

2005 Pontiac GTO

2005 ENGINE Engine Mechanical - 6.0L - GTO

2005 ENGINE**Engine Mechanical - 6.0L - GTO****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS****Fastener Tightening Specifications**

Application	Specification	
	Metric	English
Camshaft Position (CMP) Sensor Bolt/Screw	12 N.m	106 lb in
CMP Sensor Wire Harness Bolt/Screw	12 N.m	106 lb in
Camshaft Retainer Bolt/Screw	25 N.m	18 lb ft
Camshaft Sprocket Bolt/Screw	25 N.m	18 lb ft
Connecting Rod Bolt/Screw - First Pass	20 N.m	15 lb ft
Connecting Rod Bolt/Screw - Final Pass	75 degrees	
Coolant Air Bleed Pipe and Cover Bolt/Screw	12 N.m	106 lb in
Coolant Temperature Sensor	20 N.m	15 lb ft
Crankshaft Balancer Bolt/Screw - Installation Pass to Ensure the Balancer is Completely Installed	330 N.m	240 lb ft
Crankshaft Balancer Bolt/Screw - First Pass - Install a NEW Bolt/Screw After the Installation Pass and Tighten as Described in the First and Final Passes	50 N.m	37 lb ft
Crankshaft Balancer Bolt/Screw - Final Pass	140 degrees	
Crankshaft Bearing Cap M10 Bolt/Screw - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Bolt/Screw - Final Pass in Sequence	80 degrees	
Crankshaft Bearing Cap M10 Stud - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Stud - Final Pass in Sequence	51 degrees	
Crankshaft Bearing Cap M8 Bolt/Screw	25 N.m	18 lb ft
Crankshaft Oil Deflector Nut	25 N.m	18 lb ft
Crankshaft Position (CKP) Sensor Bolt/Screw	25 N.m	18 lb ft
Cylinder Head Bolts - M11 Bolt/Screw - First Pass in Sequence	30 N.m	22 lb ft
Cylinder Head Bolts - M11 Bolt/Screw - Second Pass in Sequence	90 degrees	
Cylinder Head Bolts - M11 Bolt/Screw - Final Pass in Sequence	70 degrees	
Cylinder Head Bolt/Screw - M8 Inner Bolt/Screw in Sequence	30 N.m	22 lb ft
Cylinder Head Coolant Plug	20 N.m	15 lb ft

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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 Plug	60 N.m	44 lb ft
Evaporative Emission (EVAP) Purge Valve Bracket Bolt/Screw	50 N.m	37 lb ft
Exhaust Manifold Bolt/Screw - First Pass	15 N.m	11 lb ft
Exhaust Manifold Bolt/Screw - Final Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolt/Screw	9 N.m	80 lb in
Exhaust Manifold Studs	20 N.m	15 lb ft
Flywheel Bolt/Screw - First Pass	20 N.m	15 lb ft
Flywheel Bolt/Screw - Second Pass	50 N.m	37 lb ft
Flywheel Bolt/Screw - Final Pass	100 N.m	74 lb ft
Front Cover Bolt/Screw	25 N.m	18 lb ft
Fuel Rail Bolt/Screw	10 N.m	89 lb in
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolt/Screw	12 N.m	106 lb in
Ignition Coil-to-Bracket Bolt/Screw	10 N.m	89 lb in
Intake Manifold Bolt/Screw - First Pass in Sequence	5 N.m	44 lb in
Intake Manifold Bolt/Screw - Final Pass in Sequence	10 N.m	89 lb in
Knock Sensor Bolt/Screw	20 N.m	15 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Fitting	55 N.m	40 lb ft
Oil Level Indicator Tube Bolt/Screw	25 N.m	18 lb ft
Oil Level Sensor	20 N.m	15 lb ft
Oil Pan Baffle Bolt/Screw	12 N.m	106 lb in
Oil Pan Closeout Cover Bolt/Screw - Left Side	9 N.m	80 lb in
Oil Pan Closeout Cover Bolt/Screw - Right Side	9 N.m	80 lb in
Oil Pan Cover Nuts	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan M6 Bolt/Screw - Oil Pan-to-Rear Cover	12 N.m	106 lb in
Oil Pan M8 Bolt/Screw - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pan Oil Gallery Plugs	25 N.m	18 lb ft
Oil Pressure Sensor	20 N.m	15 lb ft
Oil Pump Cover Bolt/Screw	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/Screw	12 N.m	106 lb in
Oil Pump-to-Engine Block Bolt/Screw	25 N.m	18 lb ft
Oil Filter Tube Bolt/Screw	12 N.m	106 lb in
Oil Filter Tube Studs	12 N.m	106 lb in
Rear Housing Bolt/Screw	25 N.m	18 lb ft

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Service Lift Bracket M8 Bolt/Screw	25 N.m	18 lb ft
Service Lift Bracket M10 Bolt/Screw	50 N.m	37 lb ft
Spark Plugs - New Cylinder Heads	20 N.m	15 lb ft
Spark Plugs - All Subsequent Installations	15 N.m	11 lb ft
Throttle Body Bolt/Screw	10 N.m	89 lb in
Timing Chain Dampener Bolt/Screw	25 N.m	18 lb ft
Valley Cover Bolt/Screw	25 N.m	18 lb ft
Valve Lifter Guide Bolt/Screw	10 N.m	89 lb in
Valve Rocker Arm Bolt/Screw	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolt/Screw	12 N.m	106 lb in
Water Inlet Housing Bolt/Screw	15 N.m	11 lb ft
Water Pump Bolt/Screw - First Pass	15 N.m	11 lb ft
Water Pump Bolt/Screw - Final Pass	30 N.m	22 lb ft

ENGINE MECHANICAL SPECIFICATIONS**Engine Mechanical Specifications**

Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	6.0L	364 CID
• RPO	LS2	
• VIN	U	
• Bore	101.618-101.636 mm	4.0007-4.0017 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	10.9:1	
• Firing Order	1-8-7-2-6-5-4-3	
• 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-Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	101.618-101.636 mm	4.0007-4.0017 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

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• 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	7.81 mm	0.307 in
• Camshaft Lobe Lift - Exhaust	7.77 mm	0.306 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
• 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 - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in

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• 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
• 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 Two Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Capacity - with Filter	5.2 liters	5.5 quarts
• Oil Capacity - without Filter	4.7 liters	5.0 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
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Rear Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in

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• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.25 mm	0.0-0.01 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.20-0.41 mm	0.008-0.016 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.20-0.41 mm	0.008-0.016 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.37-0.69 mm	0.015-0.027 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.37-0.69 mm	0.015-0.027 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.22-0.79 mm	0.009-0.031 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.22-0.79 mm	0.009-0.031 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.030-0.10 mm	0.0012-0.0040 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.030-0.10 mm	0.0012-0.0040 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.035-0.078 mm	0.0014-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.035-0.078 mm	0.0014-0.0031 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.013-0.201 mm	0.0005-0.0079 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.013-0.201 mm	0.0005-0.0079 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Piston Pin Bore - Production	0.002-0.01 mm	0.0008-0.0004 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Service	0.002-0.015 mm	0.0008-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.943-0.943 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	0.007-0.0022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	101.611-101.642 mm	4.0-4.001 in
• Piston - Piston to Bore Clearance - Production	-0.022-0.08 mm	-0.0009-0.0012 in

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• Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.024-0.08 mm	0.00094-0.0031 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	13.27 mm	0.522 in
• Valves - Valve Lift - Exhaust	13.25 mm	0.521 in
• Valves - Valve Seat Angle	46 degrees	
• 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

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Cylinder Head Expansion Plug	Threadlock	12345382	10953489
Cylinder Head Plug Threads	Threadlock	12345382	10953489
Engine Block Front Oil Gallery Plug	Threadlock	12345382	10953489

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Engine Block Plug Sealing Washers	Sealant	12346004	10953480
Engine Flywheel Bolts	Threadlock	12345382	10953489
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolt Threads	Threadlock	12345493	10953488
Fuel Rail Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket-to-Valve Cover Bolts	Threadlock	12345382	10953489
Ignition Coil-to-Bracket Bolts	Threadlock	12345382	10953489
Intake Manifold Bolts	Threadlock	12345382	10953489
Oil Pan Oil Gallery Plug Threads	Sealant	12346004	10953480
Oil Pan Surface at Front and Rear Covers	Sealant	12378190	-
Oil Pressure Sensor Threads	Sealant	12346004	10953480
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

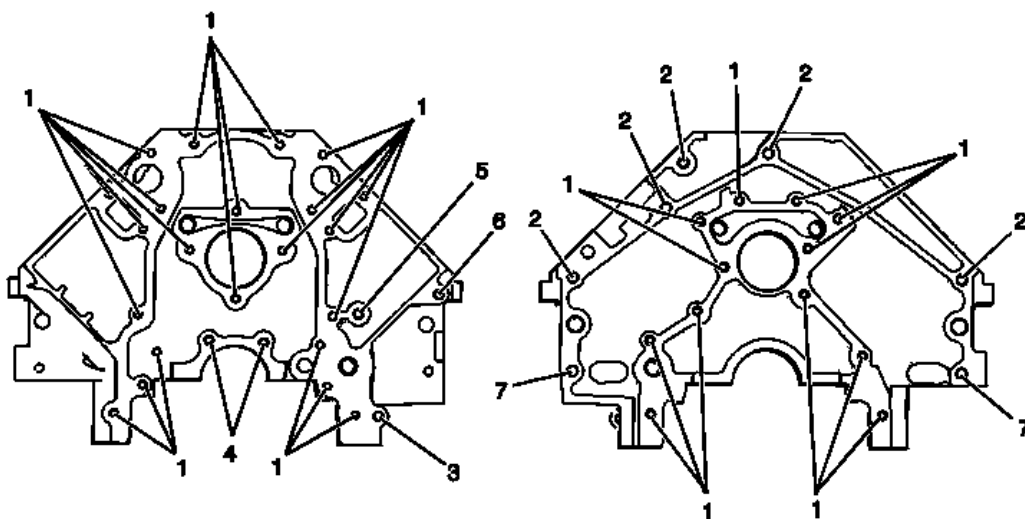


Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front/Rear Views

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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	27.5 (1.08)	22.0 (0.866)
3	M10 x 1.5	215	211	212	213	214	Thru	Thru
4	M8 x 1.25	210	206	207	208	209	Thru	Thru
5	M10 x 1.5	215	211	212	213	214	25.0 (0.984)	19.5 (0.767)
6	M10 x 1.5	215	211	212	213	214	32.5 (1.279)	25.0 (0.984)
7	M10 x 1.5	215	211	212	213	214	Thru	Thru

Bolt hole 6 is drilled and tapped for aluminum block applications only.

Engine Block - Left/Right Side Views

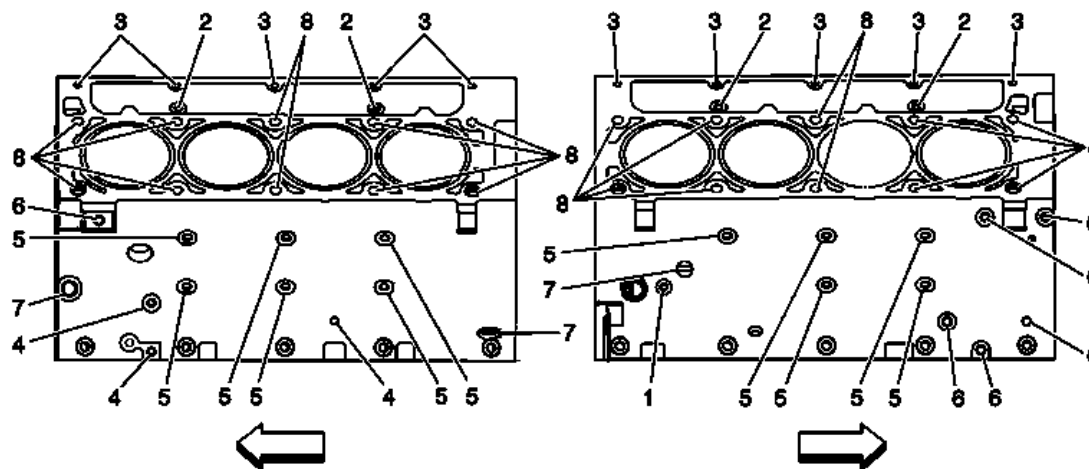


Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS CORP.

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)

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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 1.25	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
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

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

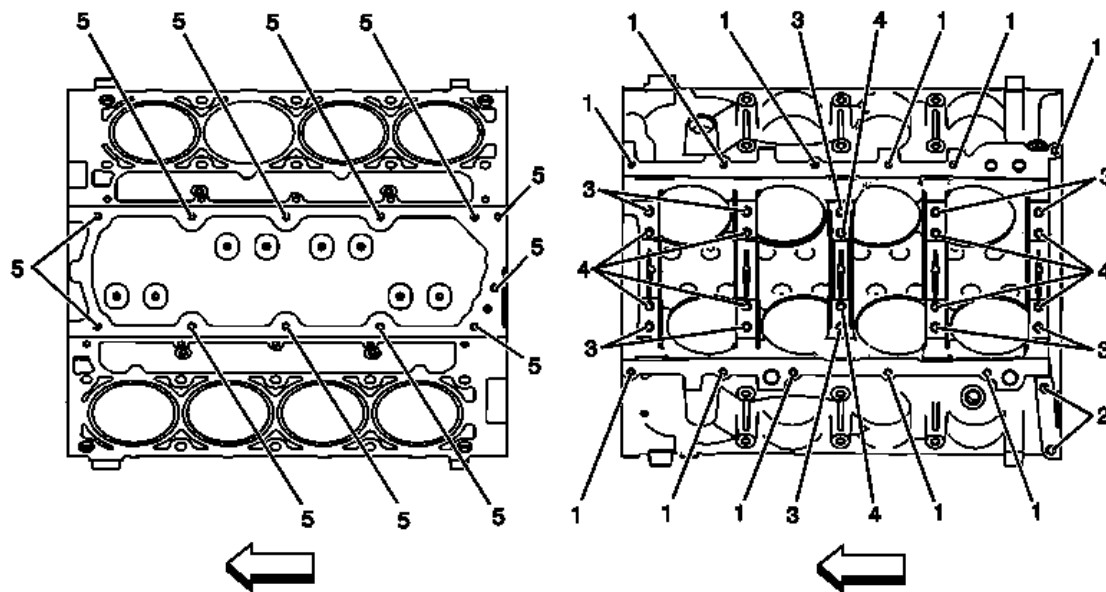


Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top/Bottom 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	22.5 (0.885)	17.5 (0.688)
2	M10 x 1.5	215	211	212	213	214	42.5 (1.67)	37.0 (1.45)
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 2 has an 11.5 mm (0.452 in) counterbore included in the 42.5 mm (1.67 in) drill depth. Use sleeve J 42385-311 with the drill and tap. - 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

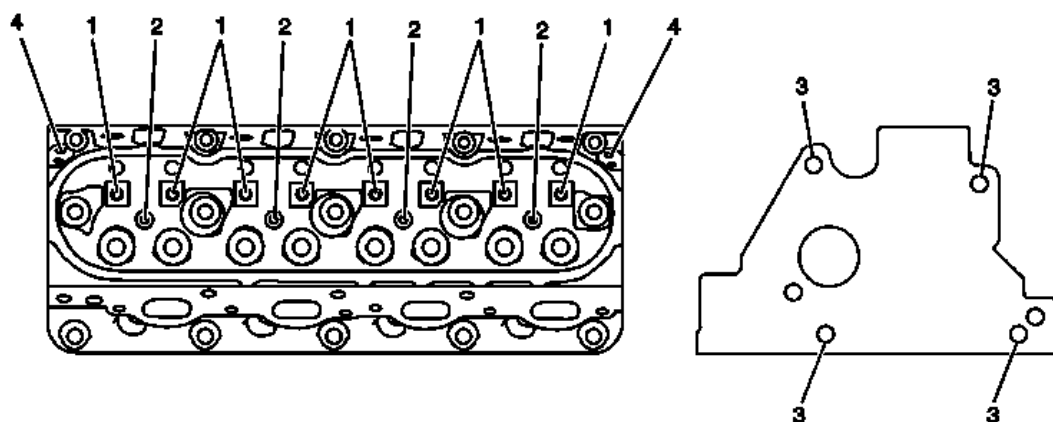


Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top/End Views

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	26.5 (1.04)	19.0 (0.784)
2	M6 x 1.0	205	201	202	203	204	20.05	16.05

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							(0.789)	(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

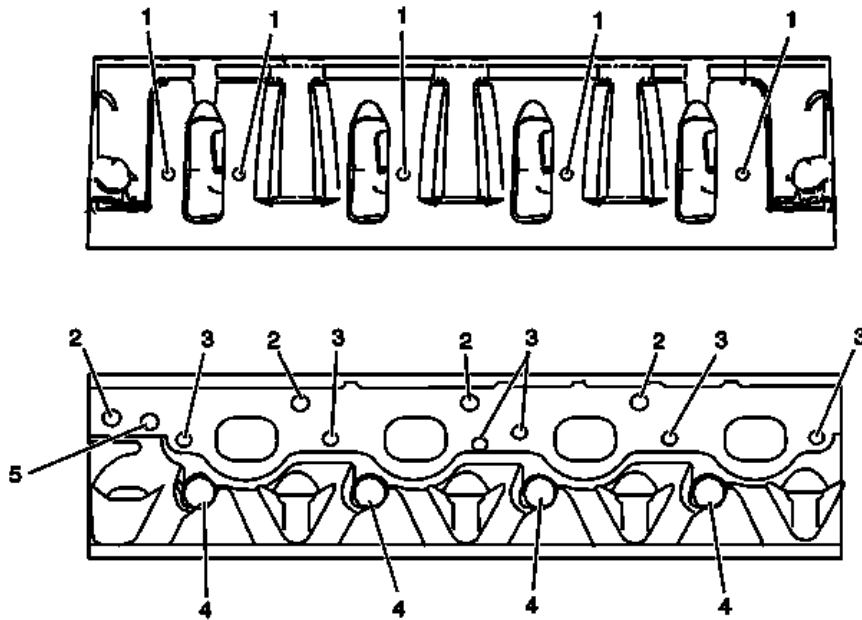


Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake/Exhaust Side Views

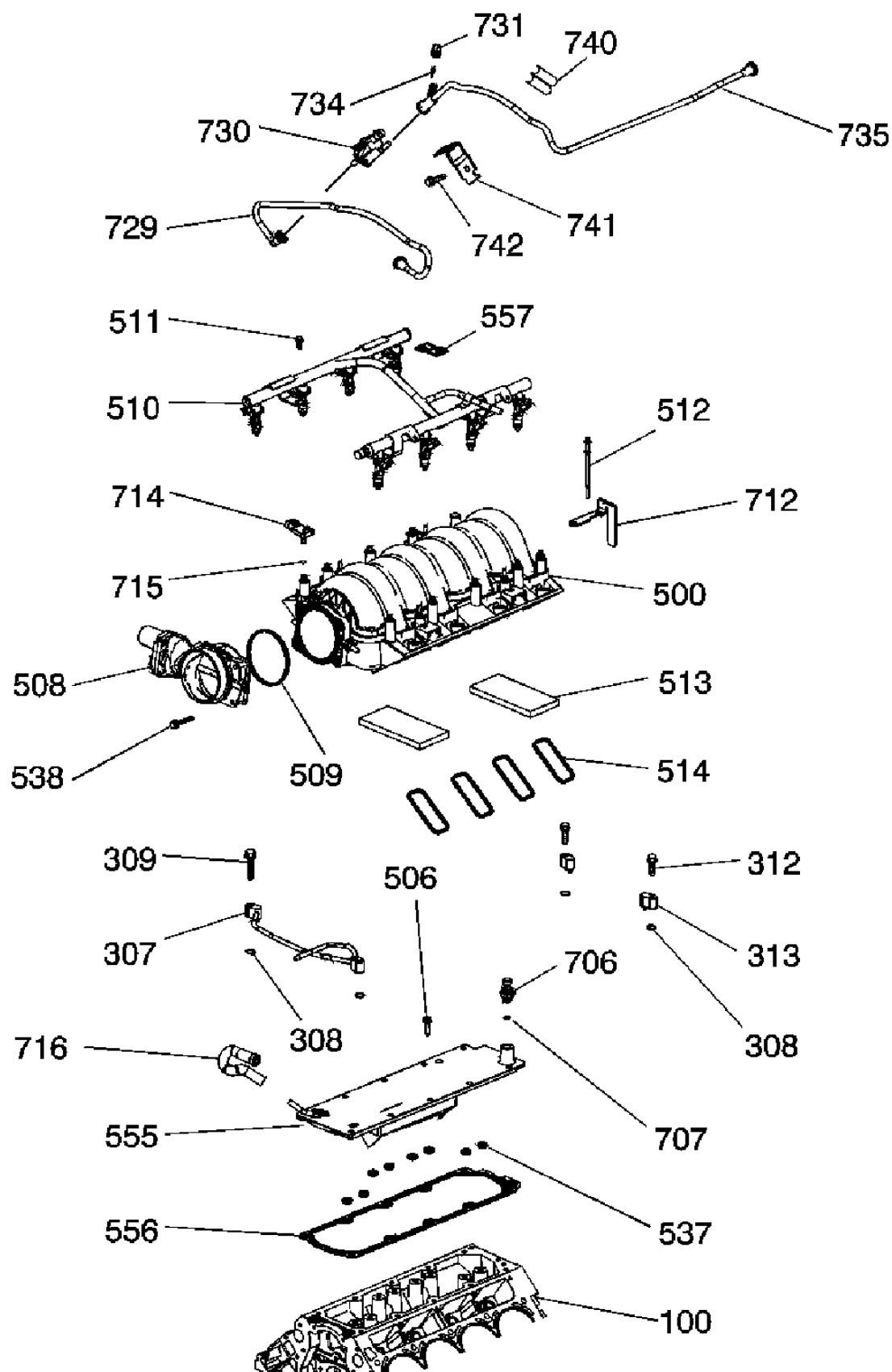
Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M6 x 1.0	205	201	202	203	204	Thru	Thru
2	M10 x 1.5	215	211	212	213	214	28.0 (1.10)	20.0 (0.787)
3	M8 x 1.25	210	206	207	208	209	21.0 (0.826)	16.0 (0.629)
4	M14 x 1.25	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: Intake Manifold/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
307	Engine Coolant Air Bleed Pipe
308	Gasket
308	Gasket
309	Bolt
312	Bolt
313	Engine Coolant Air Bleed Cover
500	Intake Manifold
506	Bolt
508	Throttle Body
509	Gasket
510	Fuel Rail with Injectors
511	Bolt
512	Bolt
513	Insulator
514	Gasket
537	O-Ring
538	Bolt
555	Valley Cover
556	Gasket
706	Oil Pressure Sensor
707	Washer
712	Fuel Rail Stop Bracket
714	Manifold Absolute Pressure (MAP) Sensor
715	O-Ring
716	Positive Crankcase Ventilation (PCV) Hose - Dirty Air
729	Evaporative Emission (EVAP) Canister Purge Tube
730	EVAP Canister Purge Valve
731	Cap
732	O-Ring
734	Service Valve
735	EVAP Canister Purge Tube
740	EVAP Tube Clip
741	EVAP Purge Valve Bracket
742	EVAP Purge Valve Bracket Bolt

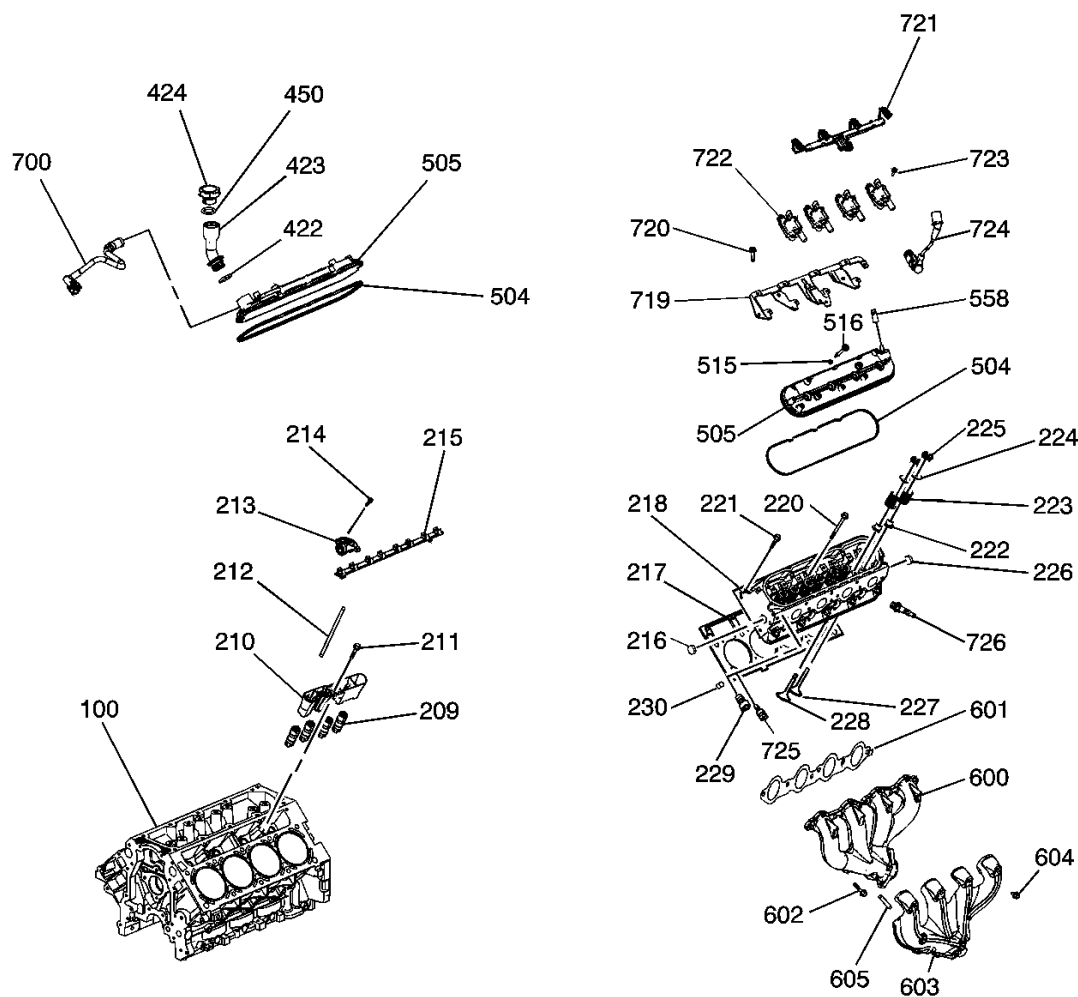


Fig. 7: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
209	Valve Lifter
210	Valve Lifter Guide
211	Bolt
212	Pushrod
213	Rocker Arm
214	Bolt
215	Rocker Arm Pedestal
216	Expansion Plug
217	Gasket
218	Cylinder Head

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220	Bolt - M11
221	Bolt - M8
222	Valve Stem Oil Seal and Shim Assembly
223	Valve Spring
224	Valve Spring Cap
225	Valve Stem Key
226	Expansion Plug
227	Intake Valve
228	Exhaust Valve
229	Cylinder Head 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	Gasket
504	Gasket
505	Valve Cover
505	Valve Cover
515	Valve Cover Bolt Grommet
516	Bolt
558	Plug
600	Exhaust Manifold
601	Gasket
602	Bolt
603	Exhaust Manifold Heat Shield
604	Bolt
605	Stud
700	Positive Crankcase Ventilation (PCV) Hose - Fresh 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
726	Spark Plug

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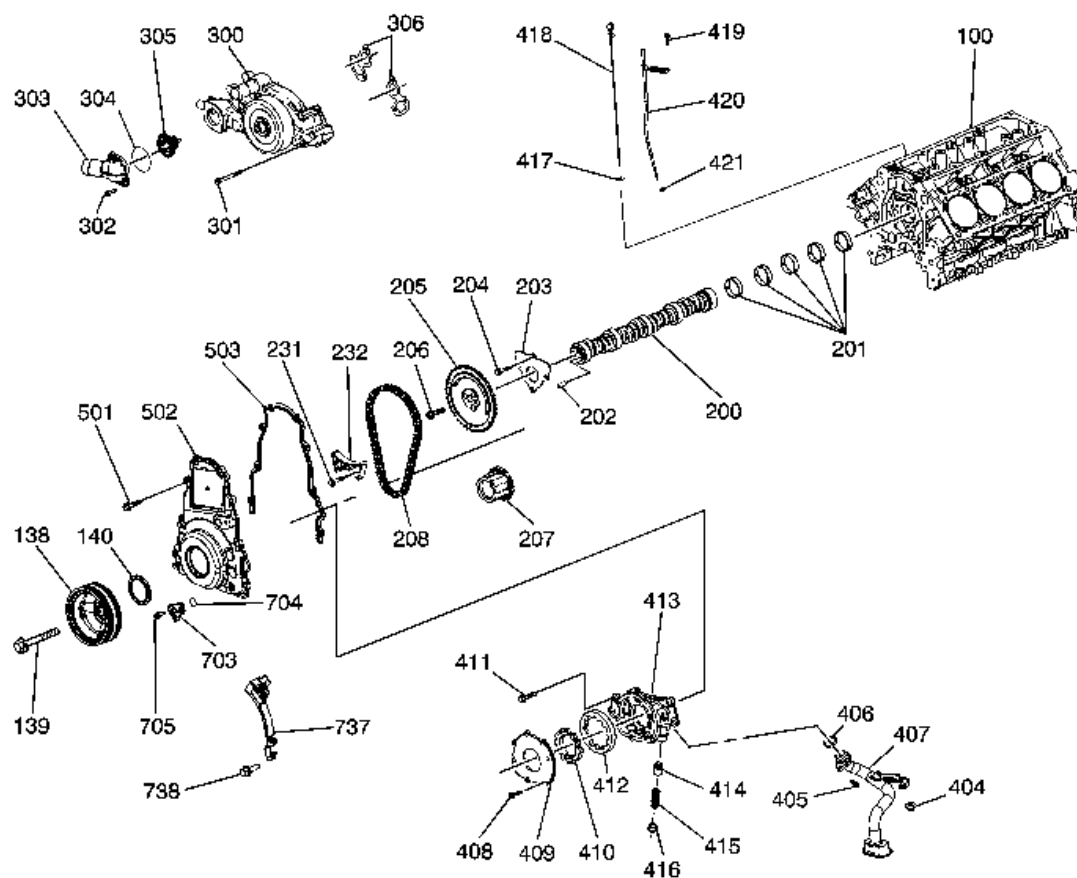


Fig. 8: Front of Engine

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
138	Crankshaft Balancer
139	Bolt
140	Crankshaft Front Oil Seal
200	Camshaft
201	Camshaft Bearings
202	Camshaft Sprocket Locating Pin
203	Camshaft Retainer Plate
204	Bolt
205	Camshaft Sprocket
206	Bolt
207	Crankshaft Sprocket
208	Timing Chain
231	Bolt

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232	Timing Chain Dampener
300	Water Pump
301	Bolt
302	Bolt
303	Water Inlet Housing
304	O-Ring
305	Thermostat
306	Gasket
404	Nut
405	Bolt
406	O-Ring
407	Oil Pump Screen
408	Bolt
409	Oil Pump Cover
410	Drive Gear
411	Bolt
412	Driven Gear
413	Oil Pump Assembly
414	Oil Pressure Relief Valve
415	Oil Pressure Relief Valve Spring
416	Plug
417	O-Ring
418	Oil Level Indicator
419	Bolt
420	Oil Level Indicator Tube
421	O-Ring
501	Bolt
502	Front Cover
503	Gasket
703	Camshaft Position (CMP) Sensor
704	O-Ring
705	Bolt
737	CMP Sensor Wire Harness
738	Bolt

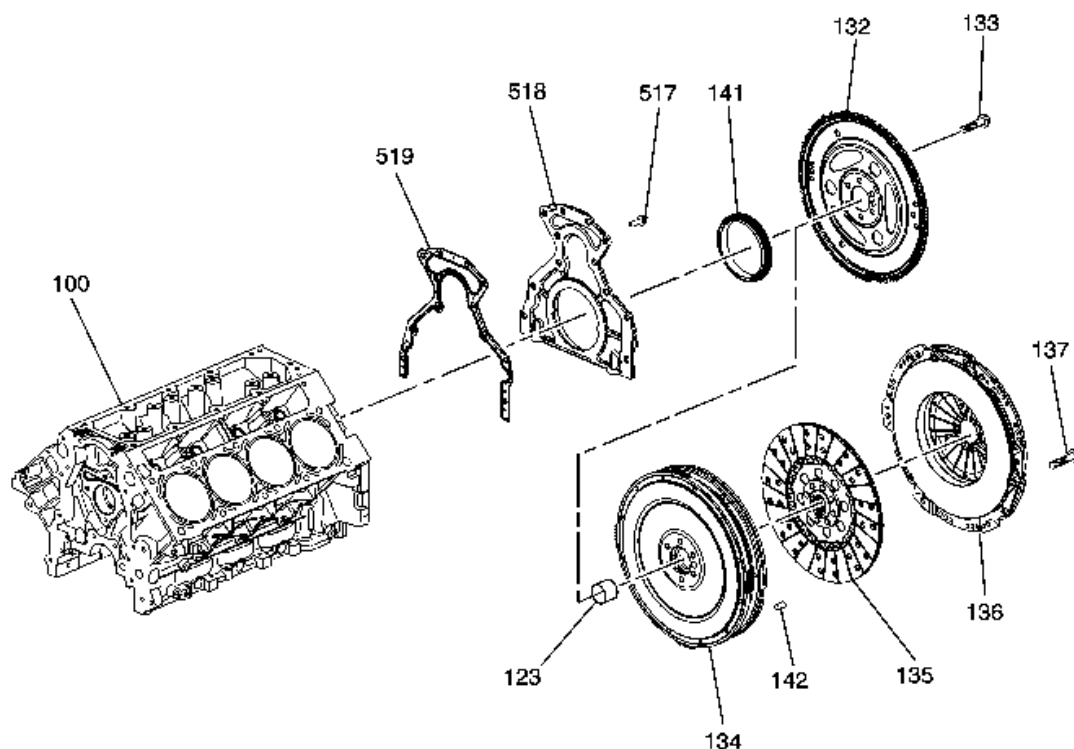


Fig. 9: Rear of Engine

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
123	Bearing - Manual Transmission
132	Flywheel - Automatic Transmission
133	Bolt
134	Flywheel - Manual Transmission
135	Clutch Disc - Manual Transmission
136	Pressure Plate - Manual Transmission
137	Bolt
141	Crankshaft Rear Oil Seal
142	Pressure Plate Locating Pin - Manual Transmission
517	Bolt
518	Rear Housing
519	Gasket

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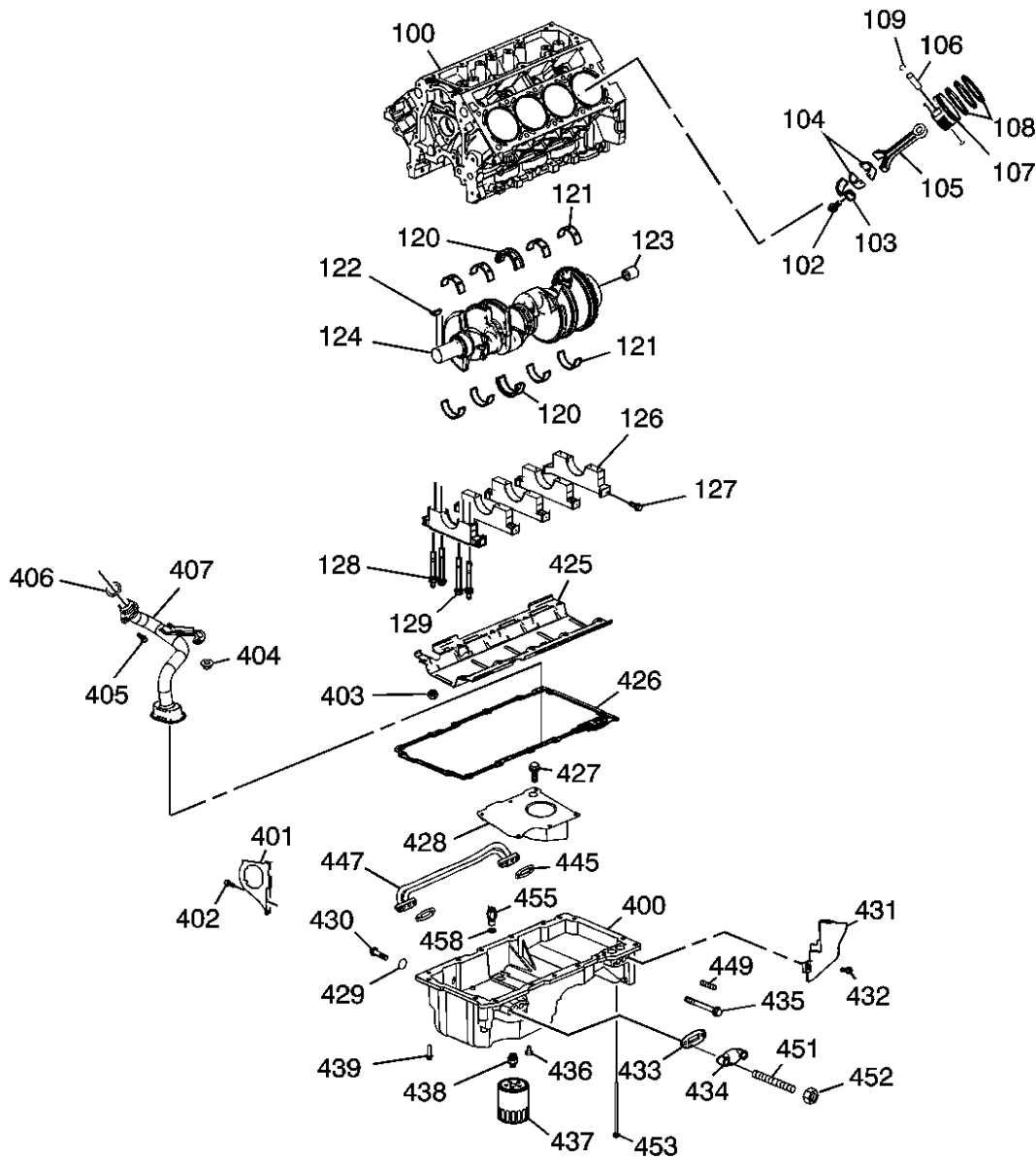


Fig. 10: Lower Engine Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
102	Bolt
103	Connecting Rod Cap
104	Connecting Rod Bearings
105	Connecting Rod

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106	Piston Pin
107	Piston
108	Piston Rings
109	Clip
120	Crankshaft Thrust Bearing
120	Crankshaft Thrust Bearing
121	Crankshaft Main Bearing
121	Crankshaft Main Bearing
122	Crankshaft Sprocket Key
123	Bearing - Manual Transmission
124	Crankshaft
126	Bearing Cap
127	Bolt - M8
128	Stud - M10
129	Bolt - M10
400	Oil Pan
401	Cover - Right
402	Bolt
403	Nut
404	Nut
405	Bolt
406	O-Ring
407	Oil Pump Screen
425	Crankshaft Oil Deflector
426	Gasket
427	Bolt
428	Baffle
429	O-Ring
430	Oil Pan Drain Plug
431	Cover - Left
432	Bolt
433	Gasket
434	Cover
435	Bolt
436	Oil Filter Bypass Valve
437	Oil Filter
438	Oil Filter Fitting
439	Bolt
445	Gasket
447	Oil Filter Tube
449	Plug
...	

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	Stud
452	Nut
453	Bolt

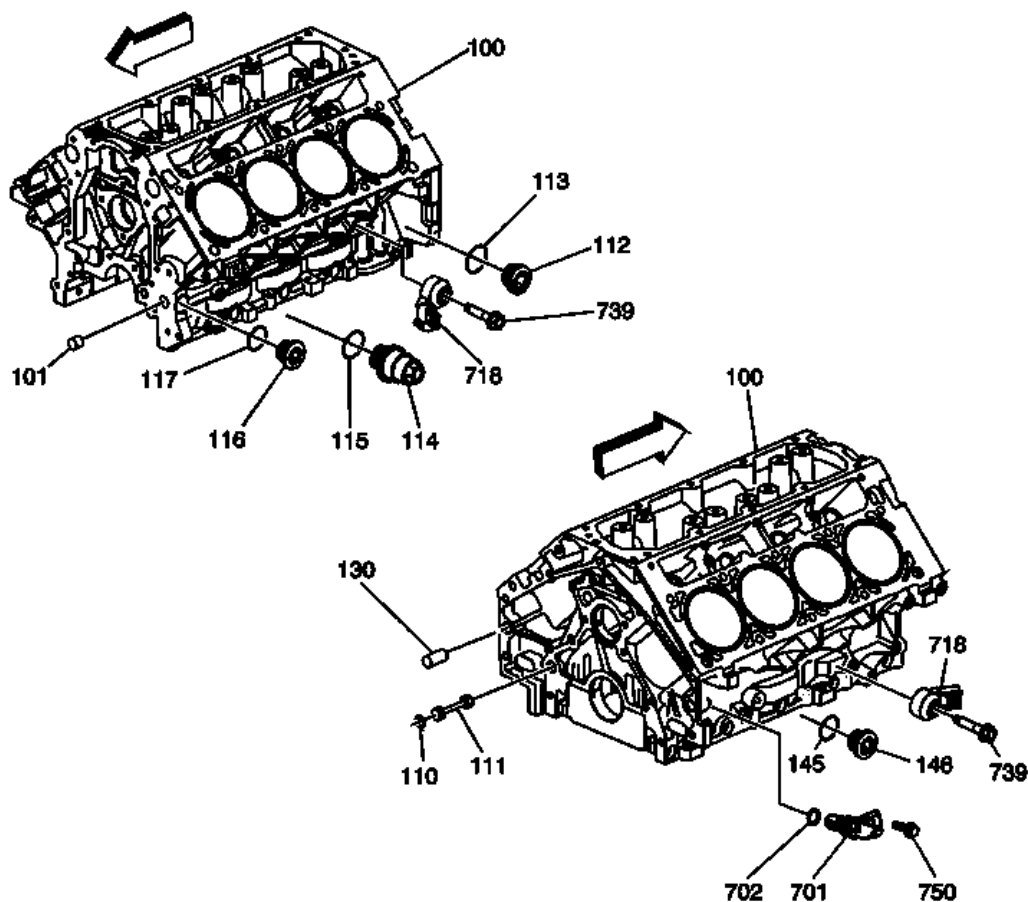


Fig. 11: Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS CORP.

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

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

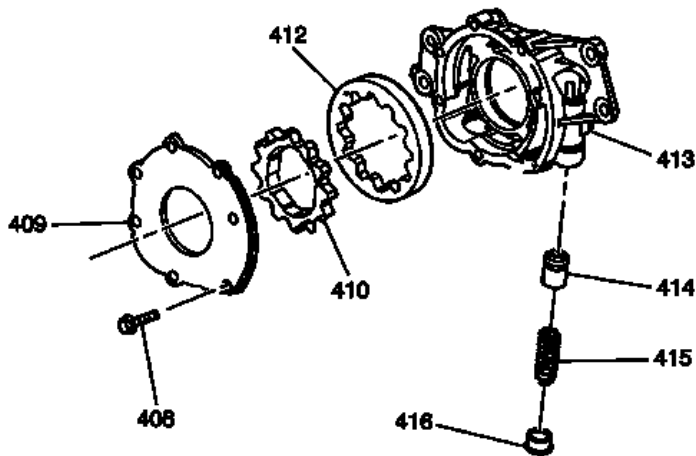


Fig. 12: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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

ENGINE IDENTIFICATION

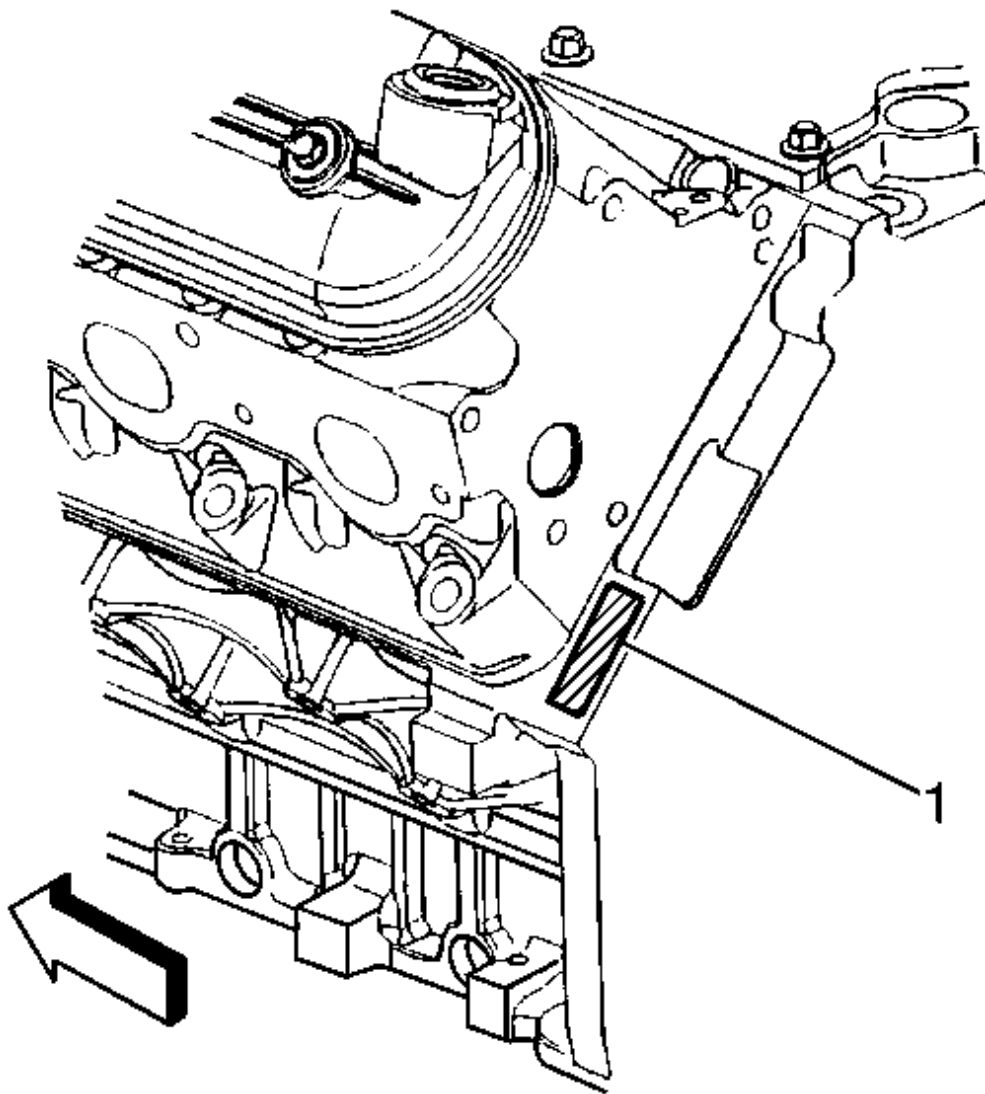


Fig. 13: Locating Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a nine digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.

- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the VIN.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Coolant in Combustion Chamber
- Coolant in Engine Oil
- Engine Compression Test
- Cylinder Leakage Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Drive Belt Chirping Diagnosis
- Drive Belt Squeal Diagnosis
- Drive Belt Whine Diagnosis
- Drive Belt Rumbling Diagnosis
- Drive Belt Vibration Diagnosis
- Drive Belt Falls Off Diagnosis
- Drive Belt Excessive Wear Diagnosis
- Drive Belt Tensioner Diagnosis

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, 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 <u>Drive Belt Replacement - Accessory</u> .
Worn, damaged, or mis-aligned accessory drive	Inspect the components, and repair or replace as

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components or excessive pulley runout - May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
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 arm 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 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 compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to <u>Spark Plug Inspection</u> in Engine Controls - 6.0L. • Inspect the cylinder heads, engine block, and/or head gaskets. Refer to <u>Coolant in Combustion Chamber</u>. • Repair or replace as required.

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Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls - 6.0L. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to identify the cause. Refer to <u>Cylinder Leakage Test</u>. • 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. • 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 P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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 <u>Drive Belt Replacement - Accessory</u>.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual	Inspect the components, repair or replace as required.

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misfire condition.	
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to <u>Engine Flywheel Replacement</u> or <u>Crankshaft Balancer Replacement</u> .
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls - 6.0L. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to determine the cause. Refer to <u>Cylinder Leakage Test</u>. • Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

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

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
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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** in Engine Controls - 6.0L.
- 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

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls - 6.0L. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to <u>Spark Plug Inspection</u> in Engine Controls - 6.0L. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to determine the cause. Refer to <u>Cylinder Leakage Test</u>. • Repair or replace as required.

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

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction
IMPORTANT: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train, upper engine, concern, or a low rumble/knocking may indicate a crankshaft or piston, lower engine concern.	
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.

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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 by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
IMPORTANT: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A light rattle/tapping noise may indicate a valve train, upper engine concern. During certain conditions, the evaporative emission solenoid and the fuel injectors may also create a sound similar to valve train noise.	
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm, bolt, and pedestal. • Repair or replace as required.
Worn or damaged valve rocker arm	• Inspect the rocker arm for wear or missing needle bearings • 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

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	replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
IMPORTANT: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded out during diagnosis. A low rumble/knocking may indicate a crankshaft or piston, lower engine, concern.	
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace damaged components as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	• Inspect the accessory drive system. • Repair or replace as required.

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Loose or damaged crankshaft balancer	- Inspect the crankshaft balancer. - Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to <u>Detonation/Spark Knock</u> in Engine Controls - 6.0L.
Loose torque converter bolts	- Inspect the torque converter bolts and flywheel. - Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	- Inspect the oil pump screen. - Repair or replace as required.
Excessive piston-to-cylinder bore clearance	- Inspect the piston and cylinder bore. - Repair as required.
Excessive piston pin-to-bore clearance	- Inspect the piston, pin, and connecting rod. - 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 repair as required: - The crankshaft bearings - The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	- Verify the pistons, piston pins and connecting rods are installed correctly. Refer to <u>Piston, Connecting Rod, and Bearing Installation</u>. - Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
IMPORTANT: A cold piston knock which disappears in 1.5 minutes should be considered acceptable. A cold engine knock usually disappears when the specific cylinder's secondary ignition circuit is grounded	

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out during diagnosis.**A low rumble/knocking may indicate a crankshaft or piston, lower engine concern.**

Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to <u>Detonation/Spark Knock</u> in Engine Controls - 6.0L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel - automatic transmission	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

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

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flywheel bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.

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Broken timing chain	• Inspect the timing chain and gears. • Repair or replace the components as required.
Seized timing chain or timing gears	• Inspect the timing chain and gears for foreign material or a seized chain. • Repair or replace the components as required.
Seized or broken camshaft	• Inspect the camshaft and the camshaft bearings. • Repair or replace the components as required.
Bent valve in the cylinder head	• Inspect the valves and the cylinder heads. • Repair or replace the components as required.
Seized oil pump	• Inspect the oil pump assembly. • 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 <u>Coolant in Combustion Chamber</u>. 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 • Piston material • Foreign material	• Inspect the cylinder for damaged components and/or foreign materials. • Repair or replace the components as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair or replace the components as required.
Bent or broken connecting rod	• Inspect the connecting rods. • Replace the piston and pin as an assembly, as required.
Broken crankshaft	• Inspect the crankshaft. • Repair or replace the components as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

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

COOLANT IN ENGINE OIL**Coolant in Engine Oil**

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

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

ENGINE COMPRESSION TEST

1. 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 four compression strokes, four puffs.
8. Check 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. Check the compression again and record the reading.
10. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1\ 035 \times 70\% = 725$) ($150 \times 70\% = 105$).
 - 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 two 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 LEAKAGE TEST

Tools Required

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

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

Test Procedure

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

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs.
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. See Special Tools.

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

Oil Consumption Diagnosis

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or more of engine oil within 3 200 kilometers (2,000 miles).	
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to <u>Oil Leak Diagnosis</u>. • 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 check 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

- **J 21867** Pressure Gage

- **J 42907** Oil Pressure Testing Tool. See **Special Tools**.

Test Procedure

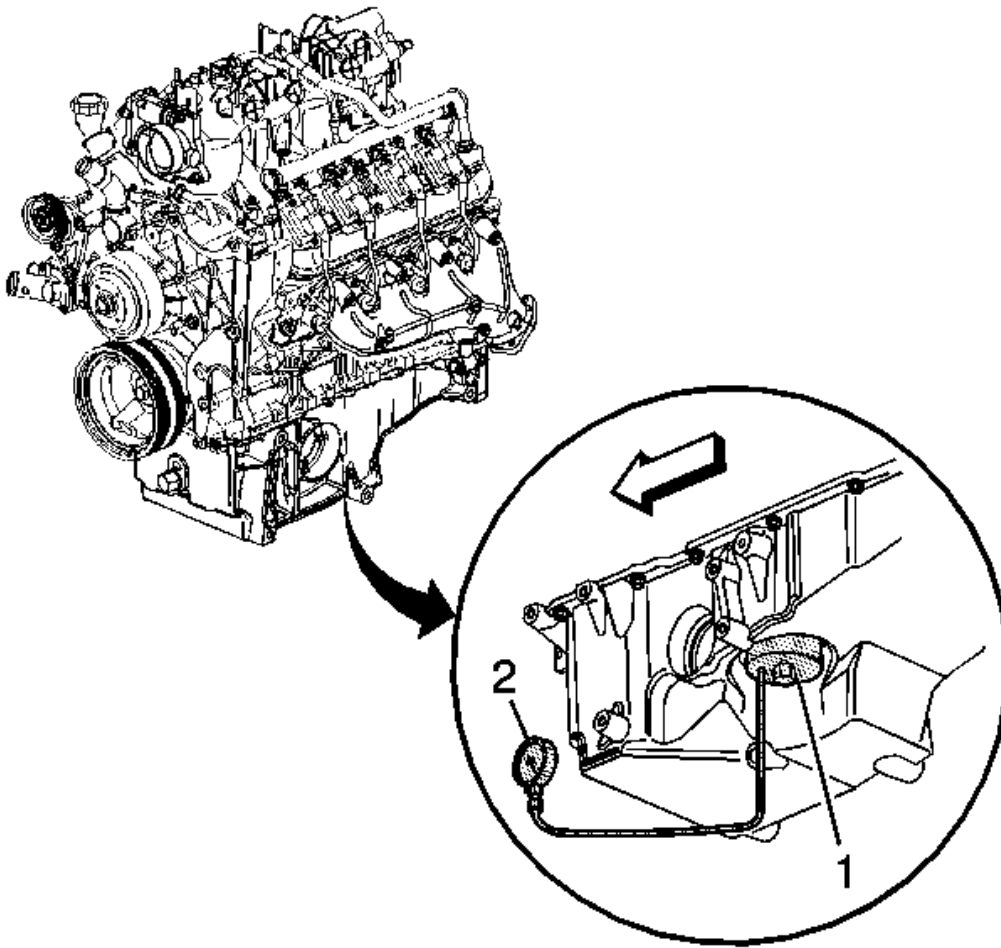


Fig. 14: View Of J 21867 & J 42907
Courtesy of GENERAL MOTORS CORP.

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.
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 anti freeze
 - Foamy oil
6. Remove the oil filter and install the **J 42907** . See Special Tools.
7. Install **J 21867** or equivalent to the **J 42907** .
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 one 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, Pump Screen and Deflector Installation.

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Oil filter loose or a leaking or damaged gasket
- 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.

- Broken valve lifters

Repair as necessary.

11. If the oil pressure reading on the **J 21867** or equivalent is within specifications, inspect for the following conditions:

- Plugged or incorrect oil filter and/or malfunctioning oil filter bypass valve
- Malfunctioning oil pressure gage or sensor

Repair as necessary.

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Step	Action	Yes	No

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IMPORTANT:

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

1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces		

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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	Go to Step 6
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate 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. See Special Tools. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components		

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	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to Step 1	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS**Crankcase Ventilation System Inspection/Diagnosis**

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

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	• Plugged PCV • Plugged or kinked PCV hose(s) • Leaking (damaged) PCV or hose(s)
Stalling or slow idle speed	Inspect for any of the following conditions: • Plugged PCV • Plugged or kinked PCV hose(s) • Leaking (damaged) PCV or hose(s)
High idle speed	Inspect for a leaking (damaged) PCV or hose(s)
Sludge in the engine	Inspect for any of the following conditions: • Plugged PCV • Plugged or kinked PCV hose(s)

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The chirping noise may be intermittent due to moisture on the drive belts or the accessory drive pulleys. In order to duplicate the customer concern, It may be necessary to spray a small amount of water onto the drive belts. If spraying water on the drive belts duplicates the symptom, cleaning the accessory drive pulleys may be the most probable solution.

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

Test Description

The numbers below refer to the steps in the diagnostic table.

2: The chirping 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 in this table.

3: The noise may be an internal engine noise. Remove the drive belts and operate the engine for a few seconds, this will verify if the chirping noise is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: Inspect the drive belts for signs of pilling. Pilling is the small balls, pills, or strings in the drive belt grooves caused by the accumulation of rubber dust.

6: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of an accessory drive component, or the pulley may be 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 removal and installation procedure for that pulley.

10: Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer

was installed.

12: Inspection the accessory drive pulleys should include inspecting for bends, dents or other damage to the pulleys that would prevent the drive belts from seating properly in the pulley grooves or on the smooth surface of a pulley when the back side of the drive belt is used to drive the pulley.

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belts or an accessory drive pulley. • Chirping may occur on cold damp startup conditions and will subside once the vehicle reaches normal operating temperature.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . 2. Operate the engine for no longer than 30-40 seconds. Does the chirping noise still exist?	Go to <u>Engine Noise on Start-Up, but Only Lasting a Few Seconds, Upper Engine Noise, Regardless of Engine Speed, or Lower Engine Noise, Regardless of Engine Speed</u>	Go to Step 4
4	Inspect for severe drive belt pilling exceeding 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the accessory drive pulleys with a suitable wire brush. Were the accessory drive pulleys cleaned?	Go to Step 14	-
6	Inspect for a misaligned accessory drive pulleys. Is there a misaligned accessory drive pulleys?	Go to Step 7	Go to Step 8
7	Replace and/or repair the misaligned accessory drive pulleys. Were the misaligned accessory drive pulleys replaced and/or repaired?	Go to Step 15	-
8	Inspect for a bent or cracked accessory drive brackets. Did you find any bent or cracked accessory drive		

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	brackets?	Go to Step 9	Go to Step 10
9	Replace the bent and/or cracked accessory drive brackets. Was the bent and/or cracked accessory drive brackets replaced?	Go to Step 15	-
10	Inspect for incorrect, loose, and/or missing fasteners. Were there any incorrect, loose, and/or missing fasteners found?	Go to Step 11	Go to Step 12
11	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . Were the fasteners replaced and/or tightened?	Go to Step 15	-
12	Inspect for a bent accessory drive pulleys. Was a bent accessory drive pulleys found?	Go to Step 13	Go to Step 14
13	Replace the bent accessory drive pulleys. Was the bent accessory drive pulleys replaced?	Go to Step 15	-
14	Replace the drive belts. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . Was the drive belts replaced?	Go to Step 15	-
15	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the chirping noise still exist?	Go to Step 3	System OK

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

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

If the noise is intermittent, verify that the accessory drive components by varying their loads, making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The numbers below refer to the steps in the diagnostic table.

2: The squeal 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 in this table.

3: The noise may be an internal engine noise. Remove the drive belts and operate the engine for a few seconds, this will verify if the squealing noise is related to the drive belts or an accessory drive component. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: This test is to verify that an accessory drive components does not have a seized bearing. With the belts removed, test the bearings in the accessory drive components for smooth operation. Also test the accessory drive components with the engine operating by varying the load on the accessory drive components to verify that the components is operating properly.

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

6: This test is to verify that the drive belts is not too long, which would prevent the drive belts tensioners from operating properly. Also if the incorrect length drive belts was installed, it may not be routed correctly and may be turning an accessory drive component in the incorrect direction.

7: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley is 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 removal and installation procedure for that pulley.

8: Inspect the accessory drive pulleys to verify that they are the correct diameter or width. Using a known good vehicle, compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belts; this is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belts, such as an air conditioning (A/C) compressor engagement, snapping the throttle, or slipping on a seized pulley, or a faulty accessory drive component.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a squealing noise. Does the engine make the squeal noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belts. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . 2. Operate the engine for no longer than 30-40 seconds.	Go to Engine Noise on Start-Up, but Only Lasting a Few Seconds, Upper Engine Noise, Regardless	

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	Does the squealing noise still exist?	<u>of Engine Speed, or Lower Engine Noise, Regardless of Engine Speed</u>	Go to Step 4
4	Inspect for a seized accessory drive component bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to Step 9	Go to Step 5
5	Inspect the drive belt tensioner for proper operation. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Did you find and correct the condition?	Go to Step 9	Go to Step 6
6	Check for the correct length drive belt. Did you find and correct the condition?	Go to Step 9	Go to Step 7
7	Inspect for misaligned pulley. Did you find and correct the condition?	Go to Step 9	Go to Step 8
8	Inspect for an incorrect size pulley. Did you find and correct the condition?	Go to Step 9	-
9	1. Install the drive belts. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . 2. Clear any codes. 3. Run the engine in order to verify the repair. Does the squealing noise still exist?	-	System OK

DRIVE BELT WHINE DIAGNOSIS**Diagnostic Aids**

The drive belts will not cause the whine.

If the whine is intermittent, verify that it is not the accessory drive components by varying their loads, making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The numbers below refer to the steps in the diagnostic table.

3: This test is to verify that the whine is being caused by the accessory drive components. Remove the drive belts and operate the engine for a few second, this will verify if the whining noise is related to the accessory drive component. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belts may have to be installed and the accessory drive components operated separately by

varying their loads. Refer to the suspected accessory drive component for the proper removal and installation procedure.

Drive Belt Whine Diagnosis

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

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

The drive belts may have a condition that can not be seen or felt. Sometimes replacing the drive belts may be

the only repair for the symptom.

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

Test Description

The numbers below refer to the steps in the diagnostic table.

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

3: This test is to verify that the drive belts is causing the rumbling. Rumbling 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. Operate the engine for a few seconds, this will verify if the rumbling noise is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

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

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

Drive Belt Rumbling Diagnosis

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

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3	<u>Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning.</u> 2. Operate the engine for no longer than 30-40 seconds. Does the rumbling noise still exist?	<u>on Start-Up, but Only Lasting a Few Seconds, Upper Engine Noise, Regardless of Engine Speed, or Lower Engine Noise, Regardless of Engine Speed</u>	Go to Step 4
4	Inspect the drive belts for damage, separation, or sections of missing ribs. Were any of these conditions found?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning.</u> Did you complete the repair?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning.</u> Did you complete the replacement?	Go to Step 8	-
8	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the rumbling noise still exist?	-	System OK

DRIVE BELT VIBRATION DIAGNOSIS**Diagnostic Aids**

The accessory drive components may have an affect on engine vibration. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or an extra load placed on the generator are suggested items to inspect. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The numbers below refer to the steps in the diagnostic table.

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

3: This test is to verify that the drive belts or accessory drive components may be causing the vibration. Remove the drive belts and operate the engine for a few seconds, this will verify if the vibration is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

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

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

8: This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smooth operation. Inspect for a bent fan shaft or a bent mounting flange.

9: Inspect the water pump drive shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known, good water pump.

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belts. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . 2. Operate the engine for no longer than 30-40 seconds. Does the engine still make the vibration?	Go to <u>Vibration Analysis - Engine</u> in Vibration Diagnosis and Correction	Go to Step 4
4	Inspect the drive belts for wear, damage, debris build-up and missing drive belt ribs. Were any of these conditions found?	Go to Step 5	Go to Step 6
5	Install a new drive belt. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> .		

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	Did you complete the replacement?	Go to Step 11	-
6	Inspect for incorrect, loose or missing fasteners. Were any of these conditions found?	Go to Step 7	Go to Step 8
7	1. Replace the incorrect or missing fasteners. 2. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . Were the fasteners replaced and/or tightened?	Go to Step 11	-
8	Inspect for damaged fan blades or a bent fan clutch shaft. Did you find and correct the condition?	Go to Step 11	Go to Step 9
9	Inspect for a bent water pump drive shaft. Did you find and correct the condition?	Go to Step 11	Go to Step 10
10	Inspect for a bent or cracked accessory drive brackets. Did you find and correct the condition?	Go to Step 11	-
11	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the vibration still exist?	-	System OK

DRIVE BELT FALLS OFF DIAGNOSIS**Diagnostic Aids**

If the drive belts repeatedly fall off the accessory drive pulleys, this may be caused by pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may also cause the drive belts to fall off. Verify that the accessory drive components are operating properly.

If the drive belts are the incorrect length, the drive belt tensioners may not maintain the proper tension on the drive belts.

Test Description

The numbers below refer to the steps in the diagnostic table.

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

4: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of an accessory drive component, or the pulley may be 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 removal

and installation procedure of that pulley.

5: Inspection of the accessory drive pulleys should include inspecting for bends, dents or other damage that would prevent the drive belt from seating properly in the pulley grooves or on the smooth surface of a pulley when the back side of the drive belts are used to drive the pulley.

6: Accessory drive component brackets that are bent or cracked will also cause the drive belts to fall off.

7: Inspection of the fasteners can eliminate the possibility that an incorrect bolt, nut, spacer, or washer was installed. Missing, loose, or incorrect fasteners may cause pulley misalignment from the accessory drive brackets moving under load. Overtightening the fasteners may cause misalignment of the accessory component brackets.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices.			
DEFINITION: The drive belts fall off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Inspect for a damaged drive belt. Was a damaged drive belt found?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Do the drive belts continue to fall off?	Go to Step 4	System OK
4	Inspect for a misaligned accessory drive pulley. Did you find and correct the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented accessory drive pulley. Did you find and correct the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked accessory drive bracket. Did you find and correct the condition?	Go to Step 12	Go to Step 7
7	Inspect for incorrect, loose or missing fasteners. Were there any incorrect, loose and/or missing fasteners?	Go to Step 8	Go to Step 9
8	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for correction operation. Refer to Drive Belt Tensioner		

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	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 Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for a failed drive belt idler and drive belt tensioner pulley bearing. Did you find and repair the condition?	Go to Step 12	-
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	-	System OK

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

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

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

4: This inspection is to verify the drive belts 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 belts should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: Refer to Belt Dressing Notice in Cautions and Notices .			
DEFINITION: Wear at the outside ribs of the drive belts due to an incorrectly installed drive belts			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform		Go to Symptoms -

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	the necessary inspections?	Go to Step 2	Engine Mechanical
2	Inspect the drive belts for the proper installation. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . Did you find this condition?	Go to Step 5	Go to Step 3
3	Inspect for the proper drive belt. Did you find this condition?	Go to Step 5	Go to Step 4
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 6	Go to Diagnostic Aids
5	Replace the drive belt. Refer to <u>Drive Belt Replacement - Accessory</u> or <u>Drive Belt Replacement - Air Conditioning</u> . Did you complete the replacement?	Go to Step 6	-
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	-	System OK

DRIVE BELT TENSIONER DIAGNOSIS

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

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

1. Remove the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**.
2. Position a hex-head socket on the belt tensioner pulley bolt.
3. Move the belt tensioner through its full travel.
 - The movement should feel smooth.
 - There should be no binding.
 - The belt tensioner should return freely.
4. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** or **Drive Belt Tensioner Replacement - Air Conditioning**.
5. Install the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**.

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement - Accessory

Removal Procedure

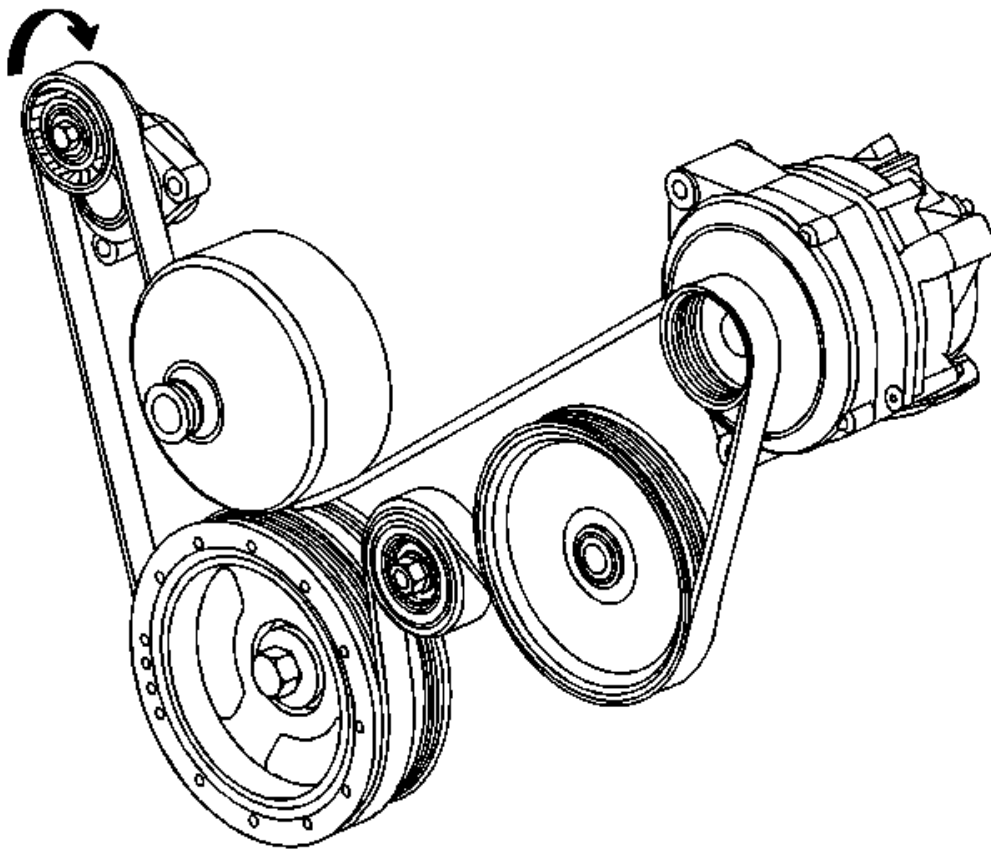


Fig. 15: View Of Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the air intake duct, if necessary. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 6.0L.
2. Install the appropriate tool to the drive belt tensioner bolt.
3. Using the appropriate tool, rotate the drive belt tensioner clockwise to relieve the tension on the accessory drive belt.
4. Remove the accessory drive belt from the pulleys and tensioner.
5. Slowly release tension on the drive belt tensioner.
6. Remove the breaker bar and socket from the drive belt tensioner bolt.
7. Clean and inspect the drive belt surfaces of all the pulleys.

Installation Procedure

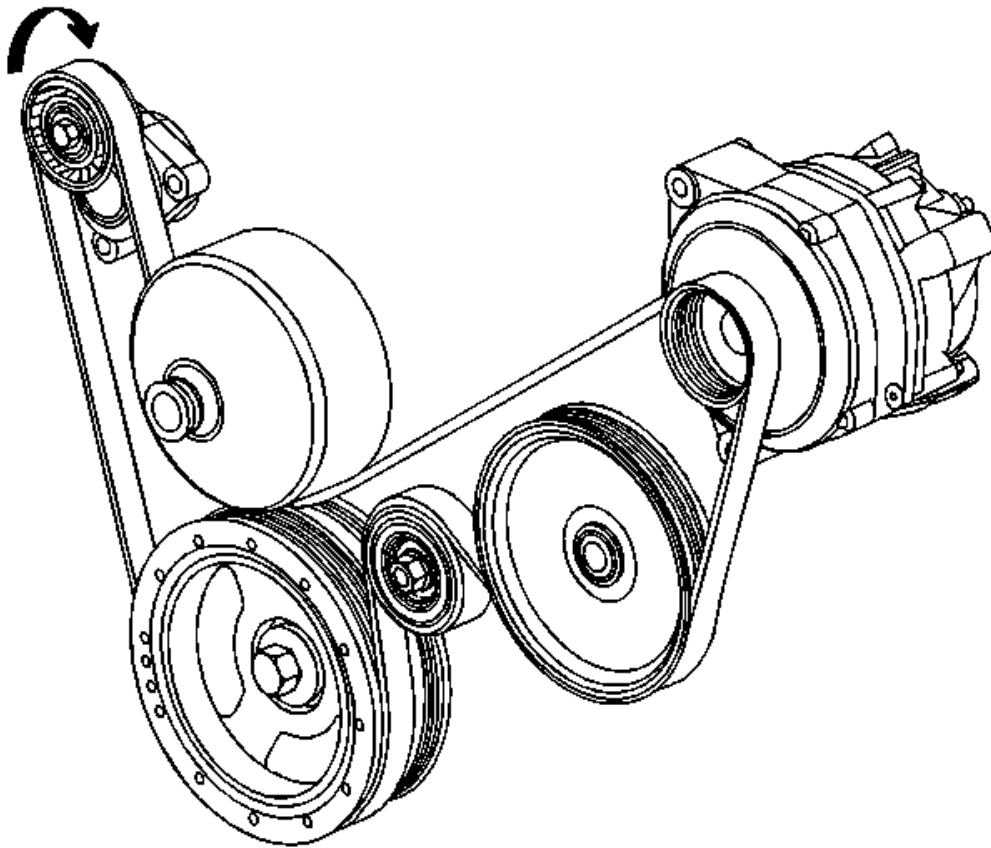


Fig. 16: View Of Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Route the accessory drive belt around all the pulleys except the water pump pulley and tensioner.
2. Install the appropriate tool to the drive belt tensioner.
3. Using the appropriate tool, rotate the drive belt tensioner clockwise to relieve tension on the drive belt tensioner.
4. Install the accessory drive belt under the water pump pulley.
5. Install the accessory drive belt onto the drive belt tensioner.
6. Slowly release the tension.
7. Remove the tool from the drive belt tensioner.
8. Install the air intake duct, if necessary. Refer to **Air Cleaner Assembly Replacement** in Engine Controls - 6.0L.
9. Inspect the accessory drive belt for correct alignment.

Drive Belt Replacement - Air Conditioning

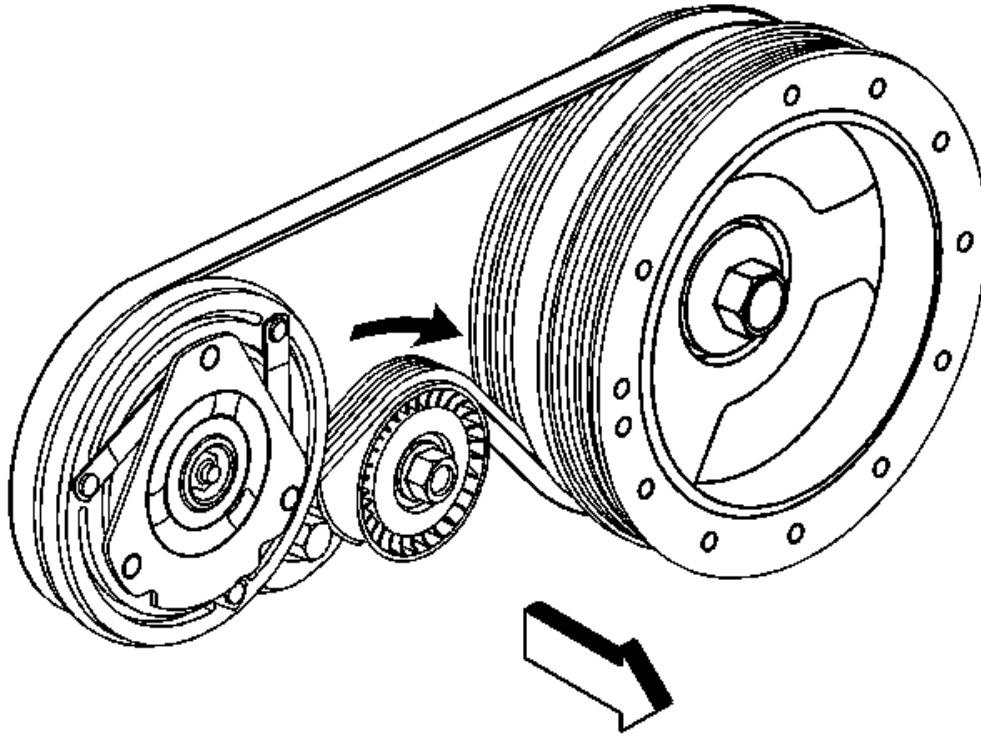
Removal Procedure

Fig. 17: A/C Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Using the appropriate tool, rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
4. Remove the A/C belt from the pulleys.
5. Slowly release the tension on the A/C belt tensioner.
6. Remove the wrench and or socket from the A/C belt tensioner.
7. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

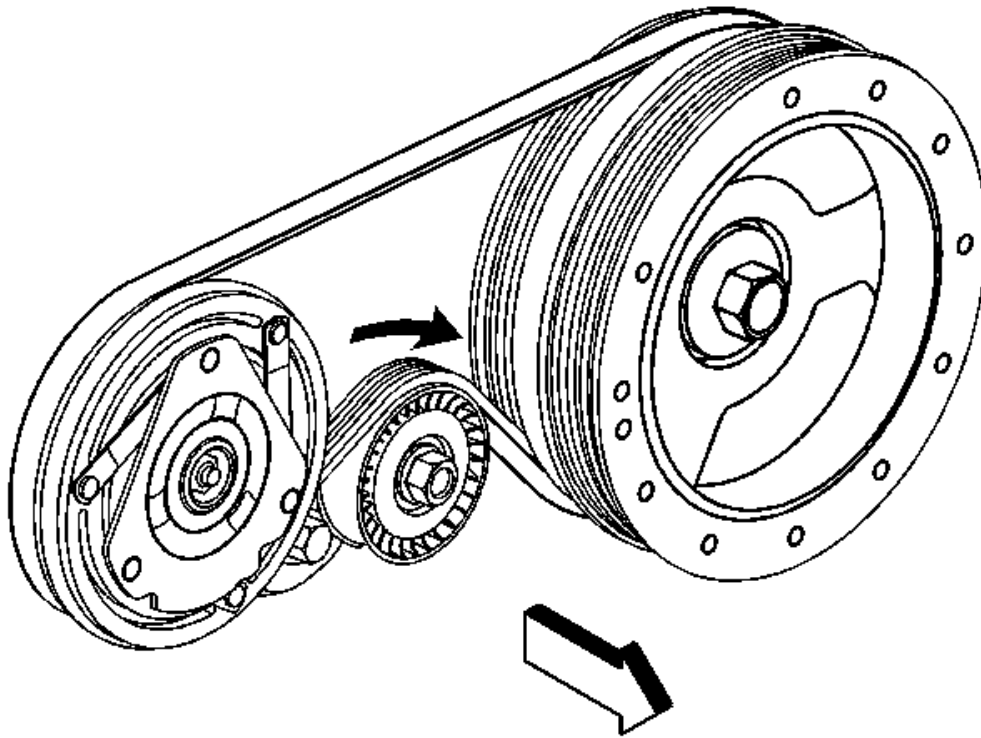


Fig. 18: A/C Drive Belt Routing
 Courtesy of GENERAL MOTORS CORP.

1. Install the A/C belt around the crankshaft balancer.
2. Using the appropriate wrench or socket, rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
4. Install the A/C belt over the idler pulley.
5. Install the A/C belt around the A/C compressor pulley.
6. Slowly release the tension on the A/C belt tensioner.
7. Remove the appropriate tool from the A/C belt tensioner.
8. Inspect the A/C belt for proper installation and alignment.
9. Lower the vehicle.
10. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.

Drive Belt Idler Pulley Replacement

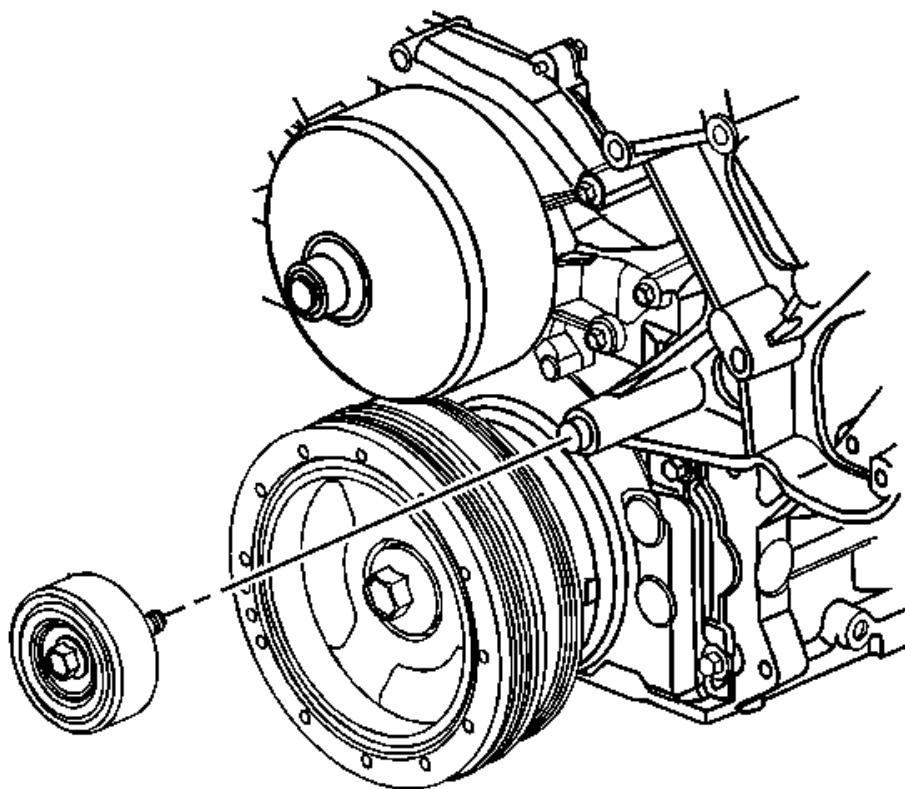
Removal Procedure

Fig. 19: Locating Accessory Drive Belt Idler Pulley & Bolt
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

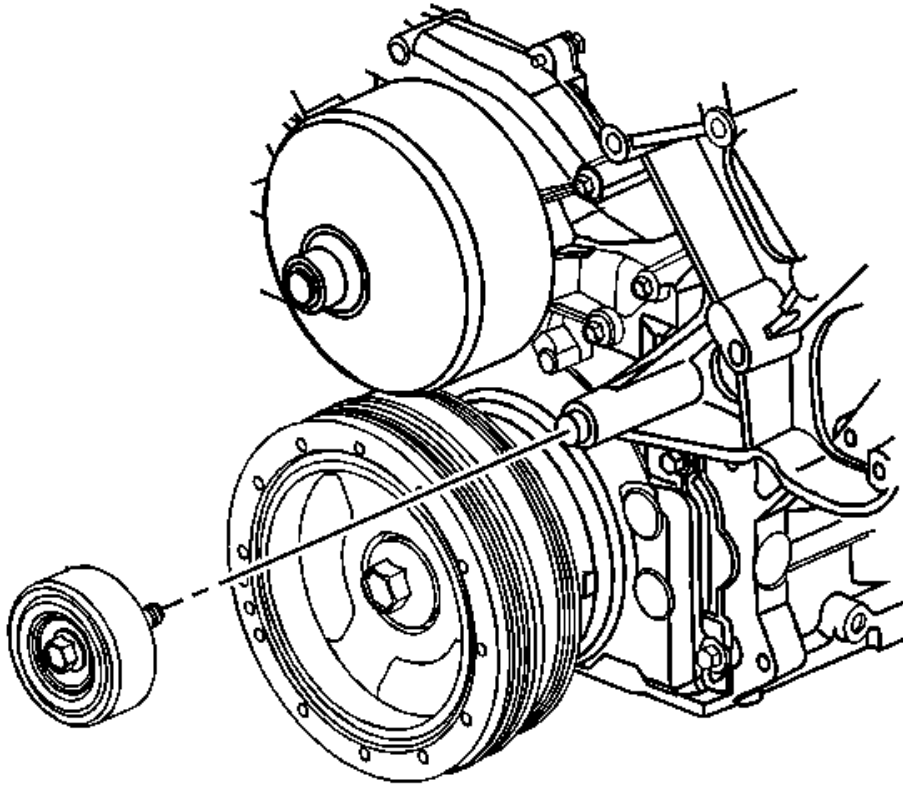


Fig. 20: Locating Accessory Drive Belt Idler Pulley & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt idler pulley on generator mounting bracket.
2. Hand tighten the drive belt idler pulley mounting bolt.

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

3. Tighten the drive belt idler pulley bolt.

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

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

Drive Belt Tensioner Replacement - Accessory

Removal Procedure

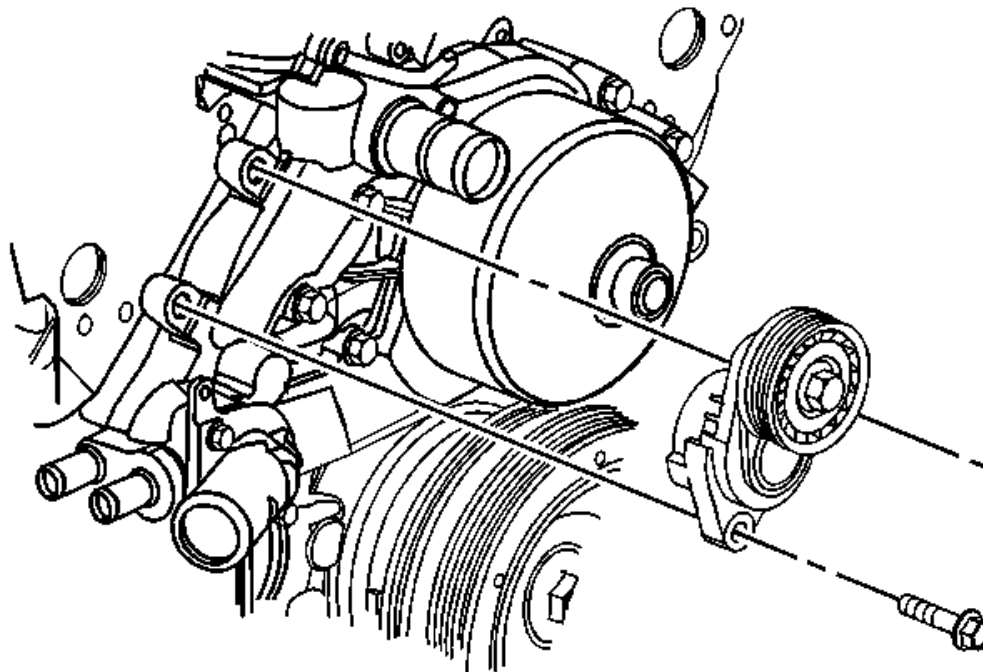


Fig. 21: Identifying Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Remove the accessory drive belt tensioner bolts.
3. Remove the accessory drive belt tensioner.

Installation Procedure

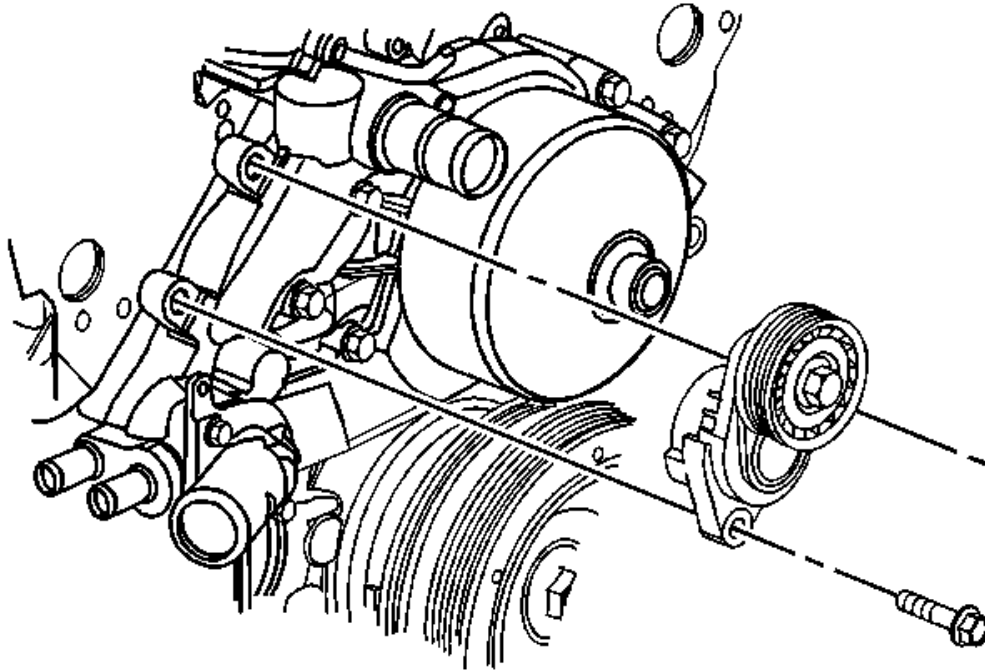


Fig. 22: Identifying Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the accessory drive belt tensioner.

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

2. Install the accessory drive belt tensioner bolts.

Tighten: Tighten the accessory drive belt tensioner bolts to 50 N.m (37 lb ft) starting with the lower bolt first.

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

Drive Belt Tensioner Replacement - Air Conditioning

Removal Procedure

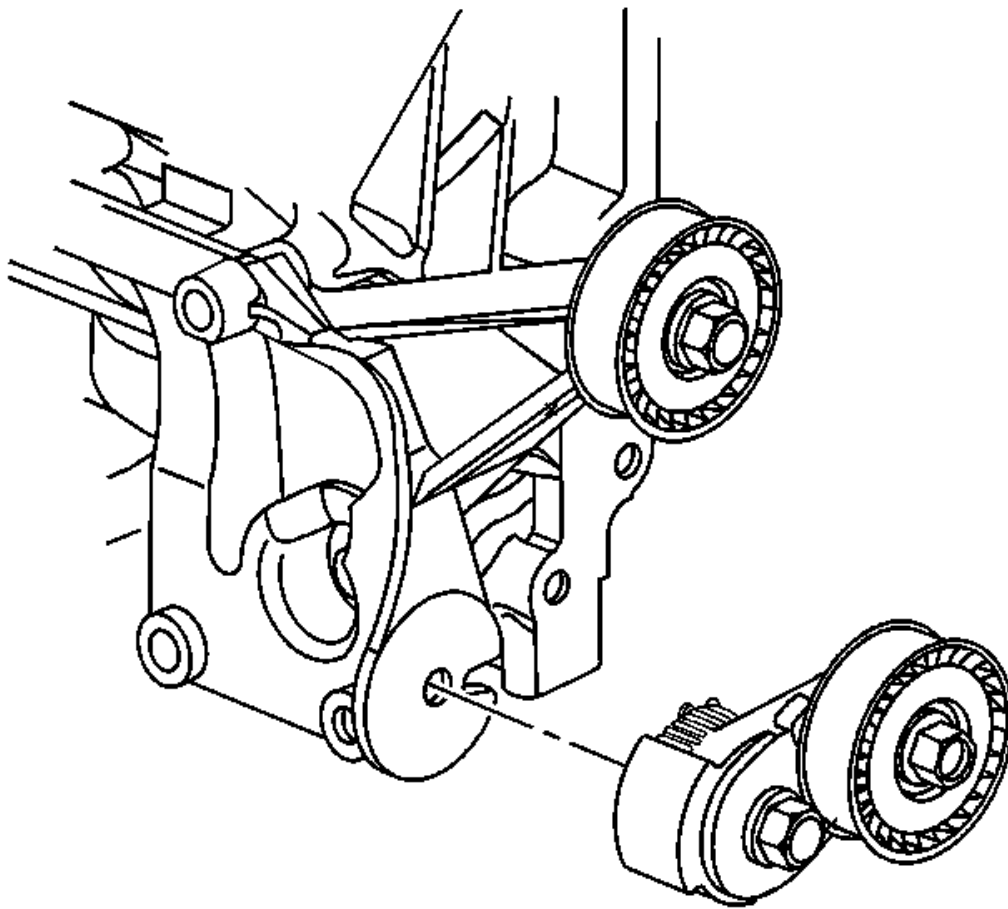


Fig. 23: View Of A/C Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Loosen the A/C drive belt tensioner bolt.
4. Remove the A/C drive belt tensioner.

Installation Procedure

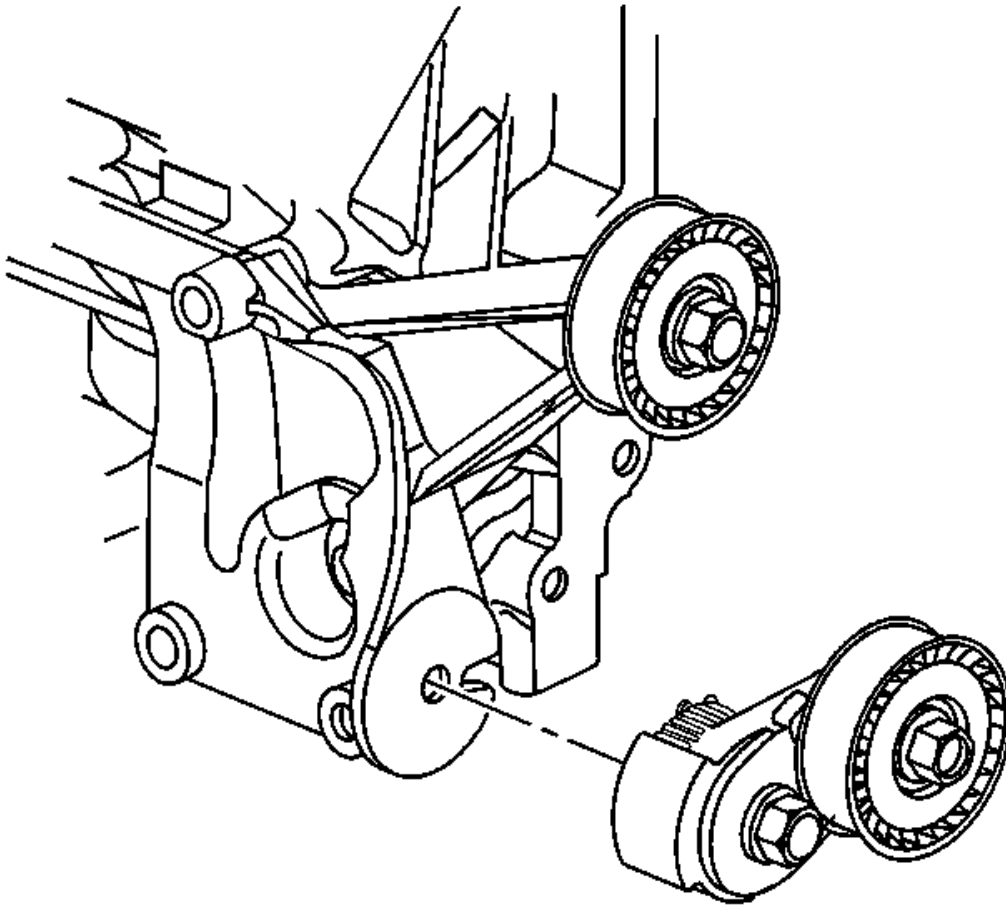


Fig. 24: View Of A/C Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the A/C drive belt tensioner.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Tighten the A/C drive belt tensioner bolt.

Tighten: Tighten the A/C drive belt tensioner bolt to 50 N.m (37 lb ft).

3. Lower the vehicle.
4. Install the A/C drive belt. Refer to Drive Belt Replacement - Air Conditioning.

Engine Mount Inspection

NOTE: Broken or deteriorated mounts can cause misalignment and destruction of

certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

NOTE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Measure the engine movement at the engine mount in order to check for damage to the rubber portions of the mount.
 1. Apply the park brake.
 2. Start the engine.
 3. Firmly apply and hold the primary brakes.
 4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
 5. Slightly load the engine shifting from drive to reverse a few times.
 6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, check for loose engine mount or engine mount bracket attachments.
2. If the engine mount and engine mount bracket bolt torque is at specifications, check the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:
 - Heat check cracks cover the rubber cushion surface.
 - The rubber cushion is separated from the metal plate of the mount.
 - There is a split through the rubber cushion.

Engine Mount Replacement - Left

Tools Required

- **J 28467-B** Universal Engine Support Fixture
- **J 41803** Engine Support Fixture

Removal Procedure

1. Remove the fuel rail covers from the engine.
2. Install **J 41803** and **J 28467-B** and support the engine.
3. Remove the left side exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
4. Remove the engine mount nuts.
5. Remove the engine mount.

Installation Procedure

1. Install the engine mount.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount nuts.

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

3. Install the left side exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
4. Remove **J 41803** and **J 28467-B** from the engine.
5. Install the fuel rail covers to the engine.

Engine Mount Bracket Replacement - Left

Removal Procedure

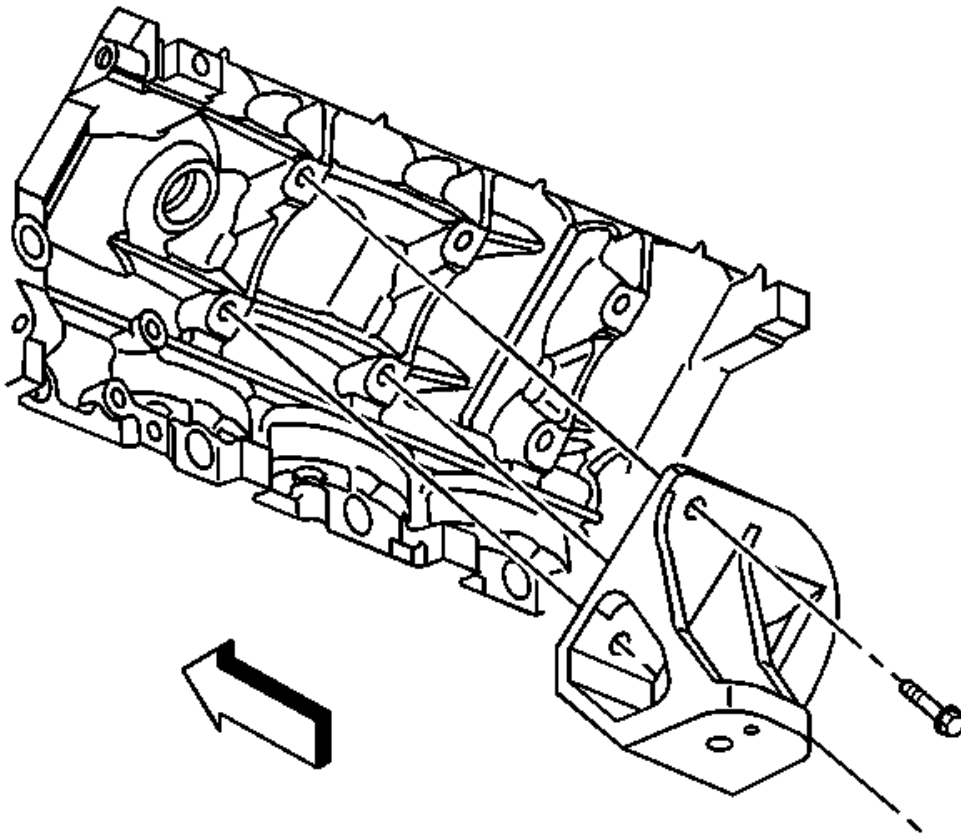


Fig. 25: View Of Fuel Rail Covers & Left Engine Mount Bracket

Courtesy of GENERAL MOTORS CORP.

1. Remove the left engine mount. Refer to **Engine Mount Replacement - Left**.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

Installation Procedure

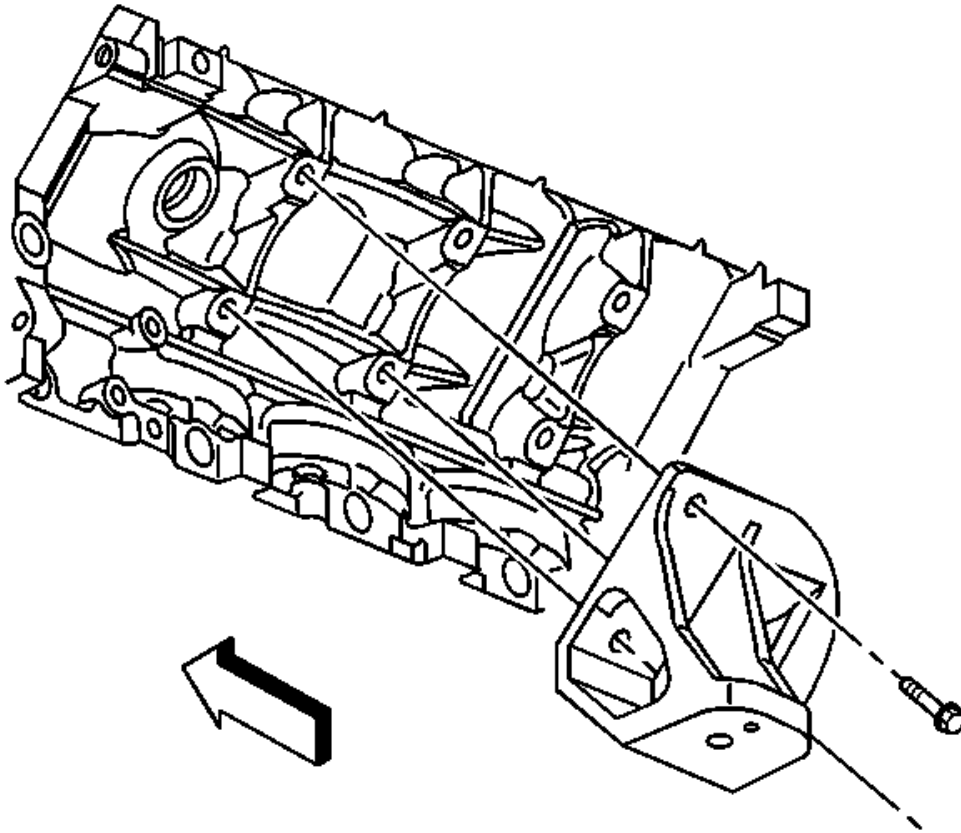


Fig. 26: View Of Fuel Rail Covers & Left Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.

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

2. Install the engine mount bracket bolts.

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

3. Install the left engine mount. Refer to **Engine Mount Replacement - Left**.

Engine Mount Replacement - Right**Tools Required**

- **J 28467-B** Universal Engine Support Fixture
- **J 41803** Engine Support Fixture

Removal Procedure

1. Remove the fuel rail covers from the engine.
2. Install **J 41803** and **J 28467-B** and support the engine.
3. Remove the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
4. Remove the engine mount nuts.
5. Remove the engine mount.

Installation Procedure

1. Install the engine mount.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount nuts.

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

3. Install the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
4. Remove **J 41803** and **J 28467-B** from the engine.
5. Install the fuel rail covers to the engine.

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

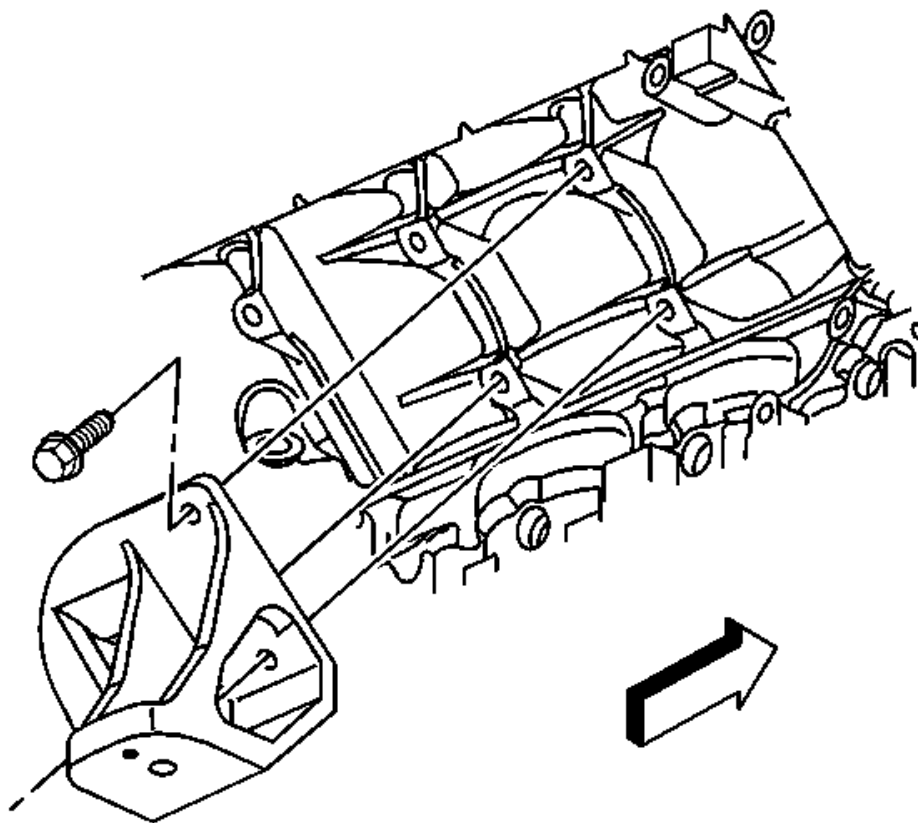


Fig. 27: View Of Fuel Rail Covers & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the right engine mount. Refer to **Engine Mount Replacement - Right**.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

Installation Procedure

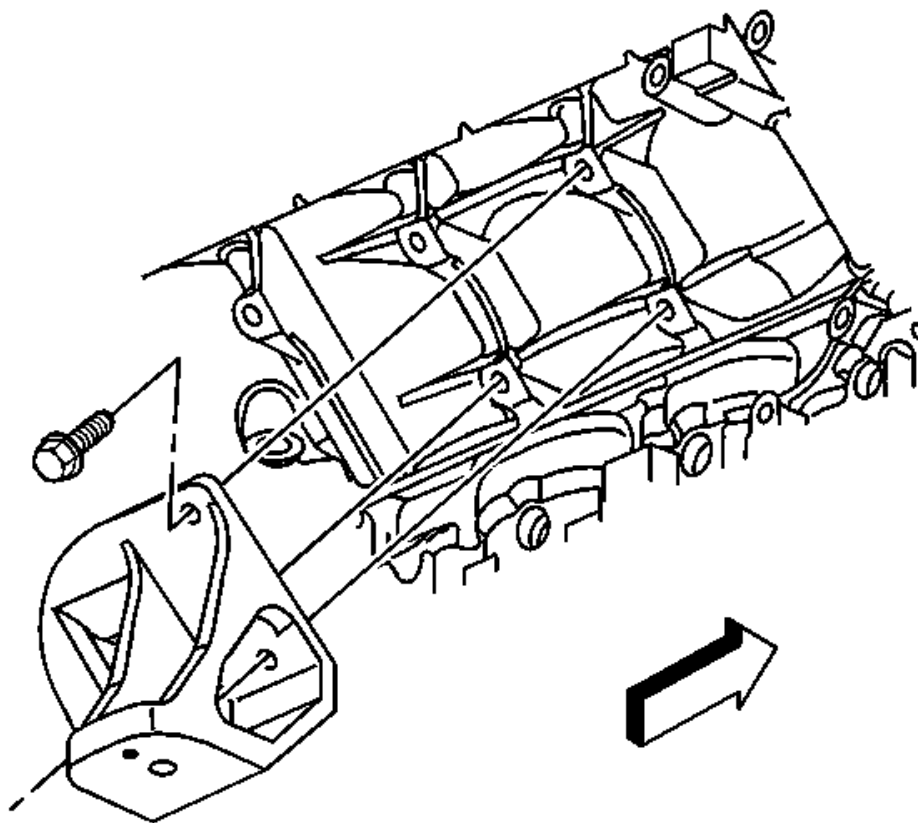


Fig. 28: View Of Fuel Rail Covers & Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.

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

2. Install the engine mount bracket bolts.

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

3. Install the right engine mount. Refer to **Engine Mount Replacement - Right.**

Engine Sight Shield Replacement

Removal Procedure

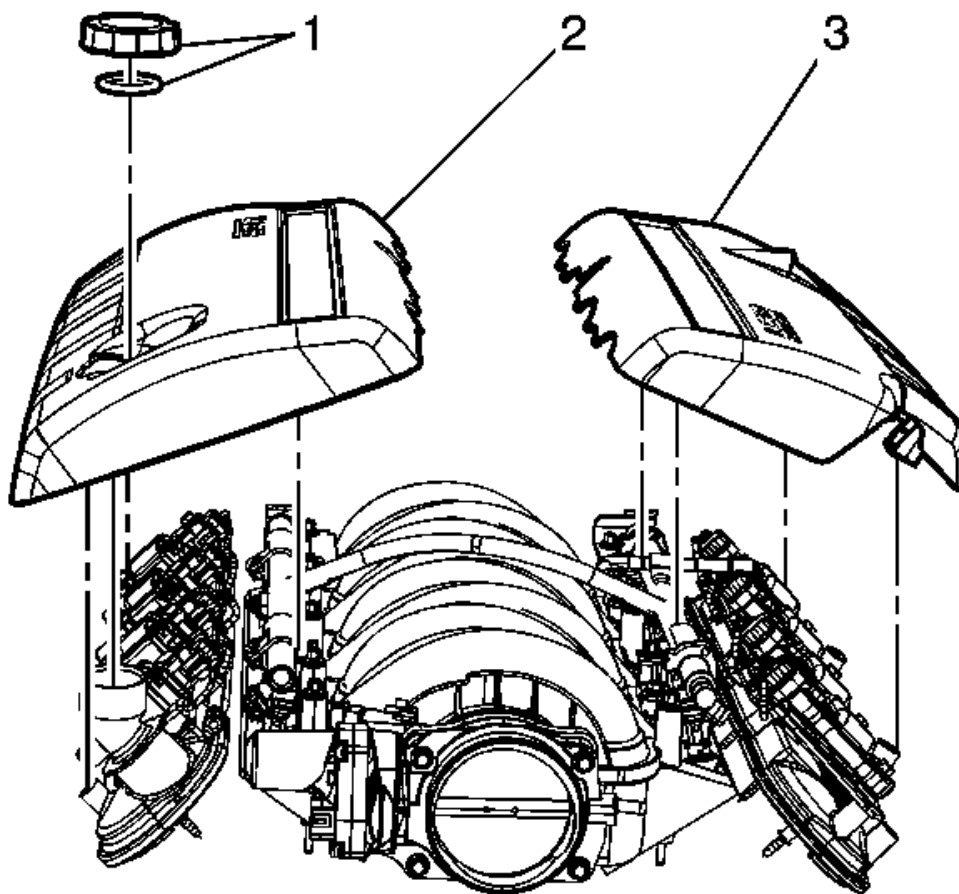


Fig. 29: Oil Filler Cap & Engine Sight Shields
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filler cap (1), if needed.
2. Remove the right engine sight shield (2), if needed.
3. Remove the left engine sight shield (3), if needed.

Installation Procedure

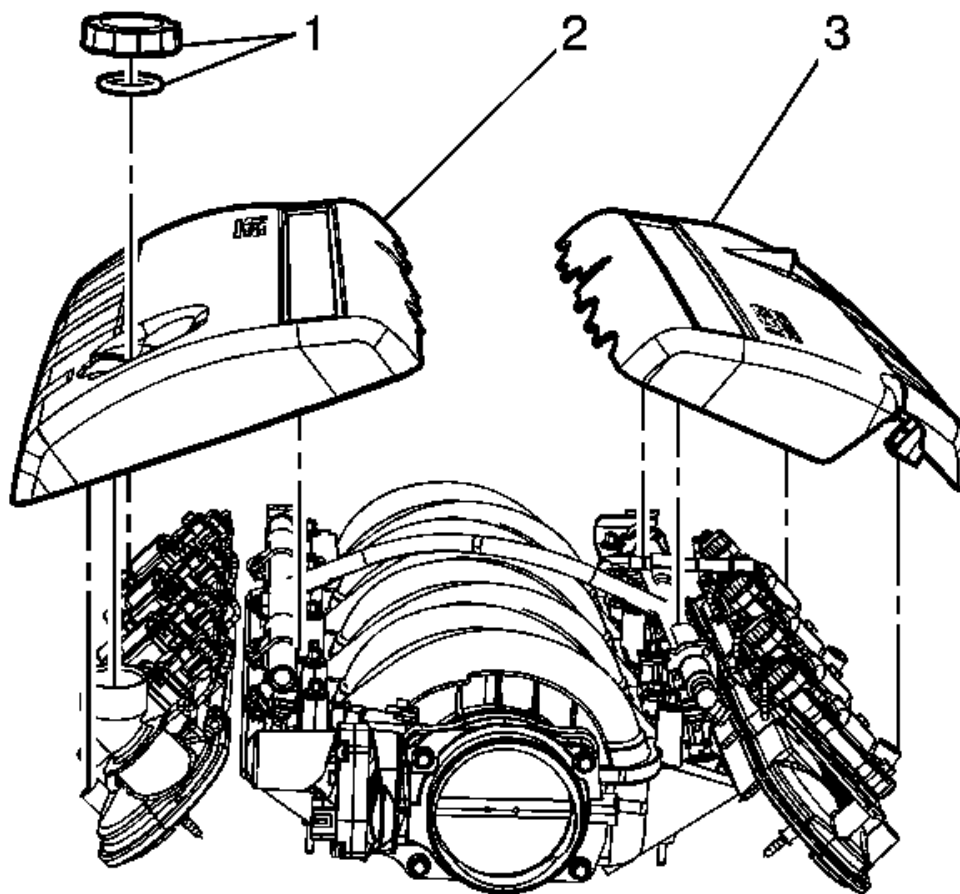


Fig. 30: Oil Filler Cap & Engine Sight Shields
Courtesy of GENERAL MOTORS CORP.

1. Install the left engine sight shield (3), if needed.
2. Install the right engine sight shield (2), if needed.
3. Install the oil filler cap (1), if needed.

Crankcase Ventilation Hoses/Pipes Replacement

Removal Procedure

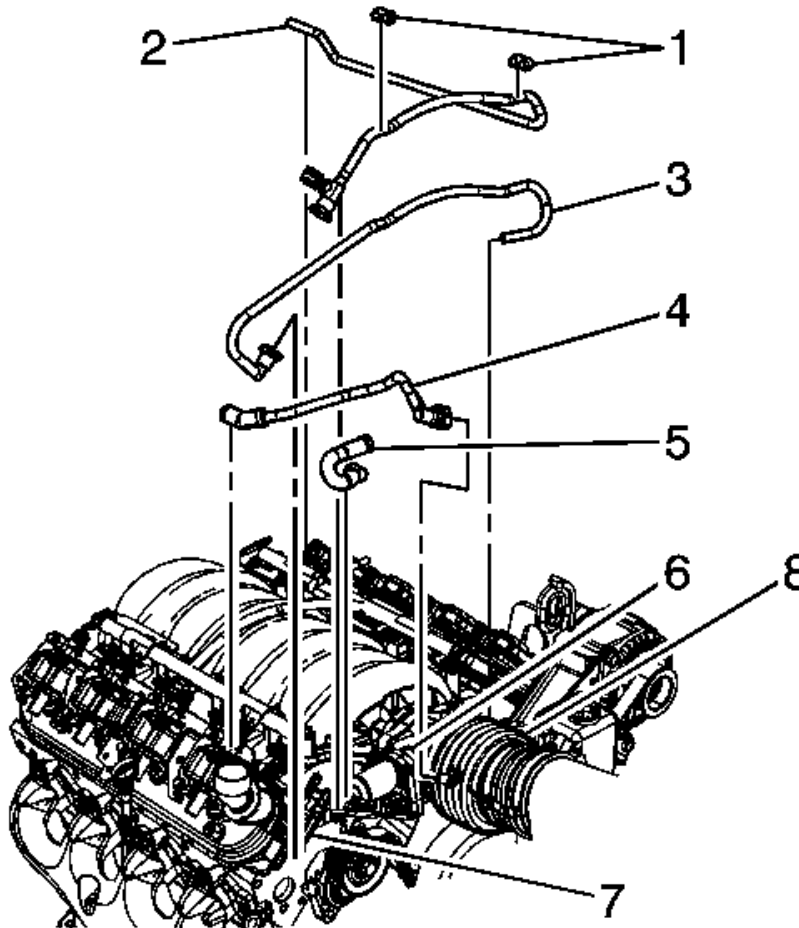


Fig. 31: EVAP System Hoses/Pipes
Courtesy of GENERAL MOTORS CORP.

1. Remove the right and left engine sight cover. Refer to Engine Sight Shield Replacement

IMPORTANT: In the following service procedure, it maybe necessary to remove the evaporative emission (EVAP) valve assembly to gain access to the positive crankcase ventilation hose.

2. Remove the evaporative emission canister purge valve (7). Refer to Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement in Engine Controls - 6.0L.
3. Remove the retaining clips (1) for the EVAP pipes (2) and (3).
4. Remove the EVAP pipes (2) and (3).
5. Remove the EVAP pipe (4) from intake air temperature (IAT) sensor at the air intake duct (8) the valve cover.
6. Remove the hose (5) from the throttle body to the engine valley cover.

Installation Procedure

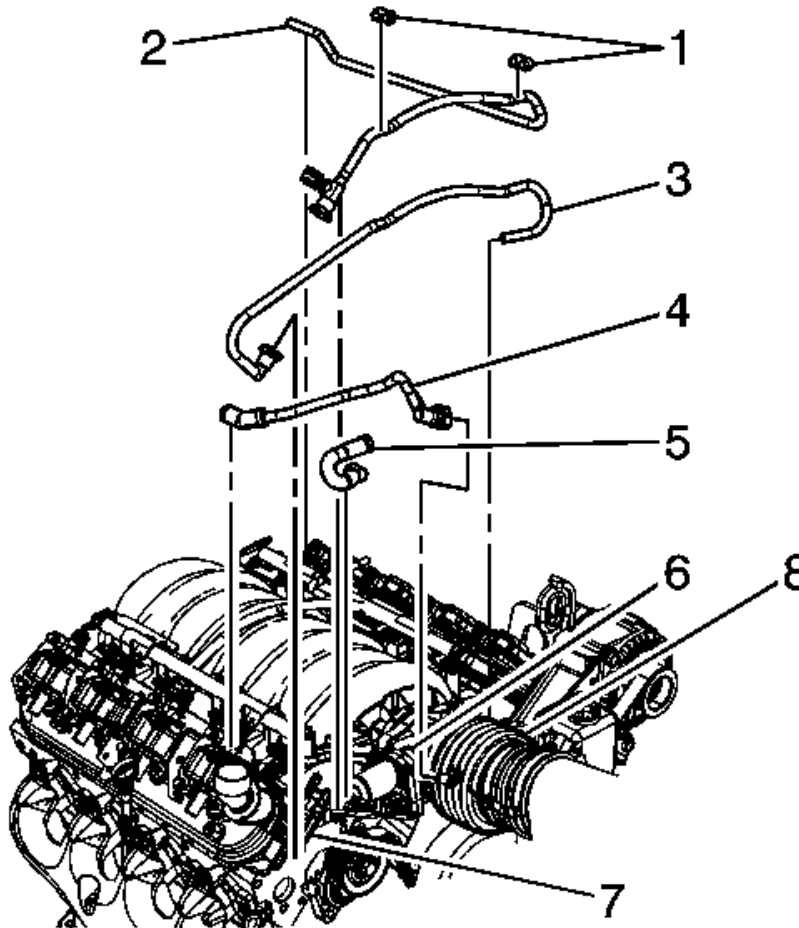


Fig. 32: EVAP System Hoses/Pipes
Courtesy of GENERAL MOTORS CORP.

1. Install the hose (5) from the throttle body to the engine valley cover.
2. Install the EVAP pipe (4) from IAT sensor at the air intake duct (8) the valve cover.
3. Install the EVAP valve, if removed. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** in Engine Controls - 6.0L.
4. Install the EVAP pipes (2) and (3).
5. Install the retaining clips (1) for the EVAP pipes (2) and (3).
6. Install the right and left engine sight cover. Refer to **Engine Sight Shield Replacement**

Intake Manifold Replacement

Removal Procedure

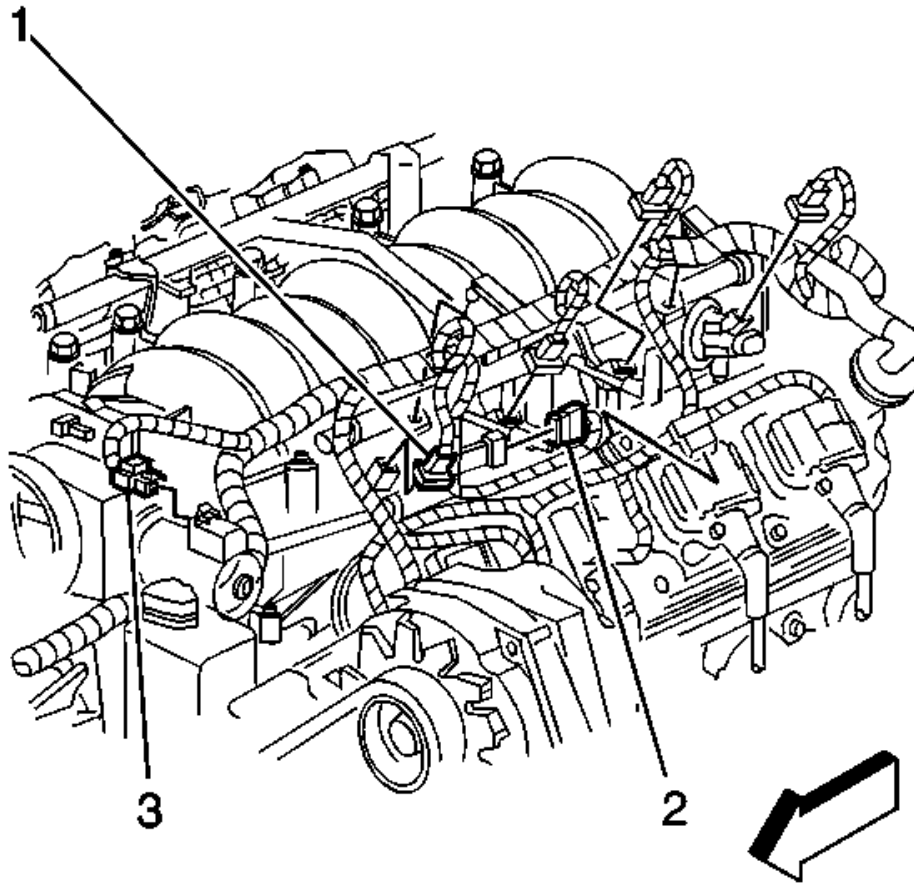


Fig. 33: Locating EVAP Canister Purge Solenoid Valve Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the engine sight covers. Refer to Engine Sight Shield Replacement.
2. Remove the air intake duct. Refer to Air Cleaner Assembly Replacement.
3. Remove the front suspension support brace. Refer to Front Suspension Support Brace Replacement in Front Suspension.
4. Drain the cooling system. Refer to Draining and Filling Cooling System in Engine Cooling.
5. Disconnect the electrical connector (1) for the fuel injectors.
6. Disconnect the electrical connectors (3) from the throttle body.
7. Disconnect the fuel feed for the fuel injectors.

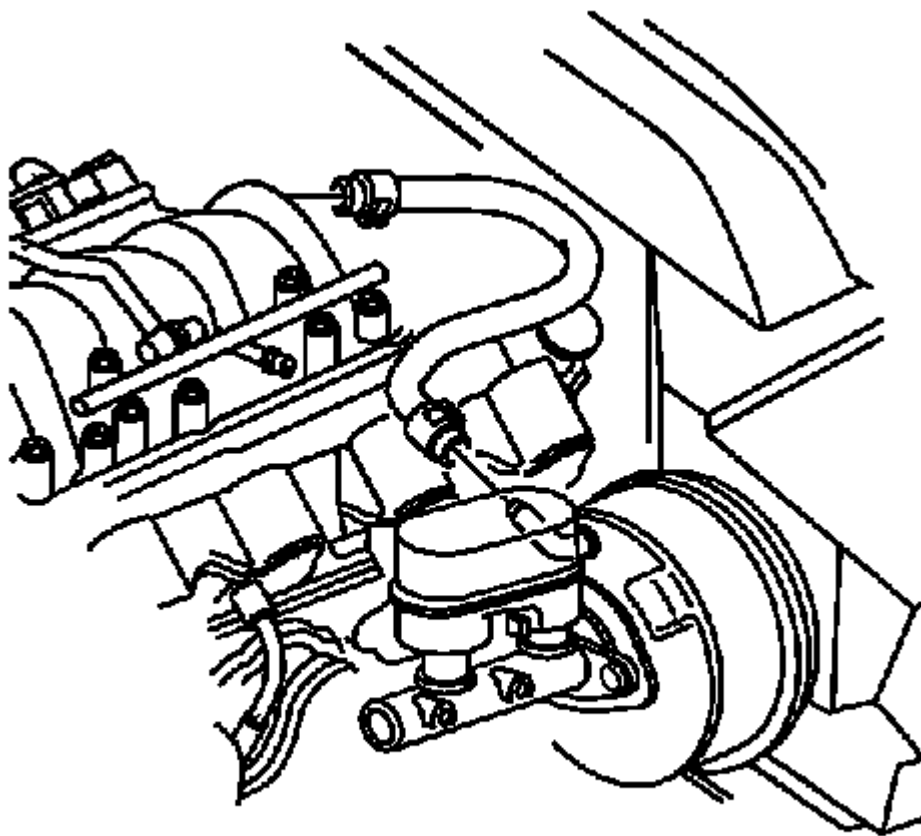


Fig. 34: Identifying Vacuum Booster Hose
Courtesy of GENERAL MOTORS CORP.

8. Remove the vacuum hose from the brake booster.
9. Disconnect the electrical connector from the manifold absolute pressure (MAP) sensor.

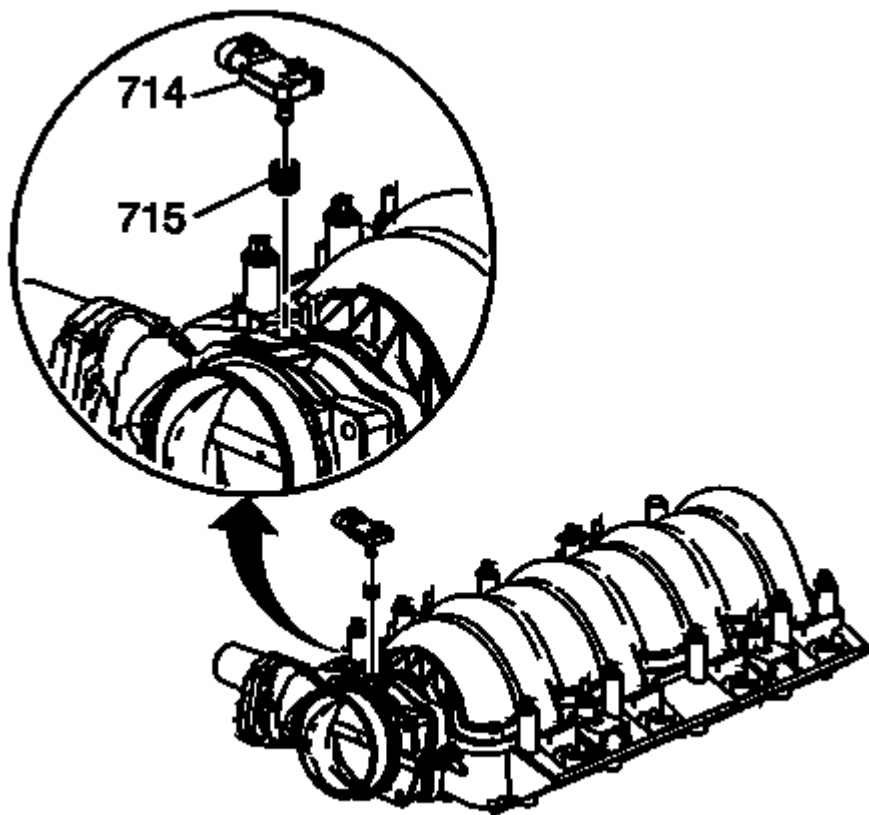


Fig. 35: MAP Sensor & Grommet
Courtesy of GENERAL MOTORS CORP.

10. Remove the MAP sensor (714).
11. Remove the grommet (715) from the sensor, as required.

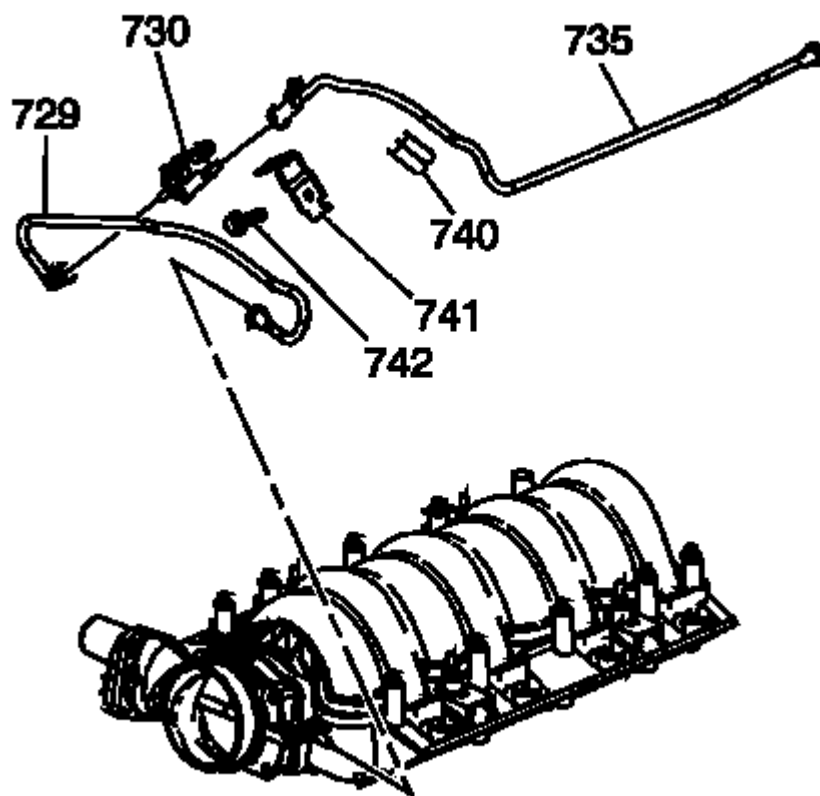


Fig. 36: EVAP Clip, Bolt, Bracket, Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

12. Remove the evaporative emission (EVAP) clip (740), bolt (742), bracket (741), valve (730), and tubes (729, 735).

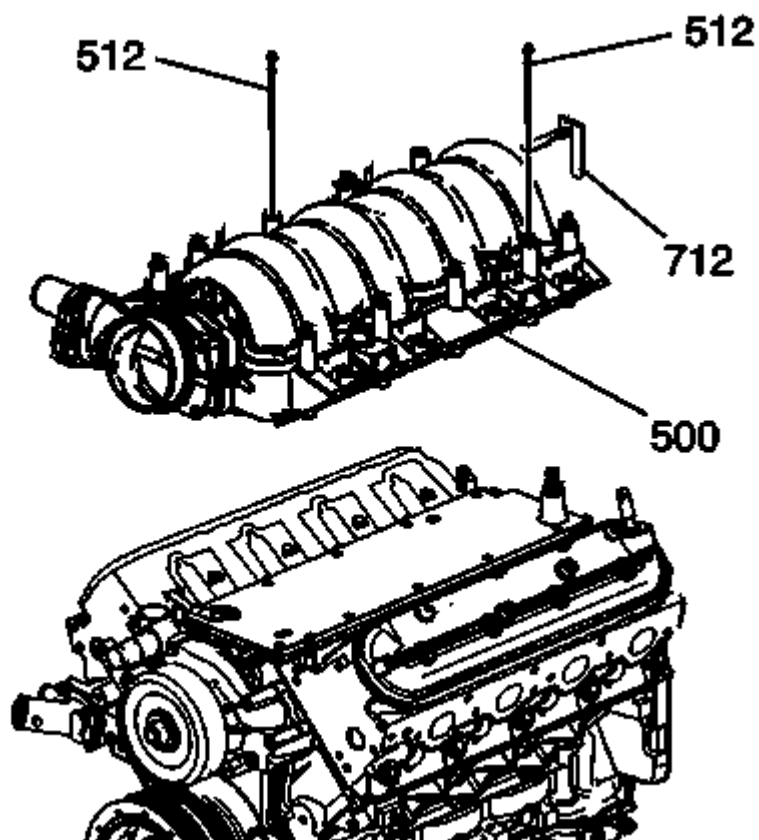


Fig. 37: Intake Manifold, Bolts & Fuel Rail Stop Bracket
Courtesy of GENERAL MOTORS CORP.

13. Remove the intake manifold bolts (512) and fuel rail stop bracket (712).
14. Remove the intake manifold (500).

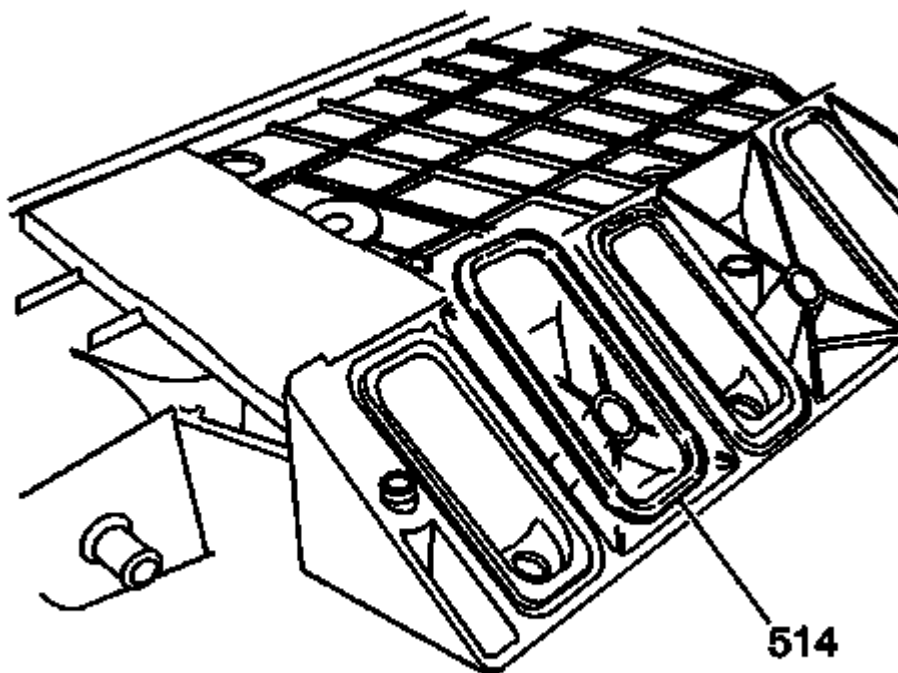


Fig. 38: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

15. Remove the intake manifold gaskets (514).
16. Discard the intake manifold gaskets.

Installation Procedure

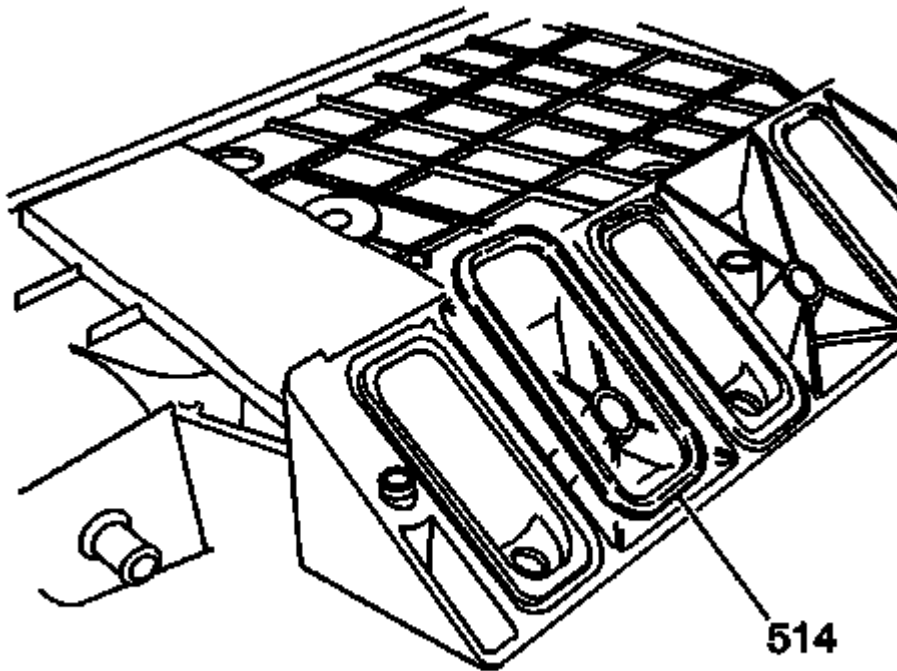


Fig. 39: View Of Intake Manifold-To-Cylinder Head Gaskets
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the intake manifold gaskets. Install NEW intake manifold gaskets.

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.

1. Install NEW intake manifold-to-cylinder head gaskets (514).

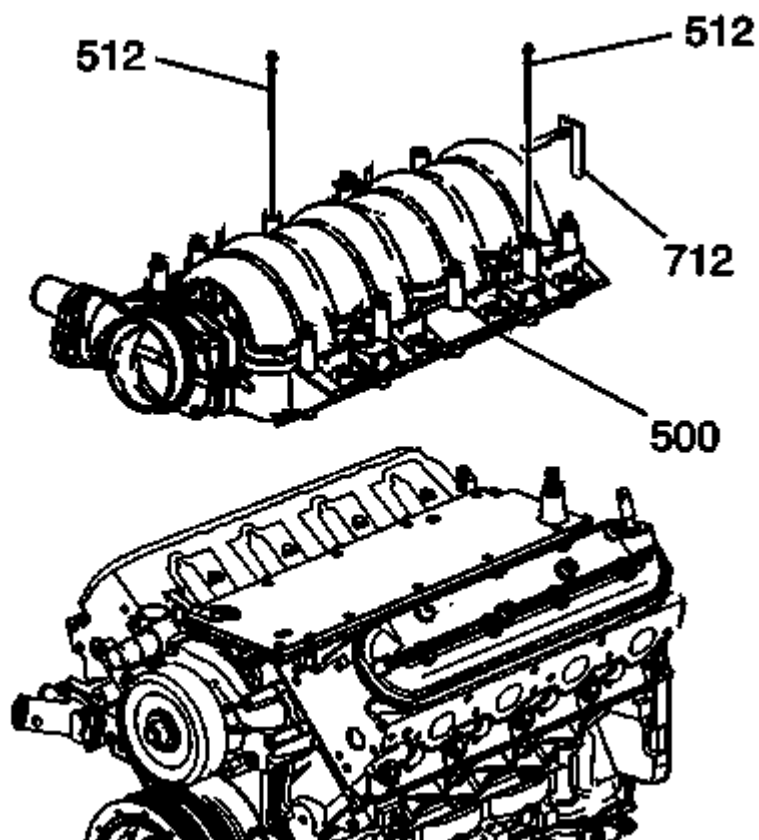


Fig. 40: Intake Manifold, Bolts & Fuel Rail Stop Bracket
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold (500).
3. Apply a 5 mm (0.20 in) band of threadlocker GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512).
4. Install the intake manifold bolts (512) and fuel rail stop bracket (712).

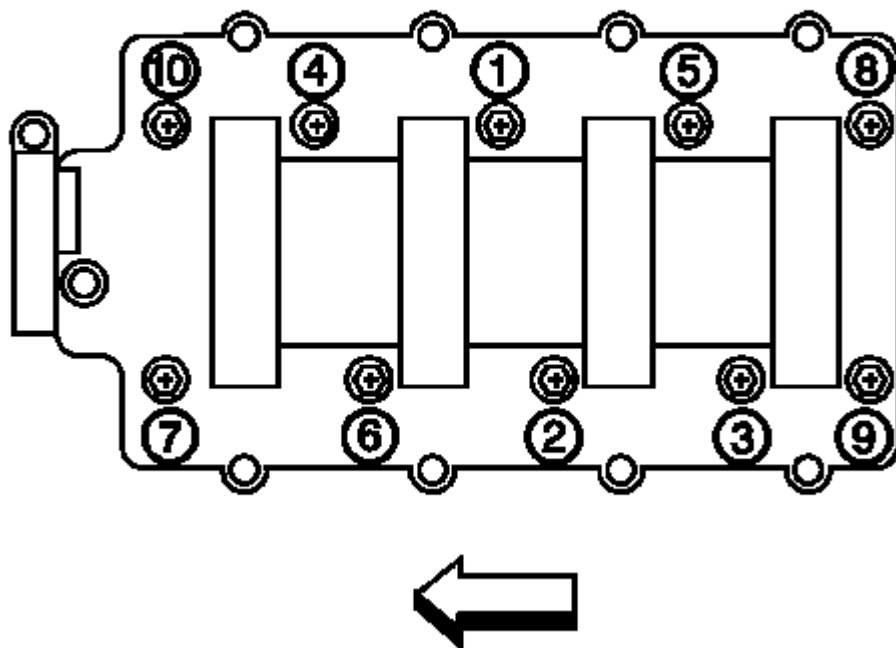


Fig. 41: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the intake manifold bolts.

Tighten:

1. Tighten the intake manifold bolts at first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts at final pass in sequence to 10 N.m (89 lb in).

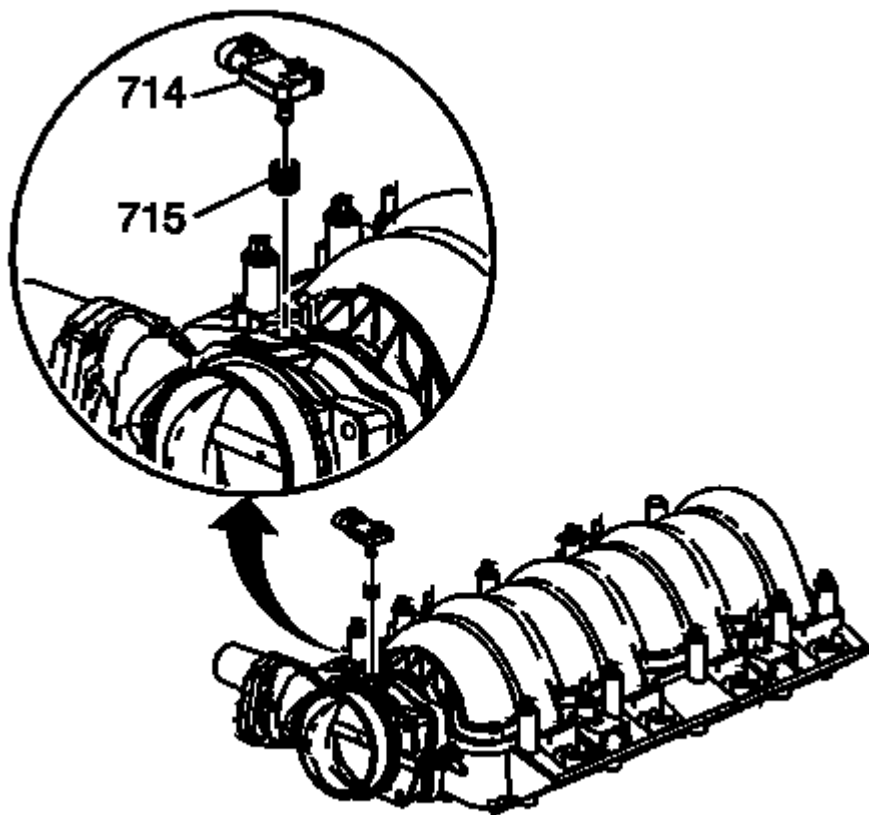


Fig. 42: MAP Sensor & Grommet
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the MAP sensor grommet (715) with clean engine oil.
7. Install the MAP sensor (714) and grommet (715).

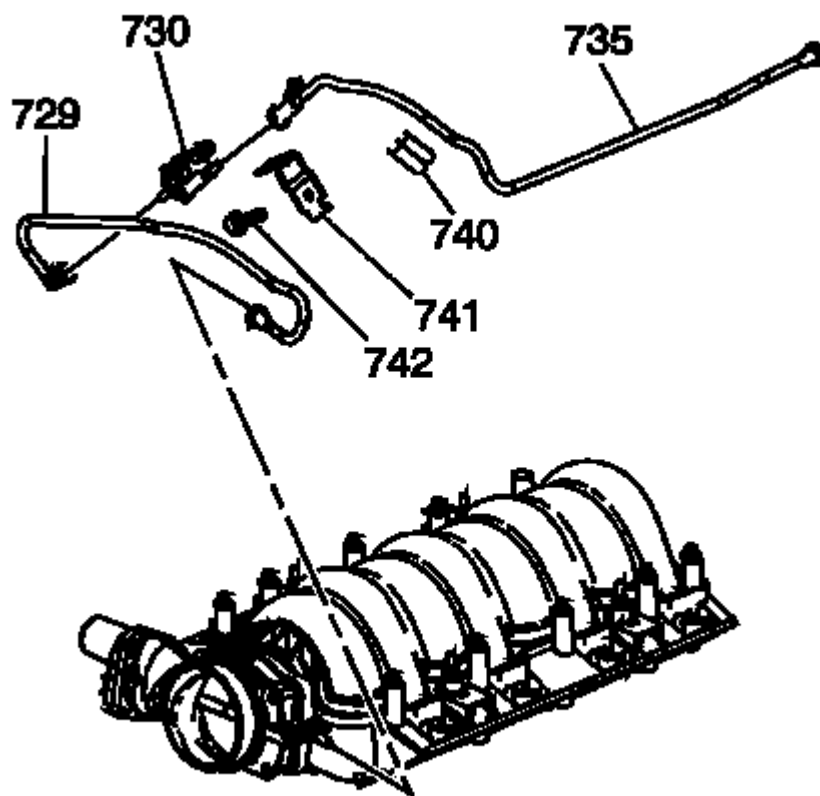


Fig. 43: EVAP Clip, Bolt, Bracket, Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

8. Install the EVAP valve (730), bracket (741), and bolt (742).

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

9. Install the EVAP tubes (729, 735).
10. Install the fuel rail. Refer to **Fuel Rail and Injectors Installation** in Engine Controls - 6.0L.
11. Reconnect the electrical connector for the MAP sensor.

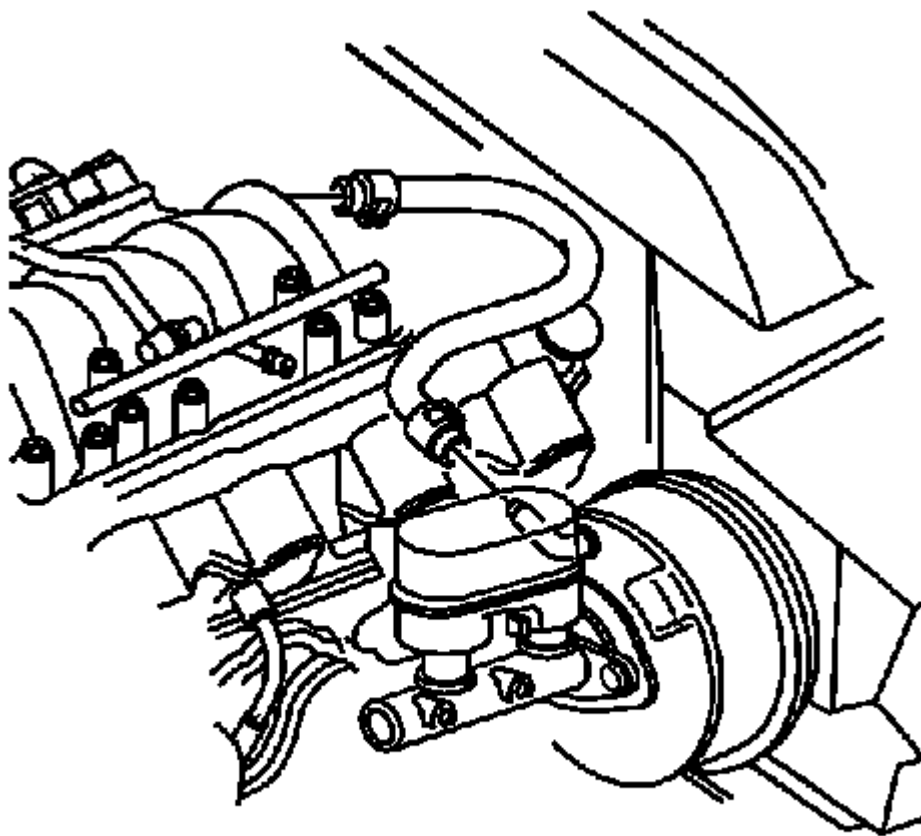


Fig. 44: Identifying Vacuum Booster Hose
Courtesy of GENERAL MOTORS CORP.

12. Install the vacuum hose for the brake booster.

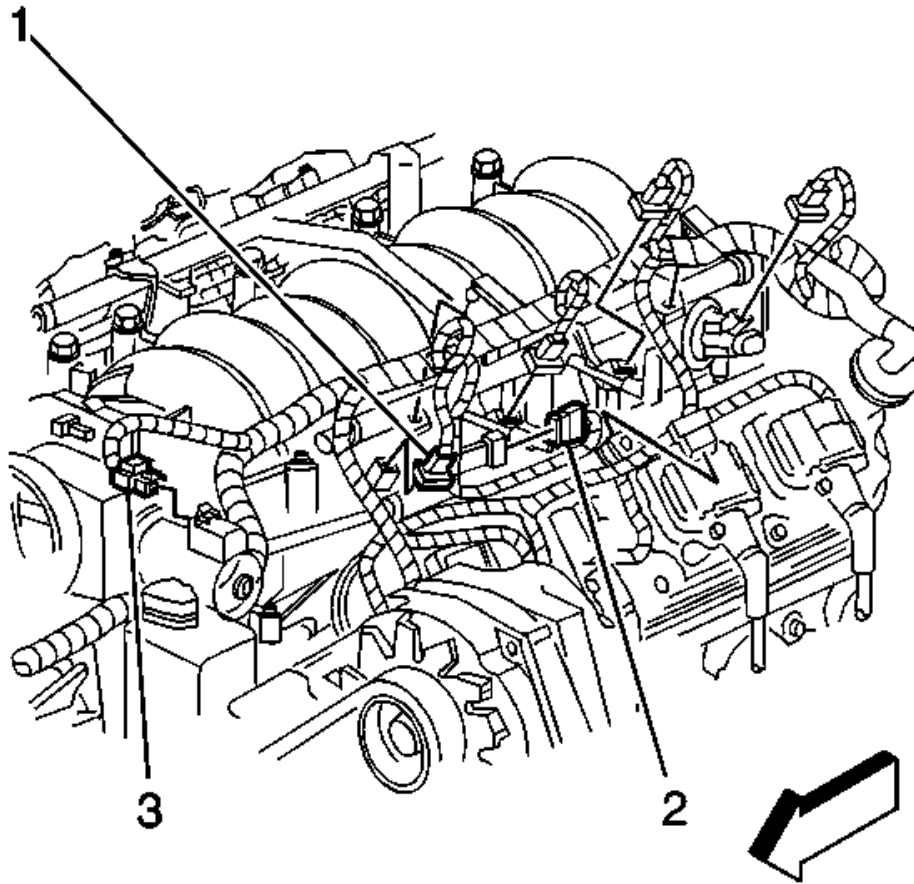


Fig. 45: Locating EVAP Canister Purge Solenoid Valve Electrical Connector
Courtesy of GENERAL MOTORS CORP.

13. Reconnect the electrical connectors (3) throttle body.
14. Reconnect the electrical connector (1) for the fuel injectors.
15. Install the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.
16. Install the air intake duct. Refer to **Air Cleaner Assembly Replacement** .
17. Refill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
18. Install the engine sight covers. Refer to **Engine Sight Shield Replacement**.

Engine Valley Cover Replacement

Removal Procedure

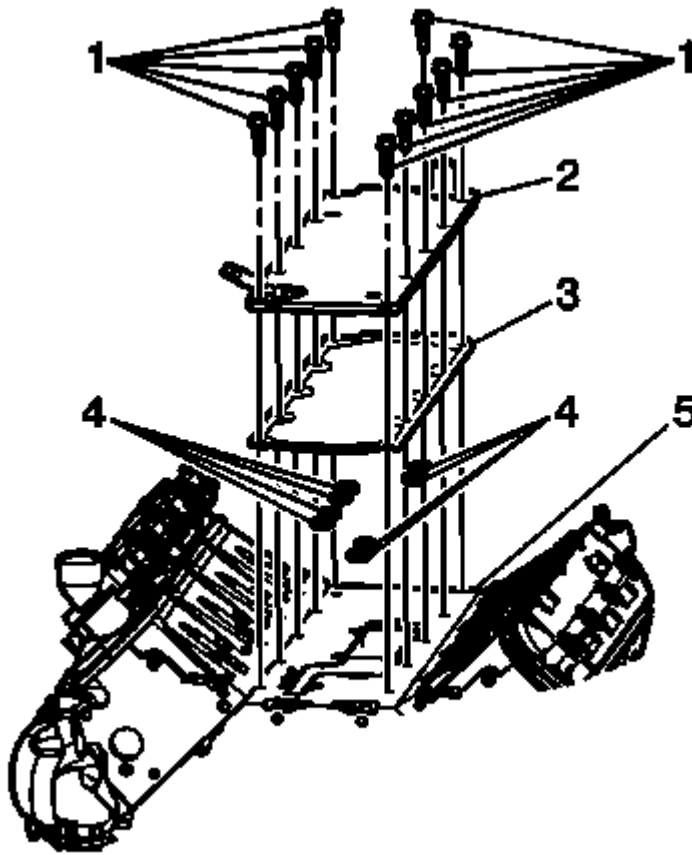


Fig. 46: Engine Valley Cover, Retaining Bolts, Gasket & O-Rings
 Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the oil pressure switch. Refer to **Engine Oil Pressure Sensor and/or Switch Replacement**.
3. Remove the engine valley retaining bolts (1).
4. Remove the engine valley cover (2).
5. Remove the engine valley gasket (3).
6. Remove the O-rings (4) from the engine valley cover (2).

Installation Procedure

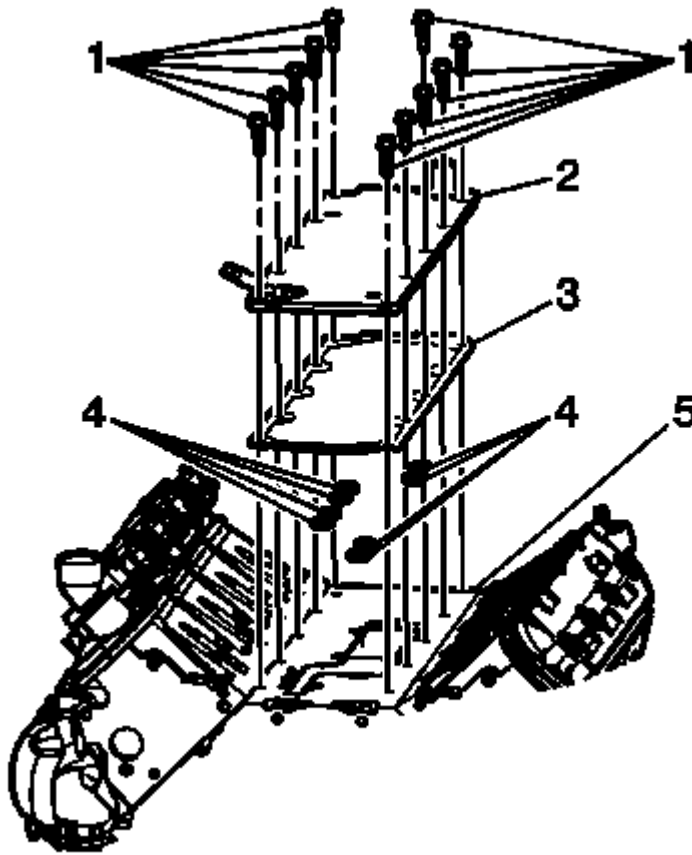


Fig. 47: Engine Valley Cover, Retaining Bolts, Gasket & O-Rings
 Courtesy of GENERAL MOTORS CORP.

1. Install the O-rings (4) to the engine valley cover (2).
2. Install the engine valley gasket (3).
3. Install the engine valley cover (2).
4. Install the retaining bolts (1).

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the engine valley retaining bolts.

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

6. Install the intake manifold. Refer to Intake Manifold Cleaning and Inspection.
7. Install the oil pressure switch. Refer to Engine Oil Pressure Sensor and/or Switch Replacement.

Valve Rocker Arm Cover Replacement - Left

Removal Procedure

1. Remove the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.
2. Remove the left engine sight cover. Refer to **Engine Sight Shield Replacement**.
3. Remove the fuel rail supply line. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment**.

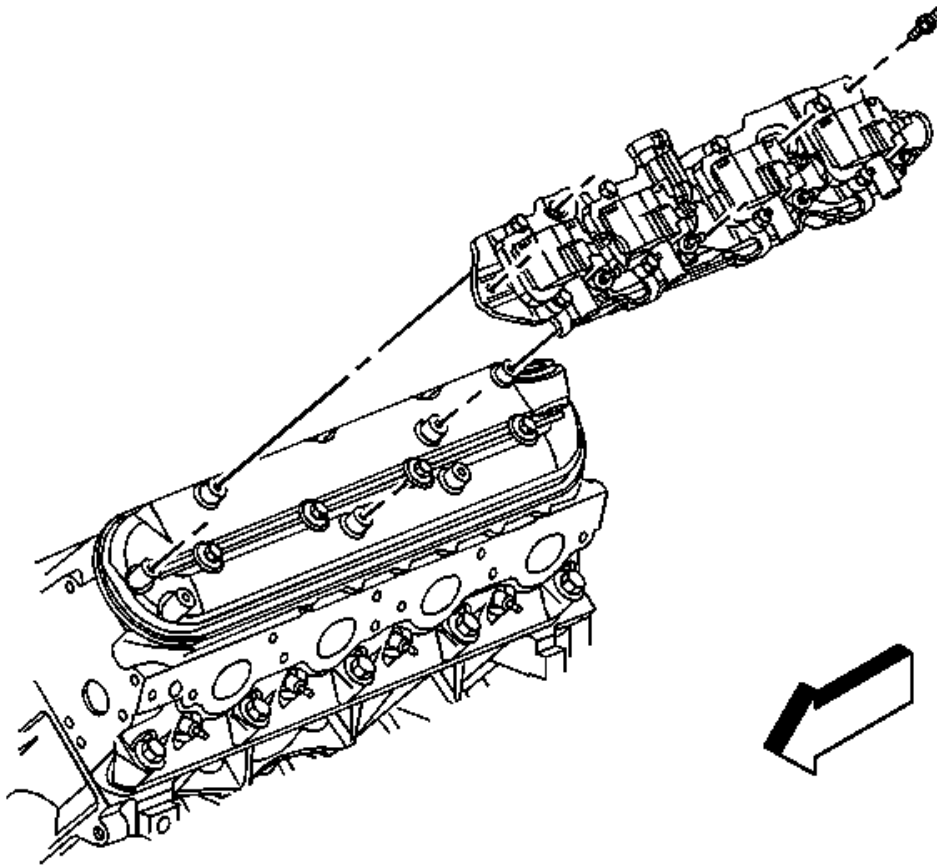


Fig. 48: Locating Ignition Coil Bracket Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the ignition coil assembly. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 6.0L.

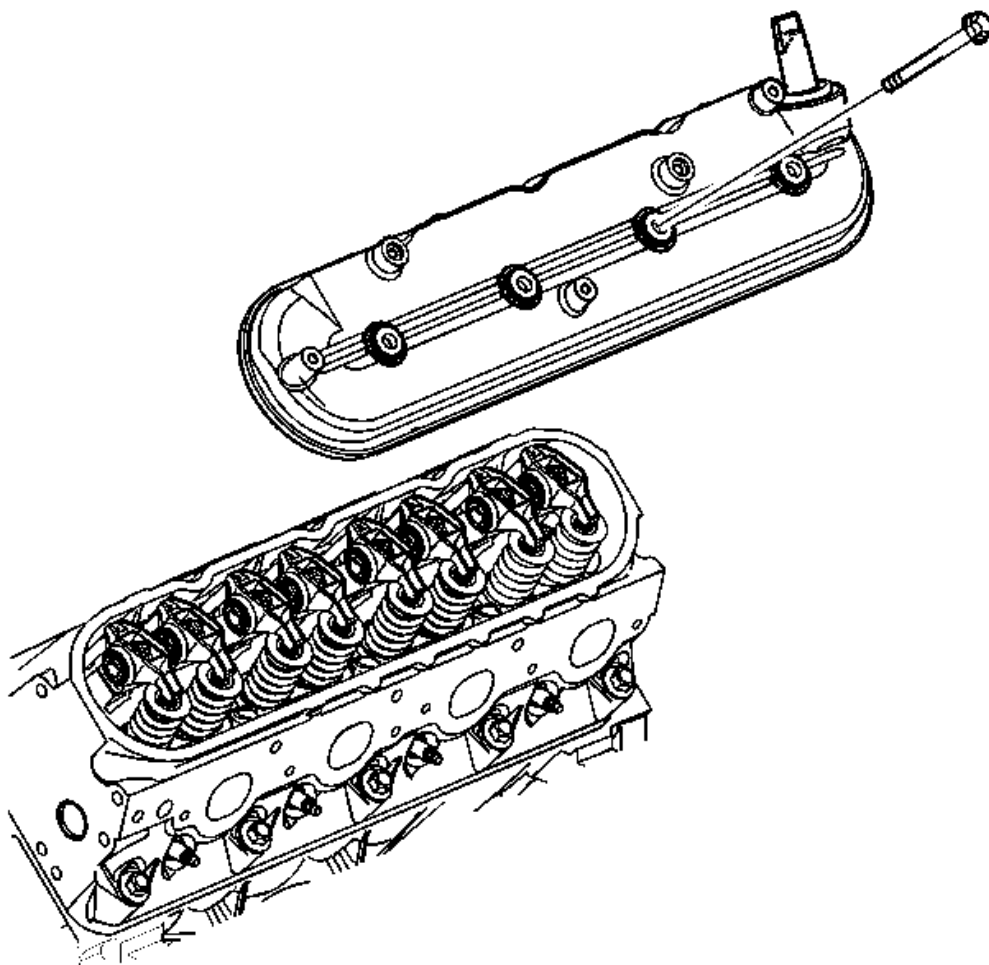


Fig. 49: Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen the valve rocker arm cover bolts.
6. Remove the valve rocker cover.

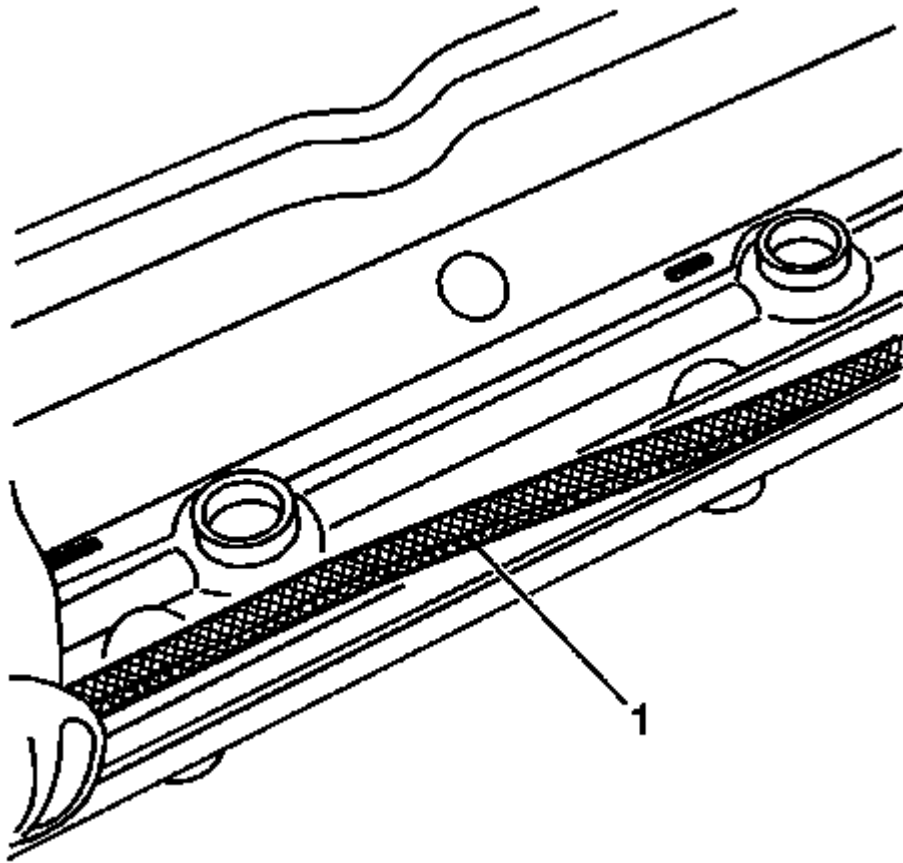


Fig. 50: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (1) from the rocker cover. Discard the OLD gasket.

Installation Procedure

IMPORTANT:

- All gasket surfaces should be free of oil and other foreign material during assembly.
- **DO NOT** reuse the valve rocker arm cover gasket.
- The valve rocker arm cover bolt grommets may be reused.
- If the positive crankcase ventilation (PCV) valve grommet has been removed from the rocker arm, install a **NEW** grommet during assembly.

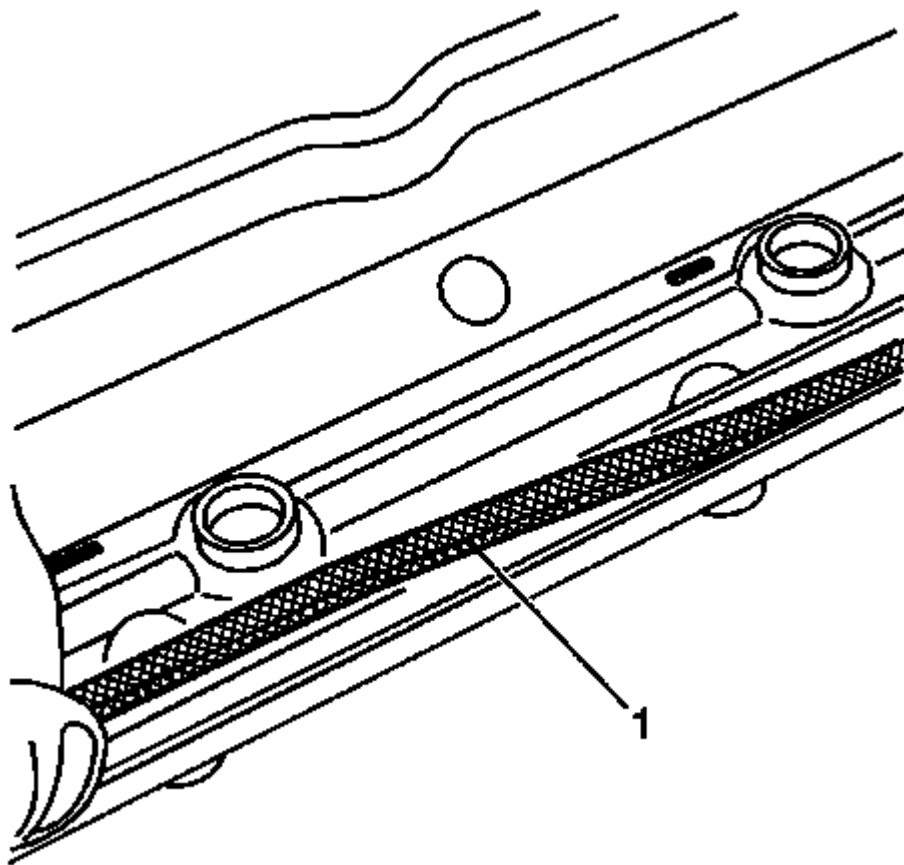


Fig. 51: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW rocker cover gasket (1) into the valve rocker cover lip.

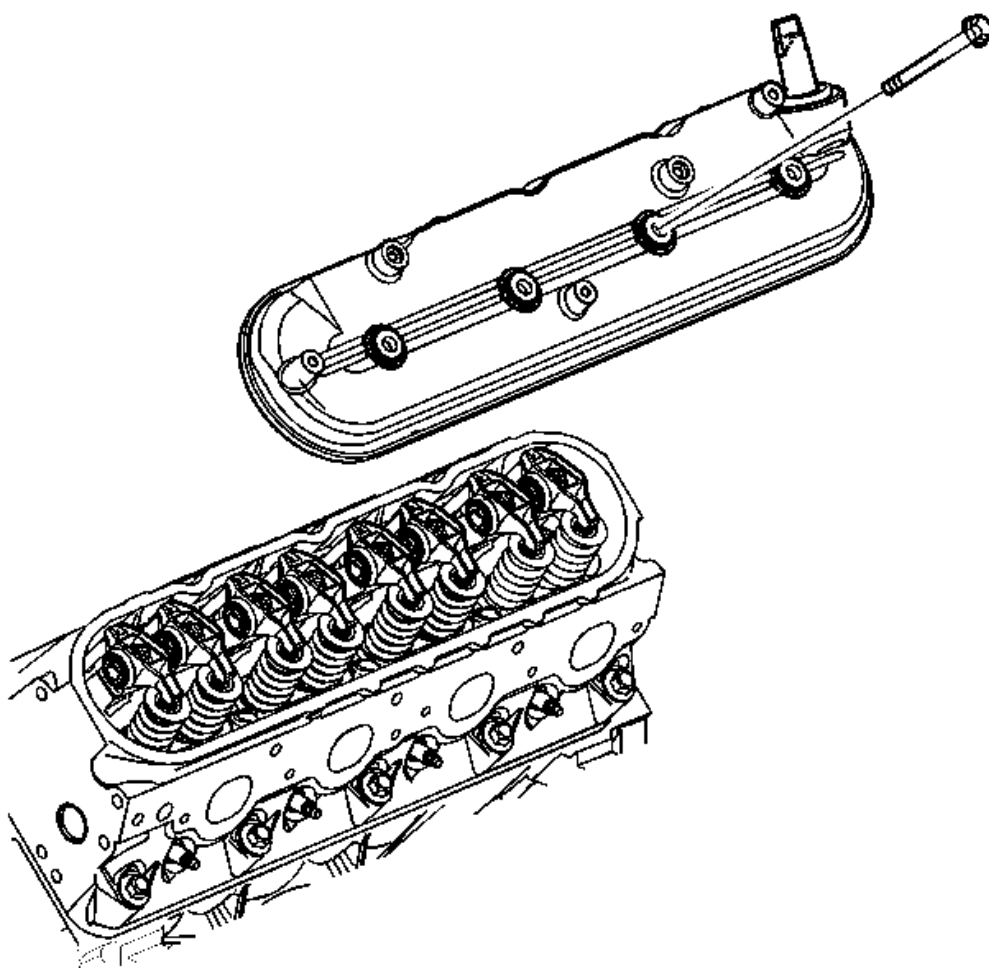


Fig. 52: Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the valve rocker cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

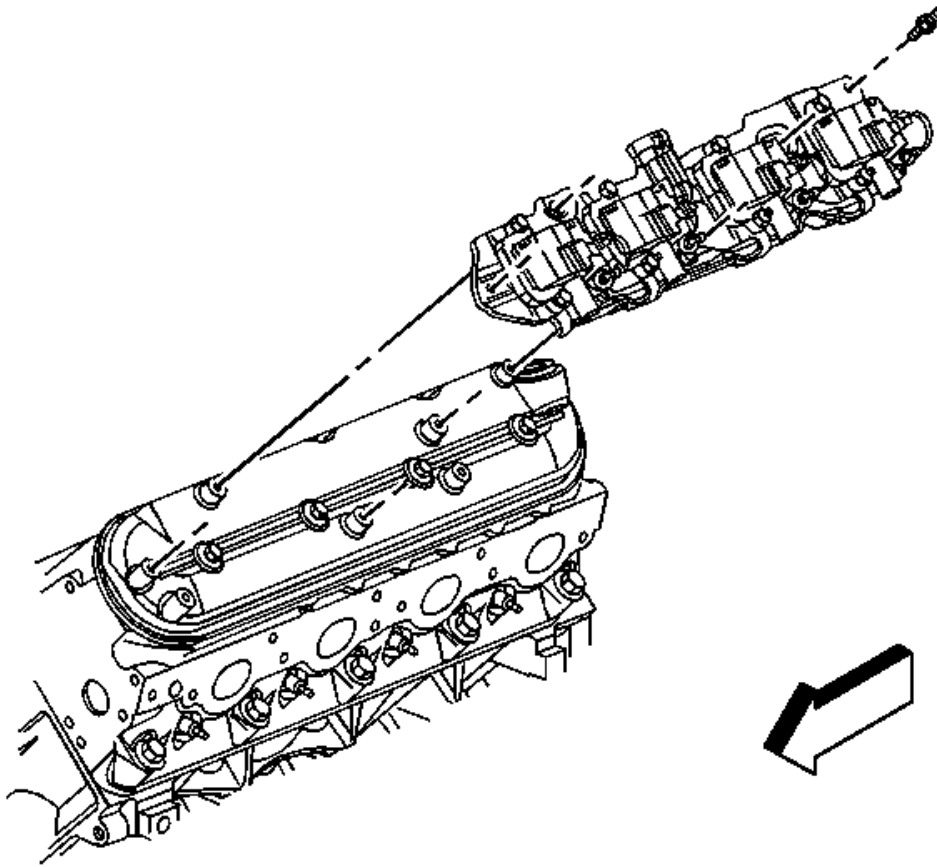


Fig. 53: Locating Ignition Coil Bracket Studs
Courtesy of GENERAL MOTORS CORP.

4. Install the ignition coil assembly. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 6.0L.
5. Install the fuel rail supply line. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment**.
6. Install the left engine sight cover. Refer to **Engine Sight Shield Replacement**.
7. Install the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

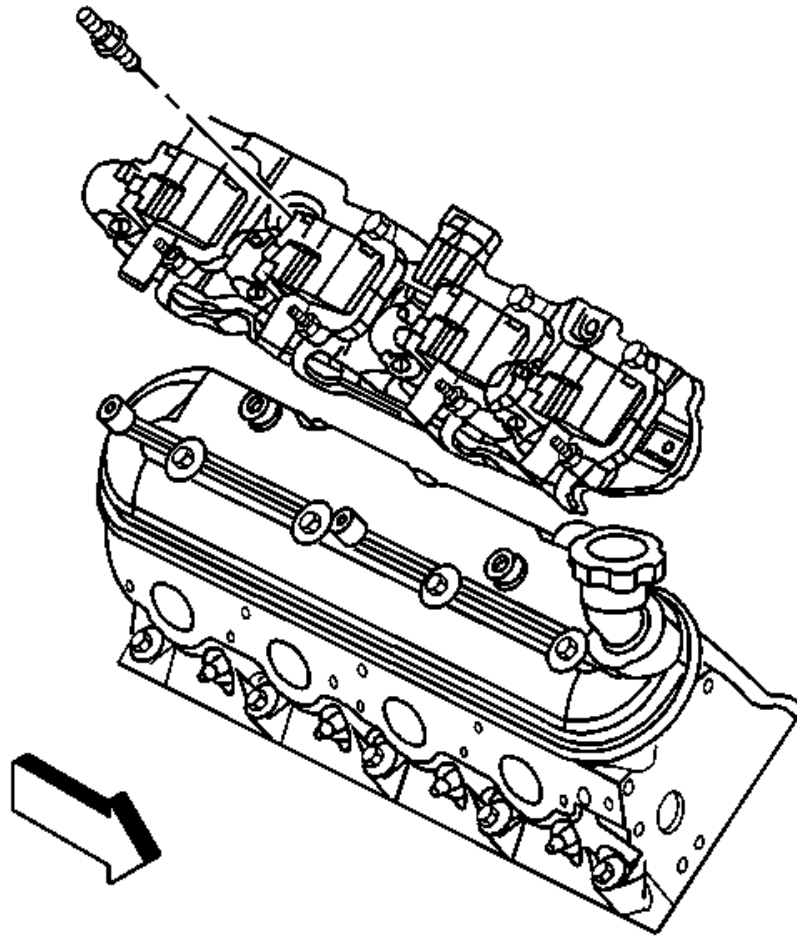


Fig. 54: Locating Ignition Coil Bracket Studs
Courtesy of GENERAL MOTORS CORP.

1. Remove the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.
2. Remove the engine sight cover. Refer to **Engine Sight Shield Replacement**.
3. Remove the crankcase ventilation hoses/pipes. Refer to **Crankcase Ventilation Hoses/Pipes Replacement**.
4. Remove the ignition coil assembly. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 6.0L.

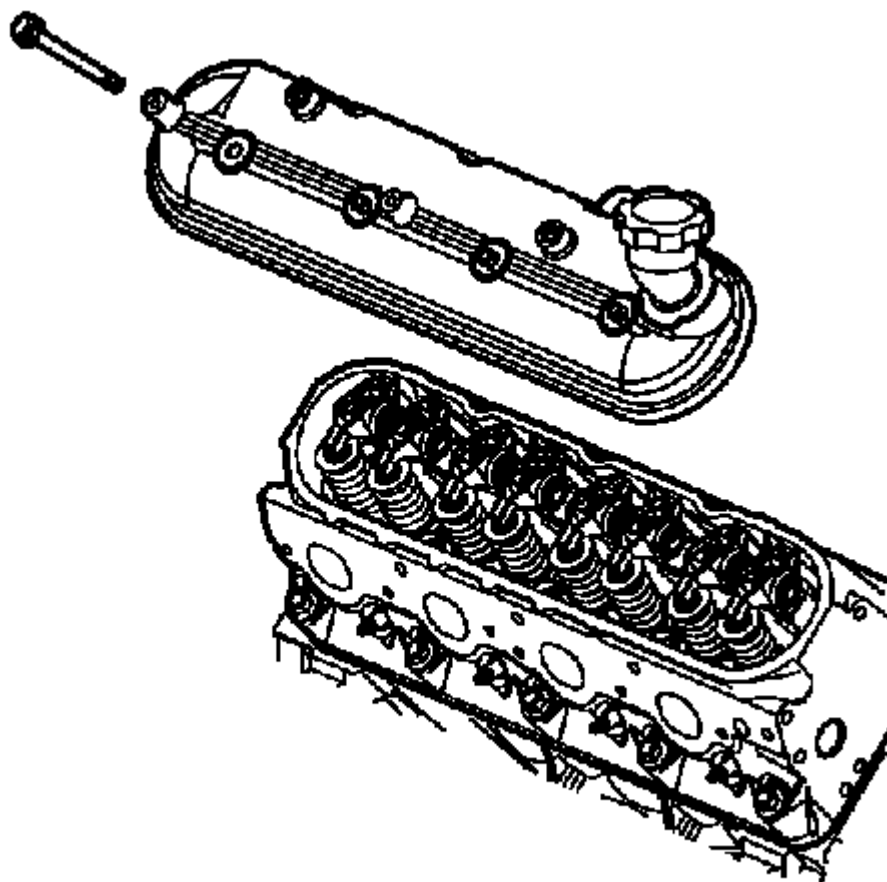


Fig. 55: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

5. Loosen the valve rocker arm cover bolts.
6. Remove the valve rocker arm cover.

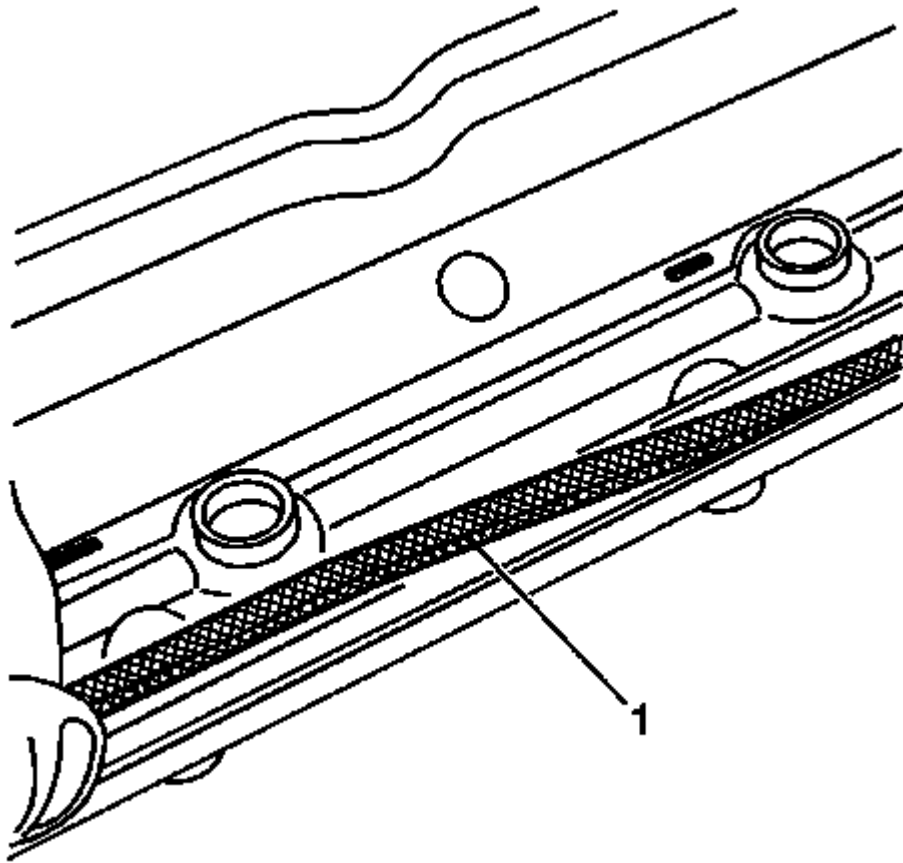


Fig. 56: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (1) from the rocker cover. Discard the OLD gasket.

Installation Procedure

IMPORTANT:

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

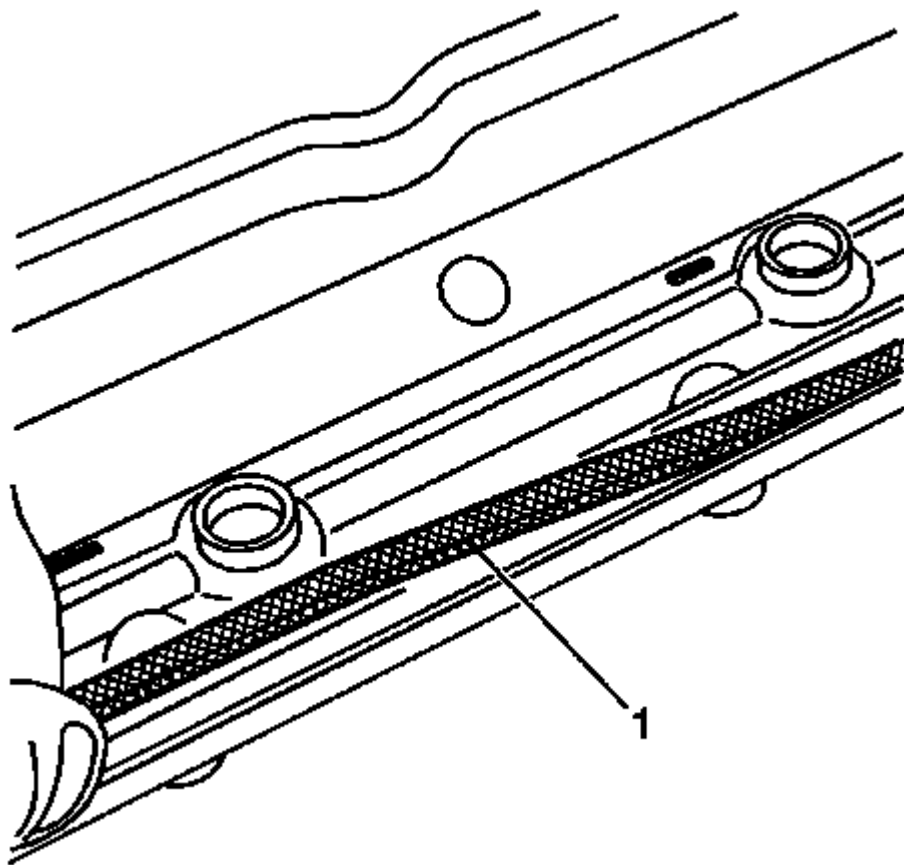


Fig. 57: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket (1) into the valve rocker cover lip.

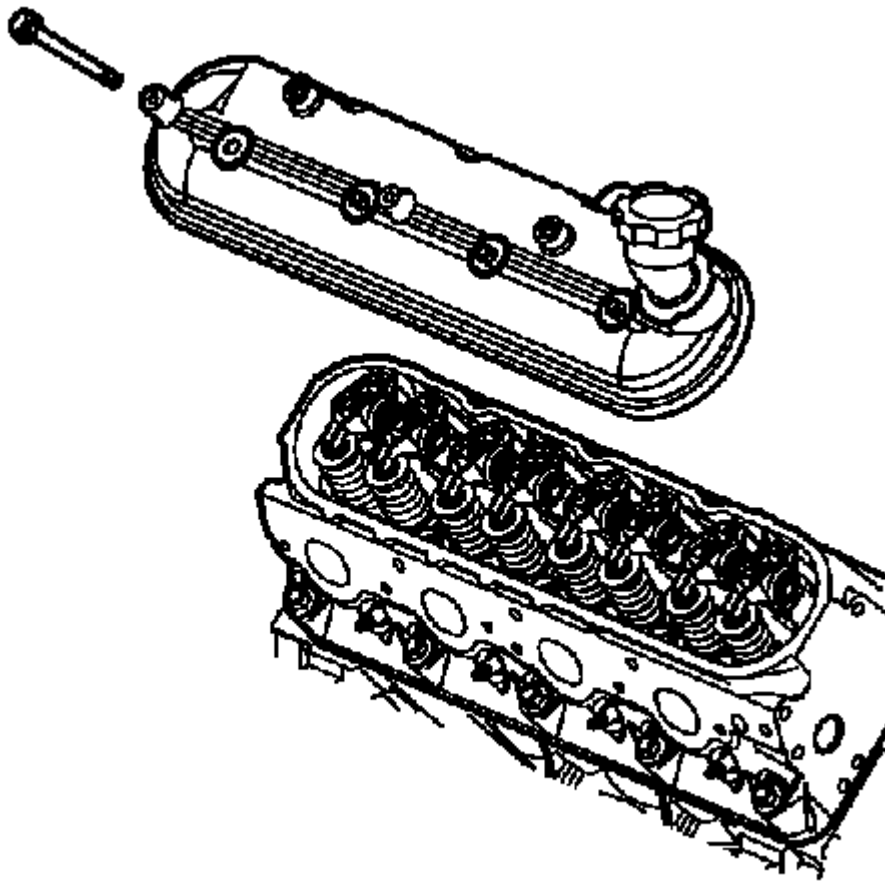


Fig. 58: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the rocker arm cover bolts.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

4. Install a new oil fill tube into the rocker arm cover.

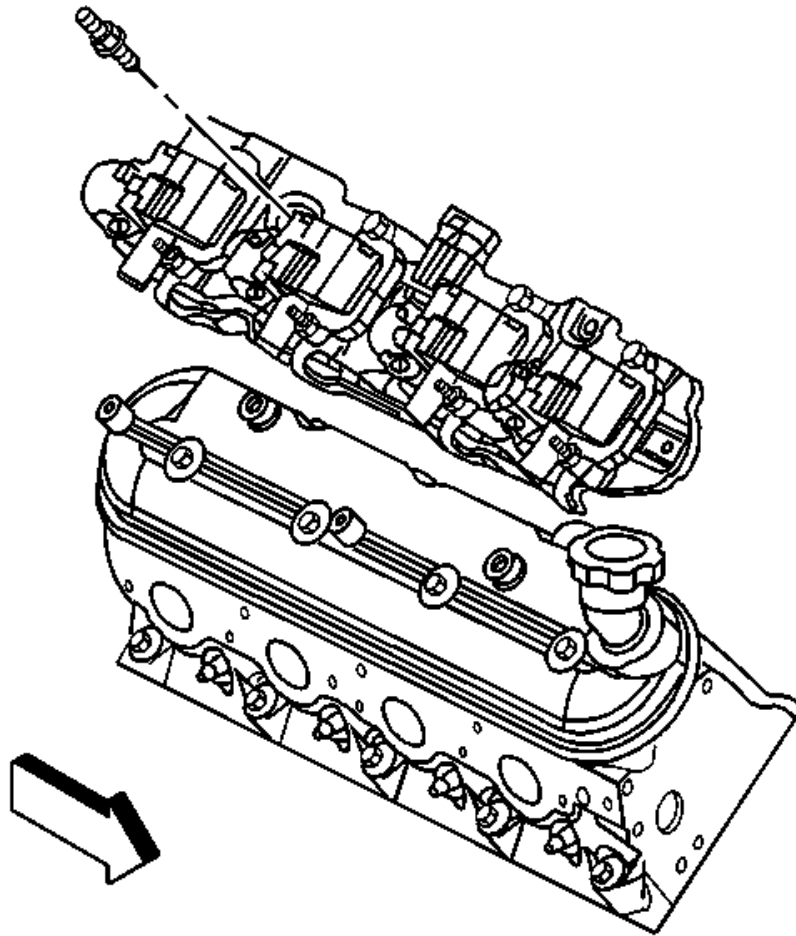


Fig. 59: Locating Ignition Coil Bracket Studs
Courtesy of GENERAL MOTORS CORP.

5. Install the ignition coil assembly. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 6.0L.
6. Install the crankcase ventilation hoses/pipes. Refer to **Crankcase Ventilation Hoses/Pipes Replacement**.
7. Install the engine sight cover. Refer to **Engine Sight Shield Replacement**.
8. Install the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

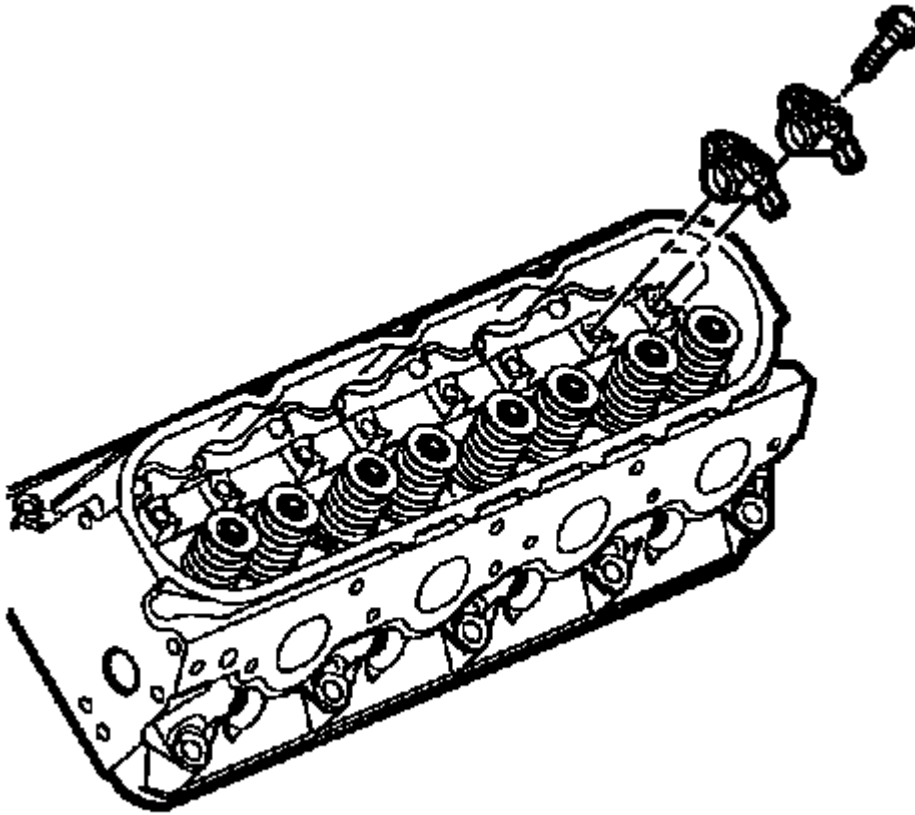


Fig. 60: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the valve rocker arm covers. Refer to [Valve Rocker Arm Cover Replacement - Left](#) or [Valve Rocker Arm Cover Replacement - Right](#).
2. Remove the valve rocker arm bolts.
3. Remove the valve rocker arms.

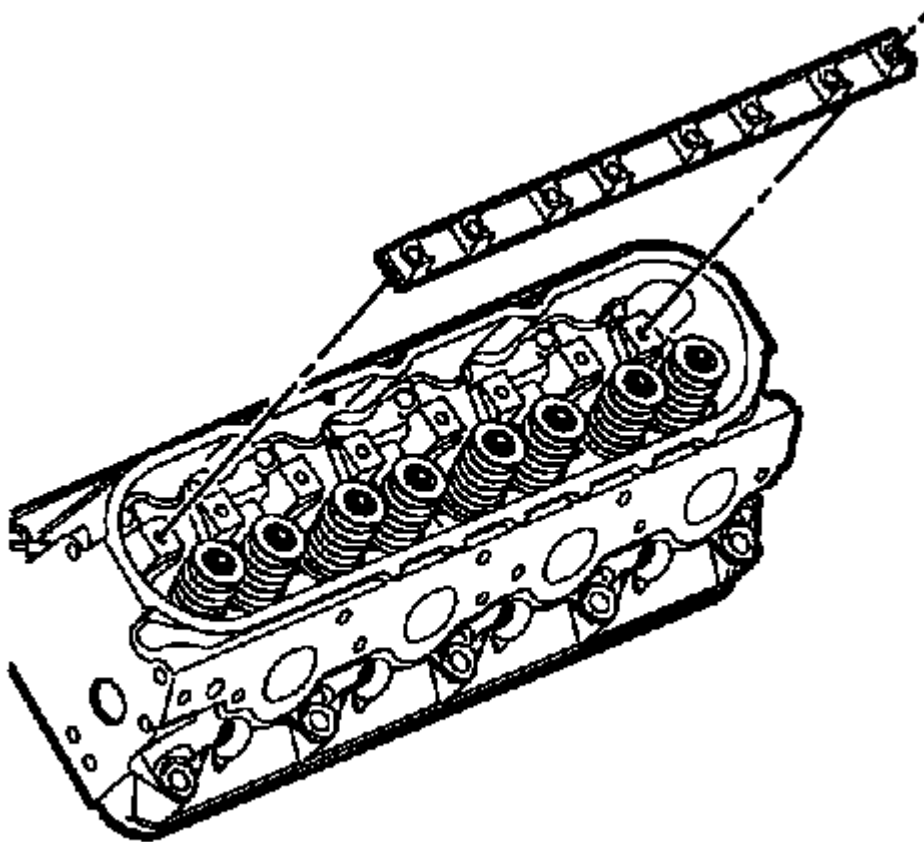


Fig. 61: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm pivot support.

