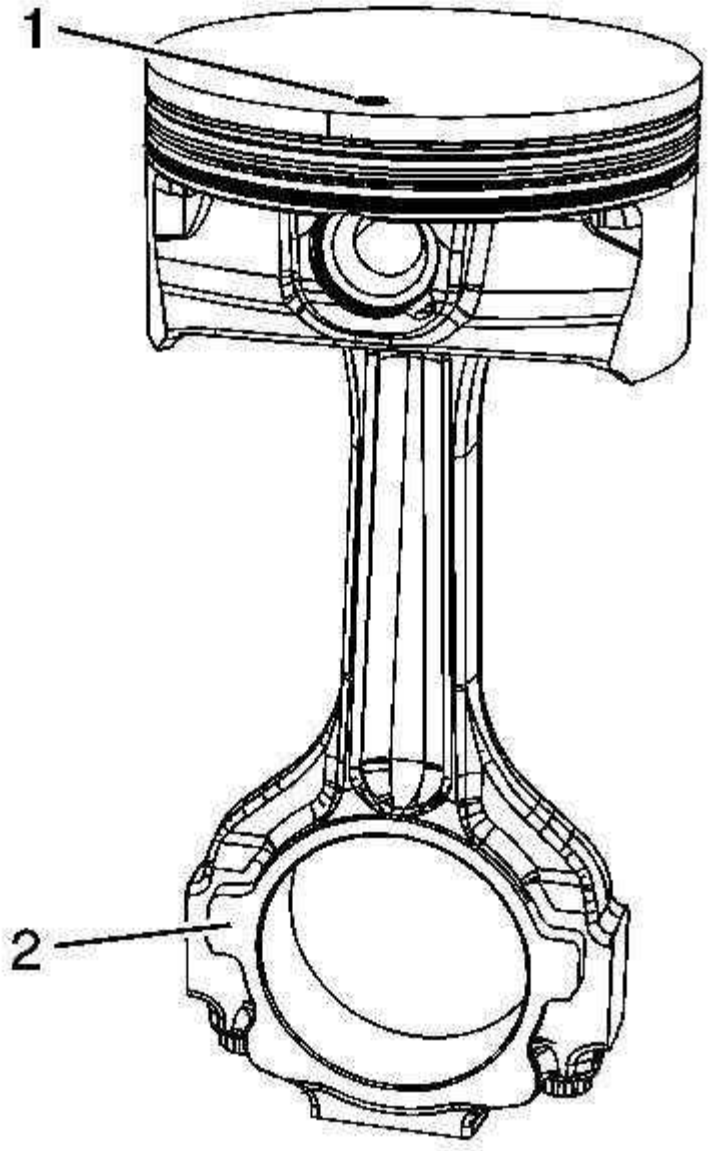


Fig. 582: View of Mark On Top Of Piston & Connecting Rod Tab
Courtesy of GENERAL MOTORS CORP.

6. Identify the proper installation direction of the piston and connecting rod assembly. When installing the piston and connecting rod assembly, the mark

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on the top of the piston (1) and the tab (2) on the side of the connecting rod should face the front of the engine.

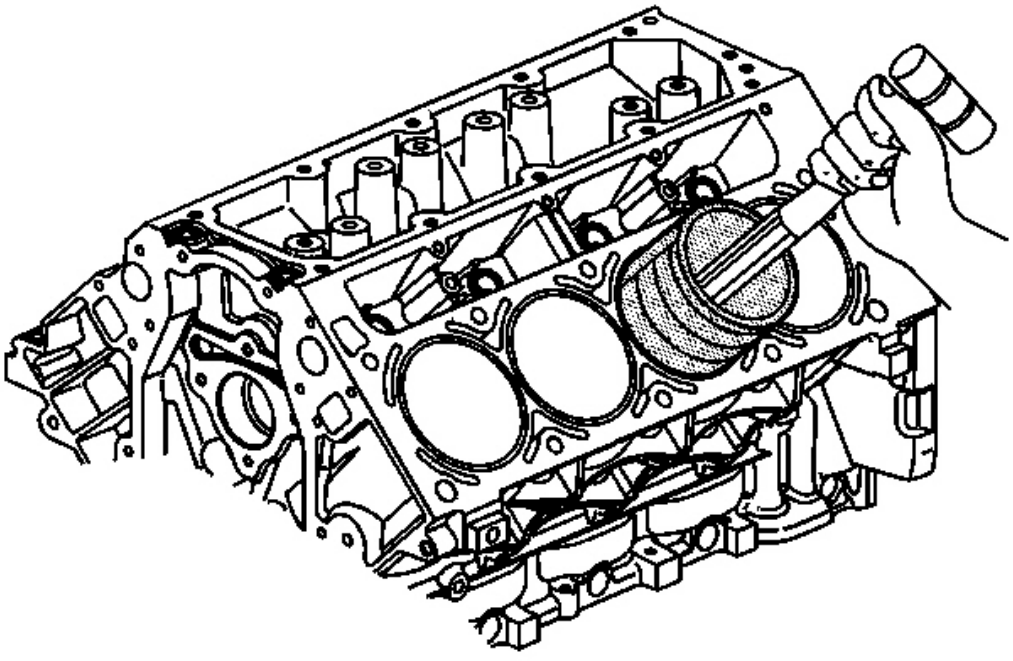


Fig. 583: Installing Piston Into Block Bore
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 8037** onto the piston and compress the piston rings.

IMPORTANT: The piston alignment mark MUST face the front of the engine block.

8. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all piston rings have entered the cylinder bore.
9. Use the **J 41556** to guide the connecting rod onto the crankshaft journal. See **Special Tools**.

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10. Remove the **J 41556** from the connecting rod. See **Special Tools**.

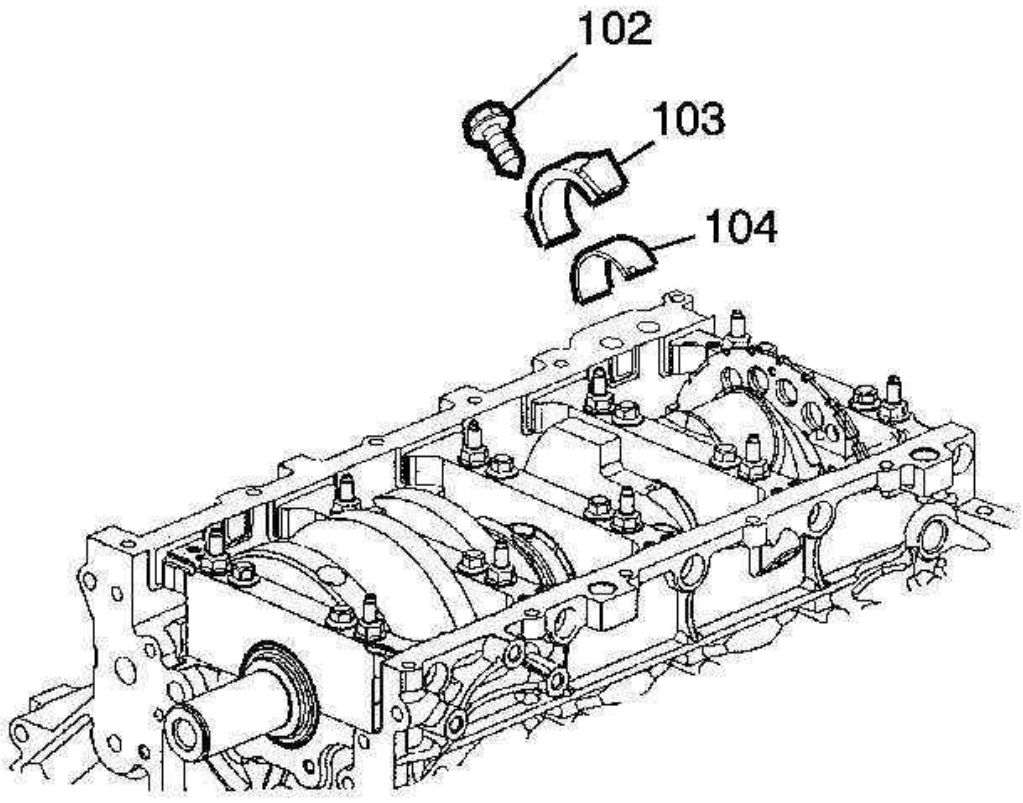


Fig. 584: View Of Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: The connecting rod and cap must be assembled with the mating surfaces properly aligned.

11. Install the bearing cap (103), bearing (104), and bolts (102).

Tighten:

1. Tighten the bolts a first pass to 20 N.m (15 lb ft).

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2. Tighten the bolts a final pass to 85 degrees using the **J 45059** .

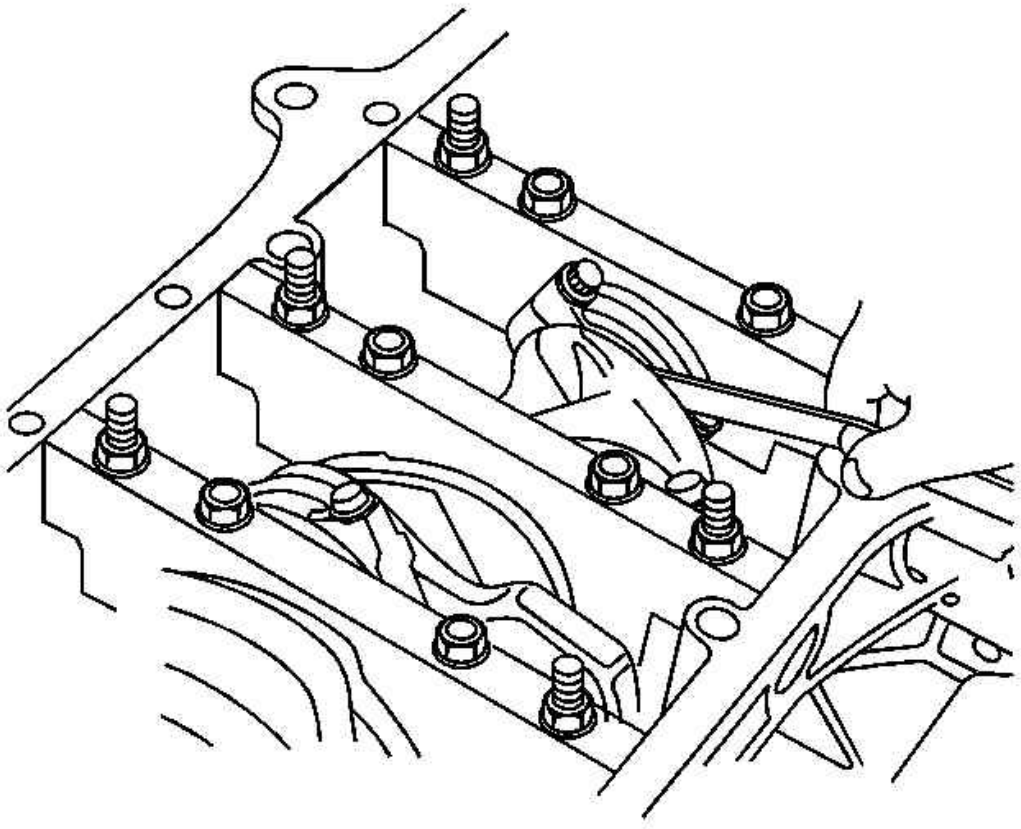


Fig. 585: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

12. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications**.

CAMSHAFT INSTALLATION

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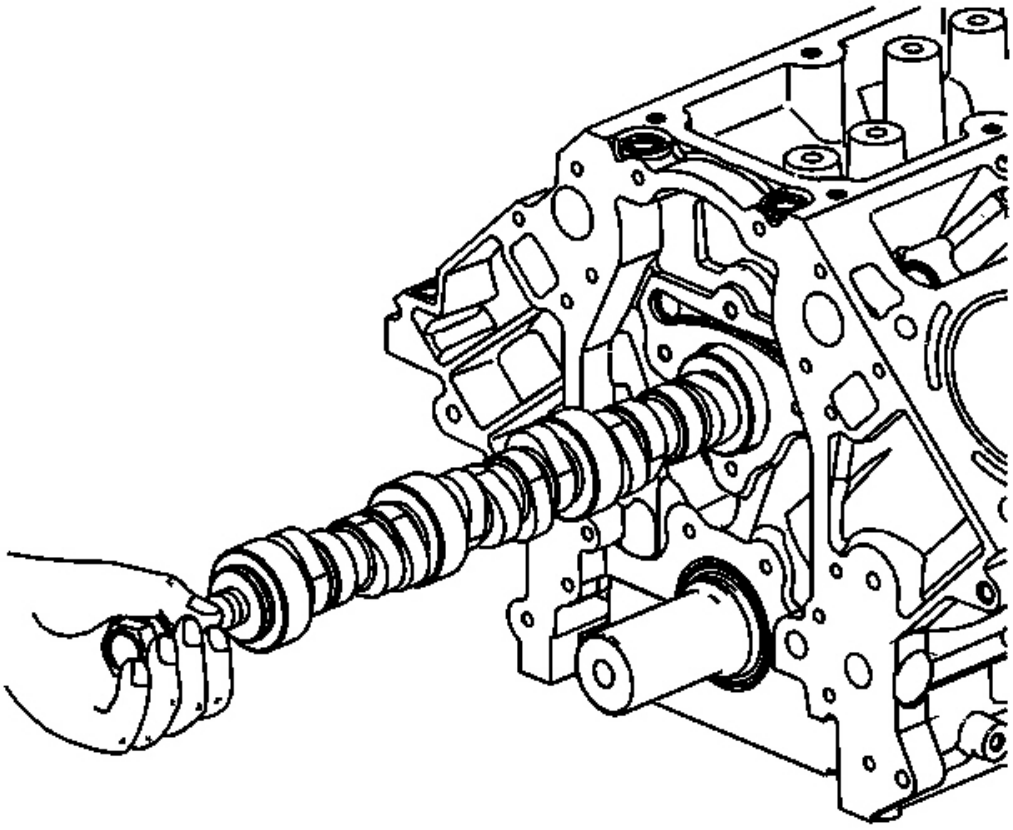


Fig. 586: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install the camshaft sprocket bolt into the camshaft front bolt hole.

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.

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3. Using the bolt as a handle, carefully install the camshaft into the engine block.
4. Remove the bolt from the front of the camshaft.

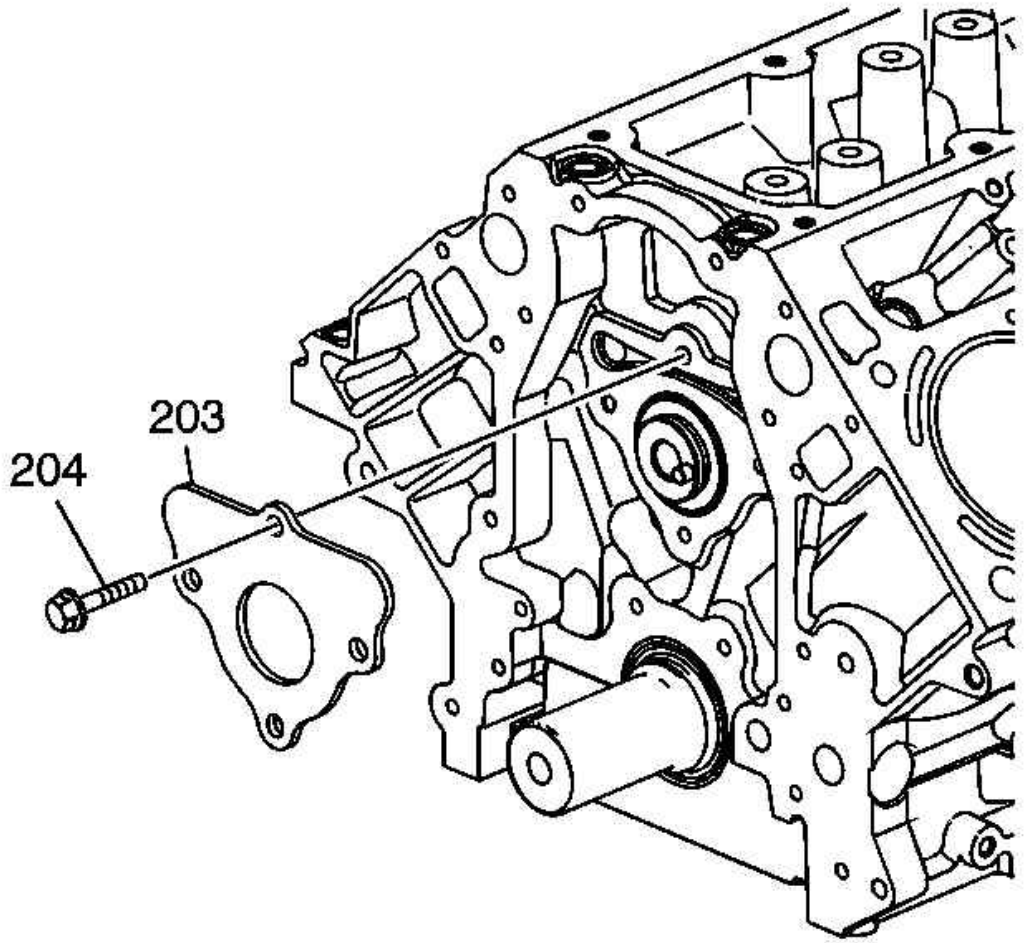


Fig. 587: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer (203) and the bolts (204). Install the retainer with

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the sealing gasket facing the front of the engine block.

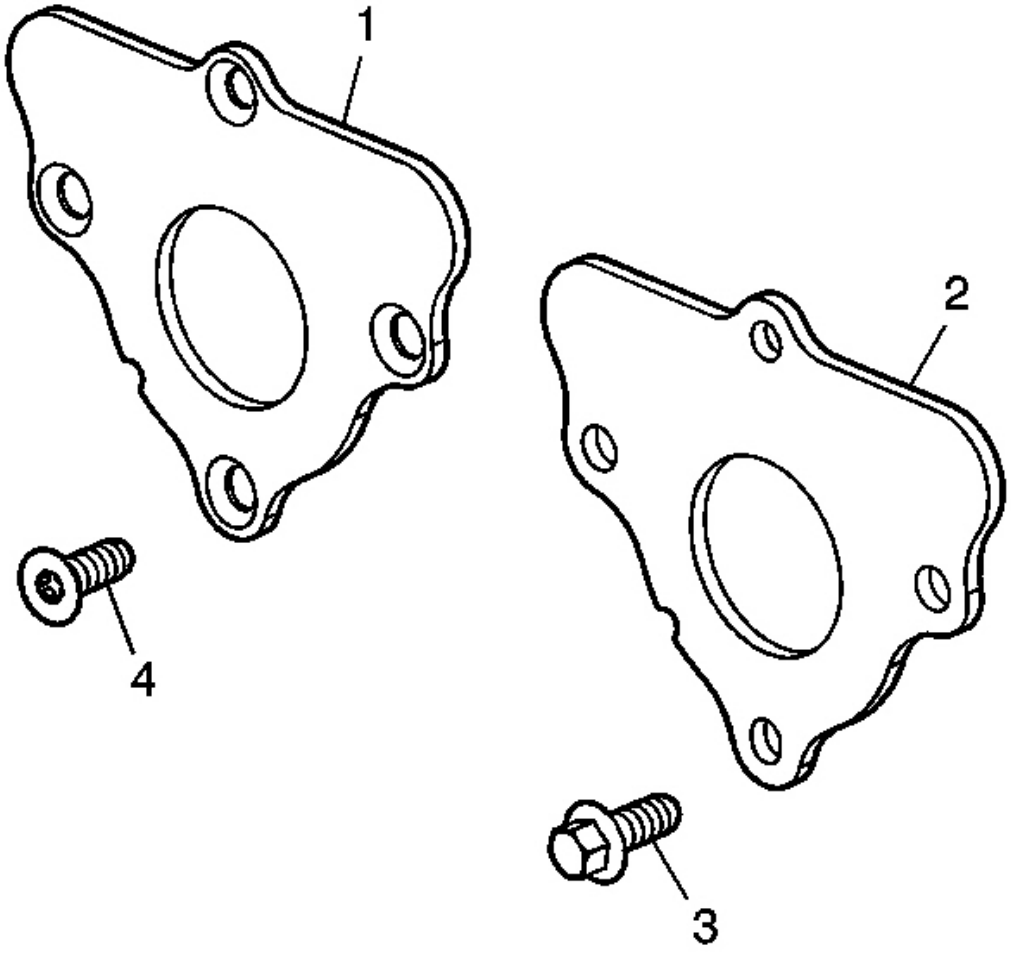


Fig. 588: Identifying Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Tighten the camshaft retainer bolts.

Tighten:

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- Tighten the first design hex head bolts (3) to 25 N.m (18 lb ft).
- Tighten the second design TORX® head bolts (4) to 15 N.m (11 lb ft).

TIMING CHAIN AND SPROCKETS INSTALLATION

Tools Required

- **EN 46330** Timing Belt Tensioner Retaining Pin. See **Special Tools**.
- **EN 47699** Flywheel Holding Tool. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 45059** Angle Meter

Installation

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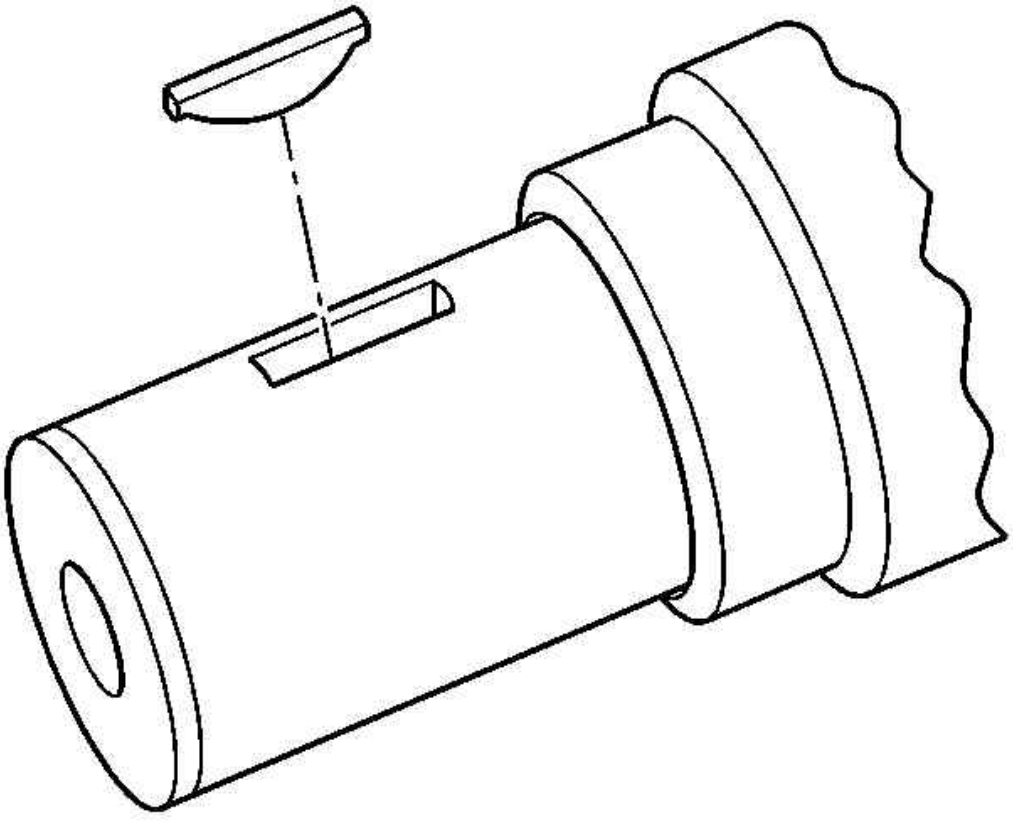


Fig. 589: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.

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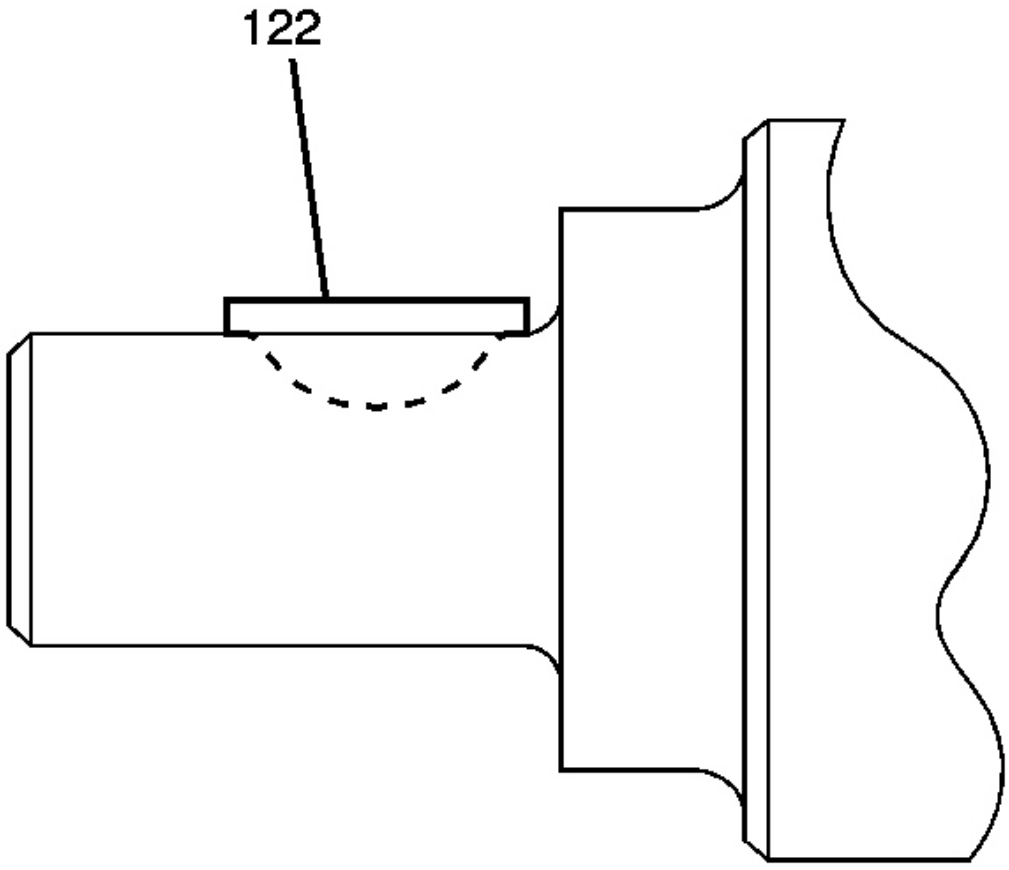


Fig. 590: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.

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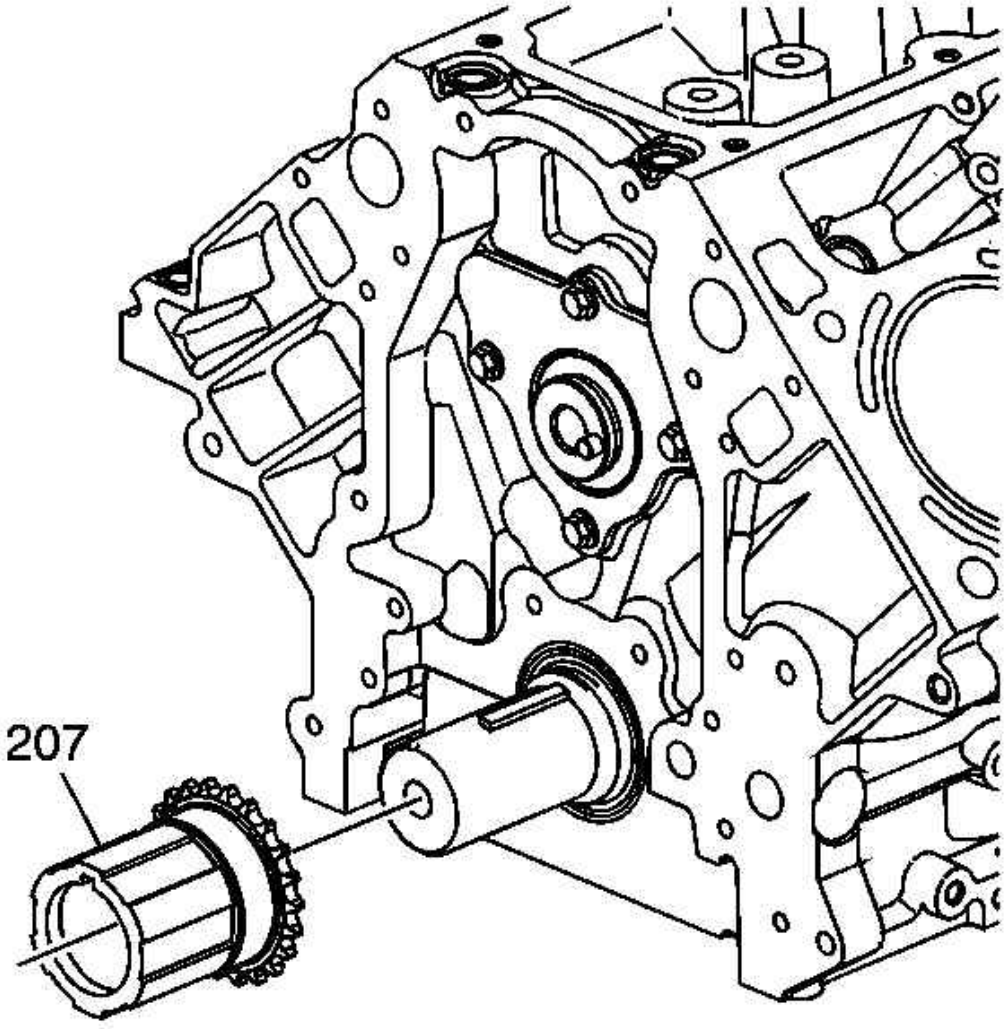


Fig. 591: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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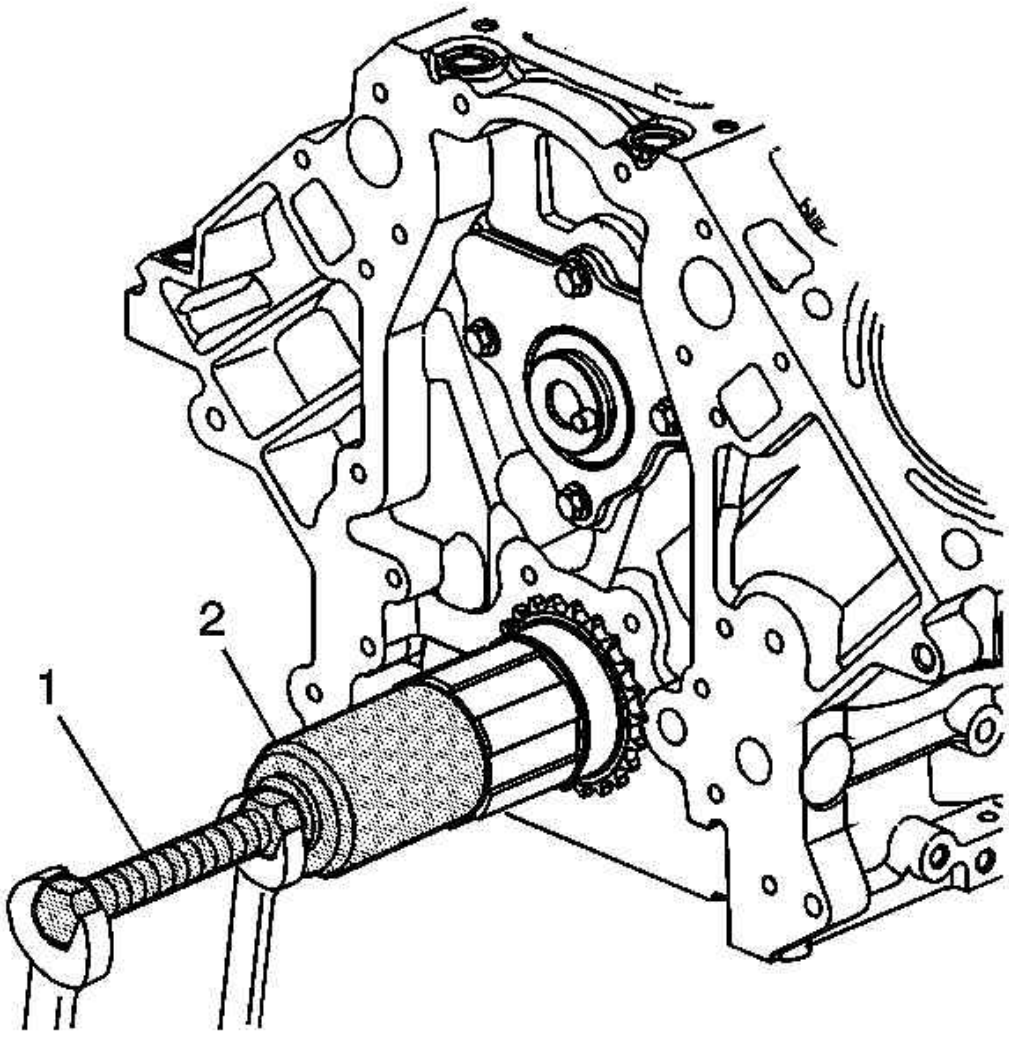


Fig. 592: View Of Crankshaft Sprocket & Installer
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41478** (1) and the **J 41665** (2) in order to install the crankshaft sprocket. See **Special Tools**.

   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

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5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.

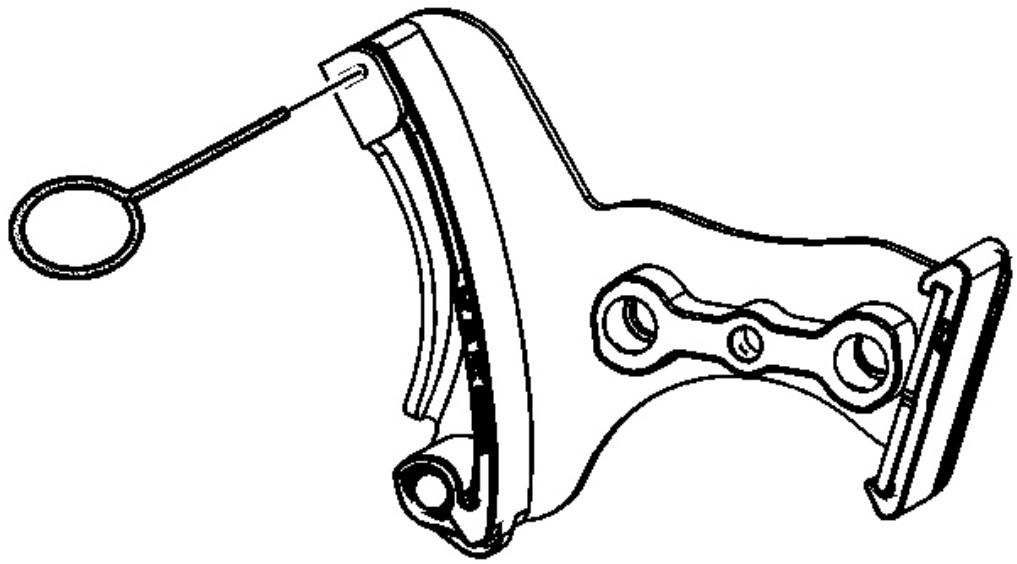


Fig. 593: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Compress the timing chain tensioner guide and install the **EN 46330** . See **Special Tools**.

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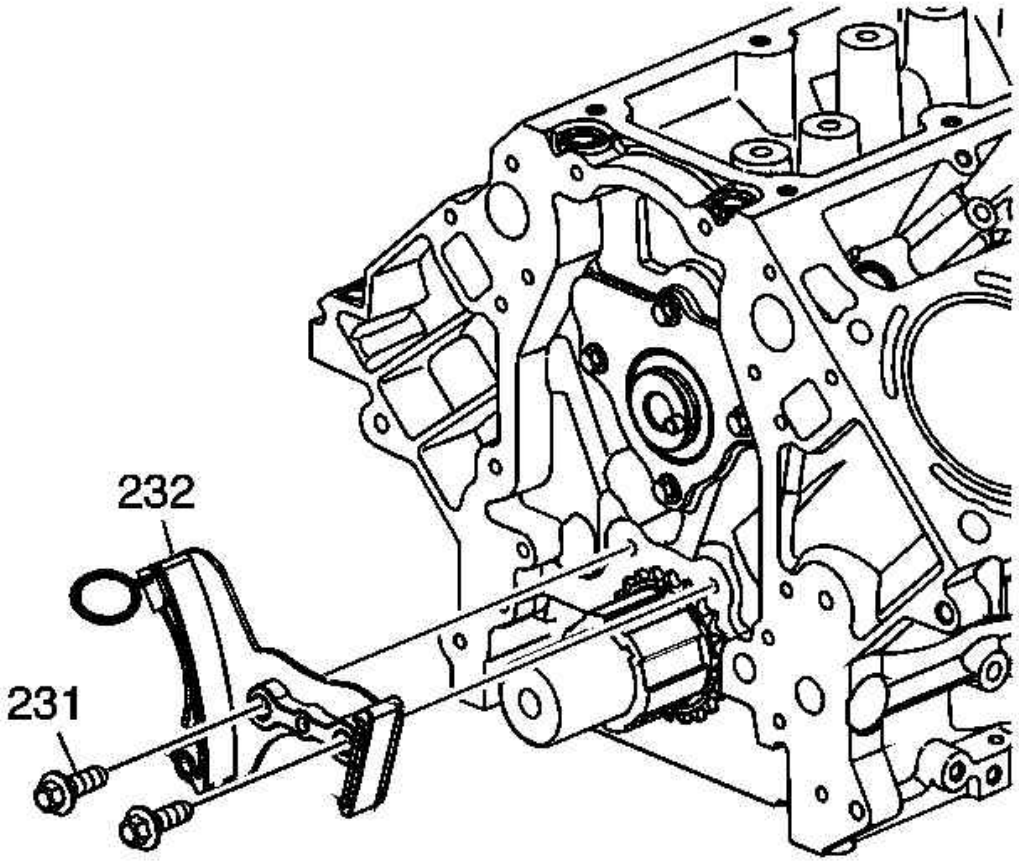


Fig. 594: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Install the timing chain tensioner (232) and bolts (231).

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

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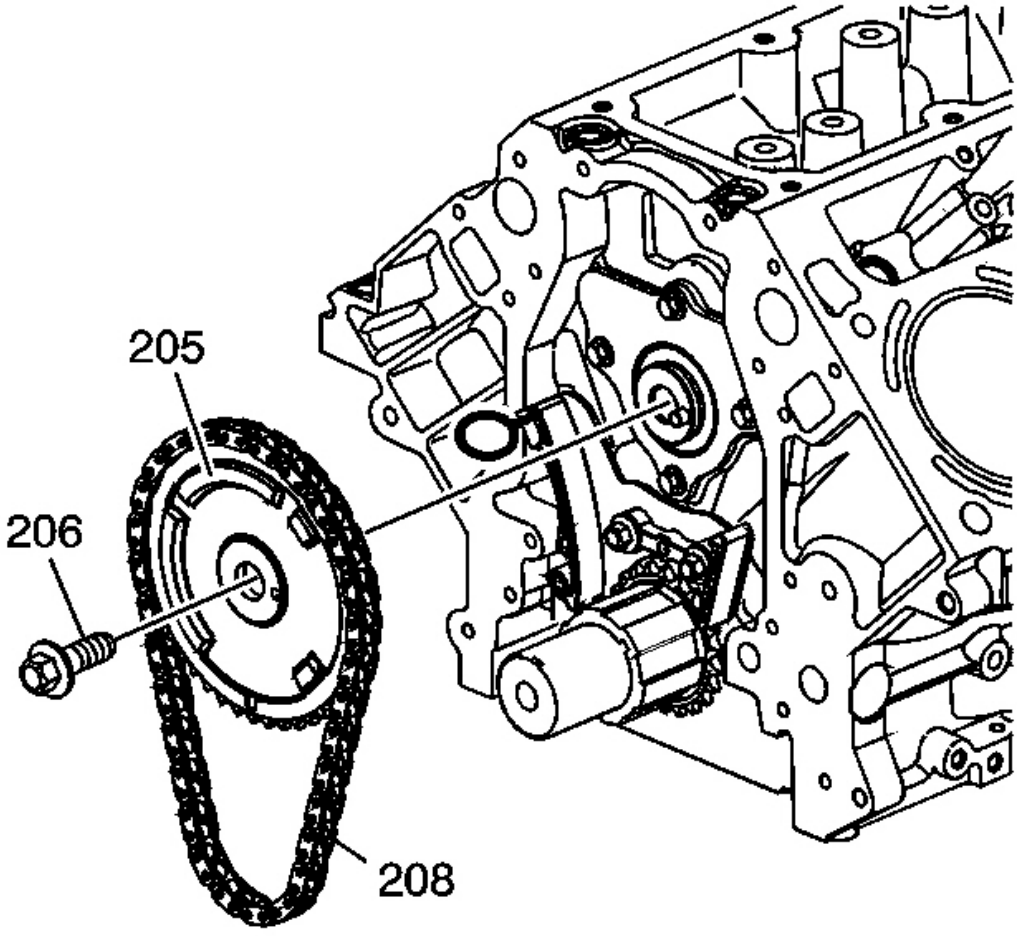


Fig. 595: View Of Camshaft Sprocket & Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the camshaft sprocket bolt again. Install a NEW bolt during assembly.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**

8. Install the camshaft sprocket (205), timing chain (208), and NEW bolt (206).

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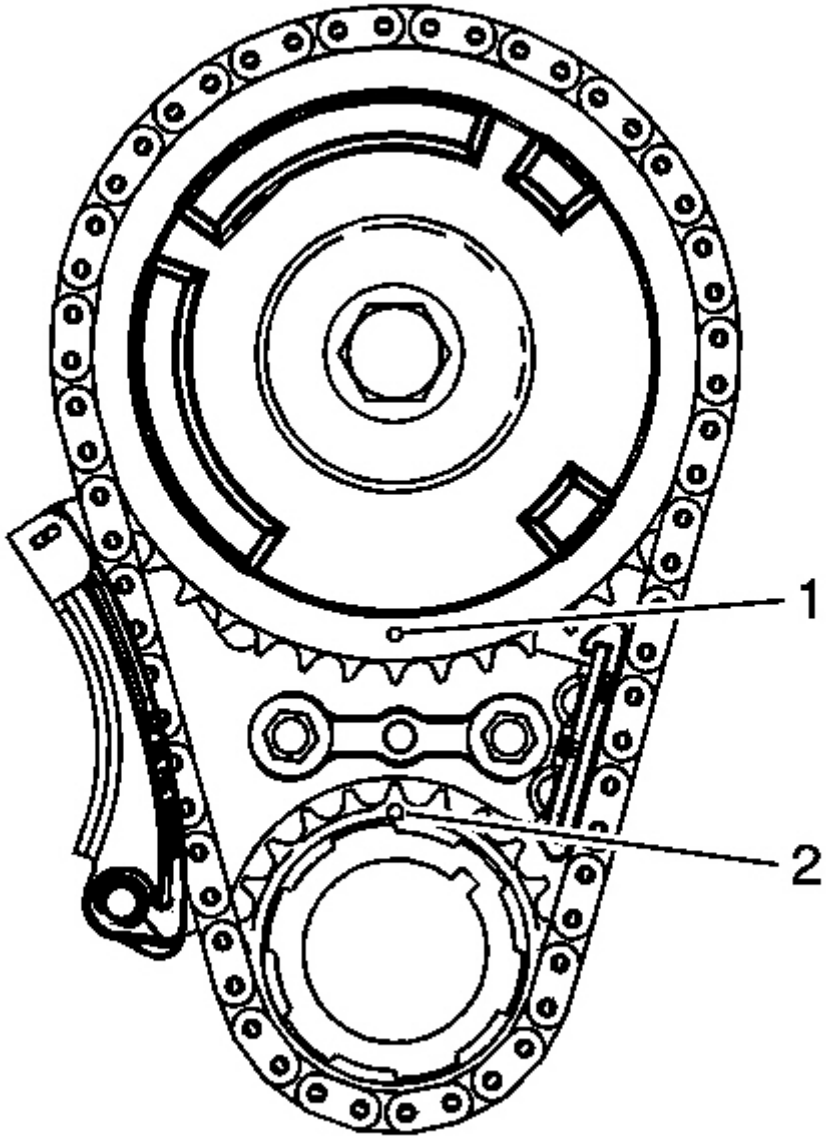


Fig. 596: Identifying Camshaft & Crankshaft Marks
Courtesy of GENERAL MOTORS CORP.

9. Inspect the sprockets for proper alignment. The mark on the camshaft sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft

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sprocket (2) should be located in the 12 o'clock position.

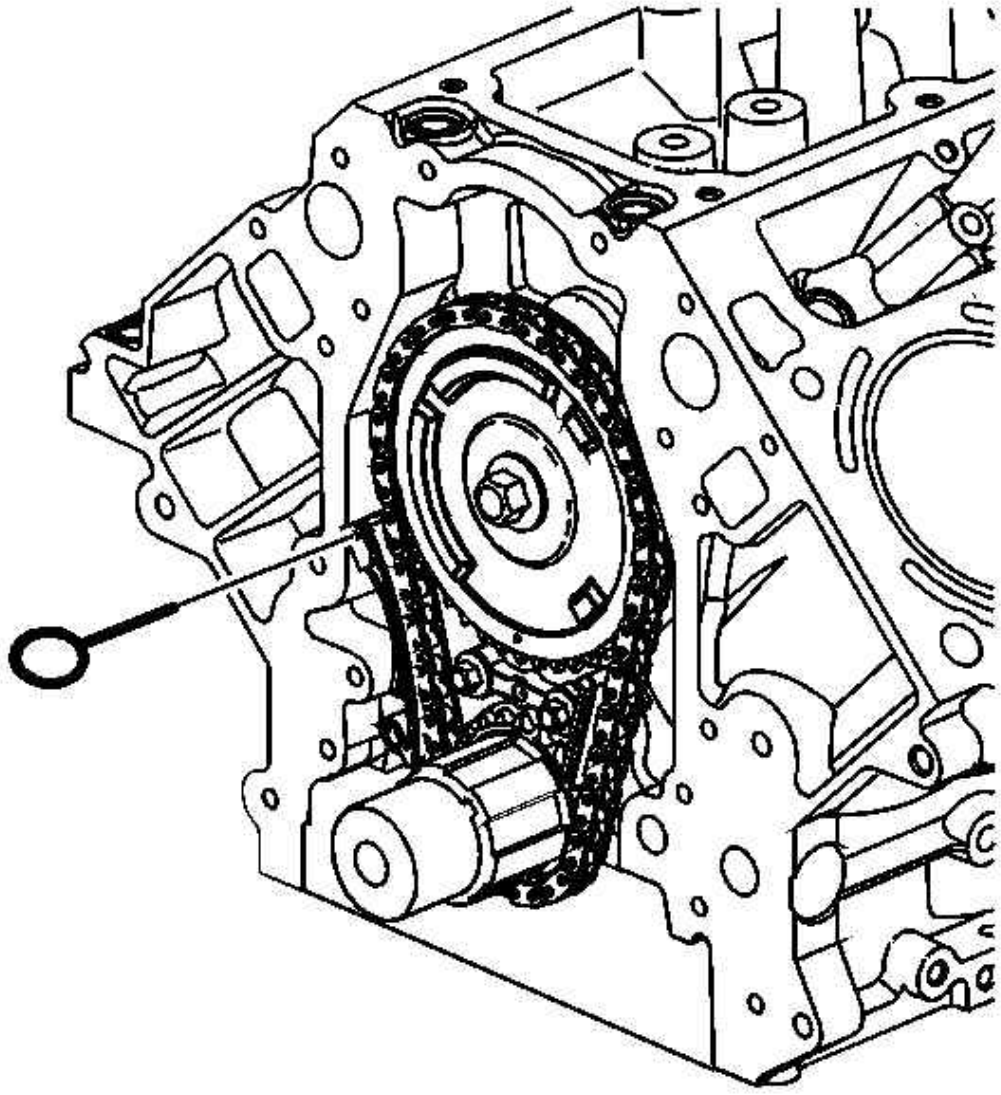


Fig. 597: Locating Tensioner Pin
Courtesy of GENERAL MOTORS CORP.

