SPECIFICATIONS

FASTENER SPECIFICATIONS

Single Use Non-Threaded Fasteners/Components

Application
NOTE: ***All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.***
Camshaft Actuator Magnet Gasket
Camshaft Position Actuator Solenoid Valve
Camshaft Position Sensor Seal
Crankshaft Rear Oil Seal Housing Gasket
Crankshaft Bearing Cap Bolts
Engine Coolant Manifold Gasket
Exhaust Manifold Gasket
Fuel Feed Intermediate Pipe - Position 1
Fuel Feed Intermediate Pipe - Position 2
Fuel Injector O-ring
Fuel Injector Plastic Spacer
Fuel Injector Retaining Clip
Fuel Injector Seal
Fuel Pump Gasket
Intake Manifold Gasket
Oil Pan Front Seal
Oil Level Indicator Switch Seal
Oil Pan High Pressure Port Seal
Throttle Body Gasket
Valve Lifter Oil Manifold Gasket
Valve Rocker Arm Cover Gasket
Water Pump Assembly Gasket
Water Pump Outlet Gasket

Single Use Threaded Fastener/Component Tightening Specifications

Application	Specification
	Metric (English)
NOTE:	

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Application	Specification Metric (English)
All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.	
Automatic Transmission Flex Plate Bolt	
• First Pass	15 N.m (11 lb ft)
• Second Pass	30 N.m (22 lb ft)
• Final Pass	45 degrees
Flywheel Bolt	
• First Pass	15 N.m (11 lb ft)
• Second Pass	30 N.m (22 lb ft)
• Final Pass	30 degrees
Camshaft Position (CMP) Actuator Magnet Bolts	10 N.m (89 lb in)
Camshaft Position (CMP) Actuator Solenoid Valve	
• First Pass	65 N.m (48 lb ft)
• Final Pass	90 degrees
Crankshaft Balancer Bolt - New Bolt with Flanged Head	
• First Pass	120 N.m (89 lb ft)
• Second Pass	Loosen 360 degrees
• Third Pass	80 N.m (59 lb ft)
• Final Pass	125 degrees
Crankshaft Balancer Bolt - New Bolt with Retained Rotating Washer	
• First Pass	120 N.m (89 lb ft)
• Second Pass	Loosen 360 degrees
• Third Pass	80 N.m (59 lb ft)
• Final Pass	200 degrees

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Application	Specification Metric (English)
Crankshaft Bearing Cap Bolt	
• Inner Bearing Cap Bolt - First Pass in Sequence	20 N.m (15 lb ft)
• Inner Bearing Cap Bolt - Final Pass in Sequence	110 degrees
• Outer Bearing Cap Bolt - First Pass in Sequence	20 N.m (15 lb ft)
• Outer Bearing Cap Bolt - Final Pass in Sequence	80 degrees
• Bearing Cap Side Bolt - First Pass in Sequence	25 N.m (18 lb ft)
• Bearing Cap Side Bolt - Final Pass in Sequence	60 degrees
Cylinder Head Bolt	
• Cylinder Head Bolt - First Pass in Sequence	80 N.m (59 lb ft)
• Cylinder Head Bolt - Second Pass in Sequence	90 degrees
• Cylinder Head Bolt - Final Pass in Sequence	60 degrees
Fuel Feed Intermediate Pipe Fittings	30 N.m (22 lb ft)

Reusable Threaded Fastener Tightening Specifications

Application	Specification Metric (English)
NOTE: ***All fasteners listed in this table can be reused after removal.***	
Accessory Drive Belt Idler Pulley Bolt	20 N.m (15 lb ft)
Accessory Drive Belt Tensioner Bolt	58 N.m (43 lb ft)
Camshaft Position (CMP) Sensor Bolt	25 N.m (18 lb ft)
Camshaft Position (CMP) Sensor Wire Harness Bolt	10 N.m (89 lb in)
Camshaft Retainer Bolt - TORX Head Bolt	15 N.m (11 lb ft)
Balance Shaft Idler Sprocket Bolt	58 N.m (43 lb ft)
Balance Shaft Retainer Bolt	10 N.m (89 lb in)
Balance Shaft Driven Sprocket Bolt	58 N.m (43 lb ft)
Balance Shaft Chain Guide Bolt	10 N.m (89 lb in)
Connecting Rod Bolt	
• First Pass	20 N.m (15 lb ft)
• Final Pass	85 degrees

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Application	Specification
	Metric (English)
Coolant Temperature Sensor	20 N.m (15 lb ft)
Crankshaft Balancer Bolt - Installation Pass with Used Bolt - to Ensure the Balancer is Completely Installed	330 N.m (244 lb ft)
Crankshaft Oil Deflector Bolt	10 N.m (89 lb in)
Crankshaft Position (CKP) Sensor Bolt	25 N.m (18 lb ft)
Crankshaft Rear Oil Seal Housing Bolt	25 N.m (18 lb ft)
Engine Block Coolant Drain Hole Plug	60 N.m (44 lb ft)
Engine Block Coolant Heater	50 N.m (37 lb ft)
Engine Block Oil Gallery Plug	30 N.m (22 lb ft)
Engine Block Valley Cover Bolts	
• FIrst Pass in Sequence	15 N.m (11 lb ft)
• Final Pass in Sequence	30 N.m (22 lb ft)
Exhaust Manifold Bolt	
• Exhaust Manifold Bolt - If installing on existing cylinder head	23 N.m (17 lb ft)
• Exhaust Manifold Bolt - If installing on NEW cylinder head	27 N.m (20 lb ft)
Exhaust Manifold Heat Shield Bolt	10 N.m (89 lb in)
Engine Oil Cooler Adapter	12 N.m (9 lb ft)
Front Cover Bolt	25 N.m (18 lb ft)
Fuel Feed Pipe Bolt	10 N.m (89 lb in)
Fuel Pump Bolt	25 N.m (18 lb ft)
Fuel Rail Fuel Pressure Sensor	33 N.m (24 lb ft)
Fuel Injection Fuel Rail Bolt	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Crossover Pipe Bolt	10 N.m (89 lb in)
Fuel Pump Lifter Follower Guide Bolt	25 N.m (18 lb ft)
Generator Bracket Bolt	50 N.m (37 lb ft)
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolt	10 N.m (89 lb in)
Intake Manifold Bolt	
• First Pass in Sequence	5 N.m (44 lb in)
• Final Pass in Sequence	10 N.m (89 lb in)
Intake Manifold Cover Stud	4.5 N.m (40 lb in)
Intake Manifold Cover Bolt	4.5 N.m (40 lb in)
Knock Sensor Bolt	25 N.m (18 lb ft)
Knock Sensor Heat Shield Bolt	25 N.m (18 lb ft)
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange
Oil Filter Fitting	55 N.m (41 lb ft)
Oil Filter Center Tube Bolt - Outside Oil Pan	10 N.m (89 lb in)

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Application	Specification
	Metric (English)
Oil Filter Center Tube Bolt - Inside Oil Pan	10 N.m (89 lb in)
Oil Level Indicator Tube Bolt	10 N.m (89 lb in)
Oil Pan Cover Bolt	10 N.m (89 lb in)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pan Bolt - Oil Pan-to-Rear Housing	12 N.m (9 lb ft)
Oil Pan Bolt - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m (18 lb ft)
Oil Pan Bolt - Lower Oil Pan to Upper Oil Pan	10 N.m (89 lb in)
Oil Pressure Sensor	35 N.m (26 lb ft)
Oil Level Sensor Bolt	10 N.m (89 lb in)
Oil Pump Screen Bolt	10 N.m (89 lb in)
Oil Pump-to-Engine Block Bolt	25 N.m (18 lb ft)
PCV Valve	6 N.m (53 lb in)
Spark Plug	20 N.m (15 lb ft)
Throttle Body Bolt	10 N.m (89 lb in)
Map Sensor Bolt	4.5 N.m (40 lb in)
Evap Purge Valve Bolt	4.5 N.m (40 lb in)
Timing Chain Tensioner Bolt	25 v(18 lb ft)
Valley Cover Bolt	
• Valve Cover Bolt - First Pass in Sequence	12 N.m (9 lb ft)
• Valve Cover Bolt - Final Pass in Sequence	25 N.m (18 lb ft)
Valve Lifter Guide Bolt	12 N.m (9 lb ft)
Valve Lifter Oil Manifold Bolt	
• Valve Lifter Oil Manifold Bolt - First Pass in Sequence	15 N.m (11 lb ft)
• Valve Lifter Oil Manifold Bolt - Final Pass in Sequence	30 N.m (22 lb ft)
Valve Lifter Oil Manifold Filter Plug	30 N.m (22 lb ft)
Valve Rocker Arm Bolt	30 N.m (22 lb ft)
Valve Rocker Arm Cover Bolt - In Sequence	10 N.m (89 lb in)
Water Inlet Housing Bolt	10 N.m (89 lb in)
Water Pump Impeller Bolt	10 N.m (89 lb in)
Engine Coolant Manifold Bolt	25 N.m (18 lb ft)
Vacuum Pump Bolt	25 N.m (18 lb ft)
Starter Heat Shield Bolt - Side	10 N.m (89 lb in)
Starter Heat Shield Bolt - Rear	25 N.m (18 lb ft)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English

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Application	Specification	
	Metric	English
4.3L (LV1))		
• Oil Capacity - with Filter	5.7 Liters	6.0 Quarts
• Oil Capacity - without Filter	5.2 Liters	5.5 Quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	V6	
• Displacement	4.3L	262 CID
• RPO	LV3	
• VIN	H	
• Bore	99.6 mm	3.92 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	11.0:1	
• Firing Order	1-6-5-4-3-2	
• Spark Plug Gap	0.95-1.10 mm	0.037-0.043 in
Balance Shaft		
• Balance Shaft Endplay	0.025-0.305 mm	0.0010-0.0120 in
• Balance Shaft Journal Diameter - Rear	49.990-50.010 mm	1.9681-1.9689 in
• Balance Shaft Journal Diameter - Front	56.990-57.010 mm	2.2437-2.2445 in
• Balance Shaft Journal to Bearing Clearance	0.045-0.110 mm	0.0018-0.0043 in
Block		
• Camshaft Bearing Bore 1 and 3 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 2 and 4 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.870-69.890 mm	2.75-2.751 in

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Application	Specification	
	Metric	English
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.0003 in
• Cylinder Bore Diameter	99.590-99.610 mm	3.920-3.921 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.58-234.832 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 25 mm (.984 in) Area	0.025 mm	0.0009 in
• Cylinder Head Deck Surface Flatness - Measured between bolt holes	0.03 mm	0.001 in
• Cylinder Head Deck Surface Flatness - Measured Within a 150 mm(5.90 in) Area	0.05 mm	0.001 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.1 mm	0.003 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	54.99-55.015 mm	2.164-2.166 in
• Camshaft Bearing Diameter	55.063-55.088 mm	2.1678-2.1688 in
• Camshaft Journal-to-Bearing Clearance	0.048-0.098 mm	0.0002-0.0038 in
• Camshaft Journal Out-of-Round	0.06 mm	0.0002 in
• Camshaft Lobe Lift - Exhaust Non AFM	6.97 mm	0.274 in
• Camshaft Lobe Lift - Exhaust AFM	7.10 mm	0.279 in
• Camshaft Lobe Lift - Intake Non AFM	7.08 mm	0.278 in
• Camshaft Lobe Lift - Intake AFM	7.21 mm	0.283 in
• Camshaft Lobe Lift - Fuel Pump	5.70 mm	0.224 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in

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Application	Specification	
	Metric	English
Camshaft Position Actuator		
• Range of Authority	62 degrees	
• Park Position	7 degrees Advanced	
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.024-0.064 mm	0.0009-0.0025 in
• Connecting Rod Bearing Clearance - Service	0.024-0.075 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	0.00157-0.00314 in
• Connecting Rod Bore Out-of-Round - Bearing End - Service	0.004-0.008 mm	0.00157-0.00314 in
• Connecting Rod Side Clearance	0.170-0.430 mm	0.0067-0.017 in
Crankshaft		
• Connecting Rod Journal Diameter - Production	53.320-53.336 mm	2.0991-2.0999 in
• Connecting Rod Journal Diameter - Service	53.31 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 Diametrical Taper - Maximum for 1/2 of Journal Length - Production	0.008 mm	0.0003 in
• Connecting Rod Journal Diametrical Taper - Maximum for 1/2 of Journal Length - Service	0.015 mm	0.00059 in
• Crankshaft End Play	0.04-0.22 mm	0.001-0.0086 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	64.982 mm	2.558 in

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Application	Specification	
	Metric	English
• Crankshaft Main Journal Out-of-Round - Production	0.005 mm	0.00019 in
• Crankshaft Main Journal Out-of-Round - Service	0.001 mm	0.00003 in
• Crankshaft Main Journal Diametrical Taper - Production	0.008 mm	0.0003 in
• Crankshaft Main Journal Diametrical Taper - Service	0.015 mm	0.0006 in
• Crankshaft Rear Flange Runout	0.025 mm	0.00098 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	0.04 mm	0.0016 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	132.5 mm	5.216 in
• Surface Flatness - Block Deck - Measured Within a 152.4 mm (6.0 in) Area	0.05 mm	0.0019 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck Face	0.1 mm	0.004 in
• Surface Flatness - Intake Manifold Deck Face	0.1 mm	0.004 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.05-17.55 mm	0.671-0.691 in
Exhaust Manifold		
• Surface Flatness Flange to Flange	0.25 mm	0.010 in
• Surface Flatness Individual Flange	0.05 mm	0.002 in
Intake Manifold		

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Application	Specification	
	Metric	English
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured Within a 200 mm (7.87 in) Area that Includes 2 Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Pressure - Minimum - Hot	152 kPa at 1,000 engine RPM 207 kPa at 2,000 engine RPM 228 kPa at 3,000 engine RPM	22 psig at 1,000 engine RPM 30 psig at 2,000 engine RPM 33 psig at 3,000 engine RPM
• Active Fuel Management Relief Valve Oil Pressure - as Measured at Oil Pressure Sensor Location	379-517 kPa Maximum	55-75 psig Maximum
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Crankshaft Rear Oil Seal Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.1 mm	0.0-0.004 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.20-0.36 mm	0.008-0.014 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.20-0.42 mm	0.008-0.016 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.37-0.63 mm	0.015-0.025 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	0.15-0.73 mm	0.006-0.029 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.15-0.79 mm	0.006-0.031 in
• Piston Ring-to-Groove Clearance - First Compression Ring - Production	0.04-0.083 mm	0.0016-0.0033 in

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Application	Specification	
	Metric	English
• Piston Ring-to-Groove Clearance - First Compression Ring - Service	0.04-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Production	0.04-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Service	0.04-0.083 mm	0.0016-0.0033 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	0.002-0.010 mm	0.0001-0.0004 in
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Service	0.002-0.015 mm	0.0001-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.9430-0.9431 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.020 mm	0.00028-0.00079 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00028-0.00087 in
• Piston - Piston Diameter - Measured Over Skirt Coating	99.608-99.639 mm	3.9216-3.9228 in
• Piston - Piston-to-Bore Clearance - Production	-0.048 to +0.001 mm	-0.0019 to +0.000 in
• Piston - Piston-to-Bore Clearance - Service Limit with Skirt Coating Worn Off	0.052 mm	0.0020 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	

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Application	Specification	
	Metric	English
• Valve Lift - Exhaust Non AFM	12.5 mm	0.492 in
• Valve Lift - Exhaust AFM	12.753 mm	0.502 in
• Valve Lift - Intake Non AFM	12.700 mm	0.499 in
• Valve Lift - Intake AFM	12.953 mm	0.509 in
• Valves - Valve Seat Angle	45 degrees	
• Valves - Valve Seat Runout - Production	0.05 mm	0.002 in
• Valves - Valve Seat Runout - Service	0.08 mm	0.003 in
• Valves - Valve Seat Width - Exhaust	2.52 mm	0.099 in
• Valves - Valve Seat Width - Intake	2.00 mm	0.078 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
NOTE: **For valve stem to guide clearance - valve guide inner diameter measurements must be recorded at a depth of 7 mm (0.26 in) in the valve guide bore.**		
• 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
• 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

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ENGINE CONTENT SPECIFICATIONS

RPO	VIN	Displacement	Camshaft Position (CMP) Actuator Control System	Active Fuel Management Control System	E85 Capable	Block Material
LV1	P	4.3L	Yes	No	No	Aluminum
LV3	H	4.3L	Yes	Yes	Yes	Aluminum

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Retainer Bolts	Threadlocker	12345382	10953489
Engine Block to the Crankshaft Rear Oil Seal Housing *	Sealant	12378521	88901148
Engine Block to the Engine Front Cover *	Sealant	12378521	88901148
Engine Block to Oil Pan *	Sealant	12378521	88901148
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480
Engine Block Oil Gallery Plug	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004	10953480
Engine Oil	5W-30	19293000	19386321
Engine Oil Pressure Sensor	Sealant	12346004	10953480
Exhaust Manifold Bolt	Threadlocker	89021297	10953488
Engine Coolant Manifold Bolt	Threadlocker	12345382	10953489
Fuel Rail Bolt	Threadlocker	12345382	10953489
Intake Manifiold Bolts	Threadlocker	12345382	10953489
Spark Plug Wires	Lubricant	19260901	19260902
Valve Lifter Oil Filter Plug	Sealant	12346004	10953480
* Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**			

THREAD REPAIR SPECIFICATIONS

Engine Block- Front/Rear Views

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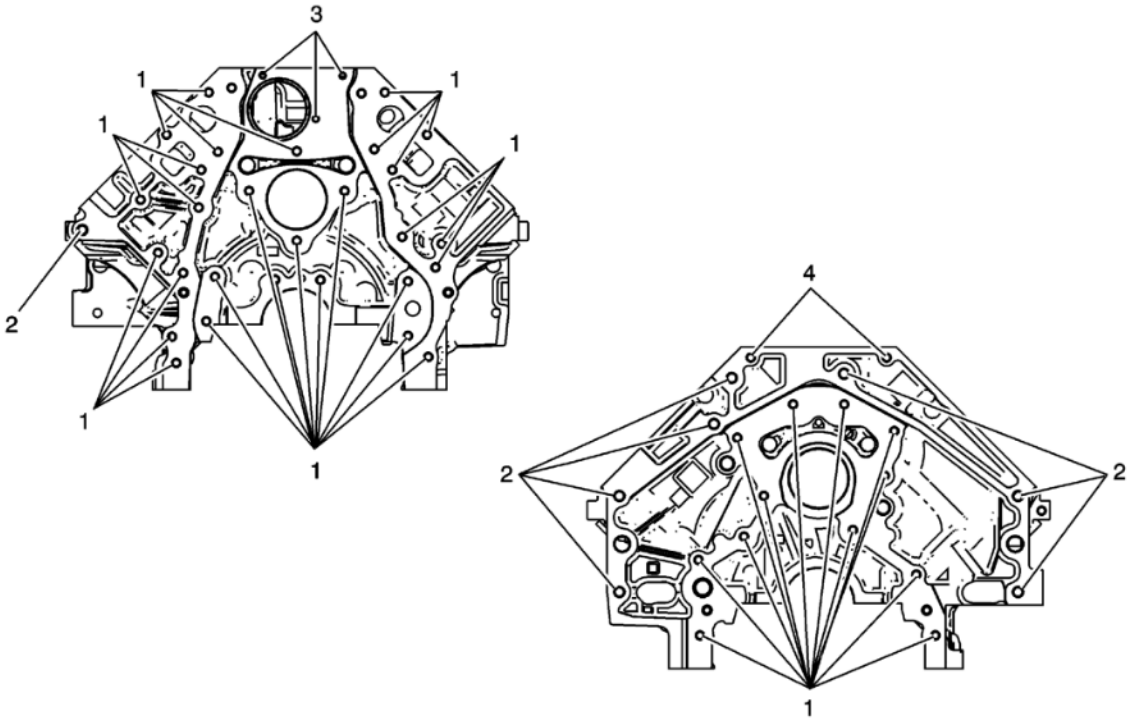

Fig. 1: Engine Block-- Front/Rear Views
Courtesy of GENERAL MOTORS COMPANY

Engine Block- Front/Rear Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth-Maximum mm (in)	Tap Depth-Maximum mm (in)
				J-42385-				
1	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M10 x 1.5	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
3	M6 x 1.20	63	201	203	204	205	23.0 (0.907)	23.0 (0.907)
4	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)

Engine Block- Left/Right Side Views

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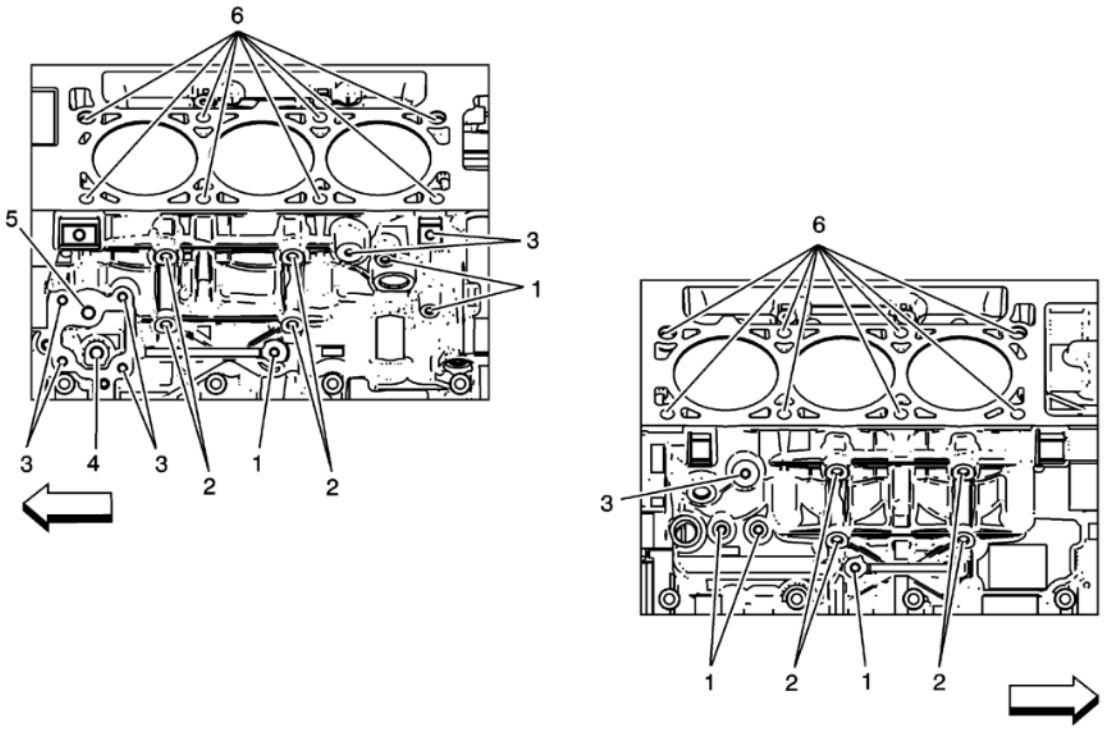

Fig. 2: Engine Block-- Left/Right Side Views
Courtesy of GENERAL MOTORS COMPANY

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)
Standard Bolts J-42385-								
1	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M10 x 1.25	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
3	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)
4	M12 x 1.75	865	856	857	858	859	16.0 (0.629)	16.0 (0.629)
5	M12 x 1.75	62	856	857	858	859	23.0 (0.907)	23.0 (0.907)
Head Bolts EN-42385-								
6	M12 x 1.75	58	51	N/A	52	53	58.0 (2.28)	58.0 (2.28)
Refer to **Thread Repair** for head bolt thread repair hardware and procedure.								

Engine Block- Top/Bottom Views

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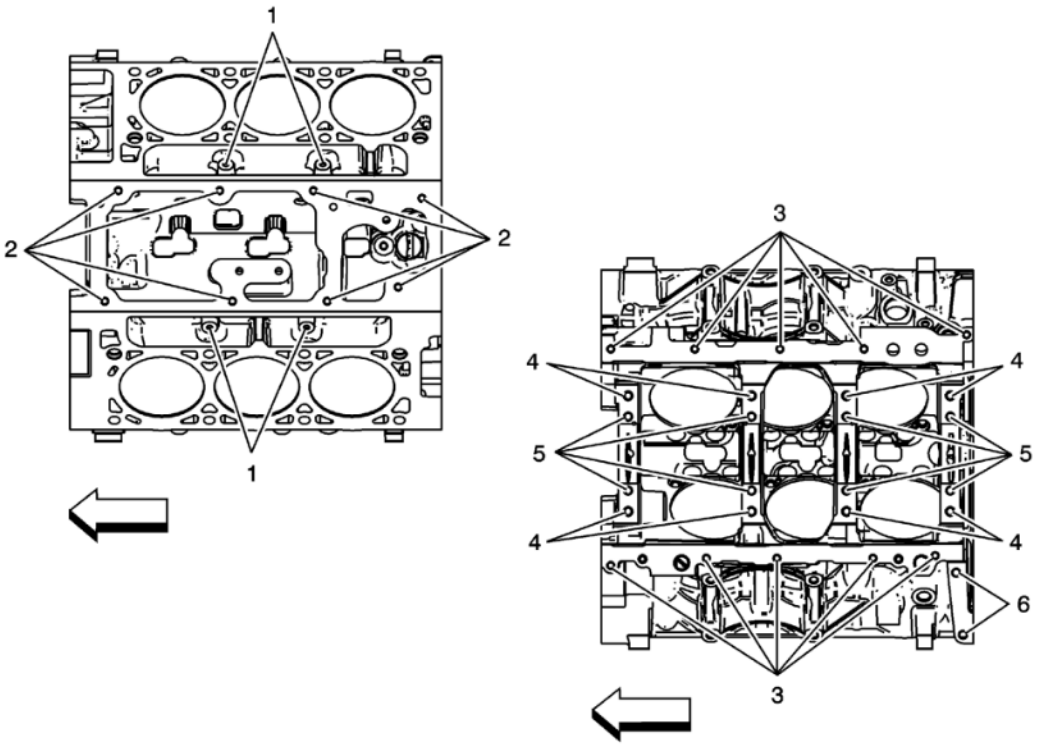

Fig. 3: Engine Block-- Top/Bottom Views
Courtesy of GENERAL MOTORS COMPANY

Engine Block- Top/Bottom Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth- Maximum mm (in)	Tap Depth- Maximum mm (in)
				J-42385-				
1	M6 x 1.0	63	201	202	203	204	23.0 (0.907)	23.0 (0.907)
2	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)
3	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
4	M10 x 2.0	104	101	N/A	102	103	30.0 (1.18)	30.0 (1.18)
5	M10 x 2.0	104	101	N/A	102	103	52.0 (2.05)	52.0 (2.05)
6	M10 x 1.5	N/A	N/A	N/A	N/A	N/A	34.0 (1.35)	34.0 (1.35)

- Bolt hole 4 has a 1.5 mm (0.059 in) counterbore included in the 30.0 mm (1.18 in) drill depth. Use sleeve **J-42385-316** with the drill tap. For the proper hardware and procedure, refer to **Thread Repair** .
- Bolt hole 5 has a 15.5 mm (0.807 in) counterbore included in the 52.0 mm (2.05 in) drill depth. For the proper hardware and procedure, refer to **Thread Repair** .

Cylinder Head- Top/End Views

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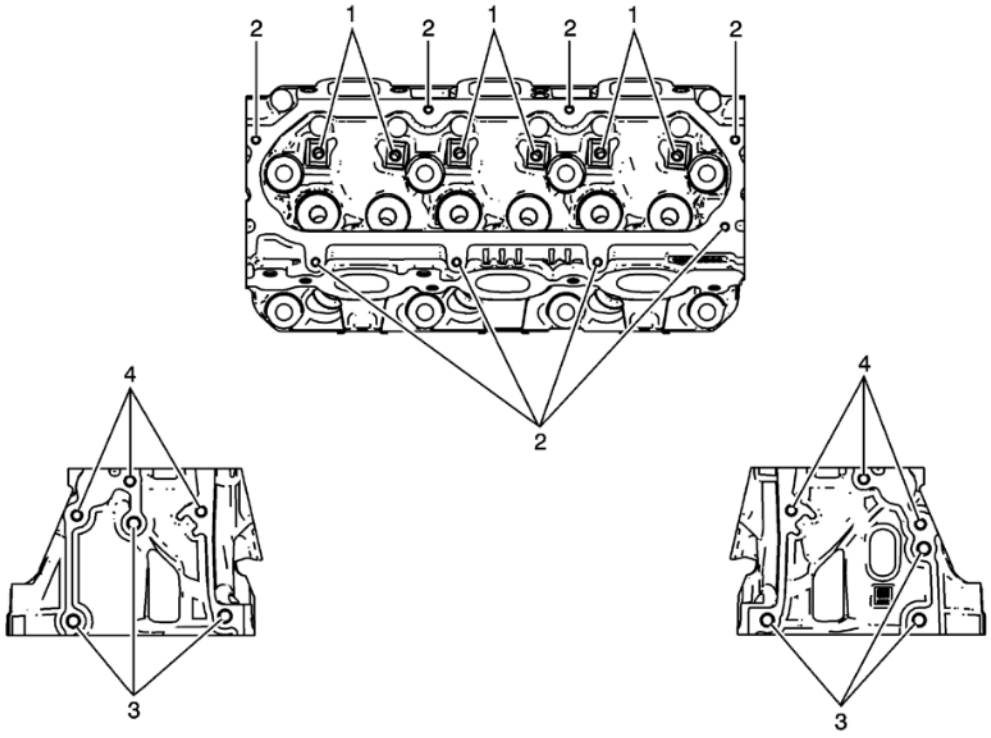

Fig. 4: Cylinder Head-- Top/End Views
Courtesy of GENERAL MOTORS COMPANY

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	N/A	N/A	N/A	N/A	N/A	23.0 (0.907)	23.0 (0.907)
2	M6 x 1.0	205	201	202	203	204	23.0 (0.907)	23.0 (0.907)
3	M10 x 1.5	420	211	212	213	214	30.0 (1.18)	30.0 (1.18)
4	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
Bolt Hole 1 (Rocker Arm Supports) are not serviceable.								

Cylinder Head- Intake/Exhaust Side Views

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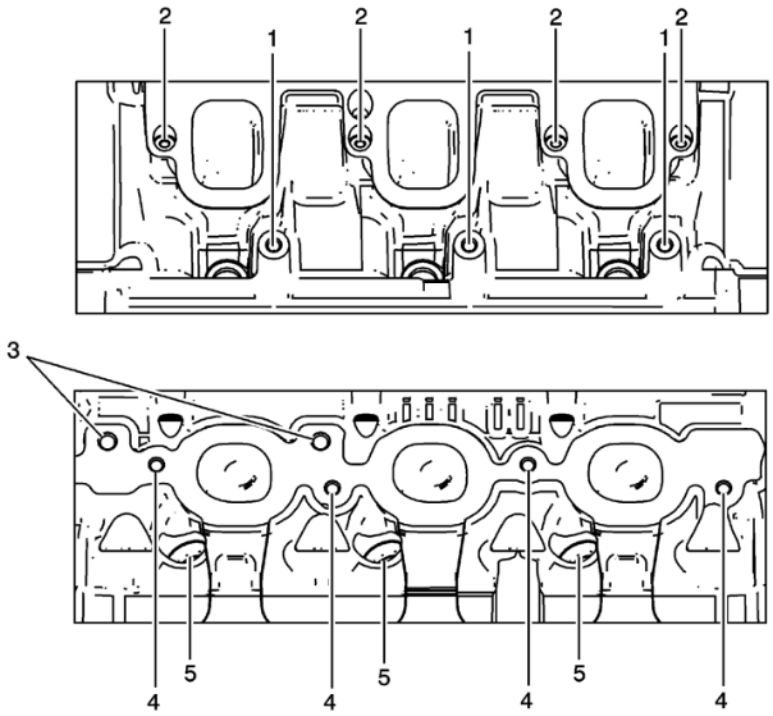

Fig. 5: Cylinder Head-- Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS COMPANY

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	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M6 x 1.0	205	201	202	203	204	21.0 (0.825)	21.0 (0.825)
3	M10 x 1.5	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
4	M8 x 1.25	210	206	207	208	209	29.0 (1.14)	29.0 (1.14)
5	M14x 1.25	N/A	N/A	N/A	N/A	N/A	26.0 (1.023)	26.0 (1.023)
Bolt Hole 5 (Spark Plug Port) is not serviceable.								

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS

Engine Oil Pressure Control

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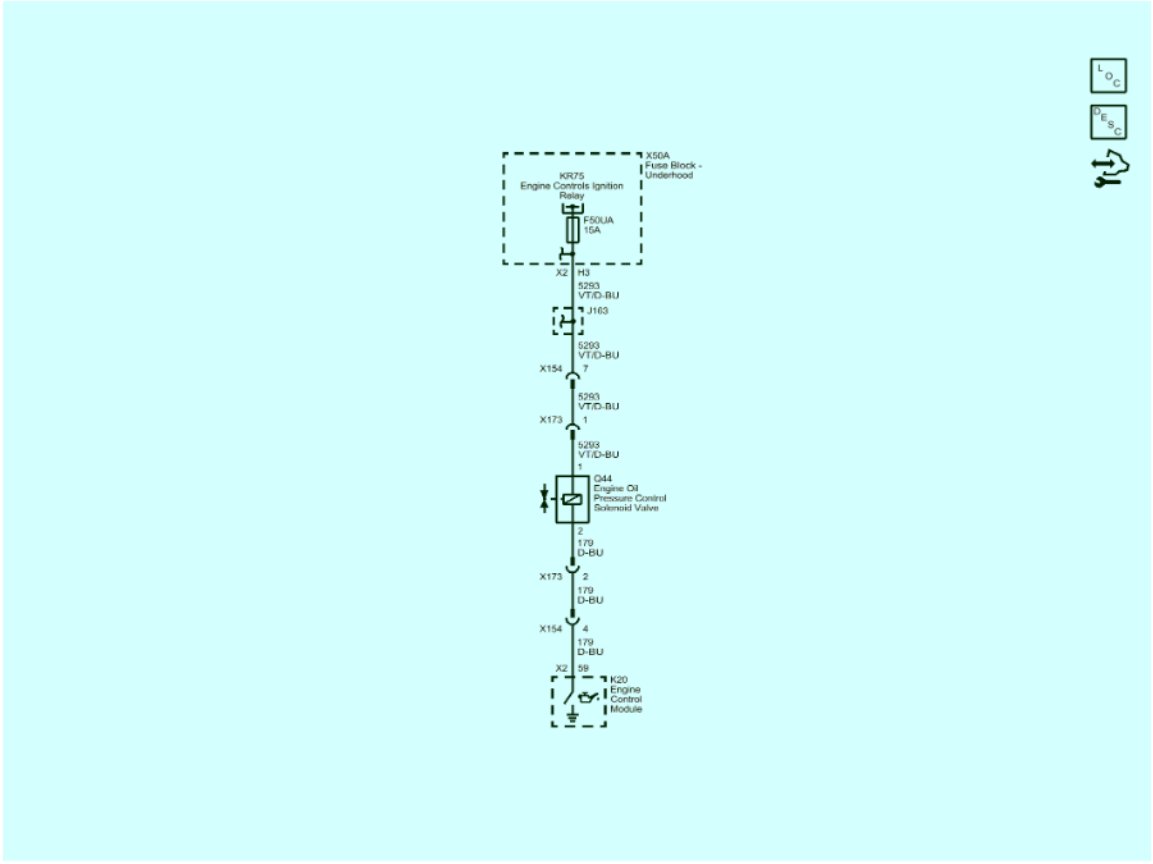

Fig. 6: Engine Oil Pressure Control
Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Cylinder Head/Upper Engine

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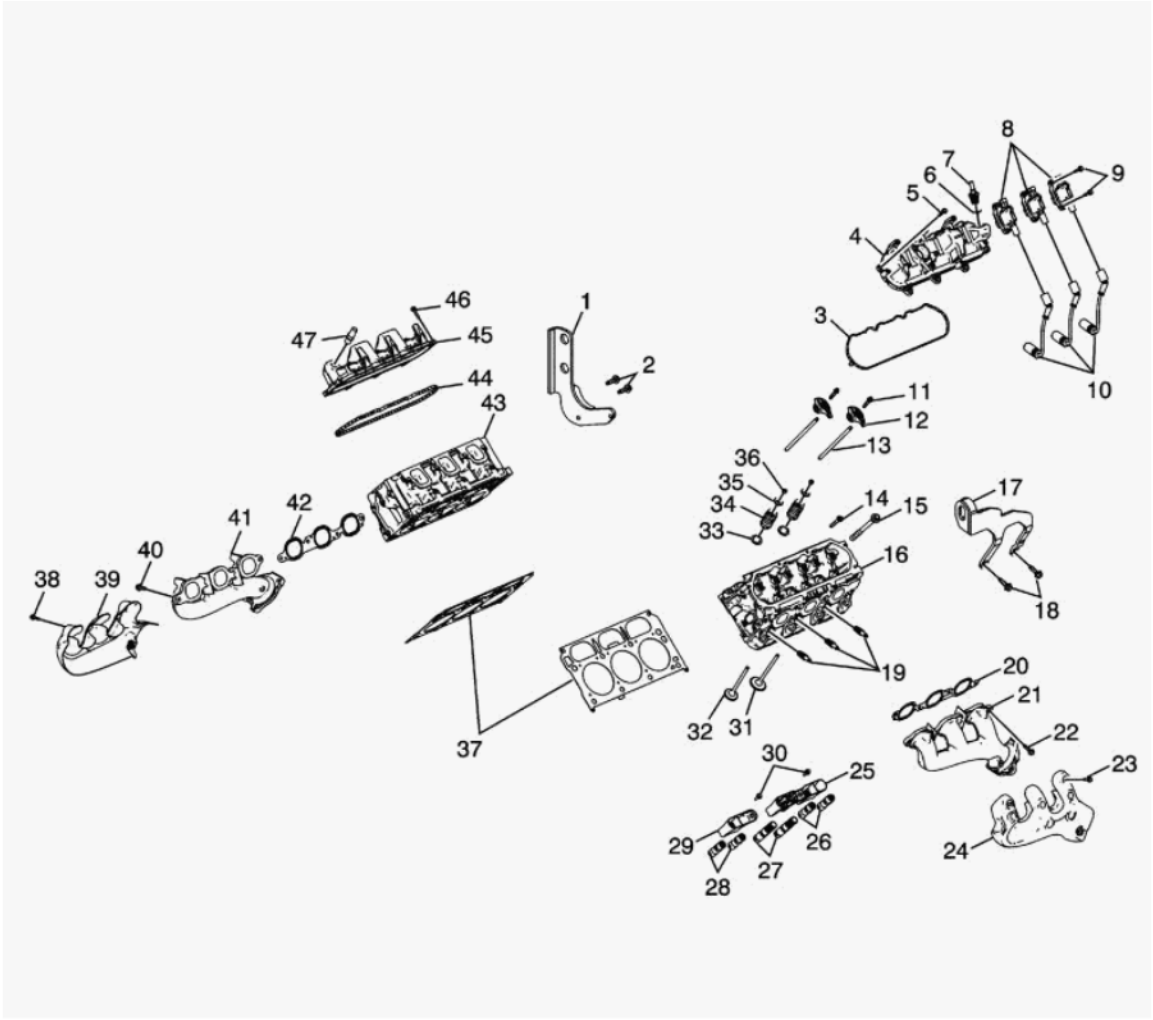

Fig. 7: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Lift Rear Bracket
2	Engine Lift Rear Bracket Bolt
3	Valve Rocker Arm Cover Gasket
4	Valve Rocker Arm Cover
5	Valve Rocker Arm Cover Bolt
6	PCV Fitting Seal
7	PCV Fitting
8	Ignition Coil Assembly
9	Ignition Coil Bolt
10	Spark Plug Wire Assembly
11	Valve Rocker Arm Pivot Support Bolt
12	Valve Rocker Arm Assembly
13	Valve Push Rod Assembly
14	Cylinder Head Bolt - Short
15	Cylinder Head Bolt - Long
16	Cylinder Head - Left Side
17	Engine Lift Front Bracket

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Callout	Component Name
18	Engine Lift Front Bracket Bolt
19	Spark Plug Assembly
20	Exhaust Manifold Gasket
21	Exhaust Manifold Assembly - Left Side
22	Exhaust Manifold Bolt
23	Exhaust Manifold Heat Shield Bolt
24	Exhaust Manifold Heat Shield - Left Side
25	Valve Lifter Guide
26	Valve Lifter
27	Valve Lifter
28	Valve Lifter
29	Valve Lifter Guide
30	Valve Lifter Guide Bolt
31	Exhaust Valve
32	Intake Valve
33	Valve Stem Oil Seal
34	Valve Spring
35	Valve Spring Cap
36	Valve Stem Key
37	Cylinder Head Gasket
38	Exhaust Manifold Heat Shield Bolt
39	Exhaust Manifold Heat Shield - Right Side
40	Exhaust Manifold Bolt
41	Exhaust Manifold Assembly - Right Side
42	Exhaust Manifold Gasket
43	Cylinder Head - Right Side
44	Valve Rocker Arm Cover Gasket
45	Valve Rocker Arm Cover
46	Valve Rocker Arm Cover Bolt
47	PCV Fitting

Front of Engine

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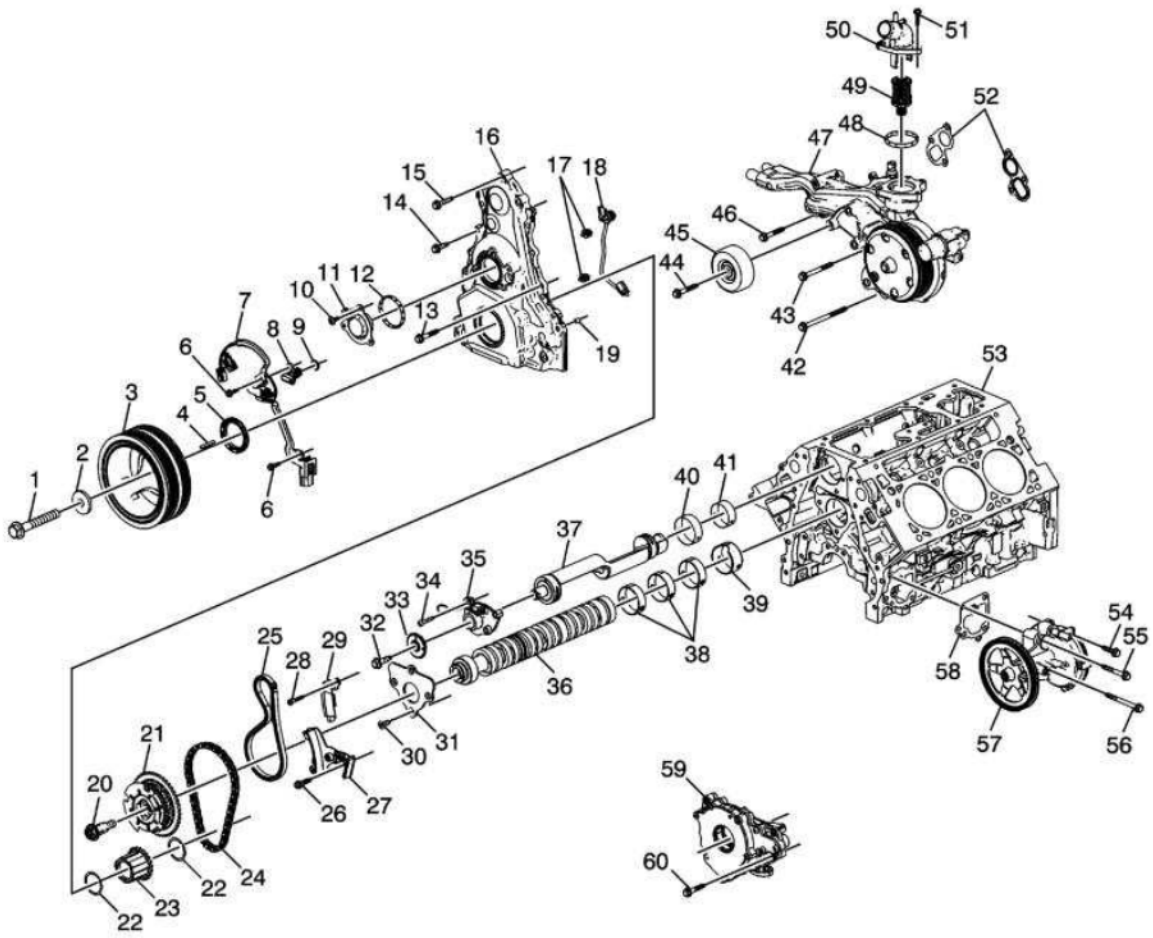

Fig. 8: Front of Engine
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Bolt
2	Crankshaft Balancer Bolt Washer
3	Crankshaft Balancer Assembly
4	Crankshaft Balancer Key
5	Crankshaft Front Oil Seal
6	Camshaft Position Sensor Wire Assembly Bracket Bolt
7	Camshaft Position Sensor Wire Assembly
8	Camshaft Position Sensor Assembly
9	Camshaft Position Sensor Seal
10	Camshaft Position Actuator Magnet Bolt
11	Camshaft Position Actuator Magnet
12	Camshaft Position Actuator Magnet Gasket
13	Engine Front Cover Bolt
14	Engine Front Cover Bolt
15	Engine Front Cover Bolt
16	Engine Front Cover Assembly
17	Oil Pump Flow Control Solenoid Valve Wire Clip

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Callout	Component Name
18	Oil Pump Flow Control Solenoid Valve Wire
19	Engine Front Cover Bolt Retainer
20	Camshaft Position Actuator Solenoid Valve
21	Camshaft Position Actuator Assembly
22	Crankshaft Sprocket Washer
23	Crankshaft Sprocket Assembly
24	Timing Chain Assembly
25	Balancer Chain Assembly
26	Timing Chain Tensioner Bolt
27	Timing Chain Tensioner Kit
28	Balancer Shaft Retainer Bolt
29	Balancer Chain Adjuster Guide
30	Camshaft Retainer Bolt
31	Camshaft Retainer
32	Balancer Shaft Driven Sprocket Bolt
33	Balancer Shaft Driven Sprocket
34	Balancer Shaft Retainer Bolt
35	Balancer Shaft Retainer
36	Camshaft Assembly
37	Balancer Shaft
38	Camshaft Bearings
39	Camshaft Bearing
40	Balancer Shaft Front Bearing
41	Balancer Shaft Rear Bearing
42	Engine Coolant Manifold Bolt - Long
43	Engine Coolant Manifold Bolt - Medium
44	Belt Idler Pulley Bolt
45	Belt Idler Pulley
46	Engine Coolant Manifold Bolt - Short
47	Engine Coolant Manifold Assembly
48	Engine Coolant Thermostat Housing Gasket
49	Engine Coolant Thermostat Assembly
50	Engine Coolant Thermostat Housing
51	Engine Coolant Thermostat Housing Bolt
52	Engine Coolant Manifold Gasket
53	Engine Block Assembly
54	Vacuum Pump Bolt - Short
55	Vacuum Pump Bolt - Medium
56	Vacuum Pump Bolt - Long
57	Vacuum Pump Assembly
58	Vacuum Pump Gasket
59	Oil Pump Assembly
60	Oil Pump Bolt

Fuel Delivery System and Components

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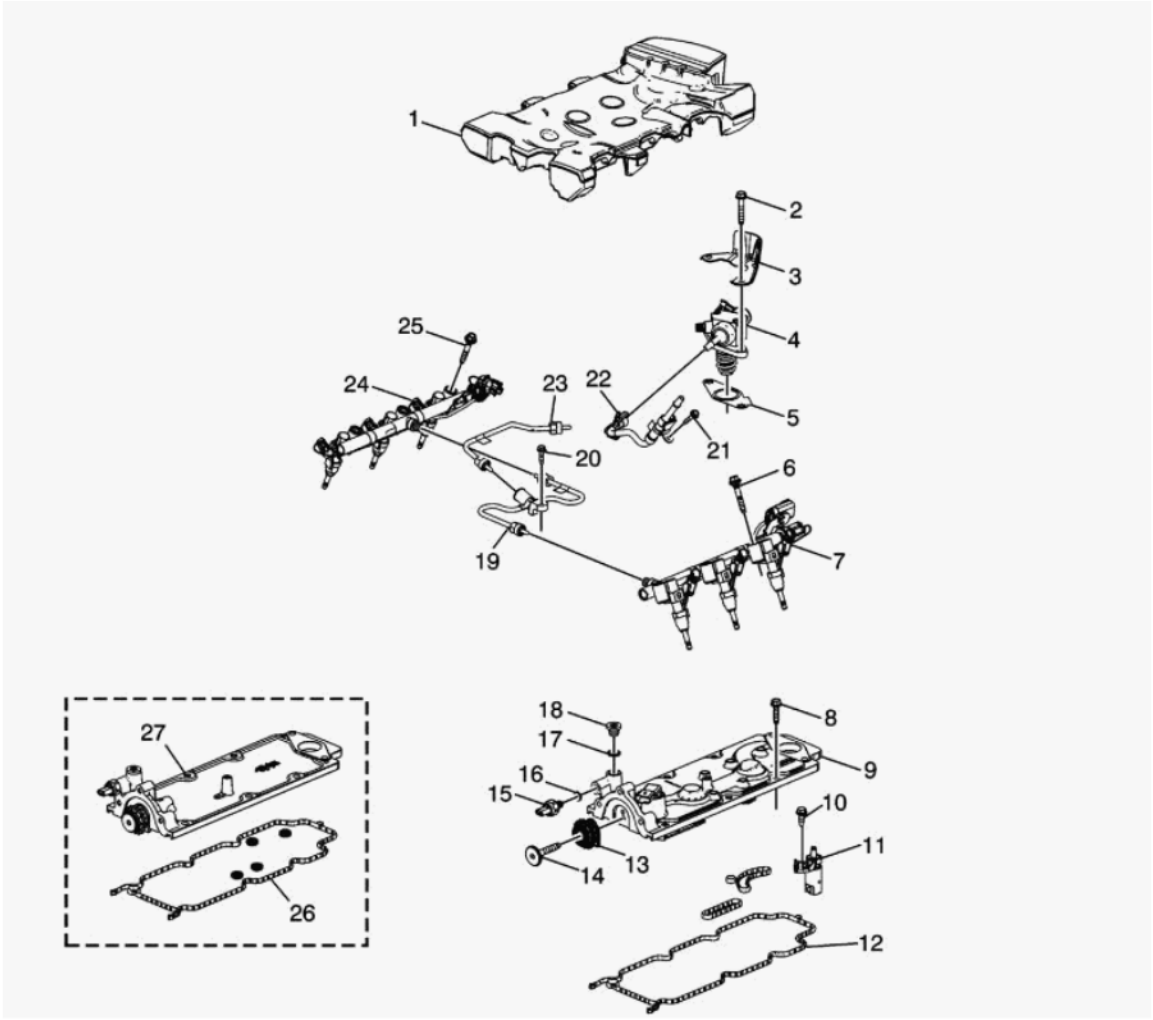

Fig. 9: Fuel Delivery System and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Pump Insulator
2	Fuel Pump Bolt
3	Fuel Pump Cover
4	Fuel Pump Assembly
5	Fuel Pump Gasket
6	Fuel Injection Fuel Rail Bolt
7	Direct Fuel Injection Fuel Rail Assembly - Left Side
8	Valve Lifter Oil Manifold Bolt
9	Valve Lifter Oil Manifold Assembly
10	Valve Lifter Follower Guide Assembly Bolt
11	Valve Lifter Follower Guide Assembly
12	Valve Lifter Oil Manifold Gasket
13	Balancer Shaft Sprocket Assembly
14	Balancer Shaft Sprocket Bolt
15	Engine Oil Pressure Sensor Assembly
16	Engine Oil Pressure Sensor Assembly Seal
17	Valve Lifter Oil Manifold Plug Seal

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Callout	Component Name
18	Valve Lifter Oil Manifold Plug
19	Fuel Feed Intermediate Pipe
20	Fuel Feed Intermediate Pipe Bolt
21	Fuel Feed Pipe Bolt
22	Fuel Feed Pipe Assembly
23	Fuel Feed Intermediate Pipe
24	Direct Fuel Injection Fuel Rail Assembly - Right Side
25	Fuel Injection Fuel Rail Bolt
26	Engine Block Valley Cover Gasket
27	Engine Block Valley Cover

Lower Engine and Components

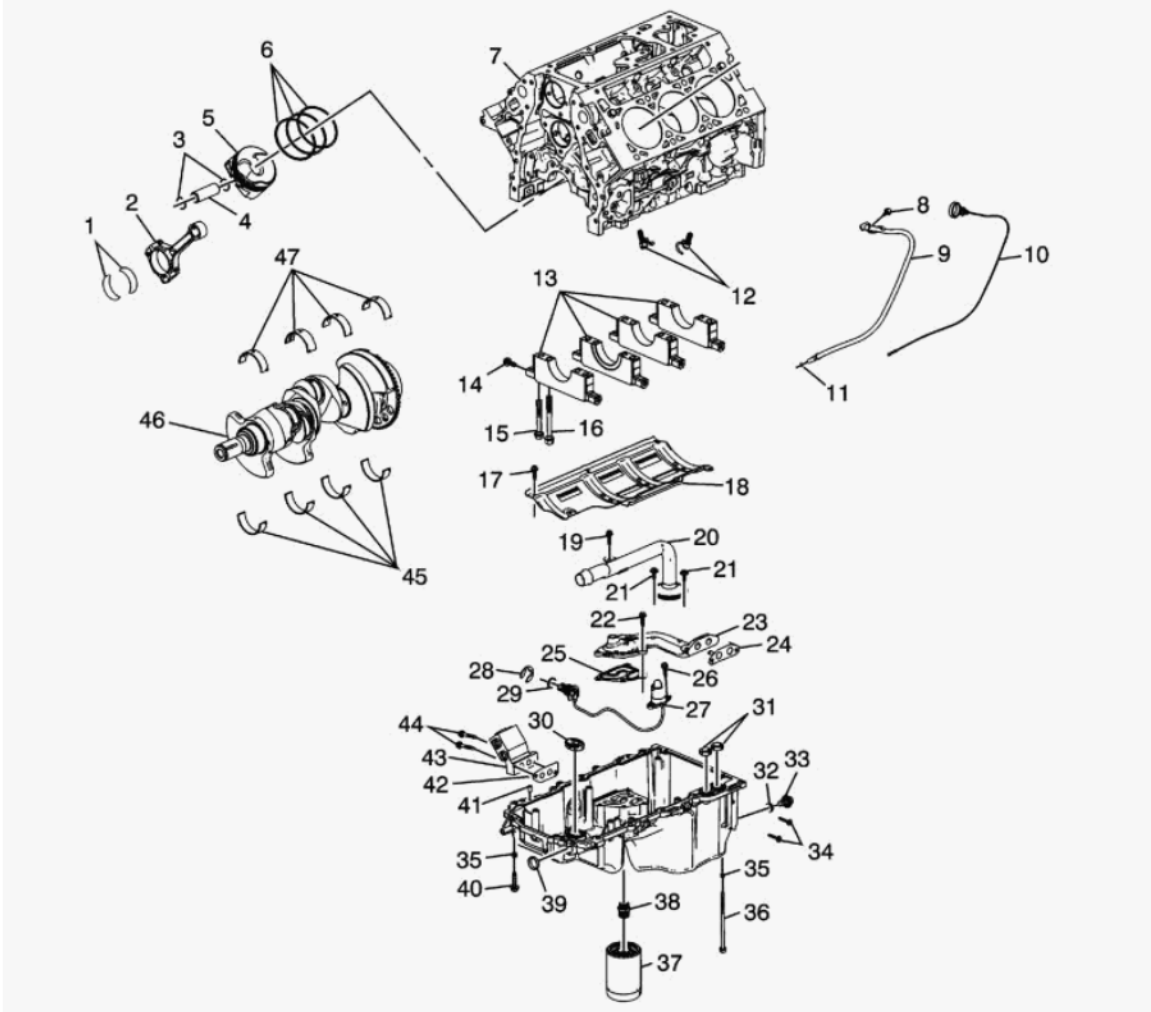

Fig. 10: Lower Engine and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Connecting Rod Bushing
2	Connecting Rod Assembly
3	Piston Pin Retainer
4	Piston Pin

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Callout	Component Name
5	Piston
6	Piston Ring Set
7	Engine Block Assembly
8	Oil Level Indicator Tube Bolt
9	Oil Level Indicator Tube
10	Oil Level Indicator Assembly
11	Oil Level Indicator Tube Seal
12	Piston Oil Nozzle Assembly
13	Crankshaft Bearing Cap
14	Crankshaft Bearing Cap Bolt - Side
15	Crankshaft Bearing Cap Bolt - Short
16	Crankshaft Bearing Cap Bolt - Long
17	Crankshaft Oil Deflector Bolt
18	Crankshaft Oil Deflector
19	Oil Pump Suction Pipe Bracket Bolt
20	Oil Pump Screen Assembly (w/Suction Pipe)
21	Oil Pump Suction Pipe Bolt
22	Oil Filter Center Tube Bolt
23	Oil Filter Center Tube
24	Oil Filter Center Tube Gasket
25	Oil Filter Center Tube Gasket
26	Oil Level Indicator Switch Bolt
27	Oil Level Indicator Switch
28	Oil Level Sensor Lead Clip
29	Oil Level Indicator Switch Seal
30	Oil Pan Front Cover Seal
31	Oil Pan High Pressure Port Seal
32	Oil Pan Drain Plug Seal
33	Oil Pan Drain Plug
34	Oil Filter Center Tube Bolt
35	Oil Pan Bolt Retainer
36	Oil Pan Bolt
37	Oil Filter
38	Oil Filter Fitting
39	Oil Pan Cup Plug
40	Oil Pan Bolt
41	Oil Pan Locating Pin
42	Crankshaft Lower Bearing
43	Crankshaft Assembly
44	Crankshaft Upper Bearing

Rear of Engine

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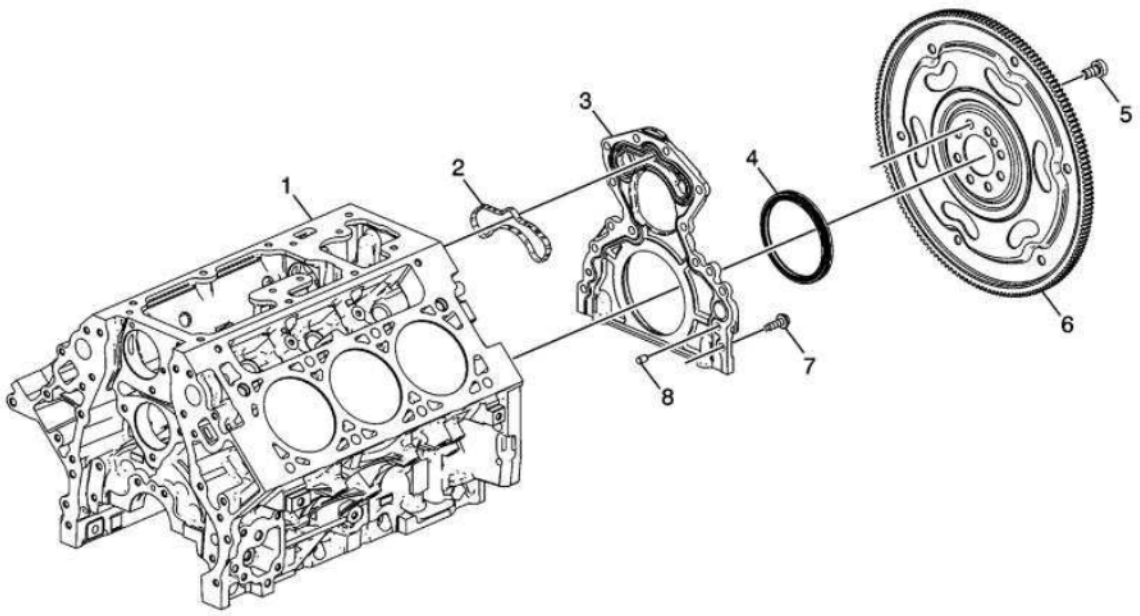

Fig. 11: Rear of Engine
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Block
2	Crankshaft Rear Oil Seal Housing Gasket
3	Crankshaft Rear Oil Seal Housing
4	Crankshaft Rear Oil Seal
5	Automatic Transmission Flex Plate Bolt
6	Automatic Transmission Flex Plate
7	Crankshaft Rear Oil Seal Housing Bolt
8	Crankshaft Rear Oil Seal Housing Locating Pin

Oil Pump Assembly

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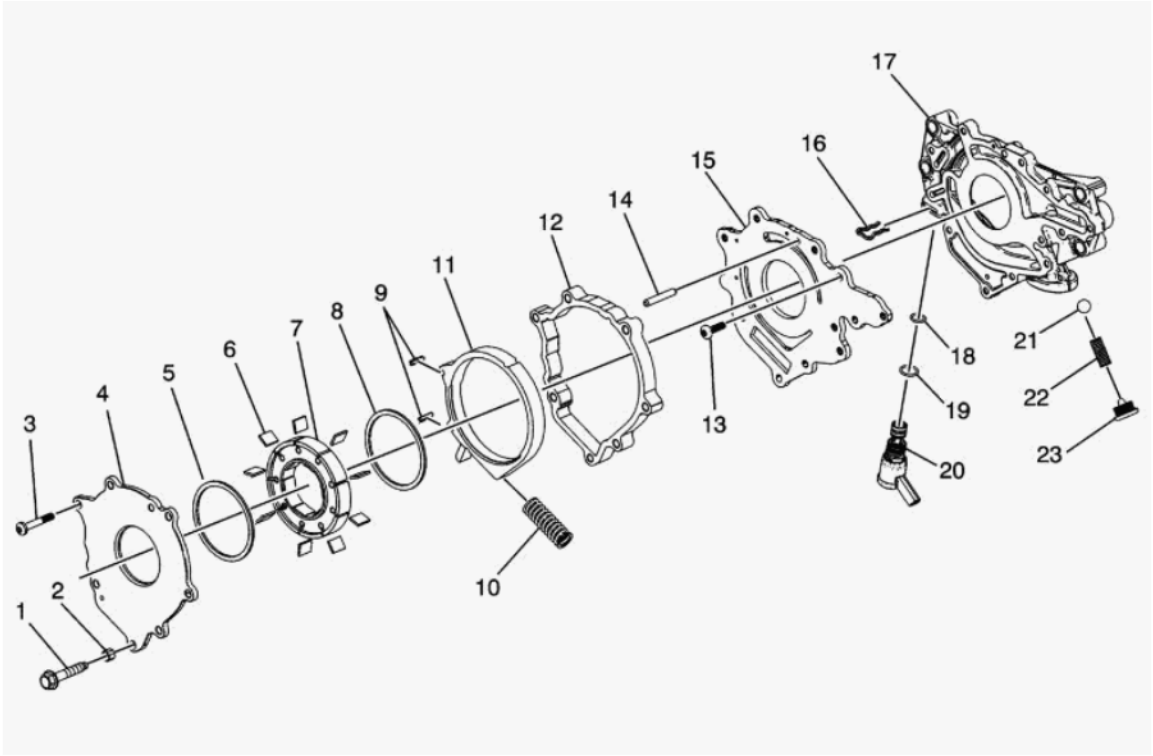

Fig. 12: Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Cover Bolt
2	Bolt Retainer
3	Oil Pump Cover Bolt
4	Oil Pump Cover
5	Oil Pump Vane Ring
6	Oil Pump Vane
7	Oil Pump Vane Rotor
8	Oil Pump Vane Ring
9	Oil Pump Slide Seal
10	Oil Pump Slide Spring
11	Oil Pump Slide
12	Oil Pump Intermediate Housing
13	Oil Pump Rear Cover Bolt
14	Oil Pump Slide Pivot Pin
15	Oil Pump Rear Cover
16	Oil Pump Flow Control Solenoid Retainer
17	Oil Pump Housing
18	Oil Pump Flow Control Solenoid O-ring
19	Oil Pump Flow Control Solenoid O-ring
20	Oil Pump Flow Control Solenoid
21	Oil Pressure Relief Valve
22	Oil Pressure Relief Valve Spring
23	Oil Pressure Relief Valve Bore Plug

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Intake Manifold and Components

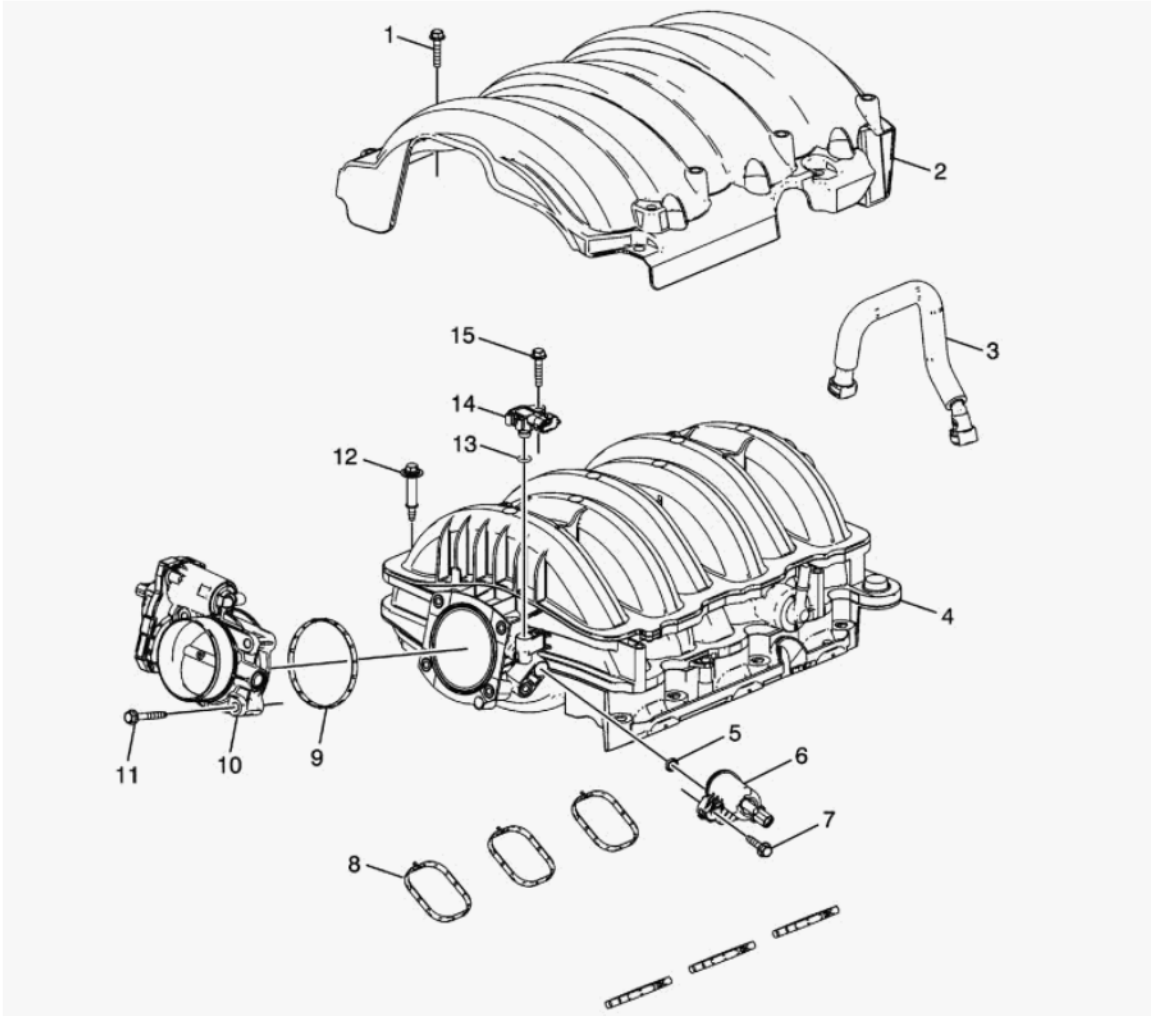

Fig. 13: Intake Manifold and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Cover Bolt
2	Intake Manifold Cover Assembly
3	PCV Tube Assembly
4	Intake Manifold Assembly
5	EVAP Emission Canister Purge Valve Seal
6	EVAP Emission Canister Purge Valve
7	EVAP Emission Canister Purge Valve Bolt
8	Intake Manifold Gasket
9	Throttle Body Gasket
10	Throttle Body Assembly
11	Throttle Body Bolt
12	Intake Manifold Bolt
13	MAP Sensor Seal
14	MAP Sensor
15	MAP Sensor Bolt

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Engine Block Plugs/Sensors

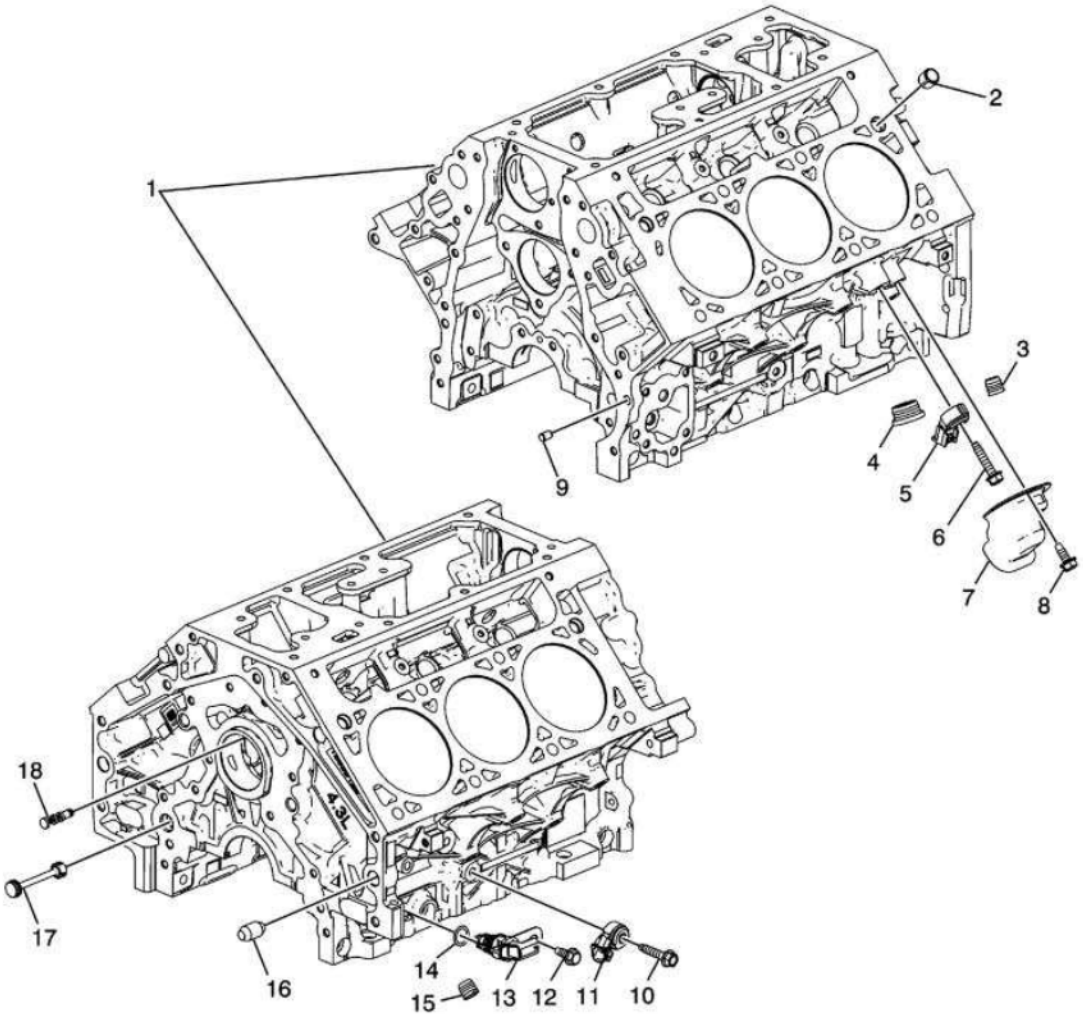

Fig. 14: Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Block
2	Cylinder Head Locating Pin
3	Engine Block Plug
4	Engine Block Plug
5	Knock Sensor Assembly
6	Knock Sensor Bolt
7	Knock Sensor Shield
8	Knock Sensor Shield Bolt
9	Engine Front Cover Locating Pin
10	Knock Sensor Bolt
11	Knock Sensor Assembly
12	Crankshaft Position Sensor Bolt
13	Crankshaft Position Sensor Assembly
14	Crankshaft Position Sensor Seal
15	Engine Block Plug
16	Transmission Locating Pin

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Callout	Component Name
17	Engine Block Oil Gallery Plug
18	Engine Block Oil Gallery Plug

ENGINE IDENTIFICATION

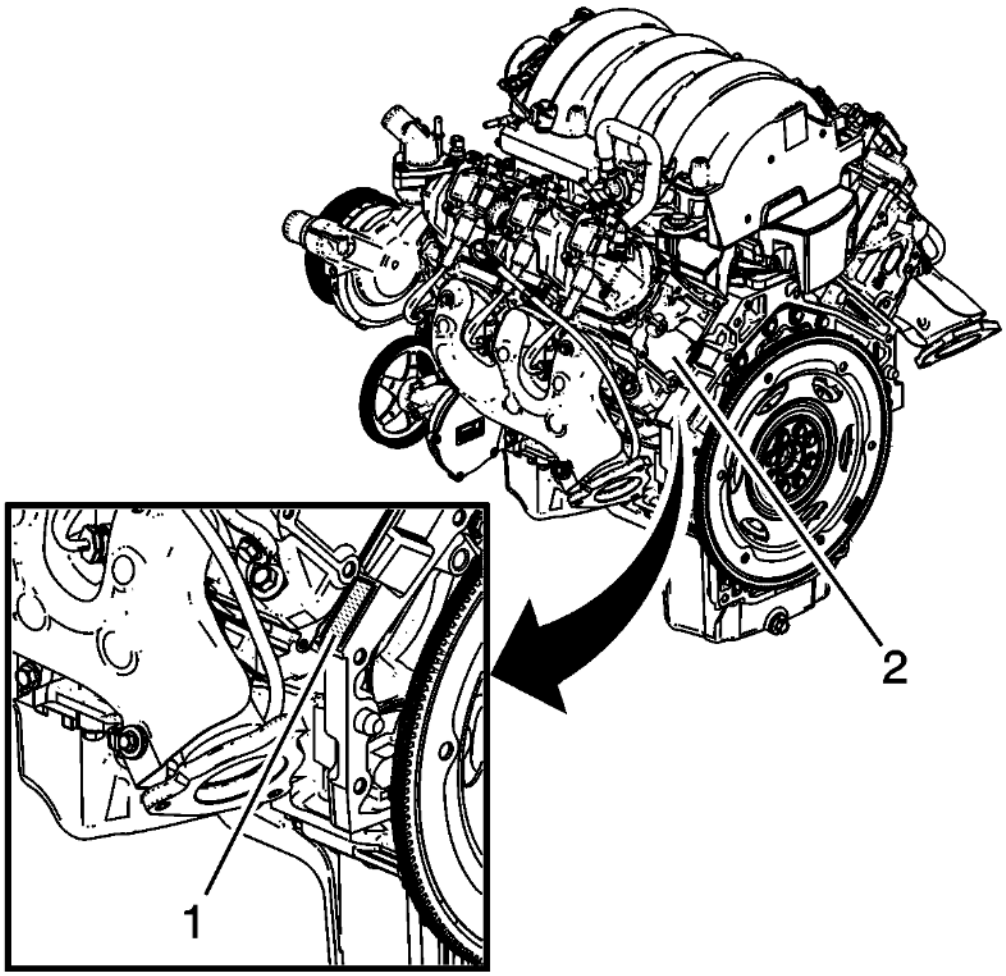

Fig. 15: Locating Vehicle Identification Number
Courtesy of GENERAL MOTORS COMPANY

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

- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last 6 digits of the VIN.

Engine identification can also be made through use of the Engine Traceability label (2) on the rear of the left cylinder head.

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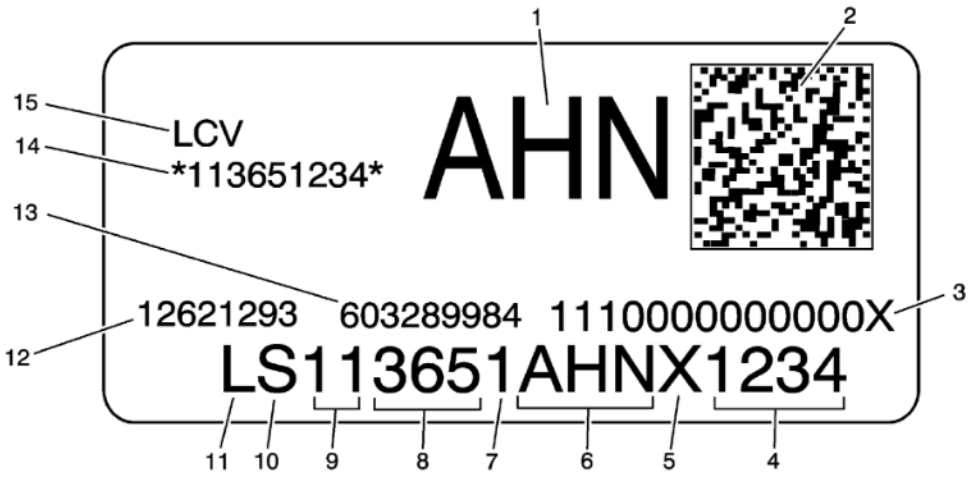

Fig. 16: Engine Traceability Label
Courtesy of GENERAL MOTORS COMPANY

1. Broadcast Code
2. Machine Readable 2D Matrix
3. VPPS Code
4. Part Sequence Number
5. Reserved use
6. Broadcast Code
7. Model year
8. Julian Date
9. Build Year
10. Shift ID
11. Plant ID
12. GM Part Number
13. Plant DUNS Number
14. Sequence Number
15. RPO/Engine Family Code

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptors

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

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Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P0030, P0031, P0050, P0051, P0135, P0155, P0300, P0443, P0458, P0506, P06DA, P3401, P3403, P3417, P3425, P3427, P3441, P3443, P3449, P3451	P06DA	P0690	-
Control	P06DB	P06DA	P06DC	P06DD, P06DE

Circuit/System Description

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate an electrical problem with the engine oil pressure control solenoid or wiring.

Conditions for Running the DTC

- The system voltage is greater than 11 V.
- DTC P06DA, P06DB or P06DC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for a minimum of 0.25 s.

Action Taken When the DTC Sets

- DTC P06DA, P06DB and P06DC are Type B DTCs.
- ECM commands the engine oil pressure control solenoid valve OFF.
- ECM commands Reduced Engine Power.

Conditions for Clearing the MIL/DTC

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- DTC P06DA, P06DB and P06DC are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    - Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status
    - Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status
    - Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status
    - **If Malfunction is displayed**

      Refer to Circuit/System Testing.

    - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
    - **If any DTC sets**

      Refer to Circuit/System Testing.

    - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the oil pressure control solenoid jumper harness X173. Refer to **Master Electrical**

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Component List .

2. Ignition ON.
3. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**

      NOTE: **An internal short in any component supplied by the fuse may cause the fuse to open and set a DTC when the component is activated.**

    1. Ignition OFF, remove the test lamp.
    2. Test for less than 2 Ω in the ignition circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp.
    2. Test for infinite resistance between the ignition circuit and ground
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, test all the components connected to fuse and replace as necessary.
    - **If the test lamp illuminates**
4. Verify that a test lamp does not illuminate between the ignition circuit terminal 1 and the control circuit terminal 2.
    - **If the test lamp illuminates**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Remove the test lamp, command the Q44 Engine Oil Pressure Control Solenoid Valve ON with a scan tool.
6. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status parameter displays OK.
    - **If OK is not displayed**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If OK is displayed**
7. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.
8. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Circuit High Voltage Test Status parameter is displaying Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    - **If Malfunction is not displayed**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.

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- If less than 2 Ω replace the K20 Engine Control Module.
- **If Malfunction is displayed**

9. Test or replace the Q44 Engine Oil Pressure Control Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the Q44 Engine Oil Pressure Control Solenoid Valve.
2. Test for 10-30 Ω between the control terminal 2 and the ignition voltage terminal 1.
   - **If not between 10.0-30.0 Ω**

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

   - **If between 10.0-30.0 Ω**
3. Test for infinite resistance between each terminal and the Q44 Engine Oil Pressure Control Solenoid Valve housing.
   - **If not OL**

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

   - **If OL**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Oil Pump Flow Control Solenoid Valve Replacement**Engine Oil Pressure Control Solenoid Valve Replacement.
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P06DA-P06DD: ENGINE OIL PRESSURE CONTROL SOLENOID

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

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DTC P06DD

Engine Oil Pressure Control Solenoid Valve Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P06DA, P06DB*	P06DA, P06DB	P0690	-
Control	P06DB	P06DA	P06DC	P06DD
*Additional DTCs may set.				

Circuit/System Description

Circuit	Description
Ignition>	Supplied from a fuse.
Control	The output circuit is switched to ground to activate the component.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
Q44 Engine Oil Pressure Control Solenoid Valve	A solenoid valve is an electro-mechanically operated valve. The valve is controlled by an electric current through the solenoid.

The engine oil pressure control solenoid valve is used to control engine oil pressure inside the mechanical engine oil pump. The control module controls the commanded state of the solenoid valve based on the following inputs:

- Engine Speed
- Calculated Engine Oil Temperature
- Engine Oil Pressure
- Engine Run Time

When the solenoid valve is commanded Off, oil pressure is higher. When the solenoid valve is commanded On, oil pressure is lower.

Conditions for Running the DTC

P06DA, P06DB, P06DC

- Engine=Running
- Ignition Voltage =Greater than 11 V

Frequency the DTC runs=Continuously-After the running conditions are met

P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228,

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P2229, P2230 = Not set

- Engine Speed =1500 to 2500 RPM

Frequency the DTC runs=Continuously-After the running conditions are met

Conditions for Setting the DTC

P06DA, P06DB, P06DC

Control Circuit=Commanded state does not match the actual state-For greater than 1 s

P06DD

Engine Oil Pressure =Less than a predefined threshold

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type B DTC

- Engine Oil Pressure Control Solenoid Valve =Off
- Reduced Engine Power =Active

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category=Type B DTC

Reference Information

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

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NOTE: **The engine oil level and condition is critical to the correct operation of the system.**

1. Ignition - On/Vehicle - In Service Mode
2. Verify there are no DTCs set related to the following system/component:
   - B35 Engine Oil Level Switch
   - B37B Engine Oil Pressure Sensor
   - B36 Engine Oil Temperature Sensor
   - **If other DTCs are set**

     Refer to:**Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If no other DTCs are set**
3. Verify the condition does not exist: Engine Oil-Contaminated/Dirty/Fill Level=Low
   - **If a condition exists**

     Repair as necessary

   - **If no condition exists**
4. Perform the scan tool control function:Engine Oil Pressure Control Solenoid Valve - On and Off

   Verify the scan tool parameter:

   - Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status =OK or Not Run
   - Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status =OK or Not Run
   - Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status =OK or Not Run
   - **If not the specified state**

     Refer to: Circuit/System Testing

   - **If the specified state**
5. Engine - Running
6. Perform the following steps:
   1. Increase the engine speed slowly to 1800 RPM.

      NOTE: **Using the scan tool line graph function may make it easier to identify if the value changes.**

   2. Perform the scan tool control function:Engine Oil Pressure Control Solenoid Valve - On

      Verify the scan tool parameter: Engine Oil Pressure =Change is greater than 30 kPa (4 PSI)

      - If the change is 30 kPa (4 PSI) or less - Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve
      - If the change is greater than 30 kPa (4 PSI)
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

   Verify the DTC does not set.

   - **If the DTC sets**

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Refer to: Circuit/System Testing

- **If the DTC is not set**

8. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems - Off
2. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
3. Ignition - On/Vehicle - In Service Mode
4. Verify a test lamp turns On between the test points:Ignition circuit terminal 1/A & Ground
   - **If the test lamp does not turn On and the circuit fuse is OK**
   1. Ignition/Vehicle - Off & Remove - Test lamp
   2. Test for less than 2 ohms between the test points:Ignition circuit terminal 1/A & Output terminal@Fuse
      - If 2 ohms or greater - Repair the open/high resistance in the circuit.
      - If less than 2 ohms - Verify the fuse is OK and there is voltage at the fuse.
   - **If the test lamp does not turn On and the circuit fuse is open**
   1. Ignition/Vehicle - Off & Remove - Test lamp

      NOTE: **The ignition circuit supplies voltage to other components. Test all circuits for a short to ground or test all components for being shorted.**

   2. Test for infinite resistance between the test points:Ignition circuit terminal 1/A & Ground
      - If less than infinite resistance - Repair the short to ground on the circuit.
      - If infinite resistance - Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
   - **If the test lamp turns On**
5. Verify a test lamp does not turn On between the test points:Control circuit terminal 2/B & B+
   - **If the test lamp turns On**
   1. Ignition/Vehicle - Off & Remove - Test lamp
   2. Disconnect the electrical connector: K20 Engine Control Module
   3. Test for infinite resistance between the test points:Control circuit terminal 2/B @Component harness & Ground
      - If less than infinite resistance - Repair the short to ground on the circuit.
      - If infinite resistance - Replace the component: K20 Engine Control Module
   - **If the test lamp does not turn On**
6. Remove - Test Lamp
7. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - On

   Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status =OK or Not Run

   - **If not the specified state**
   1. Ignition/Vehicle - Off
   2. Disconnect the electrical connector: K20 Engine Control Module
   3. Ignition - On/Vehicle - In Service Mode
   4. Test for less than 1 V between the test points:Control circuit terminal 2/B @Component harness & Ground

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- If 1 V or greater - Repair the short to voltage on the circuit.
- If less than 1 V - Replace the component: K20 Engine Control Module

- **If the specified state**

8. Connect a 3 A fused jumper wire between the test points:Control circuit terminal 2/B & Ignition circuit terminal 1/A
9. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - On

   Verify the scan tool parameter: Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status =Malfunction

   - **If not the specified state**

   1. Ignition/Vehicle - Off & Remove - Jumper wire(s)
   2. Disconnect the electrical connector: K20 Engine Control Module
   3. Test for less than 2 ohms between the test points:Control circuit terminal 2/B @Component harness & The other end of the circuit@Control module harness
      - If 2 ohms or greater - Repair the open/high resistance in the circuit.
      - If less than 2 ohms - Replace the component: K20 Engine Control Module
   - **If the specified state**

10. Test or replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

Component Testing

Static Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector:Q44 Engine Oil Pressure Control Solenoid Valve
3. Test for 10 to 30 ohms between the test points:Control terminal 2/B & Ignition terminal 1/A
   - **If not between 10 and 30 ohms**

     Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

   - **If between 10 and 30 ohms**
4. Test for infinite resistance between the test points:Each terminal of the component & The component's housing
   - **If less than infinite resistance**

     Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

   - **If infinite resistance**
5. All OK.

Dynamic Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector:Q44 Engine Oil Pressure Control Solenoid Valve
3. Connect a 3 A fused jumper wire between the test points:Ignition terminal 1/A & 12 V

   CAUTION: Complete the testing as quickly as possible in order to prevent overheating and damaging the component.

4. Momentarily connect a jumper wire between the test points:Control terminal 2/B & Ground

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Verify the component turns On and Off when connecting and disconnecting the jumper wire:Q44 Engine Oil Pressure Control Solenoid Valve

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: **Diagnostic Repair Verification**

- **Oil Pump Flow Control Solenoid Valve Replacement**-Q44 Engine Oil Pressure Control Solenoid Valve
- For control module replacement, programming, and setup refer to: **Control Module References**

DTC P06DD OR P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK OFF/ON

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptors

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Circuit/System Description

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate either a stuck on or stuck off engine oil pressure control solenoid.

Conditions for Running the DTC

P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229 or P2230 is not set.
- Engine speed within range of 1,500 RPM to 2,500 RPM.

P06DE

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- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229 or P2230 is not set.
- Engine running for greater than 20 s.
- Engine speed is within range of 1500 RPM to 2500 RPM.
- Engine oil pressure control solenoid in low pressure for greater than 1.5 s.

Conditions for Setting the DTC

P06DD or P06DE

Engine oil pressure is above or below a calibrated amount during the time the solenoid is changing from ON to OFF states.

Action Taken When the DTC Sets

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type B DTC.

Conditions for Clearing the DTC

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

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Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify correct engine oil level and condition. Refer to **Engine Mechanical Specifications**.
2. Engine Running, verify the scan tool Engine Oil Pressure parameter changes when commanding the Engine Oil Pressure Control Solenoid On and Off.
   - **If the parameter does not change**

     Replace the Q44 Engine Oil Pressure Control Solenoid.

   - **If the parameter changes**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to **Oil Pressure Diagnosis and Testing**.

   - **If the DTC does not set**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Oil Pump Flow Control Solenoid Valve Replacement Oil Pump Flow Control Solenoid Valve Replacement

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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

Visual/Physical Inspection

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

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a normal condition.

Intermittent

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

Symptom List

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

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
High oil pressure	• Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.

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Cause	Correction
Damaged, loose or improperly installed crankshaft balancer A misfire DTC may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to **Crankshaft Balancer Replacement**.
Worn, damaged, or improperly installed crankshaft reluctor wheel A worn or damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the wear or damage. • 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 re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery. A DTC P0300 or P0336 may be set.	• Inspect the crankshaft position sensor. • Inspect the crankshaft reluctor wheel. • Inspect the crankshaft. • Repair or replace damaged components as required.
Damaged, loose or improperly installed engine flywheel A misfire DTC may be present without an actual misfire condition	• Inspect the flywheel. • Repair or replace damaged components as required. Refer to **Engine Flywheel Replacement**.
Damaged, improperly installed or restricted exhaust system, collapsed or dented pipes, plugged mufflers or malfunctioning catalytic converters A DTC may be present without an actual fault condition.	• Inspect the exhaust system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed vacuum hoses	• Inspect the vacuum system components. • Repair or replace damaged components as required.
Damaged or improperly installed MAP sensor, sealing grommet nicked, torn or missing	• Inspect the MAP sensor. • Repair or replace damaged components as required.
Damaged or improperly installed throttle body	• Inspect the throttle body. • Repair or replace damaged components as required.

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Cause	Correction
Damaged or improperly installed intake manifold	• Inspect the intake manifold. • Repair or replace damaged components as required.
Damaged or improperly installed cylinder head Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as required.
Worn, damaged or loose valve rocker arm	• Inspect the valve rocker arms. • Repair or replace damaged components as required.
Worn, damaged or loose valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Worn, damaged, loose or broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.

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Cause	Correction
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.
Worn, damaged or improperly installed piston Pistons must be installed with the mark, or dimple, on the top of the piston, facing the front of the engine; piston pins must be centered in the connecting rod pin bore. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine engine flywheel, flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the engine flywheel, flex plate, and/or balancer, as required. Refer to **Engine Flywheel Removal**, and **Engine Flywheel Installation**, **Automatic Transmission Flex Plate Removal**, and **Automatic Transmission Flex Plate Installation**, and/or **Crankshaft Balancer Removal**, and **Crankshaft Balancer Installation**.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression

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Cause	Correction
	testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings, as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms, as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Stuck valves Carbon buildup on the valve stem can cause the valve to not 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.
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair, as required. Refer to **Oil Pressure Diagnosis and Testing**.
Improper operation of the active fuel management system	Repair, as required. Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis**.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. 3. 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**. 4. Repair or replace, as required.

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BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.

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

Cause	Correction
Fuel injector harness connectors are connected to the incorrect fuel injectors/cylinders	Relocate the fuel injector harness connectors, as necessary.
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire diagnostic trouble code (DTC). A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flex plate and/or balancer, as required. Refer to **Automatic Transmission Flex Plate Replacement**, or **Crankshaft Balancer Replacement**.
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 manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be	Repair or replace the MAP sensor, as required.

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

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Cause	Correction
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.	
Improper operation of the active fuel management system	Repair, as required. Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis**.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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

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

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Verify oil pressure. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components as required.
Detonation or spark knock	1. Verify the operation of the ignition controls system. Refer to **Diagnostic System Check - Vehicle** . 2. Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments in the accessory drive belt	1. Inspect the accessory drive system components. 2. Repair or replace damaged components as required.

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ENGINE NOISE UNDER LOAD

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

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.

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Cause	Correction
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material	• Inspect cylinder for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

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. **NOTE:** **While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in**	

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Cause	Correction
cooling system. It is important to follow the kit instructions. This is not a substitute for service information. Combustion leak tests are available from a wide variety of aftermarket suppliers. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection**, and **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

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

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Cause	Correction
3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection**, and **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS

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

ENGINE COMPRESSION TEST

Engine Compression Test

Special Tools

EN-22794 Spark Plug Port Adapter

Equivalent regional tools:**Special Tools (Diagnostic Tools)**

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

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge. You may wish to connect a battery charger for the duration of the test to maintain an adequate battery level.
2. Turn the engine OFF.
3. Remove the spark plug wires. **Spark Plug Wire Replacement**
4. Remove the spark plugs. **Spark Plug Replacement**
5. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position.

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The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.

6. Measure the engine compression, using the following procedure:
    1. Thread the **EN-22794** spark plug port adapter into the spark plug hole.
    2. Thread the compression gauge into the **EN-22794** spark plug port adapter.
    3. Enable cranking via the GDS2 or remote start switch (If using a remote switch, crank the engine for four compression strokes). Record the reading after cranking is complete.
    4. When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    5. Repeat the compression test for each cylinder.
7. Compare the compression readings from all of the cylinders.
    - The lowest reading should not be less than 70 percent of the highest reading.
    - No cylinder reading should be less than 690 kPa (100 PSI).
8. The following are indicators of potential problems:
    - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
    - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
    - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders
9. Disconnect the GDS2 diagnostic tool ore remote start switch.
10. Install the spark plugs. **Spark Plug Replacement**
11. Install the spark plug wires. **Spark Plug Wire Replacement**

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM COMPRESSION TEST

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

1. Measure the engine oil level. Fill, as required.
2. Perform the Diagnostic System Check - Vehicle. Refer to **Diagnostic System Check - Vehicle** .
3. Disable the ignition system for the cylinder to be tested, by disconnecting the electrical wire harness to the ignition coil.
4. Disable the fuel injection system for the cylinder to be tested, by disconnecting the electrical wire harness to the fuel injector.
5. Remove the spark plug and wire for the cylinder to be tested.
6. Install a 0-1 378 kPa (0-200 psi) compression gauge.
7. Start the engine.
8. Using the scan tool output controls, command the solenoid ON, for the cylinder to be deactivated.
9. Depress the Schrader valve on the compression gauge, in order to release the pressure and zero the gauge. With the engine running and the cylinder in active fuel management mode, the compression reading should be less than 172 kPa (25 psi).
10. Using the scan tool, de-energize the solenoid while observing the reading on the compression gauge. With the

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engine running and the cylinder NOT in active fuel management mode, the compression gauge reading should increase quickly to greater than 345 kPa (50 psi).

IMPORTANT: Only 1 cylinder can be tested at a time. When testing has been completed on a specific cylinder, the wire harness electrical connectors, spark plug, and spark plug wire must be installed prior to testing of each additional cylinder.

11. Test each of the 4 active fuel management cylinders, 1 at a time. If the readings are not within specifications, remove, and test the valve lifter oil manifold, as required. Refer to **Valve Lifter Oil Manifold Replacement**, and **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.
12. If the compression test has been performed and all active fuel management cylinders are operating within specifications, the active fuel management system is performing as designed and no repairs are required.
13. Clear the diagnostic trouble codes (DTCs) with a scan tool.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM TEST (LV3)

The Cylinder Deactivation (Active Fuel Management) System Test is a functional test of the valve lifter oil manifold and valve lifters. Using a scan tool, the technician can command the active fuel management solenoid for each cylinder on and off and monitor a specific cylinders ability to go into and out of active fuel management.

1. Measure the engine oil level. Fill, as required.
2. Perform the Diagnostic System Check - Vehicle. Refer to **Diagnostic System Check - Vehicle** .
3. Connect the scan tool.
4. Start the engine and idle.
5. Using the scan tool output controls, command the solenoid ON, for the cylinder to be deactivated. If the active fuel management system is working correctly, the engine should stumble and an engine RPM drop of at least 100 RPM should be observed.
6. Using the scan tool, de-energize the solenoid and perform step 5 for the remaining cylinders.
7. Test each of the 4 active fuel management cylinders, 1 at a time. If the behavior described in step 5 is not observed, remove, and test the valve lifter oil manifold, as required. Refer to **Valve Lifter Oil Manifold Replacement**, and **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.
8. If the system test has been performed and all active fuel management cylinders are operating normally, the active fuel management system is performing as designed and no repairs are required.
9. Clear the diagnostic trouble codes (DTCs) with a scan tool.

CYLINDER LEAKAGE TEST

Special Tools

J 35667-A Cylinder Head Leakdown Tester, or equivalent

For equivalent regional tools, refer to **Special Tools** .

NOTE: **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**

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- **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**

WARNING: **Refer to Battery Disconnect Warning .**

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

NOTE: **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** tester and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
   - Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or 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 **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes,

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Checks	Causes
	allow adequate drain down time, 2-3 minutes, and measure 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 Refer to **Crankcase Ventilation System Inspection/Diagnosis**. • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals Refer to **Spark Plug Inspection** . • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings, as necessary. Refer to **Cylinder Leakage Test**. • Piston and rings improperly installed or not fitted to the cylinder bore Refer to **Lower Engine Noise, Regardless of Engine Speed**.

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-21867** Pressure Gauge
- **EN-21867-850** Active Fuel Management Oil Pressure Adapter

For equivalent regional tools, refer to **Special Tools**.

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 gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
   - Oil diluted by water or glycol antifreeze

     Refer to **Coolant in Engine Oil**.
   - Foamy oil, which may be caused by a cut or damaged oil pump screen O-ring seal

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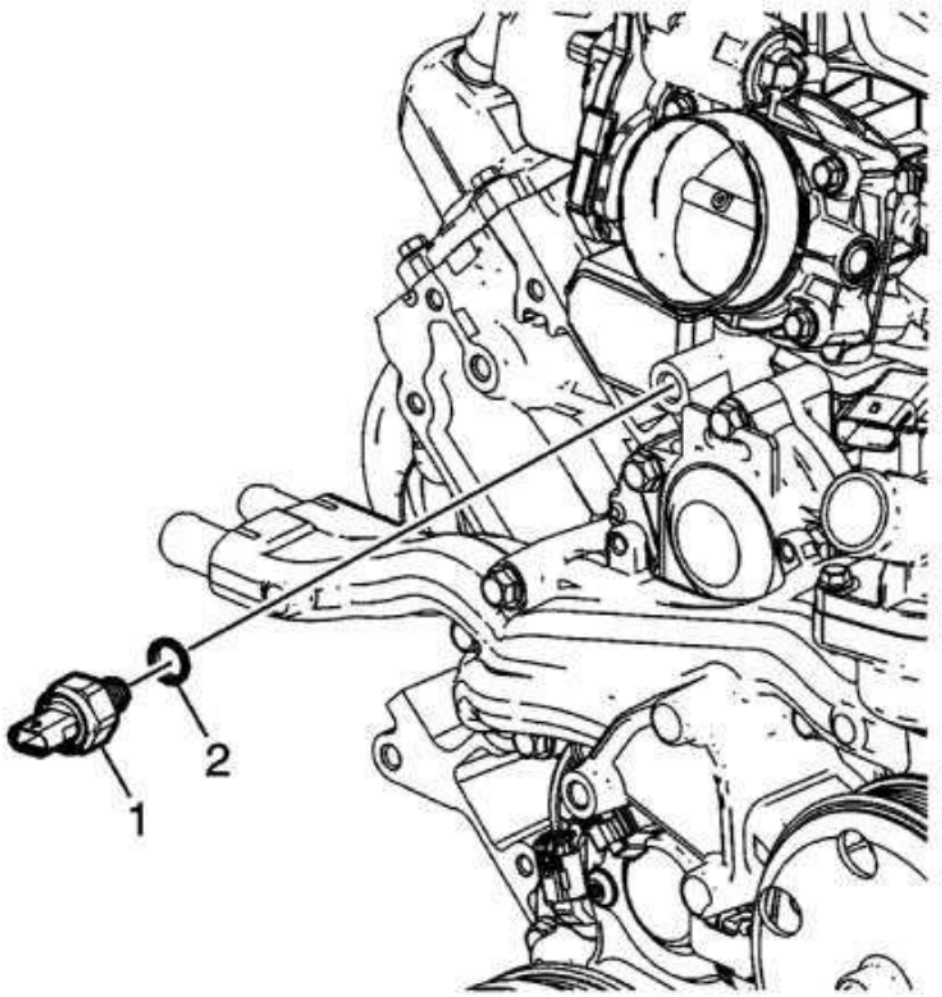

Fig. 17: Oil Pressure Sensor And Seal
Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil pressure sensor (1) and seal (2).

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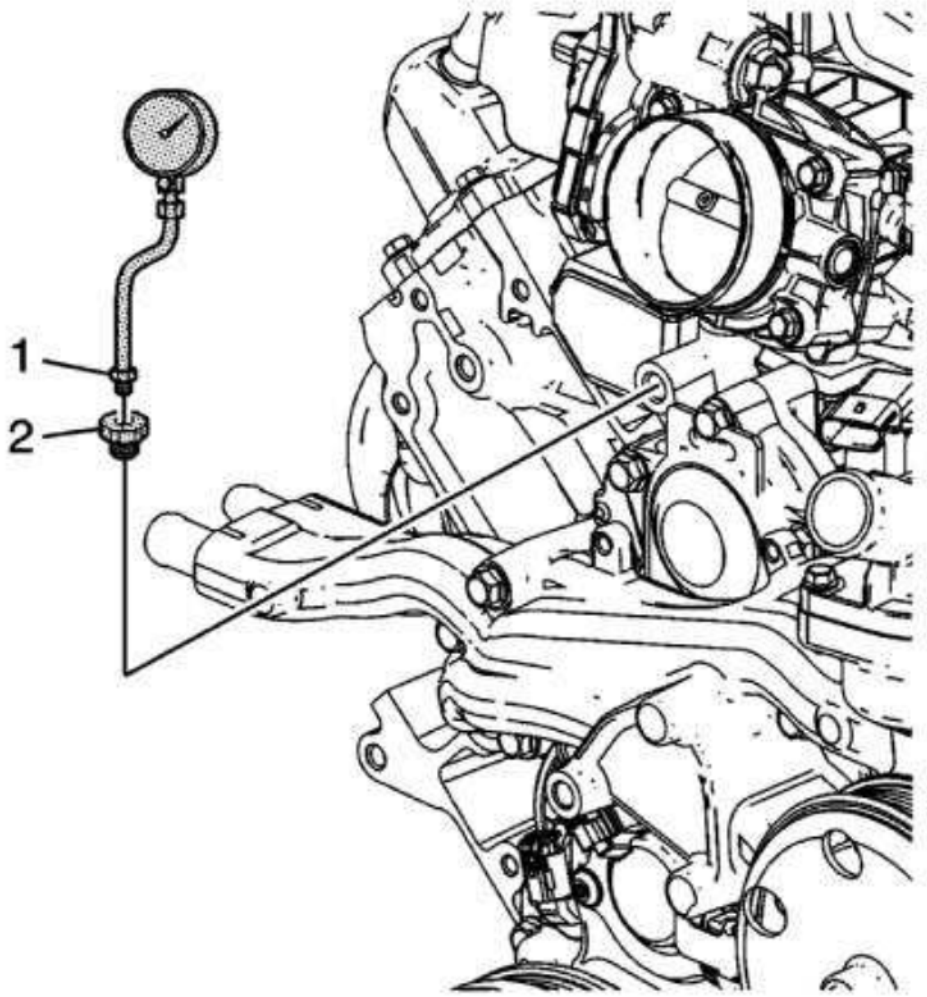

Fig. 18: EN-21867-850 Active Fuel Management Oil Pressure Adapter
Courtesy of GENERAL MOTORS COMPANY

7. Install the **EN-21867-850** active fuel management oil pressure adapter (2) and **EN-21867** pressure gauge (1), or equivalent.
8. Run the engine until the engine reaches normal operating temperature and measure the engine oil pressure.
9. Compare the readings to **Engine Mechanical Specifications**.
10. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
    - Valve lifter oil manifold filter plugged or damaged. Refer to **Valve Lifter Oil Manifold Cleaning and Inspection**.
    - Check if the engine oil cooler or oil cooler lines are plugged or damaged.
    - Oil pump worn or dirty. Refer to **Oil Pump Cleaning and Inspection**.
    - Oil pump-to-engine block bolts loose. Refer to **Oil Pump Installation**.
    - Oil pump screen loose, plugged, or damaged.
    - Oil pump screen O-ring seal missing or damaged.
    - Excessive debris in the oil pan and/or oil filter (possibly indicating internal engine damage).
    - Malfunctioning oil pump pressure relief valve. Refer to **DTC P06DA-P06DC**.
    - Excessive bearing clearance and/or bearing damage. Refer to **Crankshaft and Bearing Cleaning and Inspection**, and **Camshaft and Bearings Cleaning and Inspection**.
    - Cracked, porous, or restricted oil galleries.

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- Oil gallery plugs missing or incorrectly installed. Refer to **Engine Block Plug Installation**.

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

Special Tools

- **EN-46999** Active Fuel Management Tester
- **EN-46999-18** Active Fuel Management Tester Air Adapter
- **EN-46999-15** Active Fuel Management Tester Harness - Small Block V6

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)**

NOTE:

- **A minimum shop air source of 206 kPa (30 psi) is required for manifold testing.**
- **A water bleed is located on the side of the EN-46999 tester. Occasionally, depress the valve in order to remove excess water from the tool.**

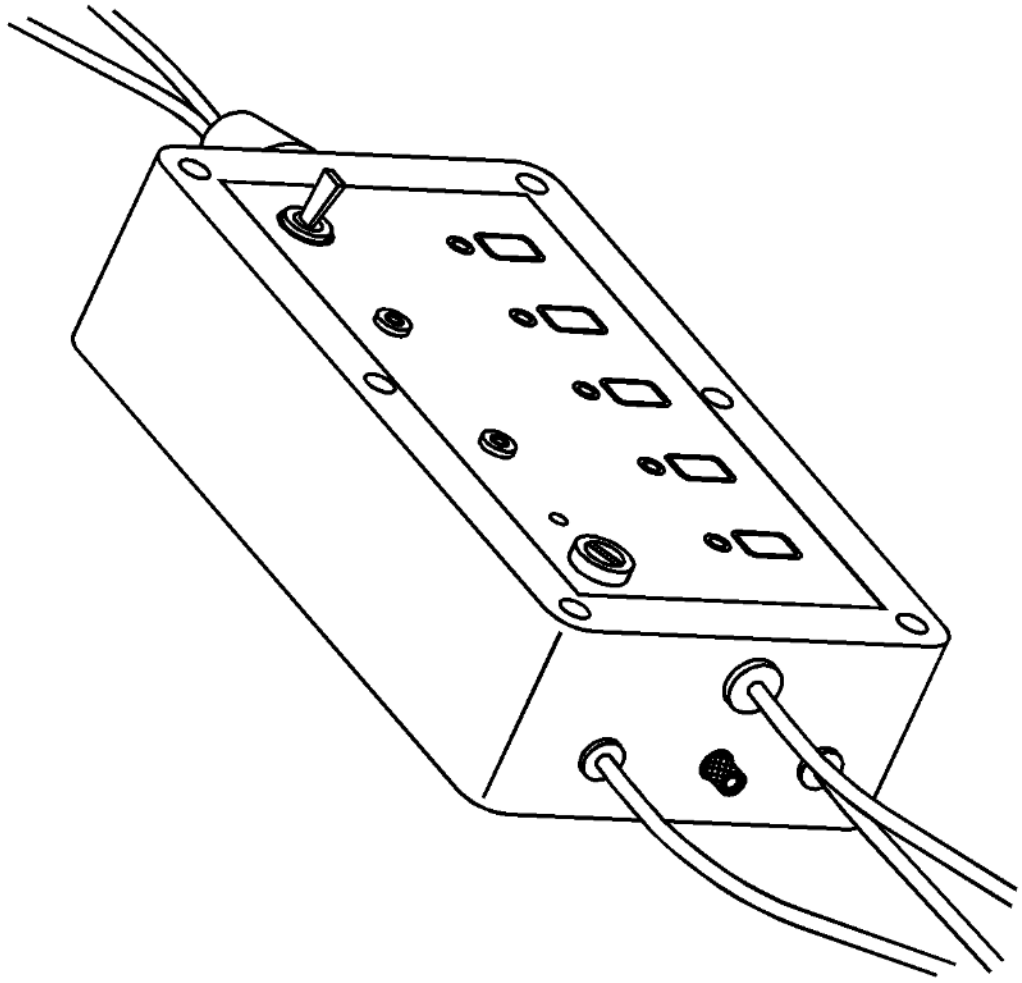

Fig. 19: Identifying Displacement On-Demand Tester
Courtesy of GENERAL MOTORS COMPANY

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

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

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

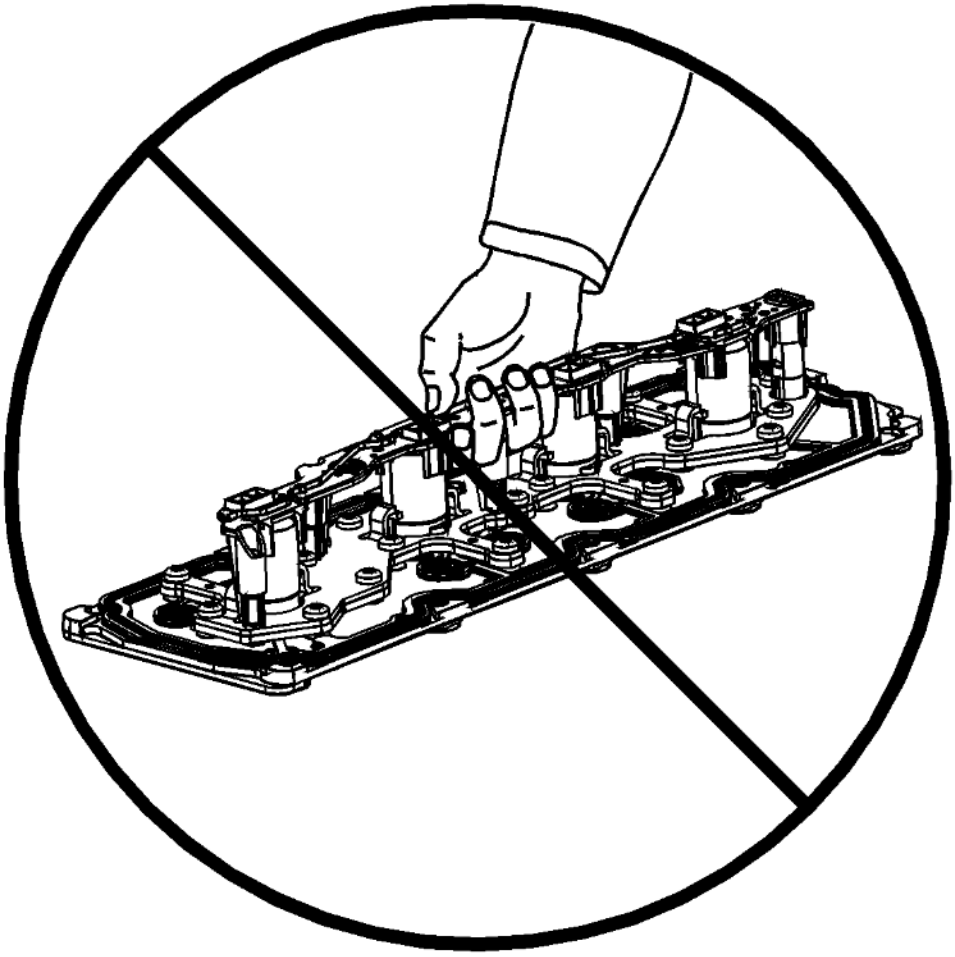

Fig. 20: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

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

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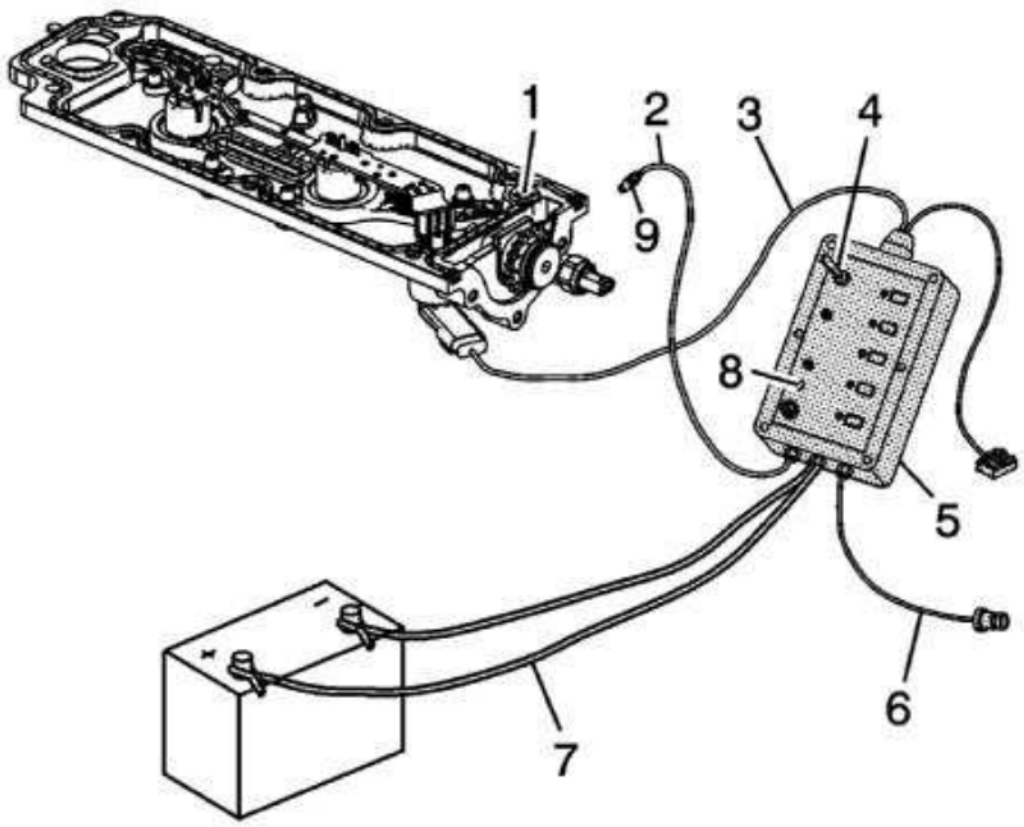

Fig. 21: EN-46999-18 Active Fuel Management Tester Air Adapter
Courtesy of GENERAL MOTORS COMPANY

3. Connect **EN-46999-18** active fuel management tester air adapter (9) to the air out hose (2) of the **EN-46999** tester (5). This will make it possible to connect an air nozzle fitted with a standard 1/4 in NPT female air fitting. Verify the air supply switch (4) is in the off position.
4. Connect the air out hose (6) of the **EN-46999** tester (5) to a shop air source.
5. Connect the 12 volt power supply connectors (7) of the **EN-46999** tester (5) to a 12 volt power supply. Verify the Power light (8) on the tool is illuminated. If the light on the tool is not illuminated when connected to a 12 volt power supply, test and/or replace the 3 amp fuse.
6. Connect the **EN-46999-15** active fuel management tester harness - small block V6 (3) to the tester. Connect **EN-46999-15** active fuel management tester harness - small block V6 to the electrical connector of the manifold.
7. Connect an air nozzle fitted with a tapered rubber tip to **EN-46999-18** active fuel management tester air adapter (9). Hold the tip of the air nozzle in the oil passage directly below the Valve Lifter Oil Manifold Oil Filter (1).

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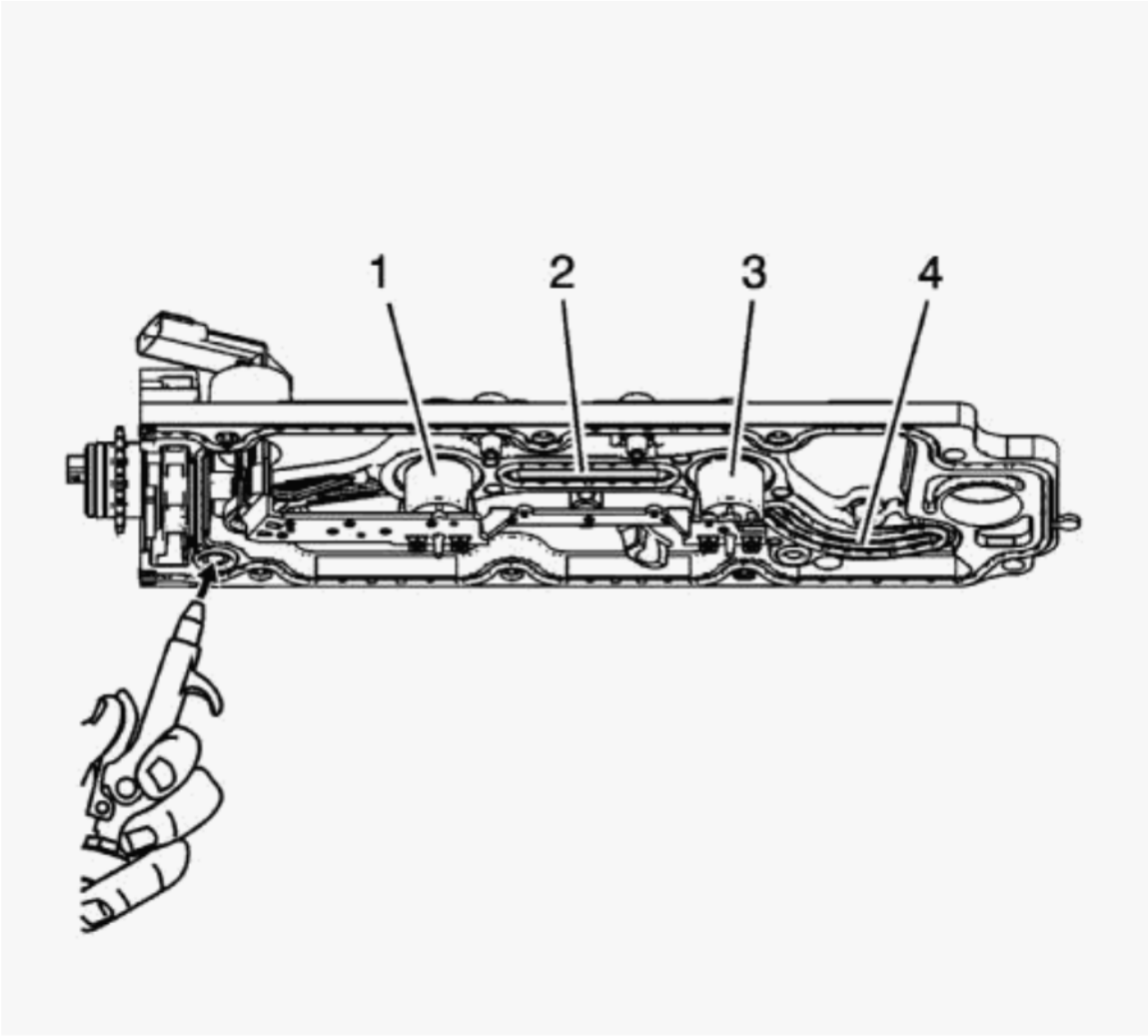

Fig. 22: Positioning Manifold Assembly Onto Bench At 45 Degree Angle
Courtesy of GENERAL MOTORS COMPANY

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

8. Turn the air supply switch of the **EN-46999** tester to the ON position. With the air supply connected to the manifold assembly and the solenoid/valves in the closed position, a limited amount of air will exit from the outlet ports (2,4) of the manifold.
9. Position the manifold assembly onto a bench at a 45 degree angle in order to test solenoid valves.
10. Depress button number 1 on the tool to activate the cylinder 3 solenoid/valve (1). With button 1 depressed, the cylinder 3 solenoid/valve (1) should open, allowing an increased amount of air to exit the outlet ports (2) of the manifold.
11. Depress button number 2 on the tool to activate the cylinder 6 solenoid/valve (2). With button 2 depressed, the cylinder 6 solenoid/valve (3) should open, allowing an increased amount of air to exit the outlet ports (4) of the manifold.

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DIAGNOSIS AND TESTING

1. Measure the engine oil level. Fill, as required.
2. Using the scan tool, inspect for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** . Repair, as required.

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3. Verify proper engine oil pressure and operation of the active fuel management oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Inspect the CMP actuator solenoid valve for proper operation. Refer to **Camshaft Position Actuator Solenoid Valve Inspection**.
    - If valve inspection confirms proper movement of the spool, replace the CMP actuator and CMP valve.
    - If valve inspection confirms improper movement of the spool, replace only the CMP valve.
5. Verify proper operation of the CMP actuator control system. Refer to **Diagnostic System Check - Vehicle** .

ENGINE OIL LEVEL SENSOR DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Engine Oil Level Sensor Signal	2	1	-
Engine Oil Level Sensor Ground	-	1	-
1. DIC message Engine Oil Level Low always ON 2. DIC message Engine Oil Level Low always OFF			

Typical Scan Tool Data

Engine Oil Level Switch

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON **Parameter Normal Range:** OK			
Engine Oil Level Sensor/Switch Signal	OK	Low	OK
Engine Oil Level Sensor/Switch Ground	-	Low	-

Circuit/System Description

The engine oil level sensor/switch is normally-closed with proper engine oil level. The switch opens when the engine oil level drops below a calibrated level. The engine control module (ECM) monitors the engine oil level signal circuit when the ignition is ON, and the engine is OFF. With the switch in the closed position, the ECM detects a low voltage on the signal circuit. With the switch in the open position, the ECM detects a high voltage on the signal circuit. When high voltage is detected on the signal circuit, the ECM will send a serial data message to the instrument panel cluster (IPC). The IPC will then display a message on the driver information center (DIC) or illuminate a low engine oil level lamp.

The following information determines the message sent from the ECM to the IPC:

- The Low Engine Oil Level message lamp is displayed only after the ECM detects a high voltage on the signal circuit for three consecutive ignition cycles, followed by an ignition OFF event from 15 minutes to greater than 50 minutes, depending on engine oil temperatures.
- The Low Engine Oil Level message is turned OFF when the ECM detects a low voltage on the signal circuit after an ignition OFF event for greater than 90 seconds, followed by an ignition ON event for less than 1 second.

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Reference Information

Schematic Reference

- **Engine Mechanical Schematics**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

- **Instrument Cluster Description and Operation**
- **Indicator/Warning Message Description and Operation**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Verify proper engine oil level.
   - **If not at proper level**

     Add oil as necessary.

   - **If at proper level**
2. Ignition ON, verify the scan tool Engine Oil Level parameter reads OK.
   - **If not OK**

     Refer to Circuit/System Testing.

   - **If OK**
3. All OK.

Circuit/System Testing

NOTE: **Verify proper engine oil level before continuing with diagnosis.**

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B35 Engine Oil Level Switch. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

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2. Test for less than 2 Ω in the ground circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, repair the open/high resistance in the ground connection.
- **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool Engine Oil Level Switch parameter reads Low.
    - **If the Engine Oil Level Switch parameter reads OK**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If the Engine Oil Level Switch parameter reads Low**

NOTE: **If a short to voltage is found on the signal circuit, the fuse in the 3A jumper wire will open.**

5. Install a 3A fused jumper wire between the signal circuit terminal 2 and the ground circuit terminal 1.
6. Verify the scan tool Engine Oil Level Switch parameter reads OK.
    - **If the Engine Oil Level Switch parameter reads Low**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance on the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If the Engine Oil Level Switch parameter reads OK**
7. Test or replace the B35 Engine Oil Level Switch.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- **Engine Oil Level Indicator Switch Replacement**
- **Control Module References** for the ECM replacement, programming, and setup

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
IMPORTANT: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet	Go to **Step 2**	System OK

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Step	Action	Yes	No
	of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings. Are drippings present?		
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 6**

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Step	Action	Yes	No
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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use the **J 28428-E** High-Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components	Go to **Step 11**	System OK

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Step	Action	Yes	No
	• 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?		
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

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

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

2

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

3

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

4

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

6

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

10

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

12

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

14

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

15

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

16

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

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17

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

19

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

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**

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Step	Action	Yes	No
4	• If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. • If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 13**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**

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Step	Action	Yes	No
19	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the repair?	Go to **Step 20**	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

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

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

Test Description

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

2

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

3

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

4

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

5

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

9

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

11

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

12

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

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: ◦ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove ◦ The separation of the drive belt ◦ A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	**NOTE:** **If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a**	Go to **Symptoms - Engine Mechanical**, or **Vibration Analysis - Engine**	Go to **Step 4**

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Step	Action	Yes	No
	belt is removed. 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?		
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement (LV3)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

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DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2

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

4

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

5

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

6

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

7

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

13

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

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14

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

15

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

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Caution** . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK

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Step	Action	Yes	No
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 13**
13	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to Diagnostic Aids
16	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
1	Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

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VACUUM PUMP BELT REPLACEMENT

Removal Procedure

1. Remove the air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**.

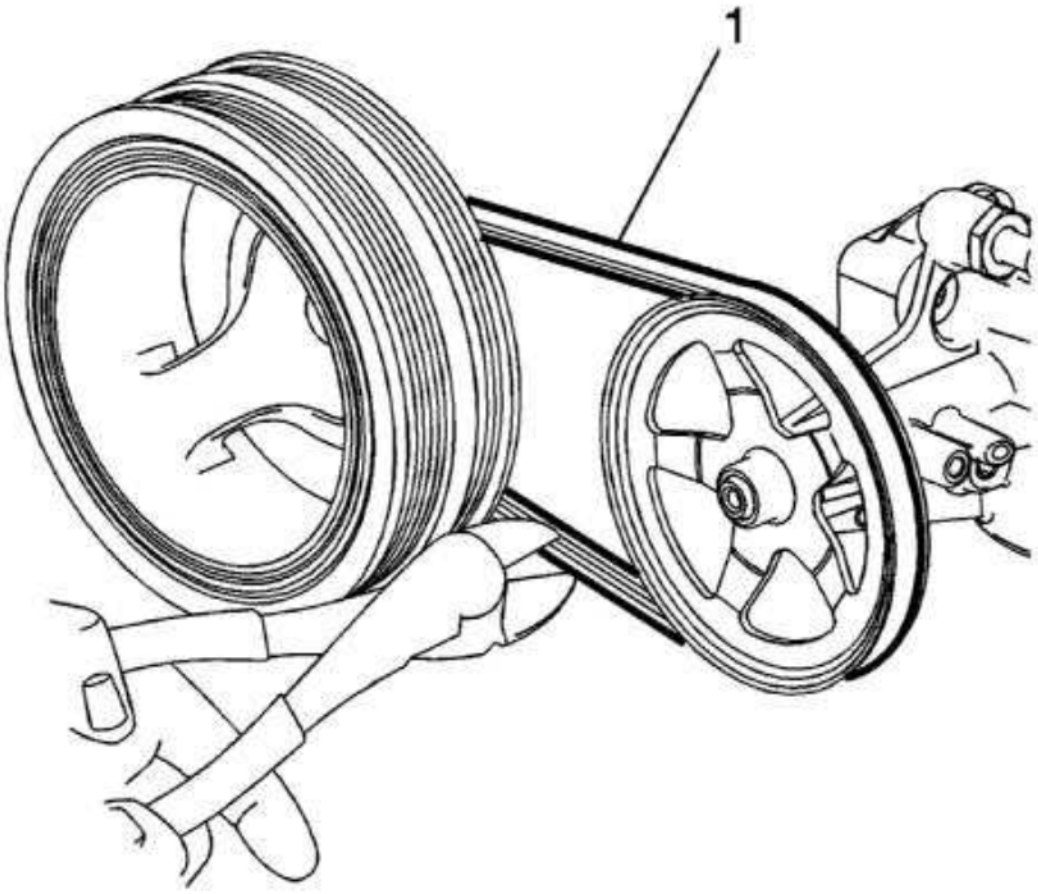

Fig. 23: Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

2. Cut the belt (1) from the vacuum pump and crankshaft pulleys.

Installation Procedure

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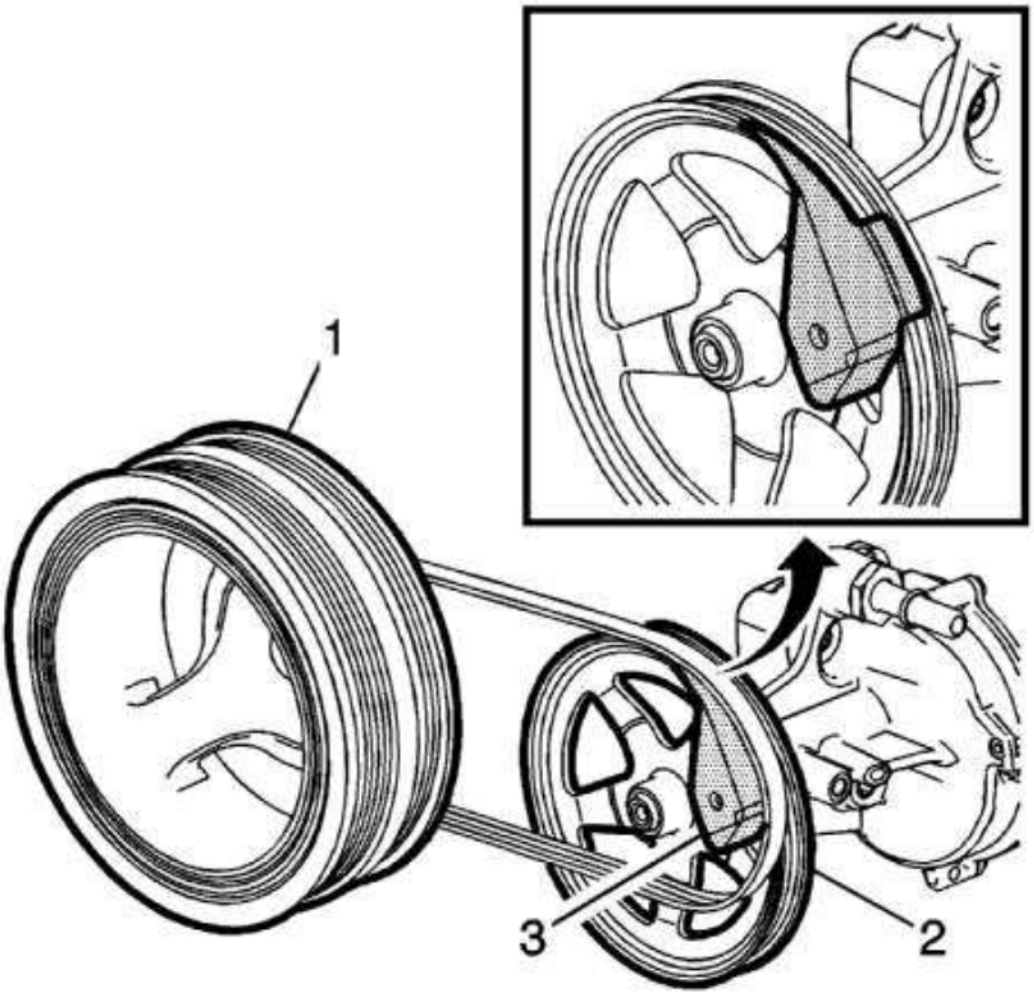

Fig. 24: Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The OEM replacement stretchy belt is packaged with a disposable installation tool.**

1. Position the belt on the crankshaft balancer (1) at the last belt placement inward and partially onto the vacuum pump pulley (2).
2. Install the belt installation tool (3) onto the vacuum pump pulley.

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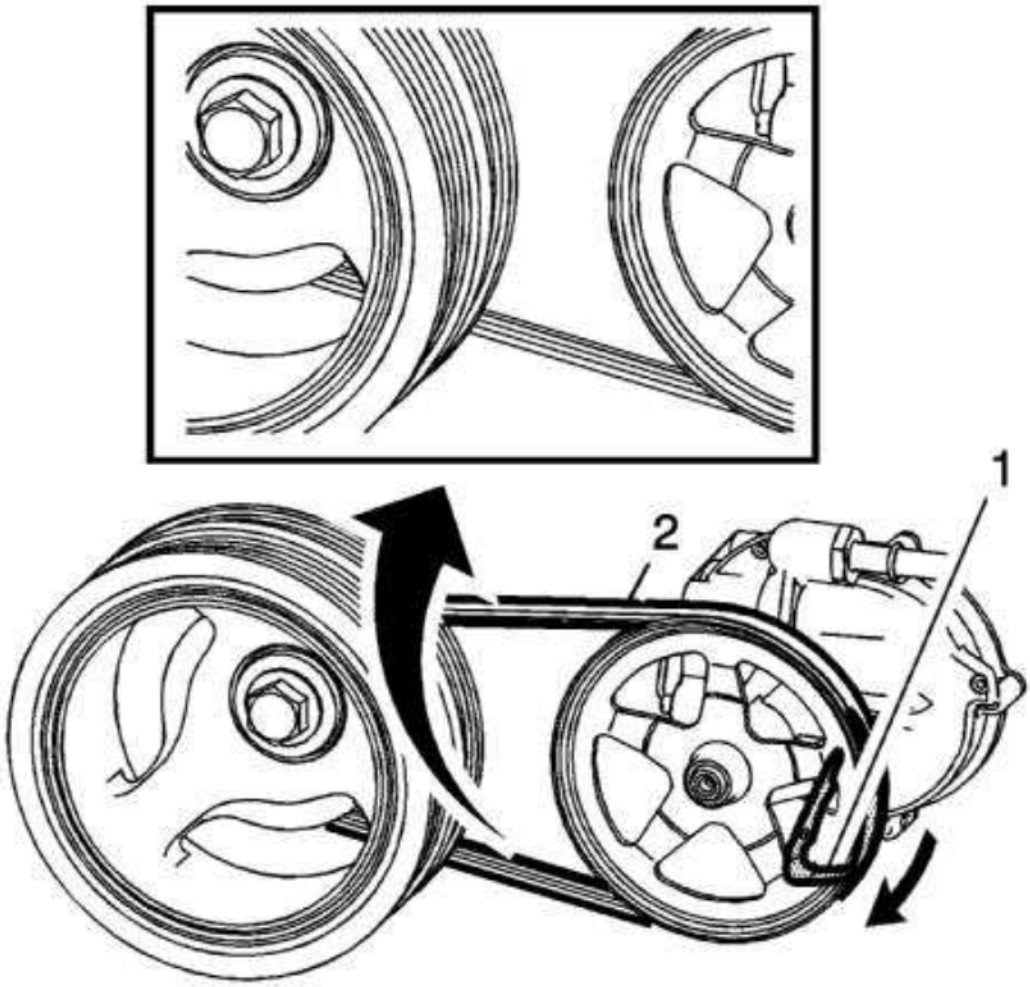

Fig. 25: Drive Belt Installation Tool
Courtesy of GENERAL MOTORS COMPANY

3. Slide the belt installation tool (1) downward, partially installing the belt (2) onto the vacuum pump pulley.
4. Slide the belt installation tool downward, applying light tension to the belt.

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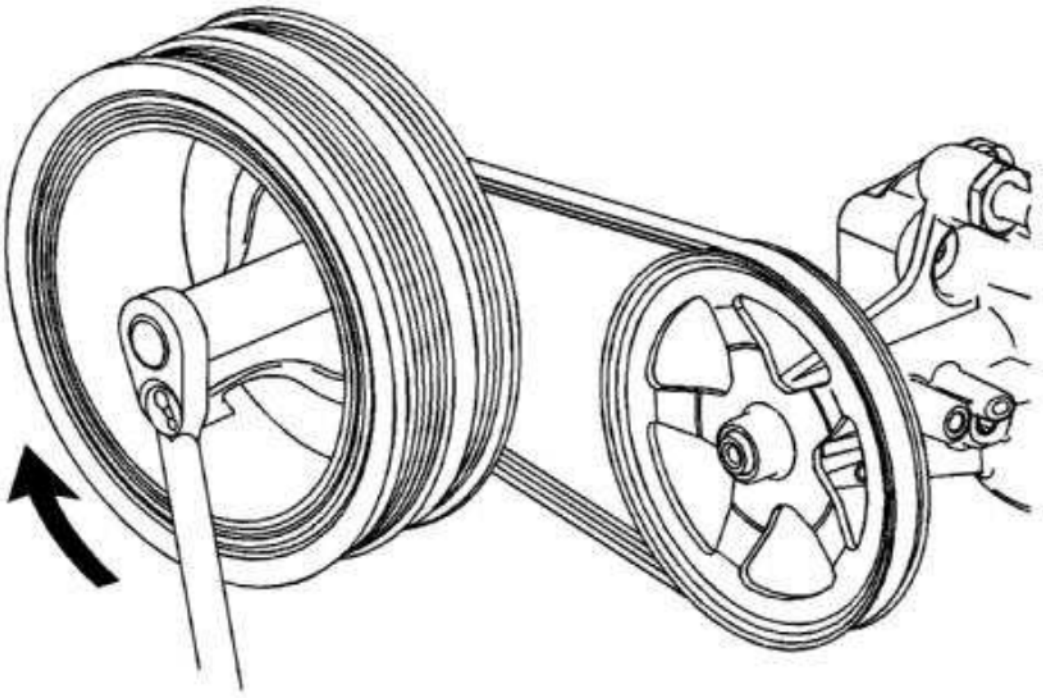

Fig. 26: Rotating Engine Clockwise
Courtesy of GENERAL MOTORS COMPANY

5. With the belt in position, rotate the engine clockwise to completely install the belt onto the vacuum pump and crankshaft pulleys.

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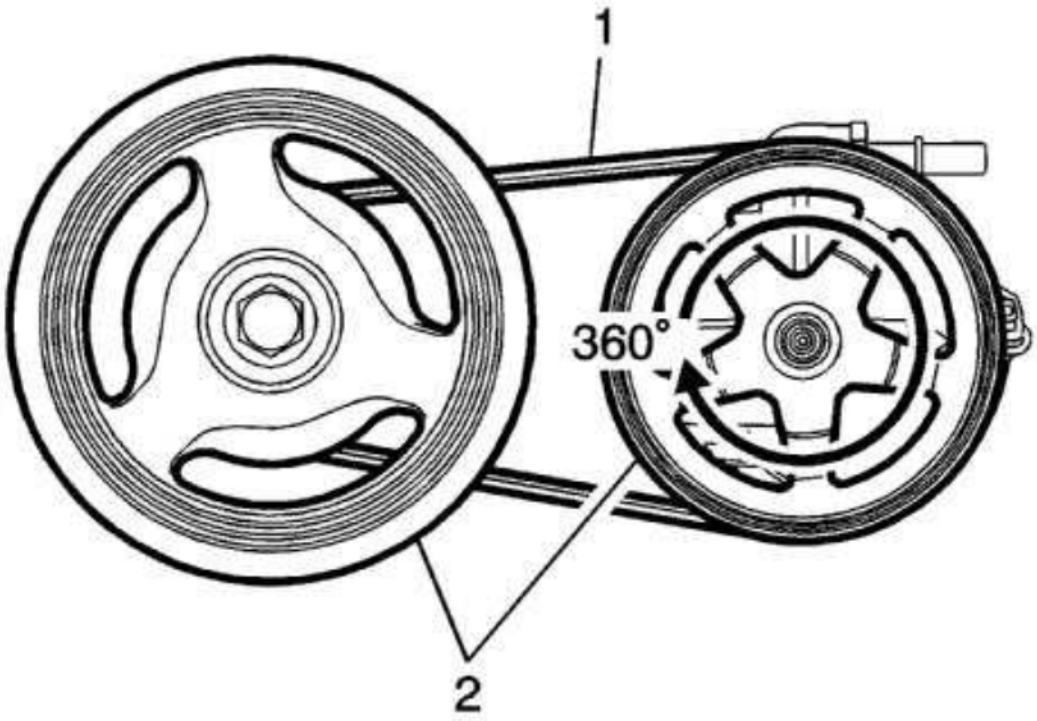

Fig. 27: Inspecting Ribbed Area Of Belt For Correct Alignment
Courtesy of GENERAL MOTORS COMPANY

6. Once the belt is installed, rotate the engine 360 degrees and inspect the ribbed area of the belt (1) to ensure that it is correctly aligned with the pulleys grooves (2).

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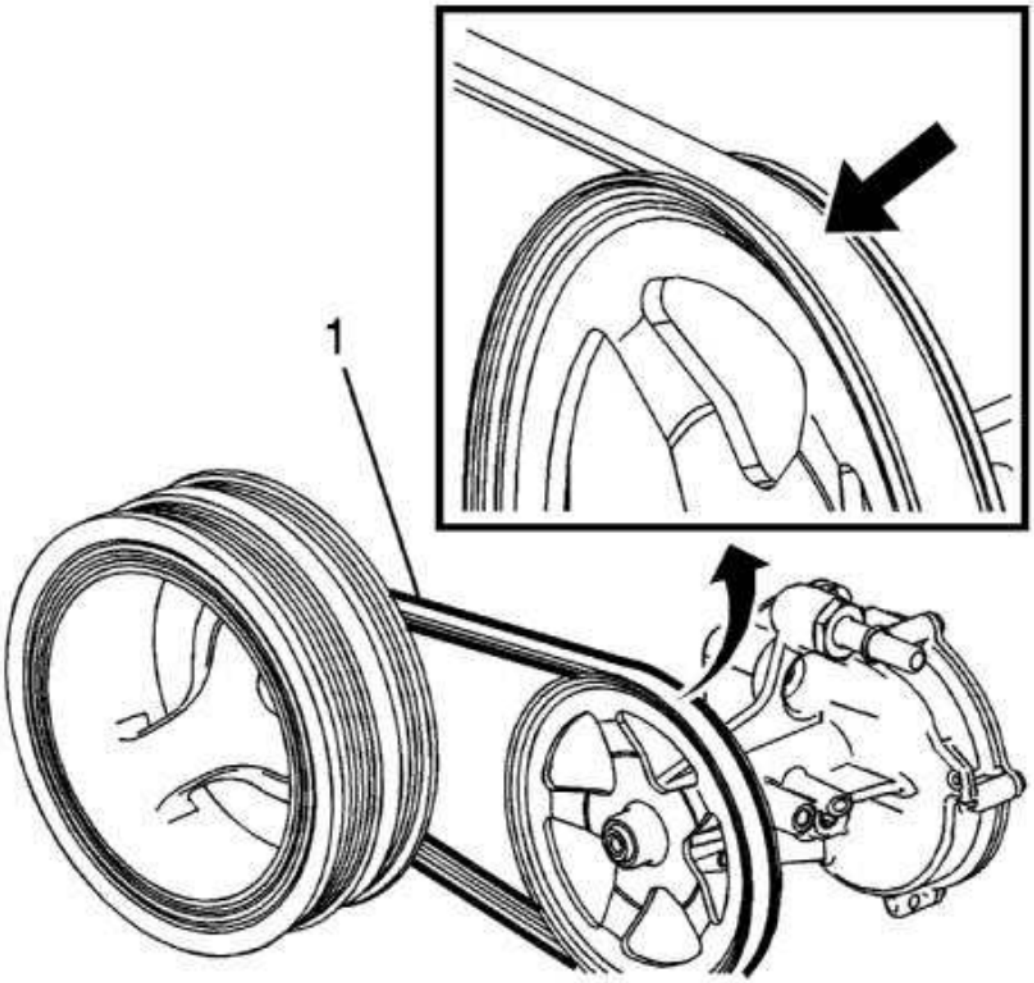

Fig. 28: Inspecting Back Side Of Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the back side of the vacuum pump belt (1) for proper orientation after rotating the engine.
8. Install the air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**.

DRIVE BELT REPLACEMENT - ACCESSORY

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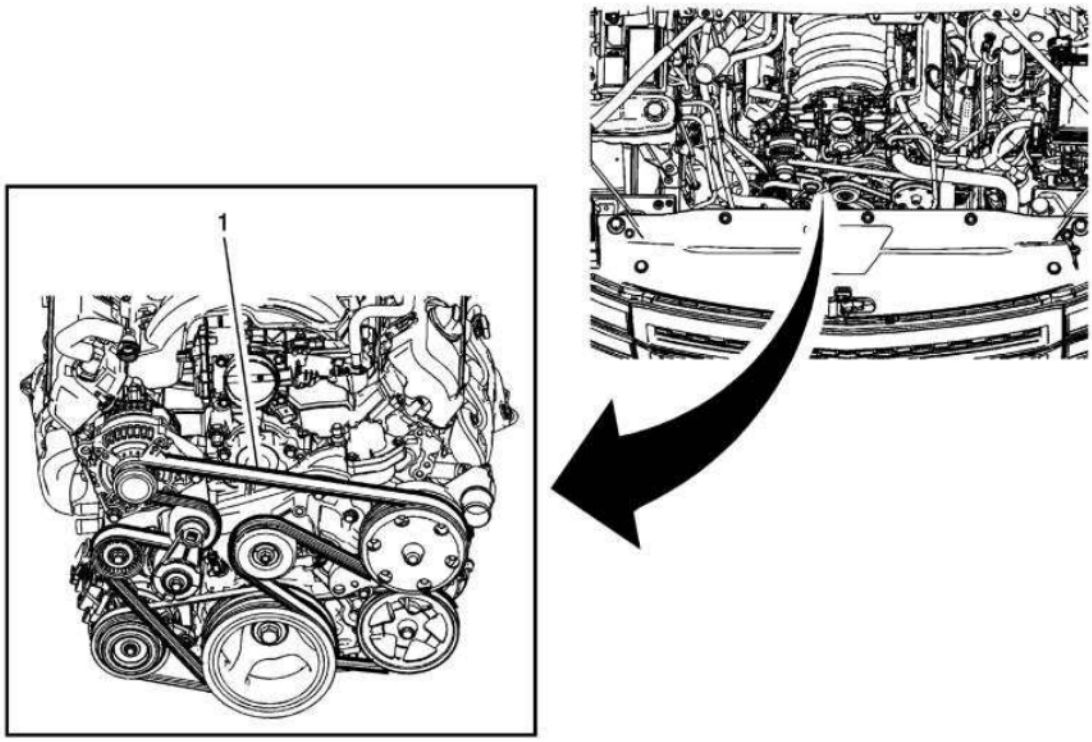

Fig. 29: Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .	
1	Drive Belt **Procedure** 1. Rotate the drive belt tensioner counterclockwise to release the drive belt tension. 2. Slide the drive belt off of the belt idler pulley. 3. Slowly release the drive belt tensioner.

AIR CONDITIONING COMPRESSOR BELT REPLACEMENT

Special Tools

- **EN-51767-1** Universal Stretchy Belt Installer
- **EN-51767-5** Webbing

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Drive Belt - Remove - **Drive Belt Replacement - Accessory**
2. Steering Gear Skid Shield - Remove - **Steering Gear Skid Shield Replacement**

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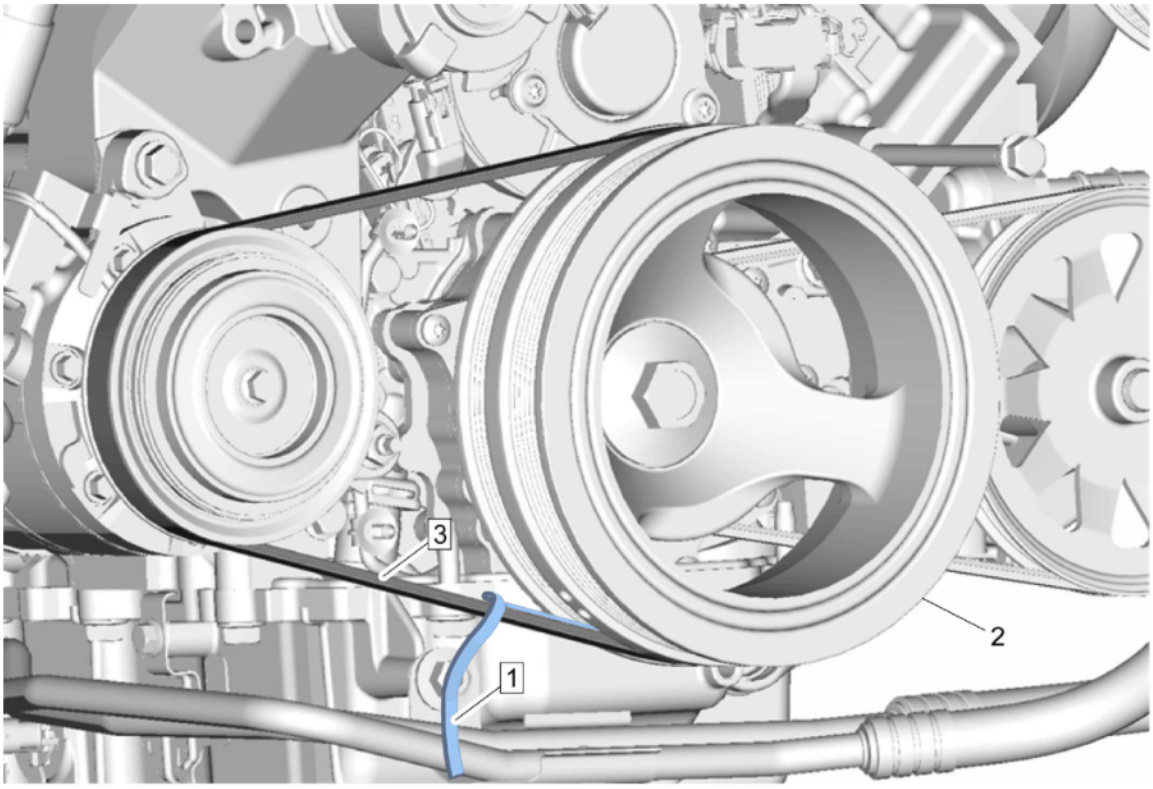

Fig. 30: Webbing
Courtesy of GENERAL MOTORS COMPANY

3. Insert the **EN-51767-5** Webbing (1) between the pulley (2) and belt (3).
4. While walking the **EN-51767-5** Webbing around the circumference of the pulley, rotate the crankshaft pulley counterclockwise.
5. Once the **EN-51767-5** Webbing is around the circumference of the crankshaft pulley, pull the loose end of the **EN-51767-5** Webbing inward toward the engine, removing the belt from the crankshaft pulley.
6. Remove the belt from the air conditioning compressor pulley and then from the vehicle.

Installation Procedure

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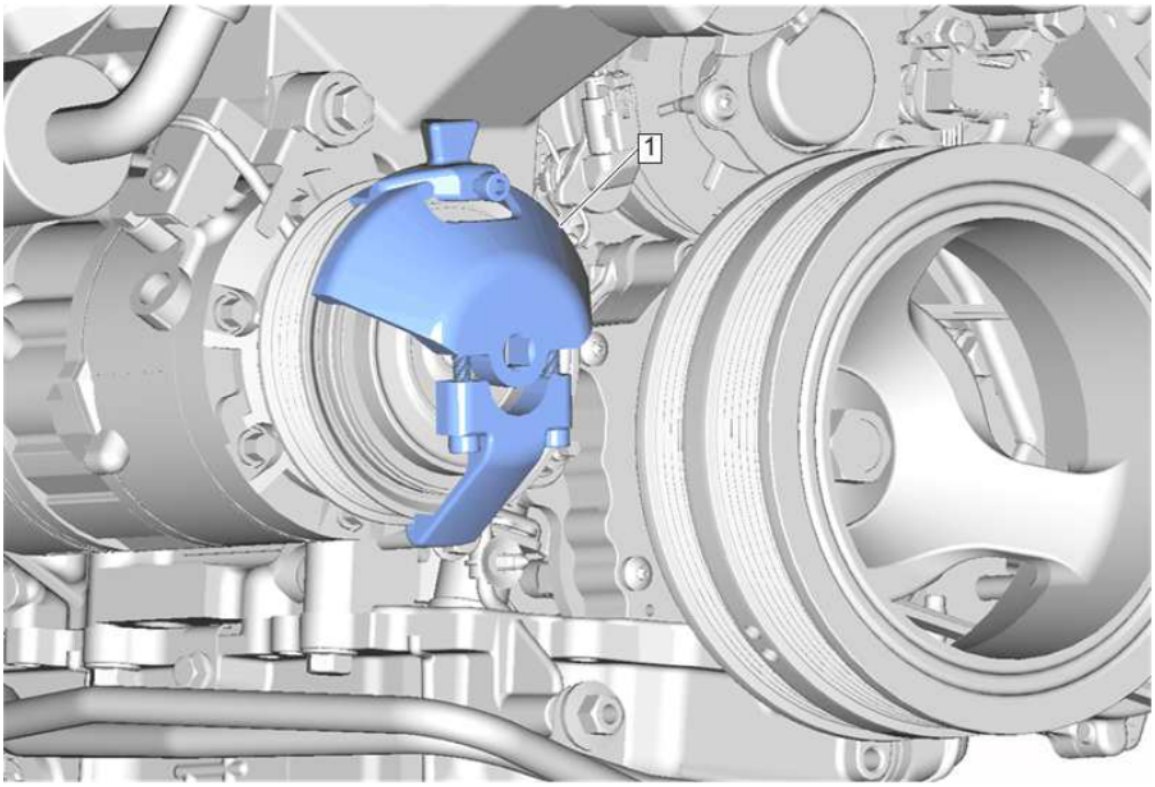

Fig. 31: Universal Stretchy Belt Installer
Courtesy of GENERAL MOTORS COMPANY

1. Install **EN-51767-1** Universal Stretchy Belt Installer 1 onto the balancer.

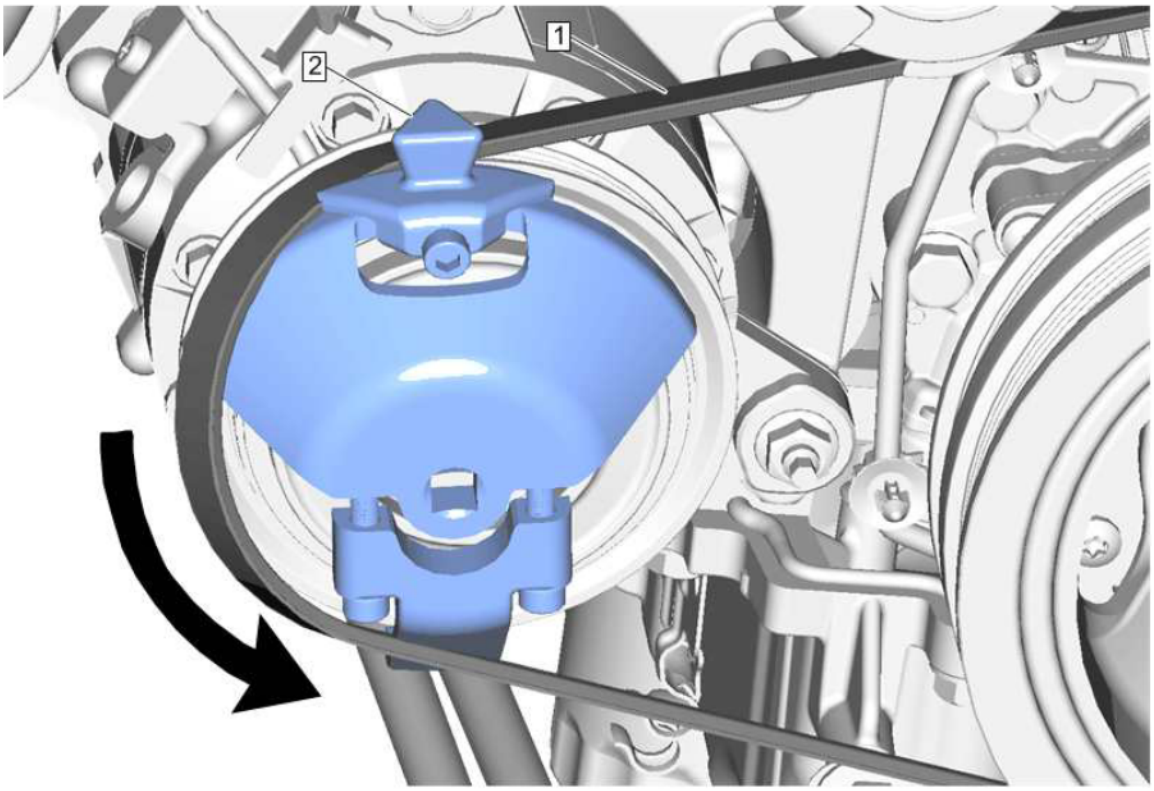

Fig. 32: Installing A/C Belt
Courtesy of GENERAL MOTORS COMPANY

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2. Position the belt 2 on the A/C pulley and the balancer as shown.
3. Slide the belt installation tool downward, positioning the belt onto the A/C pulley, applying light tension to the belt.
4. Slowly rotate the crankshaft and compressor pulleys in a counterclockwise direction until the belt 2 fully seats on both pulleys.
5. Inspect the belt for proper installation and alignment.
6. Rotate the balancer an additional 360 degrees to ensure proper belt installation.
7. Steering Gear Skid Shield - Install - **Steering Gear Skid Shield Replacement**
8. Drive Belt - Install - **Drive Belt Replacement - Accessory**

DRIVE BELT IDLER PULLEY REPLACEMENT (ENGINE COOLANT MANIFOLD)

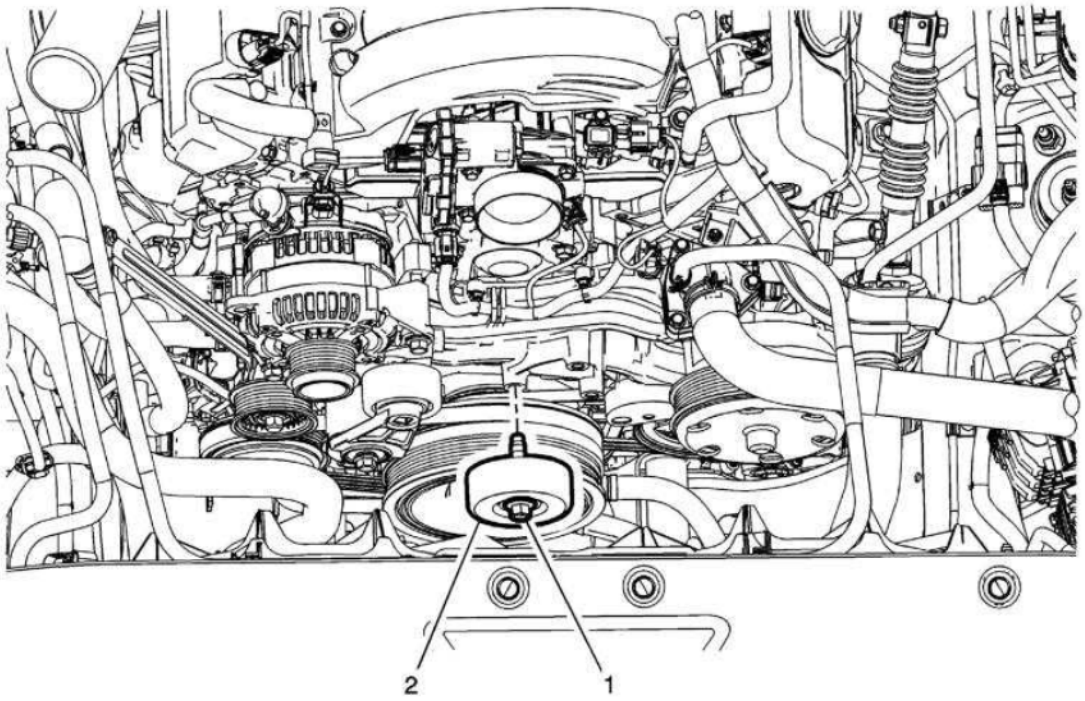

Fig. 33: Drive Belt Idler Pulley (Engine Coolant Manifold)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**.	
1	Drive Belt Idler Pulley Fastener **CAUTION:** **Refer to** **Fastener Caution** . **TIghten** 20 N.m (15 lb ft)

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Callout	Component Name
2	Drive Belt Idler Pulley

DRIVE BELT IDLER PULLEY REPLACEMENT (GENERATOR BRACKET)

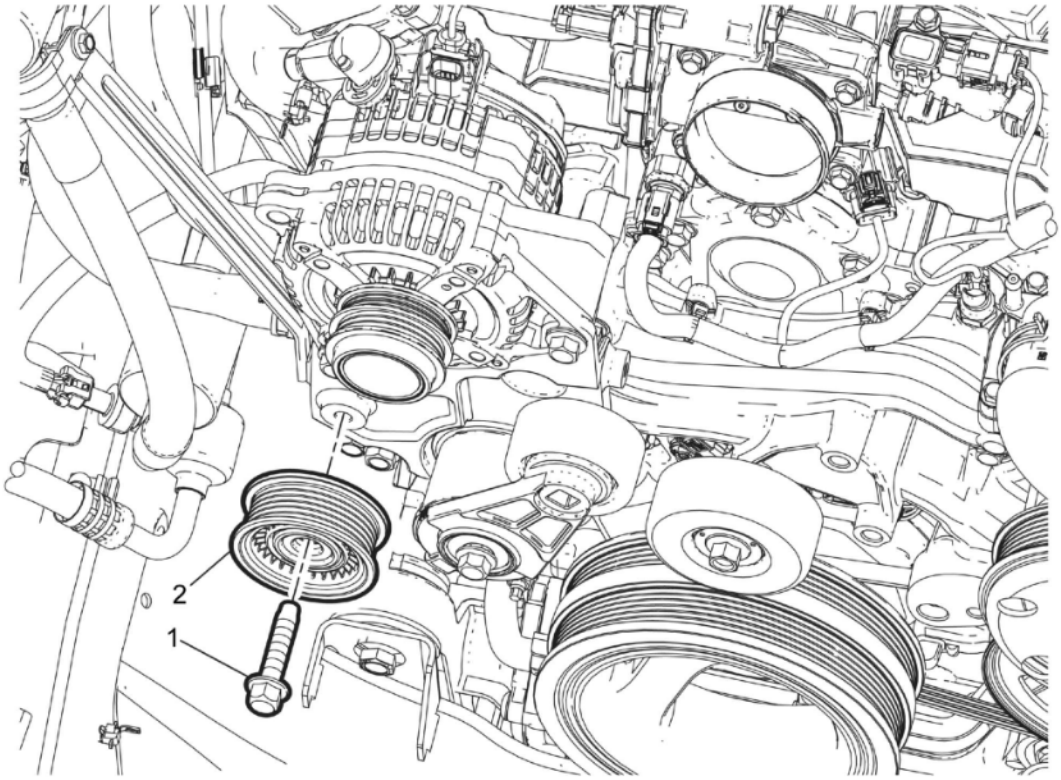

Fig. 34: Drive Belt Idler Pulley (Generator Bracket)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**.	
1	Drive Belt Idler Pulley Fastener **CAUTION:** **Refer to** **Fastener Caution** . **TIghten** 58 N.m (43 lb ft)
2	Drive Belt Idler Pulley

DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY

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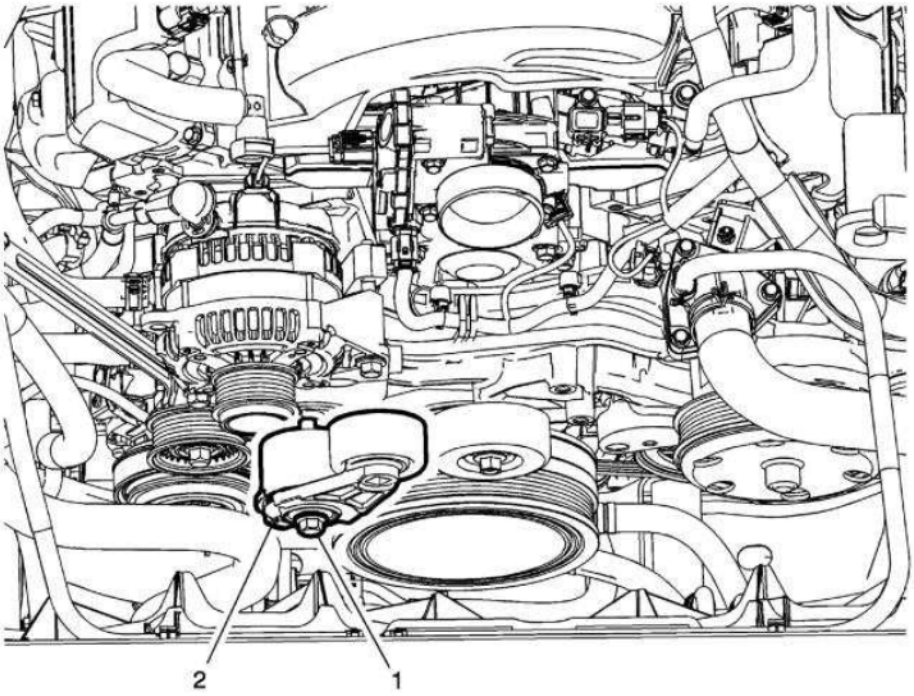

Fig. 35: Drive Belt Tensioner - Accessory
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**.	
1	Drive Belt Tensioner Fastener **CAUTION:** **Refer to** **Fastener Caution** . **TIghten** 58 N.m (43 lb ft)
2	Drive Belt Tensioner

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

CAUTION: When raising or supporting the engine for any reason, do not use a jack under any sheet metal, or the crankshaft pulley, or damage may occur.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .

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4. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Light Duty)** **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Heavy Duty)** .
5. Remove the left wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Left Side** .
6. Remove the vacuum pump. Refer to **Vacuum Pump Replacement** .

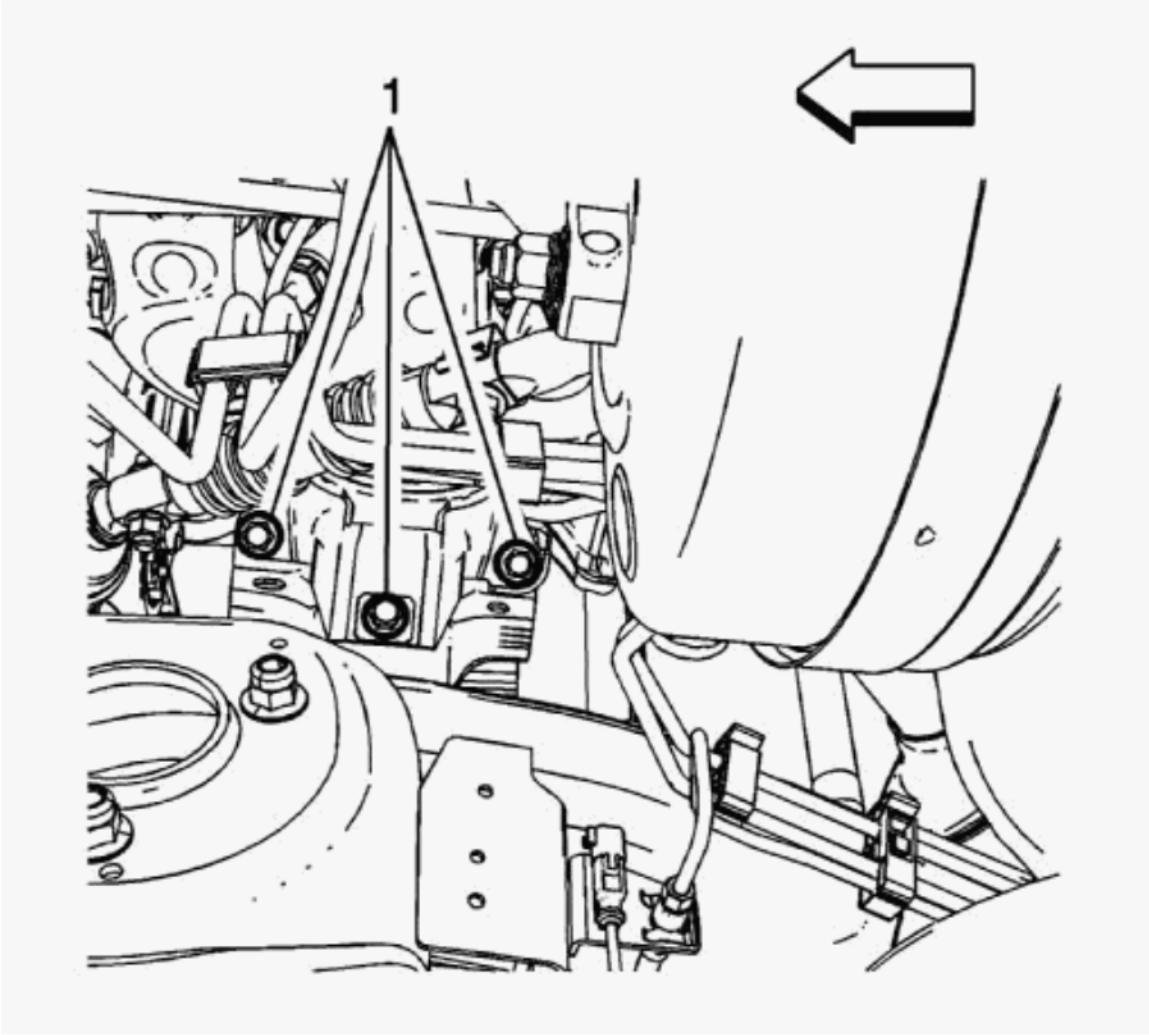

Fig. 36: Left Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine mount to frame bolts (1).
8. Remove exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Left Side (L5P)** .
9. Position a screw jack and a block of wood under the lower engine oil pan.

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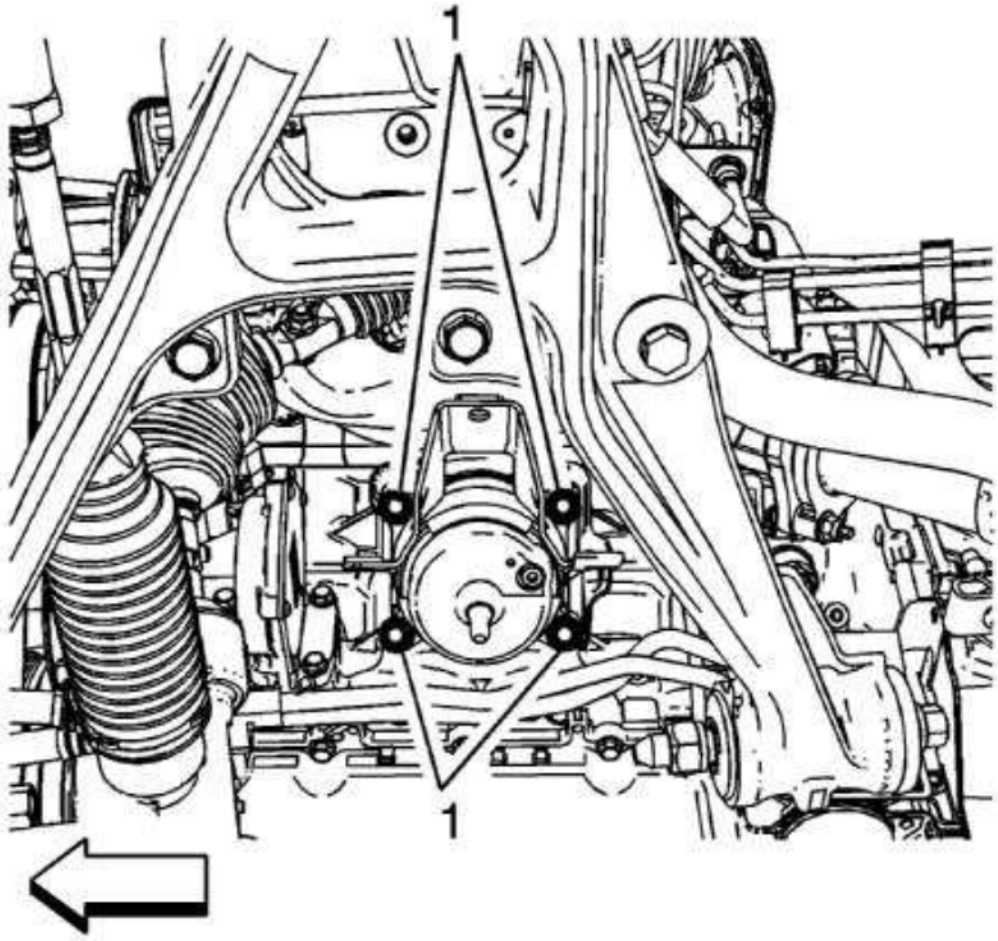

Fig. 37: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Working through the wheelhouse opening, remove the engine mount to engine block bolts (1).

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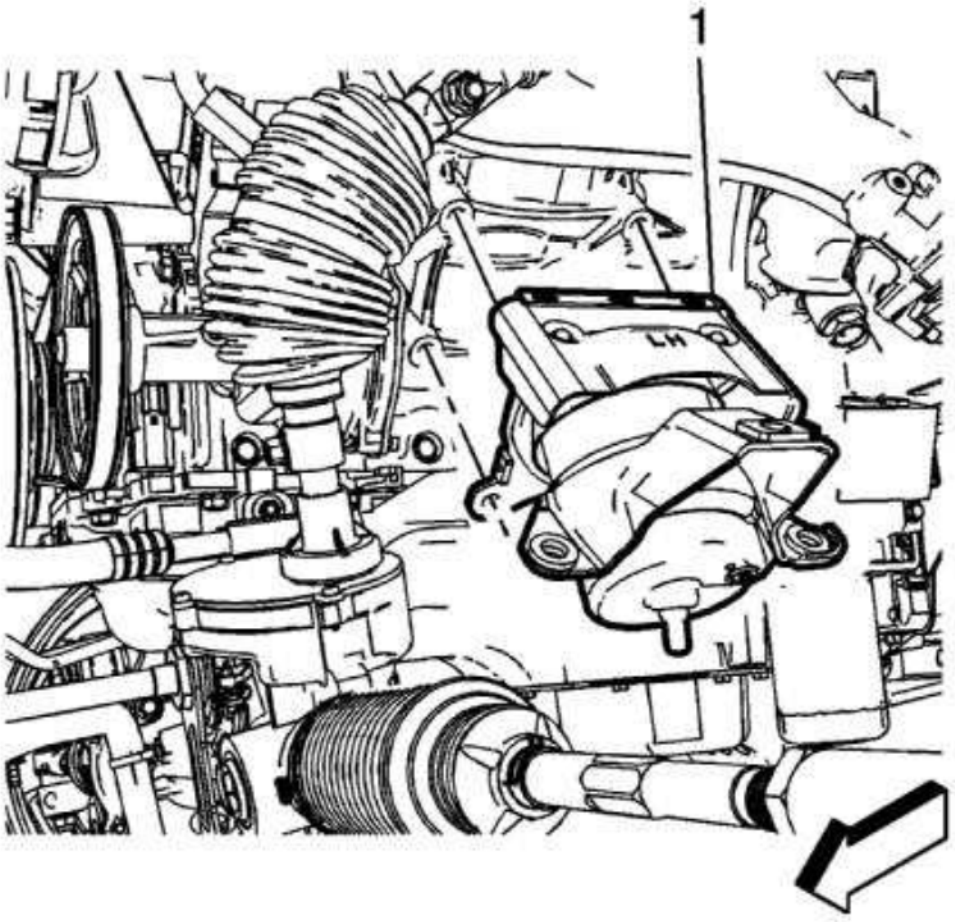

Fig. 38: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

11. Remove the engine mount (1) toward the front of the vehicle.

Installation Procedure

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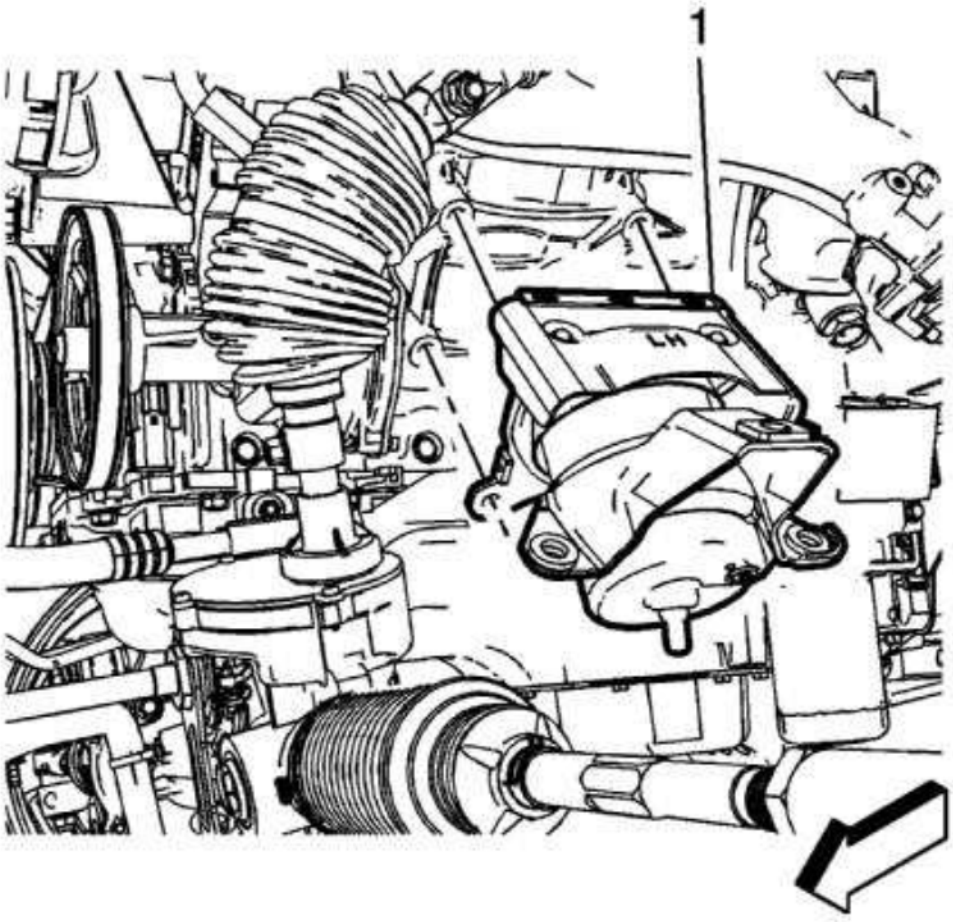

Fig. 39: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

1. Position the engine mount (1) to the engine block.

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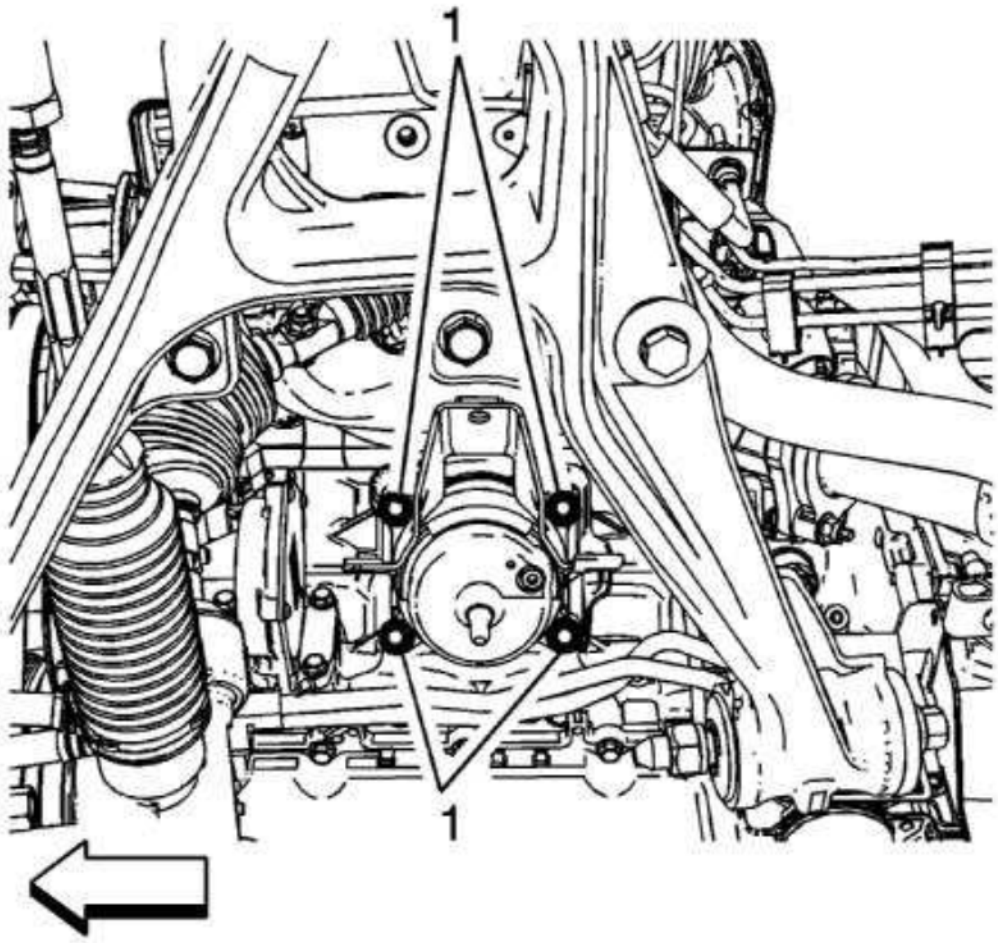

Fig. 40: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Clean the threads of the engine mount to engine bolts (1) using denatured alcohol or equivalent.
3. Apply thread locker or equivalent to the threads of the engine mount to engine bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

CAUTION: **Refer to Fastener Caution .**

4. Install the engine mount to engine bolts and tighten to 65 N.m (48 lb ft).
5. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.
6. Remove the adjustable jack and block of wood from the engine oil pan.

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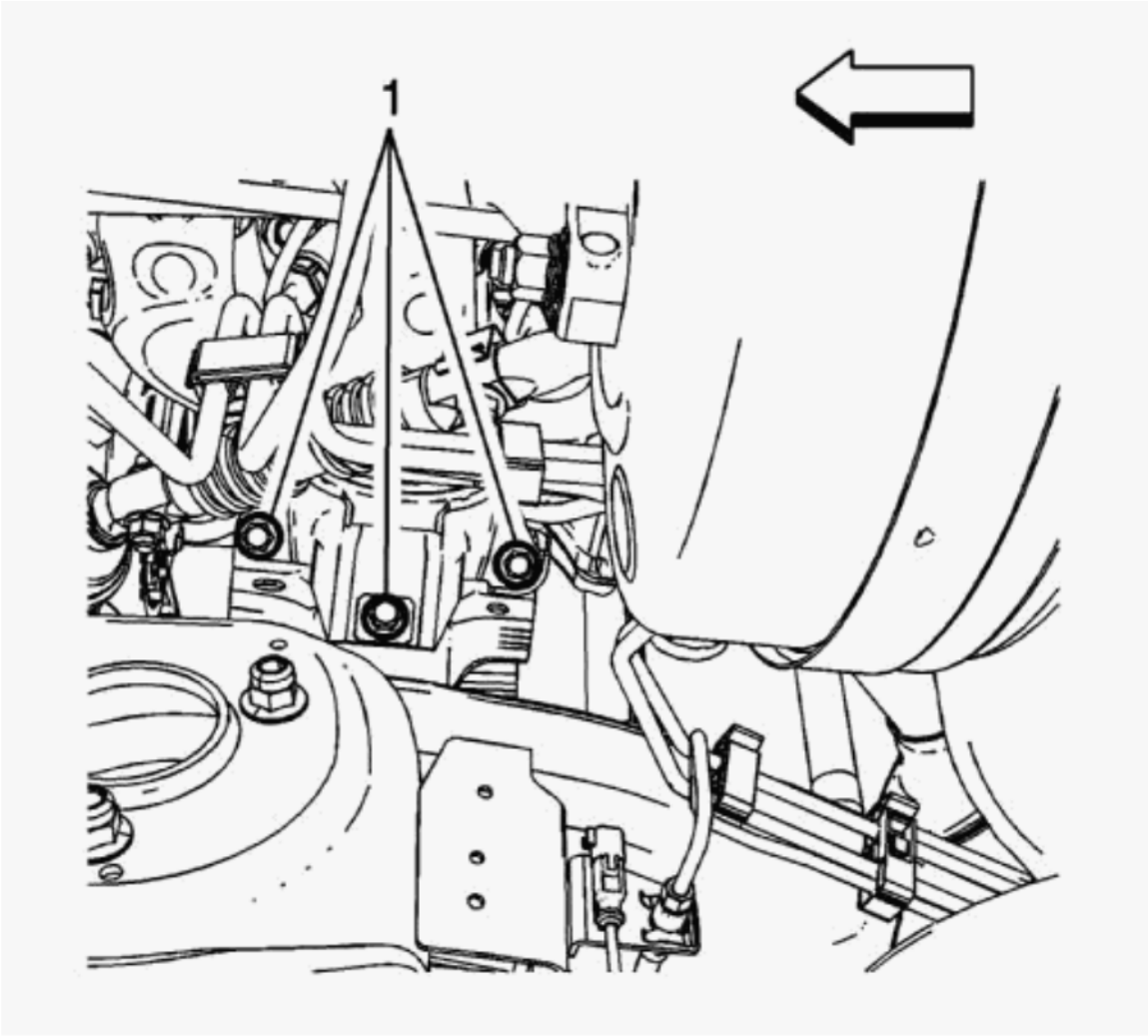

Fig. 41: Left Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Clean the threads of the engine mount to frame bolts (1) using denatured alcohol or equivalent.
8. Apply thread locker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
9. Install the engine mount to frame bolts and tighten to 71 N.m (52 lb ft).
10. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .
11. Install the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Light Duty)** **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Heavy Duty)** .
12. Install exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Left Side (LV3)** .
13. Install the vacuum pump. Refer to **Vacuum Pump Replacement** .
14. Install the left wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Left Side** .
15. Lower the vehicle.
16. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
17. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .

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ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

CAUTION: When raising or supporting the engine for any reason, do not use a jack under any sheet metal, or the crankshaft pulley, or damage may occur.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .
4. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Light Duty)** **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Heavy Duty)** .
5. Remove the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Right Side** .

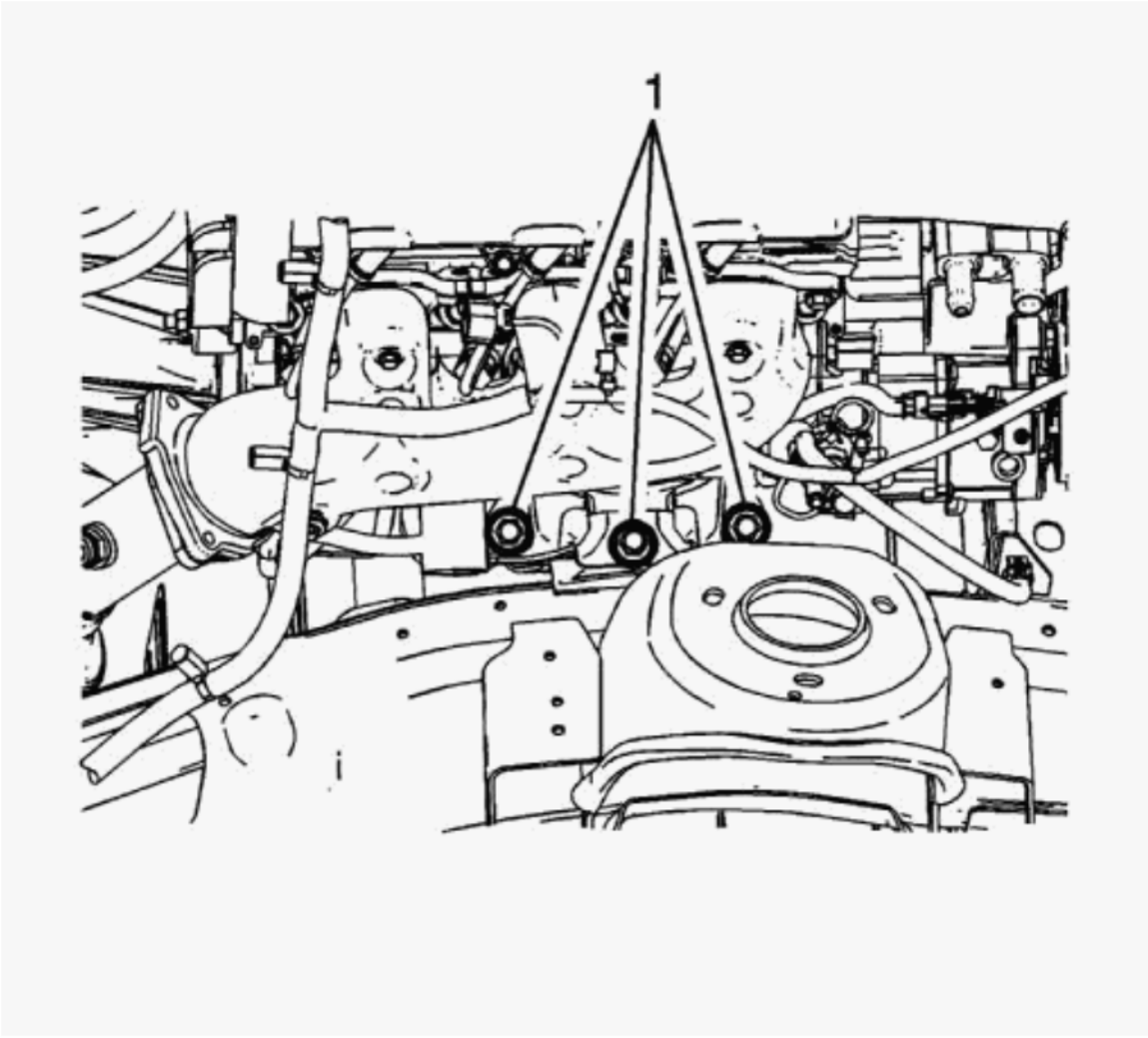

Fig. 42: Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the engine mount to frame bolts (1).
7. Remove the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LV3)** .

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8. Position a screw jack and a block of wood under the lower engine oil pan.

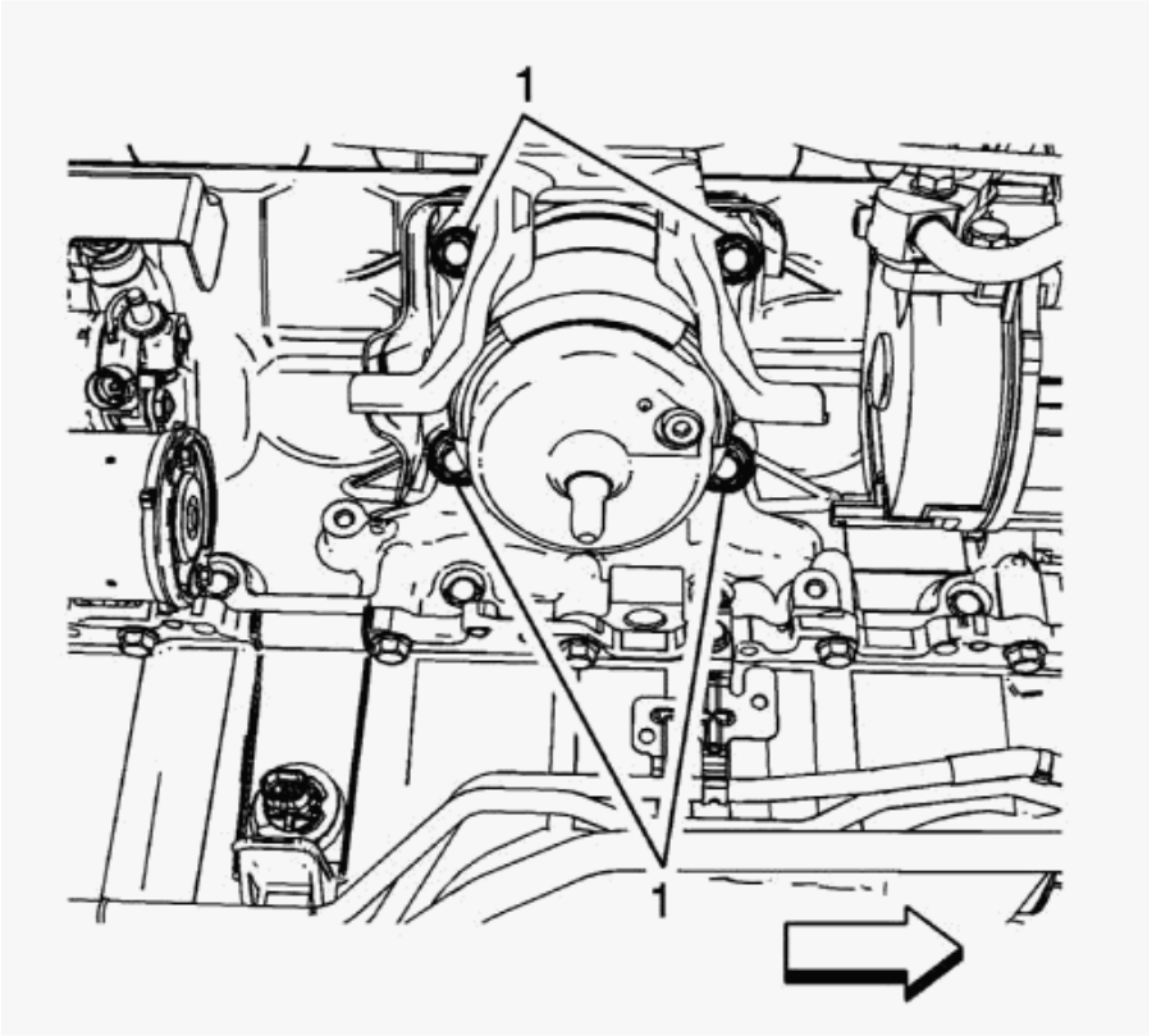

Fig. 43: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Working through the wheelhouse opening, remove the engine mount to engine block bolts (1).

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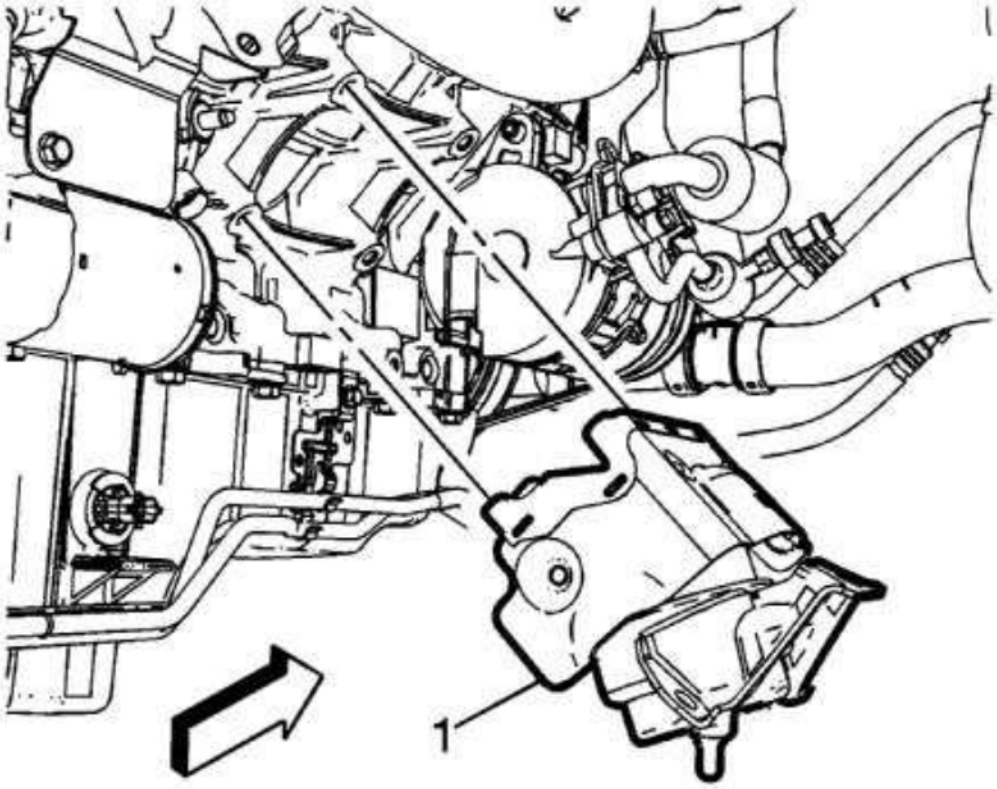

Fig. 44: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

10. Remove the engine mount (1) from the vehicle.

Installation Procedure

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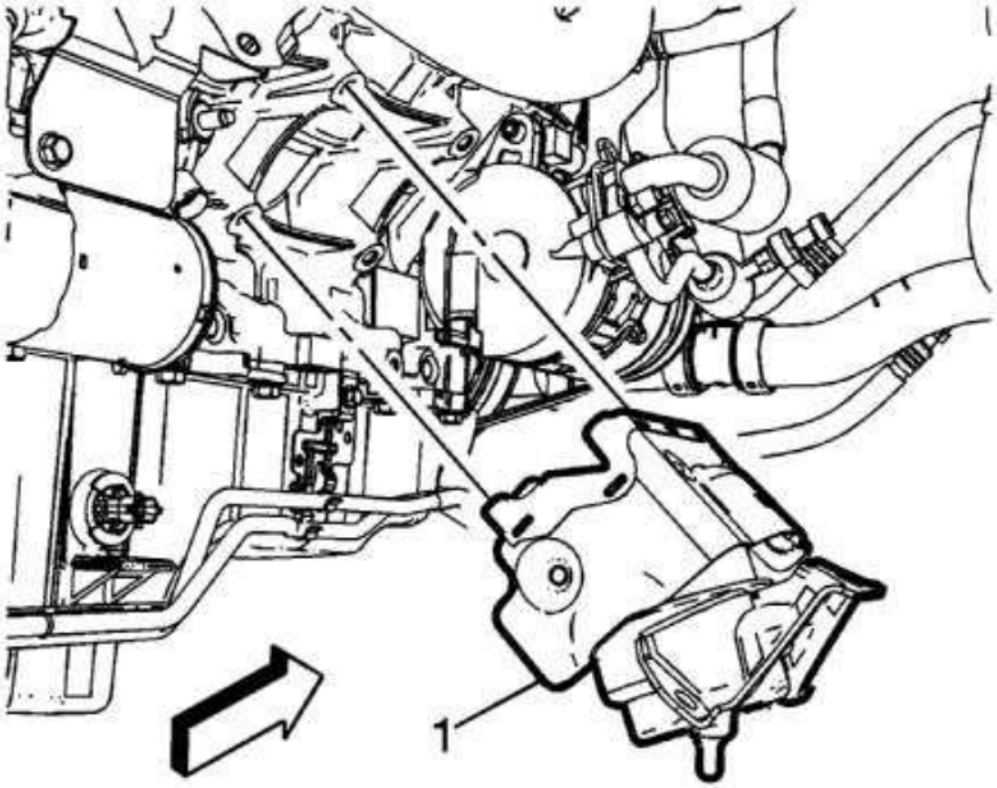

Fig. 45: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

1. Position the engine mount to the engine block.

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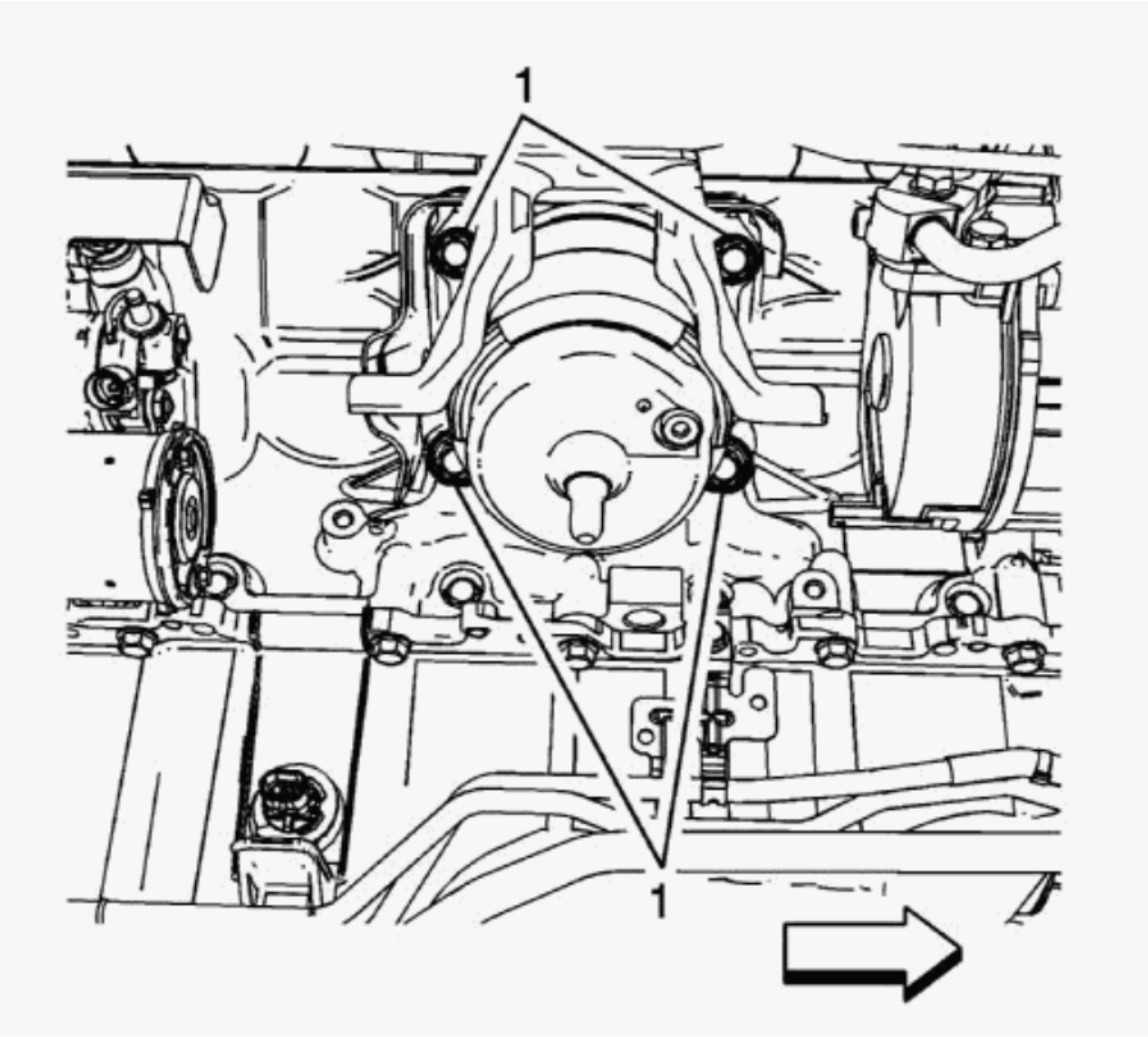

Fig. 46: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

2. Clean the threads of the engine mount to engine block bolts (1) using denatured alcohol or equivalent.
3. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
4. Install the engine mount to engine block bolts (1) and tighten to 65 N.m (48 lb ft).
5. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.
6. Remove the adjustable jack and block of wood from the engine oil pan.

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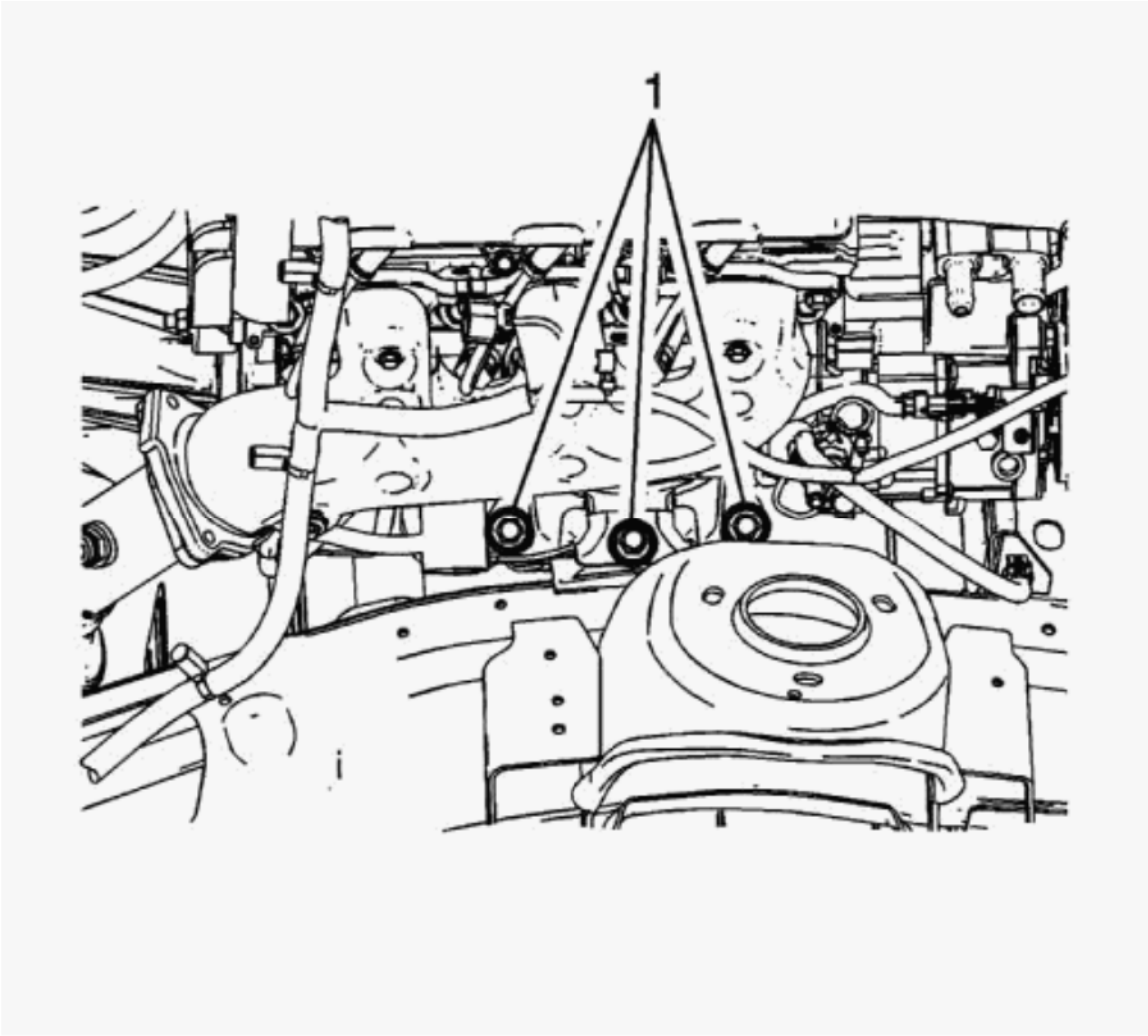

Fig. 47: Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Clean the threads of the engine mount to frame bolts (1) using denatured alcohol or equivalent.
8. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
9. Install the engine mount to frame bolts (1) and tighten to 71 N.m (52 lb ft).
10. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .
11. Install the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Light Duty)** **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Heavy Duty)** .
12. Install the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LV3)** .
13. Install the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Right Side** .
14. Lower the vehicle.
15. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
16. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (RIGHT SIDE/BANK 2)

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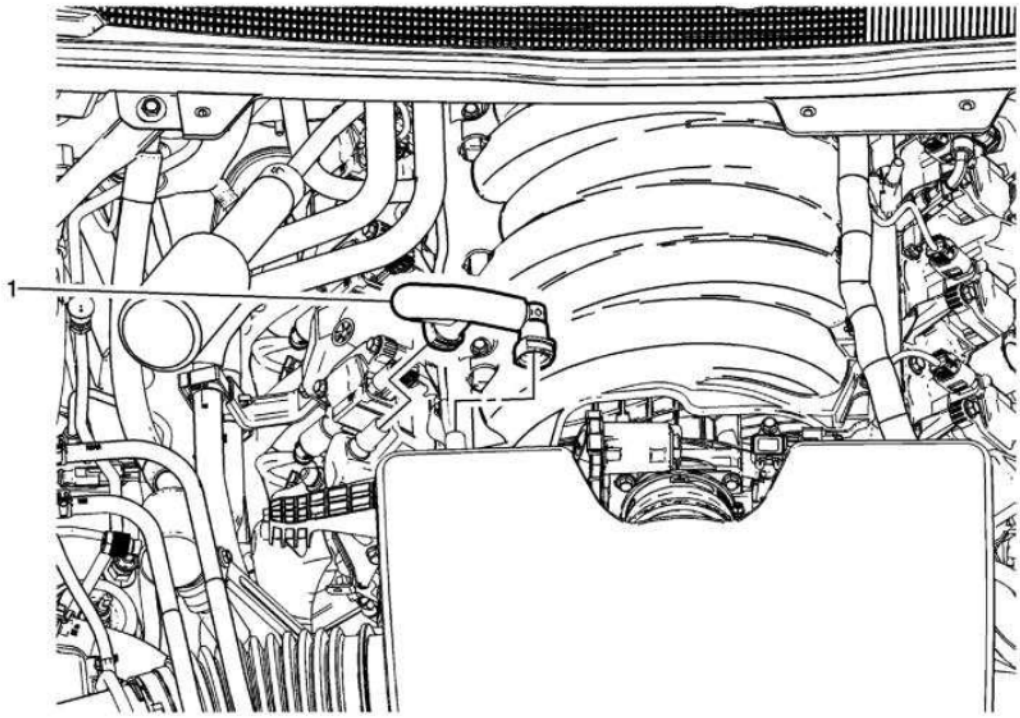

Fig. 48: Positive Crankcase Ventilation Hose/Pipe/Tube (Right Side/Bank 2)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube **Procedure** Disconnect the pcv tube from valve cover and air cleaner outlet tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (LEFT SIDE/BANK 1)

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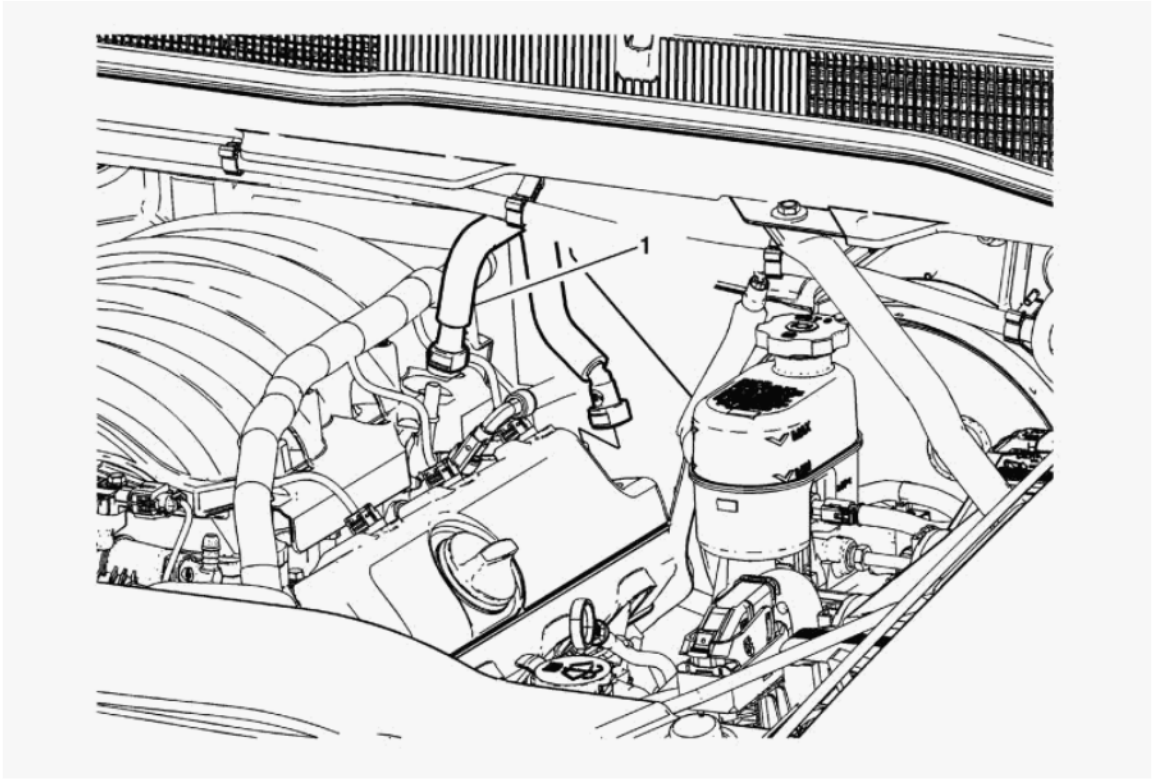

Fig. 49: Positive Crankcase Ventilation Hose/Pipe/Tube (Left Side/Bank 1)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube **Procedure** Disconnect the PCV tube from the intake manifold and valve cover . Refer to **Plastic Collar Quick Connect Fitting Service** .