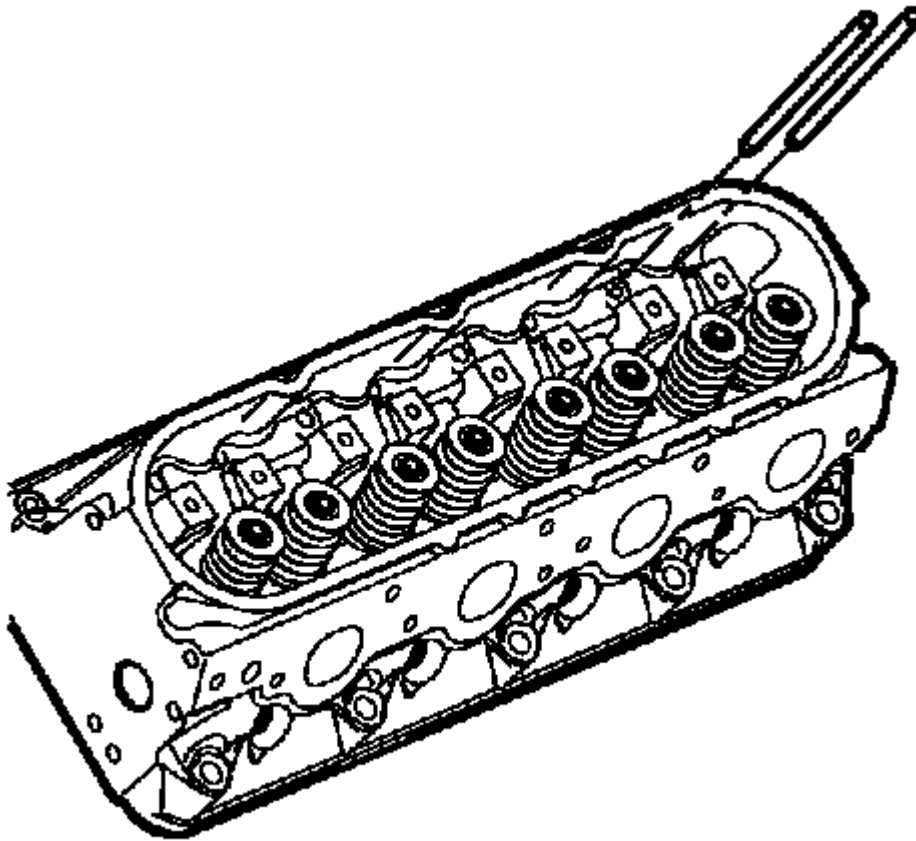


Fig. 62: View Of Pushrods

Courtesy of GENERAL MOTORS CORP.

5. Remove the pushrods.
6. Clean and inspect the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection.**

Installation Procedure

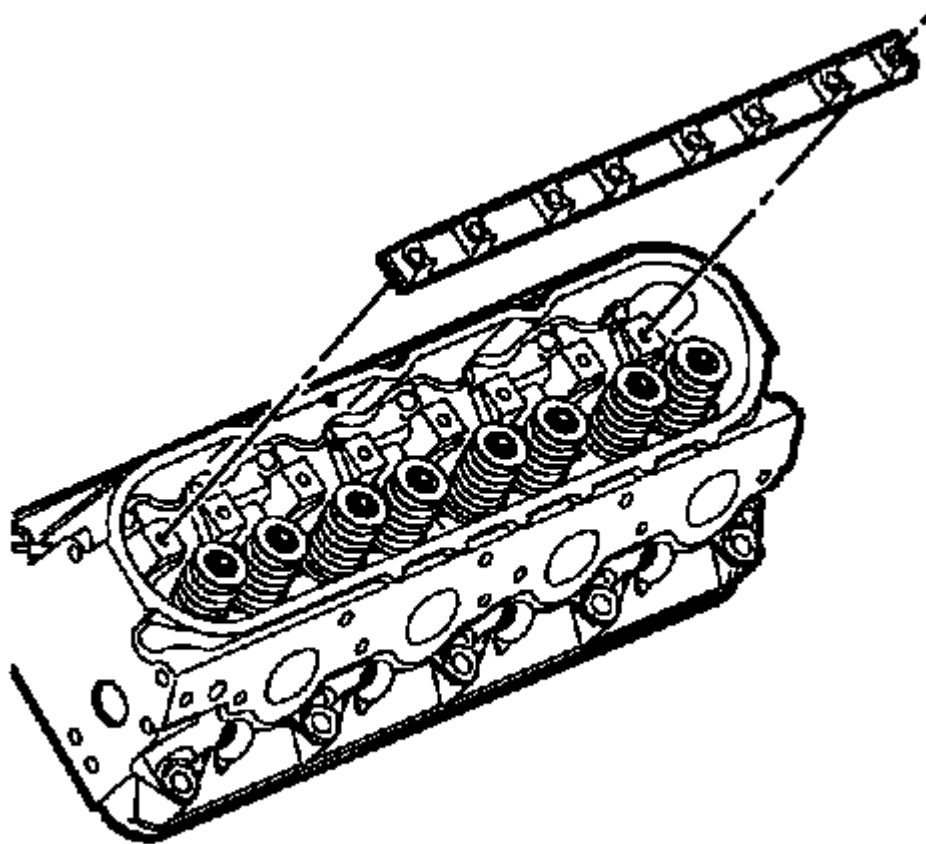


Fig. 63: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

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.
3. Install the valve rocker arm pivot support.

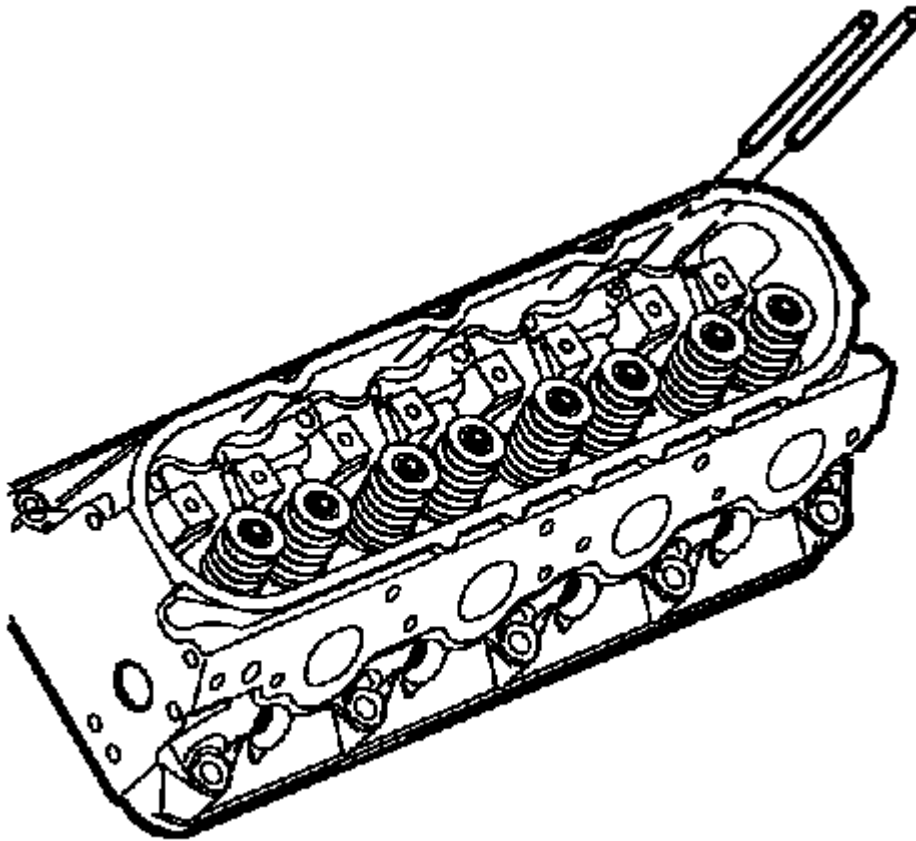


Fig. 64: View Of Pushrods

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

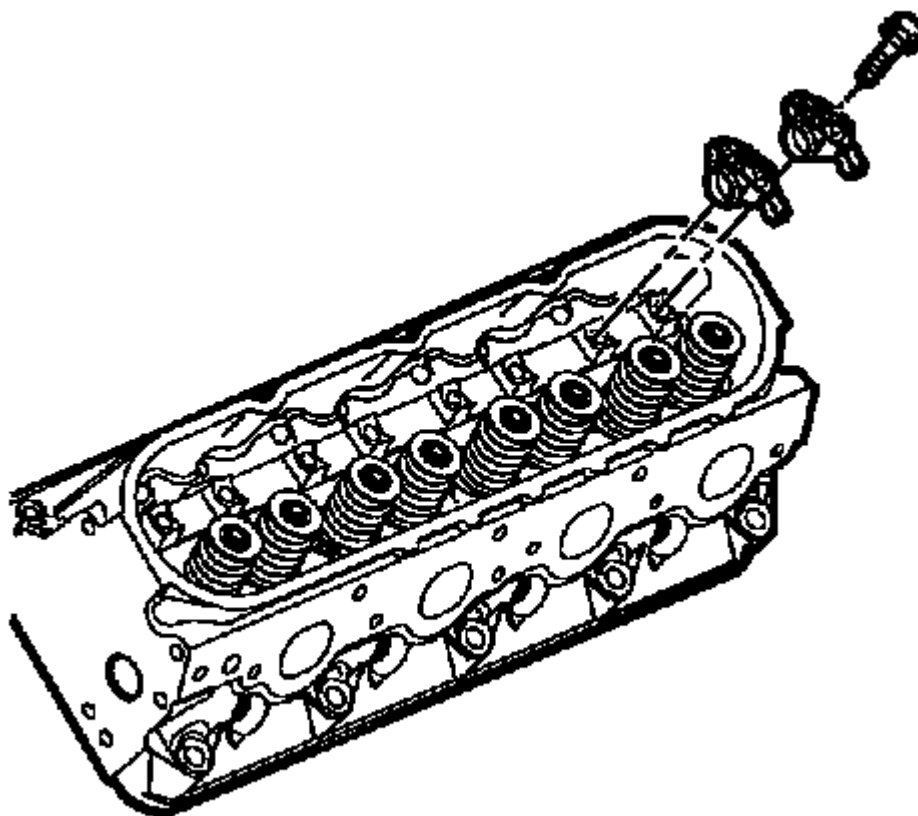


Fig. 65: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

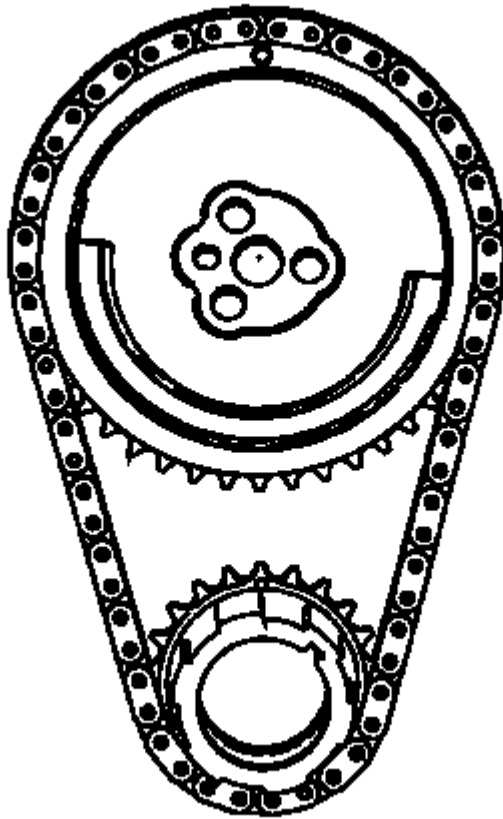


Fig. 66: Camshaft And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number one piston is at top dead center of 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 position. The camshaft and crankshaft sprocket alignment marks will be in the 12 o'clock positions. 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 in Cautions and Notices.

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

Tighten:

- Tighten exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
- Tighten 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 exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

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

Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- **J 22794** Spark Plug Port Adapter
- **J 38606** Valve Spring Compressor (Head-on)

Removal Procedure

1. Remove the valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Remove the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 6.0L.

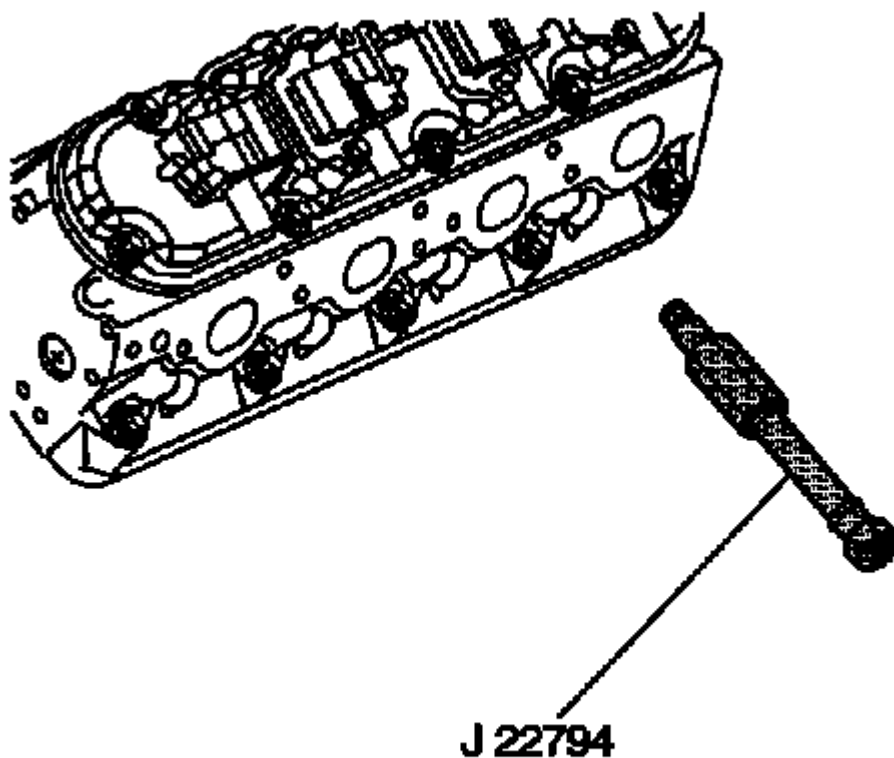


Fig. 67: Identifying J 22794

Courtesy of GENERAL MOTORS CORP.

3. Install the **J 22794** into the spark plug hole.
4. Attach an air hose to **J 22794**.
5. Tap the end of the valve stem with a plastic face hammer in order to loosen any varnish on the valve stem keys.

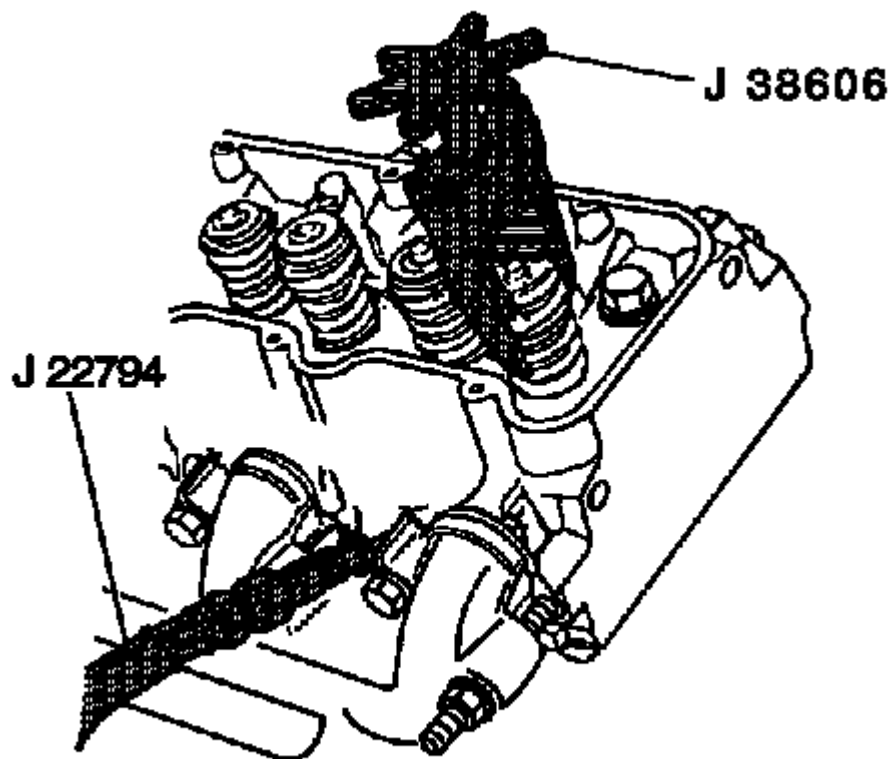


Fig. 68: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

6. Use the **J 38606** in order to compress the valve spring.

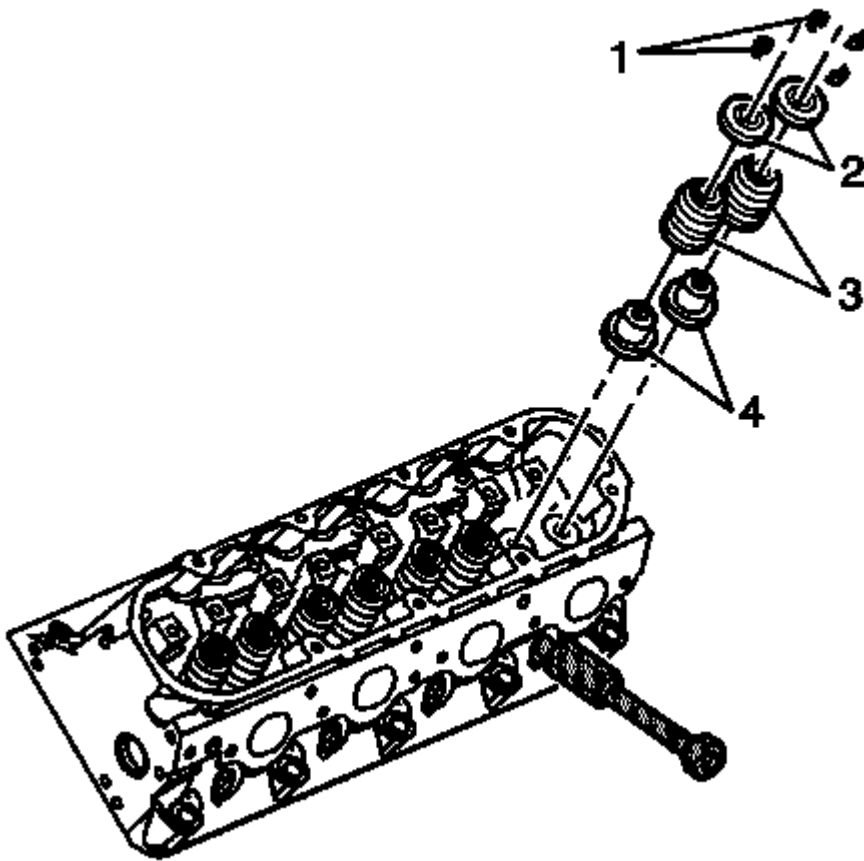


Fig. 69: Valve Stem Keys, Spring, Cap & Shim
Courtesy of GENERAL MOTORS CORP.

7. Remove the valve stem keys (1).
8. Carefully release the valve spring tension.
9. Remove the **J 38606**.
10. Remove the valve spring cap (2).
11. Remove the valve spring (3).
12. Remove the valve stem oil seal and shim (4).

Installation Procedure

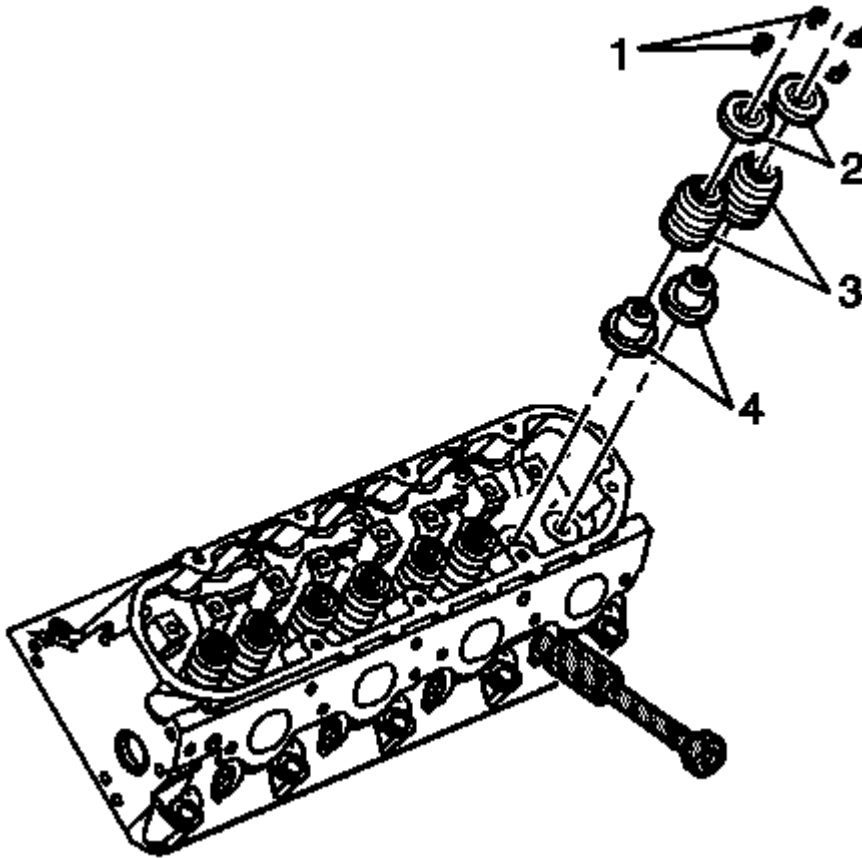


Fig. 70: Valve Stem Keys, Spring, Cap & Shim
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring seat and/or shim area.
2. Install the valve stem oil seal and shim (2).

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, and increased vehicle emissions.

3. Install the valve stem oil seal onto the guide.
 1. Lubricate the valve guide and valve stem oil seal with clean engine oil.
 2. Install the valve stem oil seal onto the valve stem. Push the seal down until the seal contacts the valve guide.

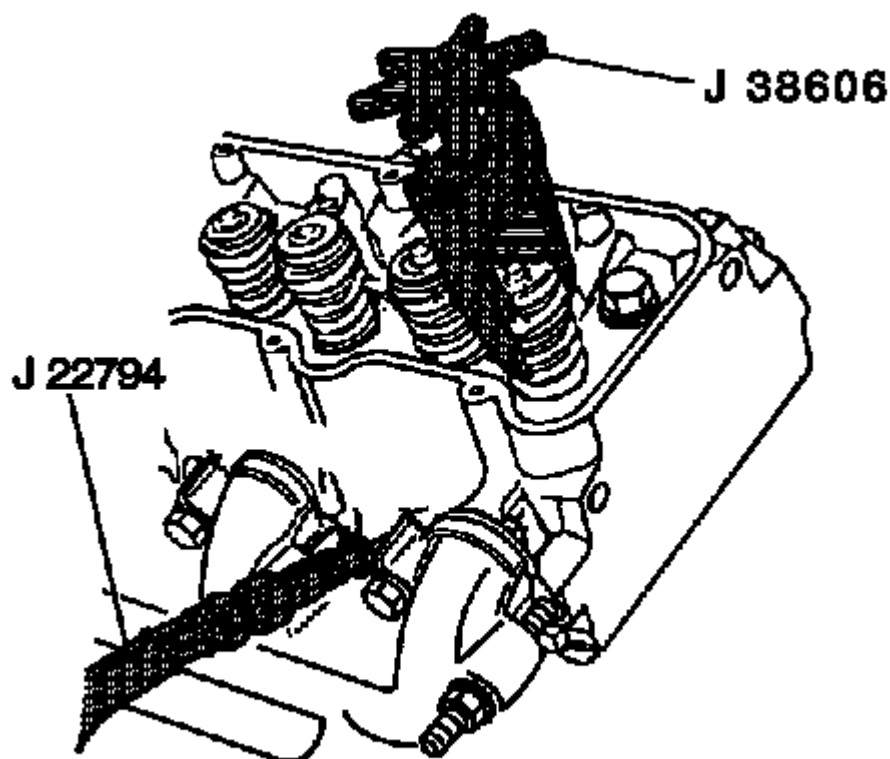


Fig. 71: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

4. Install the valve spring to the **J 38606** .
5. Compress the valve spring using the **J 38606** .
6. Install the valve spring to the cylinder head.

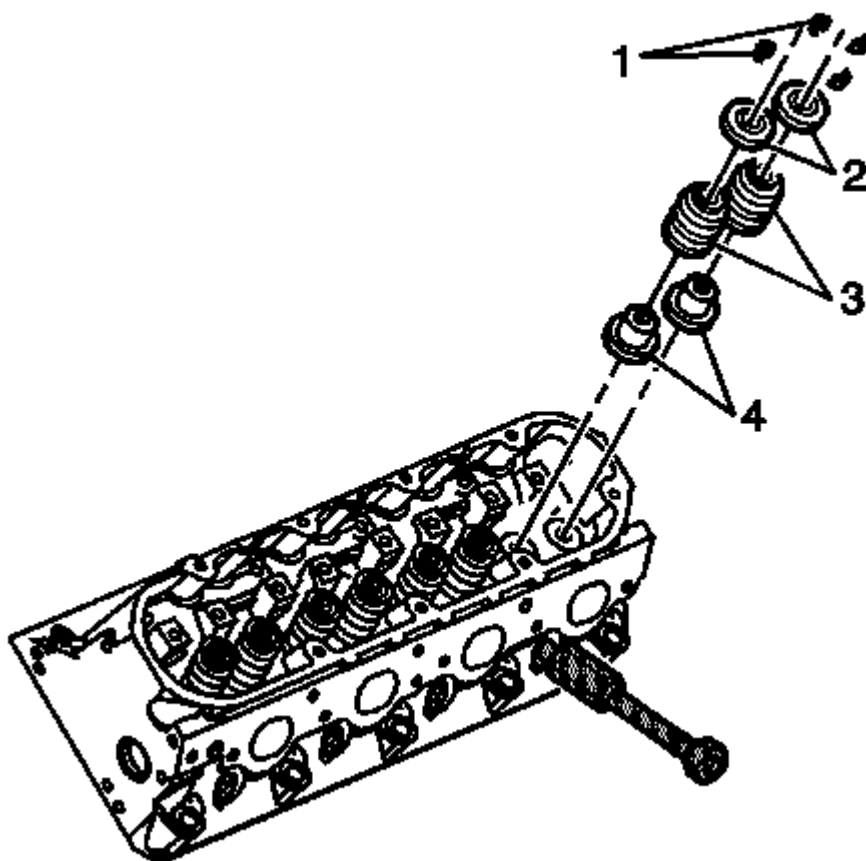


Fig. 72: Valve Stem Keys, Spring, Cap & Shim
Courtesy of GENERAL MOTORS CORP.

7. Install the valve spring cap (2).
8. Install the valve stem keys (1).
 1. Use grease to hold the keys (1) in place and remove **J 38606**.
 2. Make sure the keys (1) seat properly in the groove of the valve stem.
 3. Carefully release the valve spring pressure, making sure the valve keys stay in place.
 4. Remove the **J 38606**.
 5. Tap the end to the valve stem with a plastic faced hammer to seat the keys, if necessary.

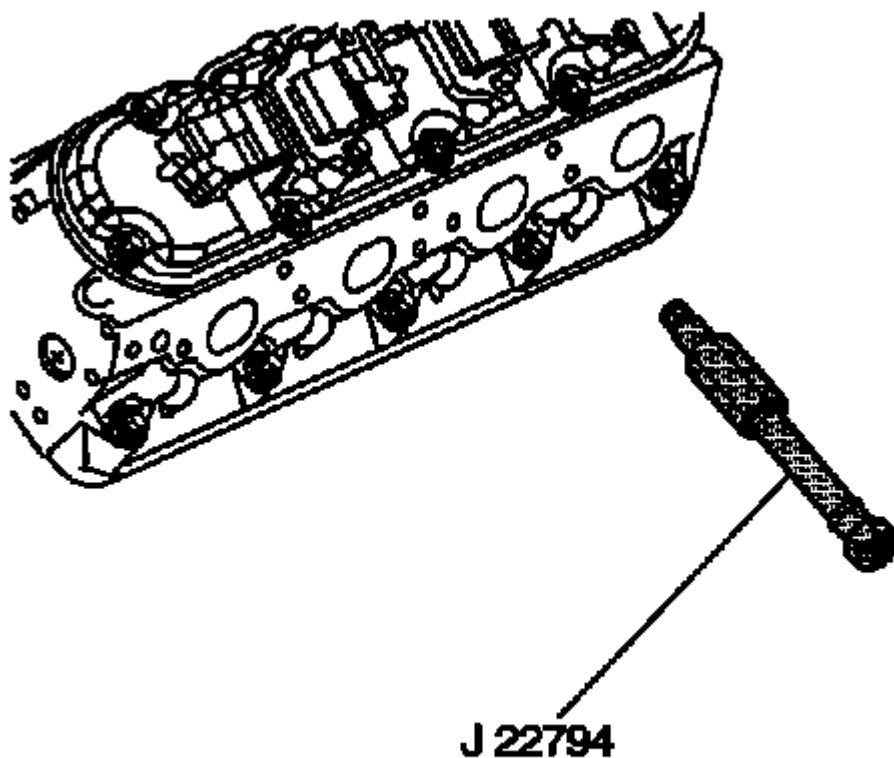


Fig. 73: Identifying J 22794

Courtesy of GENERAL MOTORS CORP.

9. Disconnect and remove the air supply from the **J 22794** .
10. Remove the **J 22794** from the spark plug hole.

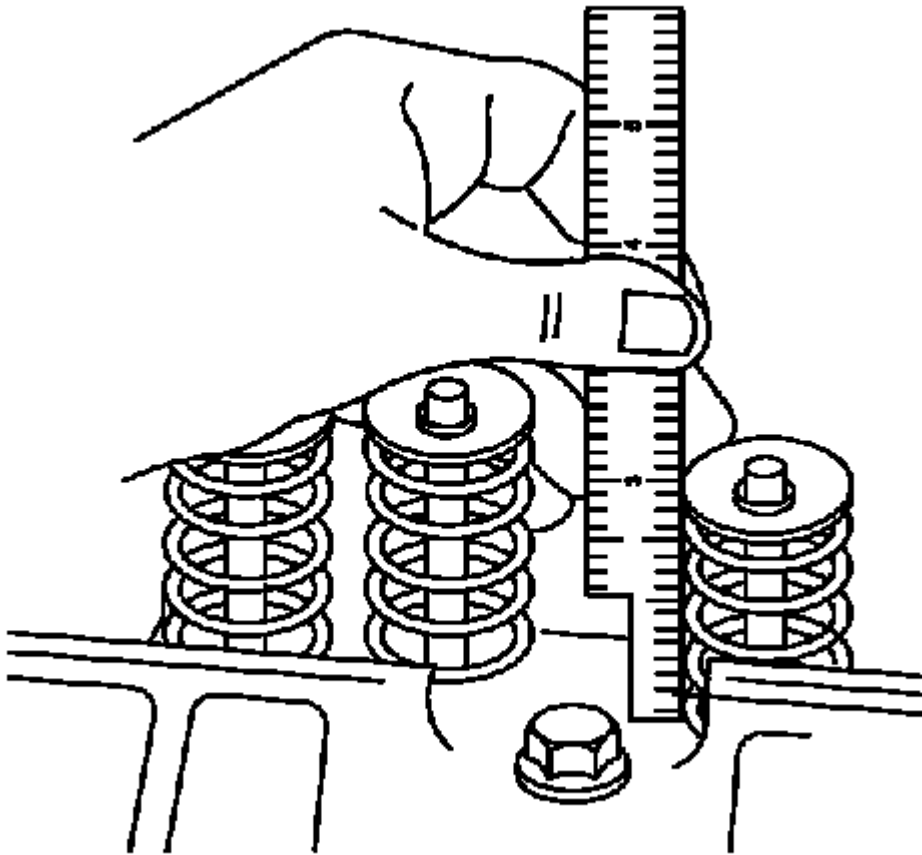


Fig. 74: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

11. Measure the valve spring installed height using a ruler.

Measure from the base of the valve spring to the top of the valve spring.

- 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.

12. Remove the air hose from the **J 22794**.

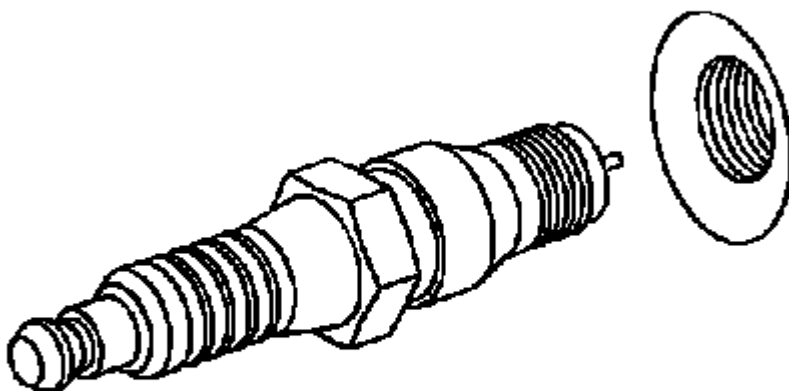


Fig. 75: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

13. Install the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 6.0L.
14. Install the valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Oil Level Indicator and Tube Replacement

Removal Procedure

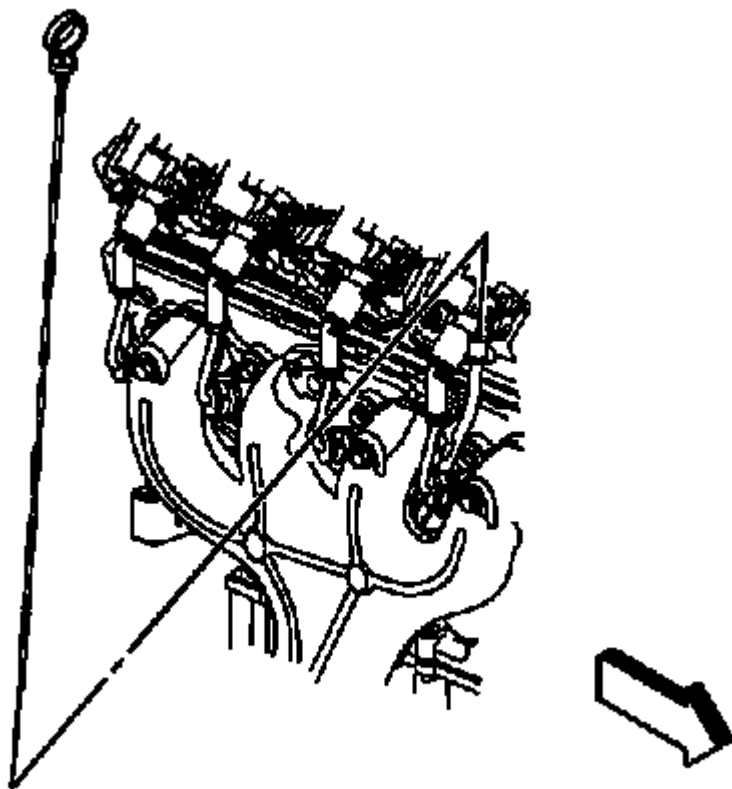


Fig. 76: Oil Level Indicator

Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.

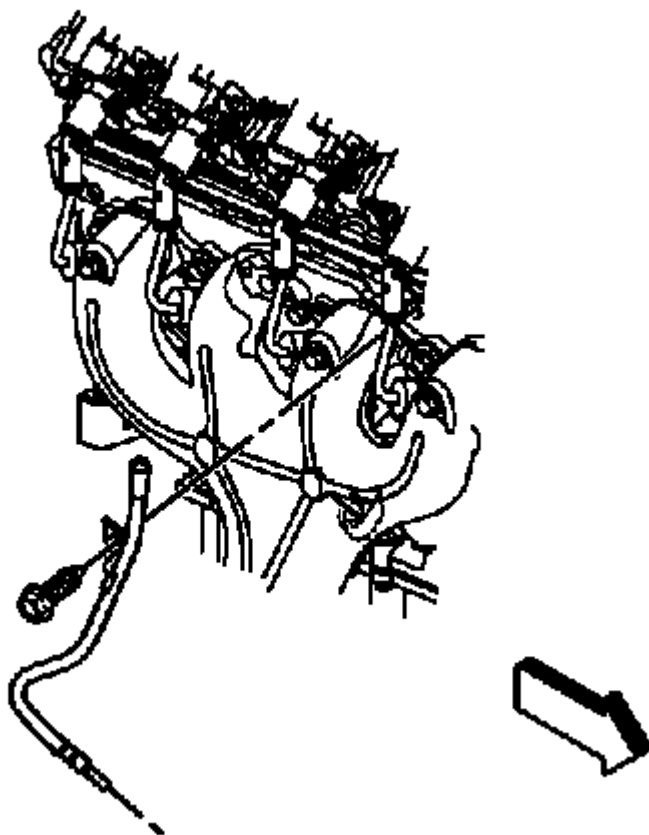


Fig. 77: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

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

4. Remove the O-ring from the oil level indicator tube, if required.

Installation Procedure

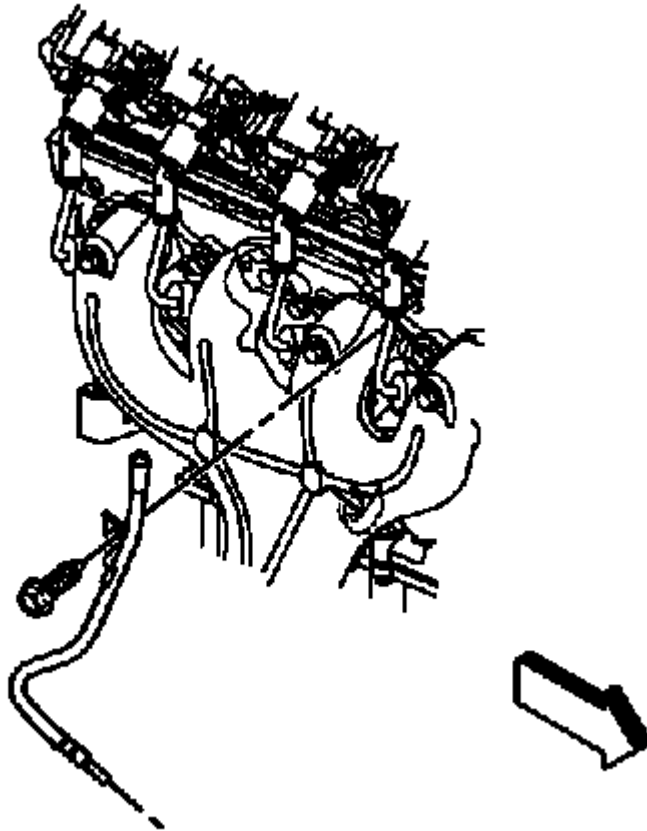


Fig. 78: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the O-ring seal with clean engine oil.
2. Install the oil level indicator tube into position.
3. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Insert the oil level indicator tube into the engine block until the collar is flush with the block.
5. Lower the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the oil level indicator tube bolt.

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

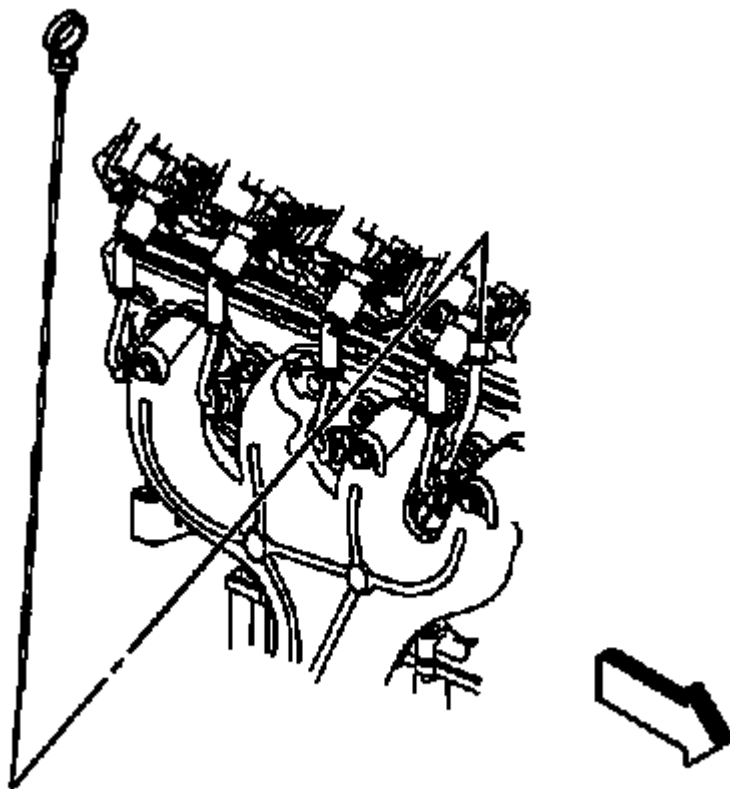


Fig. 79: Oil Level Indicator

Courtesy of GENERAL MOTORS CORP.

7. Install the oil level indicator.
8. Check the oil level and add if necessary.

Cylinder Head Replacement - Left

Tools Required

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

Removal Procedure

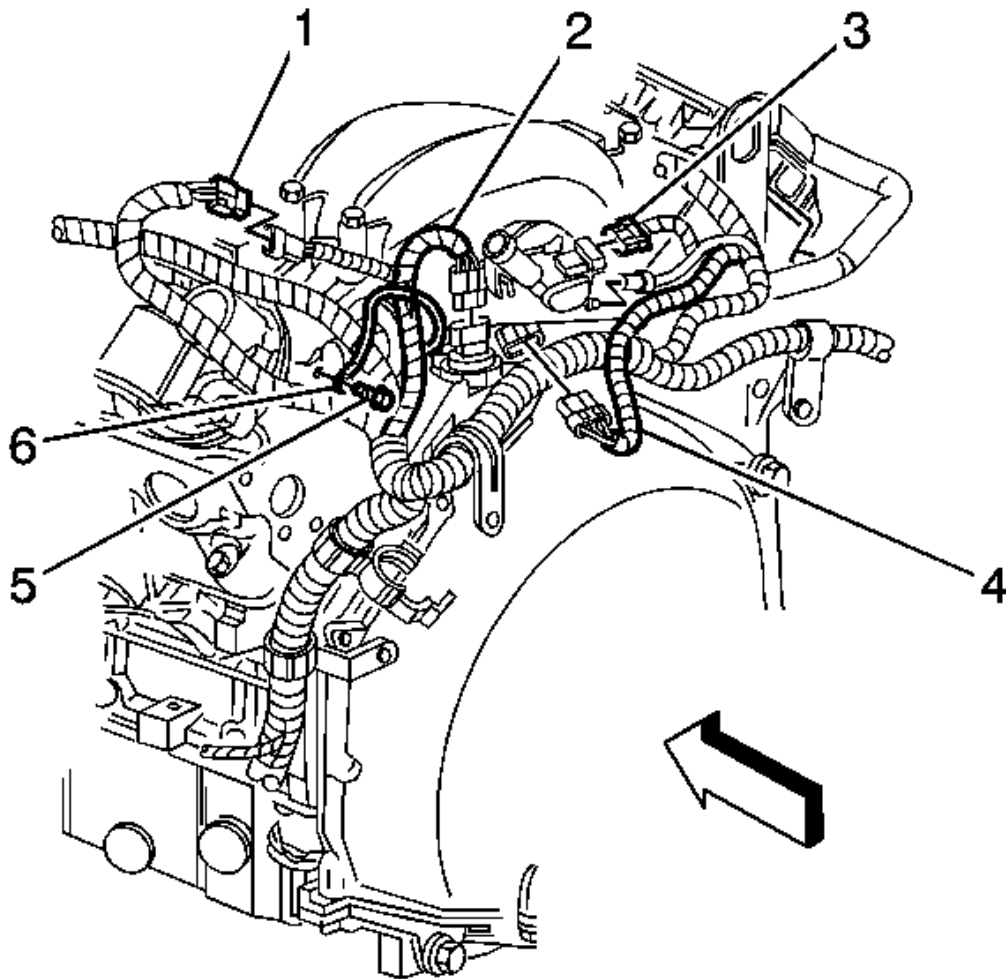


Fig. 80: View Of Harnesses & Connectors At Top & Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Remove the engine coolant air bleed pipe and cover. Refer to **Coolant Air Bleed Pipe Assembly Replacement** in Engine Cooling.
3. Remove the generator bracket. Refer to **Generator Bracket Replacement** in Engine Electrical.
4. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
5. Remove the engine wiring harness strap and the wiring harness ground bolt (5) from the rear of the left cylinder head.
6. Reposition the engine wire harness ground strap (6) away from the cylinder head.

7. Remove the power steering pump. Refer to **Power Steering Pump Replacement** in Power Steering System.
8. Remove the power steering pump bracket. Refer to **Power Steering Pump Bracket Replacement** in Power Steering System.
9. Remove the coolant temperature sensor. Refer to **Engine Coolant Temperature (ECT) Sensor Replacement** .

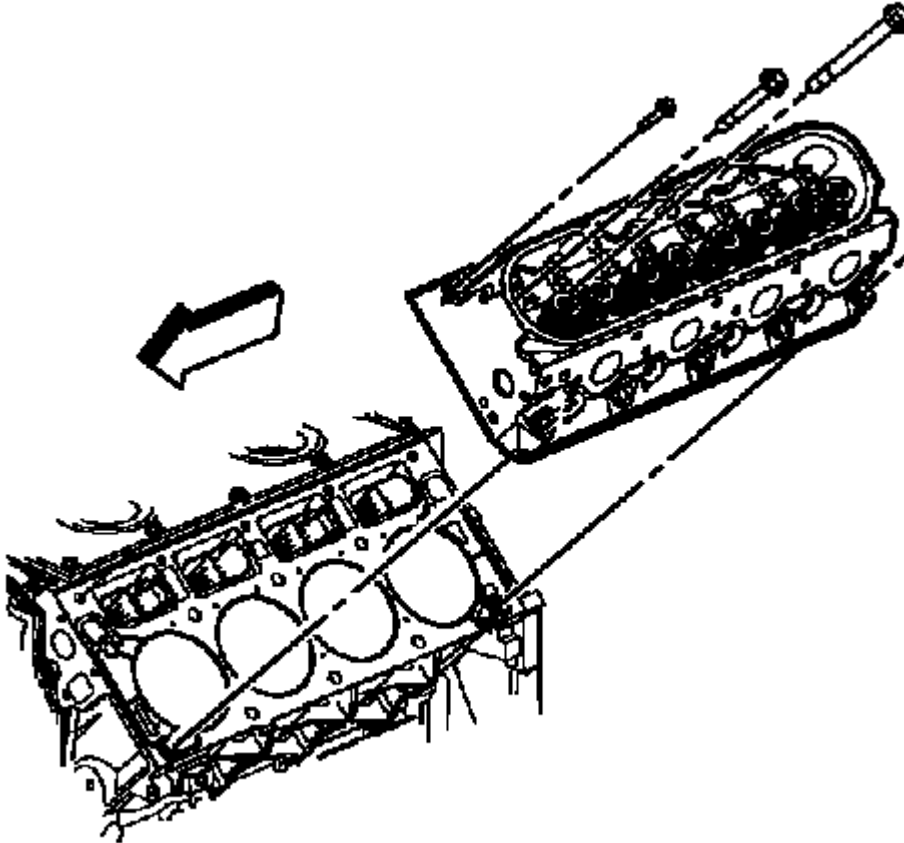


Fig. 81: View Of Cylinder Head & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are NOT reusable.

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

10. Remove the cylinder head bolts.
11. Remove the cylinder head.

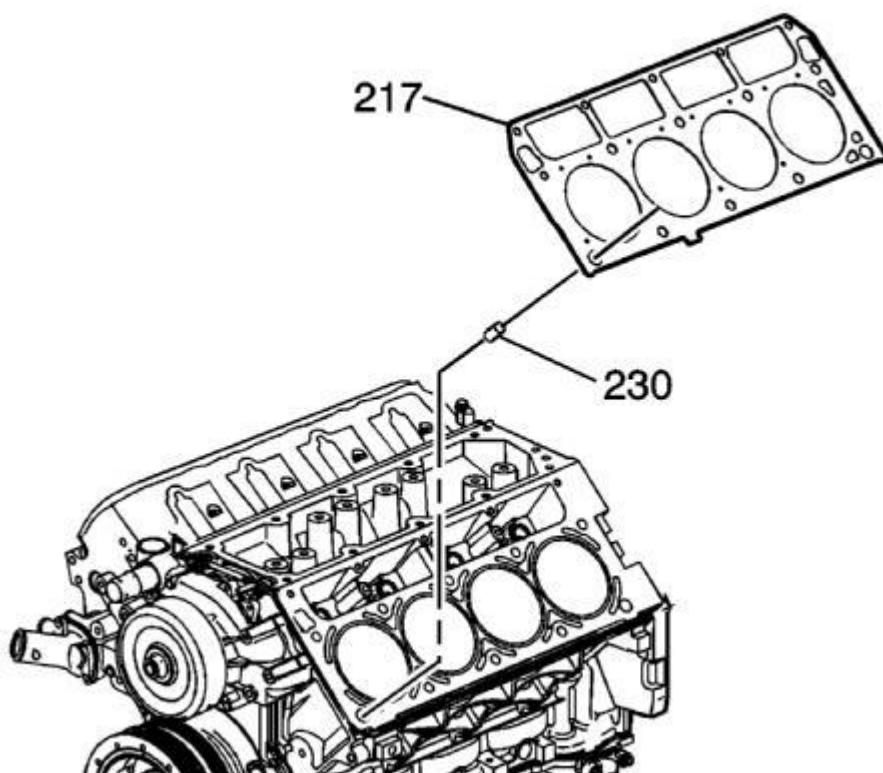


Fig. 82: View Of Cylinder Head Gasket And Alignment Pin - Left
Courtesy of GENERAL MOTORS CORP.

12. Remove the cylinder head gasket.
13. Discard the gasket (217).
14. Discard the M11 cylinder head bolts.
15. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

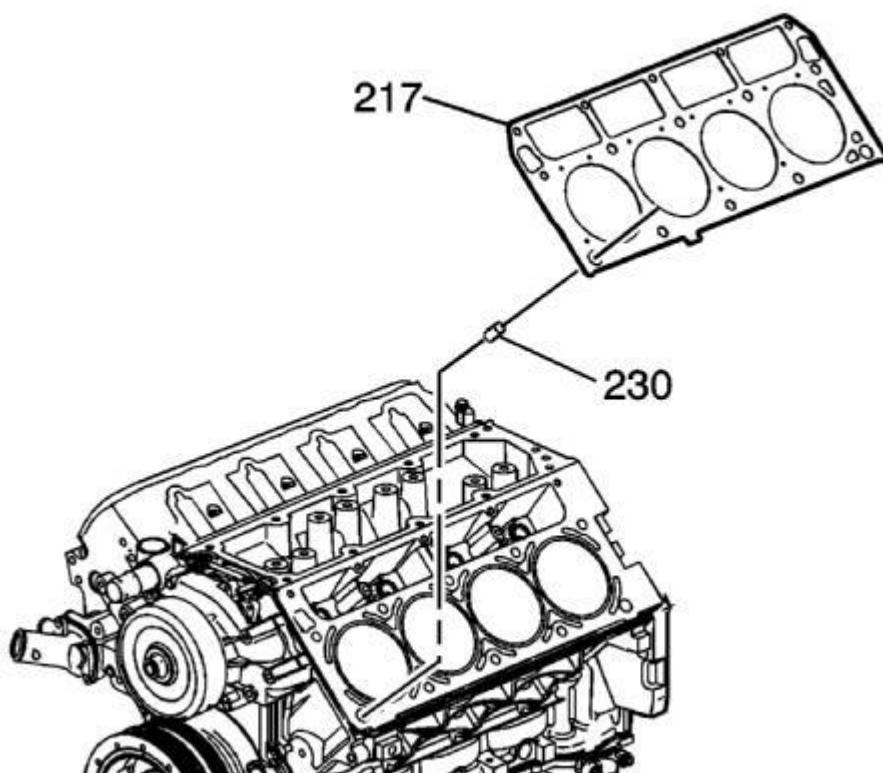


Fig. 83: View Of Cylinder Head Gasket And Alignment Pin - Left
Courtesy of GENERAL MOTORS CORP.

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

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 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).

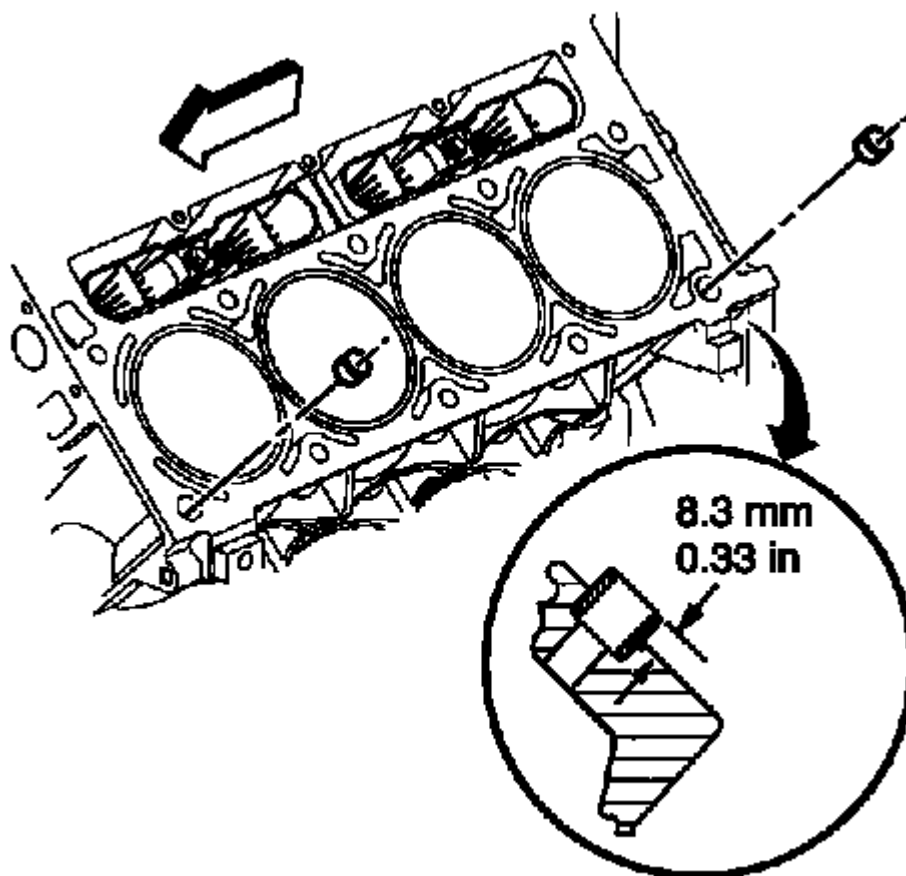


Fig. 84: Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

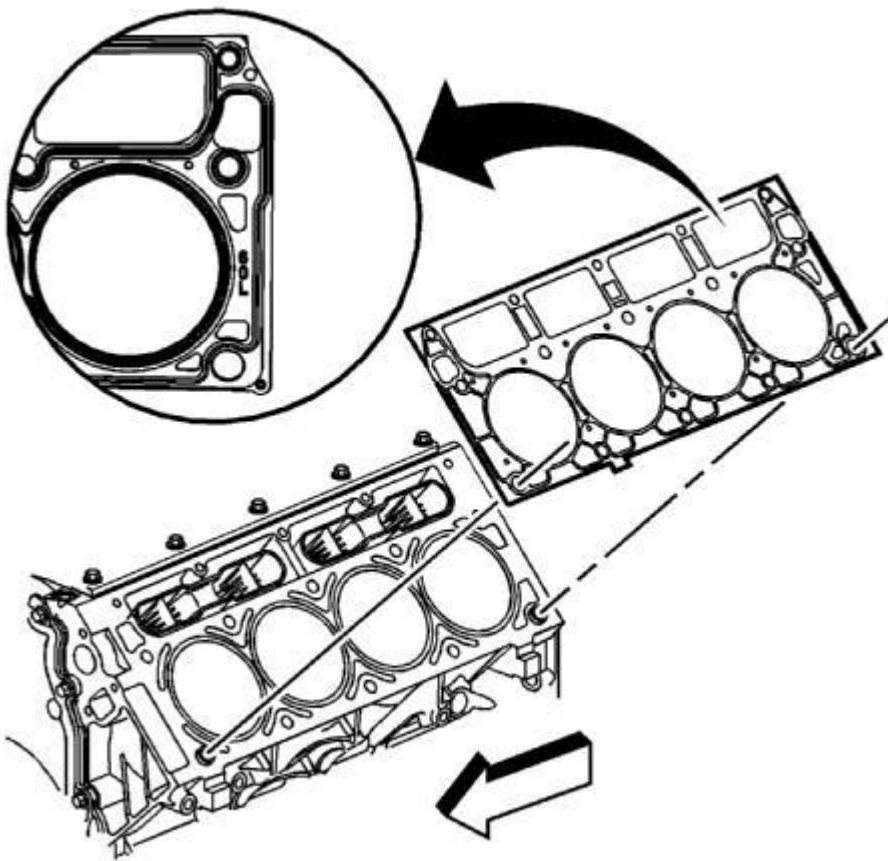


Fig. 85: Gasket Displacement Markings - Left
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the gasket for proper usage.

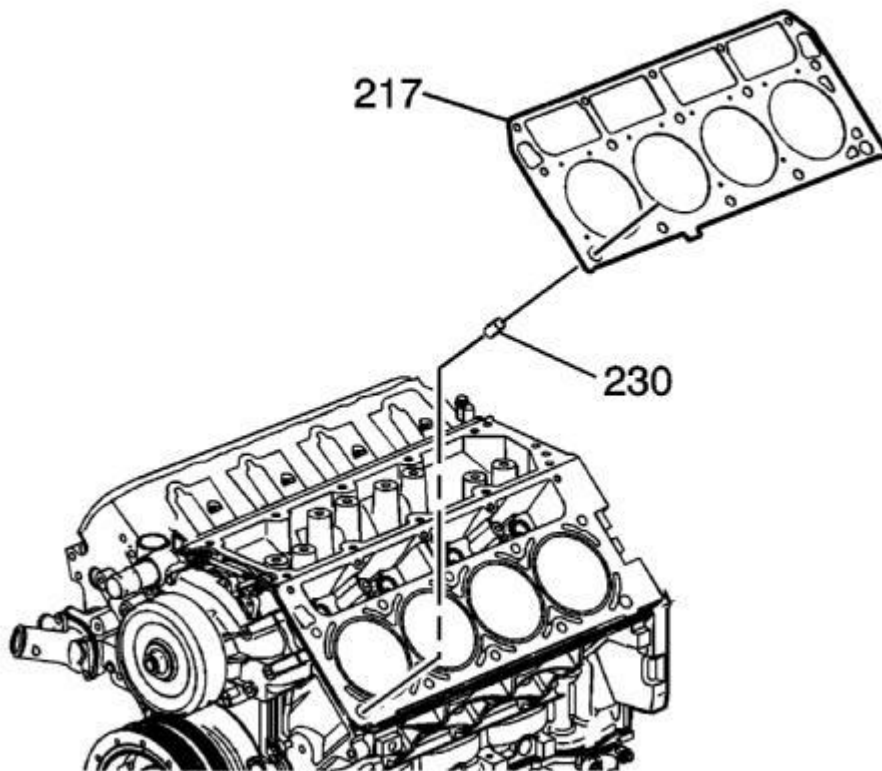


Fig. 86: View Of Cylinder Head Gasket And Alignment Pin - Left
Courtesy of GENERAL MOTORS CORP.

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

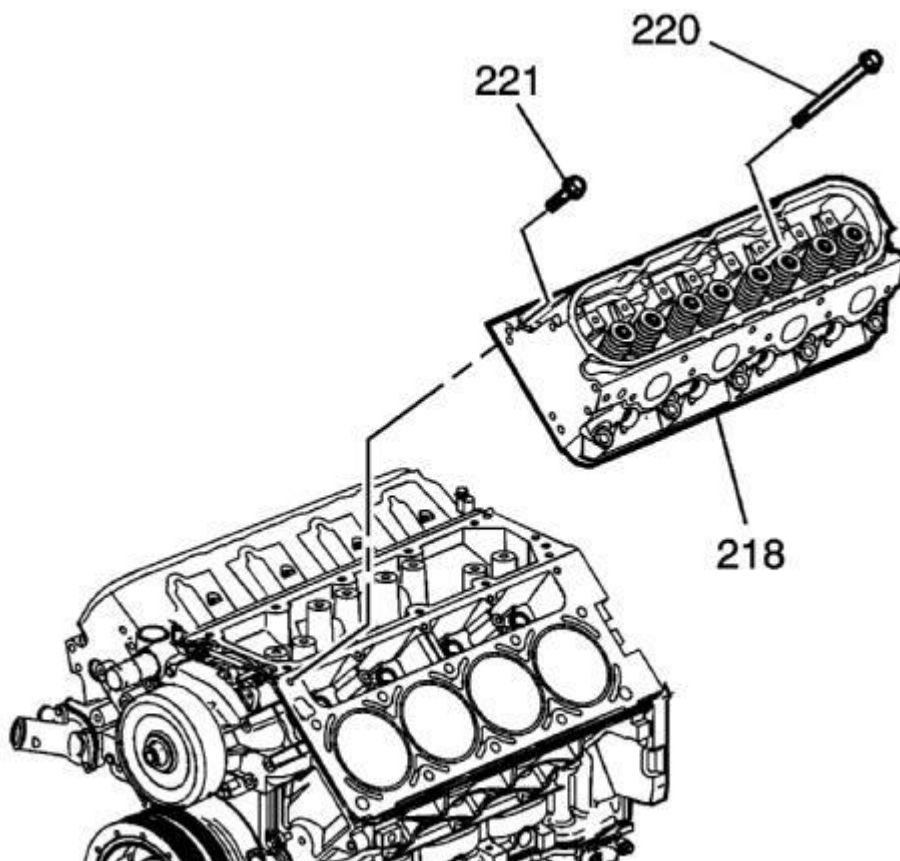


Fig. 87: Cylinder Head & Bolts

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 (219, 220).

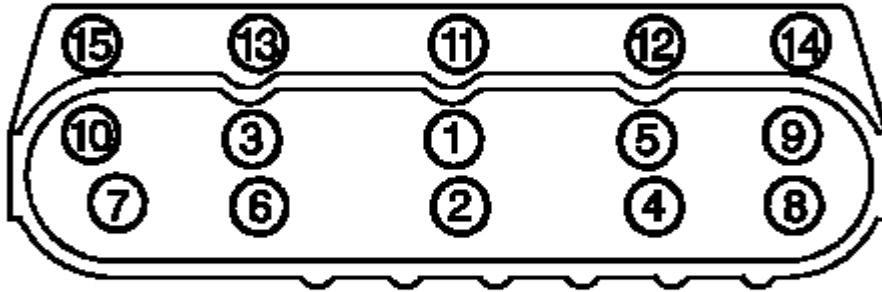


Fig. 88: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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.

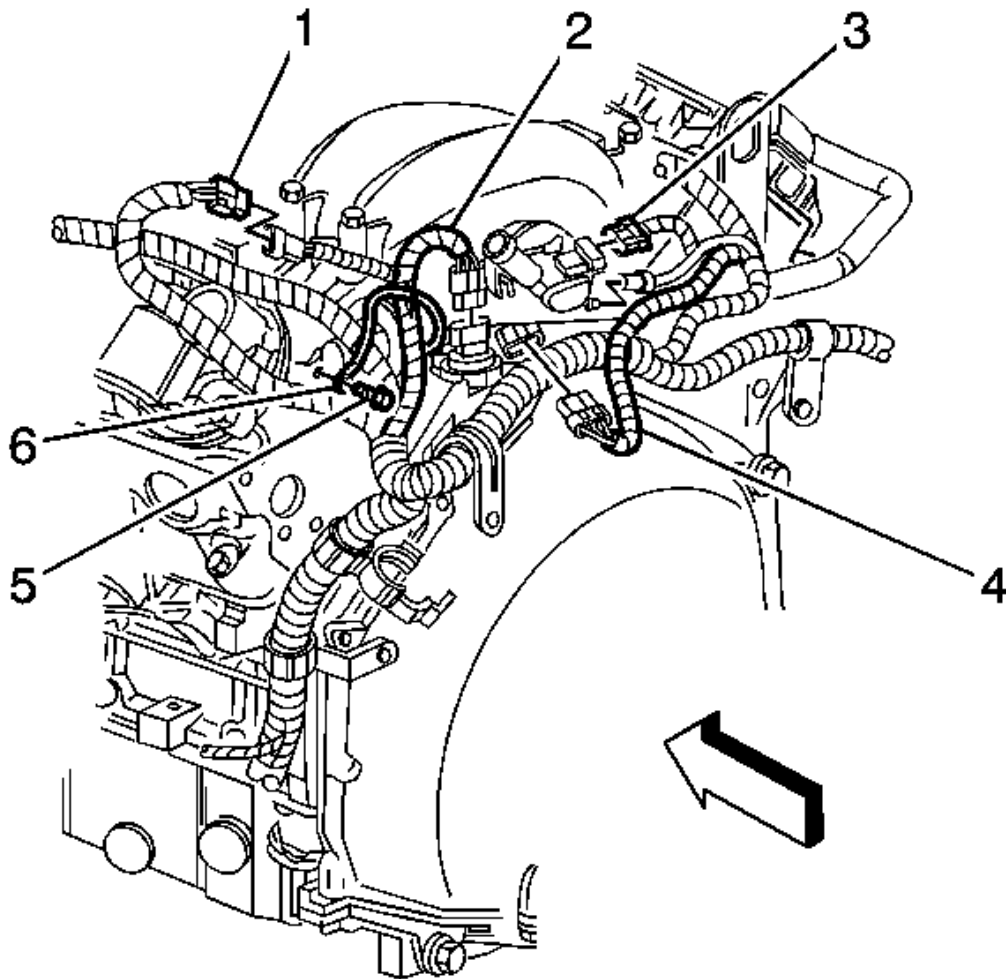


Fig. 89: View Of Harnesses & Connectors At Top & Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

11. Install the coolant temperature sensor. Refer to **Engine Coolant Temperature (ECT) Sensor Replacement**.
12. Position the engine wire harness ground strap (6) against the cylinder head.
13. Install the engine wiring harness ground bolt (5) to the rear of the left cylinder head.

Tighten: Tighten the engine wire harness ground bolt to 32 N.m (24 lb ft).

14. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
15. Install the power steering pump bracket. Refer to **Power Steering Pump Bracket Replacement** in Power

Steering System.

16. Install the power steering pump. Refer to **Power Steering Pump Replacement** in Power Steering System.
17. Install the generator bracket. Refer to **Generator Bracket Replacement** in Engine Electrical.
18. Install the engine coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** in Engine Cooling.
19. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Cylinder Head Replacement - Right

Tools Required

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

Removal Procedure

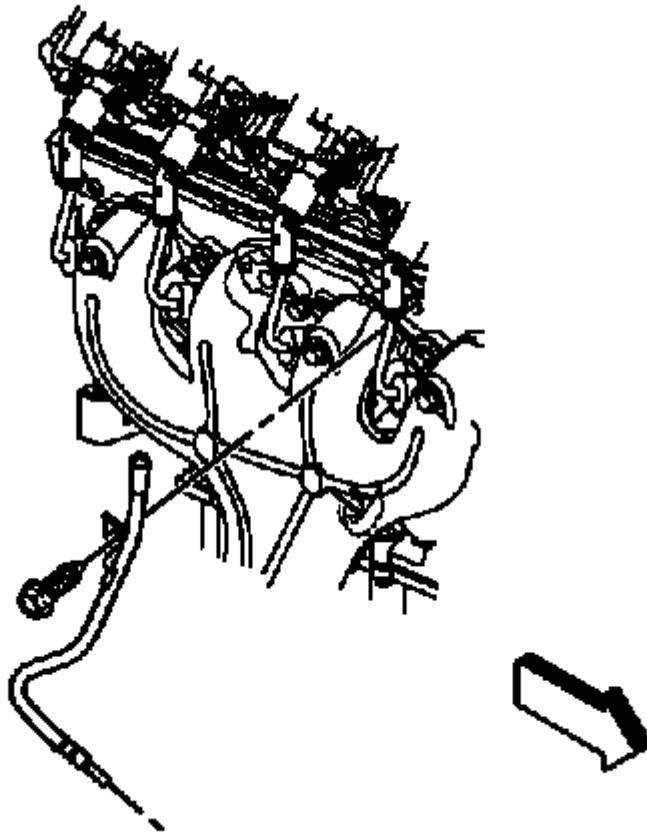


Fig. 90: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the engine coolant air bleed pipe and covers. Refer to **Coolant Air Bleed Pipe Assembly Replacement** in Engine Cooling.
3. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
4. Remove the oil level indicator tube bolt.
5. Reposition the oil level indicator tube, if necessary.
6. Remove the wiring harness from the clip at the rear of the cylinder head.

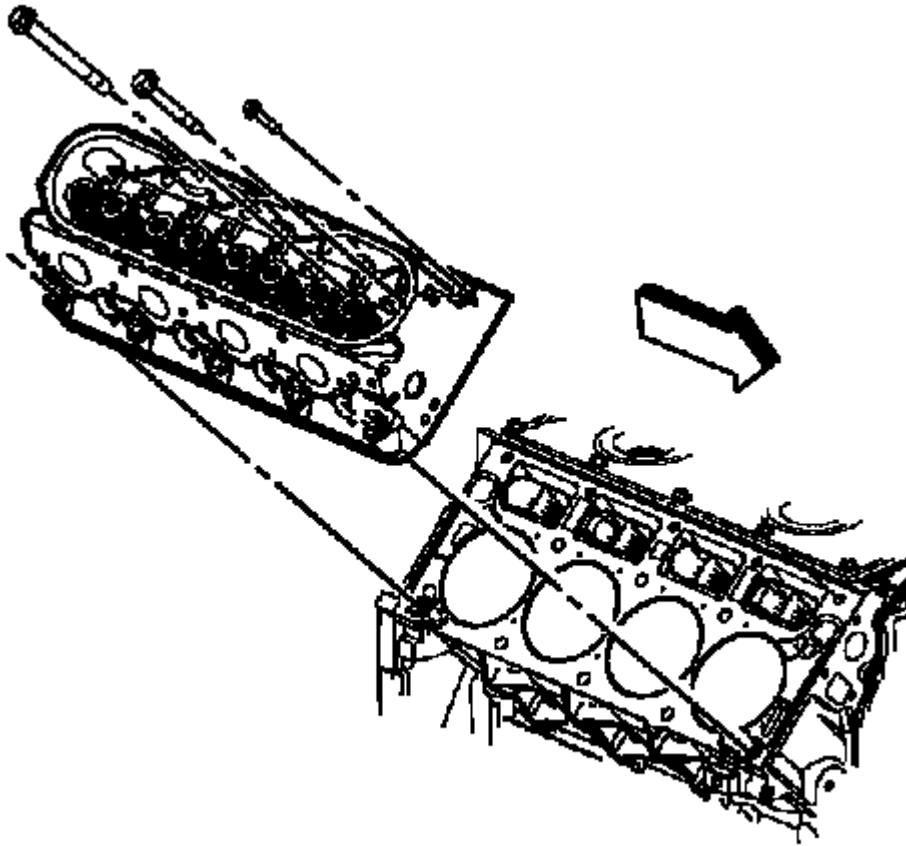


Fig. 91: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are NOT reusable.

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

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

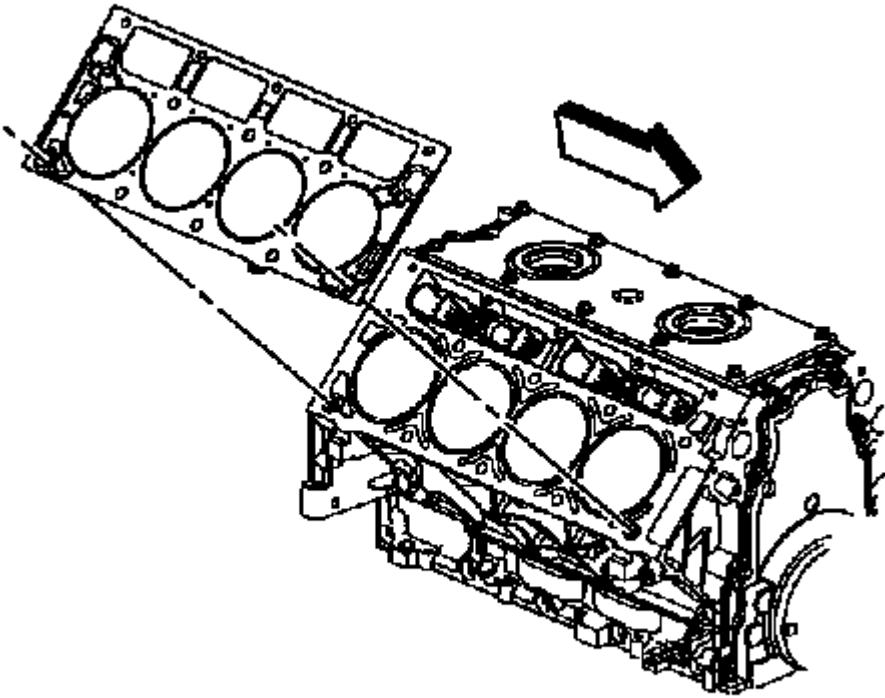


Fig. 92: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

9. Remove the cylinder head gasket.
10. Discard the gasket.
11. Discard the cylinder head bolts.
12. 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 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.

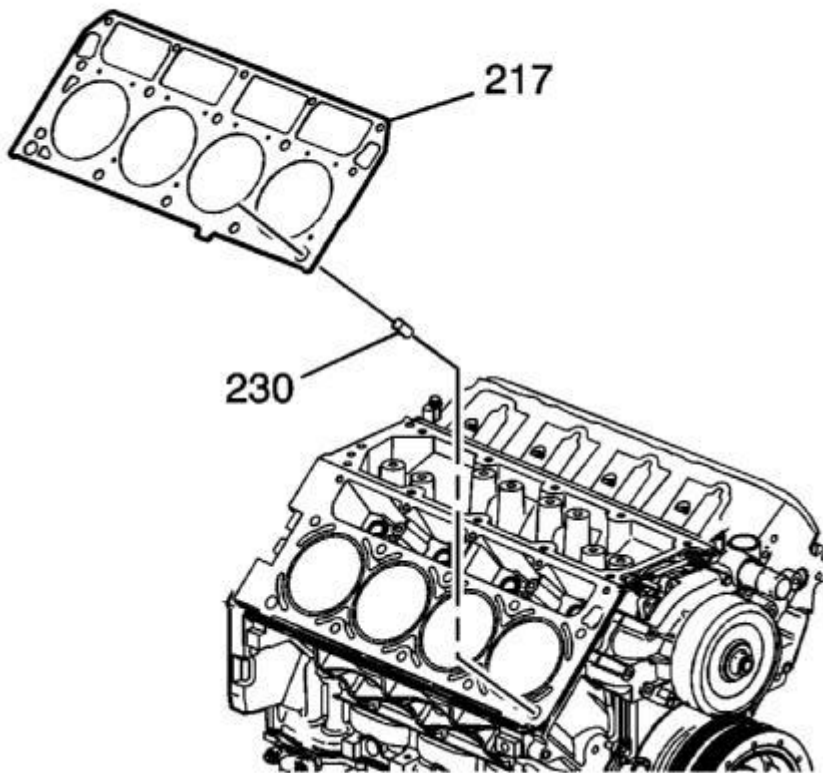


Fig. 93: Cylinder Head Gasket & Locating Pins - Right
Courtesy of GENERAL MOTORS CORP.

4. Install the cylinder head locating pins (230).

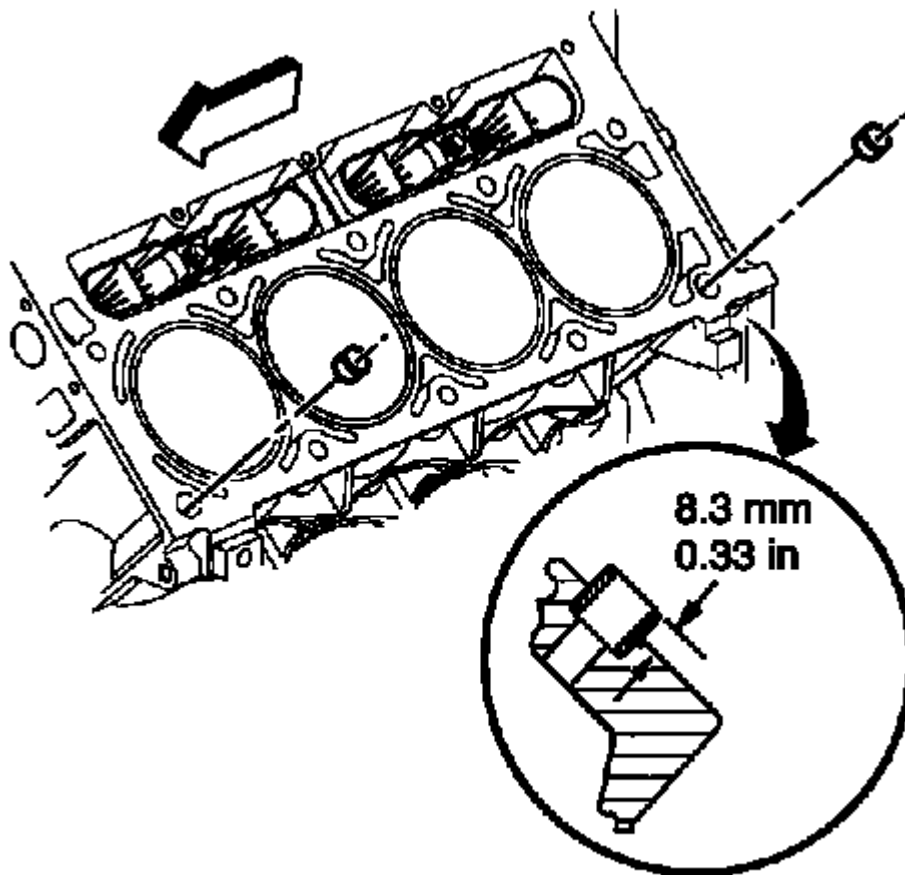


Fig. 94: Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

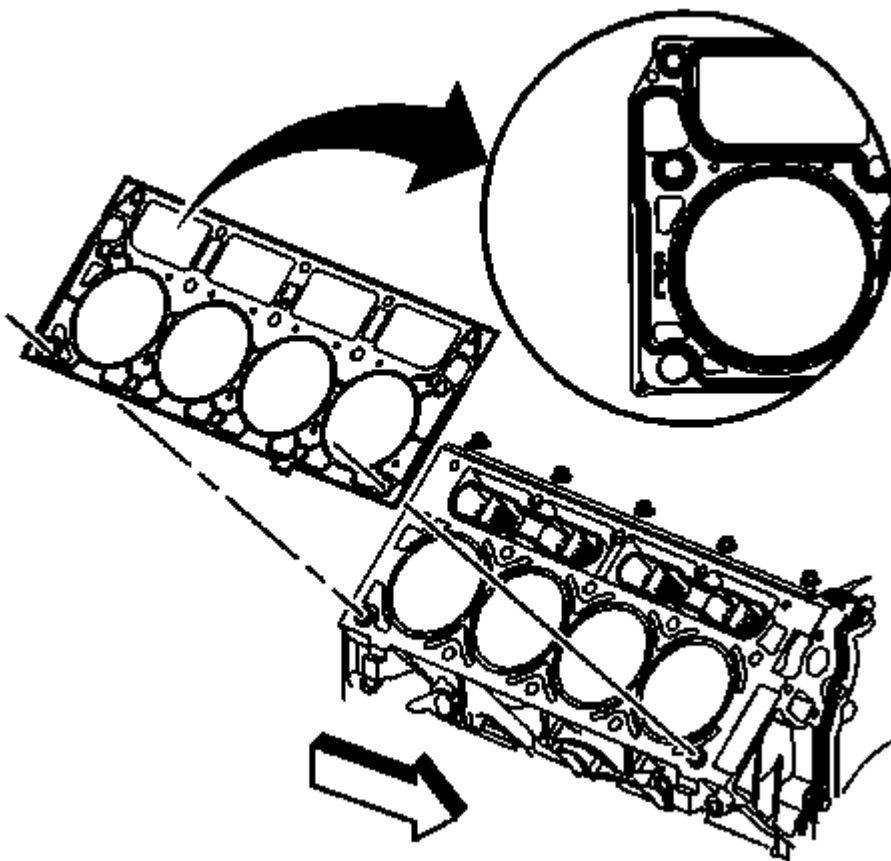


Fig. 95: Gasket Displacement Markings - Right
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the gasket for proper usage.

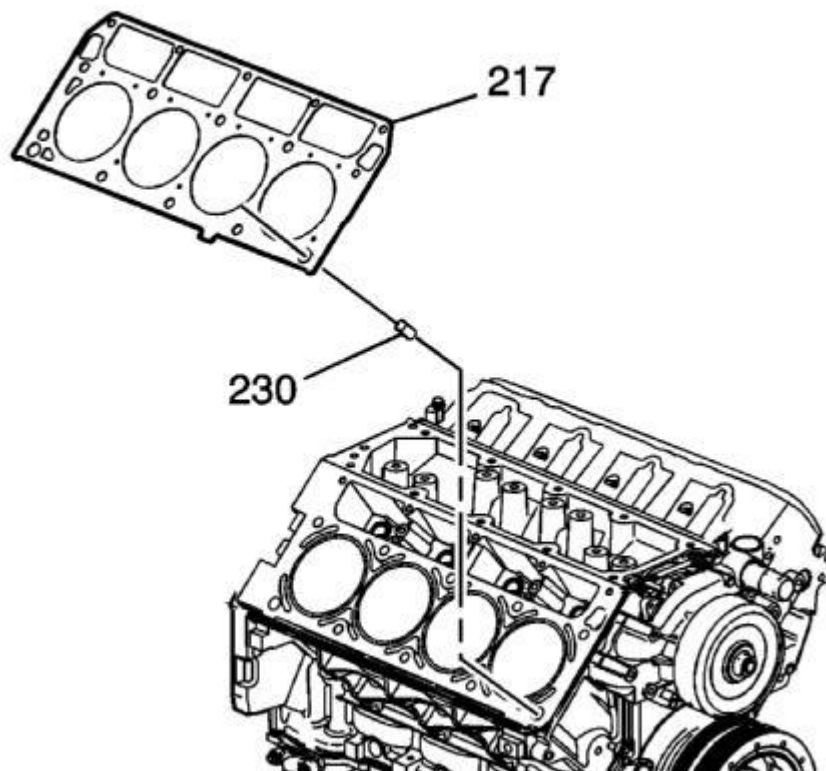


Fig. 96: Cylinder Head Gasket & Locating Pins - Right
Courtesy of GENERAL MOTORS CORP.

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

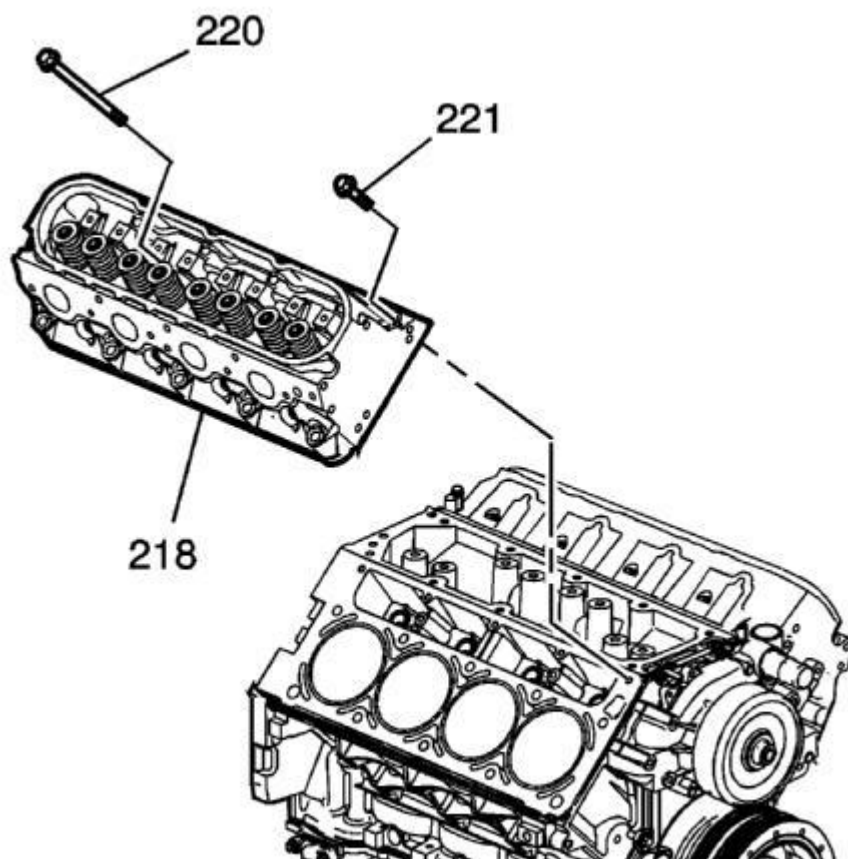


Fig. 97: Right Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (219, 220).

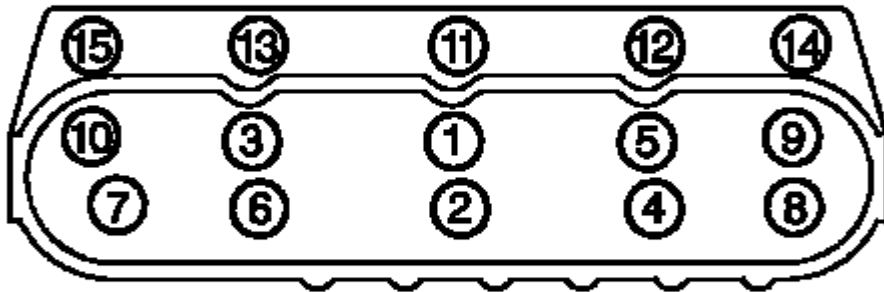


Fig. 98: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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.

11. Install the wiring harness to the clip at the rear of the cylinder head.

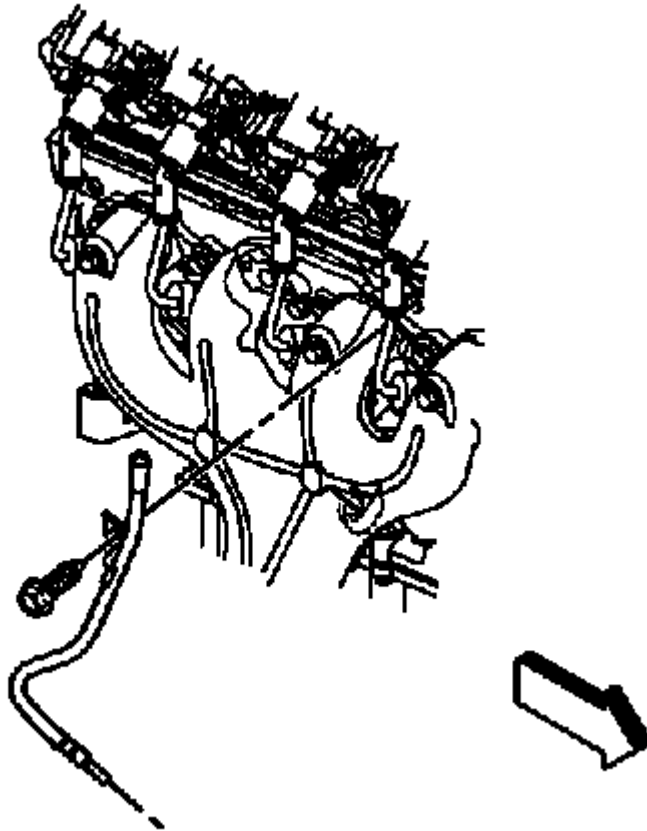


Fig. 99: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

12. Position the oil level indicator tube into place.
13. Install the oil level indicator tube bolt.

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

14. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
15. Install the engine coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** in Engine Cooling.
16. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Valve Lifter Replacement

Tools Required

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

Removal Procedure

1. Remove the cylinder head. Refer to Cylinder Head Replacement - Left or Cylinder Head Replacement - Right.

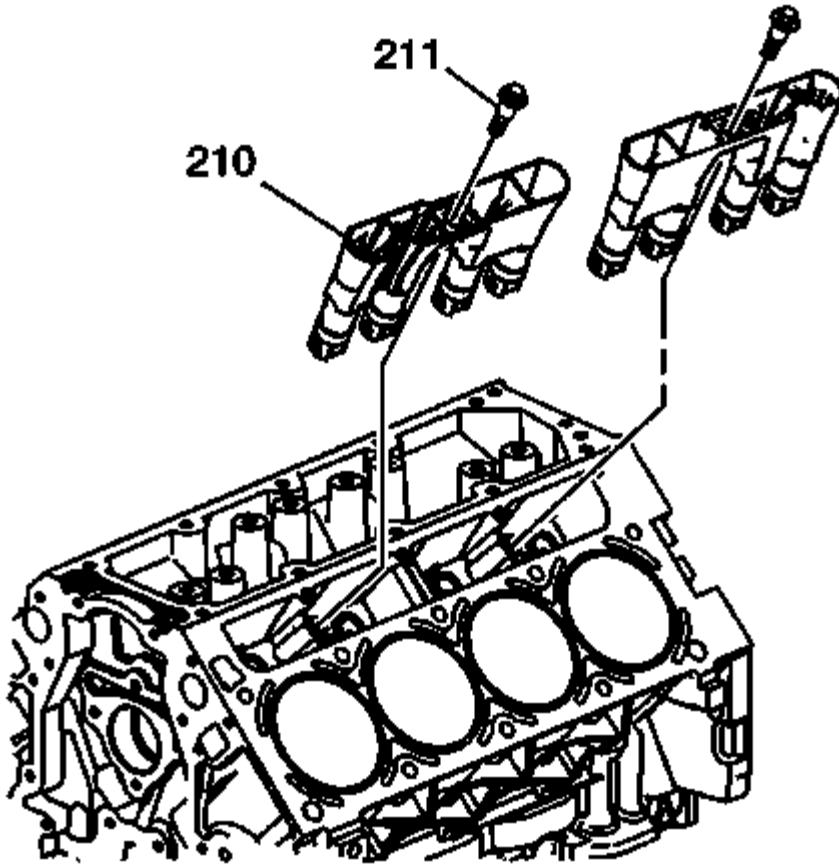


Fig. 100: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the guide bolts (211).
3. 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 on the block.

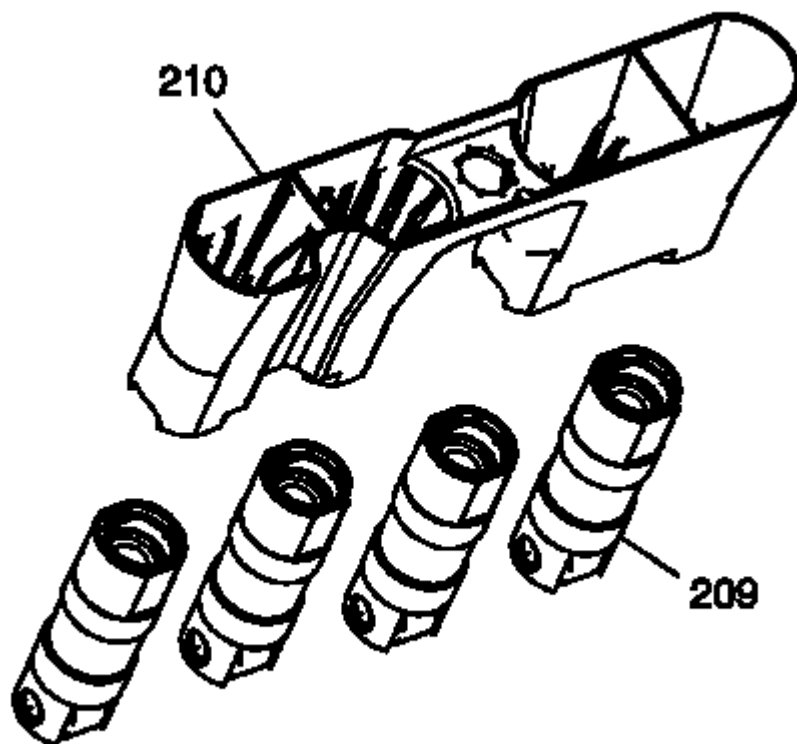


Fig. 101: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve lifters (209) from the guide (210).
5. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to **Separating Parts**.

Installation Procedure

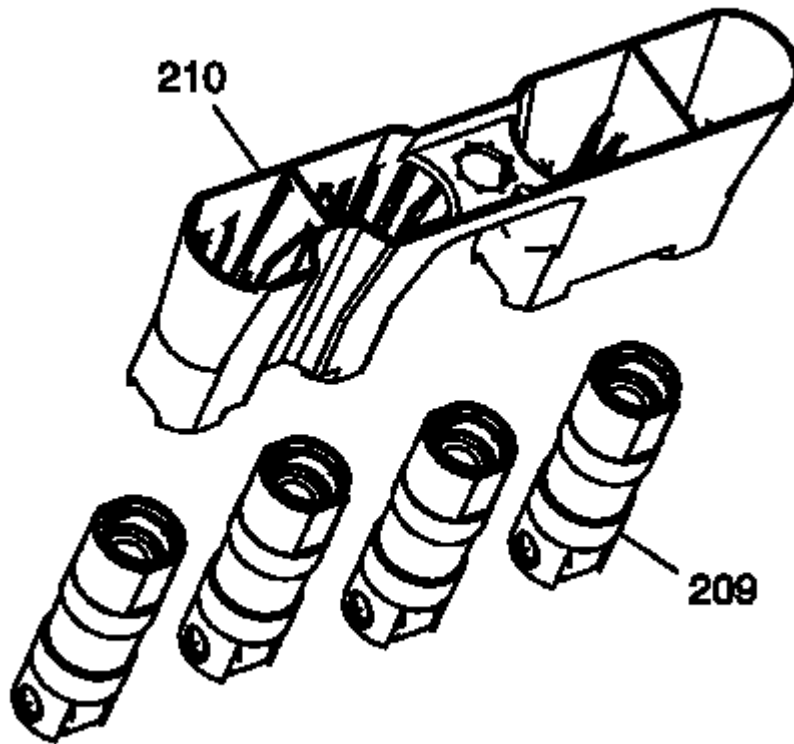


Fig. 102: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

1. Lubricate the valve lifters (209) and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides (210).

Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

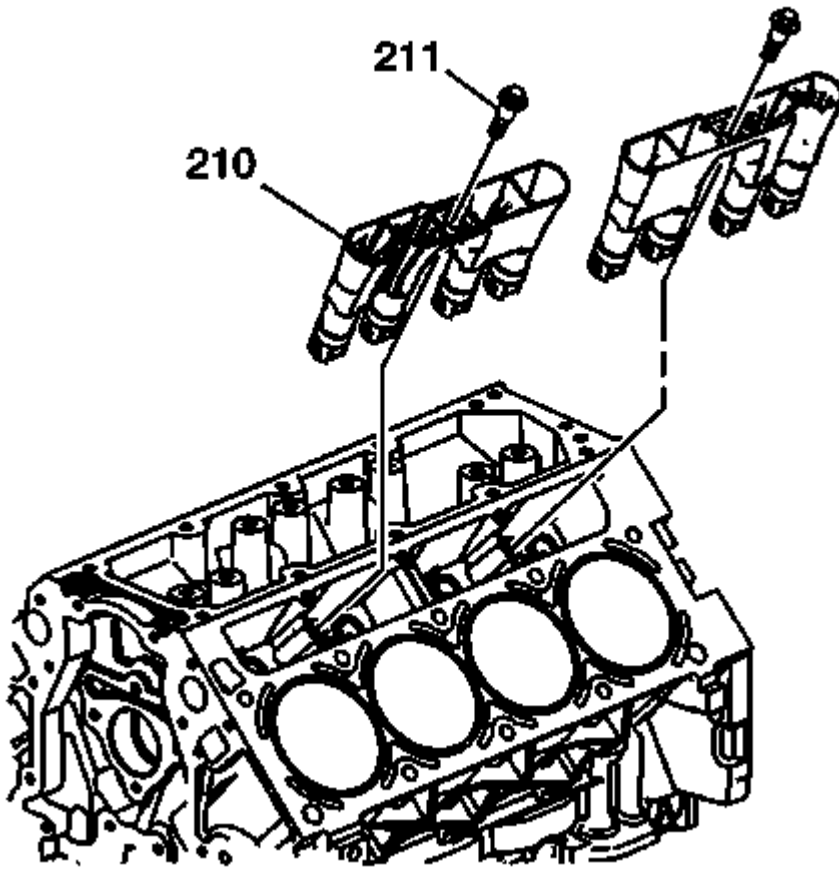


Fig. 103: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifters and guide assembly (210) to the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

5. Install the cylinder head. Refer to Cylinder Head Replacement - Left or Cylinder Head Replacement - Right.

Crankshaft Balancer Replacement

Tools Required

- **J 41816** Crankshaft Balancer Remover. See Special Tools.
- **J 41816-2** Crankshaft End Protector. See Special Tools.
- **J 42386-A** Flywheel Holding Tool. See Special Tools.

- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.

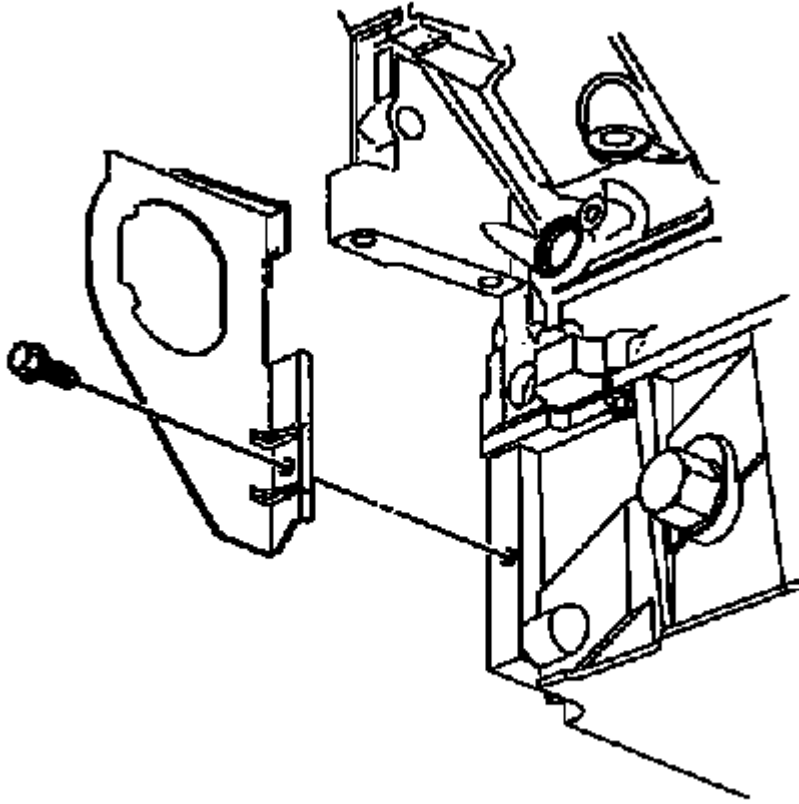
Removal Procedure

Fig. 104: View Of Right Transmission Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.
2. Remove the power steering gear. Refer to **Power Steering Gear Replacement** in Power Steering System.
3. Remove the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
4. Remove the right transmission cover and bolt.

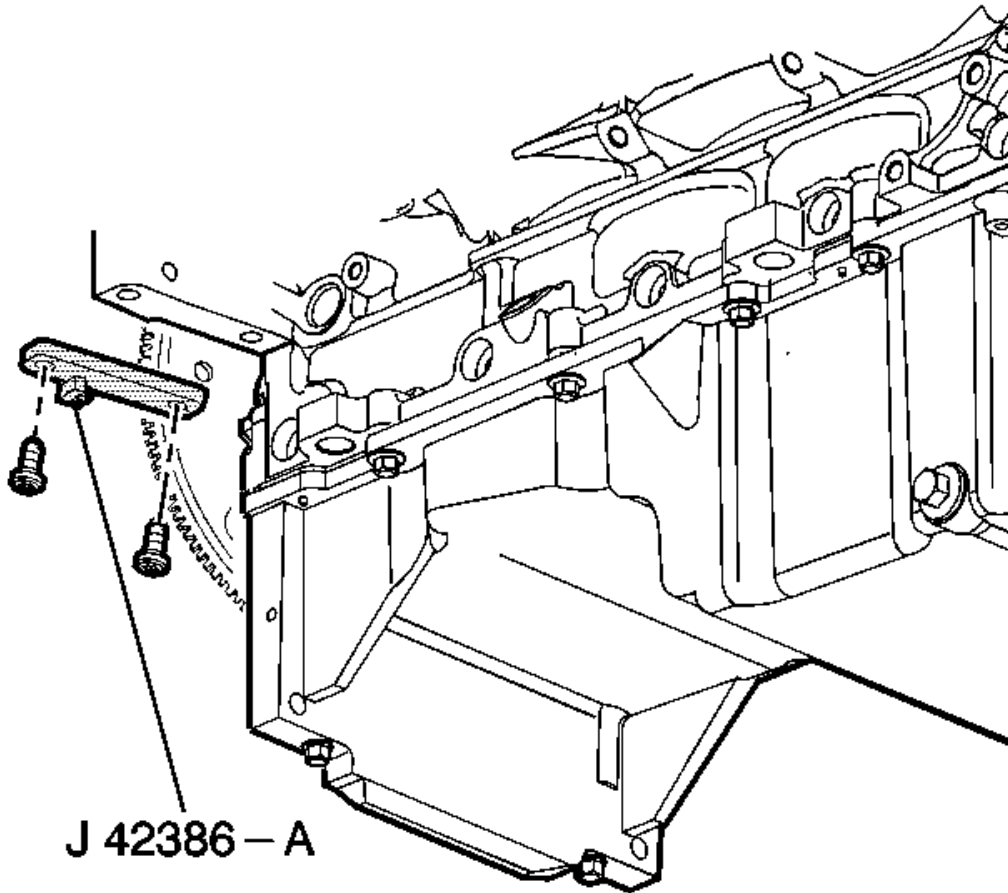


Fig. 105: View Of J 42386-A

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT:

- For manual transmission applications, note the position of the crankshaft balancer before removal. The balancer does not use a key or keyway for positioning. Mark or scribe the end of the crankshaft and the balancer before component removal. The crankshaft balancer must be installed to the original position. If replacing the crankshaft balancer, note the location of any existing balance weights, if applicable. Crankshaft balance weights must be installed into the new balancer in the same location as the old balancer. A properly installed balance weight will be either flush or below flush with the face of the balancer.

- Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

5. Install the **J 42386-A** and bolts. See Special Tools.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

Tighten: Tighten the **J 42386-A** bolts to 50 N.m (37 lb ft).

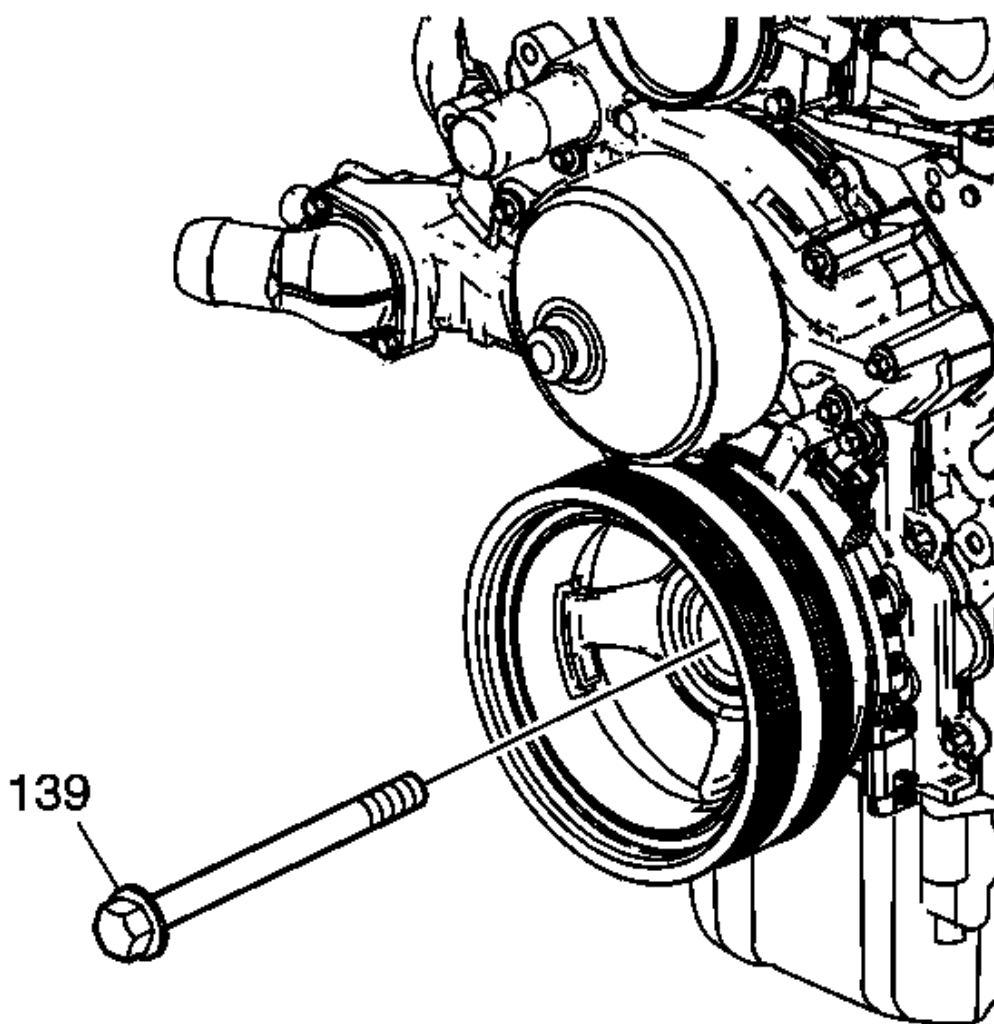


Fig. 106: Identifying Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft balancer bolt (139).

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

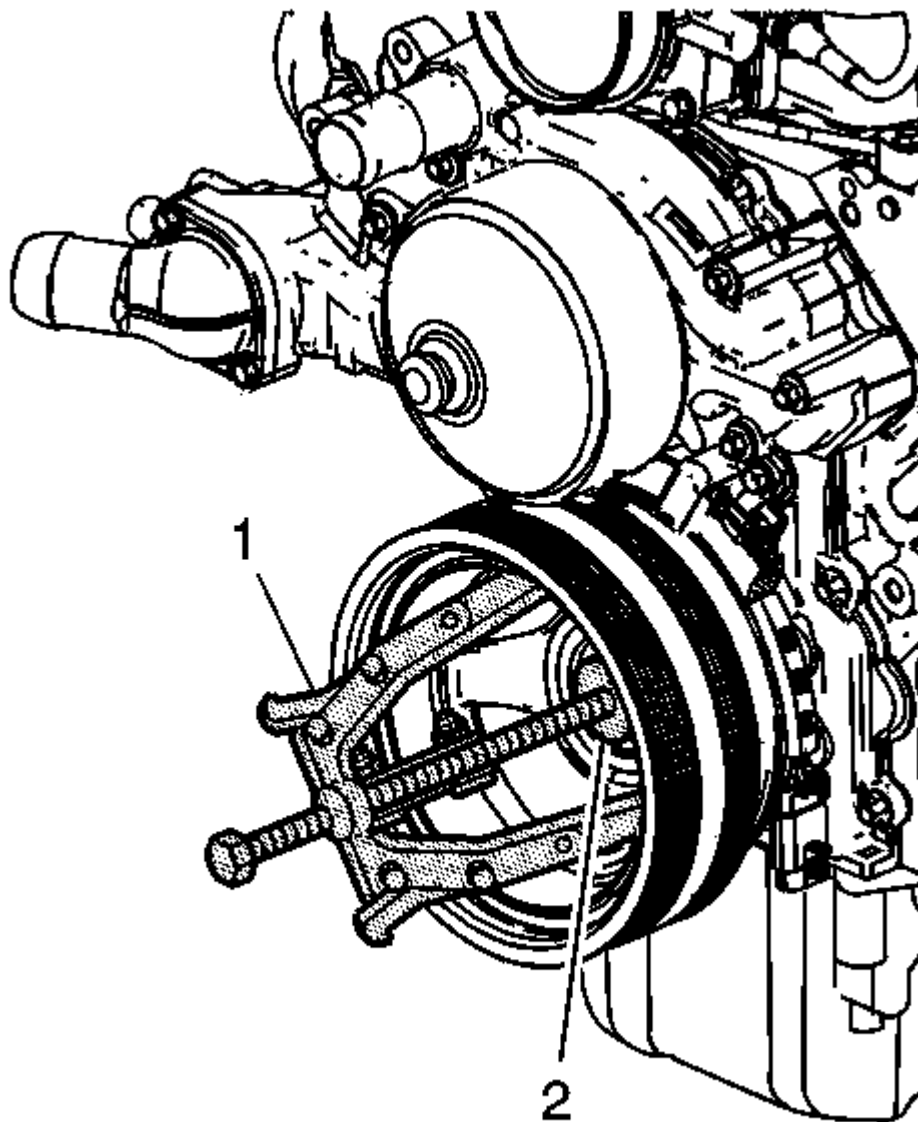


Fig. 107: Using Crankshaft Balancer Puller
Courtesy of GENERAL MOTORS CORP.

7. Use the **J 41816** (1) and the **J 41816-2** (2) in order to remove the crankshaft balancer. See **Special Tools**.

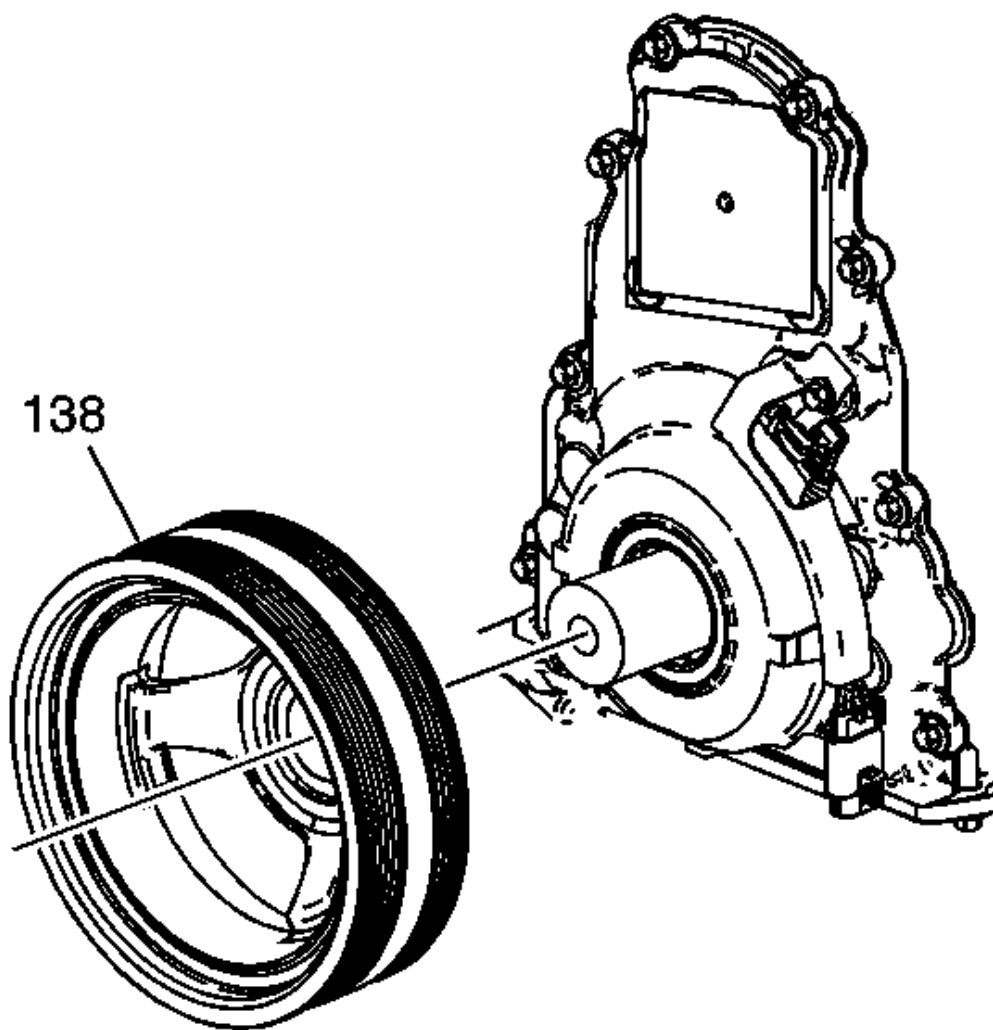


Fig. 108: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer (138).

Installation Procedure

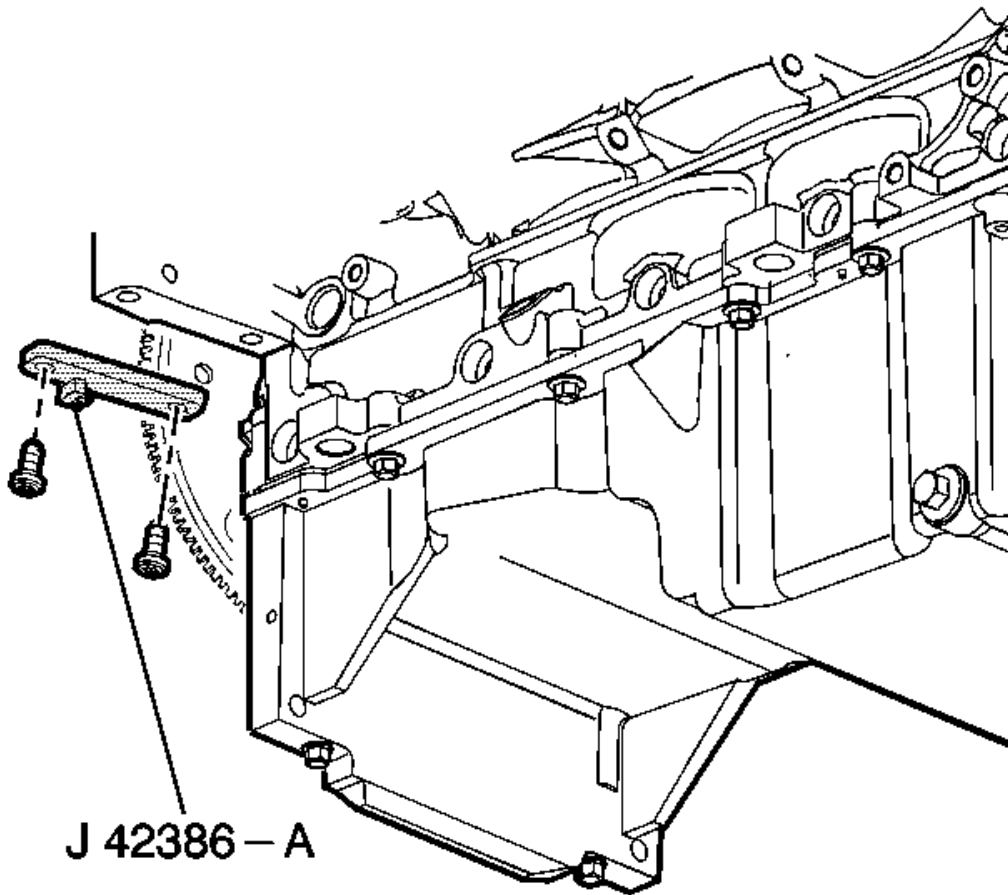


Fig. 109: View Of J 42386-A

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT:

- 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 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.

1. Install the **J 42386-A** and bolts. See **Special Tools**.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

Tighten: Tighten the **J 42386-A** bolts to 50 N.m (37 lb ft).

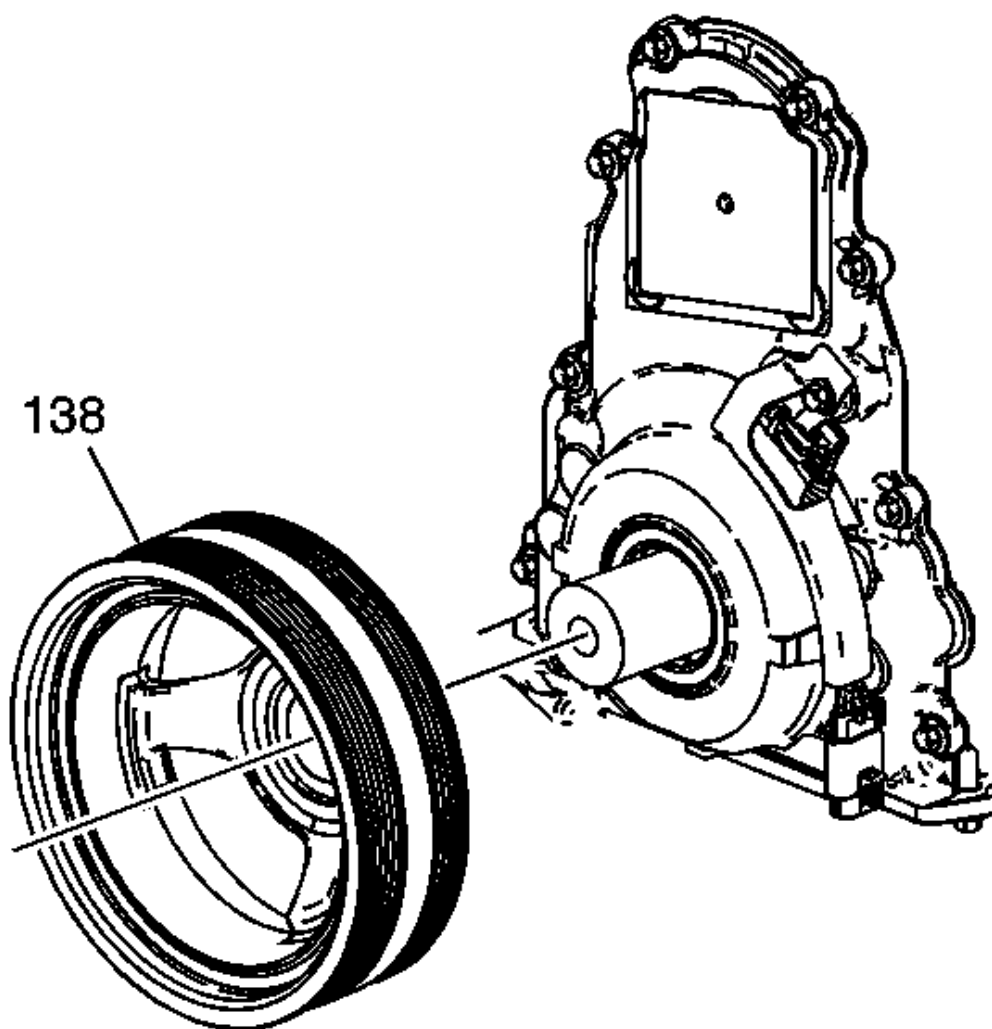


Fig. 110: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

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

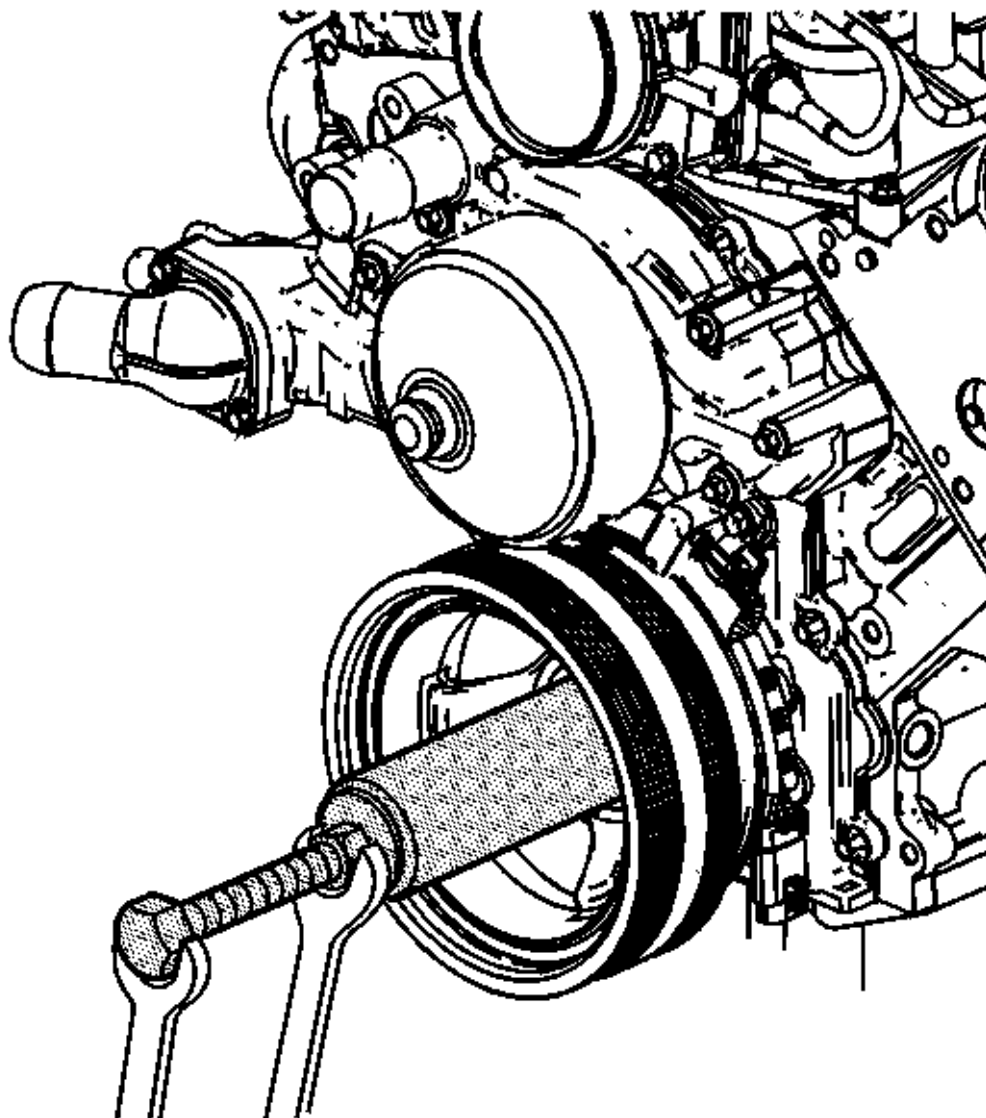


Fig. 111: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41665** in order to install the 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.
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.

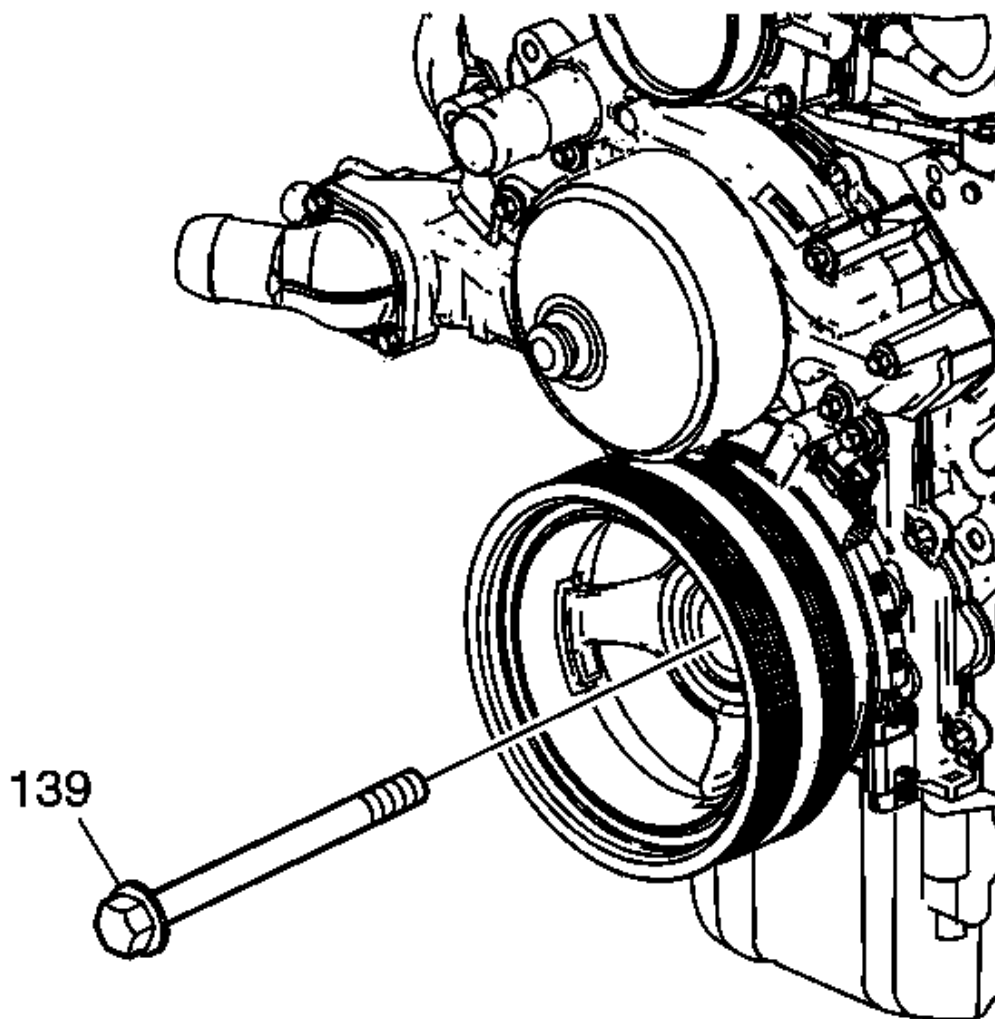


Fig. 112: Identifying Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the used crankshaft balancer bolt (139).

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

5. Remove the used crankshaft balancer bolt.

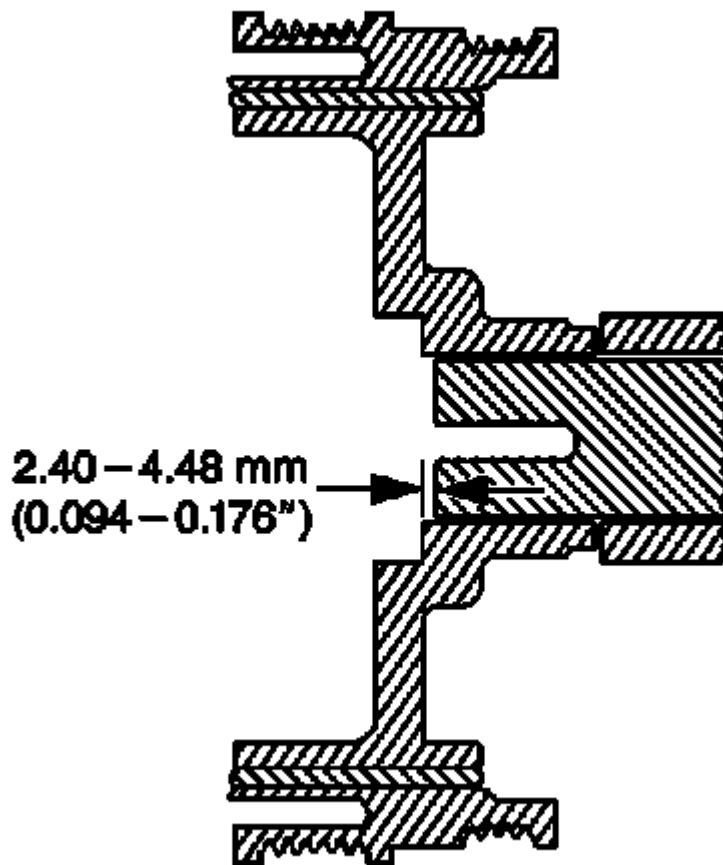


Fig. 113: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

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

6. 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**.

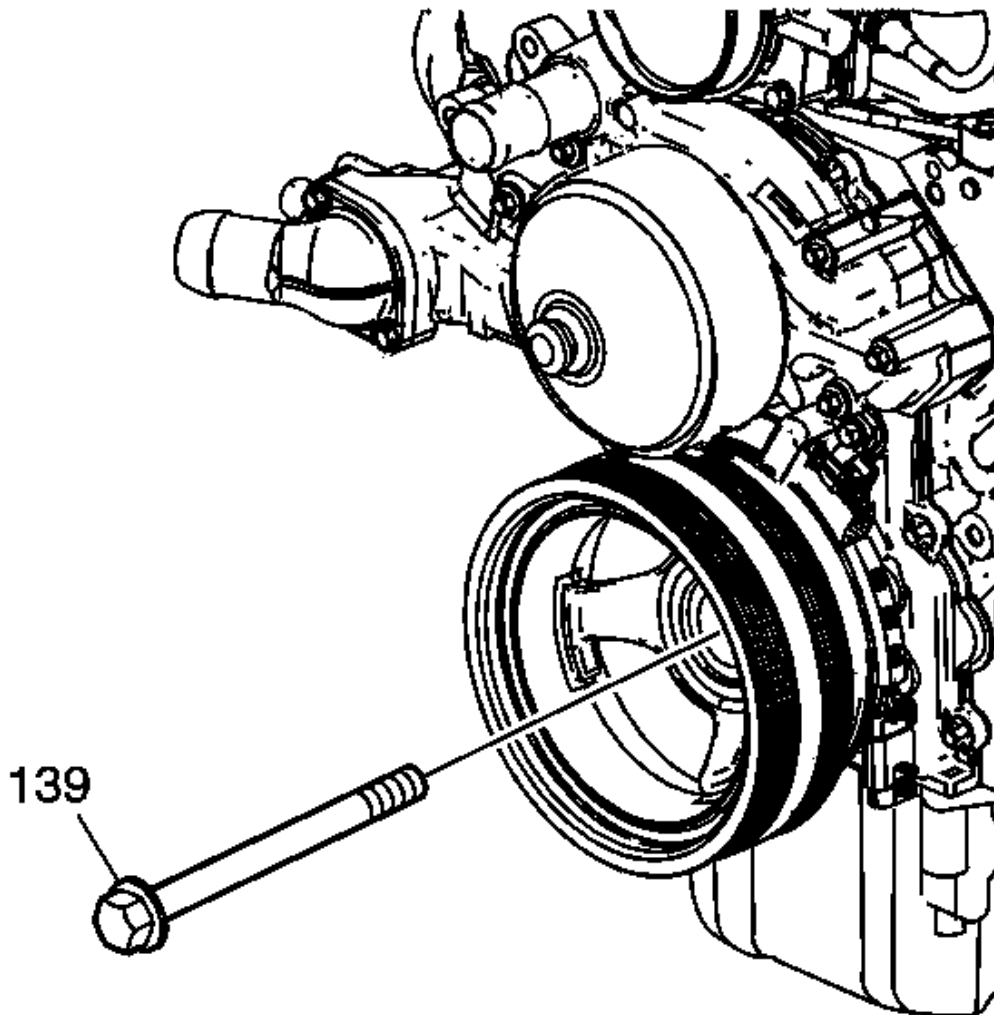


Fig. 114: Identifying Crankshaft Balancer Bolt
 Courtesy of GENERAL MOTORS CORP.

7. Install the NEW crankshaft balancer bolt (139).

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**.
8. Remove the **J 42386-A**. See **Special Tools**.
 9. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.

10. Install the power steering gear. Refer to **Power Steering Gear Replacement** in Power Steering System.
11. Install the A/C drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.
12. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 6.0L.

Crankshaft Front Oil Seal Replacement

Tools Required

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

Removal Procedure

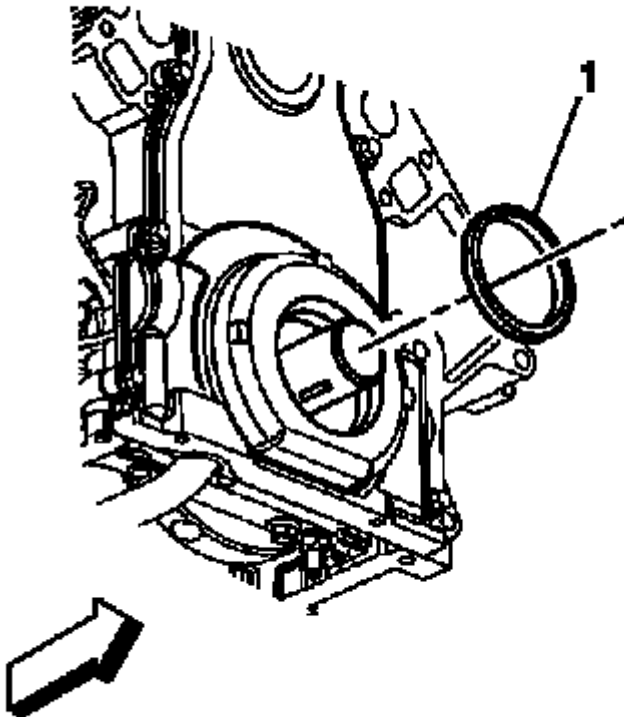


Fig. 115: Identifying Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Gently pry the crankshaft oil seal (1) from the front cover.

Installation Procedure

IMPORTANT:

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

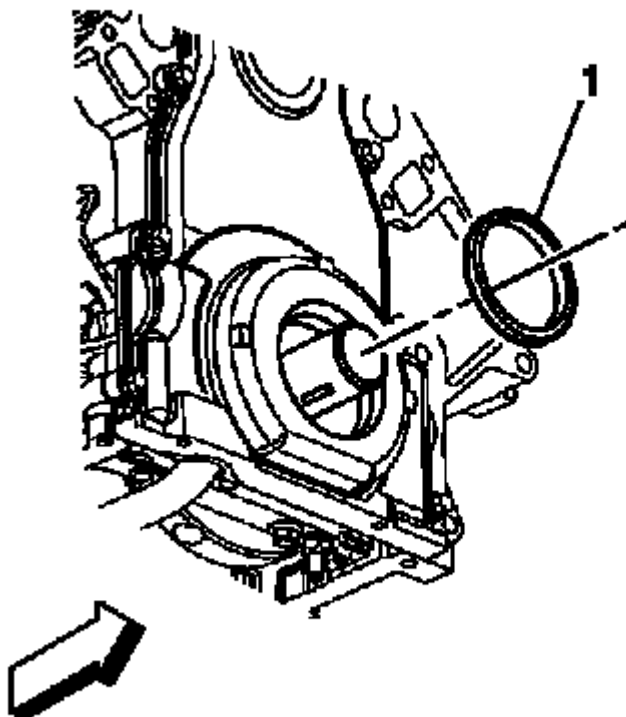


Fig. 116: Identifying Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

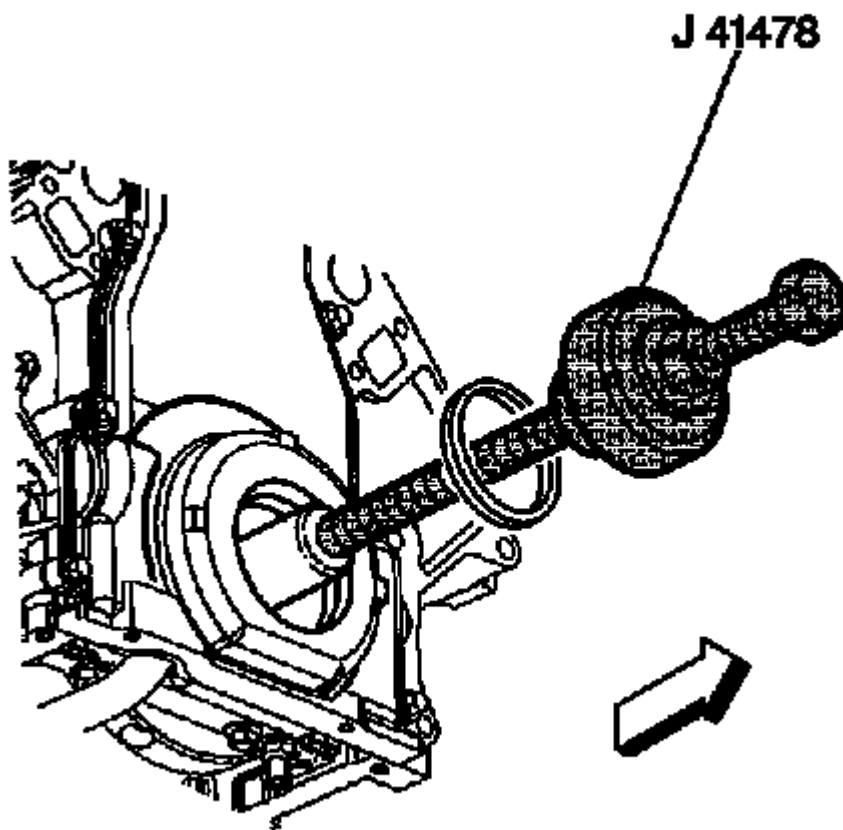


Fig. 117: Installing The Crankshaft Front Oil Seal Using J 41478
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal onto the **J 41478** guide. See **Special Tools**.
4. Install the **J 41478** threaded rod (with nut, washer, guide, and oil seal) into the end of the crankshaft.
5. Use the **J 41478** in order to install the oil seal into the cover bore.
 1. Use a wrench and hold the hex on the installer tool.
 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.
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Engine Front Cover Replacement

Tools Required

- **J 41480** Front and Rear Cover Alignment. See **Special Tools**.
- **J 41476** Front and Rear Cover Alignment Tool. See **Special Tools**.

Removal Procedure

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

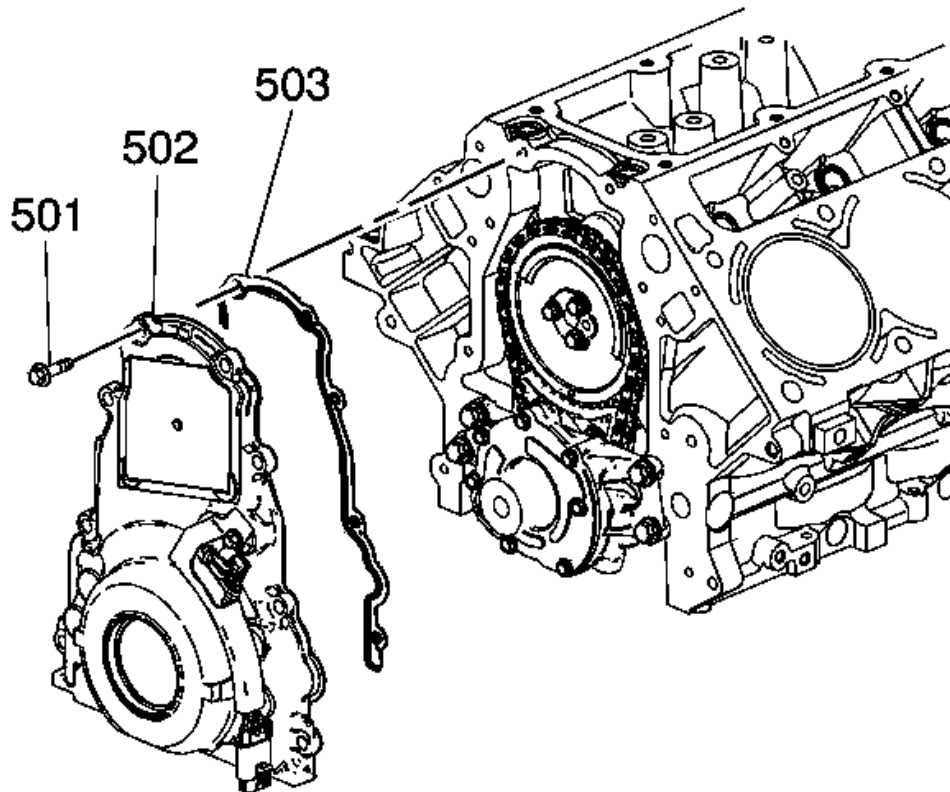


Fig. 118: Engine Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the front cover bolts (501).
4. Remove the front cover (502) and gasket (503).
5. Discard the front cover gasket.
6. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

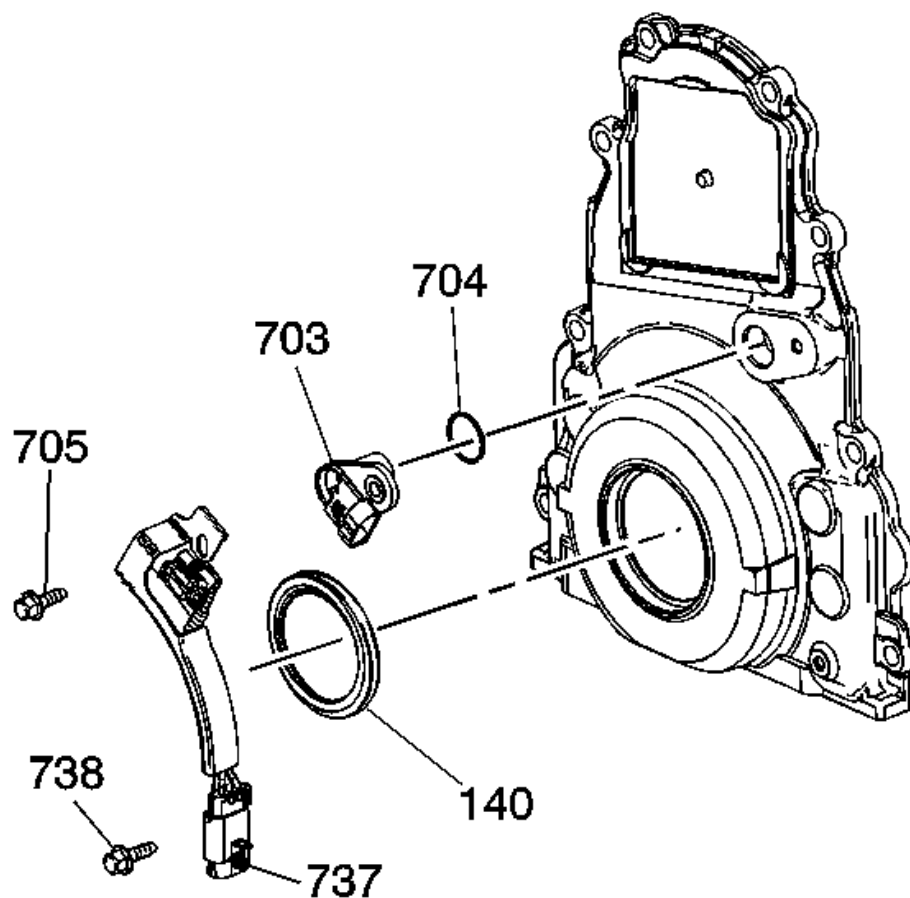


Fig. 119: Engine Front Cover, Camshaft Position Sensor, Oil Seal, Wire Harness, O-Ring & Bolts
 Courtesy of GENERAL MOTORS CORP.

7. Remove the oil seal (140).
8. Remove the bolts (705, 738), camshaft position sensor (703), and wire harness (737).
9. Remove the O-ring (704) from the sensor as required.

Installation Procedure

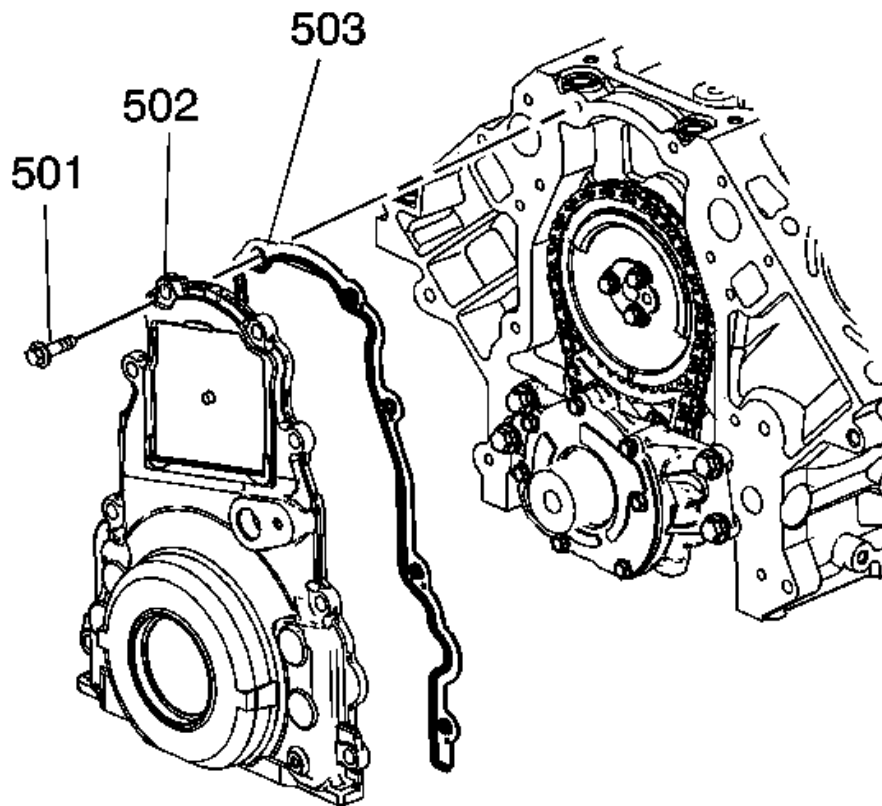


Fig. 120: Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

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.
 - 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 (503), front cover (502), and bolts (501).
2. Tighten the cover bolts finger tight. Do not overtighten.

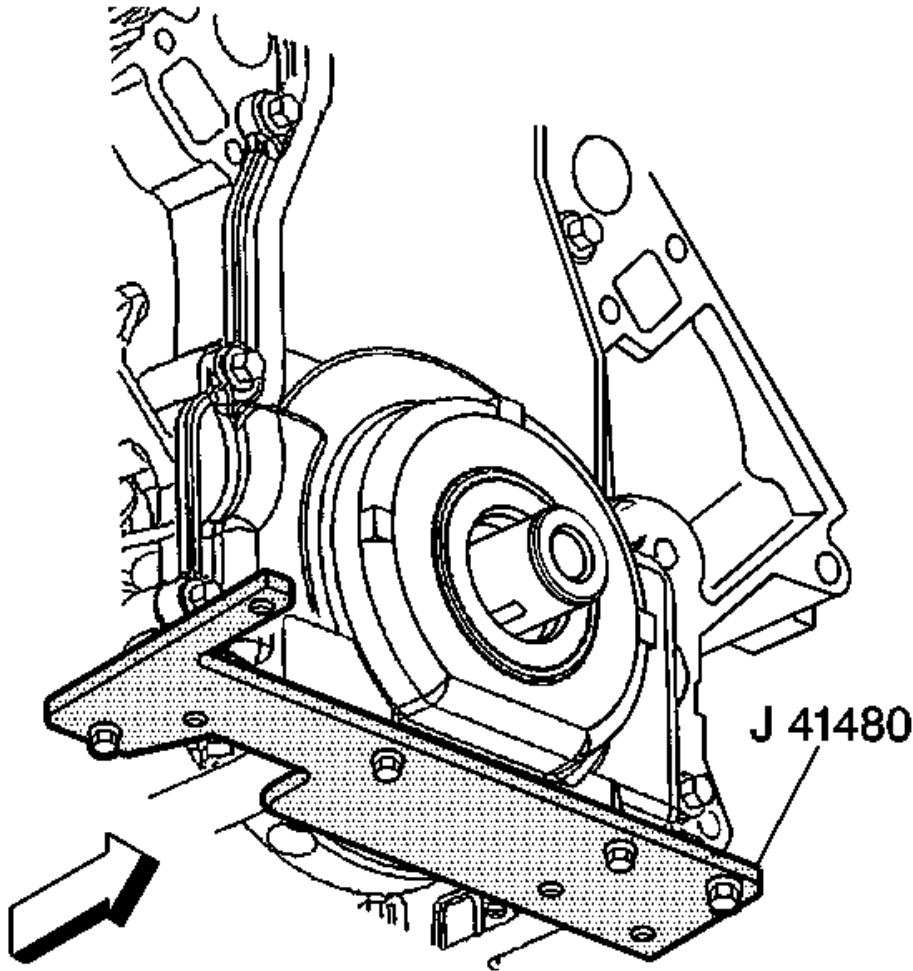


Fig. 121: View Of J 41480 Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

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

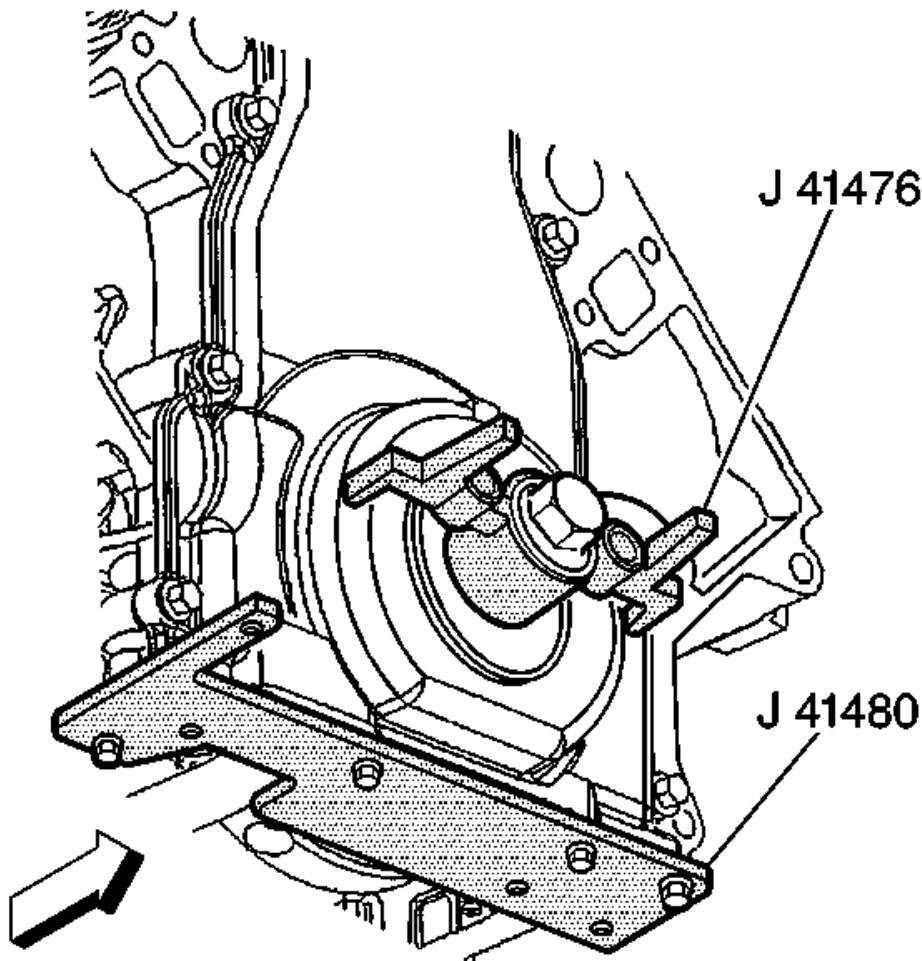


Fig. 122: View Of J 41476 & J 41480 Installed On Engine
 Courtesy of GENERAL MOTORS CORP.

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

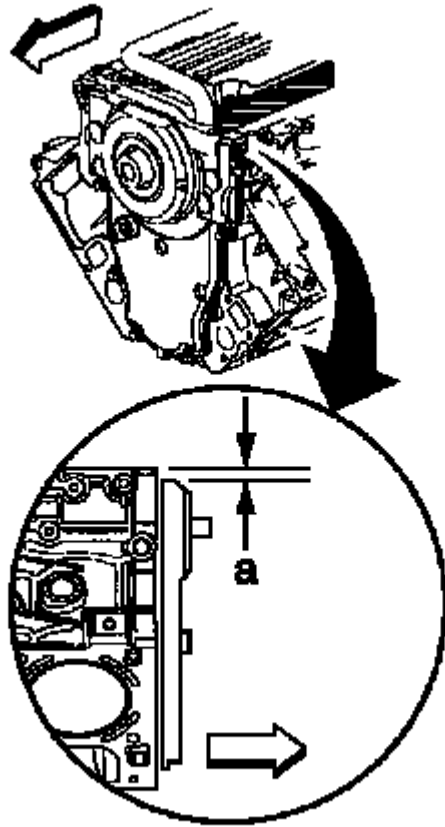


Fig. 123: Measuring Oil Pan Surface Flatness & Front Cover-To-Engine Block
Courtesy of GENERAL MOTORS CORP.

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) (a) 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.

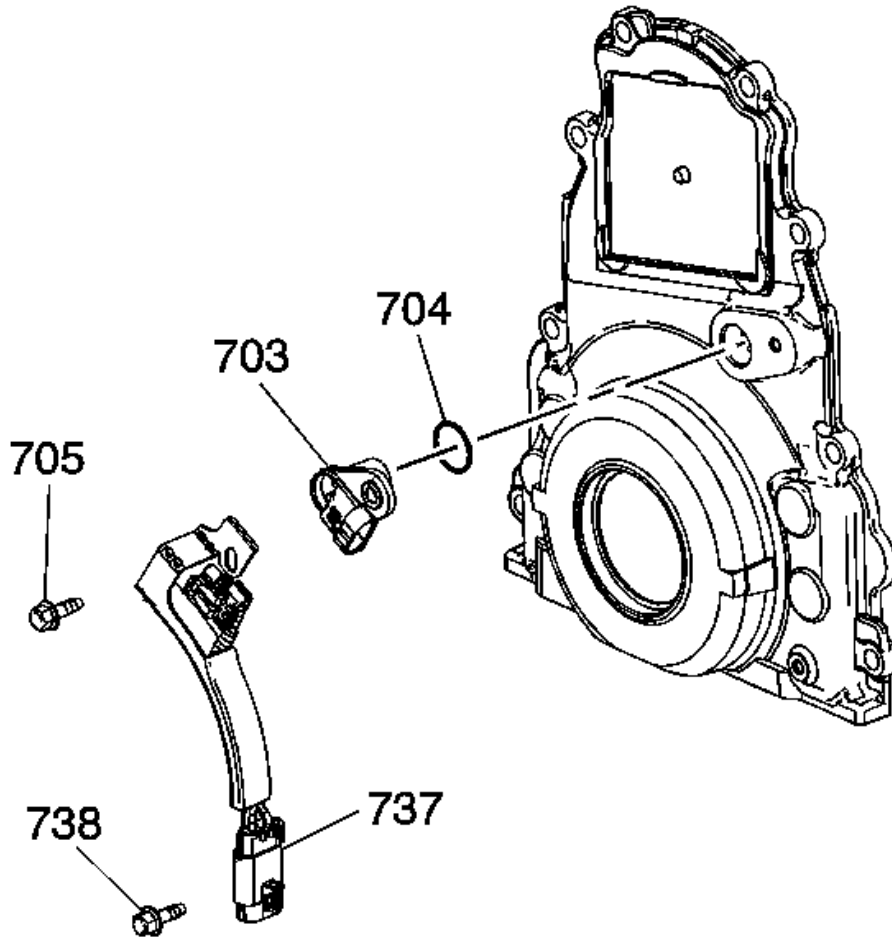


Fig. 124: O-Ring Seal, Sensor, Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position sensor O-ring seal (704) 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.
12. Install the O-ring seal onto the sensor (703).
13. Install the sensor to the cover.
14. Install the camshaft position sensor wire harness (737) and bolts (705, 738).

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

15. Install the oil pan. Refer to **Oil Pan Replacement**.
16. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer. See Special Tools.

Removal Procedure

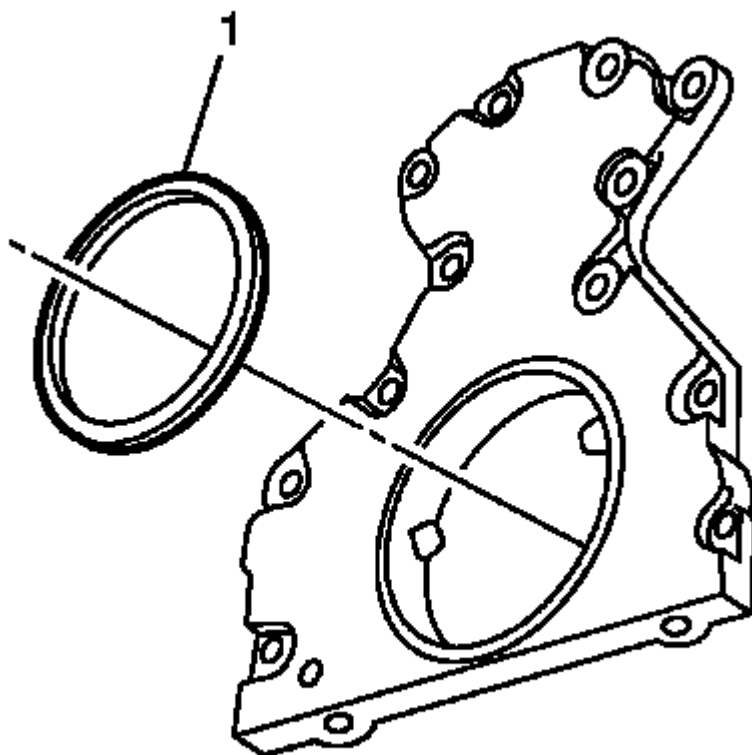


Fig. 125: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to Engine Flywheel Replacement.
2. Gently pry the crankshaft rear oil seal (1) from the rear cover.

Installation Procedure

IMPORTANT:

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

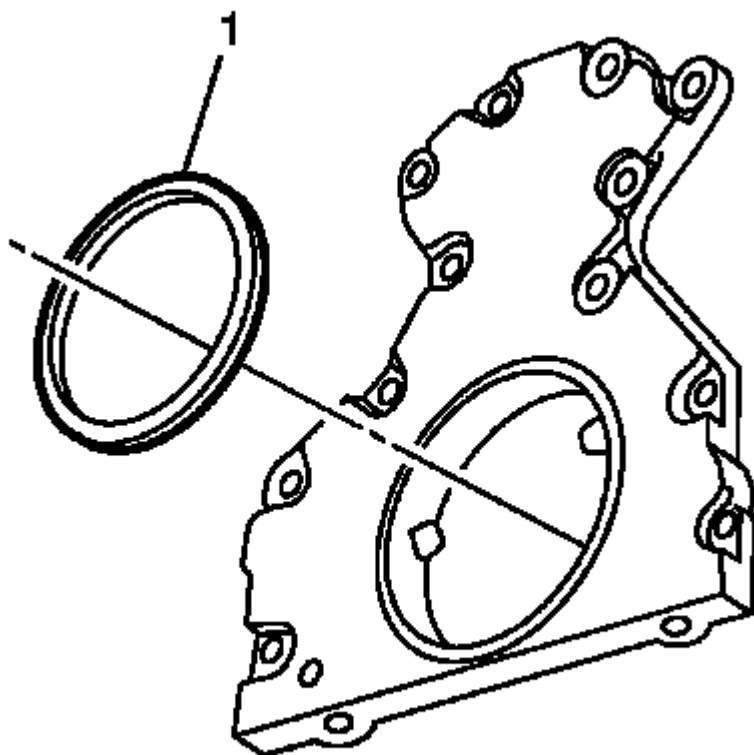


Fig. 126: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outside diameter (OD) of the oil seal (1) with clean engine oil.

DO NOT allow oil or other lubricants to contact the seal surface.

2. Lubricate the rear cover oil seal bore with clean engine oil.

DO NOT allow oil or other lubricants to contact the crankshaft surface.

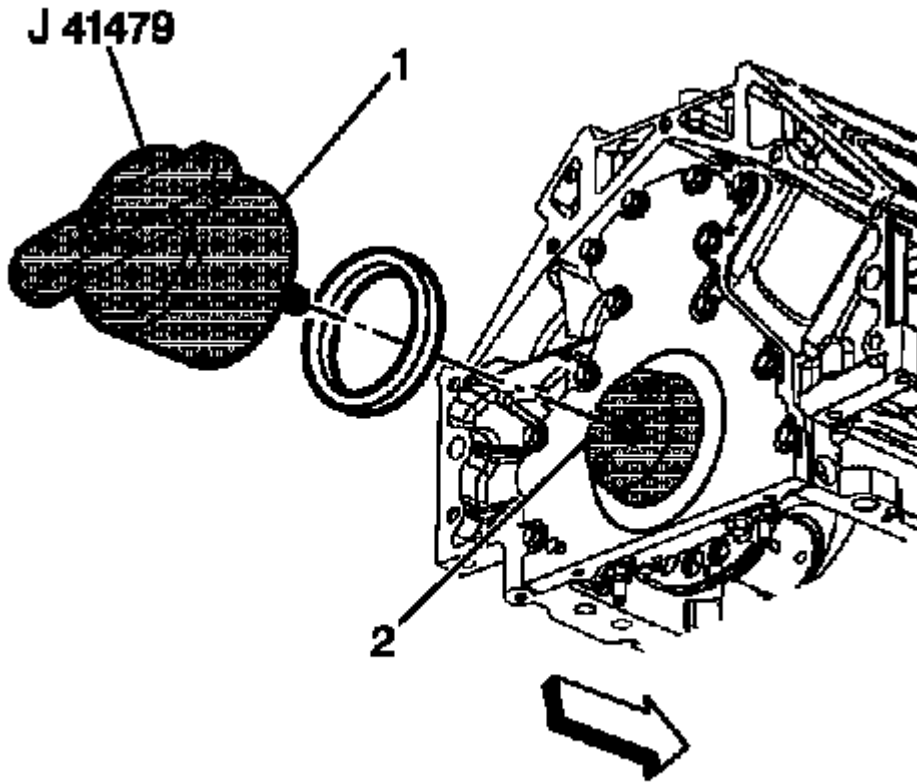


Fig. 127: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal.
7. Align the oil seal onto the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the **J 41479**.
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

Engine Rear Cover Replacement

Tools Required

- **J 41476** Front and Rear Cover Alignment. See **Special Tools**.
- **J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
3. Remove the oil pan-to-rear cover bolts.

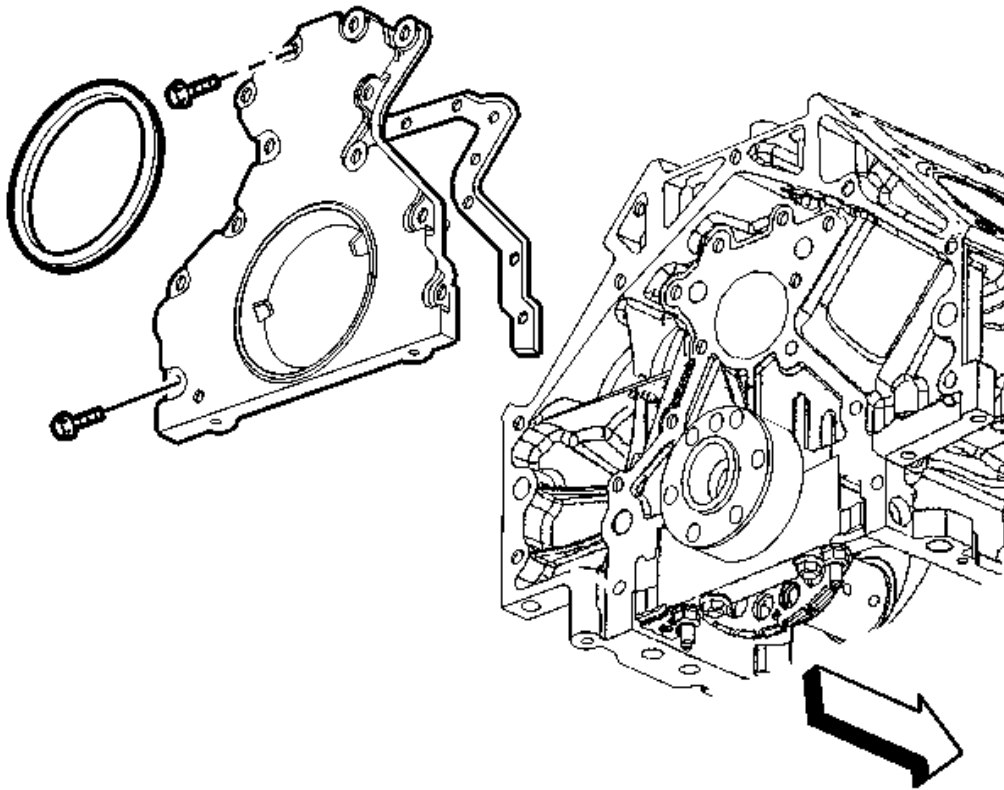


Fig. 128: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove the rear cover bolts.
5. Remove the rear cover and gasket.
6. Discard the rear cover gasket.
7. Clean and inspect the engine rear cover. Refer to **Engine Rear Cover Cleaning and Inspection**.

Installation Procedure

IMPORTANT: • **Do not reuse the crankshaft oil seal or rear cover gasket.**

- Do not apply any type of sealant to the rear cover gasket (unless specified).
- The special tool in this procedure is used to center the crankshaft rear 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.
- The crankshaft rear oil seal will be installed after the rear cover has been installed.
- An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.

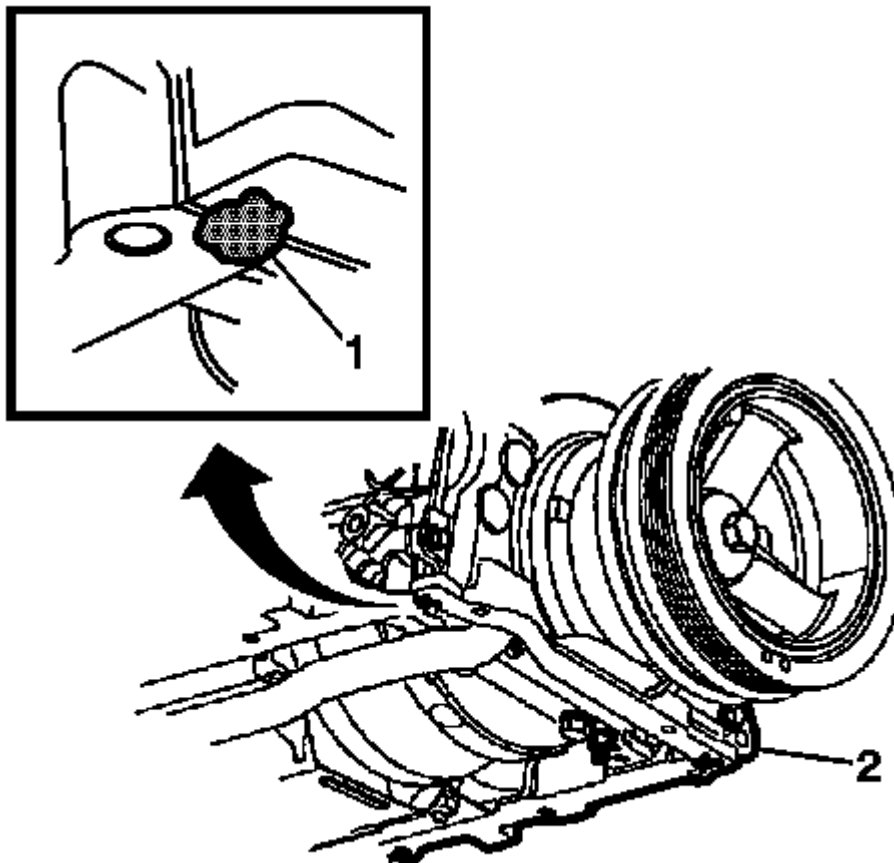


Fig. 129: View Of Sealant Applied To Front Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the oil pan to engine block junction.

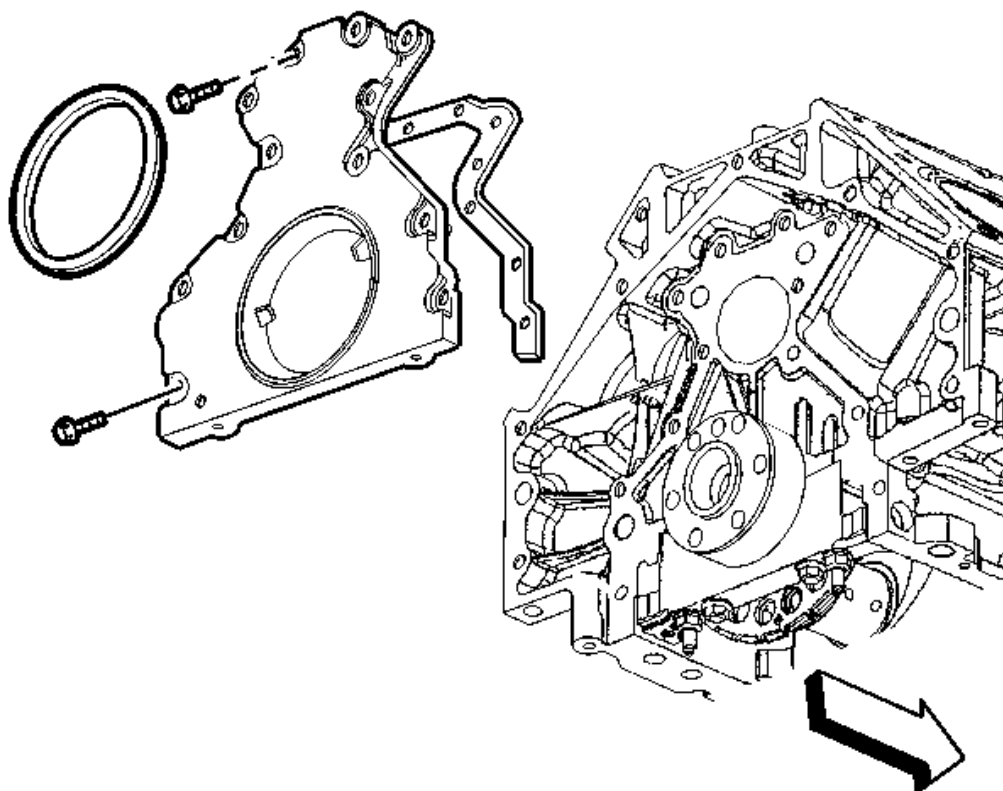


Fig. 130: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket and cover.
3. Install the rear cover bolts until snug. Do not overtighten.

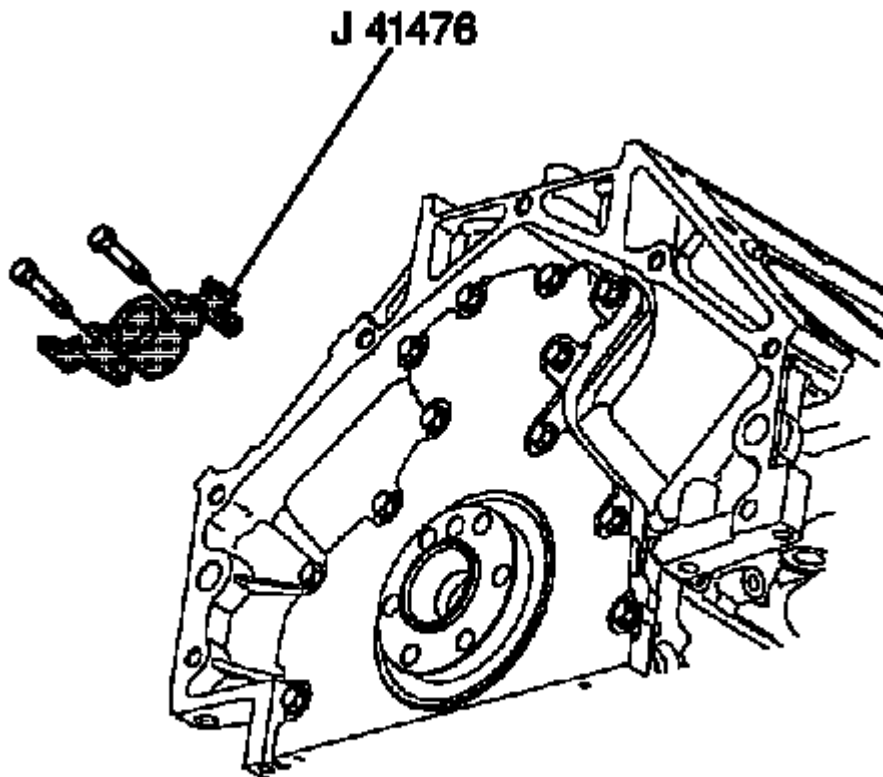


Fig. 131: View Of J 41476

Courtesy of GENERAL MOTORS CORP.

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

4. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.
5. Install the **J 41476** and bolts onto the rear of the crankshaft. See Special Tools.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the **J 41476** bolts until snug. 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 25 N.m (18 lb ft).
7. Remove the **J 41476**.

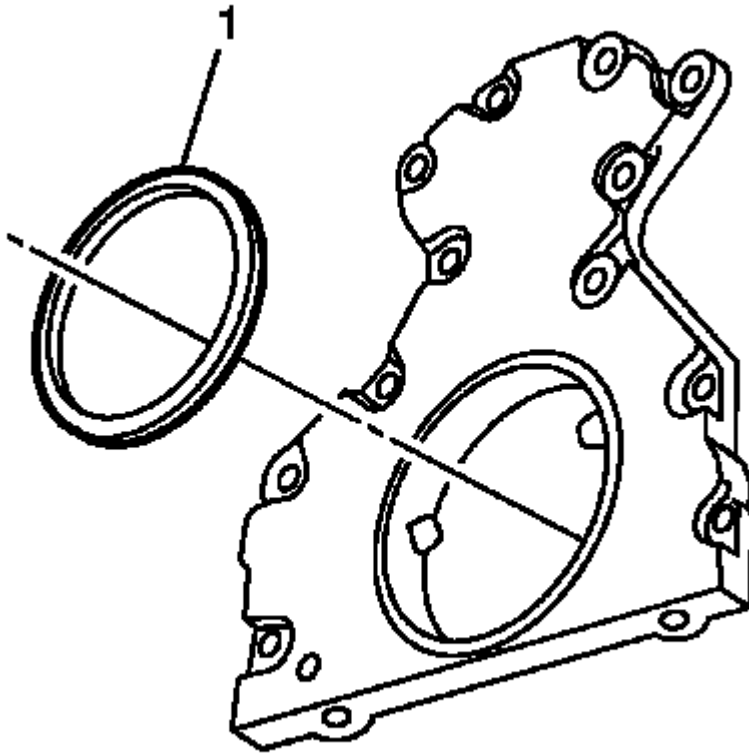


Fig. 132: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

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

8. Lubricate the outside diameter (OD) of the oil seal (1) with clean engine oil.

Do not allow oil or other lubricants to contact the seal surface.

9. Lubricate the rear cover oil seal bore with clean engine oil.

Do not allow oil or other lubricants to contact the crankshaft surface.

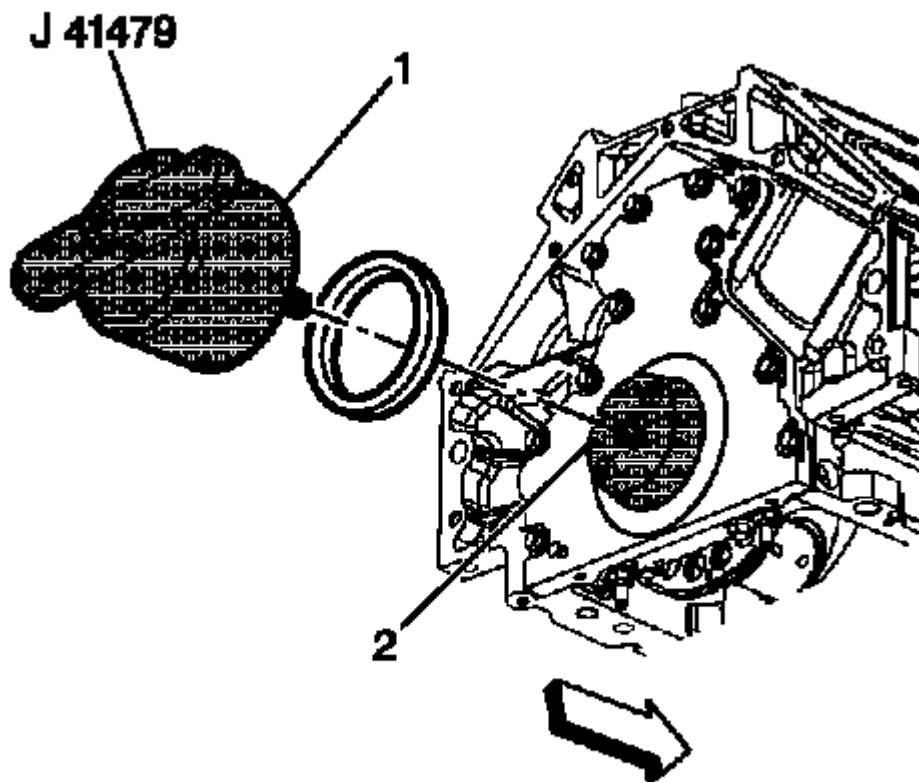


Fig. 133: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

10. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**.
11. Tighten the bolts until snug. Do not overtighten.
12. Install the rear oil seal onto the tapered cone (2) until the tool (1) contacts the oil seal.
13. Thread the **J 41479** threaded rod into the tapered cone (2) until the tool (1) contacts the oil seal.
14. Align the oil seal onto the tool (1).
15. Rotate the handle of the **J 41479** clockwise until the seal enters the rear cover and bottoms into the cover bore.
16. Remove the **J 41479**.
17. Install the oil pan. Refer to **Oil Pan Replacement**.
18. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

Oil Filter Adapter Replacement

Removal Procedure

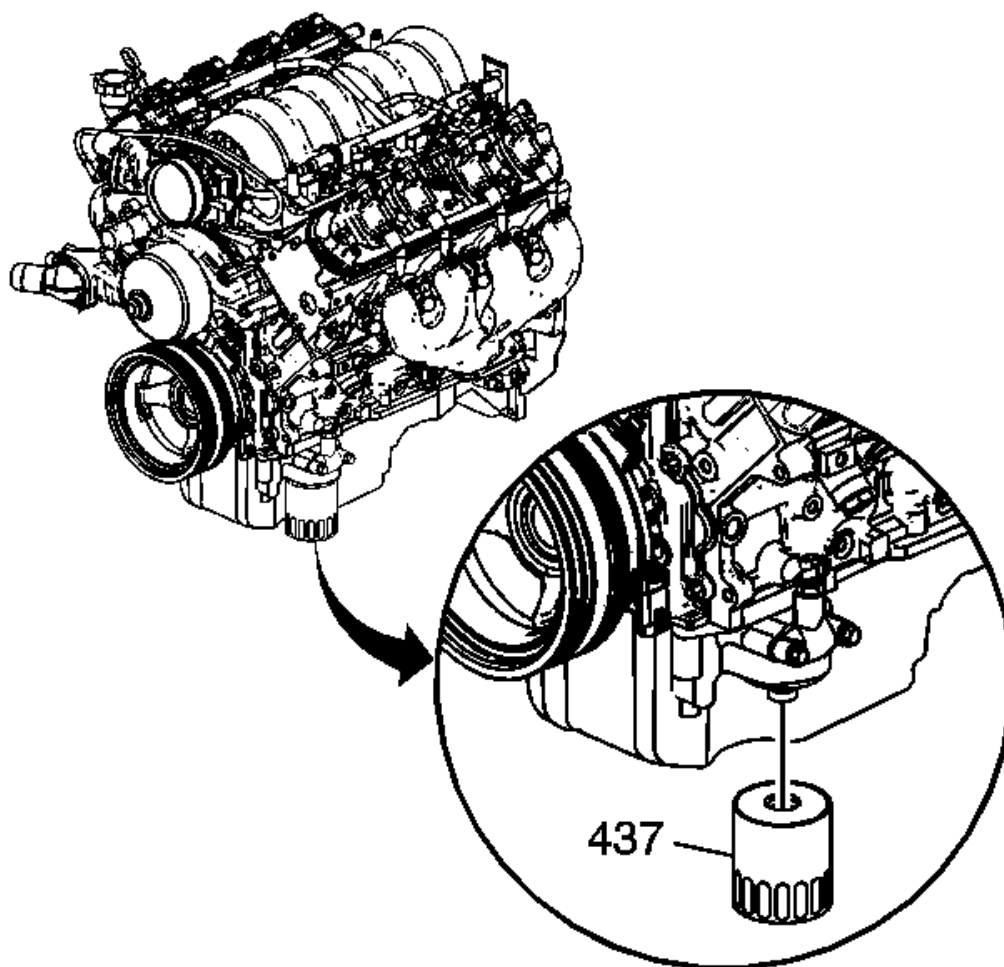


Fig. 134: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil.
2. Remove the oil filter (437).

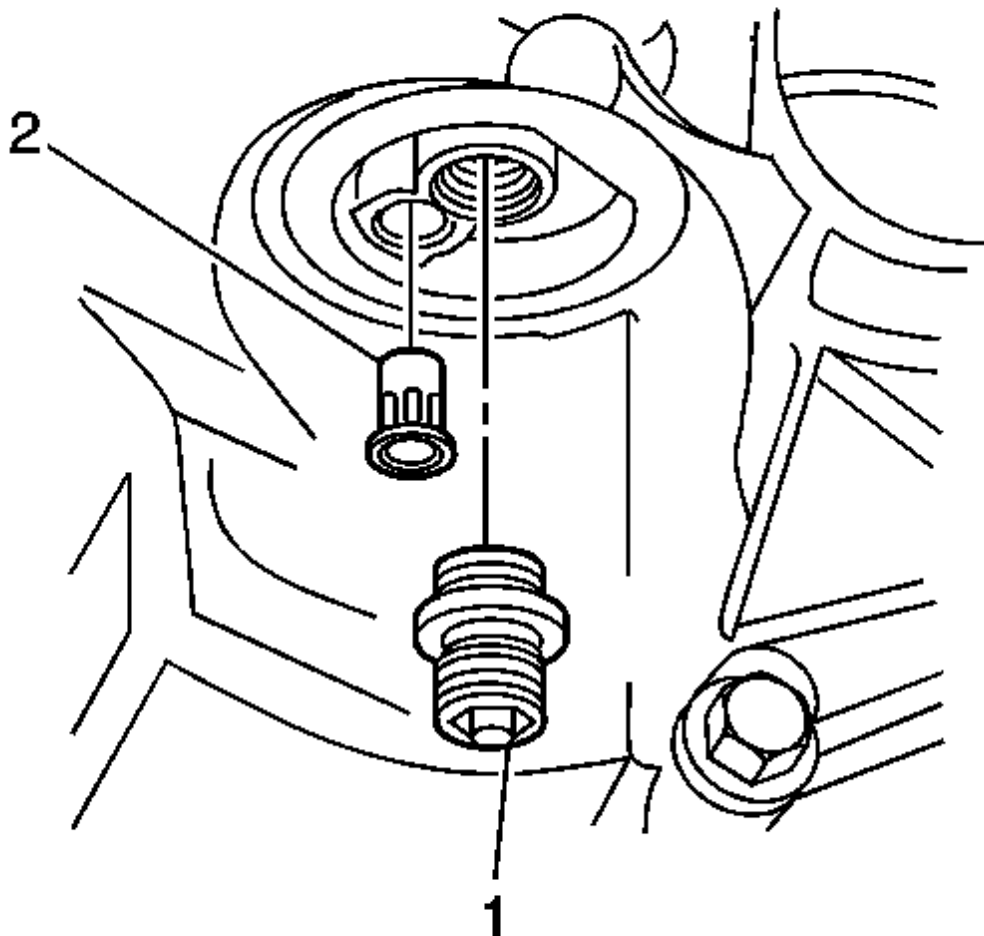


Fig. 135: View Of Oil Filter Adapter & Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).

Installation Procedure

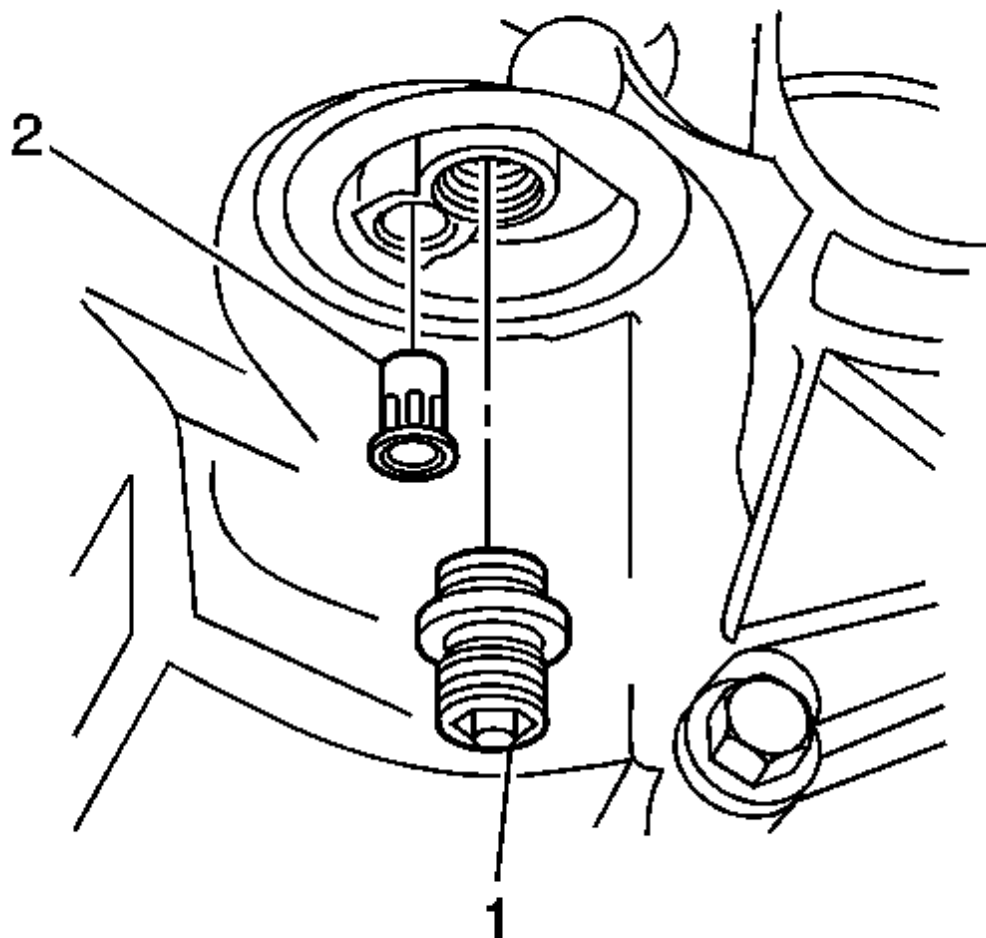


Fig. 136: View Of Oil Filter Adapter & Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil filter adapter (1).

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

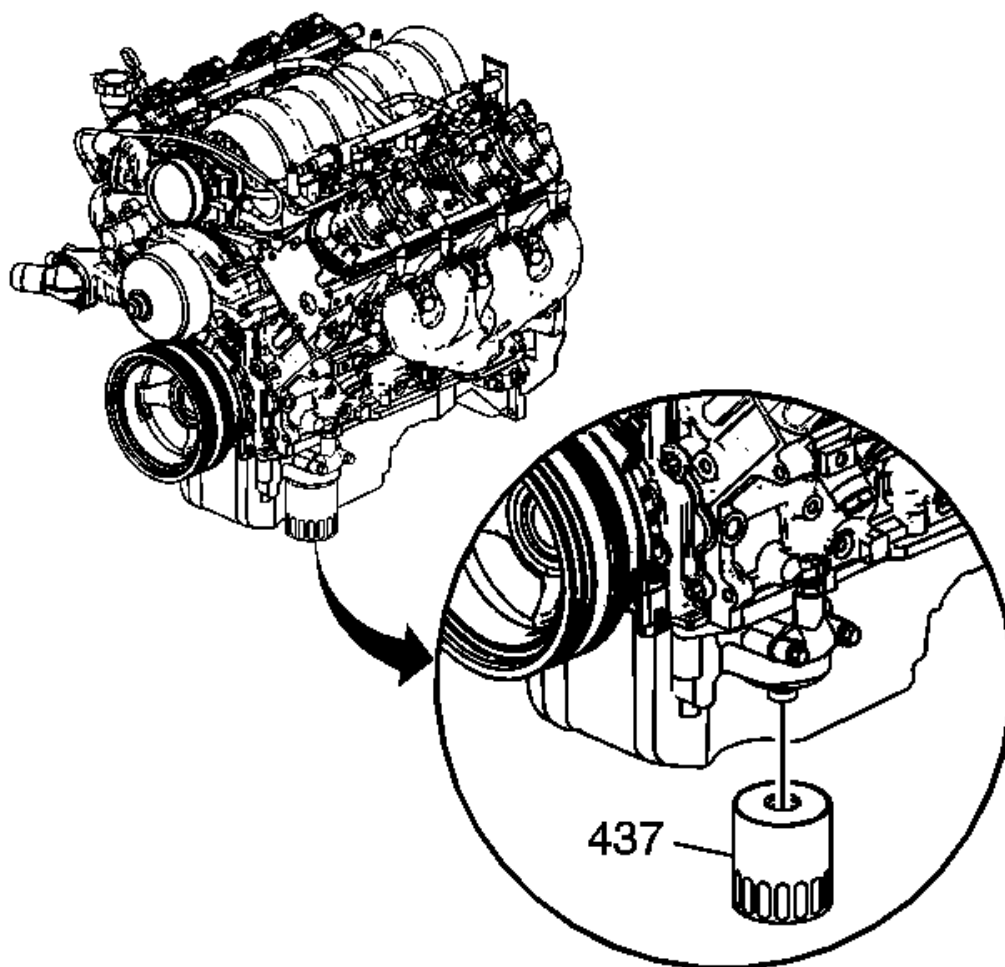


Fig. 137: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter (437).

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

3. Refill the engine oil.

Oil Filter Bypass Valve Replacement

Removal Procedure

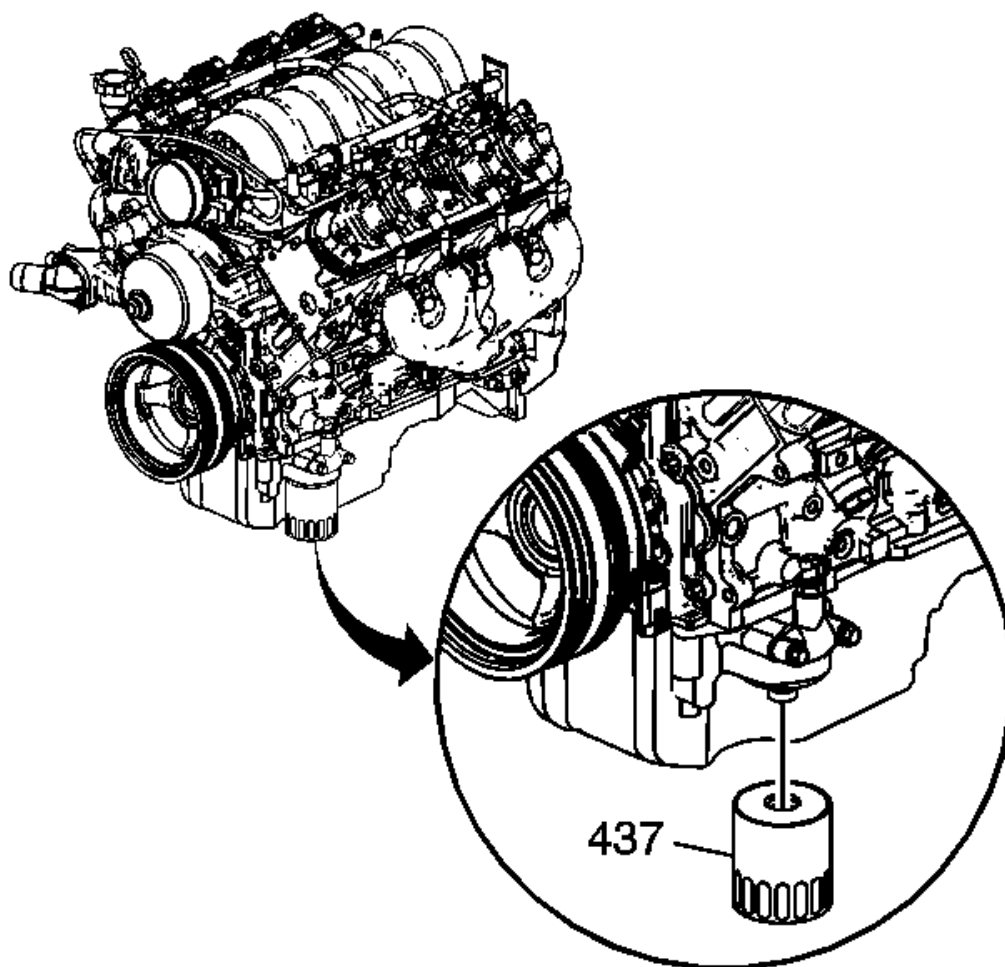


Fig. 138: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil.
2. Remove the oil filter (437).

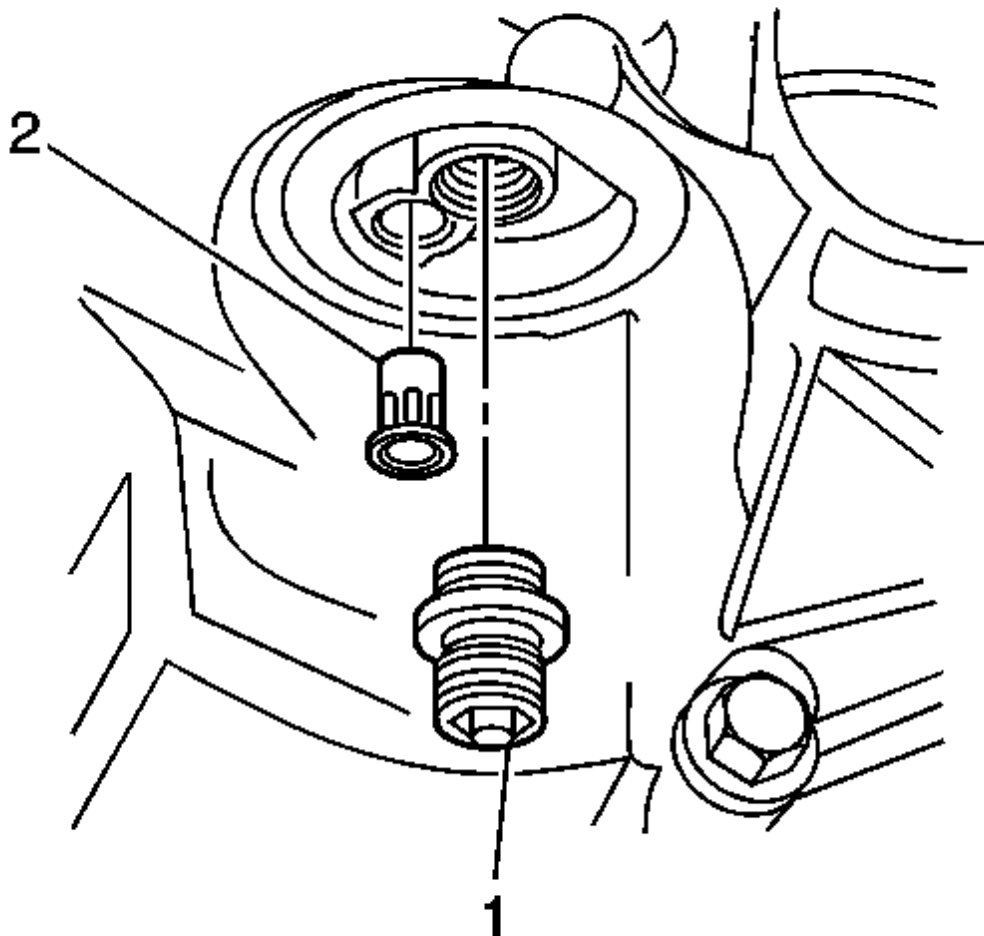


Fig. 139: View Of Oil Filter Adapter & Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).
4. Remove the oil filter bypass valve (2).