10. Remove the **EN 46330** . See **Special Tools**.

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IMPORTANT: Do not apply threadlock to the flex plate bolts at this time.

11. Temporarily install the automatic transmission flex plate and bolts. Refer to **Engine Flywheel Installation**.

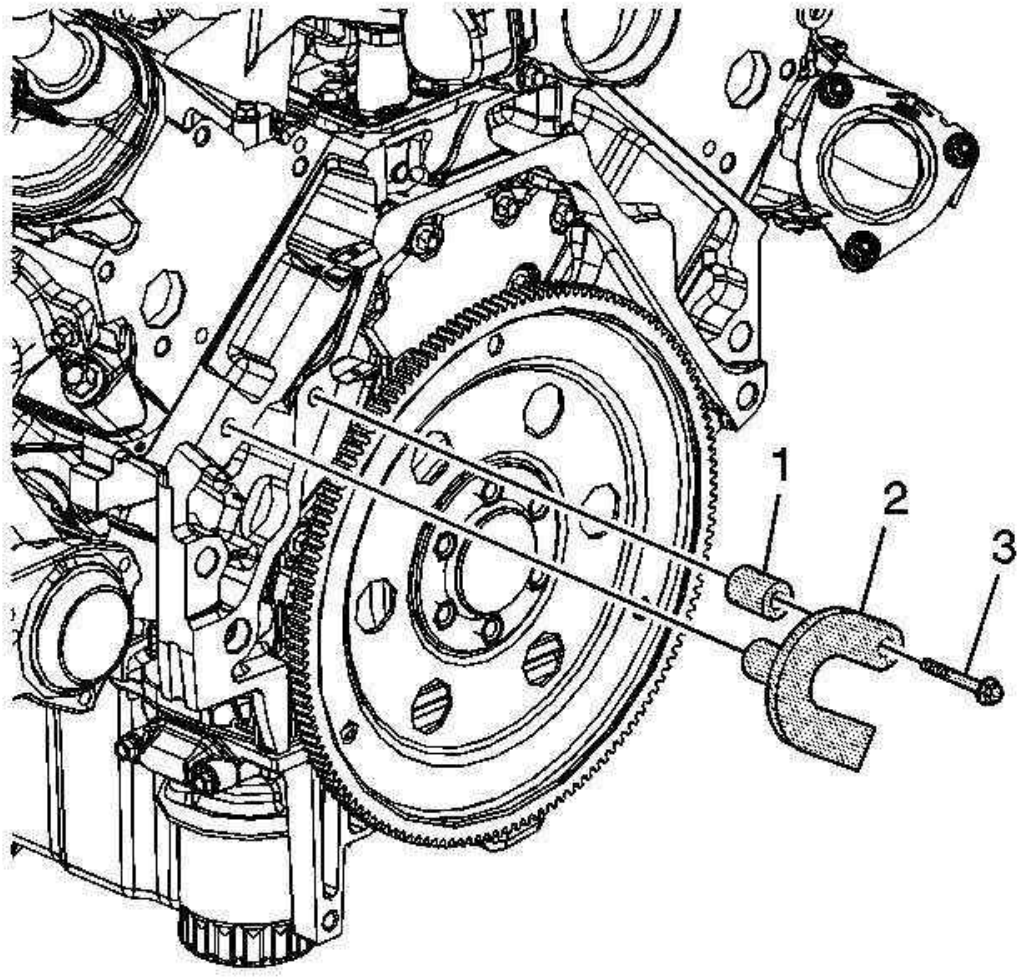


Fig. 598: View Of Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN 47699** (2), spacer (1), and bolts (3) to the block and flex plate.

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See **Special Tools**.

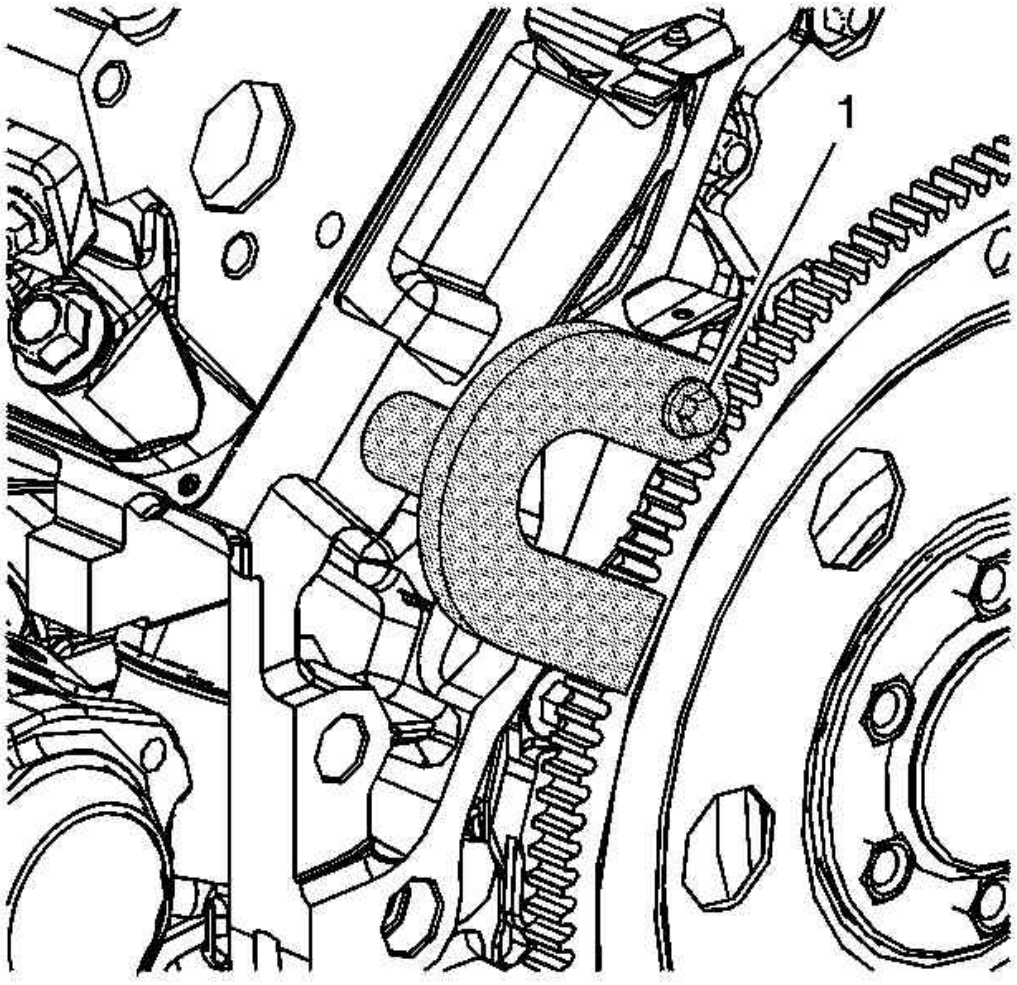


Fig. 599: Identifying Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

13. Tighten the **EN 47699** bolt (1). See **Special Tools**.

    Tighten: Tighten the bolt to 60 N.m (44 lb ft).

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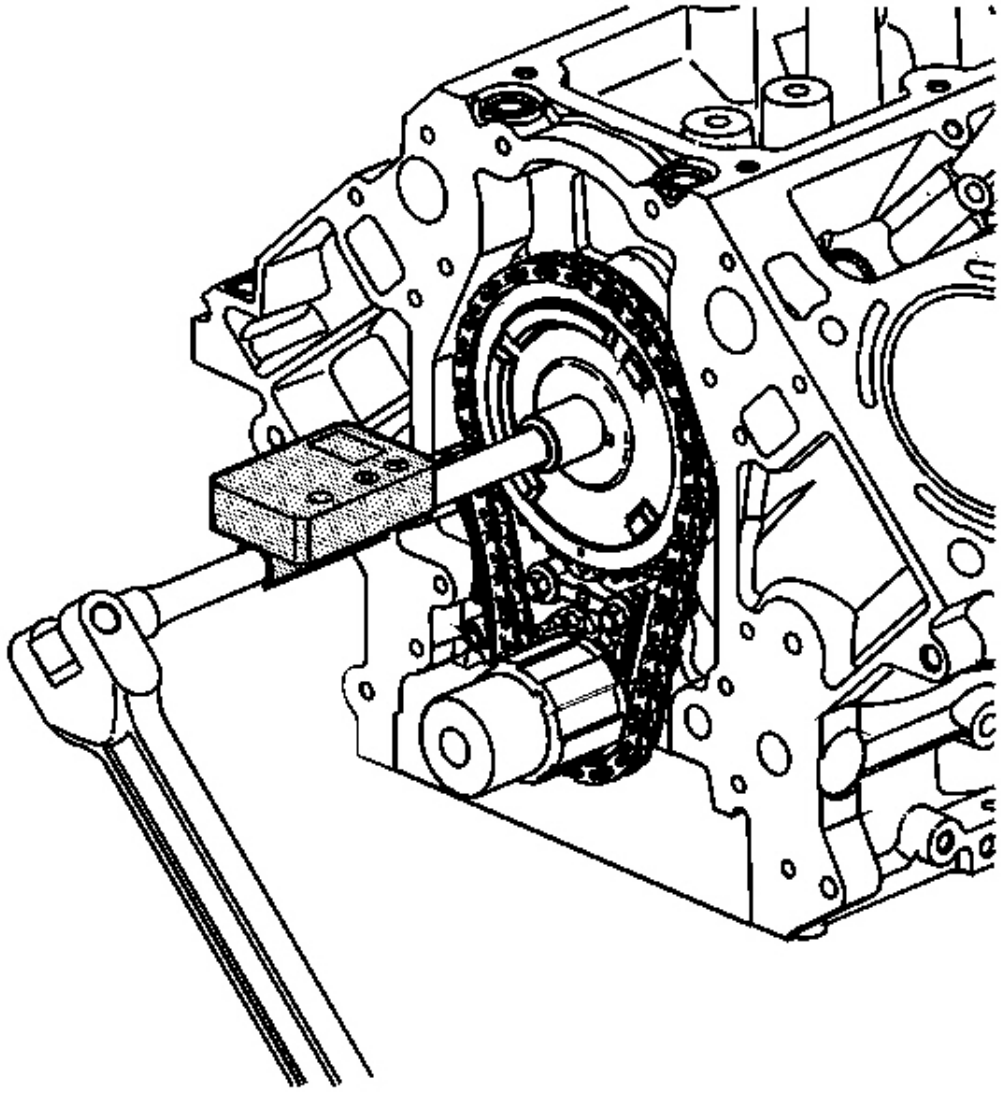


Fig. 600: Tightening Camshaft Sprocket Bolt Using J 45059
Courtesy of GENERAL MOTORS CORP.

14. Tighten the camshaft sprocket bolt.

Tighten:

1. Tighten the camshaft sprocket bolt a first pass to 75 N.m (55 lb ft).

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2. Tighten the camshaft sprocket bolt a final pass an additional 50 degrees using the **J 45059** .

15. Remove the **EN 47699** and bolts. See **Special Tools**.
16. Remove the automatic transmission flex plate and bolt. Refer to **Engine Flywheel Removal**.

OIL PUMP, SCREEN AND CRANKSHAFT OIL DEFLECTOR INSTALLATION

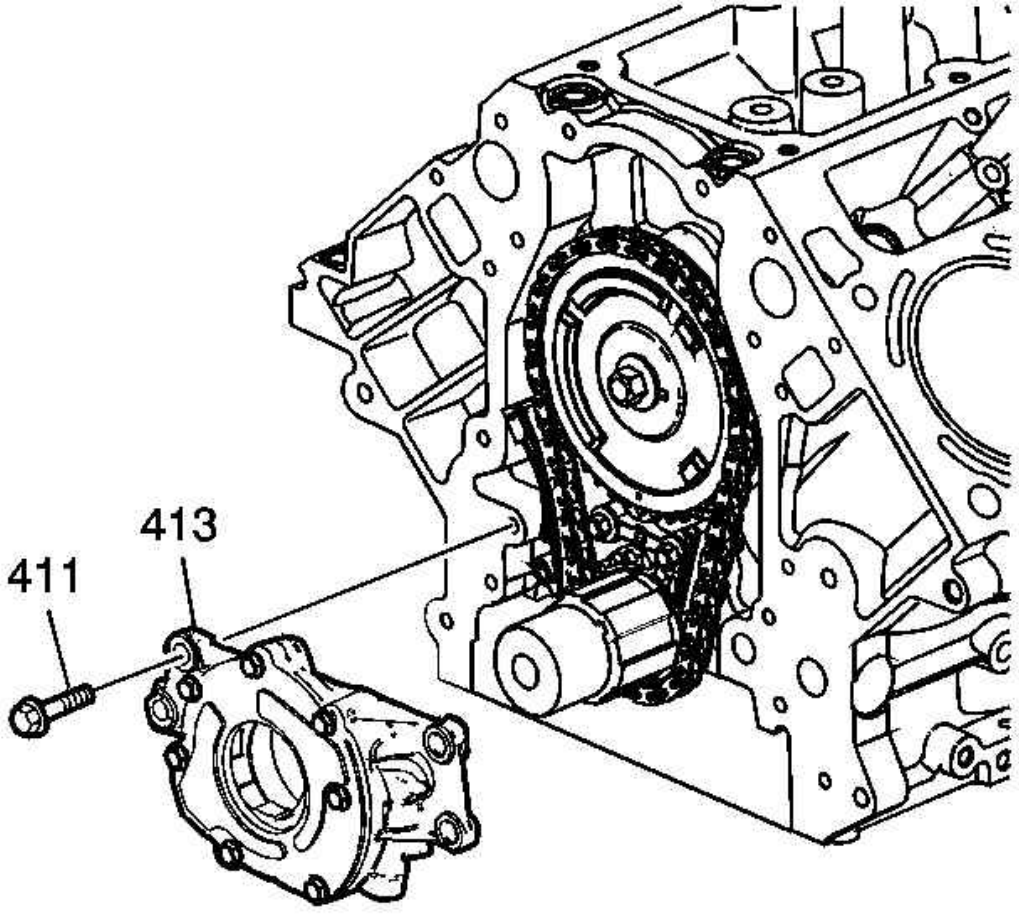


Fig. 601: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

NOTE: Refer to Fastener Notice .

3. Install the oil pump bolts (411).

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

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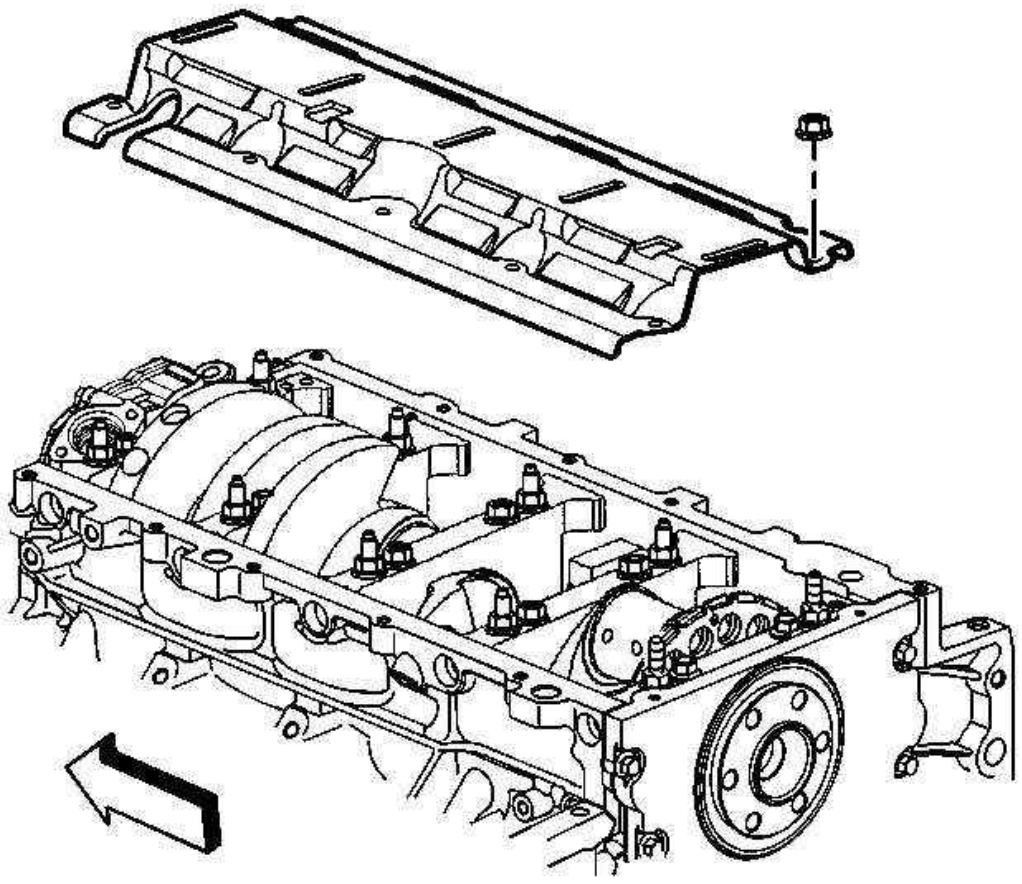


Fig. 602: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.

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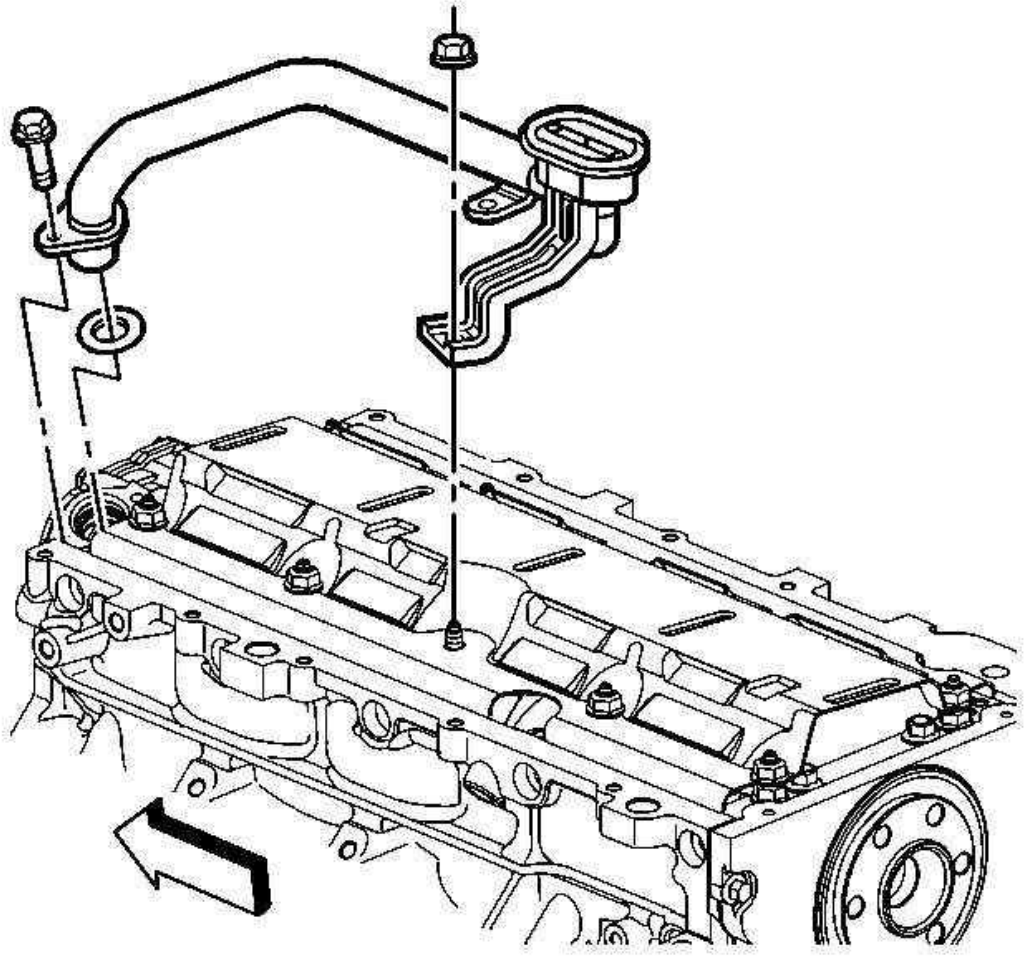


Fig. 603: View Of Oil Pump Screen, Nuts & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

IMPORTANT:

- **Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.**
- **Align the oil pump screen mounting brackets**

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with the correct crankshaft bearing cap bolt/studs.

7. Install the oil pump screen.
8. Install the oil pump screen bolt and the deflector nuts.

Tighten:

1. Tighten the oil pump screen bolt to 12 N.m (106 lb in).
2. Tighten the crankshaft oil deflector nut to 25 N.m (18 lb ft).

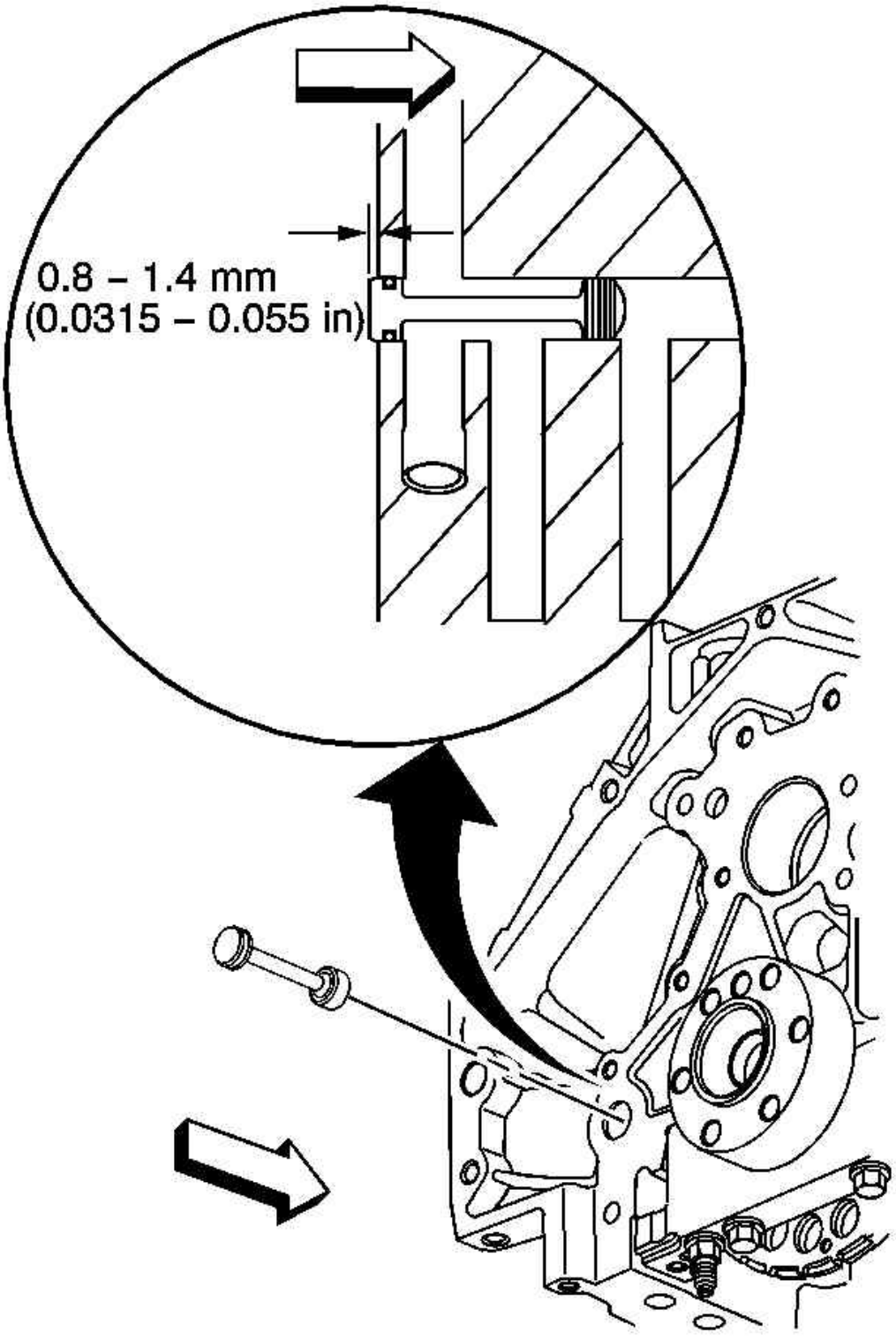
CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION

Tools Required

- **J 41476** Front and Rear Cover Alignment Tool. See **Special Tools**.
- **J 41480** Front and Rear Cover Alignment. See **Special Tools**.

Installation

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Fig. 604: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft rear oil seal or the engine rear housing gasket again.**
- **Do not apply any type of sealant to the rear housing gasket, unless specified.**
- **The special tools in this procedure are used to properly align the engine rear housing at the oil pan surface and to center the crankshaft rear oil seal.**
- **The crankshaft rear oil seal will be installed after the rear housing has been installed and aligned. Install the rear housing without the crankshaft oil seal.**
  - **The crankshaft rear oil seal MUST be centered in relation to the crankshaft.**
  - **The oil pan sealing surface at the rear housing and engine block MUST be aligned within specifications.**
  - **An improperly aligned rear housing may cause premature rear oil seal wear and/or engine assembly oil leaks.**

1. Inspect the rear oil gallery plug for proper installation.

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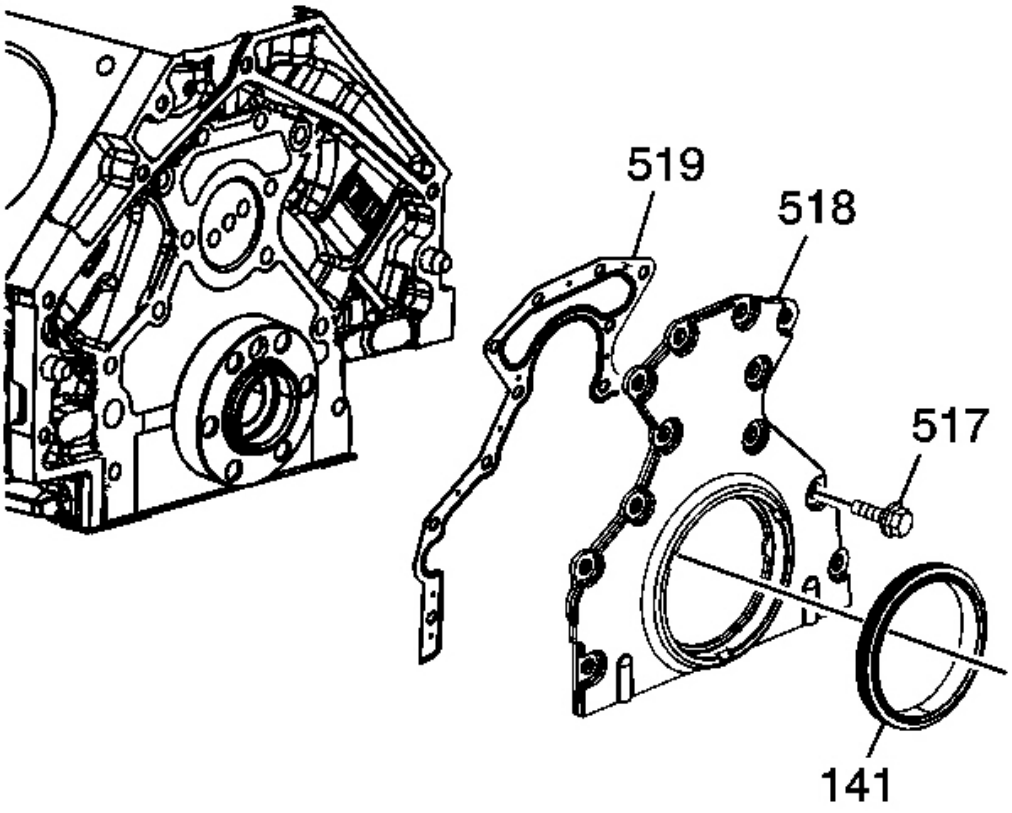


Fig. 605: View Of Rear Housing, Gasket & Seal
Courtesy of GENERAL MOTORS CORP.

2. Install the rear housing gasket (519), rear housing (518), and bolts (517).
3. Tighten the bolts finger tight. Do not overtighten.

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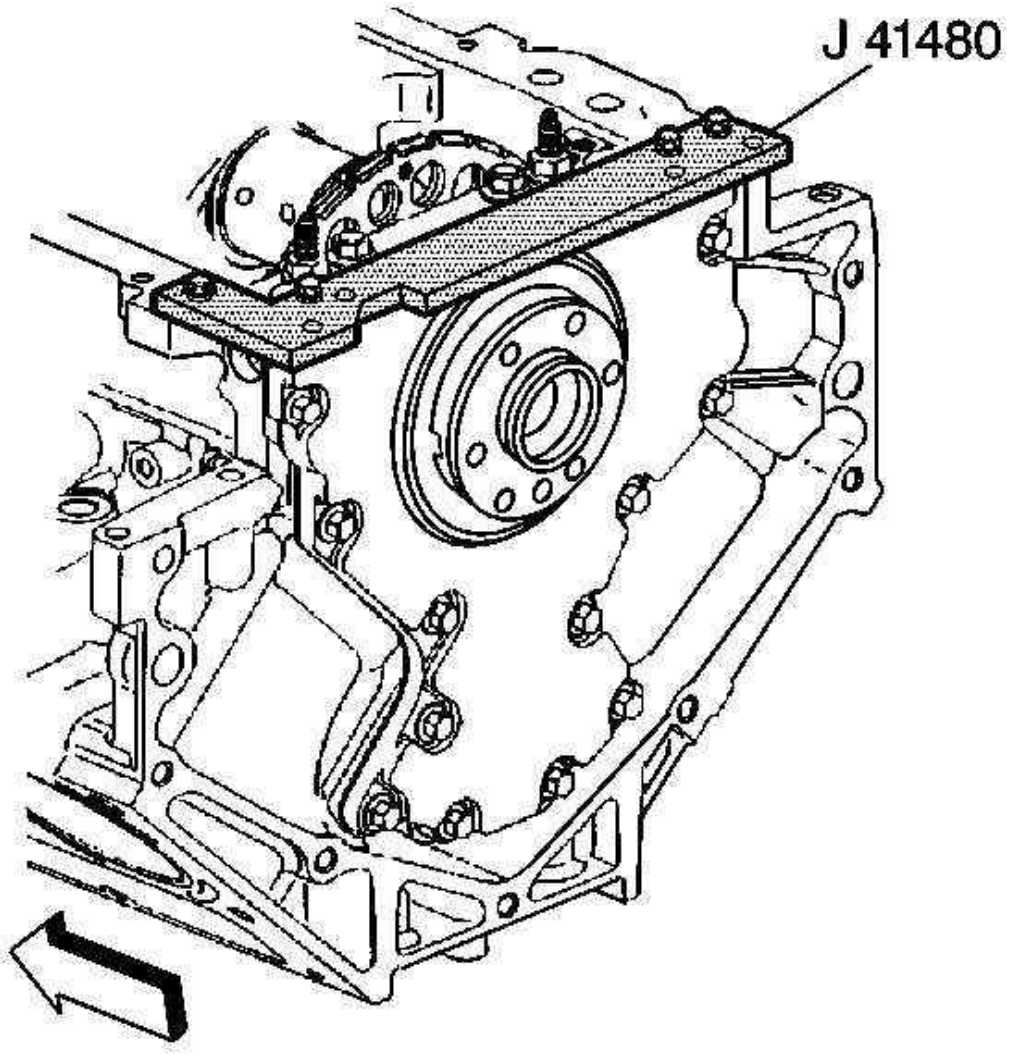


Fig. 606: View Of J 41480 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Start the J 41480 tool-to-rear housing bolts. See Special Tools. Do not tighten the bolts at this time.

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4. Install the **J 41480** and bolts. See **Special Tools**.

   Tighten: Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

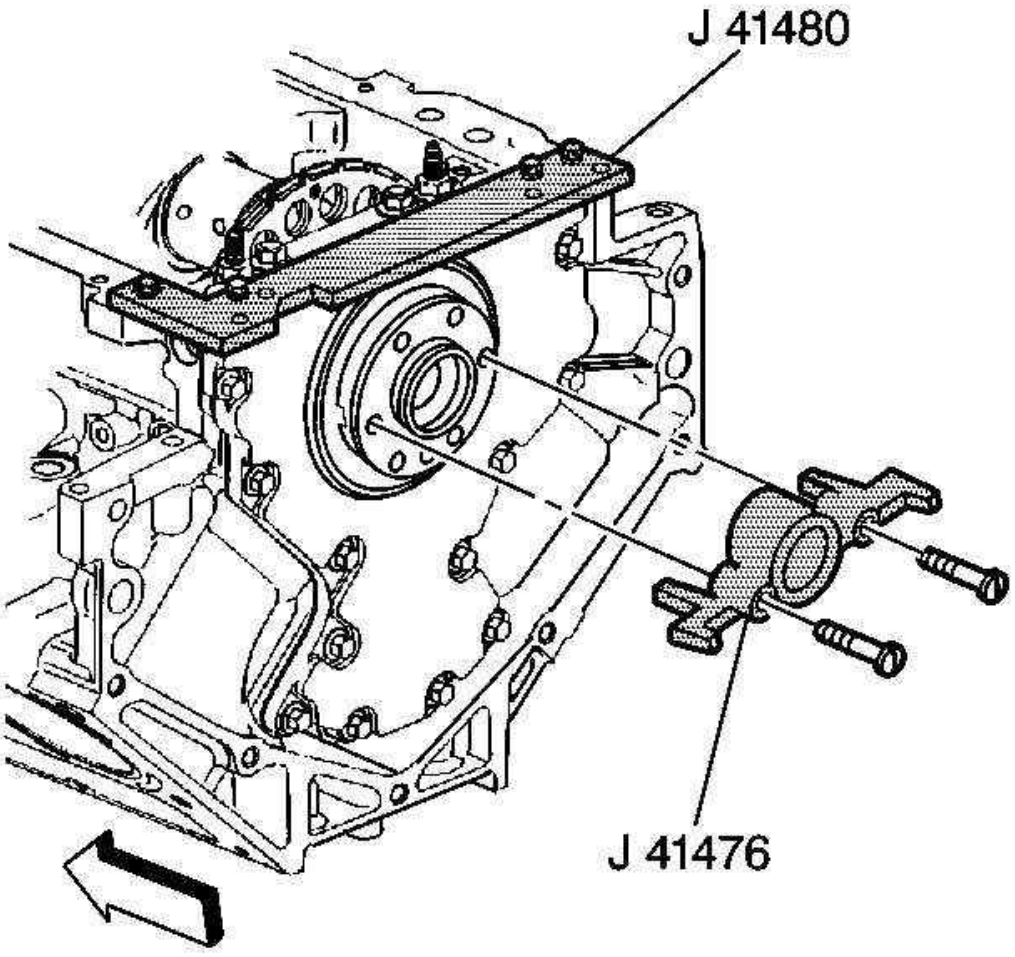


Fig. 607: View Of J 41480 & J 41476
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To properly align the rear housing, the J 41476 must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface.

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See Special Tools.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.

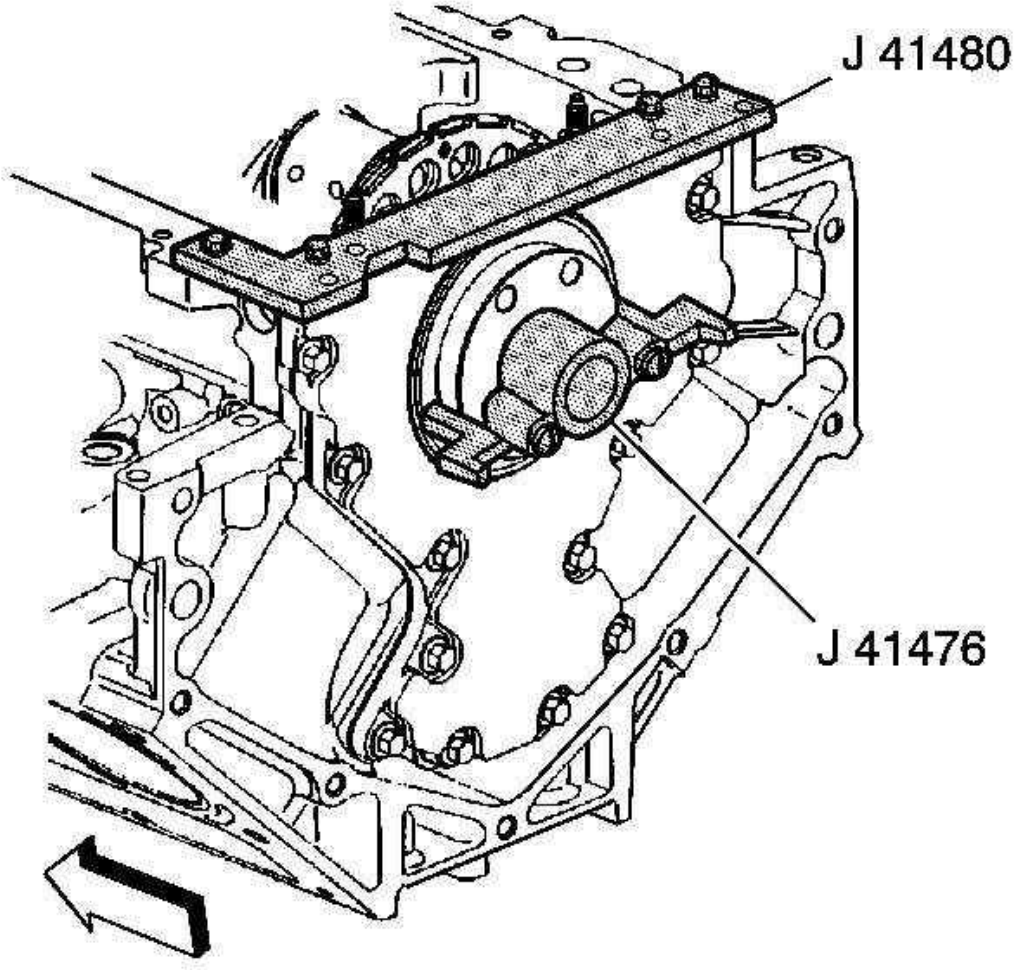


Fig. 608: View Of J 41480 & J 41476 Installed
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The tapered legs of the alignment tool must enter the rear housing oil seal bore.

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6. Install the **J 41476** and bolts onto the rear of the crankshaft. See **Special Tools**.

   Tighten:

   1. Tighten the tool mounting bolts until snug. Do not overtighten.
   2. Tighten the **J 41480** tool-to-rear housing bolts evenly to 12 N. See **Special Tools**.m (106 lb in).
   3. Tighten the rear housing bolts to 30 N.m (22 lb ft).

7. Remove the tools.

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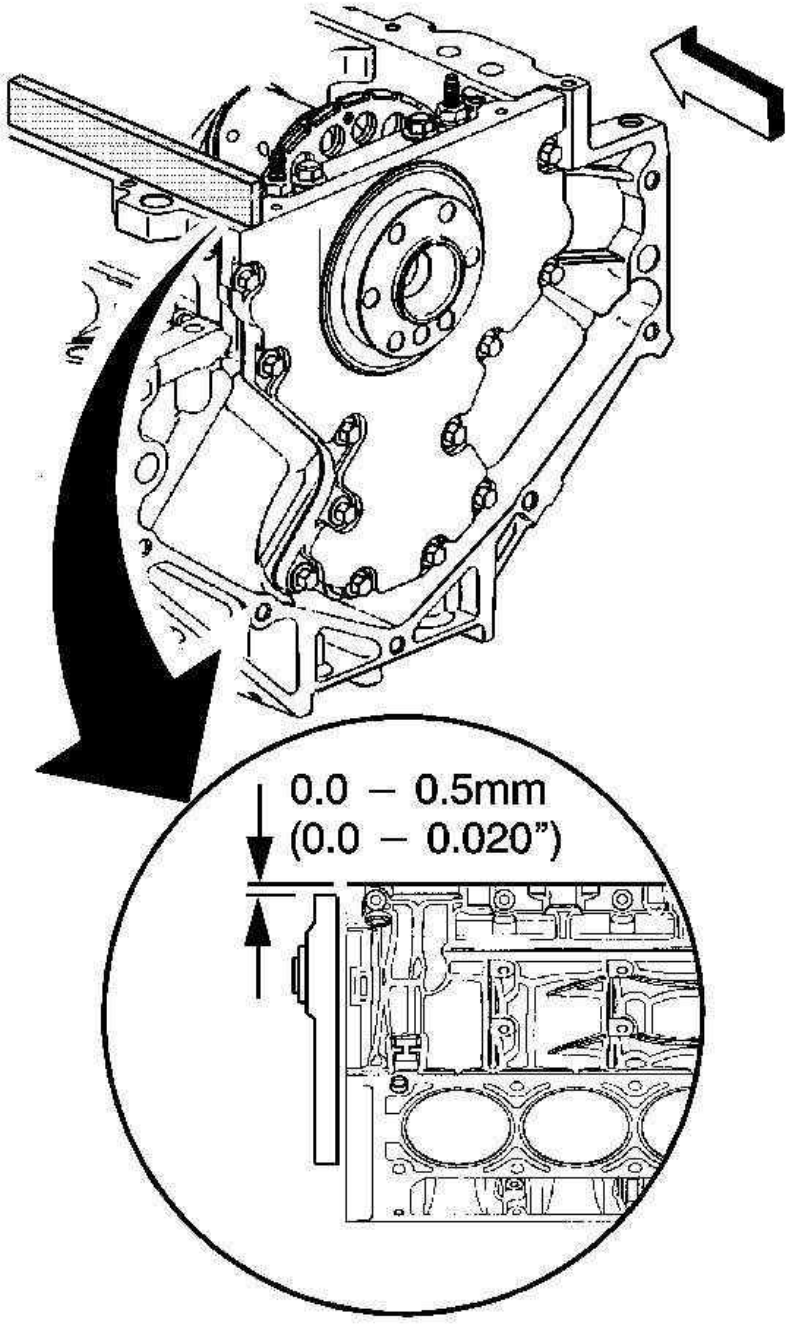


Fig. 609: Checking Rear Cover-To-Engine Block For Proper Installation
Courtesy of GENERAL MOTORS CORP.

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8. Measure the rear housing-to-engine block oil pan surface for flatness.
    1. Place a straight edge onto the engine block and rear housing oil pan sealing surfaces.

       Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

    2. Insert a feeler gage between the rear housing and the straight edge. The housing must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear housing-to-engine block oil pan surface alignment is not within specifications, repeat the housing alignment procedure.
10. If the correct rear housing-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear housing.

CRANKSHAFT REAR OIL SEAL INSTALLATION

Tools Required

- **J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools**.
- **J 41479-2A** Crankshaft Rear Oil Seal Installation Guide. See **Special Tools**.

Installation

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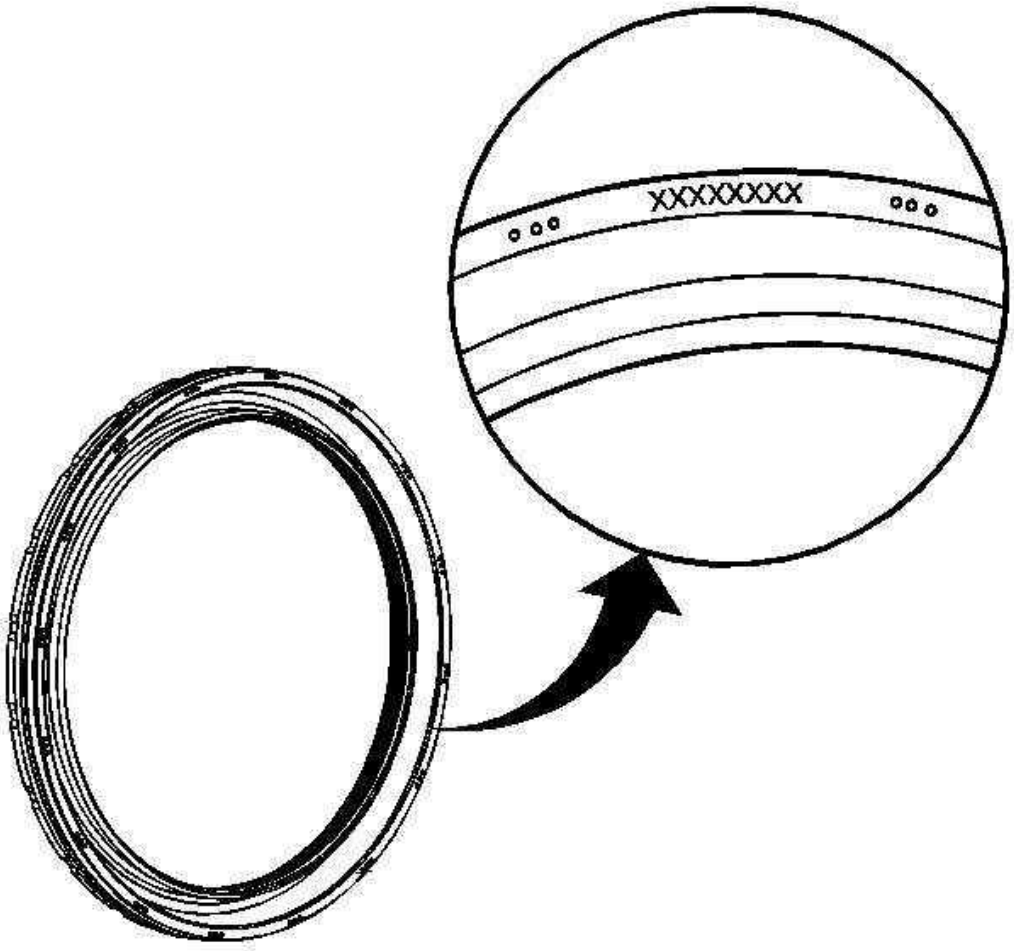


Fig. 610: Identifying Oil Seal Orientation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. The part number is applied to the outside face of the seal, as shown.

1. Inspect the seal and identify the part number markings for proper orientation.

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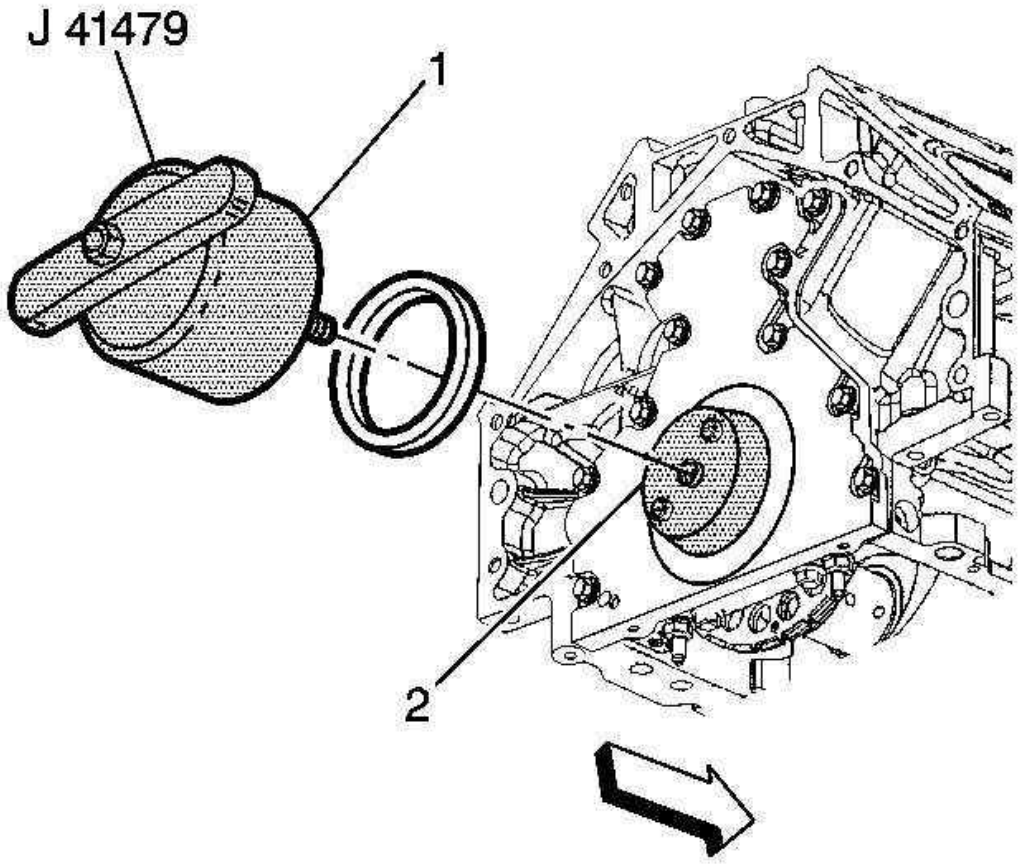


Fig. 611: View Of J 41479 Cone & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 41479** or the **J 41479-2A** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**. The **J 41479-2A** may be required for manual transmission or 5. See **Special Tools** 5.3L LS4 applications.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with the part number markings facing away from the engine.
5. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.