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT

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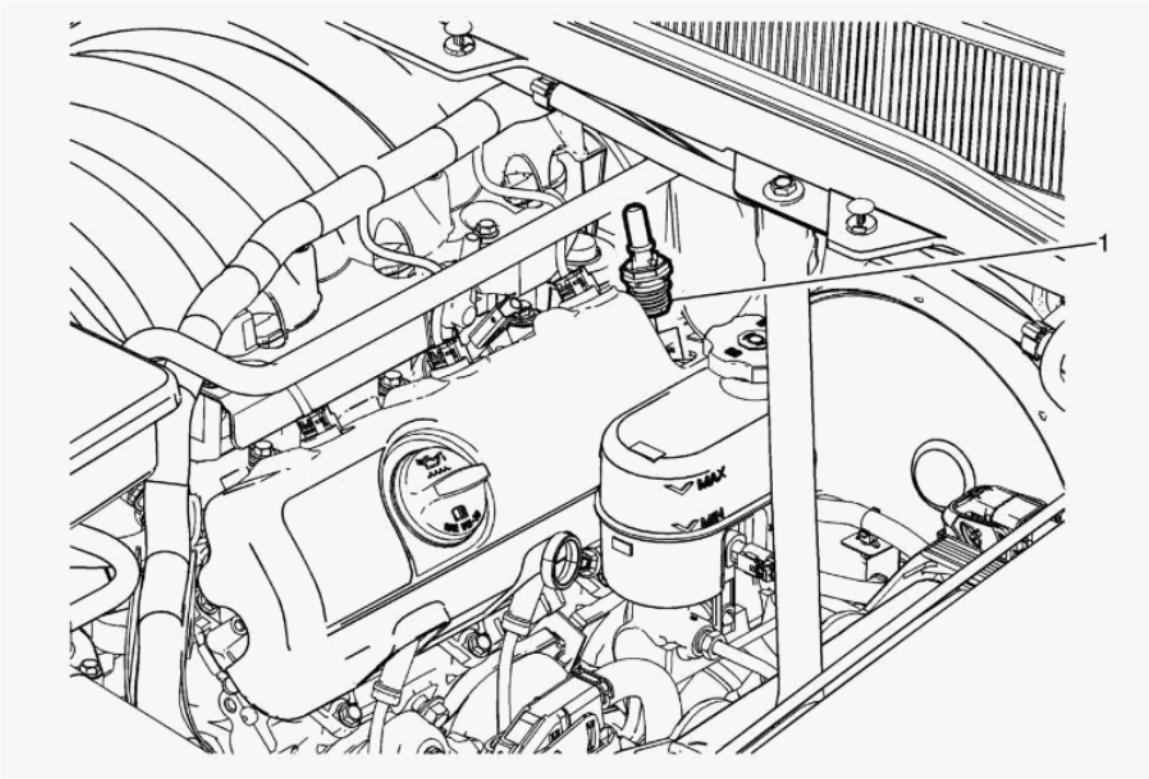

Fig. 50: Positive Crankcase Ventilation Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the left side PCV Hose. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)** **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.	
1	Positive Crankcase Ventilation Valve **CAUTION:** **Refer to** **Component** **Fastener** **Tightening** **Caution** . **Procedure** Reposition the fuel feed pipe as necessary. **Tighten** 6 N.m (53 lb in)

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

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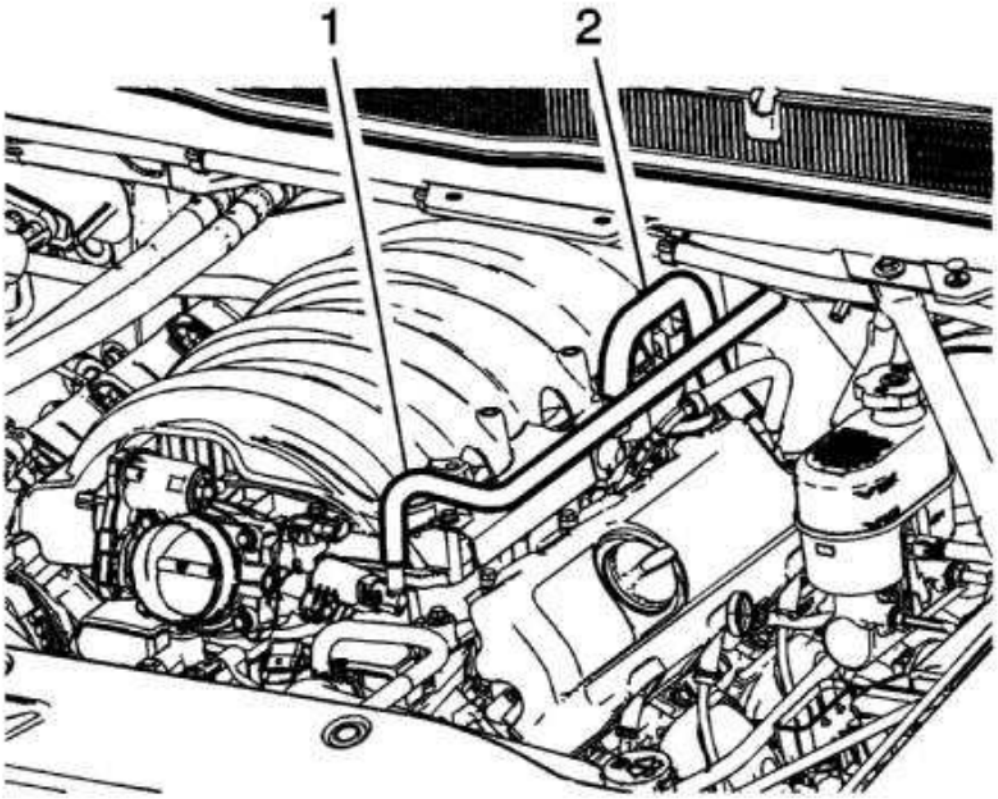

Fig. 51: EVAP Hose
Courtesy of GENERAL MOTORS COMPANY

2. Remove the EVAP hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Remove the PCV hose (2). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.
4. Disconnect electrical connectors as necessary.

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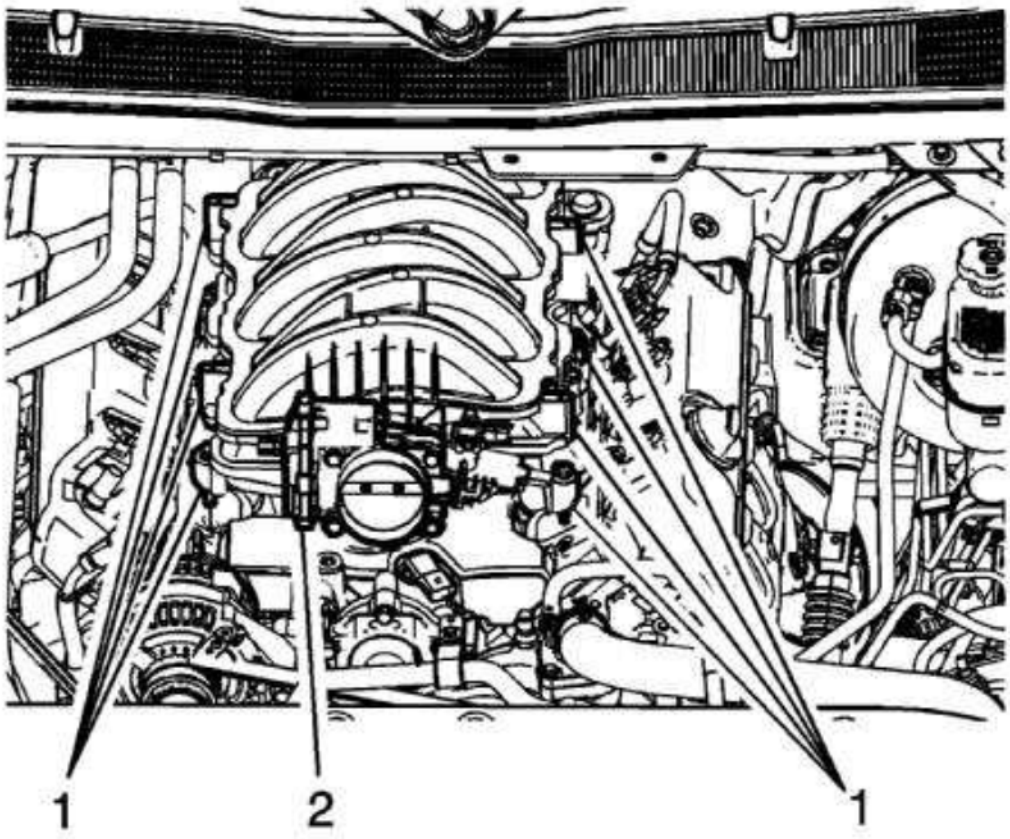

Fig. 52: Intake Manifold Bolts And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

5. Remove the intake manifold bolts (1) and intake manifold (2).

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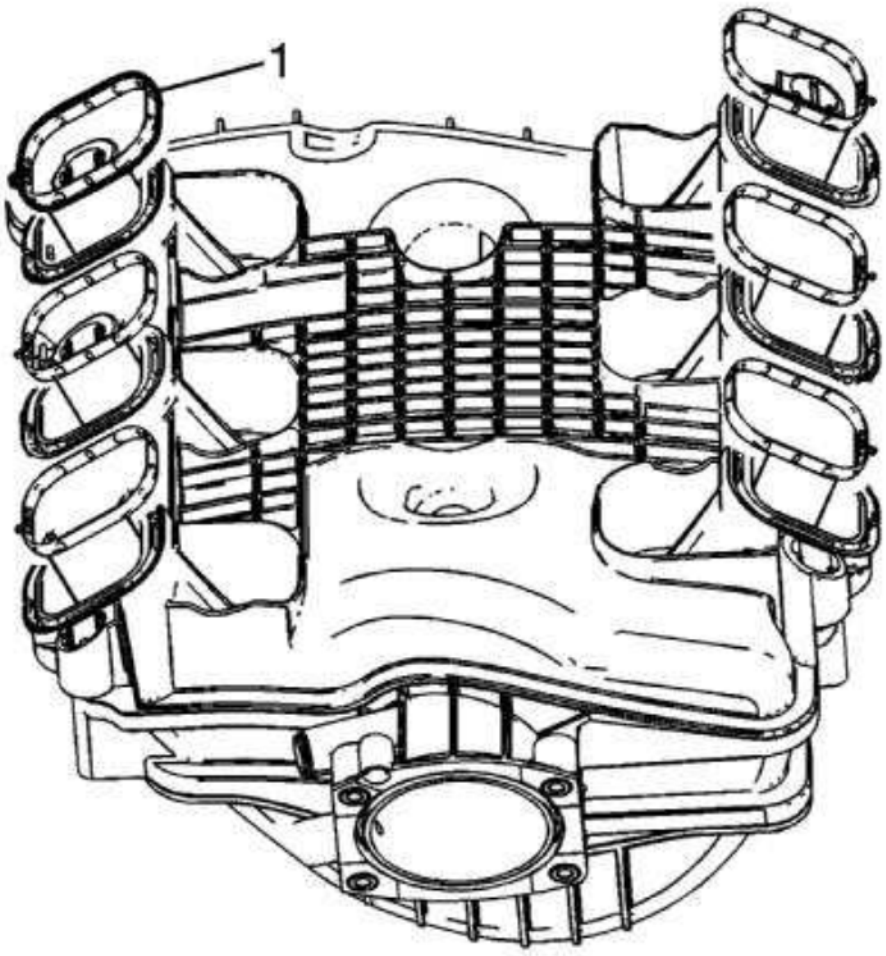

Fig. 53: Old Intake Manifold Gasket
Courtesy of GENERAL MOTORS COMPANY

6. Remove and DISCARD the old intake manifold gasket (1).
7. Transfer part as necessary.
8. For cleaning and inspection. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

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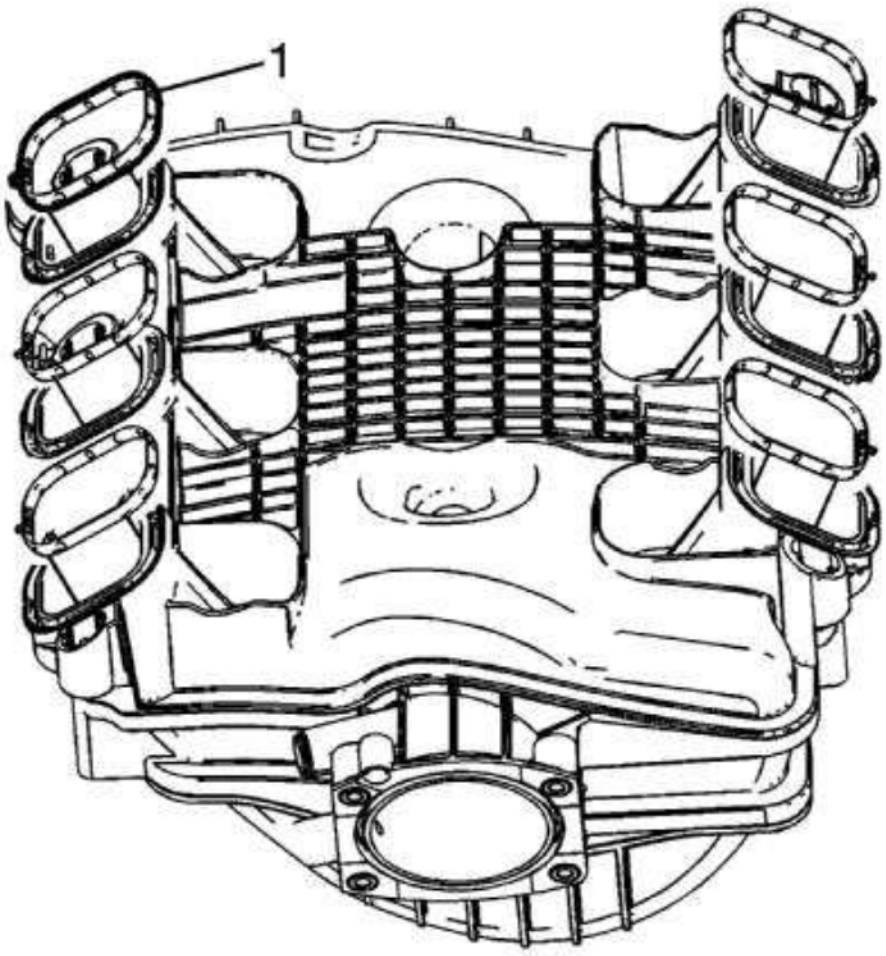

Fig. 54: Old Intake Manifold Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW intake manifold gasket (1).

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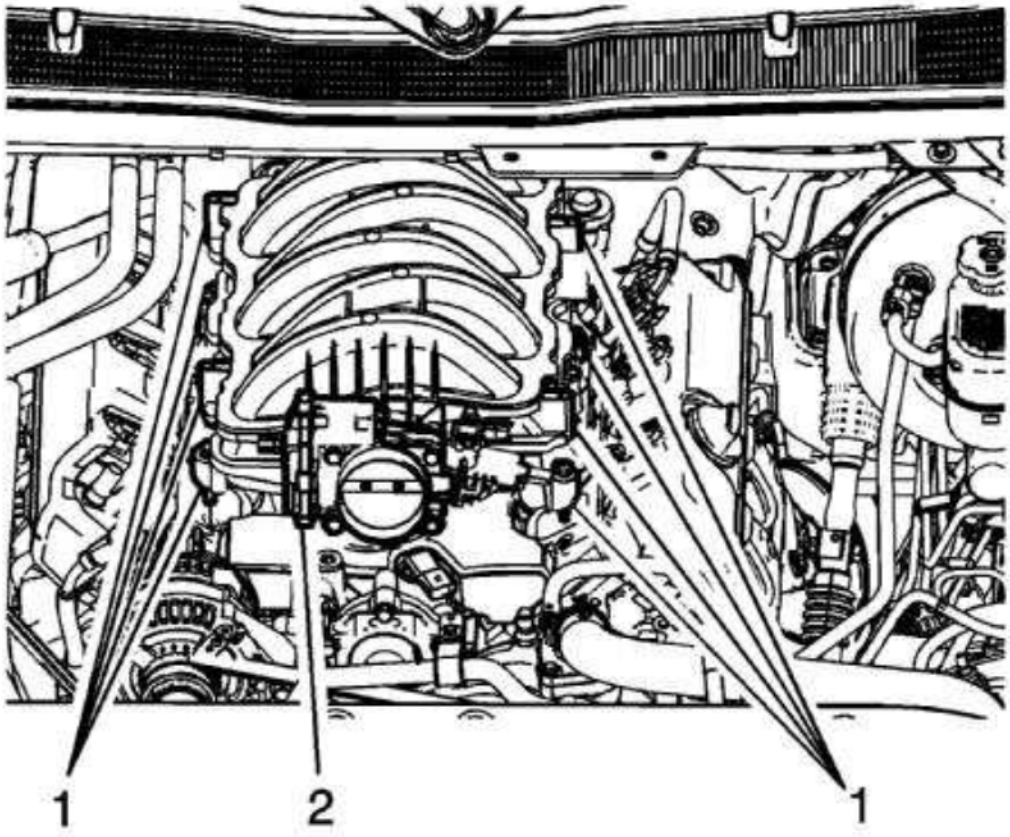

Fig. 55: Intake Manifold Bolts And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

2. Install the intake manifold (2) and hand tighten the bolts (1).

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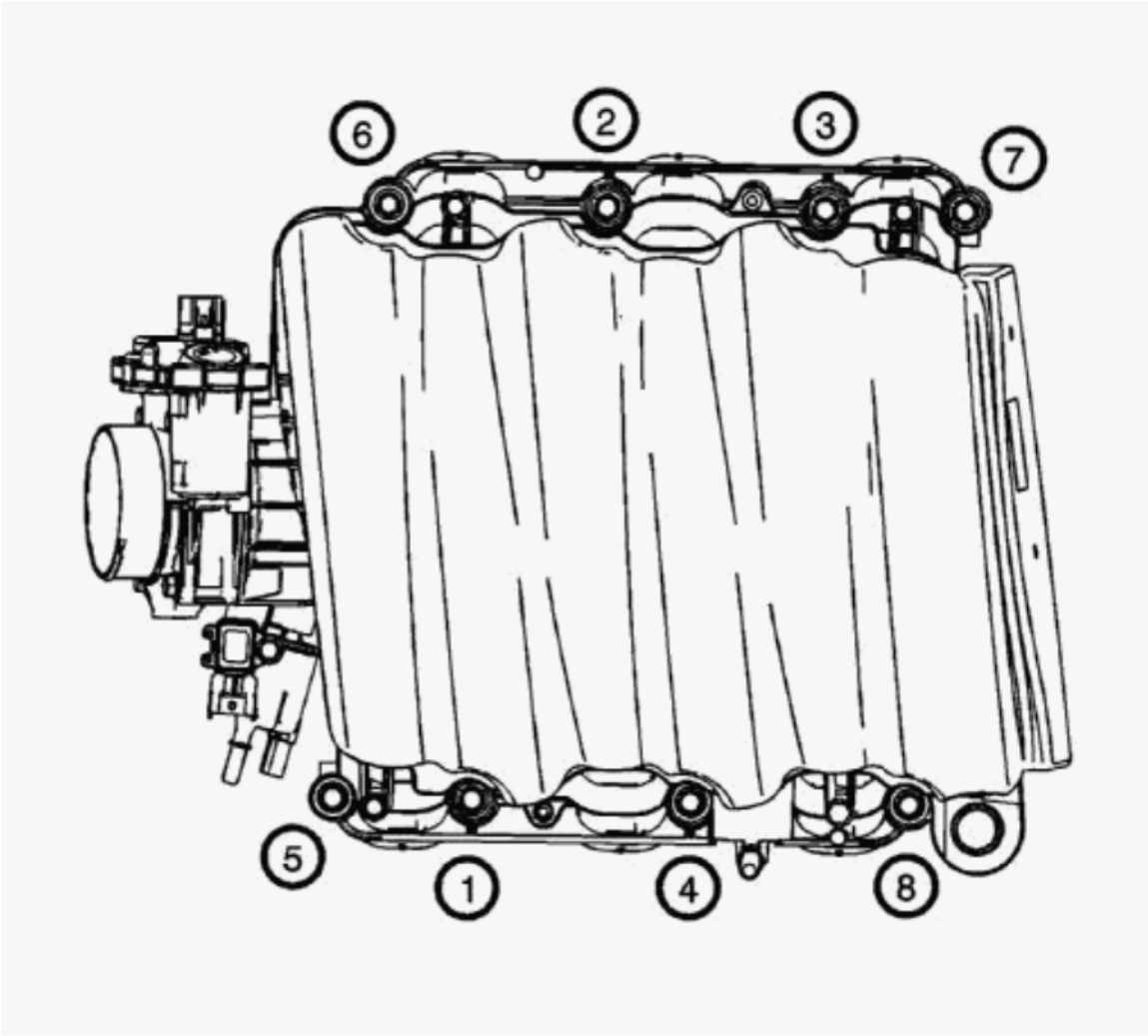

Fig. 56: Tightening Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

3. Tighten the intake manifold bolts.
    1. Tighten the intake manifold bolts (1-8) a first pass in sequence to 5 N.m (44 lb in).
    2. Tighten the intake manifold bolts (1-8) a final pass in sequence to 10 N.m (89 lb in).

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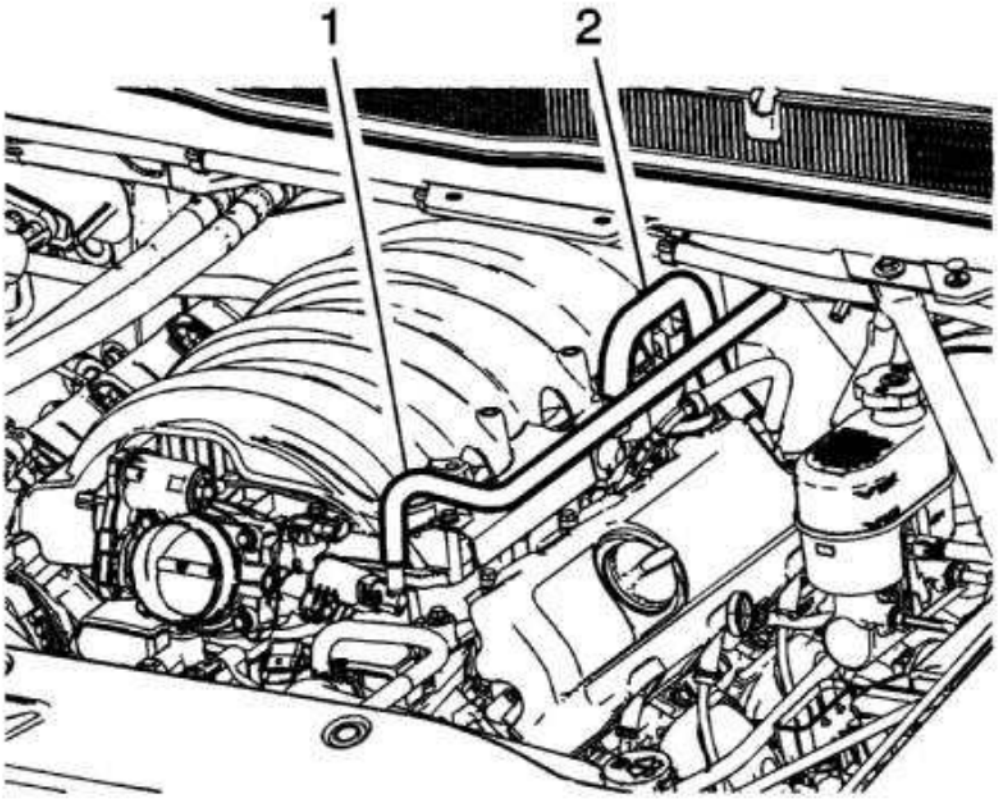

Fig. 57: EVAP Hose
Courtesy of GENERAL MOTORS COMPANY

4. Install the PCV hose (2). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.
5. Connect electrical connectors as necessary.
6. Install the EVAP hose (1). Refer to **Plastic Collar Quick Connect Fitting Service** .
7. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

VALVE LIFTER OIL MANIFOLD REPLACEMENT

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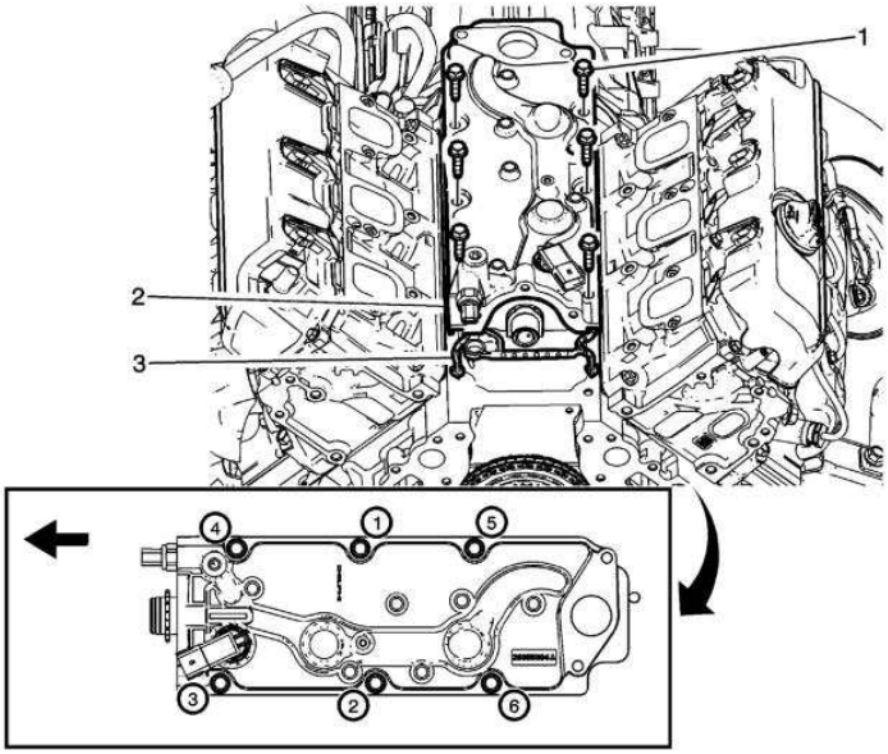

Fig. 58: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove the fuel pump. Refer to **Fuel Pump Replacement** . 2. Remove the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** , and **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** . 3. Remove the balance shaft sprocket. Refer to **Balance Shaft Sprocket Replacement**.	
1	Valve Lifter Oil Manifold Fastener (Qty; 6) **CAUTION:** **Refer to Fastener Caution .** **Procedure** Follow the tighten sequence above. **Tighten:** 1. First pass in sequence 15 N.m (11 lb ft) 2. Final pass in sequence 30 N.m (22 lb ft)
2	Valve Lifter Oil Manifold
3	Valve Lifter Oil Manifold Gasket

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VALVE LIFTER OIL FILTER REPLACEMENT

Removal Procedure

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.

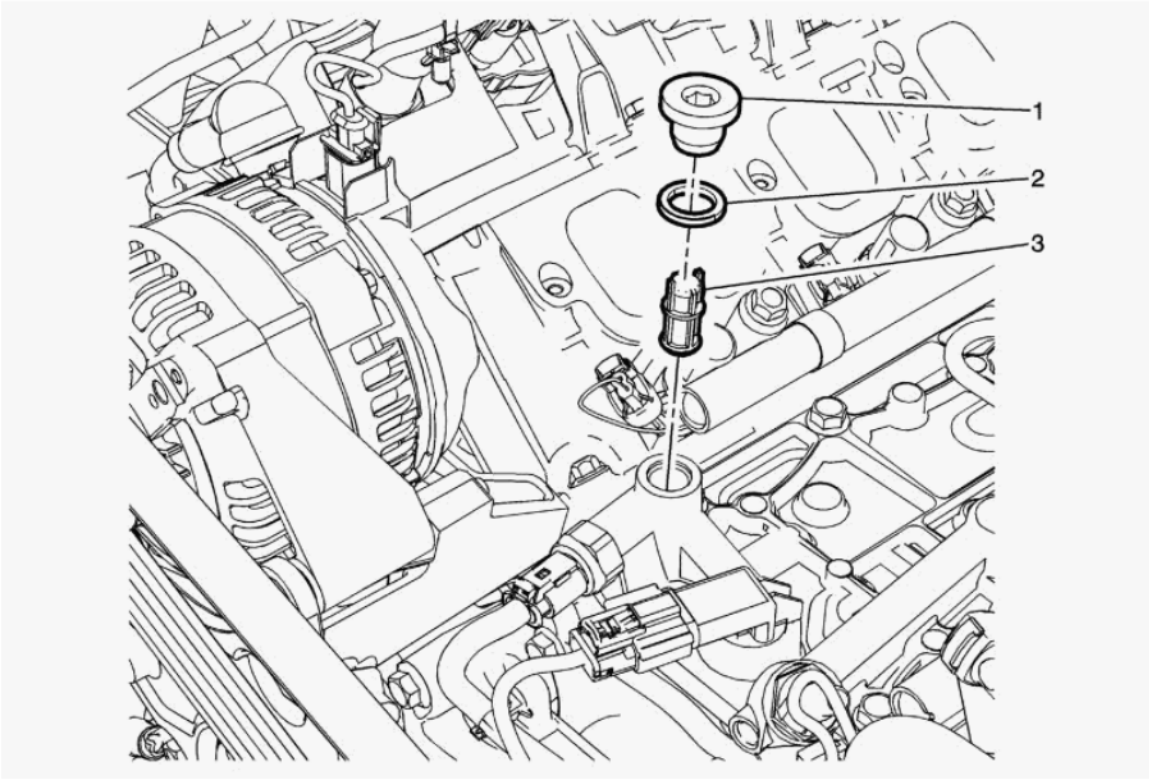

Fig. 59: Drive Motor Oil Filler Hole Plug, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil filler hole plug (1) and washer (2).
3. Remove and discard the valve lifter oil filter (3).

Installation Procedure

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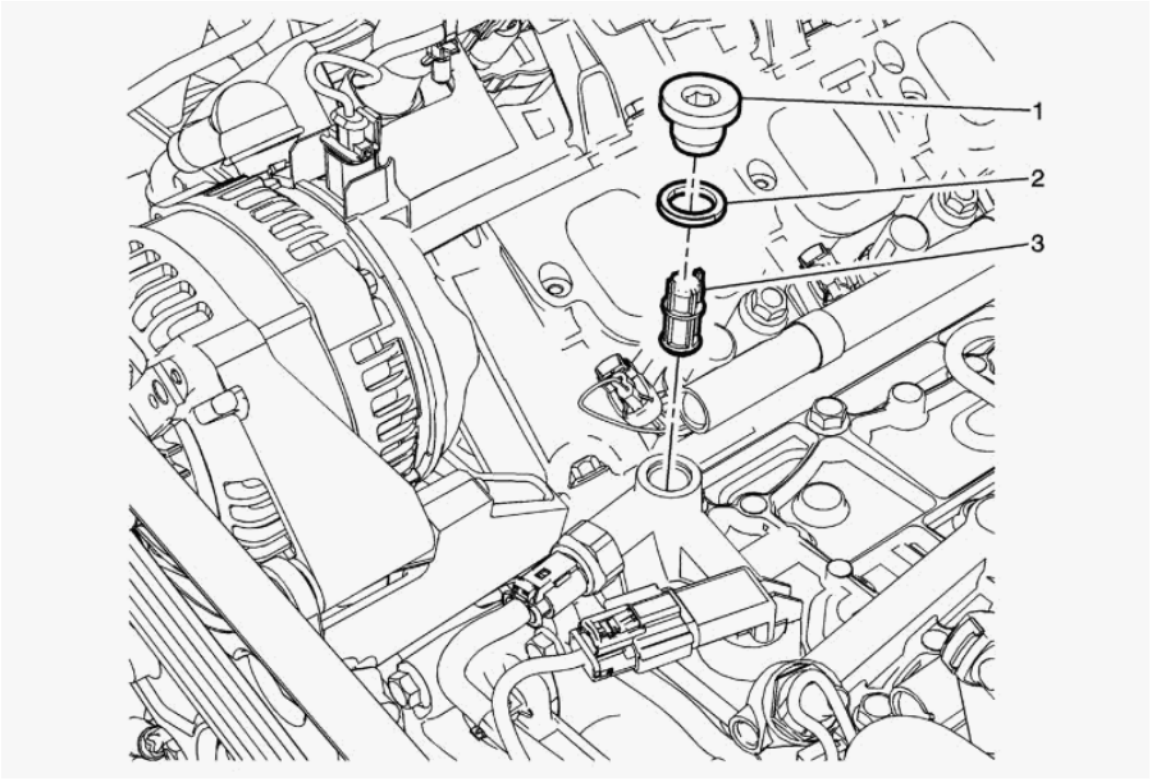

Fig. 60: Drive Motor Oil Filler Hole Plug, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

1. Install the NEW valve lifter oil filter (3).
2. Apply sealant to the threads of the drive motor oil filler hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

CAUTION: **Refer to Component Fastener Tightening Caution .**

3. Install the engine oil filler hole plug washer (2) and plug (1) and tighten to 65 N.m (48 lb ft).
4. Install the intake manifold. Refer to **Intake Manifold Replacement**.

VALVE ROCKER ARM COVER INSULATOR REPLACEMENT - LEFT SIDE

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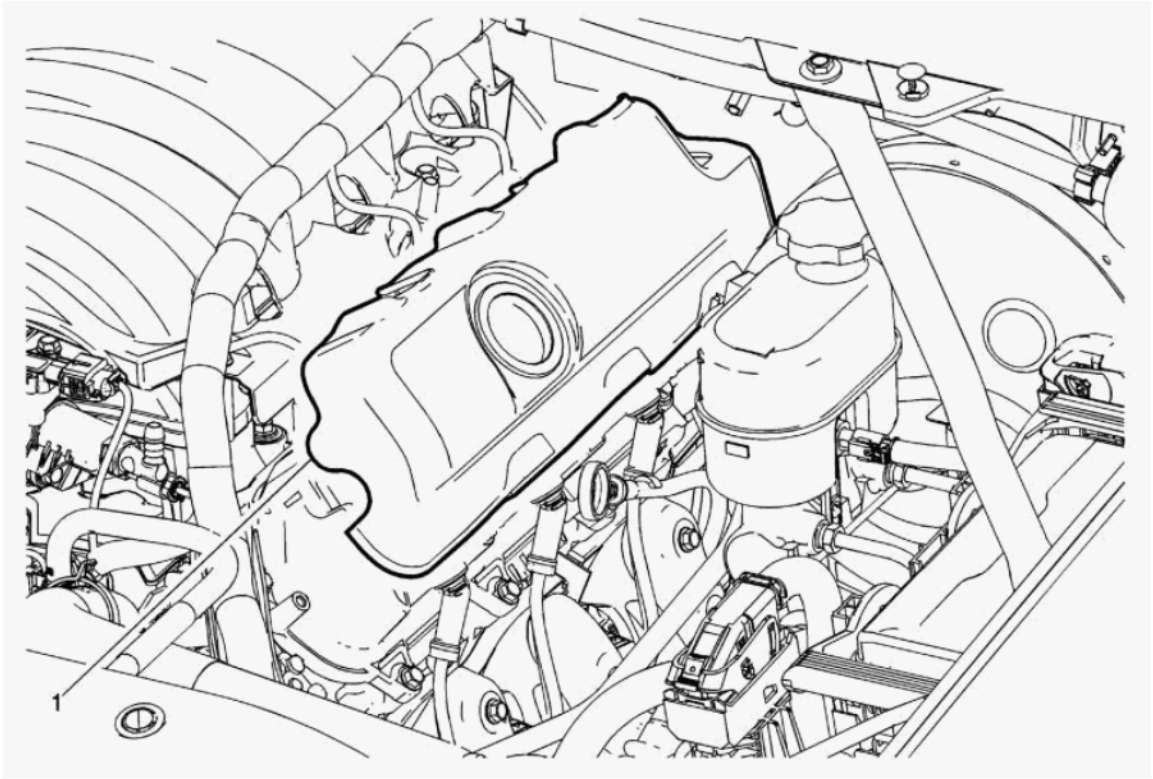

Fig. 61: Valve Rocker Arm Cover Insulator - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the left side PCV hose. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.	
1	Valve Rocker Arm Cover Insulator **Procedure** Remove the oil cap before removing the valve rocker arm cover insulator.

VALVE ROCKER ARM COVER INSULATOR REPLACEMENT - RIGHT SIDE

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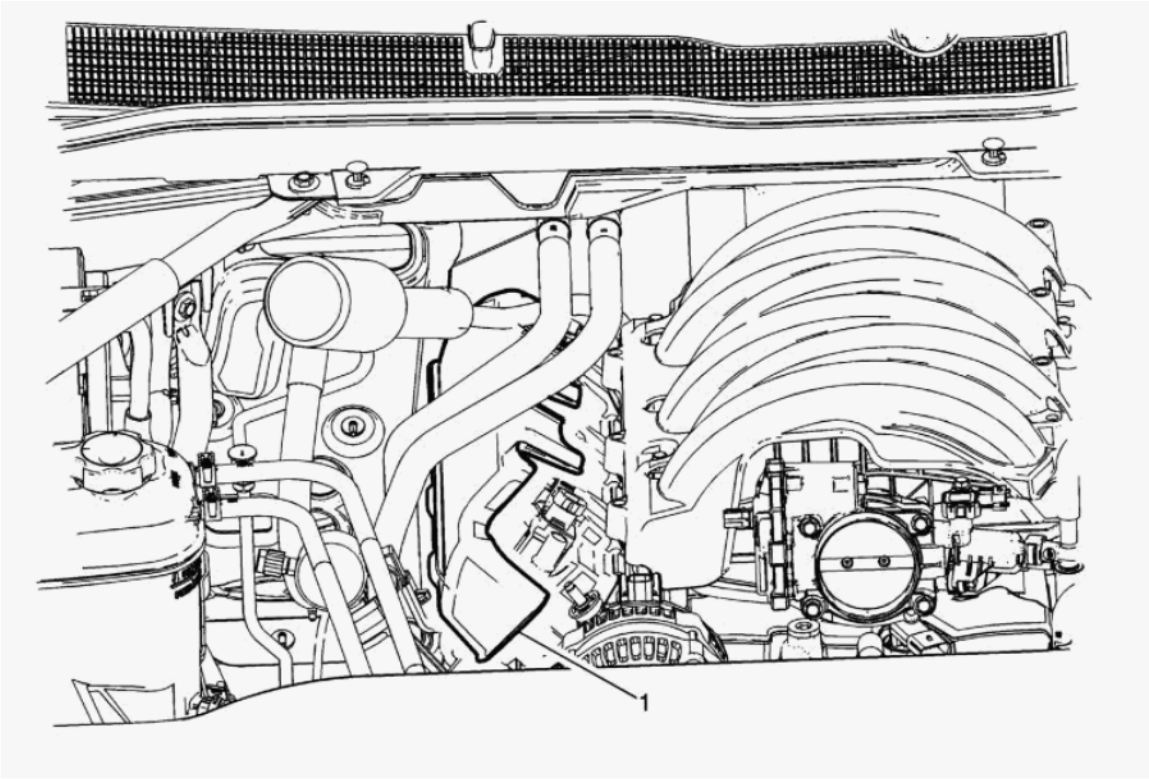

Fig. 62: Valve Rocker Arm Cover Insulator - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the right side PCV hose. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)**.	
1	Valve Rocker Arm Cover Insulator

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

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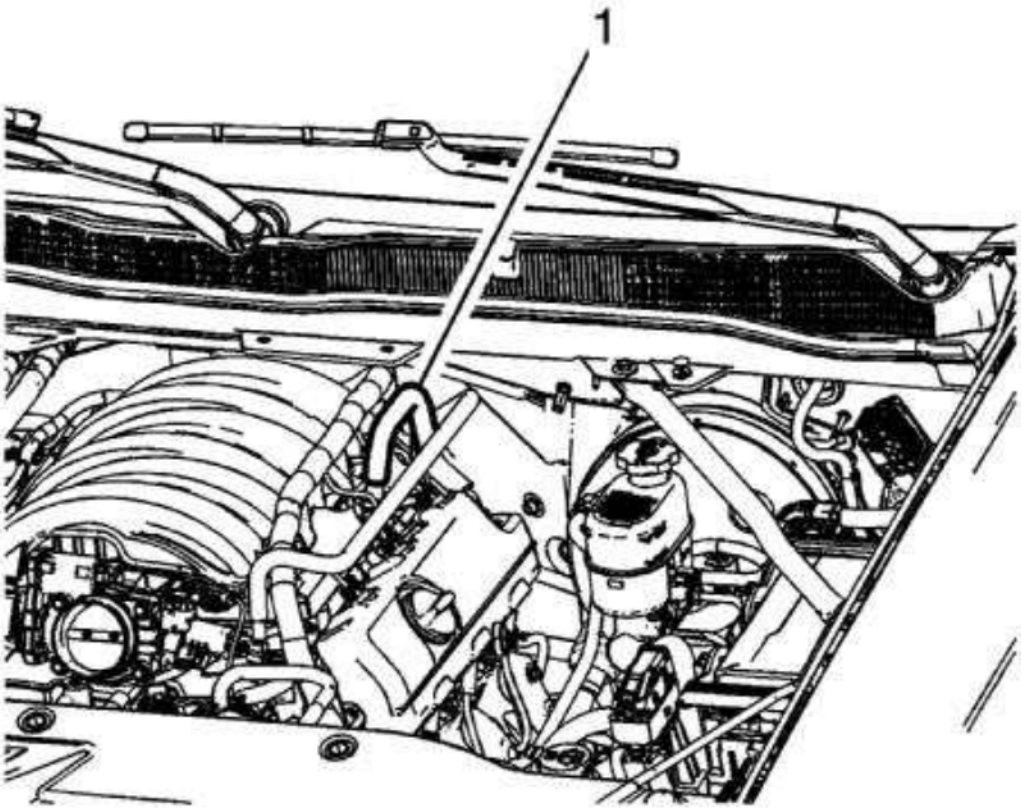

Fig. 63: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

1. Remove the PCV tube (1). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.

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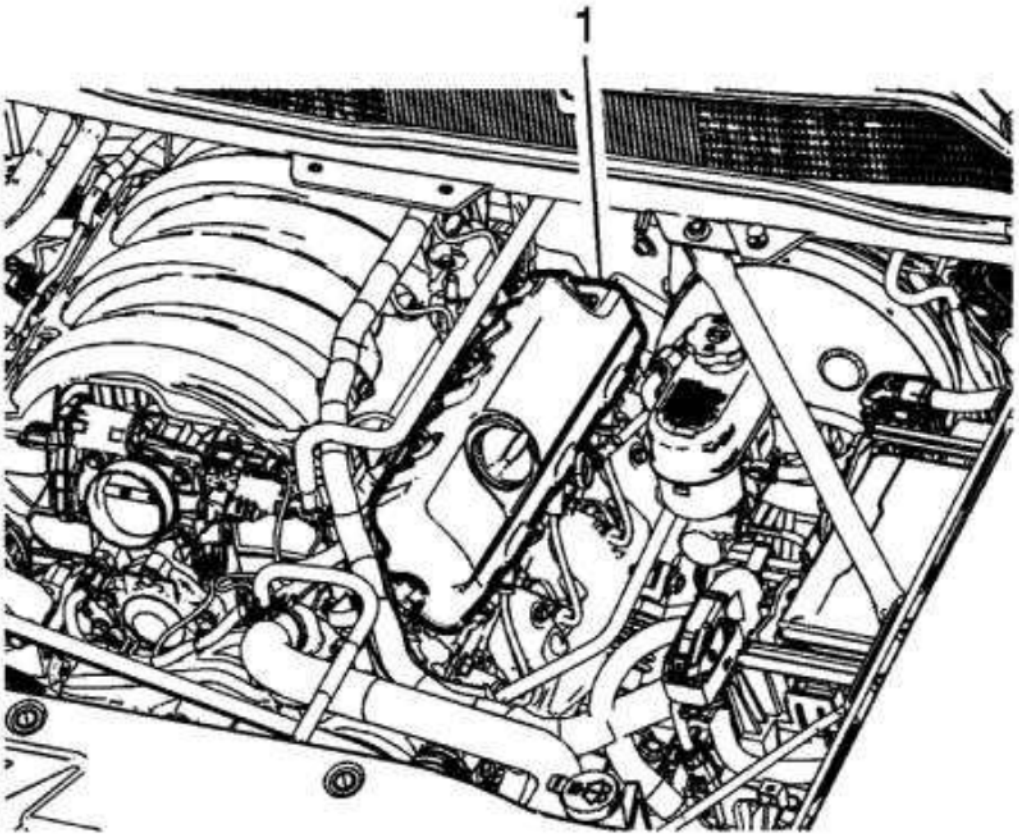

Fig. 64: Valve Rocker Arm Insulator
Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve rocker arm insulator (1). Refer to **Valve Rocker Arm Cover Insulator Replacement - Left Side**.

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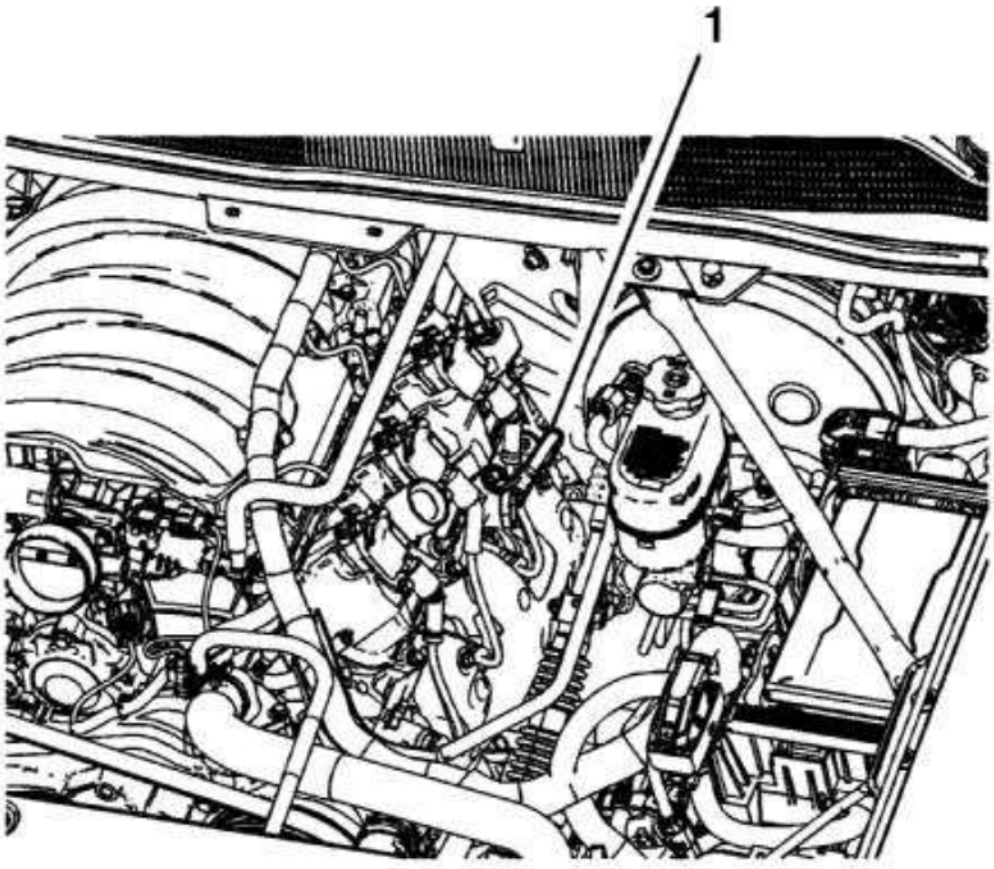

Fig. 65: Oil Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil indicator tube (1). Refer to **Oil Level Indicator Tube Replacement**.

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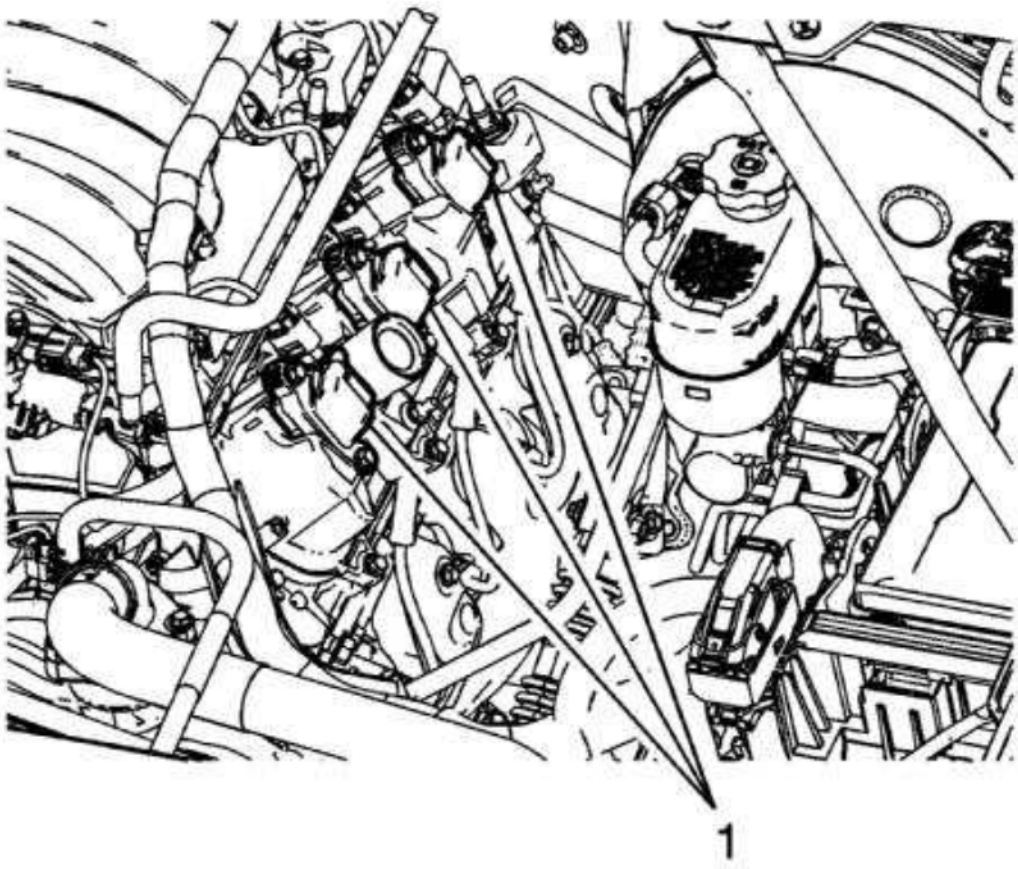

Fig. 66: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

4. Remove the ignition coil (1). Refer to **Ignition Coil Replacement** .

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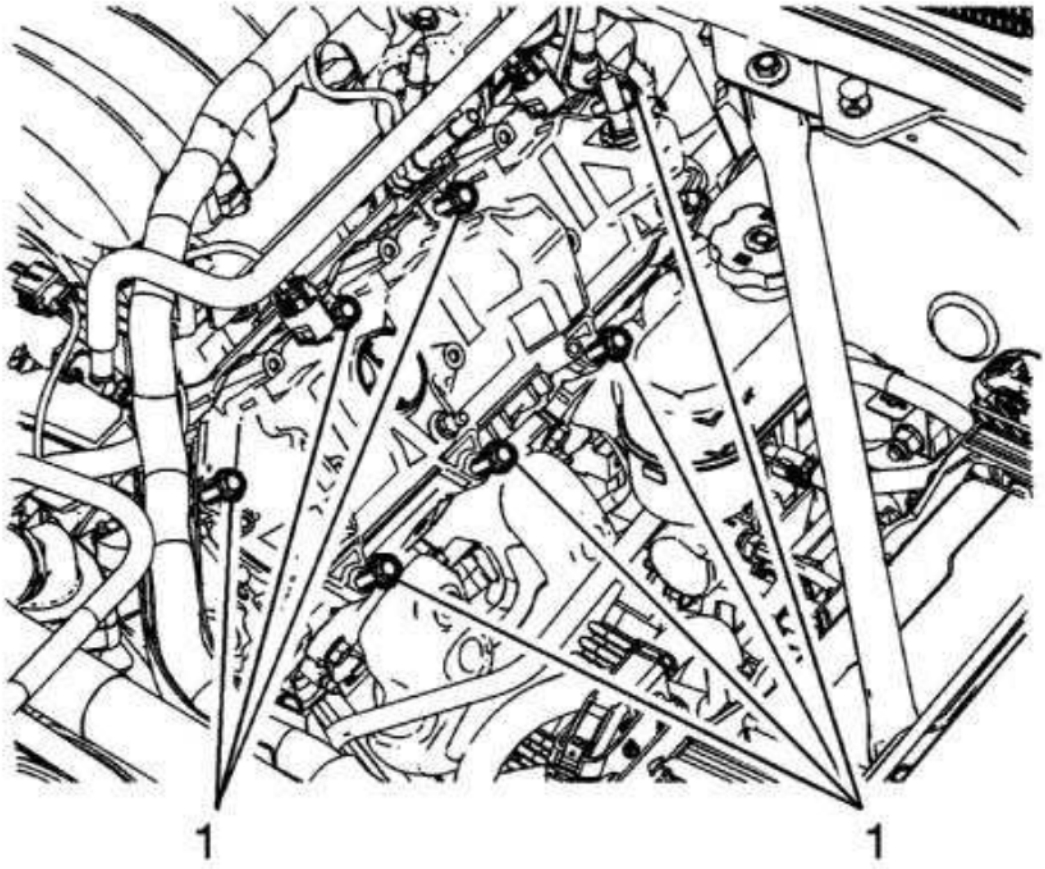

Fig. 67: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the valve rocker arm cover bolts (1).

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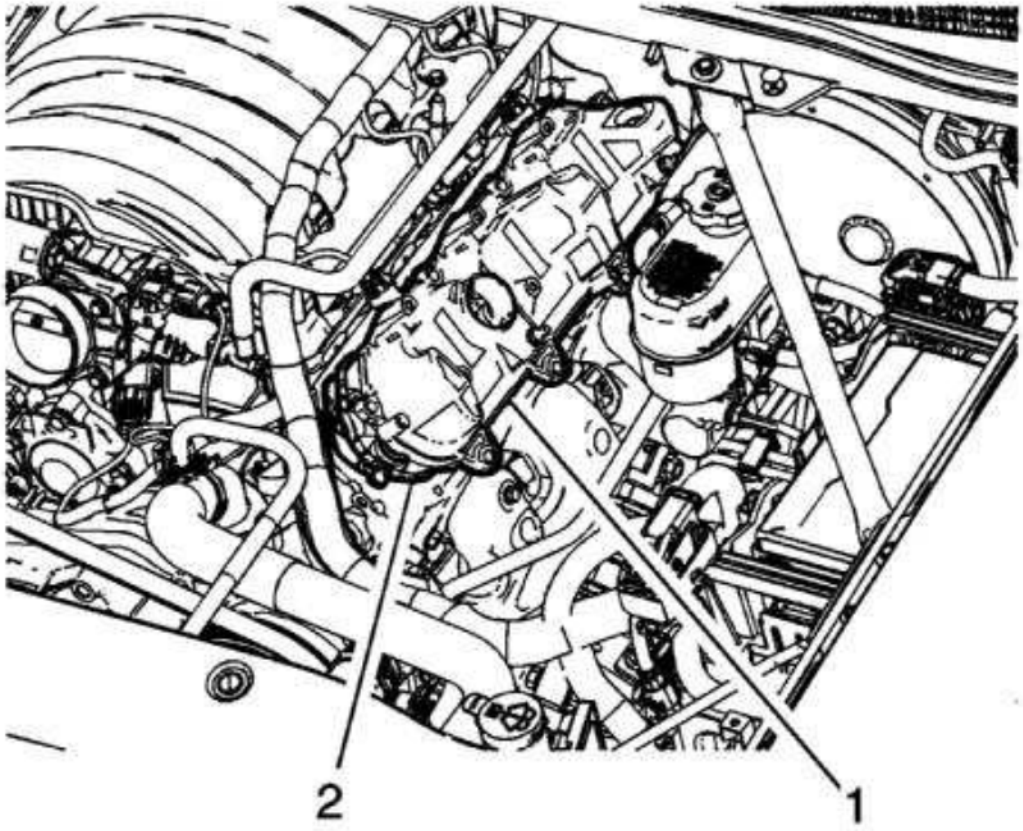

Fig. 68: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

6. Remove the valve rocker arm cover (1).
7. Remove and DISCARD valve rocker arm gasket (2). Refer to **Replacing Engine Gaskets**.
8. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection** .

Installation Procedure

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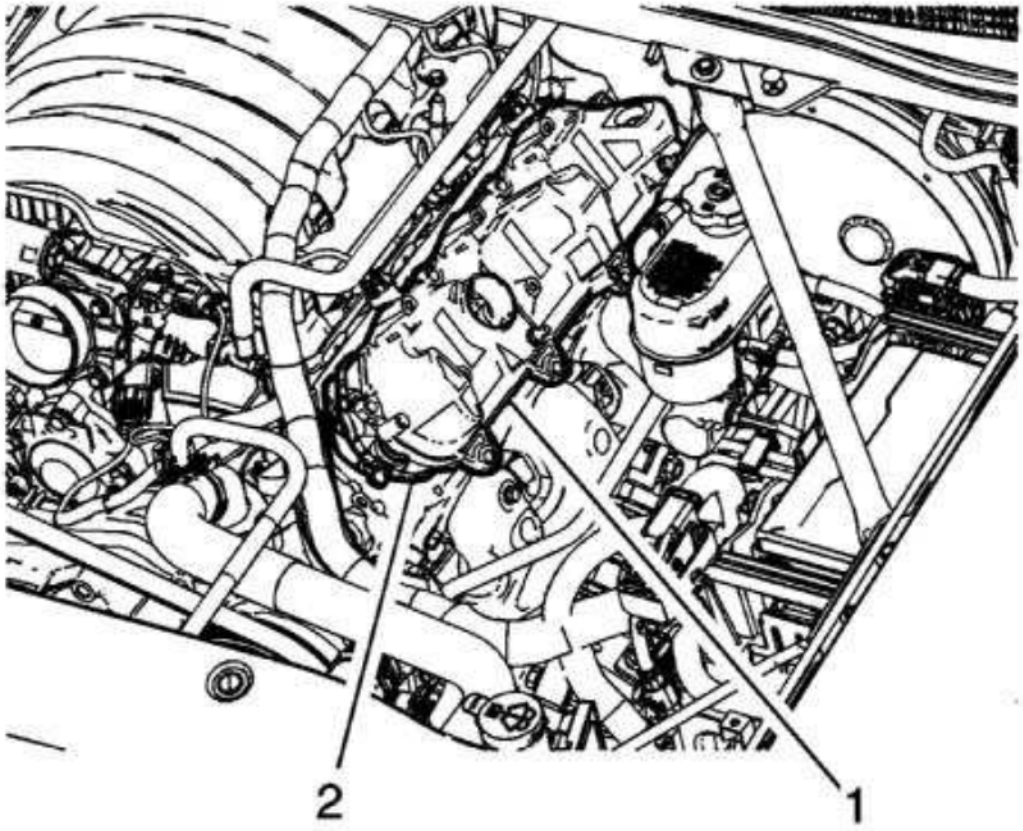

Fig. 69: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the valve rocker arm cover grommets are cracked or damaged, replace the valve rocker arm cover bolts. The grommet is serviced with the rocker arm cover bolt.**

1. Install a NEW valve rocker arm gasket (2).
2. Install the valve rocker arm cover (1).

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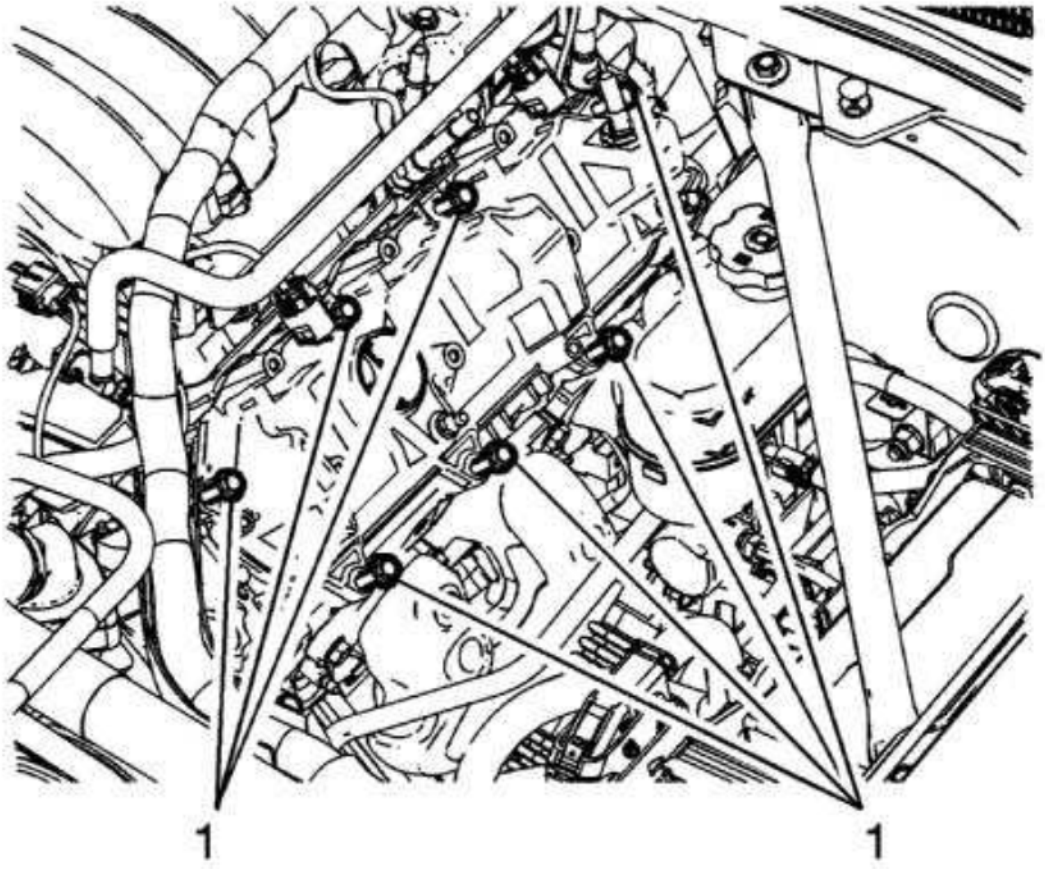

Fig. 70: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install valve rocker arm cover bolts (1) and hand tighten.

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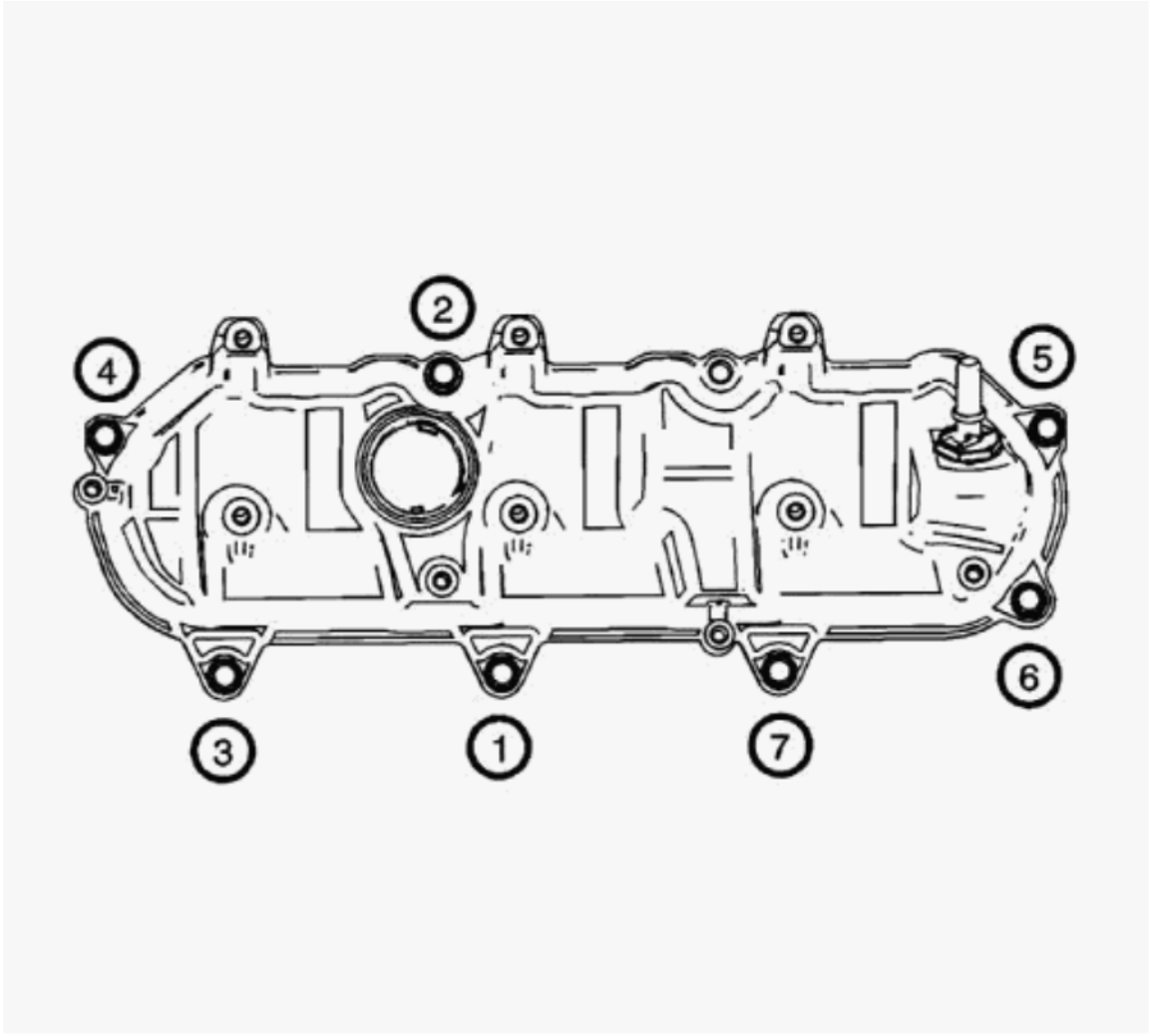

Fig. 71: Valve Rocker Arm Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

4. Tighten the bolts in sequence to 10 N.m (89 lb in) as shown.

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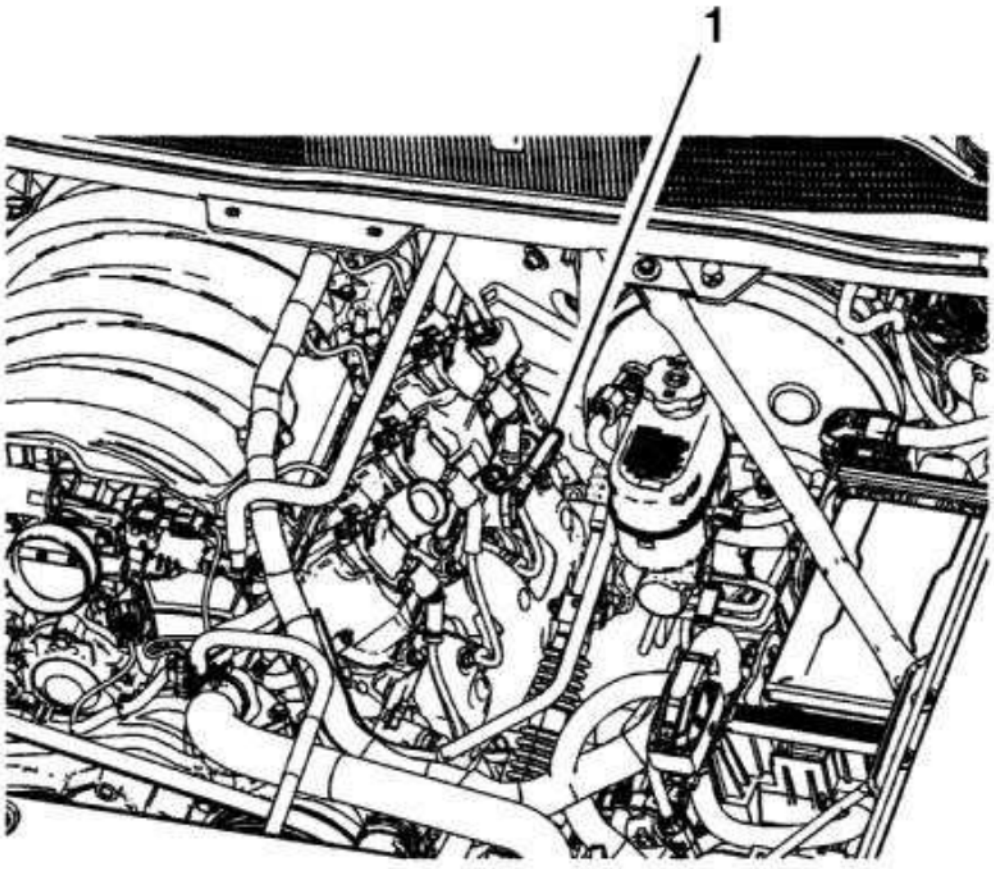

Fig. 72: Oil Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

5. Install the oil indicator tube (1). Refer to **Oil Level Indicator Tube Replacement**.

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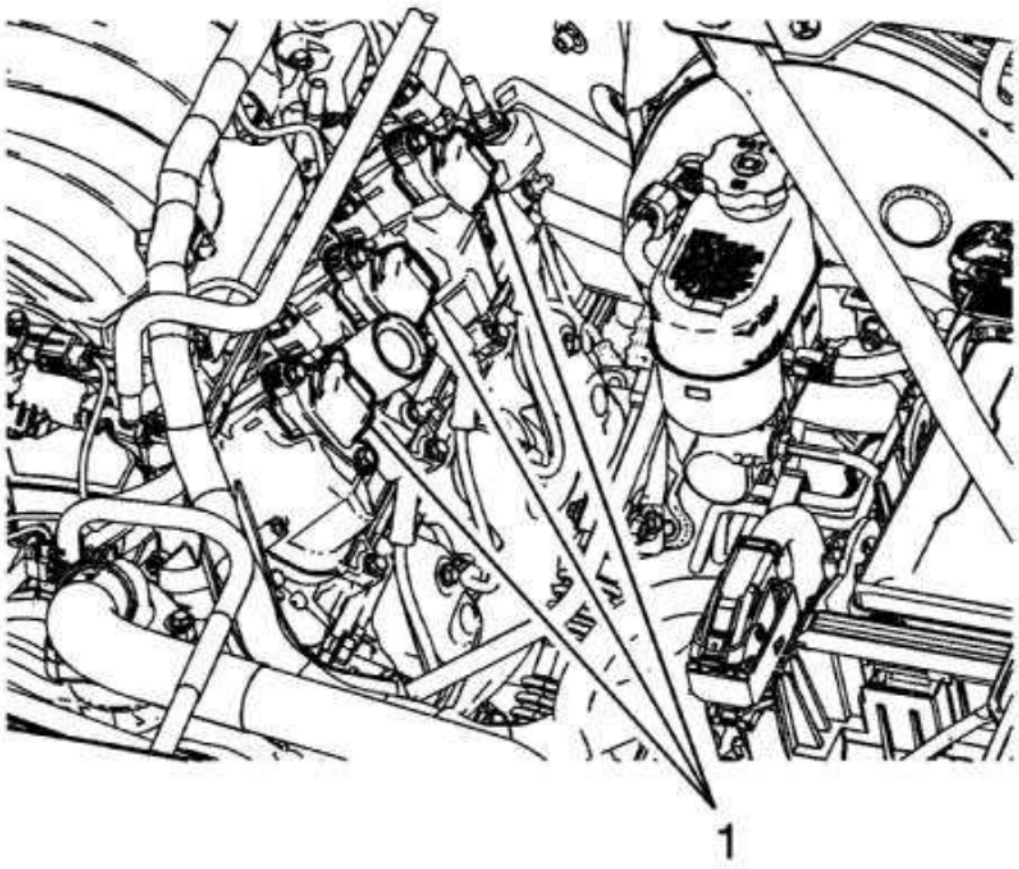

Fig. 73: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

6. Install the ignition coil (1). Refer to **Ignition Coil Replacement** .

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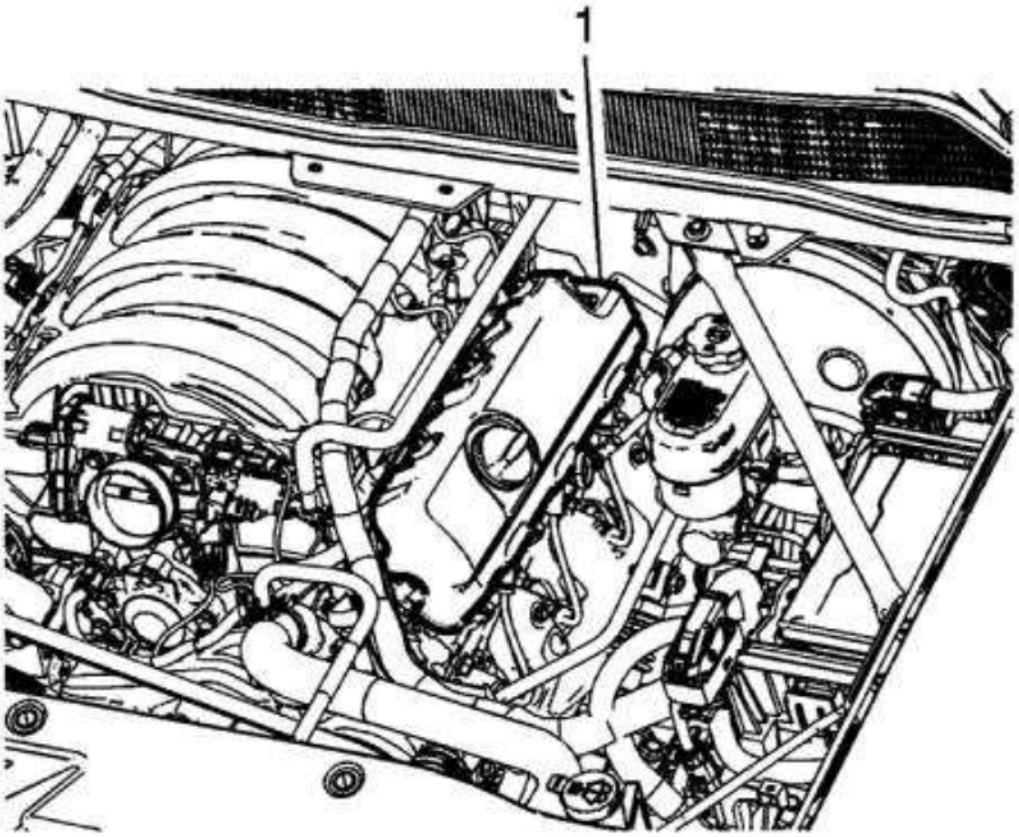

Fig. 74: Valve Rocker Arm Insulator
Courtesy of GENERAL MOTORS COMPANY

7. Install the valve rocker arm insulator (1). Refer to **Valve Rocker Arm Cover Insulator Replacement - Left Side**.

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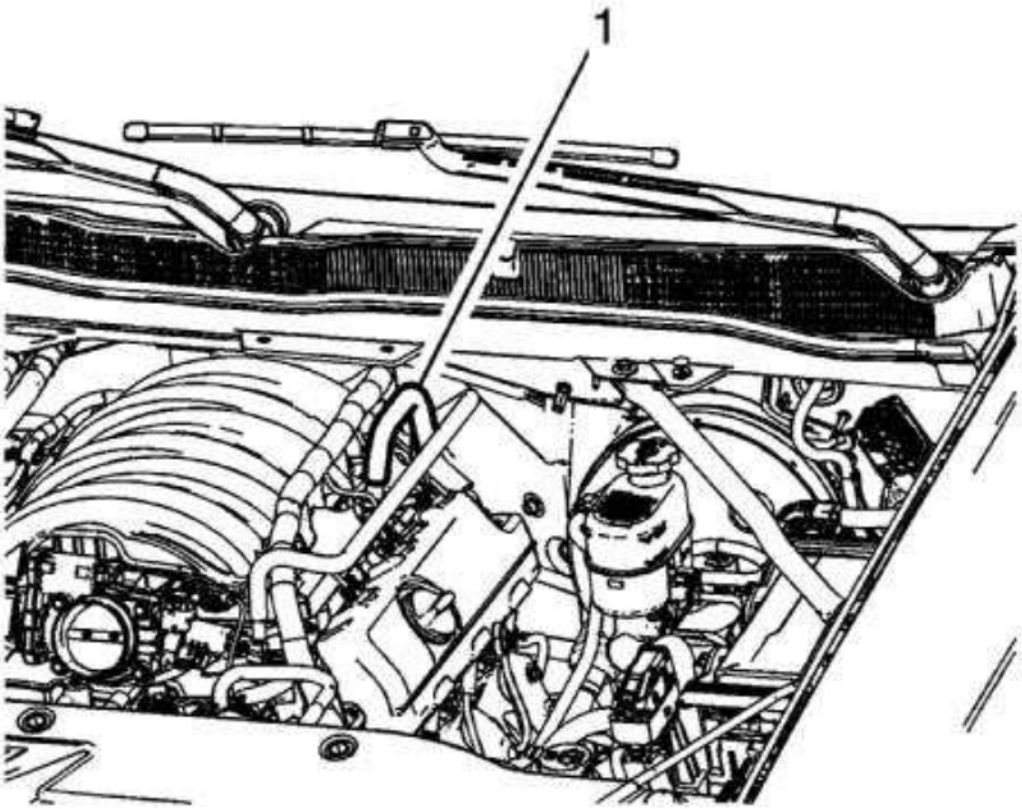

Fig. 75: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

8. Install the PCV tube (1). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side/Bank 1)**.

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

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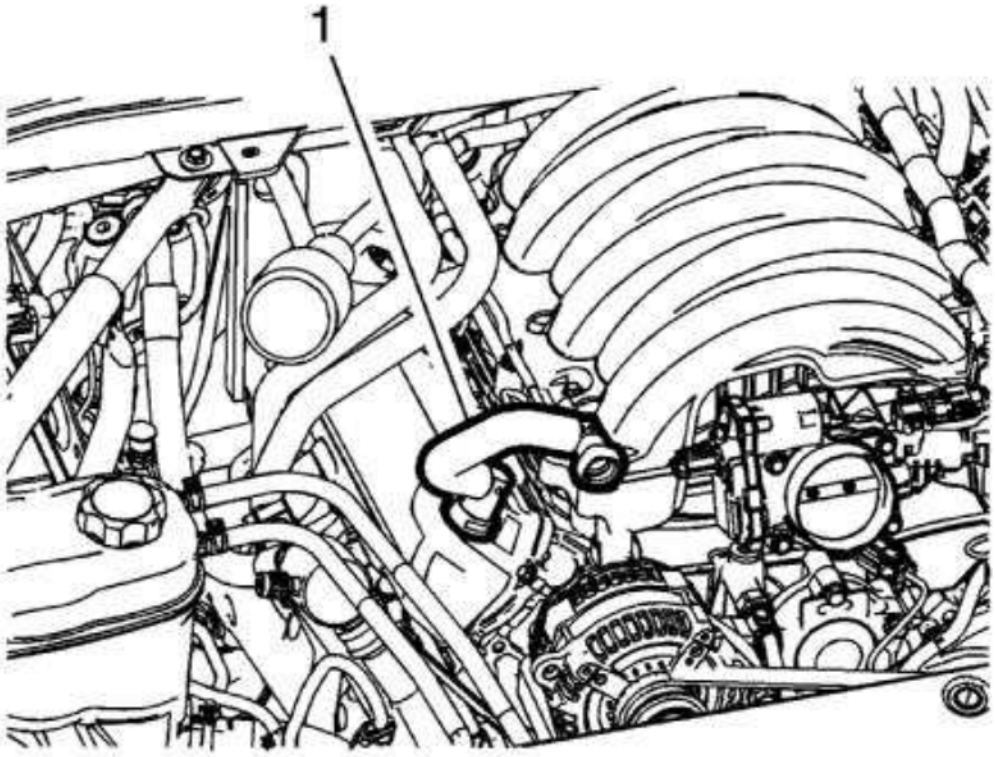

Fig. 76: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

2. Remove the PCV tube (1). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)**.

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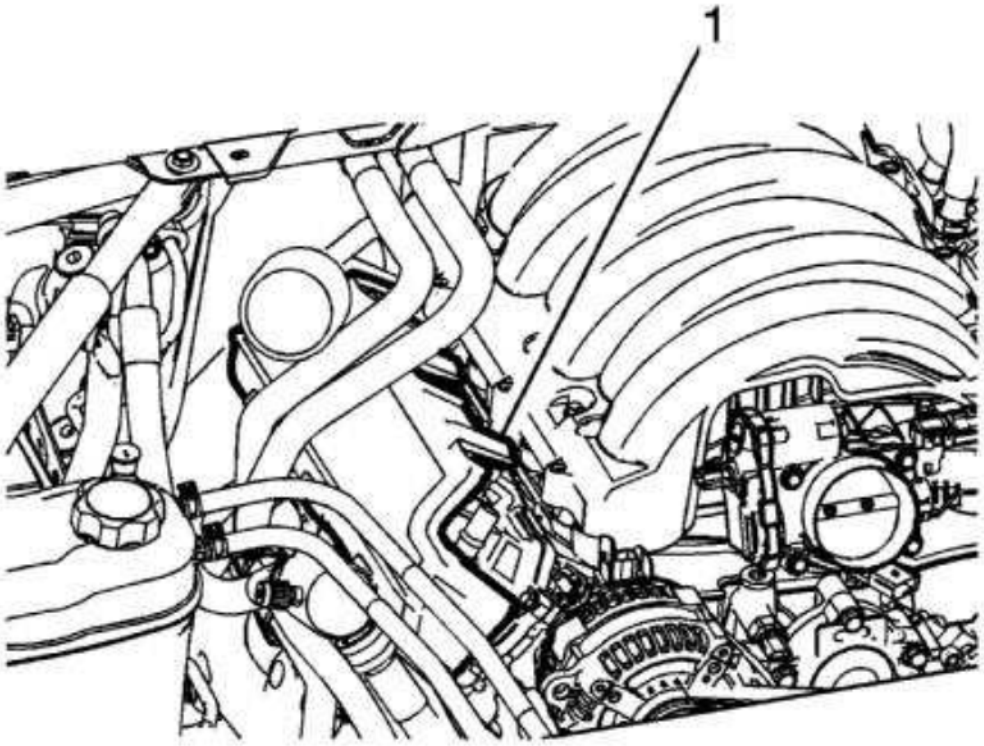

Fig. 77: Valve Rocker Arm Insulator
Courtesy of GENERAL MOTORS COMPANY

3. Remove the valve rocker arm insulator (1). Refer to **Valve Rocker Arm Cover Insulator Replacement - Right Side**.

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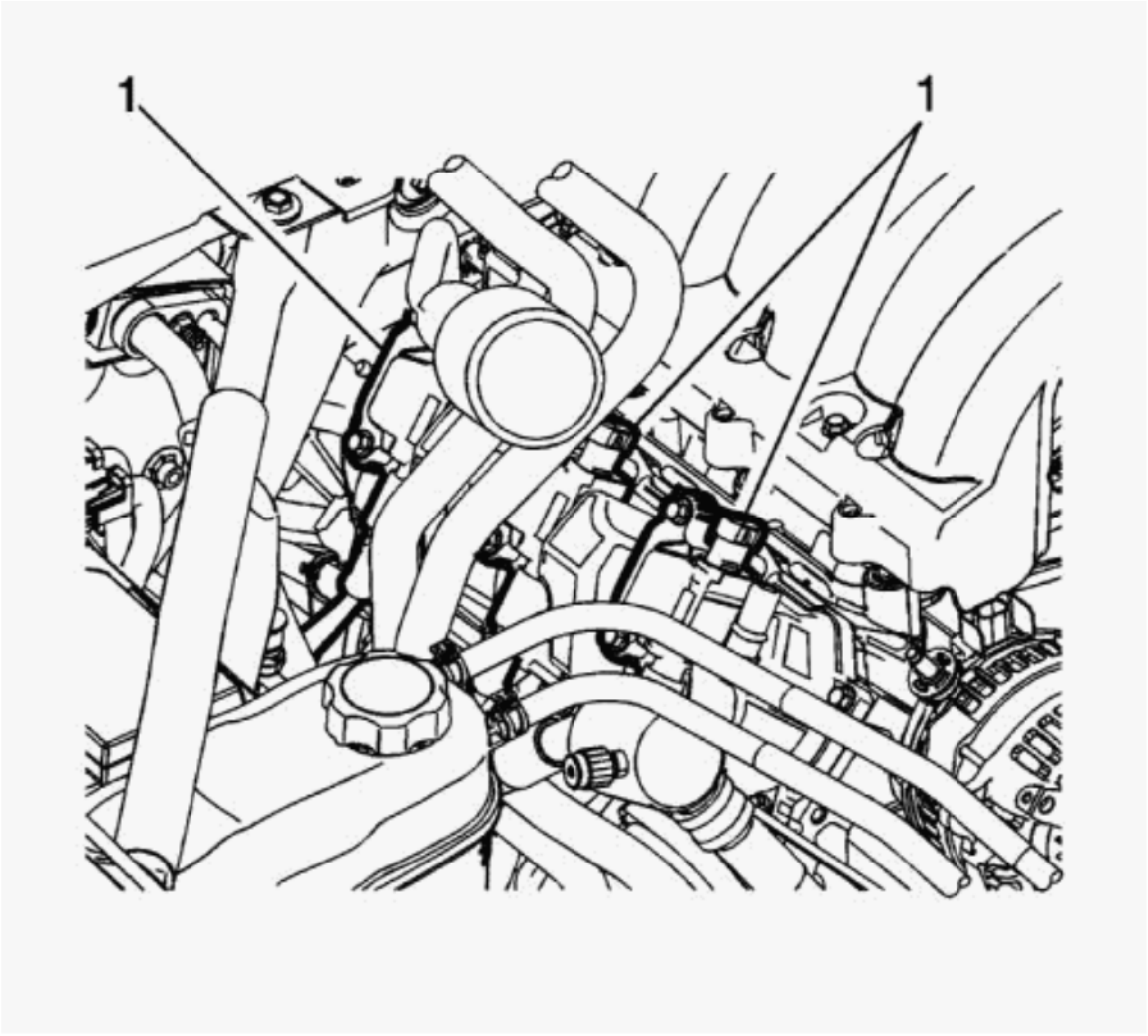

Fig. 78: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

4. Remove the ignition coil (1). Refer to **Ignition Coil Replacement** .

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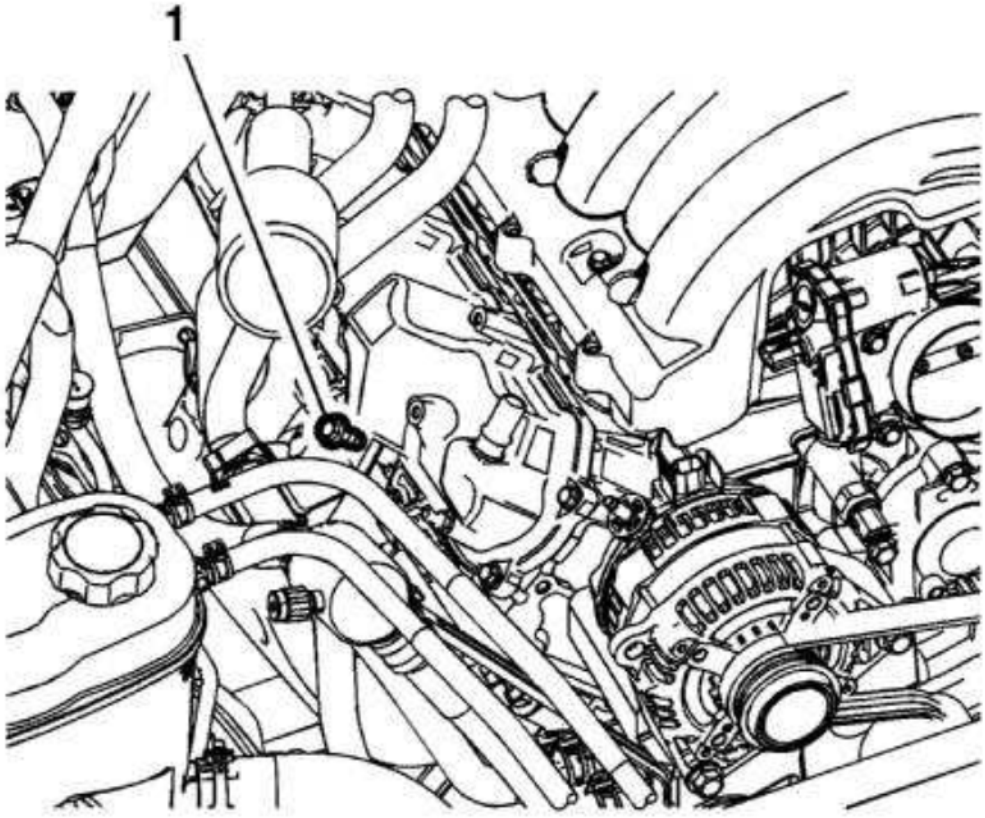

Fig. 79: Heater Hoses Fastener
Courtesy of GENERAL MOTORS COMPANY

5. Remove the heater hoses (1) fastener.

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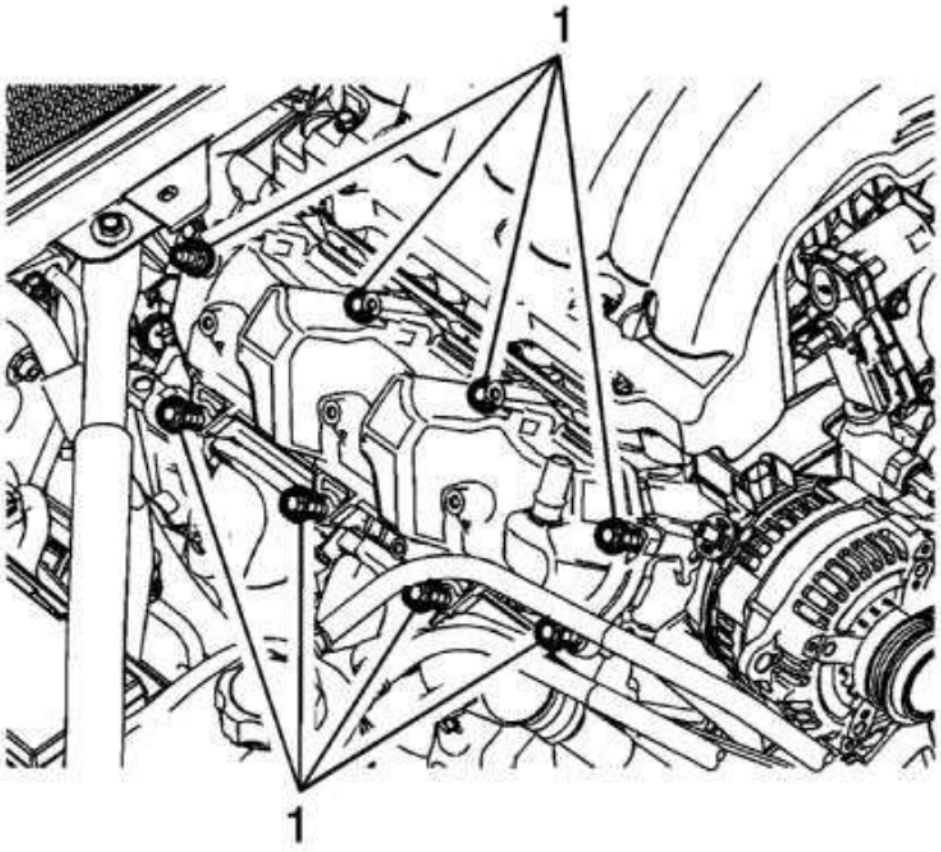

Fig. 80: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the valve rocker arm cover bolts (1).

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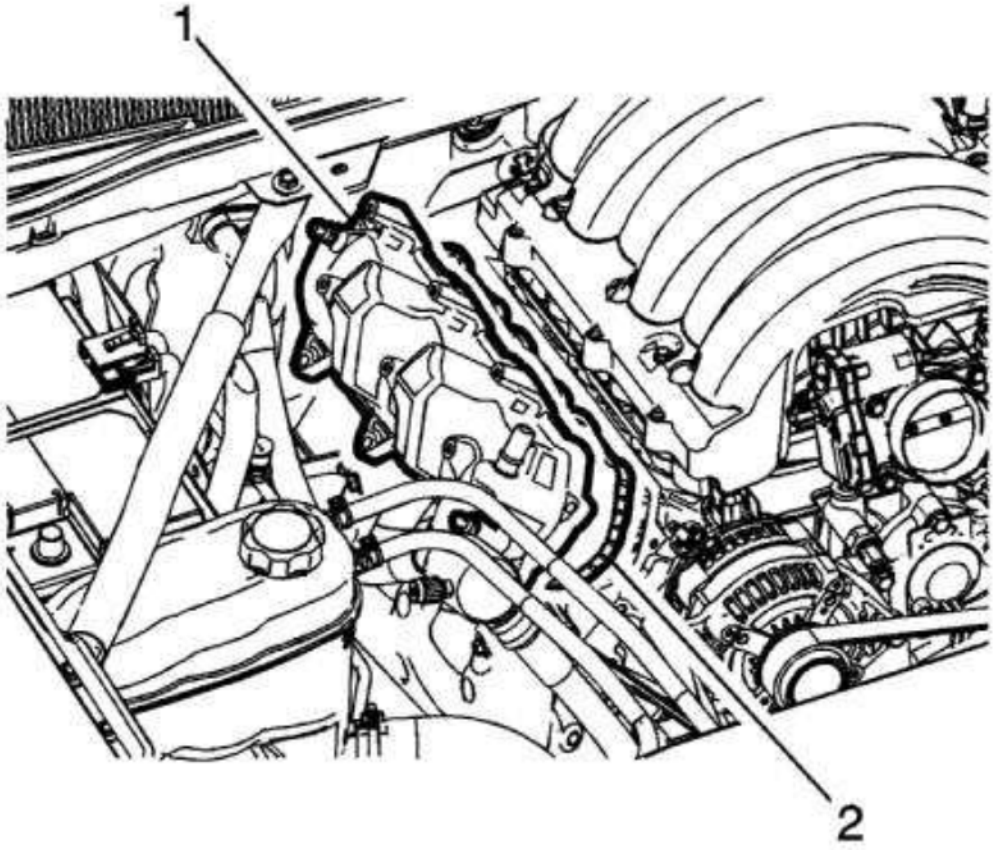

Fig. 81: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

7. Remove the valve rocker arm cover (1).
8. Remove and DISCARD valve rocker arm gasket (2). Refer to **Replacing Engine Gaskets**.
9. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection** .

Installation Procedure

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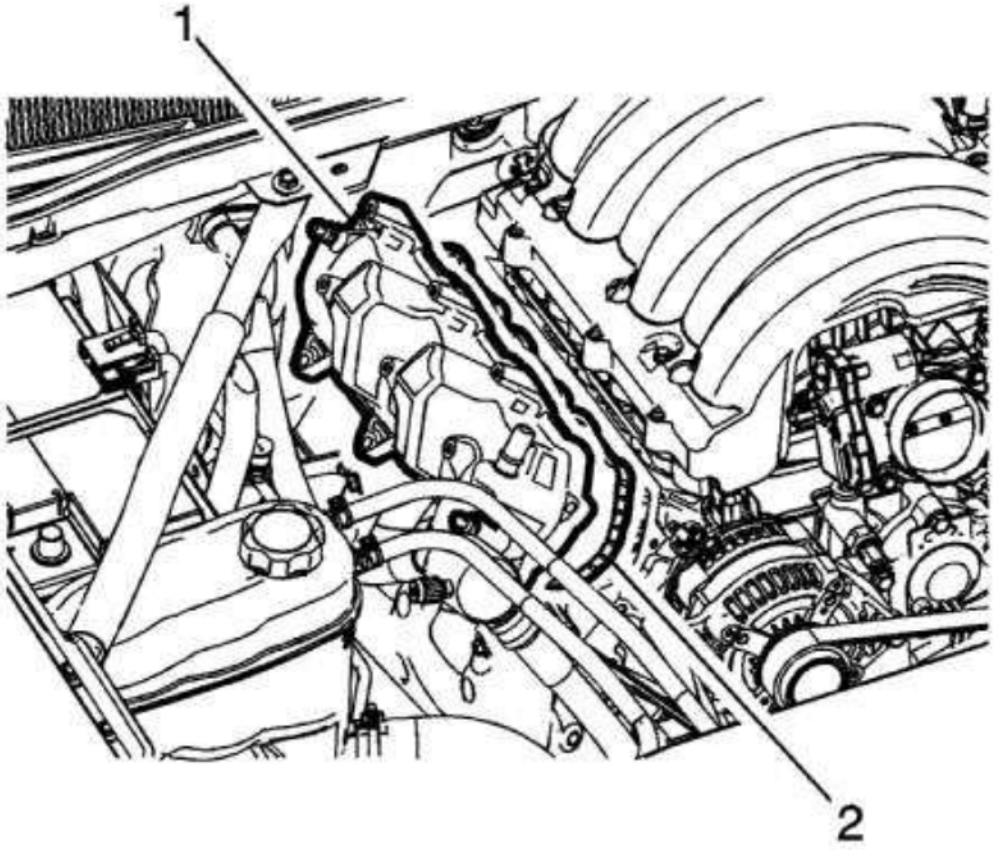

Fig. 82: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If the valve rocker arm cover grommets are cracked or damaged, replace the valve rocker arm cover bolts. The grommet is serviced with the rocker arm cover bolt.**

1. Install a NEW valve rocker arm gasket (2).
2. Install the valve rocker arm cover (1).

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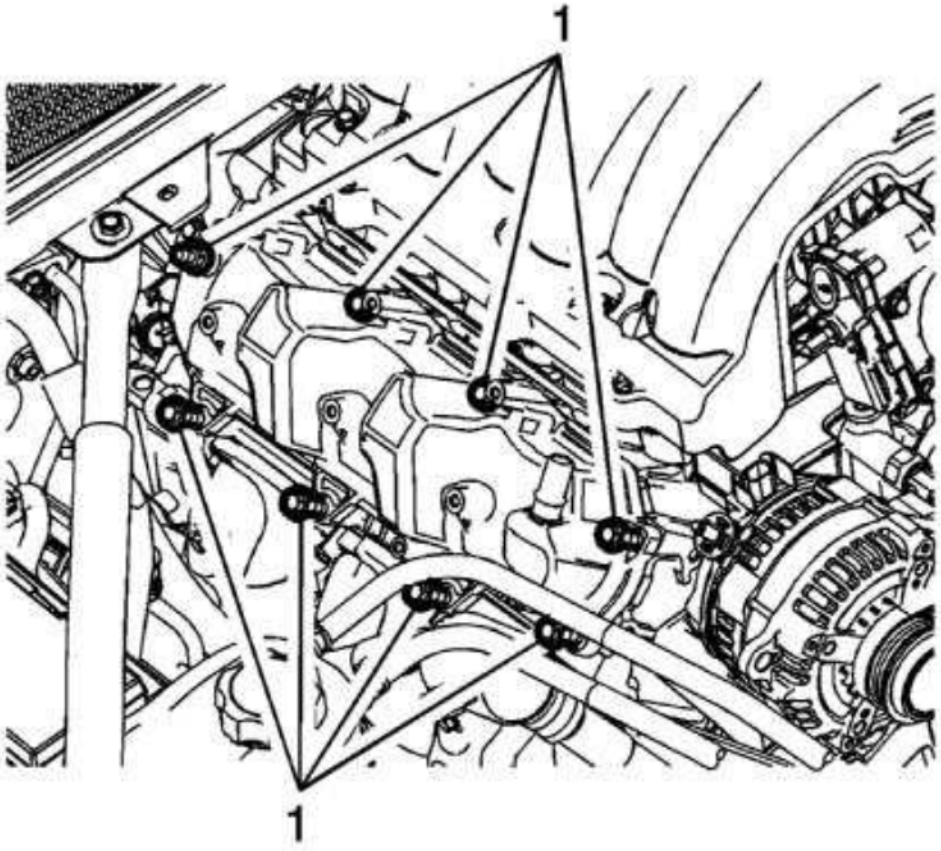

Fig. 83: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install valve rocker arm cover bolts (1) and hand tighten.

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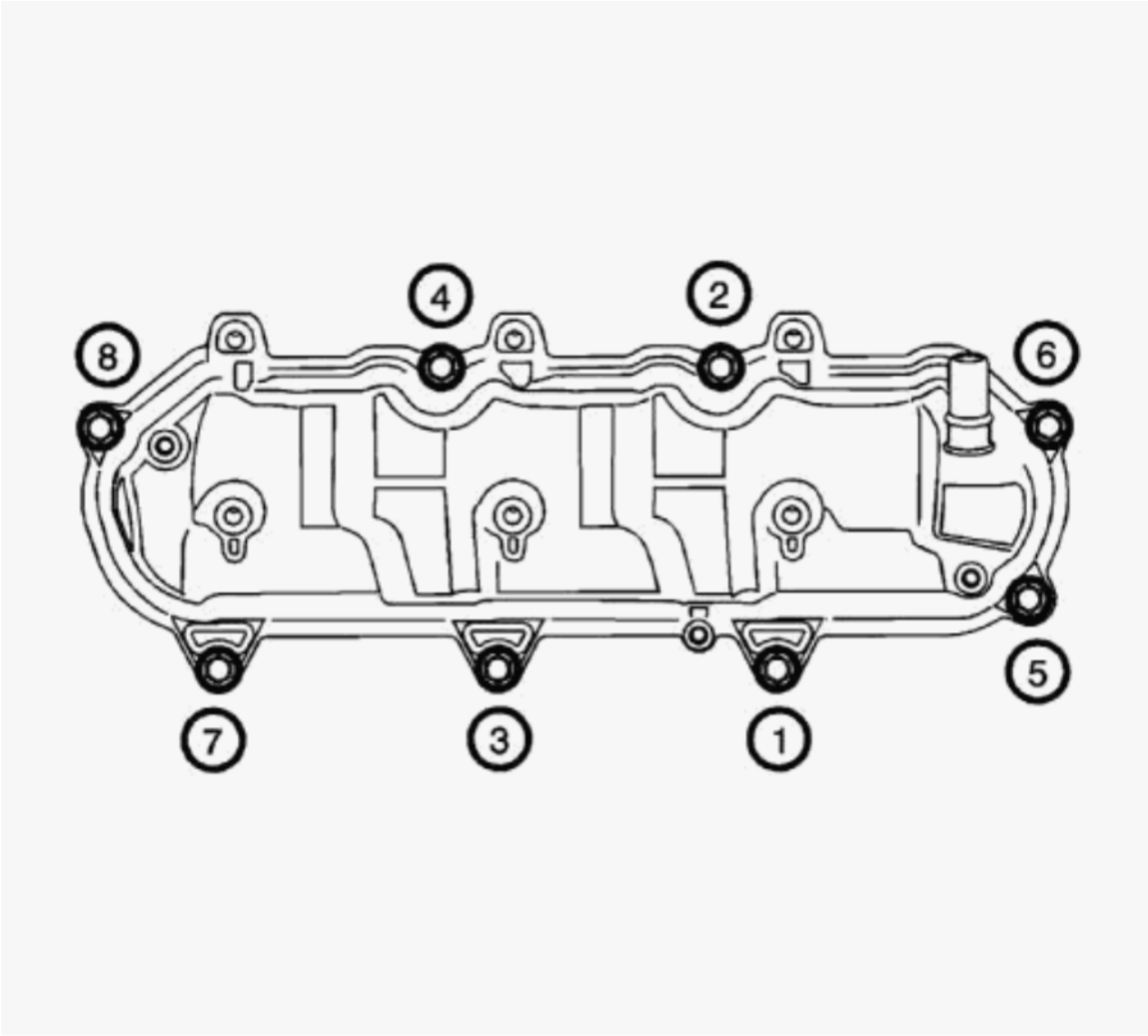

Fig. 84: Valve Rocker Arm Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

4. Tighten the bolts in sequence to 10 N.m (89 lb in) as shown.

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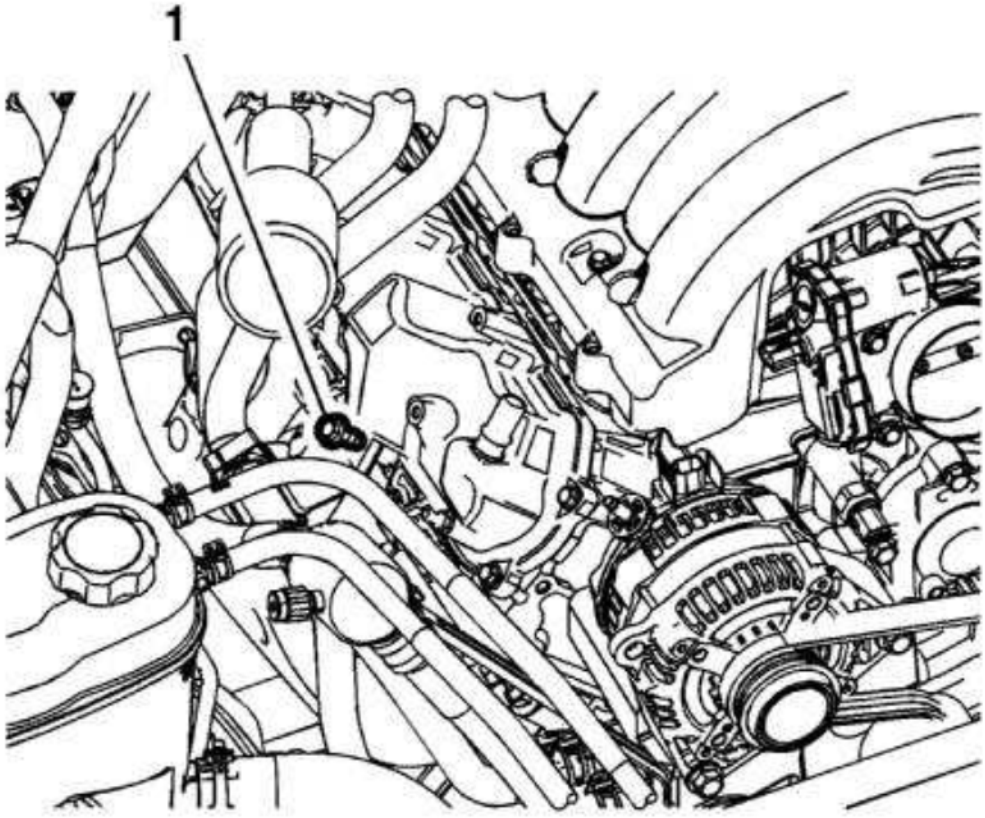

Fig. 85: Heater Hoses Fastener
Courtesy of GENERAL MOTORS COMPANY

5. Install the heater hose fastener (1) and tighten to 10 N.m (89 lb in).

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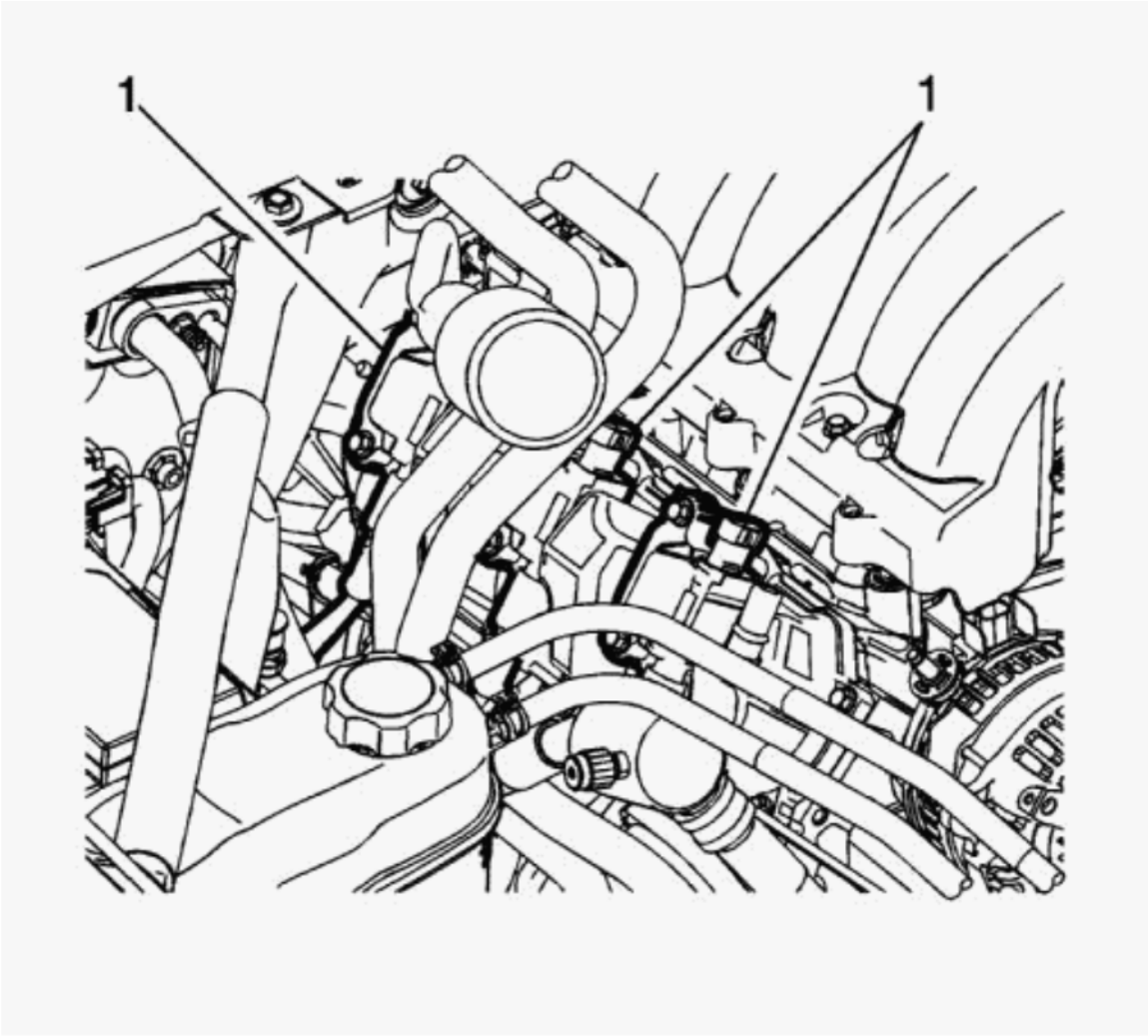

Fig. 86: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

6. Install the ignition coil (1). Refer to **Ignition Coil Replacement** .

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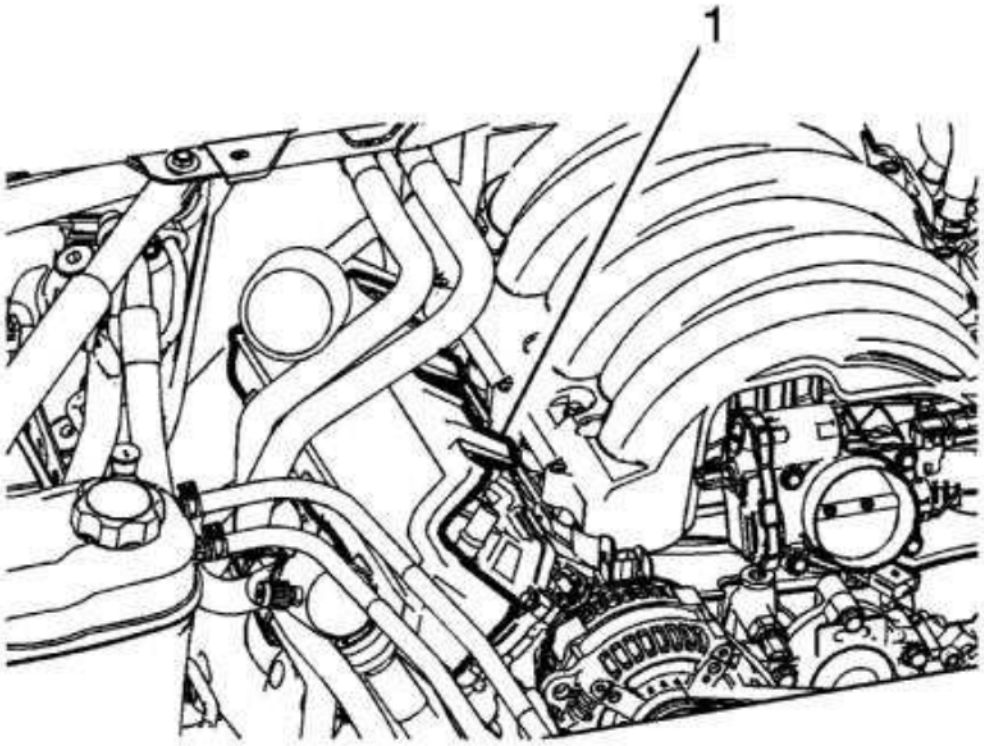

Fig. 87: Valve Rocker Arm Insulator
Courtesy of GENERAL MOTORS COMPANY

7. Install the valve rocker arm insulator (1). Refer to **Valve Rocker Arm Cover Insulator Replacement - Right Side**.

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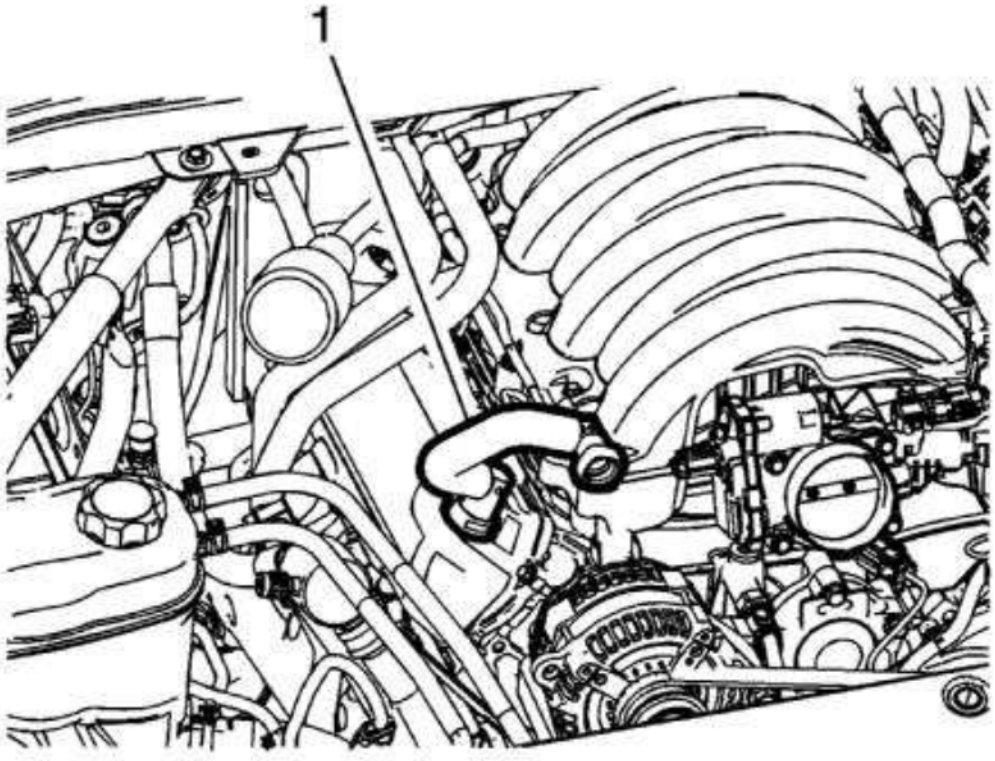

Fig. 88: PCV Tube
Courtesy of GENERAL MOTORS COMPANY

8. Install the PCV tube (1). Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Right Side/Bank 2)**.
9. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT (RIGHT SIDE/BANK 2)

Removal Procedure

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

NOTE:

- **Be sure to keep parts in order. Parts must be reinstalled into the original location and position.**
- **The rocker arm bolts are not serviced separately.**

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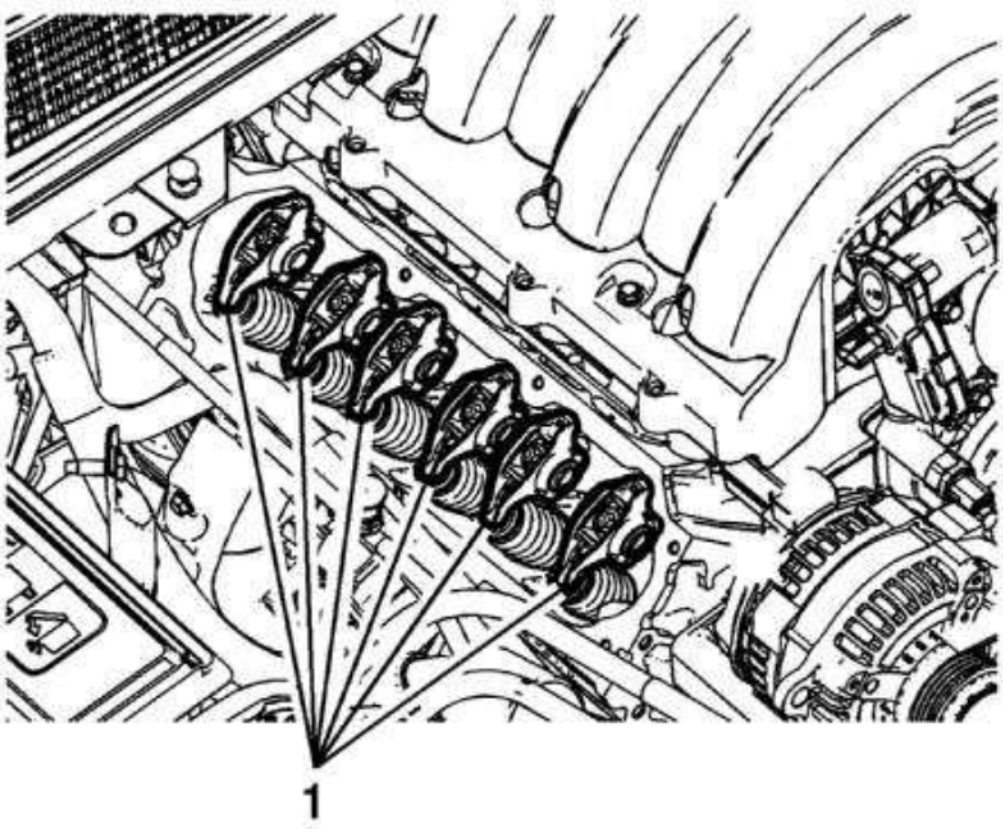

Fig. 89: Valve Rocker Arm
Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve rocker arm (1).

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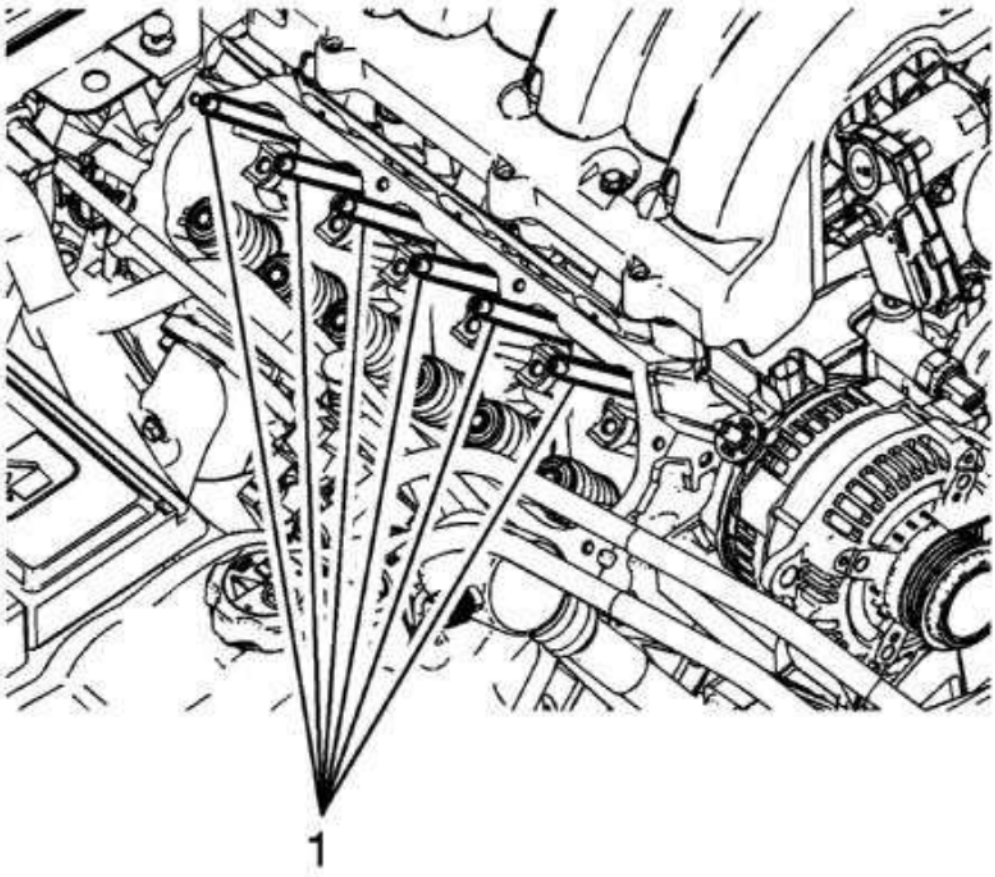

Fig. 90: Pushrods
Courtesy of GENERAL MOTORS COMPANY

3. Remove the pushrods (1).
4. Clean and inspect the rocker arms and/or pushrods, if necessary. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

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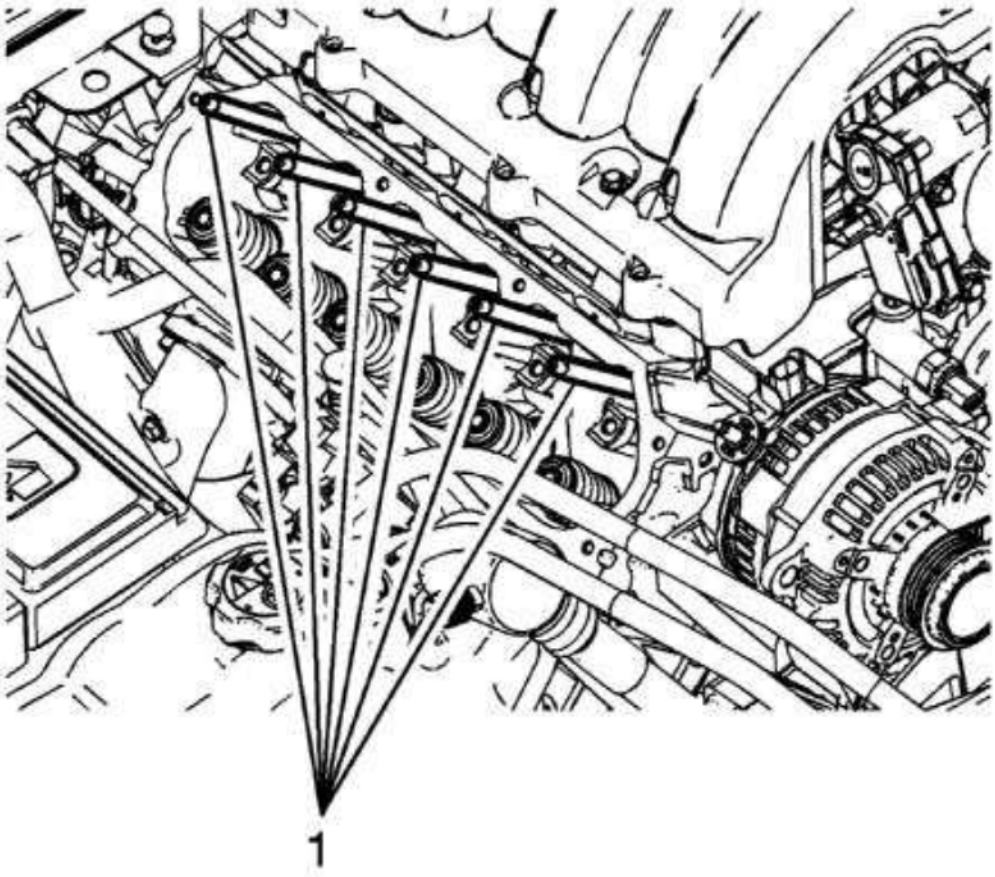

Fig. 91: Pushrods
Courtesy of GENERAL MOTORS COMPANY

1. Install the pushrods.

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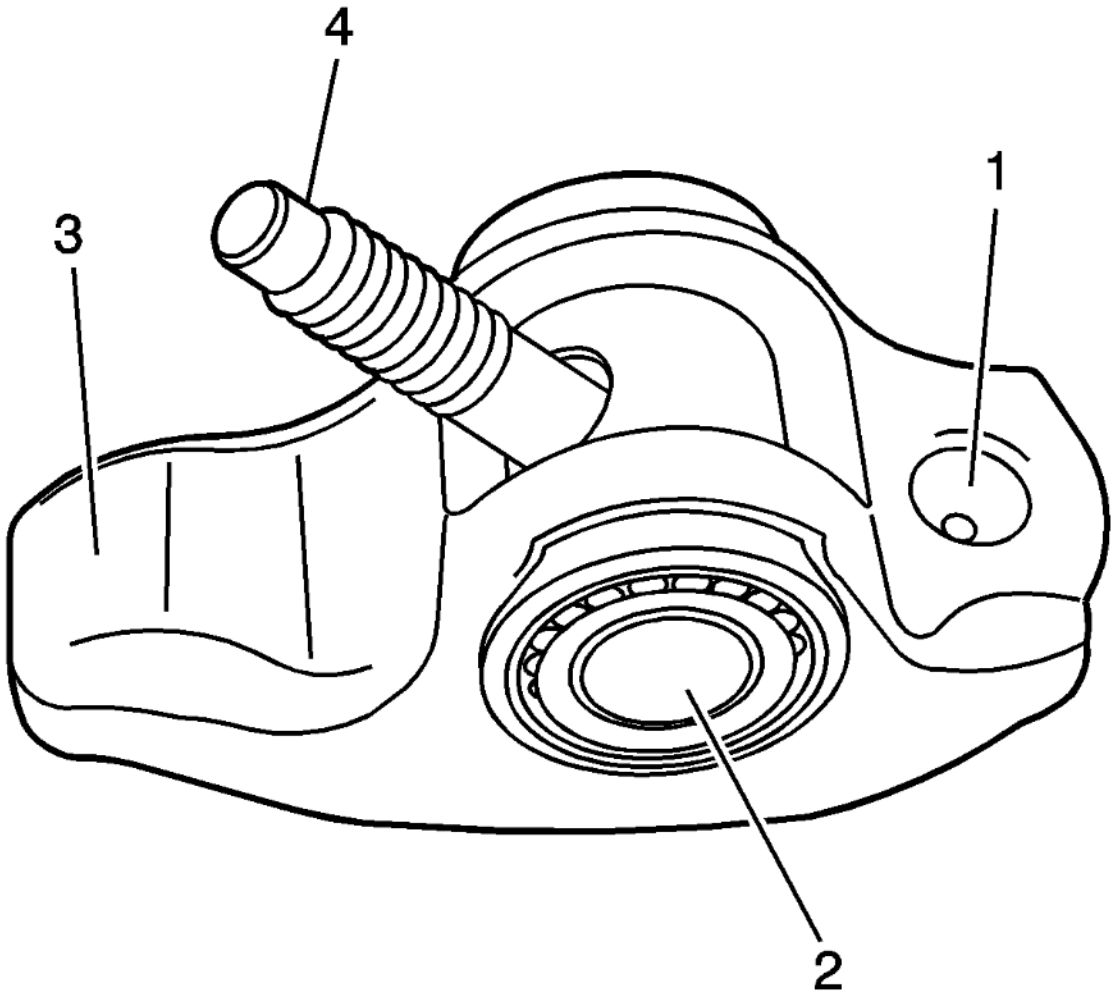

Fig. 92: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS COMPANY

2. Apply lubricant to the following rocker arm contact surfaces:
    - Pushrod socket (1)
    - Roller pivot (2)
    - Valve stem tip (3)

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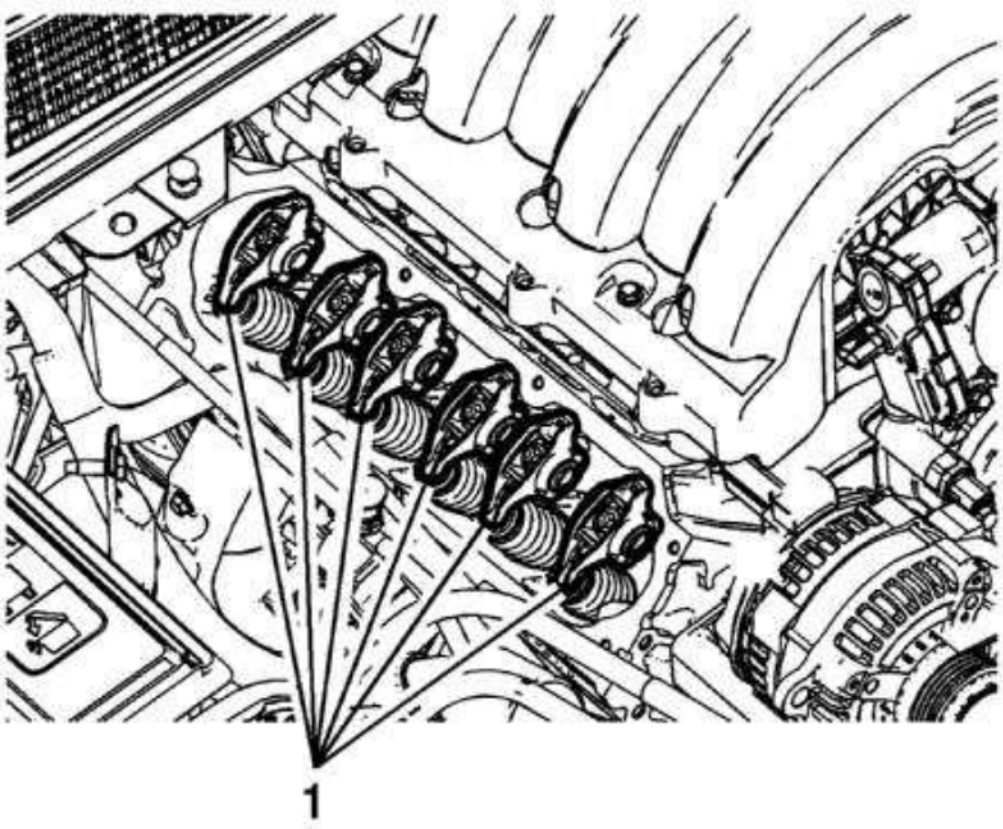

Fig. 93: Valve Rocker Arm
Courtesy of GENERAL MOTORS COMPANY

3. Install the all valve rocker arm (1) and hand tighten the bolts.

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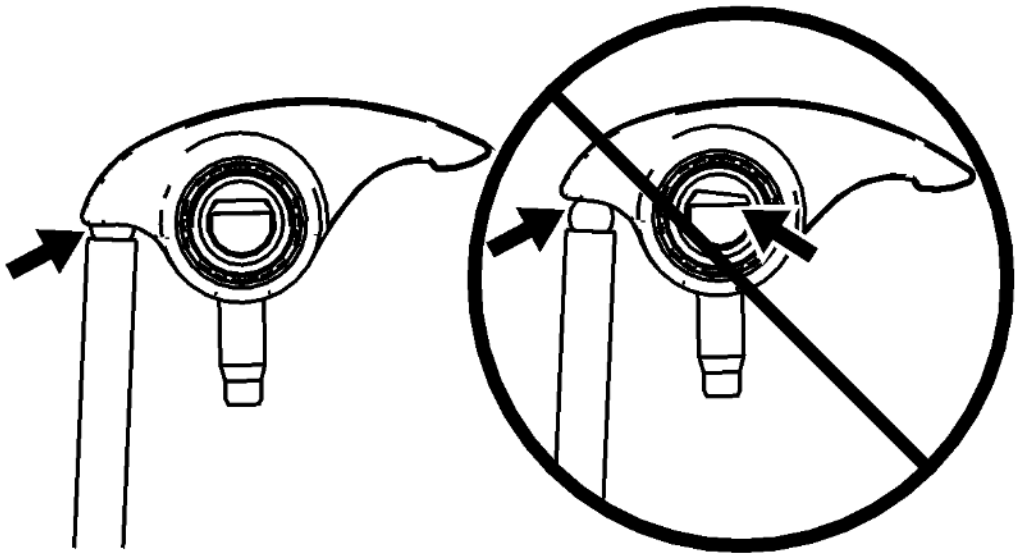

Fig. 94: Proper Seating Of Push Rod
Courtesy of GENERAL MOTORS COMPANY

4. Ensure the pushrods seat properly to the ends of the rocker arms.

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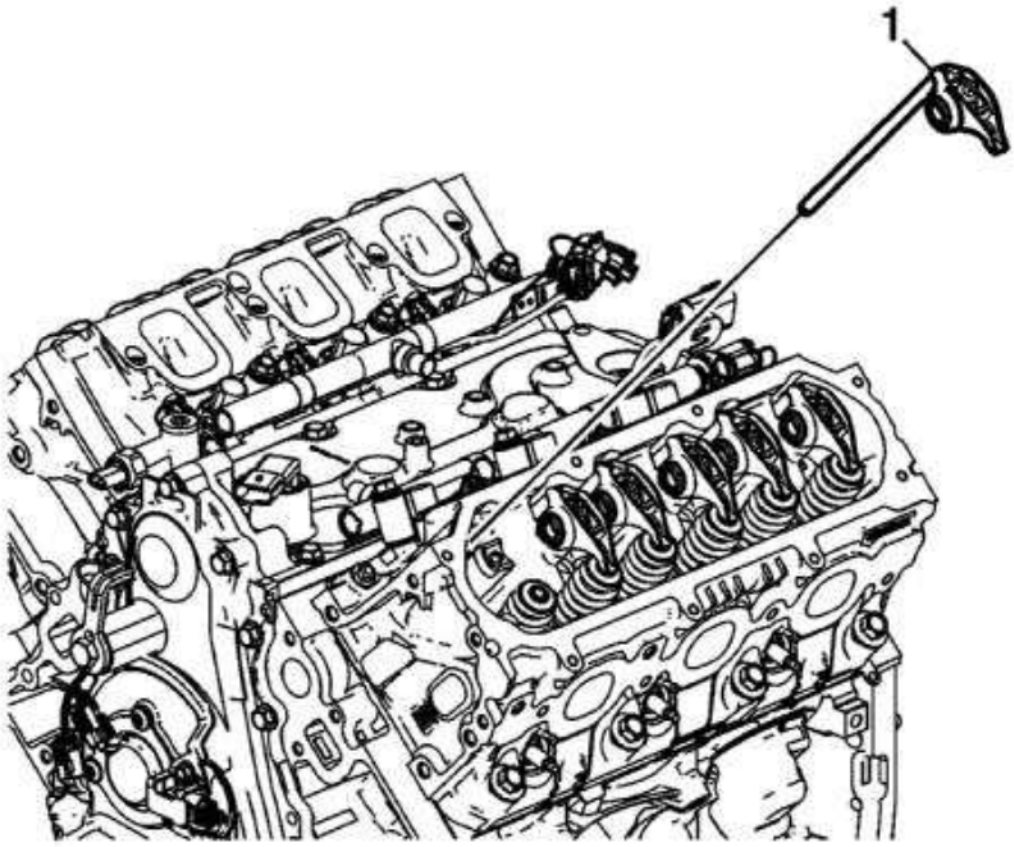

Fig. 95: Valve Rocker Arm And Pushrod Assemblies
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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.**
- **Lubricate the flange of the valve rocker arm bolts with clean engine oil.**
- **Lubricate the valve rocker arms and pushrods with clean engine oil.**
- **Ensure the pushrods seat properly to the valve lifter sockets.**
- **DO NOT tighten the rocker arm bolts at this time.**

5. Install the valve rocker arm and pushrod assemblies (1).

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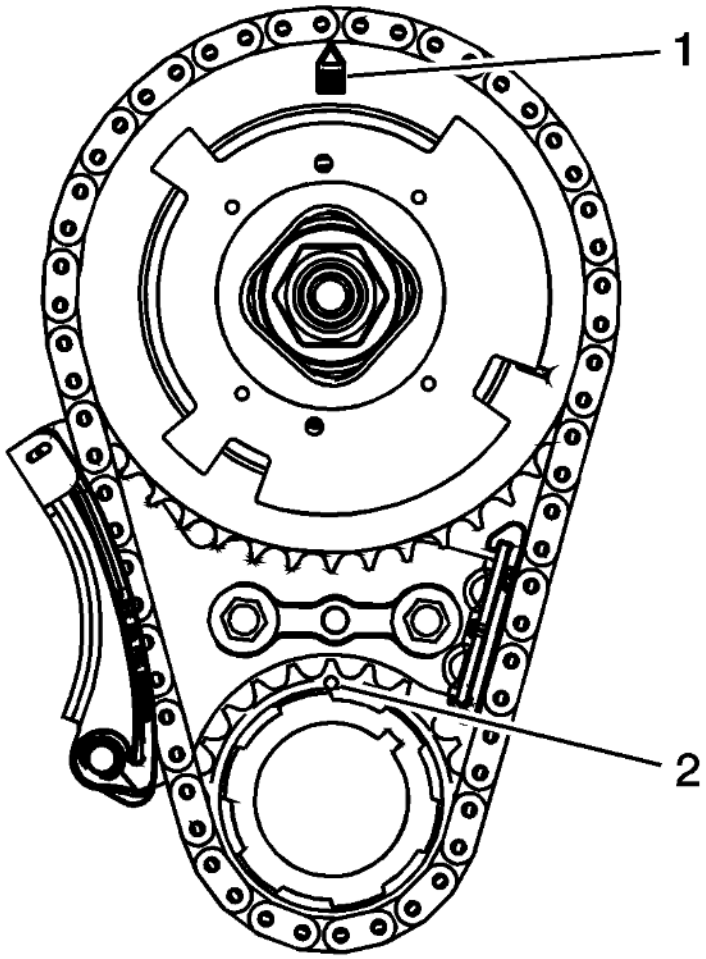

Fig. 96: View Of Camshaft & Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

6. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

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

   Cylinders 1, 3, and 5 are left bank.

   Cylinders 2, 4, and 6 are right bank.

   CAUTION: Refer to Fastener Caution

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
   1. Tighten the exhaust valve rocker arm bolts 1, 5, and 6 to 30 N.m (22 lb ft).
   2. Tighten the intake valve rocker arm bolts 1, 3, and 2 to 30 N.m (22 lb ft).
8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

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

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

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT (LEFT SIDE/BANK 1)

Removal Procedure

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

NOTE:

- **Be sure to keep parts in order. Parts must be reinstalled into the original location and position.**
- **The rocker arm bolts are not serviced separately.**

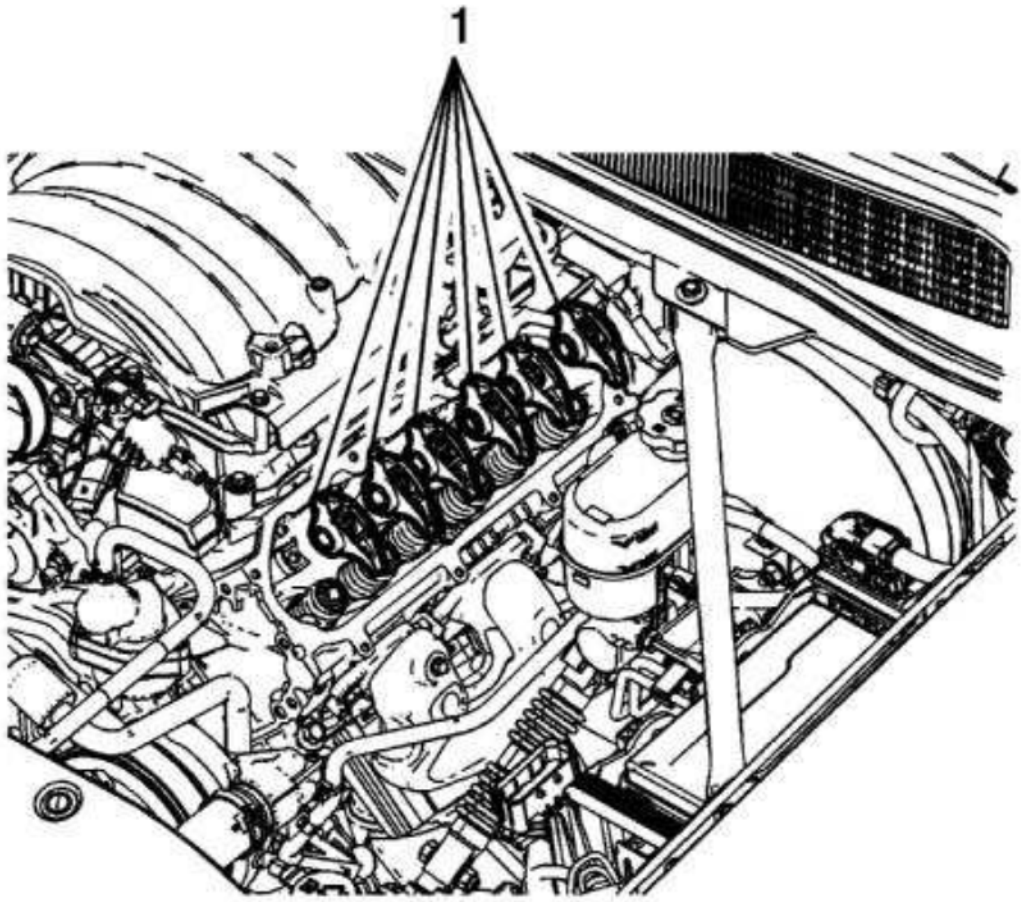

Fig. 97: Valve Rocker Arm
Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve rocker arm (1).

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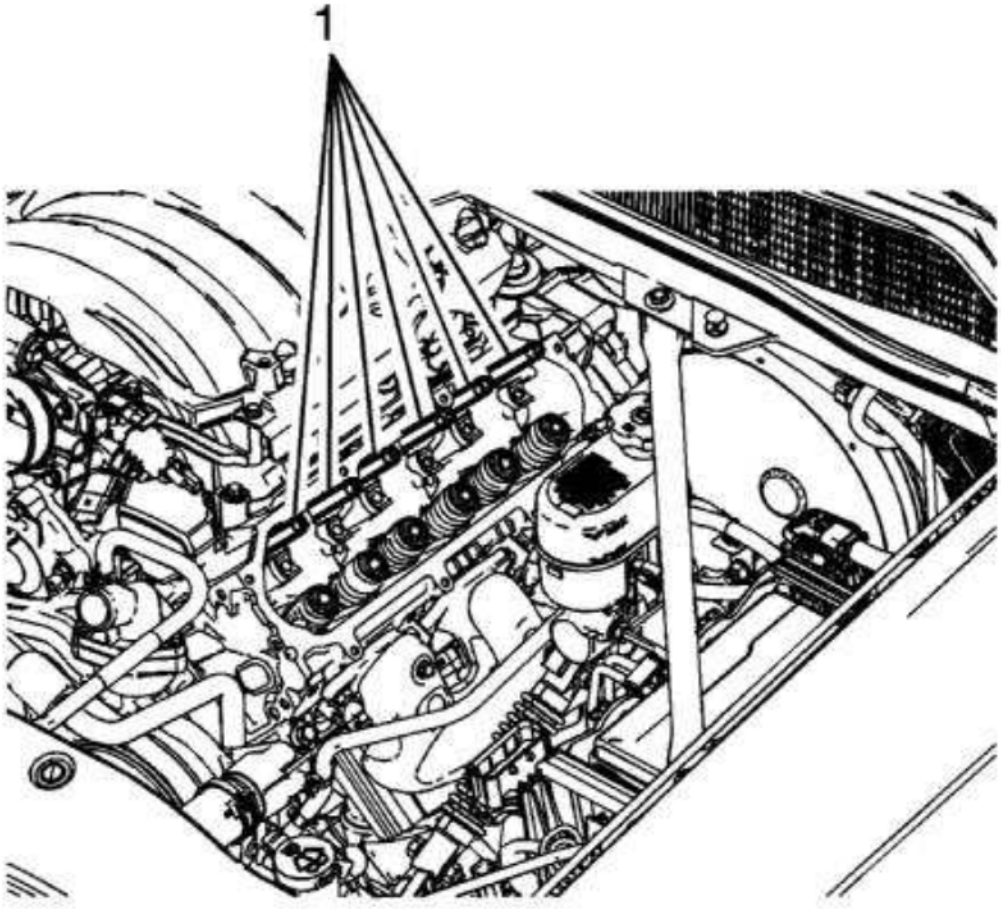

Fig. 98: Pushrods
Courtesy of GENERAL MOTORS COMPANY

3. Remove the pushrods (1).
4. Clean and inspect the rocker arms and/or pushrods, if necessary. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

NOTE: **Be sure to keep parts in order. Parts must be reinstalled into the original location and position.**

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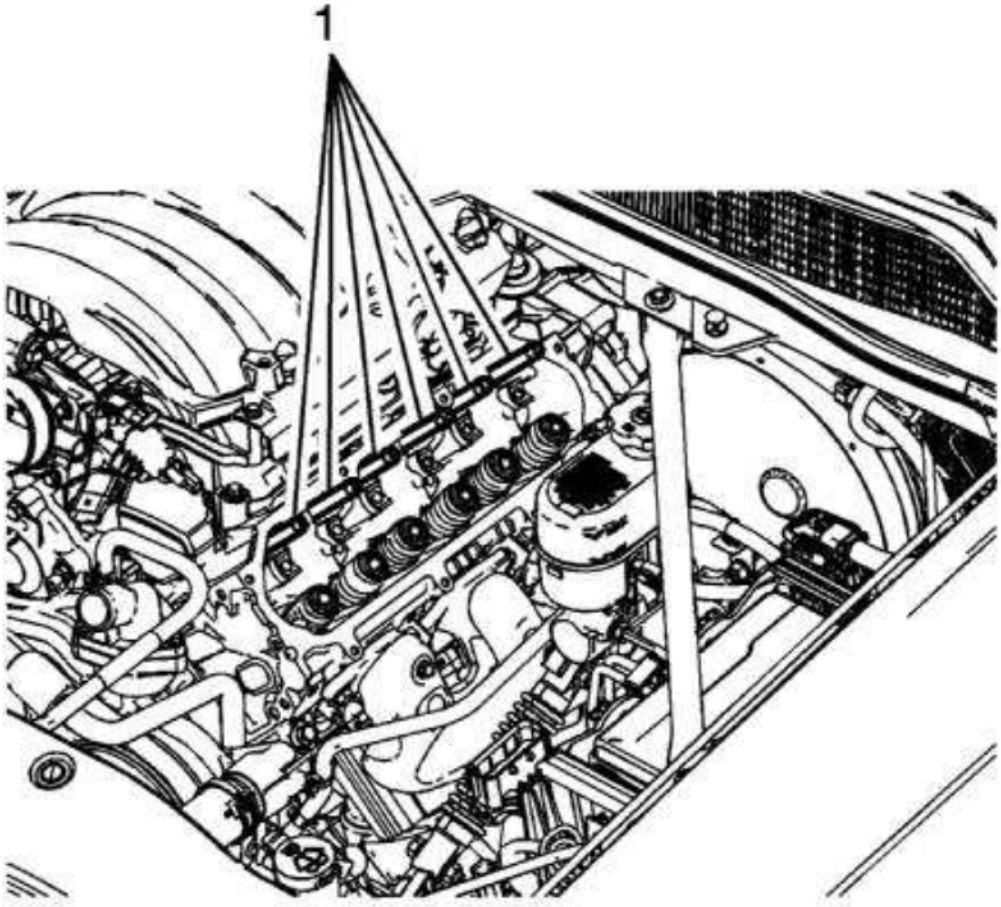

Fig. 99: Pushrods
Courtesy of GENERAL MOTORS COMPANY

1. Install the pushrods.

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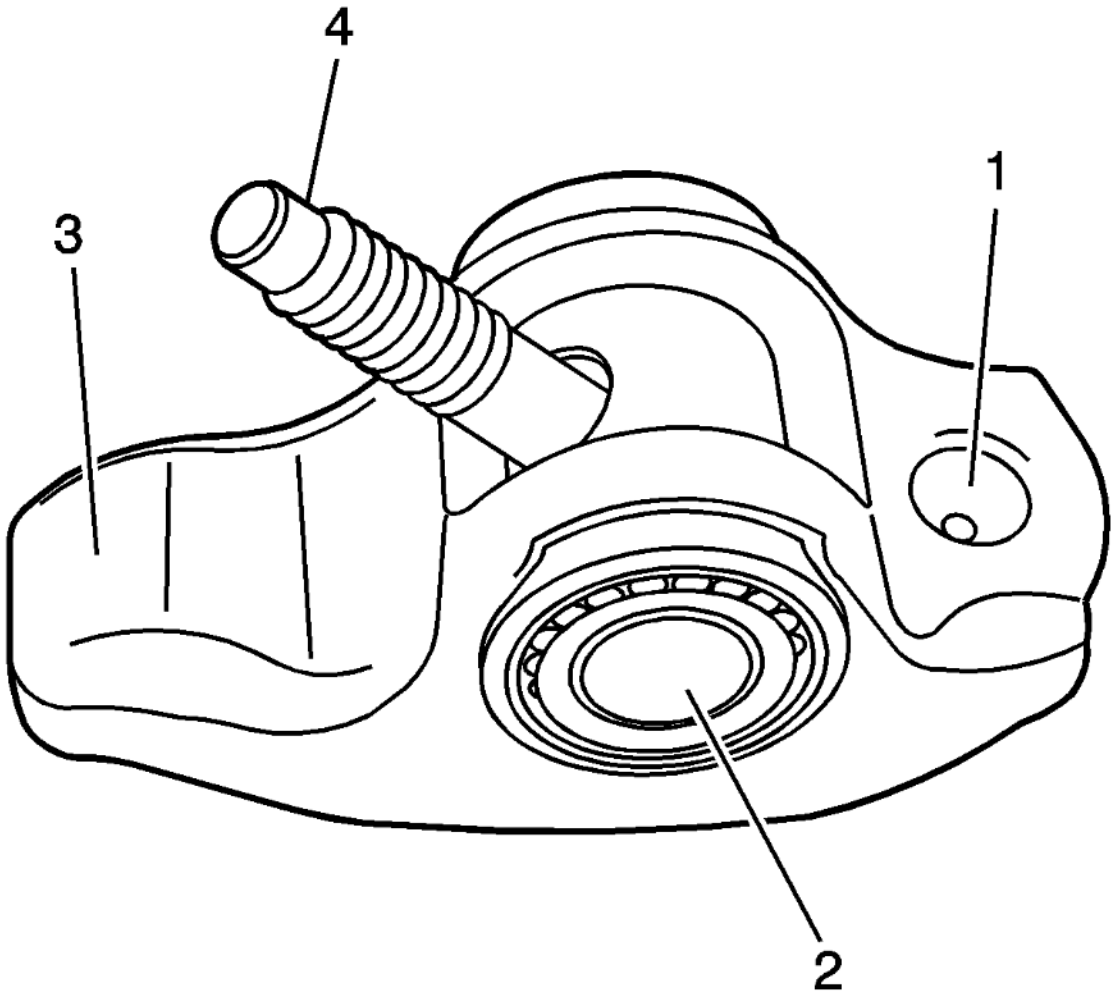

Fig. 100: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS COMPANY

2. Apply lubricant to the following rocker arm contact surfaces:
    - Pushrod socket (1)
    - Roller pivot (2)
    - Valve stem tip (3)

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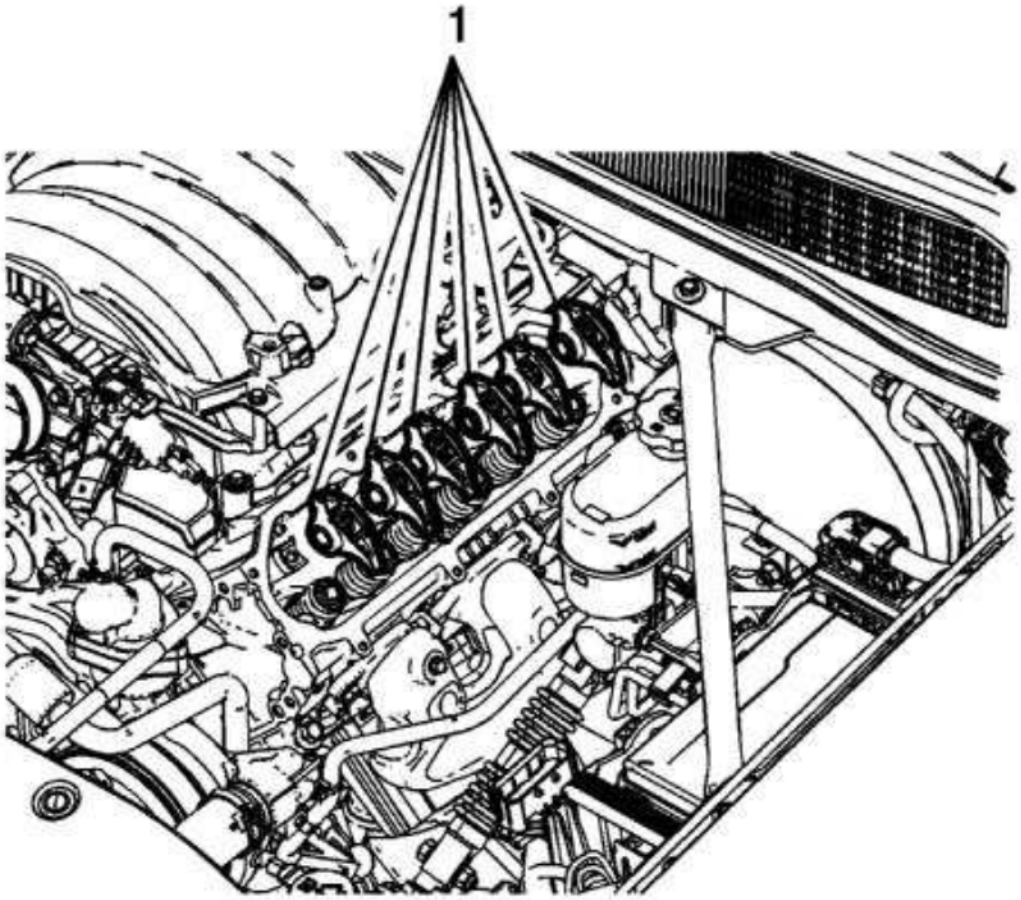

Fig. 101: Valve Rocker Arm
Courtesy of GENERAL MOTORS COMPANY

3. Install the all valve rocker arm (1) and hand tighten the bolts.

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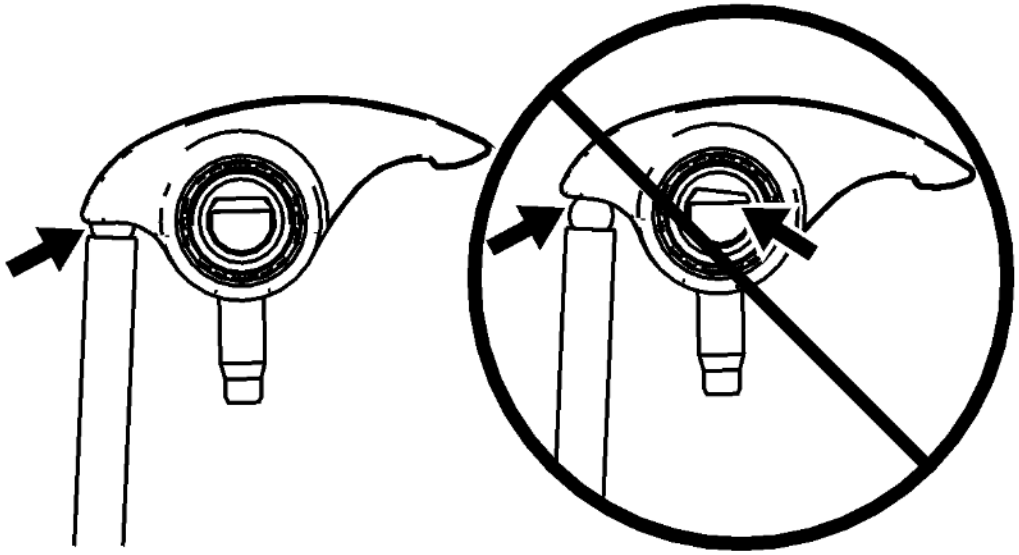

Fig. 102: Proper Seating Of Push Rod
Courtesy of GENERAL MOTORS COMPANY

4. Ensure the pushrods seat properly to the ends of the rocker arms.

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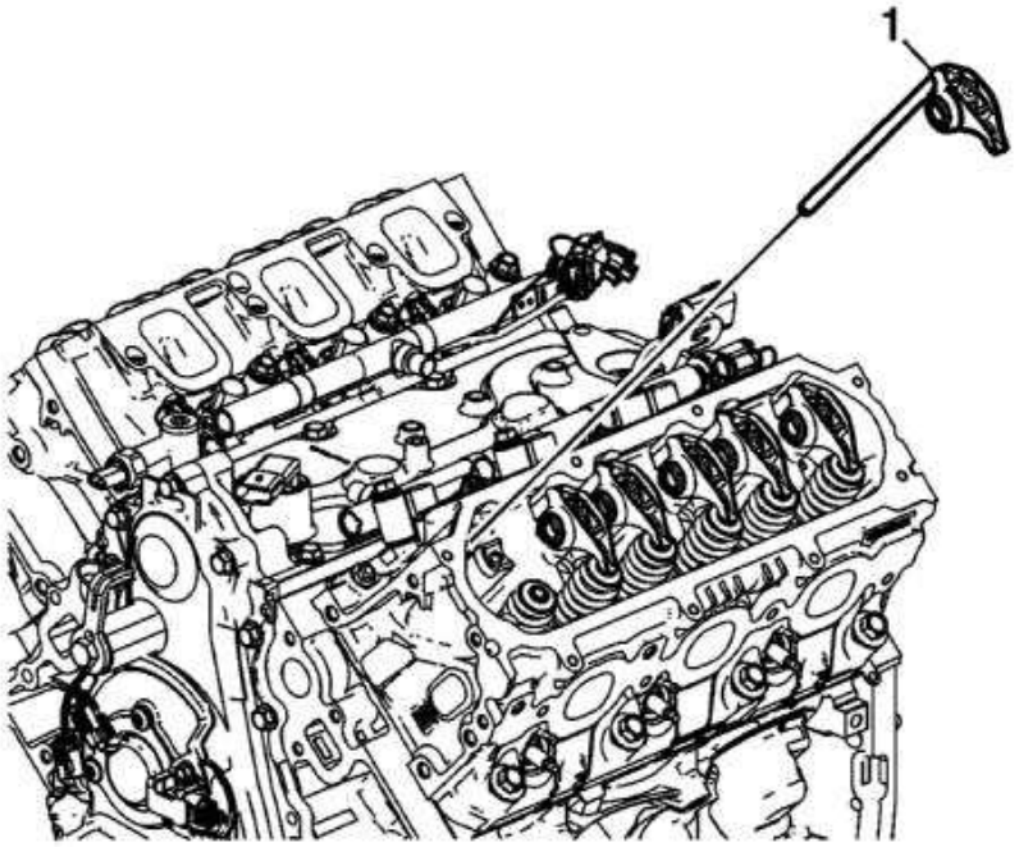

Fig. 103: Valve Rocker Arm And Pushrod Assemblies
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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.**
- **Lubricate the flange of the valve rocker arm bolts with clean engine oil.**
- **Lubricate the valve rocker arms and pushrods with clean engine oil.**
- **Ensure the pushrods seat properly to the valve lifter sockets.**
- **DO NOT tighten the rocker arm bolts at this time.**

5. Install the valve rocker arm and pushrod assemblies (1).

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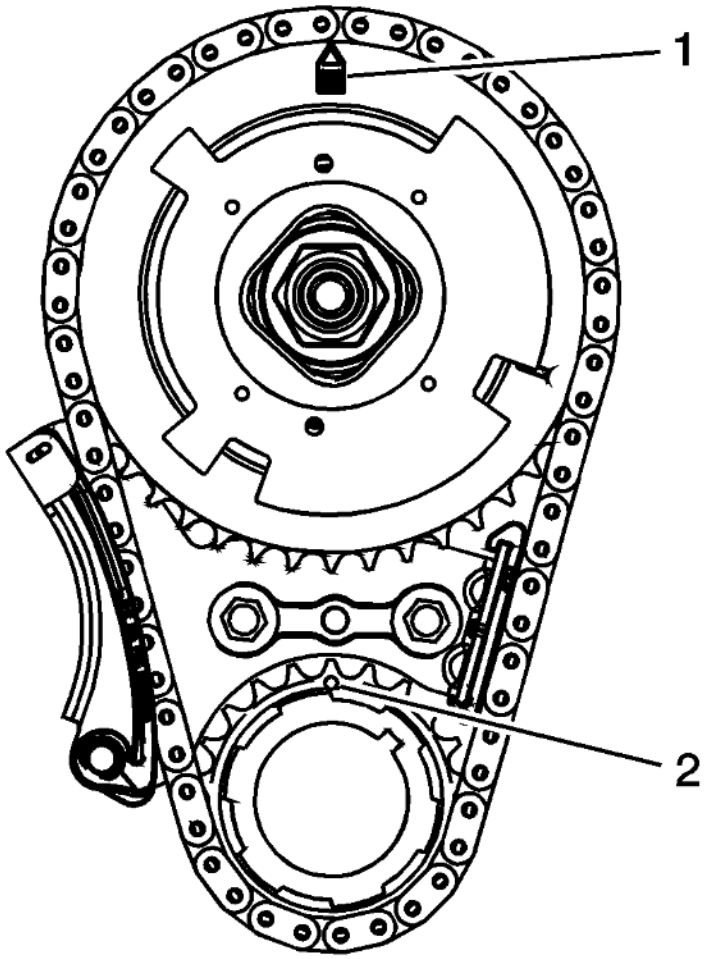

Fig. 104: View Of Camshaft & Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

6. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

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

   Cylinders 1, 3, and 5 are left bank.

   Cylinders 2, 4, and 6 are right bank.

   CAUTION: Refer to Fastener Caution

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
   1. Tighten the exhaust valve rocker arm bolts 1, 5, and 6 to 30 N.m (22 lb ft).
   2. Tighten the intake valve rocker arm bolts 1, 3, and 2 to 30 N.m (22 lb ft).
8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

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

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

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- **J-22794** Spark Plug Port Adapter
- **J-38606** Valve Spring Compressor

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the valve rocker arms as needed. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)** .
2. Remove the spark plugs as needed. Refer to **Spark Plug Replacement** .

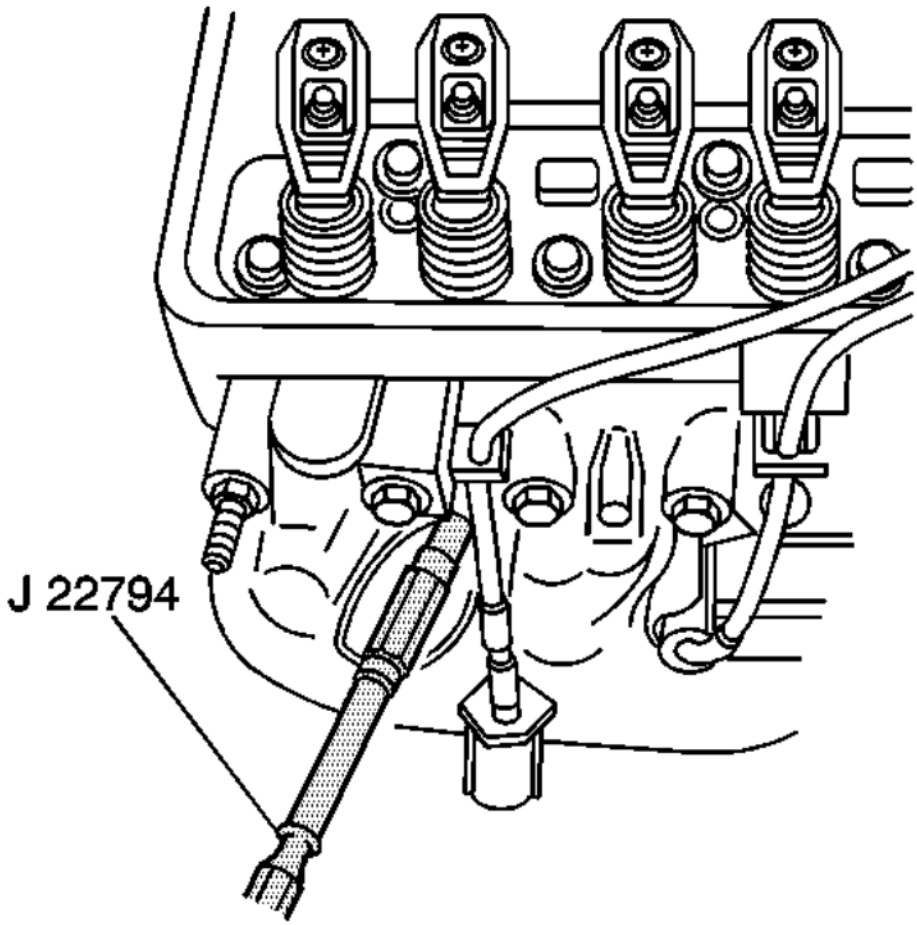

Fig. 105: Compressed Air Adapter Hose
Courtesy of GENERAL MOTORS COMPANY

3. Install the **J- 22794** adapter into the spark plug hole.

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4. Connect a shop air supply hose and apply compressed air in order to hold the valves in place.

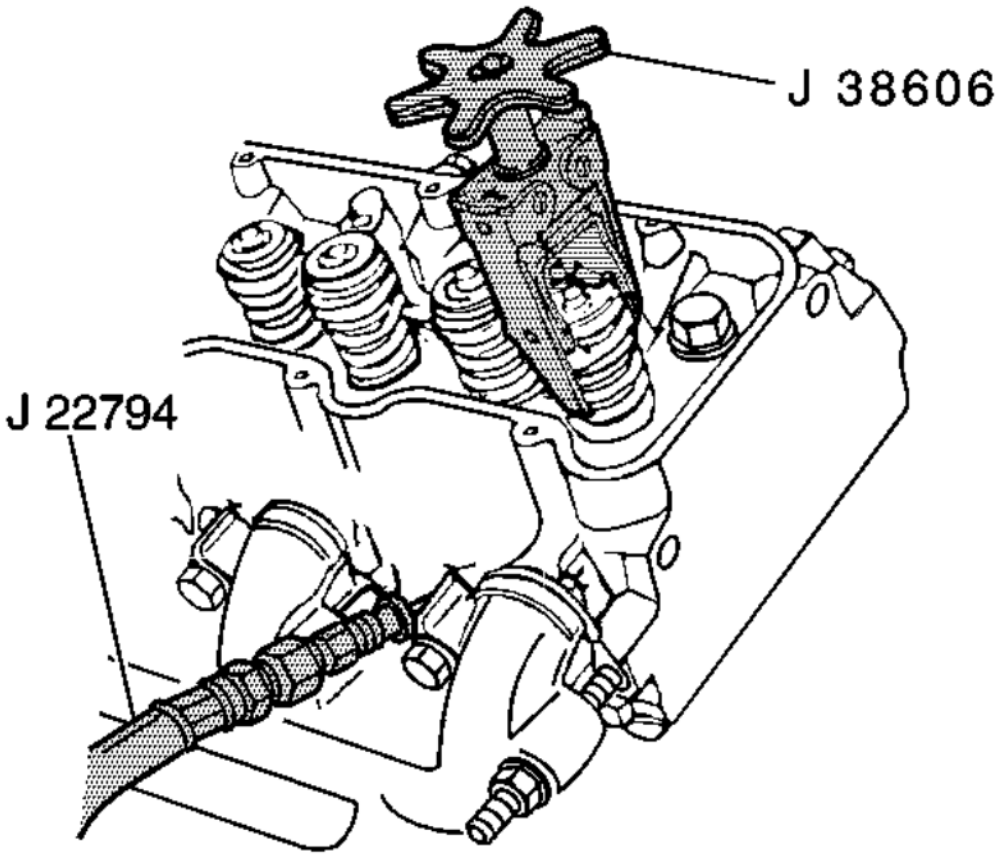

Fig. 106: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS COMPANY

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

5. Use **J 38606** compressor .

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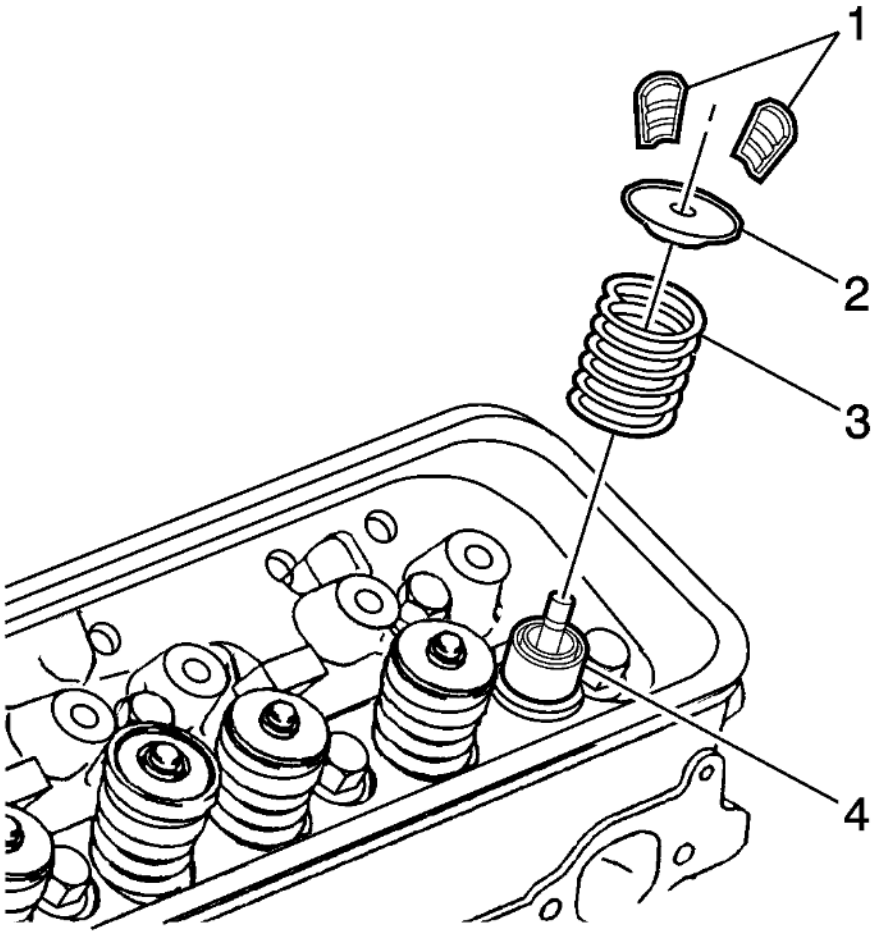

Fig. 107: Identifying Valve Components
Courtesy of GENERAL MOTORS COMPANY

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

Installation Procedure

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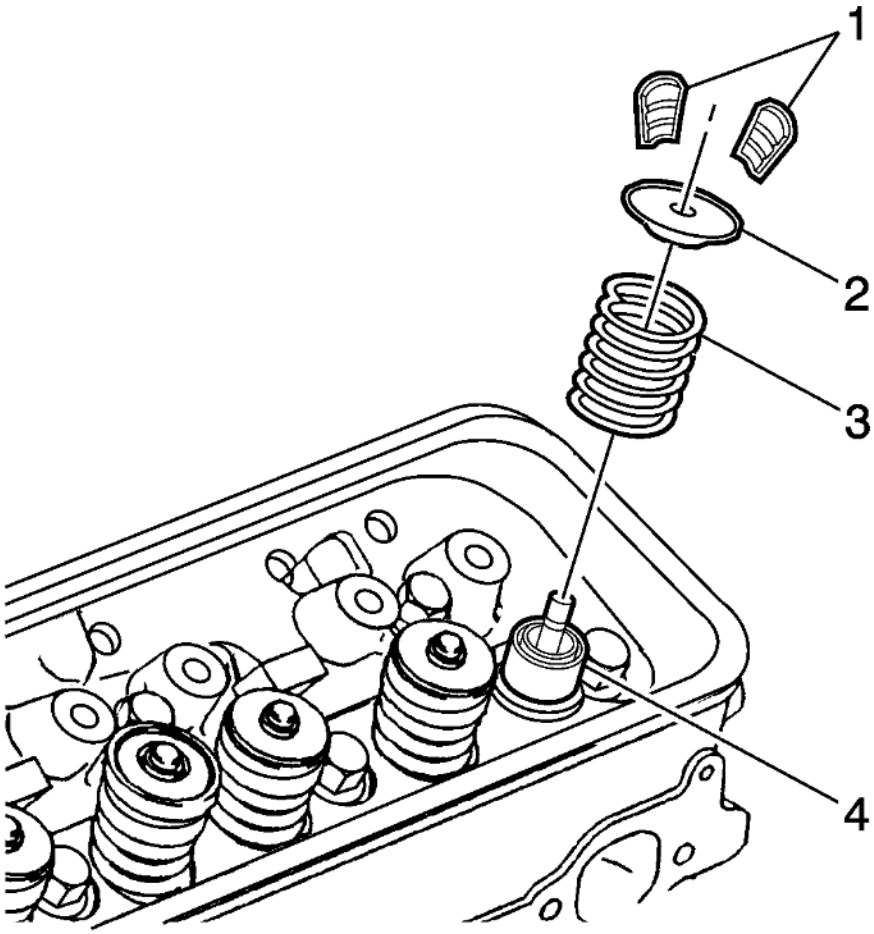

Fig. 108: Identifying Valve Components
Courtesy of GENERAL MOTORS COMPANY

1. Install the valve stem oil seal (4).
2. Install the valve spring (3).
3. Install the valve spring cap (2) onto the valve spring (3), over the valve stem.
4. Apply steady pressure on the valve spring cap until the valve keys are accessible.

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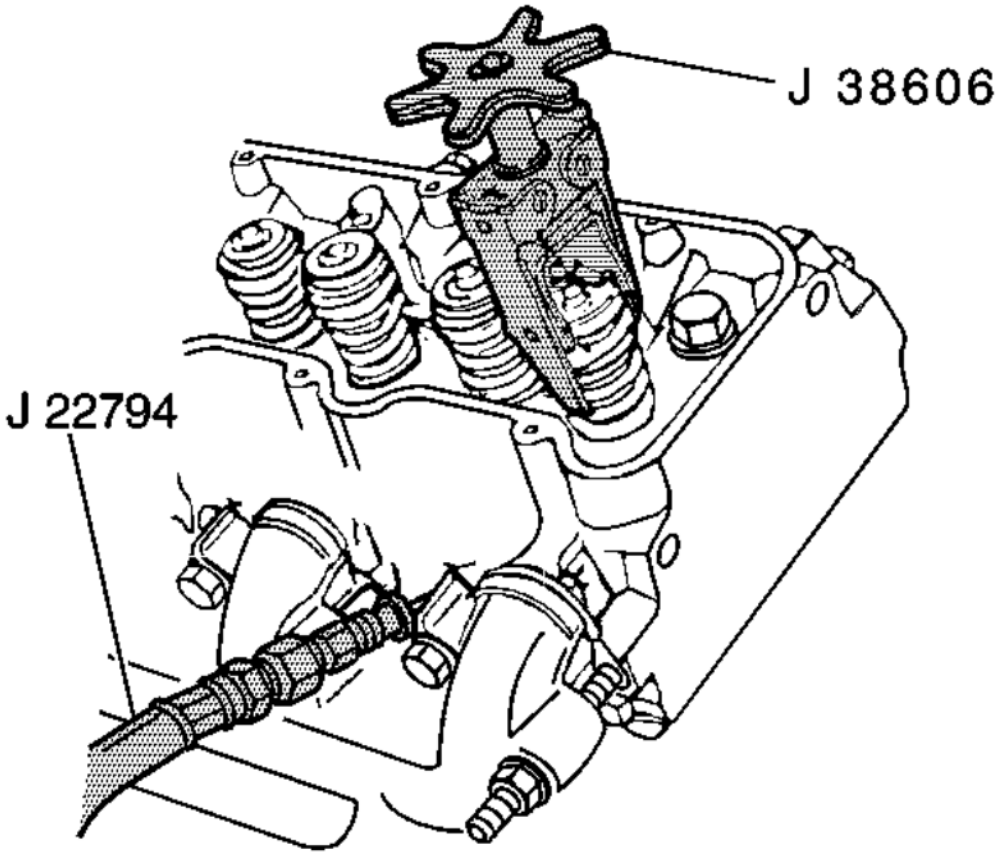

Fig. 109: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS COMPANY

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

5. Use the **J-38606** compressor.

NOTE: Use grease in order to hold the valve stem keys in place.

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

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

8. Remove the **J-38606** compressor.
    1. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
    2. Tap the end of the valve stem with a plastic faced hammer in order to seat the valve stem keys, if necessary.

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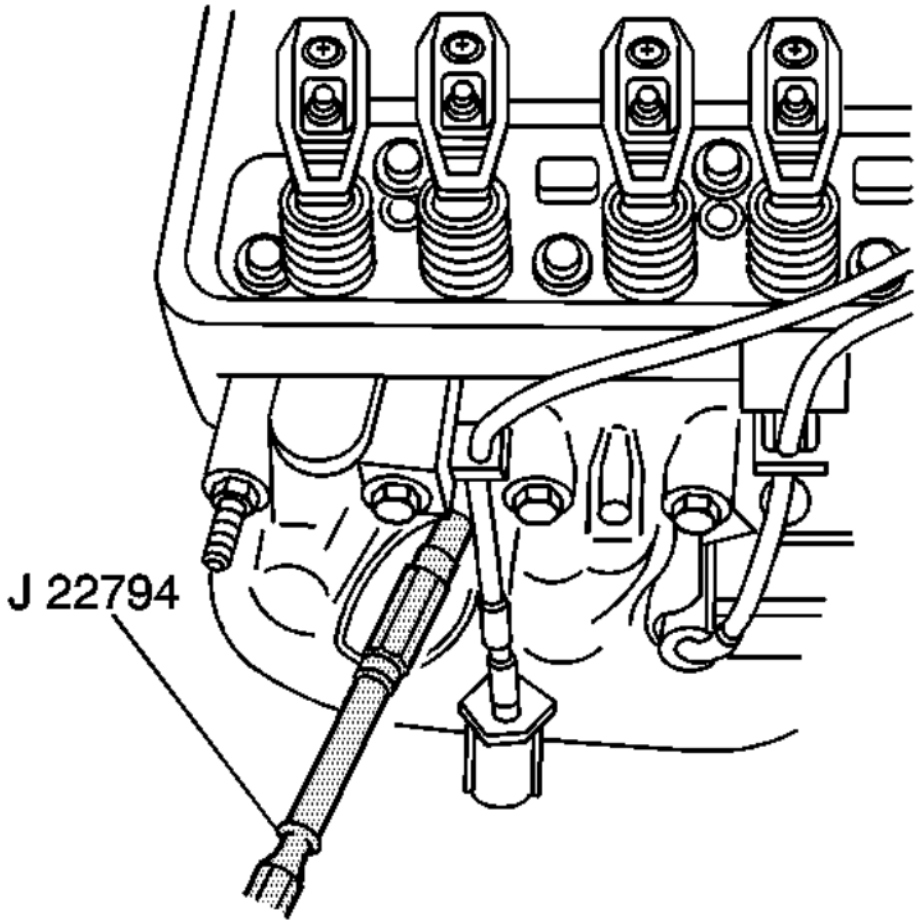

Fig. 110: Compressed Air Adapter Hose
Courtesy of GENERAL MOTORS COMPANY

9. Remove the **J-22794** adapter.
10. Install the spark plugs. Refer to **Spark Plug Replacement** .
11. Install the valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)**.

OIL LEVEL INDICATOR TUBE REPLACEMENT

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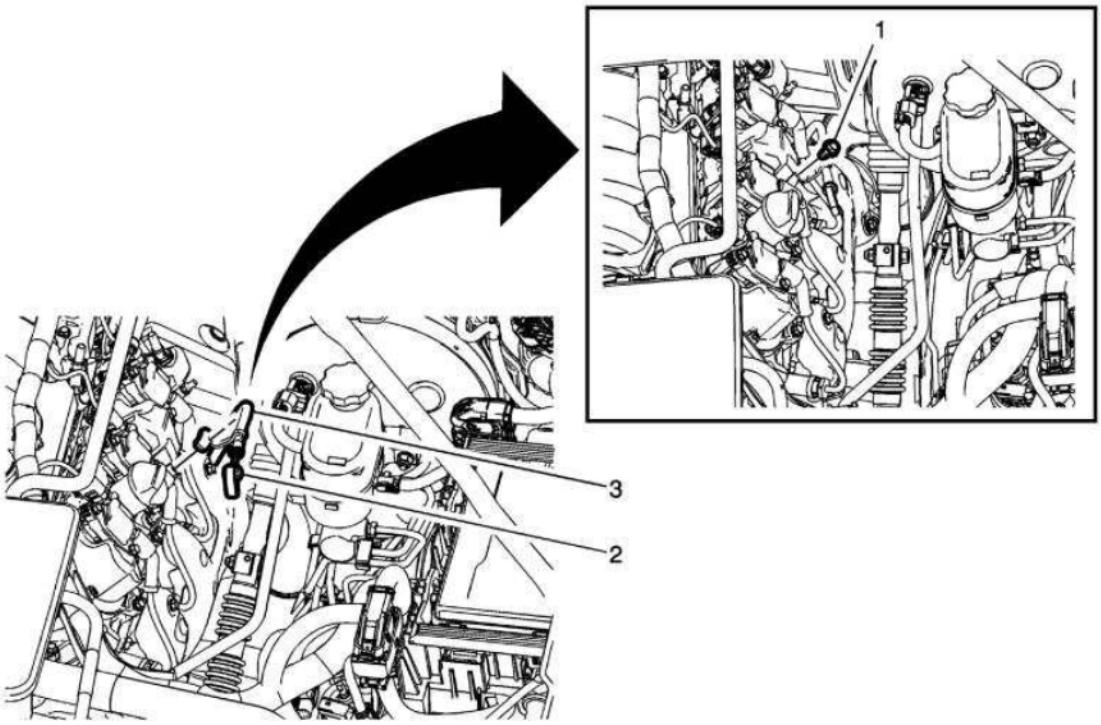

Fig. 111: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube Fastener **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 10 N.m (89 lb in)
2	Oil Level Indicator
3	Oil Level Indicator Tube **Procedure** Use a NEW oil level indicator tube seal when installing the tube.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Removal Procedure

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LV3)** **Cooling System Draining and Filling (Vac N Fill LV3)** .
2. Remove the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** .
3. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LV3)** .
4. Remove the valve rocker arm and push rod. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)**.

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5. Disconnect electrical connectors as necessary.

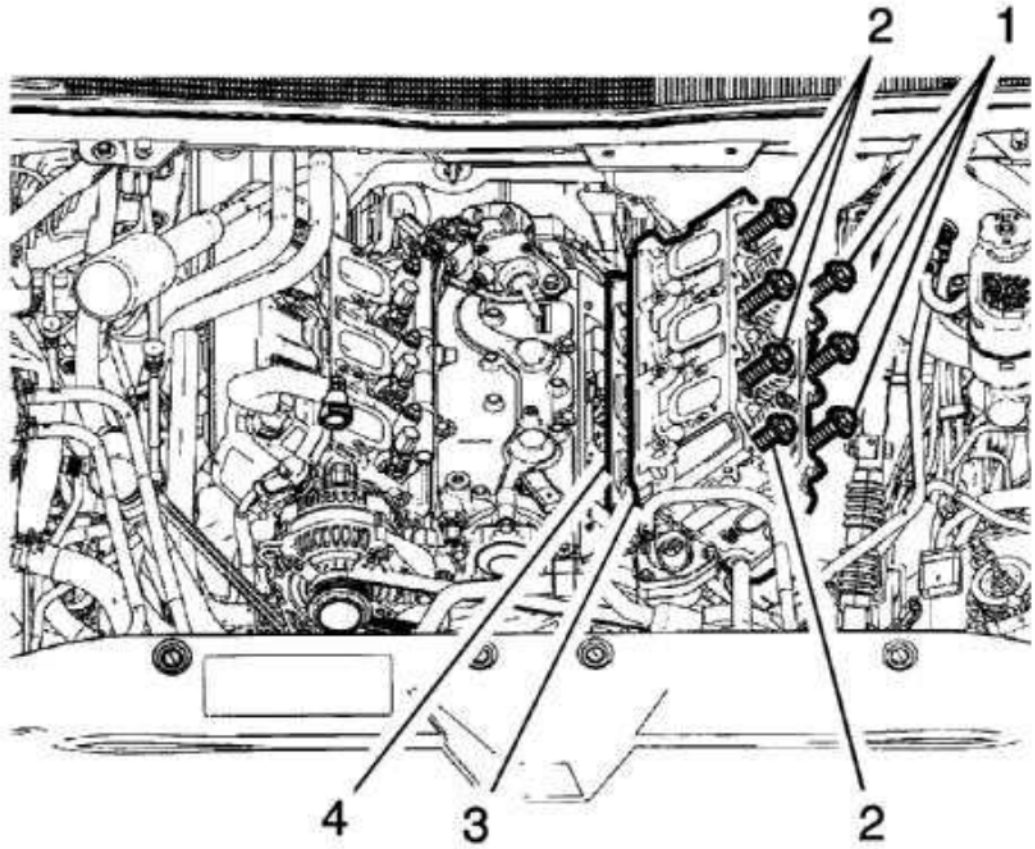

Fig. 112: Cylinder Head And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **DISCARD all cylinder head bolts.**

6. Remove the cylinder head bolts (1,2).
7. Remove cylinder head (3).
8. Remove and DISCARD cylinder head gasket (4). Refer to **Replacing Engine Gaskets**.
9. For cleaning and inspection. Refer to **Cylinder Head Cleaning and Inspection**.
10. For cylinder head disassemble. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. For cylinder head assemble. Refer to **Cylinder Head Assemble**.
2. Clean any debris or residual fastener thread sealant from the engine block cylinder head bolt holes to ensure proper torque or clamp load.

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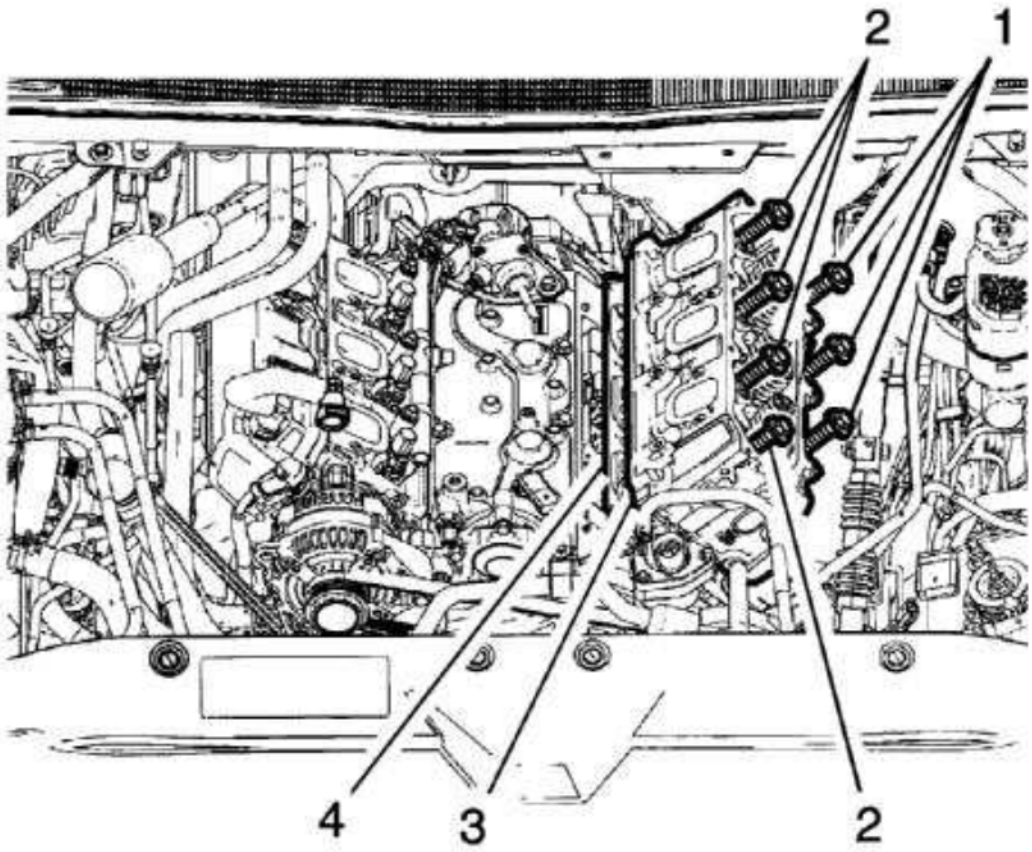

Fig. 113: Cylinder Head And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW cylinder head gasket (4).
4. Install cylinder head (3).
5. Hand start NEW cylinder head bolts (1,2).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

6. Tighten cylinder head bolts in sequence. Refer to **Cylinder Head Installation - Left Side**.
7. Install the valve rocker arm and push rod. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)**.
8. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LV3)** .
9. Connect electrical connectors as necessary.
10. Install the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** .
11. Refill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LV3)** **Cooling System Draining and Filling (Vac N Fill LV3)** .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

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Removal Procedure

1. Drain the coolant system. Refer to **Cooling System Draining and Filling (Static Fill LV3)** **Cooling System Draining and Filling (Vac N Fill LV3)** .
2. Unbolt and reposition the transmission fill tube.
3. Remove the generator bracket. Refer to **Generator Bracket Replacement (LV3)** .
4. Disconnect and reposition the heater inlet hose. Refer to **Heater Inlet Hose Replacement (LV3)** .
5. Disconnect and reposition the heater outlet hose. Refer to **Heater Outlet Hose Replacement (LV3)** .
6. Remove the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .
7. Remove the exhaust manifold - right side. Refer to **Exhaust Manifold Replacement - Right Side (LV3)** .
8. Remove the valve rocker arm and push rod. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)**.
9. Disconnect electrical connectors as necessary.

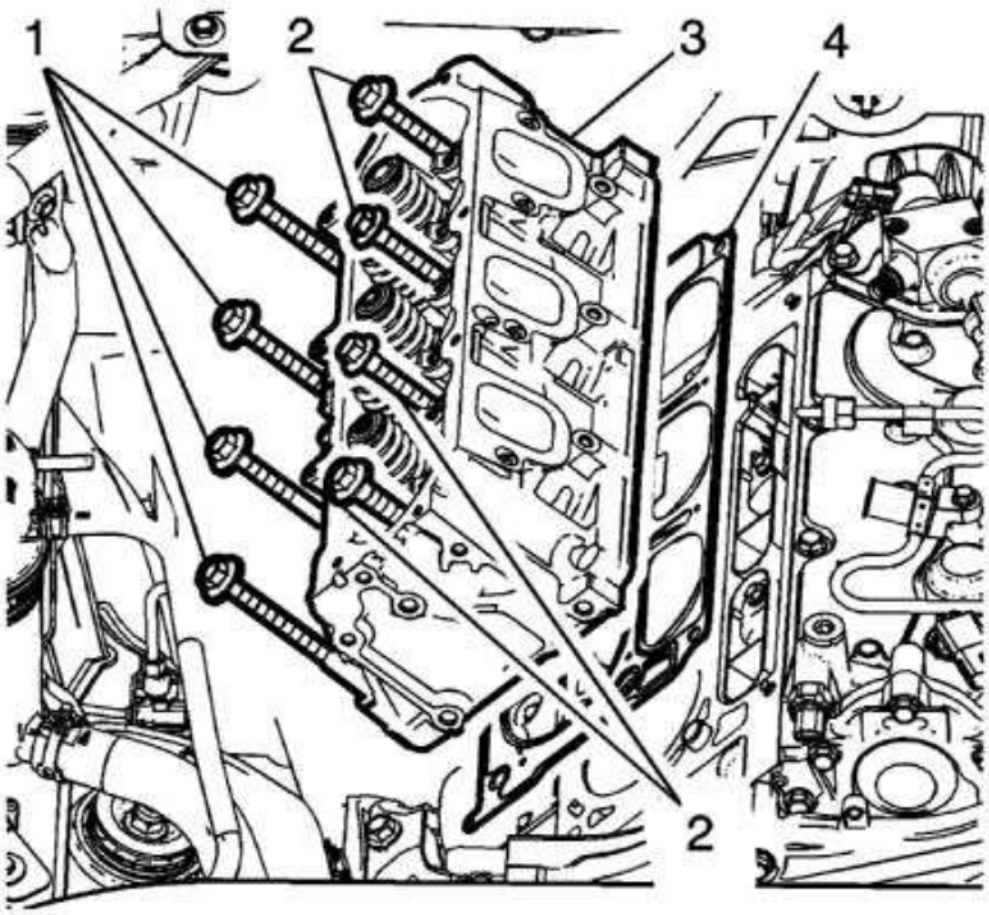

Fig. 114: Cylinder Head And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **DISCARD all cylinder head bolts.**

10. Remove the cylinder head bolts (1,2).
11. Remove cylinder head (3).

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12. Remove and DISCARD cylinder head gasket (4). Refer to **Replacing Engine Gaskets**.
13. For cleaning and inspection. Refer to **Cylinder Head Cleaning and Inspection**.
14. For cylinder head disassemble. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. For cylinder head assemble. Refer to **Cylinder Head Assemble**.
2. Clean any debris or residual fastener thread sealant from the engine block cylinder head bolt holes to ensure proper torque or clamp load.

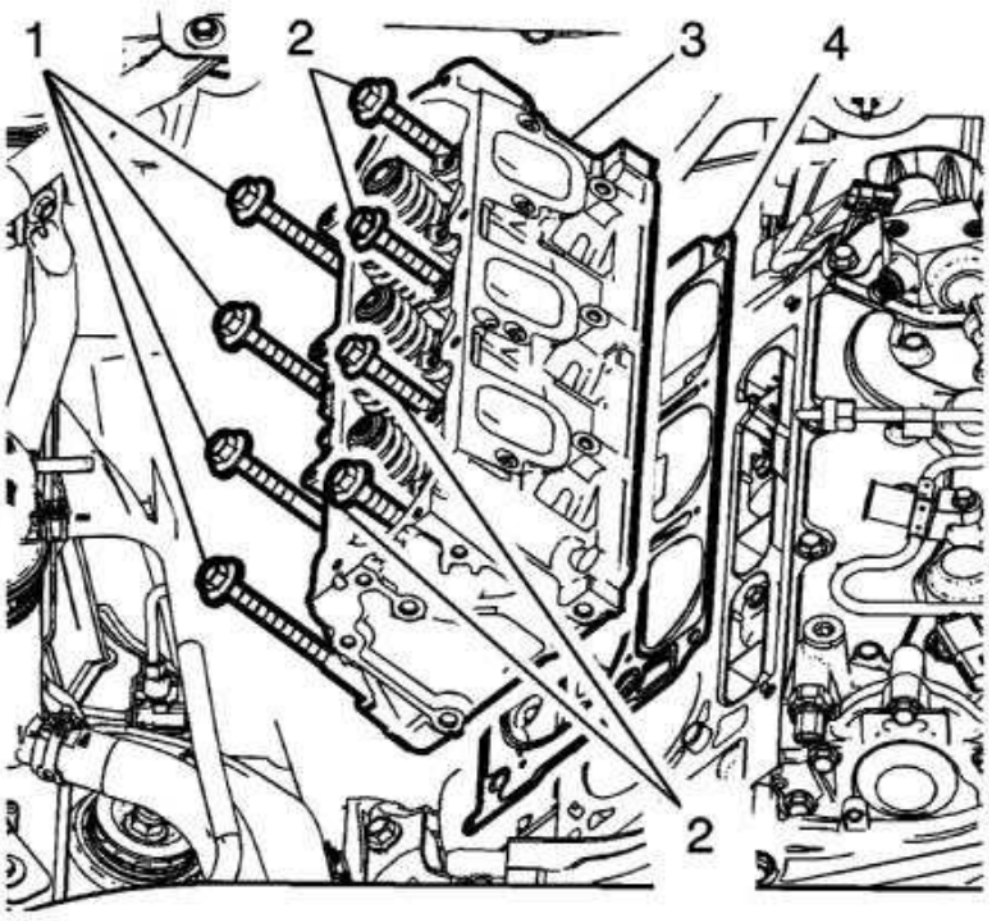

Fig. 115: Cylinder Head And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW cylinder head gasket (4).
4. Install cylinder head (3).
5. Hand start NEW cylinder head bolts (1,2).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

6. Tighten cylinder head bolts in sequence. Refer to **Cylinder Head Installation - Right Side**.

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7. Install the valve rocker arm and push rod. Refer to **Valve Rocker Arm and Push Rod Replacement (Right Side/Bank 2)Valve Rocker Arm and Push Rod Replacement (Left Side/Bank 1)**.
8. Install the exhaust manifold - right side. Refer to **Exhaust Manifold Replacement - Right Side (LV3)** .
9. Install the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .
10. Connect the heater outlet hose. Refer to **Heater Outlet Hose Replacement (LV3)** .
11. Connect the heater inlet hose. Refer to **Heater Inlet Hose Replacement (LV3)** .
12. Install the generator bracket. Refer to **Generator Bracket Replacement (LV3)** .
13. Install the transmission fill tube. Refer to **Transmission Fluid Filler Tube and Seal Replacement** .
14. Connect electrical connectors as necessary.
15. Refill the coolant system. Refer to **Cooling System Draining and Filling (Static Fill LV3)** **Cooling System Draining and Filling (Vac N Fill LV3)** .

VALVE LIFTER FOLLOWER GUIDE ASSEMBLY REPLACEMENT

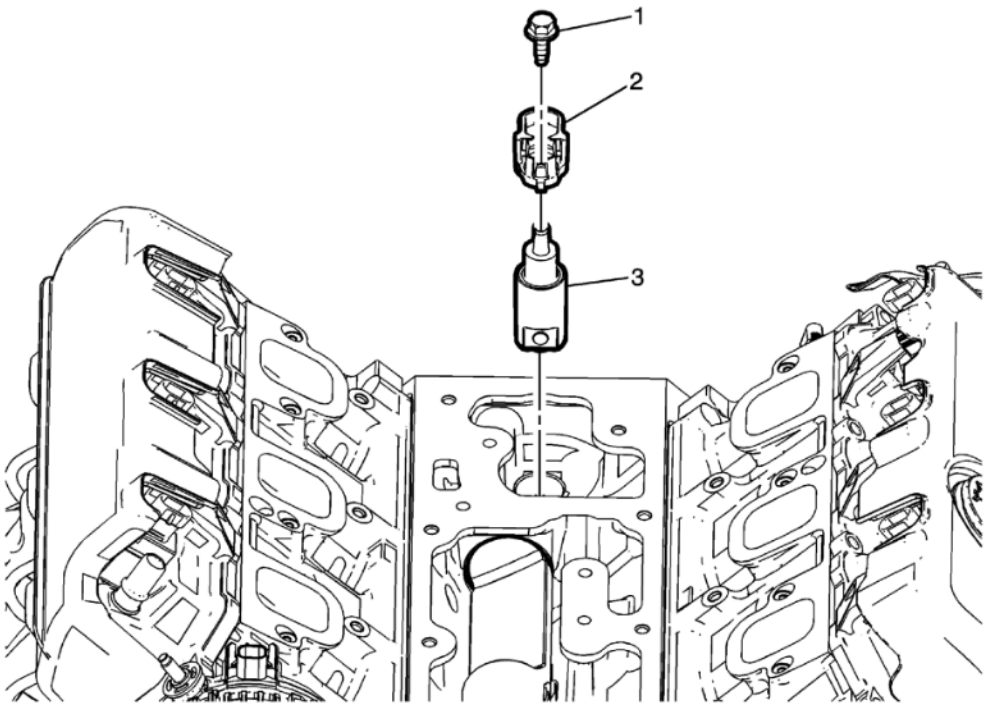

Fig. 116: Valve Lifter Follower Guide Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement** .	
1	Valve Lifter Follower Guide Fastener **CAUTION:** **Refer to** **Fastener Caution** .

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Callout	Component Name
	Tighten 12 N.m (106 lb in)
2	Valve Lifter Follower Guide
3	Valve Lifter Follower

VALVE LIFTER FOLLOWER GUIDE REPLACEMENT

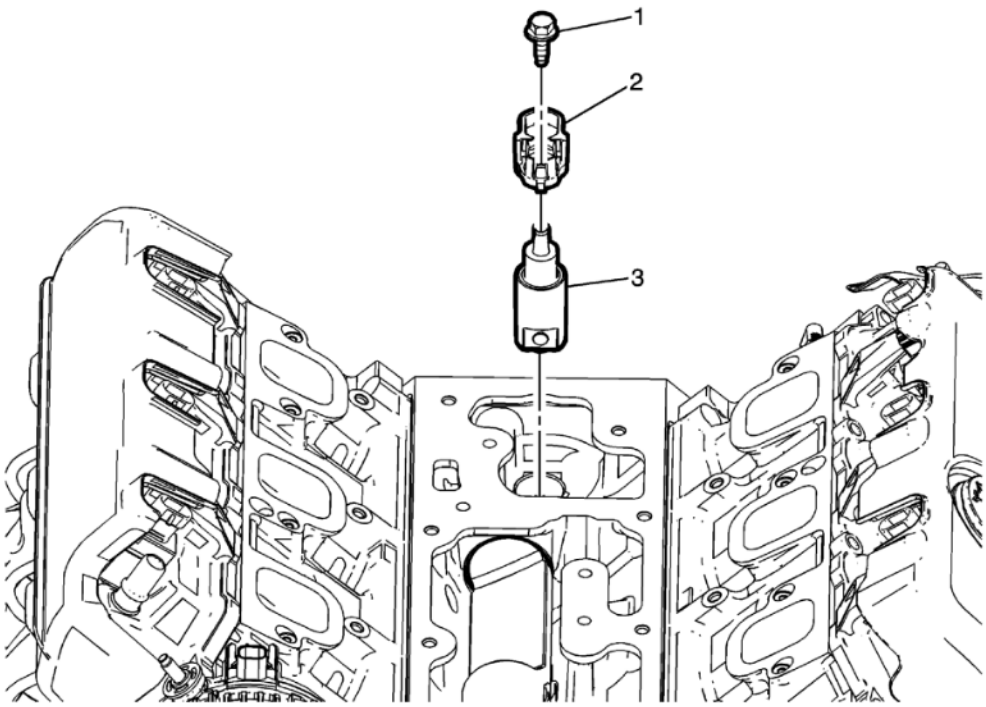

Fig. 117: Valve Lifter Follower Guide Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement** .	
1	Valve Lifter Follower Guide Fastener **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 12 N.m (106 lb in)
2	Valve Lifter Follower Guide
3	Valve Lifter Follower **Procedure** Clean and inspect the valve lifter follower. Refer to **Valve Lifter and Guide Cleaning and Inspection**.

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VALVE LIFTER REPLACEMENT

Removal Procedure

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

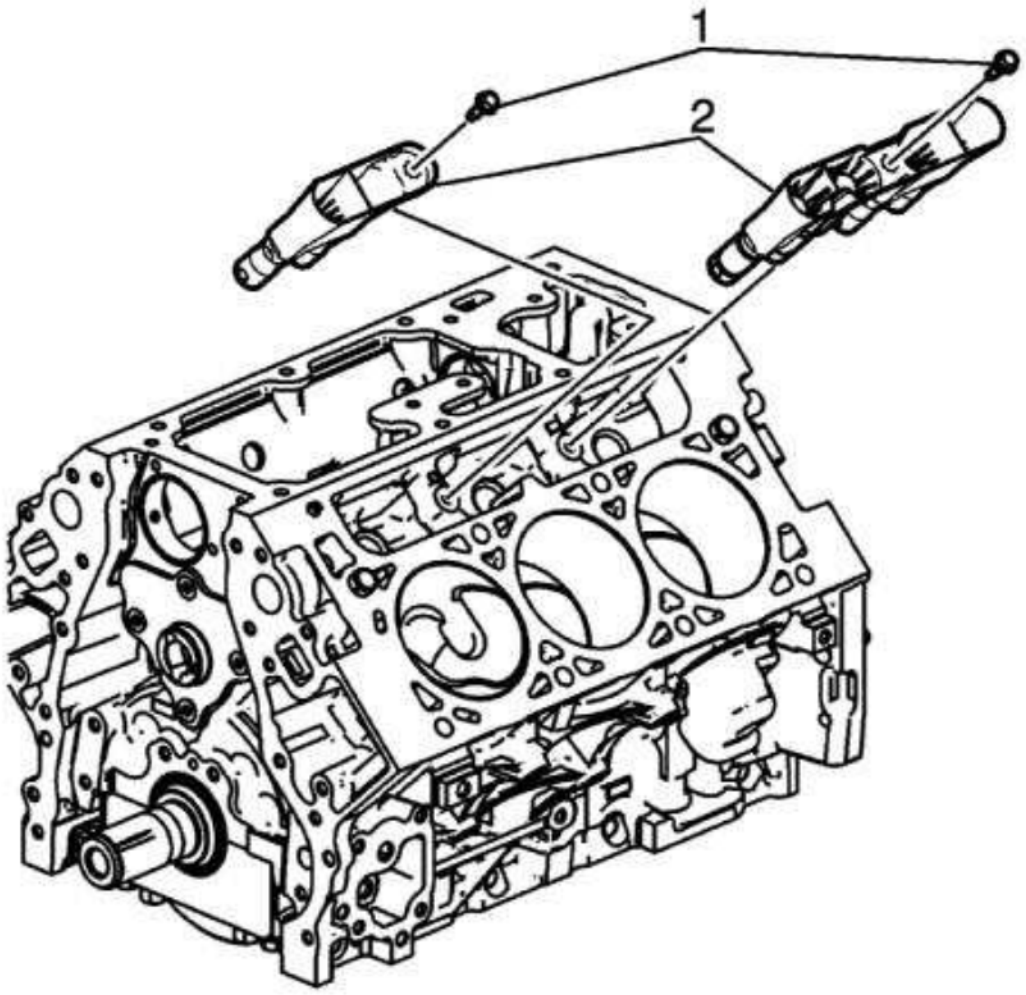

Fig. 118: Guides With Lifters And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the bolts (1).