Installation Procedure

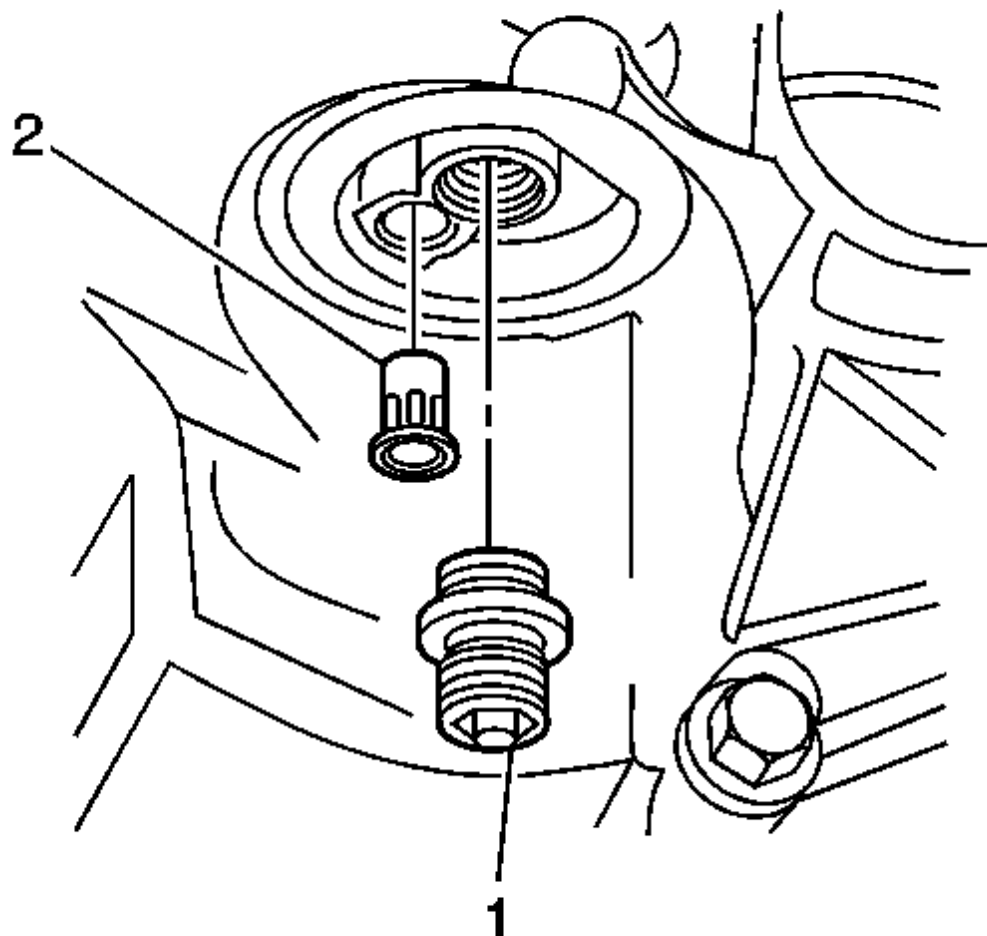


Fig. 140: View Of Oil Filter Adapter & Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil filter bypass valve (2).
2. Install the oil filter adapter (1).

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

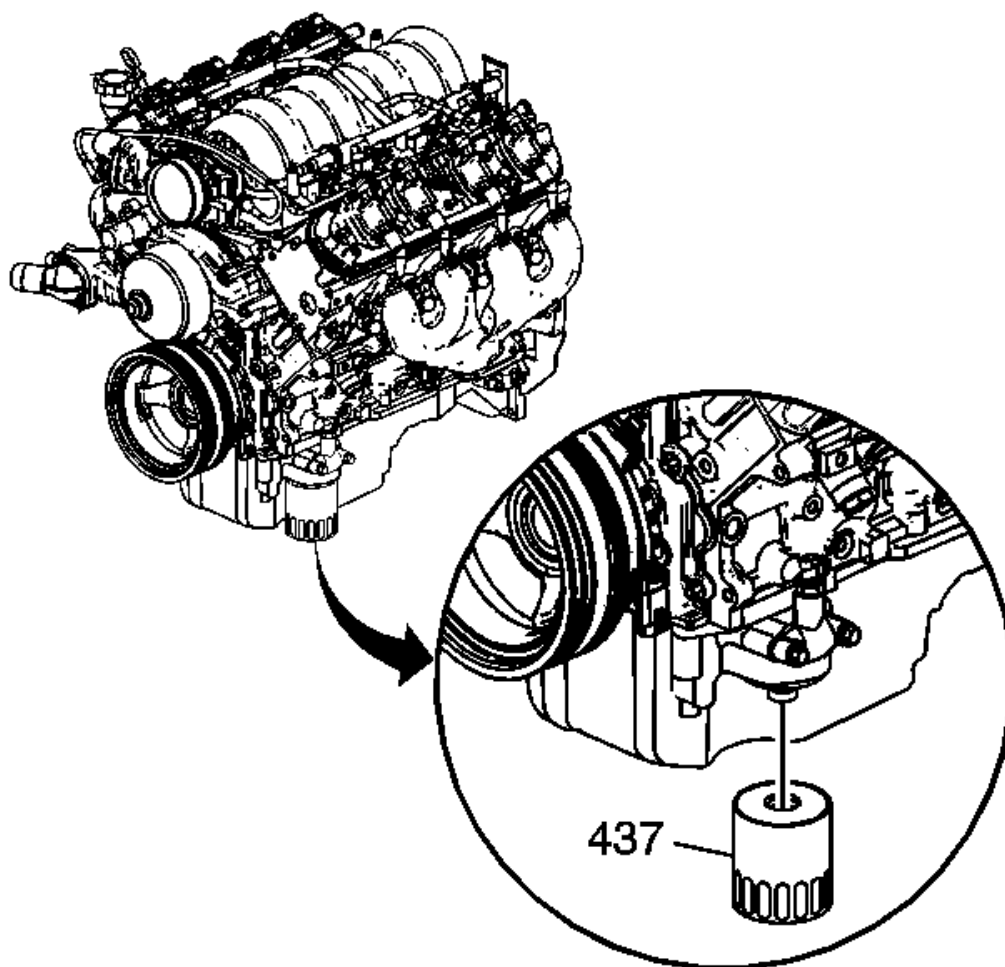


Fig. 141: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter (437).

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

4. Refill the engine oil.

Oil Pan Cover Replacement

Removal Procedure

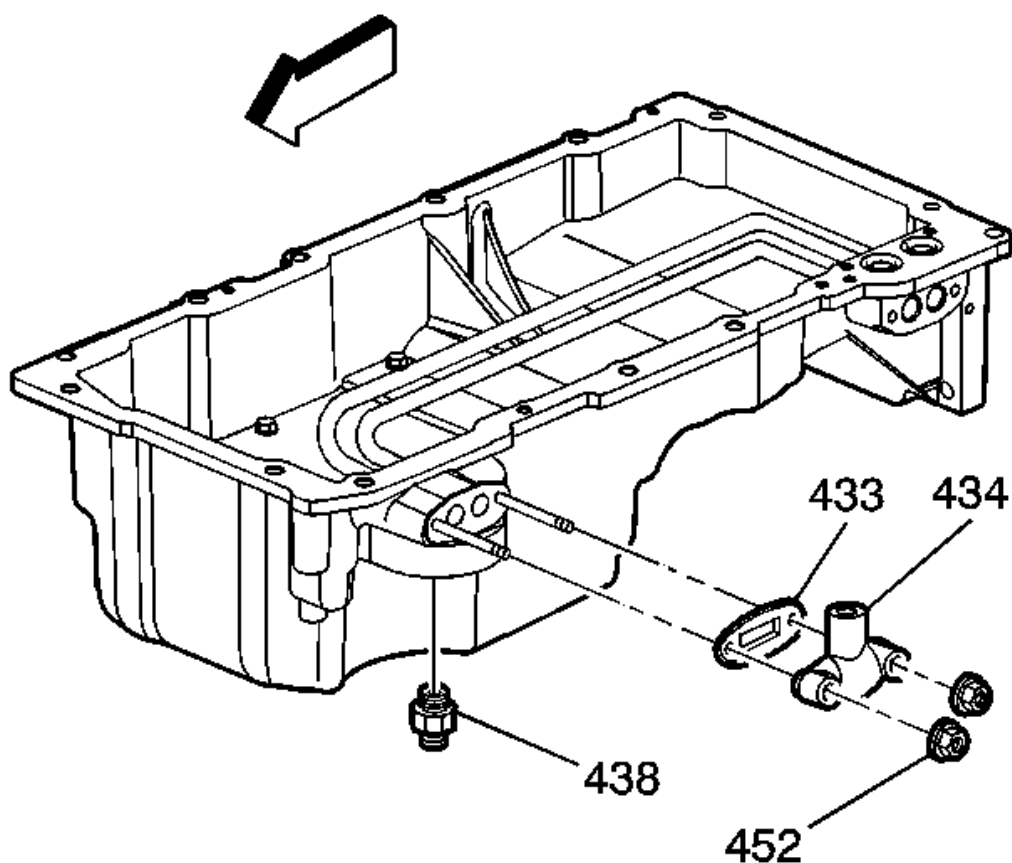


Fig. 142: View Of Oil Pan Cover, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil pan cover retaining nuts (452).
3. Remove the cover (434).
4. Remove the gasket (433).

Installation Procedure

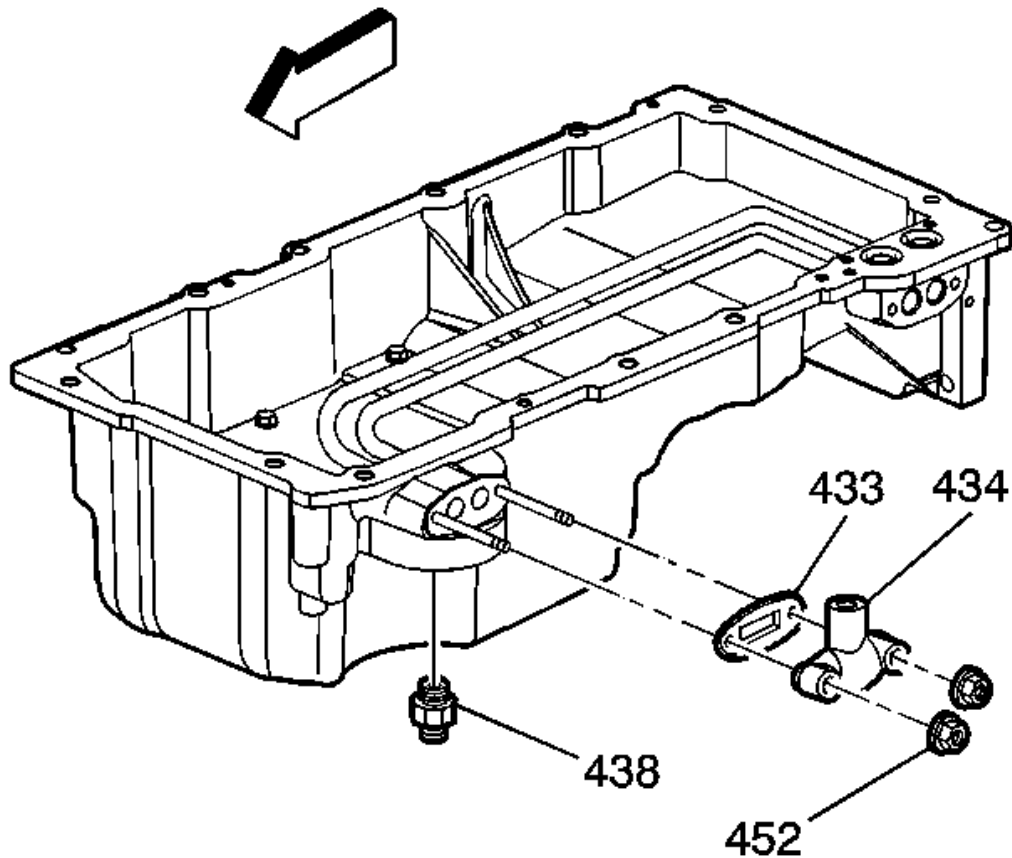


Fig. 143: View Of Oil Pan Cover, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Position the gasket (433) and cover (434) on the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the retaining nuts (452) for the cover.

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

3. Lower the vehicle.

Oil Pan Replacement

Removal Procedure

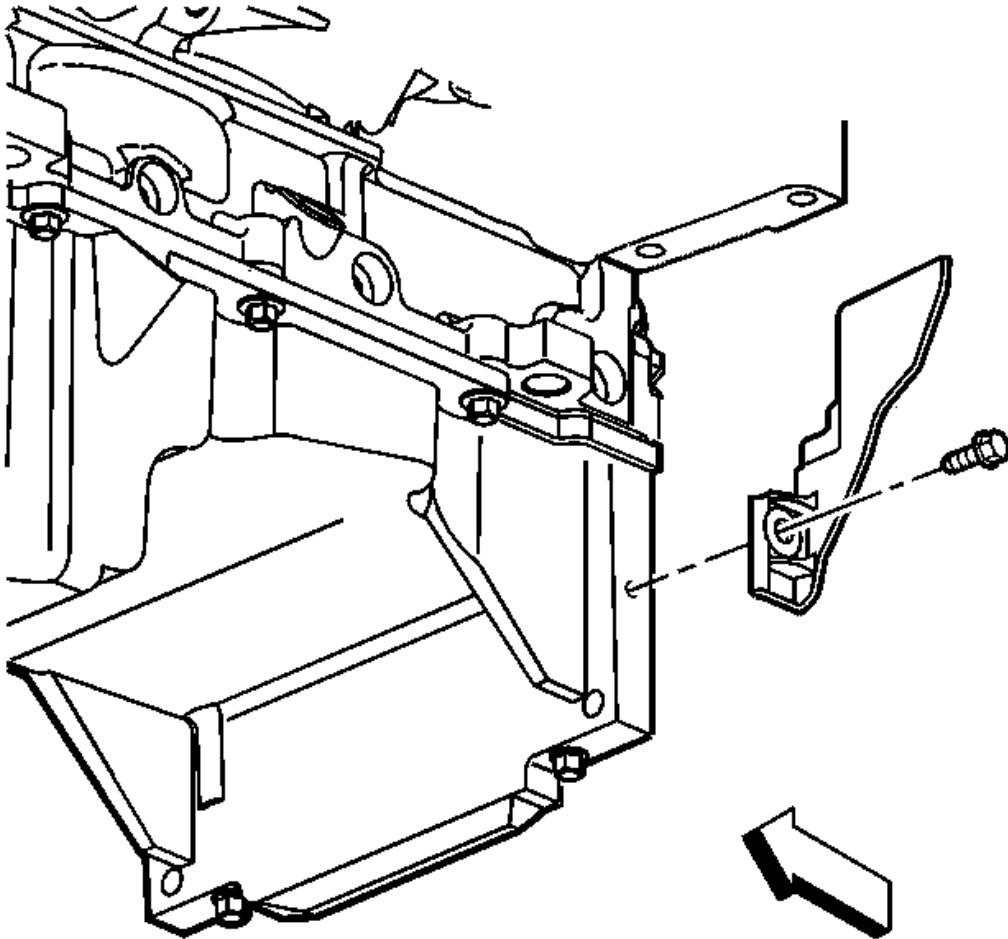


Fig. 144: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing 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 engine assembly. Refer to **Engine Replacement**.
2. Remove the left closeout cover and bolt.

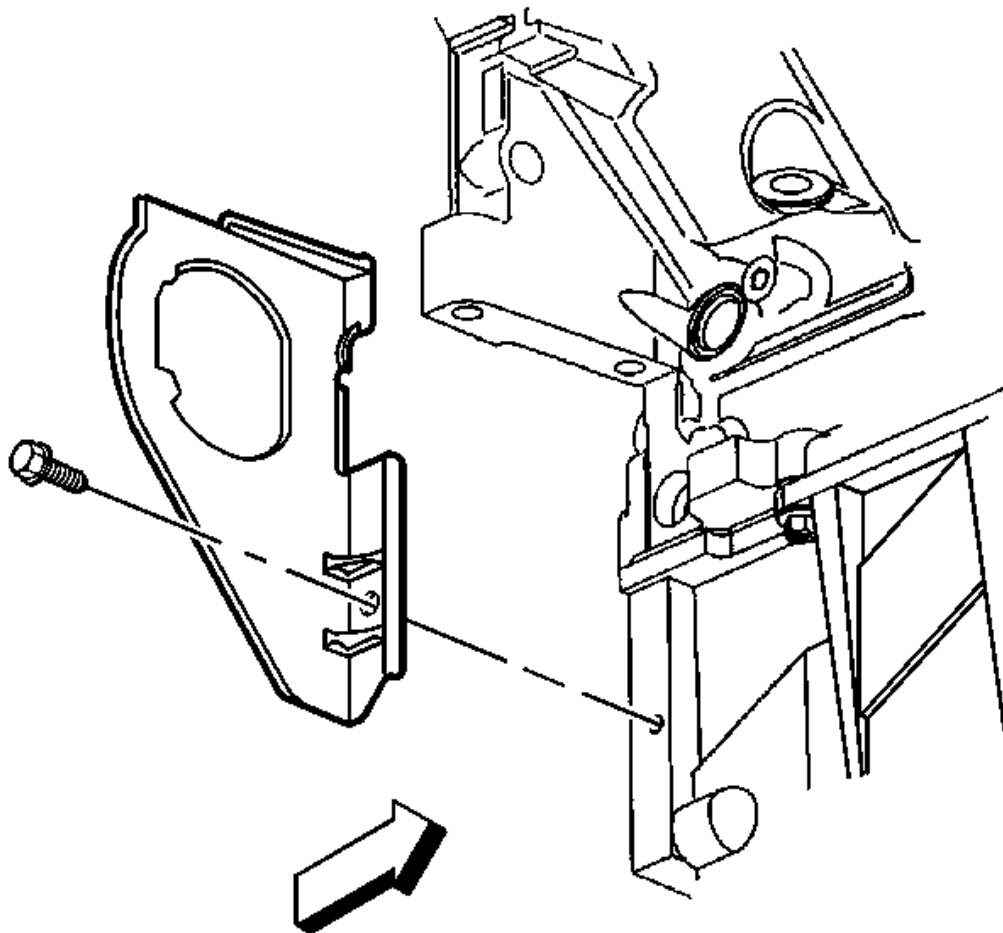


Fig. 145: View Of Right Transmission Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the right closeout cover and bolt.

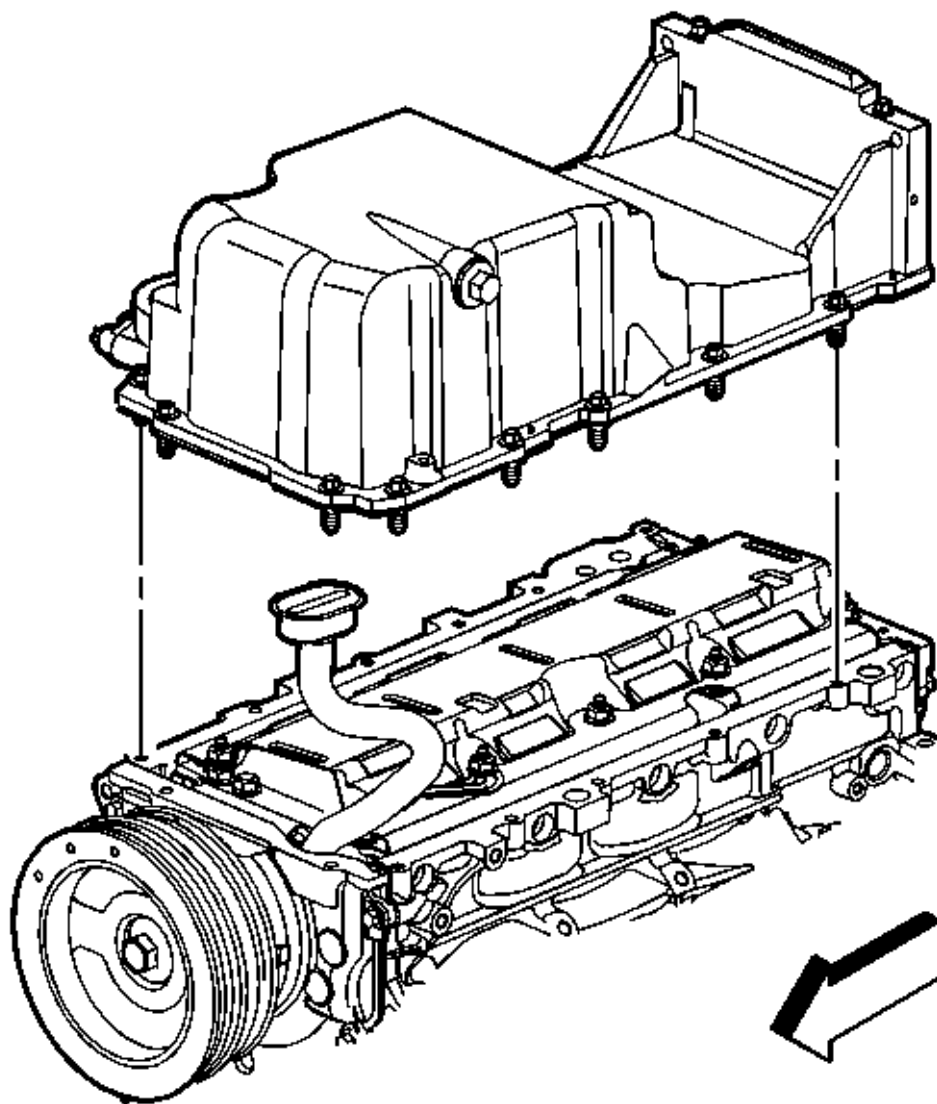


Fig. 146: View Of Rear Engine Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan bolts.
5. Remove the oil pan.

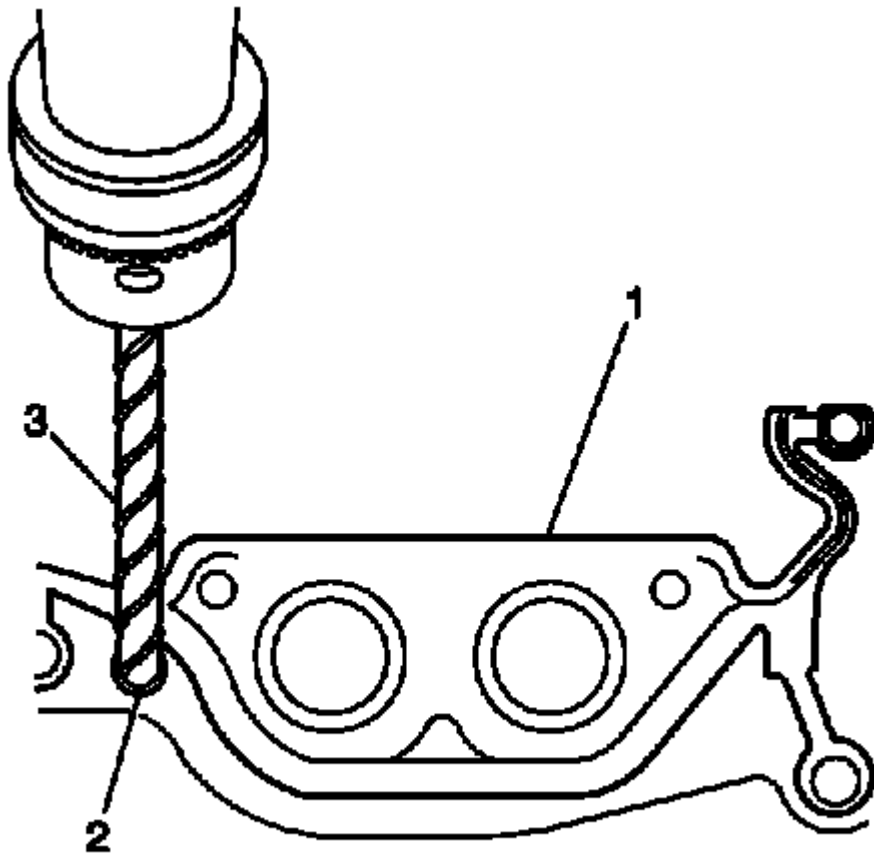


Fig. 147: Drilling Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.
Use care not to gouge, score, or damage the oil pan sealing surface.

6. Drill (3) out the retaining rivets (2), if required.
7. Remove the oil pan gasket (1) from the oil pan.
8. Discard the gasket and rivets.

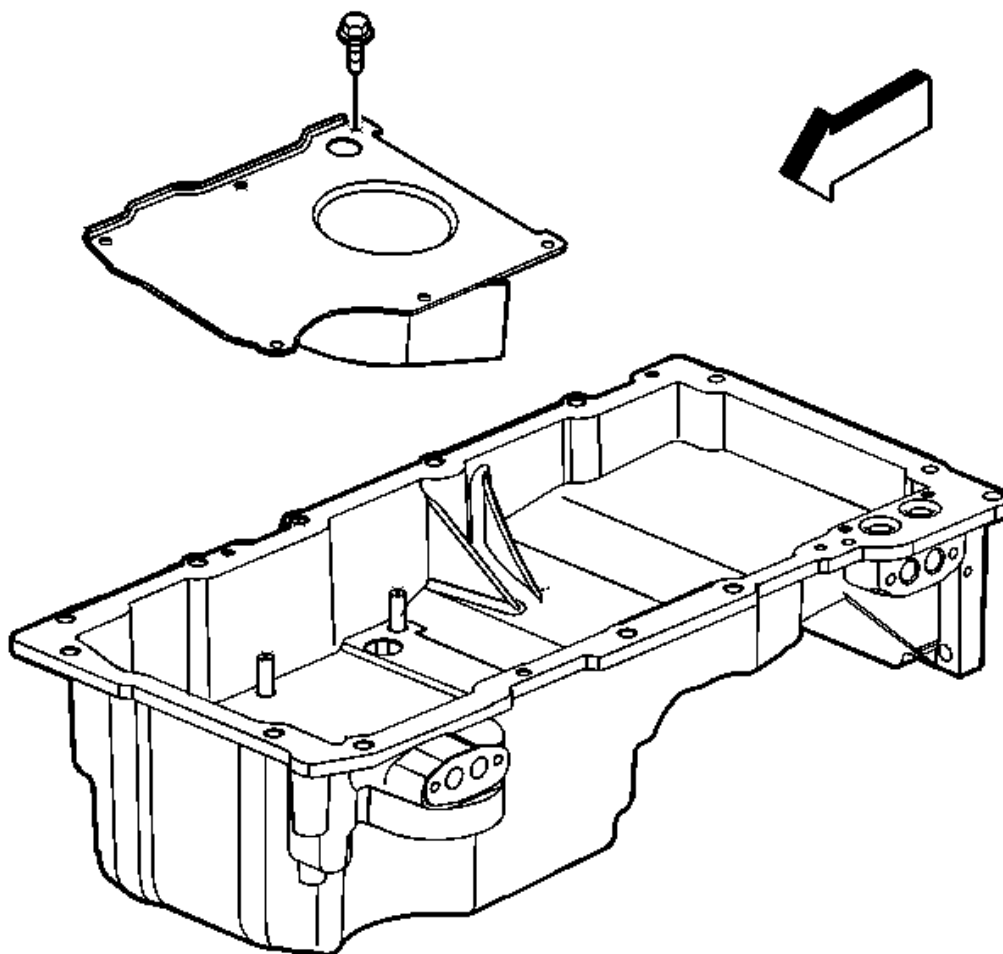


Fig. 148: View Of Oil Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the transfer tube, baffle, and other components, if required. Refer to **Oil Pan Cleaning and Inspection.**

Installation Procedure

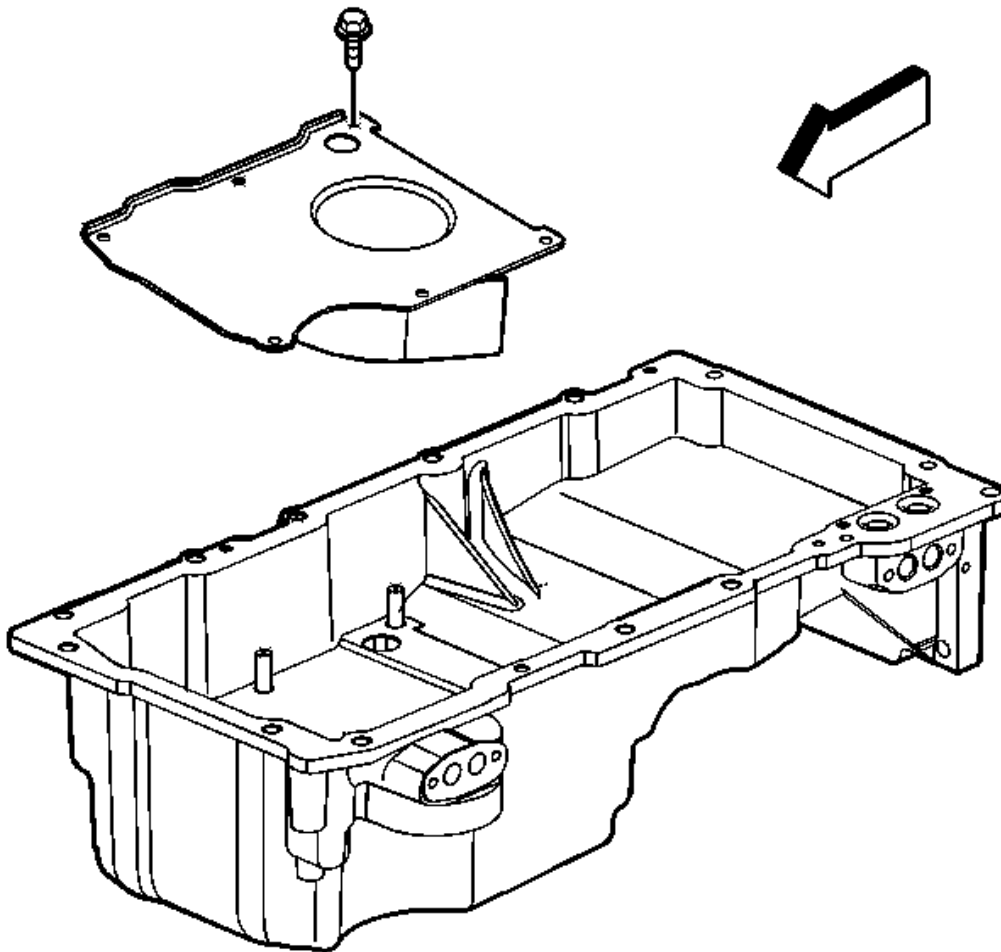


Fig. 149: View Of Oil Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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** use the oil pan gasket again. It is not necessary to rivet the **NEW** gasket to the oil pan.

1. Install the oil pan baffle and bolts.

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

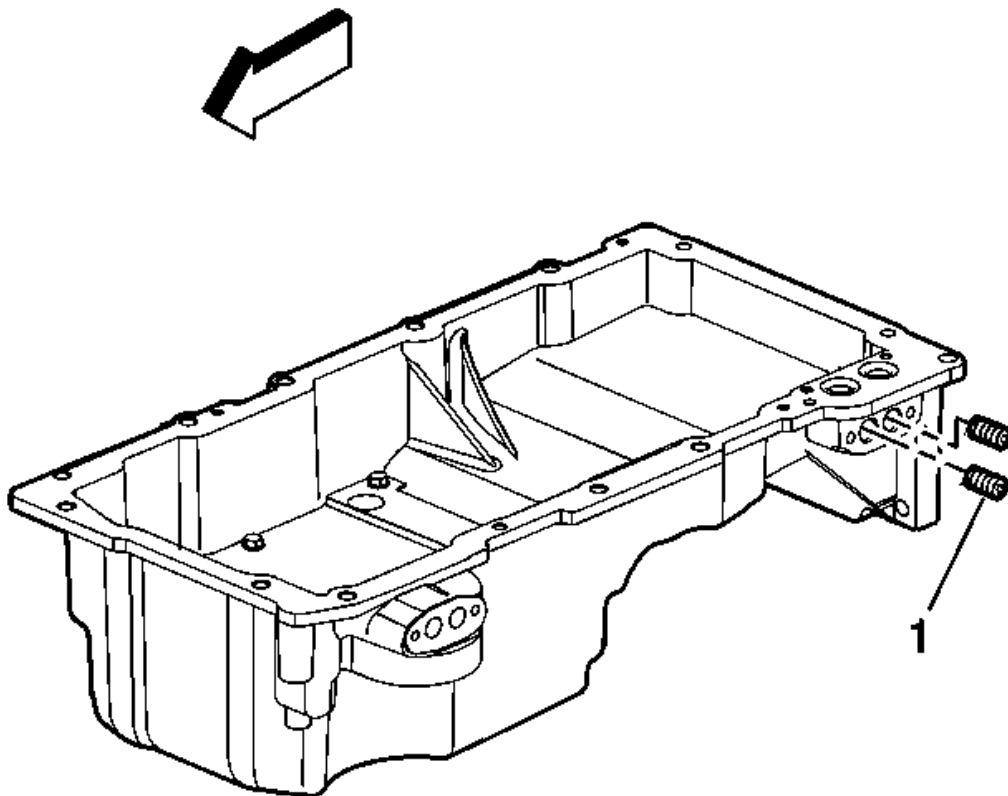


Fig. 150: View Of Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the oil pan oil gallery plugs.
3. Install the oil gallery plugs (1).

Tighten: Tighten the oil gallery plugs to 25 N.m (18 lb ft).

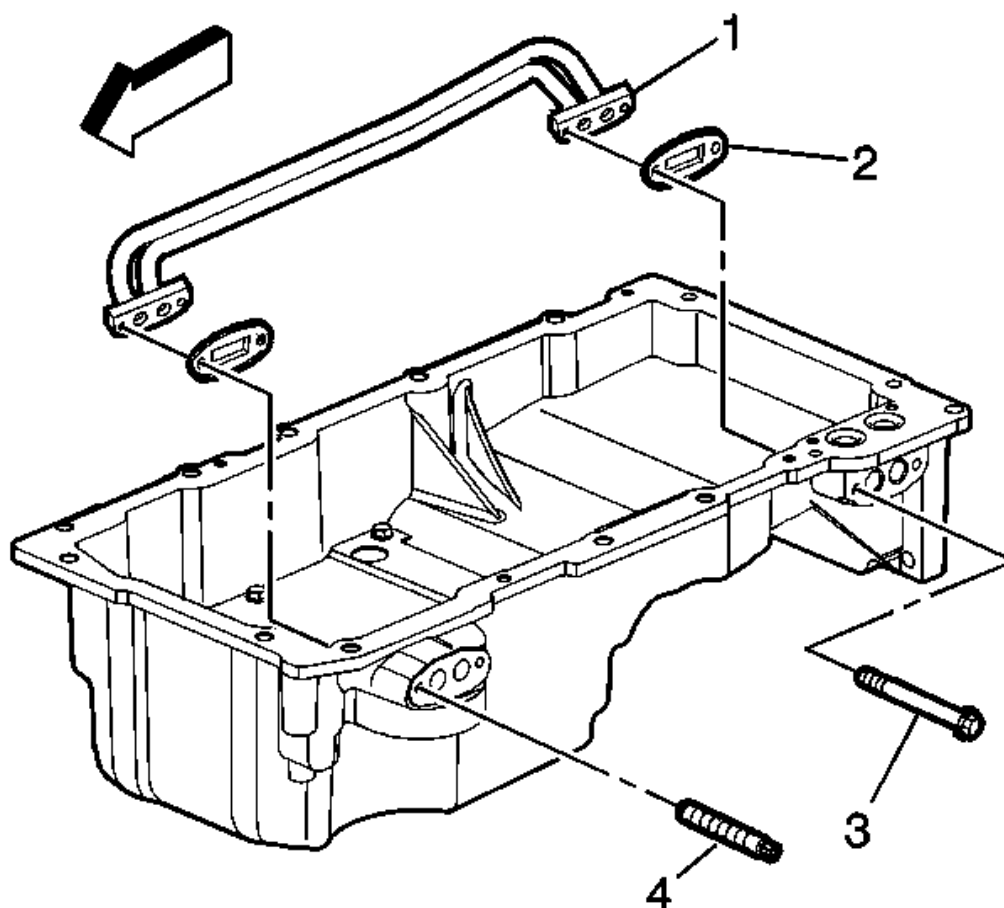


Fig. 151: View Of Oil Transfer Tube, Gaskets, Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

4. Install the oil transfer tube (1), gaskets (2), bolts (3) and studs (4).

Tighten:

1. Tighten the oil transfer tube bolts to 12 N.m (106 lb in).
2. Tighten the oil transfer tube studs to 12 N.m (106 lb in).

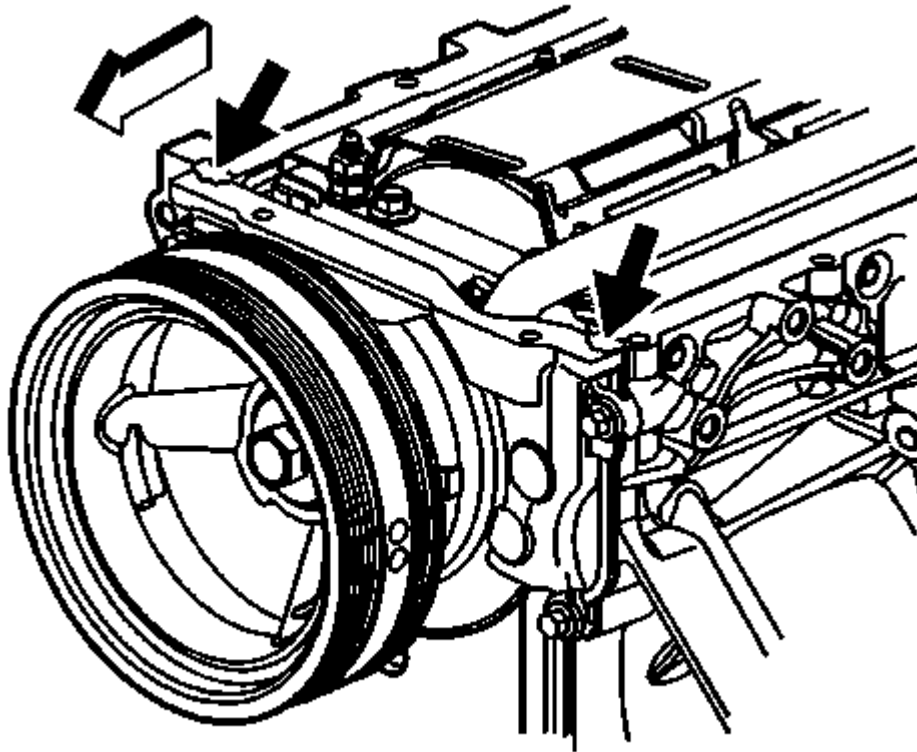


Fig. 152: View Of Sealant On Engine Front Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 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. See Sealers, Adhesives, & Lubricants.

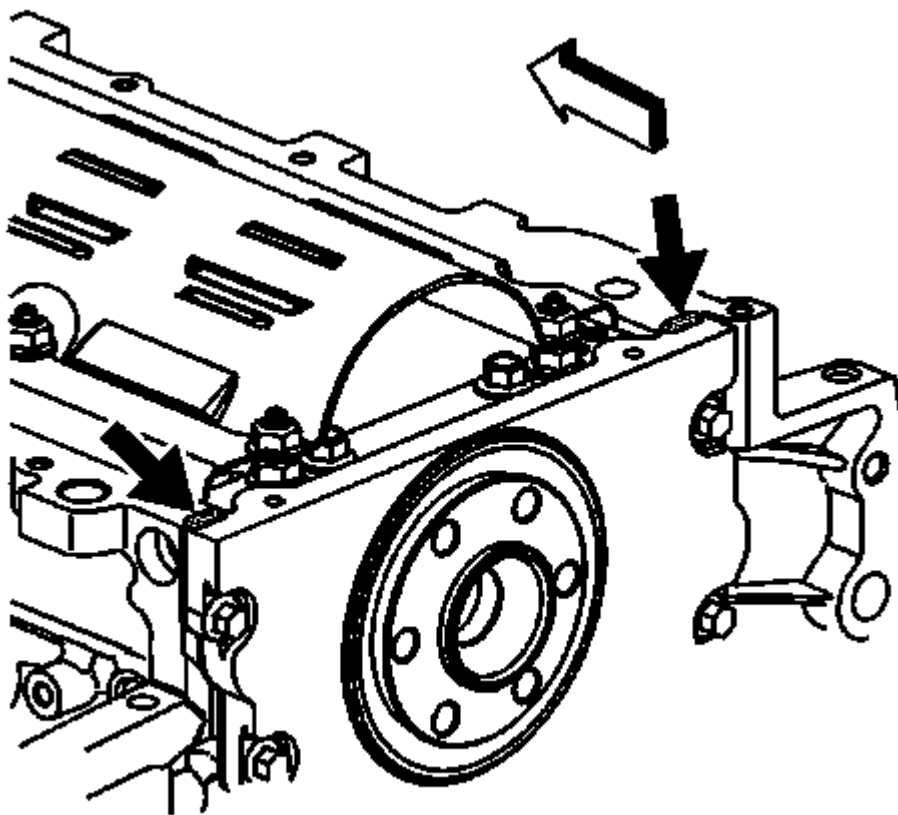


Fig. 153: View Of Sealant On Engine Rear Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

6. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 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. Refer to [Sealers, Adhesives, & Lubricants](#).

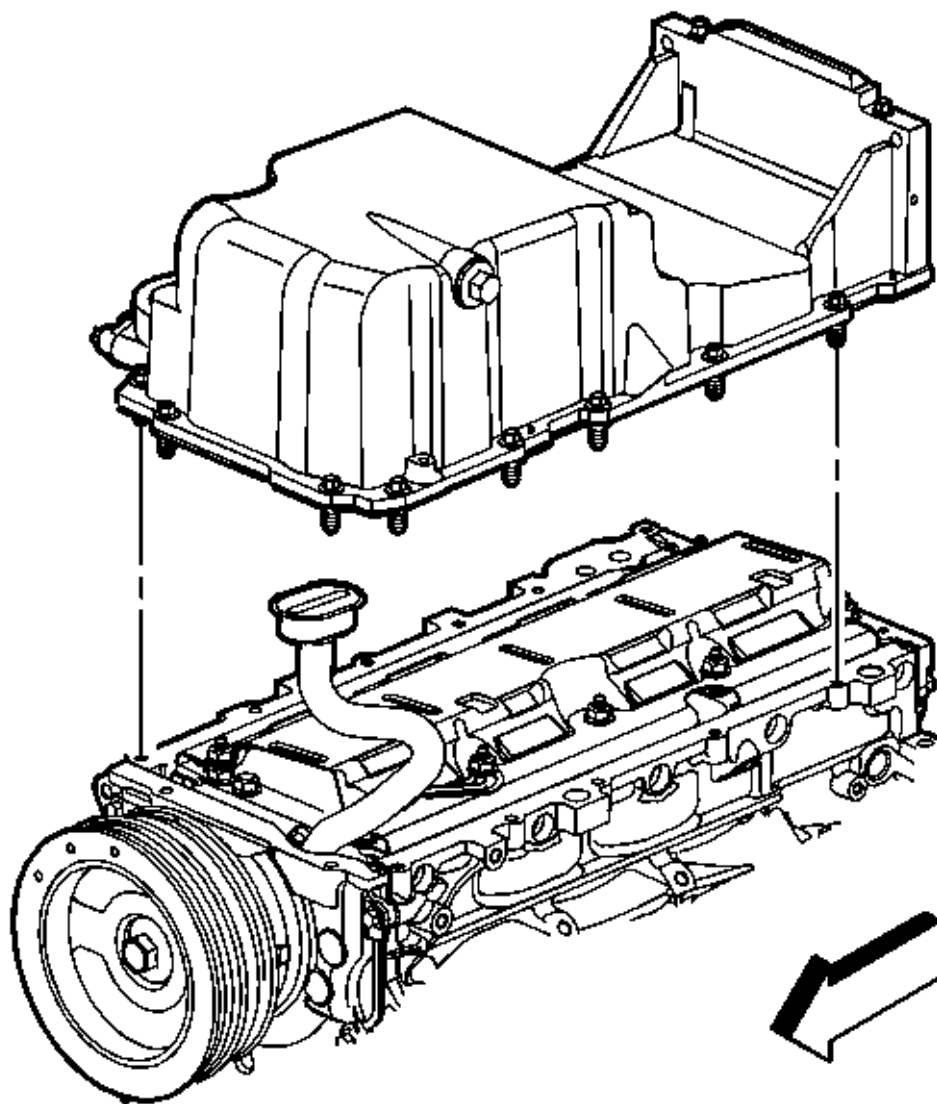


Fig. 154: View Of Rear Engine Cover
Courtesy of GENERAL MOTORS CORP.

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

7. Preassemble the oil pan gasket to the pan.
 1. Install the gasket onto the oil pan.

2. Install the oil pan bolts to the pan and through the gasket.
8. Install the oil pan, gasket and bolts to the engine block.
9. Tighten bolts finger tight. Do not overtighten.
10. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

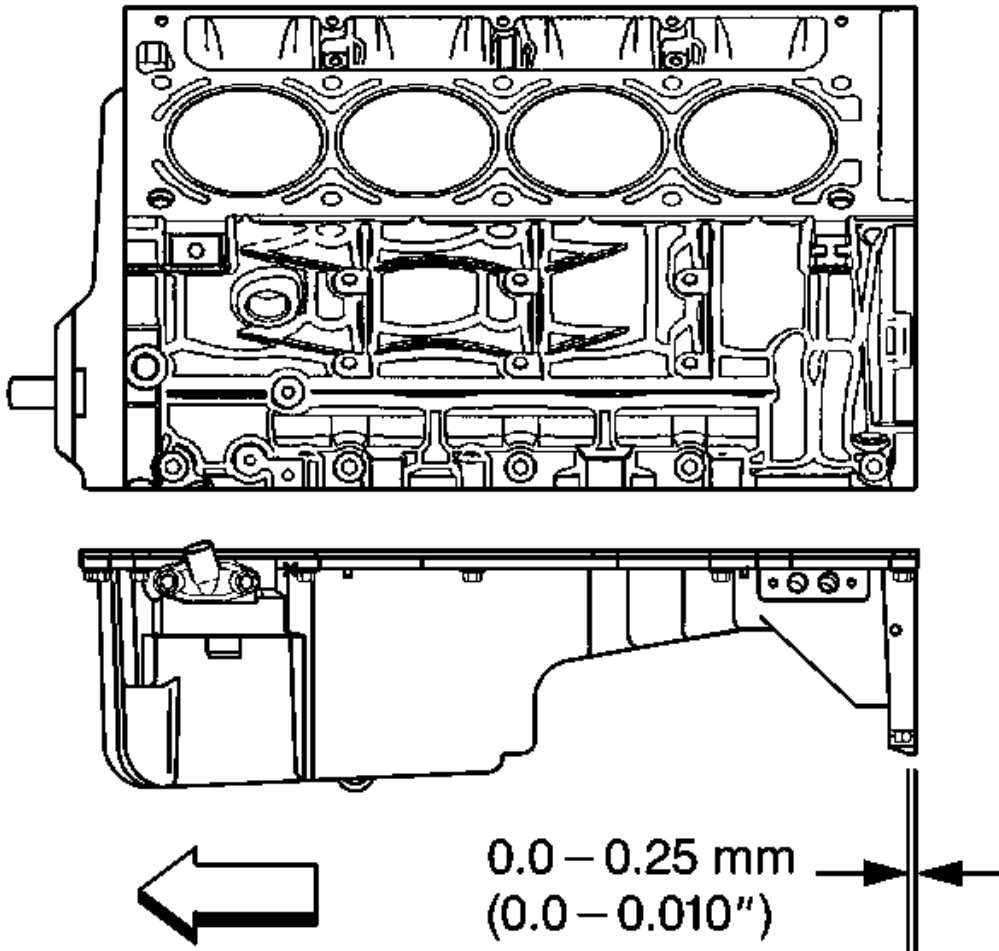


Fig. 155: Aligning Oil Pan

Courtesy of GENERAL MOTORS CORP.

11. 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).

12. 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 check to make sure that there is no more than a 0.25 mm (0.01 in) gap 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.

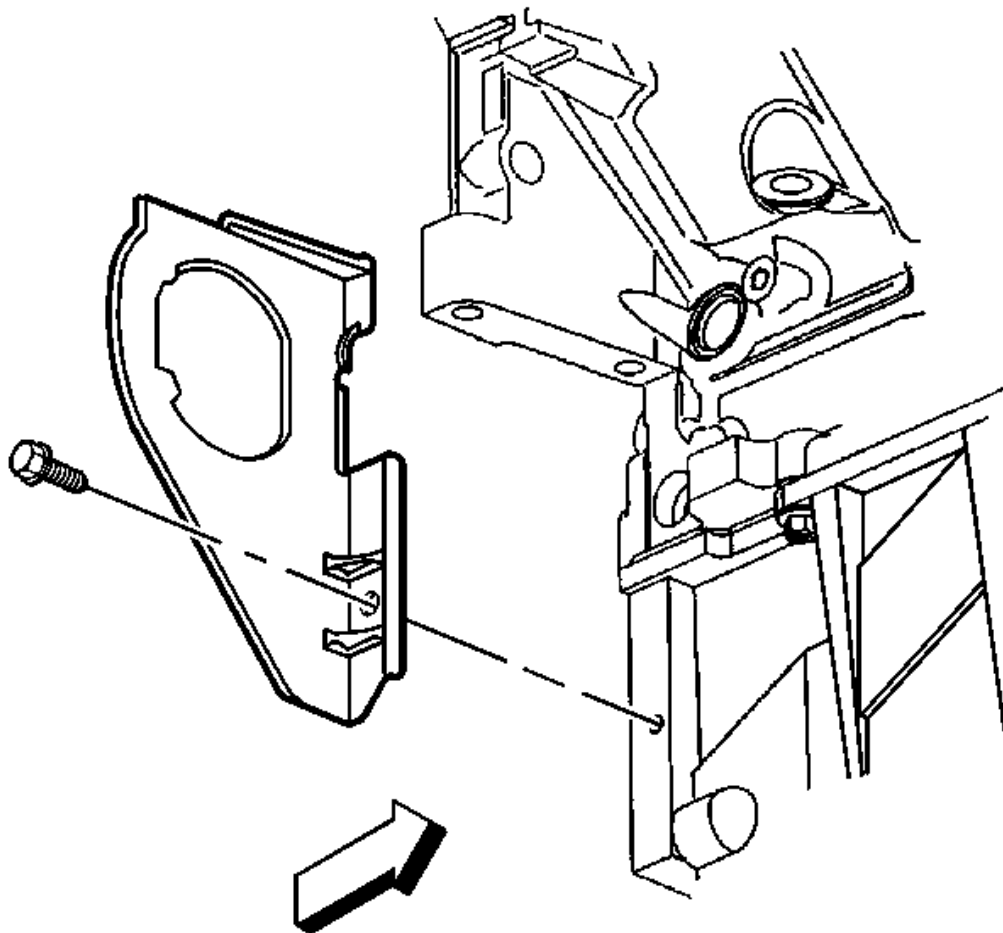


Fig. 156: View Of Right Transmission Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the right closeout cover and bolt.

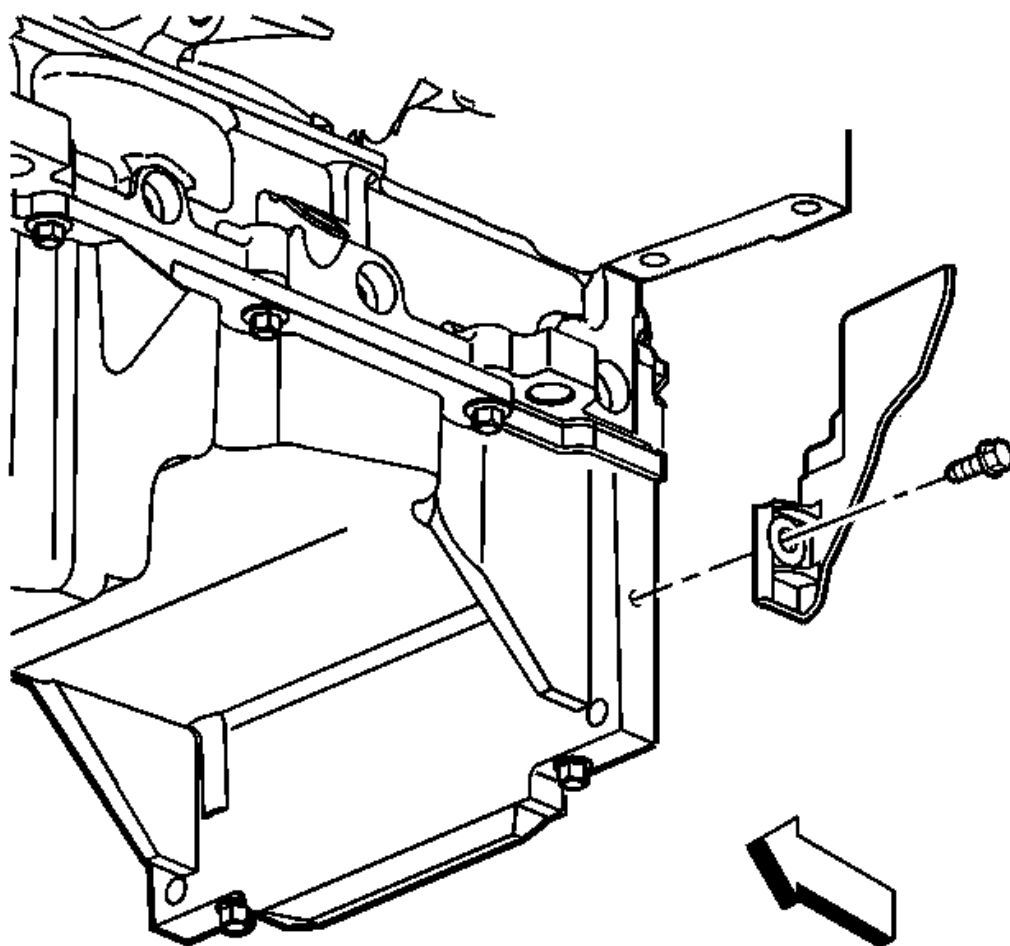


Fig. 157: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the left closeout cover and bolt.
15. Install the engine assembly. Refer to **Engine Replacement**.

Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

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

Removal Procedure

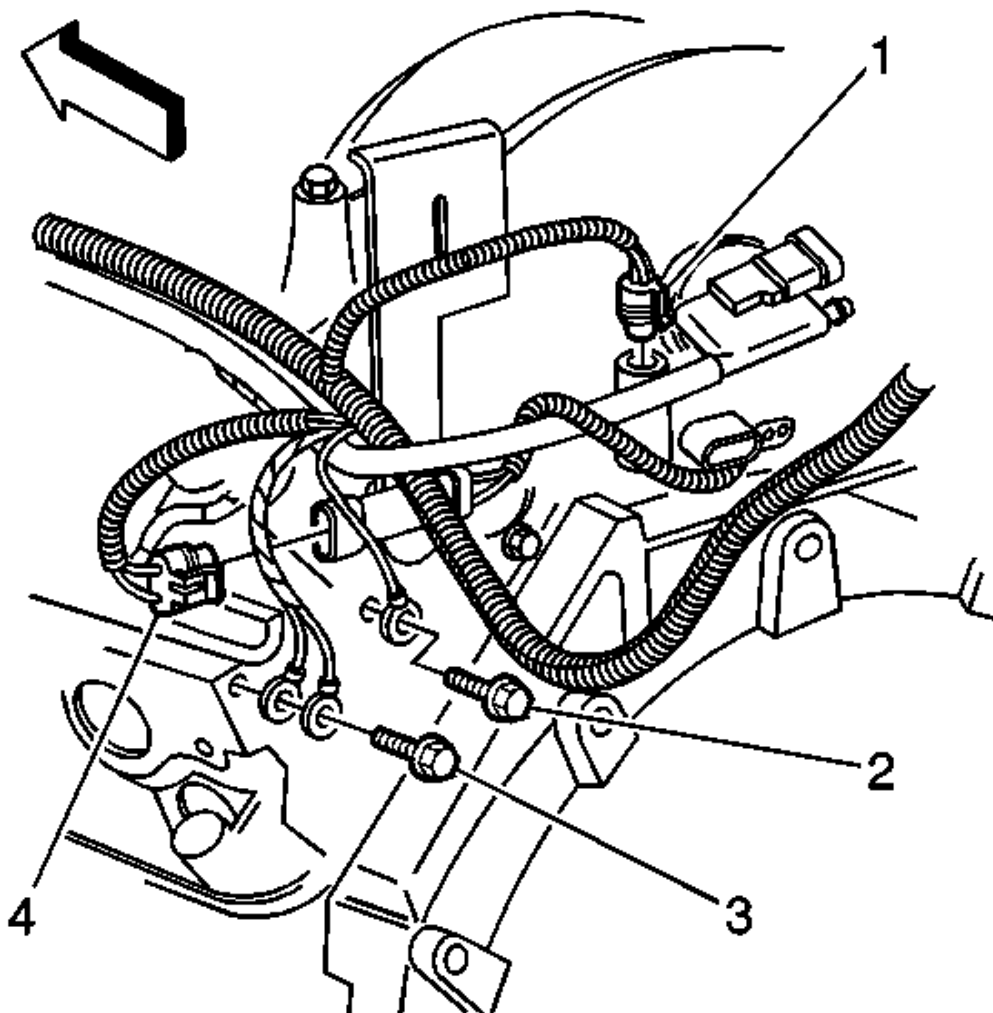


Fig. 158: View Of Oil Pressure Sensor Electrical Connector & Engine Wiring Harness Ground Bolts

Courtesy of GENERAL MOTORS CORP.

1. Disconnect the oil pressure sensor electrical connector (1).

IMPORTANT: Clean the area around the sensor before removal. This prevents debris from entering the engine.

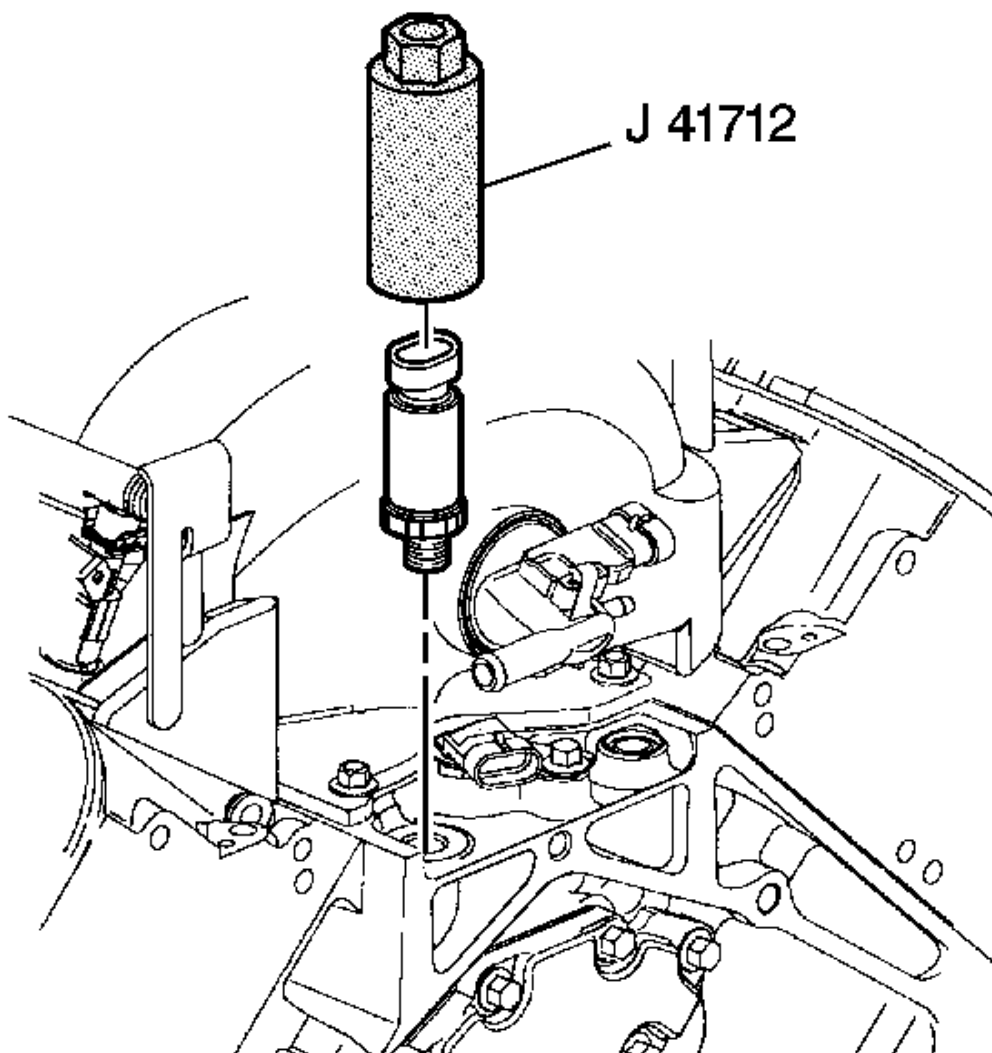


Fig. 159: View Of J 41712

Courtesy of GENERAL MOTORS CORP.

2. Use **J 41712** to remove the oil pressure sensor from the engine block. See **Special Tools**.

Installation Procedure

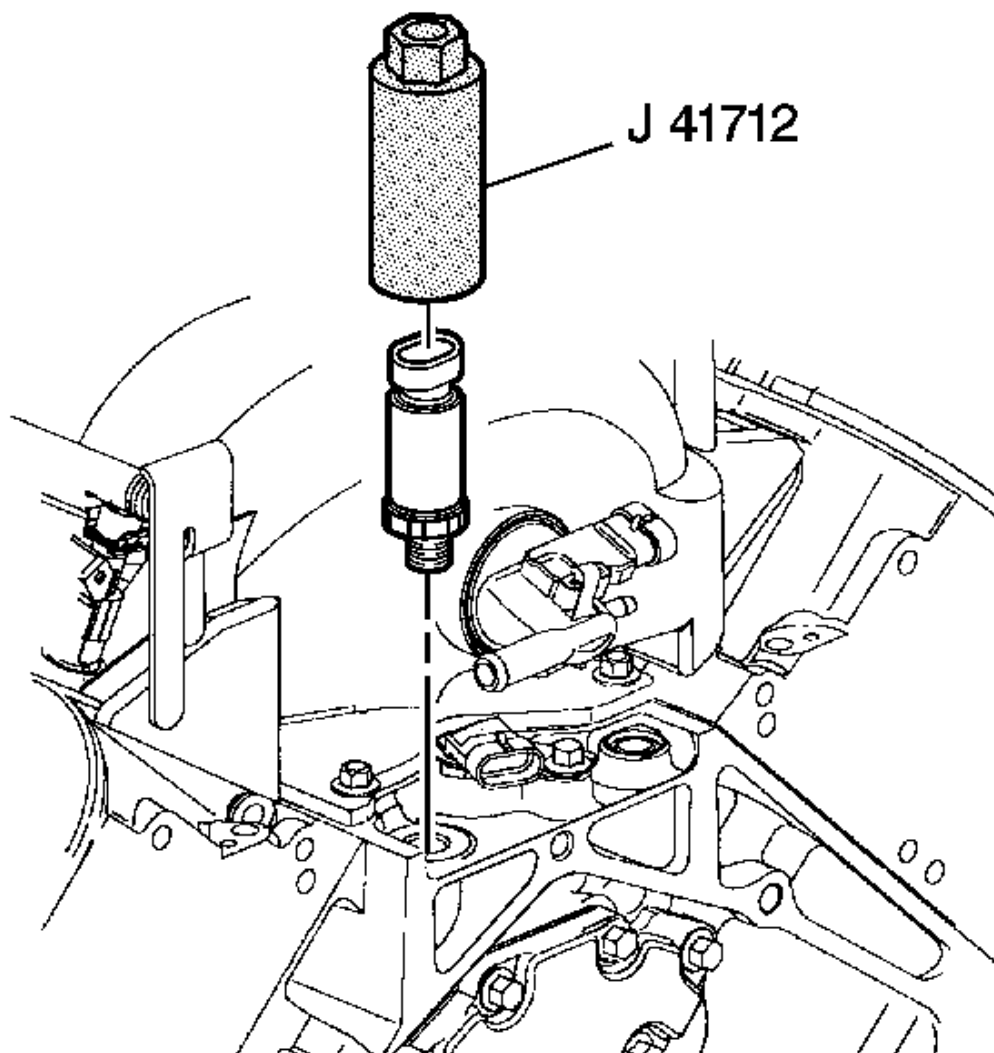


Fig. 160: View Of J 41712

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. If installing the old sensor, apply thread sealant GM P/N 12346004, (Canadian P/N 1093480), or equivalent.
2. Use to install the **J 41712** oil pressure sensor to the engine block. See **Special Tools**.

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

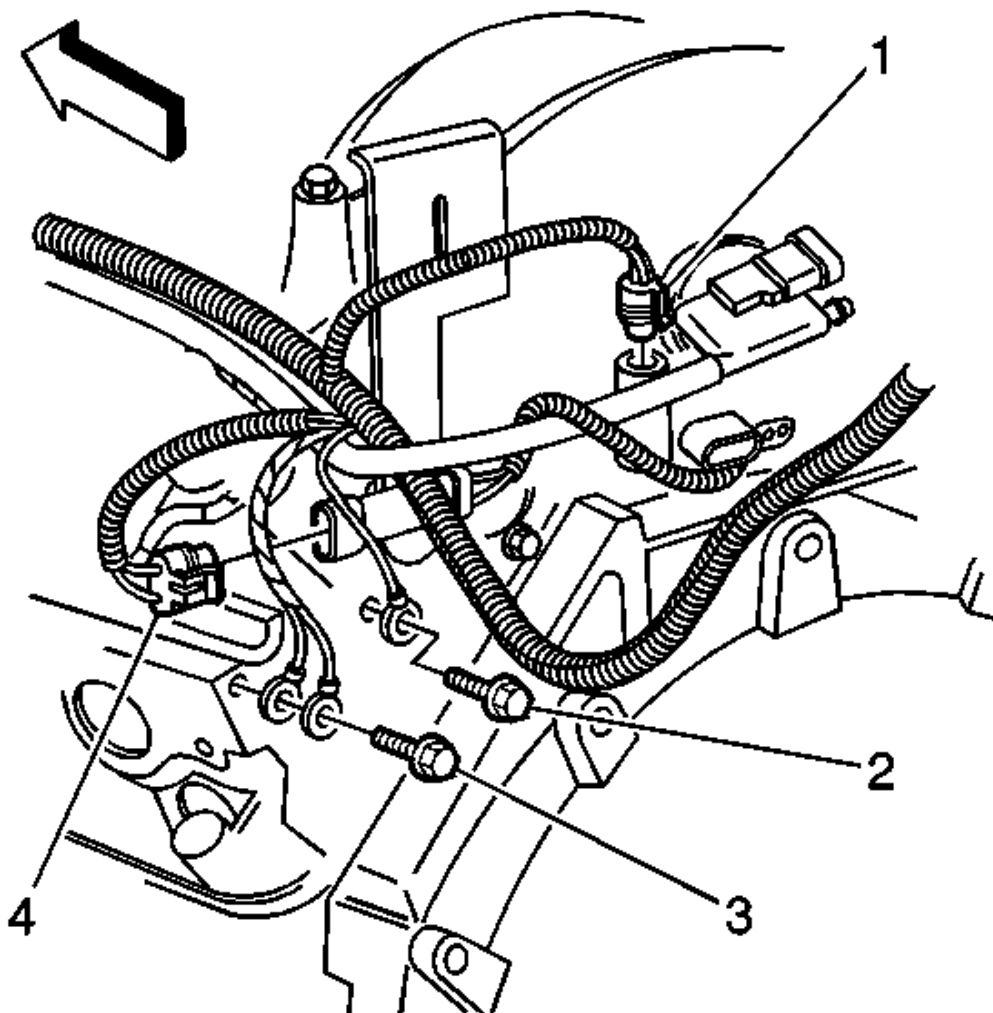


Fig. 161: View Of Oil Pressure Sensor Electrical Connector & Engine Wiring Harness Ground Bolts

Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (1).

Engine Oil Level Sensor and/or Switch Replacement

Removal Procedure

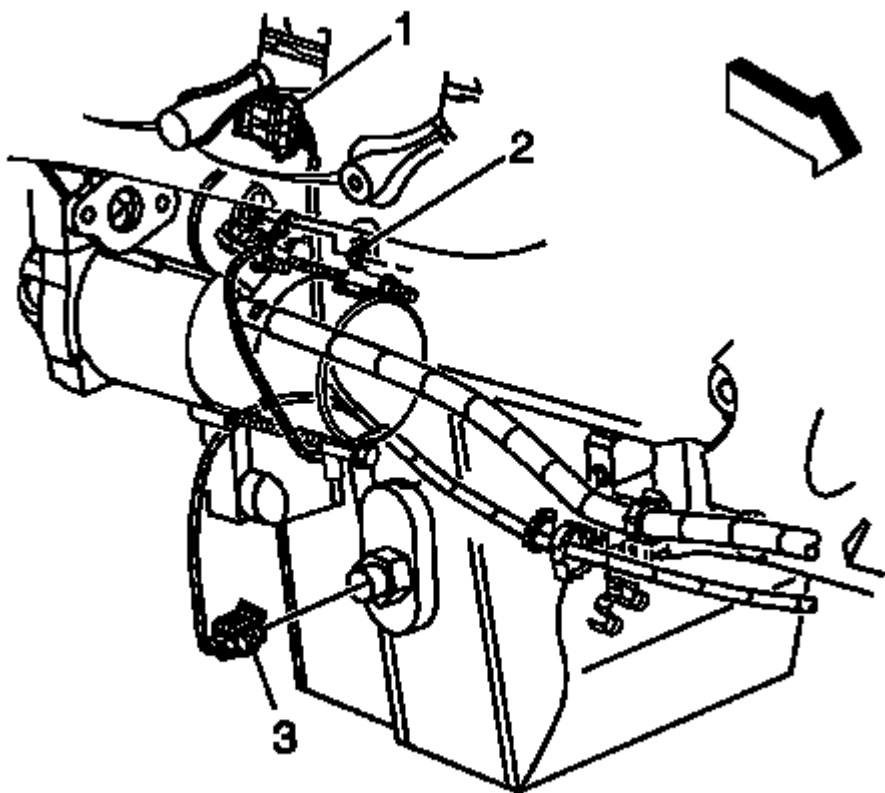


Fig. 162: View Of Oil Level Sensor & CKP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Drain the engine of oil.
3. Disconnect the electrical connector (3).

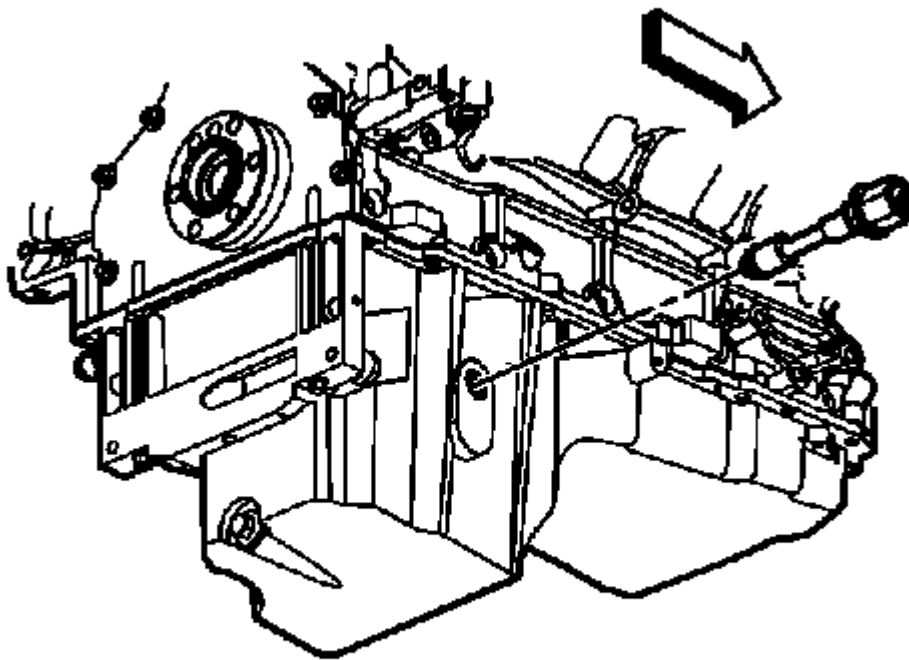


Fig. 163: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine oil lever sensor.

Installation Procedure

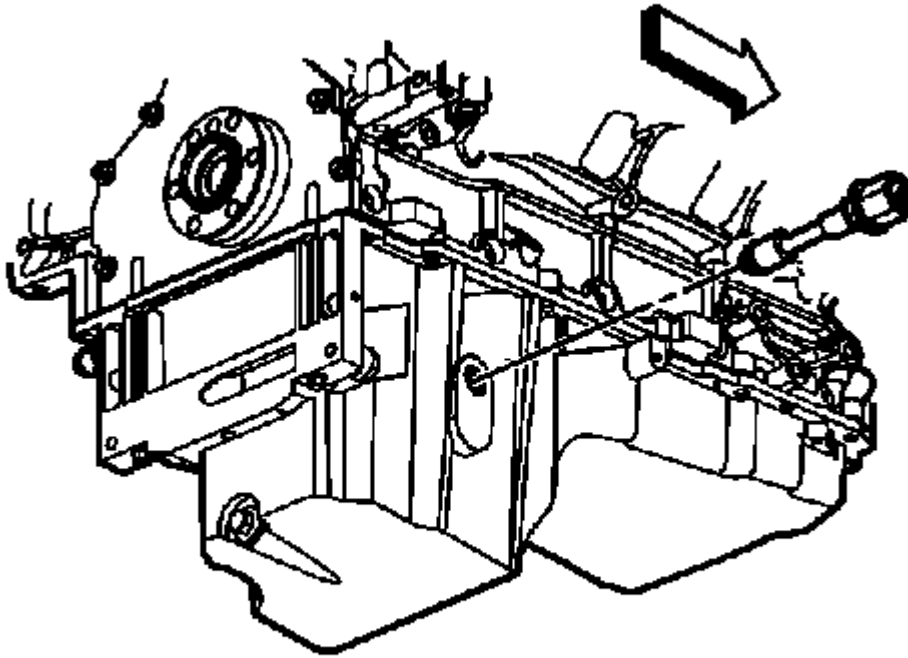


Fig. 164: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the drain plug.

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

2. Install the engine oil level sensor.

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

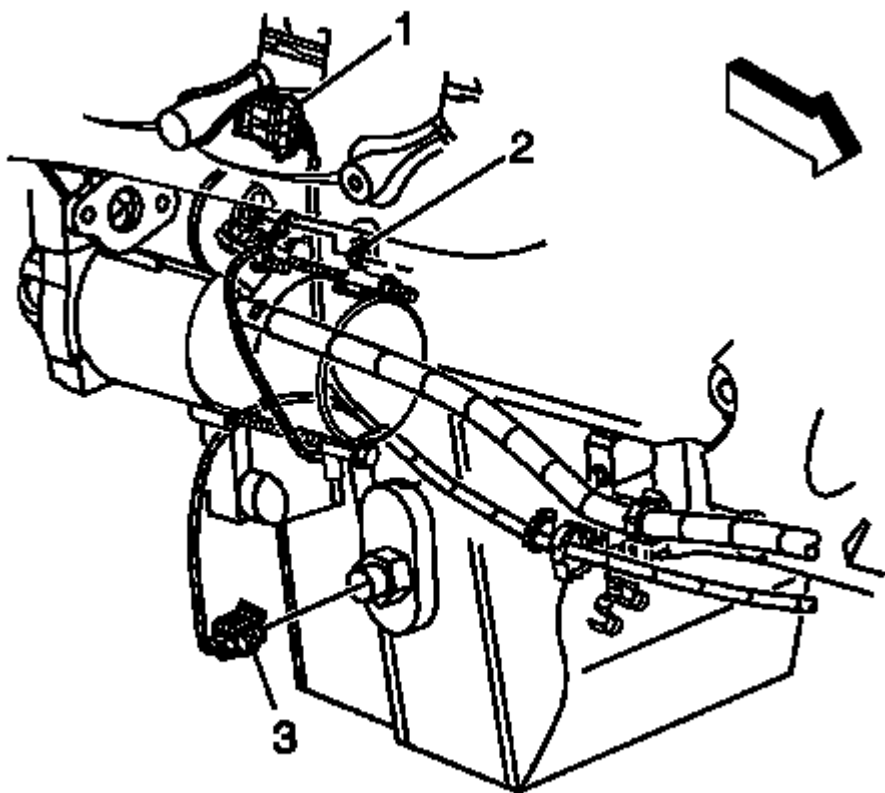


Fig. 165: View Of Oil Level Sensor & CKP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Reconnect the electrical connector (3).
4. Lower the vehicle.
5. Refill the engine. Refer to **Capacities - Approximate Fluid** in General Information.

Oil Pump, Pump Screen and Deflector Replacement

Removal Procedure

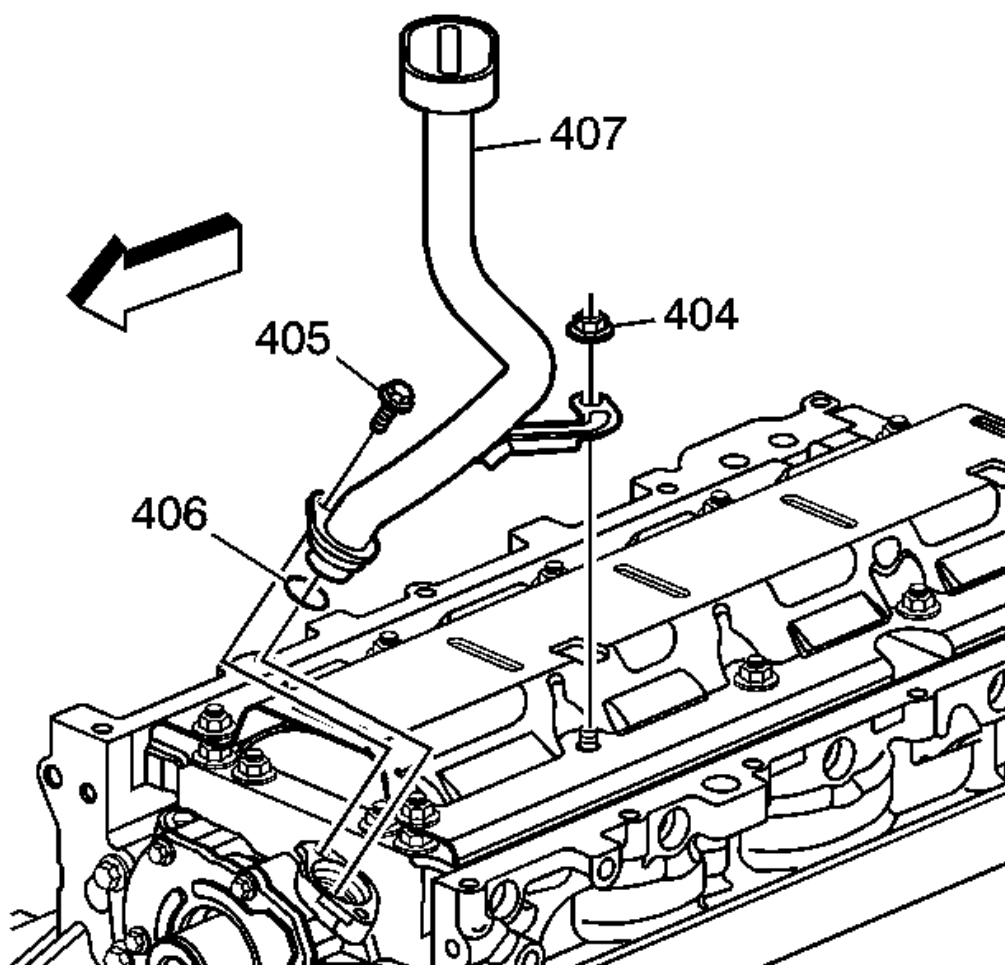


Fig. 166: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Remove the engine oil pan. Refer to **Oil Pan Replacement**.
3. Remove the oil pump screen bolt (405) and nut (404).
4. Remove the oil pump screen and tube assembly.
5. Remove the O-ring seal (406) from the pump screen.
6. Discard the O-ring seal.

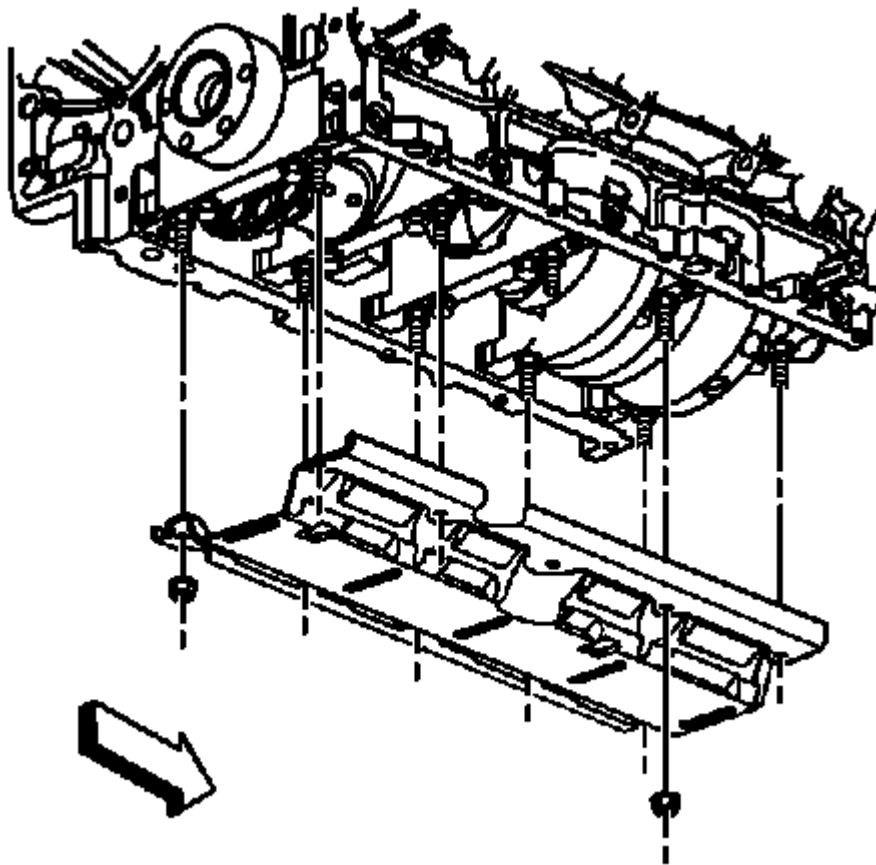


Fig. 167: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

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

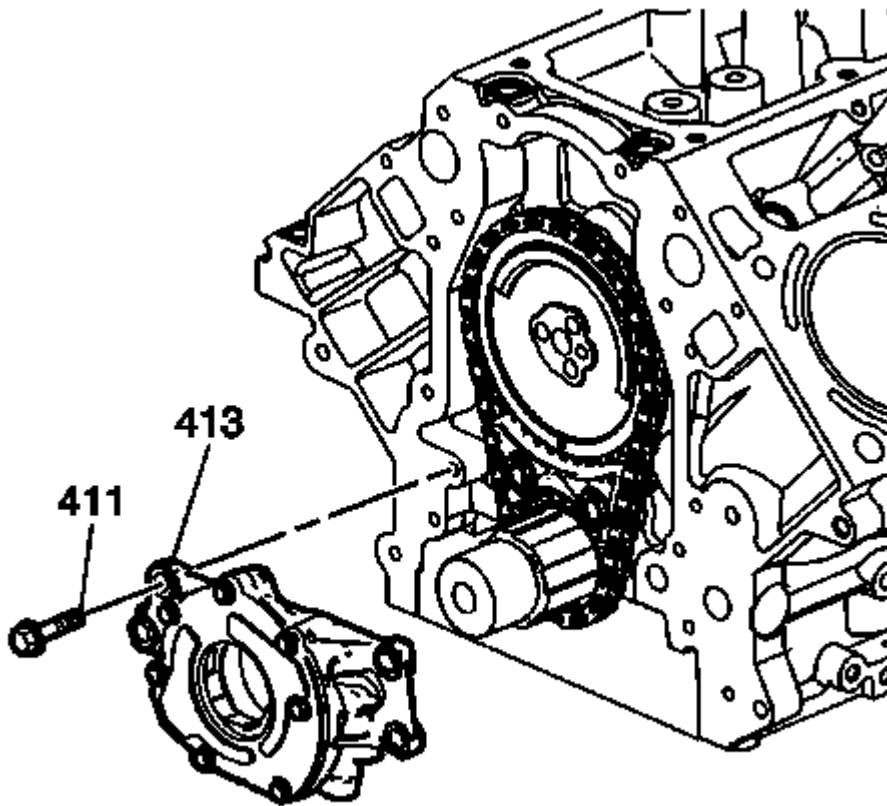


Fig. 168: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

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

9. Remove the oil pump (413) and bolts (411).
10. Remove the oil pump.
11. Clean and inspect the oil pump. Refer to Oil Pump Cleaning and Inspection.

Installation Procedure

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

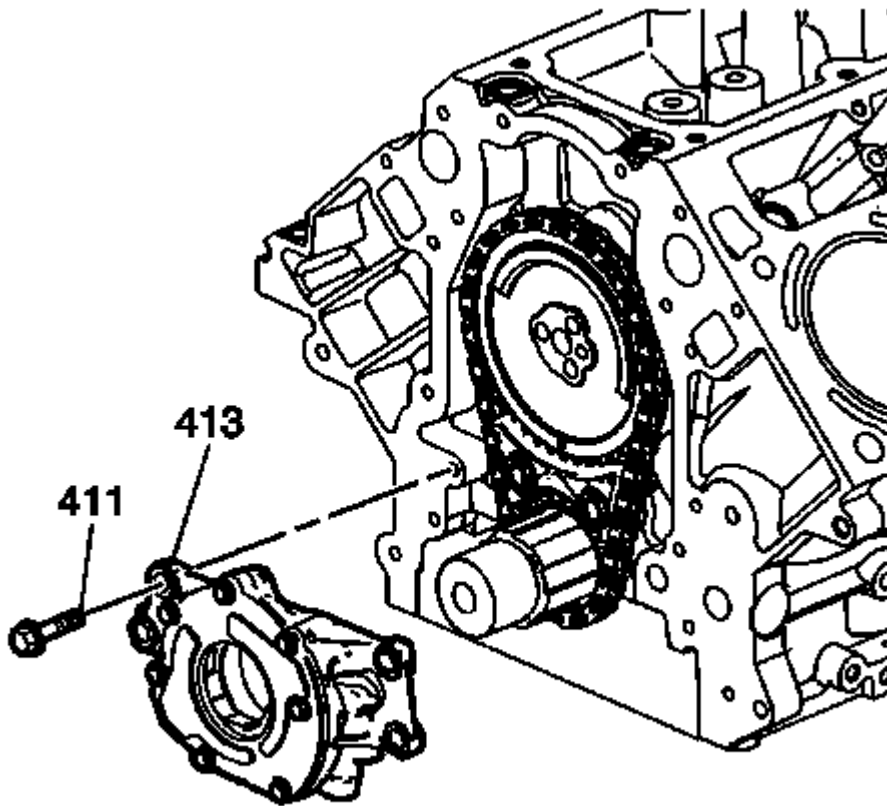


Fig. 169: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

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 (413) onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump bolts (411).

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

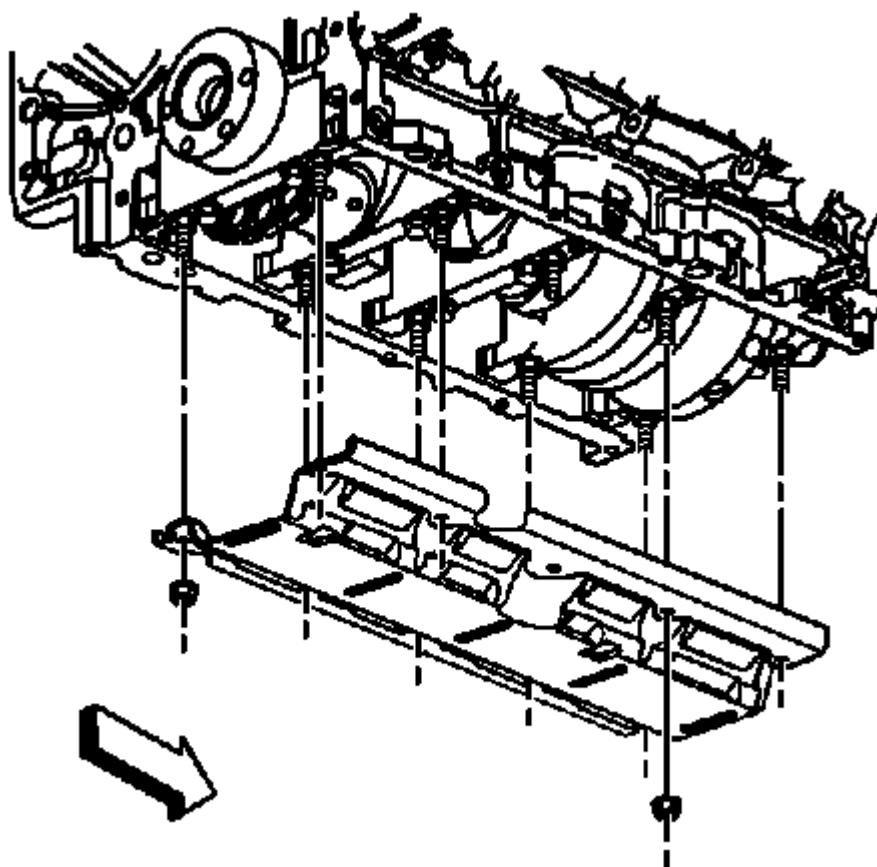


Fig. 170: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.
5. Install the crankshaft oil deflector nuts.

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

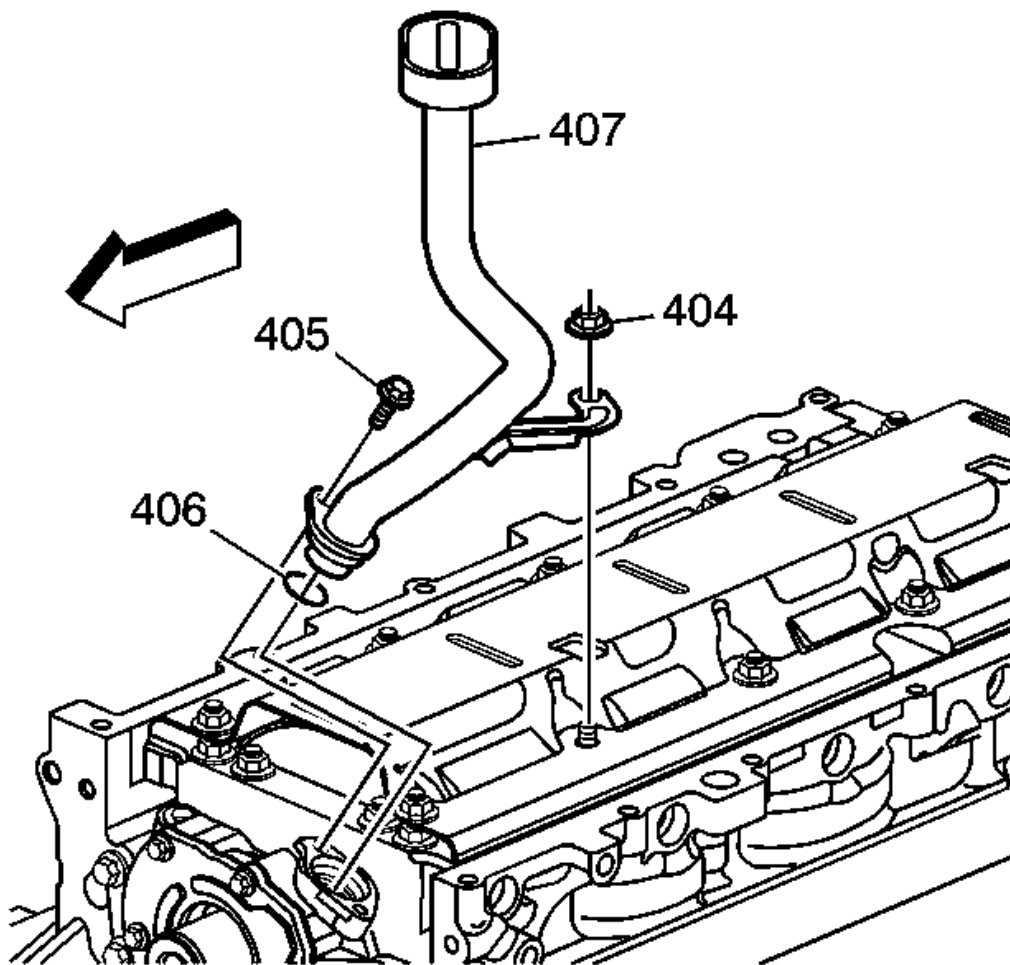


Fig. 171: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

6. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
7. 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 brackets with the correct crankshaft bearing cap studs.

8. Install the oil pump screen and pick up tube assembly (407).
9. Install the oil pump screen bolt (405) and nut (404).

Tighten:

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

10. Install the engine oil pan. Refer to **Oil Pan Replacement**.

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

Timing Chain and Sprockets Replacement**Tools Required**

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

Removal Procedure

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.

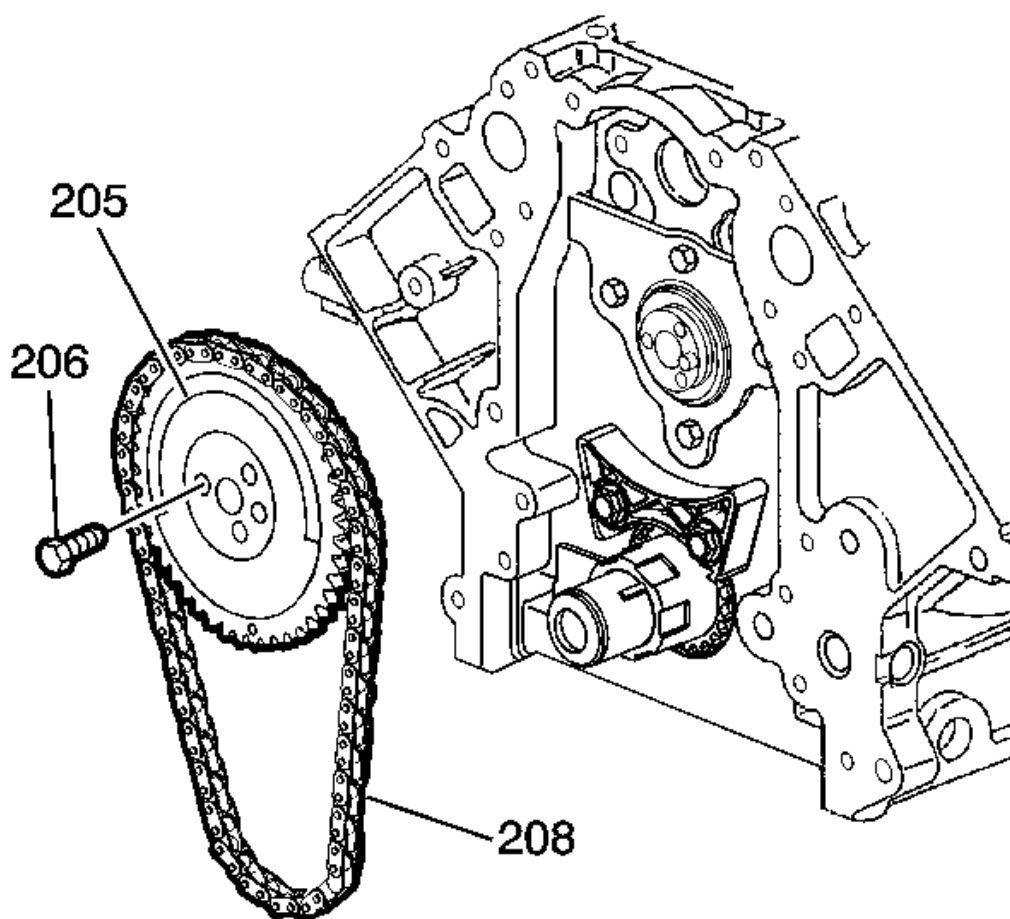


Fig. 172: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump, Pump Screen and Deflector Replacement**.
2. Remove the camshaft sprocket bolts (206).
3. Remove the camshaft sprocket (205) and timing chain (208).

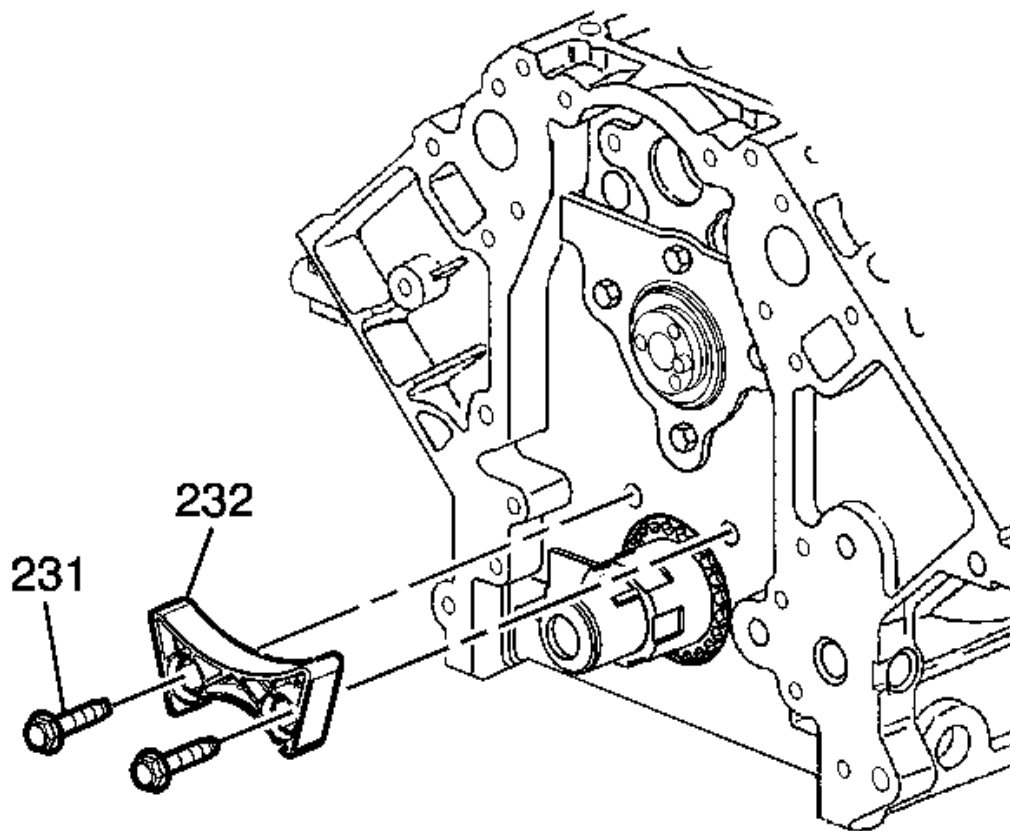


Fig. 173: Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts (231) and chain guide (232).

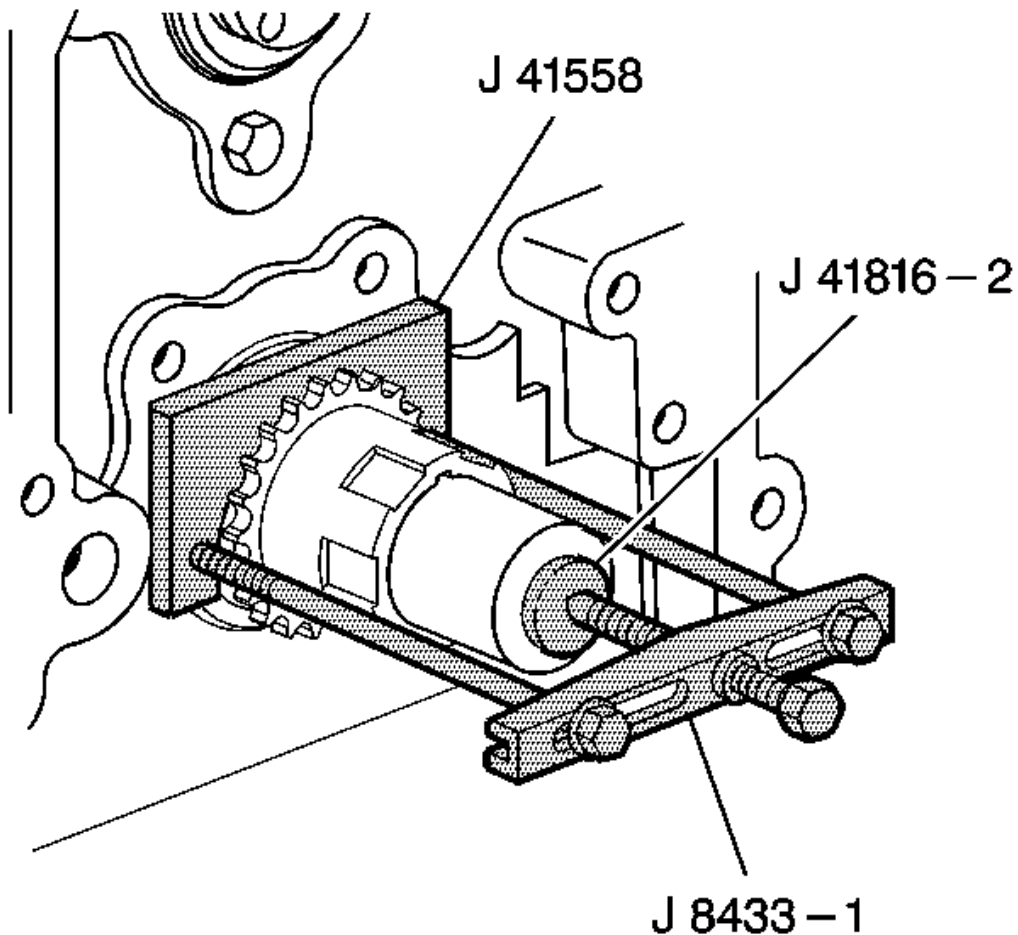


Fig. 174: Removing The Crankshaft Sprocket Using J 8433-1, J 41816-2 & J 41558
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 8433** , **J 41816-2** and **J 41558** in order to remove the crankshaft sprocket. See **Special Tools**.

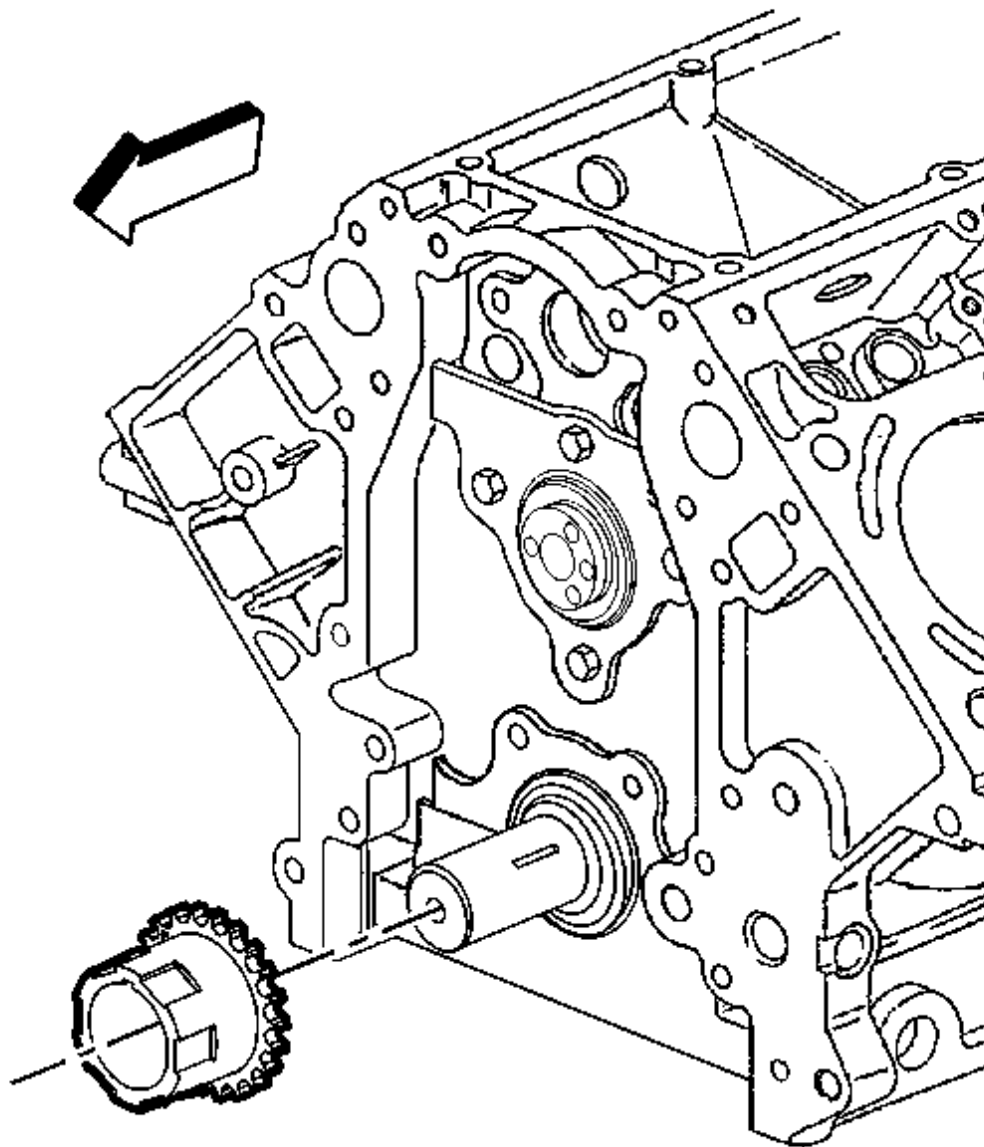


Fig. 175: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket.

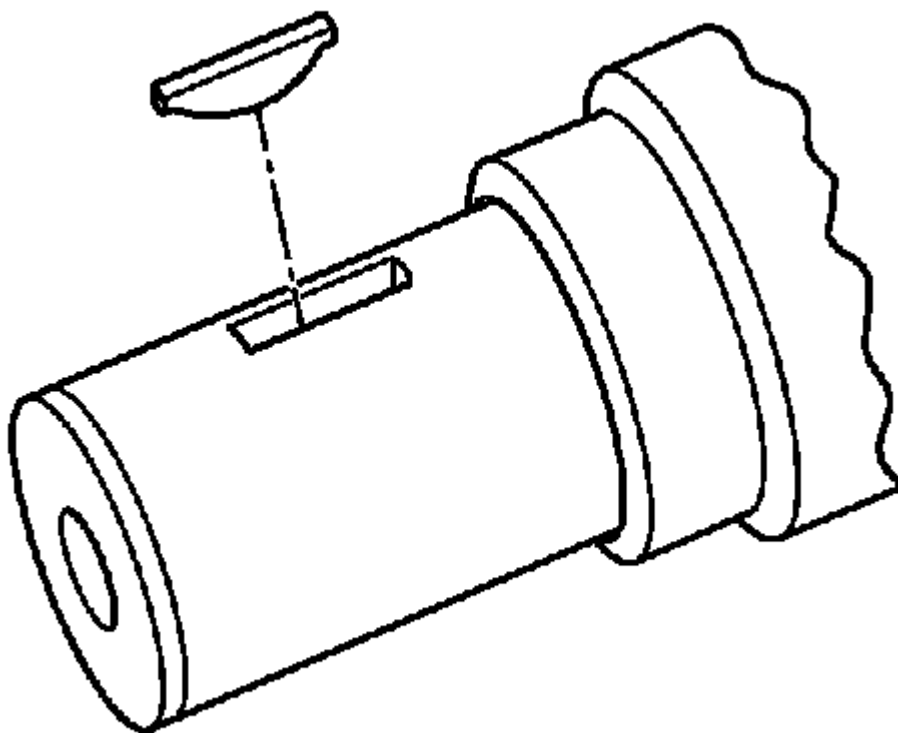


Fig. 176: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket key (if required).
8. Clean and inspect the timing chain and sprockets. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

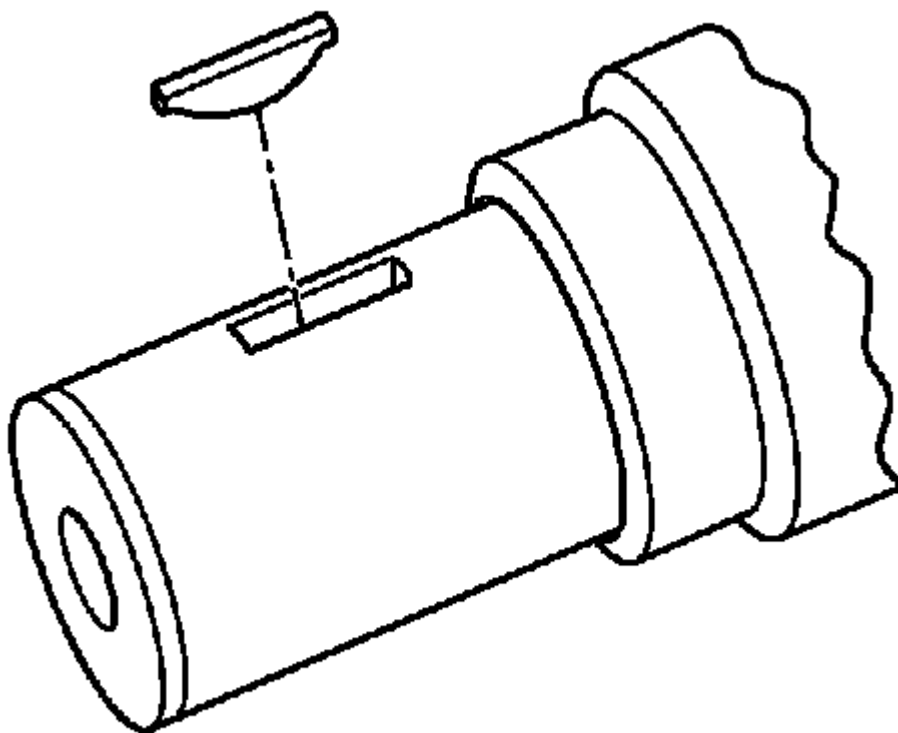


Fig. 177: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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

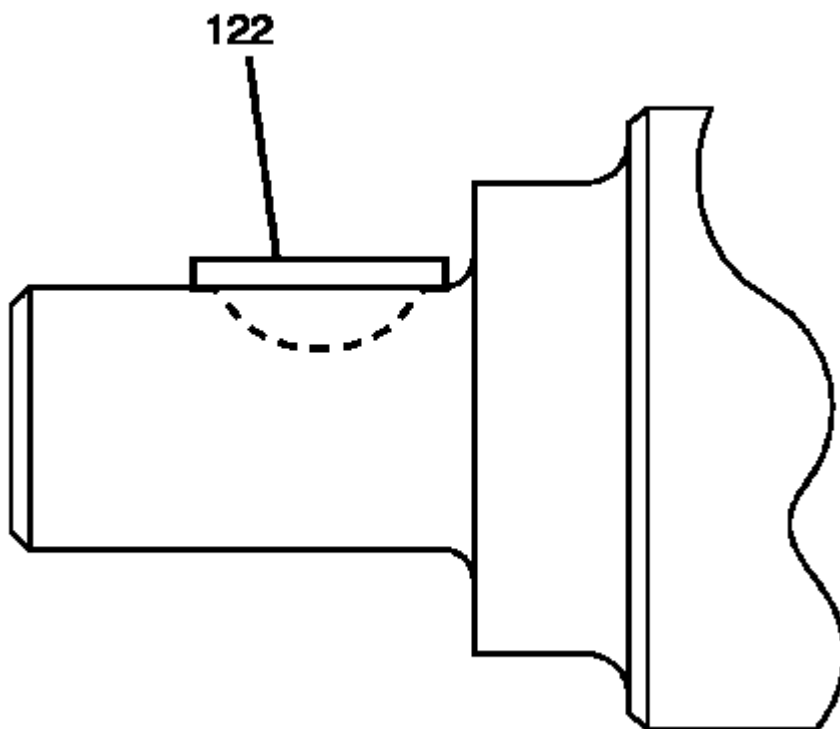


Fig. 178: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

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

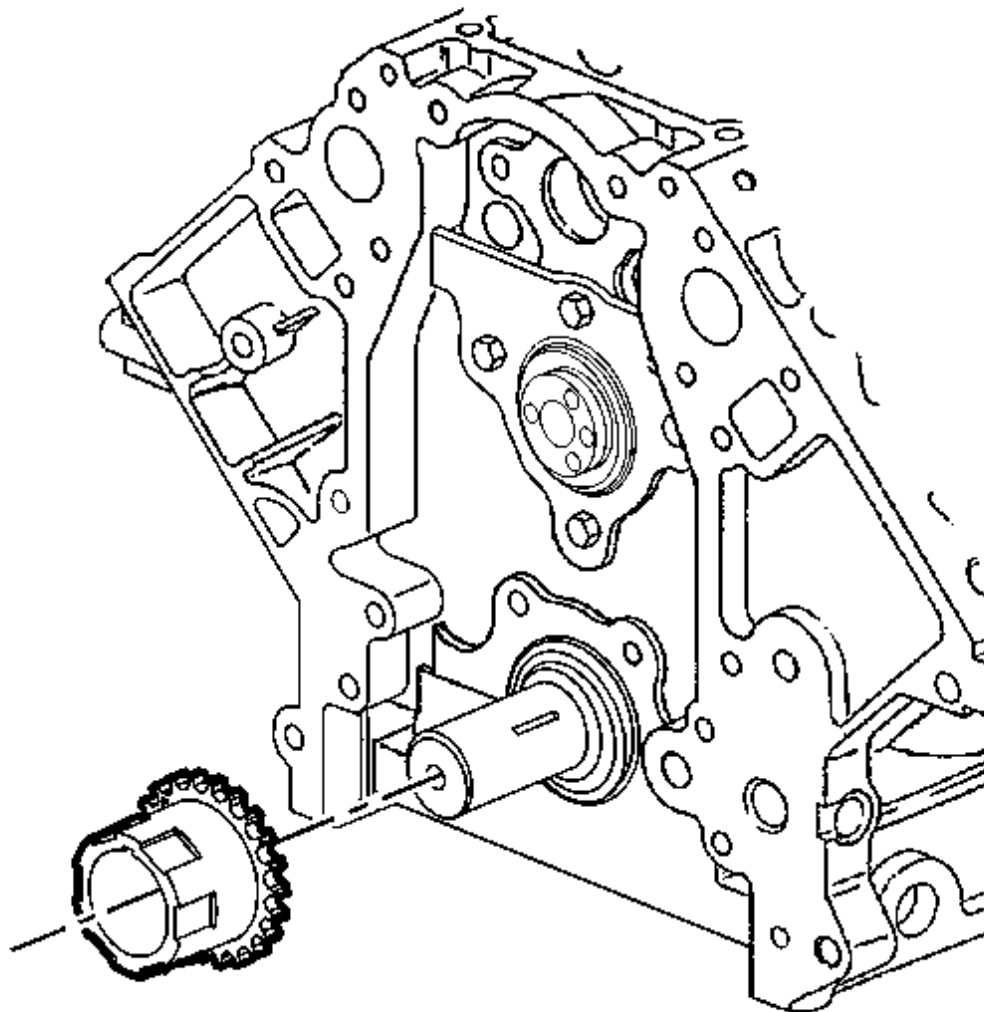


Fig. 179: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

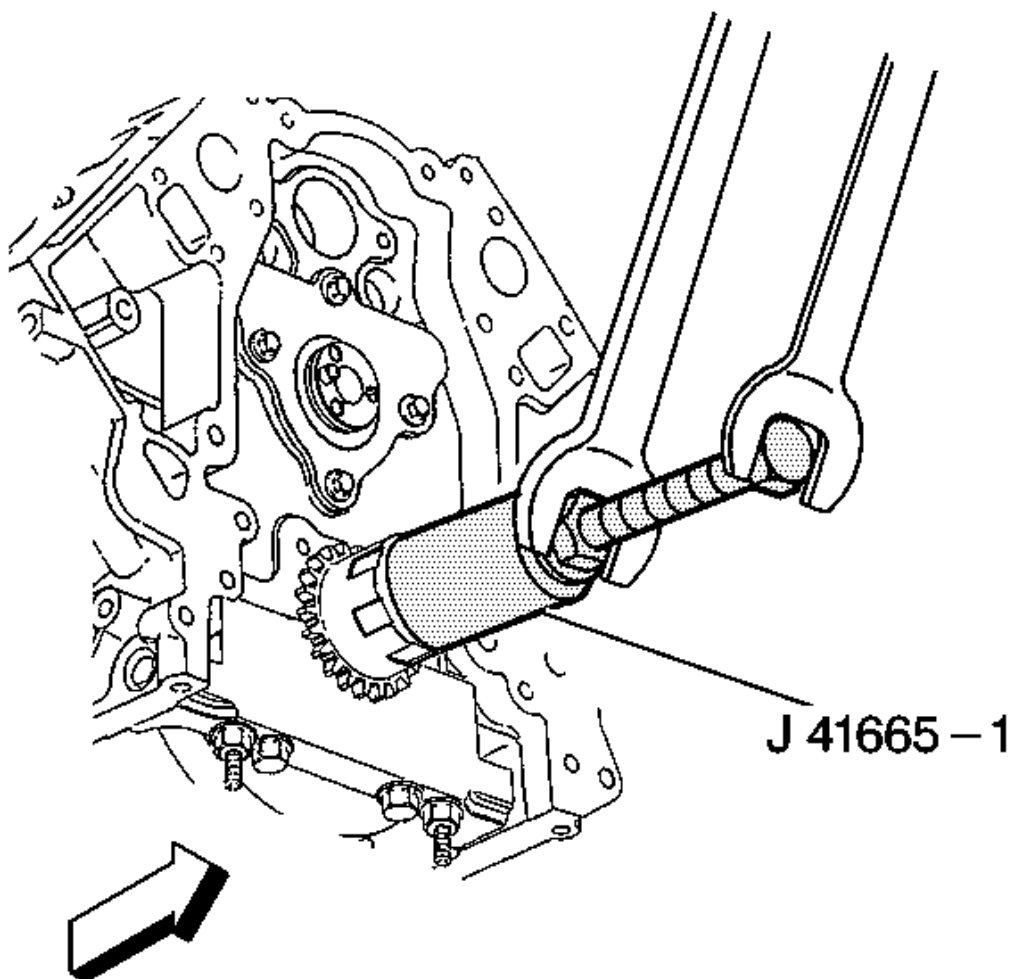


Fig. 180: Using J 41665 To Install Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41665** in order to install the crankshaft sprocket. See **Special Tools**.

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

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

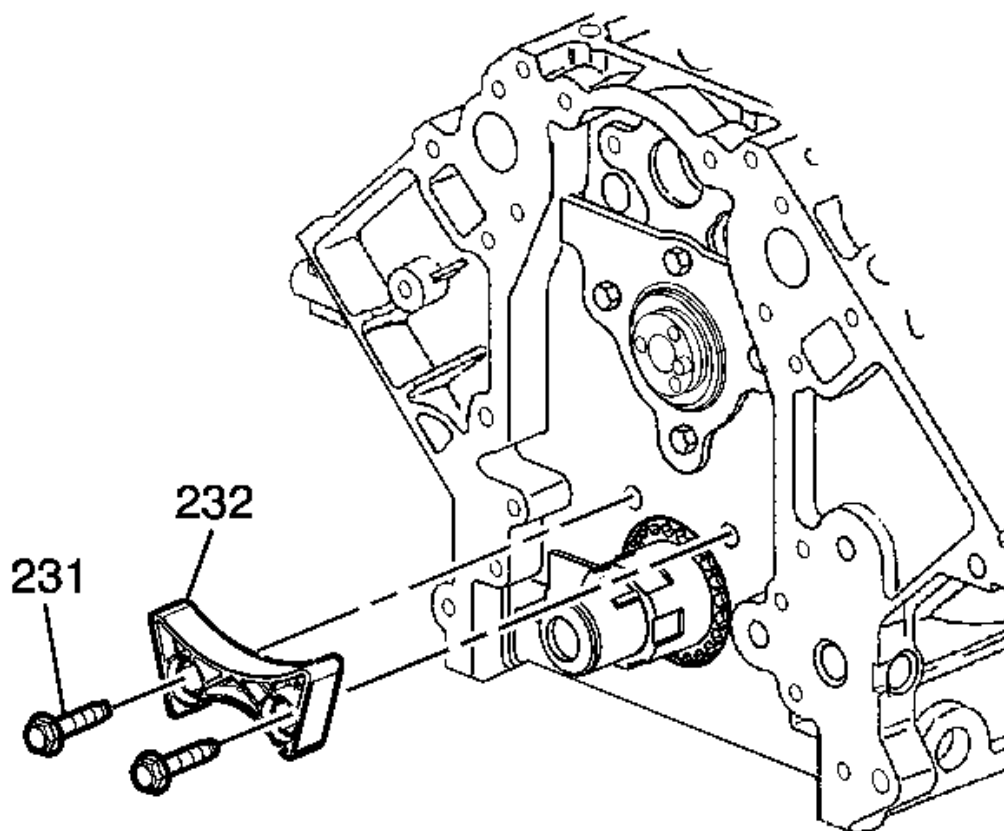


Fig. 181: Timing Chain Damper & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the timing chain guide (232) and bolts (231).

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

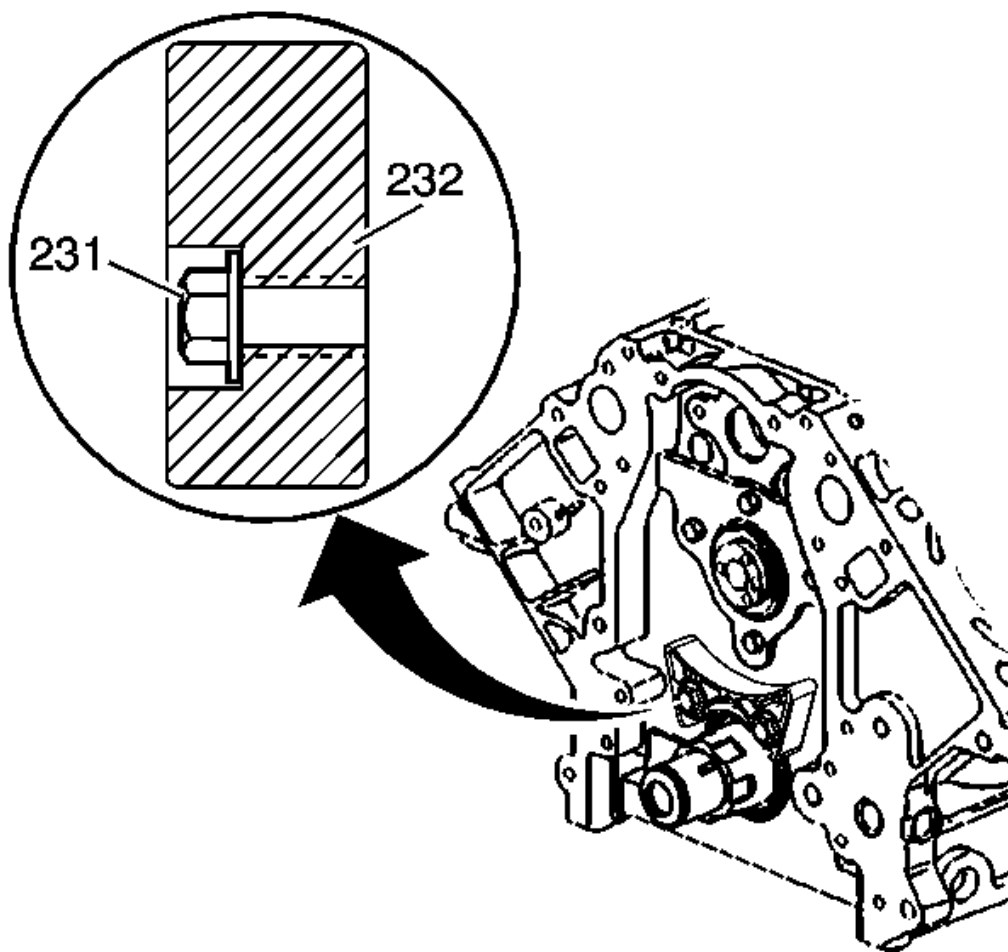


Fig. 182: Identifying Timing Chain Dampener Bolt Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

7. With the chain guide properly installed, the heads of the bolts (231) should install to flush or below the face of the guide (232).

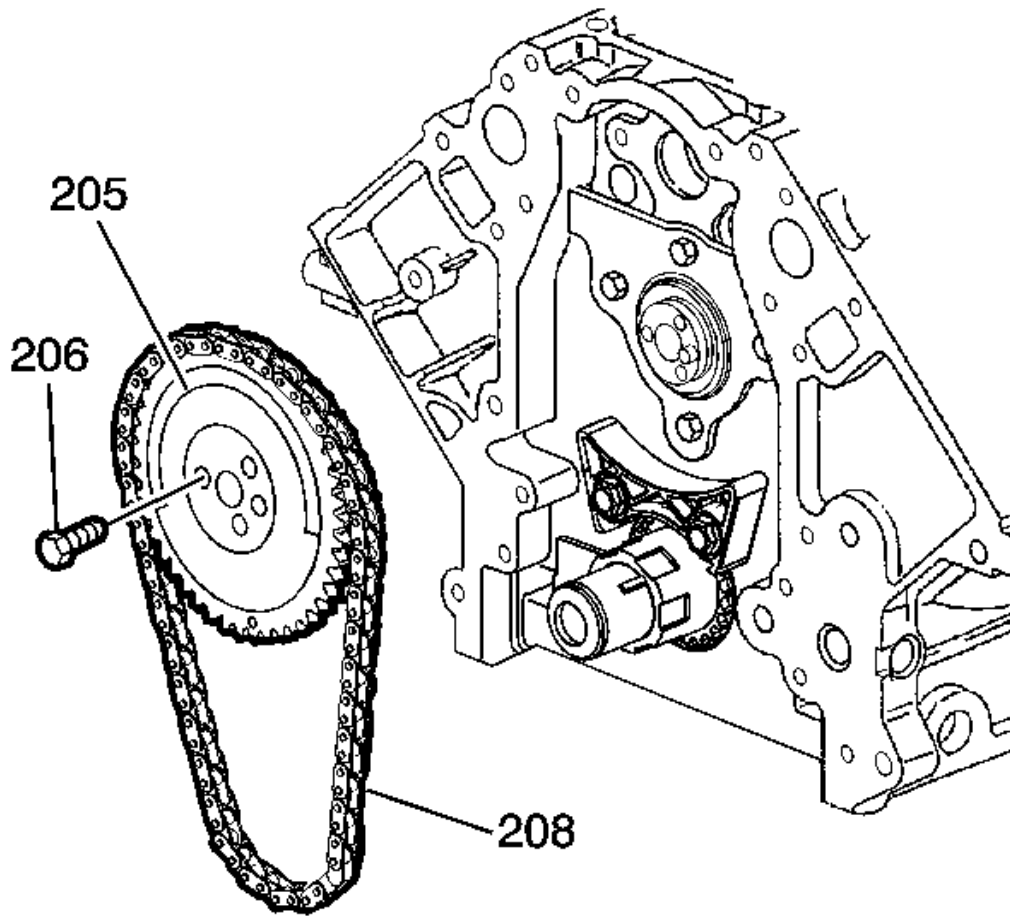


Fig. 183: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Properly locate the camshaft sprocket onto the locating pin of the camshaft.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

Position the camshaft sprocket alignment mark in the 6 o'clock position.

8. Install the camshaft sprocket (205) and timing chain (208). If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

9. Install the camshaft sprocket bolts (206).

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

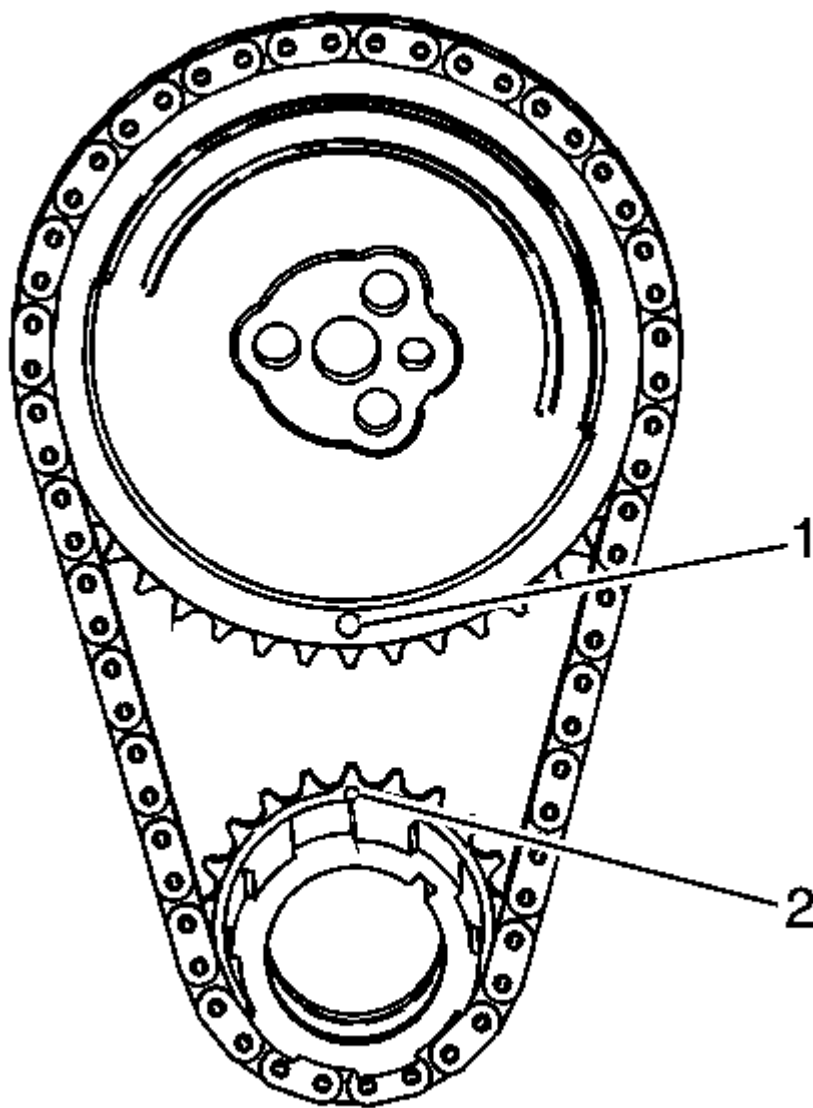


Fig. 184: View Of Camshaft And Crankshaft Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

10. Inspect for proper alignment of the camshaft and crankshaft sprocket timing marks (1, 2).

11. Install the oil pump. Refer to **Oil Pump, Pump Screen and Deflector Replacement**.

Camshaft Replacement

Tools Required

J 41476 Front and Rear Cover Alignment Tool. See **Special Tools**.

Removal Procedure

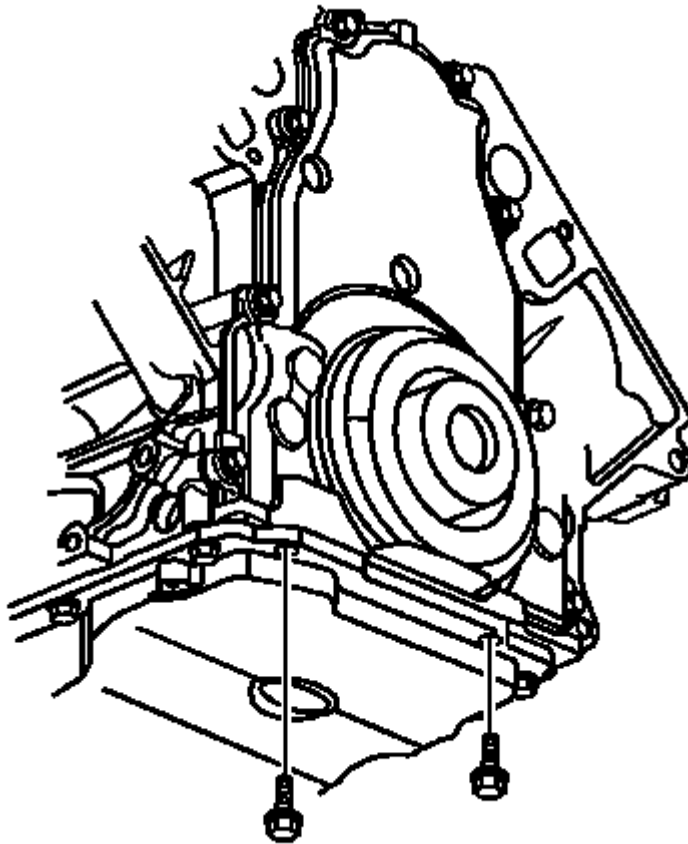


Fig. 185: Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine assembly. Refer to **Engine Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Removal**.
3. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Removal**.
4. Remove the left and right exhaust manifolds Refer to **Exhaust Manifold Removal - Left** and **Exhaust Manifold Removal - Right**.
5. Remove the water pump. Refer to **Water Pump Removal**.
6. Remove the intake manifold. Refer to **Intake Manifold Removal**.

7. Remove the engine valley cover. Refer to **Engine Valley Cover Removal**.
8. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Removal**.
9. Remove the left and right valve rocker arm covers. Refer to **Valve Rocker Arm Cover Removal - Left** and **Valve Rocker Arm Cover Removal - Right**.
10. Remove the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Removal**.
11. Remove the left and right cylinder heads. Refer to **Cylinder Head Removal - Left** and **Cylinder Head Removal - Right**.
12. Remove the valve lifters. Refer to **Valve Lifter Removal**.
13. Remove the oil pan-to-front cover bolts (2).

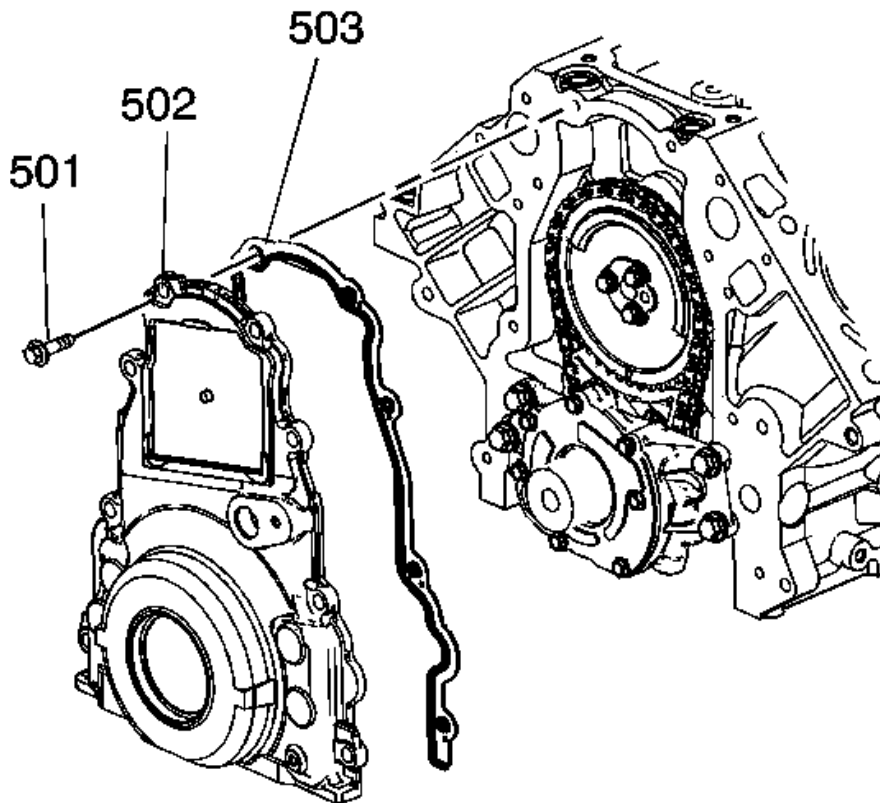


Fig. 186: Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the front cover bolts (501).
15. Remove the front cover and gasket (503). Discard the old gasket.

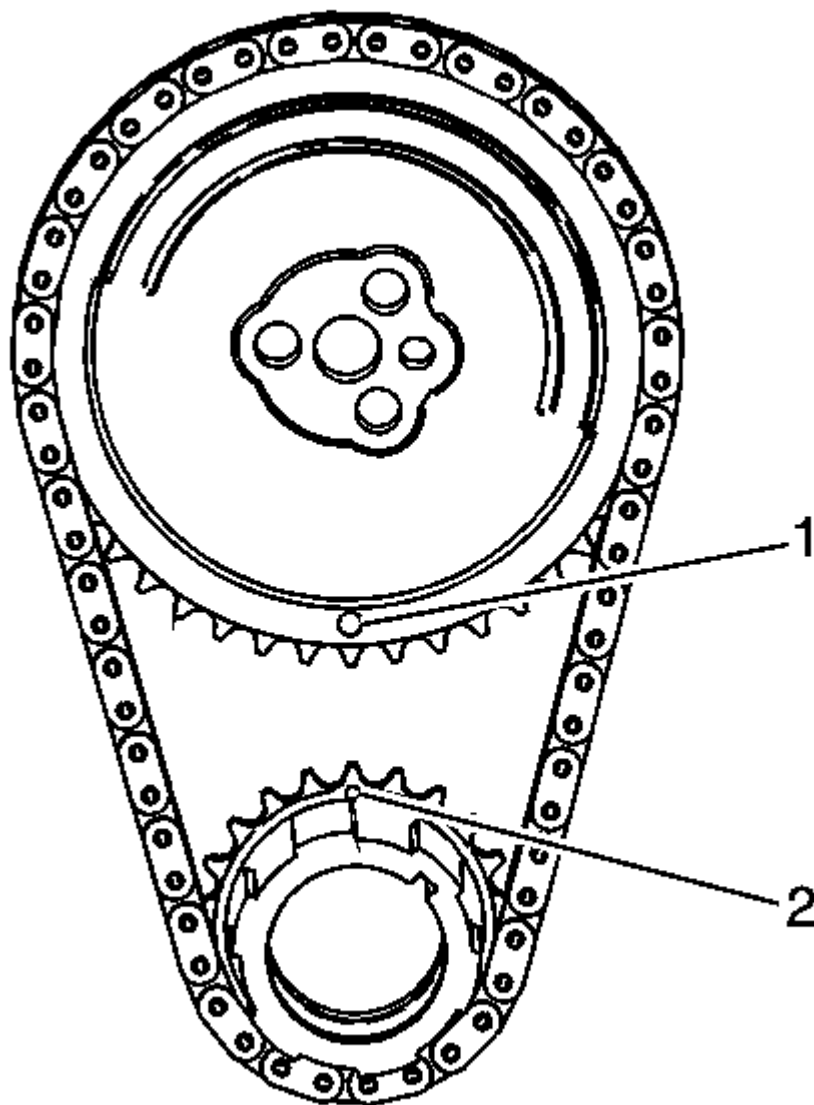


Fig. 187: View Of Camshaft And Crankshaft Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

16. Rotate the engine in order to align the timing marks (1,2).

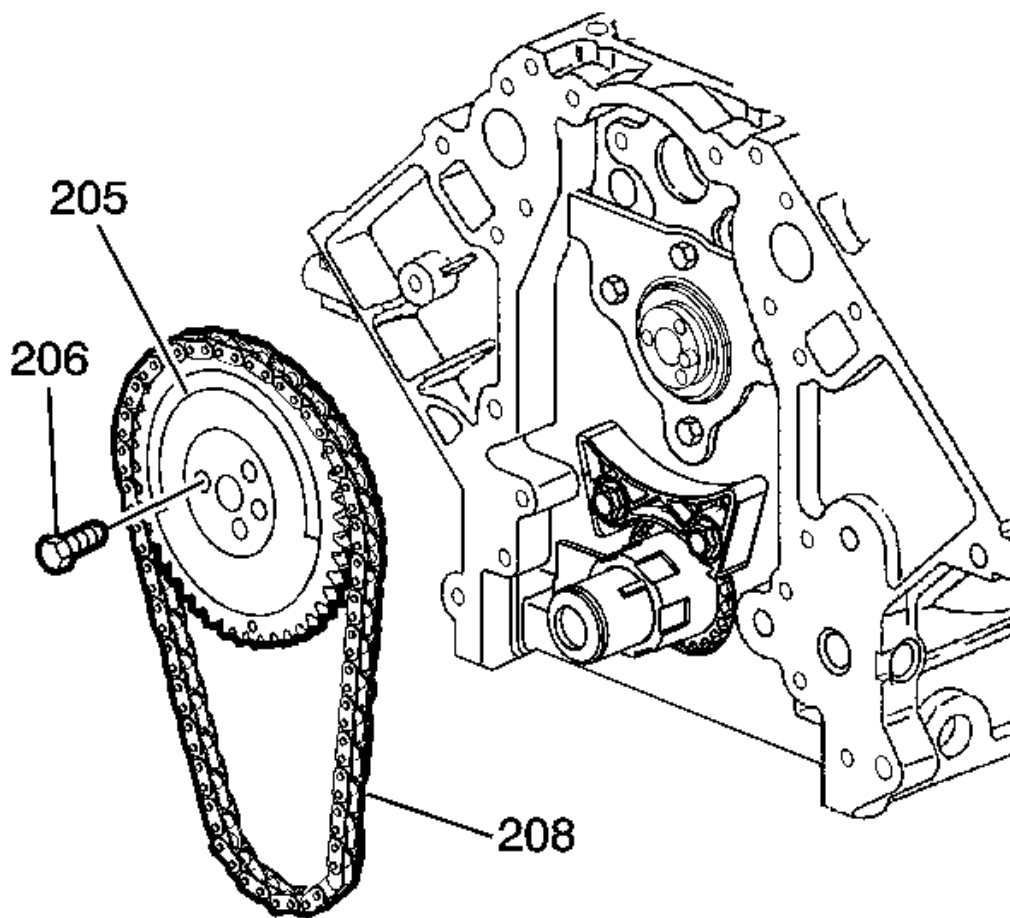


Fig. 188: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

17. Remove the camshaft sprocket bolts (206).
18. Remove the timing chain (205), from the camshaft sprocket, and allow the timing chain to rest on the crankshaft sprocket.
19. Remove the camshaft. Refer to **Camshaft Removal**.

Installation Procedure

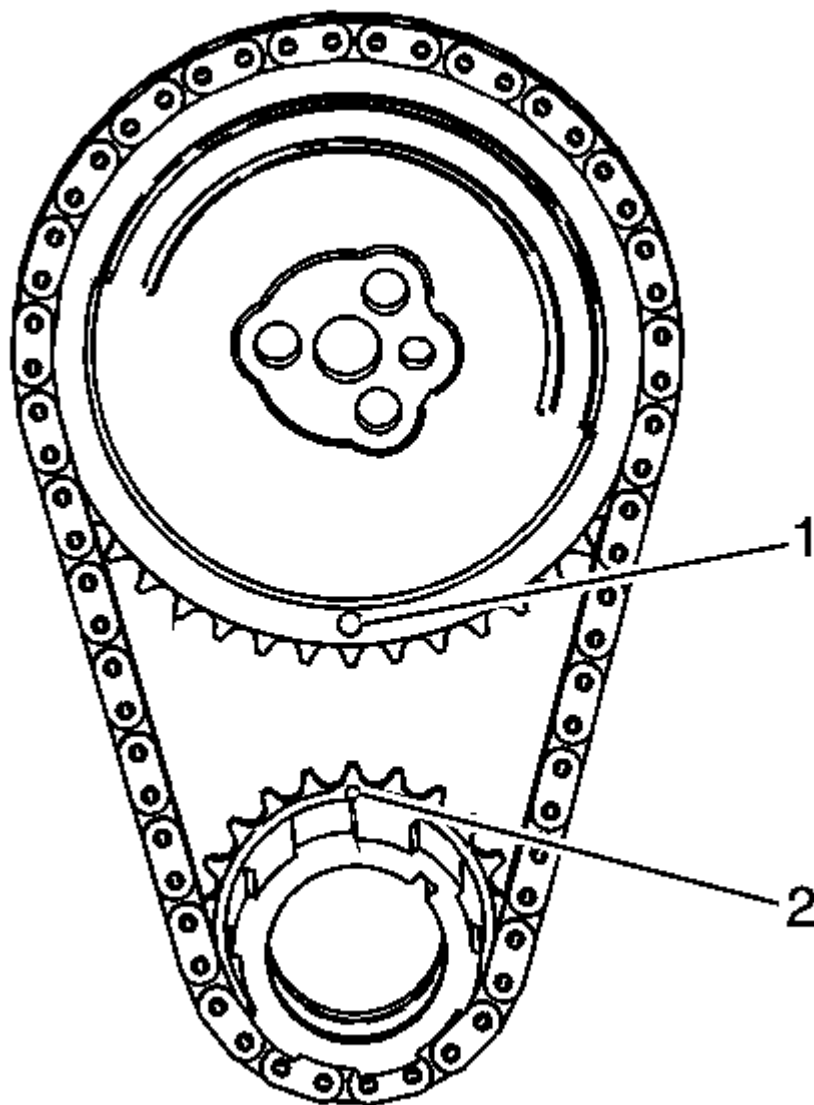


Fig. 189: View Of Camshaft And Crankshaft Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

1. Install the camshaft. Refer to Camshaft Installation.
2. Align the camshaft sprocket alignment mark (1), in the 6 o'clock position.

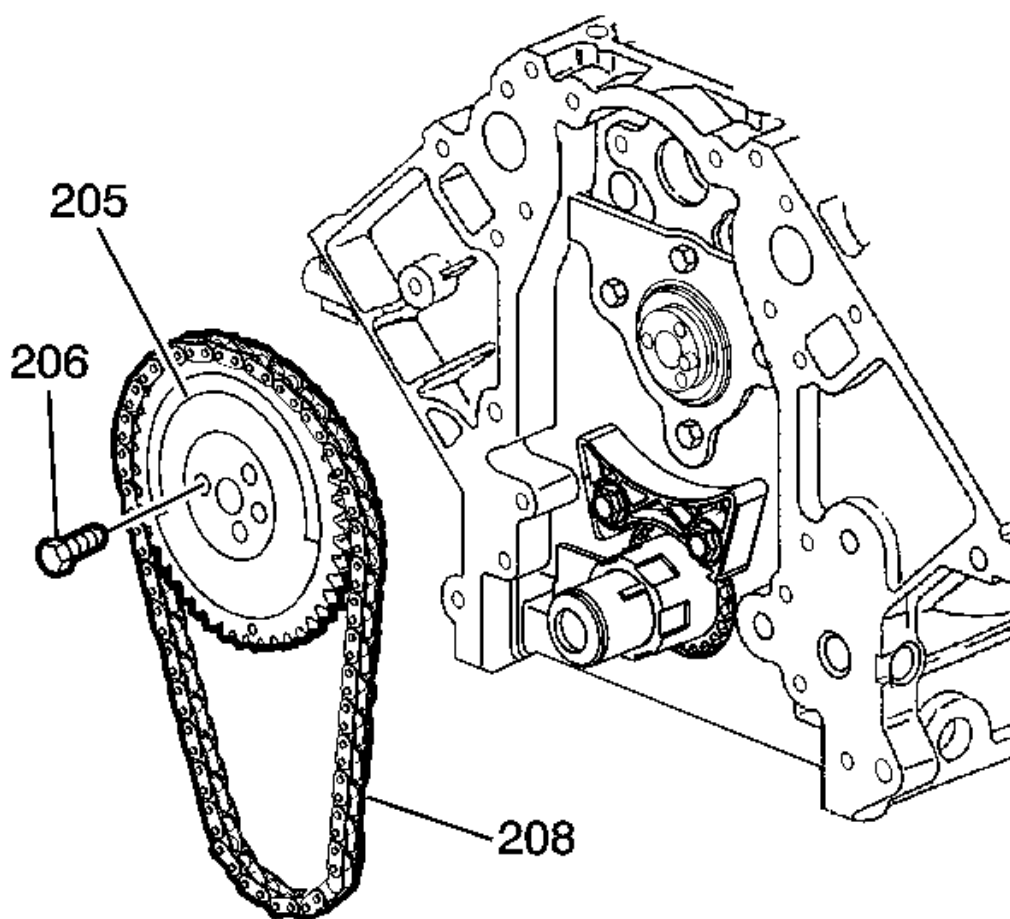


Fig. 190: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft sprocket (205),& timing chain (208).

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft sprocket bolts.

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

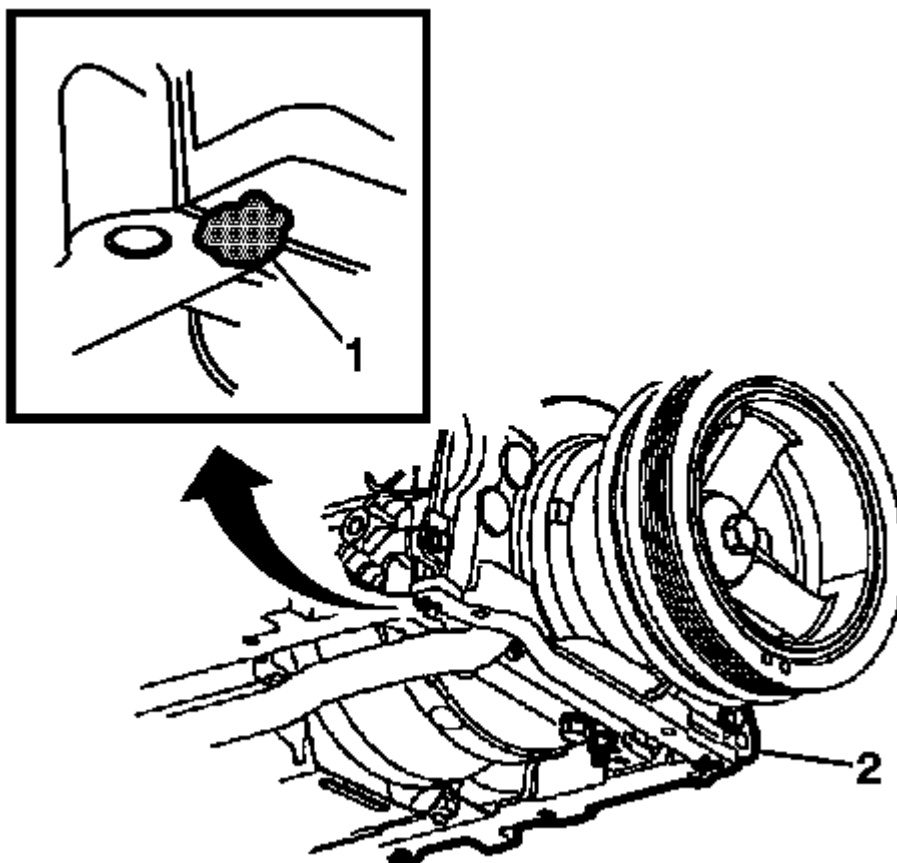


Fig. 191: View Of Sealant Applied To Front Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.8 in) long to the oil pan to engine block junction.

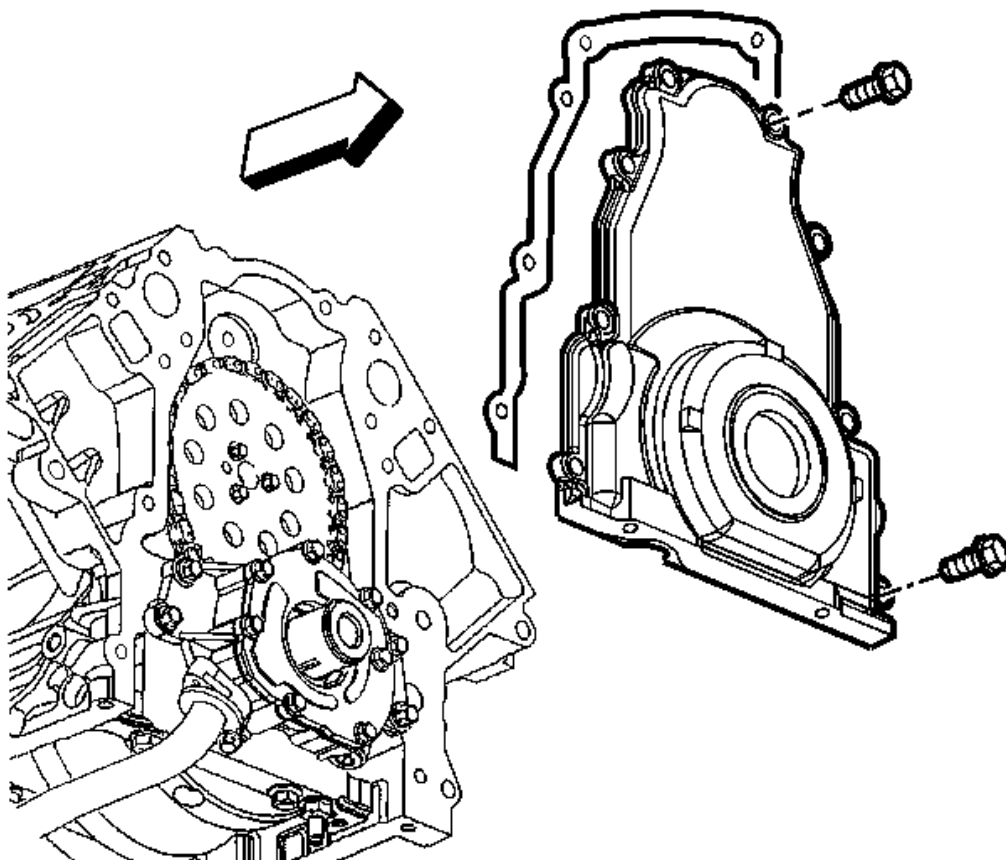


Fig. 192: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

6. Install the front cover and a new gasket.
7. Install the front cover bolts until snug.

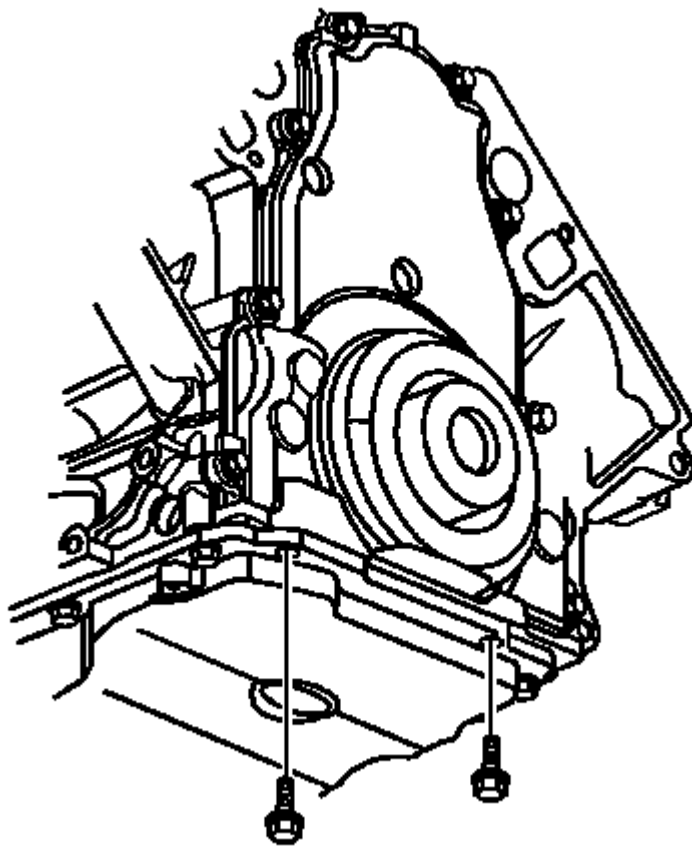


Fig. 193: Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the oil pan-to-front cover bolts until snug.

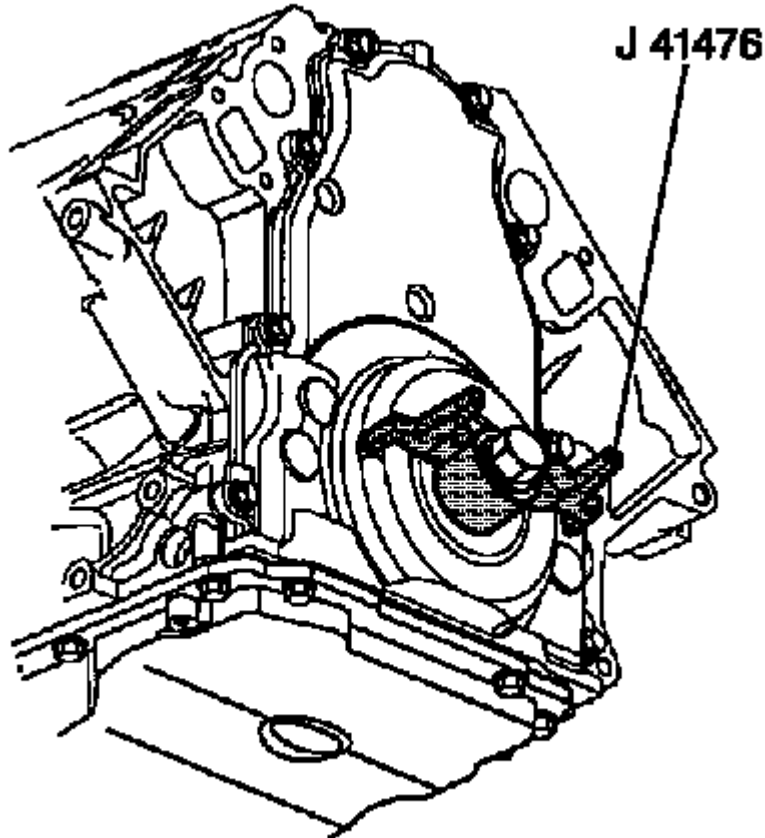


Fig. 194: View of J 41476 Installed To Front Cover
Courtesy of GENERAL MOTORS CORP.

9. Install the **J 41476** and crankshaft balancer bolt to the front cover. See **Special Tools**.
10. Align the tapered legs of the **J 41476** with the machined alignment surfaces on the front cover.
11. Install the crankshaft balancer bolt until snug. Do not overtighten.

Tighten:

1. Tighten the oil pan-to-front cover bolts to 25 N.m (18 lb ft).
 2. Tighten the engine front cover bolts to 25 N.m (18 lb ft).
12. Remove the **J 41476**.
 13. Install a NEW crankshaft front oil seal. Refer to **Crankshaft Front Oil Seal Installation**.
 14. Install the valve lifters. Refer to **Valve Lifter Installation**.
 15. Install the right and left cylinder heads. Refer to **Cylinder Head Installation - Right** and **Cylinder Head Installation - Left**.
 16. Install the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Installation**.
 17. Install the right and left valve rocker arm covers. Refer to **Valve Rocker Arm Cover Installation -**

Right and Valve Rocker Arm Cover Installation - Left.

18. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Installation**.
19. Install the intake manifold. Refer to **Intake Manifold Installation**.
20. Install the water pump. Refer to **Water Pump Installation**.
21. Install the left and right exhaust manifolds. Refer to **Exhaust Manifold Installation - Left** and **Exhaust Manifold Installation - Right**.
22. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Installation**.
23. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation**.
24. Install the engine assembly. Refer to **Engine Replacement**.

Engine Flywheel Replacement**Removal Procedure**

1. Remove the automatic transmission, if applicable. Refer to **Transmission Replacement**.
2. Remove the manual transmission, if applicable. Refer to **Transmission Replacement**.

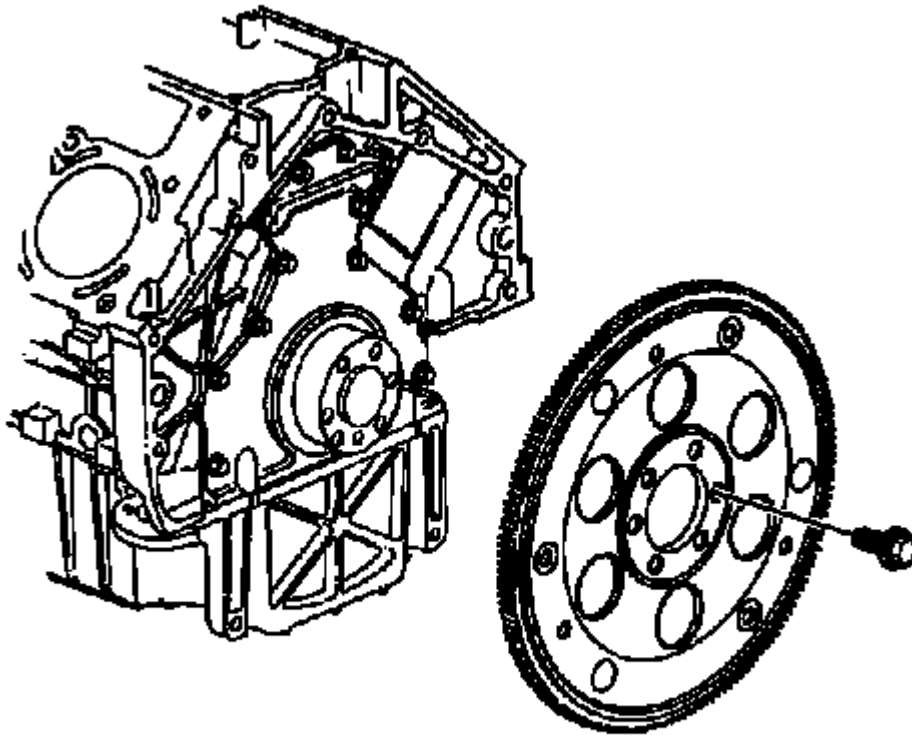


Fig. 195: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the position and direction of the engine flywheel before removal. The flywheel does not use a locating pin for alignment. Mark or scribe the end of the crankshaft and the flywheel before component removal. The engine flywheel will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.

IMPORTANT: If replacing a flywheel, note the location of any existing balance weight pins relative to the position of the flywheel locating hole. If replacing the flywheel and balance weight pins are installed in the original flywheel, use a suitable pin punch and remove the pins from the old flywheel and then reinstall them in the same relative location in the replacement part. Install the balance weight pins either flush or below flush with the machined surface of the flywheel.

3. Mark or scribe the end of the crankshaft and the flywheel.
4. Remove the engine flywheel bolts.
5. Remove the automatic transmission flywheel, if applicable.

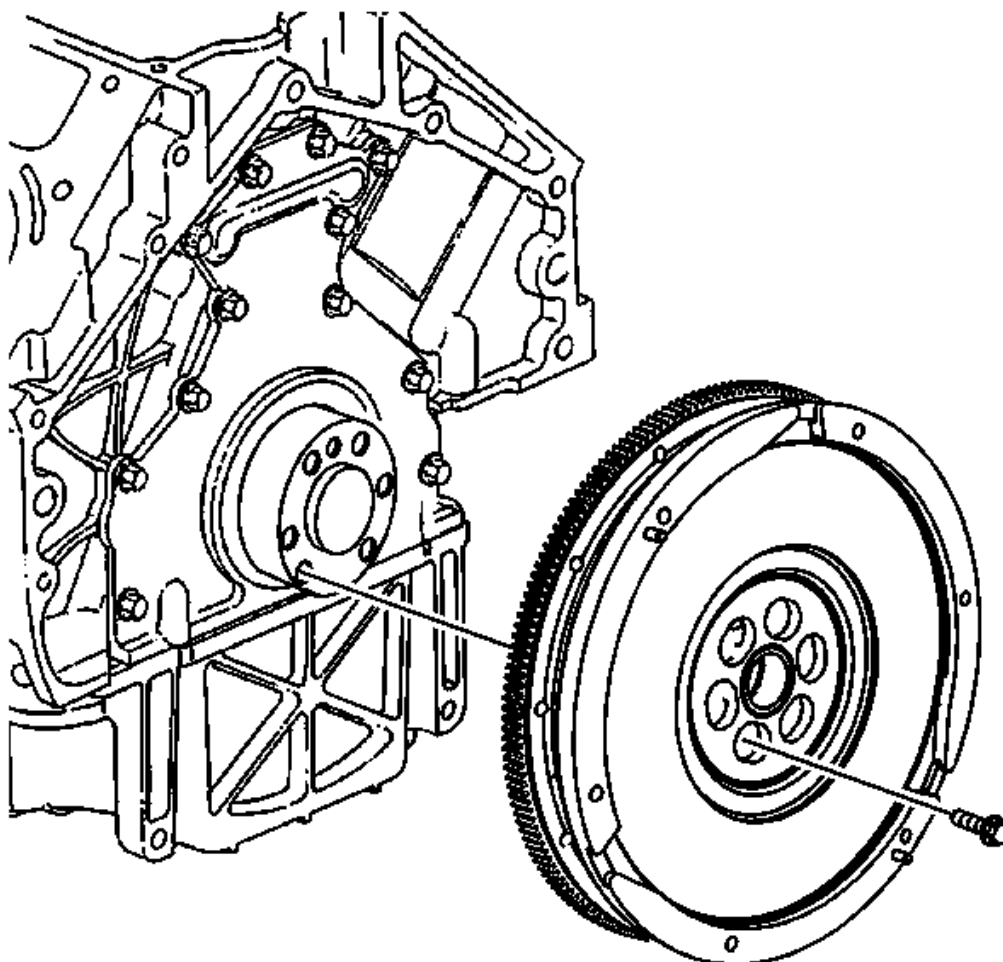


Fig. 196: View Of Manual Transmission Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

6. Remove the manual transmission flywheel, if applicable.
7. If replacing the flywheel, remove any balance weights, if applicable.

Installation Procedure

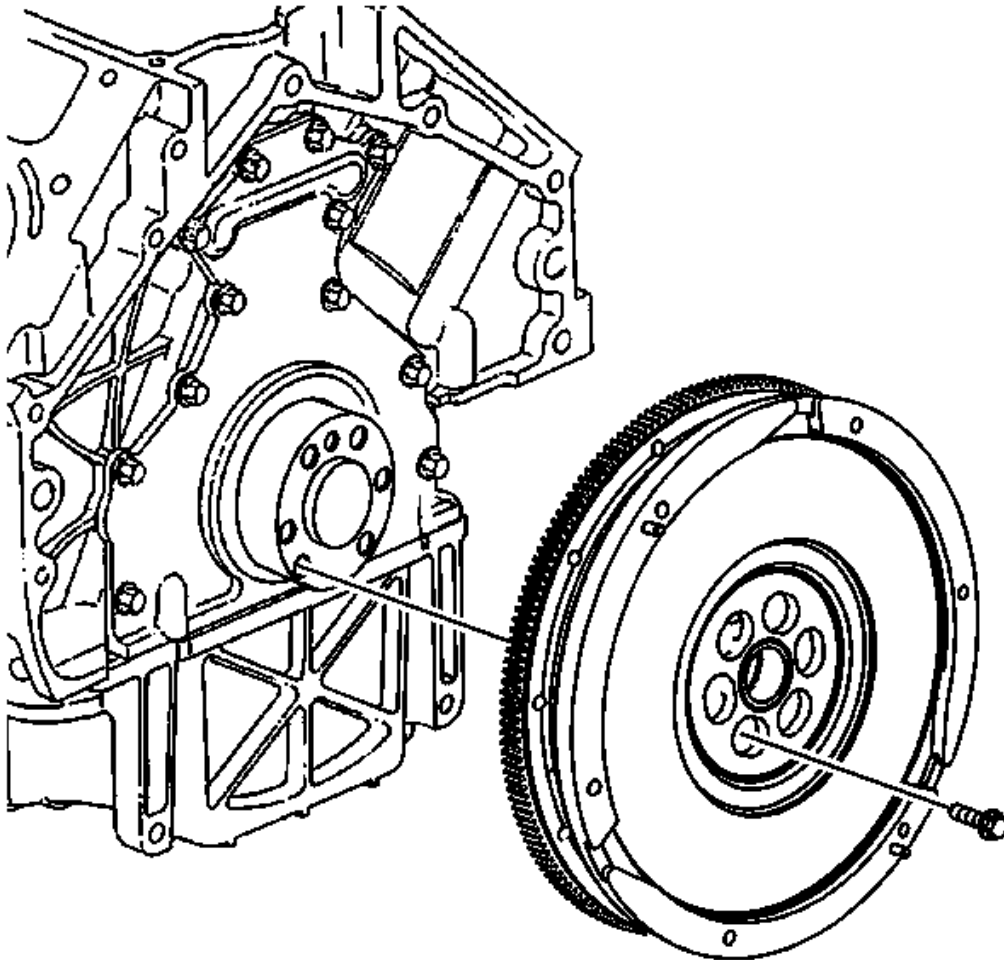


Fig. 197: View Of Manual Transmission Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If replacing a flywheel, note the location of any existing balance weight pins relative to the position of the flywheel locating hole. If replacing the flywheel and balance weight pins are installed in the original flywheel, use a suitable pin punch and remove the pins from the old flywheel and then reinstall them in the same relative location in the replacement part. Install the balance weight pins either flush or below flush with the machined surface of the flywheel.

1. If replacing the flywheel, Install any balance weights, if applicable.
2. Install the manual transmission flywheel to the crankshaft, if applicable.

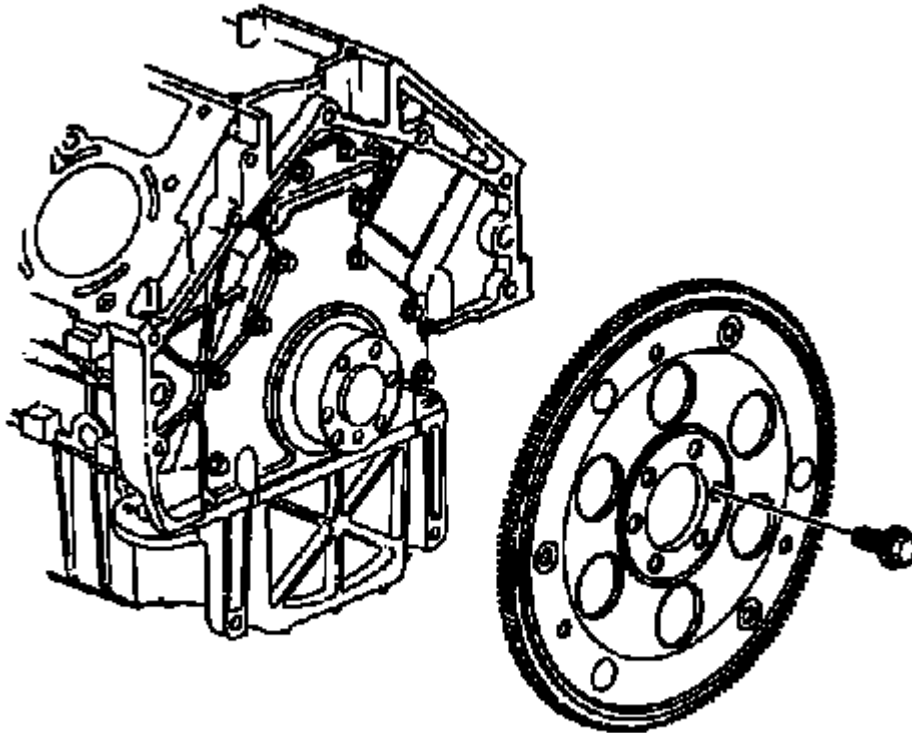


Fig. 198: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the automatic transmission flywheel to the crankshaft, if applicable.

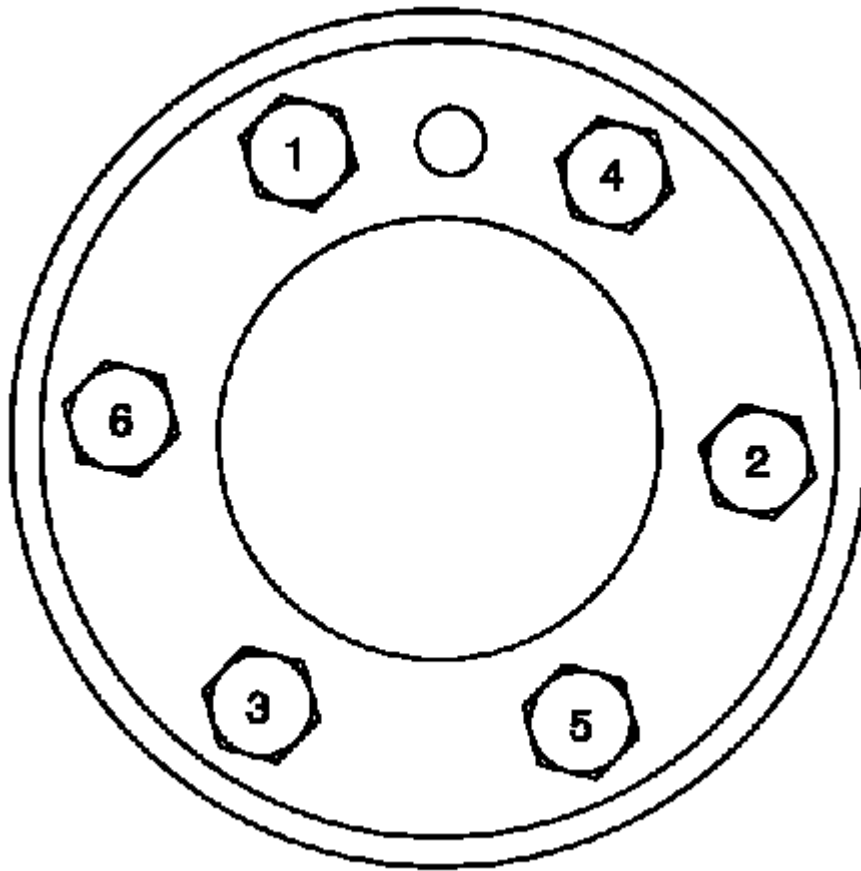


Fig. 199: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Apply threadlock GM U.S. P/N 12345382, Canada P/N 10953489, or equivalent to the threads of the flywheel bolts.
5. Install the flywheel bolts.

Tighten:

1. Tighten the engine flywheel bolts a first pass in sequence to 20 N.m (15 lb ft).
 2. Tighten the engine flywheel bolts a second pass in sequence to 50 N.m (37 lb ft).
 3. Tighten the engine flywheel bolts a final pass in sequence to 100 N.m (74 lb ft).
6. Install the manual transmission, if applicable. Refer to **Transmission Replacement**.
 7. Install the automatic transmission, if applicable. Refer to **Transmission Replacement**.

Engine Replacement

Tools Required

J 41798 Engine Lifting Brackets. See **Special Tools**.

Removal Procedure

1. Disconnect the negative battery cable.
2. Recover the air conditioning (A/C) refrigerant. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
3. Remove the hood. Refer to **Hood Replacement (Without Hood Scoops)** or **Hood Replacement (With Hood Scoops)** in Body Front End.
4. Remove the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** .
5. Remove the fuel rail covers.
6. Remove the intake duct from the vehicle. Refer to **Air Cleaner Assembly Replacement** .
7. Depressurize the fuel system. Refer to **Fuel Pressure Relief Procedure** in Engine Controls.
8. Remove the radiator. Refer to **Radiator Replacement** in Engine Cooling.

IMPORTANT: Cap the hoses and inlets when separating the cooling system components, this prevents dirt and other contaminants from entering the cooling system.

9. Remove the radiator hoses from the water pump.
10. Remove the heater hoses from the water pump.

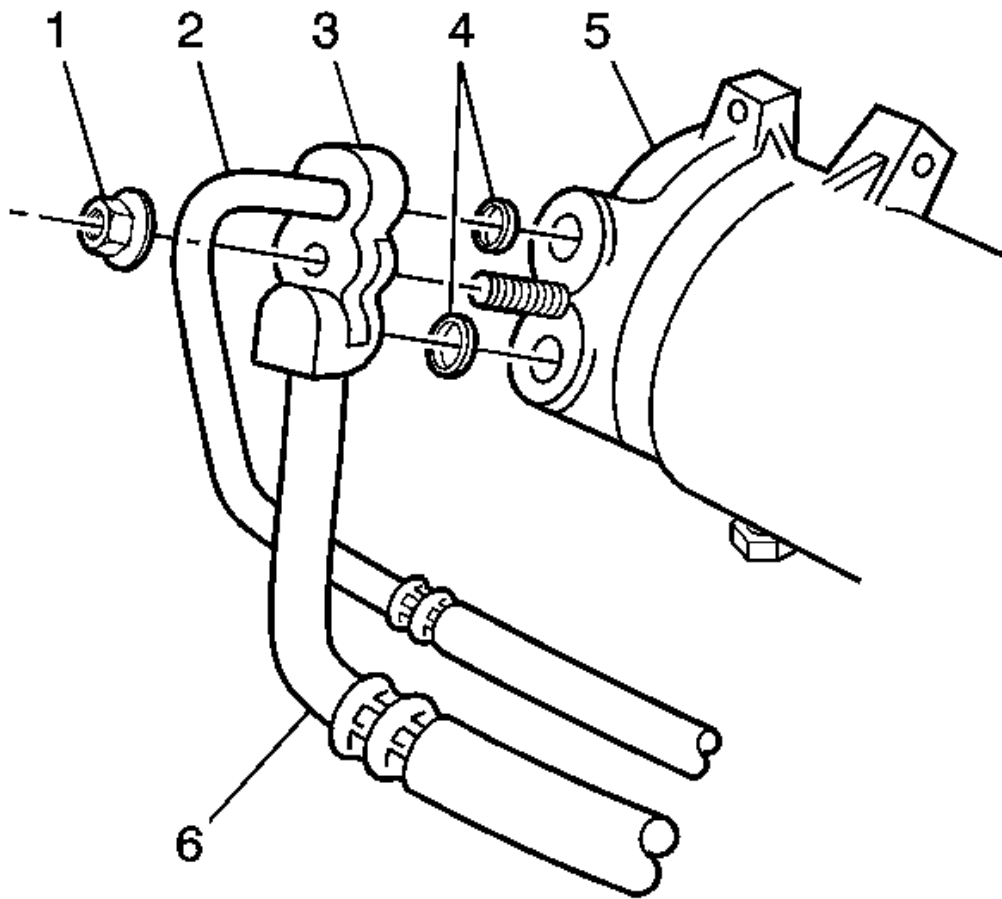


Fig. 200: View Of A/C Compressor & Components
Courtesy of GENERAL MOTORS CORP.

11. Remove the A/C compressor and condenser hose nut (1) at the compressor.
12. Separate the A/C compressor and condenser hose (6) from the A/C compressor (5).
13. Remove the ground lead screw from the engine block and left had engine mount.
14. Disconnect the positive lead terminal from the battery. Lay the harness on the engine.
15. Disconnect the A/C wiring harness connector
16. Remove the fuel rail feed line. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment**
17. Remove the evaporative emission (EVAP) lines. Refer to **Evaporative Emission (EVAP) Hoses/Pipes Replacement - Engine** .
18. Loosen the hose clamp on the return hose at the power steering reservoir.
19. Place a suitable container under the reservoir and remove the hose and drain the reservoir fluid.

20. Remove the high pressure line flare nut and O-ring from the pump outlet fitting at the rear of the power steering pump.

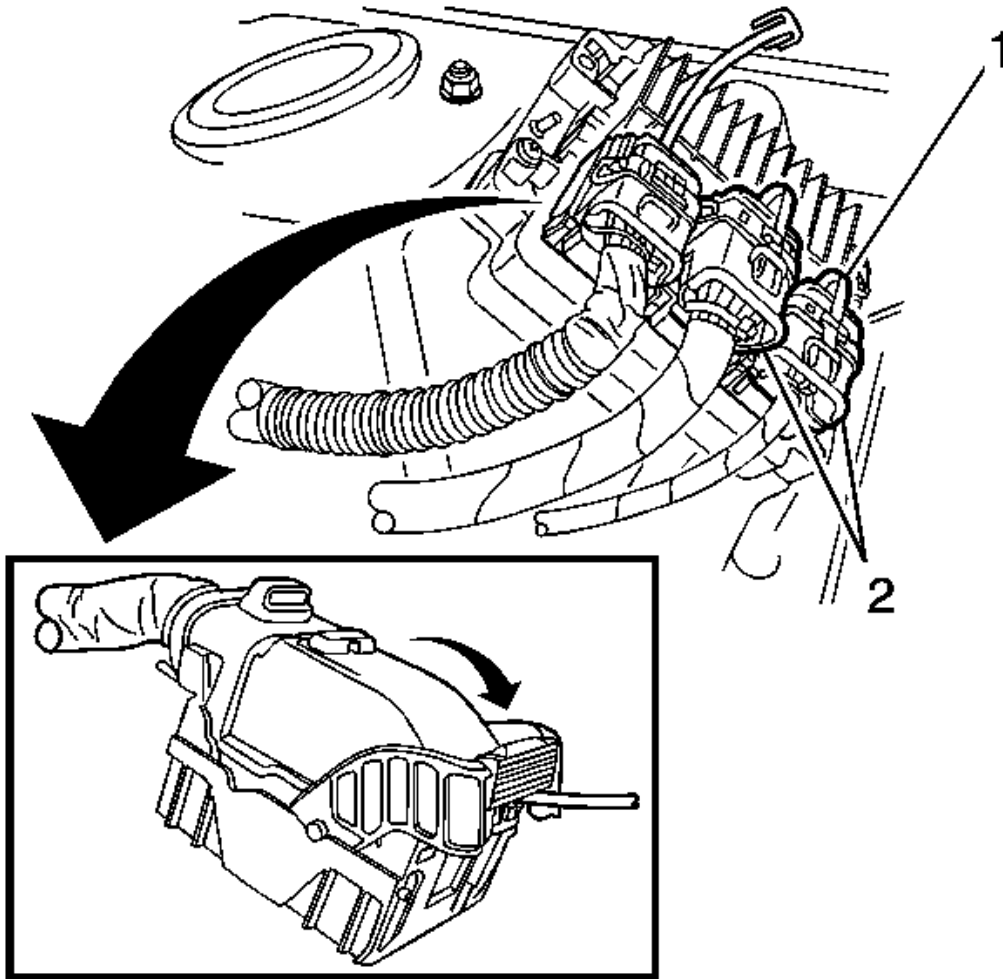


Fig. 201: Identifying Engine Control Module (ECM)
 Courtesy of GENERAL MOTORS CORP.

21. Remove 2 engine control module (ECM) electrical connector locks (1).
22. Disconnect 2 electrical ECM electrical connectors (2).
23. Feed the ECM harness under the brake and clutch master cylinder, if equipped.
24. Remove the harness to dash panel clips, then lay the harness on top of the engine.
25. Disconnect the brake booster vacuum hose and heater control, vacuum hose at the rear of the intake manifold.

26. Remove the ignition coil and module for cylinder No. 7. Refer to **Ignition Coil(s) Replacement**
27. Remove the right and left engine mount to engine bracket nuts.
28. If equipped with manual transmission, remove the bolt attaching the clutch master cylinder reservoir bracket to the end of the master cylinder.
29. Remove both exhaust manifolds. Refer to **Exhaust Manifold Replacement - Left** and **Exhaust Manifold Replacement - Right** in Engine Exhaust.
30. Remove the 4 bolts securing the undertray to the crossmember.
31. Remove the tray from the crossmember.
32. Remove the 2 bolts securing the power steering high pressure line brackets to the oil pan.
33. Remove the transmission. Refer to **Transmission Replacement** in Manual Transmission - Tremec 6-Speed and **Transmission Replacement** in Automatic Transmission - 4L60-E/4L65-E.
34. Attach a suitable lifting chain and hooks to the 2 J-41798, engine lifting brackets.
35. Using a suitable lifting crane, slightly raise the engine to clear the engine mount stud.
36. Slowly lift the engine out of the engine bay.

Installation Procedure

1. Prepare the engine for installation. Refer to **Engine Prelubing**.
2. Install the **J 41798** to the engine. See **Special Tools**.
3. Using an engine hoist and the **J 41798** raise the engine slightly.
4. Remove the engine from the engine stand.
5. Using an engine hoist and the **J 41798** lower the engine onto the crossmember.
6. Slowly lift the engine into the engine bay.
7. Install the transmission. Refer to **Transmission Replacement** in Manual Transmission - Tremec 6-Speed and **Transmission Replacement** in Automatic Transmission - 4L60-E/4L65-E.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the 2 bolts securing the power steering high pressure line brackets to the oil pan.

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

9. Install the undertray to the crossmember.
10. Install the 4 bolts securing the undertray to the crossmember.

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

11. Install both exhaust manifolds. Refer to **Exhaust Manifold Replacement - Left** and **Exhaust Manifold Replacement - Right** in Engine Exhaust.
12. If equipped with manual transmission, Install the bolt attaching the clutch master cylinder reservoir bracket to the end of the master cylinder.

Tighten: Tighten the bolt to 10 N.m (7 lb ft).

13. Install the right and left engine mount to engine bracket nuts.

Tighten: Tighten the nuts to 80 N.m (59 lb ft).

14. Install the ignition coil and module for cylinder No. 7. Refer to **Ignition Coil(s) Replacement** .
15. Connect the brake booster vacuum hose and heater control, vacuum hose at the rear of the intake manifold.
16. Install the harness to dash panel clips.
17. Feed the ECM harness under the brake and clutch master cylinder, if equipped.

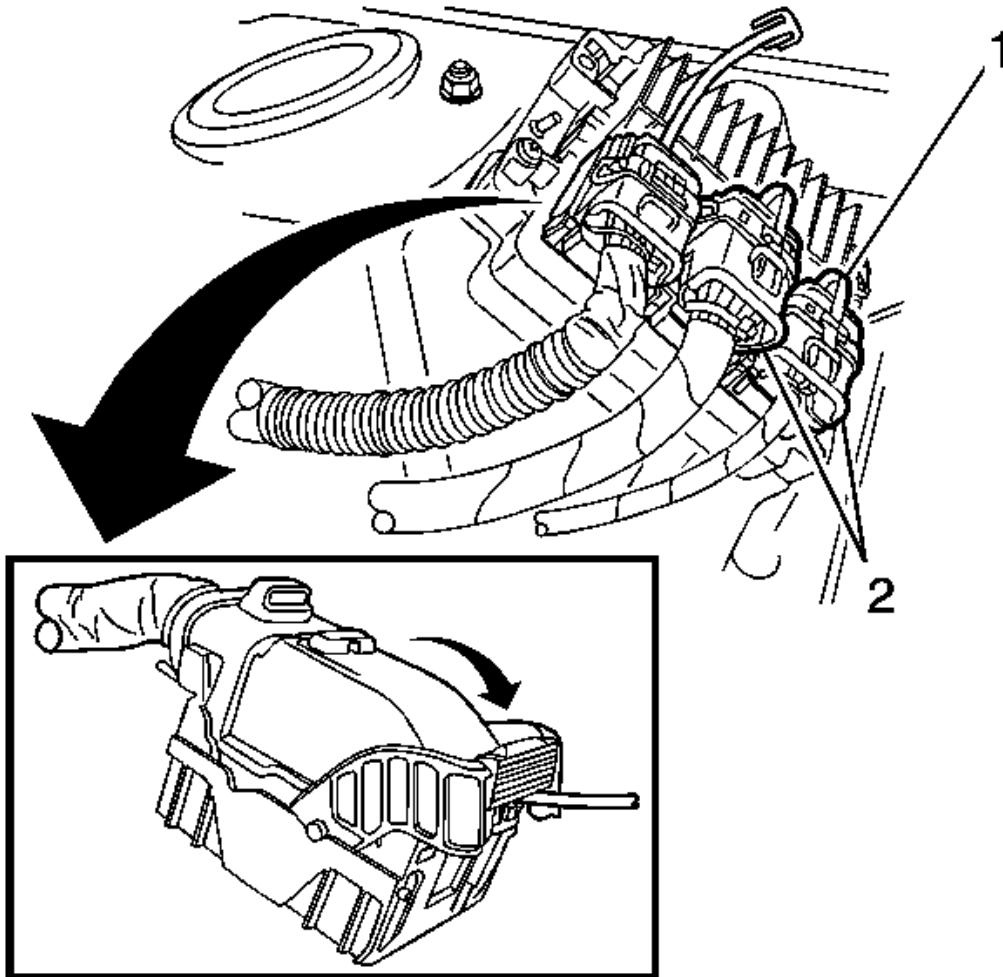


Fig. 202: Identifying Engine Control Module (ECM)**Courtesy of GENERAL MOTORS CORP.**

18. Connect 2 electrical ECM electrical connectors.
19. Install 2 ECM electrical connector locks.
20. Install the high pressure line flare nut and O-ring from the pump outlet fitting at the rear of the power steering pump.
21. Position the power steering return hose to the power steering reservoir then tighten the hose clamp on the return hose.
22. Install the EVAP lines. Refer to **Evaporative Emission (EVAP) Hoses/Pipes Replacement - Engine** .
23. Install the fuel rail feed line. Refer to **Fuel Hose/Pipes Replacement - Engine Compartment** .
24. Connect the A/C wiring harness connector
25. Connect the positive lead terminal to the battery.
26. Install the ground lead screw to the engine block and left had engine mount.

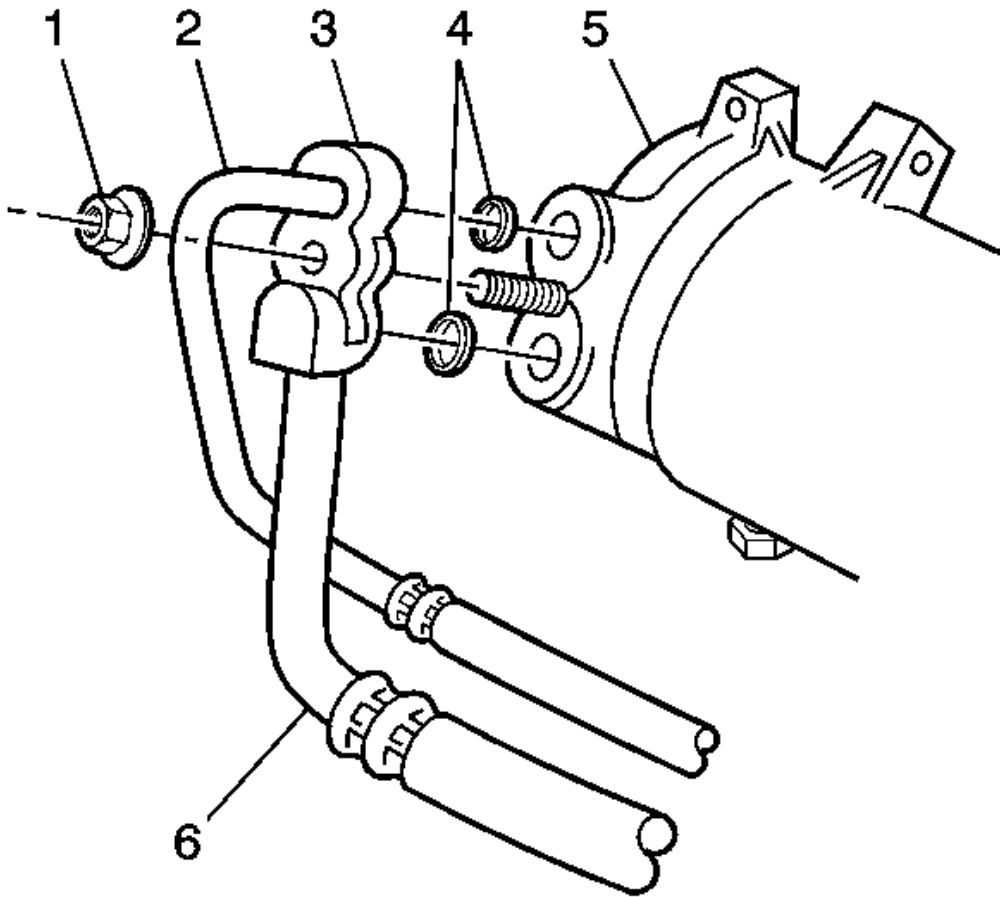


Fig. 203: View Of A/C Compressor & Components
Courtesy of GENERAL MOTORS CORP.

27. Install new O-rings (4) onto the A/C compressor hose block fitting (3). Refer to **O-Ring Replacement** in Heating, Ventilation and Air Conditioning.
28. Install the A/C compressor and condenser hose to the A/C compressor (6). Secure with the nut (1).

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

29. Install the heater hoses to the water pump.
30. Install the radiator hoses to the water pump.
31. Install the radiator. Refer to **Radiator Replacement** in Engine Cooling.
32. Install the intake duct from the vehicle. Refer to **Air Cleaner Assembly Replacement**.
33. Install the fuel rail covers.

34. Install the front suspension support brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.
35. Install the hood. Refer to **Hood Replacement (Without Hood Scoops)** or **Hood Replacement (With Hood Scoops)** in Body Front End.
36. Refill the air conditioning (A/C) refrigerant. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
37. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.
38. Connect the negative battery cable.
39. Disable the ignition system.
40. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
41. Enable the ignition system.
42. Start the engine and listen for unusual noises.
43. Check the vehicle oil pressure gage and confirm that the engine has acceptable oil pressure.

If necessary, install an oil pressure gage and measure the engine oil pressure.

44. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
45. Listen for sticking lifters and other unusual noises.
46. Inspect for fuel, oil, and/or other coolant leaks while the engine is running.

Engine Oil and Oil Filter Replacement

Removal Procedure

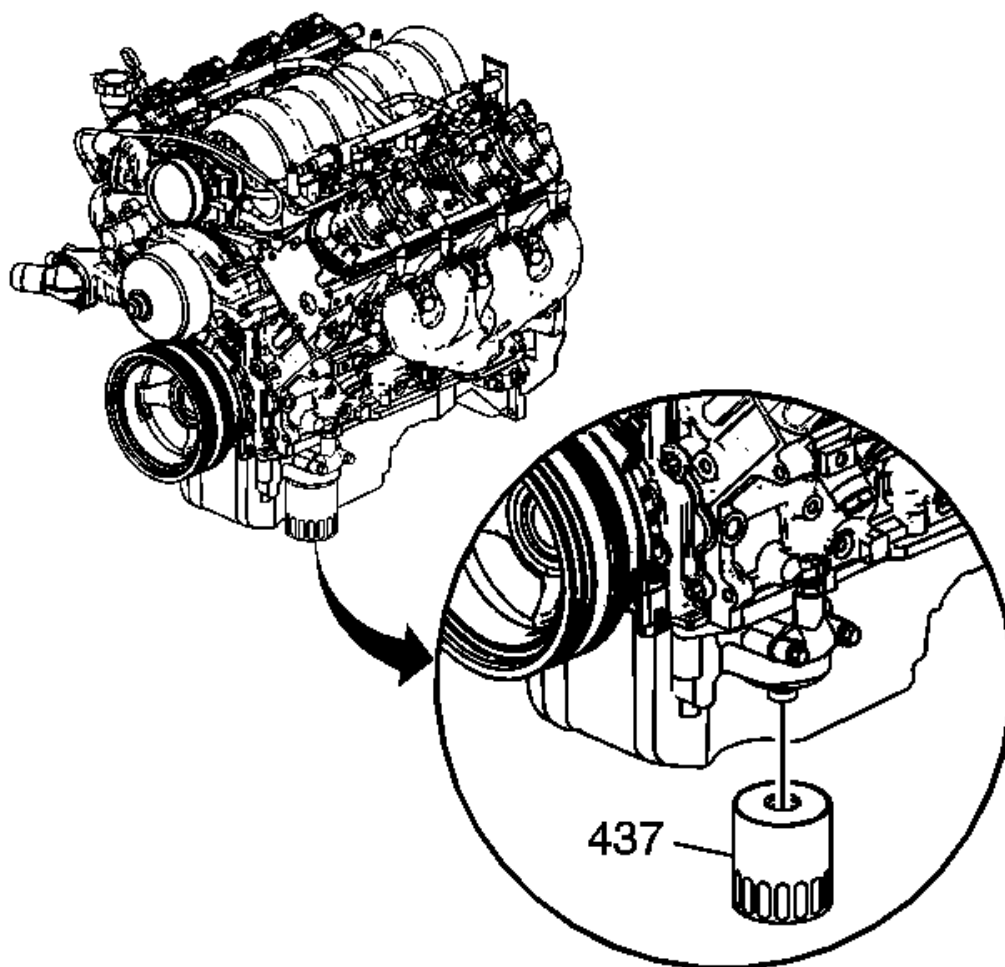


Fig. 204: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Remove the oil pan drain plug.
5. Drain the engine oil into an appropriate container.
6. Remove the engine oil filter (437) from the engine block.