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6. Align the oil seal onto the tool (1).
7. Rotate the handle of the tool (1) clockwise until the seal enters the rear housing and bottoms into the seal bore.
8. Remove the tool.

ENGINE FRONT COVER INSTALLATION

Tools Required

- **J 41476** Front and Rear Cover Alignment Tool. See **Special Tools**.
- **J 41480** Front and Rear Cover Alignment. See **Special Tools**.

Installation

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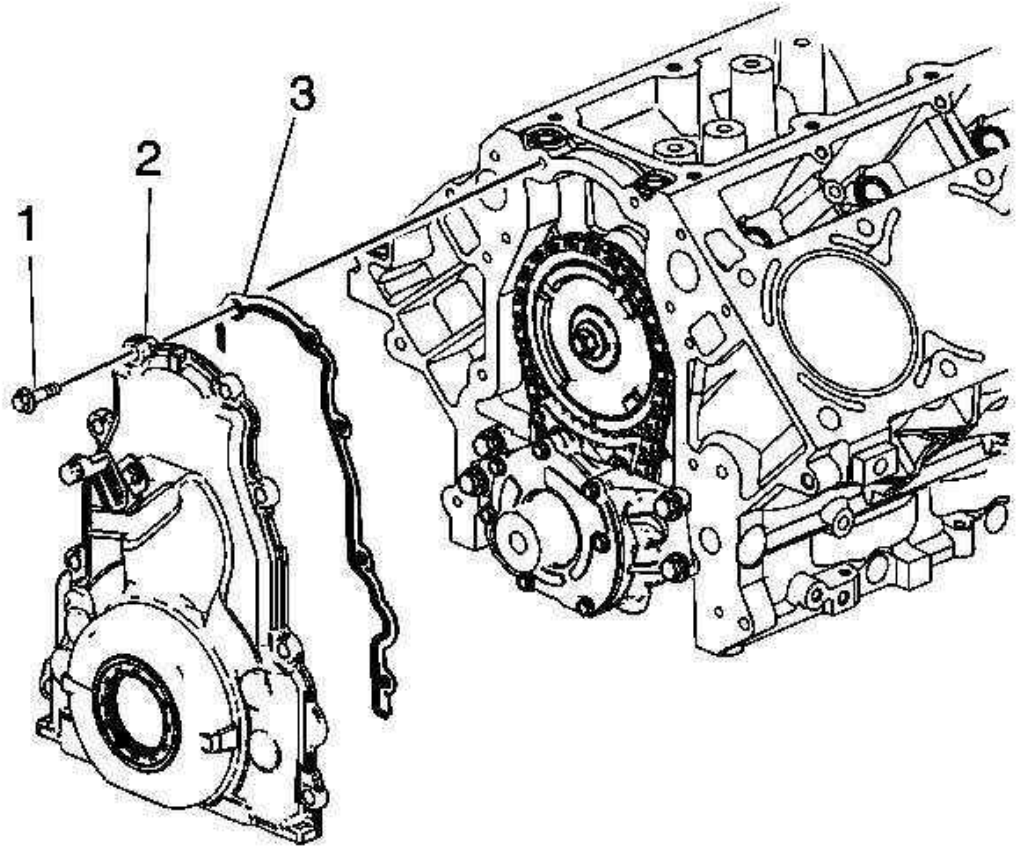


Fig. 612: View Of Engine Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft oil seal or the engine front cover gasket again.**
- **Do not apply any type of sealant to the front cover gasket, unless specified.**
- **The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.**

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- **All gasket surfaces should be free of oil or other foreign material during assembly.**

  The crankshaft front oil seal MUST be centered in relation to the crankshaft.

- **The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.**
- **An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.**

1. Install the front cover gasket (3), front cover (2), and bolts (1).
2. Tighten the cover bolts finger tight. Do not overtighten.

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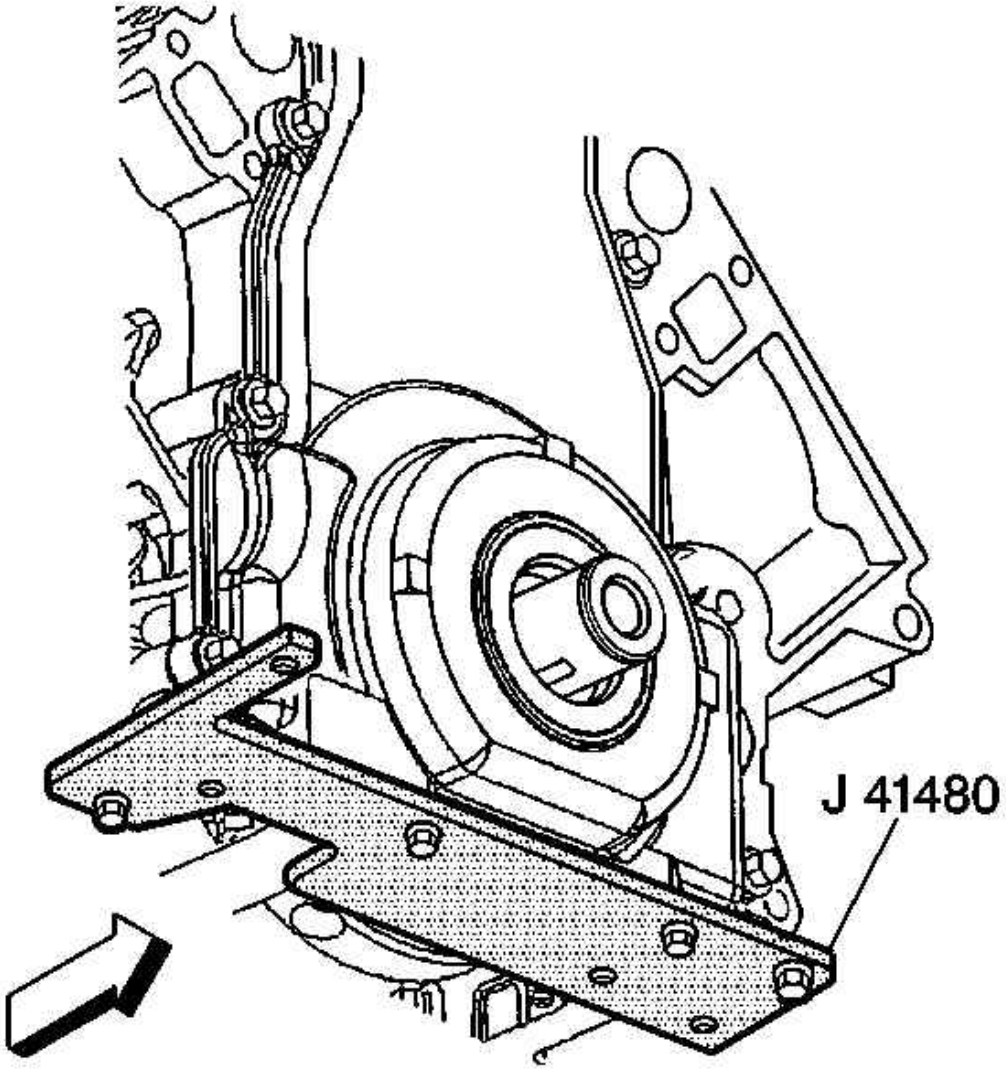


Fig. 613: View Of J 41480 Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

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3. Install the **J 41480** . See **Special Tools**.

   Tighten: Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

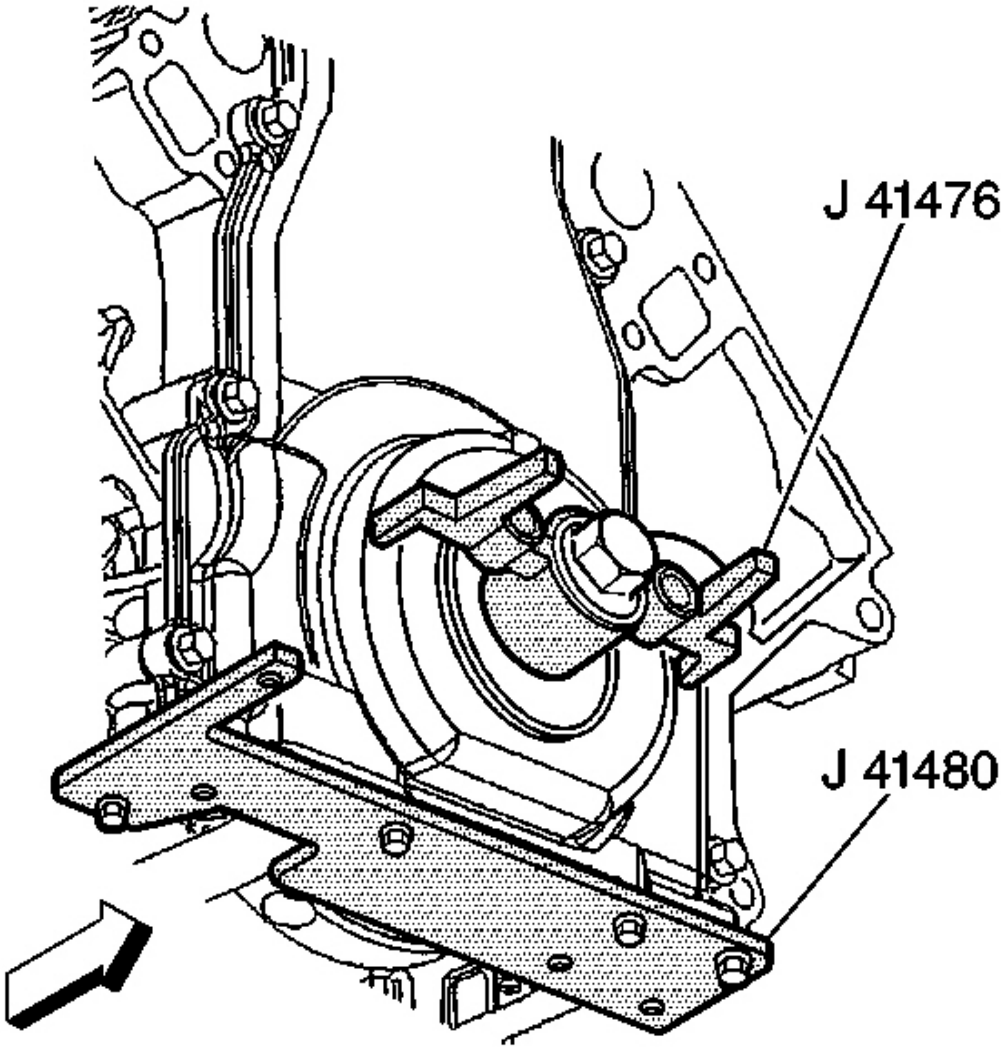


Fig. 614: View Of J 41476 & J 41480 Installed On Engine
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the tapered legs of the tool with the machined

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alignment surfaces on the front cover.

4. Install the **J 41476** . See **Special Tools**.
5. Install the crankshaft balancer bolt.

   Tighten:

   1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
   2. Tighten the **J 41480** . See **Special Tools**.
   3. Tighten the engine front cover bolts to 25 N.m (18 lb ft).

6. Remove the tools.

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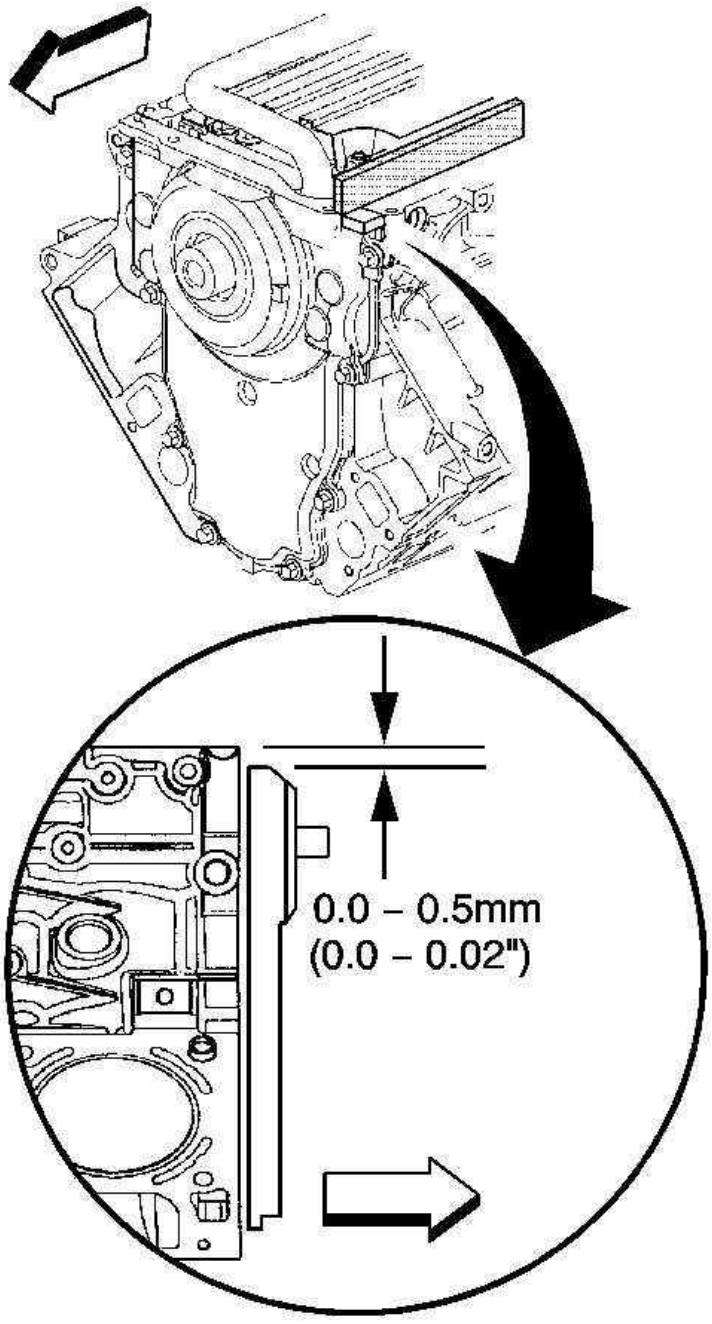


Fig. 615: View Of Front Cover-To-Engine Block Proper Installation Position

Courtesy of GENERAL MOTORS CORP.

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7. Measure the oil pan surface flatness, front cover-to-engine block.
    1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

       Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

    2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface, or no greater than 0.5 mm (0.02 in) below flush.
8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.

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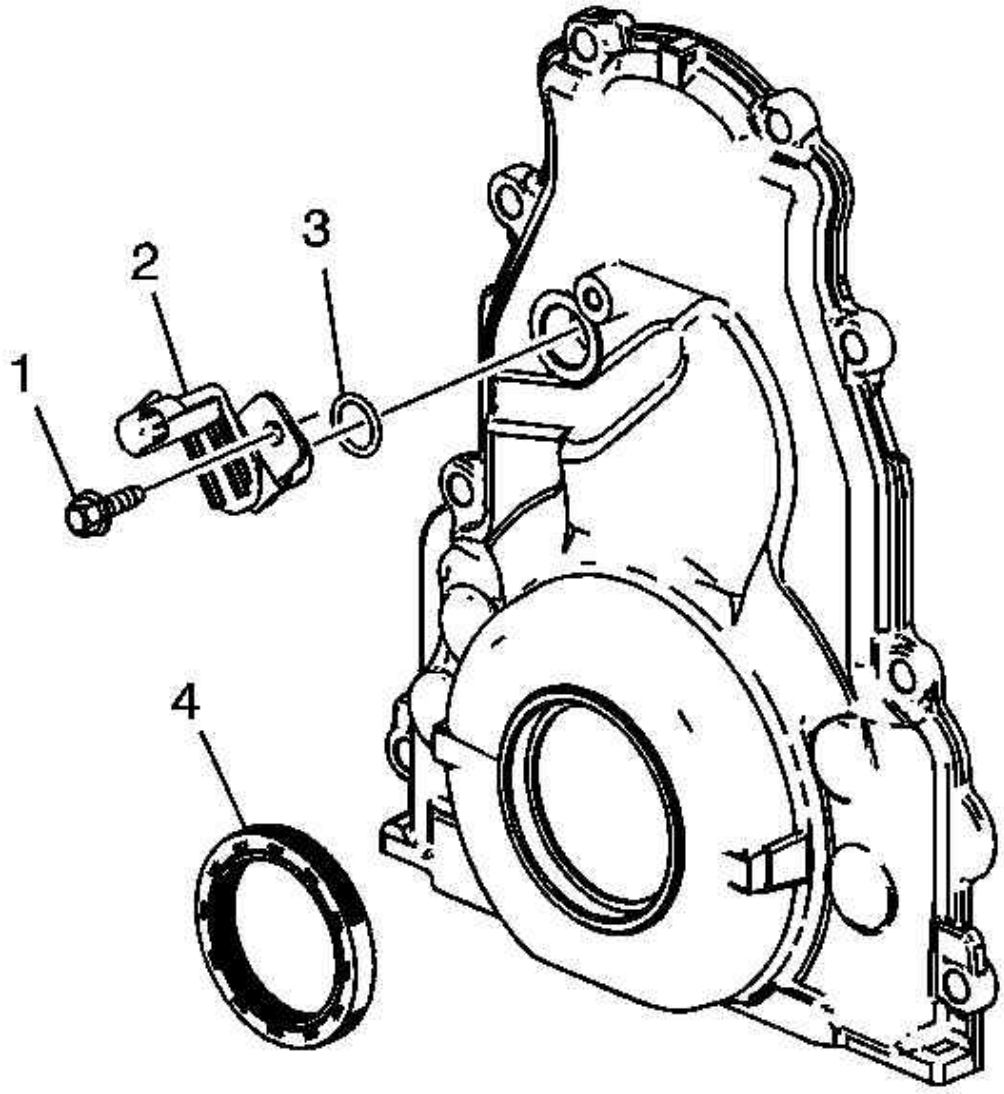


Fig. 616: View Of Engine Front Cover, Seal & CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position (CMP) sensor O-ring seal (3) for cuts or damage. If the seal is not cut or damaged, it may be used again.
11. Lubricate the O-ring seal with clean engine oil.

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12. Install the O-ring seal onto the sensor (2).
13. Install the sensor to the cover.
14. Install the bolt (1).

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

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

J 41478 Crankshaft Front Oil Seal Installer. See **Special Tools**.

Installation Procedure

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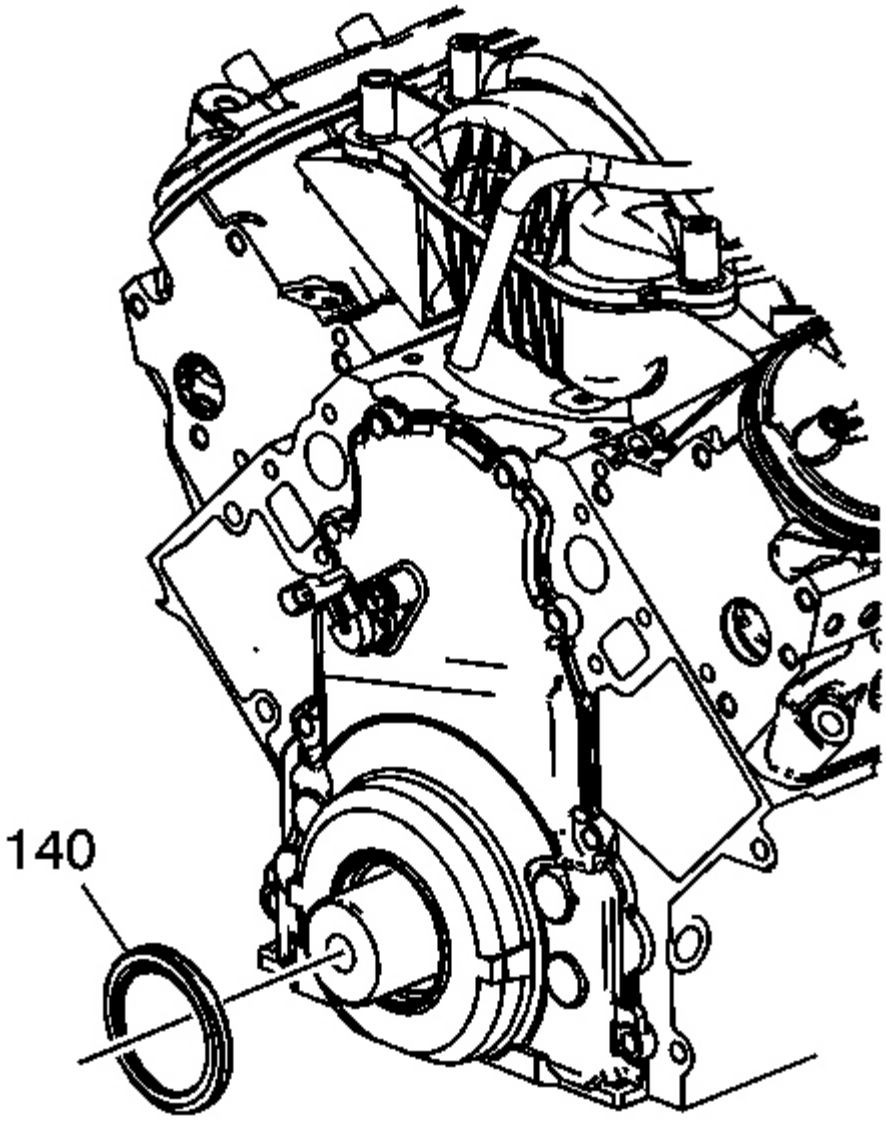


Fig. 617: Aligning Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not lubricate the oil seal sealing surface.**
- **Do not use the crankshaft front oil seal again.**

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1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

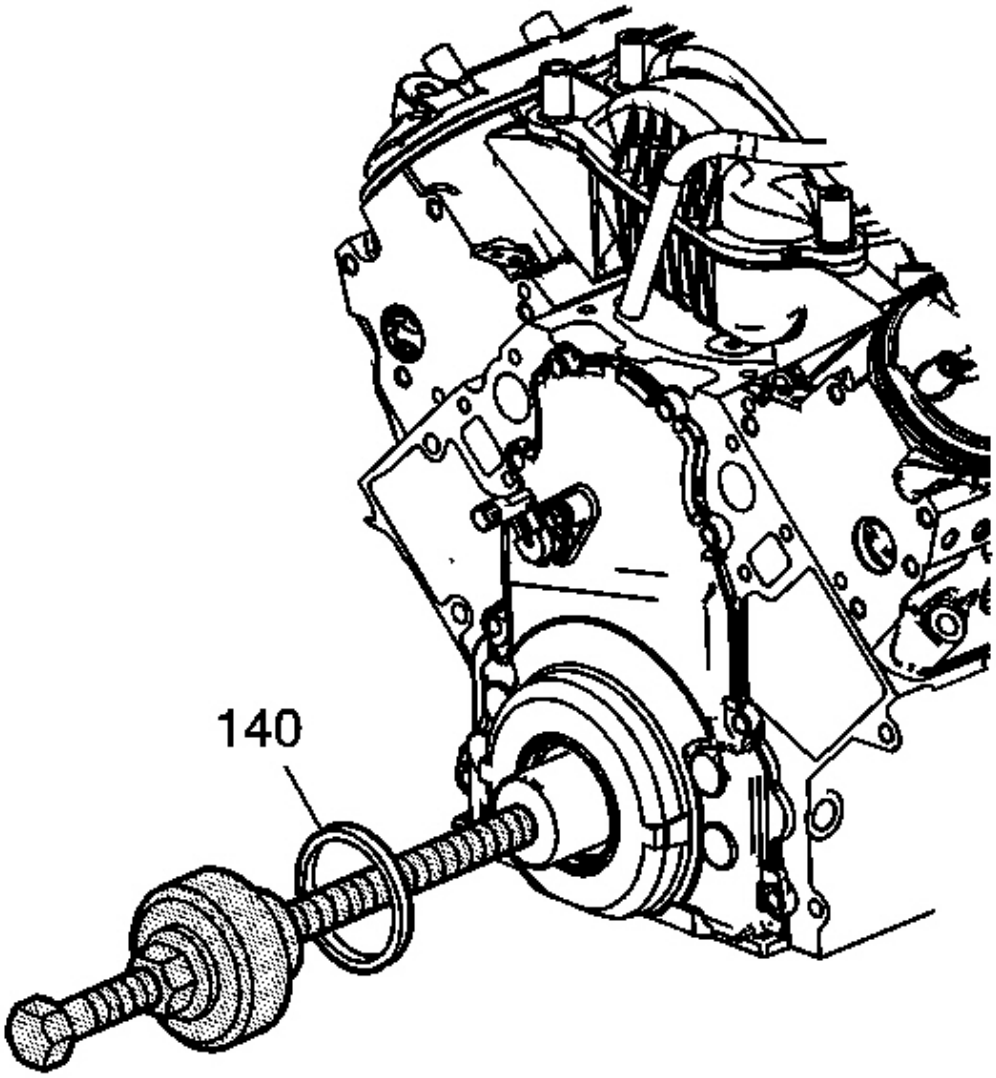


Fig. 618: Using Special Tools To Install Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) onto the **J 41478** . See **Special Tools**.

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4. Install the **J 41478** threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft. See **Special Tools**.
5. Use the **J 41478** in order to install the oil seal into the cover bore. See **Special Tools**.
    1. Use a wrench and hold the hex on the installer bolt.
    2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
    3. Remove the tool.
    4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

OIL PAN INSTALLATION

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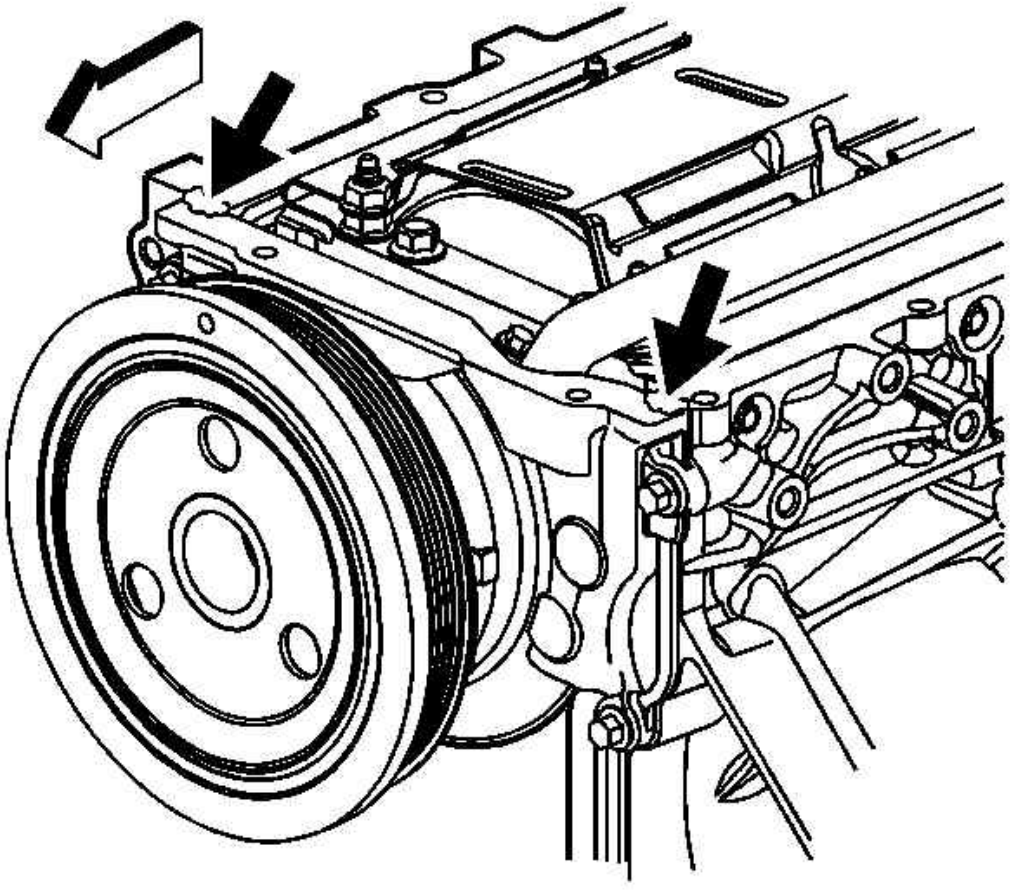


Fig. 619: Applying Bead Of Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush, or even. The rear of the oil pan must NEVER protrude beyond the**

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engine block and transmission housing plane.

- **Do not use the oil pan gasket again.**
- **It is not necessary to rivet the NEW gasket to the oil pan.**

1. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to **Sealers, Adhesives, and Lubricants**.

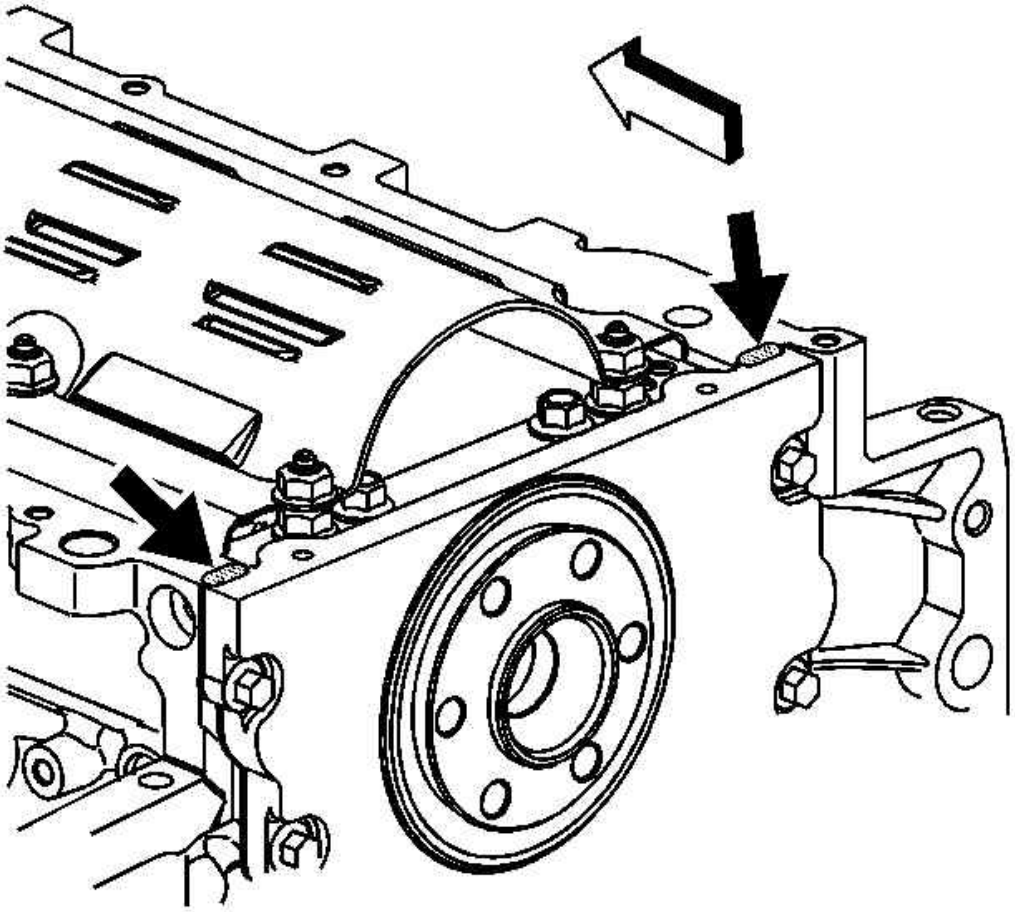


Fig. 620: View Of Sealant On Engine Rear Cover Gasket Tabs

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Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrude into the oil pan surface.

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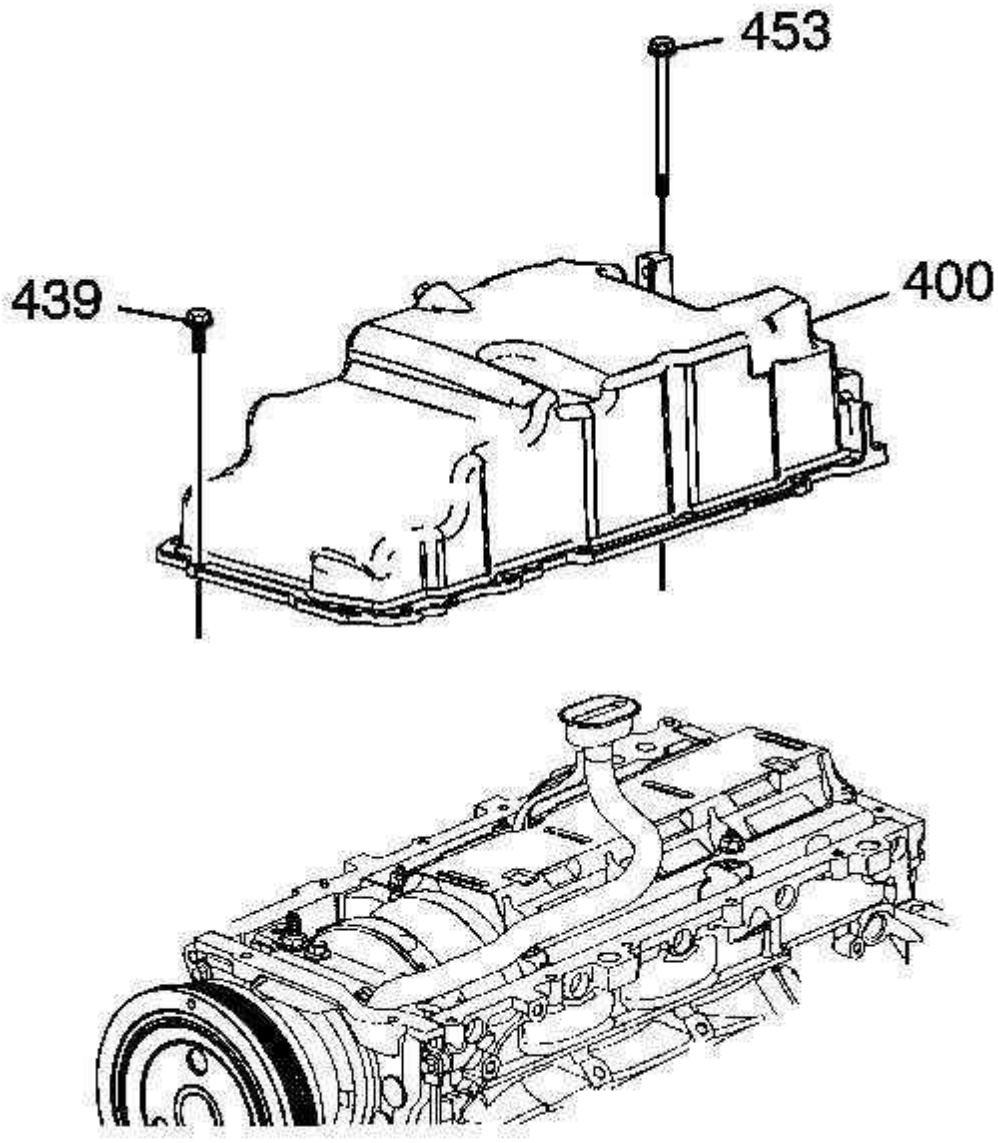


Fig. 621: Identifying Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the oil gallery passages in the oil pan and engine block properly align with the oil pan gasket.

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3. Pre-assemble the oil pan gasket to the pan.
    1. Install the gasket onto the oil pan.
    2. Install the oil pan bolts (439, 453) to the pan and through the gasket.
4. Install the oil pan, gasket and bolts to the engine block.
5. Tighten bolts finger tight. Do not overtighten.

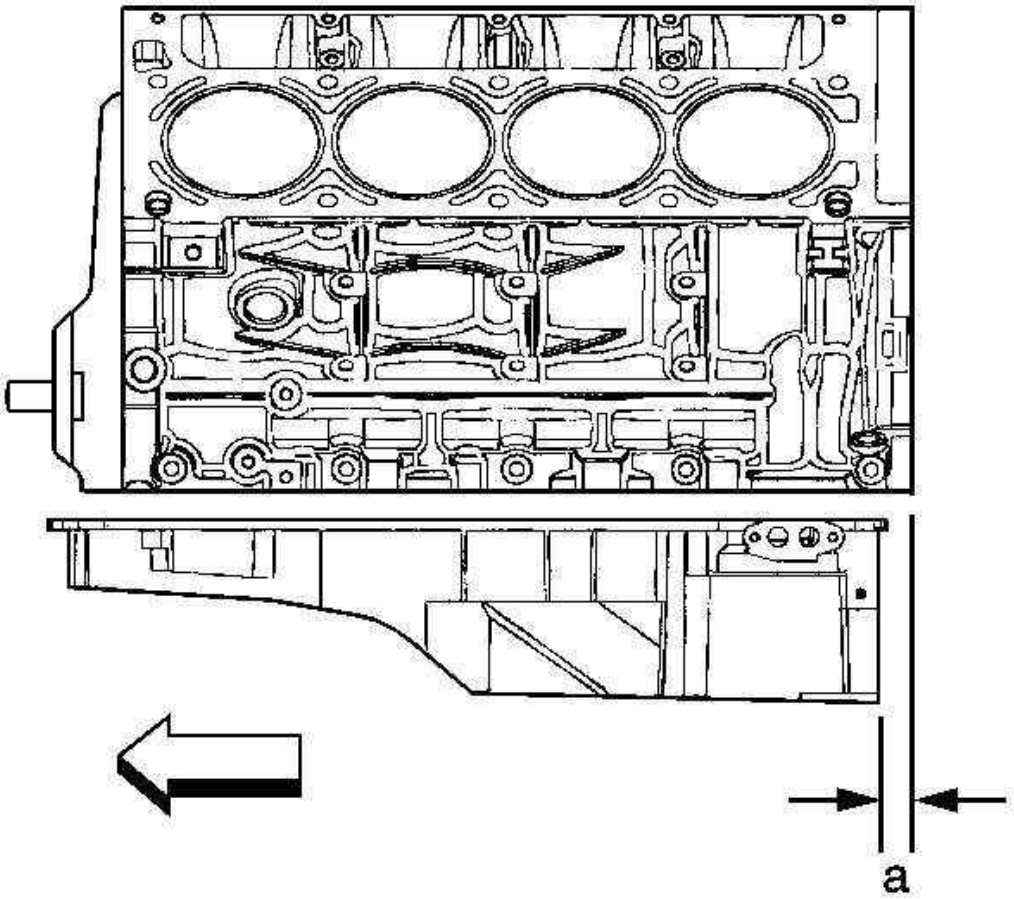


Fig. 622: Measuring Oil Pan-To-Engine Block Alignment
Courtesy of GENERAL MOTORS CORP.

6. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

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NOTE: Refer to Fastener Notice .

7. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.

   Tighten:

   1. Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N.m (18 lb ft).
   2. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).

8. Measure the oil pan-to-engine block alignment.
   1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

      IMPORTANT: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

   2. Insert a feeler gage between the straight edge and the oil pan transmission housing mounting surface, and inspect to ensure there is no greater than a 0.1 mm (0.004 in) gap (a) between the pan and straight edge.
   3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

OIL FILTER INSTALLATION

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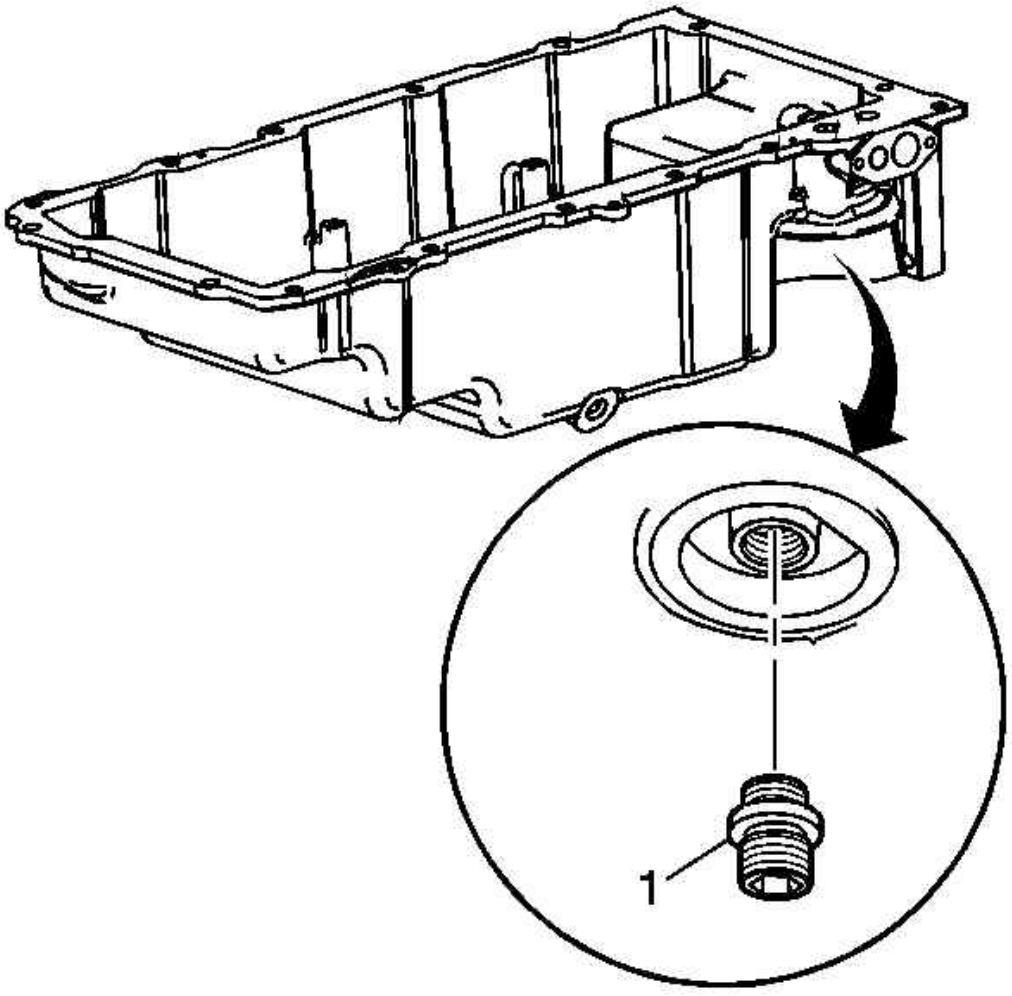


Fig. 623: Identifying Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil filter fitting (1).

   Tighten: Tighten the oil filter fitting to 55 N.m (40 lb ft).

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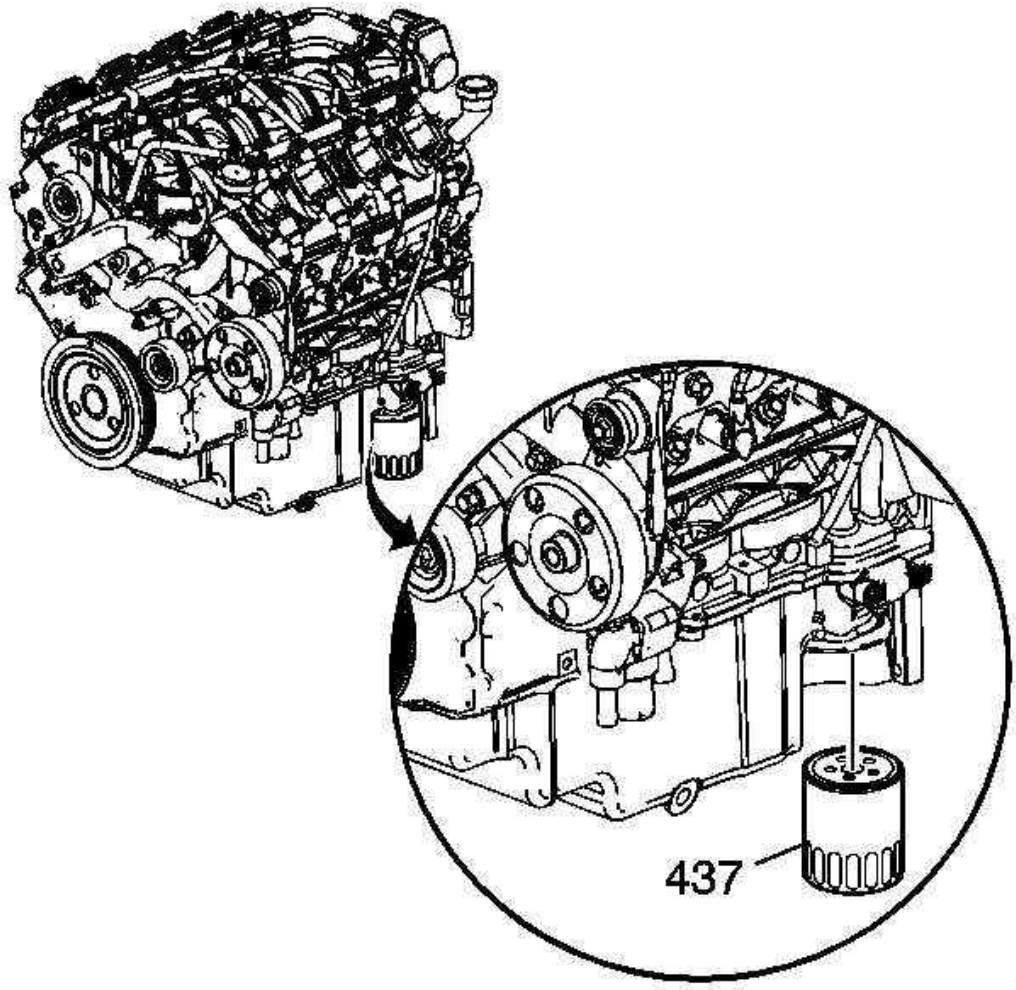


Fig. 624: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the oil filter seal with clean engine oil.
3. Install the oil filter (437).