NOTE: **Installed position of the guides. The notched area of the guide is to align with the locating tab of the block.**

3. Remove the guides (2) with lifters.

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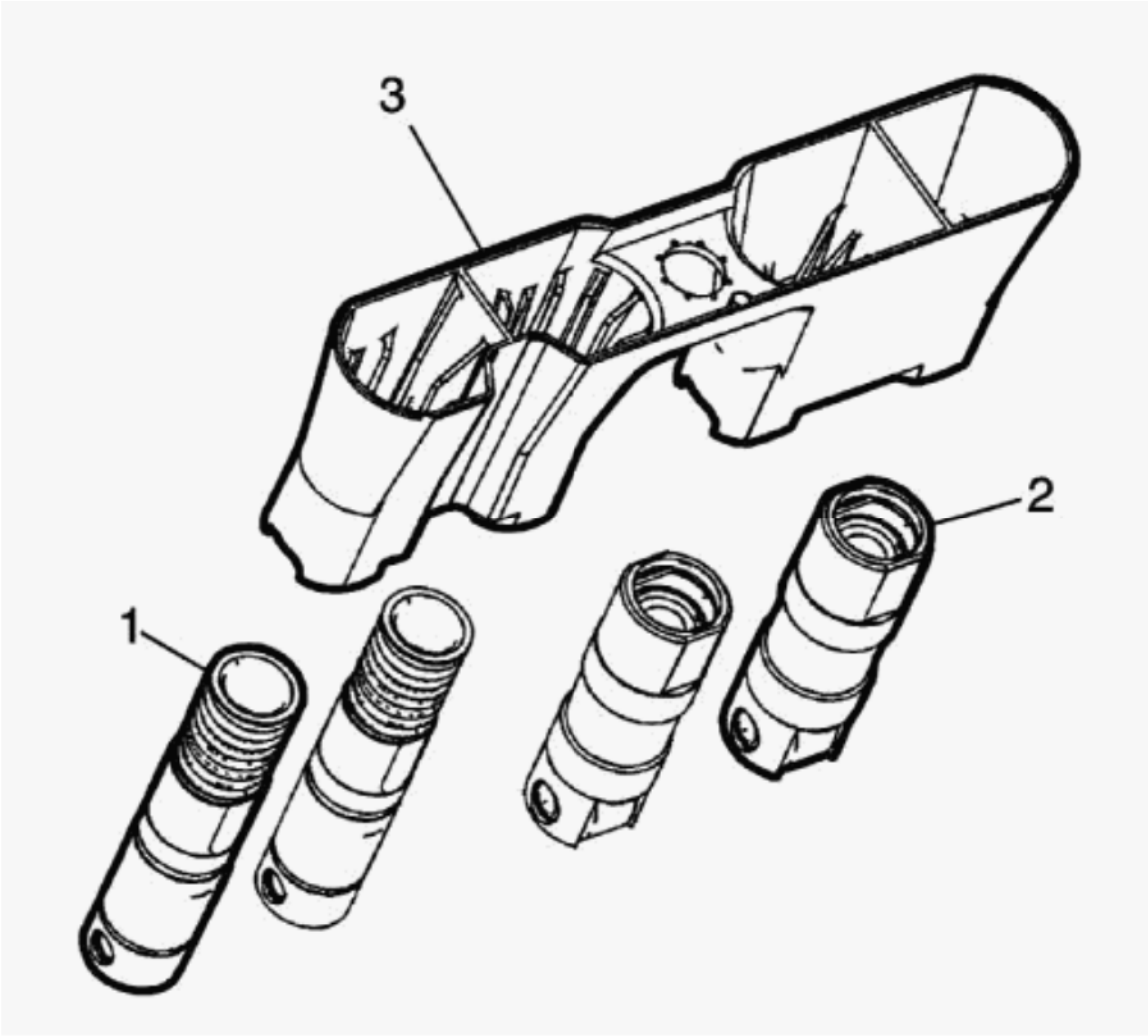

Fig. 119: Valve Lifters And Guide
Courtesy of GENERAL MOTORS COMPANY

4. Remove the valve lifters (1, 2) from the guide (3).

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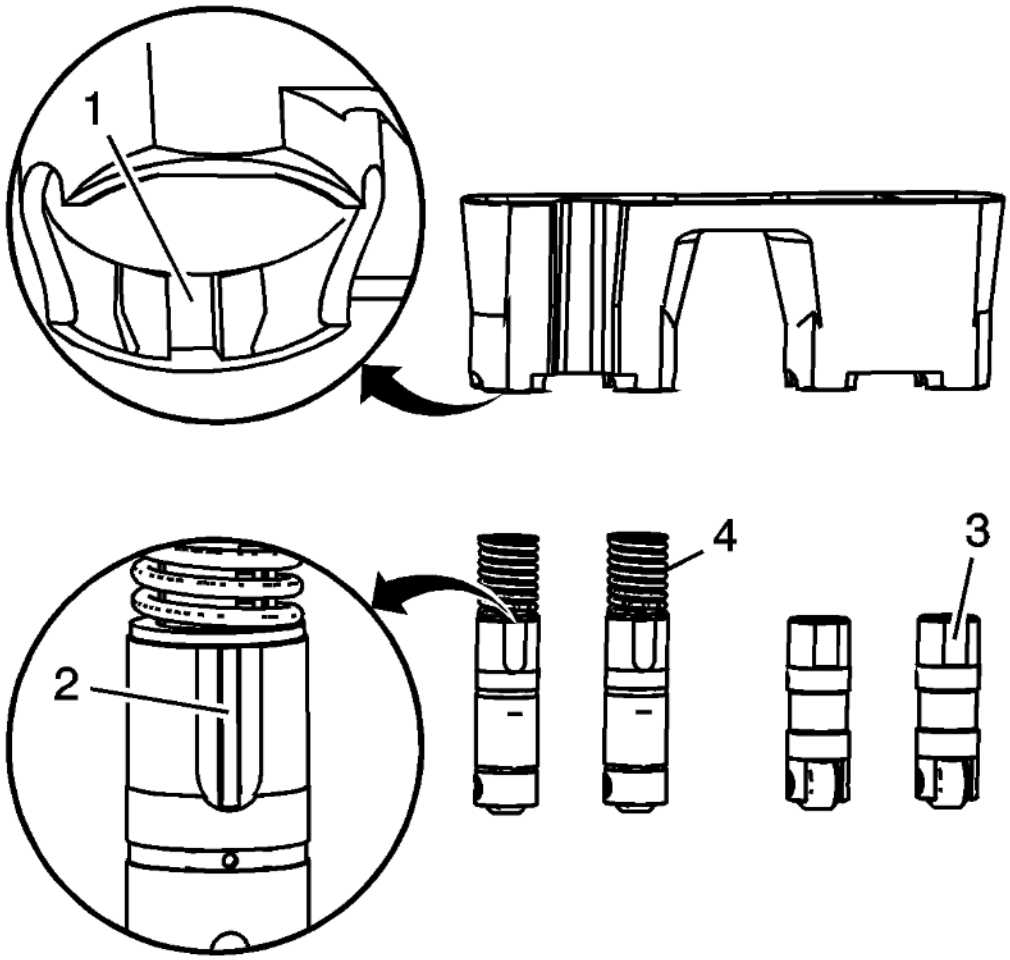

Fig. 120: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

5. Organize or mark the components so they can be installed in the same location from which they were removed. The active fuel management lifters (4) are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to **Separating Parts**.
6. For valve lifter and guide cleaning and inspection. Refer to **Valve Lifter and Guide Cleaning and Inspection**.

Installation Procedure

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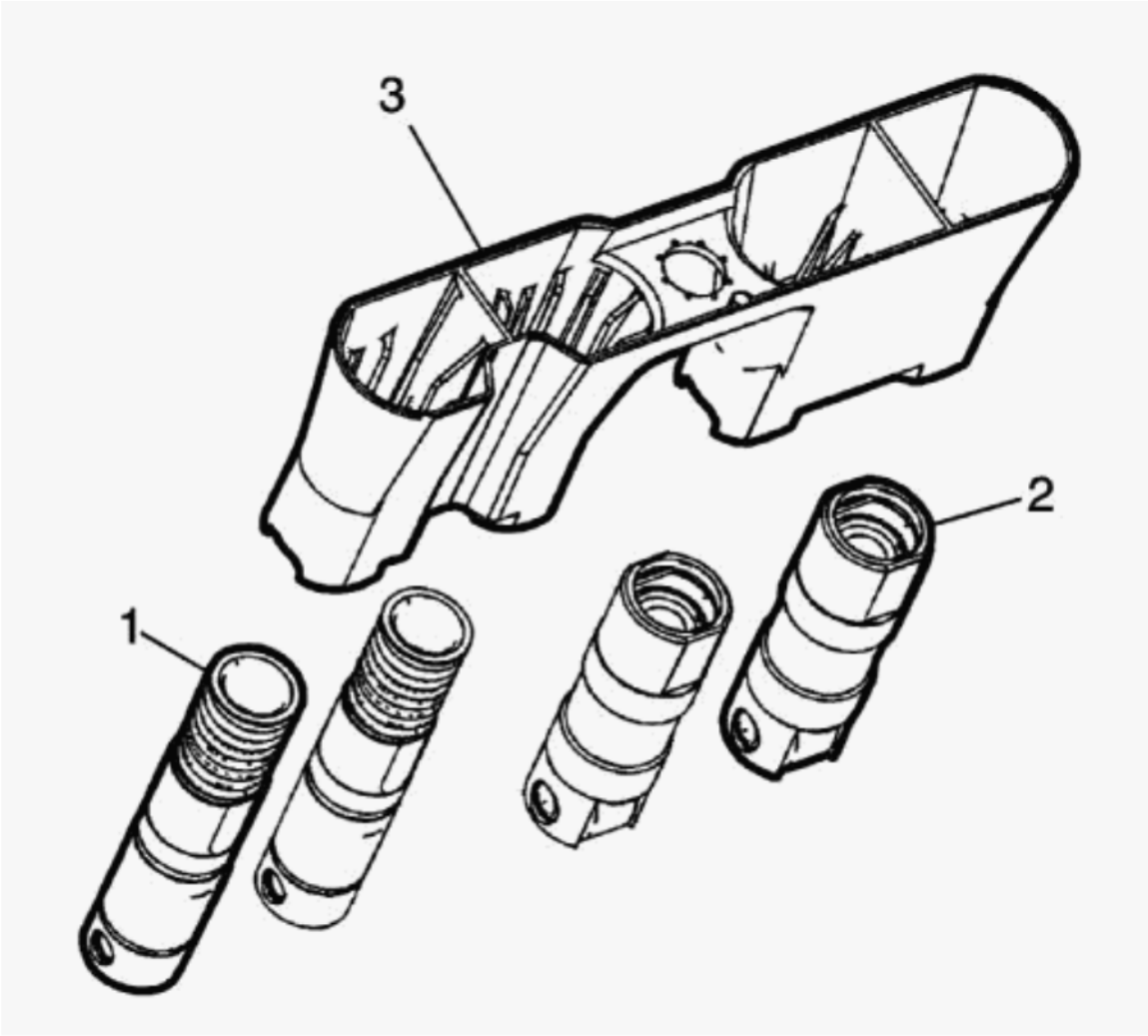

Fig. 121: Valve Lifters And Guide
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the 4 valve guide assemblies will contain 2 active fuel management valve lifters and 2 non-active fuel management valve lifters.**
- **With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain 2 active fuel management valve lifters.**

1. Lubricate the valve lifters (1, 2) and engine block valve lifter bores with clean engine oil.

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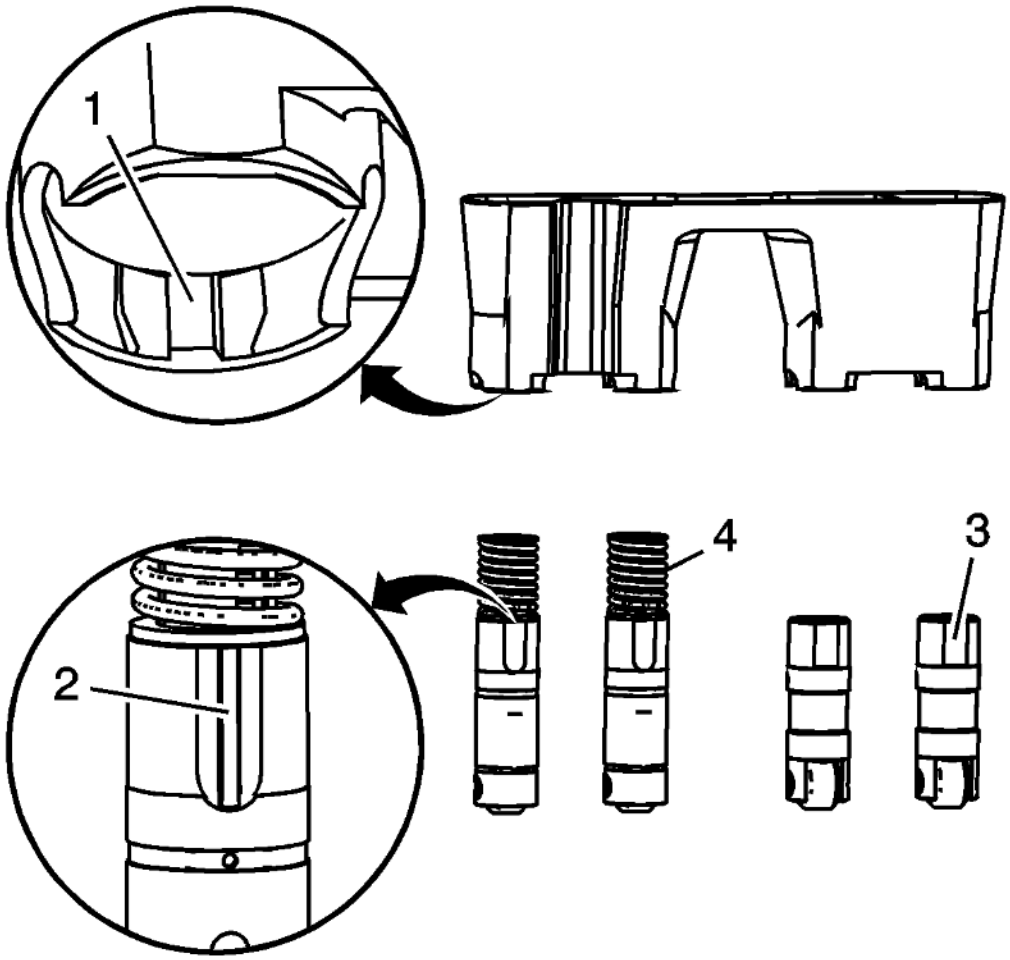

Fig. 122: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

2. Insert the valve lifters into the lifter guides.
    - Align the flat area (3) on the top of the non-active fuel management lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
    - The active fuel management lifters (4) are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.

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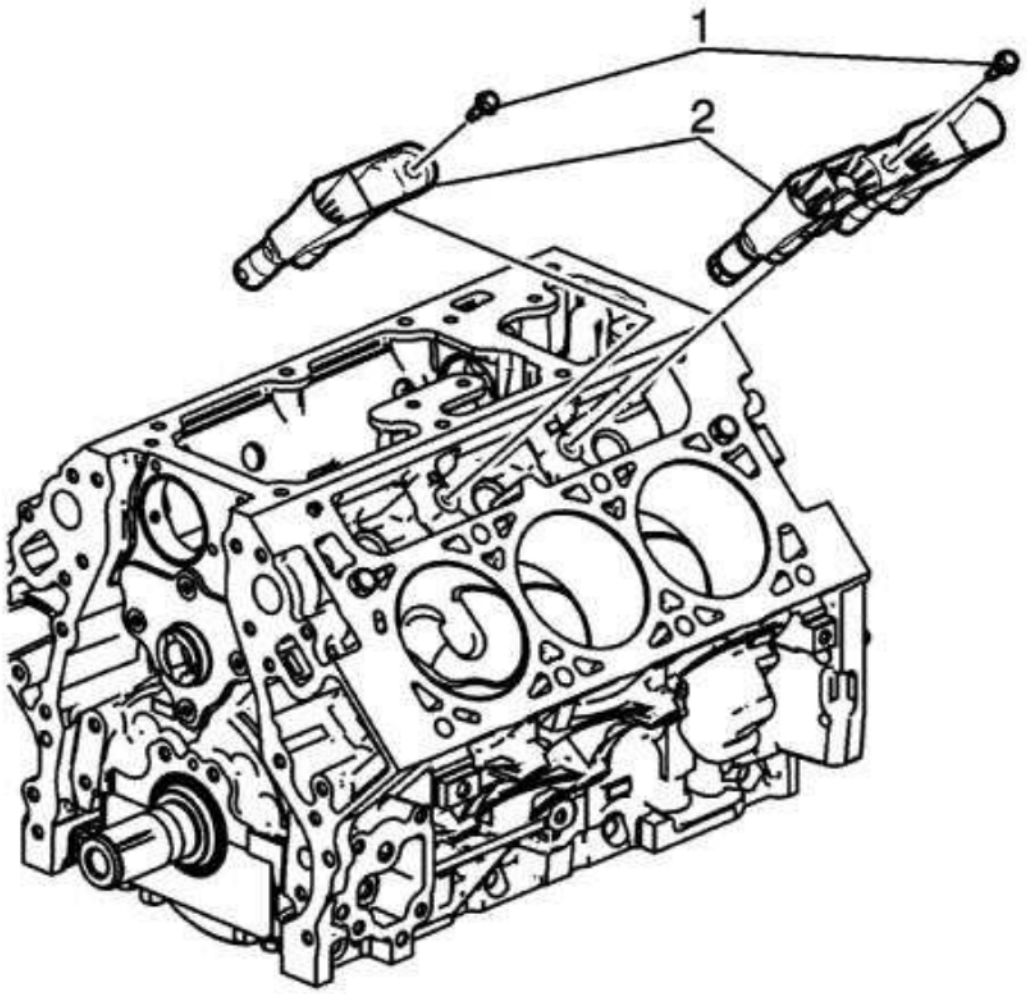

Fig. 123: Guides With Lifters And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the valve lifters and guide assembly (2) to the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the valve lifter guide bolts (1) and tighten to 12 N.m (106 lb in).
5. Install the cylinder head. Refer to Cylinder Head Replacement - Left Side, or Cylinder Head Replacement - Right Side.

BALANCER SHAFT REPLACEMENT

Special Tools

EN-46330 tension pin

For equivalent regional tools, refer to Special Tools

Removal Procedure

1. Remove engine. Refer to Engine Replacement.
2. Remove the balance shaft sprocket. Refer to Balance Shaft Sprocket Replacement.

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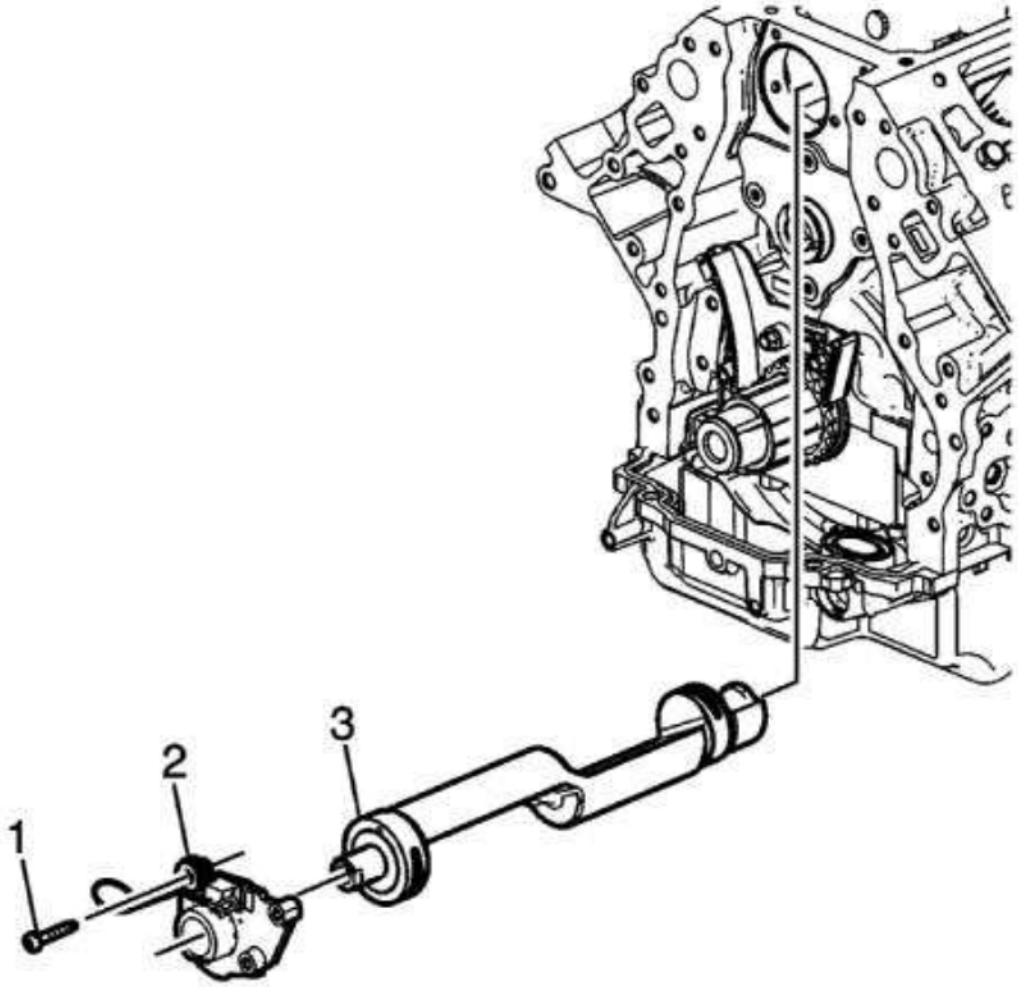

Fig. 124: Remaining Balancer Shaft Retainer Bolt And Balancer Shaft Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Remove the balancer shaft retainer bolt (1) and the balancer shaft retainer (2).
4. Remove the balancer shaft assembly (3).

Installation Procedure

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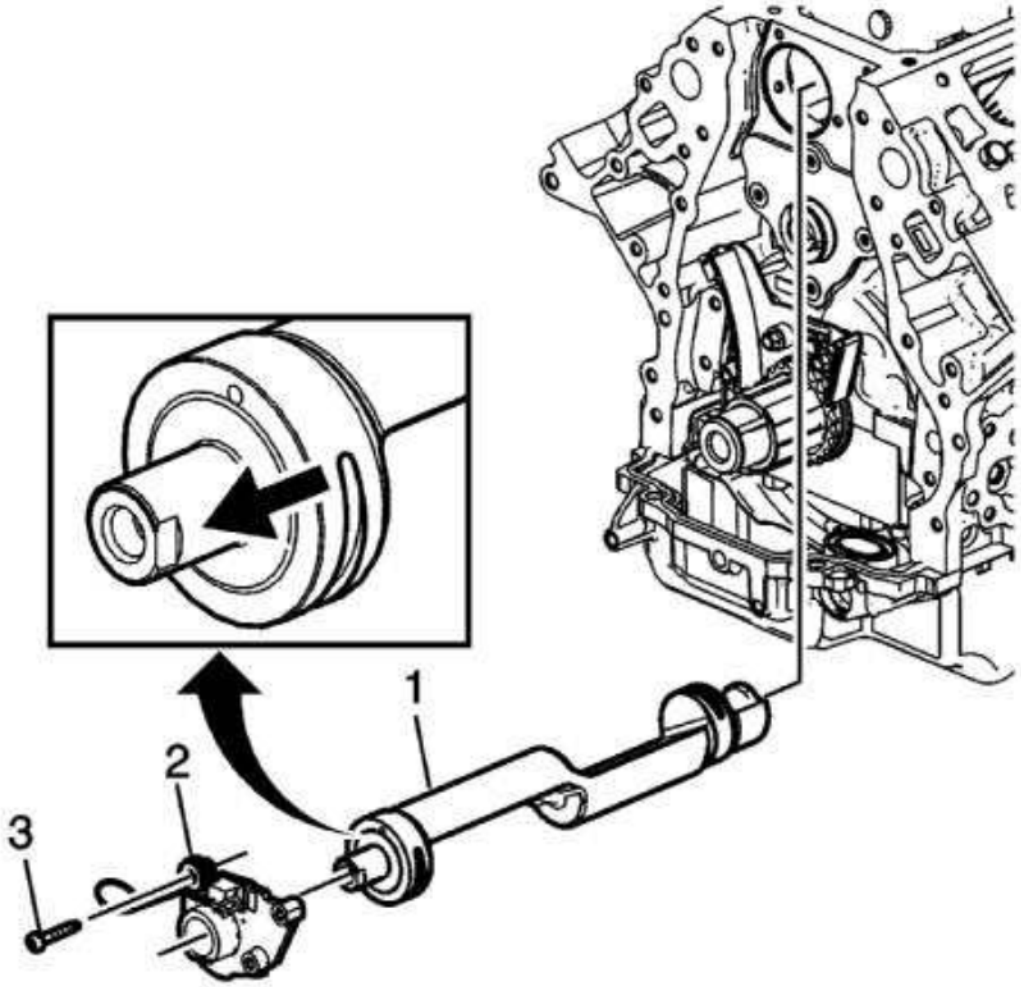

Fig. 125: Balancer Shaft And Balancer Shaft Retainer
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

NOTE: **Ensure the balancer shaft (1) is installed with the flat spot facing the 3 o'clock position.**

1. Install the balancer shaft (1) and the balancer shaft retainer (2) with EN-46330 installed.
2. Install the 11 o'clock position balancer shaft retainer bolt (3) hand tight.
3. Install the balance shaft sprocket. Refer to **Balance Shaft Sprocket Replacement**.
4. Install engine. Refer to **Engine Replacement**.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **EN-41665** Crankshaft Balancer and Sprocket Installer
- **EN-41816** Crankshaft Balancer Remover
- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

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For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement**.
2. Remove the starter motor. Refer to **Starter Replacement (LV3)** .

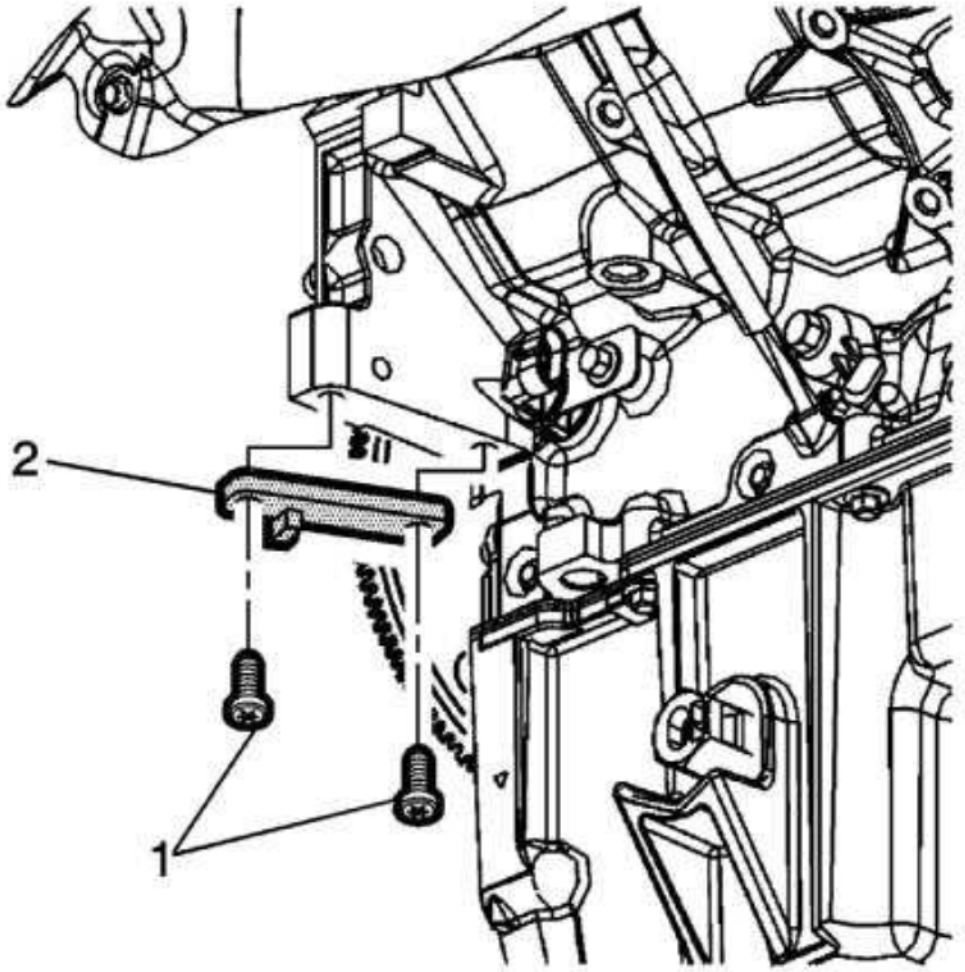

Fig. 126: Flywheel Holding Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

NOTE: **Ensure that the teeth of the EN-42386-A flywheel holding tool mesh with the teeth of the engine flywheel.**

3. Install the **EN-42386-A** flywheel holding tool (2) and bolts. Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool operation. Tighten the **EN-42386-A** flywheel holding tool bolts (1) to 50 N.m (37 lb ft).

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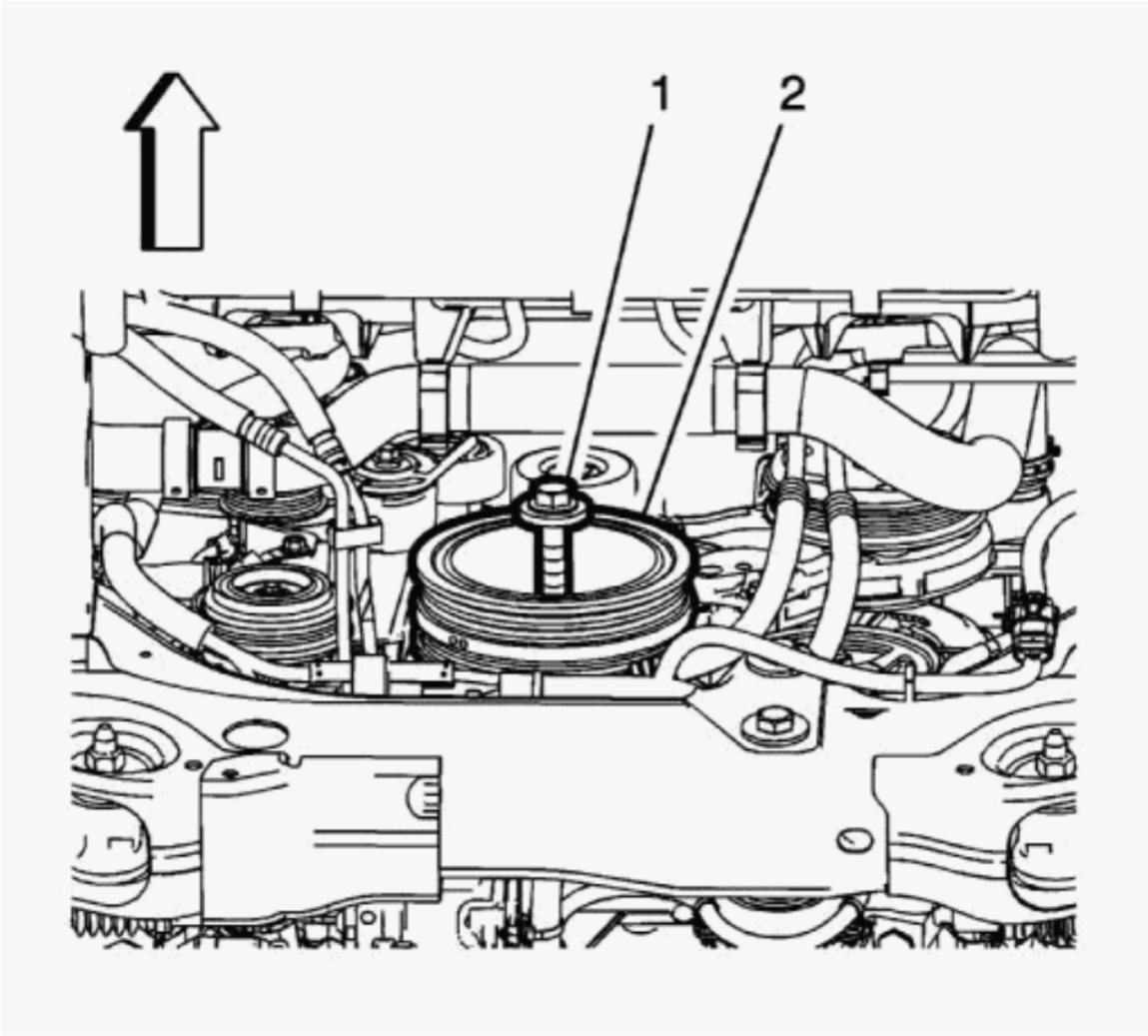

Fig. 127: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft balancer bolt (1). Do not discard the crankshaft balancer bolt at this time. The old balancer bolt will be used during the balancer installation procedure.

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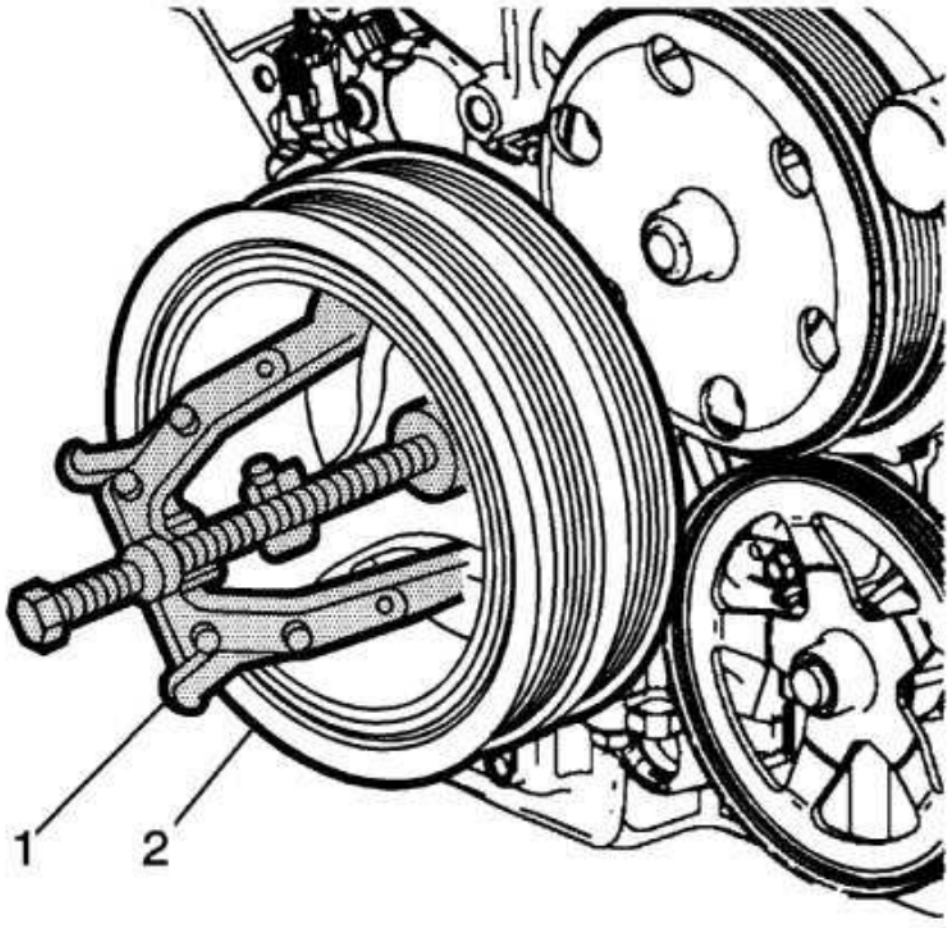

Fig. 128: EN-41816 Crankshaft Balancer Remover
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-41816** crankshaft balancer remover (1) and **EN-41816-2** crankshaft end protector to the crankshaft balancer.
6. Remove the crankshaft balancer (2).
7. For crankshaft balancer cleaning and inspection. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

NOTE:

- **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 will be used ONLY during the first pass of the balancer installation procedure. Install a NEW bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.**

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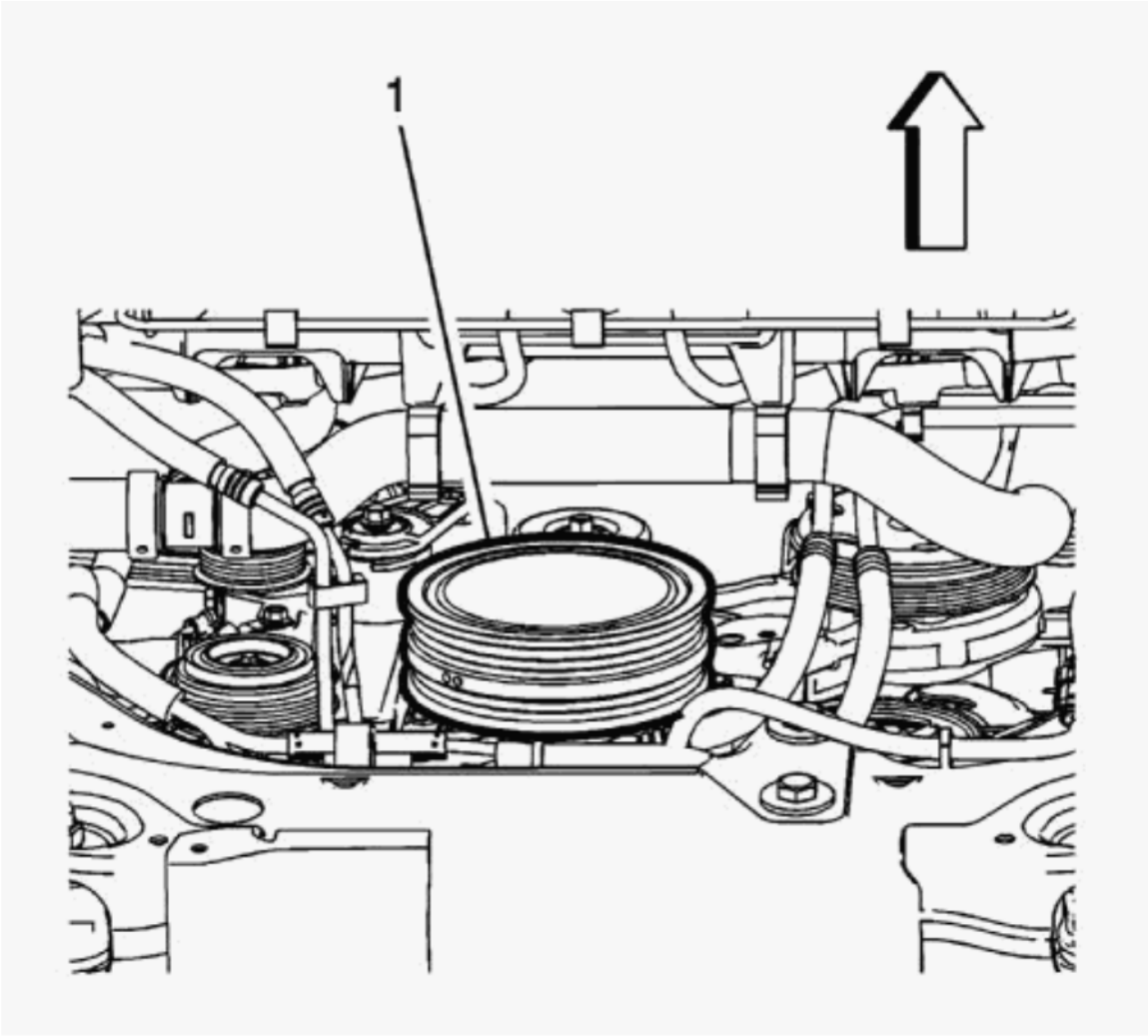

Fig. 129: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

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

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

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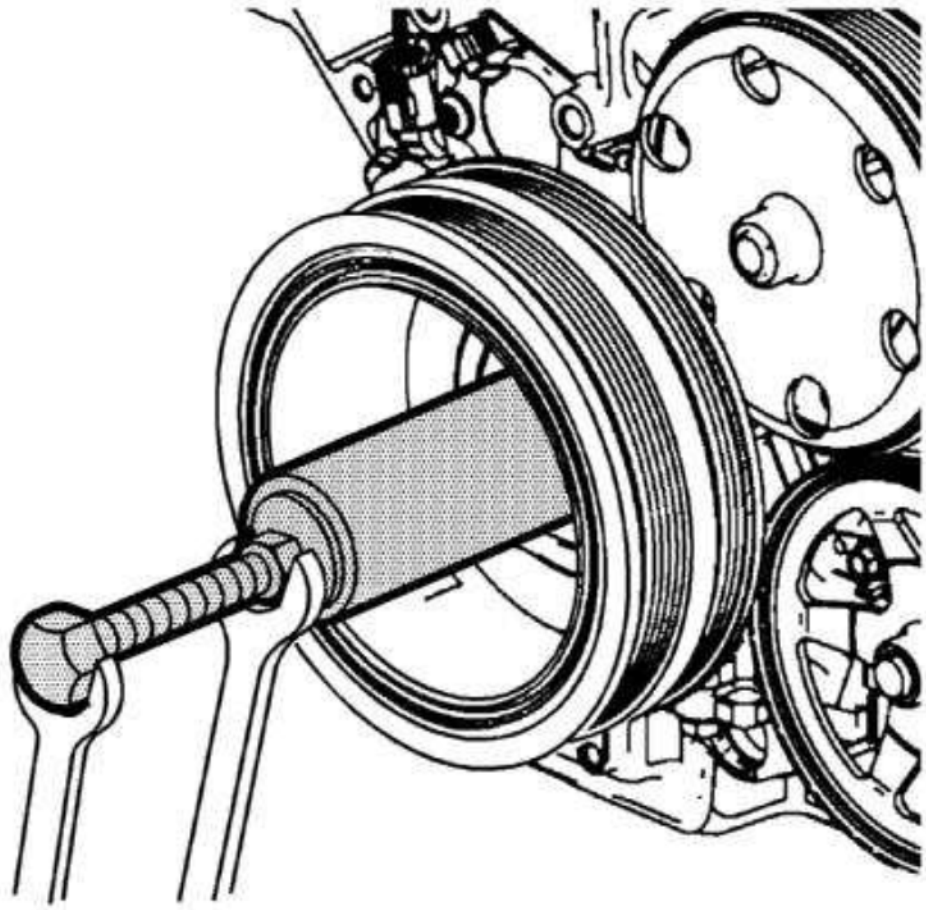

Fig. 130: EN-41665 Crankshaft Balancer And Sprocket Installer
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41665** crankshaft balancer and sprocket installer and the threaded rod from the **EN-41478** crankshaft front oil seal installer to crankshaft balancer and install the balancer.
    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 **J 41665** crankshaft balancer and sprocket installer and the threaded rod.

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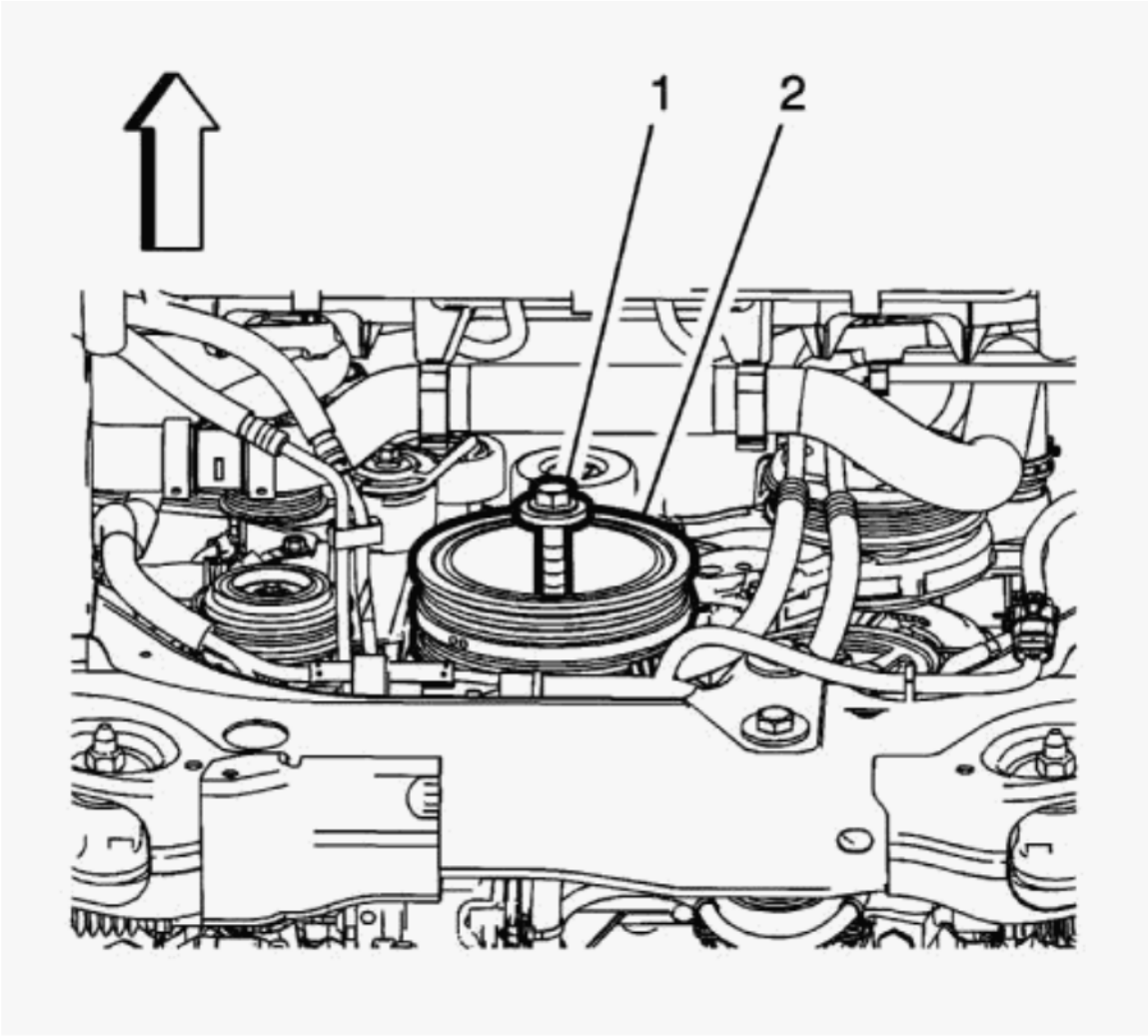

Fig. 131: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install the USED crankshaft balancer bolt (1) . Tighten the USED bolt to 330 N.m (240 lb ft).
4. Remove the USED crankshaft balancer bolt.

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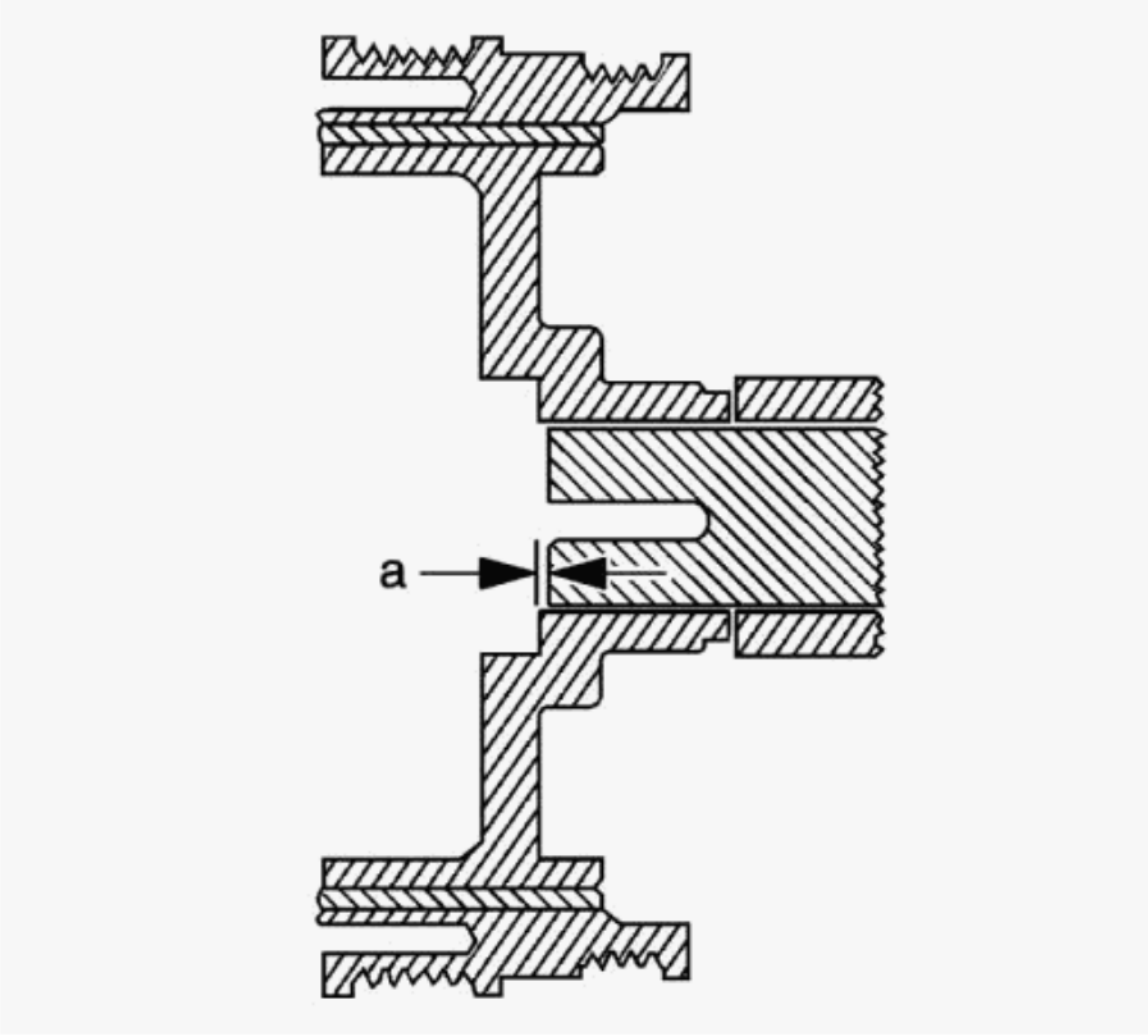

Fig. 132: EN-41665 Crankshaft Balancer And Sprocket Installer
Courtesy of GENERAL MOTORS COMPANY

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

5. Measure for a correctly installed balancer. If the balancer is not installed to the proper dimension, install the **EN-41665** crankshaft balancer and sprocket installer and repeat the installation procedure.

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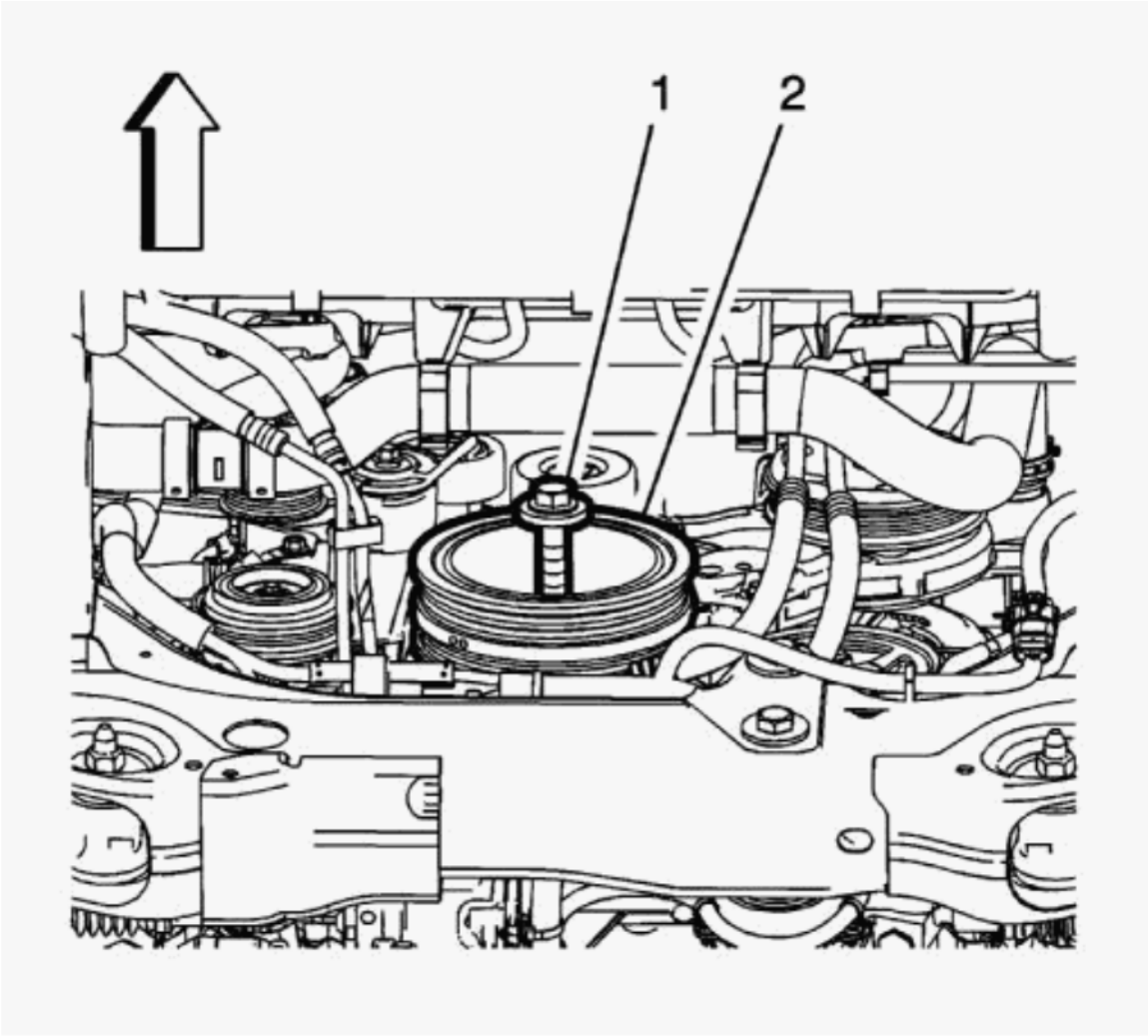

Fig. 133: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

6. Install the NEW crankshaft balancer bolt (1).
    1. Tighten the bolt a first pass to 120 N.m (89 lb ft).
    2. Loosen 360 degrees.
    3. Tighten the bolt a second pass to 80 N.m (59 lb ft).
    4. Balancer bolt with flanged head, tighten the crankshaft balancer bolt a final pass to 125 degrees using the **J 45059** angle meter.
    5. Balancer bolt with retained rotating washer, tighten the crankshaft balancer bolt a final pass to 200 degrees using the **J 45059** angle meter.

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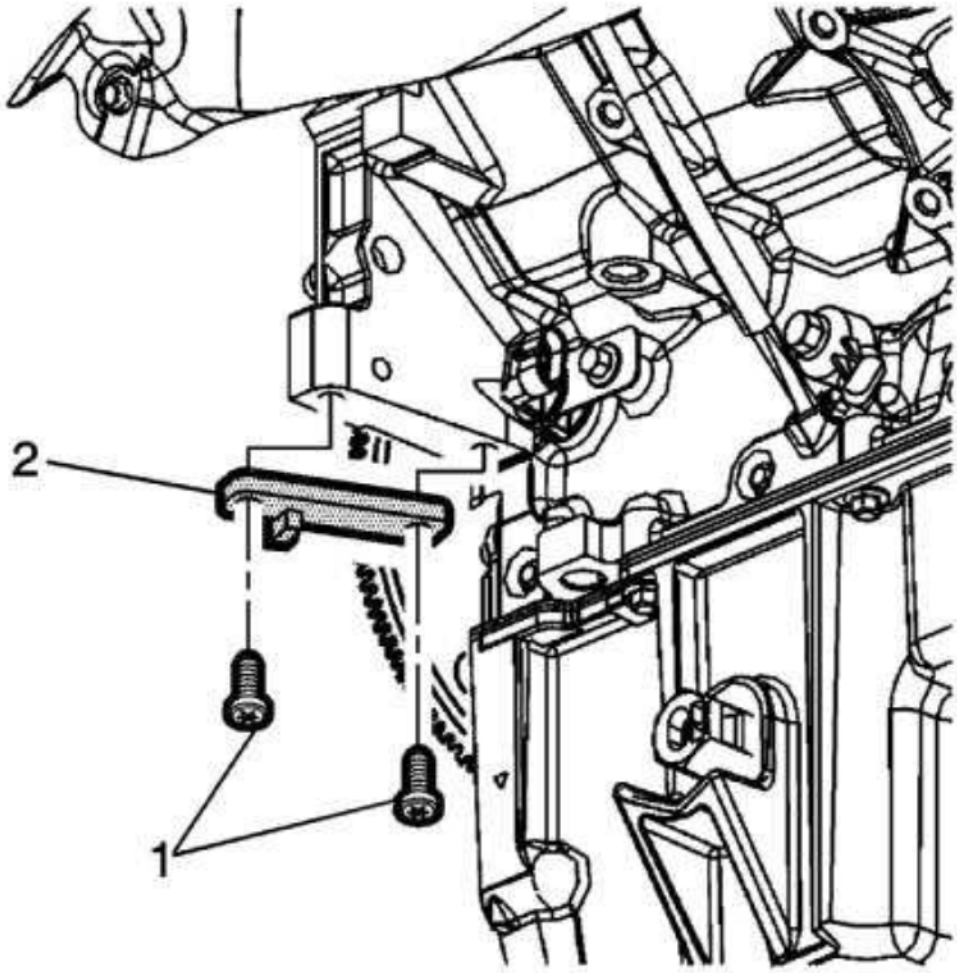

Fig. 134: Flywheel Holding Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the **EN-42386-A** flywheel holding tool (2) and bolts.
8. Install the starter motor. Refer to **Starter Replacement (LV3)** .
9. Install the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

- **J-41478-A** Crankshaft Front Oil Seal Installer
- **EN-51091** Crankshaft Front Oil Seal Installer

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

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

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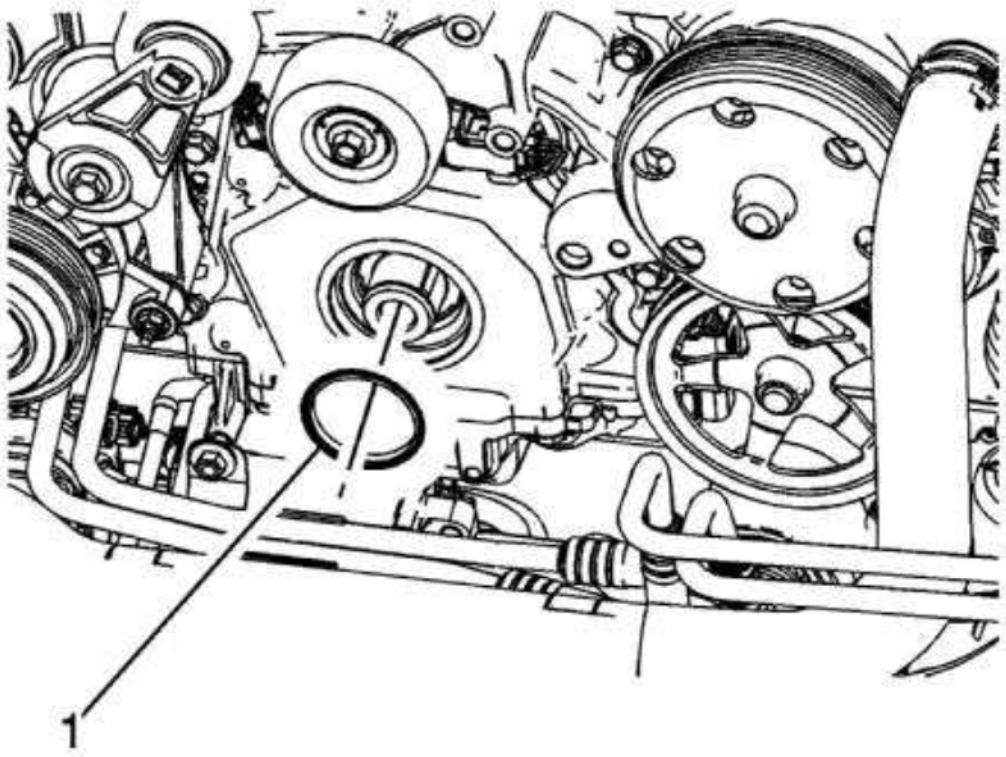

Fig. 135: Crankshaft Front Oil Seal And Front Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use suitable tool to remove the crankshaft front seal.**

2. Remove the crankshaft front oil seal (1) from the front cover.

Installation Procedure

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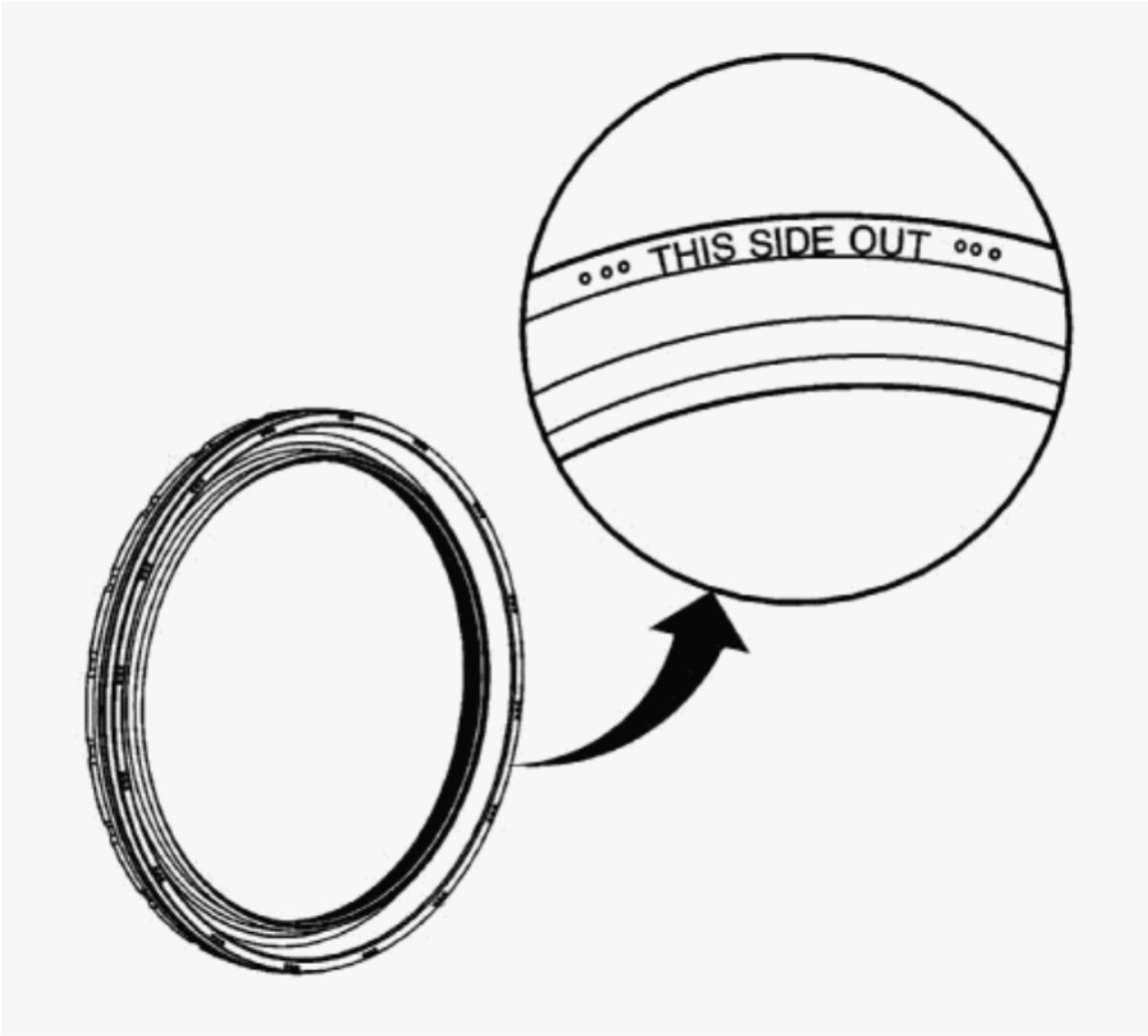

Fig. 136: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

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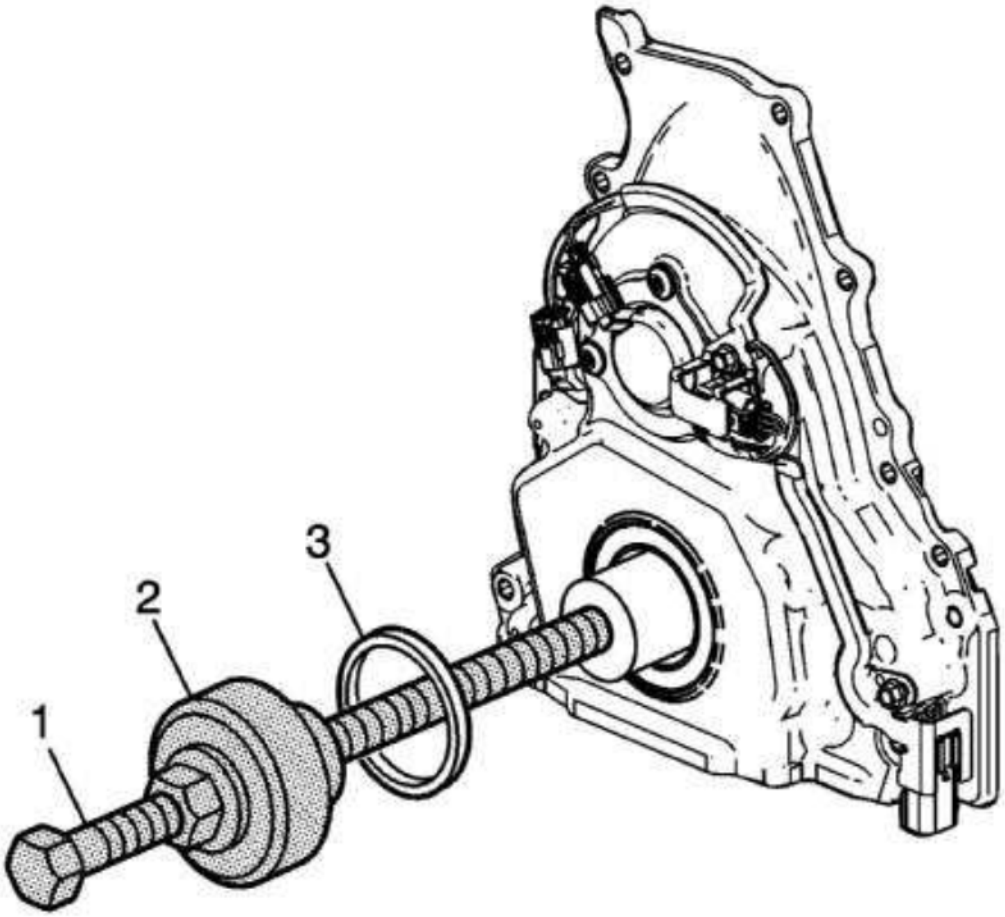

Fig. 137: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. Install the crankshaft front oil seal (3) onto the threaded rod, nut and washer from **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2).
3. Install the **J-41478-A** crankshaft front oil seal installer threaded rod, nut and washer (1) and **EN-51091** crankshaft front oil seal installer (2) and oil seal (3), into the end of the crankshaft.
4. Use the **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2) in order to install the oil seal (3) 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.
5. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Removal Procedure

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .
2. Remove the vacuum pump. Refer to **Vacuum Pump Belt Replacement**.

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3. Remove the engine coolant manifold. Refer to **Engine Coolant Manifold Replacement (LV3, L83)** .
4. Unbolt and reposition the AC conditioning compressor without disconnecting the lines.
5. Remove the oil pan. Refer to **Oil Pan Replacement**
6. Disconnect electrical connectors as necessary.

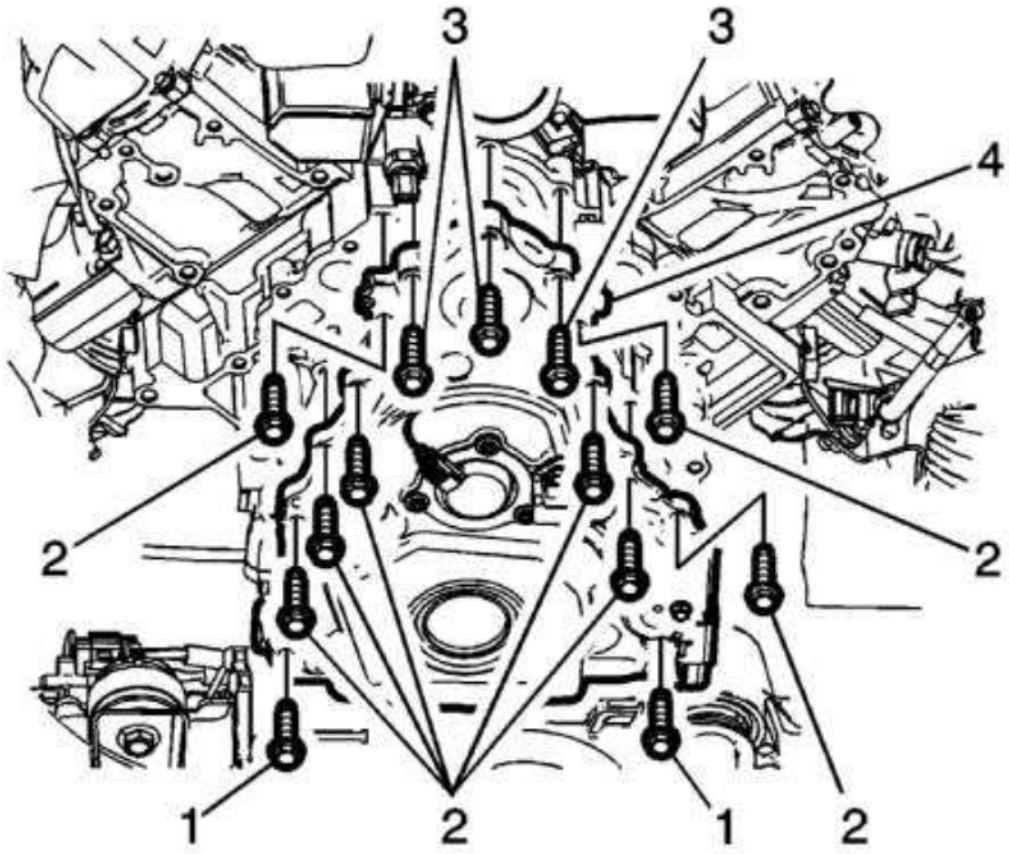

Fig. 138: Front Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the front cover bolts (1-3).
8. Remove front cover (4).
9. Ensure to clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

Installation Procedure

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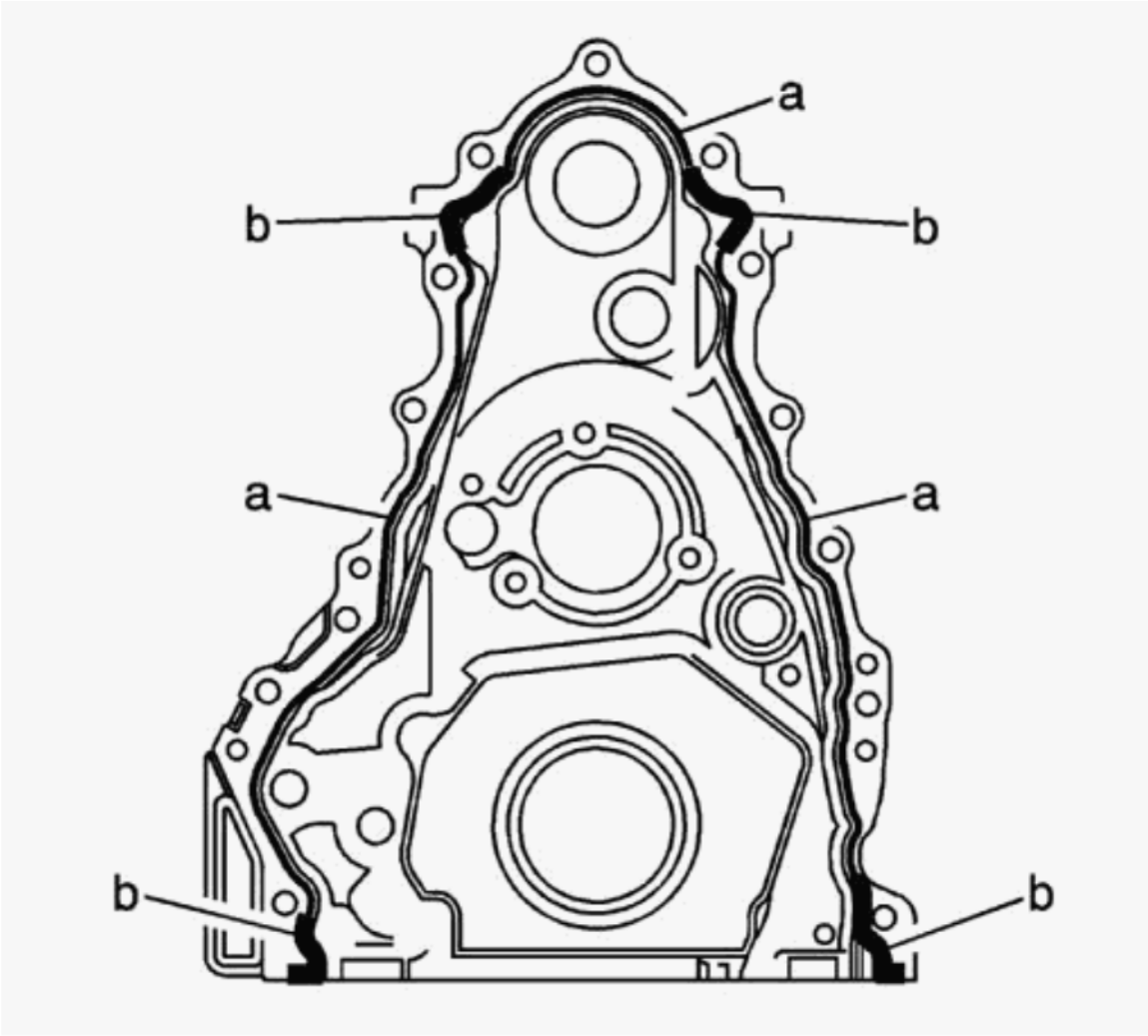

Fig. 139: Applying 3mm (0.118 in) Bead Of RTV Sealant On Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

1. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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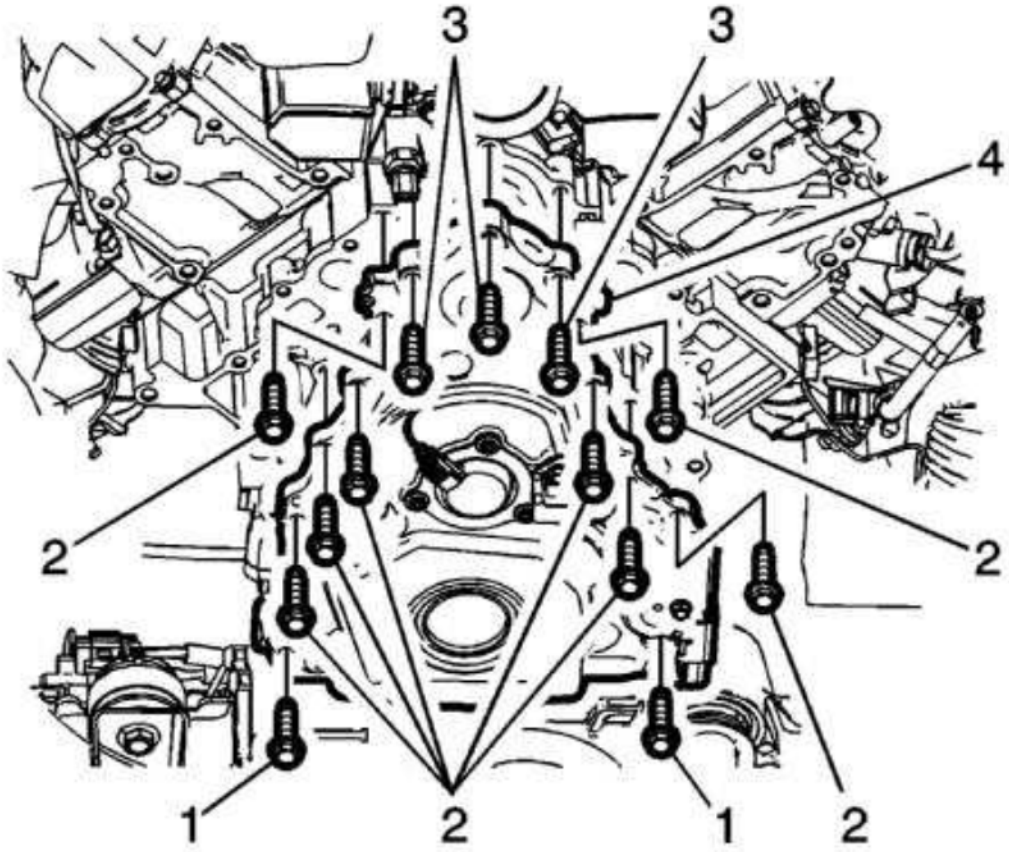

Fig. 140: Front Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the front cover (4).

CAUTION: **Refer to Fastener Caution .**

3. Install the front cover bolts (1-3).

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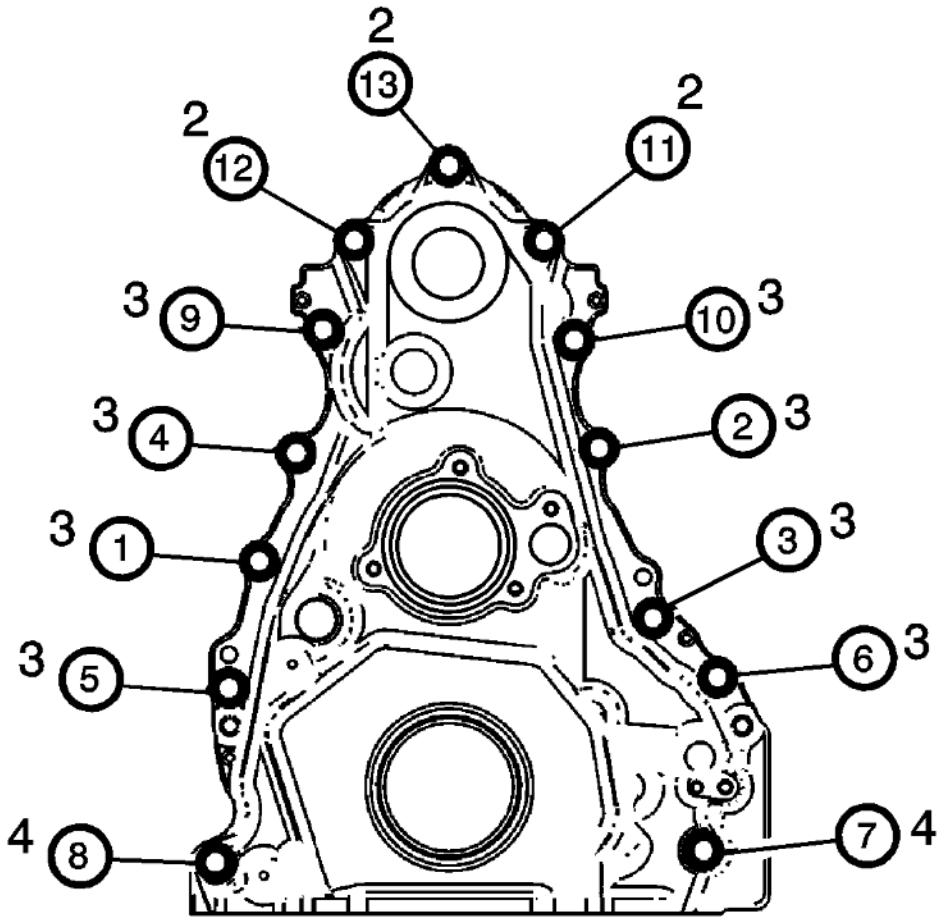

Fig. 141: Engine Front Cover Bolt Identification And Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Tighten bolts (2-4) in sequence as shown above to 25 N.m (18 lb ft).
5. Install the oil pan. Refer to **Oil Pan Replacement**
6. Connect electrical connectors as necessary.
7. Install the engine coolant manifold. Refer to **Engine Coolant Manifold Replacement (LV3, L83)** .
8. Install the vacuum pump. Refer to **Vacuum Pump Belt Replacement**.
9. Install the A/C compressor. Refer to **Air Conditioning Compressor Replacement (LV3)** .
10. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement** .

OIL PUMP REPLACEMENT

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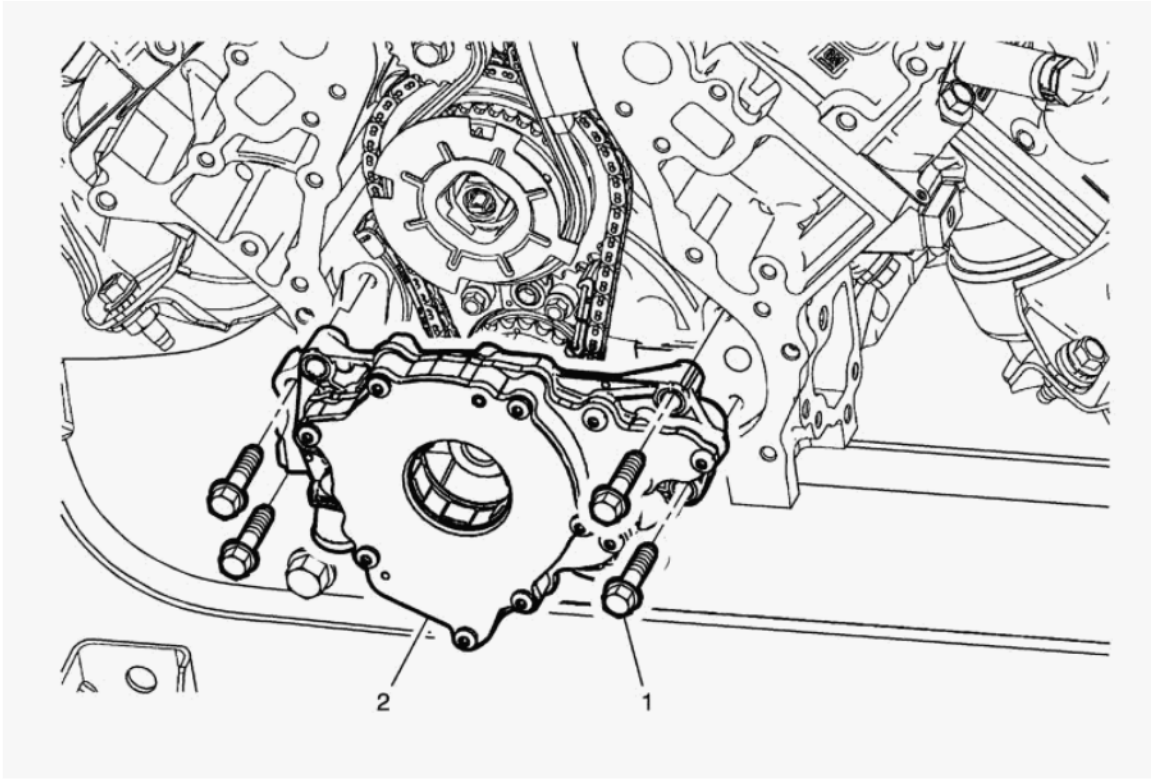

Fig. 142: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**. 2. Remove the oil pan. Refer to **Oil Pan Replacement**. **NOTE:** **If the oil pump is removed to perform a different repair and is going to be REUSED, the EN-51267 oil pump alignment tool must be installed on the engine block BEFORE the oil pump is removed and left in place until the**	

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Callout	Component Name
	installation of the original oil pump. If the EN-51267 oil pump alignment tool IS NOT installed prior to oil pump housing removal, AND left in place while other repairs are performed, a NEW oil pump MUST be installed.
1	Oil Pump Fastener (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Procedure** For oil pump tighten sequence. Refer to **Oil Pump Installation**. **NOTE:** **Upward pressure must be applied to the oil pump while tightening the fasteners. Contact between the oil pump housing and the oil pump alignment tool must be maintained while oil**

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Callout	Component Name
	pump bolts are tightened. Prior to removing the oil pump alignment tool, ensure that there is no gap between the oil pump housing and the tool. If there is a gap, the oil pump bolts need to be loosened and the installation procedure repeated. **Tighten** 25 N.m (18 lb ft)

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Callout	Component Name
2	Oil Pump **NOTE:** **Prior to installing the oil pump, ensure that oil pump housing gasket is fully installed in the timing chain tensioner assembly and is not damaged. If the gasket is missing or damaged, replace the tensioner assembly.** **Procedure** For oil pump cleaning and inspection. Refer to **Oil Pump Cleaning and Inspection**. **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.

OIL FILTER CENTER TUBE REPLACEMENT

Removal Procedure

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

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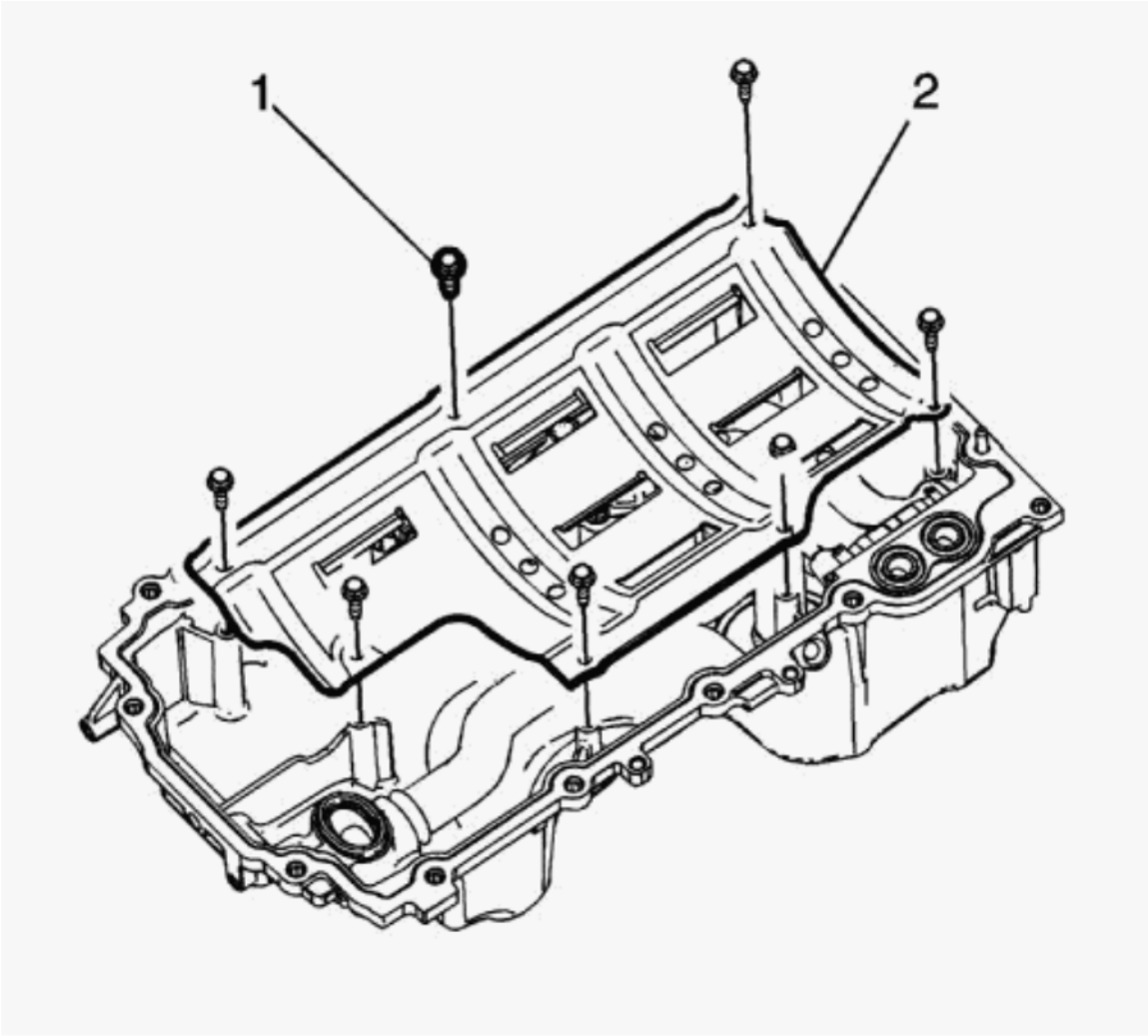

Fig. 143: Crankshaft Oil Deflector Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft oil deflector bolts (1).
3. Remove the crankshaft oil deflector (2).

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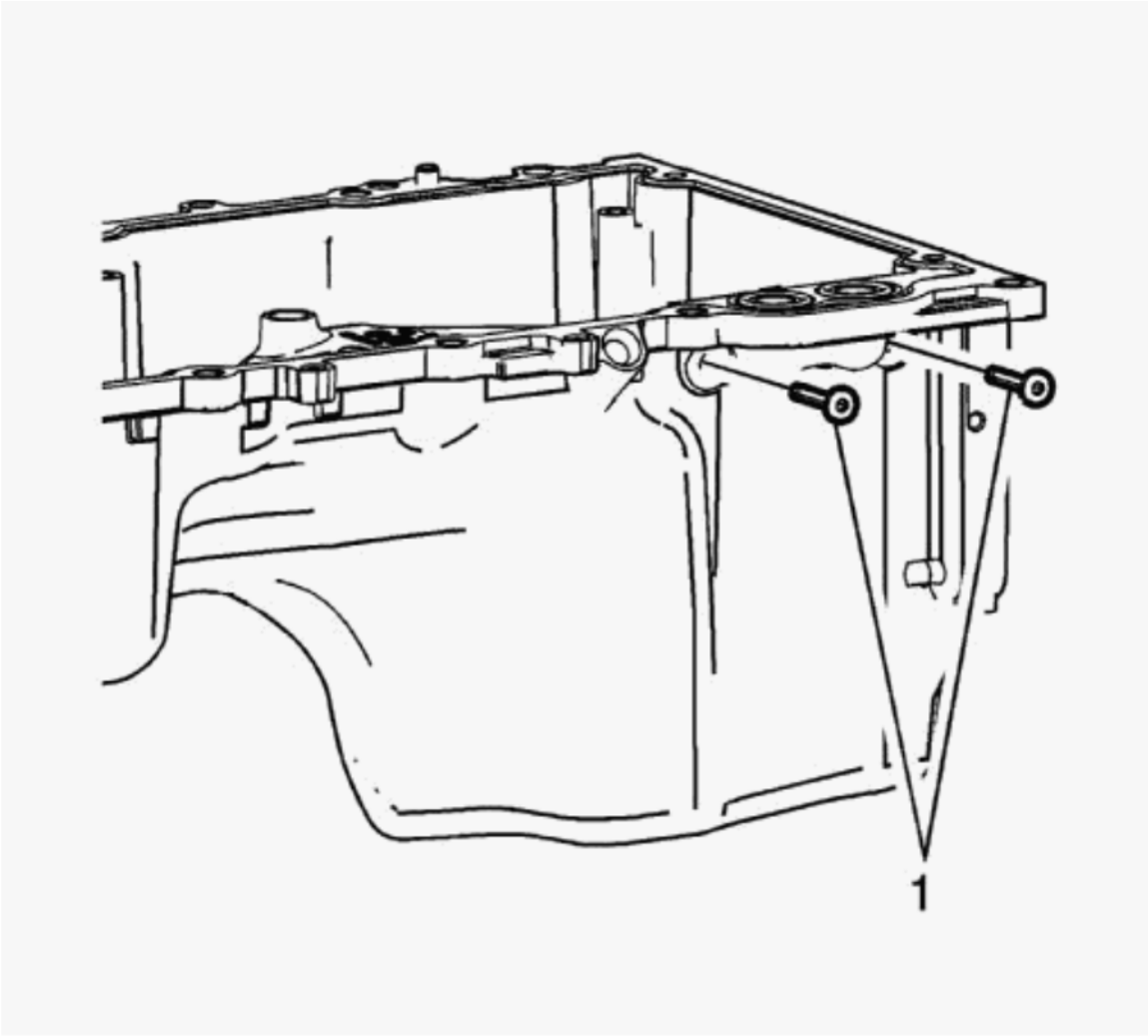

Fig. 144: Oil Filter Center Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the oil filter center tube bolts (1)

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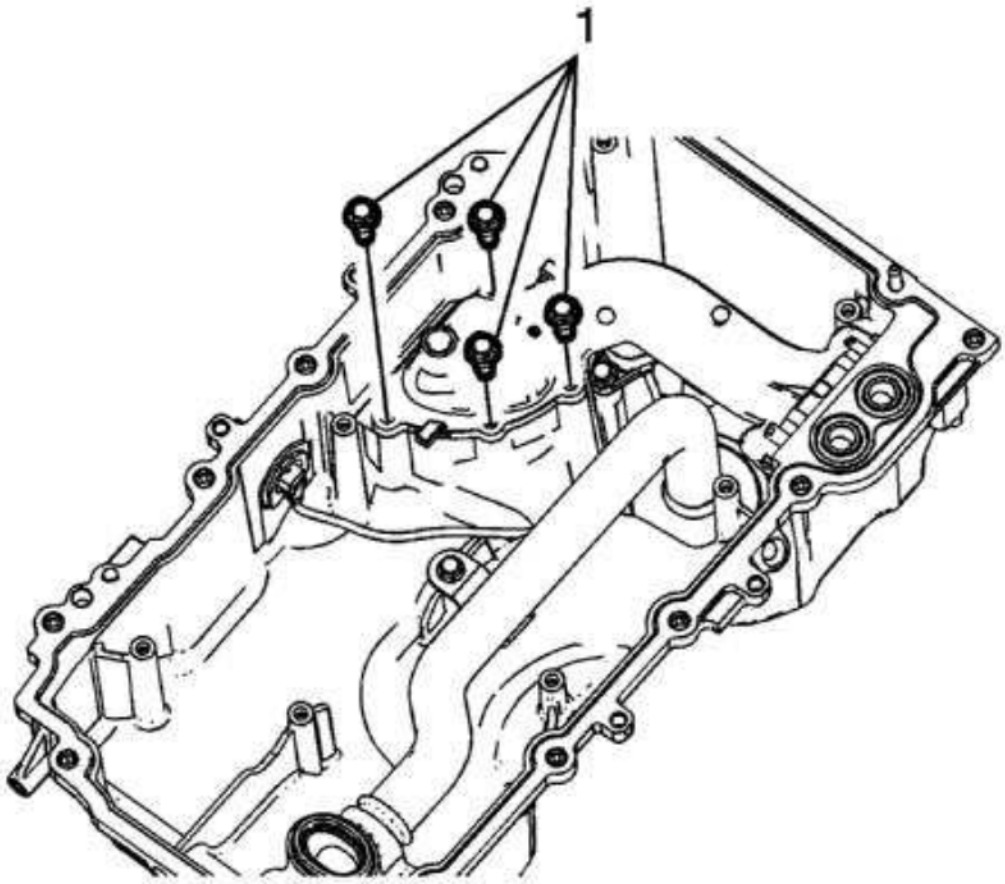

Fig. 145: Oil Filter Center Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil filter center tube bolts (1).

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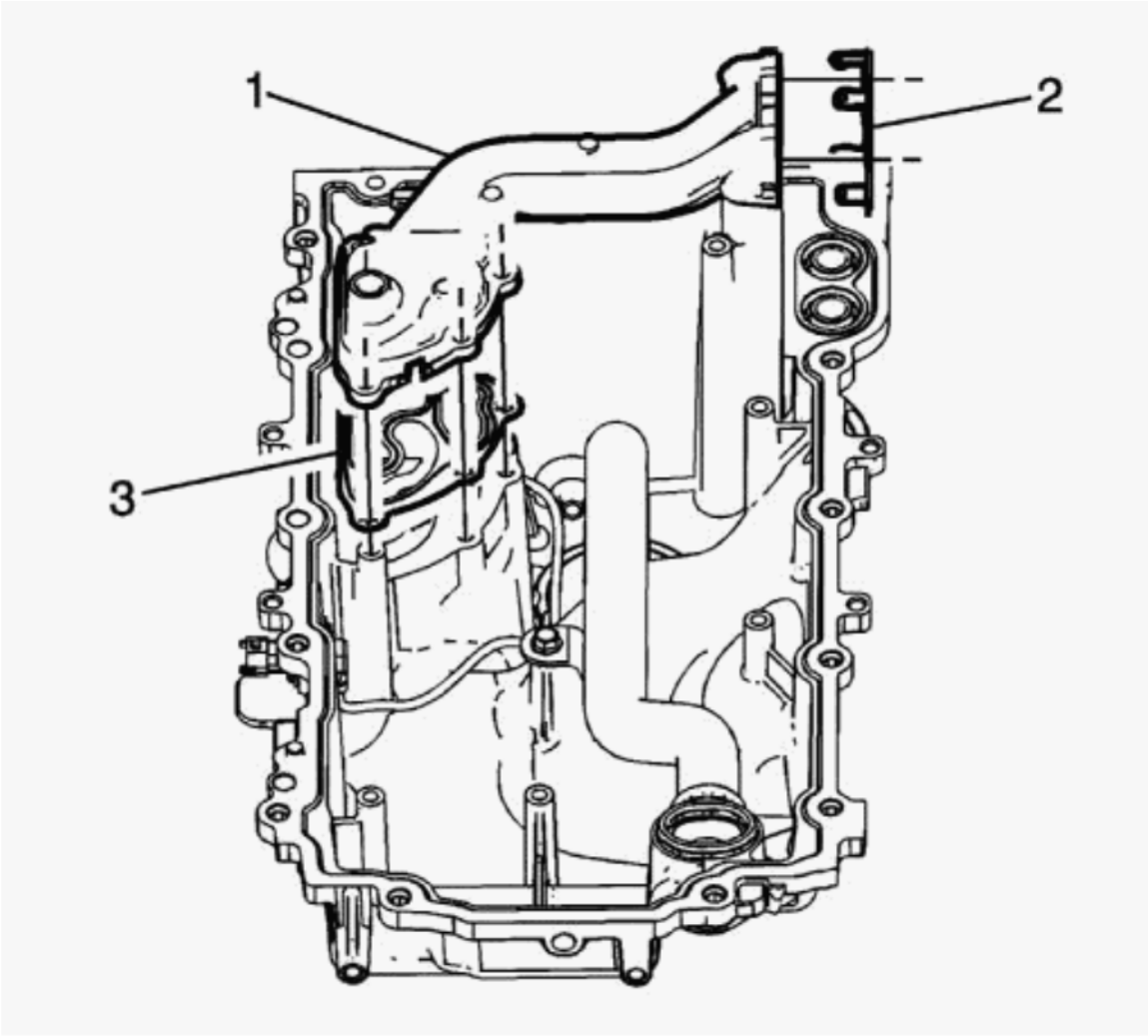

Fig. 146: Oil Filter Center Tube
Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil filter center tube (1).
7. Remove the and DISCARD oil filter center tube gasket (2,3).

Installation Procedure

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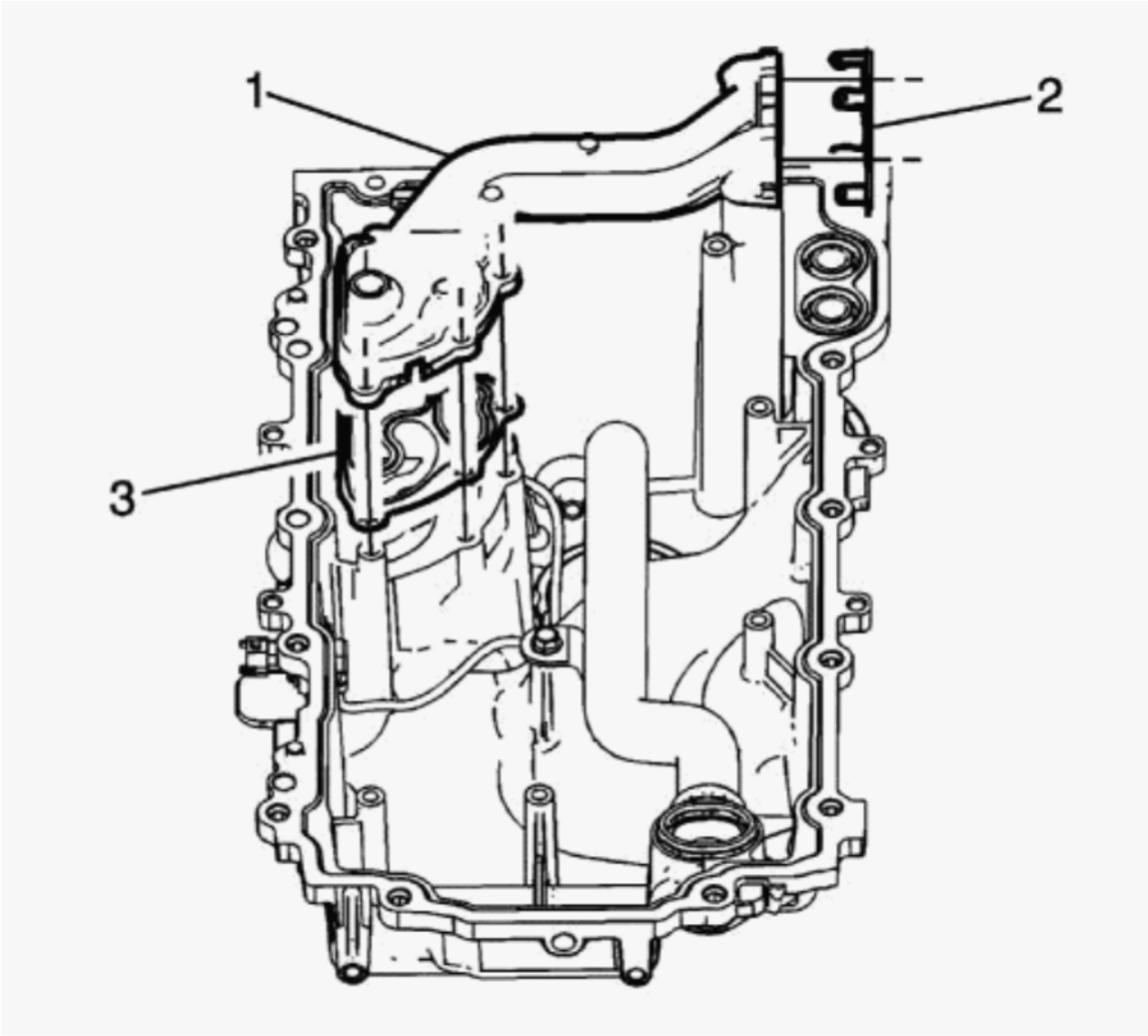

Fig. 147: Oil Filter Center Tube
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW oil filter center tube gasket (2,3).
2. Install the oil filter center tube (1).

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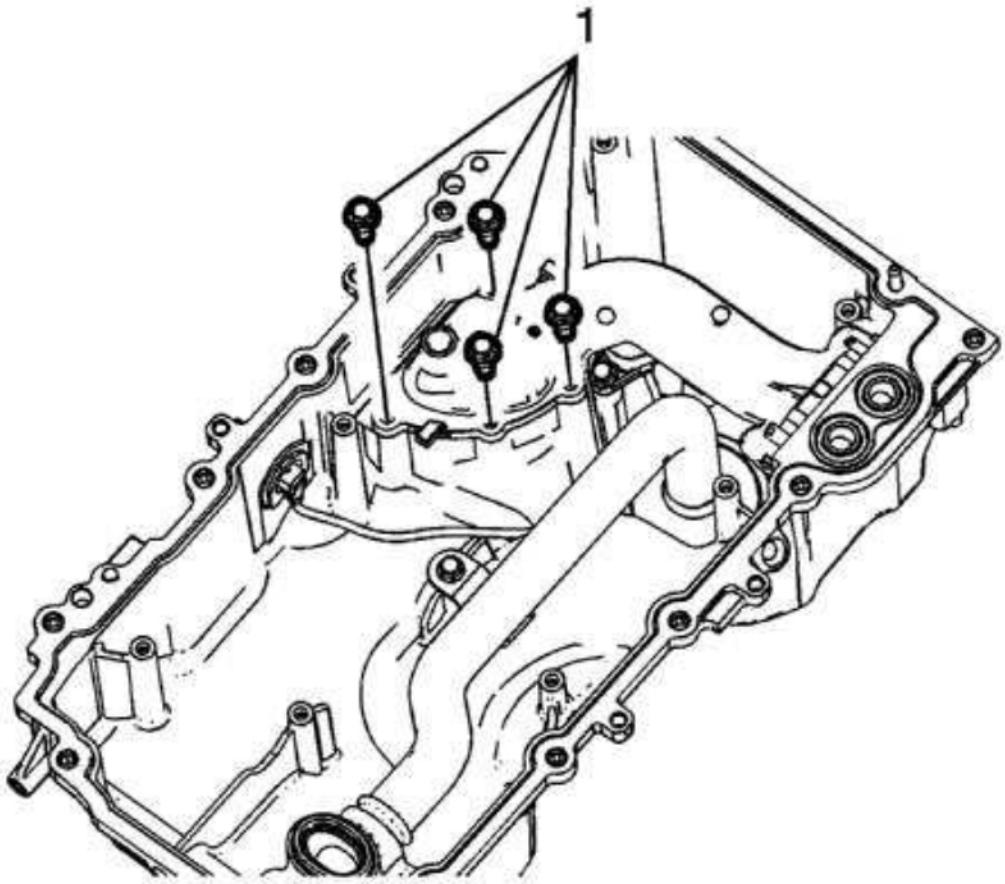

Fig. 148: Oil Filter Center Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

3. Install the oil filter center tube bolts (1) and tighten to 10 N.m (89 lb in).

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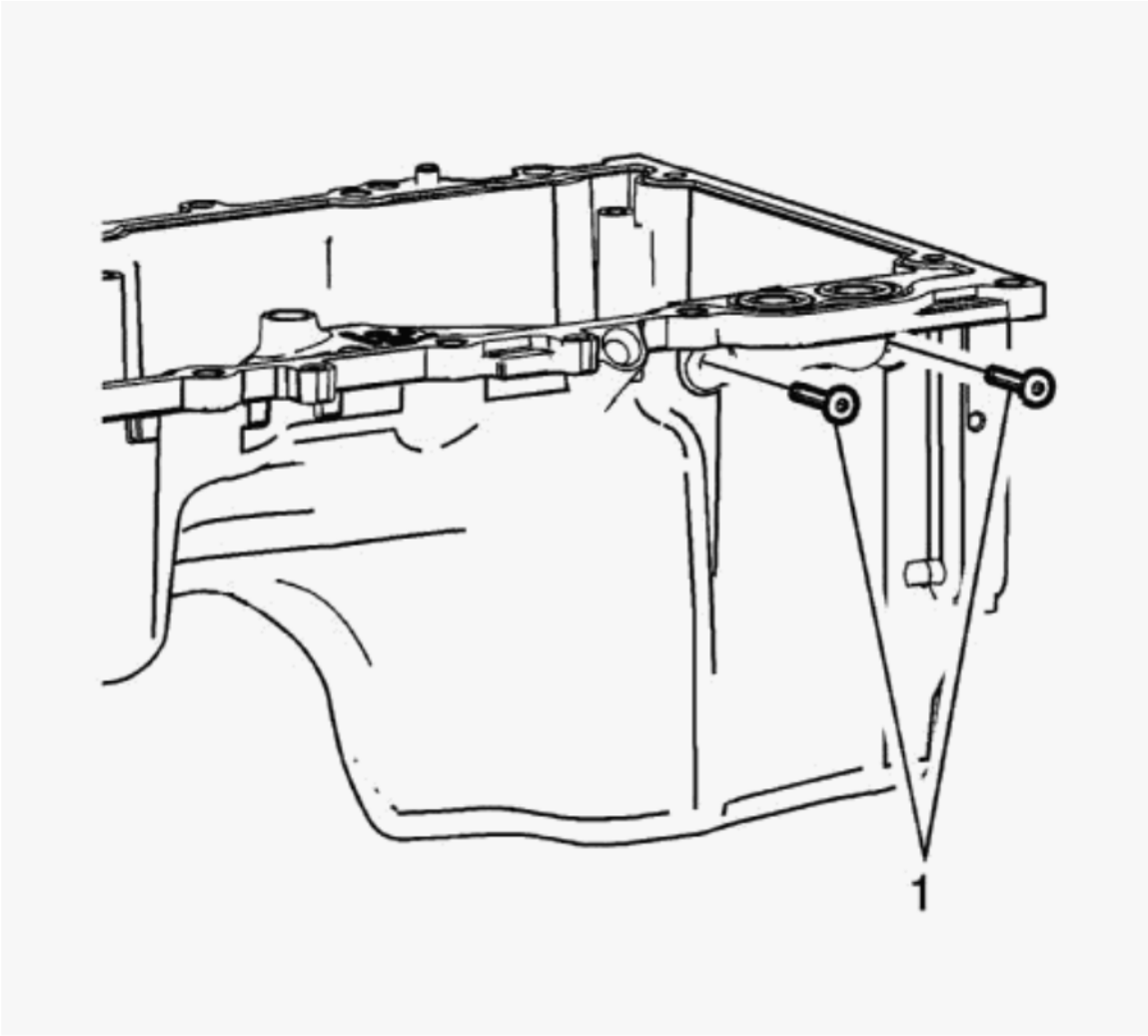

Fig. 149: Oil Filter Center Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Install the oil filter center tube bolts (1) and tighten to 10 N.m (89 lb in).

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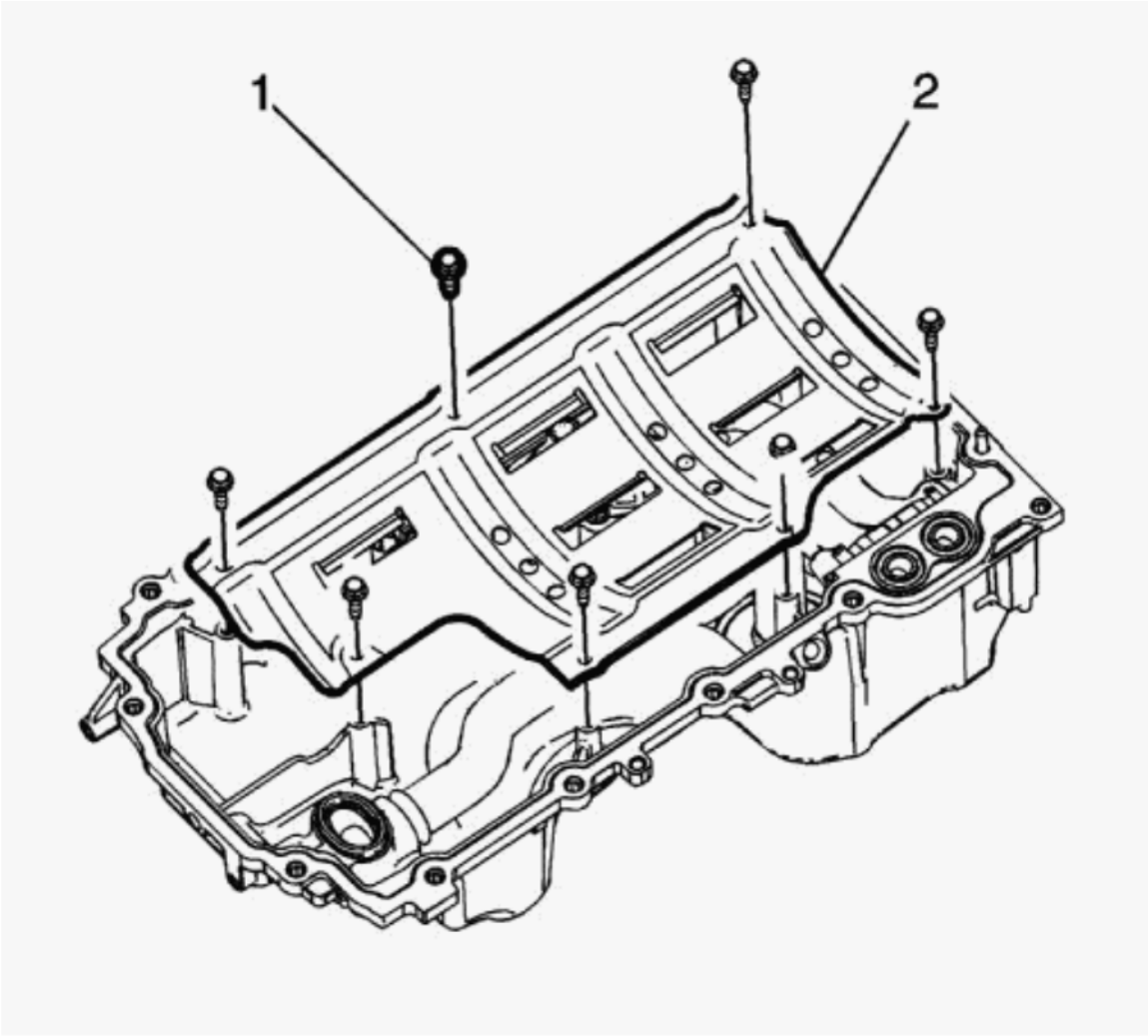

Fig. 150: Crankshaft Oil Deflector Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Install the crankshaft oil deflector (2).
6. Install the crankshaft oil deflector bolts (1) and tighten to 10 N.m (89 lb in)
7. Install the oil pan. Refer to **Oil Pan Replacement**.

OIL PUMP FLOW CONTROL SOLENOID VALVE REPLACEMENT

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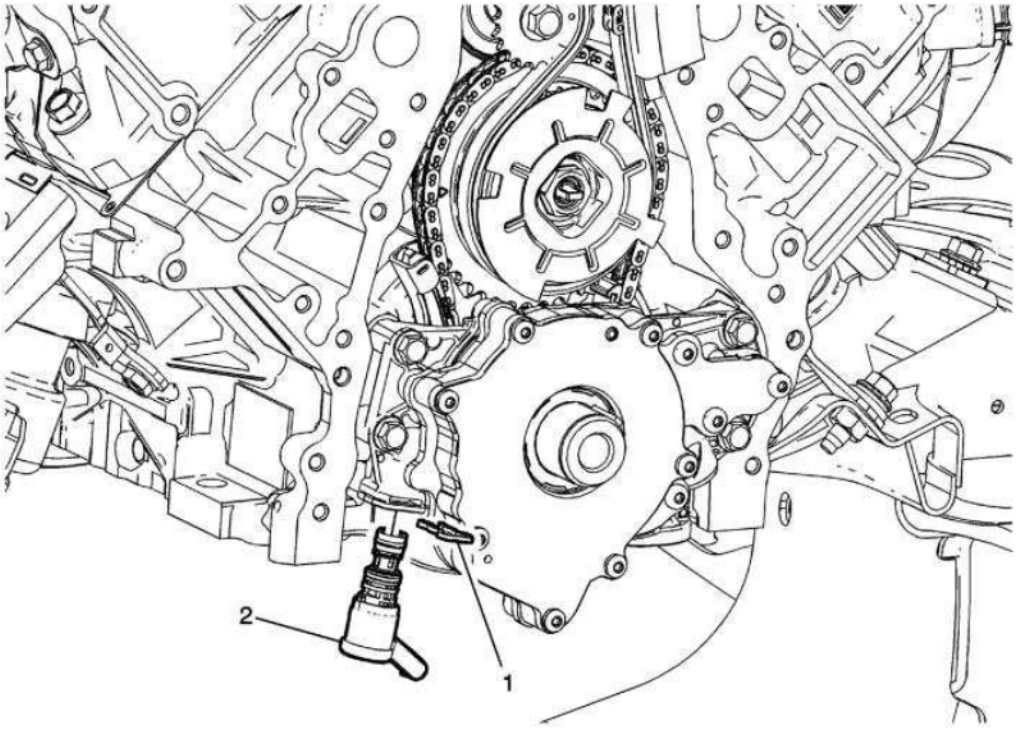

Fig. 151: Oil Pump Flow Control Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**. 2. Remove the oil pan. Refer to **Oil Pan Replacement**.	
1	Oil Pump Flow Control Solenoid Valve Clip
2	Oil Pump Flow Control Solenoid Valve **Procedure** Disconnect the electrical connectors as necessary.

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REPLACEMENT

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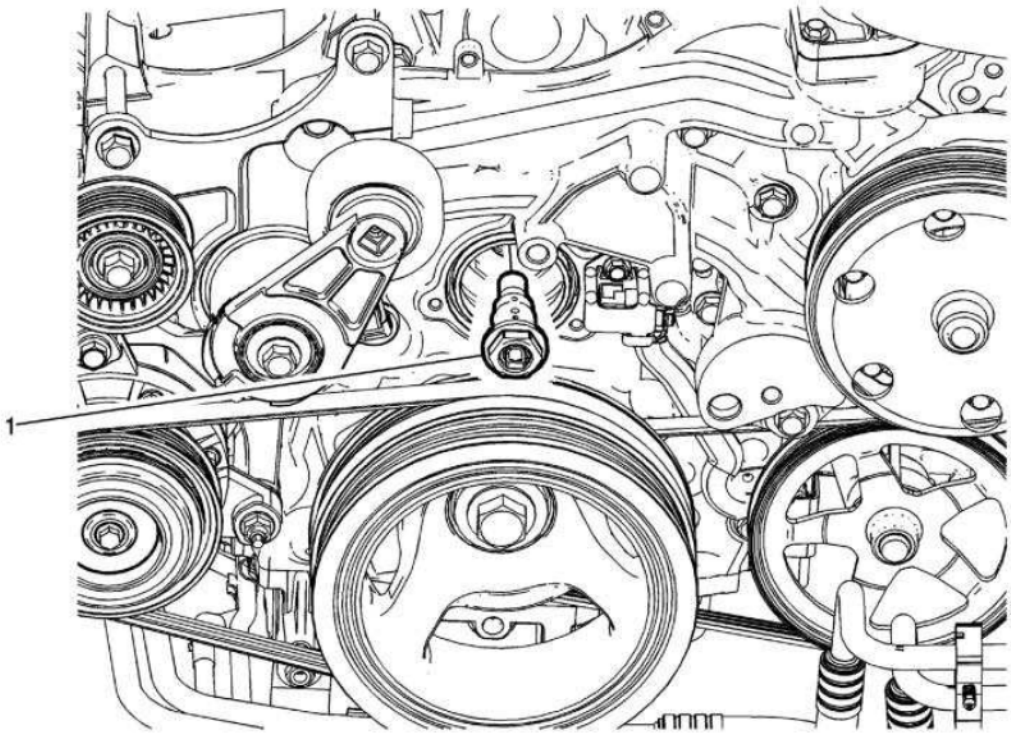

Fig. 152: Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the camshaft position actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement** .	
	Camshaft Position Actuator Solenoid Valve **WARNING:** **Refer to Camshaft Position Actuator Removal and Installation Warning .**
1	**CAUTION:** **Refer to Component Fastener Tightening Caution .** **CAUTION:** **The camshaft position**

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Callout	Component Name
	actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process. **NOTE:** **The CPA solenoid valve must be Discarded and replaced with a NEW valve.** **Tighten** 1. First pass 65 N.m (48 lb ft). 2. Final pass 90 degrees. **Special Tools** **J 45059** Angle Meter For equivalent regional tools, refer to **Special Tools** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

- **EN-51096** Crankshaft Rear Seal Remover
- **GE-23907-1** Slide Hammer
- **EN-41479** Crankshaft Rear Oil Seal Installer

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- **EN-41479-2A** Crankshaft Rear Oil Seal Installation Guide
- **EN-41479-10** Crankshaft Rear Oil Seal Installer Adapter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. If equipped with an automatic transmission, remove the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**
2. If equipped with a manual transmission, remove the flywheel. Refer to **Engine Flywheel Replacement**.

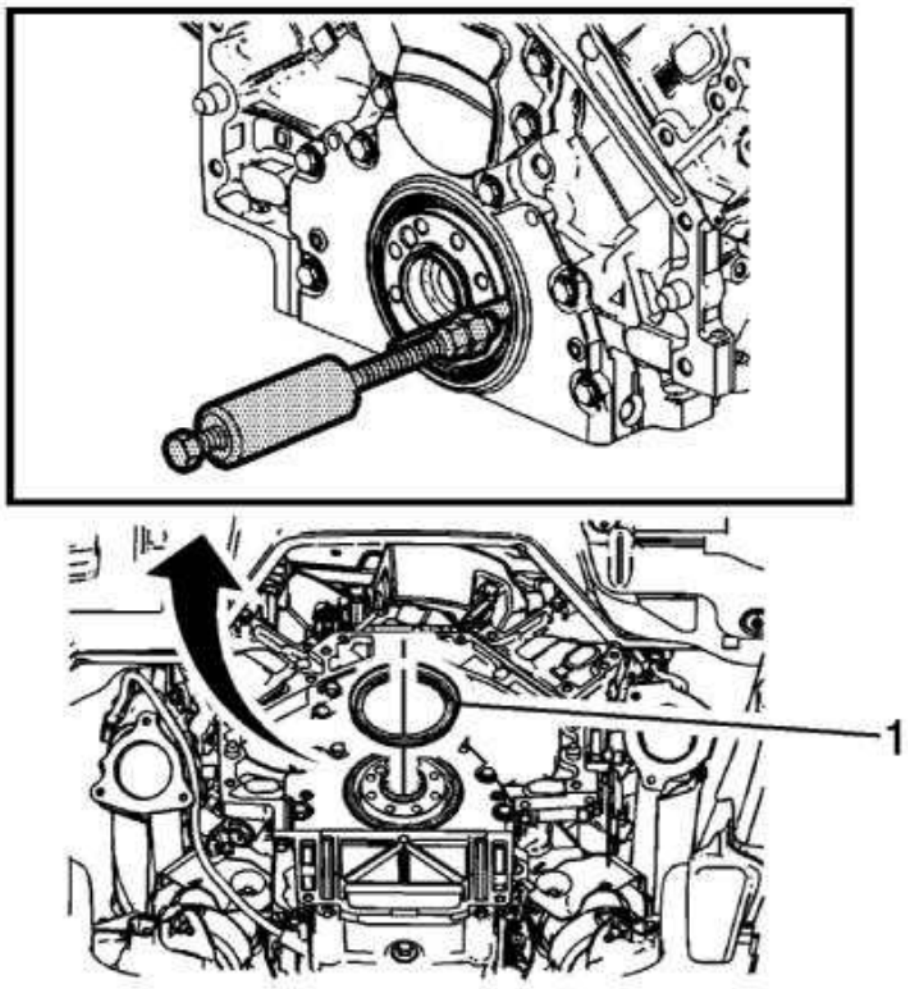

Fig. 153: EN-51096 Crankshaft Rear Seal Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **EN-51096 crankshaft rear seal remover has two ends. The end with the small bend will be used to remove the seal.**

3. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer.
4. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the rear seal and crankshaft. Ensure that the small bend of **EN-51096** crankshaft rear seal remover engages the rear side of the rear seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal and use the slide hammer to remove the seal.
5. Remove and DISCARD the crankshaft rear oil seal (1).

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Installation Procedure

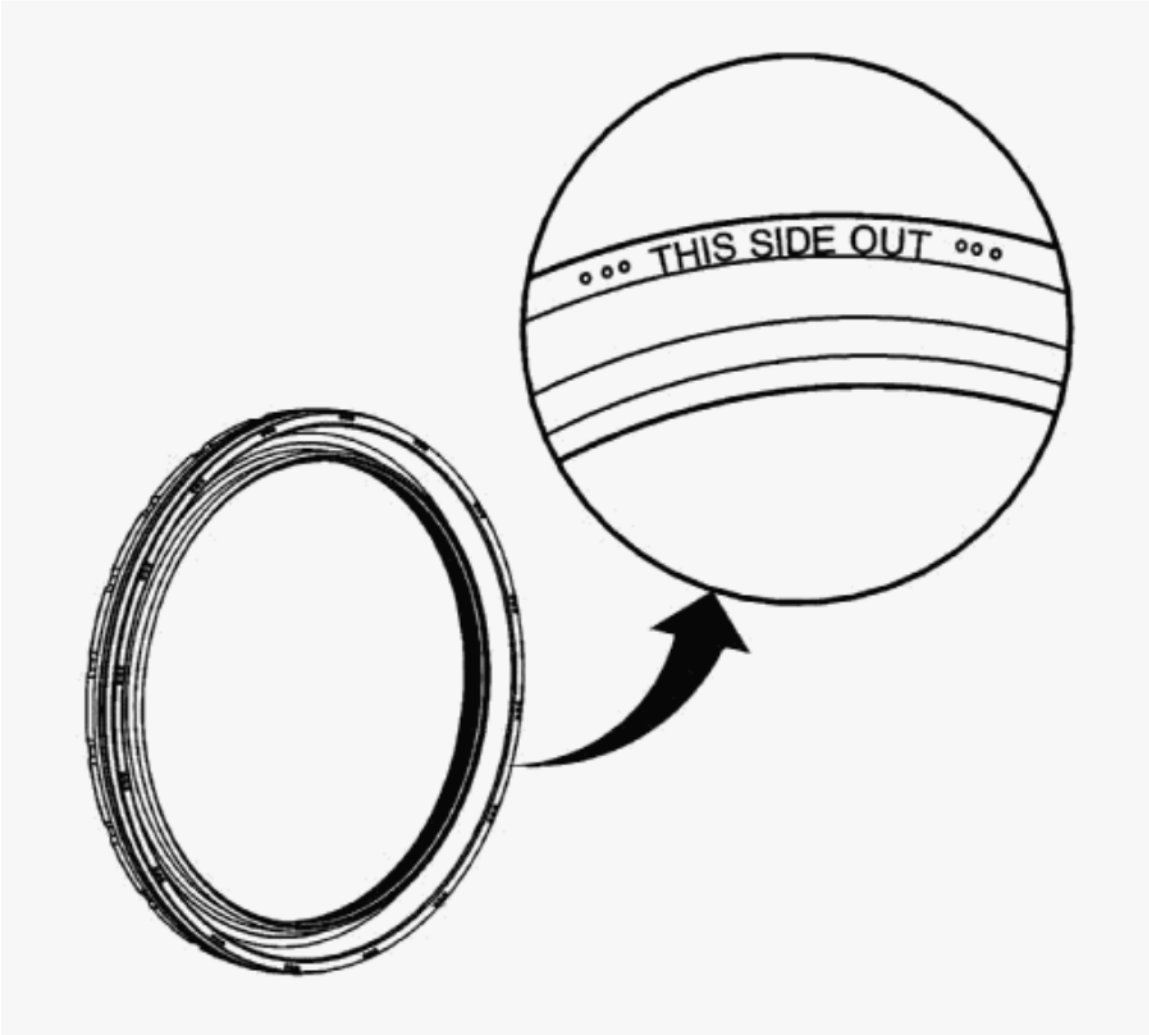

Fig. 154: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

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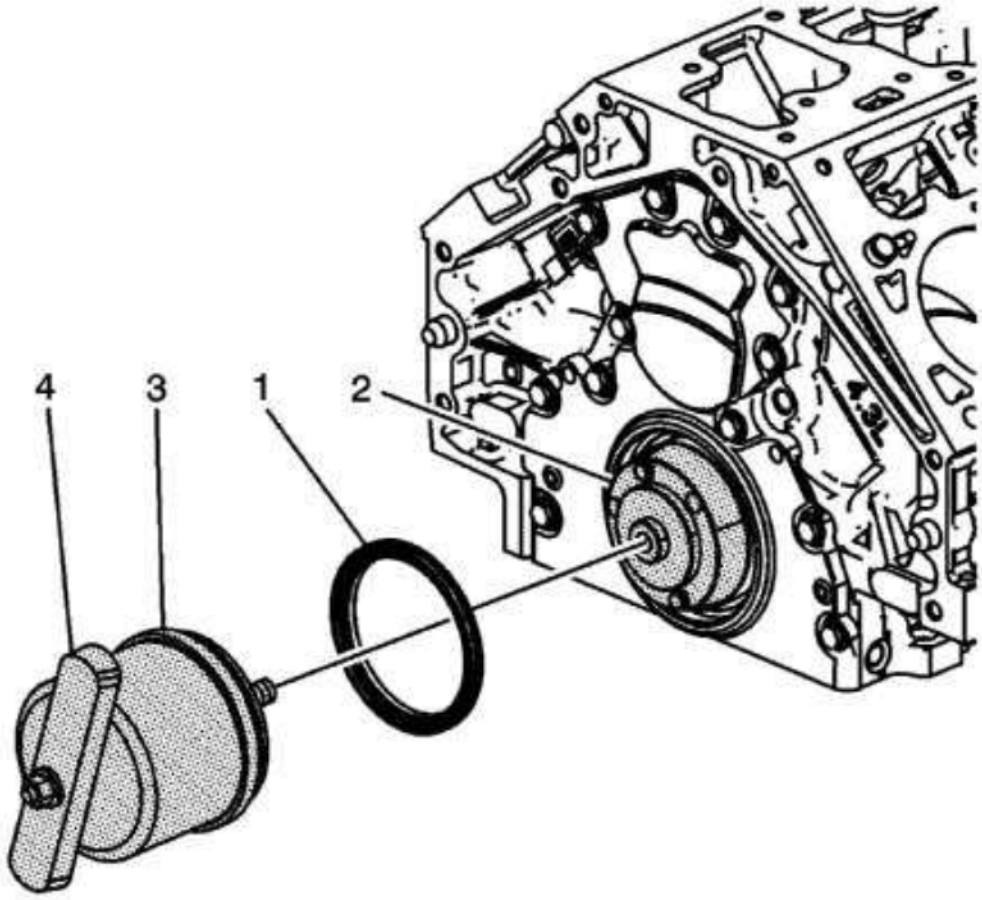

Fig. 155: Crankshaft Rear Oil Seal Installation Guide Cone
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41479-2A** crankshaft rear oil seal installation guide cone (2) and bolts onto the rear of the crankshaft.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal (1) onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with "THIS SIDE OUT" facing away from the engine.
5. Install the **EN-41479-10** crankshaft rear oil seal installer adapter (3) onto **EN-41479** crankshaft rear oil seal installer (4).
6. Thread the **EN-41479** crankshaft rear oil seal installer threaded rod into the tapered cone until the tool contacts the oil seal.
7. Align the oil seal (1) onto the tool.
8. Rotate the handle of the tool clockwise until the seal enters the rear housing and bottoms into the seal bore.
9. Remove the tool.
10. If equipped with an automatic transmission, install the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**
11. If equipped with a manual transmission, install the flywheel. Refer to **Engine Flywheel Replacement**.

CRANKSHAFT REAR OIL SEAL HOUSING REPLACEMENT

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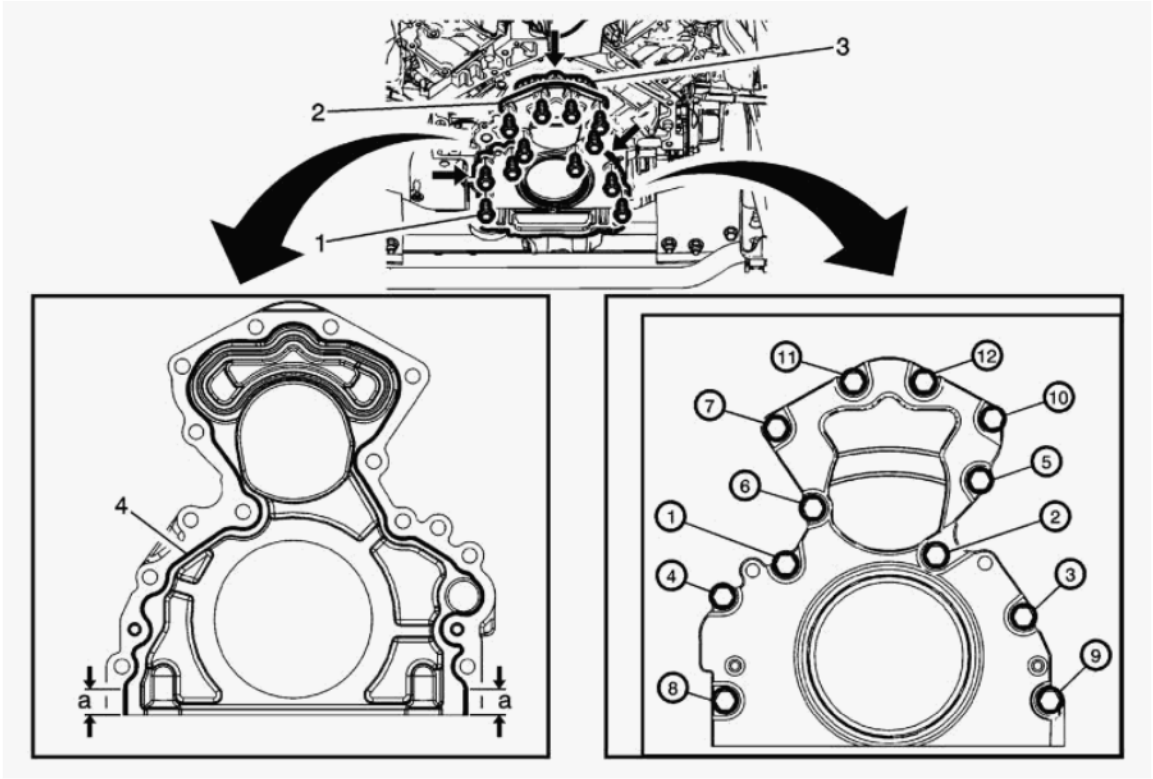

Fig. 156: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. If equipped with a automatic transmission, remove the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement** . 2. If equipped with a manual transmission, remove the engine flywheel. Refer to **Engine Flywheel Replacement**.	
1	Crankshaft Rear Oil Seal Housing Fastener (Qty; 12) **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 25 N.m (18 lb ft)
2	Crankshaft Rear Oil Seal Housing **Procedure** To separate the rear housing from the engine, pry at the points that are shown by the arrows.
3	Crankshaft Rear Oil Seal Housing Gasket **Procedure** 1. A NEW gasket must be used when installing the rear housing.

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Callout	Component Name
4	**Procedure** Apply a 3 mm (0.118 in) bead of RTV sealant on the engine rear cover as shown. Apply a 5 mm (0.197 in) bead of RTV sealant on the engine rear cover as shown. The 5 mm (0.197 in) bead (5) must be applied only 10 mm (0.393 in) up from the bottom of the rear cover as shown (a). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

OIL PAN COVER REPLACEMENT

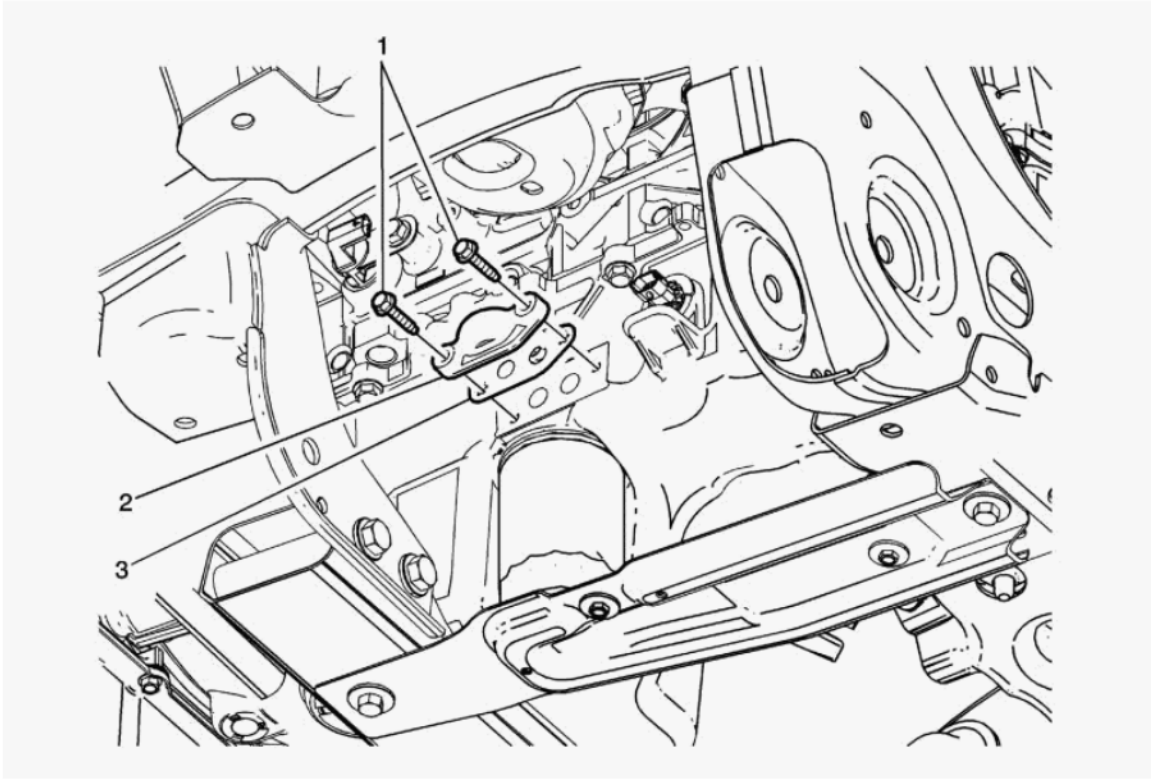

Fig. 157: Oil Pan Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement**	
1	Oil Pan Cover Fastener **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 10 N.m (89 lb in)
2	Oil Pan Cover
3	Oil Pan Cover Gasket **Procedure** A NEW gasket must be used when installing the oil pan cover.

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OIL PAN REPLACEMENT

Removal Procedure

1. Remove the steering rack. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .
2. Remove the starter. Refer to **Starter Replacement (LV3)** .
3. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .

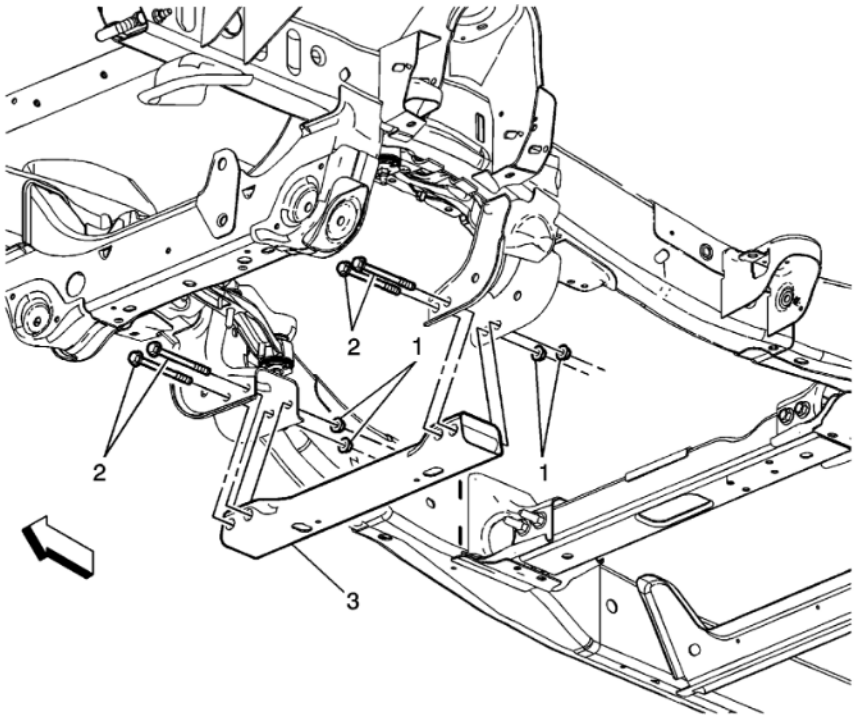

Fig. 158: View Of Lower Control Arm Crossmember, Front Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the drivetrain and front suspension frame front crossmember (3). Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Light Duty)** **Drivetrain and Front Suspension Frame Front Crossmember Replacement (Heavy Duty)** .

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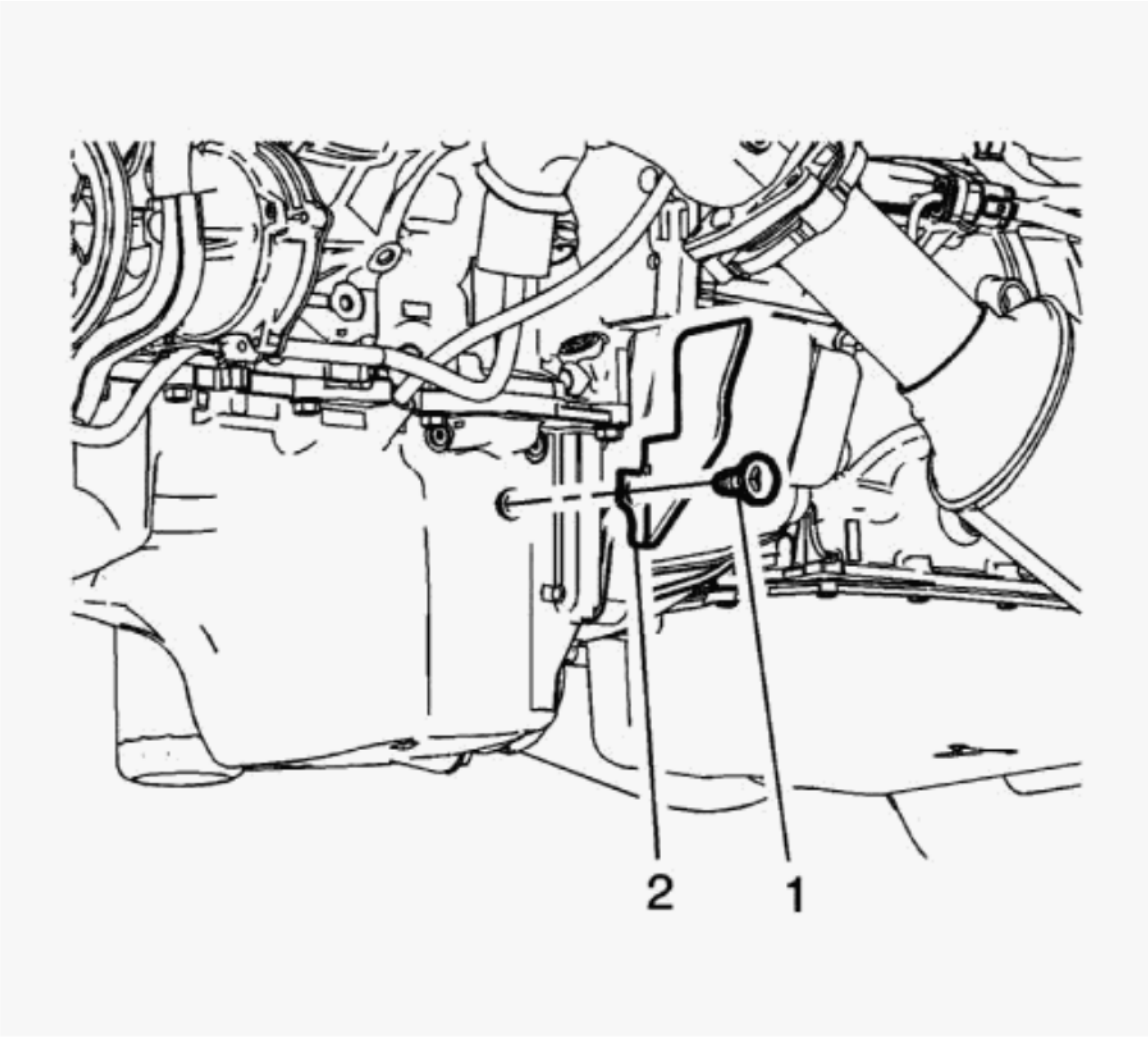

Fig. 159: Left Flywheel Inspection Cover Bolt And Cover
Courtesy of GENERAL MOTORS COMPANY

5. Remove the left flywheel inspection cover bolt (1) and cover (2).

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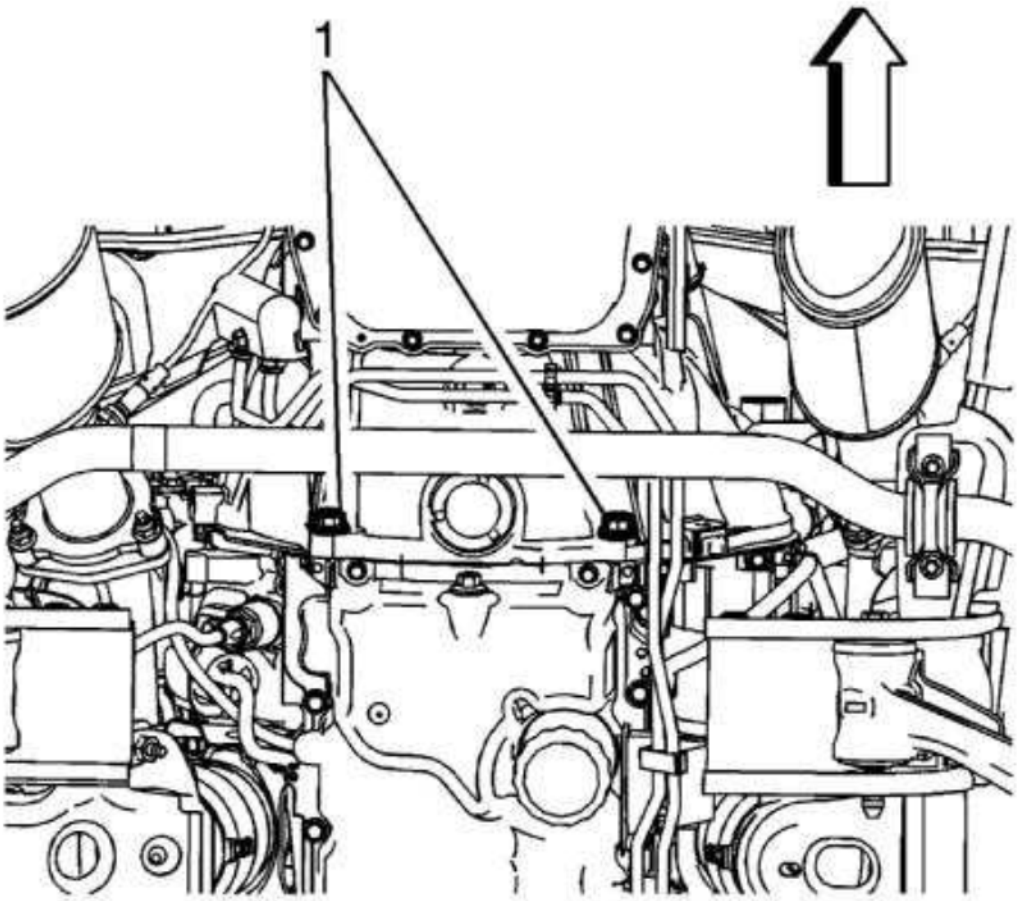

Fig. 160: Transmission To Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the transmission to oil pan bolts (1).
7. Disconnect electrical connectors as necessary.

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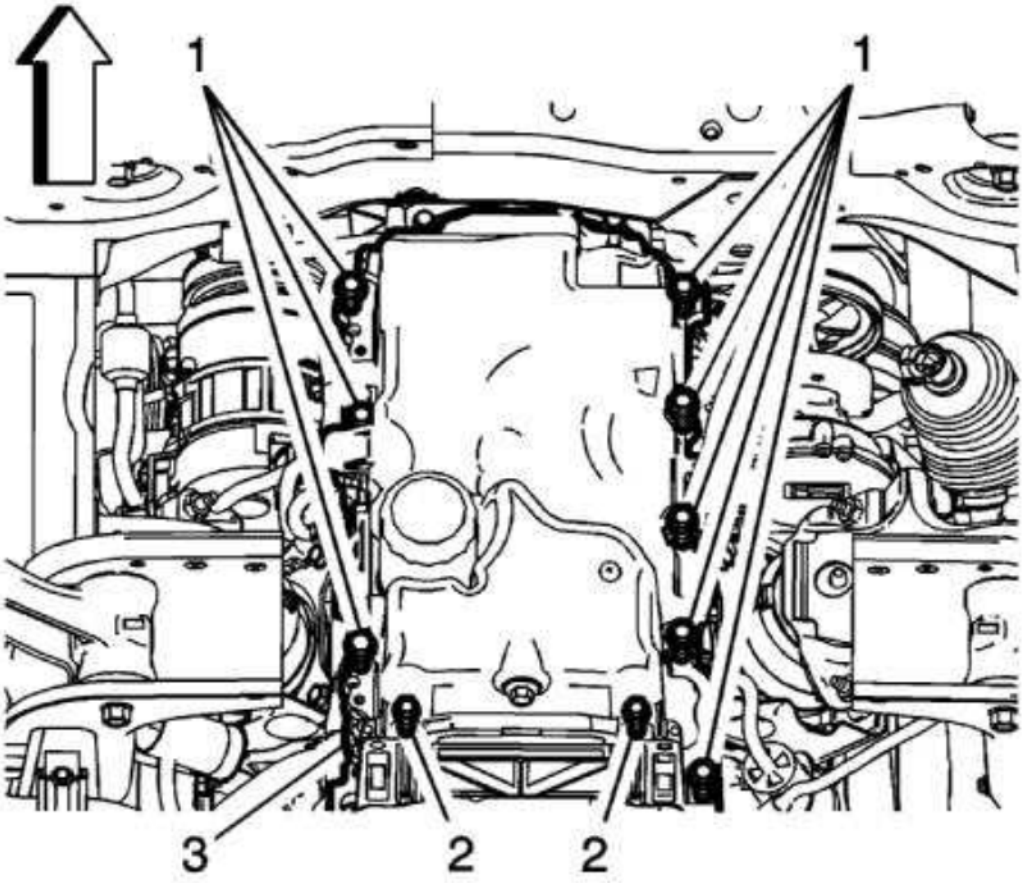

Fig. 161: Oil Pan And Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Remove the oil pan bolts (1,2).
9. Remove the oil pan (3).
10. Transfer parts as necessary.
11. For oil pan disassemble. Refer to **Oil Pan Disassemble**.
12. For cleaning and inspection. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

1. For oil pan assemble. Refer to **Oil Pan Assemble**.

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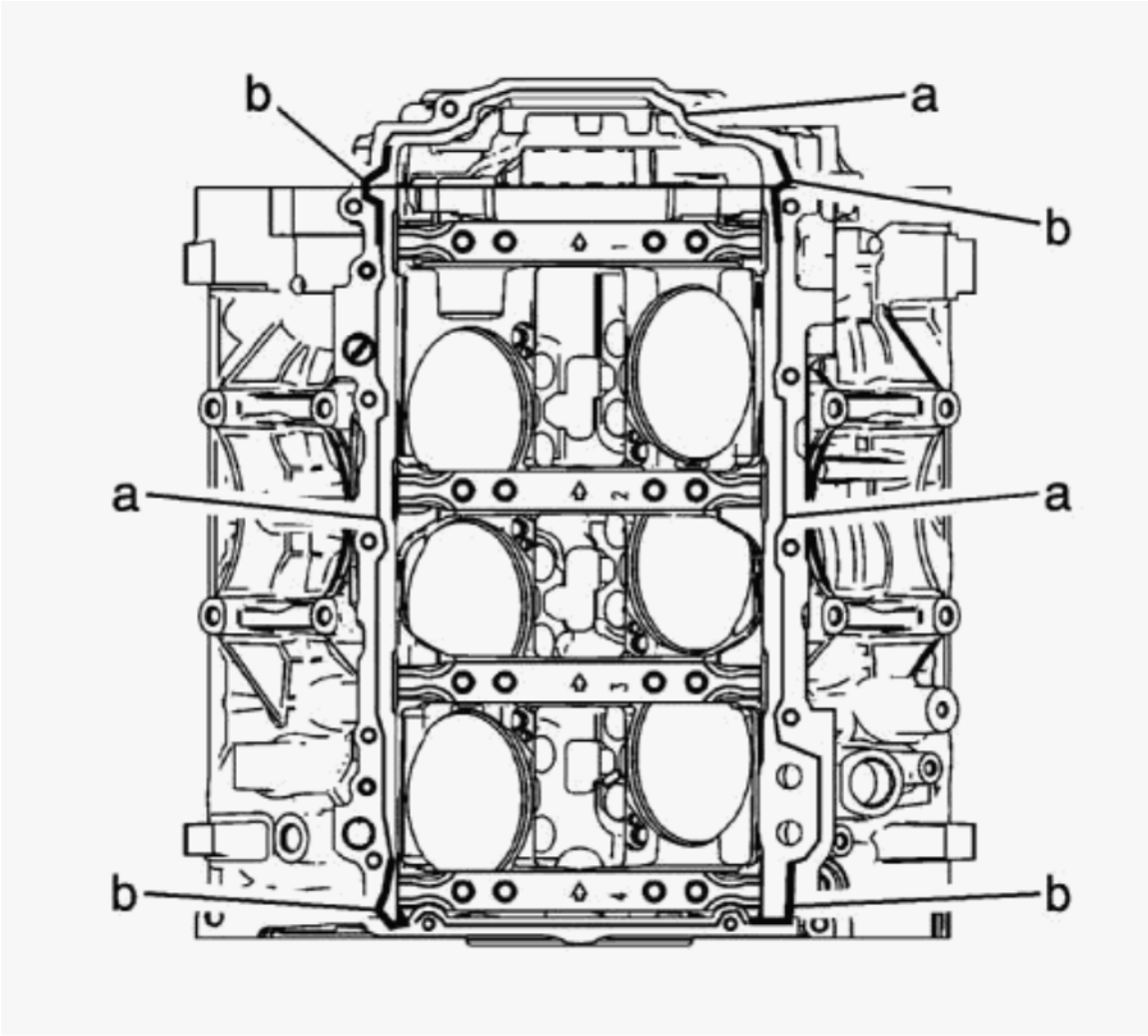

Fig. 162: Applying 3 mm (0.118 in) Bead Of RTV Sealant On Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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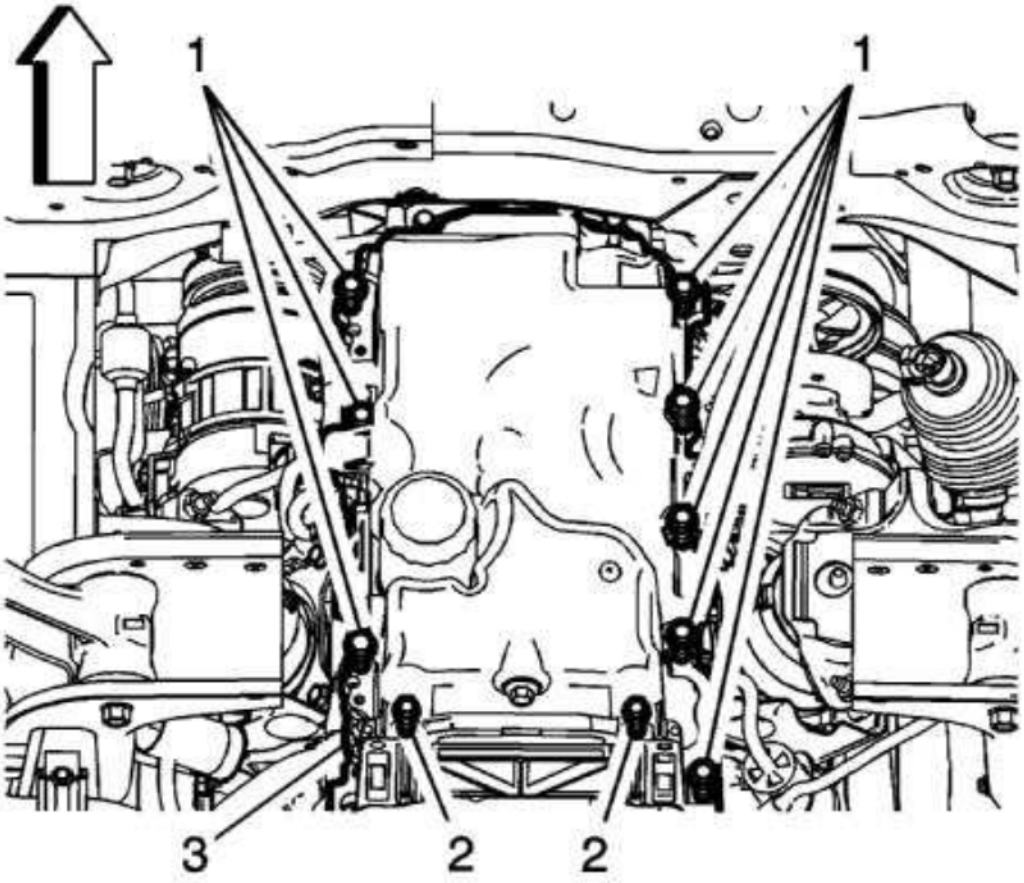

Fig. 163: Oil Pan And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the oil pan (3).
4. Install the oil pan bolts (1,2) and hand tighten.

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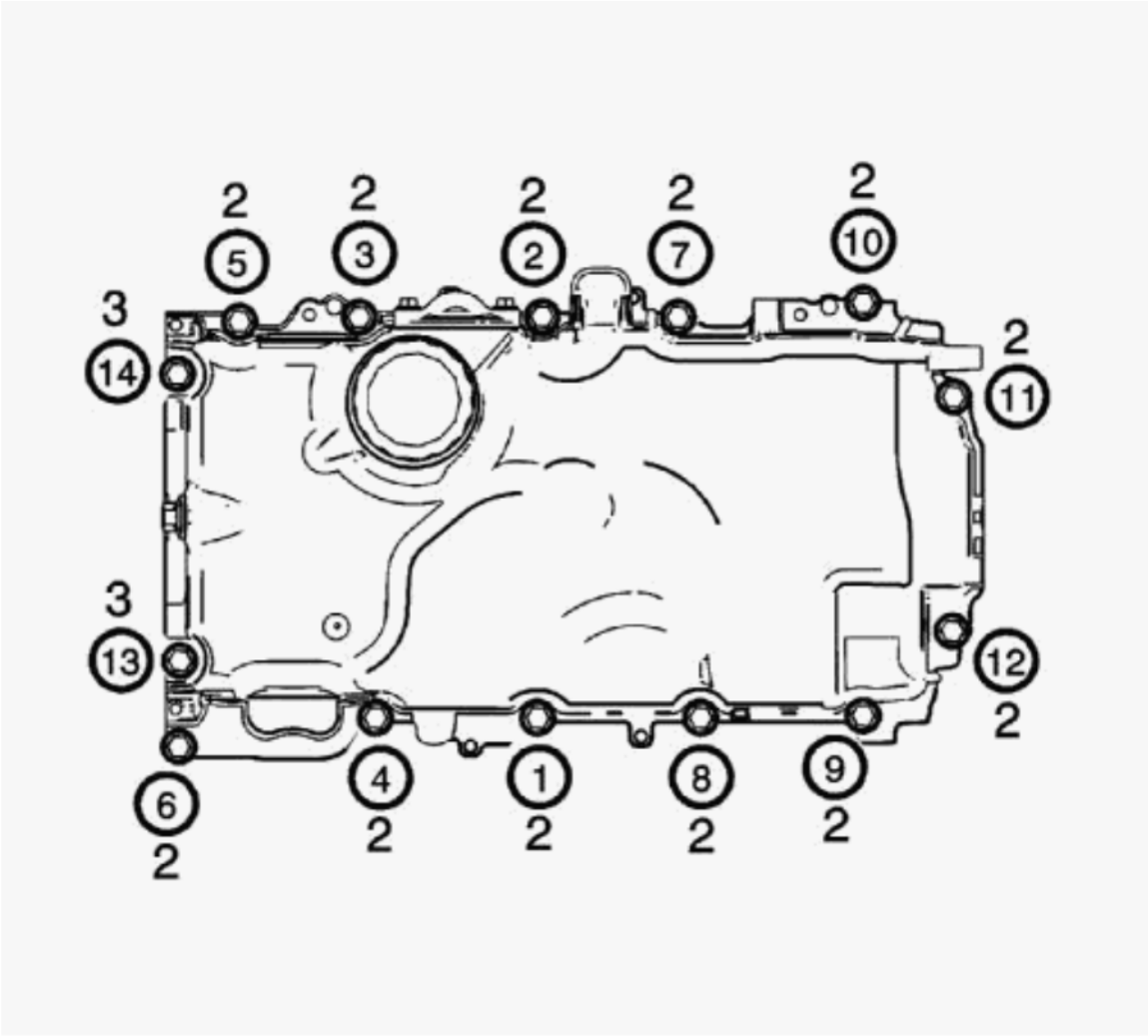

Fig. 164: Tightening Oil Pan Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

5. Tighten the oil pan bolts in sequence as shown above.
    1. Oil pan bolts (2) 25 N.m (18 lb ft).
    2. Oil pan bolts (3) 12 N.m (106 lb in).

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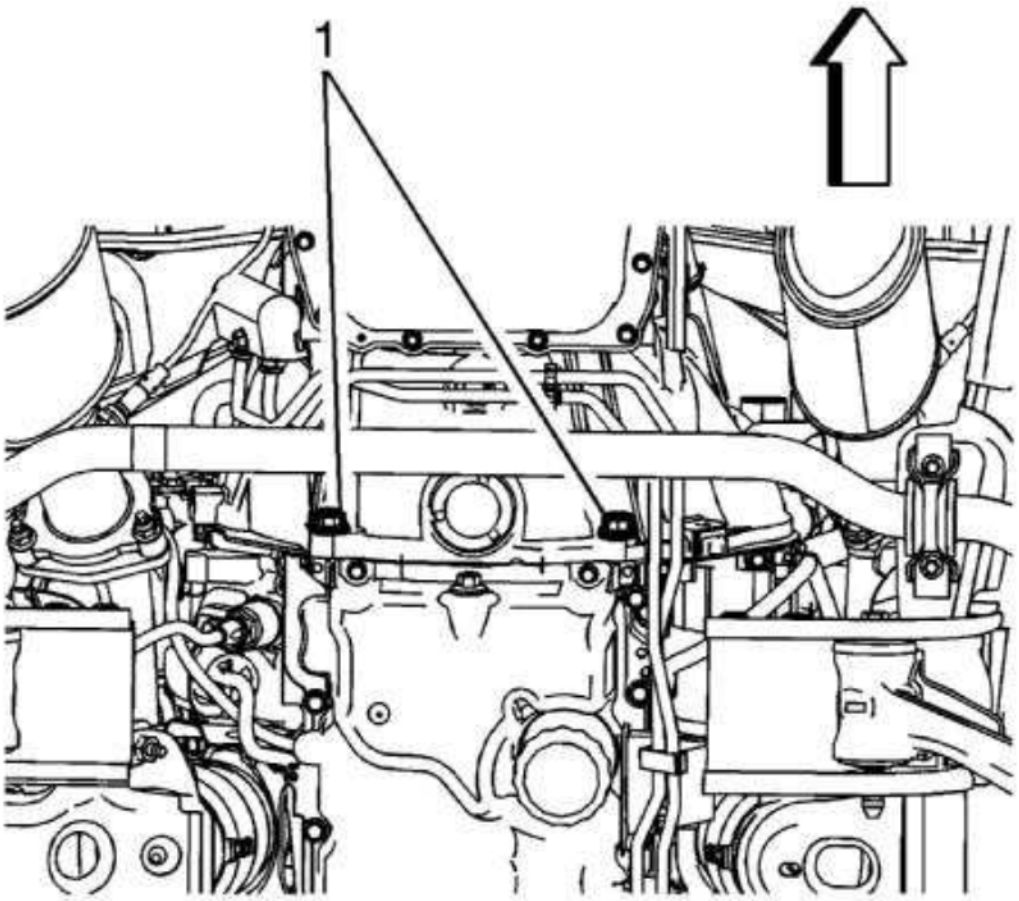

Fig. 165: Transmission To Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Install the transmission to oil pan bolts (1) and tighten to 50 N.m (37 lb ft)

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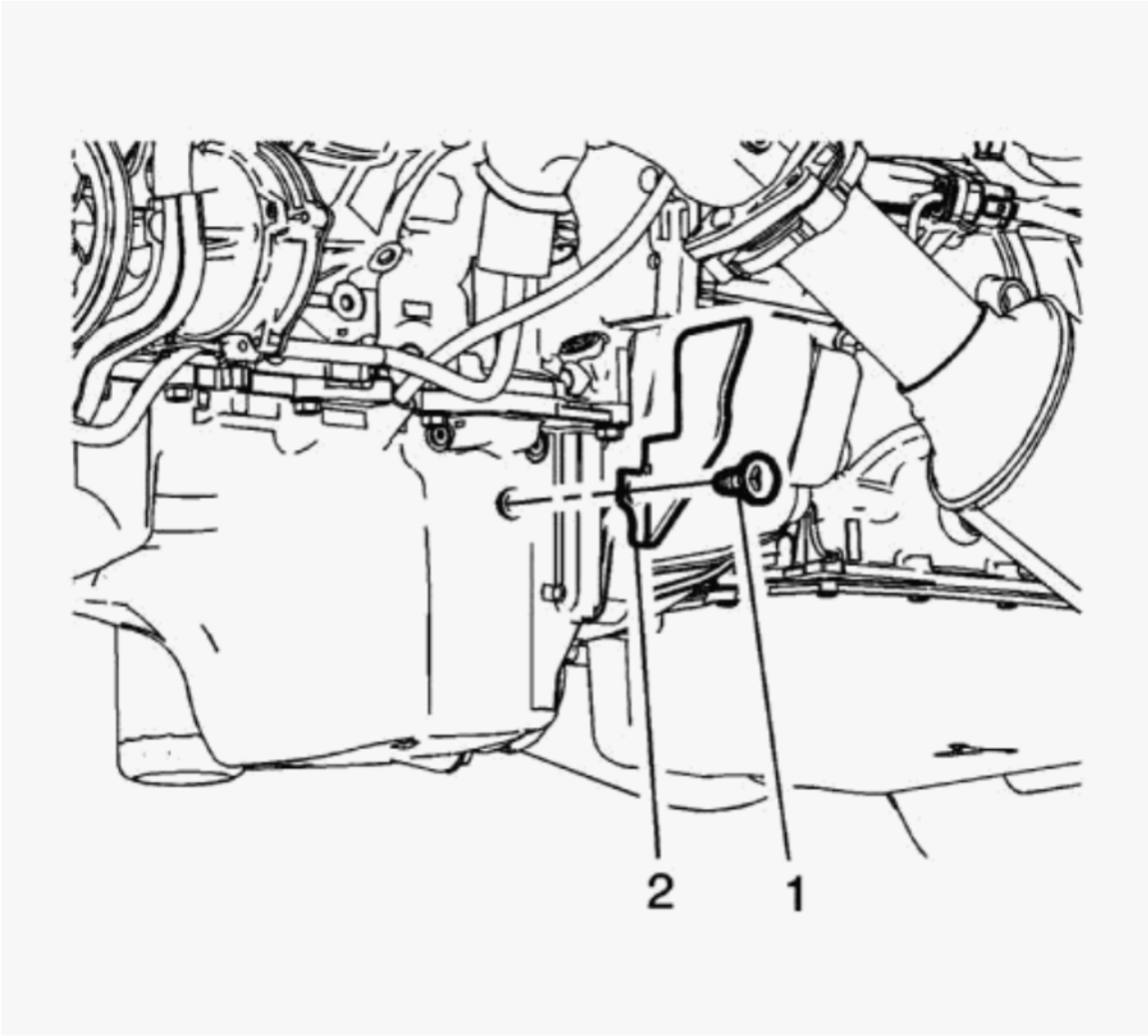

Fig. 166: Left Flywheel Inspection Cover Bolt And Cover
Courtesy of GENERAL MOTORS COMPANY

7. Install the left flywheel inspection cover (2) and tighten the bolt (1) to 10 N.m (89 lb in).
8. Connect electrical connectors as necessary.
9. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch Axle)** **Front Axle Replacement (9.25 Inch Axle)** .
10. Install the starter. Refer to **Starter Replacement (LV3)** .
11. Install the steering rack. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT

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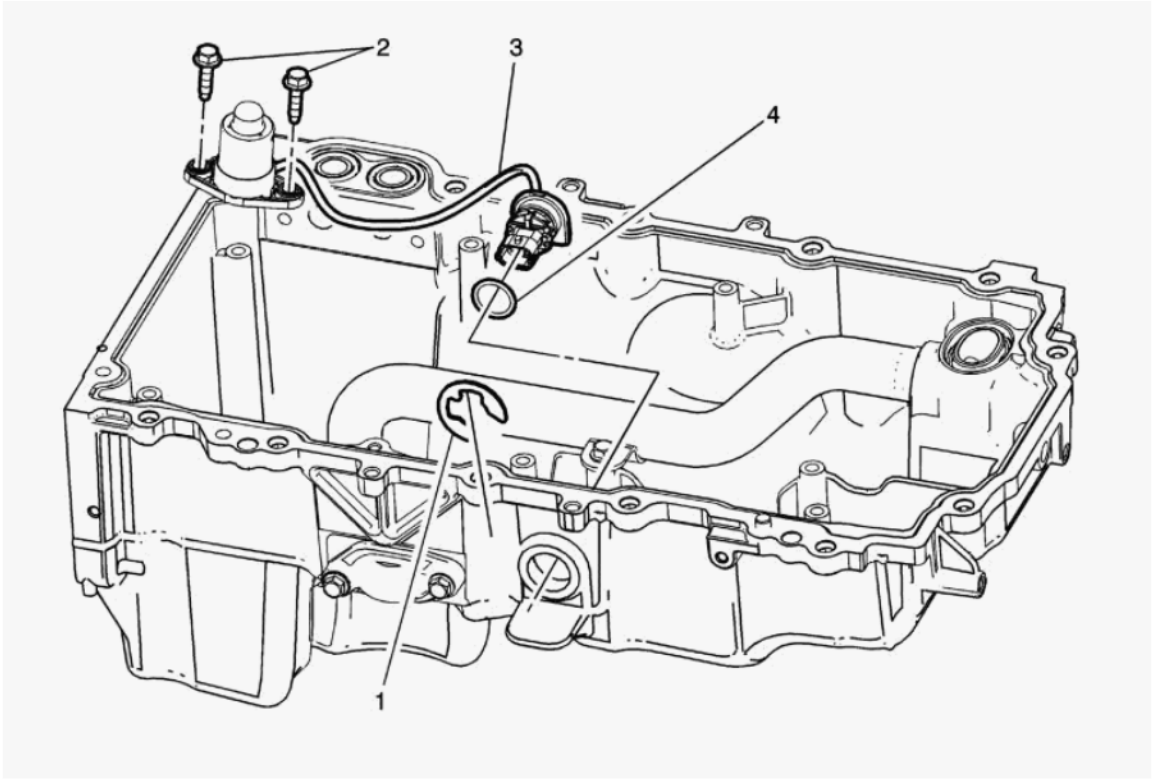

Fig. 167: Engine Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the oil filter center tube. Refer to **Oil Filter Center Tube Replacement**.	
1	Engine Oil Level Indicator Switch Clip
2	Engine Oil Level Indicator Switch Fastener (Qty: 2) **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 10 N.m (89 lb in)
3	Engine Oil Level Indicator Switch
4	Engine Oil Level Indicator Switch Seal

BALANCE CHAIN REPLACEMENT

Special Tools

- **EN-42386-A** Flywheel Holding Tool.
- **EN-46330** Tension Pin

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

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1. Remove the oil pump. Refer to **Oil Pump Replacement**
2. Lock the flex plate using the EN-42386-A flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft).
3. Align timing marks before disassembly. Refer to **Balancer Shaft and Timing Chain Assembly Installation**.

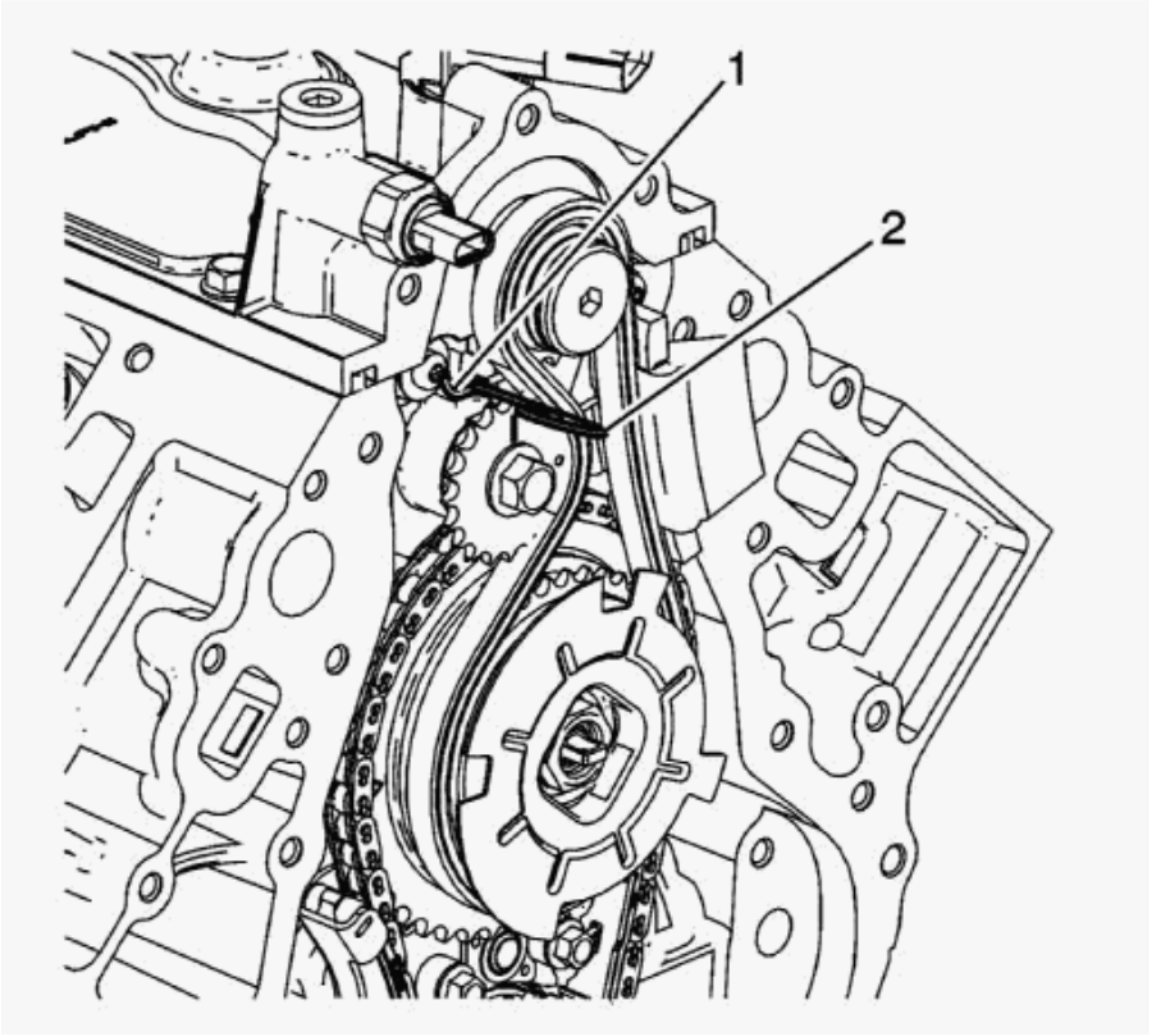

Fig. 168: Balance Shaft Thrust Plate Torsion Spring And Tension Pin
Courtesy of GENERAL MOTORS COMPANY

4. Push down the balance shaft thrust plate torsion spring (1) and install **EN-46330** tension pin (2).

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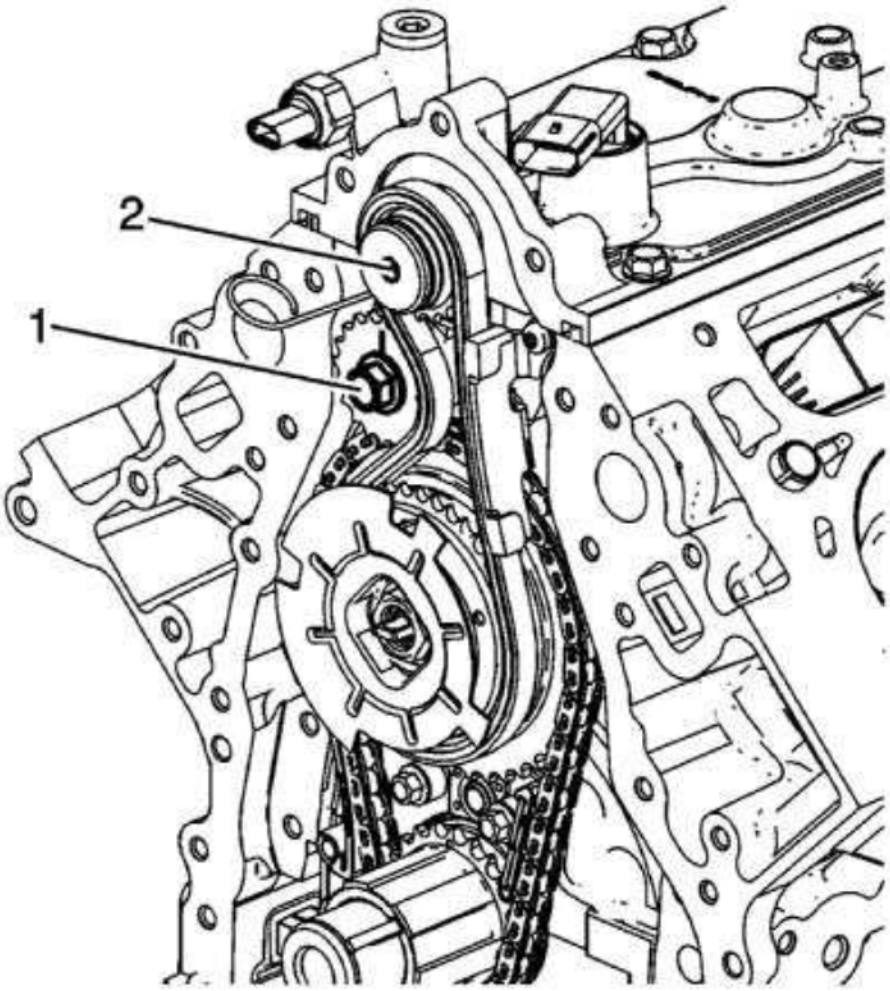

Fig. 169: Balancer Shaft Bolt And Idler Shaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Loosen the balancer shaft bolt (1) and the idler shaft sprocket bolt (2).

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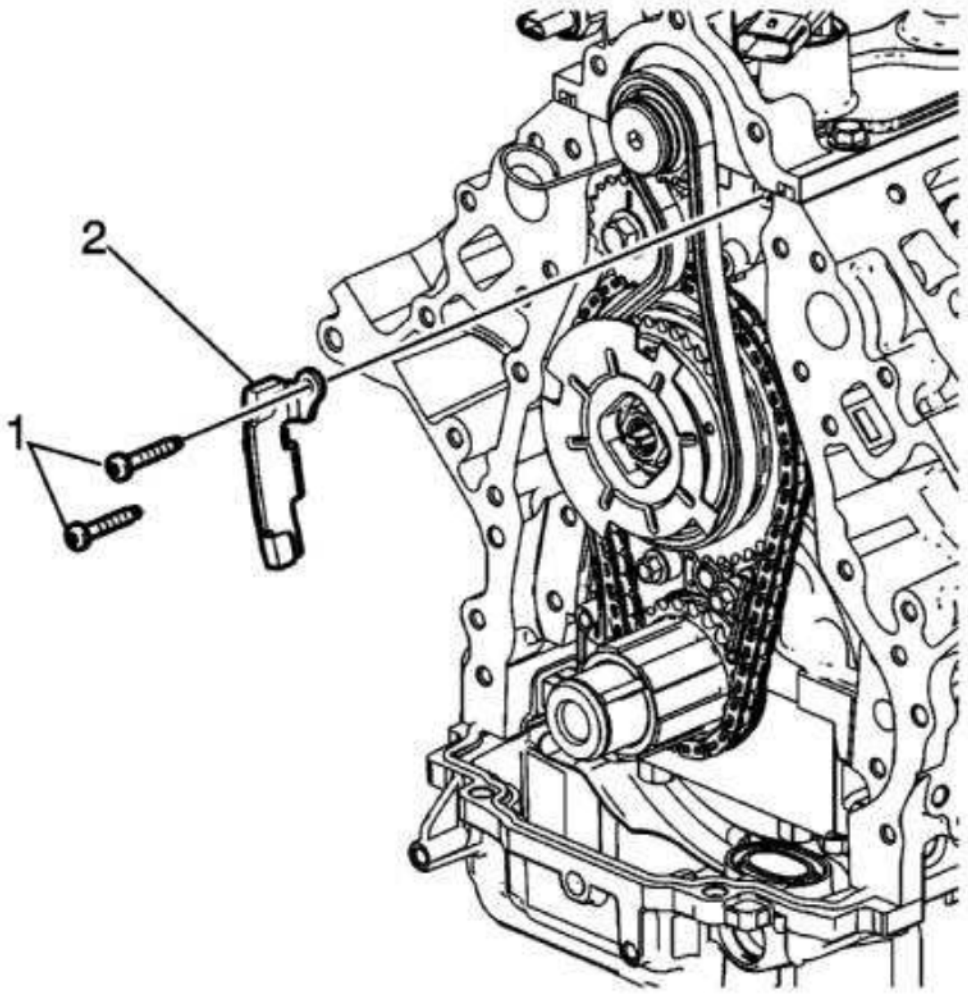

Fig. 170: Balancer Shaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the two balancer shaft retainer bolts (1).
7. Remove the balancer chain guide (2).

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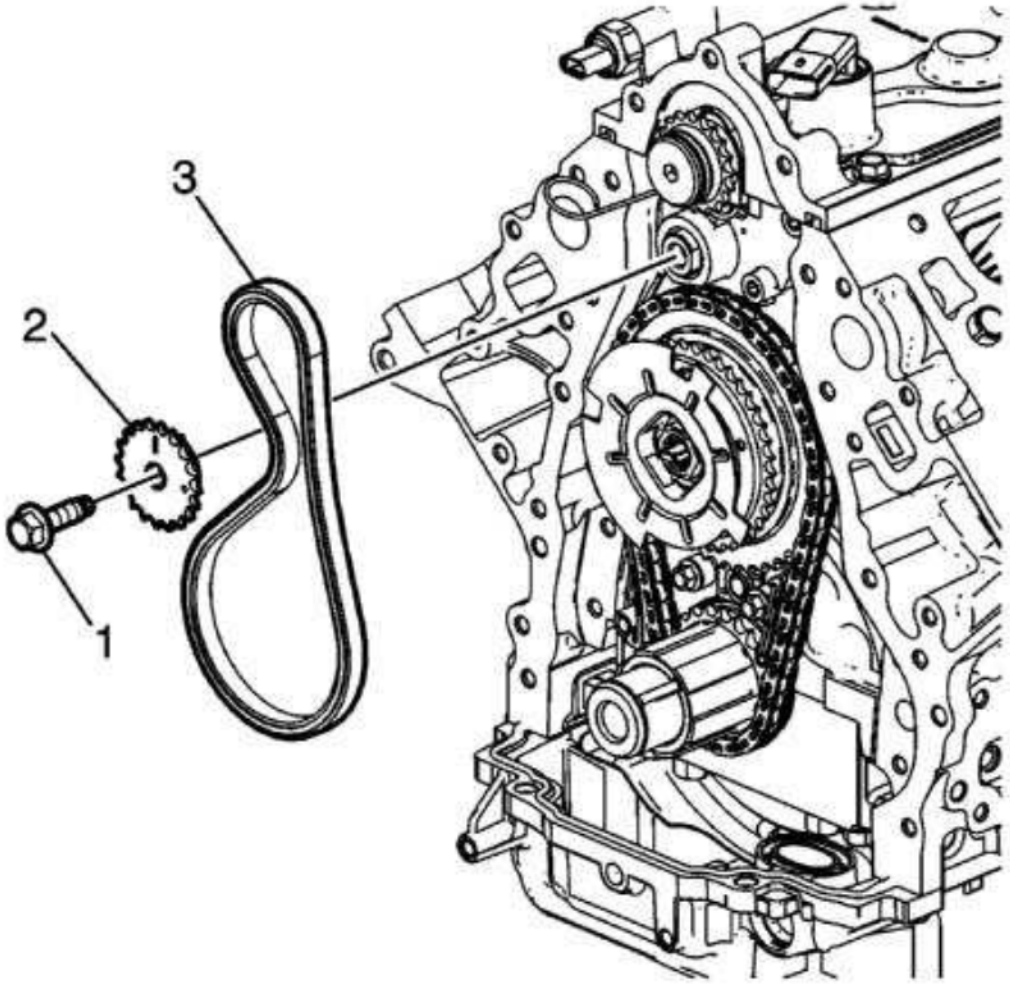

Fig. 171: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove the balancer shaft driven sprocket bolt (1) and the balancer shaft driven sprocket (2).
9. Remove the balancer shaft chain (3).

Installation Procedure

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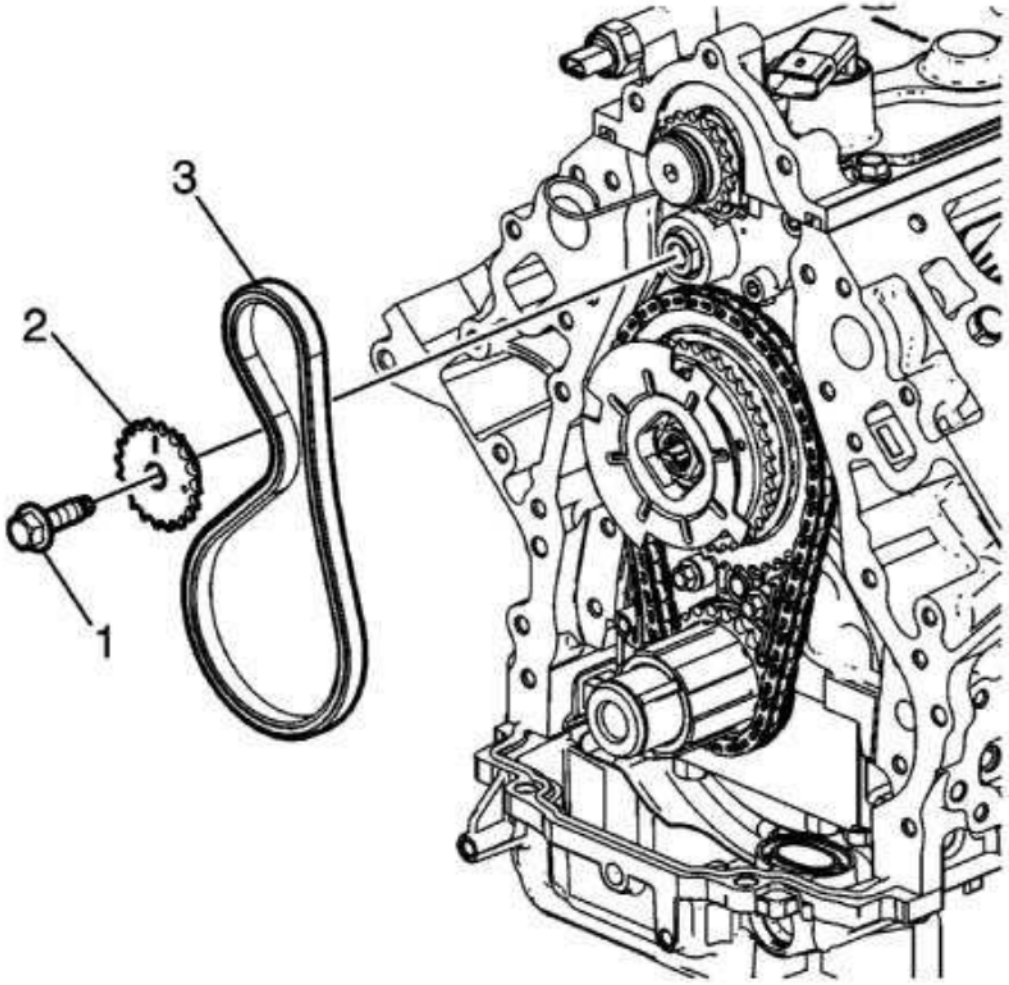

Fig. 172: Balancer Chain And Driven Sprocket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the balancer shaft (2) is installed with the flat spot facing the 3 o'clock position.**

1. Install the balancer chain (3) by wrapping it around the camshaft actuator and the balancer shaft idler sprocket.
2. Install the driven sprocket (2), and driven sprocket bolt (1) hand tight.

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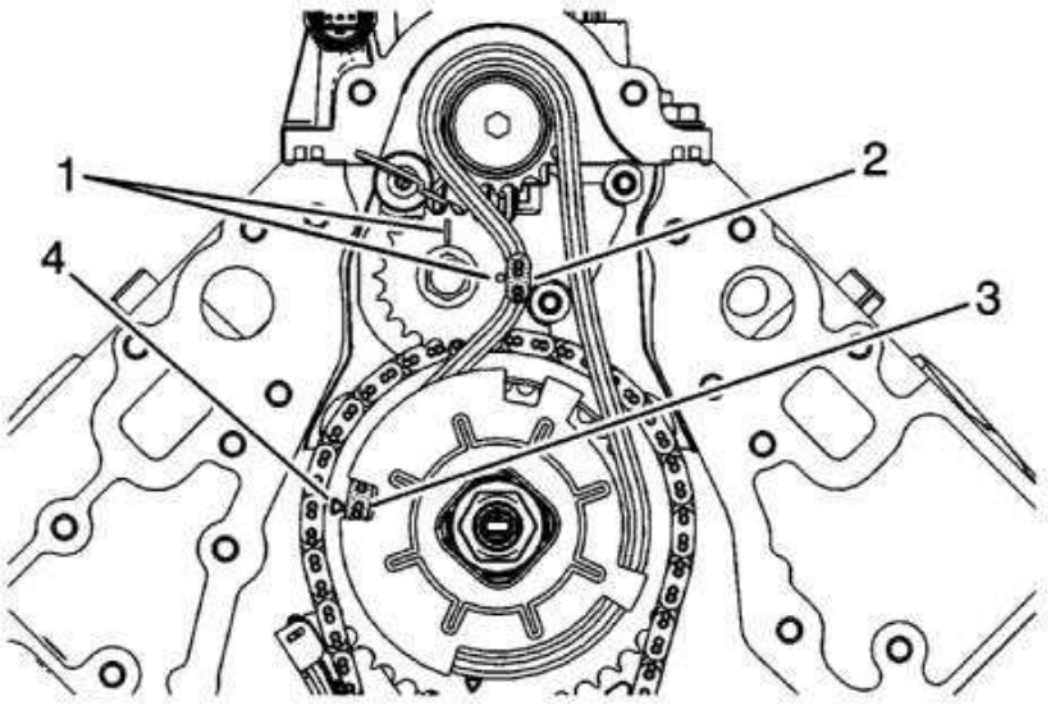

Fig. 173: Blue Link Plate And Camshaft Actuator Triangle Mark
Courtesy of GENERAL MOTORS COMPANY

3. The lower blue link plate (3) of the balancer chain must align with the camshaft actuator triangle mark (4).
4. The upper blue link plate (2) of the balancer chain must alight with the dot (1) on balancer driven sprocket. The 20 tooth driven sprocket will also have a molded in vertical line (1) pointing at 12 o'clock.

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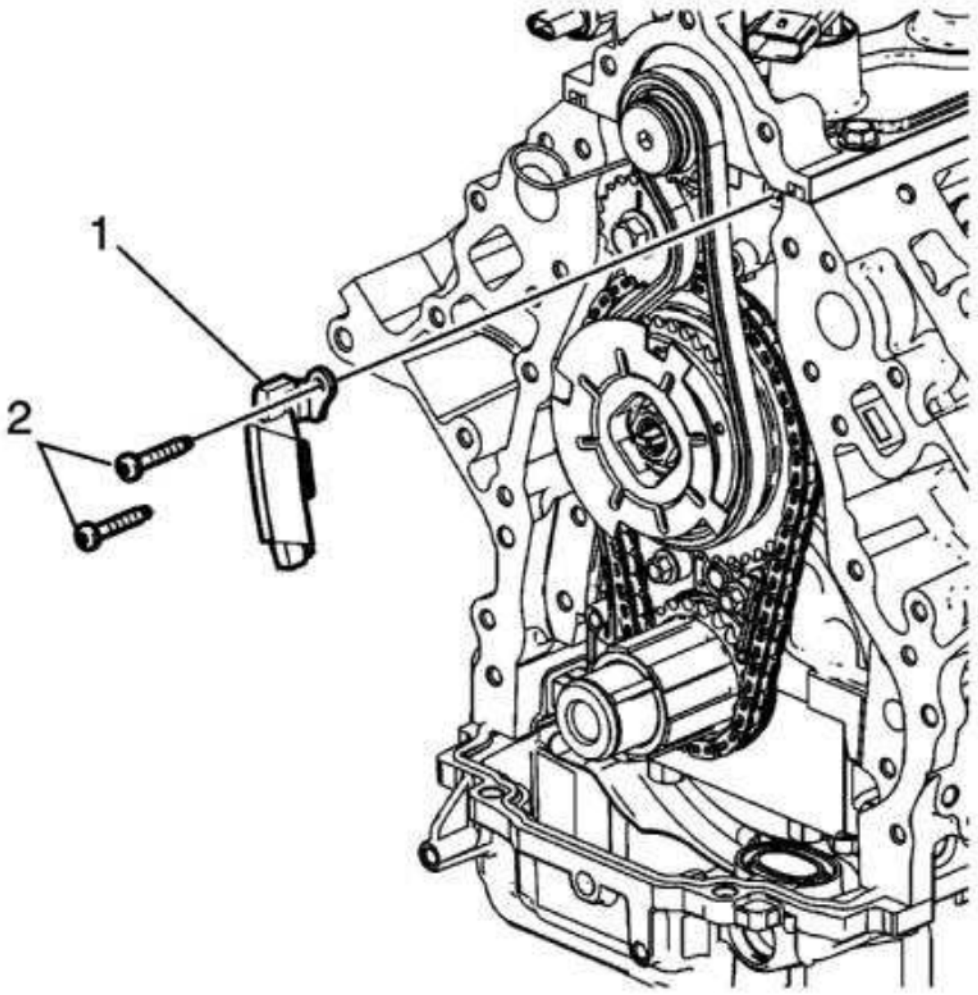

Fig. 174: Balancer Chain Guide With Shim And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If plastic shim is not available, a 1.1 mm (0.04 in) size shim will need to be placed between the balancer chain and guide during installation.**

5. Install the balancer chain guide with shim (1) and bolts (2).

CAUTION: **Refer to Fastener Caution .**

6. Tighten the 2 o'clock and 3:30 o'clock position guide bolts (2) to 10 N.m (89 lb in).

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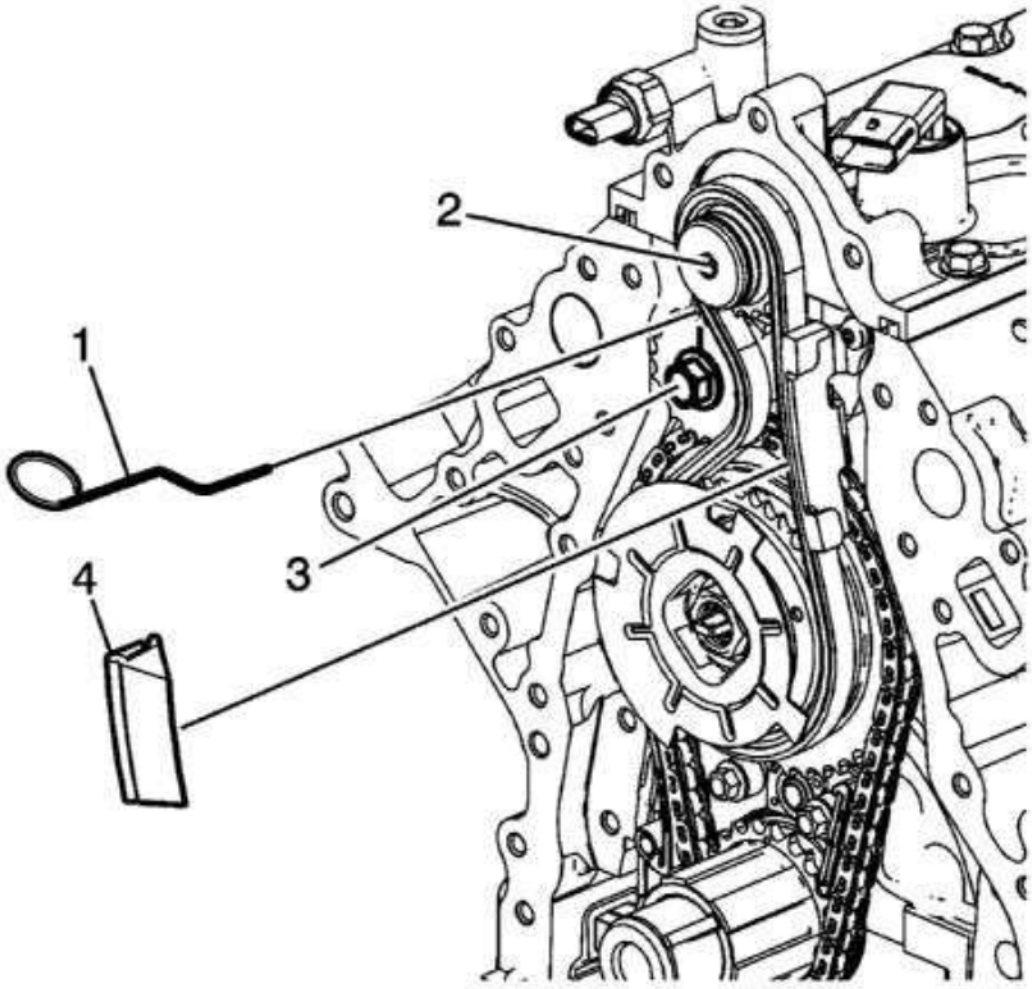

Fig. 175: Driven Sprocket Bolt And Idler Sprocket
Courtesy of GENERAL MOTORS COMPANY

7. Tighten the driven sprocket bolt (3) to 58 N.m (43 lb ft).
8. With the idler sprocket (2) free to slide up and down, pull (remove) the **EN-46330** tension pin (1).
9. Tighten the idler sprocket bolt (2) to 58 N.m (43 lb ft).
10. The chain should now be tight. Remove the shim (4) from between the balancer guide and the chain. The chain should now be slightly loose.
11. Remove the **EN-42386-A** flywheel holding tool.
12. Install the oil pump. Refer to **Oil Pump Replacement**.

BALANCE SHAFT SPROCKET REPLACEMENT

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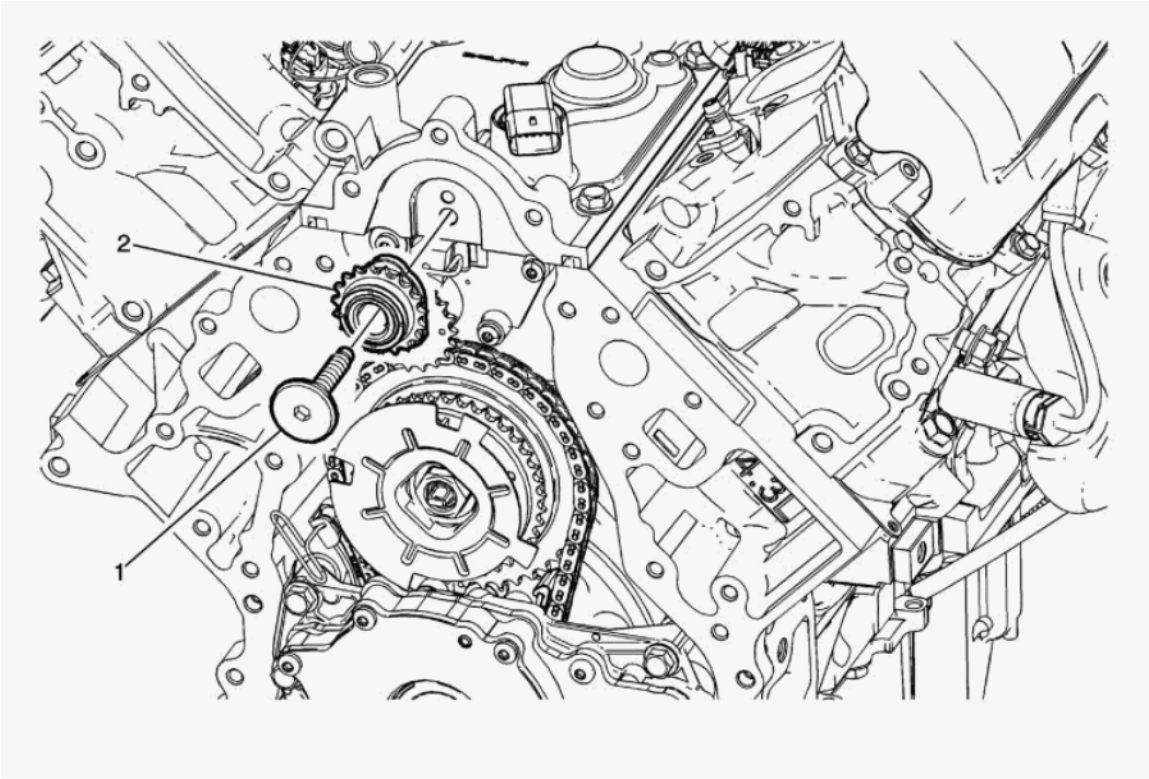

Fig. 176: Balancer Shaft Driven Sprocket
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the balancer chain. Refer to **Balance Chain Replacement**.	
1	Balancer Shaft Sprocket Fastener **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 58 N.m (43 lb ft)
2	Balancer Shaft Sprocket

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE REPLACEMENT

Special Tools

- **EN-42386-A** Flywheel Holding Tool.
- **EN-46330** Tension Pin
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

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1. Remove oil pump. Refer to **Oil Pump Replacement**.
2. Remove the starter. Refer to **Starter Replacement (LV3)** .
3. Align timing and install flywheel locking tool.

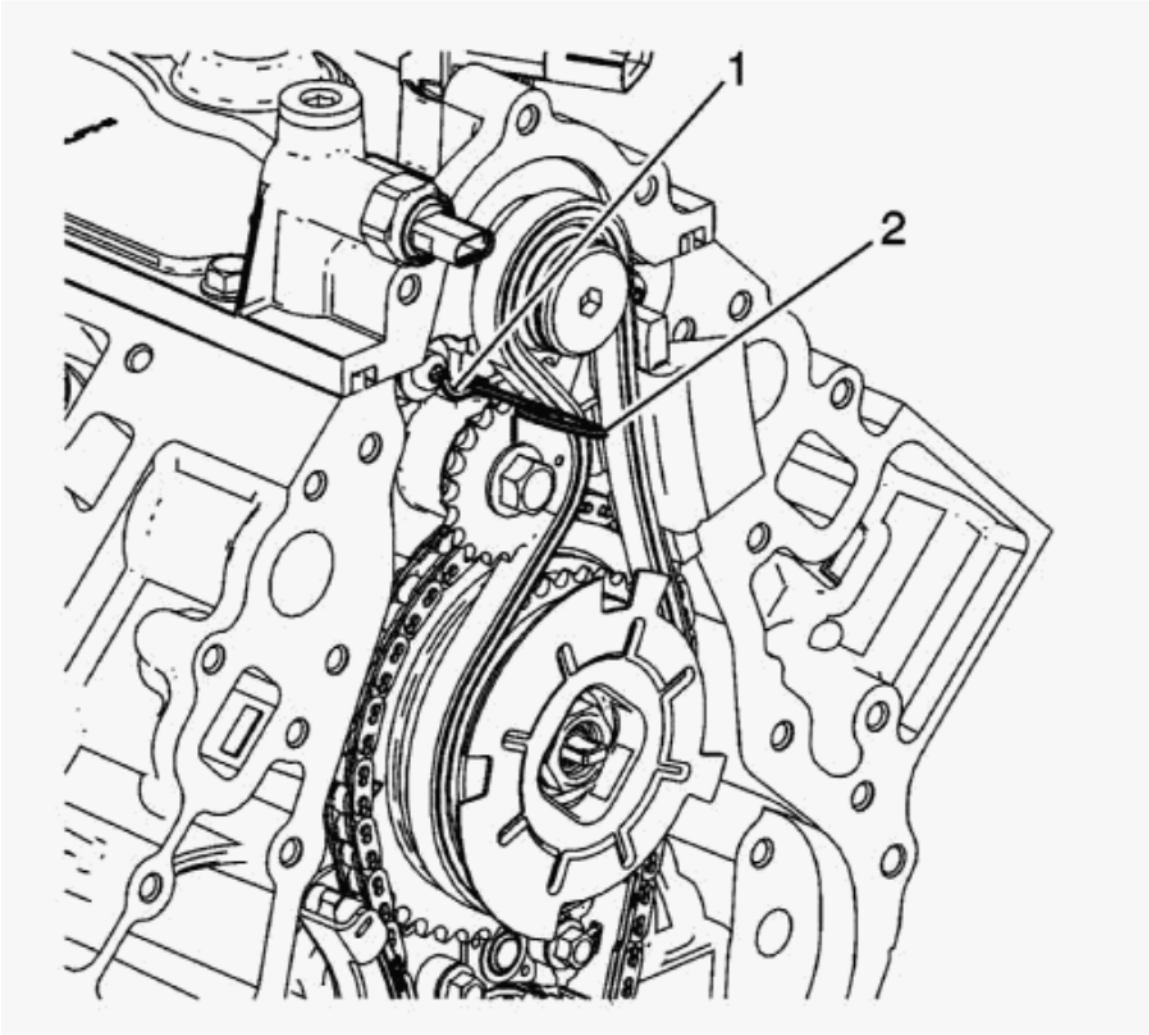

Fig. 177: Balance Shaft Thrust Plate Torsion Spring And Tension Pin
Courtesy of GENERAL MOTORS COMPANY

4. Push down the balance shaft thrust plate torsion spring (1) and install **EN-46330** tension pin (2).

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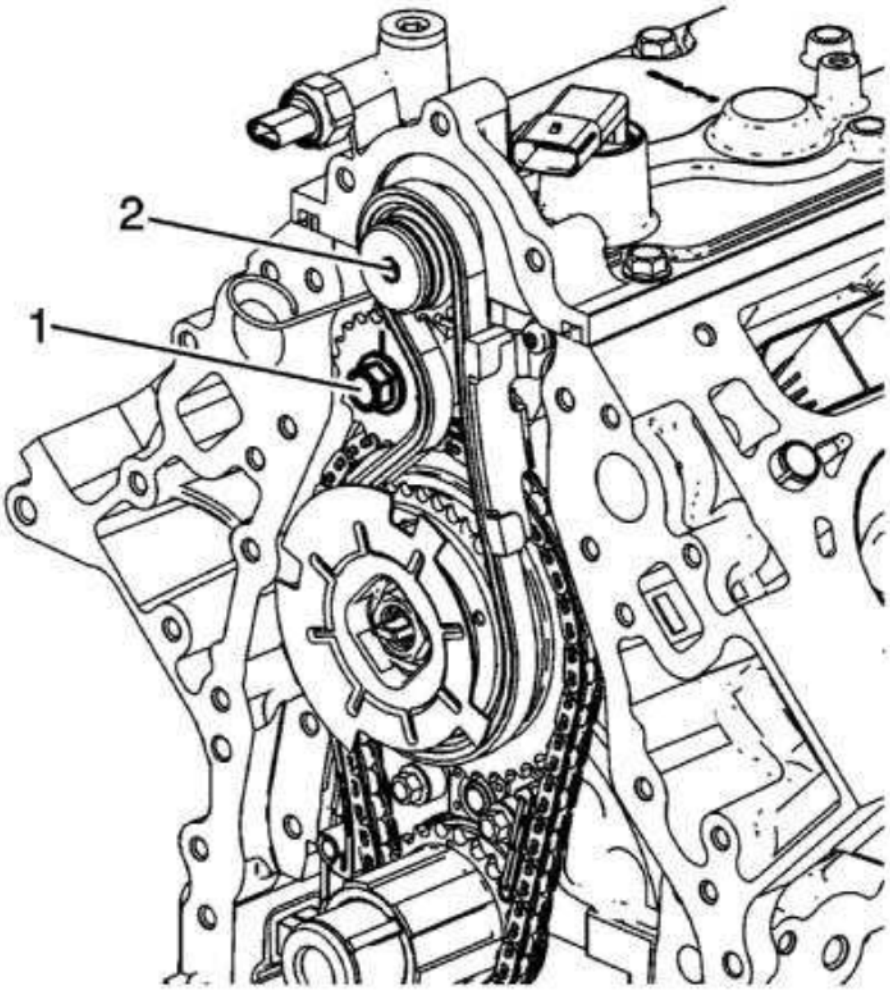

Fig. 178: Balancer Shaft Bolt And Idler Shaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Loosen the balancer shaft bolt (1) and the idler shaft sprocket bolt (2).