Installation Procedure

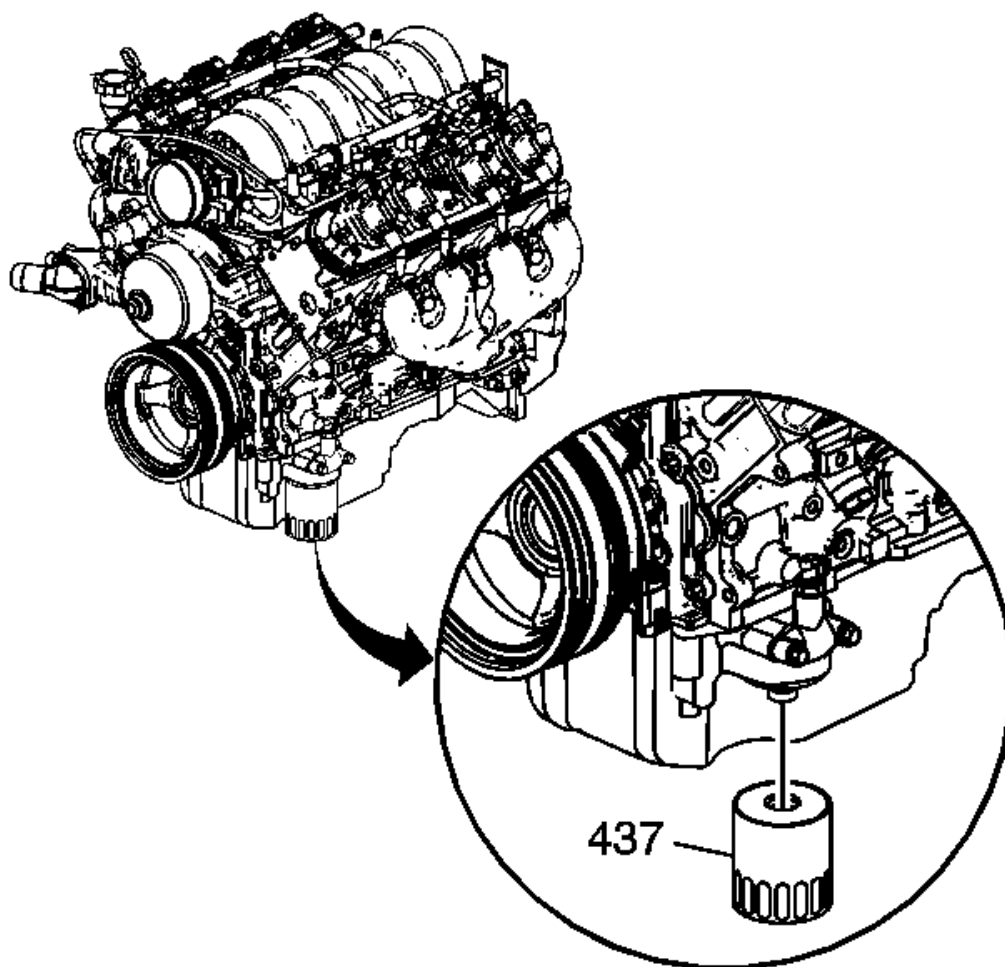


Fig. 205: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Before installing the new oil filter, ensure that the old oil filter gasket has been removed. If not, remove the old gasket.

1. Install the oil filter (437) to the engine block.

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

2. Install the oil pan drain plug.

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

3. Lower the vehicle.

IMPORTANT: DO NOT use any engine oil additives in Corvette engines.

4. Fill the engine with the appropriate amount and type of engine oil. Refer to **Capacities - Approximate Fluid** and **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.
5. Check the oil level.
6. Install the oil fill cap.
7. Close the hood.
8. Reset the engine oil life monitor. Refer to **GM Oil Life System - Resetting** in Maintenance and Lubrication.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

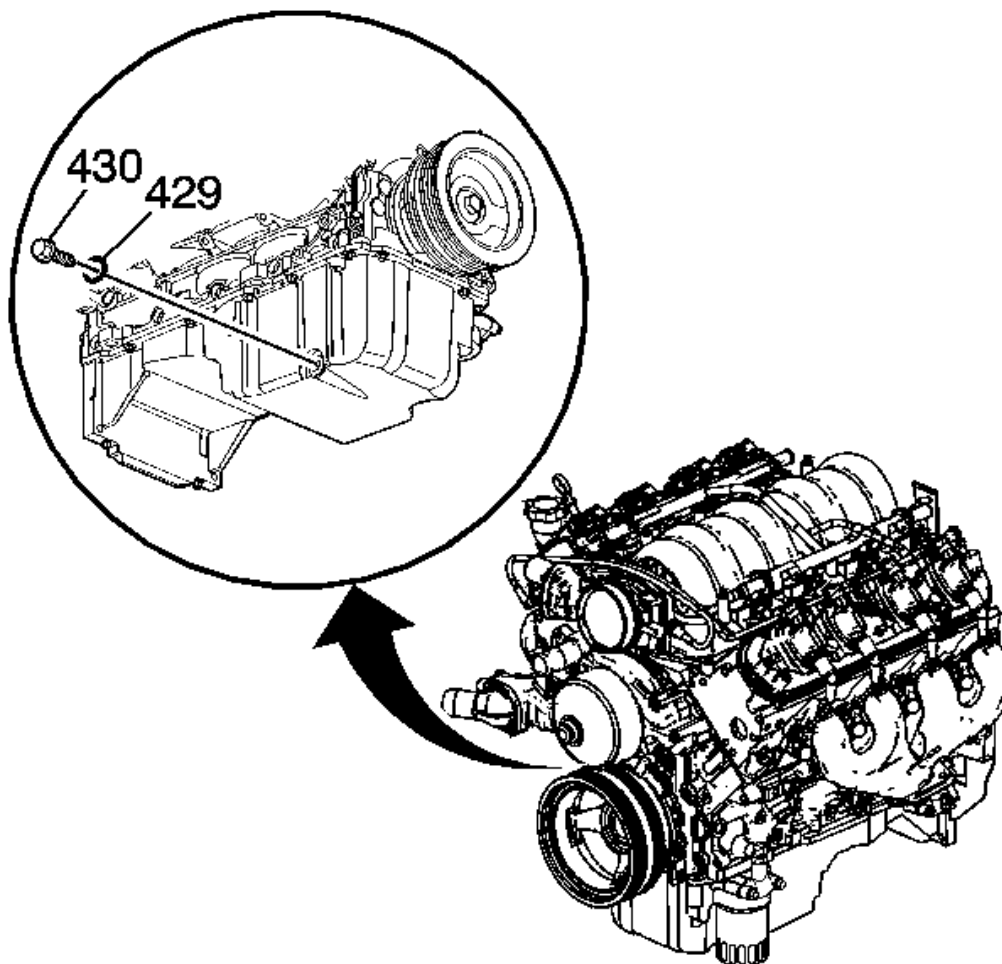


Fig. 206: Identifying Oil Pan Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug (430) and O-ring (429).

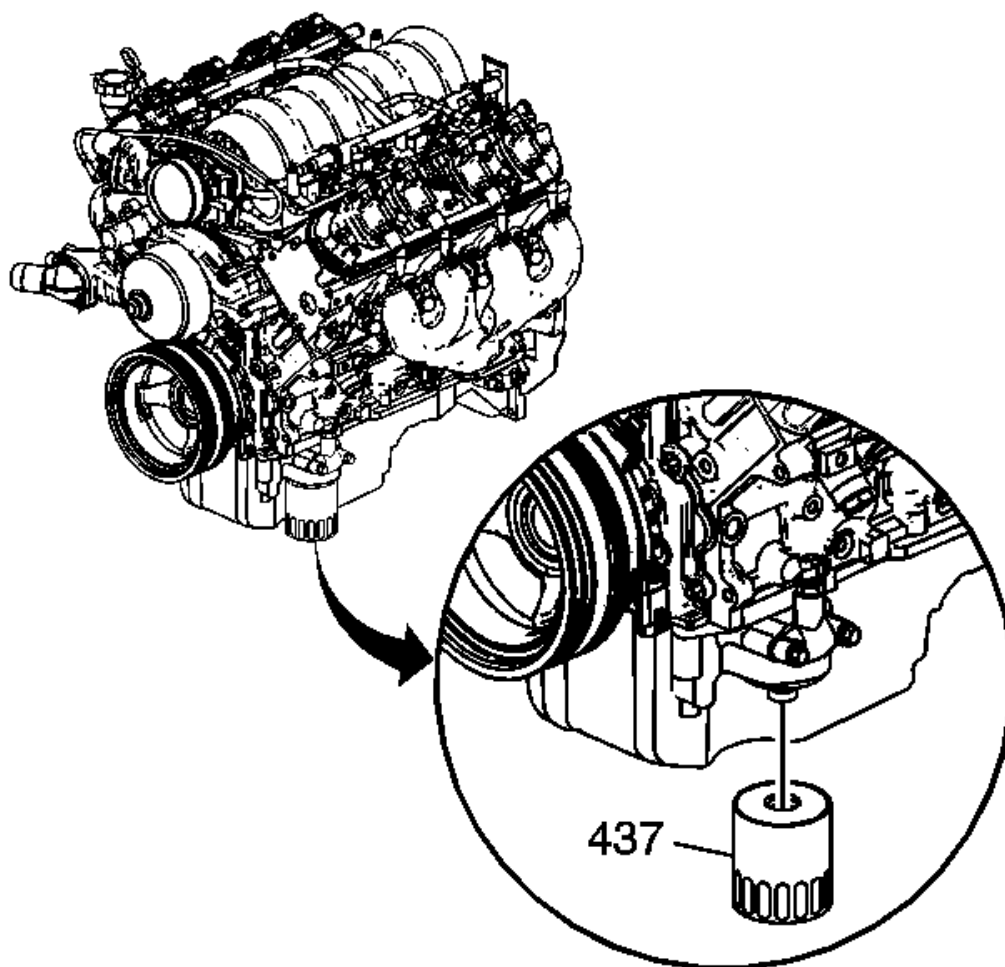


Fig. 207: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter (437).

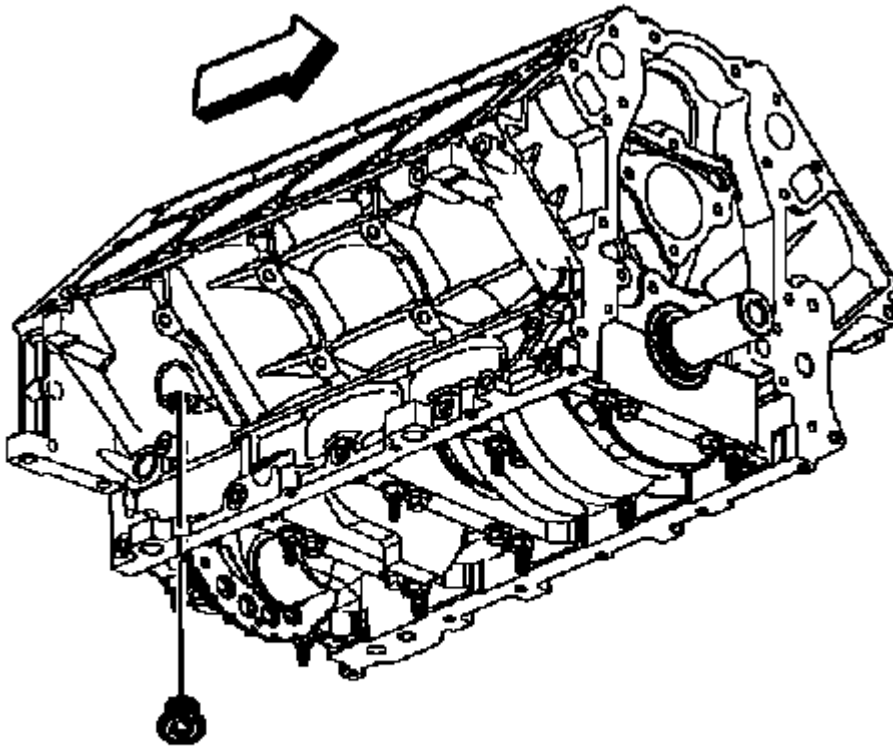


Fig. 208: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block coolant drain hole plug and washer.

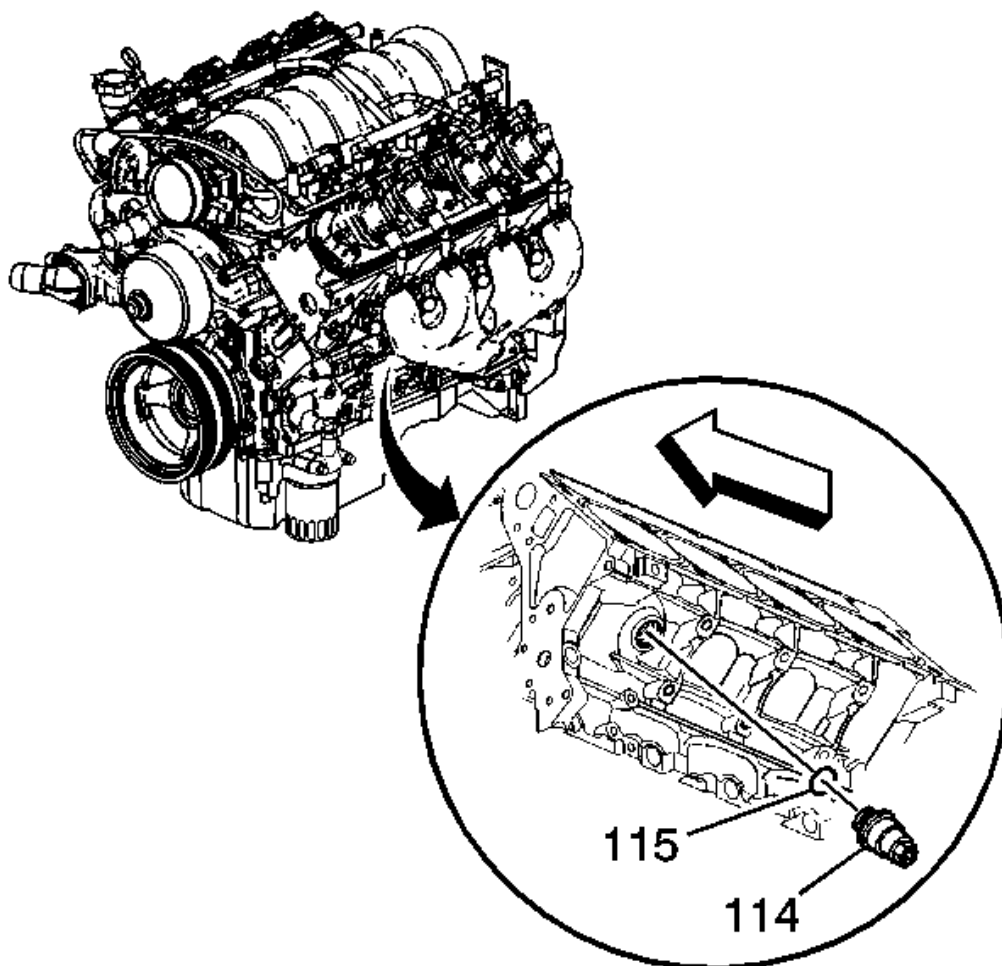


Fig. 209: Identifying Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block coolant heater (114) and washer (115).

Crankshaft Balancer Removal

Tools Required

- **J 41816** Crankshaft Balancer Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.

Removal Procedure

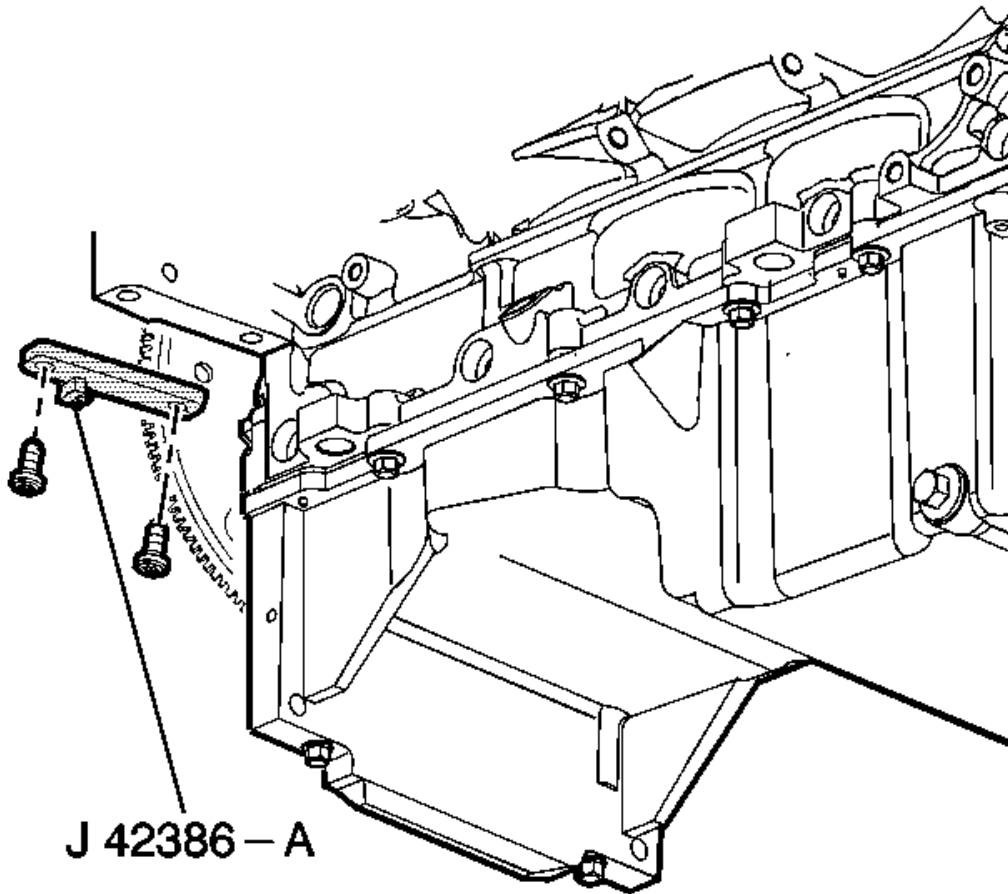


Fig. 210: View Of J 42386-A

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

1. Install the J 42386-A and bolts. See Special Tools.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

Tighten: Tighten the J 42386-A bolts to 50 N.m (37 lb ft).

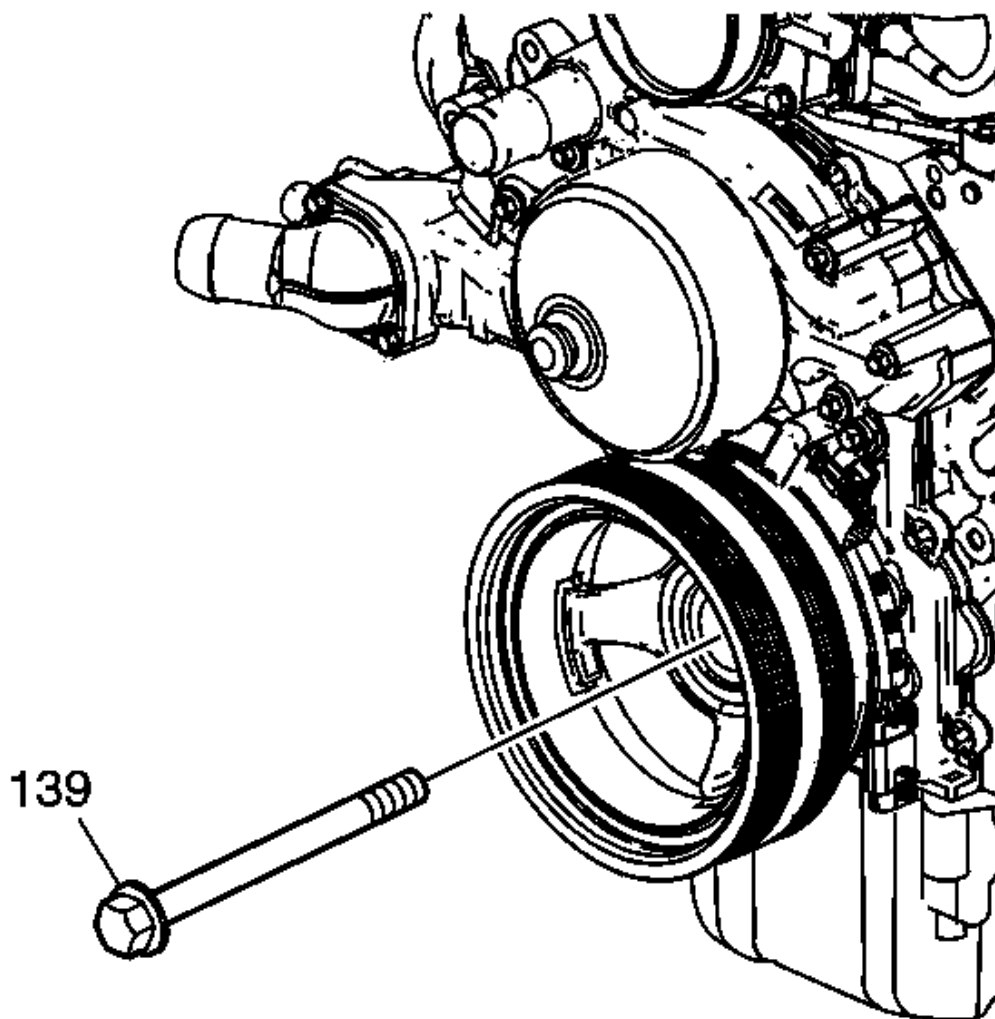


Fig. 211: Identifying Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt (139).

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

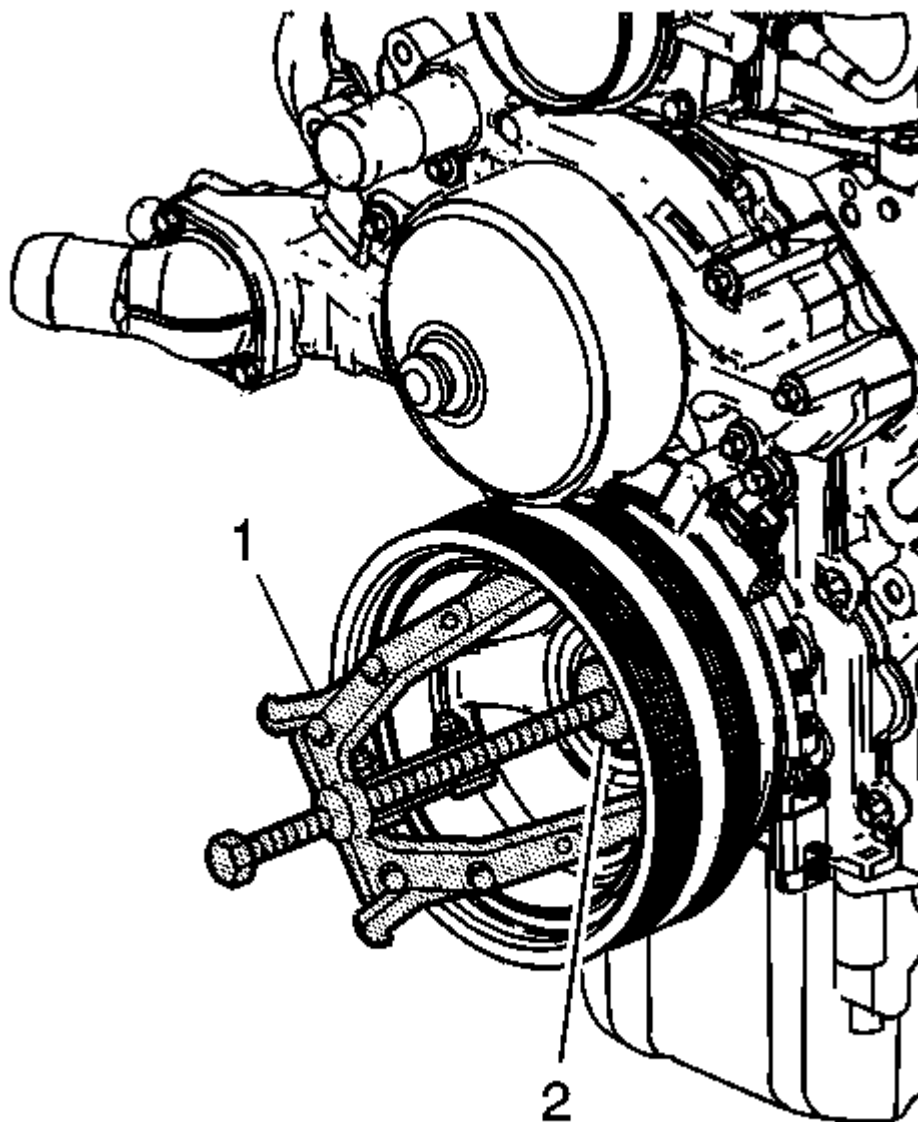


Fig. 212: Using Crankshaft Balancer Puller
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41816** (1) and the **J 41816-2** (2) in order to remove the crankshaft balancer. See **Special Tools**.

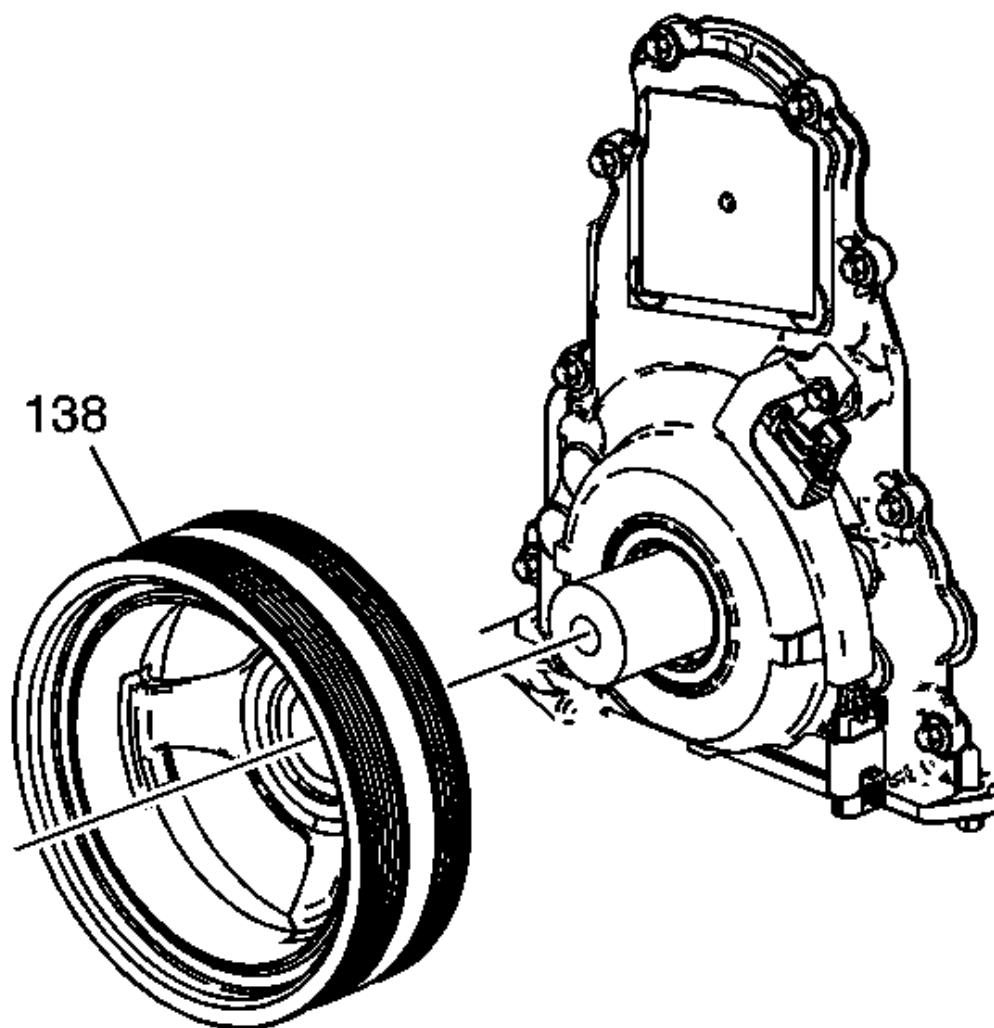


Fig. 213: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer (138).
5. Remove the **J 42386-A** and bolts. See **Special Tools**.

Engine Flywheel Removal

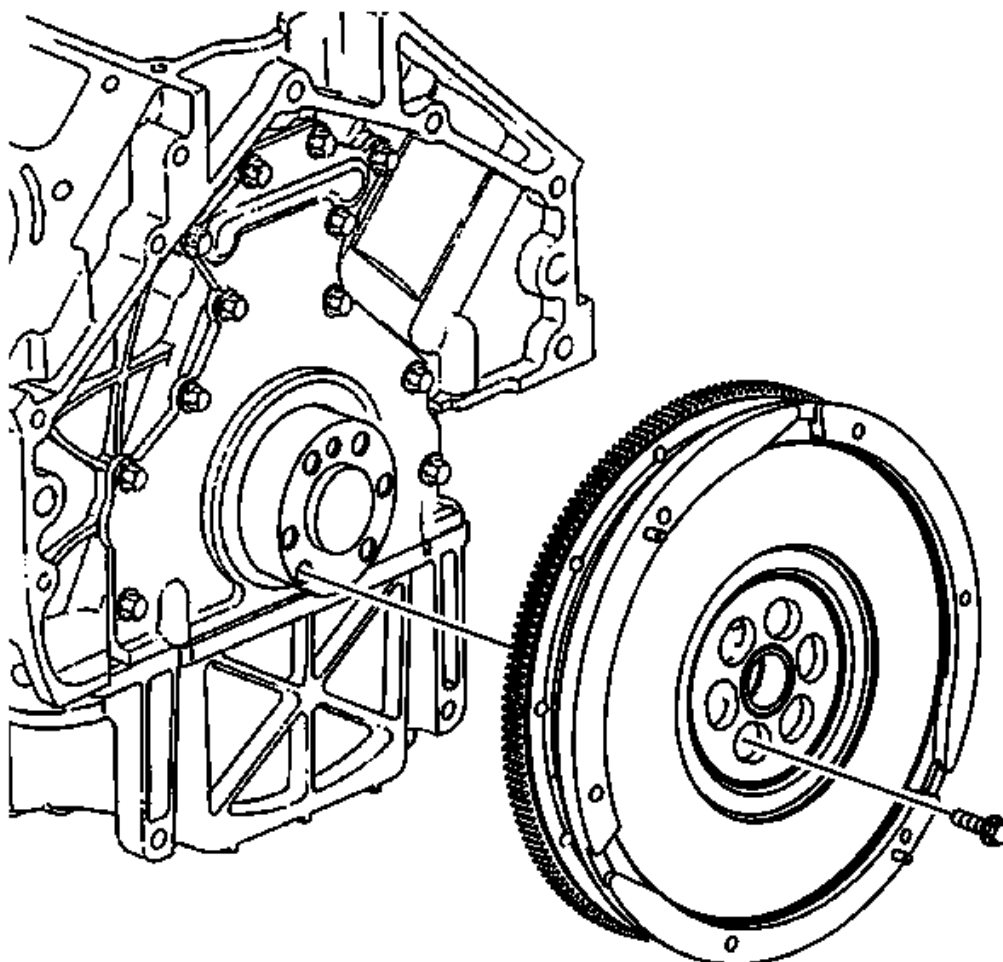


Fig. 214: View Of Manual Transmission Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel bolts.
2. Remove the manual transmission flywheel.

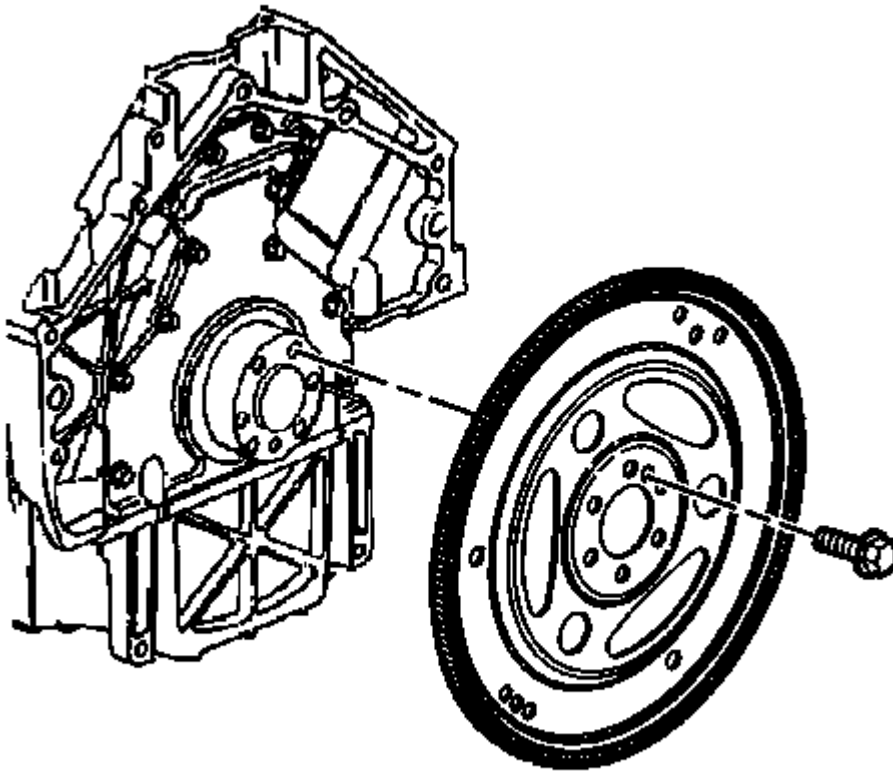


Fig. 215: Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

3. Remove the automatic transmission flywheel.

Clutch Pilot Bearing Removal

Tools Required

J 43276 Clutch Pilot Bearing Remover

Removal Procedure

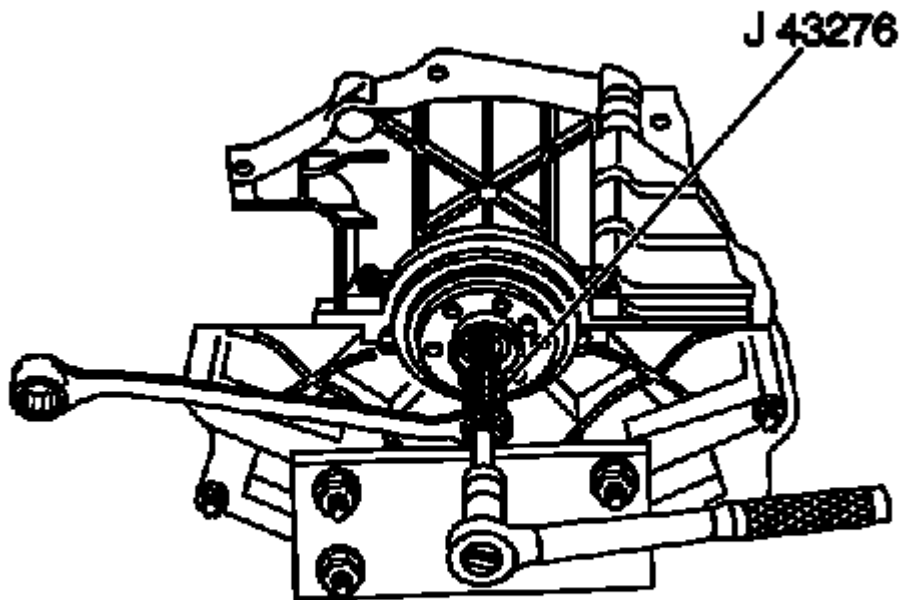


Fig. 216: Removing Clutch Pilot Bearing Using J 43276
Courtesy of GENERAL MOTORS CORP.

NOTE: When using the J 43276 Clutch Pilot Bearing Remover, always secure the J 43276-1 Clutch Pilot Bearing Remover tool body using a wrench. Do not allow the J 43276-1 tool body to rotate. Failing to do so causes damage to the J 43276-1 tool body.

1. Remove the clutch pilot bearing using the J 43276 .
 1. Install the J 43276-1 into the clutch pilot bearing.
 2. Using a wrench, secure the J 43276-1.
 3. Insert the J 43276-2 into the J 43276-1.
 4. Rotate the J 43276-2 clockwise into the J 43276-1 until the clutch pilot bearing is completely removed from the crankshaft.
 5. Rotate the J 43276-2 counterclockwise to remove the J 43276-2 from the J 43276-1.
 6. Remove the J 43276-1 from the tool body.

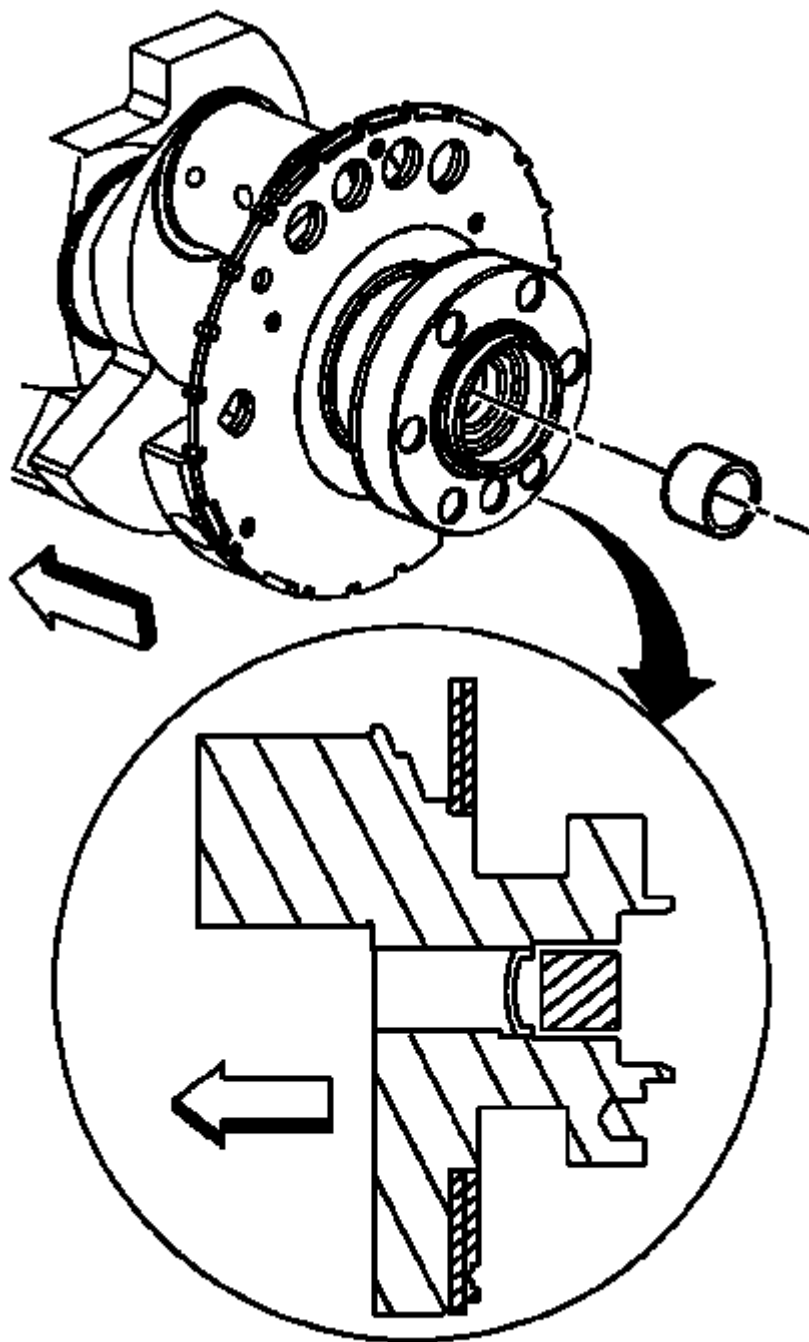


Fig. 217: Locating Clutch Pilot Bearing
Courtesy of GENERAL MOTORS CORP.

2. Discard the pilot bearing.

Oil Level Indicator and Tube Removal

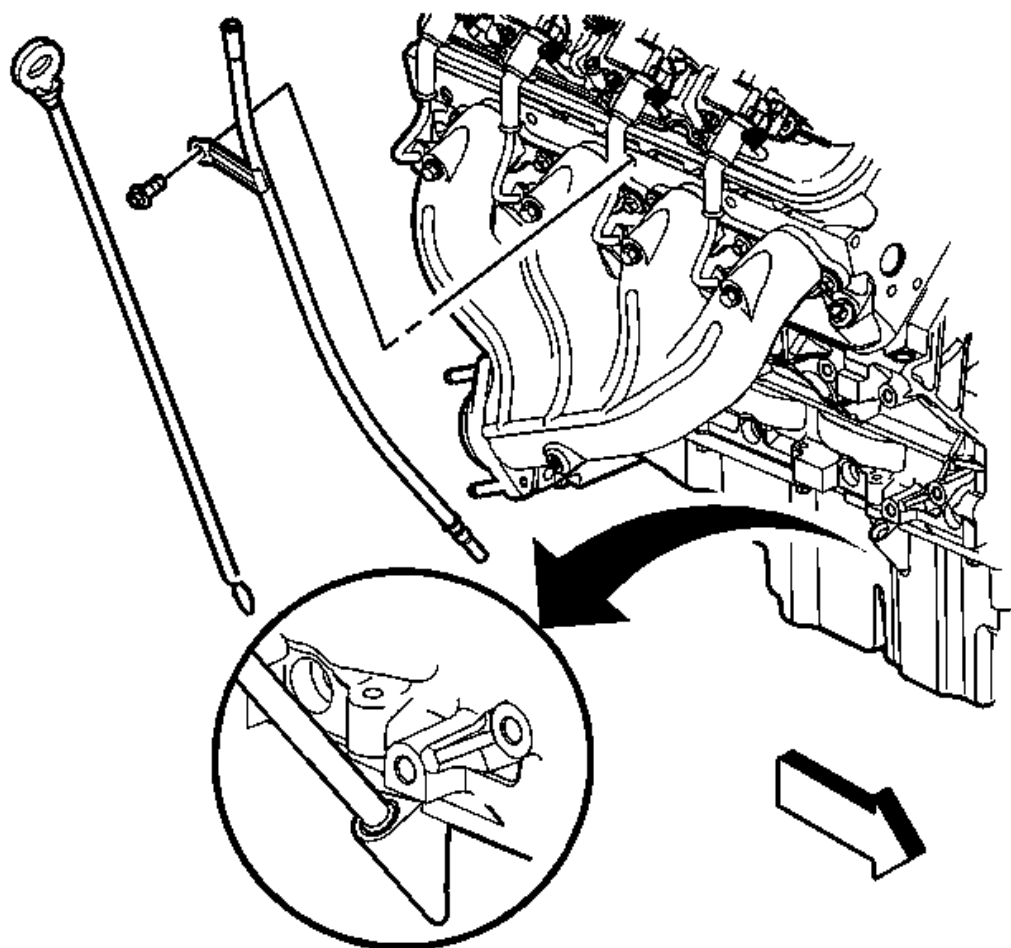


Fig. 218: View Of Oil Lever Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

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

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 from the tube as required.

Exhaust Manifold Removal - Left

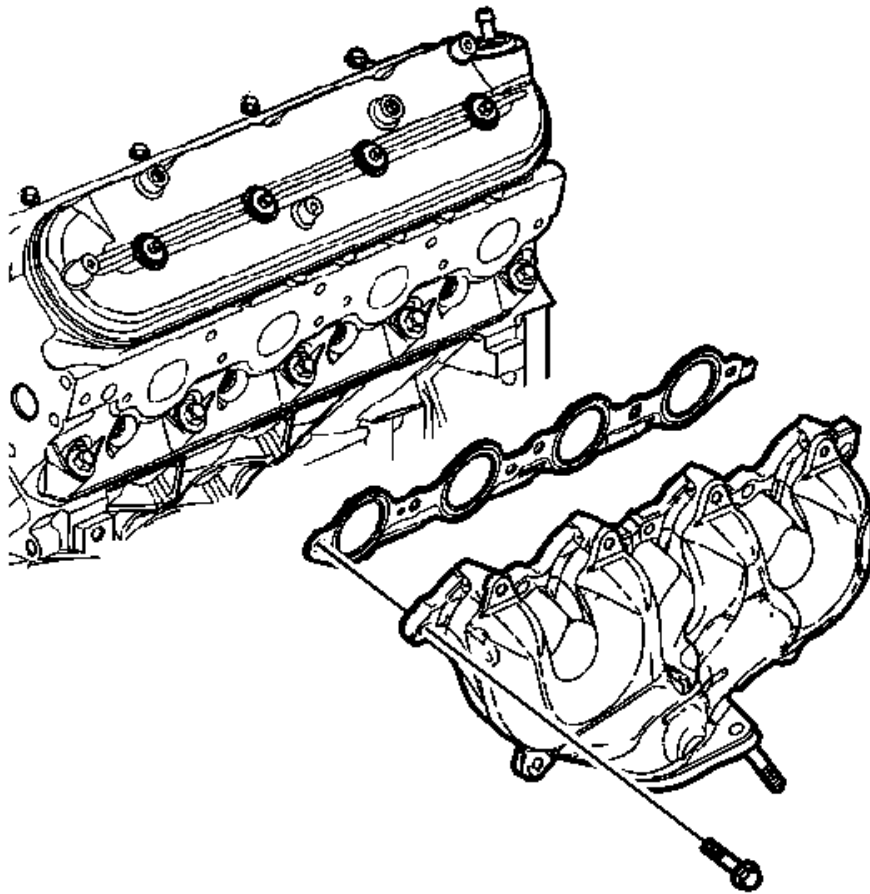


Fig. 219: Left Exhaust Manifold, Gasket & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

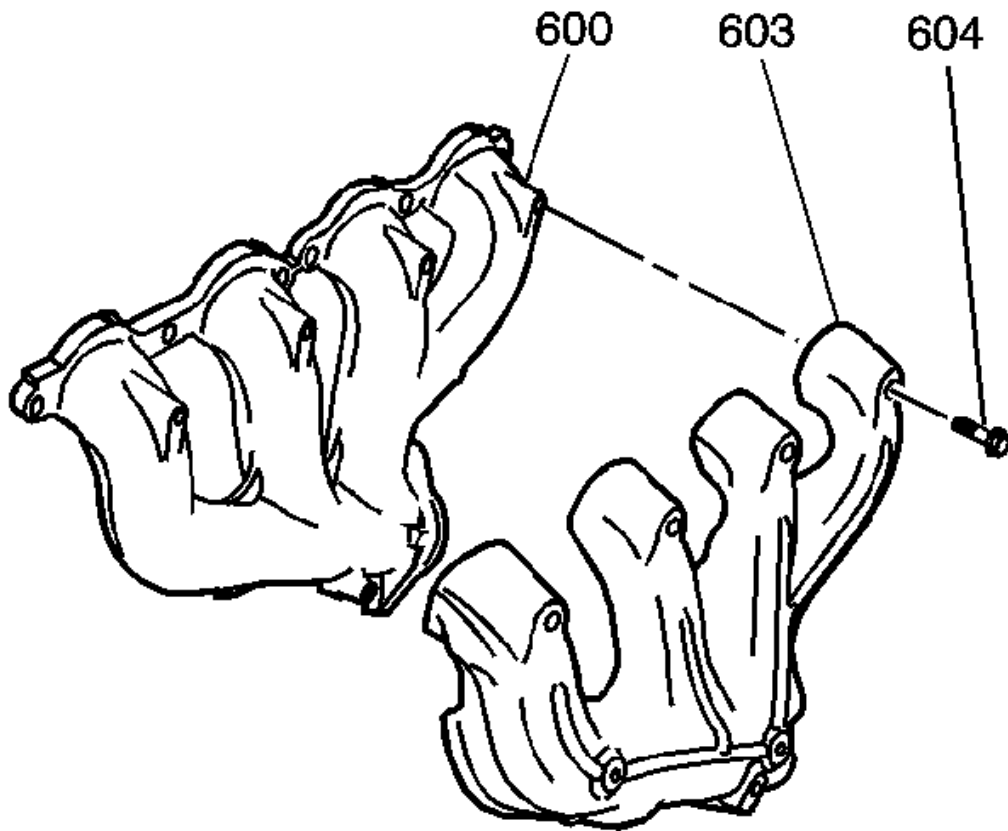


Fig. 220: View Of Heat Shield, Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600) as required.
5. Remove the studs as required.

Exhaust Manifold Removal - Right

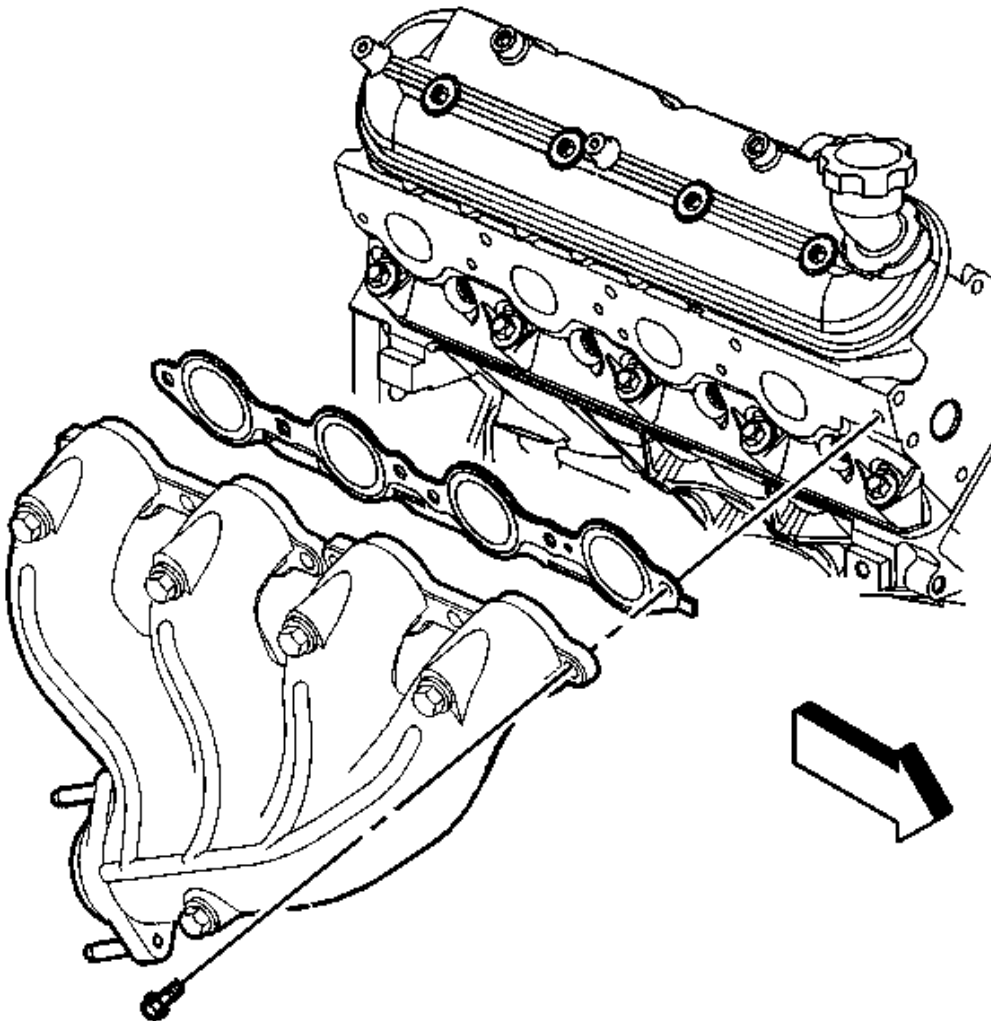


Fig. 221: View Of Right Exhaust Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

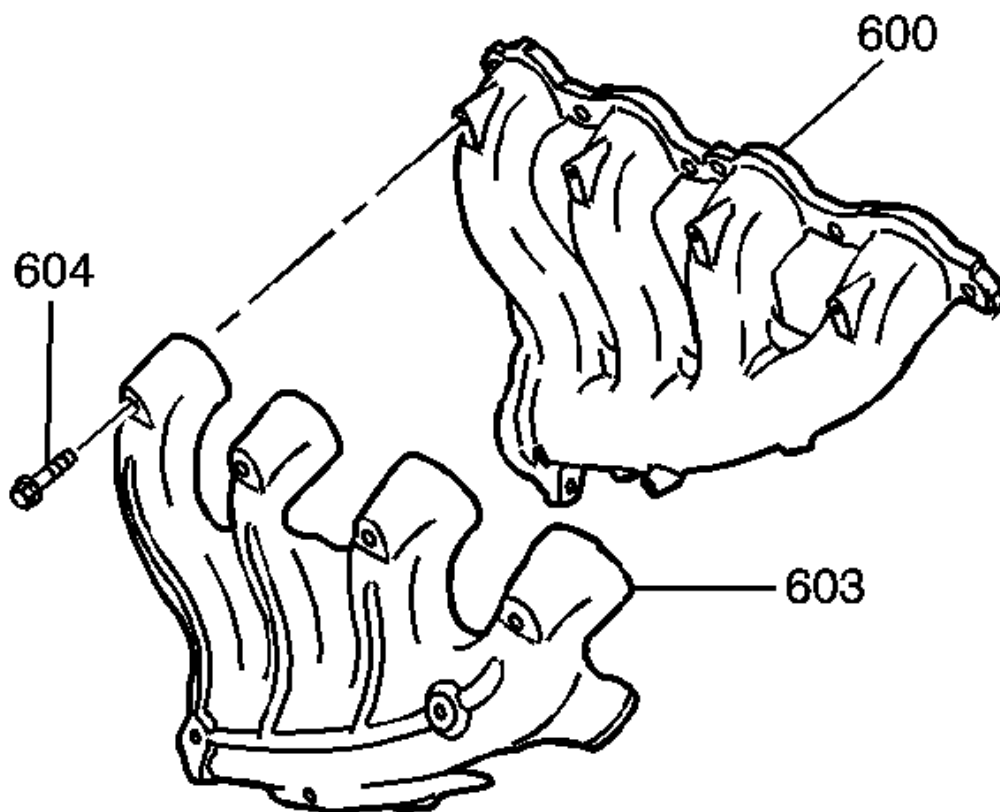


Fig. 222: View Of Right Manifold, Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600) as required.
5. Remove the studs as required.

Water Pump Removal

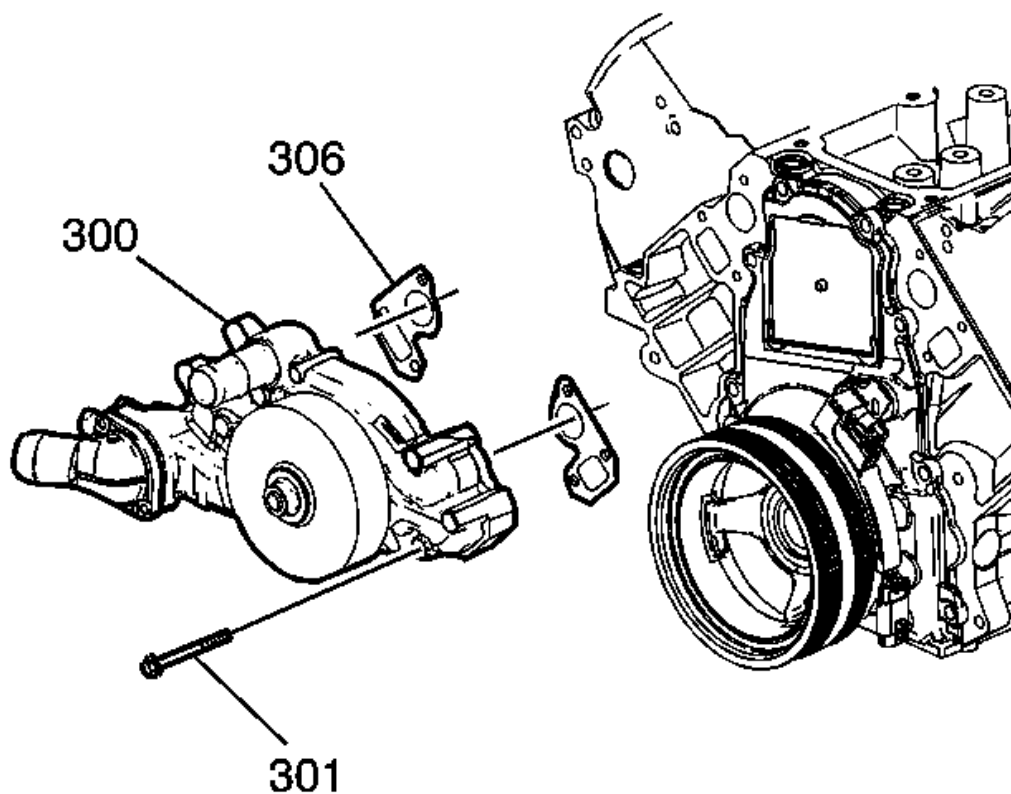


Fig. 223: View Of Water Pump, Gaskets & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump bolts (301).
2. Remove the water pump (300) and gaskets (306).
3. Discard the water pump gaskets.

Throttle Body Removal

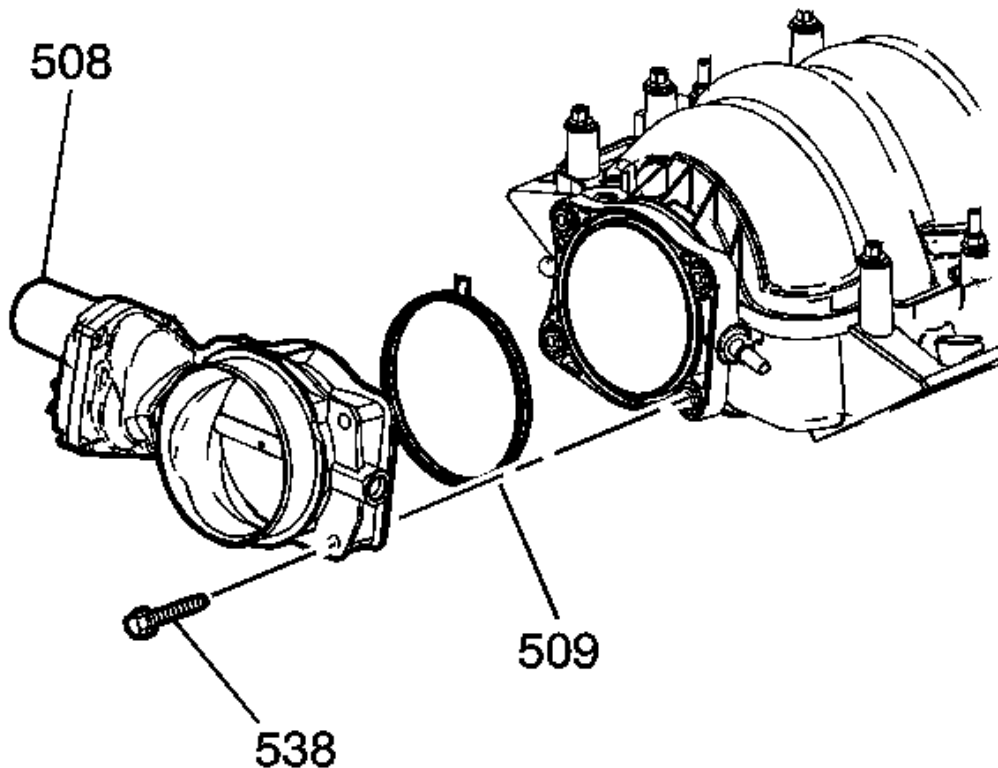


Fig. 224: Throttle Body, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: Handle the electronic throttle control components carefully. Use cleanliness in order to prevent damage. Do not drop the electronic throttle control components. Do not roughly handle the electronic throttle control components. Do not immerse the electronic throttle control components in cleaning solvents of any type.

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 connector from the throttle body.
2. Remove the throttle body bolts (538).
3. Remove the throttle body (508).
4. Remove the throttle body gasket (509).

5. Discard the gasket.

Fuel Rail and Injectors Removal

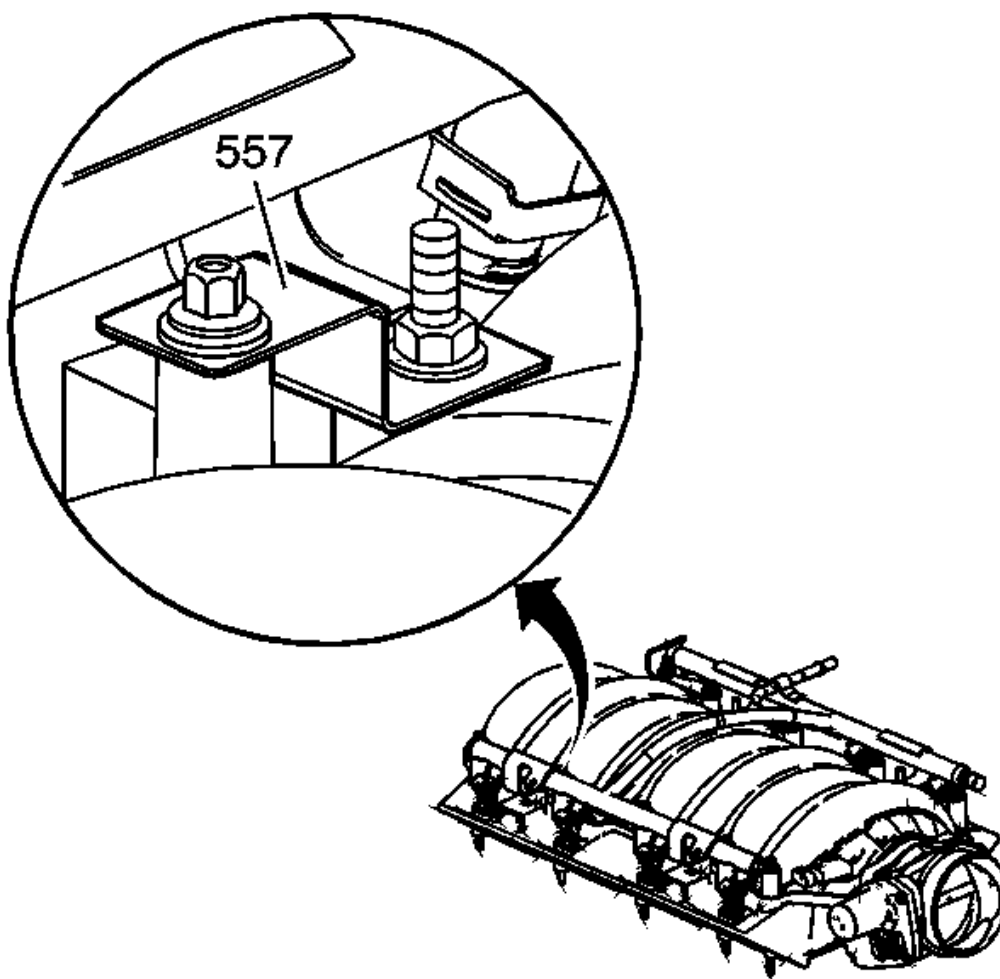


Fig. 225: Fuel Rail Ground Strap
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

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.

- 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. Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends as necessary.

1. Note the location of the fuel rail ground strap (557).

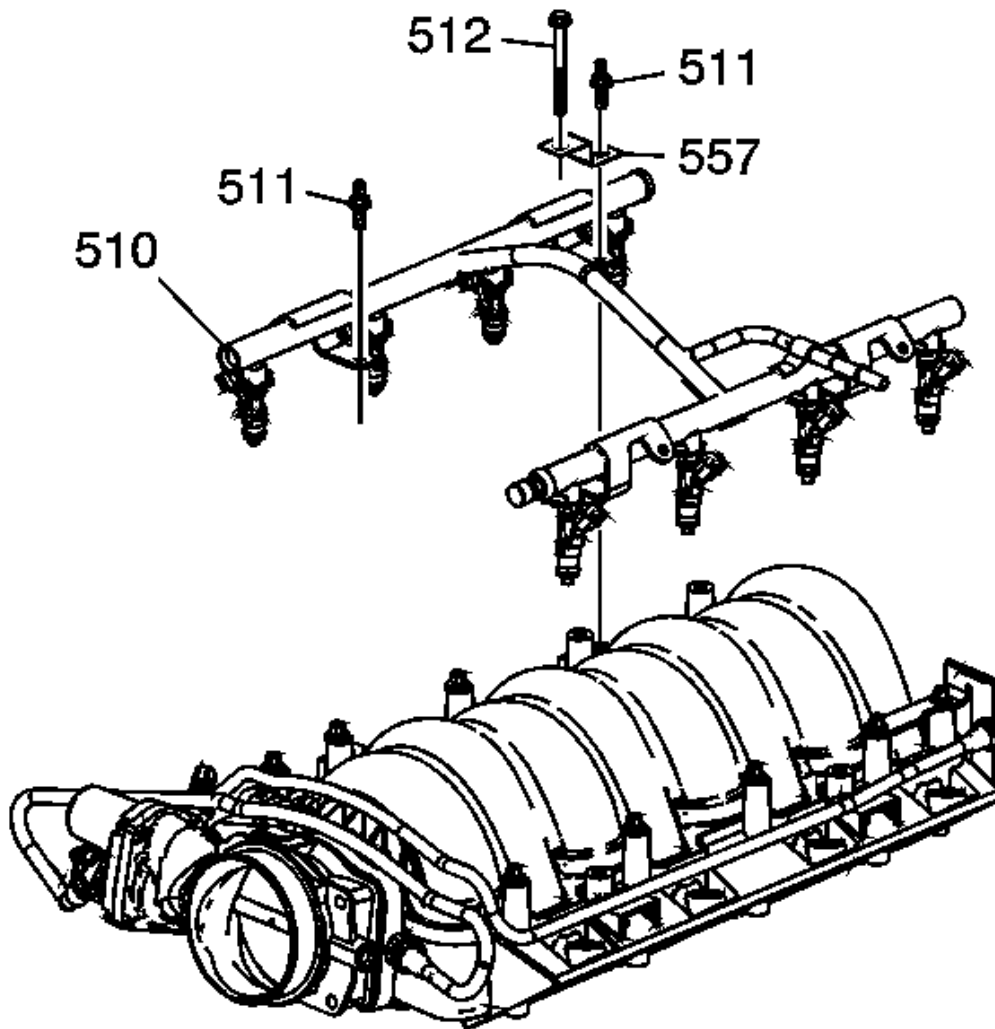


Fig. 226: Fuel Rail, Ground Strap & Bolts

Courtesy of GENERAL MOTORS CORP.

2. Remove the bolts (511, 512), ground strap (557), and fuel rail with injectors (510). Lift evenly on both sides of the fuel rail until all injectors have left their bores.

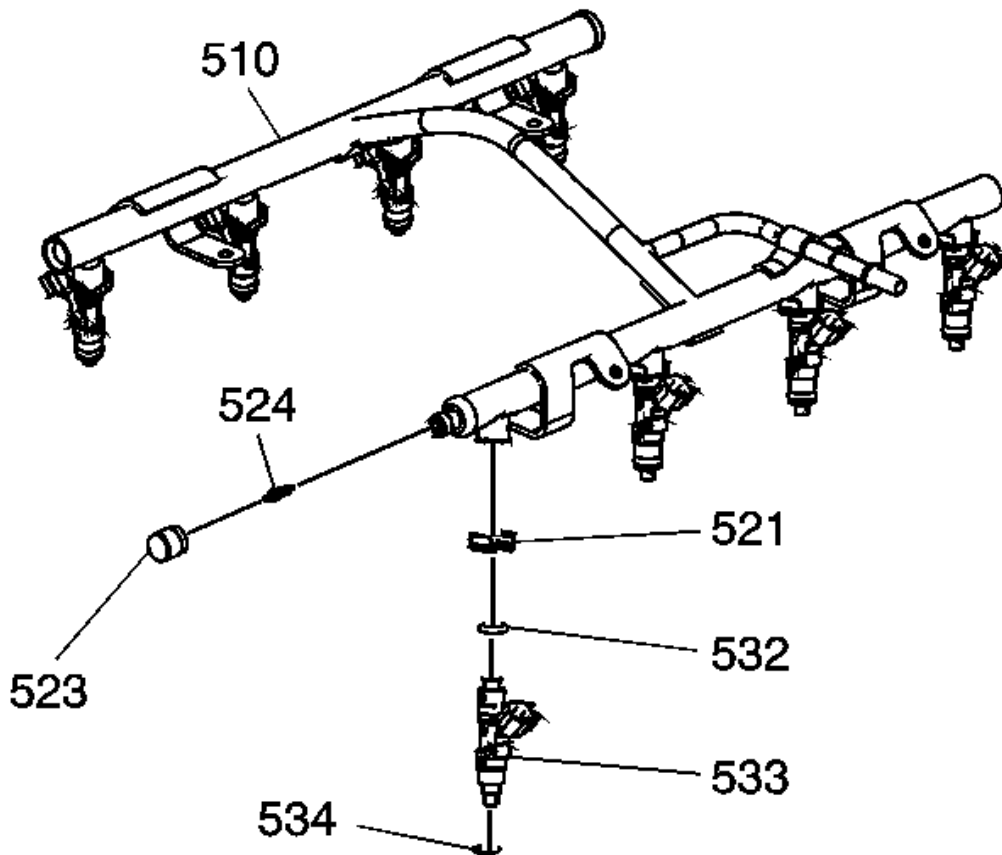


Fig. 227: Fuel Injectors, Retainers, O-Rings, Cap & Service Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel injectors (533) and retaining clips (521).
4. Remove the O-rings (532, 534) as required.
5. Remove the cap (523), service valve (524), and O-ring (522) as required.

Intake Manifold Removal

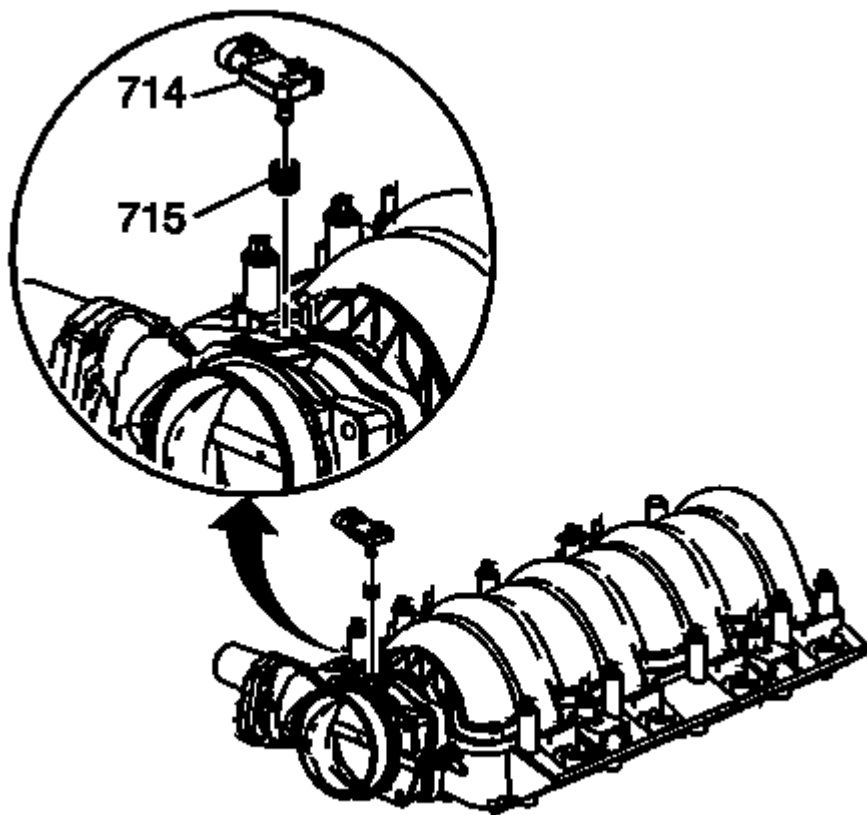


Fig. 228: MAP Sensor & Grommet
Courtesy of GENERAL MOTORS CORP.

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 manifold absolute pressure (MAP) sensor (714).
2. Remove the grommet (715) from the sensor as required.

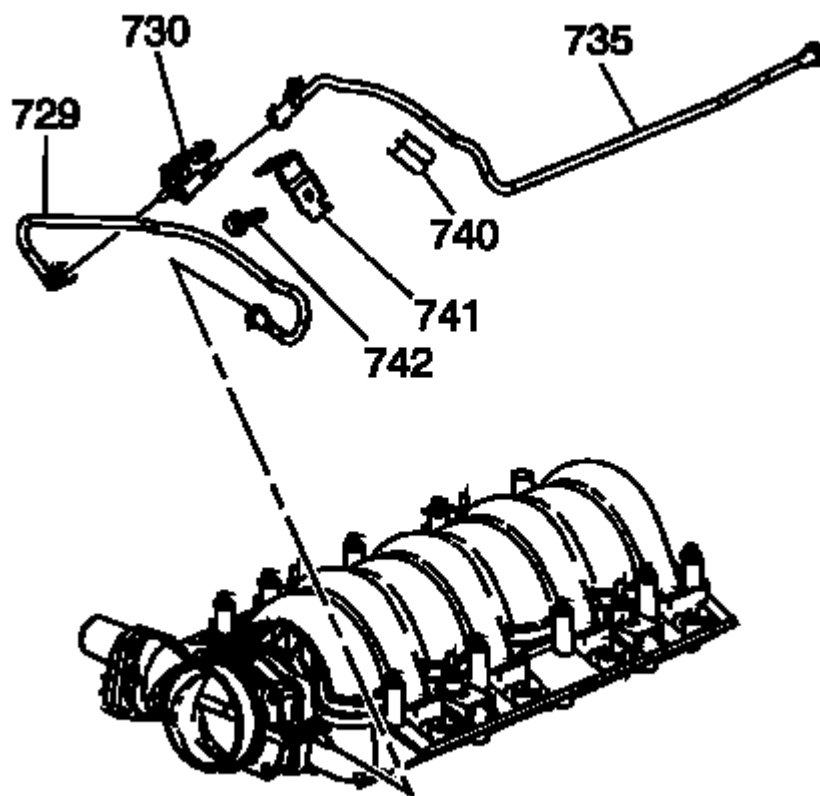


Fig. 229: EVAP Clip, Bolt, Bracket, Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

3. Remove the evaporative emission (EVAP) clip (740), bolt (742), bracket (741), valve (730), and tubes (729, 735).
4. Remove the positive crankcase ventilation (PCV) hose - dirty air from the manifold.

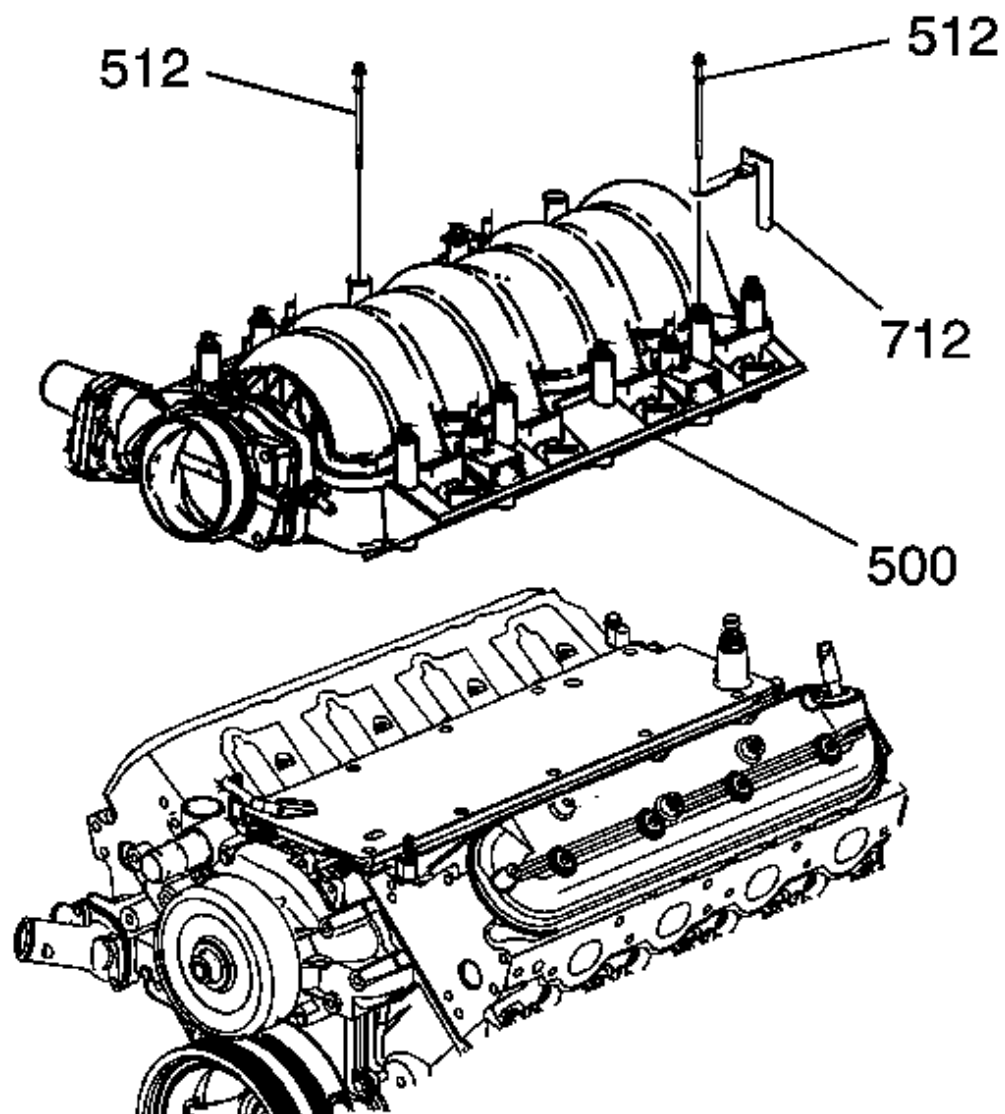


Fig. 230: Identifying Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake manifold bolts (512) and fuel rail stop bracket (712).
6. Remove the intake manifold (500).

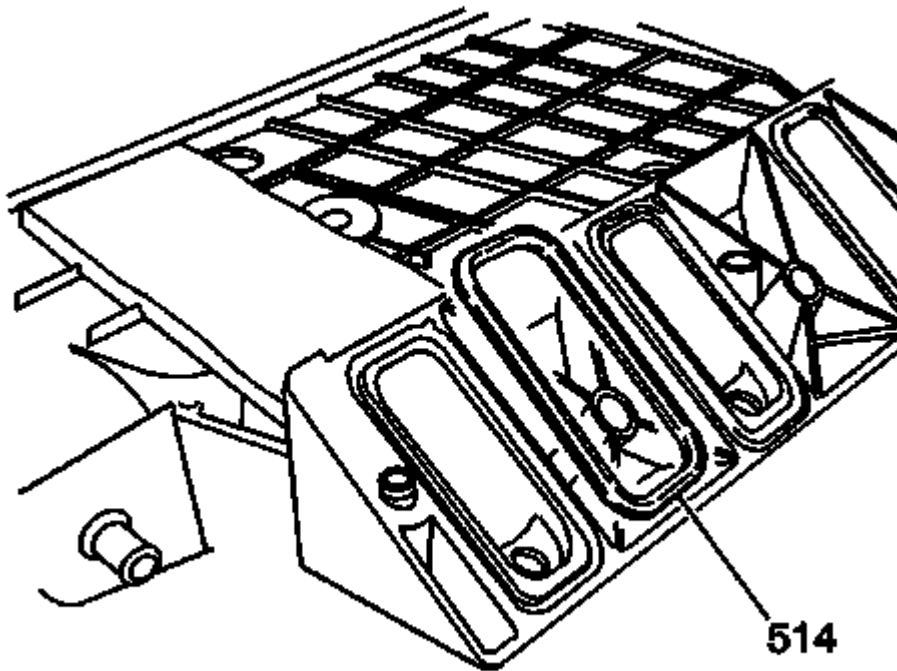


Fig. 231: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

7. Remove the intake manifold gaskets (514).
8. Discard the intake manifold gaskets.

Coolant Air Bleed Pipe Removal

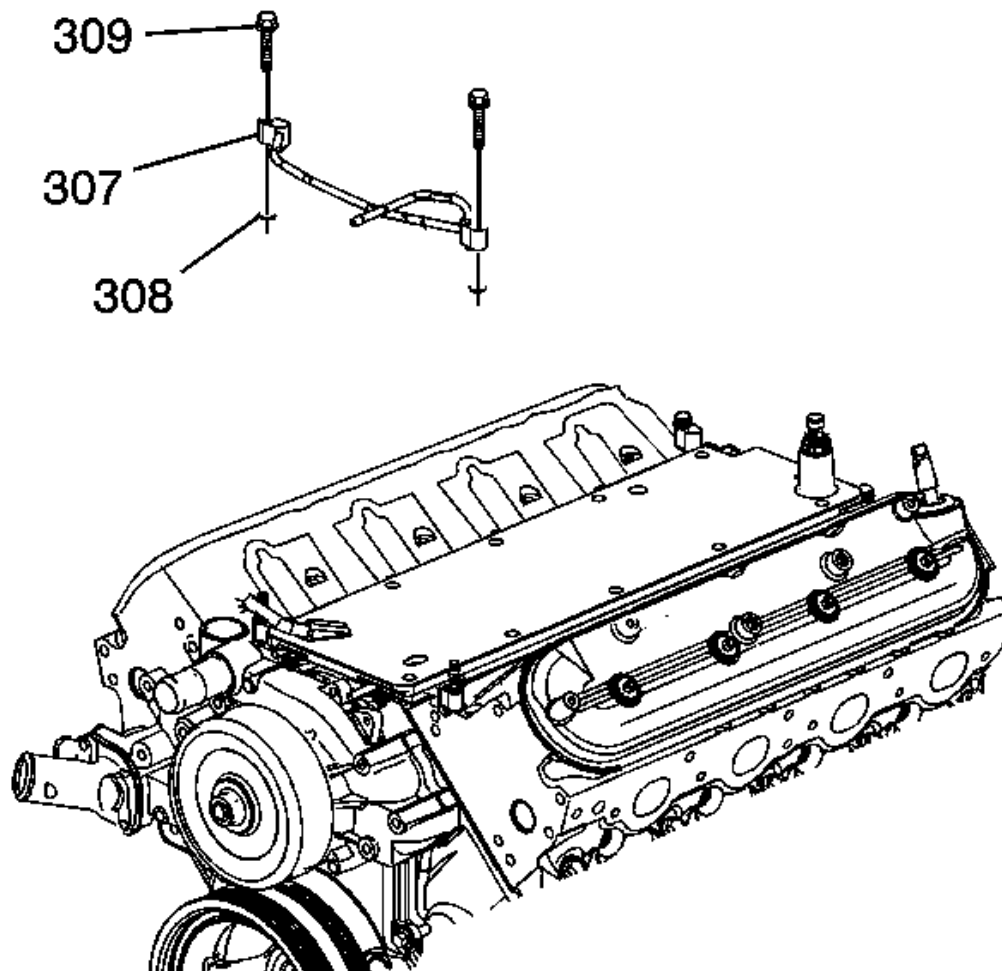


Fig. 232: View Of Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with gaskets (308).

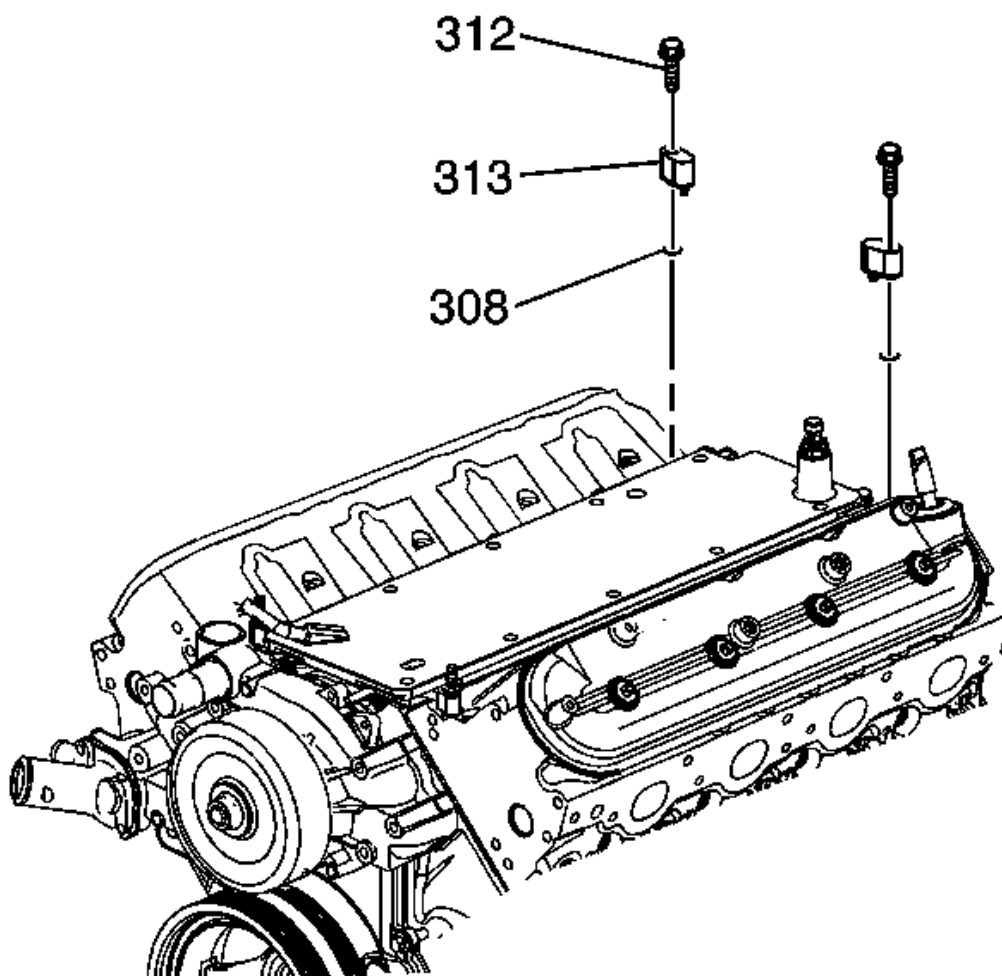


Fig. 233: View Of Coolant Air Bleed Pipe Covers & Gaskets
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine coolant air bleed cover bolts (312).
4. Remove the covers (313) with gaskets (308).

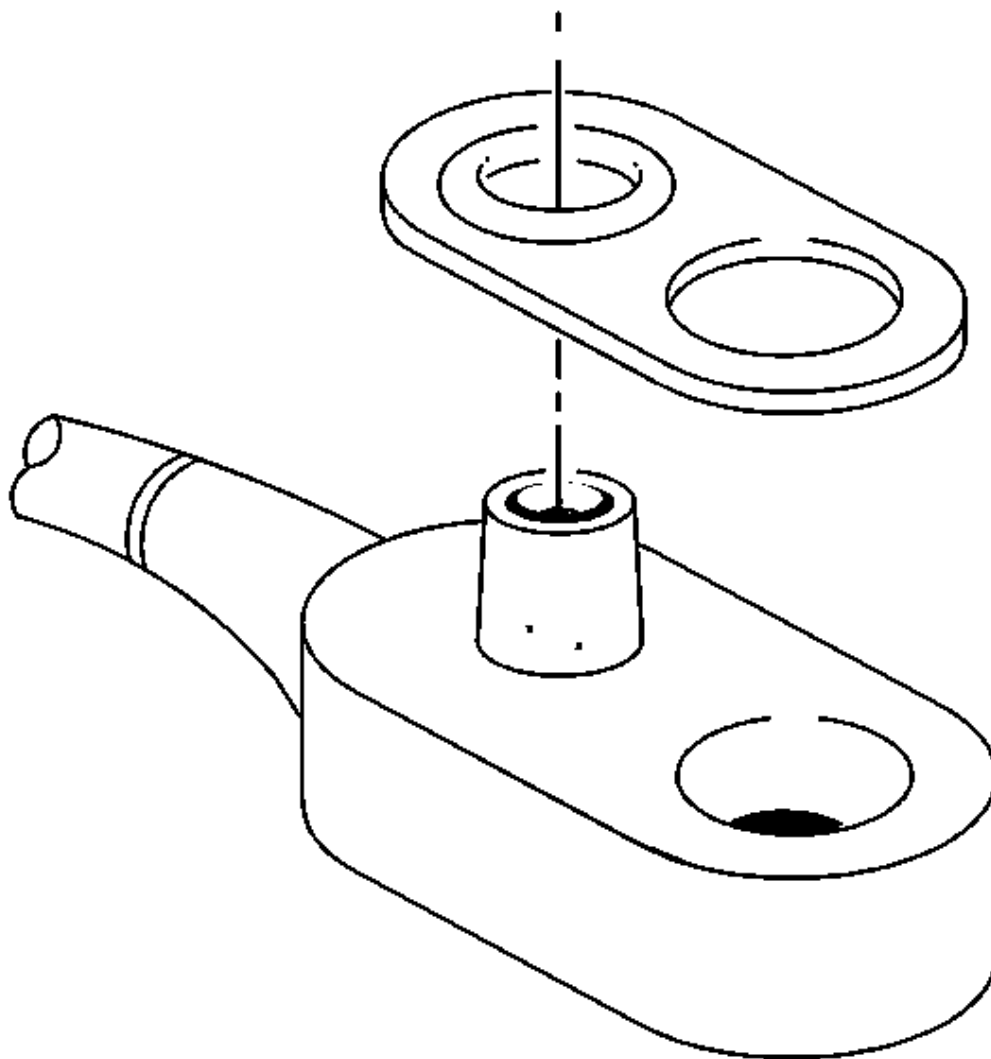


Fig. 234: View Of Air Bleed Pipe Sealing Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the gaskets from the pipe and covers.
6. Discard the gaskets.

Engine Valley Cover Removal

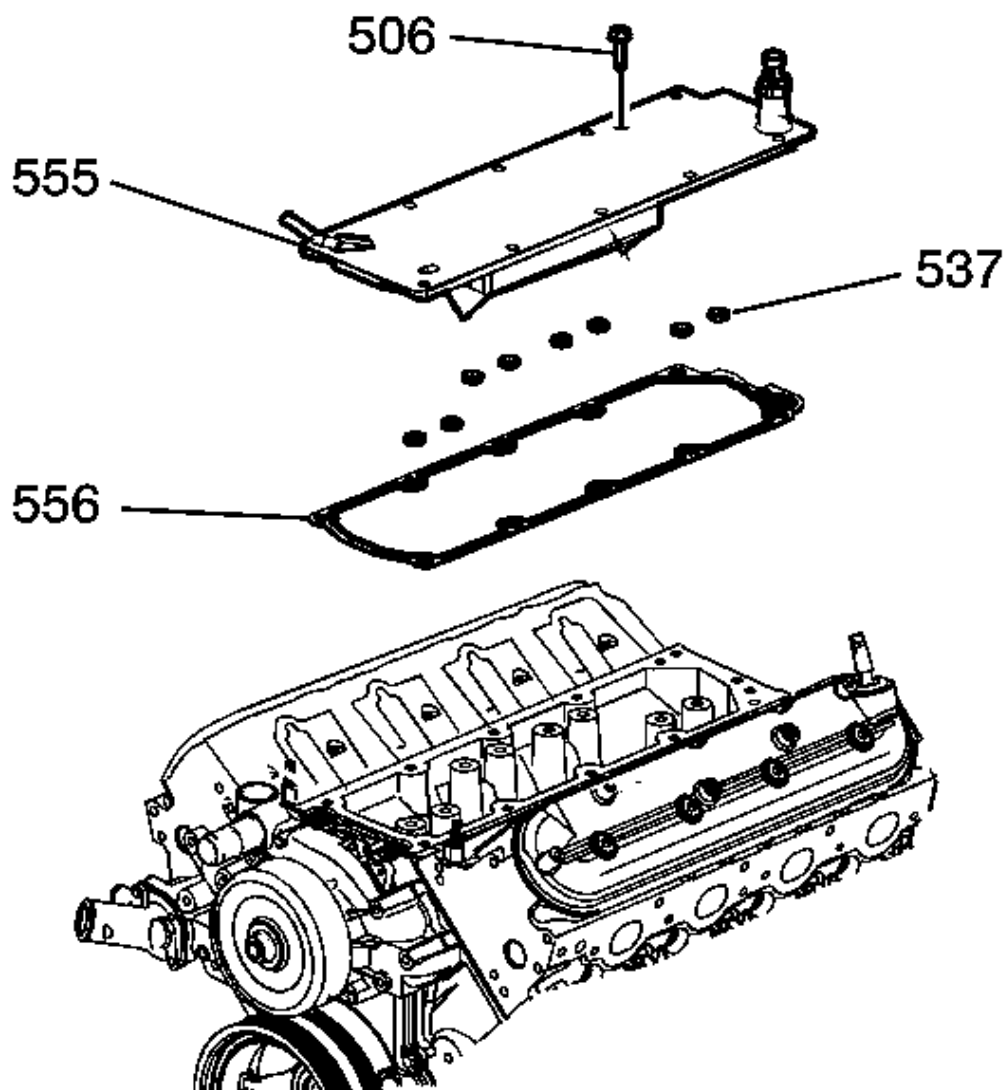


Fig. 235: Identifying Engine Valley Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the valley cover bolts (506).
2. Remove the valley cover (555) and gasket (556).
3. Remove the O-ring seals (537) as required.

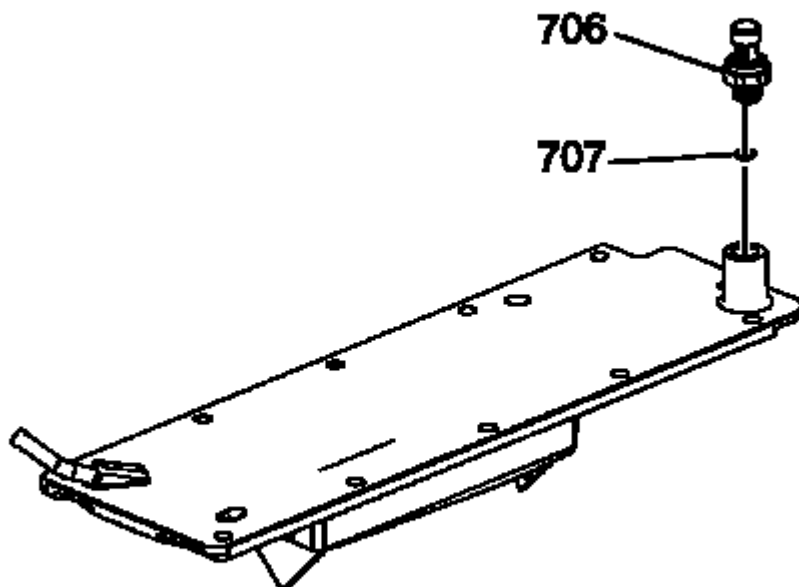


Fig. 236: Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pressure sensor (706) and washer (707) as required.

Valve Rocker Arm Cover Removal - Left

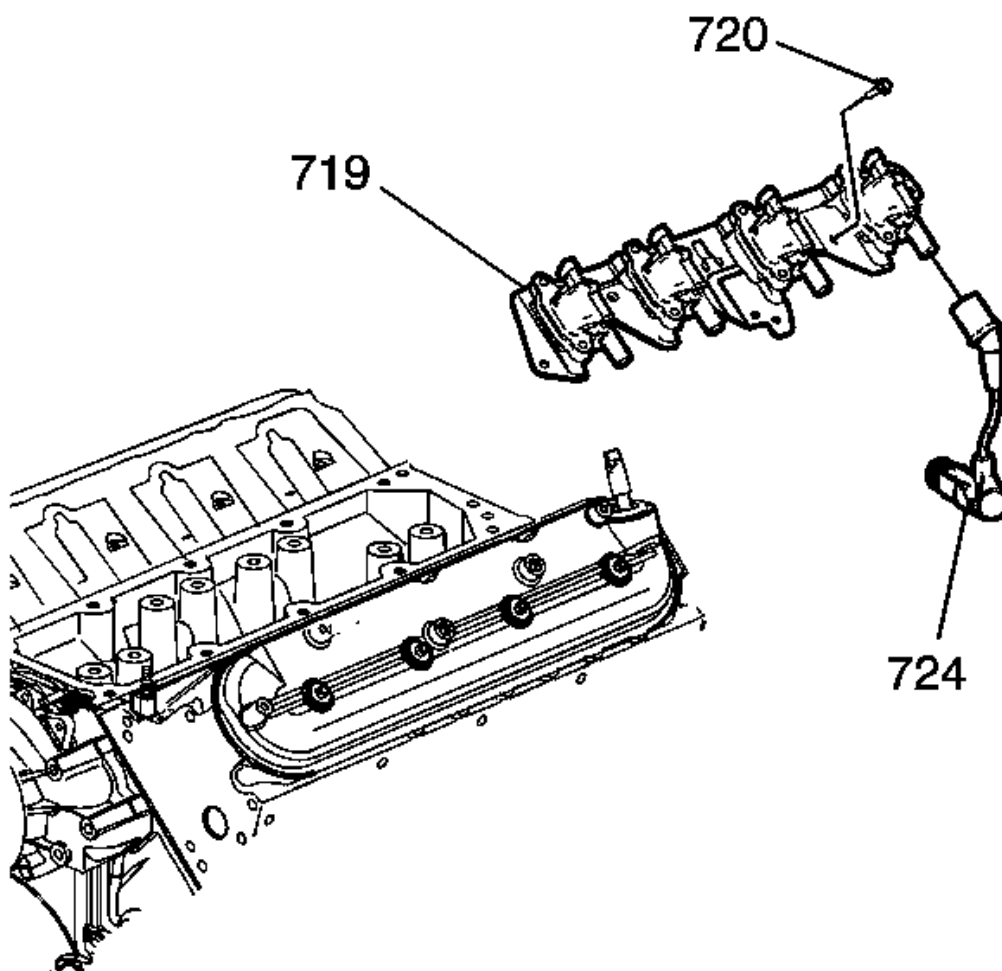


Fig. 237: Identifying Valve Rocker Arm Cover Attachments
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket bolts (720).
3. Remove the ignition coil and bracket assembly (719).

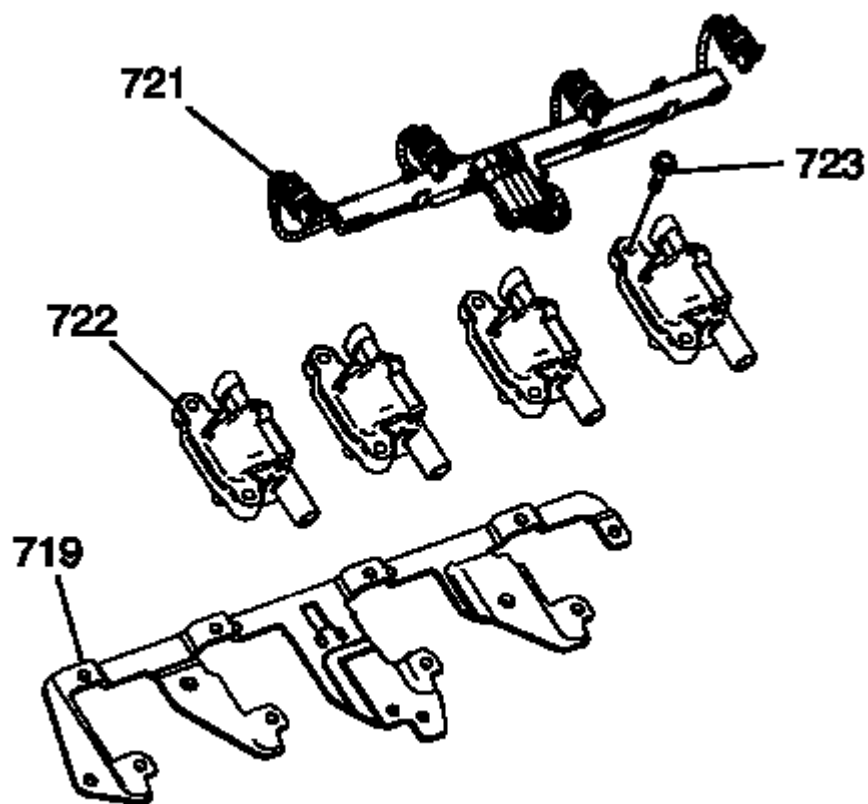


Fig. 238: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket as required.

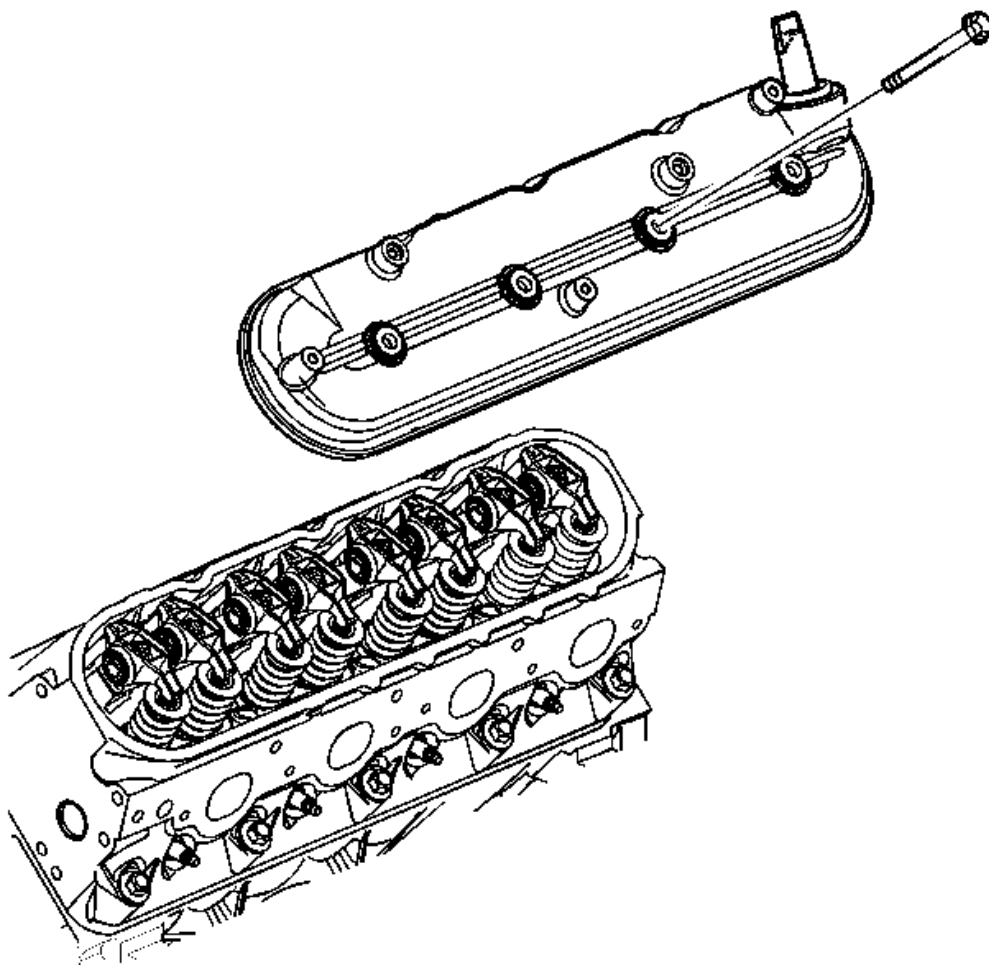


Fig. 239: Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

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

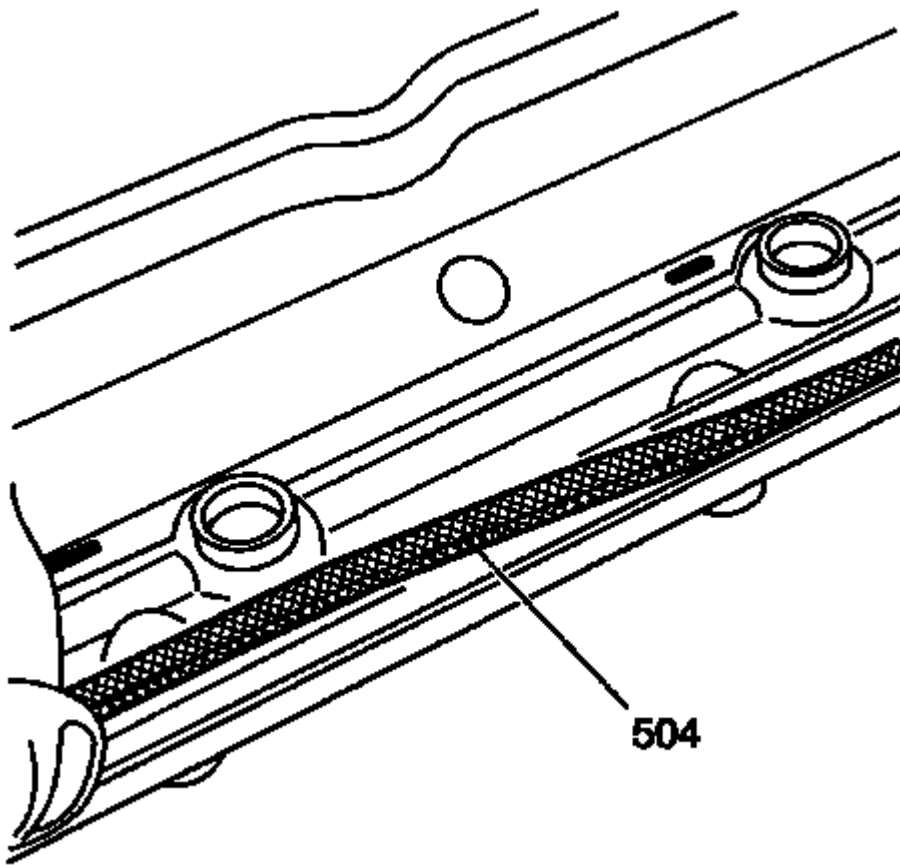


Fig. 240: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

Valve Rocker Arm Cover Removal - Right

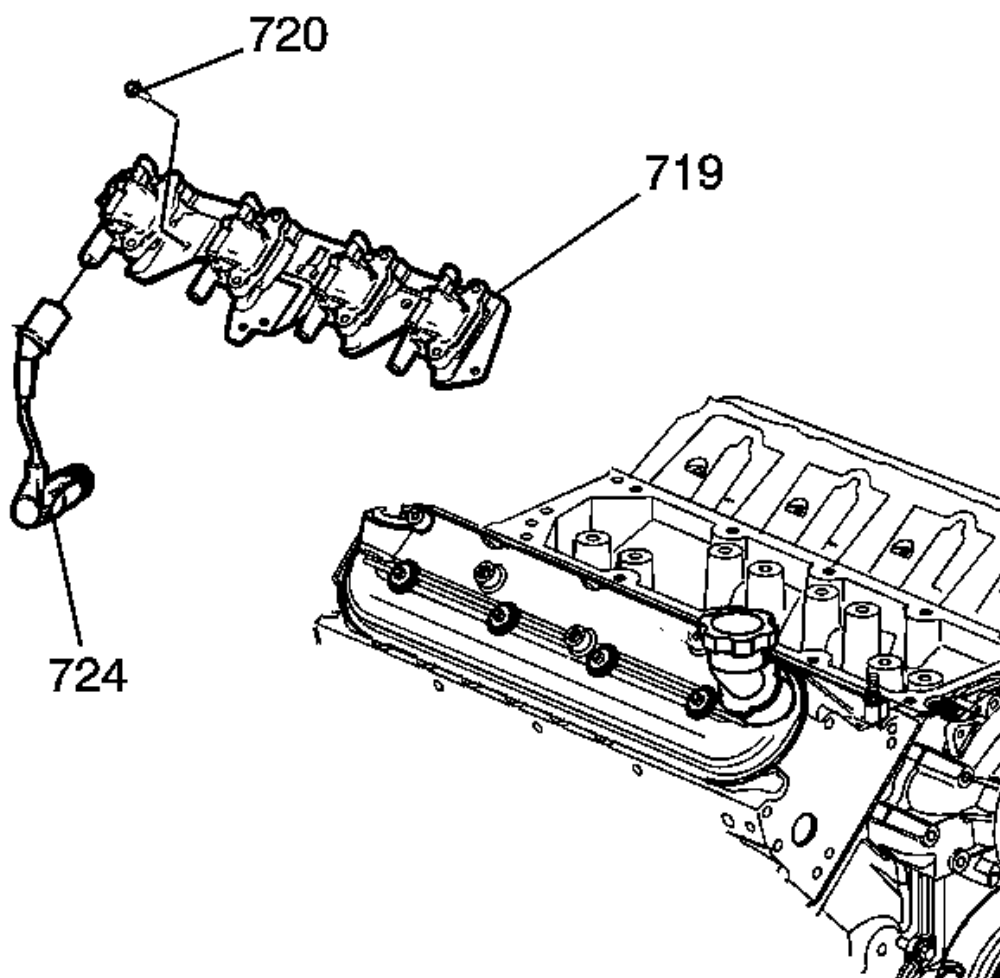


Fig. 241: Identifying Right Valve Rocker Arm Cover Attachments
Courtesy of GENERAL MOTORS CORP.

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.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket bolts (720).
3. Remove the ignition coil and bracket assembly (719).

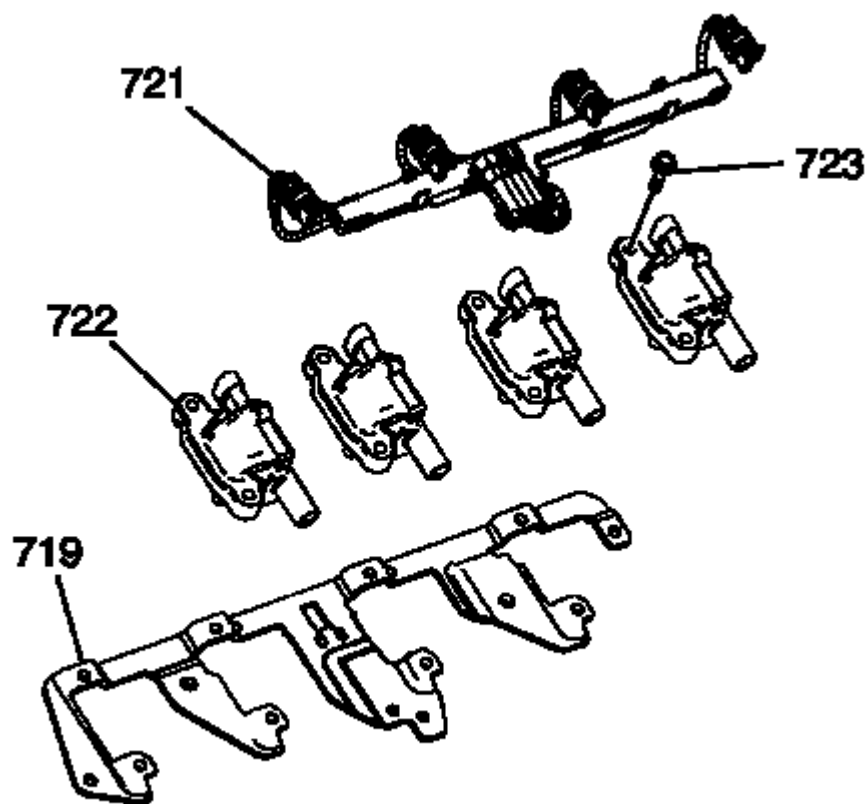


Fig. 242: View Of Bracket, Bolts, Coils & Wire Harness
 Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket as required.

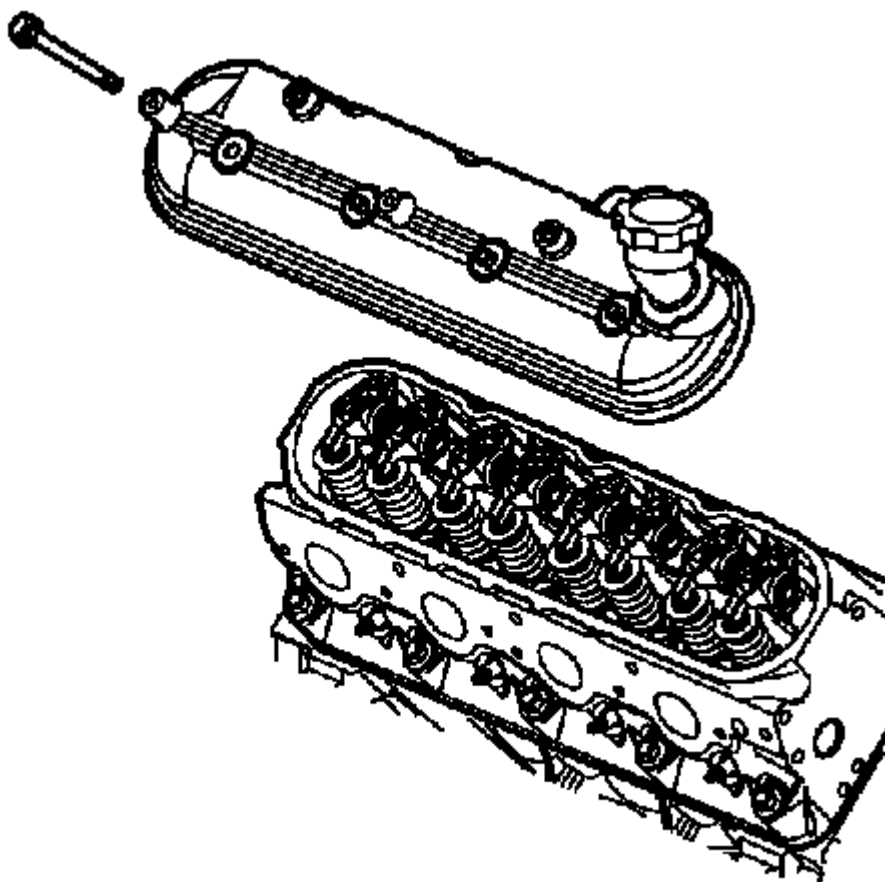


Fig. 243: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

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

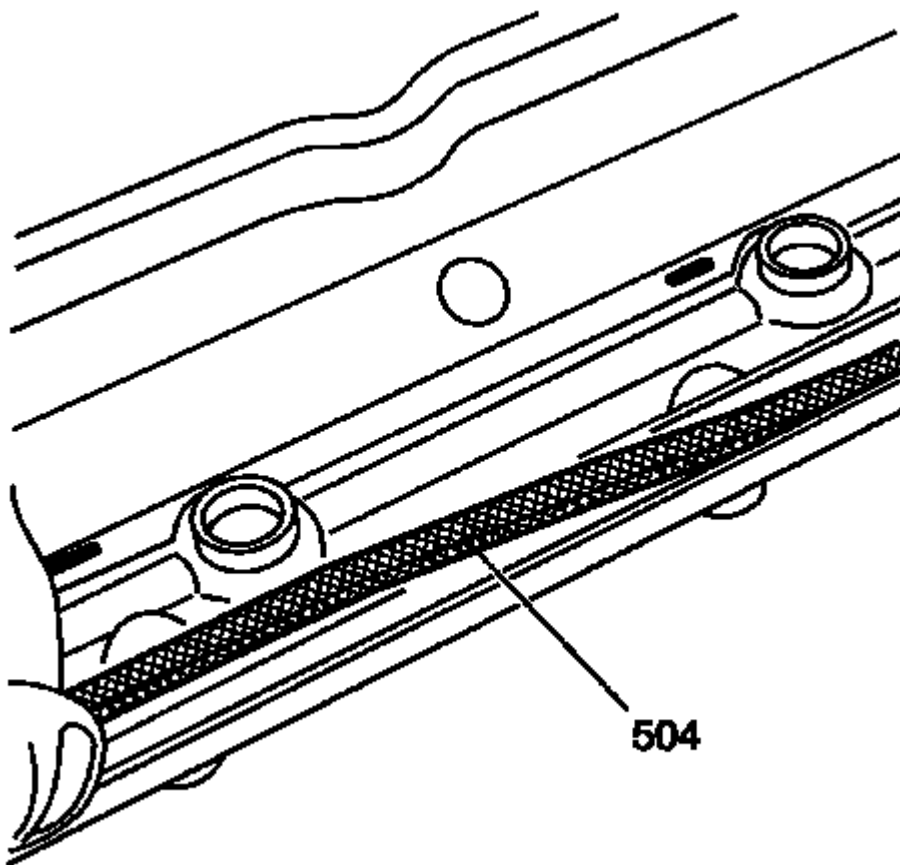


Fig. 244: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

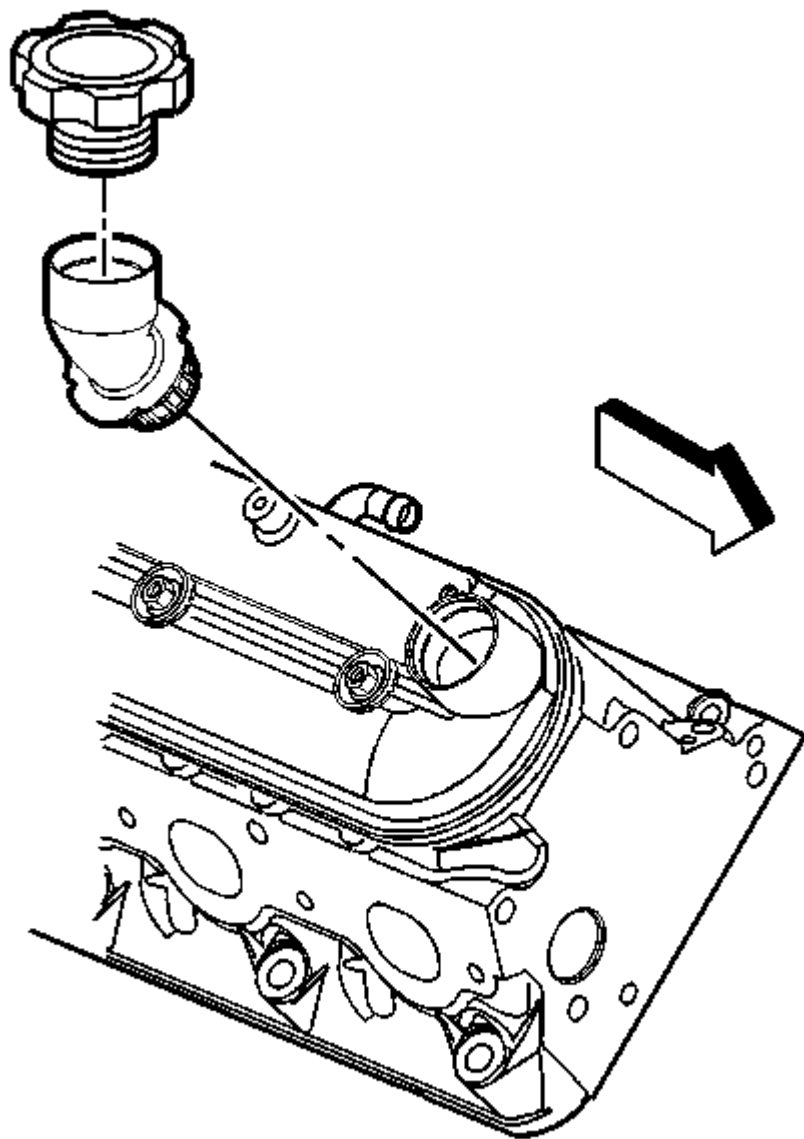


Fig. 245: View Of Oil Fill Cap & Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil fill cap from the oil fill tube.
9. Remove the oil fill tube as required.
10. Discard the oil fill tube.

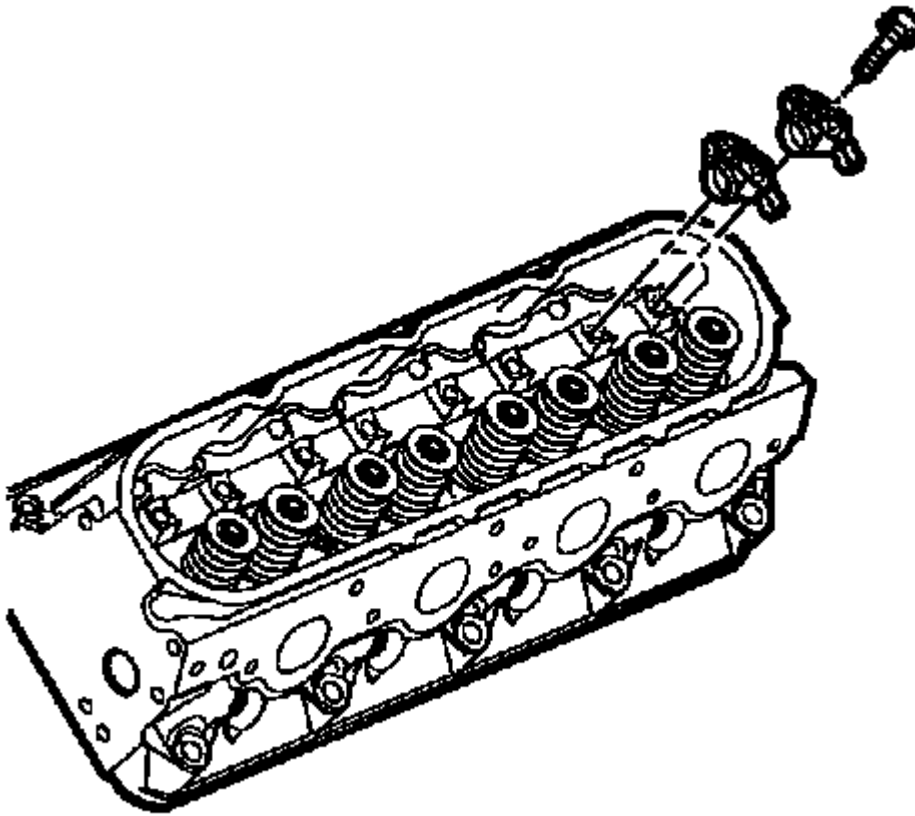
Valve Rocker Arm and Push Rod Removal

Fig. 246: 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.

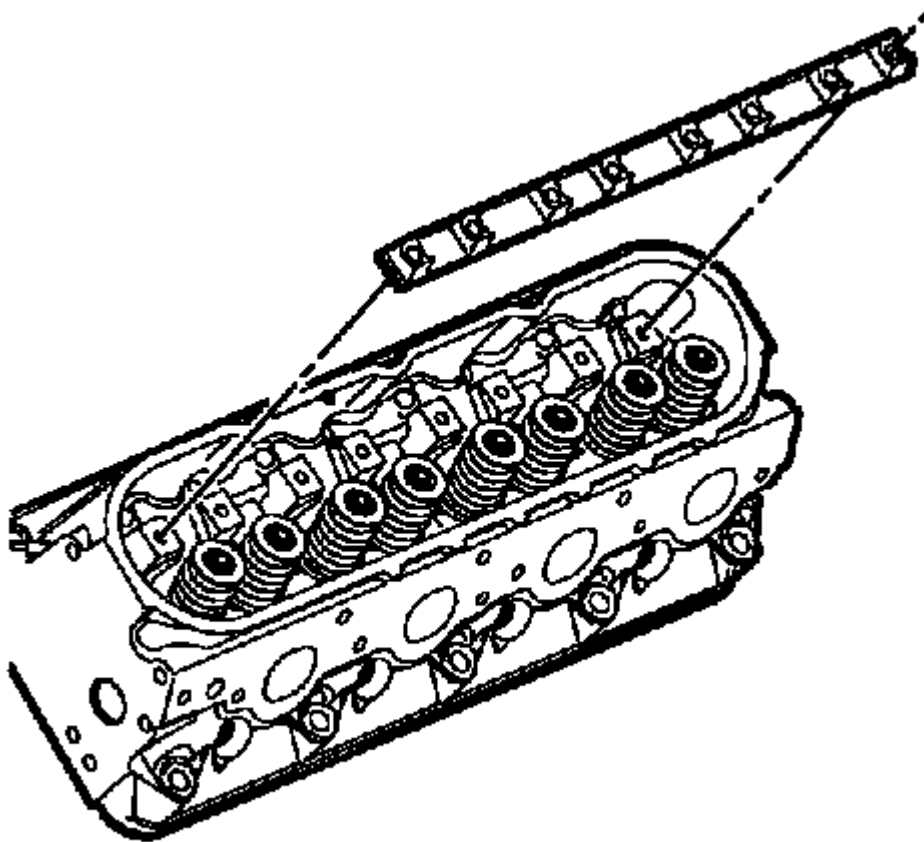


Fig. 247: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

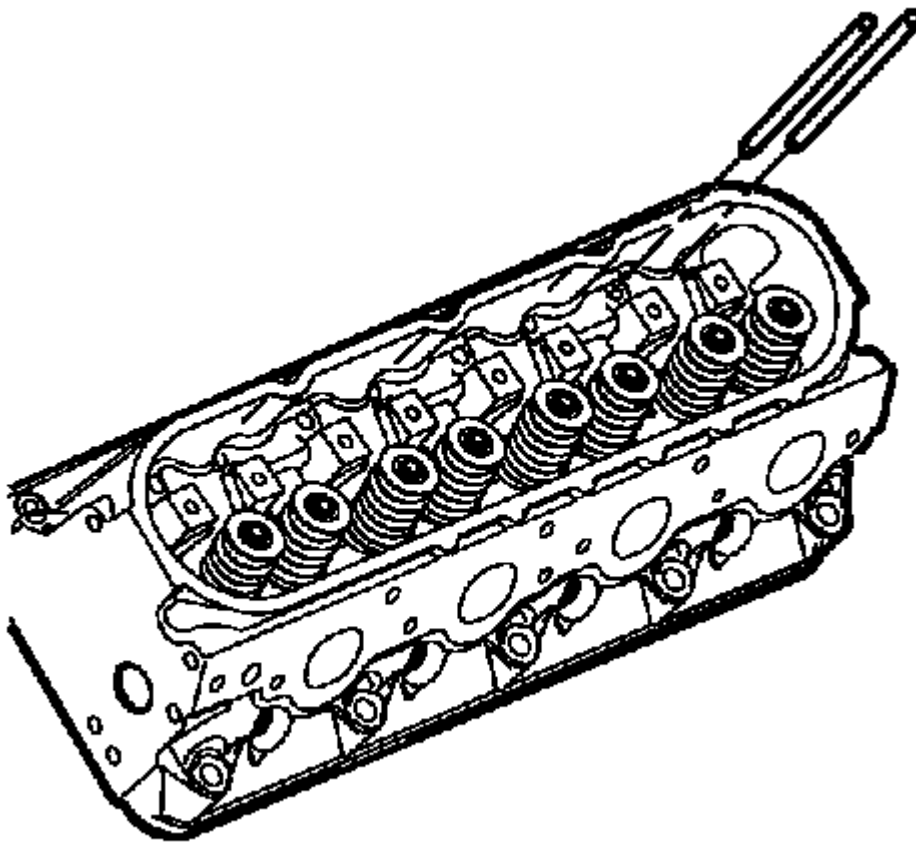


Fig. 248: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

Cylinder Head Removal - Left

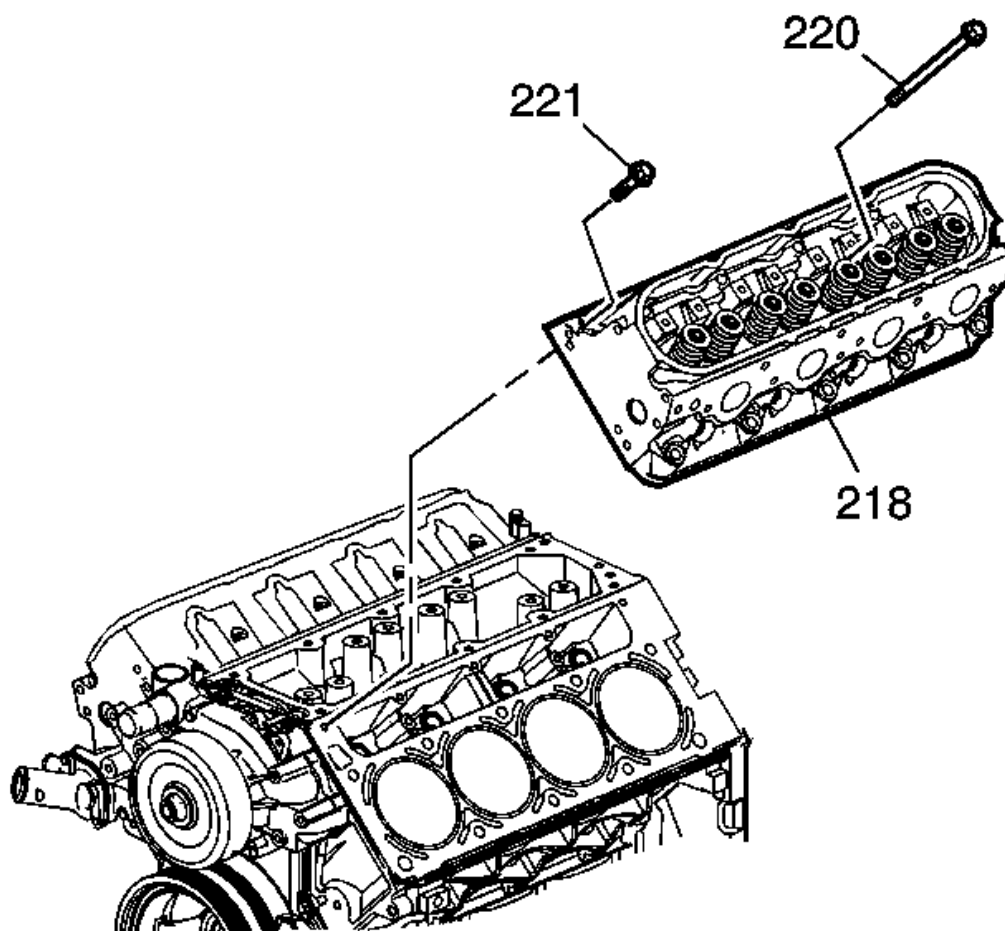


Fig. 249: Removing/Installing Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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 M8 and M11 cylinder head bolts (220 and 221).

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

2. Remove the cylinder head (218).

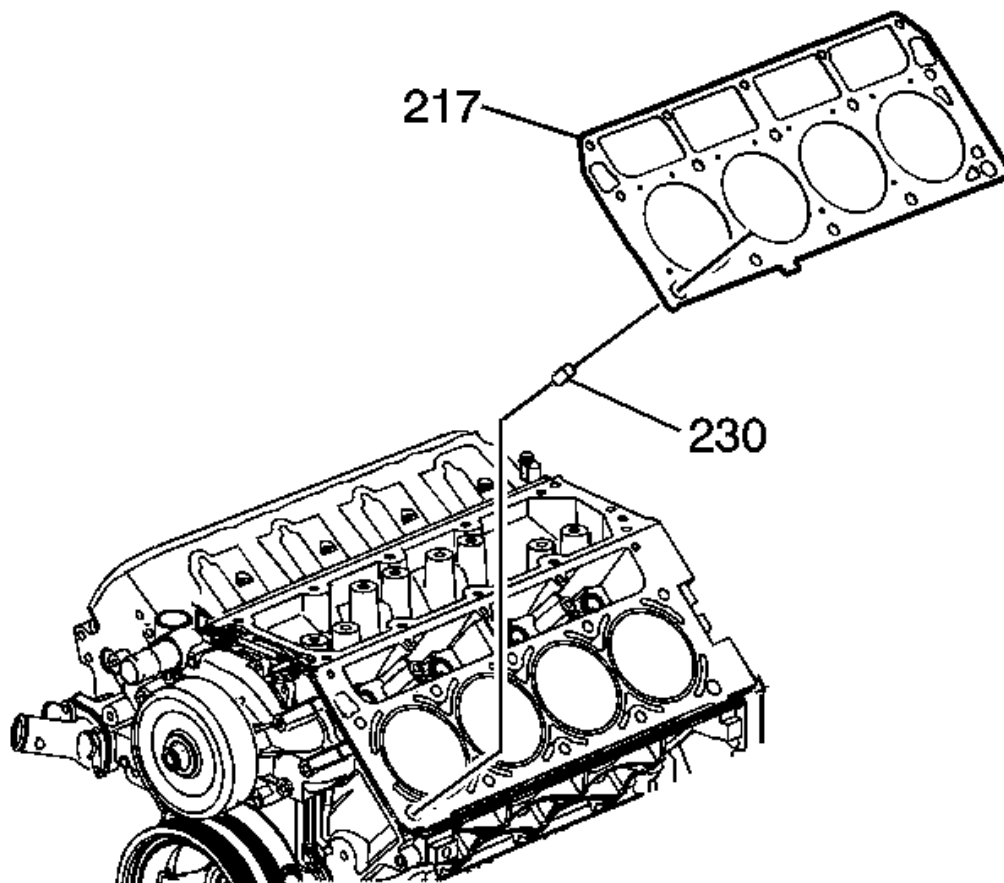


Fig. 250: Removing/Installing Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

Cylinder Head Removal - Right

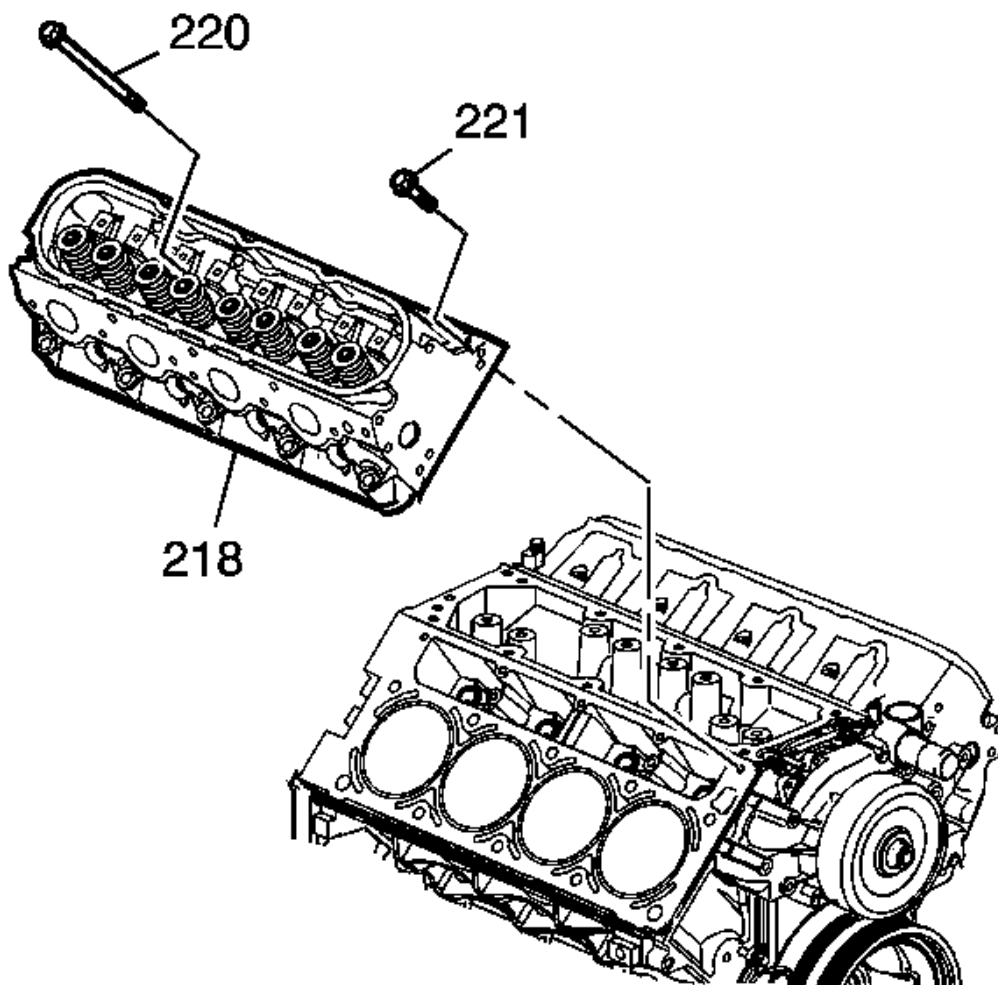


Fig. 251: Removing/Installing Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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 and 221).

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

2. Remove the cylinder head (218).

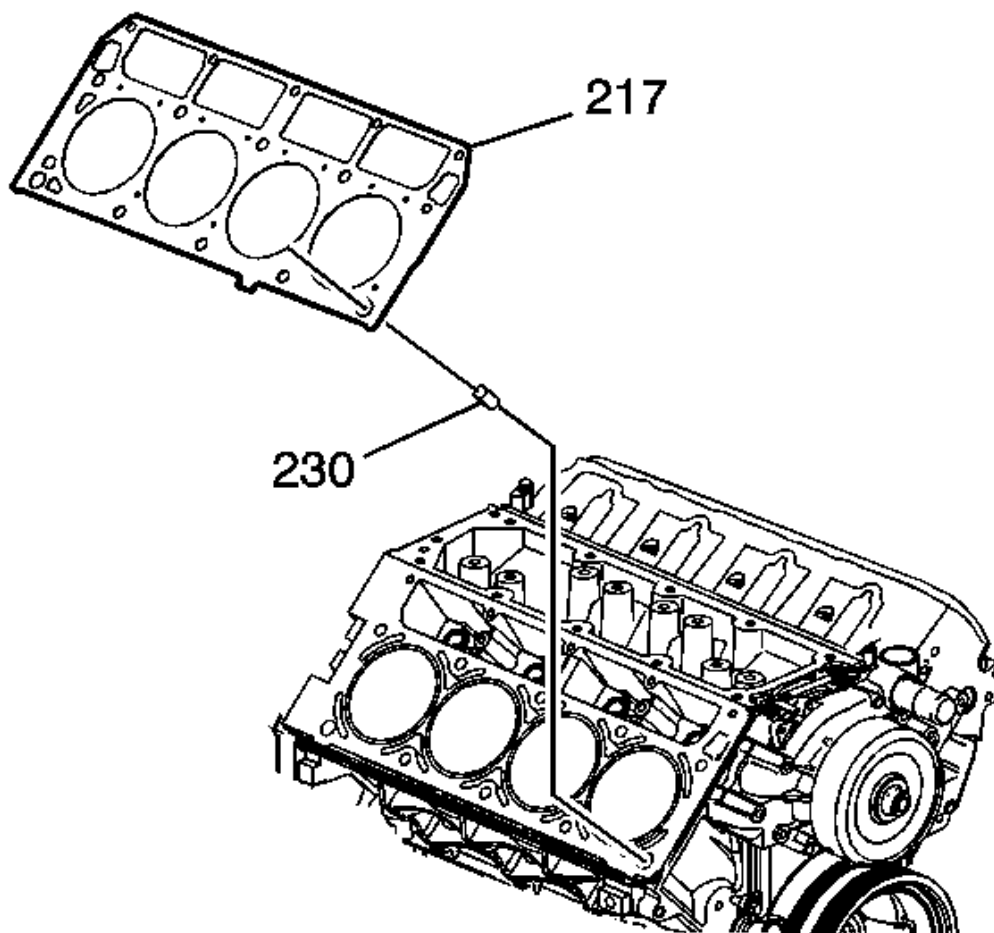


Fig. 252: Removing/Installing Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

Valve Lifter Removal

Tools Required

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

Removal Procedure

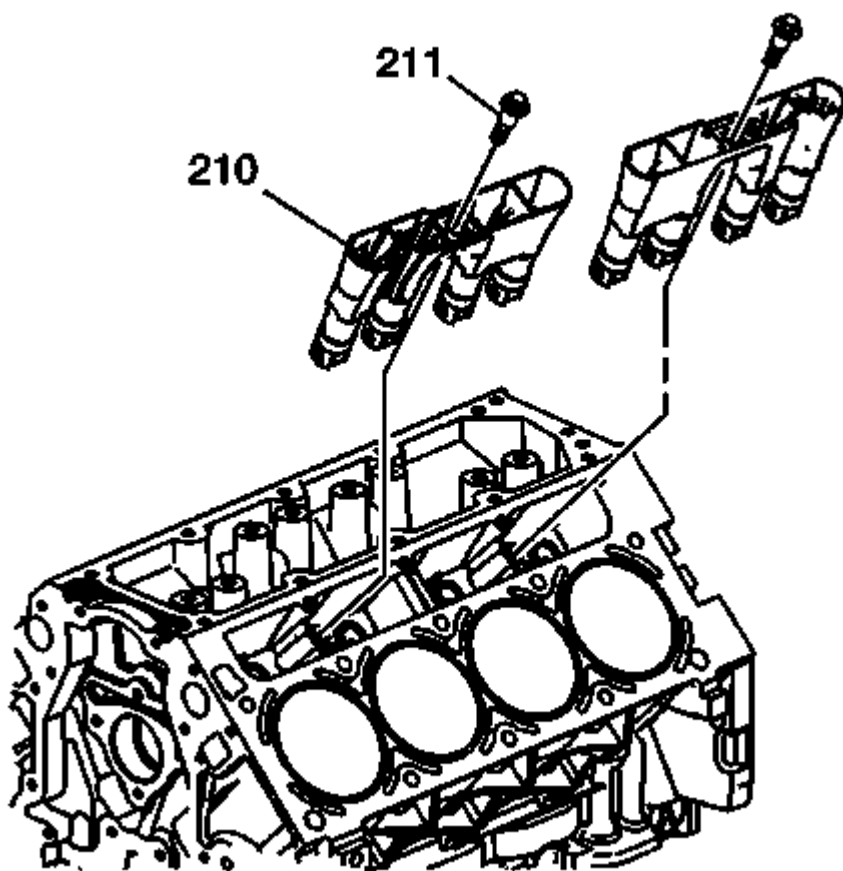


Fig. 253: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the guide 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 on the block.

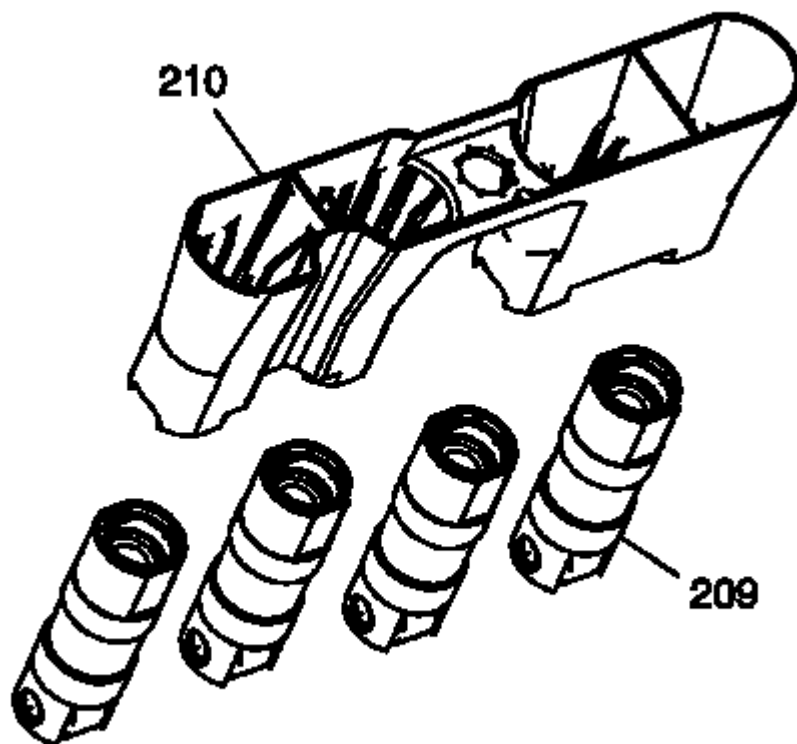


Fig. 254: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifters (209) from the guide (210).
4. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to **Separating Parts**.

Oil Filter, Adapter and Pan Cover Removal

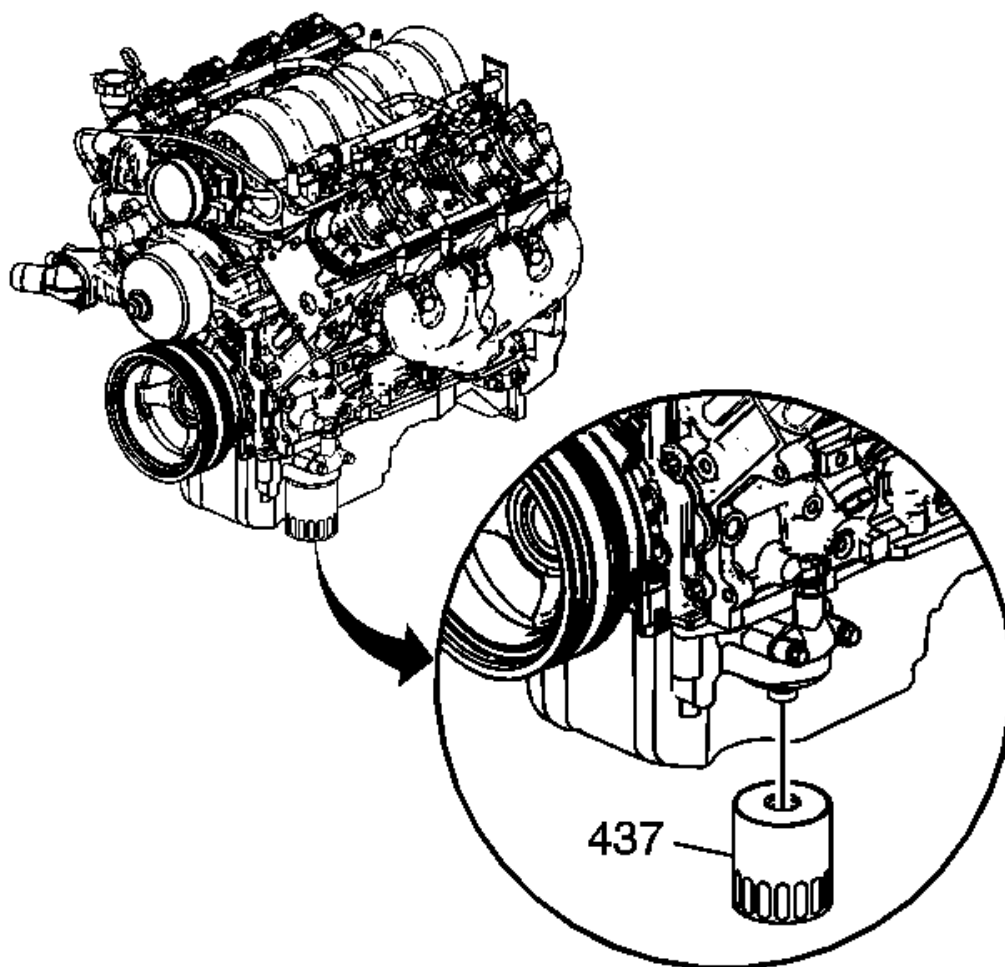


Fig. 255: Locating Oil Filter

Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (437).

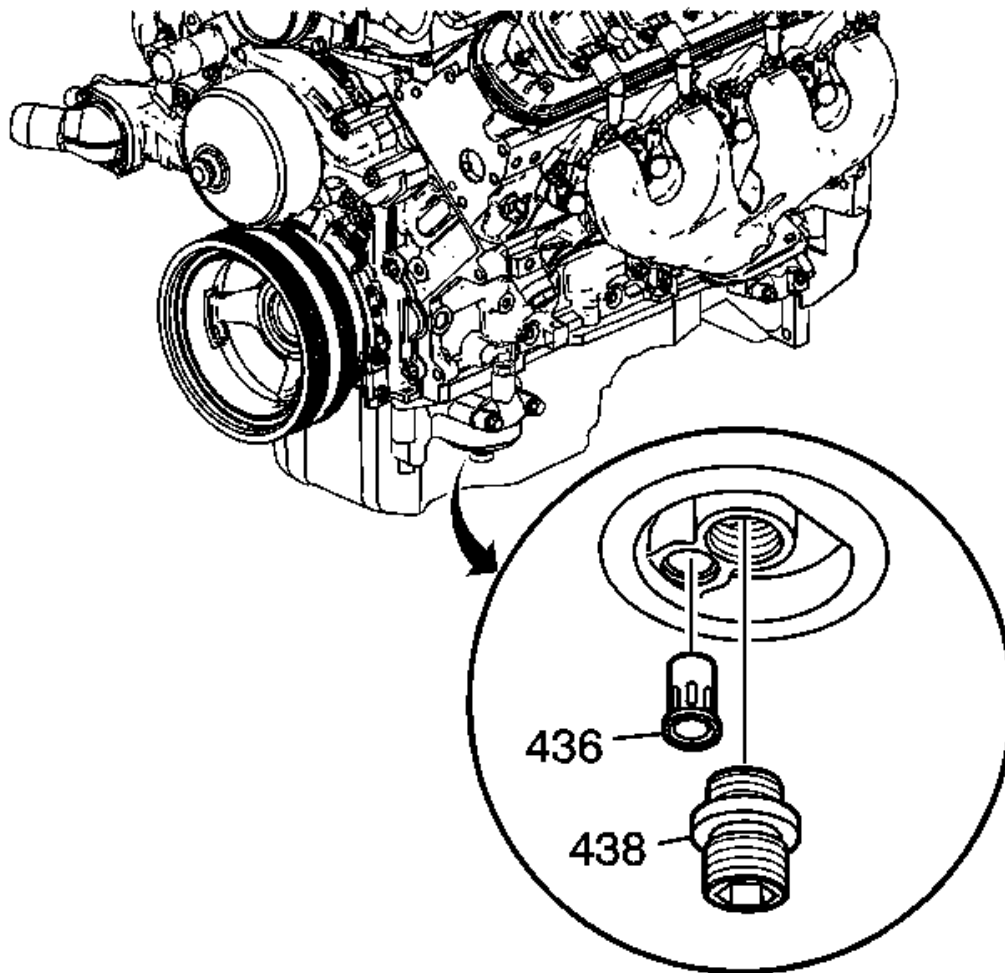


Fig. 256: Identifying Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting (438) and bypass valve (436) as required.

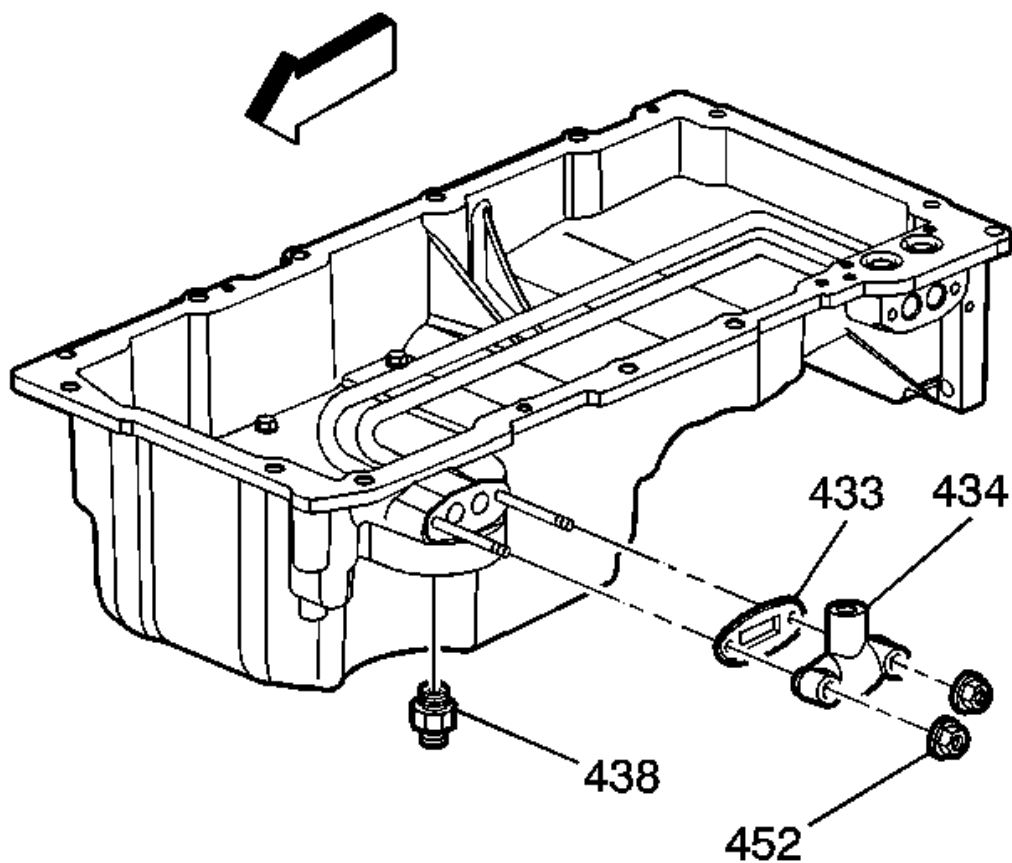


Fig. 257: View Of Oil Pan Cover, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the nuts (452), cover (434), and gasket (433).

Oil Pan Removal

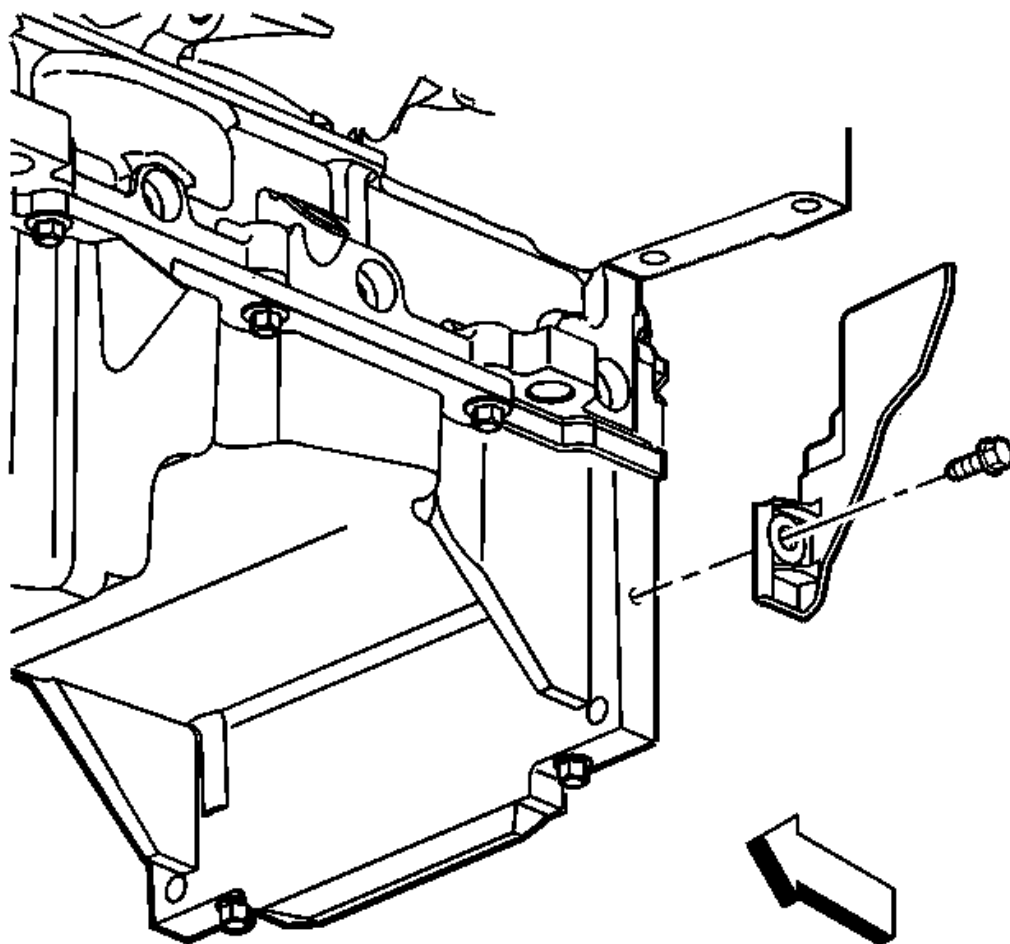


Fig. 258: View Of Left Closeout Cover & Bolt

Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing 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.

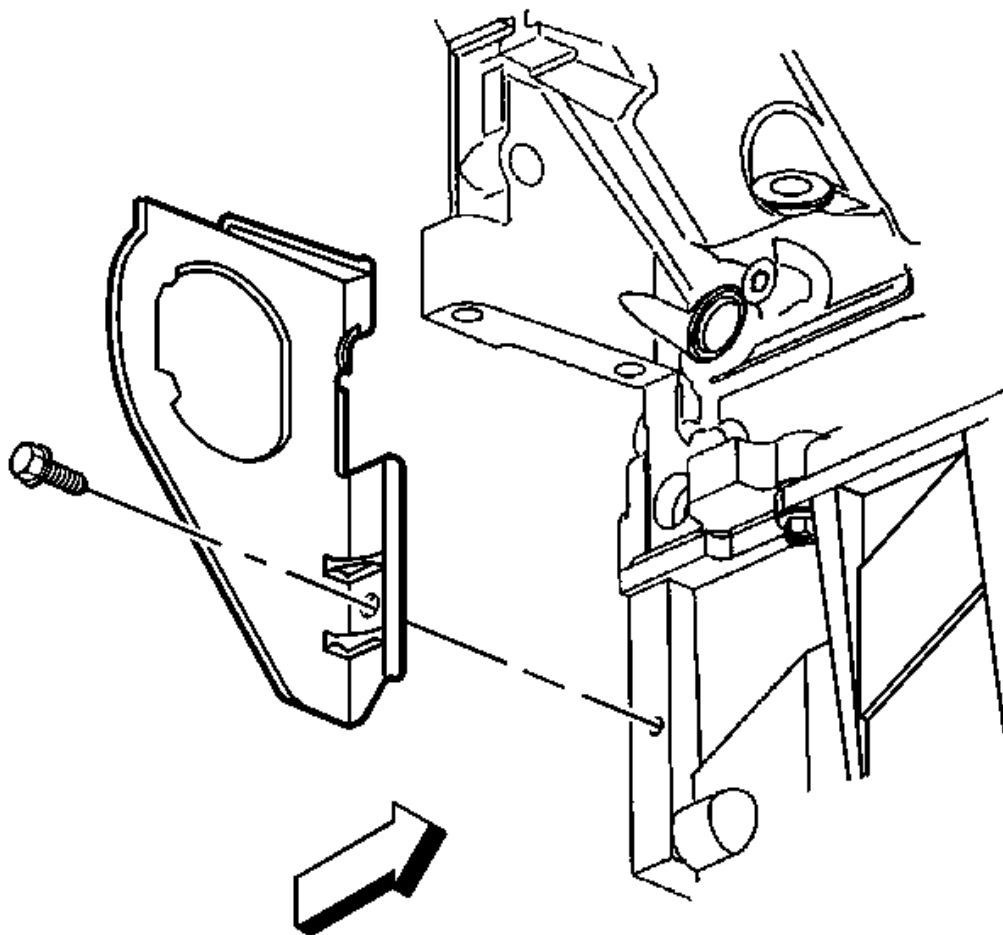


Fig. 259: View Of Right Transmission Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the right closeout cover and bolt.

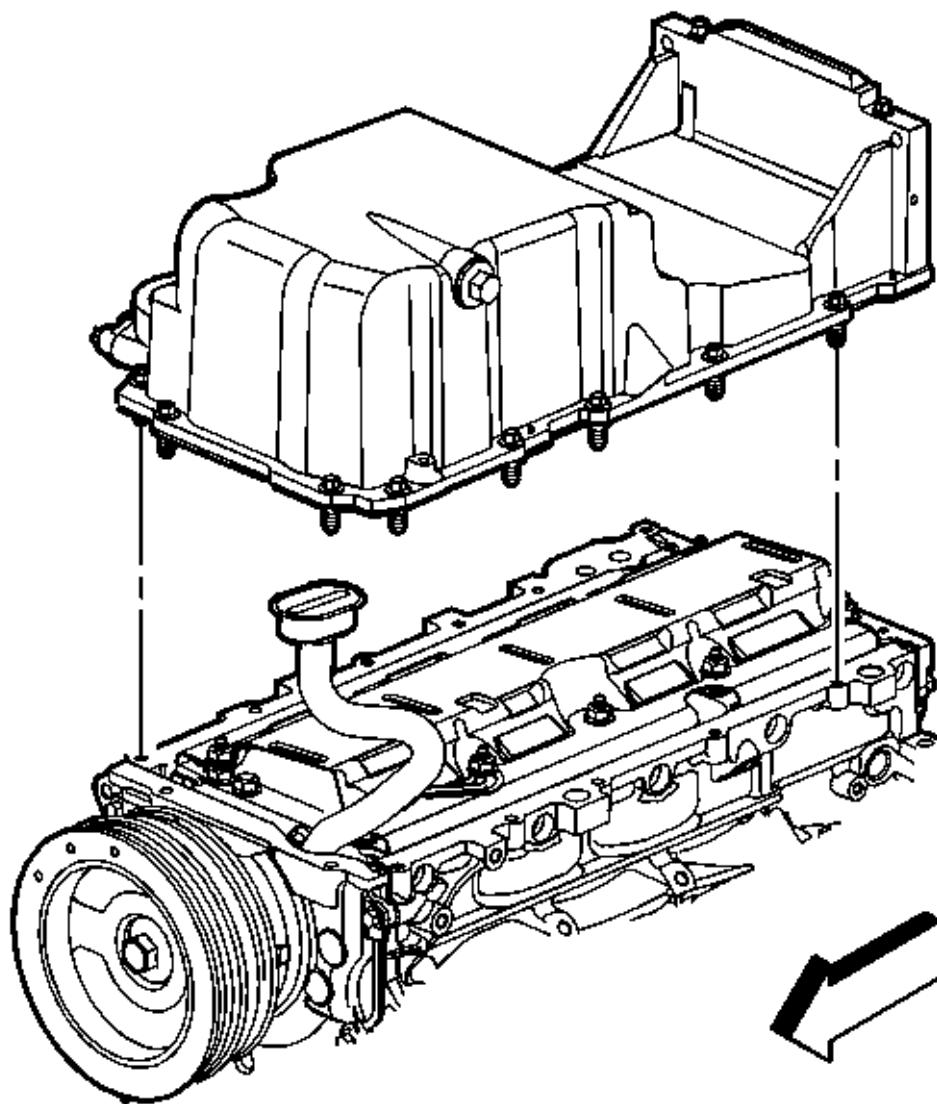


Fig. 260: View Of Rear Engine Cover
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan bolts.
4. Remove the oil pan.

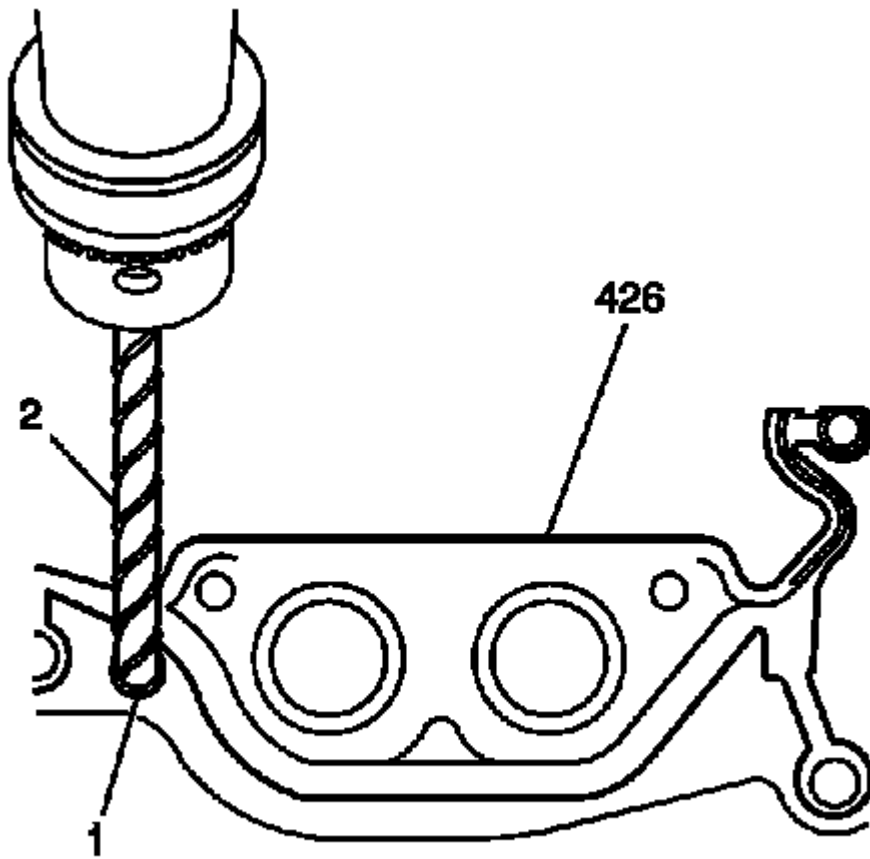


Fig. 261: Drilling Out Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

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 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 transfer tube, baffle and other internal components as required. Refer to **Oil Pan Cleaning and Inspection**.

Engine Front Cover Removal

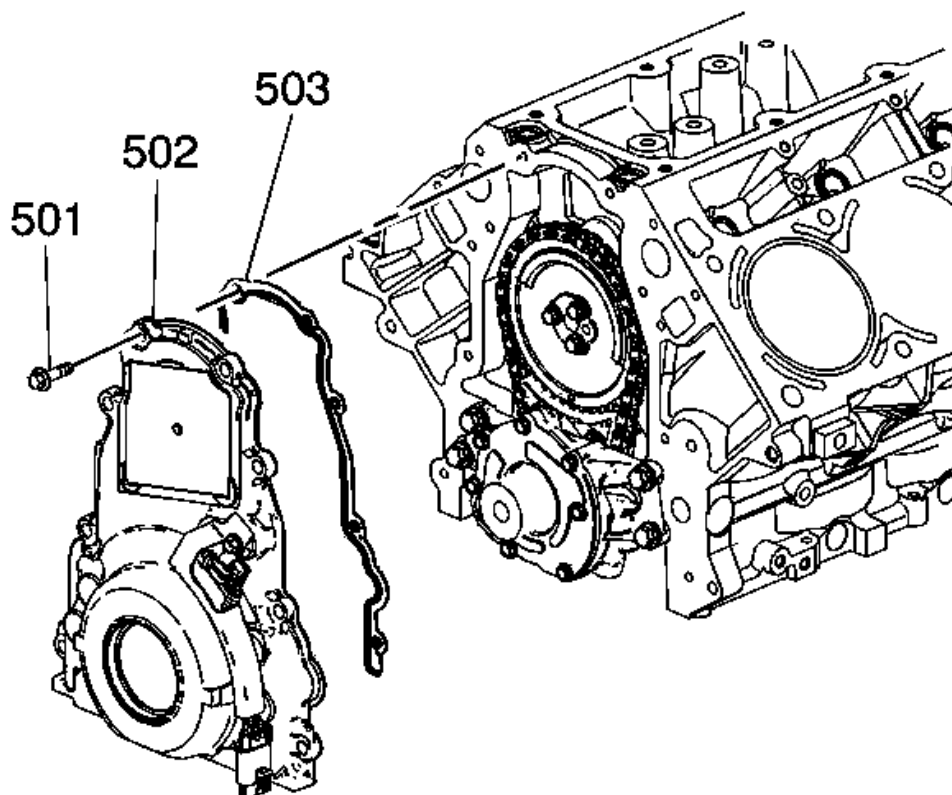


Fig. 262: Engine Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the front cover bolts (501).
2. Remove the front cover (502) and gasket (503).
3. Discard the front cover gasket.

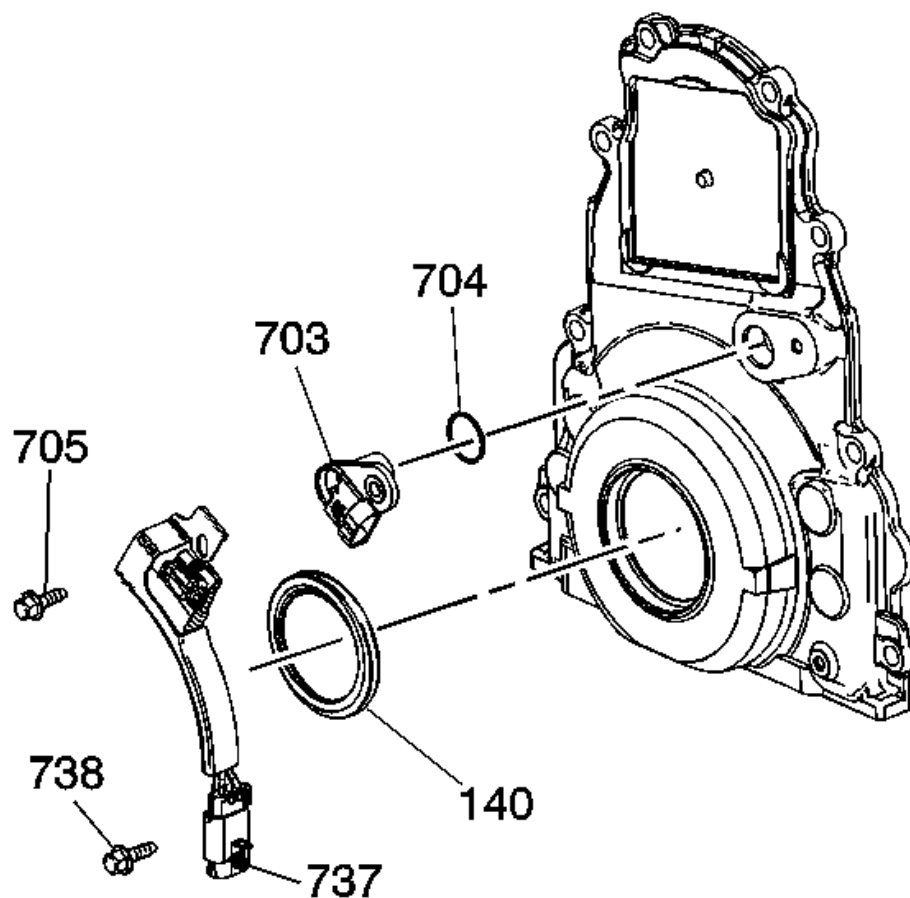


Fig. 263: Engine Front Cover, Camshaft Position Sensor, Oil Seal, Wire Harness, O-Ring & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil seal (140).
5. Remove the bolts (705, 738), camshaft position (CMP) sensor (703), and wire harness (737).
6. Remove the O-ring (704) from the sensor as required.

Engine Rear Cover Removal

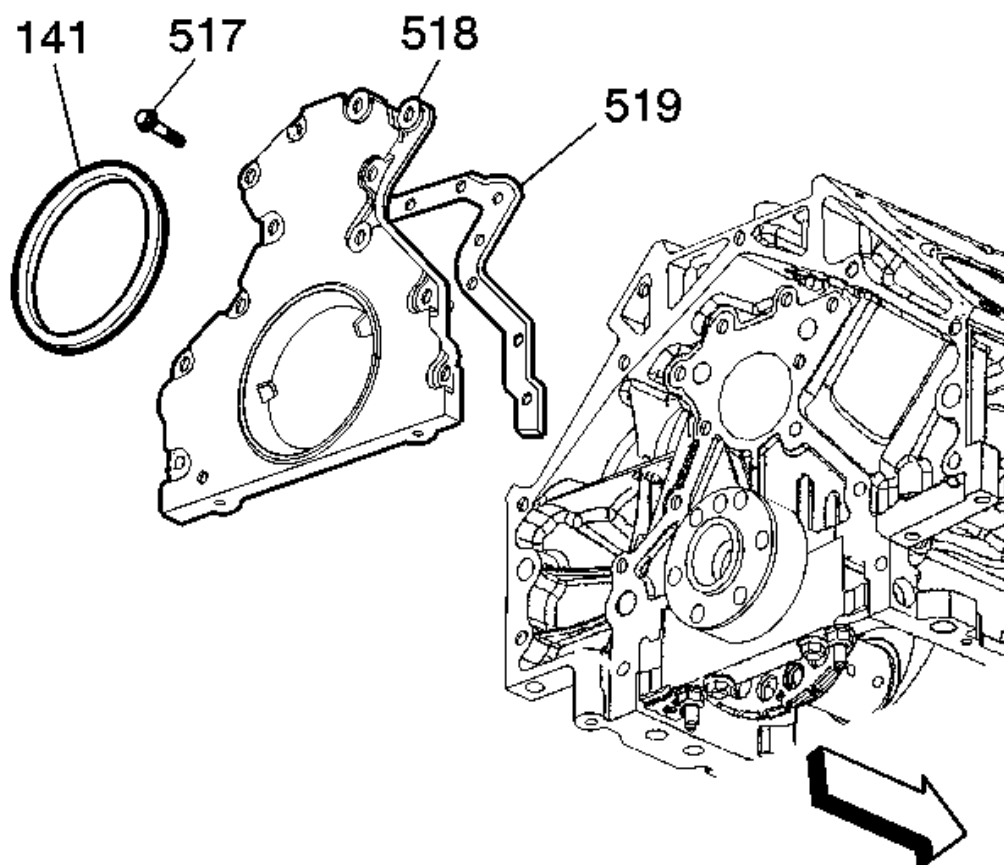


Fig. 264: Exploded View Of Engine Rear Cover
 Courtesy of GENERAL MOTORS CORP.

1. Remove the rear cover bolts (517).
2. Remove the rear cover (518) and gasket (519).
3. Discard the rear cover gasket.
4. Remove the rear oil seal (141).

Oil Pump, Pump Screen and Deflector Removal

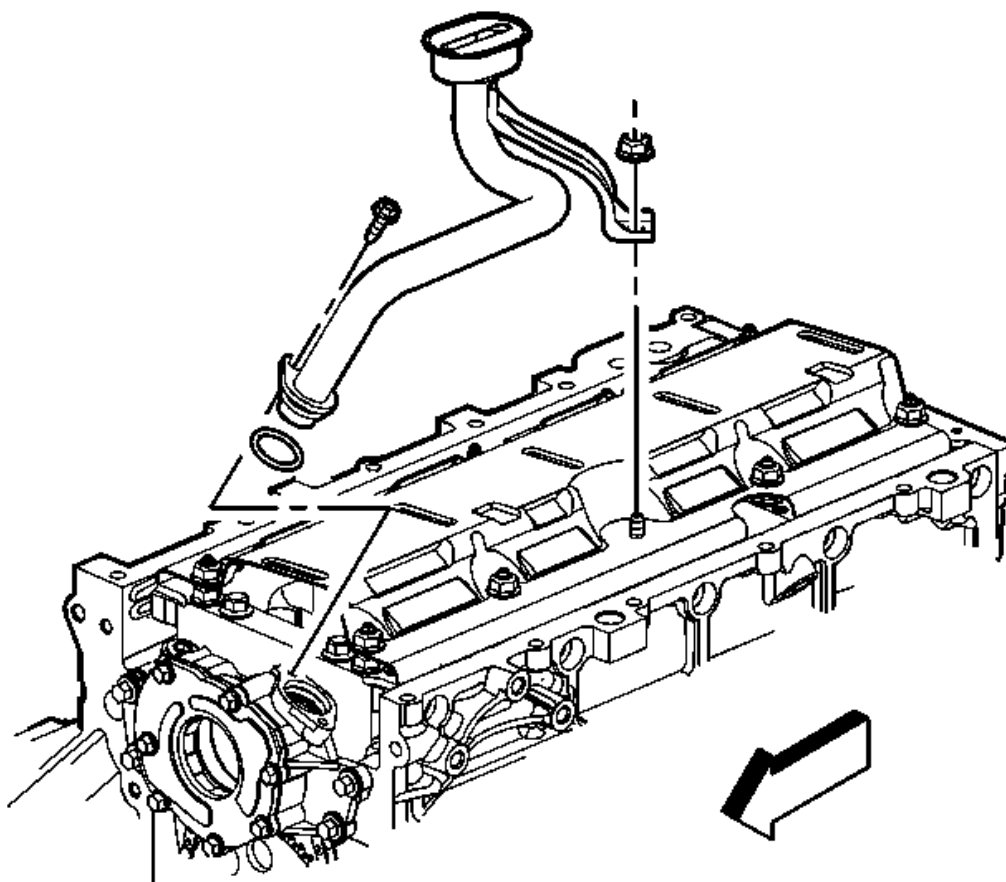


Fig. 265: View Of Oil Pump Screen, Bolt & Nuts
Courtesy of GENERAL MOTORS CORP.

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.

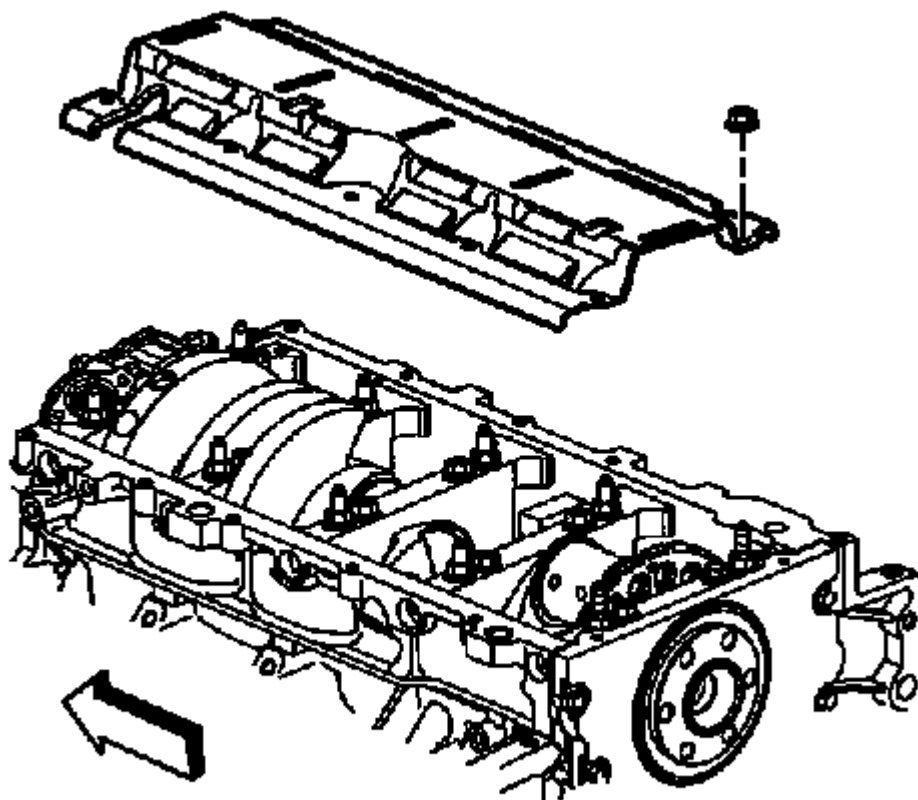


Fig. 266: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

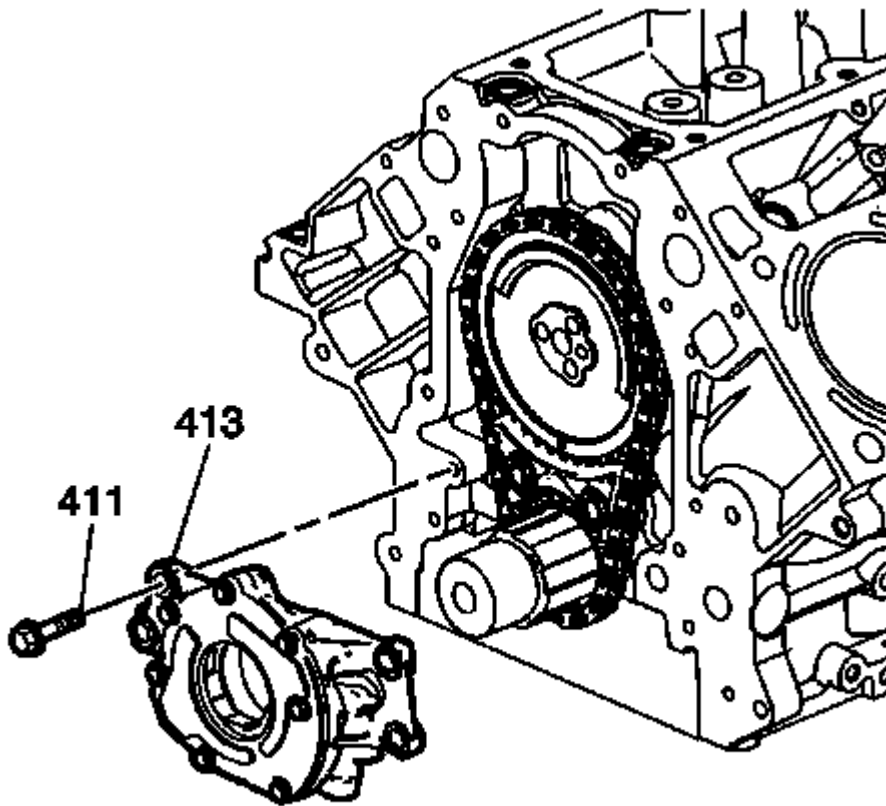


Fig. 267: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

- **J 8433-1** Puller Bar. See Special Tools.
- **J 41558** Crankshaft Sprocket Remover. See Special Tools.
- **J 41816-2** Crankshaft End Protector. See Special Tools.

Removal Procedure

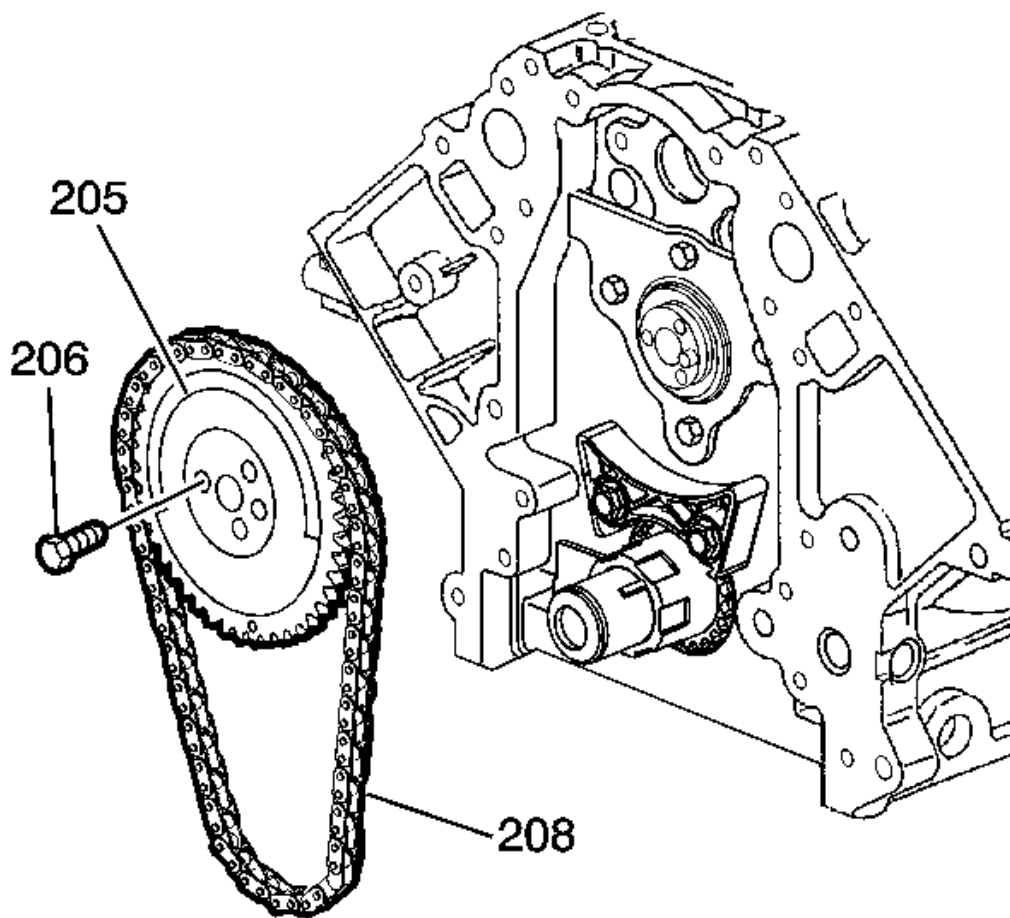


Fig. 268: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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 camshaft sprocket bolts (206).
2. Remove the camshaft sprocket (205) and timing chain (208).

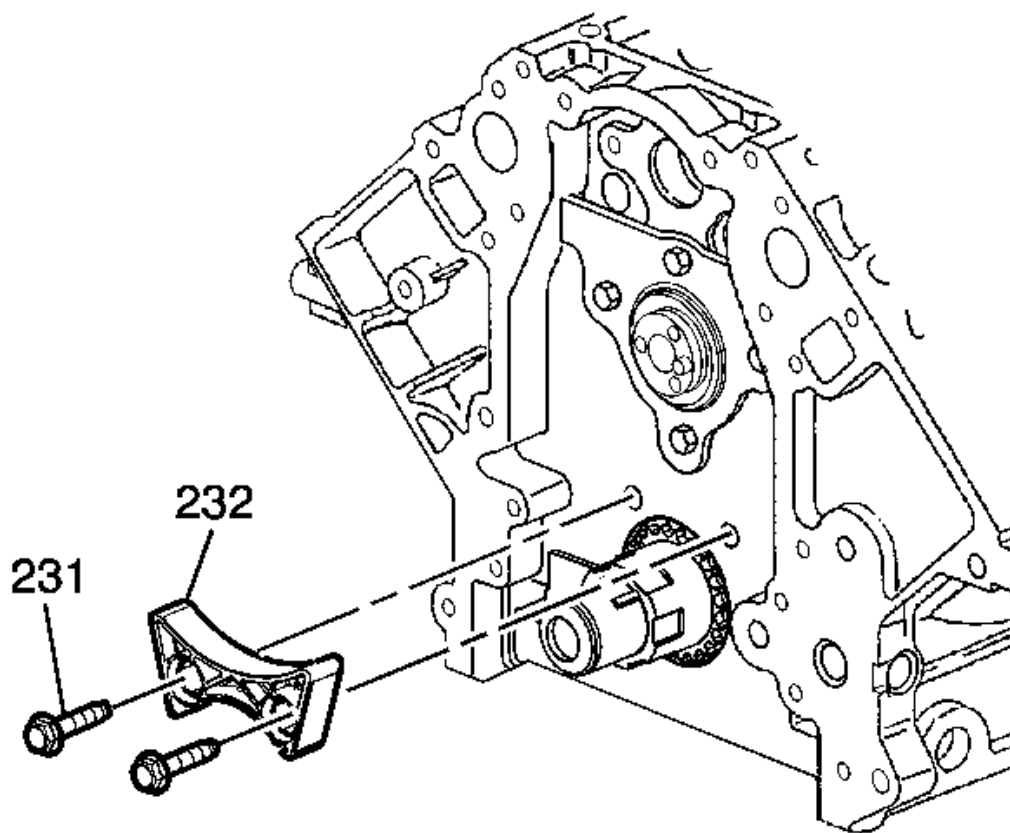


Fig. 269: Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts (231) and chain dampener (232).

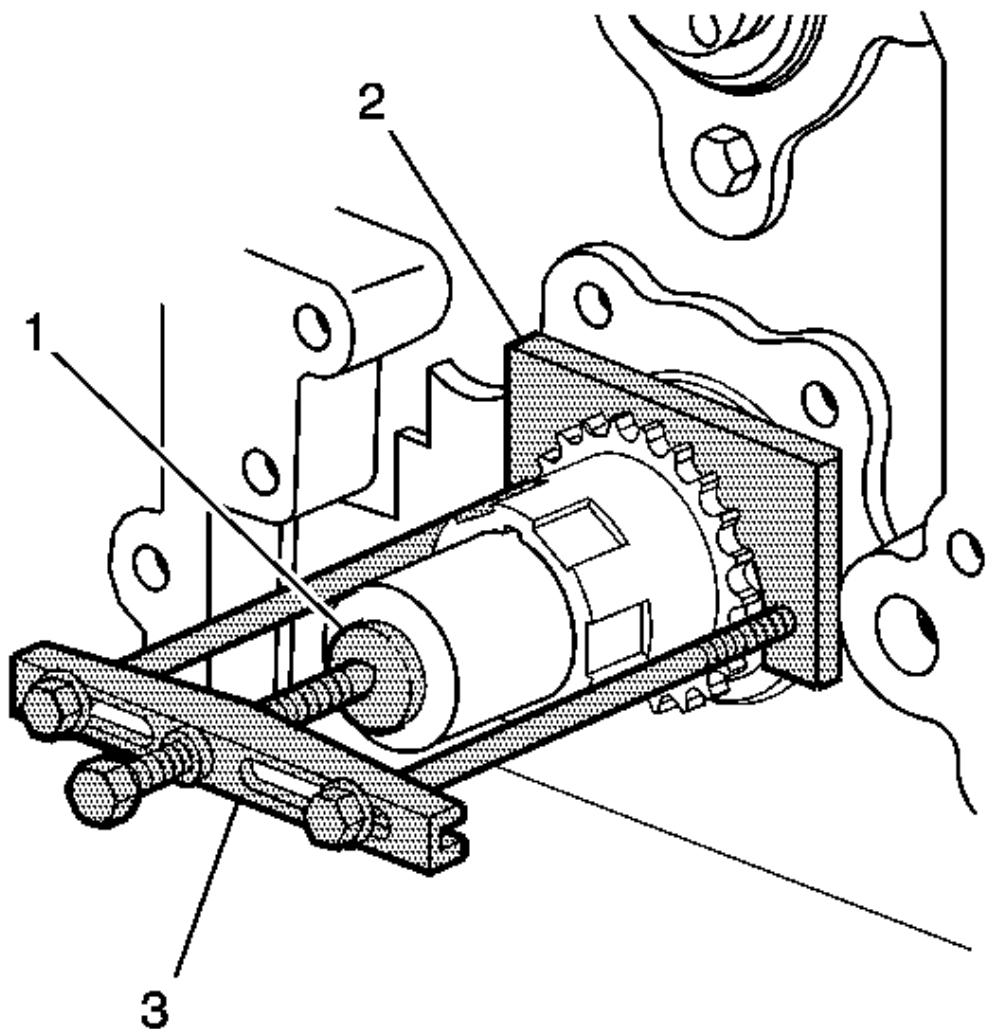


Fig. 270: Removing Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

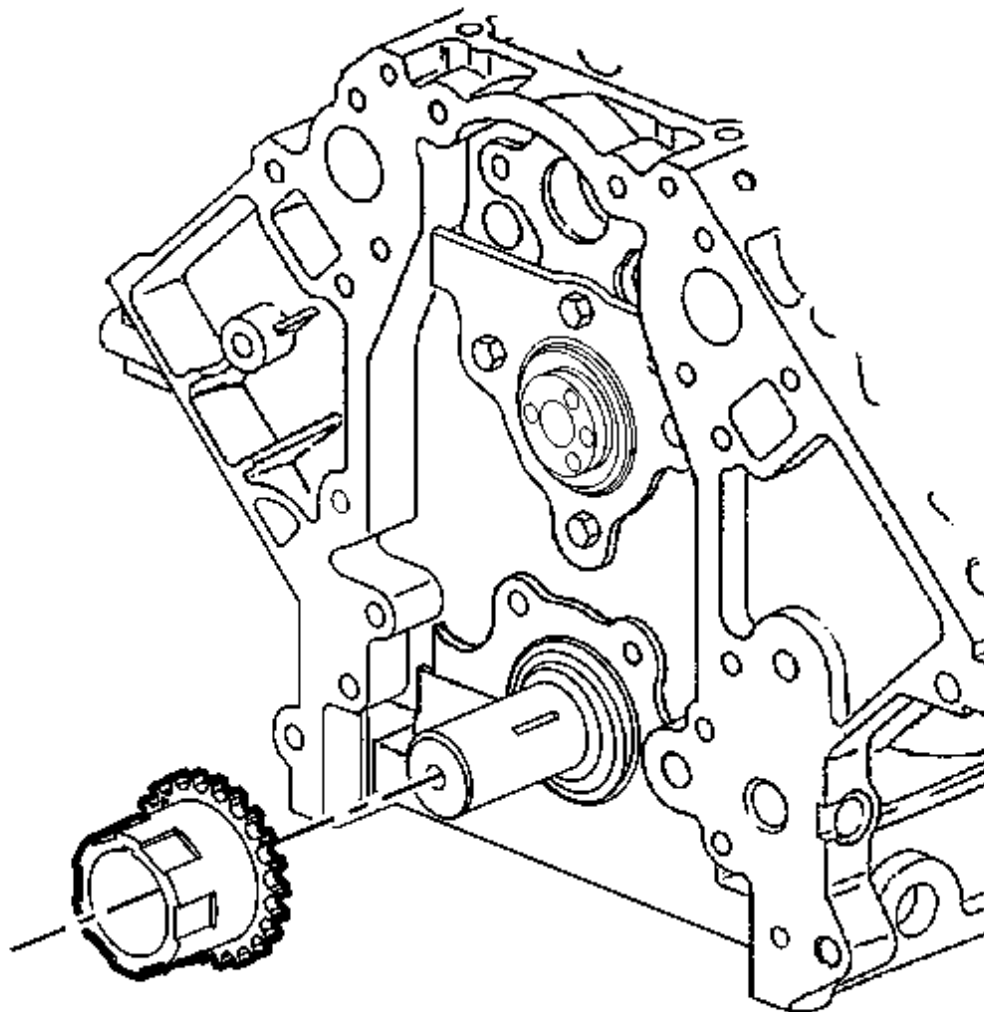


Fig. 271: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket.

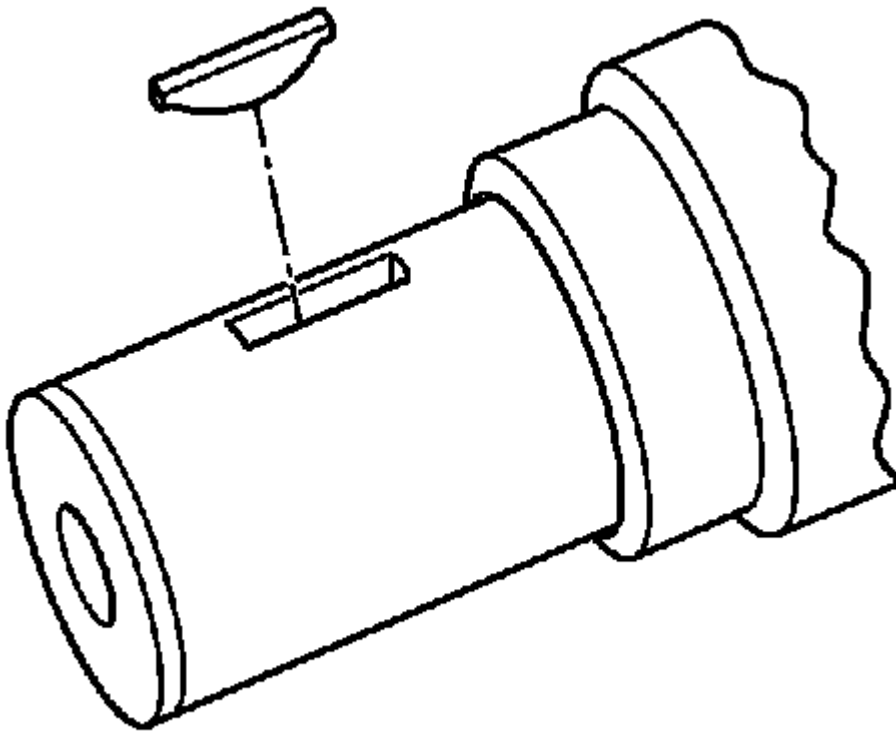


Fig. 272: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket key as required.