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

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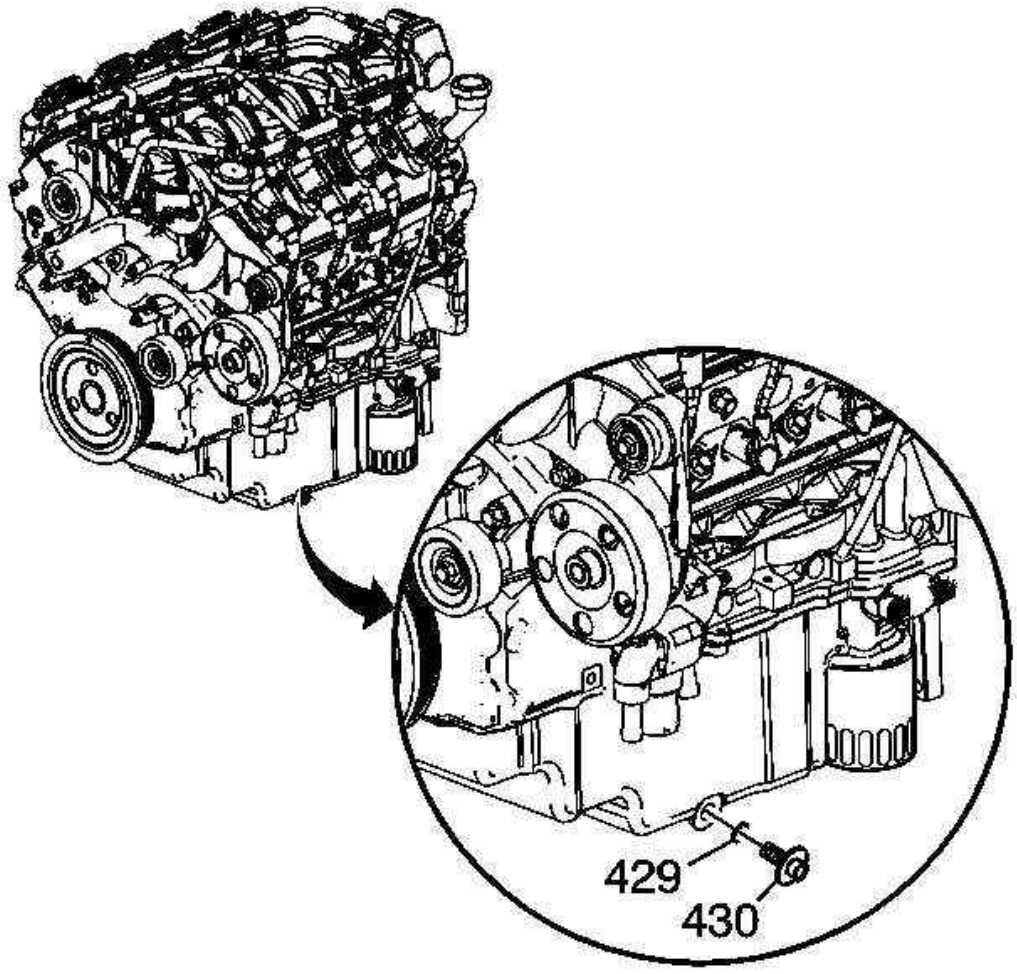


Fig. 625: View Of Oil Pan Drain Plug & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan drain plug (430) and O-ring (429).

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

VALVE LIFTER INSTALLATION (5.3L)

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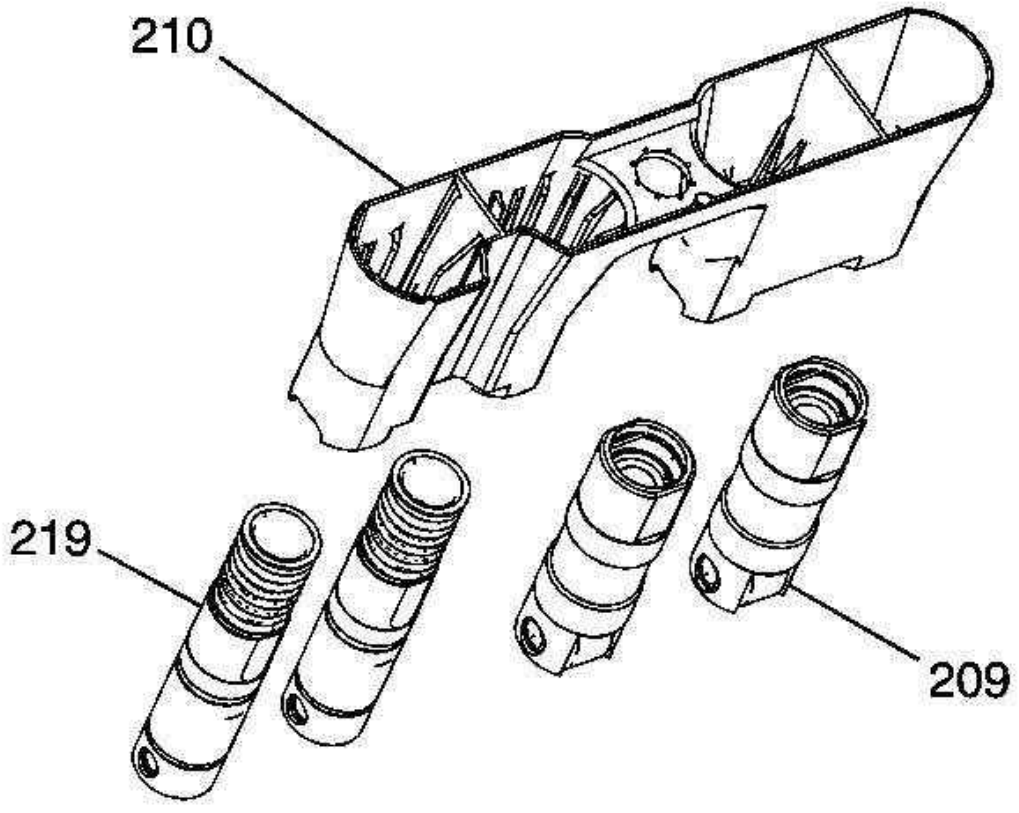


Fig. 626: View Of Valve Lifters & Guides
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the 4 valve guide assemblies will contain 2 active fuel management valve lifters and 2 non-active fuel management valve lifters.**
- **With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each**

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contain 2 active fuel management valve lifters.

1. Lubricate the valve lifters (209, 219) and engine block valve lifter bores with clean engine oil.

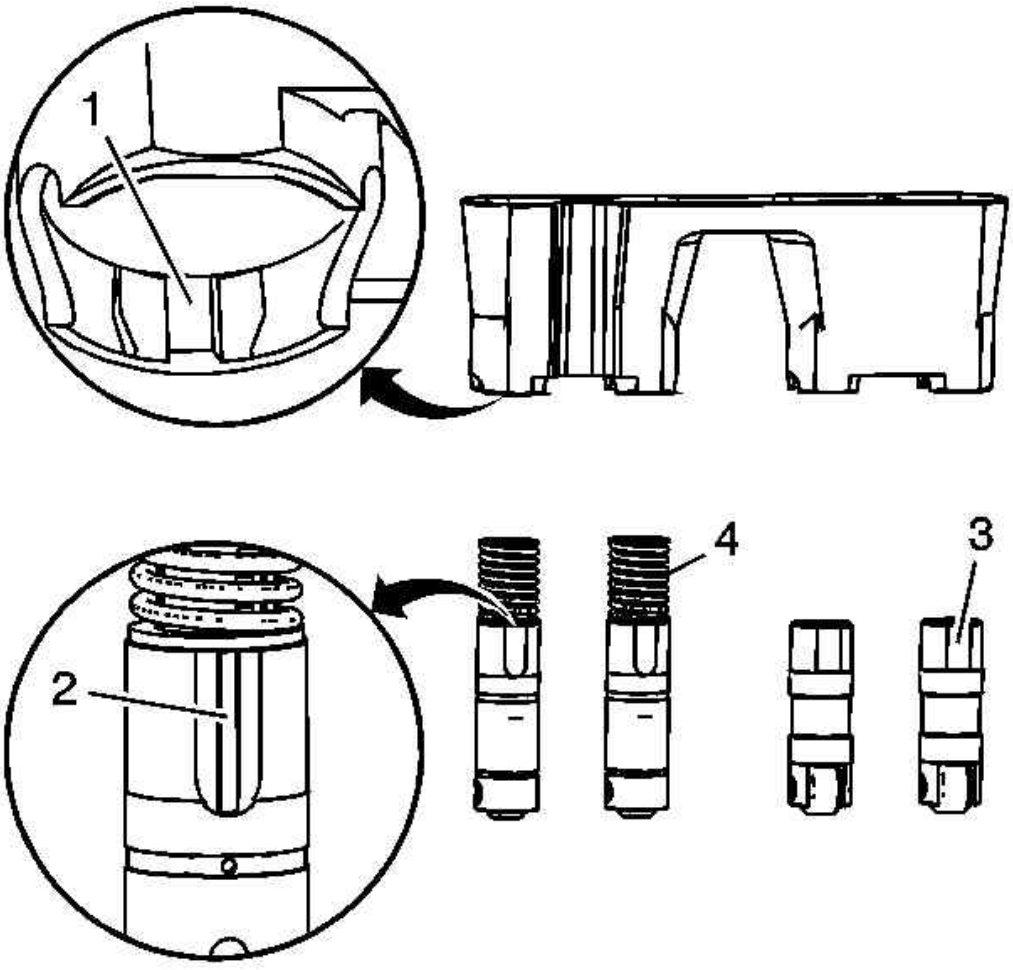


Fig. 627: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS CORP.

2. Insert the valve lifters into the lifter guides.
   - Align the flat area (3) on the top of the non-active fuel management lifter

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with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

- The active fuel management lifters (4) are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.

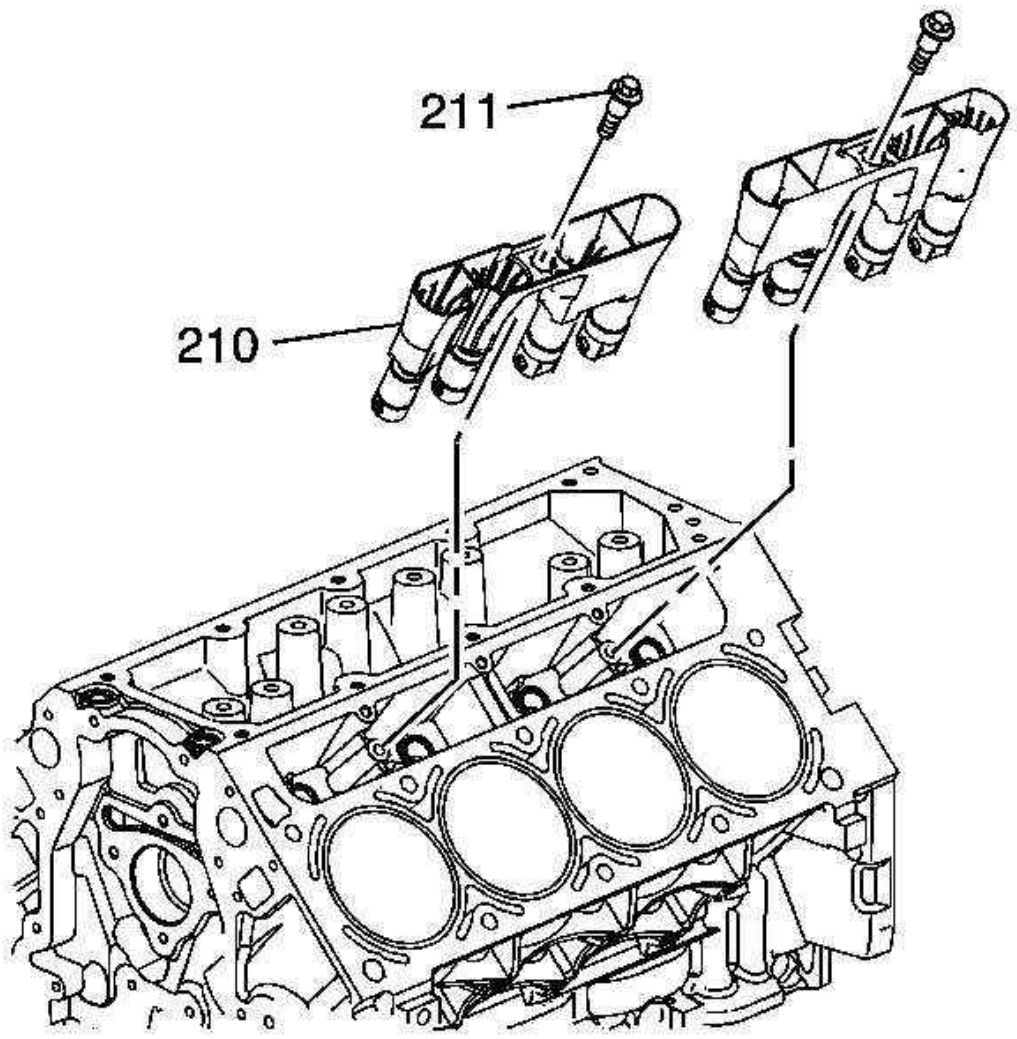


Fig. 628: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

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3. Install the valve lifters and guide assembly (210) to the engine block.

NOTE: Refer to Fastener Notice .

4. Install the valve lifter guide bolts (211).

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

CYLINDER HEAD INSTALLATION - LEFT SIDE

Tools Required

- **J 42385-100** Thread Repair Kit. See **Special Tools**.
- **J 45059** Angle Meter

Installation

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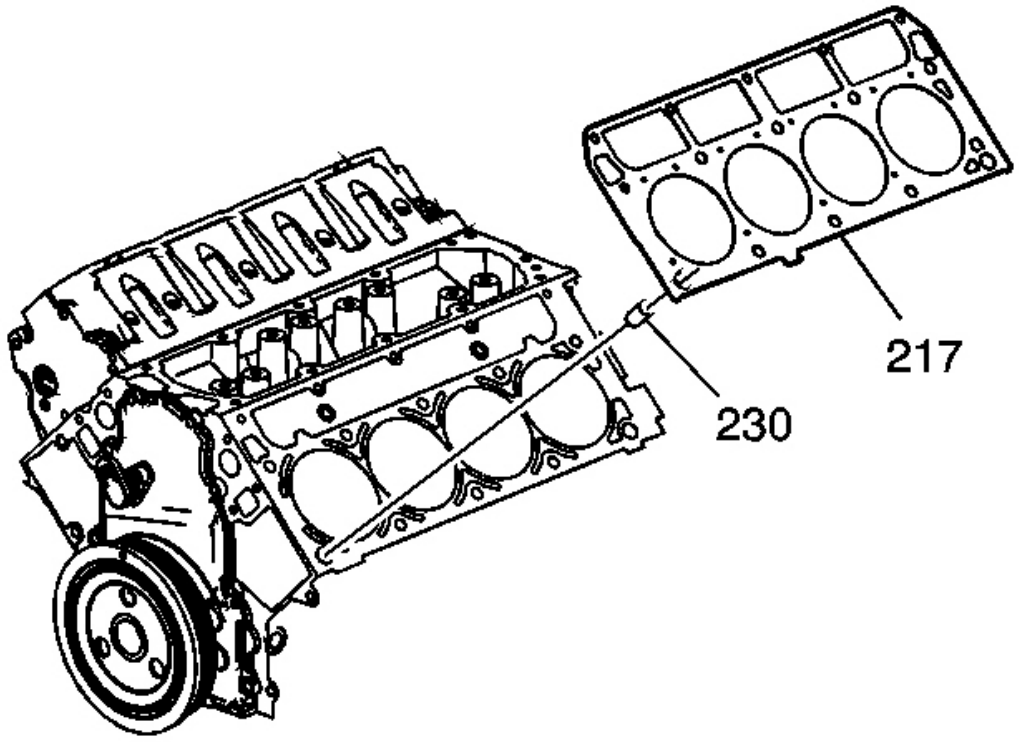


Fig. 629: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

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.

IMPORTANT:

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder**

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head gasket, unless specified.

- **The cylinder head gaskets must be installed in the proper direction and position.**

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

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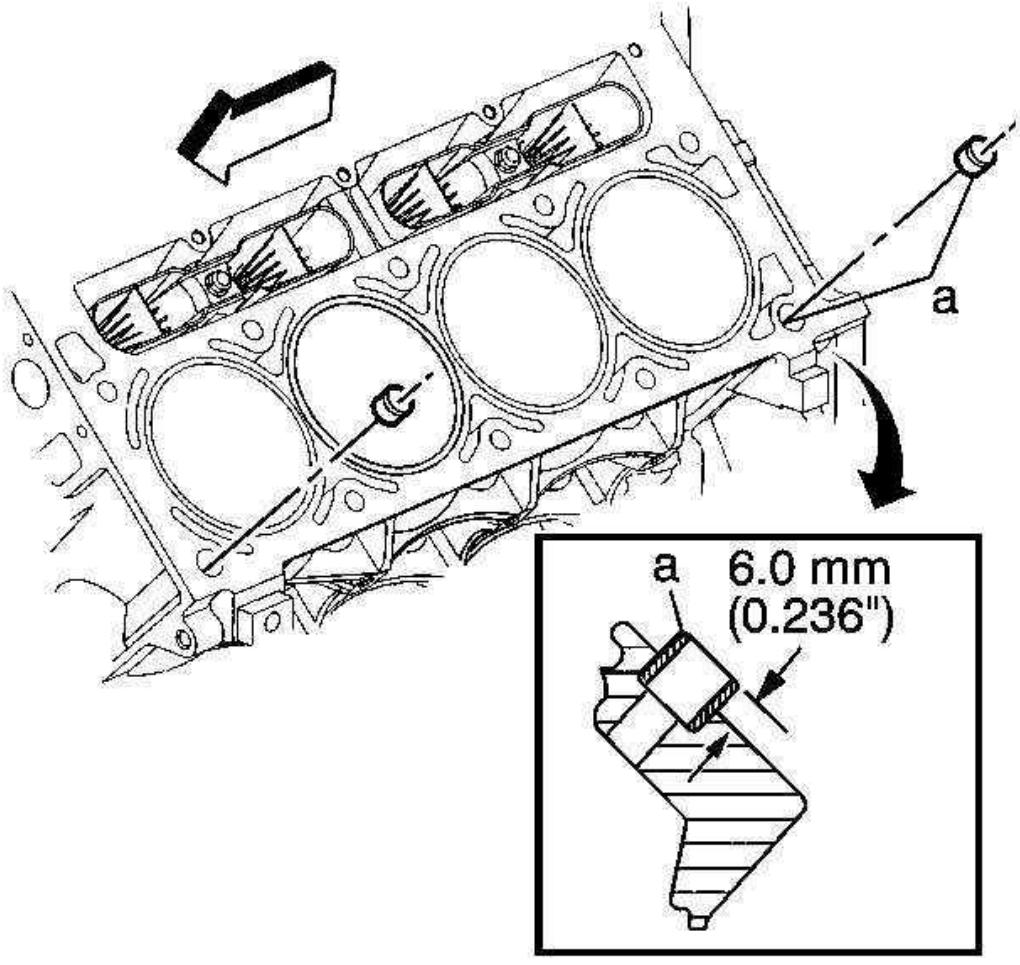


Fig. 630: View Of Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

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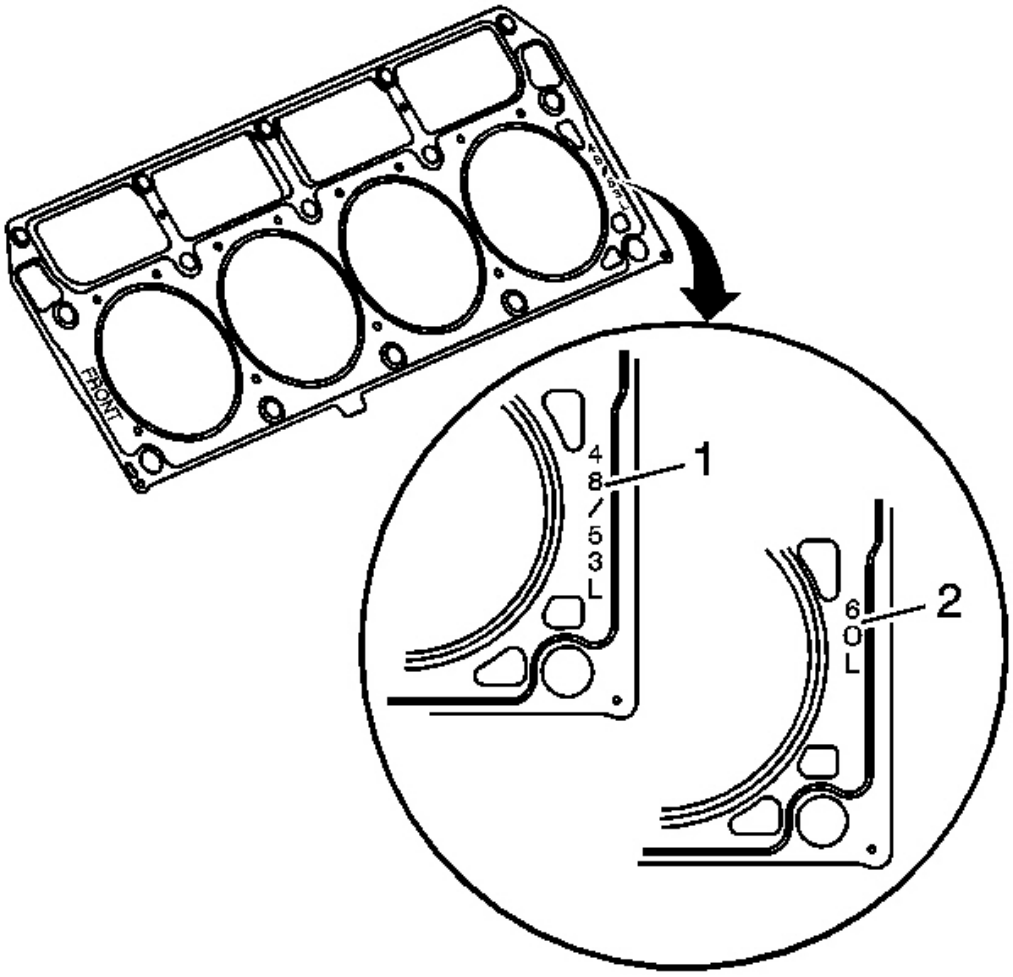


Fig. 631: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket for proper usage.

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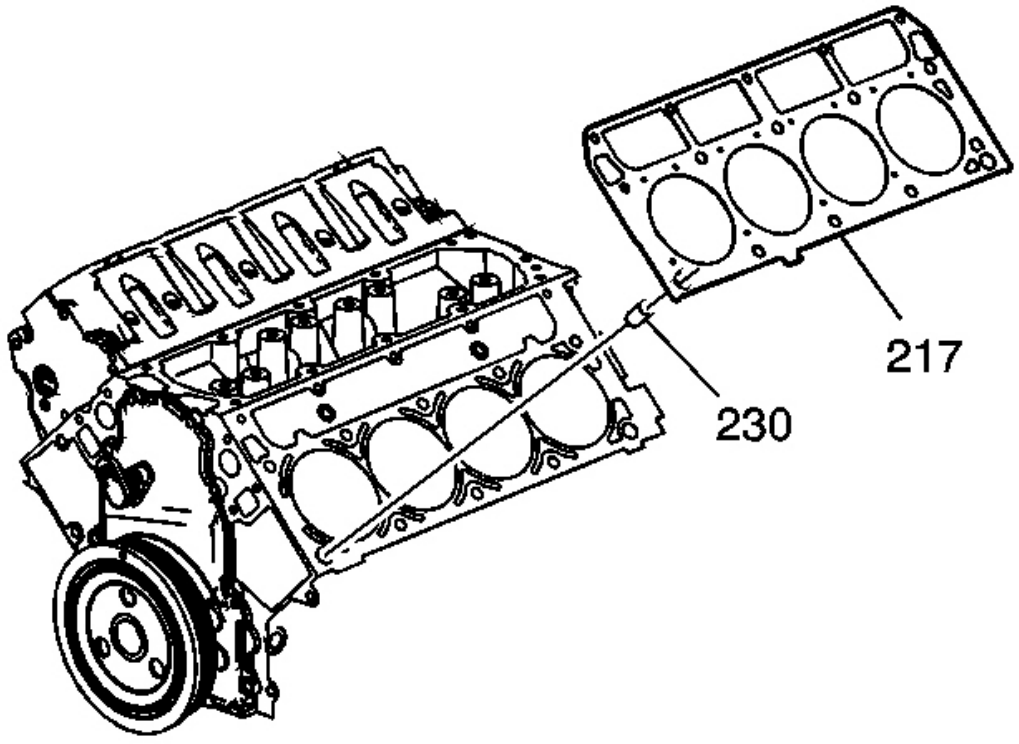


Fig. 632: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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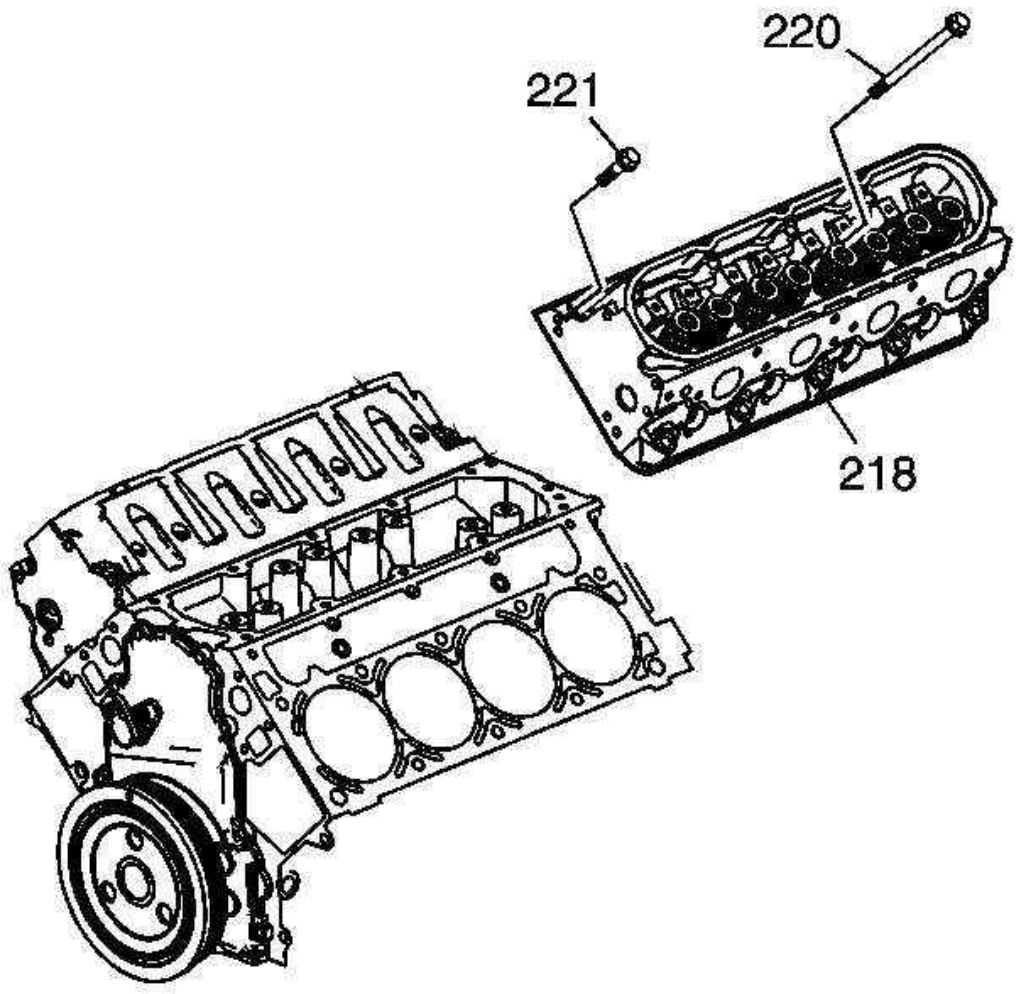


Fig. 633: View Of Cylinder Head & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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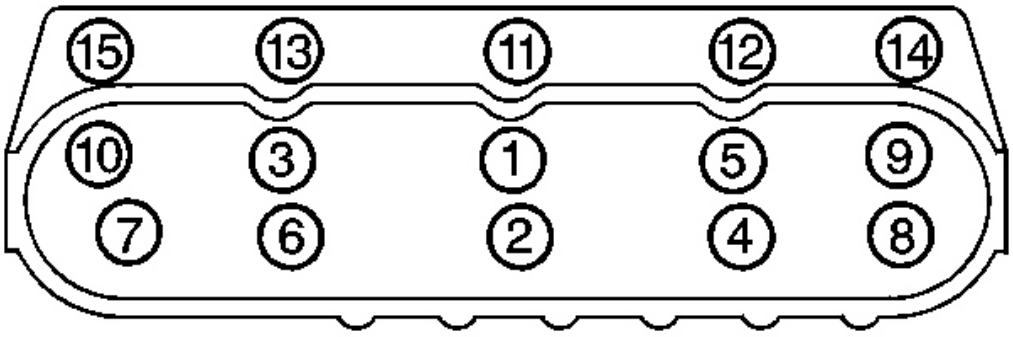


Fig. 634: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

10. Tighten the cylinder head bolts.

Tighten:

1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** .
3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** .
4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

CYLINDER HEAD INSTALLATION - RIGHT SIDE

Tools Required

- **J 42385-100** Thread Repair Kit. See **Special Tools**.

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- **J 45059** Angle Meter

Installation

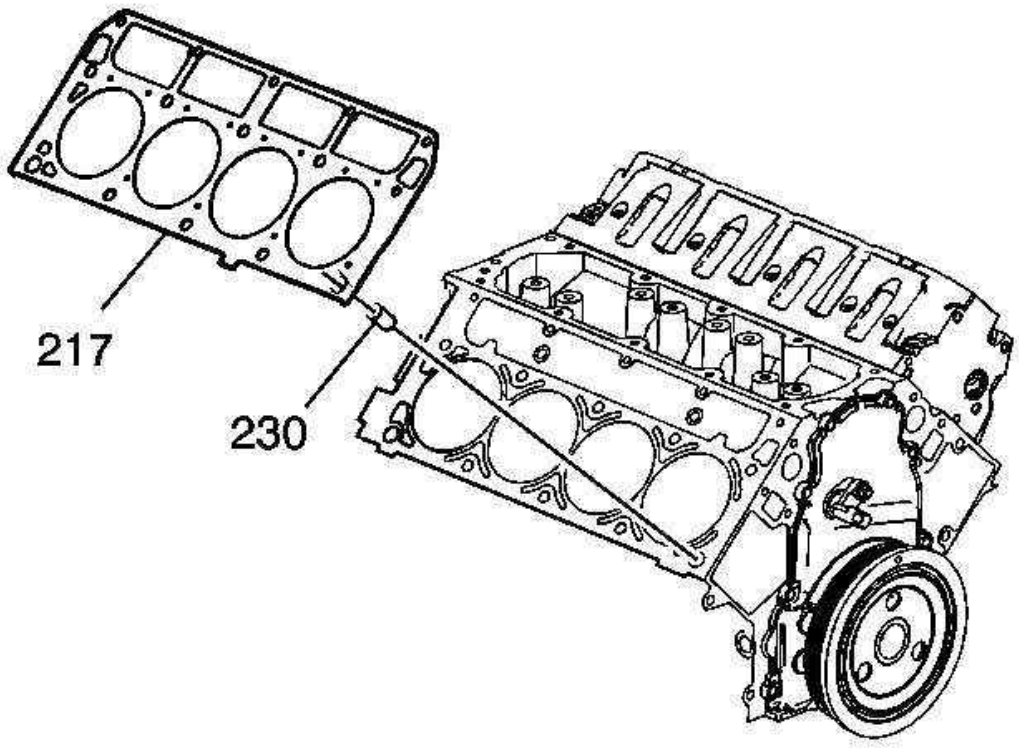


Fig. 635: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

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.

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IMPORTANT:

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless specified.**
- **The cylinder head gaskets must be installed in the proper direction and position.**

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

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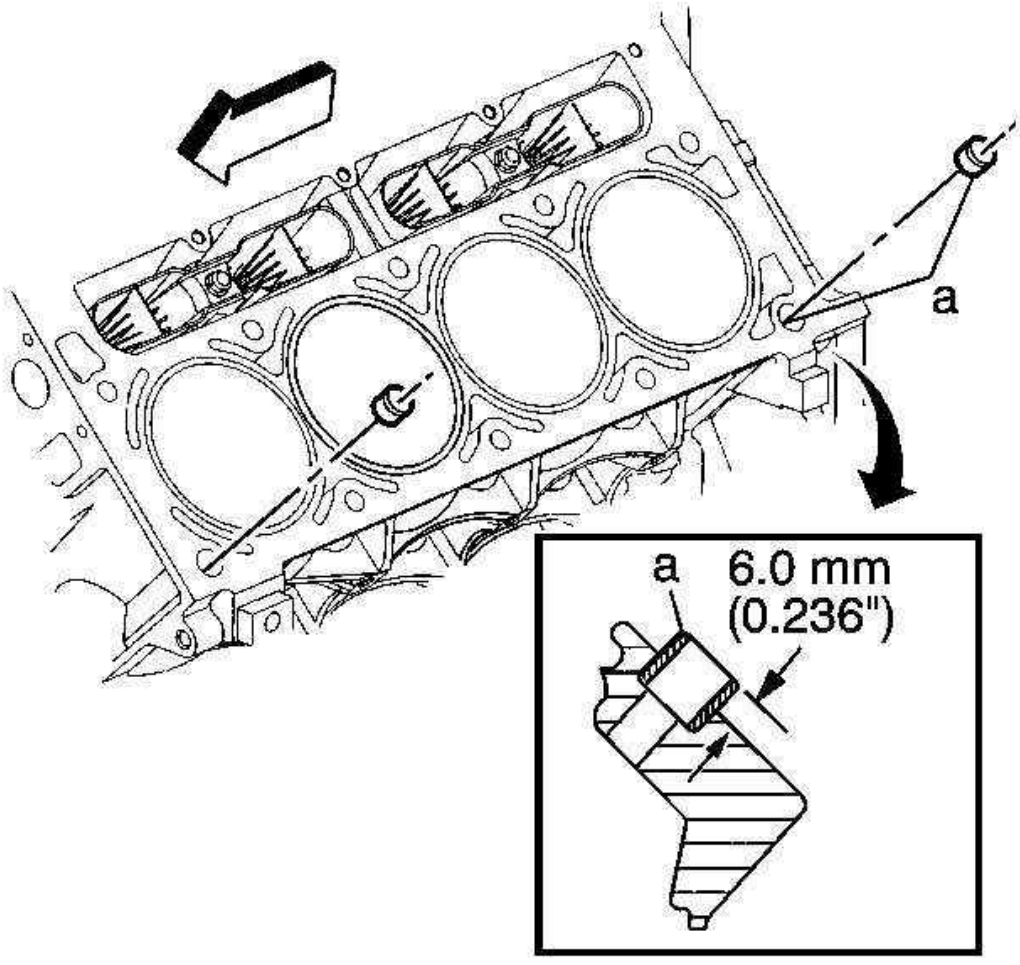


Fig. 636: View Of Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

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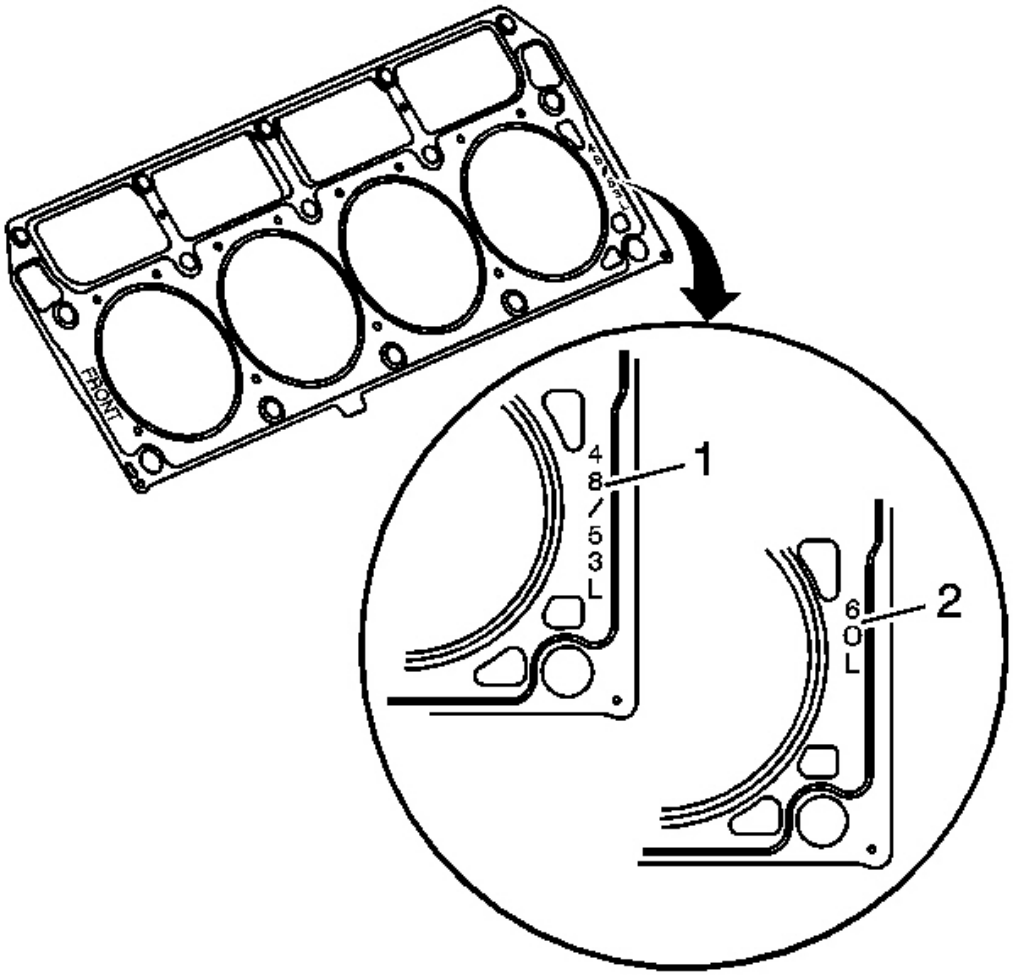


Fig. 637: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket for proper usage.

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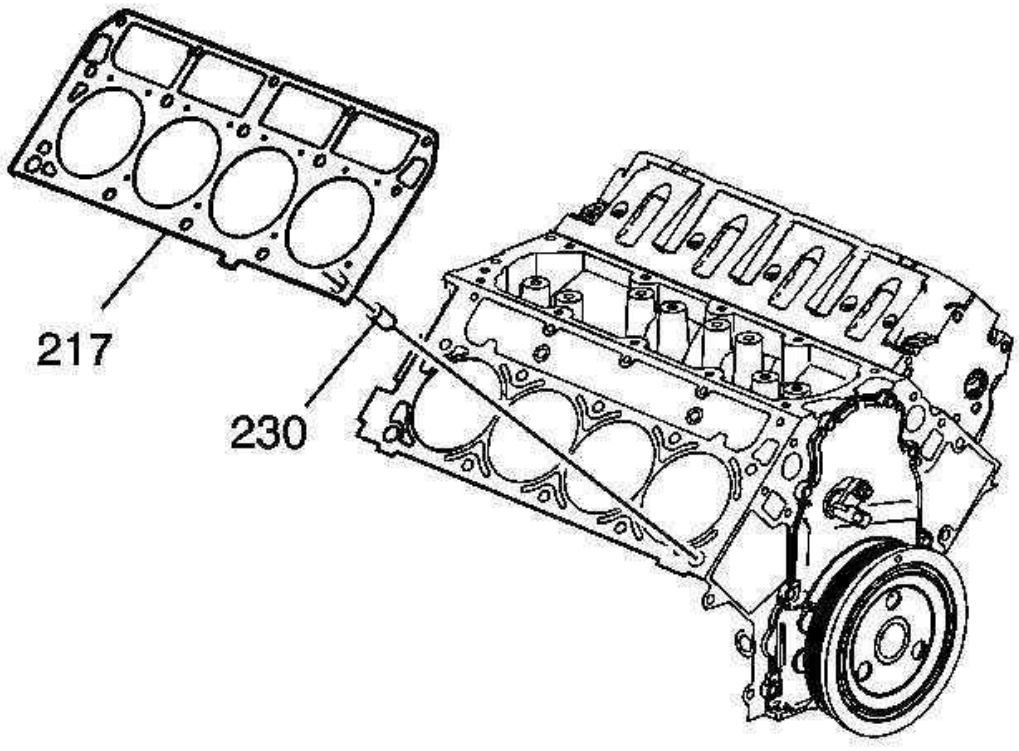


Fig. 638: View Of Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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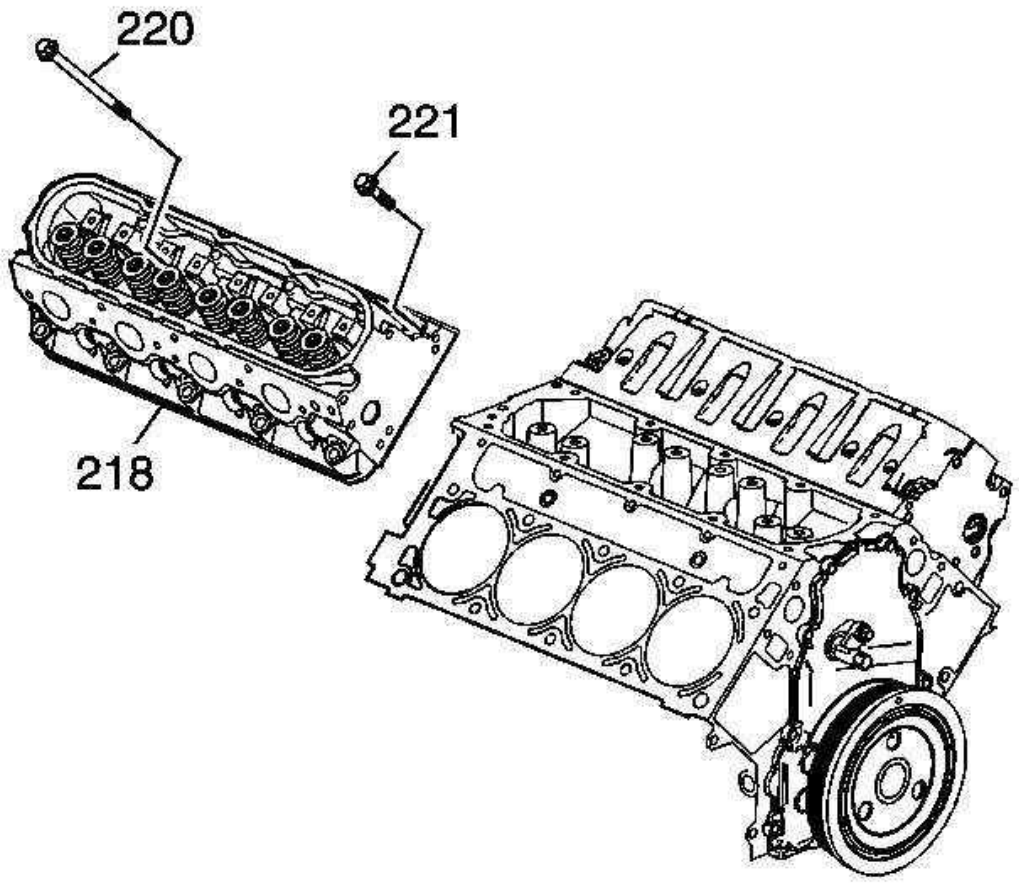


Fig. 639: View Of Cylinder Head & Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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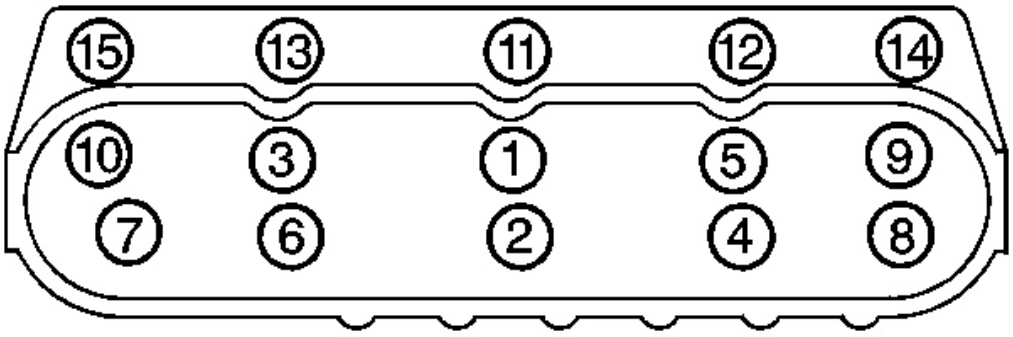


Fig. 640: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

10. Tighten the cylinder head bolts.

Tighten:

1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** .
3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** .
4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

VALVE ROCKER ARM AND PUSH ROD INSTALLATION

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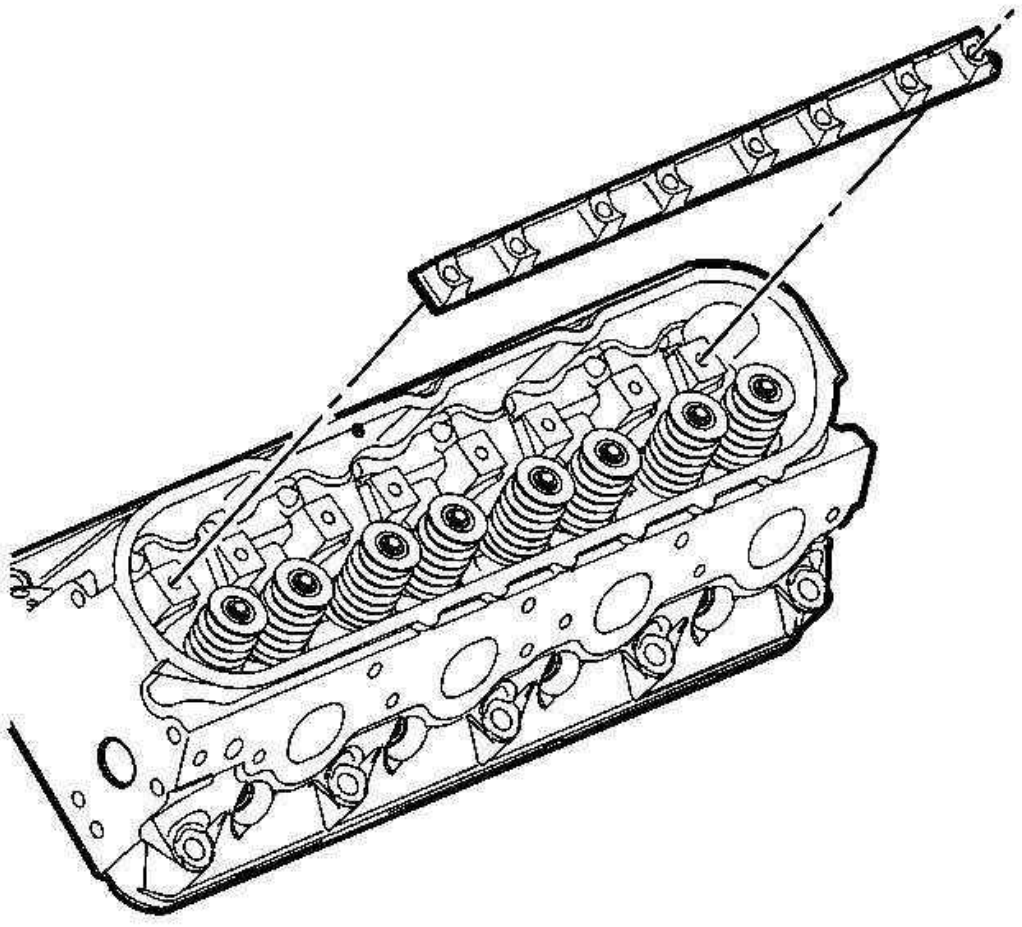


Fig. 641: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **When using the valve train components again, always install the components to the original location and position.**
- **Valve lash is net build. No valve adjustment is required.**

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.

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3. Install the valve rocker arm pivot support.