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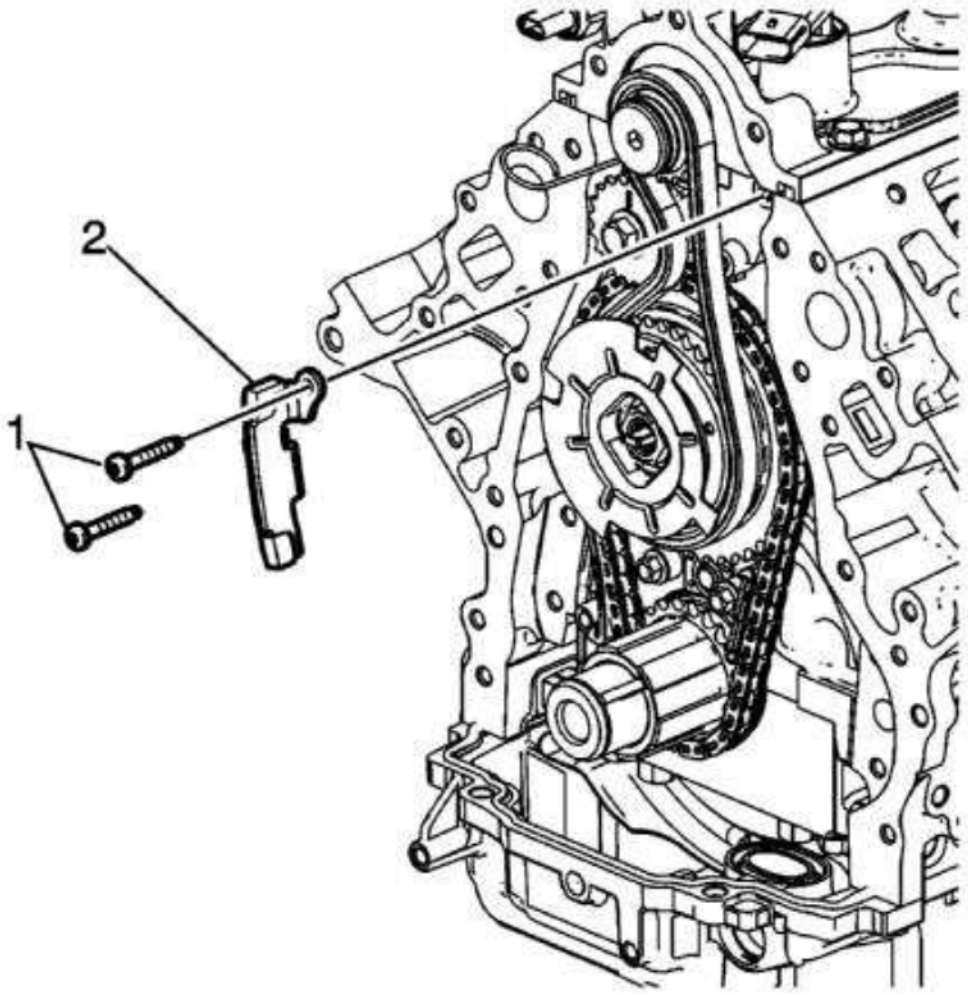

Fig. 179: Balancer Shaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the two balancer shaft retainer bolts (1).
7. Remove the balancer chain guide (2).

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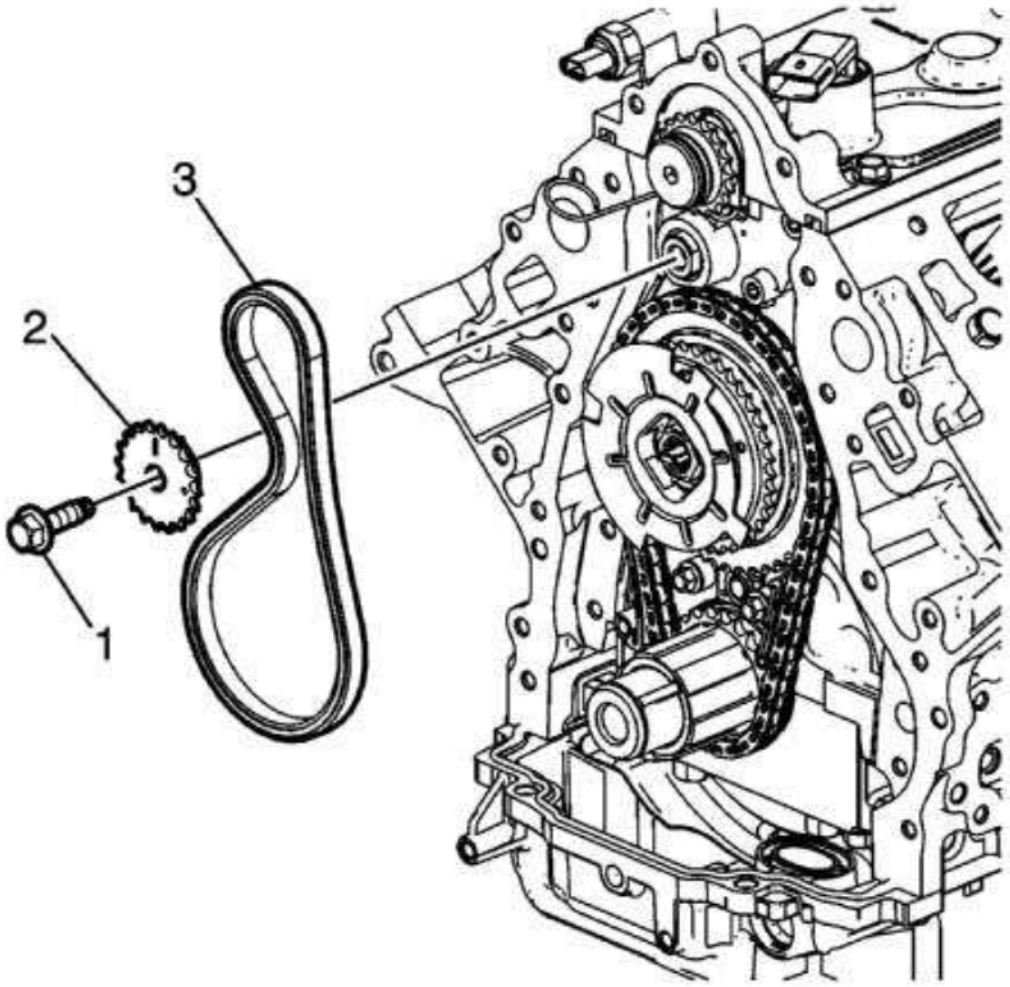

Fig. 180: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove the balancer shaft driven sprocket bolt (1) and the balancer shaft driven sprocket (2).
9. Remove the balancer shaft chain (3).

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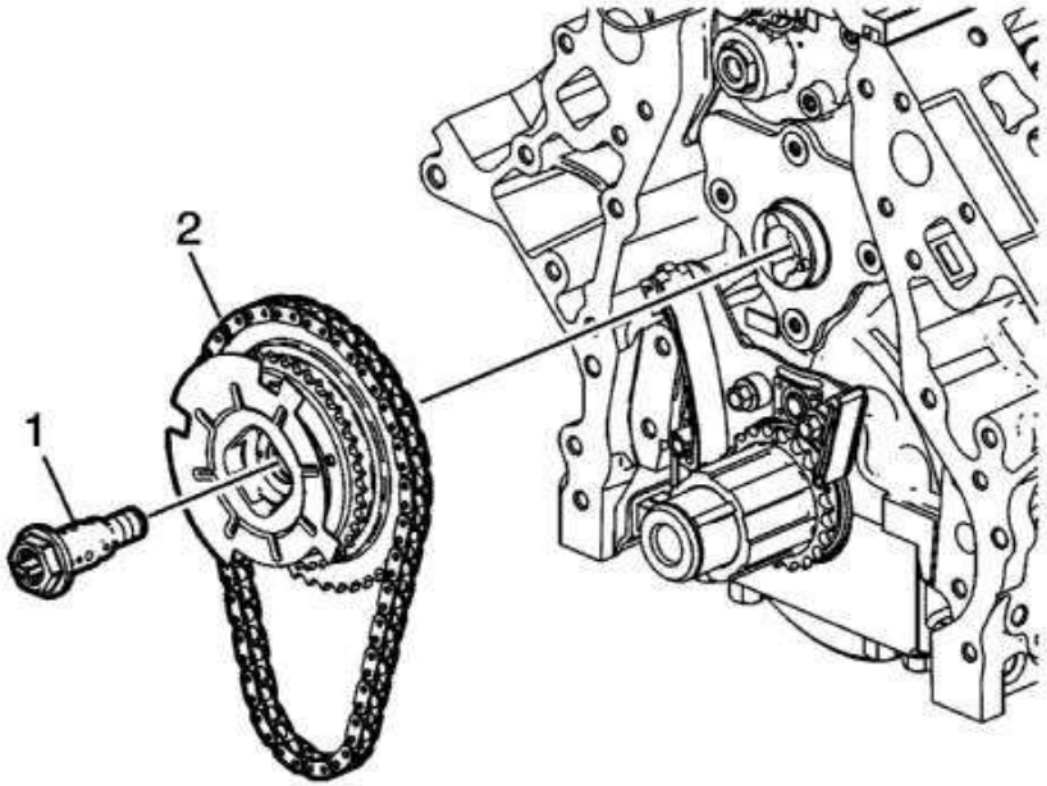

Fig. 181: Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

10. Remove the CMP actuator solenoid valve (1).
11. Loosen and separate the CMP actuator and timing chain (2) from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

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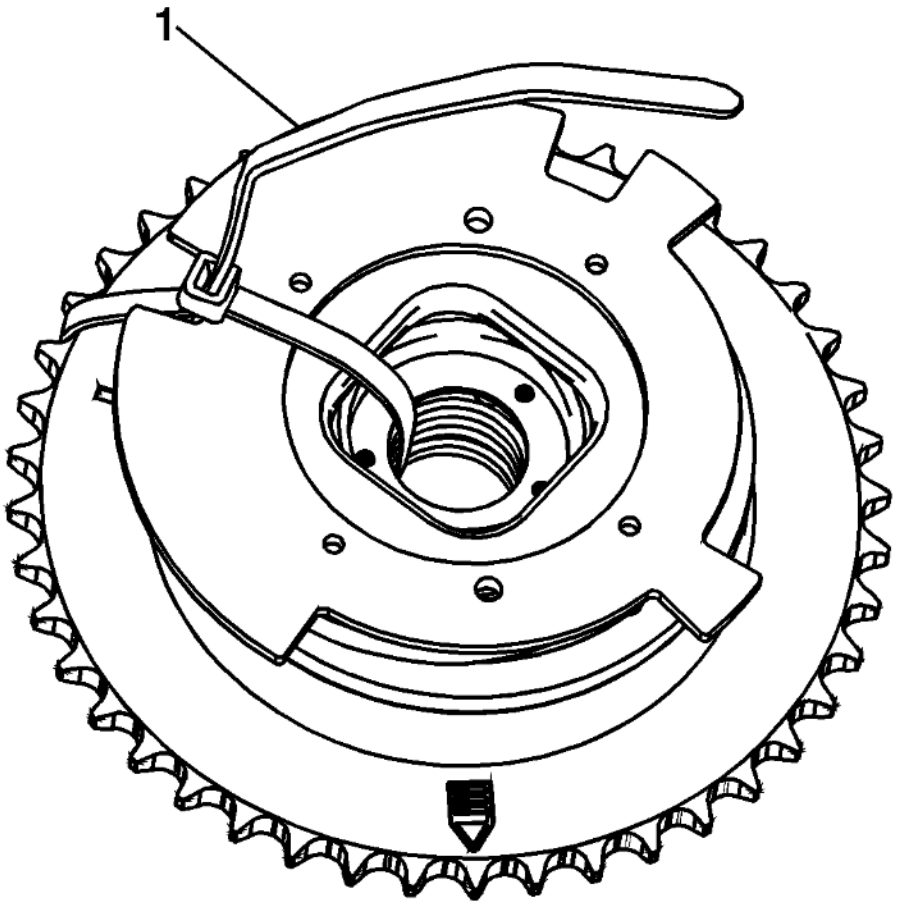

Fig. 182: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

12. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.

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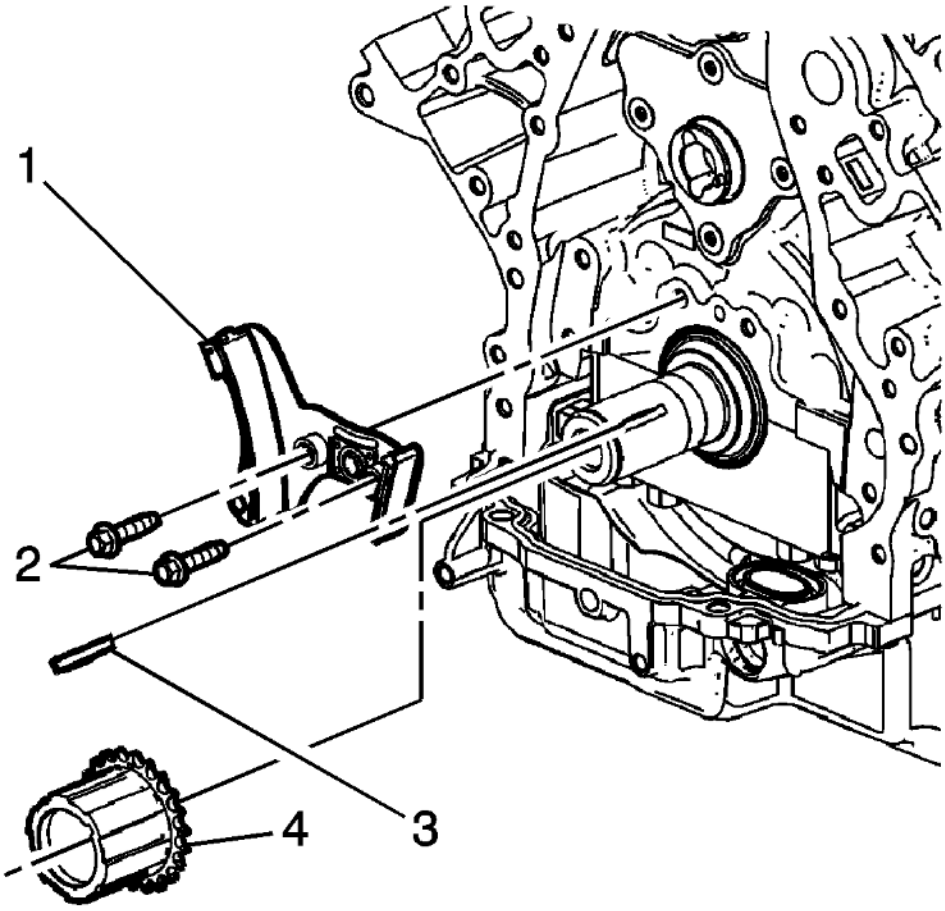

Fig. 183: Crankshaft Sprocket And Key
Courtesy of GENERAL MOTORS COMPANY

13. Remove the crankshaft sprocket (4), and key (3).
14. Remove the timing chain tensioner bolts (2) and the timing chain tensioner (1).

Installation Procedure

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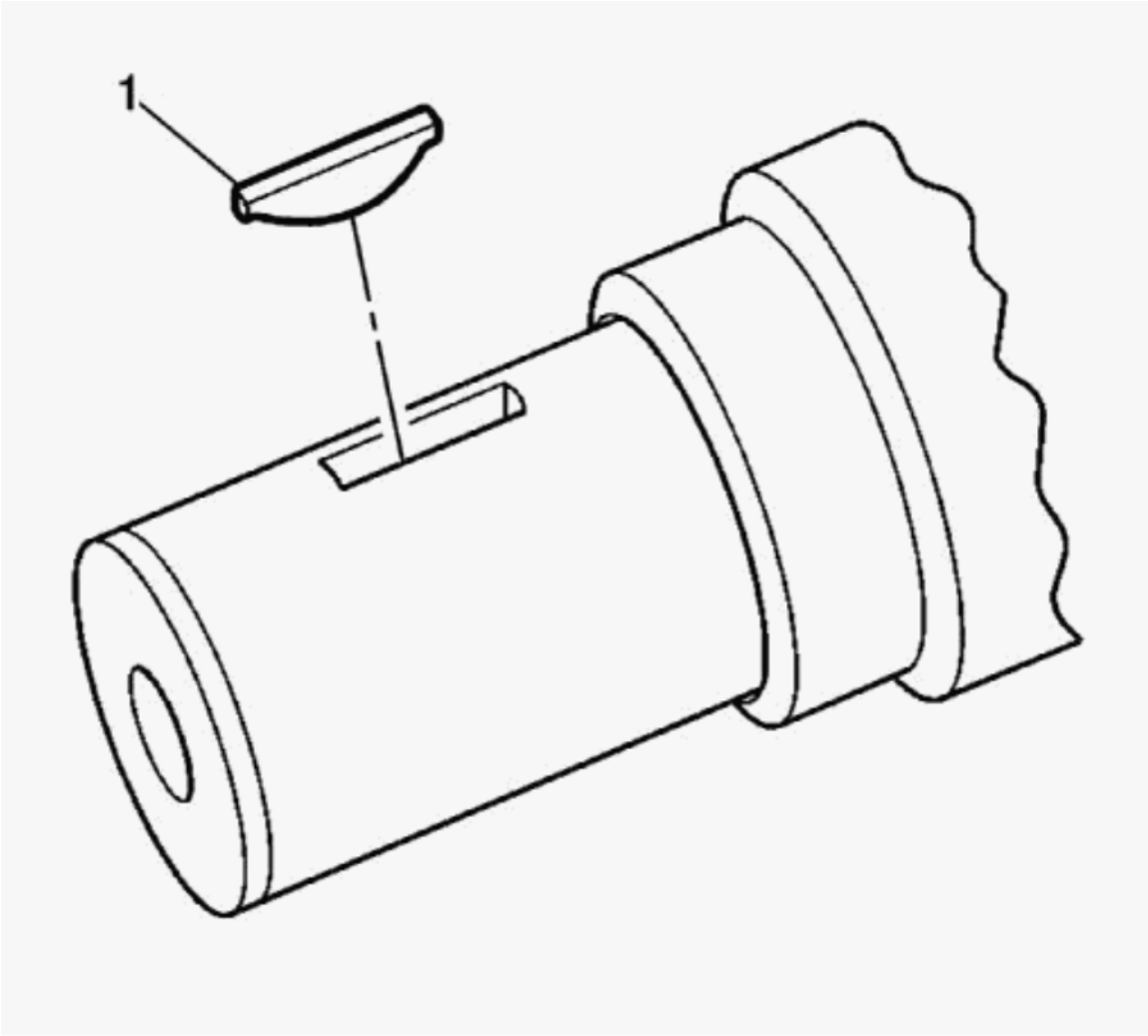

Fig. 184: Key Into Crankshaft Keyway
Courtesy of GENERAL MOTORS COMPANY

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

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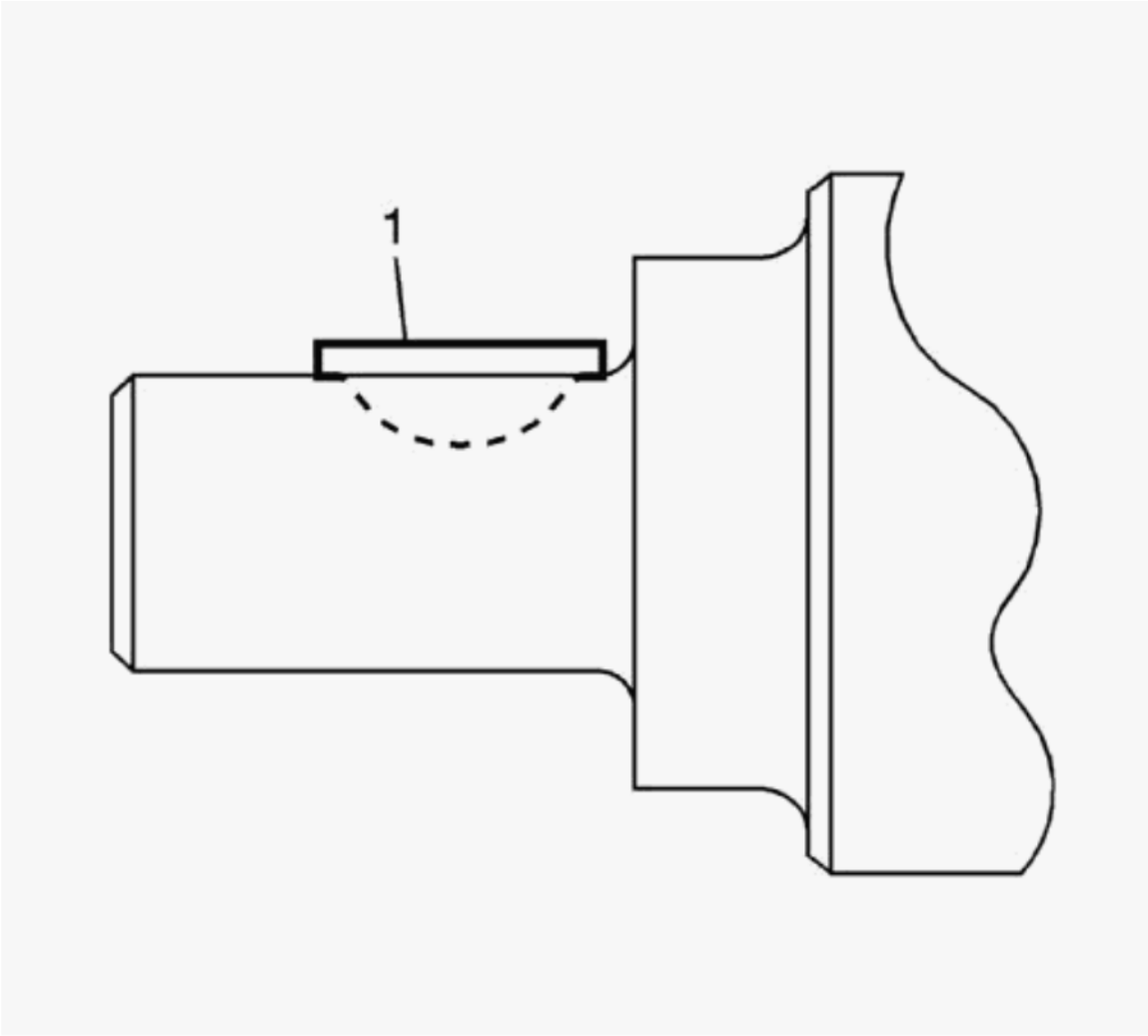

Fig. 185: Key Into Keyway
Courtesy of GENERAL MOTORS COMPANY

2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.

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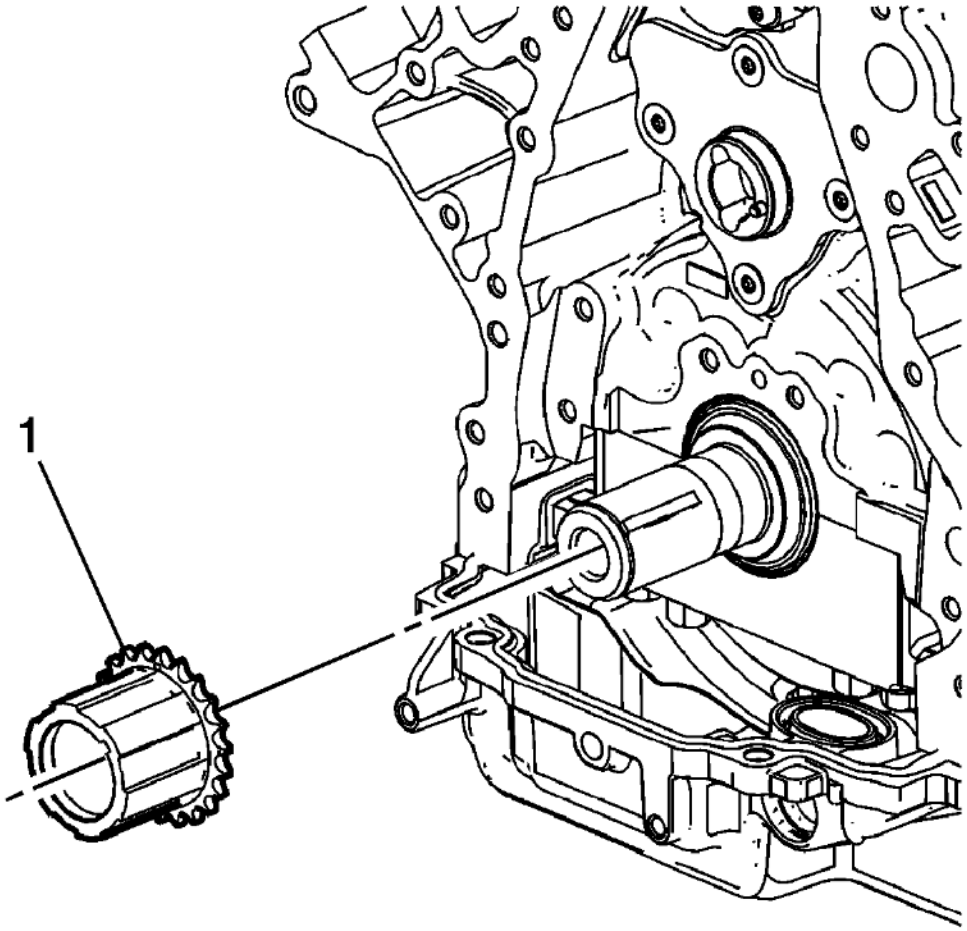

Fig. 186: Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft sprocket washers (2) and the crankshaft sprocket (1). Align the crankshaft key with the crankshaft sprocket keyway.

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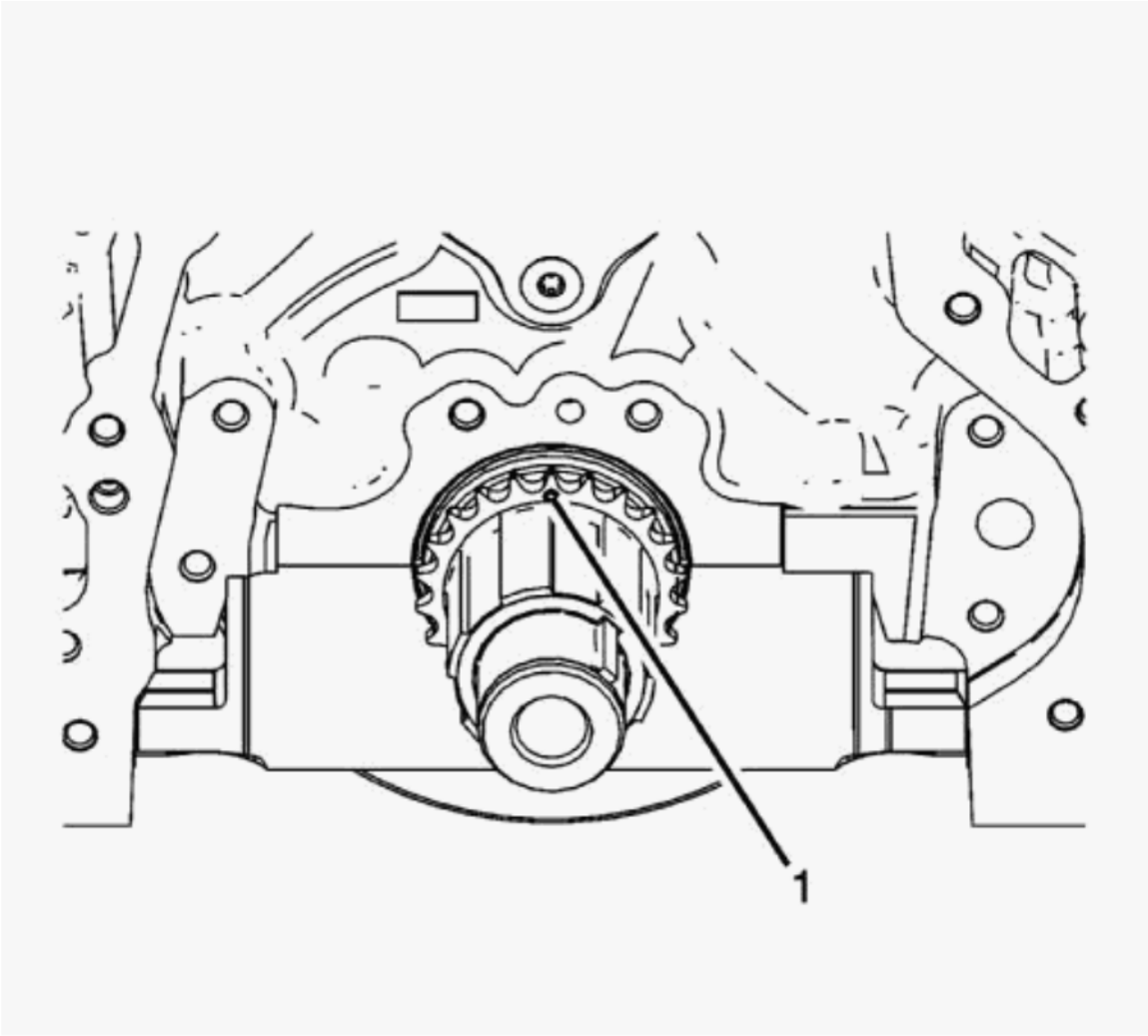

Fig. 187: Rotating Crankshaft Until Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft until the sprocket alignment mark (1) is in the 12 o'clock position.

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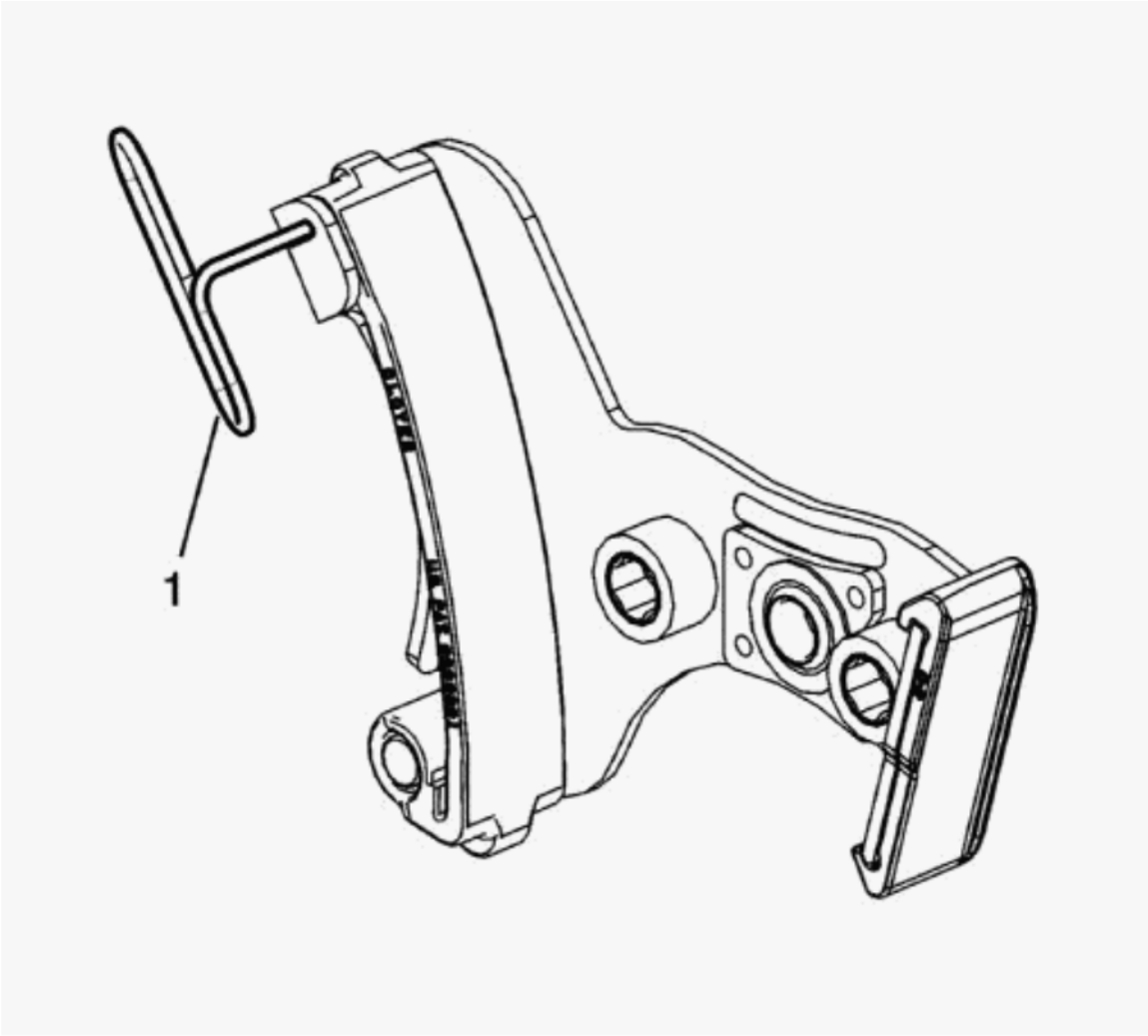

Fig. 188: Timing Chain Tensioner Guide And Pin
Courtesy of GENERAL MOTORS COMPANY

5. Compress the timing chain tensioner guide and install the **EN-46330** tension pin (1).

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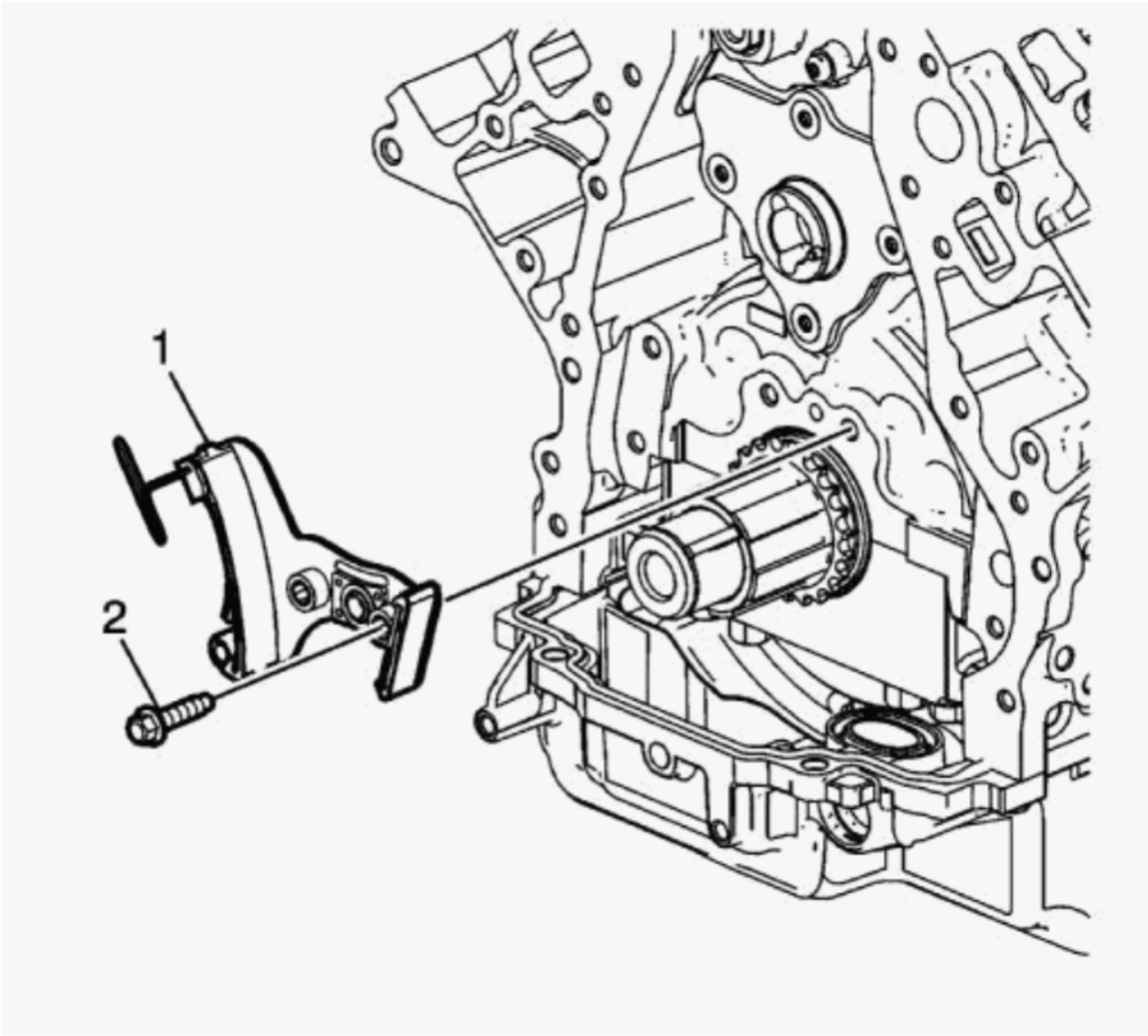

Fig. 189: Timing Chain Tensioner And Left Side Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Install the timing chain tensioner and left side bolt (1) hand tight. Do not install the right side bolt at this time. The right side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.

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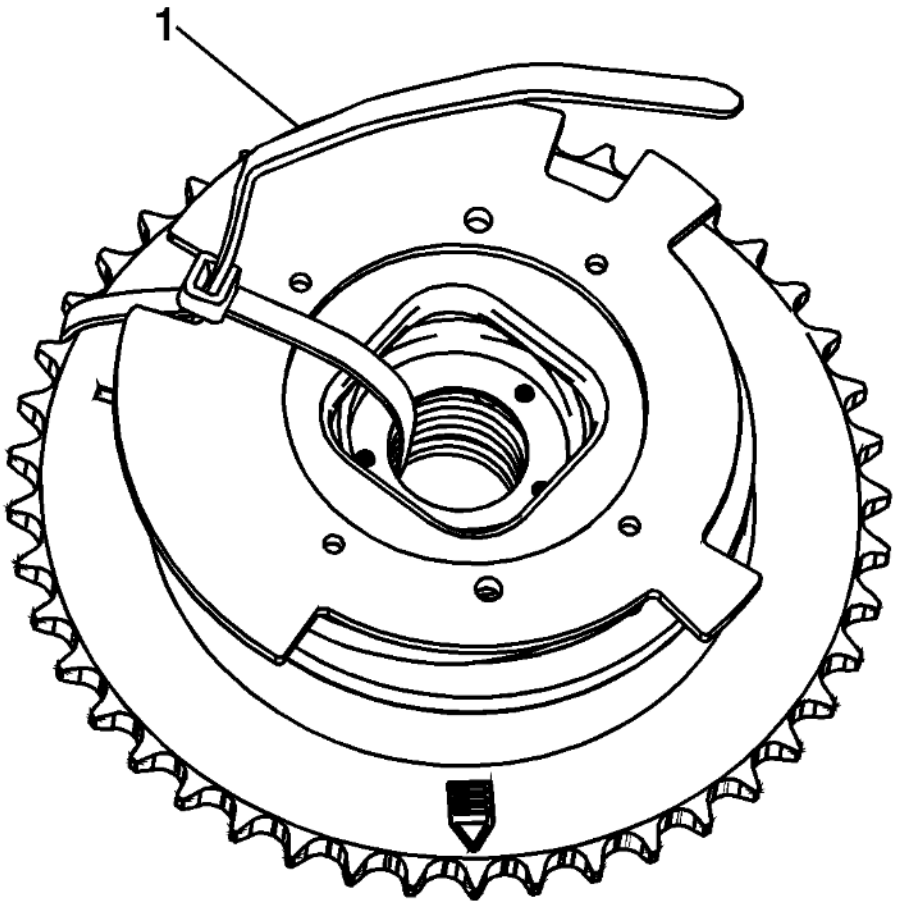

Fig. 190: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Camshaft Position Actuator Removal and Installation Warning .**

7. Remove the tie strap (1) from the actuator.

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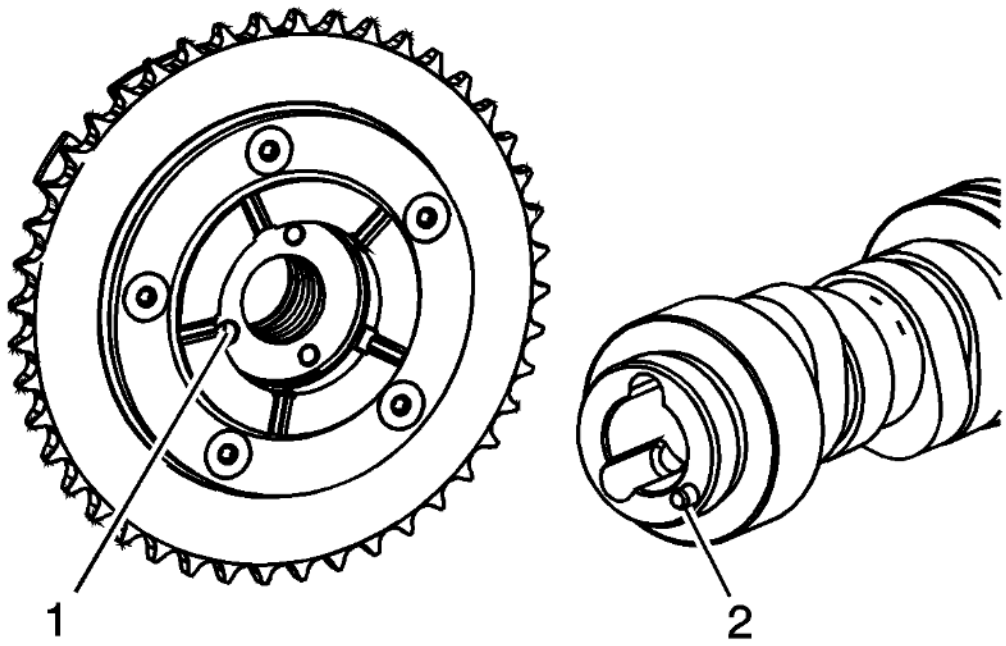

Fig. 191: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh**
- **The camshaft and the sprocket alignment marks MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW valve during assembly.**

8. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

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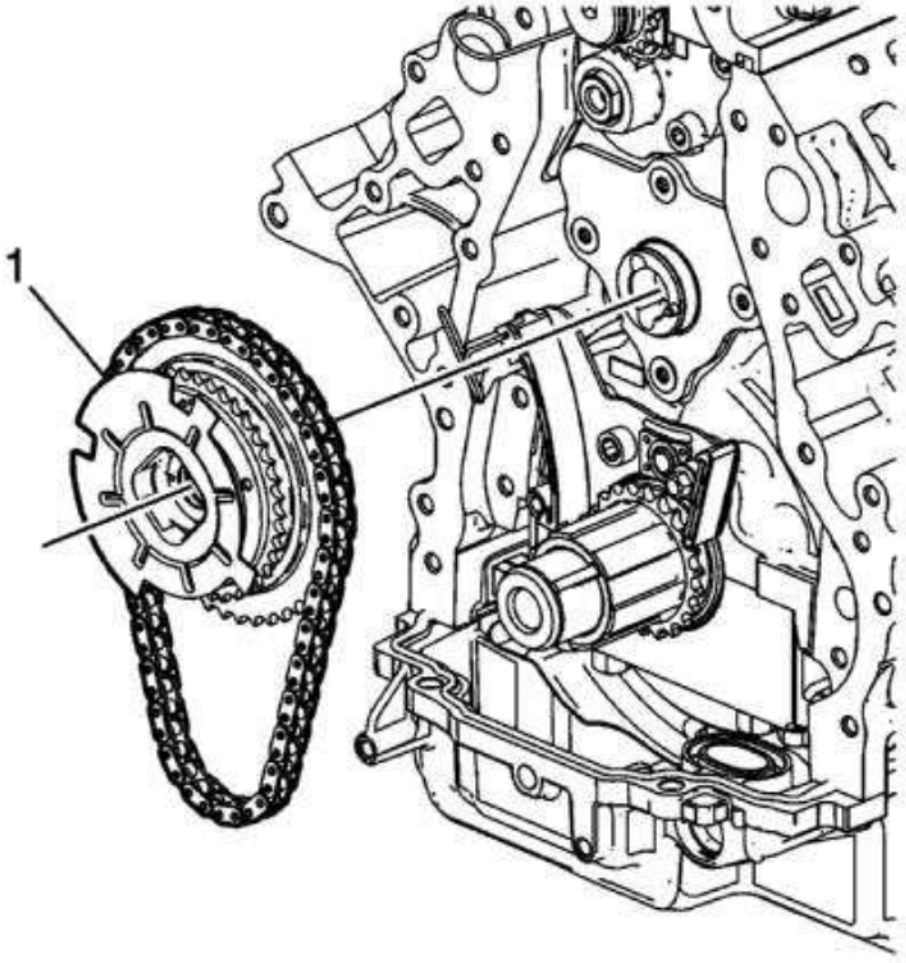

Fig. 192: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

9. Install the CMP actuator and timing chain (1). Use care to install the actuator completely onto the front of the camshaft. Position fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

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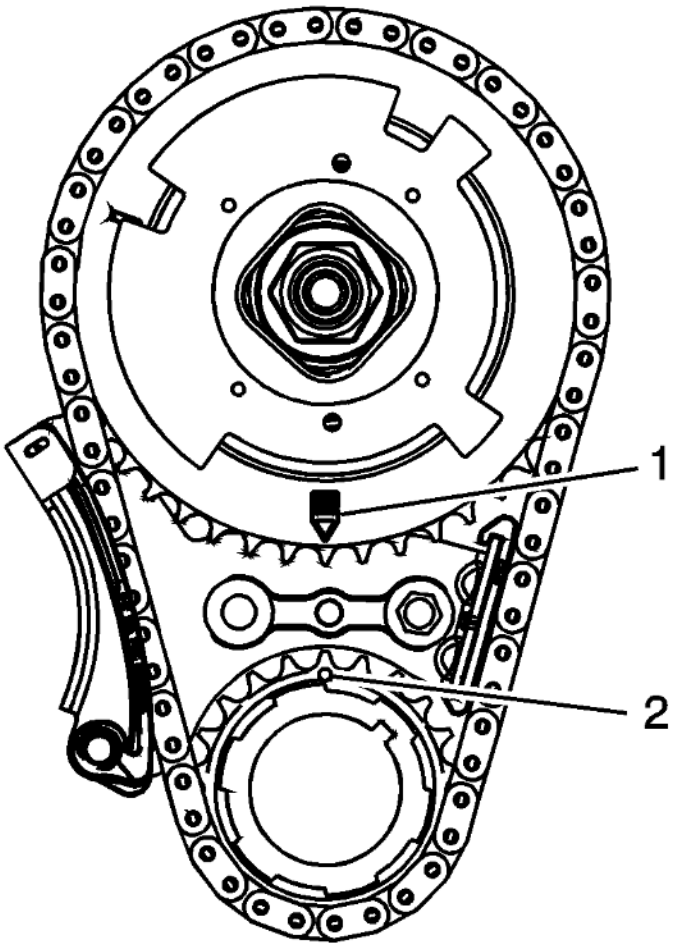

Fig. 193: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

10. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be in the 6 o'clock position and the mark on the crankshaft sprocket (2) should be located in the 12 o'clock position.

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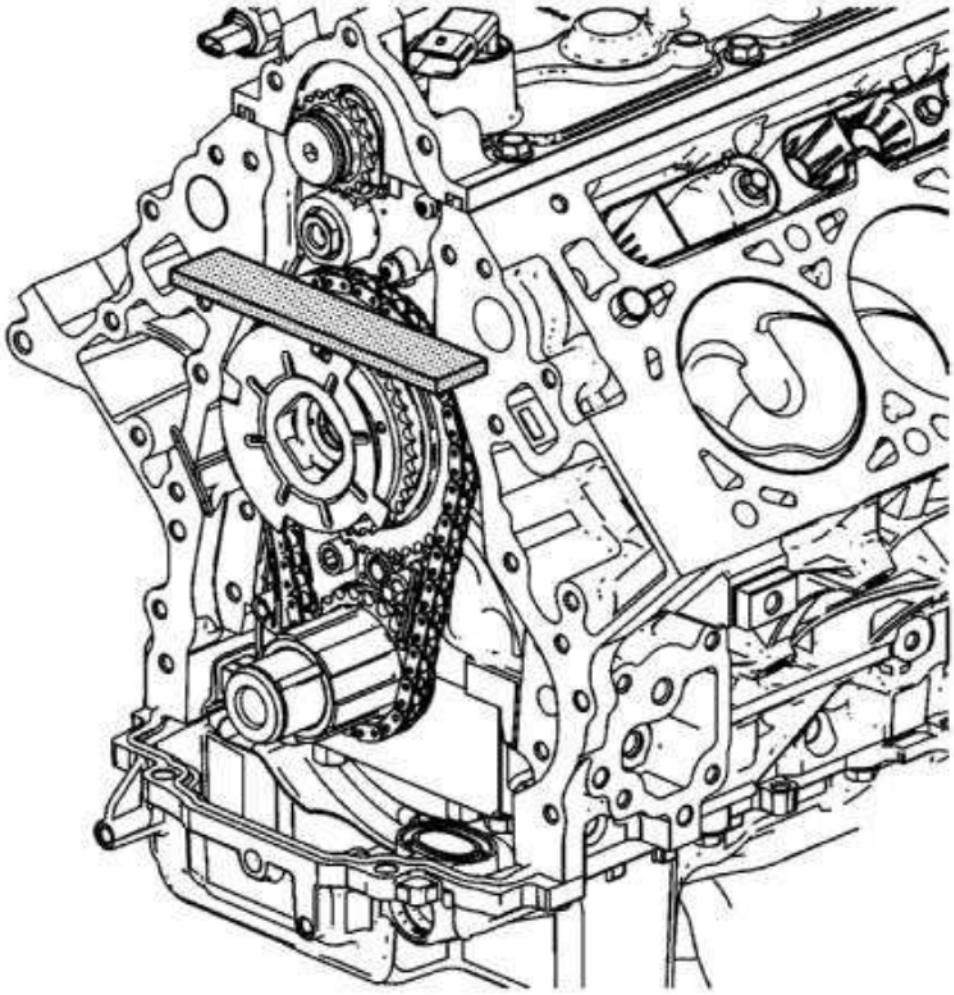

Fig. 194: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is possible to push the camshaft rearward when installing the CMP actuator. Verify that the camshaft lobes are centered in the valve lifter bores after the CMP actuator is installed.**

11. Locate a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of the camshaft, the timing chain will not protrude beyond the front face of the engine block.

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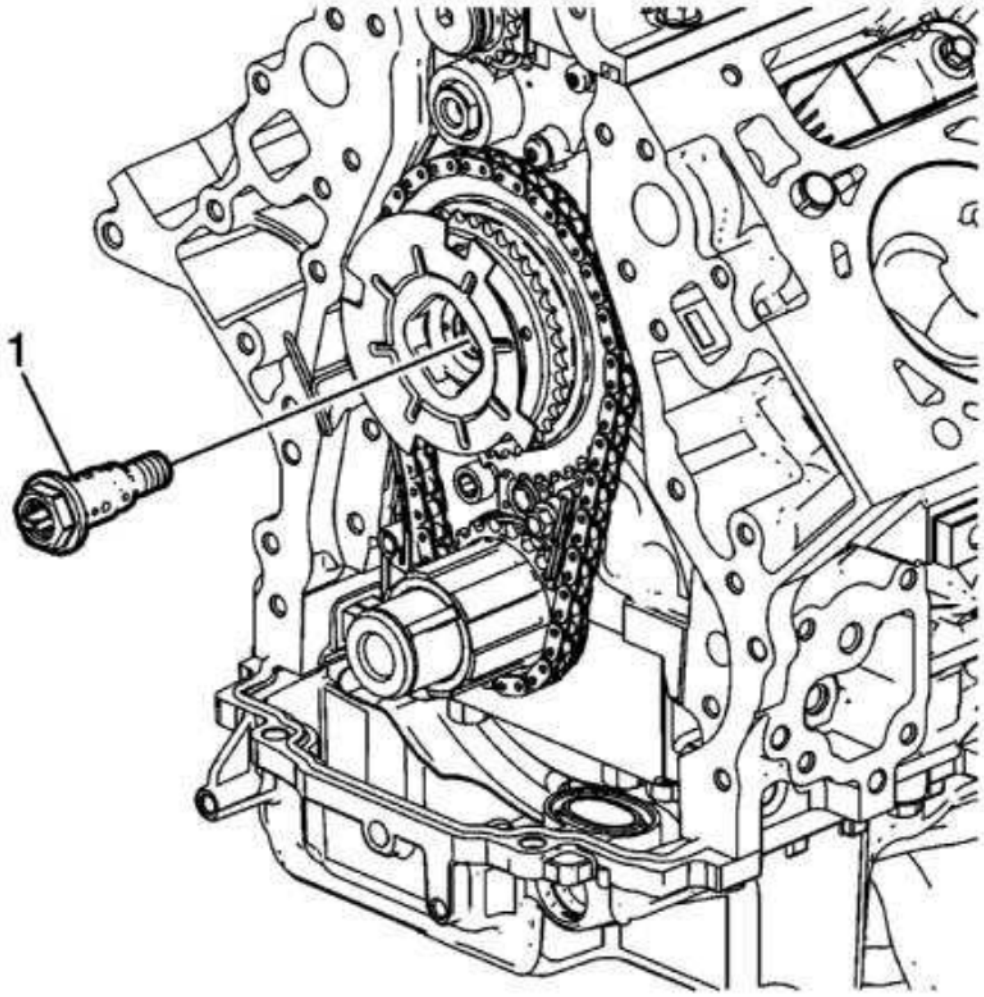

Fig. 195: NEW CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

12. Install a NEW CMP actuator solenoid valve (1). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.
    1. First pass 65 N.m (48 lb ft).
    2. Final pass 90 degrees.

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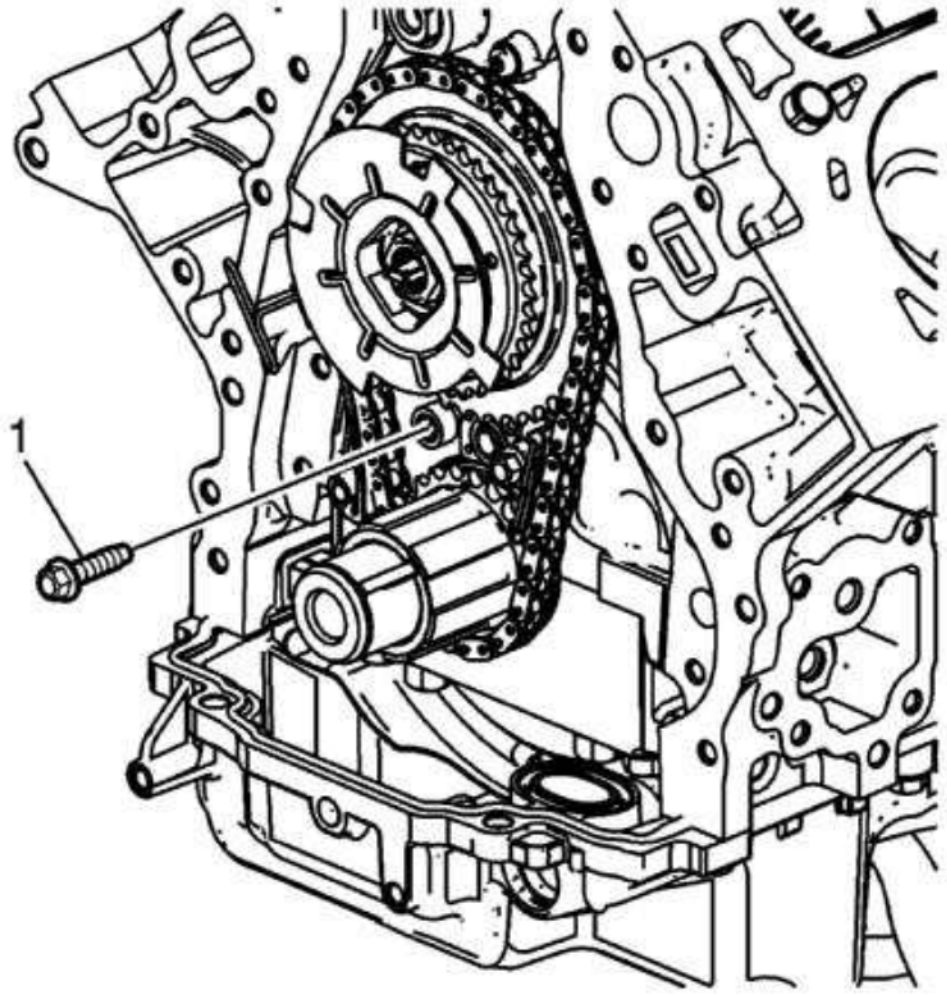

Fig. 196: Left Side Bolt And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

13. Install the right side bolt (1) onto the timing chain tensioner. Tighten both bolts to 30 N.m (22 lb ft).

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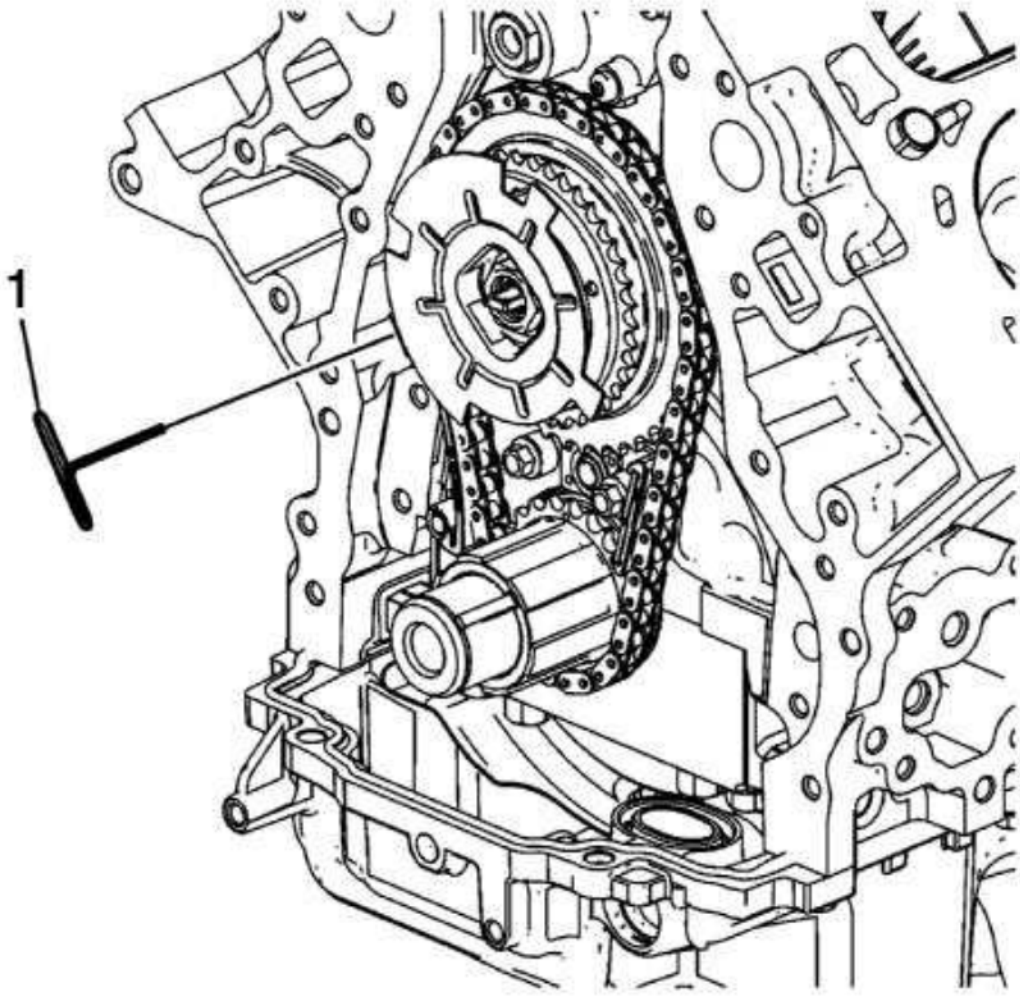

Fig. 197: Tension Pin
Courtesy of GENERAL MOTORS COMPANY

14. Remove the **EN-46330** tension pin.

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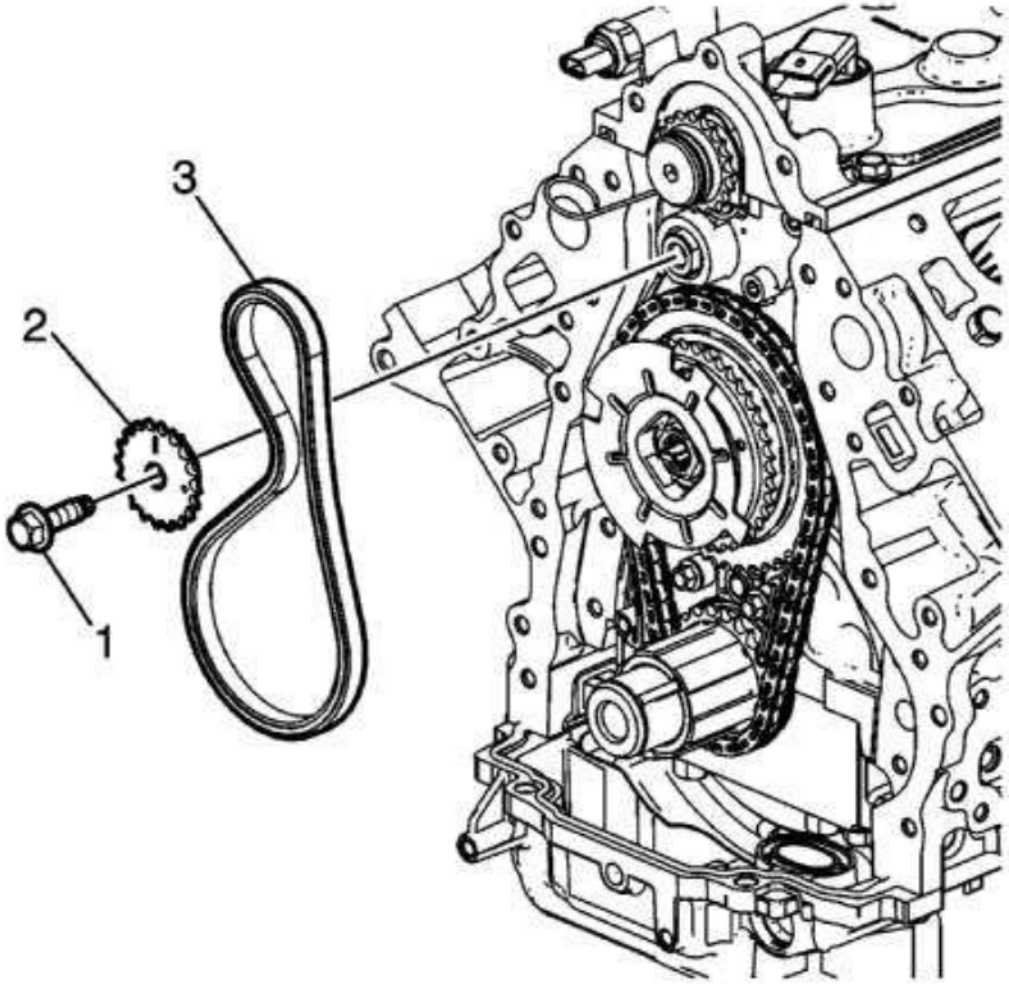

Fig. 198: Balancer Chain And Driven Sprocket
Courtesy of GENERAL MOTORS COMPANY

15. Install the balancer chain (3) by wrapping it around the camshaft actuator and the balancer shaft idler sprocket.
16. Install the driven sprocket (2), and driven sprocket bolt (1) hand tight.

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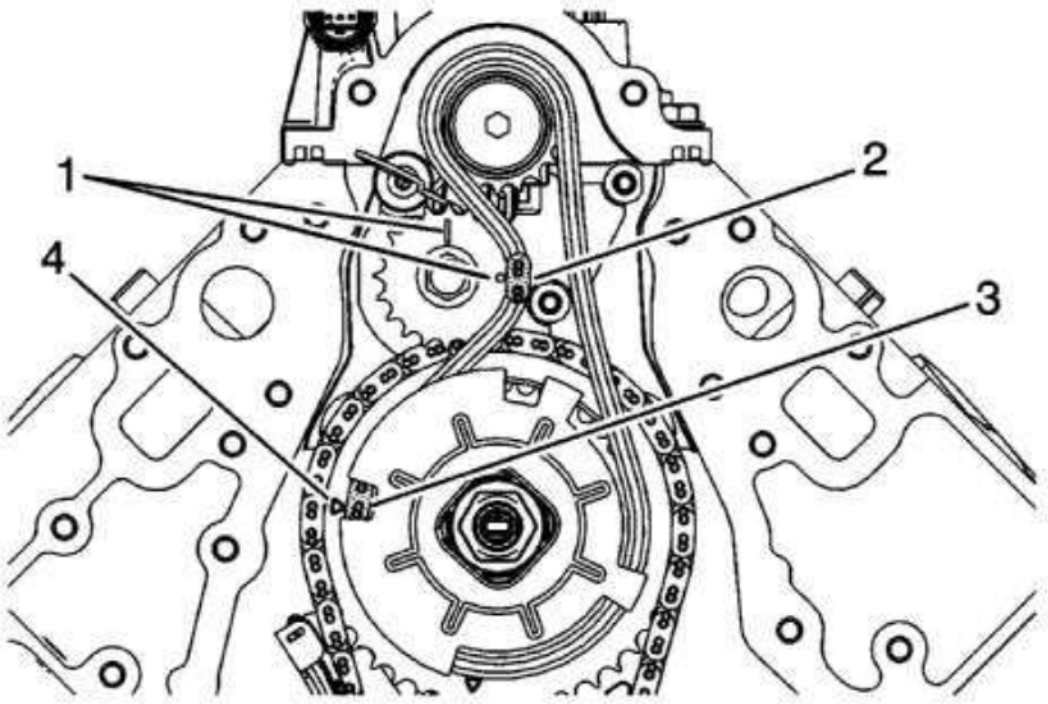

Fig. 199: Blue Link Plate And Camshaft Actuator Triangle Mark
Courtesy of GENERAL MOTORS COMPANY

17. The lower blue link plate (3) of the balancer chain must align with the camshaft actuator triangle mark (4).
18. The upper blue link plate (2) of the balancer chain must alight with the dot (1) on balancer driven sprocket. The 20 tooth driven sprocket will also have a molded in vertical line (1) pointing at 12 o'clock.

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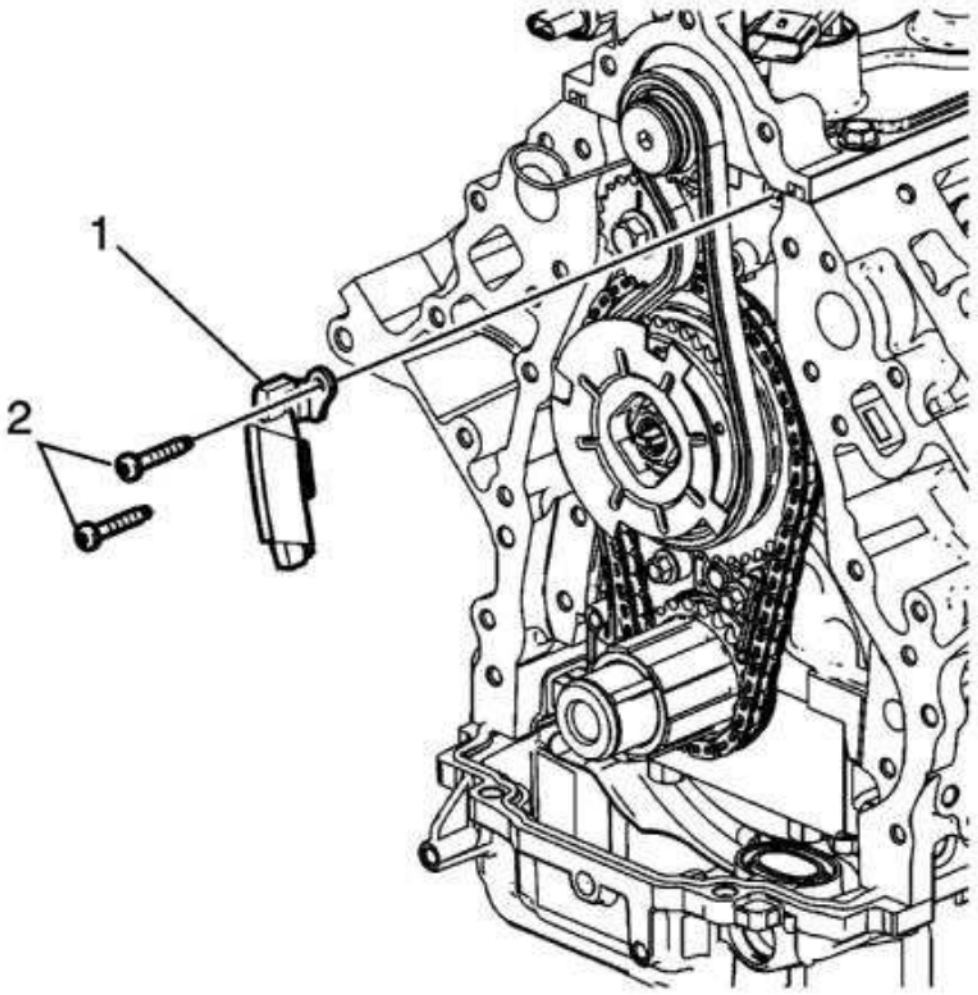

Fig. 200: Balancer Chain Guide With Shim And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If plastic shim is not available, a 1.1 mm (0.04 in) size shim will need to be placed between the balancer chain and guide during installation.**

19. Install the balancer chain guide with shim (1) and bolts (2).
20. Tighten the 2 o'clock and 3:30 o'clock position guide bolts (2) to 10 N.m (89 lb in).

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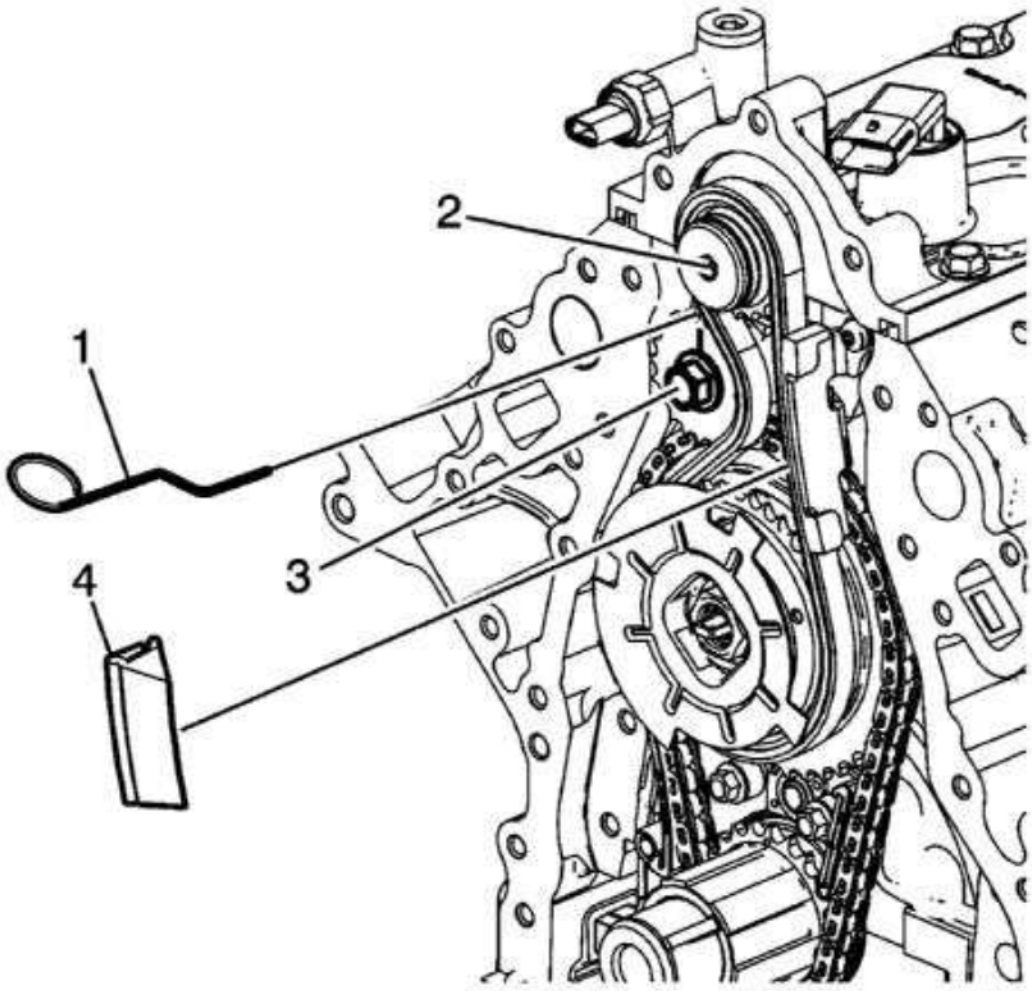

Fig. 201: Driven Sprocket Bolt And Idler Sprocket
Courtesy of GENERAL MOTORS COMPANY

21. Tighten the driven sprocket bolt (3) to 58 N.m (43 lb ft).
22. With the idler sprocket (2) free to slide up and down, pull (remove) the **EN-46330** tension pin (1).
23. Tighten the idler sprocket bolt (2) to 58 N.m (43 lb ft).
24. The chain should now be tight. Remove the shim (4) from between the balancer guide and the chain. The chain should now be slightly loose.
25. Remove flywheel locking tool.
26. Install the starter. Refer to **Starter Replacement (LV3)** .
27. Install oil pump. Refer to **Oil Pump Replacement**.

CAMSHAFT REPLACEMENT

Removal Procedure

1. Remove the engine. Refer to **Engine Replacement**.
2. Remove the valve lifter follower guide. Refer to **Valve Lifter Follower Guide Replacement**.
3. Remove the valve lifters. Refer to **Valve Lifter Replacement**.

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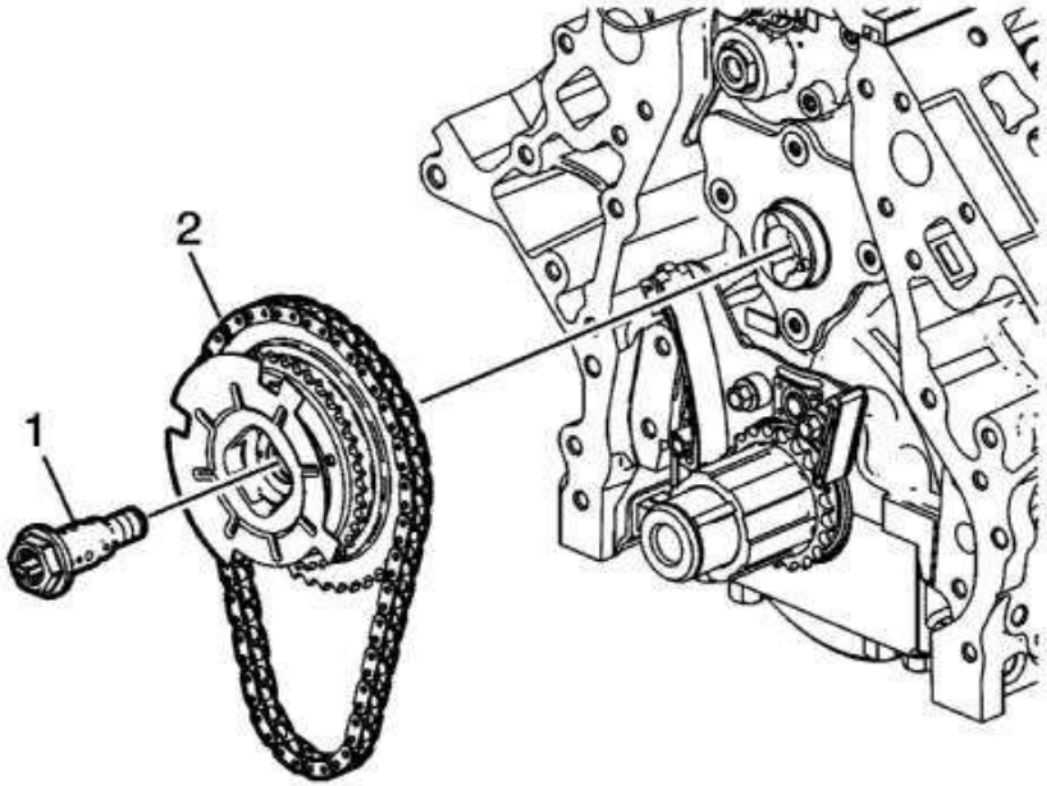

Fig. 202: Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

4. Remove the CMP actuator and timing chain (2). Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**.

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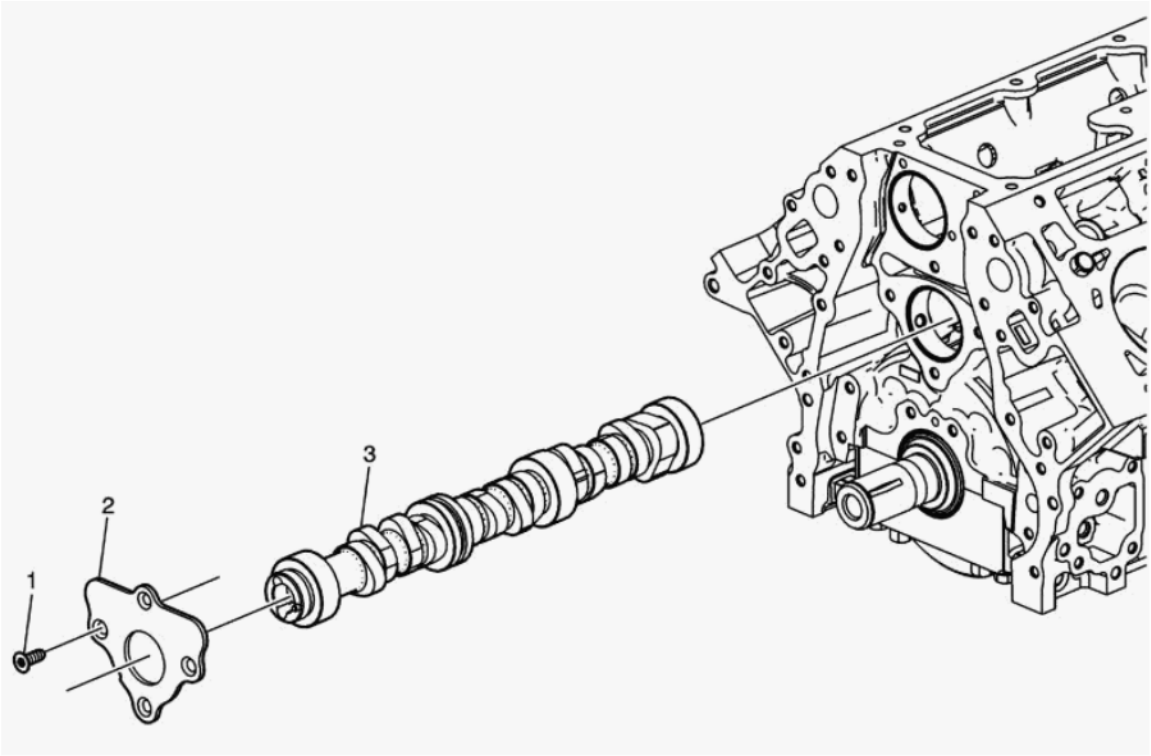

Fig. 203: Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the camshaft retainer bolt (1).
6. Remove the camshaft retainer (2).
7. Remove the camshaft (3).
8. For camshaft cleaning and inspection, refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

NOTE: **he threads of the camshaft retainer bolts and threaded holes of the engine block must be free of residue and debris prior to the application of threadlocker to ensure proper adhesion and fastener retention.**

1. Prepare the camshaft retainer bolts and engine block threaded holes for assembly:
   - Thoroughly clean the residue from the bolt threads with denatured alcohol and allow to dry.
   - Thoroughly clean the residue from the threaded holes of the engine block with denatured alcohol and allow to dry.
   - Apply threadlocker to 2/3 of the threaded length of the camshaft retainer bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
   - Ensure there are no gaps in the threadlocker along the filled area of the bolts.
   - Allow the threadlocker to cure approximately 10 minutes before installation.

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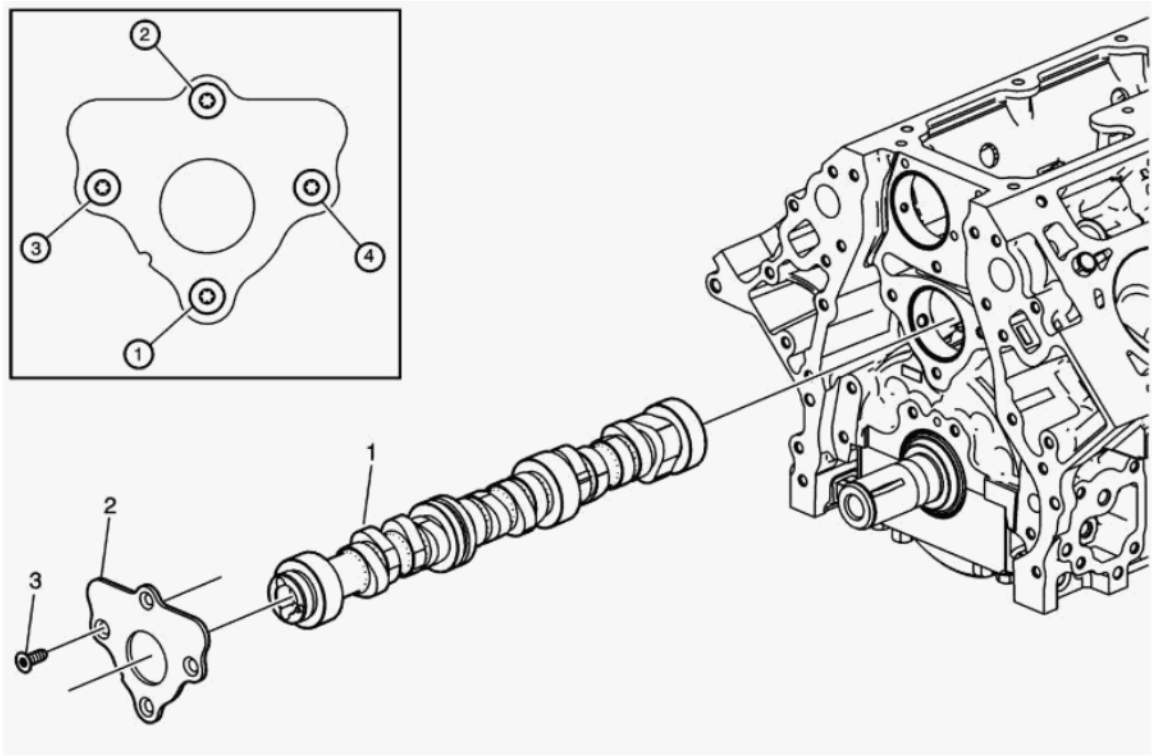

Fig. 204: Camshaft Retainer And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the camshaft (1), camshaft retainer (2), and camshaft retainer bolts (3). Refer to **Camshaft Installation**.

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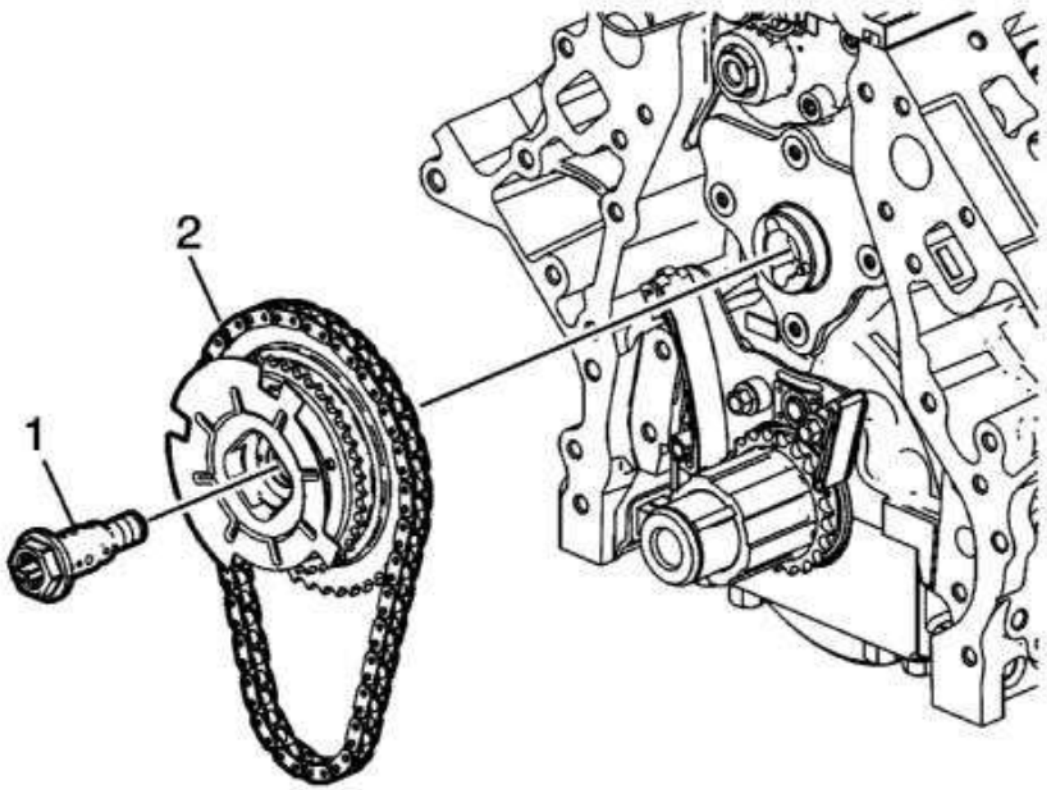

Fig. 205: Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

3. Install the CMP actuator and timing chain (2). Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**.
4. Install the valve lifters. Refer to **Valve Lifter Replacement**.
5. Install the valve lifter follower guide. Refer to **Valve Lifter Follower Guide Replacement**.
6. Install the engine. Refer to **Engine Replacement**.

ENGINE FLYWHEEL REPLACEMENT

Special Tools

- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the clutch assemble. Refer to **Clutch Assembly Replacement** .
2. Install the **EN-42386-A** flywheel holding tool in order to lock the flywheel.

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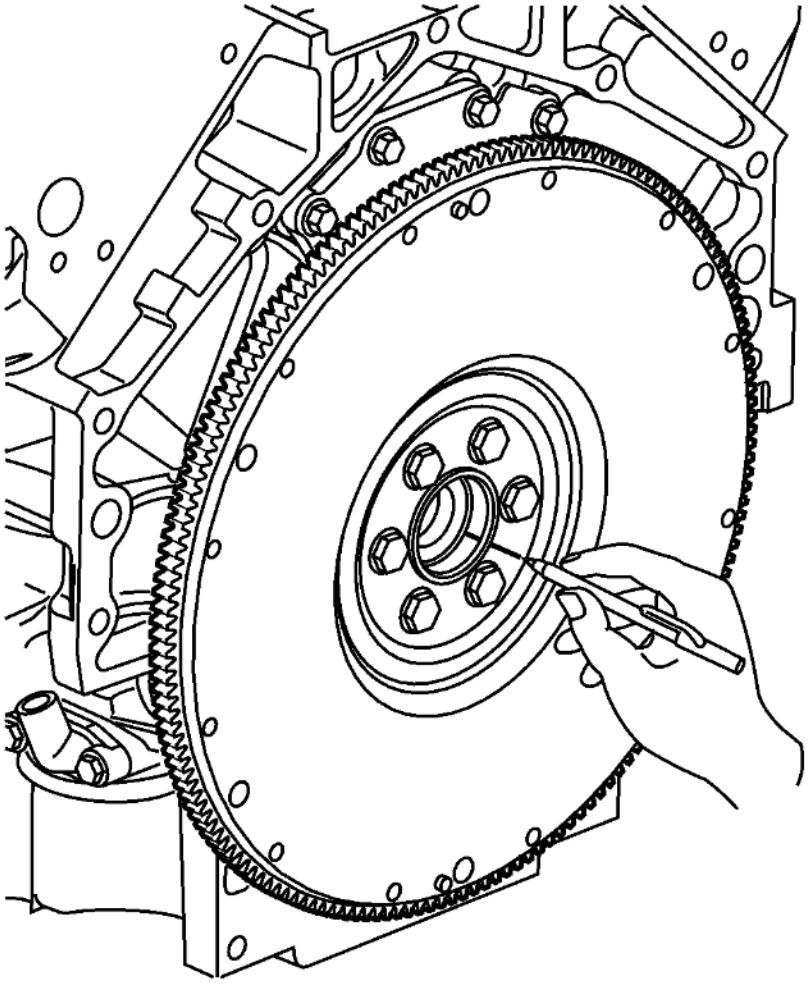

Fig. 206: Marking End Of Crankshaft & Manual Transmission Flywheel
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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 existing engine flywheel must be installed to the original position and direction. The engine flywheel will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts.**

3. Mark or scribe the end of the crankshaft and the engine flywheel.

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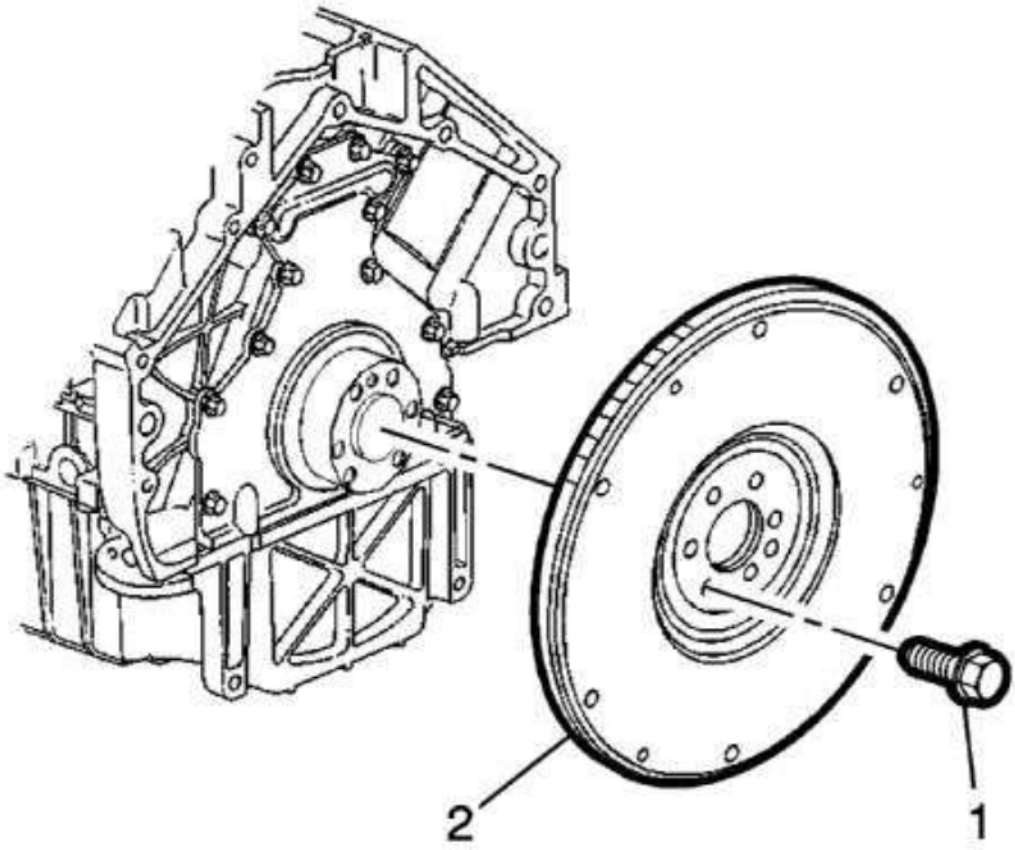

Fig. 207: Engine Flywheel Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove and DISCARD the engine flywheel bolts (1).
5. Remove the engine flywheel (2).

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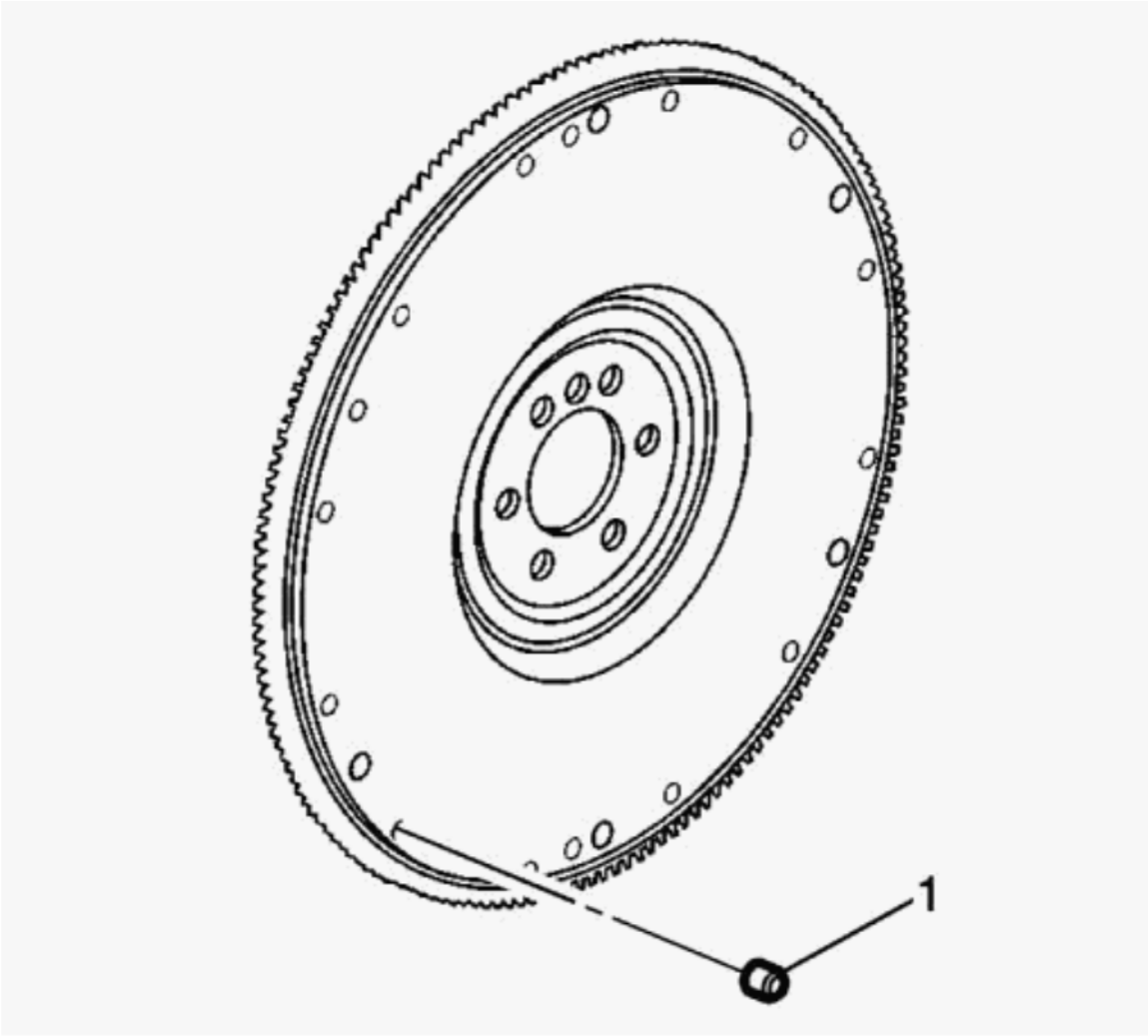

Fig. 208: Engine Flywheel Balance Weights
Courtesy of GENERAL MOTORS COMPANY

6. Note the location of the engine flywheel balance weights (1).
7. Remove the **EN-42386-A** flywheel holding tool .

Installation Procedure

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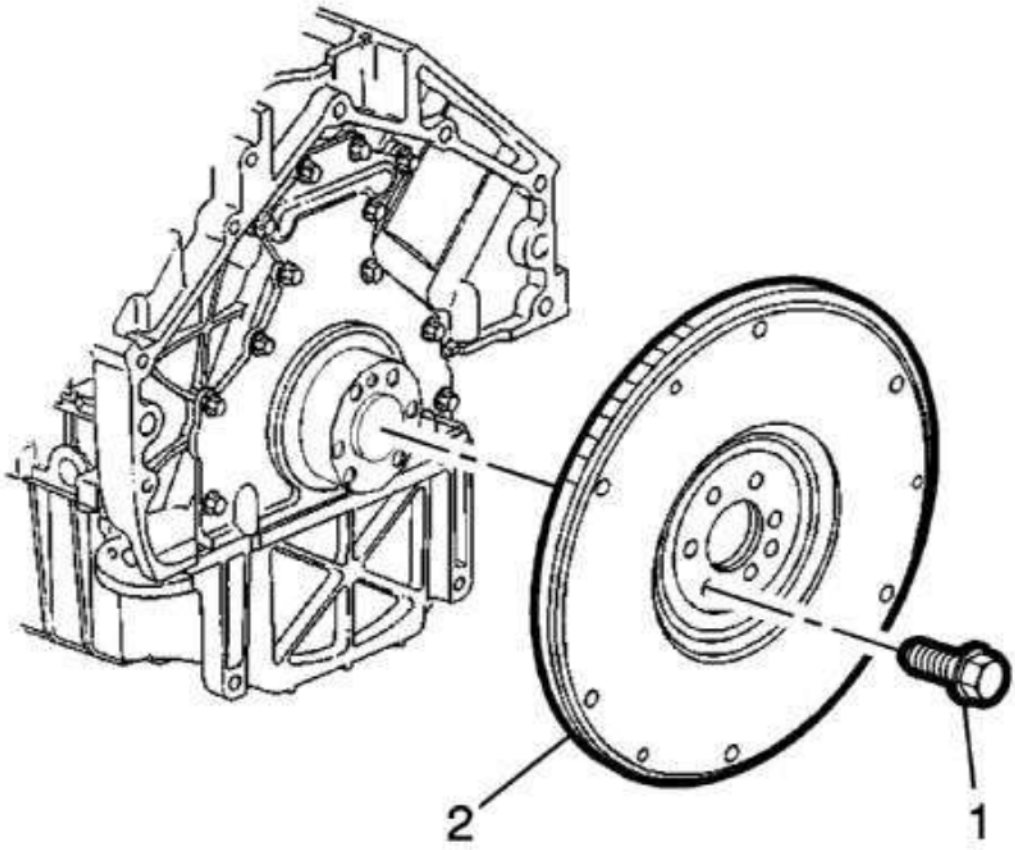

Fig. 209: Engine Flywheel Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Note the position and direction of the engine flywheel before removal. Mark or scribe the end of the crankshaft and flywheel before component removal. The existing engine flywheel must be installed to the original position and direction.**
- **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 3 stage tightening process.**

1. Install the engine flywheel (2) to the crankshaft, in the original position and direction.

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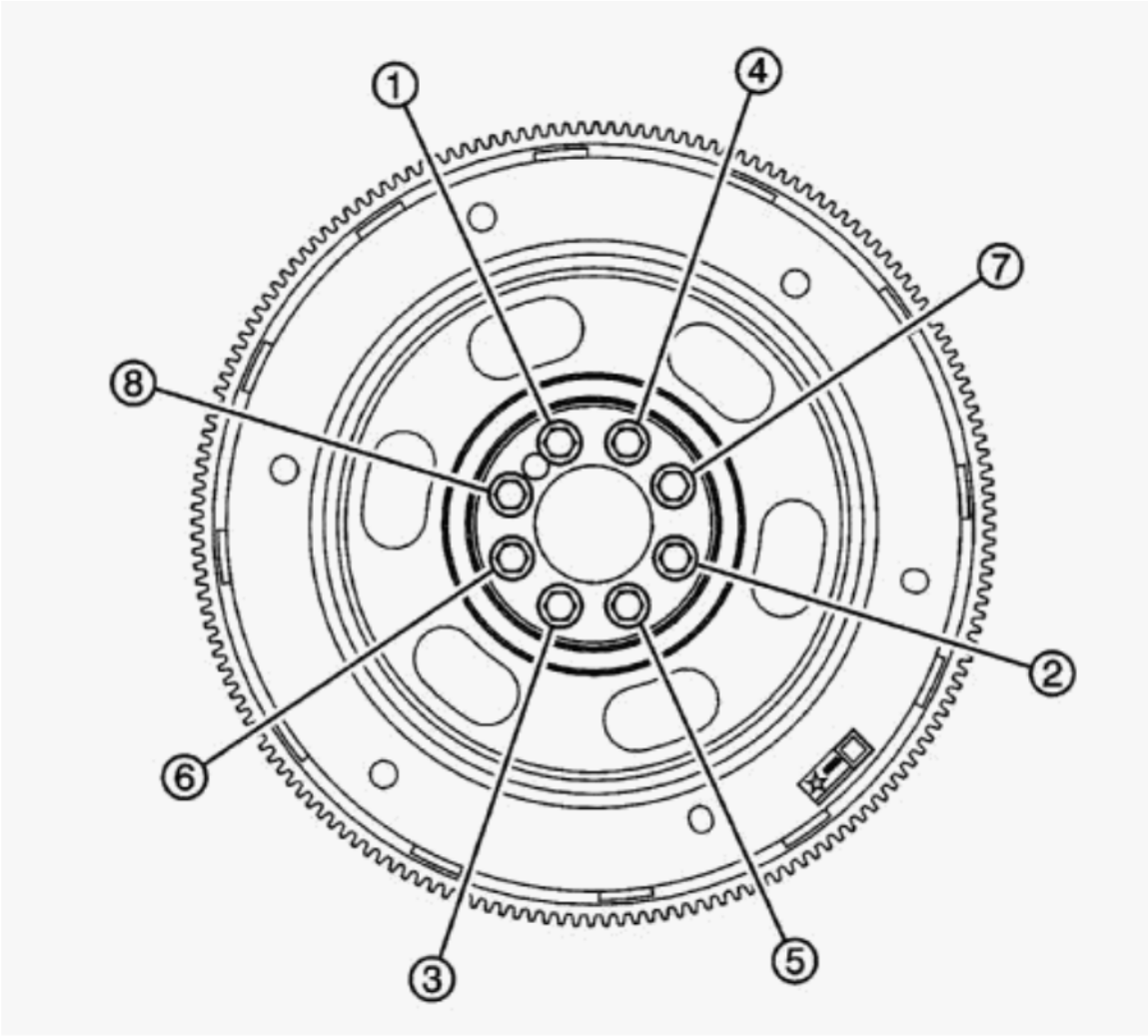

Fig. 210: NEW Engine Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

2. Install NEW bolts.
    1. Install the **EN-42386-A** flywheel holding tool in order to lock the flywheel.
    2. Tighten the bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).
    3. Tighten the bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
    4. Tighten the bolts (1-8) a final pass in sequence an additional 30 degrees using **EN-45059** angle meter.
3. Remove the **EN-42386-A** flywheel holding tool .
4. Install the clutch assemble. Refer to **Clutch Assembly Replacement** .

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Special Tools

- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

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For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement** .
2. Install the **EN-42386-A** flywheel holding tool in order to lock the flywheel.

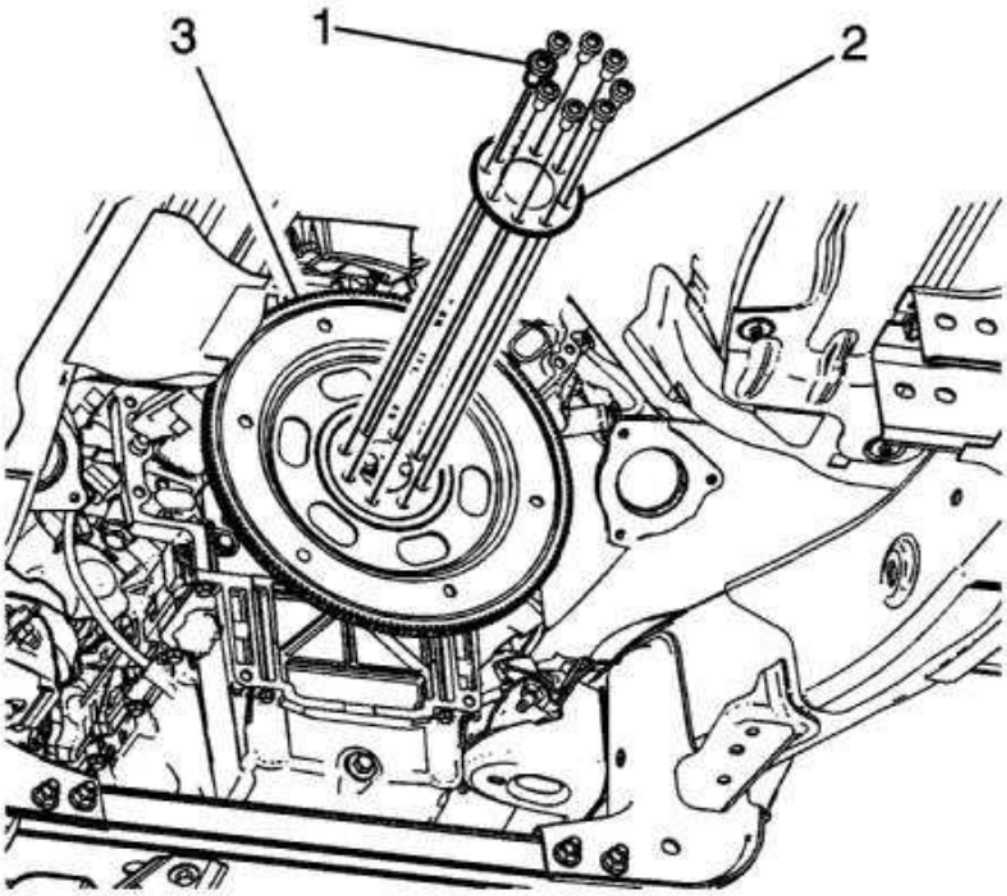

Fig. 211: Automatic Transmission Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.**

3. Remove and DISCARD the automatic transmission flex plate bolts (1).
4. Remove the automatic transmission flex plate washer (2).
5. Remove the automatic transmission flex plate assembly (3).
6. Remove the **EN-42386-A** flywheel holding tool .

Installation Procedure

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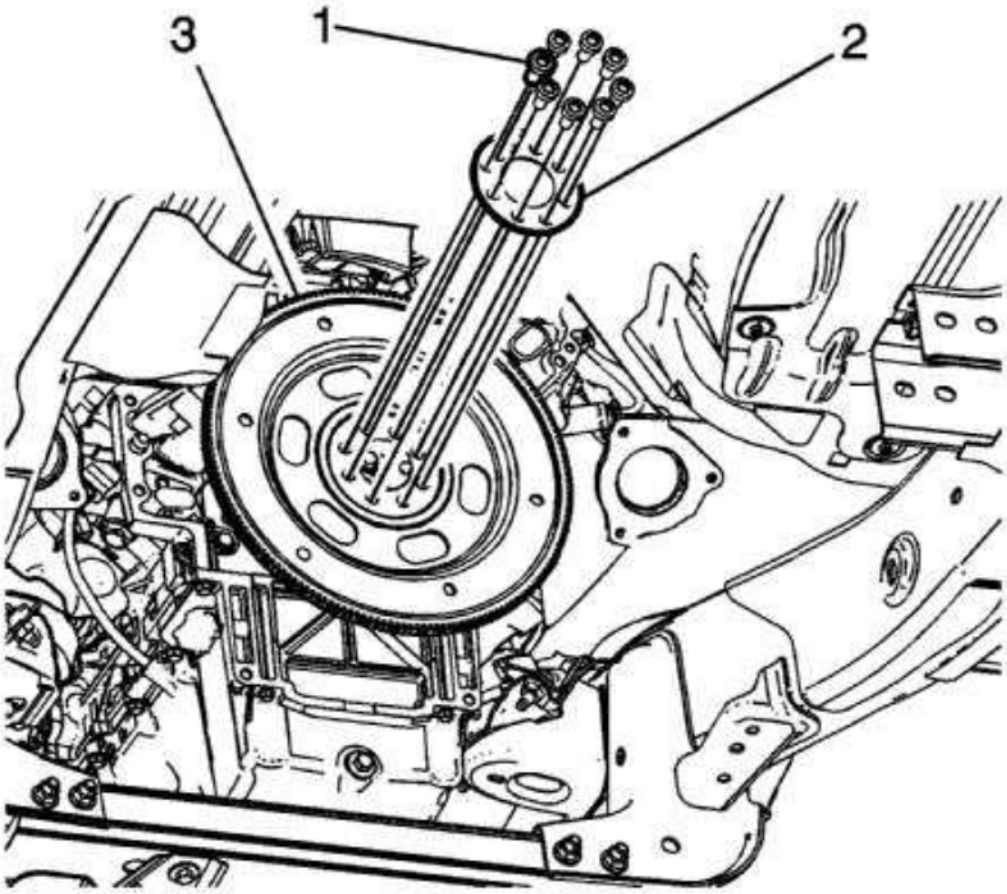

Fig. 212: Automatic Transmission Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.**

1. Install the flex plate (1) to the crankshaft.
2. Install the flex plate washer (2).

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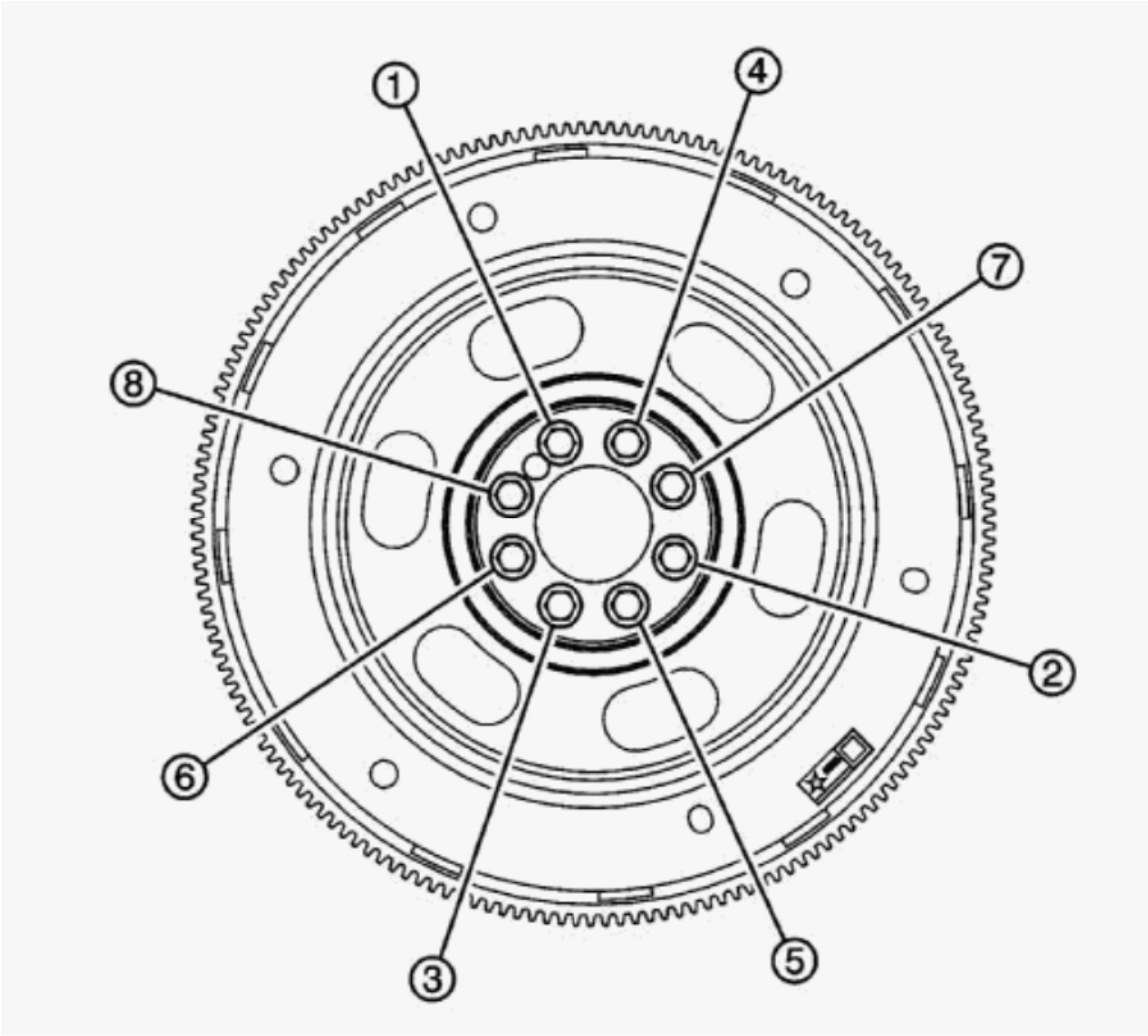

Fig. 213: NEW Engine Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

3. Install the NEW engine flex plate bolts.
    1. Install the **EN-42386-A** flywheel holding tool .
    2. Tighten the engine flex plate bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).
    3. Tighten the engine flex plate bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
    4. Tighten the engine flex plate bolts (1-8) a final pass in sequence an additional 30 degrees using **EN-45059** angle meter.
4. Remove the **EN-42386-A** flywheel holding tool .
5. Install the transmission. Refer to **Transmission Replacement** .

ENGINE REPLACEMENT

Special Tools

- **J-21366** Converter Holding Strap
- **J-36857** Engine Lift Bracket (Qty 2)

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For equivalent regional tools, refer to **Special Tools** .

Removal Procedure

1. Place the hood in the service position. Refer to **Hood Service Positioning** .

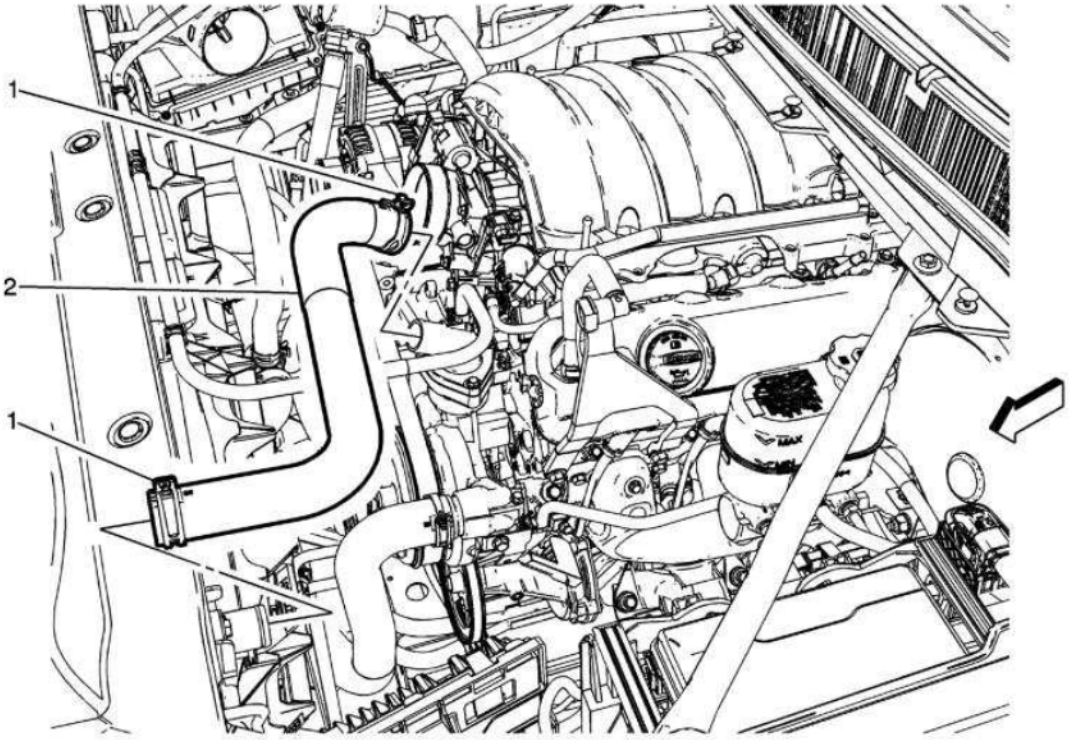

Fig. 214: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

2. Remove the radiator inlet hose (2). Refer to **Radiator Inlet Hose Replacement (LV3)** .

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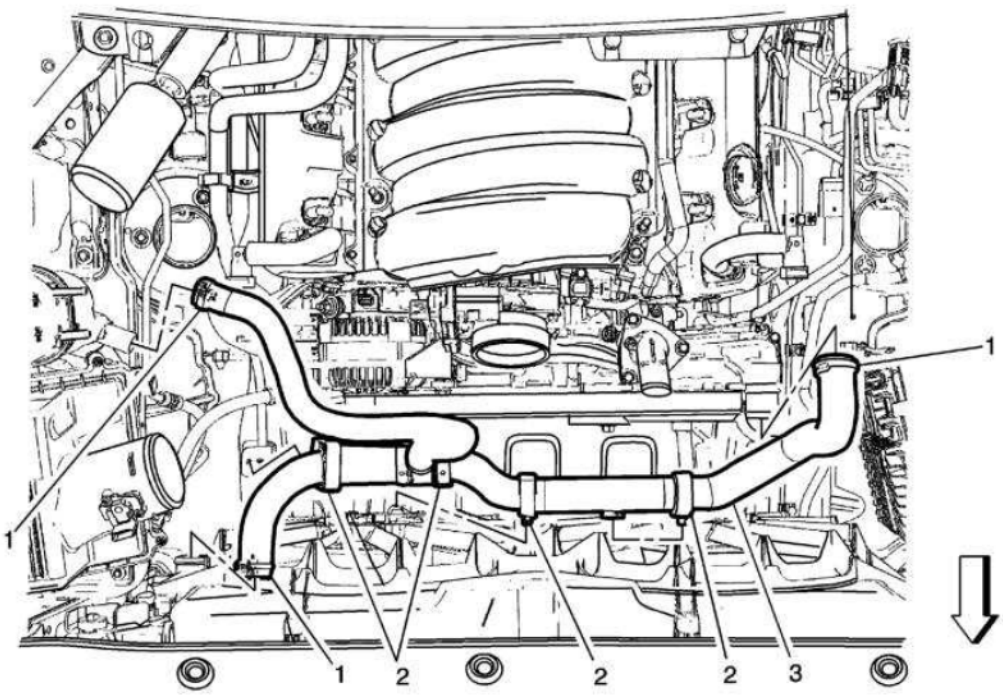

Fig. 215: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

3. Remove the radiator outlet hose (3). Refer to **Radiator Outlet Hose Replacement (LV3)** .

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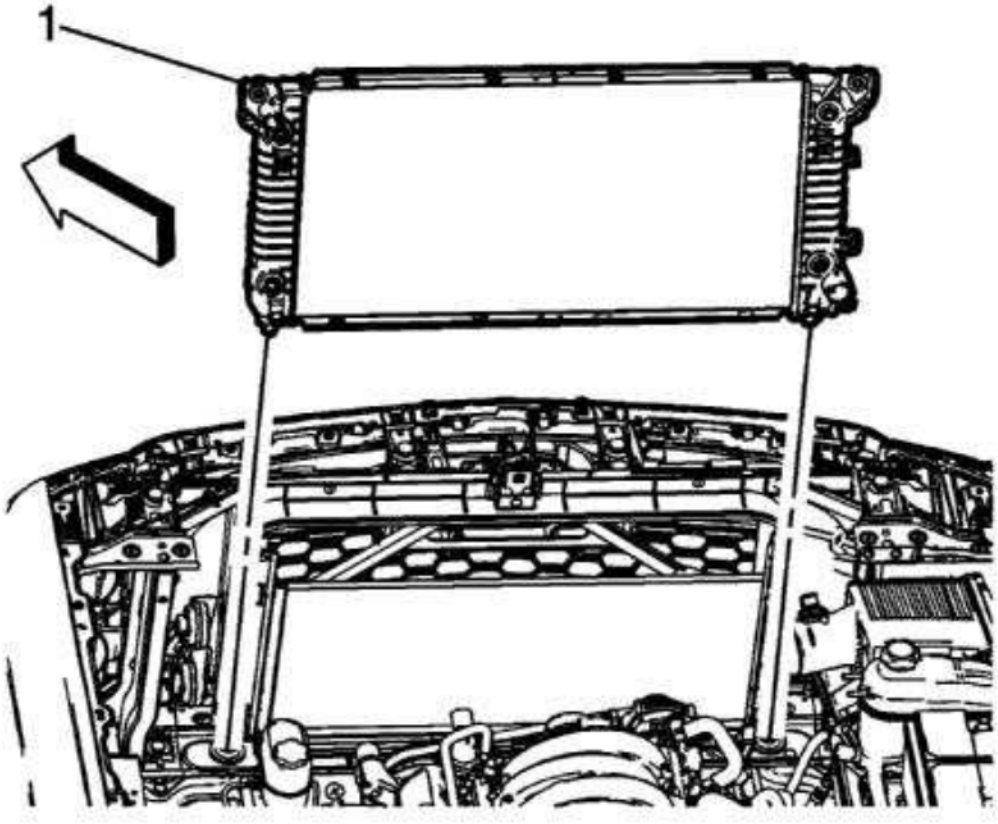

Fig. 216: Radiator
Courtesy of GENERAL MOTORS COMPANY

4. Remove the radiator. Refer to **Radiator Replacement (LV3)** .

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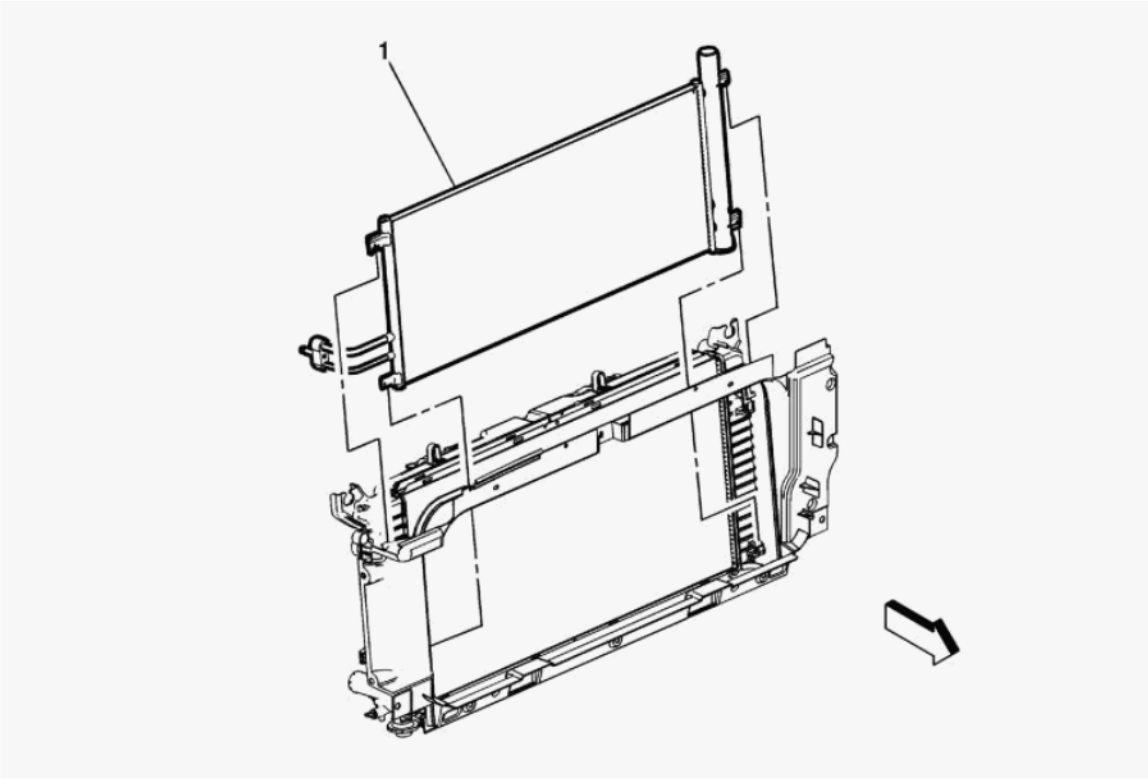

Fig. 217: Air Conditioning Condenser (LV3)
Courtesy of GENERAL MOTORS COMPANY

5. Remove the air conditioning condenser. Refer to **Air Conditioning Condenser Replacement (LV3)** .
6. Remove the headlamp and radiator grille mount panel. Refer to **Headlamp and Radiator Grille Mount Panel Replacement (Without LP)** **Headlamp and Radiator Grille Mount Panel Replacement (With LP5)** .
7. Remove the front end upper tie bar support. Refer to **Front End Upper Tie Bar Support Replacement** .

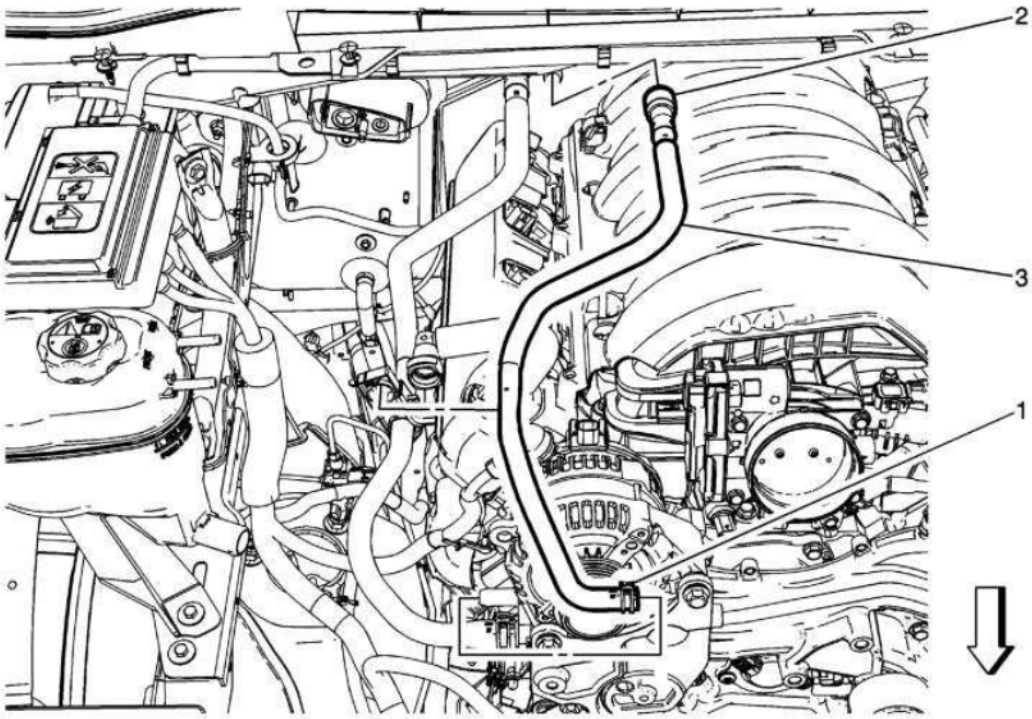

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Fig. 218: Heater Inlet Hose (LV3)
Courtesy of GENERAL MOTORS COMPANY

8. Remove the heater inlet hose (1). Refer to **Heater Inlet Hose Replacement (LV3)** .
9. Remove the heater outlet hose. Refer to **Heater Outlet Hose Replacement (LV3)** .

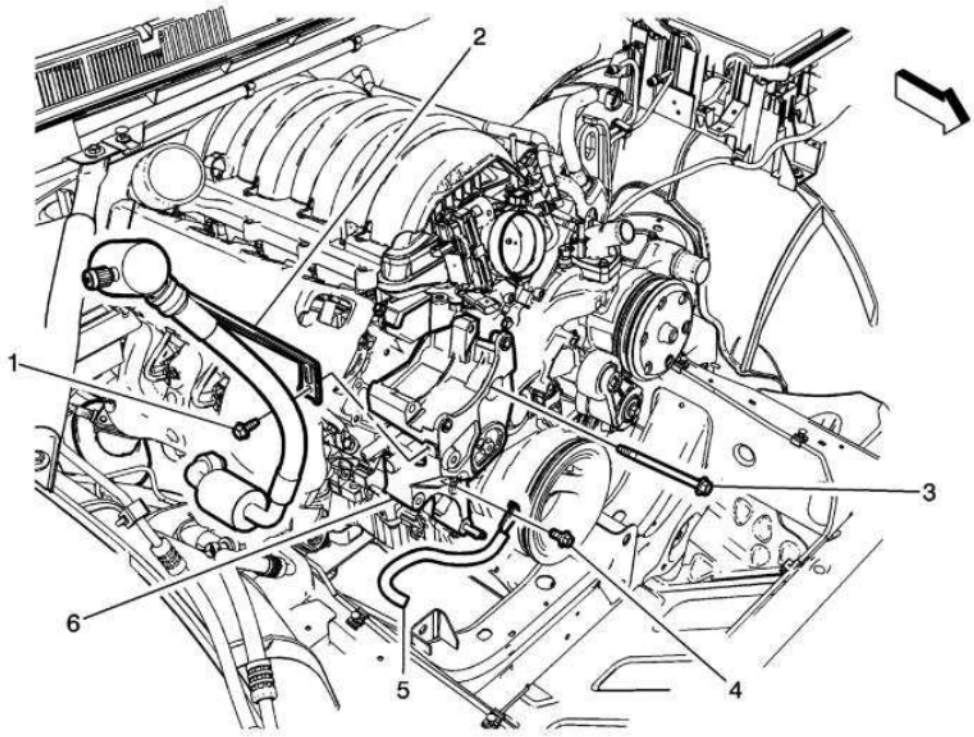

Fig. 219: Generator Bracket (LV3)
Courtesy of GENERAL MOTORS COMPANY

10. Remove the generator bracket (6) from the engine assembly. Refer to **Generator Bracket Replacement (LV3)** .

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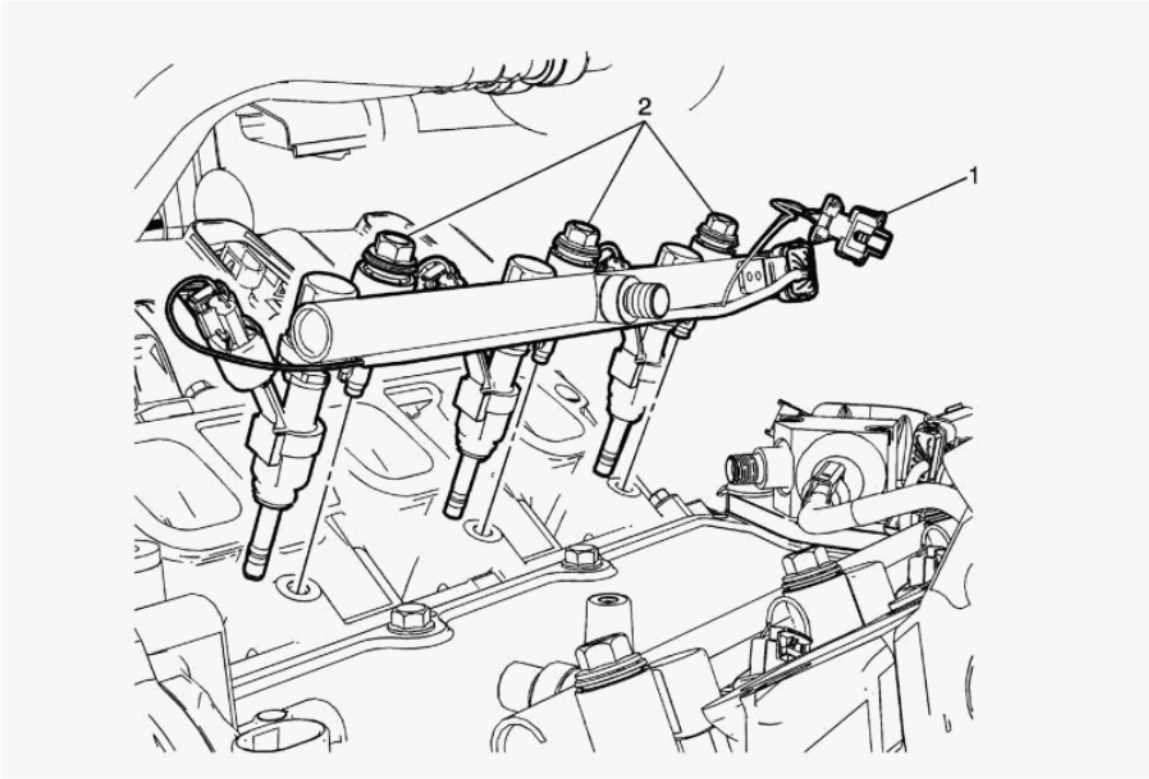

Fig. 220: Fuel Injection Fuel Rail Assembly -- bank 2
Courtesy of GENERAL MOTORS COMPANY

11. Remove the fuel injection fuel rail assembly - bank 2 (2). refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .

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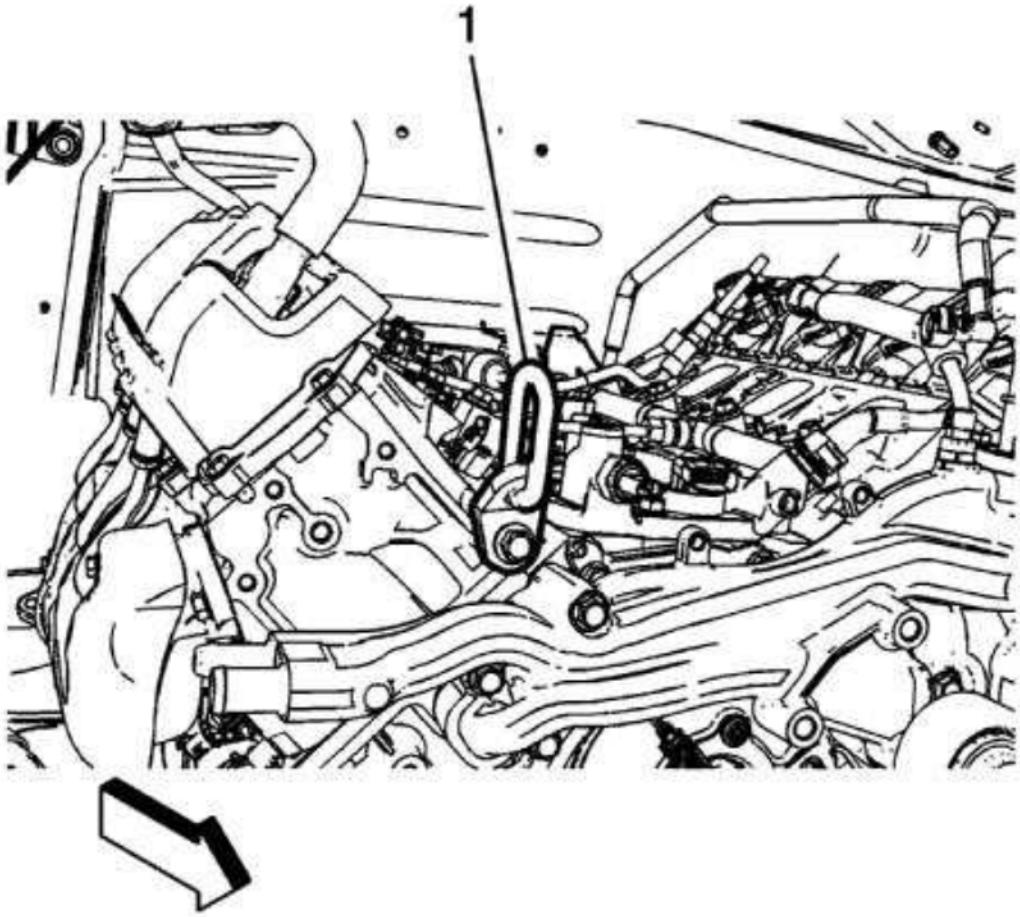

Fig. 221: Front Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure using a correct length bolt to keep the engine lift bracket firmly against the cylinder head.**

12. Install the front engine lift bracket (1) to the position shown.

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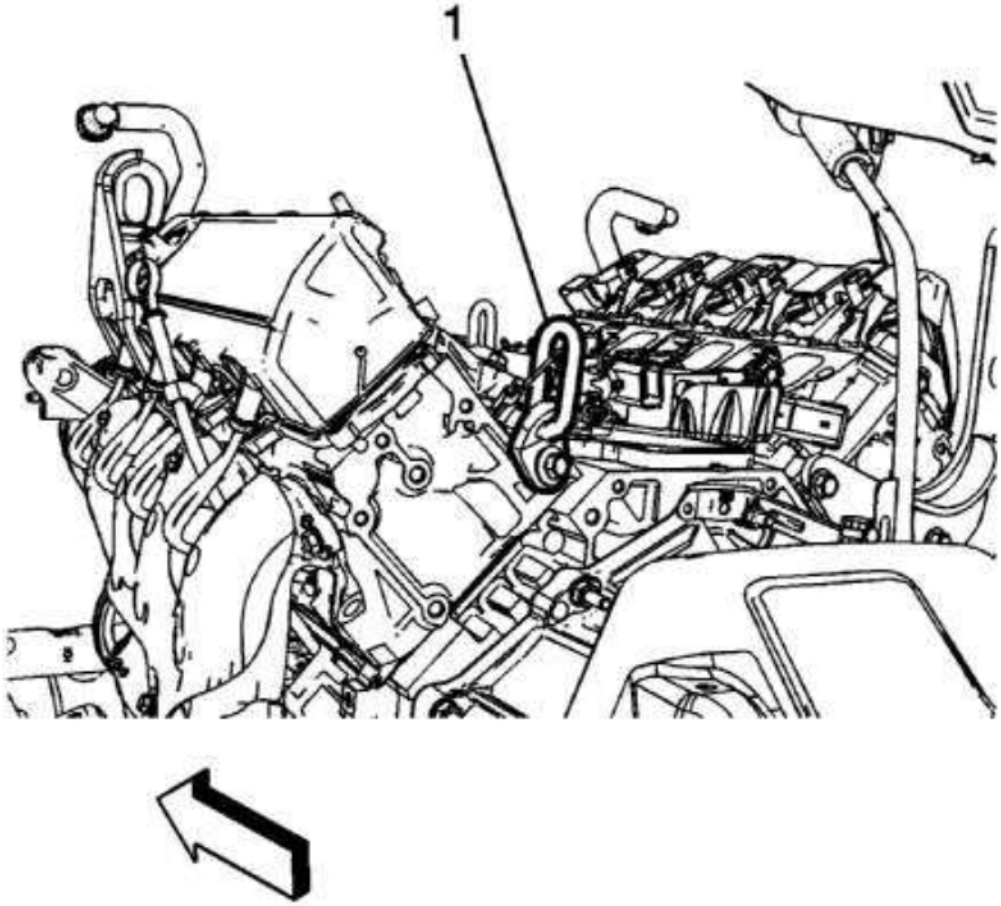

Fig. 222: Rear Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure using a correct length bolt to keep the engine lift bracket firmly against the cylinder head.**

13. Install the rear engine lift bracket (1) to the position shown.

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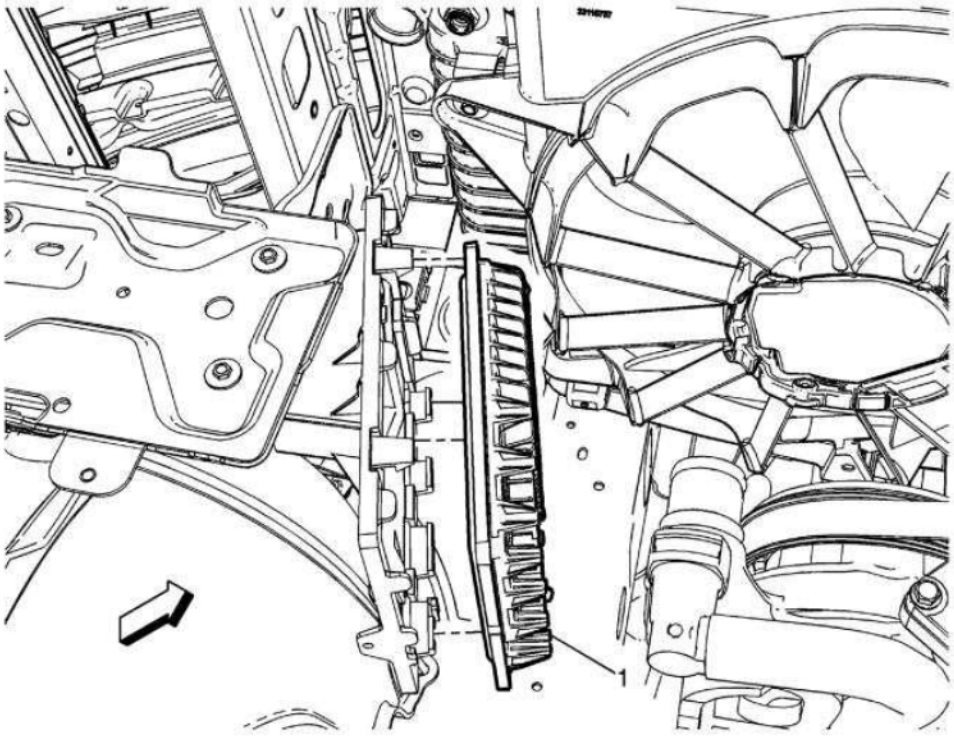

Fig. 223: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

14. Remove the engine control module (1). Refer to **Engine Control Module Replacement** .

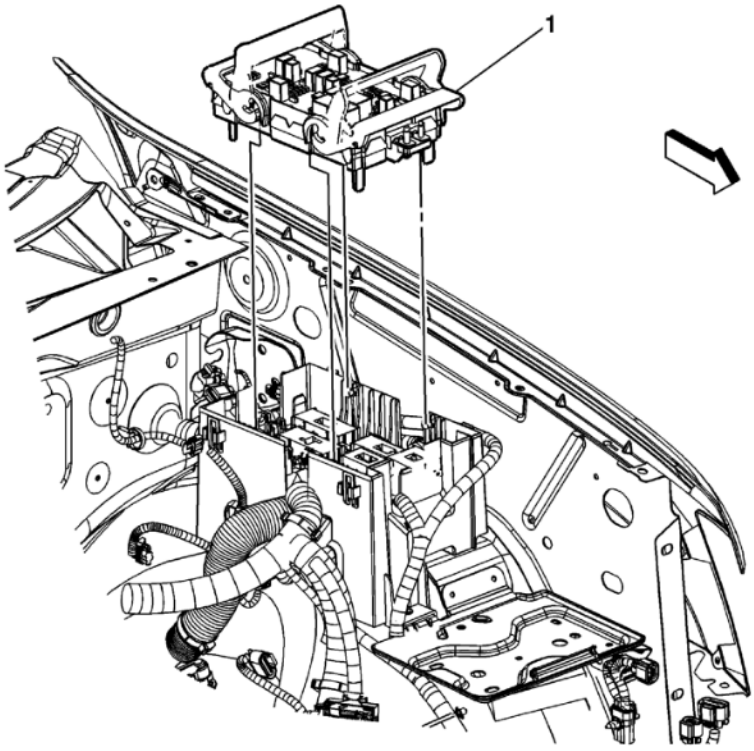

Fig. 224: View Of Underhood Electrical Center/Junction Block
Courtesy of GENERAL MOTORS COMPANY

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15. Disconnect the engine main wiring harness from the underhood electrical center junction block (1). Refer to **Underhood Electrical Center or Junction Block Replacement** .
16. Position the engine main wiring harness on to the engine assembly.

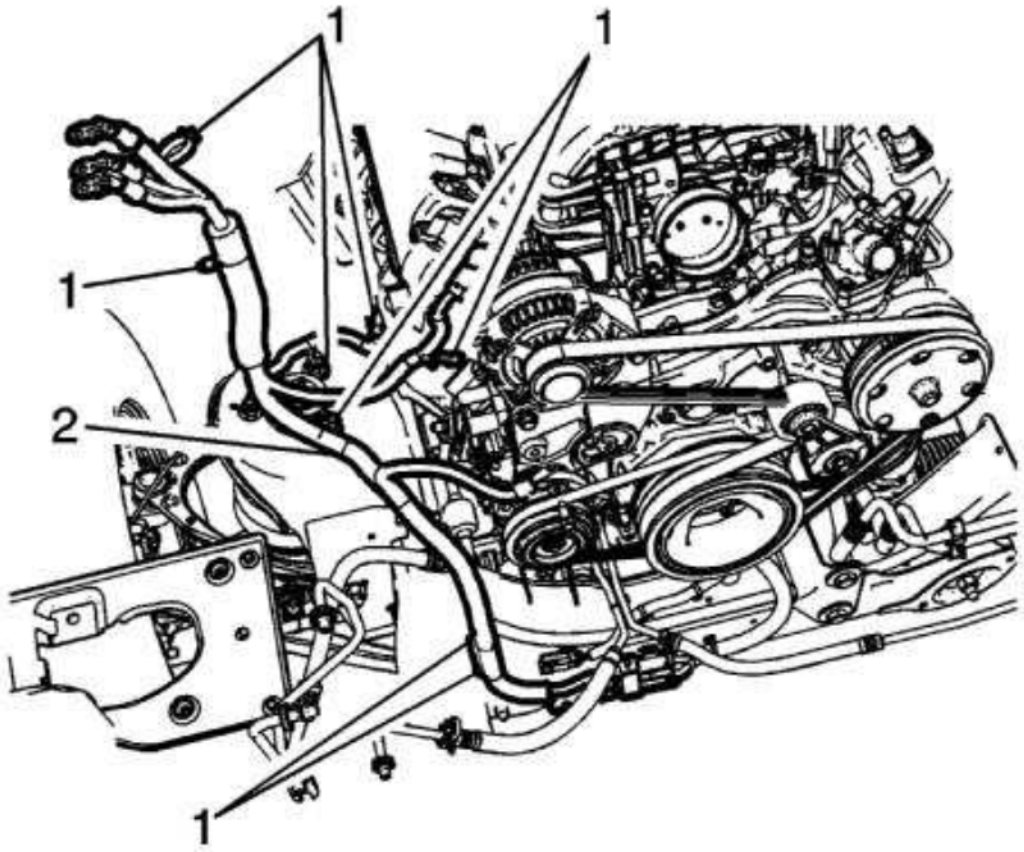

Fig. 225: Generator Battery Control Wiring Harness Retainers And Generator Battery Control Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

17. Remove the generator battery control wiring harness (2). Refer to **Generator Battery Control Wiring Harness Replacement (L83, L8B, LV3)** .
18. Disconnect the fuel feed pipe from the fuel pump feed pipe. Refer to **Metal Collar Quick Connect Fitting Service** .
19. Remove the engine oil cooler hose assembly from the engine. Refer to **Engine Oil Cooler Hose Replacement**.

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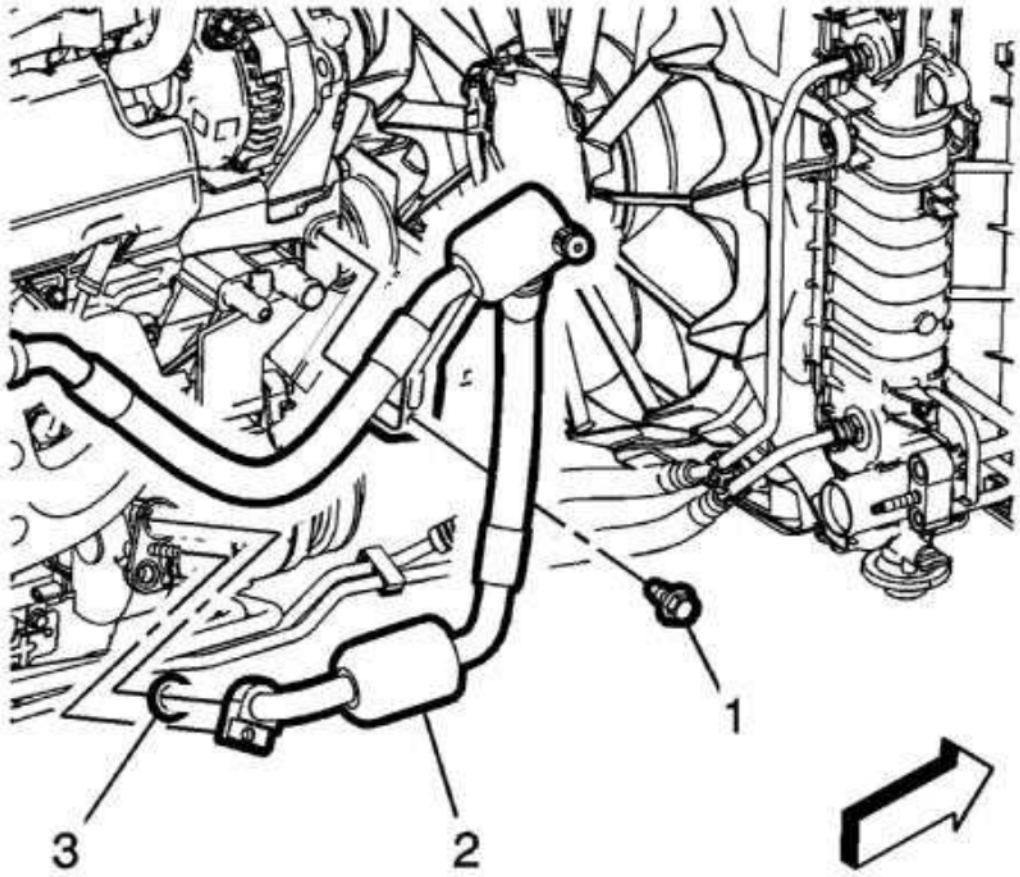

Fig. 226: Air Conditioning Tube Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

20. Remove the air conditioning tube bracket bolt (1) from the generator and drive belt tensioner bracket.
21. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
22. If the vehicle is equipped with a transfer case, remove the front propeller shaft. Refer to **Front Axle Propeller Shaft Replacement** .

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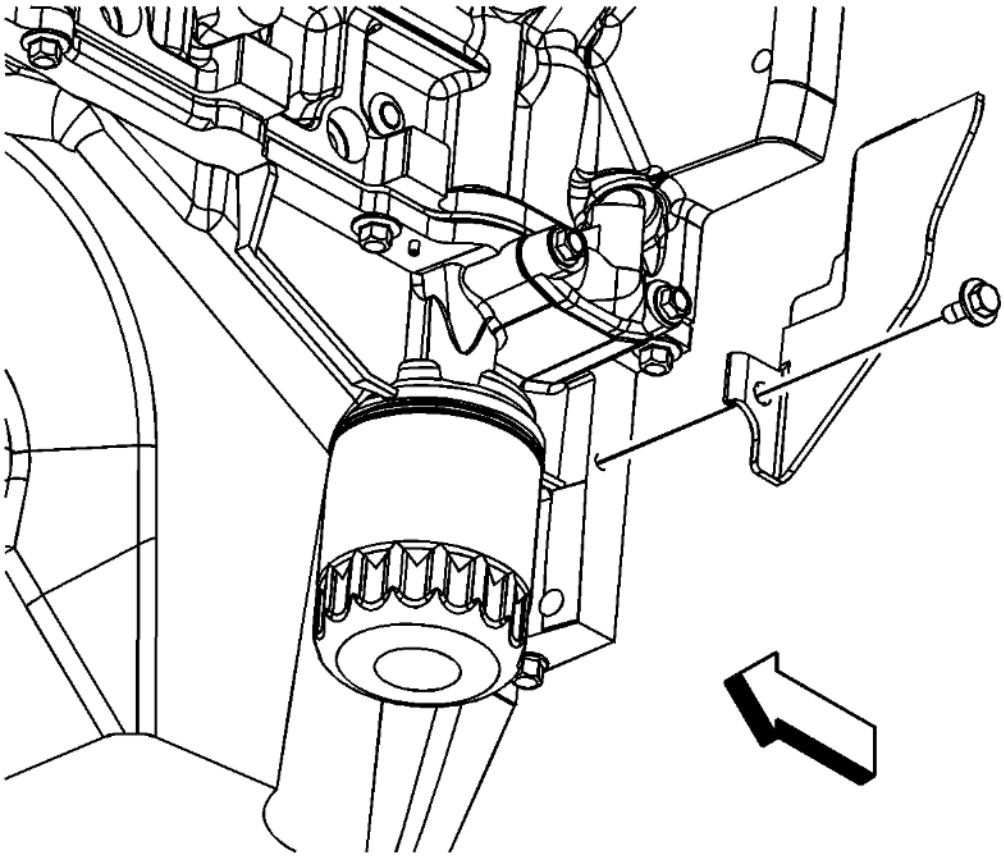

Fig. 227: View Of Left Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

23. Remove the left flywheel inspection cover.
24. Remove the starter motor. Refer to **Starter Replacement (LV3)** .

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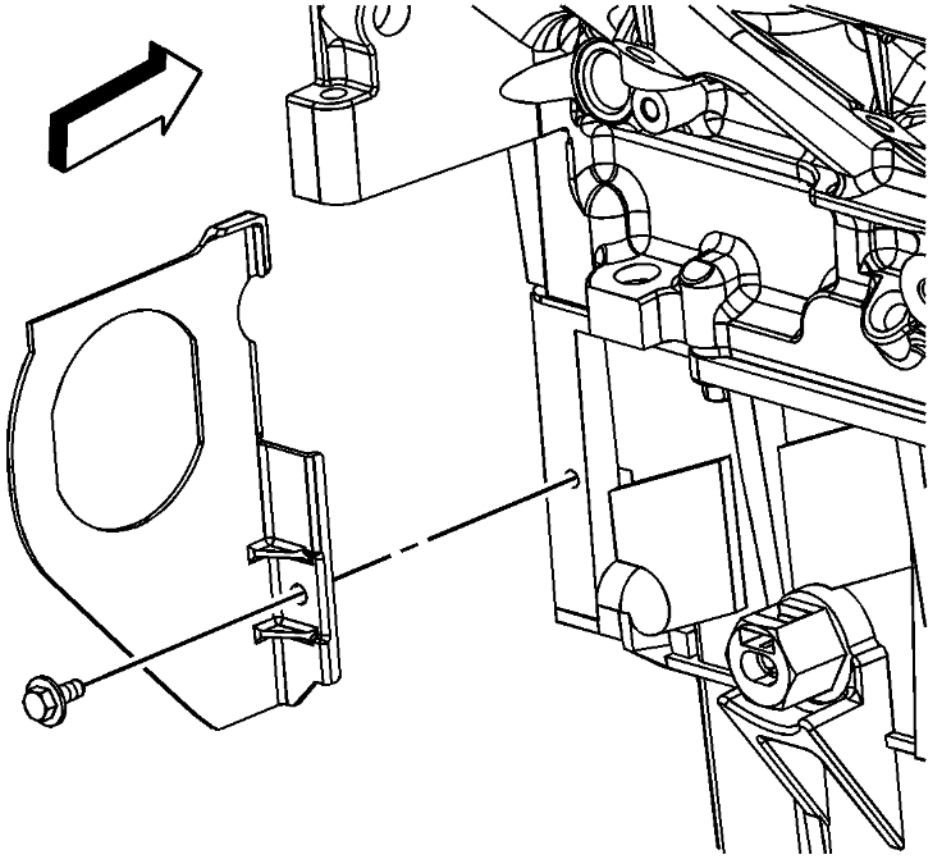

Fig. 228: View Of Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

25. Remove the right flywheel inspection cover.
26. Support the transmission with a transmission jack.

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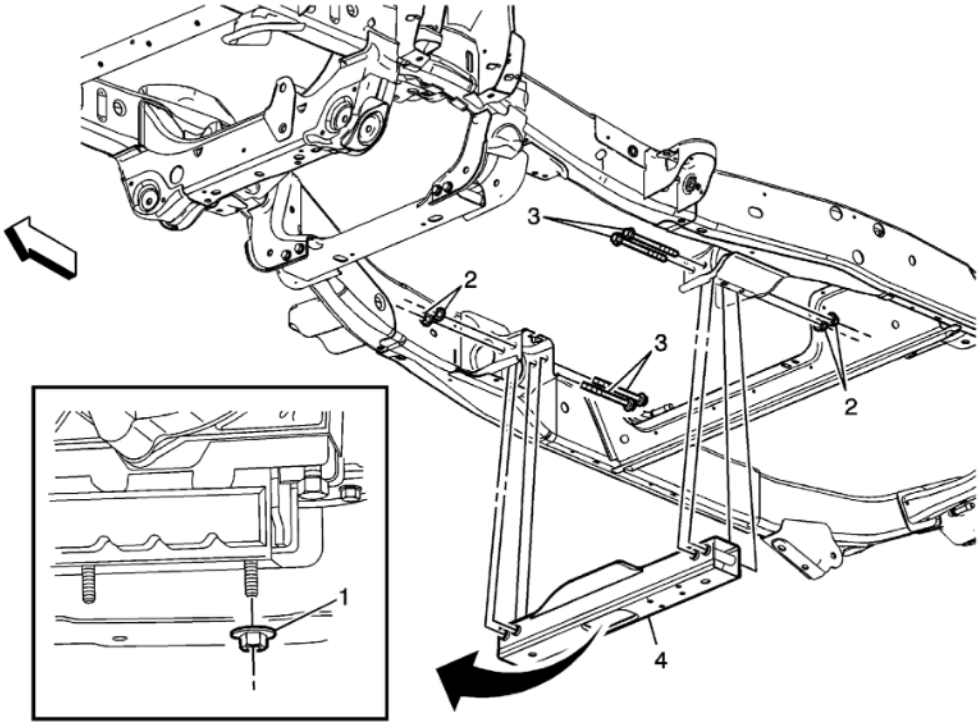

Fig. 229: View Of Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

27. Remove the transmission crossmember (4). Refer to **Transmission Support Crossmember Replacement (2WD - Light Duty)** **Transmission Support Crossmember Replacement (2WD - Heavy Duty)** **Transmission Support Crossmember Replacement (4WD - Light Duty)** **Transmission Support Crossmember Replacement (4WD - Heavy Duty)** .
28. Remove the three-way catalytic converter. Refer to **Three-Way Catalytic Converter Replacement (LV3, L83, L8B, or L86)** .

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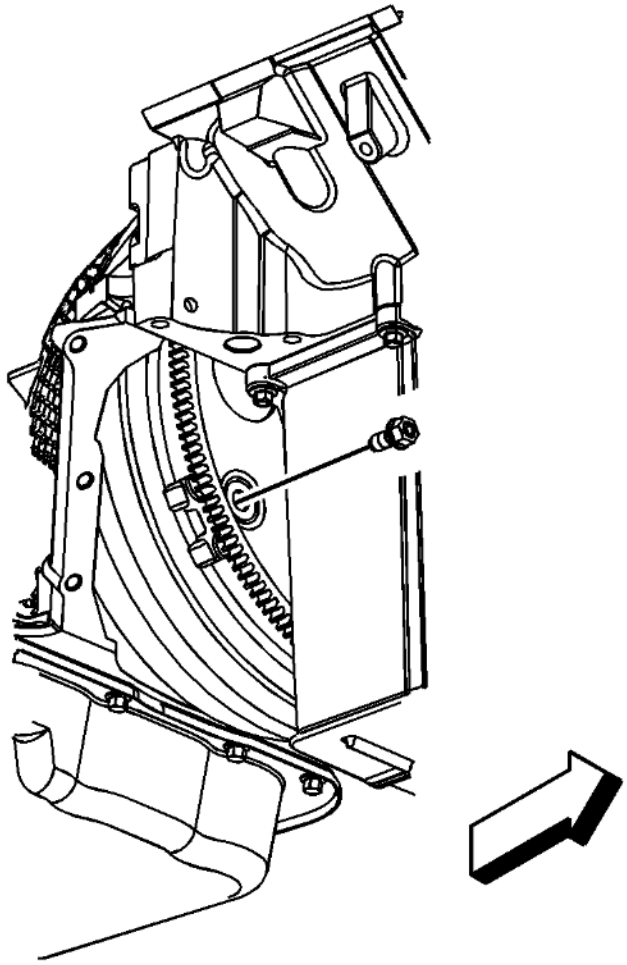

Fig. 230: View Of Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS COMPANY

29. Remove the flywheel to torque converter bolts.
30. Lower the transmission to gain access to the top and sides of the transmission.

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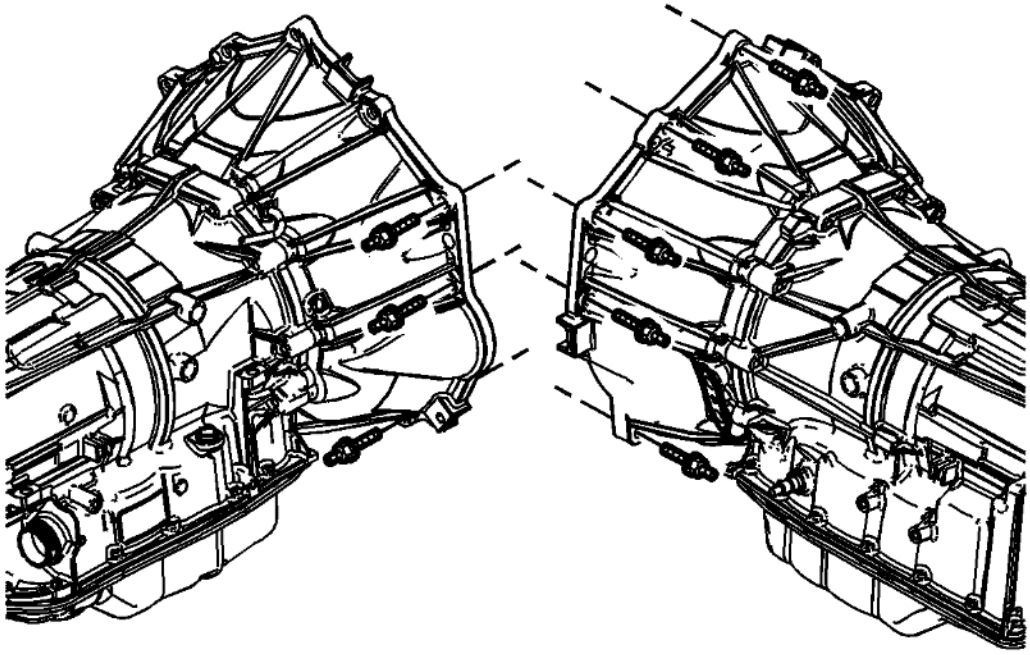

Fig. 231: View Of Transmission Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Leave the two lower transmission bolts in place.**

31. Remove the 6 upper bolts securing the transmission to the engine.
32. Raise the transmission to the original installation position.

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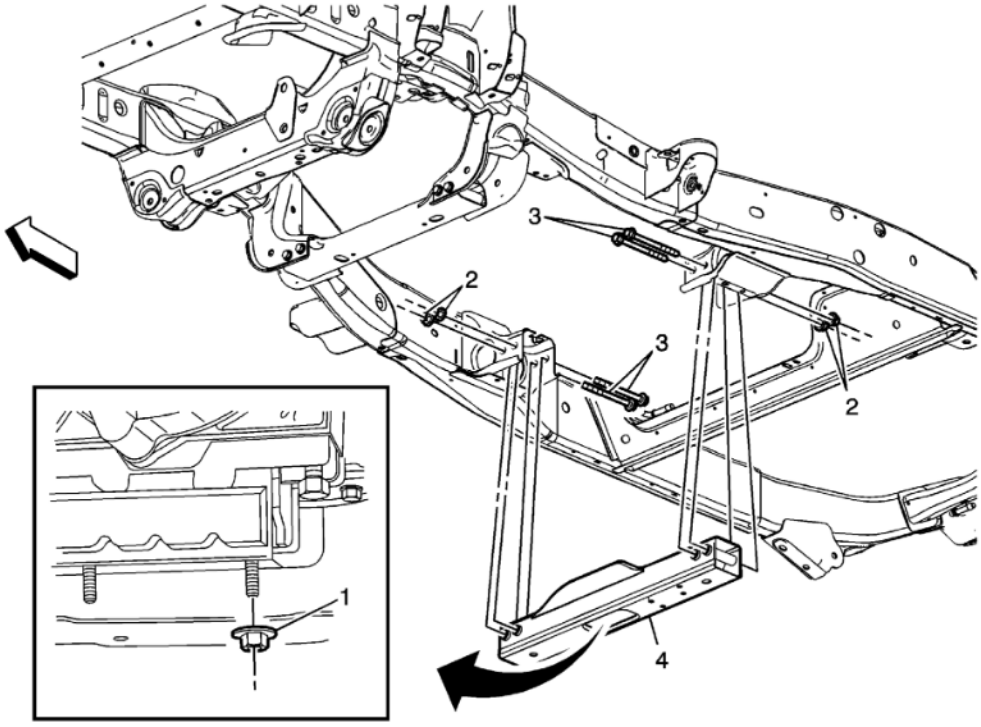

Fig. 232: View Of Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

33. Temporary install the transmission crossmember (4) to support the transmission.
34. Disconnect the electrical connectors from the transmission assembly, then position the wiring harness on the engine assembly.

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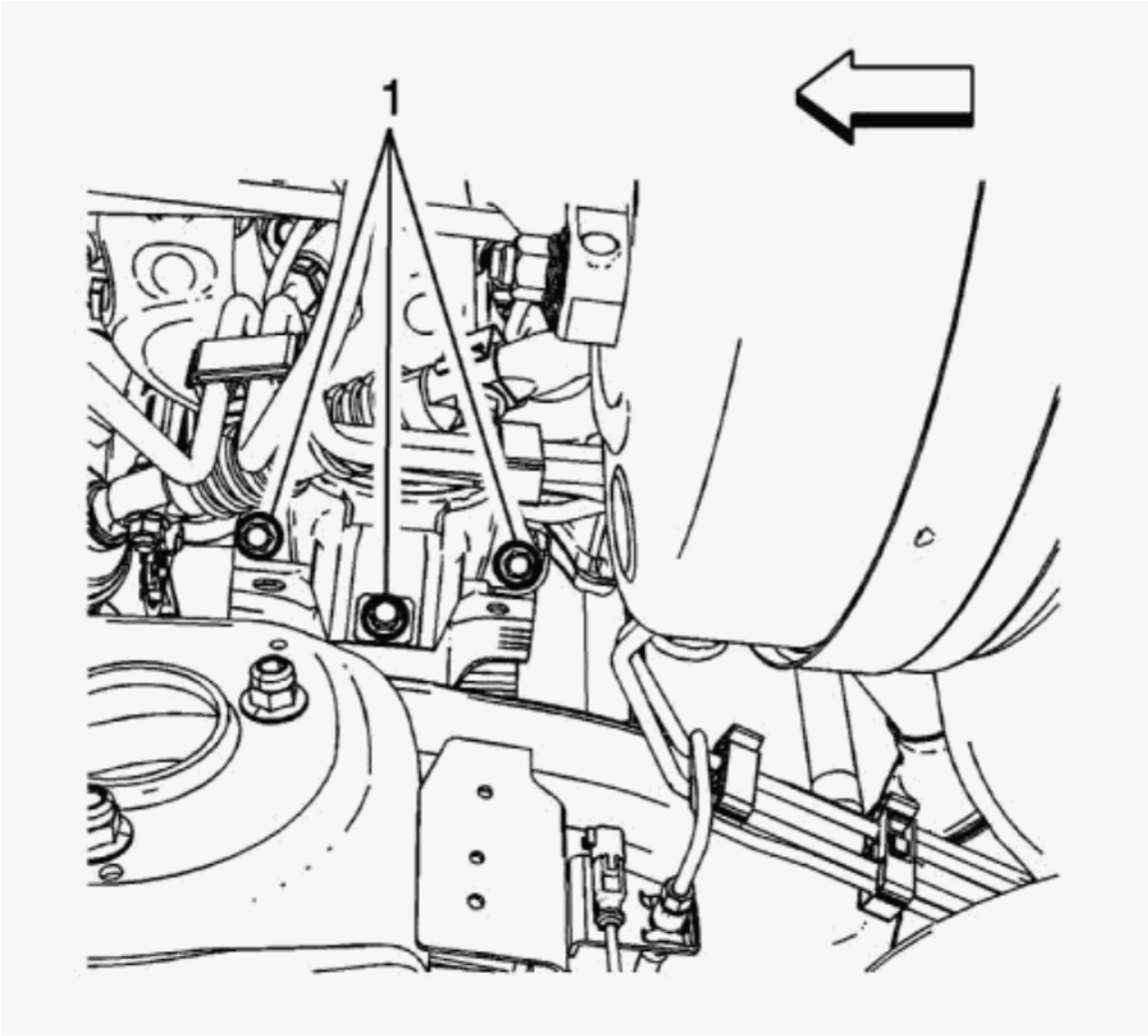

Fig. 233: Left Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

35. Remove the left upper engine mount bolts (1). Refer to **Engine Mount Replacement - Left Side**.

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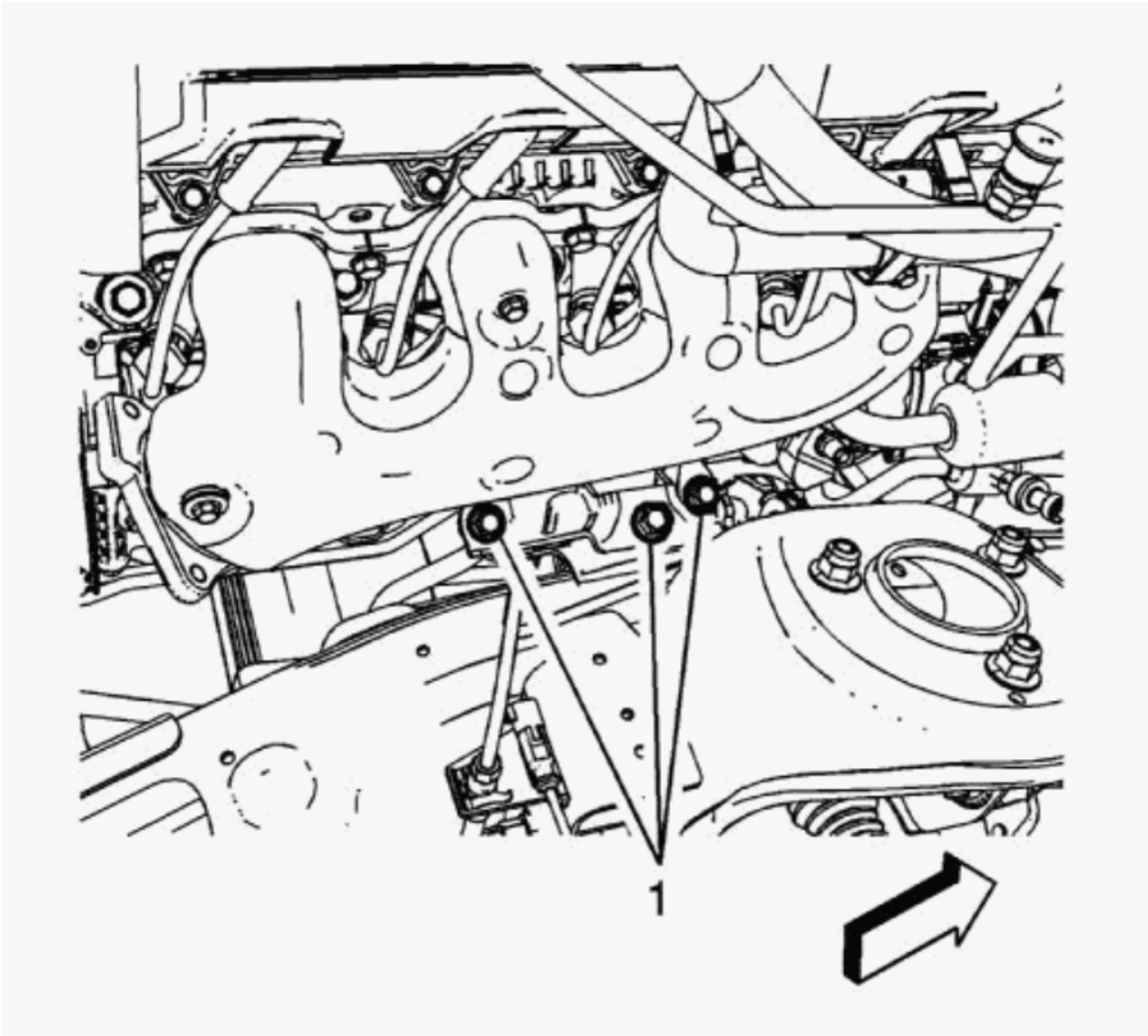

Fig. 234: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

36. Remove the right upper engine mount bolts (1). Refer to **Engine Mount Replacement - Right Side**.
37. Install a suitable chain as tight as possible to the two engine lift brackets.
38. Remove the two lower transmission to engine retaining bolts.
39. Using a suitable engine lifting device, remove the engine from the vehicle.
40. Install the **J-21366** strap onto the transmission bell housing to retain the torque converter.
41. Transfer components as necessary.

Installation Procedure

1. Remove the **J-21366** strap from the transmission bell housing which is retaining the torque converter.
2. Install the engine to the vehicle.
3. Align and install the engine to the transmission. Raise or lower the transmission as required using a suitable jack.

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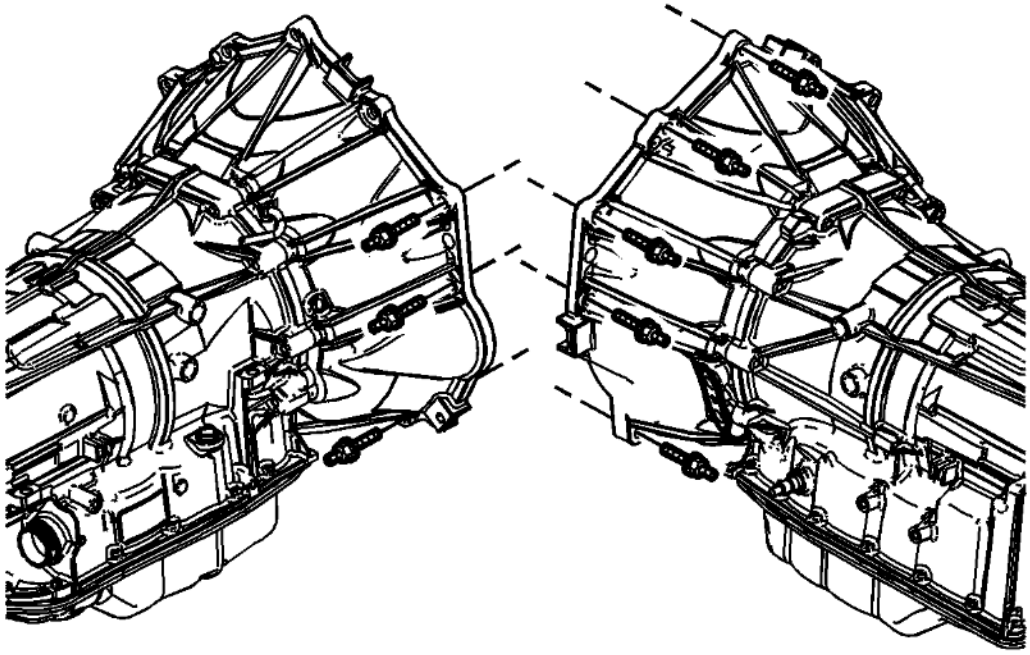

Fig. 235: View Of Transmission Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

4. Install the 2 lower bolts securing the transmission to the engine and tighten to 50 N.m (37 lb ft).
5. Once aligned and mated together completely lower and remove the engine lift brackets.

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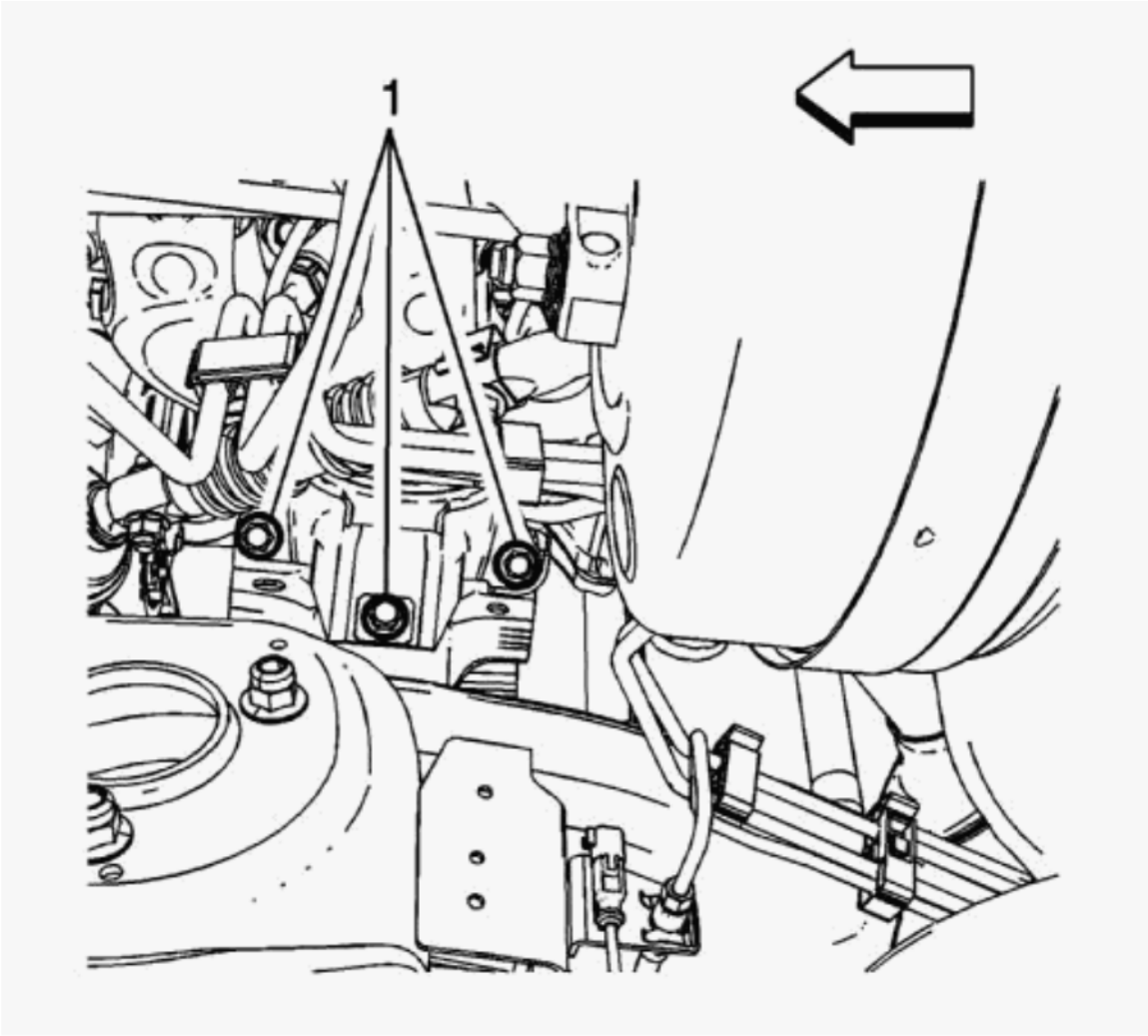

Fig. 236: Left Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Install the left upper engine mount bolts (1). Refer to **Engine Mount Replacement - Left Side**.

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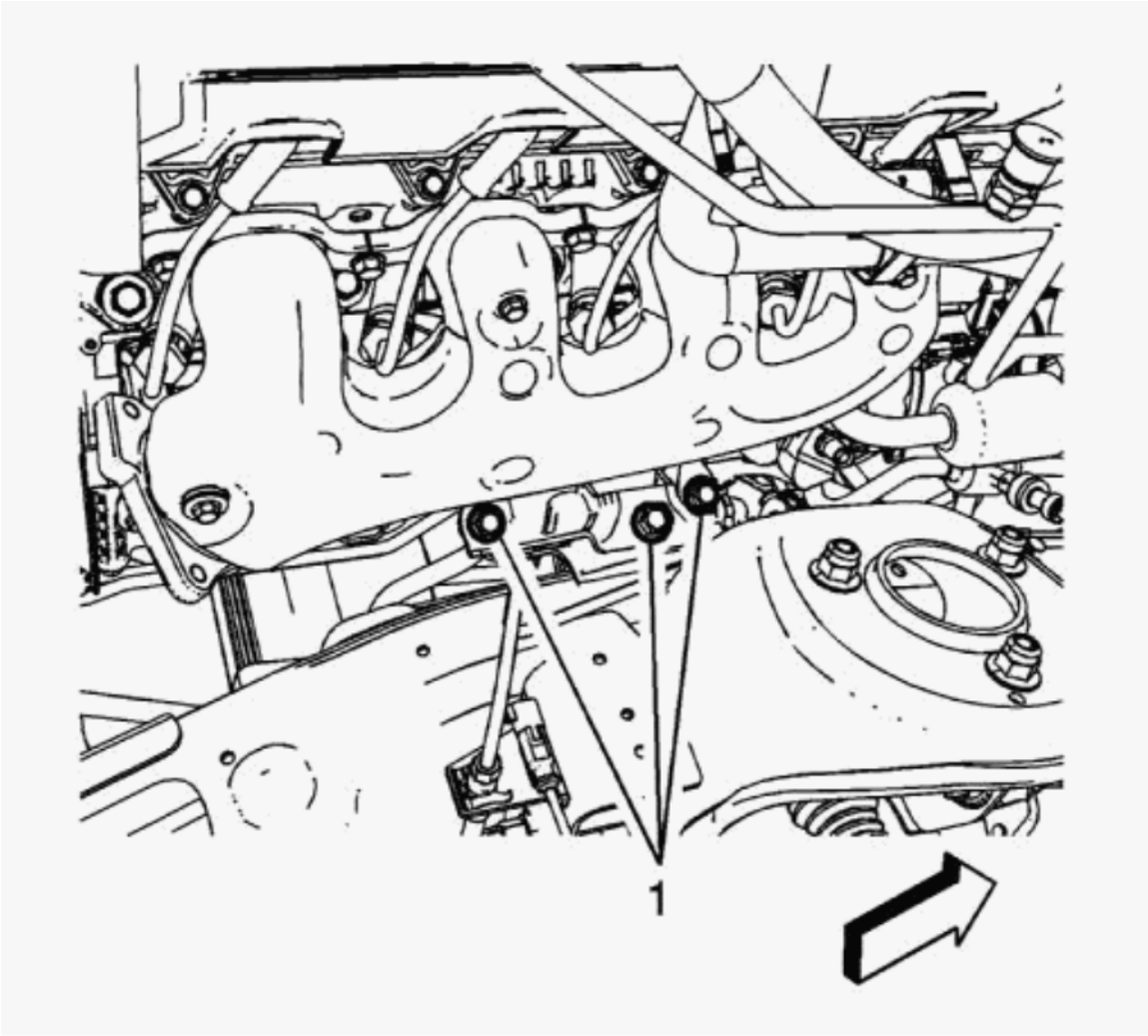

Fig. 237: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Install the right upper engine mount bolts (1). Refer to **Engine Mount Replacement - Right Side**.
8. Raise the vehicle.

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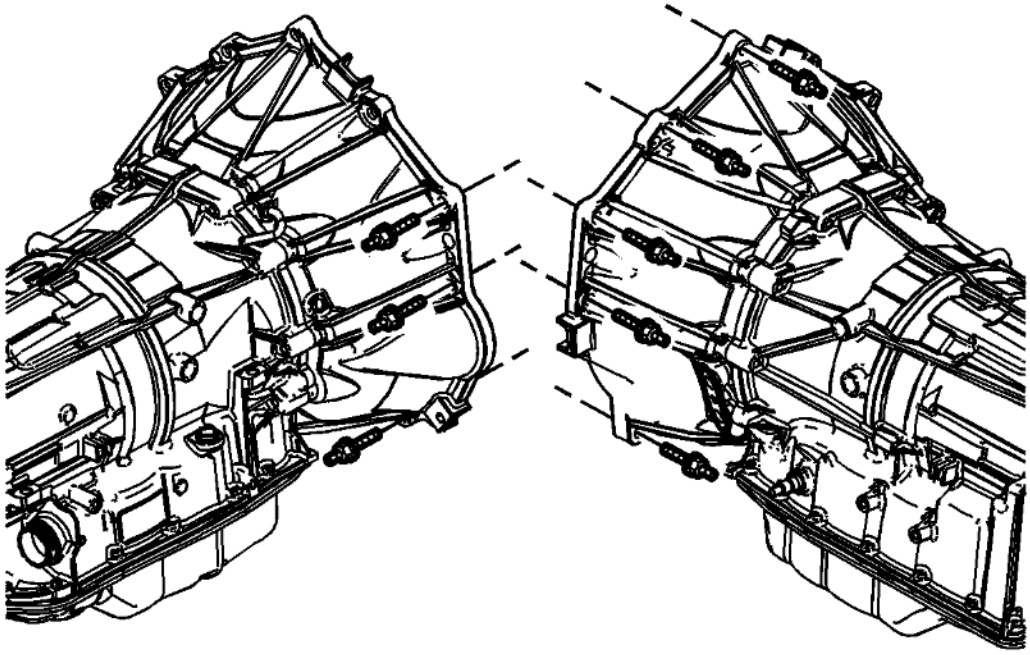

Fig. 238: View Of Transmission Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Install the 6 upper bolts securing the transmission to the engine and tighten to 50 N.m (37 lb ft).

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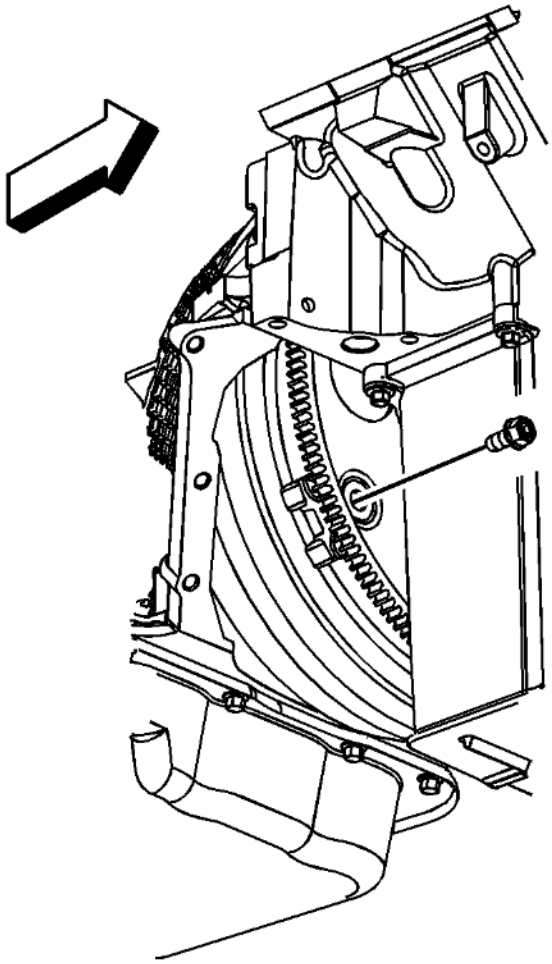

Fig. 239: View Of Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Align the torque converter bolt holes to the flywheel bolt holes.
11. Install the flywheel to torque converter bolts and tighten to 60 N.m (44 lb ft).
12. Install the three-way catalytic converter. Refer to **Three-Way Catalytic Converter Replacement (LV3, L83, L8B, or L86)** .

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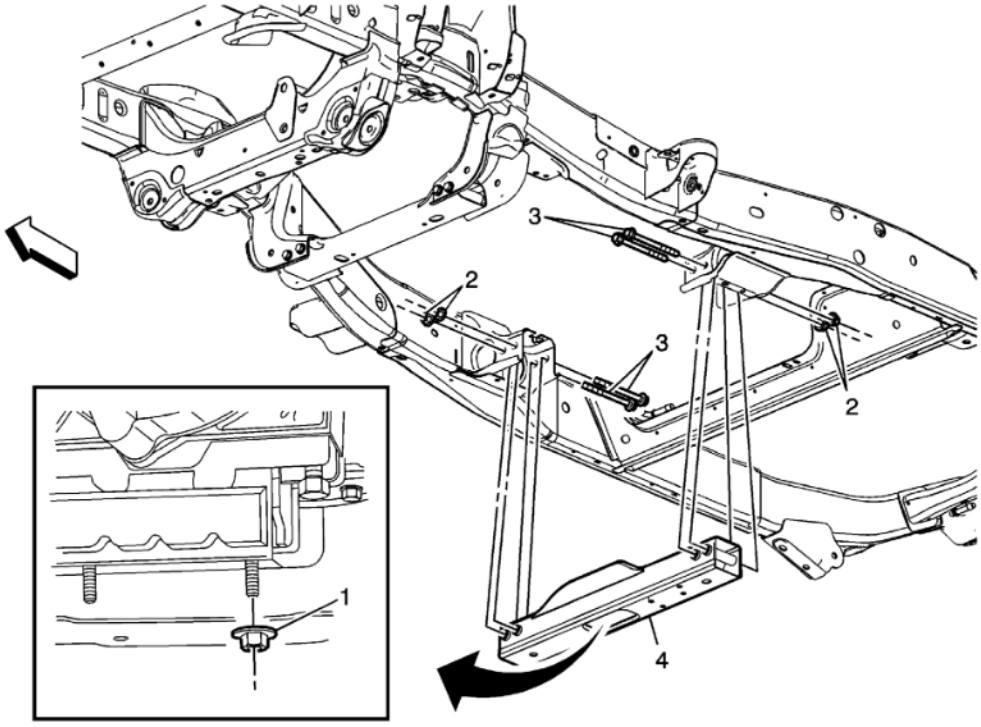

Fig. 240: View Of Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

13. Install the transmission crossmember (4). Refer to **Transmission Support Crossmember Replacement (2WD - Light Duty)** **Transmission Support Crossmember Replacement (2WD - Heavy Duty)** **Transmission Support Crossmember Replacement (4WD - Light Duty)** **Transmission Support Crossmember Replacement (4WD - Heavy Duty)** .
14. Connect the electrical connectors to the transmission assembly.

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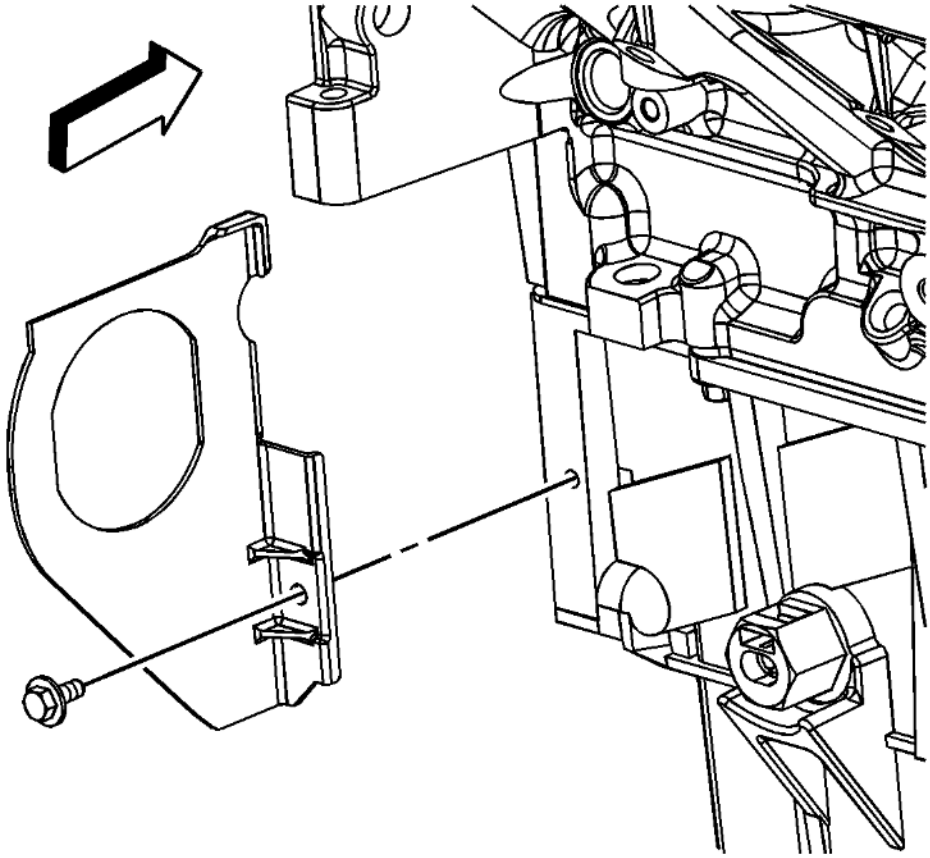

Fig. 241: View Of Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

15. Install the right flywheel inspection cover and bolt. Tighten the bolt to 10 N.m (89 lb in).
16. Install the starter motor. Refer to **Starter Replacement (LV3)** .

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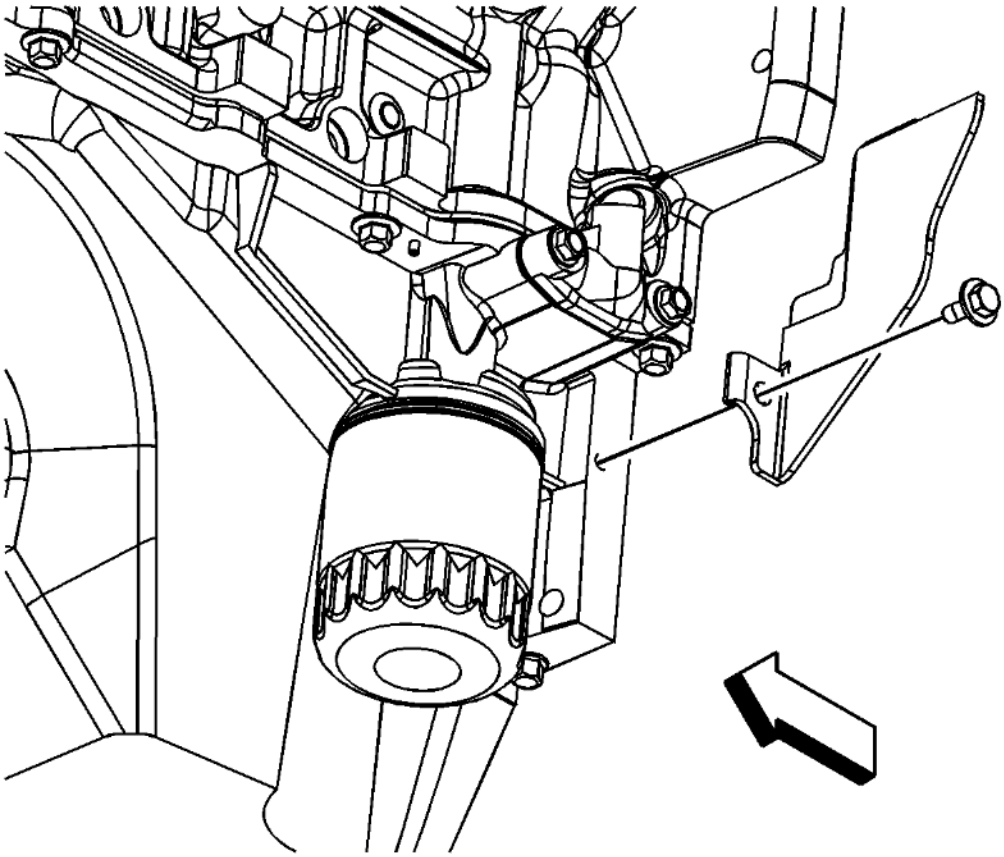

Fig. 242: View Of Left Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

17. Install the left flywheel inspection cover and bolt. Tighten the bolt to 10 N.m (89 lb in).
18. If the vehicle is equipped with a transfer case, install the front propeller shaft. Refer to **Front Axle Propeller Shaft Replacement** .
19. Lower the vehicle.

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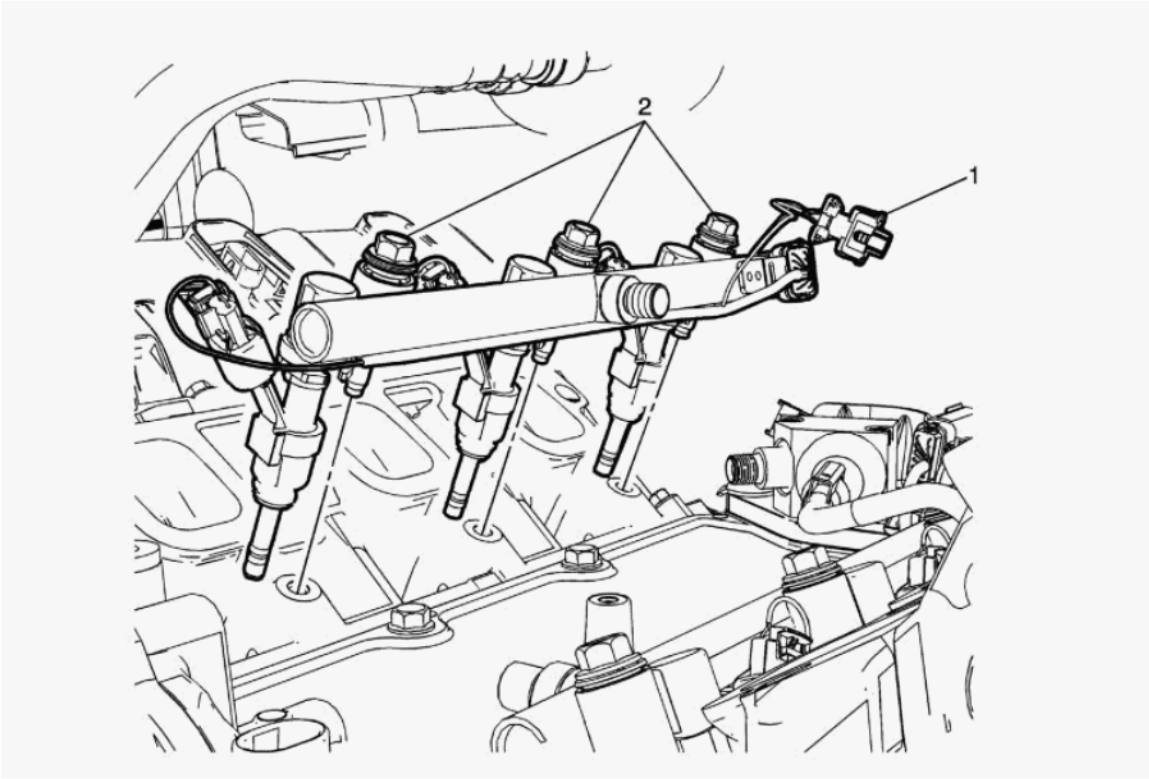

Fig. 243: Fuel Injection Fuel Rail Assembly -- bank 2
Courtesy of GENERAL MOTORS COMPANY

20. Install the fuel injection fuel rail assembly - bank 2 (2). refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .

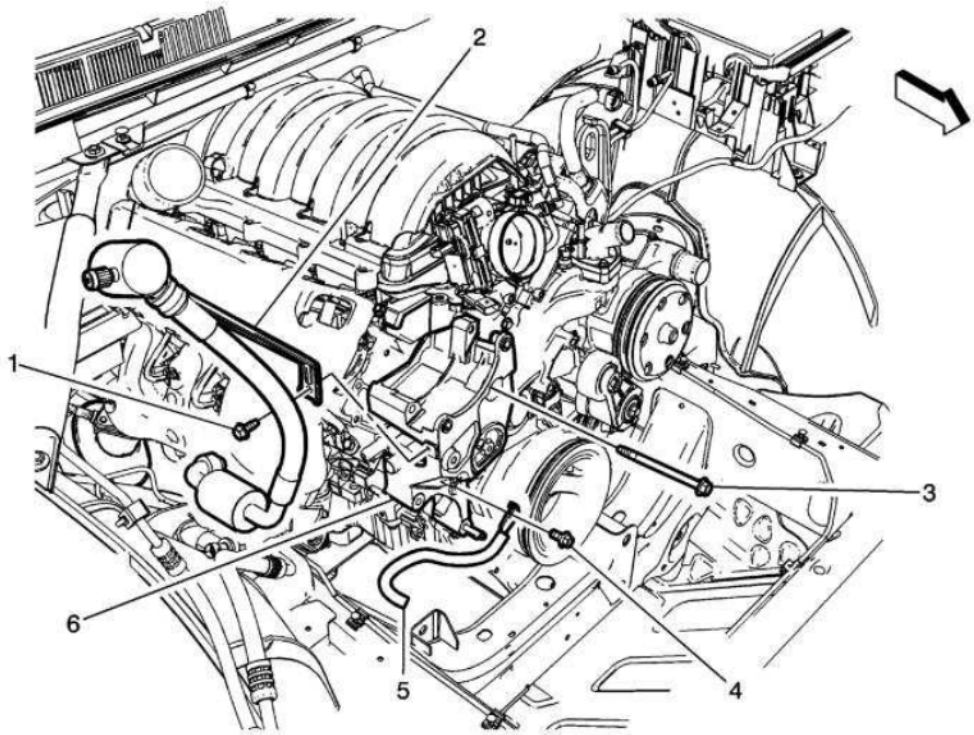

Fig. 244: Generator Bracket (LV3)
Courtesy of GENERAL MOTORS COMPANY

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21. Install the generator bracket (6) to the engine assembly. Refer to **Generator Bracket Replacement (LV3)** .

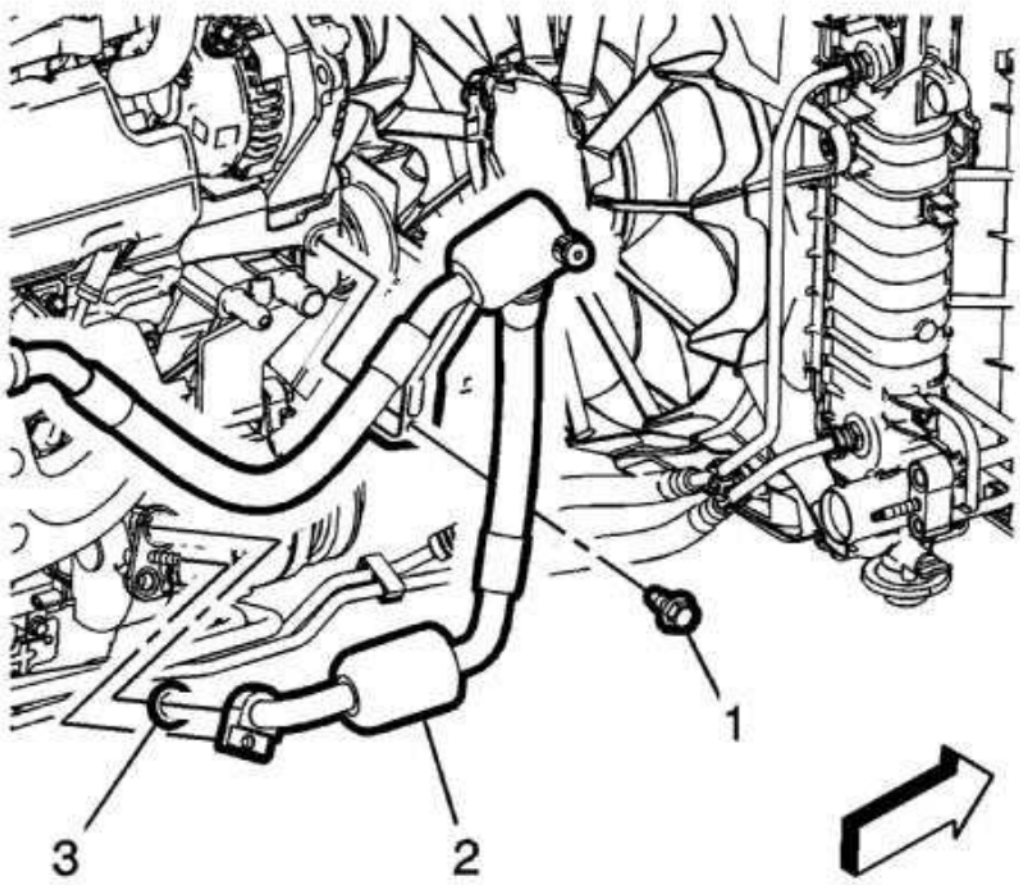

Fig. 245: Air Conditioning Tube Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

22. Install the air conditioning tube bracket bolt (1) to the generator and drive belt tensioner bracket and tighten to 22 N.m (16 lb ft).

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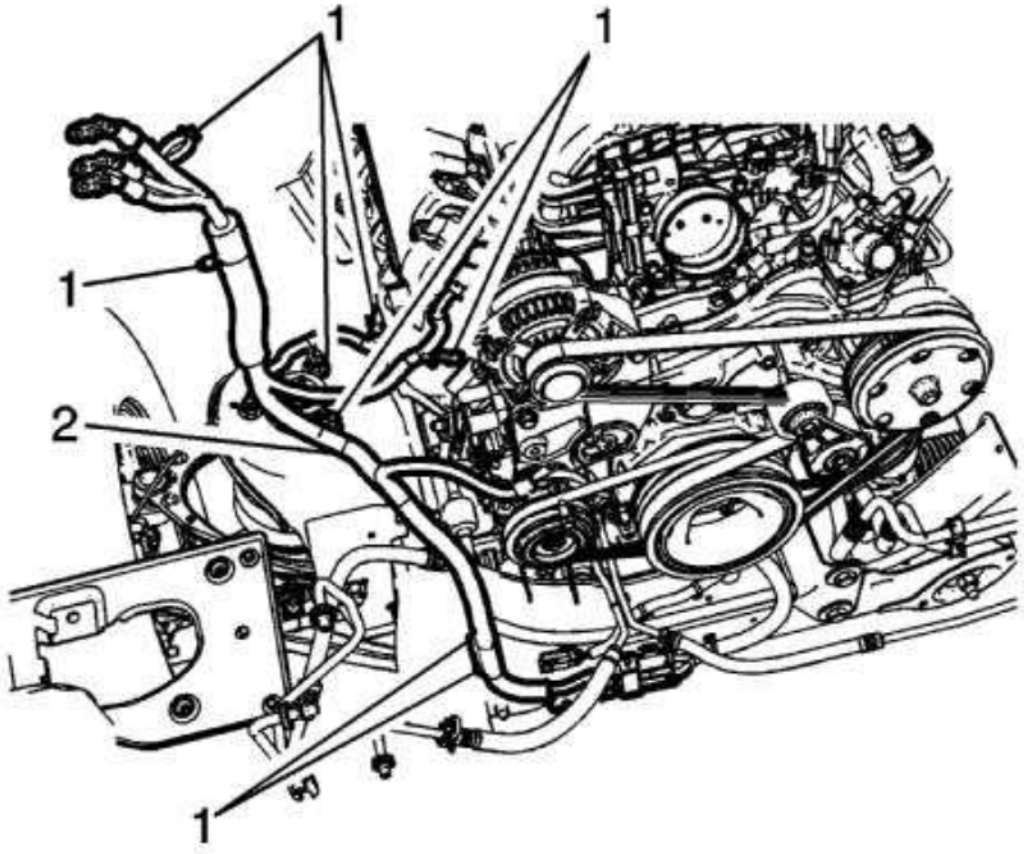

Fig. 246: Generator Battery Control Wiring Harness Retainers And Generator Battery Control Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

23. Install the generator battery control wiring harness (2). Refer to **Generator Battery Control Wiring Harness Replacement (L83, L8B, LV3)** .
24. Install the headlamp and radiator grille mount panel. Refer to **Headlamp and Radiator Grille Mount Panel Replacement (Without LP)** .
25. Install the front end upper tie bar support. Refer to **Front End Upper Tie Bar Support Replacement** .