Camshaft Removal

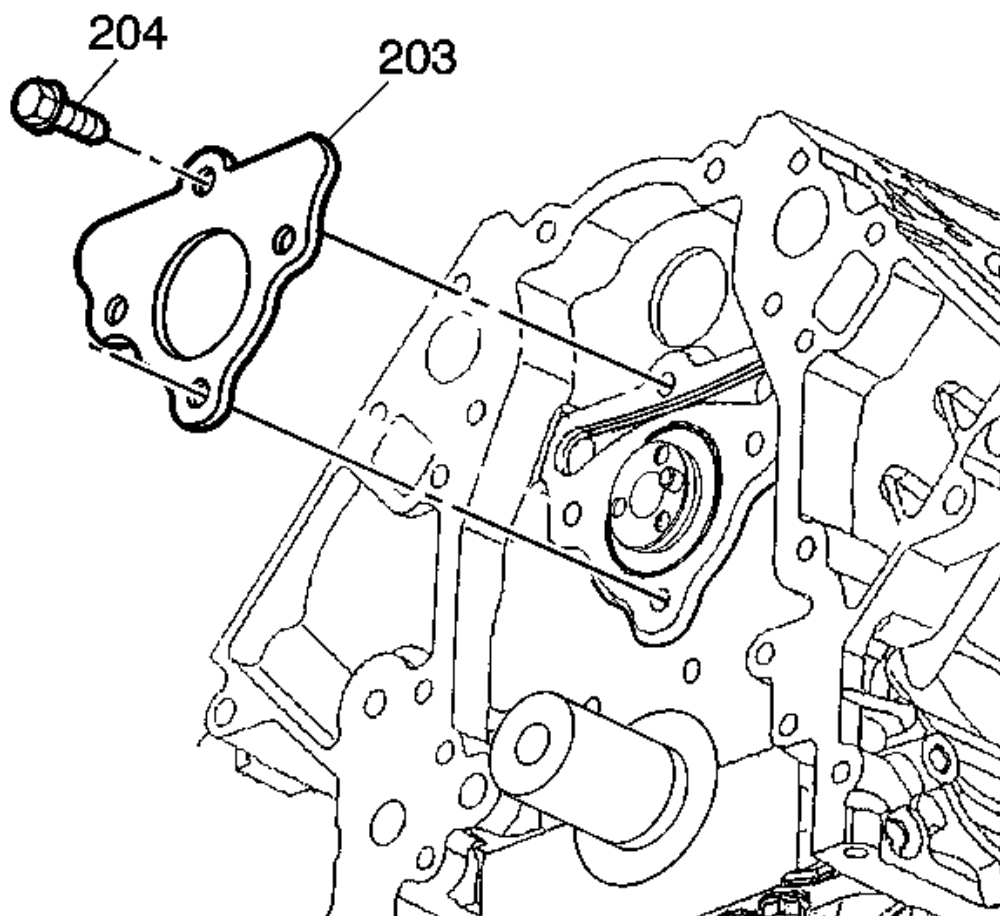


Fig. 273: Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts (204) and retainer (203).

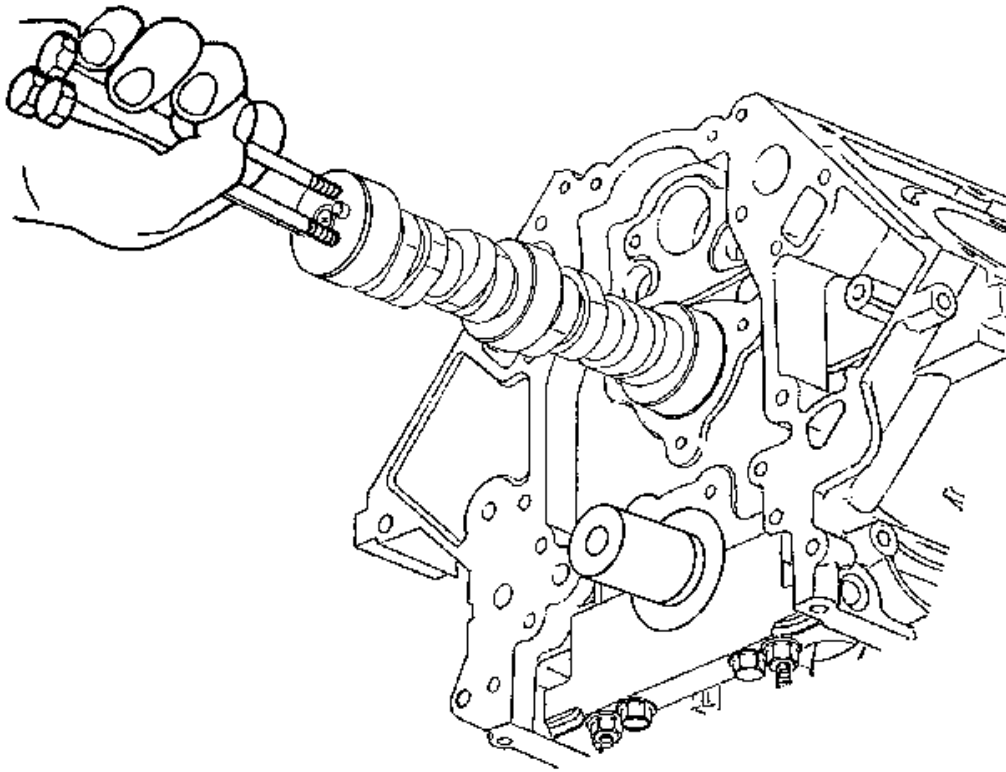


Fig. 274: Removing/Installing The Camshaft
Courtesy of GENERAL MOTORS CORP.

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 3 M8-1.25 x 100 mm bolts in the camshaft front bolt holes.
 2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
 3. Remove the bolts from the front of the camshaft.

Piston, Connecting Rod, and Bearing Removal

Tools Required

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

Removal Procedure

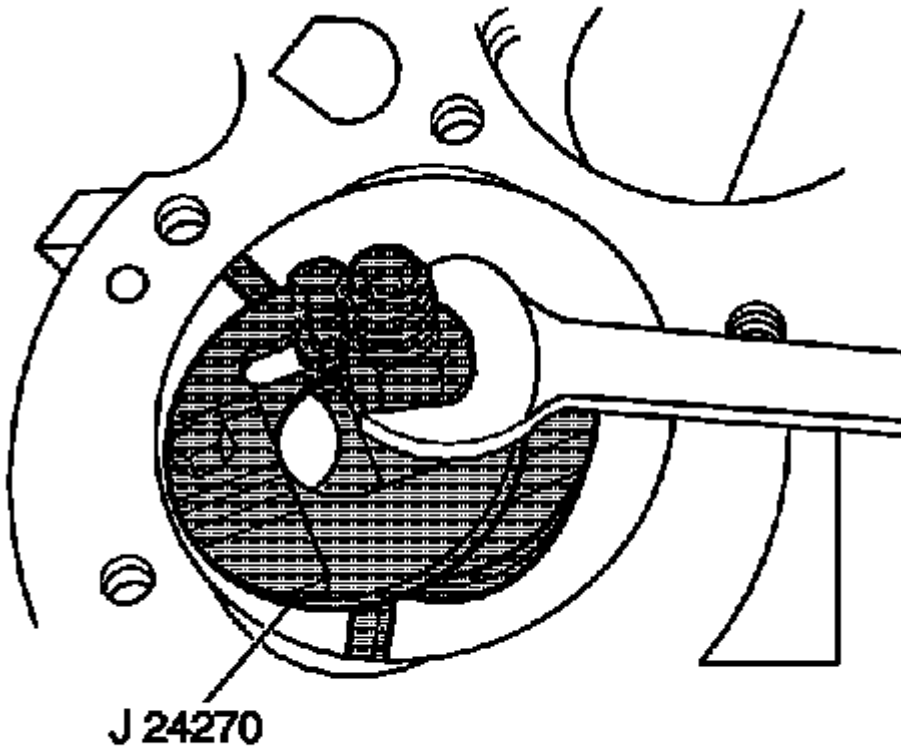


Fig. 275: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The connecting rods and the bearing caps are NOT interchangeable.

1. Use the **J 24270** in order to remove the cylinder bore ring ridge, if required. See Special Tools.
 1. Turn the crankshaft until the piston is at the bottom of the stroke.
 2. Place a cloth on top of the piston.
 3. Use the **J 24270** 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.

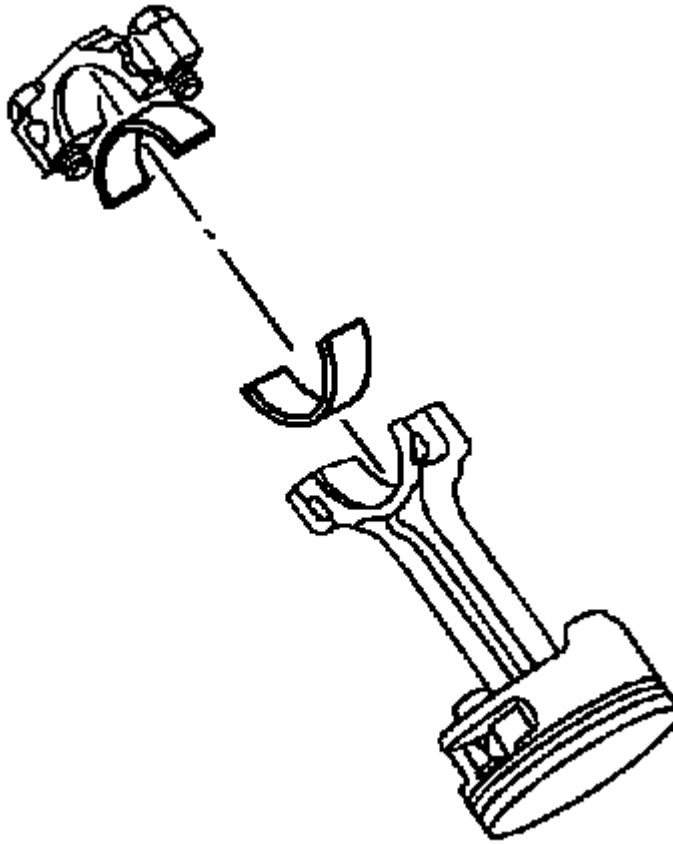


Fig. 276: View Of Piston, Connecting Rod, Bearing Cap, Bearing Halves & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- 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.

2. Remove the connecting rod bolts.

IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location.

3. Remove the connecting rod cap. Refer to Separating Parts.

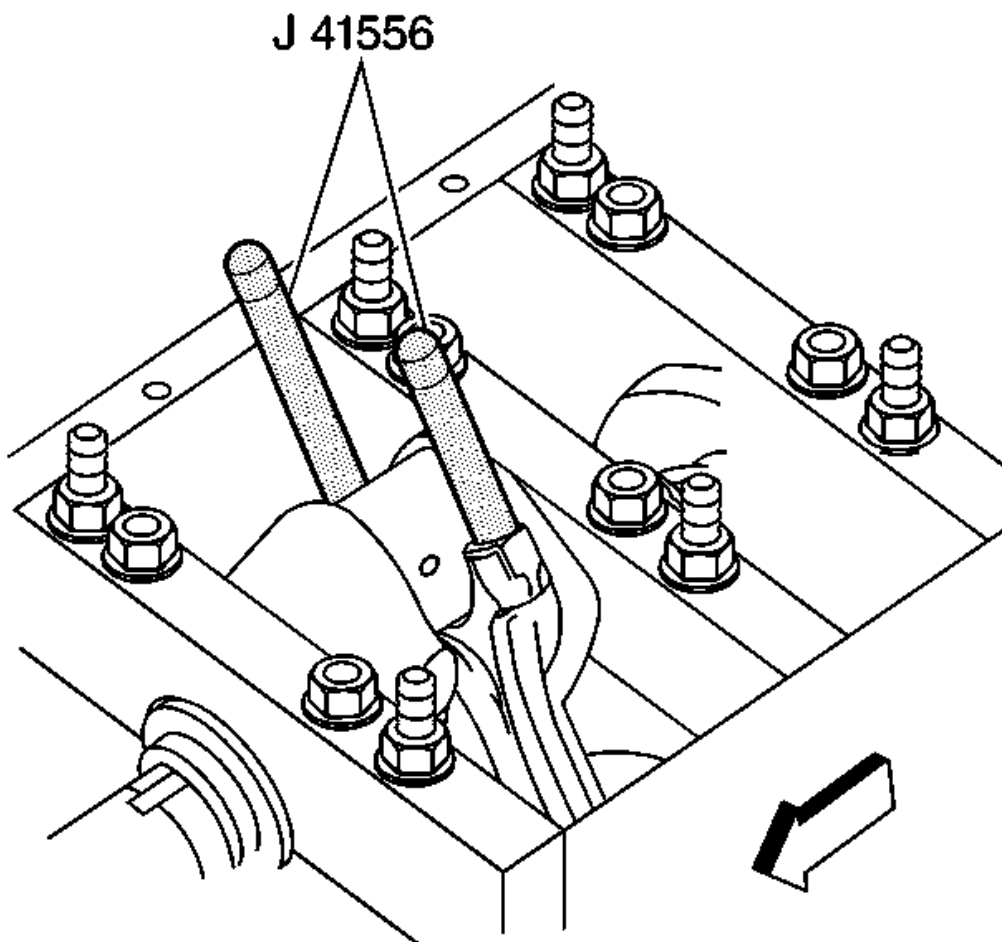


Fig. 277: View Of J 41556 & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod. See **Special Tools**.
5. Use a hammer and tap lightly on the end of the **J 41556** in order to remove the piston and connecting rod assembly from the cylinder bore.

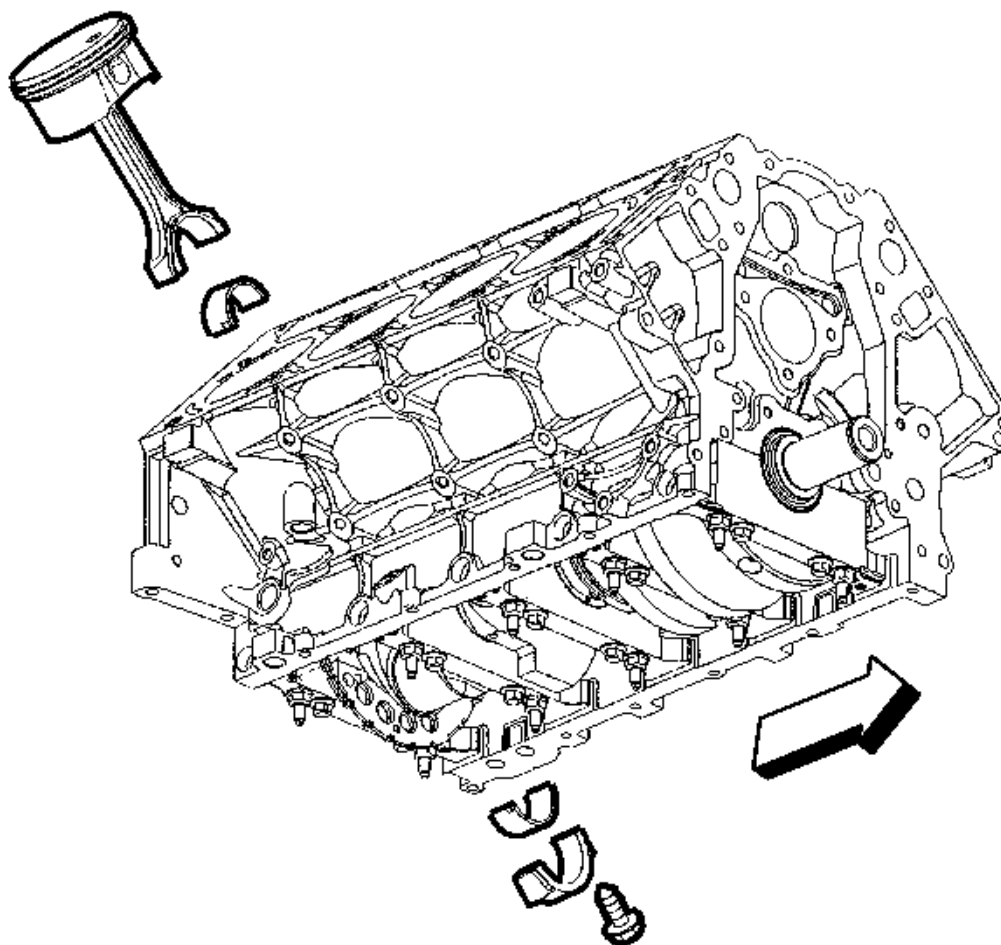


Fig. 278: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

6. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

Crankshaft and Bearings Removal

Tools Required

- **J 6125-1B** Slide Hammer with Adapter
- **J 41818** Crankshaft Bearing Cap Remover. See **Special Tools**.

Removal Procedure

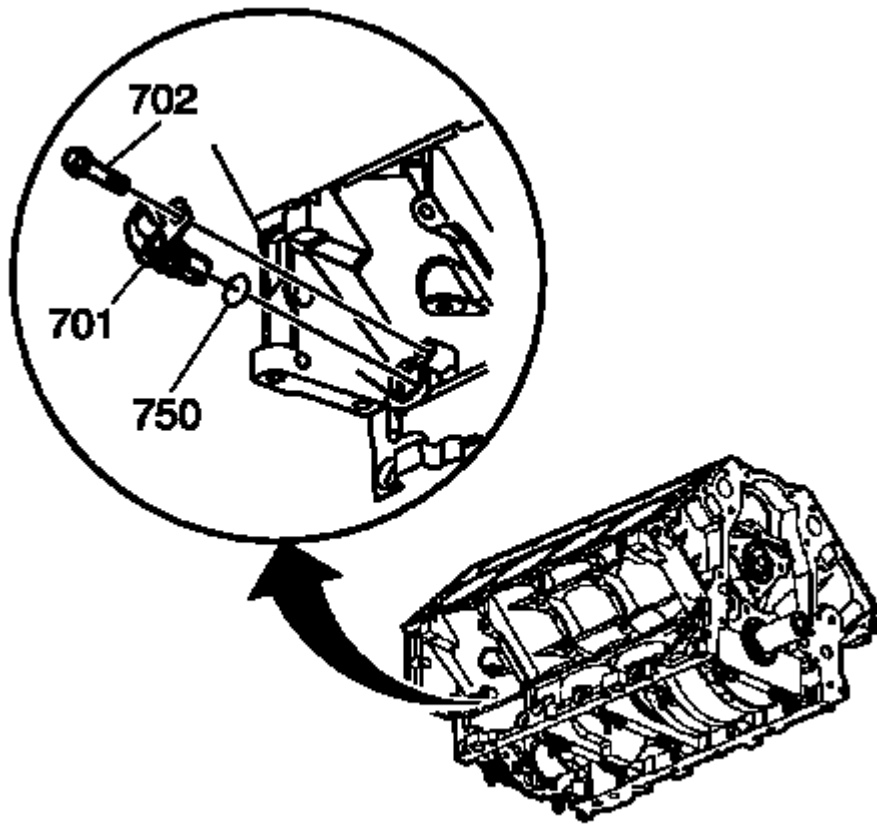


Fig. 279: CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- The crankshaft bearing caps are machined with 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.

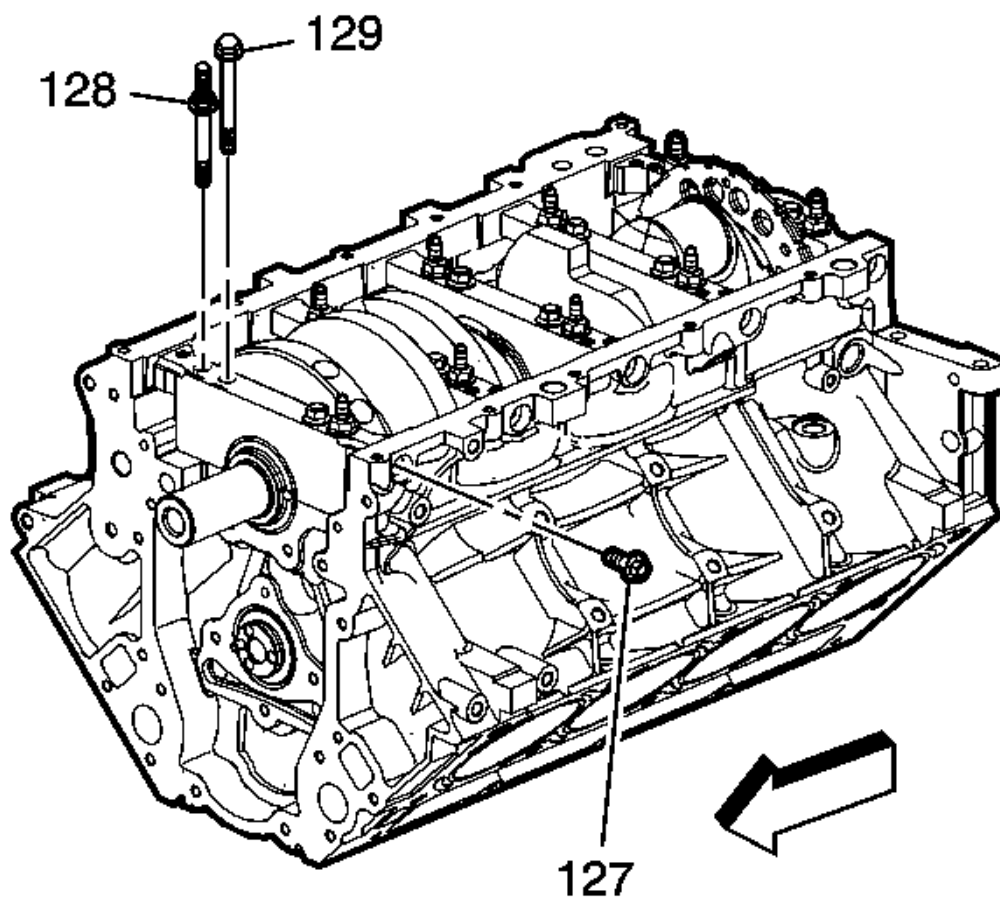


Fig. 280: Crankshaft Bearing Caps & Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft bearing cap M8 bolts (127).
5. Remove the crankshaft bearing cap M10 bolts (129) and studs (128).

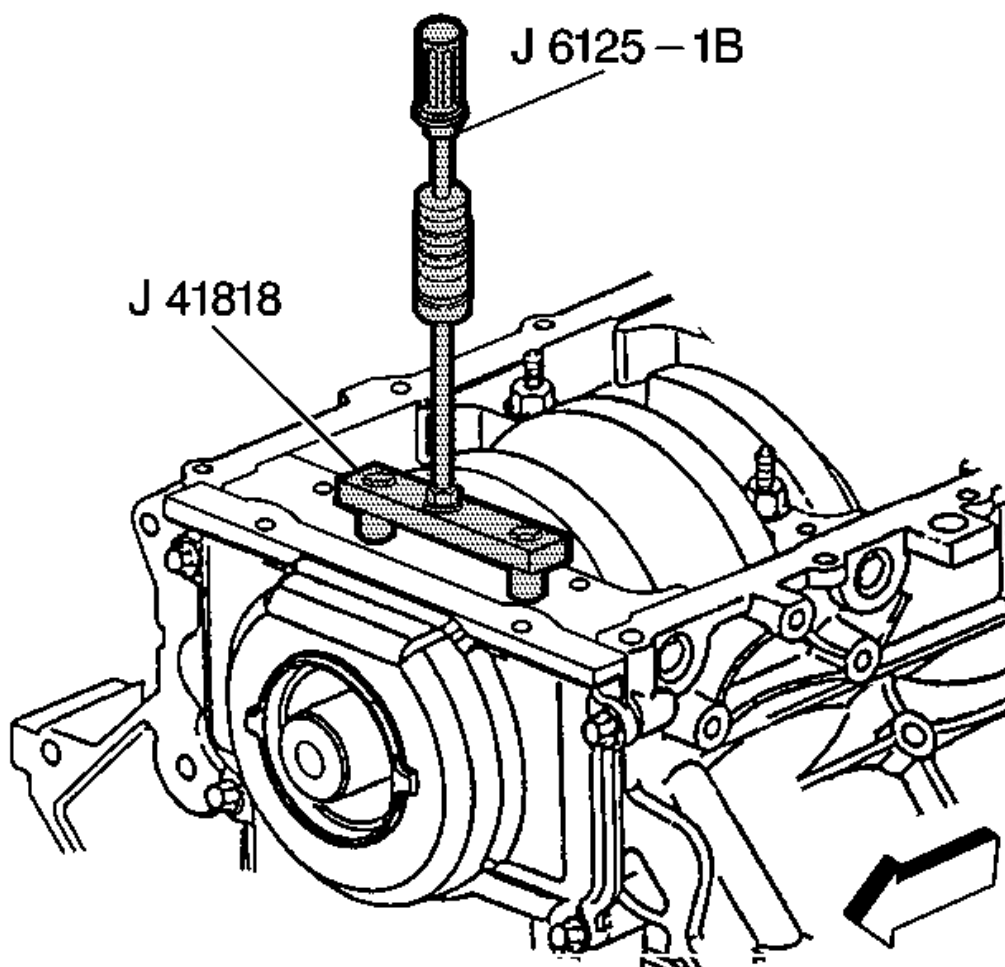


Fig. 281: View Of J 6125-1B & J 41818 Removing Main Bearing Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the **J 41818** . See Special Tools.

Tighten: Tighten the **J 41818** bolts to 11 N.m (100 lb in).

7. Install the **J 6125-1B** to the **J 41818** in order to remove the crankshaft bearing caps.

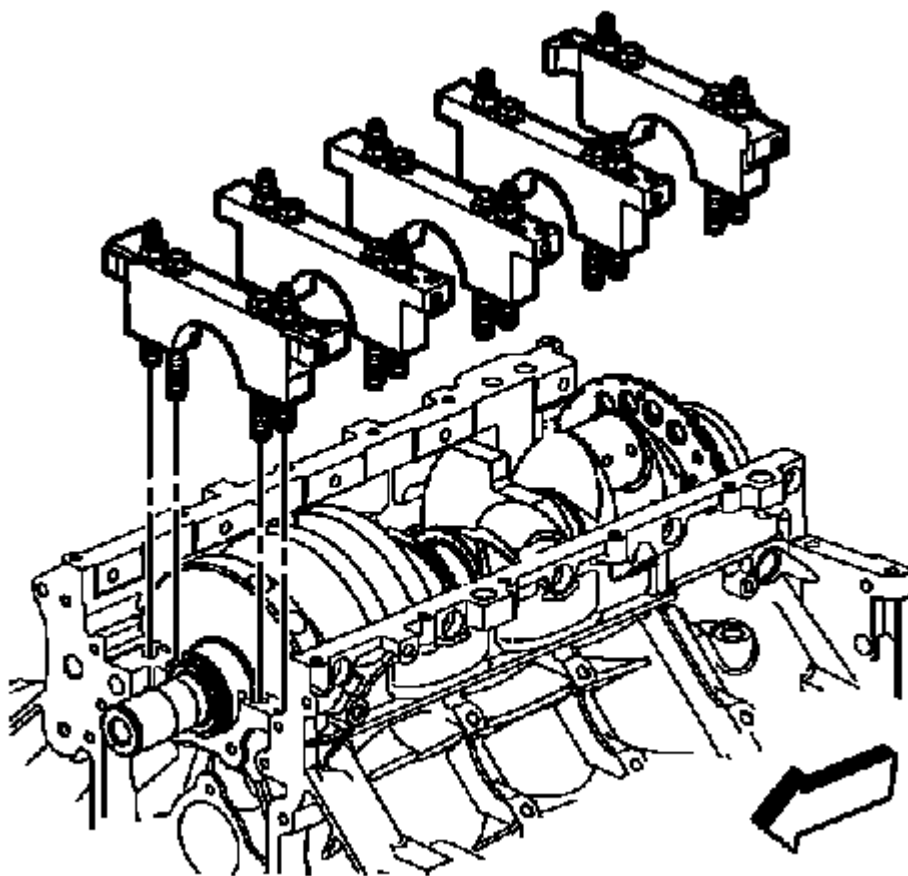


Fig. 282: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Remove the bearing caps.

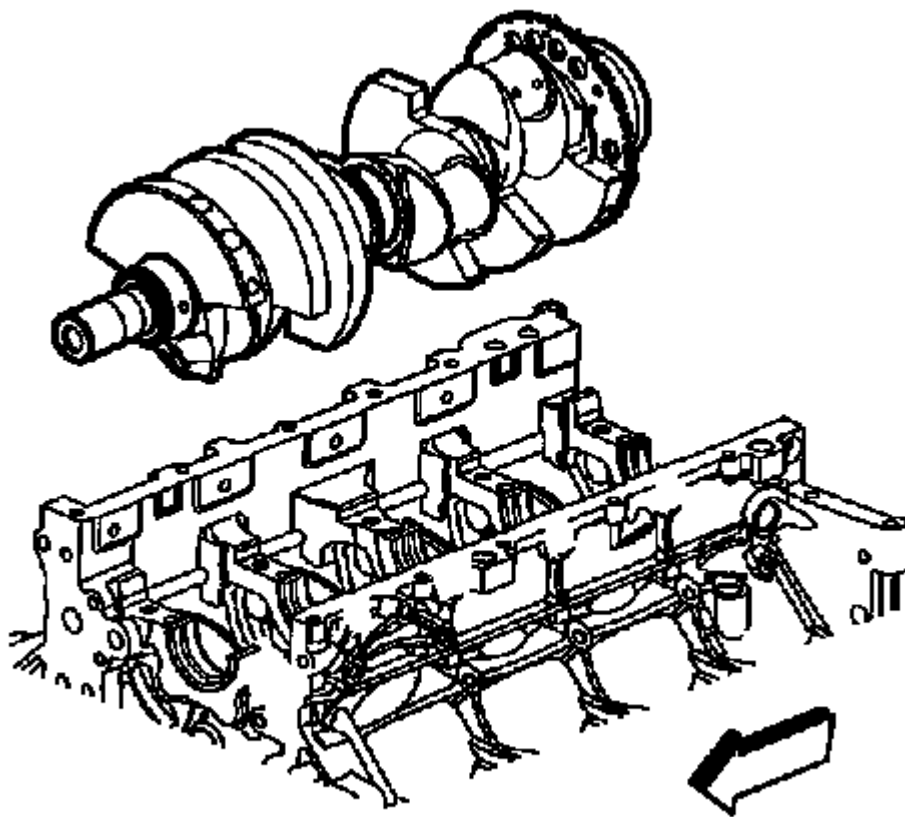


Fig. 283: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft.

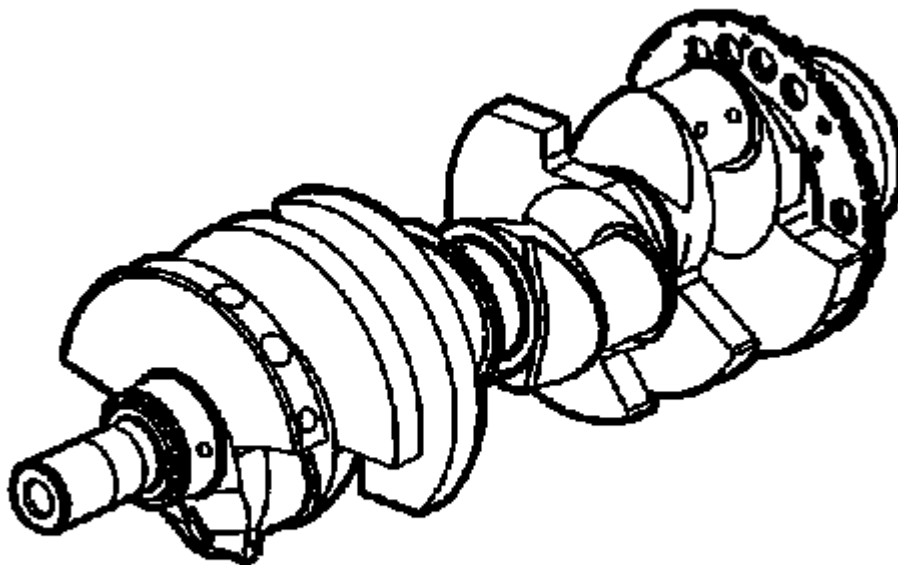


Fig. 284: View Of Crankshaft

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 effect on-board diagnostics (OBD) II system performance.

10. Lay the crankshaft onto wooden V blocks or other protective surface.

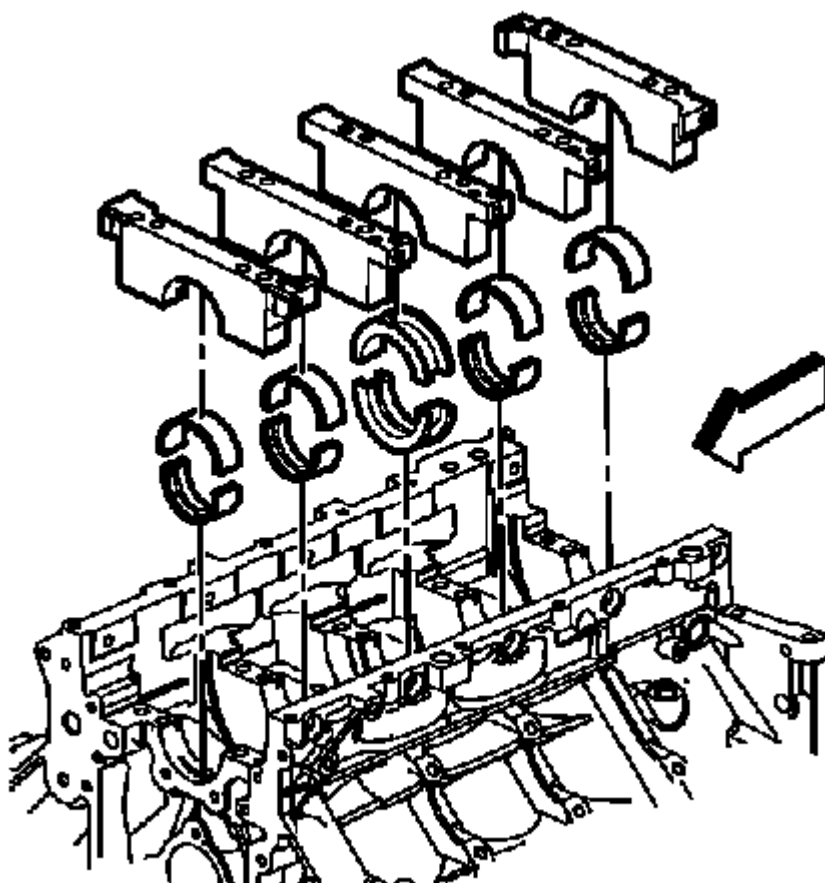


Fig. 285: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

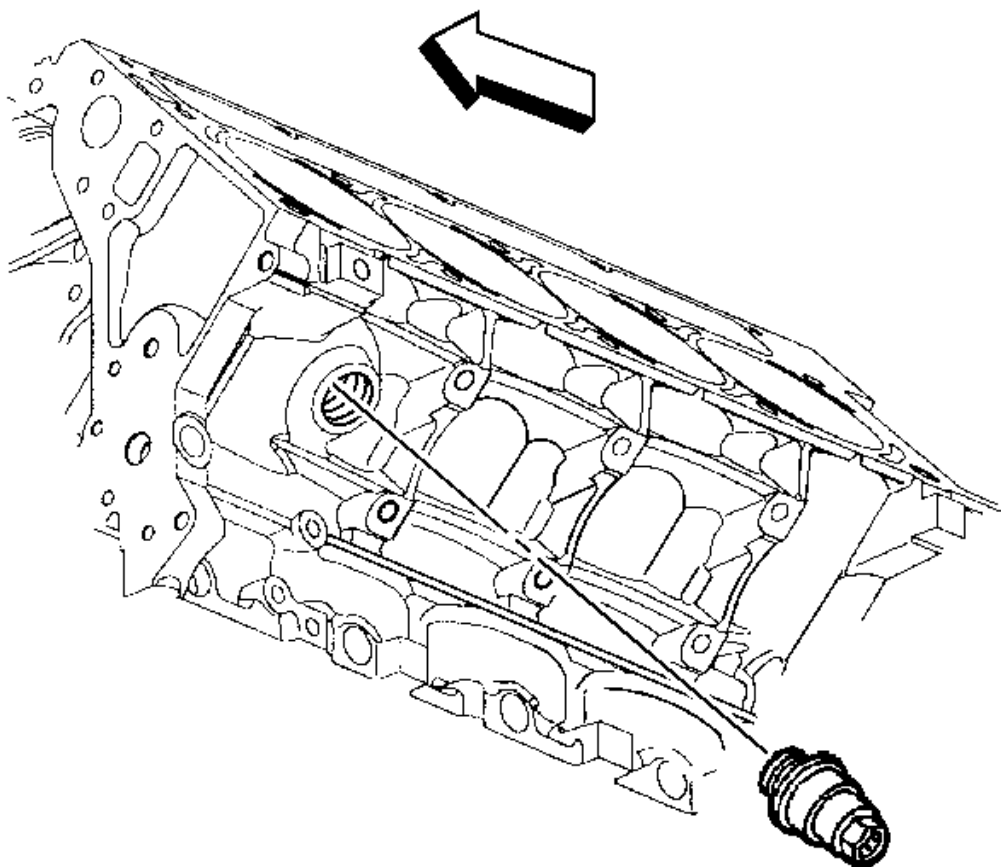


Fig. 286: View Of Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the engine block front oil gallery plug unless service is required. If the front oil gallery plug is removed for service, a **NEW** oil gallery plug must be installed.

1. Remove the engine block coolant heater.

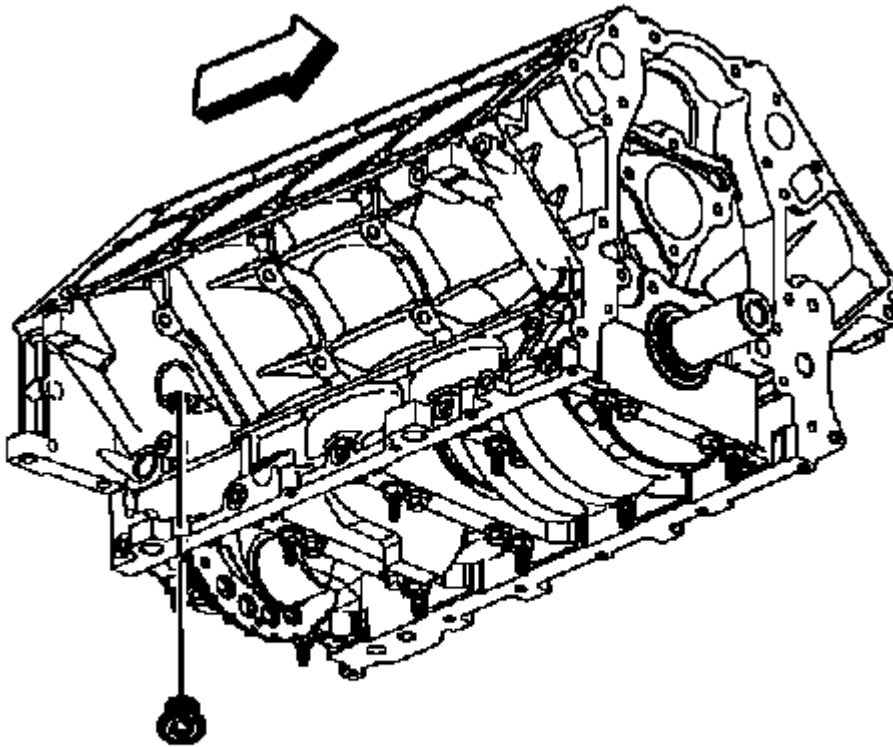


Fig. 287: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block coolant drain hole plug.

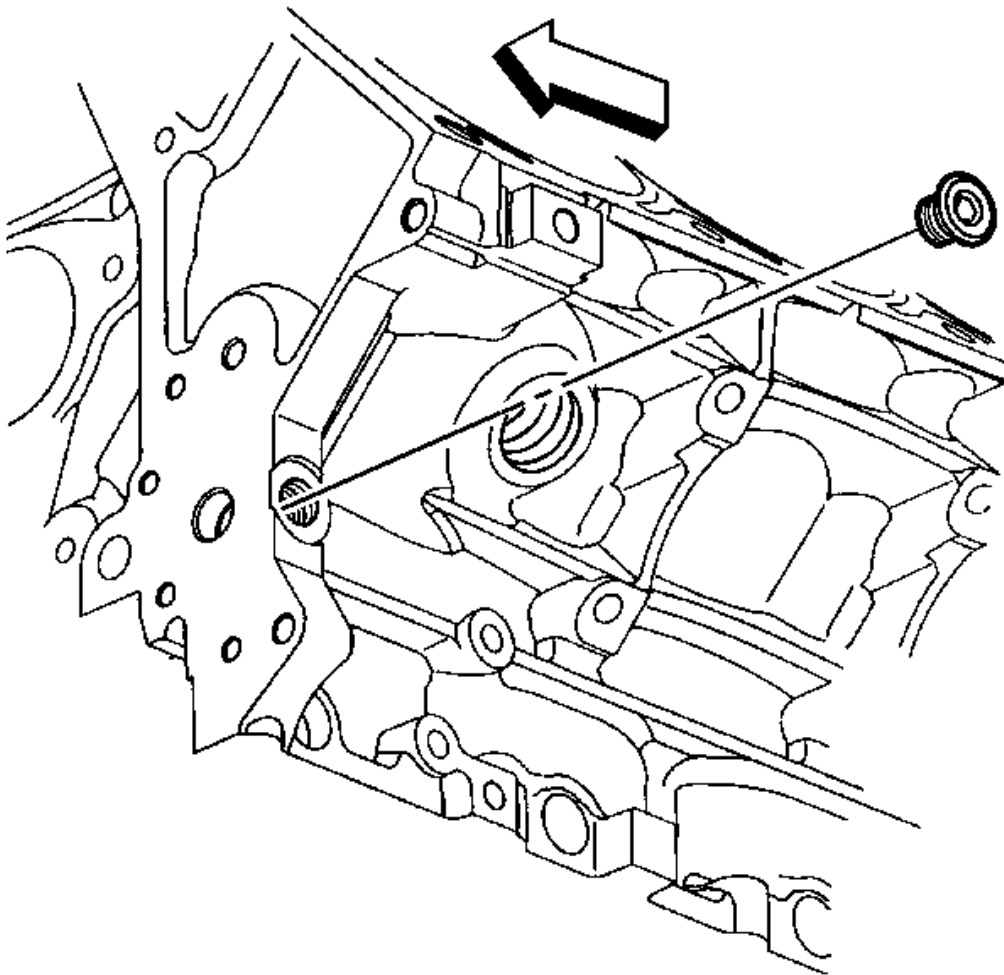


Fig. 288: View Of Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block left front oil gallery plug.

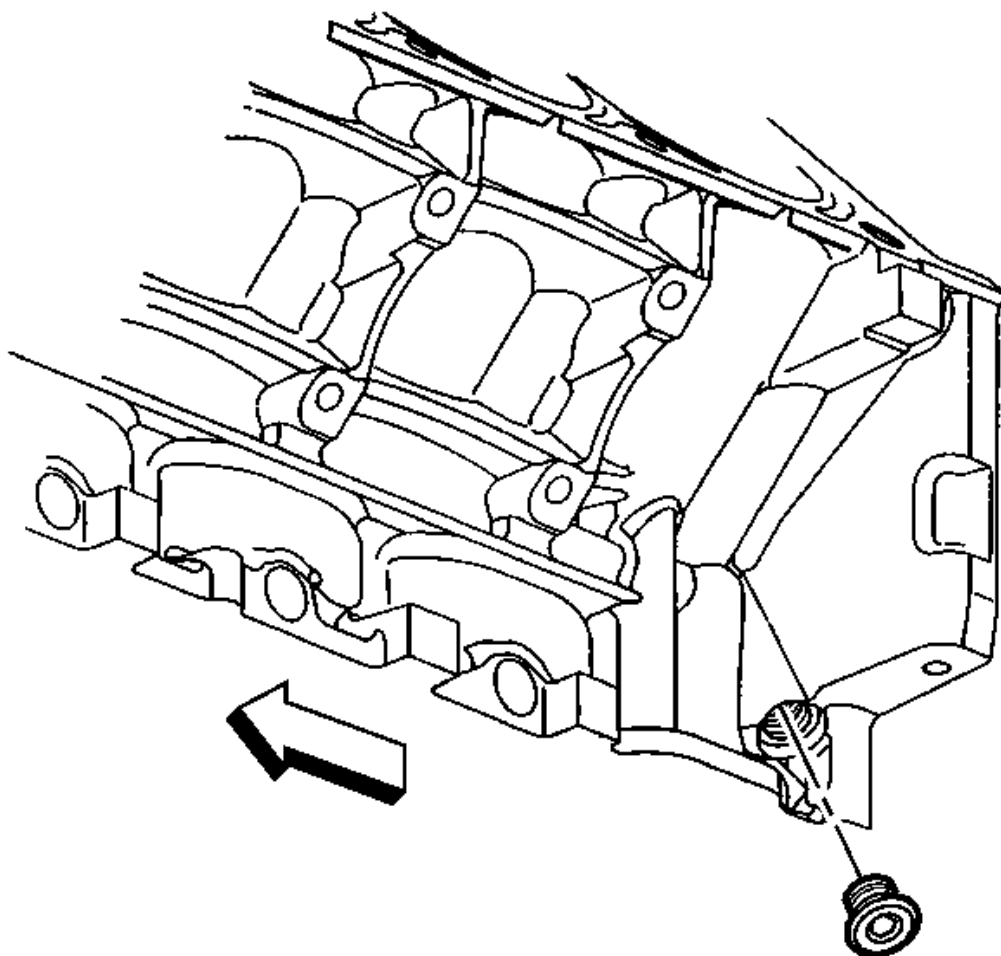


Fig. 289: View Of Engine Block Left Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

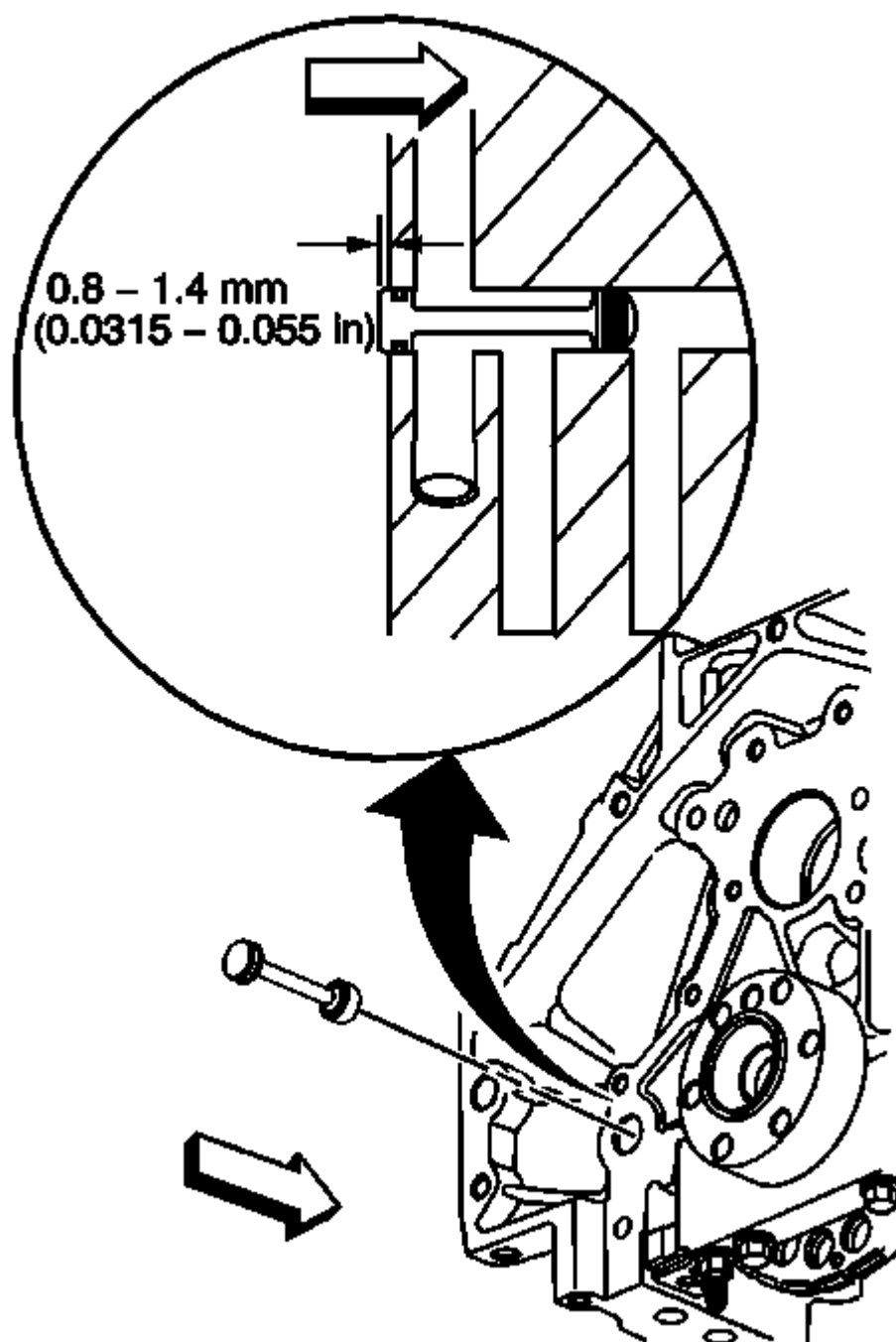


Fig. 290: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

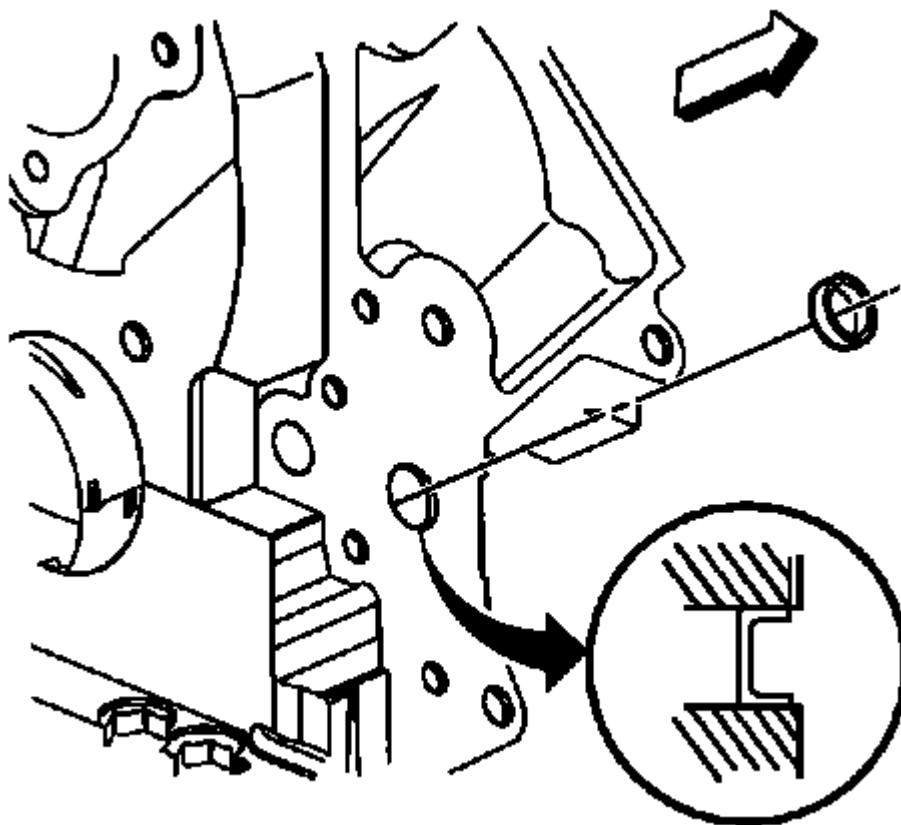


Fig. 291: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

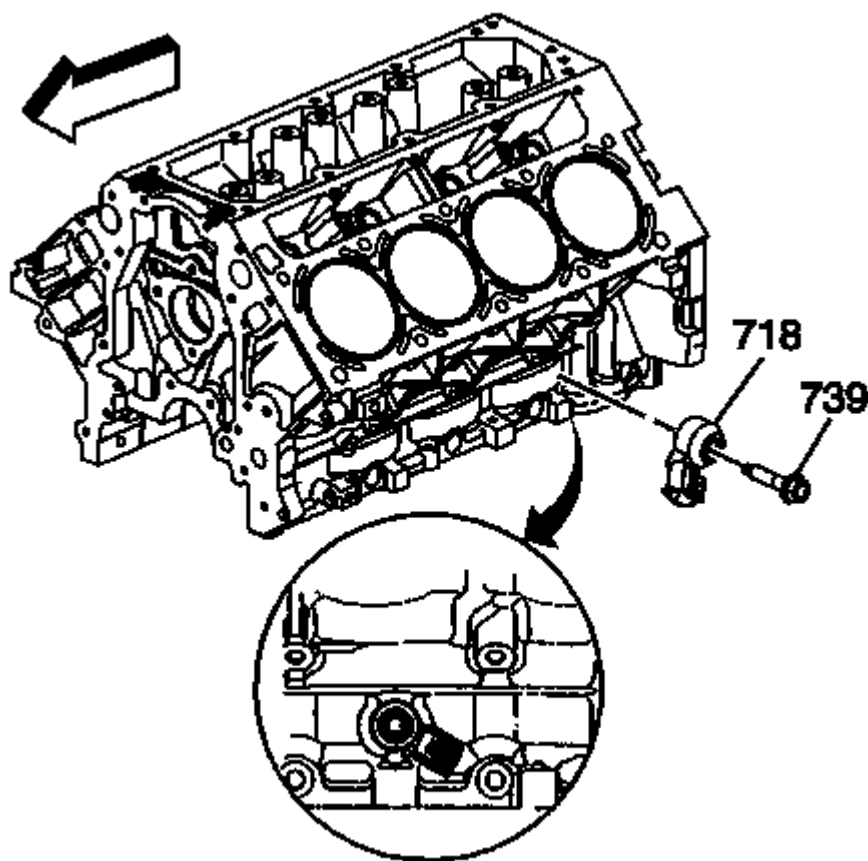


Fig. 292: Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the left side knock sensor (718) and bolt (739).

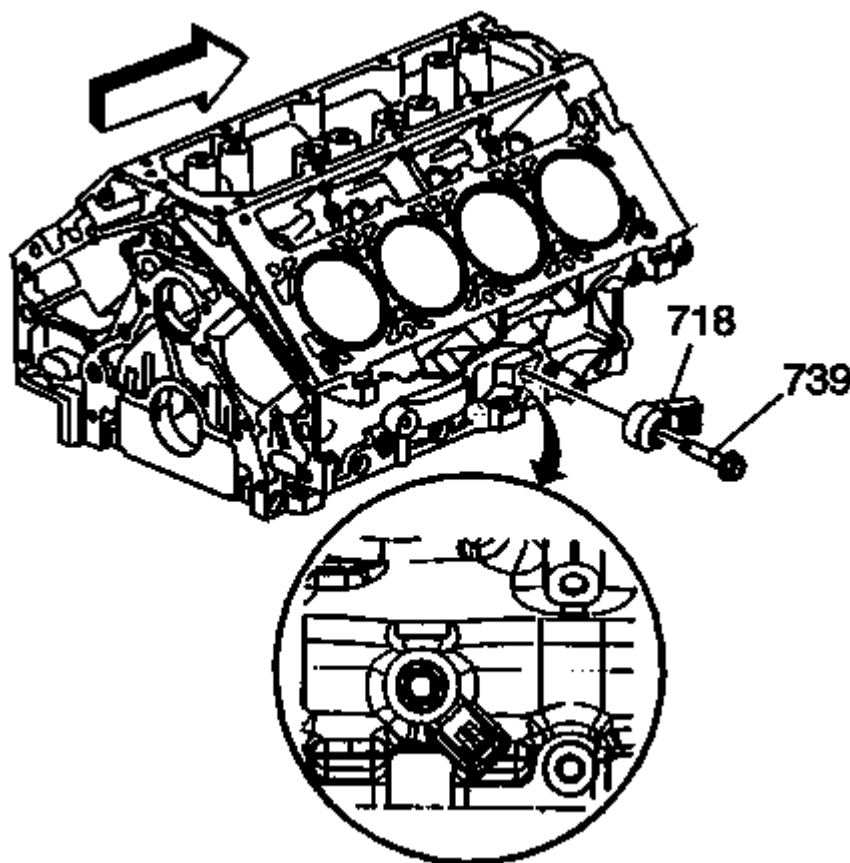


Fig. 293: Right Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove the right side knock sensor (718) and bolt (739).

Engine Block Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage. See Special Tools.
- **J 42385-100** Head/Main Bolt Thread Repair Kit. See Special Tools.

Cleaning Procedure

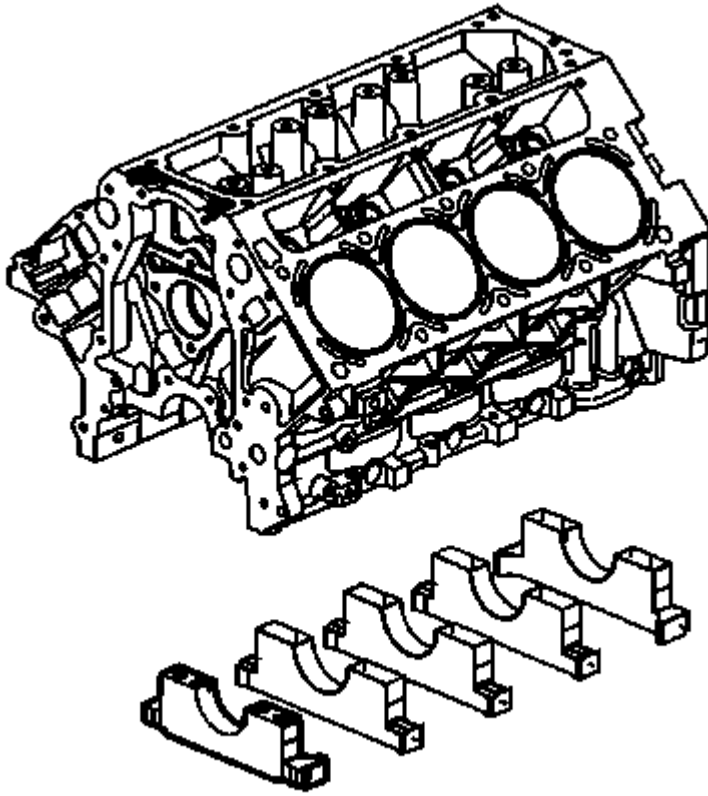


Fig. 294: Main Bearing Caps

Courtesy of GENERAL MOTORS CORP.

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

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
- Threaded bolt holes for damaged threads

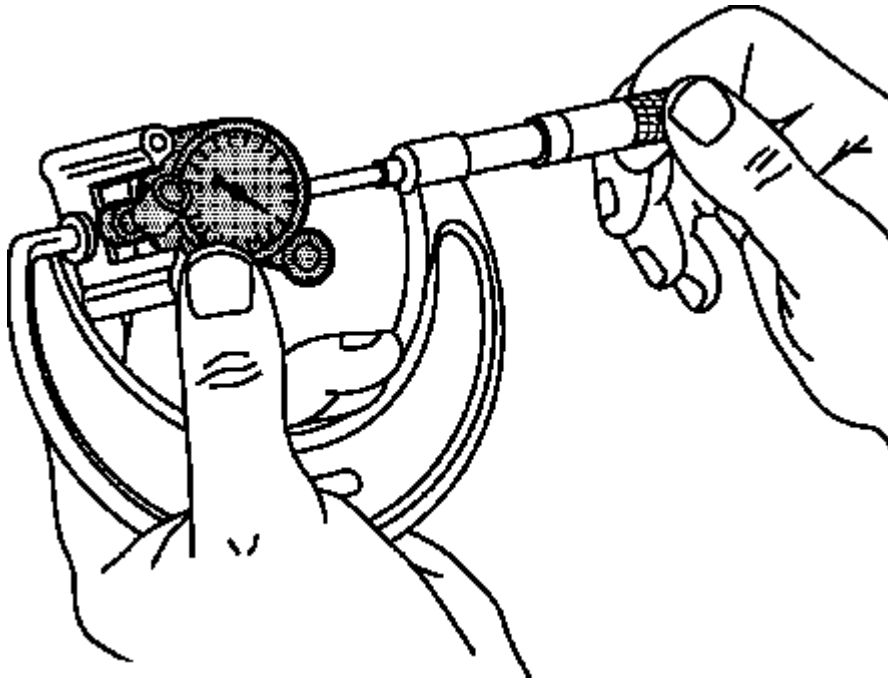
Measuring the Cylinder for Oversize

Fig. 295: 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**.
2. Insert the **J 8087** bore gage into the micrometer and zero the bore gage dial. See **Special Tools**.

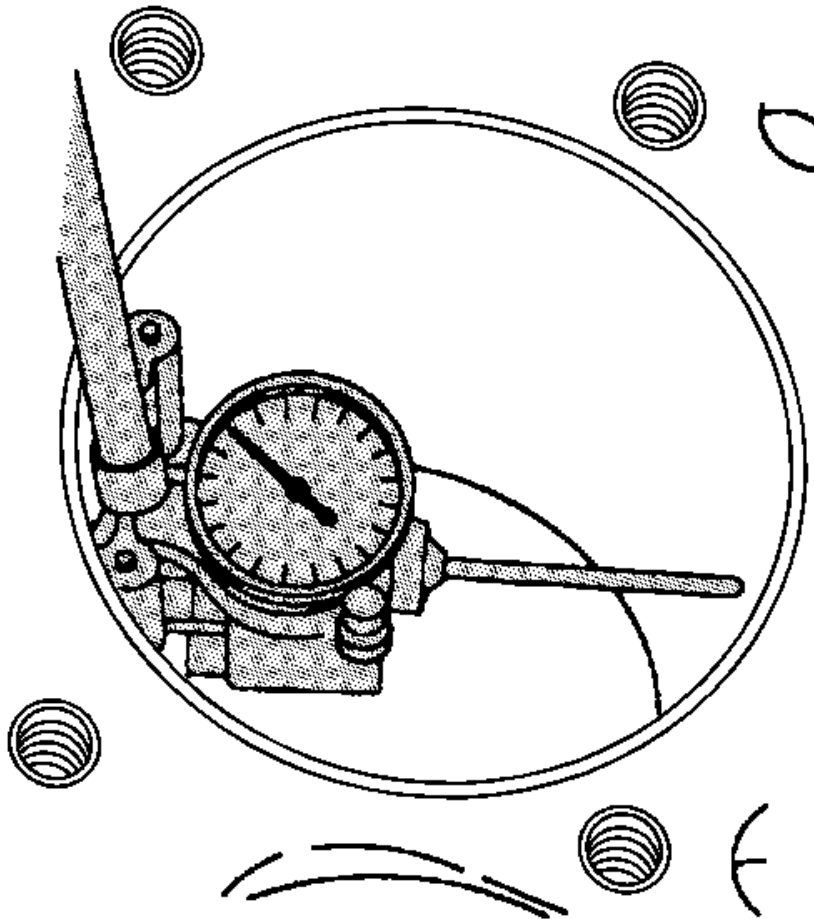


Fig. 296: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 8087** , measure the cylinder bore for oversize.

Slide the bore gage up and down throughout the length of the cylinder bore. Check 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.

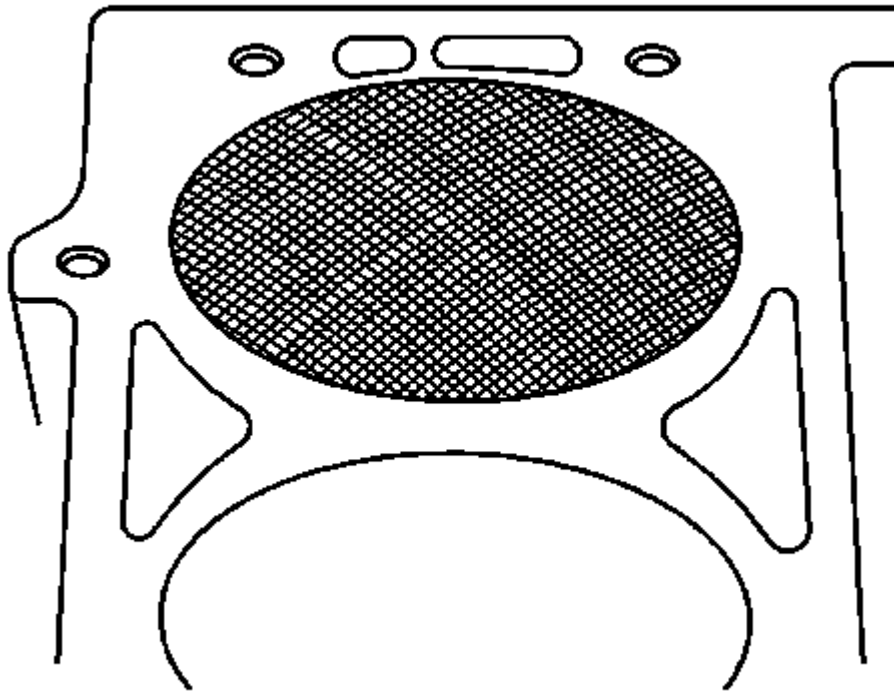
Honing Procedure

Fig. 297: Identifying Cylinder Bore Cross Hatch Pattern
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 cross hatch pattern.

Repeatedly check the measurement at the top, the middle, and the bottom of the bore.

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

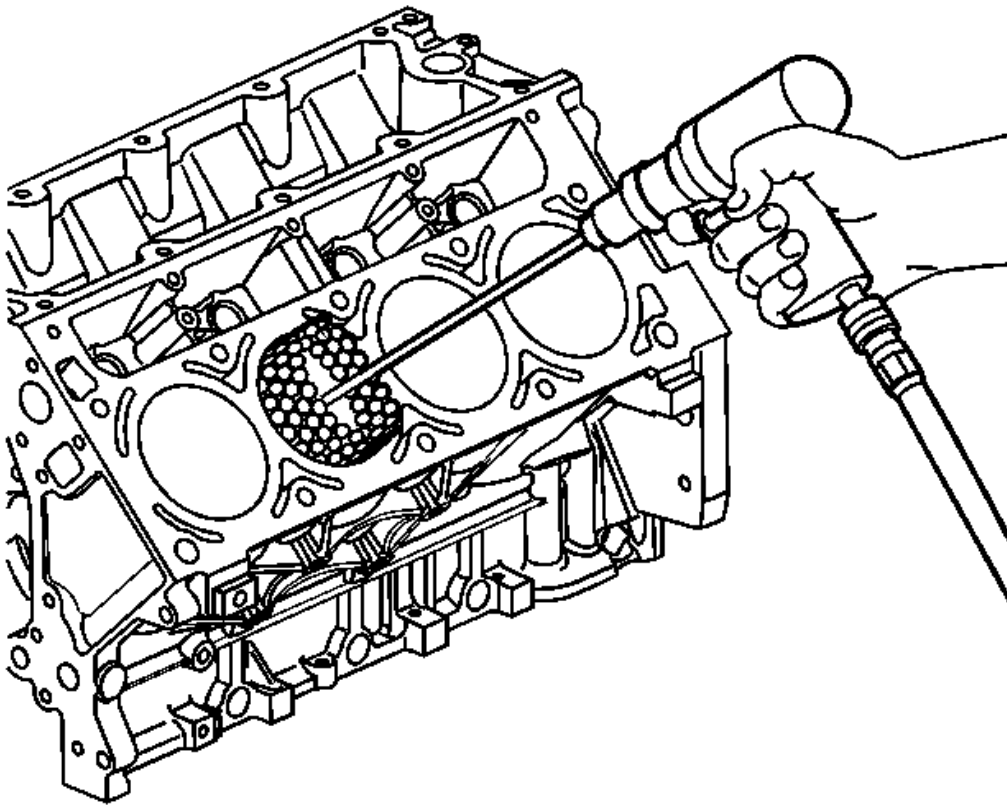


Fig. 298: Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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 performing 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.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator Set. See **Special Tools**.
- **J 43690** Rod Bearing Checking Tool. See **Special Tools**.
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit. See **Special Tools**.

Cleaning Procedure

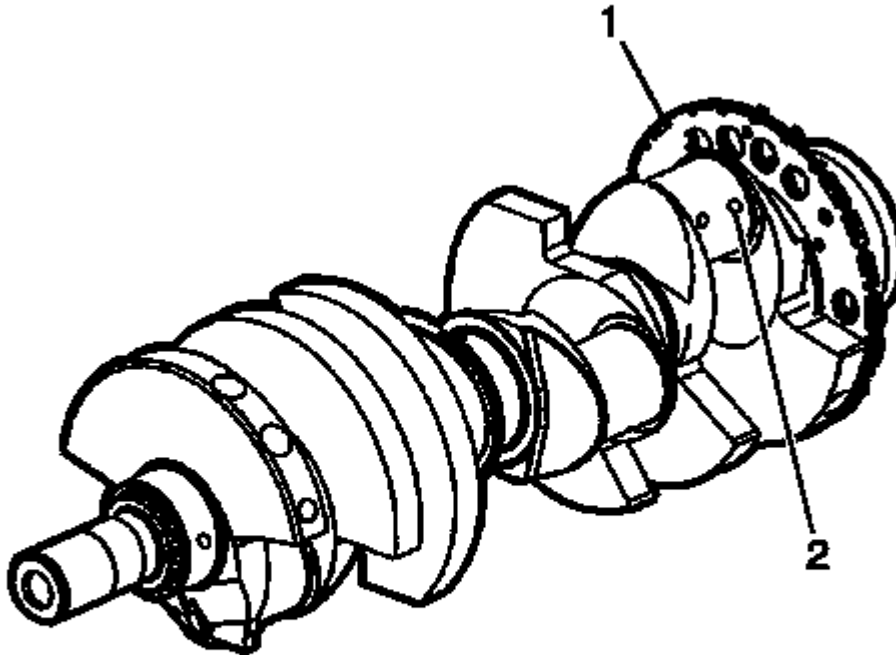


Fig. 299: Oil Passages & CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

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 effect 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 in Cautions and Notices.

3. Dry the crankshaft with compressed air.

Inspection Procedure

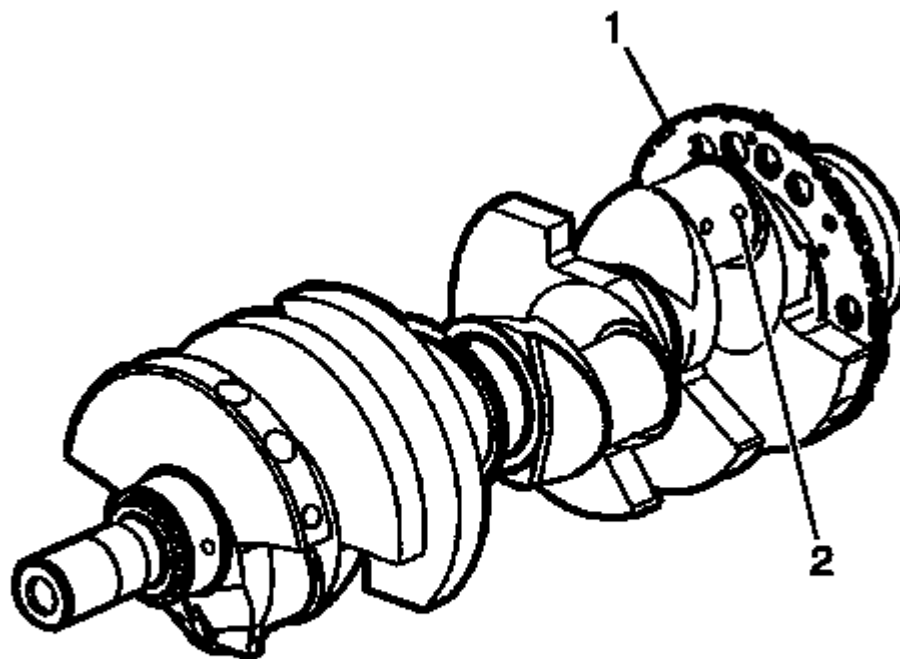


Fig. 300: Oil Passages & CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may effect OBD II system performance.

1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the CKP reluctor ring teeth (1) for damage.

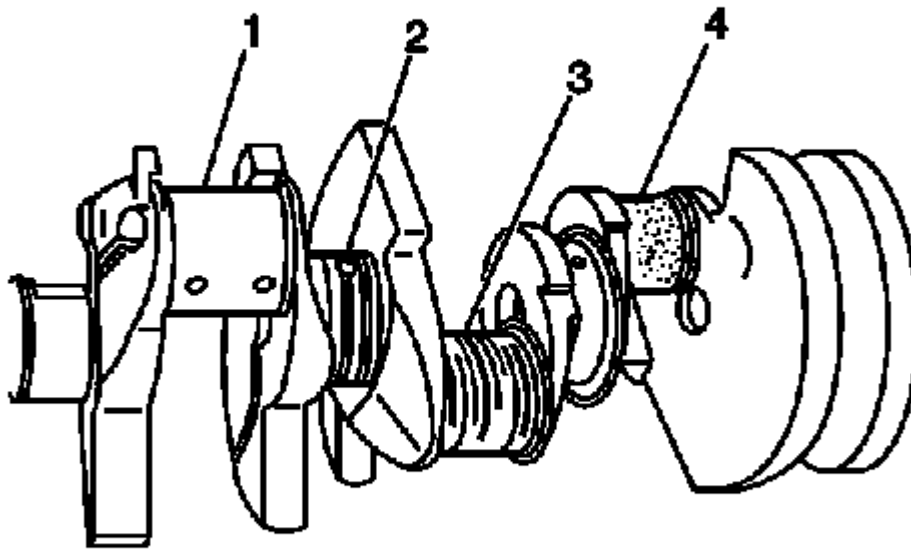


Fig. 301: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft journals (1) for wear.

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).

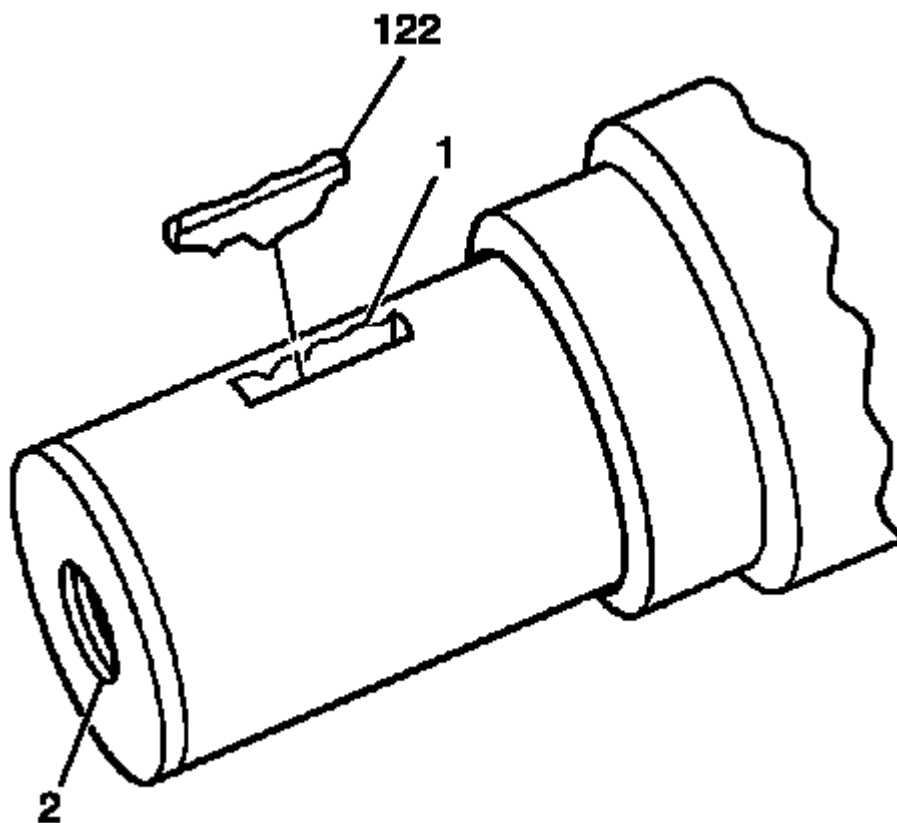


Fig. 302: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

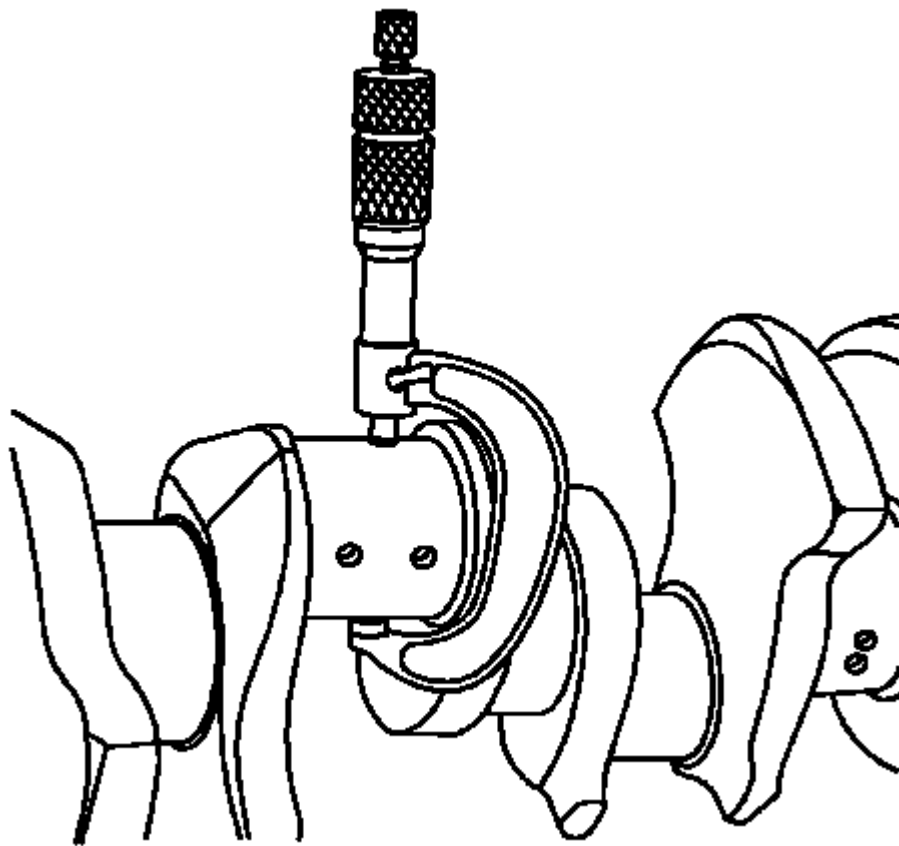


Fig. 303: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

8. Measure the crankpins for the out-of-round.
9. Measure the crankpins for taper.

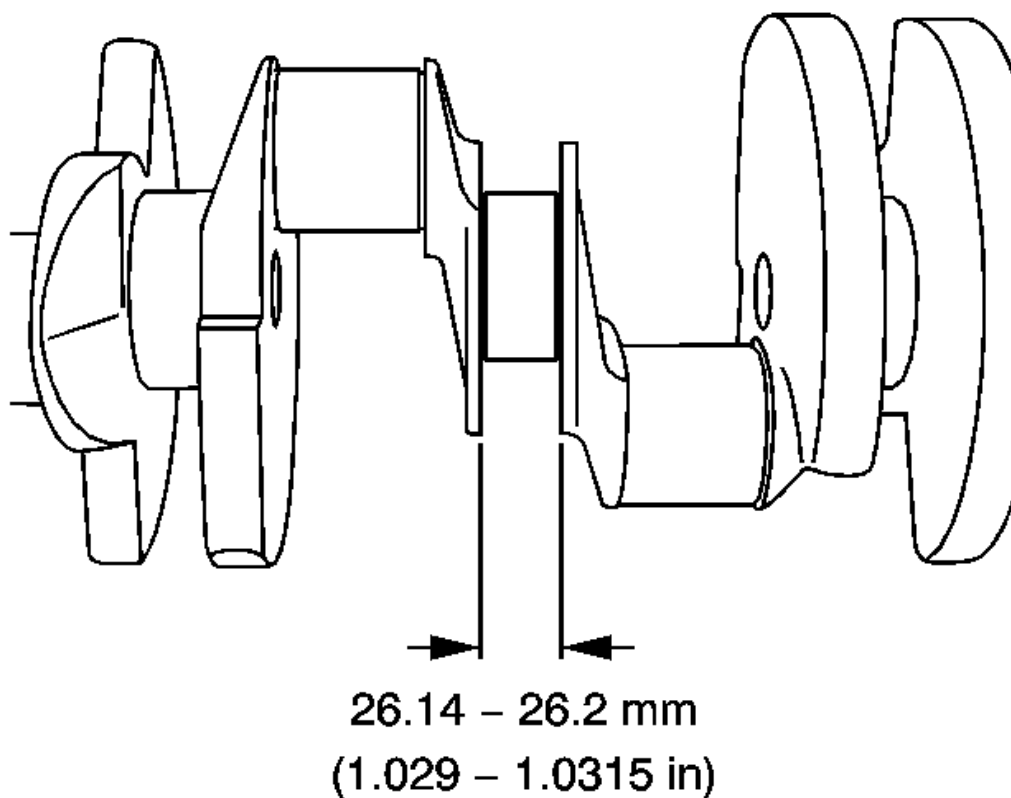


Fig. 304: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft thrust wall width.

A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) must be replaced.

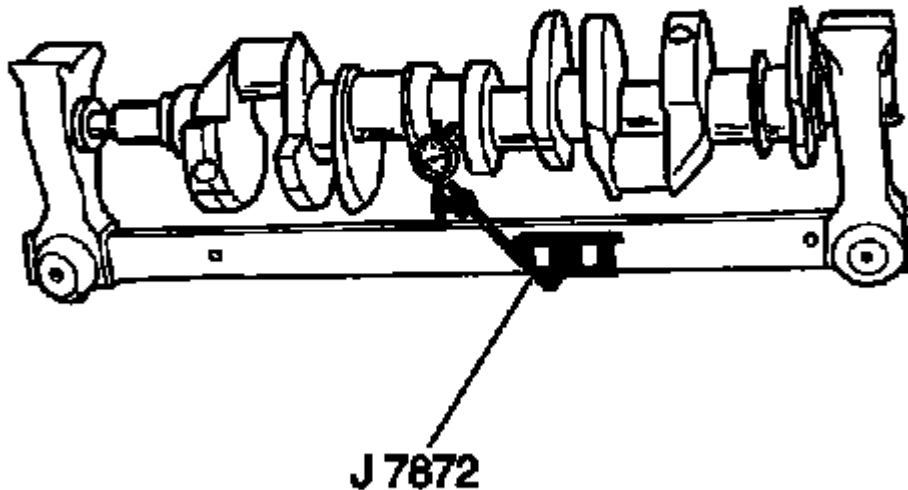


Fig. 305: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft runout.

Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.

12. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals. See **Special Tools**.
13. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
14. 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.

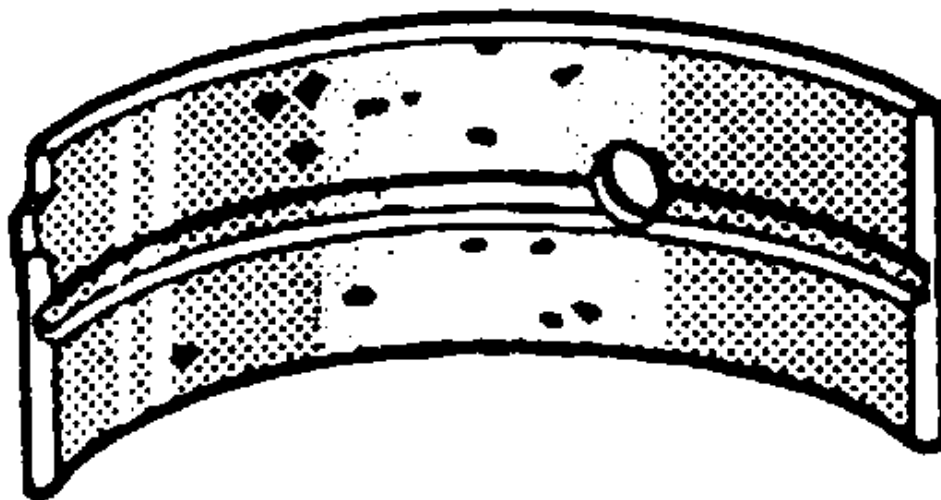


Fig. 306: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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

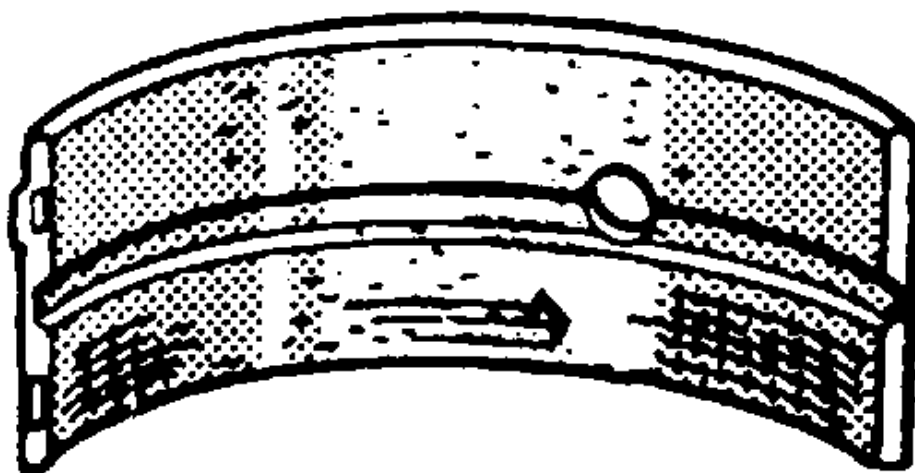


Fig. 307: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

16. Inspect the crankshaft bearings for excessive scoring or discoloration.
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

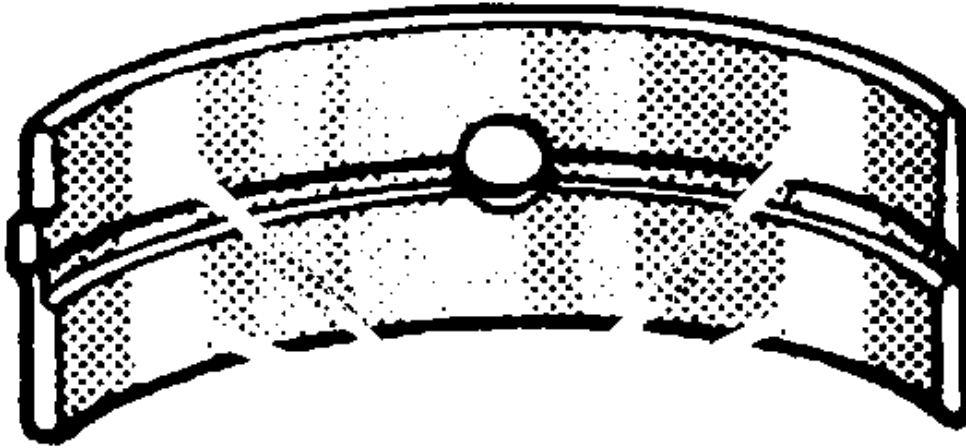


Fig. 308: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

18. 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

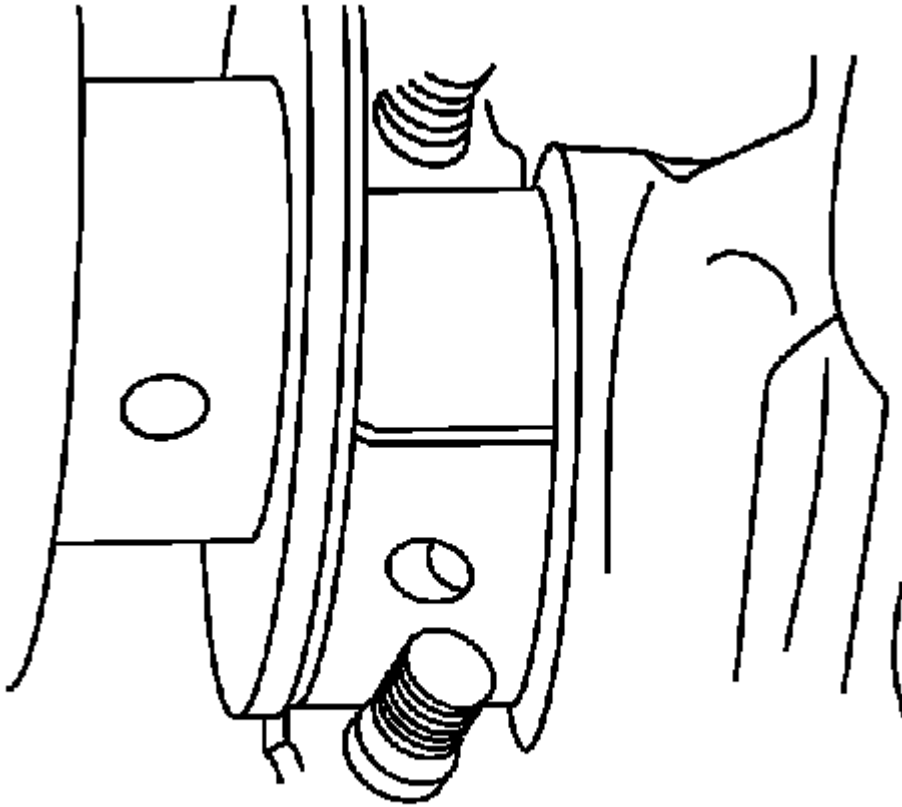


Fig. 309: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

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 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 effect on-board diagnostics (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 Bearings 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 Bearings Installation**.

4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearings Removal**.

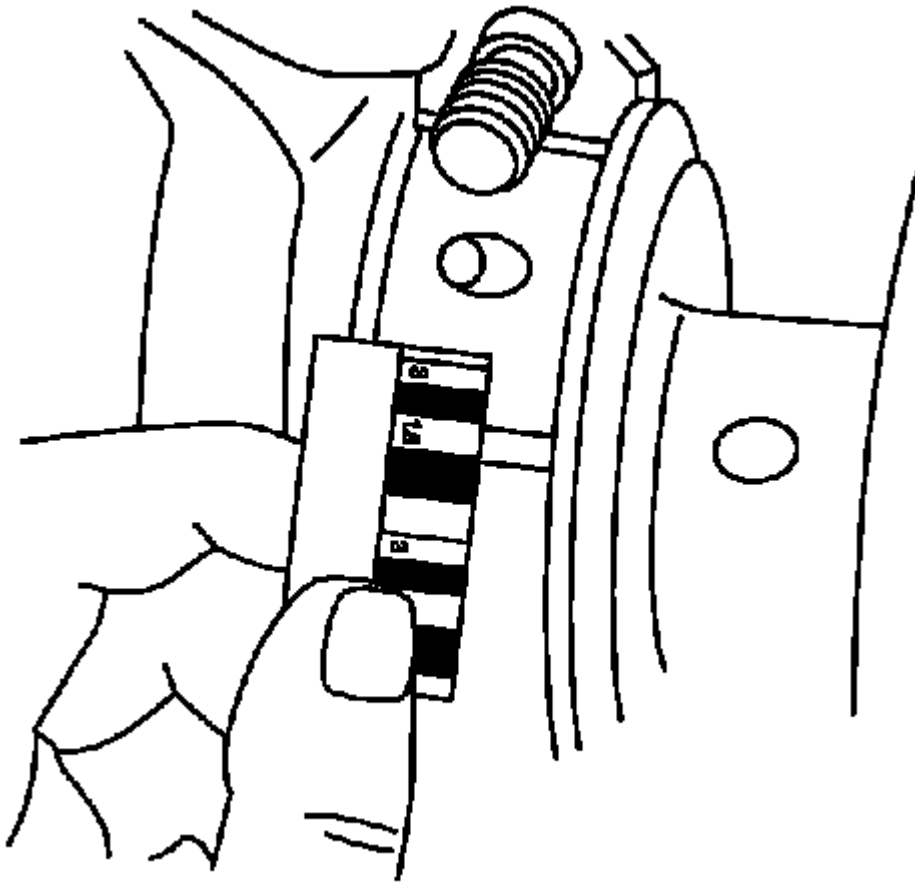


Fig. 310: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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**.

Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method

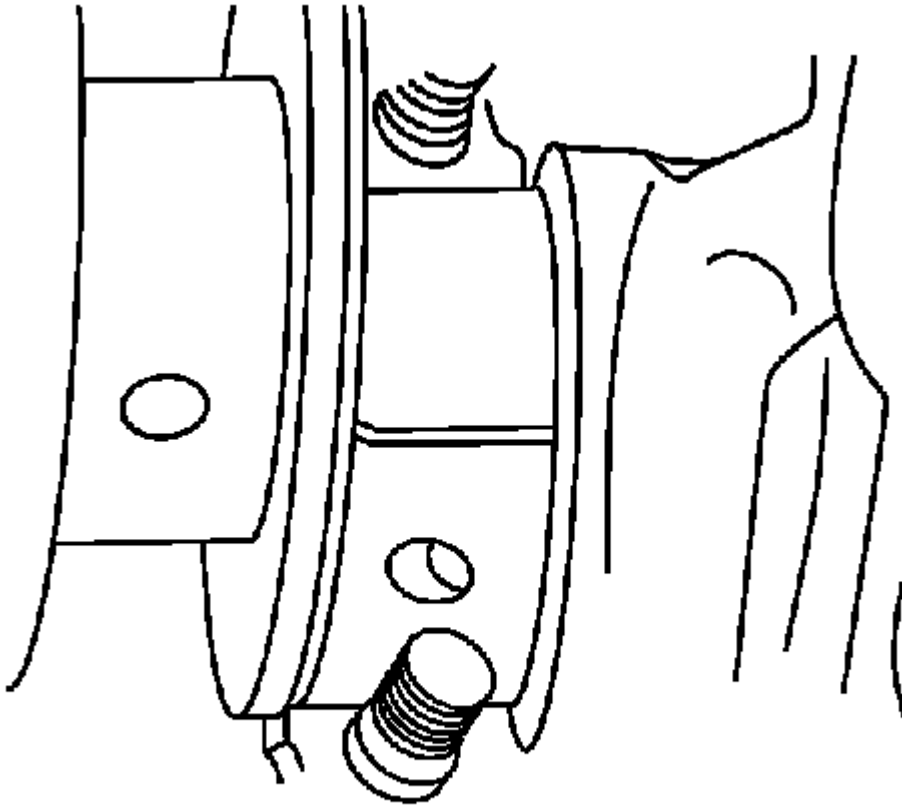


Fig. 311: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

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.
- 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**.

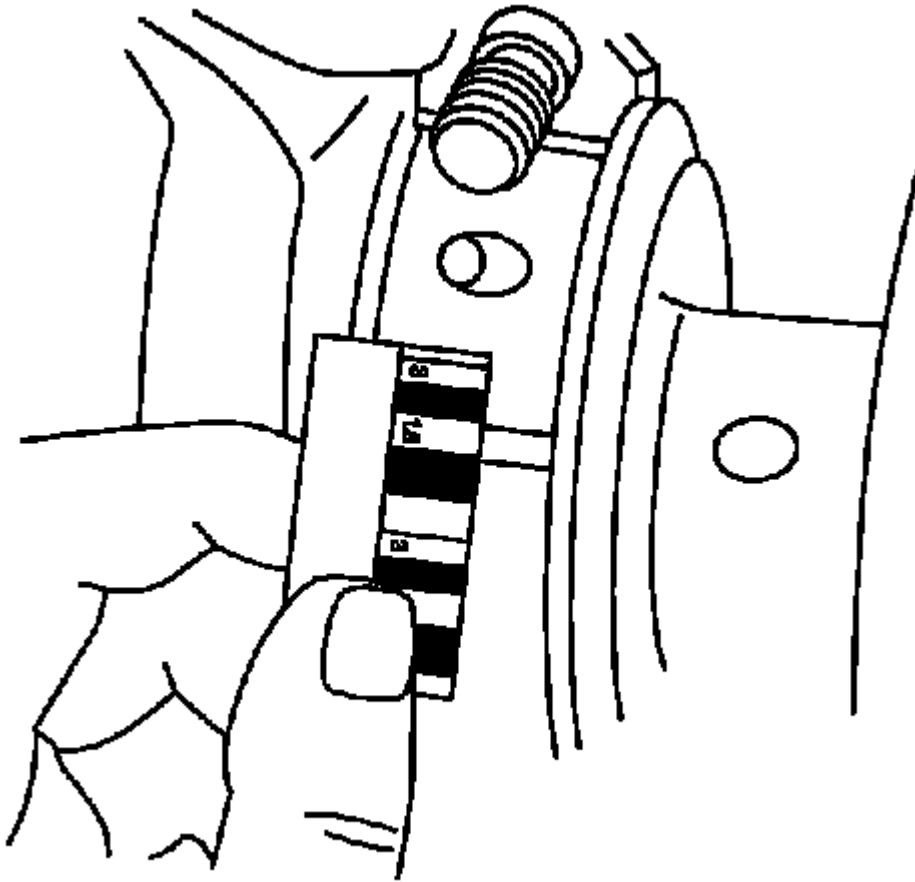


Fig. 312: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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. See **Special Tools**. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

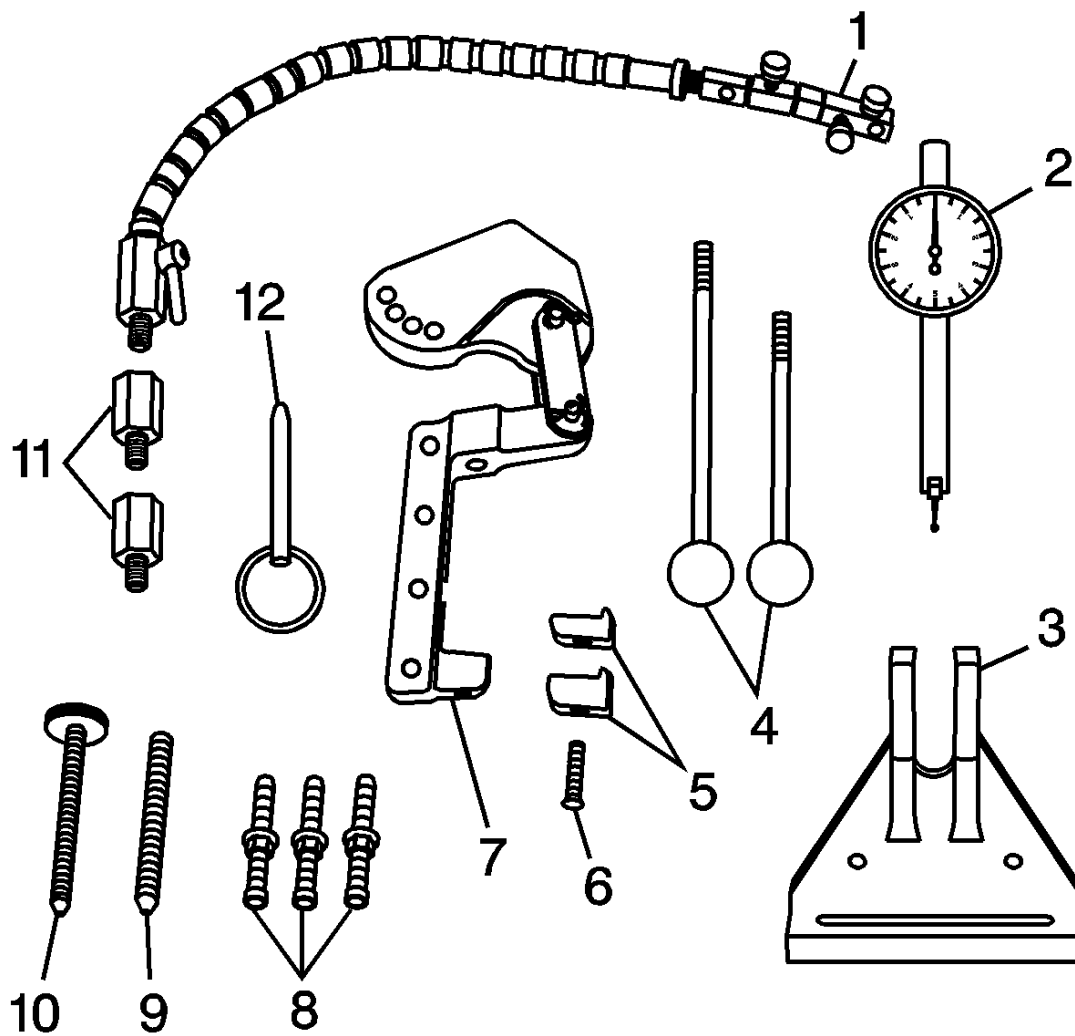


Fig. 313: Identifying Rod Bearing Clearance Checking Tool
 Courtesy of GENERAL MOTORS CORP.

J 43690 Rod Bearing Checking Tool. See Special Tools.

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)

- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

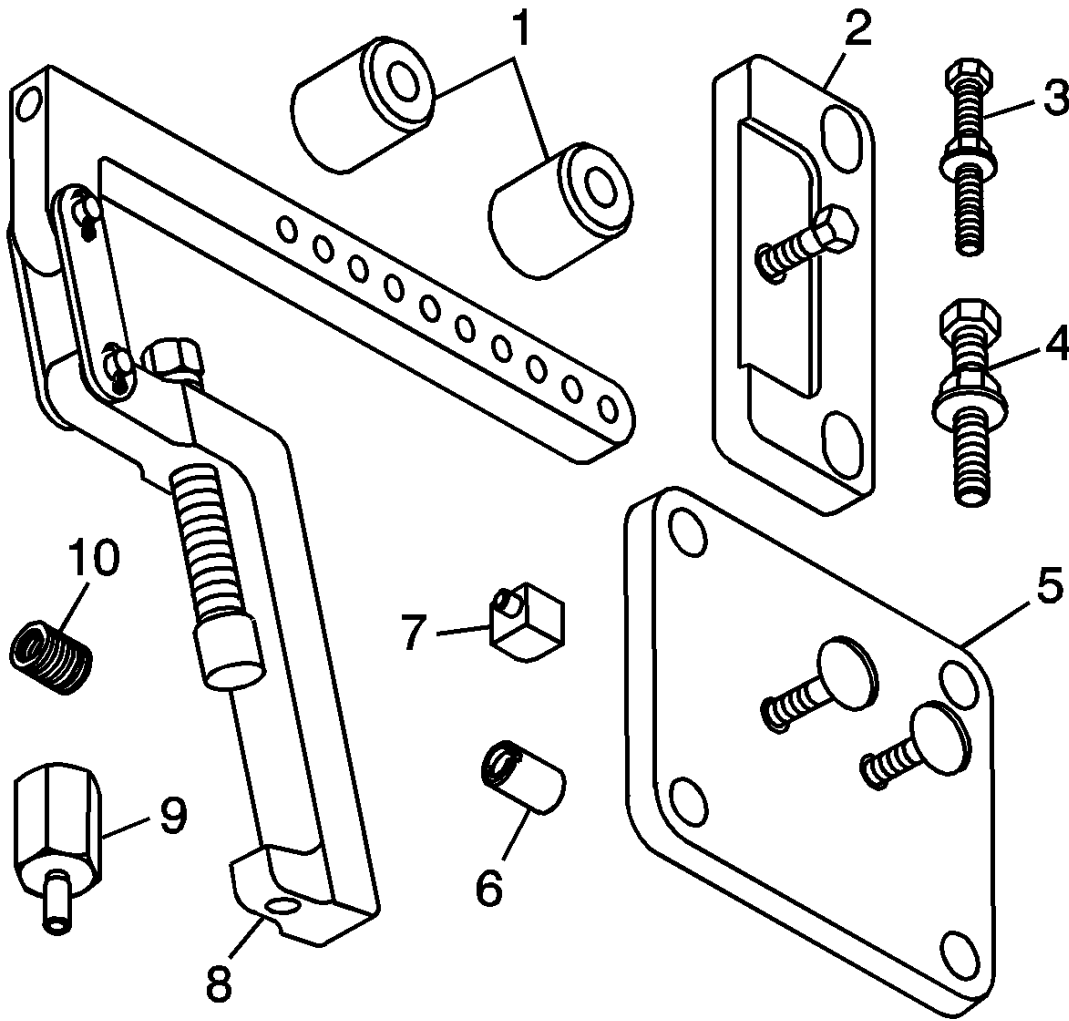


Fig. 314: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

J 43690-100 Rod Bearing Checking Tool - Adapter Kit. See Special Tools.

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- 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)

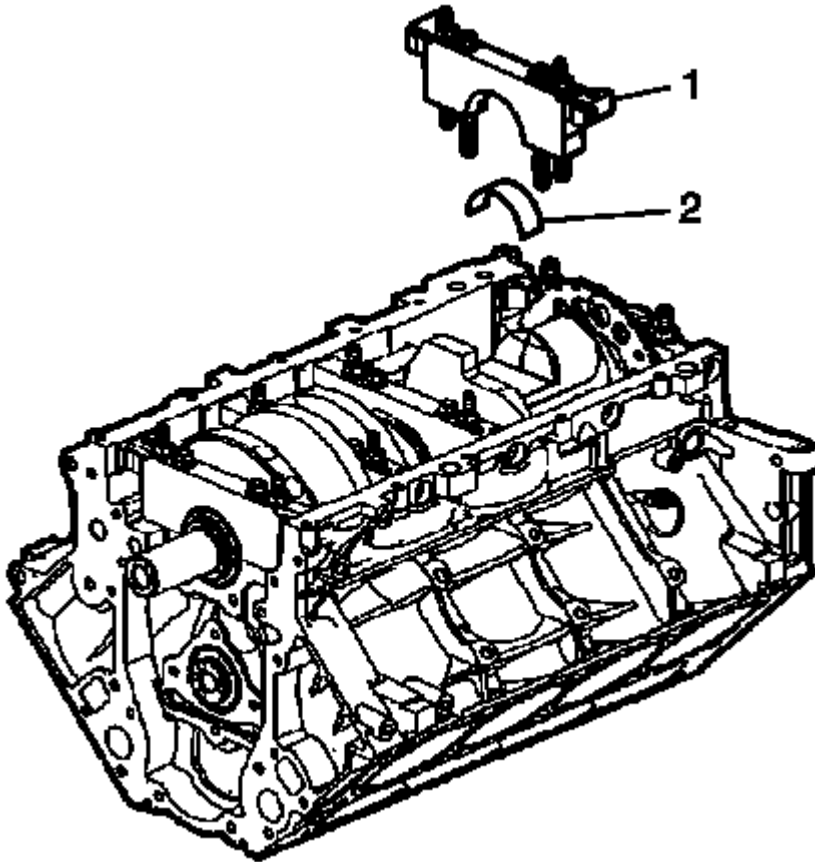


Fig. 315: View Of Bearing Cap, Bolt & Bearing Half
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

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**.

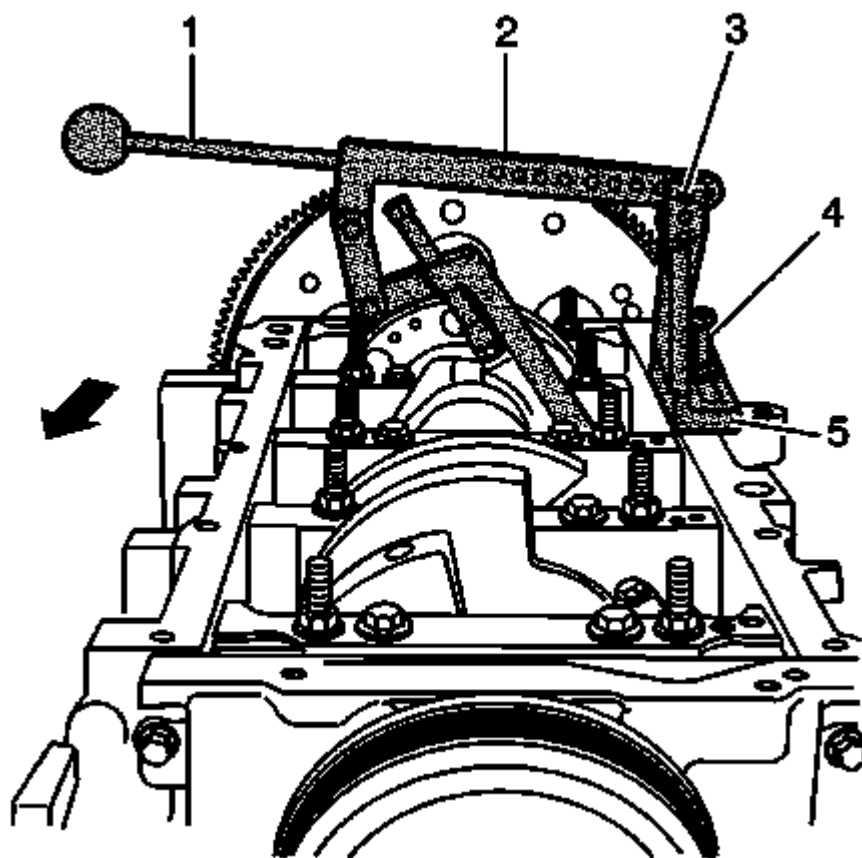


Fig. 316: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Install the following:
 1. J 43690-2 (5)
 2. J 43690-3 (4)
 3. J 43690-101 (2)
 4. 280310 (3)
 5. J 43690-5 (1)

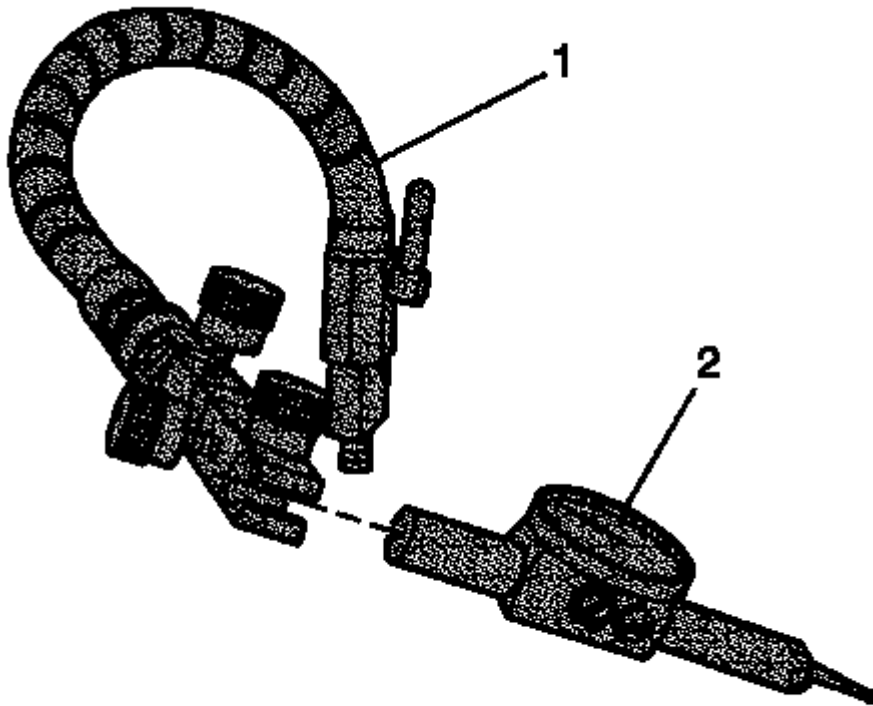


Fig. 317: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

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

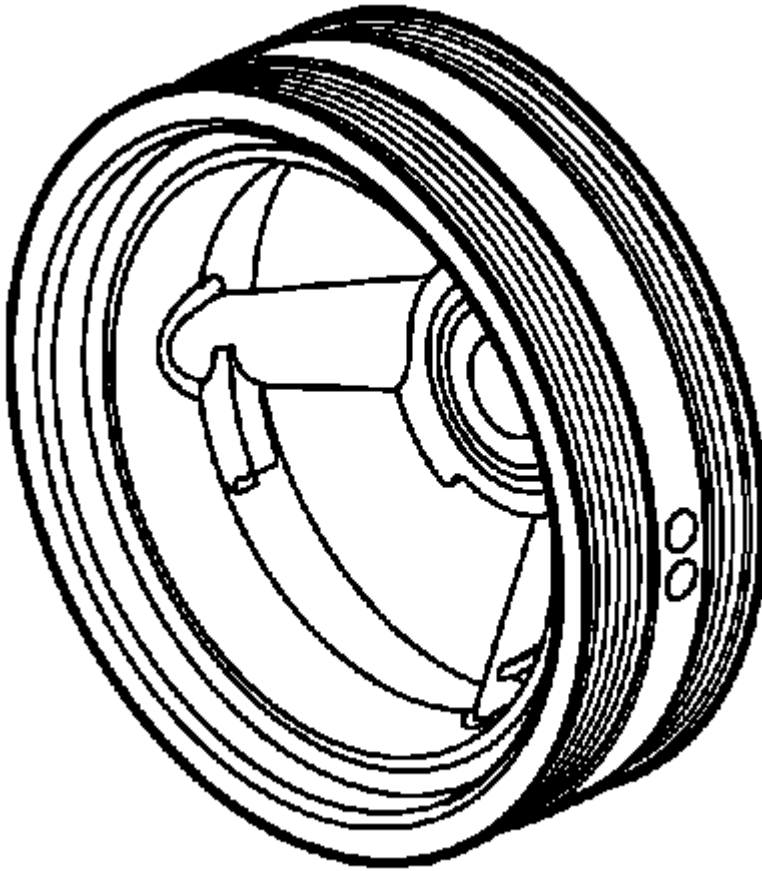


Fig. 318: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

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 between the hub and pulley

Engine Flywheel Cleaning and Inspection

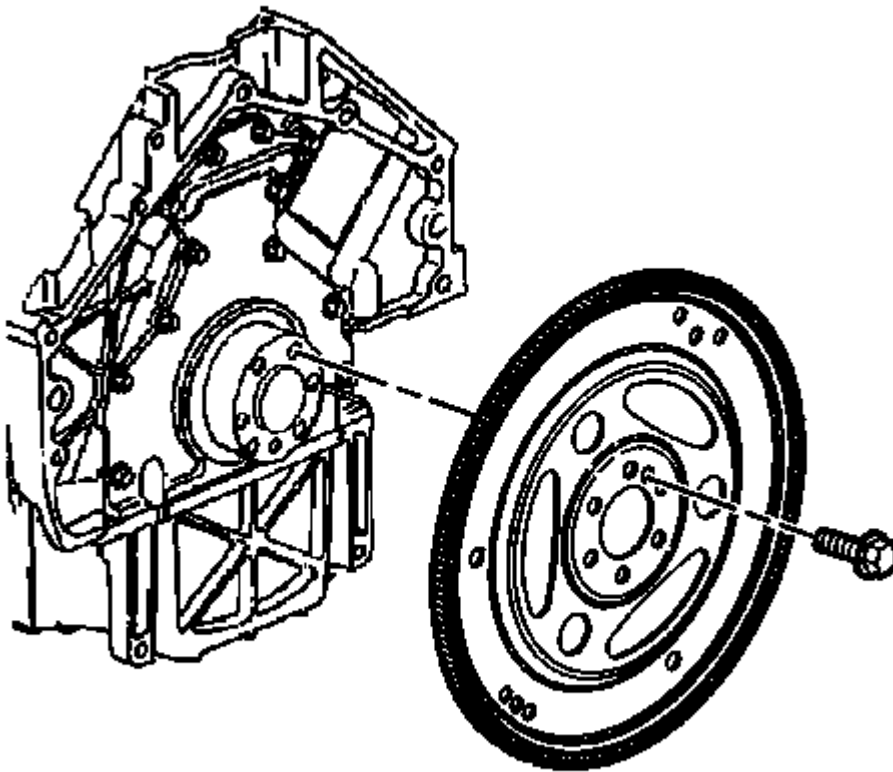


Fig. 319: Engine Flywheel

Courtesy of GENERAL MOTORS CORP.

1. Clean the automatic transmission flywheel in solvent.
2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following conditions:
 - Damaged ring gear teeth
 - Stress cracks around the flywheel-to-crankshaft bolt hole locations

IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to

the flywheel plate. Install a new flywheel.

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

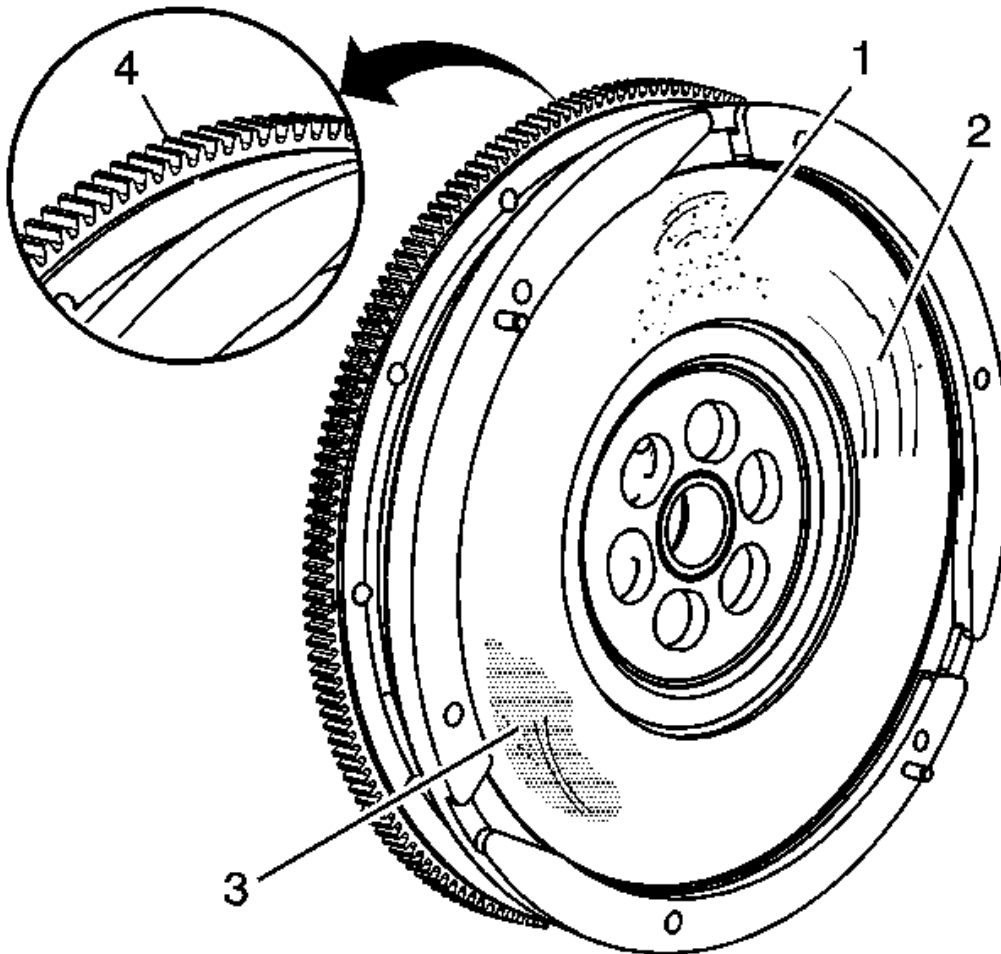


Fig. 320: Identifying Manual Transmission Flywheel Wear & Damage
Courtesy of GENERAL MOTORS CORP.

4. Clean the manual transmission flywheel in solvent.
5. Dry the flywheel with compressed air.
6. Inspect the flywheel for the following conditions:
 - Pitted surface (1)
 - Grooved or scored surface (2)

- Rusted surface (3)
- Damaged ring gear teeth (4)
- Loose or improperly positioned ring gear. The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.
- Missing, bent, or damaged pressure plate locating pins. The 2 locating pins are installed into the flywheel and spaced 170 degrees apart to ensure proper orientation of the clutch pressure plate to the engine flywheel during assembly.

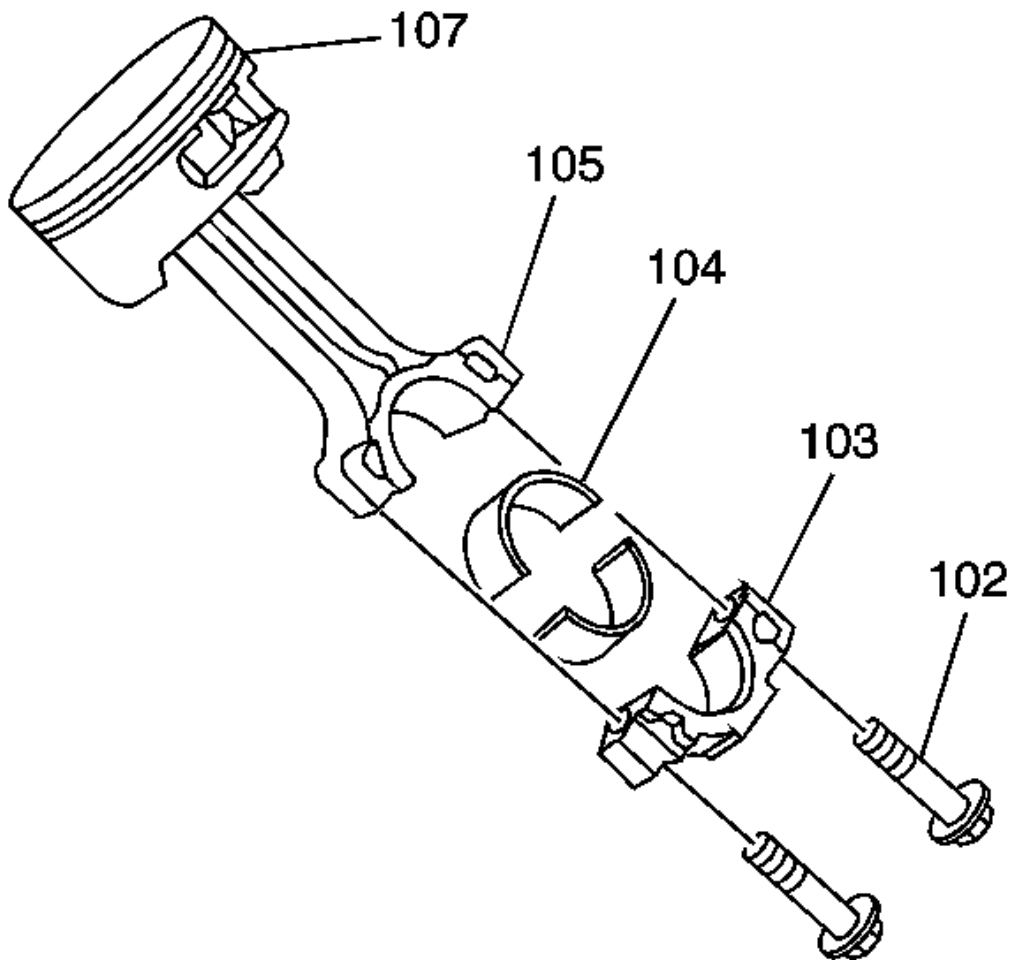
Piston and Connecting Rod Disassemble

Fig. 321: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings (104) from the rod (105) and cap (103).

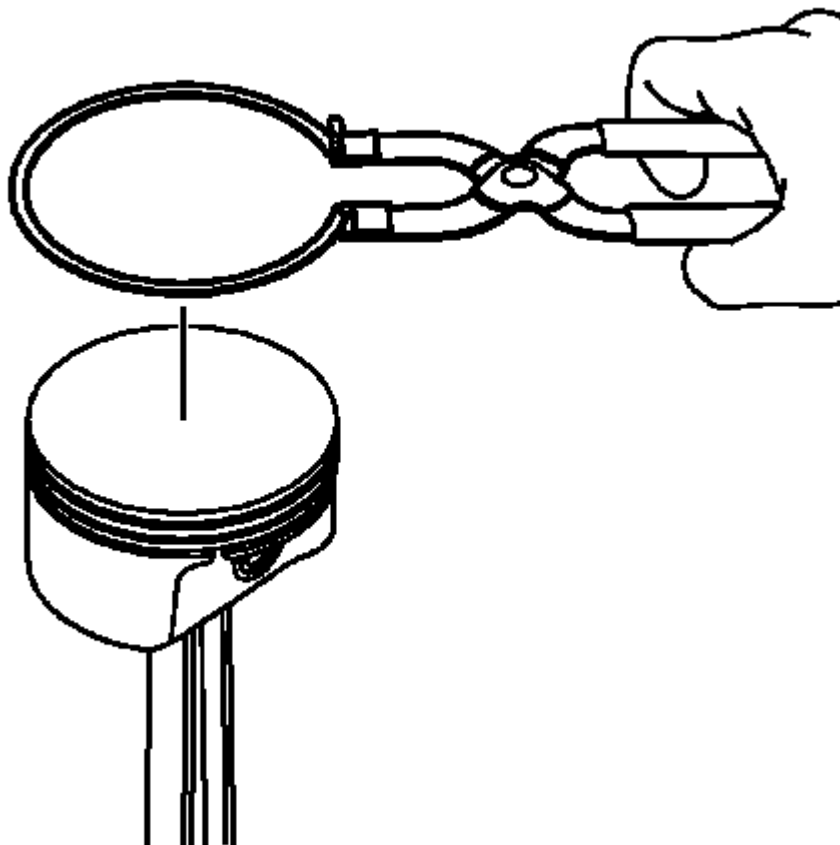


Fig. 322: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

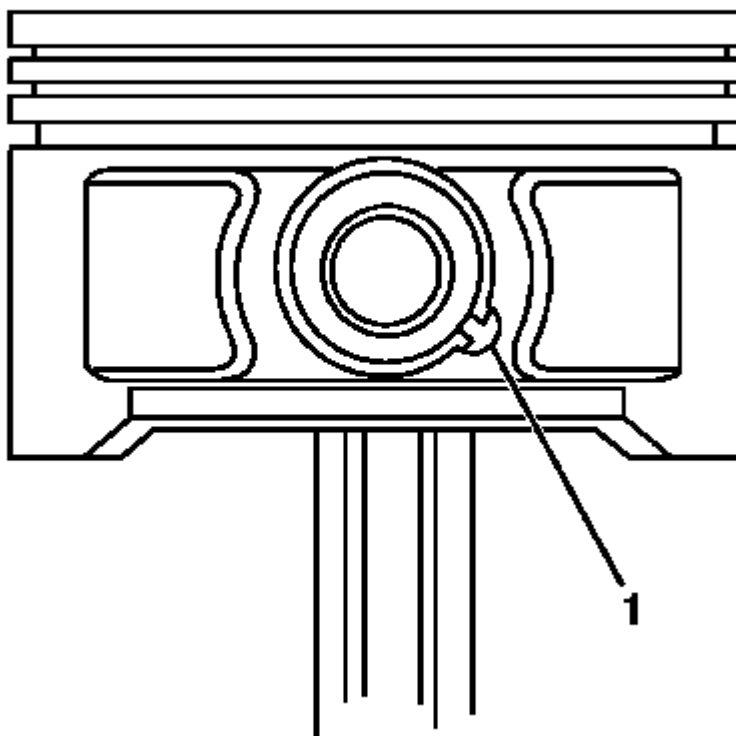


Fig. 323: View Of Piston Pin Retaining Clip & Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retainer until the ring end gap is positioned in the cutout area (1) of the pin bore.

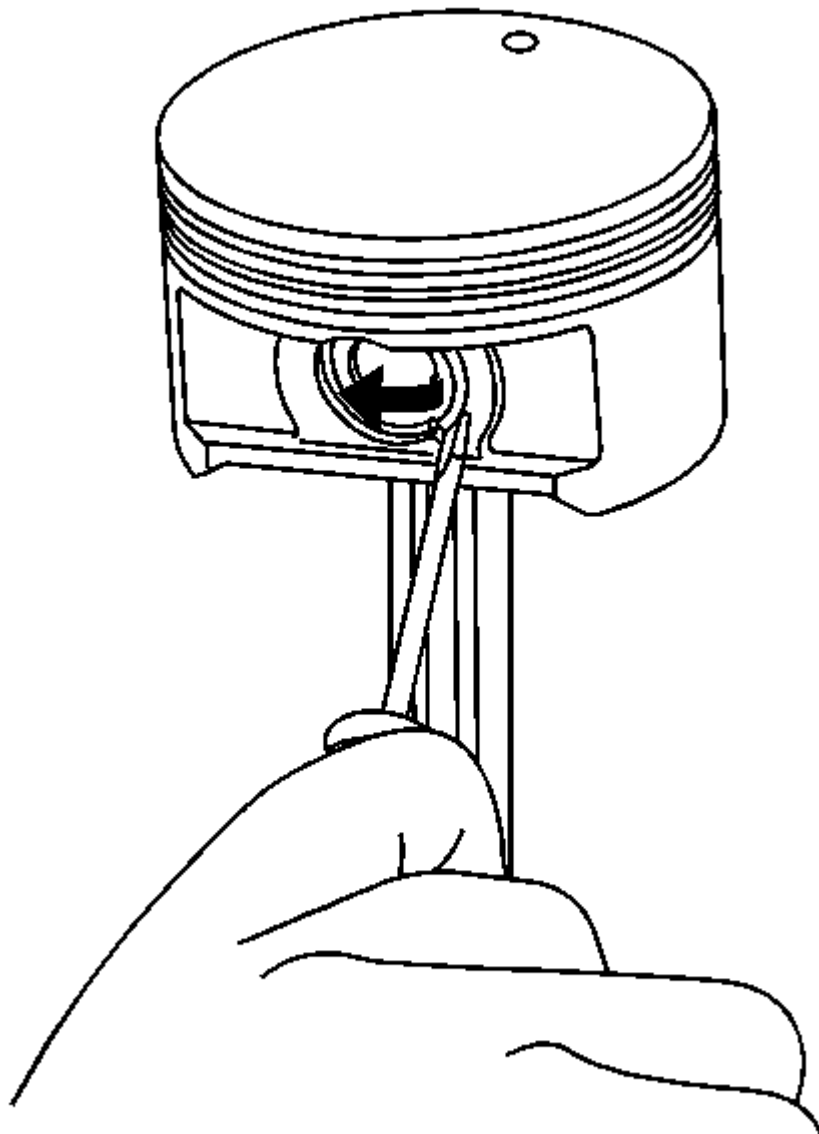


Fig. 324: Removing Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainer starting in the cutout area of the pin bore.

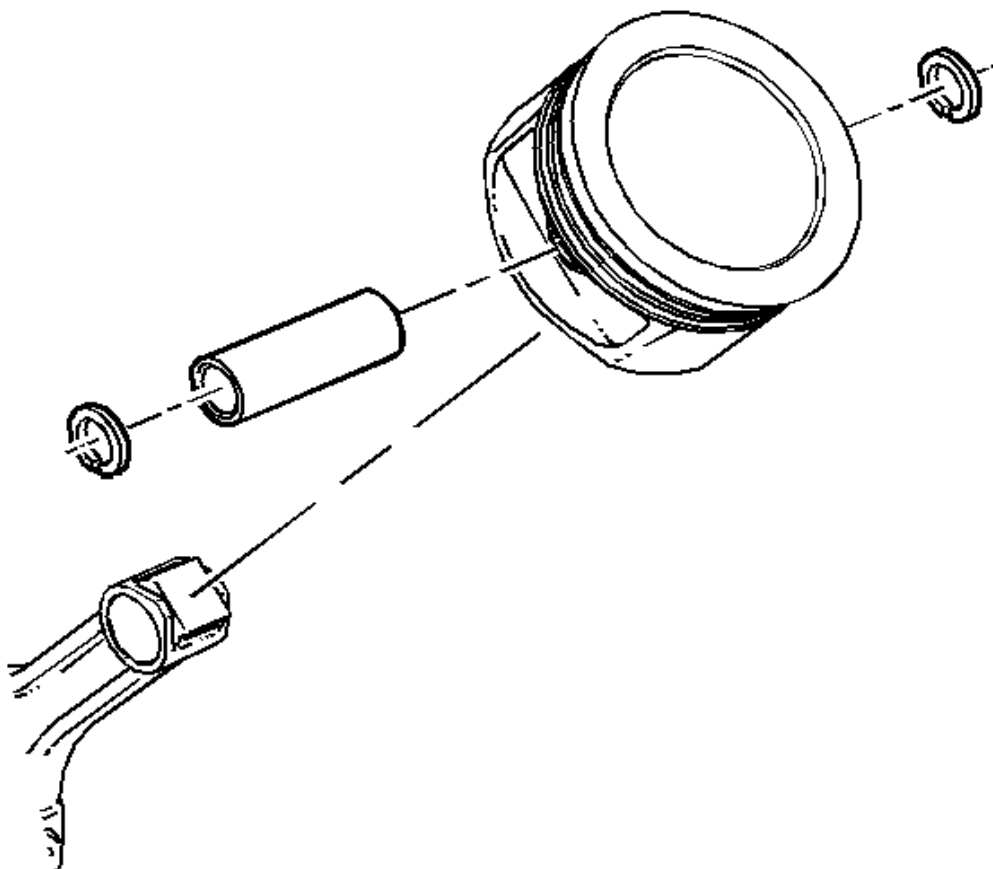


Fig. 325: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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 Bearings Cleaning and Inspection

Piston, Pin, and Piston Rings

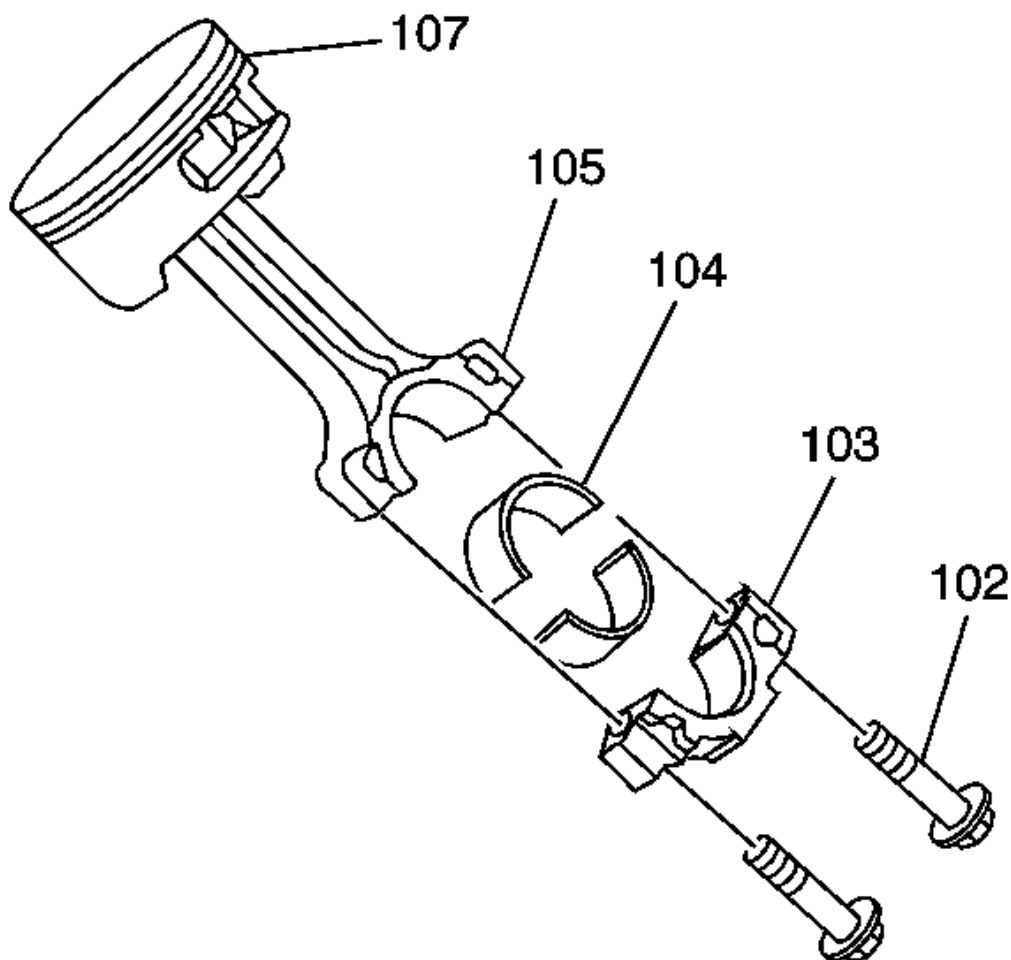


Fig. 326: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

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 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 in Cautions and Notices.

2. Dry the components with compressed air.

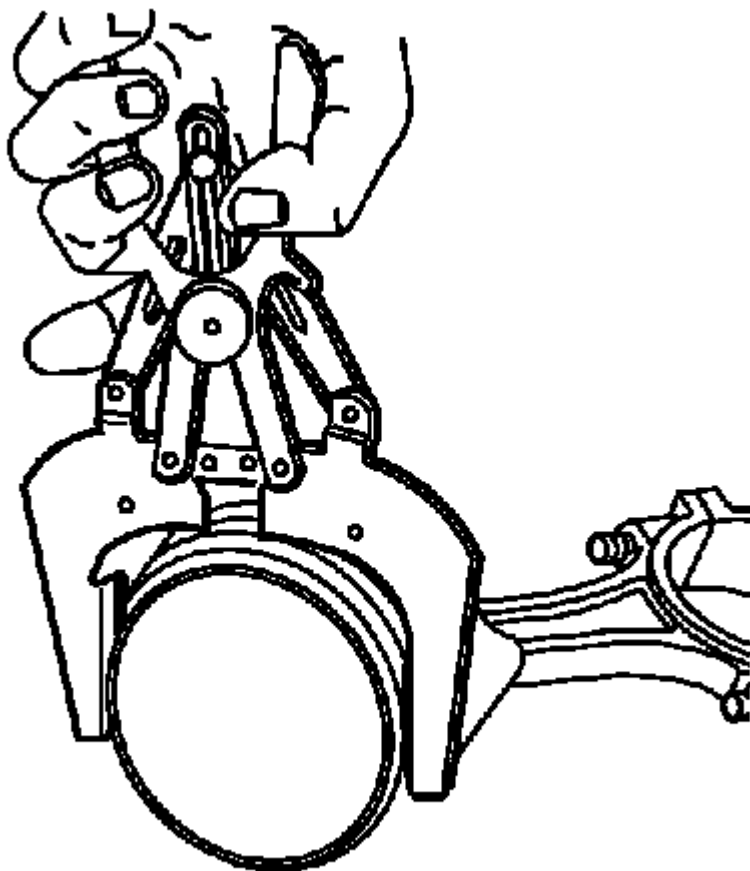


Fig. 327: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

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

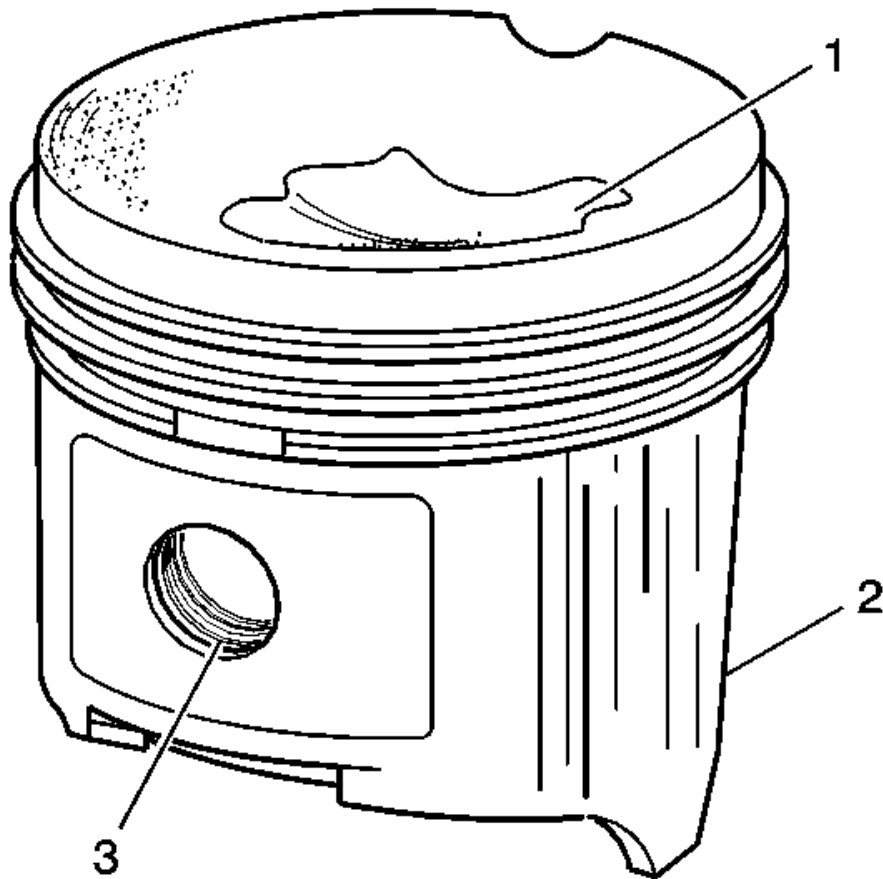


Fig. 328: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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.

- 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

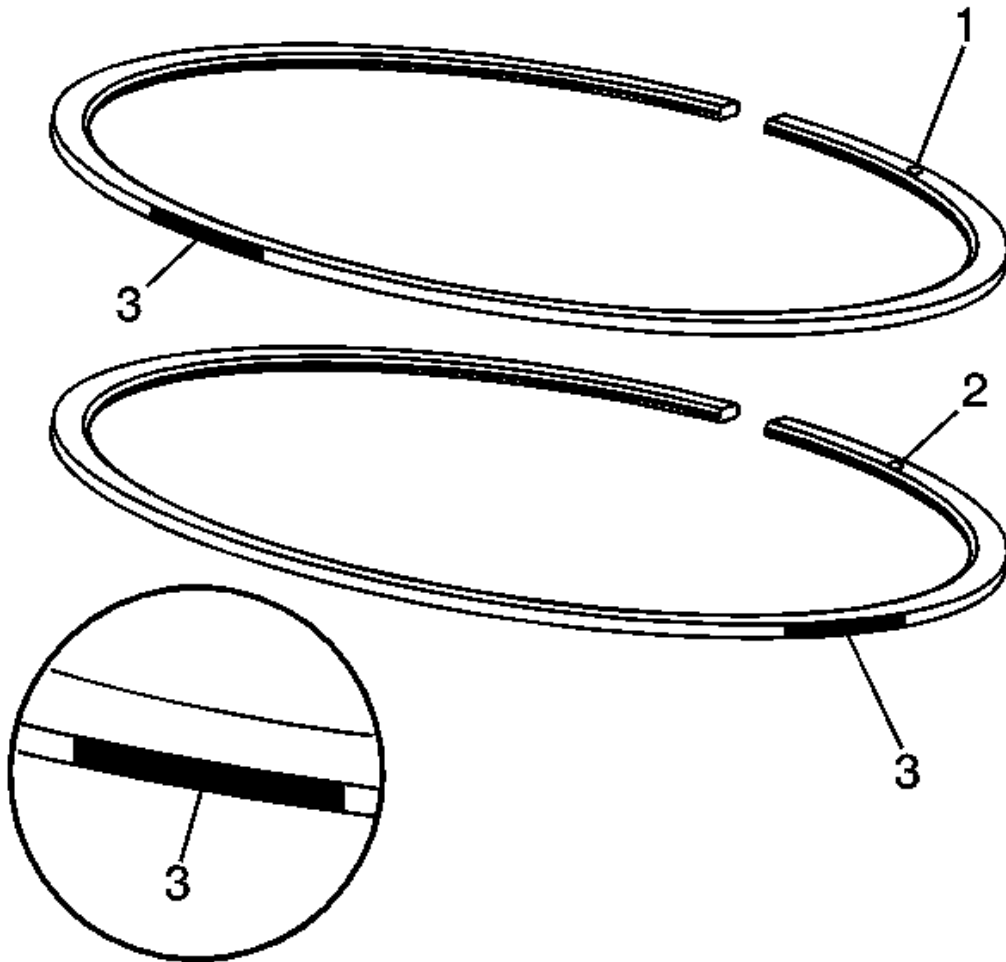


Fig. 329: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

6. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

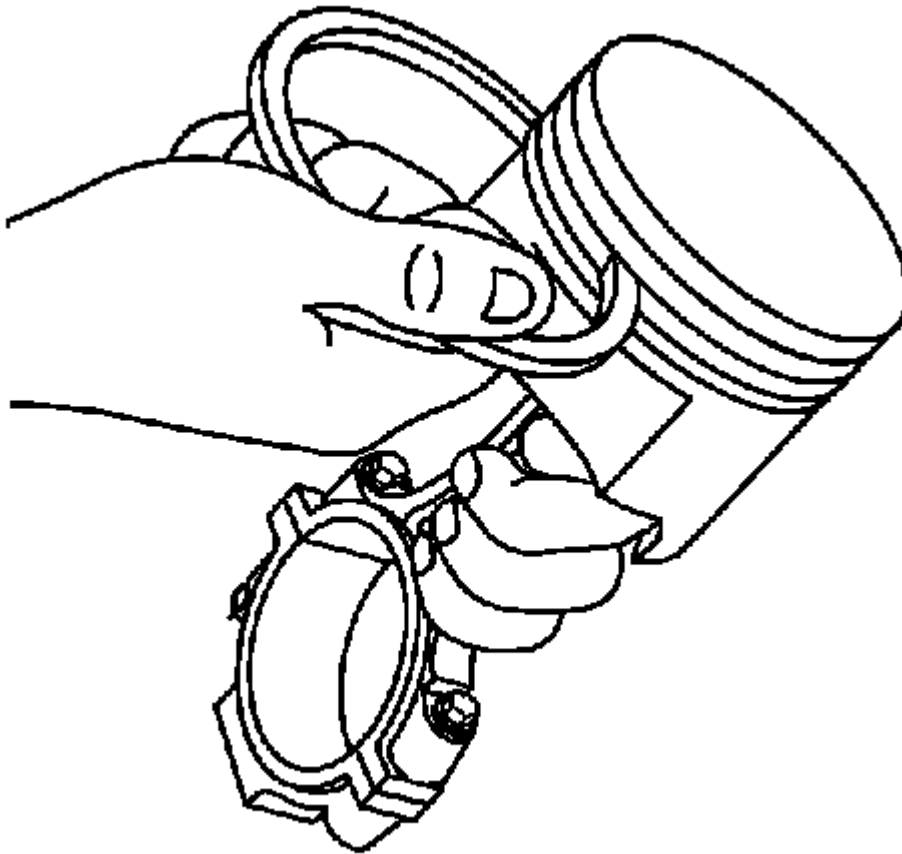


Fig. 330: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. 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 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.

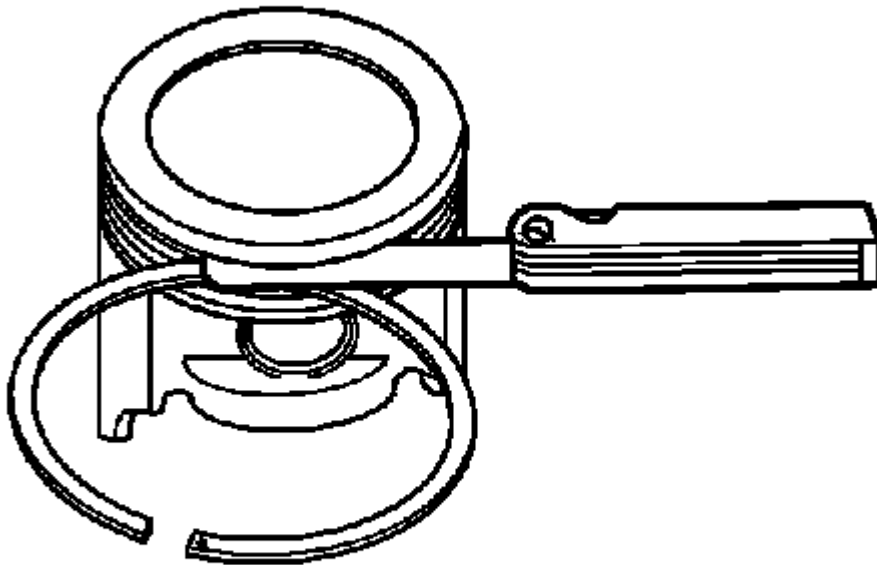


Fig. 331: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. 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**.

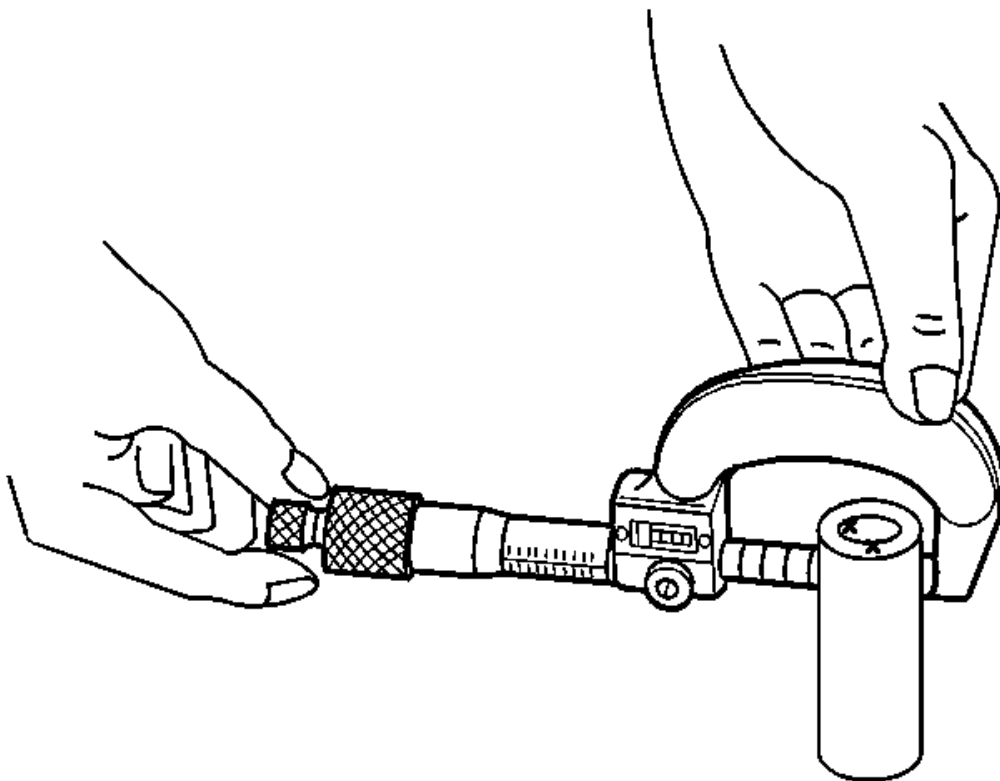


Fig. 332: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

9. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

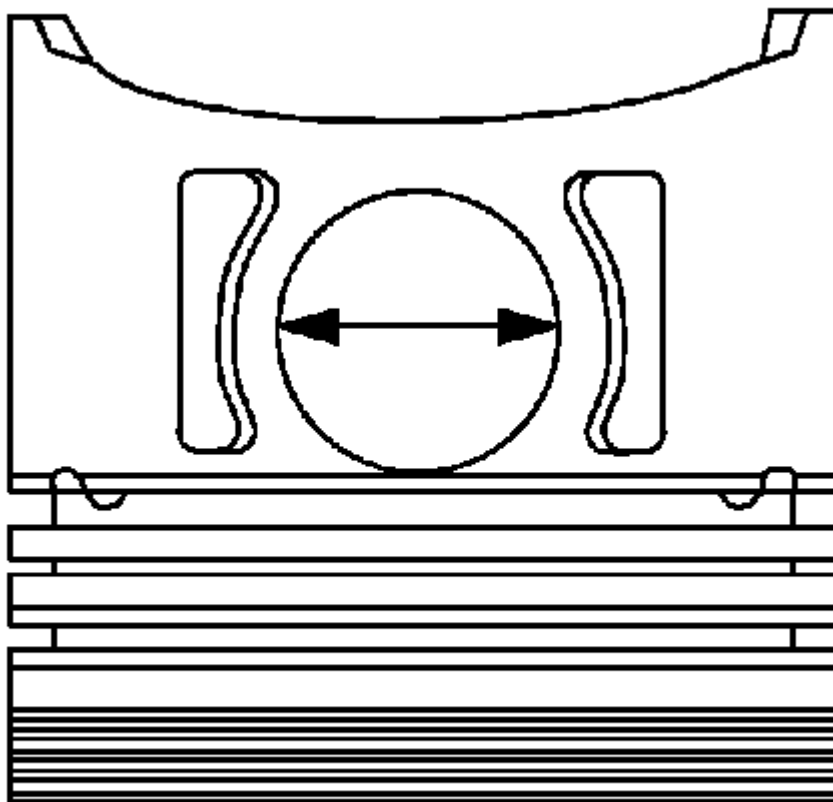


Fig. 333: Measuring The Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

10. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
11. 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

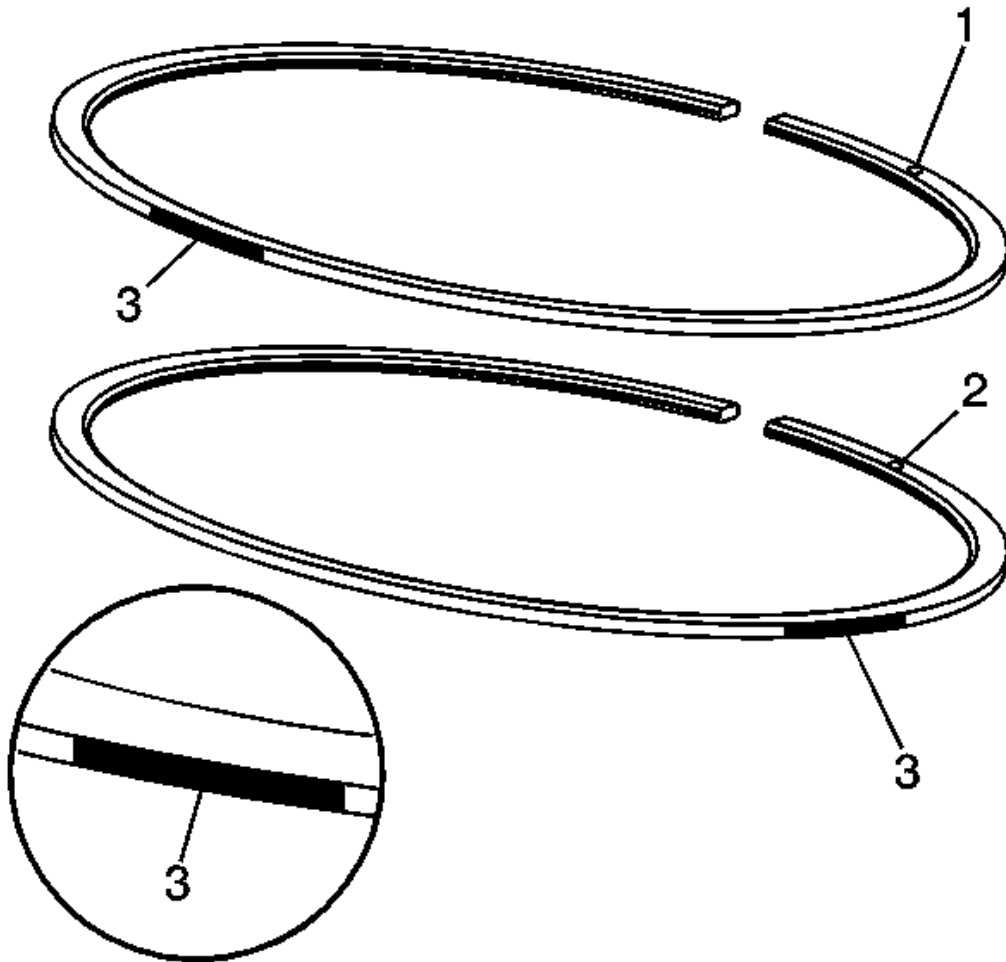


Fig. 334: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.
- Measure the piston ring in the cylinder in which it will be used.

1. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

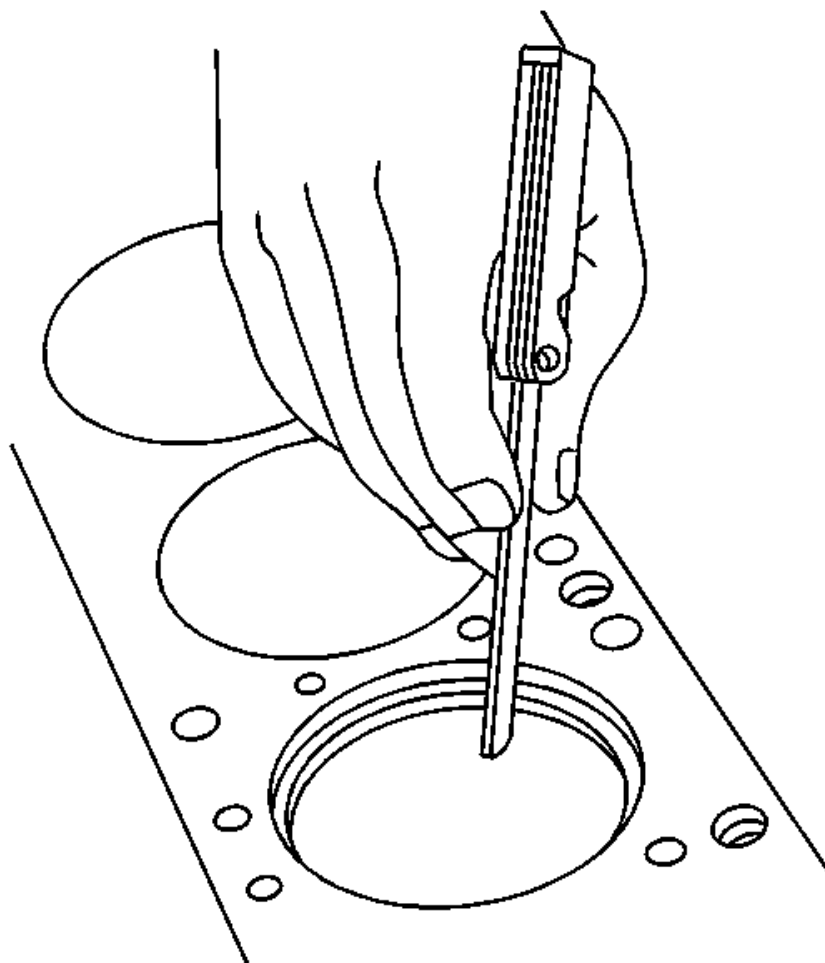


Fig. 335: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

2. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area.
3. Insert a feeler gage and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings

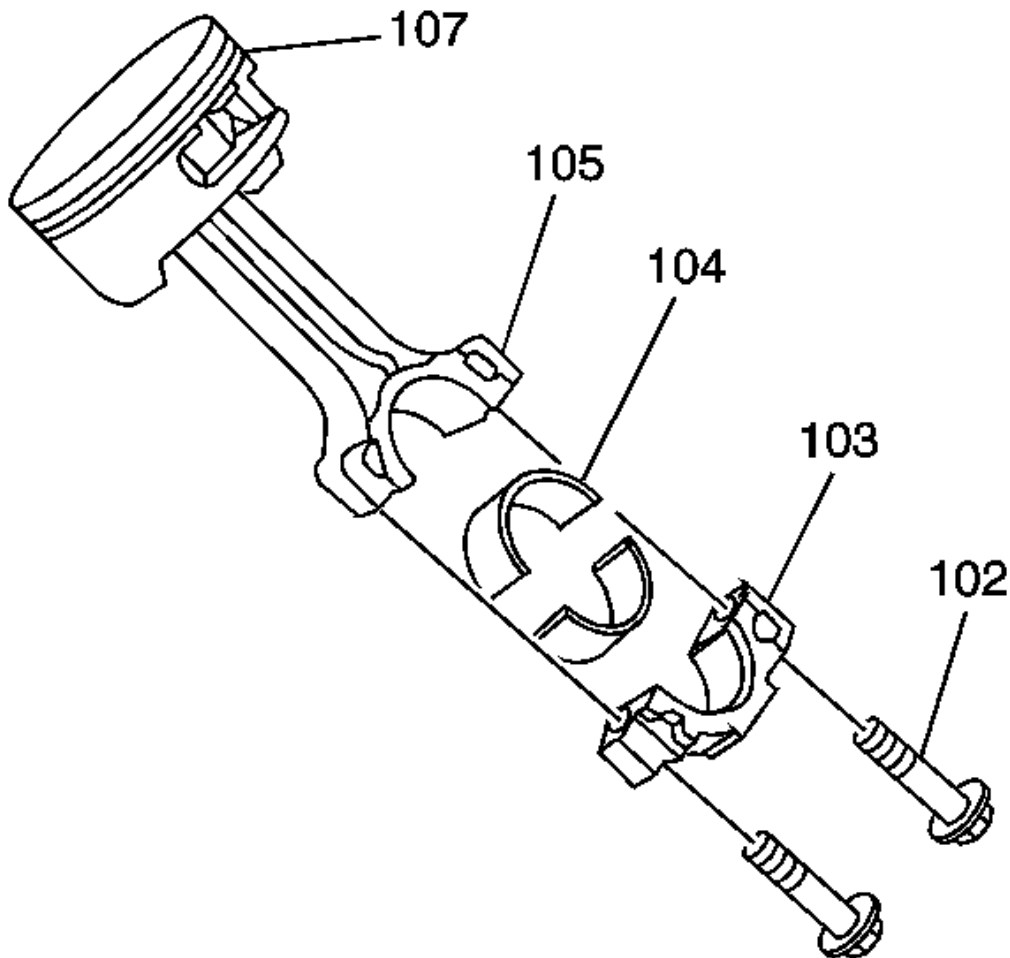


Fig. 336: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

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 and pin 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 in Cautions and Notices.

2. Dry the components with compressed air.

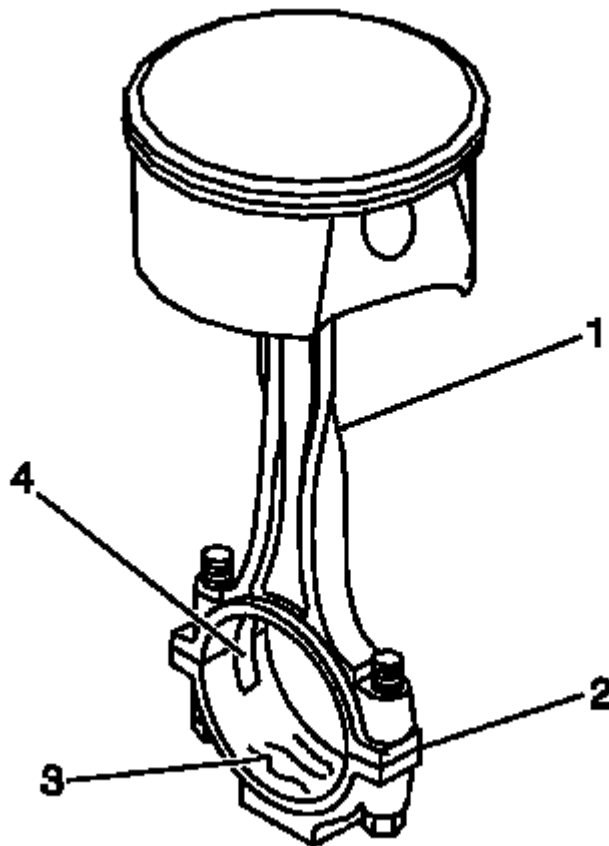


Fig. 337: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the connecting rod for the following conditions:
 - Twisting (1)
 - 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)

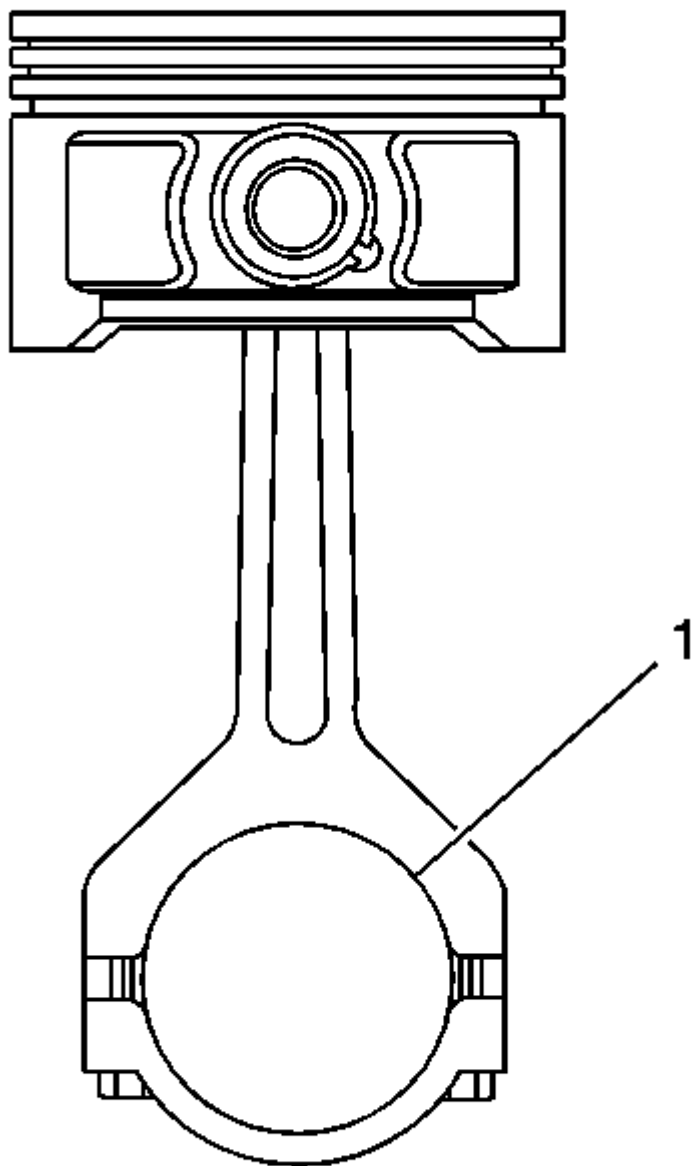


Fig. 338: View Of Connecting Rod Bearing Bore
Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore (1) for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

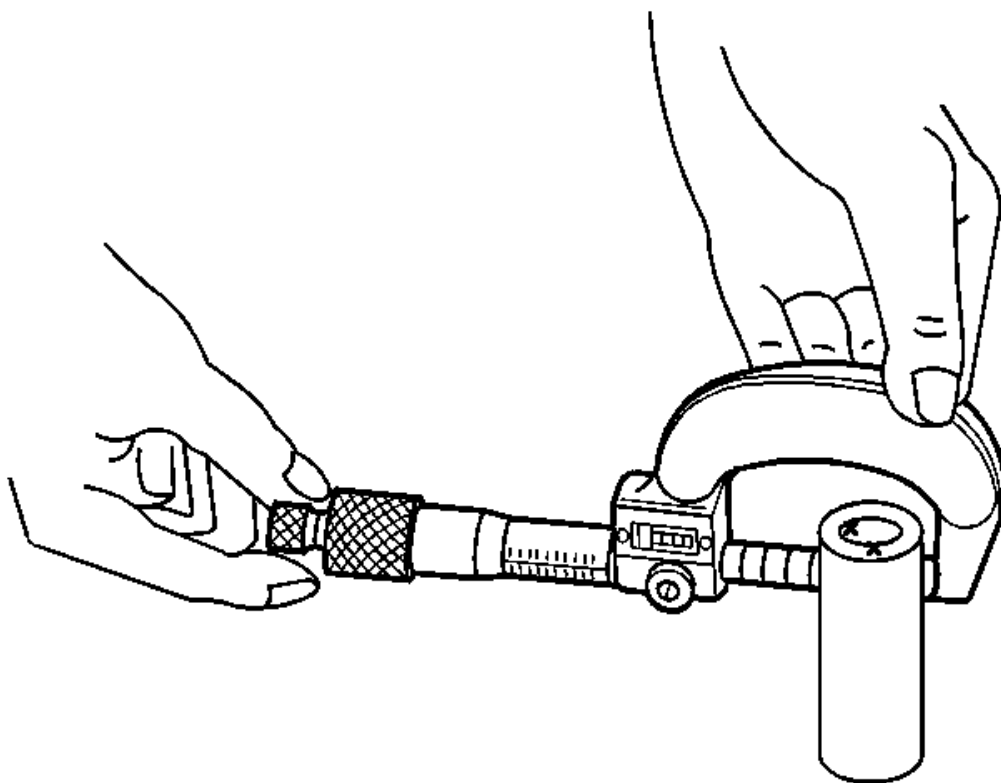


Fig. 339: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. To determine full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

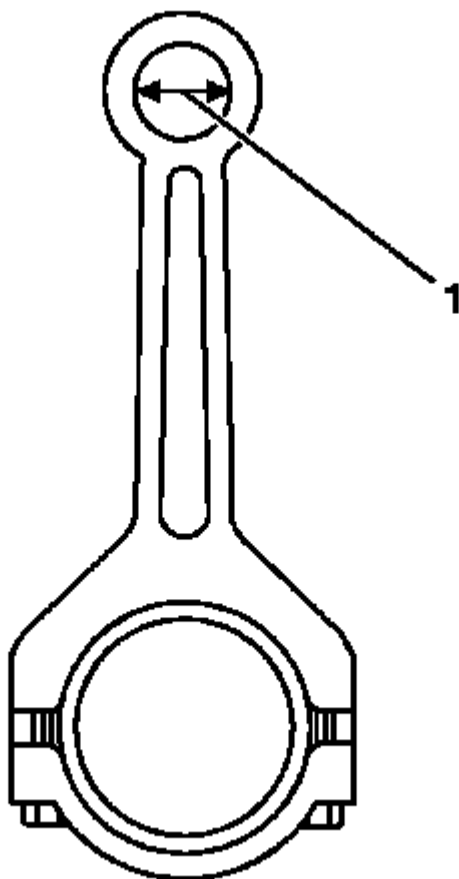


Fig. 340: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS CORP.

6. To determine the full-floating piston pin-to-connecting rod bore clearance, use 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**.

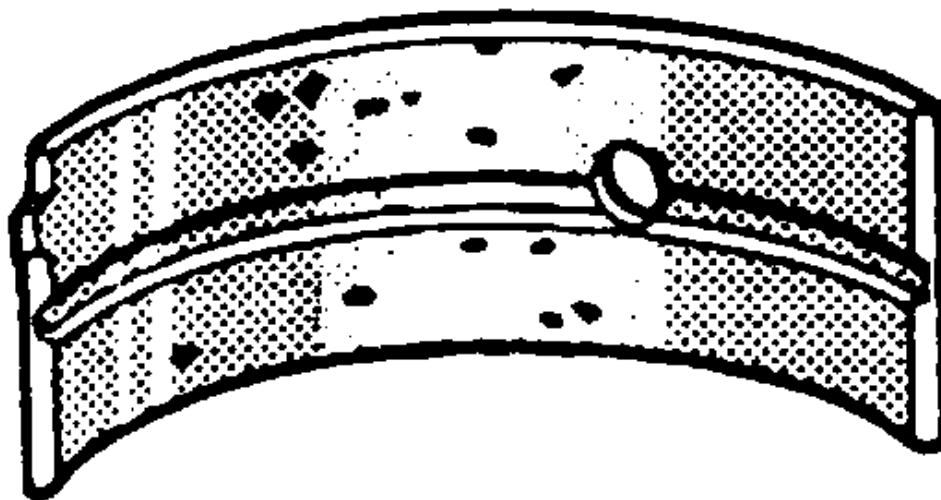


Fig. 341: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

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

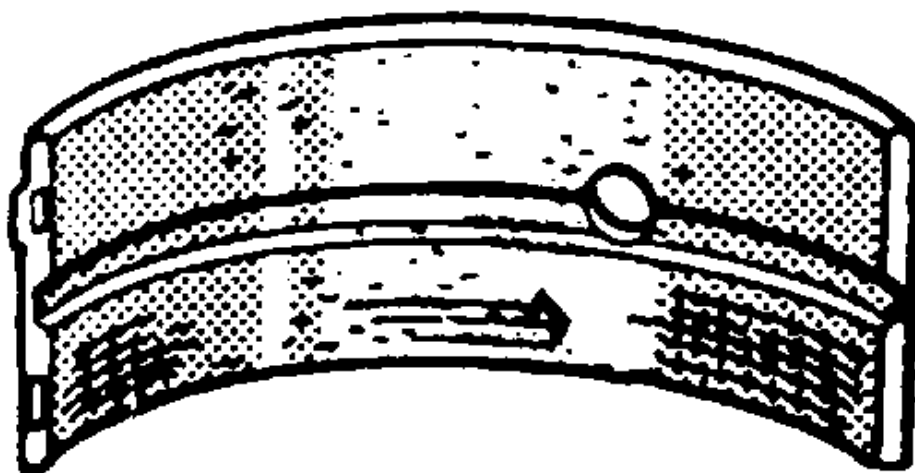


Fig. 342: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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.

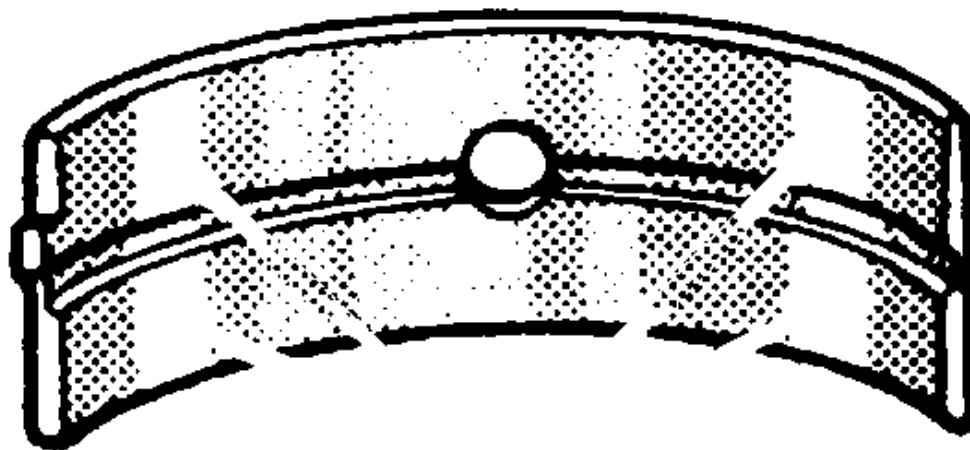


Fig. 343: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.

Piston and Connecting Rod Assemble

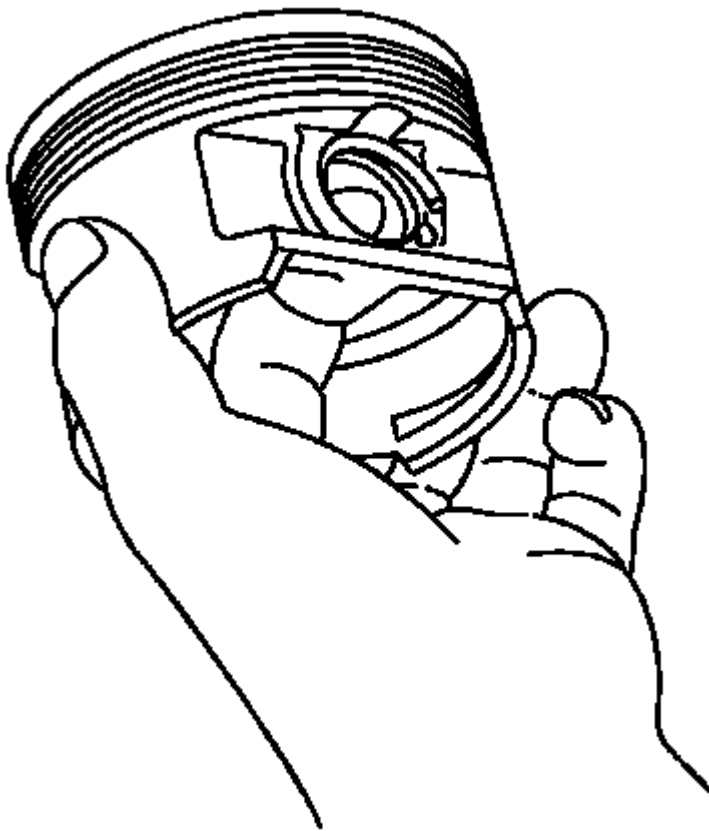


Fig. 344: View Of Retaining Clip In Pin Bore Groove
Courtesy of GENERAL MOTORS CORP.

1. Install the retaining clip. The clip should be seated in the groove of the pin bore.

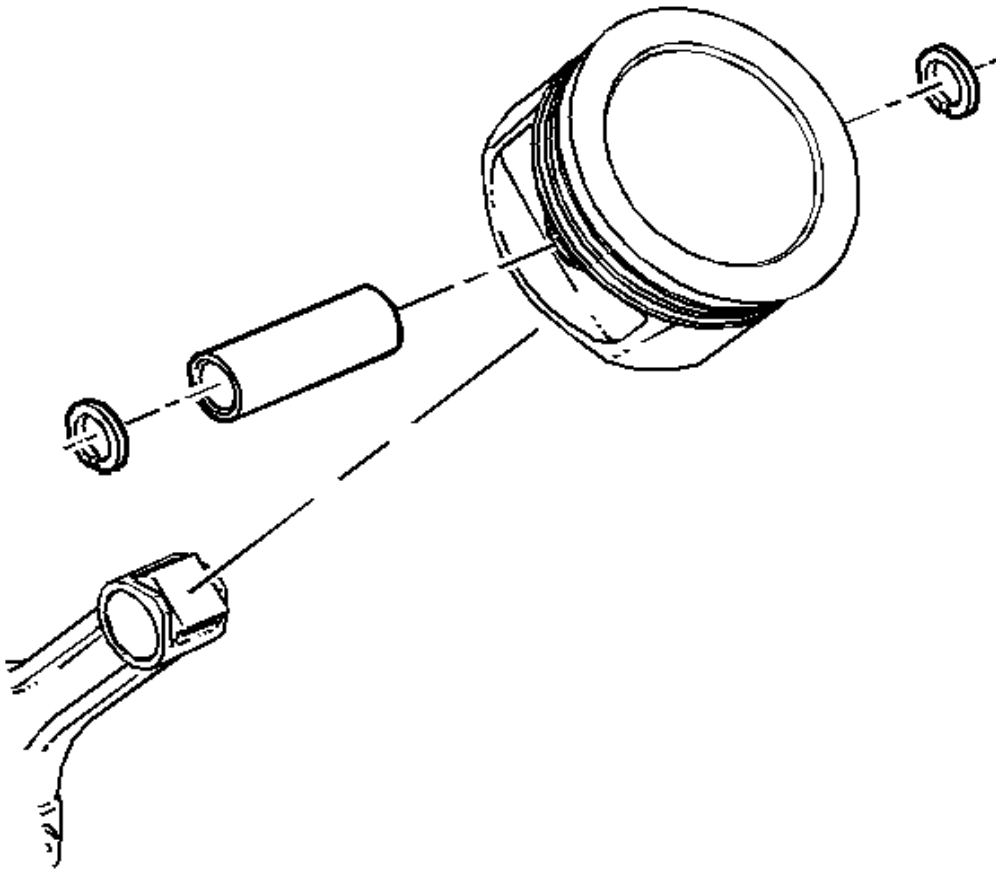


Fig. 345: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

2. Install the piston pin to the piston and connecting rod.
3. Install the retainers. The retainers should be seated in the groove of the pin bore.

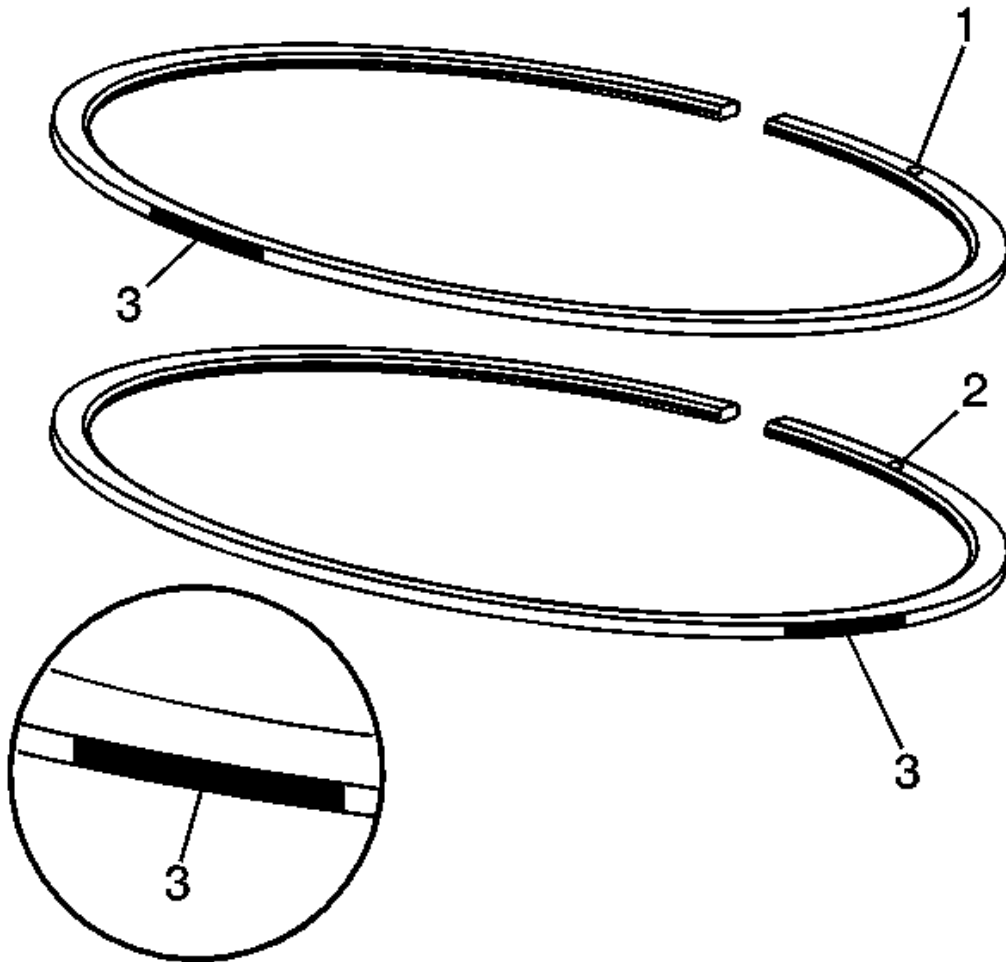


Fig. 346: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

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.

4. Identify the compression and oil control rings for proper installation. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

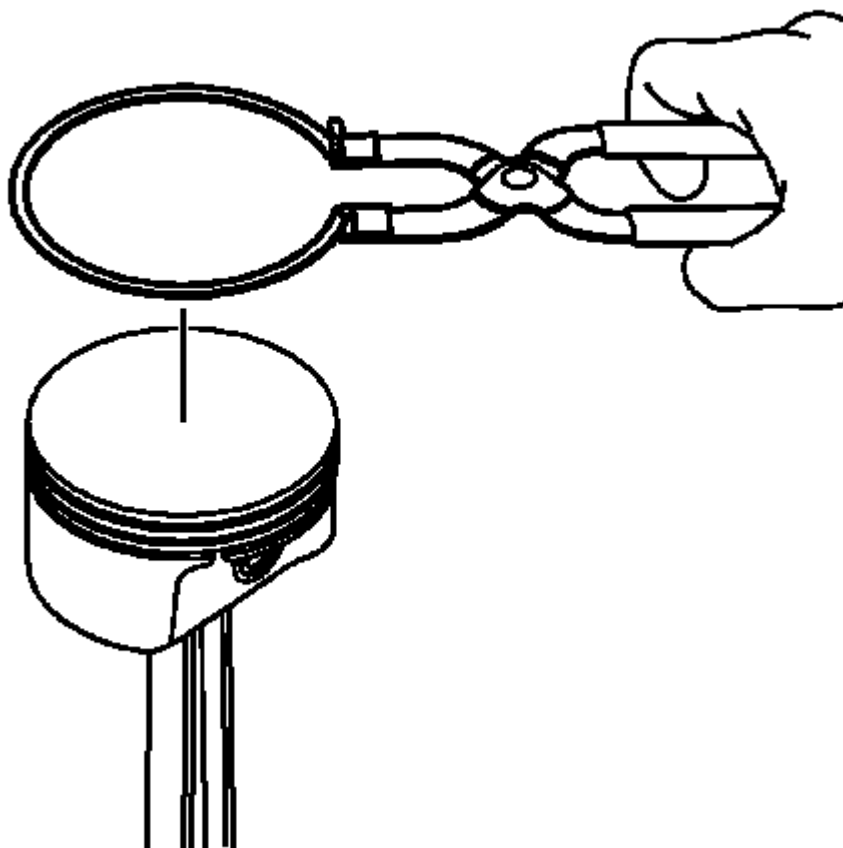


Fig. 347: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

5. Using piston ring pliers, install the piston rings onto the piston.
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.

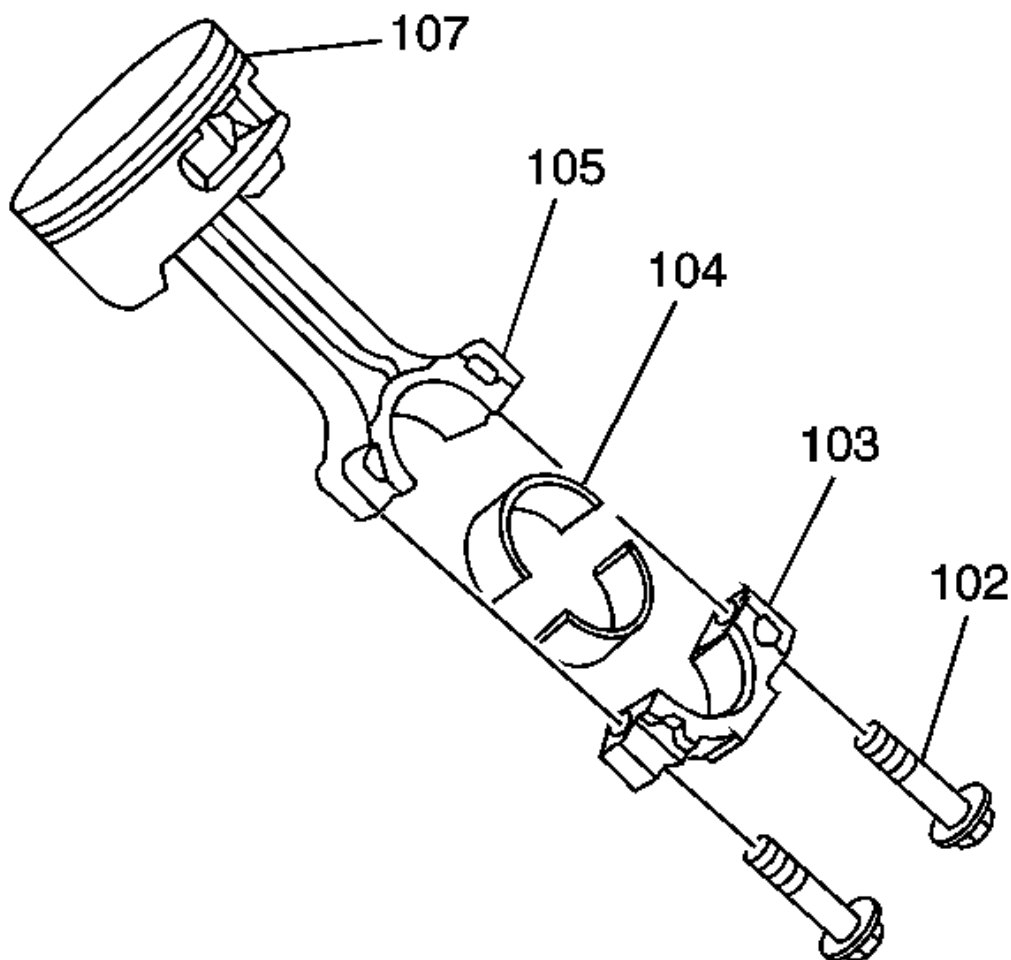


Fig. 348: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod bearings (104) to the rod (105) and cap (103).

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

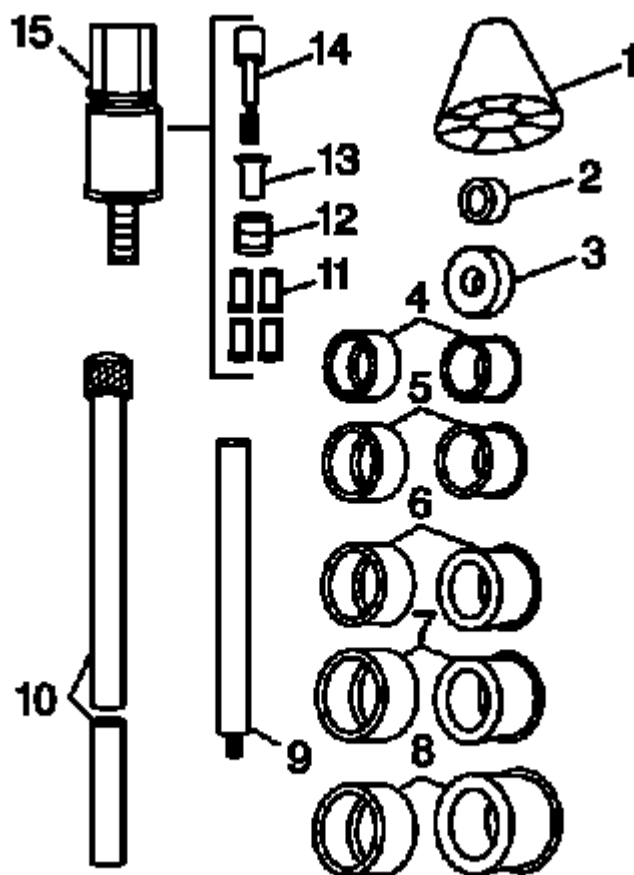


Fig. 349: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

- 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 sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).
- Expander bearing driver number one 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 two inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number one expanding driver and the small washer.
- Expander bearing driver number three inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number two expanding driver and the large washer.
- Expander bearing driver number four inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number three expanding driver and the large washer.
- Expander bearing driver number five inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with number four expanding driver and the large washer.
- Expander bearing driver number six inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number five 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. Check to insure that the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. Place the guide cone over the driving bar, with the small end of the cone facing the driver assembly.
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.

It may be necessary to install the driver bar extension for removal of the inner bearings.

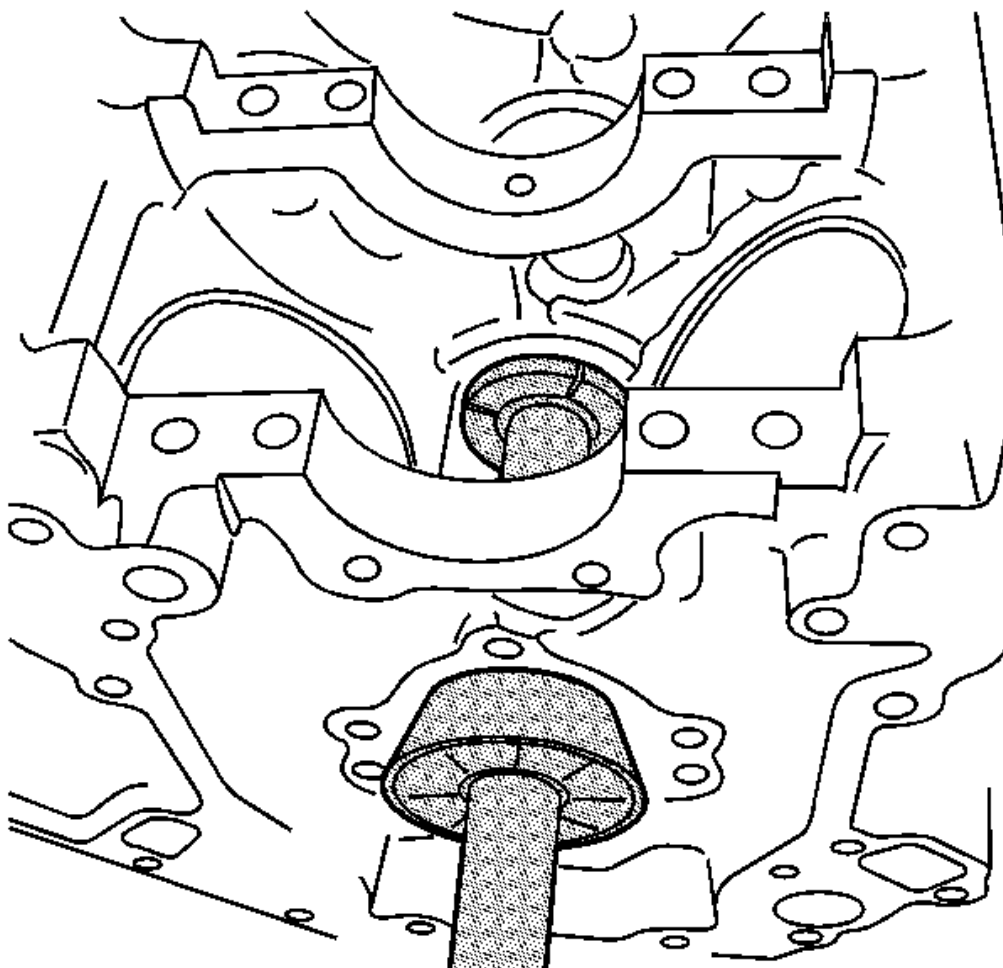


Fig. 350: View Of J 33049 Camshaft Bearing Tool & Nylon Cone
Courtesy of GENERAL MOTORS CORP.

7. Insert the tool into a 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 enlarge and reduce the expander assembly.

8. Slide the nylon cone into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.

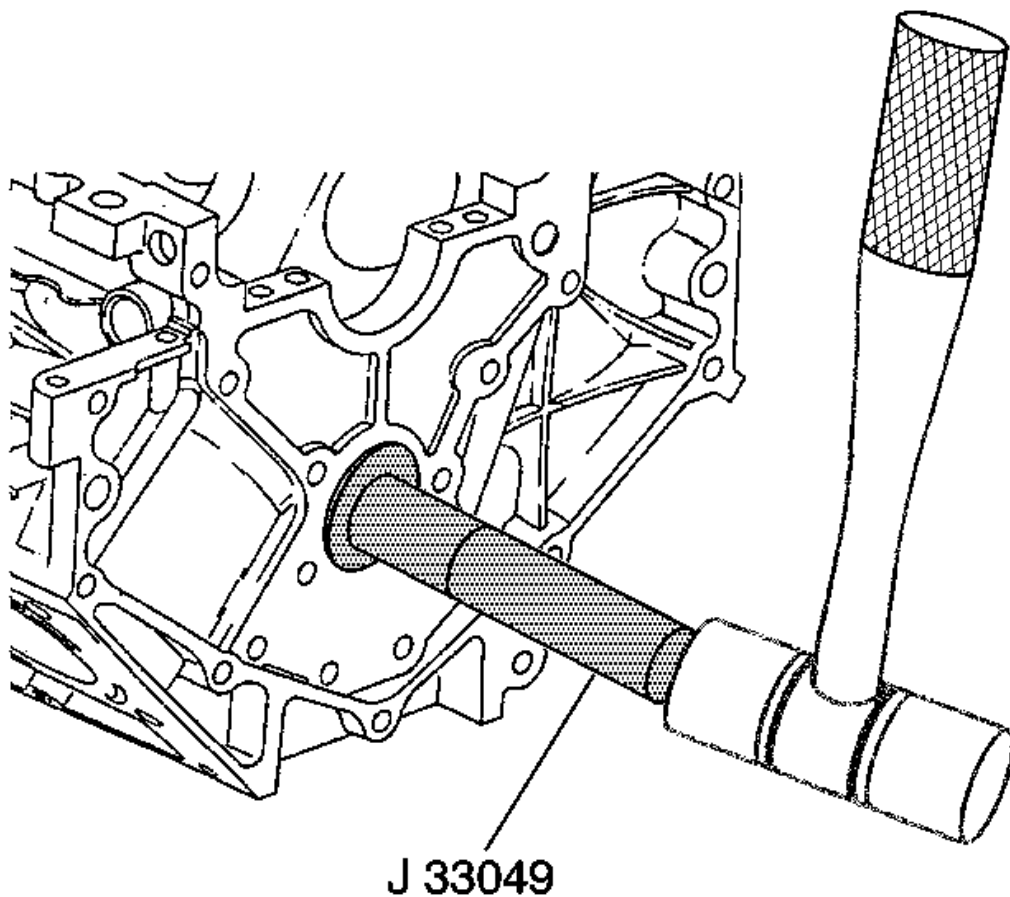


Fig. 351: Driving Bearing From/Into Block Bore
Courtesy of GENERAL MOTORS CORP.