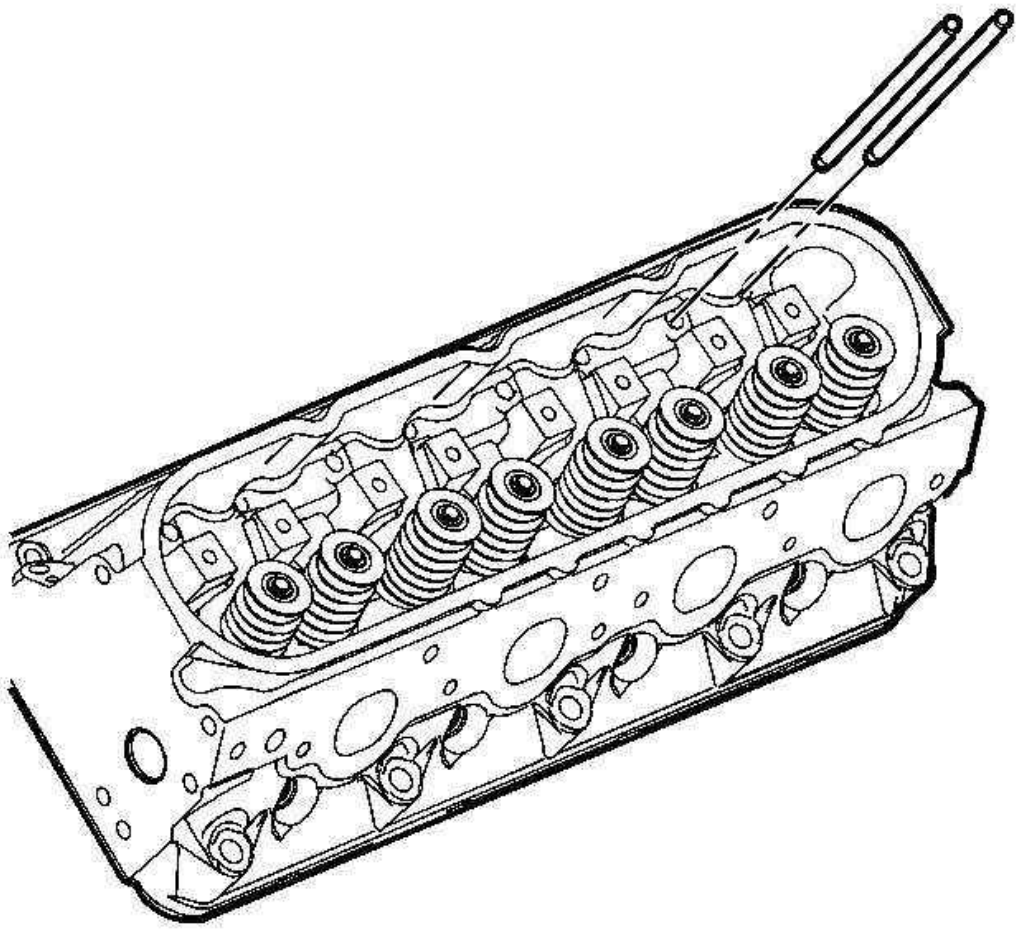


Fig. 642: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

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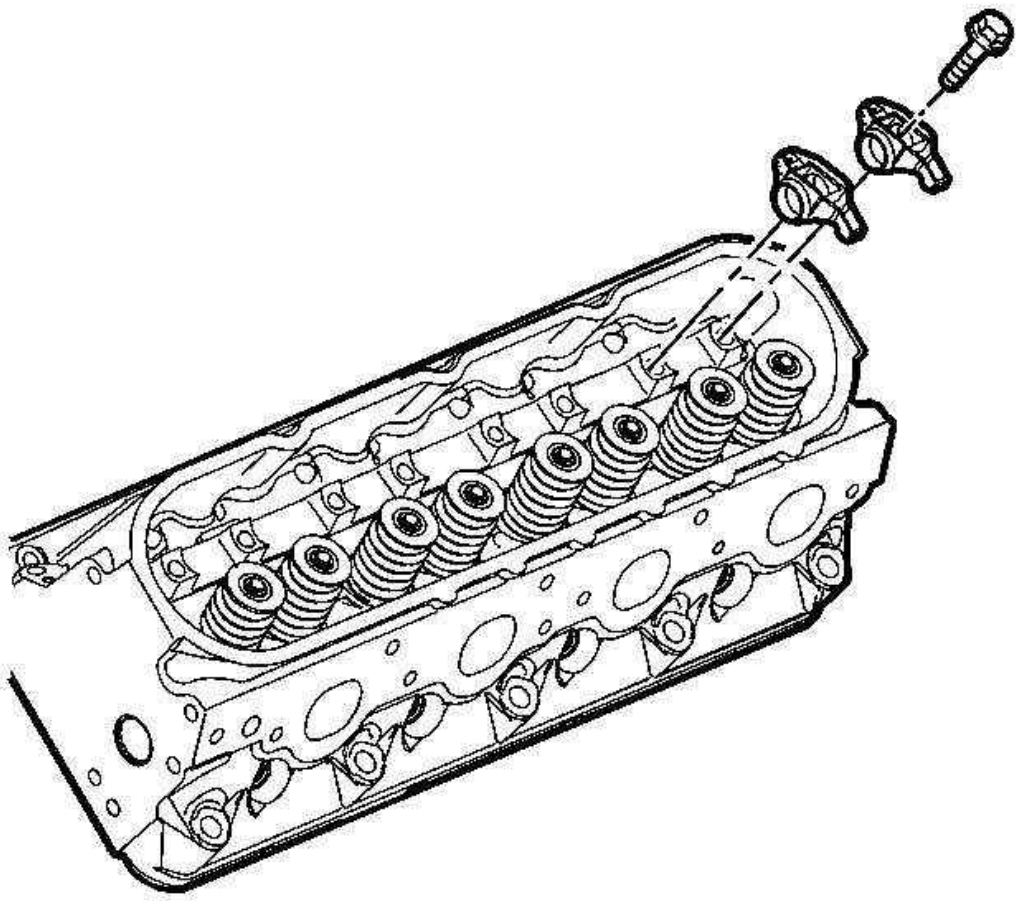


Fig. 643: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure the pushrods seat properly to the ends of the rocker arms.**
- **DO NOT tighten the rocker arm bolts at this time.**

5. Install the rocker arms and bolts.

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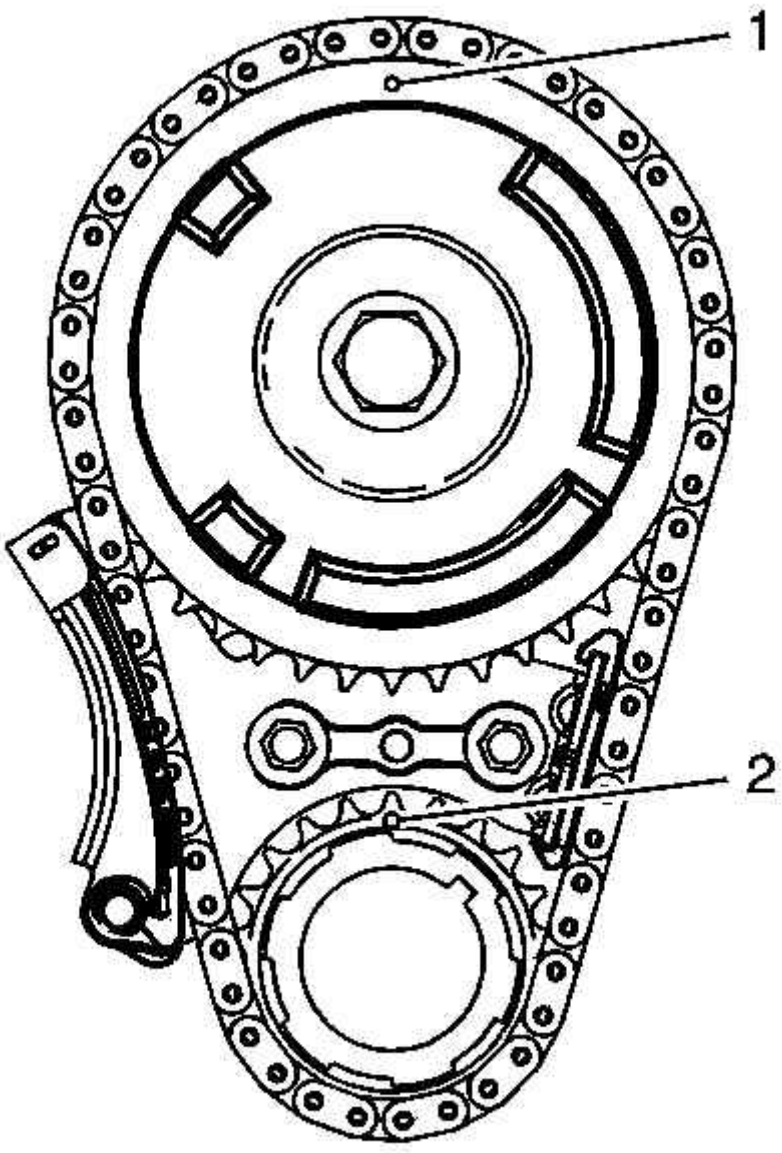


Fig. 644: View Of Camshaft & Crankshaft Sprocket Alignment Marks In 12 O'clock Position
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number 1 piston is at top dead center of

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compression stroke.

In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

Cylinders 1, 3, 5 and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

NOTE: Refer to Fastener Notice .

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:

   Tighten:
   - Tighten the exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
   - Tighten the intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N.m (22 lb ft).

8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

   Tighten:
   - Tighten the exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
   - Tighten the intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

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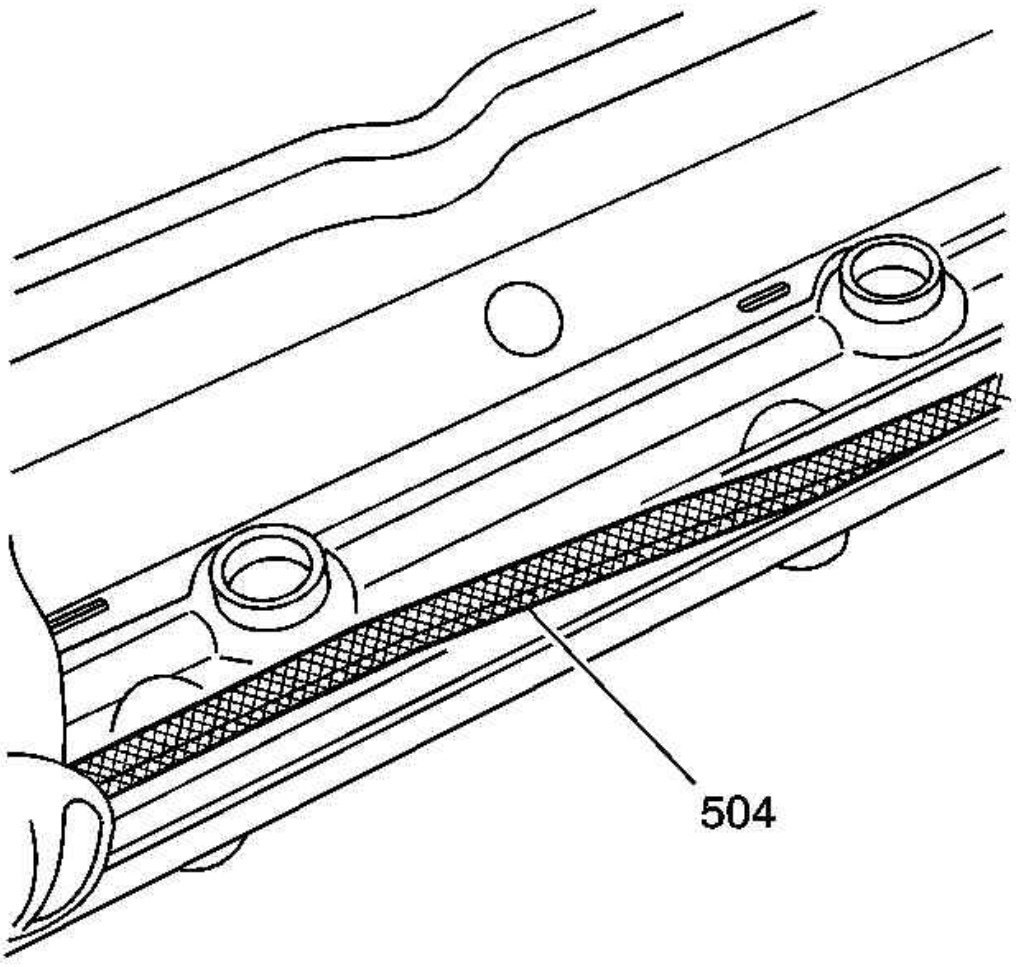


Fig. 645: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**
- **The valve rocker arm cover bolt grommets may be used again if not damaged.**

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1. Install a NEW gasket (504) into the valve rocker arm cover.

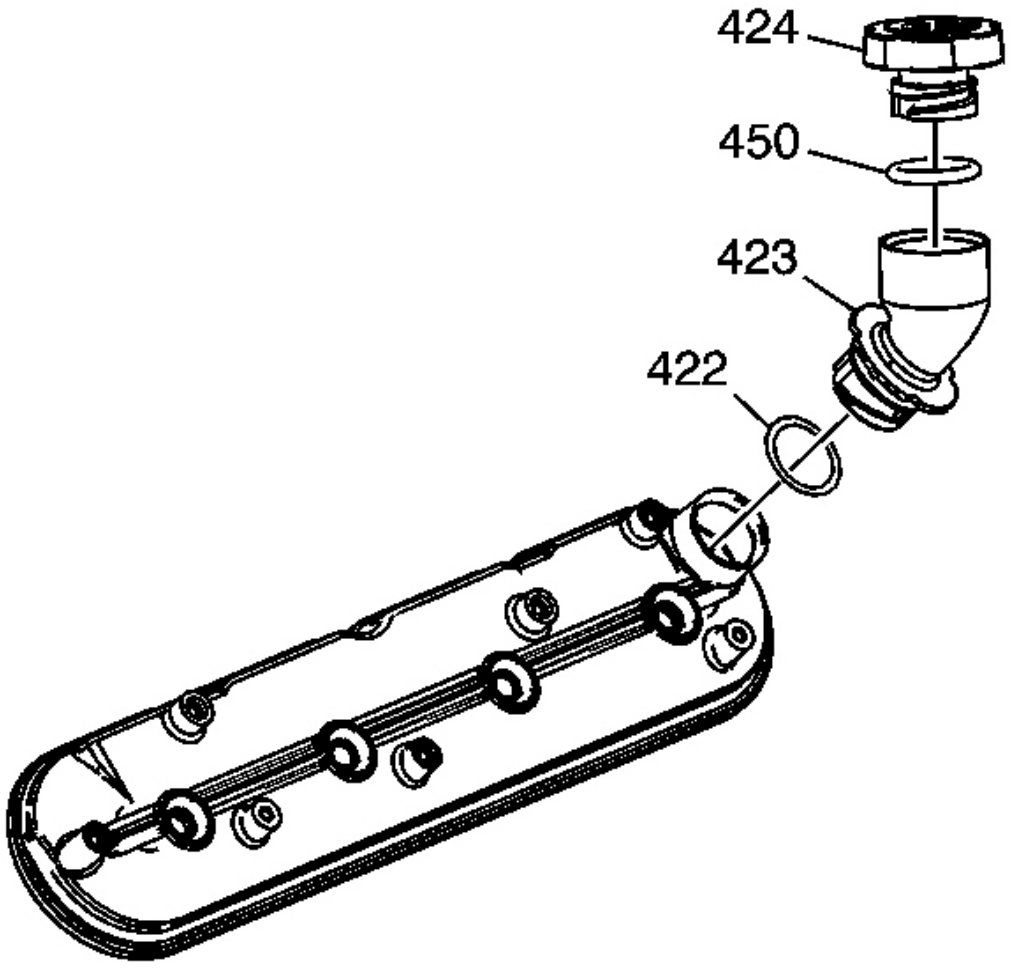


Fig. 646: Identifying Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

2. Install a new oil fill tube (423) and O-ring (422).
3. Install the oil fill cap (424) and O-ring (450).

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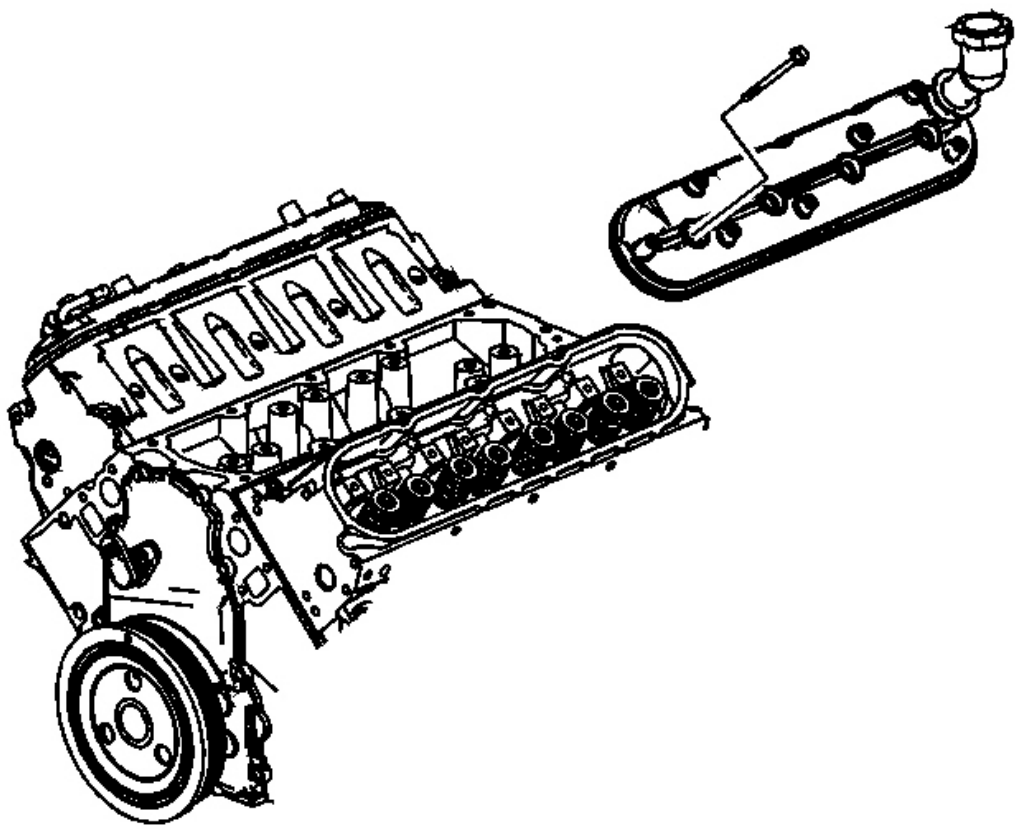


Fig. 647: View Of Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice .

5. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

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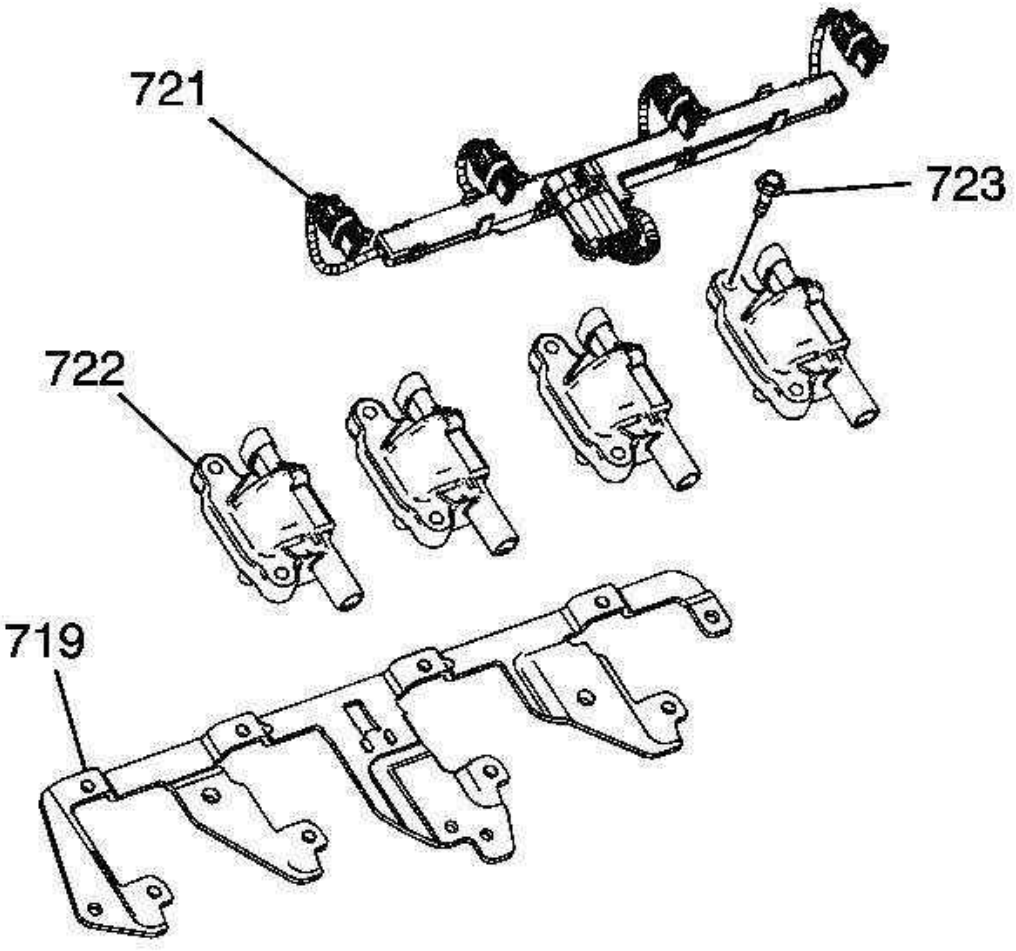


Fig. 648: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
7. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719).

Tighten: Tighten the ignition coil bolts to 8 N.m (71 lb in).

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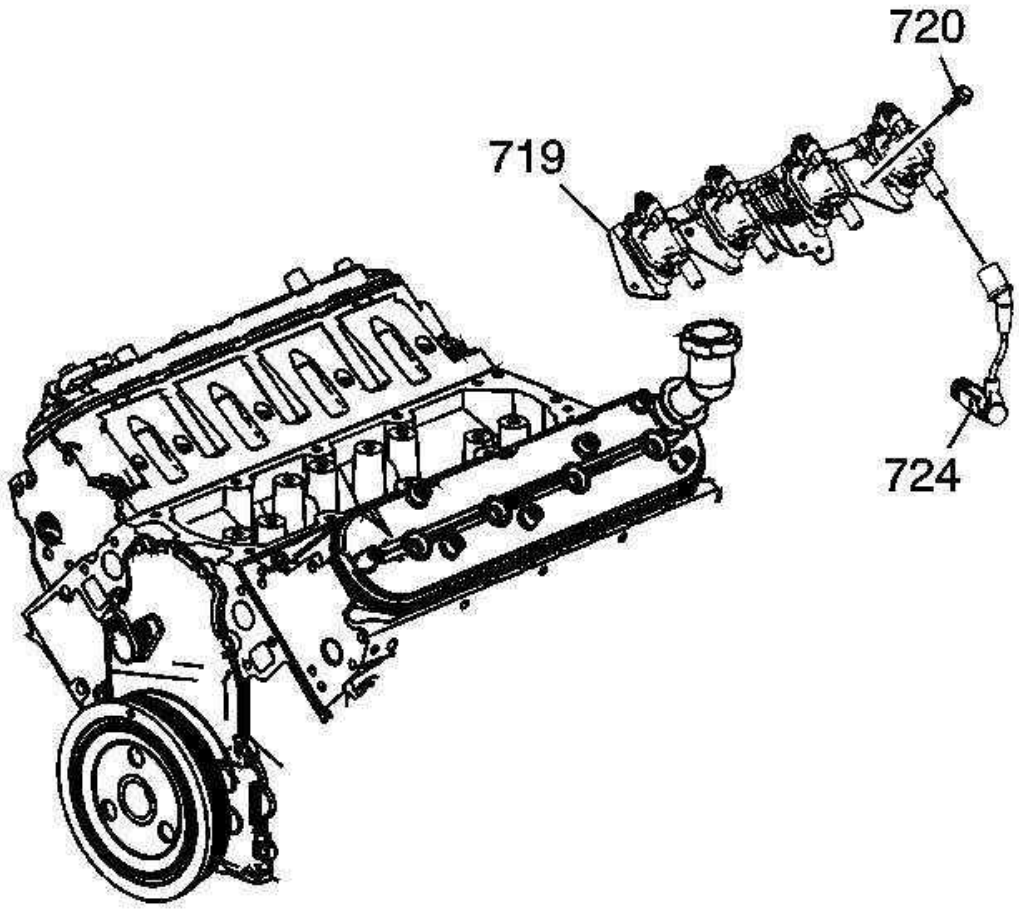


Fig. 649: View Of Ignition Coil & Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

8. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).
9. Install the ignition coil and bracket assembly (719) and studs (720).

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

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

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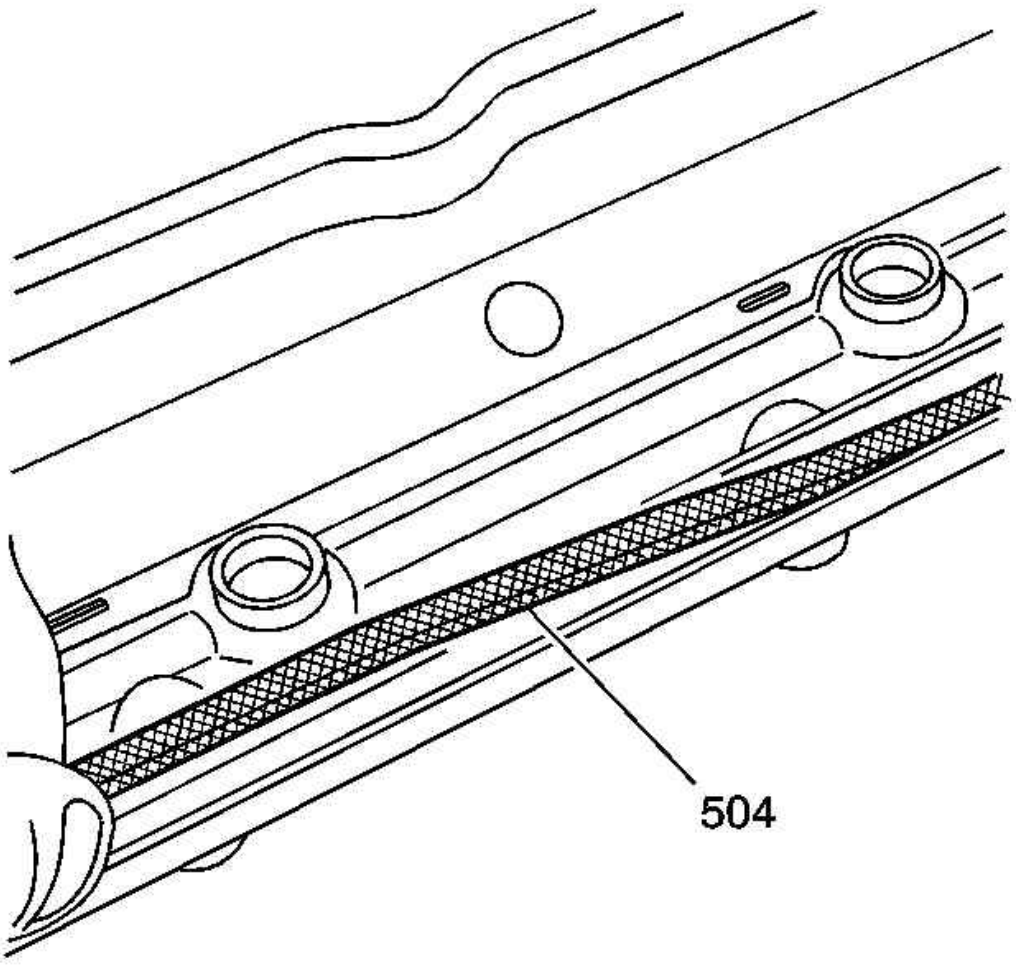


Fig. 650: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**
- **The valve rocker arm cover bolt grommets may be used again if not damaged.**

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1. Install a NEW gasket (504) into the valve rocker arm cover.

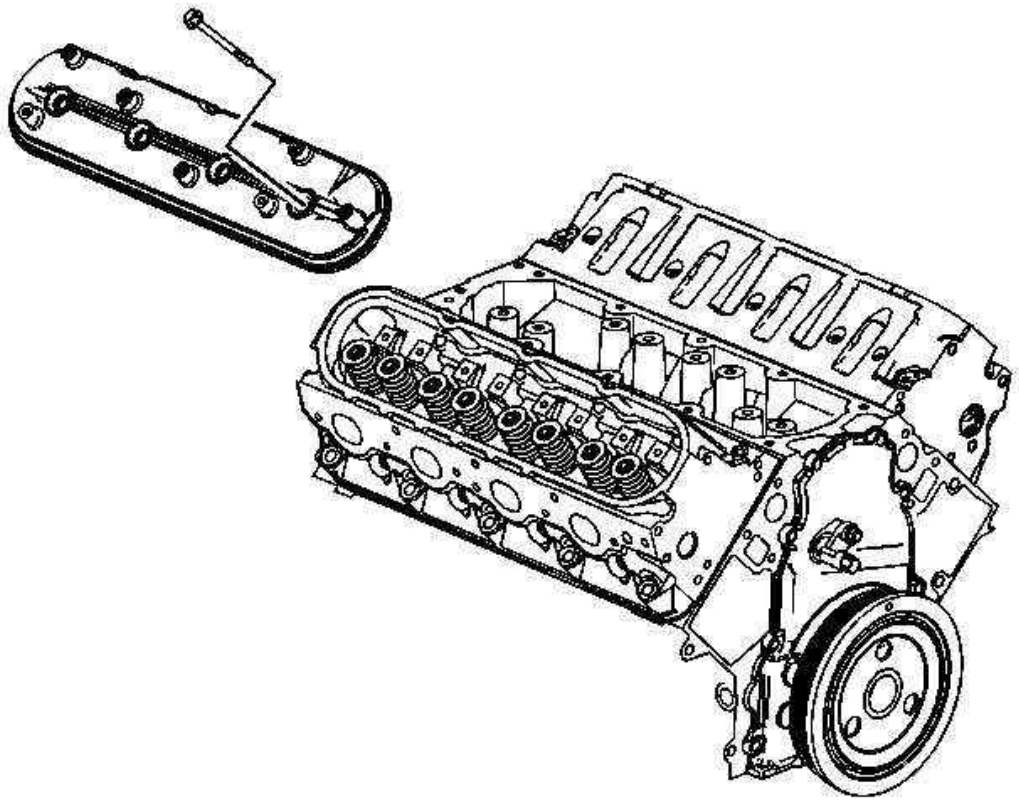


Fig. 651: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice .

3. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

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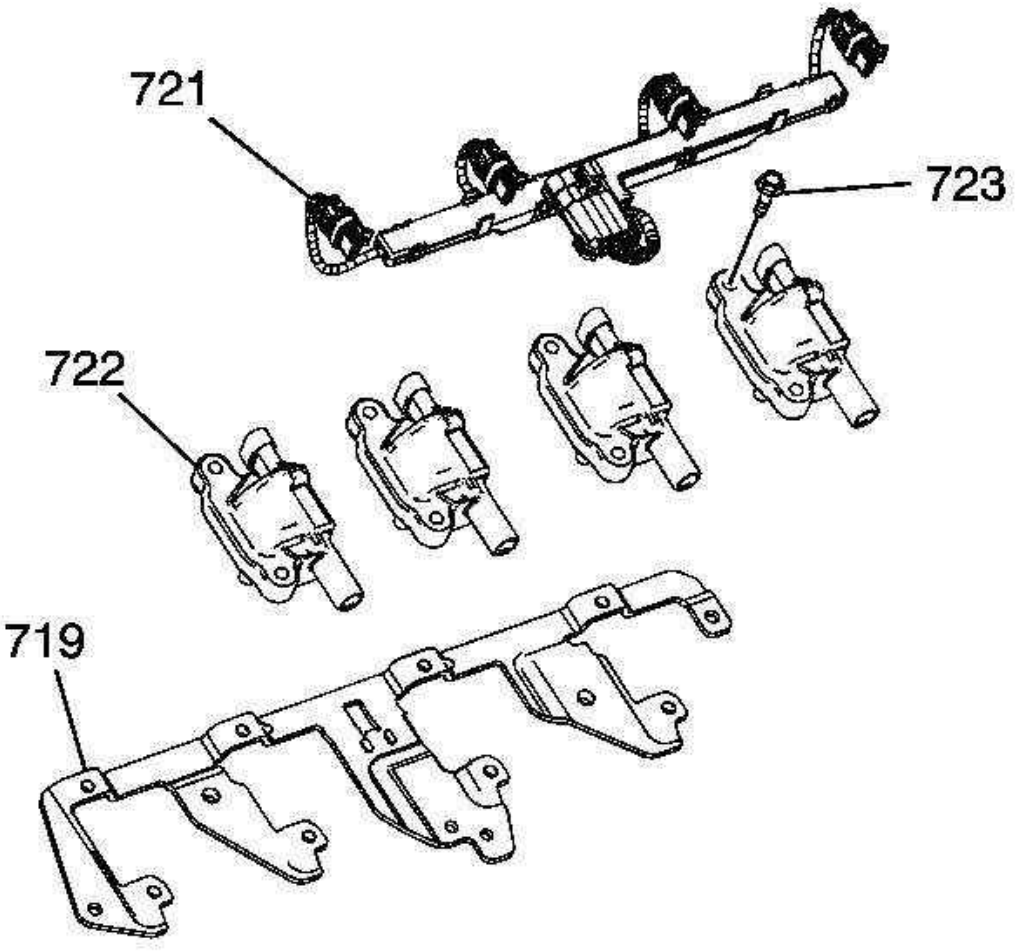


Fig. 652: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
5. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719).

Tighten: Tighten the ignition coil bolts to 8 N.m (71 lb in).

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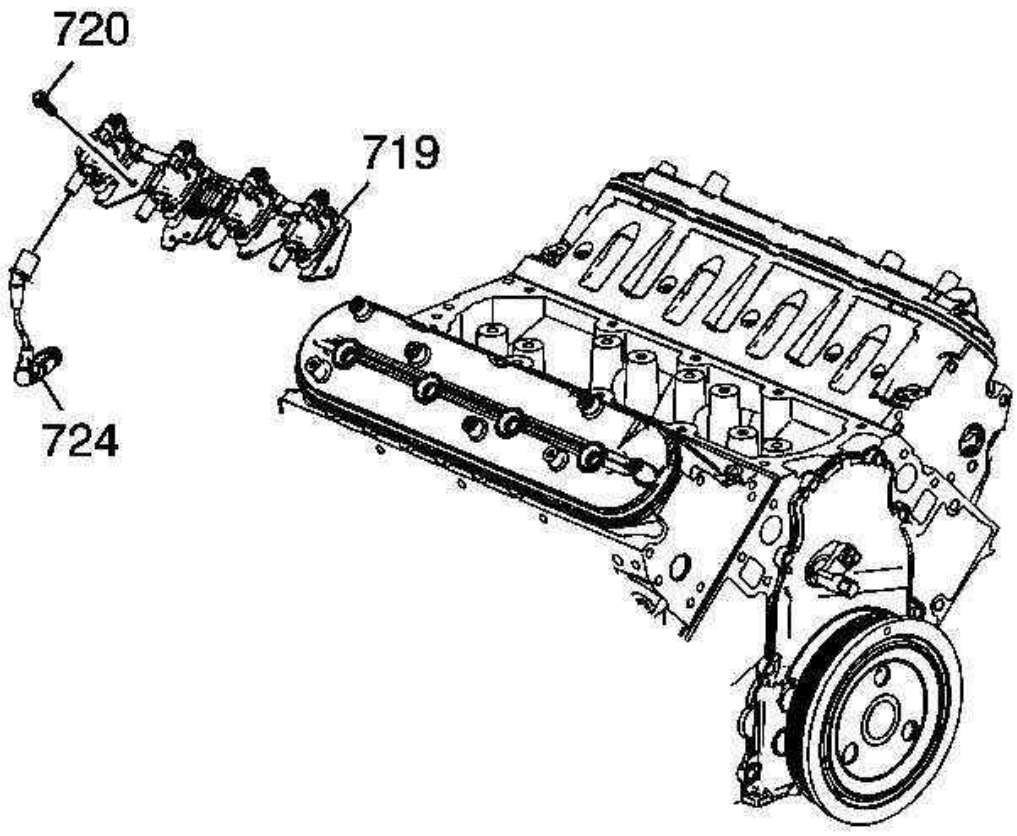


Fig. 653: View Of Ignition Coil & Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).
7. Install the ignition coil and bracket assembly (719) and studs (720).

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

VALVE LIFTER OIL FILTER INSTALLATION

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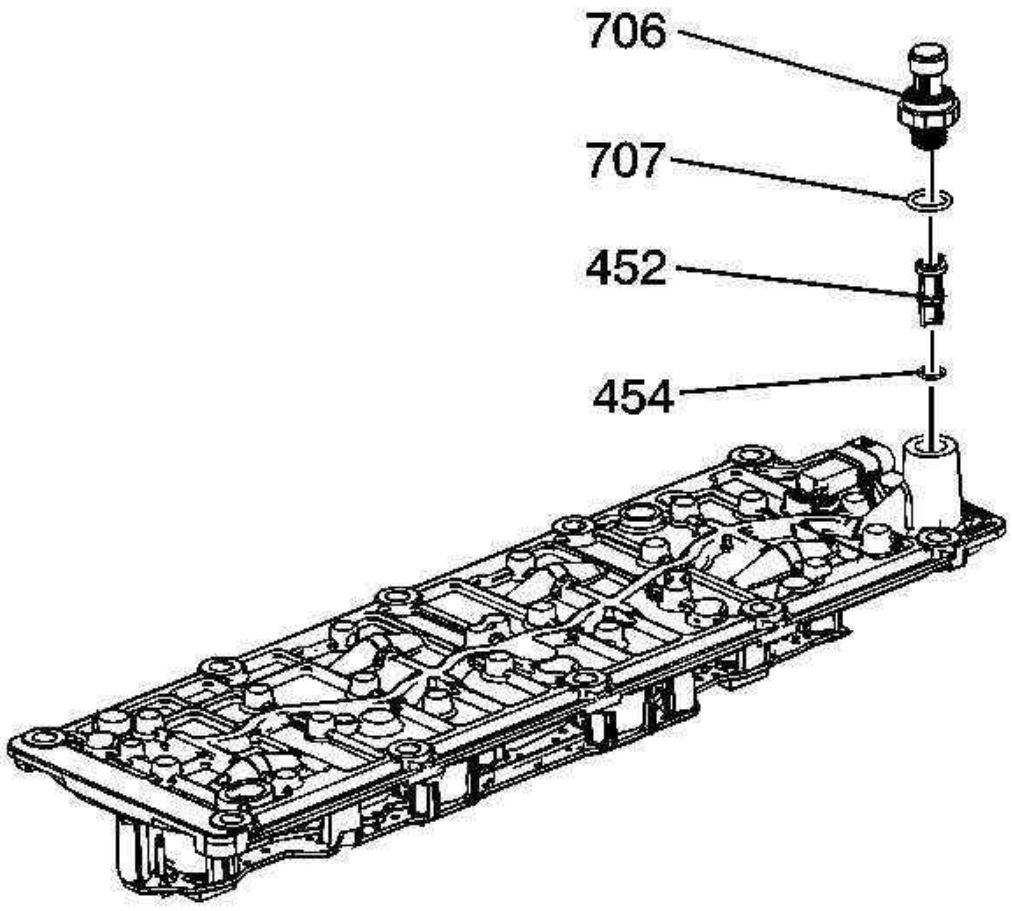


Fig. 654: View Of Oil Pressure Sensor, Washer & Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.

1. Install a NEW oil filter (452) and O-ring (454) assembly.
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor.

NOTE: Refer to Fastener Notice .

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3. Install the oil pressure sensor (706) and washer (707).

   Tighten: Tighten the oil pressure sensor to 35 N.m (26 lb ft).

VALVE LIFTER OIL MANIFOLD INSTALLATION

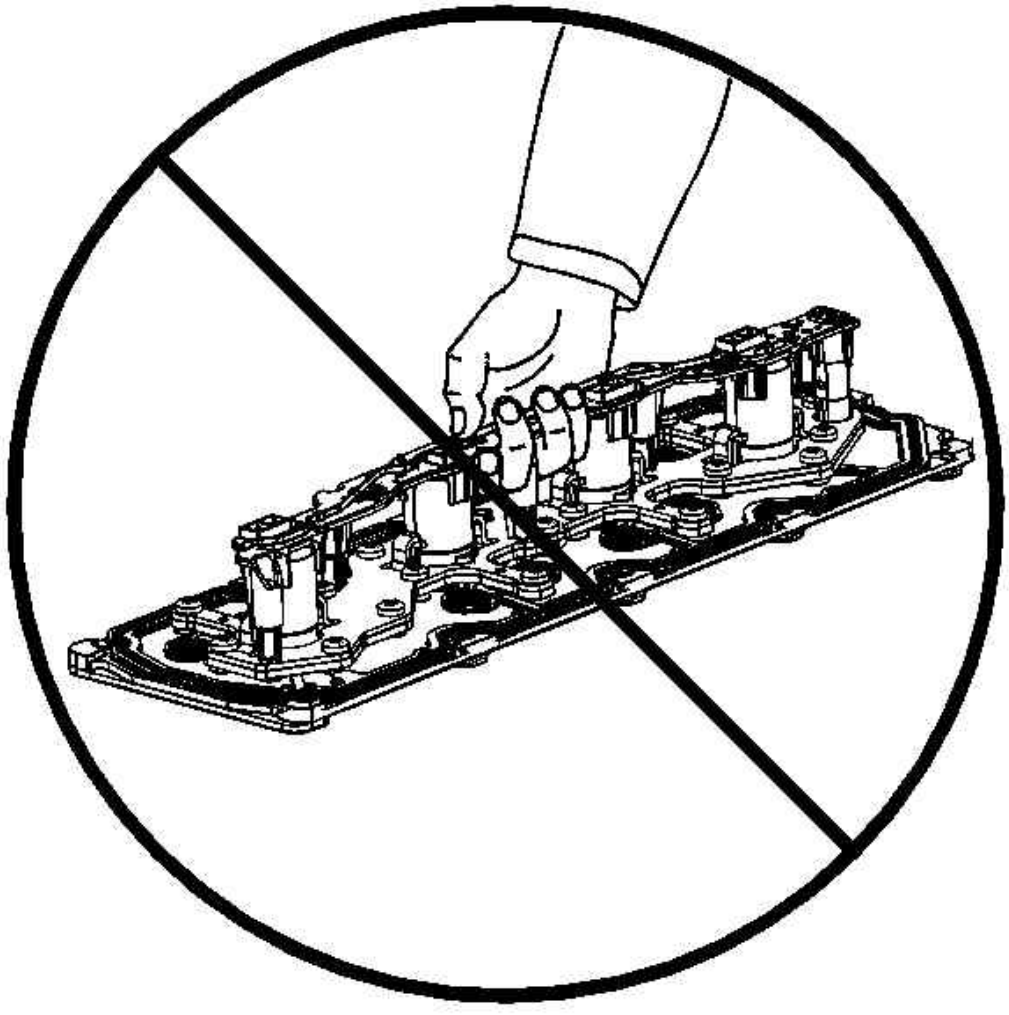


Fig. 655: Identifying Manifold Lift Caution
Courtesy of GENERAL MOTORS CORP.

1. Do not lift the manifold assembly by the electrical lead frame.

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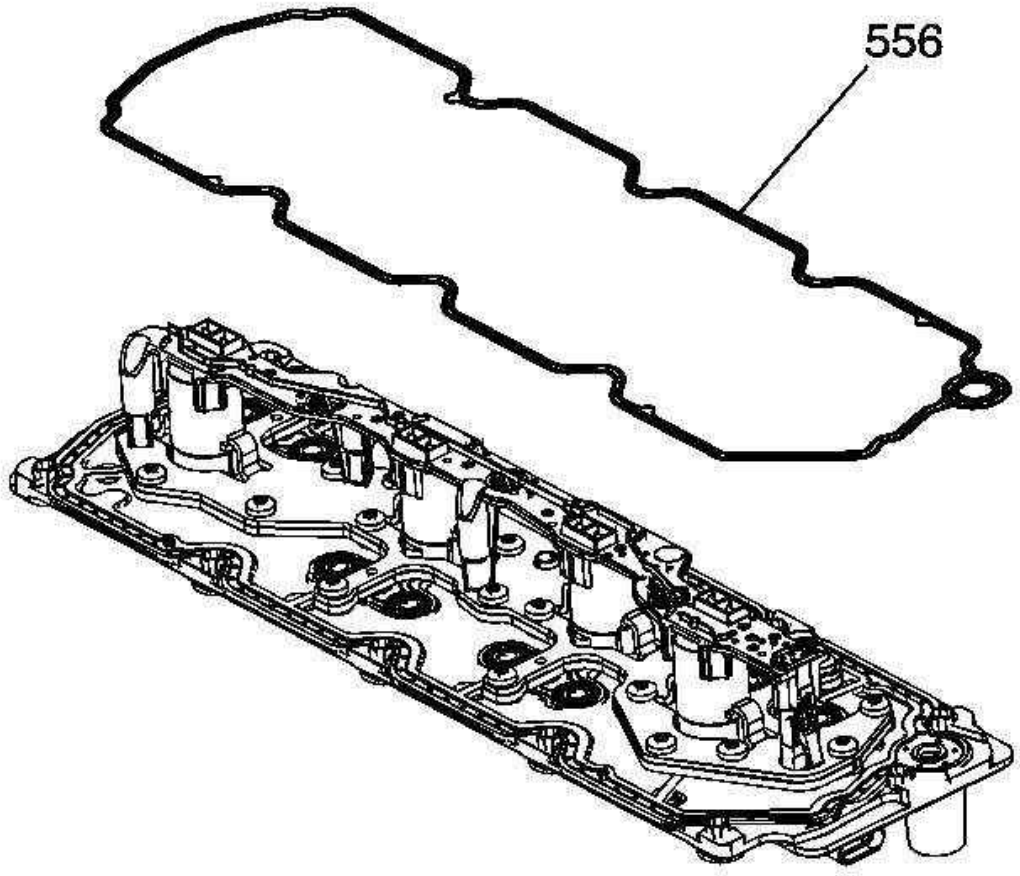


Fig. 656: Valve Lifter Oil Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.**

2. Install the service gasket (556) onto the manifold.

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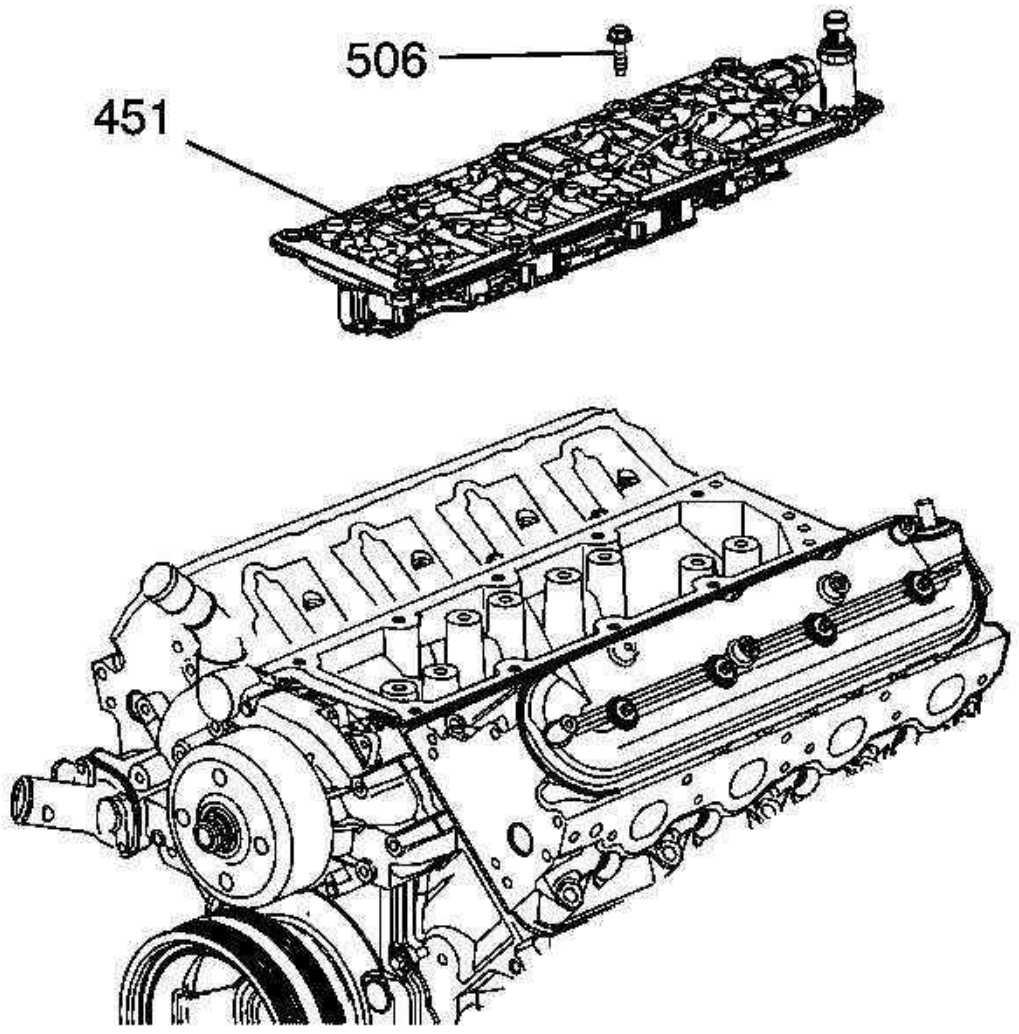


Fig. 657: View Of Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

3. Install the manifold (451) with gasket.

NOTE: Refer to Fastener Notice .