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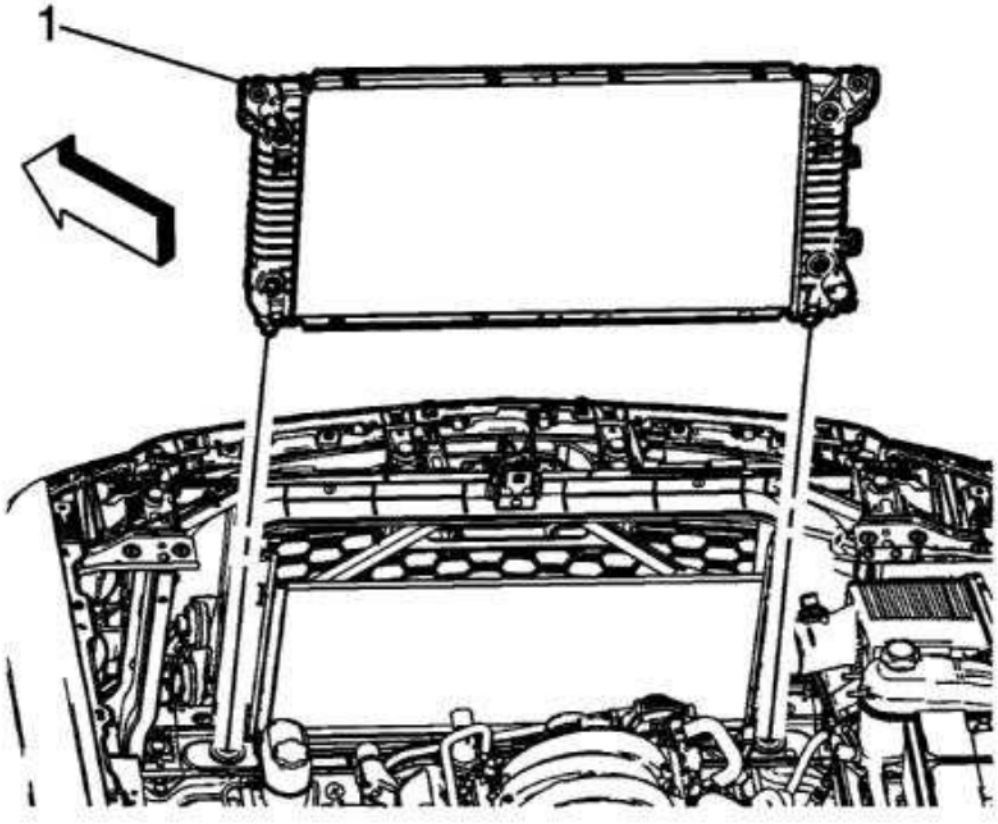

Fig. 247: Radiator
Courtesy of GENERAL MOTORS COMPANY

26. Install the radiator. Refer to **Radiator Replacement (LV3)** .

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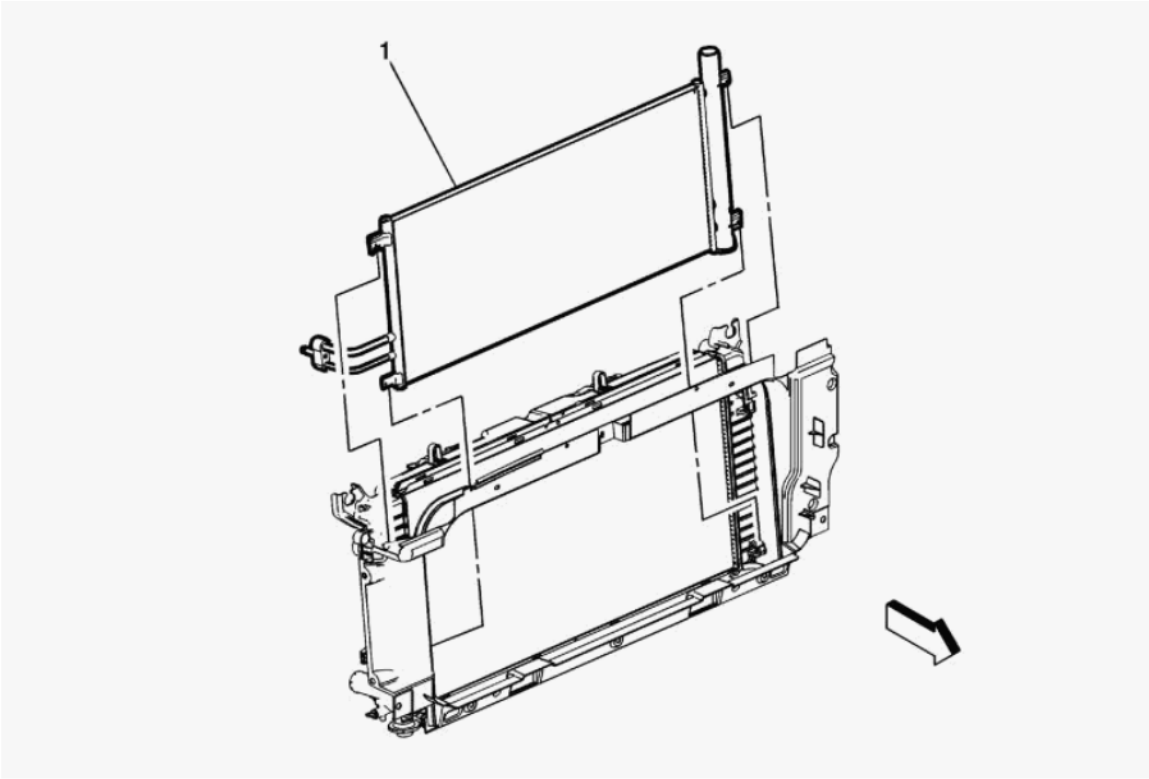

Fig. 248: Air Conditioning Condenser (LV3)
Courtesy of GENERAL MOTORS COMPANY

27. Install the air conditioning condenser. Refer to **Air Conditioning Condenser Replacement (LV3)** .

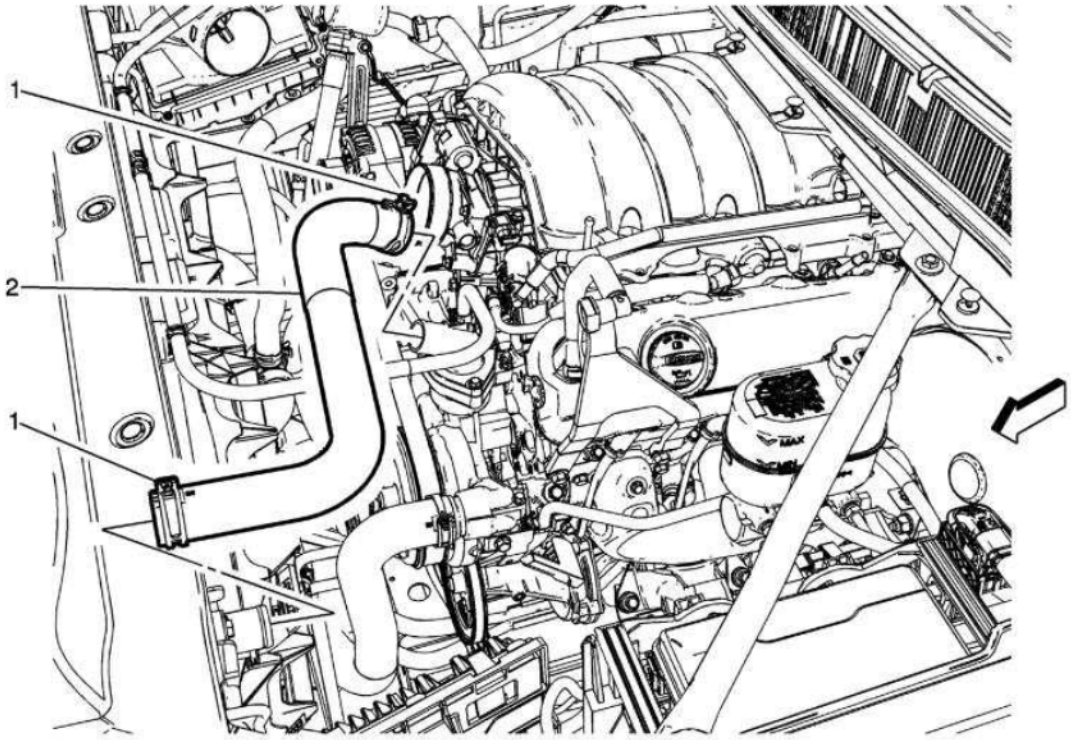

Fig. 249: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

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28. Install the radiator inlet hose (2). Refer to **Radiator Inlet Hose Replacement (LV3)** .

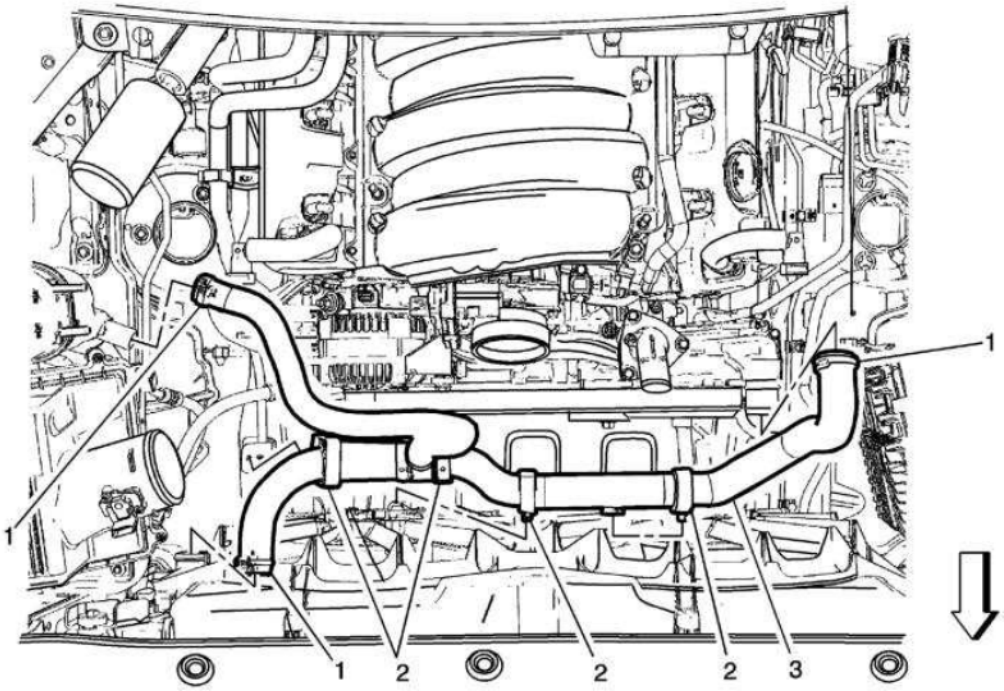

Fig. 250: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

29. Install the radiator outlet hose (3). Refer to **Radiator Outlet Hose Replacement (LV3)** .

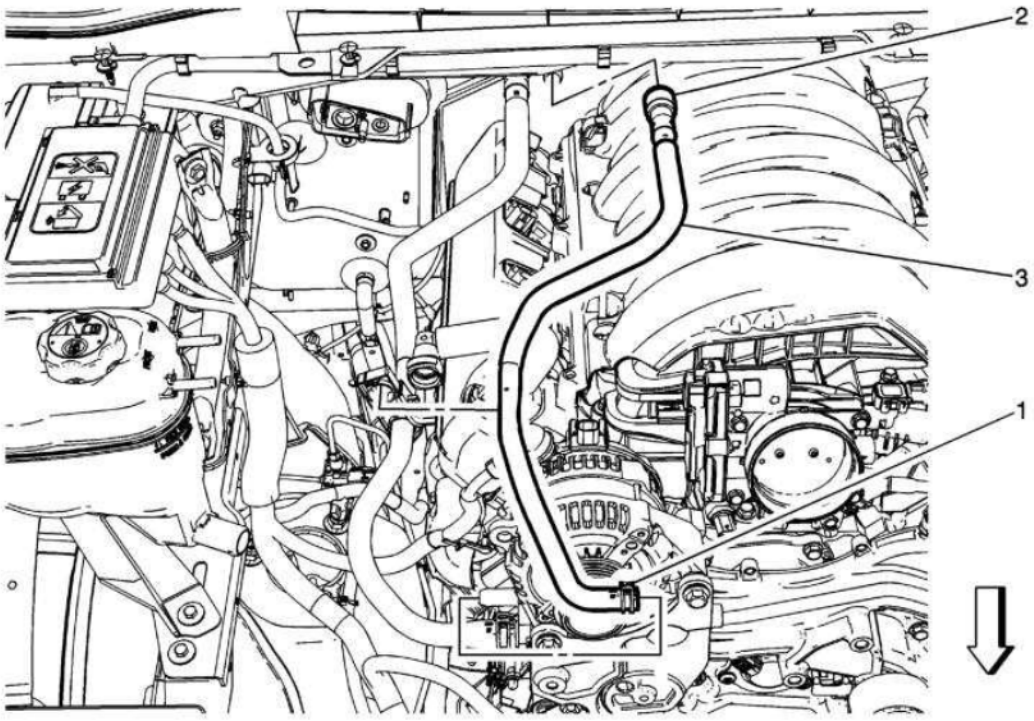

Fig. 251: Heater Inlet Hose (LV3)

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Courtesy of GENERAL MOTORS COMPANY

30. Install the heater inlet hose (1). Refer to **Heater Inlet Hose Replacement (LV3)** .
31. Install the heater outlet hose. Refer to **Heater Outlet Hose Replacement (LV3)** .

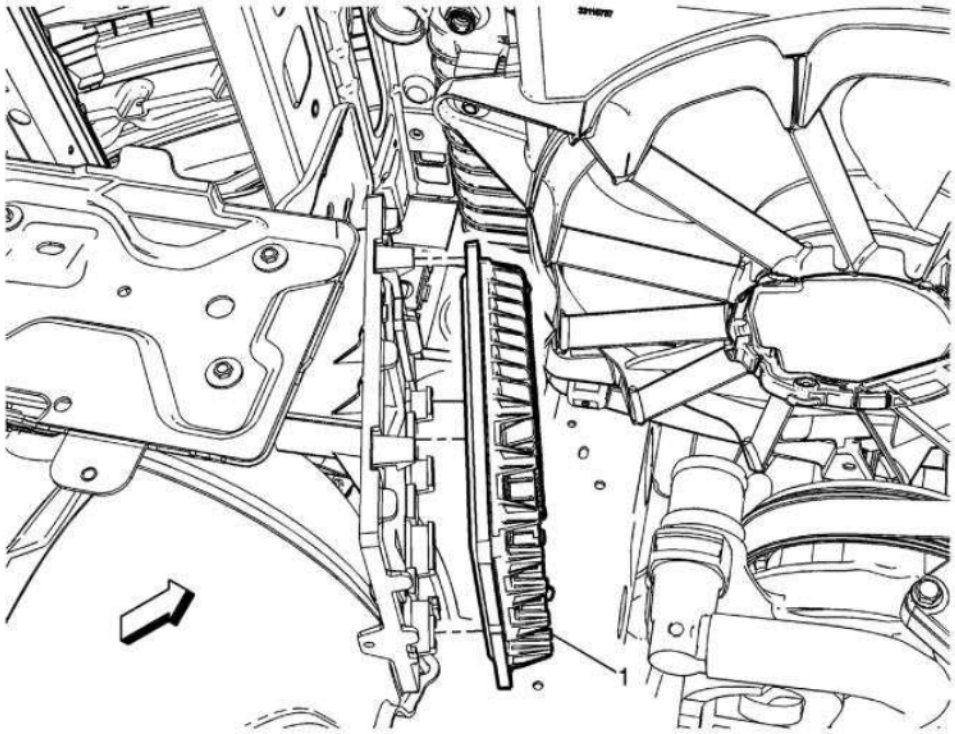

Fig. 252: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

32. Install the engine control module (1). Refer to **Engine Control Module Replacement** .

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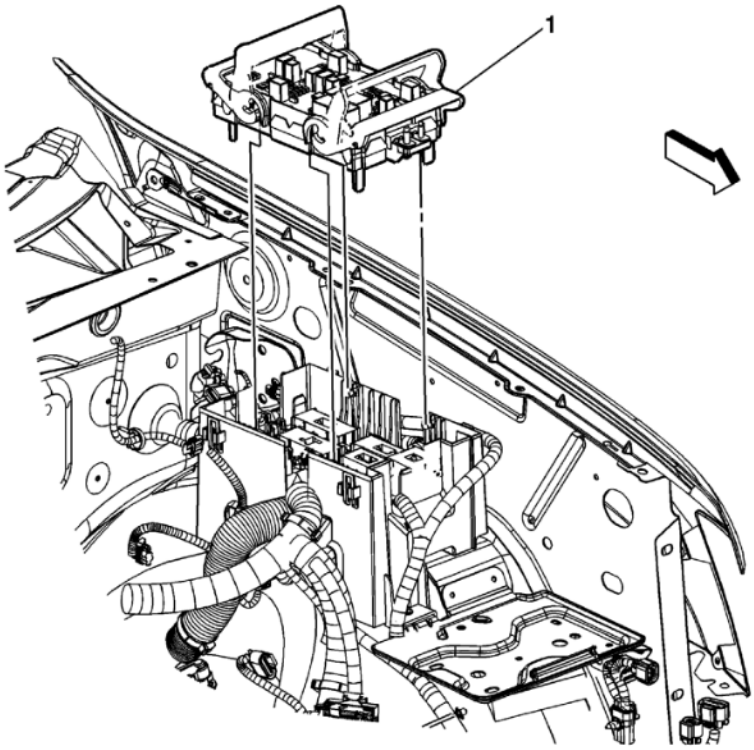

Fig. 253: View Of Underhood Electrical Center/Junction Block
Courtesy of GENERAL MOTORS COMPANY

33. Connect the engine main wiring harness to the underhood electrical center junction block (1). Refer to **Underhood Electrical Center or Junction Block Replacement** .
34. Connect the fuel feed pipe to the fuel pump feed pipe. Refer to **Metal Collar Quick Connect Fitting Service** .
35. Install the engine oil cooler hose assembly to the engine. Refer to **Engine Oil Cooler Hose Replacement**.

NOTE: **Prelube is necessary if the engine is replaced or overhauled.**

36. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to **Engine Prelubing**.
37. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (L83, L8B, LV3)** .
38. Place the hood in the normal operating position. Refer to **Hood Service Positioning** .
39. If a NEW TCM has been installed into the vehicle, the NEW module needs to be reprogrammed. Refer to **Service Programming System (SPS)** .

NOTE: **The Service Fast Learn Adapts procedure must be performed when one of the following repairs have been made to the vehicle. Failure to perform the procedure after one of the following repairs may result in poor transmission performance, as well as transmission DTCs being set:**

- **Transmission internal service/overhaul**
- **Valve body repair or replacement**
- **Control solenoid valve assembly replacement**
- **TCM software/calibration update**
- **Any service in response to a shift quality concern**

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40. Perform the Reset Transmission Adapts. Refer to **Reset Transmission Adapts** .

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Remove the skid plate. Refer to **Steering Gear Skid Shield Replacement** .

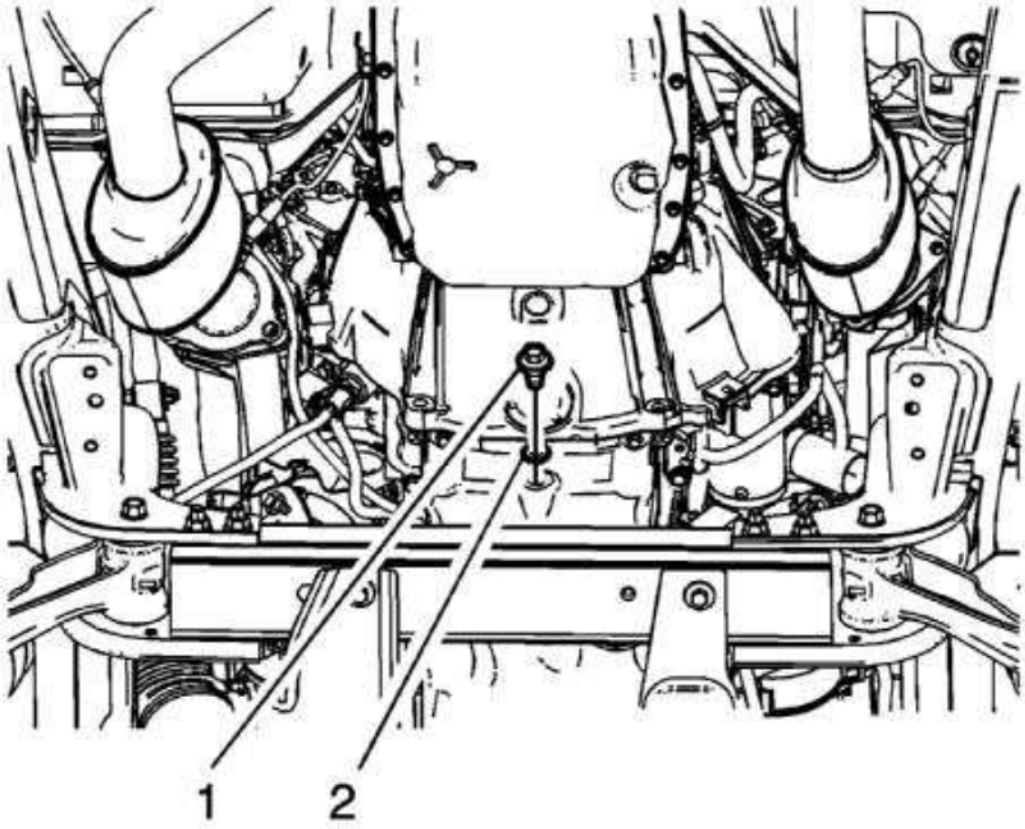

Fig. 254: Oil Drain Plug
Courtesy of GENERAL MOTORS COMPANY

2. Position a suitable drain pan under the oil pan drain plug.
3. Remove the oil drain plug (1).
4. Clean and inspect the oil pan drain plug, replace if necessary.
5. Clean and inspect the oil pan drain plug sealing surface (2), replace the oil pan drain plug sealing surface if necessary.

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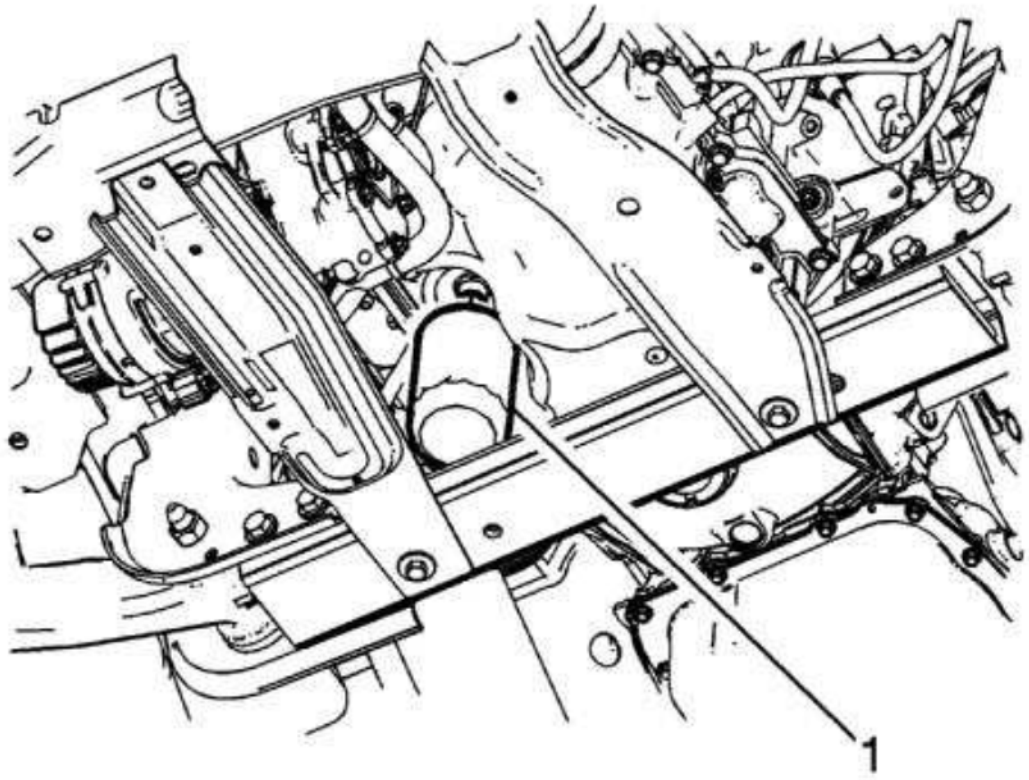

Fig. 255: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil filter (1).
7. Inspect to ensure the engine oil filter gasket is removed.

Installation Procedure

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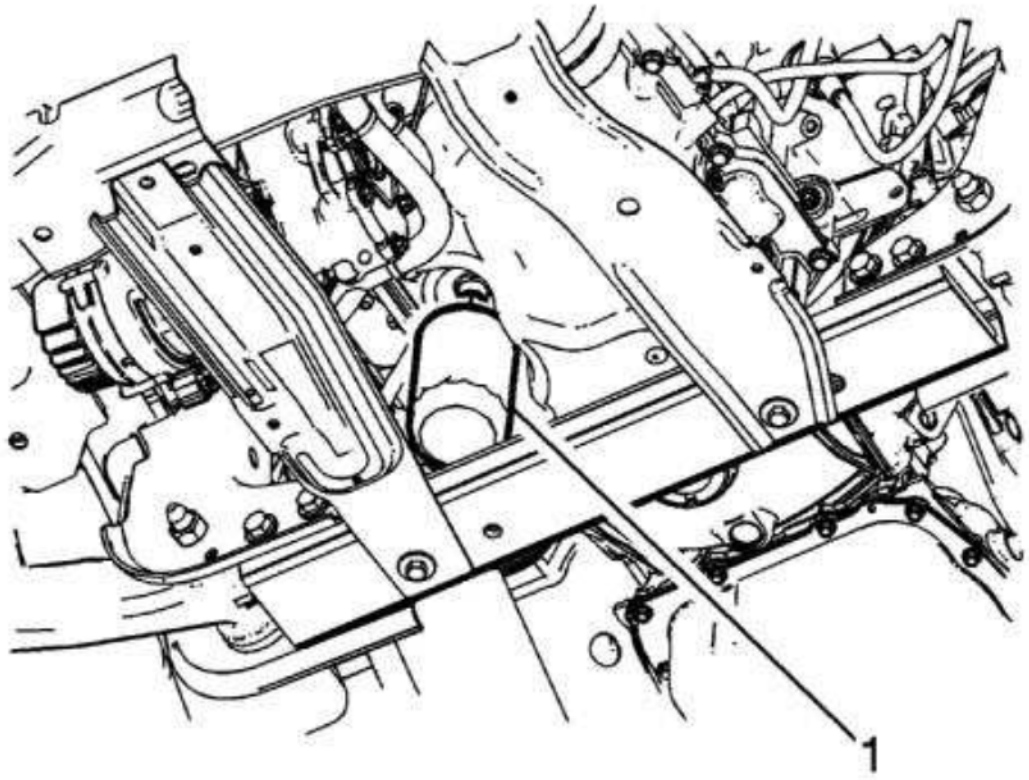

Fig. 256: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the oil filter gasket with clean engine oil.

CAUTION: **Refer to Fastener Caution .**

2. Install the oil filter (1) and tighten to 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.

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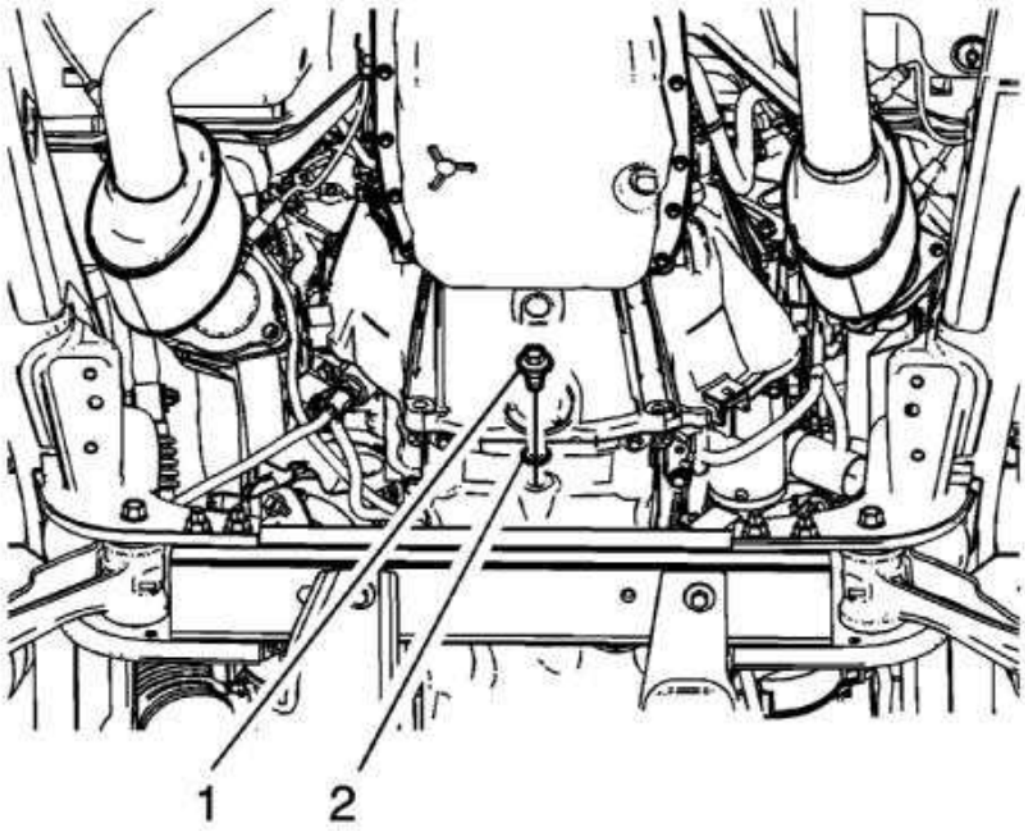

Fig. 257: Oil Drain Plug
Courtesy of GENERAL MOTORS COMPANY

3. Install the drain plug (1) and tighten to 25 N.m (18 lb ft).
4. Lower the vehicle.
5. Fill the engine with the appropriate oil type and quantity. **Approximate Fluid Capacities** , and **Adhesives, Fluids, Lubricants, and Sealers**
6. Operate the engine, check for leaks, and oil pressure.
7. Install the skid plate. Refer to **Steering Gear Skid Shield Replacement** .
8. Reset the oil monitor

ENGINE OIL COOLER HOSE REPLACEMENT

Removal Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

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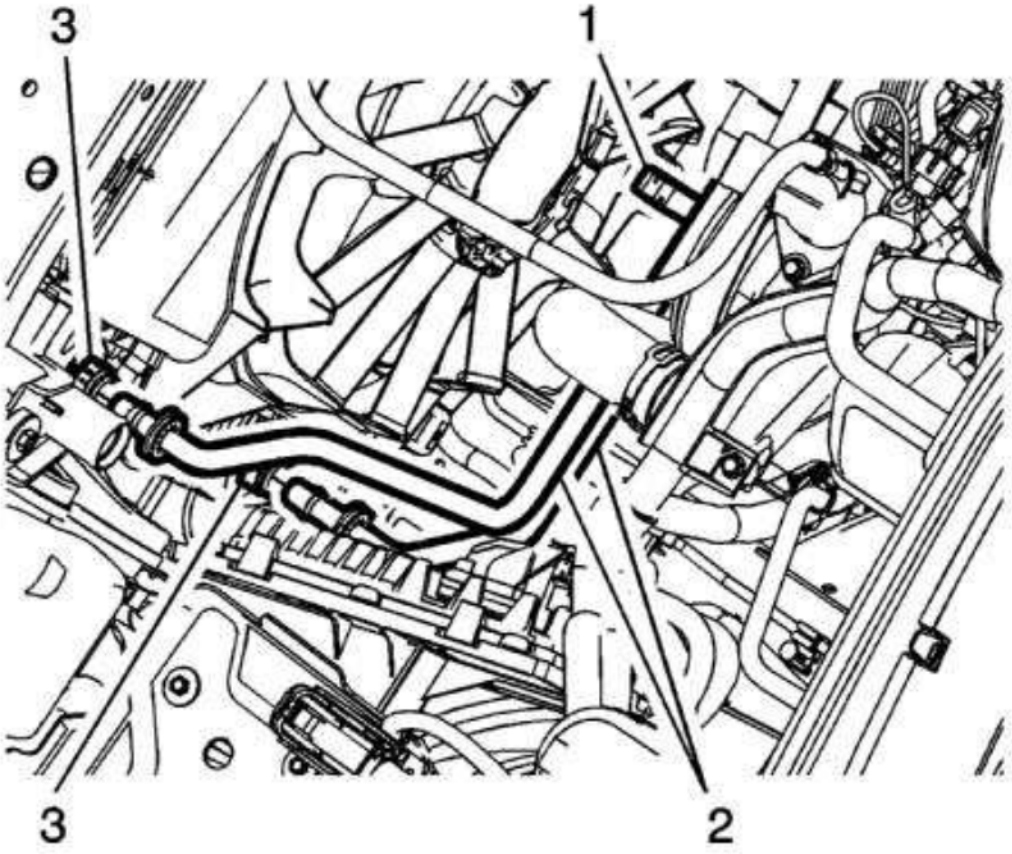

Fig. 258: Engine Oil Cooler Hoses And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil cooler hoses (2) from the retainer (1).
3. Disconnect the engine oil cooler hoses (2) from the radiator fittings (3). Refer to **Metal Collar Quick Connect Fitting Service** .
4. Remove the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .

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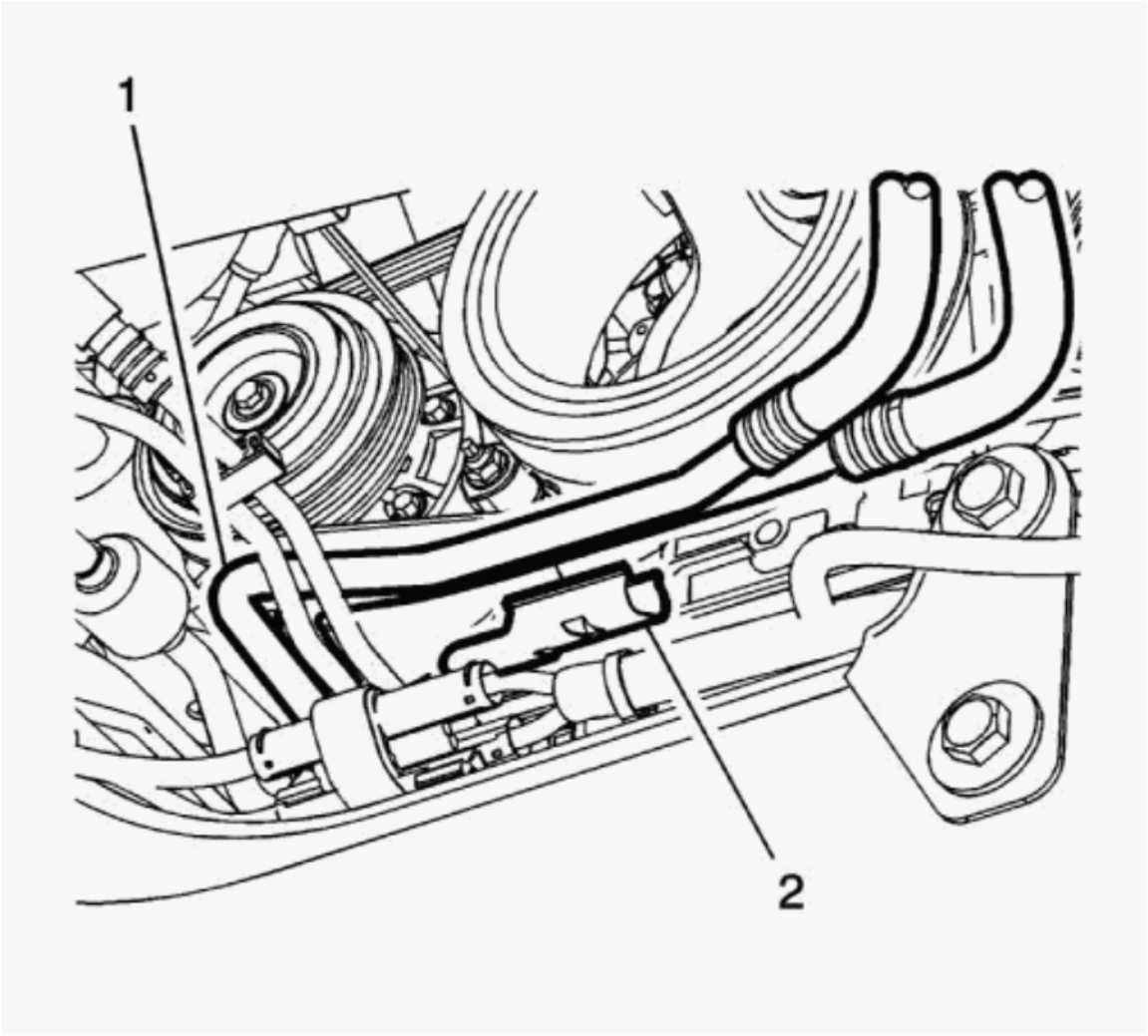

Fig. 259: Oil Cooler Hoses And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil cooler hoses (1) from the retaining clip (2).
6. Using a suitable adjustable Jack, support the front axle.
7. Remove the two left side front axle bolts and lower the axle enough to create clearance for oil cooler line removal.

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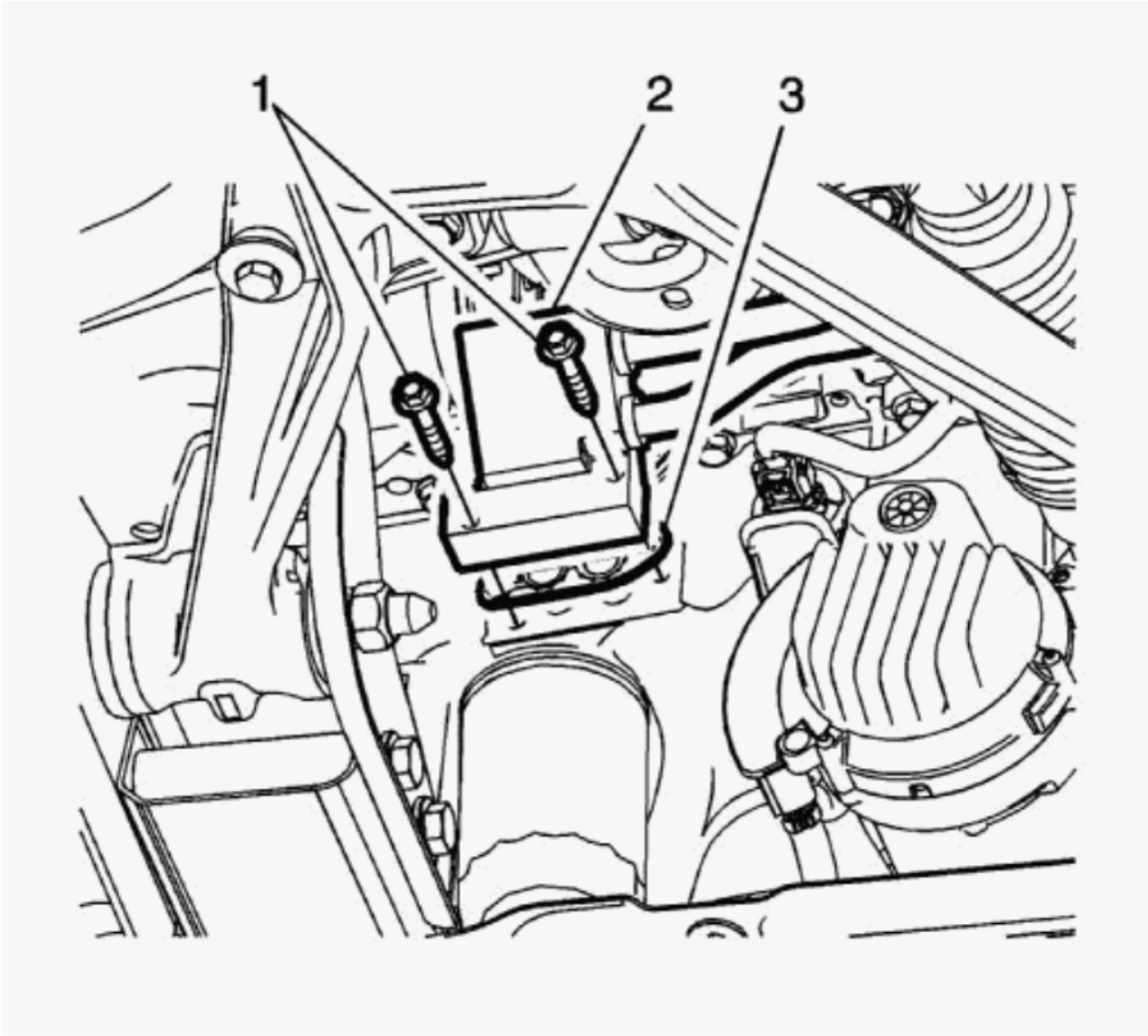

Fig. 260: Engine Oil Cooler Adapter Fasteners And Separate Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

8. Remove the engine oil cooler adapter fasteners (1) and separate the oil cooler adapter (2) from the engine block.

   DISCARD the oil cooler adapter gasket (3).

   NOTE: Note the routing and orientation of the engine oil cooler hoses to insure proper installation.

9. Remove the oil cooler hoses and gasket from the vehicle.

Installation Procedure

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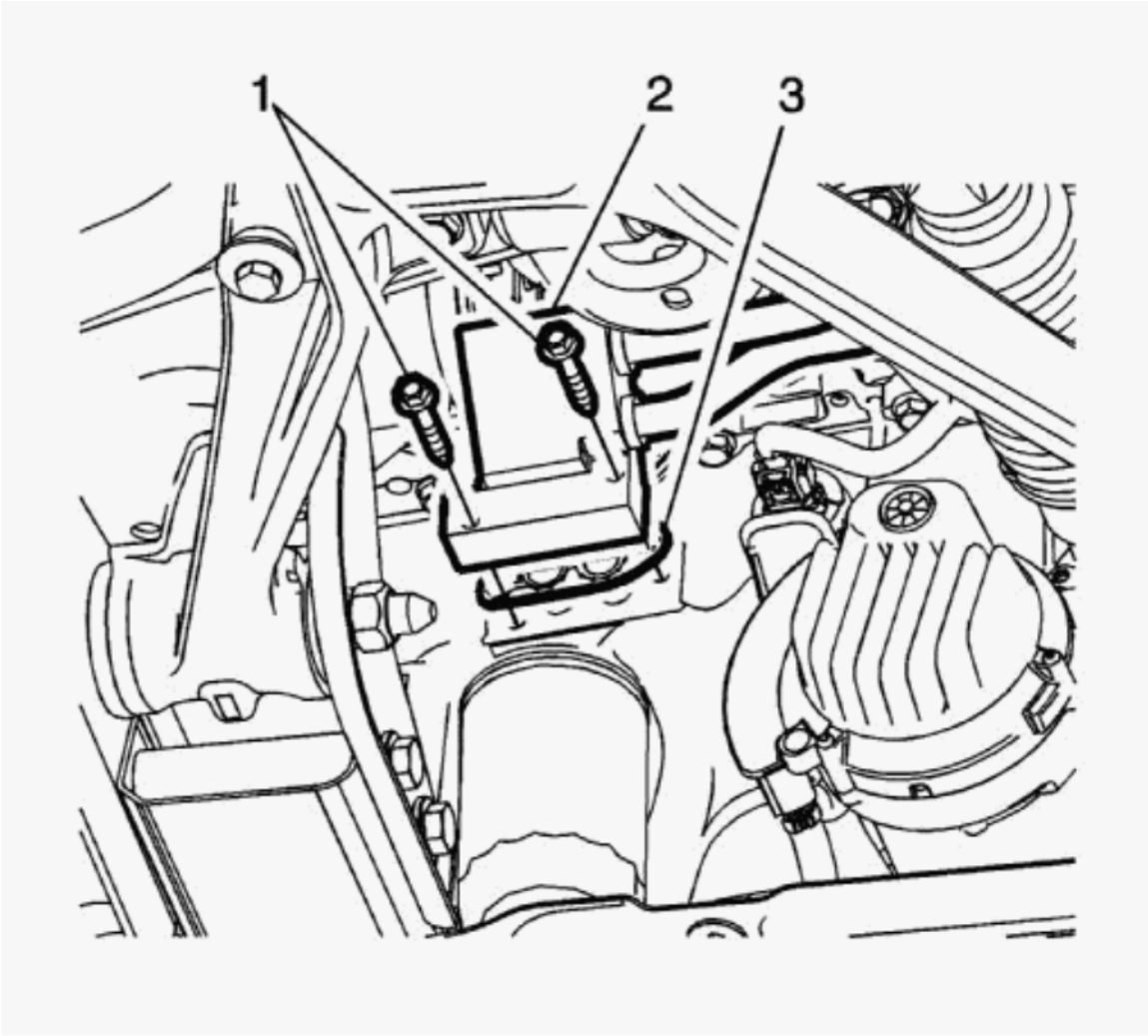

Fig. 261: Engine Oil Cooler Adapter Fasteners And Separate Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

NOTE: **When installing the gasket, ensure that the part number stamped on the gasket is facing away from the engine.**

1. Install a NEW oil cooler adapter gasket (3) and the oil cooler hose adapter (2) and tighten the fasteners (1) to 12 N.m (9 lb ft).

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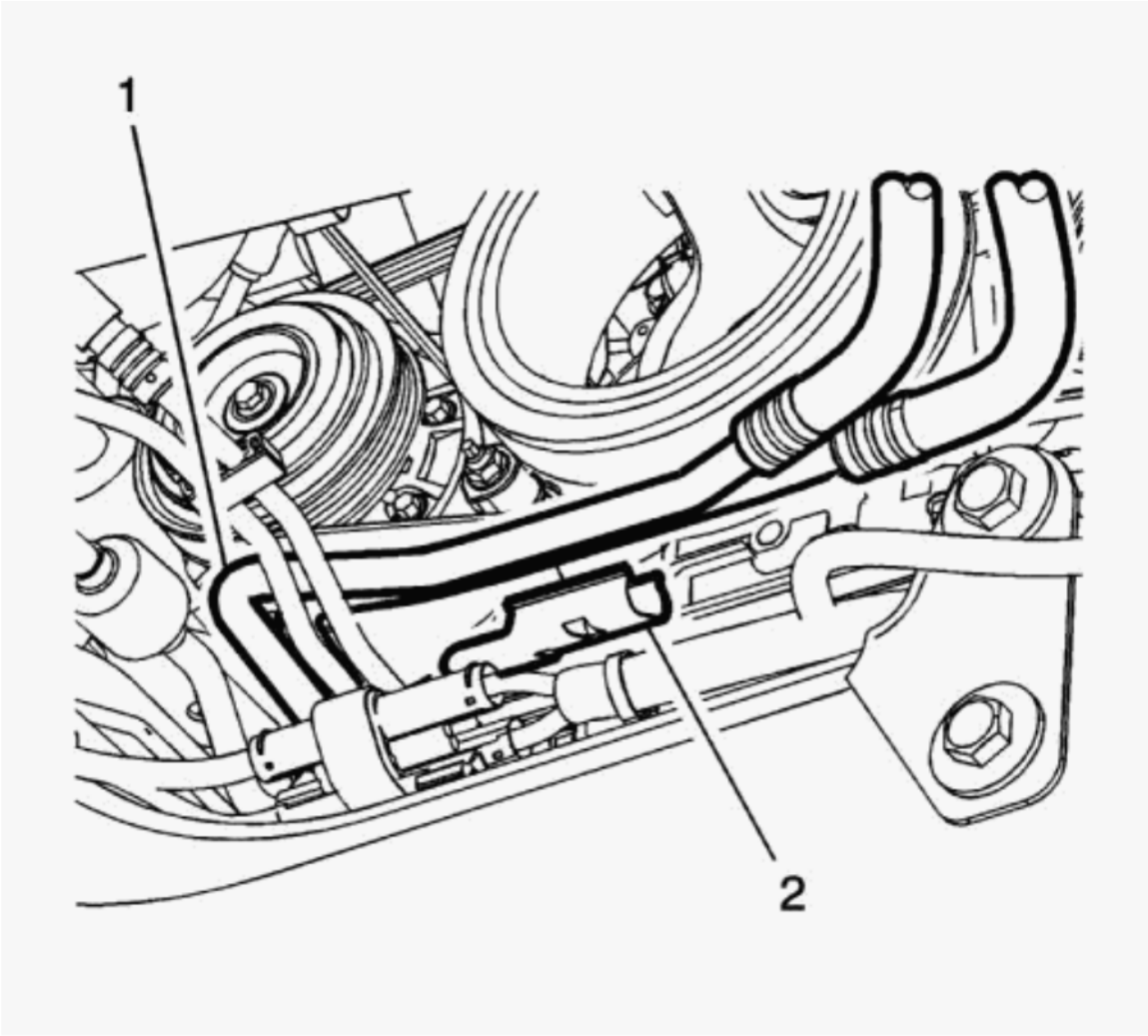

Fig. 262: Oil Cooler Hoses And Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

2. Install the oil cooler hoses into the retaining clip.
3. Raise the axle into position.
4. Install the left axle bolts and tighten to 75 N.m (55 lb ft).
5. Remove the adjustable jack.
6. Install the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .
7. Lower the vehicle.

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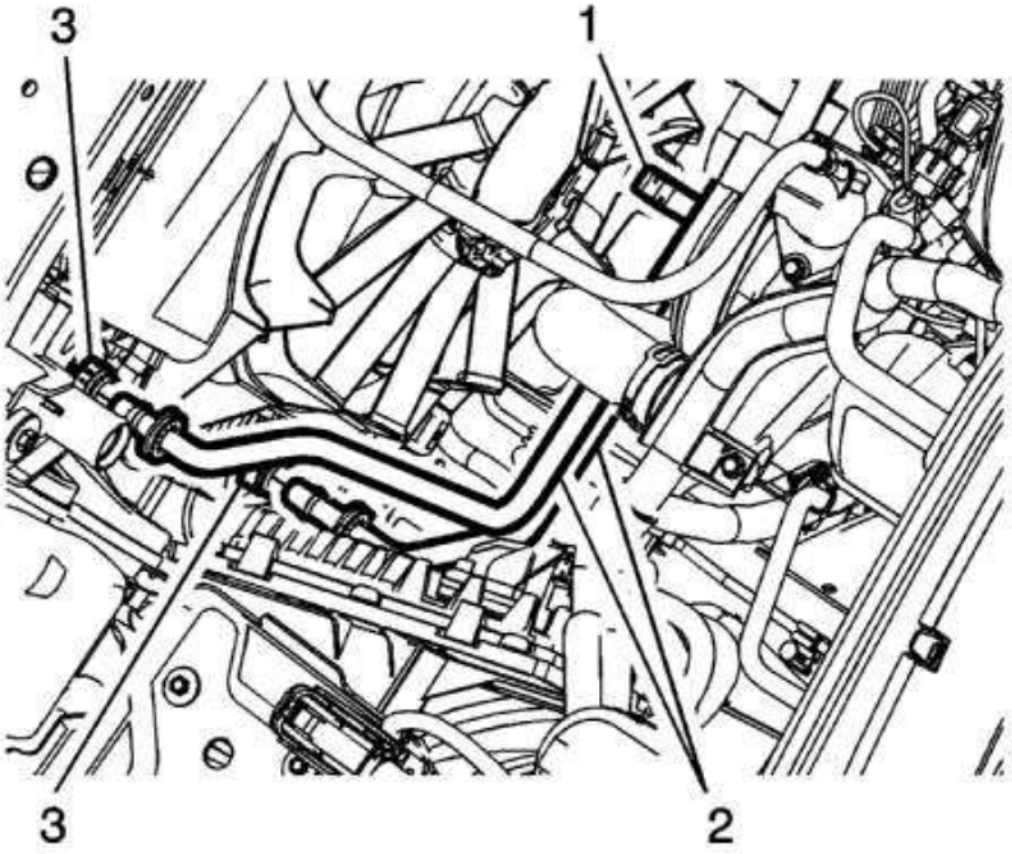

Fig. 263: Engine Oil Cooler Hoses And Retainer
Courtesy of GENERAL MOTORS COMPANY

8. Install the engine oil cooler hoses (2) into the radiator fittings (3). Refer to **Metal Collar Quick Connect Fitting Service** .

   Install the engine oil cooler hoses (2) into the retainer (1).

9. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

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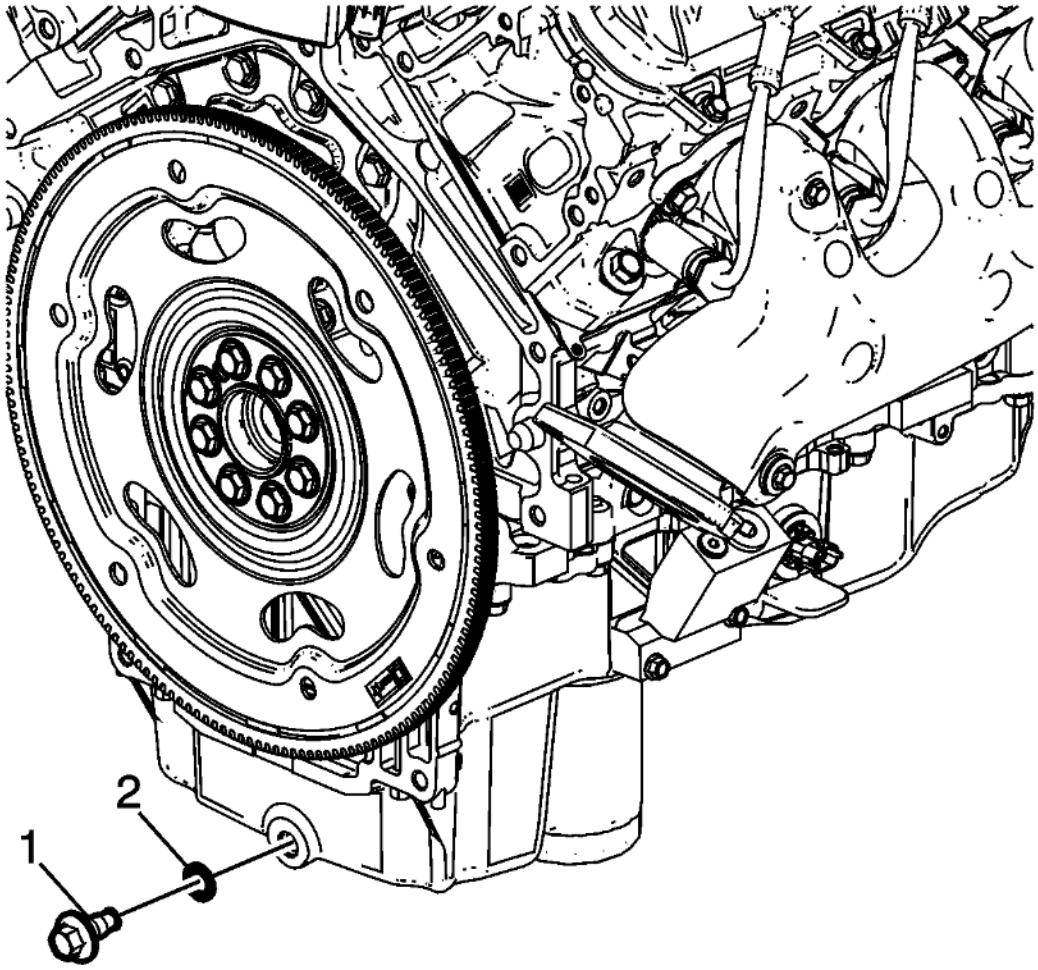

Fig. 264: Oil Pan Drain Plug
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pan drain plug (1) with O-ring (2).

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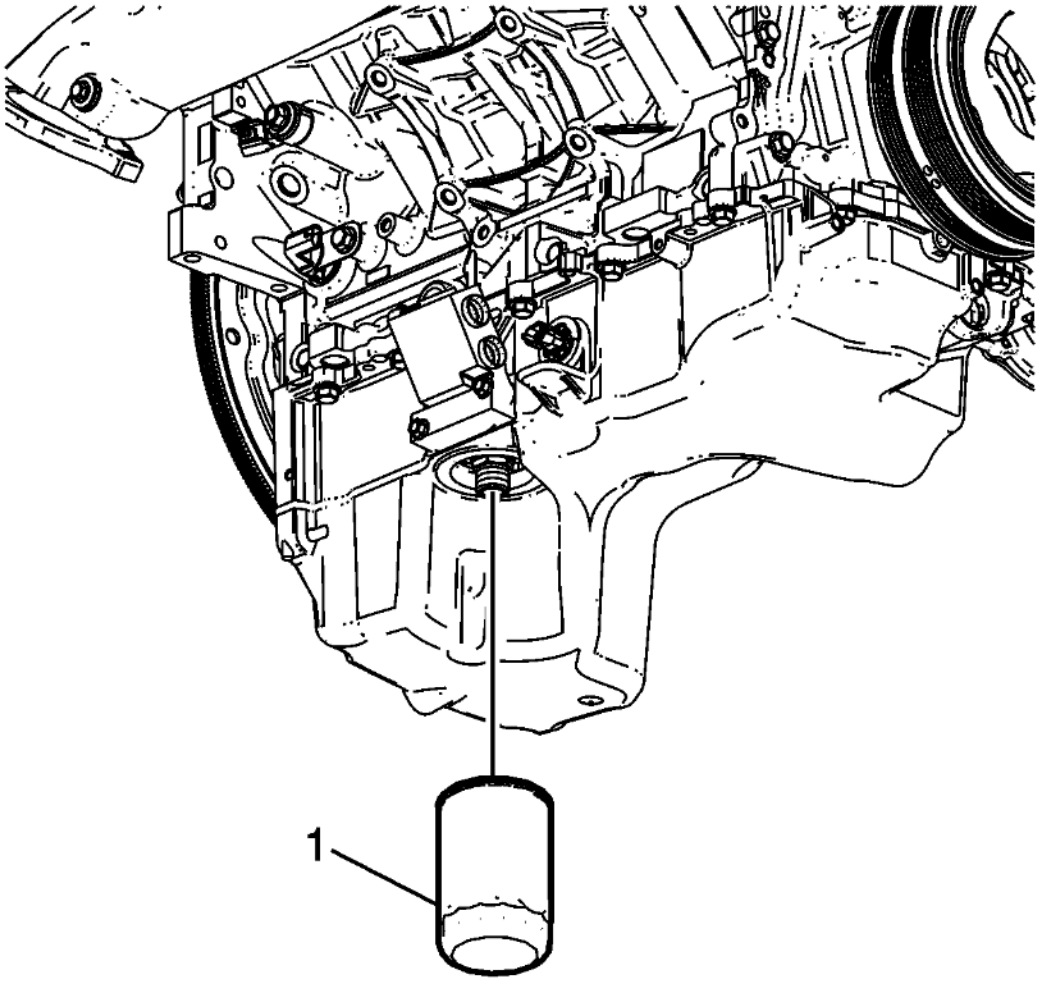

Fig. 265: Engine Oil Filter
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil filter (1).

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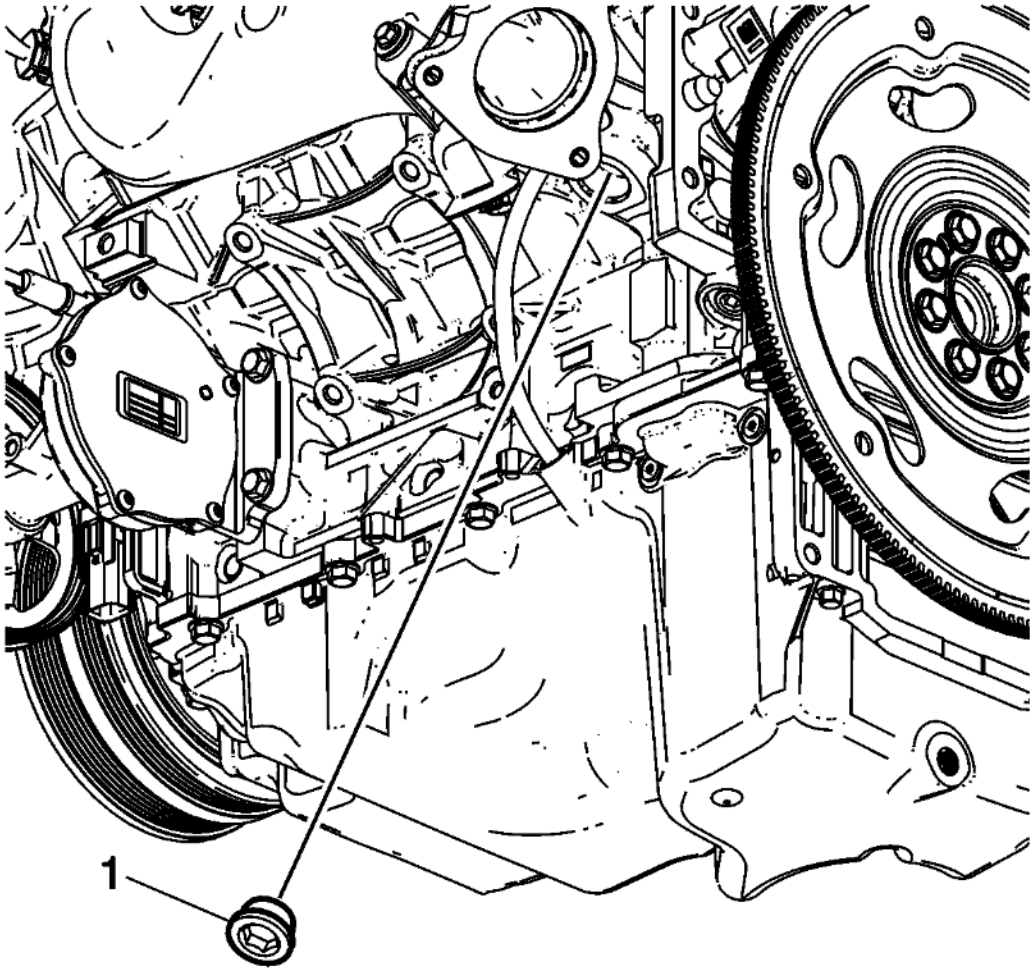

Fig. 266: Left Side Rear Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS COMPANY

3. Remove the left side rear engine block coolant drain hole plug (1).

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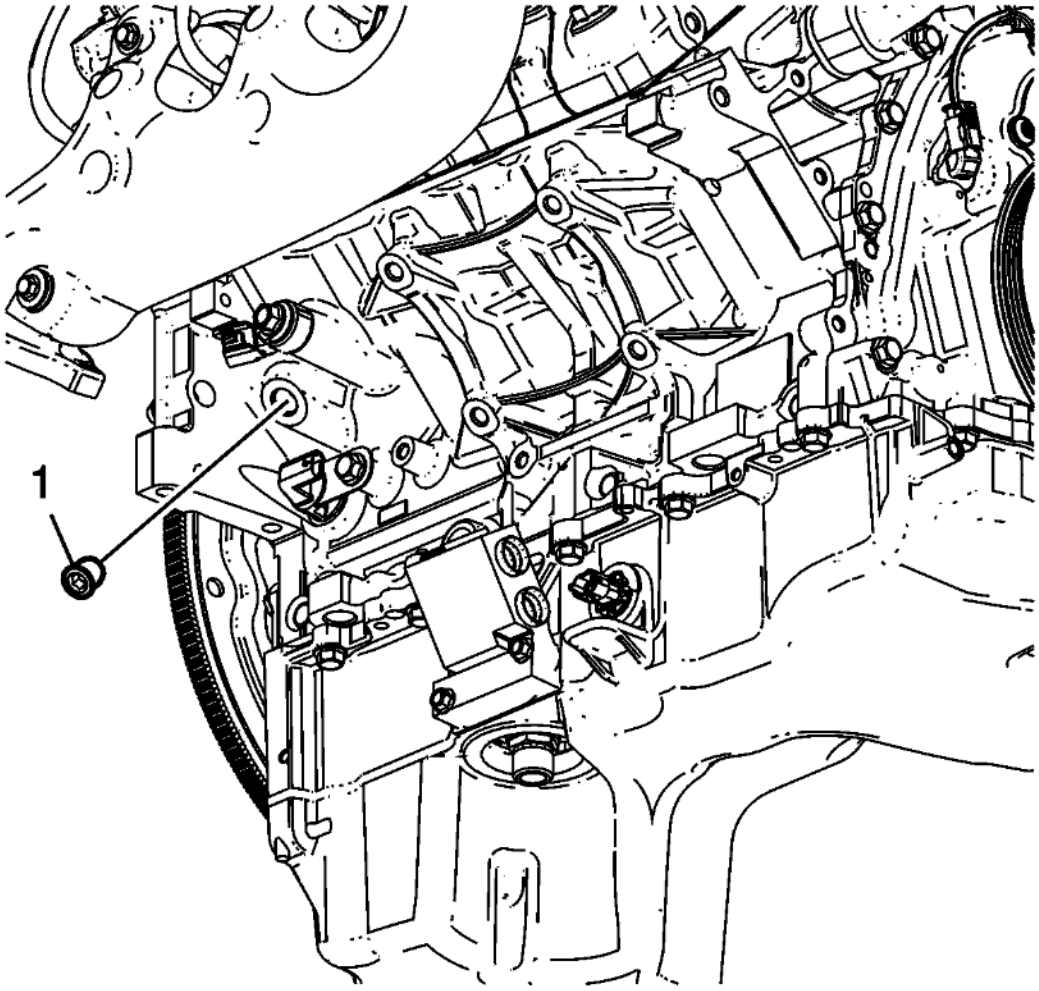

Fig. 267: Right Side Rear Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS COMPANY

4. Remove the right side rear engine block coolant drain hole plug (1).

CRANKSHAFT BALANCER REMOVAL

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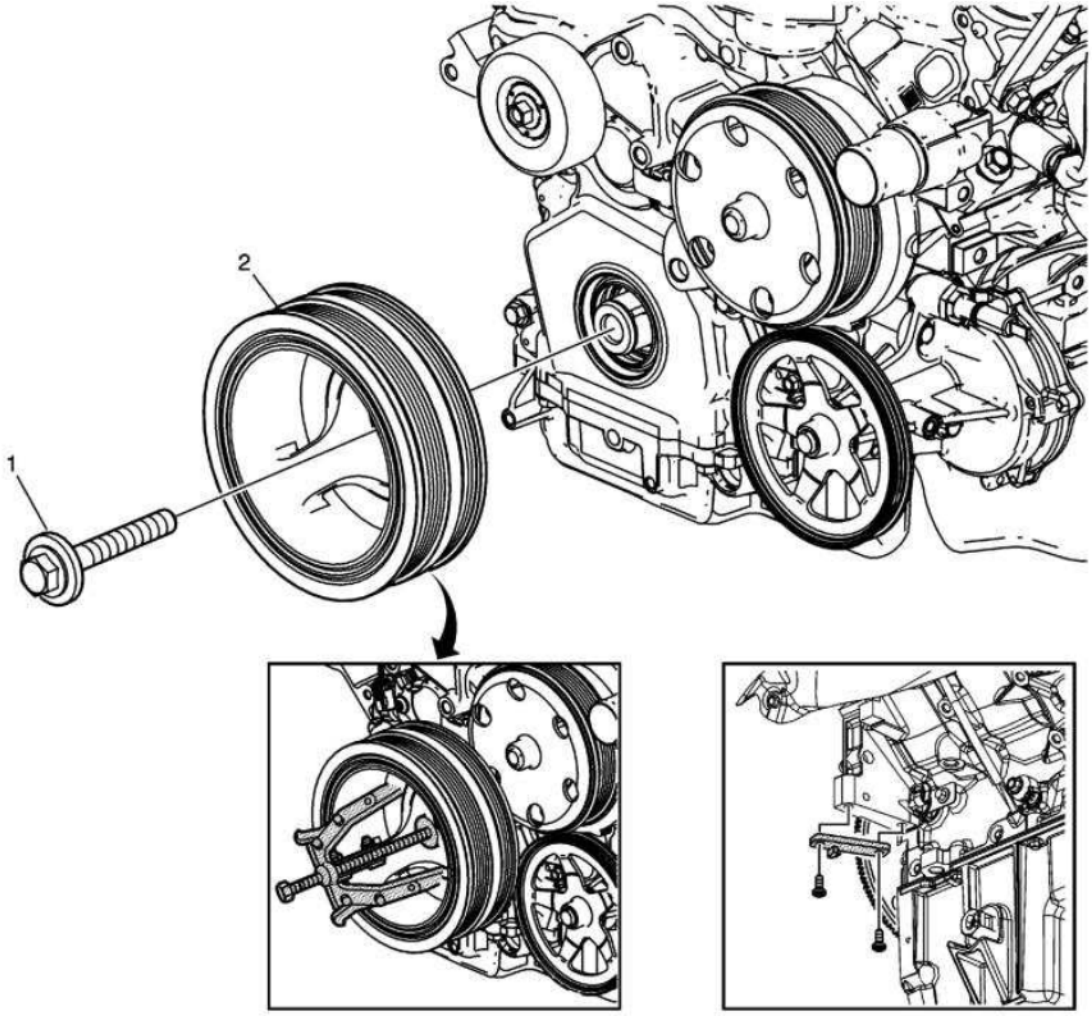

Fig. 268: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Bolt **Procedure** Install the **J-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft). **NOTE:** **Do not discard balancer bolt, it will be used later for installation.** **Special Tools** **J-42386-A** Flywheel Holding Tool For equivalent regional tools, refer to **Special Tools**.

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Callout	Component Name
2	Crankshaft Balancer Assembly **Procedure** 1. Install the **EN-41816-2** crankshaft end protector , 2. Install the **EN-41816** crankshaft balancer remover. 3. Using both tools remove the crankshaft balancer. **Special Tools** • **EN-41816** Crankshaft Balancer Remover • **EN-41816-2** Crankshaft End Protector For equivalent regional tools, refer to **Special Tools**.

ENGINE FLYWHEEL REMOVAL

Special Tools

J-42386-A Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**.

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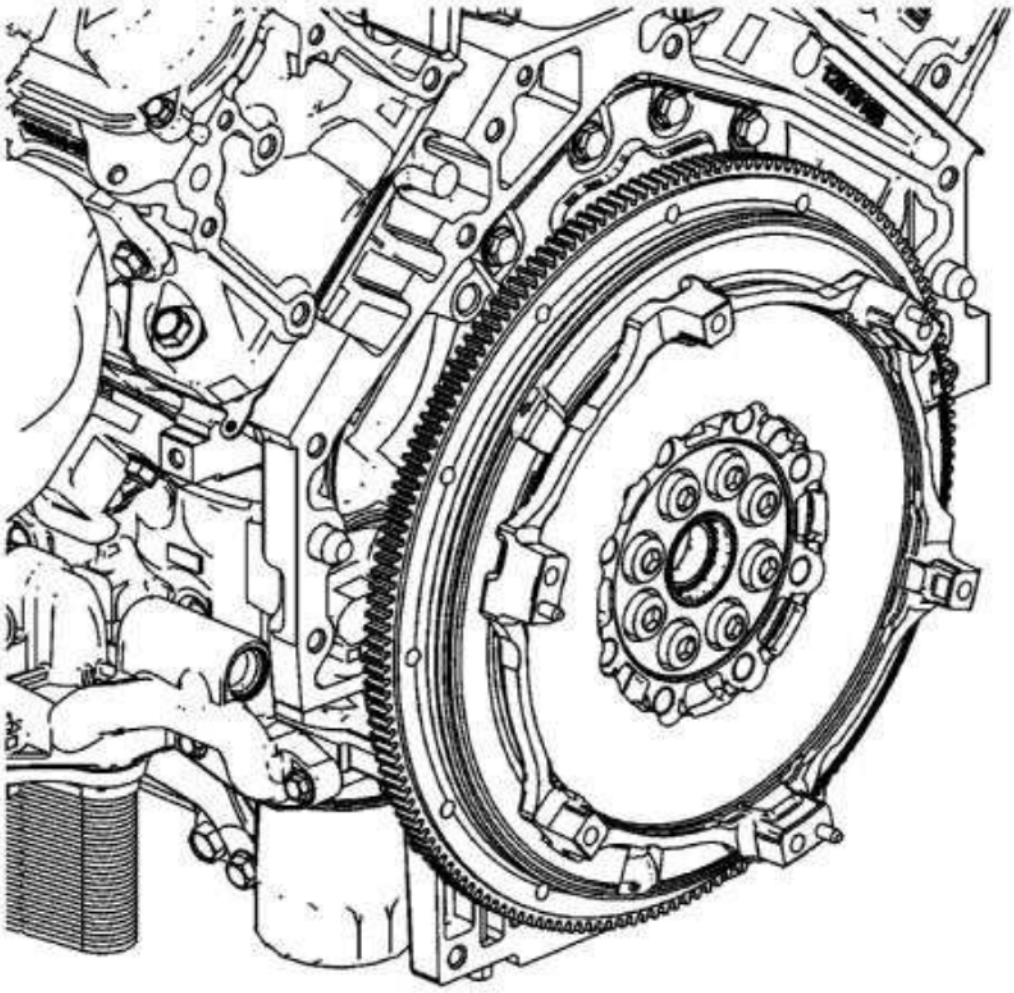

Fig. 269: Mark Or Scribe End Of Crankshaft And Manual Transmission Flywheel
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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 existing manual transmission engine flywheel must be installed to the original position and direction.**

1. Mark or scribe the end of the crankshaft and the manual transmission flywheel.

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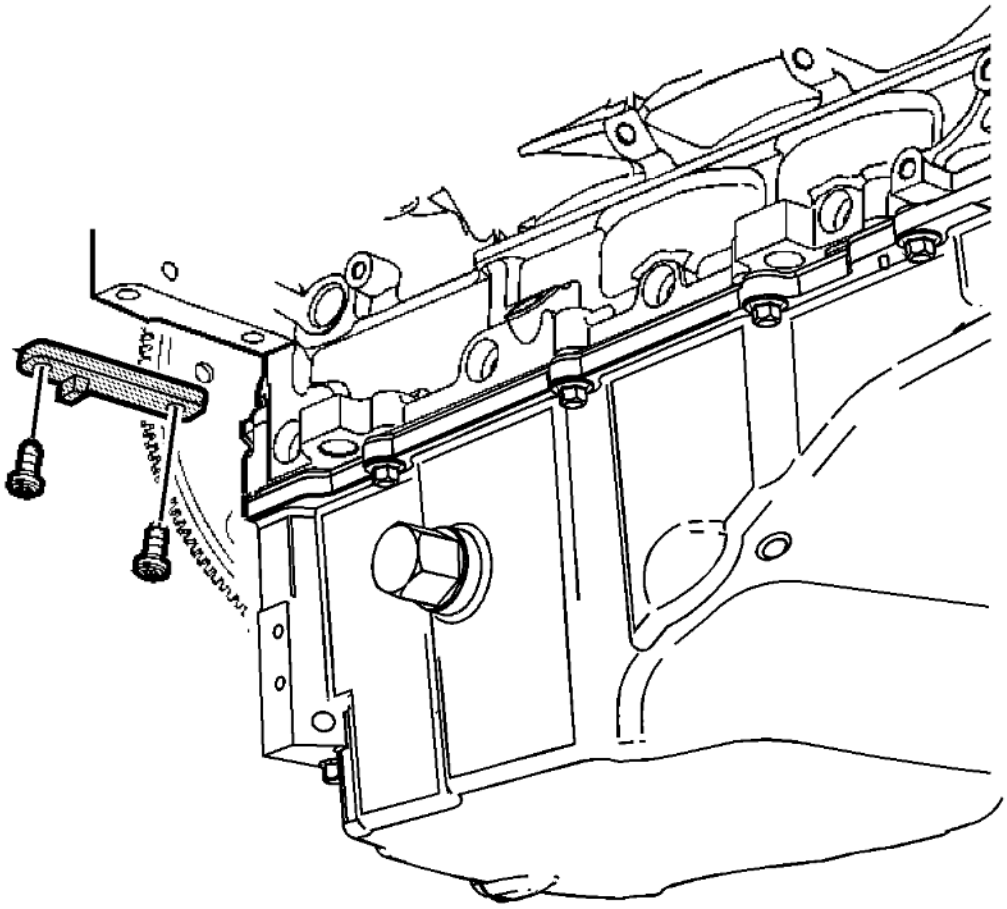

Fig. 270: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

2. Install the **J-42386-A** flywheel holding tool and bolts.

   Use 1 M10 -1.5 x 120 mm and 1 M10 -1.5 x 45 mm bolt for proper tool operation.

   Tighten the **J-42386-A** flywheel holding tool and bolts to 50 N.m (37 lb ft).

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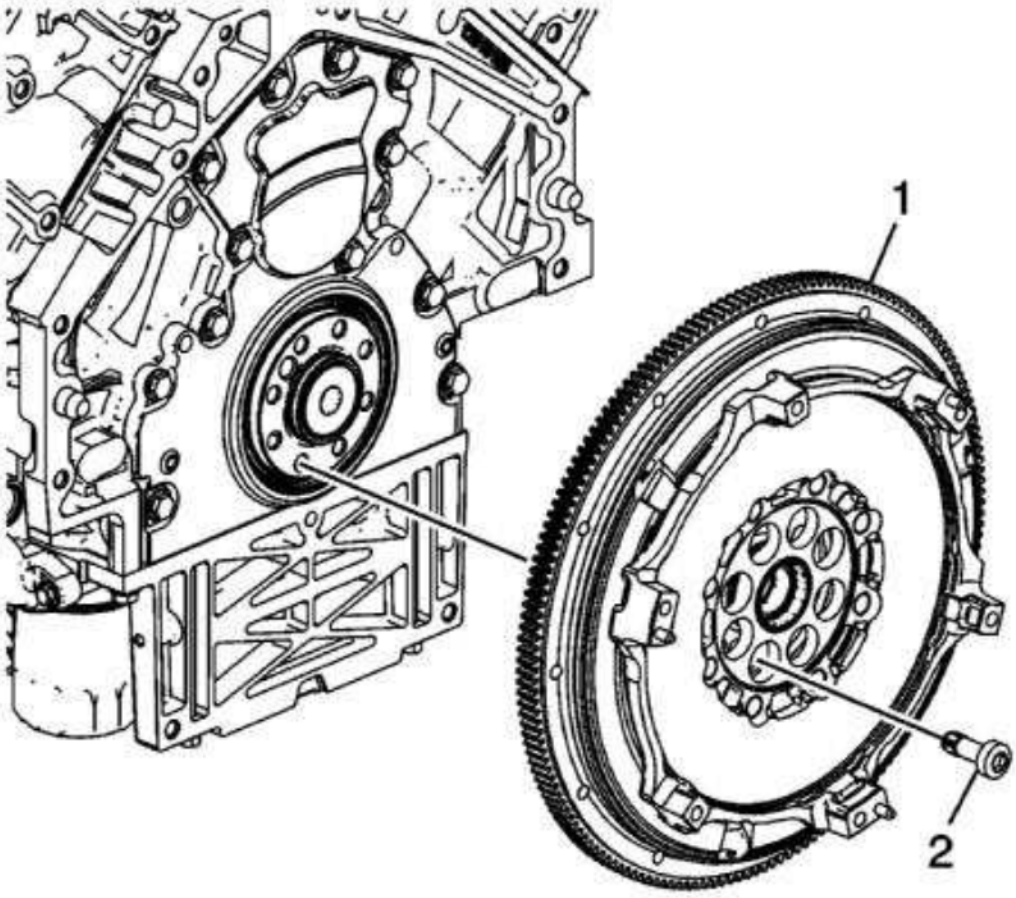

Fig. 271: Manual Transmission Flywheel
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT reuse the flywheel bolts.**

3. Remove and discard the flywheel bolts (2).
4. Remove the manual transmission flywheel (1).

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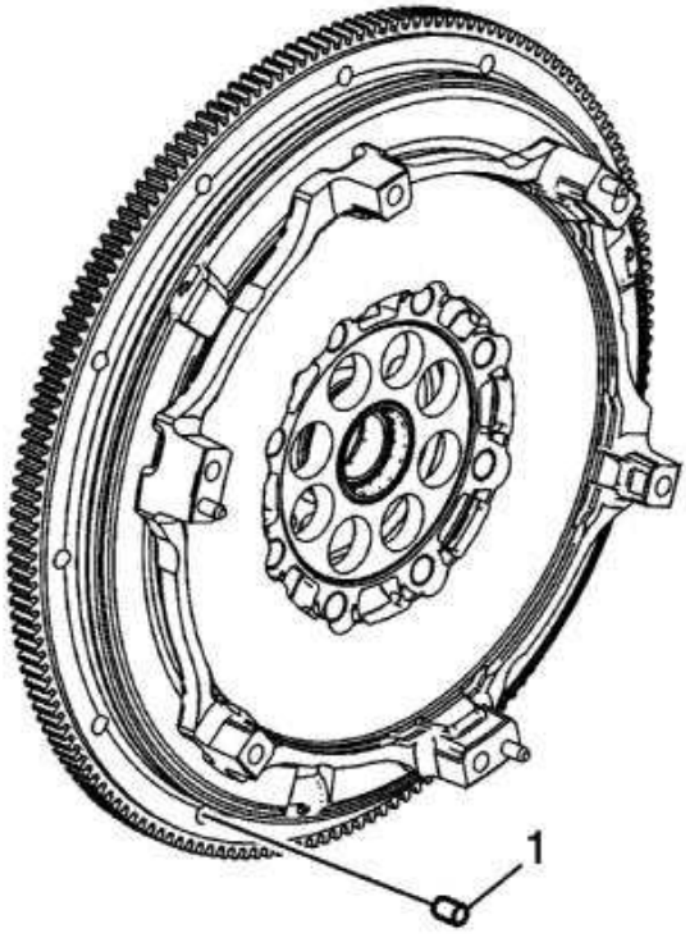

Fig. 272: Manual Transmission Flywheel Balance Weights
Courtesy of GENERAL MOTORS COMPANY

5. Note the location of the manual transmission flywheel balance weights (1), if applicable.
6. Remove the **J-42386-A** flywheel holding tool

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

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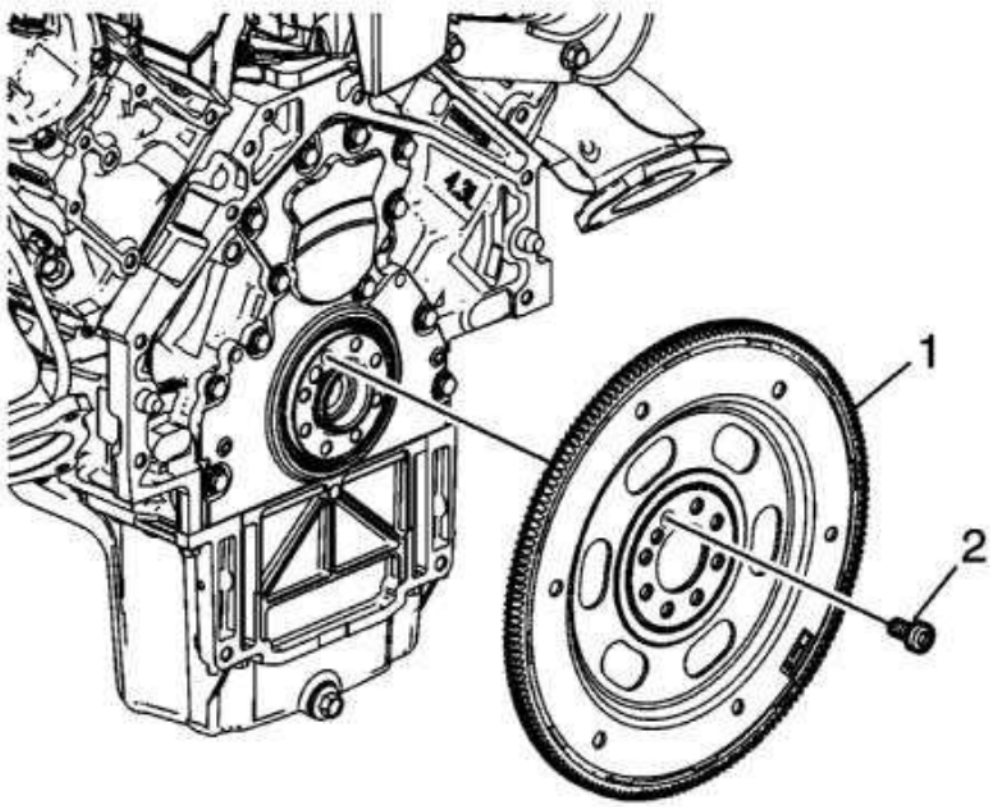

Fig. 273: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Mark or scribe the end of the crankshaft and the flex plate before removal.**

1. Remove the engine flex plate bolts (2).
2. Remove the flex plate (1).

CLUTCH PILOT BEARING REMOVAL

Special Tools

- **GE-2619-01** Slide Hammer
- **GE-23907** Slide Hammer with Bearing Adapter
- **GE-23907-1** Slide Hammer

For equivalent regional tools, refer to **Special Tools**.

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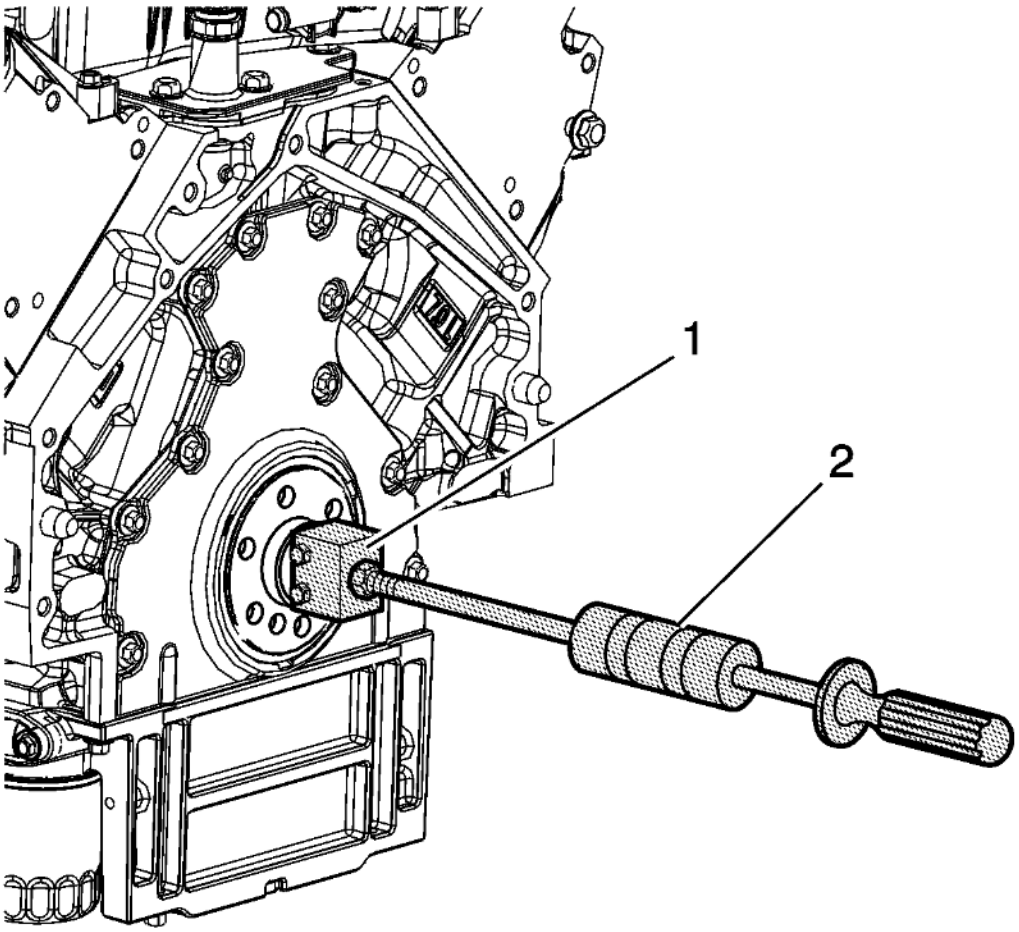

Fig. 274: Clutch Pilot Bearing Slide Hammer & Adapter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **GE-23907-1 slide hammer was part of the GE-23907 slide hammer with bearing adapter set. The adapter is still available as GE-23907 adapter.**

1. Remove the clutch pilot bearing using the **GE-23907** adapter (1) and **GE-23907-1** slide hammer (2).
    1. Install the legs of the **GE-23907** adapter (1) into the clutch pilot bearing.
    2. Rotate the shaft of the tool until the legs of the tool are snug and contacting the I.D. surface of the bearing.
    3. Install the **GE-23907-1** slide hammer (2) to the **GE-23907** adapter (1).
    4. Remove the bearing from the rear of the crankshaft.
    5. Remove the special tools from the bearing.

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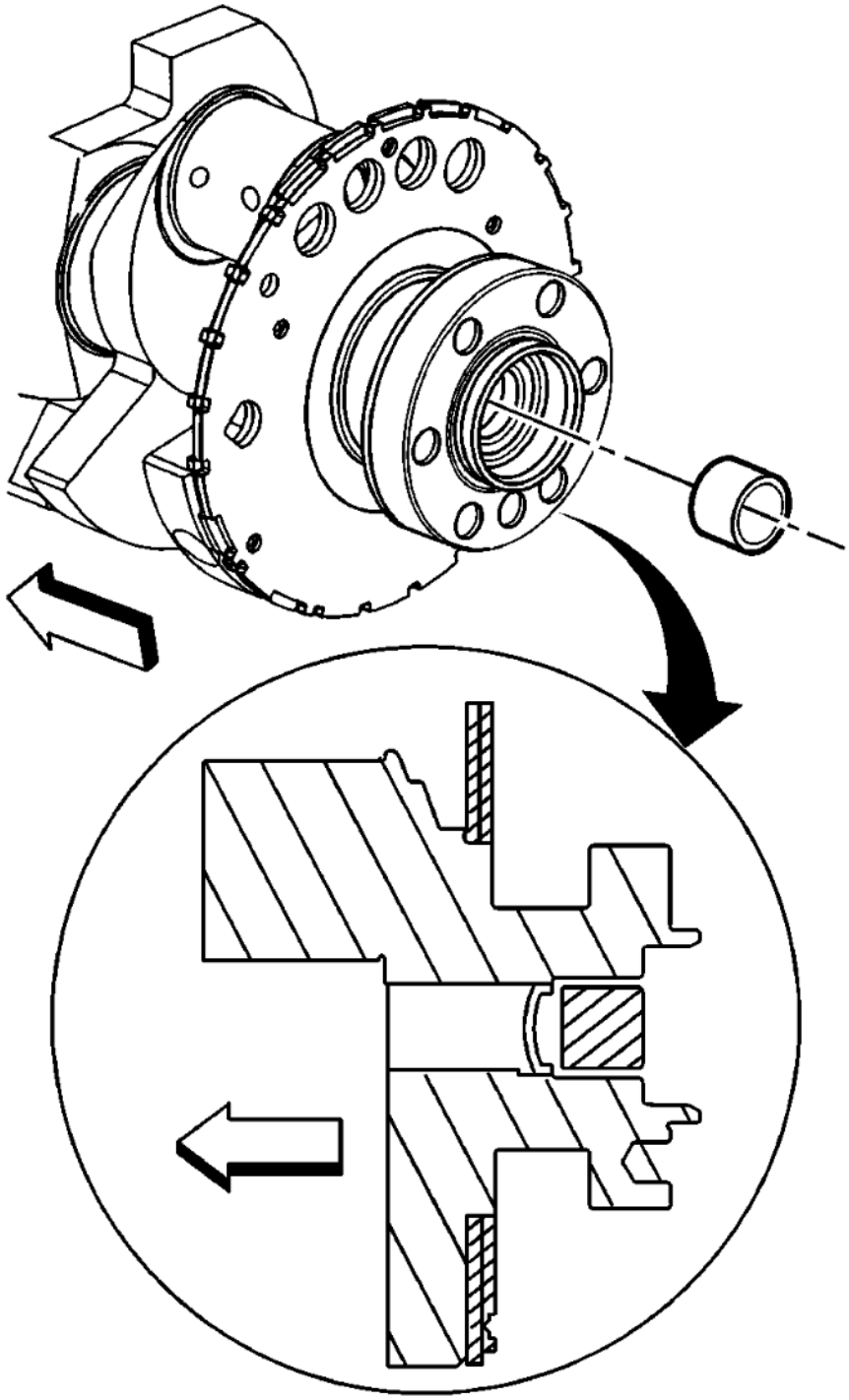

Fig. 275: Locating Clutch Pilot Bearing
Courtesy of GENERAL MOTORS COMPANY

2. Discard the bearing.

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

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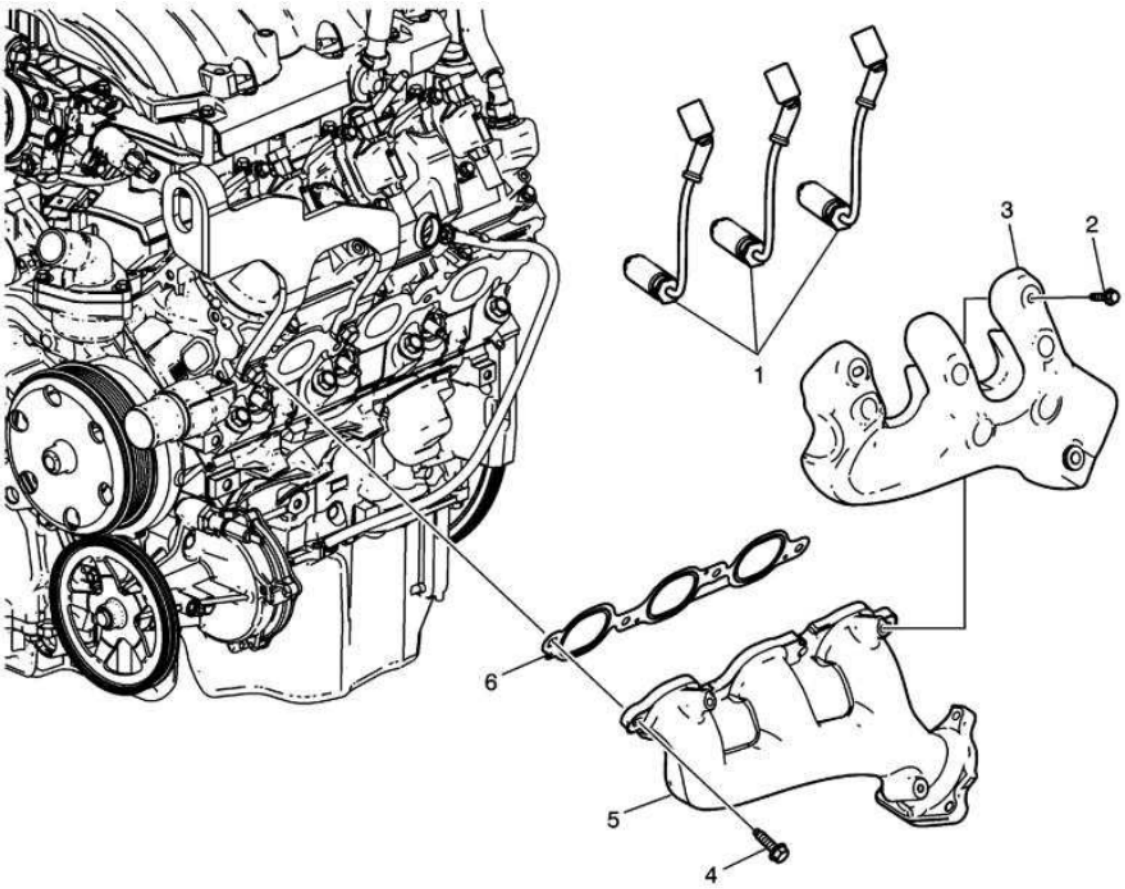

Fig. 276: Exhaust Manifold Removal - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Spark Plug Wires
2	Heat Shield Bolt
3	Heat Shield
4	Exhaust Manifold Bolt
5	Exhaust Manifold
6	Exhaust Manifold Gasket Refer to **Replacing Engine Gaskets**.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

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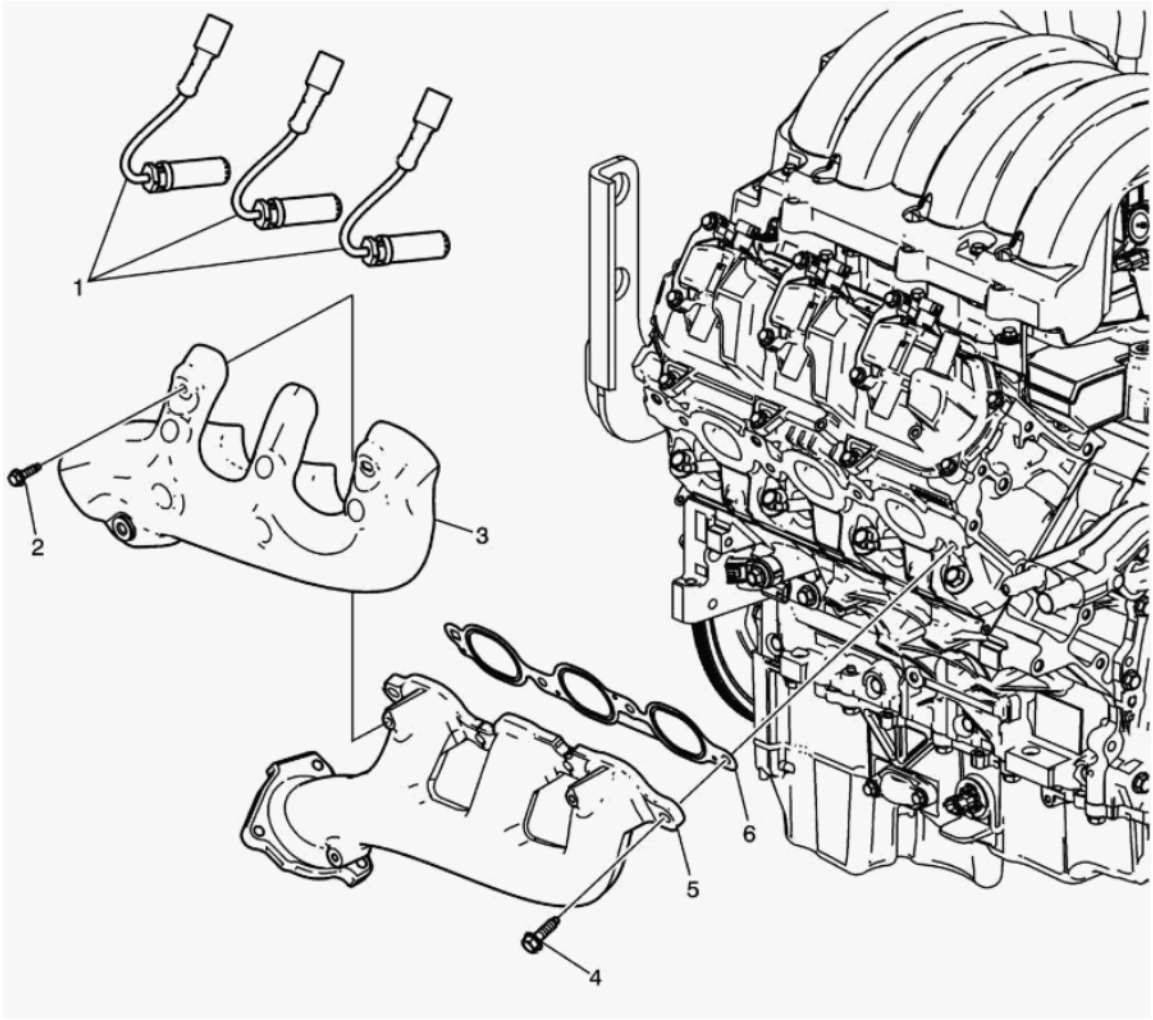

Fig. 277: Exhaust Manifold Removal - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Spark Plug Wires
2	Heat Shield Bolt
3	Exhaust Manifold Heat Shield
4	Exhaust Manifold Bolt
5	Exhaust Manifold
6	Exhaust Manifold Gasket Refer to **Replacing Engine Gaskets**.

VACUUM PUMP REMOVAL

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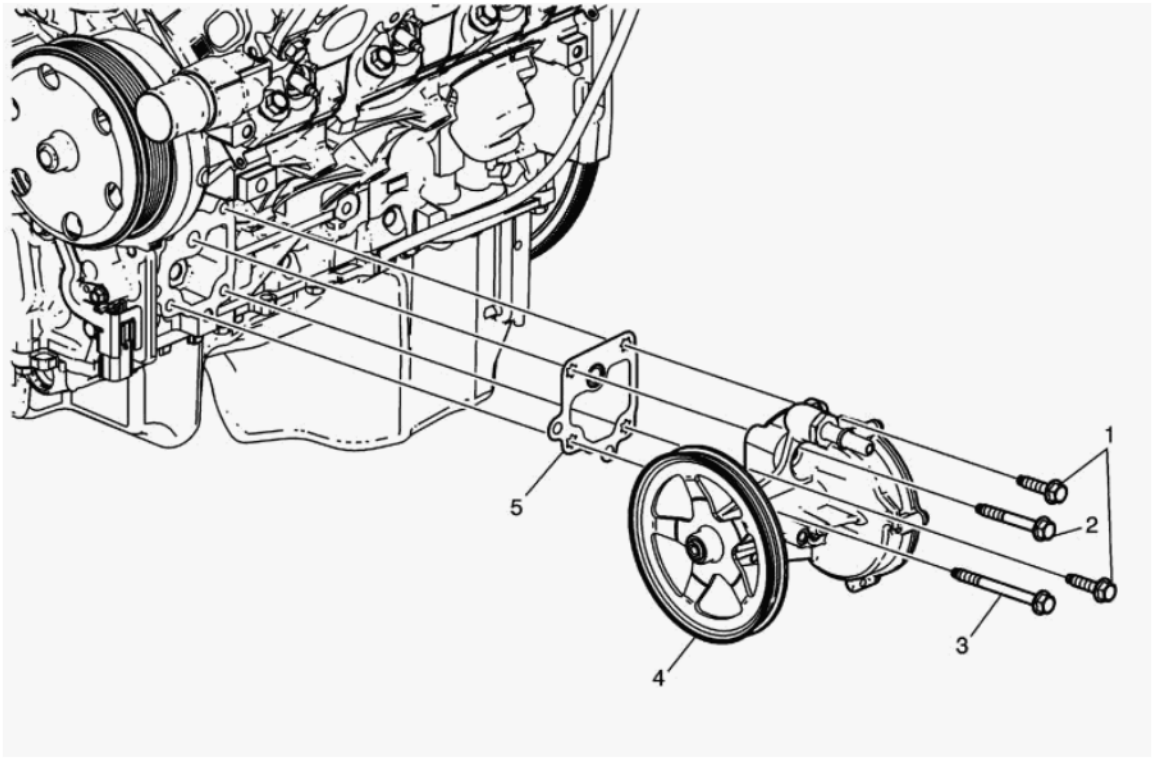

Fig. 278: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Bolts
2	Vacuum Pump Bolt
3	Vacuum Pump Bolt
4	Vacuum Pump Assembly
5	Vacuum Pump Gasket Refer to **Replacing Engine Gaskets**.

OIL LEVEL INDICATOR AND TUBE REMOVAL

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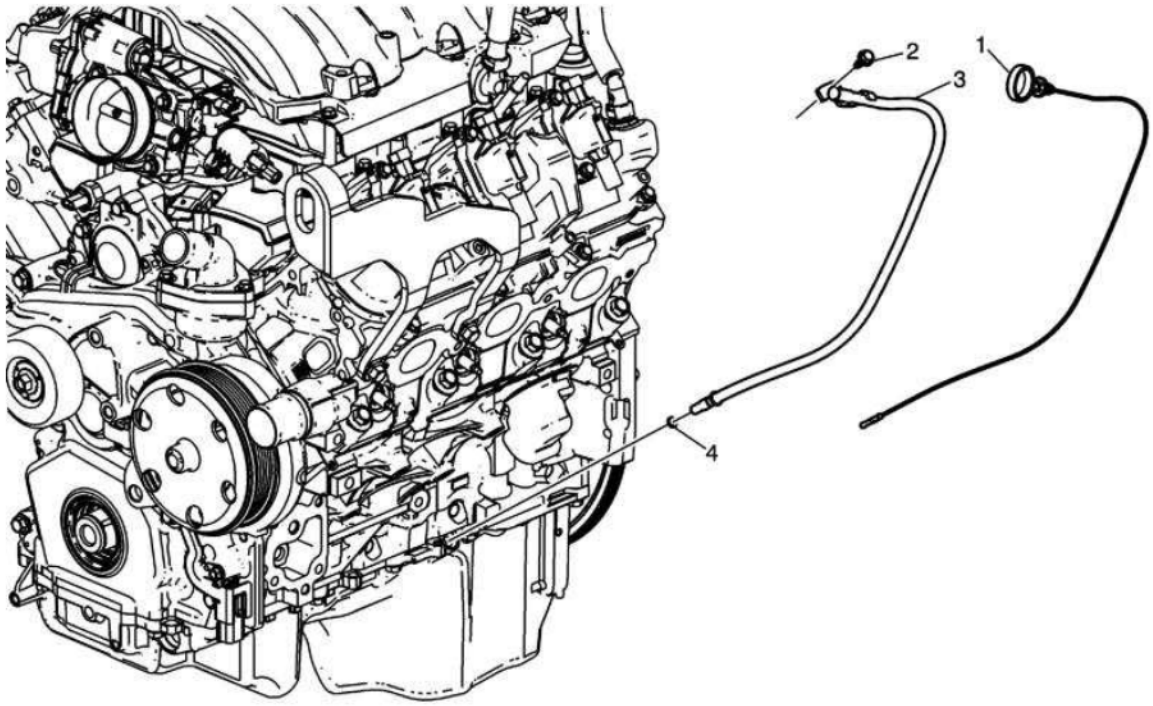

Fig. 279: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator
2	Oil Level Indicator Tube Bracket Bolt
3	Oil Level Indicator Tube
4	Oil Level Indicator Tube Seal

ENGINE COOLANT MANIFOLD REMOVAL

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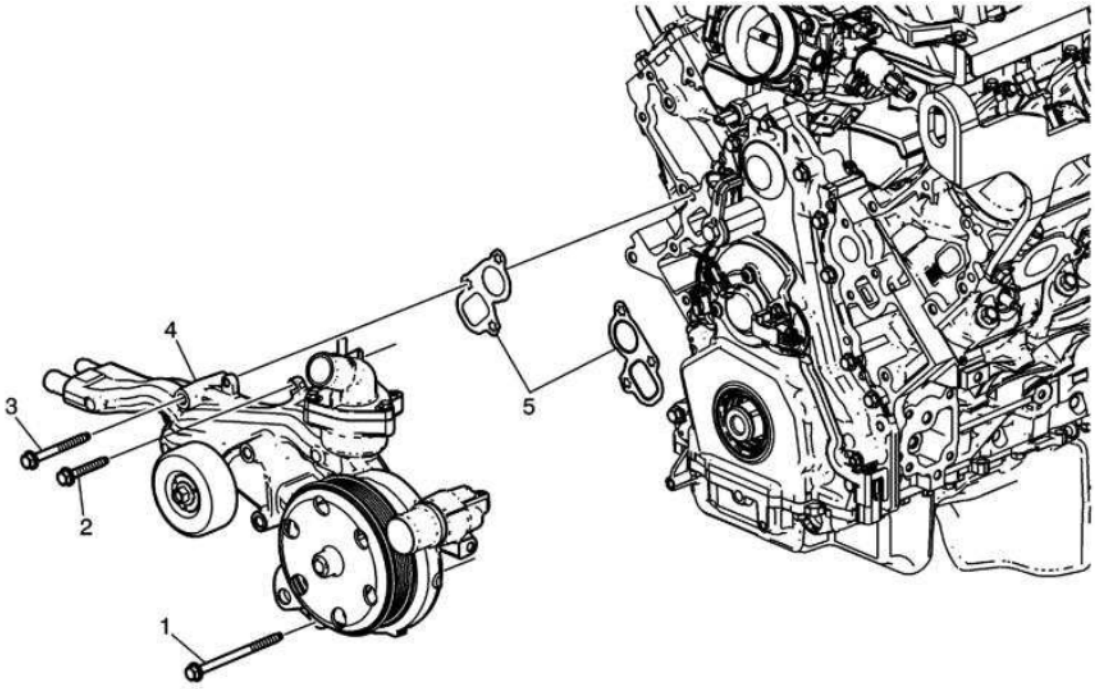

Fig. 280: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Manifold Bolt
2	Engine Coolant Manifold Bolt
3	Engine Coolant Manifold Bolt
4	Engine Coolant Manifold Assembly
5	Engine Coolant Manifold Gasket Refer to **Replacing Engine Gaskets**.

THROTTLE BODY ASSEMBLY REMOVAL

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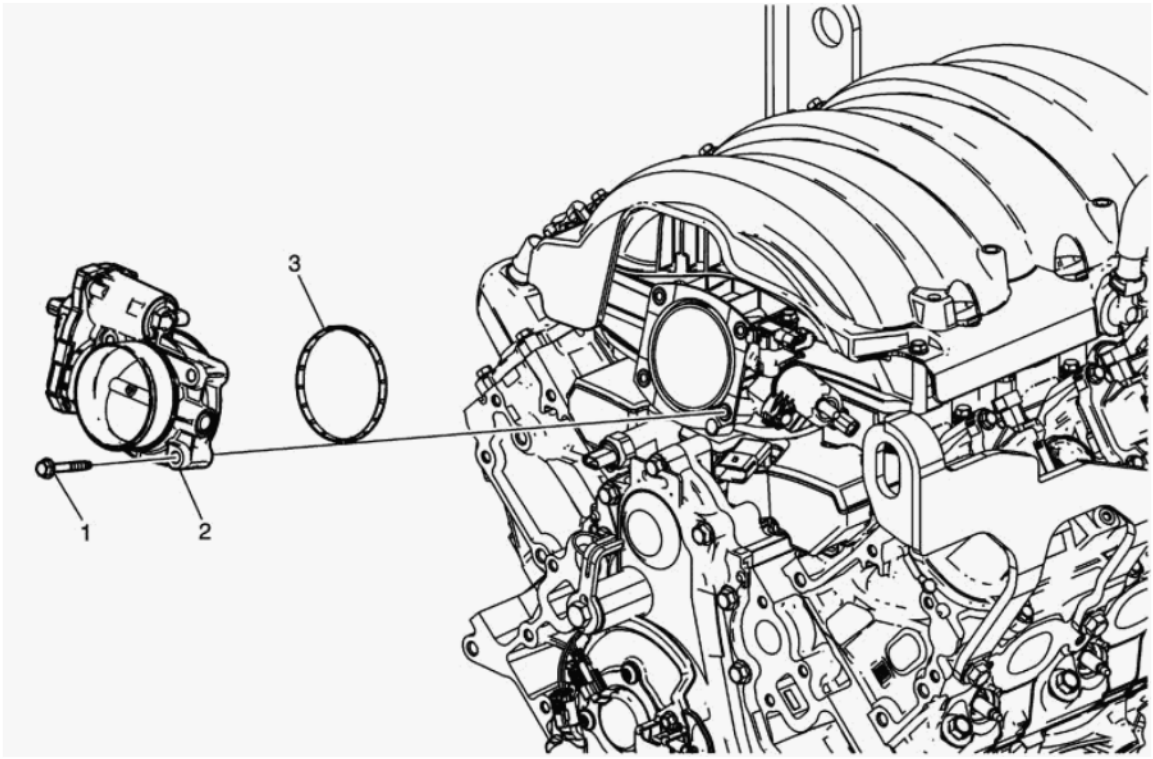

Fig. 281: Throttle Body Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Bolt
2	Throttle Body Assembly
3	Throttle Body Gasket Refer to **Replacing Engine Gaskets**.

INTAKE MANIFOLD REMOVAL

Intake Manifold Cover Removal

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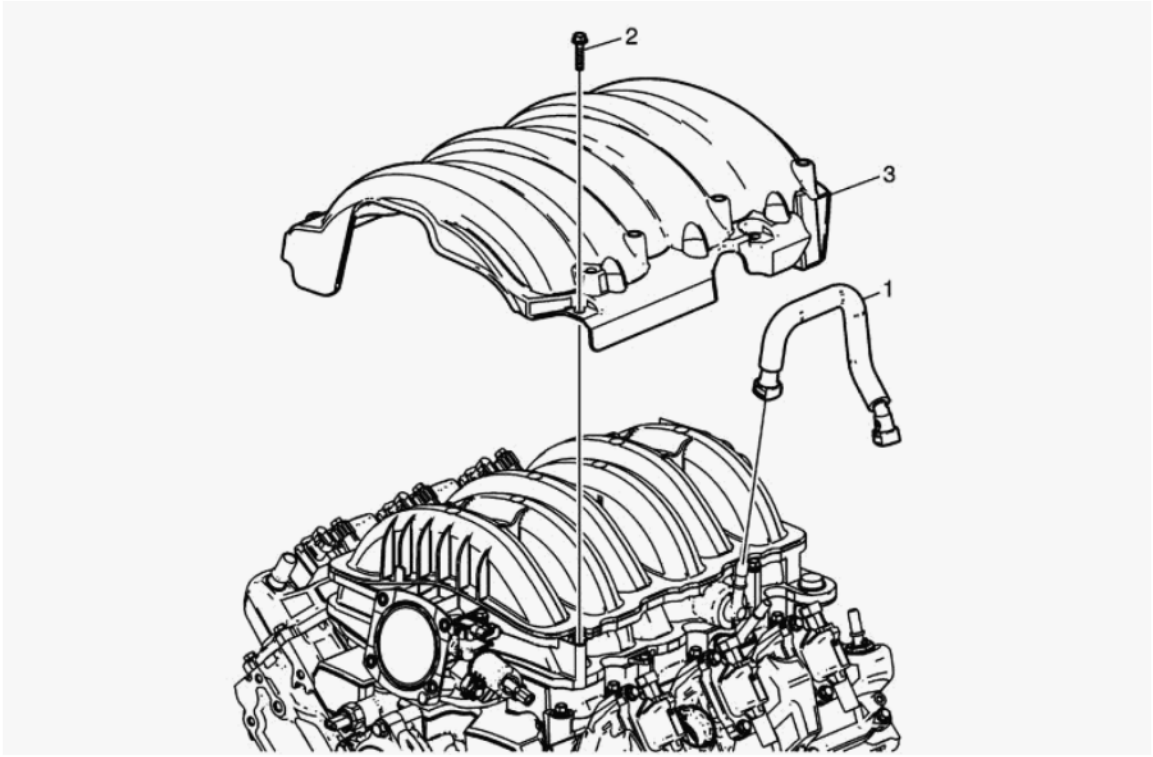

Fig. 282: Intake Manifold Cover
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Cover Removal

Callout	Component Name
1	PCV Tube Assembly **Procedure** 1. The PCV tube is connected to the intake manifold and the engine via a plastic collar quick connect fitting. 2. To remove the PCV tube, refer to **Plastic Collar Quick Connect Fitting Service** .
2	Intake Manifold Cover Bolt
3	Intake Manifold Cover Assembly

Intake Manifold Removal

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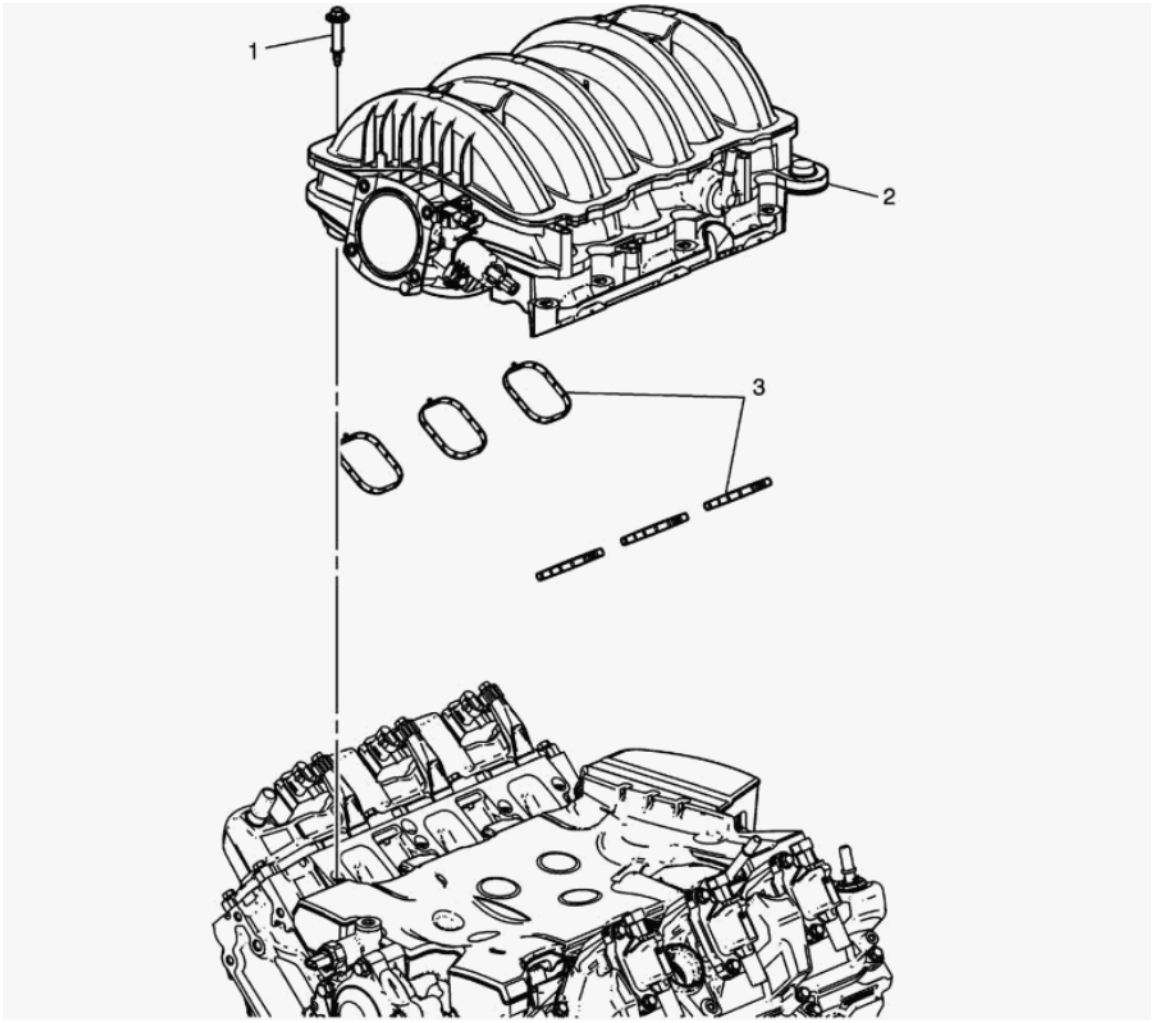

Fig. 283: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Removal

Callout	Component Name
1	Intake Manifold Bolt
2	Intake Manifold Assembly
3	Intake Manifold Gasket Refer to **Replacing Engine Gaskets**.

FUEL PUMP INSULATOR AND FUEL FEED PIPES REMOVAL

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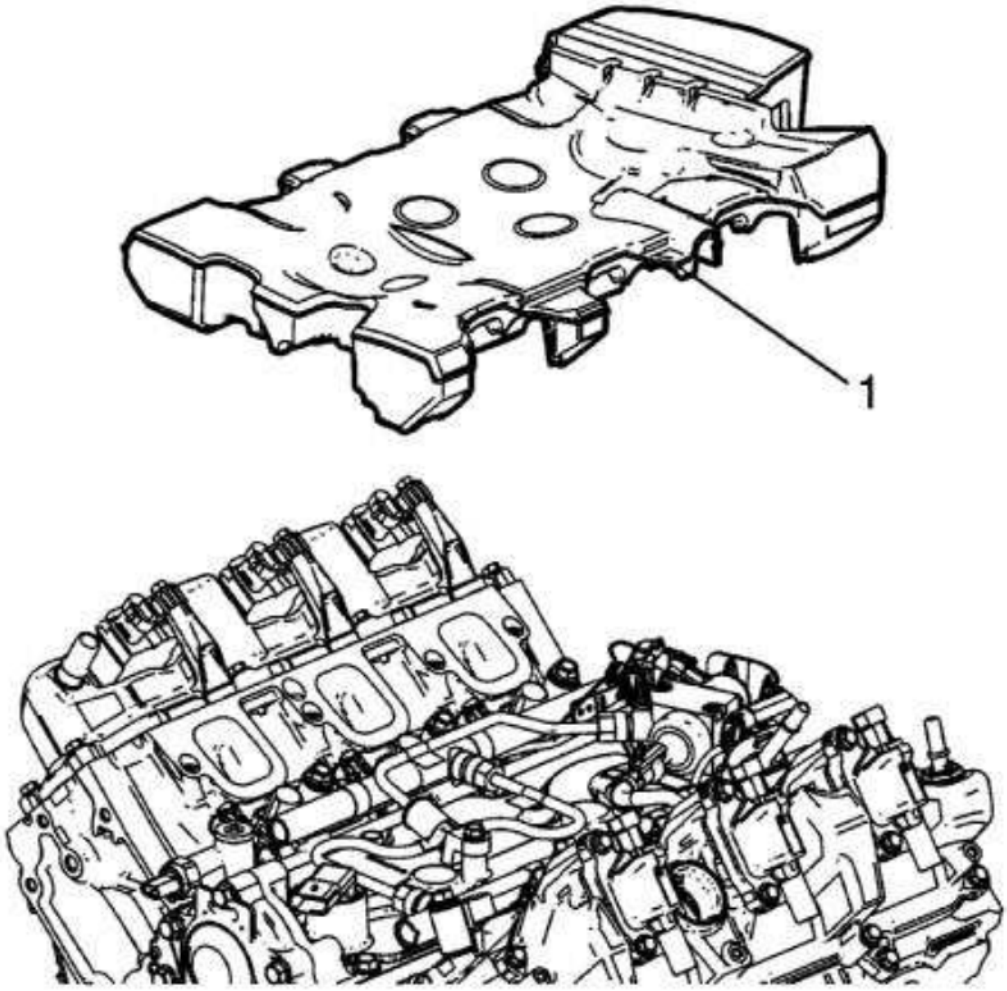

Fig. 284: Fuel Rail Insulator
Courtesy of GENERAL MOTORS COMPANY

WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

1. Remove the fuel pump insulator (1).

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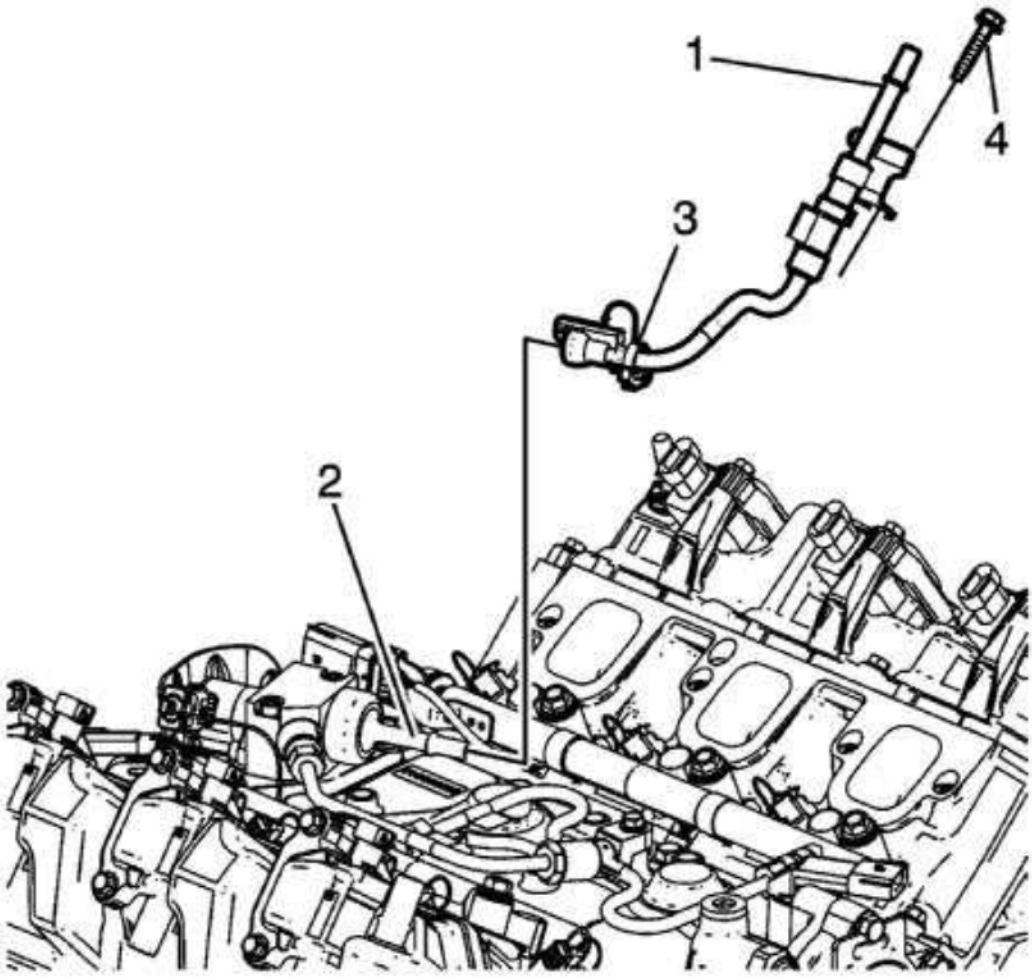

Fig. 285: Pressure Fuel Feed Pipe To Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

2. Remove low pressure fuel feed pipe bolt to LH rocker cover bolt (4).
3. Remove redundant clip (3). Remove low pressure fuel feed pipe (1) from the fuel pump (2).

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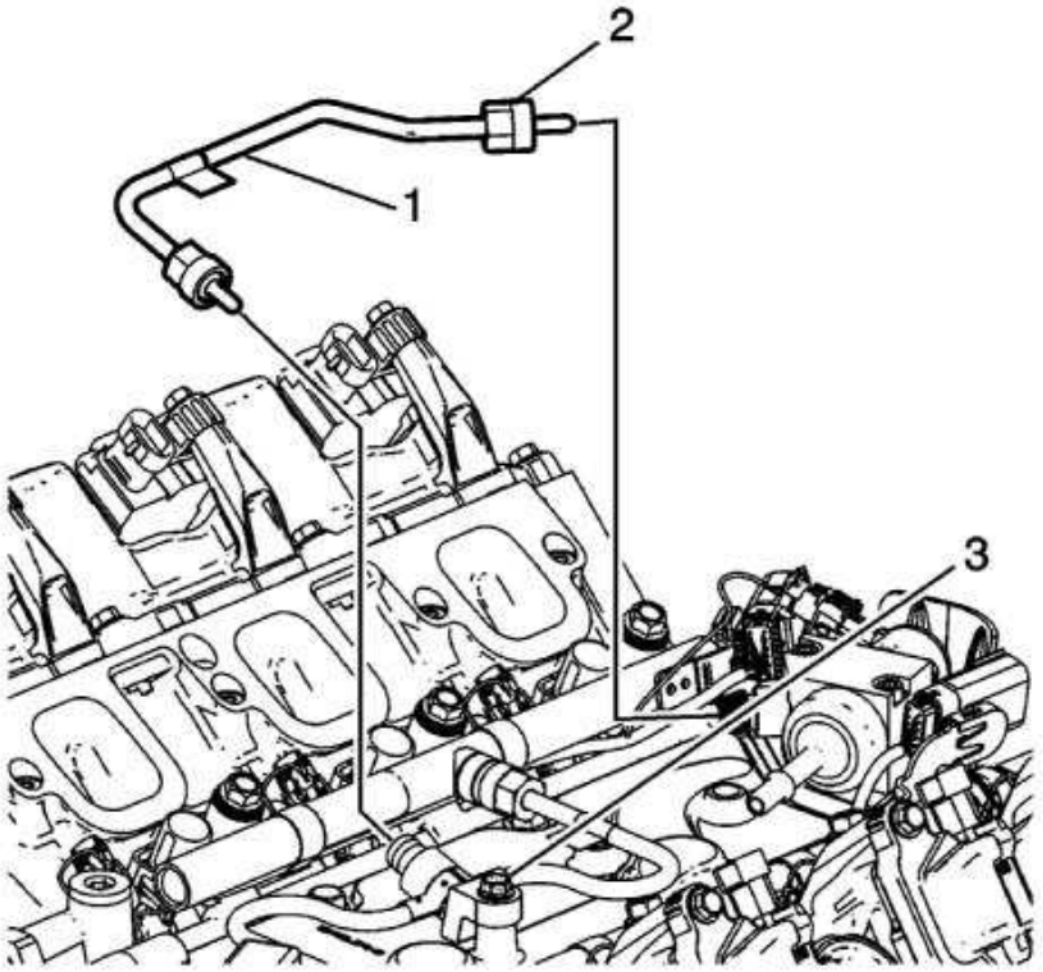

Fig. 286: Fuel Pump To Crossover Pipe And Finger-Tighten Both Fuel Pipe Fitting Nuts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE:

- **DO NOT reuse the high pressure fuel feed pipe.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

4. Remove the high pressure fuel feed pipe that connects the fuel pump to the crossover pipe (1) by loosening the fuel feed pipe fittings (2).

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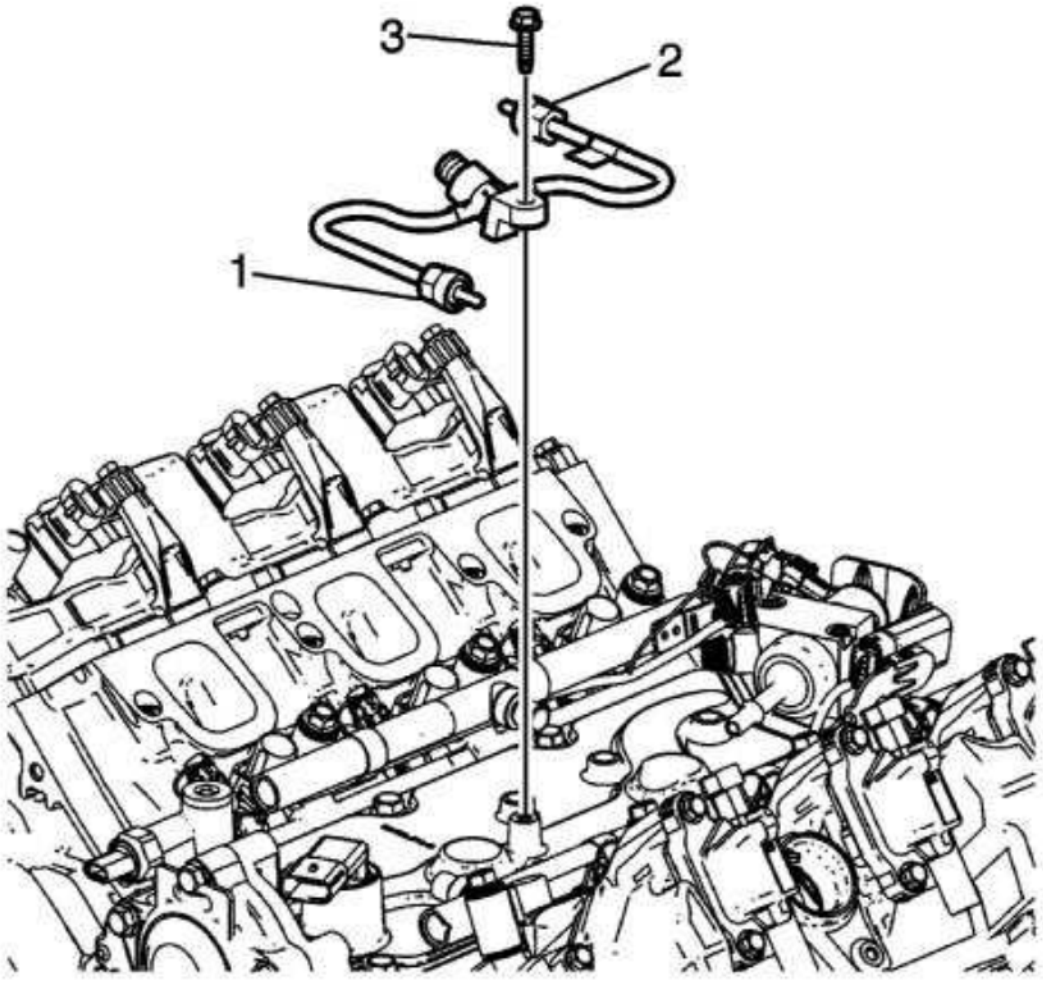

Fig. 287: Left Fuel Rail And Right Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE:

- **DO NOT reuse the high pressure fuel rail crossover pipe.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow Installation and tightening steps exactly.**

5. Remove the high pressure LH to RH fuel rail crossover pipe bolt (3).
6. Remove the fuel rail crossover pipe by loosening the pipe fittings (1 and 2).

FUEL RAIL AND INJECTORS REMOVAL

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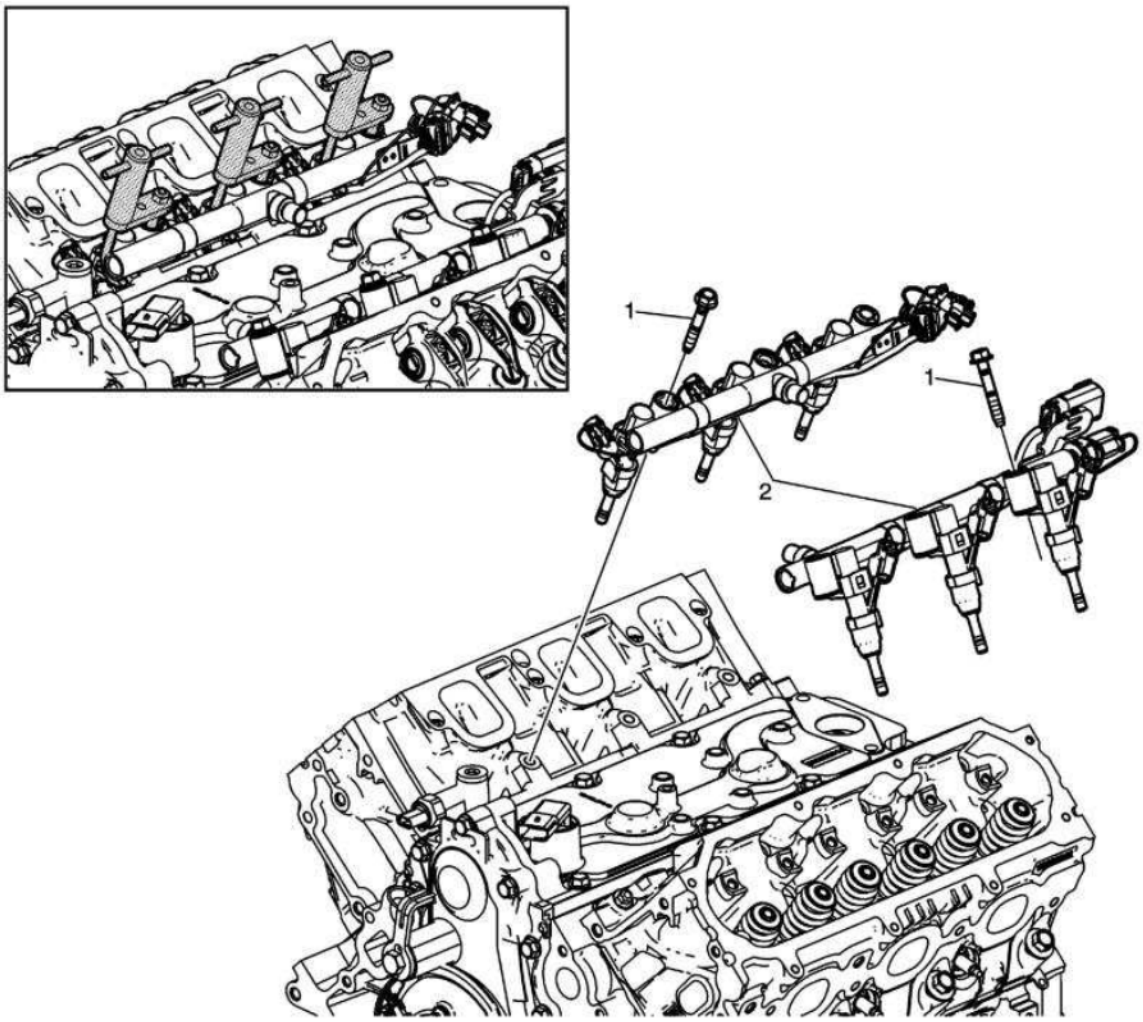

Fig. 288: Fuel Rail and Injectors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Bolt
2	Direct Fuel Injection Fuel Rail Assembly **Procedure** **NOTE:** • **In some cases, the fuel injectors may be difficult to remove because of heavy carbon build-up or other factors.**

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Callout	Component Name
	Excessive force with the removal tool can damage the fuel rail, injectors or both. If injectors are difficult to remove, apply solvent to the base of the injector bores, and allow adequate soaking time, to loosen the fuel injectors. • **Pull the fuel rail and injectors as an assembly.** • **To prevent material from entering the combustions chambers make sure the area around each injector is clean and free of debris before the injectors are removed from the injector bores.** 1. Install two sets of **EN-49248** remover. 2. Install one remover in each of the fuel rail fastener bores. 3. Remove by turning each section of the remover an equal amount to pull the fuel rail and

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Callout	Component Name
	injectors out evenly. **Special Tools** **EN-49248** Injector Rail Assembly Remover For equivalent regional tools, refer to **Special Tools**.
3	Fuel Rail Insulator

FUEL PUMP REMOVAL

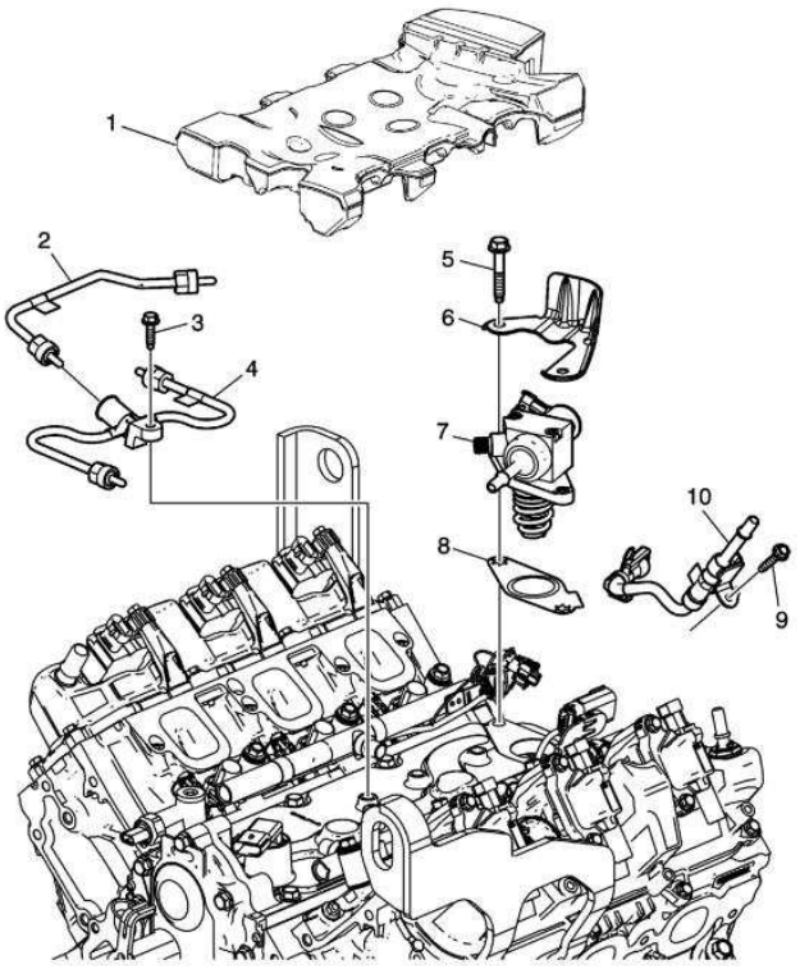

Fig. 289: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	**CAUTION:** **Alternately loosen the fuel pump bolts one turn at a time until the pump is fully**

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Callout	Component Name
	disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage Fuel Pump Bolt
2	Fuel Pump Cover
3	Fuel Pump Bolt Retainer
4	Fuel Pump Assembly
5	Fuel Pump Gasket Refer to **Replacing Engine Gaskets**.

VALVE LIFTER OIL FILTER REMOVAL

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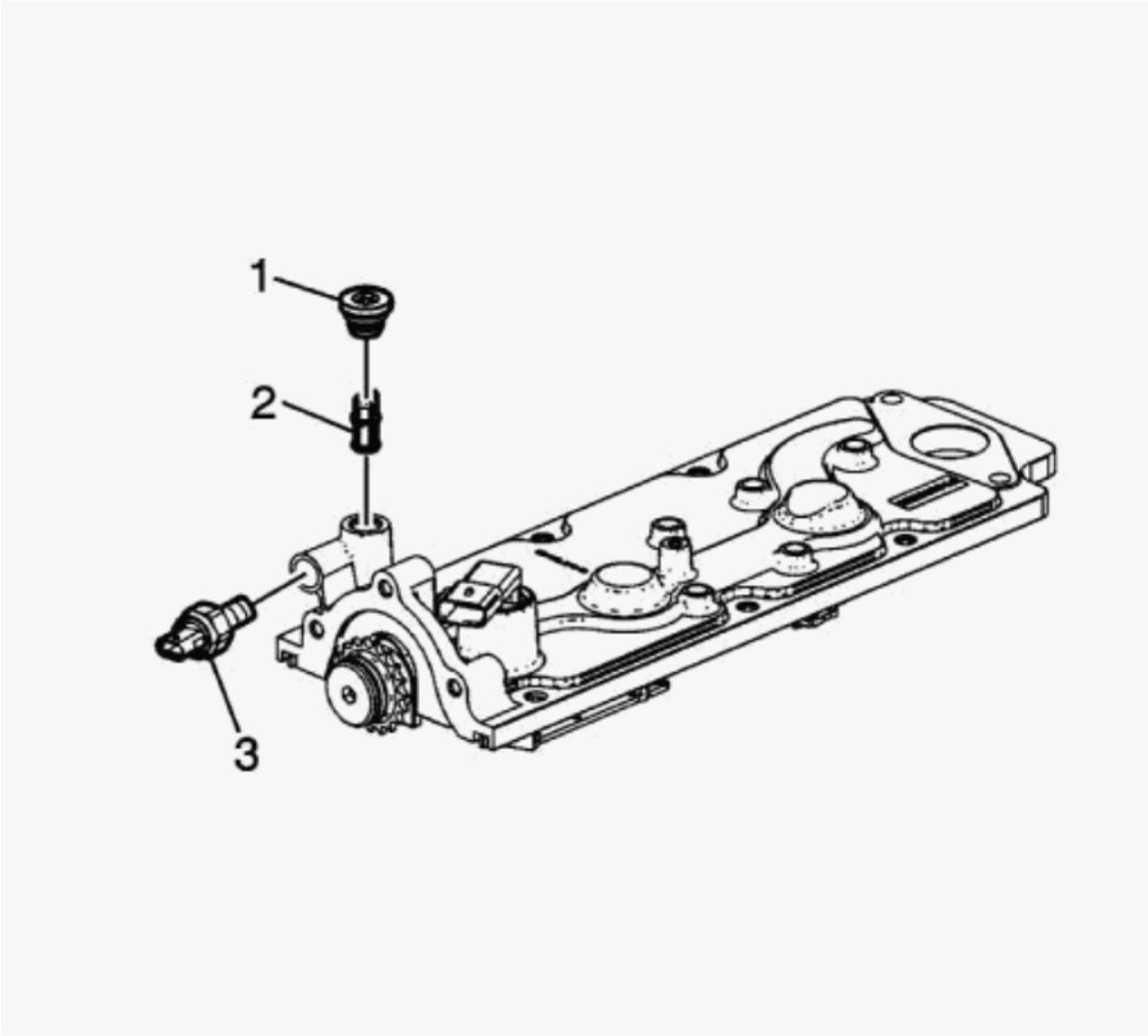

Fig. 290: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

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

1. Remove the oil pressure sensor (3).
2. Remove the valve lifter oil manifold plug (1) and oil filter (2).

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

Valve Rocker Arm Cover Removal - Left Side

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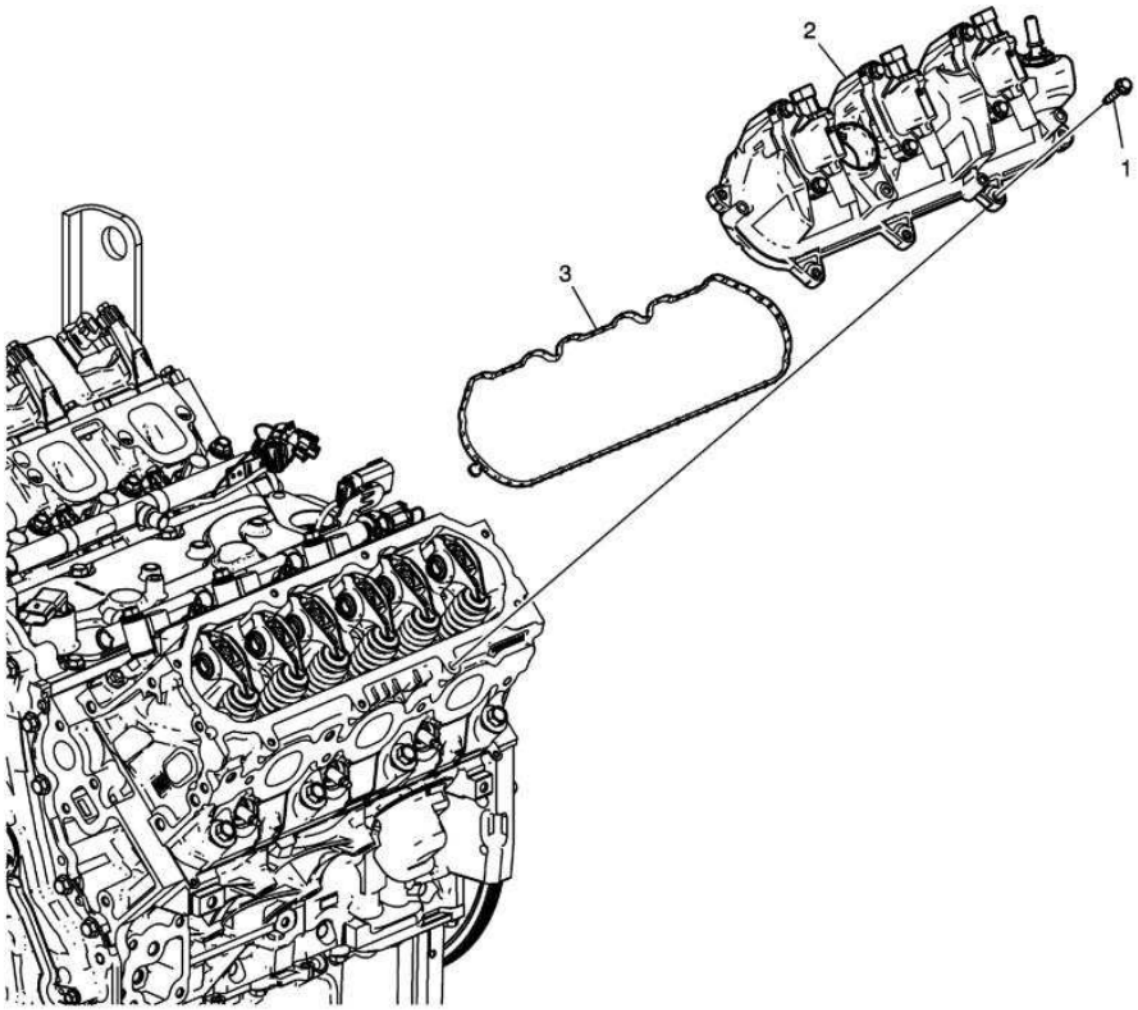

Fig. 291: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Removal - Left Side

Callout	Component Name
1	Valve Rocker Arm Cover Bolt
2	Valve Rocker Arm Cover - Left Side
3	Valve Rocker Arm Cover Gasket Refer to **Replacing Engine Gaskets**.

Valve Rocker Arm Cover Disassemble - Left Side

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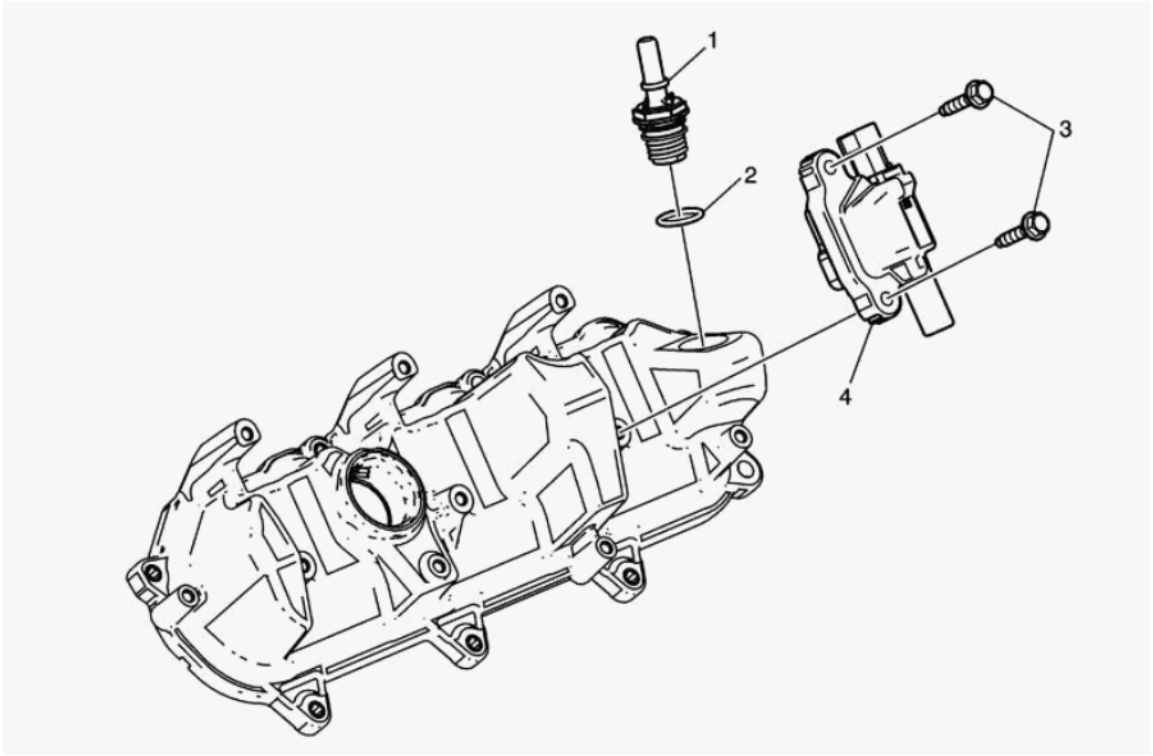

Fig. 292: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Disassemble - Left Side

Callout	Component Name
1	PCV Fitting
2	PCV Fitting Seal **NOTE:** **Discard seal, it is not reusable.**
3	Ignition Coil Bolt
4	Ignition Coil

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

Valve Rocker Arm Cover Removal - Right Side

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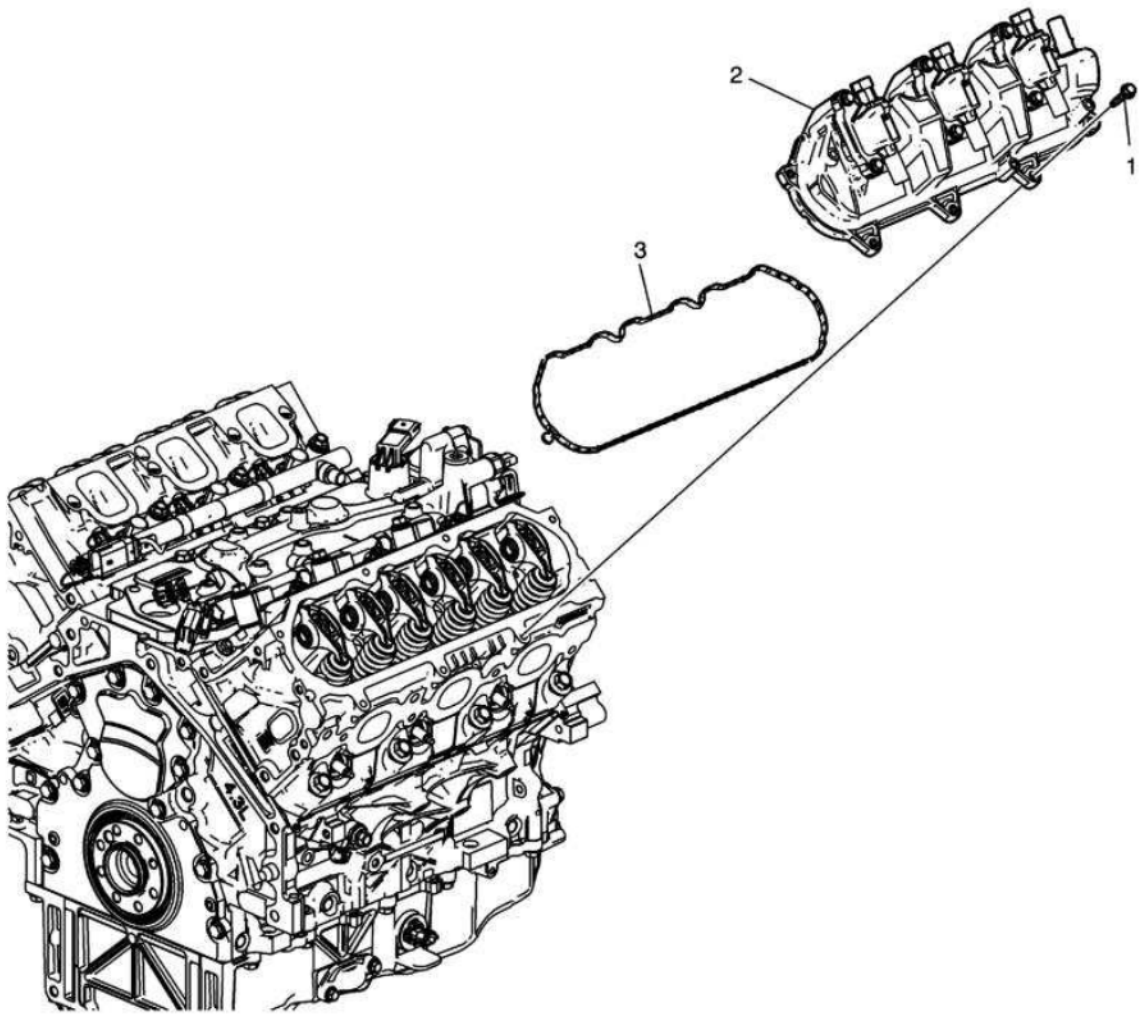

Fig. 293: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Removal - Right Side

Callout	Component Name
1	Valve Rocker Arm Cover Bolt
2	Valve Rocker Arm Cover - Right Side
3	Valve Rocker Arm Cover Gasket Refer to **Replacing Engine Gaskets**.

Valve Rocker Arm Cover Disassemble - Right Side

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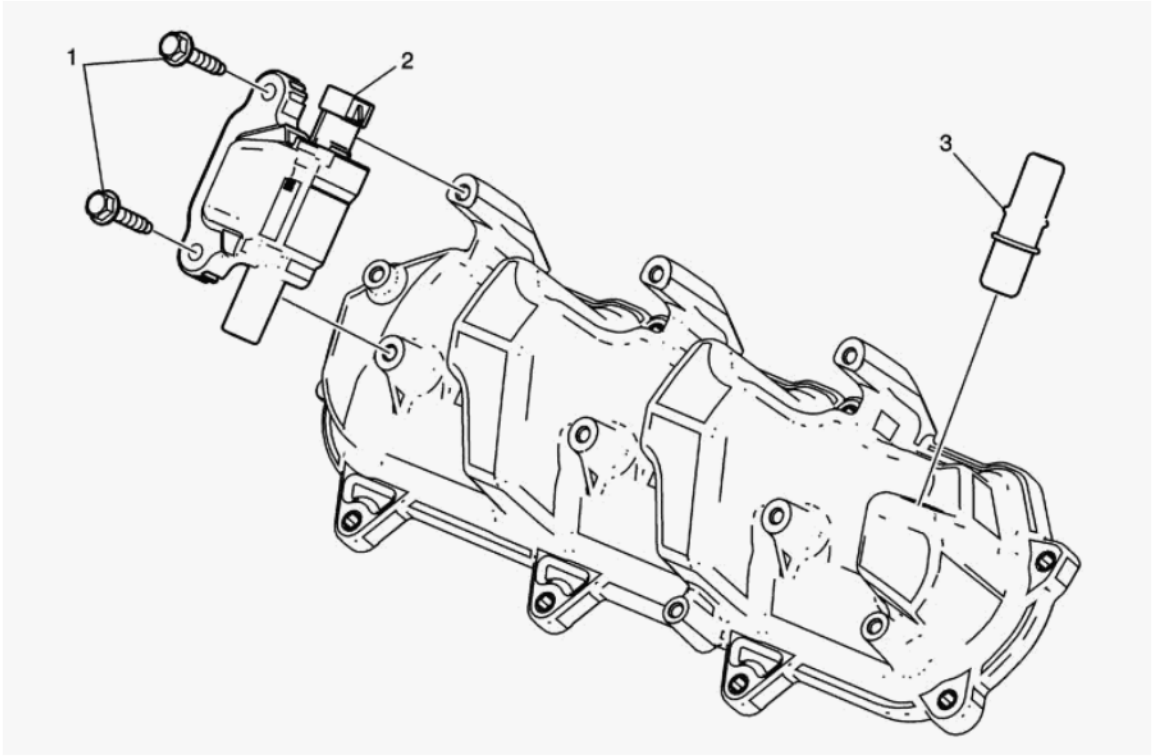

Fig. 294: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Disassemble - Right Side

Callout	Component Name
1	Ignition Coil Bolt
2	Ignition Coil

VALVE ROCKER ARM AND PUSH ROD REMOVAL

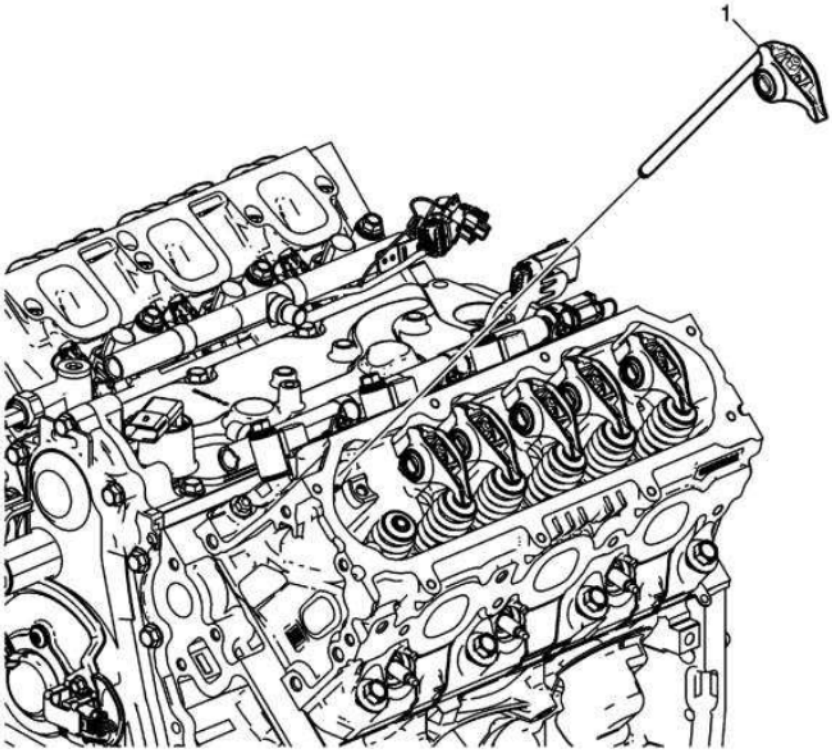

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Fig. 295: Valve Rocker Arm and Push Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Place the valve rocker arms and valve pushrods in a rack so they can be installed in the same location from which they were removed.**

Callout	Component Name
1	Valve Rocker Arm and Push Rod Assembly **NOTE:** **The rocker arm bolts are not serviced separately.**

CYLINDER HEAD REMOVAL - LEFT SIDE

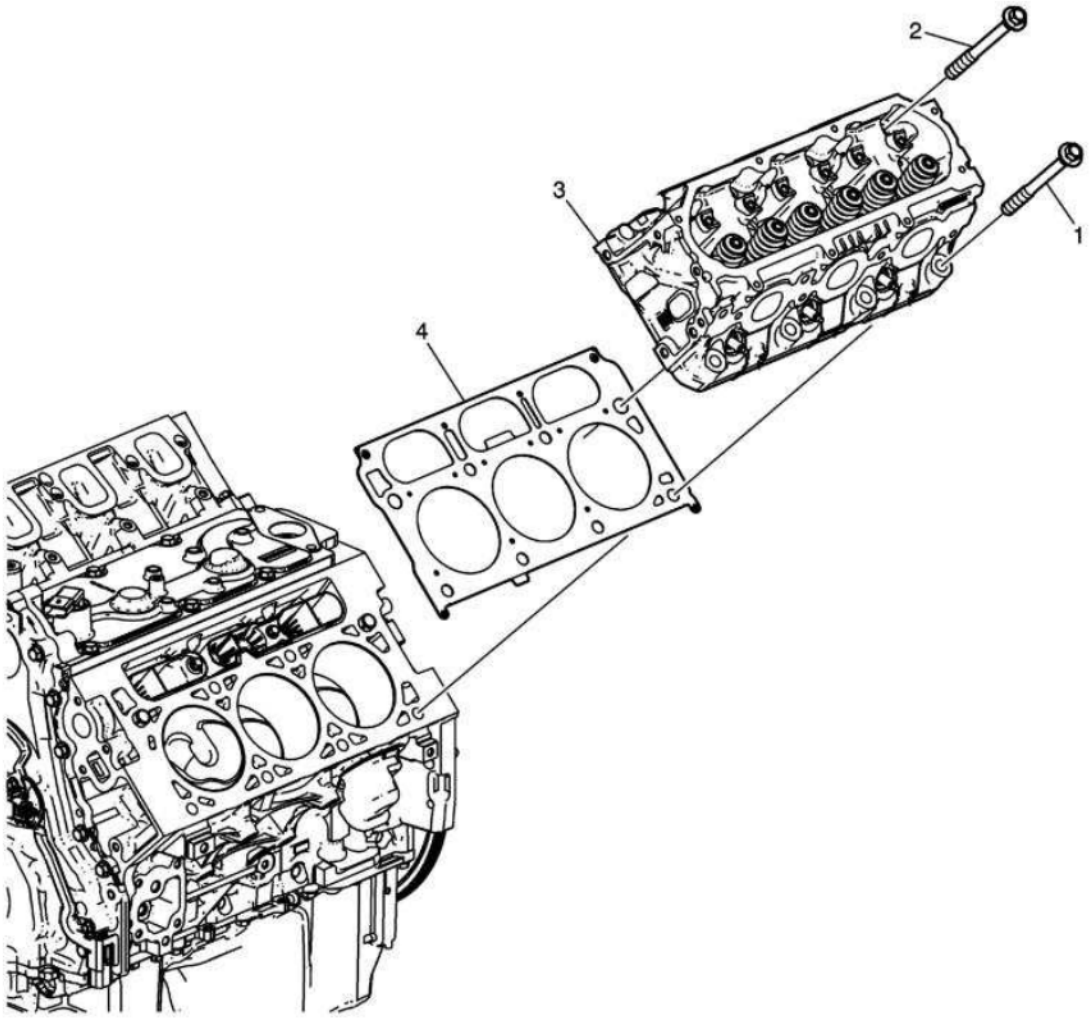

Fig. 296: Cylinder Head - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

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Callout	Component Name
If camshaft lobe lift measurement is required, perform measurement prior to removal of the cylinder heads. Refer to **Camshaft and Bearings Cleaning and Inspection**.	
1	Cylinder Head Bolt
2	Cylinder Head Bolt
3	Cylinder Head Assembly
4	Cylinder Head Gasket Refer to **Replacing Engine Gaskets**.

CYLINDER HEAD REMOVAL - RIGHT SIDE

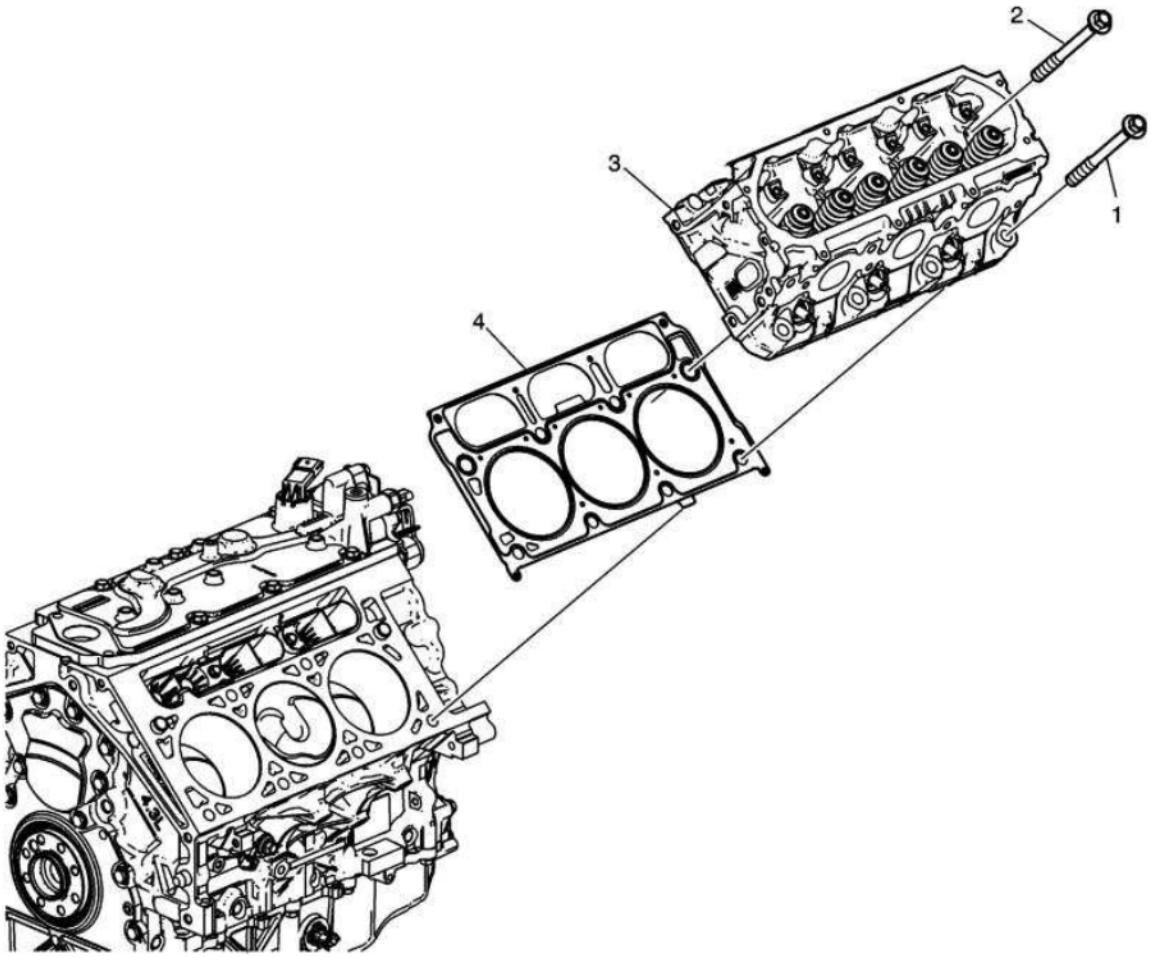

Fig. 297: Cylinder Head - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If camshaft lobe lift measurement is required, perform measurement prior to removal of the cylinder heads. Refer to **Camshaft and Bearings Cleaning and Inspection**.	
1	Cylinder Head Bolt
2	Cylinder Head Bolt
3	Cylinder Head Assembly

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Callout	Component Name
4	Cylinder Head Gasket Refer to **Replacing Engine Gaskets**.

OIL PAN REMOVAL

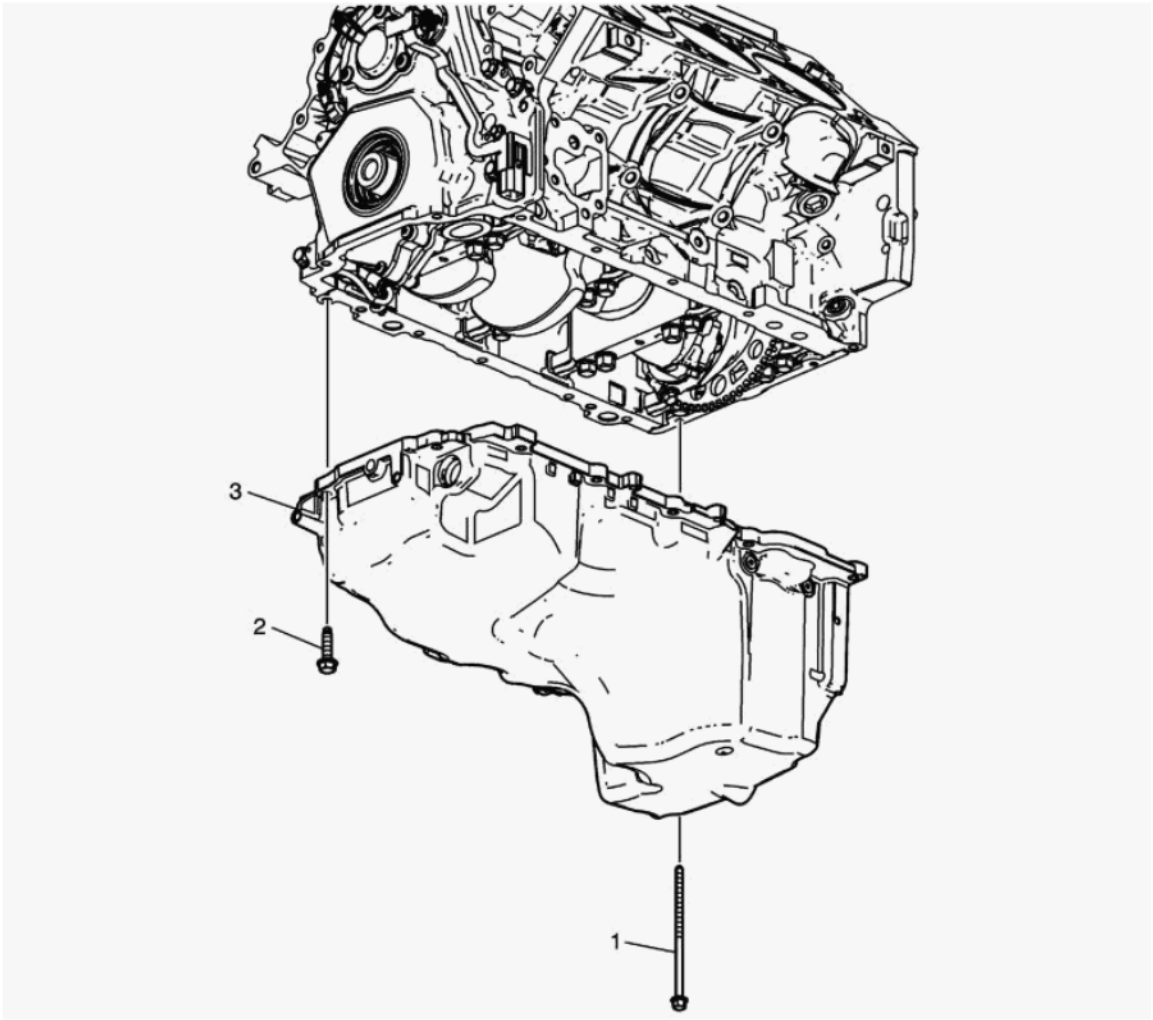

Fig. 298: Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt
2	Oil Pan Bolt
3	Oil Pan

CRANKSHAFT FRONT OIL SEAL REMOVAL

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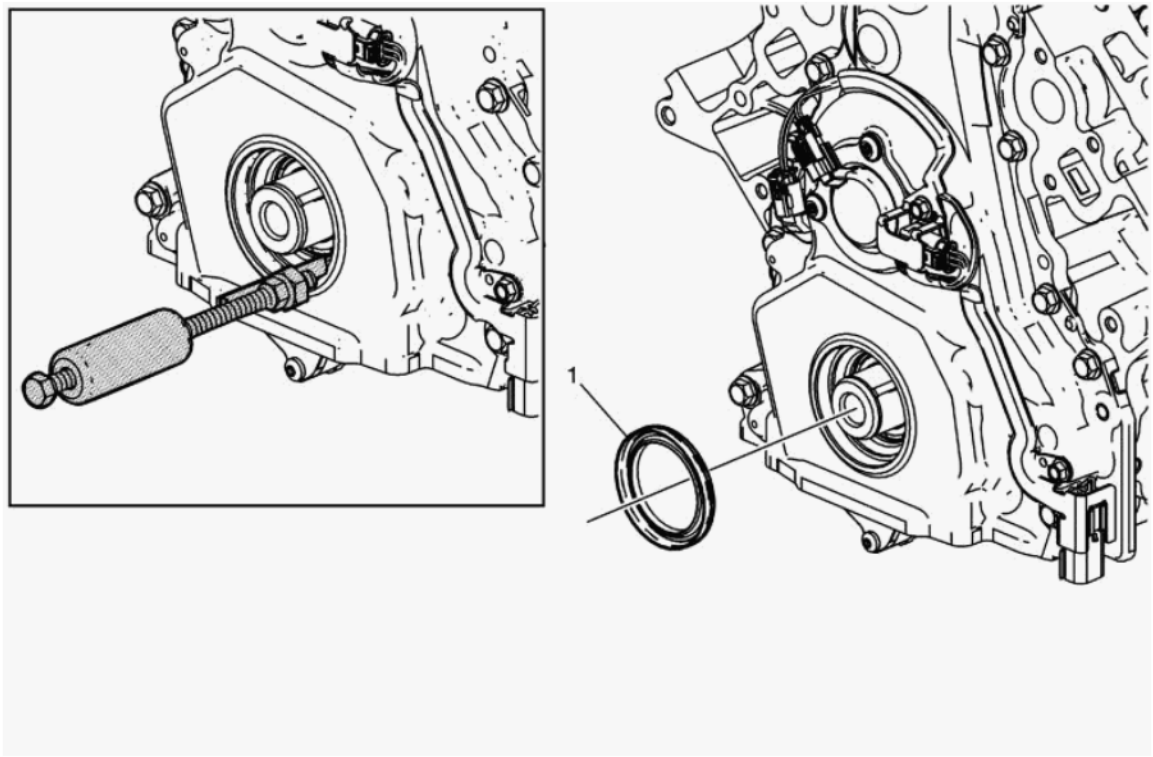

Fig. 299: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Front Oil Seal **Procedure** 1. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer. **NOTE:** **EN-51096 crankshaft rear seal remover has two ends. The end with the small bend will be used to remove the seal.** 2. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the front seal and crankshaft. Ensure that the small bend of **EN-51096** crankshaft rear seal remover engages the rear side of the front seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal, use the slide hammer to remove the seal. **Special Tools**

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Callout	Component Name
	• **EN-51096** Crankshaft Rear Seal Remover • **GE-23907-1** Slide Hammer For equivalent regional tools, refer to **Special Tools**.

ENGINE FRONT COVER REMOVAL

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Removal

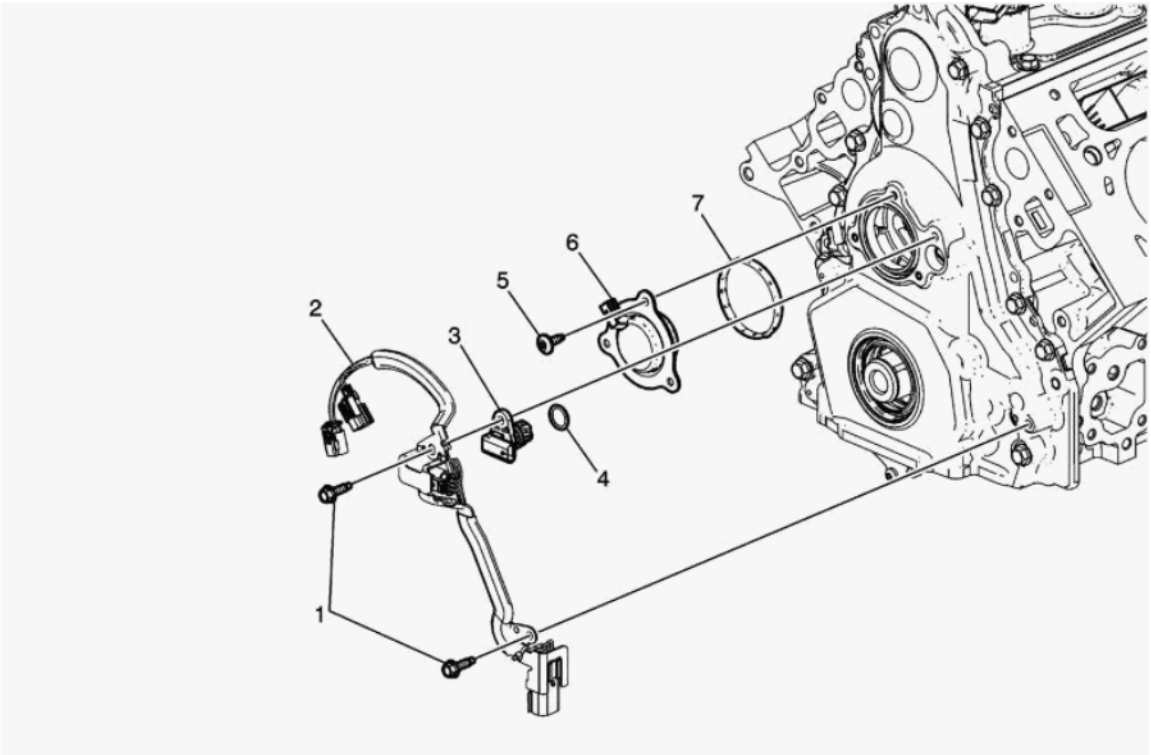

Fig. 300: Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Removal

Callout	Component Name
1	Camshaft Position Sensor Harness Bolts
2	Camshaft Position Sensor Harness
3	Camshaft Position Sensor
4	Camshaft Position Sensor Seal Refer to **Replacing Engine Gaskets**. **NOTE:** **Discard seal, it is not reusable.**
5	Camshaft Actuator Magnet Bolts
6	Camshaft Actuator Magnet

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Callout	Component Name
7	Camshaft Actuator Magnet Gasket **NOTE:** **Discard gasket, it is not reusable.**

Front Cover Removal

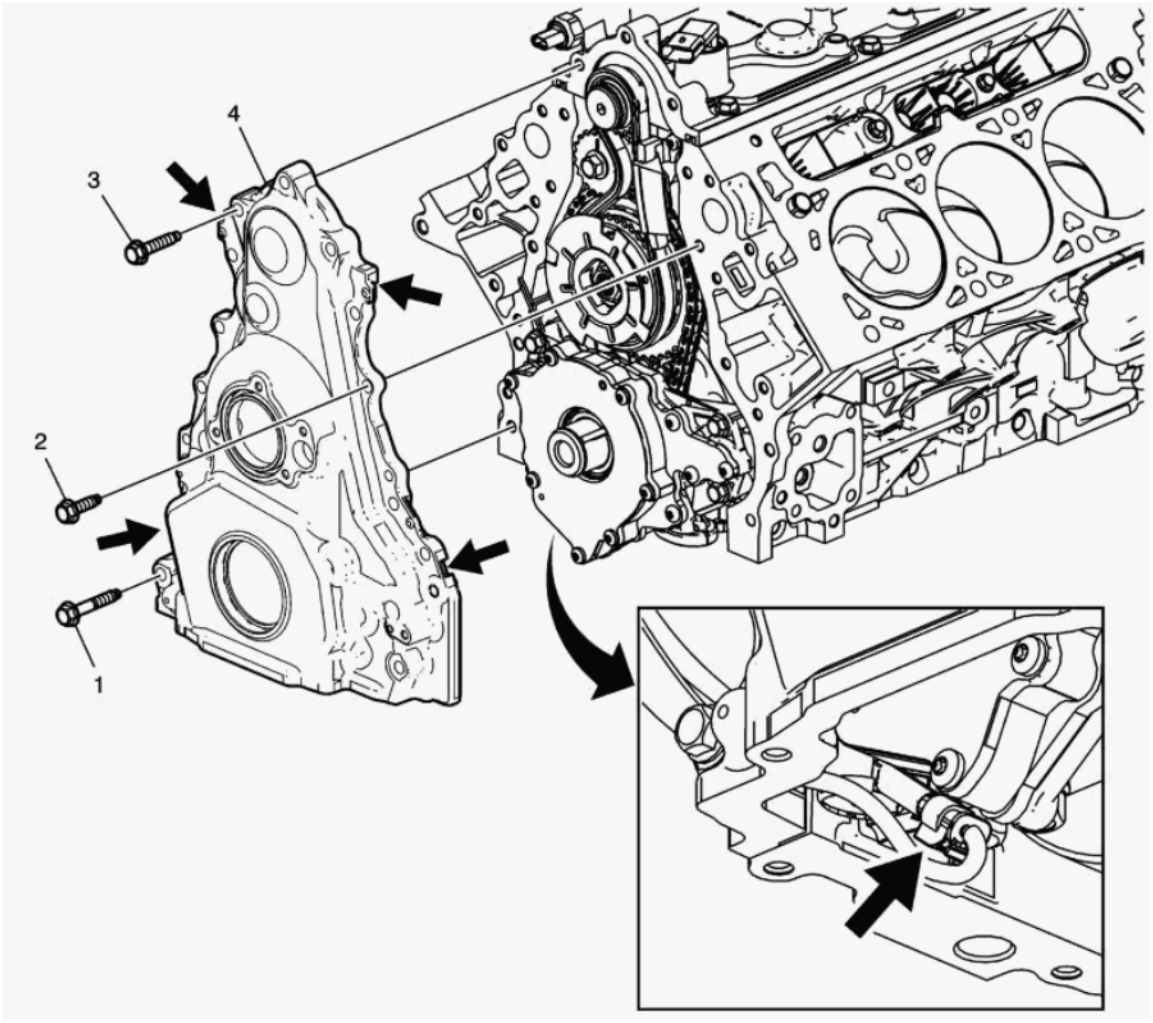

Fig. 301: Front Cover
Courtesy of GENERAL MOTORS COMPANY

Front Cover Removal

Callout	Component Name
Preliminary Prodedure: The oil pump flow control valve harness must be removed before the front cover can be removed.	
1	Engine Front Cover Bolt
2	Engine Front Cover Bolt
3	Engine Front Cover Bolt
4	Engine Front Cover

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Callout	Component Name
	NOTE:

Oil Pump Flow Control Valve Harness Removal

To separate the front cover from

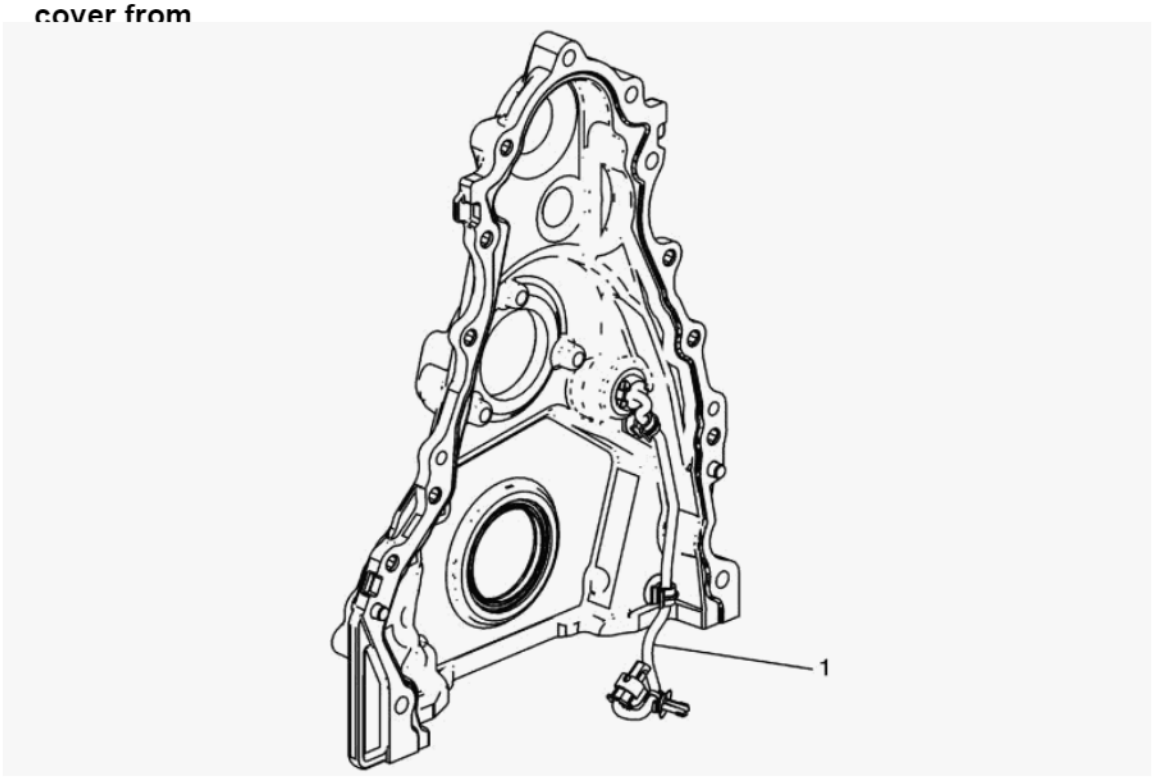

Fig. 302: Oil Pump Flow Control Valve Harness
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Harness Removal

Callout	Component Name
1	Oil Pump Flow Control Valve Harness **Procedure** 1. Remove the wire from the 2 retainer clips. 2. Push the tabs in and pull the harness and connector through the front of the engine front cover

CRANKSHAFT REAR OIL SEAL REMOVAL

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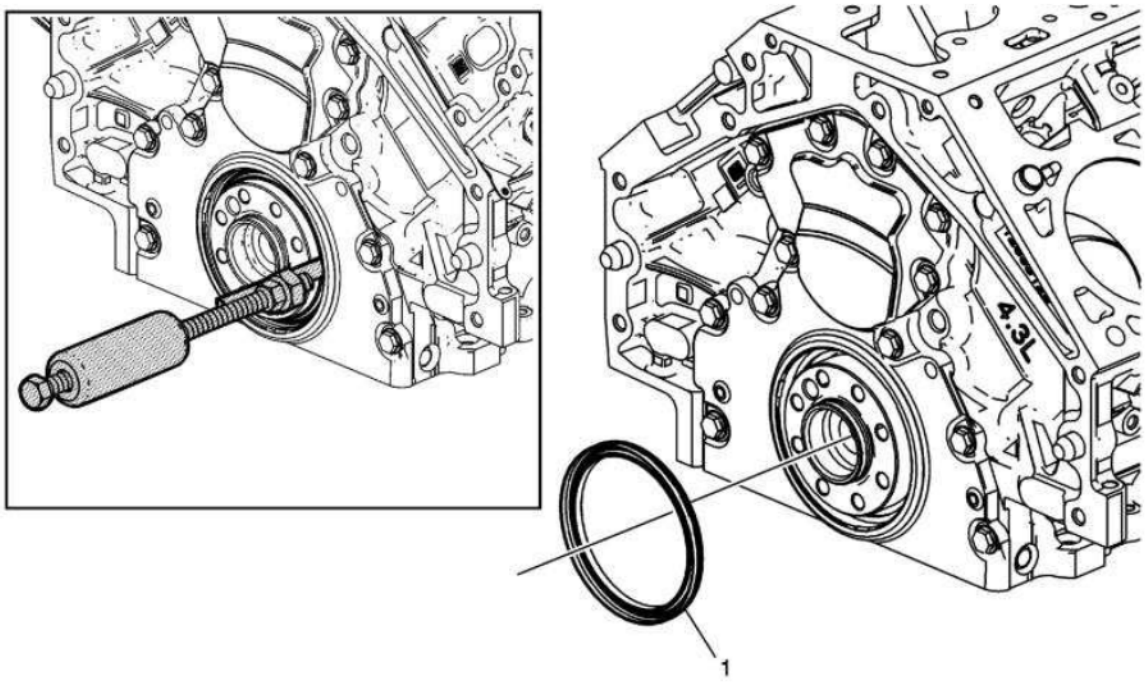

Fig. 303: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal **Procedure** 1. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer. **NOTE:** **EN-51096 crankshaft rear seal remover has two ends. The end with the small bend will be used to remove the seal.** 2. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the rear seal and crankshaft. Ensure that the small bend of **EN-51096** crankshaft rear seal remover engages the rear side of the rear seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal and use the slide hammer to remove the seal. **Special Tools**

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Callout	Component Name
	• **EN-51096** Crankshaft Rear Seal Remover • **GE-23907-1** Slide Hammer For equivalent regional tools, refer to **Special Tools**.

CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

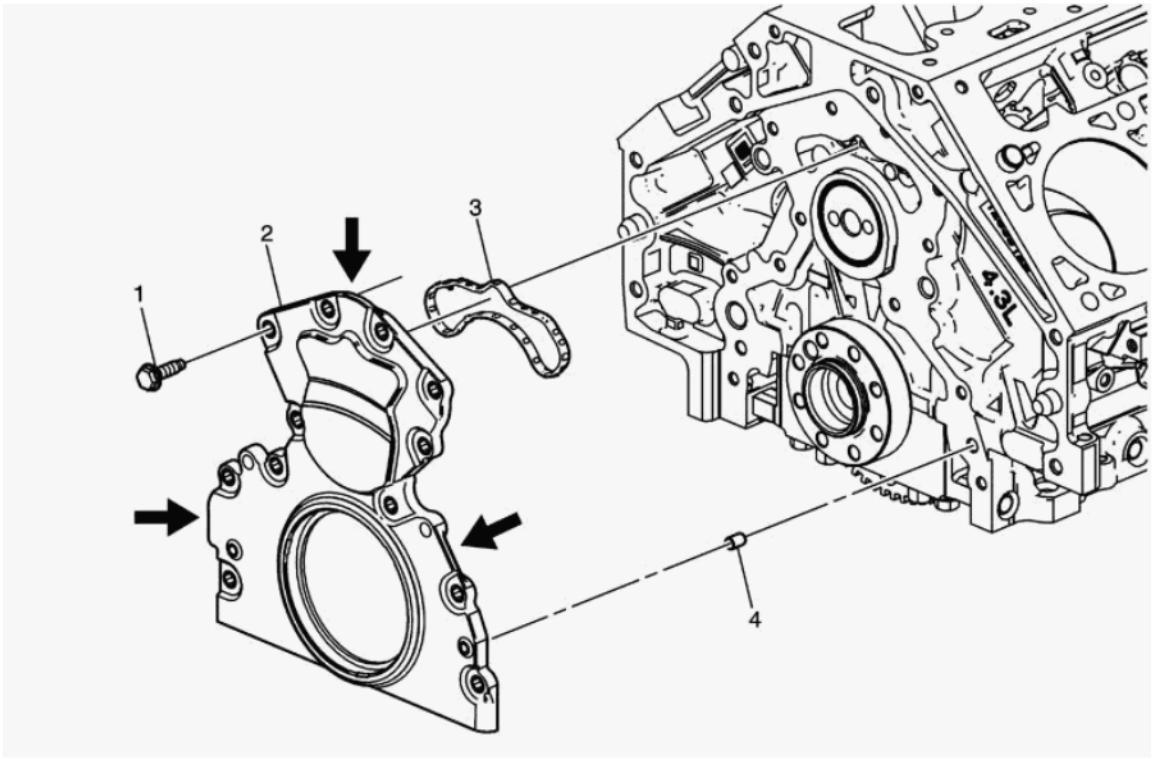

Fig. 304: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Bolt
2	Crankshaft Rear Oil Seal Housing **NOTE:** **To separate the rear housing from the engine, pry at the points that are shown by the arrows.**
3	Crankshaft Rear Oil Seal Housing Gasket Refer to **Replacing Engine Gaskets**.
4	Crankshaft Rear Oil Seal Housing Locating Pin

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OIL PUMP REMOVAL

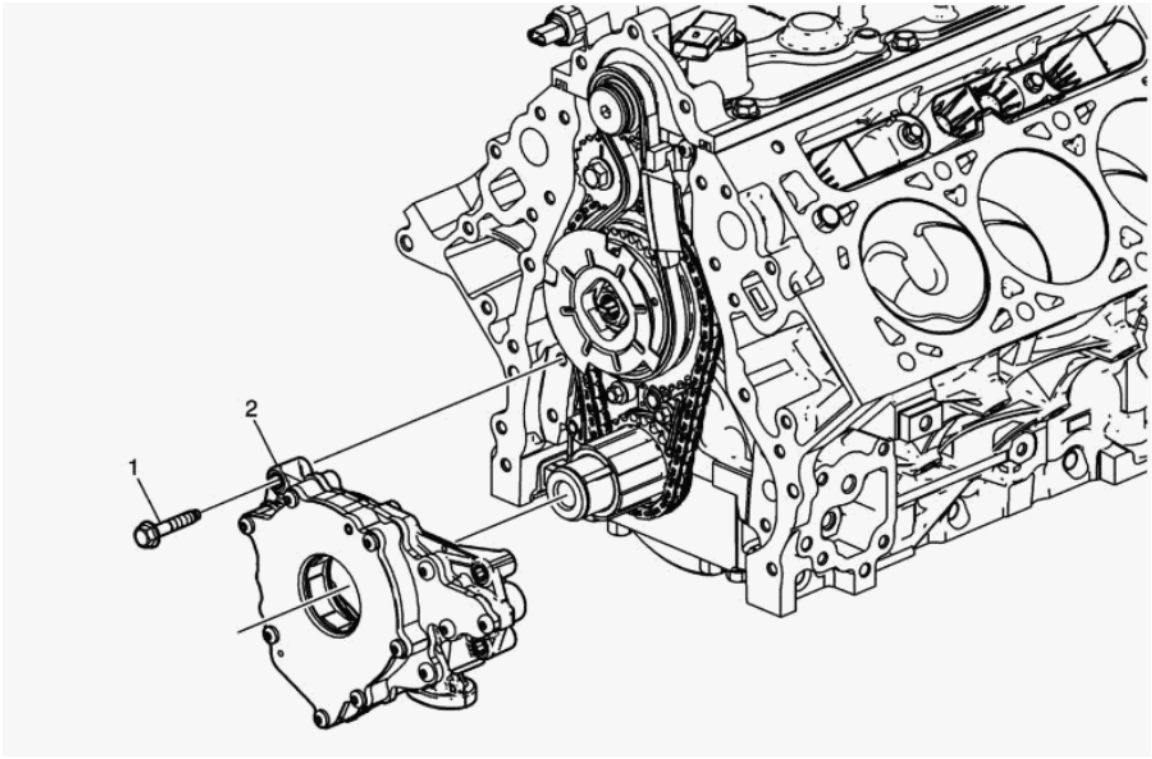

Fig. 305: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If oil pump is being removed to perform a different repair and is going to be reused, then **EN-51267** oil pump alignment tool MUST be installed on the engine block before the oil pump is removed and left in place until the oil pump is reinstalled. Failure to do so before the oil pump is removed will result in the original oil pump having to be replaced with a new oil pump.	
1	Oil Pump Bolt **NOTE:** **If the Oil Pump is going to be reused, then prior to removing oil Pump Bolts, install the oil pump alignment tool. If the oil pump is going to be replaced, then just remove the bolts and**

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Callout	Component Name
	proceed to step 2. **Procedure** 1. Hand Tighten the supplied bolts in the positions shown. 2. Hold the alignment tools tight to the oil pump housing and then torque the alignment tool bolts to 10 N.m (86 lb in). **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.
2	Oil Pump Assembly

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

- **EN-24270** Cylinder Bore Ridge Reamer
- **EN-41556** Connecting Rod Guide

For equivalent regional tools, refer to **Special Tools**.

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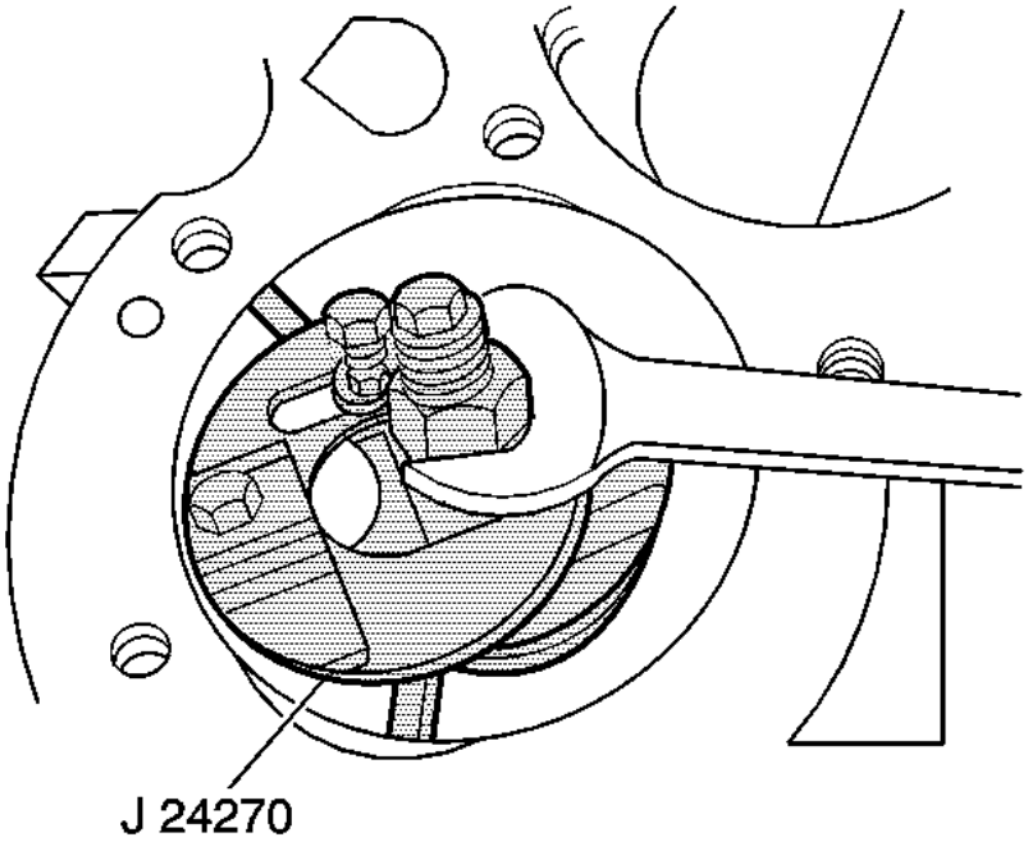

Fig. 306: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS COMPANY

1. Use the **EN-24270** cylinder bore ridge reamer in order to remove the cylinder bore ring ridge, if required.
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Place a cloth on top of the piston.
    3. Use the **EN-24270** cylinder bore ridge reamer , 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.

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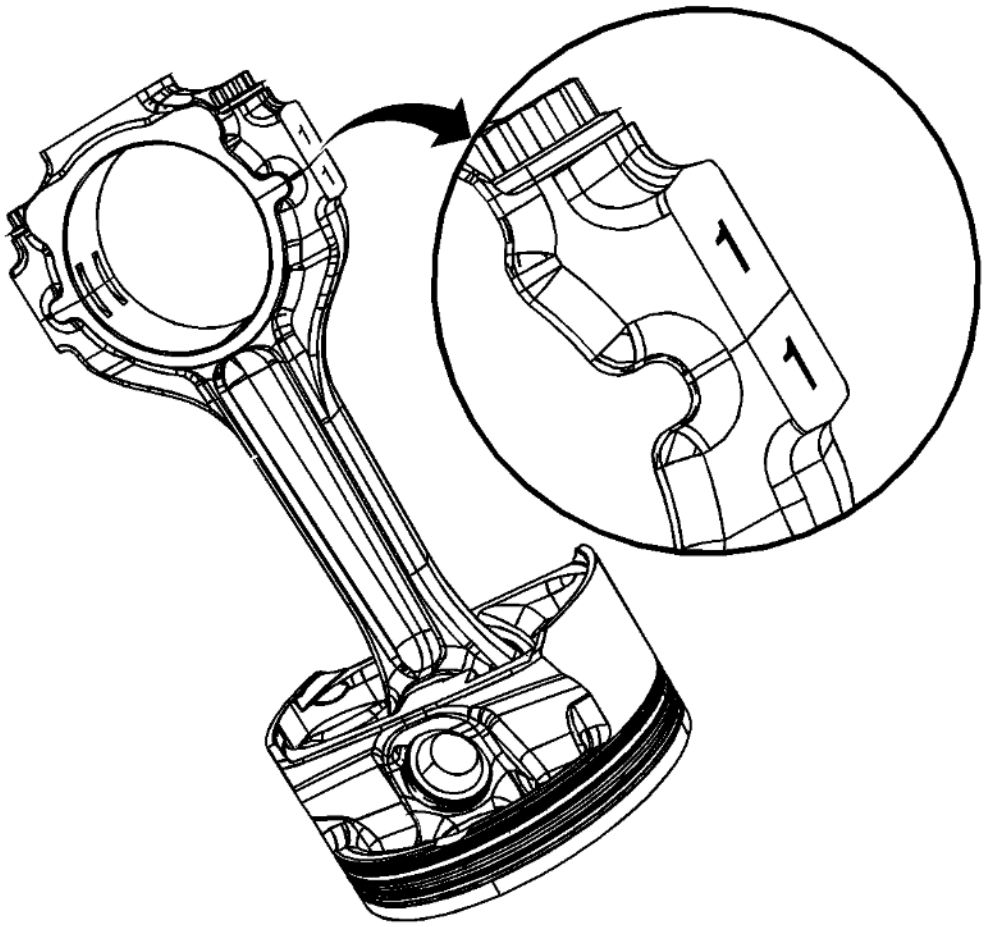

Fig. 307: Matchmarks On Connecting Rods & Caps
Courtesy of GENERAL MOTORS COMPANY

2. Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
    - A stamping mark on the side of the connecting rod, at the crankshaft journal, may affect component geometry.
    - Mark the top of the piston to the specific cylinder bore.

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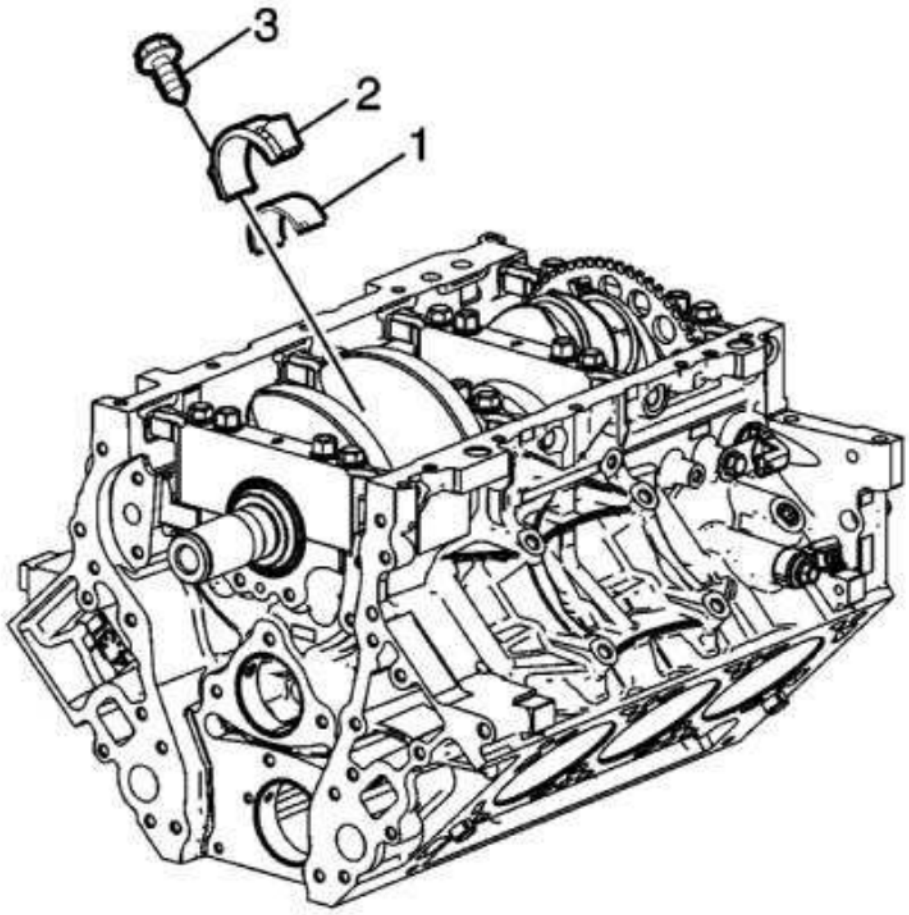

Fig. 308: Connecting Rod Bolts, Cap And Bearing
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location. The connecting rods and the bearing caps are NOT interchangeable. Refer to **Separating Parts**.

3. Remove the connecting rod bolts (3), cap (2) and bearing (1).

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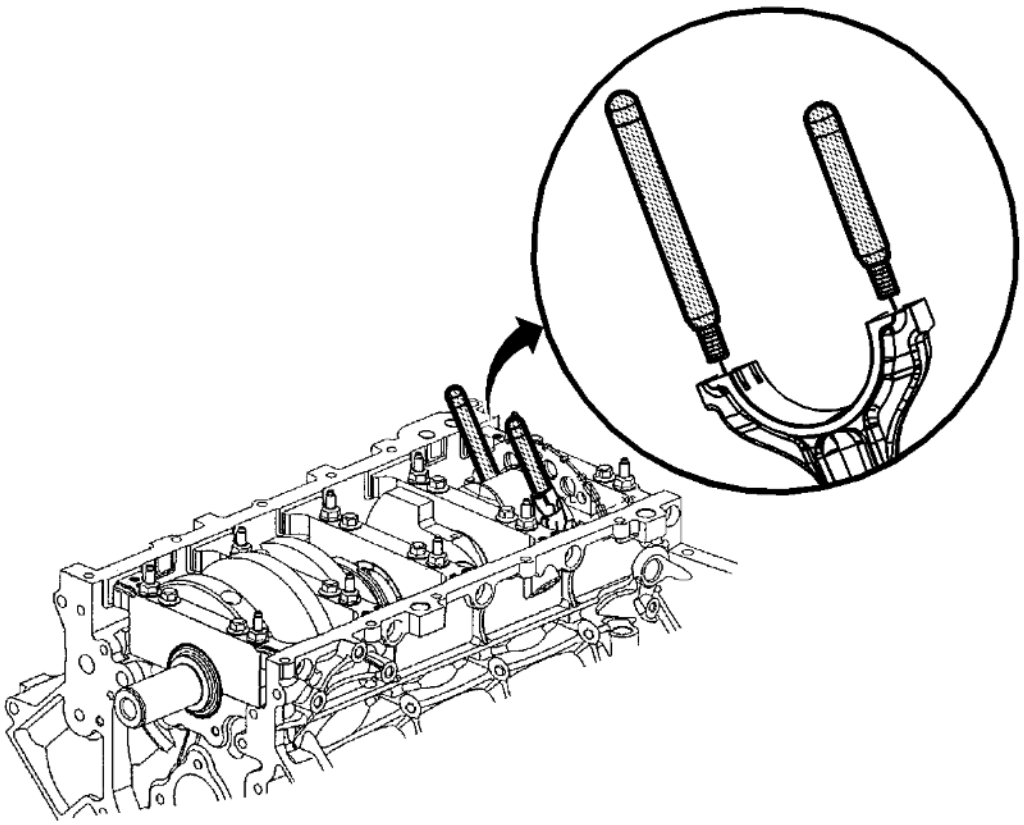

Fig. 309: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

4. Install the **EN-41556** connecting rod guide to the connecting rod.

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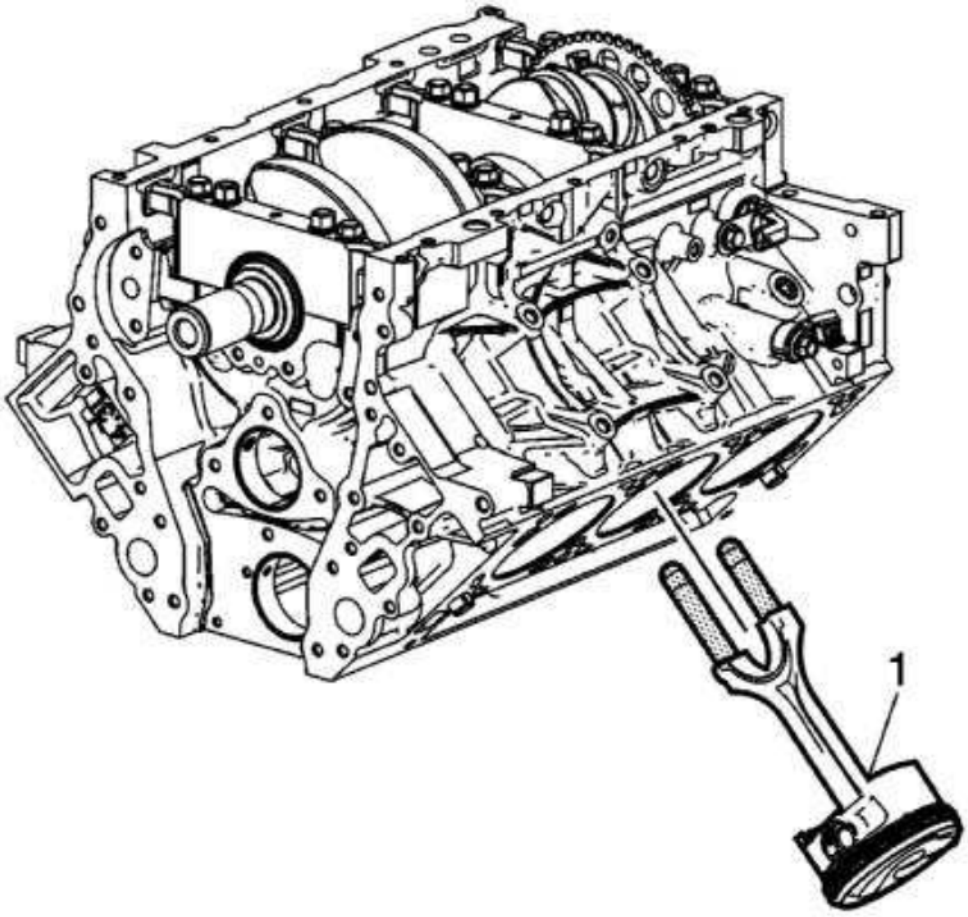

Fig. 310: Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

5. Using a hammer, tap lightly on the end of the **EN-41556** connecting rod guide in order to remove the piston and connecting rod assembly (1) from the cylinder bore.
6. Remove the **EN-41556** connecting rod guide.