11. For the two end bearings, front and rear, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

Removal Procedure

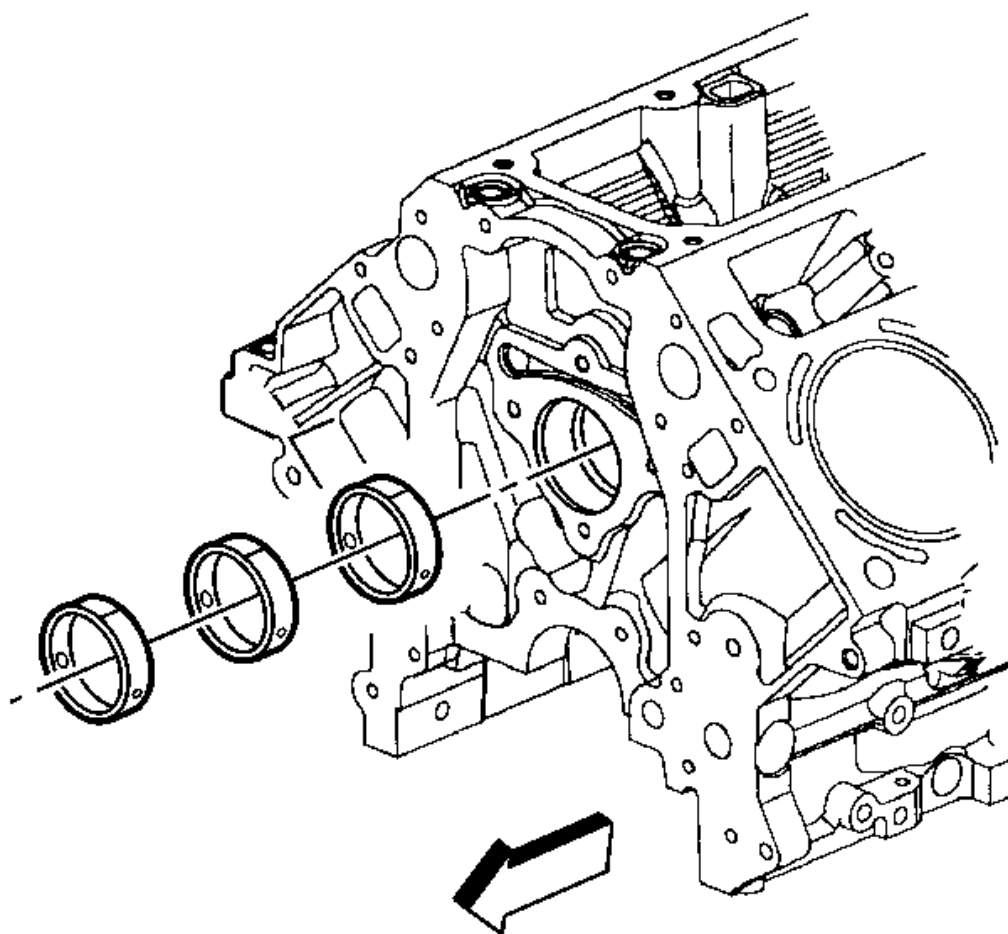


Fig. 352: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.

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.

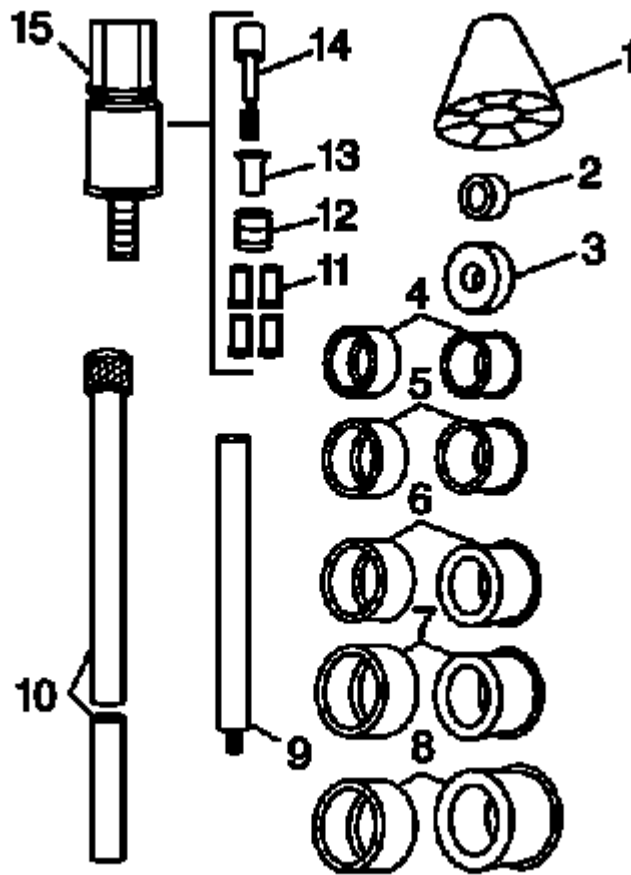


Fig. 353: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . See **Special Tools**.
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 to align the tool.

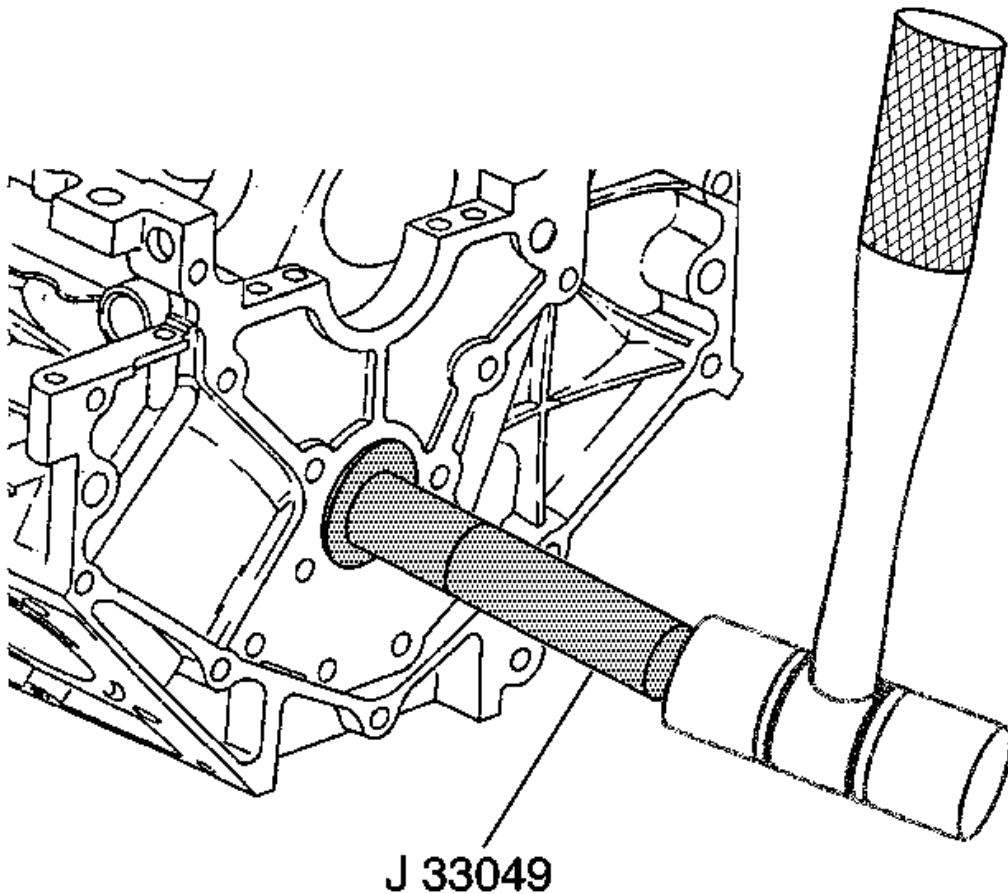


Fig. 354: Driving Bearing From/Into Block Bore
Courtesy of GENERAL MOTORS CORP.

8. Drive the bearing from the block bore.

IMPORTANT: 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.

9. Repeat the above procedures to remove the remaining bearings.

Camshaft and Bearings Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator Set. See **Special Tools**.
- **J 8520** Camshaft Lobe Lift Indicator. See **Special Tools**.

General Procedure

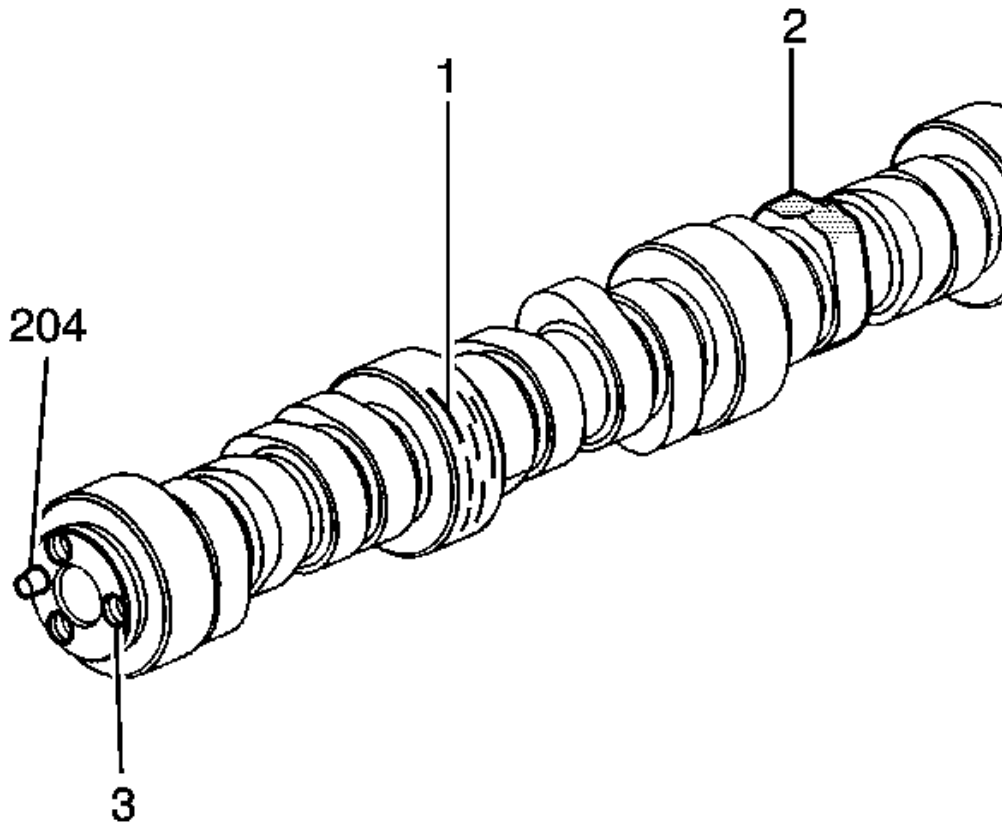


Fig. 355: Identifying Camshaft & Bearing Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Clean the components in solvent.

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

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 holes (3) in the front of the camshaft for damaged threads or debris.
6. Inspect the camshaft sprocket pin (204) for damage.

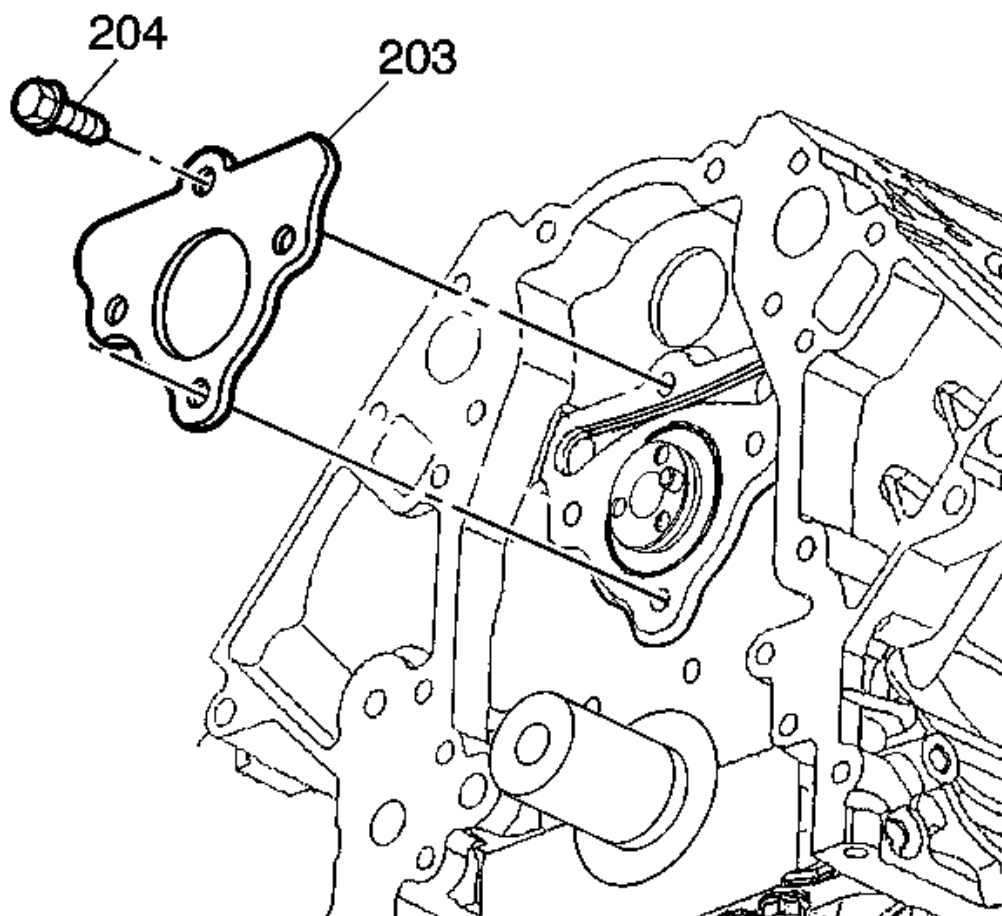


Fig. 356: Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Inspect the camshaft retainer plate (203) for wear or a damaged sealing gasket.

If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

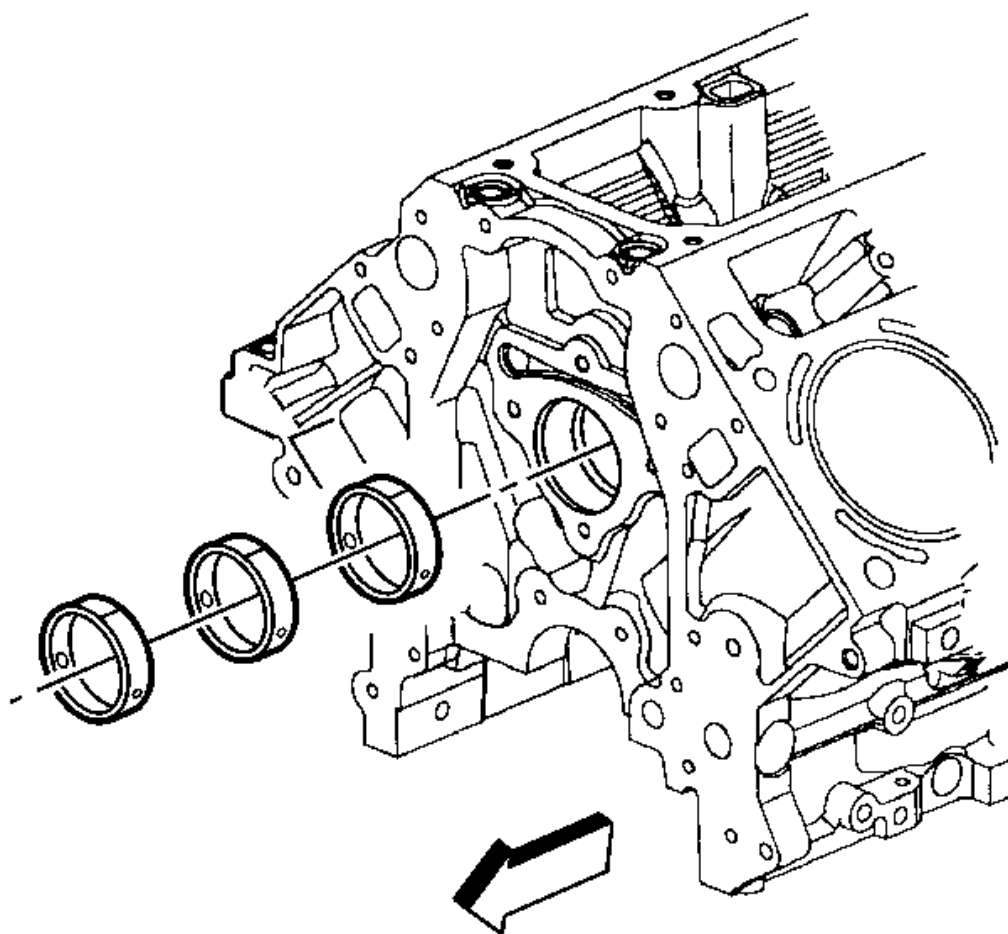


Fig. 357: View Of Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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 their engine block bearing bores.
9. Inspect the camshaft bearings for excessive wear or scoring.

Bearings with excessive scoring or wear must be replaced.

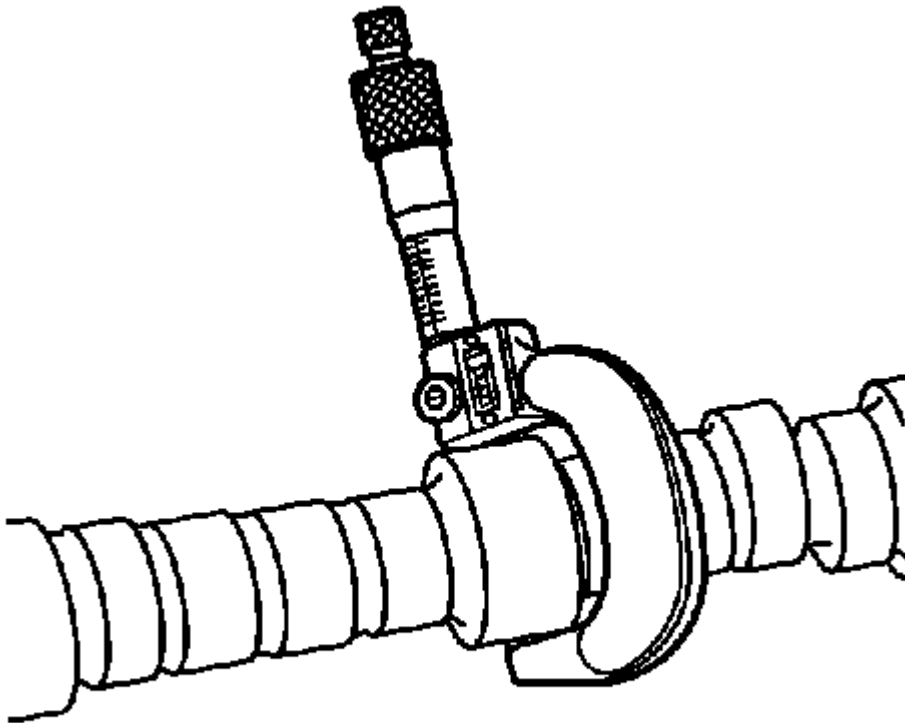


Fig. 358: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

10. Measure the camshaft journals for wear and out-of-round with a micrometer.
 - If the camshaft bearing journals are more 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.

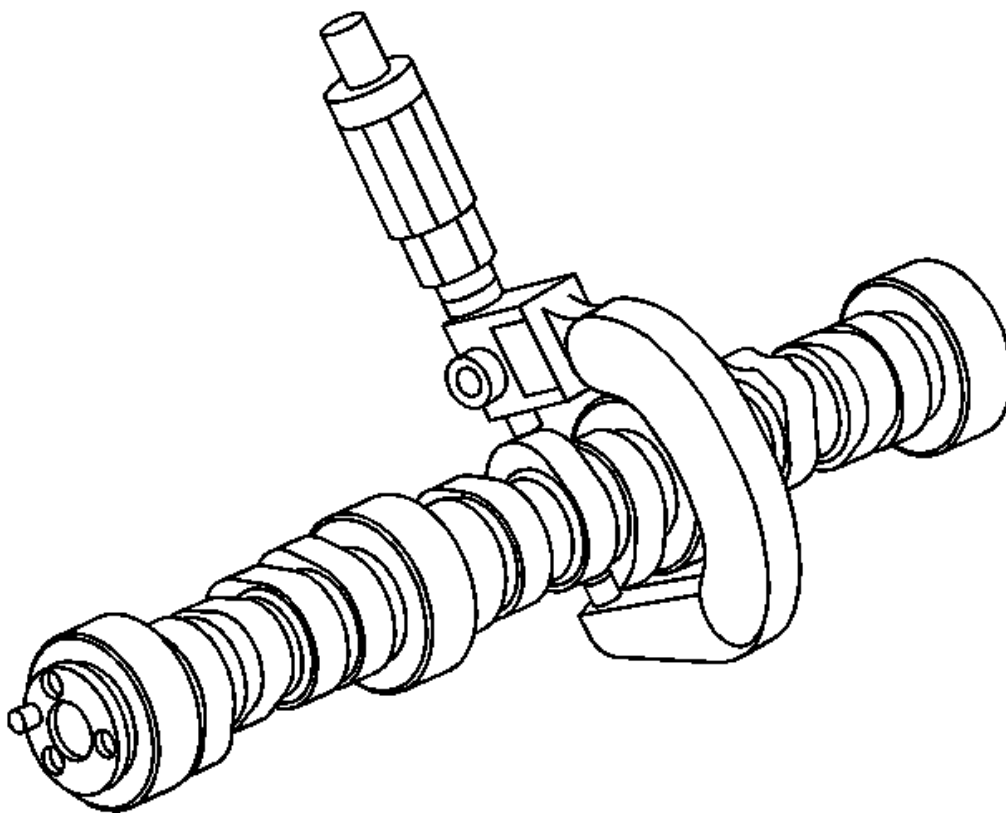


Fig. 359: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

11. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

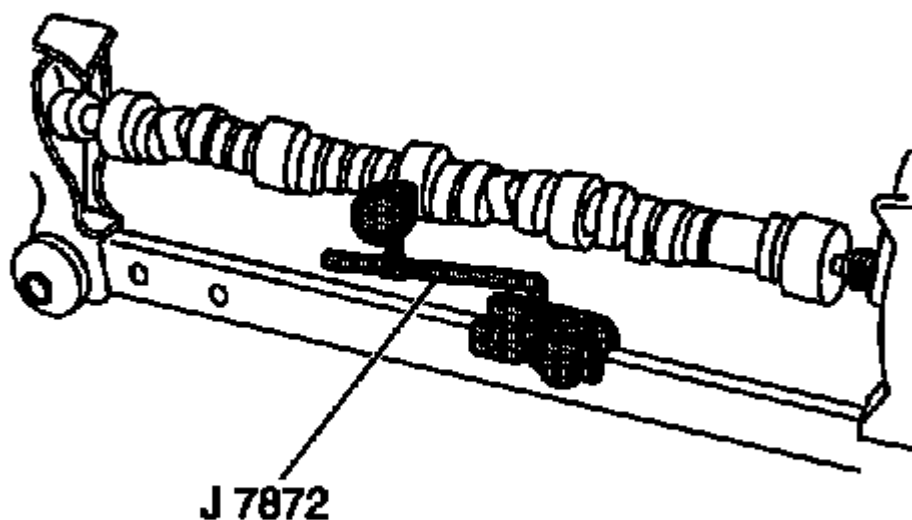


Fig. 360: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the camshaft runout.
 1. Mount the camshaft in wooden V blocks or between centers on a fixture.
 2. Using the **J 7872** , check the runout of the intermediate camshaft bearing journals. See **Special Tools**.
 3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift

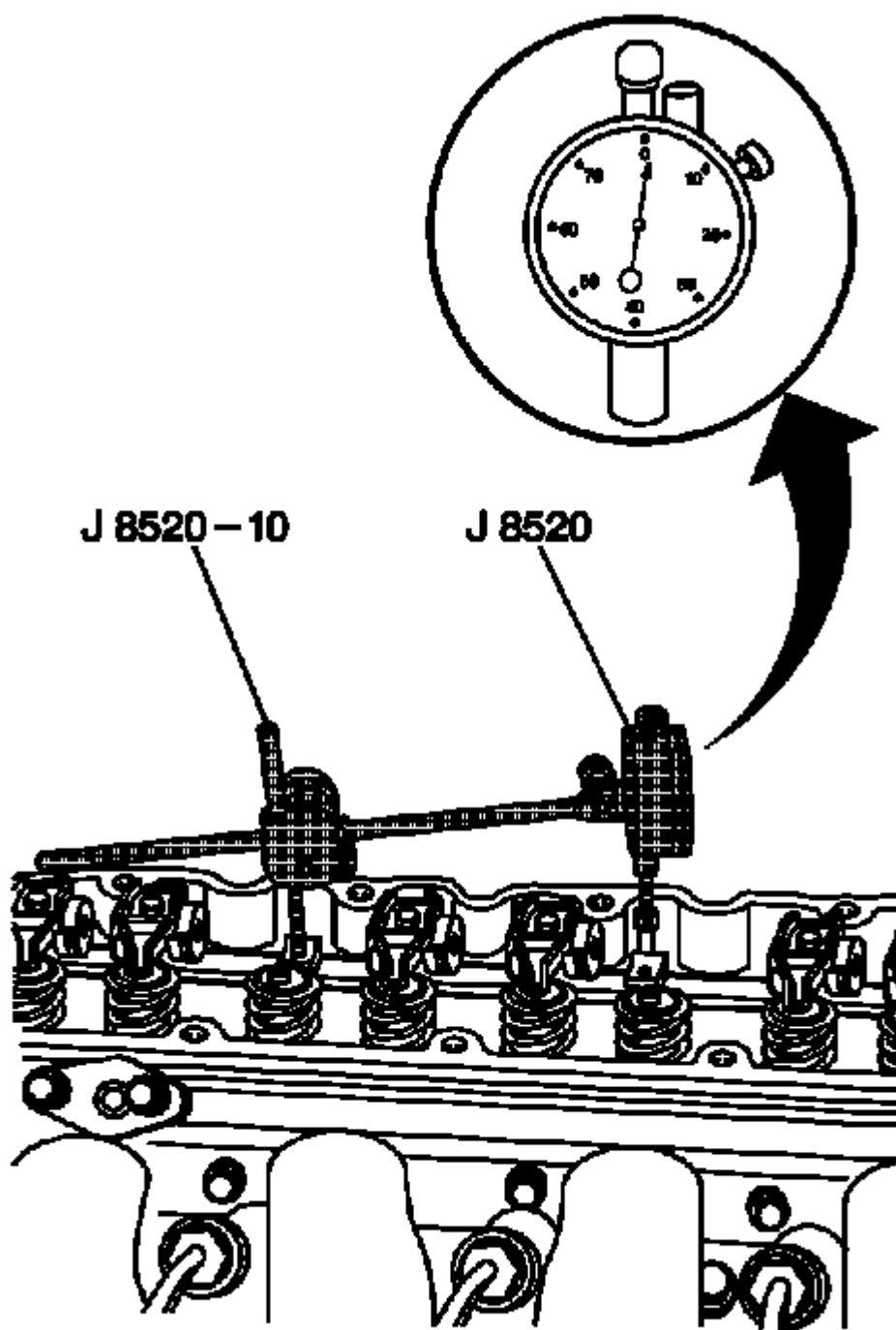


Fig. 361: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS CORP.

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. Measure camshaft lobe lift using **J 8520** . 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.
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. See **Special Tools**.

Installation Procedure

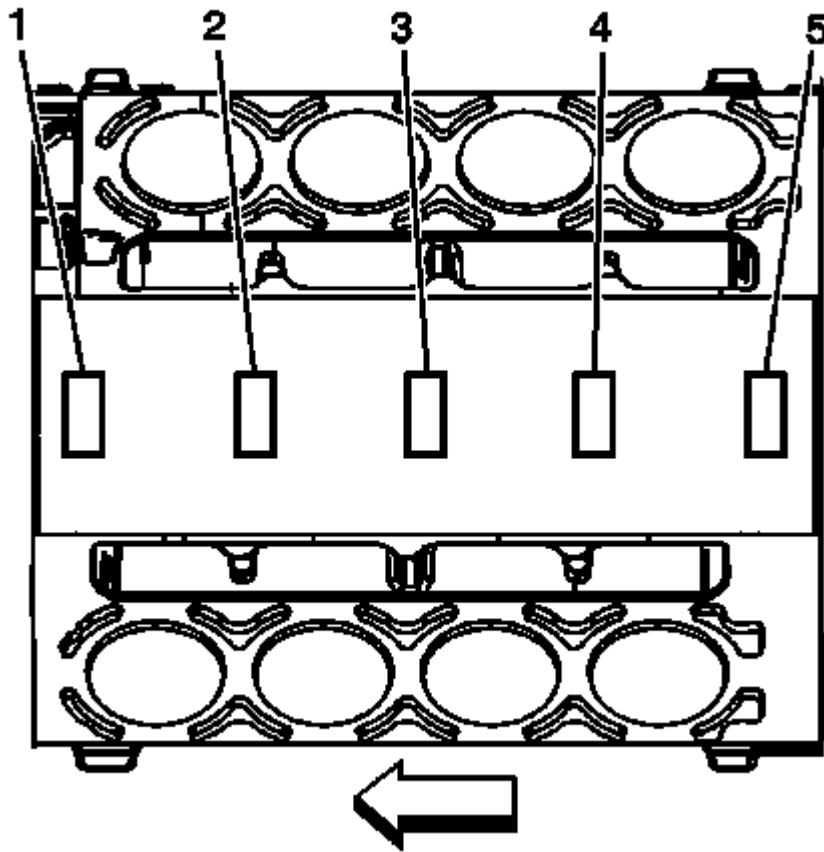


Fig. 362: Identifying Engine Block Camshaft Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Positions 1 and 5 are the largest diameter bores. Position 3 is the smallest diameter bore. Positions 2 and 4 are the intermediate size bores. The inside diameter (ID) for all camshaft bearings is the same size.

1. Measure the engine block camshaft bearing bores (1-5) to identify the correct OD size bearing for each position. Refer to Engine Mechanical Specifications.

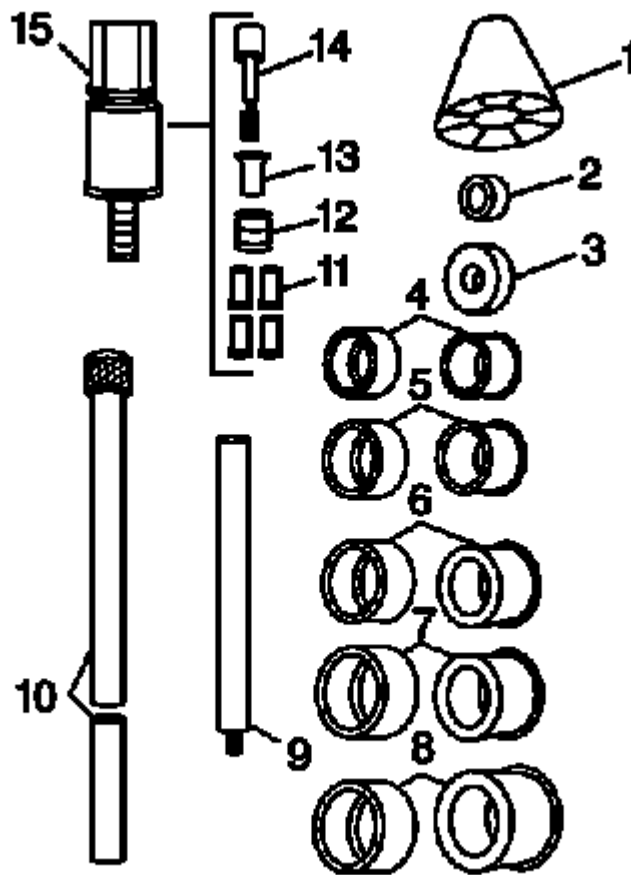


Fig. 363: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

2. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . See Special Tools. Refer to Piston and Connecting Rod Assemble.
3. Assemble the tool.

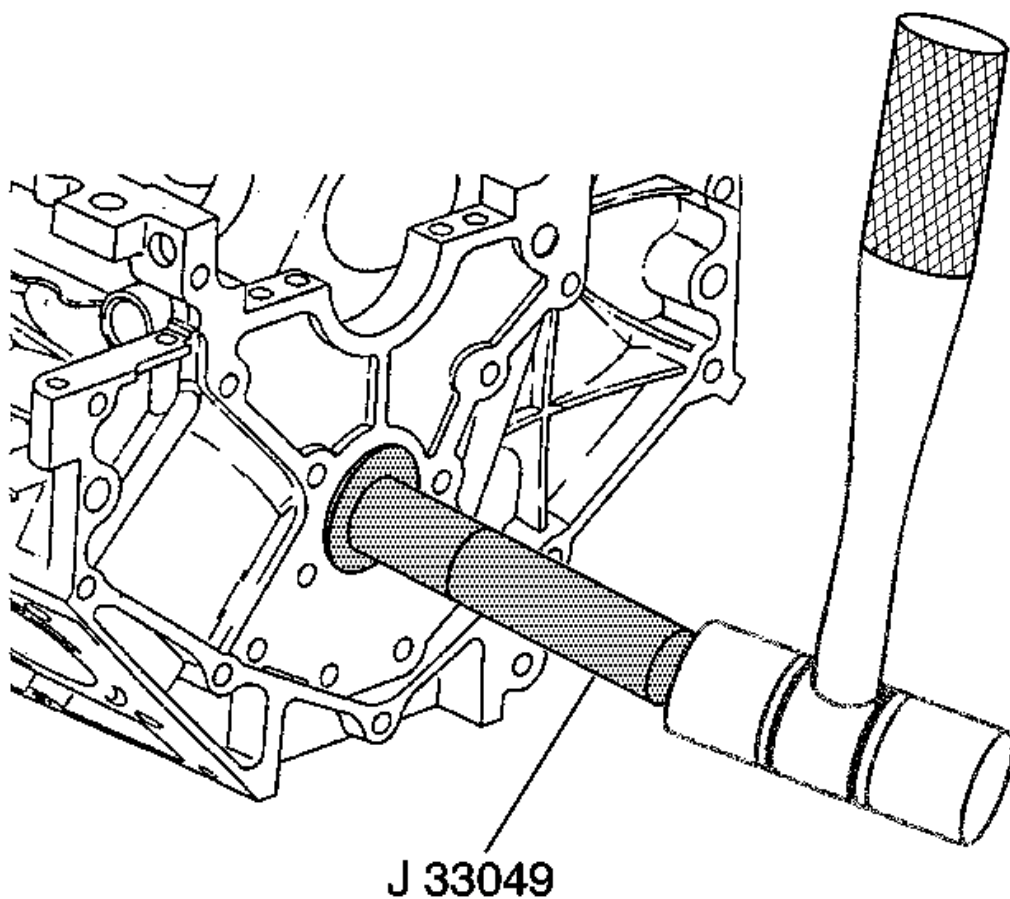


Fig. 364: Driving Bearing From/Into Block Bore
Courtesy of GENERAL MOTORS CORP.

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 guide cone into the front camshaft bearing to align the tool.
7. Drive the bearing into the block bore.
8. Repeat the above procedures to install the remaining bearings.

Timing Chain and Sprockets Cleaning and Inspection

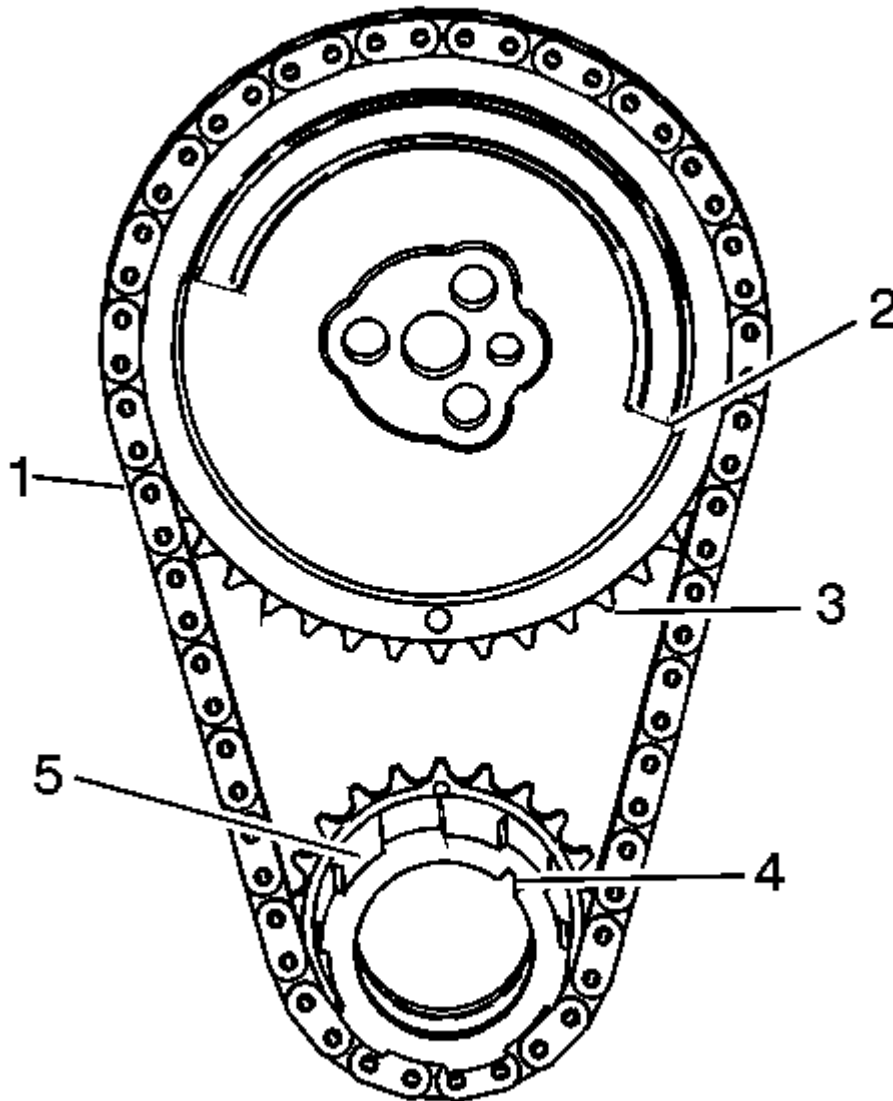


Fig. 365: Timing Chain & Sprockets Assembly
Courtesy of GENERAL MOTORS CORP.

1. Clean the components with cleaning solvent.

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

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 area (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).

Valve Rocker Arm and Push Rods Cleaning and Inspection

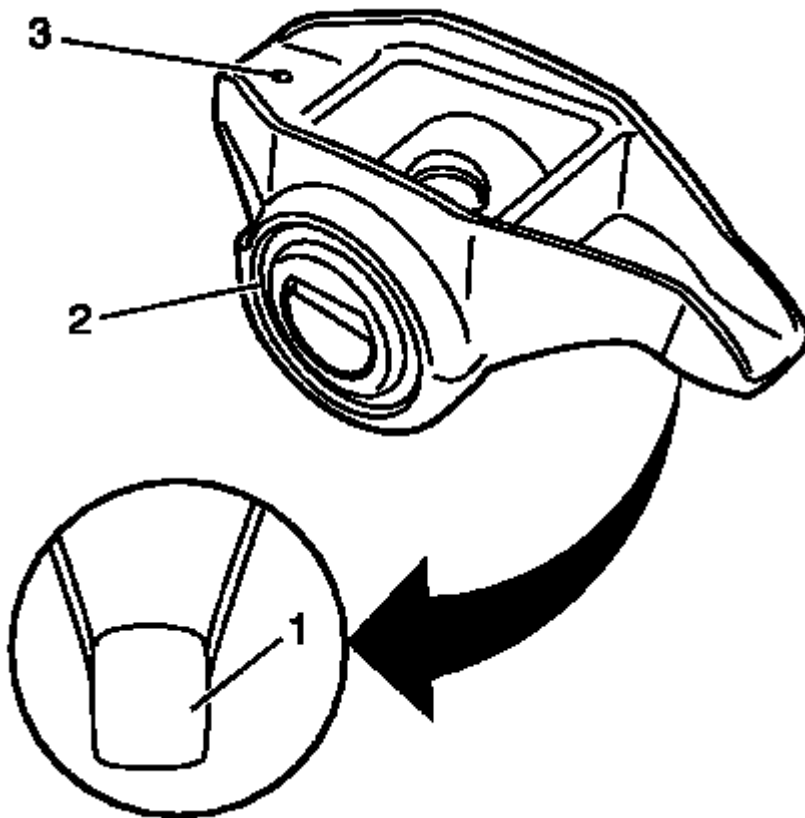


Fig. 366: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS CORP.

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.
2. Clean the components with cleaning solvent.

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

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

Valve Lifters

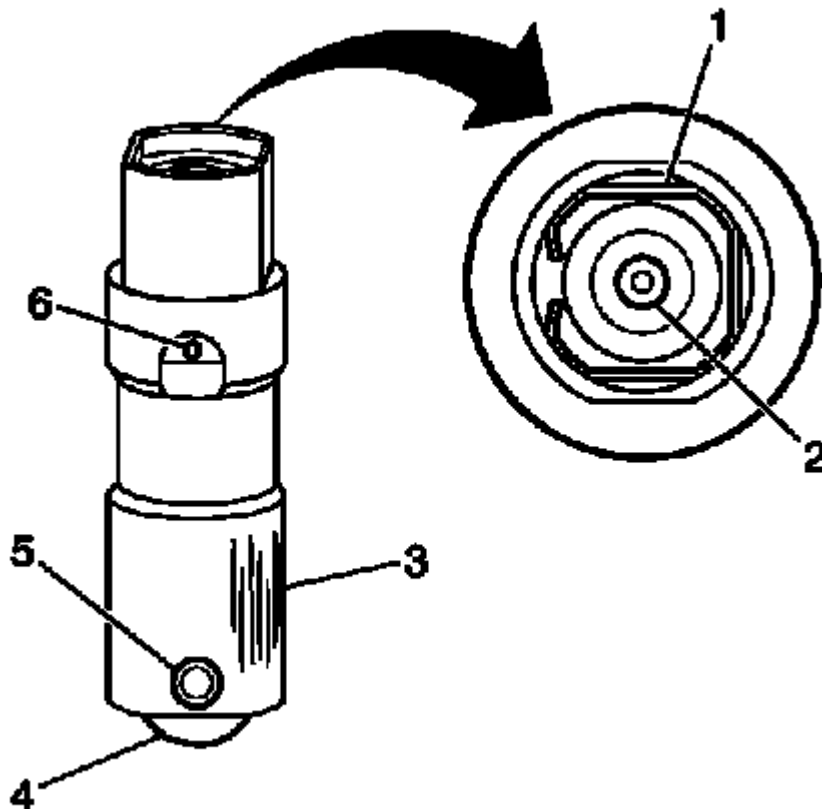


Fig. 367: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

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.

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. See **Special Tools**.

Disassembly Procedure

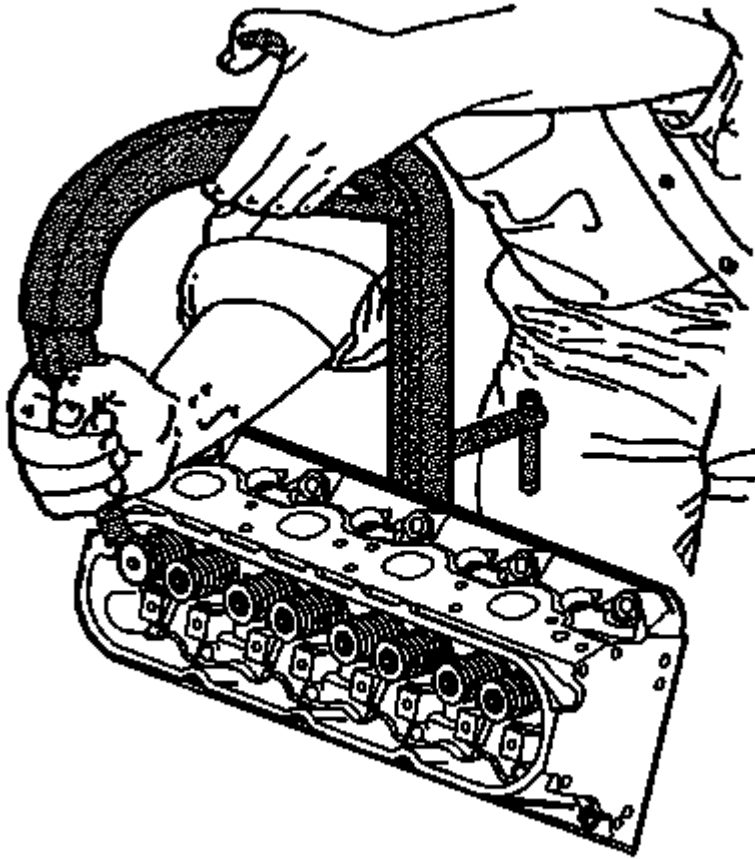


Fig. 368: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- With the components at room temperature, remove the spark plugs from the cylinder head.
- 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. See Special Tools.

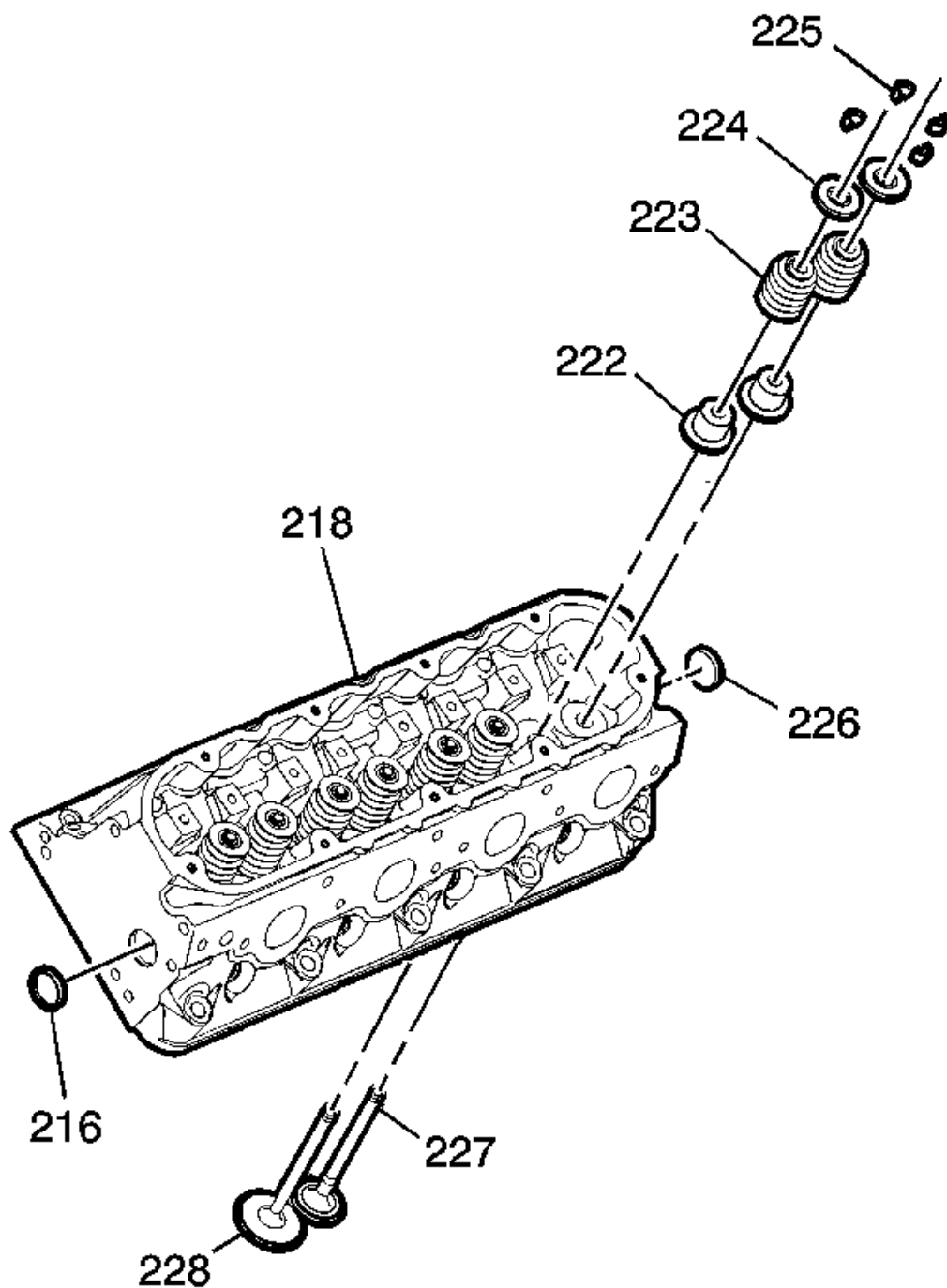


Fig. 369: View Of Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

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**.

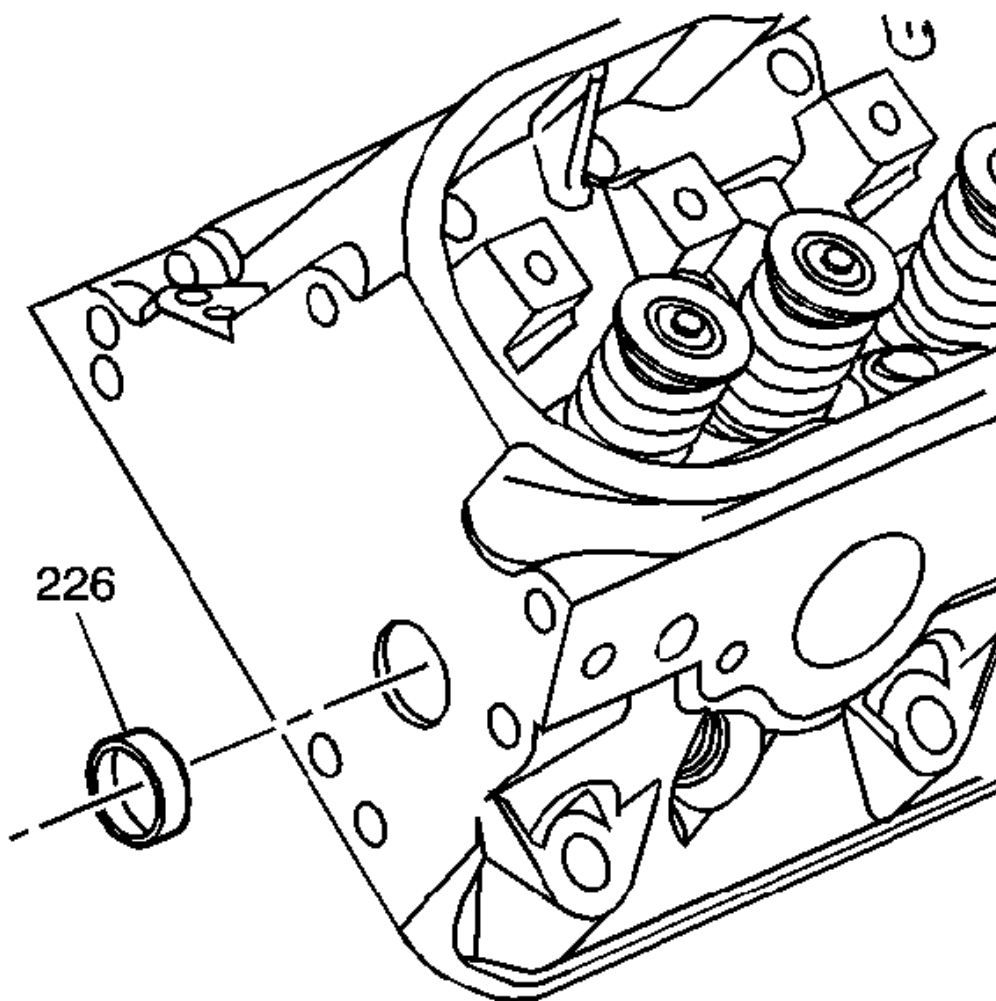


Fig. 370: View Of Cylinder Head Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head expansion plugs (226) as required.

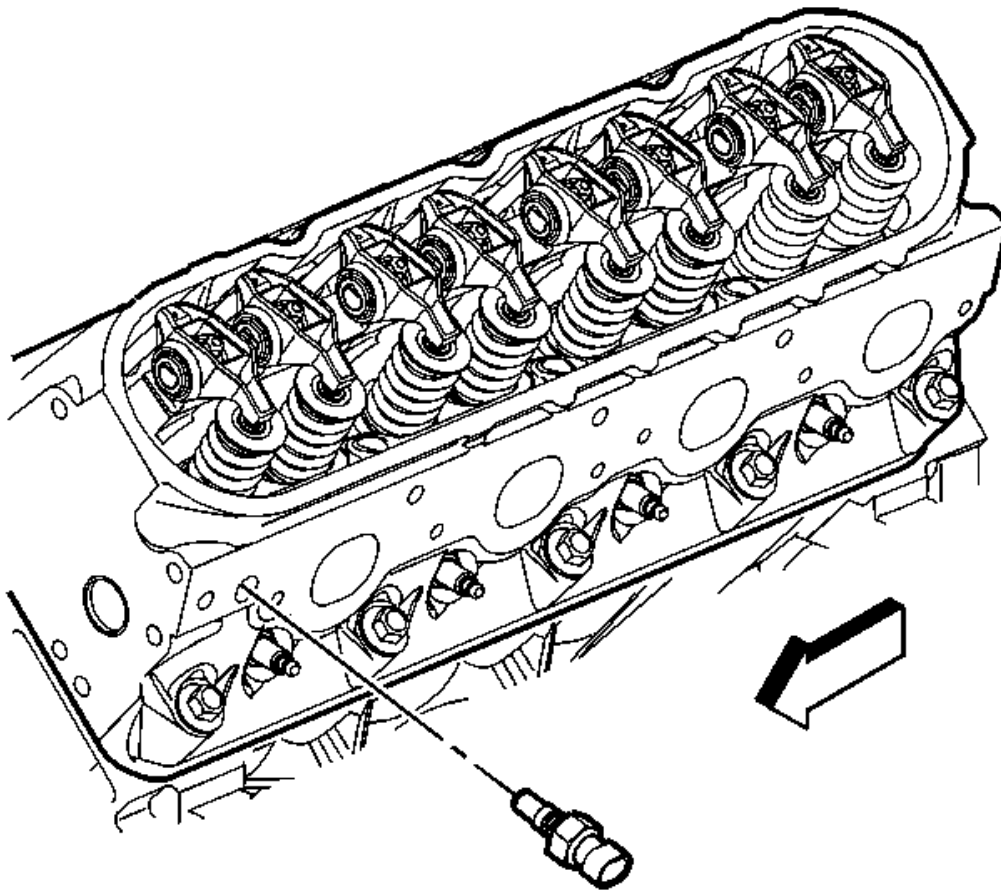


Fig. 371: View Of Coolant Temperature Sensor (Left Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor from the left cylinder head.

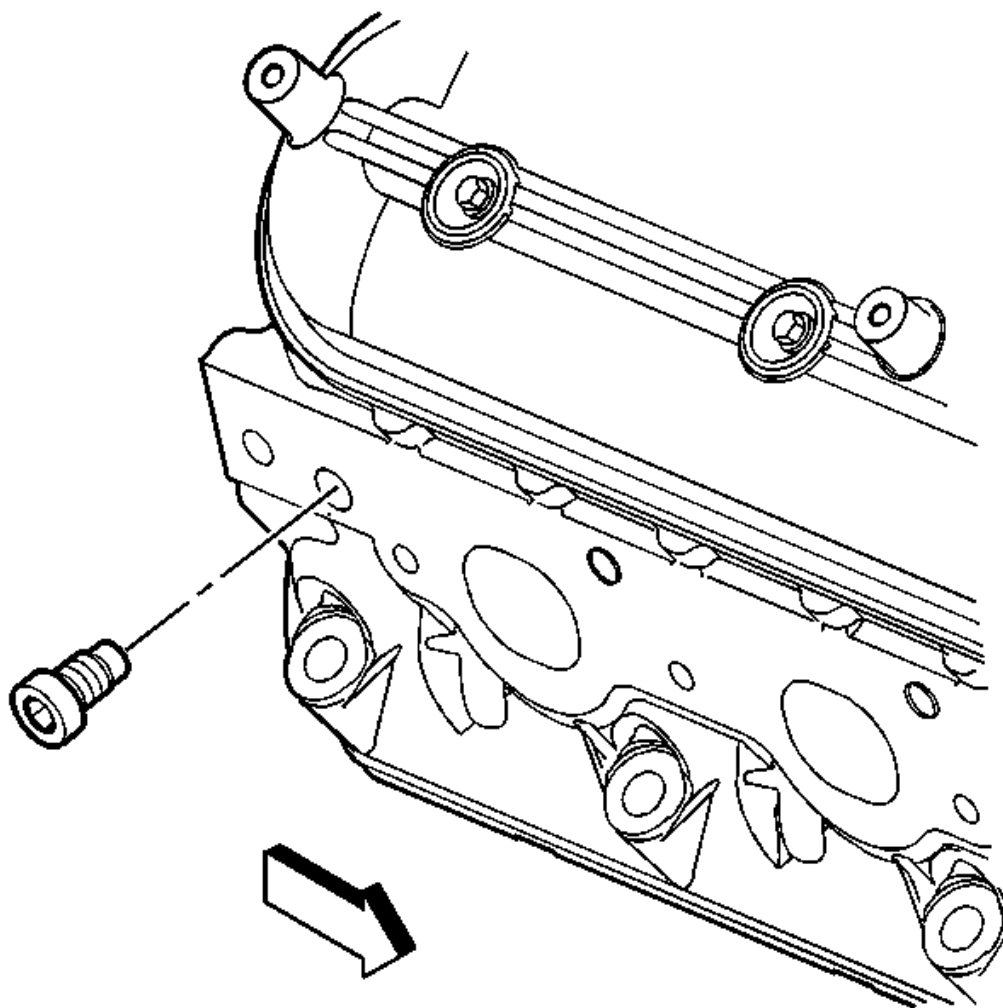


Fig. 372: View Of Coolant Plug (Right Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant plug 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. See **Special Tools**.

Cleaning & Inspection Procedure

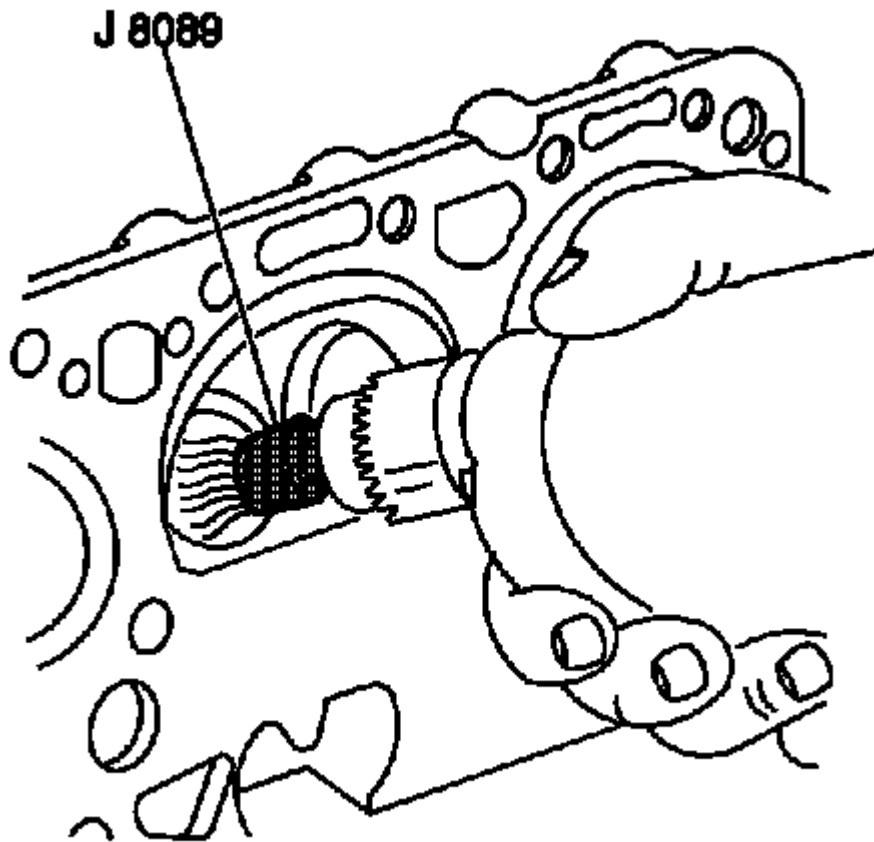


Fig. 373: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

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

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.

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**.

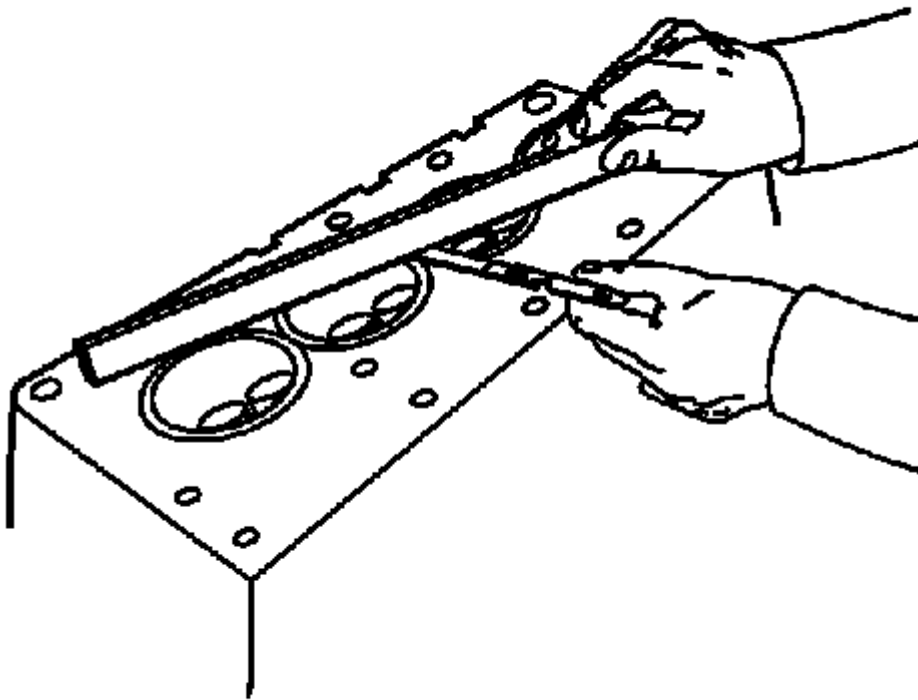


Fig. 374: Inspecting Cylinder Head For Warp
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warp. Refer to **Engine Mechanical Specifications**.

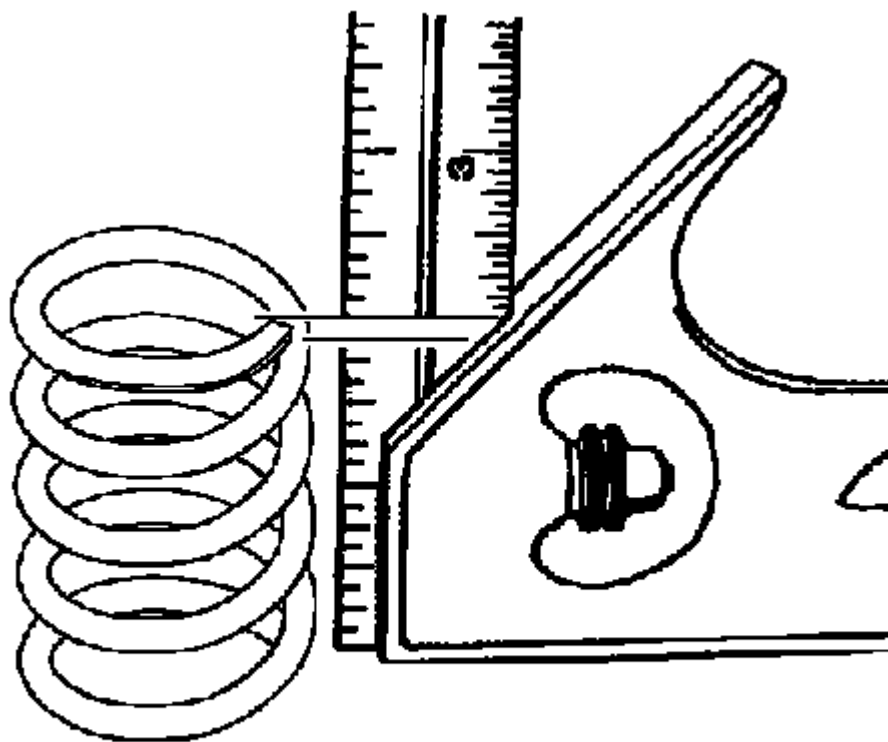


Fig. 375: Inspecting Valve Spring For Squareness
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve springs for squareness.

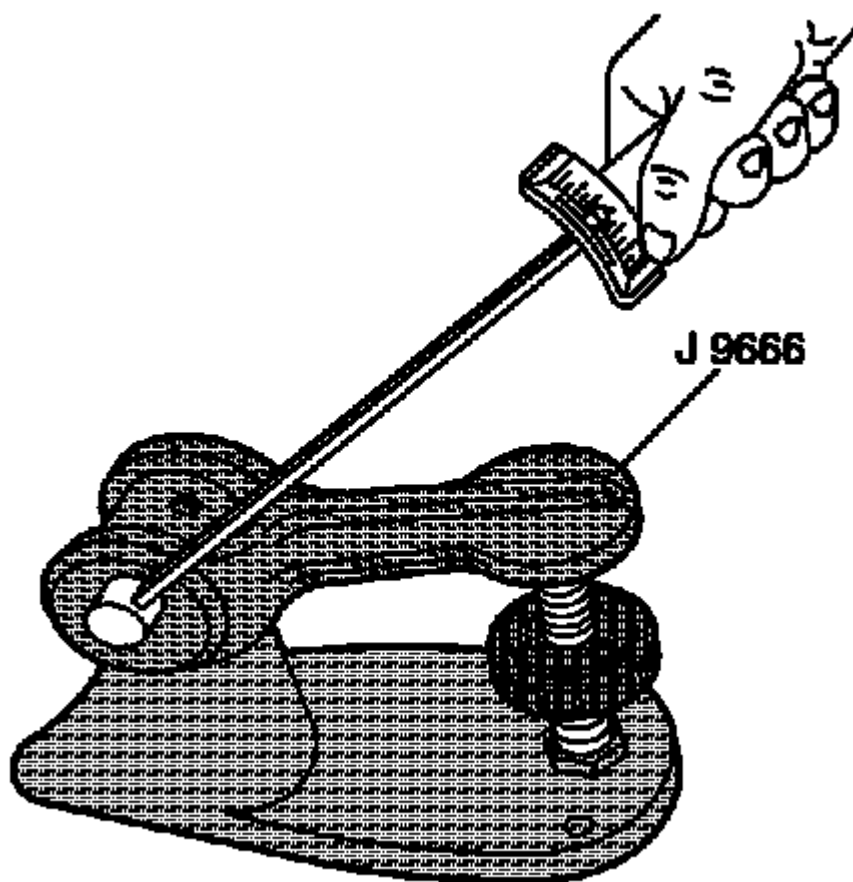


Fig. 376: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 9666** in order to measure the valve spring tension. See **Special Tools**. Refer to **Engine Mechanical Specifications**.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

J 37378-1 Valve Guide Reamer. See **Special Tools**.

Valve Guide Reaming

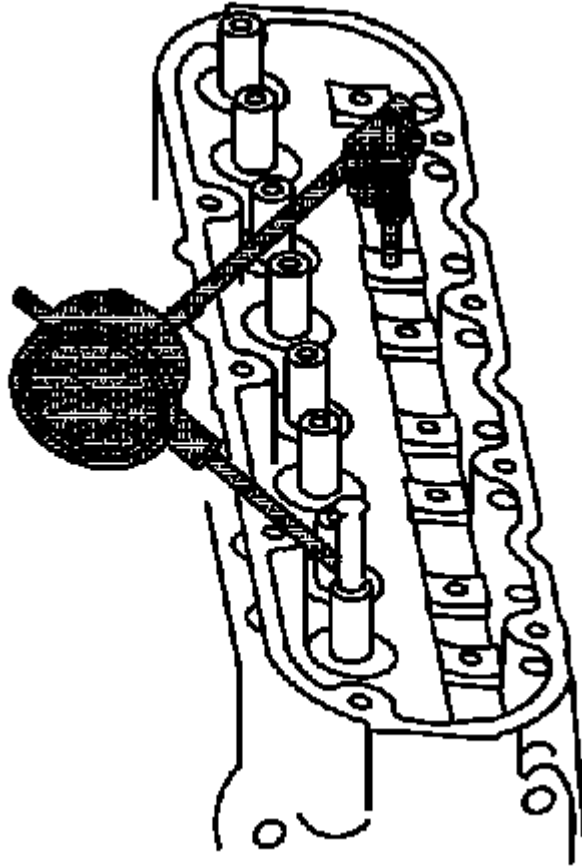


Fig. 377: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem 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.

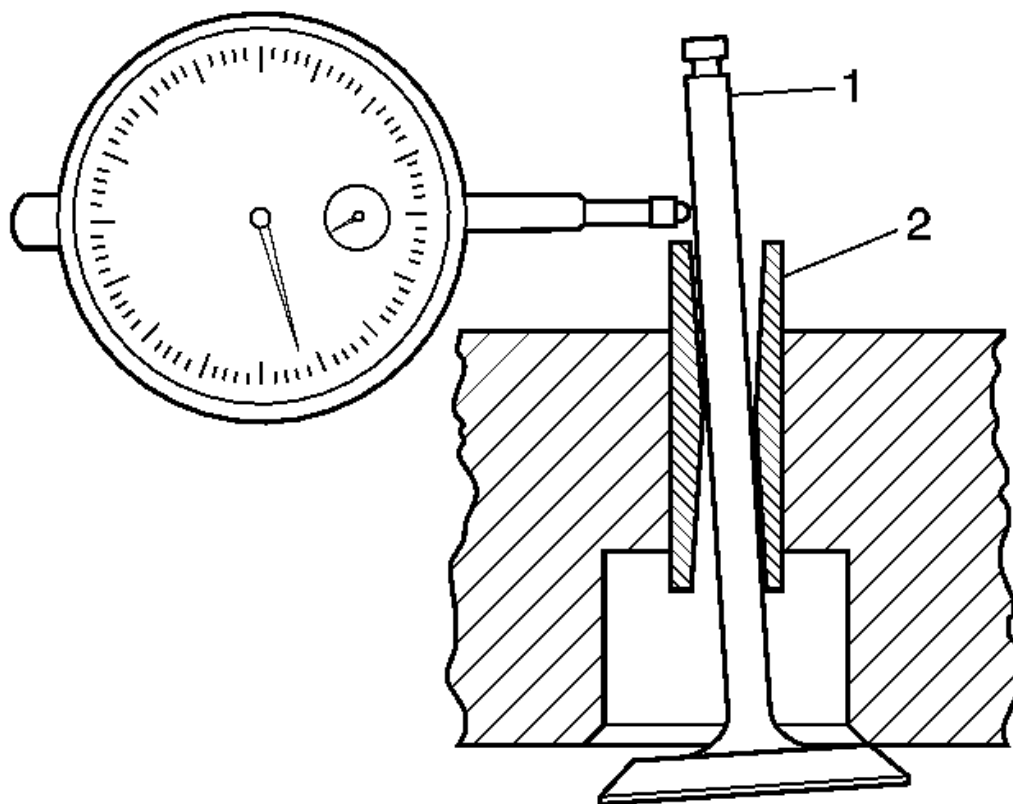


Fig. 378: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the cylinder head replaced.

Refer to **Engine Mechanical Specifications**.

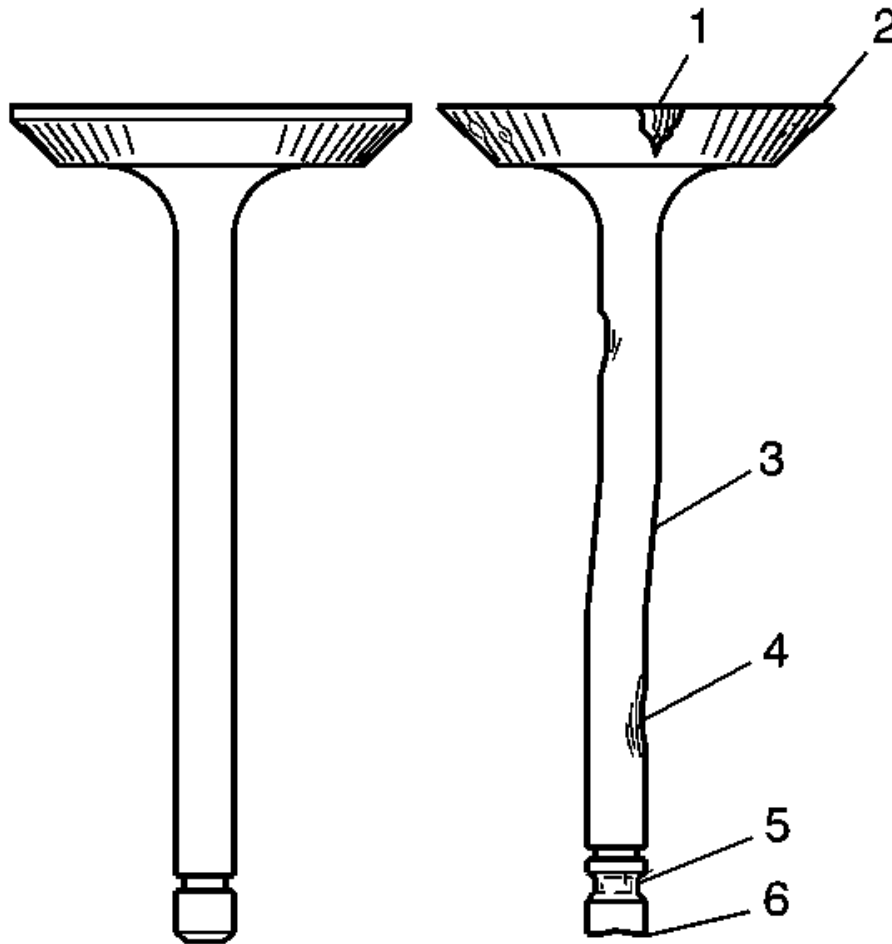


Fig. 379: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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.
 - A valve guide that is worn and has excessive stem-to-guide clearance should be reamed and valves with oversize stems installed.
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 valve guide must be reamed oversize and a valve with oversize stem installed.

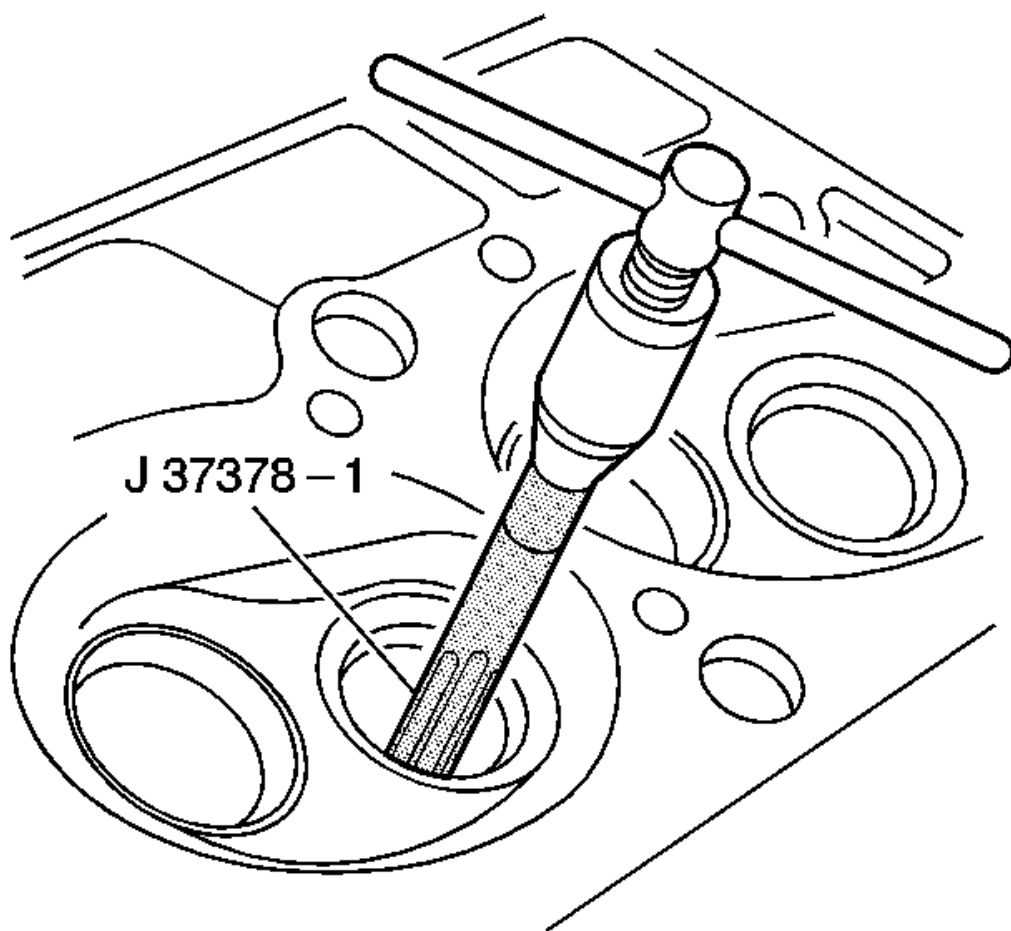


Fig. 380: Reaming Valve Guide Using J 37378-1
Courtesy of GENERAL MOTORS CORP.

5. Ream the valve guide using the **J 37378-1** . See **Special Tools**.
6. Clean the guide bore of all metal shavings and debris.

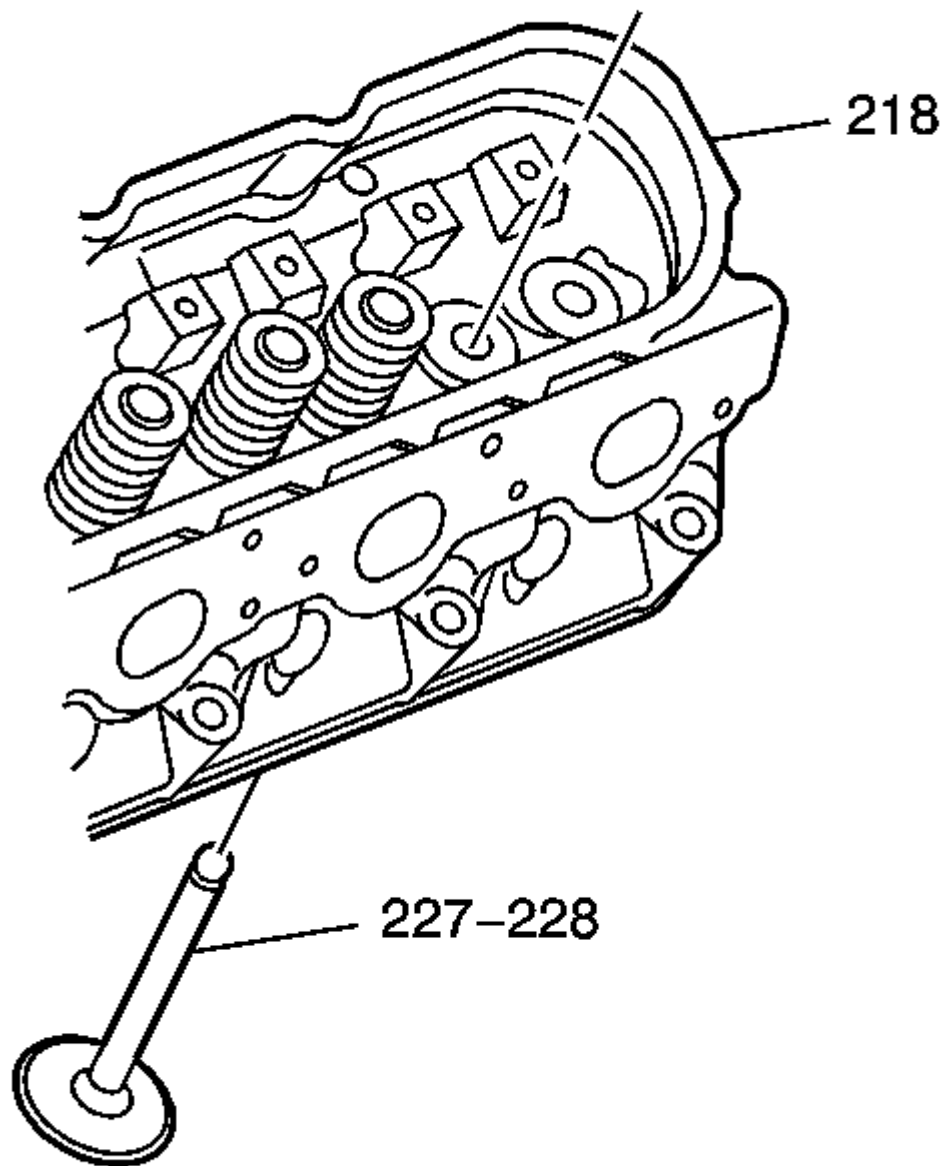


Fig. 381: View Of Valve & Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Install the valve (227-228), with oversize stem, into the cylinder head (218).
8. Inspect the valve for the proper fit.

Move the valve back and forth in the guide. The valve should move freely with no resistance or drag.

Valve and Seat Grinding

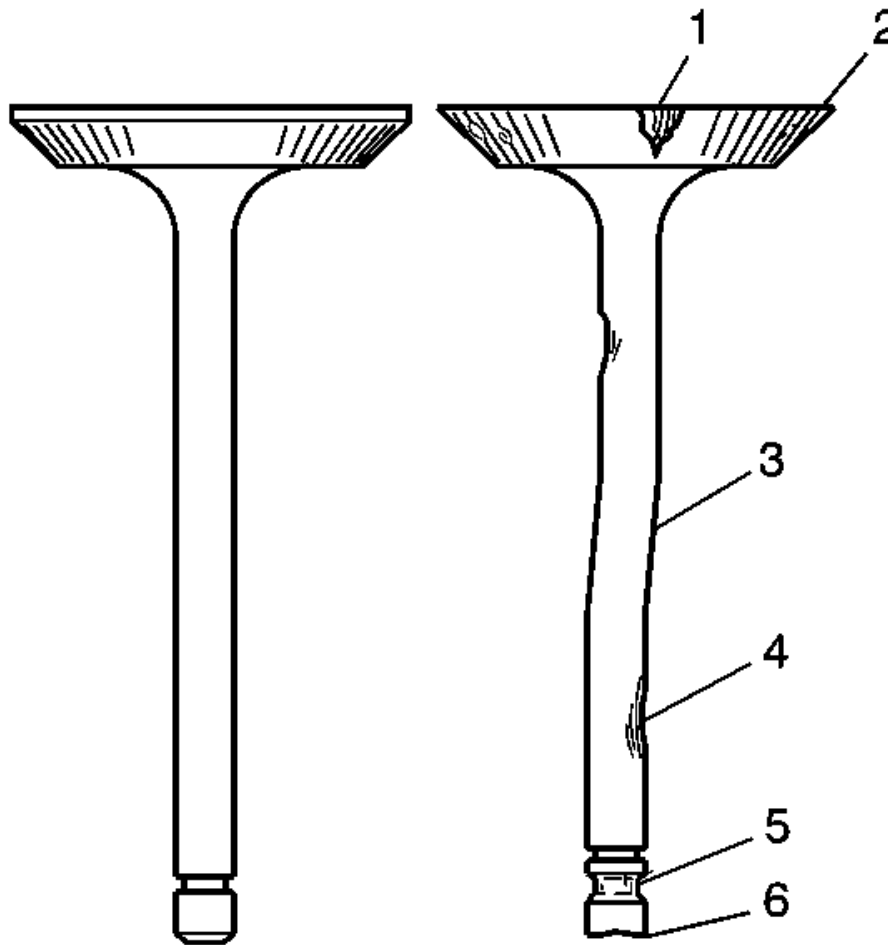


Fig. 382: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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 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:

- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)

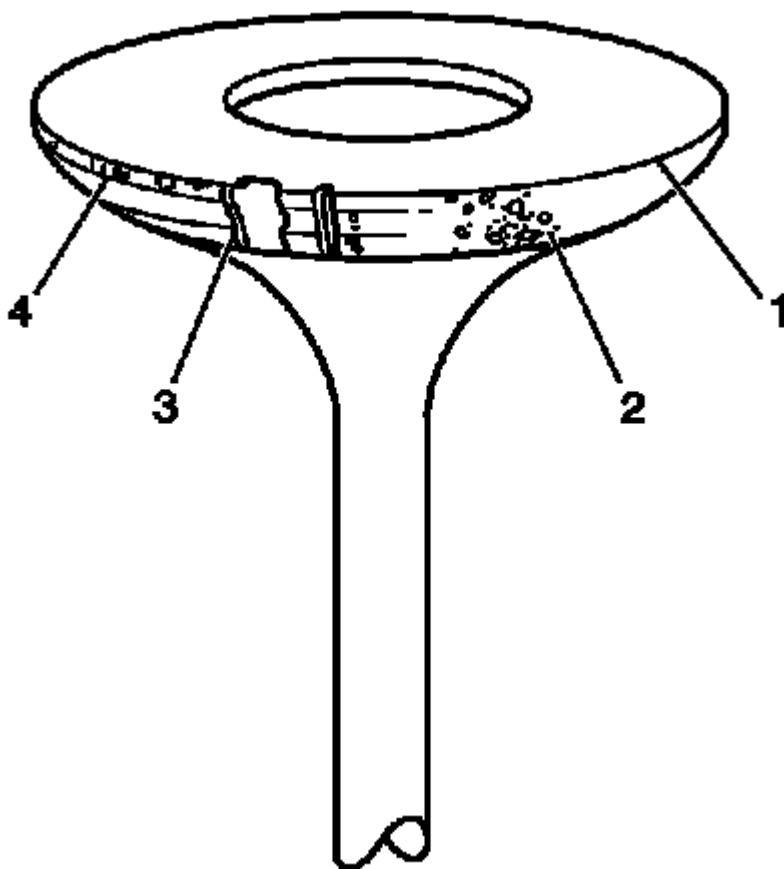


Fig. 383: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
 - Worn or no margin (1 or 4)
 - Pitted surfaces (2)
 - Burnt or eroded areas (3)

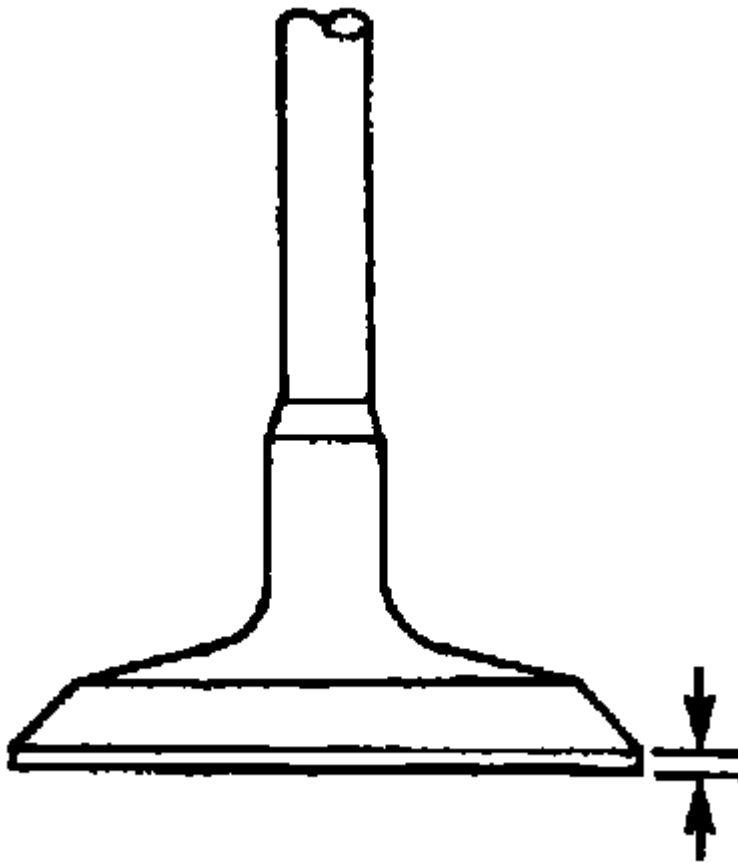


Fig. 384: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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

J 8062 Valve Spring Compressor - Head Off. See **Special Tools**.

Assembly Procedure

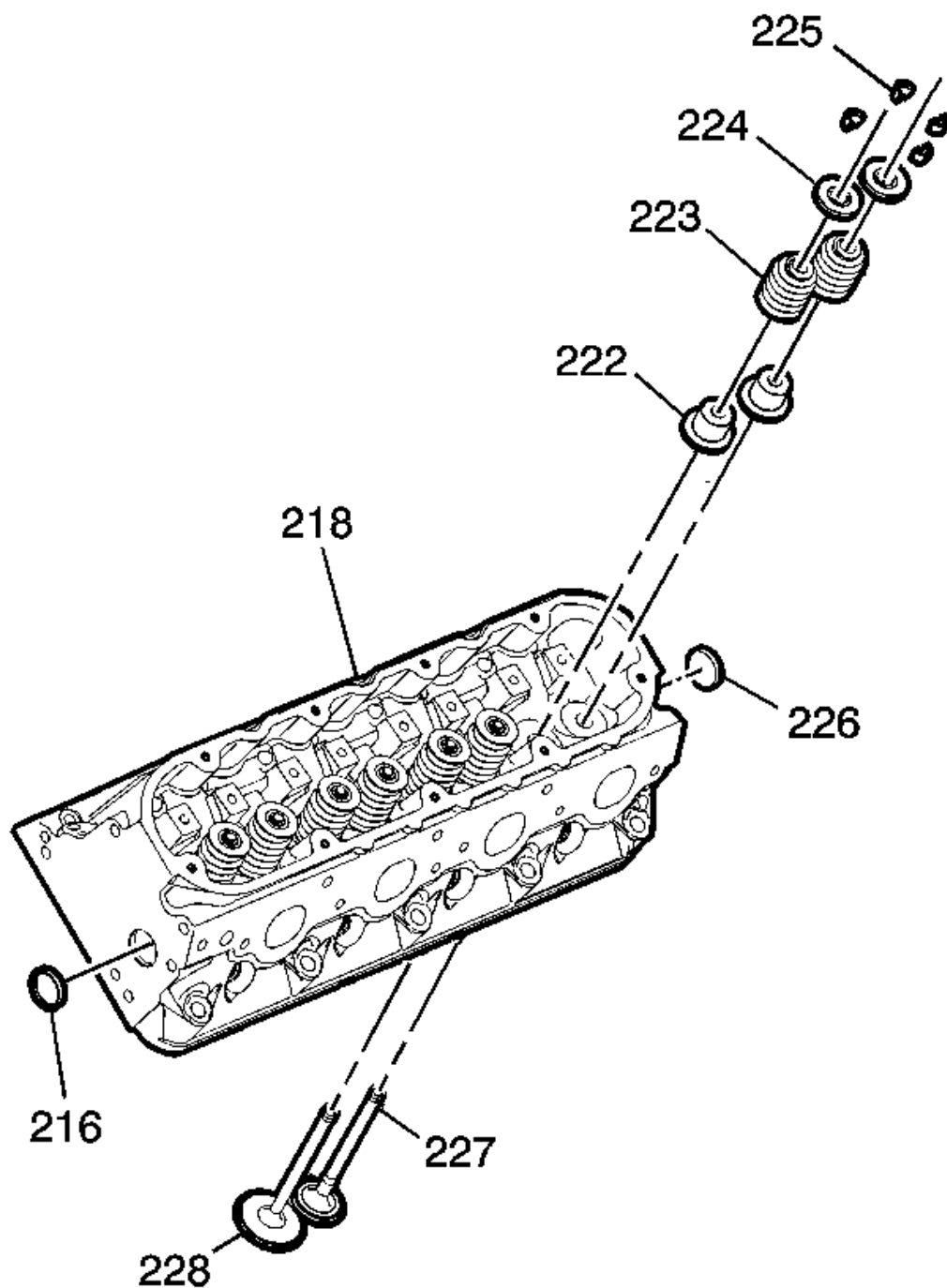


Fig. 385: View Of Cylinder Head Components
 Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring shim area.

IMPORTANT: When using the valves and related components again, install the parts to their original location.

2. Install the valves (227 and 228) into the proper port.

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).

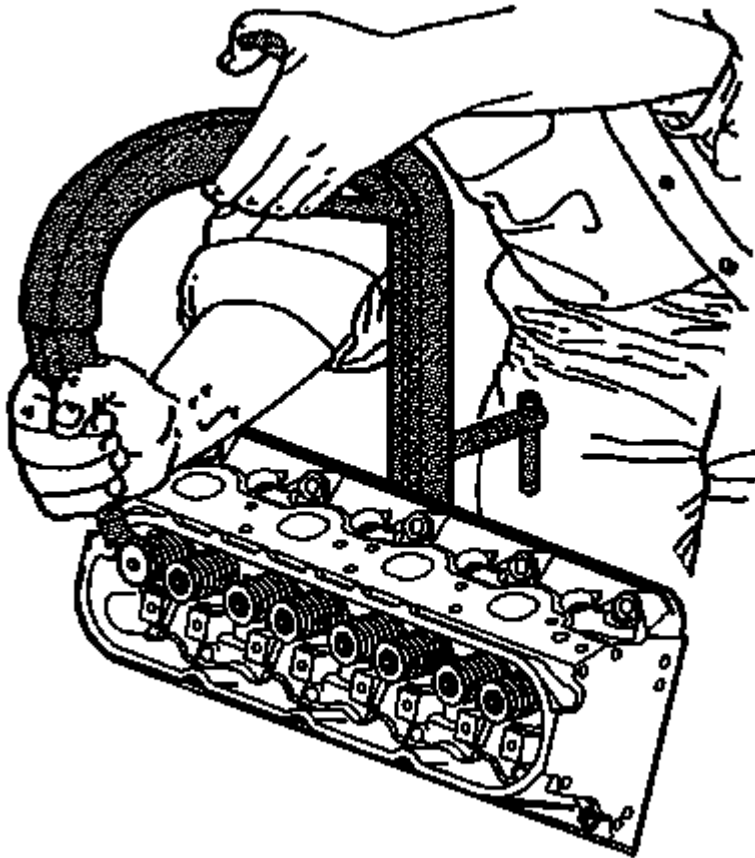


Fig. 386: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve spring using the **J 8062** . See **Special Tools**.
7. Install the valve stem keys.
 1. Use grease to hold the keys in place and remove the **J 8062** .
 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.

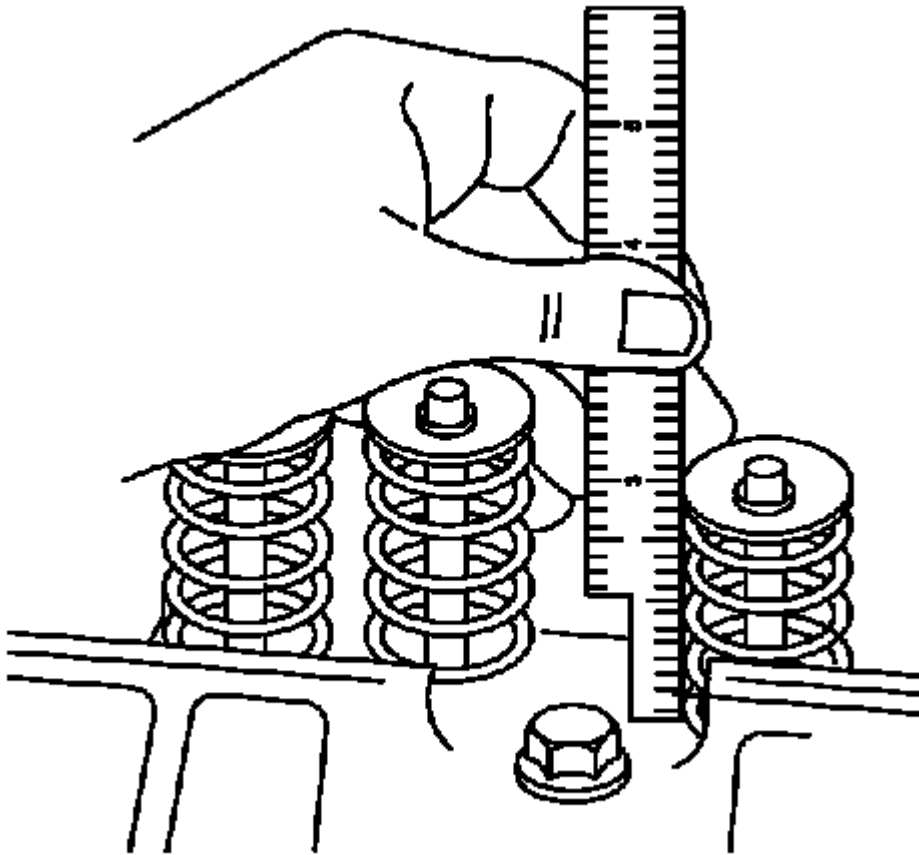


Fig. 387: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

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.

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.

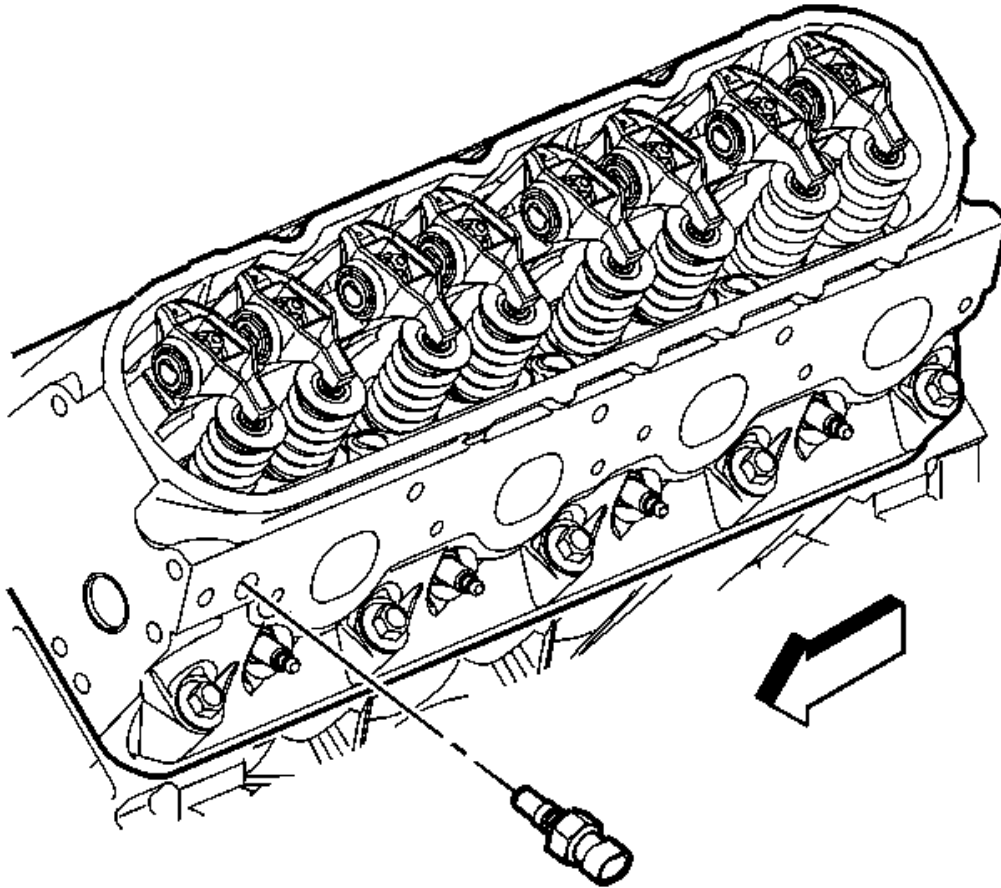


Fig. 388: View Of Coolant Temperature Sensor (Left Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

11. Install the coolant temperature sensor into the left cylinder head.

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

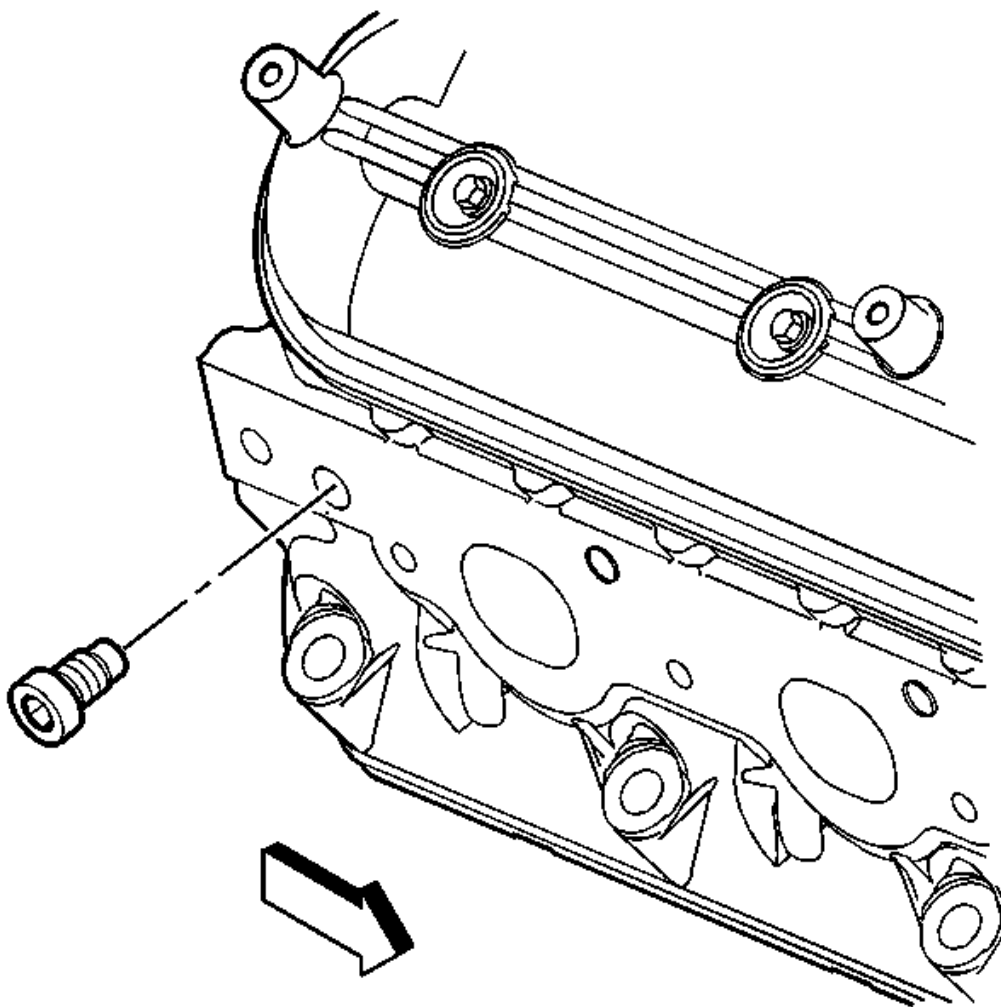


Fig. 389: View Of Coolant Plug (Right Cylinder Head)

Courtesy of GENERAL MOTORS CORP.

12. Install sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the coolant plug.
13. Install the coolant plug to the right cylinder head.

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

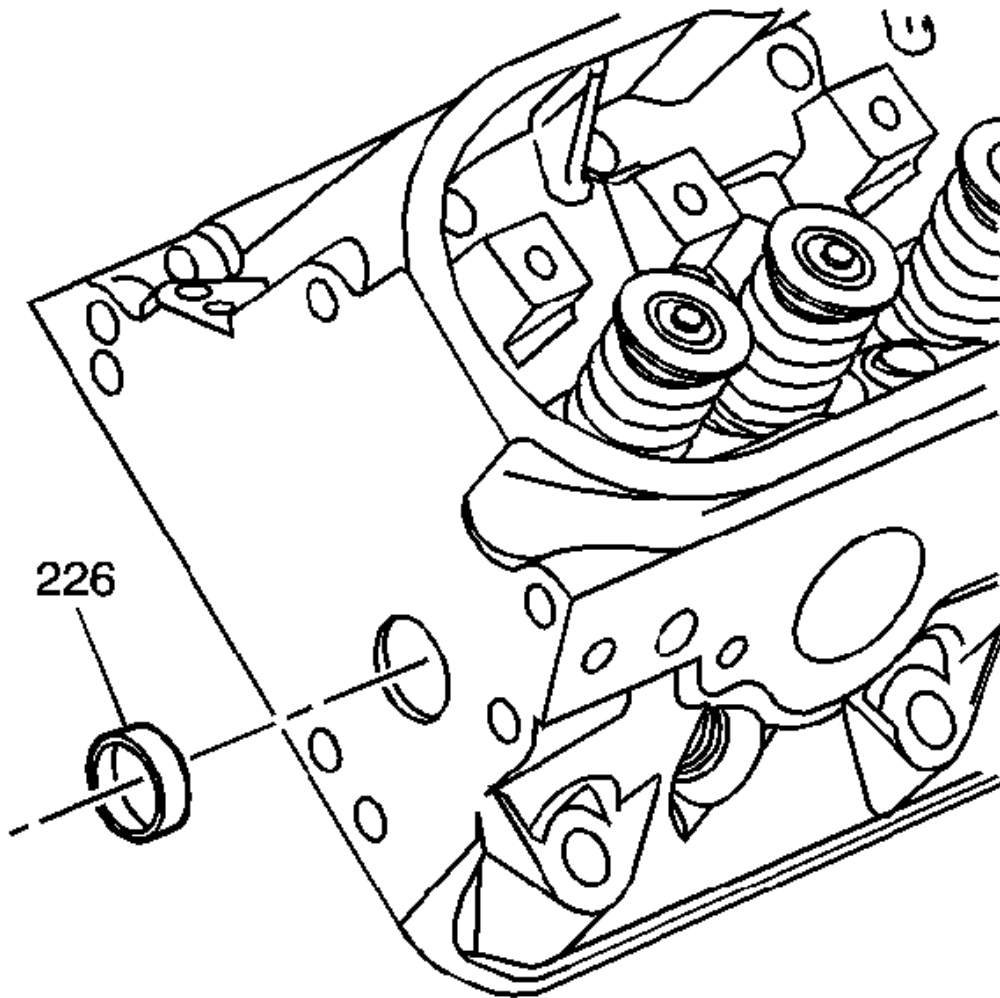


Fig. 390: View Of Cylinder Head Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the sides of the cylinder head expansion plugs (226).
15. Install the expansion 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.

Oil Pump Disassemble

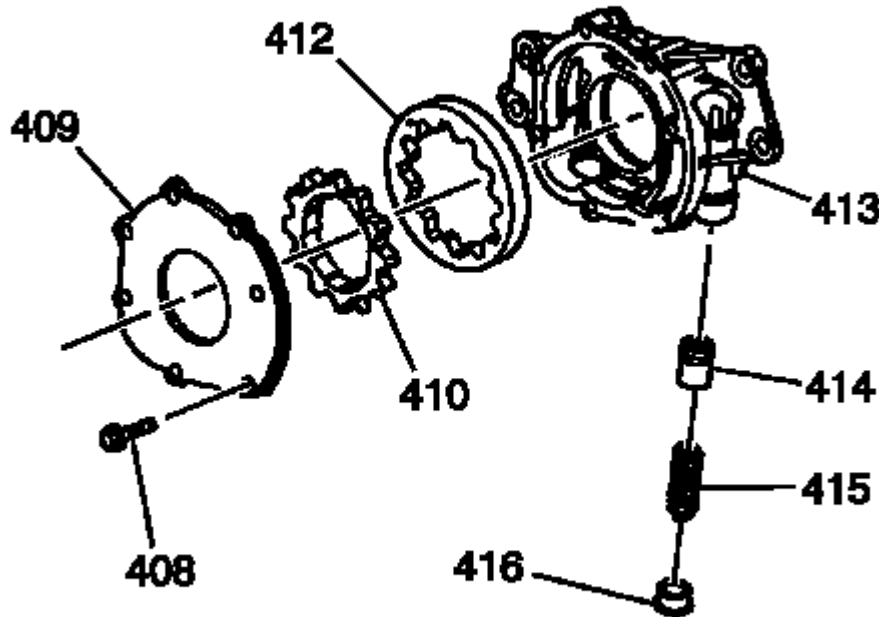


Fig. 391: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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.

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

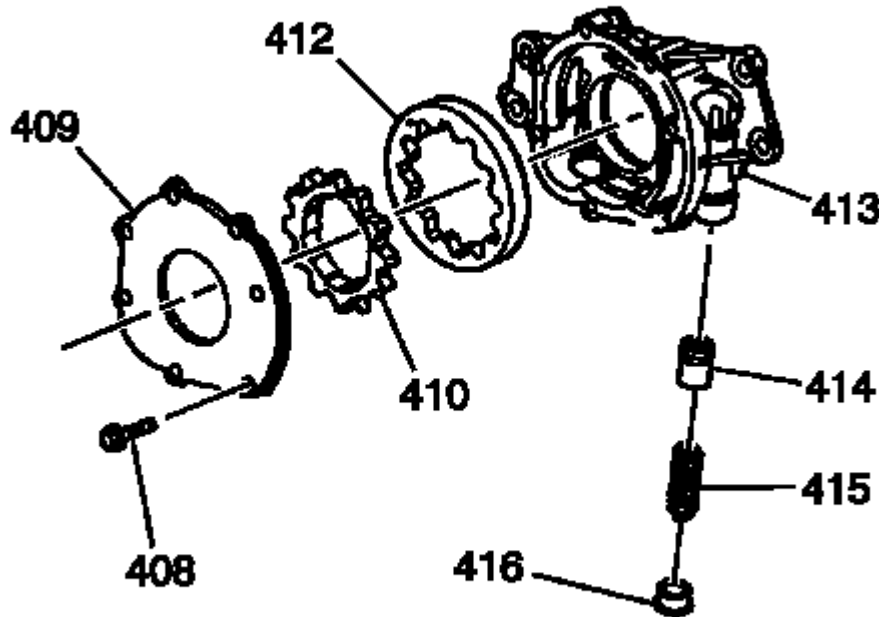


Fig. 392: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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.
- 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 in Cautions and Notices.

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.

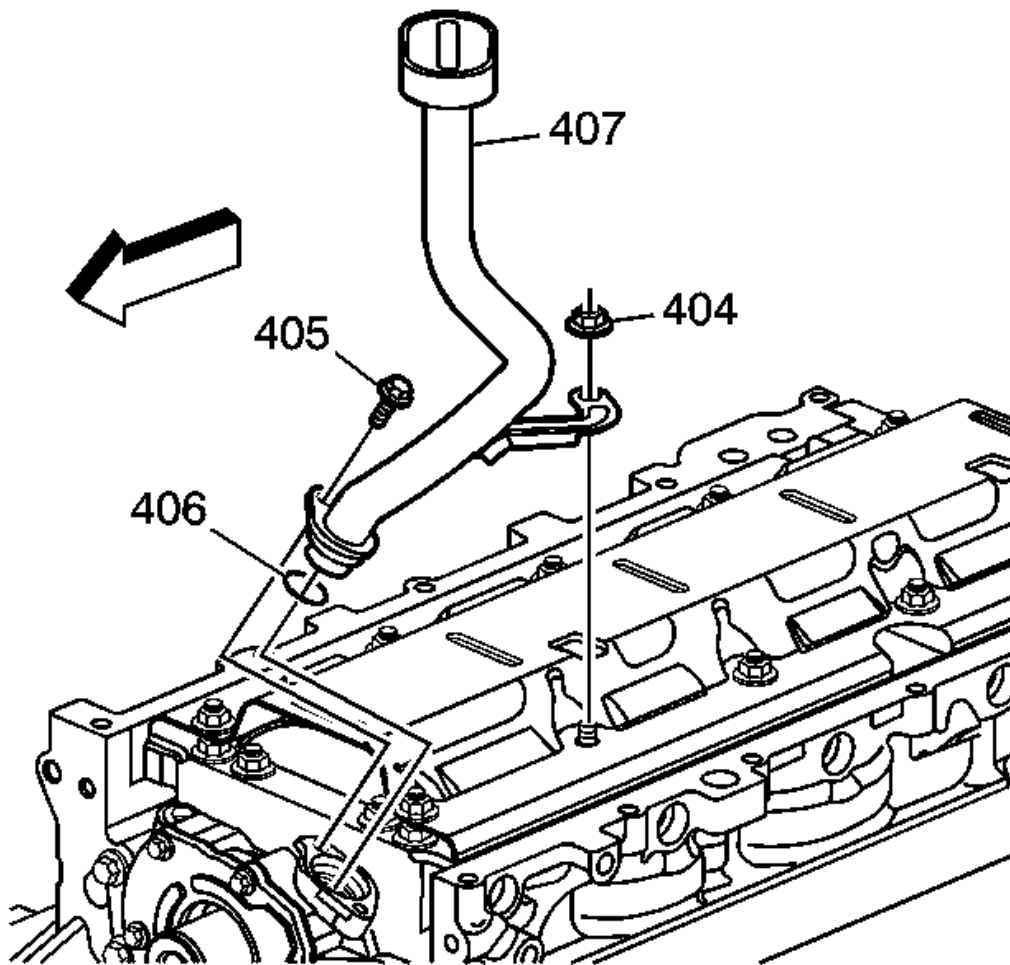


Fig. 393: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

11. Inspect the oil pump screen (407) for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.

Oil Pump Assemble

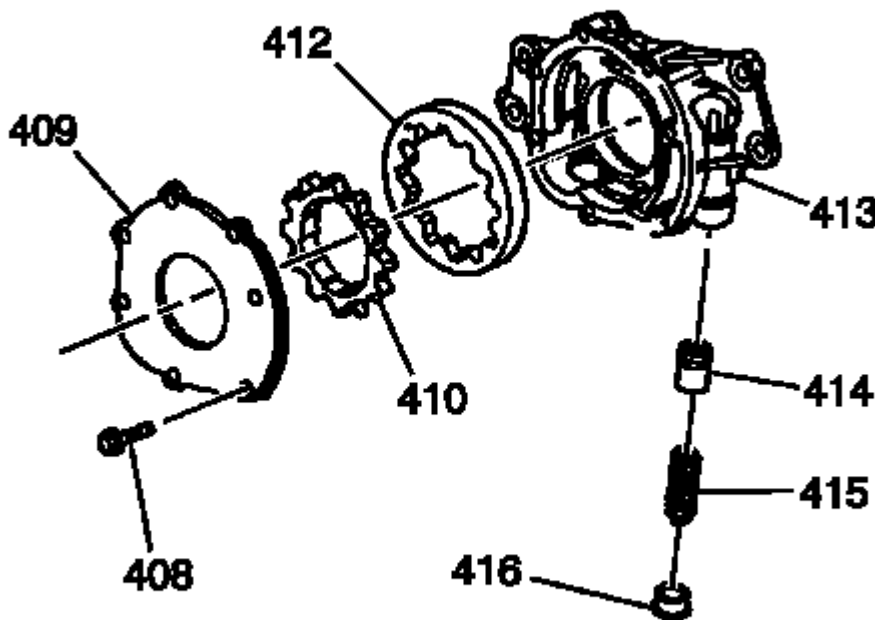


Fig. 394: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

4. Install the pump cover bolts (408).

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

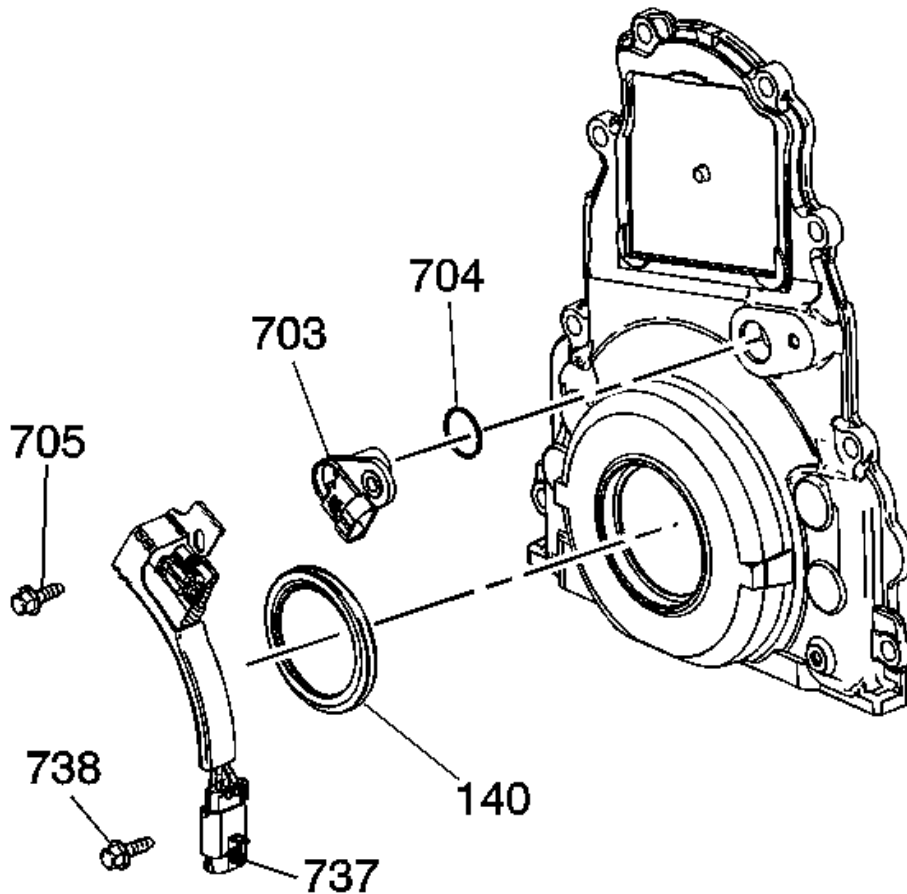


Fig. 395: Engine Front Cover, Camshaft Position Sensor, Oil Seal, Wire Harness, O-Ring & Bolts
Courtesy of GENERAL MOTORS CORP.

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 gasket again. Install a **NEW** gasket during assembly.

1. Remove the crankshaft oil seal (140) 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** in Cautions and Notices.

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.

Engine Rear Cover Cleaning and Inspection

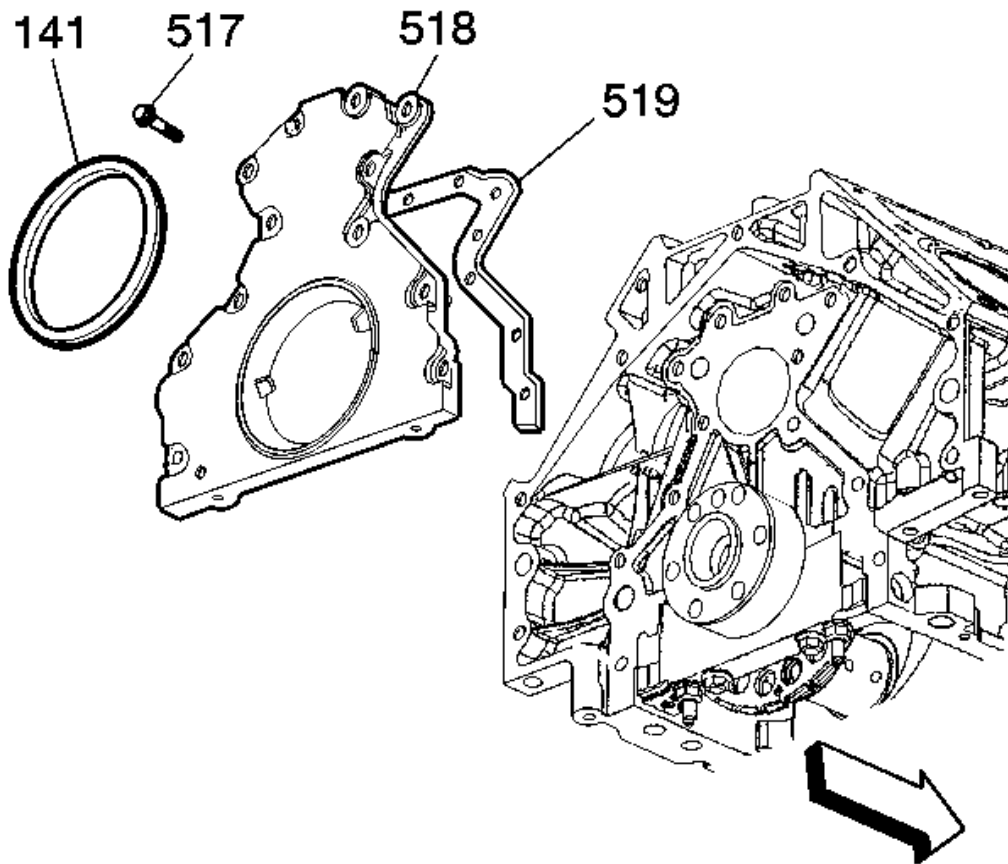


Fig. 396: Exploded View Of Engine Rear Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Do not use the crankshaft oil seal again. Install a **NEW** crankshaft oil seal during assembly.
- Do not use the rear cover-to-engine block gasket again. Install a **NEW** gasket during assembly.

1. Remove the crankshaft oil seal (141) from the rear 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** in Cautions and Notices.

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

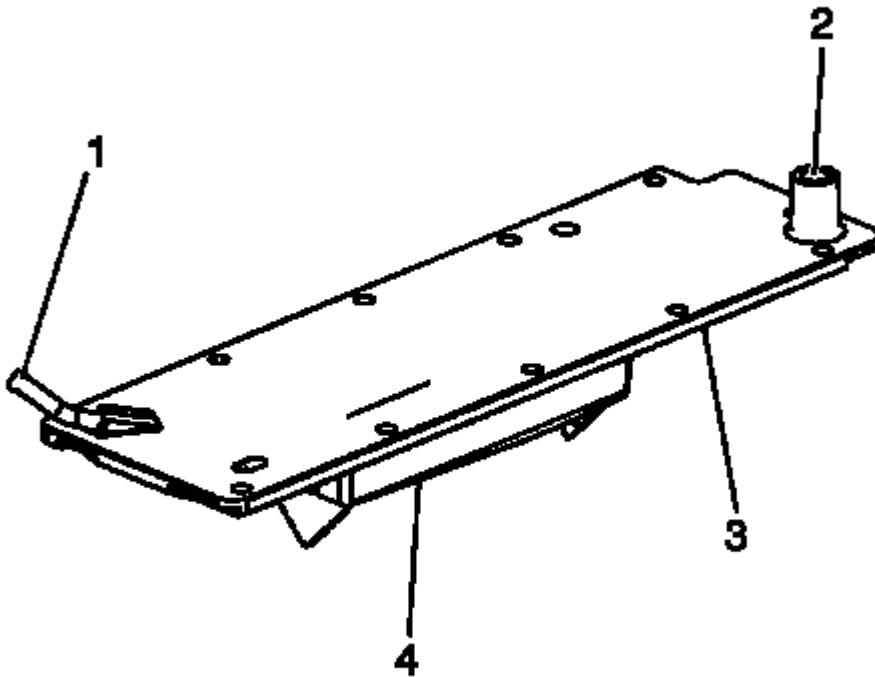
Engine Valley Cover Cleaning and Inspection

Fig. 397: PCV Passages, Damaged Threads & Damaged Sealing Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the valley cover in solvent.

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

2. Dry with compressed air.
3. Inspect for restrictions within the positive crankcase ventilation (PCV) passages (1, 4).
4. Inspect for damaged threads (2) and damaged sealing surfaces (3).

Valve Rocker Arm Cover Cleaning and Inspection

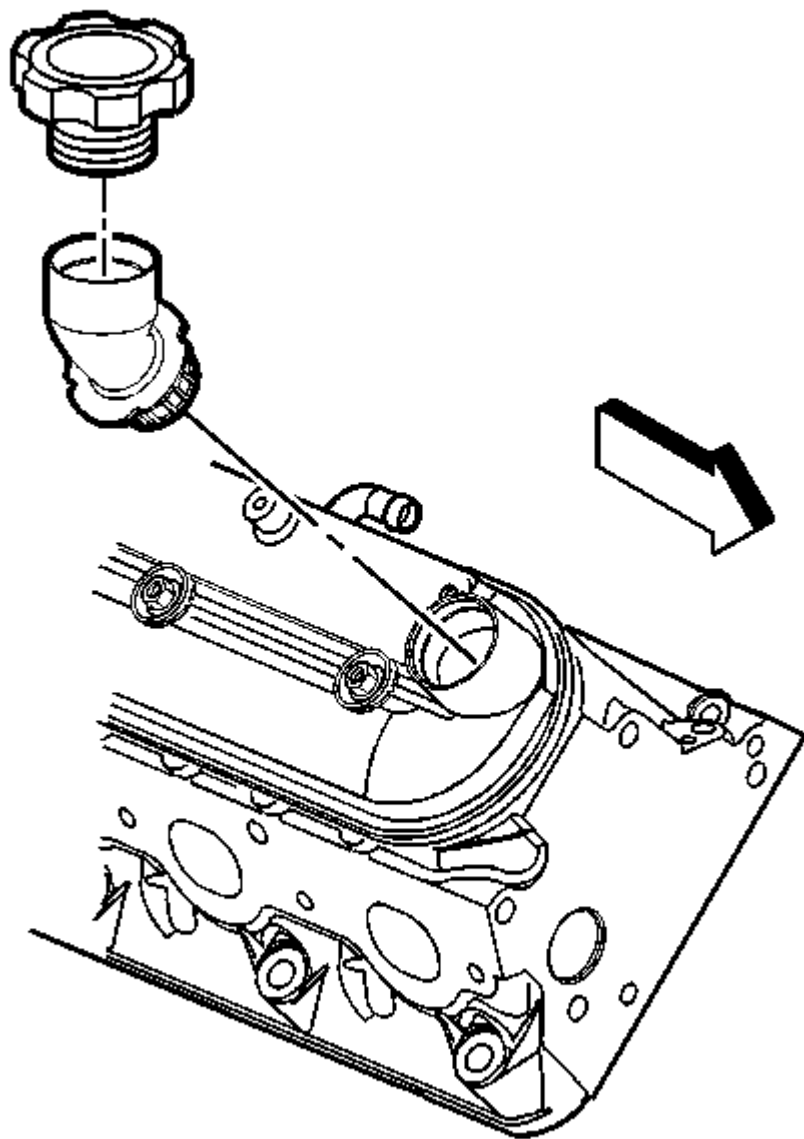


Fig. 398: View Of Oil Fill Cap & Tube
Courtesy of GENERAL MOTORS CORP.

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 unless service is required.**

1. Inspect the oil fill tube for a loose fit or damage.

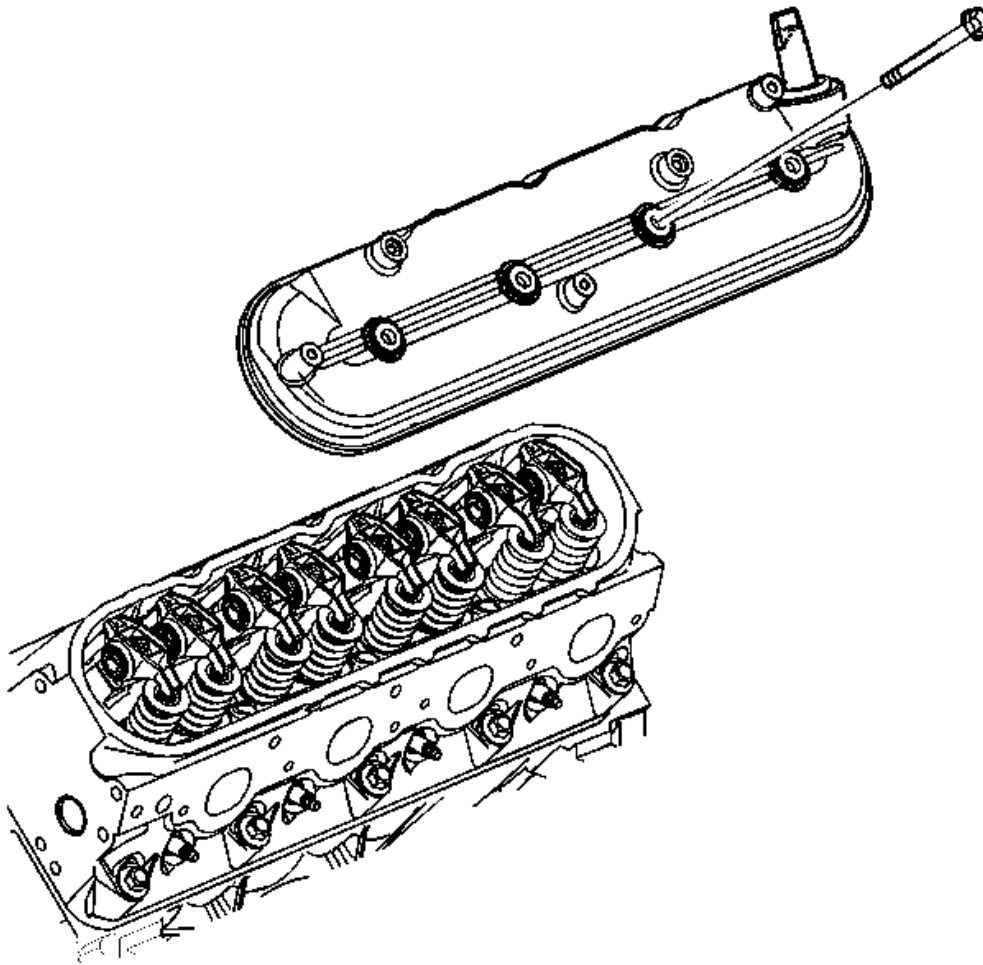


Fig. 399: Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Inspect the covers for the following conditions:
 - Scoring or damage to the gasket surfaces
 - Ventilation system passages for restrictions
 - Threaded bolt holes for damage or debris

Oil Pan Cleaning and Inspection

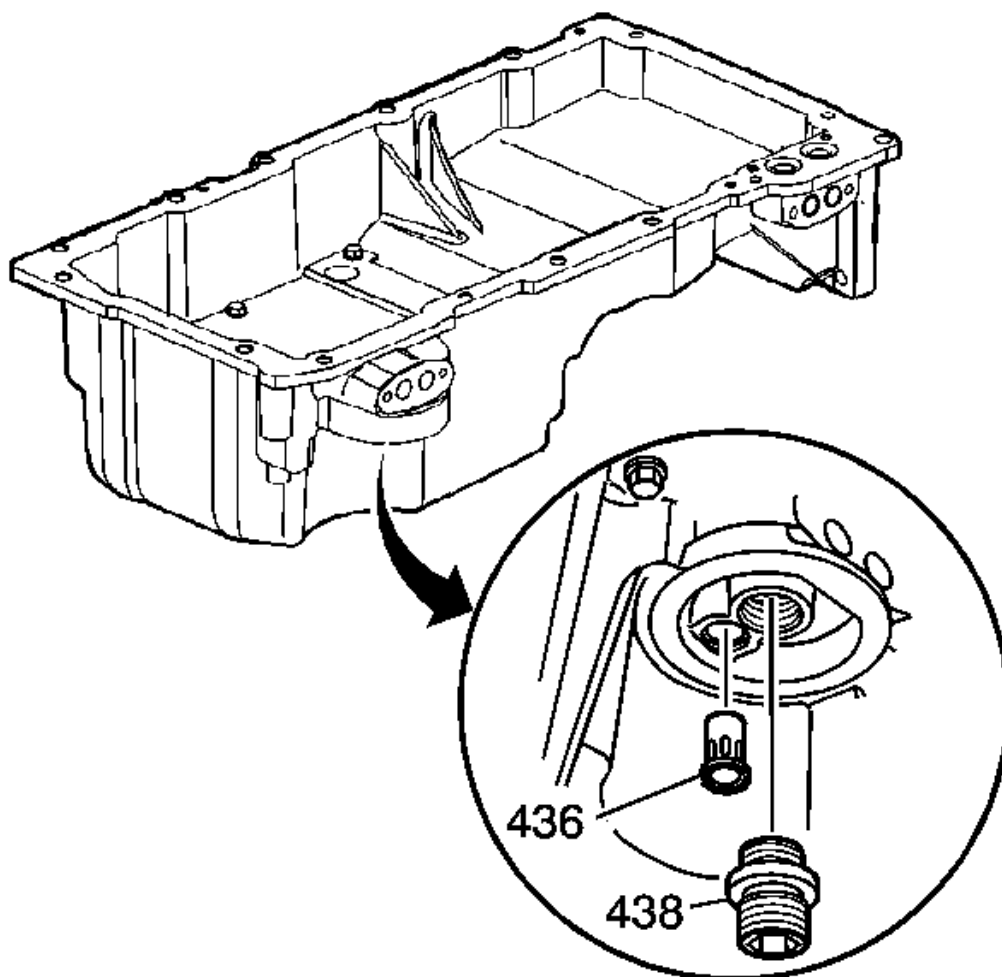


Fig. 400: Identifying Oil Filter Fitting & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter fitting (438) and bypass valve (436) as required. Refer to **Oil Filter, Adapter and Pan Cover Removal**.

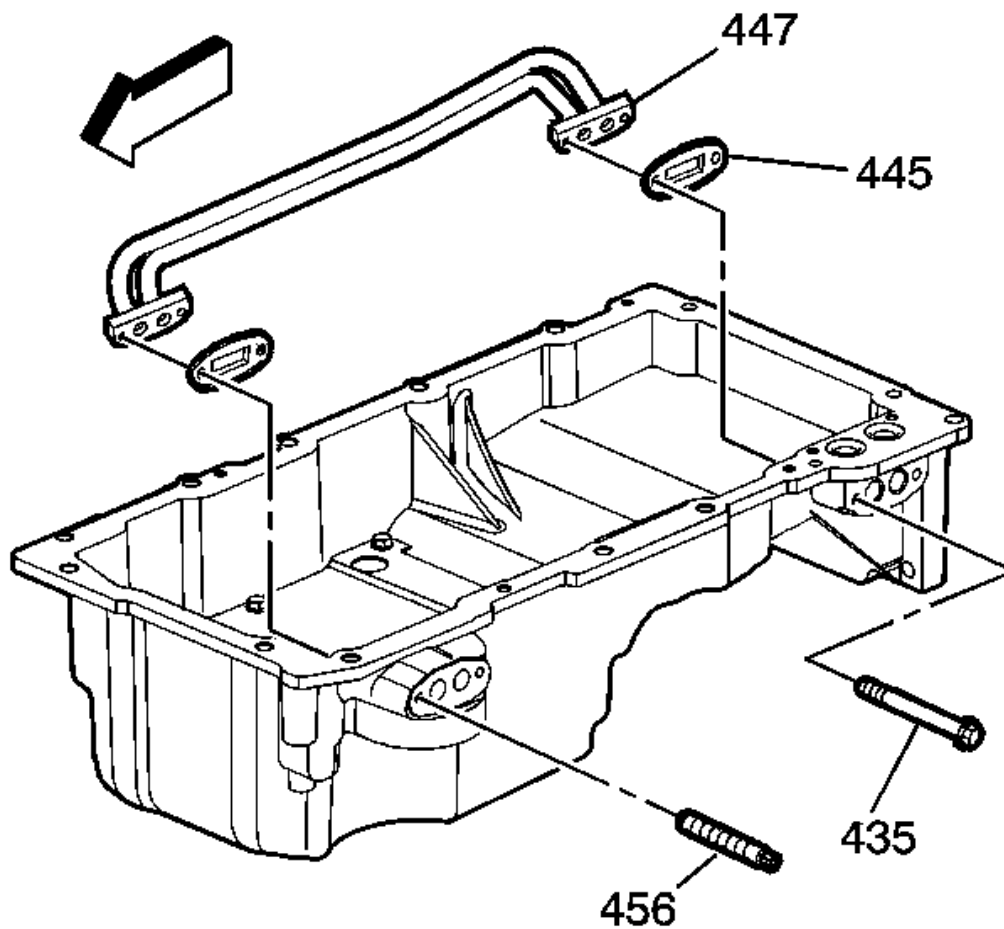


Fig. 401: View Of Oil Transfer Tube, Bolts, Studs & Gaskets
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter tube (447), bolts (435), studs (451), and gaskets (445).

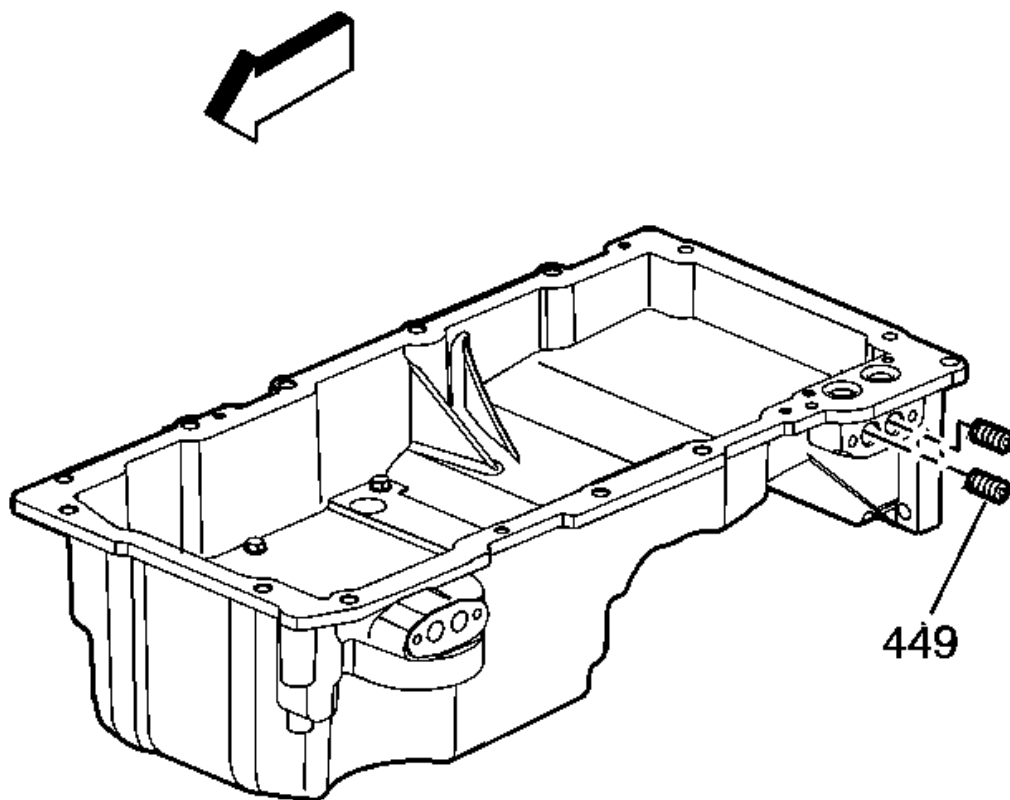


Fig. 402: View Of Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil gallery plugs (449).

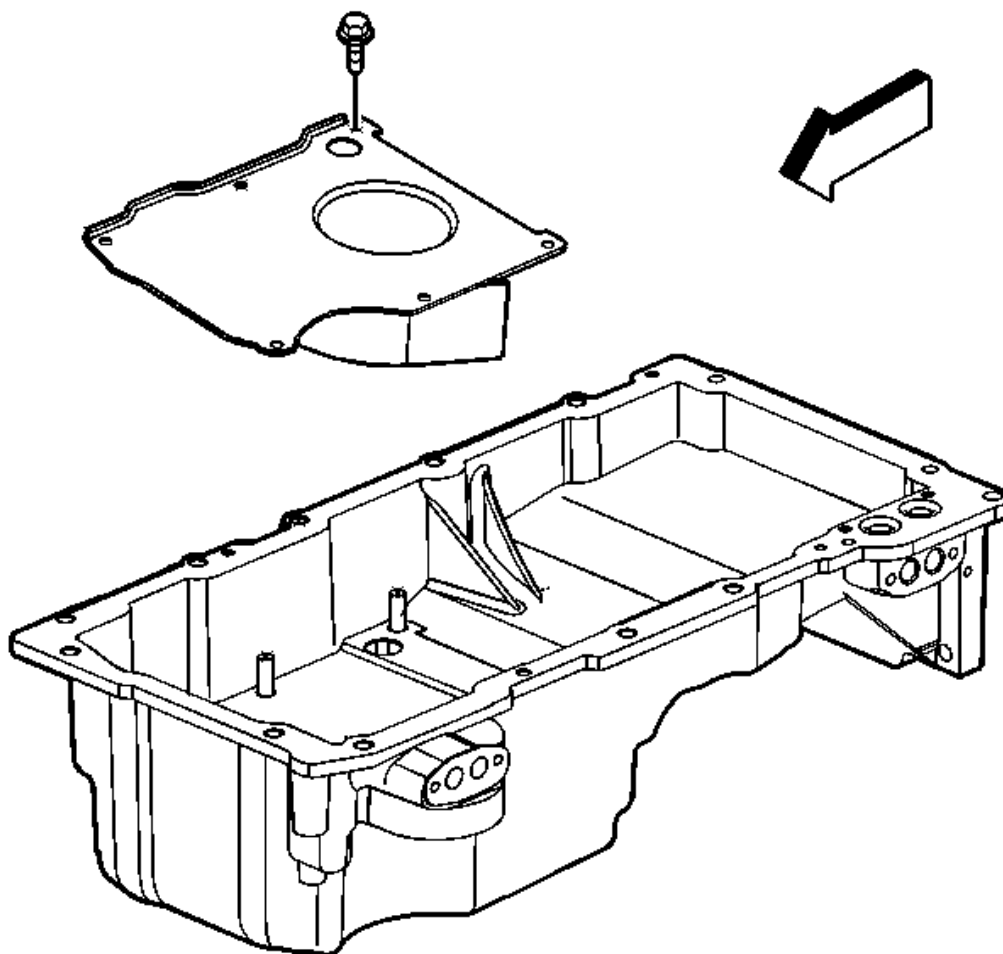


Fig. 403: View Of Oil Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts and baffle.
5. Clean the oil pan in solvent.

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

6. Dry the oil pan with compressed air.
7. Inspect the oil pan for the following conditions:
 - Damaged gasket surfaces

- Restrictions within the oil passages of the pan
- Damaged oil filter seal surface or inoperative oil filter bypass valve

Lightly depress the valve. The valve spring should seat the valve to the proper closed position.

- Threaded bolt holes for damage
8. Inspect the oil transfer tube for restrictions or damage.

Intake Manifold Cleaning and Inspection

Cleaning Procedure

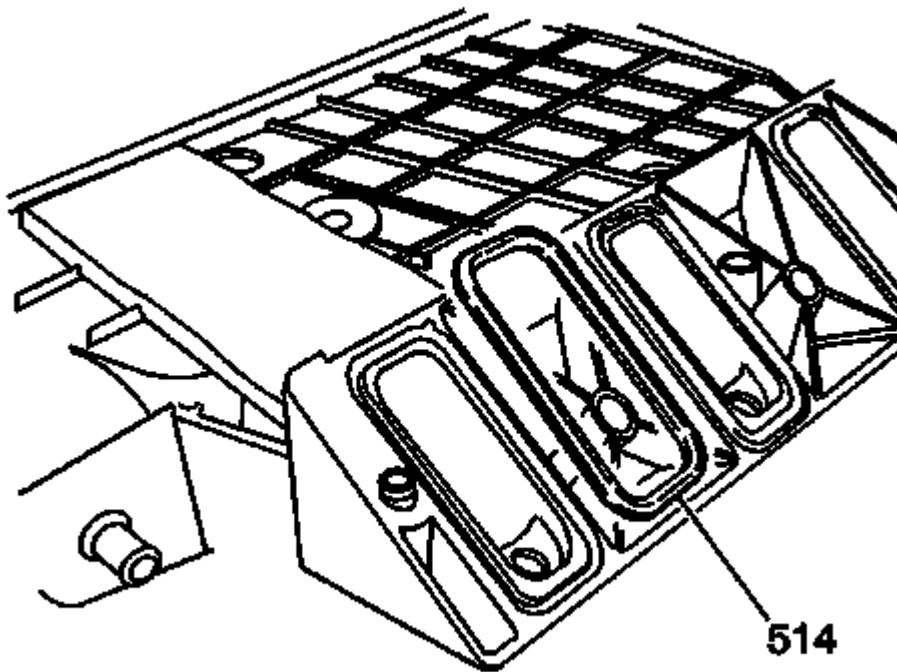


Fig. 404: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the intake manifold-to-cylinder head gaskets (514).

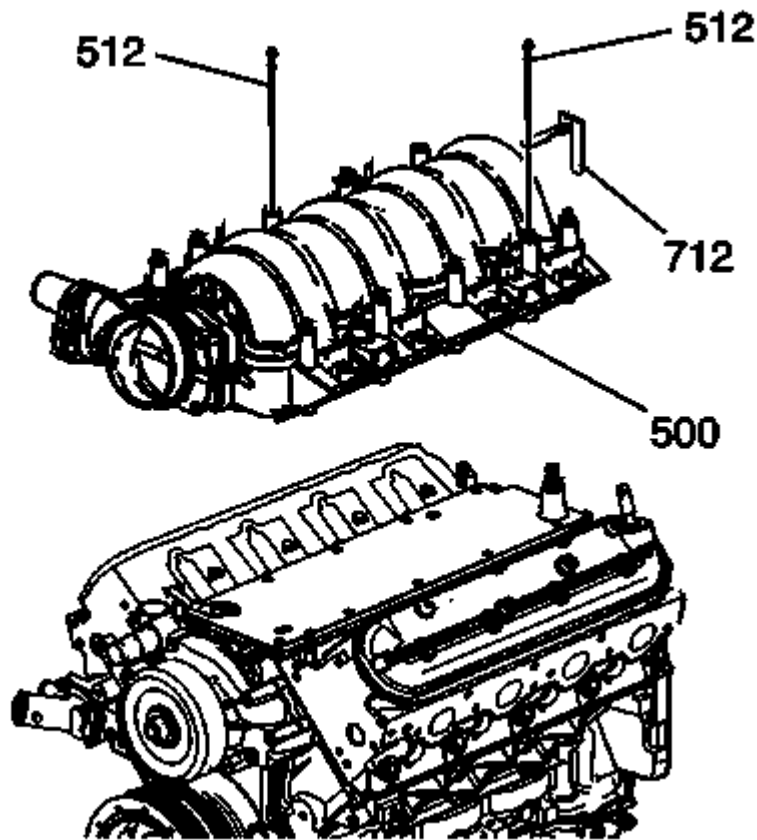


Fig. 405: Intake Manifold, Bolts & Fuel Rail Stop Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor. Refer to **Intake Manifold Removal**.
3. Remove the evaporative emission (EVAP) valve, EVAP tubes, 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 (500) in solvent.

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

6. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the manifold for the following conditions:
 - Damaged gasket or sealing surfaces
 - Loose threaded inserts or studs
 - Debris or restrictions within the passages of the manifold

- Damaged or broken vacuum fittings
 - Inspect the composite intake manifold assembly for cracks or other 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 two 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

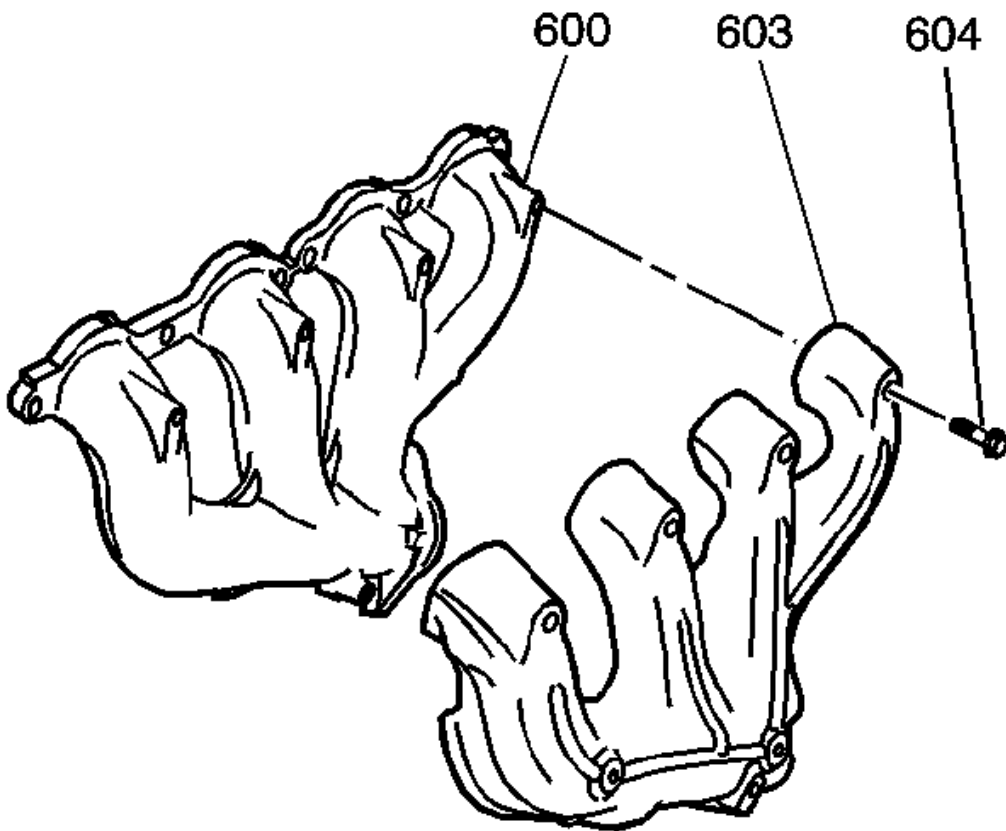


Fig. 406: View Of Heat Shield, Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

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 effect On-Board Diagnostics (OBD) II system performance.

1. Clean the exhaust manifold (600) and heat shield (603) in solvent.

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

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 take down studs for damaged threads.

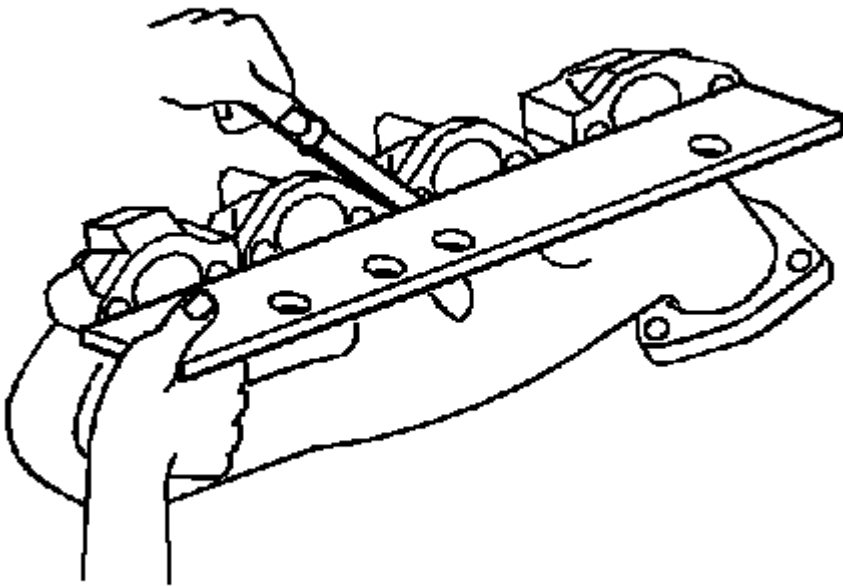


Fig. 407: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Use a straight edge and a feeler gage and measure the exhaust manifold cylinder head deck for warpage.

An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the two front or two rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

Coolant Air Bleed Pipe Cleaning and Inspection

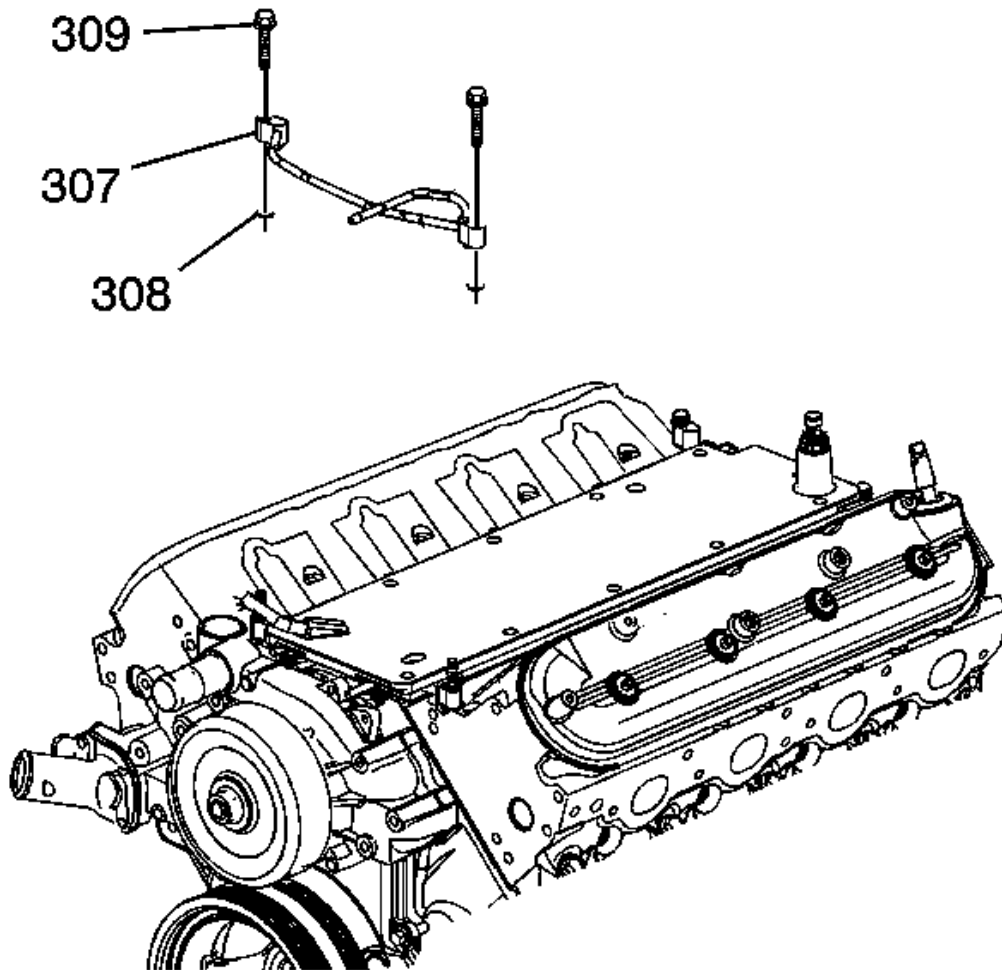


Fig. 408: Identifying Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

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 sealing gaskets (308) from the pipe (307) and covers.

2. Clean the pipe and covers in solvent.

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

3. Dry the pipe and covers with compressed air.
4. Inspect the pipe and covers for damaged sealing surfaces or restrictions within the pipe.

Water Pump Cleaning and Inspection

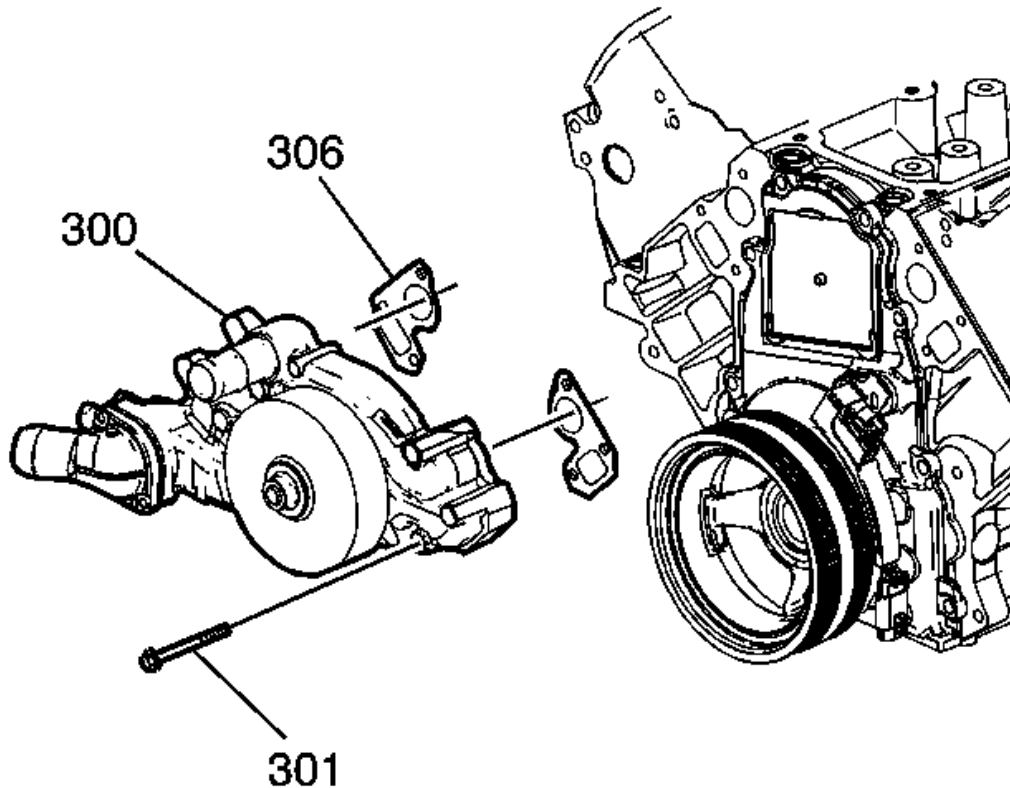


Fig. 409: View Of Water Pump, Gaskets & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the old gasket from the water pump sealing surfaces. Refer to Replacing Engine Gaskets.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump (300) for the following conditions:
 - Gasket and hose sealing surfaces for excessive scratches or gouging

- Restrictions within the internal coolant passages
- Excessive side-to-side play in the pulley shaft
- Leakage at the water outlet housing or rear cover gasket
- 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

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

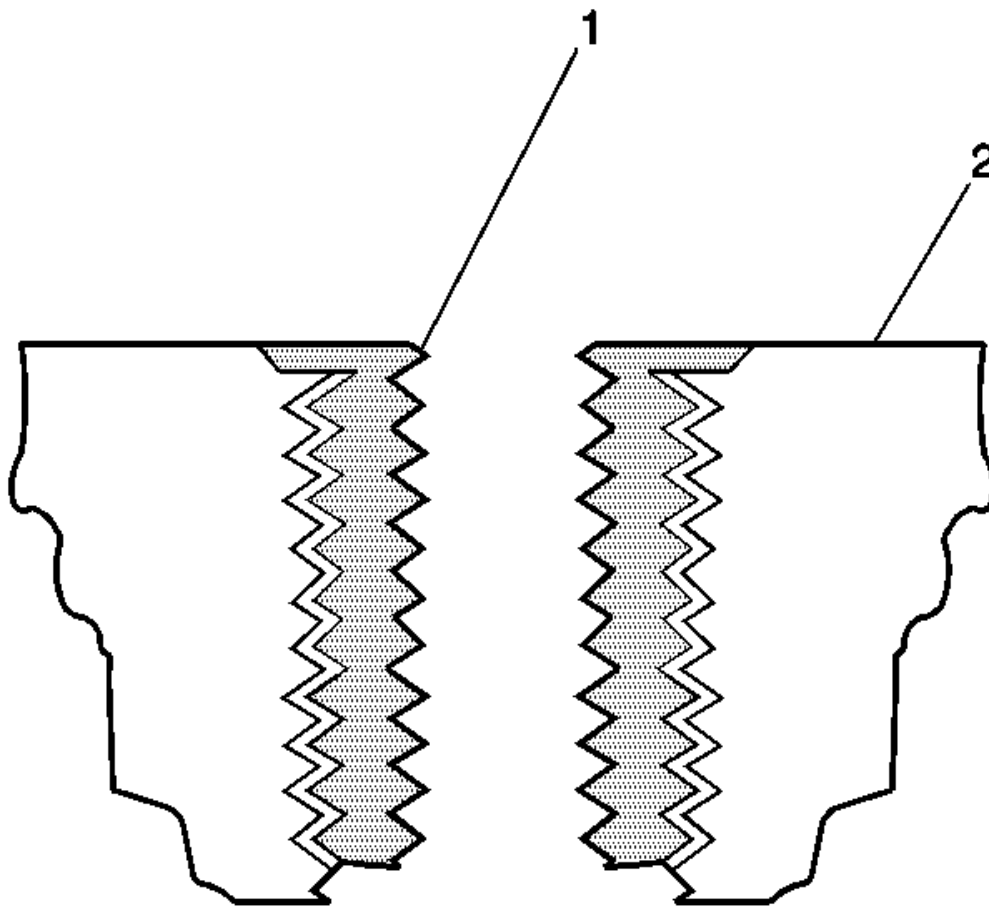


Fig. 410: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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.

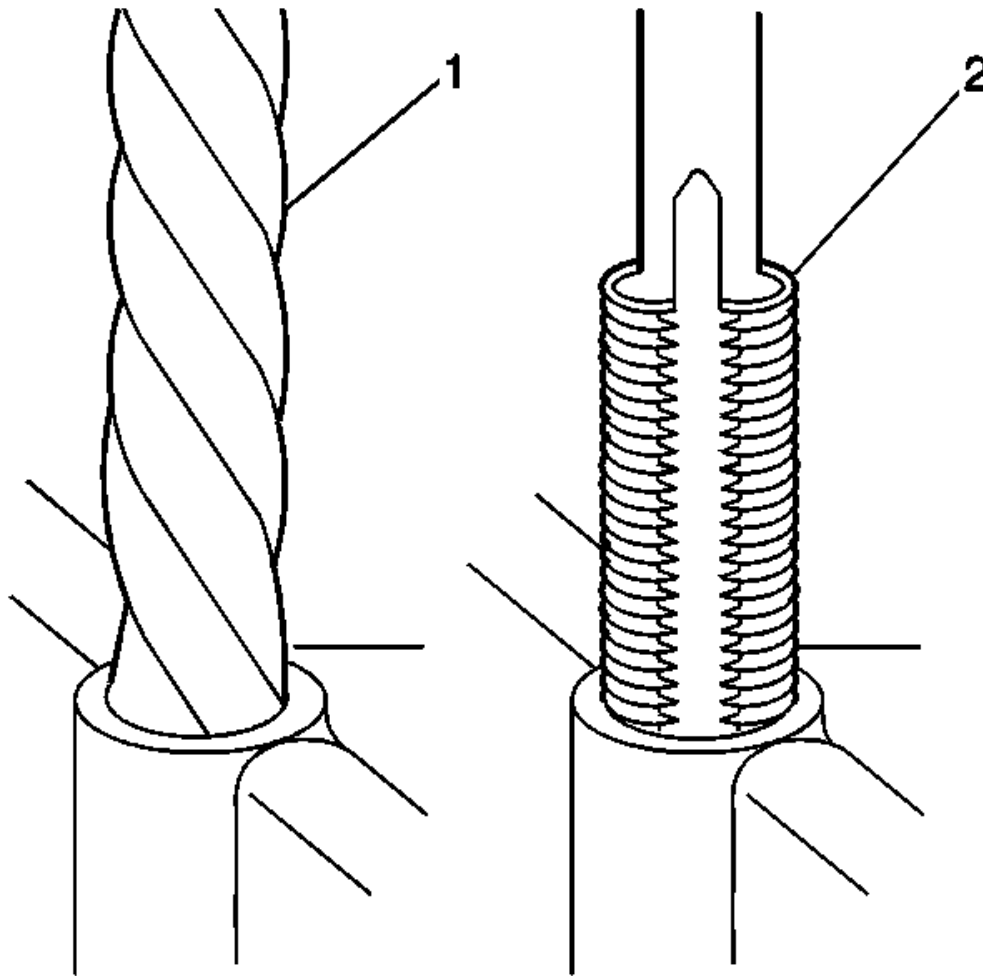


Fig. 411: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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

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.

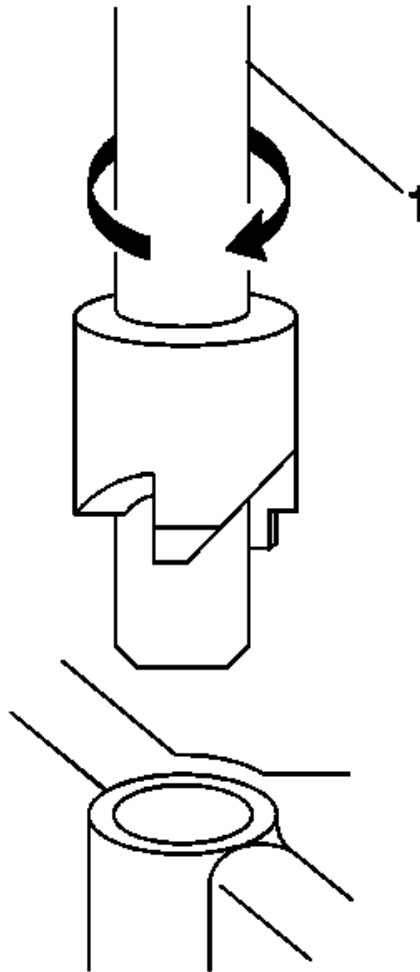


Fig. 412: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

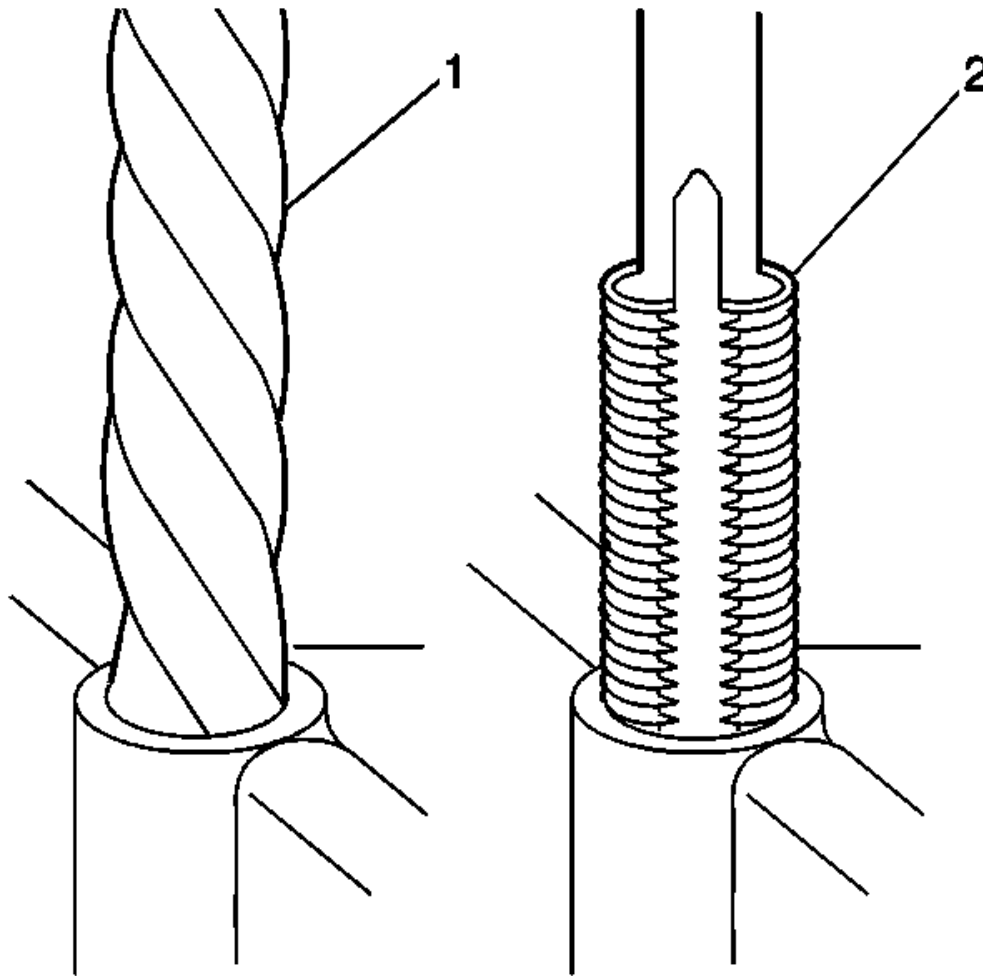


Fig. 413: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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.
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.

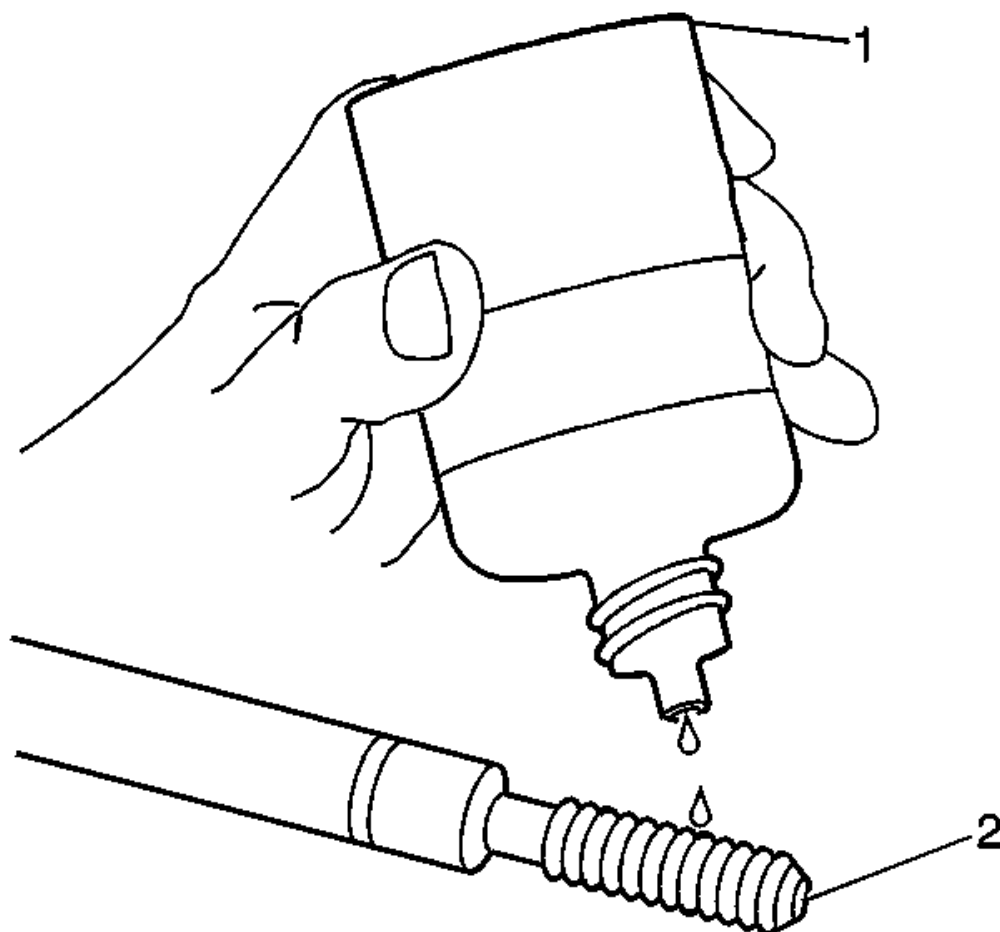


Fig. 414: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

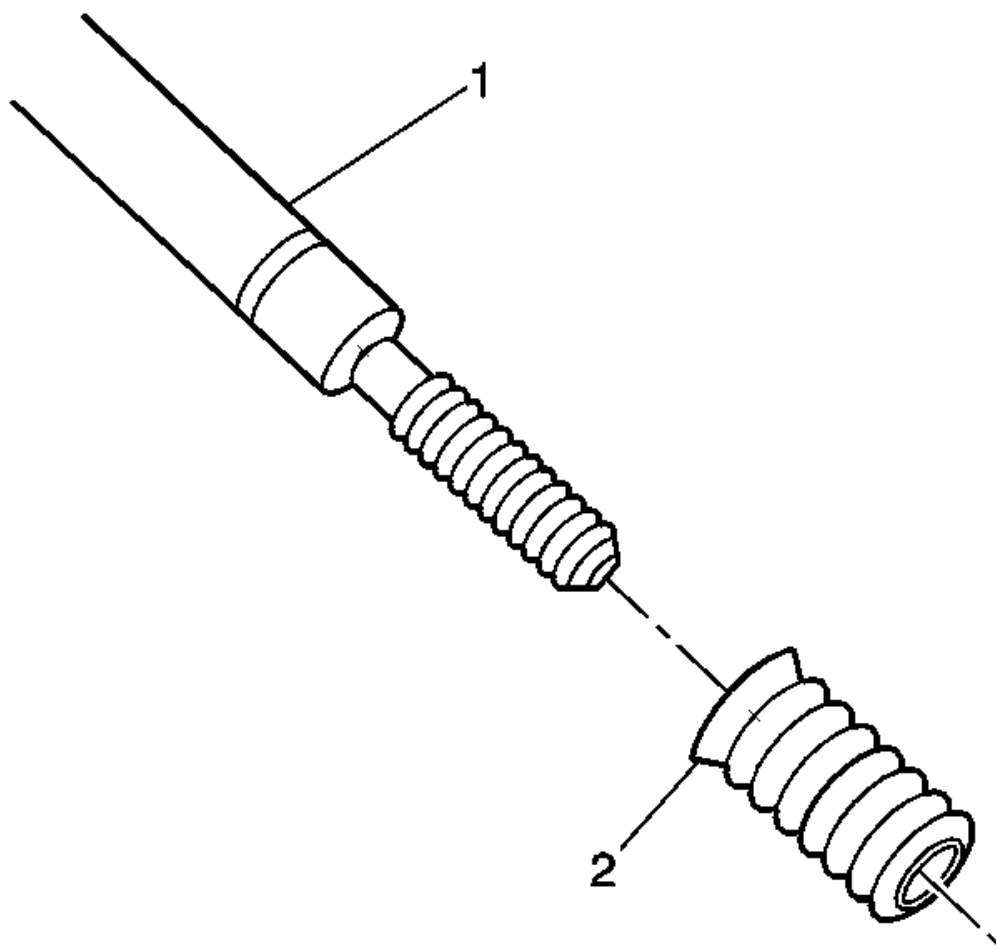


Fig. 415: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

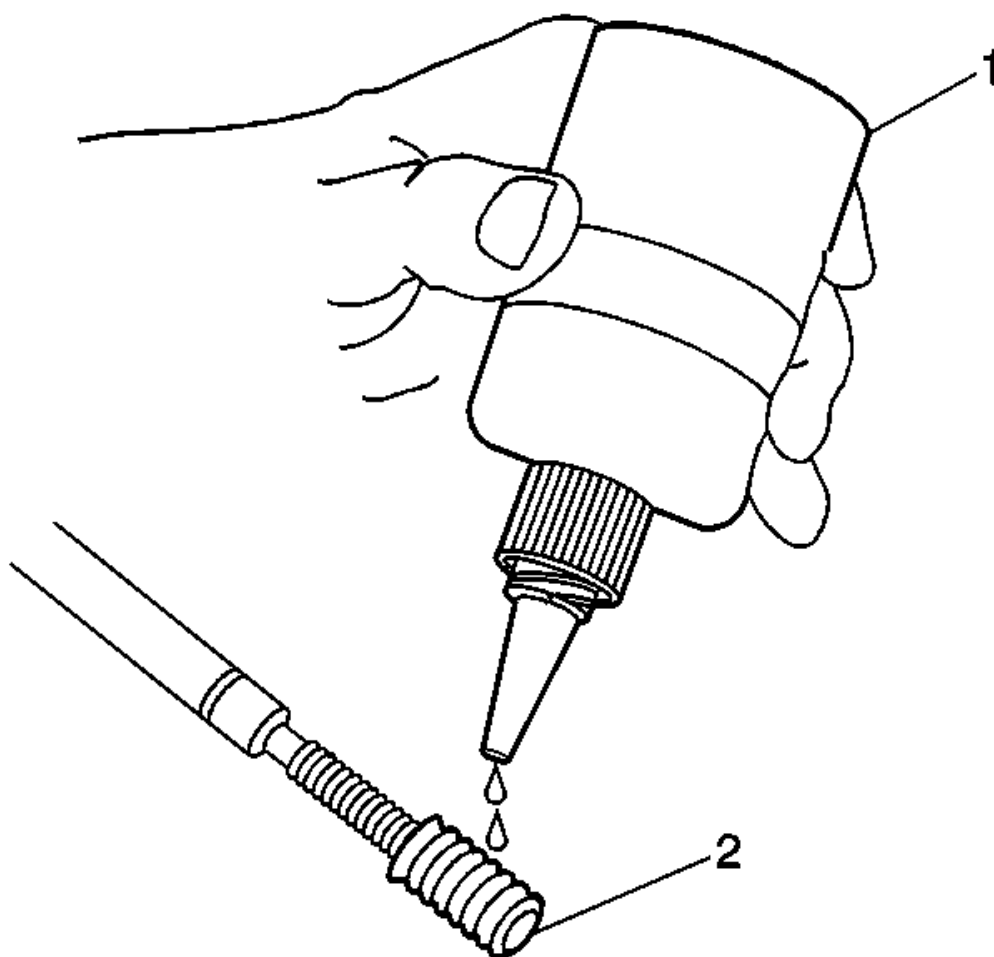


Fig. 416: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

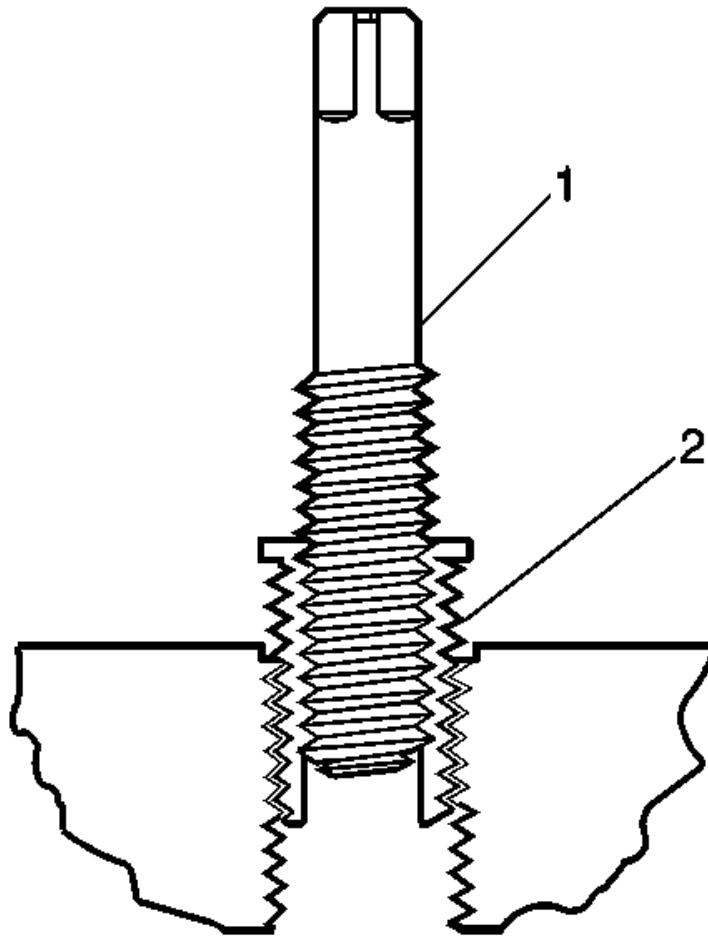


Fig. 417: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. 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.

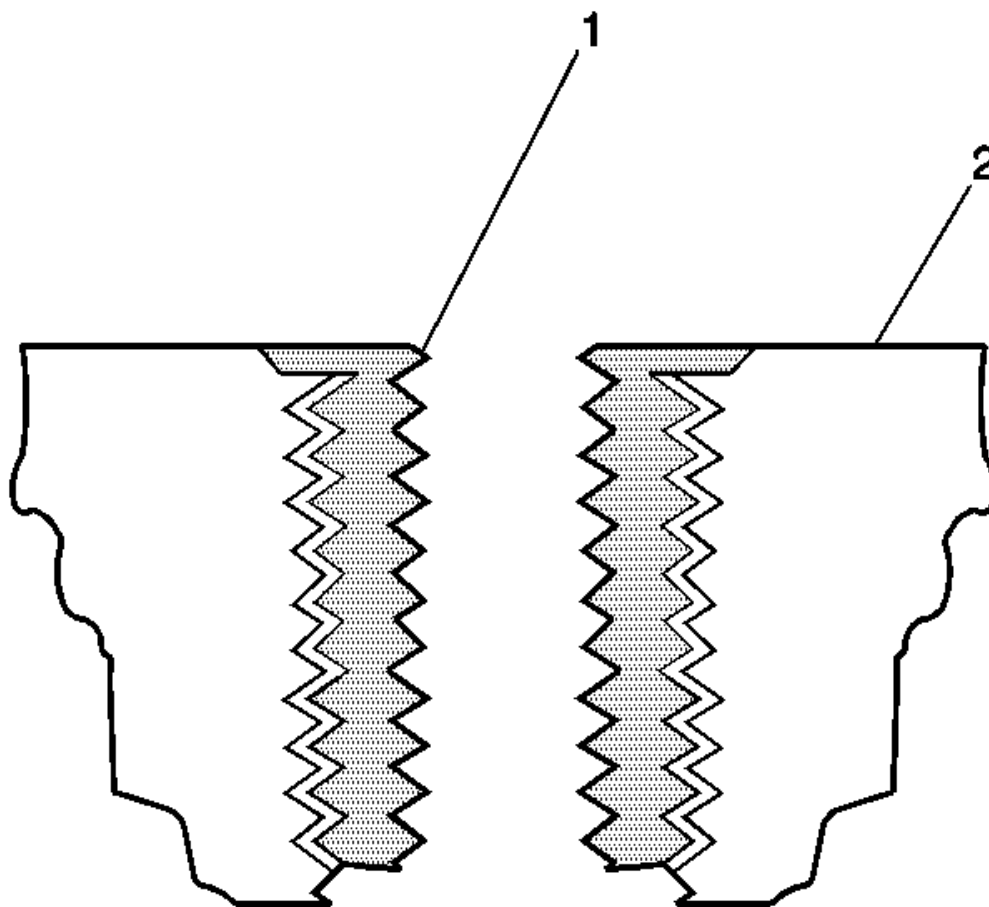


Fig. 418: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

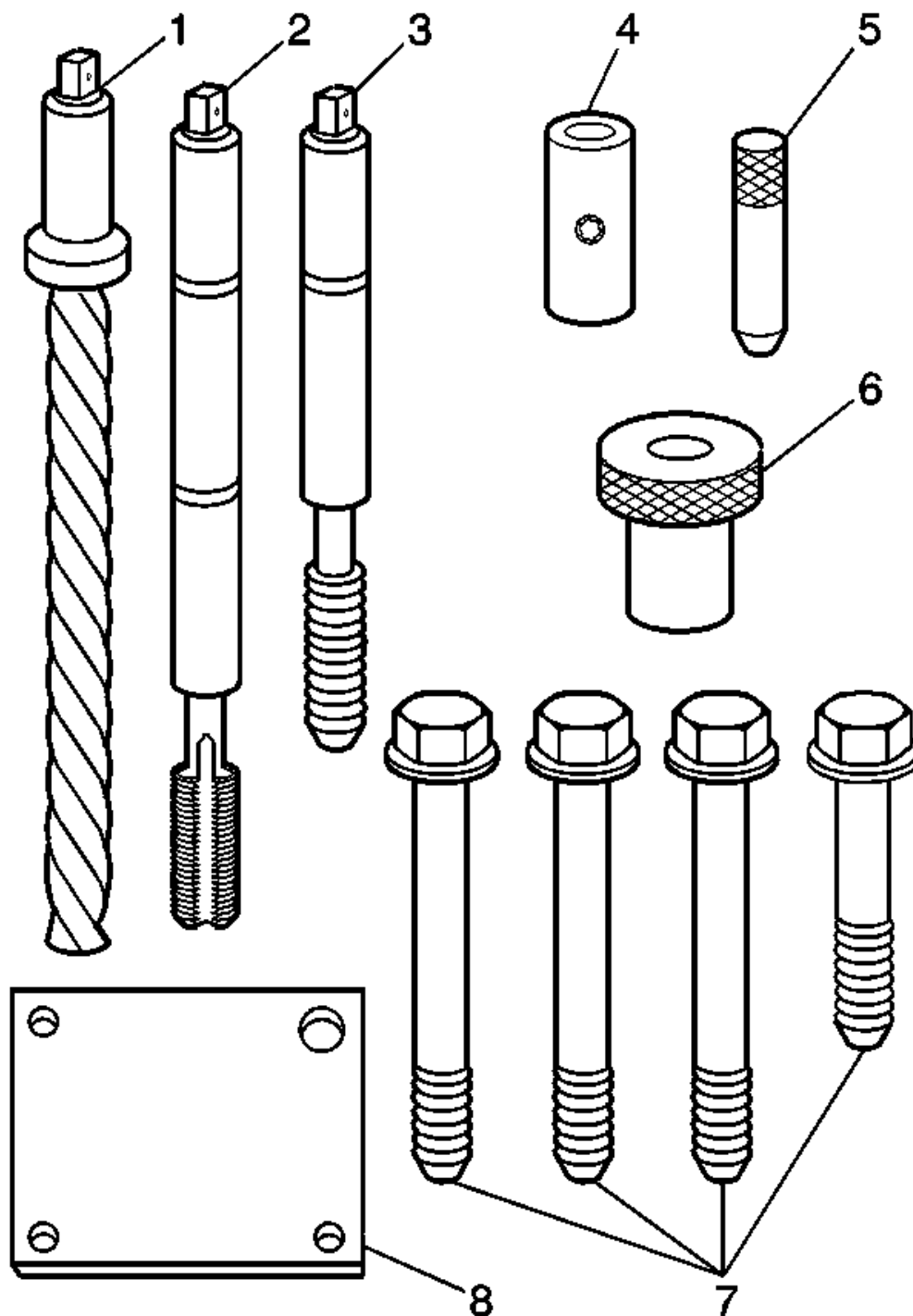


Fig. 419: Identifying Thread Repair Kit Components
 Courtesy of GENERAL MOTORS CORP.

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)

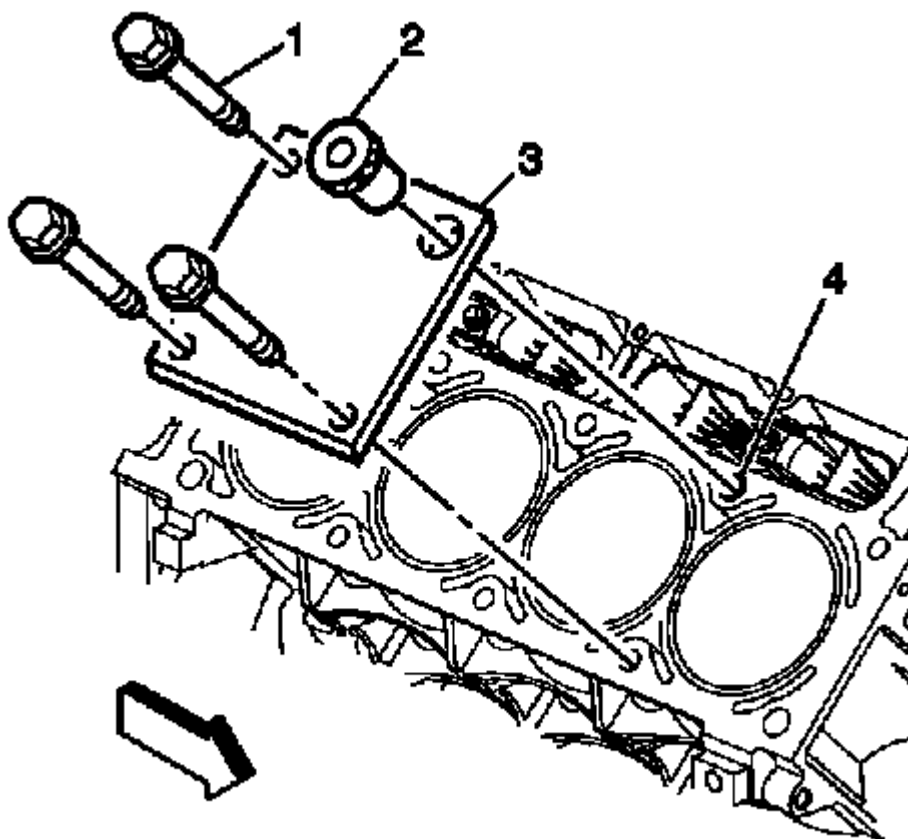


Fig. 420: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS CORP.

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

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.

- **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).

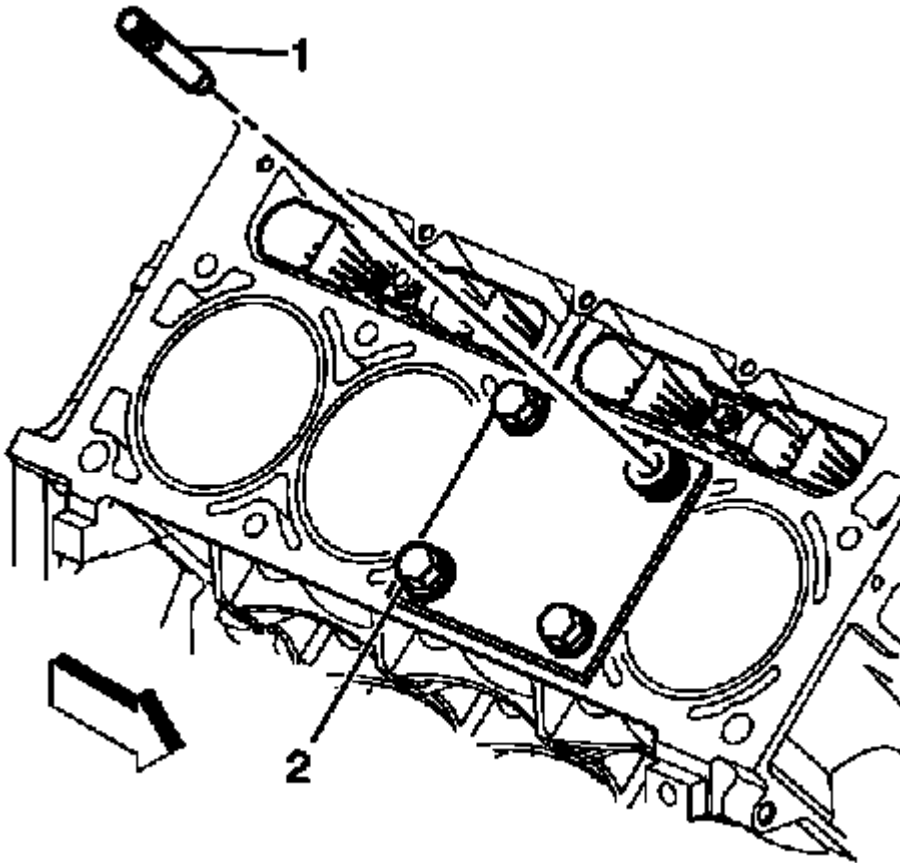


Fig. 421: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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.

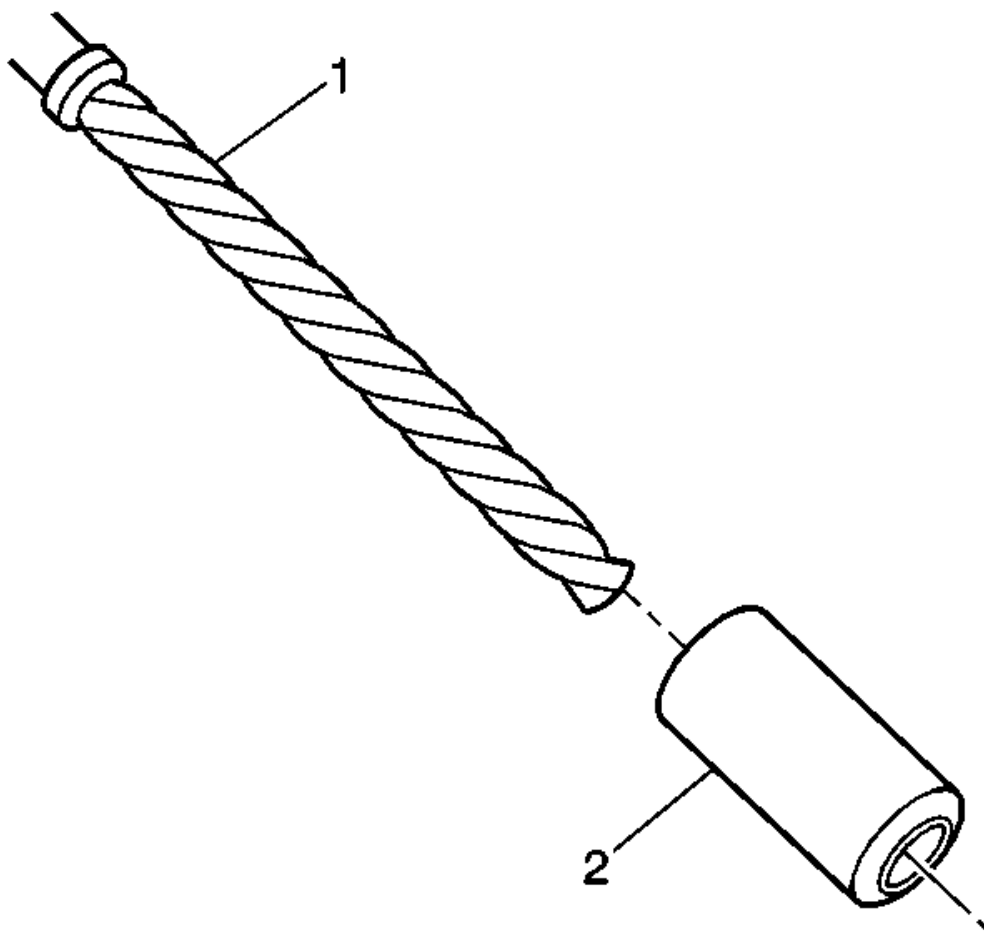


Fig. 422: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1).