4. Install the manifold bolts (506).

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

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER INSTALLATION

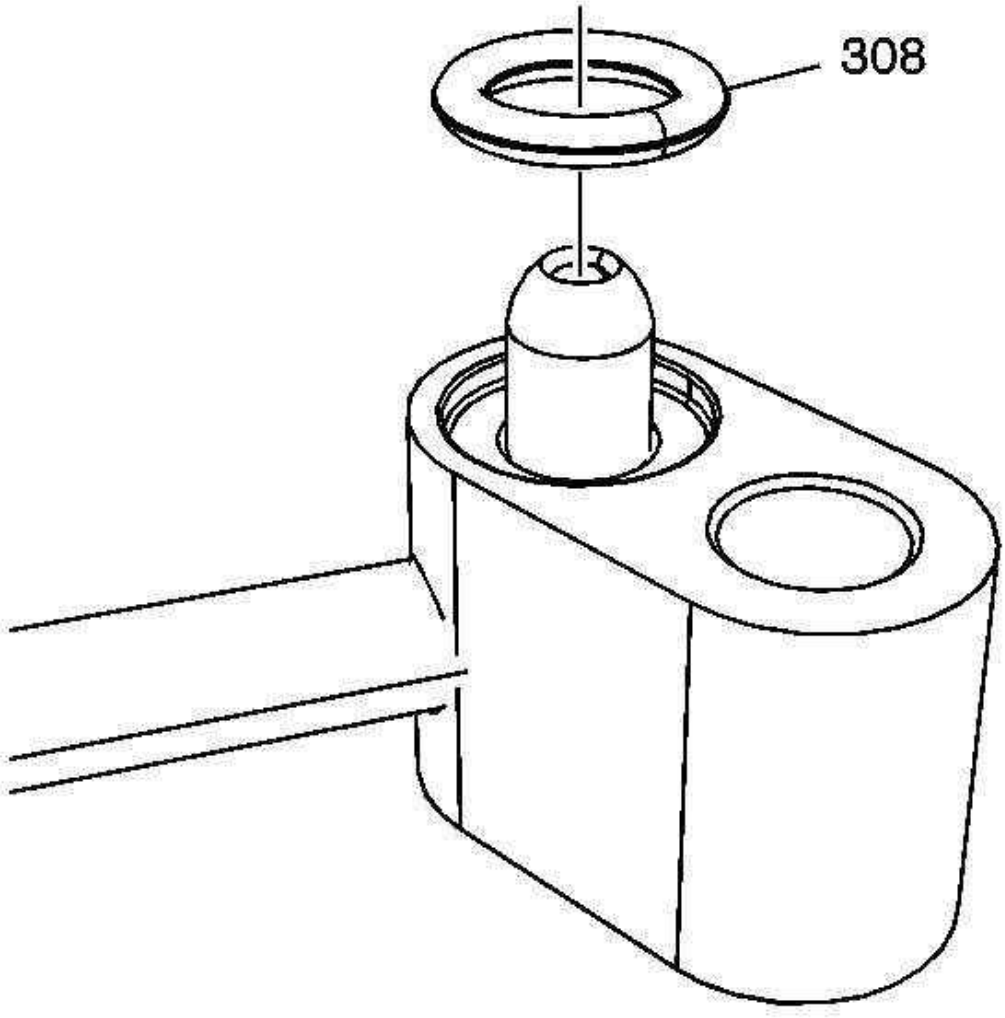


Fig. 658: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the gasket O-ring seal onto the nipple portion of the pipe.

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1. Install the seals (308) onto the engine coolant air bleed pipe and covers.

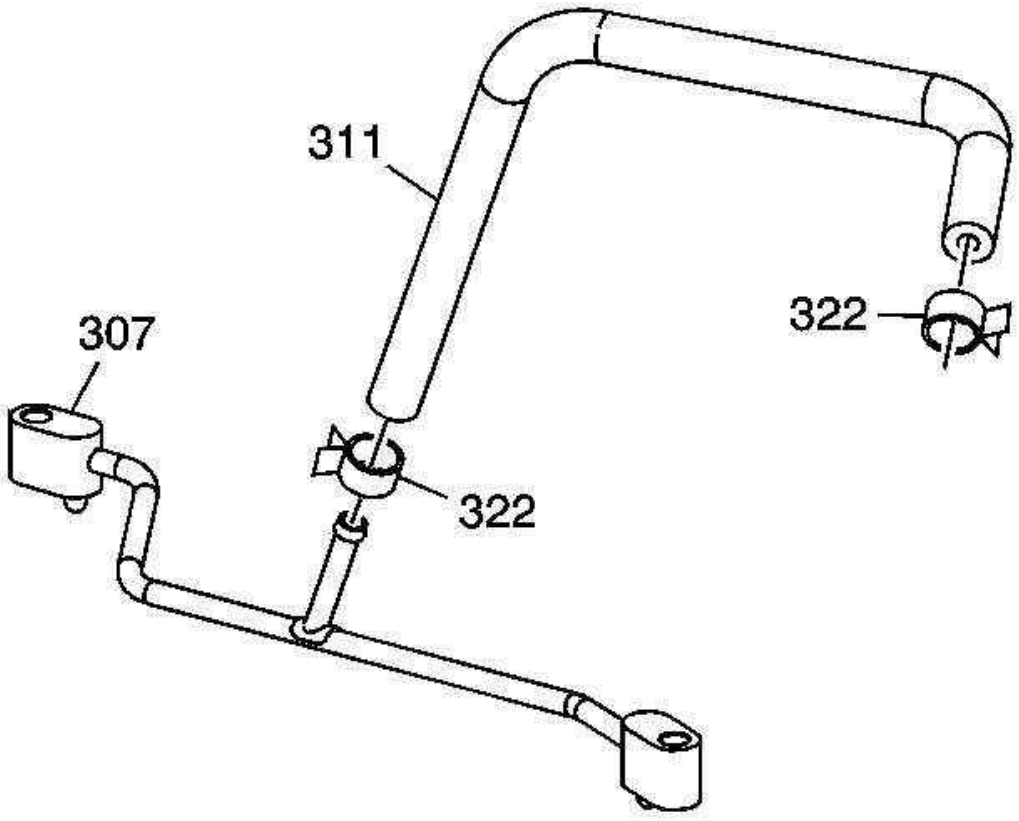


Fig. 659: View Of Coolant Air Bleed Pipe & Clamp
Courtesy of GENERAL MOTORS CORP.

2. Install the hose (311) and clamps (322) onto the pipe (307).

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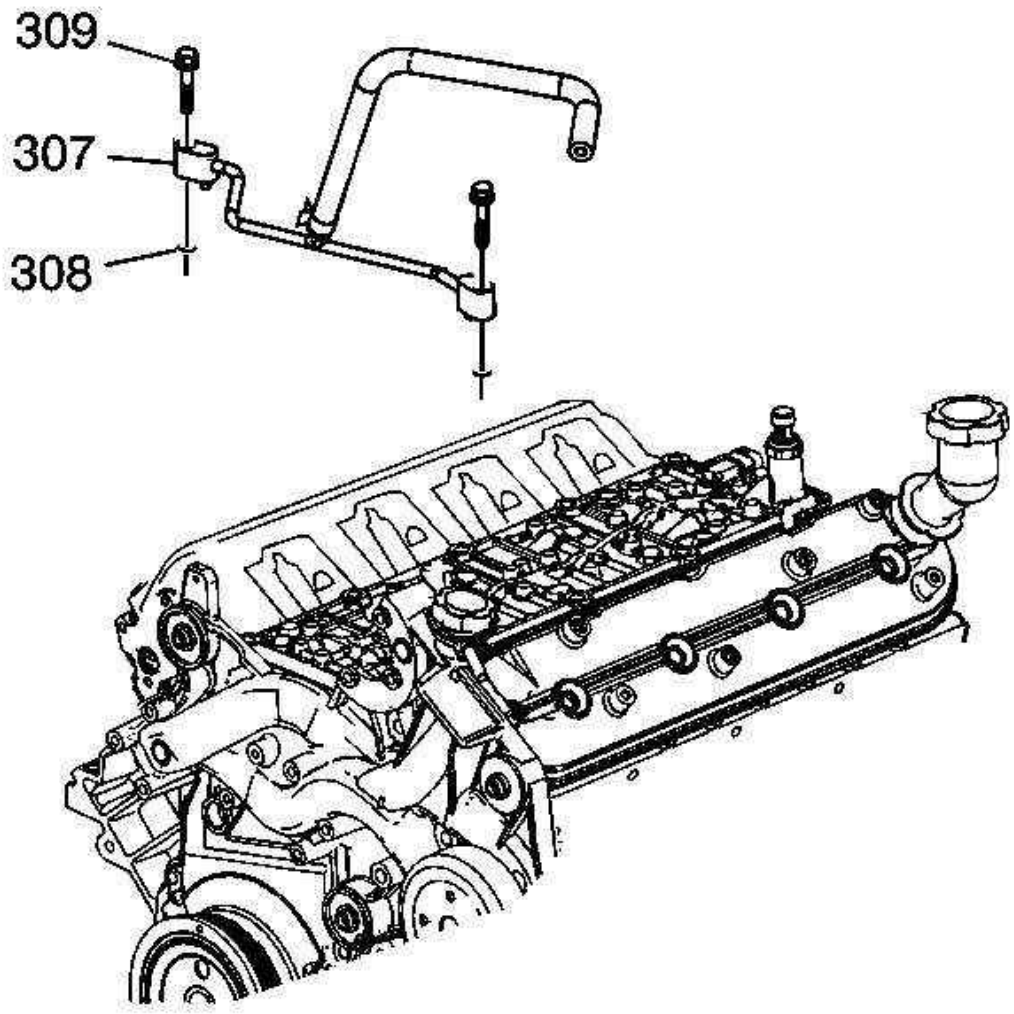


Fig. 660: View Of Coolant Air Bleed Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the pipe (307).

NOTE: Refer to Fastener Notice .

4. Install the bolts (309).

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

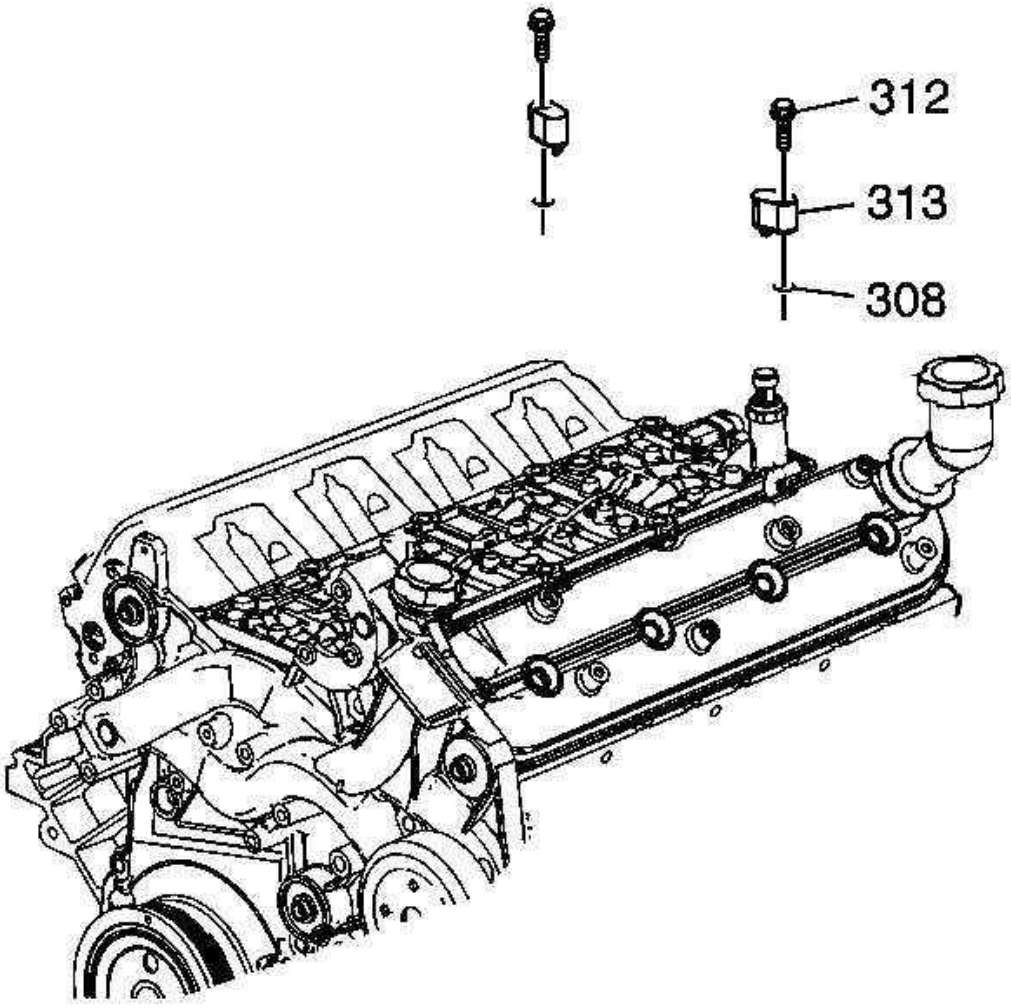


Fig. 661: View Of Engine Coolant Air Bleed Cover, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Install the covers (313).
6. Install the bolts (312).

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

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INTAKE MANIFOLD INSTALLATION

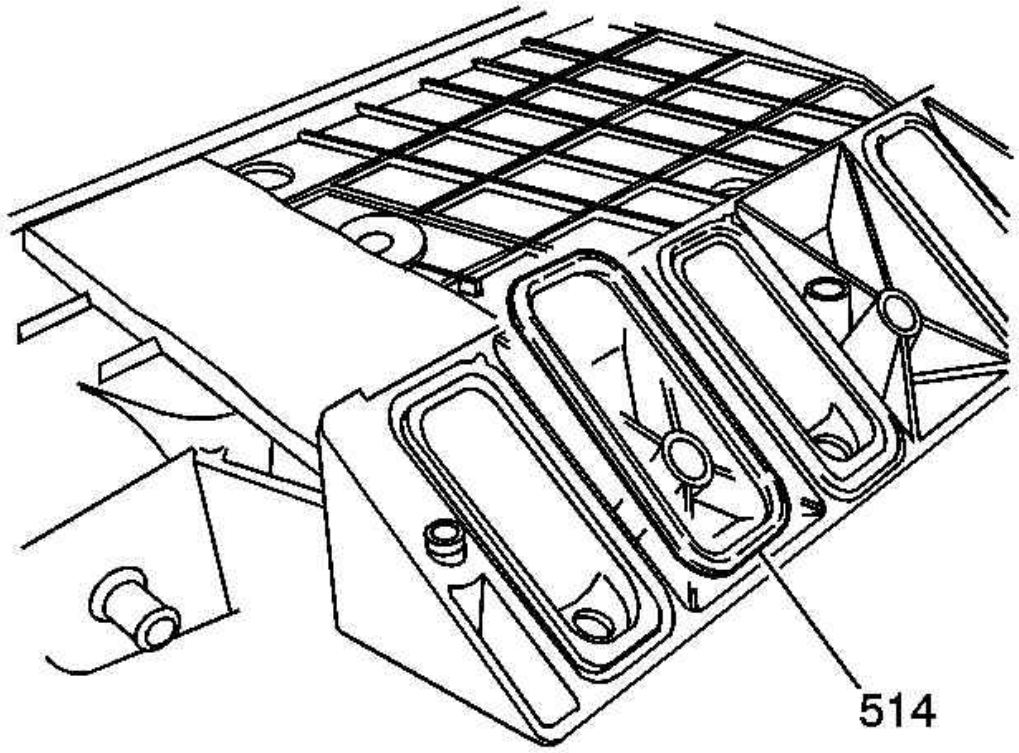


Fig. 662: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.**
- **DO NOT use the intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.**

1. Install NEW intake manifold-to-cylinder head gaskets (514).

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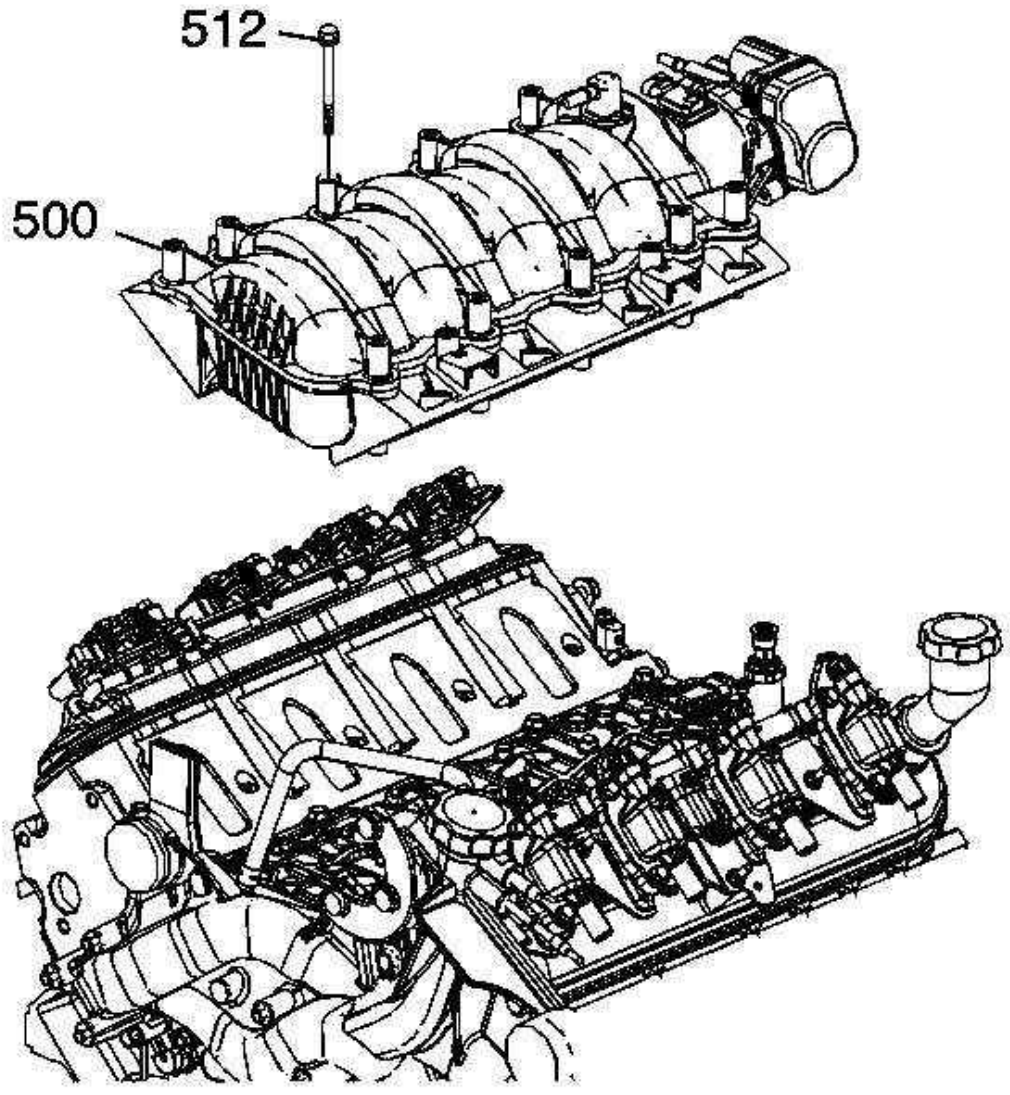


Fig. 663: View Of The Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold (500).
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512). Refer to **Sealers, Adhesives, and Lubricants**.

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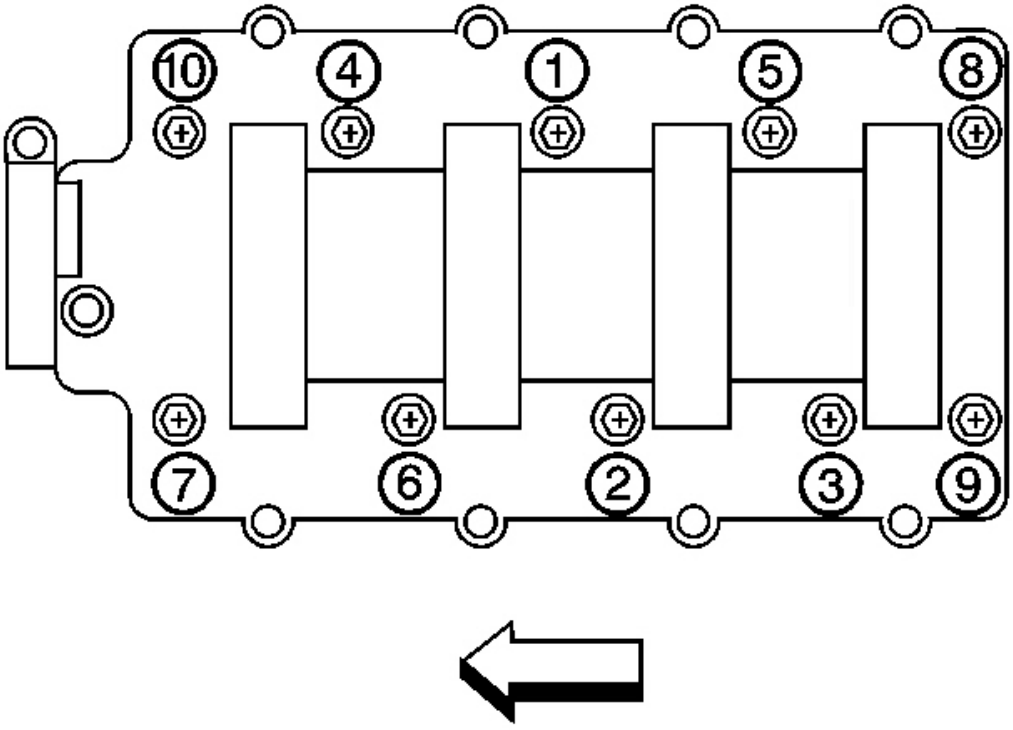


Fig. 664: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the intake manifold bolts.

Tighten:

1. Tighten the intake manifold bolts (1-10) a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts (1-10) a final pass in sequence to 10 N.m (89 lb in).

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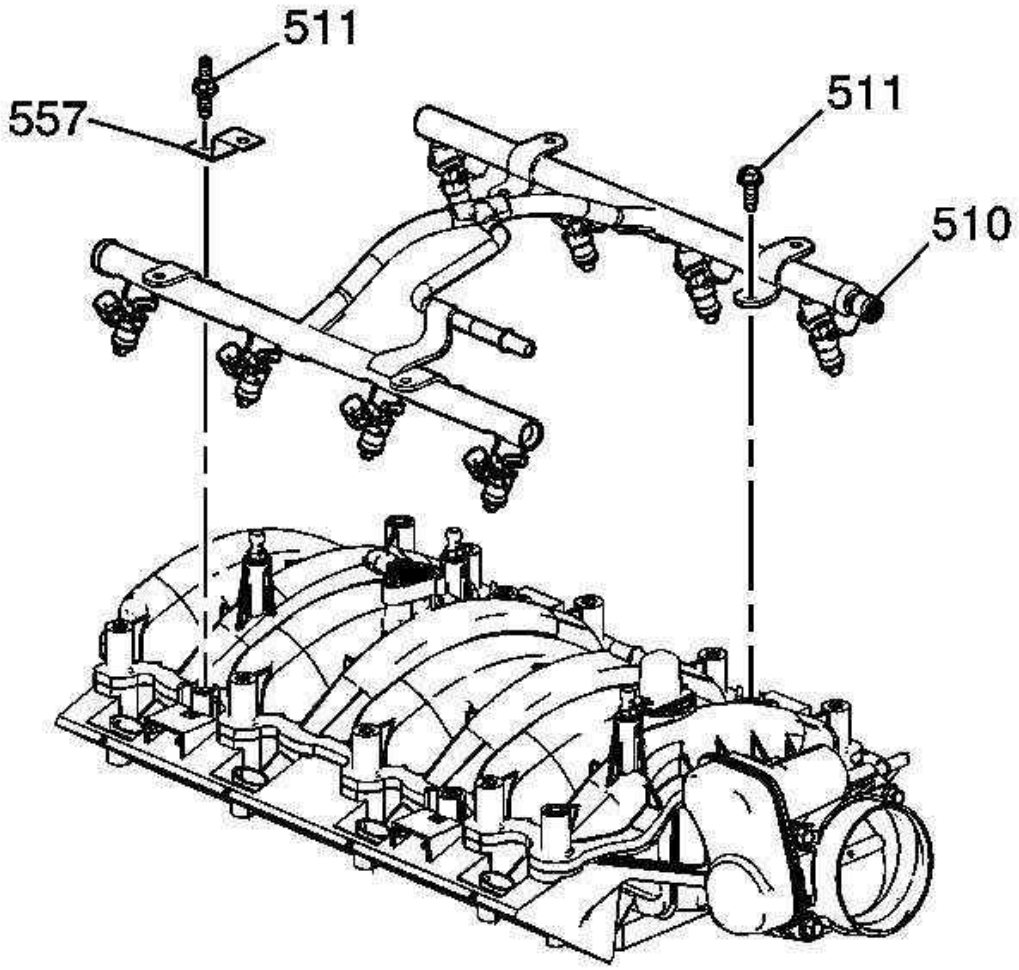


Fig. 665: View Of Fuel Rail Bolts & Ground Strap
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail (510). Refer to **Fuel Rail and Injectors Installation**.

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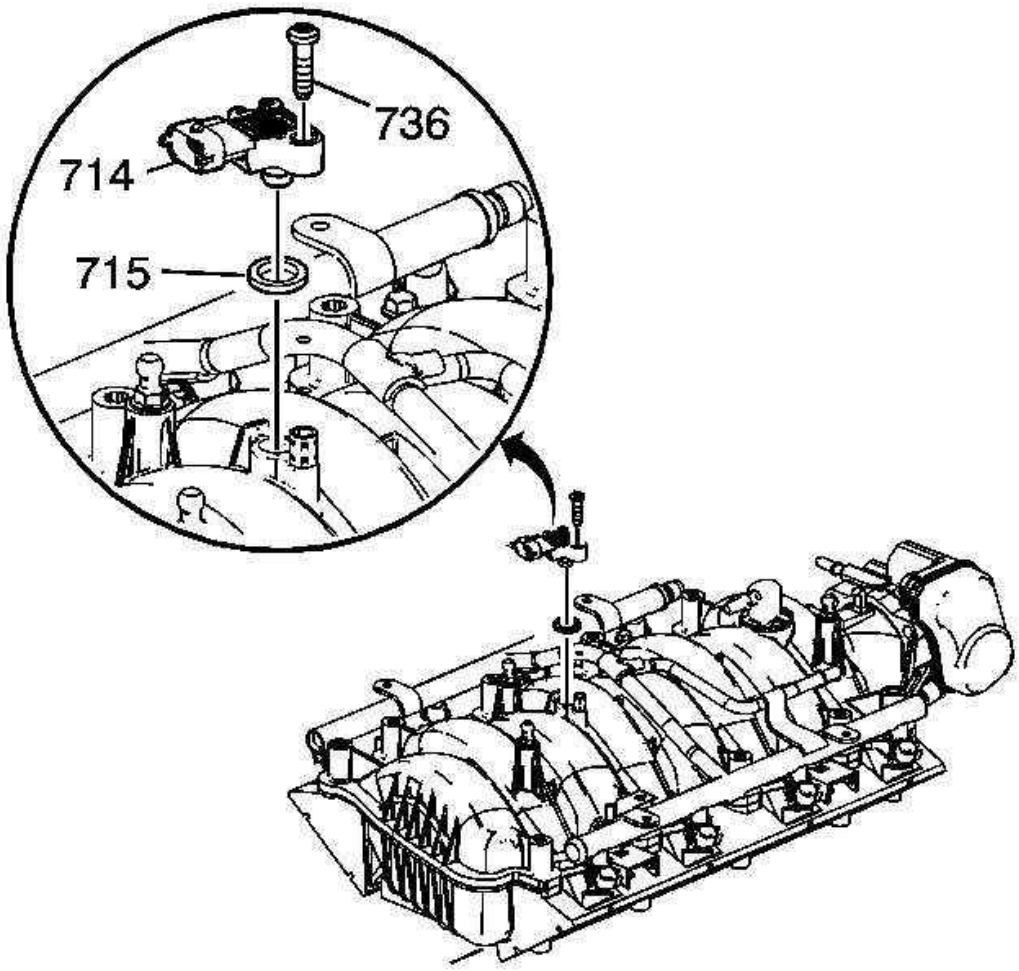


Fig. 666: Identifying MAP Sensor
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the manifold absolute pressure (MAP) sensor seal (715) with clean engine oil.
7. Install the seal onto the MAP sensor (714).
8. Install the MAP sensor (714) and bolt (736).

Tighten: Tighten the bolt to 5 N.m (44 lb in).

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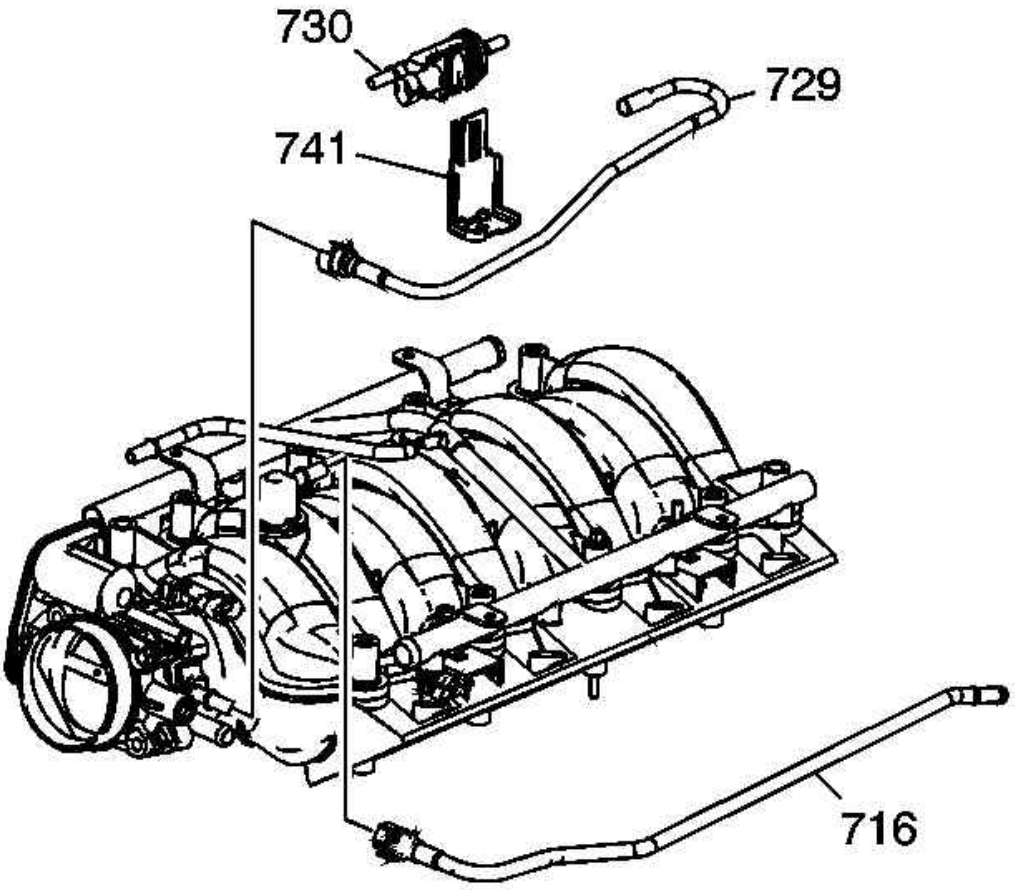


Fig. 667: View Of EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

9. Install the positive crankcase ventilation (PCV) hose - dirty air (716).

FUEL RAIL AND INJECTORS INSTALLATION

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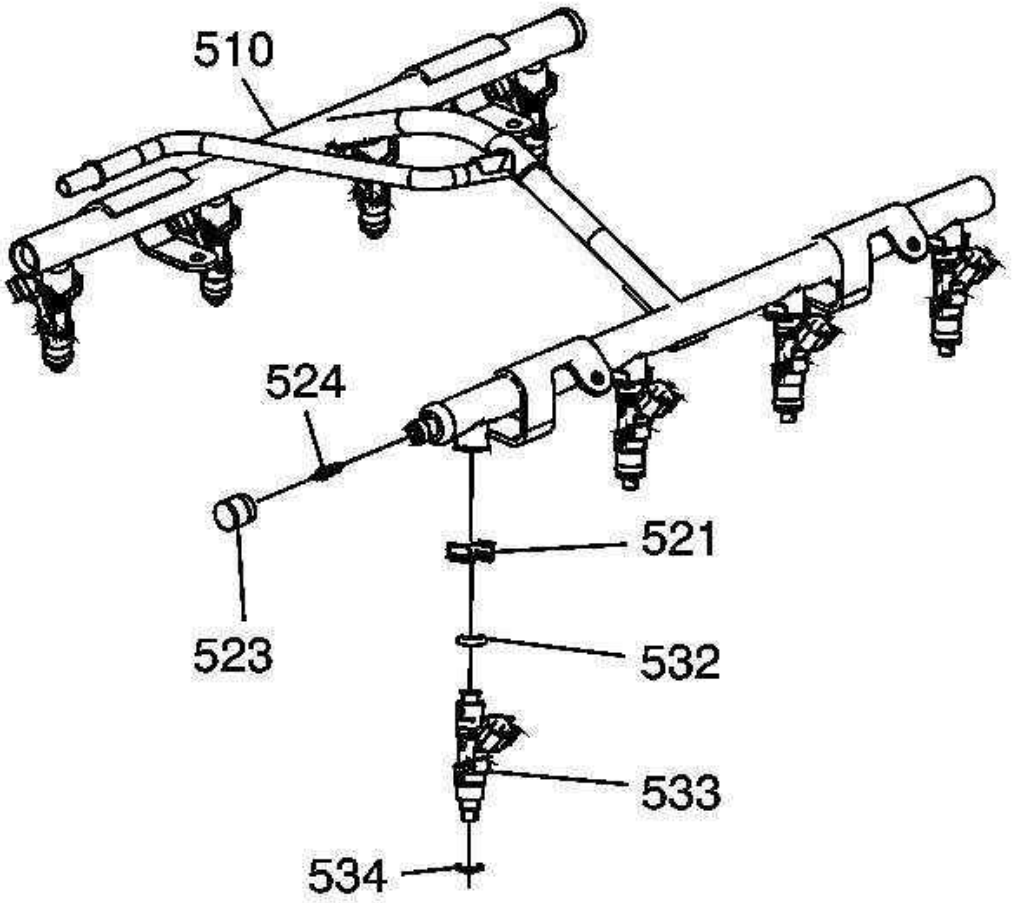


Fig. 668: View Of Fuel Rail With Injectors
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution .

IMPORTANT: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals (532, 534) with clean engine oil.

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2. Install the O-ring seals to the fuel injectors.
3. Install the fuel injectors (533) and retainers (521).

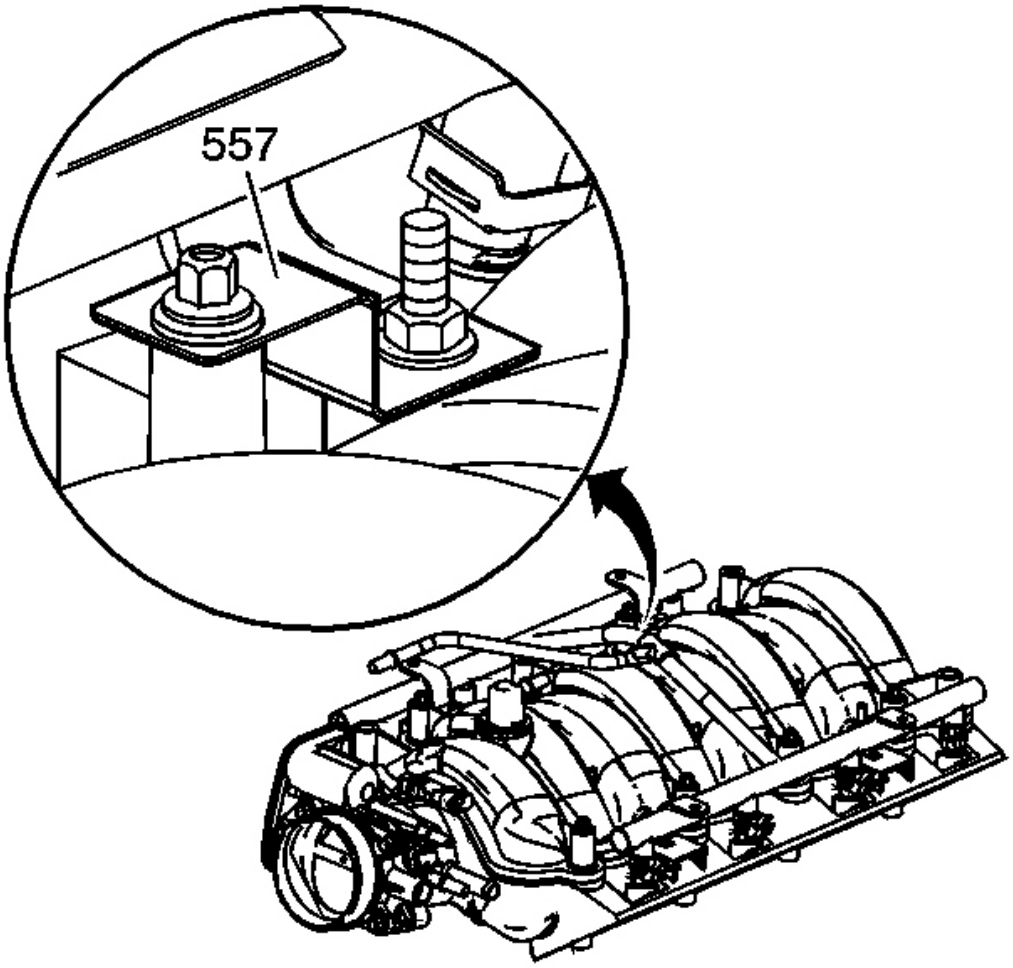


Fig. 669: View Of Fuel Rail Ground Strap
Courtesy of GENERAL MOTORS CORP.

4. Note the installed location of the fuel rail ground strap (557).

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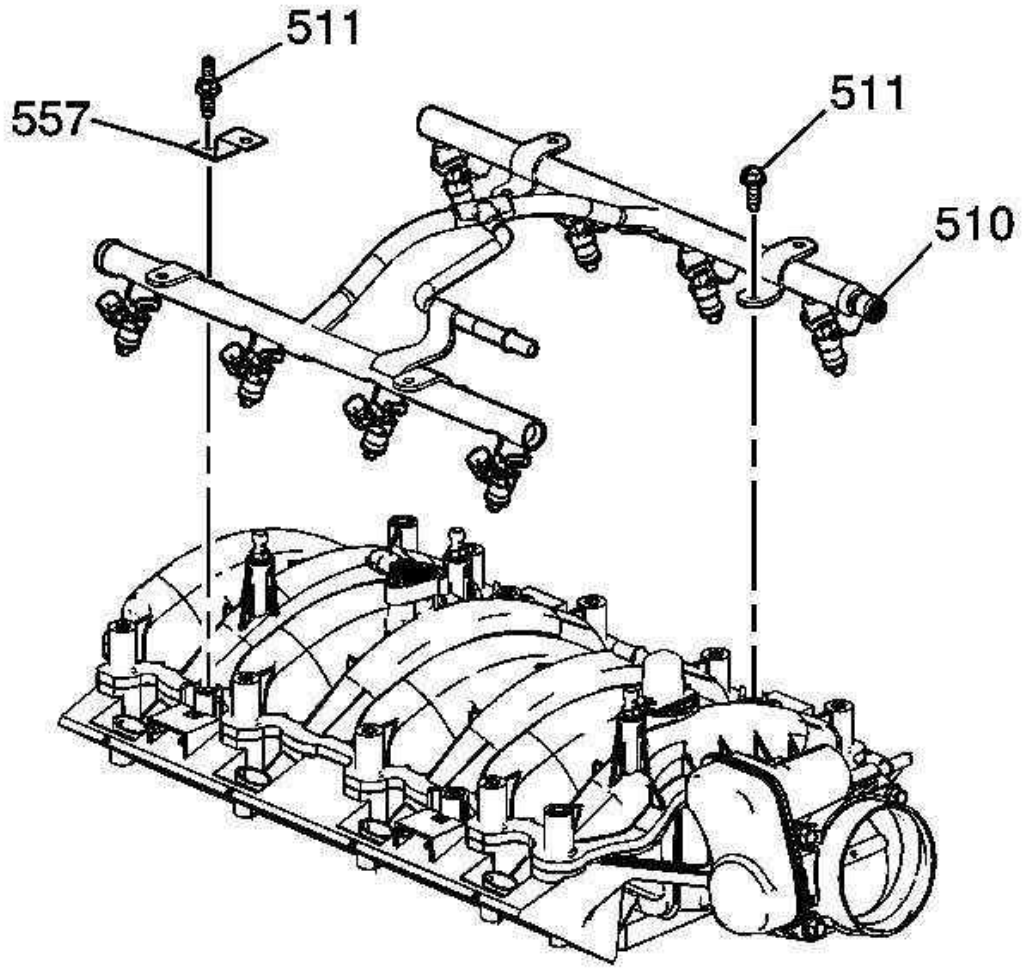


Fig. 670: View Of Fuel Rail Bolts & Ground Strap
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail assembly (510) to the manifold. Push firmly on both sides of the rail until all injectors have entered their bores.
6. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the fuel rail bolts. Refer to **Sealers, Adhesives, and Lubricants**.

NOTE: Refer to Fastener Notice .

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7. Install the fuel rail bolts (511) and ground strap (557).

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

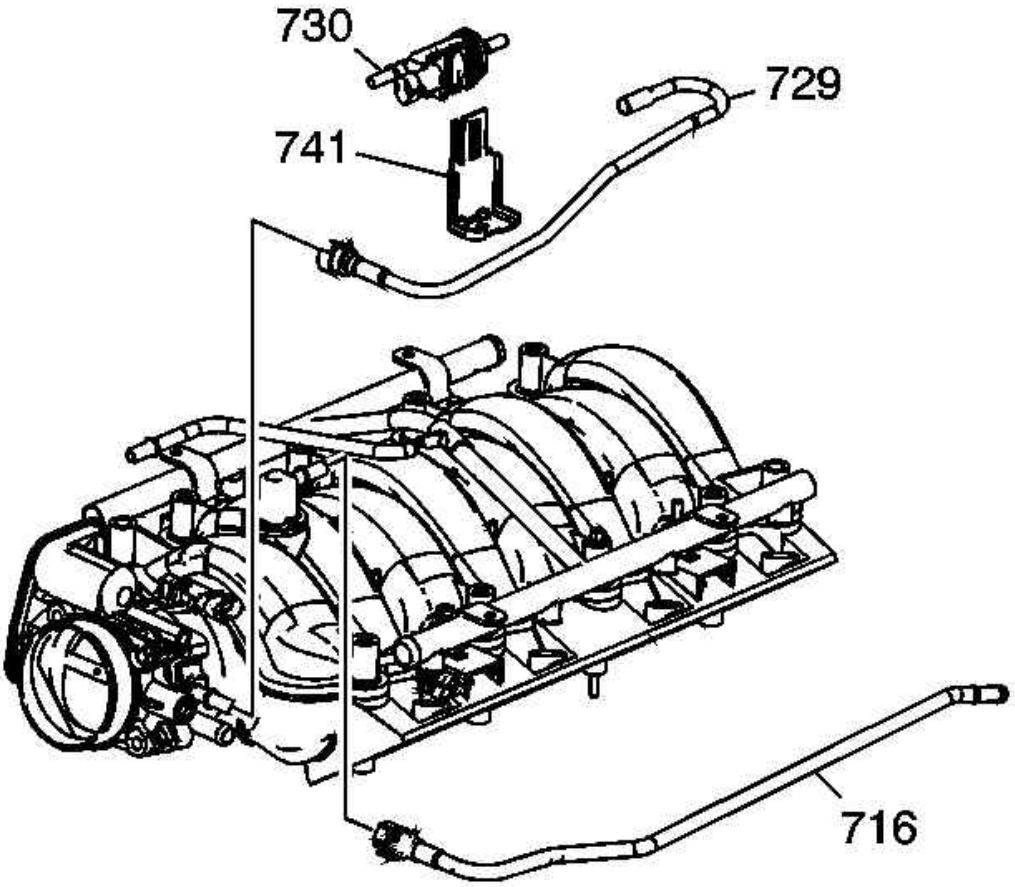


Fig. 671: View Of EVAP Purge Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

8. Install the evaporative emission (EVAP) canister purge solenoid valve (730), bracket (741), and tube (729).

THROTTLE BODY INSTALLATION

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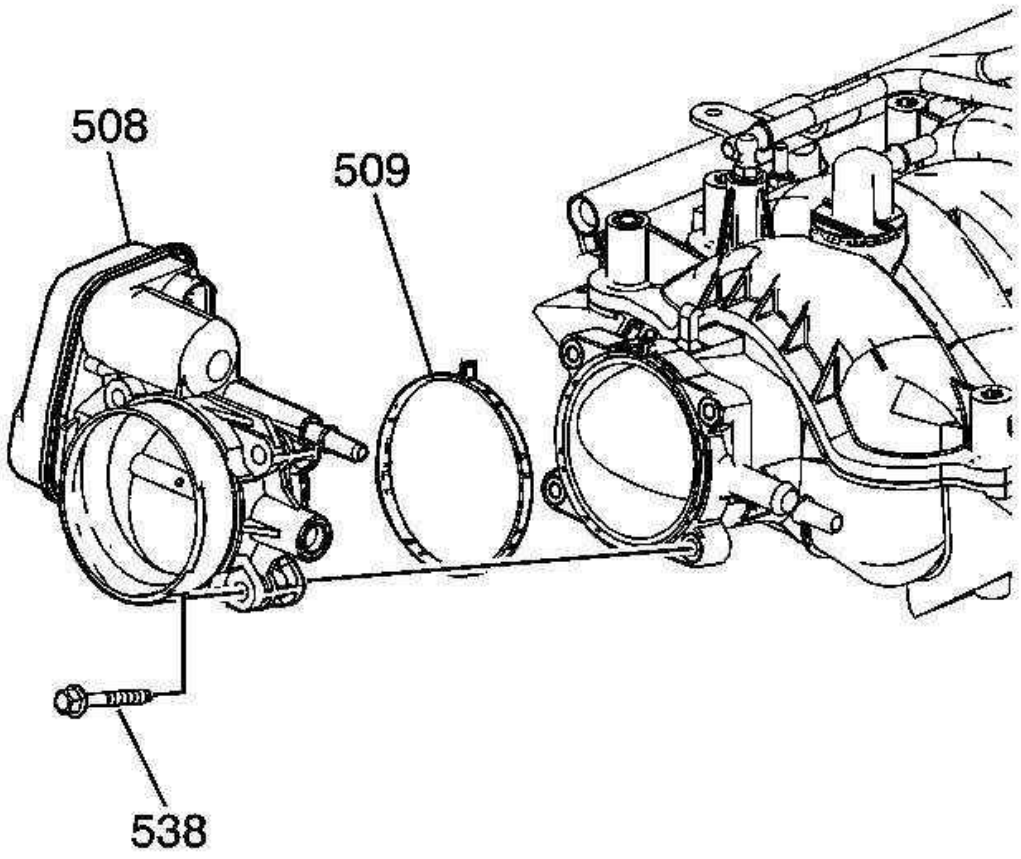


Fig. 672: Exploded View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use the throttle body gasket again. Install a NEW gasket during assembly.