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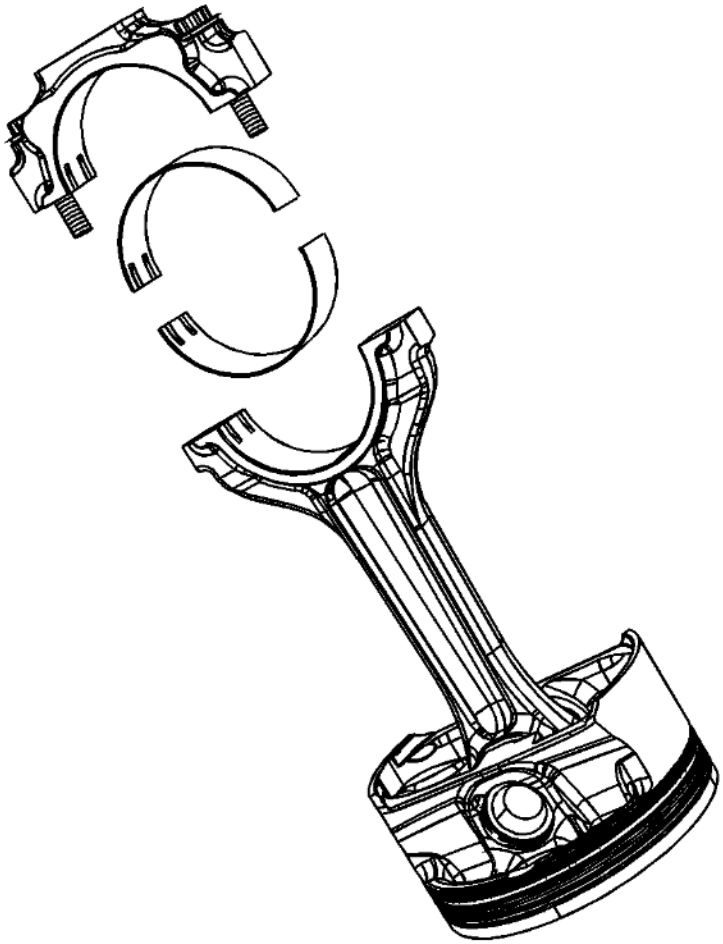

Fig. 311: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS COMPANY

7. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

BALANCER SHAFT AND TIMING CHAIN ASSEMBLY REMOVAL

Special Tools

- **EN-42386-A** Flywheel Holding Tool
- **EN-46330** Tension Pin

For equivalent regional tools, refer to **Special Tools**.

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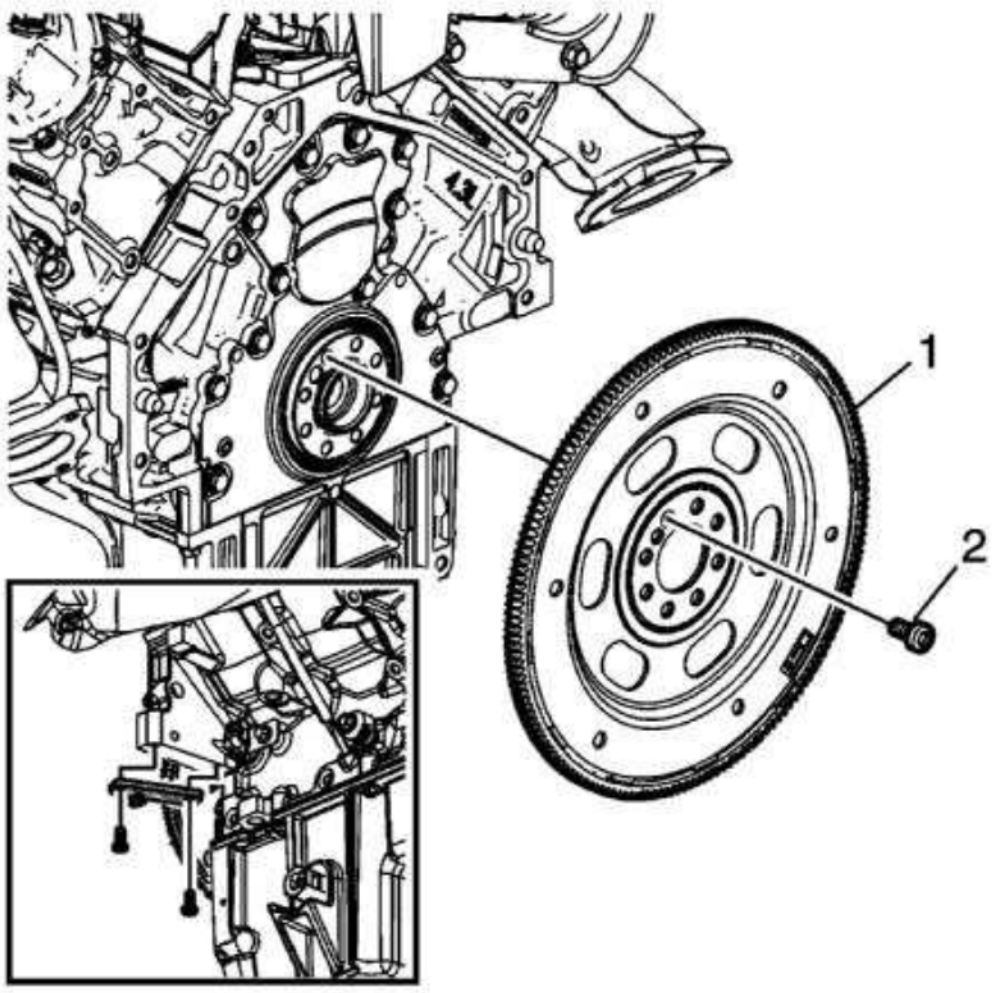

Fig. 312: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Temporarily install the flex plate (1) and bolts (2). Tighten the bolts (2) hand tight.
2. Lock the flex plate using the **EN-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft).

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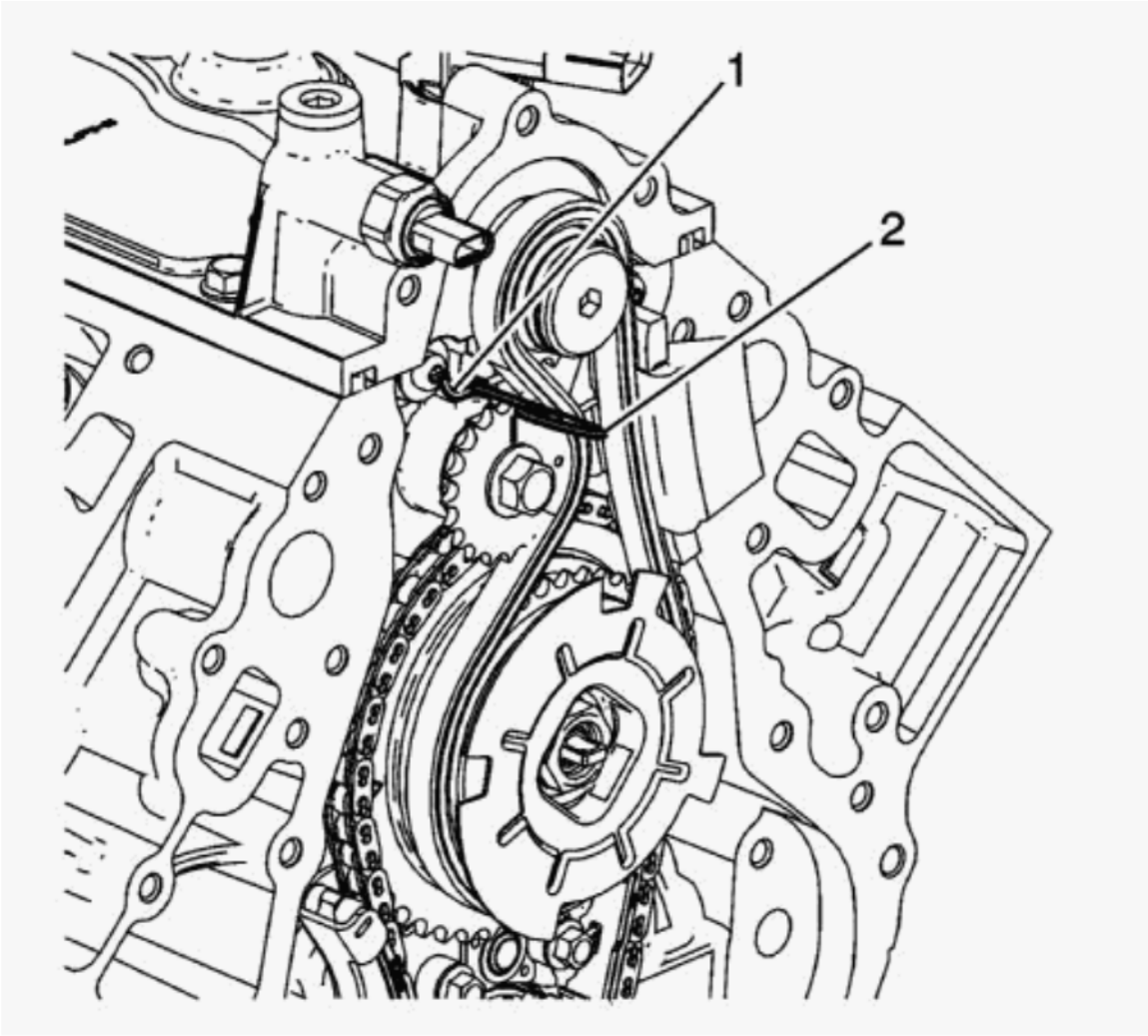

Fig. 313: Balance Shaft Thrust Plate Torsion Spring And Tension Pin
Courtesy of GENERAL MOTORS COMPANY

3. Push down the balance shaft thrust plate torsion spring (1) and install **EN-46330** tension pin (2).

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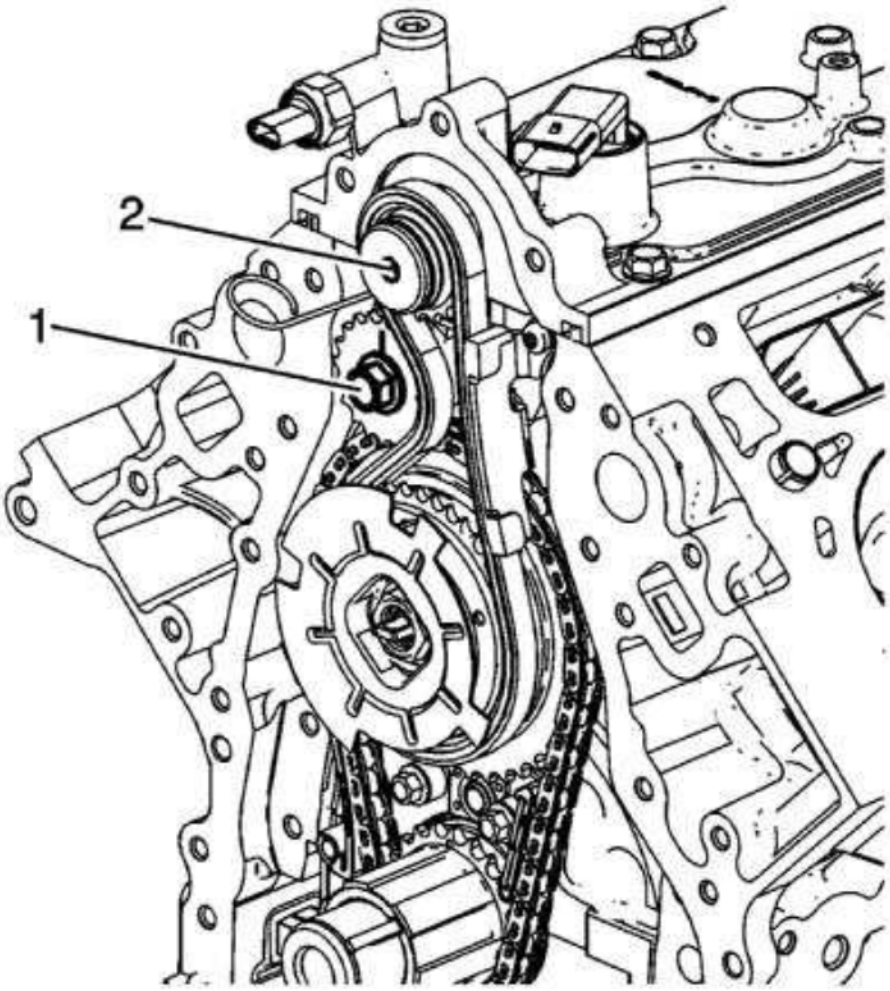

Fig. 314: Balancer Shaft Bolt And Idler Shaft Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Loosen the balancer shaft bolt (1) and the idler shaft sprocket bolt (2).

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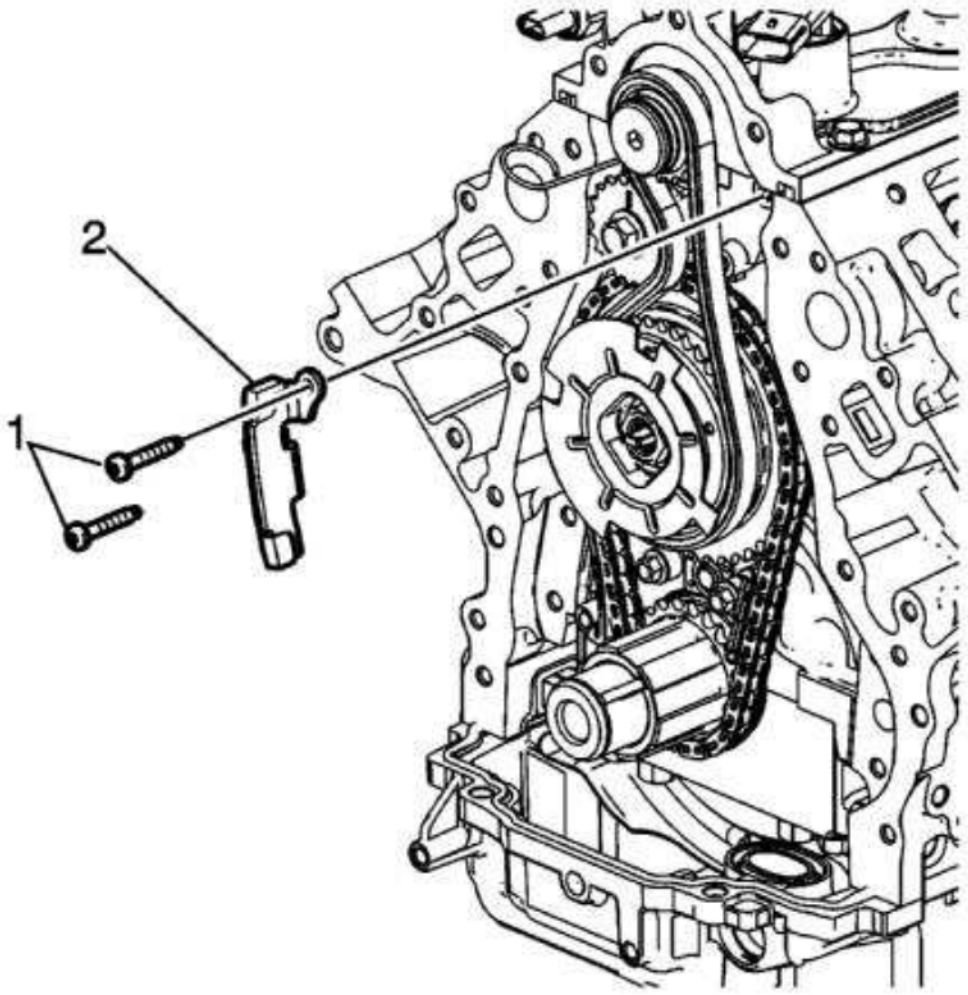

Fig. 315: Balancer Shaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the two balancer shaft retainer bolts (1).
6. Remove the balancer chain guide (2).

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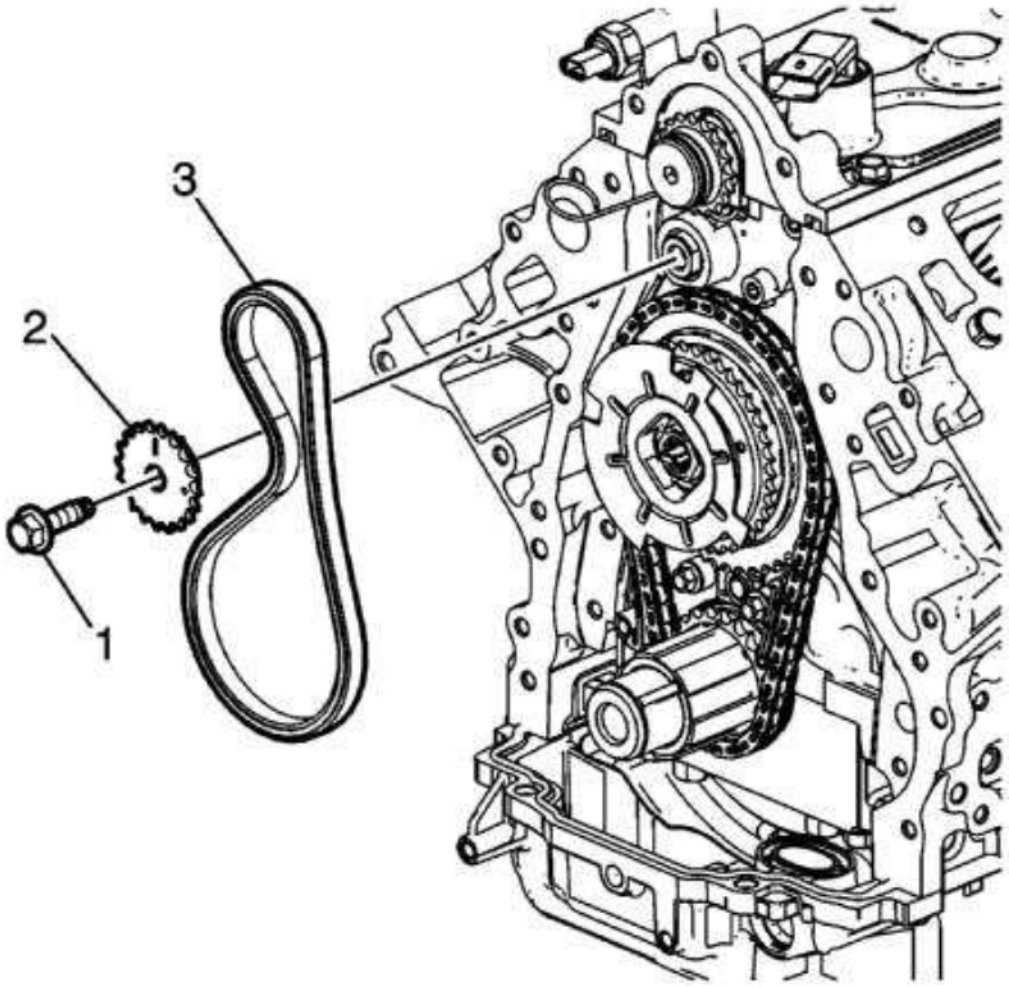

Fig. 316: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Remove the balancer shaft driven sprocket bolt (1) and the balancer shaft driven sprocket (2).
8. Remove the balancer shaft chain (3).

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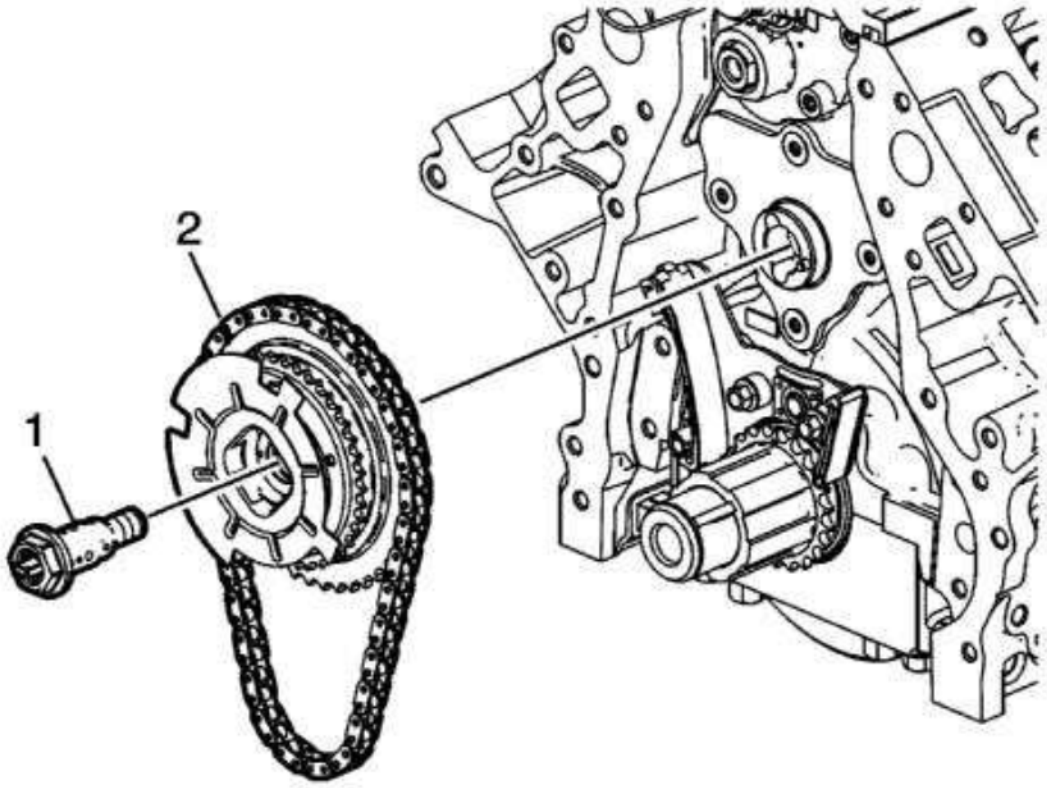

Fig. 317: Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

9. Remove the CMP actuator solenoid valve (1).
10. Loosen and separate the CMP actuator and timing chain (2) from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

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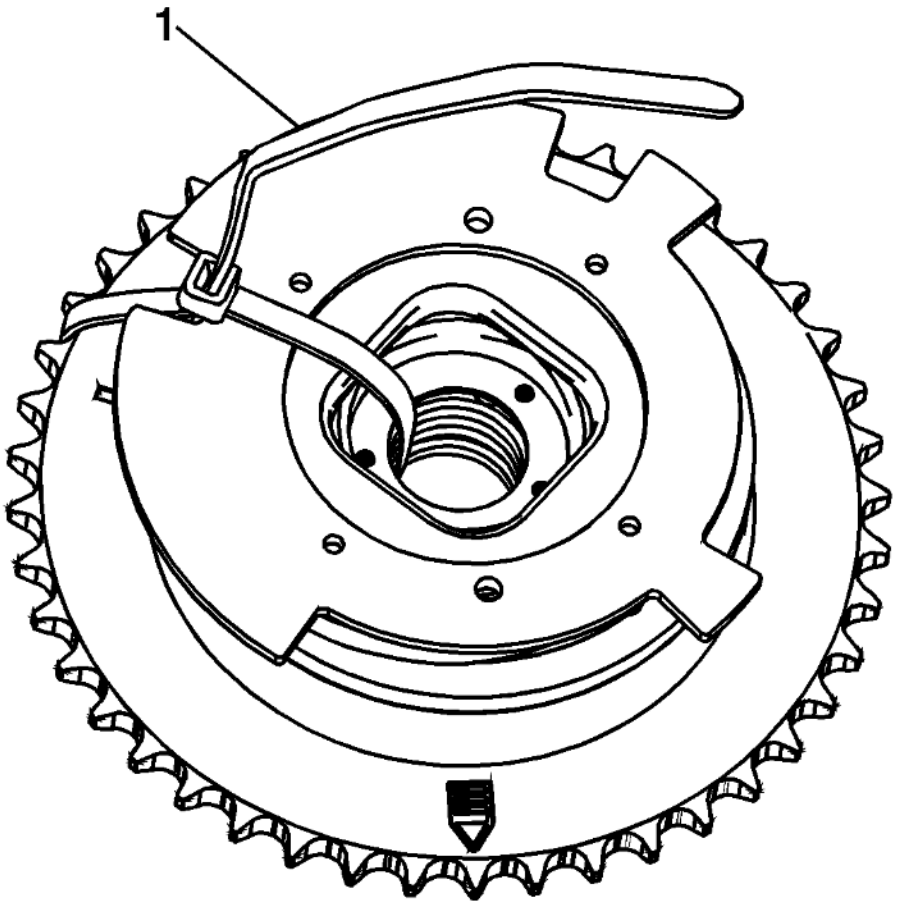

Fig. 318: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

11. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.

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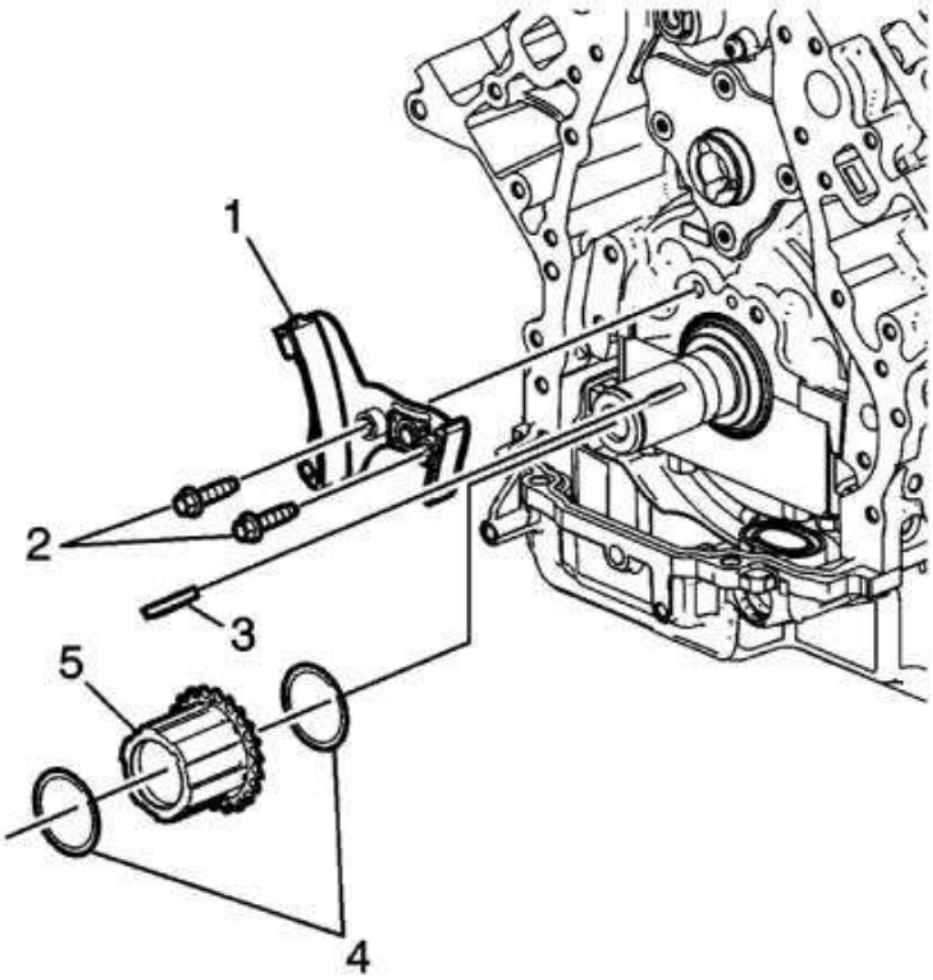

Fig. 319: Crankshaft Sprocket Washers, Crankshaft Sprocket And Key
Courtesy of GENERAL MOTORS COMPANY

12. Remove the crankshaft sprocket (4) and key (3).
13. Remove the timing chain tensioner bolts (2) and the timing chain tensioner (1).

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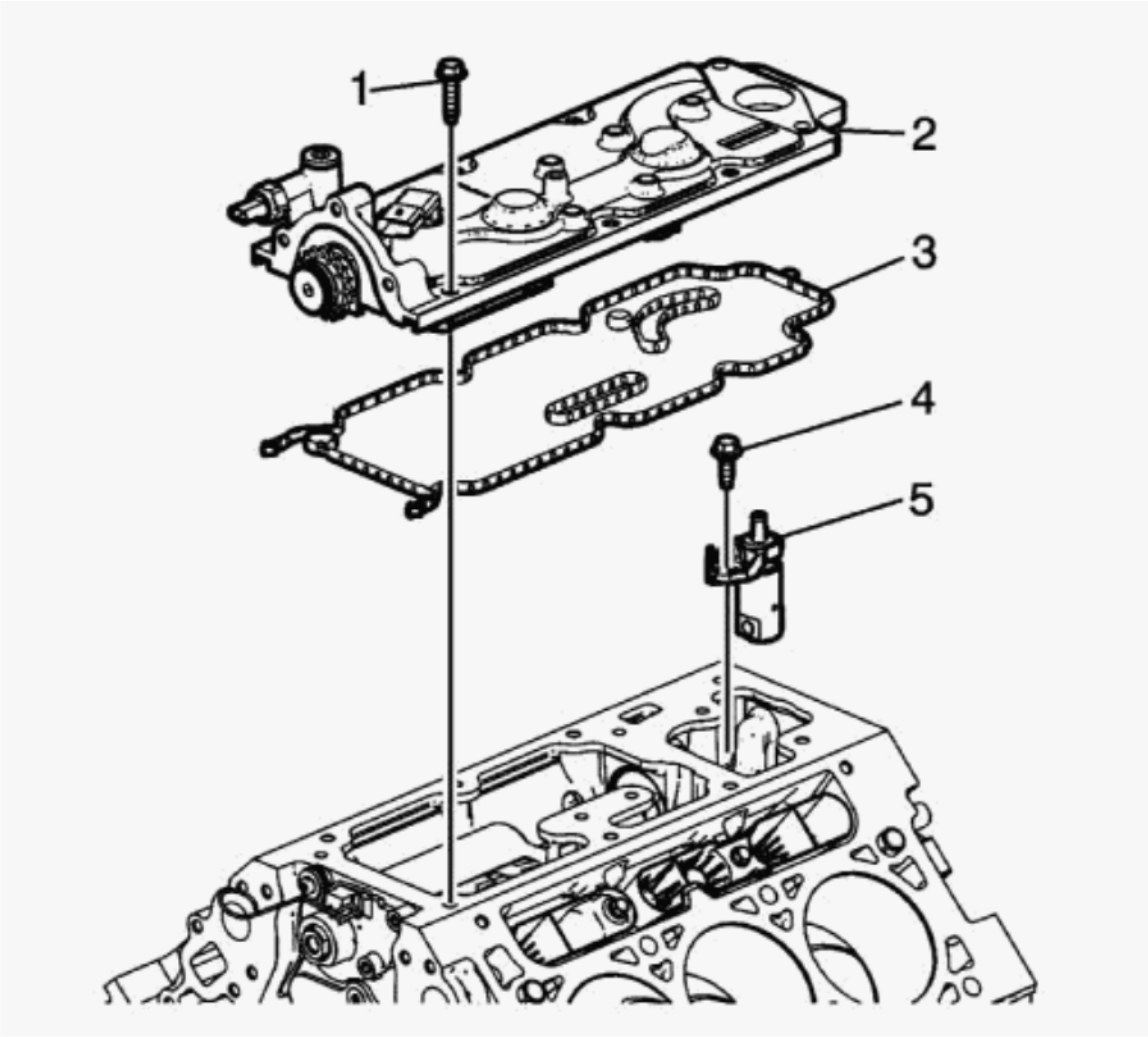

Fig. 320: Valve Lifter Oil Manifold Assembly Bolts
Courtesy of GENERAL MOTORS COMPANY

14. Remove the valve lifter oil manifold assembly bolts (1).
15. Remove the valve lifter oil manifold assembly (2) and gaskets (3).
16. Remove the valve lifter follower guide bolt (4) and the valve lifter follower guide (5).

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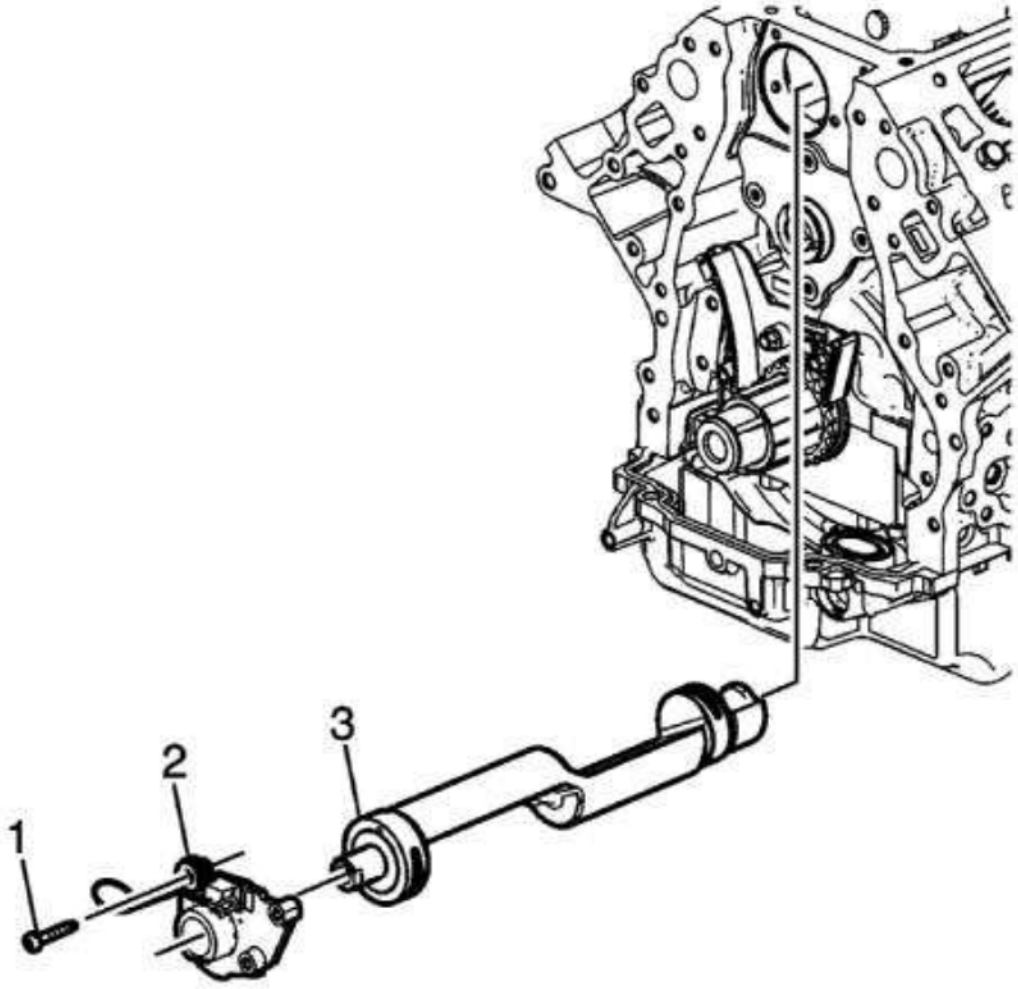

Fig. 321: Remaining Balancer Shaft Retainer Bolt And Balancer Shaft Retainer
Courtesy of GENERAL MOTORS COMPANY

17. Remove the remaining balancer shaft retainer bolt (1) and the balancer shaft retainer (2).
18. Remove the balancer shaft assembly (3).

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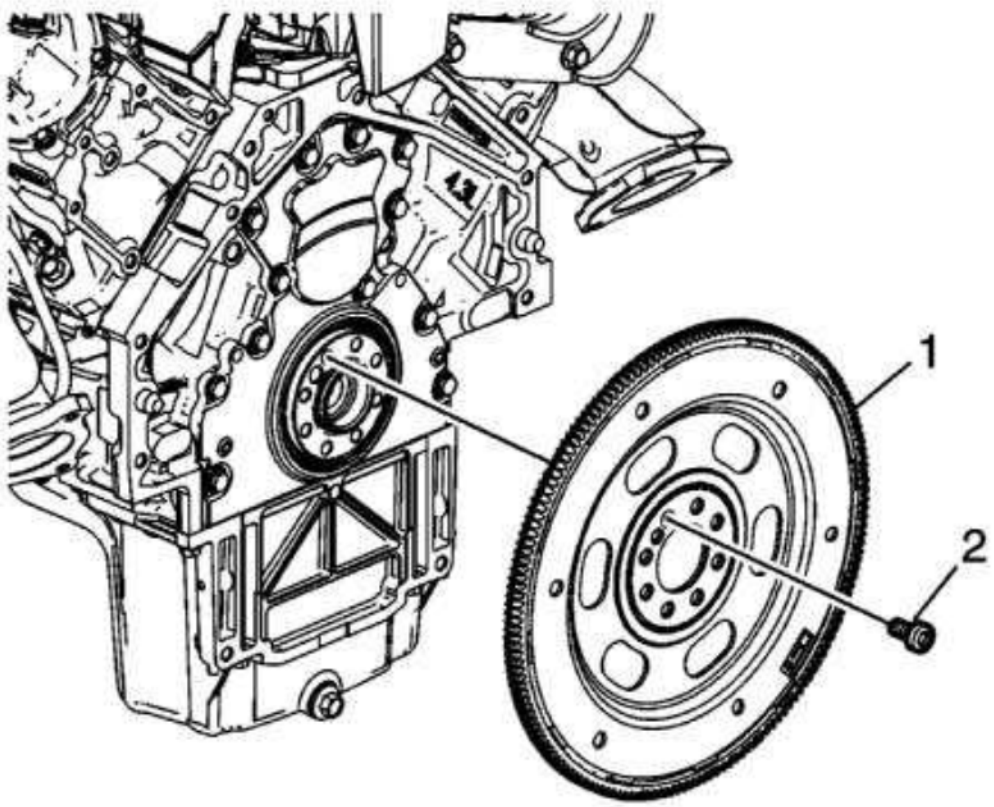

Fig. 322: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

19. Remove the flex plate (1) and bolts (2).

ENGINE BLOCK VALLEY COVER REMOVAL

For removal of the Engine Block Valley Cover. Refer to **Balancer Shaft and Timing Chain Assembly Removal**.

Engine Block Valley Cover Disassemble

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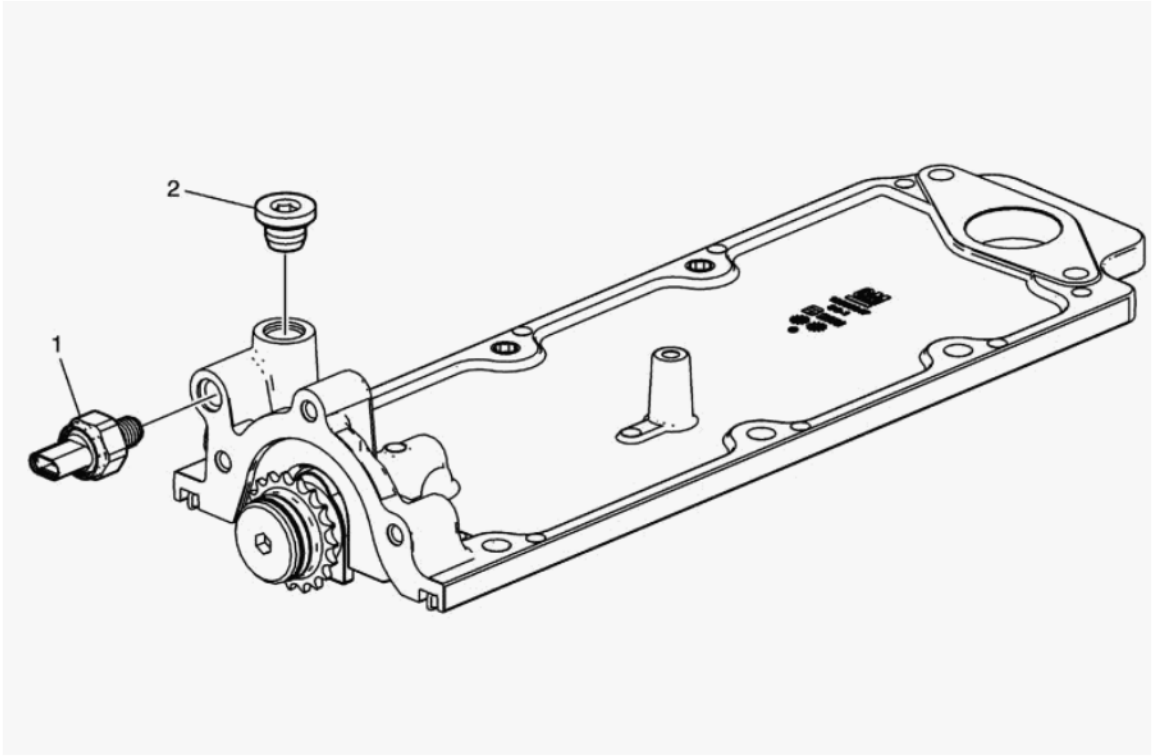

Fig. 323: Engine Block Valley Cover
Courtesy of GENERAL MOTORS COMPANY

Engine Block Valley Cover Disassemble

Callout	Component Name
1	Oil Pressure Sensor
2	Engine Block Valley Cover Plug
3	Balance Shaft Driven Sprocket Bolt
4	Balance Shaft Driven Sprocket

VALVE LIFTER OIL MANIFOLD REMOVAL

For removal of the Valve Lifter Oil Manifold Assembly. Refer to **Balancer Shaft and Timing Chain Assembly Removal**.

Valve Lifter Oil Manifold Disassemble

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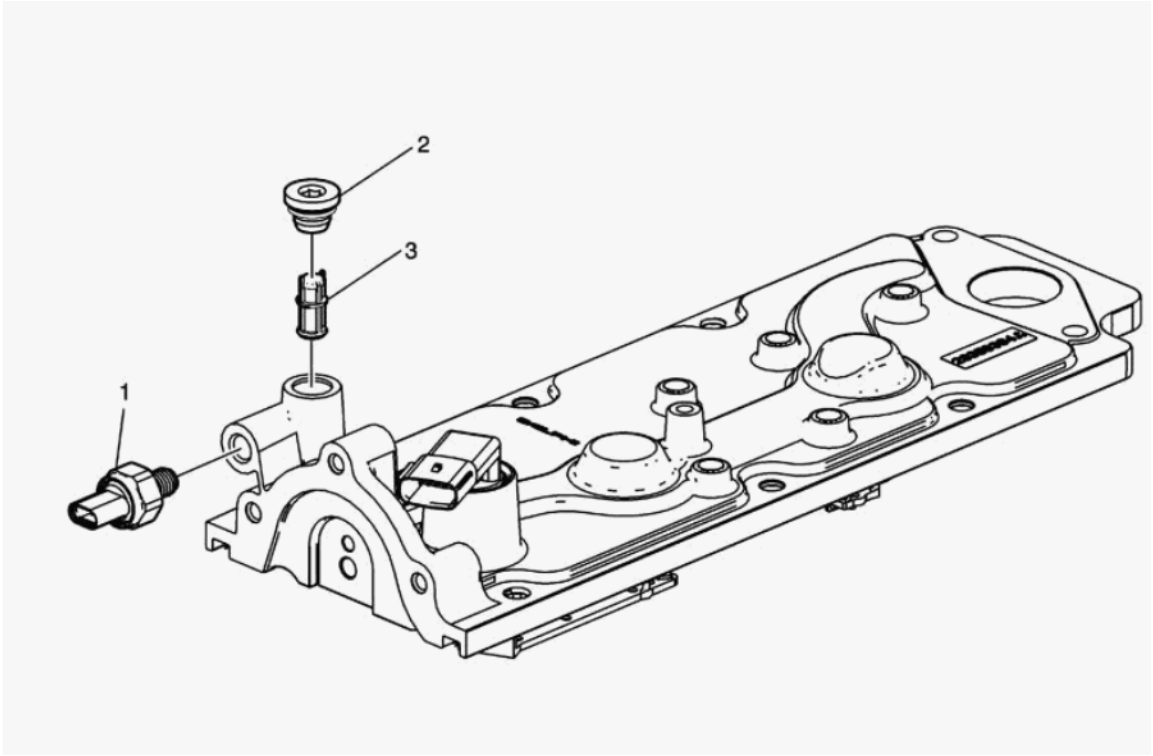

Fig. 324: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Disassemble

Callout	Component Name
1	Oil Pressure Sensor
2	Valve Lifter Oil Manifold Plug
3	Valve Lifter Oil Filter
4	Balance Shaft Driven Sprocket Bolt
5	Balance Shaft Driven Sprocket

VALVE LIFTER FOLLOWER GUIDE REMOVAL

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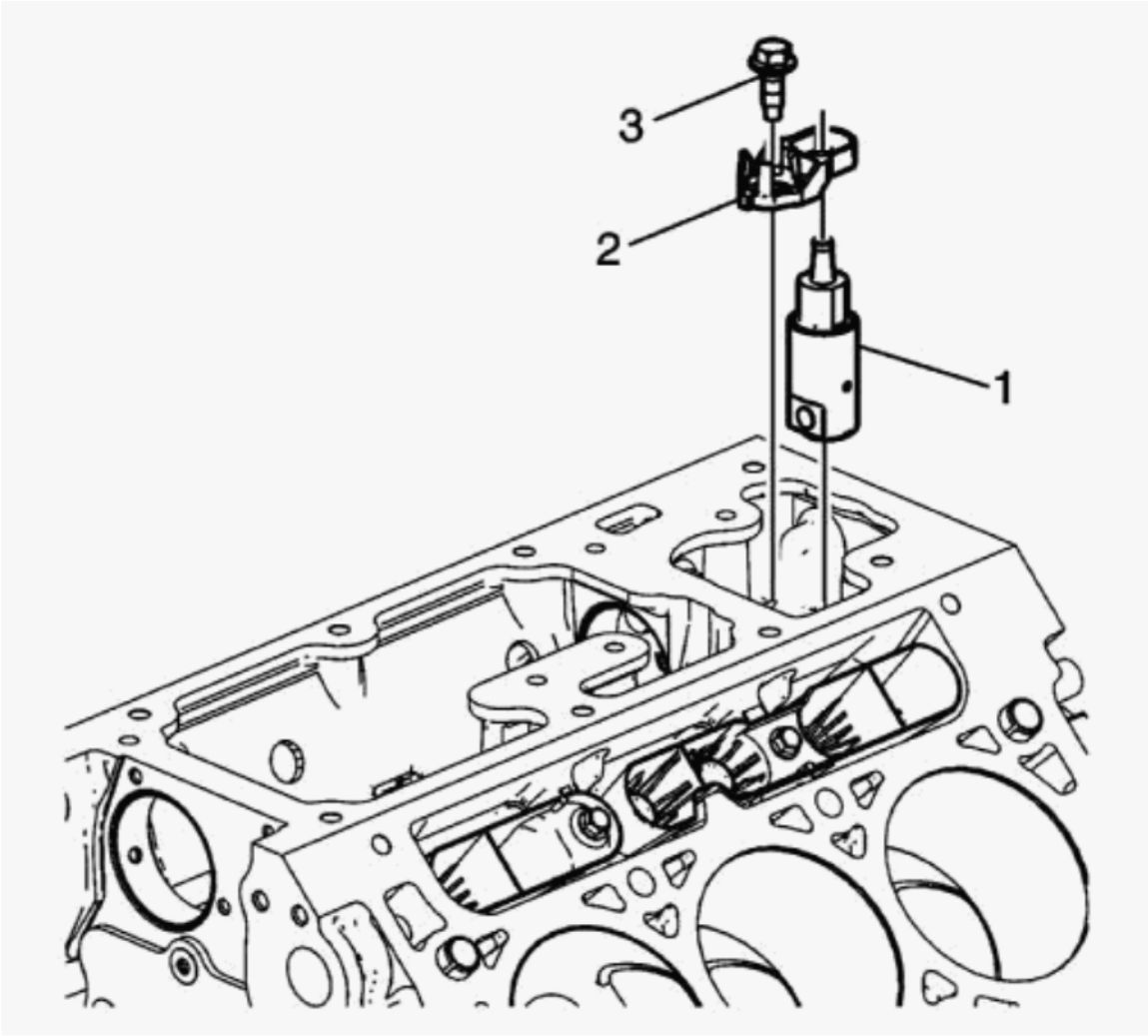

Fig. 325: Valve Lifter Follower Guide And Valve Filter Follower
Courtesy of GENERAL MOTORS COMPANY

1. Remove the valve lifter follower guide bolt (3).
2. Remove the valve lifter follower guide (2).
3. Remove the valve filter follower (1).

VALVE LIFTER REMOVAL

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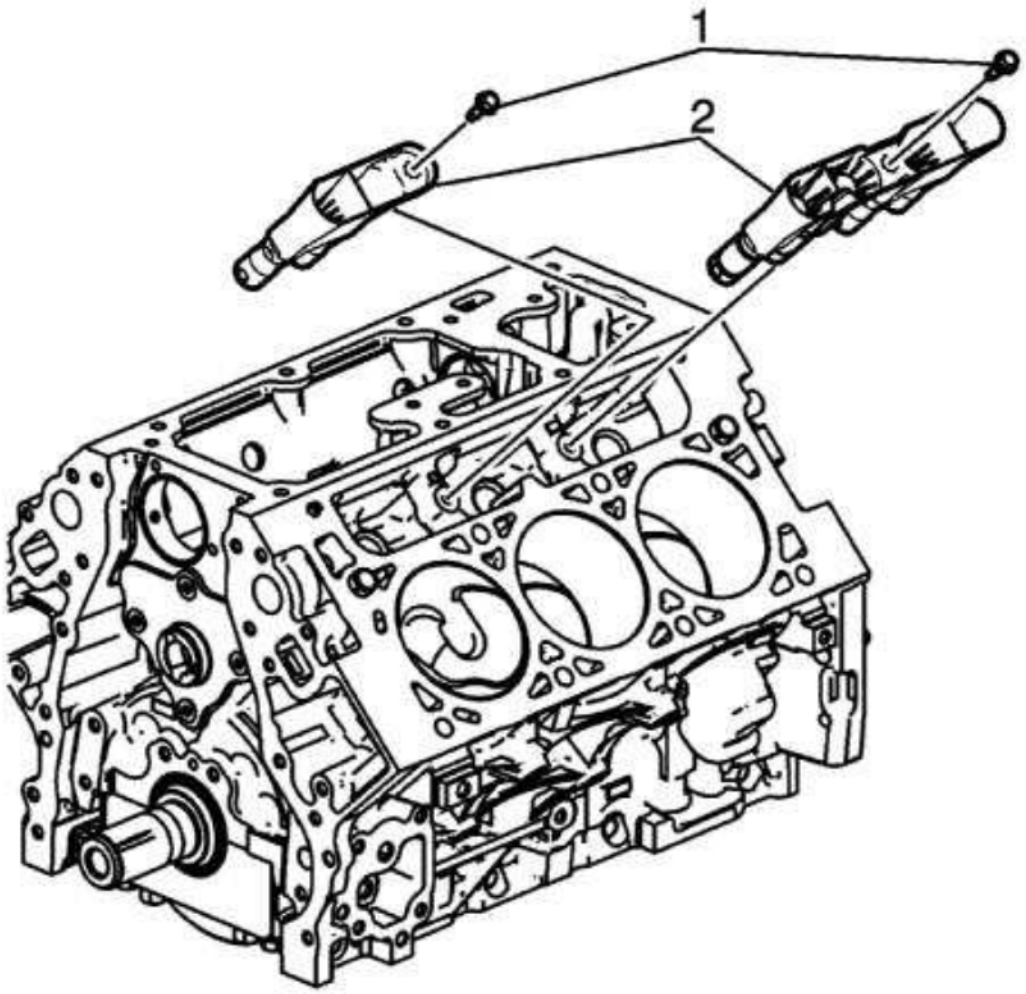

Fig. 326: Guides With Lifters And Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the bolts (1).
2. Remove the guides (2) with lifters.

Note the installed position of the guides. The notched area of the guide is to align with the locating tab of the block.

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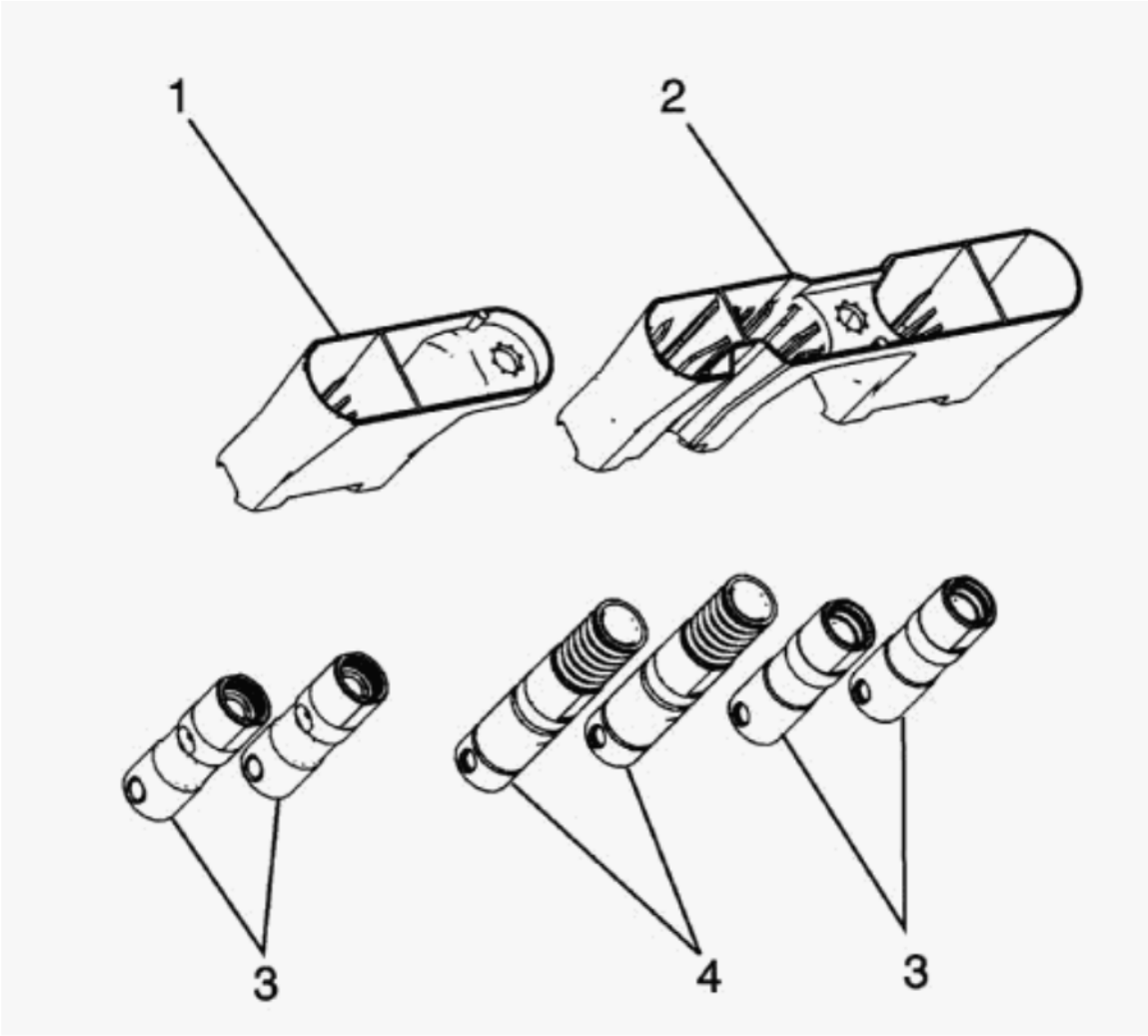

Fig. 327: Valve Lifters And Guides
Courtesy of GENERAL MOTORS COMPANY

3. Remove the valve lifters (3 and 4) from the guides (1 and 2).

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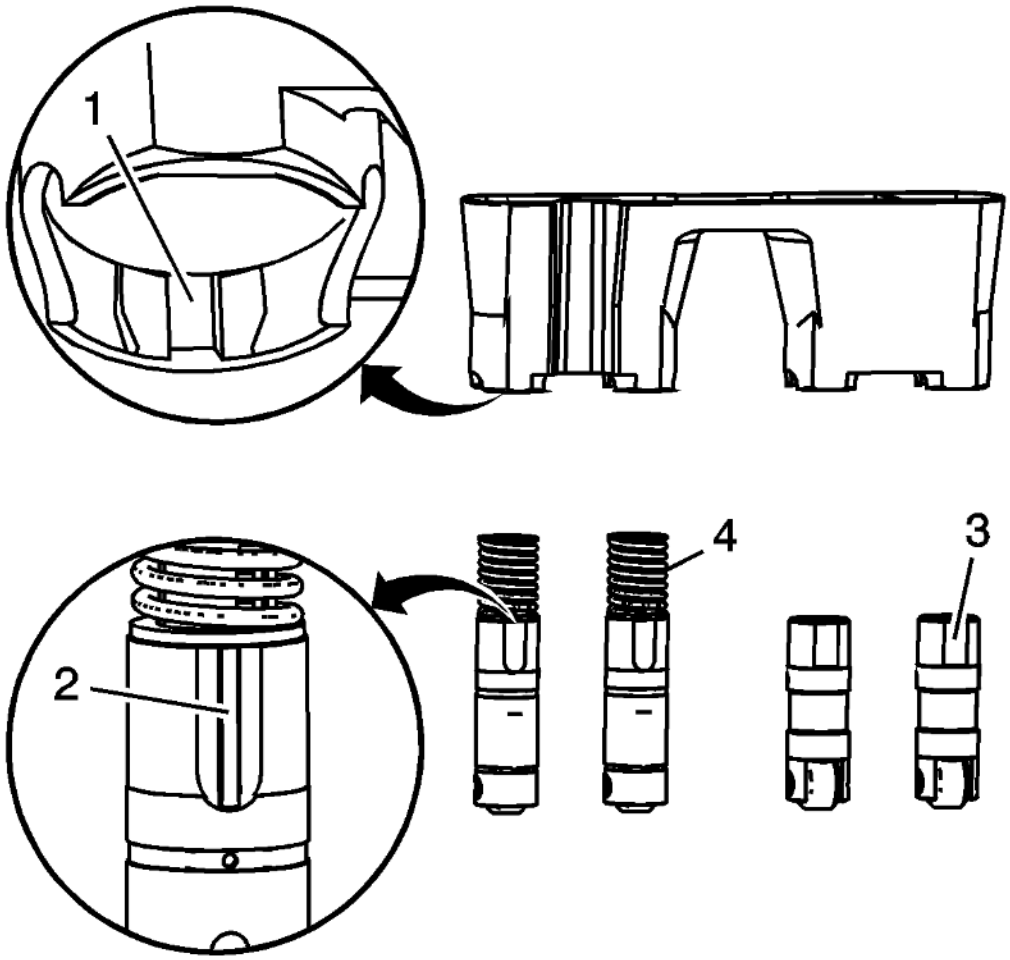

Fig. 328: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

4. Organize or mark the components so they can be installed in the same location from which they were removed. The active fuel management lifters (4) are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to **Separating Parts**.

CAMSHAFT REMOVAL

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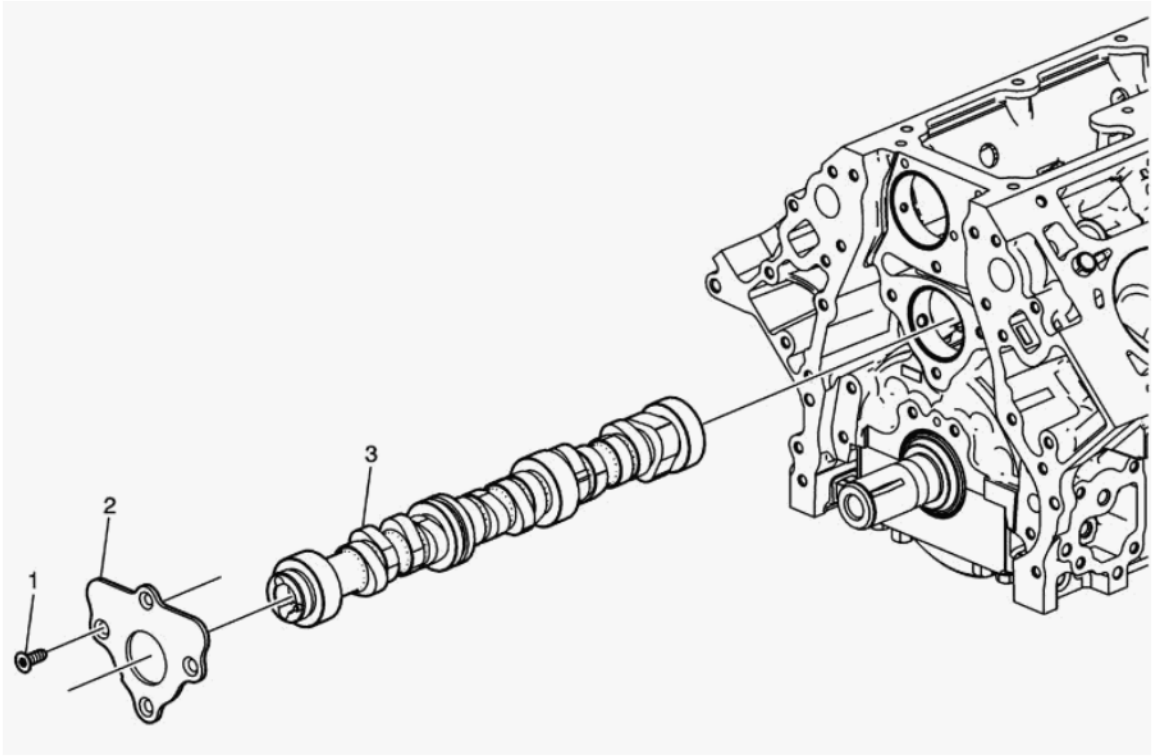

Fig. 329: Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Retainer Bolt
2	Camshaft Retainer
3	Camshaft Assembly

CRANKSHAFT AND BEARING REMOVAL

Special Tools

- **EN-6125-1B** Slide Hammer
- **EN-41818** Crankshaft Bearing Cap Remover

For equivalent regional tools, refer to **Special Tools**

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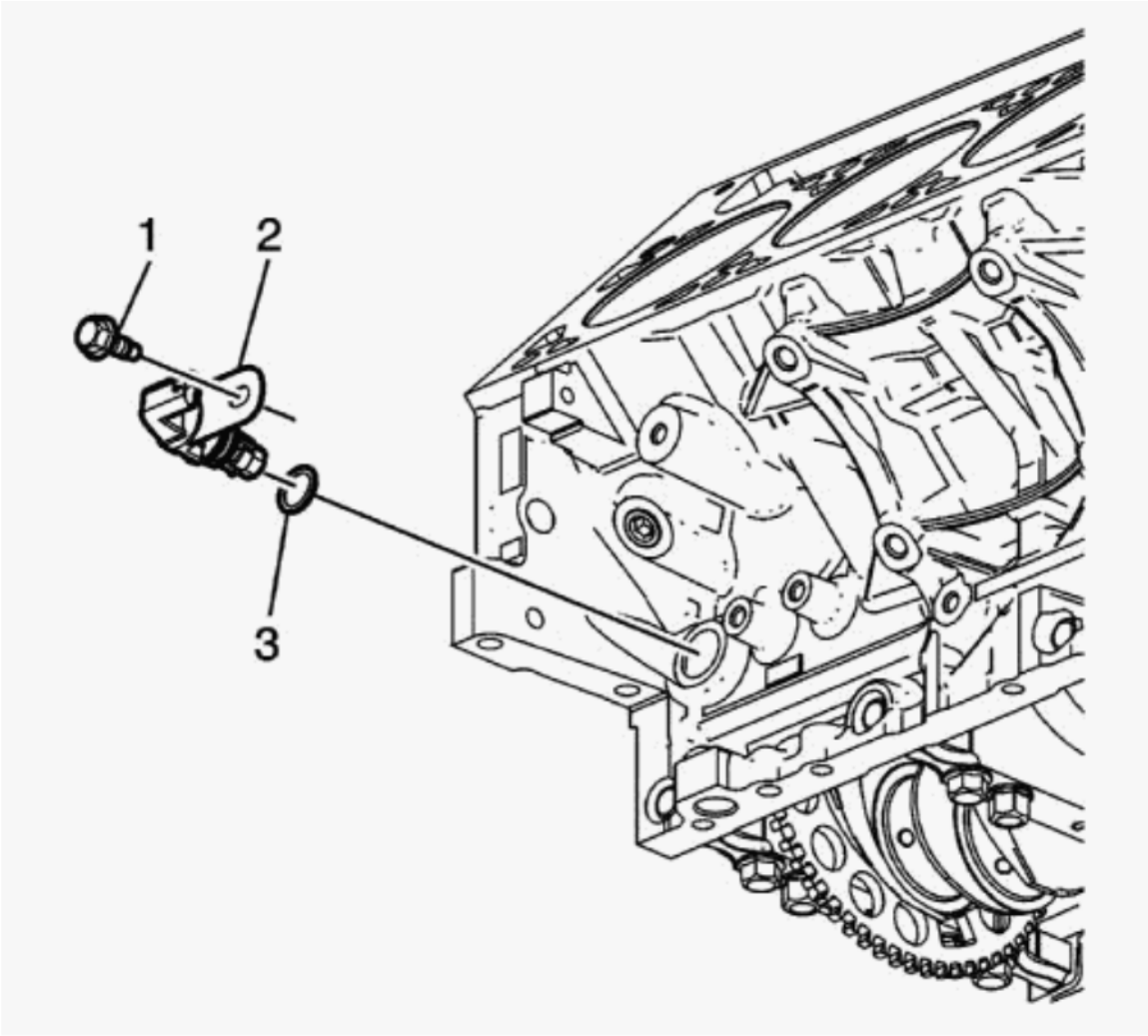

Fig. 330: O-ring, CKP Sensor And Crankshaft Position (CKP) Sensor Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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.**
- **All bolts are to be discarded and replaced with NEW.**

1. Remove the crankshaft position (CKP) sensor bolt (1).
2. Remove the CKP sensor (2).
3. Remove the O-ring (3) from the sensor, as required.

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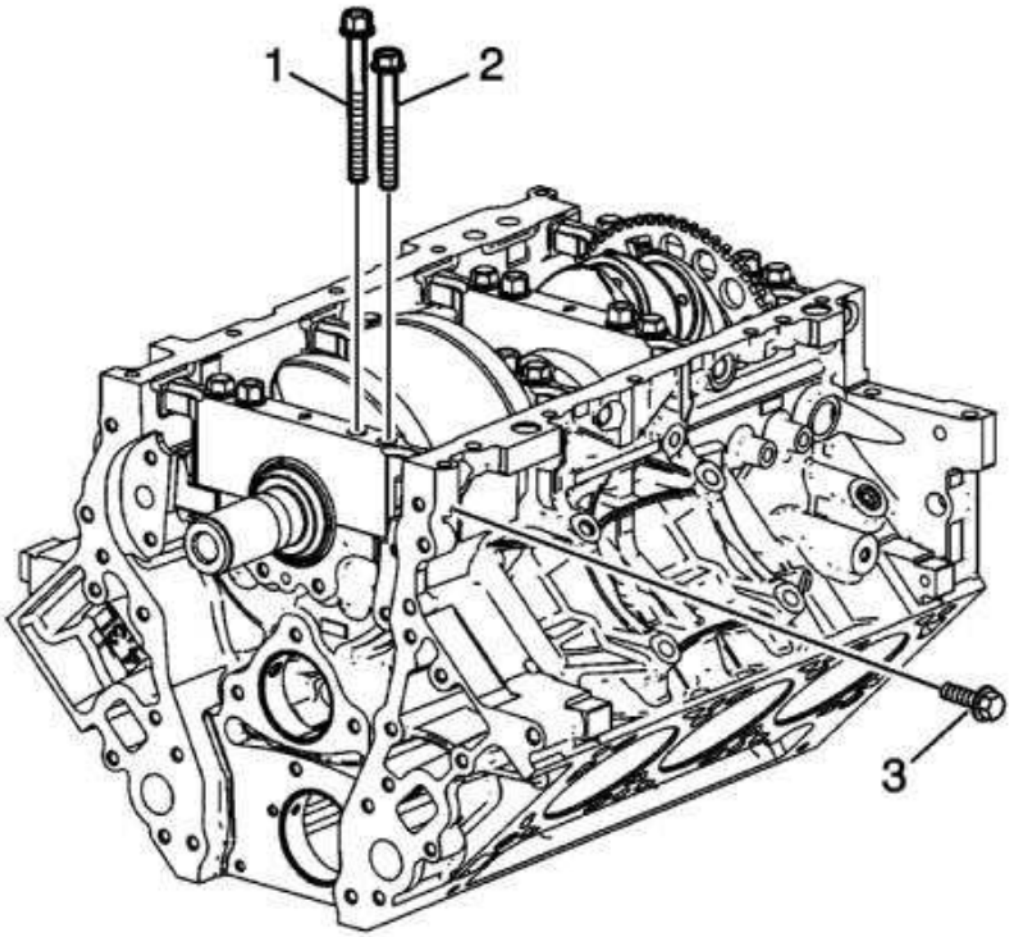

Fig. 331: Crankshaft Inner Bearing Cap Bolts And Outer Bearing Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove and discard the crankshaft inner bearing cap bolts (1) and outer bearing cap bolts (2).
5. Remove and discard the bearing cap side bolts (3).

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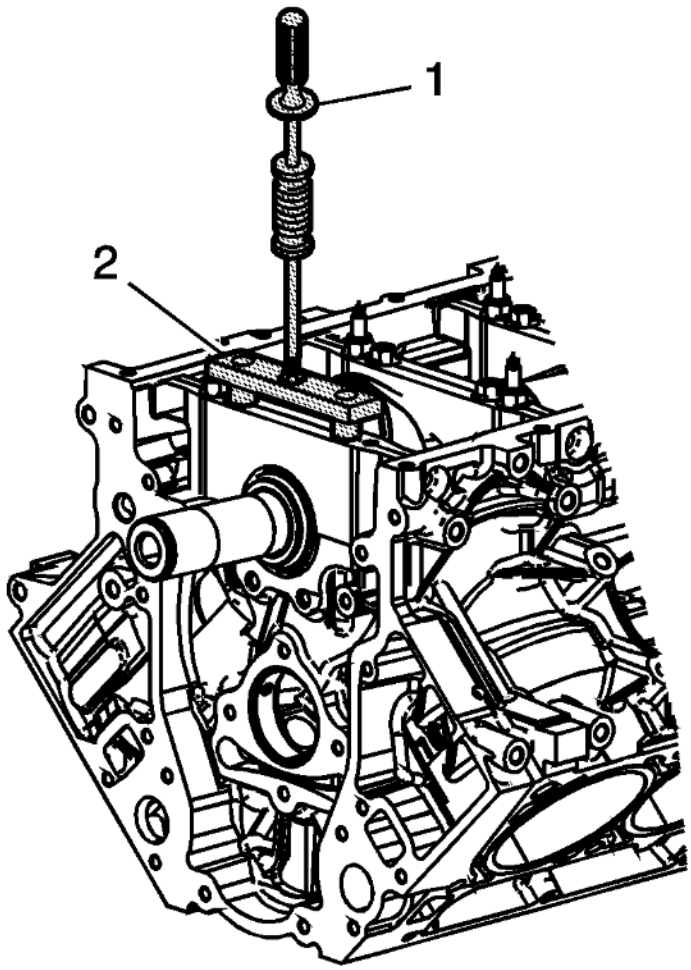

Fig. 332: View Of Crankshaft Bearing Cap Bolts (M10)
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

6. Install the **EN-41818** remover (2) and tighten to 11 N.m (100 lb in).
7. Install the **EN-6125-1B** hammer (1) to the **EN-41818** remover (2) in order to remove the crankshaft bearing caps.

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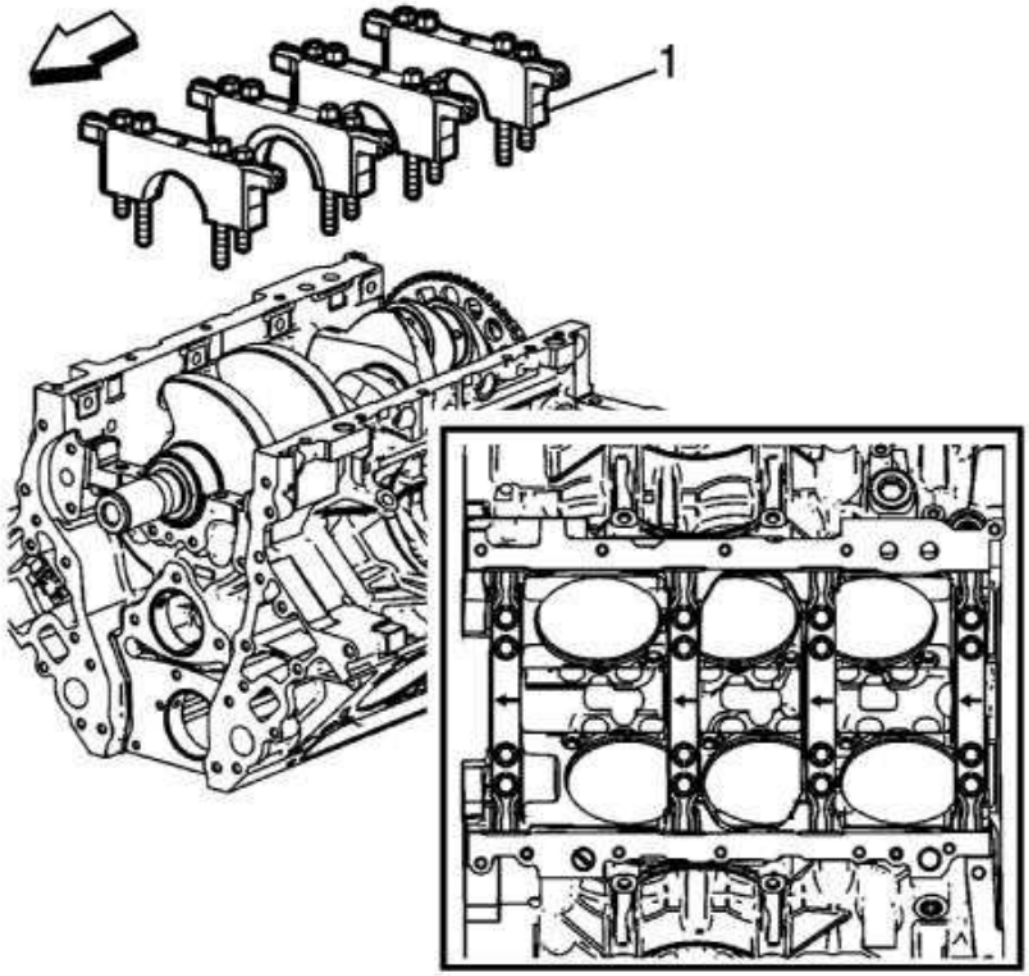

Fig. 333: Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Before removal note the direction of the bearing caps arrows and location.**

8. Remove the bearing caps (1).

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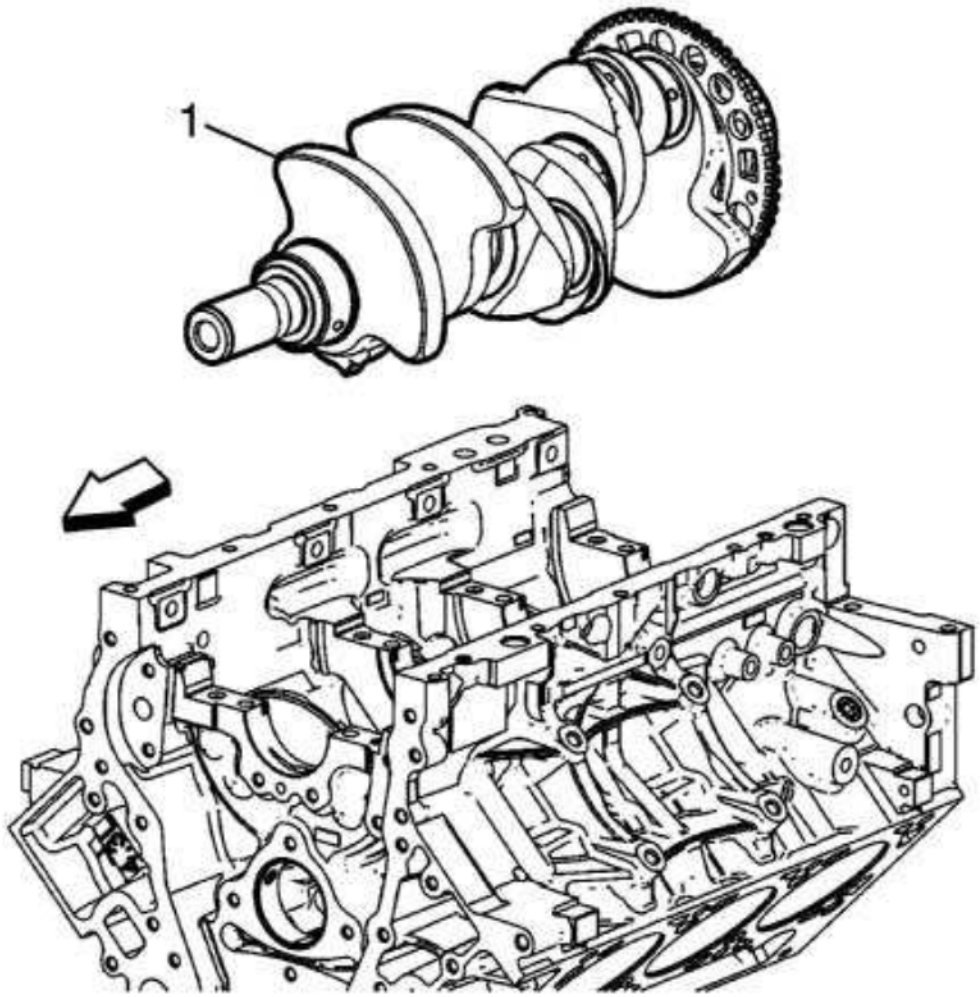

Fig. 334: Crankshaft
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may affect on-board diagnostics (OBD) II system performance.**

9. Remove the crankshaft (1).
10. Lay the crankshaft onto 2 wooden V-blocks or other protective surface.

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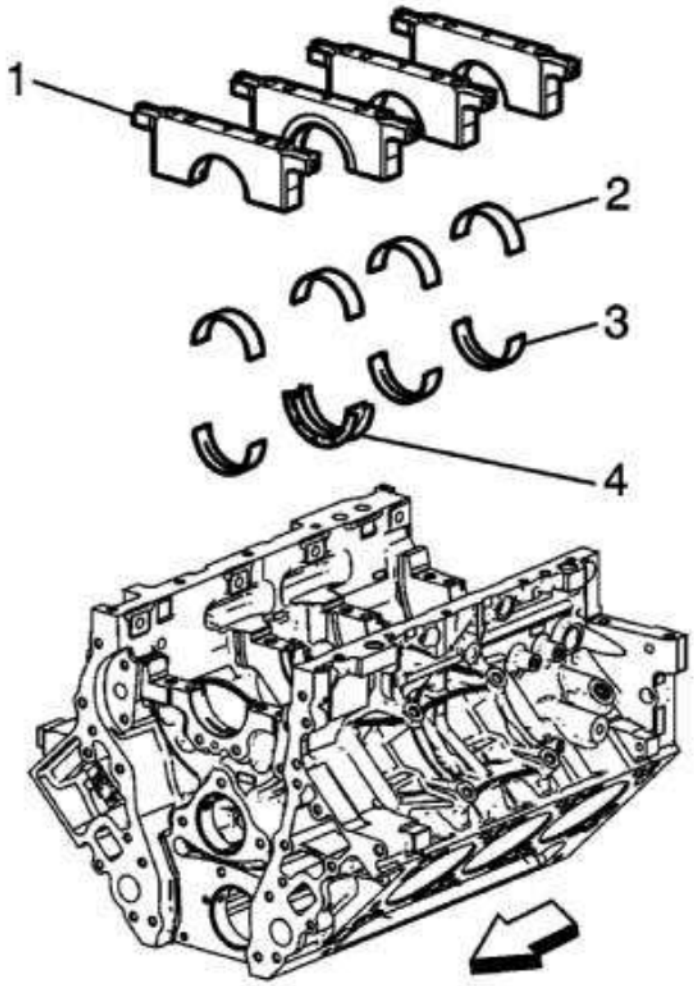

Fig. 335: Crankshaft Bearings, Bearing Caps And Engine Block
Courtesy of GENERAL MOTORS COMPANY

11. Remove the crankshaft bearings (2,3, and 4) from the bearing caps (1) 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

Plug Removal - Left Side

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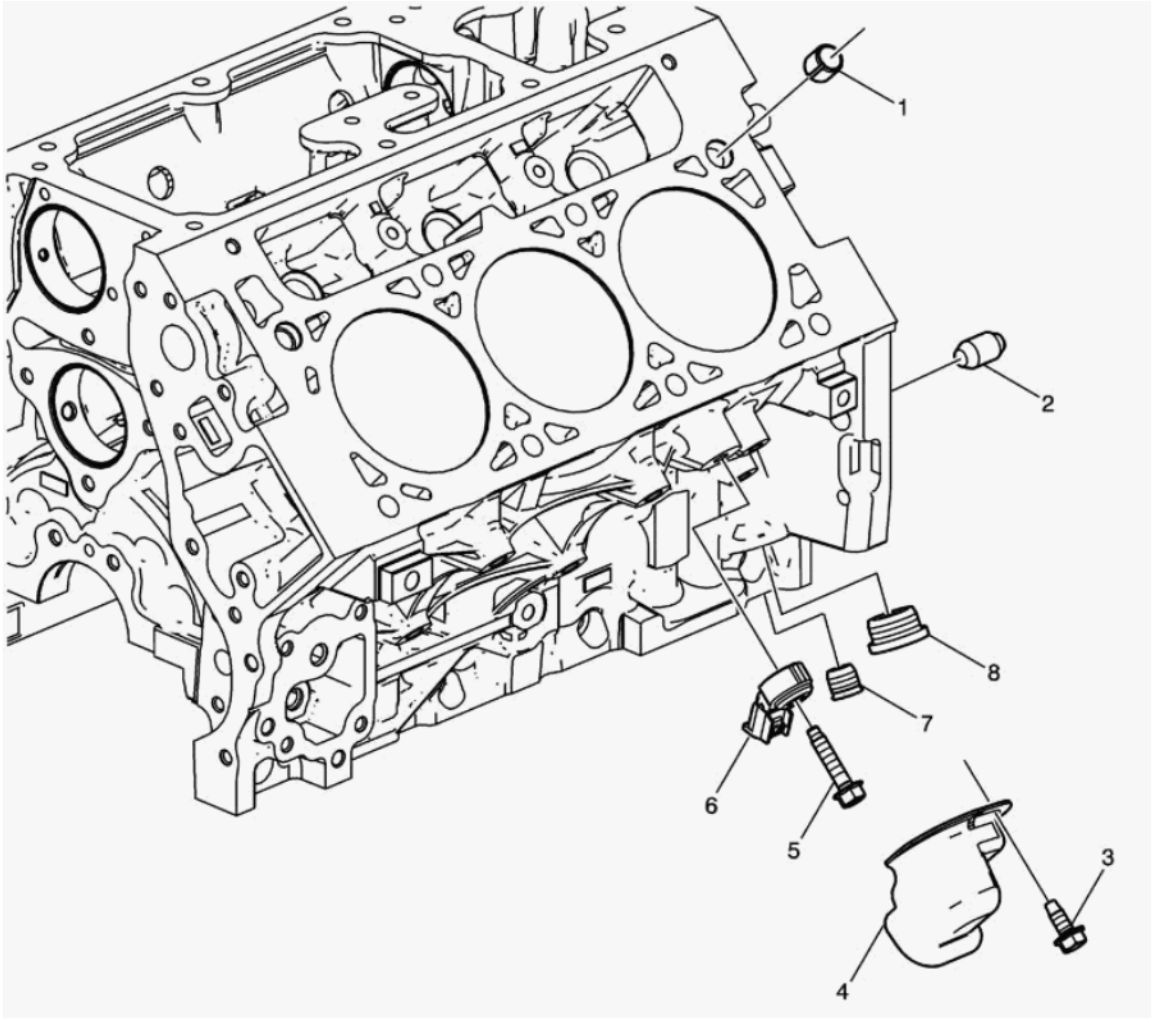

Fig. 336: Engine Block Plug -- Left Side
Courtesy of GENERAL MOTORS COMPANY

Plug Removal - Left Side

Callout	Component Name
1	Cylinder Head Locating Pin
2	Transmission Locating Pin
3	Knock Sensor Shield Bolt
4	Knock Sensor Shield
5	Knock Sensor Bolt
6	Knock Sensor Assembly
7	Engine Block Plug
8	Engine Block Plug

Plug Removal - Right Side

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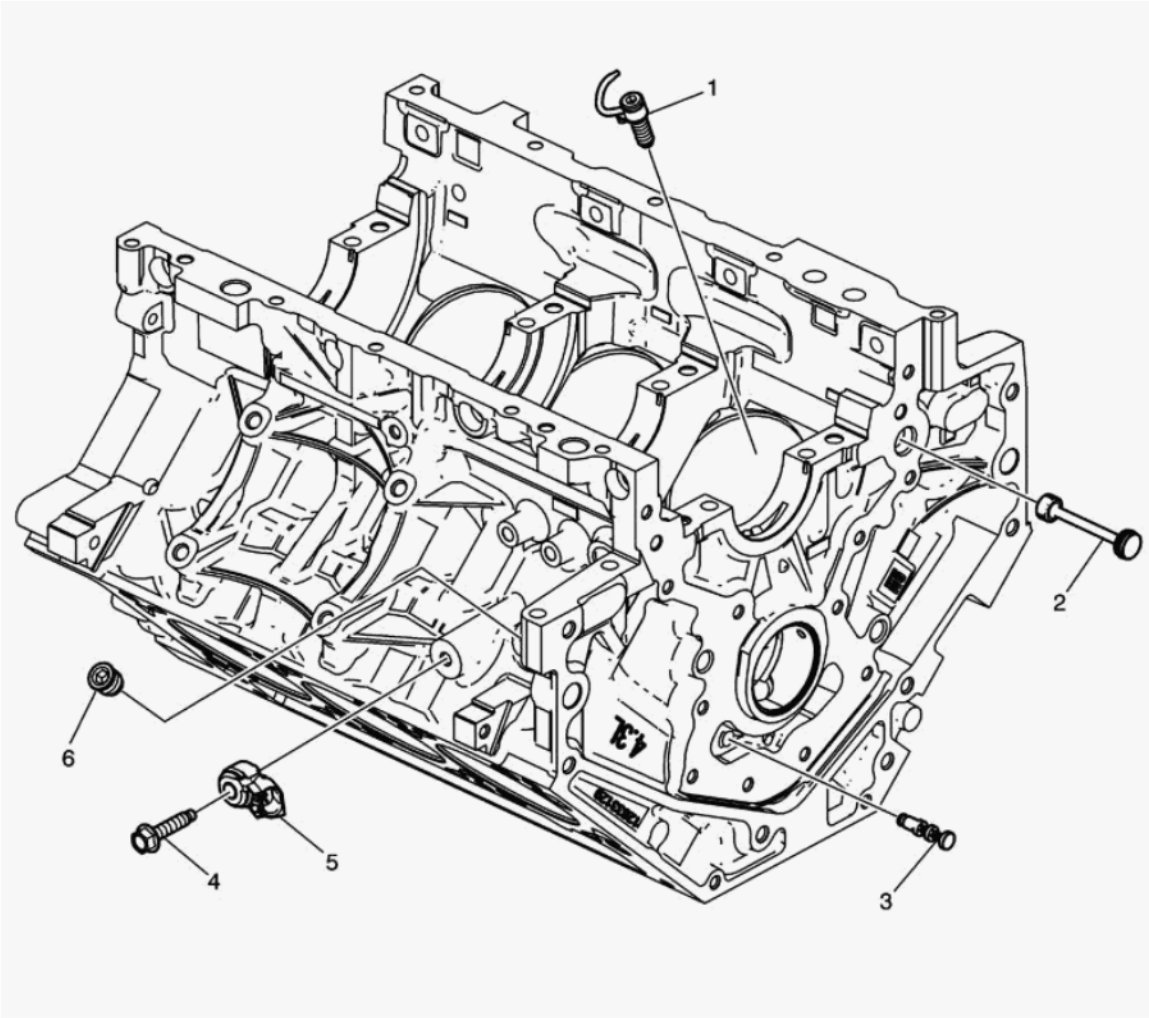

Fig. 337: Engine Block Plug -- Right Side
Courtesy of GENERAL MOTORS COMPANY

Plug Removal - Right Side

Callout	Component Name
1	Piston Oil Nozzle Assembly
2	Engine Block Oil Gallery Plug
3	Engine Block Oil Gallery Plug
4	Knock Sensor Bolt
5	Knock Sensor Assembly
6	Engine Block Plug

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

J 8087 Cylinder Bore Gauge

For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

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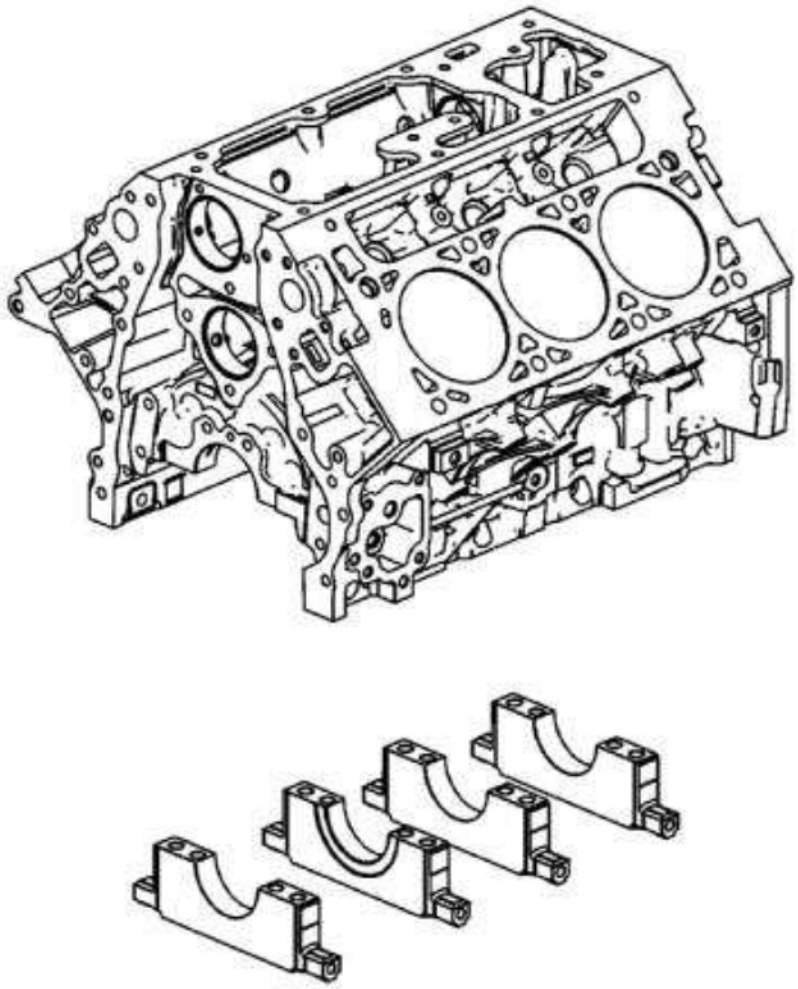

Fig. 338: Engine Block Cleaning Procedure
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Do not use a caustic solution to clean the aluminum engine block.**

NOTE: **When cleaning the engine block in a thermal type oven, do not exceed 232Â°C (450Â°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

Inspection Procedure

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1. Inspect the following components:

NOTE: **Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.**

- 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
- Cylinder bores for excessive ring ridge at the top of the cylinder

2. Measure the cylinder bores for an oversize condition:

Measuring the Cylinder for Oversize

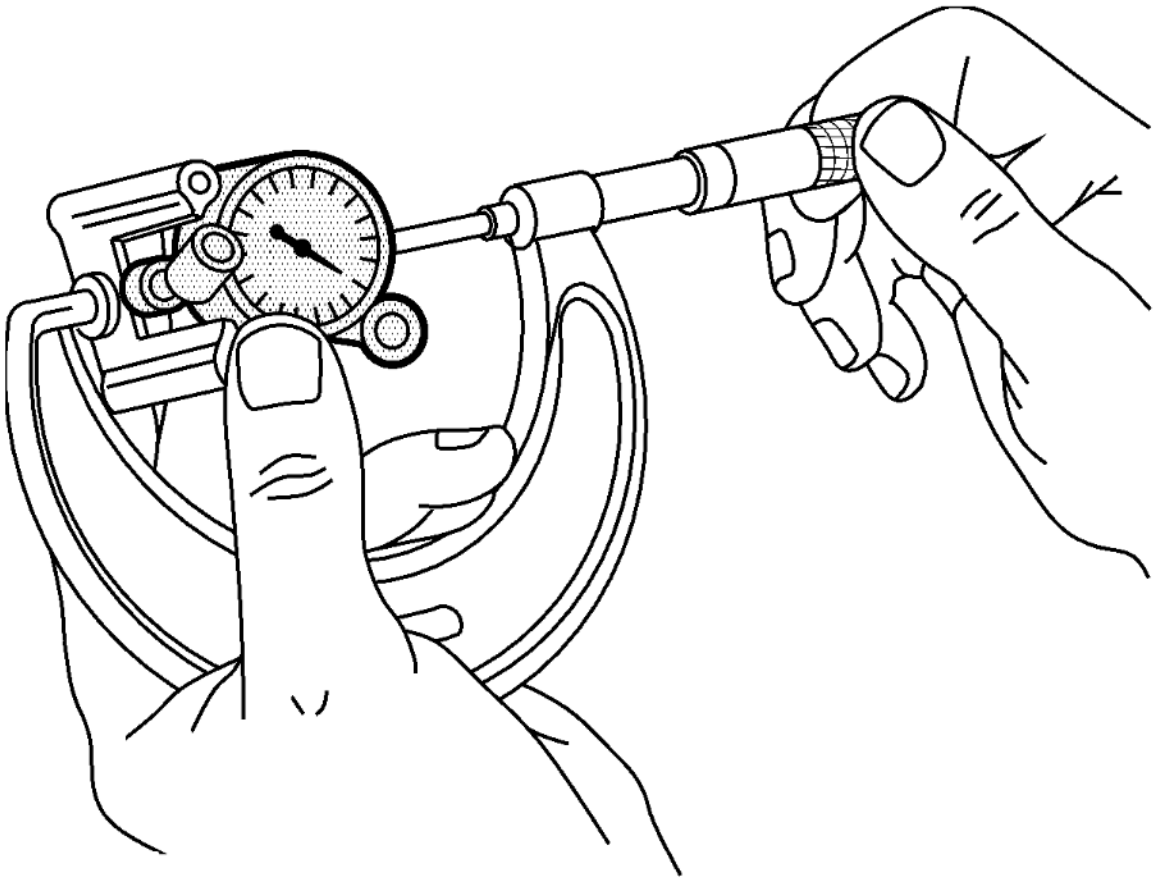

Fig. 339: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS COMPANY

1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical**

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Specifications.

2. Insert the **J 8087** gauge into the micrometer and zero the bore gauge dial.

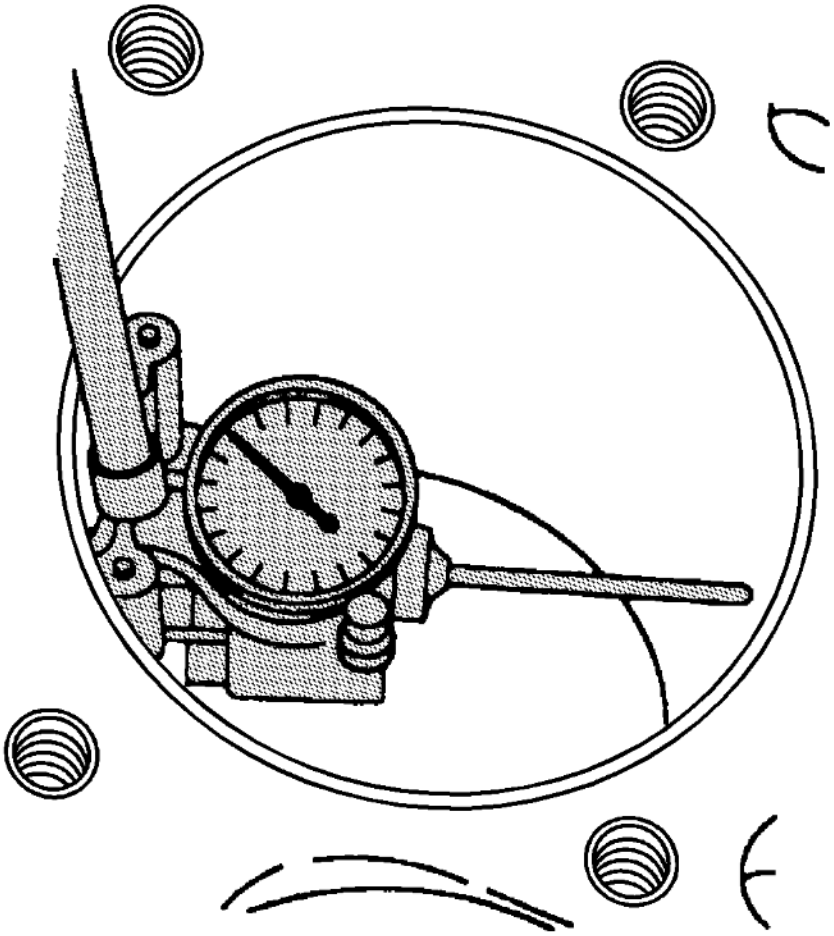

Fig. 340: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

3. Use the **J 8087** gauge and measure the cylinder bore for oversize.

   Slide the bore gauge up and down throughout the length of the cylinder bore. Measure the bore, both parallel and perpendicular to the centerline of the crankshaft, at the top, center, and bottom of the bore. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston. Refer to **Engine Mechanical Specifications**.

PISTON OIL NOZZLE CLEANING AND INSPECTION

NOTE: **The piston oil nozzle assembly is designed to provide oil to the bottom side of the piston for cooling purposes. The internal check ball is held in the normally closed position by the spring until system oil pressure exceeds 300 kPa (43.5 psi).**

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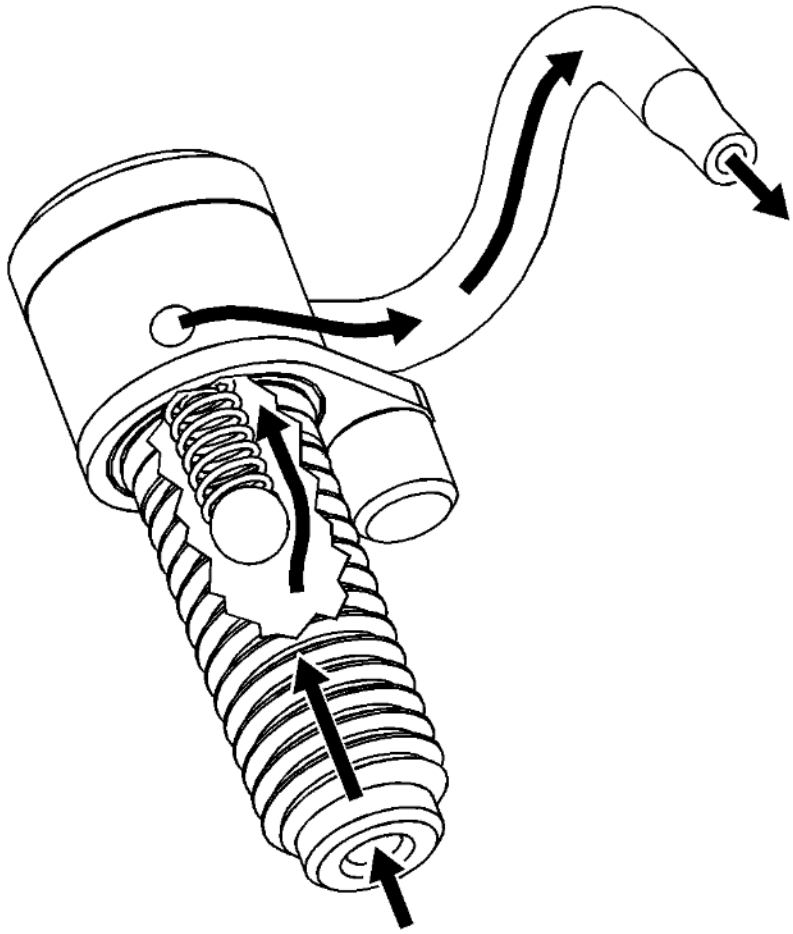

Fig. 341: View Of Piston Oil Nozzle Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Clean the nozzle assembly in solution.
2. Inspect the nozzle assembly for the following:
    - damaged bolt threads
    - damaged or cut O-ring seal
    - bent nozzle
    - A restricted or stuck-open nozzle assembly
3. With no oil pressure, the check ball should be seated and not permit flow through the nozzle tube. Using a blow gun, apply air pressure to the inlet portion of the bolt. Air pressure should unseat the check ball and permit flow through and out of the nozzle tube.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

- **J 7872** Magnetic Base Dial Indicator Set
- **J 43690** Rod Bearing Checking Tool
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit

For equivalent regional tools, refer to **Special Tools**

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Cleaning Procedure

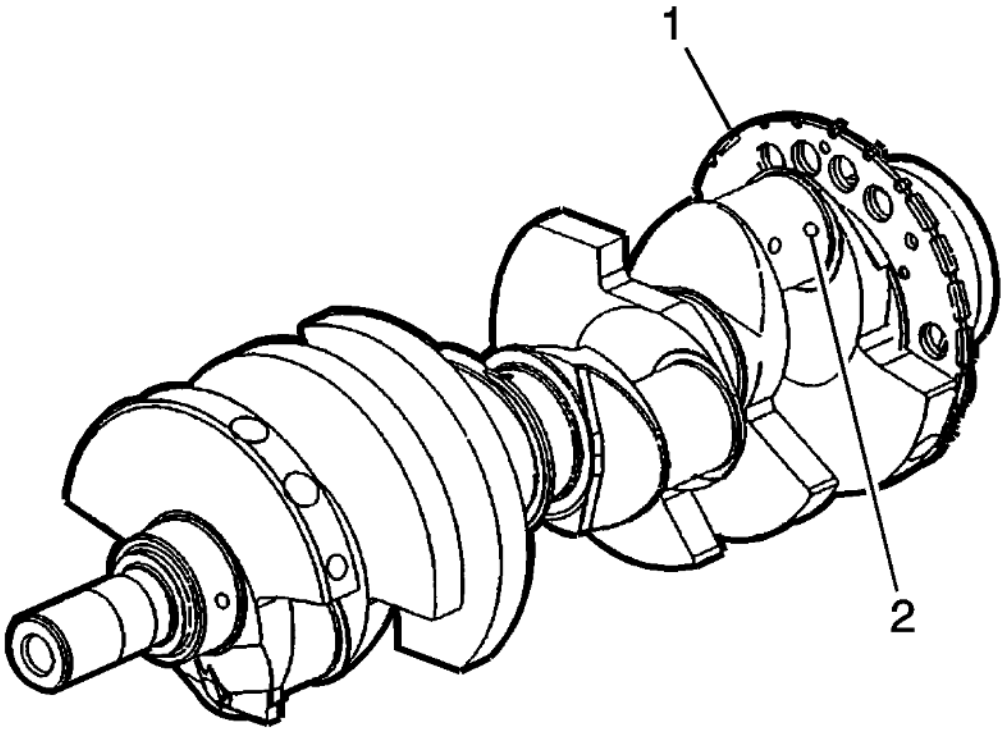

Fig. 342: Oil Passages & CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position (CKP) reluctor ring. Damage to the teeth of the CKP reluctor ring may affect on-board diagnostics (OBD) II system performance.**

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages (2) and inspect for restrictions or burrs.

WARNING: **Refer to Safety Glasses Warning .**

3. Dry the crankshaft with compressed air.

Inspection Procedure

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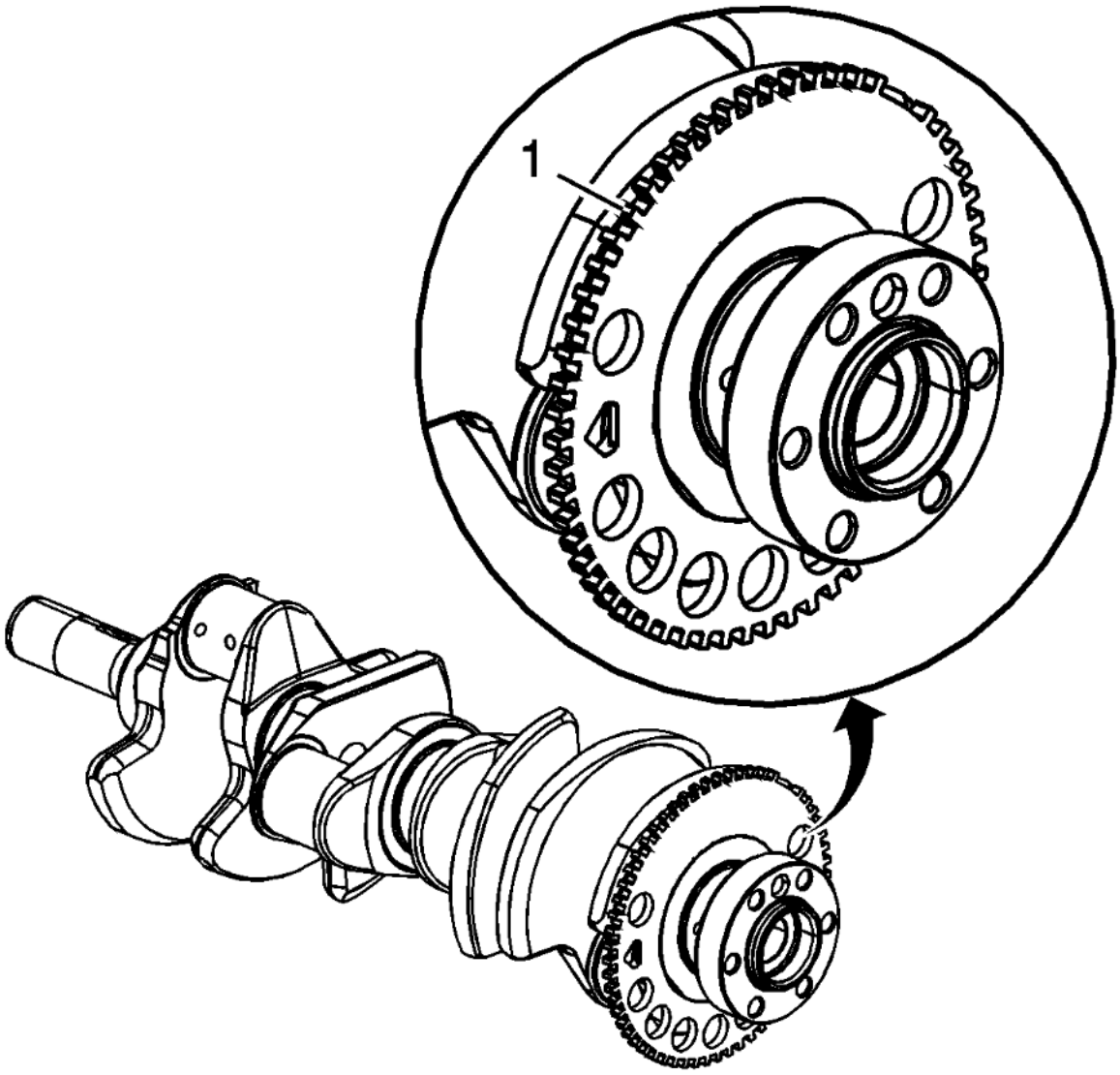

Fig. 343: View Of Reluctor Ring Teeth
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may affect OBD II system performance.**

1. Inspect the CKP reluctor ring teeth (1) for damage.

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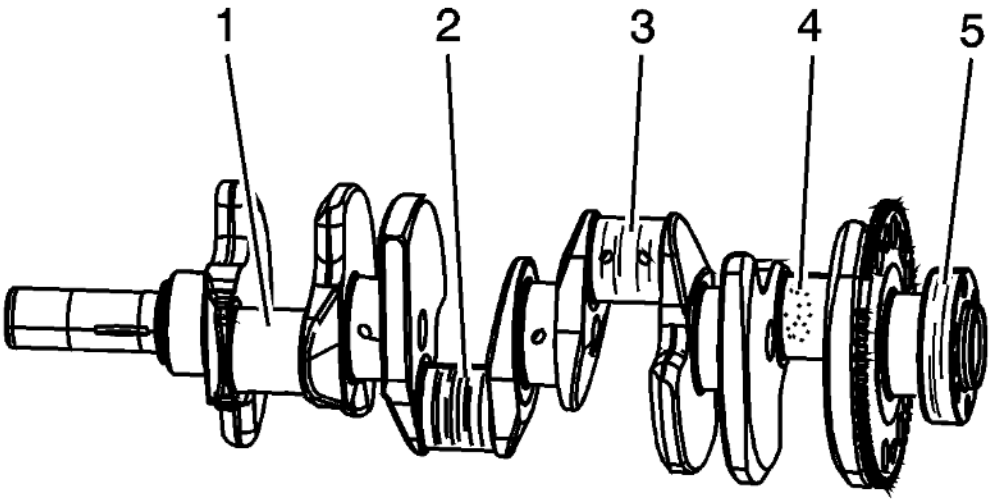

Fig. 344: View Of Crankshaft Journals
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the crankshaft journals for wear.

   Journals should be smooth (1) with no signs of scoring, wear, or damage.

3. Inspect the crankshaft journals for grooves or scoring (2).
4. Inspect the crankshaft journals for scratches or wear (3).
5. Inspect the crankshaft journals for pitting or imbedded bearing material (4).
6. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.

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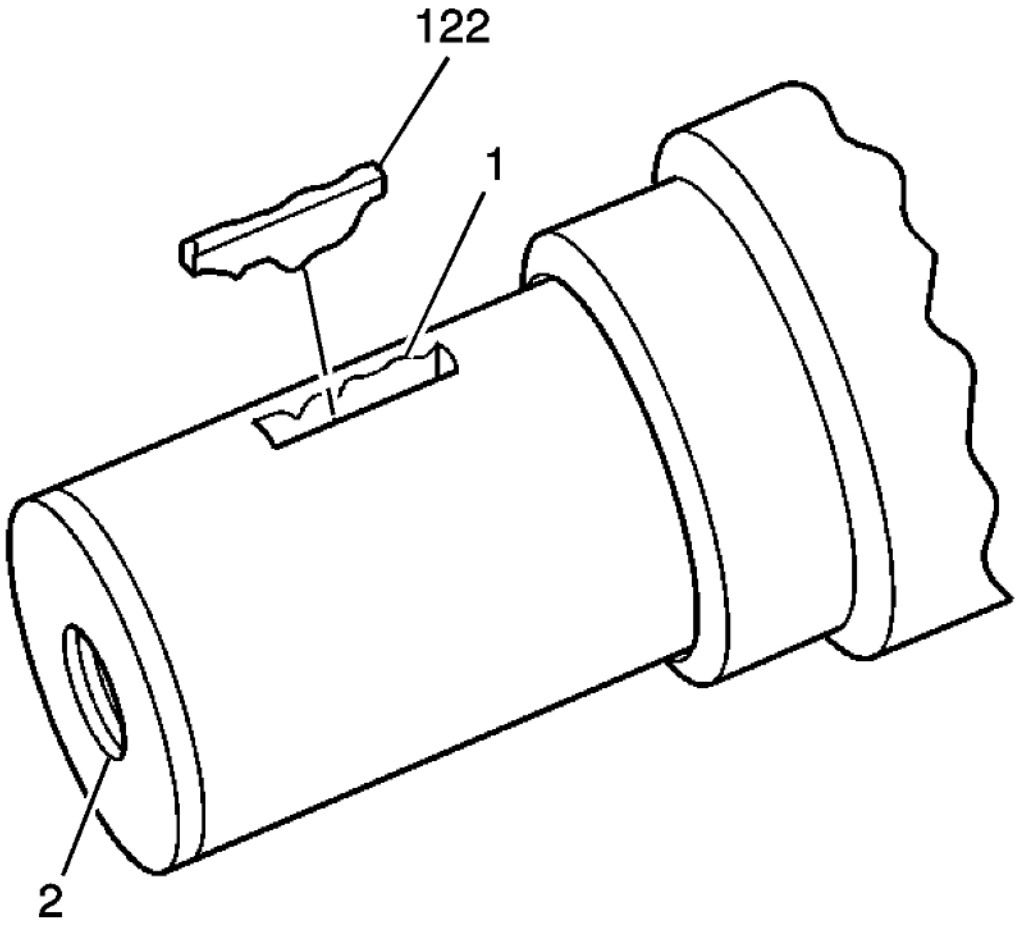

Fig. 345: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

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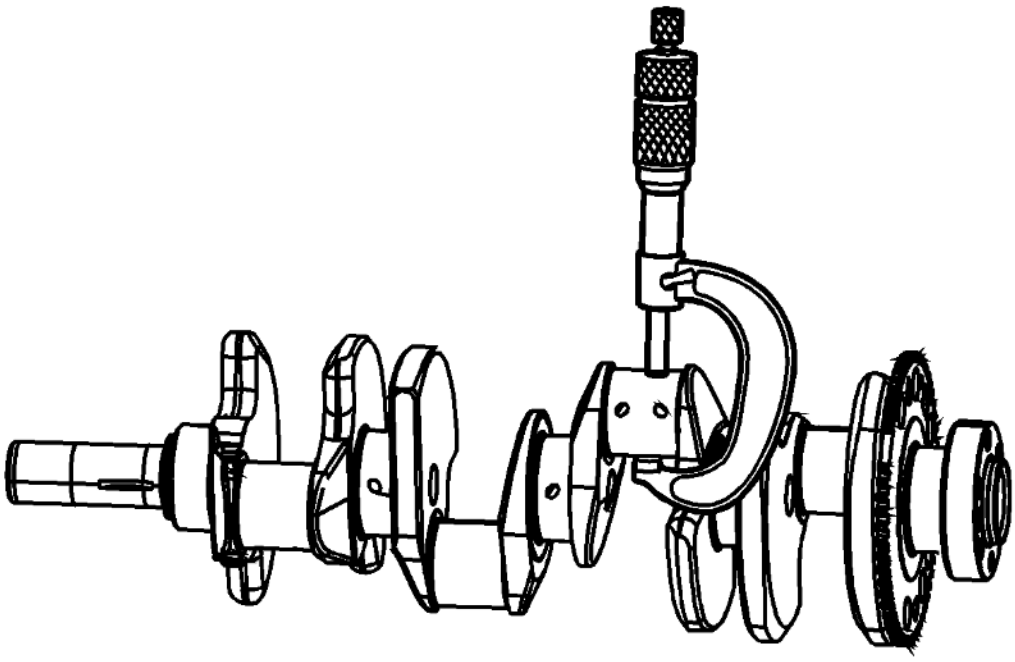

Fig. 346: Measuring Connecting Rod Journals For Out-Of-Round And Taper
Courtesy of GENERAL MOTORS COMPANY

8. Measure the connecting rod journals for out-of-round and taper.

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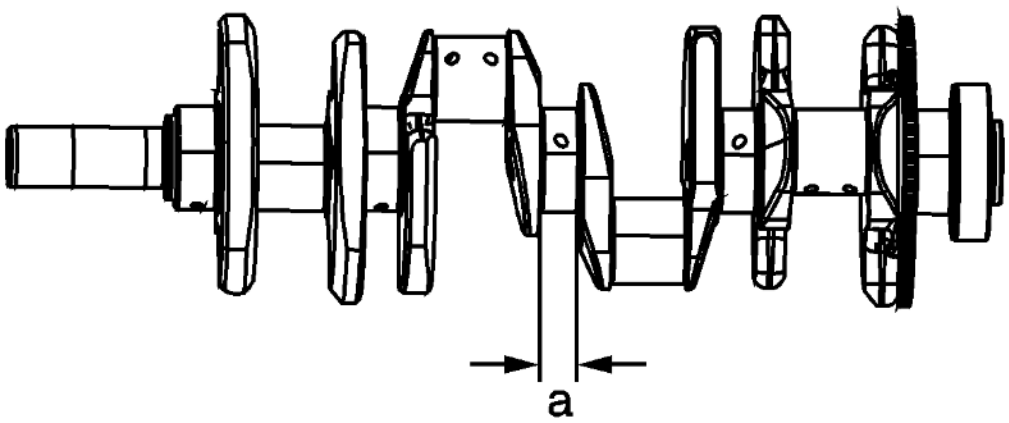

Fig. 347: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS COMPANY

9. Measure the crankshaft thrust wall width.

   A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) (a) must be replaced.

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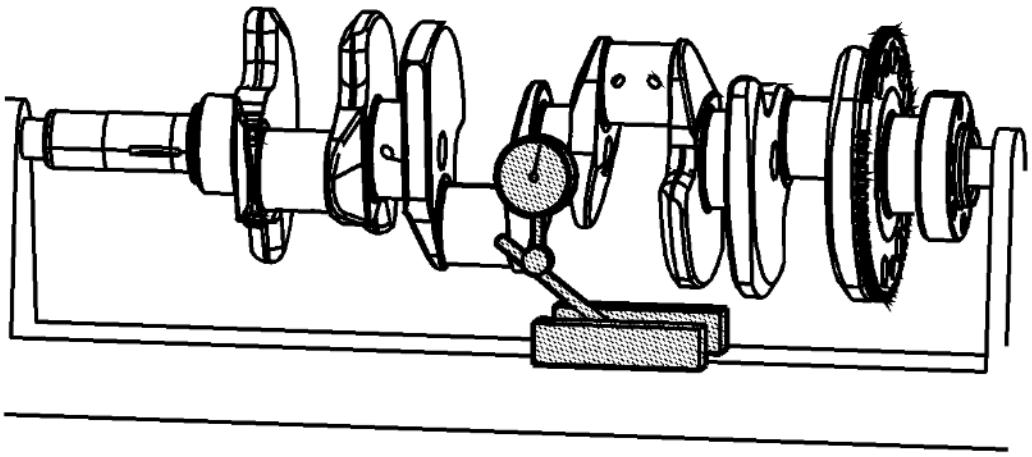

Fig. 348: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS COMPANY

10. Measure the crankshaft runout.

    Use wooden V-blocks or a fixture to support the crankshaft on the front and rear journals.

11. Use the **J 7872** set in order to measure the crankshaft runout at the front and rear intermediate journals.
12. Use the **J 7872** set in order to measure the runout of the crankshaft rear flange.
13. Use the **J 7872** set 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 front and rear intermediate journals, crankshaft rear flange, or reluctor ring runout exceeds specification, replace the crankshaft. Refer to **Engine Mechanical Specifications**.

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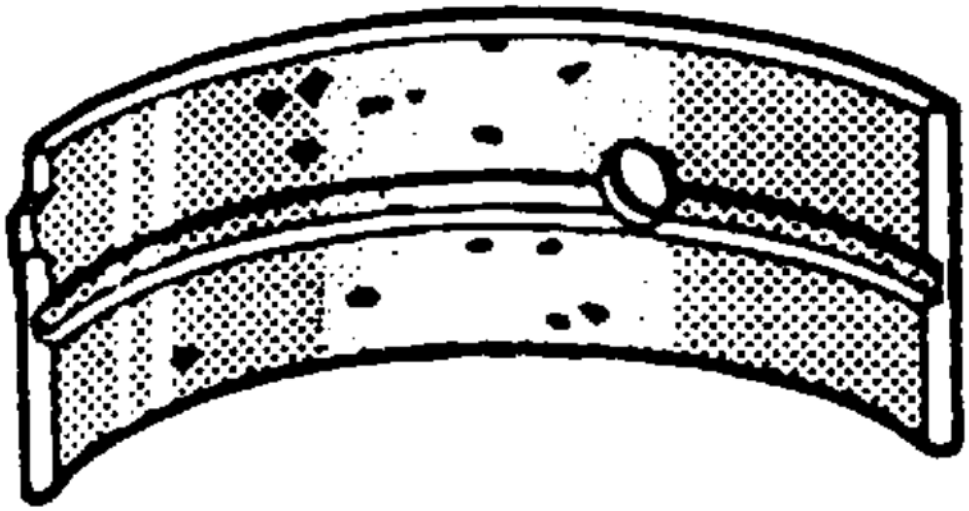

Fig. 349: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

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

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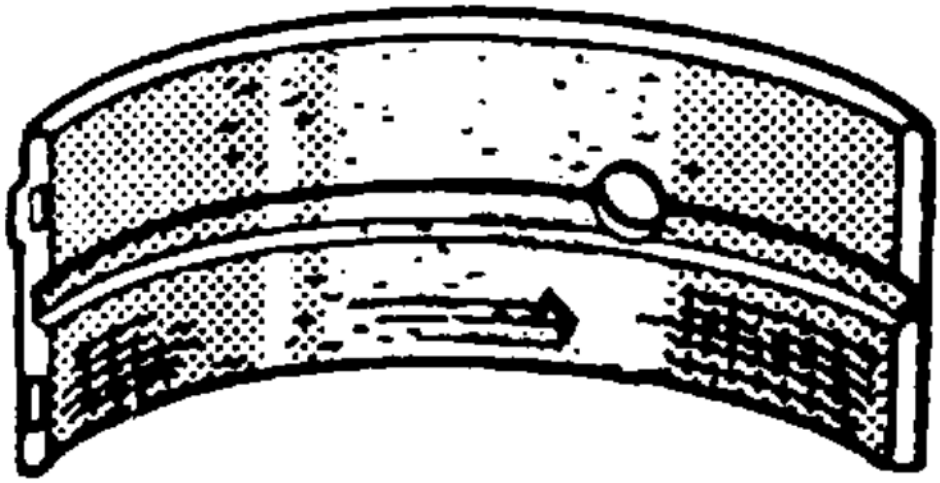

Fig. 350: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

15. Inspect the crankshaft bearings for excessive scoring or discoloration.
16. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

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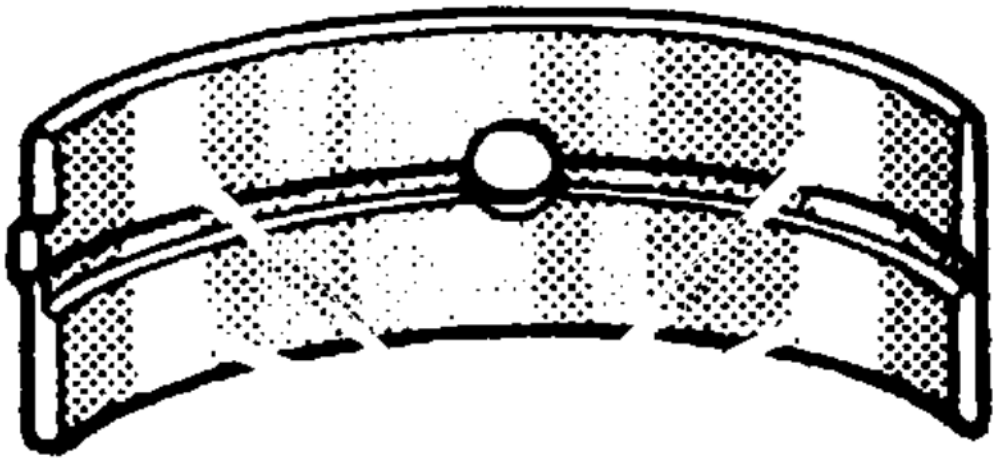

Fig. 351: View Of Crankshaft Bearing Improper Seating
Courtesy of GENERAL MOTORS COMPANY

17. Inspect the crankshaft bearings for improper seating, indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Measuring Main Bearing Clearance - Gaging Plastic Method

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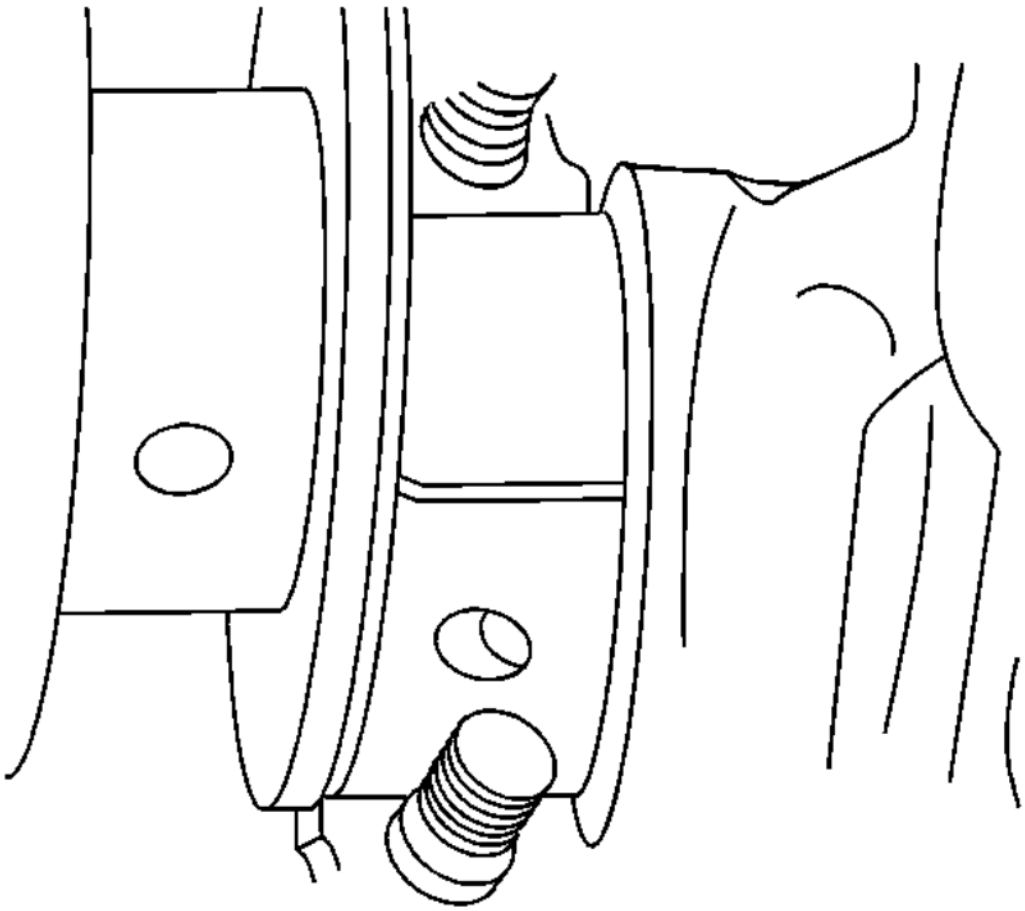

Fig. 352: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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 affect crankshaft position sensor signals and may affect OBD II system operation.**
- **Remove the bearing cap side bolts prior to cap removal.**

1. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.
2. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of the crankshaft bearing journal.
3. Install the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Installation**.
4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.

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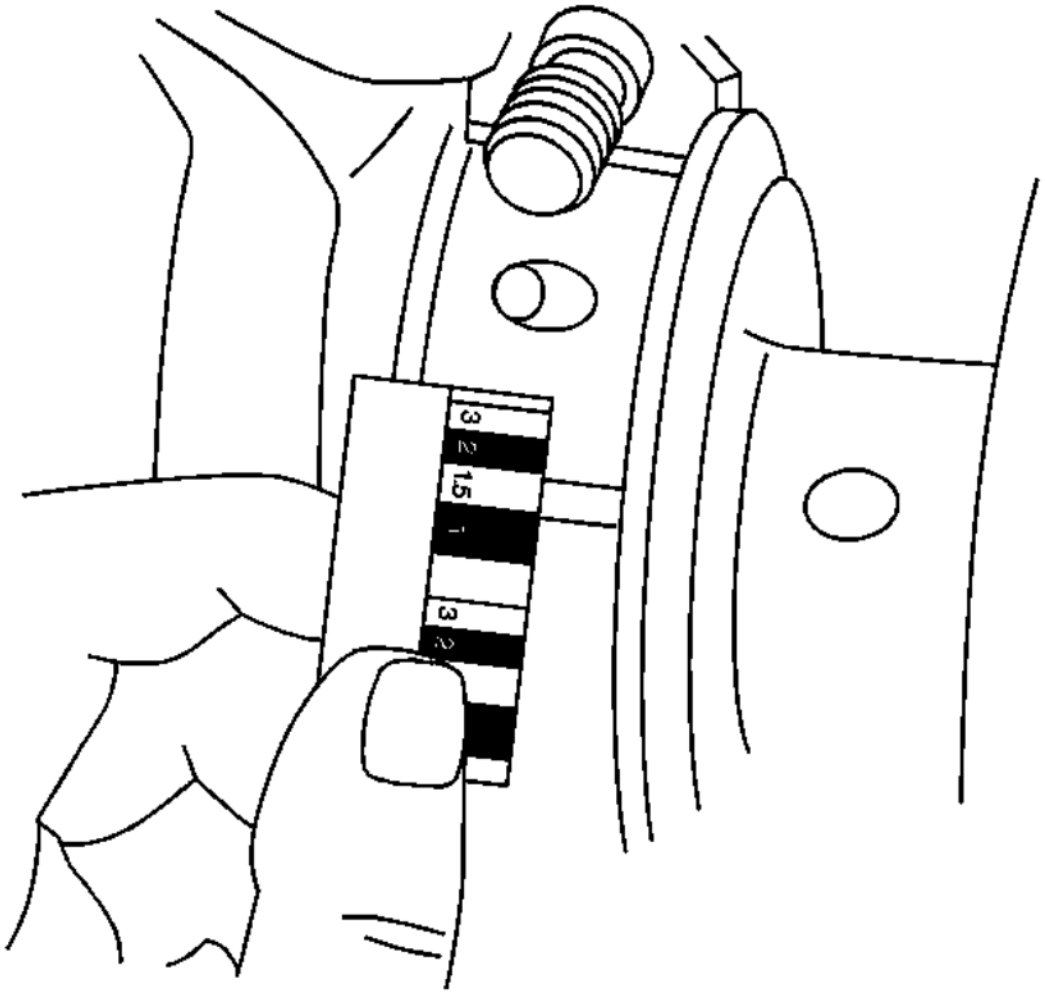

Fig. 353: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS COMPANY

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area.
    - 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

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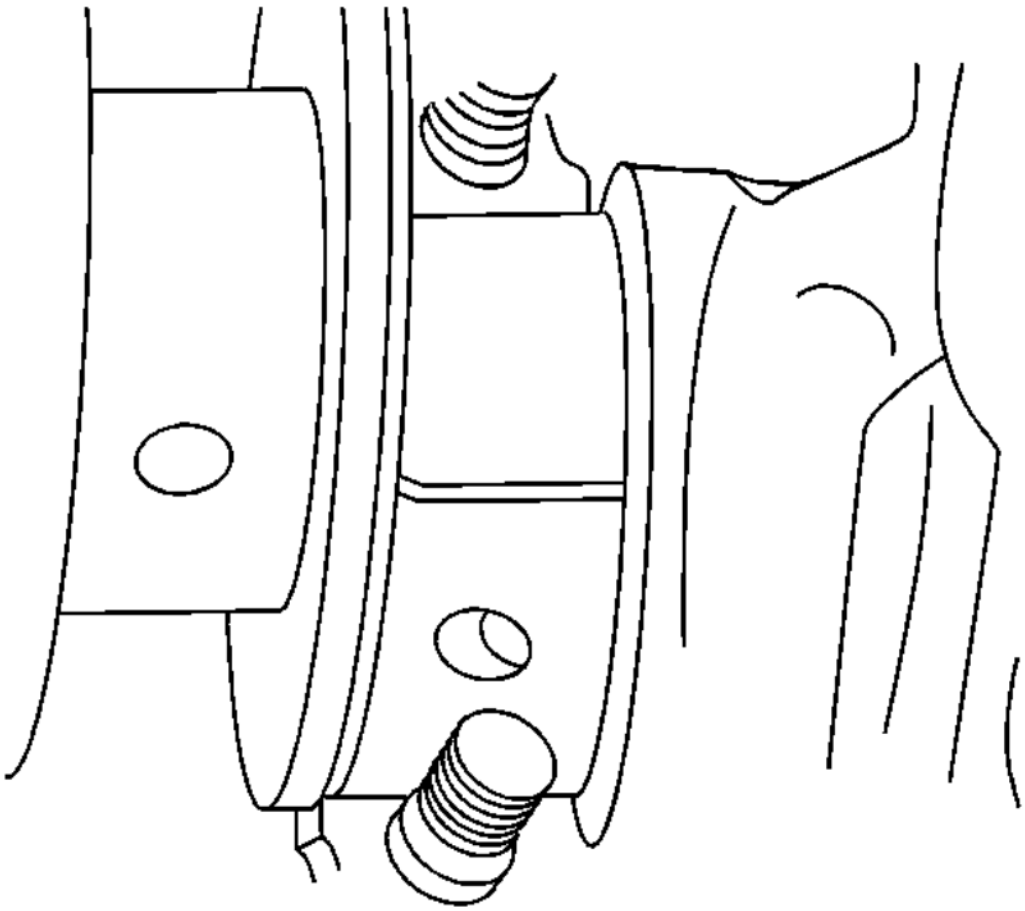

Fig. 354: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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 is 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**.

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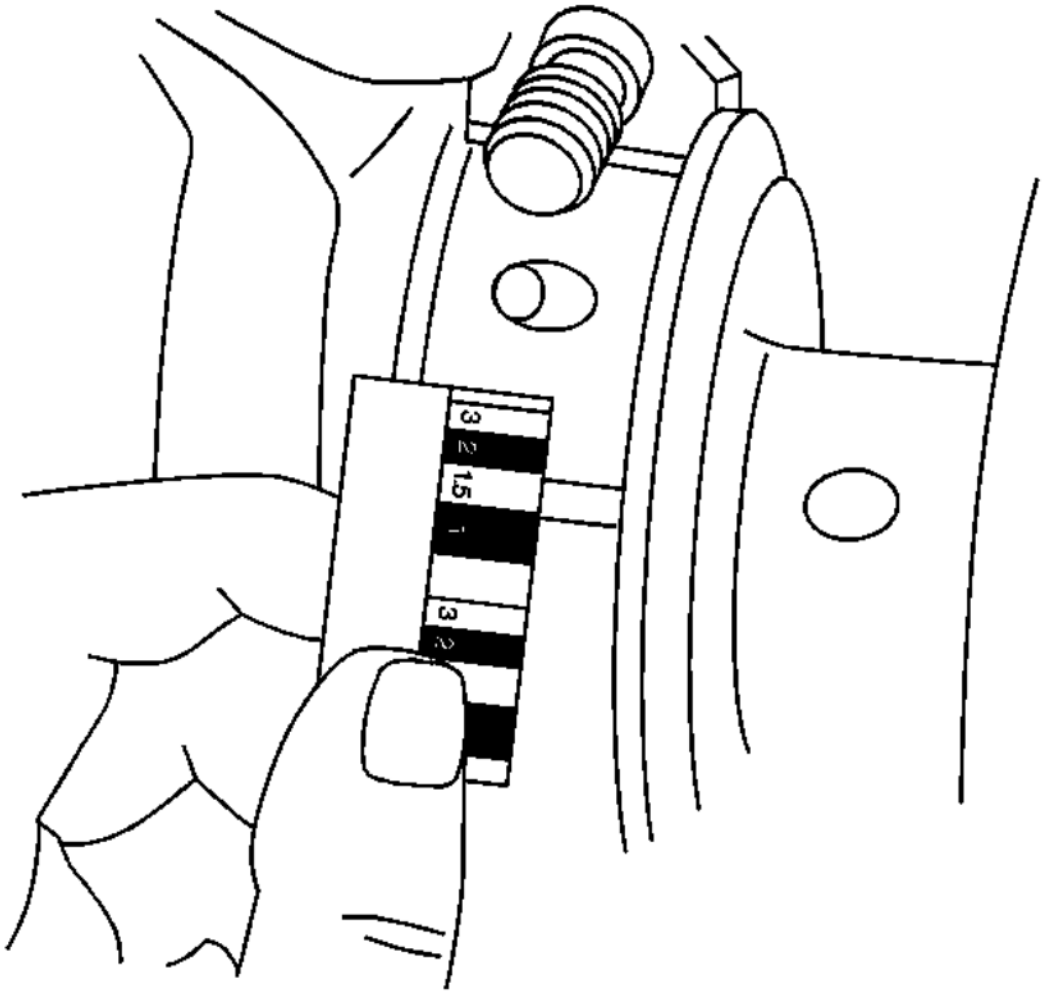

Fig. 355: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS COMPANY

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area. Refer to **Engine Mechanical Specifications**.

Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

J 43690 tool and **J 43690-100** kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets supplied by the tool manufacturer.

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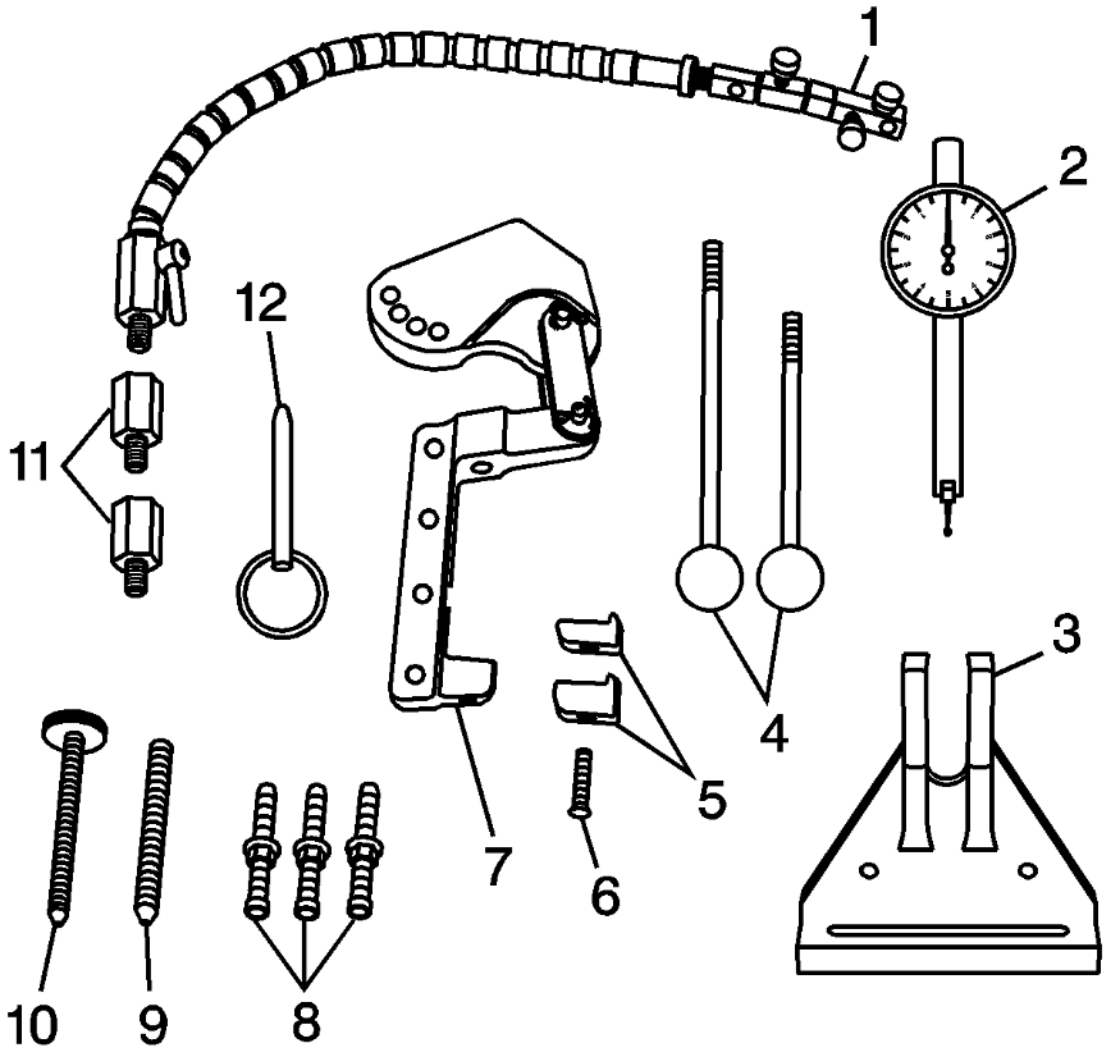

Fig. 356: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS COMPANY

J 43690 tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, J 43690-6 Handle (4)
- J 43690-10, J 43690-11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, J 43690-7, J 43690-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

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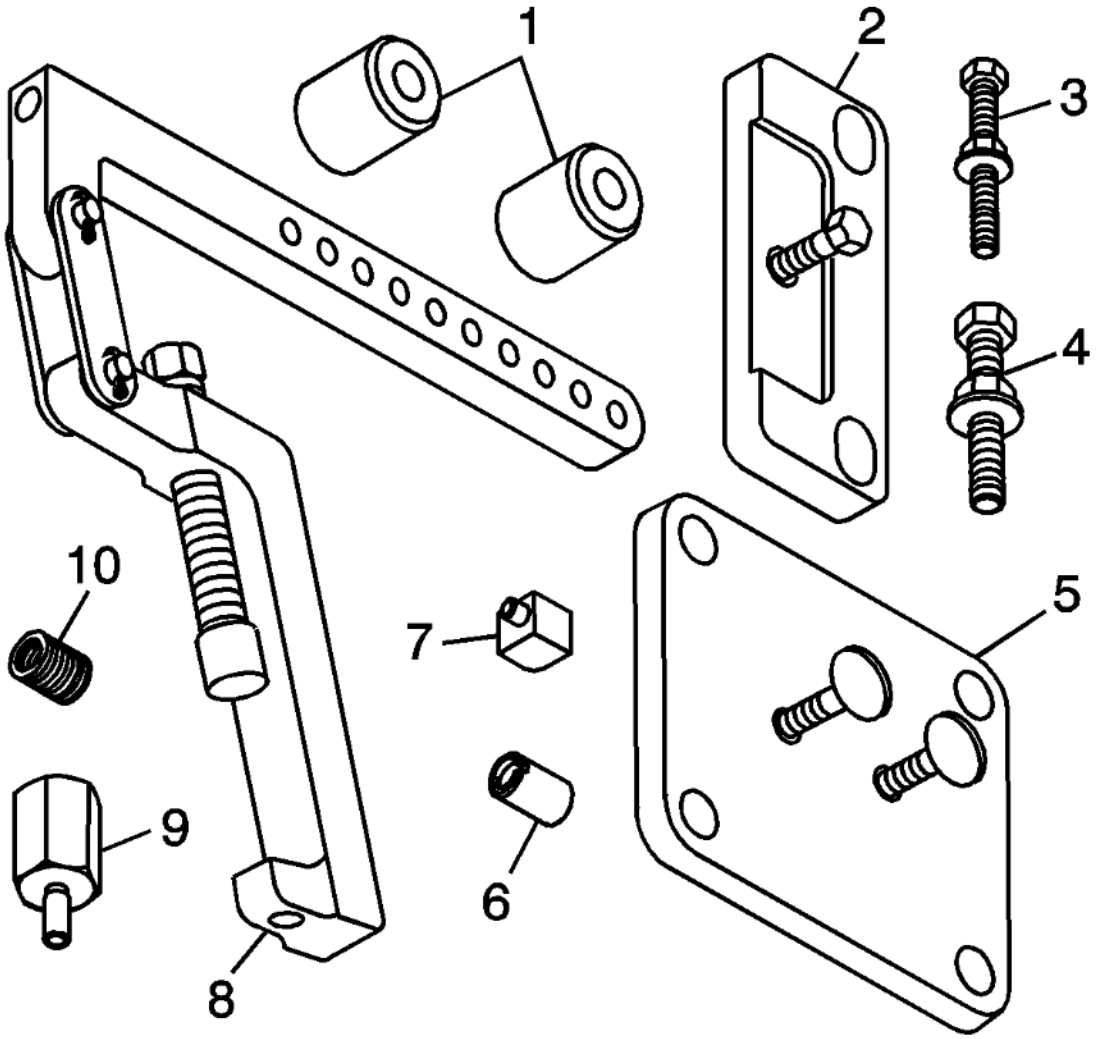

Fig. 357: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS COMPANY

J 43690 Rod Bearing Checking Tool

- 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)

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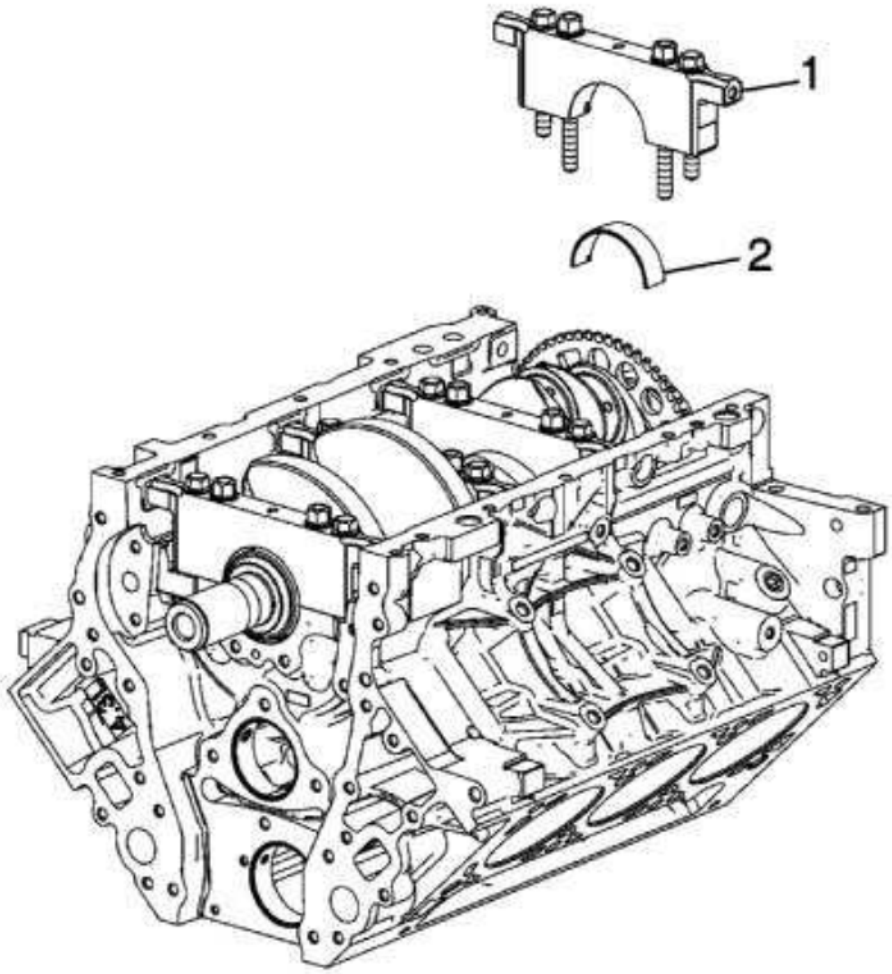

Fig. 358: Bearing Cap Bolts And Bearing Half
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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 Specifications**.

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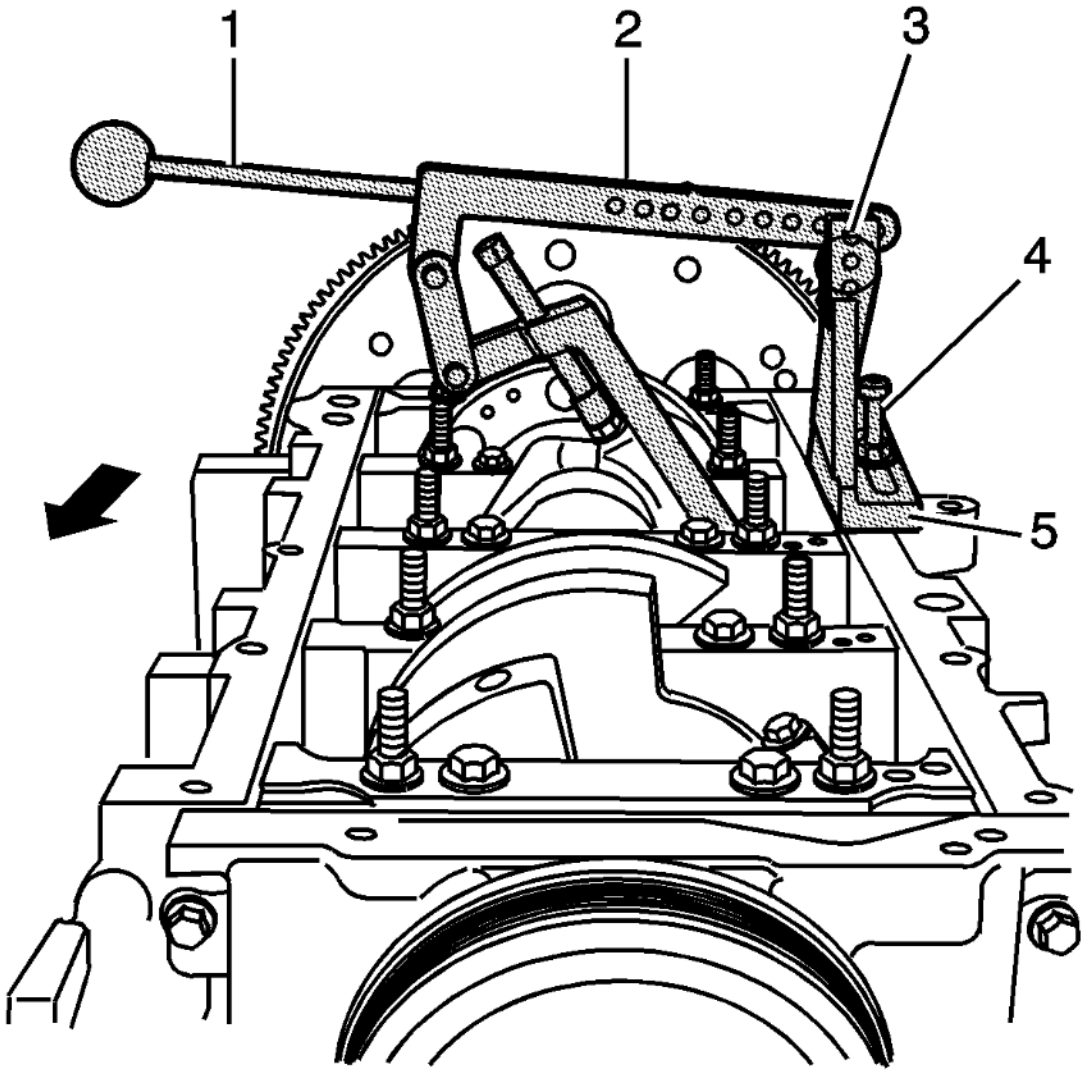

Fig. 359: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS COMPANY

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)

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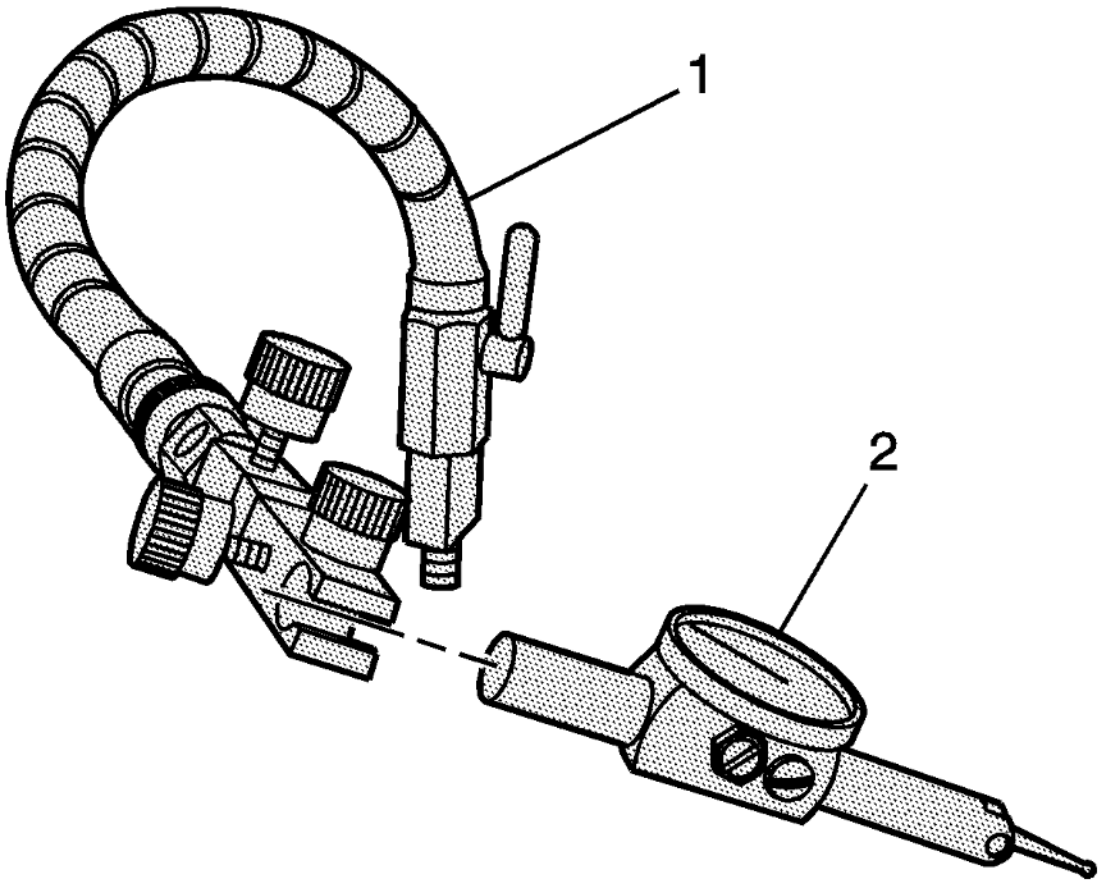

Fig. 360: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS COMPANY

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

   A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components, as required.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

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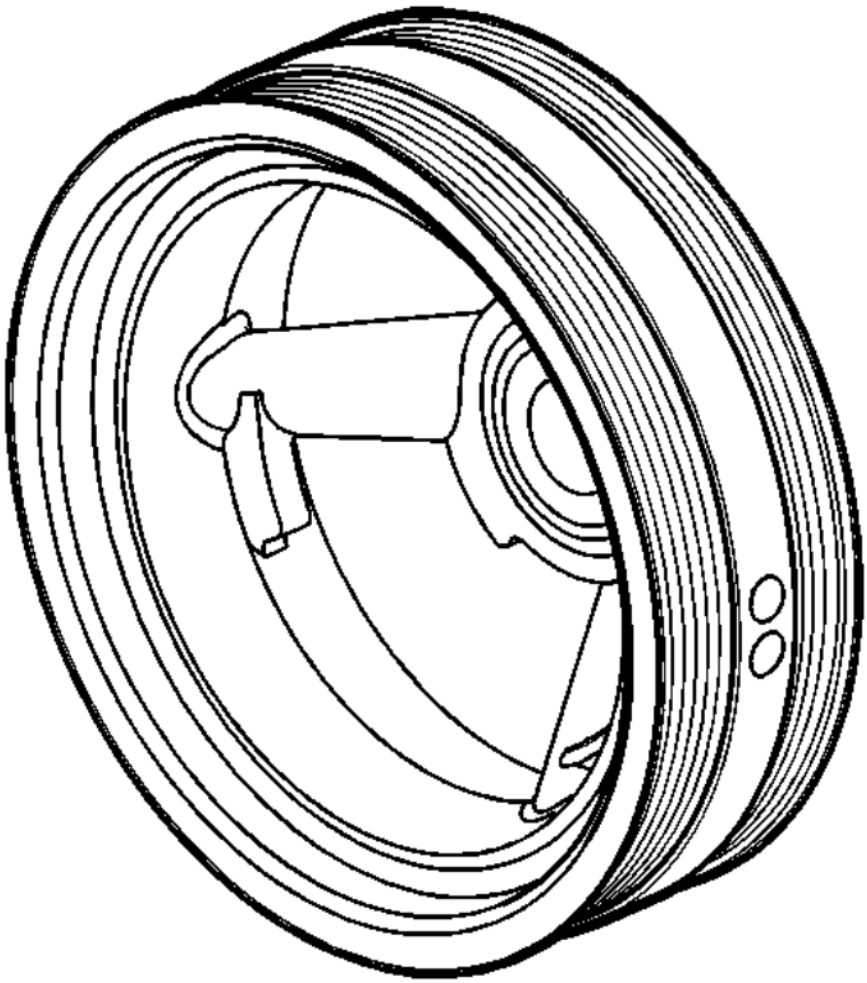

Fig. 361: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

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.

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Minor imperfections may be removed with a fine file.

- Worn, chunking, or deteriorated rubber between the hub and pulley

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

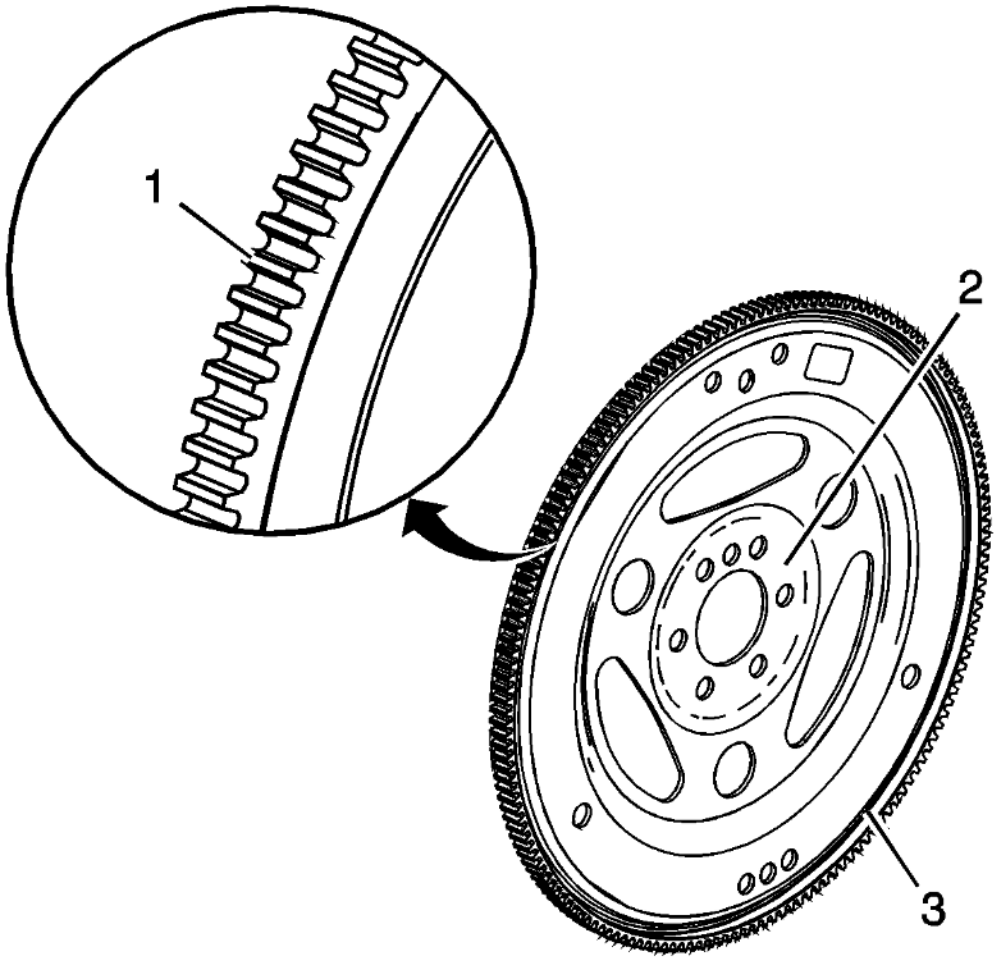

Fig. 362: View Of Ring Gear Teeth
Courtesy of GENERAL MOTORS COMPANY

1. Clean the flex plate in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the flex plate with compressed air.
3. Inspect the flex plate for the following conditions:
   - Damaged ring gear teeth (1)
   - Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

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

   - Welded areas (3) that retain the ring gear onto the flex plate for cracking

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PISTON AND CONNECTING ROD DISASSEMBLE

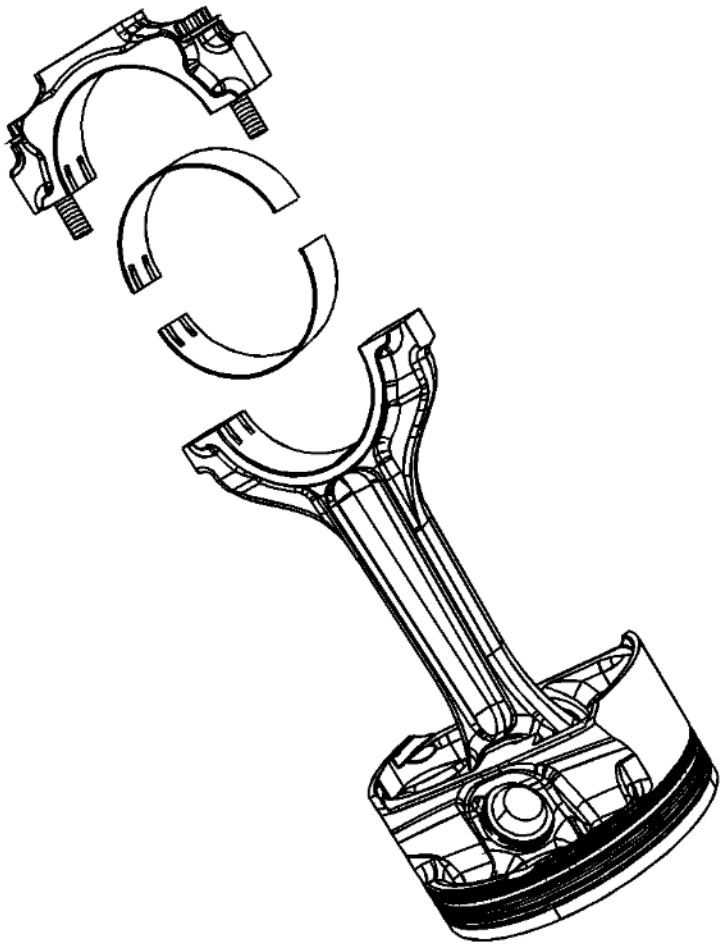

Fig. 363: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Remove the connecting rod bearings from the rod and cap.

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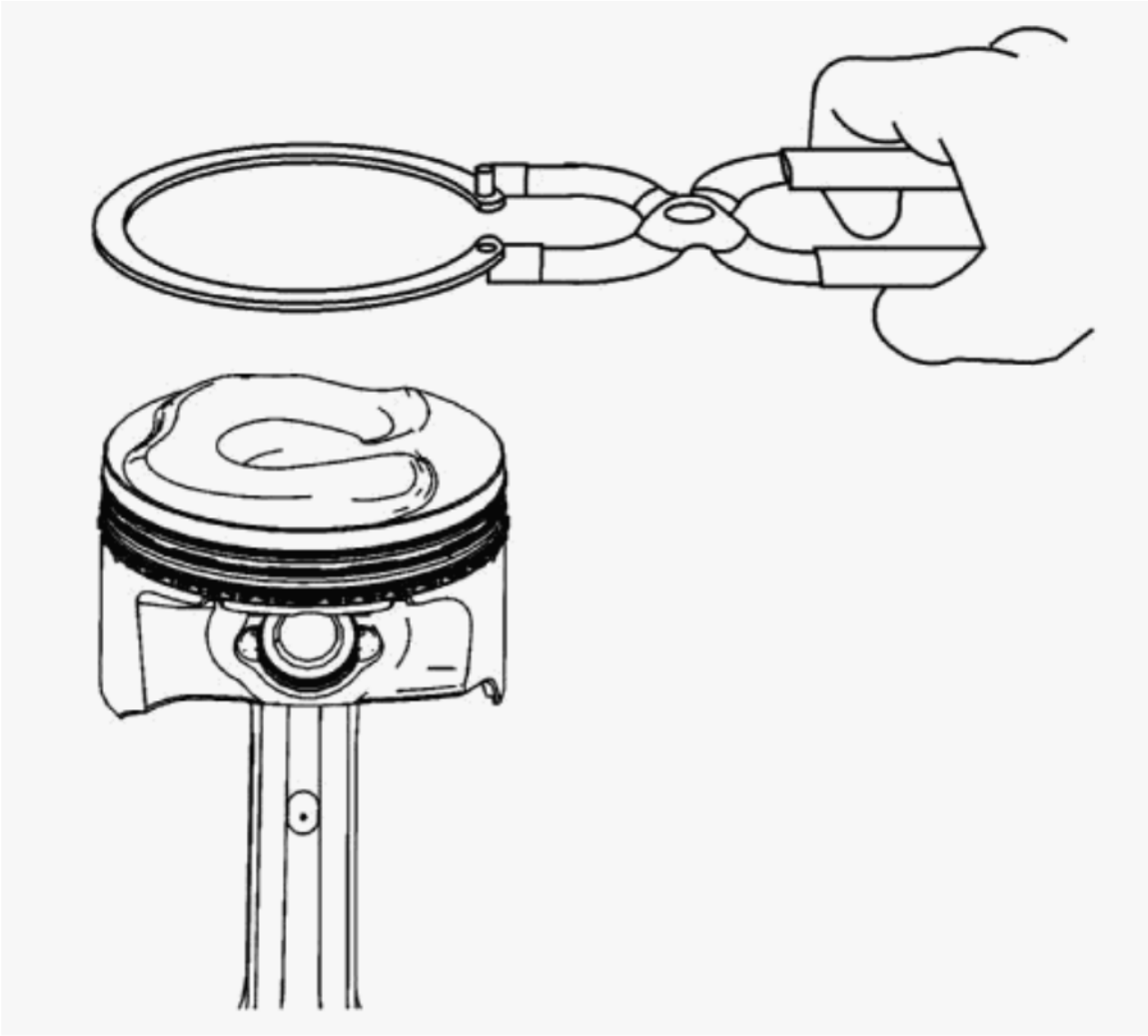

Fig. 364: Removing Piston Rings From Piston Using Piston Ring Pliers
Courtesy of GENERAL MOTORS COMPANY

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

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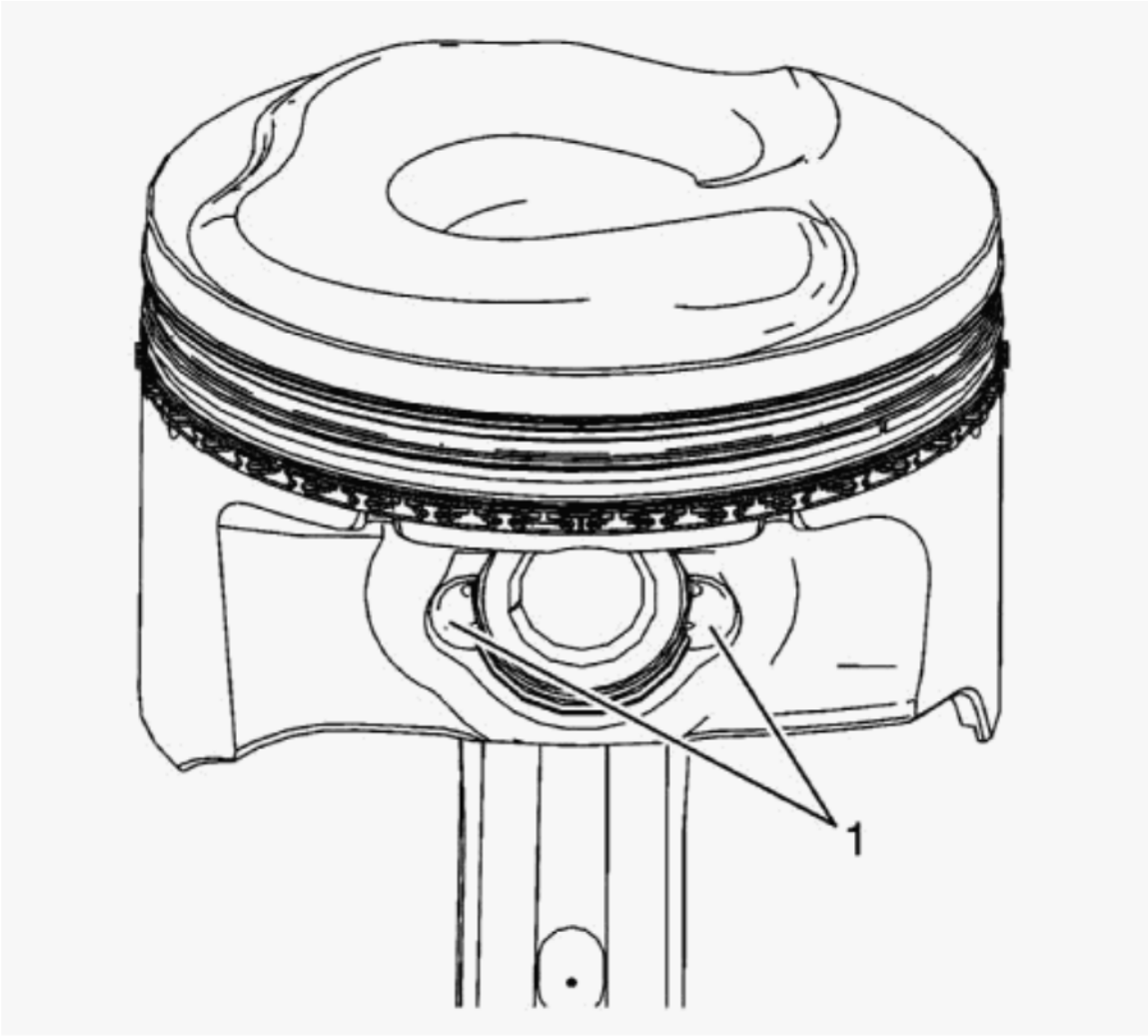

Fig. 365: Rotating Piston Pin Retainers Until Ring End Gaps Are Positioned In Cutout Area
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.

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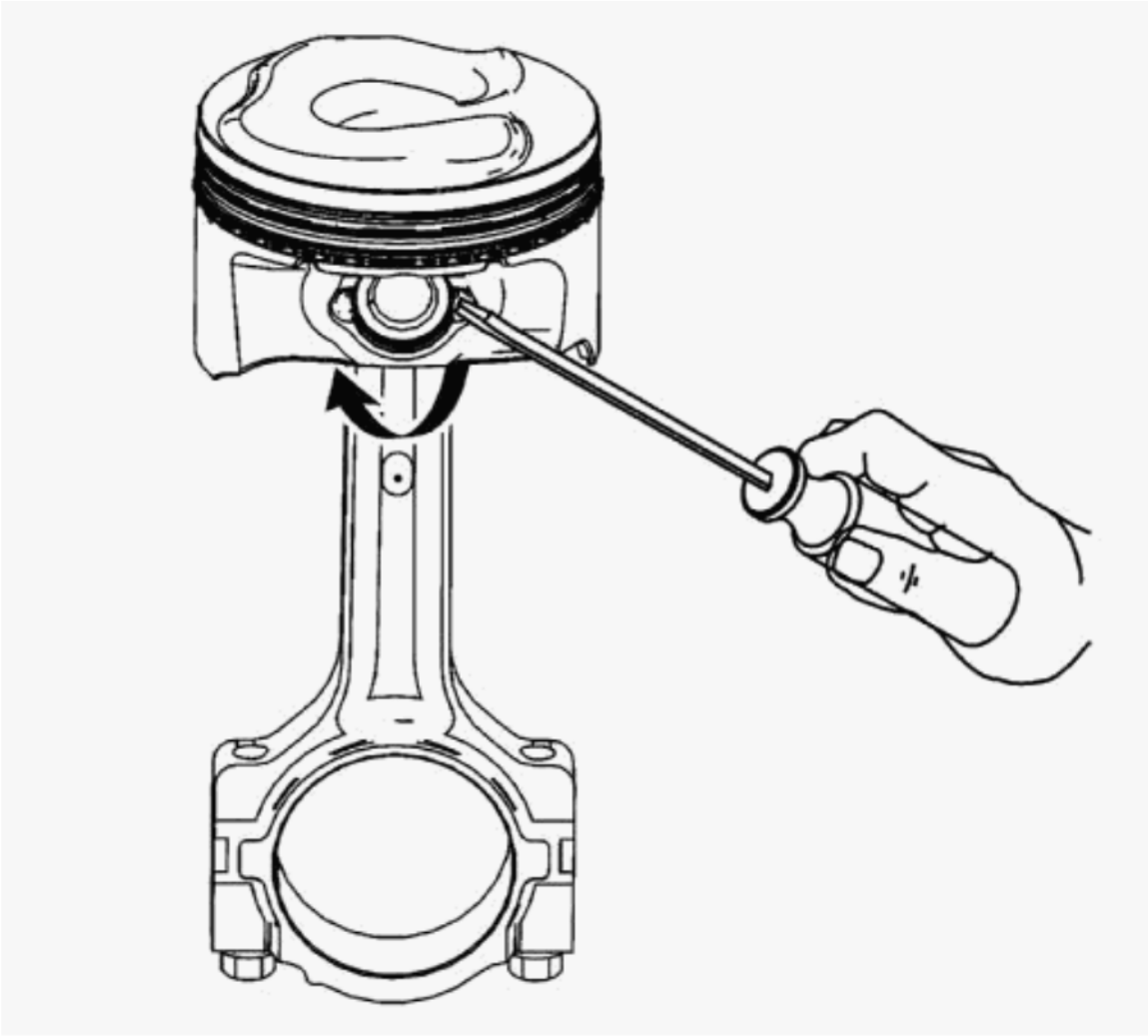

Fig. 366: Retainers Starting In Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS COMPANY

4. Remove the retainers starting in the cutout area of the pin bore.

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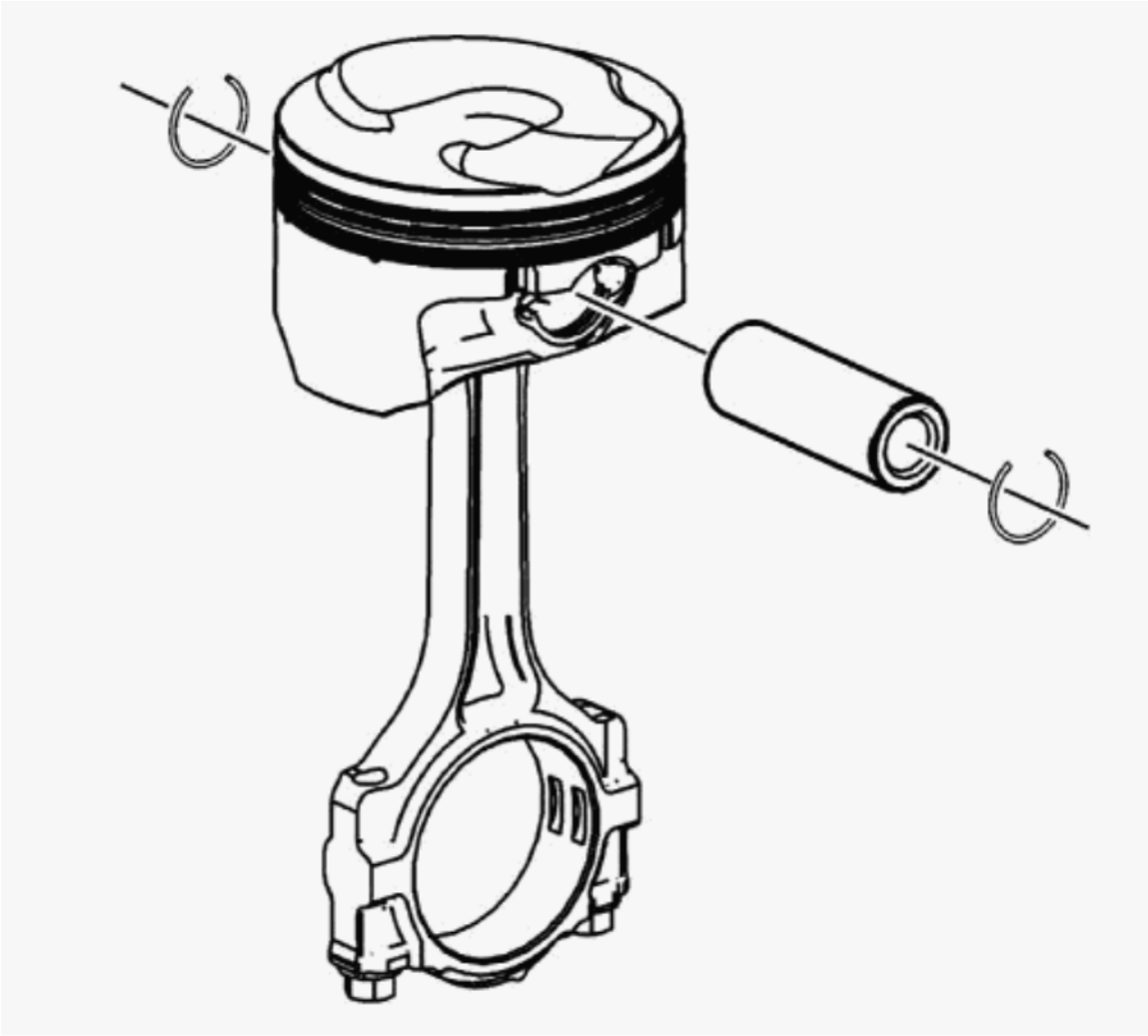

Fig. 367: Removing Pin From Piston And Connecting Rod
Courtesy of GENERAL MOTORS COMPANY

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

Mark, sort, or organize the piston and the matching piston pin.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Piston, Pin, and Piston Rings

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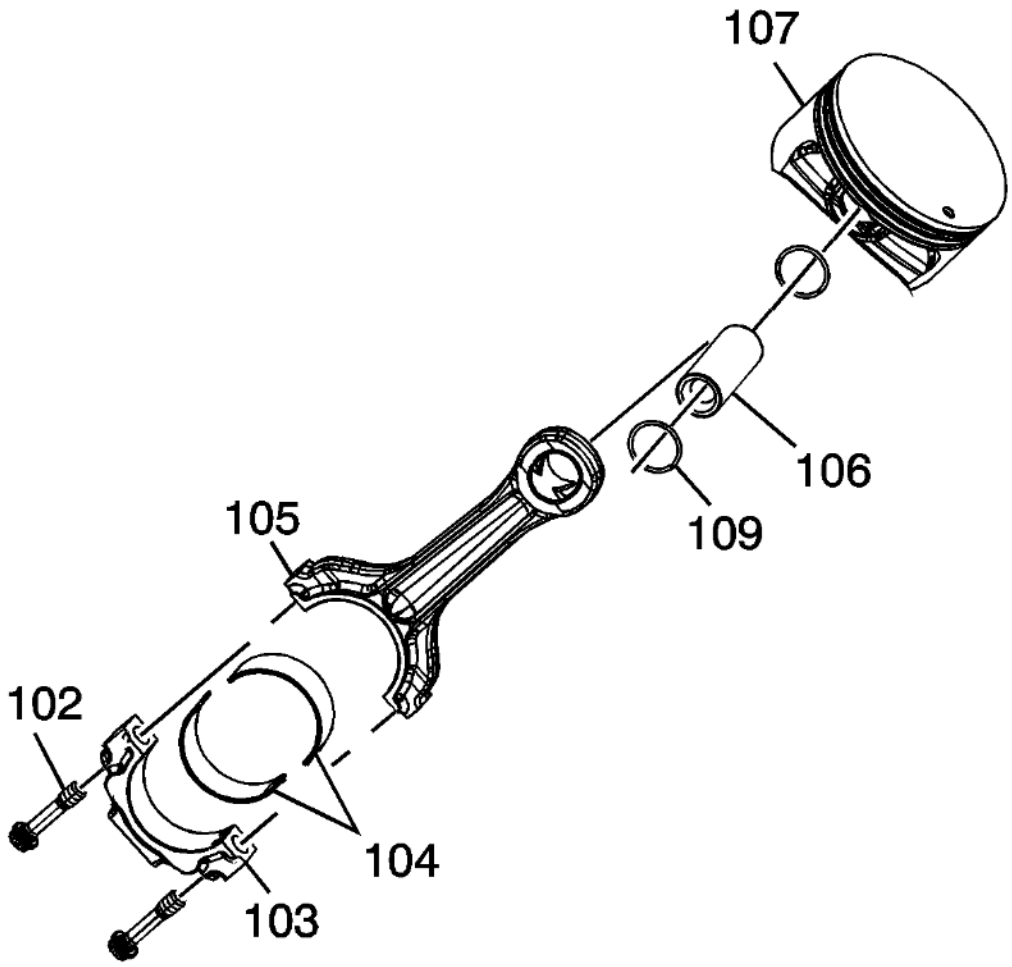

Fig. 368: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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.

WARNING: **Refer to Safety Glasses Warning .**

2. Dry the components with compressed air.

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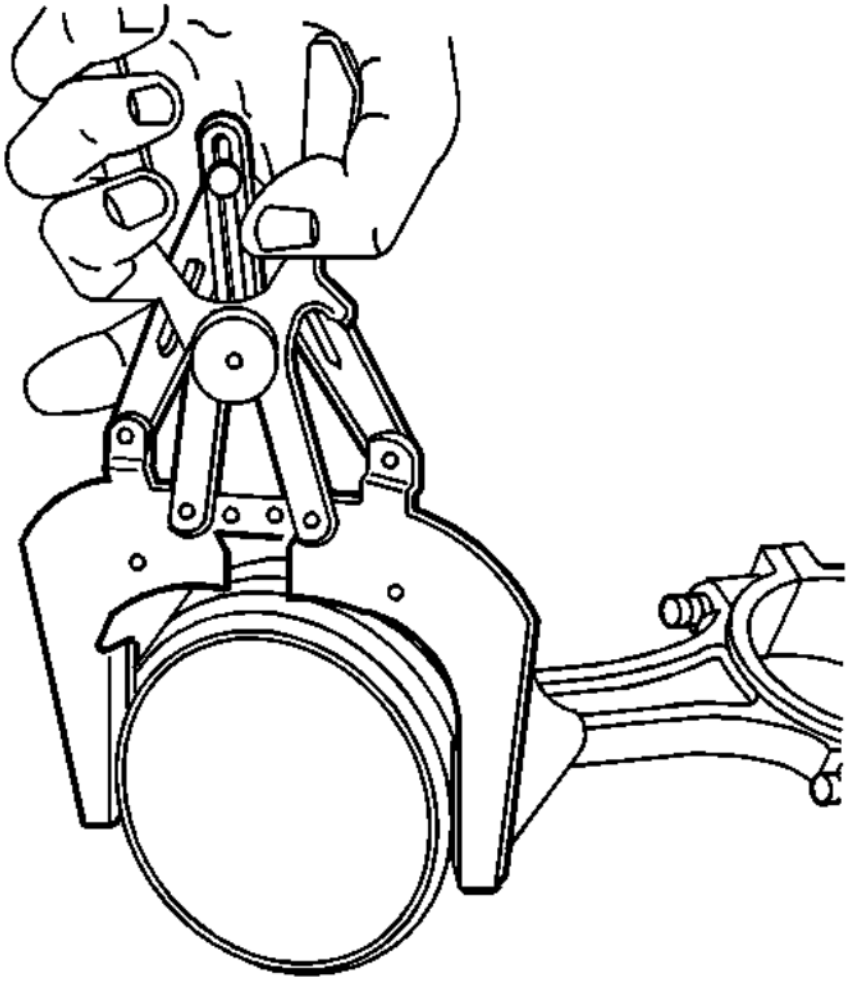

Fig. 369: Cleaning Piston Ring Grooves
Courtesy of GENERAL MOTORS COMPANY

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

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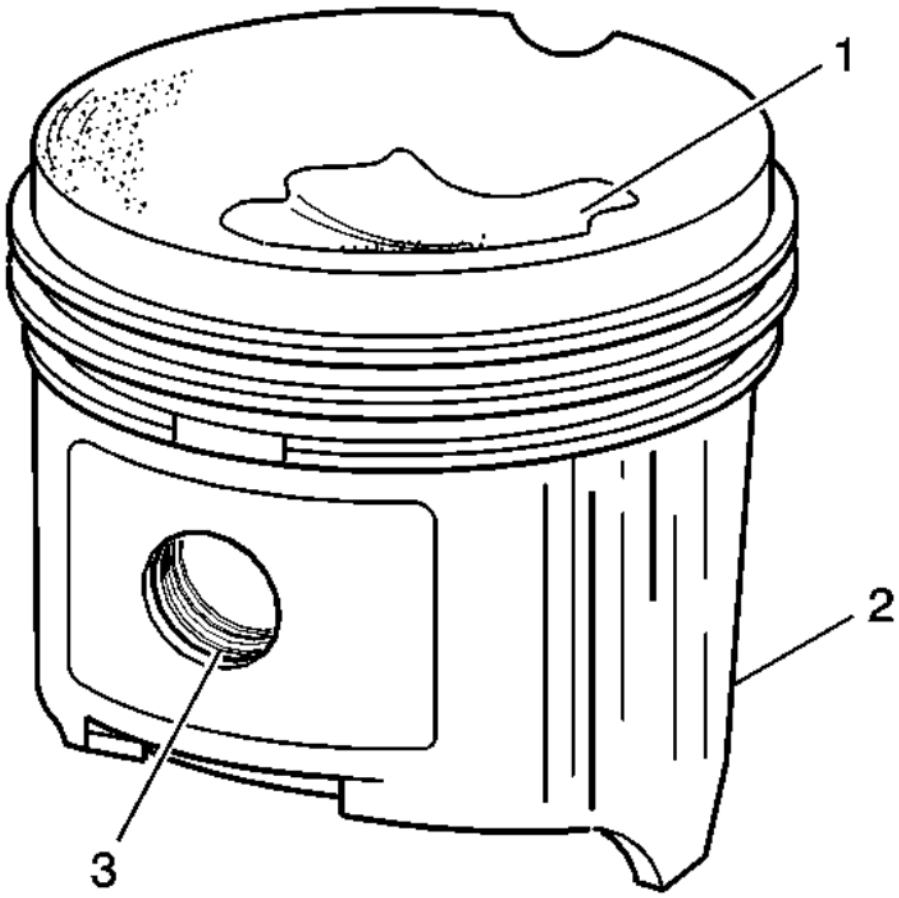

Fig. 370: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

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.

    - Eroded areas at the top of the piston (1)
    - Scuffed or damaged skirts (2)
    - Scoring to the piston pin bore (3) or piston pin

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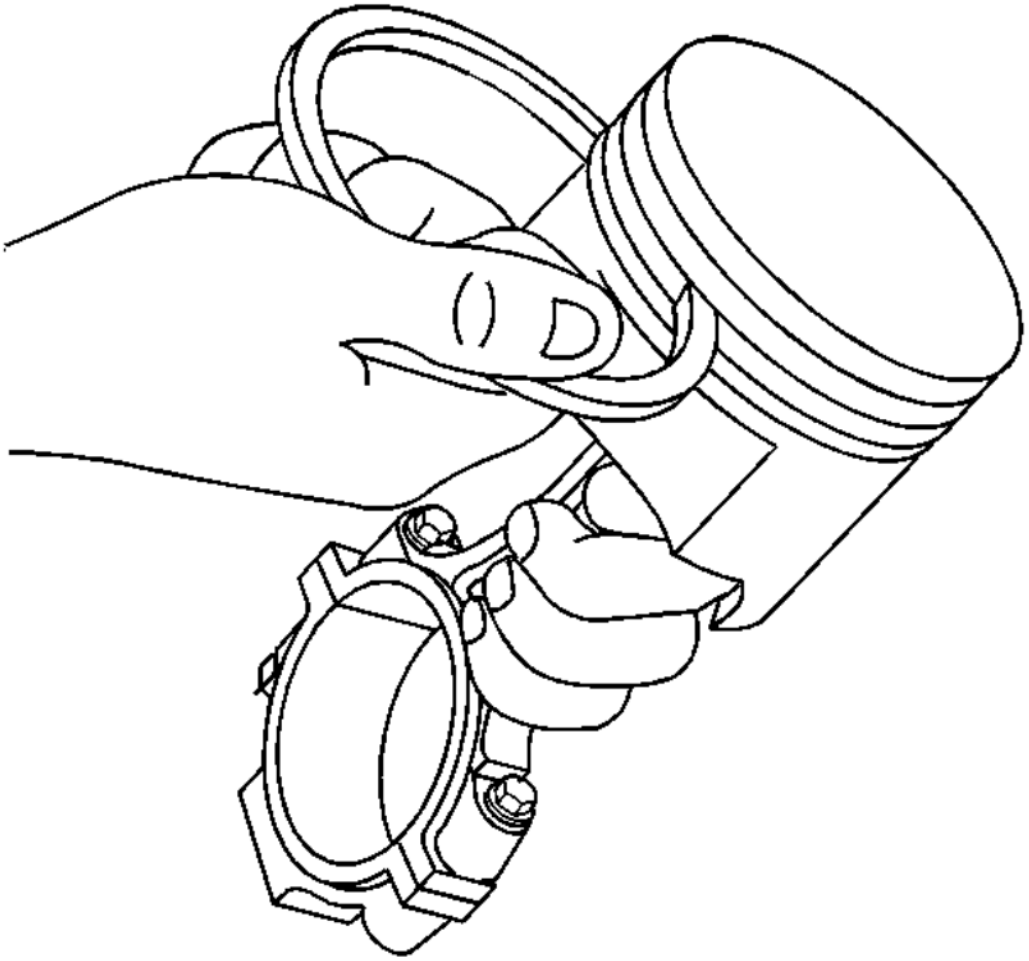

Fig. 371: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS COMPANY

6. Insert the edge of the piston ring into the piston ring groove.

   Roll the piston ring completely around the piston. If binding is caused by a 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.

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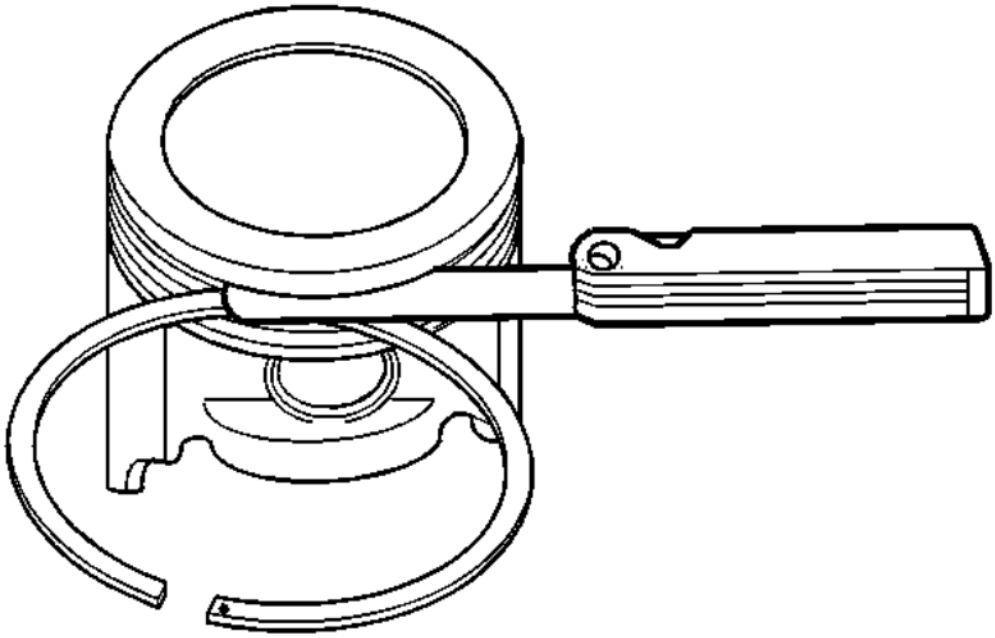

Fig. 372: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

7. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston and pin as an assembly. Refer to **Engine Mechanical Specifications**.

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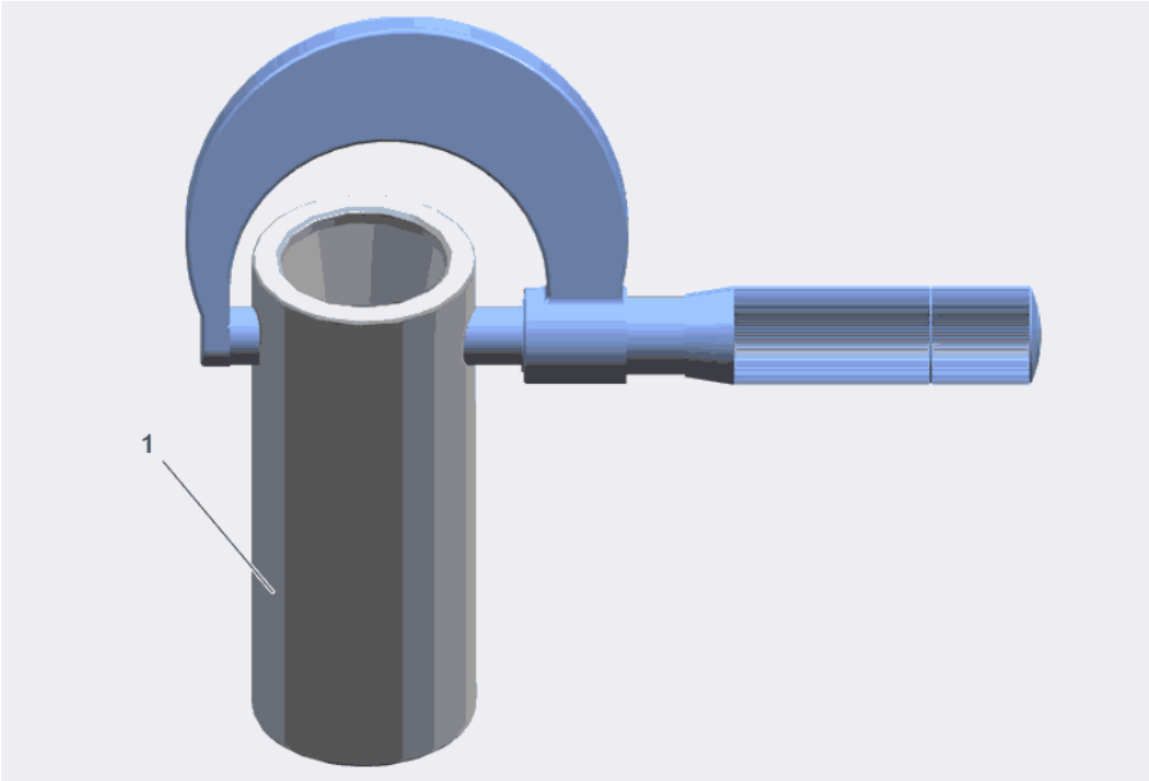

Fig. 373: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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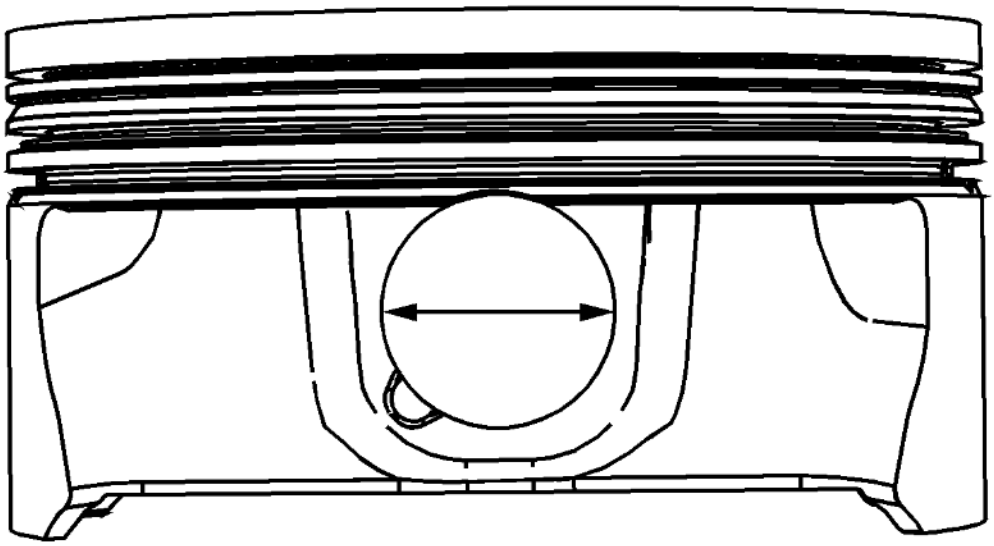

Fig. 374: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS COMPANY

9. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
10. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications**.

Measuring Piston Ring End Gap

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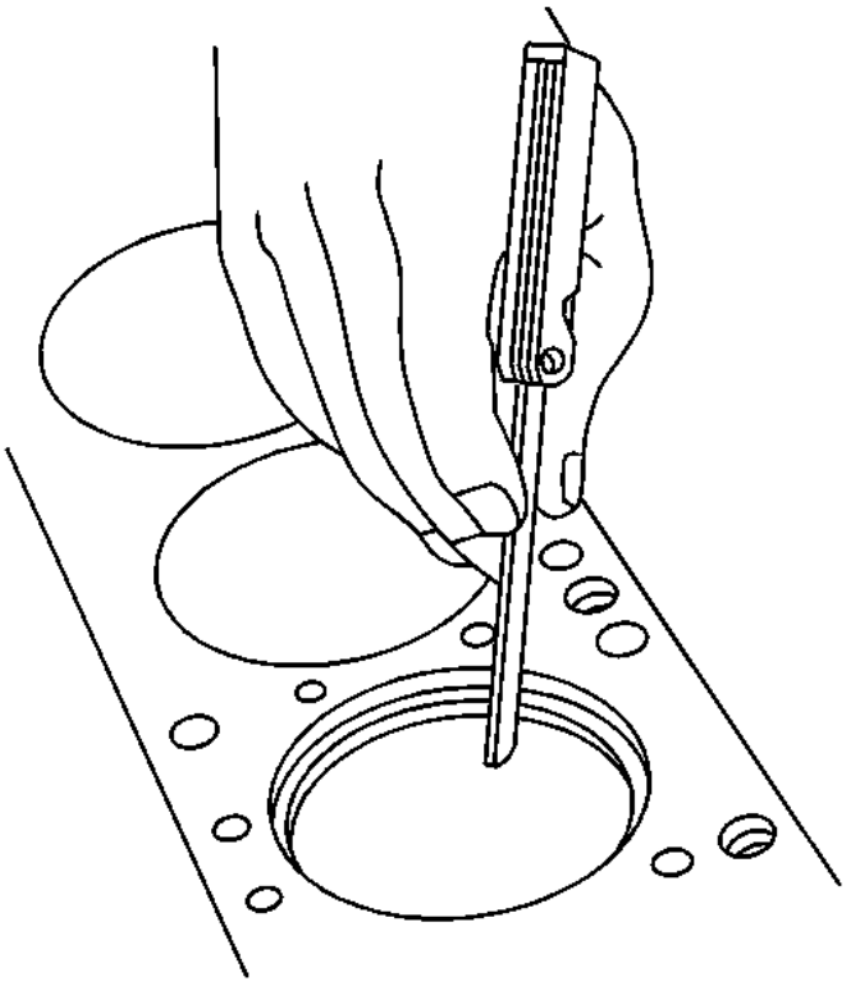

Fig. 375: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area. Both rings should be installed with the orientation marks facing the top of the piston.
2. Insert a feeler gauge and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings

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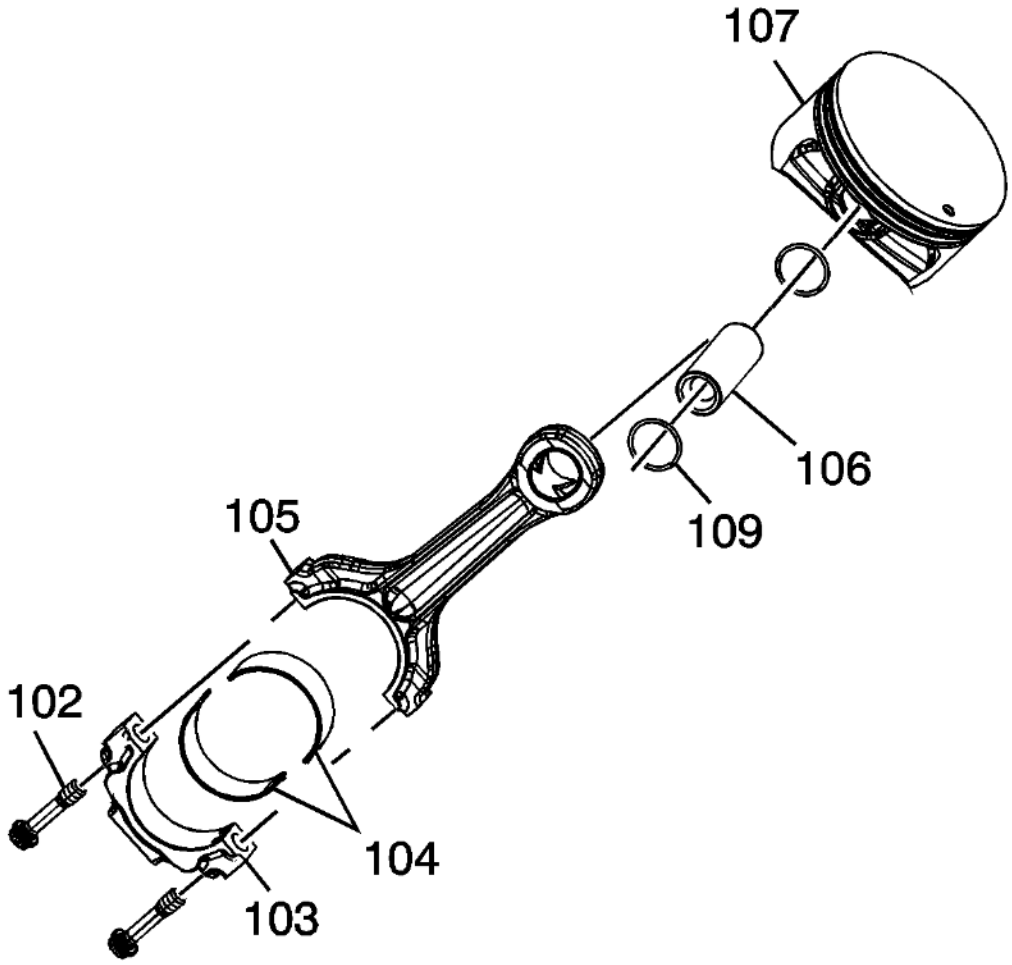

Fig. 376: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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 rod and cap 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.

WARNING: Refer to Safety Glasses Warning .

2. Dry the components with compressed air.

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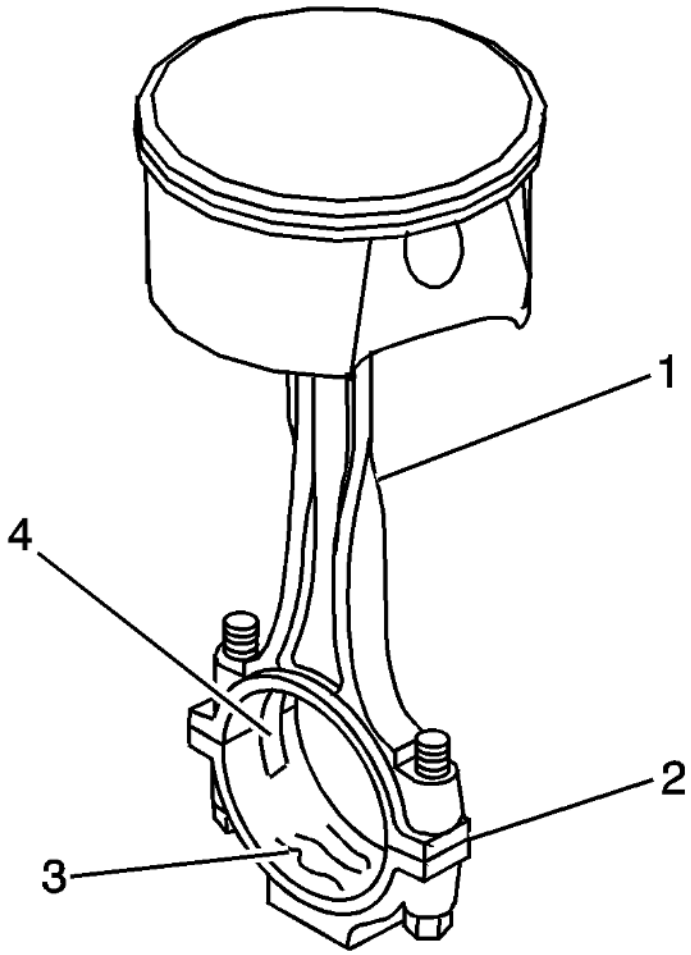

Fig. 377: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

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)

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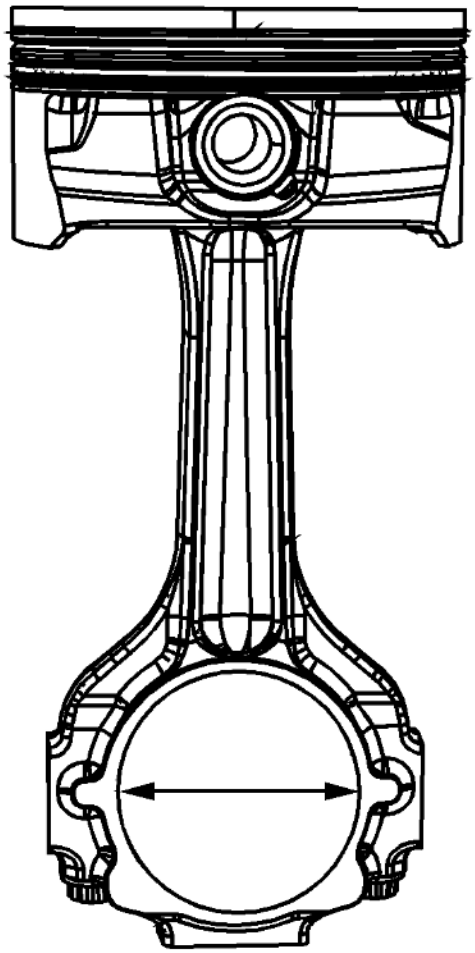

Fig. 378: Identifying Connecting Rod Bearing Bore
Courtesy of GENERAL MOTORS COMPANY

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

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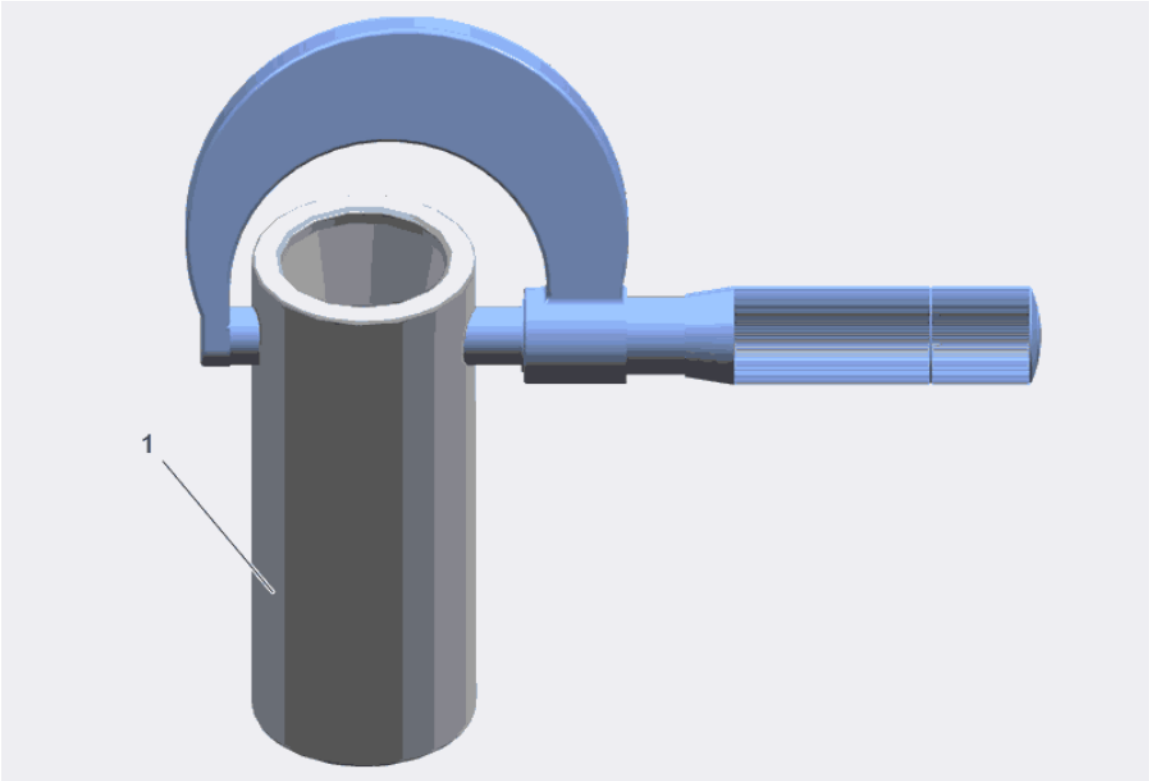

Fig. 379: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

5. To determine piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin OD.

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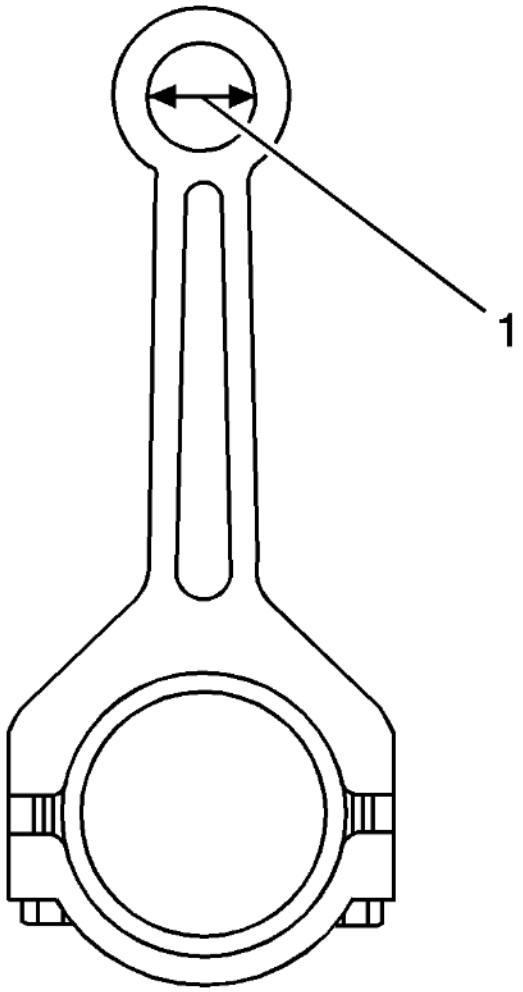

Fig. 380: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS COMPANY

6. To determine the piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) 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**.