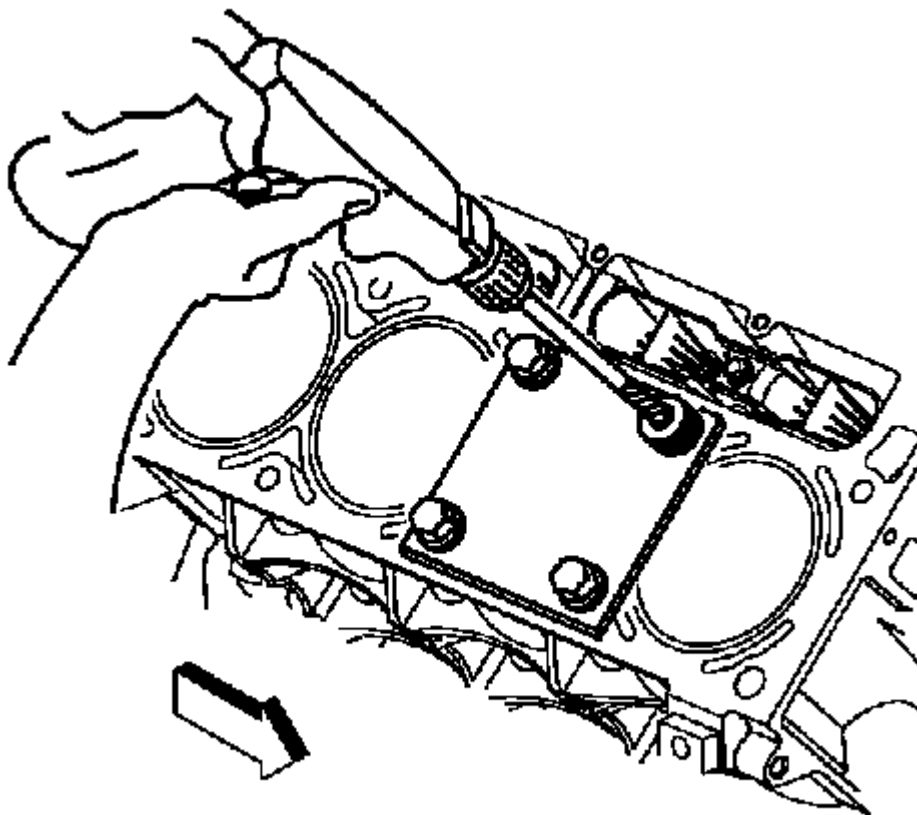


Fig. 423: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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 bushing.

8. Using compressed air, clean out any chips.

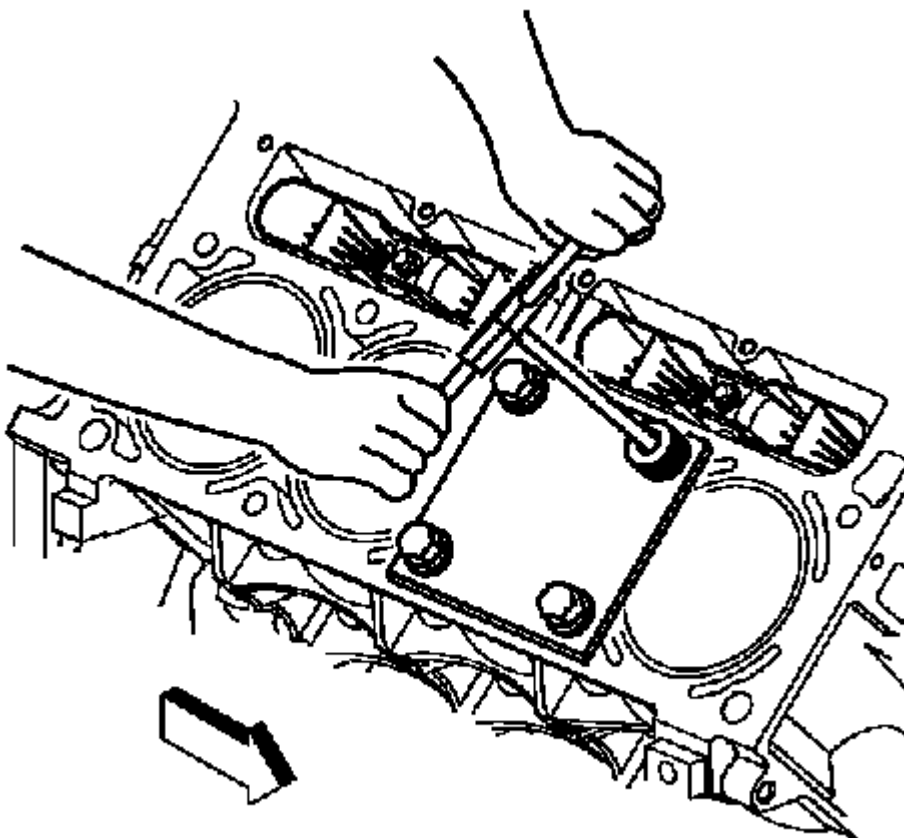


Fig. 424: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

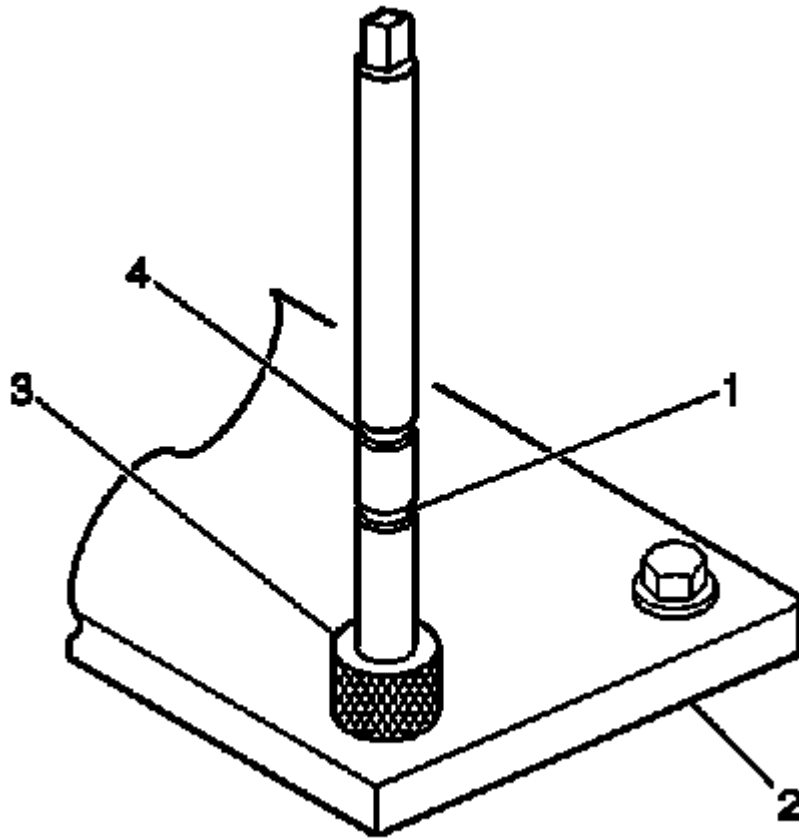


Fig. 425: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

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.
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.

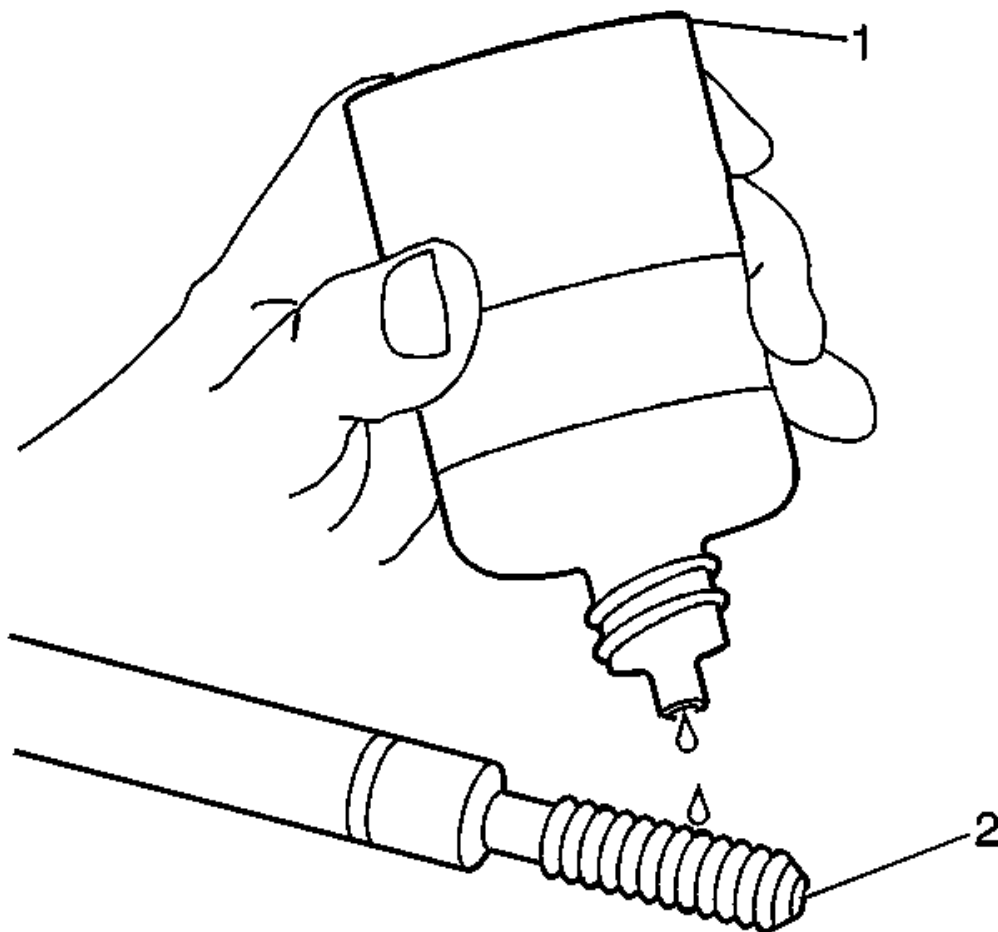


Fig. 426: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or foreign material to contact the OD of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

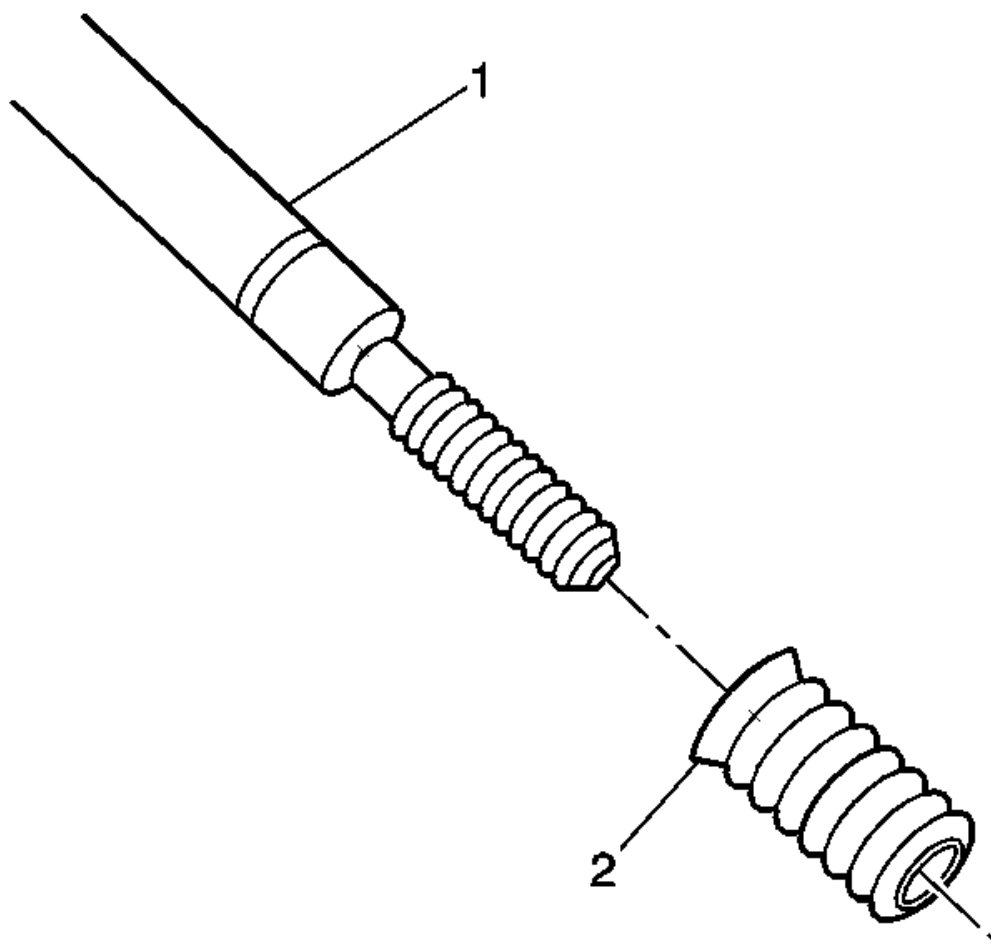


Fig. 427: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

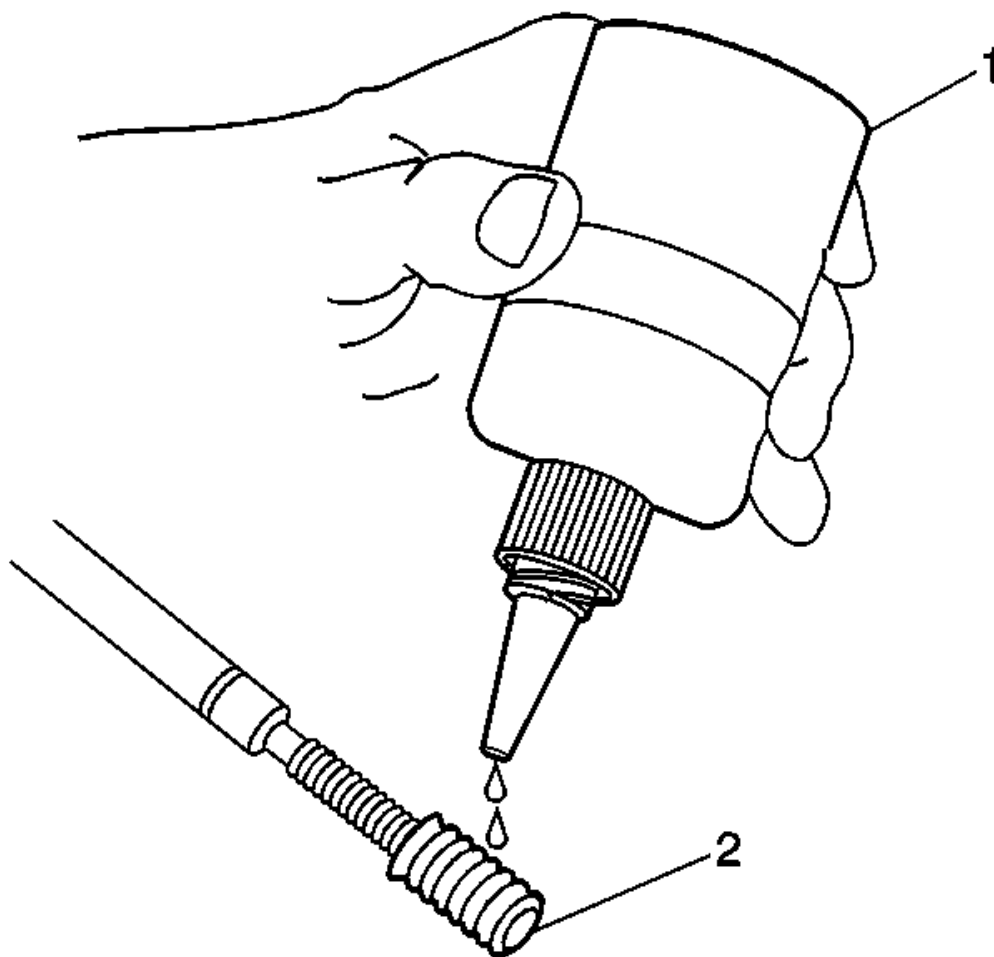


Fig. 428: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

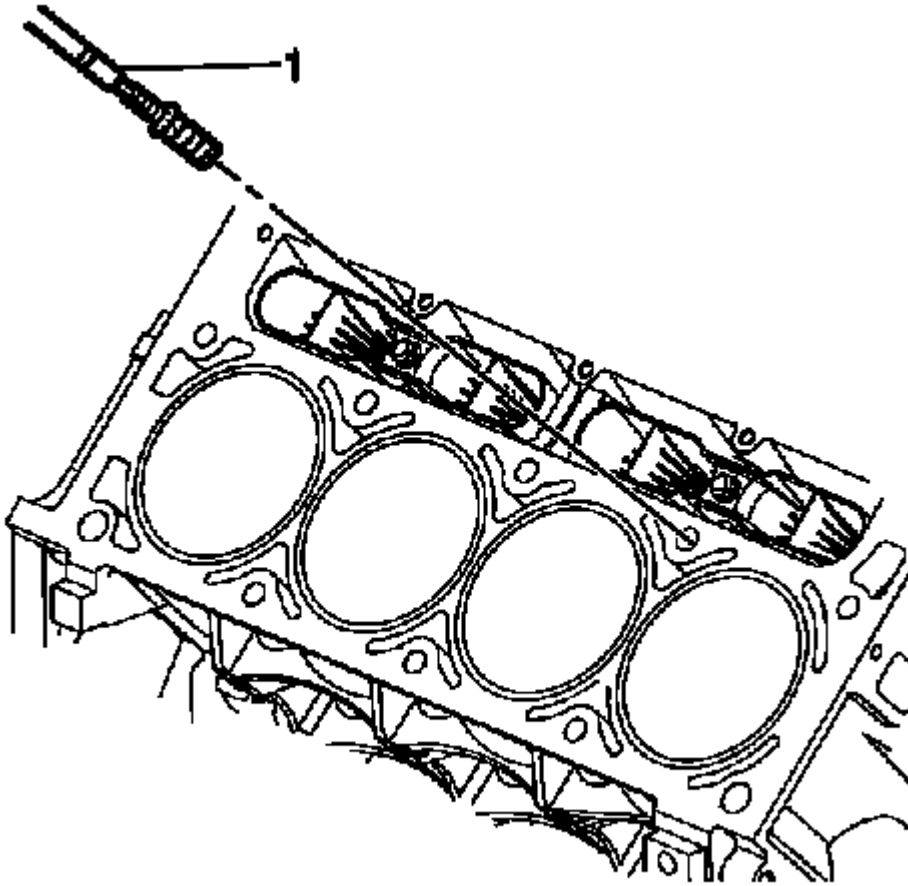


Fig. 429: Installing Insert & Driver Into Cylinder Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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 mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

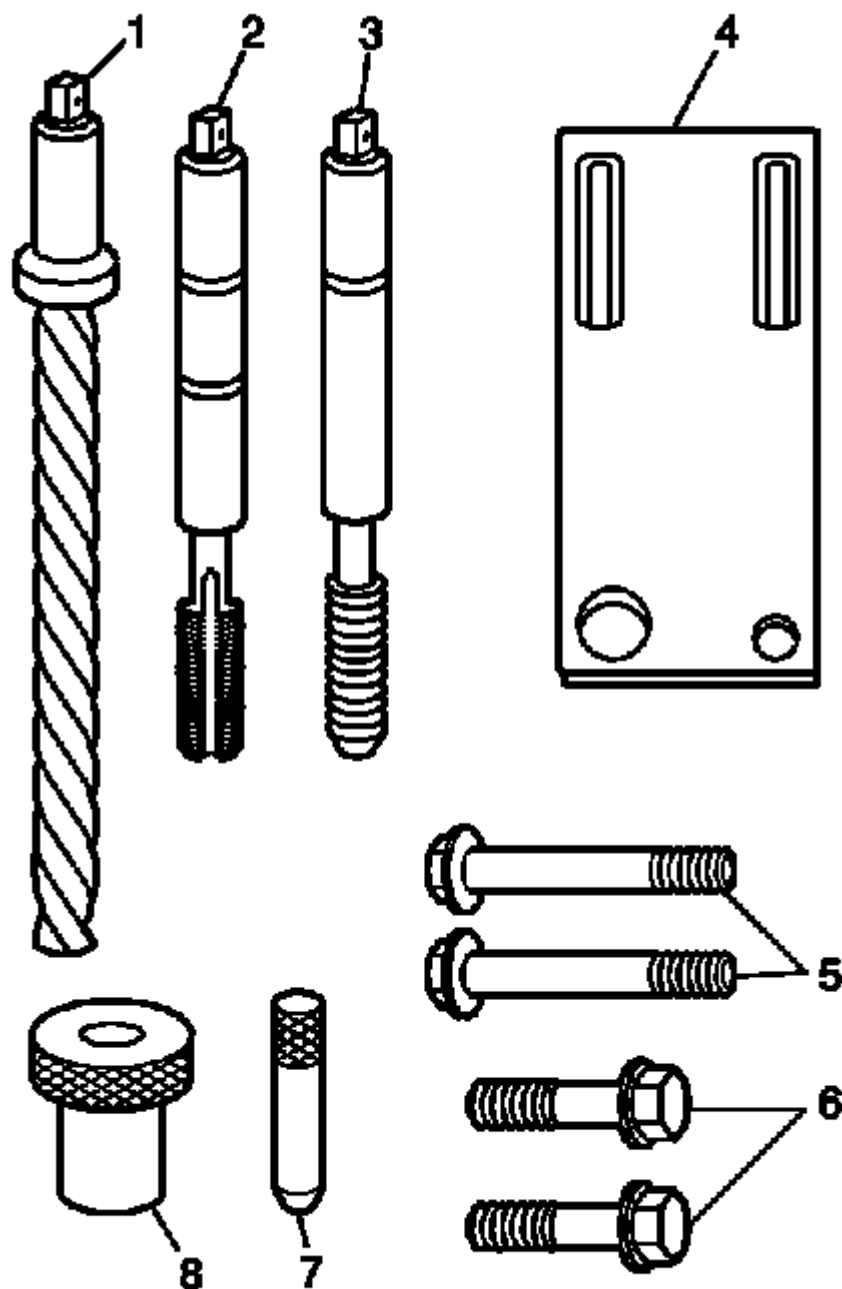


Fig. 430: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

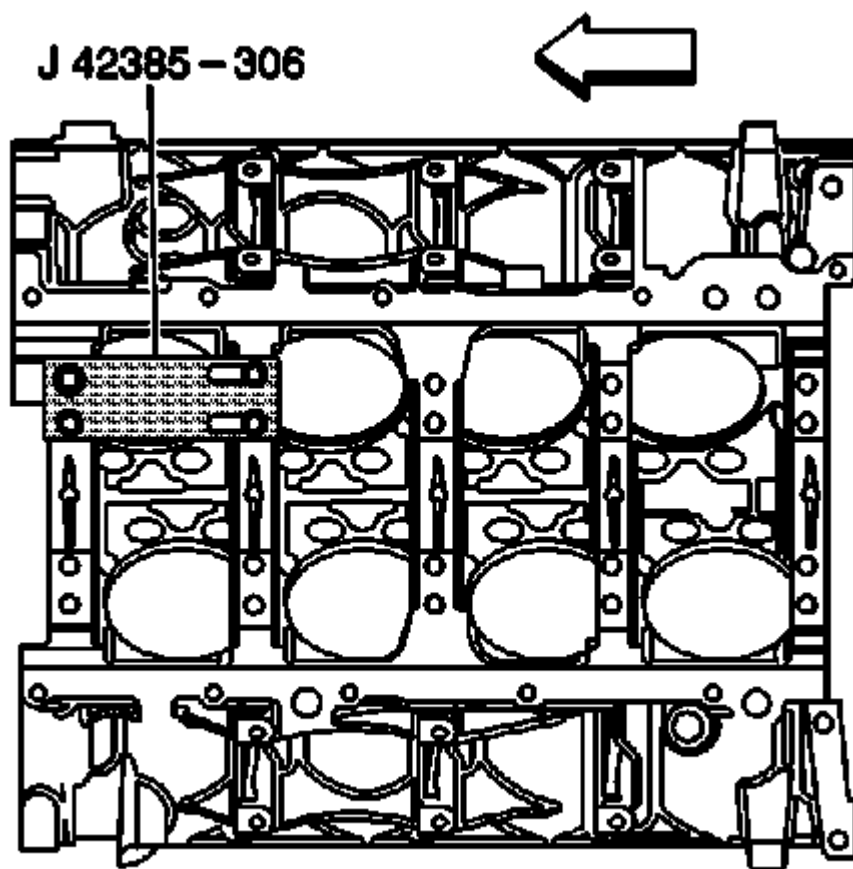


Fig. 431: View Of Fixture Plate, Bolt & Bushing
Courtesy of GENERAL MOTORS CORP.

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.

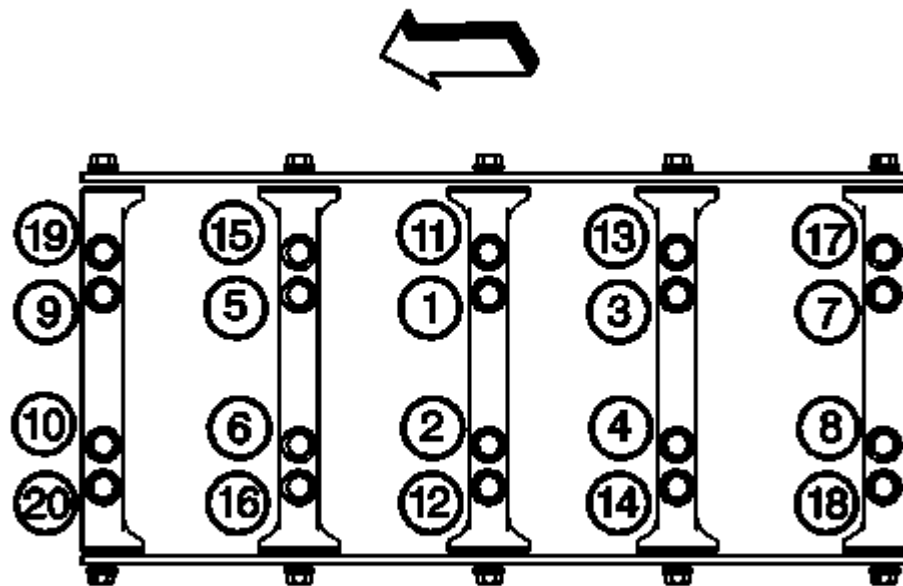


Fig. 432: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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.

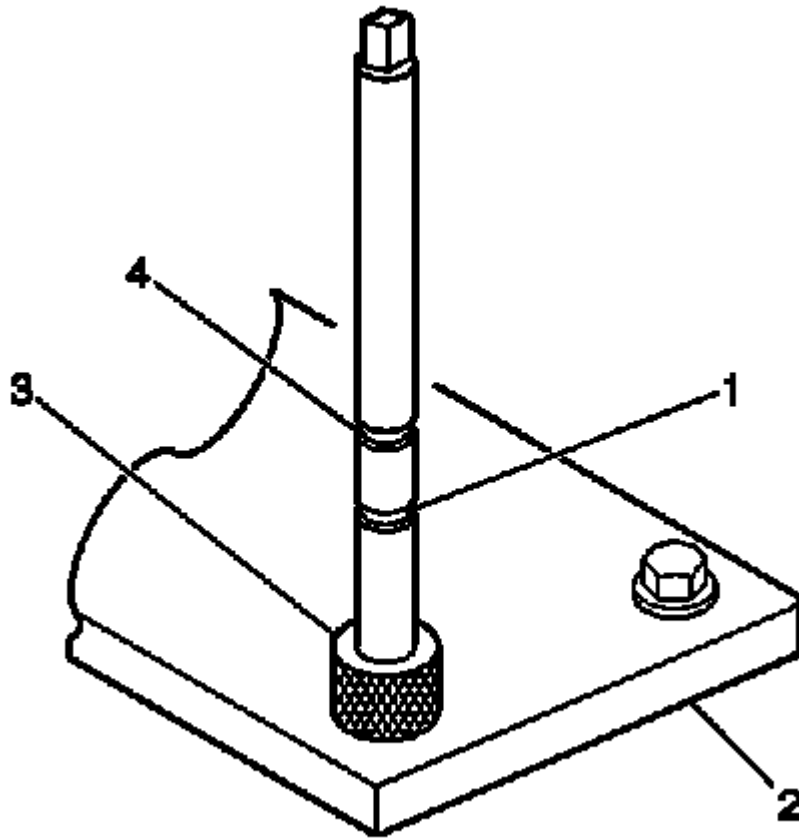


Fig. 433: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

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.

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.

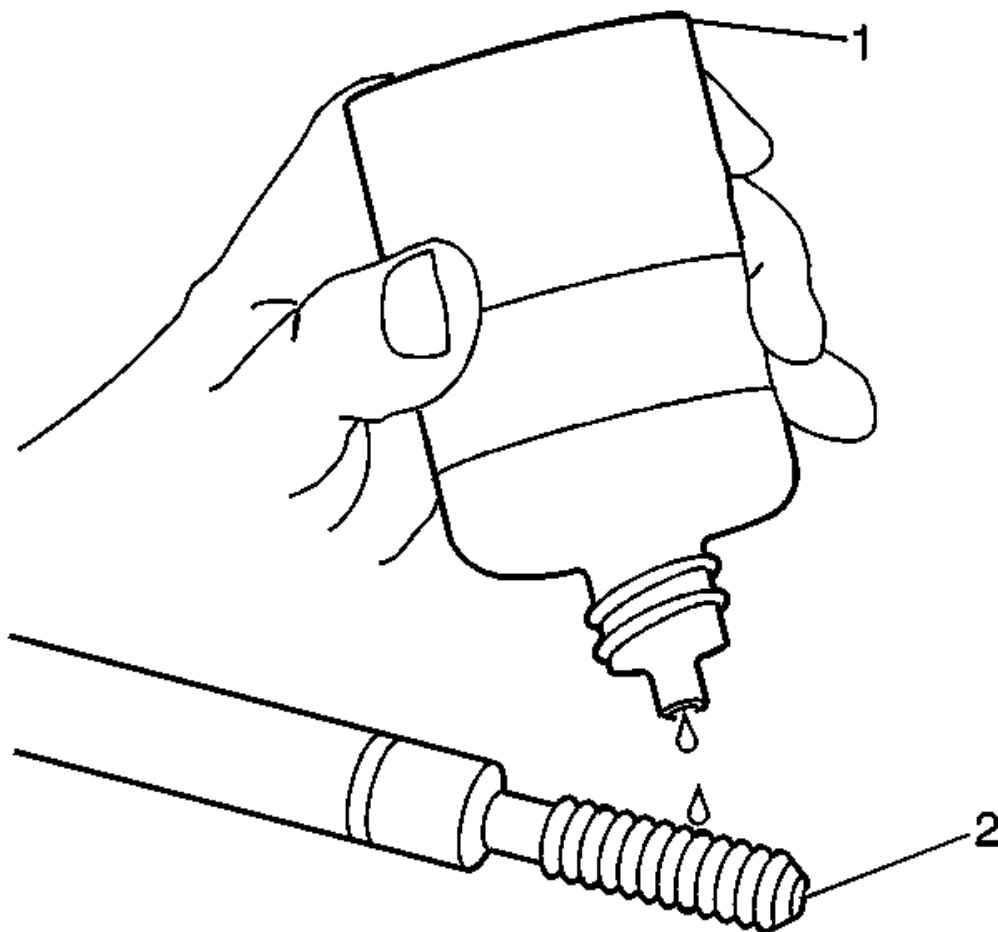


Fig. 434: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

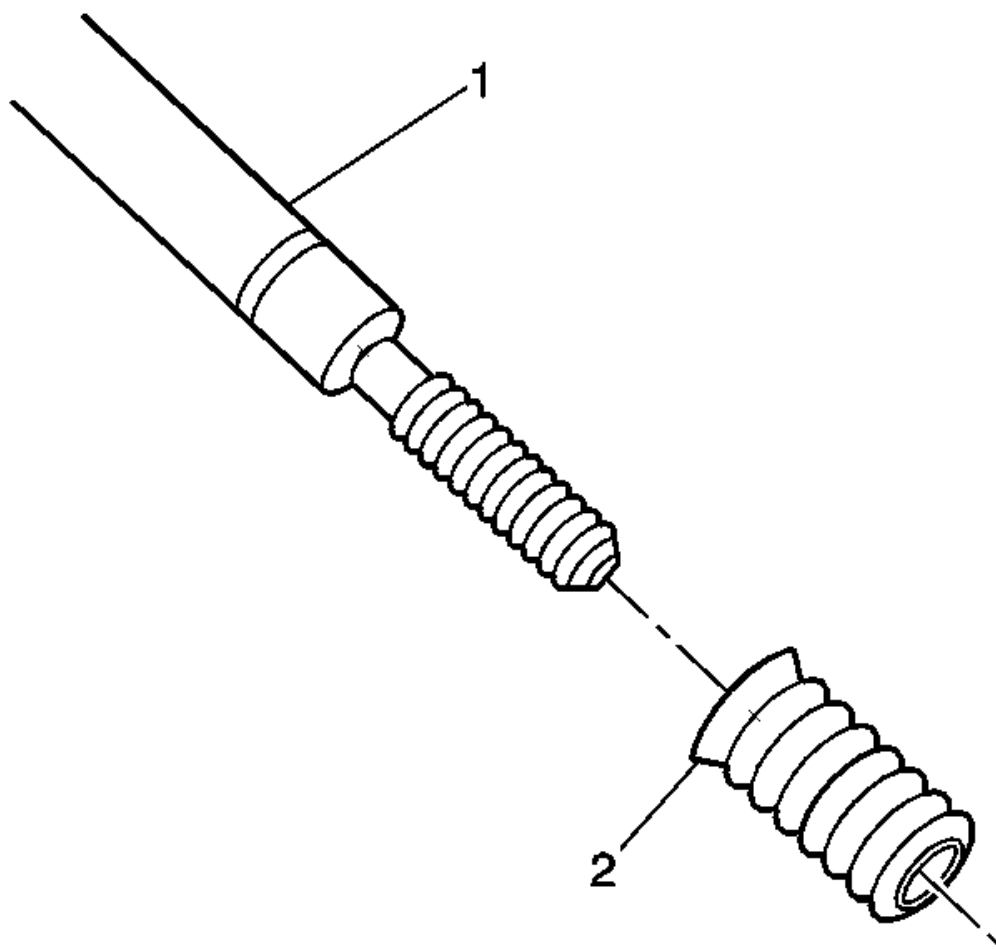


Fig. 435: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) onto the driver tool (1).

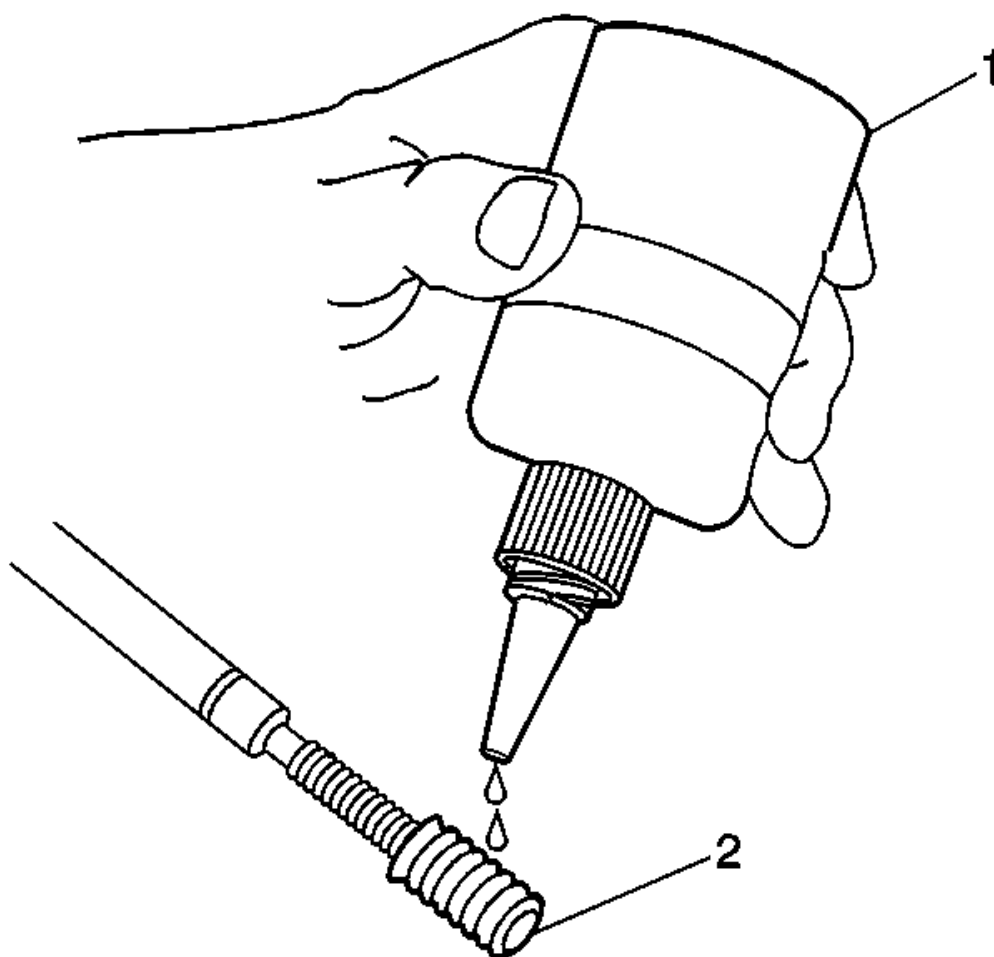


Fig. 436: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

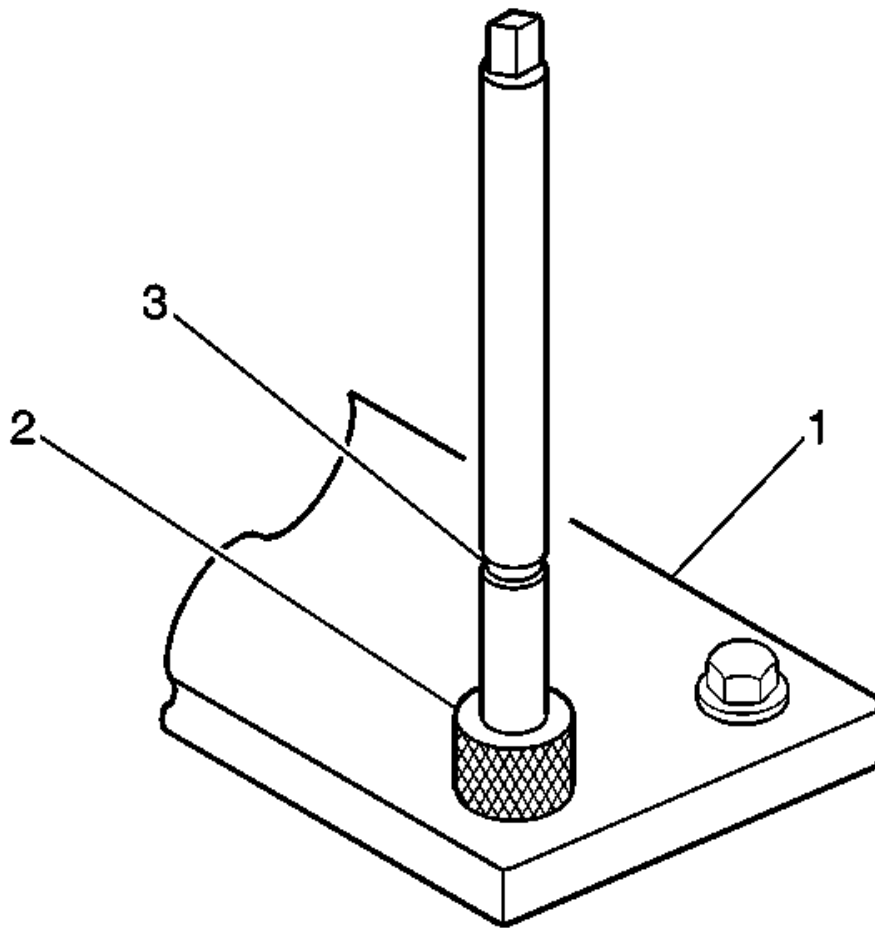


Fig. 437: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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 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 will cause 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.

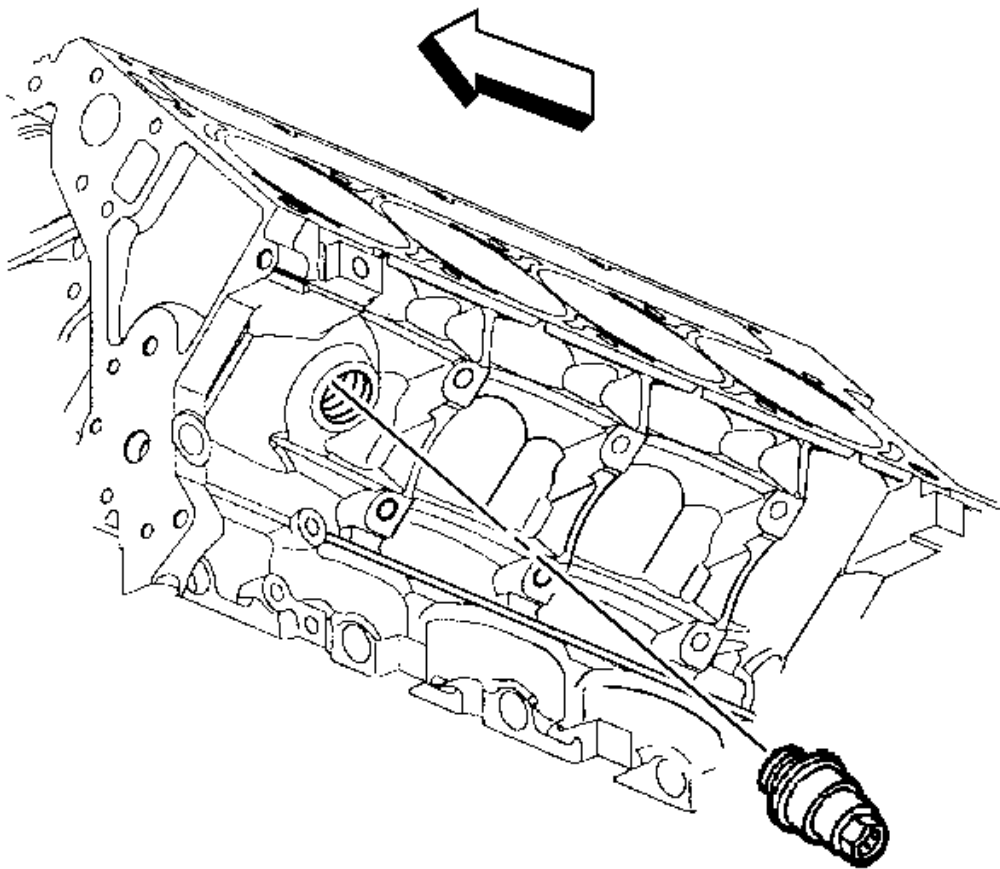
Engine Block Plug Installation

Fig. 438: View Of 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** in Cautions and Notices.

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.

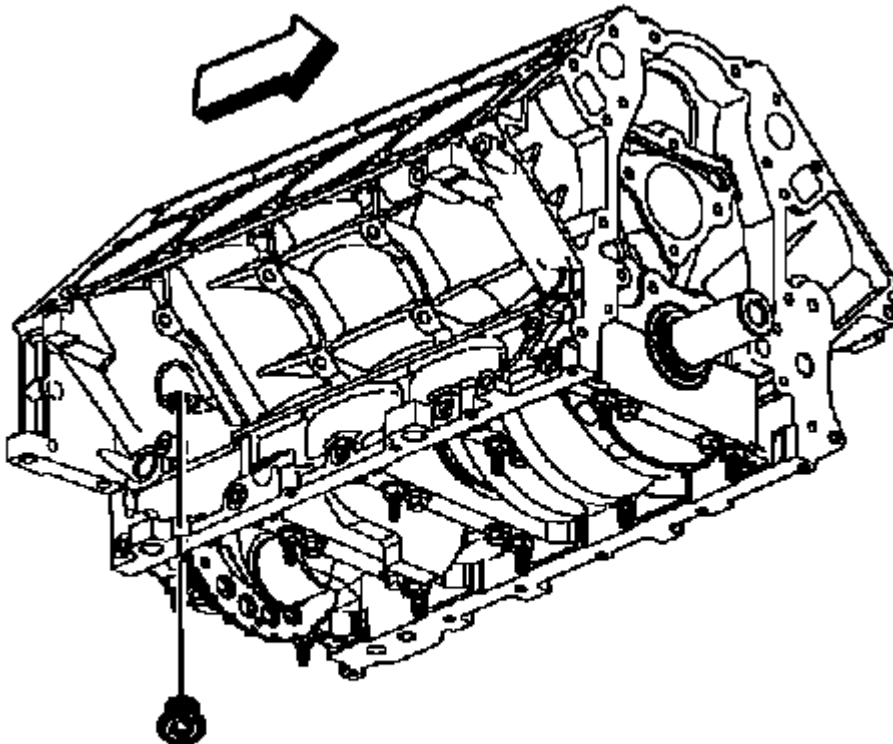


Fig. 439: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

4. Install the engine block coolant drain hole plug.

Tighten: Tighten the coolant drain hole plug to 60 N.m (44 lb ft).

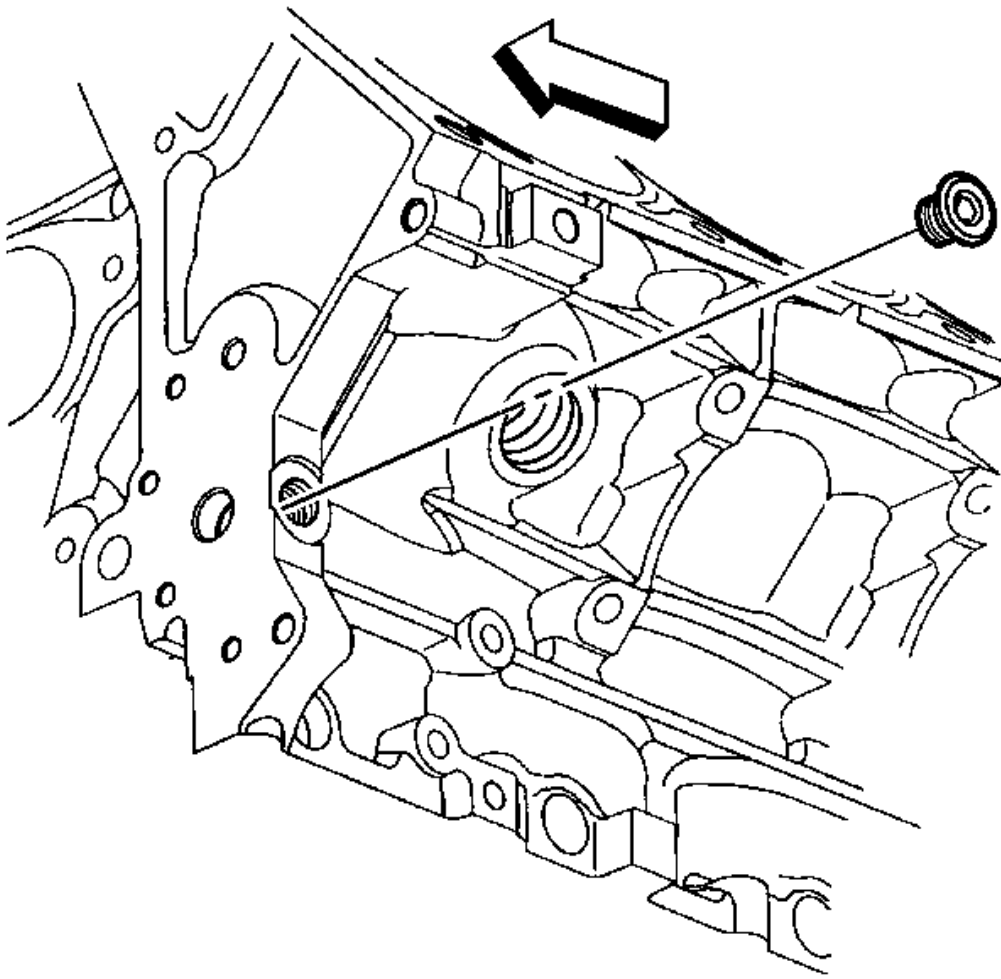


Fig. 440: View Of Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.
6. Install the engine block left front oil gallery plug.

Tighten: Tighten the block left front oil gallery plug to 60 N.m (44 lb ft).

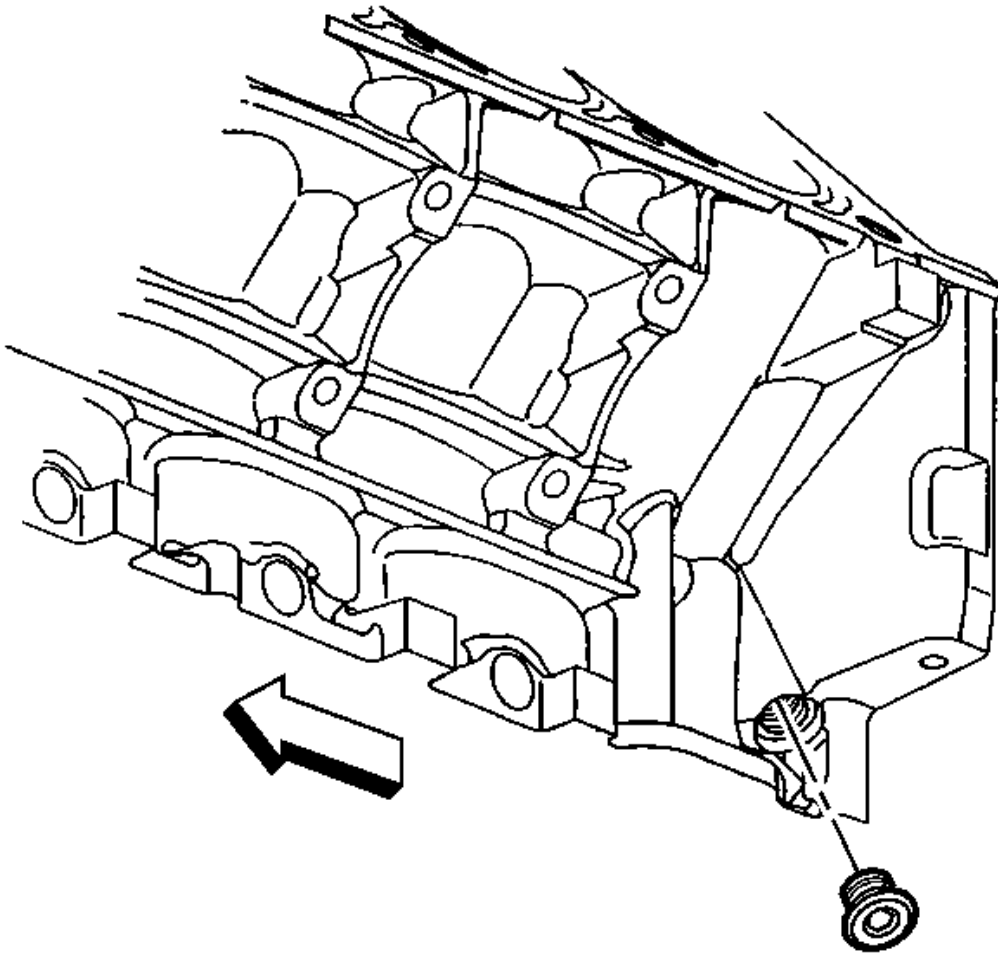


Fig. 441: View Of Engine Block Left Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.
8. Install the engine block left rear oil gallery plug.

Tighten: Tighten the block left rear oil gallery plug to 60 N.m (44 lb ft).

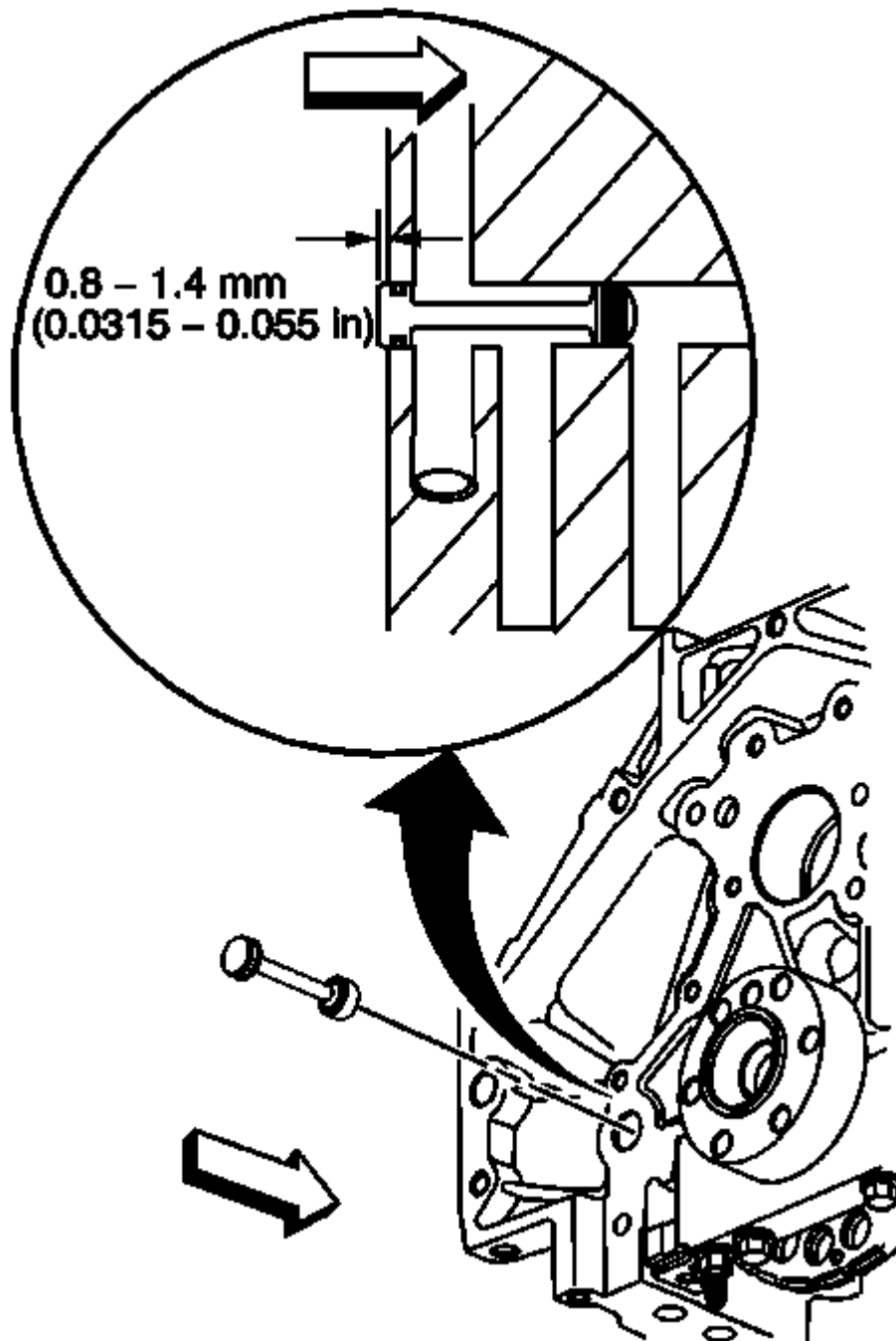


Fig. 442: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

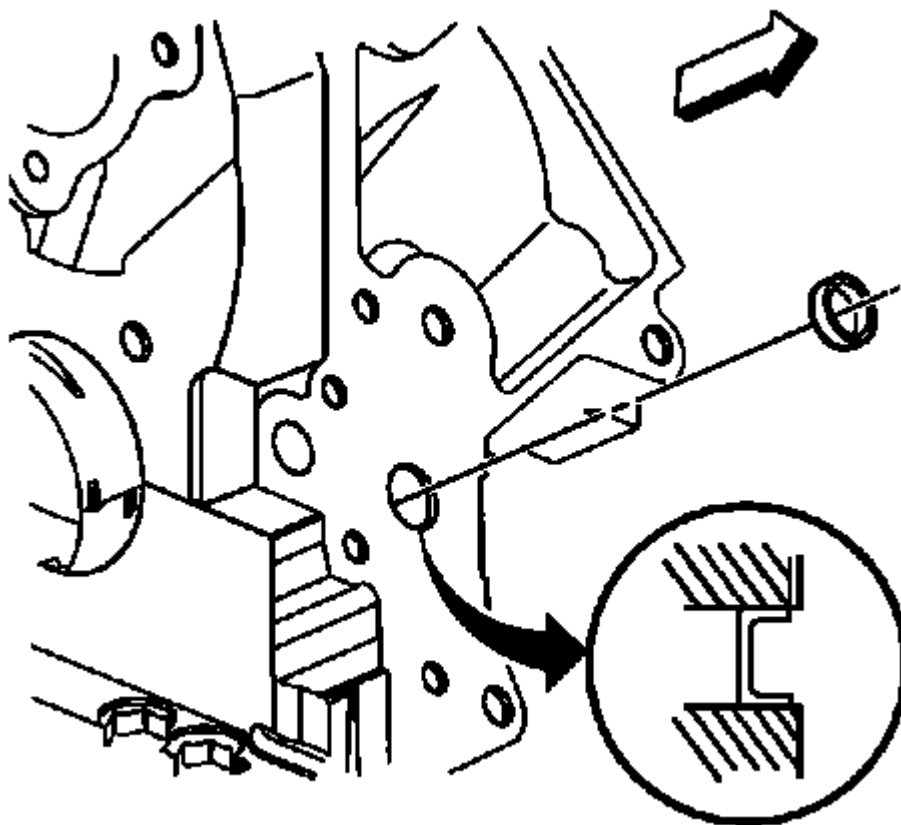


Fig. 443: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug.
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.

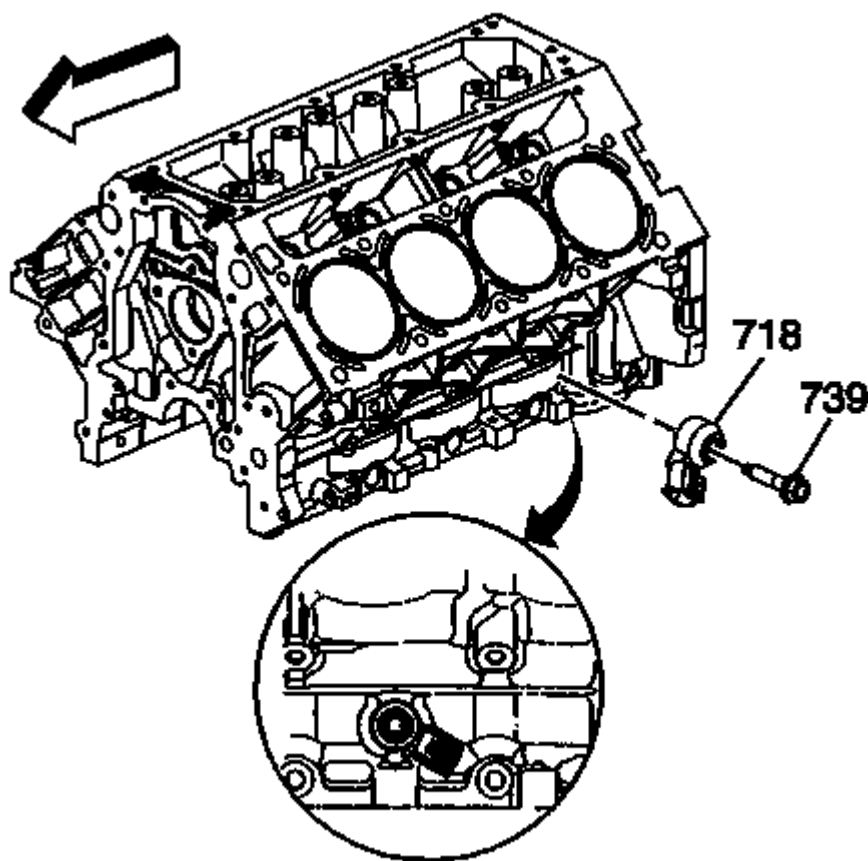


Fig. 444: Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Install the left side knock sensor (718) and bolt (739).

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

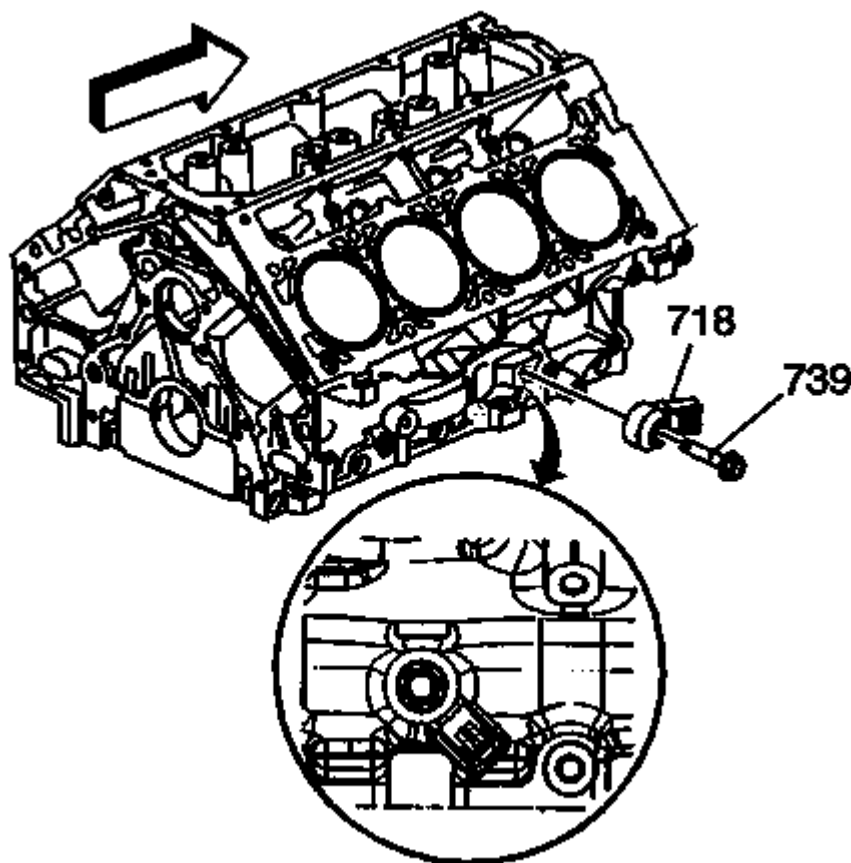


Fig. 445: Right Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

16. Install the right side knock sensor (718) and bolt (739).

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

Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter

Installation Procedure

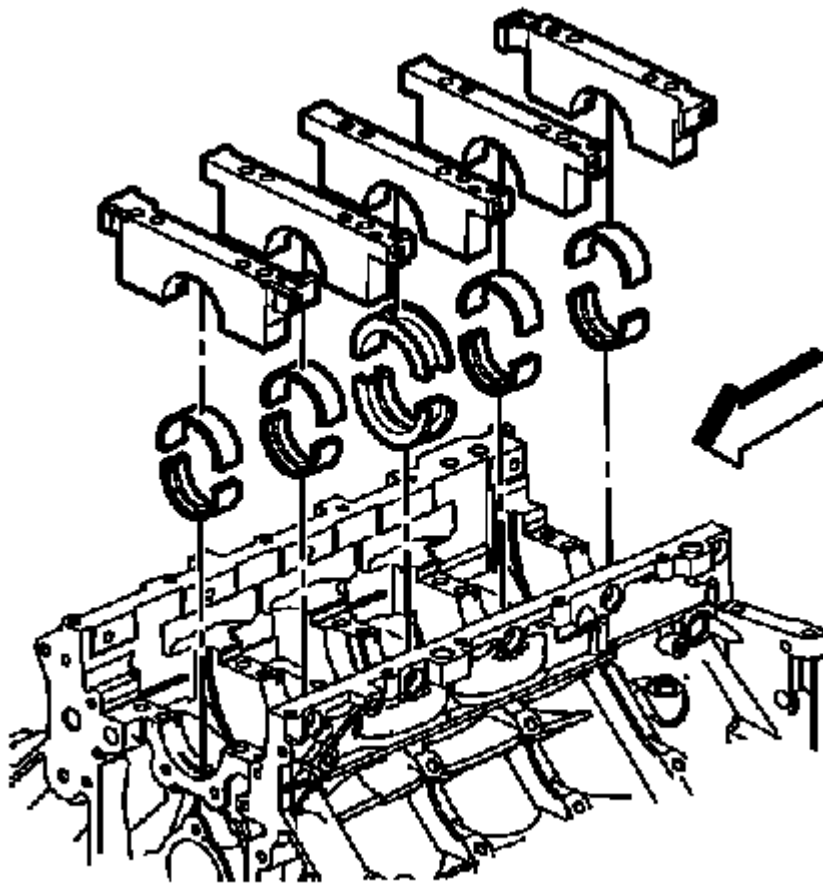


Fig. 446: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may effect 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.

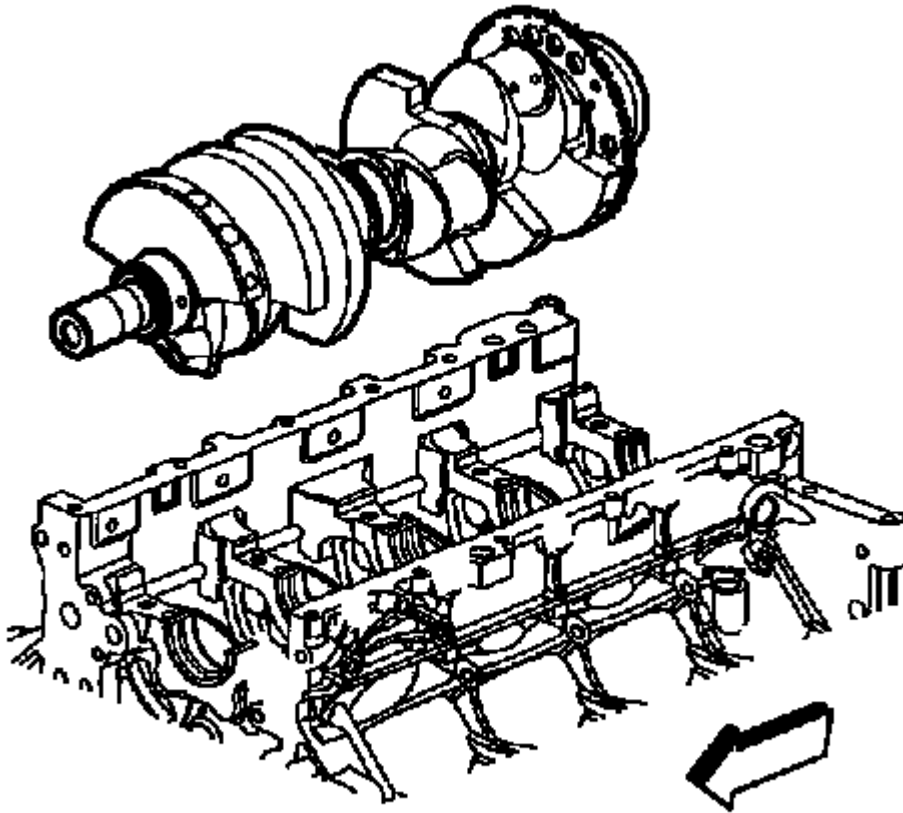


Fig. 447: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft.

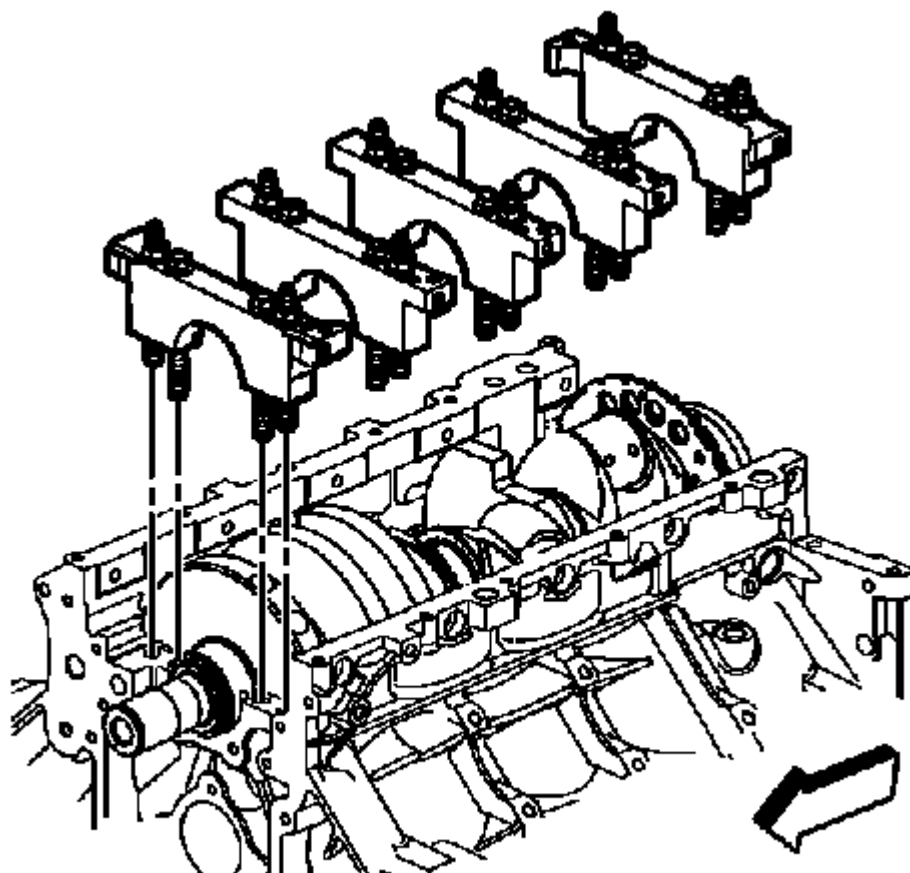


Fig. 448: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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.

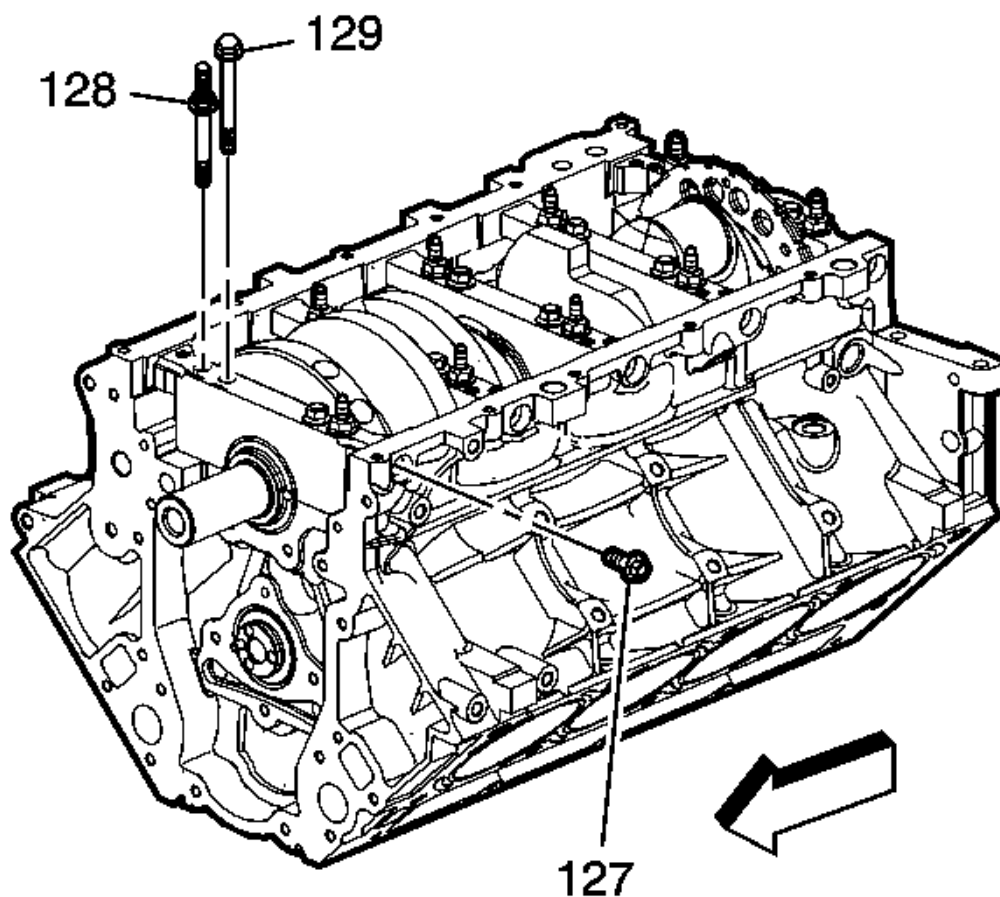


Fig. 449: Crankshaft Bearing Caps & Studs
Courtesy of GENERAL MOTORS CORP.

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).

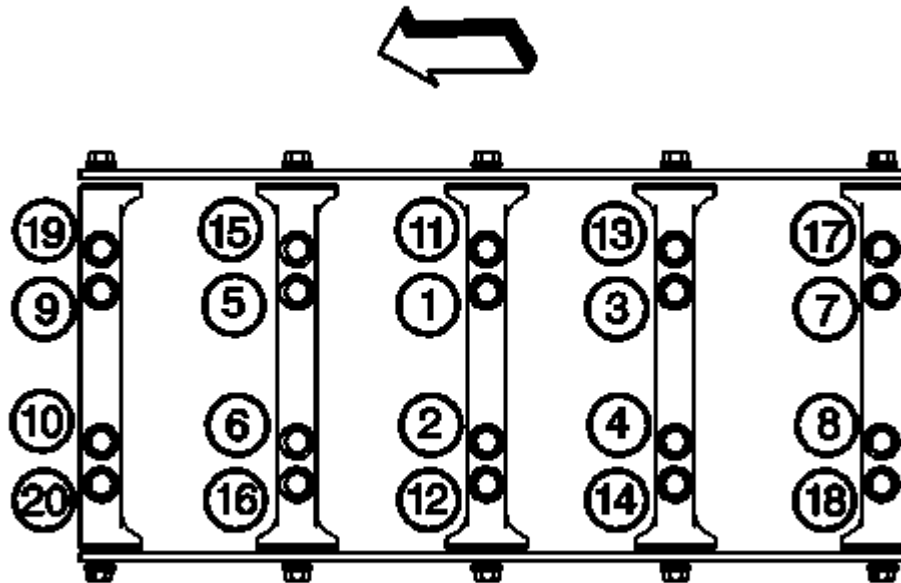


Fig. 450: Crankshaft Main Bearing Cap Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the bearing cap inner M10 bolts (1-10).

Tighten: Tighten the inner M10 bearing cap bolts 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.

Tighten:

1. Tighten the inner M10 bolts a final pass in sequence 80 degrees using the **J 45059**.
2. Tighten the outer M10 studs a first pass in sequence to 20 N.m (15 lb ft).
3. Tighten the outer M10 studs a final pass in sequence 51 degrees using the **J 45059**.
4. Tighten the bearing cap side 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.

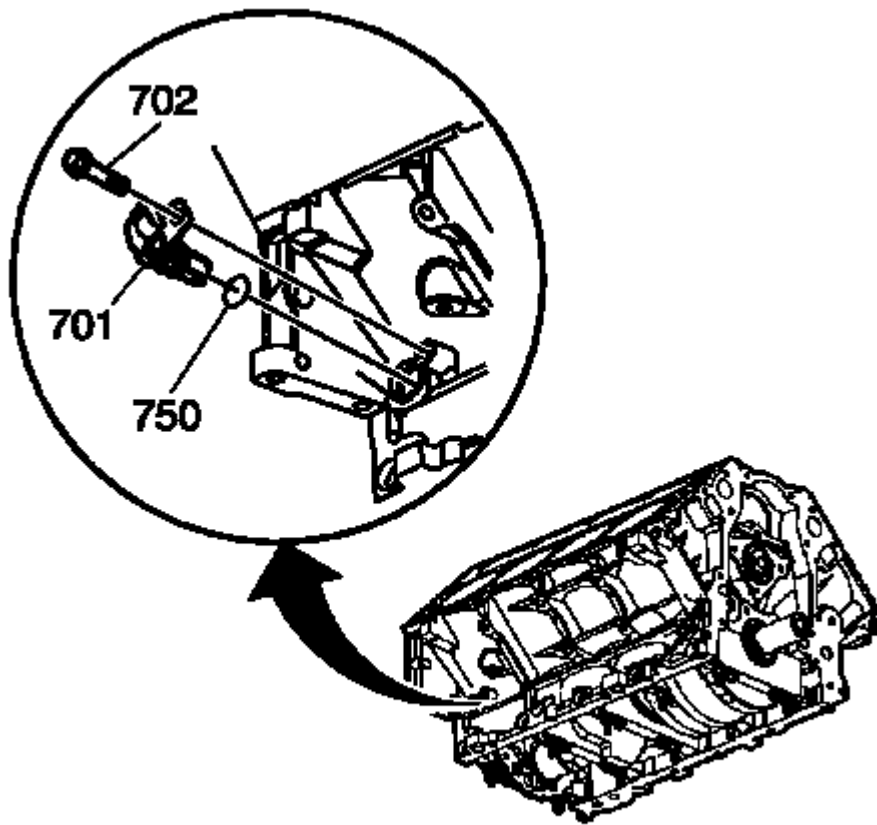


Fig. 451: CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

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.
 5. Install the sensor bolt (702).

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

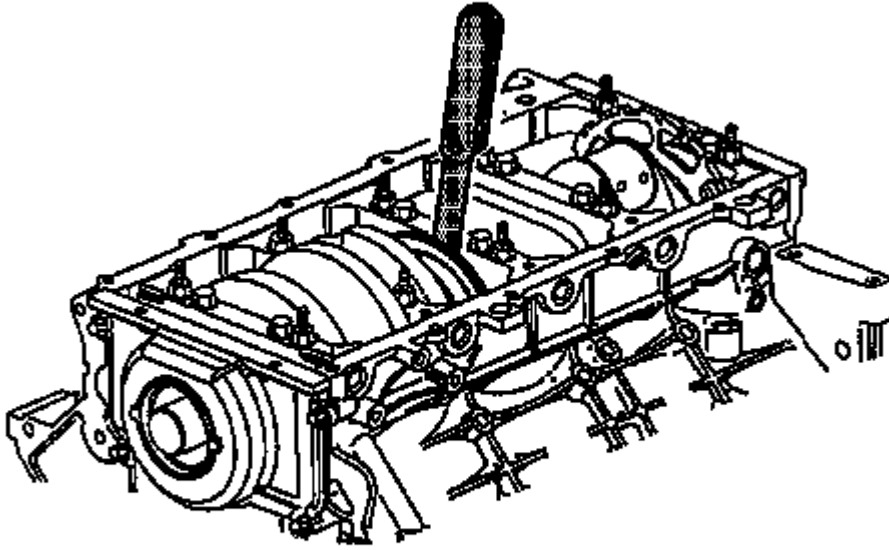


Fig. 452: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 8037** Ring Compressor. See **Special Tools**.
- **J 8087** Cylinder Bore Gage. See **Special Tools**.
- **J 41556** Connecting Rod Guide. See **Special Tools**.

- J 45059 Angle Meter

Piston Selection

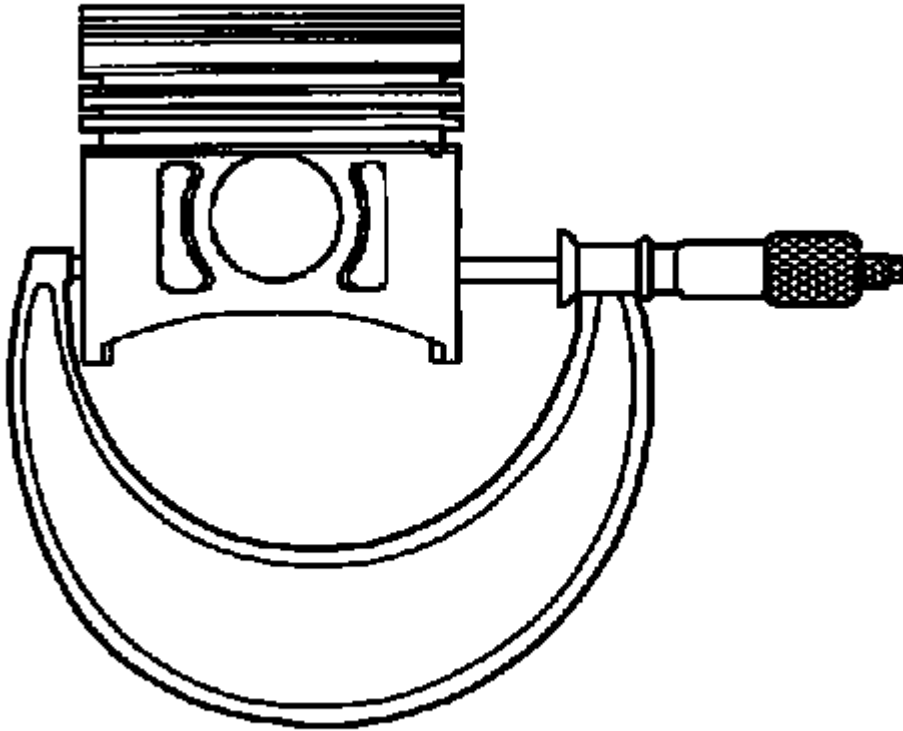


Fig. 453: Measuring Piston Outside Diameter Using Micrometer
Courtesy of GENERAL MOTORS CORP.

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.

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.

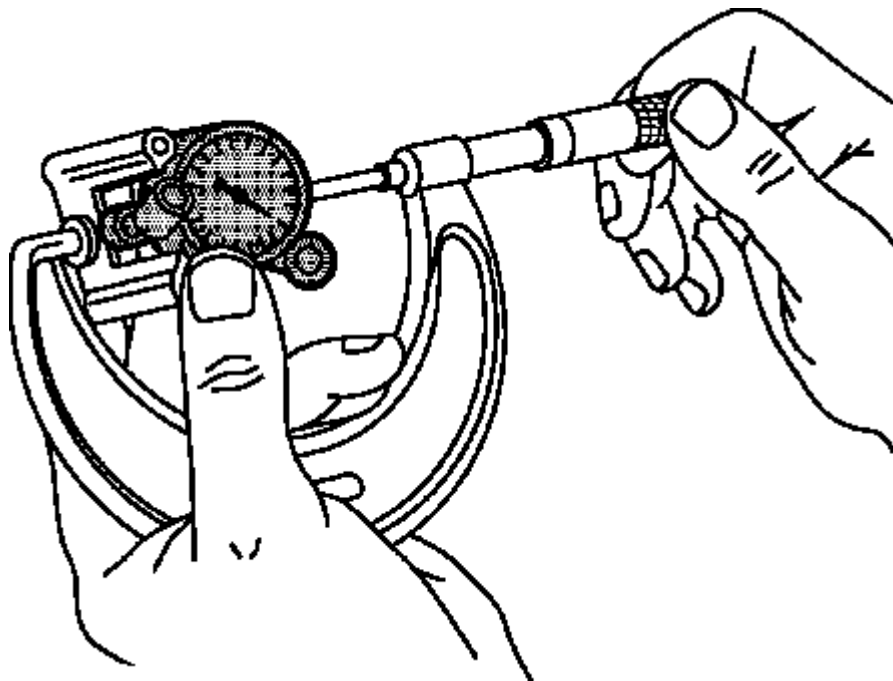


Fig. 454: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **J 8087** into the micrometer and zero the gage dial. See **Special Tools**.

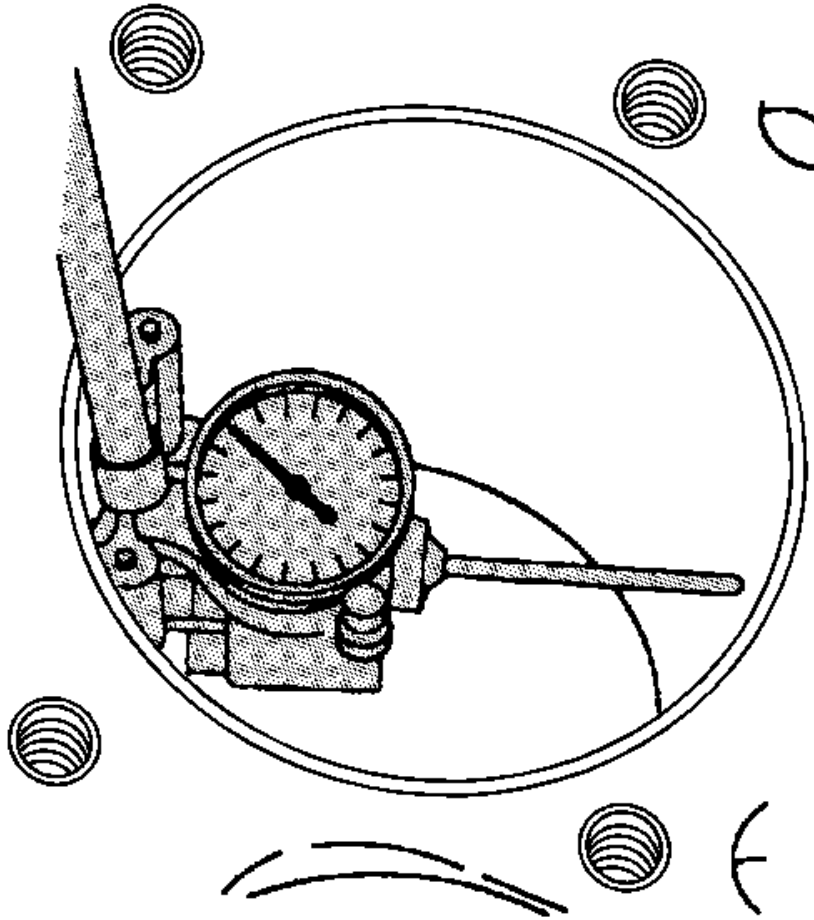


Fig. 455: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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.
7. Subtract the piston OD from the cylinder bore ID to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston, pin, and connecting rod assembly and again measure the clearances. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

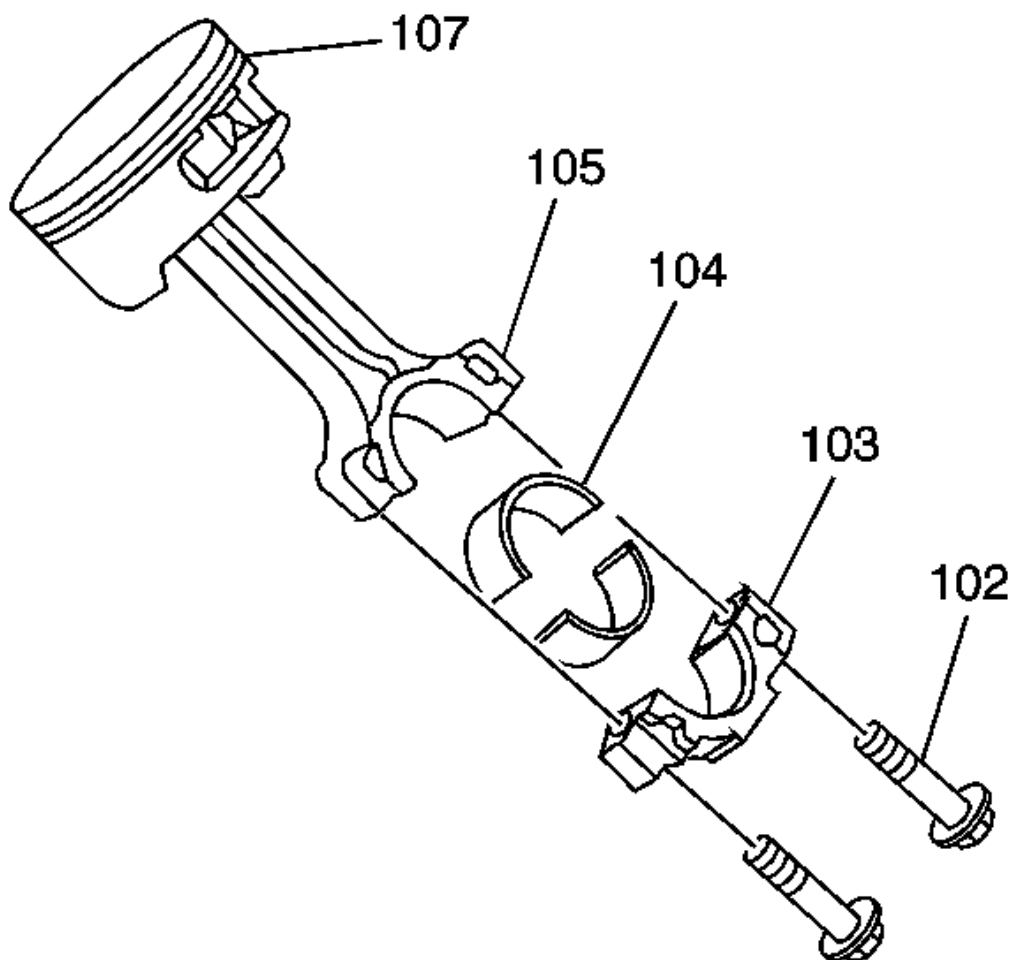


Fig. 456: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Lightly lubricate the following components with clean engine oil:
 - Piston (107)
 - Piston rings
 - Cylinder bore
 - Bearings (104) and bearing surfaces
2. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
3. Position the compression ring end gaps 180 degrees opposite each other.

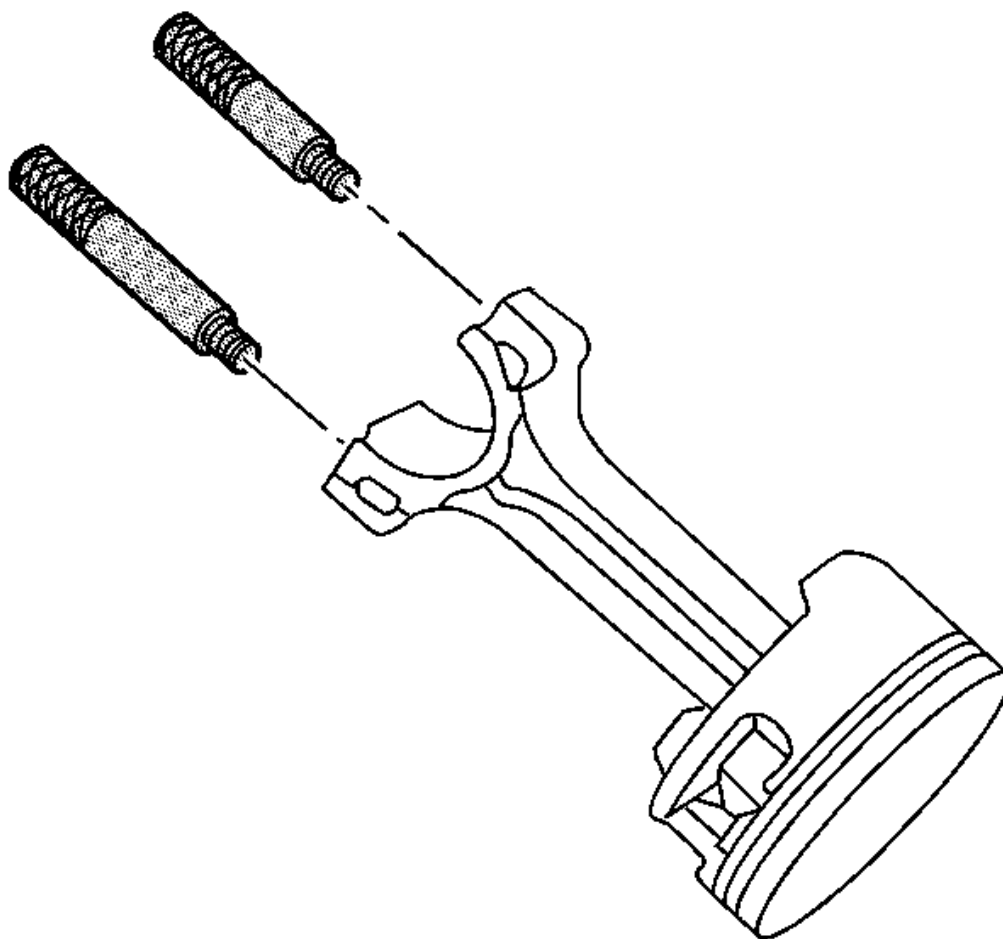


Fig. 457: View Of J 41556 & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod. See **Special Tools**.

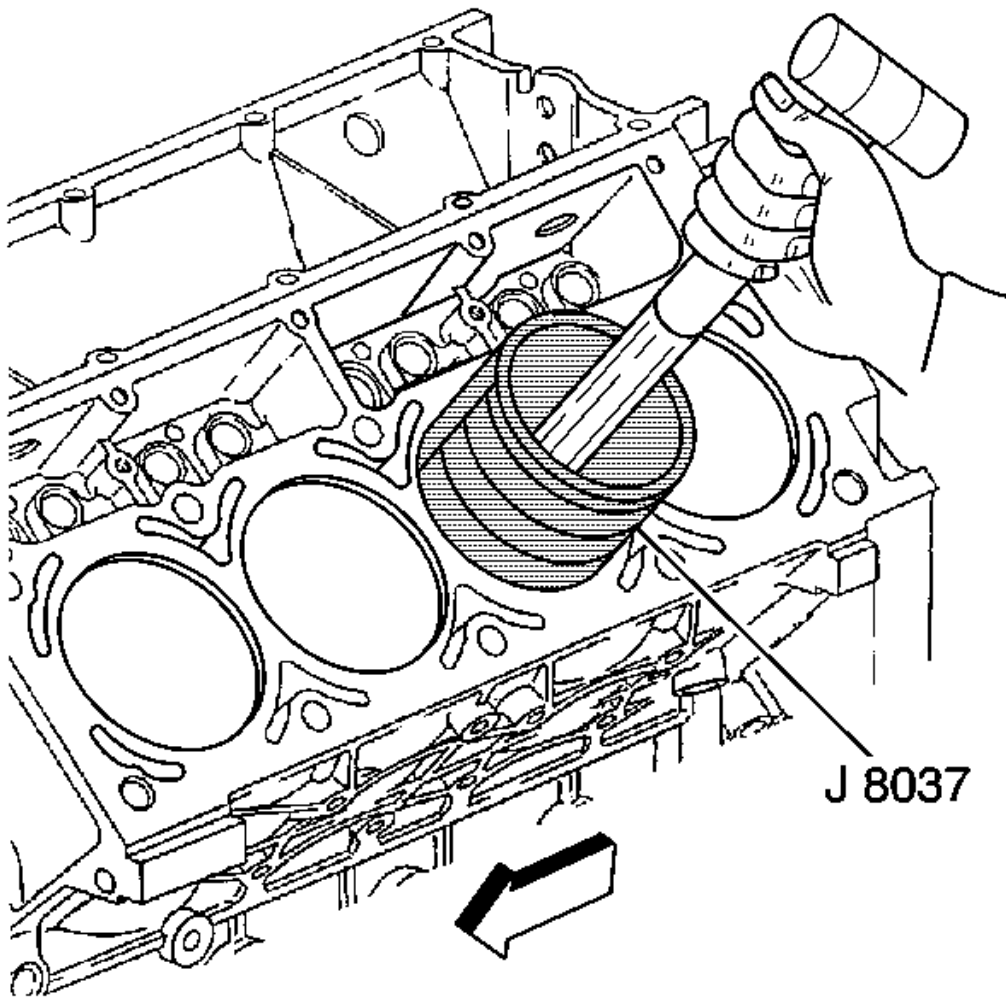


Fig. 458: Compressing Piston Using J 8037
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools**.

IMPORTANT: The piston alignment mark **MUST** face the front of the engine block.

6. 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 the piston rings have entered the cylinder bore.

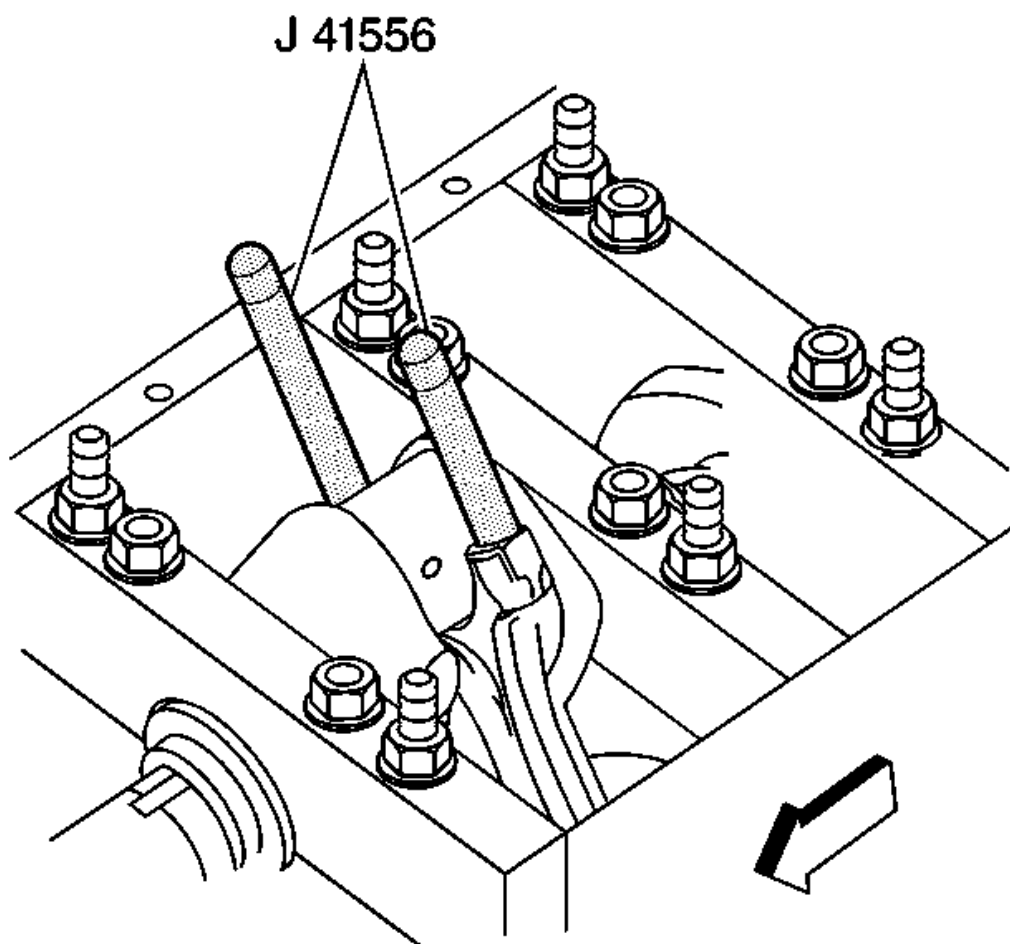


Fig. 459: View Of J 41556 & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

7. Use the **J 41556** to guide the connecting rod onto the crankshaft journal. See **Special Tools**.
8. Remove the **J 41556** from the connecting rod.

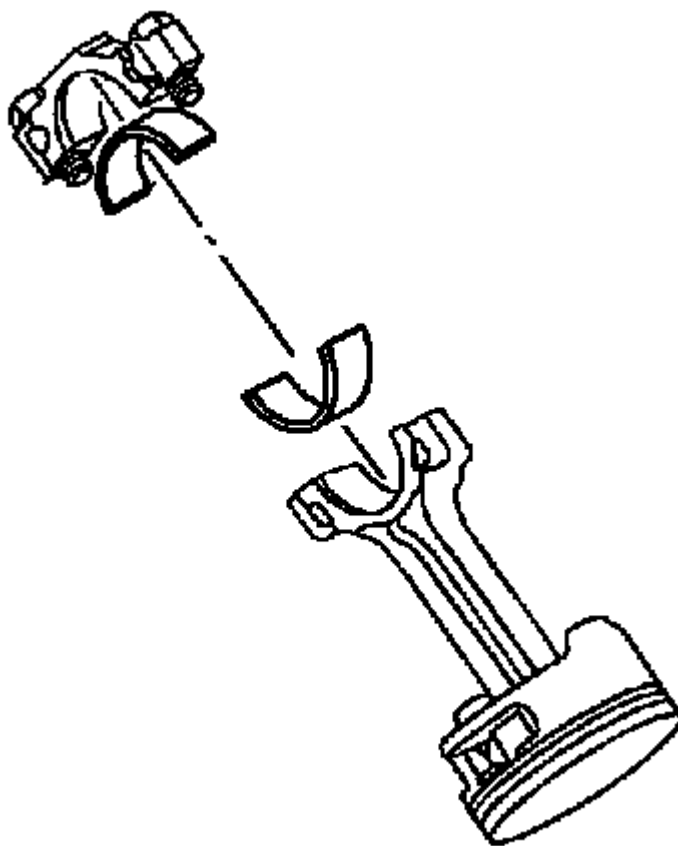


Fig. 460: View Of Piston, Connecting Rod, Bearing Cap, Bearing Halves & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The connecting rod and cap must be assembled with the mating surfaces properly aligned.

9. Install the bearing cap, bearing half, and bolts.

Tighten:

1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
2. Tighten the bolts a final pass to 75 degrees using the **J 45059**.

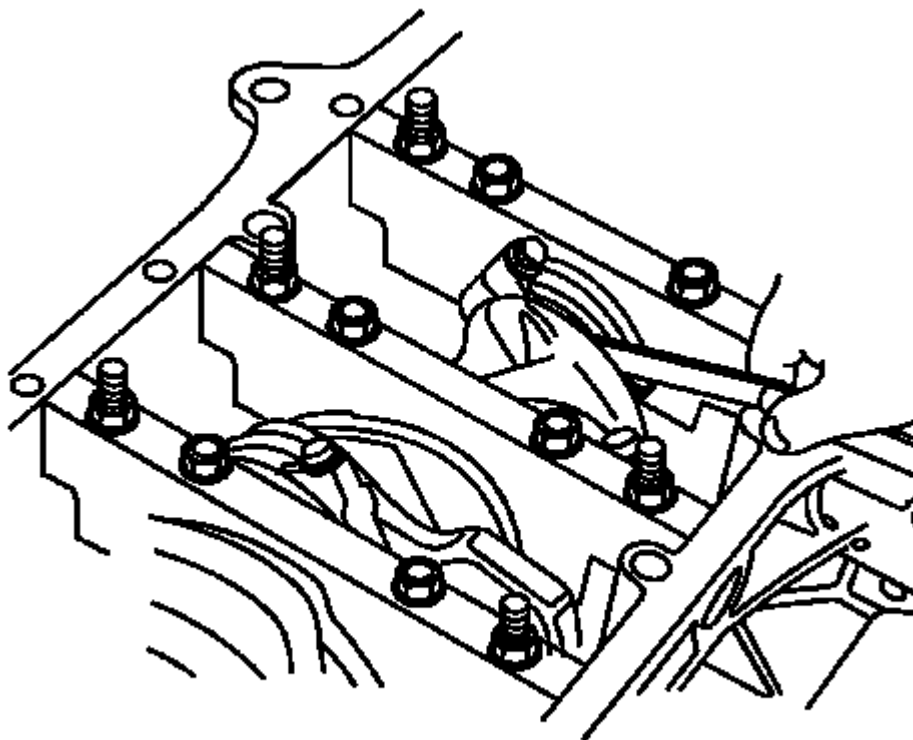


Fig. 461: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

10. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications**.

Camshaft Installation

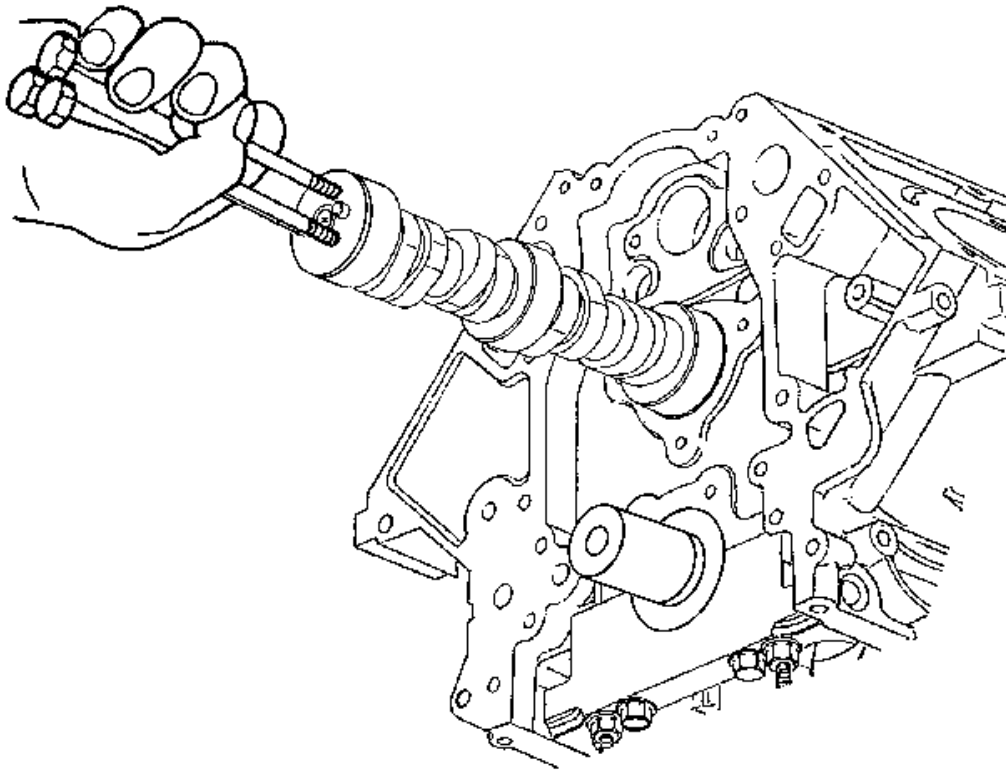


Fig. 462: Removing/Installing The Camshaft
Courtesy of GENERAL MOTORS CORP.

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 3 M8 - 1.25 x 100 mm (M8 - 1.25 x 4.0 in) bolts into the camshaft front bolt holes.

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

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the 3 bolts from the front of the camshaft.

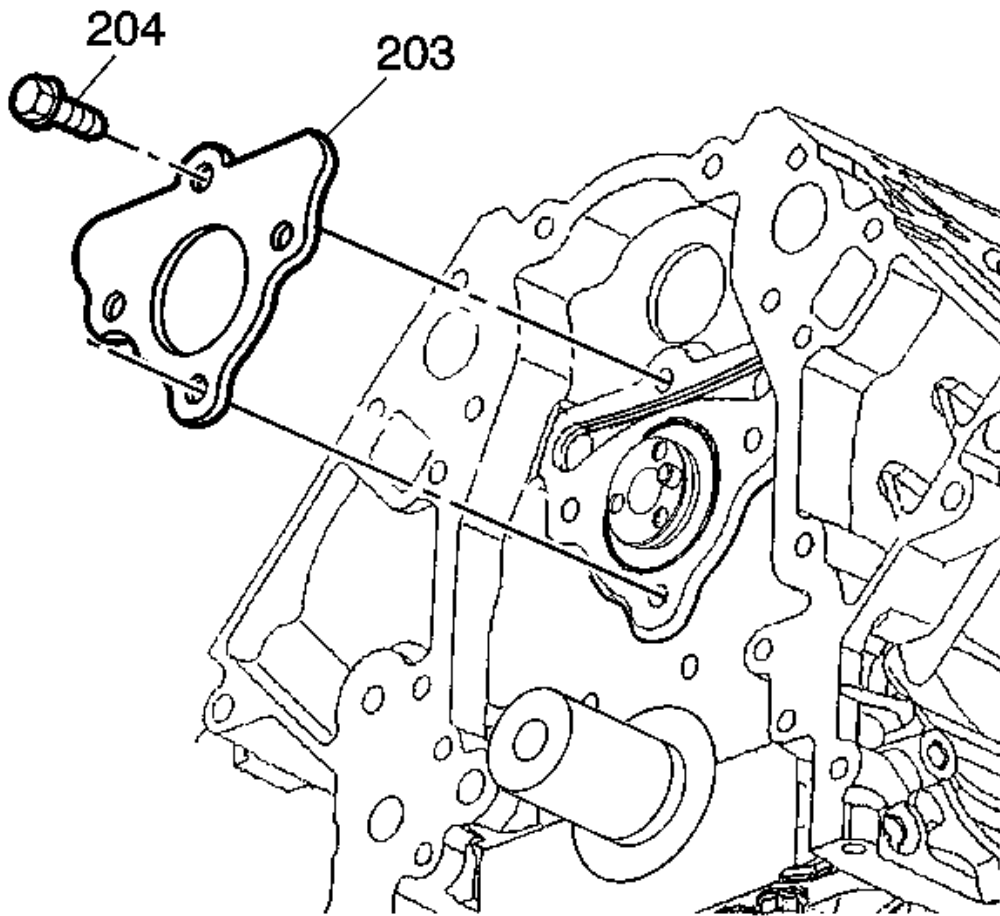


Fig. 463: Camshaft Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT:

- Install the retainer plate with the sealing gasket facing the engine block.
- 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).

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

Timing Chain and Sprockets Installation**Tools Required**

J 41665 Crankshaft Balancer and Sprocket Installer. See Special Tools.

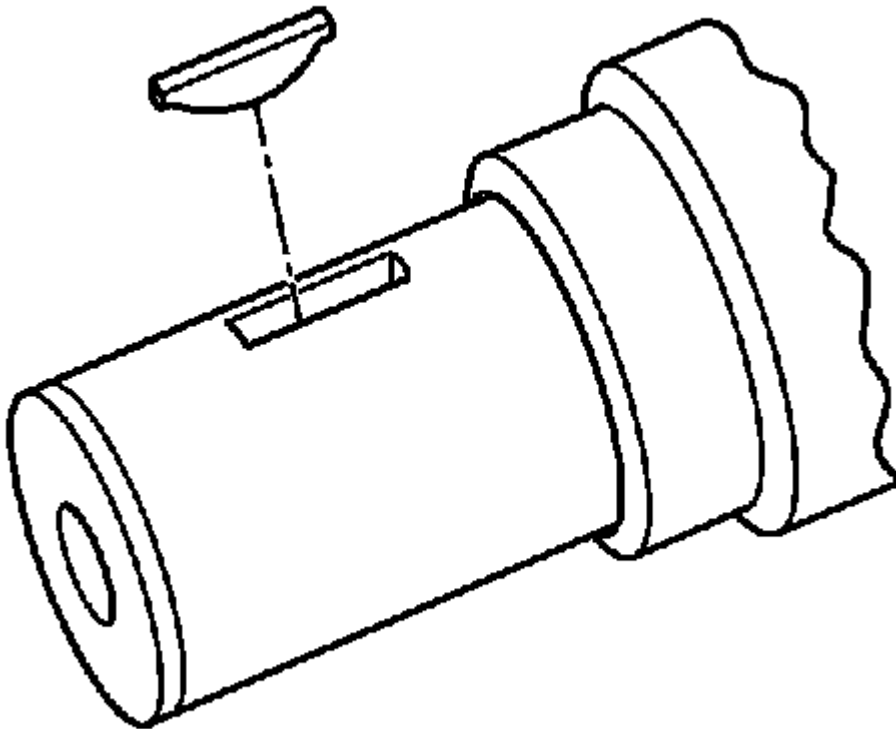
Installation Procedure

Fig. 464: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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

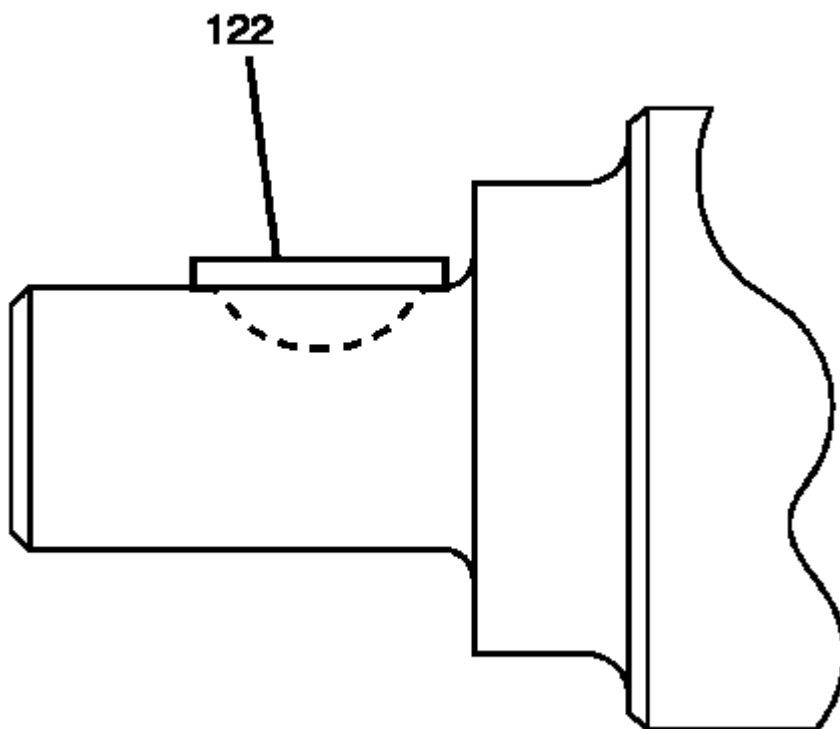


Fig. 465: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

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

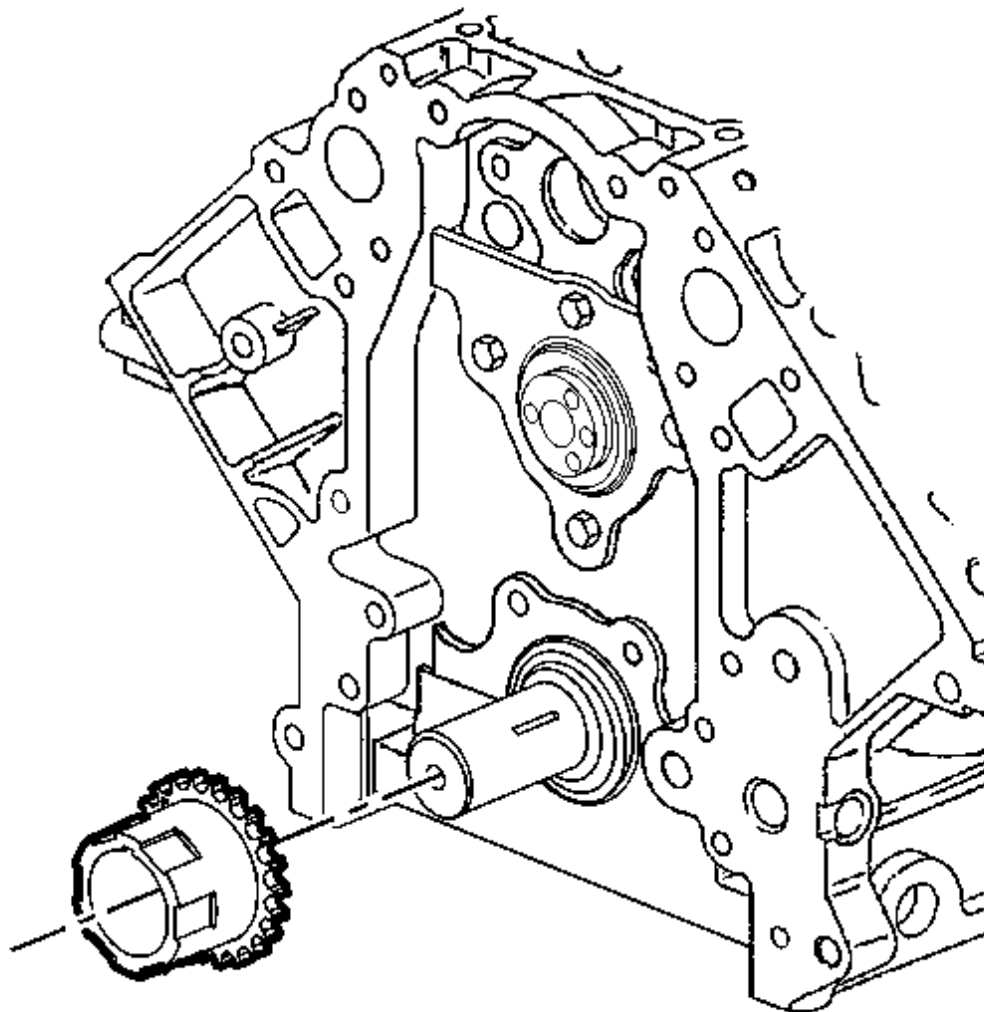


Fig. 466: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

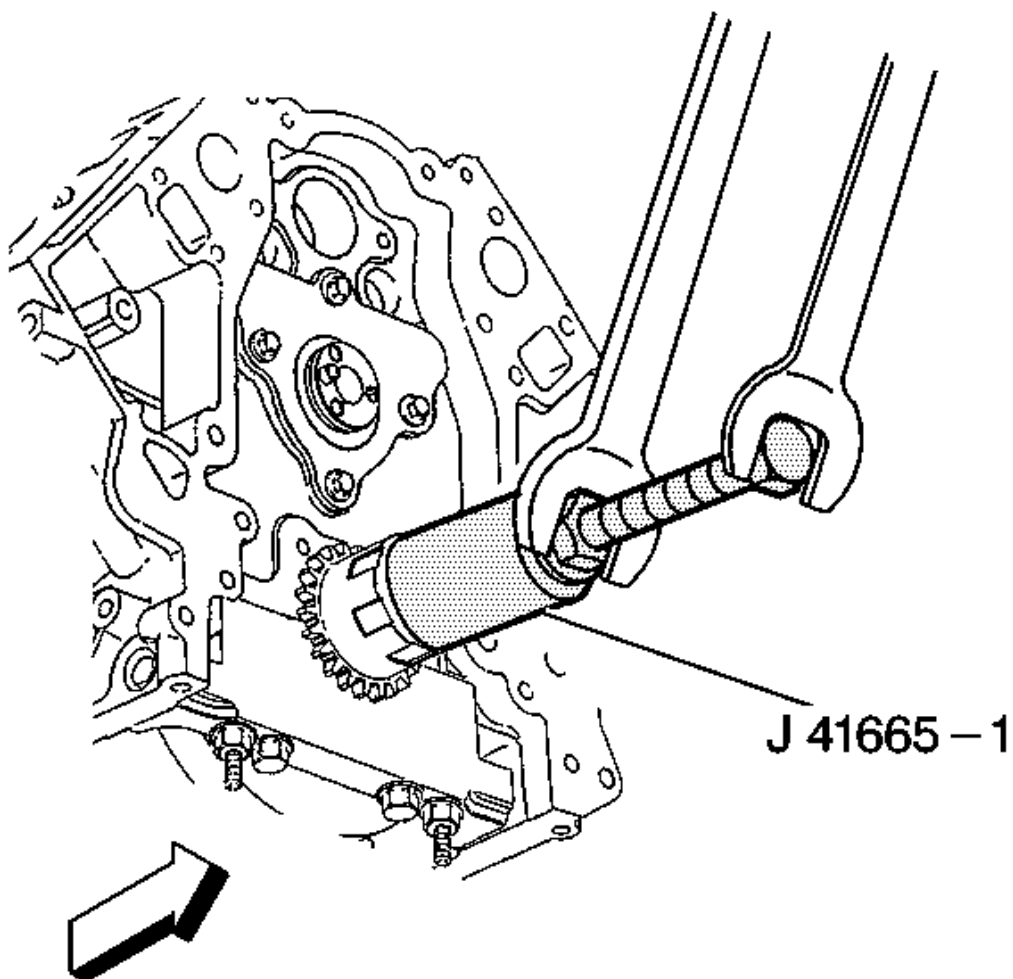


Fig. 467: Using J 41665 To Install Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41665** in order to install the crankshaft sprocket. See **Special Tools**.

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

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

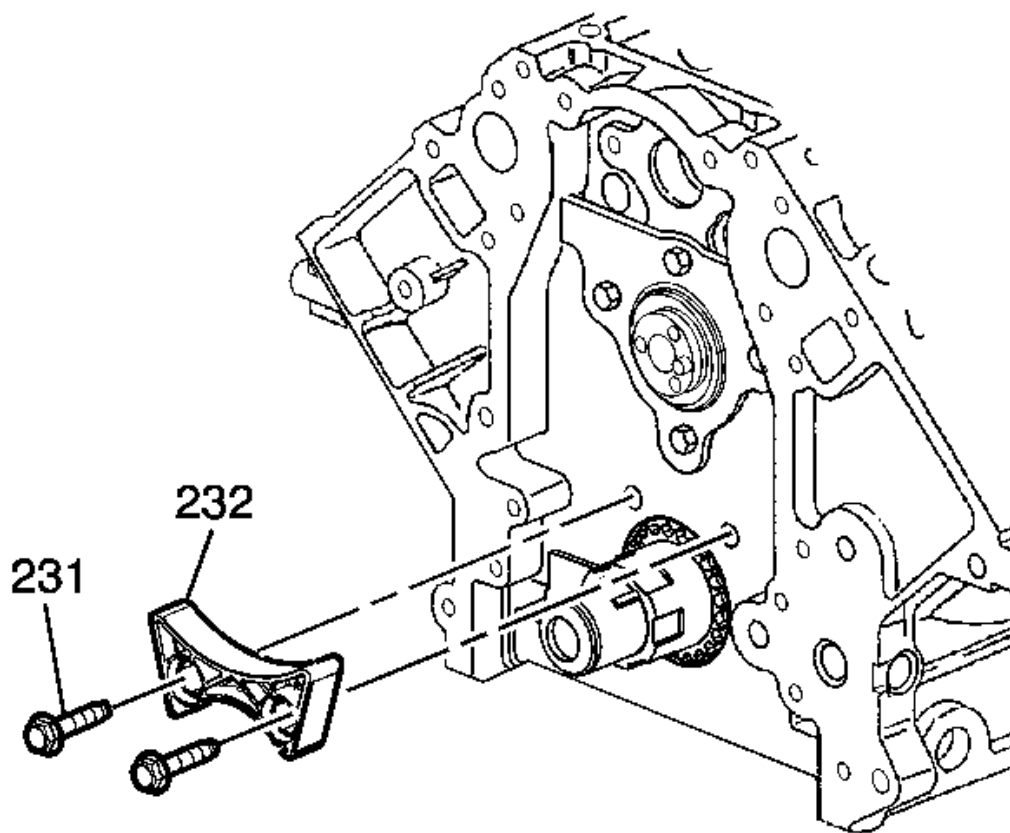


Fig. 468: Timing Chain Dampener & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the timing chain dampener (232) and bolts (231).

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

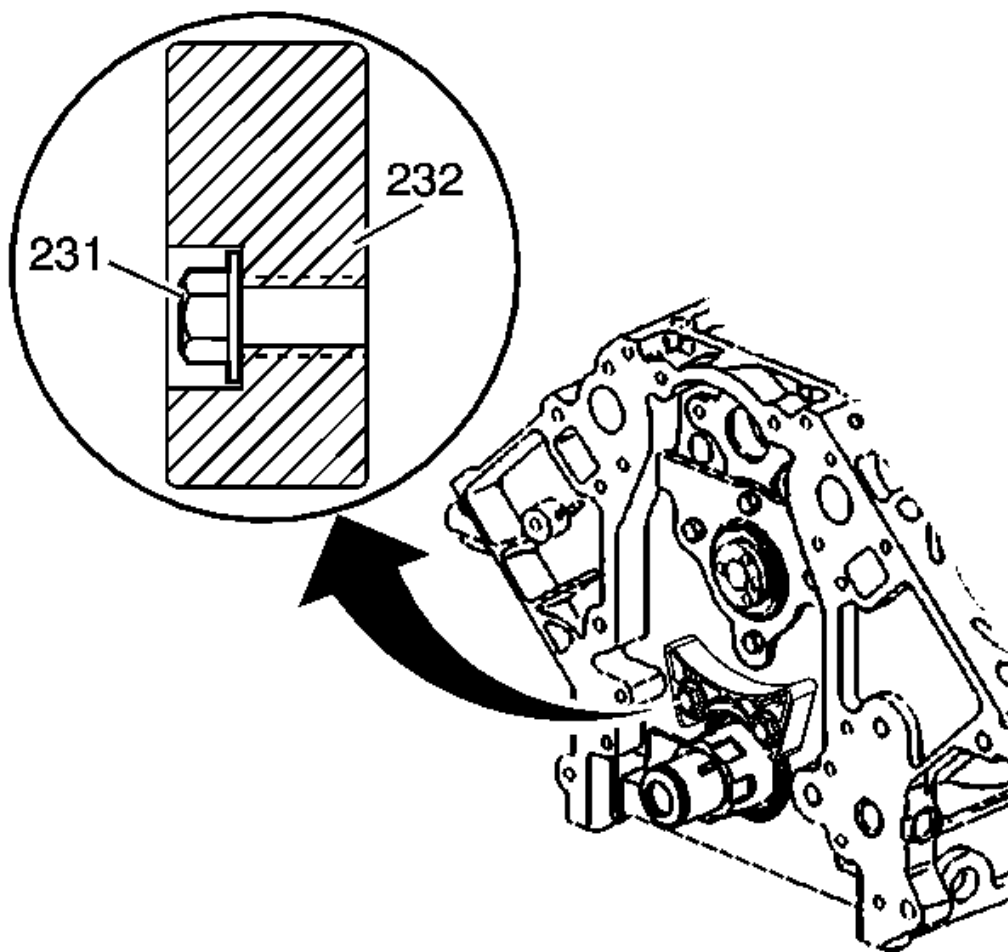


Fig. 469: Identifying Timing Chain Dampener Bolt Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

7. With the chain guide properly installed, the head of the bolts (231) should install flush or below the face of the dampener (232).

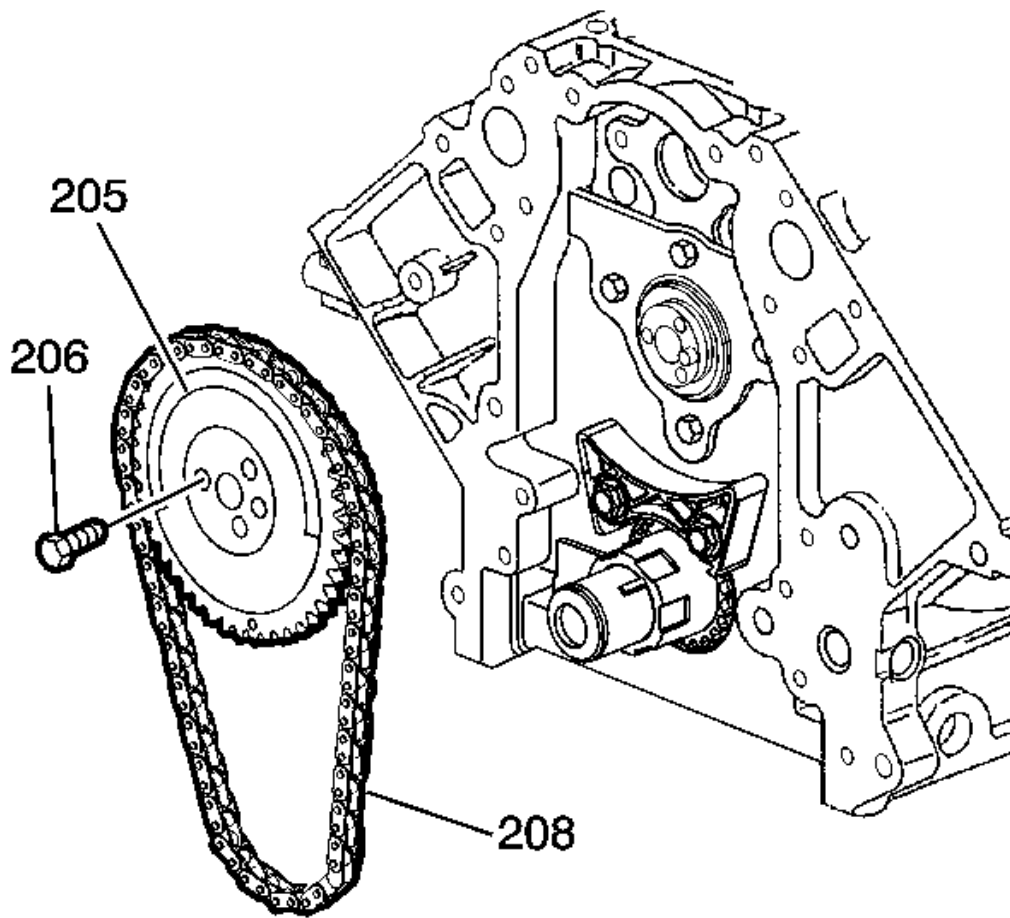


Fig. 470: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Properly locate the camshaft sprocket onto the locating pin of the camshaft.
- The sprocket teeth and timing chain must mesh.
- The camshaft and the crankshaft sprocket alignment marks **MUST** be aligned properly.

Position the camshaft sprocket alignment mark in the 6 o'clock position.

8. Install the camshaft sprocket (205) and timing chain (208). If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Install the camshaft sprocket bolts (206).

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

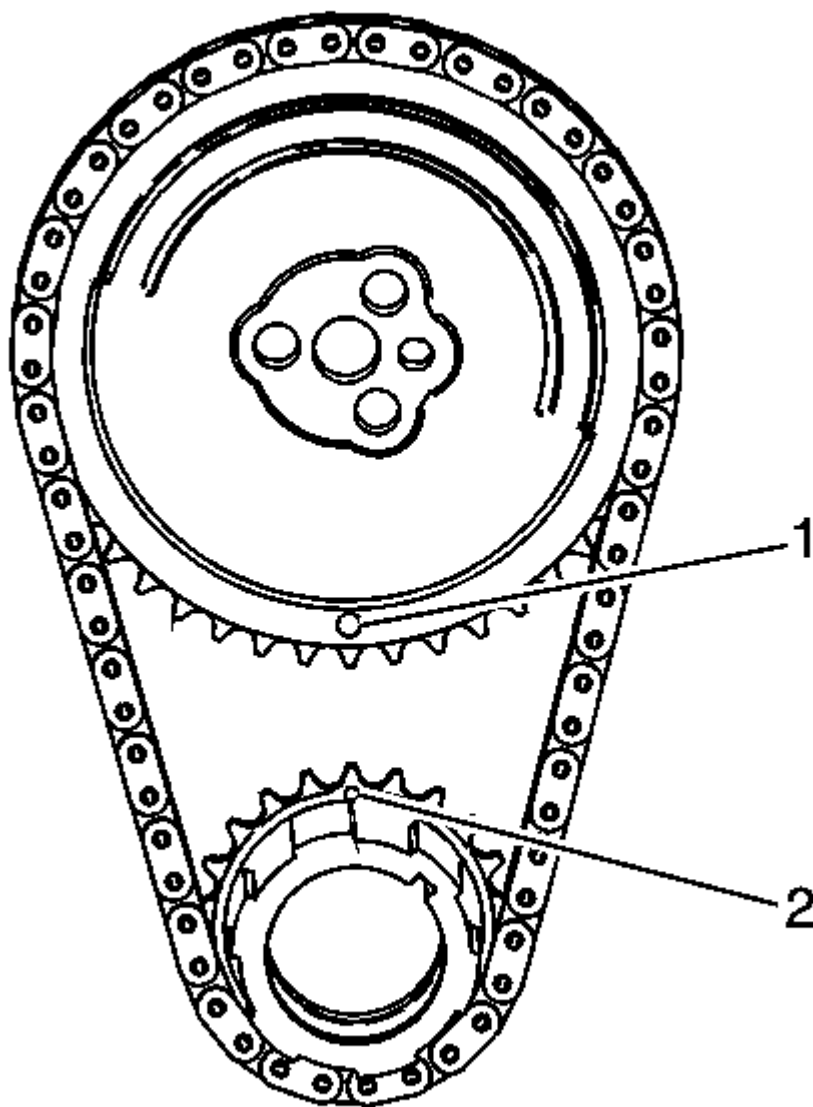


Fig. 471: View Of Camshaft And Crankshaft Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

10. Inspect for proper alignment of the camshaft and crankshaft sprocket timing marks (1, 2).

Oil Pump, Pump Screen and Deflector Installation

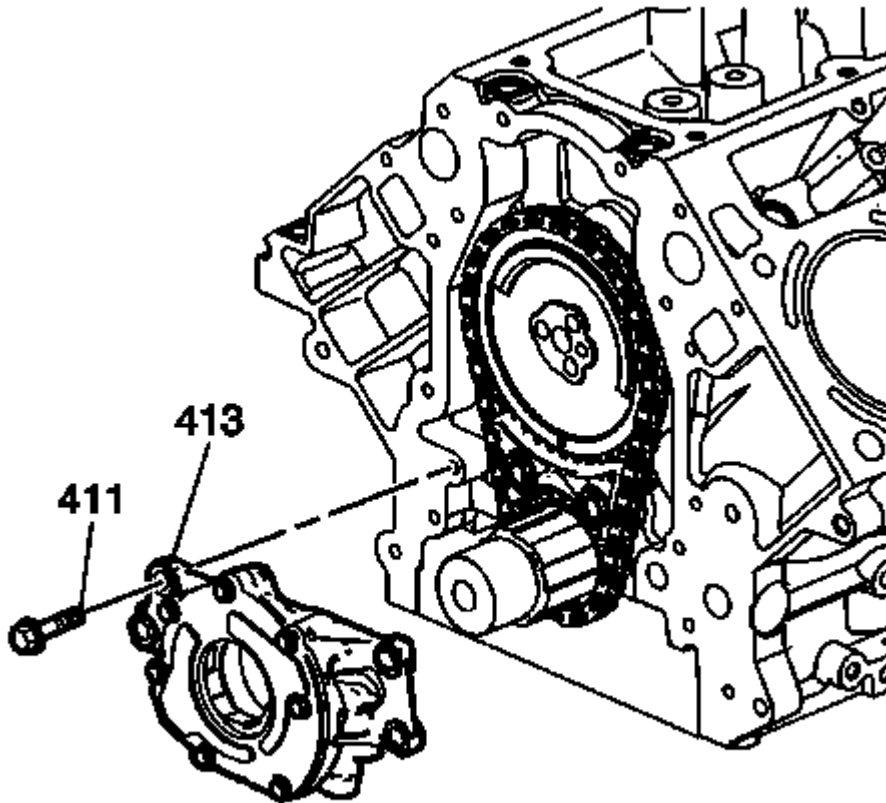


Fig. 472: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump bolts (411).

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

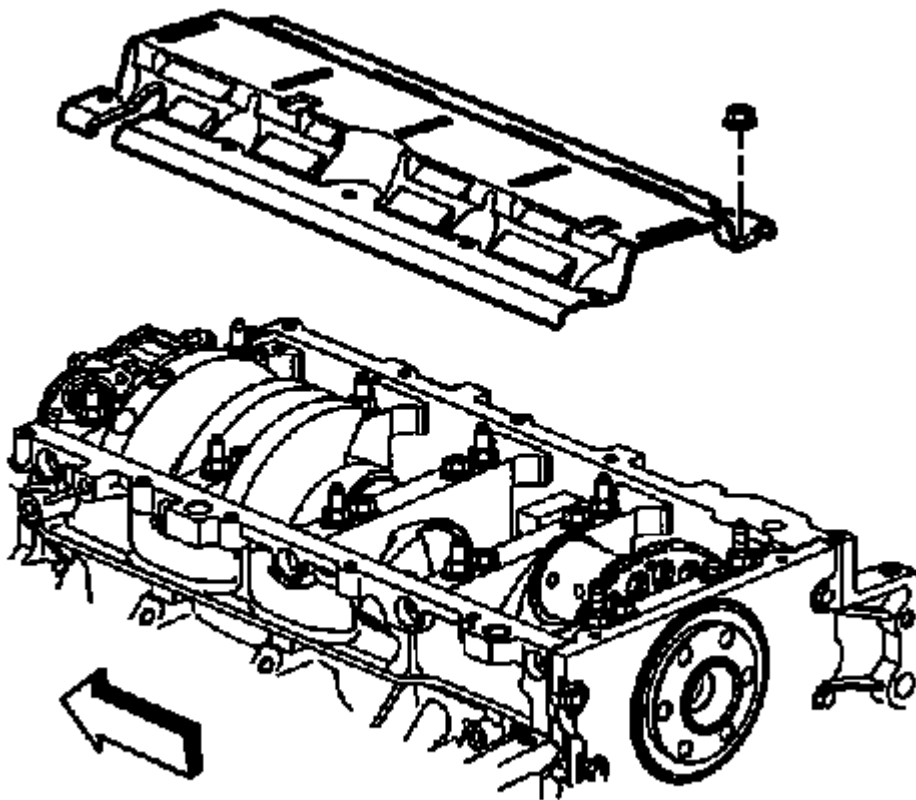


Fig. 473: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.

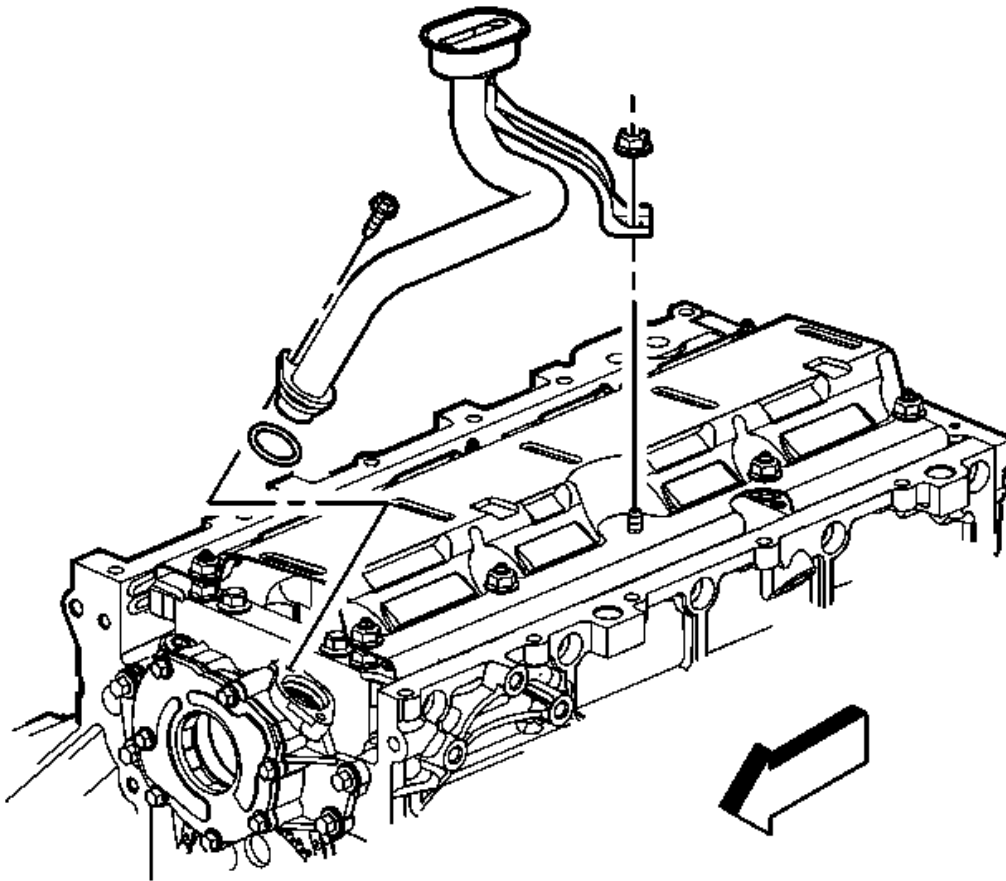


Fig. 474: View Of Oil Pump Screen, Bolt & Nuts
Courtesy of GENERAL MOTORS CORP.

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 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 nuts to 25 N.m (18 lb ft).

Engine Rear Cover Installation**Tools Required**

- **J 41480** Front/Rear Cover Alignment - Oil Pan Surface. See **Special Tools**.
- **J 41476** Front/Rear Cover Alignment - Crankshaft Oil Seal Area. See **Special Tools**.

Installation Procedure

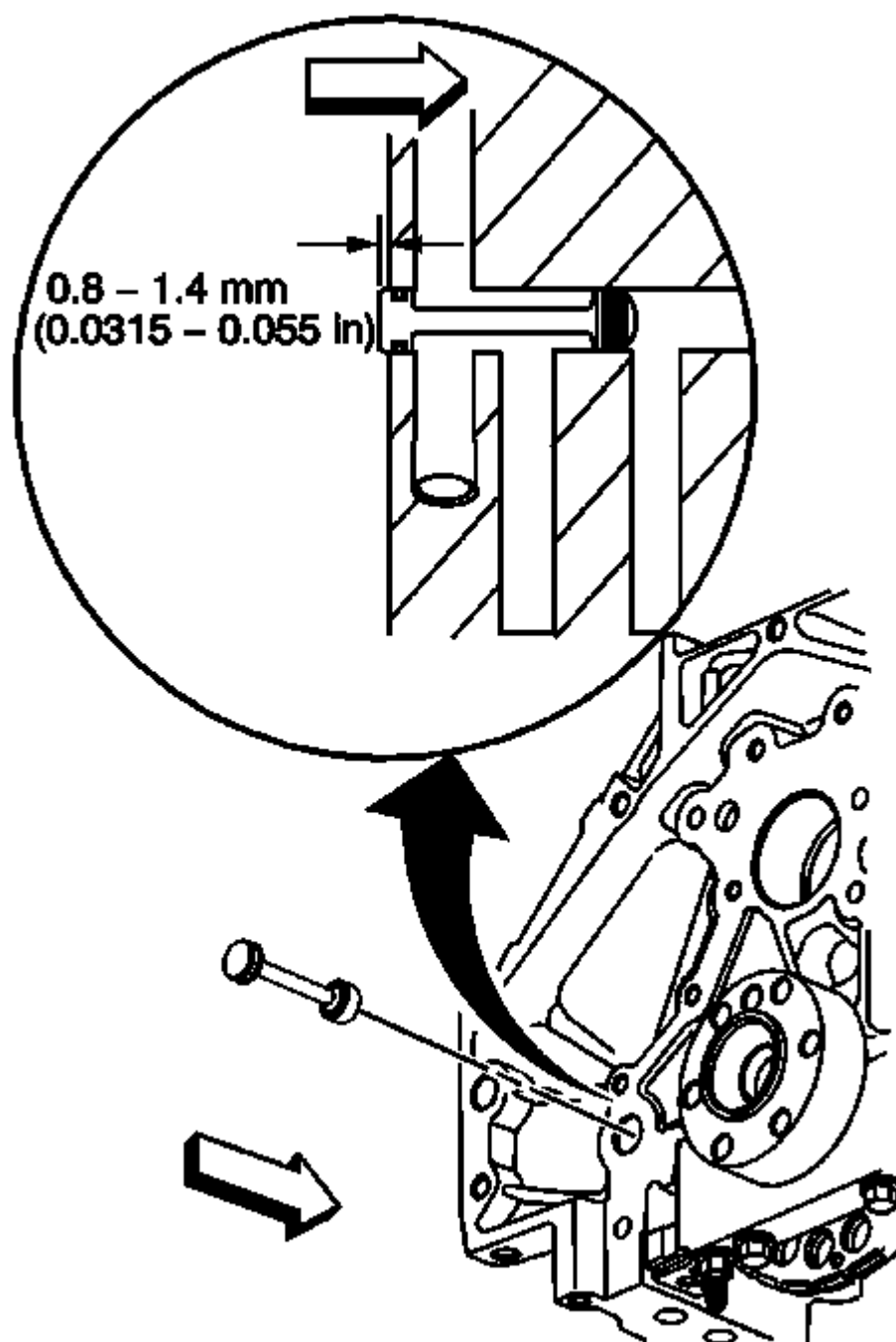


Fig. 475: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Do not use the crankshaft rear oil seal or the engine rear cover gasket again.
- Do not apply any type of sealant to the rear cover gasket, unless specified.
- The special tools in this procedure are used to properly align the

engine rear cover at the oil pan surface and to 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.
 - The crankshaft rear oil seal **MUST** be centered in relation to the crankshaft.
 - The oil pan sealing surface at the rear cover and engine block **MUST** be aligned within specifications.
 - An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.

1. Inspect the rear oil gallery plug for proper installation.

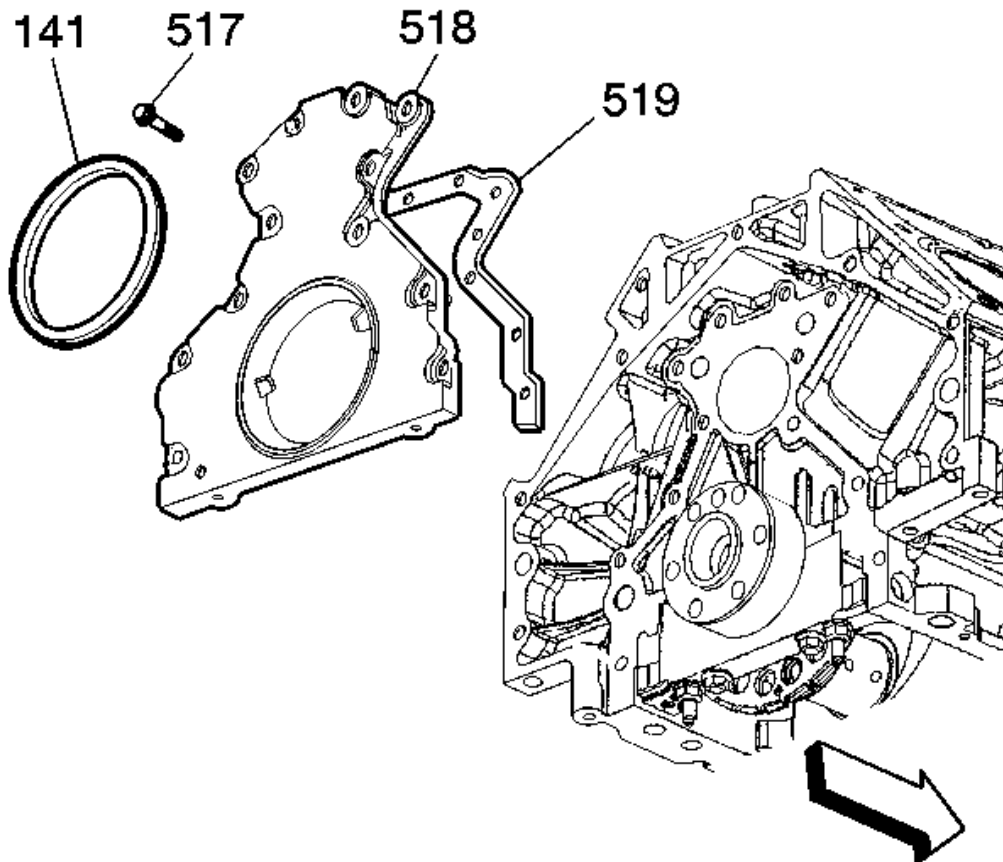


Fig. 476: Exploded View Of Engine Rear Cover

Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket (519), rear cover (518), and bolts (517).
3. Tighten the bolts finger tight. Do not overtighten.

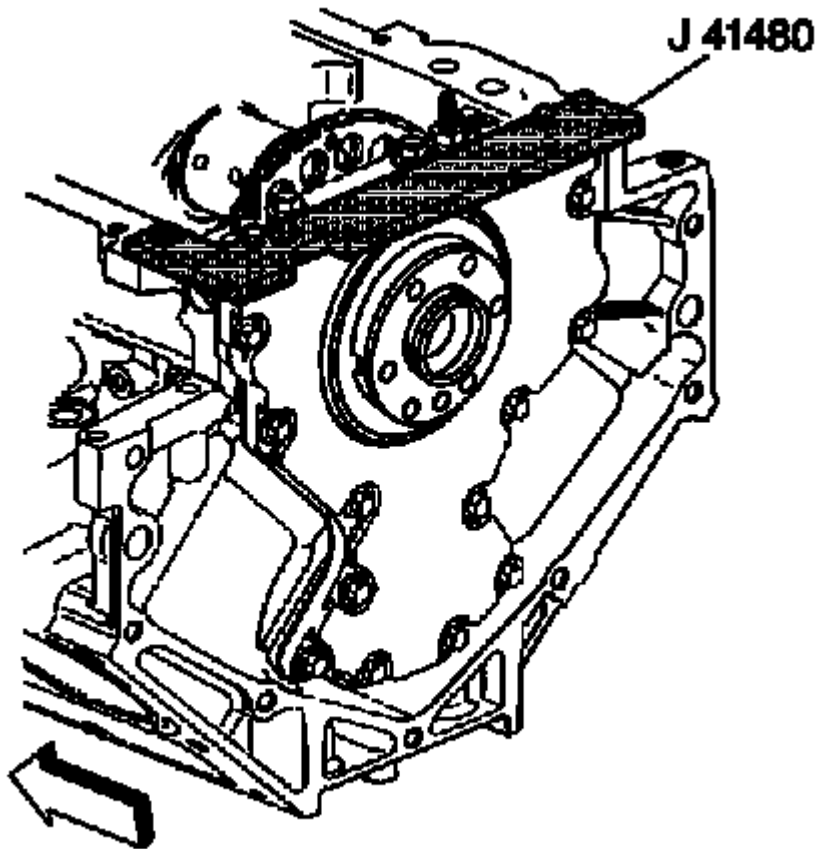


Fig. 477: View Of J 41480 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Start the J 41480 tool-to-rear cover bolts. Do not tighten the bolts at this time.

4. Install the **J 41480** and bolts.

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

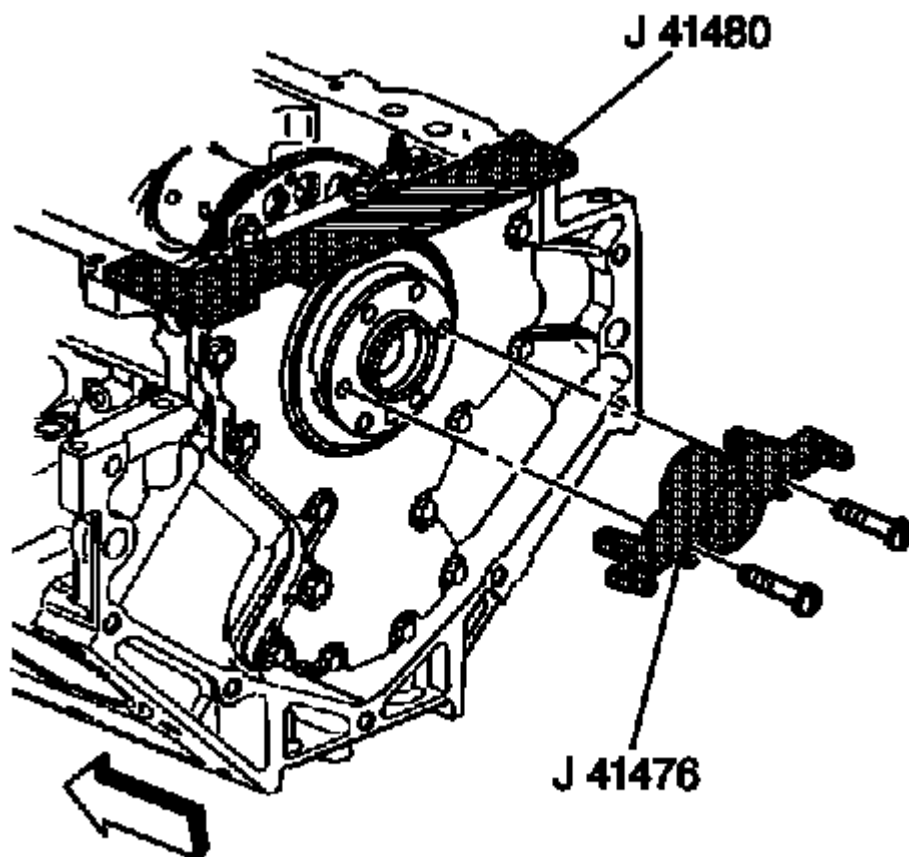


Fig. 478: View Of J 41480 & J 41476
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To properly align the rear cover, the J 41476 must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface. See Special Tools.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.

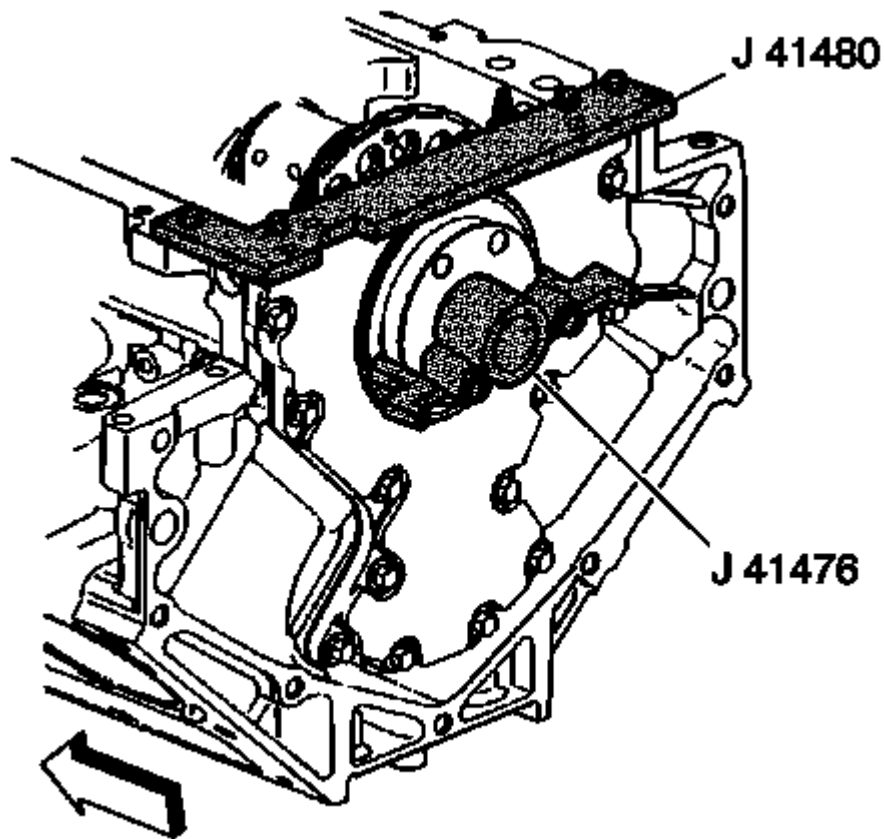


Fig. 479: View Of J 41480 & J 41476 Installed
Courtesy of GENERAL MOTORS CORP.

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

6. Install the **J 41476** and bolts onto the rear of the crankshaft.

Tighten:

1. Tighten the tool mounting bolts until snug. Do not overtighten.
2. Tighten the **J 41480** tool-to-rear cover bolts evenly to 12 N.m (106 lb in).
3. Tighten the rear cover bolts to 25 N.m (18 lb ft).

7. Remove the tools.

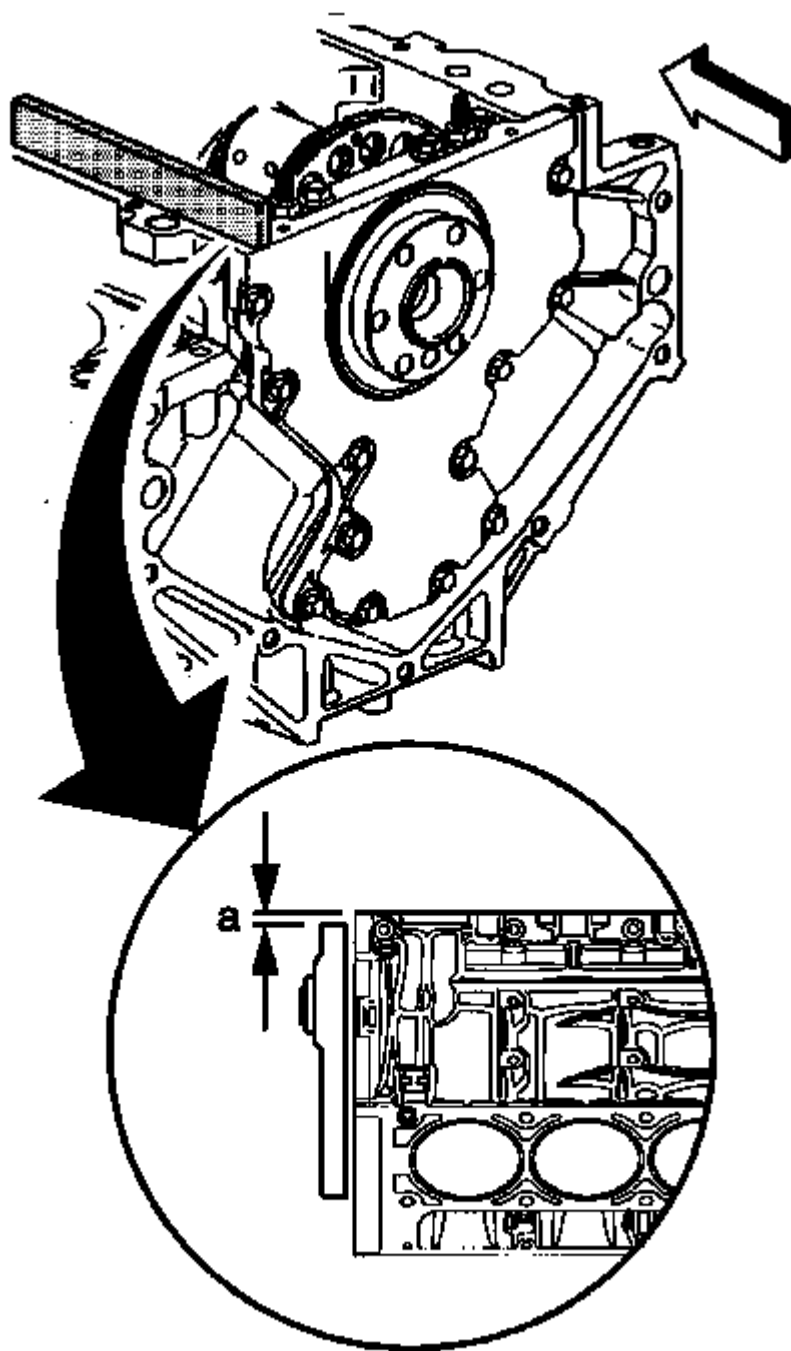


Fig. 480: Checking Rear Cover-To-Engine Block Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

8. Measure the rear cover-to-engine block oil pan surface for flatness.
 1. Place a straight edge onto the engine block and rear 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 rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.
9. If the rear cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
10. If the correct rear cover-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear cover.

Crankshaft Rear Oil Seal Installation

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer. See **Special Tools**.

Installation Procedure

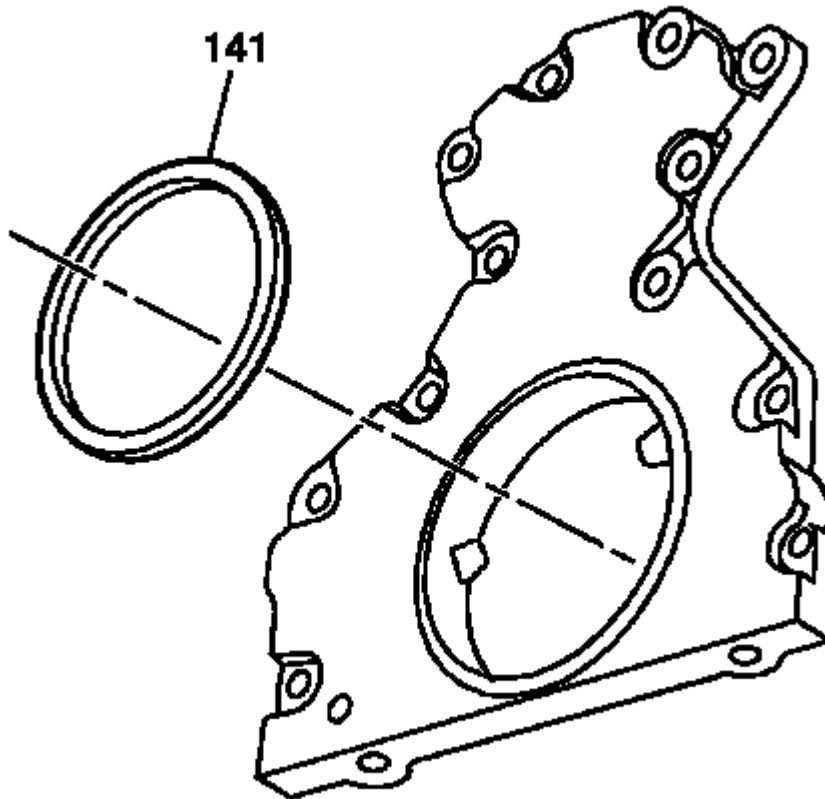


Fig. 481: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: • Do not lubricate the oil seal inside diameter (ID) or the crankshaft

surface.

- **Do not use the crankshaft rear oil seal again.**

1. 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.

2. Lubricate the rear cover oil seal bore with clean engine oil.

DO NOT allow oil or other lubricants to contact the crankshaft surface.

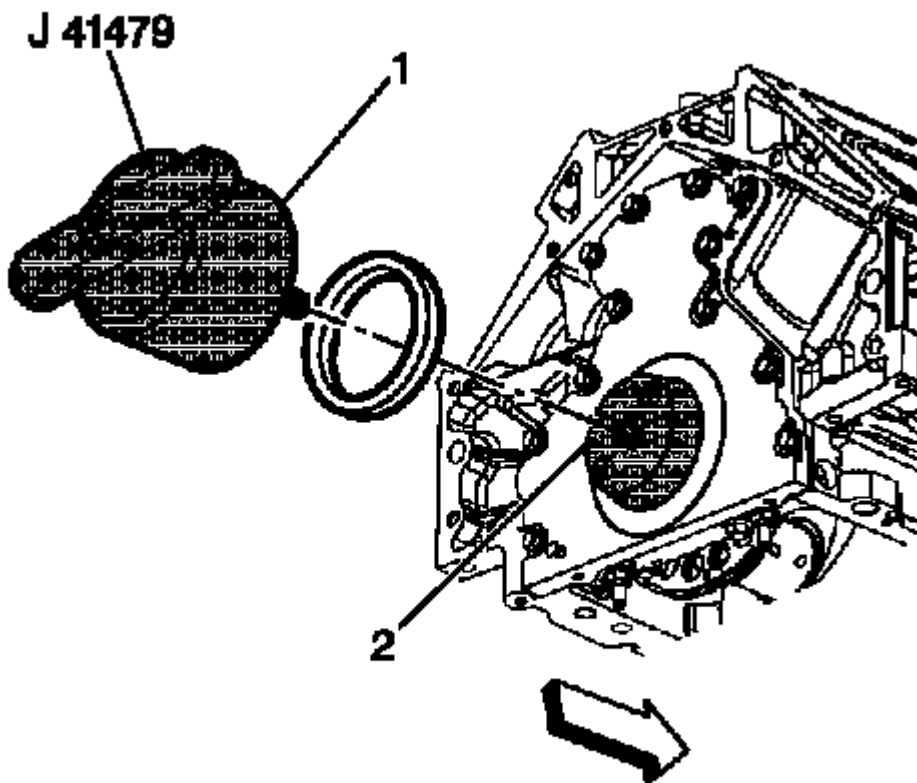


Fig. 482: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See Special Tools.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal.
7. Align the oil seal onto the tool (1).

8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove the tool.

Engine Front Cover Installation

Tools Required

- **J 41480** Front/Rear Cover Alignment - Oil Pan Surface. See **Special Tools**.
- **J 41476** Front/Rear Cover Alignment - Crankshaft Oil Seal Area. See **Special Tools**.

Installation Procedure

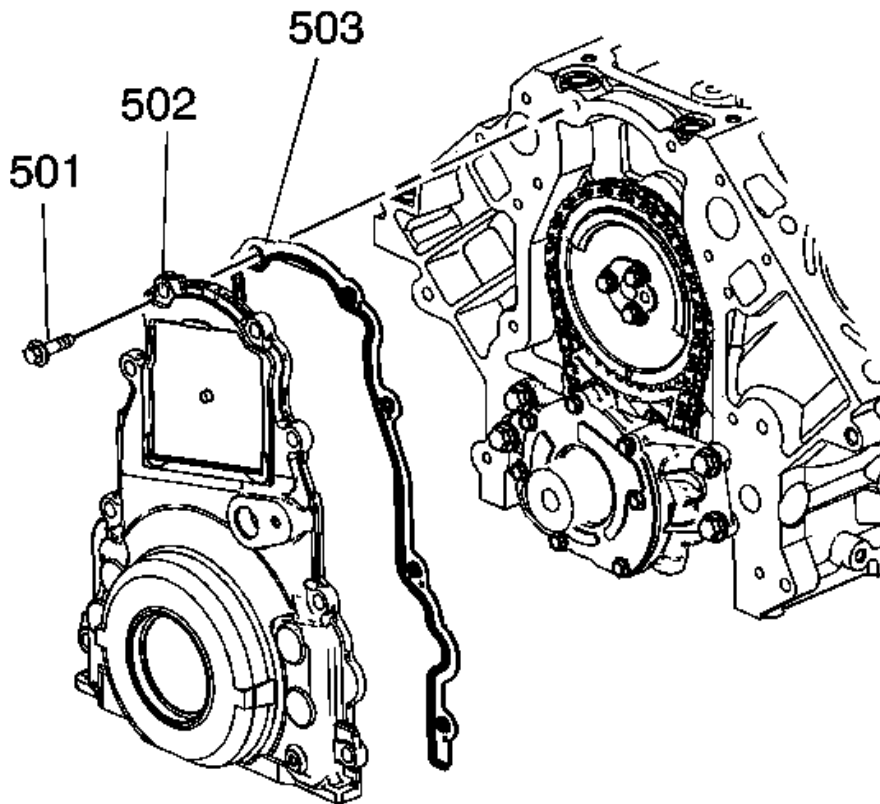


Fig. 483: Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

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.**
 - **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 (503), front cover (502), and bolts (501).
2. Tighten the cover bolts finger tight. Do not overtighten.

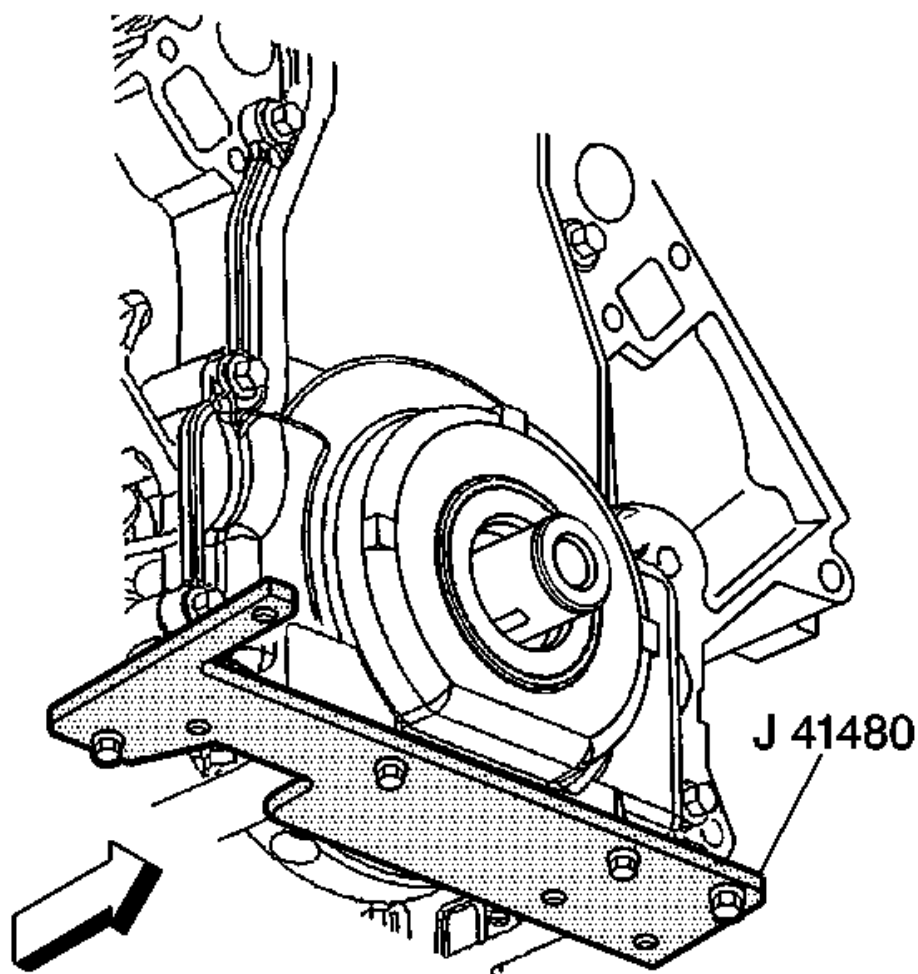


Fig. 484: View Of J 41480 Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

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

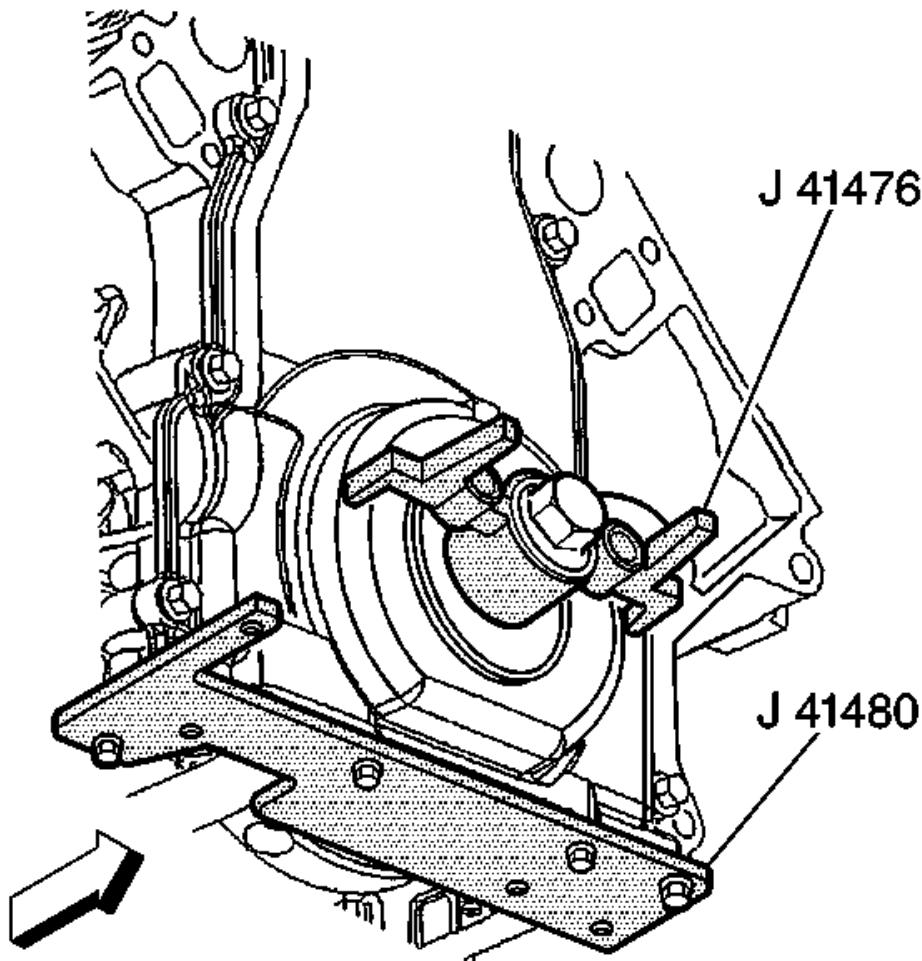


Fig. 485: View Of J 41476 & J 41480 Installed On Engine
Courtesy of GENERAL MOTORS CORP.

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

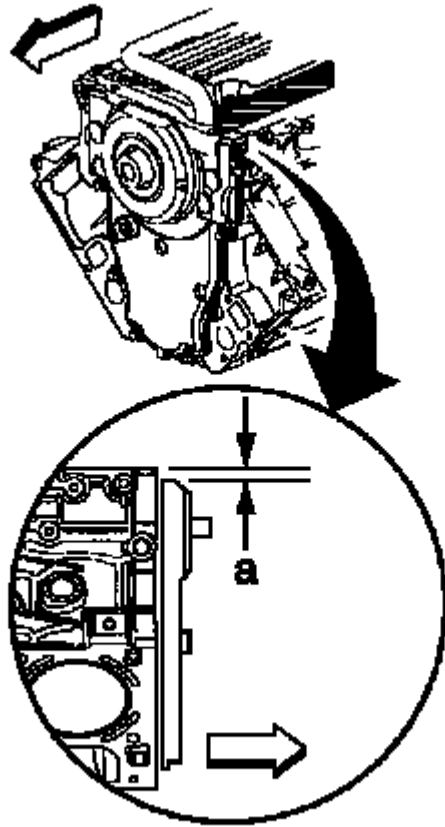


Fig. 486: Measuring Oil Pan Surface Flatness & Front Cover-To-Engine Block
Courtesy of GENERAL MOTORS CORP.

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) (a) 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.

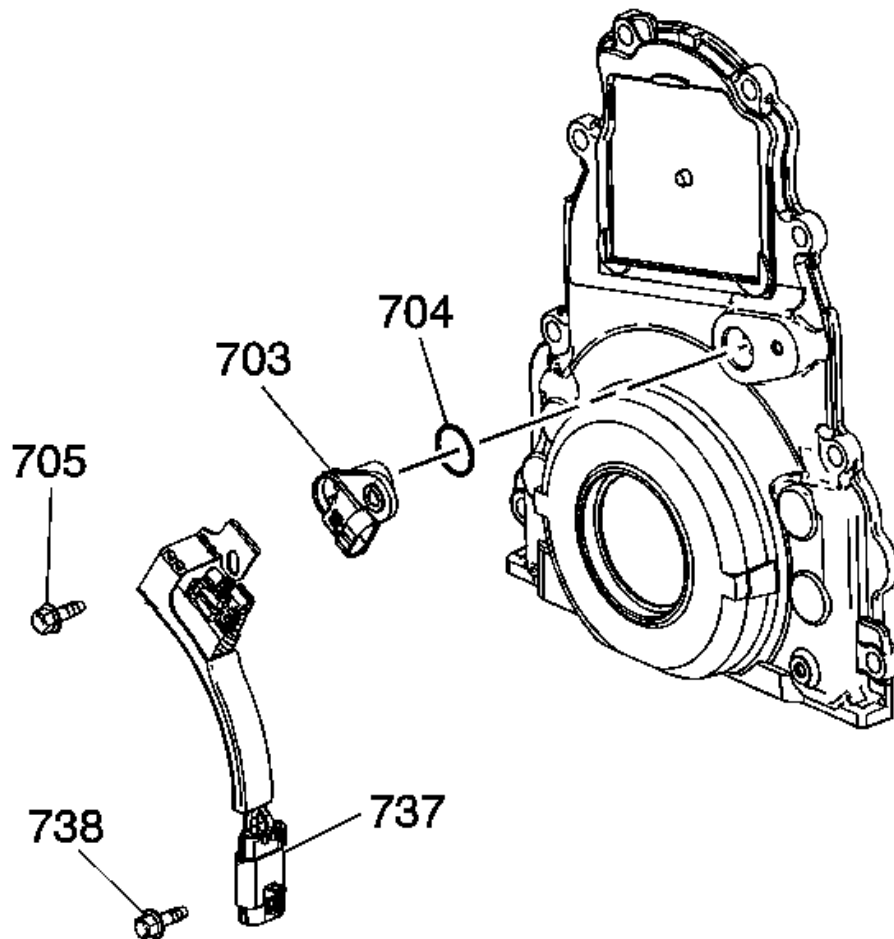


Fig. 487: O-Ring Seal, Sensor, Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position (CMP) sensor O-ring seal (704) 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.
12. Install the O-ring seal onto the sensor (703).
13. Install the sensor to the cover.
14. Install the CMP sensor wire harness (737) and bolts (705, 738).

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

Crankshaft Front Oil Seal Installation

Tools Required

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

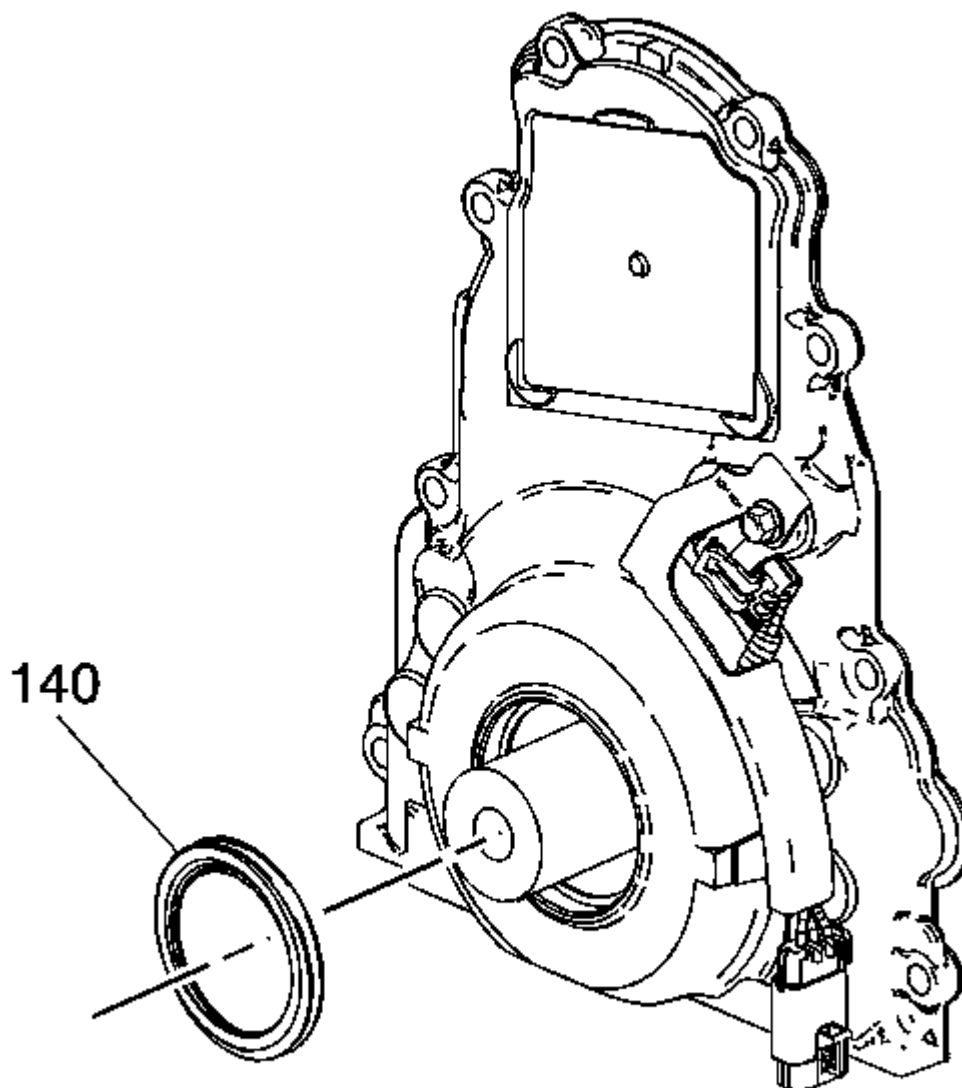
Installation Procedure

Fig. 488: 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.

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.

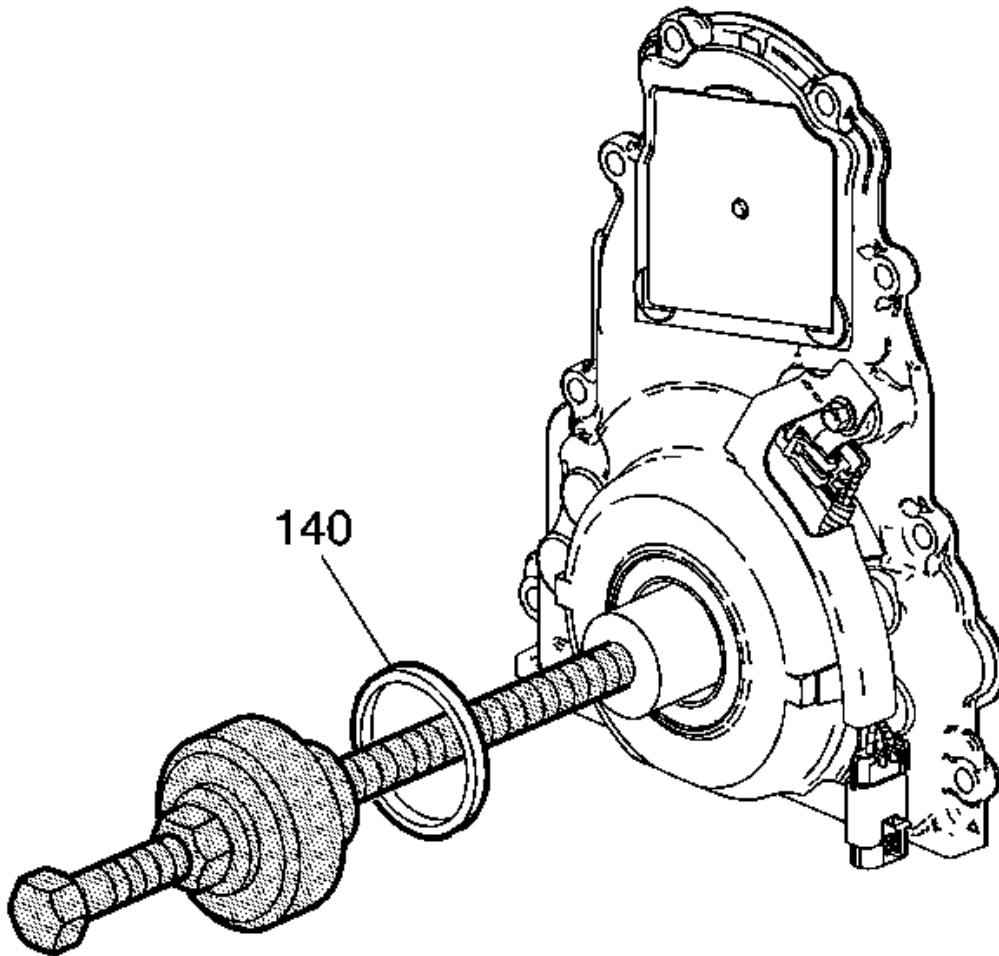


Fig. 489: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) onto the **J 41478** . See **Special Tools**.
4. Install the **J 41478** threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft.
5. Use the **J 41478** in order to install the oil seal into the cover bore.
 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

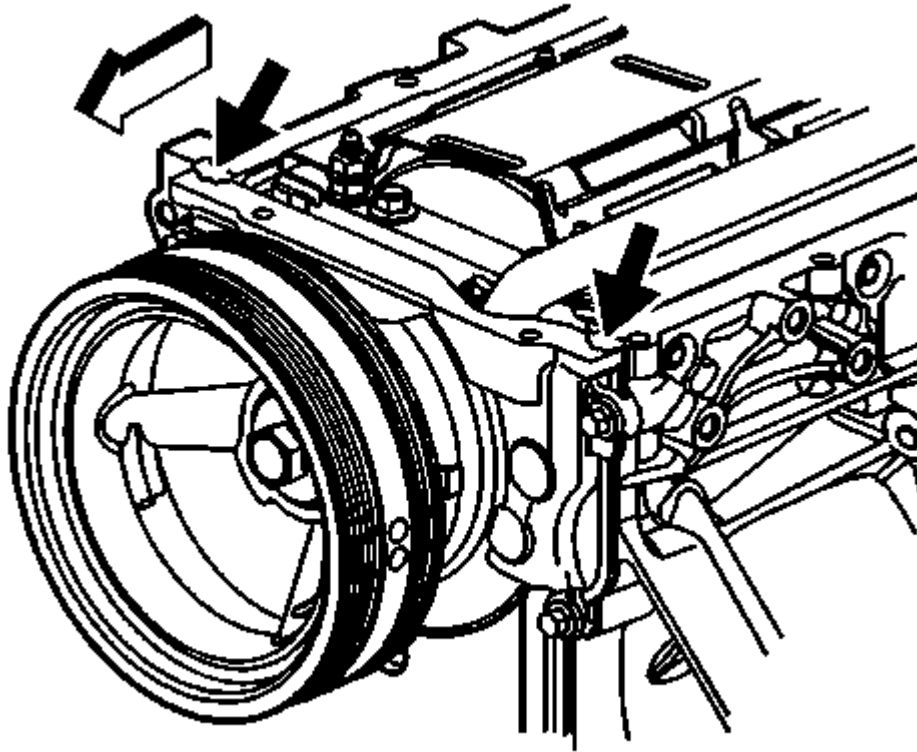


Fig. 490: View Of Sealant On Engine Front Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

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 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. Install the oil transfer tube, baffle, and bypass valve. Refer to **Oil Pan Cleaning and Inspection**.
2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 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](#).

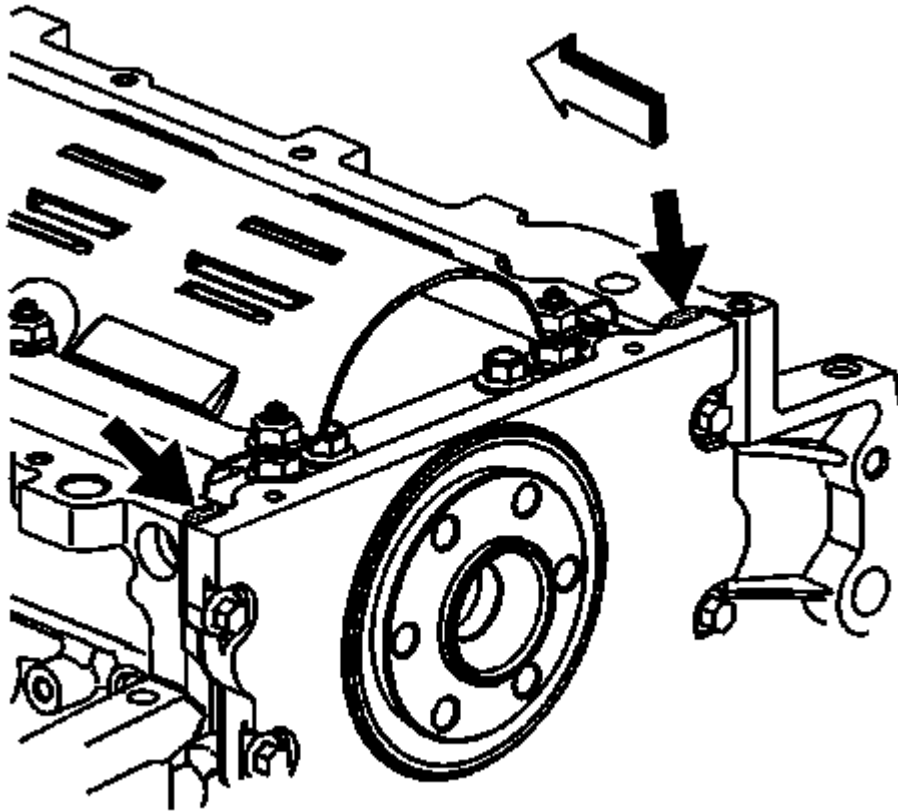


Fig. 491: View Of Sealant On Engine Rear Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 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.

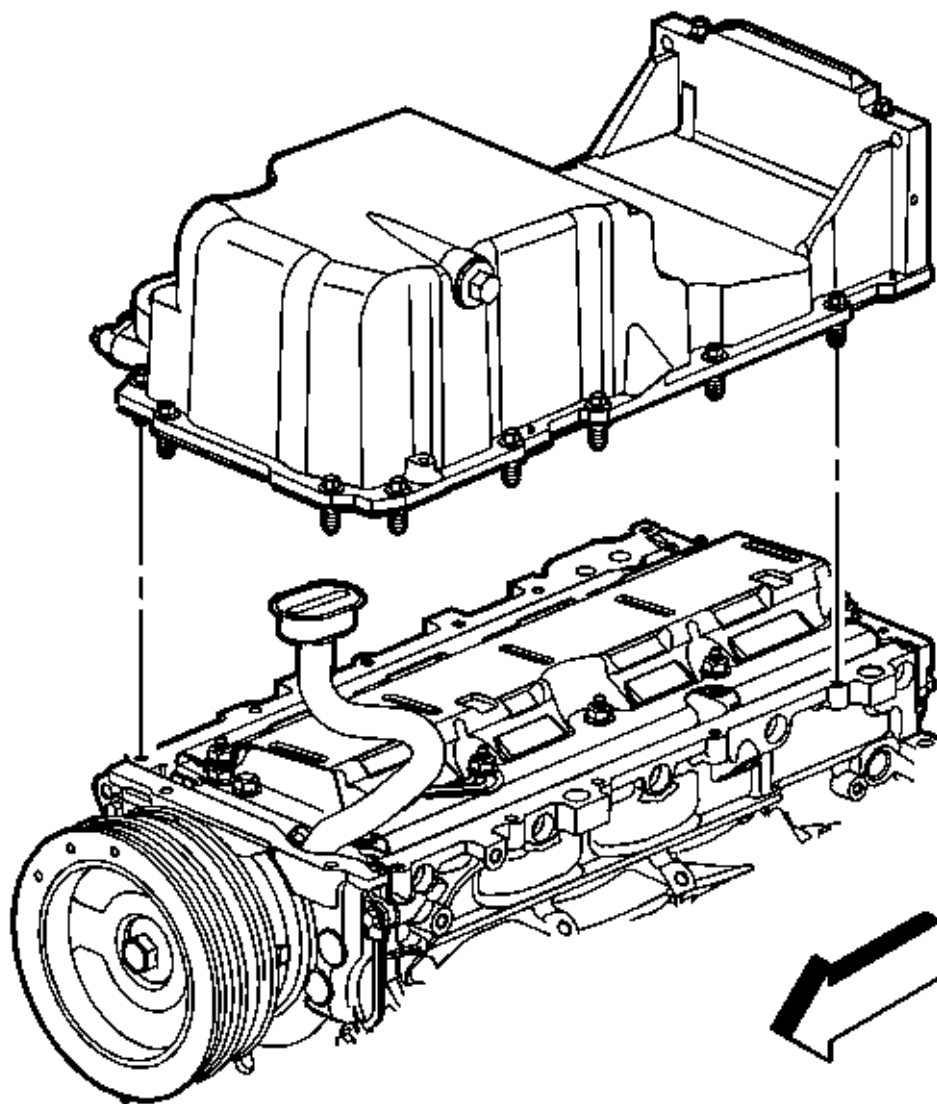


Fig. 492: View Of Rear Engine Cover
Courtesy of GENERAL MOTORS CORP.

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

4. Pre-assemble the oil pan gasket to the pan.
 1. Install the gasket onto the oil pan.

2. Install the oil pan bolts to the pan and through the gasket.
5. Install the oil pan, gasket, and bolts to the engine block.
6. Tighten the bolts finger tight. Do not overtighten.

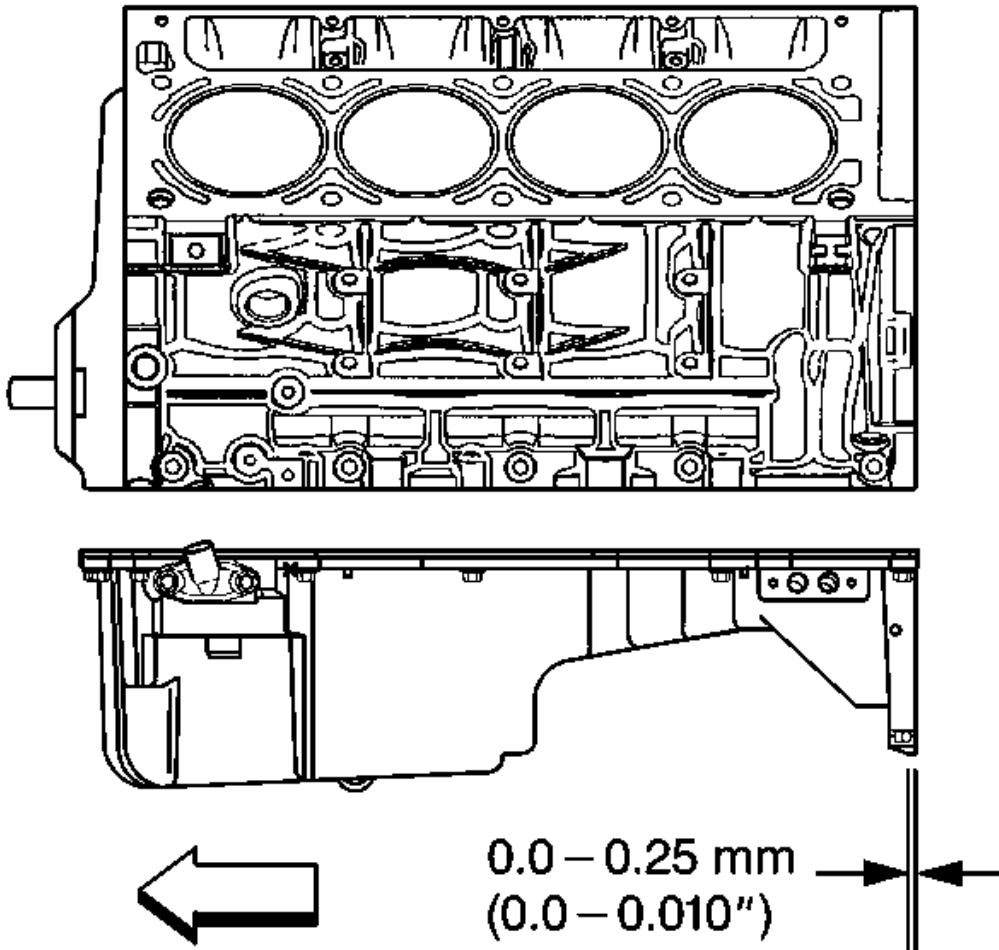


Fig. 493: Aligning Oil Pan
Courtesy of GENERAL MOTORS CORP.

7. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. 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).
9. 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 more than a 0.25 mm (0.01 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, Adapter, Pan Cover Installation

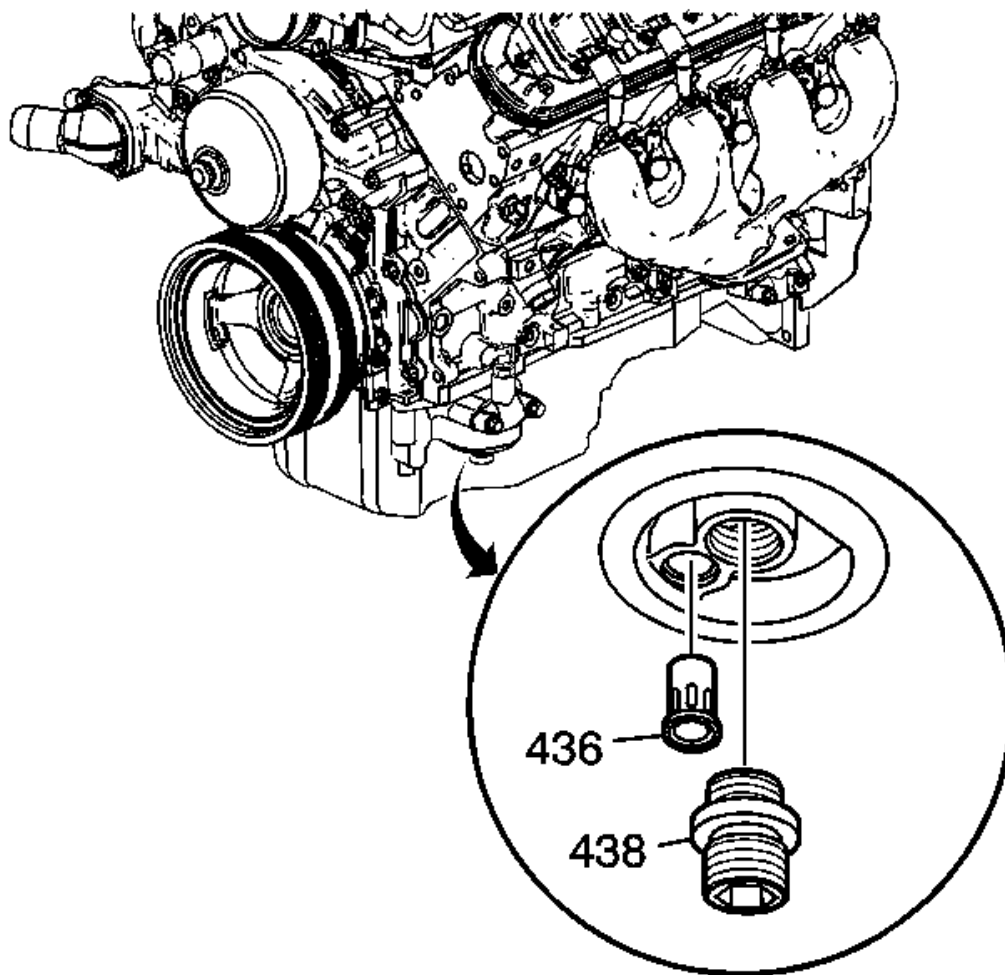


Fig. 494: Identifying Oil Filter, Adapter
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter bypass valve (436) into the oil pan as required.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter fitting (438).