1. Install the throttle body gasket (509) to the intake manifold. Align the locating tab of the gasket with the notch in the manifold.

NOTE: Refer to Fastener Notice .

2. Install the throttle body (508) and bolts (538).

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

WATER PUMP INSTALLATION

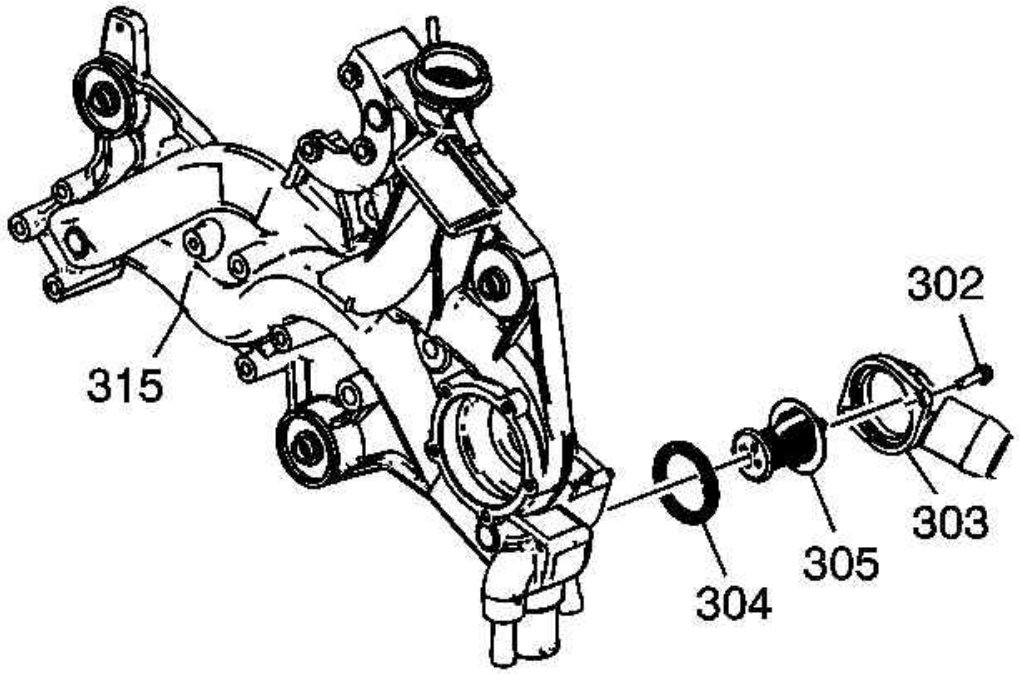


Fig. 673: View Of Thermostat Housing, Bolts, Thermostat & O-Ring
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

NOTE: Refer to Fastener Notice .

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IMPORTANT: All gasket surfaces are to be free of oil or other foreign material during assembly.

1. Install the thermostat (305), O-ring (304), inlet housing (303), and bolts (302).

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

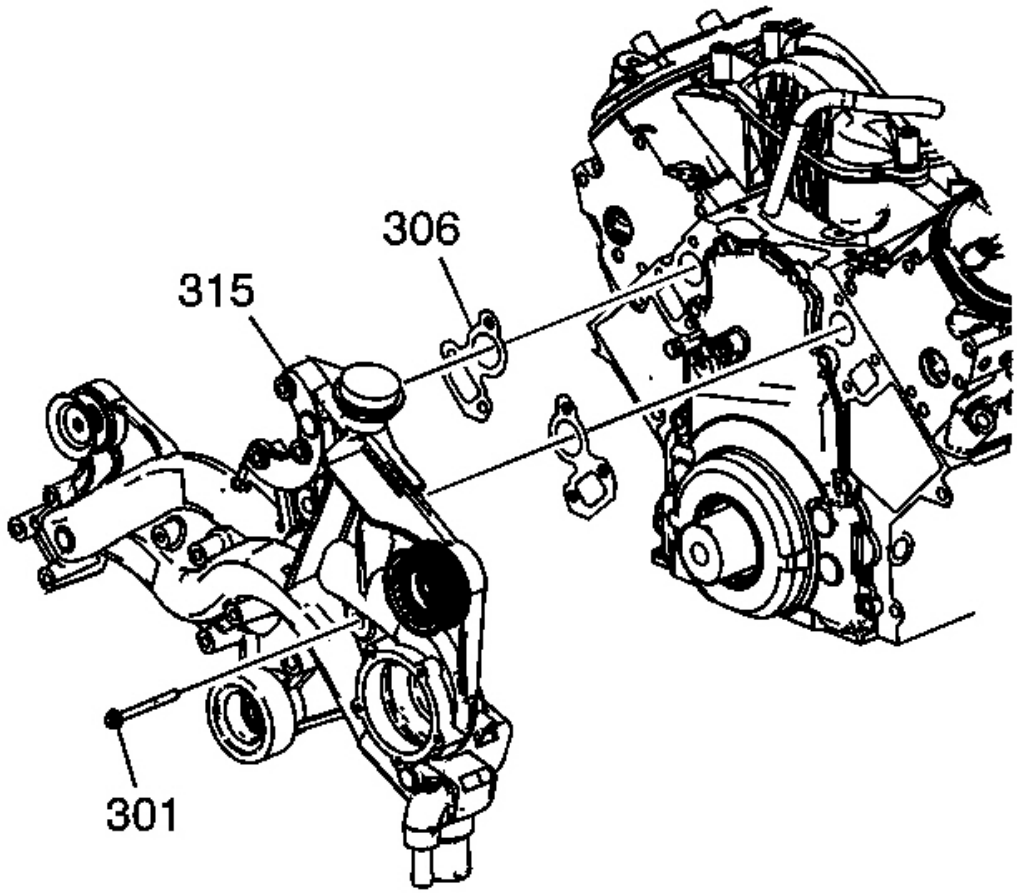


Fig. 674: View Of Water Manifold, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

2. Install the water manifold (315), gaskets (306), and bolts (301).

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Tighten:

1. Tighten the water manifold M8 bolts to 30 N.m (22 lb ft).
2. Tighten the water manifold M10 bolts to 60 N.m (44 lb ft).

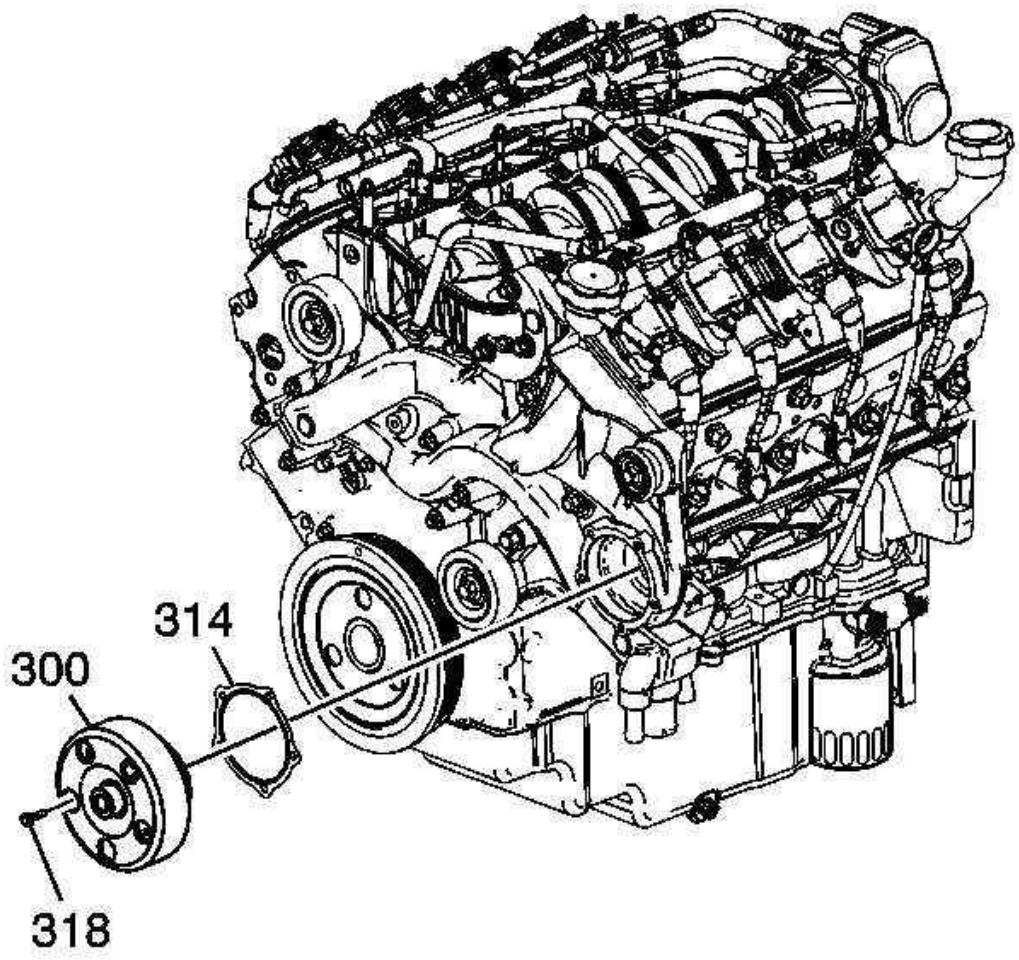


Fig. 675: View Of Water Pump, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the water pump (300) and NEW gasket (314).
4. Install the water pump bolts (318).

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

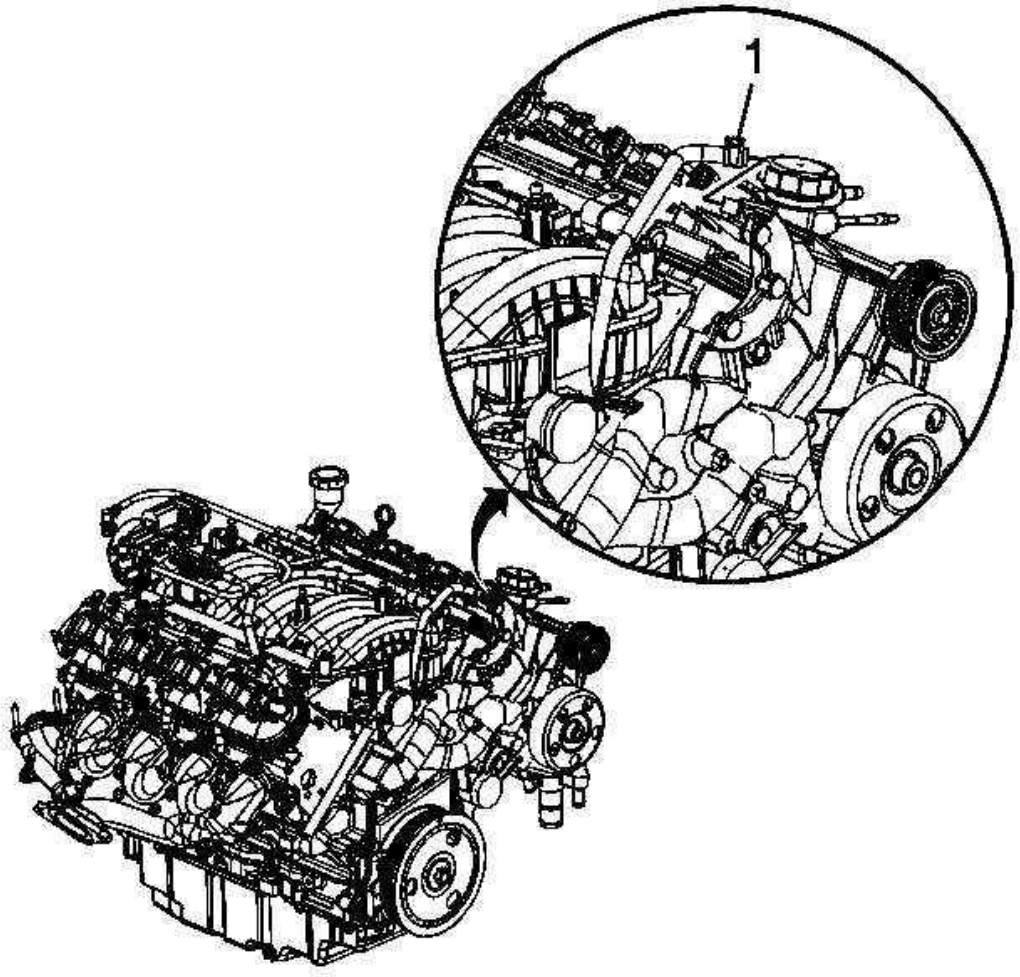


Fig. 676: Locating Engine Coolant Air Bleed Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

5. Install the coolant air bleed hose and clamp (1) to the manifold.

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

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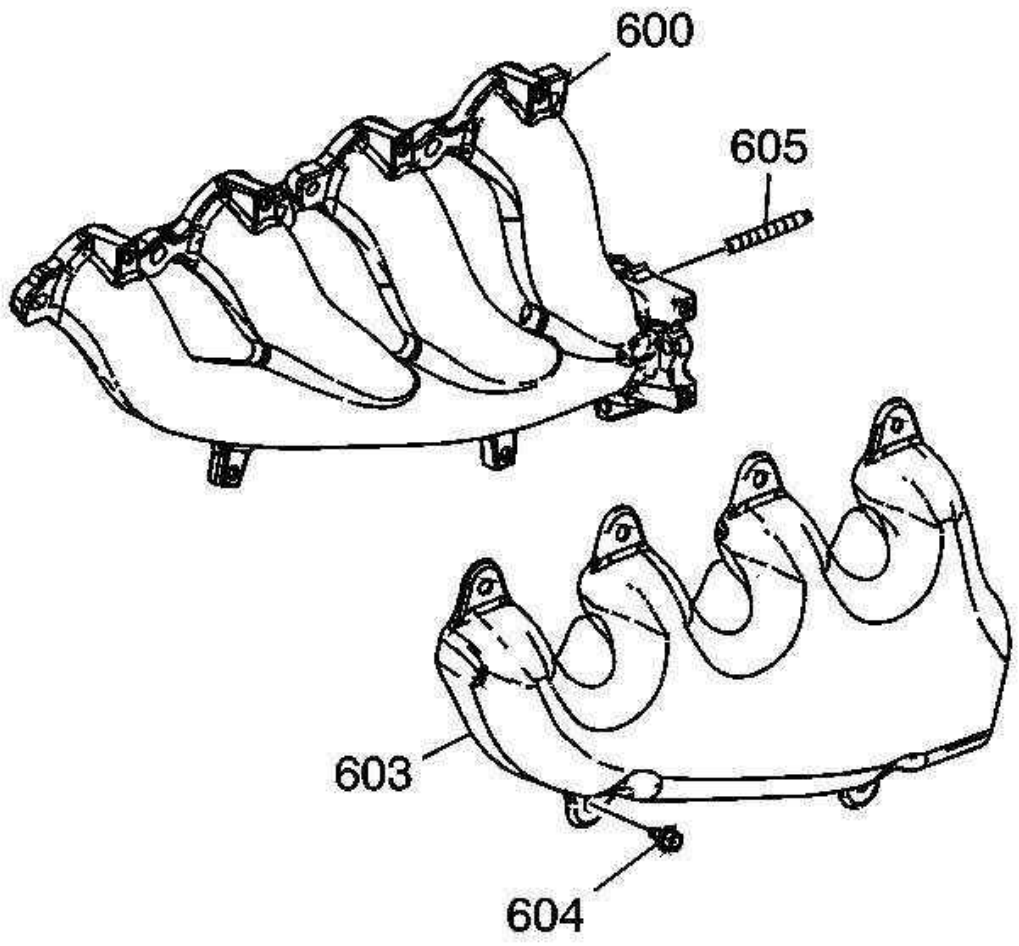


Fig. 677: Identifying Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.**

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- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first 3 threads of the bolt.**

1. Install the heat shield (603) and bolts (604).

   Tighten: Tighten the bolts to 9 N.m (80 lb in).

2. Install the exhaust pipe studs (605).

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

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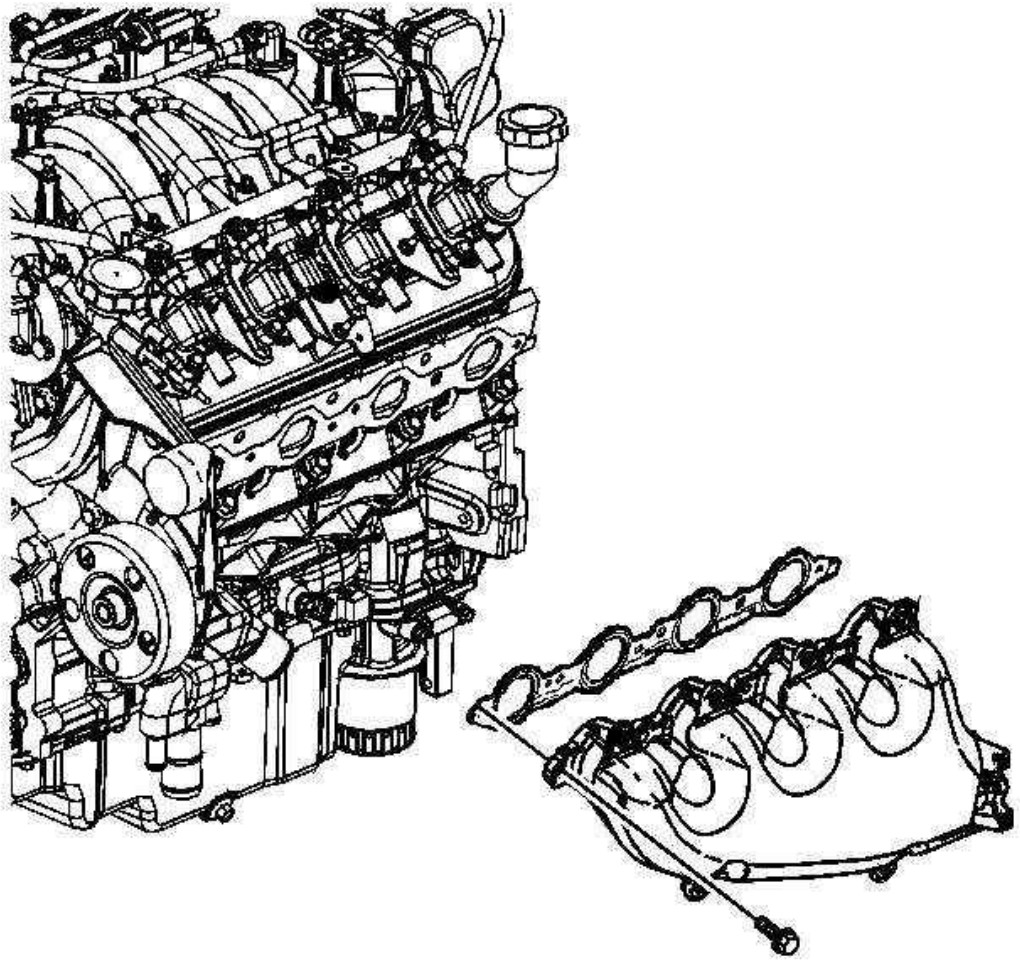


Fig. 678: View Of Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants**.
4. Install the exhaust manifold, NEW gasket, and bolts.

Tighten:

1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft).

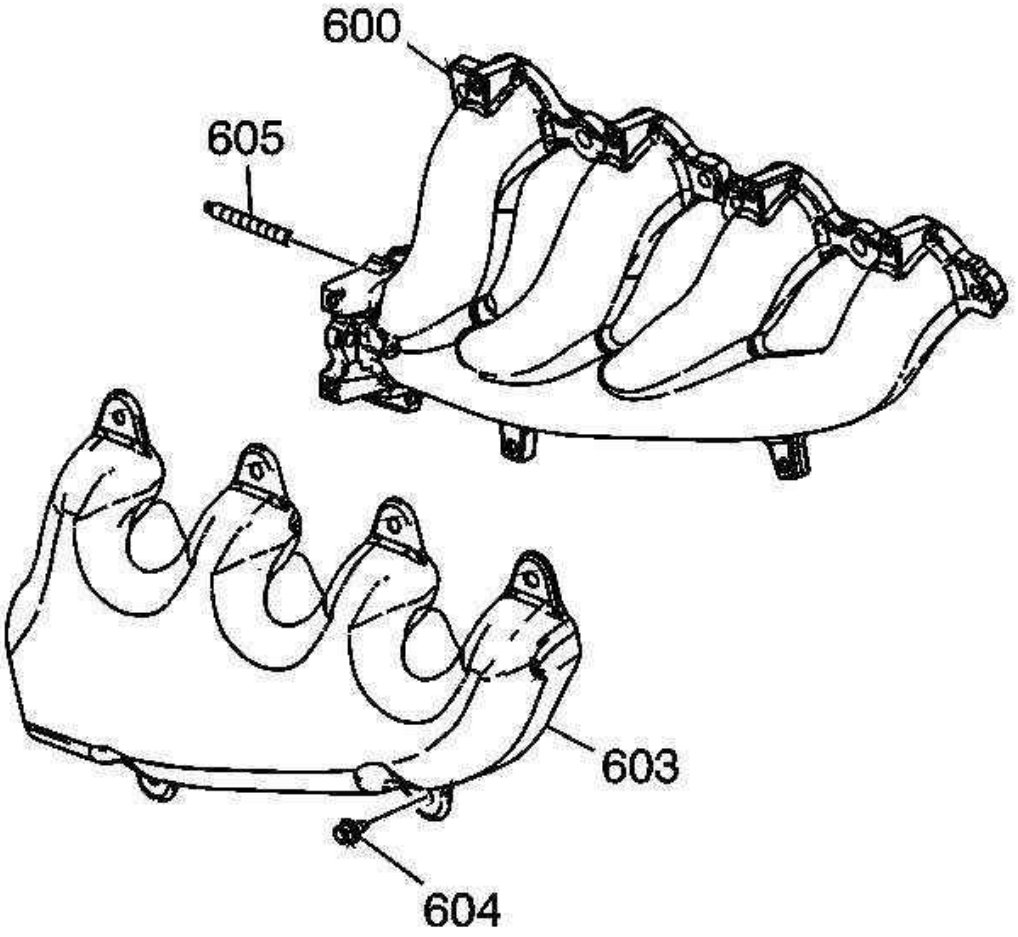
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Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

2. Tighten the exhaust manifold bolts a final pass to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE



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Fig. 679: View Of Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.**
- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first 3 threads of the bolt.**

1. Install the heat shield (603) and bolts (604).

   Tighten: Tighten the bolts to 9 N.m (80 lb in).

2. Install the exhaust pipe studs (605).

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

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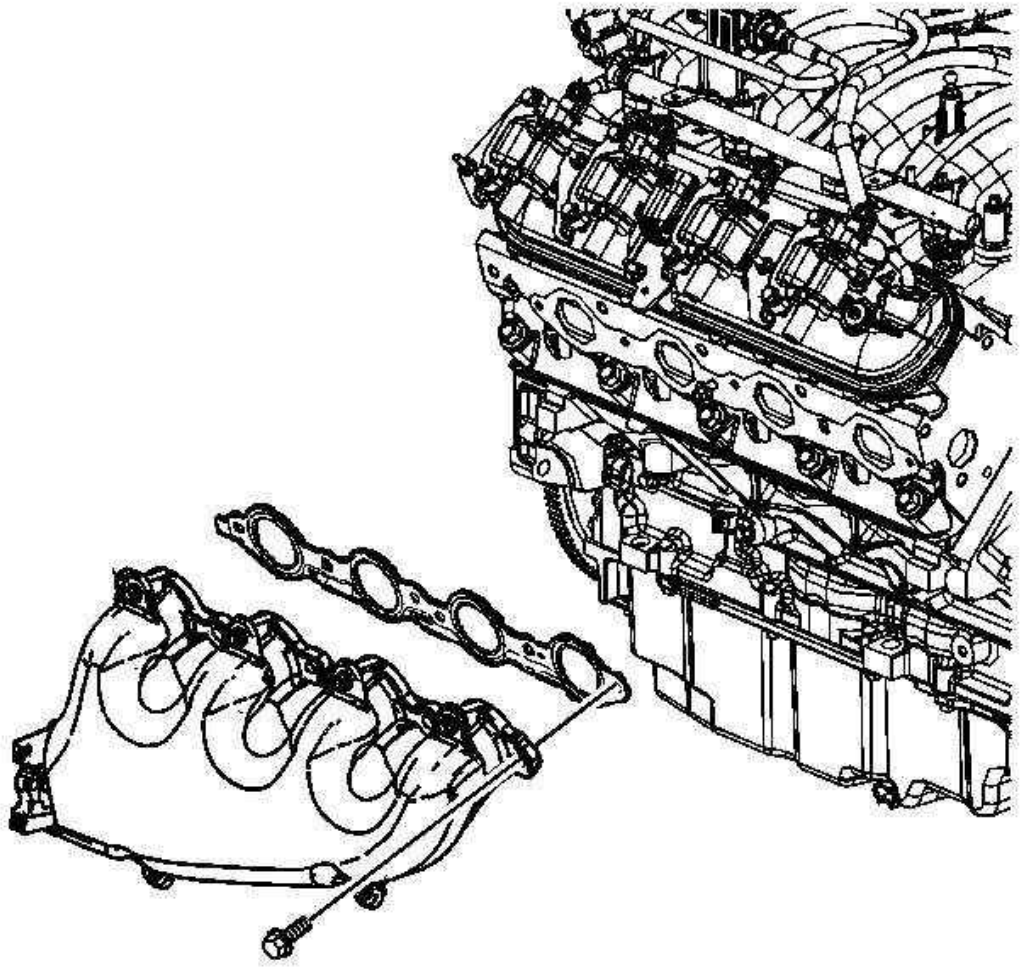


Fig. 680: View Of Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants**.
4. Install the exhaust manifold, NEW gasket, and bolts.

Tighten:

1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft).

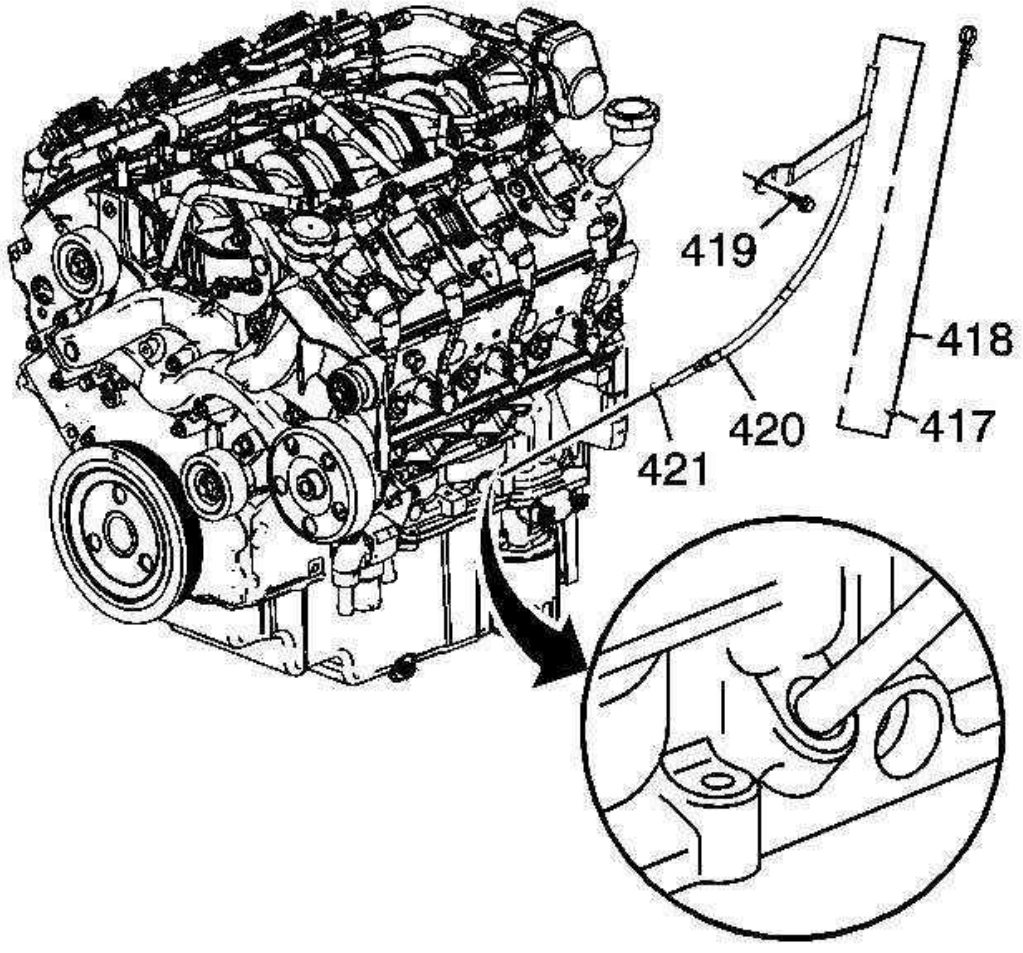
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Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

2. Tighten the exhaust manifold bolts a final pass to 25 N.m (18 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

OIL LEVEL INDICATOR AND TUBE INSTALLATION



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Fig. 681: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Inspect the O-ring seal (421) for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be used again.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube (420).
4. Install the oil level indicator tube into the engine and rotate into proper position.

NOTE: Refer to Fastener Notice .

5. Install the tube bolt (419).

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

6. Install the oil level indicator (418) into the tube.

ENGINE FLYWHEEL INSTALLATION

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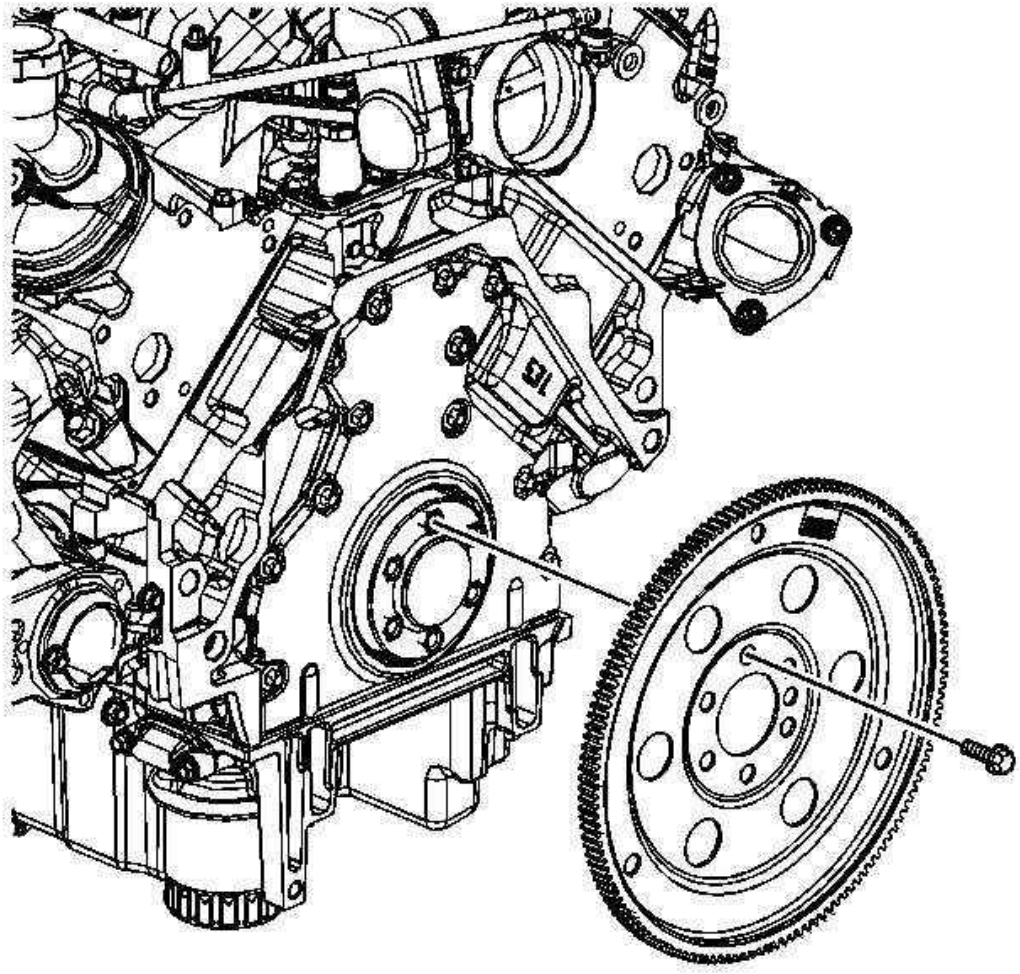


Fig. 682: Identifying Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.

1. Install the flex plate to the crankshaft.

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2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the flex plate bolts.

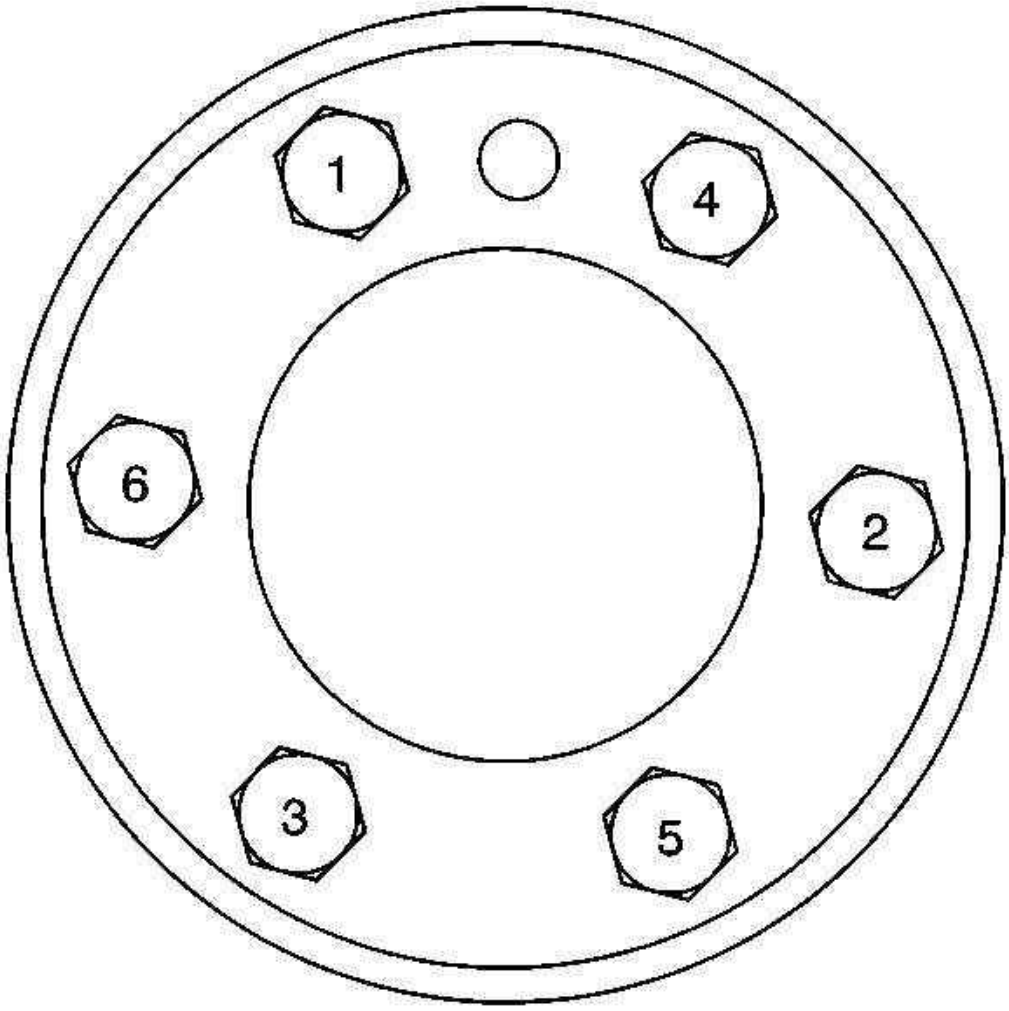


Fig. 683: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the engine flex plate bolts.

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Tighten:

1. Tighten the engine flex plate bolts (1-6) a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine flex plate bolts (1-6) a second pass in sequence to 50 N.m (37 lb ft).
3. Tighten the engine flex plate bolts (1-6) a final pass in sequence to 100 N.m (74 lb ft).

CRANKSHAFT BALANCER INSTALLATION

Tools Required

- **EN 47699** Flywheel Holding Tool. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 45059** Angle Meter

Installation

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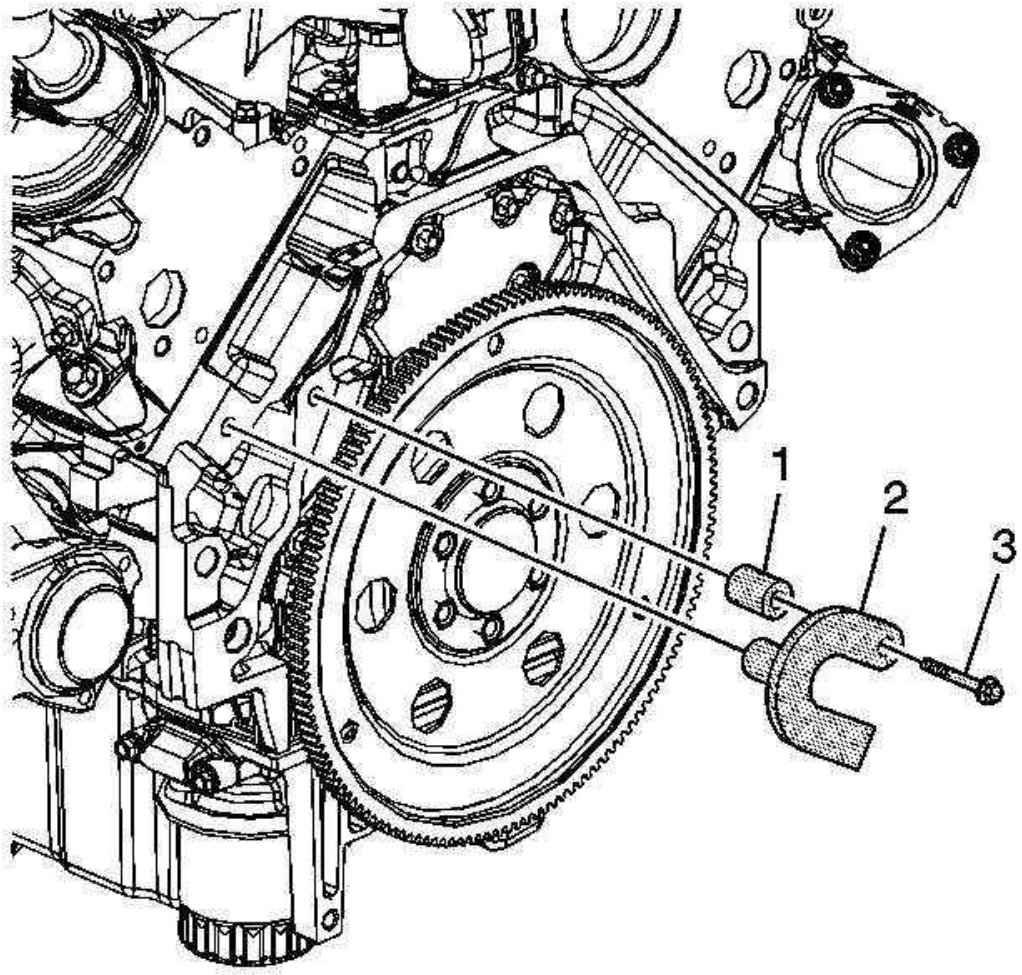


Fig. 684: View Of Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

IMPORTANT:

- **The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.**
- **The crankshaft balancer installation and bolt**

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tightening involves a 4 stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third and fourth passes tighten the NEW bolt to the proper torque.

- **The used crankshaft balancer bolt is used only during the first pass of the balancer installation procedure. Install a NEW crankshaft balancer bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.**
- **Ensure the teeth of the tool engage the engine flywheel teeth.**

1. Install the **EN 47699** (2), spacer (1), and bolt (3) to the block and flywheel. See **Special Tools**.

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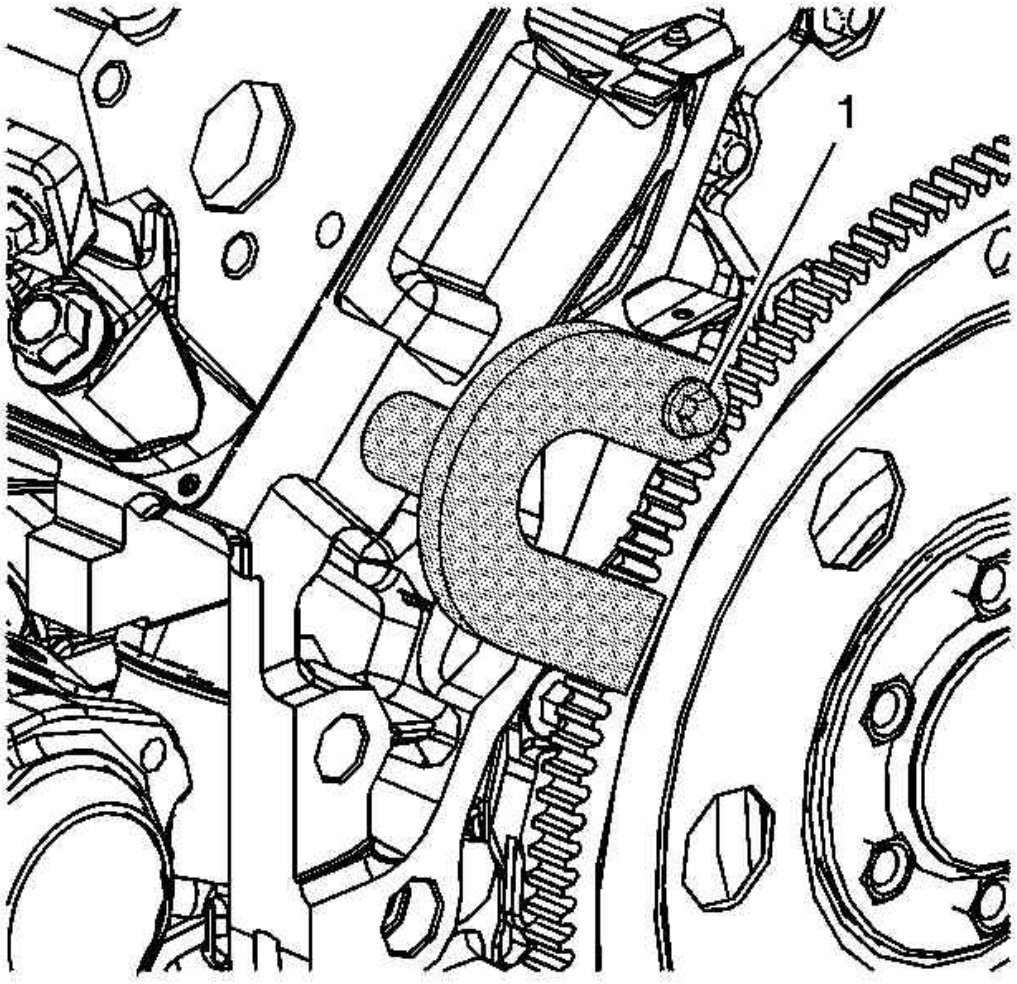


Fig. 685: Identifying Flywheel Holding Tool
Courtesy of GENERAL MOTORS CORP.

2. Tighten the **EN 47699** bolt (1). See **Special Tools**.

   Tighten: Tighten the bolt to 60 N.m (44 lb ft).

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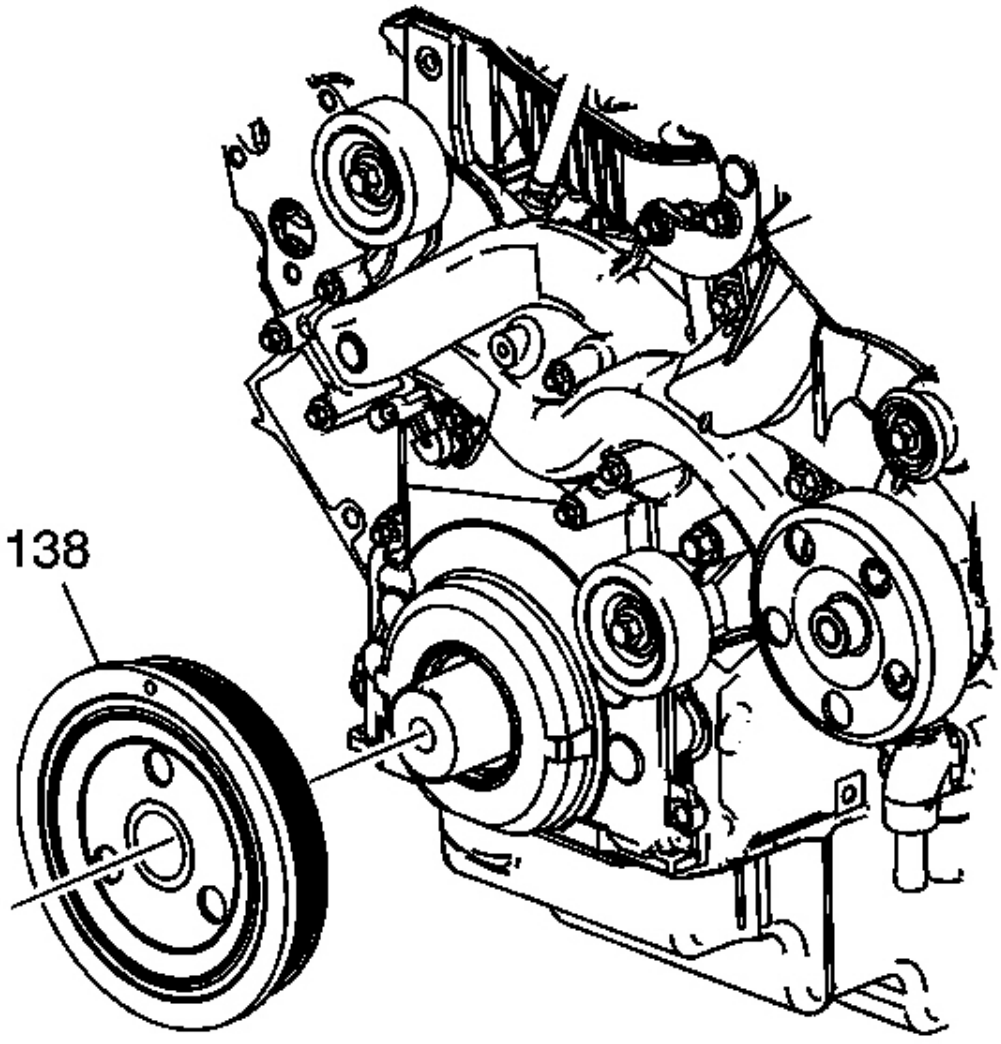


Fig. 686: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

3. Position the balancer (138) onto the end of the crankshaft.

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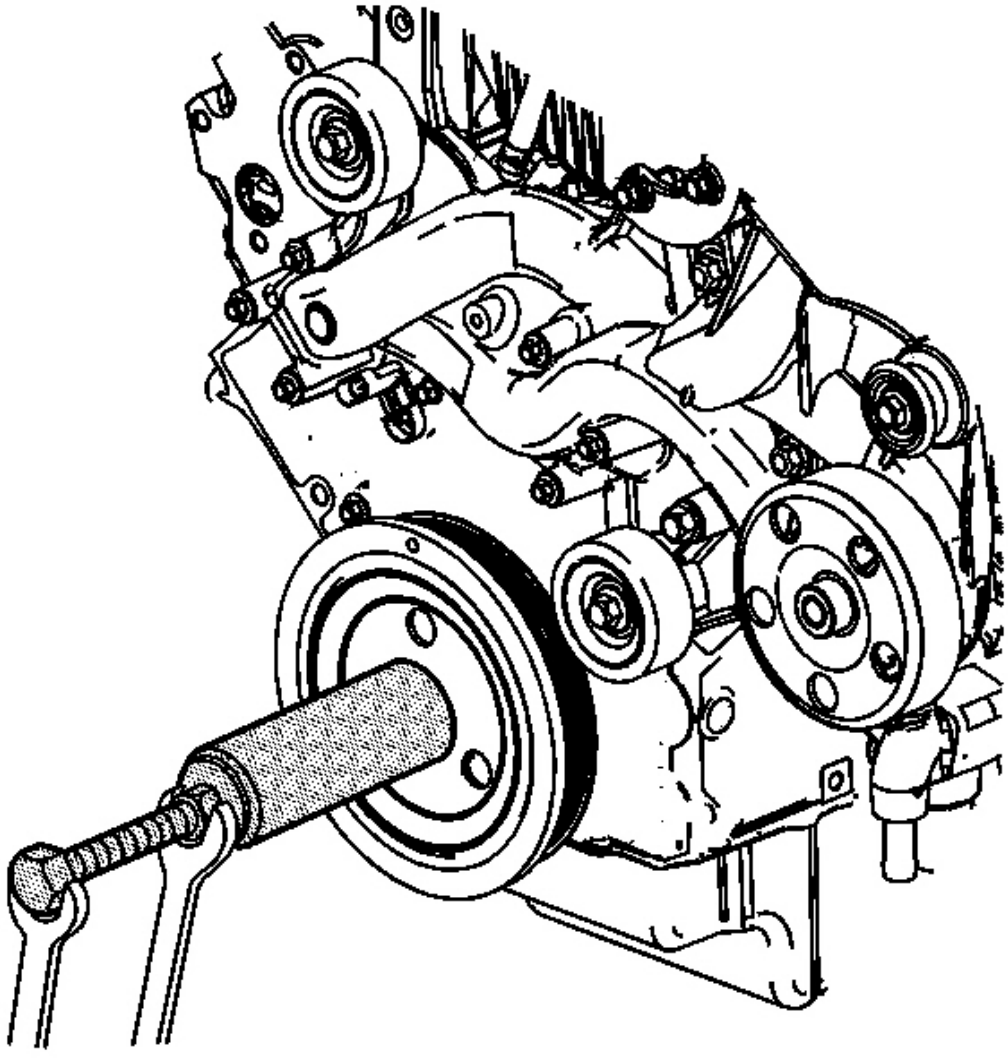


Fig. 687: Using Special Tools To Install Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41478** and the **J 41665** in order to install the balancer. See **Special Tools**.
    1. Assemble the **J 41478** threaded rod, nut, washer and **J 41665** installer. See **Special Tools**.