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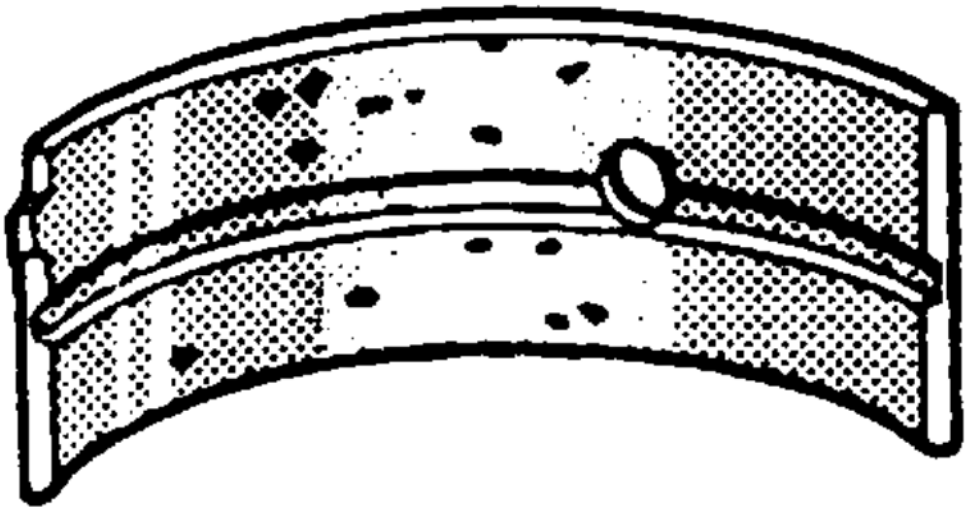

Fig. 381: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

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

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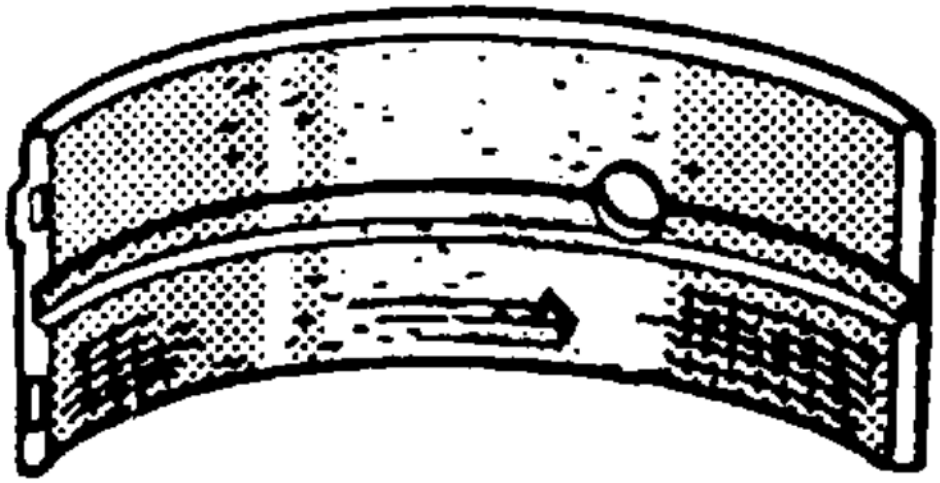

Fig. 382: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

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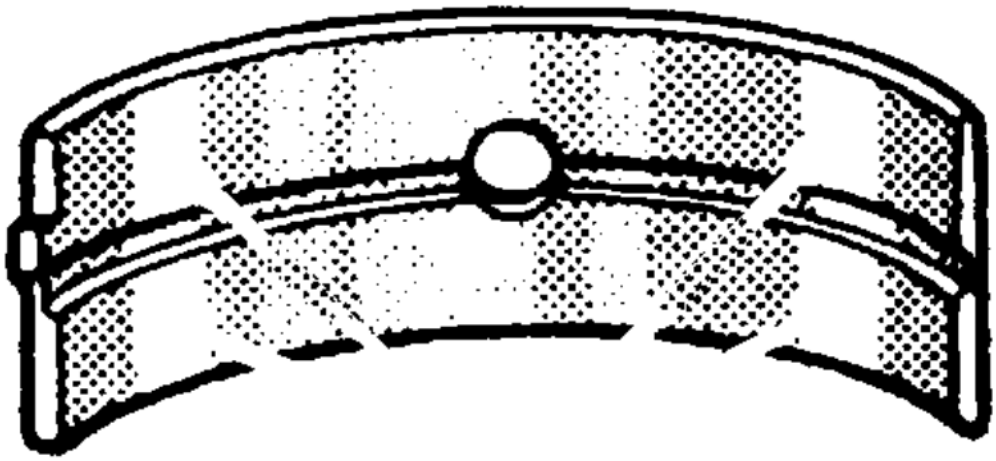

Fig. 383: View Of Crankshaft Bearing Improper Seating
Courtesy of GENERAL MOTORS COMPANY

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.
12. Measure the connecting rod bearings for excessive connecting rod bearing-to-crankshaft journal clearance. Refer to **Crankshaft and Bearing Cleaning and Inspection**.

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to **Special Tools**.

1. Lubricate the piston pin bores in the piston, the piston pin, and the connecting rod pin bore with clean engine oil.

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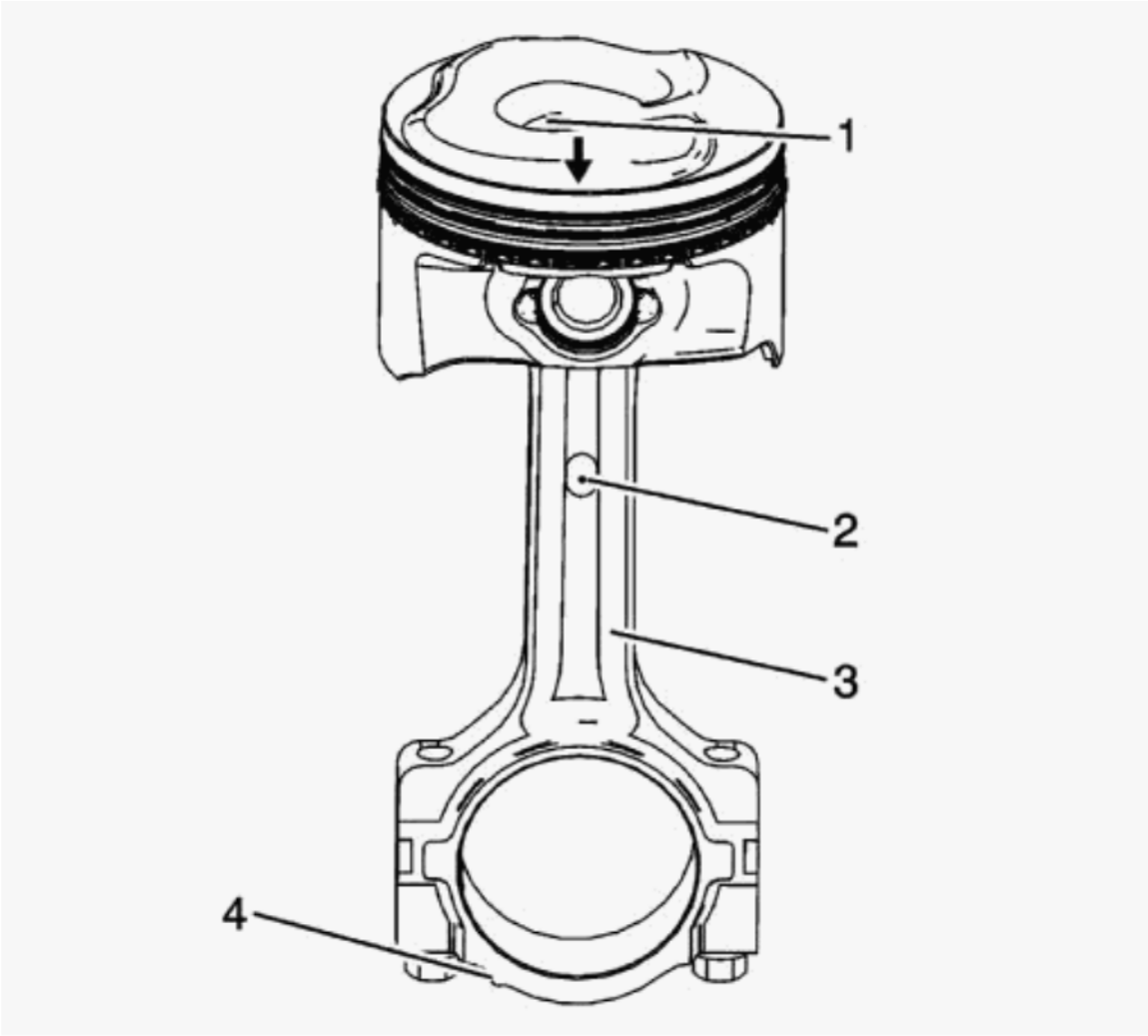

Fig. 384: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The left side and right side piston and rod assemblies are assembled differently.**

2. Ensure that on the right side piston and rod assemblies, the arrow on the top of the piston (1) and the dimple on the rod (2) are facing the same direction.

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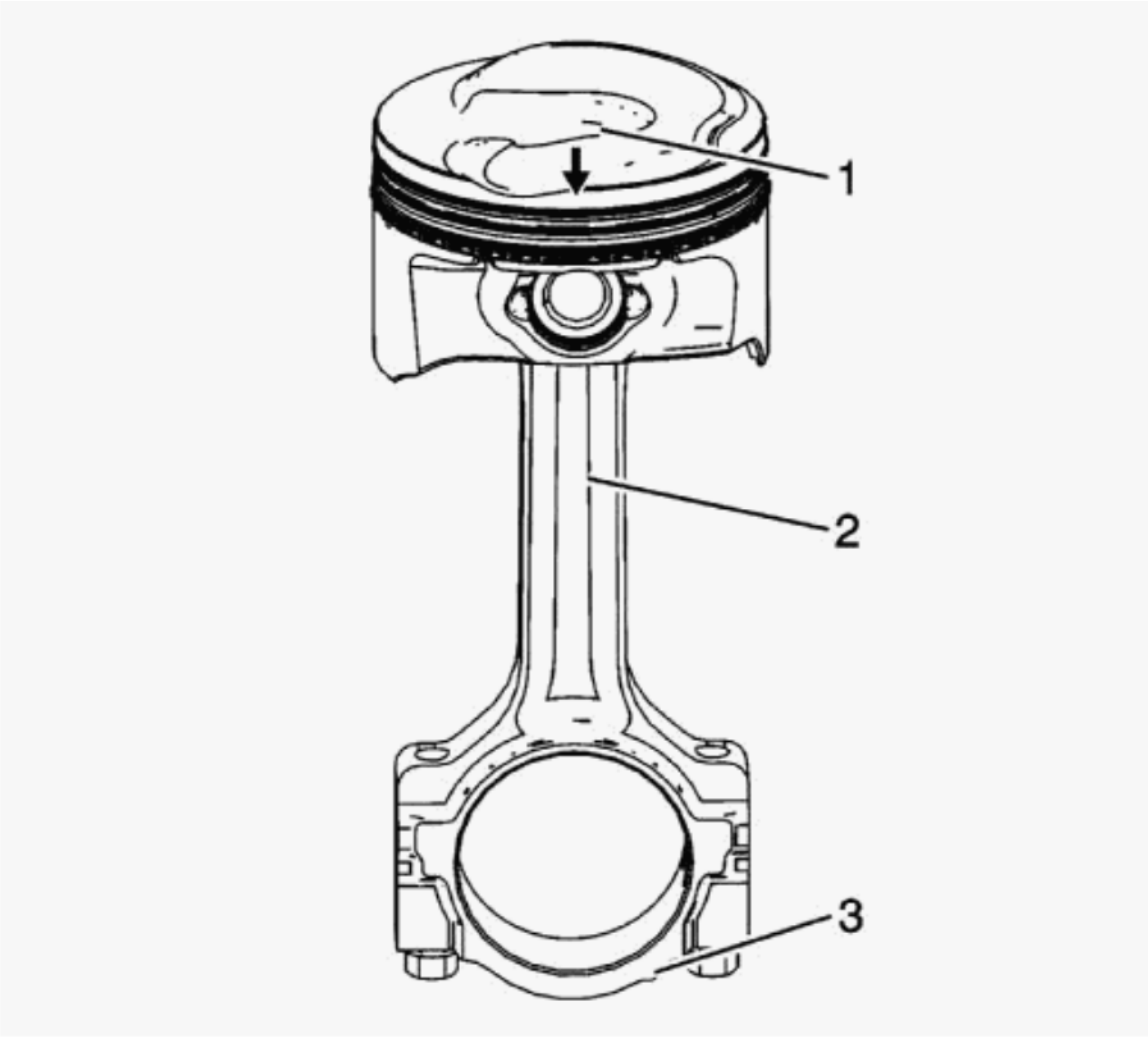

Fig. 385: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

3. Ensure that on the left side piston and rod assemblies, the arrow on the top of the piston (1) and the dimple on the rod (2) are facing the opposite direction.

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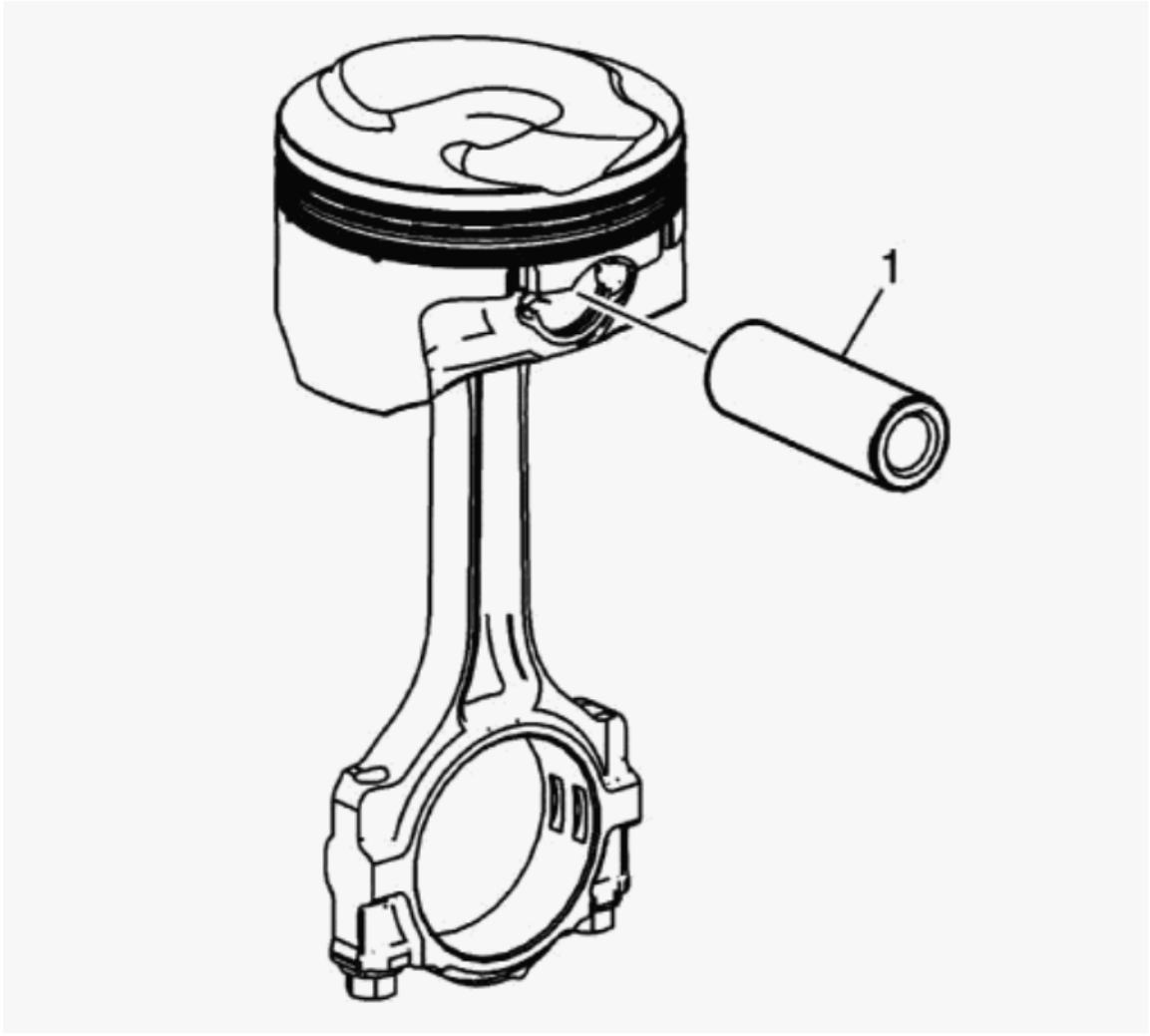

Fig. 386: Piston Pin
Courtesy of GENERAL MOTORS COMPANY

4. Install the piston pin (1) to the piston and connecting rod.

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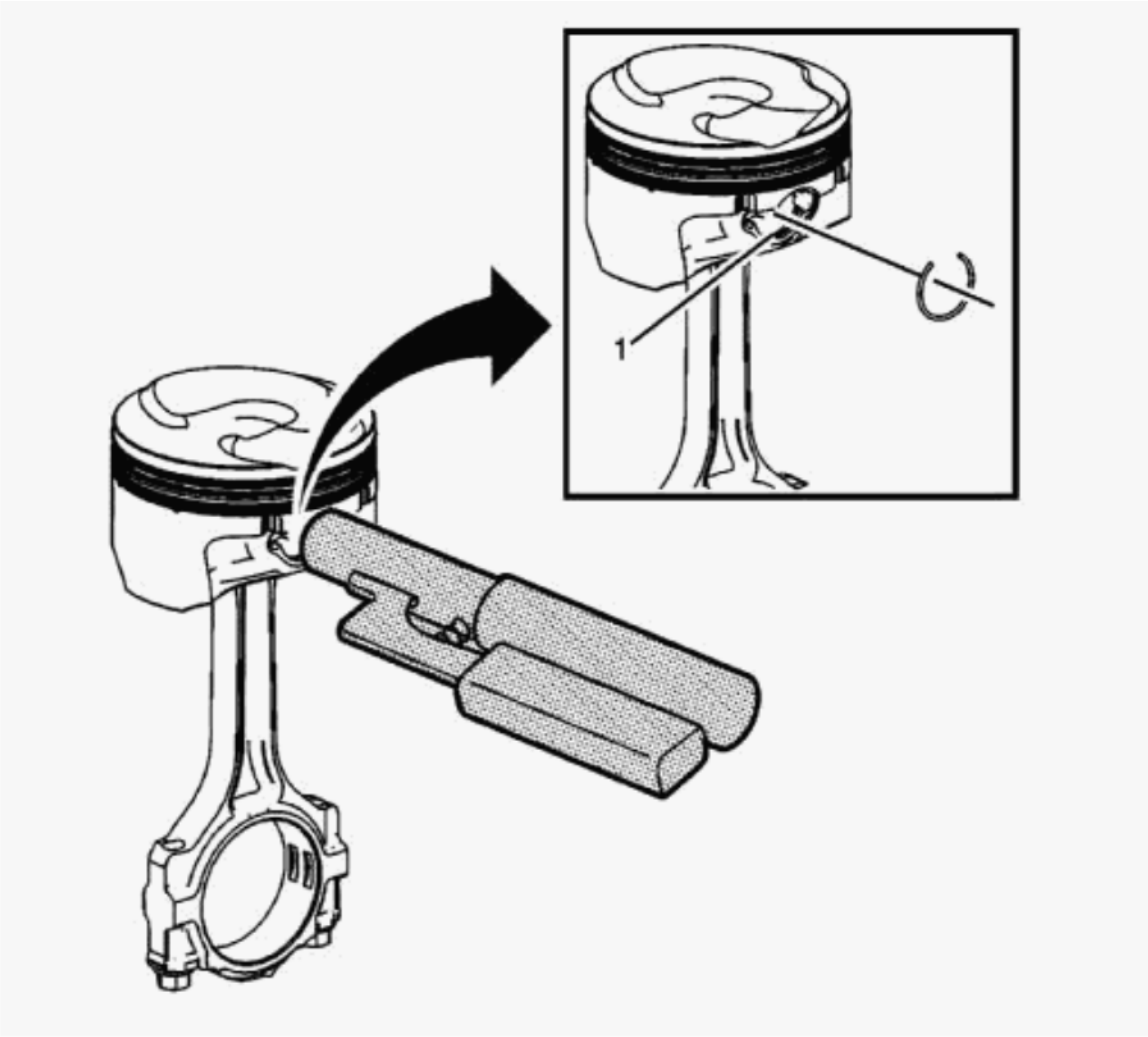

Fig. 387: NEW Piston Pin Retainers Using EN-46745 Remover/Installer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **NEW piston pin retainers must be used. Never reuse the piston pin retainers.**

5. Install NEW piston pin retainers using the **EN-46745** remover/installer. Align the **EN-46745** remover/installer to one of the notches (1) in the piston.

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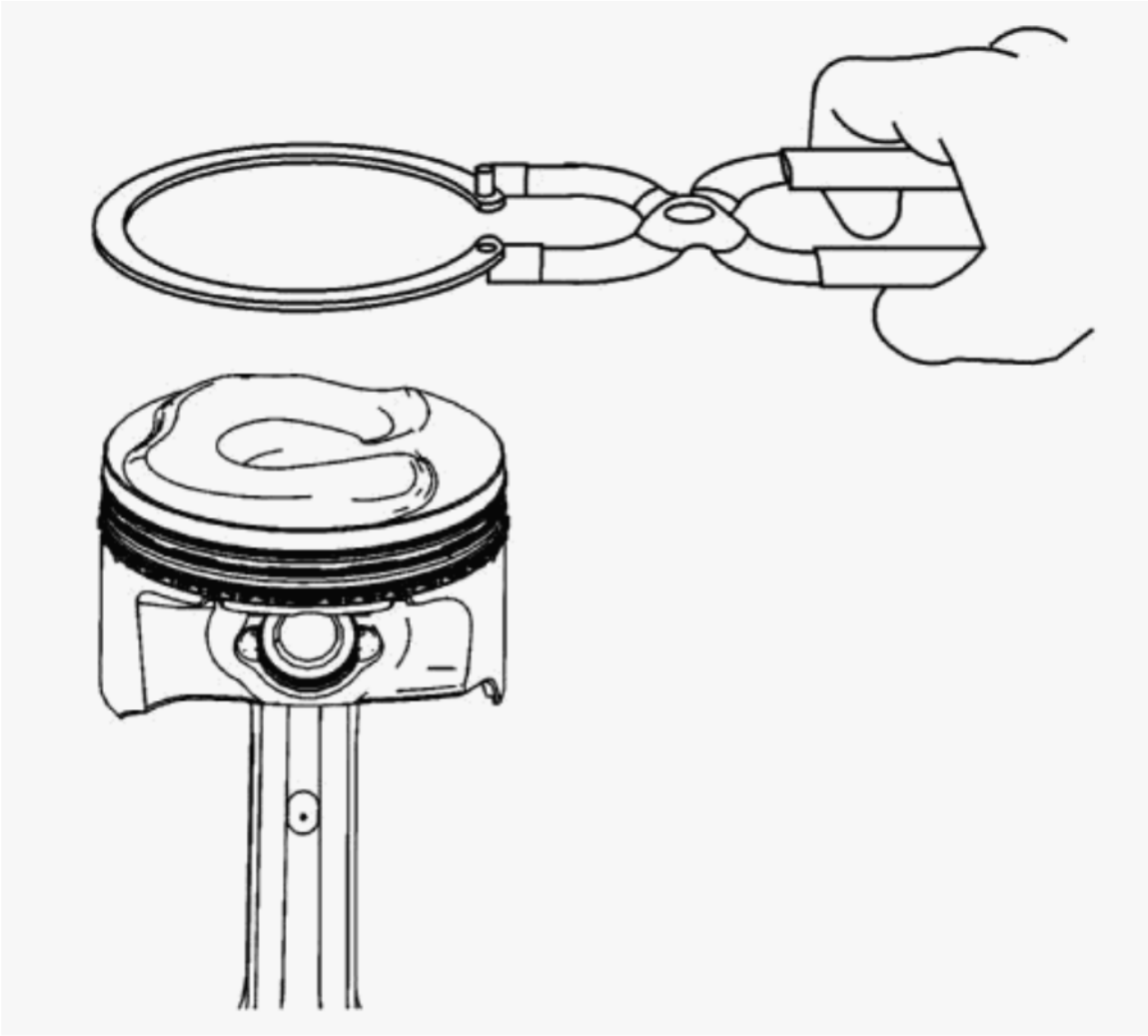

Fig. 388: Removing Piston Rings From Piston Using Piston Ring Pliers
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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.**

6. Using piston ring pliers, install the piston rings onto the piston.
7. Position the oil control ring end gaps 180 degrees opposite each other.
8. Position the compression ring end gaps 180 degrees opposite each other.

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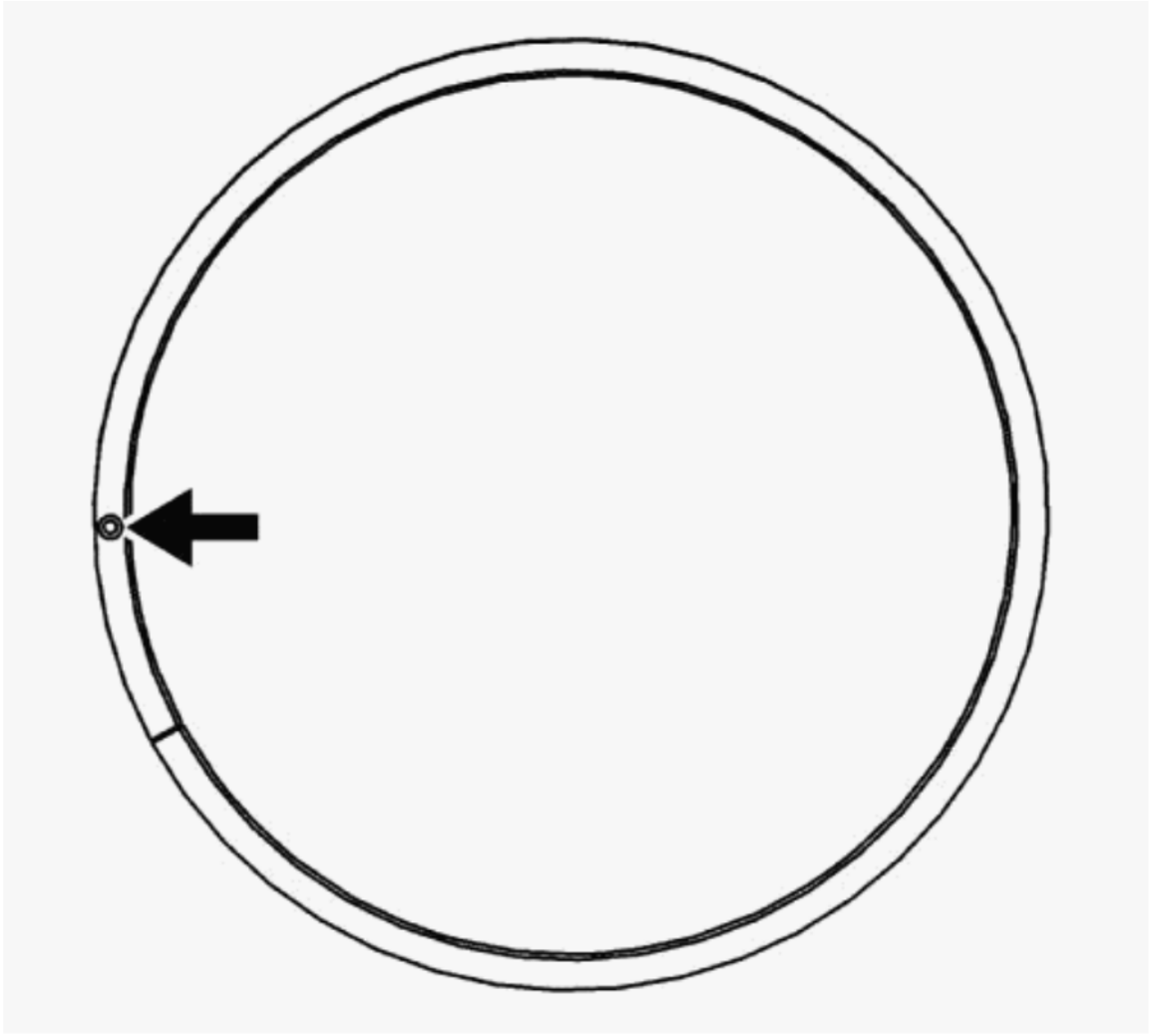

Fig. 389: Positioning Compression Ring End Gaps 180 Degrees Opposite Each Other
Courtesy of GENERAL MOTORS COMPANY

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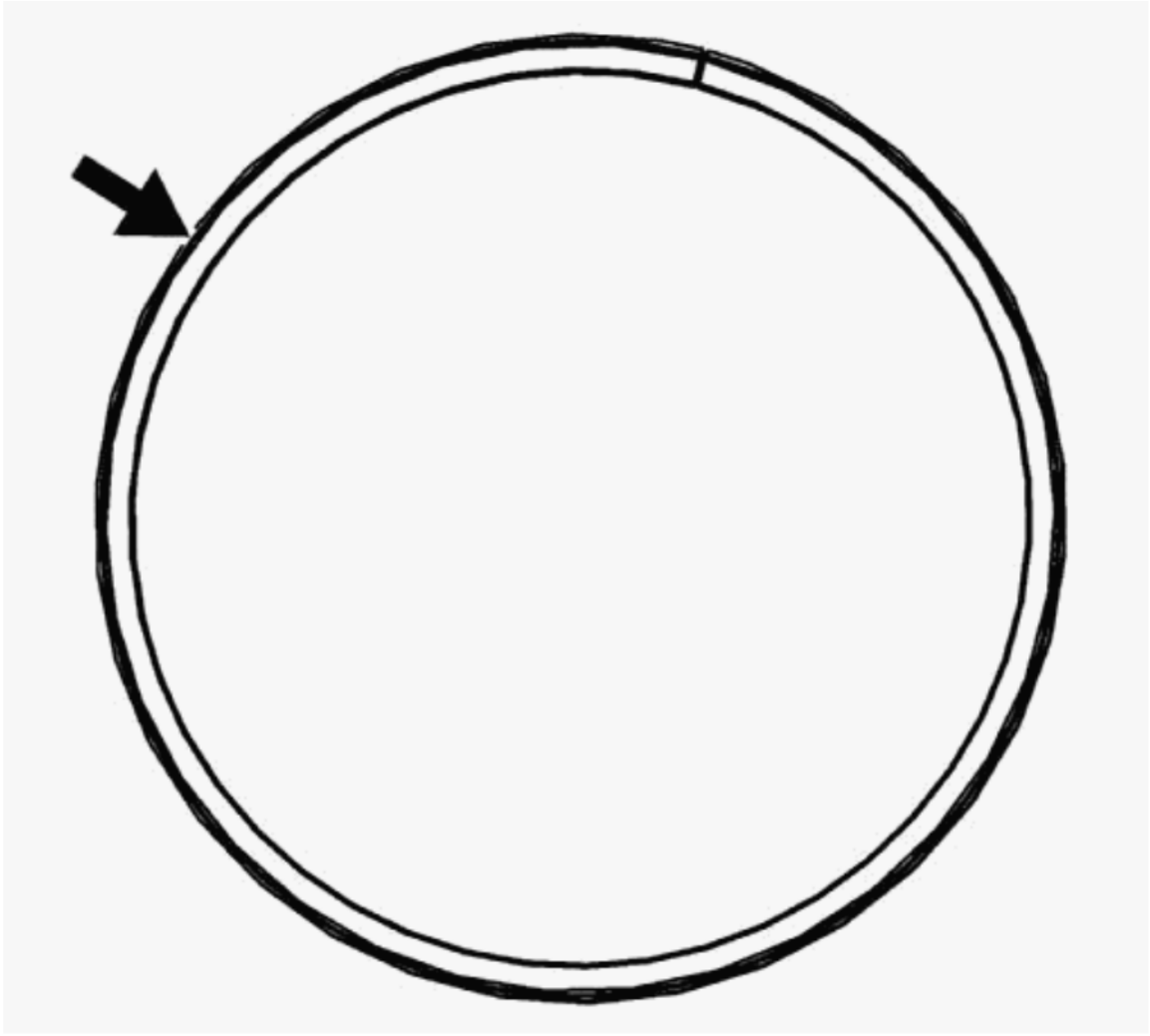

Fig. 390: Positioning Compression Ring End Gaps 180 Degrees Opposite Each Other
Courtesy of GENERAL MOTORS COMPANY

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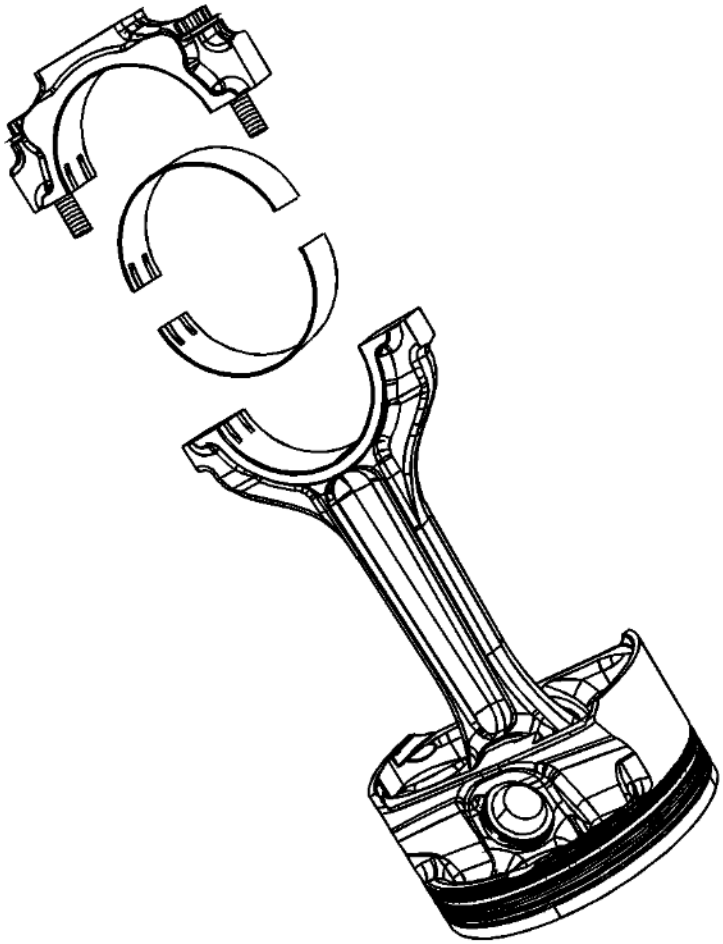

Fig. 391: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS COMPANY

9. The upper compression ring has a dimple on the top of the ring. The dimple on upper compression ring should face the top of the piston.

   The lower compression ring has a groove on the bottom of the ring. The groove on the lower compression ring should face the bottom of the piston.

   Install the connecting rod bearings to the rod and cap.

CAMSHAFT BEARING REMOVAL

Special Tools

J 33049 Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**.

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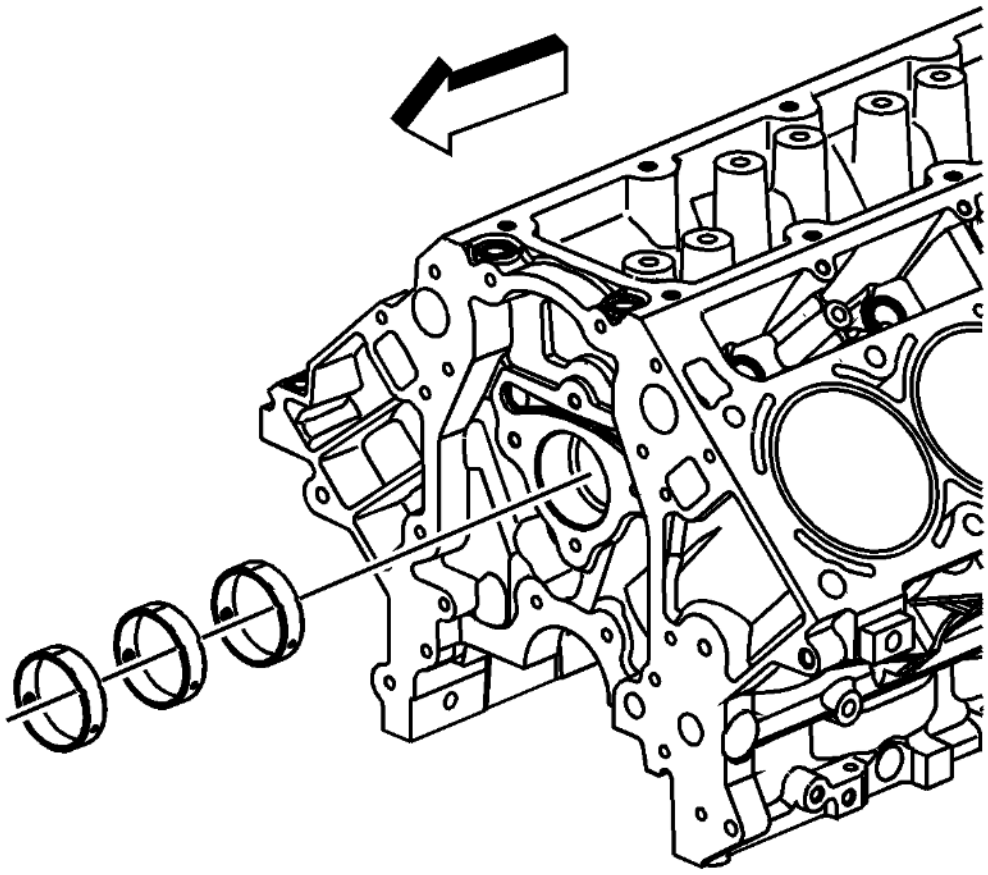

Fig. 392: Camshaft Bearings
Courtesy of GENERAL MOTORS COMPANY

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.

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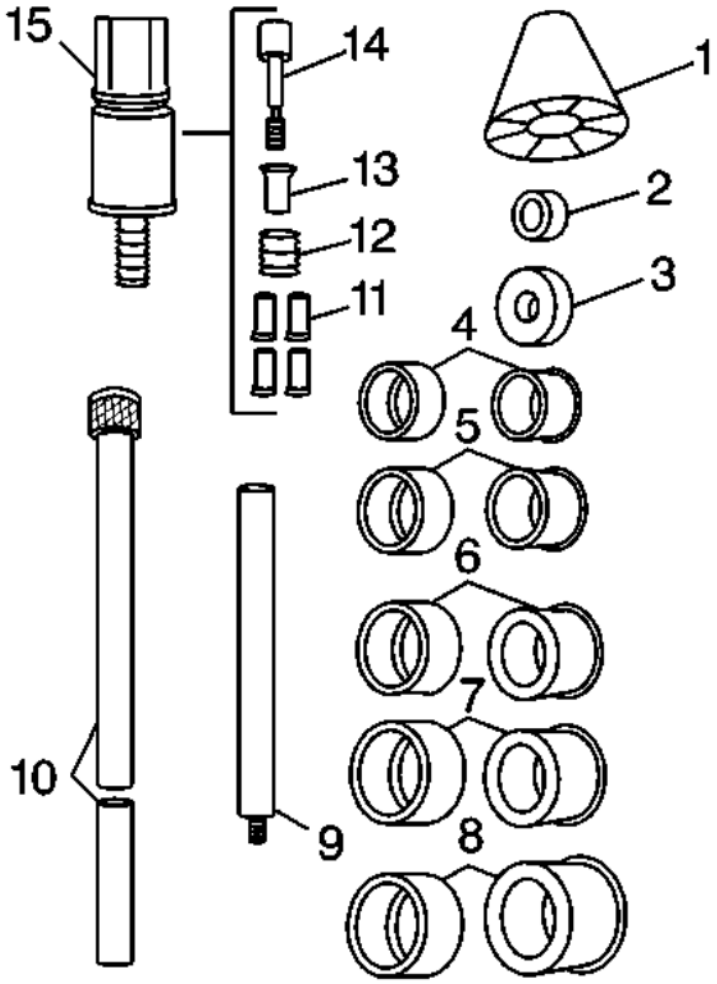

Fig. 393: Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS COMPANY

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** service set.
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 in order to align the tool.

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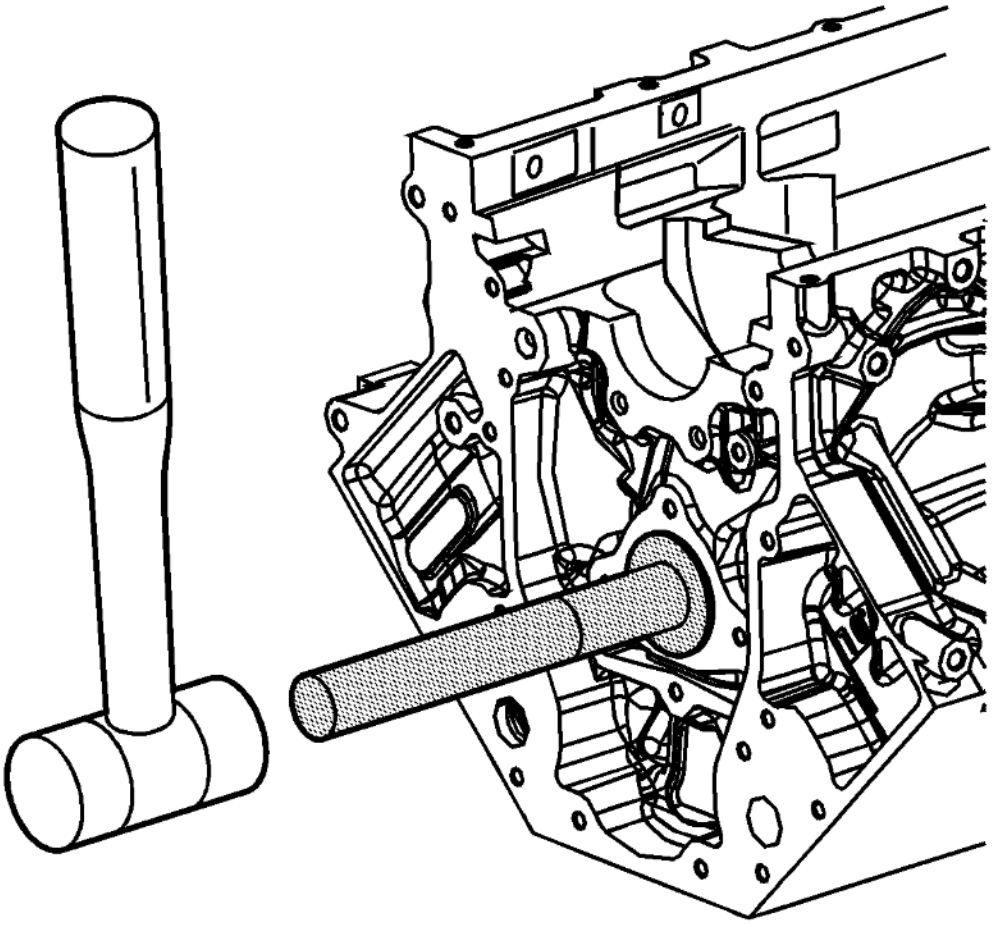

Fig. 394: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

8. Drive the bearing from the block bore.

IMPORTANT: In order to remove the inner camshaft bearings, operate the tool from either end of the block, using the driver bar extension and the guide cone in the front or rear camshaft bearing bore.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

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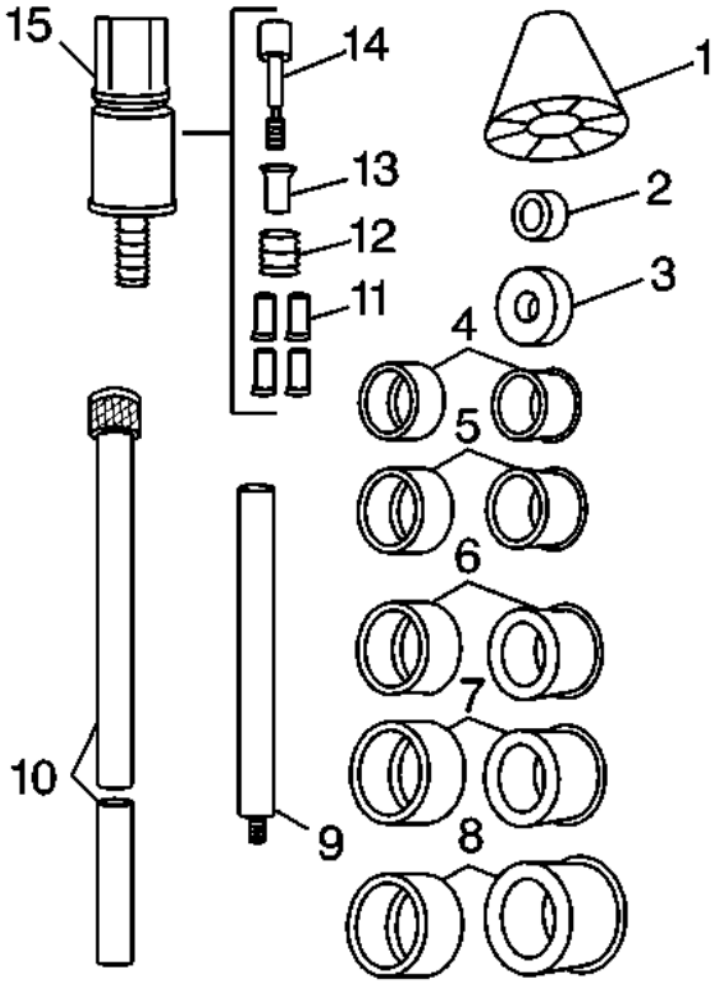

Fig. 395: Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS COMPANY

- 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).

NOTE: **The expander bearing drivers (4-8) in the J 33049 service set are stamped with a number (1-5) to assist in identifying the appropriate diameter driver.**

- Expander assembly (15) is used as a driver for the bearing when inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the small washer.
- Expander bearing driver number 1 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with the expander assembly (15) and the small washer.
- Expander bearing driver number 2 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 3 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 4 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with expander assembly (15) and the large washer.
- Expander bearing driver number 5 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with

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expander assembly (15) and the large washer.

Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

IMPORTANT: To install or remove the expanding driver, always push on or pull from the ends. Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Ensure the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. With the small end of the cone facing the driver assembly, place the guide cone over the driving bar.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

For removal of the inner bearings, it may be necessary to install the driver bar extension.

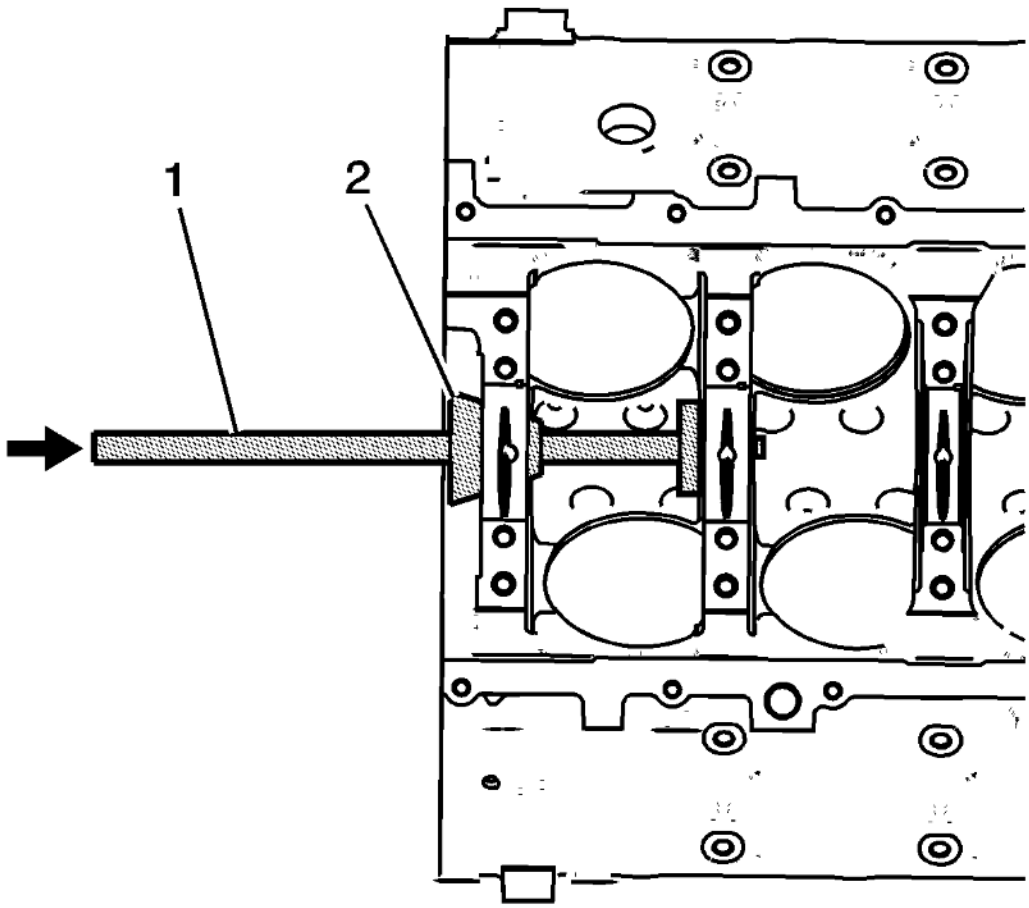

Fig. 396: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

7. Insert the tool (1) into an inner camshaft bearing and tighten until snug.

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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 (2) 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.

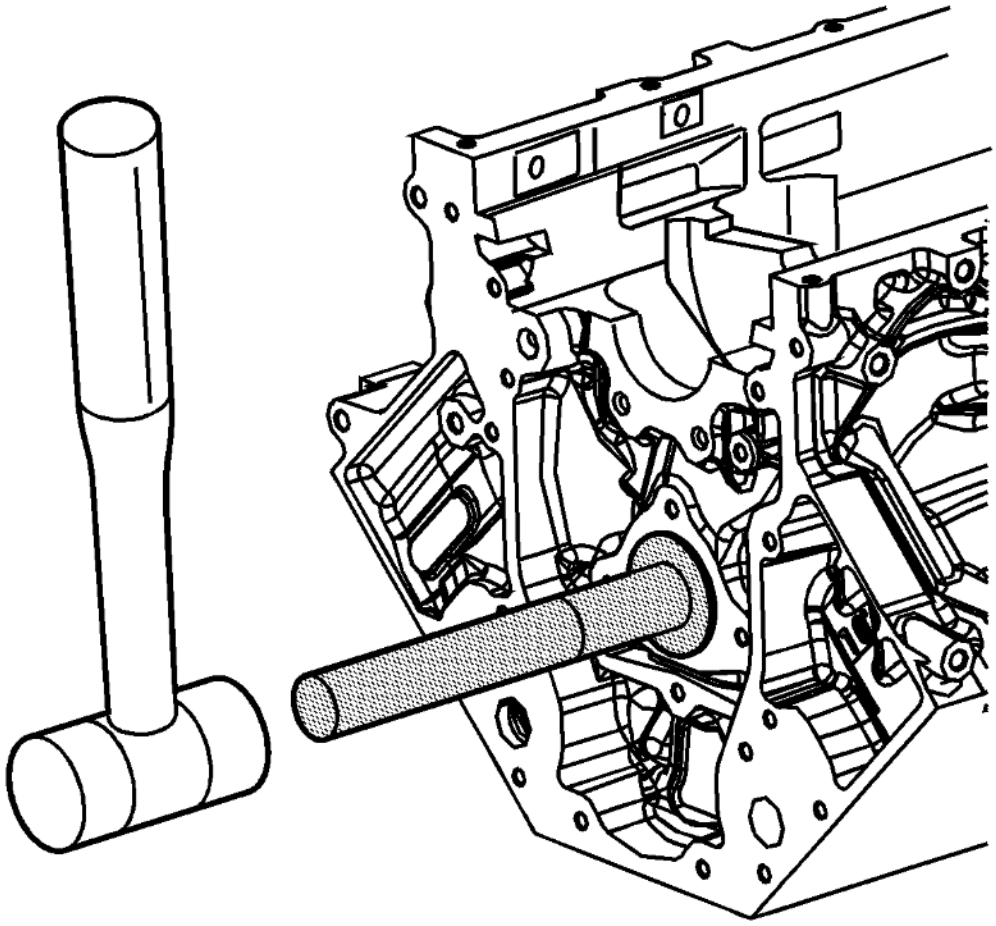

Fig. 397: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

11. For the end bearings, front, position number 1, and the rear, position number 5, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

CAMSHAFT AND BEARINGS CLEANING AND INSPECTION

Special Tools

- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Camshaft Lobe Lift Indicator

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For equivalent regional tools, refer to **Special Tools**

Measuring Camshaft Lobe Lift

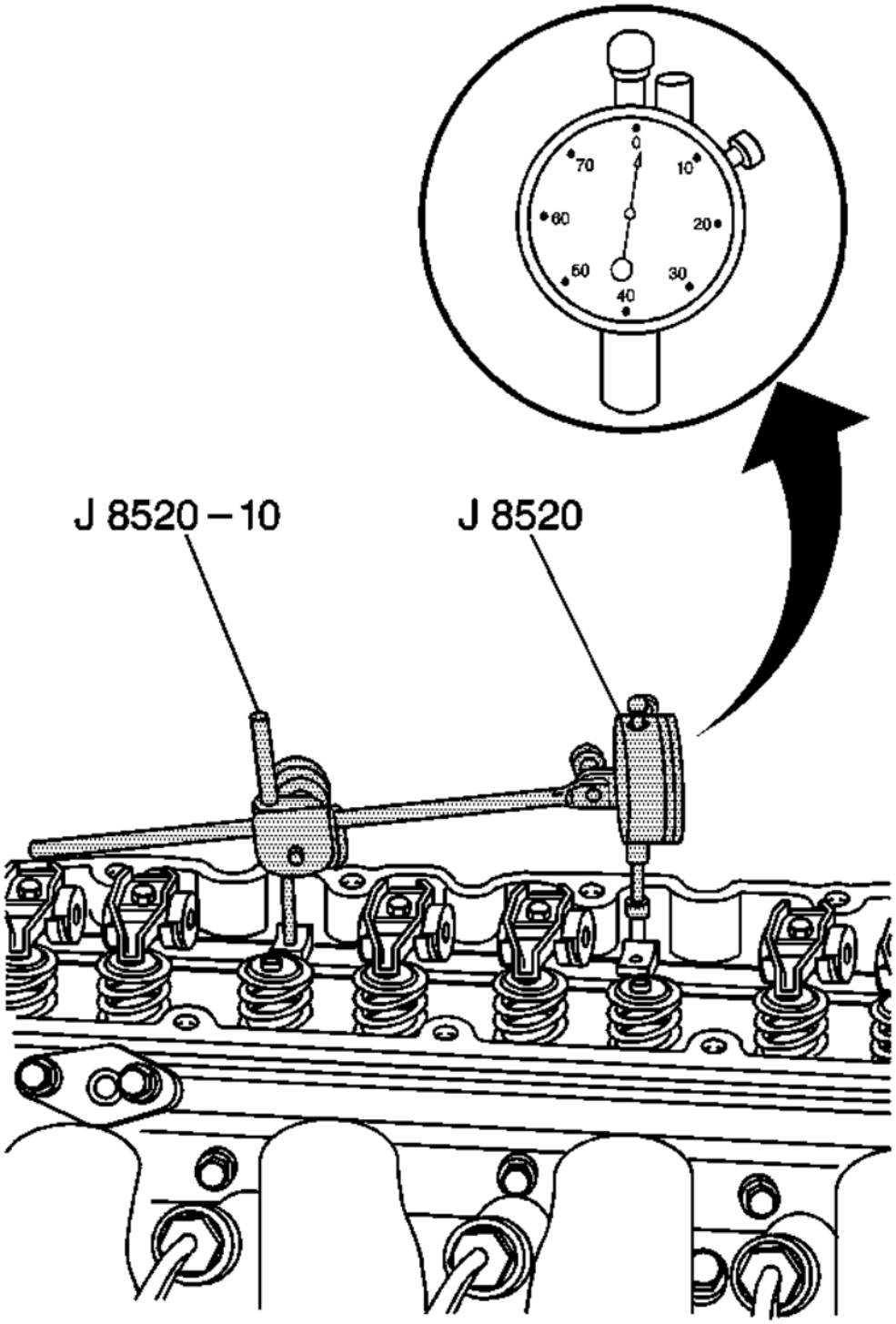

Fig. 398: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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.**

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1. Using the **J 8520** indicator , measure camshaft lobe lift.
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** indicator 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**. The total lobe lift is the difference between the highest and lowest reading.

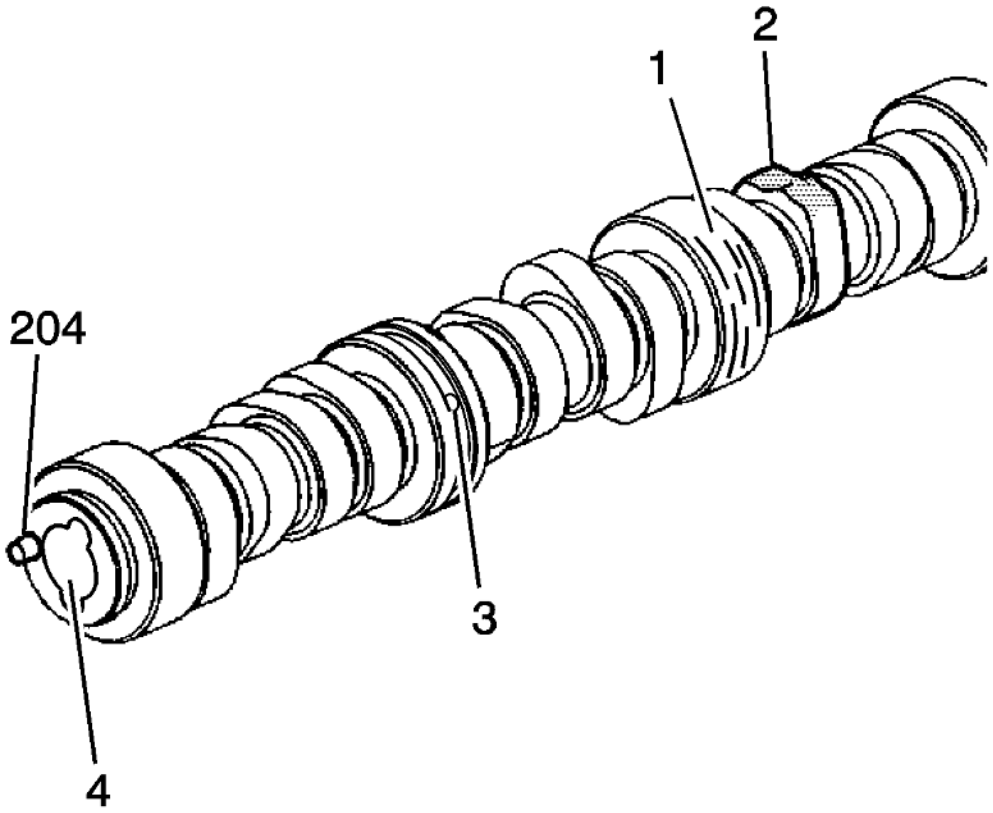

Fig. 399: View Of Camshaft Inspection Points
Courtesy of GENERAL MOTORS COMPANY

1. Clean the components in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning

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.

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5. Inspect the camshaft position (CMP) actuator oil passages (3) for restrictions.
6. Inspect the threaded bolt hole (4) in the front of the camshaft for damaged threads or debris.
7. Inspect the camshaft sprocket pin (204) for damage.
8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

   If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

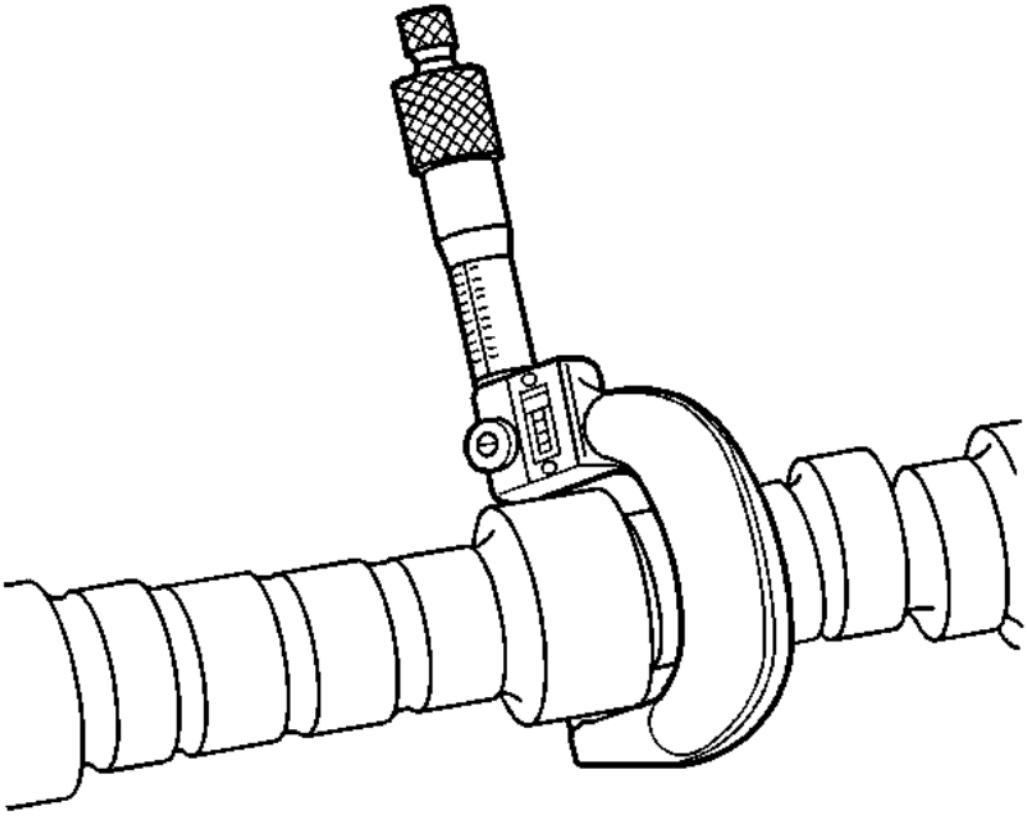

Fig. 400: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS COMPANY

9. Using a micrometer, measure the camshaft journals for wear and out-of-round. Refer to **Engine Mechanical Specifications**.
   - If the camshaft bearing journals are out-of-round, replace the camshaft.
   - If the camshaft bearing journal diameter is not within specification, replace the camshaft.

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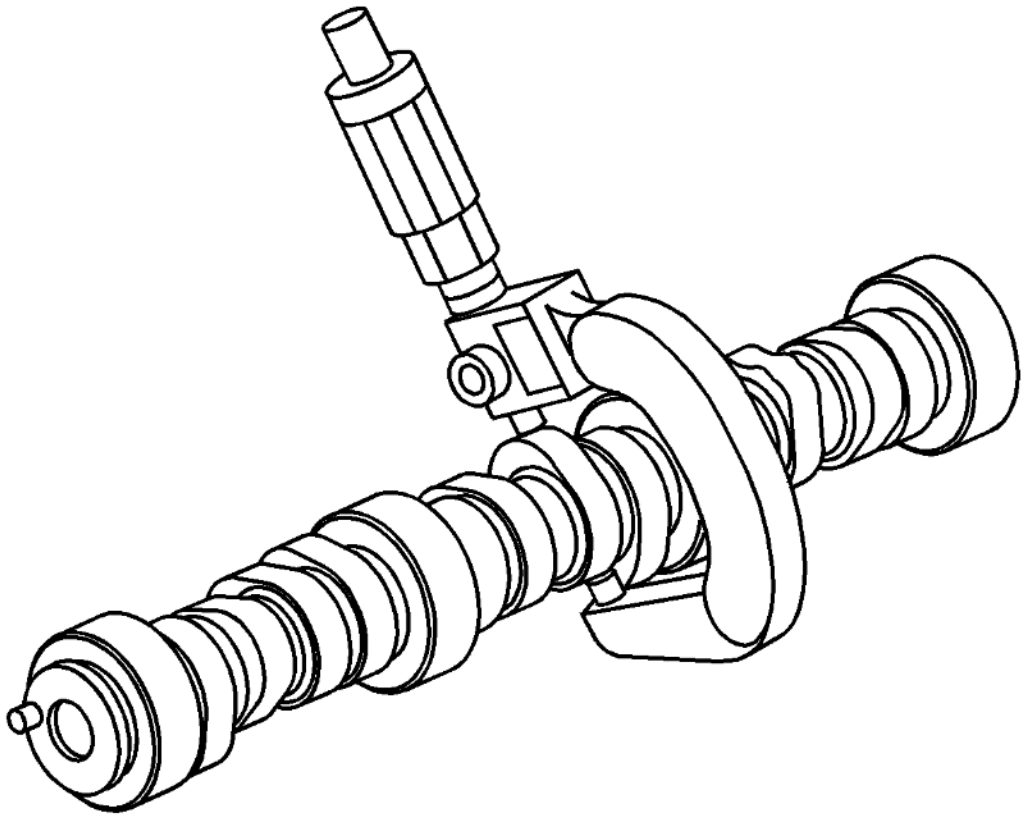

Fig. 401: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS COMPANY

10. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

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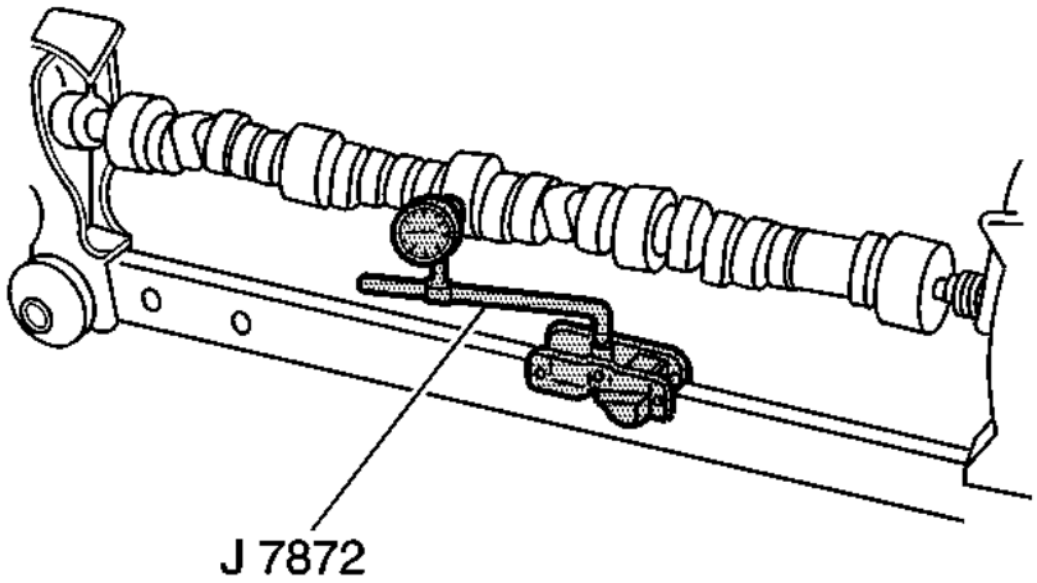

Fig. 402: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS COMPANY

11. Measure the camshaft runout.
    1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
    2. Using the **J 7872** set , measure the runout of the intermediate camshaft bearing journals.
    3. If camshaft runout is not within specification, the camshaft is bent and should be replaced. Refer to **Engine Mechanical Specifications**.

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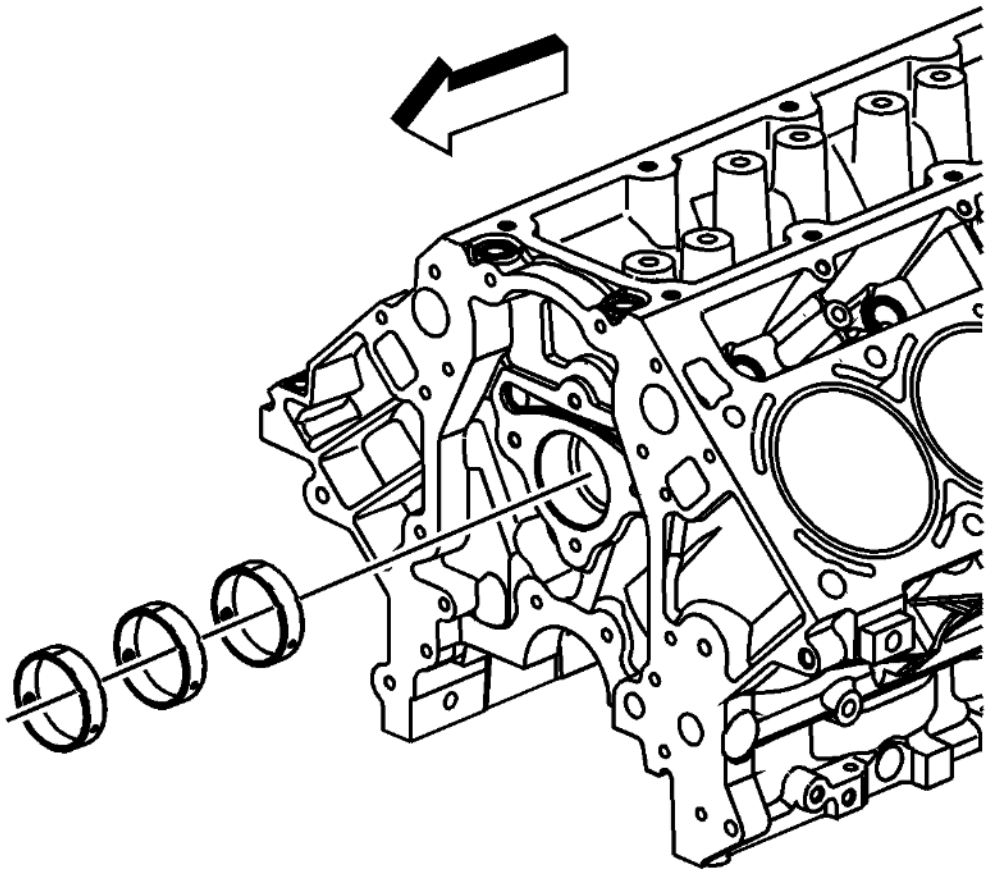

Fig. 403: Camshaft Bearings
Courtesy of GENERAL MOTORS COMPANY

12. Inspect the camshaft bearings for the following:
    - Excessive wear, evidence of galling, pitting, scoring, or embedded debris. The appearance of the bearing material being different shades of gray are considered normal, and are not guideline for bearing replacement. Measure the bearing inside diameter (ID) as required for an over-sized condition. Refer to **Engine Mechanical Specifications**.
    - Proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in the engine block bearing bores.
    - The oil lubrication feed hole in the bearing must be in alignment with the drilled out passage in the block.
    - The oil lubrication feed hole is not plugged by debris.
    - Bearings with excessive wear or scoring must be replaced.
    - Bearings with excessive wear, galling, pitting, scoring, or embedded debris must be replaced.

CAMSHAFT BEARING INSTALLATION

Special Tools

J 33049 Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**

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1. Measure the engine block camshaft bearing bores (1-5) in order to identify the correct OD size bearing for each position. Refer to **Engine Mechanical Specifications**.

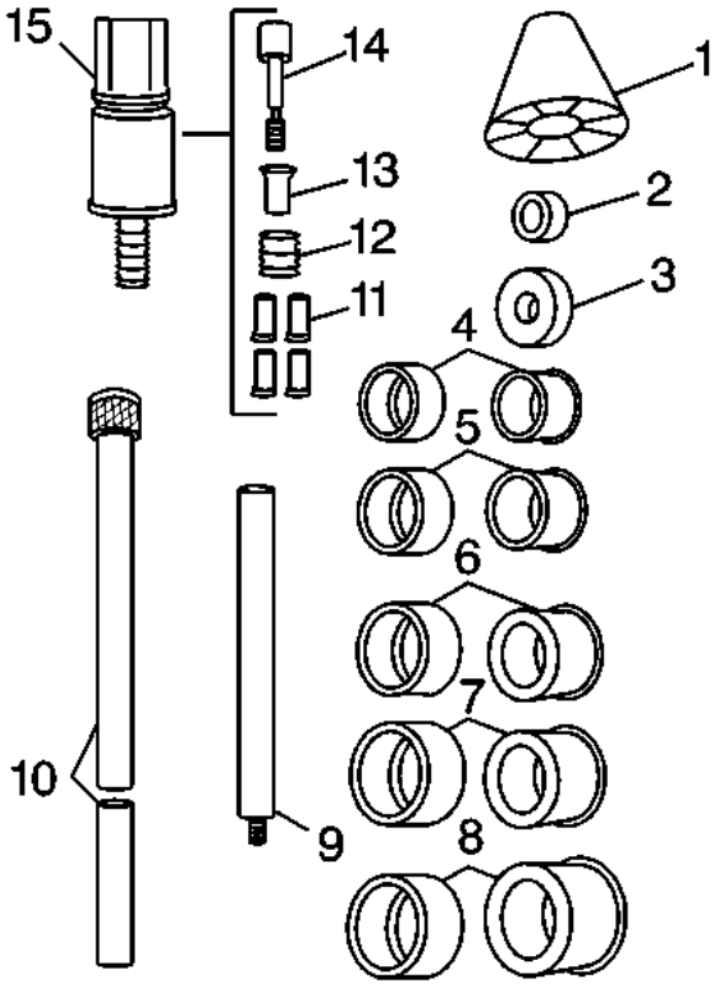

Fig. 404: Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS COMPANY

2. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** set. Refer to **Camshaft Bearing Removal**.
3. Assemble the tool.

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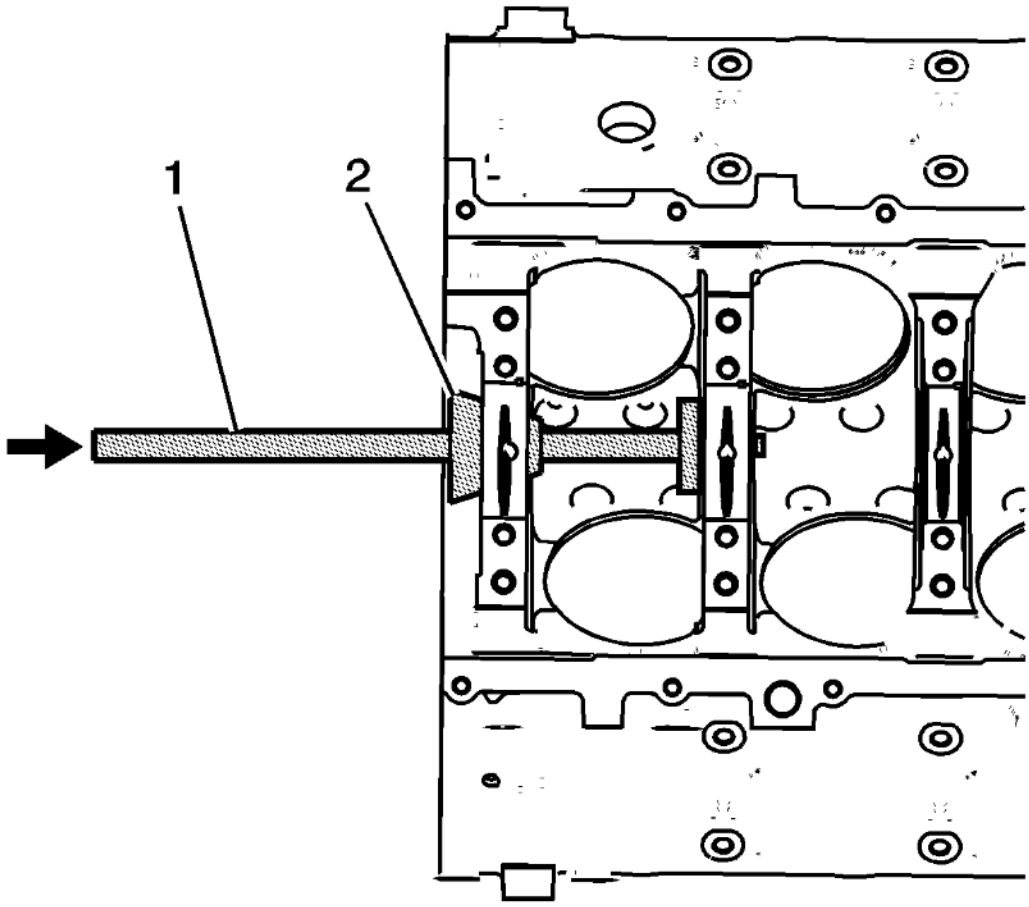

Fig. 405: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

4. Insert the tool (1) through the front or rear of the engine block and into the bearing. For installation of inner bearings, it may be necessary to install the driver bar extension.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone (2) into the front camshaft bearing in order to align the tool.

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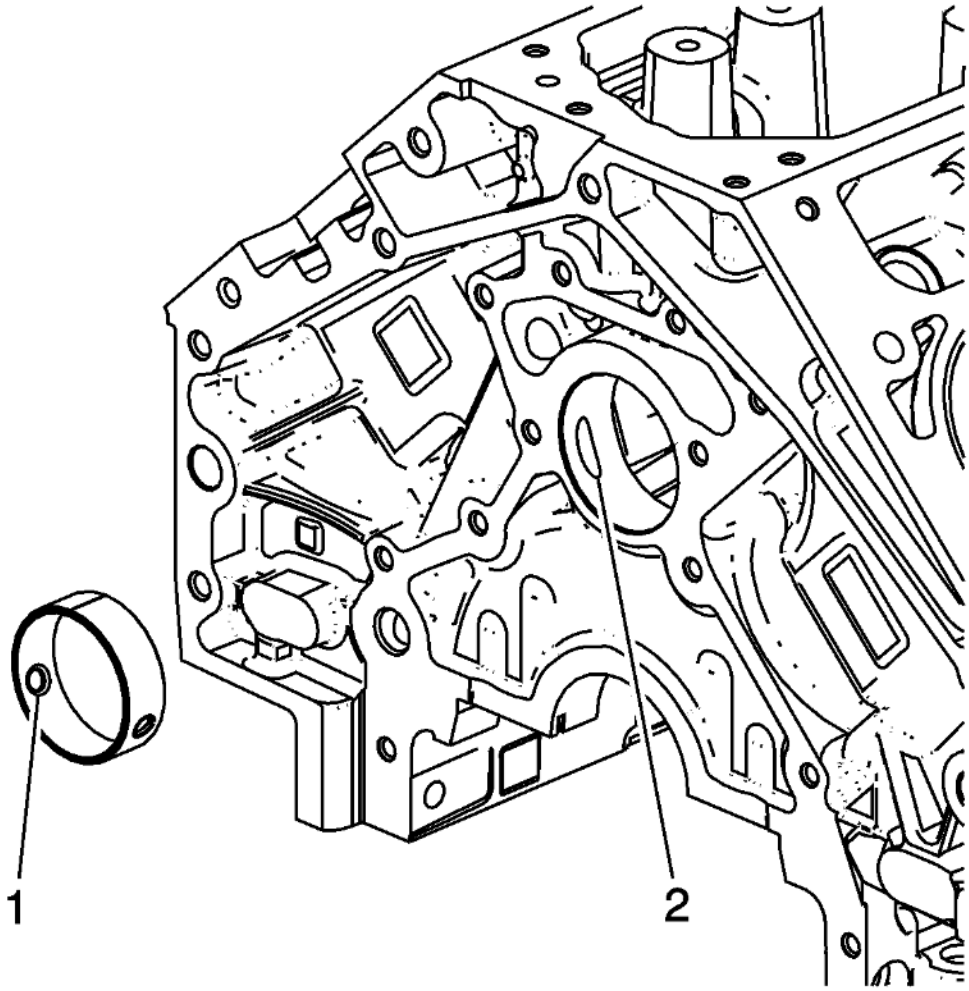

Fig. 406: Positioning Camshaft Bearing With Oil Feed Hole
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Camshaft bearings must be installed with bearing oil feed hole in alignment with the drilled oil passage in the block bore to ensure proper oil flow to the camshaft. If the bearings have a split seam, the split seam in the bearing must be installed in the 12 o'clock position towards the top of the block. Improperly installed bearings may restrict oil flow causing engine damage.

7. Position the camshaft bearing with oil feed hole (1) in alignment with drilled oil passage in block bore (2).

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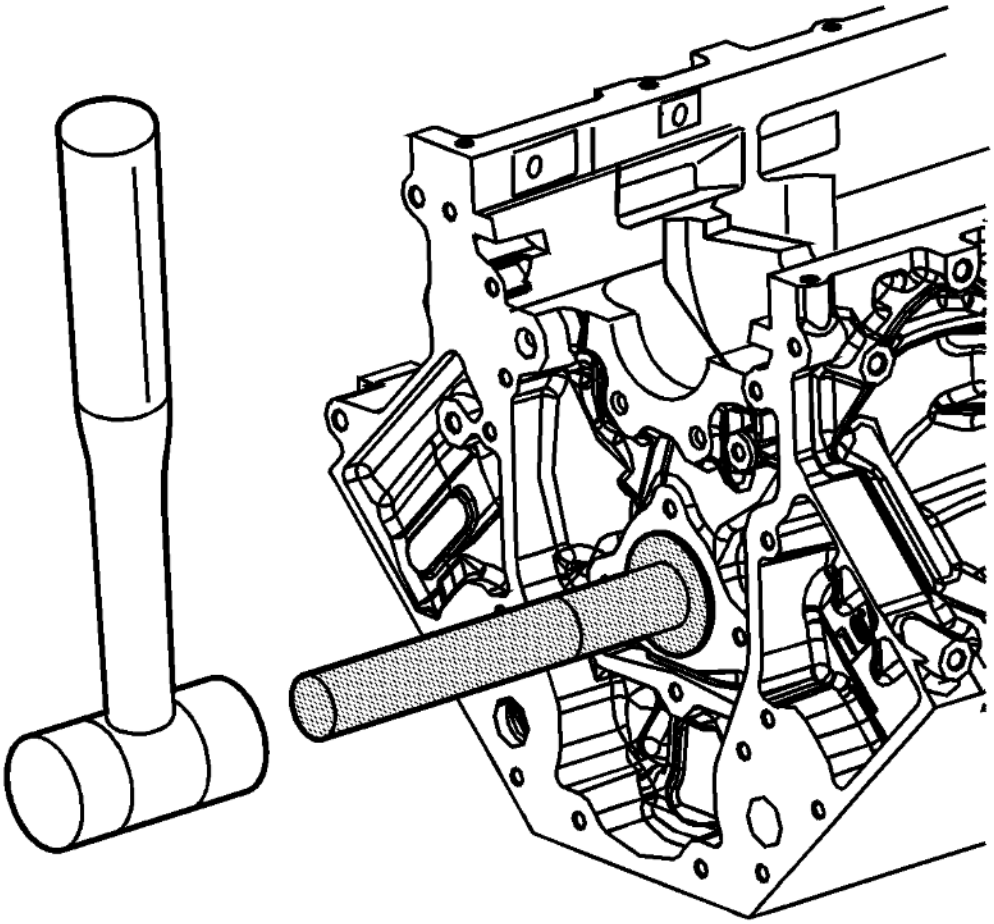

Fig. 407: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

8. Drive the bearing into the block bore. During installation, ensure the bearing is installed straight.
9. Remove **J 33049** service set , inspect bearing to confirm the oil hole in the bearing is in alignment with the drilled oil passage in the block bore.
10. Repeat procedure to install the remaining bearings into the block.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

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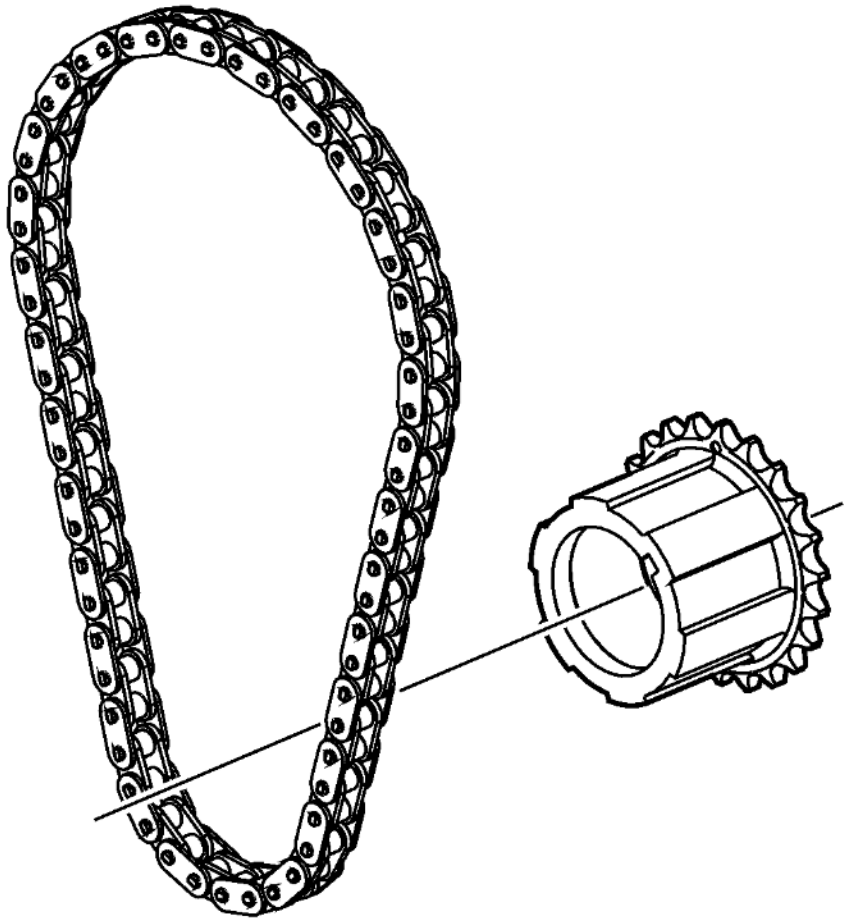

Fig. 408: Camshaft Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

1. Clean the components with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.
4. Inspect the crankshaft sprocket for worn, damaged, or chipped teeth.
5. Inspect for a damaged keyway.
6. Inspect for worn oil pump drive splines.

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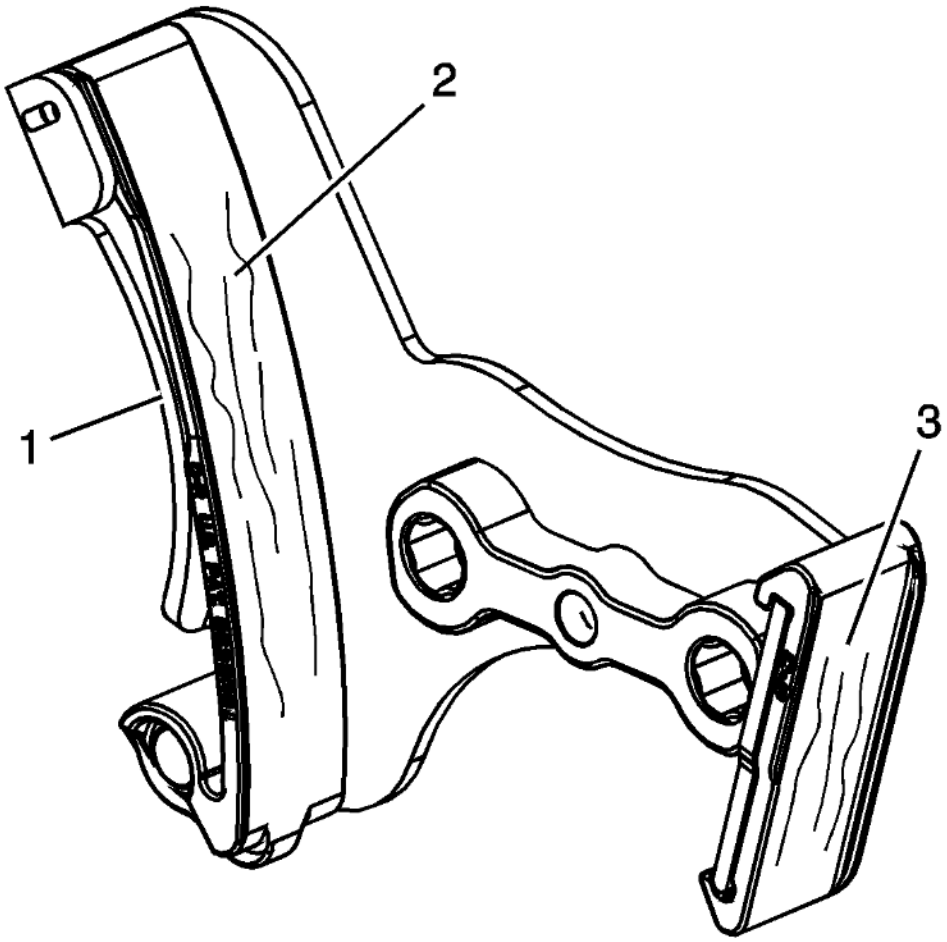

Fig. 409: View Of Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the timing chain tensioner for the following conditions:
    - Damaged or broken tension spring (1)
    - Excessive wear or scoring on the chain guide surfaces (2, 3)

CAMSHAFT POSITION ACTUATOR CLEANING AND INSPECTION

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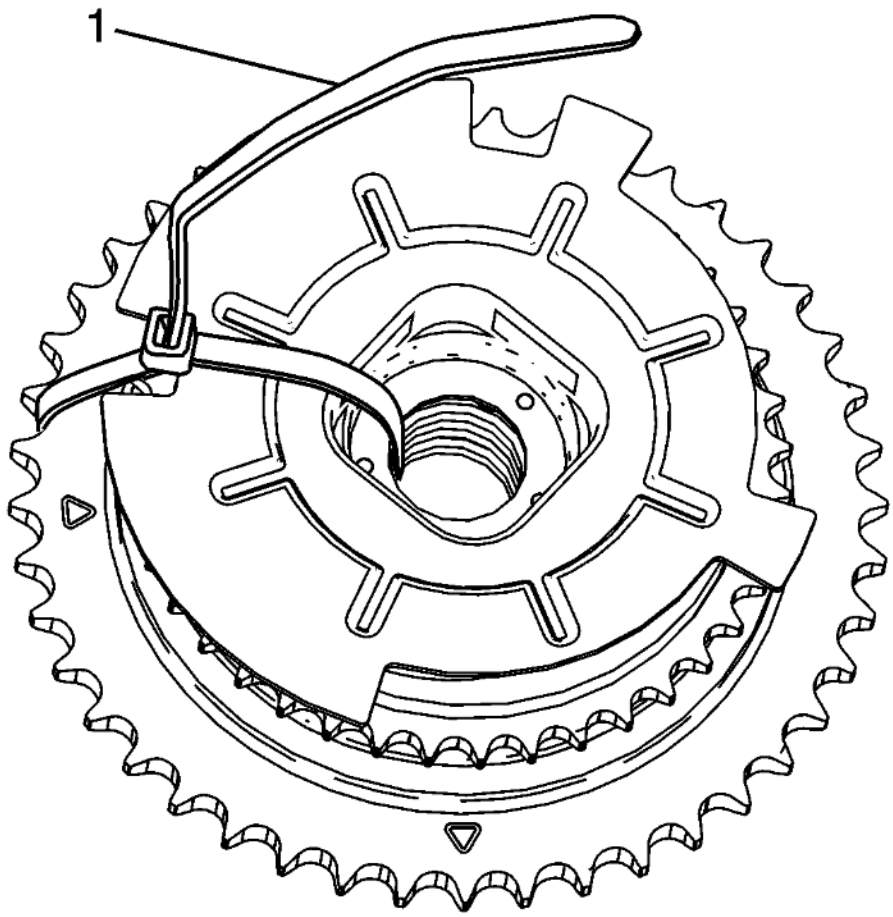

Fig. 410: Camshaft Position (CMP) Actuator And Reluctor Wheel
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Camshaft Position Actuator Removal and Installation Warning .**

1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.

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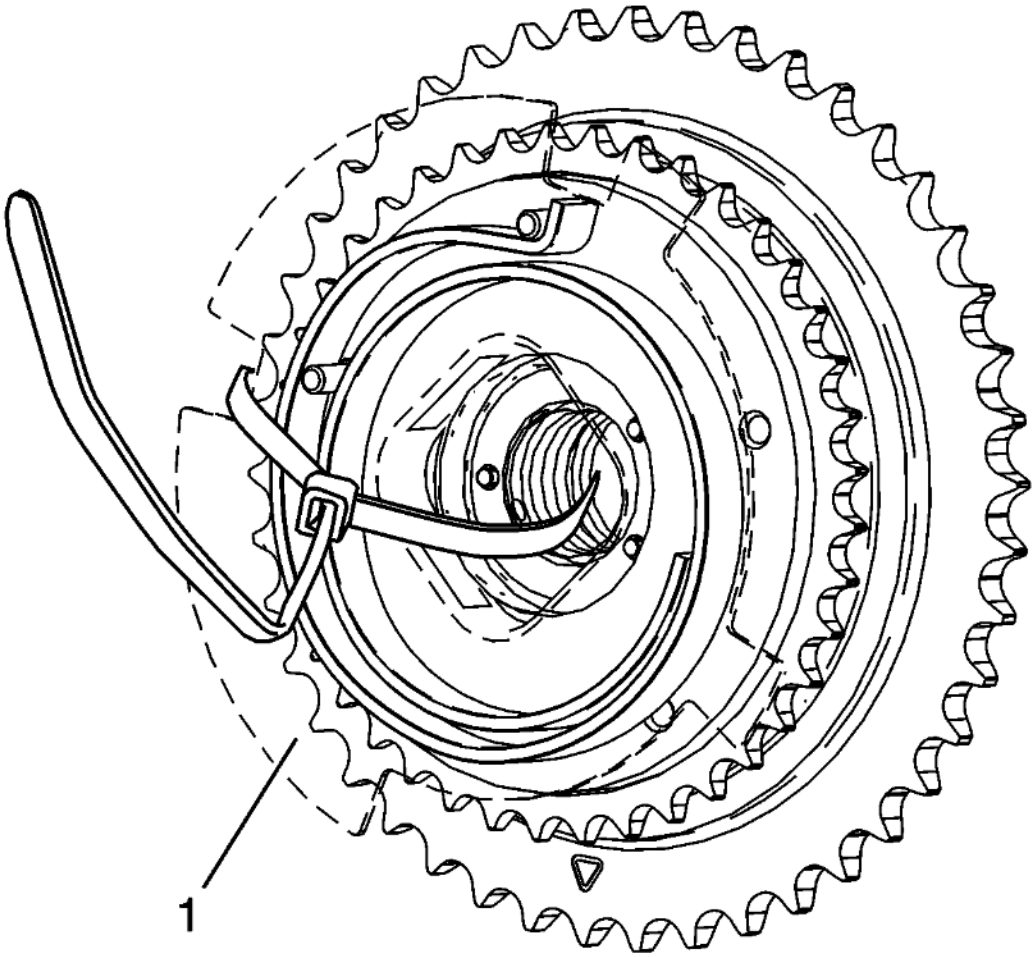

Fig. 411: CMP Actuator
Courtesy of GENERAL MOTORS COMPANY

2. Clean the CMP actuator with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).

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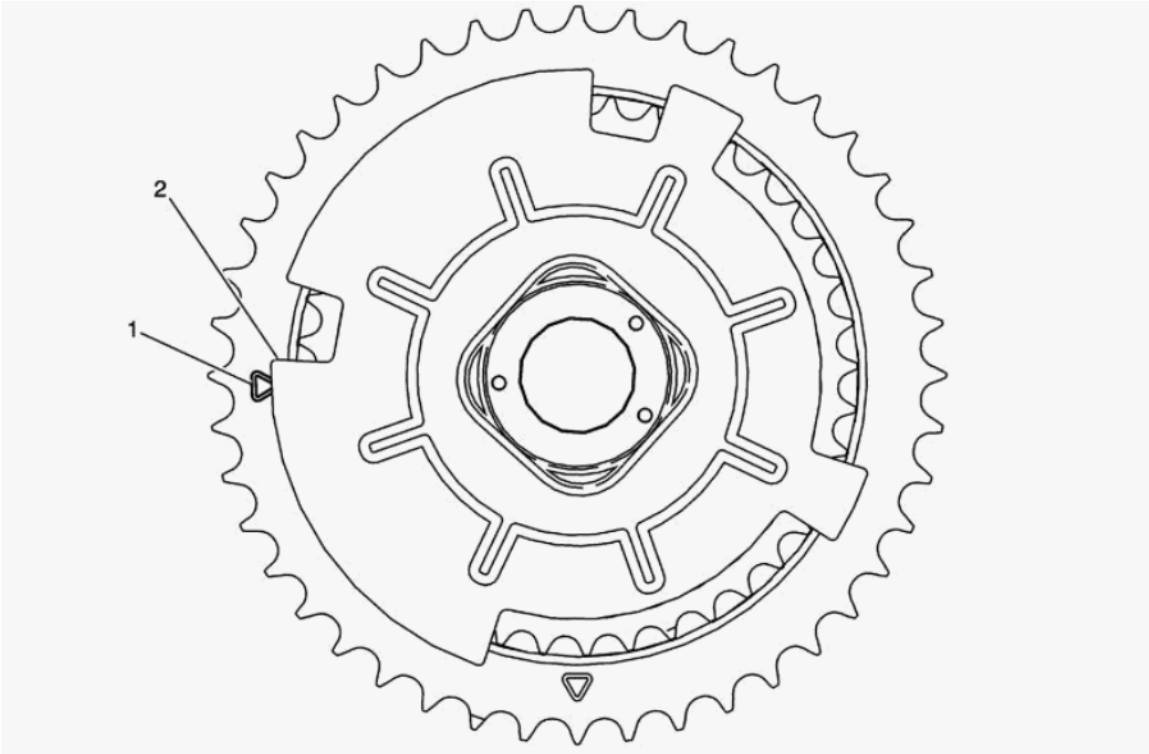

Fig. 412: CMP Actuator Park Position
Courtesy of GENERAL MOTORS COMPANY

5. Inspect the CMP actuator for the following conditions:
    - Improper positioning of the CMP reluctor wheel. The actuator return spring should reposition the reluctor wheel to the PARK position. Inspect for proper alignment of the mark on the face of the sprocket (1) with the flat edge of the reluctor wheel (2). If the reluctor wheel is not properly positioned, the internal components of the actuator are sticking or the return spring is broken and the actuator should be replaced as an assembly.
    - Nicked or damaged edges (3) on the CMP reluctor wheel
    - Damaged timing sprocket teeth (4)

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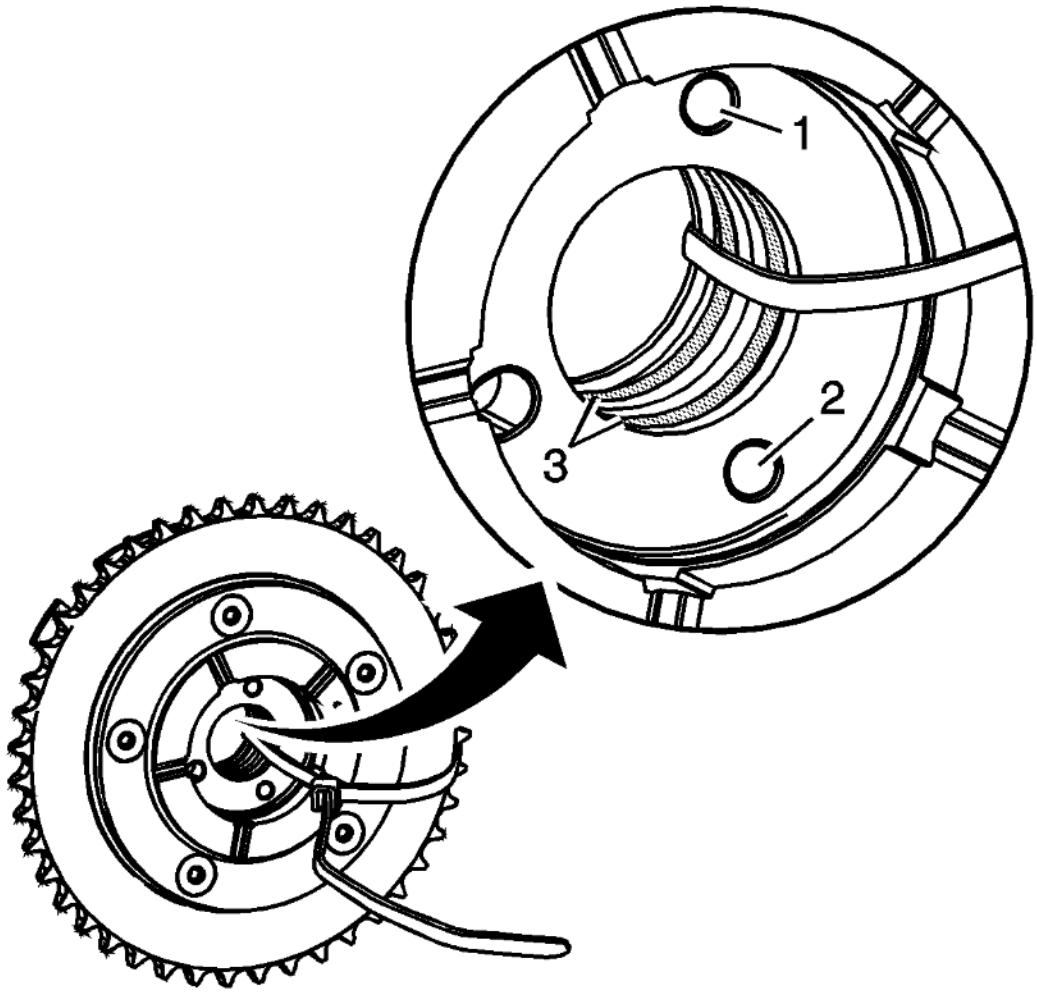

Fig. 413: View Of Oil Passages
Courtesy of GENERAL MOTORS COMPANY

6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).

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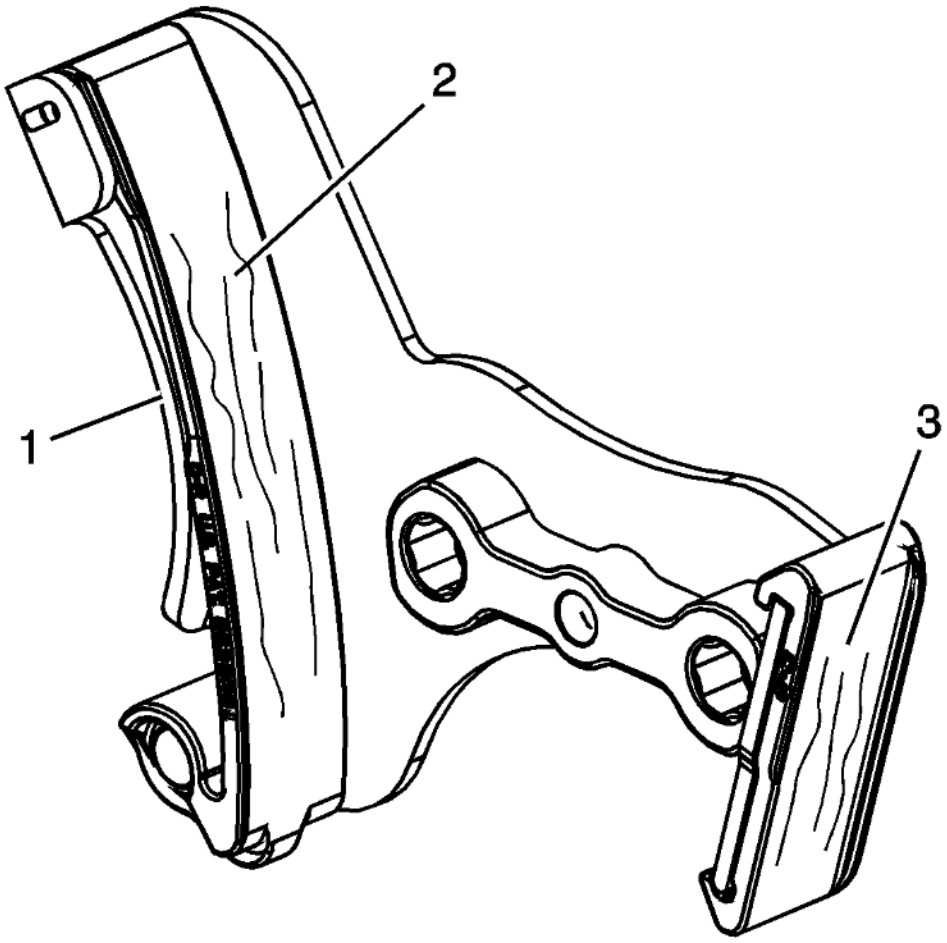

Fig. 414: View Of Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the timing chain tensioner for the following conditions:
    - Damaged or broken tension spring (1)
    - Excessive wear or scoring on the chain guide surfaces (2, 3)

CAMSHAFT POSITION ACTUATOR MAGNET CLEANING AND INSPECTION

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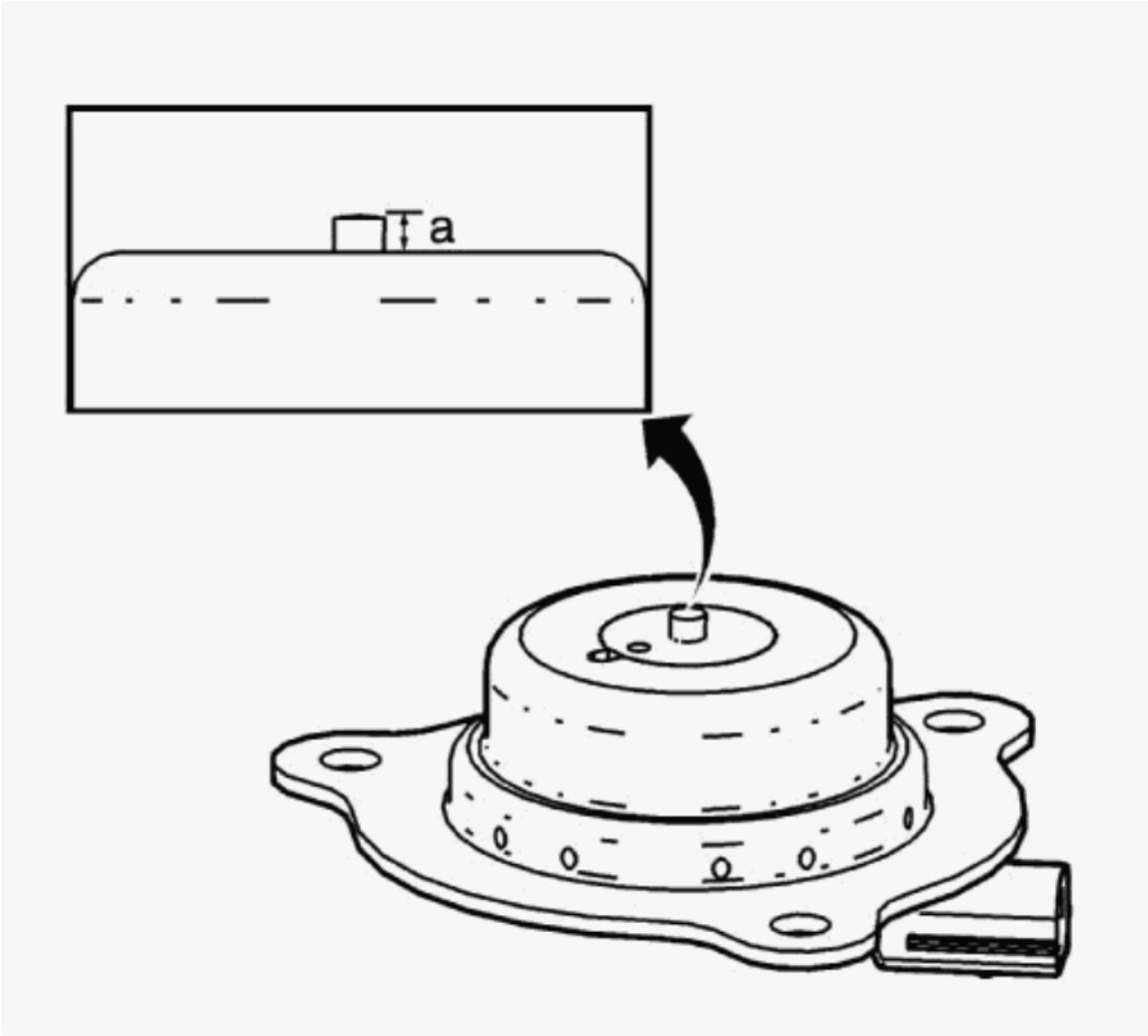

Fig. 415: Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: If checking the operating range of the CMP magnet pintle, DO NOT energize the magnet with a 12V power supply. Use steps 2 thru 5 below to check pintle operating range. To dynamically test the magnet pintle with a power supply, refer to the dynamic test instructions listed under the component testing portion of DTC P0011. Refer to **DTC P0010, P0011, P2088, OR P2089: CAMSHAFT POSITION ACTUATOR SOLENOID**

1. Inspect the CMP magnet for the following conditions:
   - A damaged electrical connector
   - An accumulation of dirt or debris in the recessed area around the pintle
   - A build-up of burnt engine oil on the shaft of the pintle which may cause the pintle to stick and not move freely within the proper range of travel
2. Holding the CMP magnet with the pintle facing upward, measure the pintle retracted position (a). Record the dimension.

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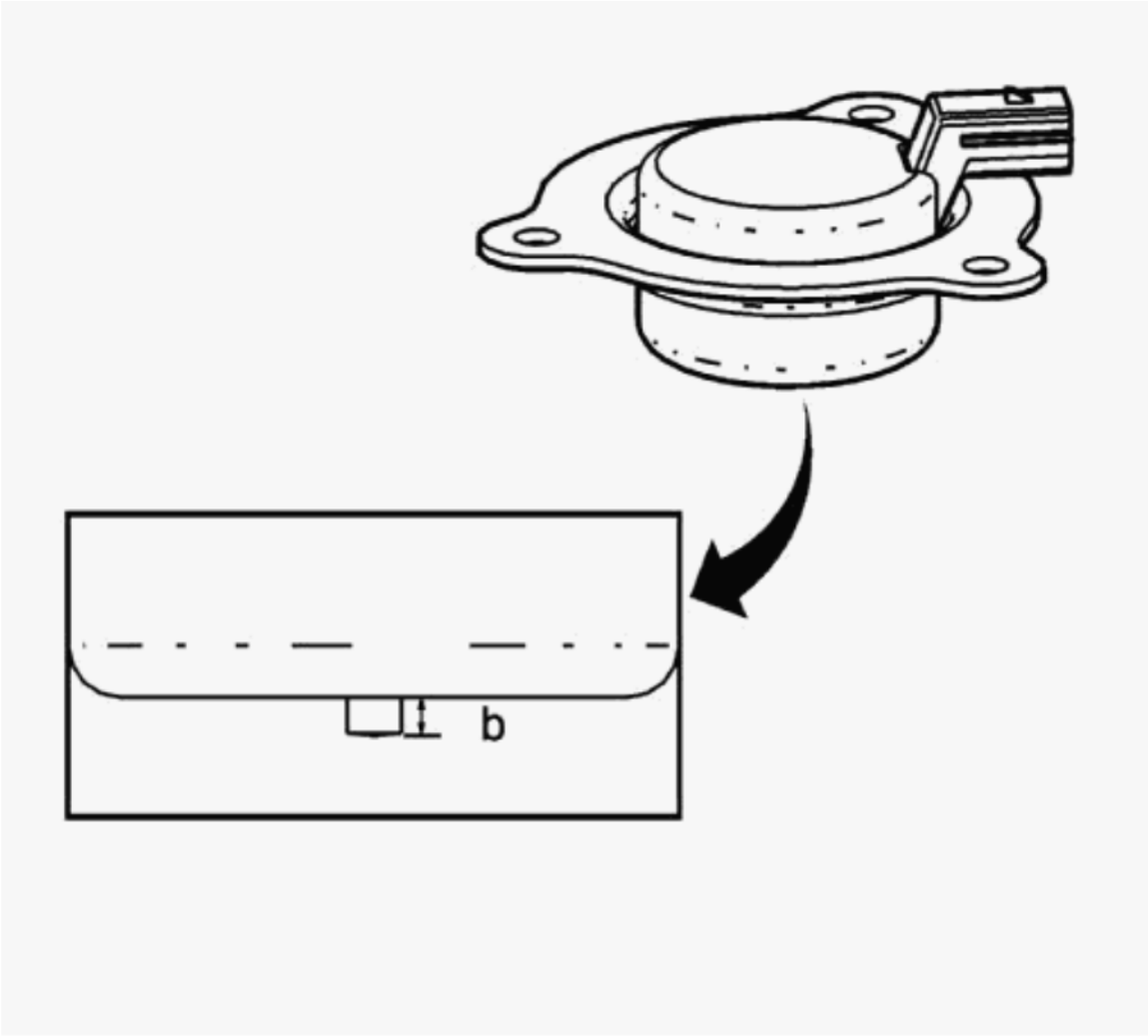

Fig. 416: Pintle Extended Position
Courtesy of GENERAL MOTORS COMPANY

3. Holding the CMP magnet with the pintle facing downward, measure the pintle extended position (b). Record the dimension.
4. Subtract the retracted dimension (a) from the extended dimension (b) to determine pintle travel. A properly moving pintle will travel 3.0-5.5 mm (0.12-0.22 in).
5. If the pintle of the CMP magnet is binding or does not move within the proper range of travel, replace the CMP magnet as an assembly.

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSPECTION

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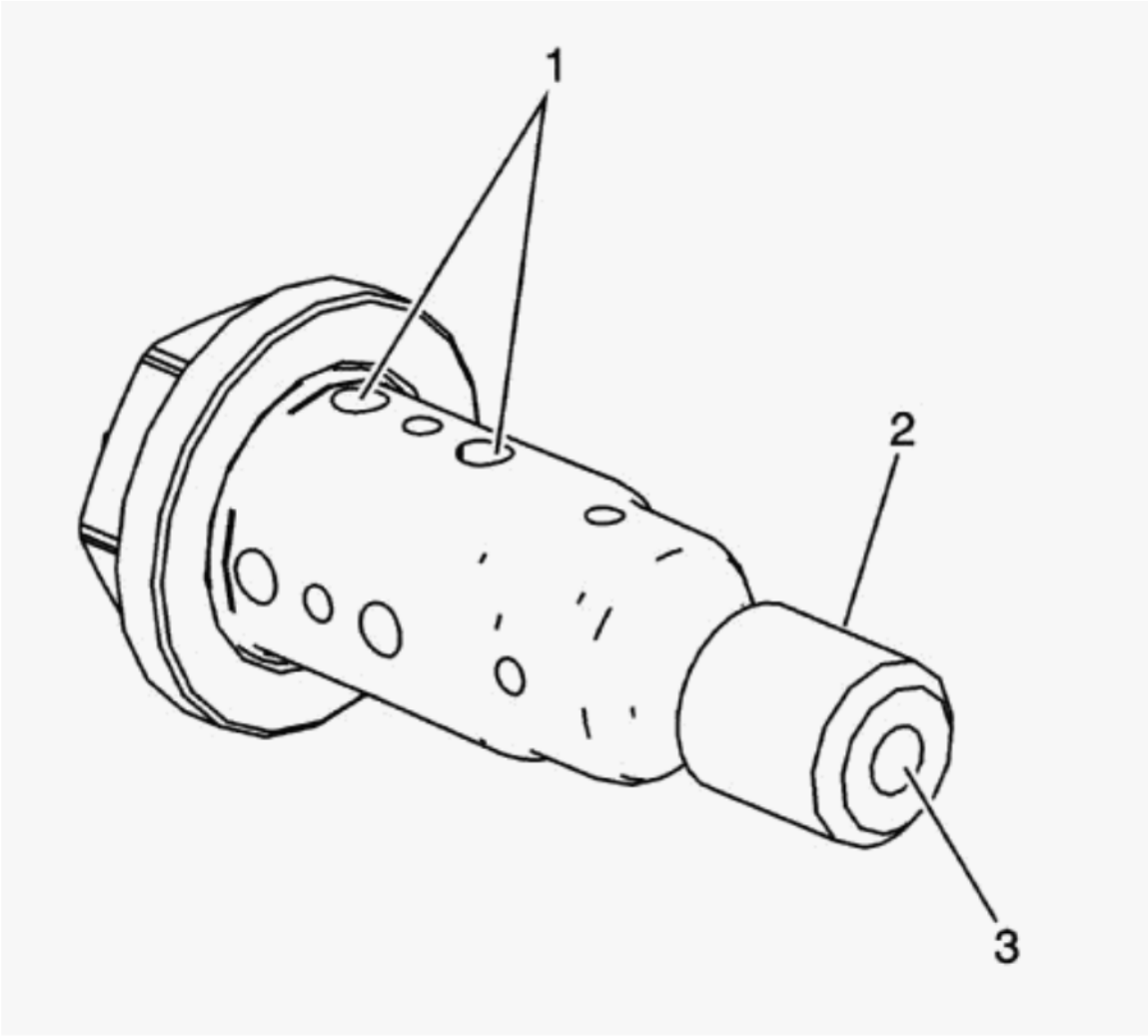

Fig. 417: Camshaft Position Actuator Solenoid Valve Inspection
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for off-vehicle diagnostic purposes only.

1. Inspect the CMP valve for the following conditions:
   - Dirt, debris, or restrictions within the oil passages (1)
   - Damaged threads (2)

     If the threads of the valve are damaged, also inspect the threads in the front of the camshaft for damage.

   - Dirt, debris, or restrictions within the oil inlet (3)

     If debris is detected, the engine assembly should be inspected to determine the source of contamination.

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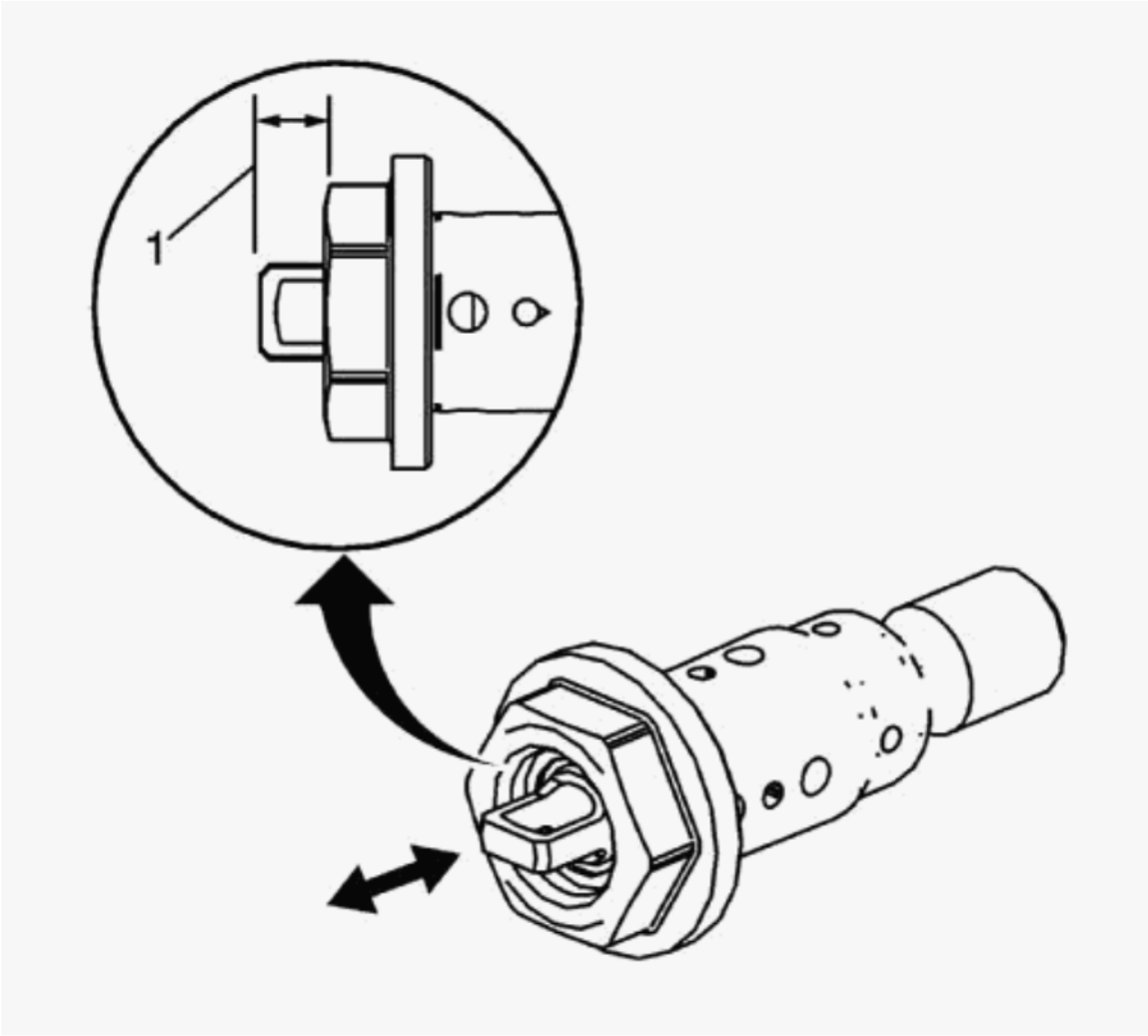

Fig. 418: Camshaft Position Actuator Solenoid Valve Inspection
Courtesy of GENERAL MOTORS COMPANY

2. Inspect for a sticking valve spool or broken valve spool spring.
3. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.52-6.92 mm (0.257-0.272 in).

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

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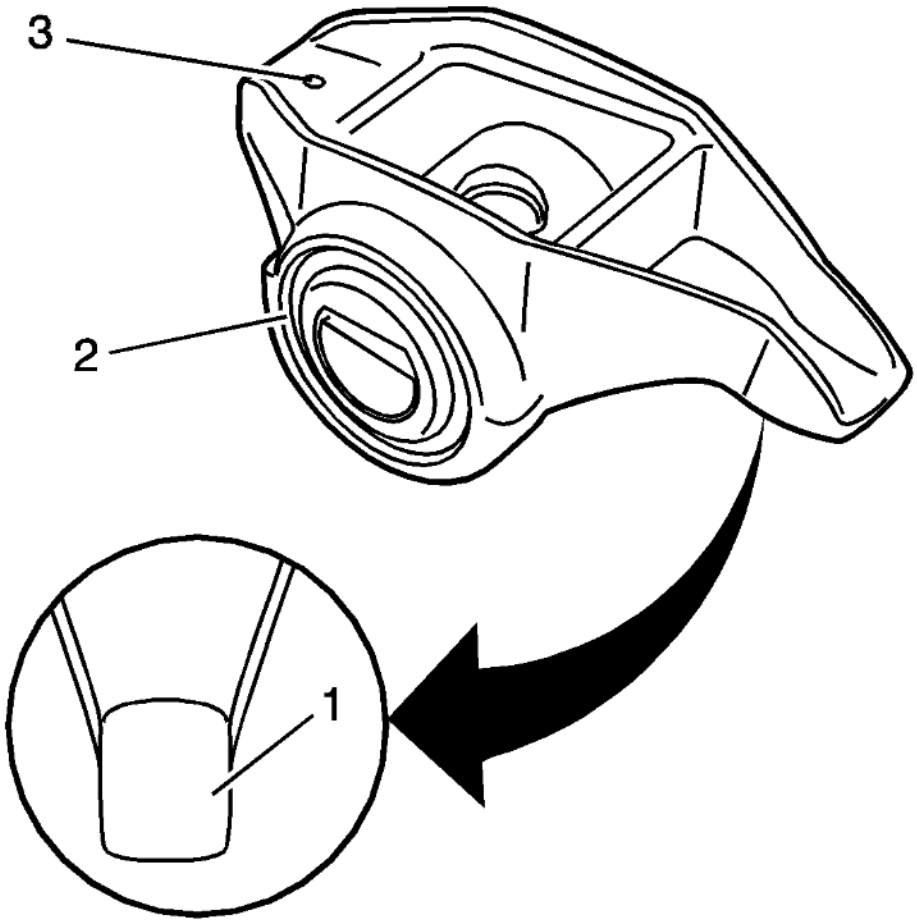

Fig. 419: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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.

WARNING: **Refer to Safety Glasses and Compressed Air Warning .**

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 LIFTER AND GUIDE CLEANING AND INSPECTION

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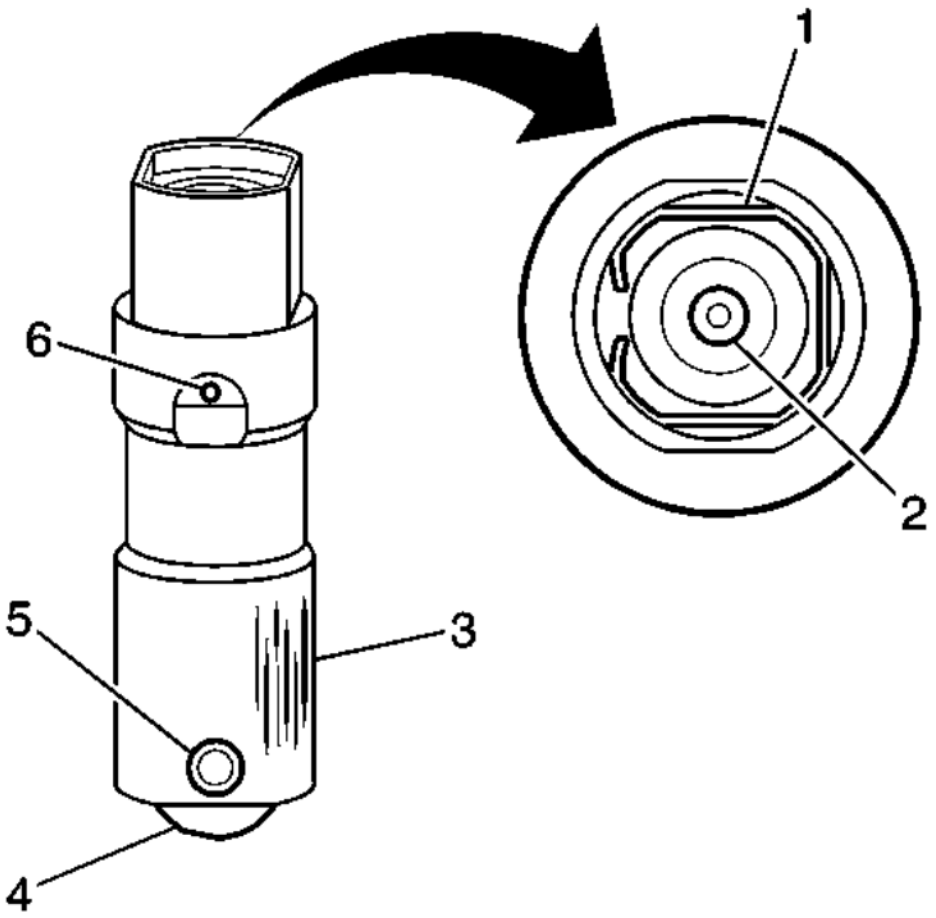

Fig. 420: Identifying Valve Lifter Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Components that are to be used again must be marked, sorted or organized for assembly.**

1. Clean the components in cleaning solvent.

WARNING: **Refer to Safety Glasses and Compressed Air Warning .**

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)

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- Loose or damaged pin (5)
- Plugged oil hole (6)
- Worn or damaged roller bearing

The roller should rotate freely with no binding or roughness.

Active Fuel Management Valve Lifters

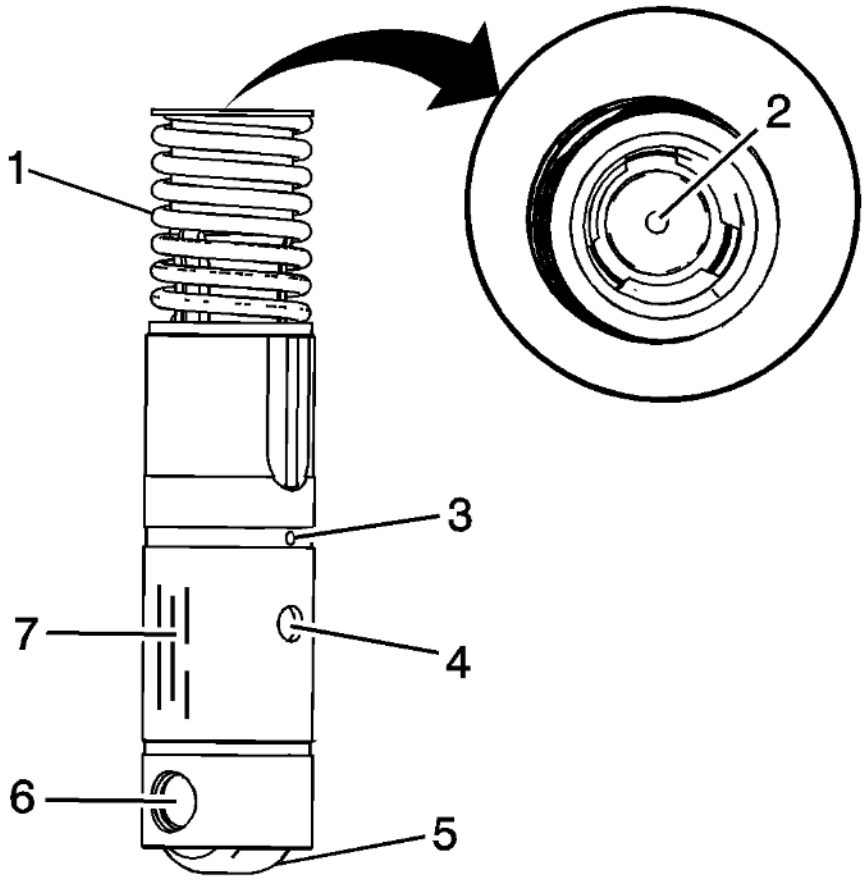

Fig. 421: Displacement On Demand Valve Lifters Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Components that are to be used again must be marked, sorted or organized for assembly.**

1. Clean the components in cleaning solvent.

WARNING: **Refer to Safety Glasses and Compressed Air Warning .**

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
   - Broken or collapsed spring (1)
   - Worn pushrod socket (2)

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- Plugged lubrication hole (3)
- Plugged lifter oil-switching hole (4)
- Flat spots on the roller (5)
- Worn or damaged roller bearing (6)

  The roller should rotate freely with no binding or roughness.

- Scuffed or worn sides (7)

Valve Guides

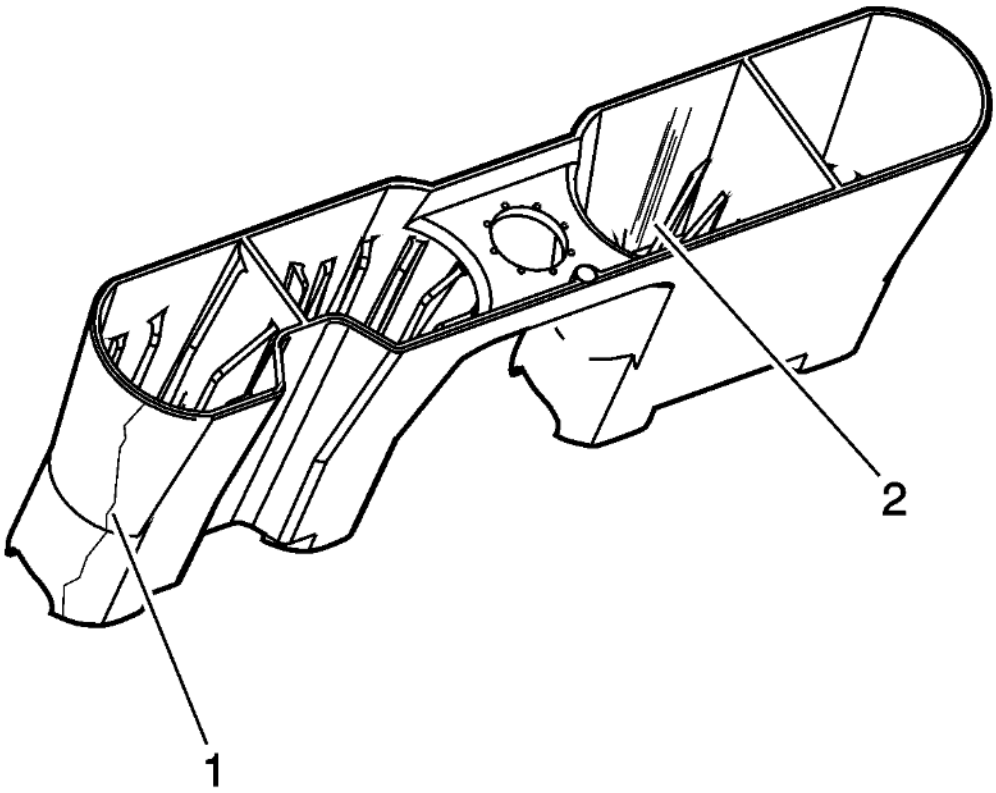

Fig. 422: Inspecting Valve Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

Inspect the valve lifter guides for the following conditions:

- Cracks or damage (1)
- Excessive wear in the lifter mounting bores (2)

CYLINDER HEAD DISASSEMBLE

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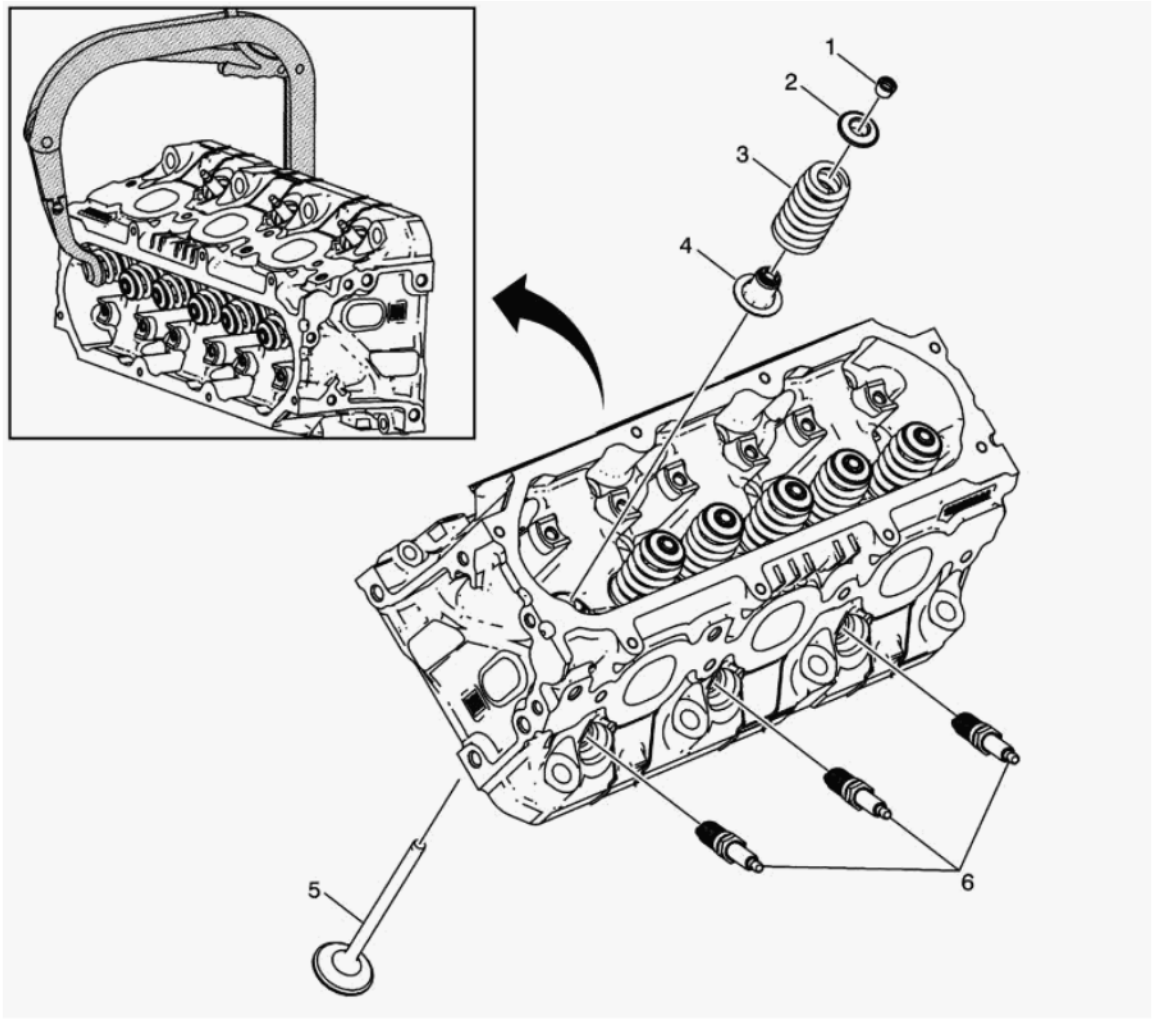

Fig. 423: Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Stem Key **Procedure** 1. Install the **J-8062** compressor (3) onto the head. 2. Remove the valve stem keys. **Special Tools** **J-8062** Valve Spring Compressor For equivalent regional tools, refer to **Special Tools** .
2	Valve Stem Spring Cap
3	Valve Spring
4	Valve Stem Oil Seal **NOTE:** **NEVER reuse a valve stem**

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Callout	Component Name
	oil seal.
5	Valve
6	Spark Plug

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **J 8089** Carbon Removal Brush
- **J 9666** Valve Spring Tester

For equivalent regional tools, refer to **Special Tools**.

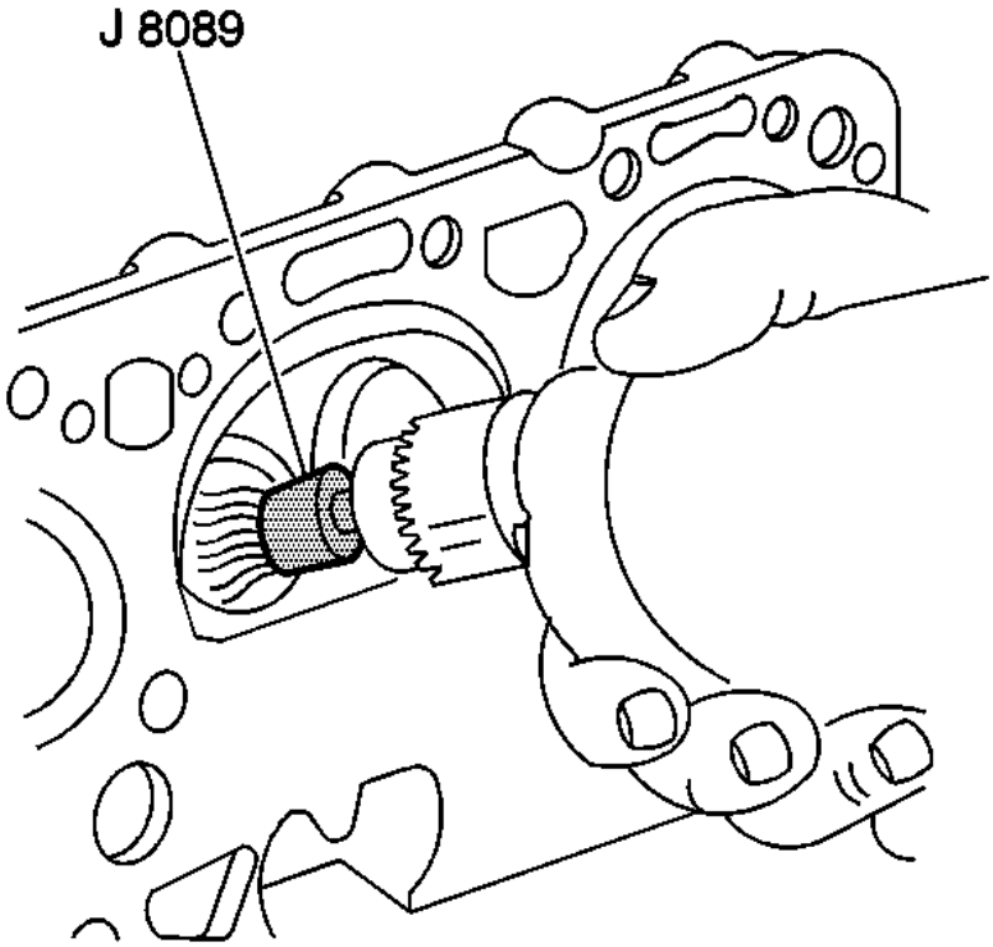

Fig. 424: Cleaning Carbon
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **When cleaning a cylinder head in a thermal type oven, do not exceed 204Â°C (400Â°F).**

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- **Be careful not to scuff the chamber.**

1. Clean the following components:
   - Use the **J 8089** brush in order to remove the carbon from the combustion chambers.
   - Gasket surfaces

     Refer to **Replacing Engine Gaskets**.

   - Valve stems and heads on a buffing wheel
   - Bolt hole threads

     Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:
   1. Cracks in the exhaust ports and combustion chambers
   2. External cracks in the water chambers
   3. Gasket surfaces for excessive scratches or gouging

      Refer to **Replacing Engine Gaskets**.

   4. Bolt hole threads for debris or damaged threads

      Refer to **Thread Repair**, or **Thread Repair Specifications**.

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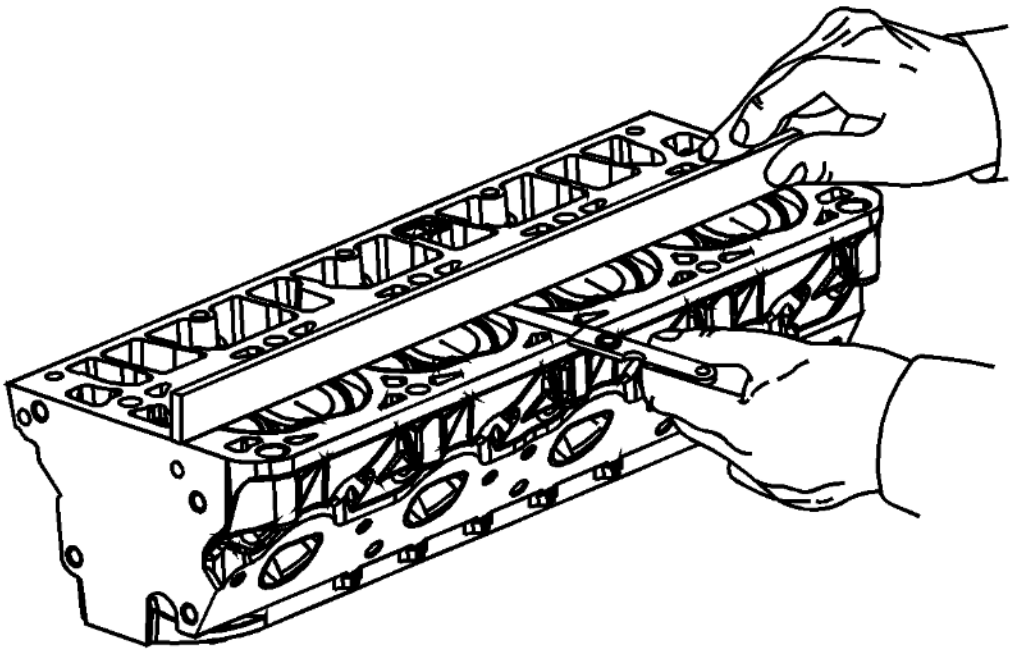

Fig. 425: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications**.

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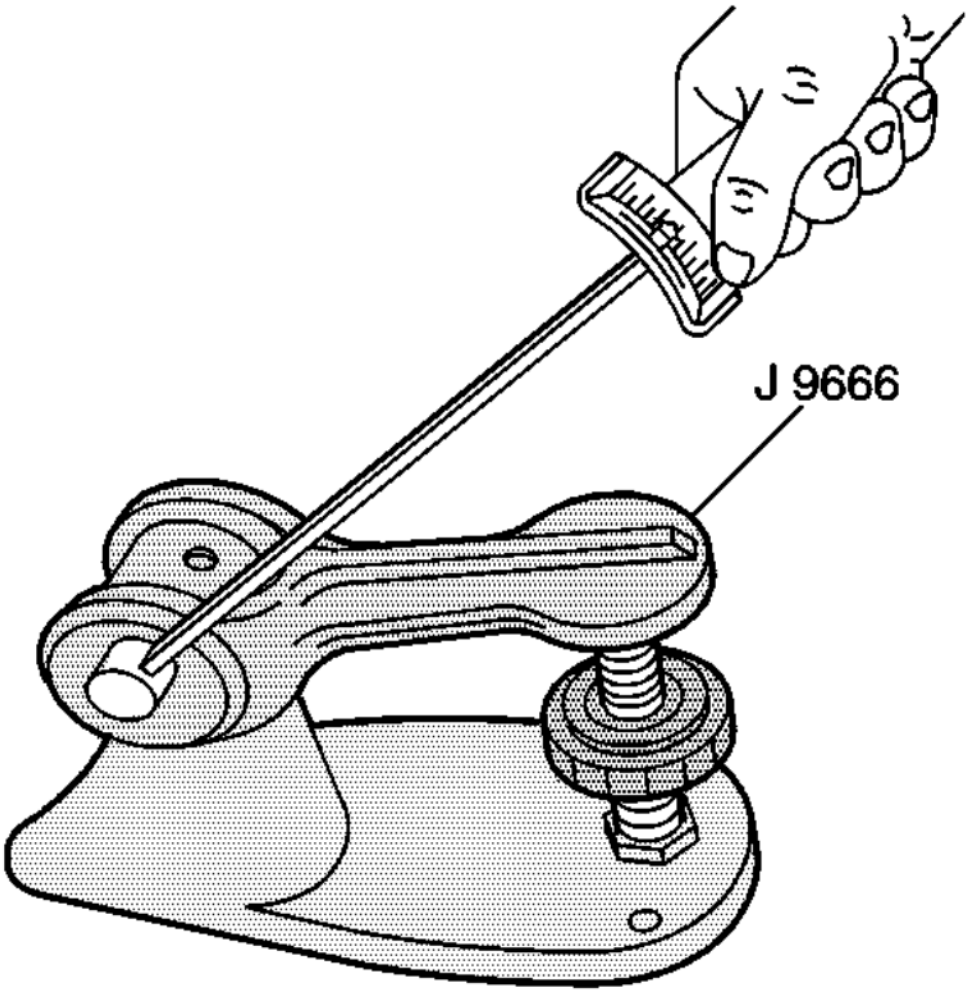

Fig. 426: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS COMPANY

4. Use the **J 9666** tester in order to measure the valve spring tension. Refer to **Engine Mechanical Specifications**.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Valve Guide Reaming

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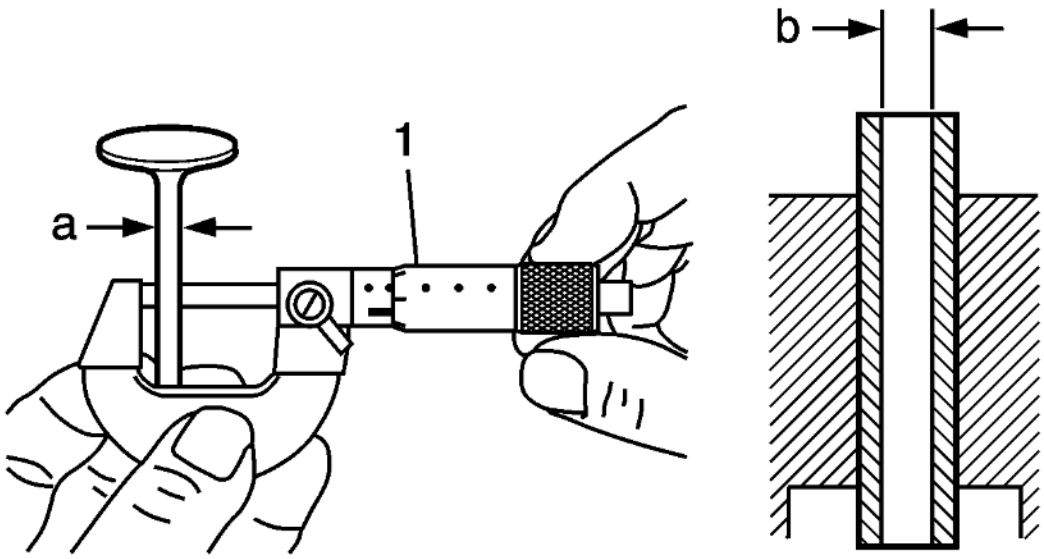

Fig. 427: Valve Guide Reaming, and Valve and Seat Grinding (LS7)
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **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.**

CAUTION: **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.
    1. Using a micrometer (1) measure the diameter of the valve stem (a).
    2. Using a ball style measuring gauge, measure the inner diameter (b) of the valve guide at the specified depth. Refer to **Engine Mechanical Specifications (L96 VIN G)** **Engine Mechanical Specifications (LC8 VIN B)** .
    3. Subtract the valve stem diameter (a) from the valve guide inner diameter (b) to obtain the valve stem to guide clearance.
2. If the clearance measurement between the valve stem and guide is not within specification, the valve and/or the cylinder head must be replaced. Refer to **Engine Mechanical Specifications (L96 VIN G)** **Engine Mechanical Specifications (LC8 VIN B)** .

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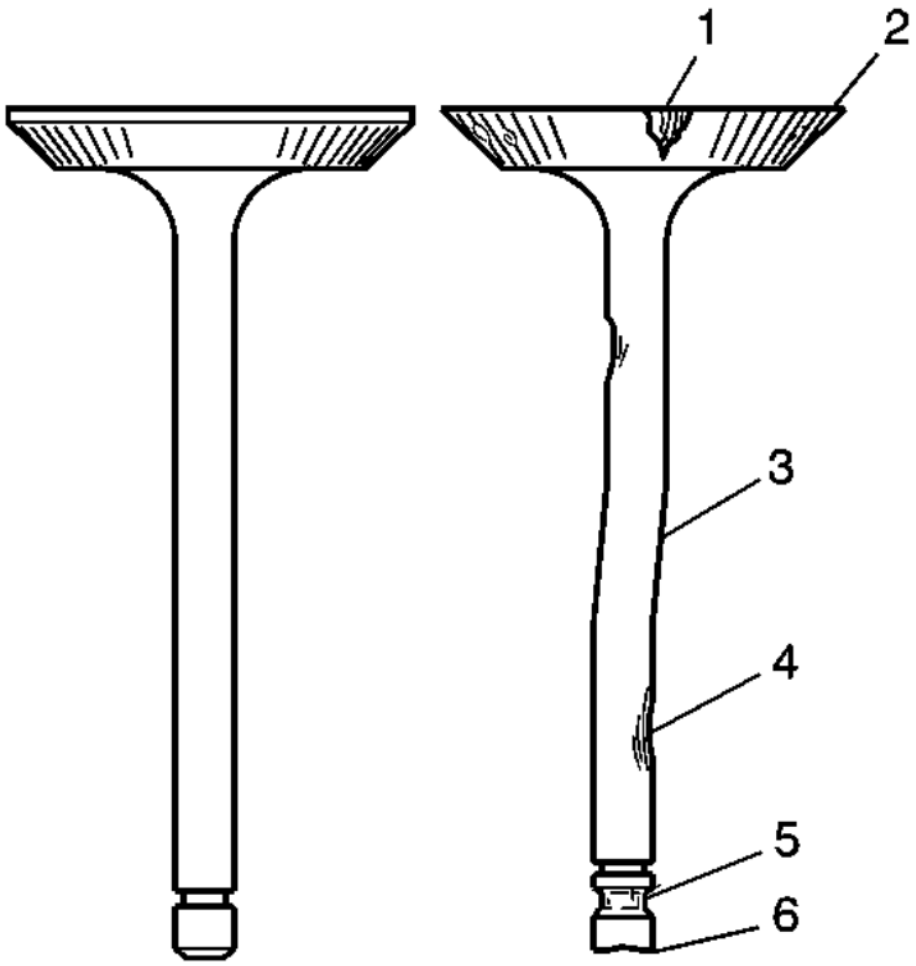

Fig. 428: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the valve stems for excessive scoring, wear, or warpage.
    - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
    - If a valve guide is worn or has excessive stem-to-guide clearance, the cylinder head should be replaced.
4. Measure the valve stem diameter. If the valve stem diameter is not within specification, the valve must be replaced. Refer to **Engine Mechanical Specifications (L96 VIN G)** **Engine Mechanical Specifications (LC8 VIN B)** .

    If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the cylinder head must be replaced.

Valve and Seat Grinding

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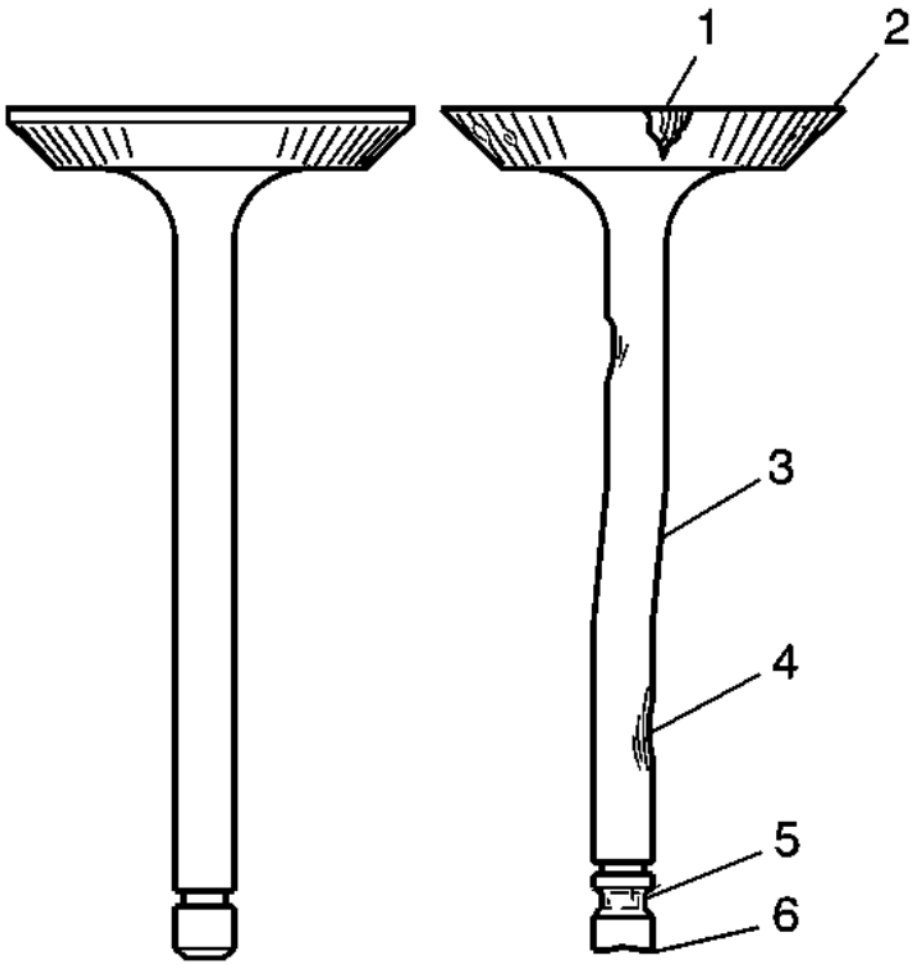

Fig. 429: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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 equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free of carbon or dirt to ensure proper centering of the tool pilot in the guide.**
- **Valves that are pitted or have stems that stems that show excessive wear, or valves that are warped excessively must be replaced.**
- **DO NOT reface valves. Valves with excessive wear or damage MUST be replaced.**

1. Inspect the valve for the following conditions:

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- Burnt or eroded areas (1)
- A worn margin (2)
- A bent stem (3)
- A worn or scored stem (4)
- A worn key groove (5)
- A worn stem tip (6)

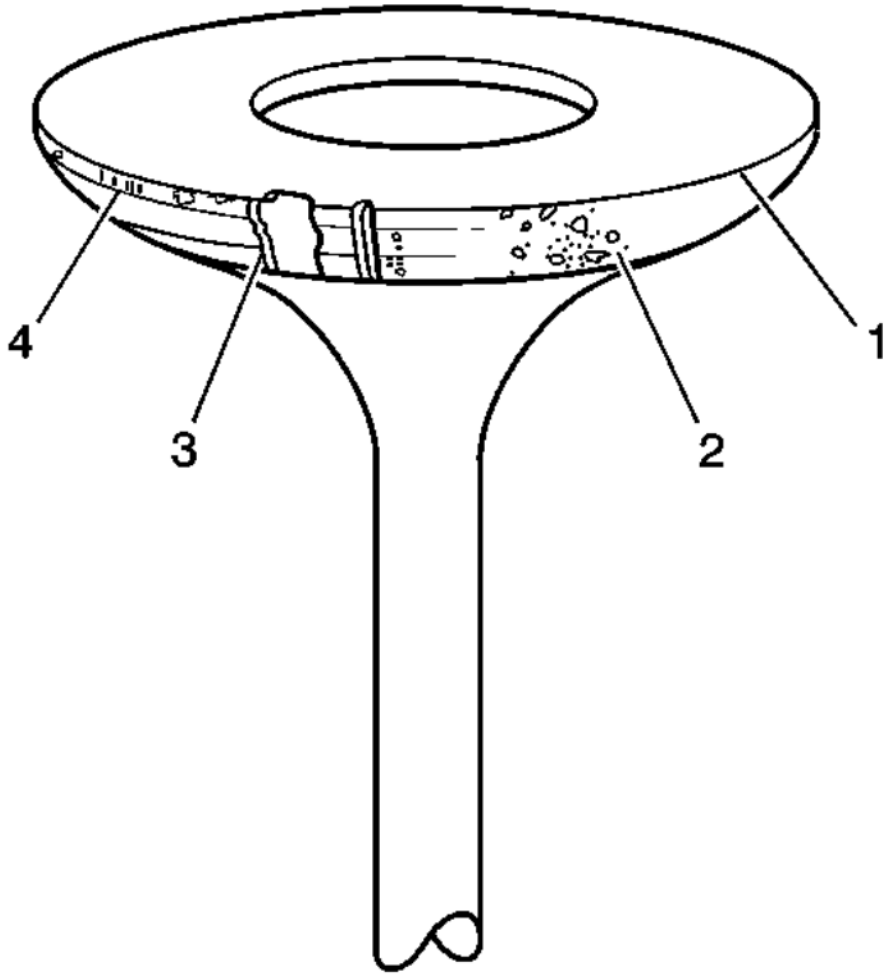

Fig. 430: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the valve face for the following conditions:
   - Worn or no margin (1 or 4)
   - Pitted surfaces (2)
   - Burnt or eroded areas (3)

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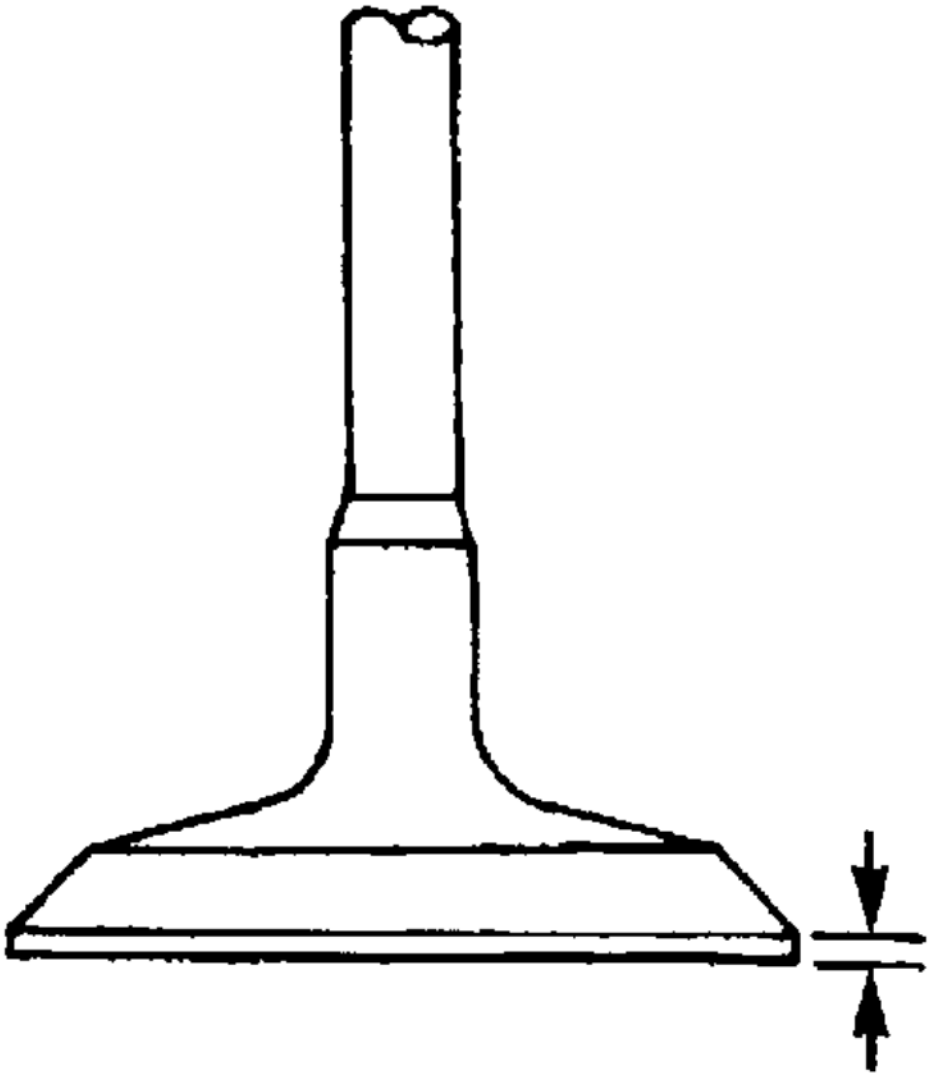

Fig. 431: Inspecting Valve Margin
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the valve margin.

   If the margin has worn away, it can lead to breakage, burning or pre-ignition due to heat localizing on this edge. If the vertical edge of the valve head, margin, is not visible and only a sharp edge remains, replace the valve.

4. Inspect for a loose valve seat in the cylinder head. The valve seat has an interference fit to the cylinder head.
5. 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.

6. Grind the valve seat.

   The recommendations of the equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment 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.

7. Inspect the valve seats.

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- The valve seats should be concentric to the centerline of the guide, measure valve seat runout. The total indicator runout reading must be within specification. Refer to **Engine Mechanical Specifications**.
- If the valve seat has been ground, measure the valve stem height after reassembly of the cylinder head. The cylinder head, and/or valve must be replaced if the valve stem height is not within specification after seat grinding. Refer **Engine Mechanical Specifications**.

CYLINDER HEAD ASSEMBLE

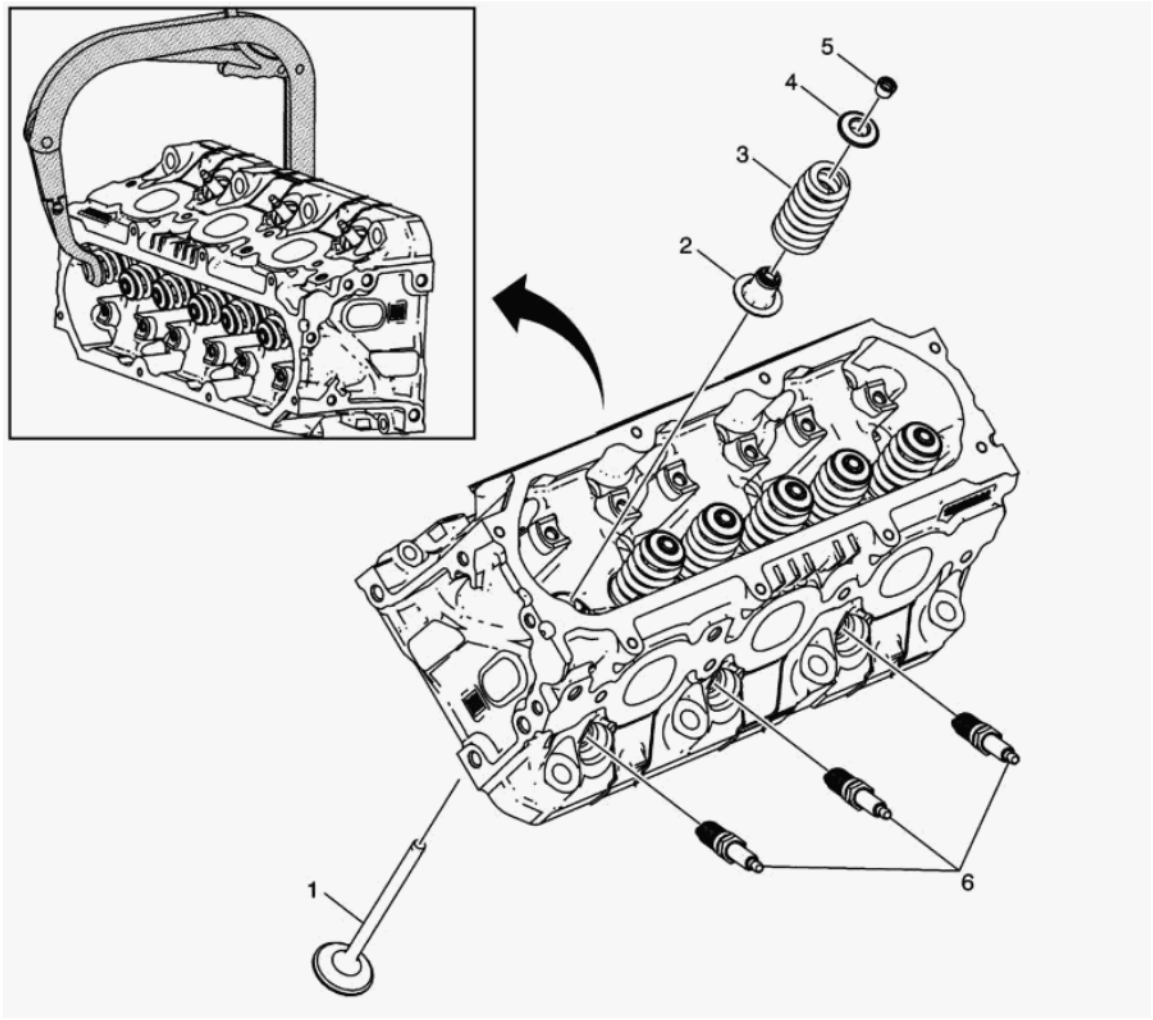

Fig. 432: Cylinder Head
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve
2	Valve Stem Oil Seal **NOTE:** **NEVER reuse a valve stem oil seal.**
3	Valve Spring
4	Valve Stem Spring Cap

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Callout	Component Name
5	Valve Stem Key **Procedure** 1. Install the **J-8062** compressor (3) onto the head. 2. Install the valve stem keys. **Special Tools** **J-8062** Valve Spring Compressor For equivalent regional tools, refer to **Special Tools** .
6	Spark Plug

OIL PUMP CLEANING AND INSPECTION

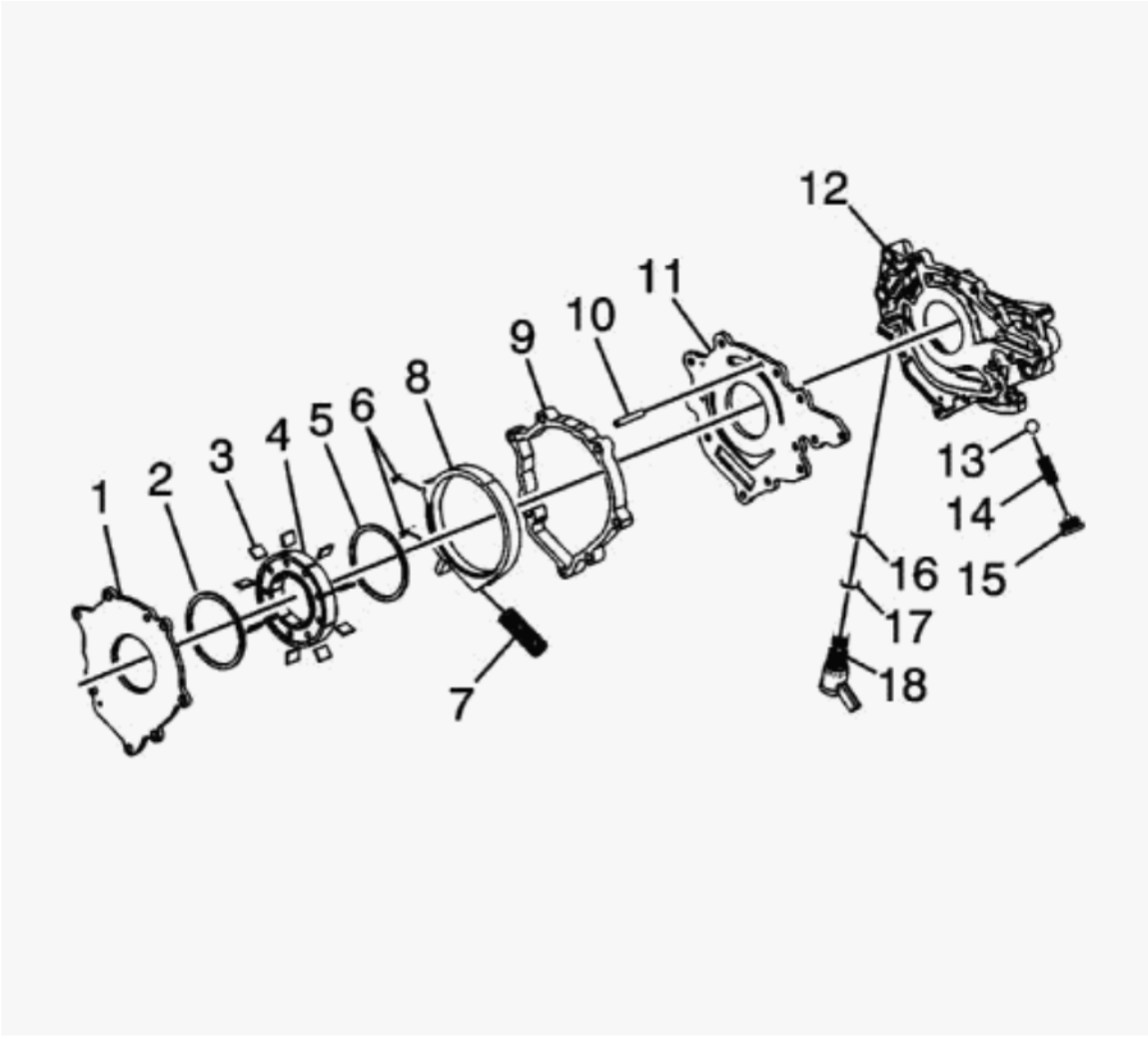

Fig. 433: Oil Pump Components (LT1 Without Z52 Option)
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The internal components of the oil pump assembly are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly.**

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1. Clean the components in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the oil pump housing (12), intermediate cover (11), intermediate housing (9), and the housing cover (1) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-oil pan sealing surface for scratches or gouging.
5. Inspect the oil pump base-to-engine block oil gallery surfaces for scratches or gouging.
6. Inspect the oil pump base for damaged bolt hole threads.
7. Inspect the pump slide (8) for excessive wear, scoring, or gouges.
8. Inspect the oil pump internal oil passages for restrictions.
9. Inspect the oil pump rotor (4) and vanes (3) for cracks, wear, or damage.
10. Inspect the oil pump slide spring (7) for breakage.
11. Inspect the oil pump slide (8) and slide seals (6) for cuts or damage.
12. Inspect the Oil Pressure Relief Valve Plug (15) for leaks or damage.
13. Inspect the Oil Flow Control Solenoid O-rings (16,17) cracks or damage.

ENGINE FRONT COVER CLEANING AND INSPECTION

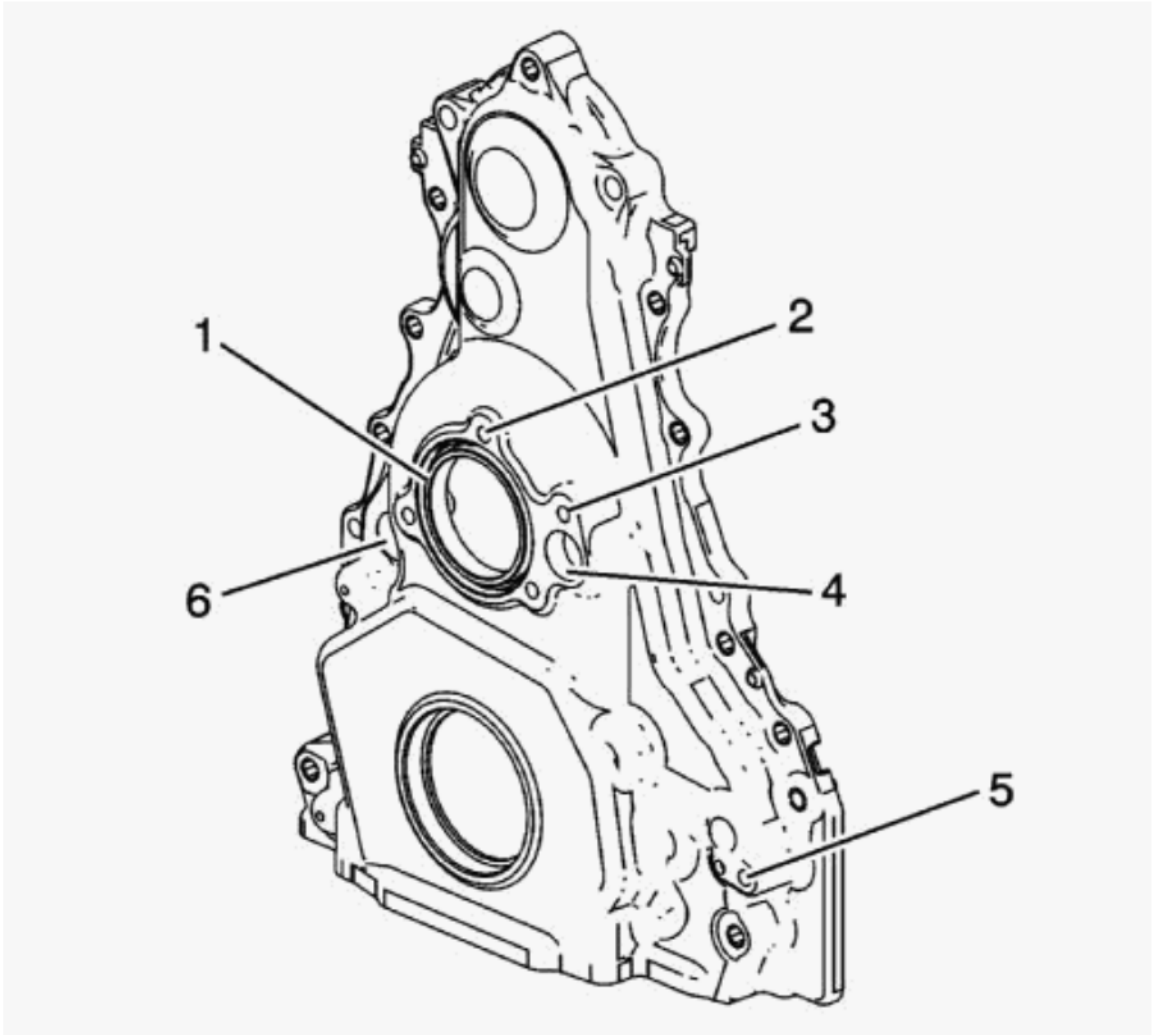

Fig. 434: Engine Front Cover

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Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not use the crankshaft front oil seal again. Install a NEW crankshaft front oil seal during assembly.**
- **Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.**
- **Do not use the camshaft position (CMP) actuator magnet gasket again. Install a NEW gasket during assembly.**

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Clean the cover in solvent. Remove the sealant from the cover surface. Refer to **Replacing Engine Gaskets**.

WARNING: **Refer to Safety Glasses and Compressed Air Warning .**

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surface (1) for excessive scratches or gouging.
5. Inspect the threaded bolt holes (2, 3, and 5) for damaged threads or debris.
6. Inspect the camshaft position sensor pass-thru hole and sealing surface (4) for excessive scratches or gouging.
7. Inspect the oil flow control valve connector pass-thru hole and sealing surface (6) for excessive scratches or gouging.

CRANKSHAFT REAR OIL SEAL HOUSING CLEANING AND INSPECTION

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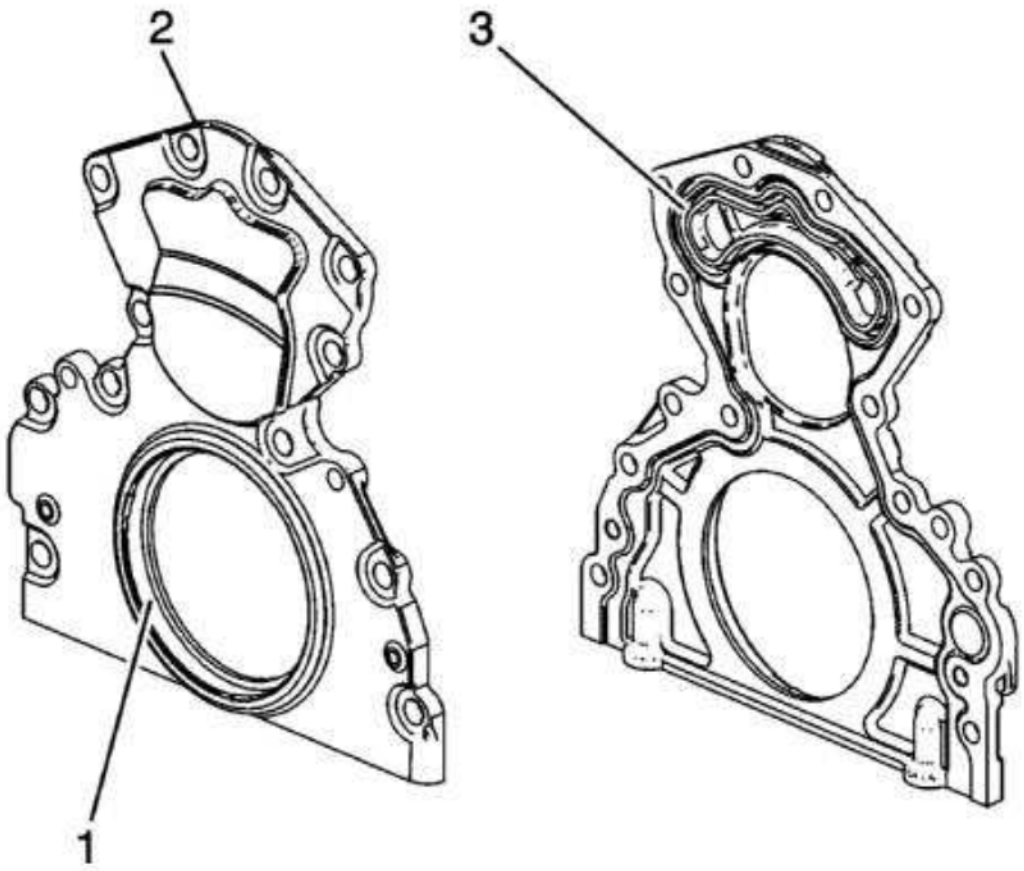

Fig. 435: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not use the crankshaft rear oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the rear housing-to-engine block gasket again. Install a NEW gasket during assembly.**

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Clean the housing in solvent. Remove the sealant from the housing surface. Refer to **Replacing Engine Gaskets** .

WARNING: Refer to Safety Glasses Warning .

3. Dry the housing with compressed air.
4. Inspect the gasket sealing surfaces (3) for excessive scratches or gouging.
5. Inspect the housing-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage (1).

ENGINE BLOCK VALLEY COVER CLEANING AND INSPECTION

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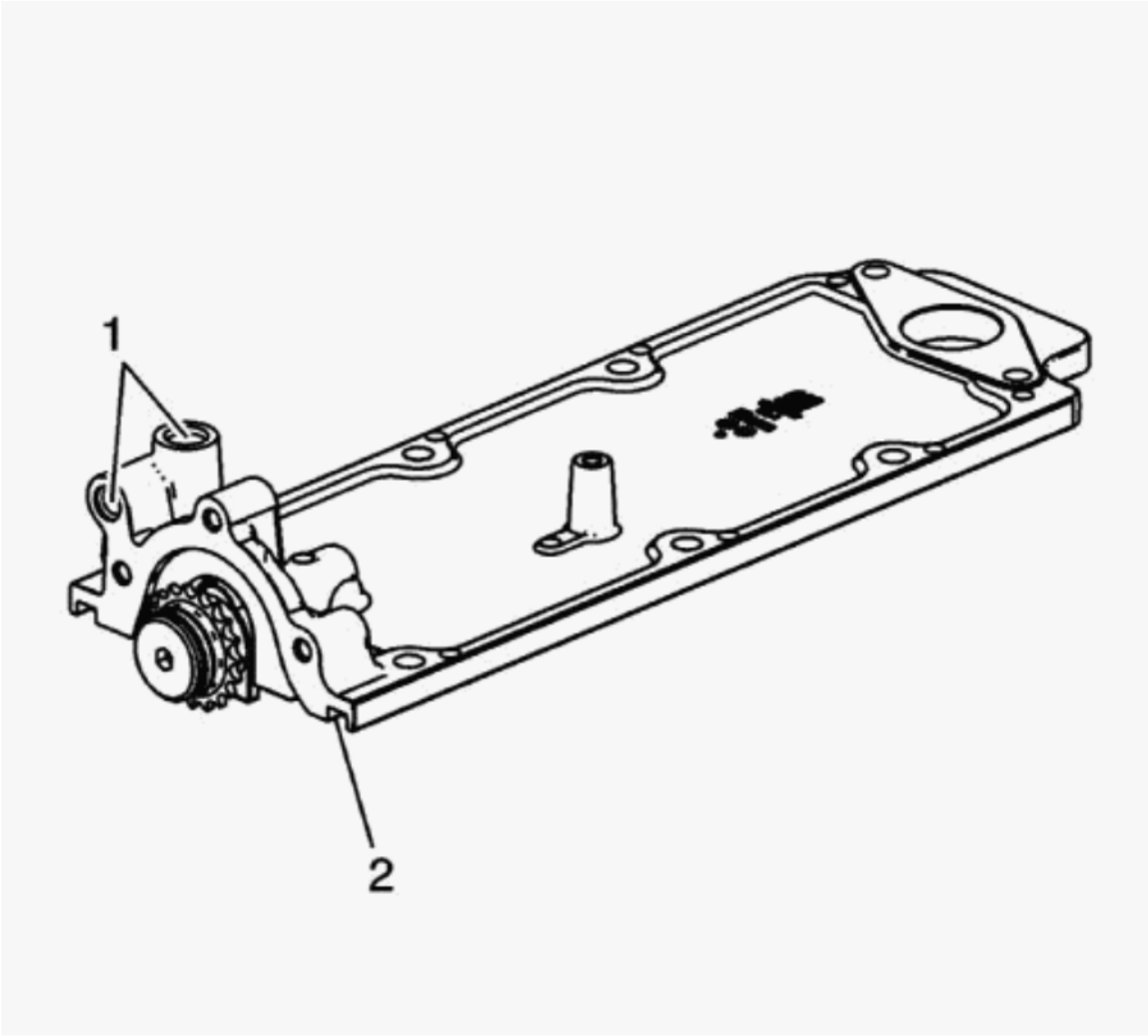

Fig. 436: Engine Block Valley Cover
Courtesy of GENERAL MOTORS COMPANY

1. Clean the valley cover in solvent.

WARNING: **Refer to Safety Glasses Warning .**

2. Dry with compressed air.
3. Inspect for damaged threads (1) and damaged sealing surfaces (2).

VALVE LIFTER OIL MANIFOLD CLEANING AND INSPECTION

NOTE:

- **DO NOT allow dirt or debris to enter the oil passages of the Valve Lifter Oil Manifold (VLOM). Plug, as required.**
- **DO NOT disassemble the electrical components from the VLOM.**
- **DO NOT submerge the electrical components in cleaning solvent.**
- **DO NOT use the VLOM outer gasket again. Remove the VLOM outer gasket and install a NEW VLOM outer gasket during assembly.**

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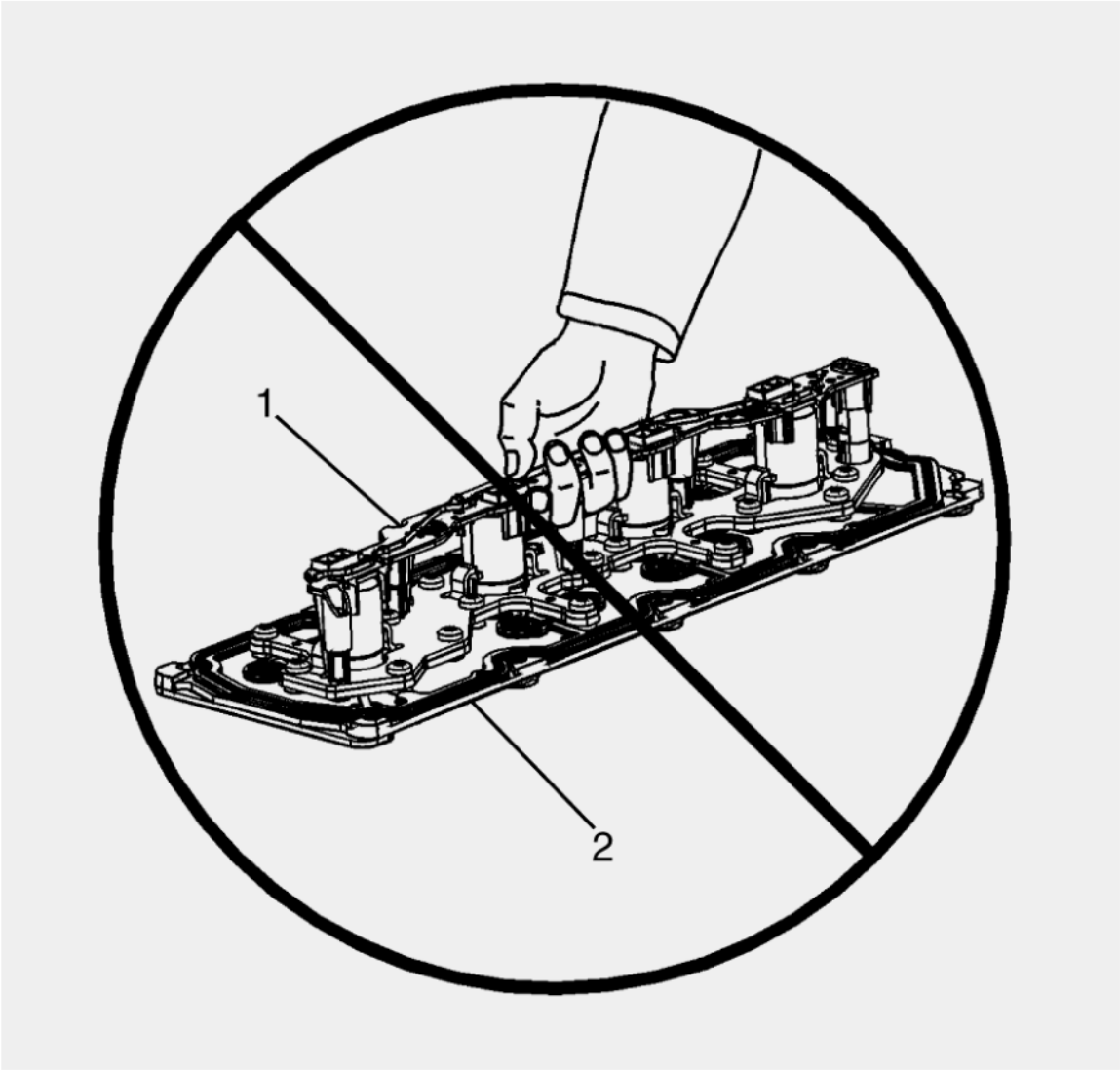

Fig. 437: Identifying Improper Lifting Of VLOM
Courtesy of GENERAL MOTORS COMPANY

1. DO NOT lift the VLOM (2) by the electrical lead frame (1).

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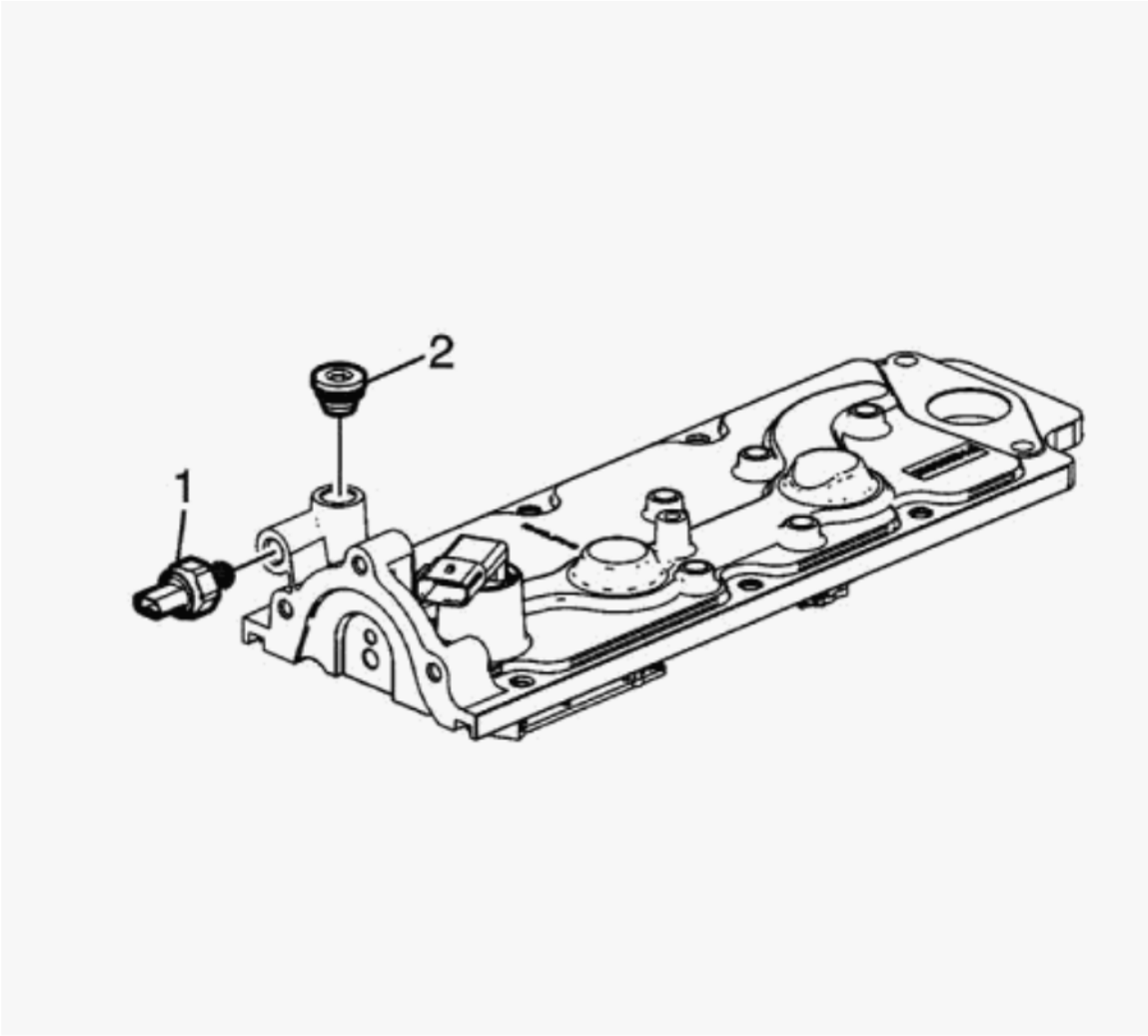

Fig. 438: Oil Pressure Sensor And VLOM
Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil pressure sensor (1) from the VLOM.
3. Remove the VLOM plug (2).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

4. Clean the VLOM with compressed air.

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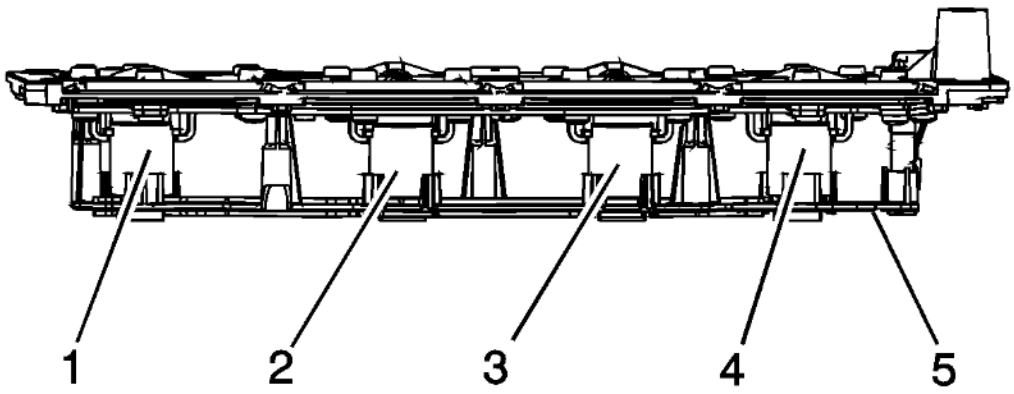

Fig. 439: Electrical Solenoids
Courtesy of GENERAL MOTORS COMPANY

5. Inspect for loose electrical solenoids (1-4) or loose or missing bolts.
6. Inspect for damage to the electrical lead frame (5).
7. Inspect for a damaged electrical connector, for bent or corroded pins.

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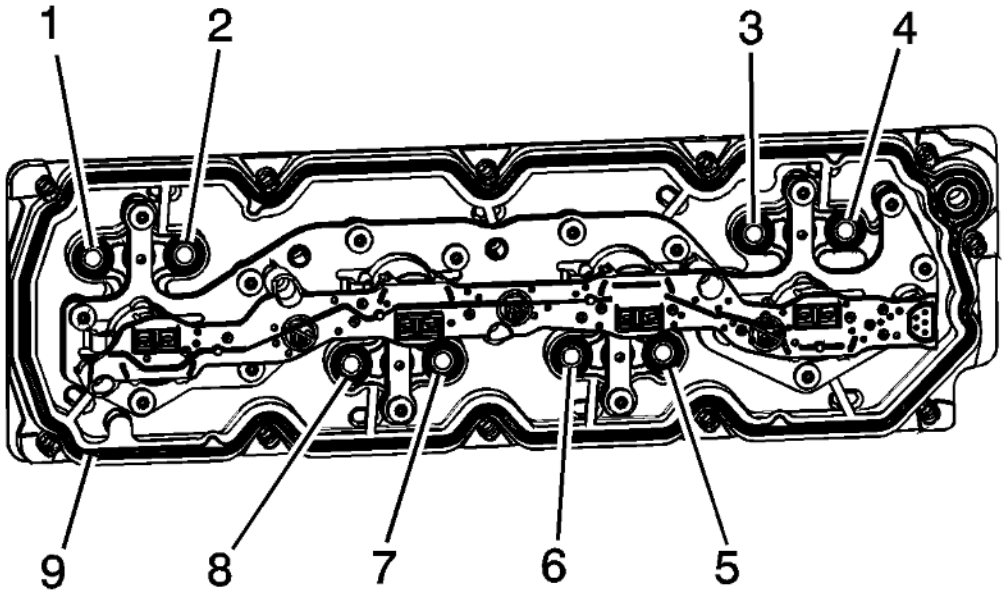

Fig. 440: Sealing Gaskets
Courtesy of GENERAL MOTORS COMPANY

8. Inspect for damaged VLOM inner gaskets (1-8). If the VLOM inner gaskets are damaged, the VLOM must be replaced as an assembly.
9. Inspect for a damaged VLOM outer gasket (9) or scored gasket surfaces.
10. Inspect for debris or restrictions within the oil passages of the VLOM. Refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

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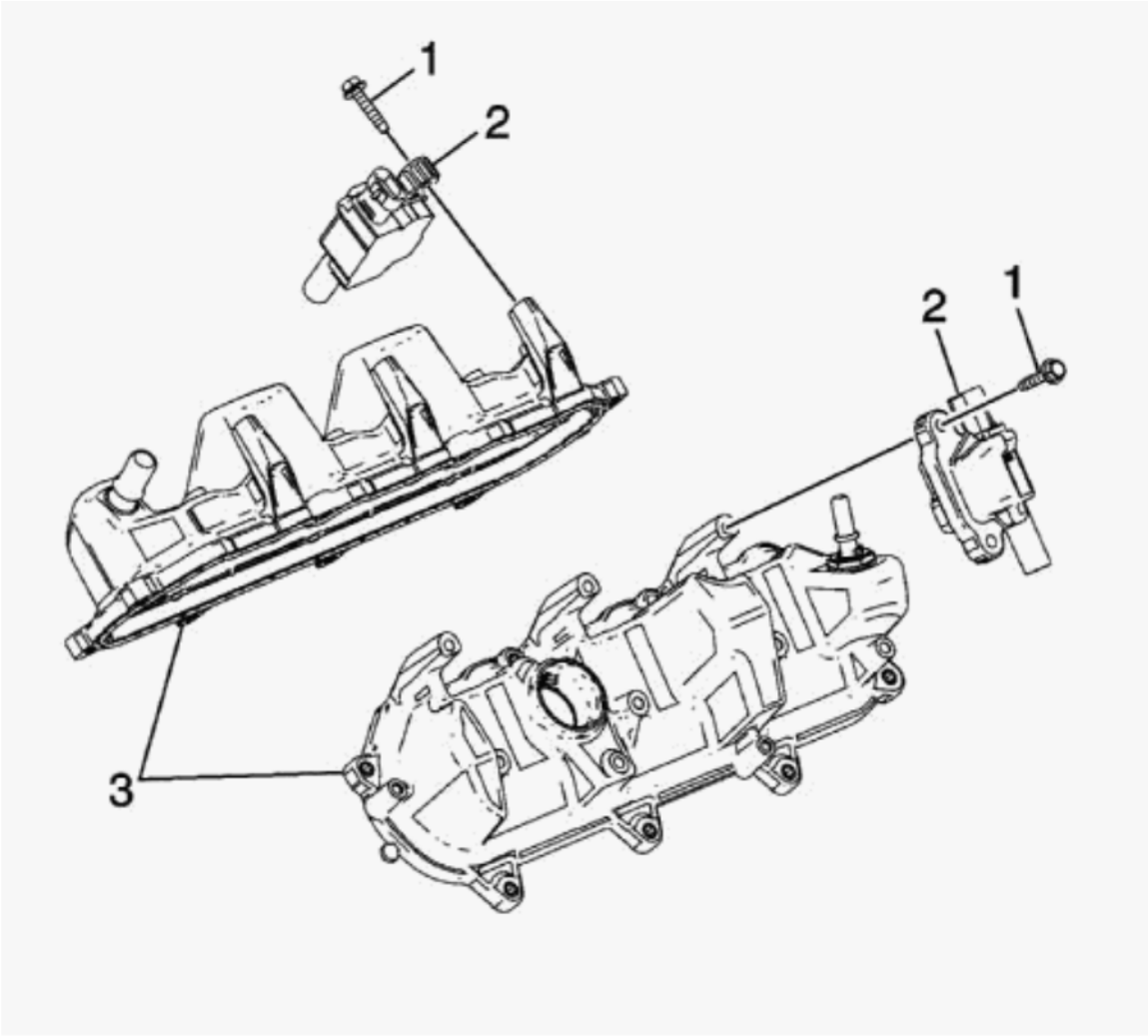

Fig. 441: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT:

- Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.
- Remove the ignition bolts (1) and coils (2) before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.