Tighten: Tighten the oil filter fitting to 55 N.m (40 lb ft).

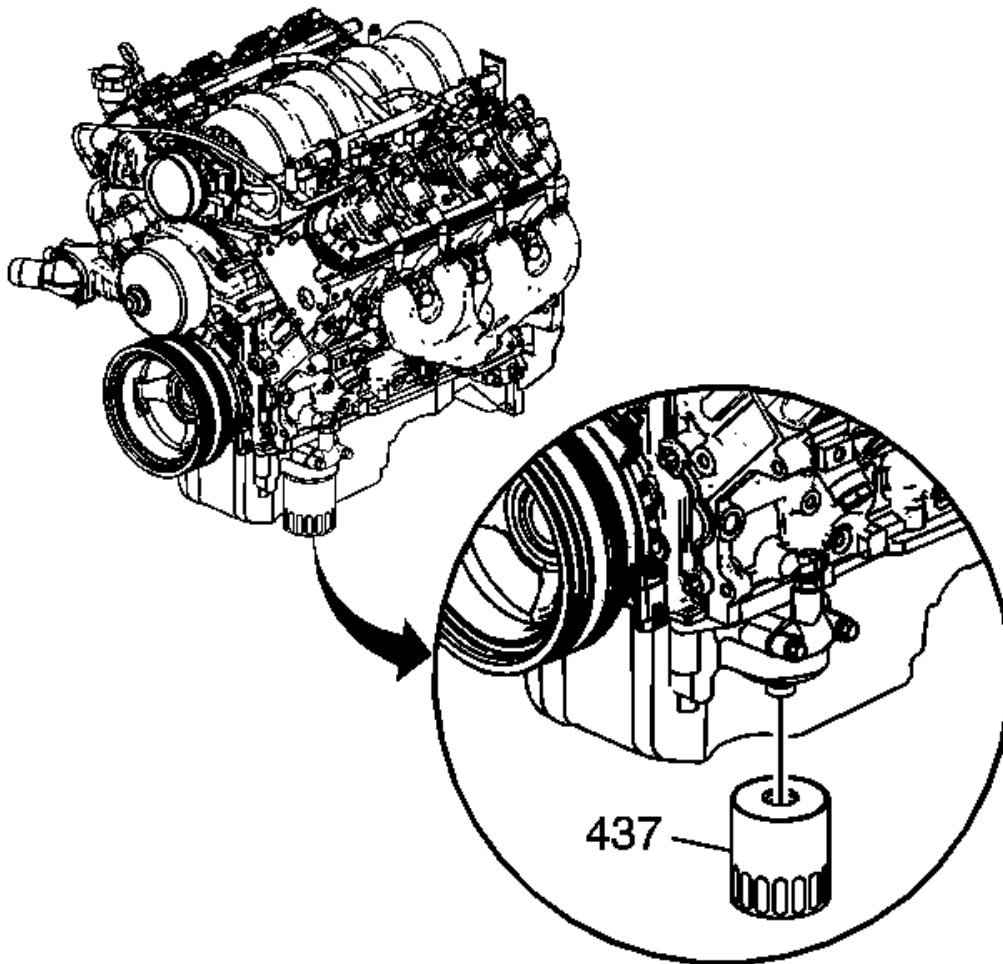


Fig. 495: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the oil filter seal with clean engine oil.
4. Install the oil filter (437).

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

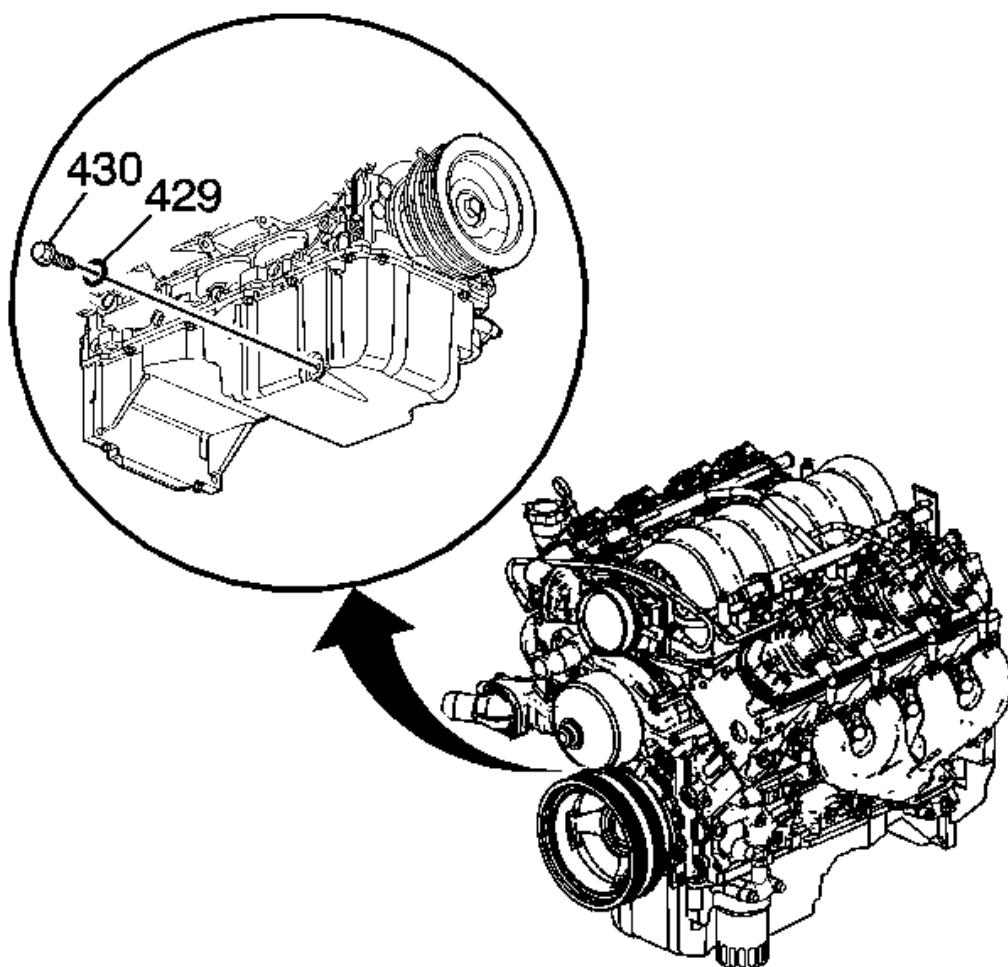


Fig. 496: Identifying Oil Pan Plug
Courtesy of GENERAL MOTORS CORP.

5. 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).

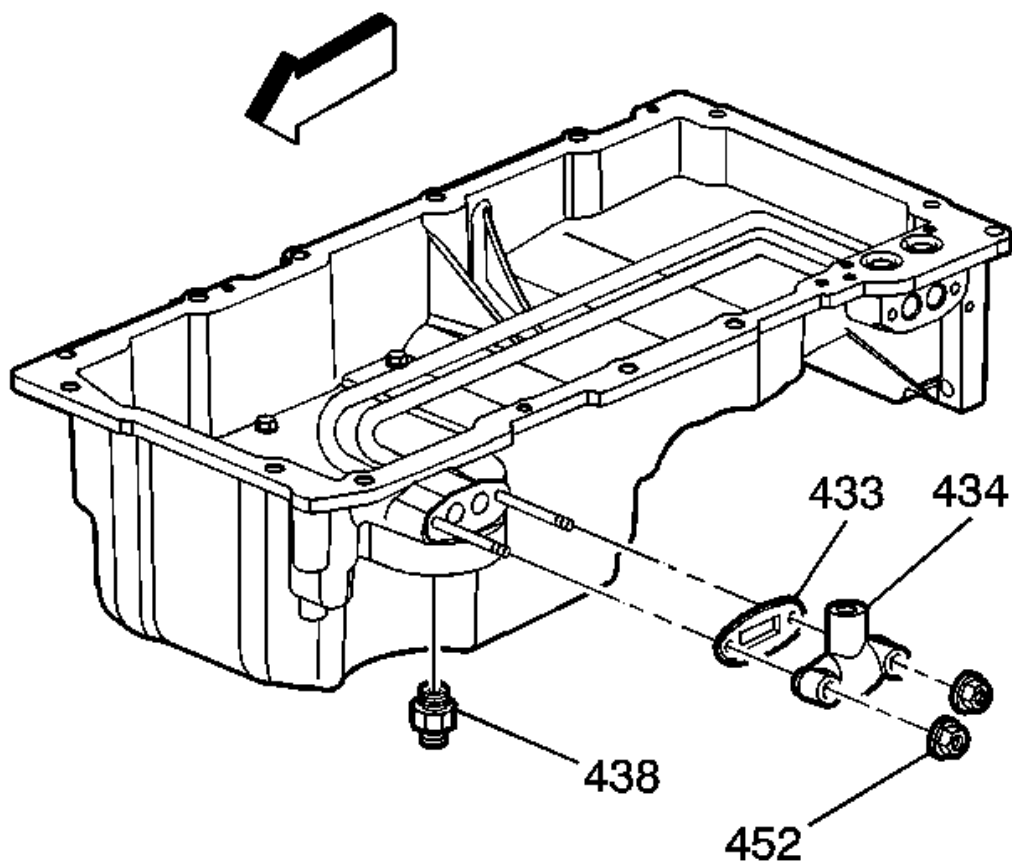


Fig. 497: View Of Oil Pan Cover, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the gasket (433), cover (434), and nuts (452).

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

Valve Lifter Installation

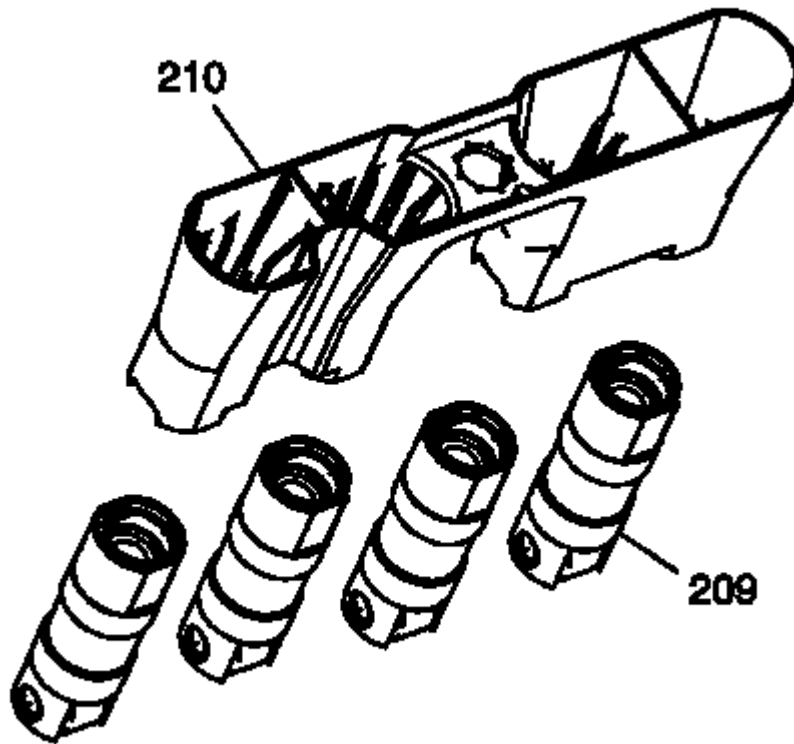


Fig. 498: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

1. Lubricate the valve lifters (209) and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides (210).

Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

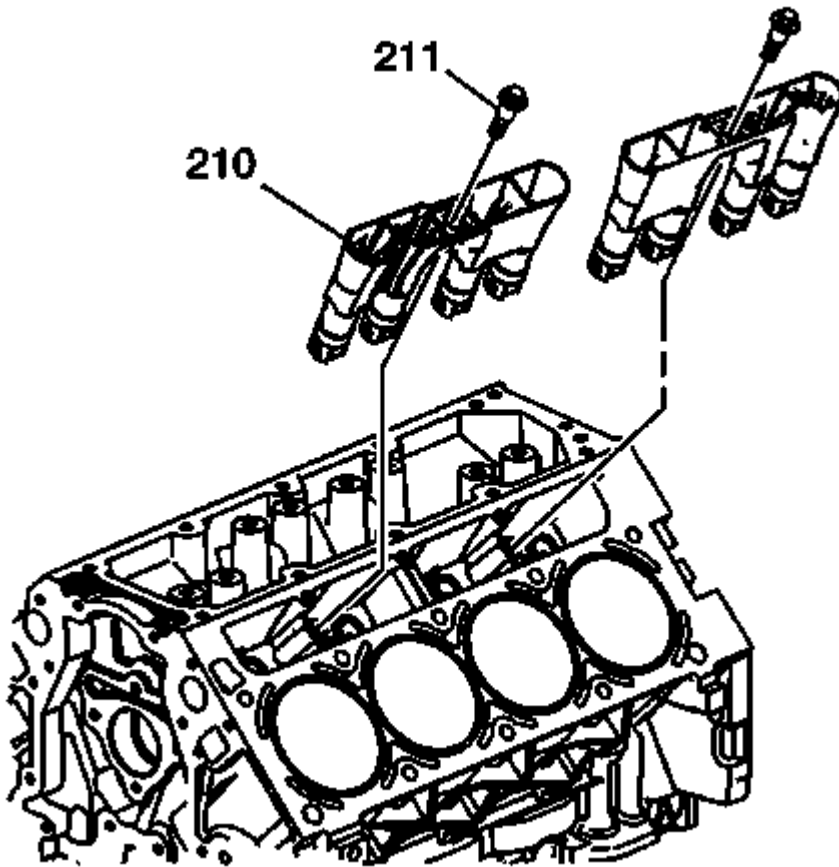


Fig. 499: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifters and guide assembly (210) to the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tools Required

- J 42385-100 Thread Repair Kit. See Special Tools.
- J 45059 Angle Meter

Installation Procedure

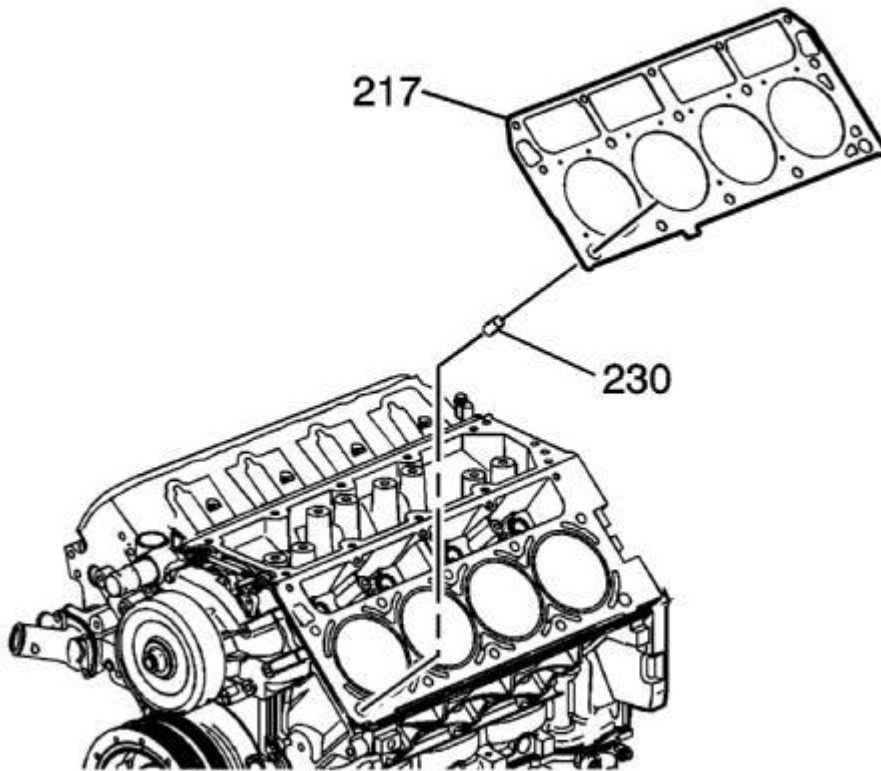


Fig. 500: View Of Cylinder Head Gasket And Alignment Pin - Left
Courtesy of GENERAL MOTORS CORP.

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

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 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).

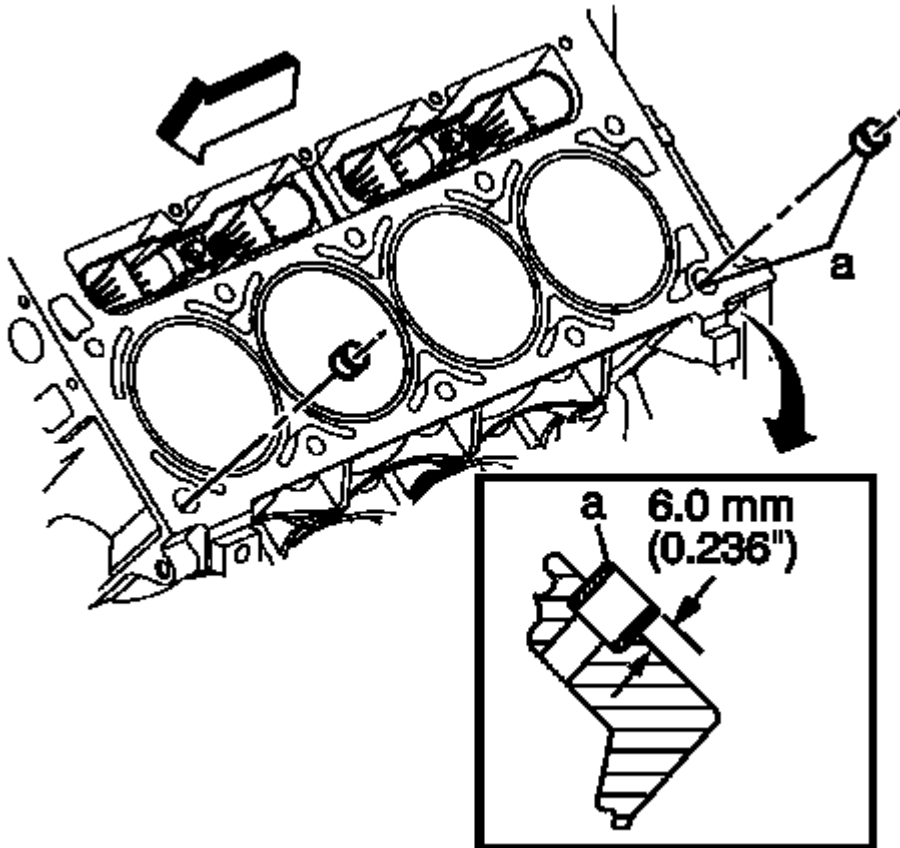


Fig. 501: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

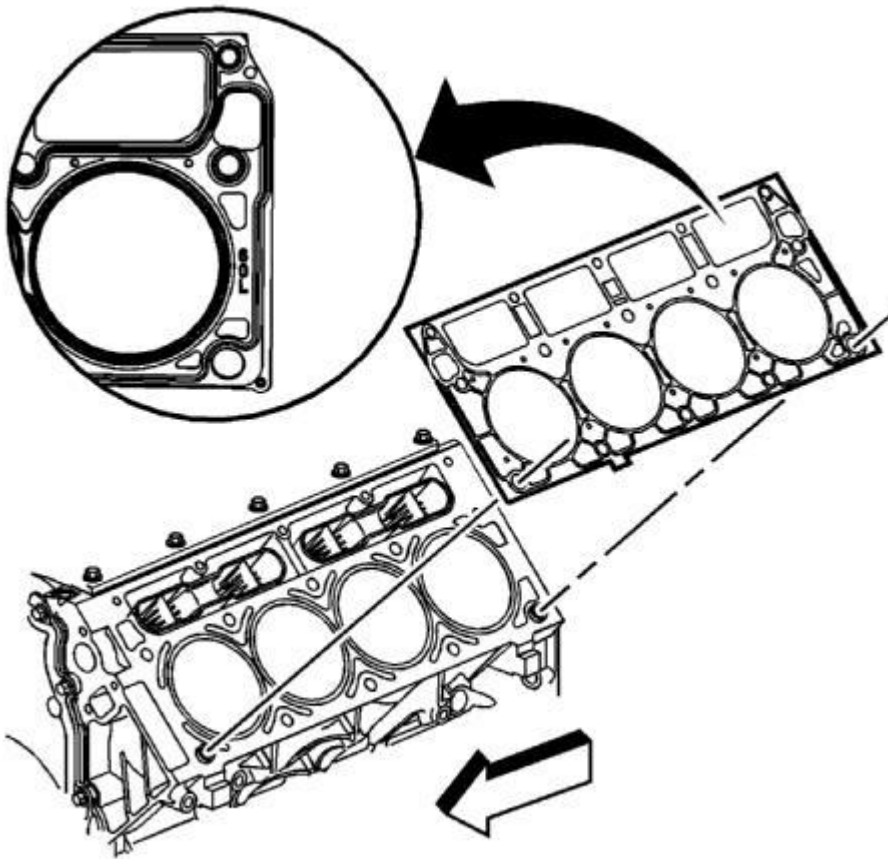


Fig. 502: Gasket Displacement Markings - Left
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the gasket for proper usage.

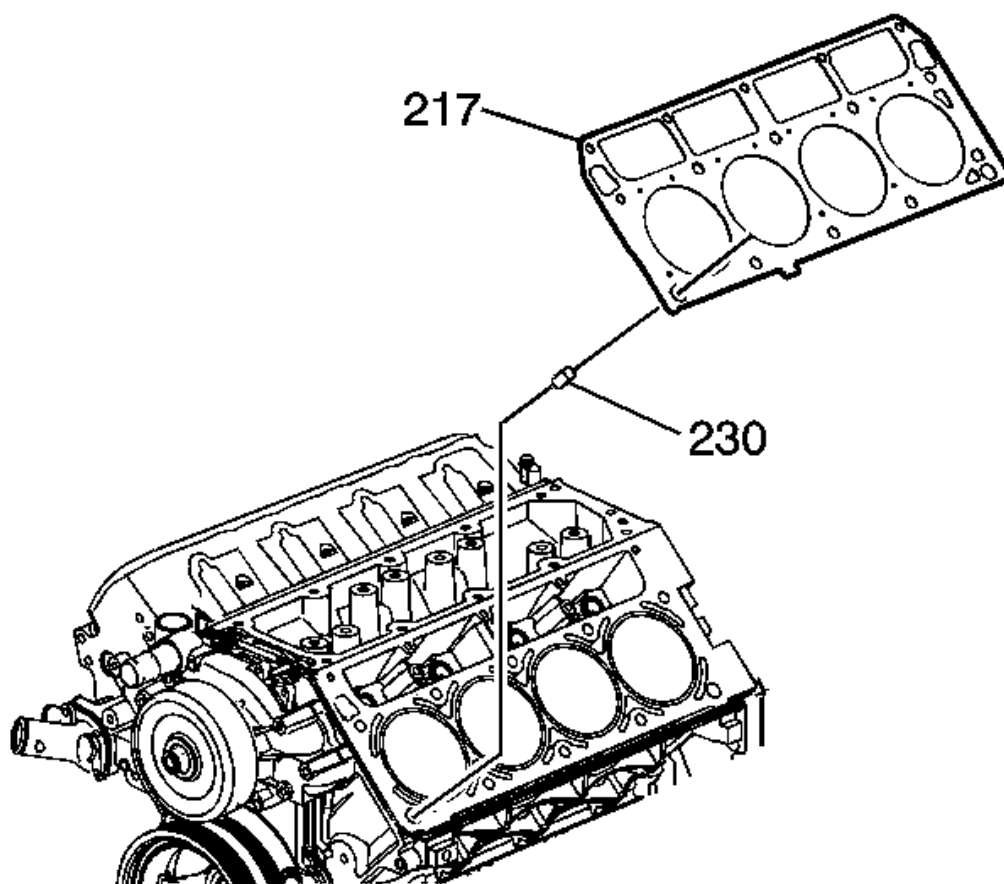


Fig. 503: Removing/Installing Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

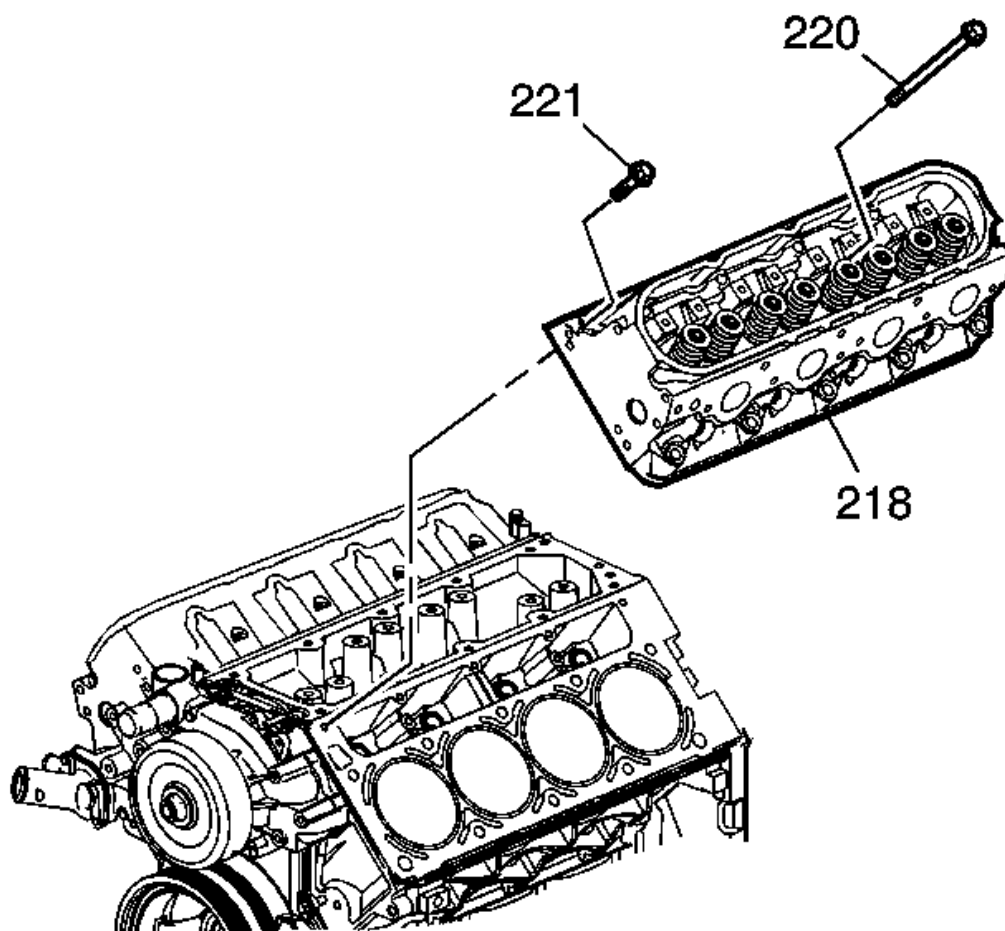


Fig. 504: Removing/Installing Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

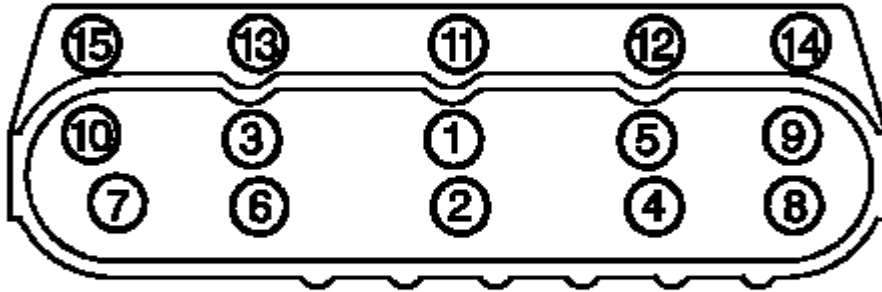


Fig. 505: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tools Required

- **J 42385-100** Thread Repair Kit. See Special Tools.
- **J 45059** Angle Meter

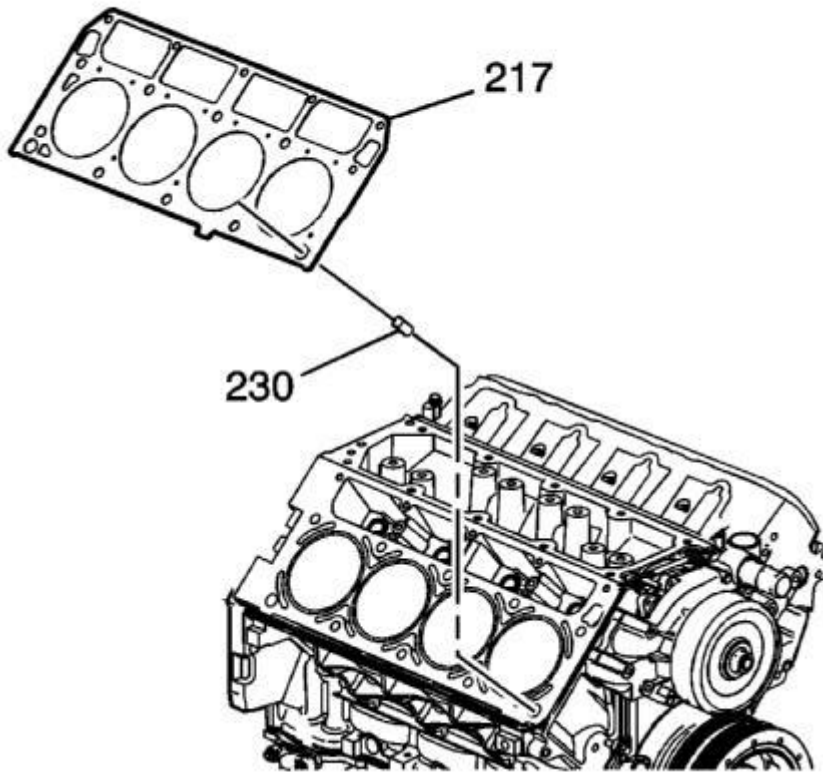
Installation Procedure

Fig. 506: Cylinder Head Gasket & Locating Pins - Right
Courtesy of GENERAL MOTORS CORP.

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

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 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).

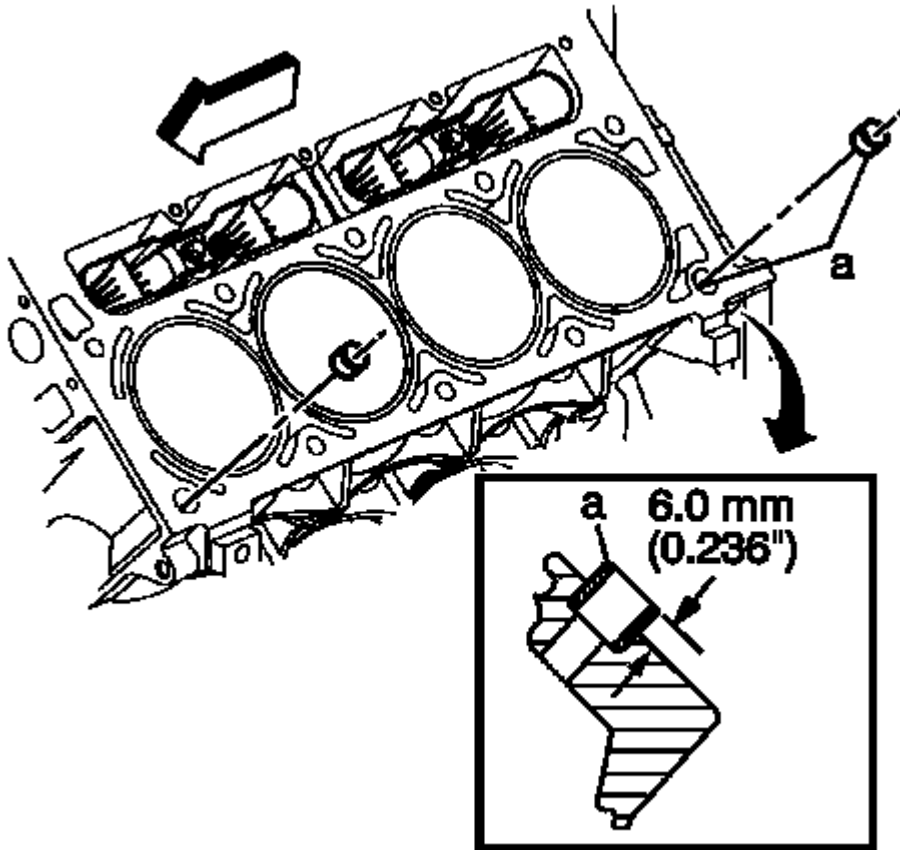


Fig. 507: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

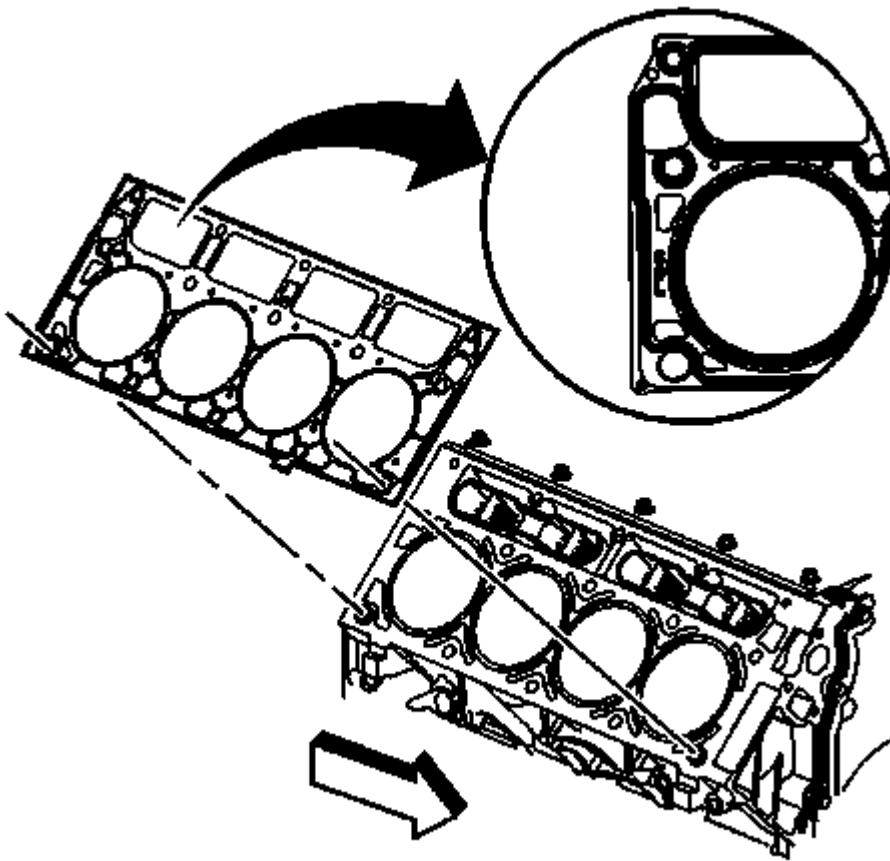


Fig. 508: Gasket Displacement Markings - Right
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings on the gasket for proper usage.

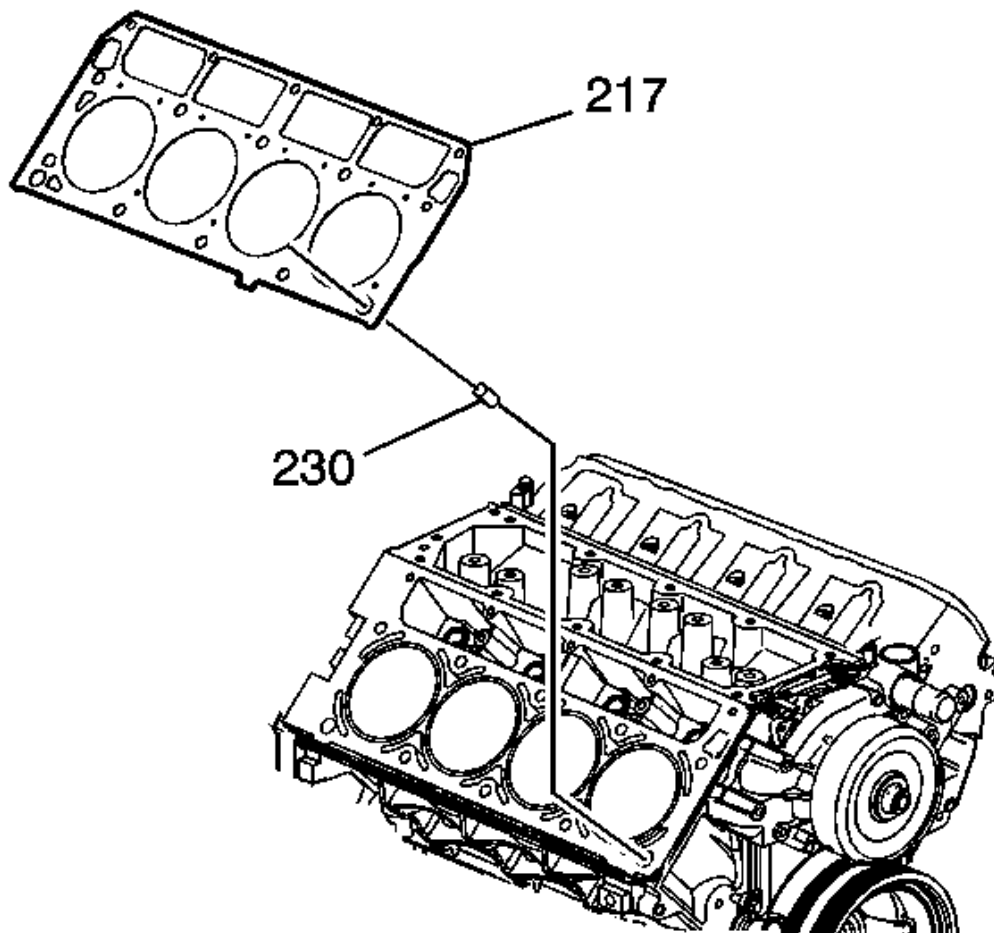


Fig. 509: Removing/Installing Right Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

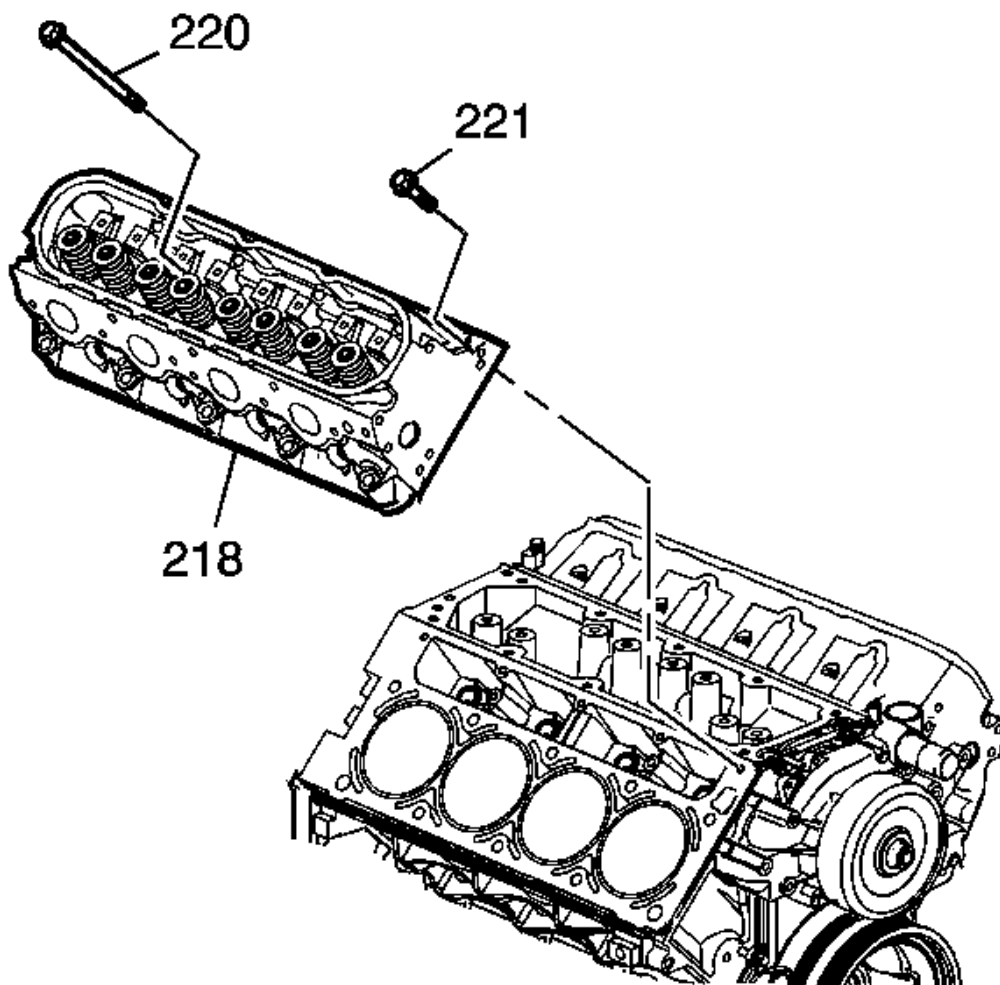


Fig. 510: Removing/Installing Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

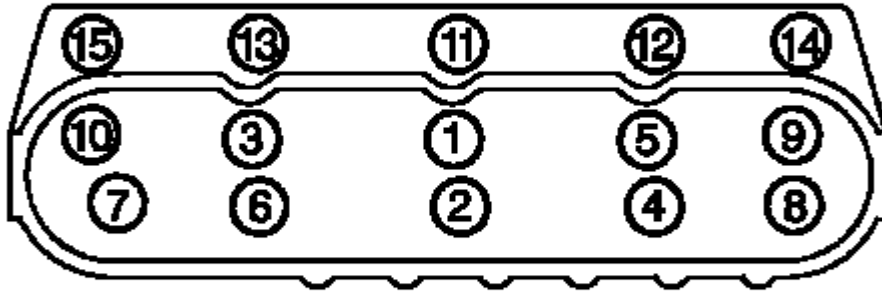


Fig. 511: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

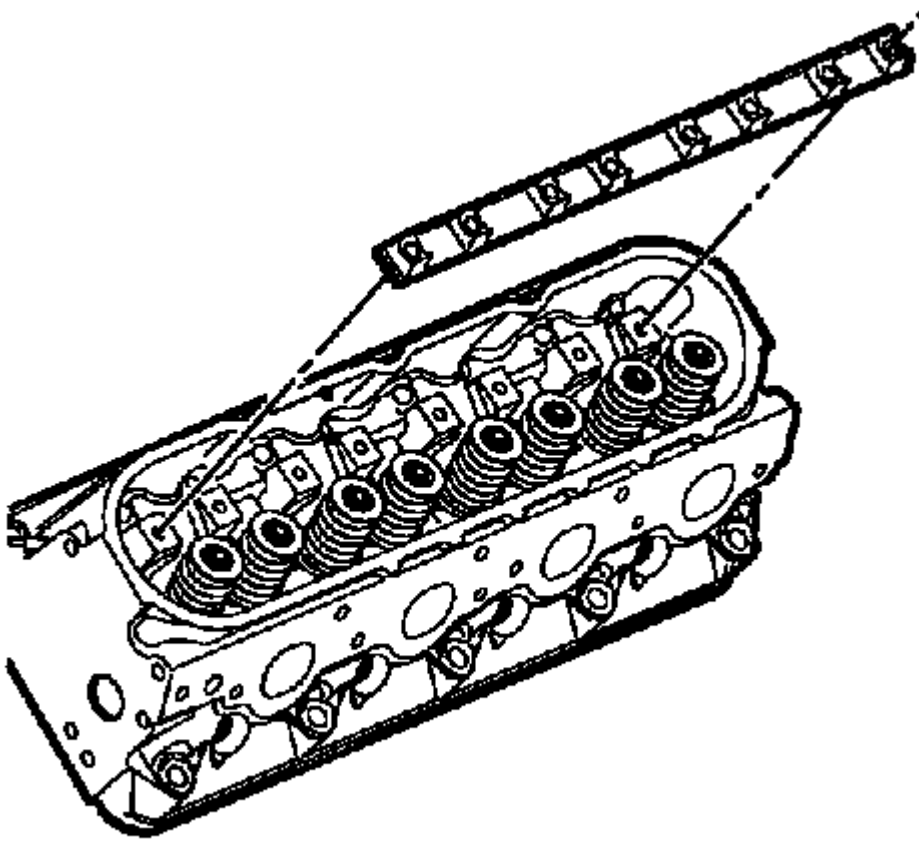


Fig. 512: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

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.
3. Install the valve rocker arm pivot support.

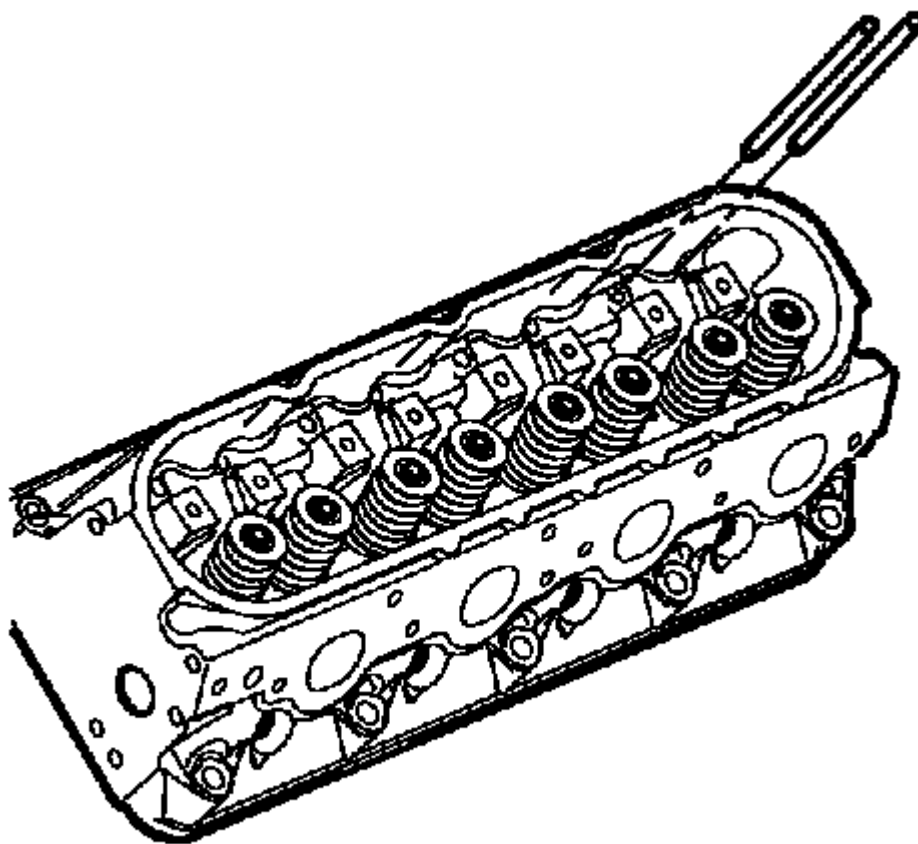


Fig. 513: View Of Pushrods

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

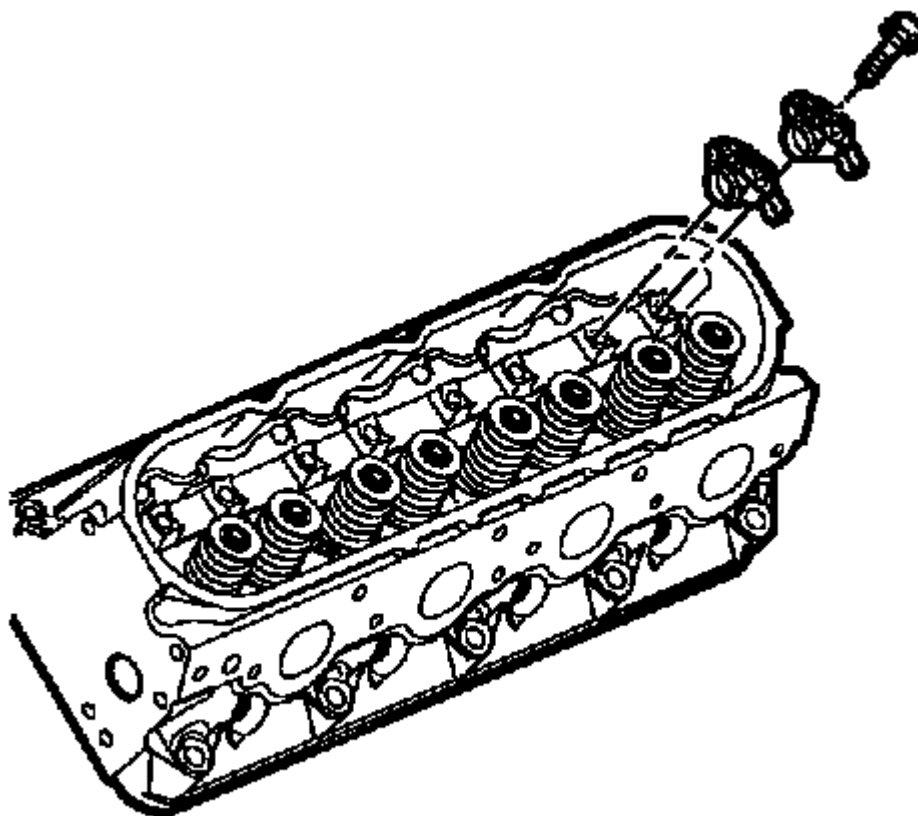


Fig. 514: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

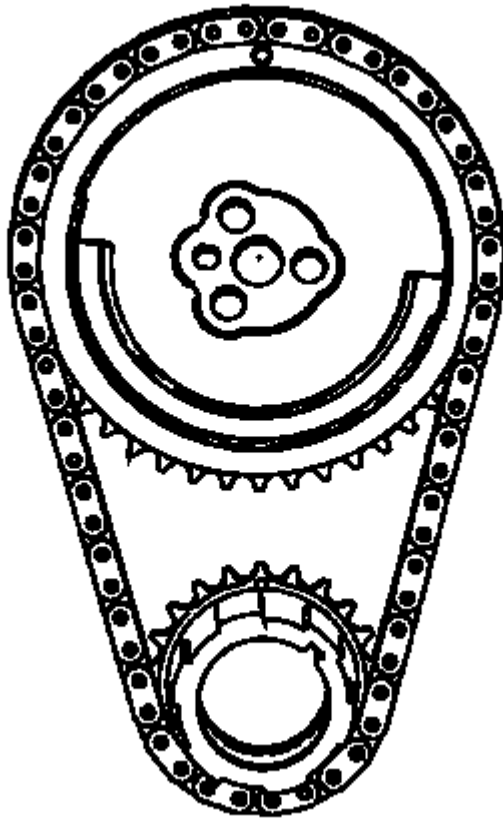


Fig. 515: Camshaft And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number one piston is at top dead center of 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 position. The camshaft and crankshaft sprocket alignment marks will be in the 12 o'clock positions. 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 in Cautions and Notices.

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

Tighten:

- Tighten exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
 - Tighten 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 exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

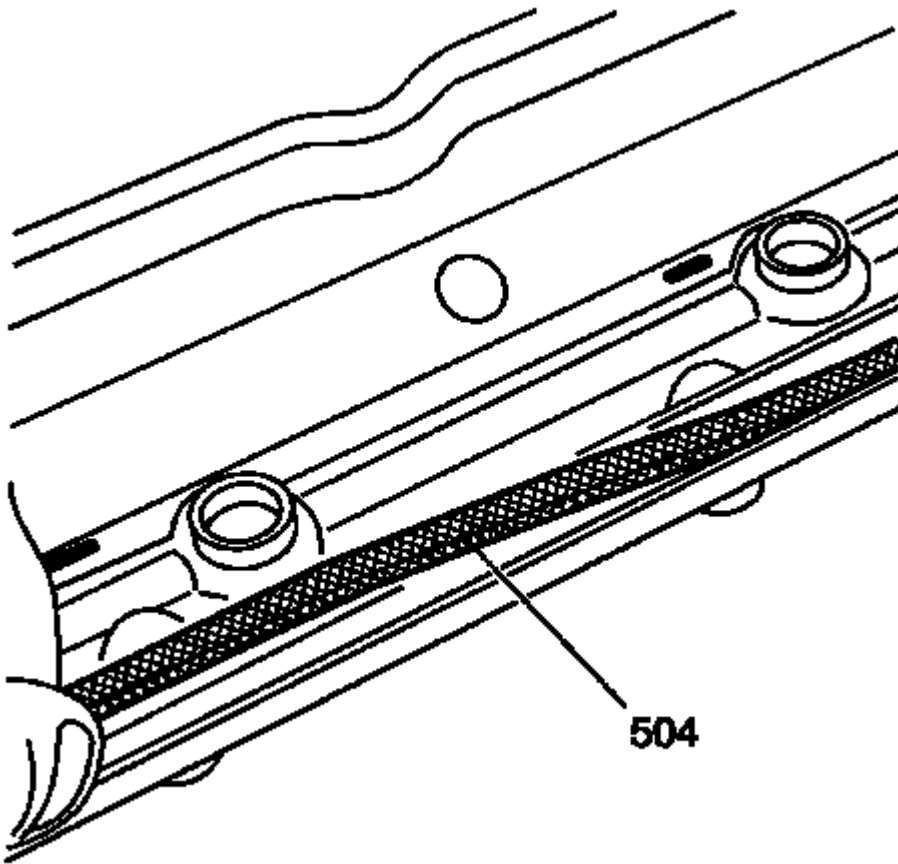
Valve Rocker Arm Cover Installation - Left

Fig. 516: 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.

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

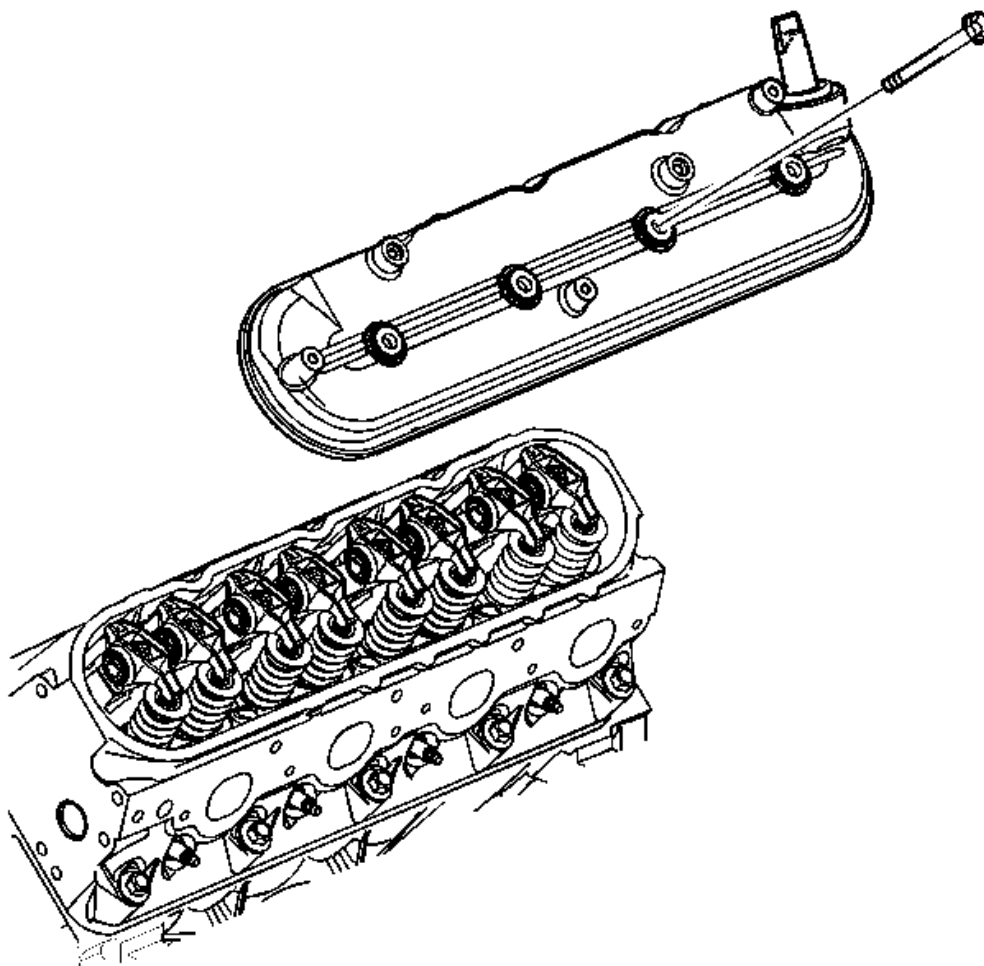


Fig. 517: Valve Rocker Arm Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

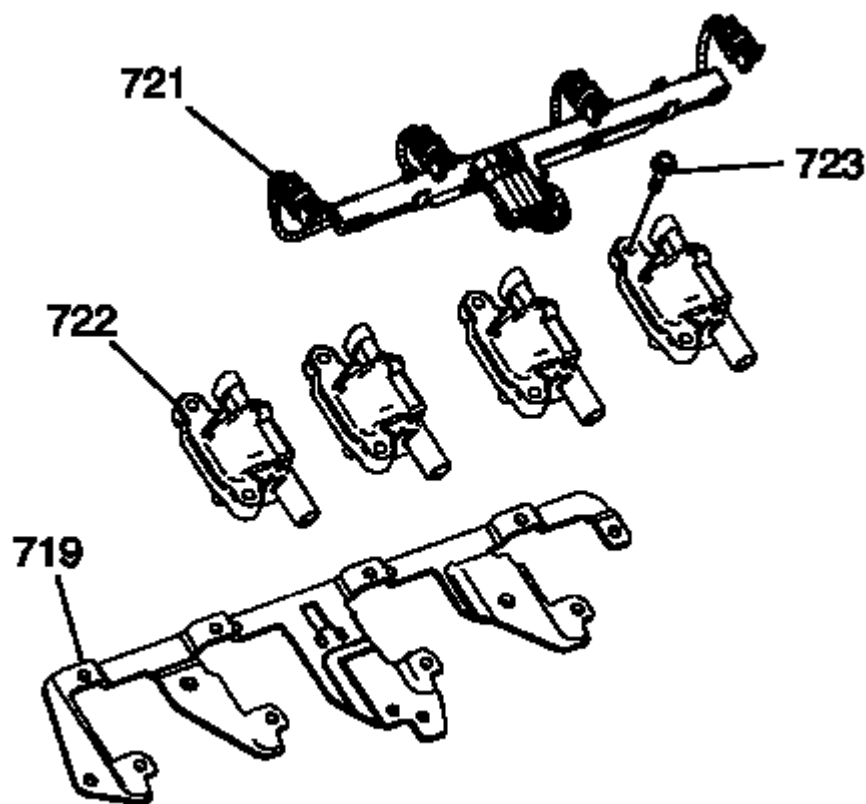


Fig. 518: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

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 10 N.m (89 lb in).

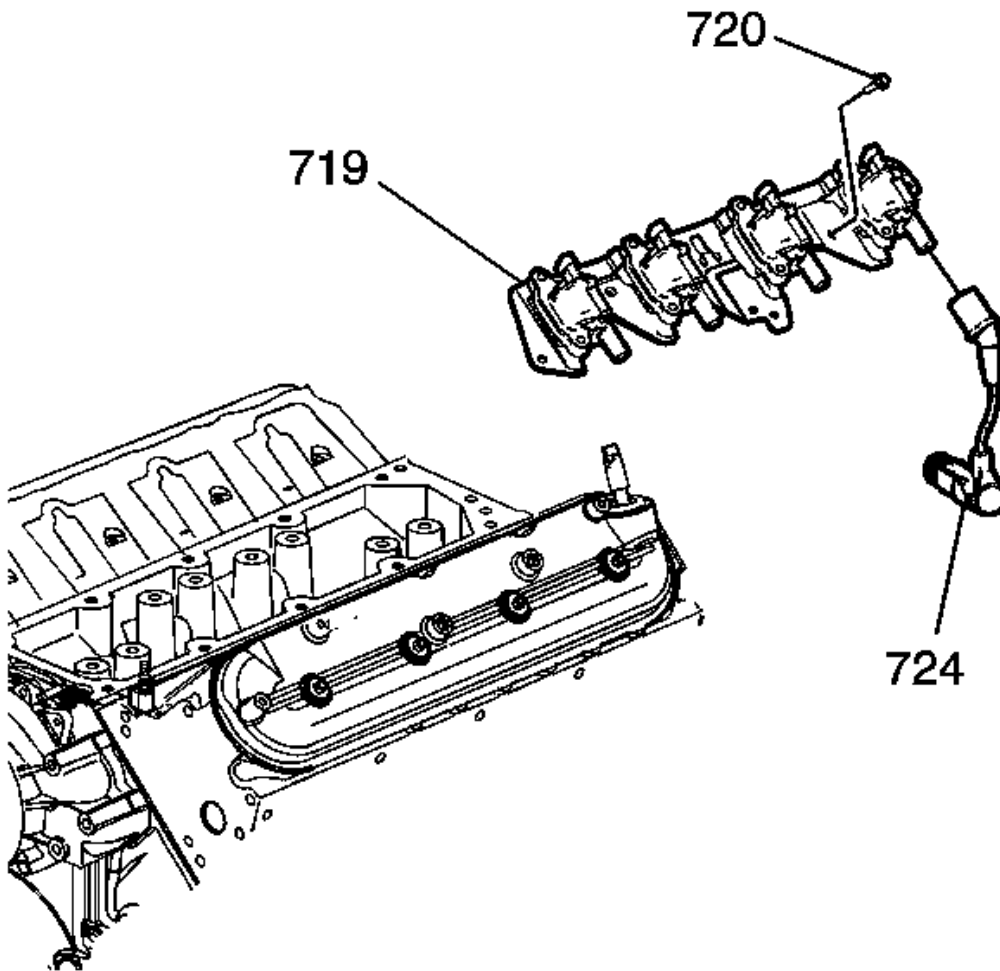


Fig. 519: Identifying Left Valve Rocker Arm Cover Attachments
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bracket bolts (723).
7. Install the ignition coil and bracket assembly (719) and bolts (720).

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

Valve Rocker Arm Cover Installation - Right

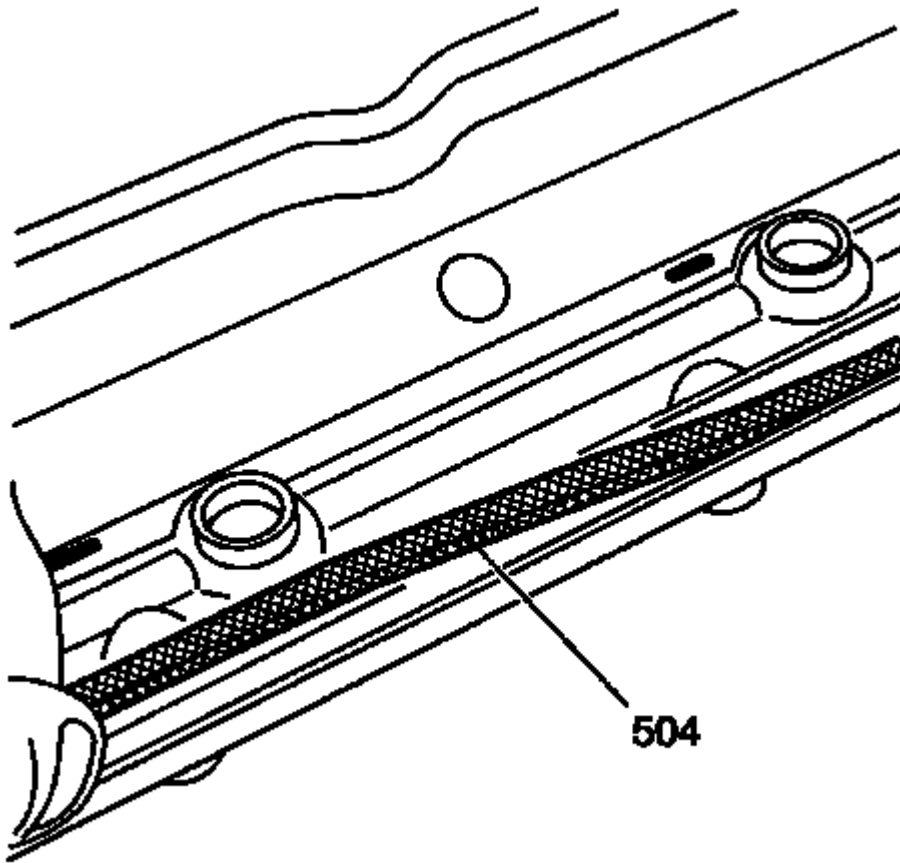


Fig. 520: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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.

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

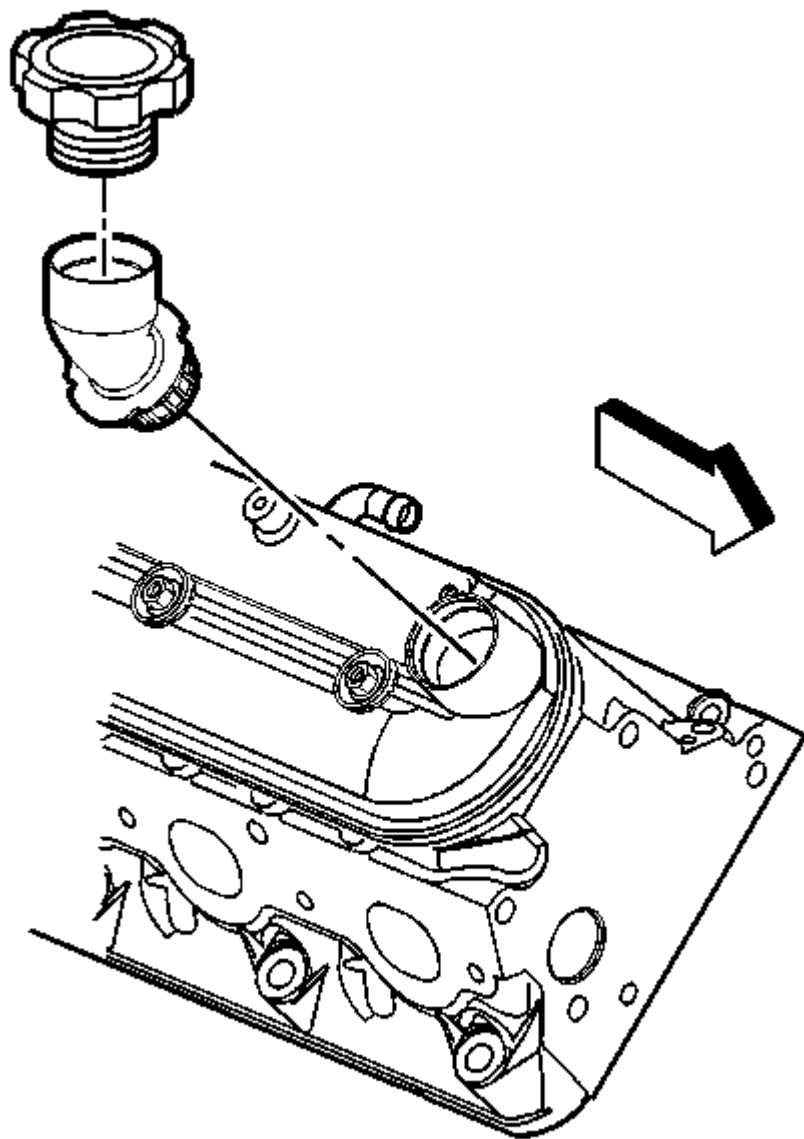


Fig. 521: View Of Oil Fill Cap & Tube
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW oil fill tube to the valve rocker arm cover

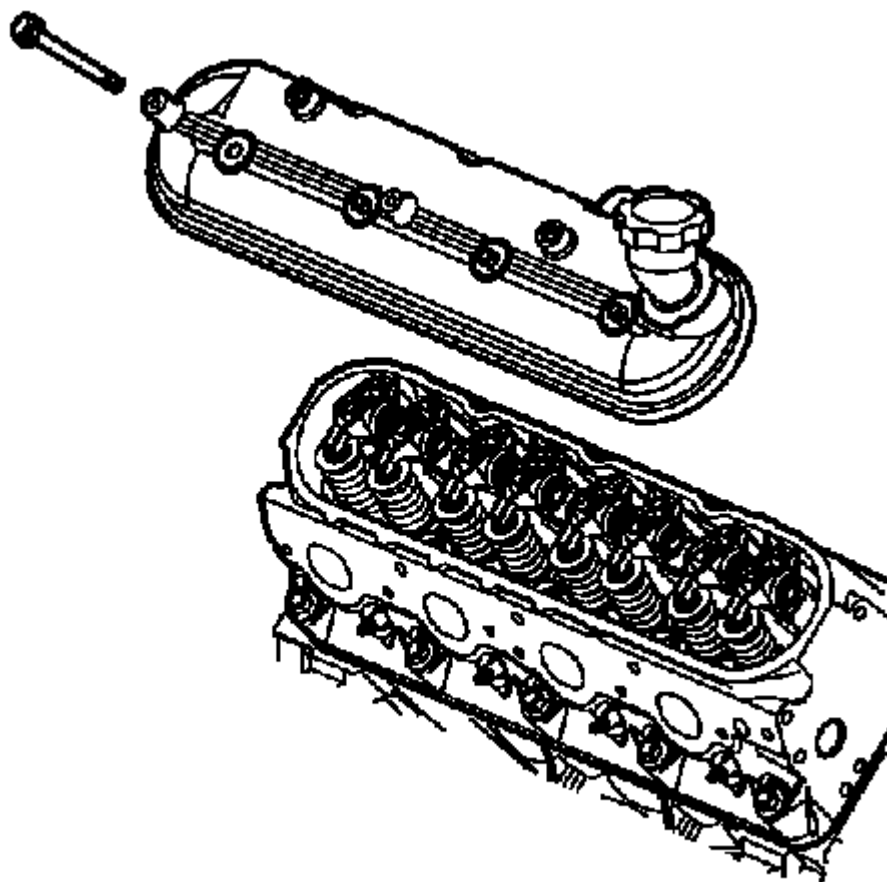


Fig. 522: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

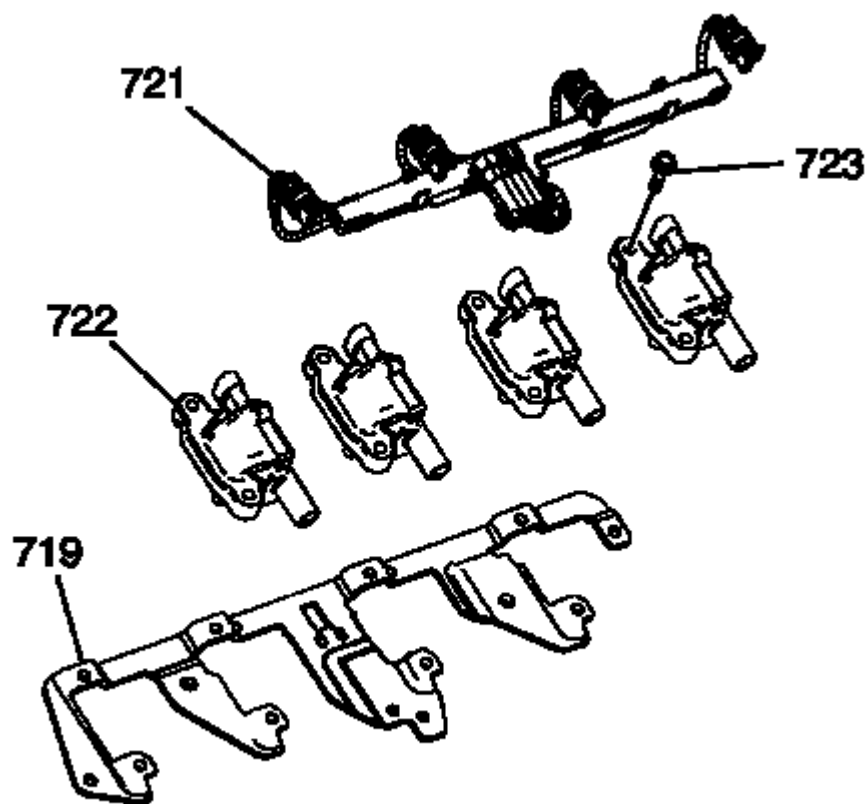


Fig. 523: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bolts (723).
6. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719).

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

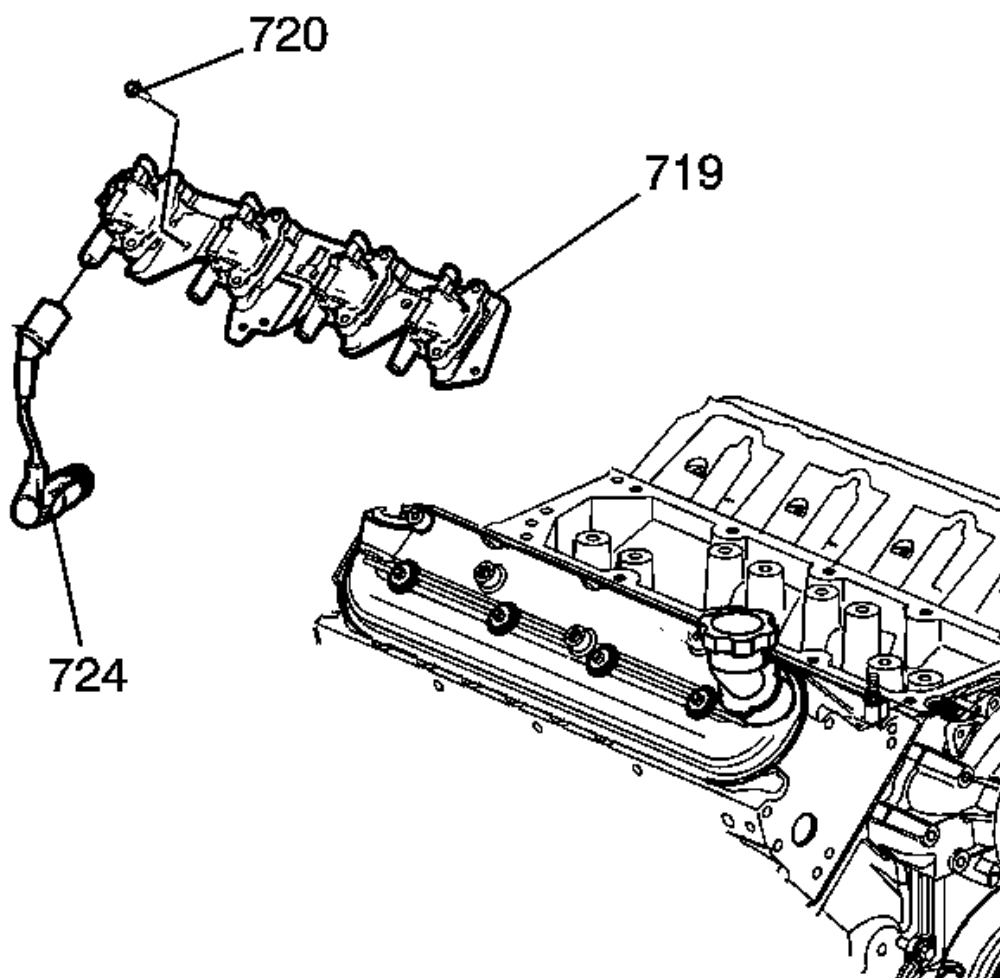


Fig. 524: Identifying Right Valve Rocker Arm Cover Attachments
Courtesy of GENERAL MOTORS CORP.

7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bracket bolts (723).
8. Install the ignition coil and bracket assembly (719) and bolts (720).

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

Engine Valley Cover Installation

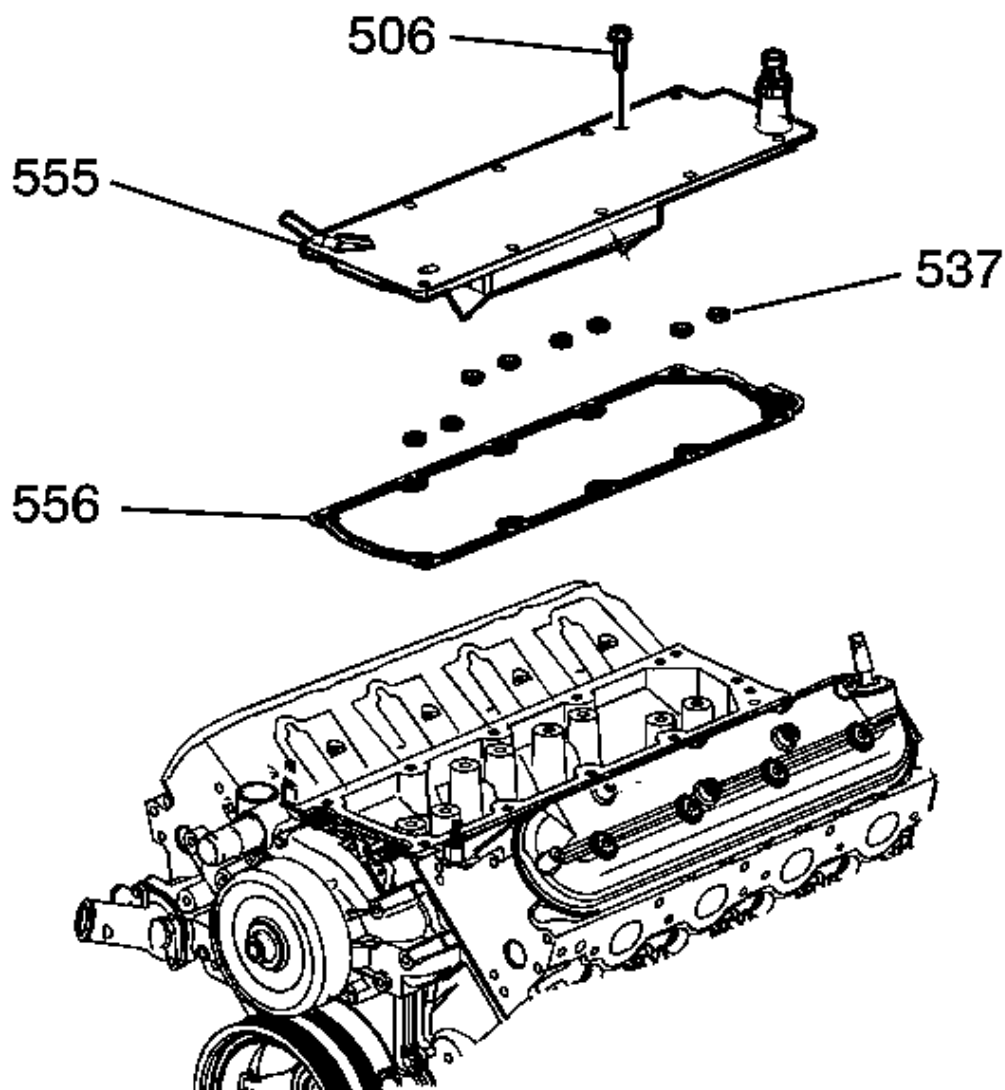


Fig. 525: Identifying Engine Valley Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

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

1. Lubricate the O-ring seals with clean engine oil.
2. Install the O-ring seals (537) to the cover (555).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the cover (555), gasket (556), and bolts (506).

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

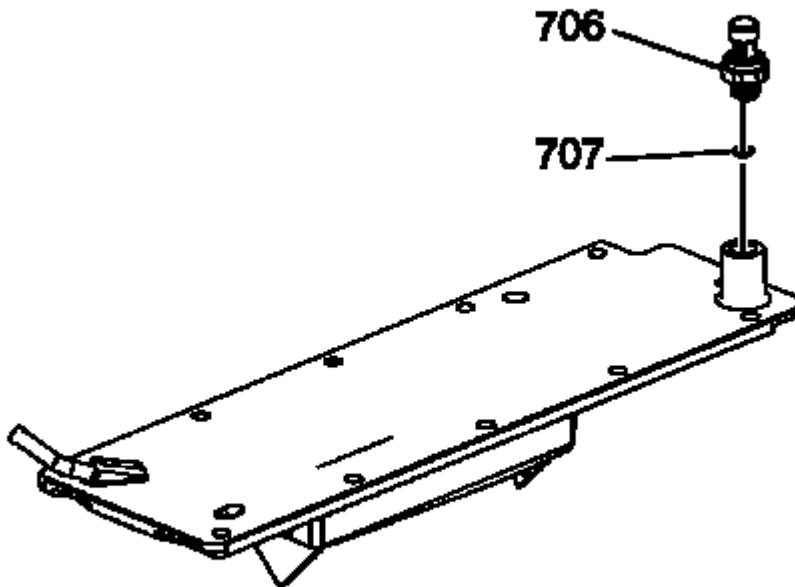


Fig. 526: Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the sensor.
5. Install the oil pressure sensor (706) and sealing washer (707).

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

Coolant Air Bleed Pipe Installation

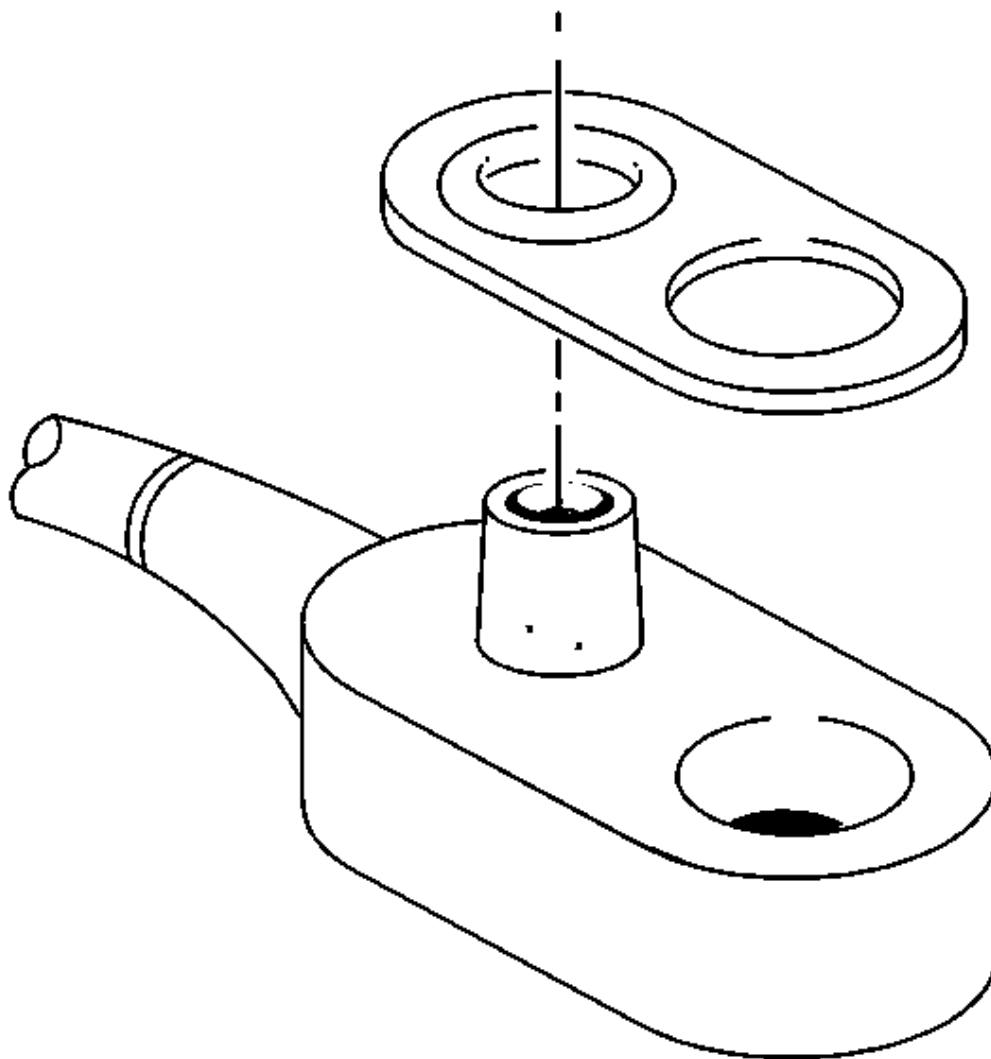


Fig. 527: View Of Air Bleed Pipe Sealing Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the gasket O-ring seal onto the nipple portion of the pipe.

1. Install the gaskets onto the engine coolant air bleed pipe and covers.

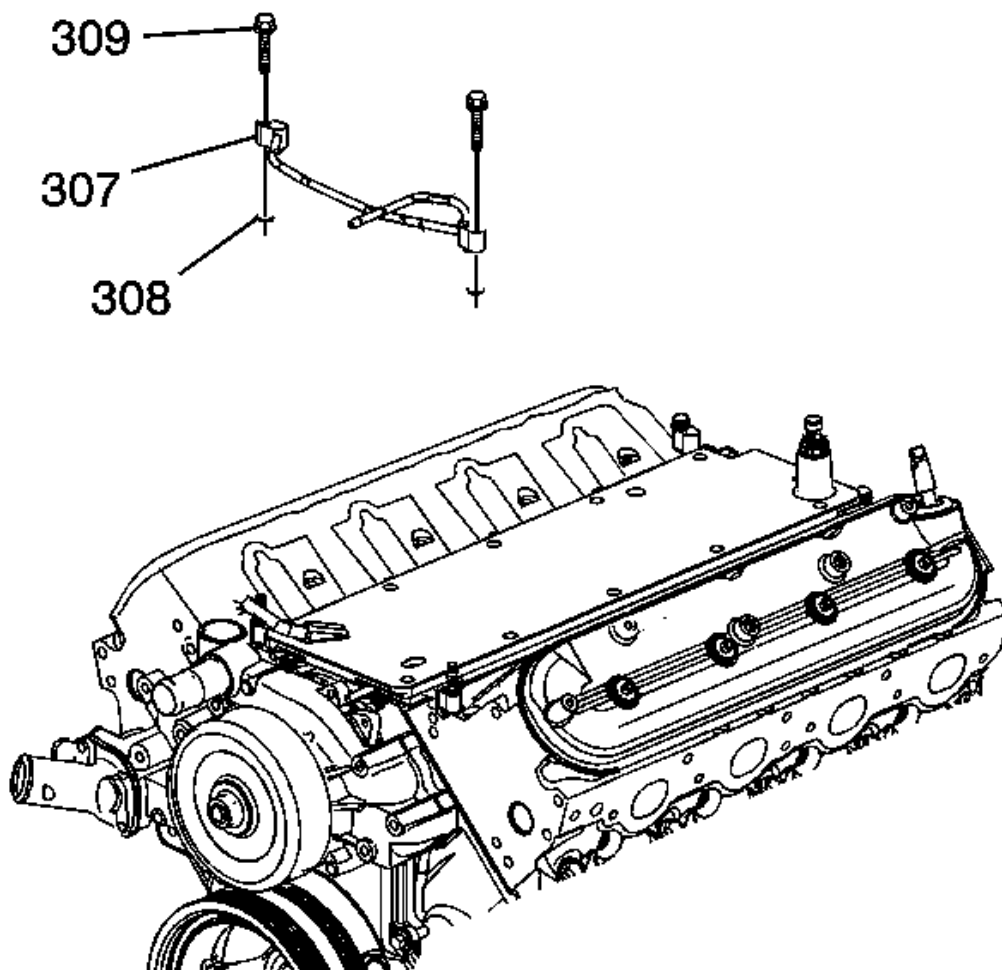


Fig. 528: View Of Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

2. Install the pipe (307) and gaskets (308).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts (309).

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

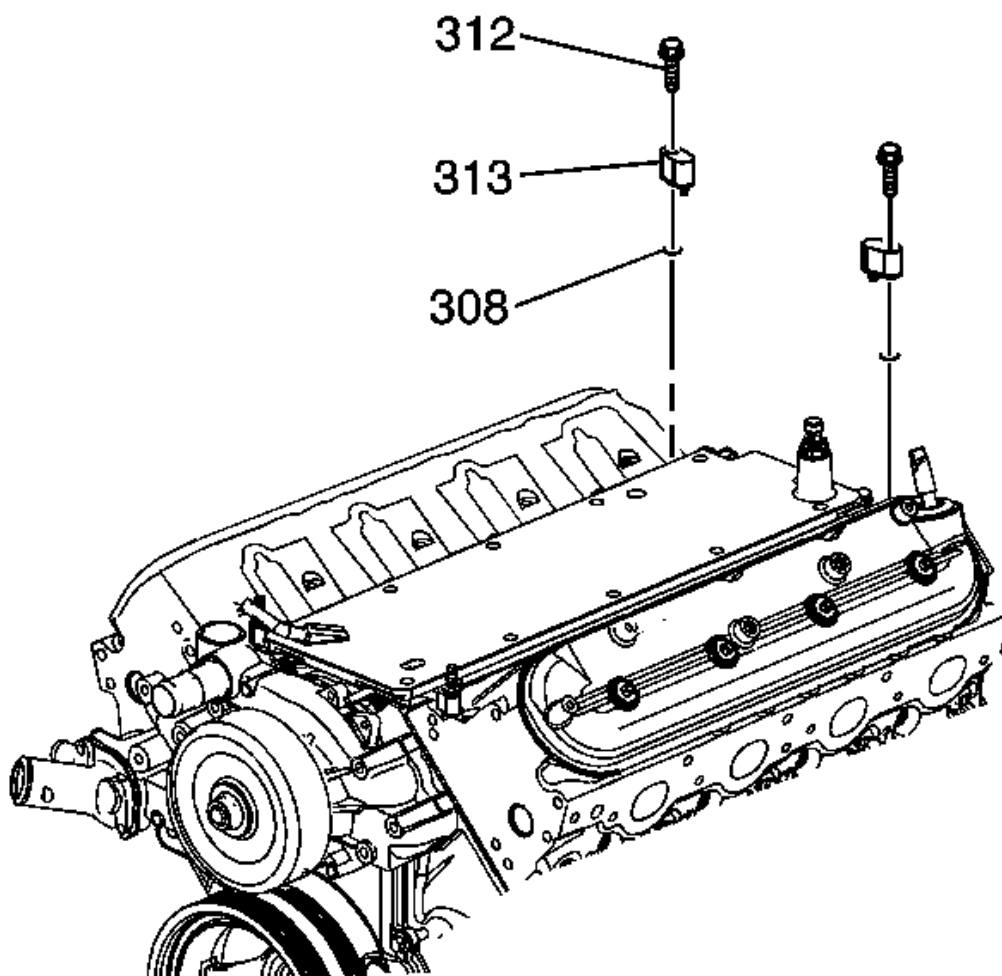


Fig. 529: View Of Coolant Air Bleed Pipe Covers & Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Install the covers (313) and gaskets (308).
5. Install the bolts (312).

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

Intake Manifold Installation

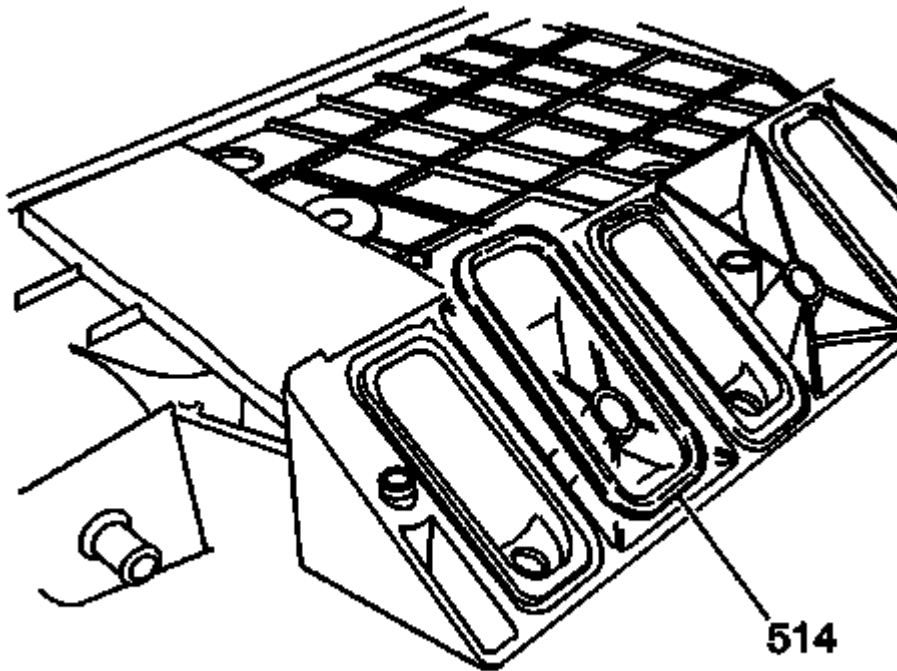


Fig. 530: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

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).

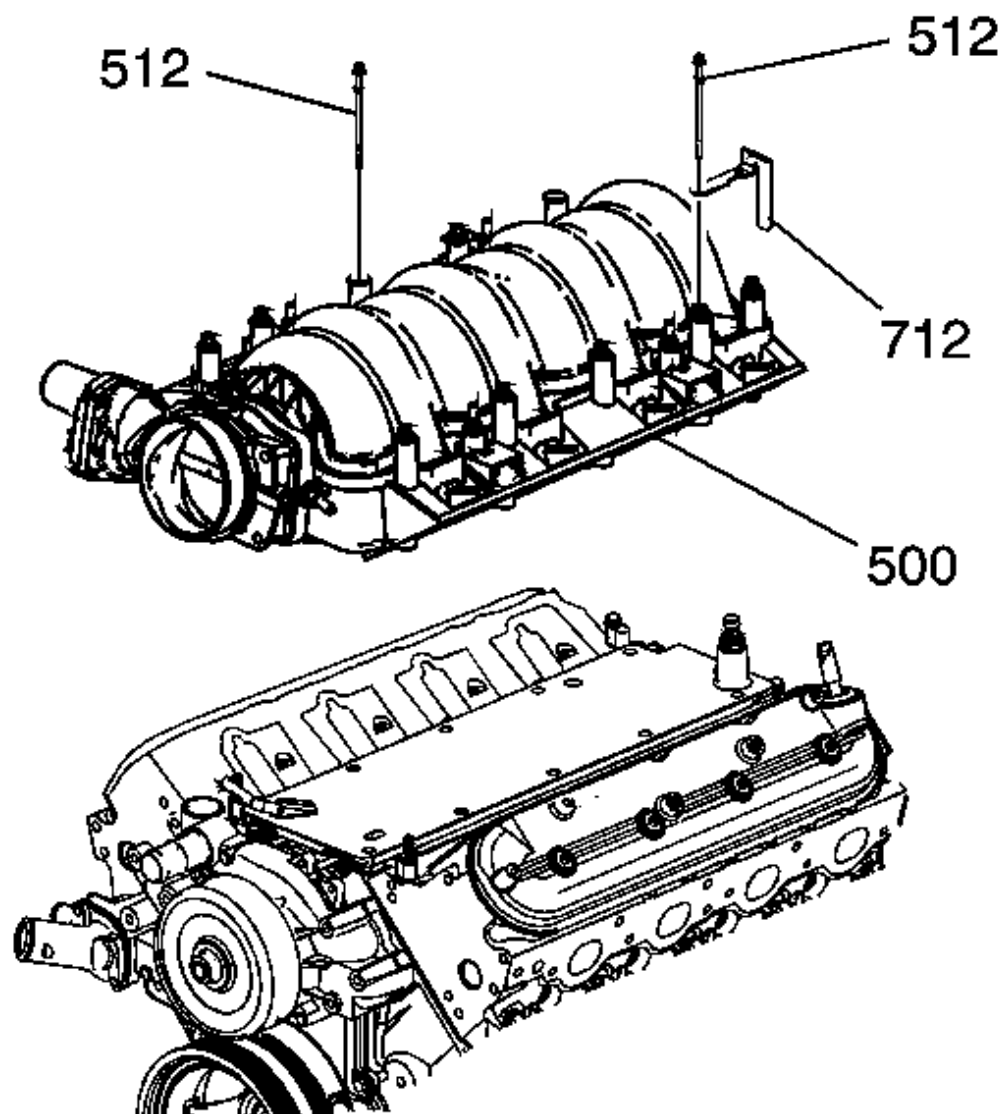


Fig. 531: Identifying Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

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**.

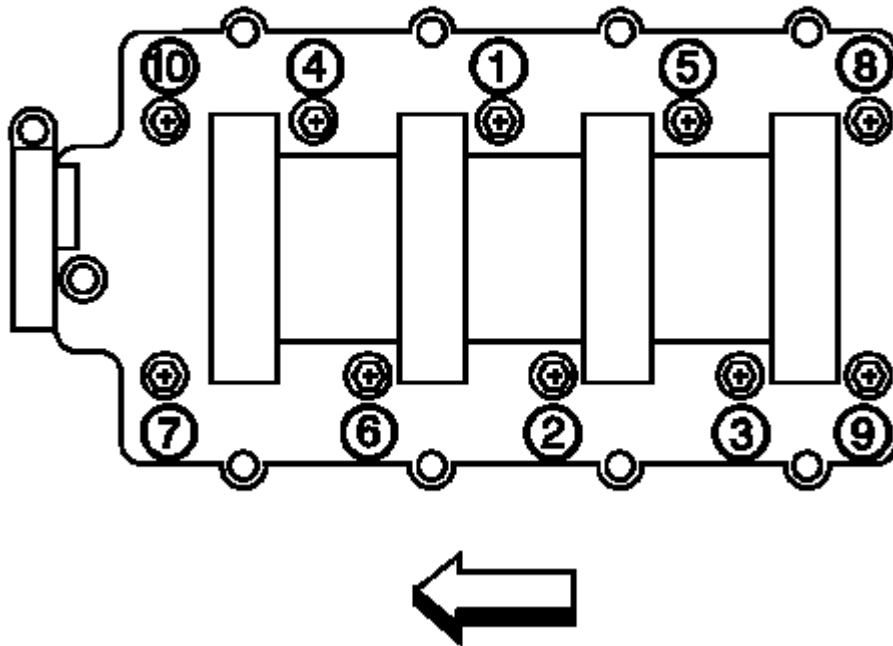


Fig. 532: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the intake manifold bolts (512) and fuel rail stop bracket (712).

Tighten:

1. Tighten the intake manifold bolts a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts a final pass in sequence to 10 N.m (89 lb in).

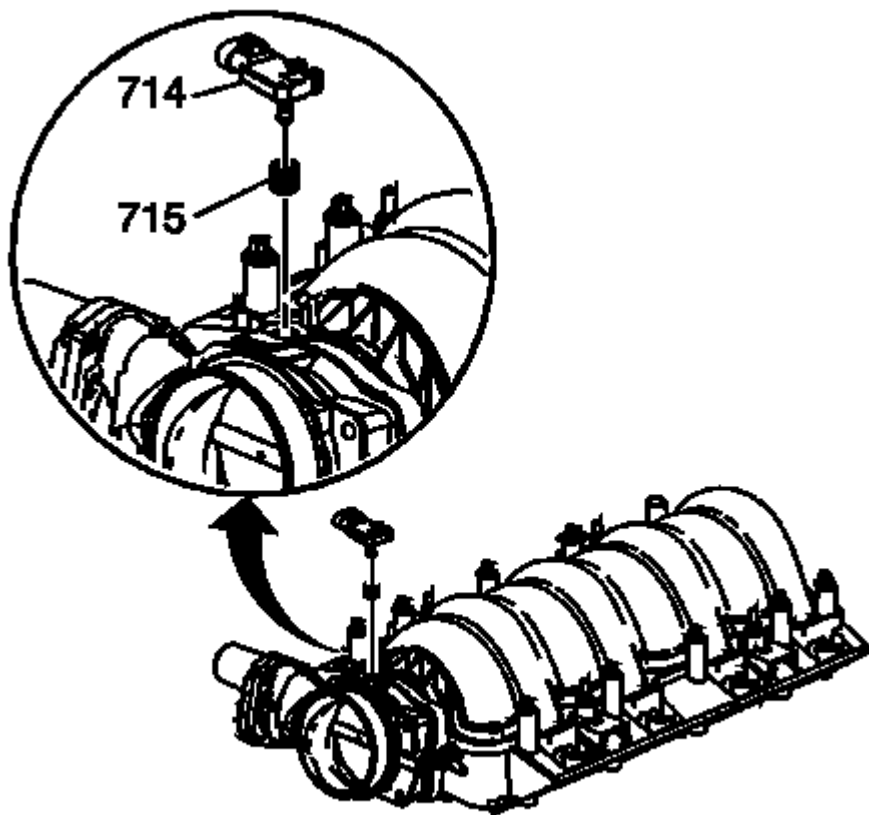


Fig. 533: MAP Sensor & Grommet

Courtesy of GENERAL MOTORS CORP.

5. Lubricate the manifold absolute pressure (MAP) sensor grommet (715) with clean engine oil.
6. Install the MAP sensor (714) and grommet (715).

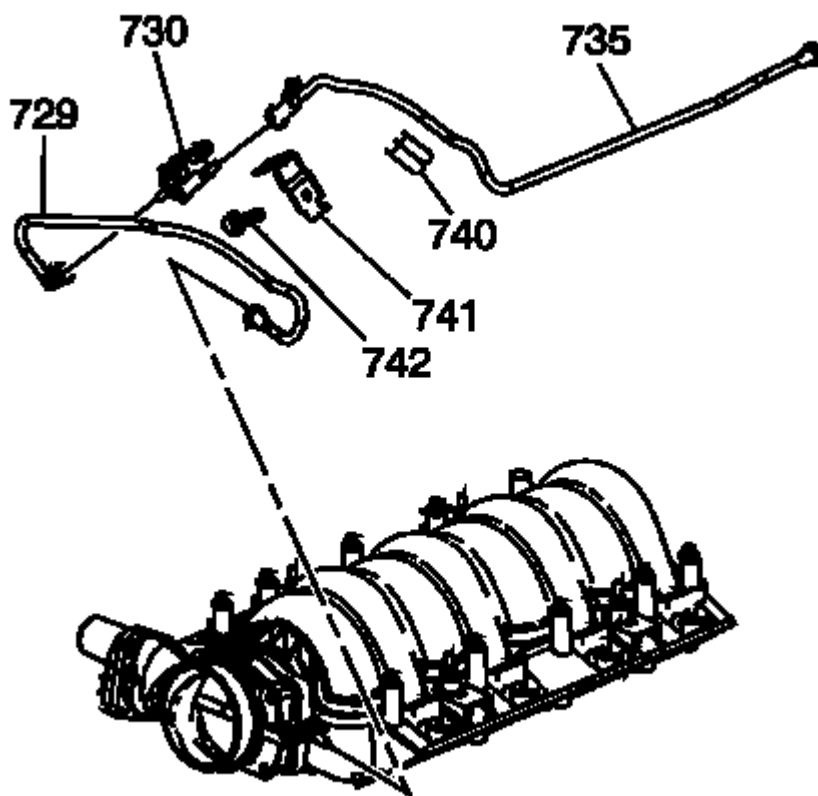


Fig. 534: EVAP Clip, Bolt, Bracket, Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

7. Install the evaporative emission (EVAP) valve (730), bracket (741), and bolt (742).

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

8. Install the EVAP tubes (729, 735).
9. Install the fuel rail. Refer to **Fuel Rail and Injectors Installation**.
10. Install the positive crankcase ventilation (PCV) hose - dirty air to the manifold and valley cover.

Fuel Rail and Injectors Installation

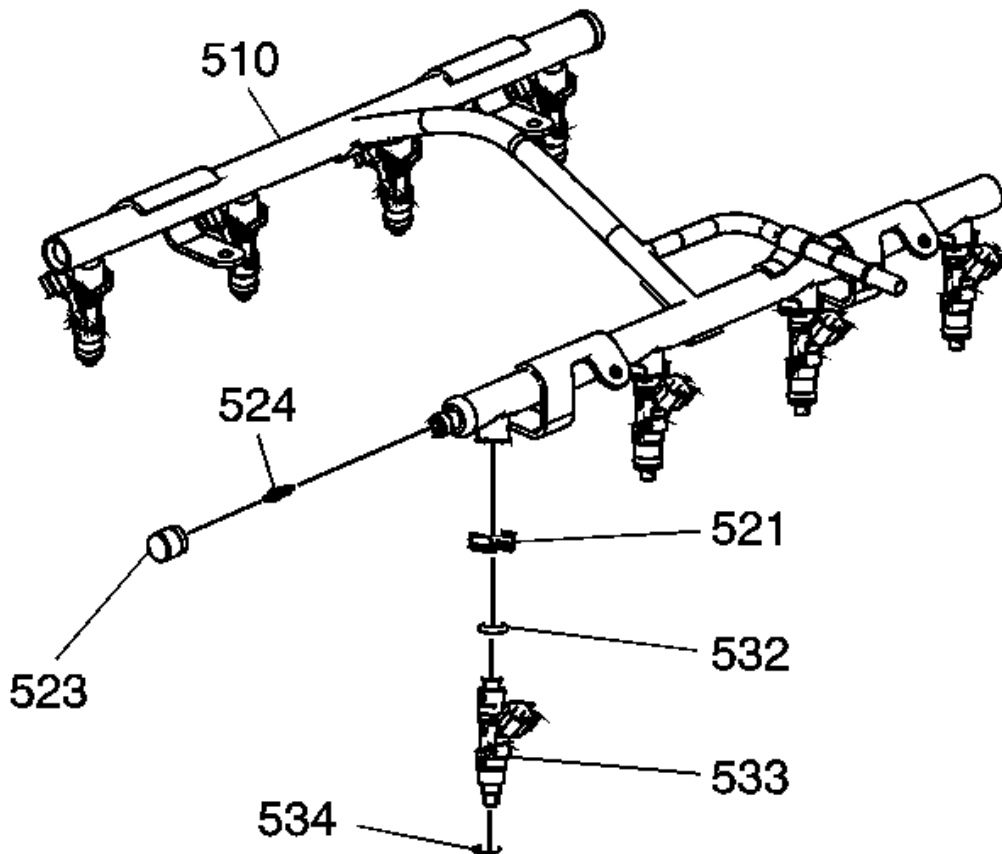


Fig. 535: Fuel Injectors, Retainers, O-Rings, Cap & Service Valve
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

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.
2. Install the O-ring seals to the fuel injectors.
3. Install the fuel injectors (533) and retaining clips (521).

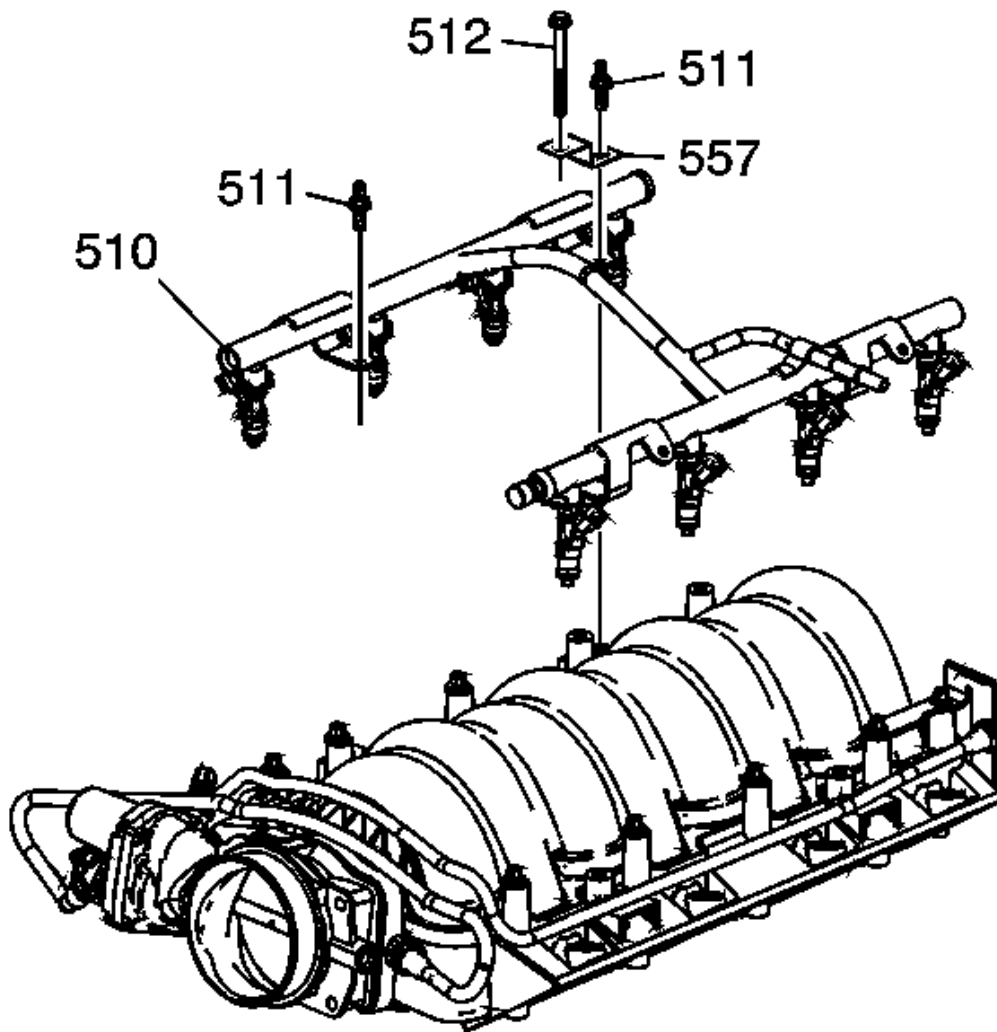


Fig. 536: Fuel Rail, Ground Strap & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel rail assembly (510) to the manifold. Push firmly on both sides of the rail until all injectors have entered their bores.
5. 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 in Cautions and Notices.

6. Install the fuel rail bolts (511, 512) and fuel rail ground strap (557).

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

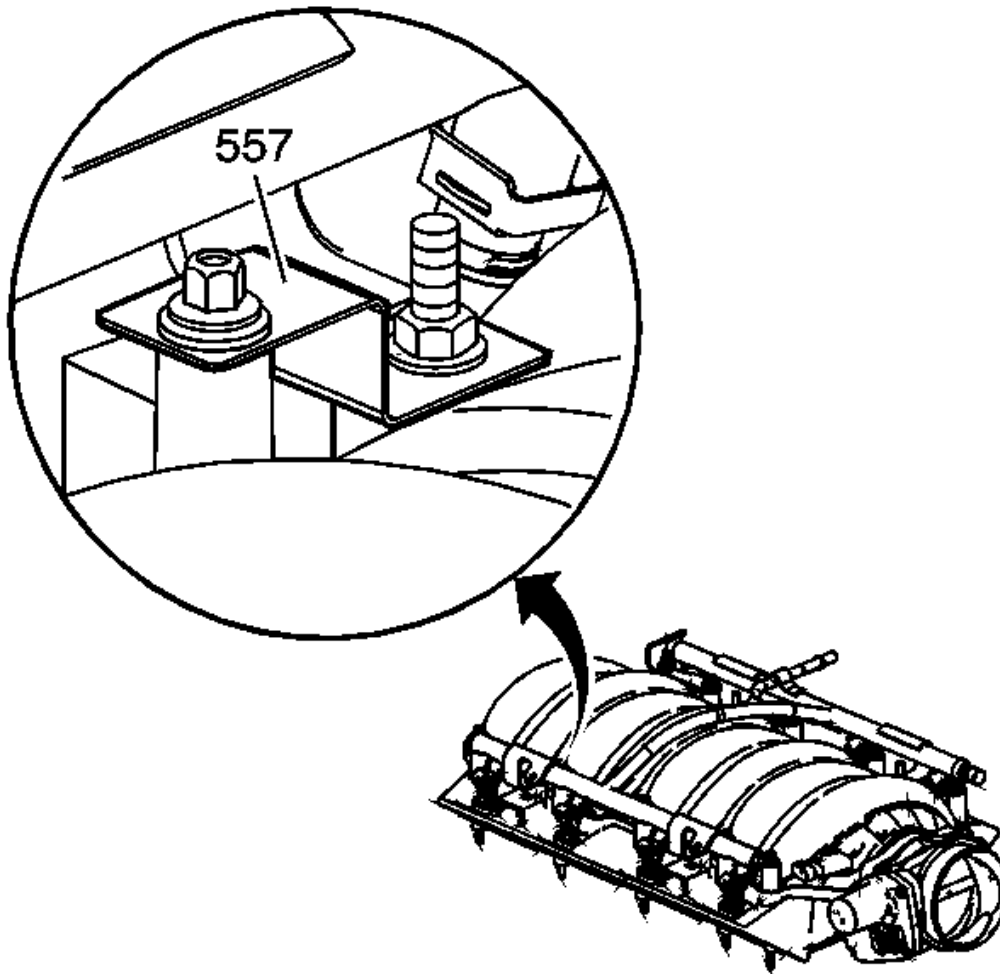


Fig. 537: Fuel Rail Ground Strap
Courtesy of GENERAL MOTORS CORP.

7. Inspect the fuel rail ground strap (557) for proper installation.

Throttle Body Installation

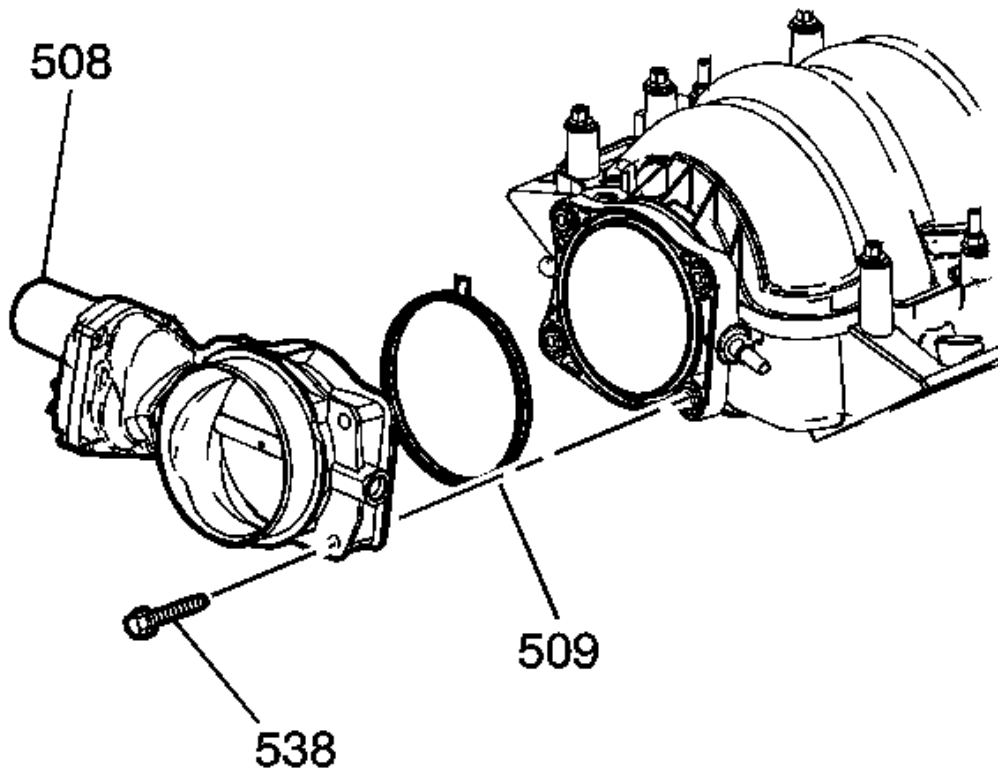


Fig. 538: Throttle Body, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

2. Install the throttle body (508) and bolts (538).

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

Water Pump Installation

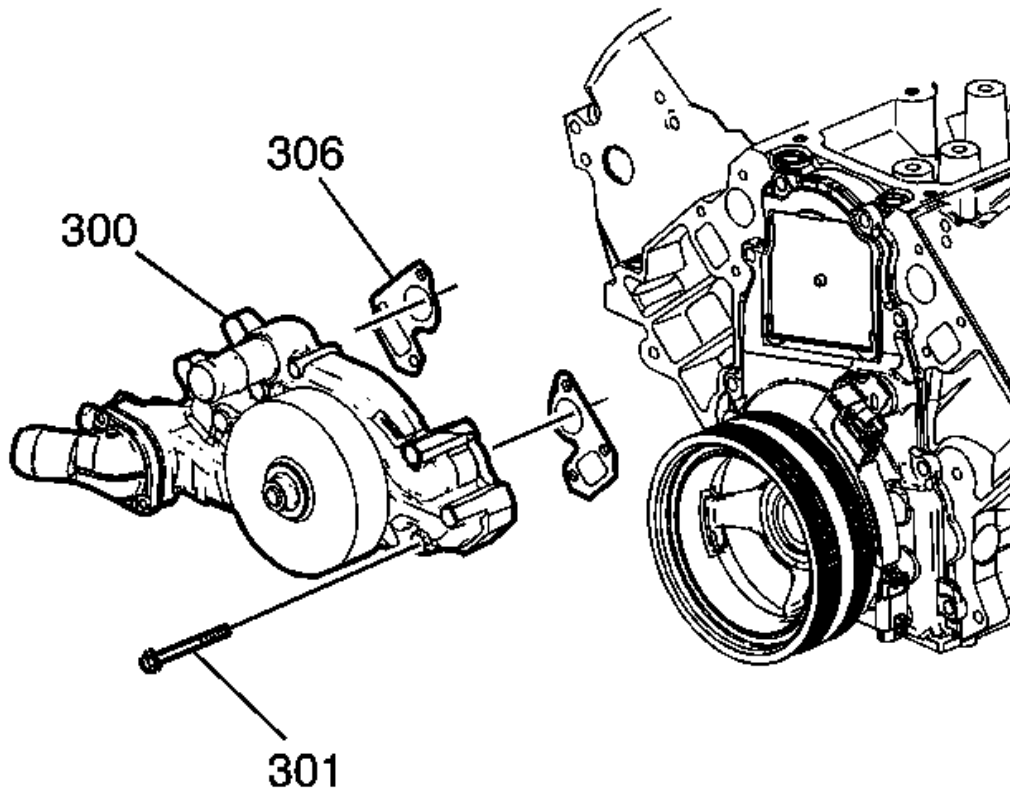


Fig. 539: View Of Water Pump, Gaskets & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

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

1. Install the water pump (300) and NEW gaskets (306).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the water pump bolts (301).

Tighten:

1. Tighten the water pump bolts a first pass to 15 N.m (11 lb ft).
2. Tighten the water pump bolts a final pass to 30 N.m (22 lb ft).

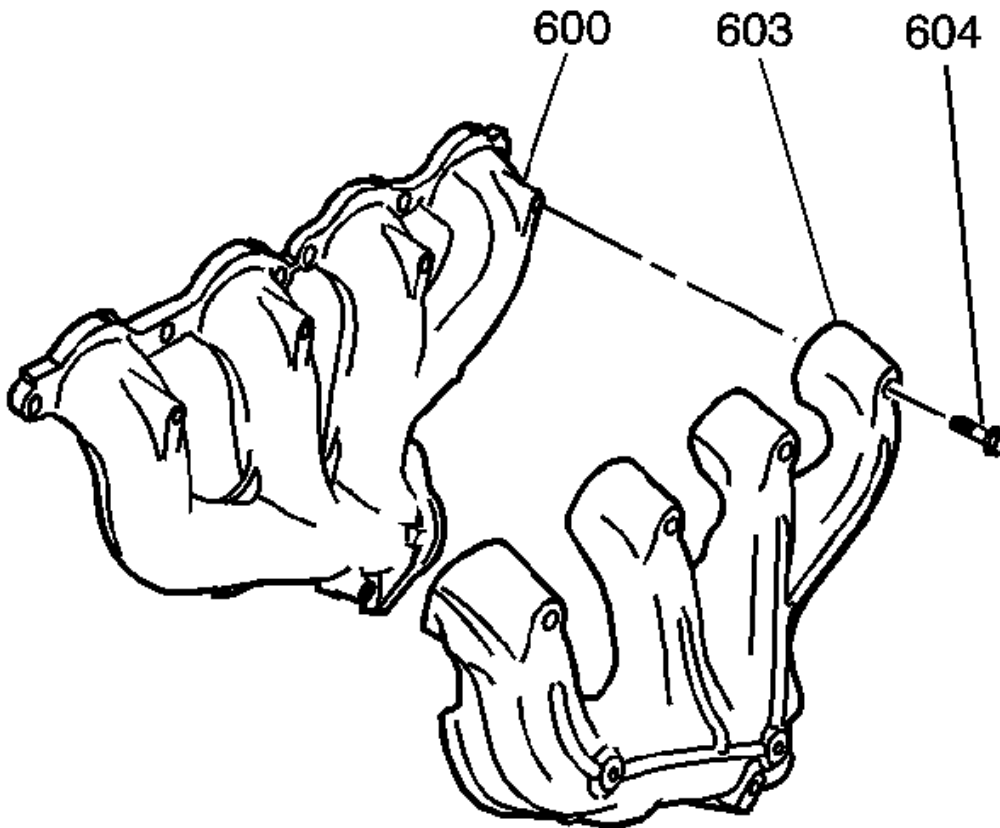
Exhaust Manifold Installation - Left

Fig. 540: View Of Heat Shield, Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 three 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.

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

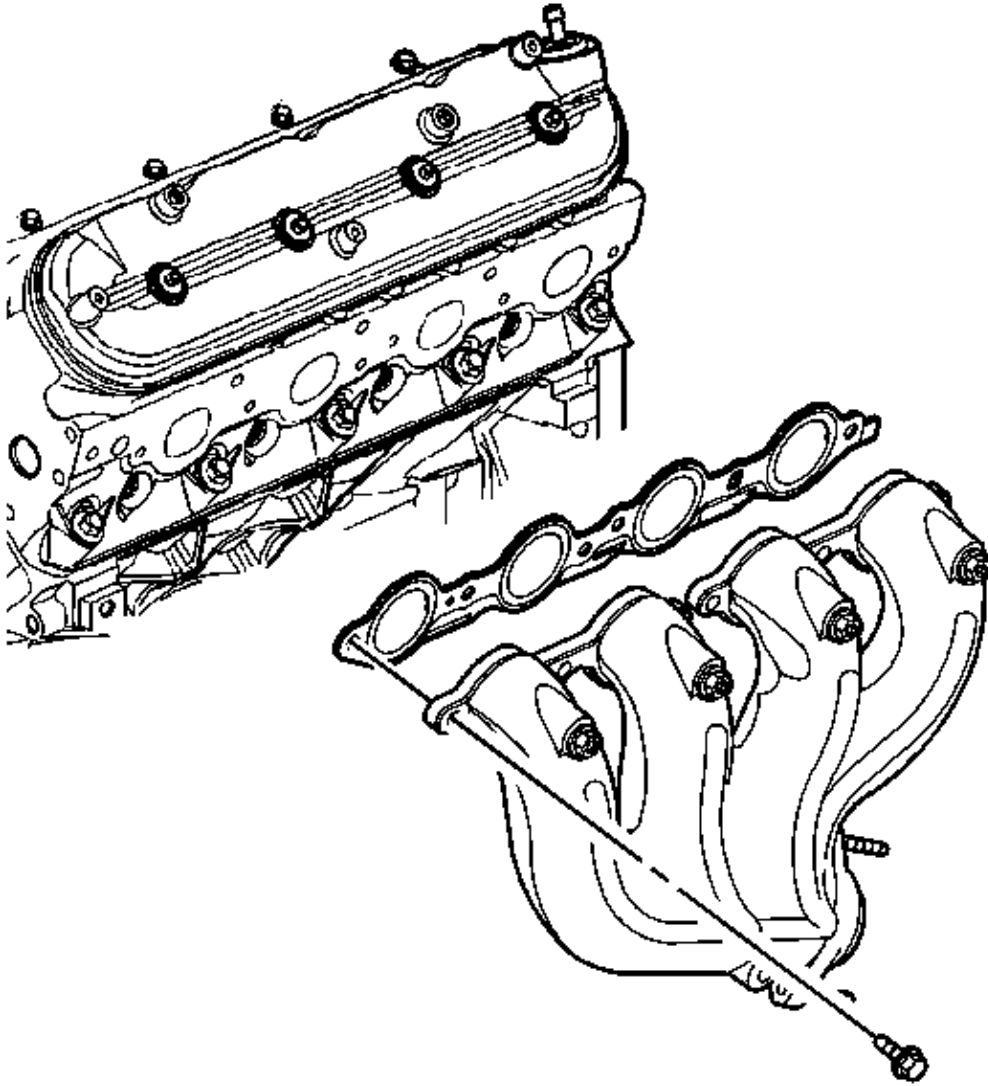


Fig. 541: View Of Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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). Tighten the exhaust manifold

- bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center two 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

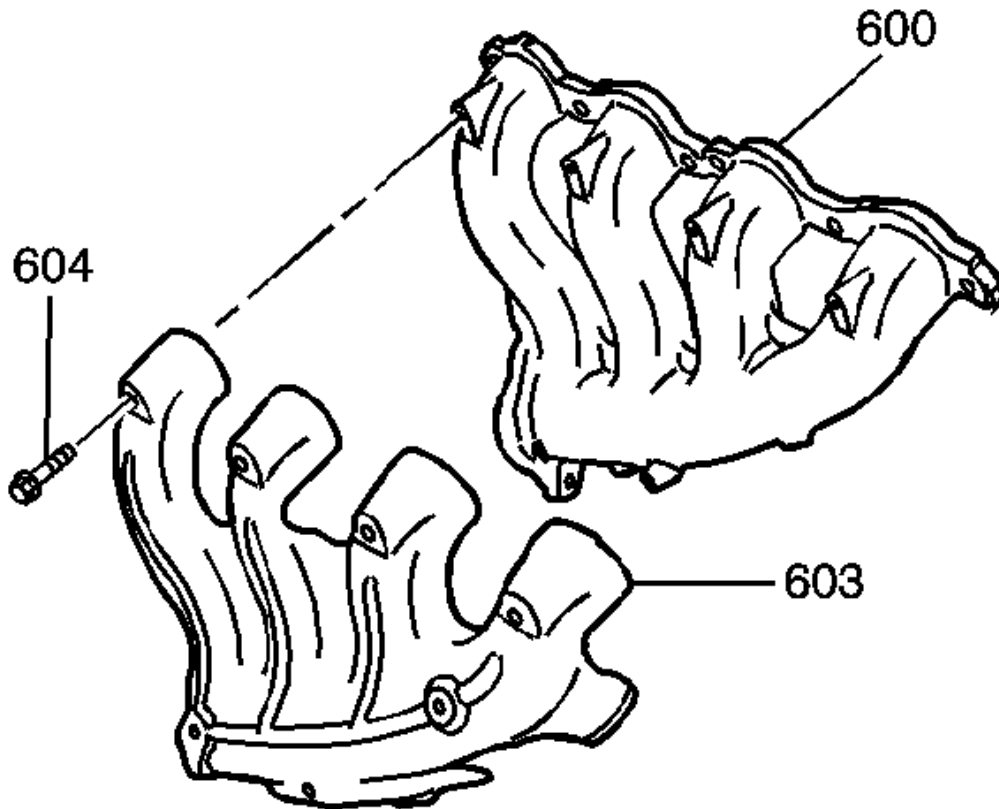


Fig. 542: View Of Right Manifold, Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 three 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.

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

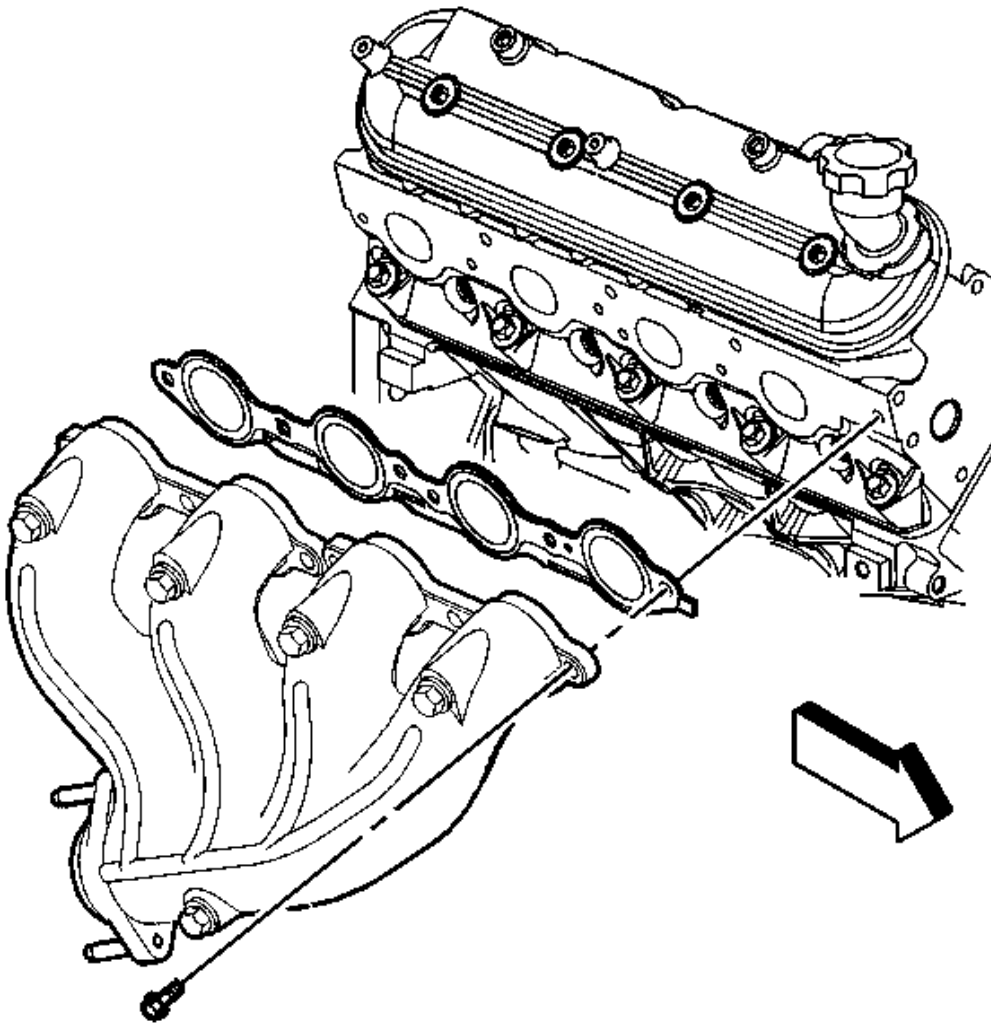


Fig. 543: View Of Right Exhaust Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

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). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center two 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.

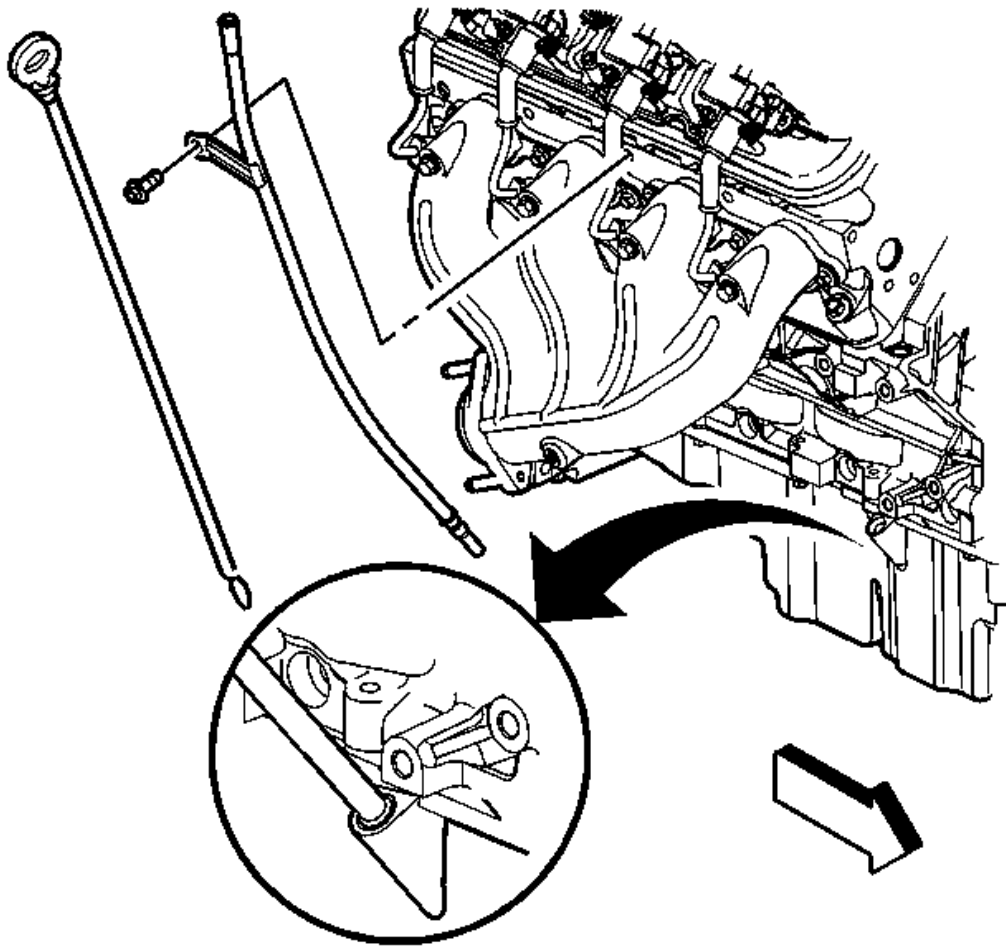
Oil Level Indicator and Tube Installation

Fig. 544: View Of Oil Lever Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Inspect the O-ring seal 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.
4. Install the oil level indicator tube into the engine block and rotate into proper position.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the tube bolt.

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

6. Install the oil level indicator into the tube.

Clutch Pilot Bearing Installation

Tools Required

J 38836 Pilot Bushing Installer/Clutch

Installation Procedure

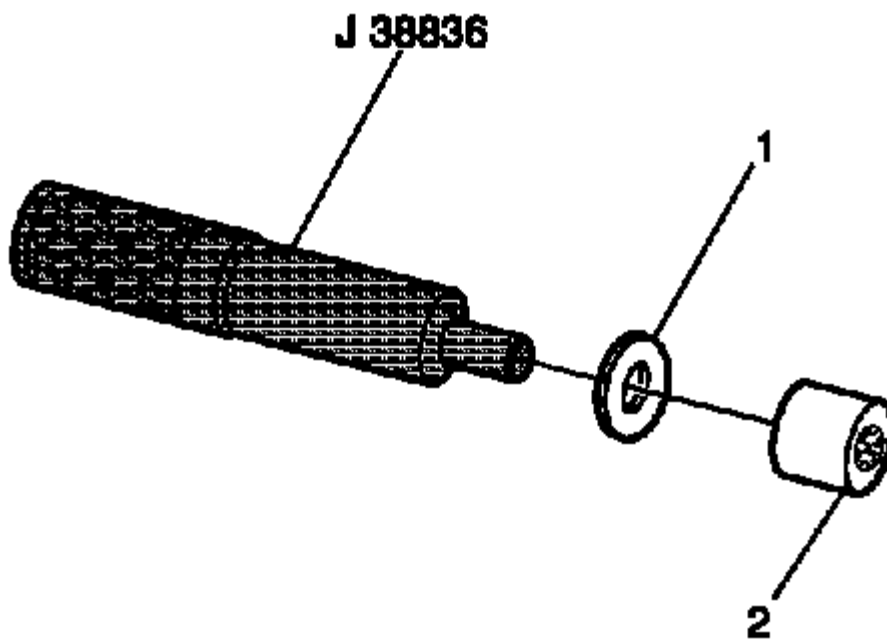


Fig. 545: View Of J 38836, Washer & Pilot Bearing (without RPO HP2)
Courtesy of GENERAL MOTORS CORP.

1. Install a 5/8 inch washer (1) onto the **J 38836** or equivalent.

The washer serves as a stop against the crankshaft face and assists in installing the bearing to the proper depth.

2. Install the new pilot bearing (2) onto the tool.

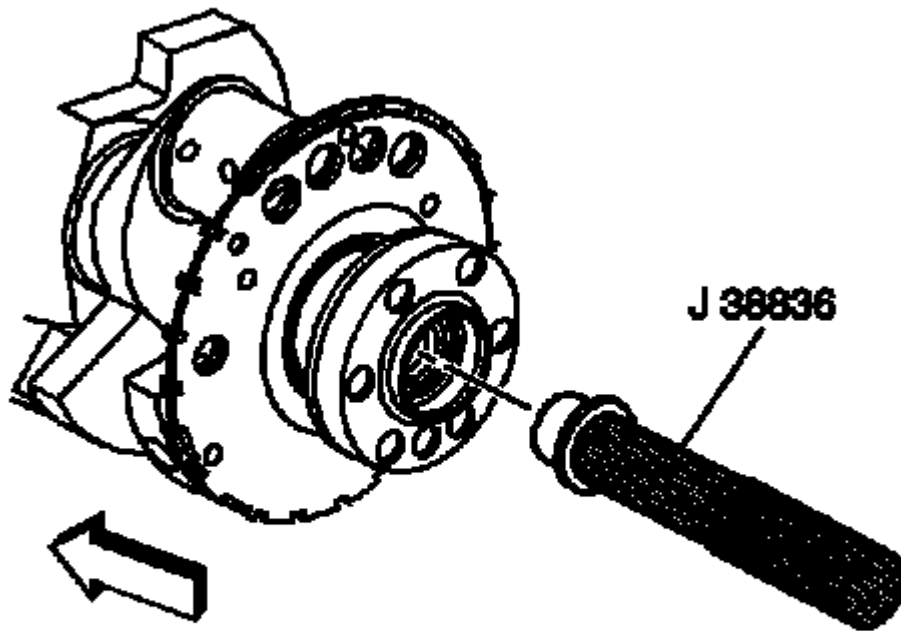


Fig. 546: Installing Pilot Bearing Using J 38836 (without RPO HP2)
Courtesy of GENERAL MOTORS CORP.

3. Install the new pilot bearing into the crankshaft using the **J 38836**.

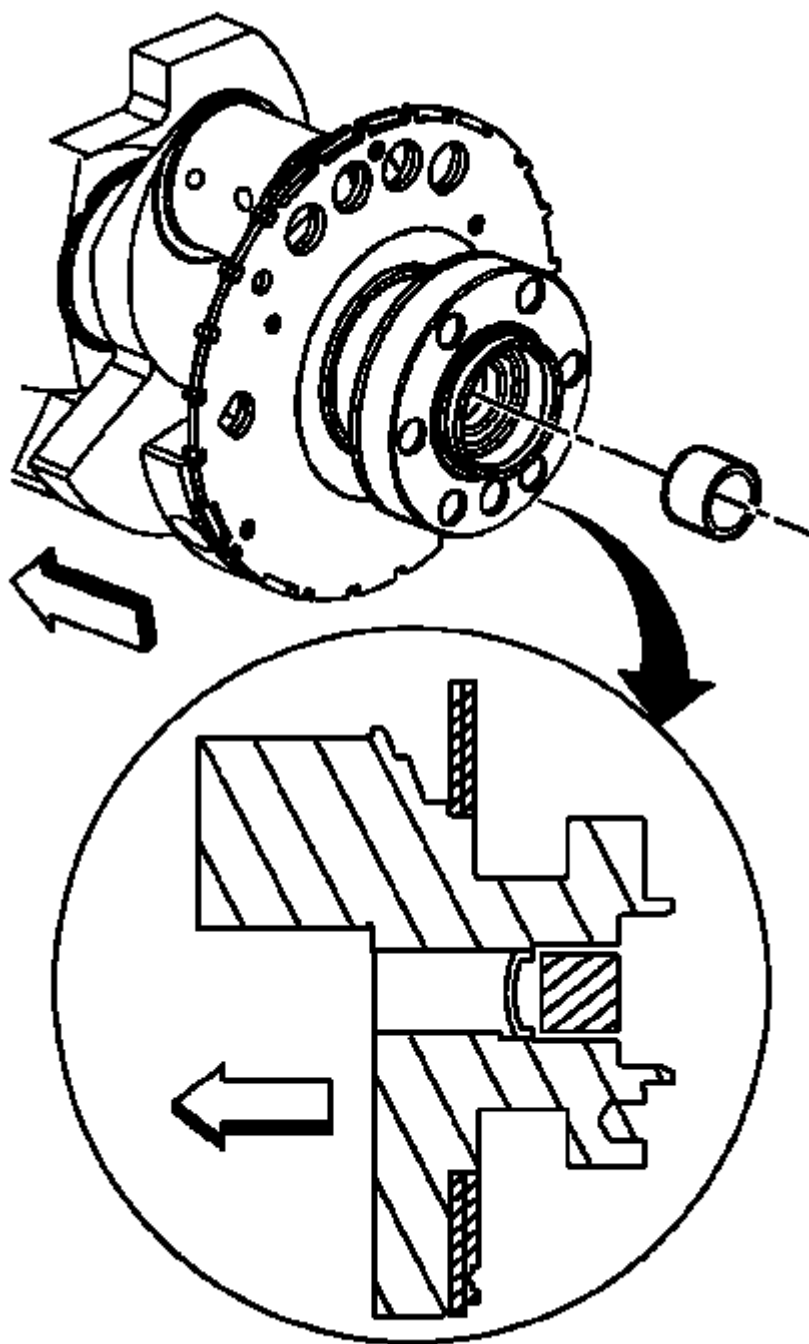


Fig. 547: Locating Clutch Pilot Bearing
Courtesy of GENERAL MOTORS CORP.

4. Inspect the clutch pilot bearing for proper installation.

A properly installed clutch pilot bearing will be installed until flush to the rear face of the crankshaft.

Engine Flywheel Installation

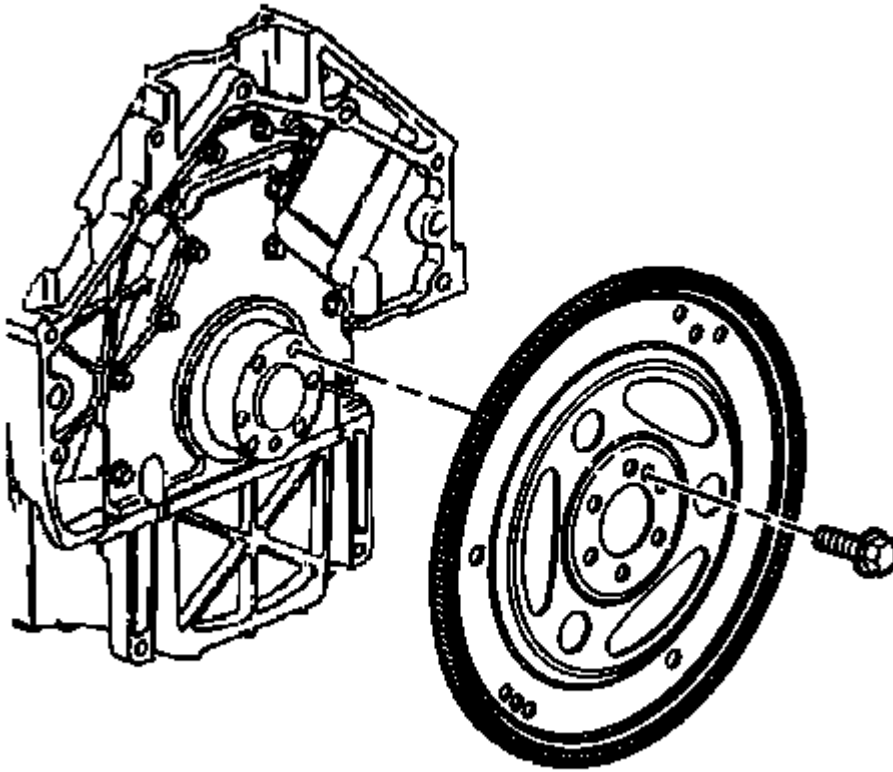


Fig. 548: Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flywheel 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 flywheel bolts. This procedure requires a three stage tightening process.

1. Install the automatic transmission flywheel to the crankshaft, if applicable.

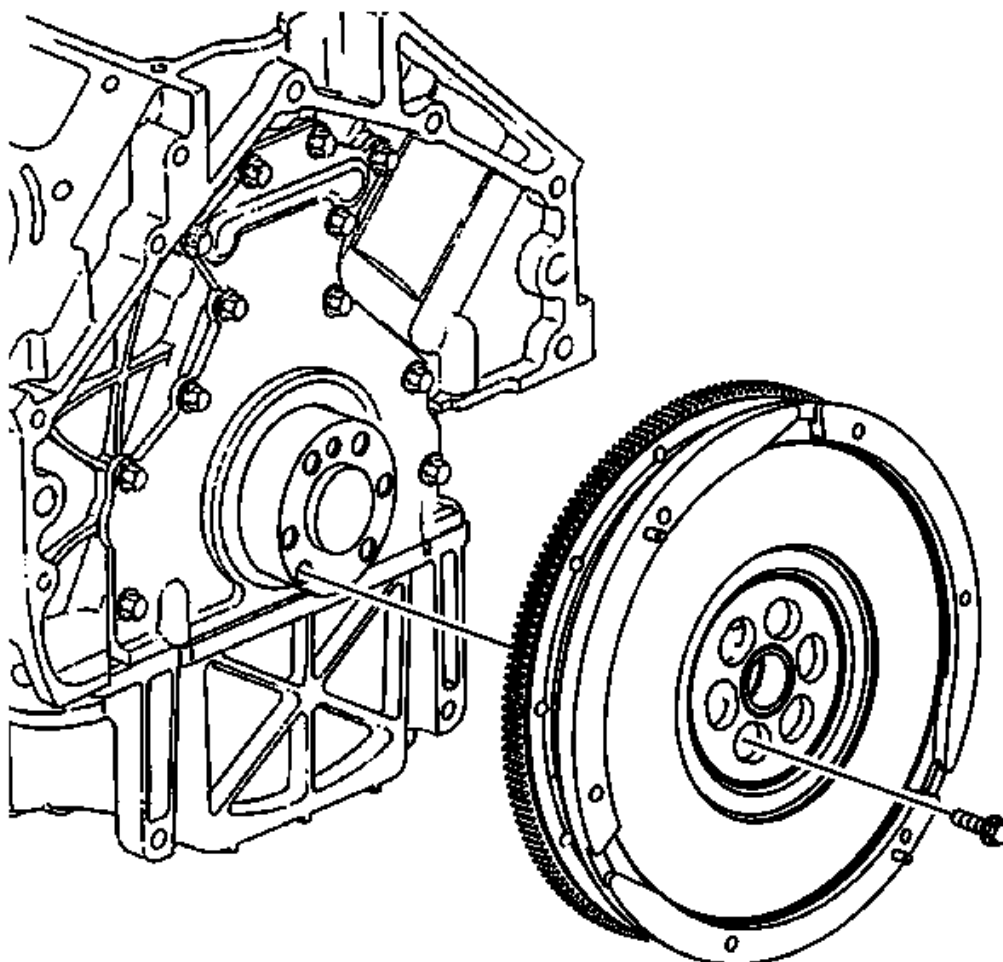


Fig. 549: View Of Manual Transmission Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

2. Install the manual transmission flywheel to the crankshaft, if applicable.
3. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.

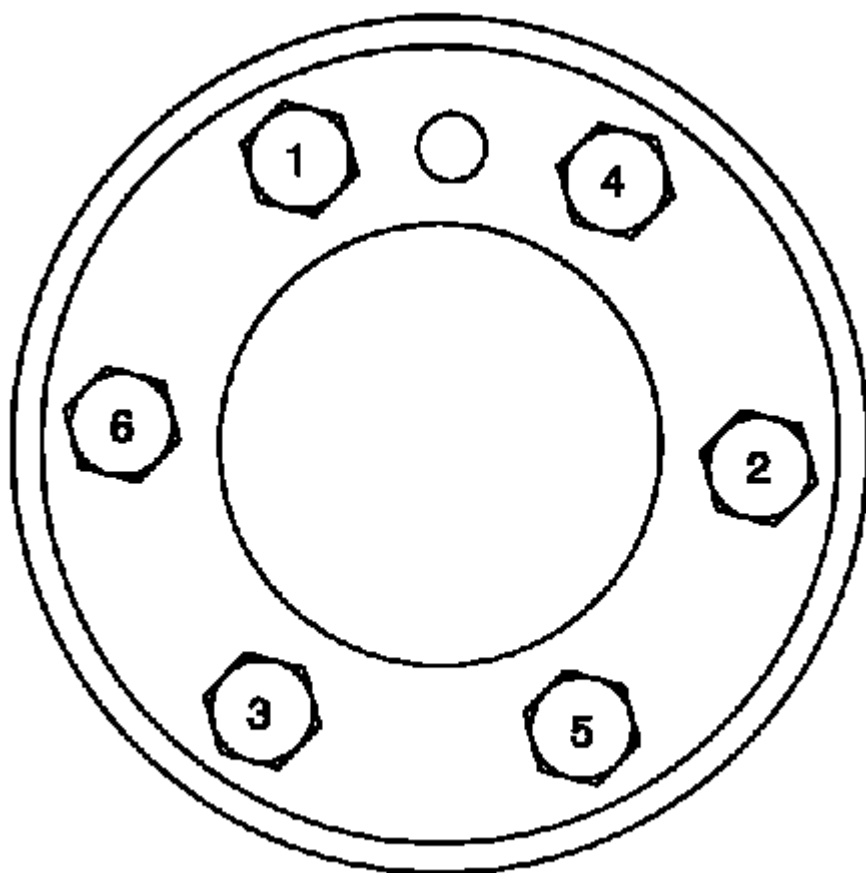


Fig. 550: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the engine flywheel bolts.

Tighten:

1. Tighten the engine flywheel bolts a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine flywheel bolts a second pass in sequence to 50 N.m (37 lb ft).
3. Tighten the engine flywheel bolts a final pass in sequence to 100 N.m (74 lb ft).

Crankshaft Balancer Installation

Tools Required

- **J 41665** Crankshaft Balancer and Sprocket Installer. See Special Tools.
- **J 42386-A** Flywheel Holding Tool. See Special Tools.
- **J 45059** Angle Meter

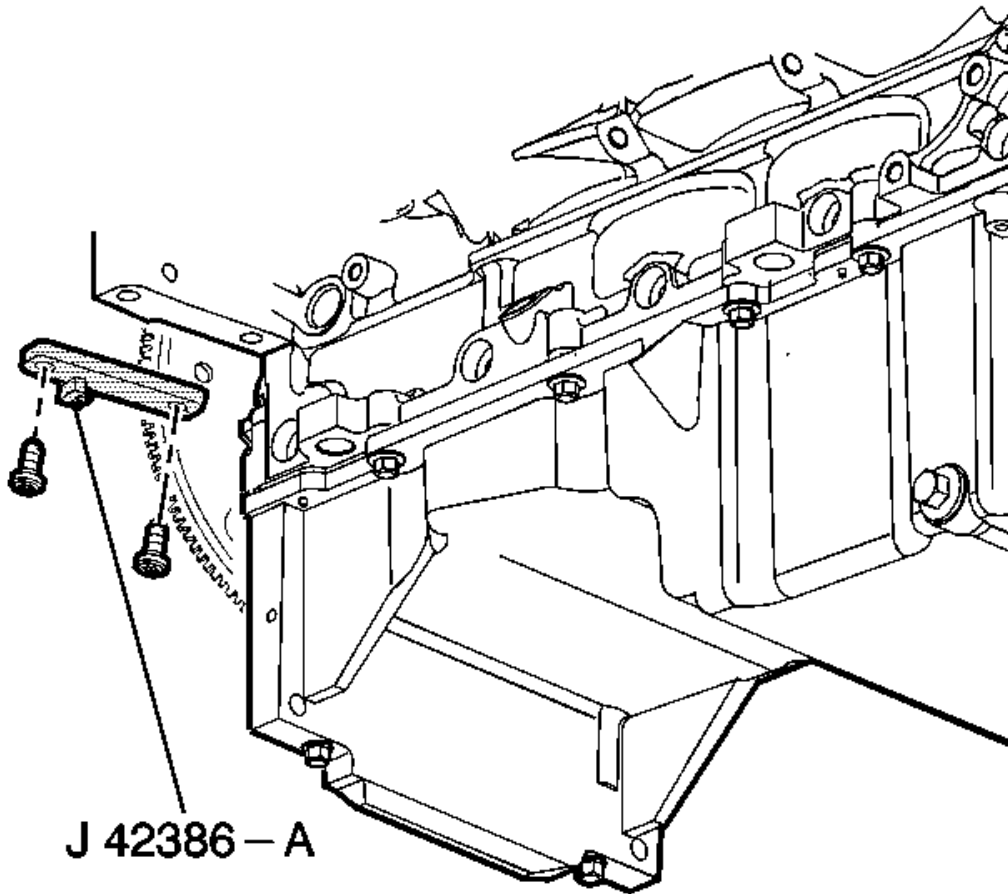
Installation Procedure

Fig. 551: View Of J 42386-A

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT:

- 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 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.

1. Install the **J 42386-A** and bolts. See **Special Tools**.

Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

Tighten: Tighten the **J 42386-A** bolts to 50 N.m (37 lb ft).

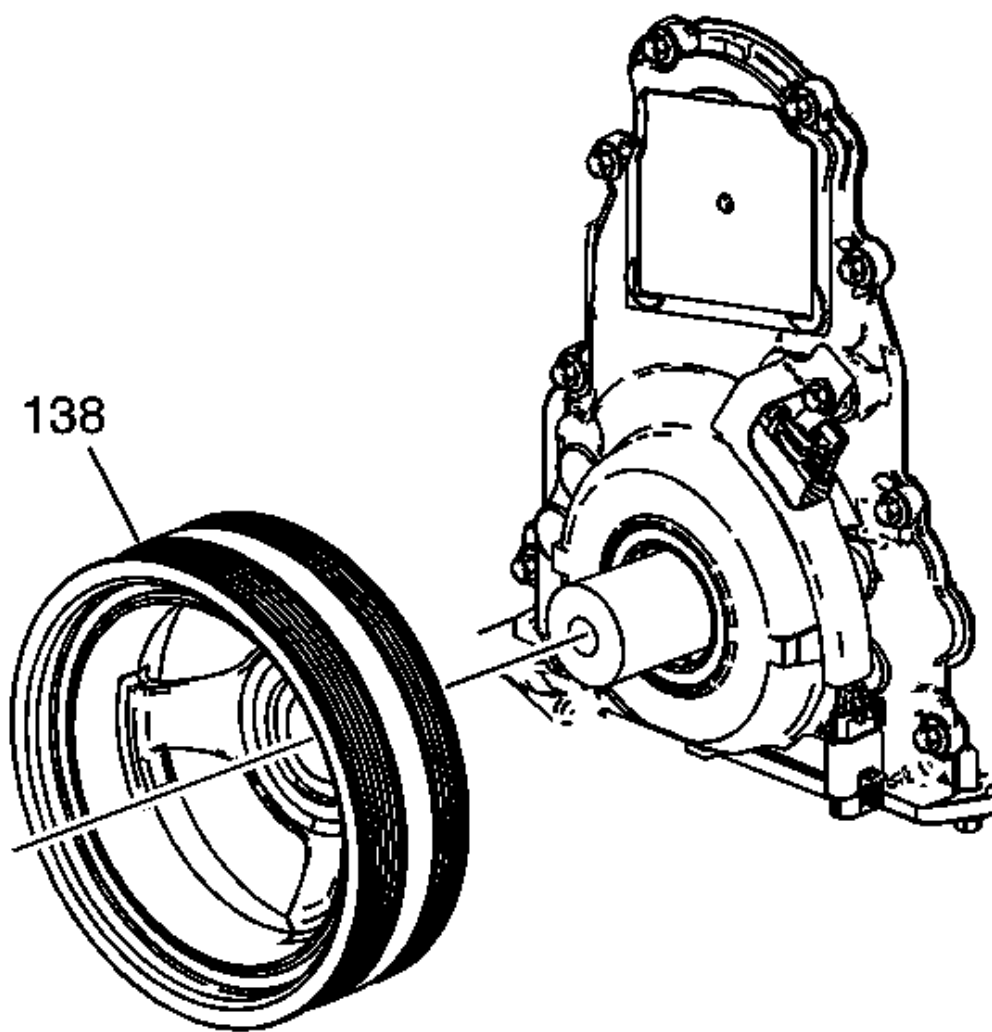


Fig. 552: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

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

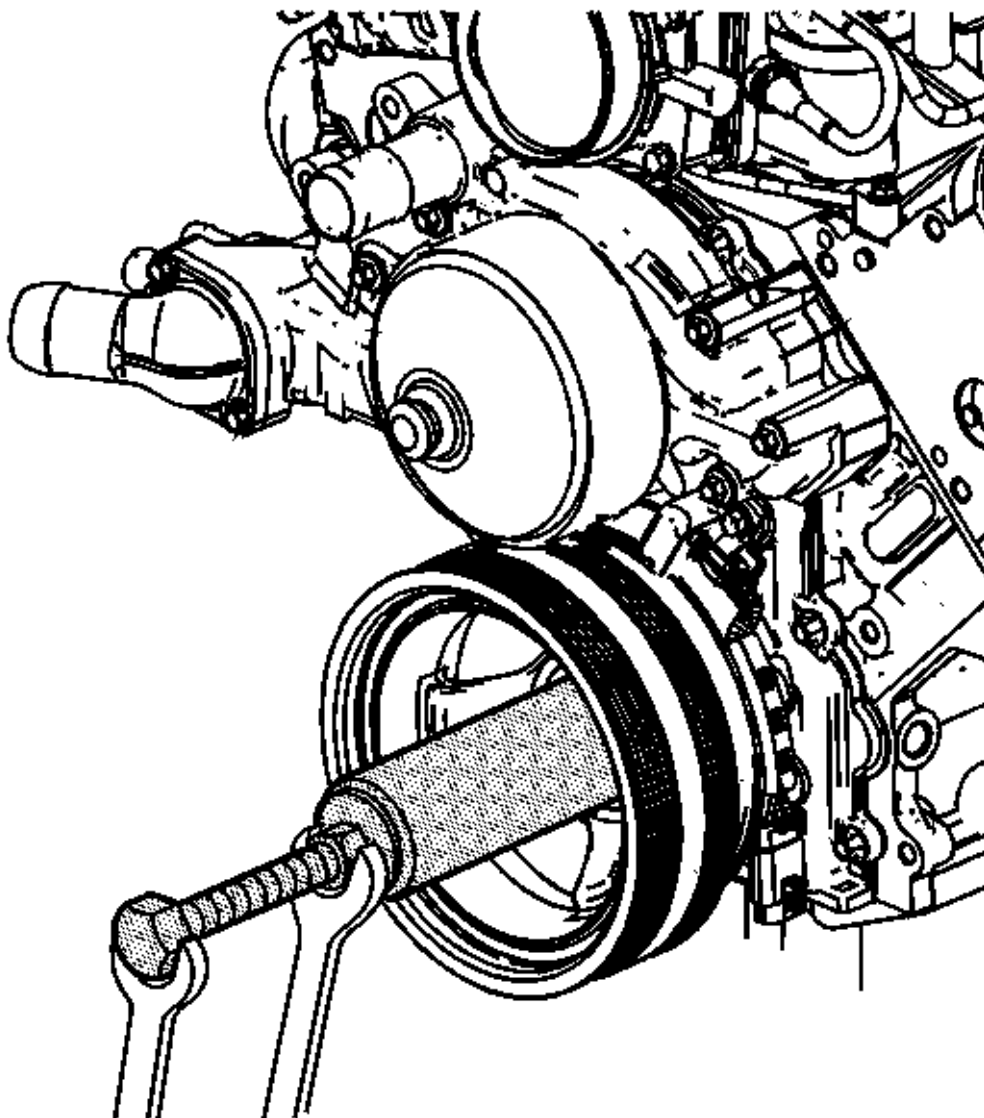


Fig. 553: Installing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41665** in order to install the 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.
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.

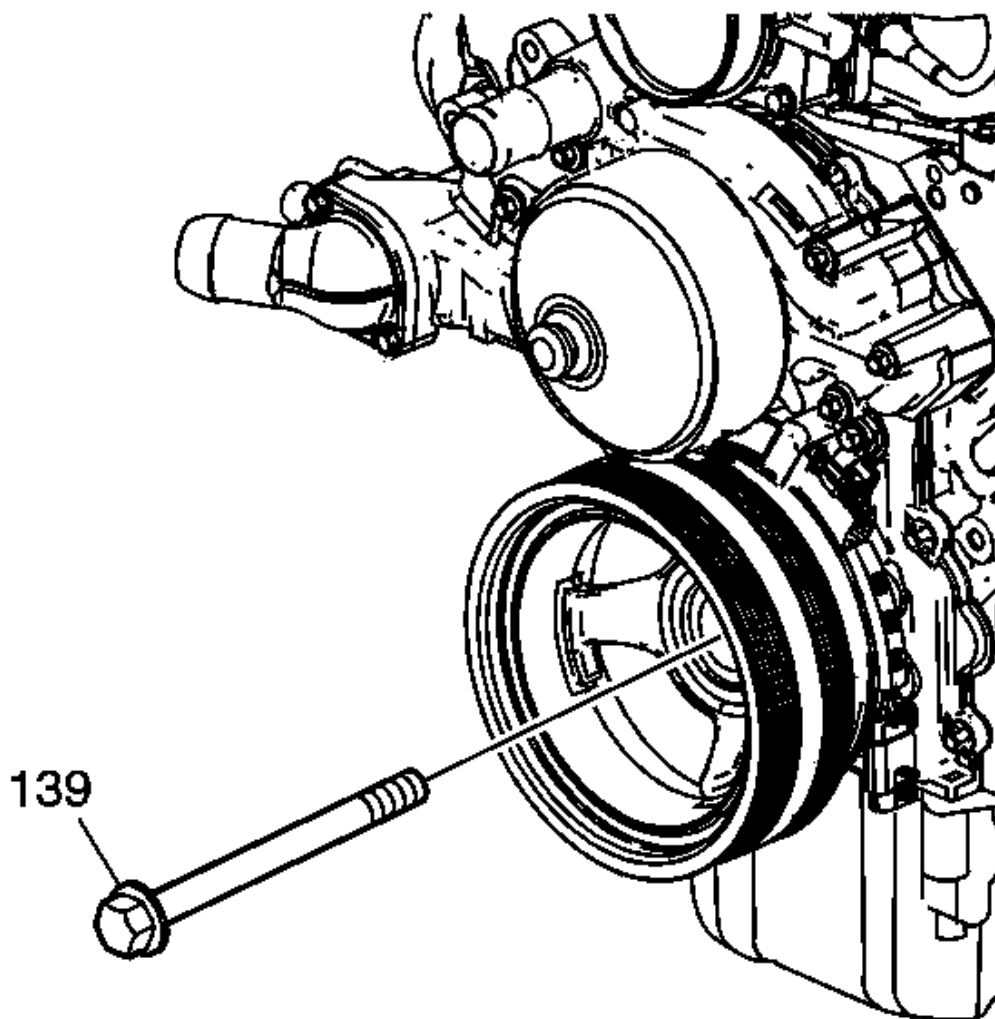


Fig. 554: Identifying Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the used crankshaft balancer bolt (139).

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

5. Remove the used crankshaft balancer bolt.

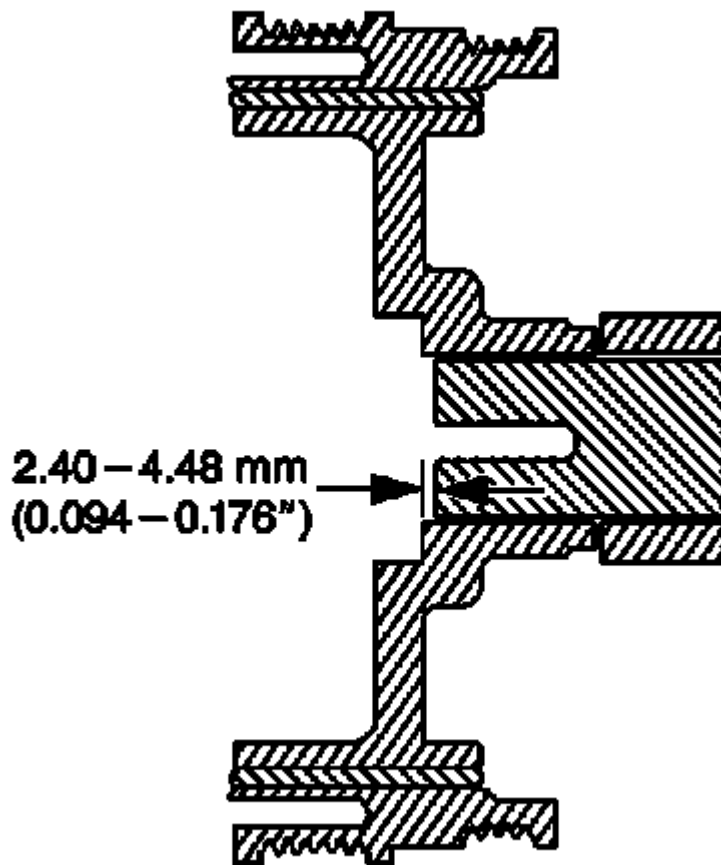


Fig. 555: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

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

6. 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**.

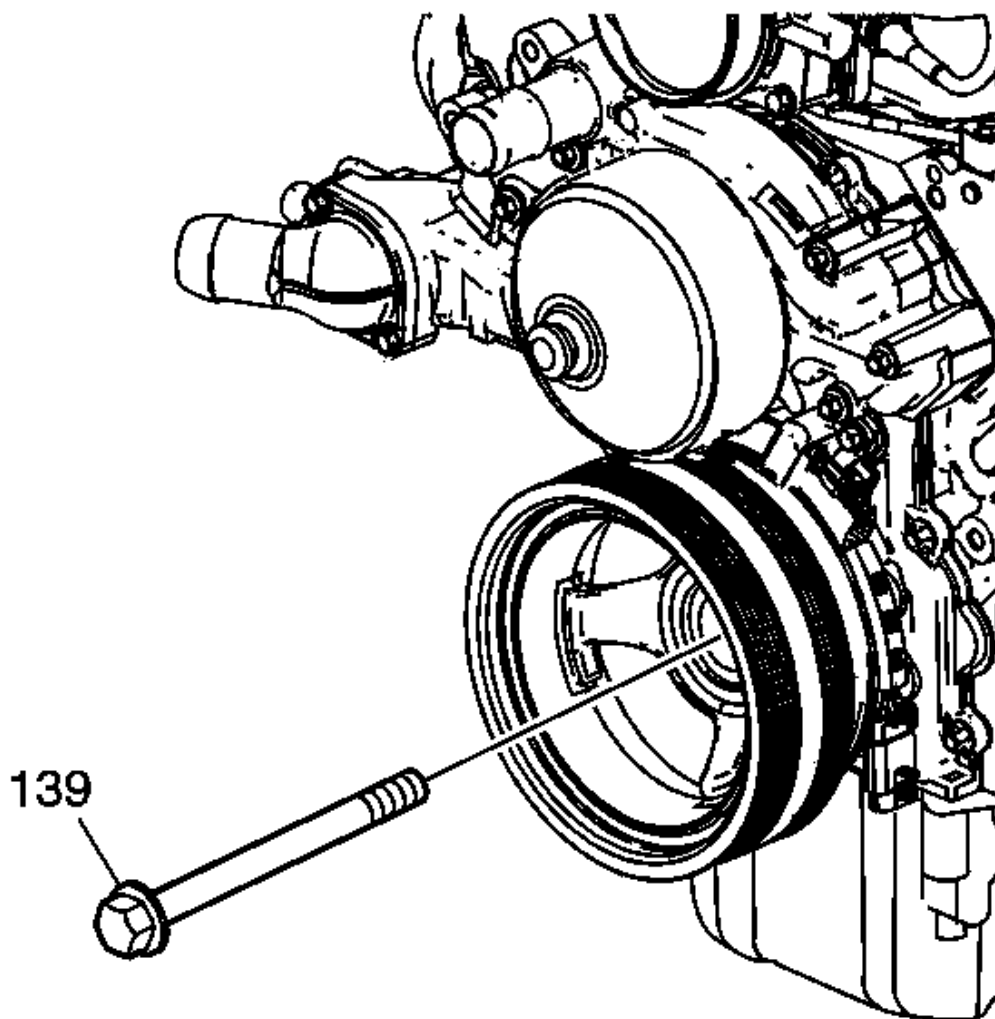


Fig. 556: Identifying Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW crankshaft balancer bolt.

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** .

8. Remove the **J 42386-A** . See **Special Tools**.

Engine Prelubing**Tools Required**

J 45299 Engine Preluber. See Special Tools.

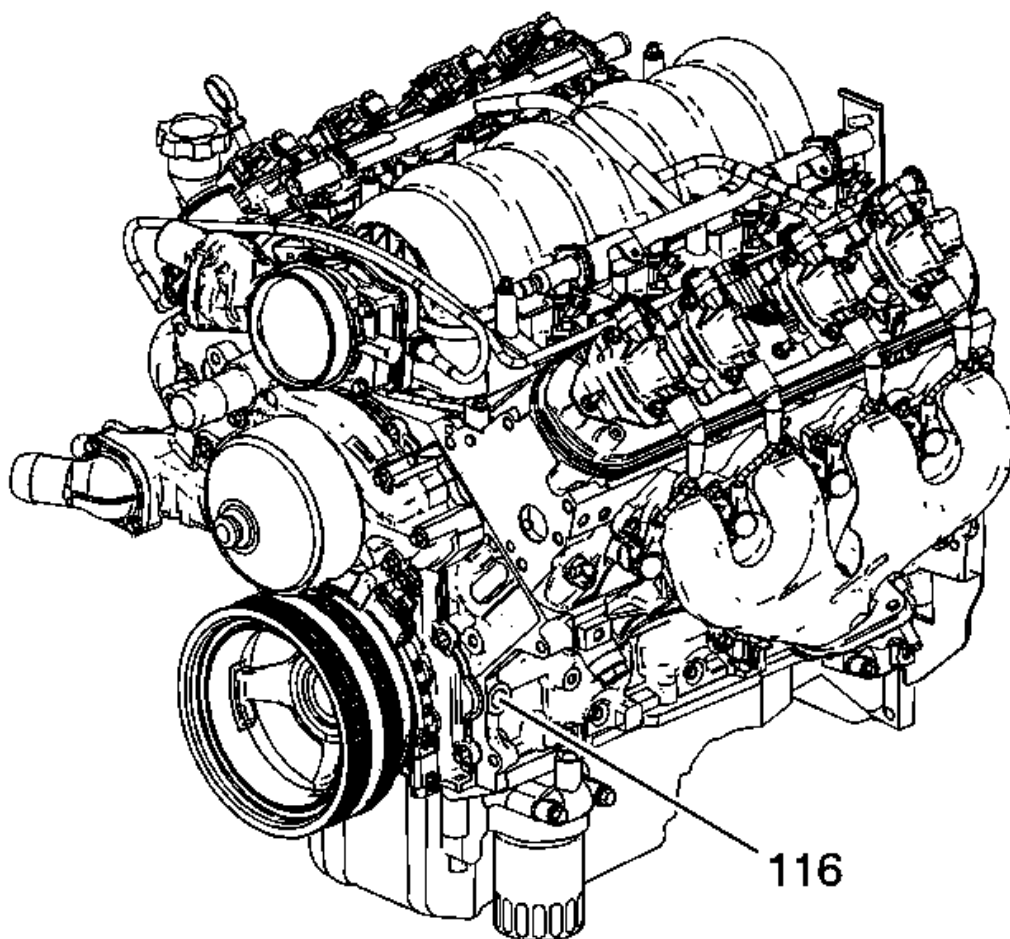
Procedure

Fig. 557: Locating Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter, and fill with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

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

3. Locate the engine block left front oil gallery plug (116).
4. Install the M16 x 1.5 adapter P/N 509375.

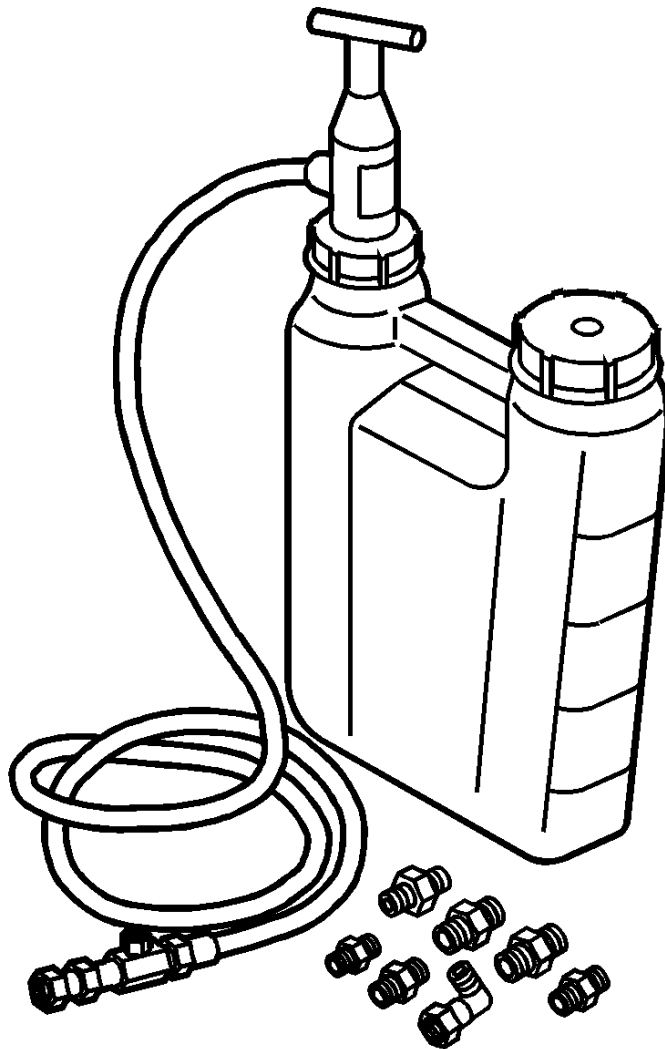


Fig. 558: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

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 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. Filtered air from the air induction system duct is supplied to the crankcase, mixed with blow-by vapors, and passes through a crankcase ventilation metering device before entering the intake manifold. The primary component in the positive crankcase ventilation (PCV) system is the PCV flow metering device (or orifice). Vacuum changes within the intake manifold result in flow variations of the blow-by vapors. If abnormal operating conditions occur, the design of the PCV system permits excessive amounts of blow-by vapors to back flow through the crankcase vent tube and into the engine induction system to be consumed during normal combustion. This engine ventilation system design minimizes oil consumption and significantly reduces the potential for oil ingestion during vehicle limit handling maneuvers.

LS2 Engine

The LS2 engine utilizes an integral positive crankcase ventilation (PCV) system which is located in the engines valley cover beneath the intake manifold. The engine valley cover contains composite oil separating baffles and PCV plumbing. Filtered fresh air is routed from up stream of the throttle plate to the front of the right valve rocker arm cover through a formed nylon tube. The design of the rocker cover shields rocker arm oil spray thereby reducing the potential for oil being drawn into the throttle bore area during back flow of the ventilation system. Blow-by vapors are routed from the valley cover through a fixed orifice (2.5 mm) within a steel PCV tube, then through a formed rubber hose before entering the intake manifold behind the throttle body.

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped

- The engine cooling fan, if belt driven
- The water pump, if belt driven
- The vacuum pump, if equipped
- The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers - chloroprene or EPDM - and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

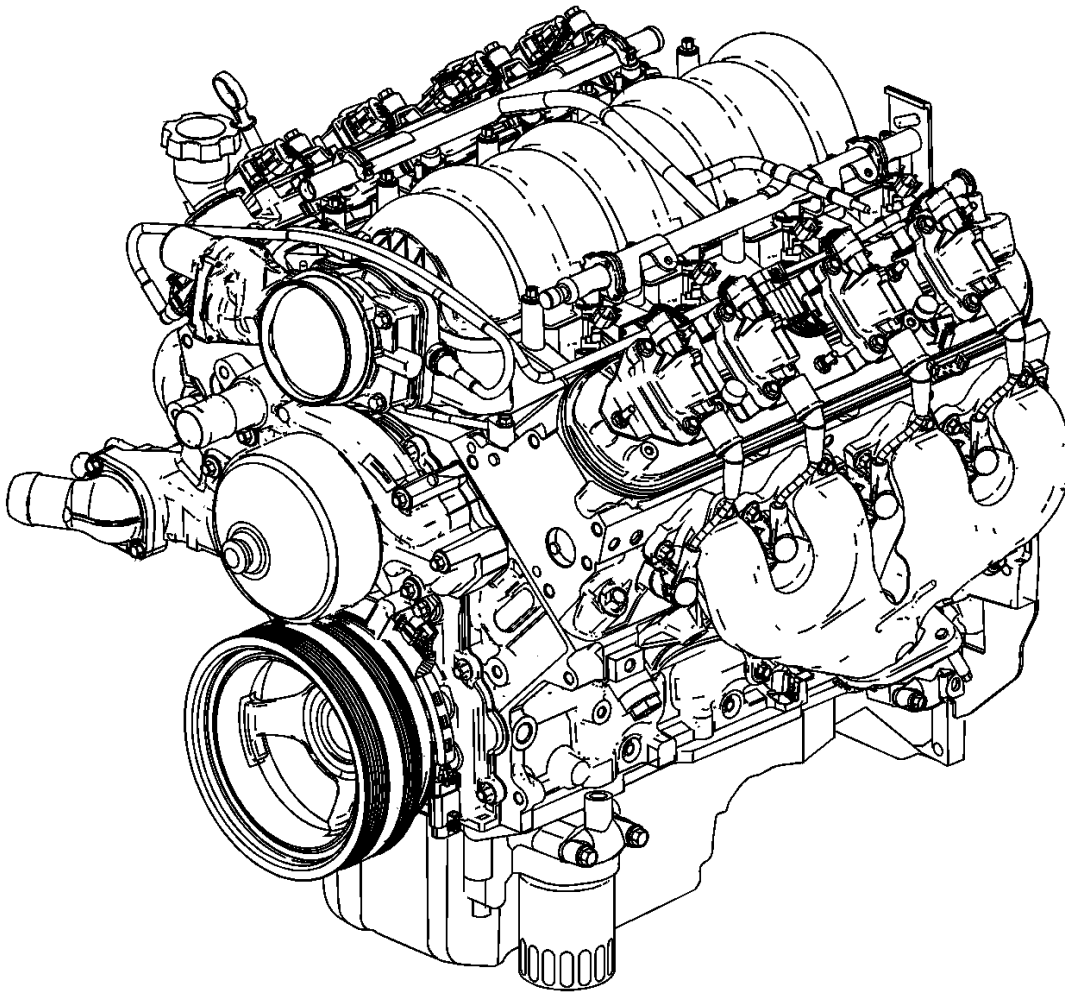


Fig. 559: The 6.0 Liter V8 Engine
Courtesy of GENERAL MOTORS CORP.

The 6.0 Liter V8 engine is identified as RPO LS2 VIN U.

Camshaft and Drive System

A billet steel one piece camshaft is supported by five 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 camshaft position (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 dampener 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 five 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 four center mounted rocker arm cover bolts.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V configuration with five crankshaft bearing caps. The engine block is cast aluminum. The five crankshaft bearing caps each have four vertical M10 and two horizontal M8 mounting bolts. The camshaft is supported by five camshaft bearings pressed into the block.

Exhaust Manifolds

The exhaust manifolds are a one-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 one-piece composite design that incorporates brass threaded inserts for mounting the fuel rail, throttle body, and wire harness studs. Each side of the intake manifold is sealed to the cylinder head by a non-reusable push-in-place silicone sealing gasket. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a one-piece push-in-place silicone gasket. The fuel rail assembly, with eight separate fuel injectors, is retained to the intake by four bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. A fuel rail stop bracket is retained to the rear left of the intake manifold by mounting bolts. The manifold absolute pressure (MAP) sensor is installed and retained to the top front of the intake manifold and sealed by an O-ring seal. The evaporative emission (EVAP) solenoid valve is mounted to the front of the right cylinder head. There are no coolant passages within the intake manifold.

Oil Pan

The structural front-sump oil pan is cast aluminum. Incorporated into the design is the oil pan baffle, oil filter mounting boss, drain plug opening and oil level indicator tube opening. An internal oil filter tube directs pressurized oil from the engine block to the oil filter. Filtered oil is then returned to the engine block through the tube into the engine block oil galleries. The alignment of the structural oil pan to the rear of the engine block and transmission bell housing is critical.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use two compression rings and one 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 right cover is the oil fill tube and the positive crankcase ventilation (PCV) fresh air passage.

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.

LUBRICATION DESCRIPTION

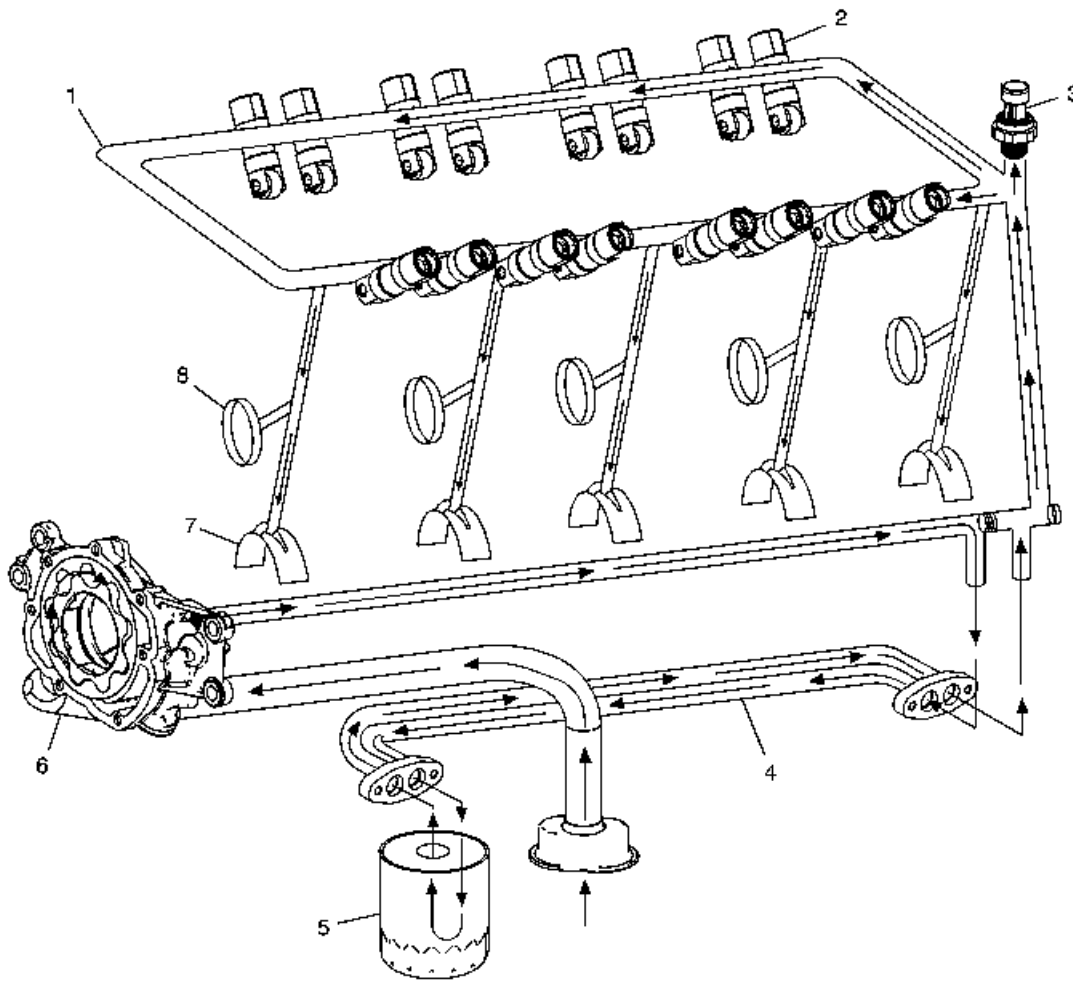


Fig. 560: View Of Engine Lubrication System
 Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly (5). 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 through the oil pan oil filter tube (4) to the full flow oil filter (5) where harmful contaminants are removed. A bypass valve is incorporated into the oil pan at the oil filter boss, which permits oil flow in the event the filter becomes restricted.

Oil is then directed from the filter to the upper main oil galleries (1). Oil from the left upper oil gallery is directed to the crankshaft bearings (7) and camshaft bearings (8). Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies (2) 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 (3) is located at the top rear of the engine.

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.
- 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

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 in Cautions and Notices.

- When assembling components, use only the sealant specified or equivalent in 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 SEALER

Pipe Joint Compound

IMPORTANT: Three 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 two 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** in Cautions and Notices.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.
- Apply a continuous bead of pipe joint compound to one 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 two 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** in Cautions and Notices.

- 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 two rigid parts, such as castings, are assembled together. When two 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**.

- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be sealed must be clean and dry.

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

- 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 five 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
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

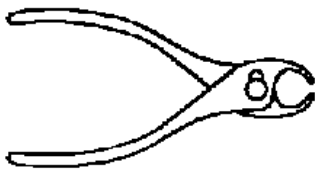
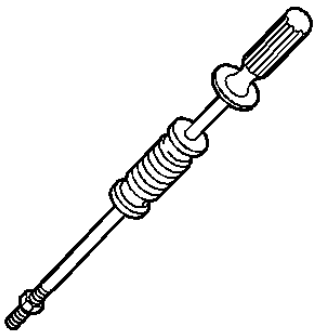
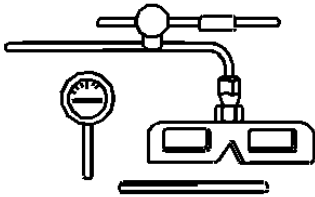
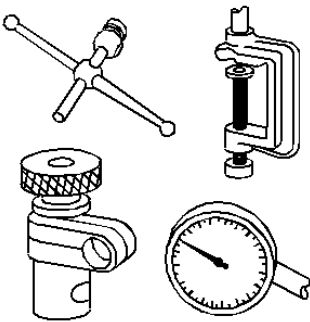
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Special Tools

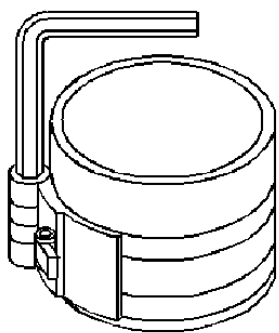
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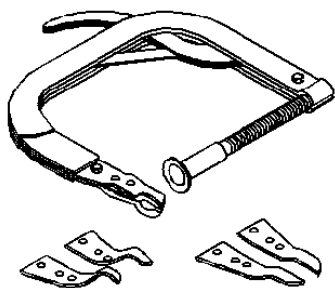
Illustration	Tool Number/Description
	J 3049-A Valve Lifter Remover
	J 6125-1B Slide Hammer Adapter
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set
	J 8037

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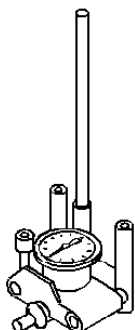
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Ring Compressor



J 8062
Valve Spring Compressor - Head Off



J 8087
Cylinder Bore Gage

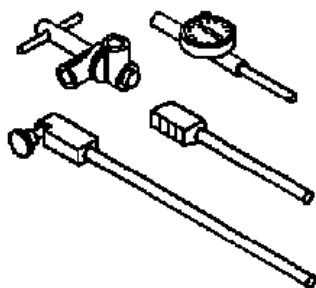
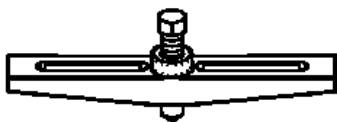


J 8089
Carbon Removal Brush

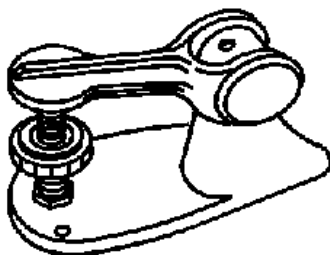
J 8433-1
Puller Bar

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J 8520
Cam Lobe Lift Indicator



J 9666
Valve Spring Tester

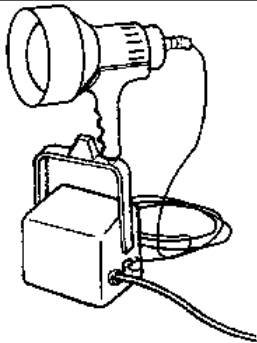


J 24270
Cylinder Bore Ridge Reamer

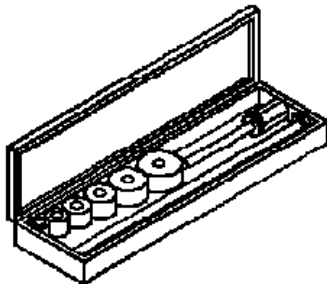
J 28410
Gasket Remover

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J 28428-E
High-Intensity Black Light Kit



J 33049
Camshaft Bearing Service Set

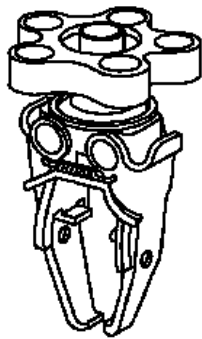
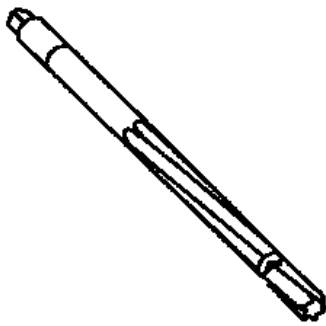


J 35667-A
Cylinder Leakdown Tester

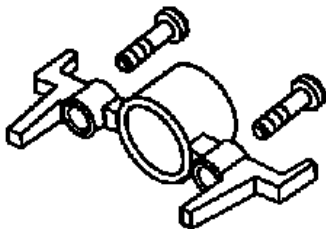
J 37378-1
Valve Guide Reamer

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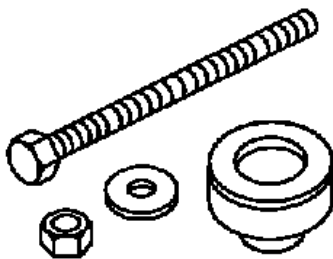
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J 38606
Valve Spring Compressor



J 41476
Front and Rear Cover Alignment Tool

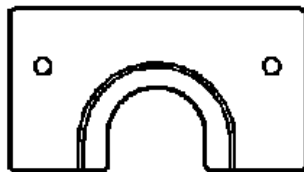
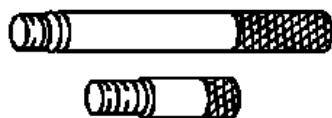
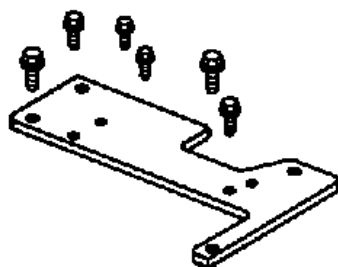
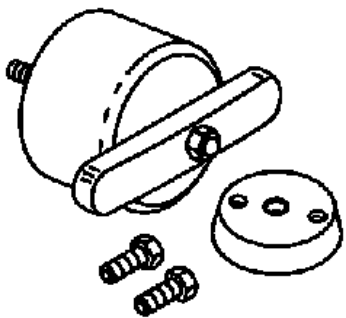


J 41478
Crankshaft Front Oil Seal Installer

J 41479
Crankshaft Rear Oil Seal Installer

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J 41480
Front and Rear Cover Alignment

J 41556
Connecting Rod Guide

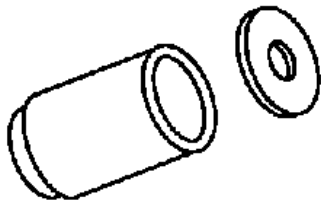
J 41558
Crankshaft Sprocket Remover

J 41665

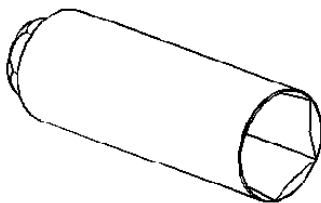
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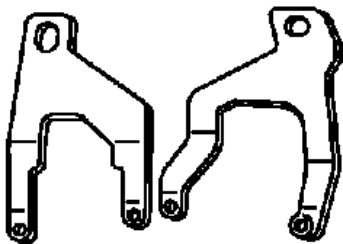
Crankshaft Balancer and Sprocket Installer



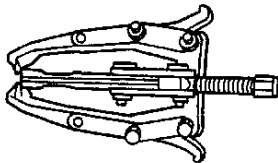
J 41712
Oil Pressure Switch Socket



J 41798
Engine Lift Bracket



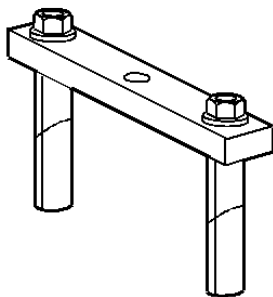
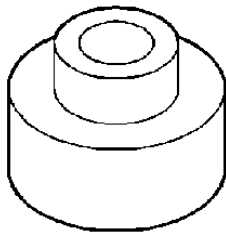
J 41816
Crankshaft Balancer Remover



J 41816-2
Crankshaft End Protector

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J 41818
Crankshaft Bearing Cap Remover



J 42385-100
Head/Main Bolt Thread Repair Kit



J 42385-200
Common Threads Repair Kit

J 42385-300

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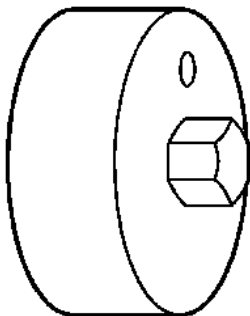
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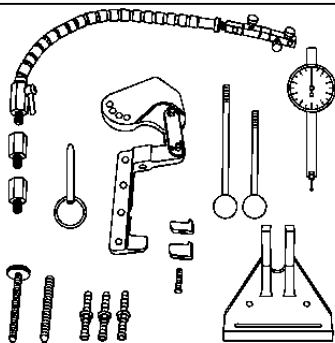
Fixtures and Hardware Kit



J 42386-A
Flywheel Holding Tool



J 42907
Oil Pressure Tester

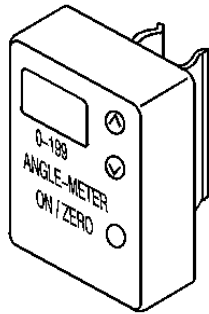
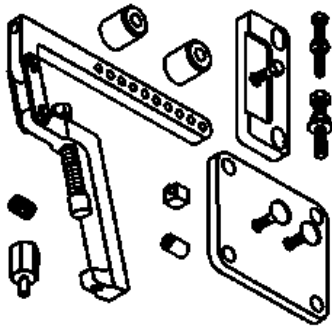


J 43690
Rod Bearing Checking Tool

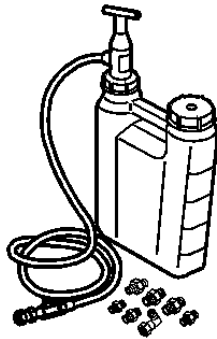
J 43690-100
Rod Bearing Checking Tool - Adapter Kit

2005 Pontiac GTO

2005 ENGINE Engine Mechanical - 6.0L - GTO



J 45059
Angle Meter



J 45299
Engine Preluber