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Insert the smaller end of the installer into the front of the balancer.

2. Use a wrench and hold the hex end of the threaded rod.
3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
4. Remove the tool and reverse the installation tool.

   Position the larger end of the installer against the front of the balancer.

5. Use a wrench and hold the hex end of the threaded rod.
6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
7. Remove the balancer installation tools.

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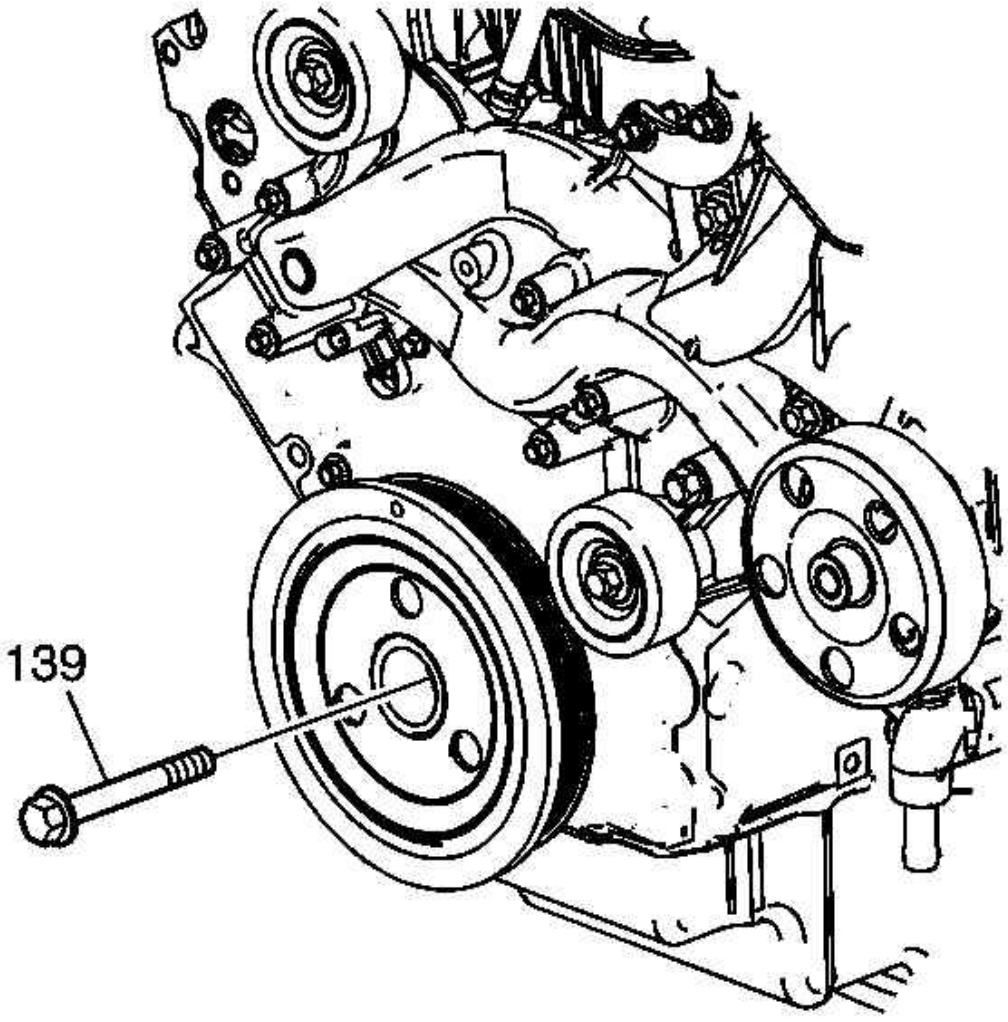


Fig. 688: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the used crankshaft balancer bolt (139).

   Tighten: Tighten the crankshaft balancer bolt to 330 N.m (240 lb ft).

6. Remove the used crankshaft balancer bolt (139).

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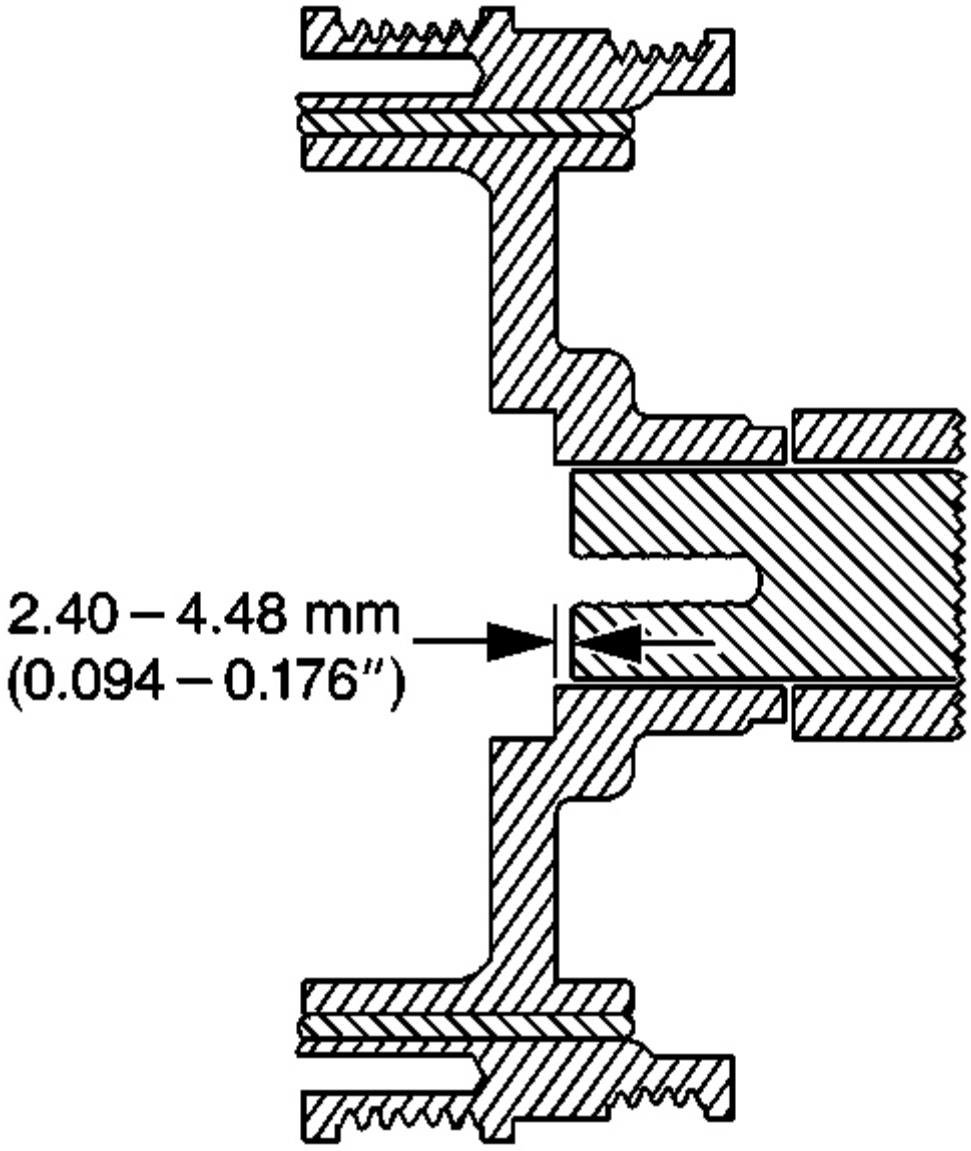


Fig. 689: View Of Balancer Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.

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7. Measure for a correctly installed balancer.

   If the balancer is not installed to the proper dimensions, install the **J 41665** and repeat the installation procedure. See **Special Tools**.

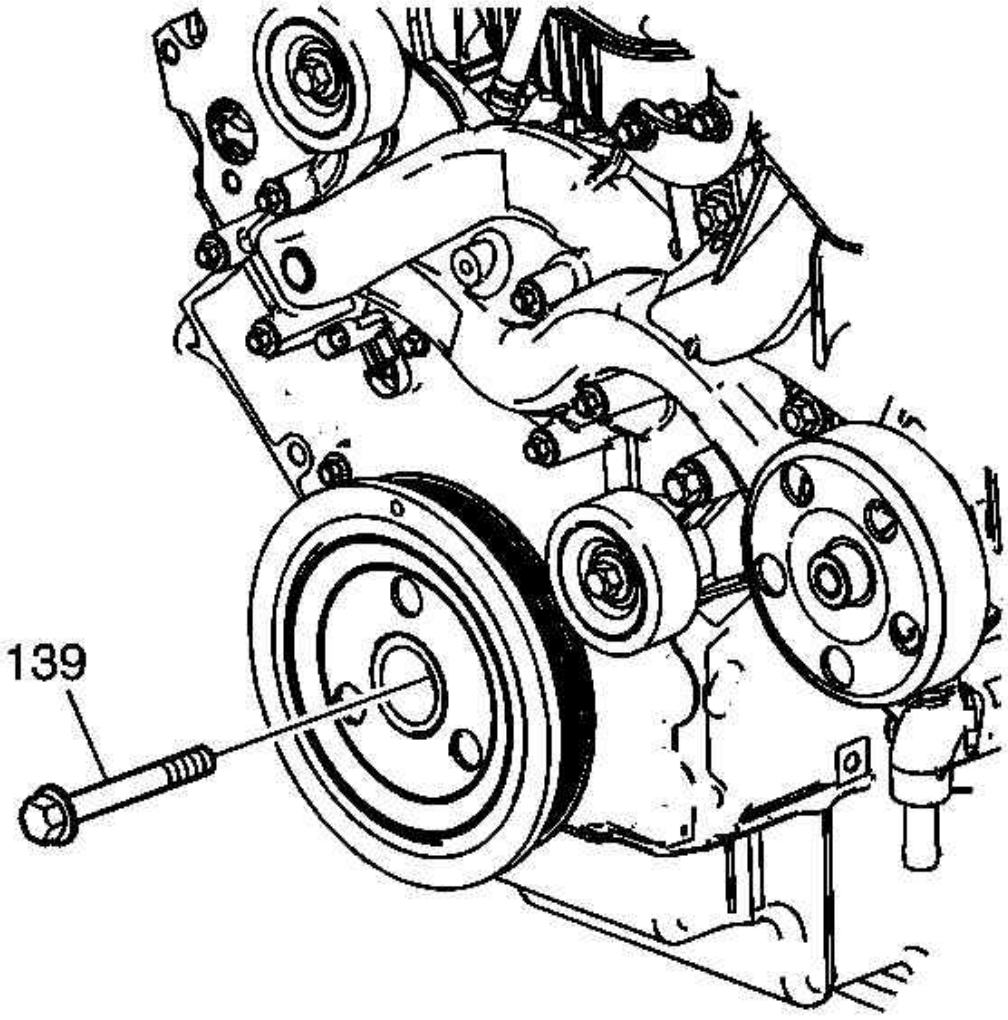


Fig. 690: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the NEW crankshaft balancer bolt.

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Tighten:

1. Tighten the crankshaft balancer bolt a first pass to 50 N.m (37 lb ft).
2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the **J 45059** .

9. Remove the **EN 47699** , spacer, and bolt. See **Special Tools**.

ENGINE PRELUBING

Tools Required

J 45299 Engine Preluber

Prelubing Procedure

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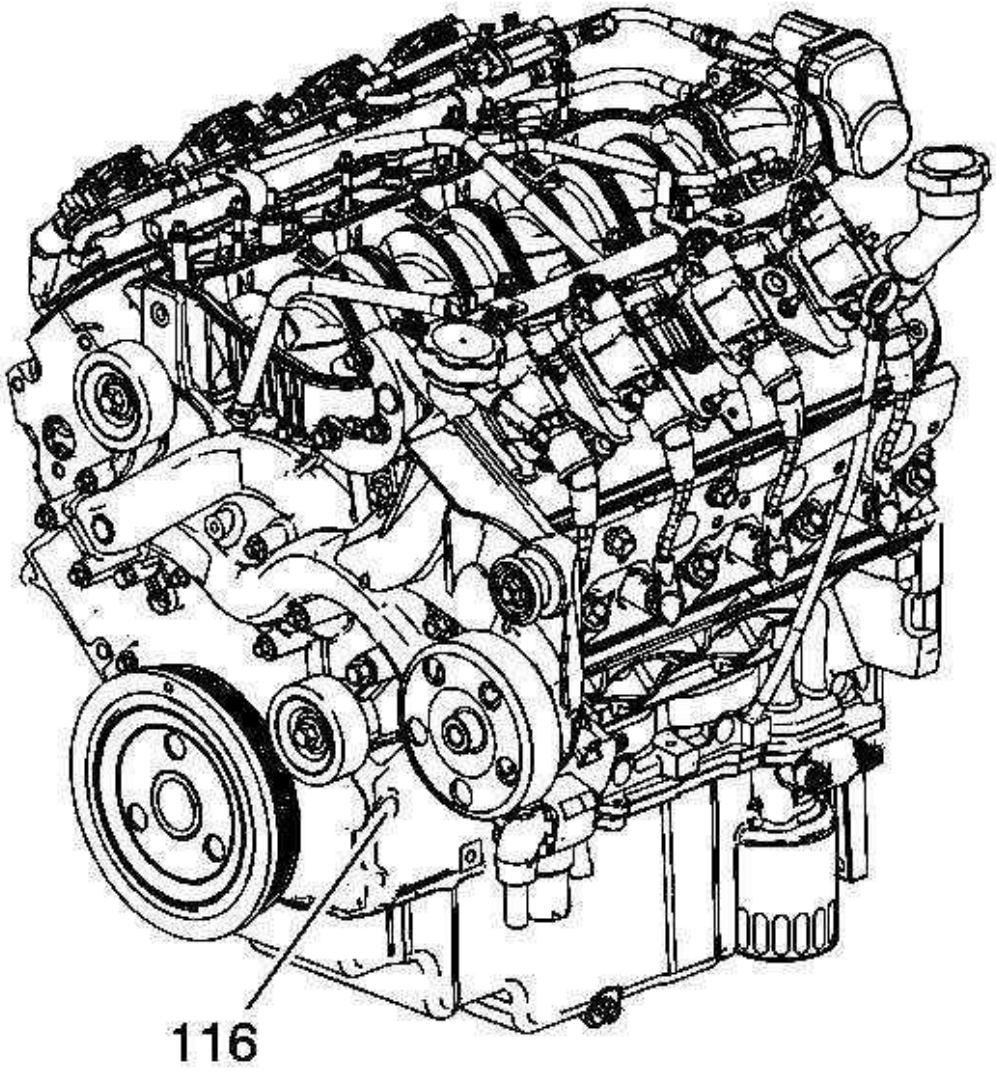


Fig. 691: Locating Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

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1. Remove the engine oil filter and fill with clean engine oil.

   NOTE: Refer to Fastener Notice .

2. Install the oil filter.

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

3. Locate the engine block left front oil gallery plug (116).
4. Install the M16 x 1.5 adapter P/N 509375.

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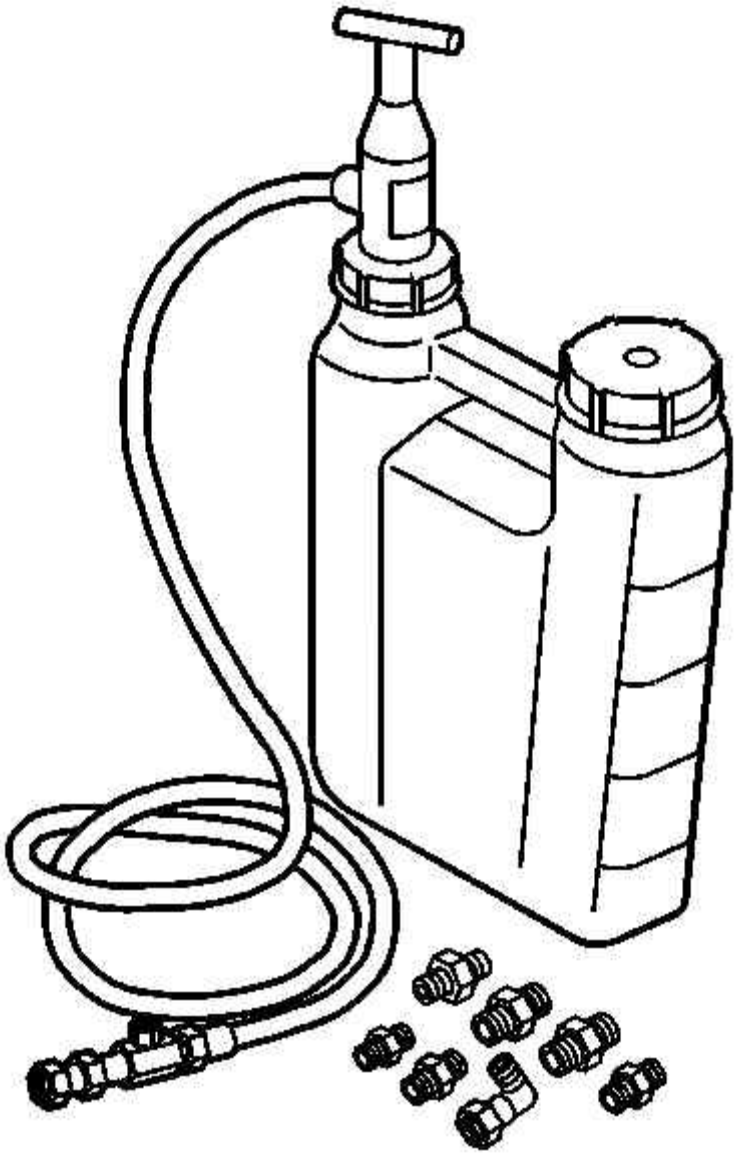


Fig. 692: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

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 1-1.9 liters (1-2

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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

A closed crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation pipe/passage into the intake manifold.

Results of Incorrect Operation

A plugged PCV Pipe/passage way may cause:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

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

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- 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. 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

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Fig. 693: View Of 5.3 Liter V8 Engine
Courtesy of GENERAL MOTORS CORP.

The 5.3 Liter V8 engine is identified as RPO LS4 VIN C.

Camshaft and Drive System

A billet steel 1 piece camshaft is supported by 5 bearings pressed into the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the camshaft timing chain. The CMP sensor lobes are incorporated into the front face of the camshaft sprocket with the CMP sensor mounted in the engine front cover. A timing chain tensioner is

mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location.

Crankshaft

The crankshaft is cast nodular iron. The crankshaft is supported by 5 crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A crankshaft position (CKP) reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.

Cylinder Heads

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. Passages for the engine coolant air bleed system are at the front of each cylinder head. The valve rocker arm covers are retained to the cylinder heads by 4 center mounted rocker arm cover bolts.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V configuration with 5 crankshaft bearing caps. The engine block is cast aluminum. The 5 crankshaft bearing caps each have 4 vertical M10 and 2 horizontal M8 mounting bolts. The camshaft is supported by 5 camshaft bearings pressed into the block.

Exhaust Manifolds

The exhaust manifolds are a 1 piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a 1 piece composite design that incorporates brass threaded inserts for mounting the fuel rail and throttle body. Each side of the intake manifold

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is sealed to the cylinder head by 8 non-reusable silicone sealing gaskets. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a 1 piece push in place silicone gasket. The fuel rail assembly, with 8 separate fuel injectors, is retained to the intake by 4 bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. The manifold absolute pressure (MAP) sensor is installed and retained to the top of the intake manifold and sealed by an O-ring seal. The evaporative emission (EVAP) canister purge solenoid valve is retained to the manifold by a mounting bracket. There are no coolant passages within the intake manifold. The manifold is installed with the throttle body facing the rear of the engine.

Oil Pan

The structural rear-sump oil pan is cast aluminum. Incorporated into the design is the oil filter mounting boss, the active fuel management oil pressure relief valve and the drain plug opening. Filtered oil is returned to the engine block through the oil filter to the engine block upper oil galleries. The press-fit oil pressure relief valve is located at the left rear of the oil pan and can be inspected by removing the oil pan cover. The alignment of the structural oil pan to the rear of the engine block and transmission housing is critical.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a flat or recessed top and barrel shaped skirt. The piston pins are chromium steel and are a full-floating design. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance. All applications use a piston with a graphite coated skirt. The piston and pin are to be serviced as an assembly.

Valve Rocker Arm Cover Assemblies

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the coil and bracket assemblies. Incorporated into the left cover is the oil fill tube and the positive crankcase ventilation (PCV) fresh air passage. Incorporated into the right cover is the PCV system dirty air passage.

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Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve lifter guides position and retain the valve lifters. The valve rocker arms for each bank of cylinders are mounted on pedestals or pivot supports. Each rocker arm is retained on the pivot support and cylinder head by a bolt. Valve lash is net build. Cylinders 1, 4, 6, and 7 are active fuel management. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

System Operation

General Motors Active Fuel Management engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy by deactivating 4 of the engines 8 cylinders. The engine will normally operate on 8 cylinders in V8 mode during, starting, idling, and medium or heavy throttle conditions. When commanded ON, the powertrain control module (PCM) will direct the active fuel management system and deactivate cylinders 1 and 7 on the left bank and cylinders 4 and 6 on the right bank, forcing V4 mode. Refer to:

- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) Off**
- **Lubrication Description - Main Pressure Below 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Lubrication Description - Main Pressure Above 55 psi with Cylinder Deactivation (Active Fuel Management) On**
- **Cylinder Deactivation (Active Fuel Management) System Description**

Valve Lifter Oil Manifold Assembly

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Fig. 694: View Of Valve Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

The valve lifter oil manifold assembly (1) is bolted to the top of the engine block beneath the intake manifold assembly. The oil manifold consists of 4 electrically

operated and normally-closed solenoids (2). Each solenoid directs the flow of pressurized engine oil to the active fuel management intake and exhaust valve lifters (5). The oil pressure relief valve (6), located in the left rear area of the oil pan, regulates engine oil pressure to the lubrication system and the oil manifold.

When enabling conditions are met for active fuel management operation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the windings energized, the solenoid valves open and direct pressurized engine oil through the manifold into 8 vertical passages in the engine block lifter valley. The 8 vertical passages, 2 per cylinder, direct pressurized oil to the valve lifter bores of the cylinders to be deactivated. When vehicle operating conditions require a return to V8 mode, the ECM will turn OFF the ground circuit for the solenoids, allowing the solenoid valves to close. When the solenoid valves are closed, remaining oil pressure is exhausted through the bleed passages of the manifold into the engine block lifter valley. The housing of the oil manifold incorporates several oil bleed passages that continually purge trapped air from the manifold and engine block.

To help control contamination within the active fuel management hydraulic system, a small replaceable oil filter (4) is located in the manifold oil inlet passage. The oil pressure sensor (3) monitors engine oil pressure and provides information to the ECM.

Active Fuel Management Valve Lifters

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Fig. 695: View Of Displacement on Demand Valve Lifters
Courtesy of GENERAL MOTORS CORP.

When operating in V8 mode, the active fuel management valve lifters function similar to the non-active fuel management valve lifters. The active fuel management oil manifold solenoids are in the closed position with no pressurized oil directed to the valve lifters. The pushrod (1) travels upward and downward to actuate the rocker arm and valve. The spring loaded locking pins (5) of the lifter are extended outward and mechanically lock the pin housing (4) to the outer body of the valve lifter (3).

When the active fuel management system is commanded ON, the ECM will direct the solenoids of the oil manifold to open and direct pressurized oil to the valve lifters. Oil travels through the manifold and engine block oil galleries and enters the inlet port (6) of the valve lifter.

When operating in V4 mode, pressurized oil forces the locking pins (11) inward. The pushrod (7) remains in a constant position and does not travel upward and downward. The outer body of the lifter (9) moves upward and downward

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independently from the pin housing (10). The valve lifter spring (8) retains tension on the valve train components to eliminate valve train noise.

When the active fuel management system is commanded OFF, the ECM directs the solenoids of the oil manifold to close, stopping the flow of pressurized oil to the valve lifters. The oil pressure within the lifter will decrease and the locking pins will move outward to mechanically lock the pin housing and outer body.

Engine Block

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Fig. 696: View Of DOD Engine Block
Courtesy of GENERAL MOTORS CORP.

The active fuel management engine block incorporates additional features to support active fuel management system operation. Engine oil pressure is routed to the manifold assembly from an oil gallery (2) in the rear of the cylinder block.

Cylinders 1, 4, 6, and 7 each have 2 vertical, cast-in-block oil passages (1). The vertical oil passages permit oil flow from the manifold assembly to the valve lifter bores.

Powertrain Control Module (PCM)

Refer to **Cylinder Deactivation (Active Fuel Management) System Description** .

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 1 or more of the following items:

- 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
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes on the LS4 engine utilize metric threads.
- Certain fasteners should not be used again. Bolts, studs, or other fasteners that must be replaced, will be called out in the specific service procedure.

New Sealants and/or Adhesives

Sealers and adhesives, as required, are identified within the specific service procedures. Refer to **Sealers, Adhesives, and Lubricants**.

Disassembly and Assembly Procedure Revisions

A variety of new procedures have been added for the LS4 application.

Engine Mechanical Diagnostic Procedure Revisions

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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 condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Diagnostic Starting Point - Engine Mechanical**.

New Special Tools Required

The small block V8 LS4 application requires the following tools:

- **EN 46330** Timing Belt Tensioner Retaining Pin. See **Special Tools**.
- **EN-46999** Active Fuel Management Tester
- **EN-46999-1** Active Fuel Management Tester Air Adapter. See **Special Tools**.
- **EN-46999-5** Active Fuel Management Tester Harness - Small Block V8. See **Special Tools**.
- **EN 47699** Flywheel Holding Tool. See **Special Tools**.
- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **EN-47988** Serpentine Belt Tensioner Unloader. See **Special Tools**.
- **J-21867-16** Oil Pressure Adapter. See **Special Tools**.
- **J 41476** Front and Rear Cover Alignment Tool. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools**.
- **J 41479-2A** Crankshaft Rear Oil Seal Installation Guide. See **Special Tools**.
- **J 41480** Front and Rear Cover Alignment. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 41816-A** Crankshaft Balancer Remover
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 41818** Crankshaft Bearing Cap Remover
- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 42385-200** Common Thread Repair Kit. See **Special Tools**.

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- **J 42385-300** Fixtures and Hardware Kit. See **Special Tools**.

Refer to **Special Tools**.

A Component Comparison from the Previous Year

- The 5.3L RPO LS4 V8 engine is optional for the 2008 model year.
- The LS4 V8 engine includes active fuel management.

LUBRICATION DESCRIPTION - MAIN PRESSURE BELOW 55 PSI WITH CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) OFF

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Fig. 697: Lubrication Diagram (Main Pressure Below 55 psi with Cylinder Deactivation Off)
Courtesy of GENERAL MOTORS CORP.

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Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. A second valve, the active fuel management oil pressure relief valve is incorporated into the left rear side of the oil pan. The active fuel management oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 448 kPa (65 psi) at 3,000 RPM and 21°C (70°F).

Oil is then directed from the filter to the upper main oil galleries and the oil manifold assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

LUBRICATION DESCRIPTION - MAIN PRESSURE ABOVE 55 PSI WITH CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) OFF

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Fig. 698: Lubrication Diagram (Main Pressure Above 55 psi with Cylinder Deactivation Off)
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. A second valve, the active fuel management oil pressure relief valve is incorporated

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into the left rear side of the oil pan. The active fuel management oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 448 kPa (65 psi) at 3,000 RPM and 21°C (70°F). When main oil pressure exceeds 448 kPa (65 psi), the active fuel management oil pressure relief valve exhausts excess oil to the sump.

Oil is then directed from the filter to the upper main oil galleries and the oil manifold assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

LUBRICATION DESCRIPTION - MAIN PRESSURE BELOW 55 PSI WITH CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) ON

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Fig. 699: Lubrication Diagram (Main Pressure Below 55 psi with Cylinder Deactivation On)
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. A second valve, the active fuel management oil pressure relief valve is incorporated

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into the left rear side of the oil pan. The active fuel management oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 448 kPa (65 psi) at 3,000 RPM and 21°C (70°F).

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With active fuel management activated, the ECM commands the 4 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 1, 4, 6, and 7. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

LUBRICATION DESCRIPTION - MAIN PRESSURE ABOVE 55 PSI WITH CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) ON

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Fig. 700: Lubrication Diagram (Main Pressure Above 55 psi with Cylinder Deactivation On)
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. A second valve, the active fuel management oil pressure relief valve is incorporated

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into the left rear side of the oil pan. The active fuel management oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 448 kPa (65 psi) at 3,000 RPM and 21°C (70°F). When main oil pressure exceeds 448 kPa (65 psi), the active fuel management oil pressure relief valve exhausts excess oil to the sump.

Oil is then directed from the filter to the upper main oil galleries and the oil manifold assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine.

With active fuel management activated, the ECM commands the 4 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 1, 4, 6, and 7. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

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, they should be marked, organized or retained in a specific order for assembly. Refer to **Separating Parts**.
- At the time of installation, 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. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.

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- Proper lubrication will protect and lubricate friction surfaces 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, or organized in a way to ensure installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod location and orientation to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Tools Required

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J 28410 Gasket Remover

Gasket Use and Applying Sealants

- Do not use any gasket again unless specified.
- Gaskets that can be used again will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or 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 oil.
  - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

NOTE: Refer to Sealant Notice .

- When assembling components, use only the sealant specified or equivalent in

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the service procedure.

- Sealing surfaces should 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.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Pipe Joint Compound

IMPORTANT: 3 types of sealer are commonly used in engines. These are room temperature vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer, or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type of sealer is used where 2 non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

NOTE: Refer to Sealant Notice .

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity

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as specified in the procedure. Run the bead to the inside of any bolt holes.

- Apply a continuous bead of pipe joint compound to 1 sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- RTV sealant hardens when exposed to air. This type of sealer is used where 2 non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

NOTE: Refer to Sealant Notice .

- Apply RTV sealant to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes.
- Assemble components while the RTV sealant is still wet, within 3 minutes. Do not wait for the RTV sealant to skin over.
- Tighten bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

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- Apply a continuous bead of gasket eliminator to 1 flange. Surfaces to be sealed must be clean and dry.

NOTE: Refer to Sealant Notice .

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

IMPORTANT: Anaerobic sealed joints that are partially torqued and allowed to cure more than 5 minutes may result in incorrect shimming and sealing of the joint.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section, with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools 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:

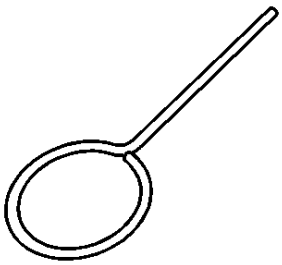
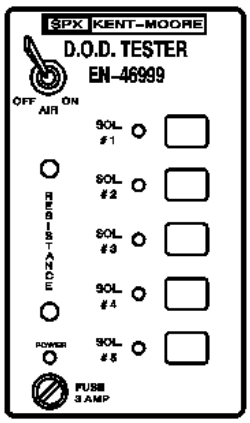
- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools

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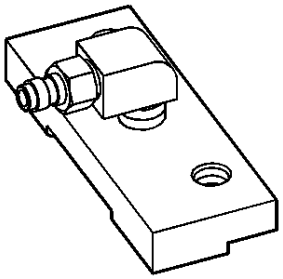
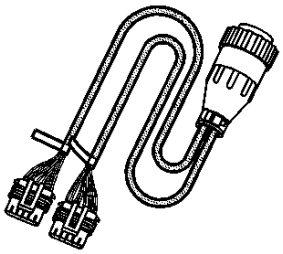
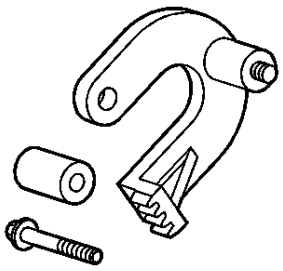
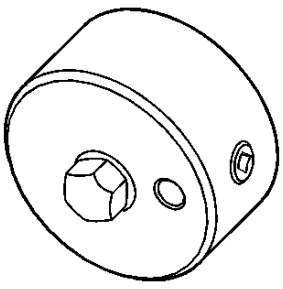
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

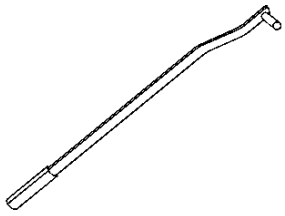
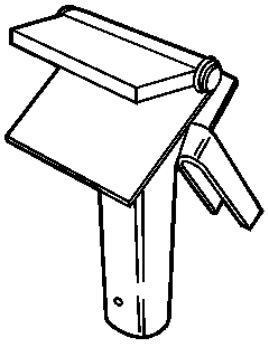
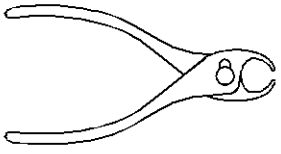
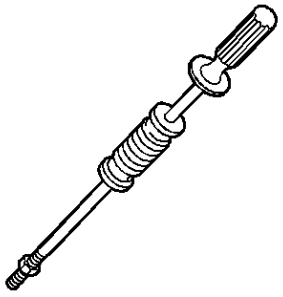
SPECIAL TOOLS

Illustration	Tool Number/Description
	EN-46330 Timing Belt Tensioner Retaining Pin
	EN-46999 Active Fuel Management Tester
	EN-46999-1 Active Fuel Management Tester Air

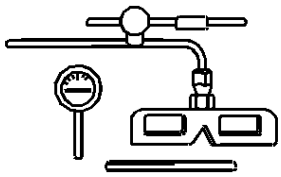
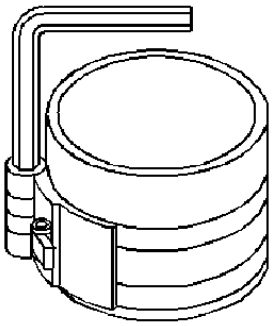
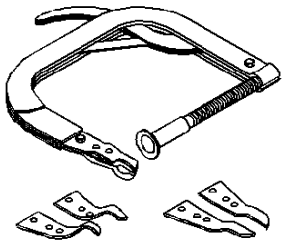
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	Adapter
	EN-46999-5 Active Fuel Management Tester Harness - Small Block V8
	EN-47699 Flywheel Holding Tool
	EN-47971 Oil Pressure Gage Adapter

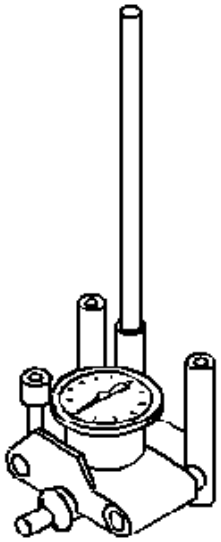
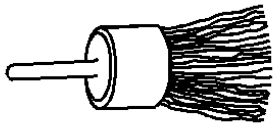
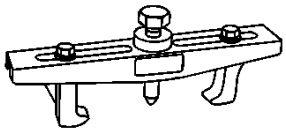
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	EN-47988 Serpentine Belt Tension Unloader
	GE-48326 Sealant Dispenser
	J 3049-A Valve Lifter Remover
	J 6125-1B Slide Hammer Adapter

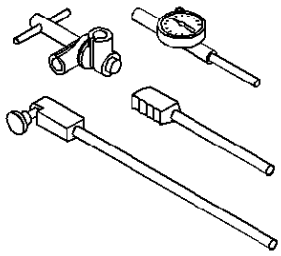
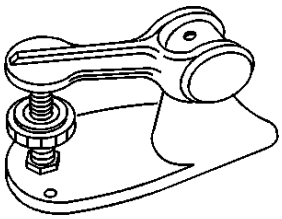
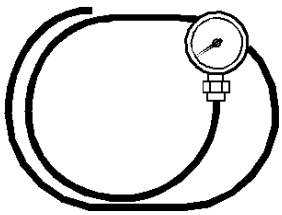
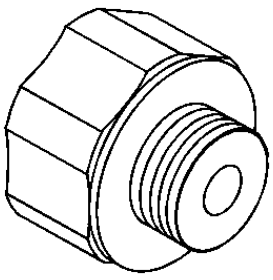
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	J 7872 Magnetic Base Dial Indicator
	J 8037 Ring Compressor
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage

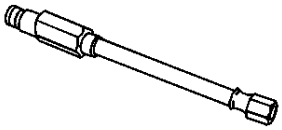
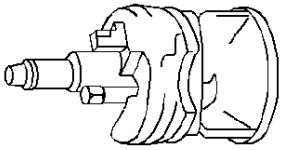
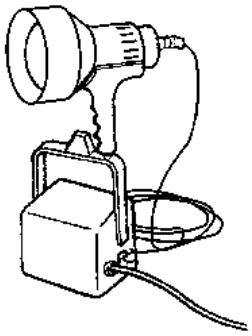
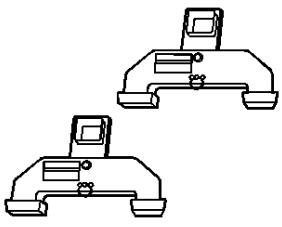
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	J 8089 Carbon Removal Brush
	J 8433 Two Jaw Puller
	J 8520 Cam Lobe Lift Indicator

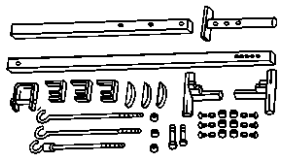
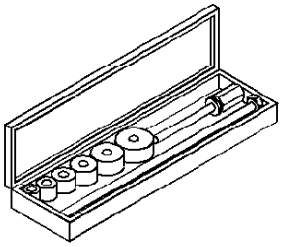
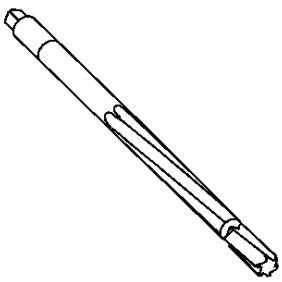
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	J 9666 Valve Spring Tester
	J 21867 Pressure Gage
	J 21867-16 Oil Pressure Adapter
	J 22794

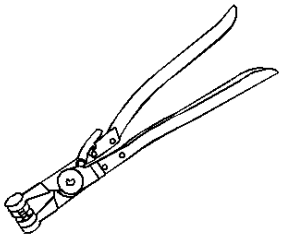
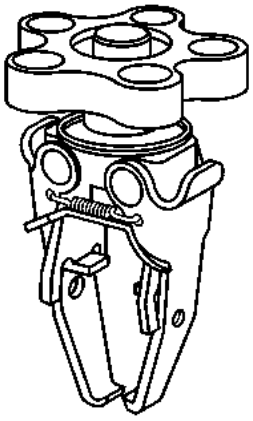
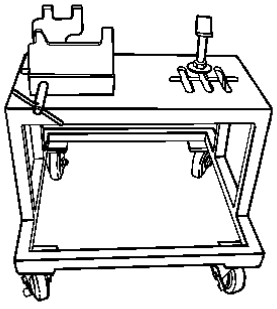
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	Spark Plug Port Adapter
	J 24270 Cylinder Bore Ridge Reamer
	J 28410 Gasket Remover
	J 28428-E High-Intensity Black Light Kit
	J 28467-501 Engine Support Fixture Adapters

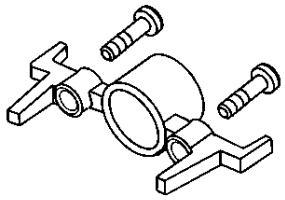
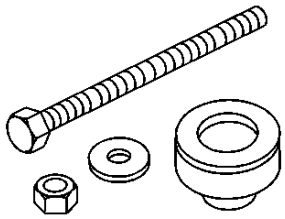
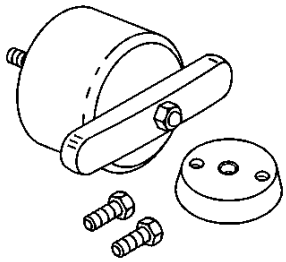
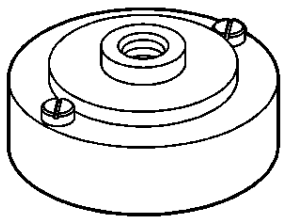
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	J 28467-B Universal Engine Support Fixture
	J 33049 Camshaft Bearing Service Set
	J 35667-A Cylinder Head Leakdown Tester
	J 37378-1 Valve Guide Reamer

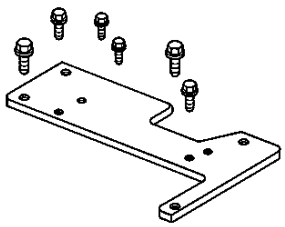
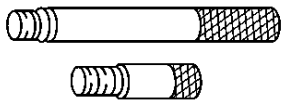
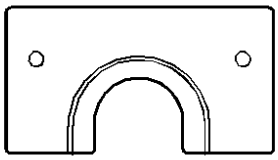
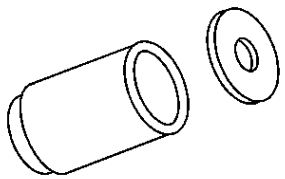
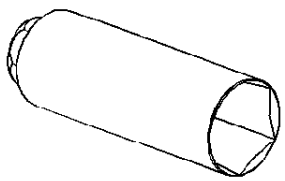
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	J 38185 Hose Clamp Pliers
	J 38606 Valve Spring Compressor
	J 39580 Power Pack Stand Engine and Transaxle Assembly Support
	J 41476 Front and Rear Cover Alignment Tool

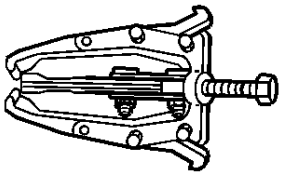
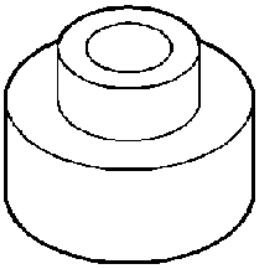
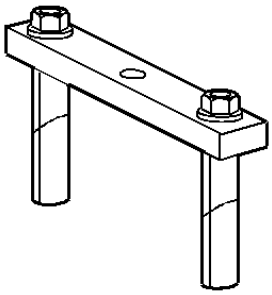
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	J 41478 Crankshaft Front Oil Seal Installer
	J 41479 Crankshaft Rear Oil Seal Installer
	J 41479-2A Crankshaft Rear Oil Seal Installation Guide
	J 41480 Front and Rear Cover Alignment

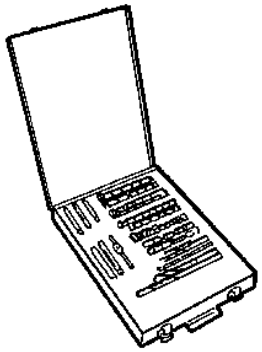
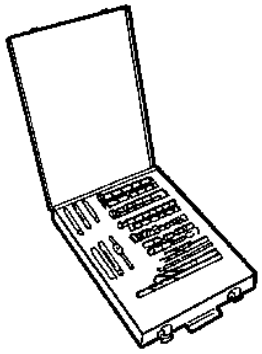
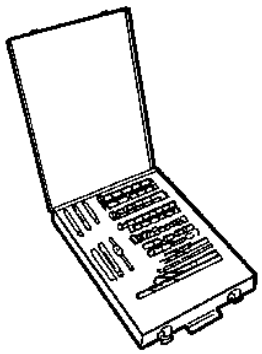
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	J 41556 Connecting Rod Guide
	J 41558 Crankshaft Sprocket Remover
	J 41665 Crankshaft Balancer and Sprocket Installer
	J 41712 Oil Pressure Switch Socket
	J 41816-A

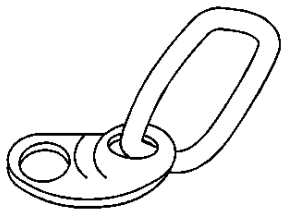
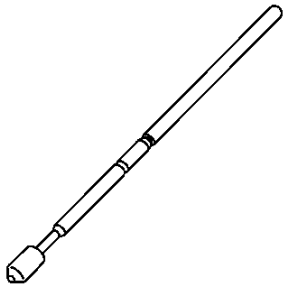
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	Crankshaft Balancer Remover
	J 41816-2 Crankshaft End Protector
	J 41818 Crankshaft Bearing Cap Remover
	J 42385-100 Head/Main Bolt Thread Repair Kit

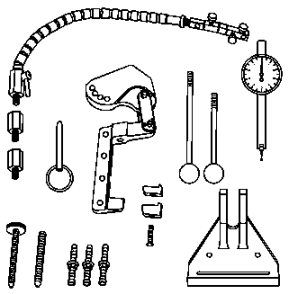
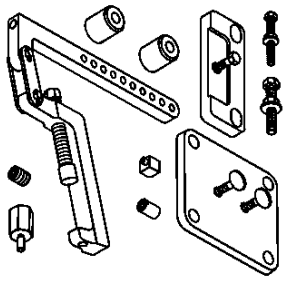
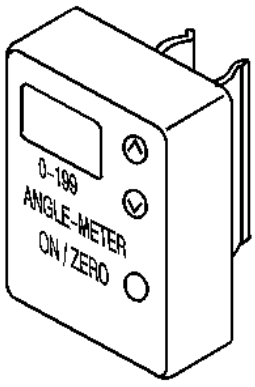
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	J 42385-200 Common Threads Repair Kit
	J 42385-300 Fixtures and Hardware Kit

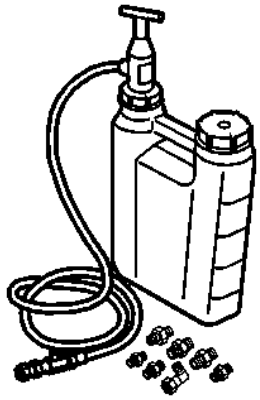
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	J 42451-1 Engine Support Adapter
	J 42504 Engine Lift Bracket
	J 42640 Steering Column Anti-rotation Pin

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	J 43690 Rod Bearing Checking Tool
	J 43690-100 Rod Bearing Checking Tool - Adapter Kit
	J 45059 Angle Meter

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	J 45299 Engine Preluber

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