1. Inspect the covers (3) 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 DISASSEMBLE

Oil Filter Fitting and Cup Plug Removal

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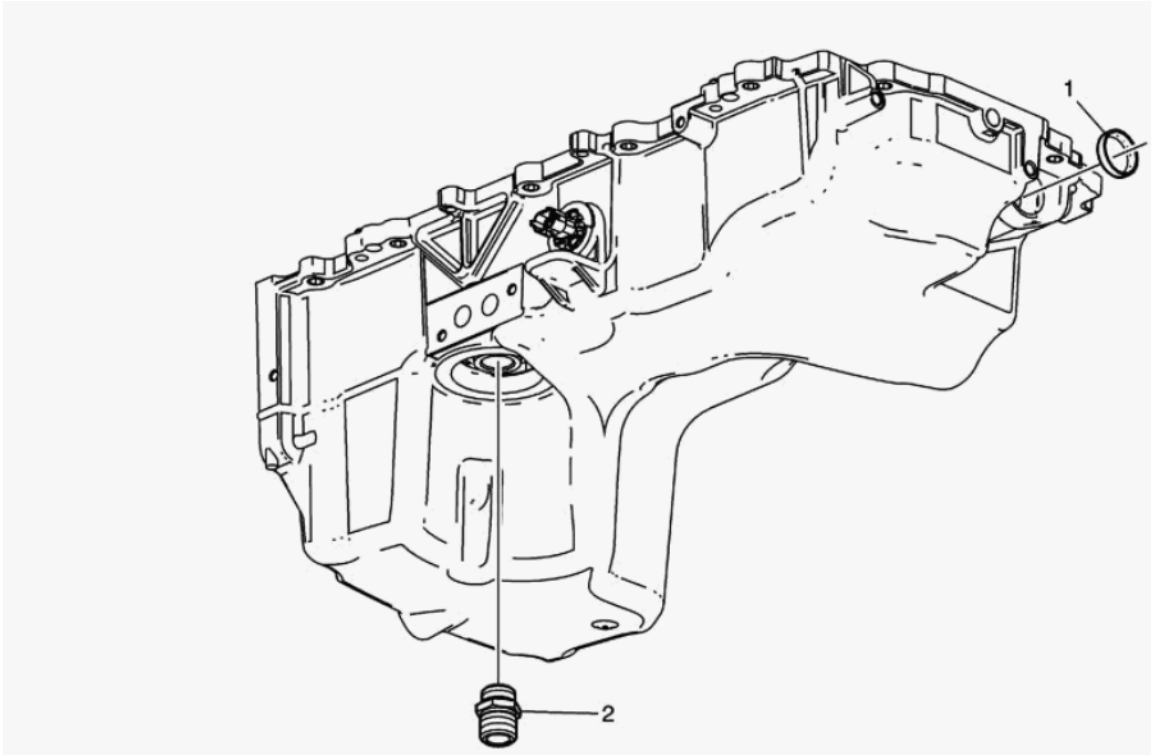

Fig. 442: Oil Filter Fitting and Cup Plug
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Fitting and Cup Plug Removal

Callout	Component Name
1	Oil Pan Cup Plug
2	Oil Filter Fitting

Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal, and Oil Level Indicator Switch Removal

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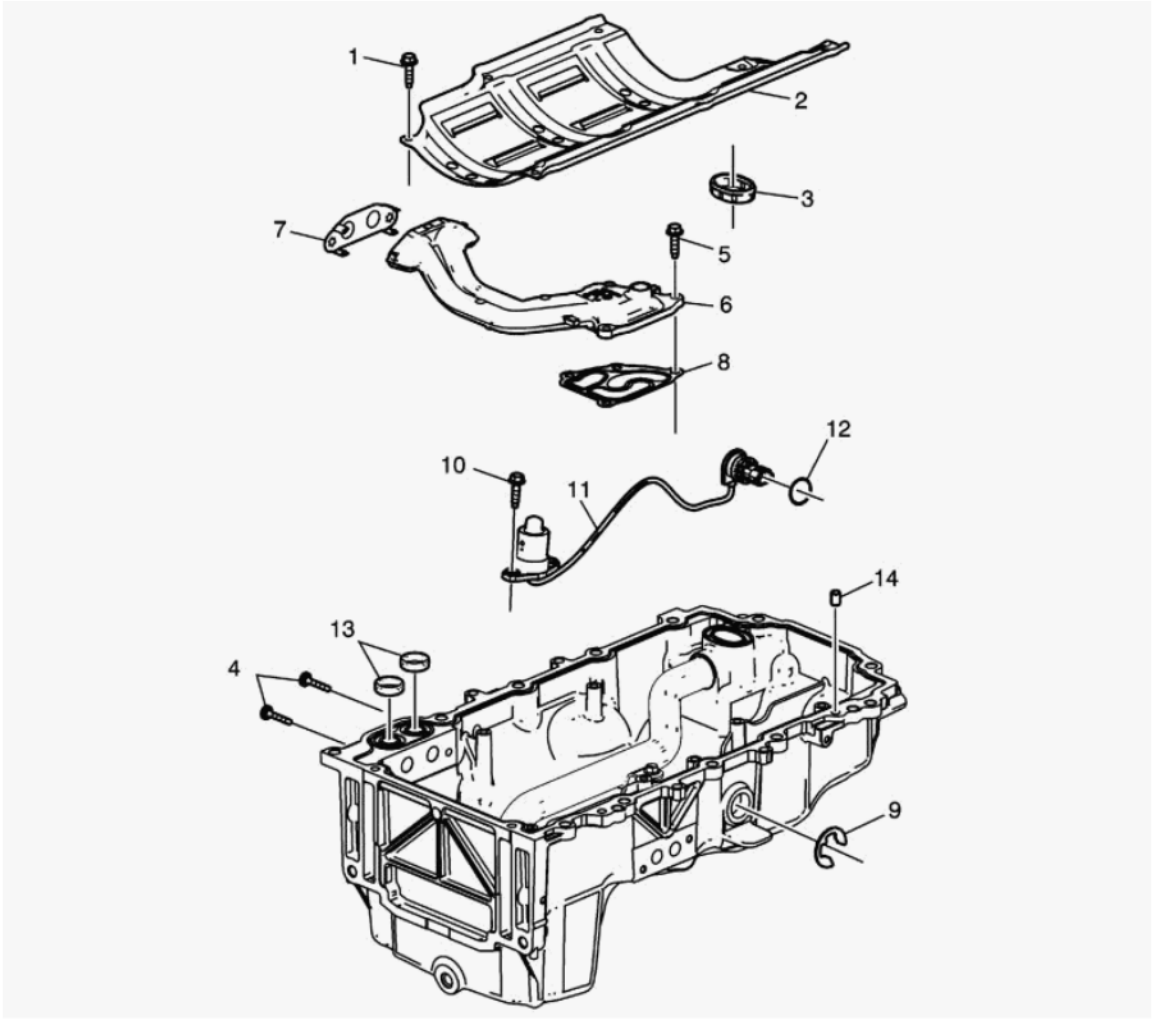

Fig. 443: Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal and Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal, and Oil Level Indicator Switch Removal

Callout	Component Name
1	Crankshaft Oil Deflector Bolt
2	Crankshaft Oil Deflector
3	Oil Pan Front Seal **NOTE:** **Discard seal, it is not reusable.**
4	Oil Filter Center Tube Bolt - Outer
5	Oil Filter Center Tube Bolt - Inner
6	Oil Filter Center Tube Assembly
7	Oil Filter Center Tube Gasket **NOTE:** **Discard gasket, it is not reusable.**

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Callout	Component Name
8	Oil Filter Center Tube Gasket **NOTE:** **Discard gasket, it is not reusable.**
9	Oil Level Sensor Lead Clip
10	Oil Level Indicator Switch Bolt
11	Oil Level Indicator Switch
12	Oil Level Indicator Switch Seal **NOTE:** **Discard seal, it is not reusable.**
13	Oil Pan High Pressure Port Seal **NOTE:** **Discard seal, it is not reusable.**
14	Oil Pan Locating Pin

OIL PAN CLEANING AND INSPECTION

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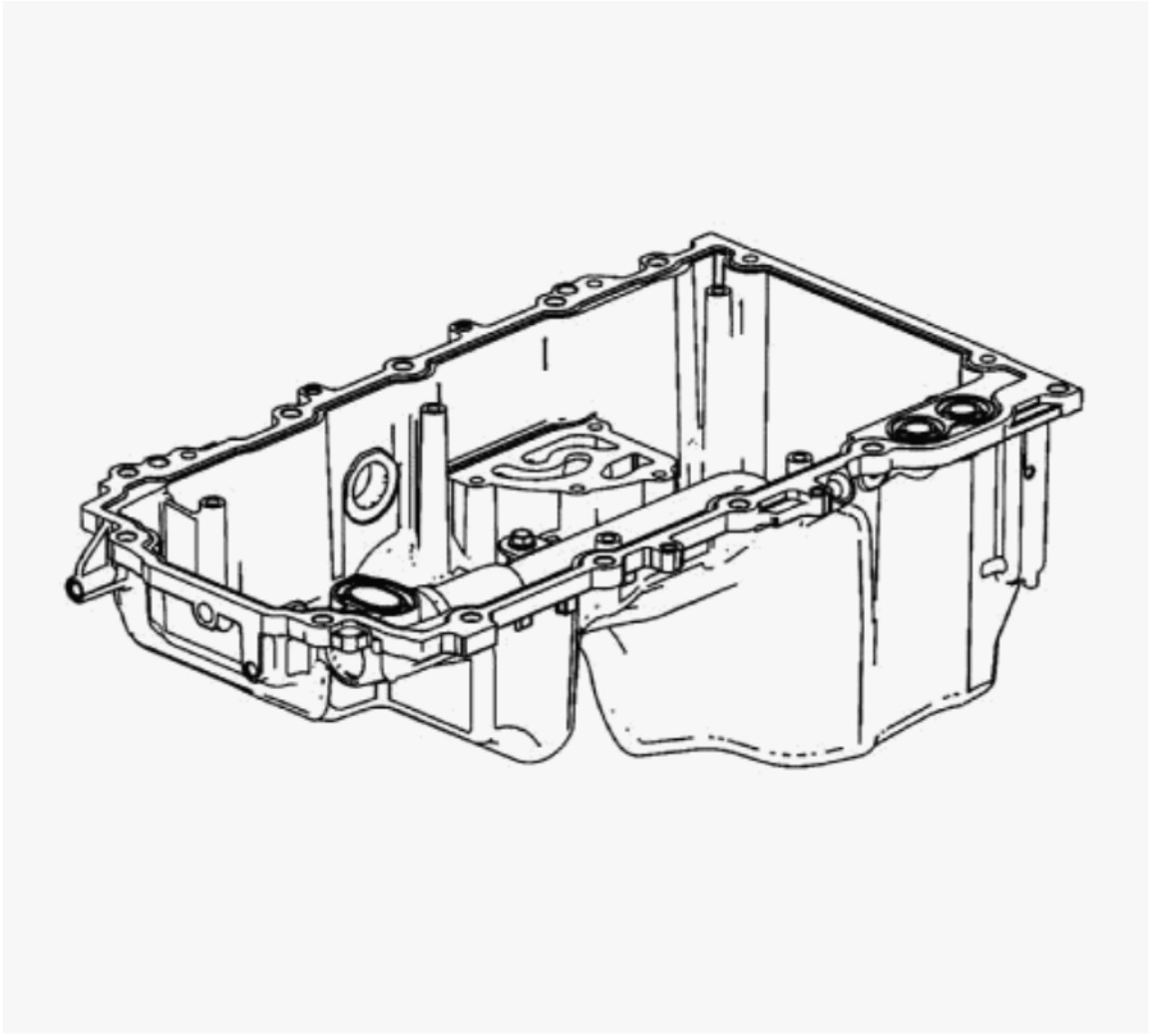

Fig. 444: Oil Pan
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not remove the pickup tube.**

Inspect the oil pan for the following conditions:

- Damaged gasket surfaces
- Restrictions within the oil passages of the pan
- Damaged oil filter seal surface

OIL PAN ASSEMBLE

Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal, and Oil Level Indicator Switch Installation

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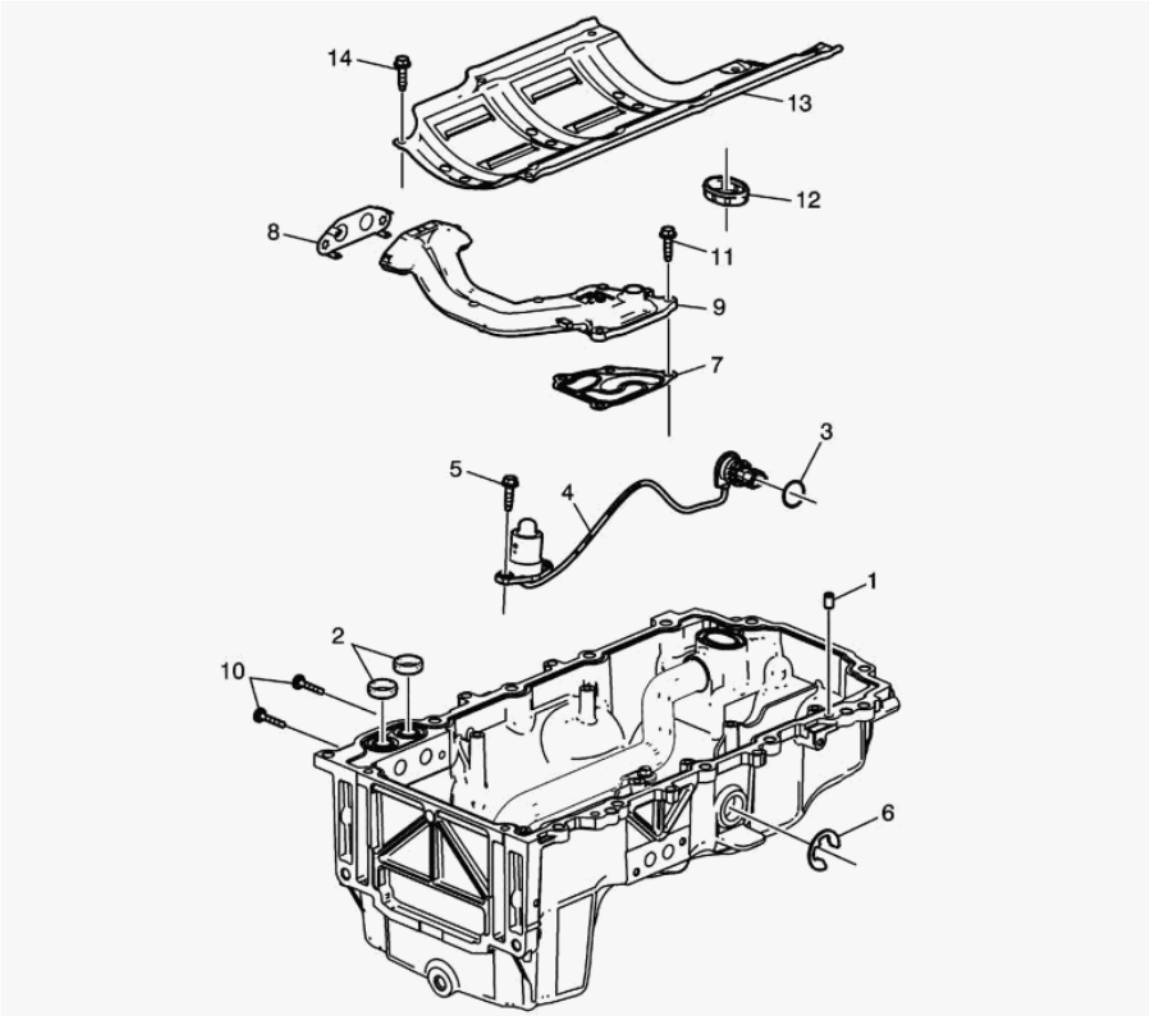

Fig. 445: Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal and Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Oil Deflector, Center Tube, High Pressure Port Seal, and Oil Level Indicator Switch Installation

Callout	Component Name
1	Oil Pan Locating Pin
2	Oil Pan High Pressure Port Seal **NOTE:** **Must use a NEW seal.**
3	Oil Level Indicator Switch Seal **NOTE:** **Must use a NEW seal.**
4	Oil Level Indicator Switch
5	Oil Level Indicator Switch Bolt **Tighten** 10 N.m (88 lb in)
6	Oil Level Sensor Lead Clip

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Callout	Component Name
7	Oil Filter Center Tube Gasket **NOTE:** **Must use a NEW gasket.**
8	Oil Filter Center Tube Gasket **NOTE:** **Must use a NEW gasket.**
9	Oil Filter Center Tube Assembly
10	Oil Filter Center Tube Bolt - Outer **Tighten** 10 N.m (88 lb in)
11	Oil Filter Center Tube Bolt - Inner **Tighten** 10 N.m (88 lb in)
12	Oil Pan Front Seal **NOTE:** **Must use a NEW seal.**
13	Crankshaft Oil Deflector
14	Crankshaft Oil Deflector Bolt **Tighten** 10 N.m (88 lb in)

Oil Filter Fitting and Cup Plug Installation

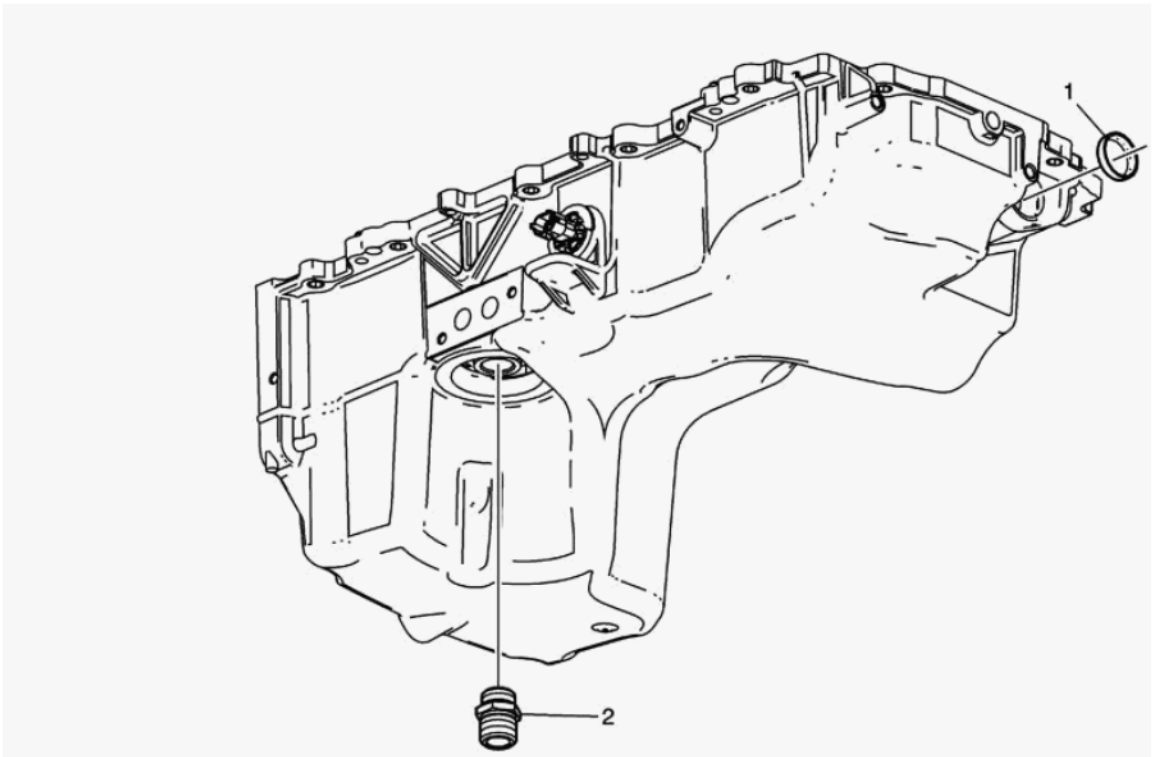

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Fig. 446: Oil Filter Fitting and Cup Plug
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Fitting and Cup Plug Installation

Callout	Component Name
1	Oil Pan Cup Plug
2	Oil Filter Fitting **Tighten** 55 N.m (40 lb ft)

VACUUM PUMP CLEANING AND INSPECTION

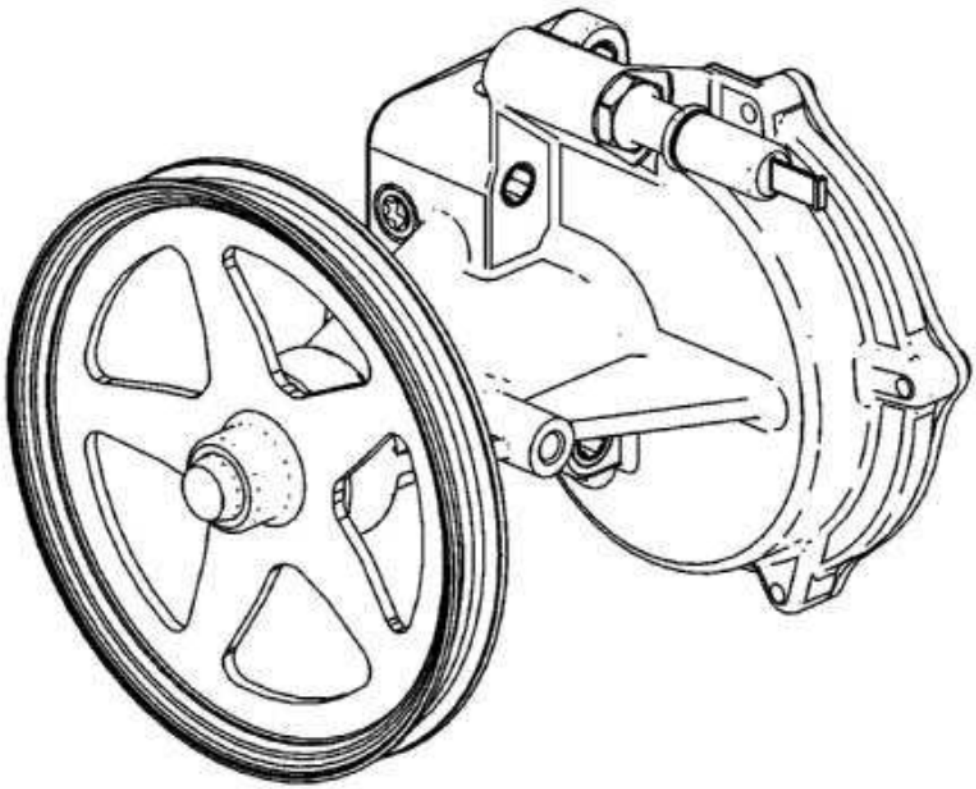

Fig. 447: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

1. Remove the old gasket from the vacuum pump sealing surfaces. Refer to **Replacing Engine Gaskets**.
2. Clean all excess dirt and debris from the vacuum pump housing.
3. Inspect the vacuum pump for the following conditions:
   - Gasket and hose sealing surfaces for excessive scratches or gouging
   - Excessive side-to-side play in the pulley shaft
   - Leakage at the vacuum inlet housing or rear cover
   - Leakage at the vacuum pump vent hole

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- Wear or damage in the belt tracking area of the pulley

INTAKE MANIFOLD CLEANING AND INSPECTION

Cleaning Procedure

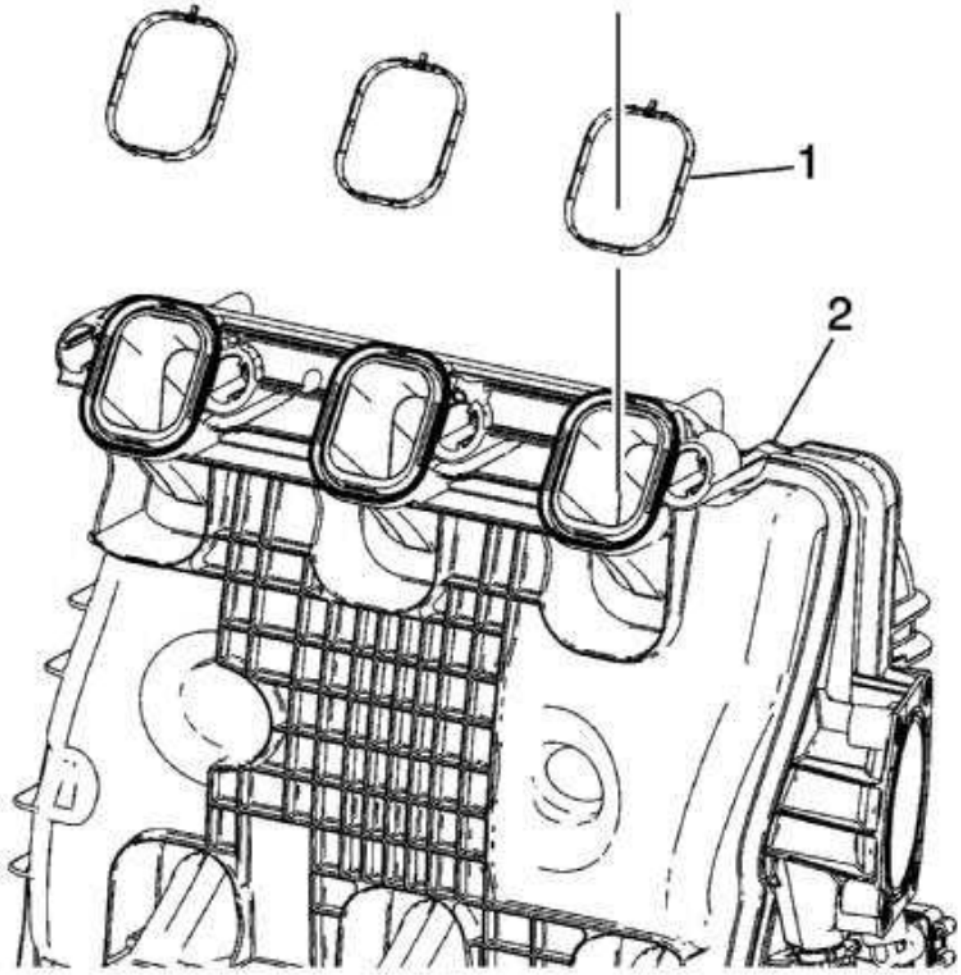

Fig. 448: Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Remove and discard the intake manifold-to-cylinder head gaskets (1).

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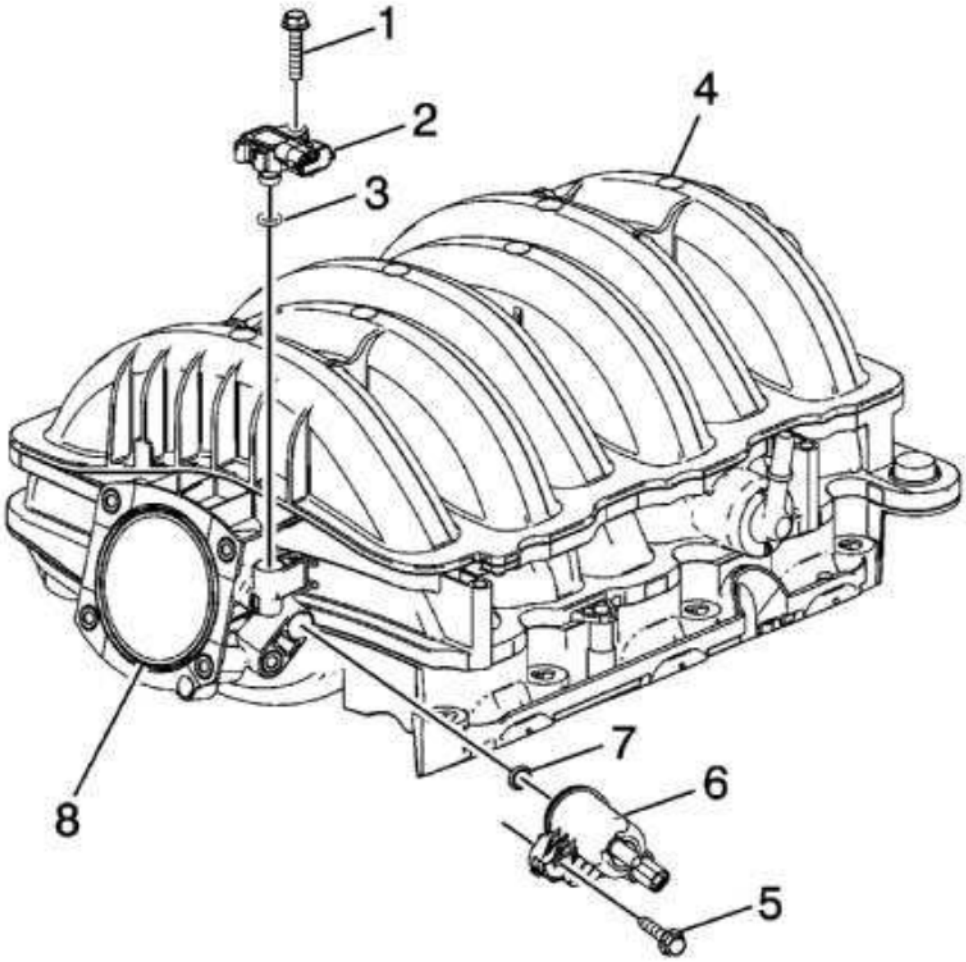

Fig. 449: Manifold Absolute Pressure (MAP) Sensor Bolt, MAP Sensor And Seal
Courtesy of GENERAL MOTORS COMPANY

2. Remove the manifold absolute pressure (MAP) sensor bolt (1), MAP sensor (2), and seal (3).
3. Remove the evaporative emission (EVAP) canister purge solenoid valve bolt (5), EVAP canister purge solenoid valve (6), and seal (7).
4. Clean the intake manifold (4) in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

5. 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.

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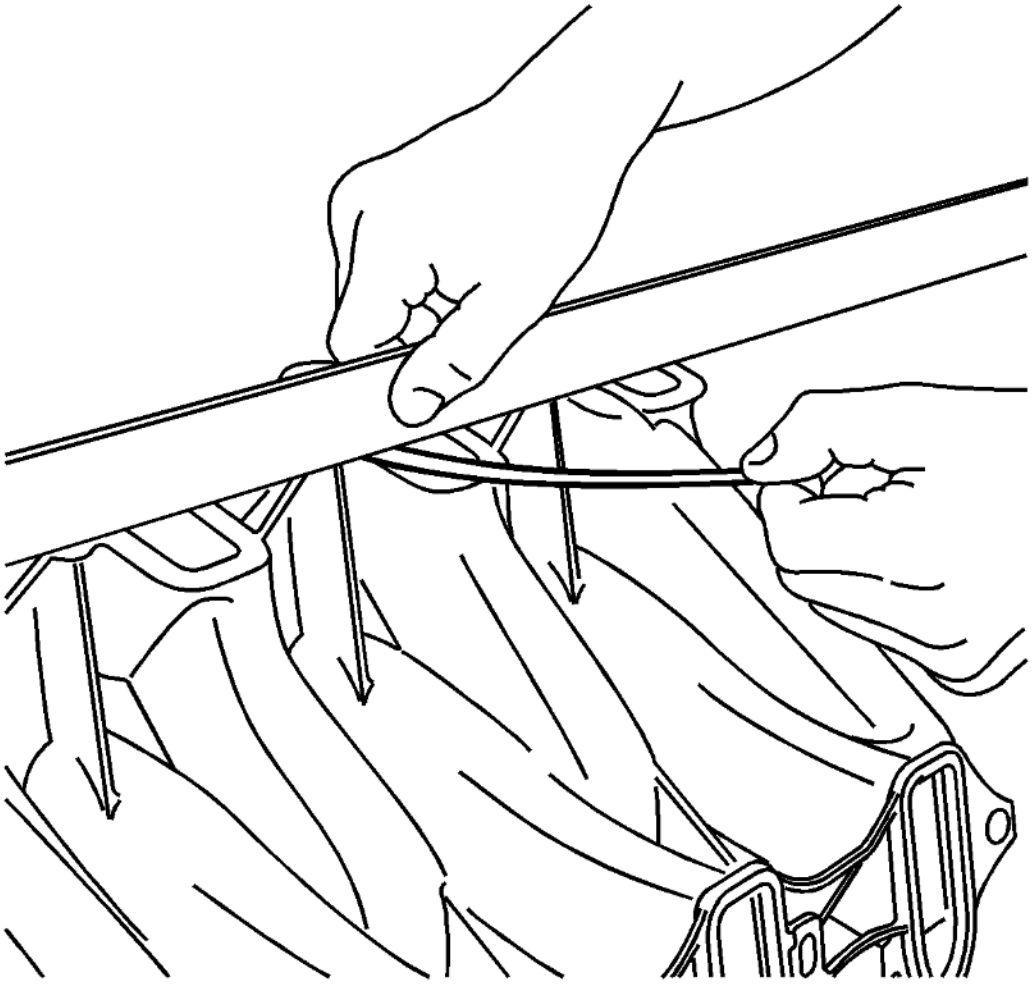

Fig. 450: Inspecting Intake Manifold Cylinder Head Deck For Warpage
Courtesy of GENERAL MOTORS COMPANY

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 gauge between the intake manifold and the straight edge.

       An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION

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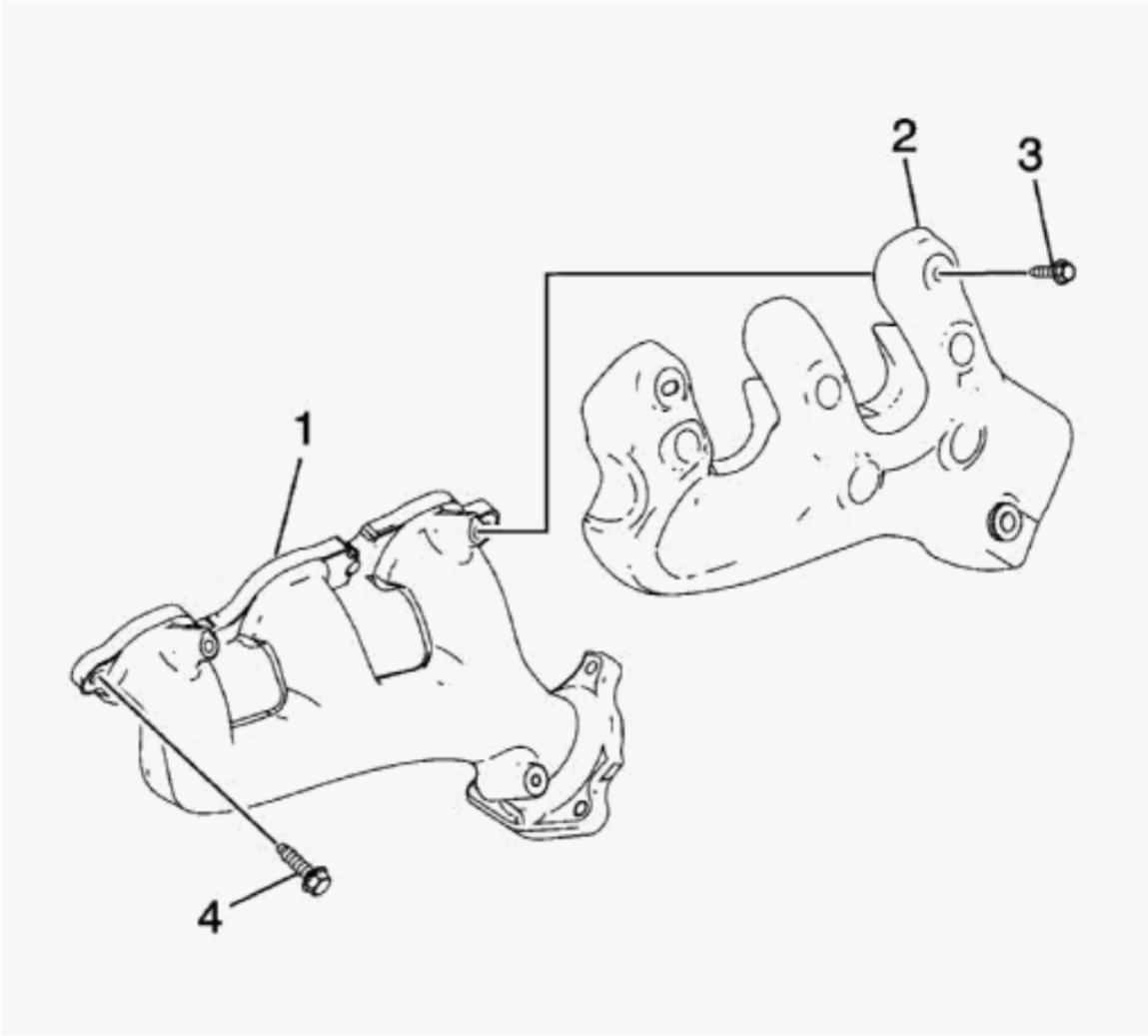

Fig. 451: Exhaust Manifold And Heat Shield
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may affect on-board diagnostics (OBD) II system performance.**

1. Clean the exhaust manifold (1) and heat shield (2) in solvent.

WARNING: **Refer to Safety Glasses Warning .**

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 (2).
5. Inspect the bolts (3 and 4) for damaged threads.

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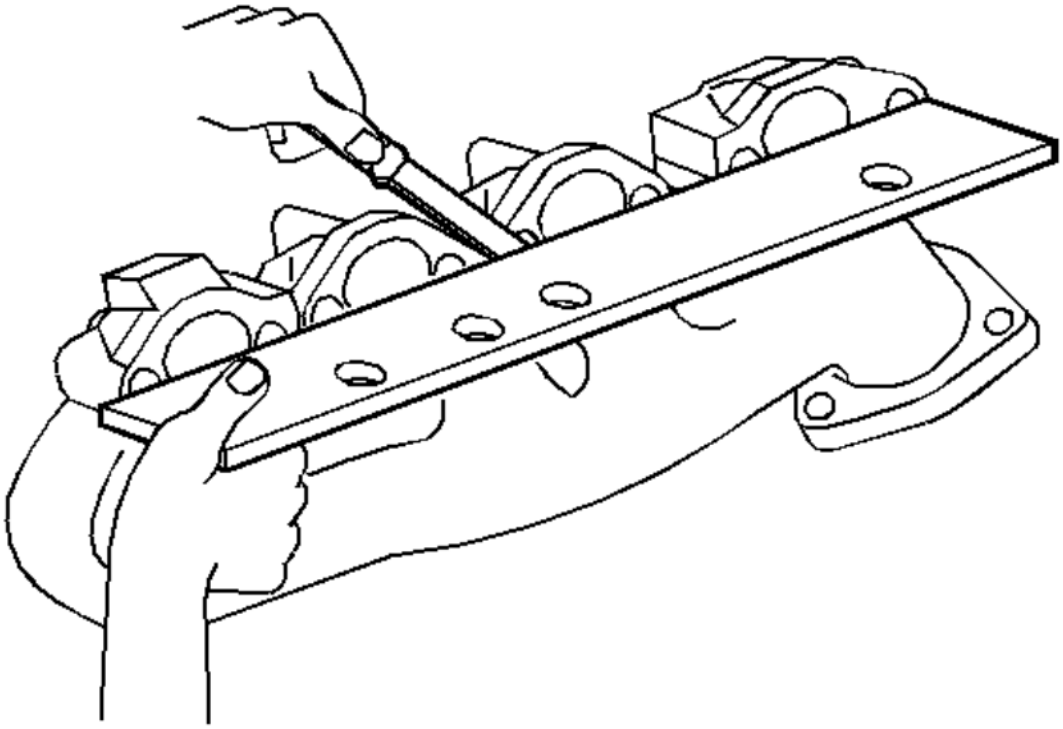

Fig. 452: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS COMPANY

6. Use a straight edge and a feeler gauge 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 2 front or 2 rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

ENGINE COOLANT MANIFOLD DISASSEMBLE

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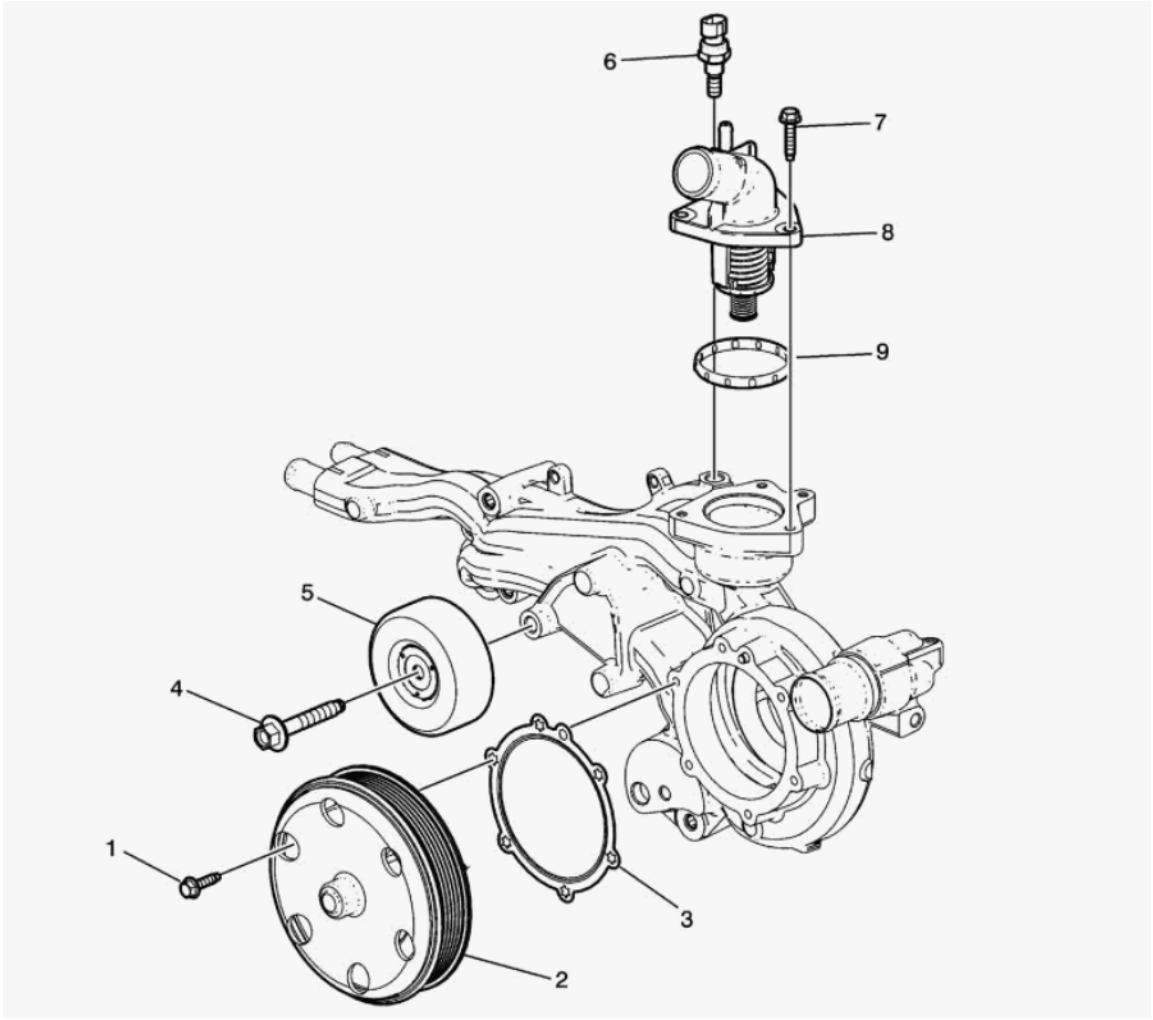

Fig. 453: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Assembly Bolts
2	Water Pump Assembly
3	Water Pump Assembly Gasket **NOTE:** **Discard gasket, it is not reusable.** Refer to **Replacing Engine Gaskets**.
4	Belt Idler Pulley Bolt
5	Belt Idler Pulley
6	Engine Coolant Temperature Sensor
7	Water Pump Outlet Bolt
8	Water Pump Outlet Assembly (with Thermostat)
9	Water Pump Outlet Gasket

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Callout	Component Name
	NOTE: Discard gasket, it is not reusable.

ENGINE COOLANT MANIFOLD CLEANING AND INSPECTION

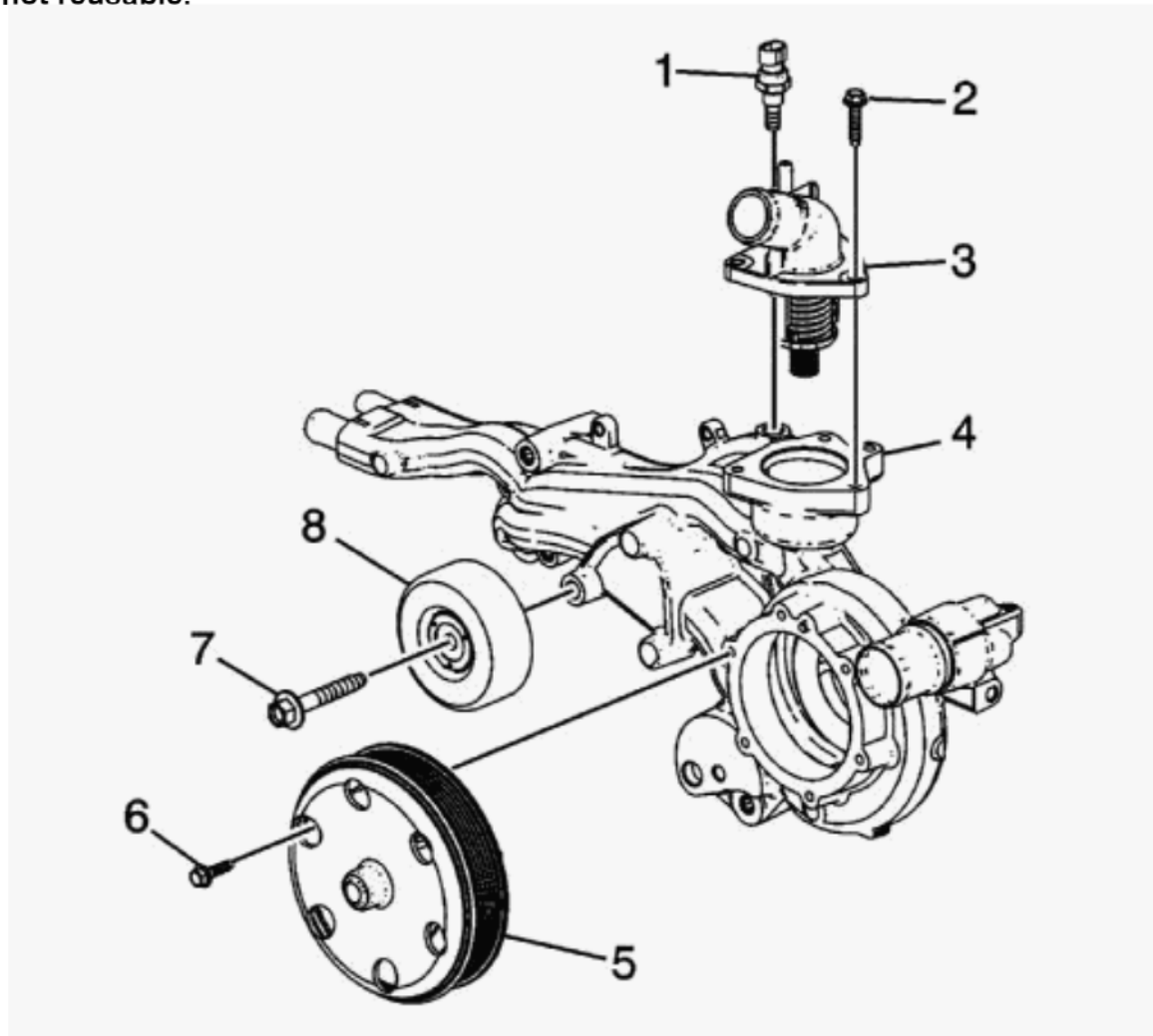

Fig. 454: Water Output Flange And Thermostat Housing
Courtesy of GENERAL MOTORS COMPANY

1. Clean all excess dirt and debris from the engine coolant manifold housing.
2. Inspect for leakage between the water output flange (4) and the water pump outlet assembly (3).
3. Inspect the water pump 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 inlet housing or rear cover
   - Leakage at the water outlet housing or water pump outlet assembly
   - 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.

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- Wear or damage in the belt tracking area of the pulley

ENGINE COOLANT MANIFOLD ASSEMBLE

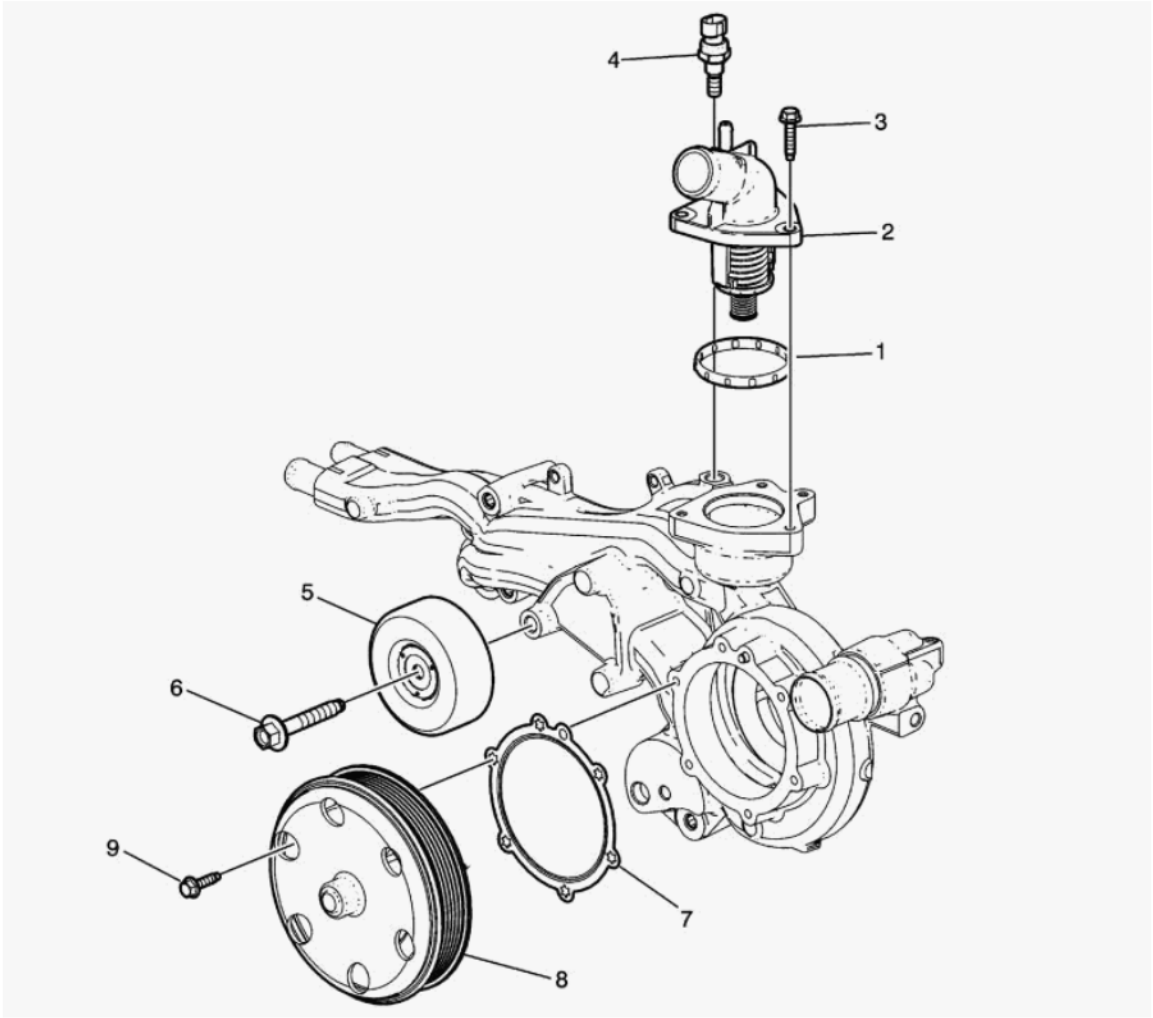

Fig. 455: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Outlet Gasket **NOTE:** **Install a NEW Gasket.**
2	Water Pump Outlet Assembly (with Thermostat)
3	Water Pump Outlet Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure**

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Callout	Component Name
	1. Install and hand tighten all three bolts. 2. Tighten bolts to final torque. **Tighten** 10 N.m (88 lb in)
4	Engine Coolant Temperature Sensor **Tighten** 20 N.m (15 lb ft)
5	Belt Idler Pulley
6	Belt Idler Pulley Bolt **Tighten** 20 (15 lb ft)
7	Water Pump Assembly Gasket **NOTE:** **Install a NEW Gasket.**
8	Water Pump Assembly
9	Water Pump Assembly Bolt **Tighten** 10 N.m (88 lb in)

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- **EN-49245** Injector Seal Installer Kit
- **EN-51097** Injector Retaining Clip Installer and Sizer
- **EN-51105** Injector Seal Installer and Sizer

For equivalent regional tools, refer to **Special Tools**.

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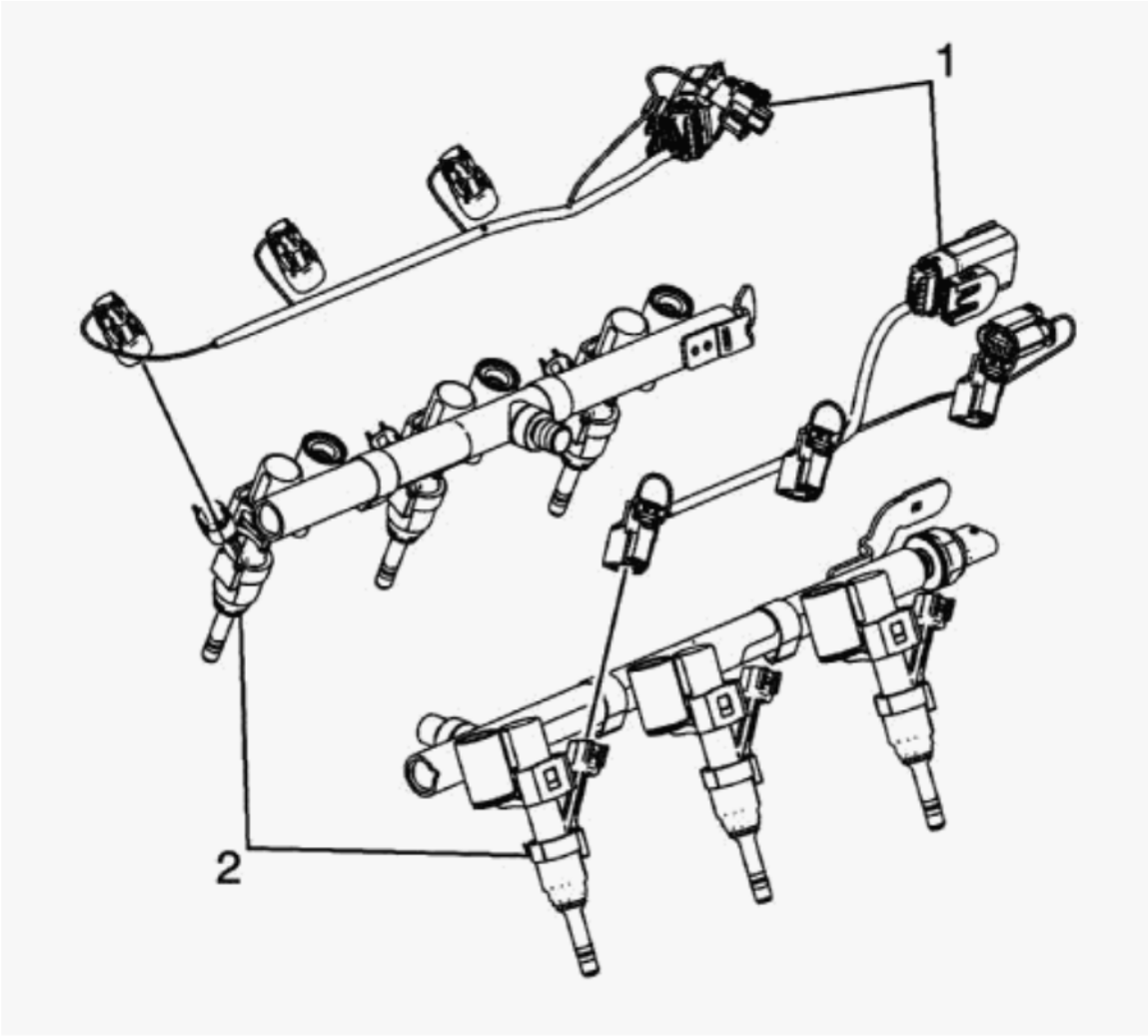

Fig. 456: Fuel Rail Wiring Harnesses
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect and remove the fuel rail wiring harnesses (1).

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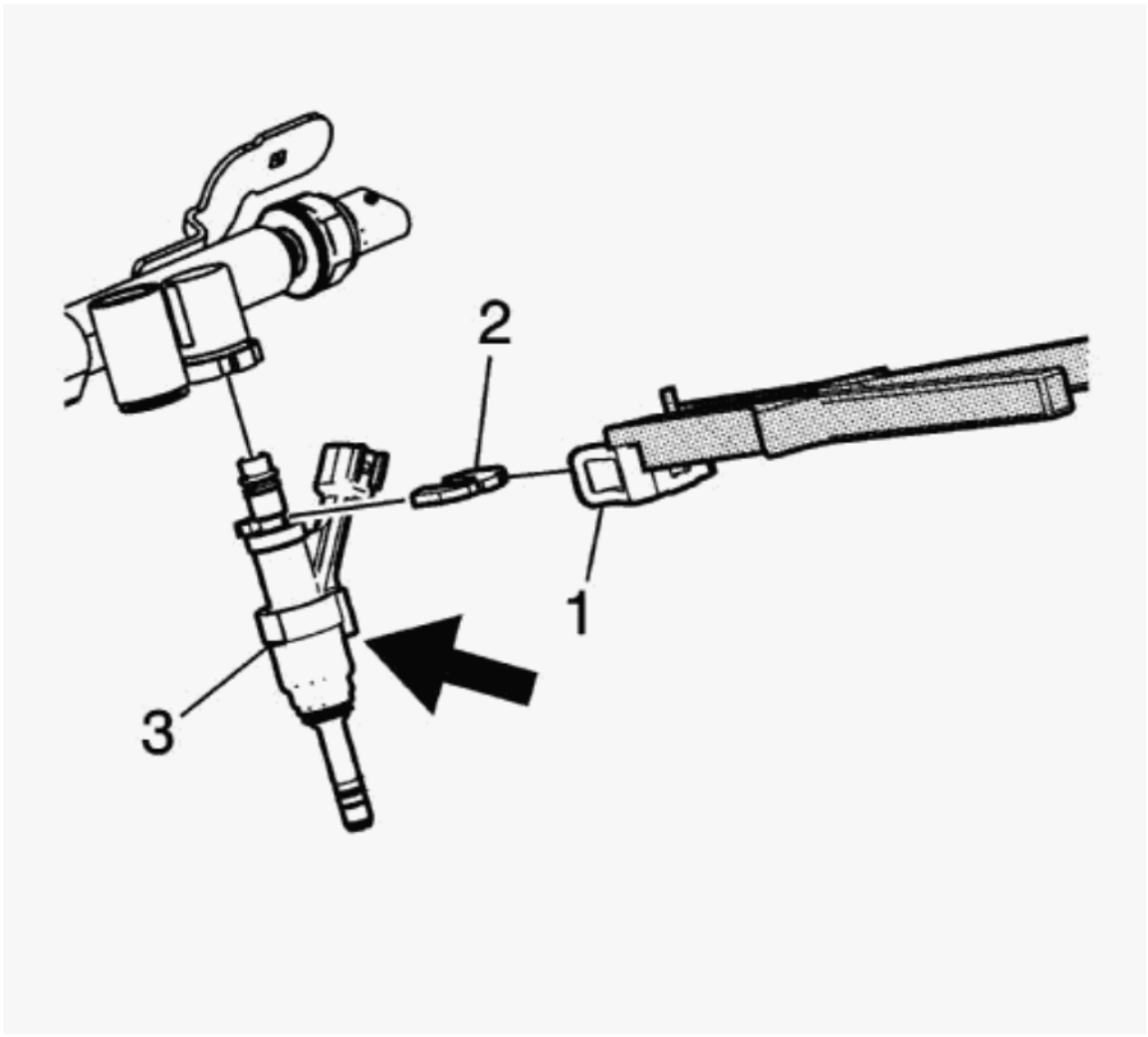

Fig. 457: Fuel Injector Retainer Clips
Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the fuel injector retainer clips (1) by installing **EN-51097** injector retaining clip installer and spreading both sides of the clip evenly.
3. Remove the fuel injector collars (2).

Fig. 458: Fuel Injector Dust Seal

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Courtesy of GENERAL MOTORS COMPANY

NOTE: **Some vehicles were not originally equipped with fuel injector dust seals. A NEW seal must be installed when the injectors are removed.**

4. Remove and DISCARD the fuel injector dust seal (1).

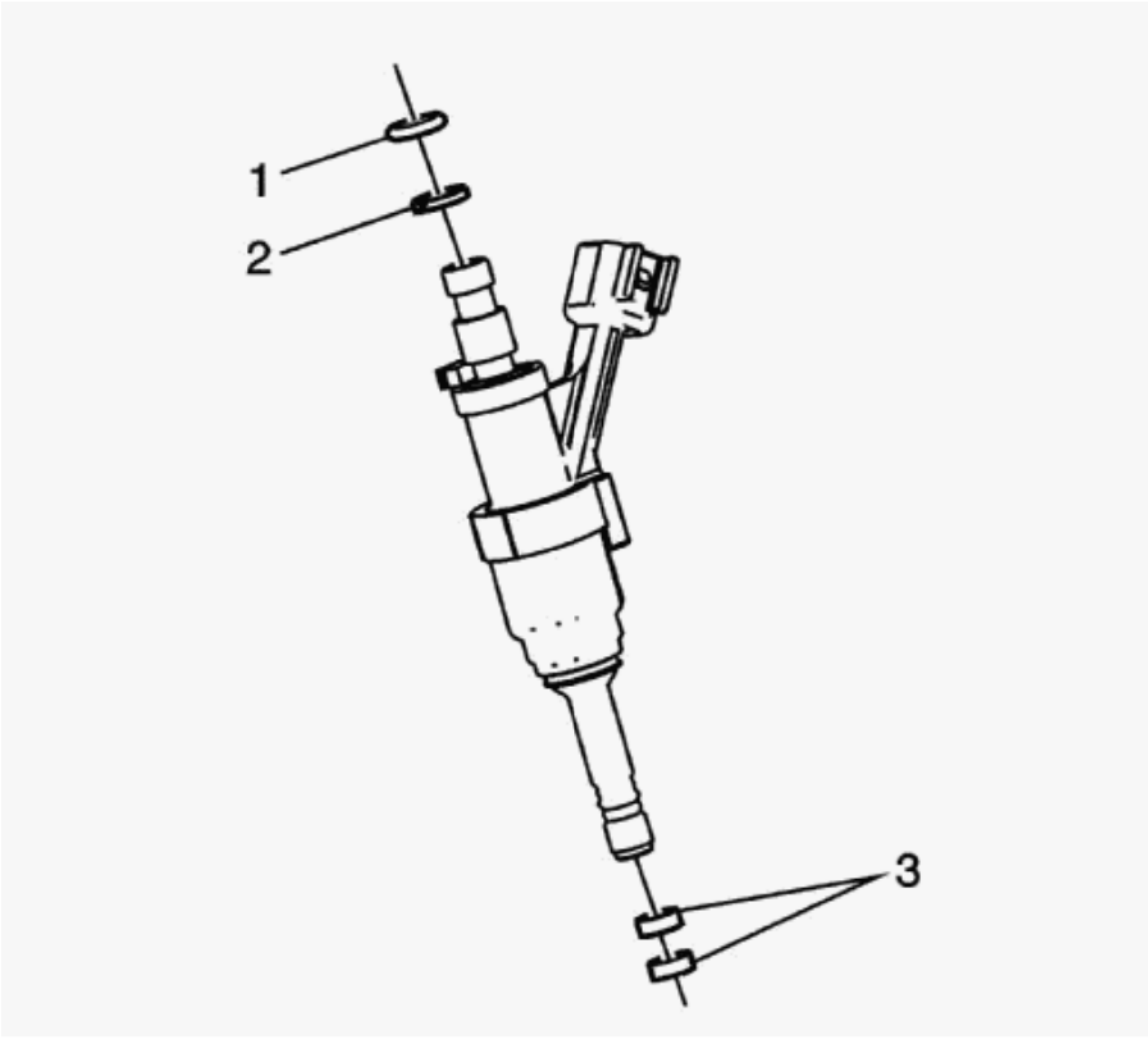

Fig. 459: Fuel Injector O-Ring And Plastic Spacer
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Do not use a metal tool to remove O-rings, spacers or injector seals. Care must be taken not to scratch or damage the tubes of the injector.**

5. Remove and discard the fuel injector O-ring (1) and plastic spacer (2).
6. Remove and discard the fuel injector seals (3).

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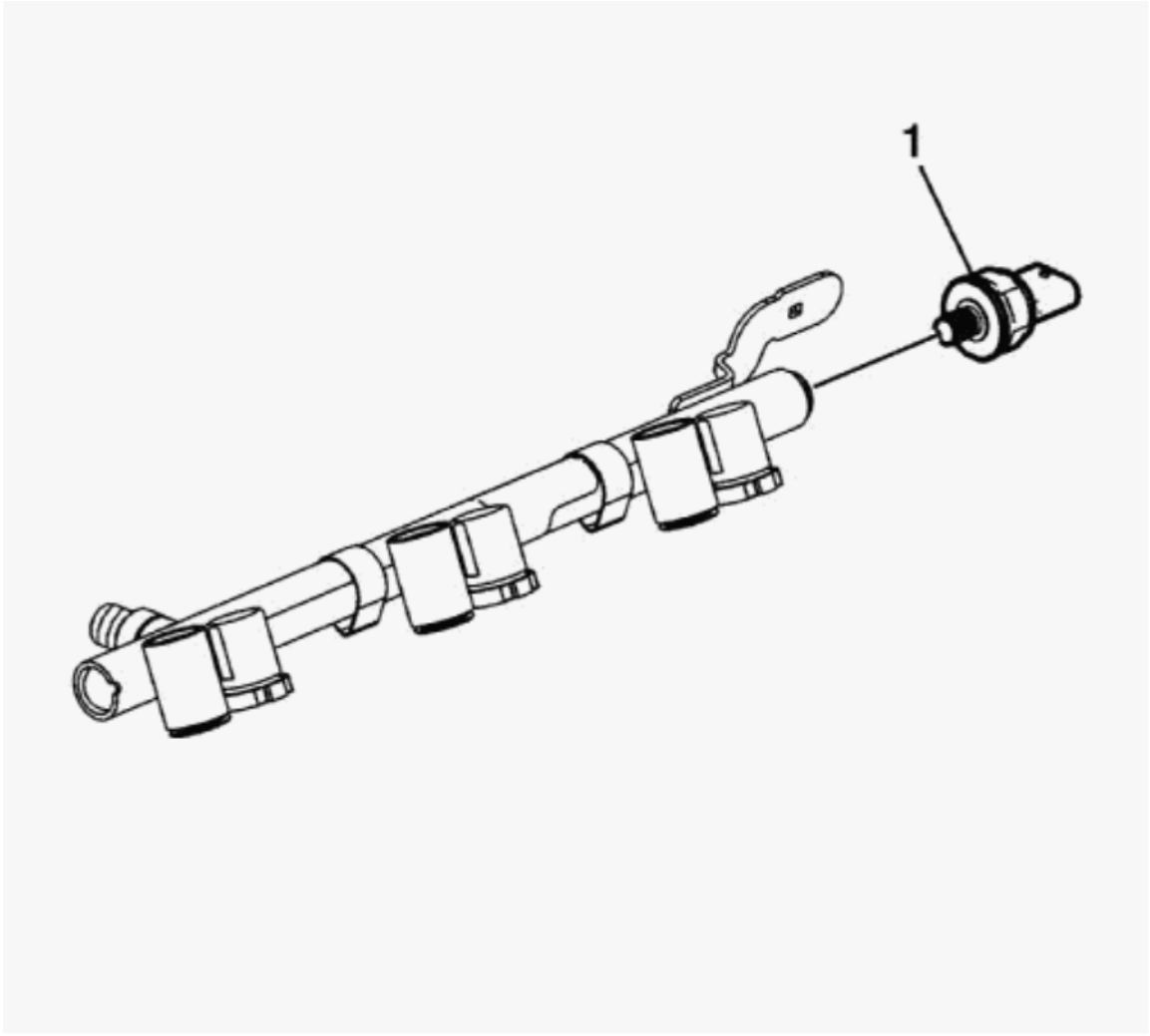

Fig. 460: Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

7. Remove the fuel pressure sensor (1) from the LH fuel rail.

NOTE: **Do not soak or submerge the fuel rail or injectors in solvent.**

8. Clean the exterior of the fuel rail and injectors with solvent.

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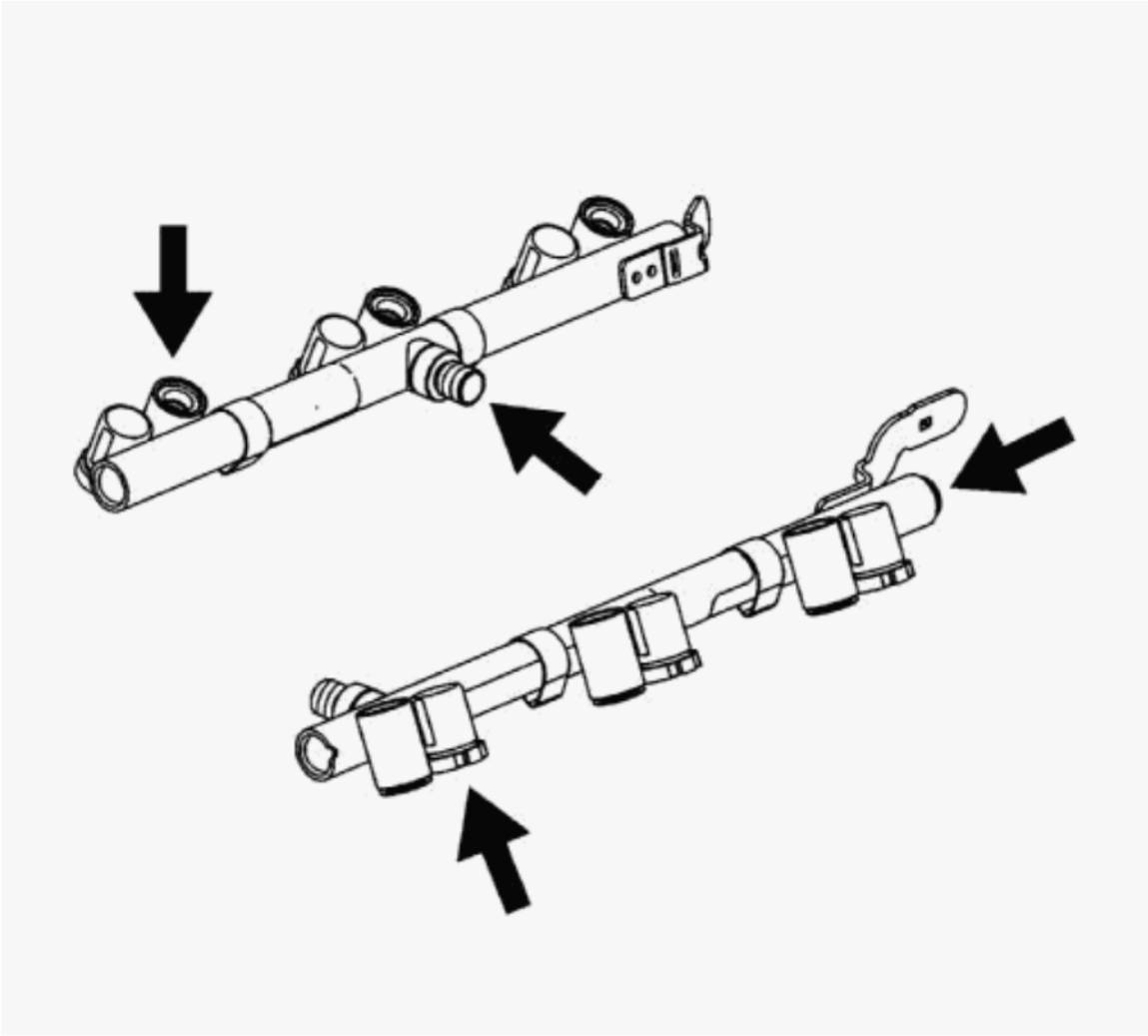

Fig. 461: Fuel Rail And Components
Courtesy of GENERAL MOTORS COMPANY

9. Inspect the fuel rail and components for the following conditions:
    - Damage, debris or restrictions to the fuel rail
    - Damage, debris or restrictions to the fuel ports in the fuel rail
    - Damage to the mounting area for the fuel rail
    - Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
    - Damage to the threads on the fuel rail feed fitting
    - Damage to the threads in the fuel pressure sensor bore
    - Damage to the fuel pressure sensor connector, threads, or sealing face

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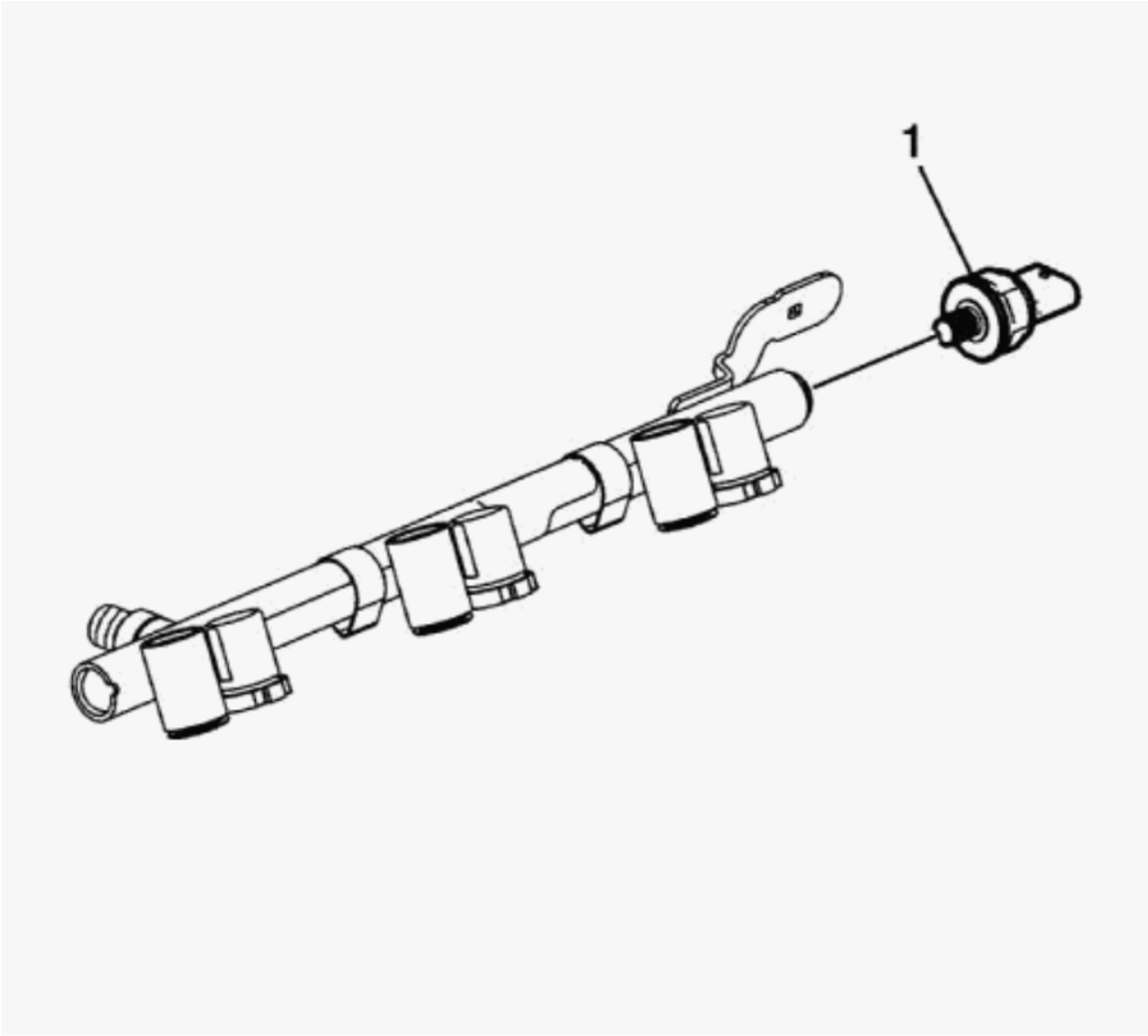

Fig. 462: Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

10. Install the fuel pressure sensor (1).

NOTE: **Ensure that the fuel rail threads have been cleaned of any excess fuel or the fuel pressure sensor will NOT seal properly.**

11. Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.
12. Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.
13. Install the fuel pressure sensor hand tight.
14. Remove the fuel pressure sensor and re-lubricate.

CAUTION: **Refer to Fastener Caution .**

15. Install the fuel pressure sensor and tighten to 33 N.m (24 lb ft)

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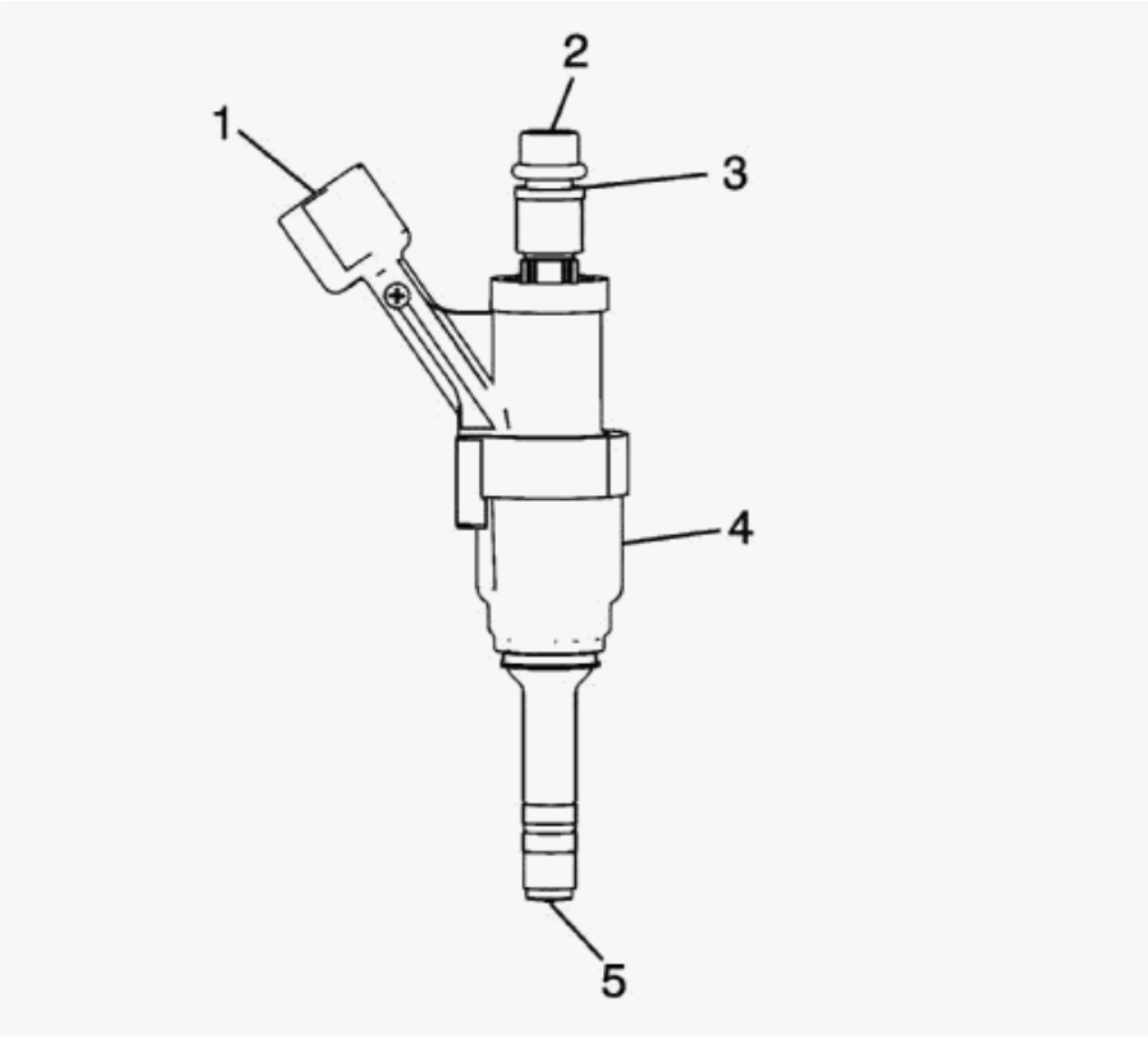

Fig. 463: Fuel Injector Connector Components
Courtesy of GENERAL MOTORS COMPANY

16. Inspect the fuel injectors for the following conditions:
    - Damage to the fuel injector connector (1)
    - Damage to the fuel inlet cone (2)
    - Damage to the O-ring (cracking, splitting, tearing) and the O-ring sealing surface (3)

      Damaged O-rings can result in fuel odor, fuel leaks, and other symptoms. Refer to **Symptoms - Engine Controls** .

    - Damage to the fuel injector body (4)
    - Damage to the fuel injector tip (5)
17. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.

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Fig. 464: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If there was not previously a dust seal installed on the fuel injector, install a new one.**

18. Install a NEW fuel injector dust seal (1).

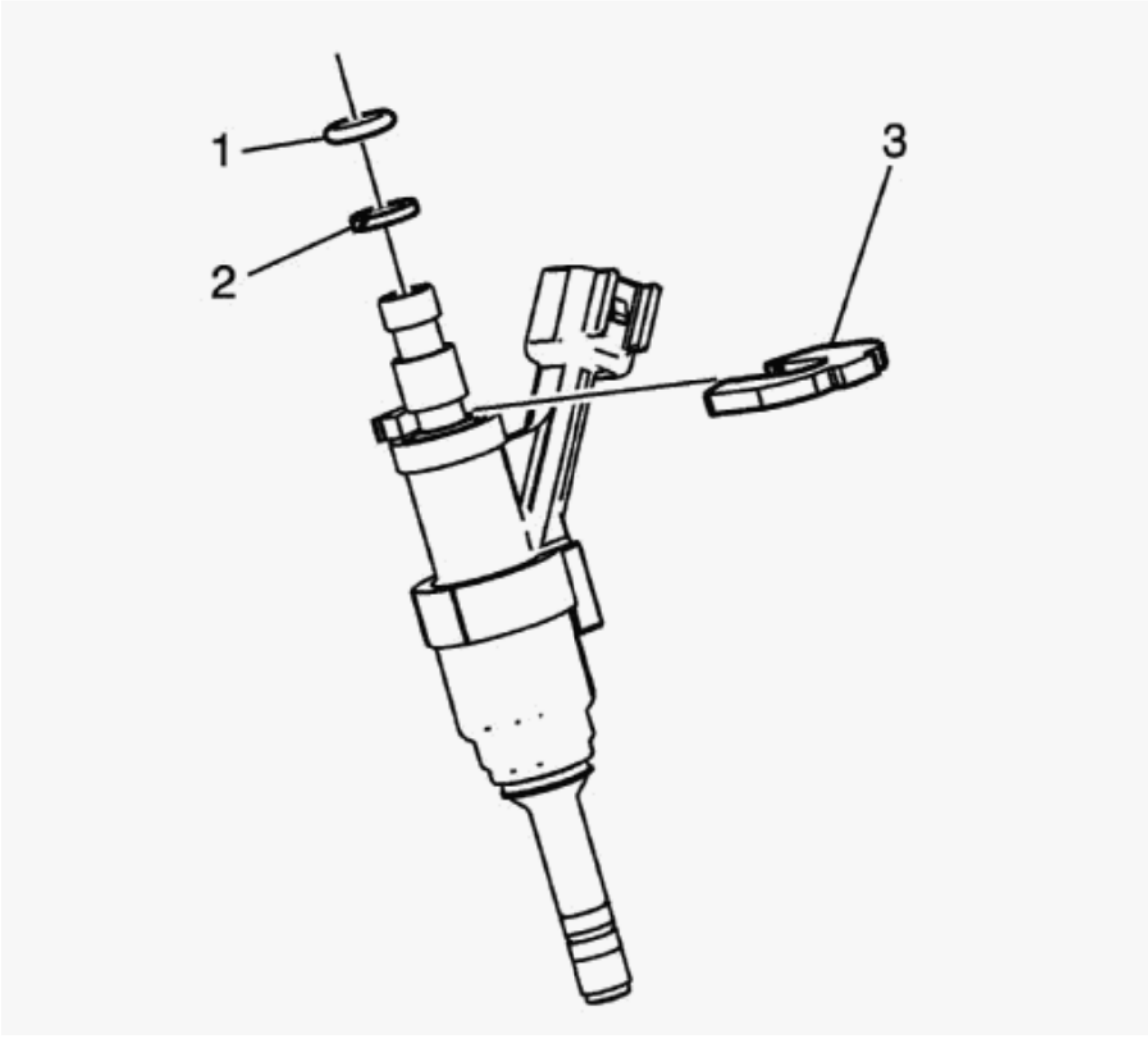

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Fig. 465: Installing NEW Spacer On Fuel Injector
Courtesy of GENERAL MOTORS COMPANY

19. Install a NEW spacer (2) on the fuel injector.
20. Lubricate the NEW O-ring (1) with a drop of clean engine oil and install on injector.
21. Install injector collar (3) on fuel injector.

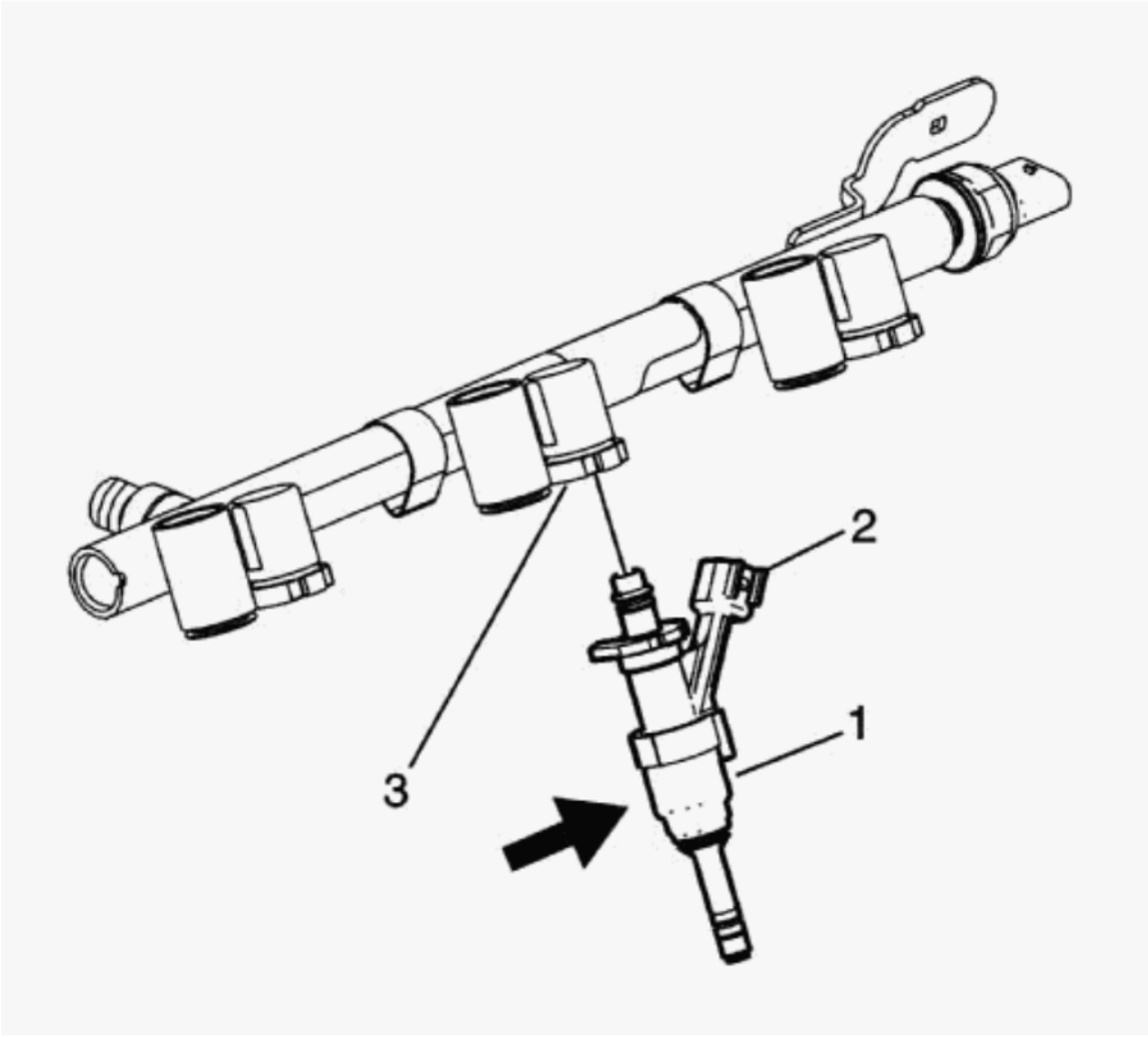

Fig. 466: Electrical Connector And Injector Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT install the injector tip/bore seals until AFTER the injectors are installed on the fuel rail.**

22. Lubricate the socket (3) of the fuel rail with clean engine oil. Holding the largest diamenter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2). LH Rail: Electrical connectors face the front of the engine. RH Rail: Electrical connectors face the rear of the engine.

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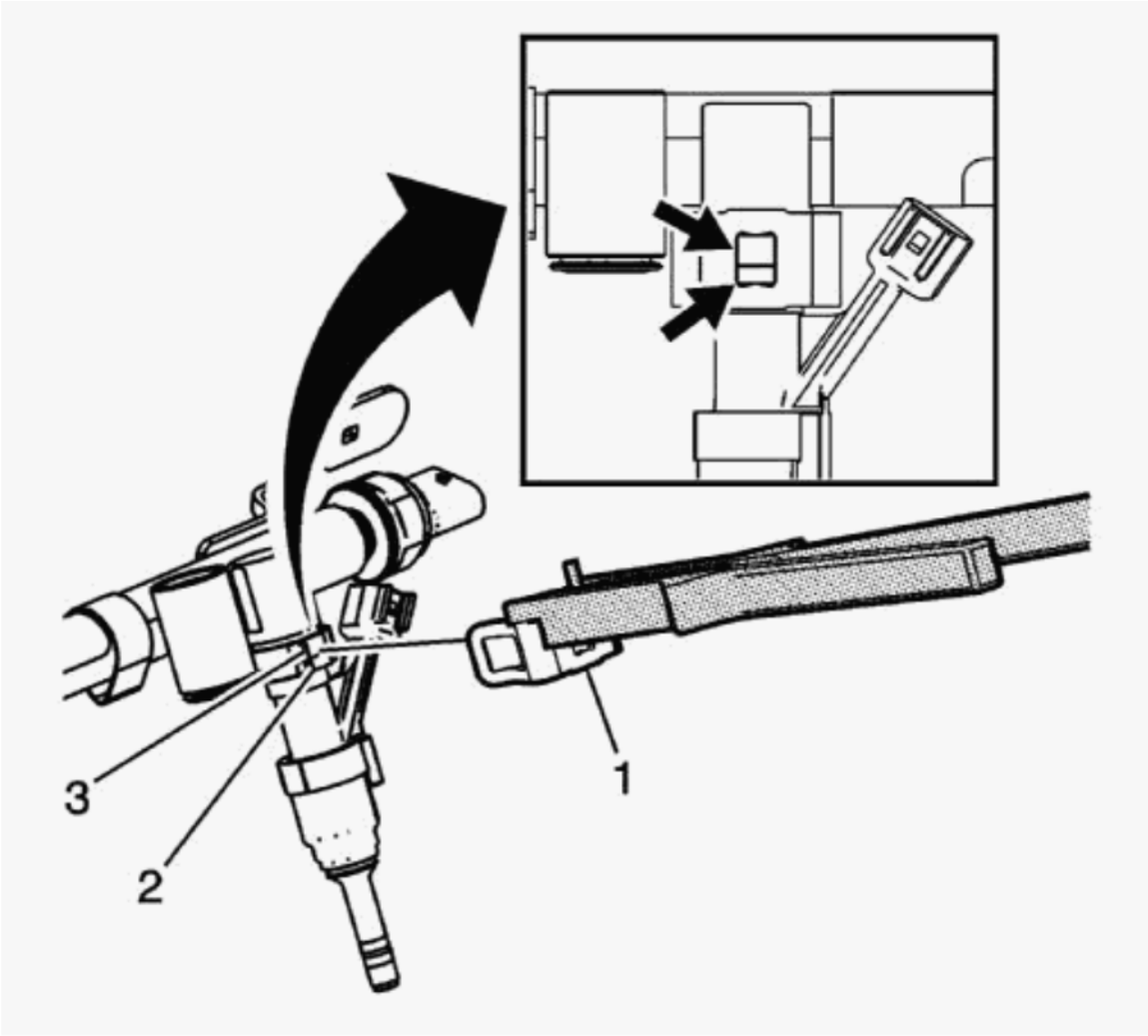

Fig. 467: Installing Fuel Injector Clip Onto EN-51097 Injector Retaining Clip Installer
Courtesy of GENERAL MOTORS COMPANY

23. Install the fuel injector clip onto the **EN-51097** injector retaining clip installer.
24. Using **EN-51097** injector retaining clip installer spread the retainer clip (1) and install onto the fuel rail. Inspect the front and side windows of the retainer clip to ensure that the flange on the rail (3) and the tab on the injector collar (2) are completely captured and firmly seated in the retainer clip (1) as shown.
25. Repeat for remaining injectors until all are installed and retained in fuel rail.

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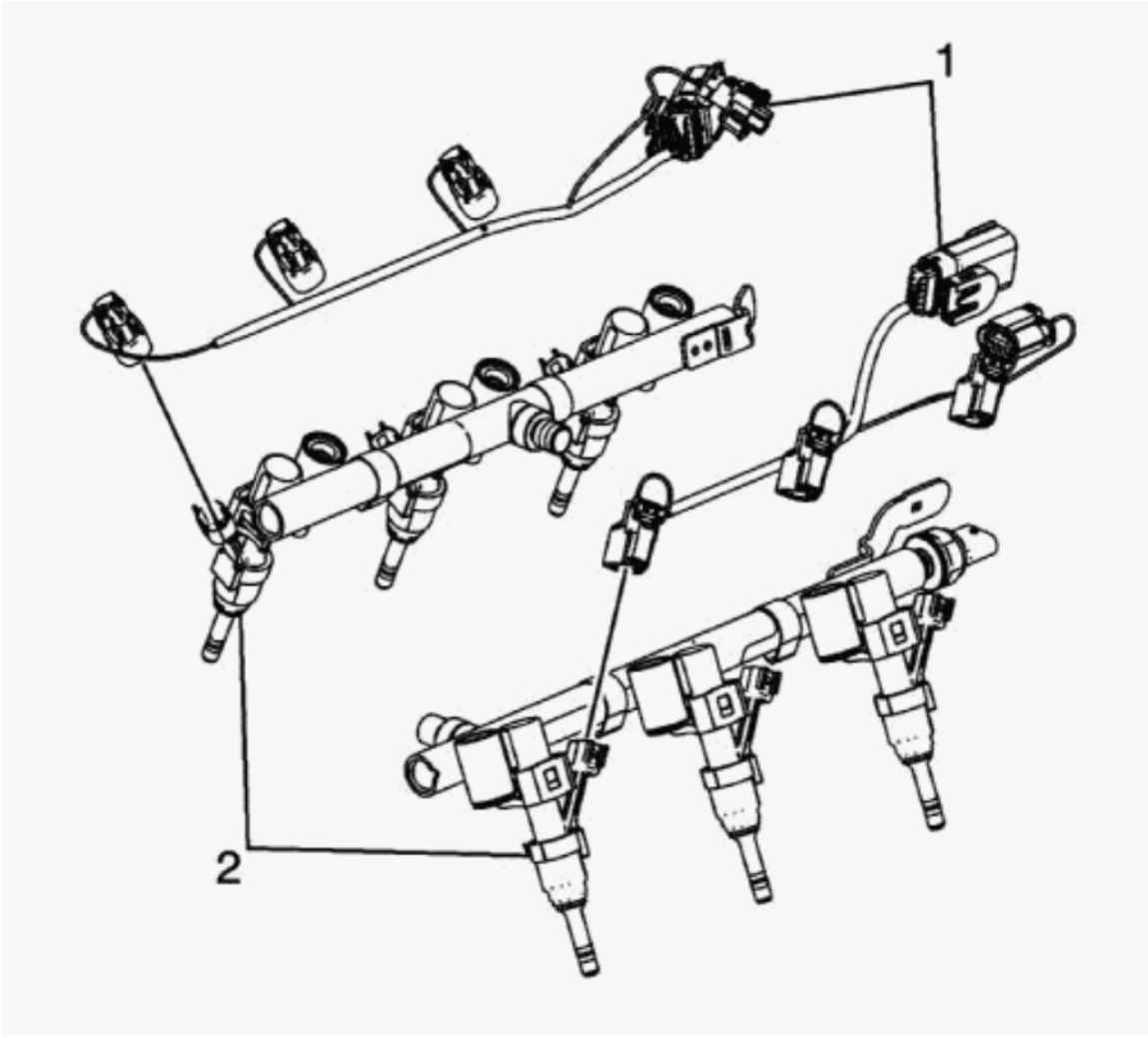

Fig. 468: Fuel Rail Wiring Harnesses
Courtesy of GENERAL MOTORS COMPANY

26. Install the fuel rail wiring harnesses (1).

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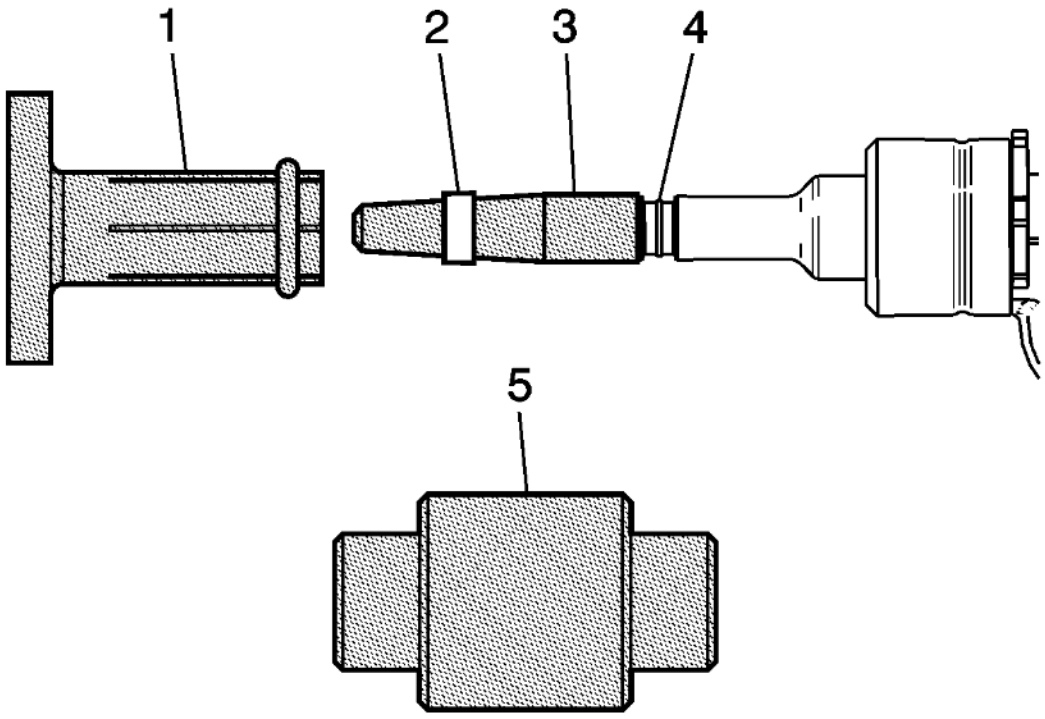

Fig. 469: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

27. Install **EN-51105-1** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a new seal (2) on **EN-51105-1** long protector.
28. Using **EN-49245-3** pusher (1), install the seal into the second recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 sizer is two sided, and either direction will size the seal correctly.**

29. Compress the seal with your fingers, then resize the seal if using the **EN-49245-4** sizer (5).

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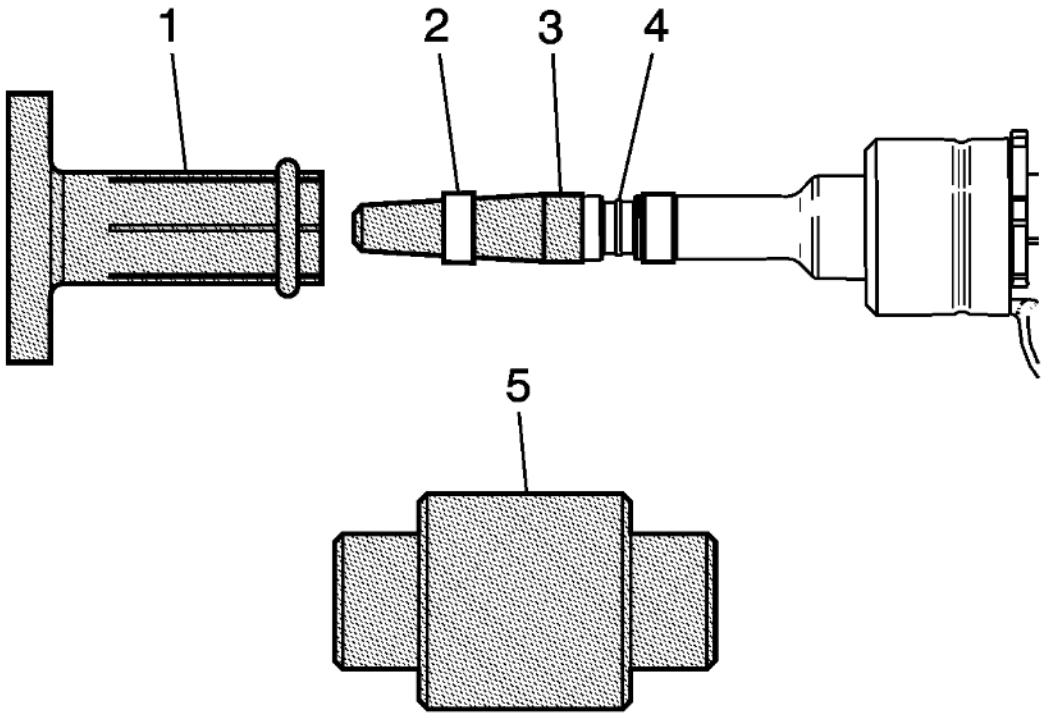

Fig. 470: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

30. Install **EN-51105-2** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-51105-2** short protector.
31. Using **EN-49245-3** pusher (1), install the seal into the first recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 sizer is two sided, and either direction will size the seal correctly.**

32. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

THREAD REPAIR

Special Tools

- **EN-42385-50** Head/Main Bolt Thread Repair Kit
- **J 42385-200** Fixtures and Hardware Kit
- **J 42385-300** Fixtures and Hardware Kit

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For equivalent regional tools, refer to **Special Tools**.

General Thread Repair

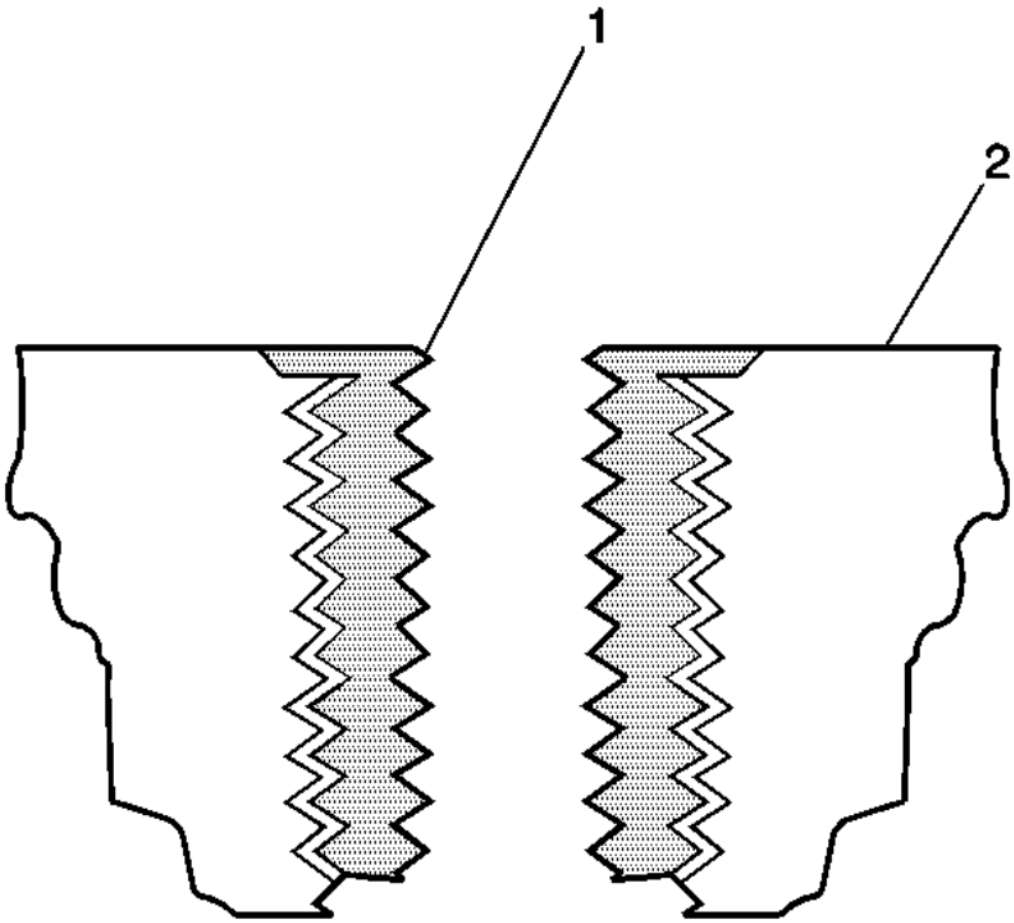

Fig. 471: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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.

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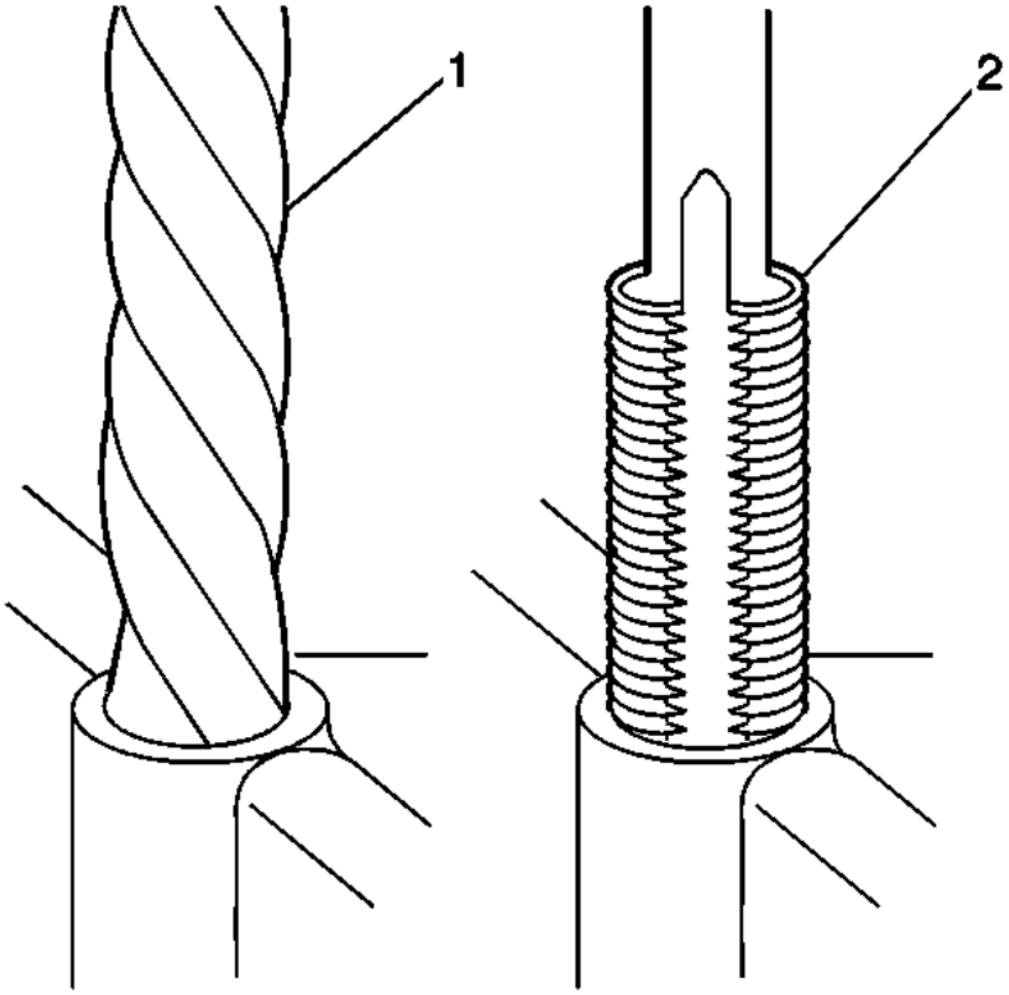

Fig. 472: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40Â®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.**
- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

1. Drill out the threads of the damaged hole (1).
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

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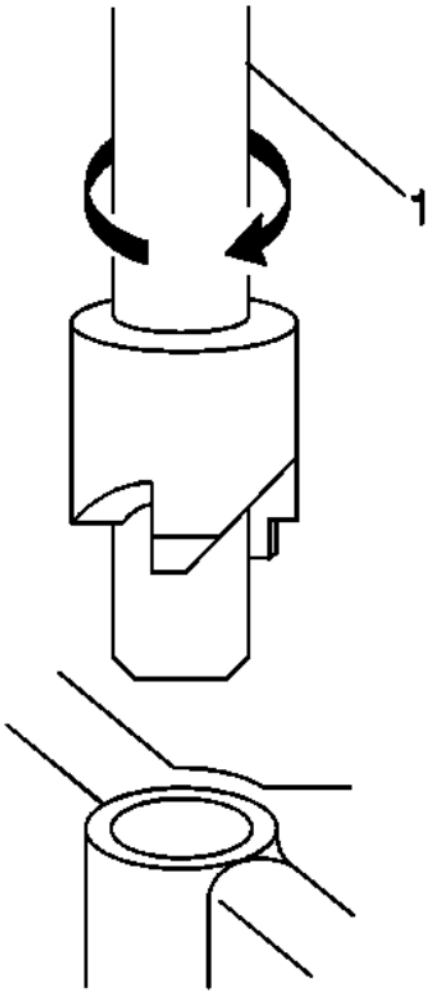

Fig. 473: Identifying Tool Used To Counterbore The Hole
Courtesy of GENERAL MOTORS COMPANY

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

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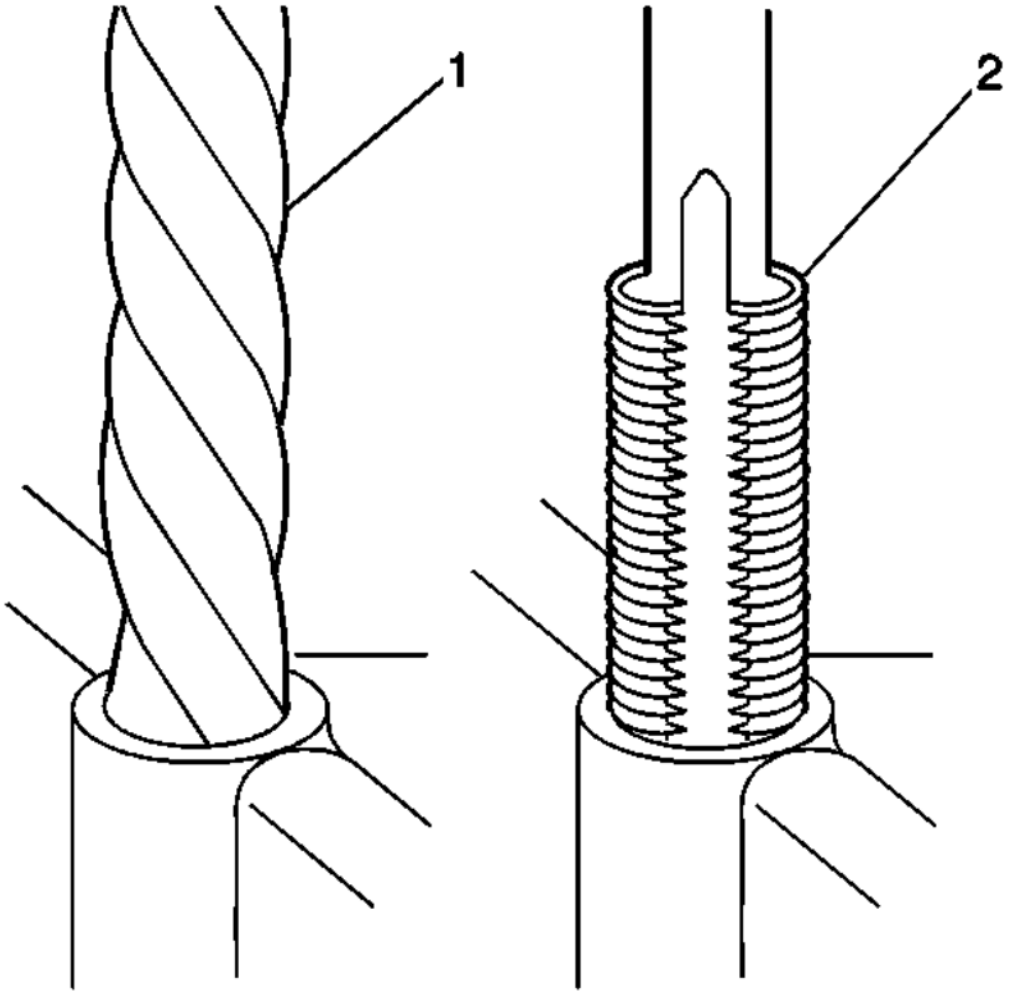

Fig. 474: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

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.

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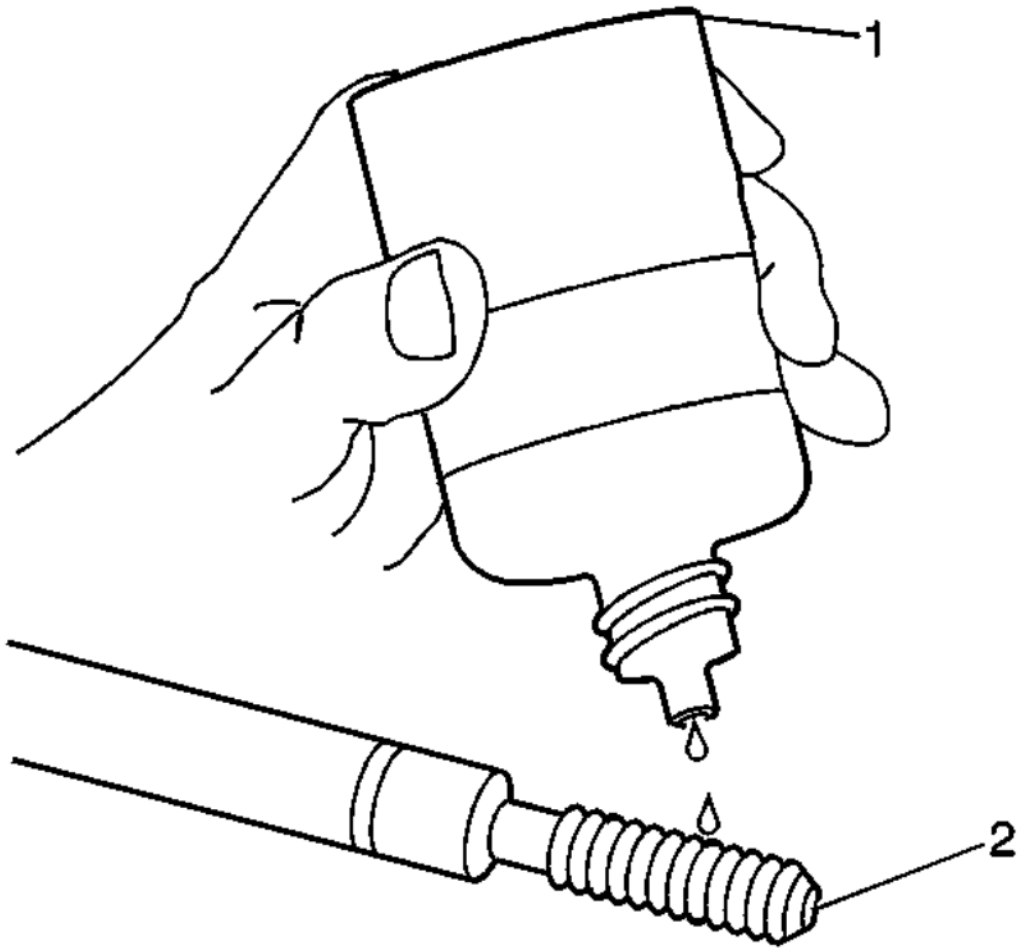

Fig. 475: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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).

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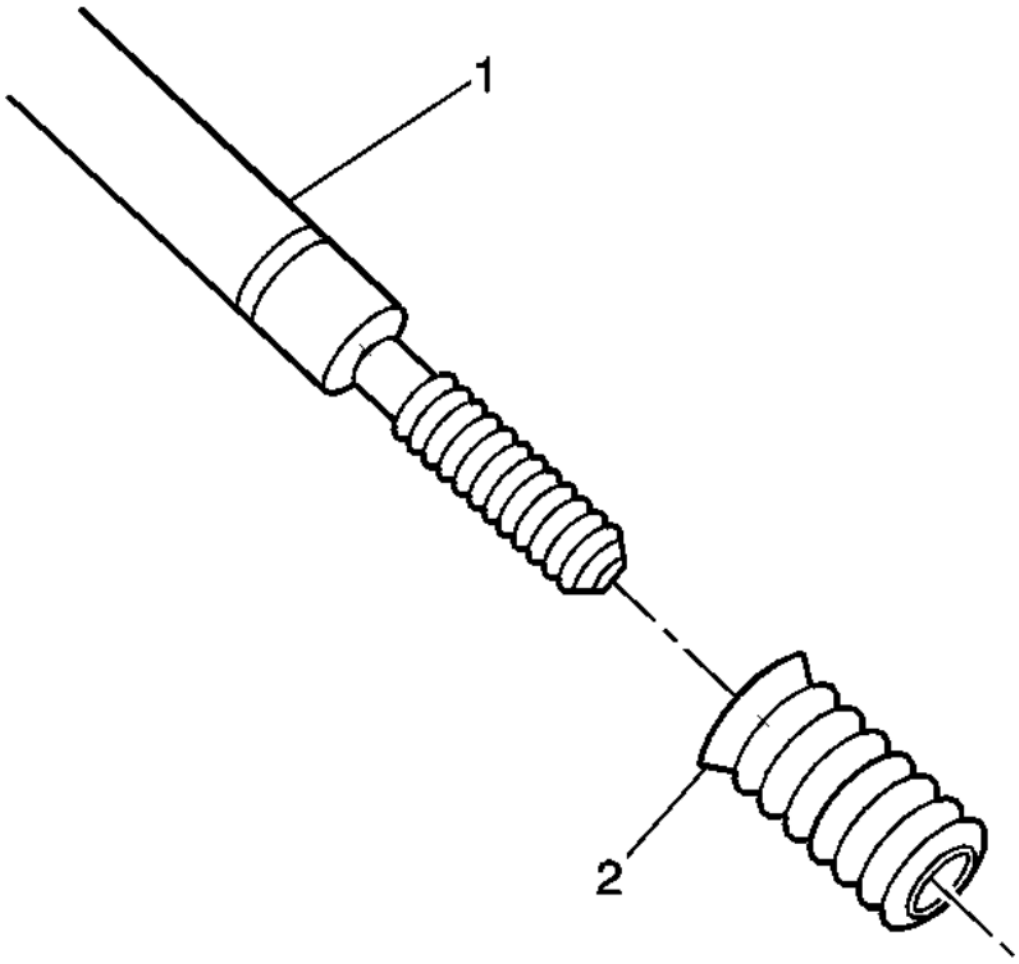

Fig. 476: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

10. Install the insert (2) onto the driver tool (1).

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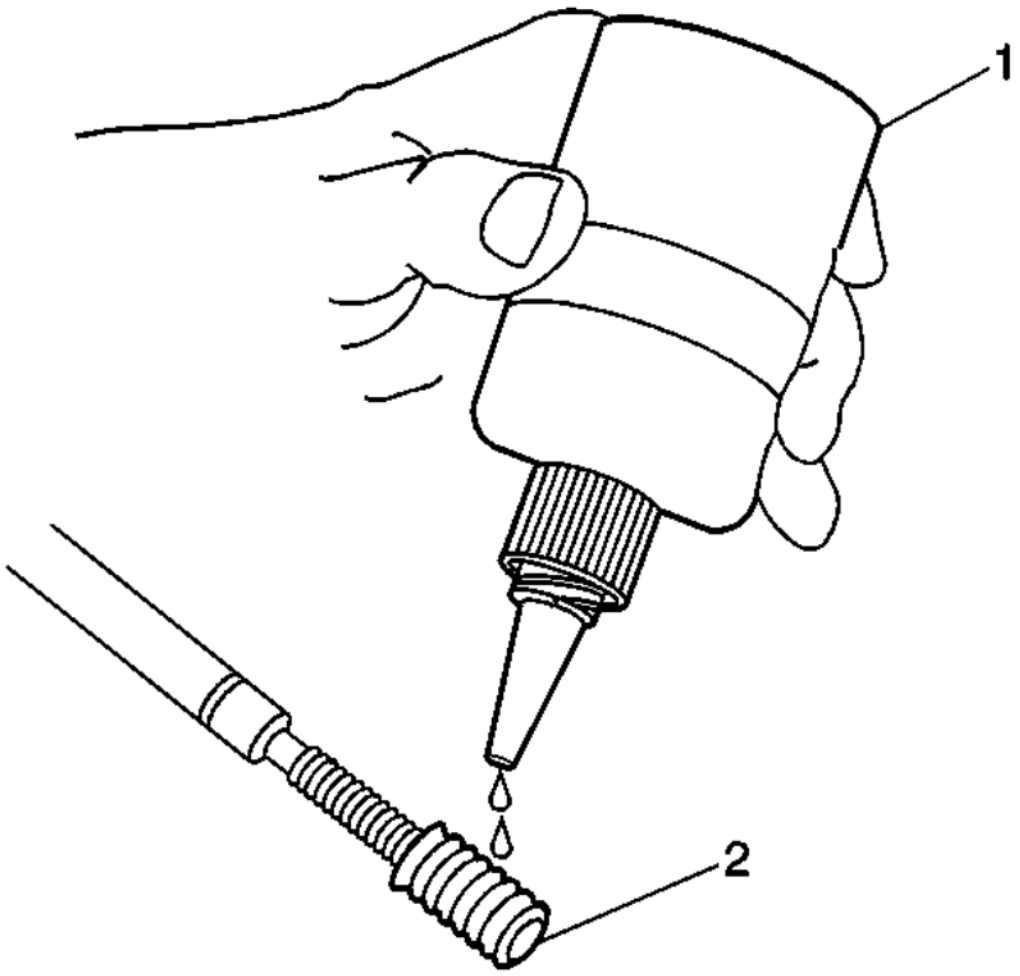

Fig. 477: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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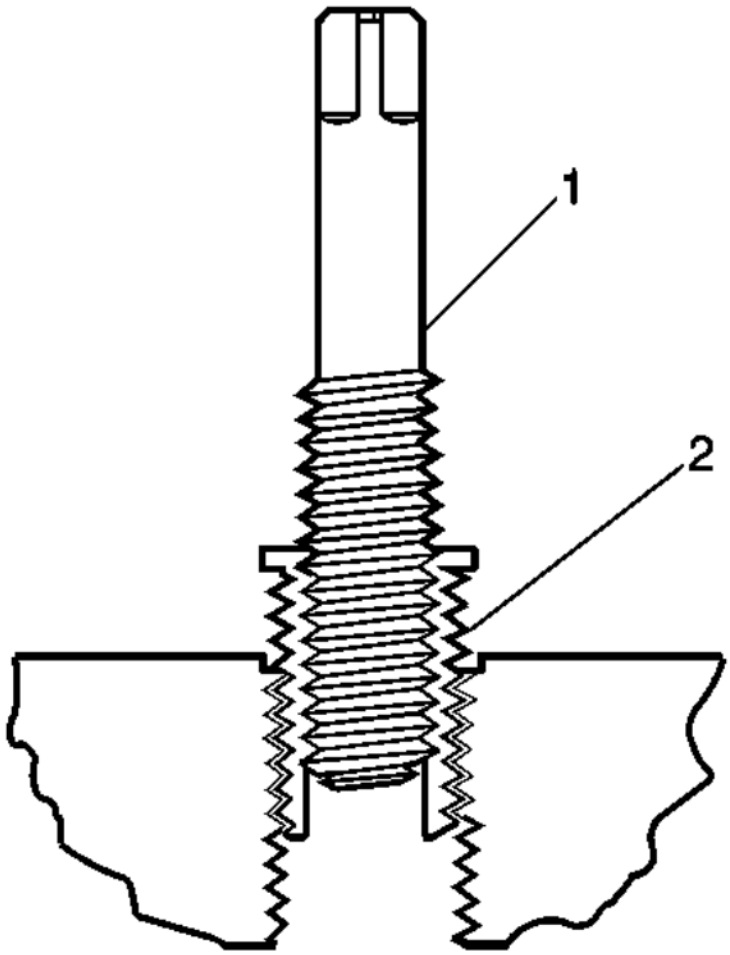

Fig. 478: View Of Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

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.

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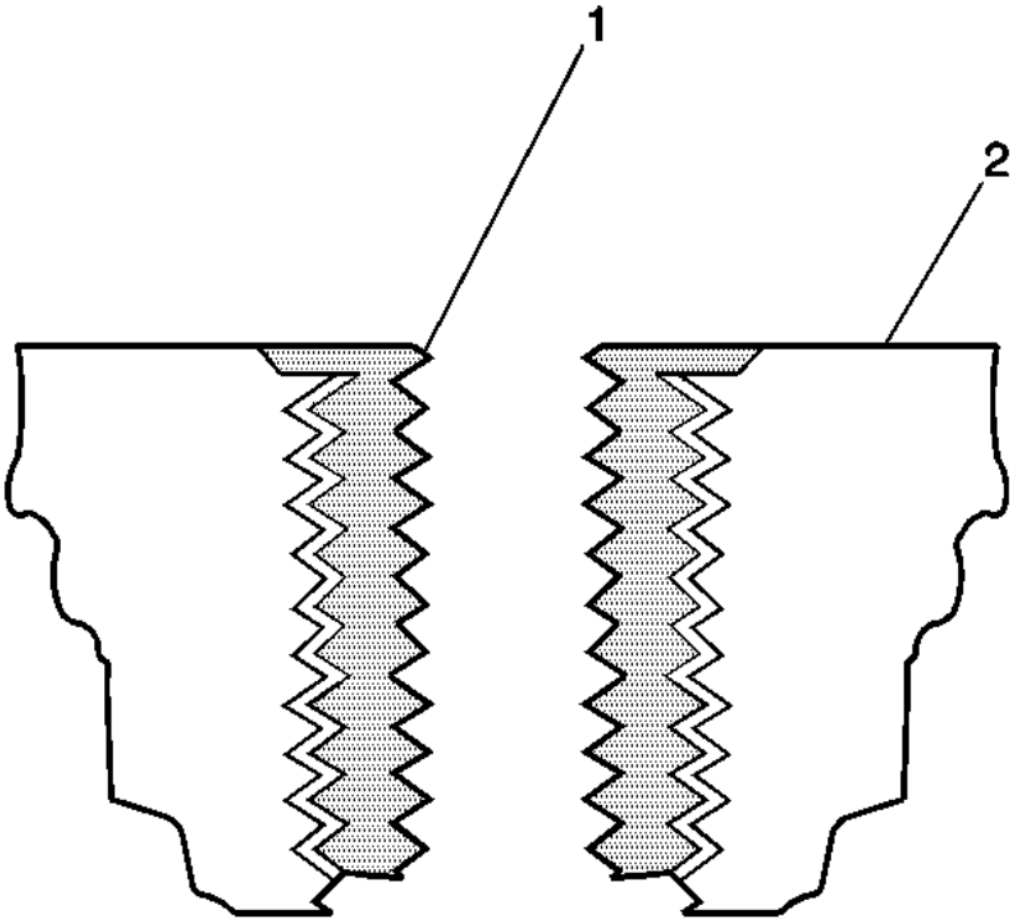

Fig. 479: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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

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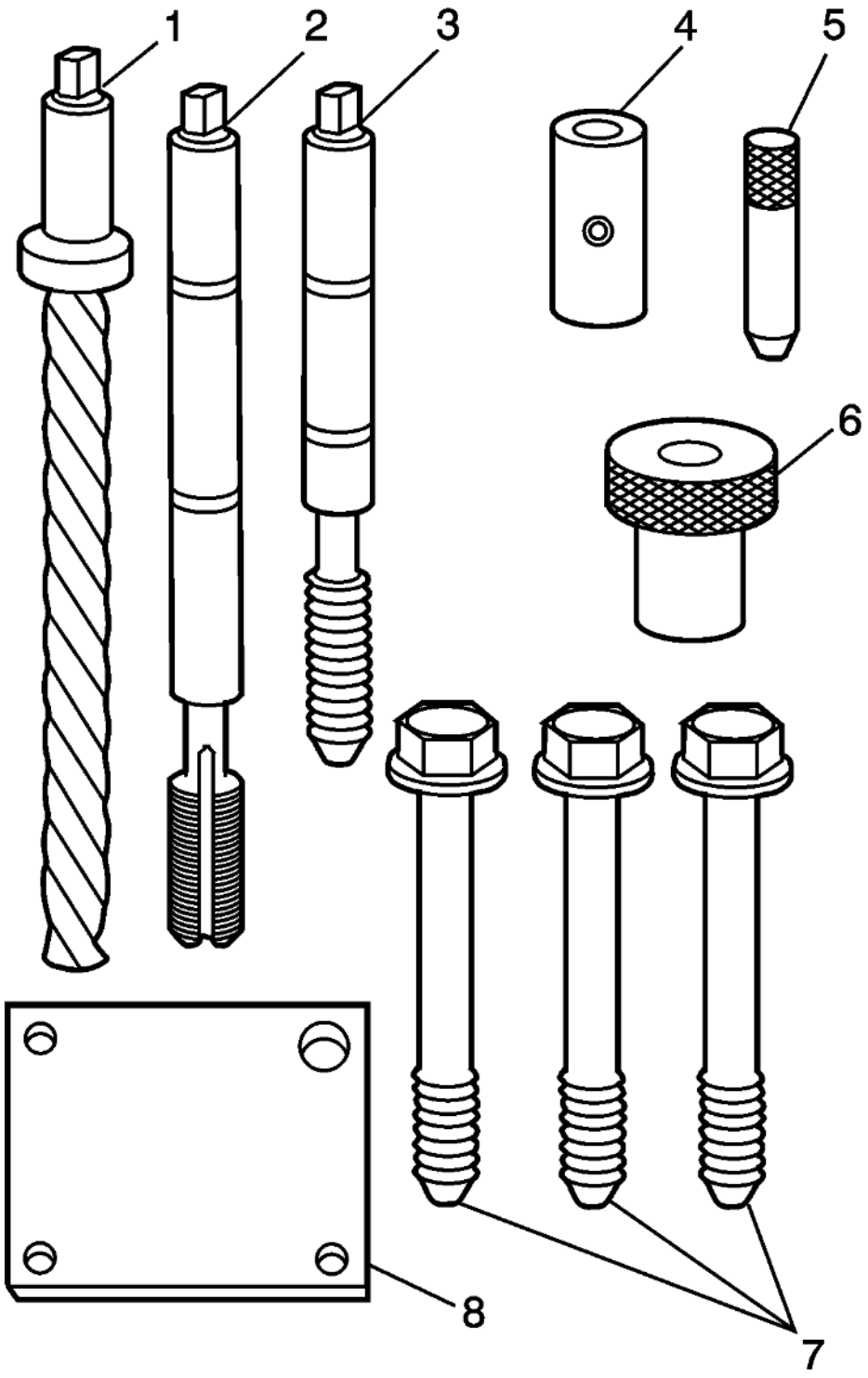

Fig. 480: Cylinder Head Bolt Hole Thread Repair Kit
Courtesy of GENERAL MOTORS COMPANY

1. The cylinder head bolt hole thread repair kit consists of the following items:
    - **EN-42385-51** The drill (1)
    - **EN-42385-52** The tap (2)
    - **EN-42385-53** The installer (3)
    - **EN-42385-57** The sleeve (4)

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- **EN-42385-55** The alignment pin (5)
- **EN-42385-54** The bushing (6)
- **EN-42385-56** The bolts (7)
- **J-42385-301** The fixture plate (8) (Part of **J-42385-300** Fixtures and Hardware Kit

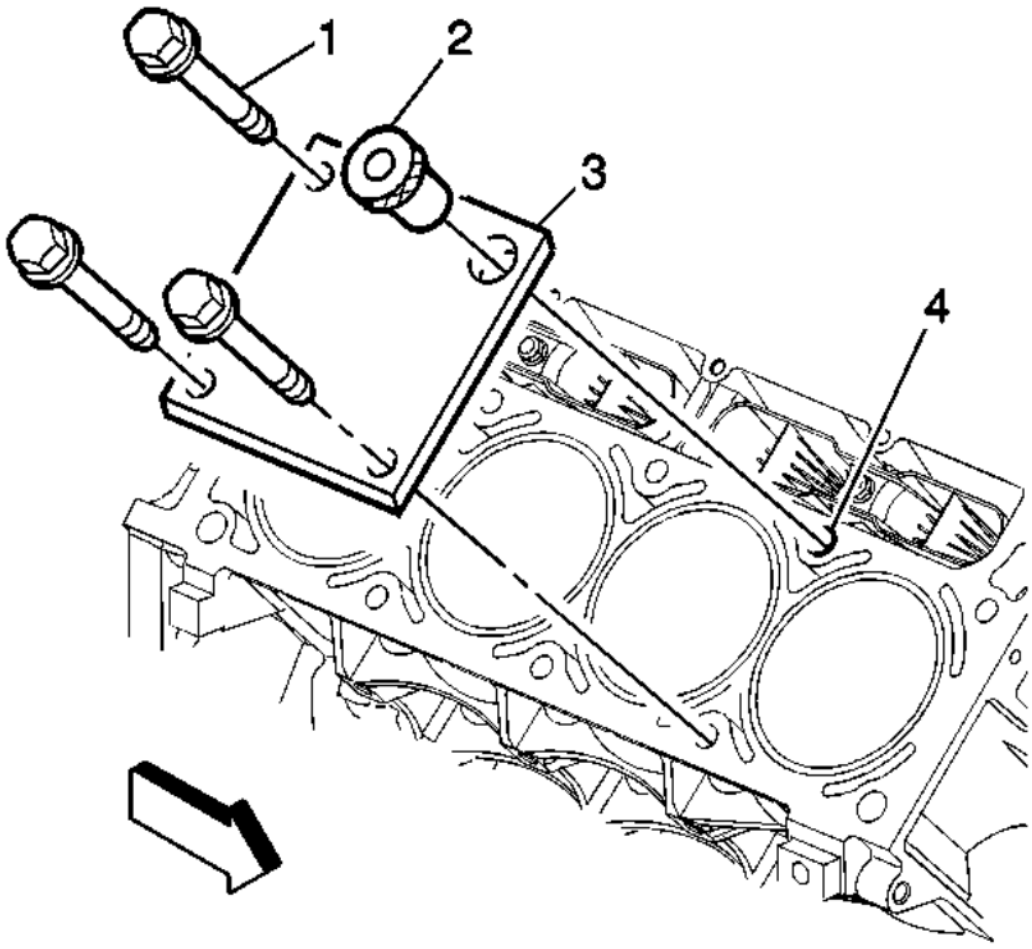

Fig. 481: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40Â®, 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).

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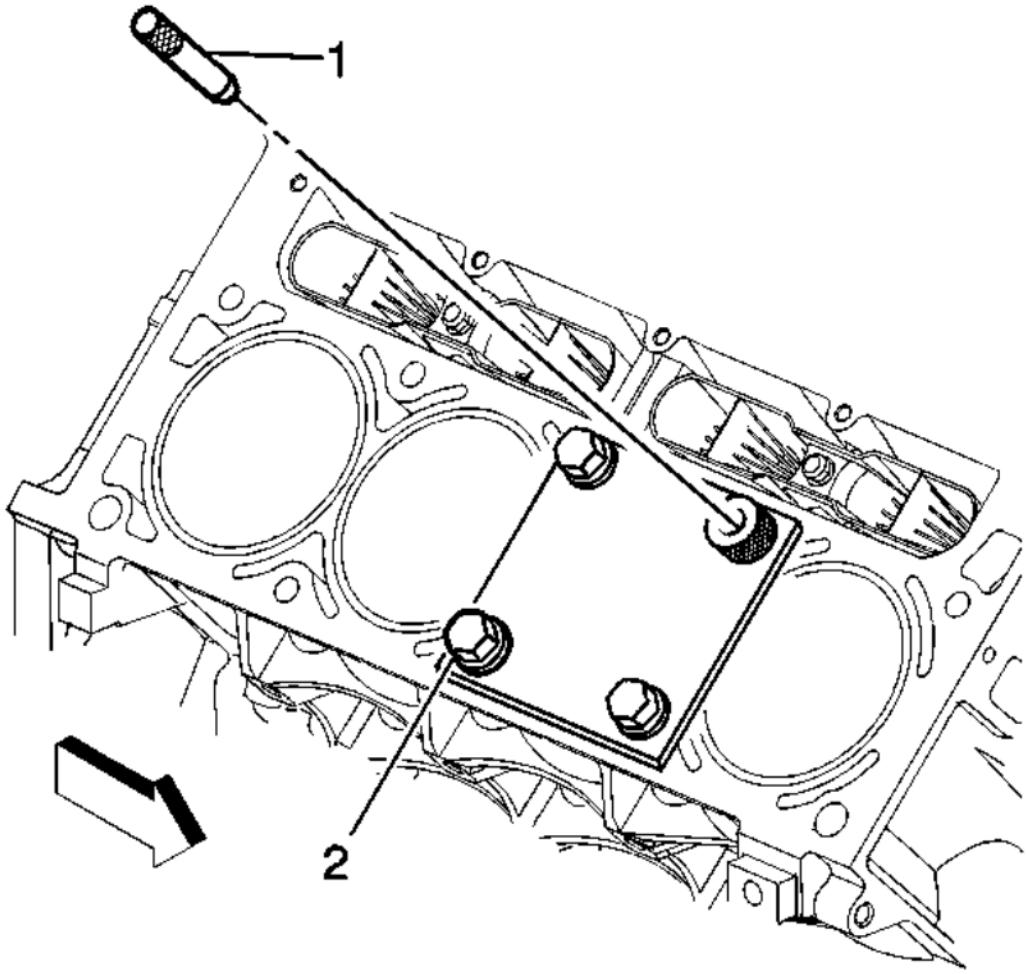

Fig. 482: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS COMPANY

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.

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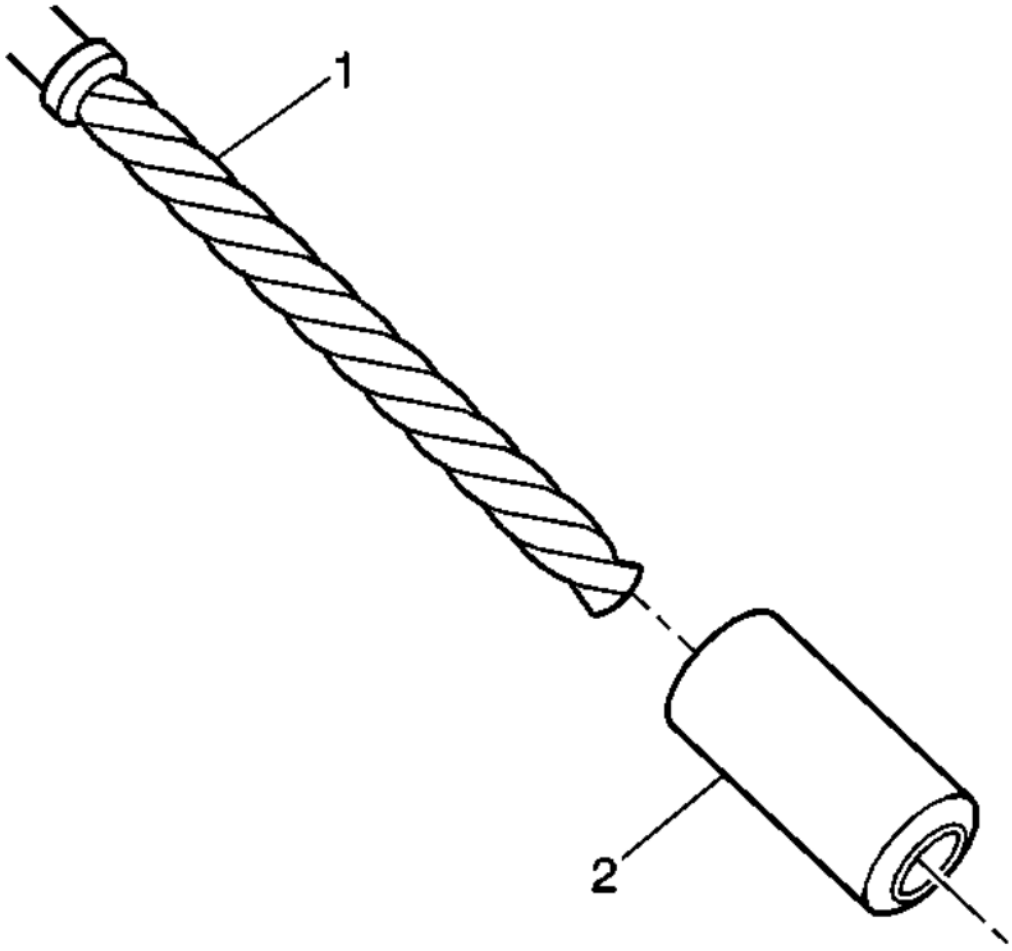

Fig. 483: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

6. Install the sleeve (2) onto the drill (1).

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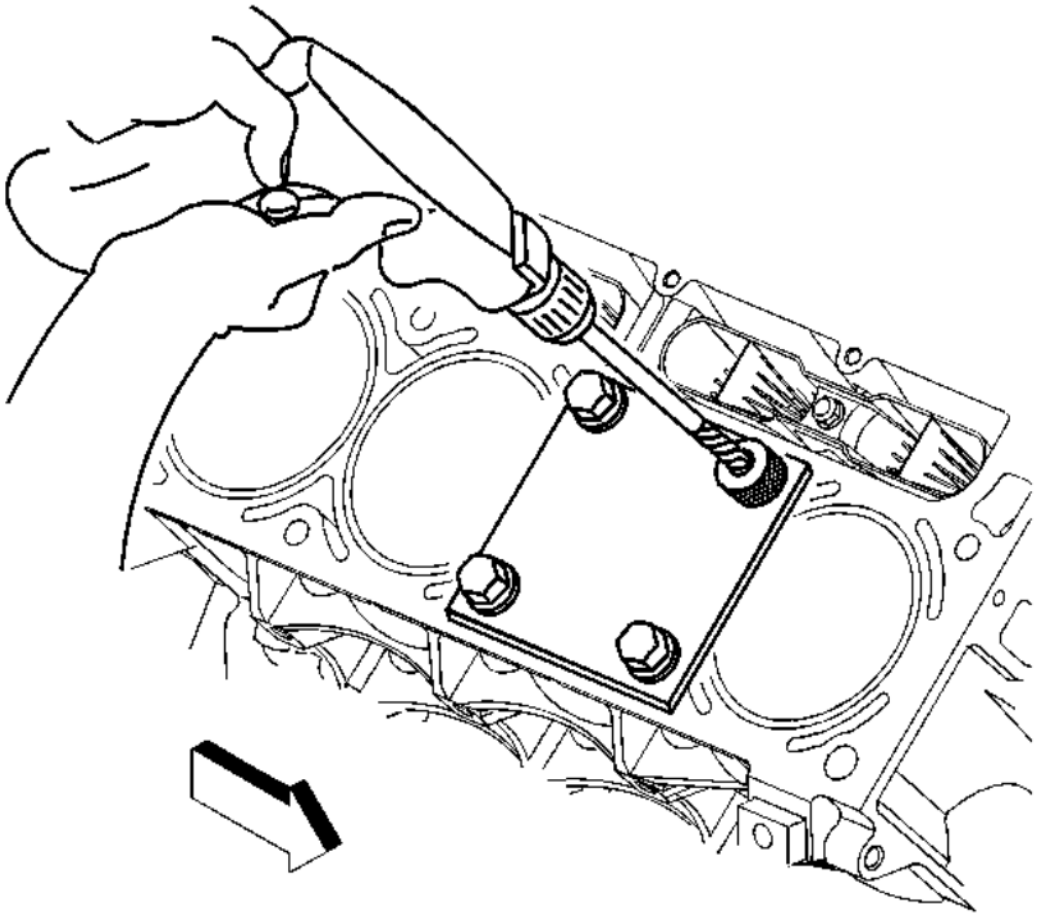

Fig. 484: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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.

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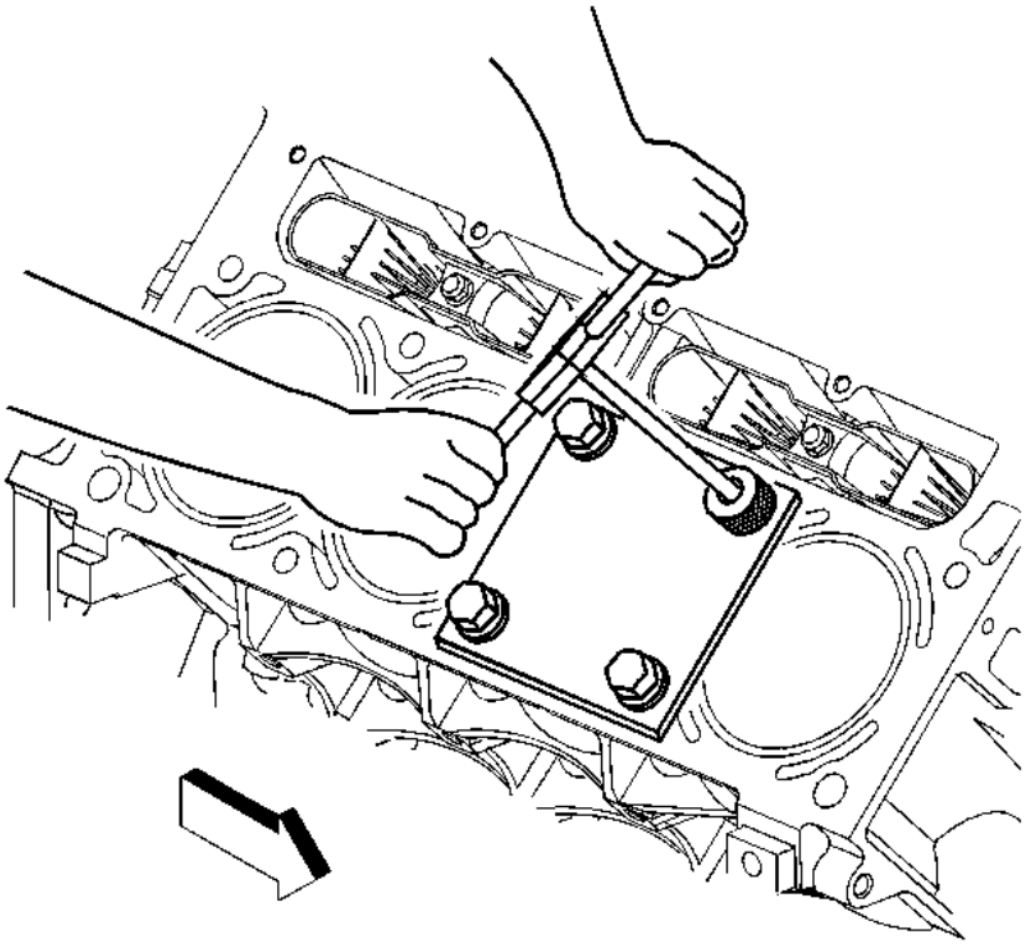

Fig. 485: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS COMPANY

9. Using a tap wrench, tap the threads of the drilled hole.

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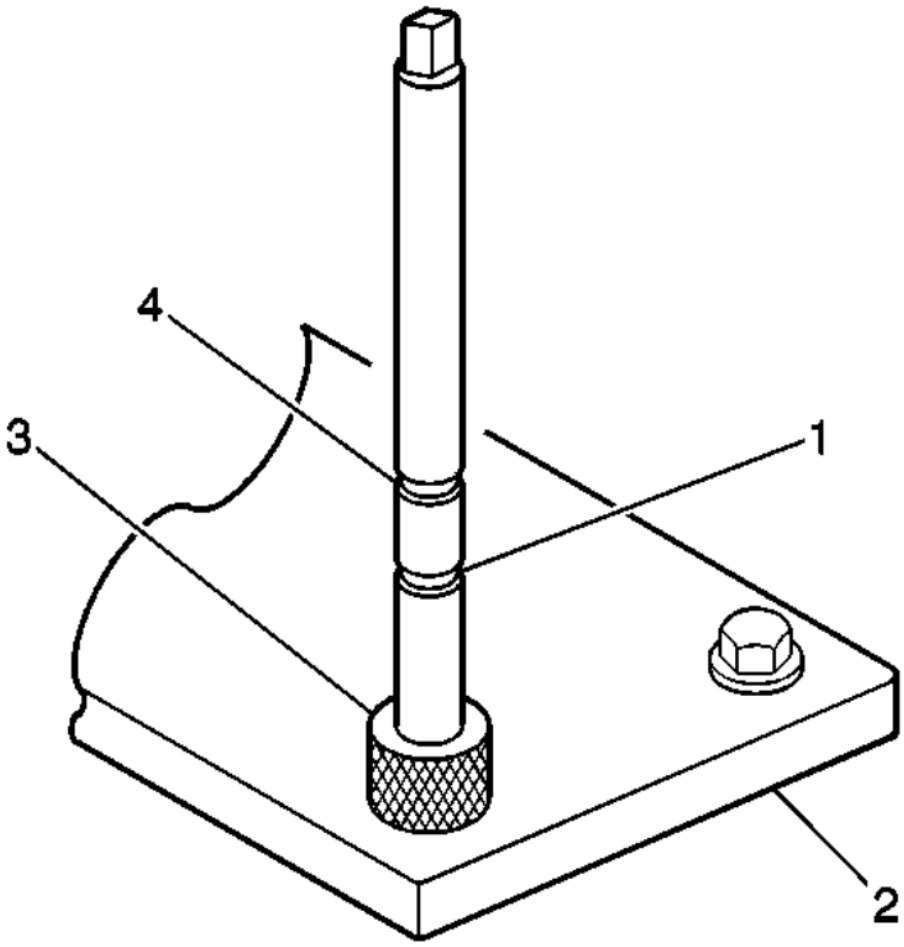

Fig. 486: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS COMPANY

10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (4) 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.

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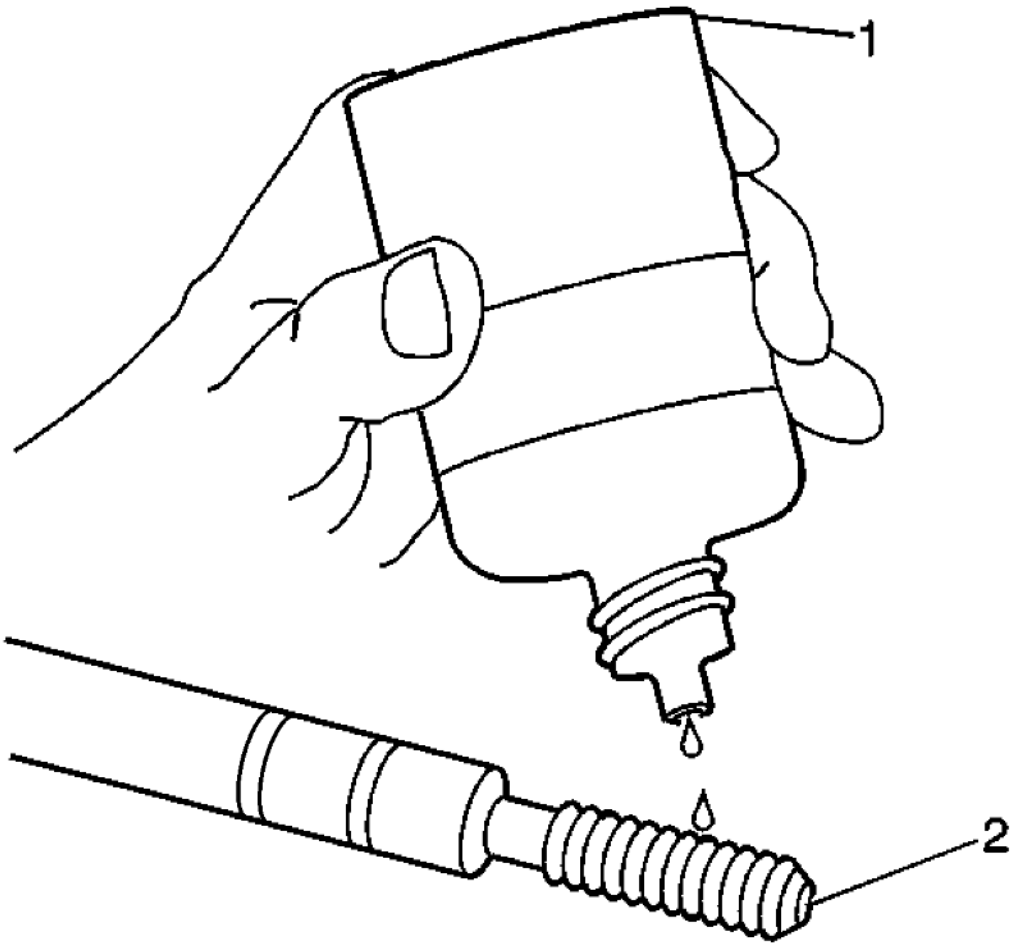

Fig. 487: Lubricating Threads Of Installer Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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).

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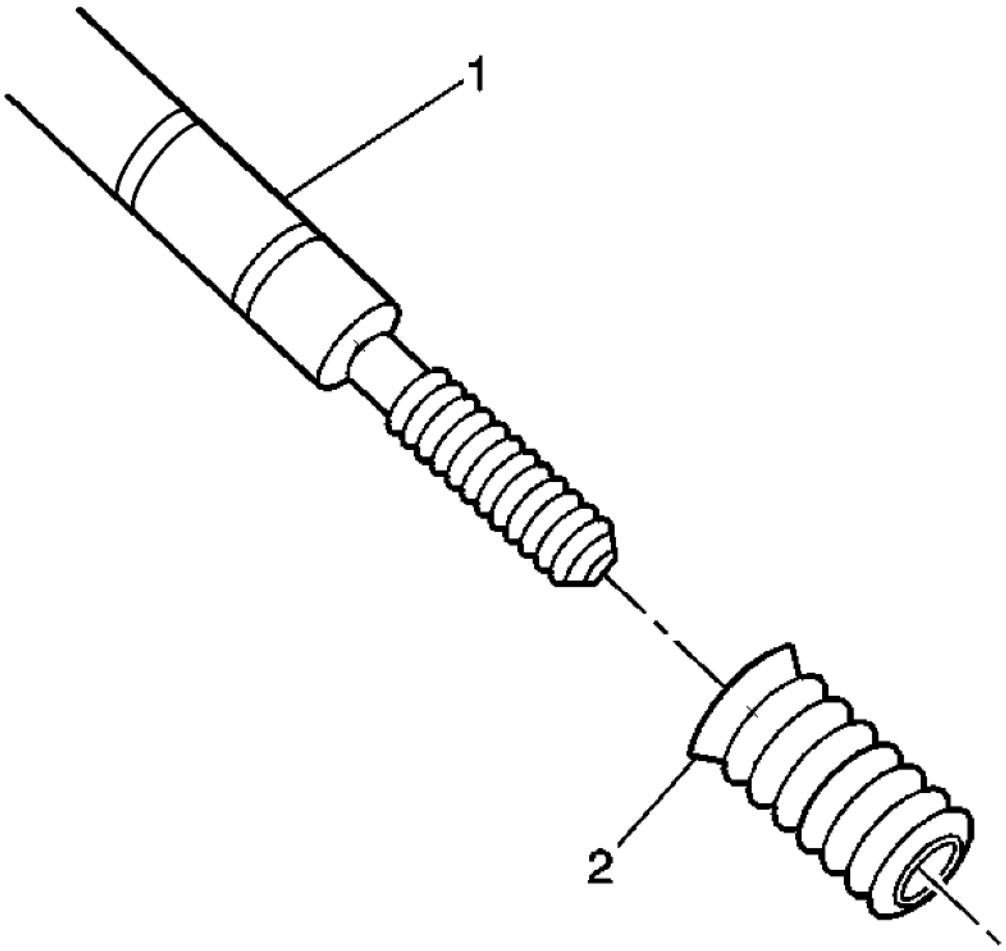

Fig. 488: Insert And Driver Tool
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert (2) onto the driver tool (1).

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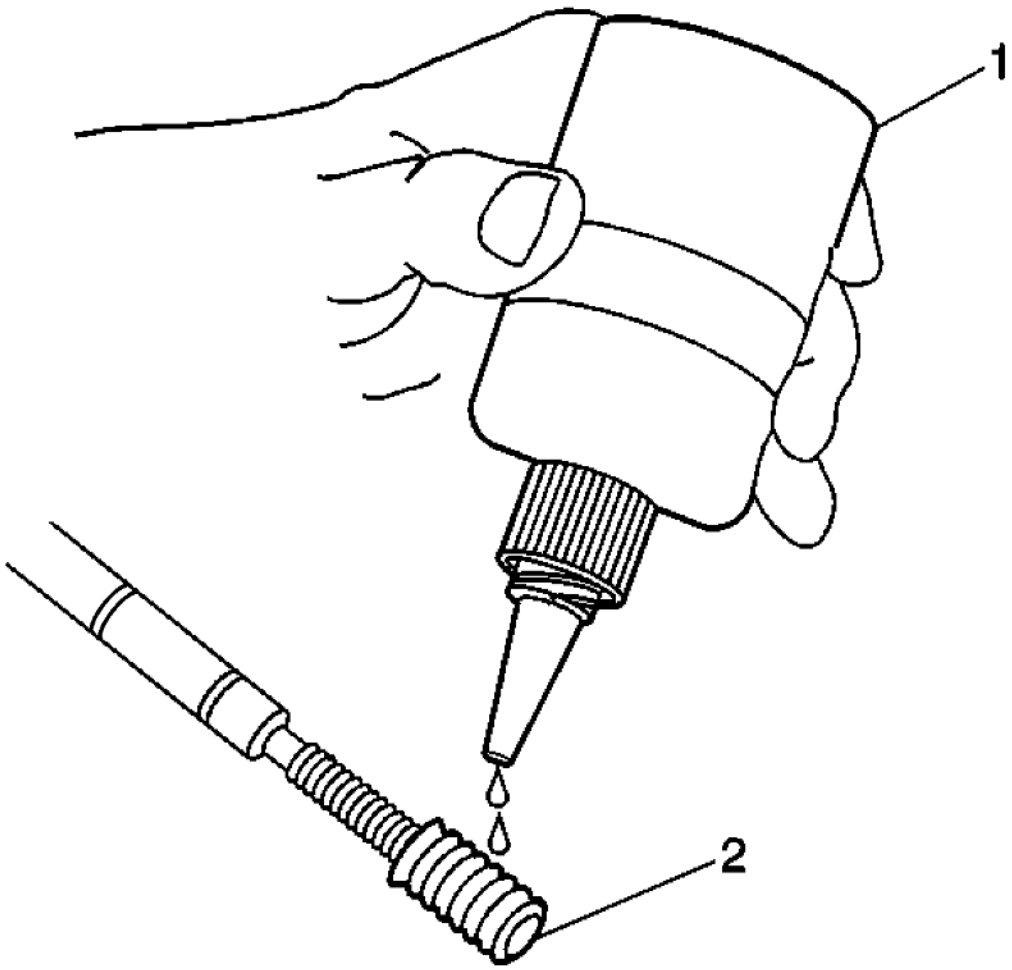

Fig. 489: Threadlock
Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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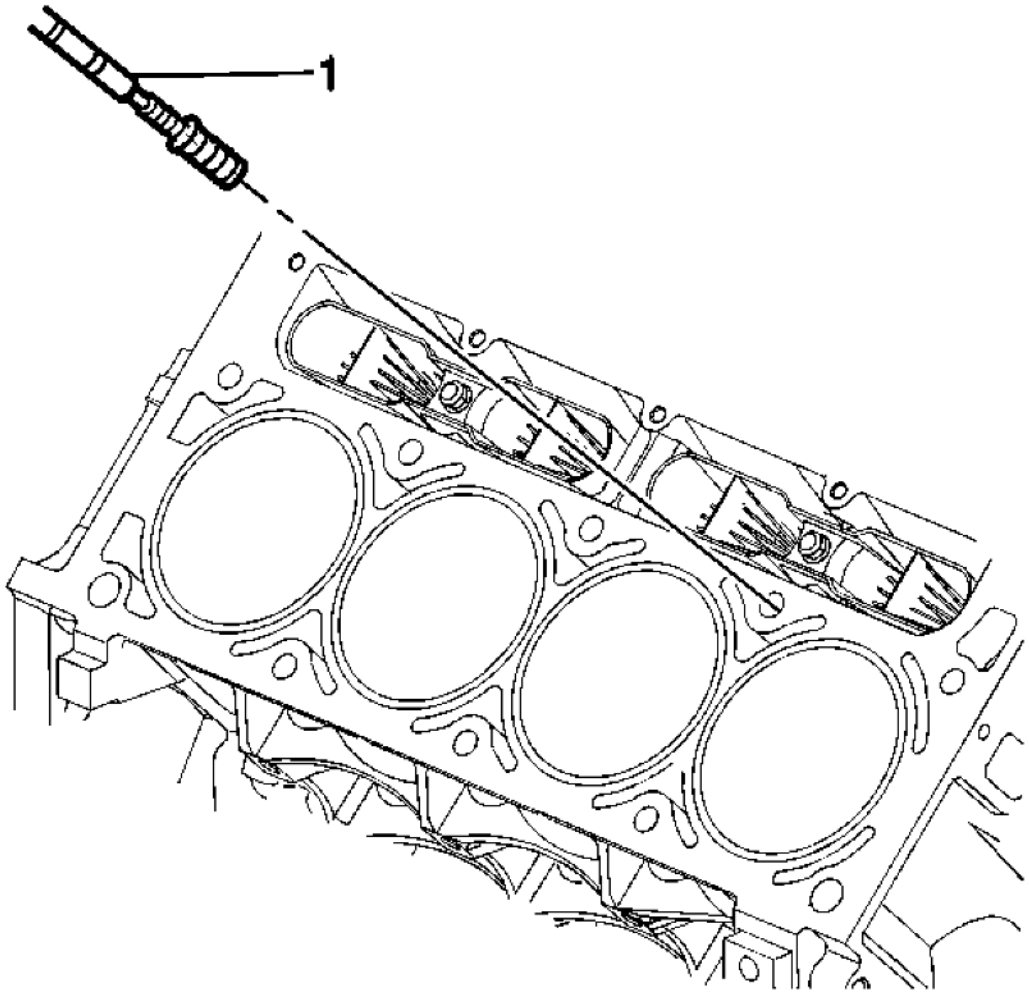

Fig. 490: Insert And Driver
Courtesy of GENERAL MOTORS COMPANY

18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the upper mark on the driver 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

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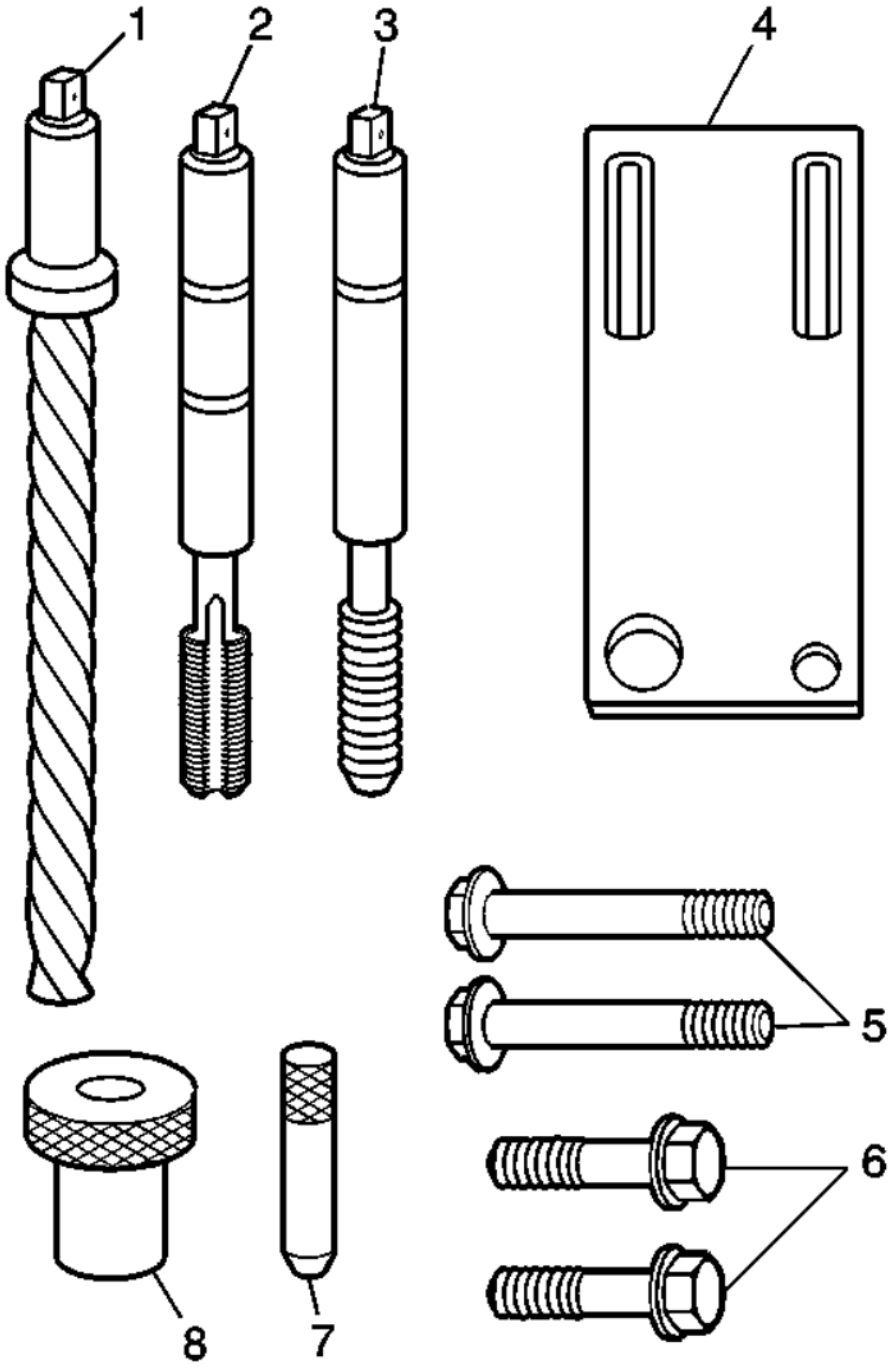

Fig. 491: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS COMPANY

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)

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- The long bolts (5)
- The short bolts (6)
- The alignment pin (7)
- The bushing (8)

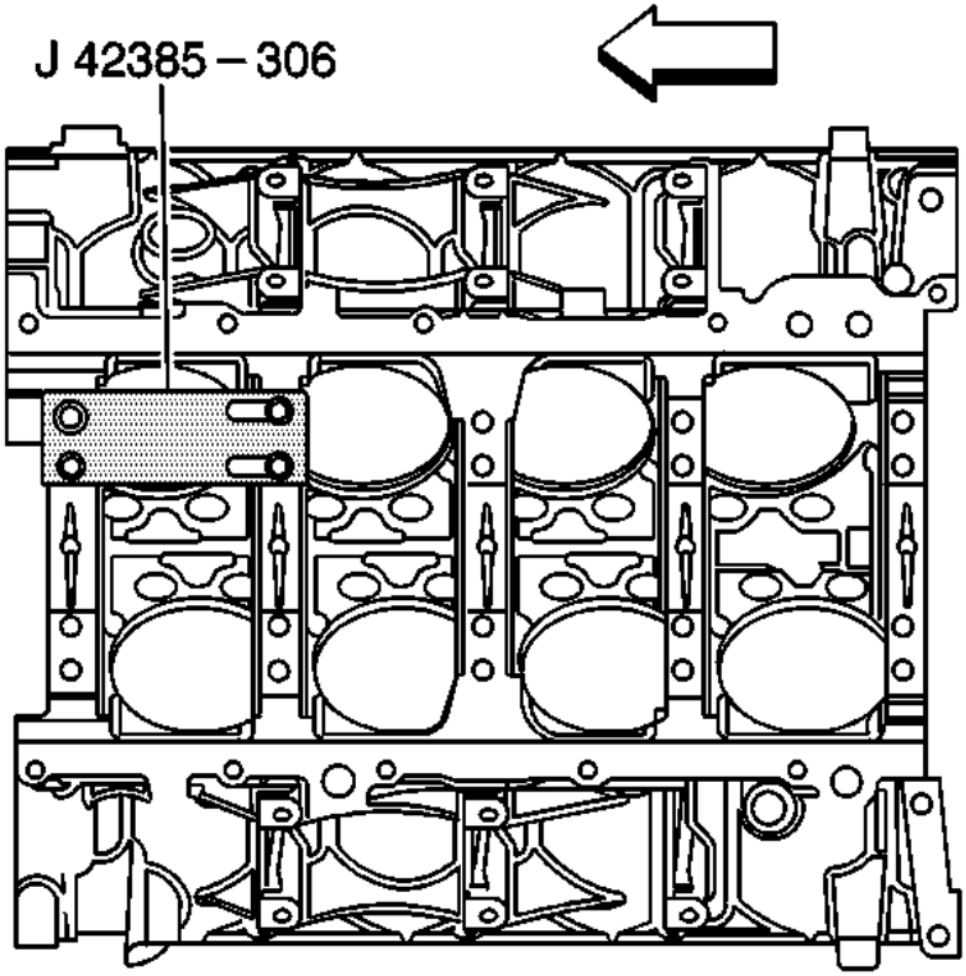

Fig. 492: View Of Fixture Plate, Bolt & Bushing
Courtesy of GENERAL MOTORS COMPANY

2. Install the fixture plate, bolt, and bushing onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

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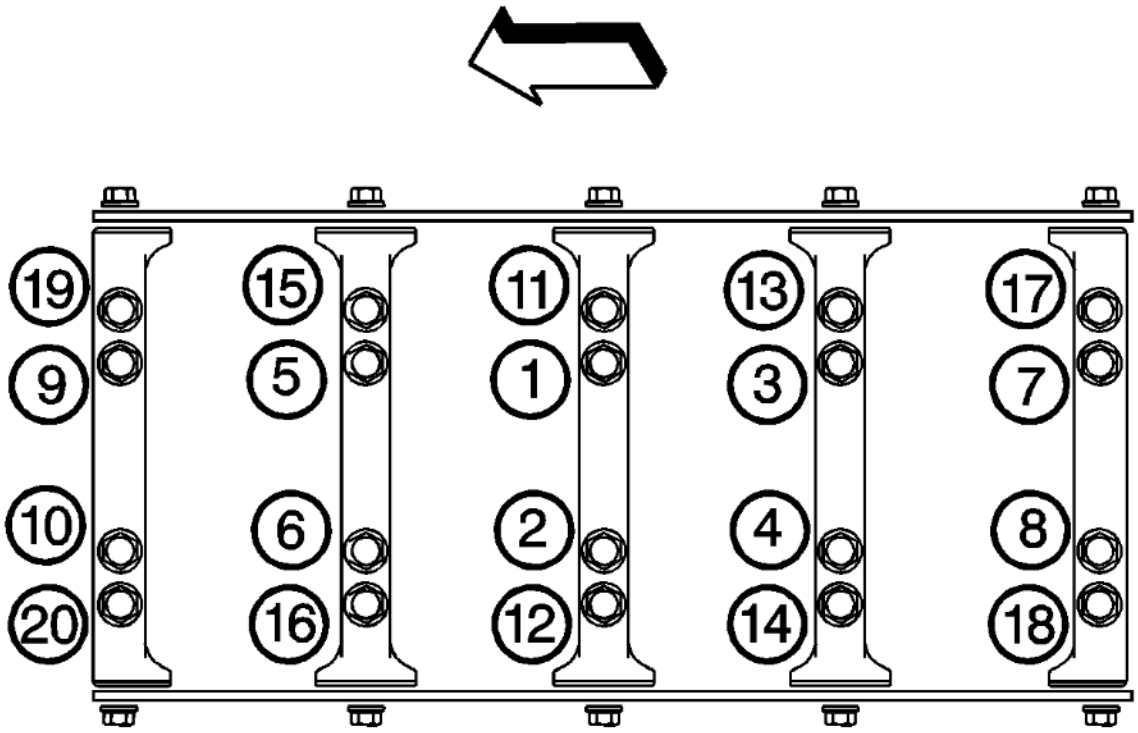

Fig. 493: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Drill out the damaged hole.

   The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

   Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.

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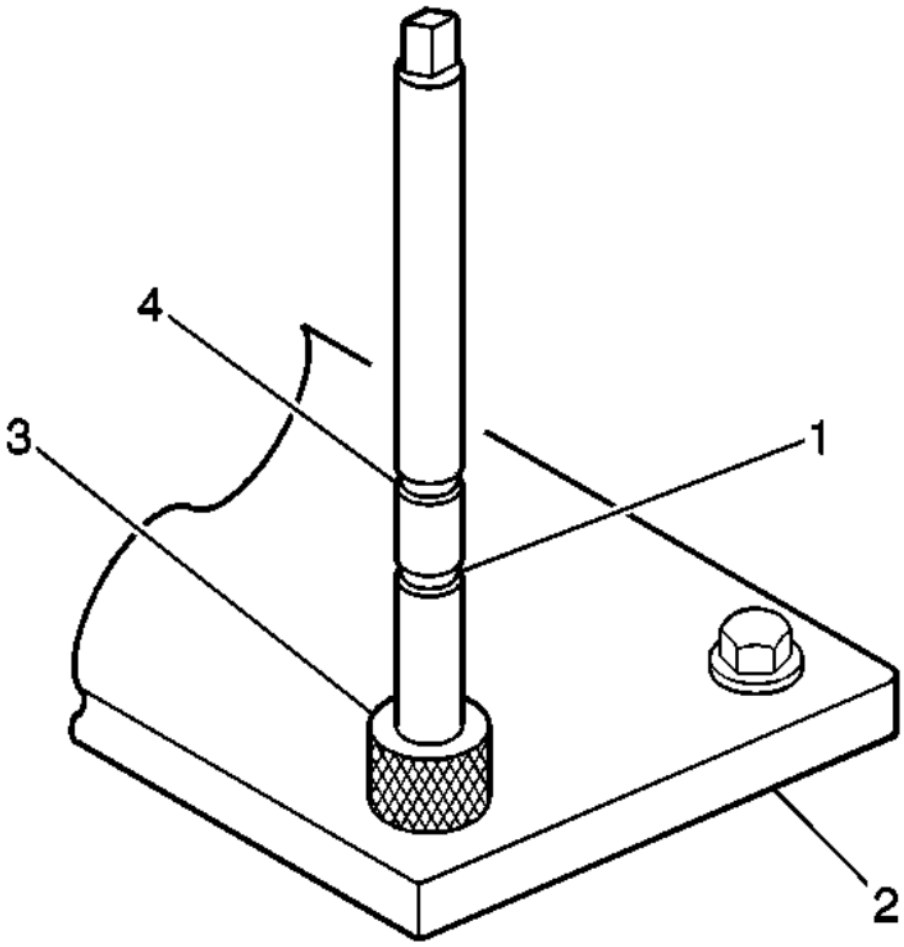

Fig. 494: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS COMPANY

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.

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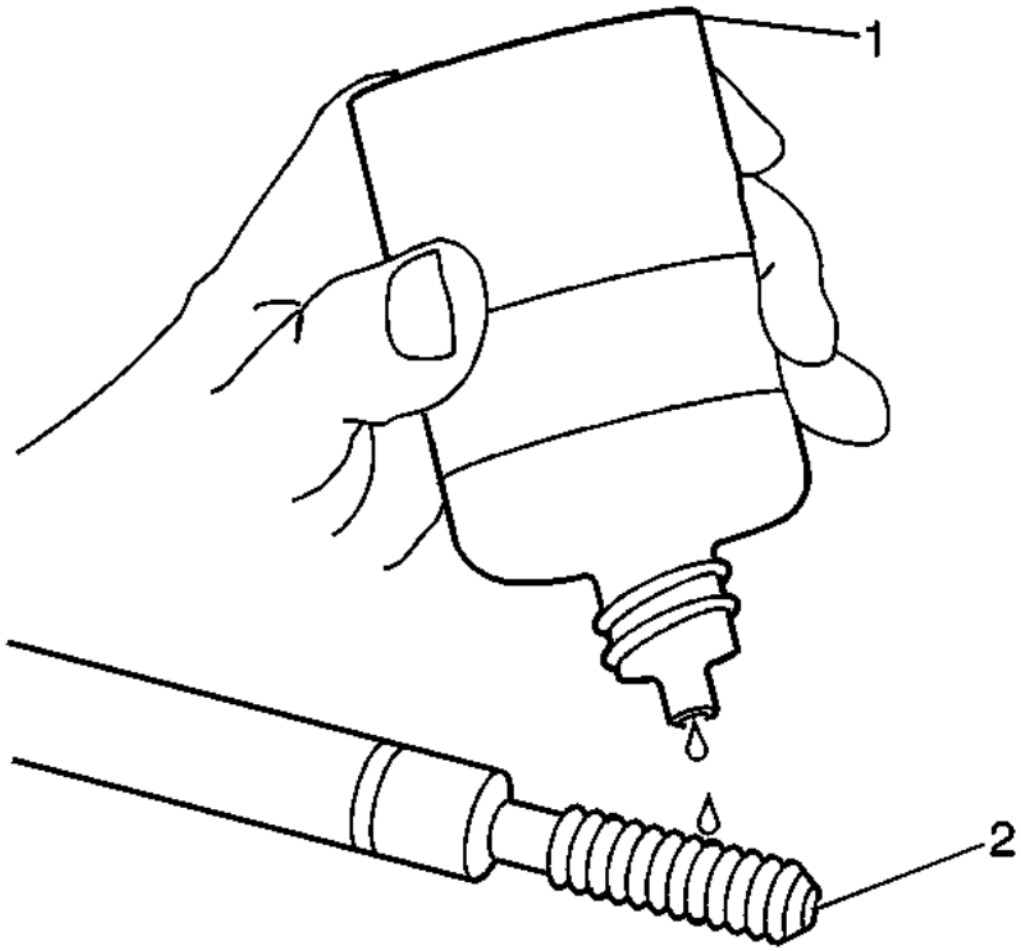

Fig. 495: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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).

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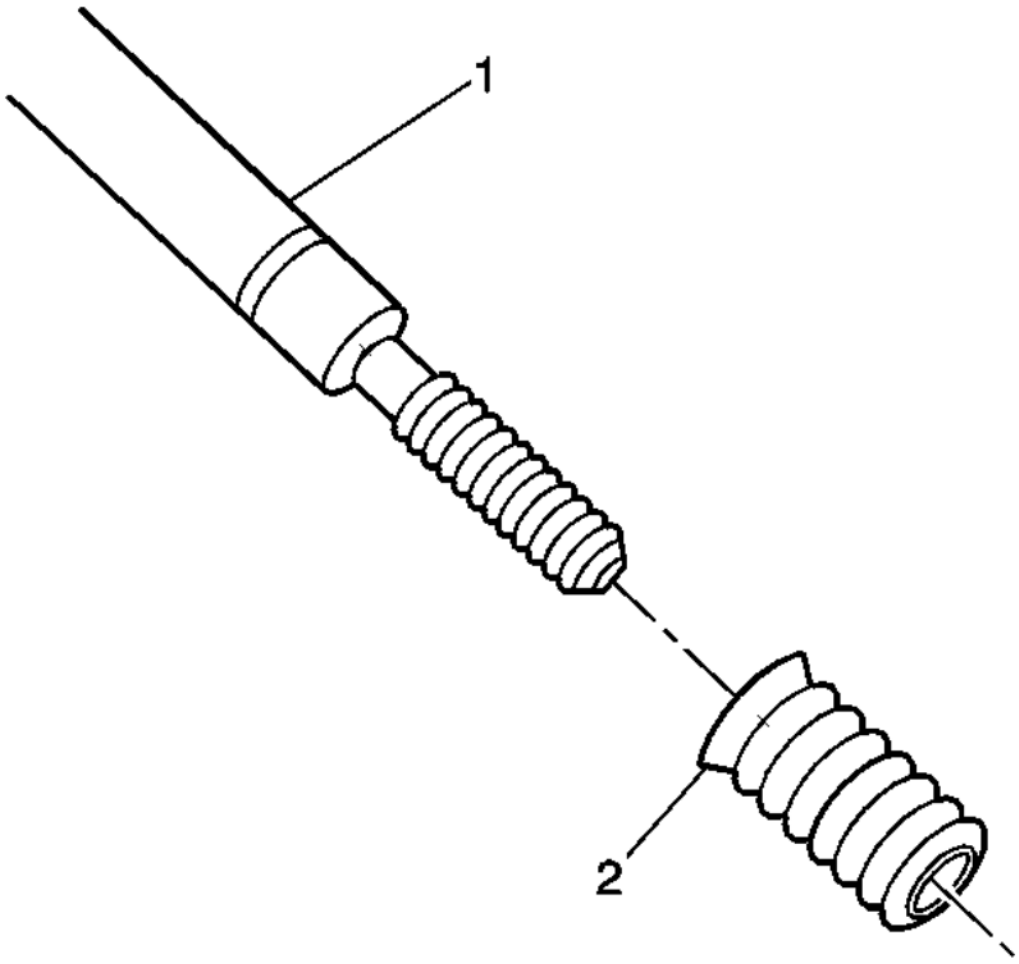

Fig. 496: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) onto the driver tool (1).

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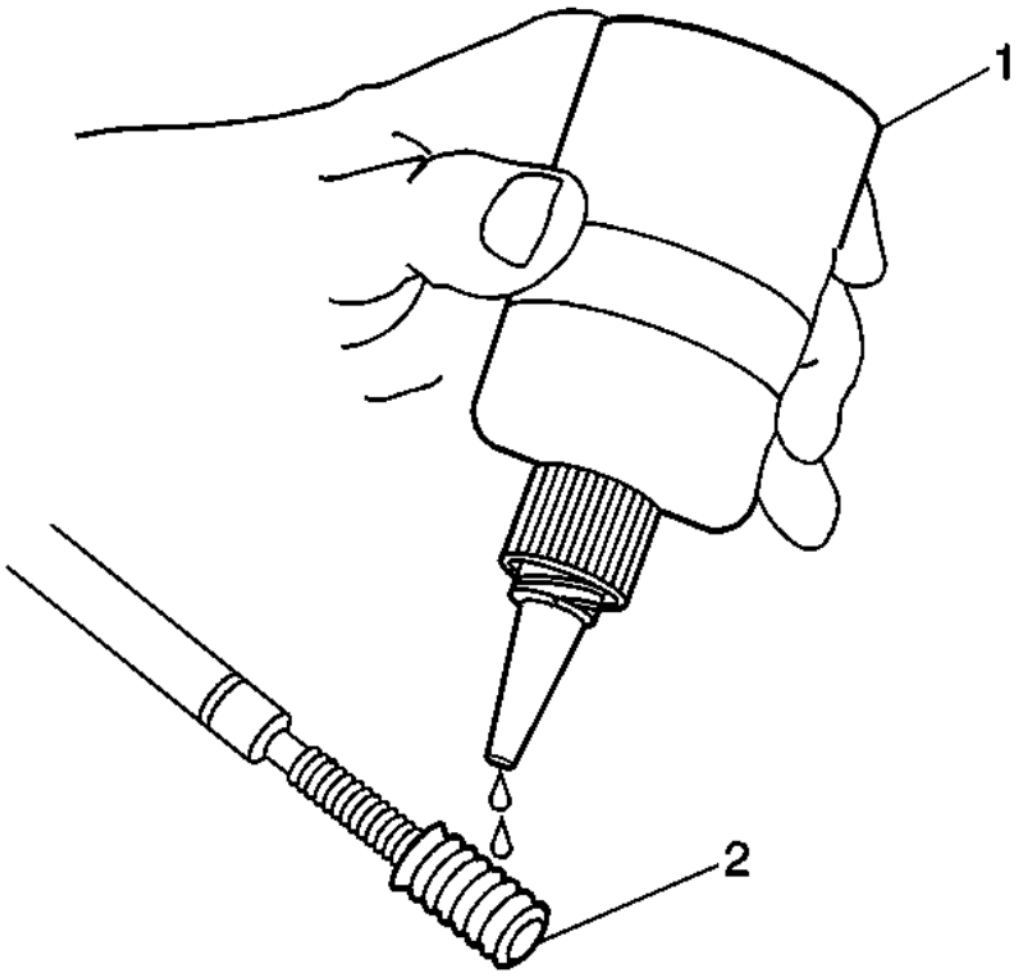

Fig. 497: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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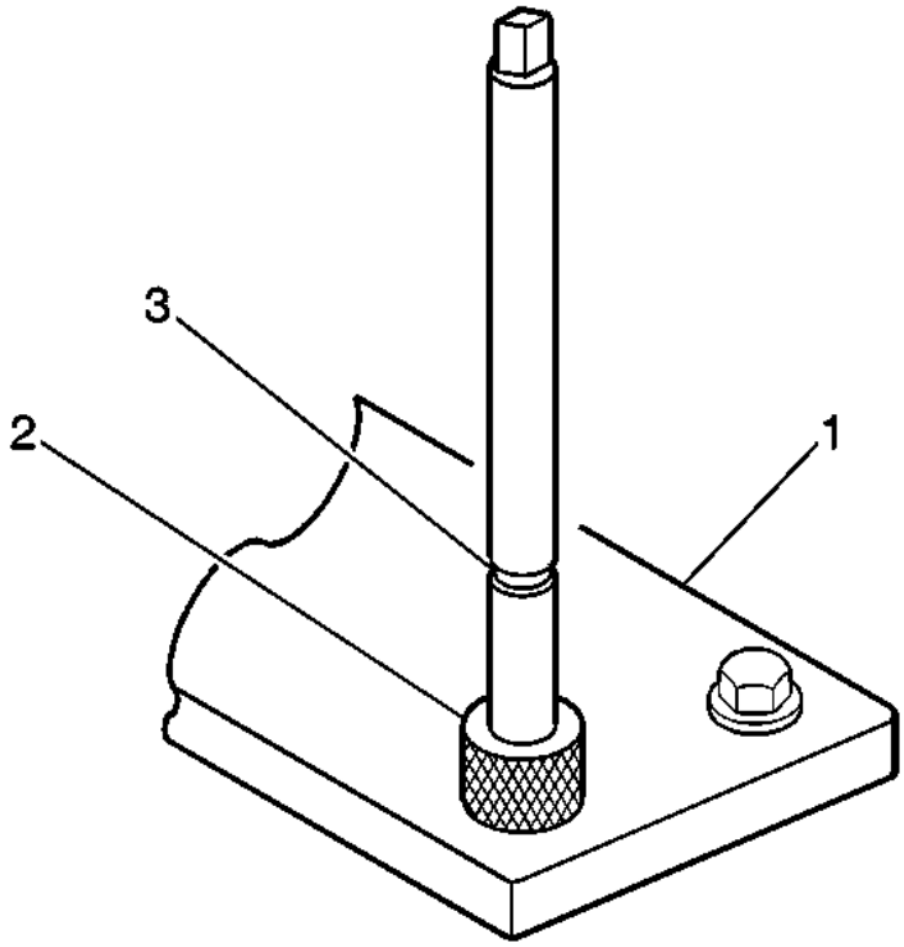

Fig. 498: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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 will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are re-installed into an engine, return the components to the original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil, unless otherwise specified. The engine oil will provide the initial lubrication when the engine is first started.

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ENGINE BLOCK PLUG INSTALLATION

Plug Installation - Right Side

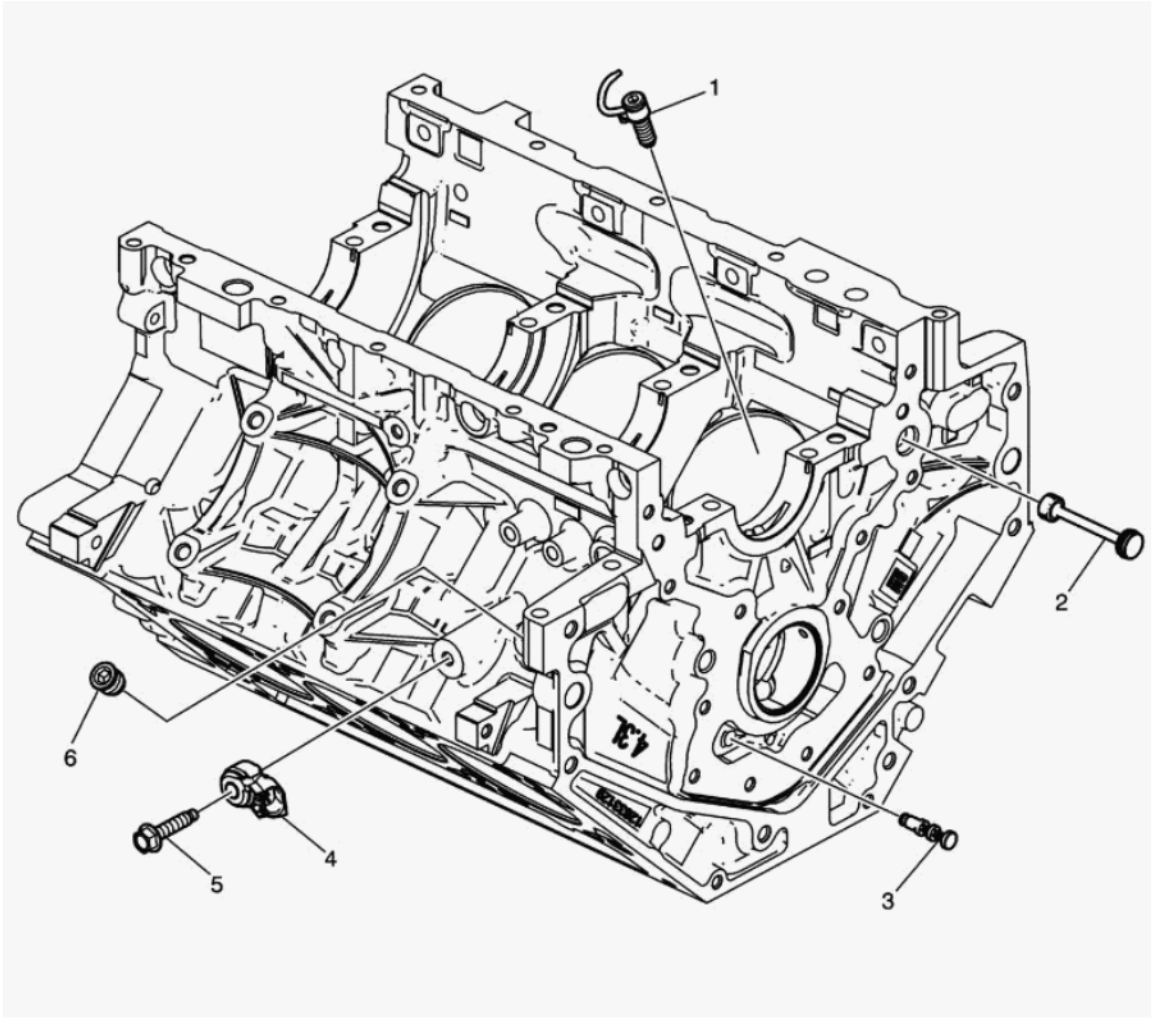

Fig. 499: Plug -- Right Side
Courtesy of GENERAL MOTORS COMPANY

Plug Installation - Right Side

Callout	Component Name
1	Piston Oil Nozzle Assembly **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 20 N.m (15 lb ft)
2	Engine Block Oil Gallery Plug
3	Engine Block Oil Gallery Plug
4	Knock Sensor Assembly

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Callout	Component Name
5	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)
6	Engine Block Plug **Tighten** 30 N.m (22 lb ft)

Plug Installation - Left Side

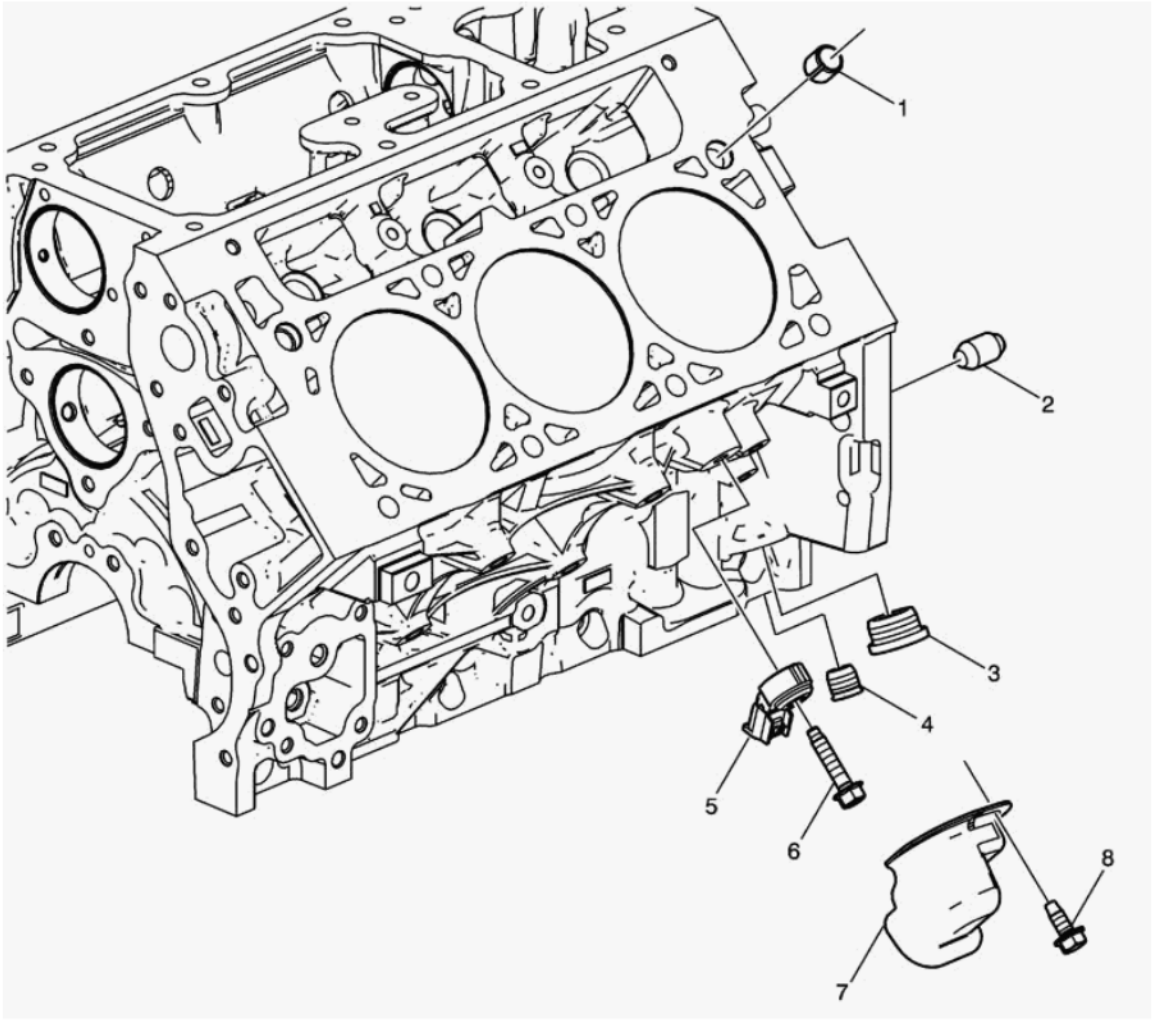

Fig. 500: Plug -- Left Side
Courtesy of GENERAL MOTORS COMPANY

Plug Installation - Left Side

Callout	Component Name
1	Cylinder Head Locating Pin
2	Transmission Locating Pin
3	Engine Block Plug **Tighten** 60 N.m (44 lb ft)
4	Engine Block Plug **Tighten** 30 N.m (22 lb ft)

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Callout	Component Name
5	Knock Sensor Assembly
6	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)
7	Knock Sensor Shield
8	Knock Sensor Shield Bolt **Tighten** 25 N.m (18 lb ft)

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to **Special Tools**

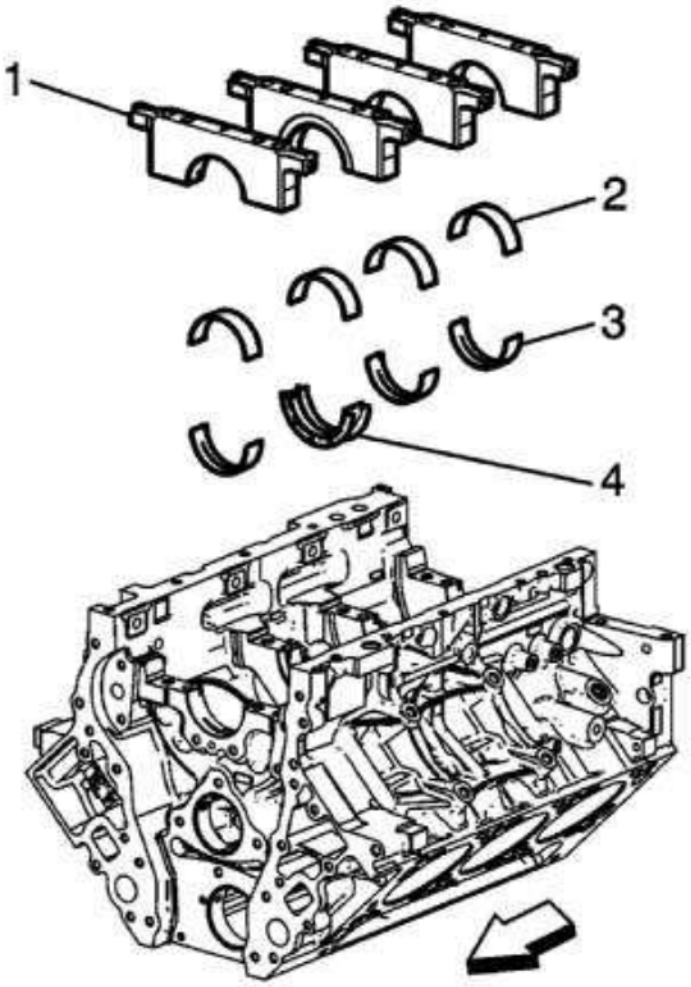

Fig. 501: Crankshaft Bearings, Bearing Caps And Engine Block
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may affect crankshaft position (CKP) sensor signals and/or on-**

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board diagnostic (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.**
- **In order to prevent engine block oil leakage, install NEW crankshaft bearing cap side bolts.**

1. Install the crankshaft bearings (2 and 3) to the engine block and bearing caps (1). The thrust bearings (4) are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

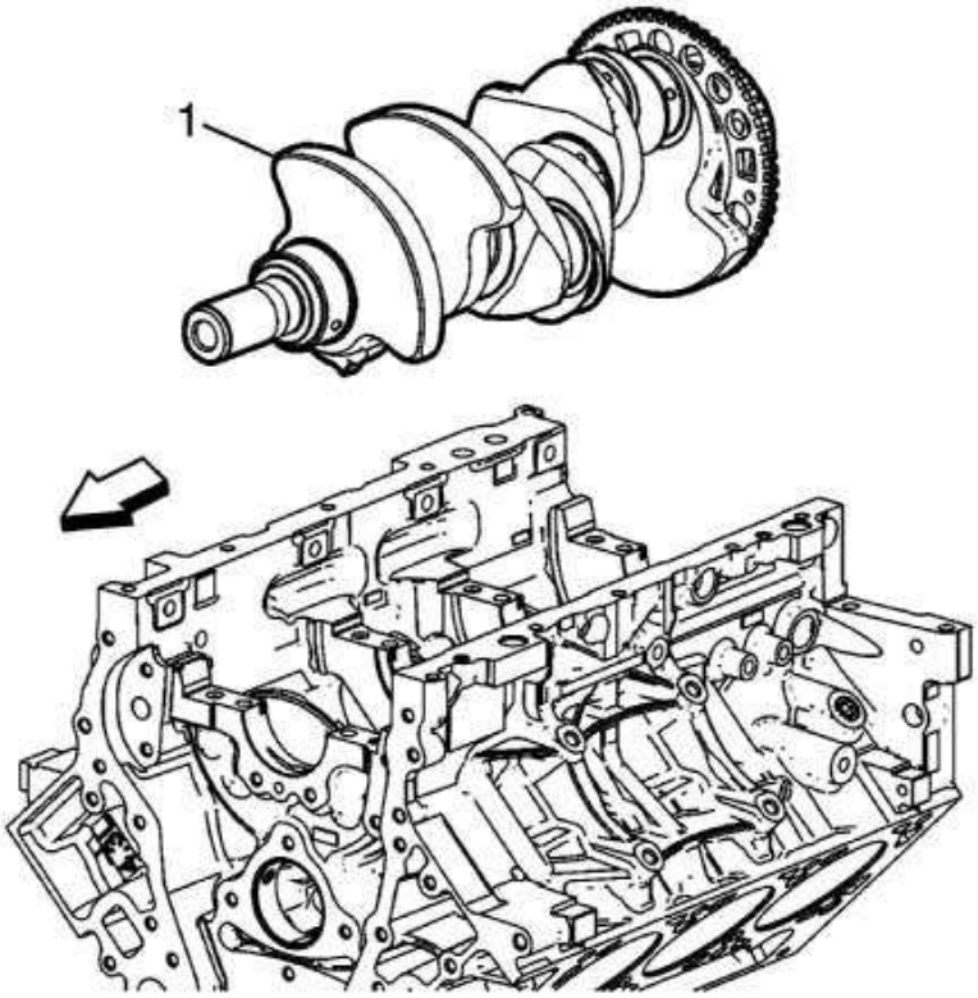

Fig. 502: Crankshaft
Courtesy of GENERAL MOTORS COMPANY

CAUTION: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft (1).

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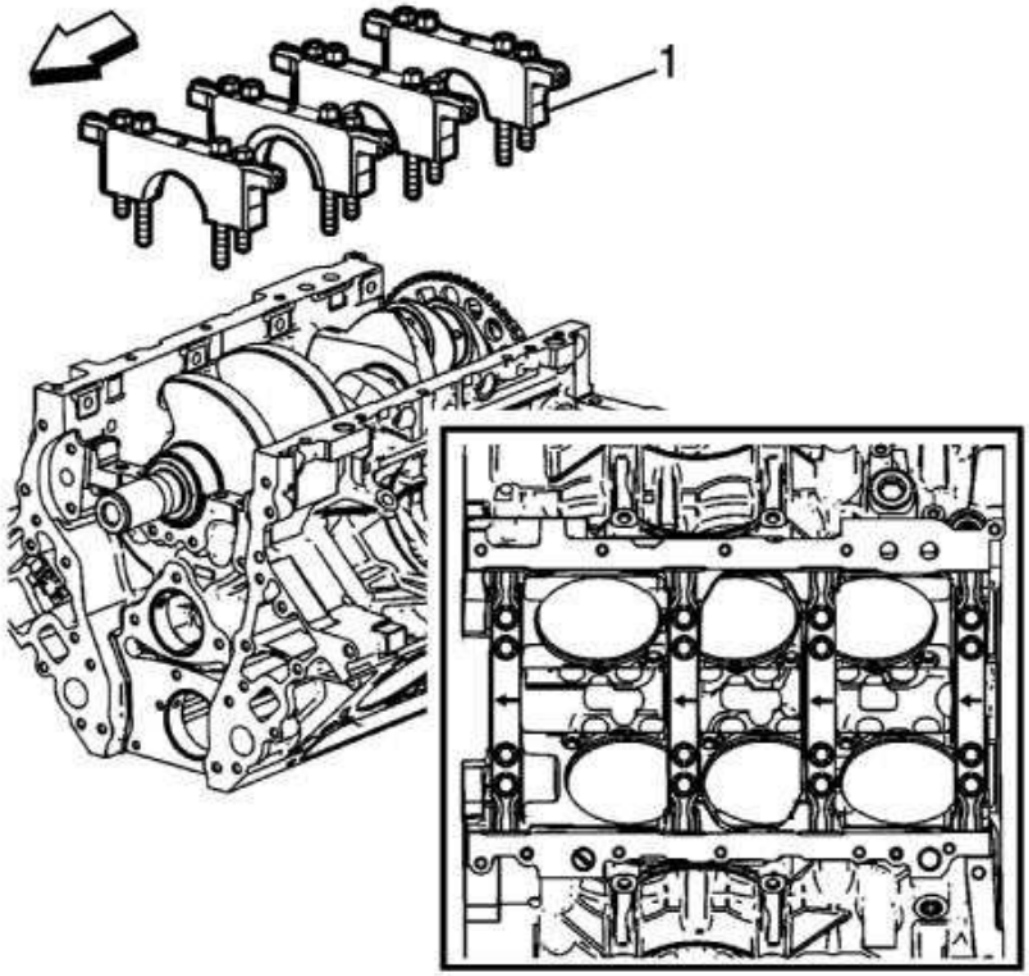

Fig. 503: Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The bearing caps (1) must be installed in the proper location and direction. The arrows on the bearing caps must point toward front of engine.**

4. Install the crankshaft bearing caps (1), with bearings, into the engine block.

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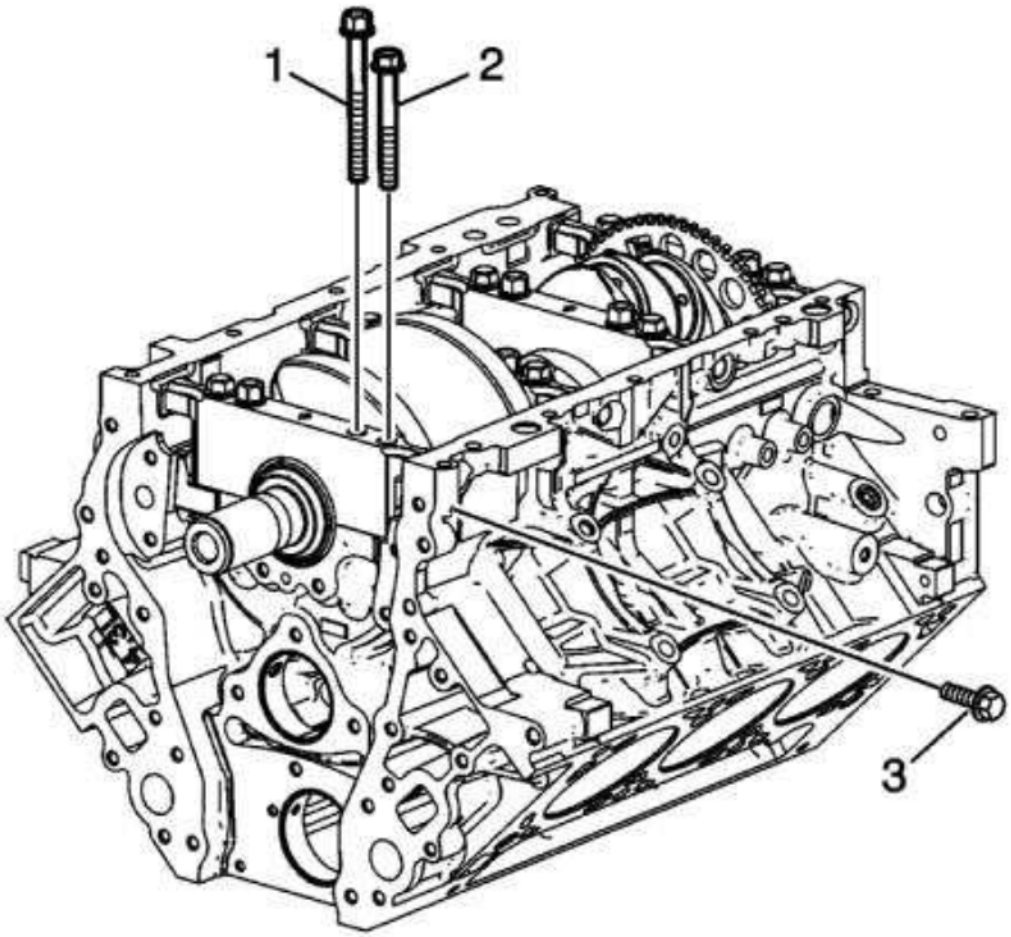

Fig. 504: Crankshaft Inner Bearing Cap Bolts And Outer Bearing Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE: **The inner bearing cap bolts are longer than the outer bearing cap bolts.**

5. Install NEW inner bearing cap bolts (1) and NEW outer bearing cap bolts (2)
6. Using a plastic-face hammer, tap the bearing caps into place.
7. Install the NEW bearing cap side bolts (3).

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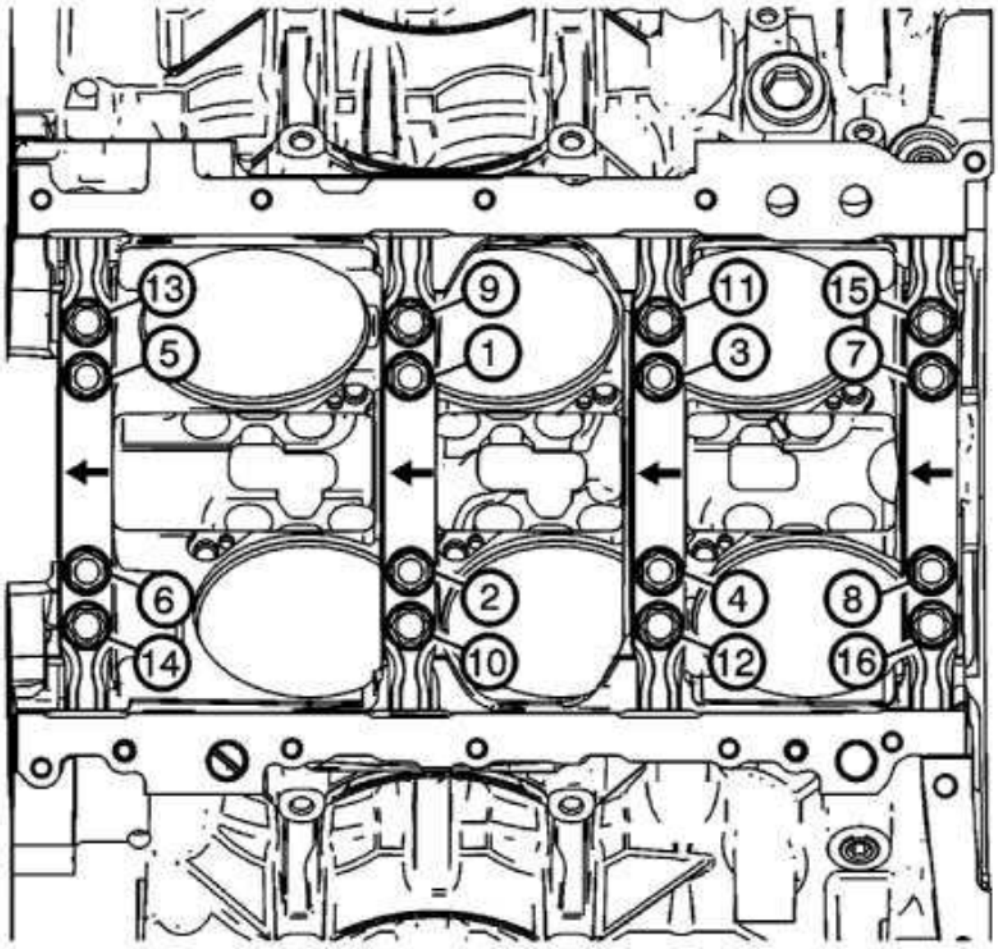

Fig. 505: Inner Bearing Cap Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

8. Tighten the inner bearing cap bolts (1-8) a first pass in sequence to 20 N.m (15 lb ft).

NOTE: **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 in order to align the thrust bearings.
   - Tighten the inner bearing cap bolts (1-8) a final pass in sequence 110 degrees using the **EN-45059** meter.
   - Tighten the outer bearing cap bolts (9-16) a first pass in sequence to 20 N.m (15 lb ft).
   - Tighten the outer bearing cap bolts (9-16) a final pass in sequence 80 degrees using the **EN-45059** meter.

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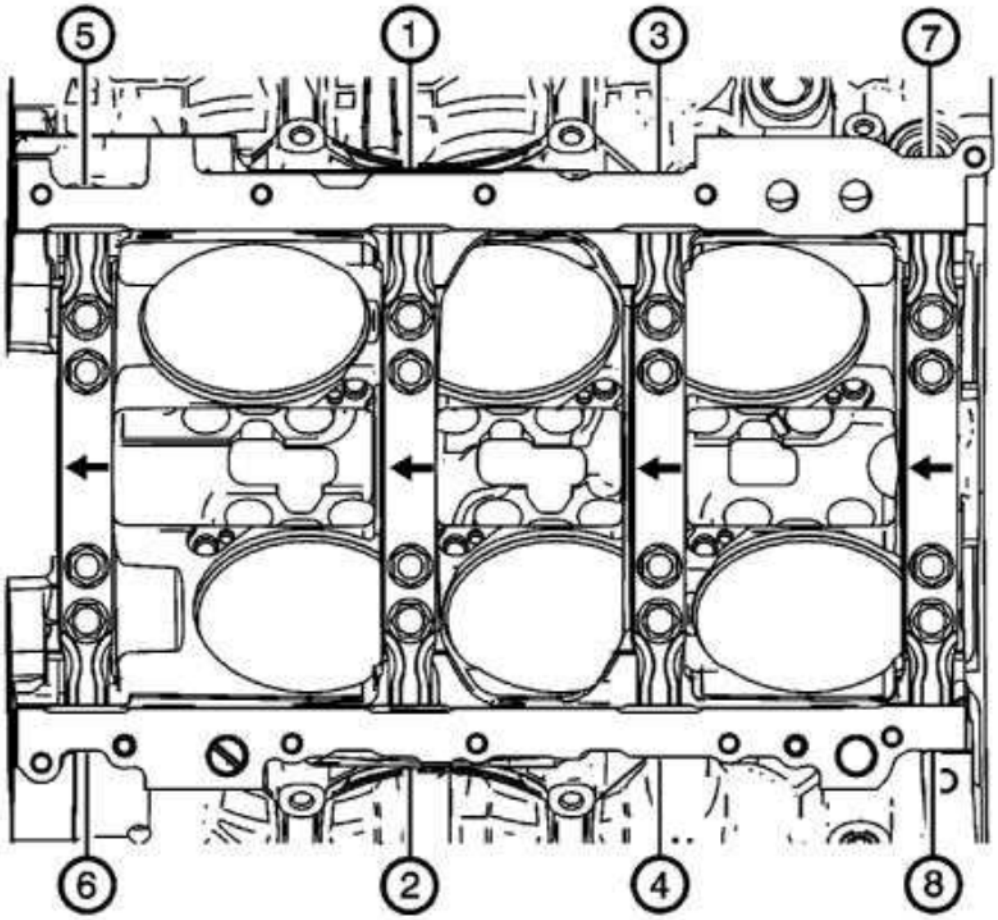

Fig. 506: Main Bearing Cap Side Bolt Tighten Sequence
Courtesy of GENERAL MOTORS COMPANY

10. Tighten the main bearing cap side bolts (1-8).
    - Tighten the bearing cap side bolts (1-8) a first pass in sequence to 25 N.m (18 lb ft).
    - Tighten the bearing cap side bolts (1-8) a final pass in sequence to 60 degrees using the **EN-45059** meter.

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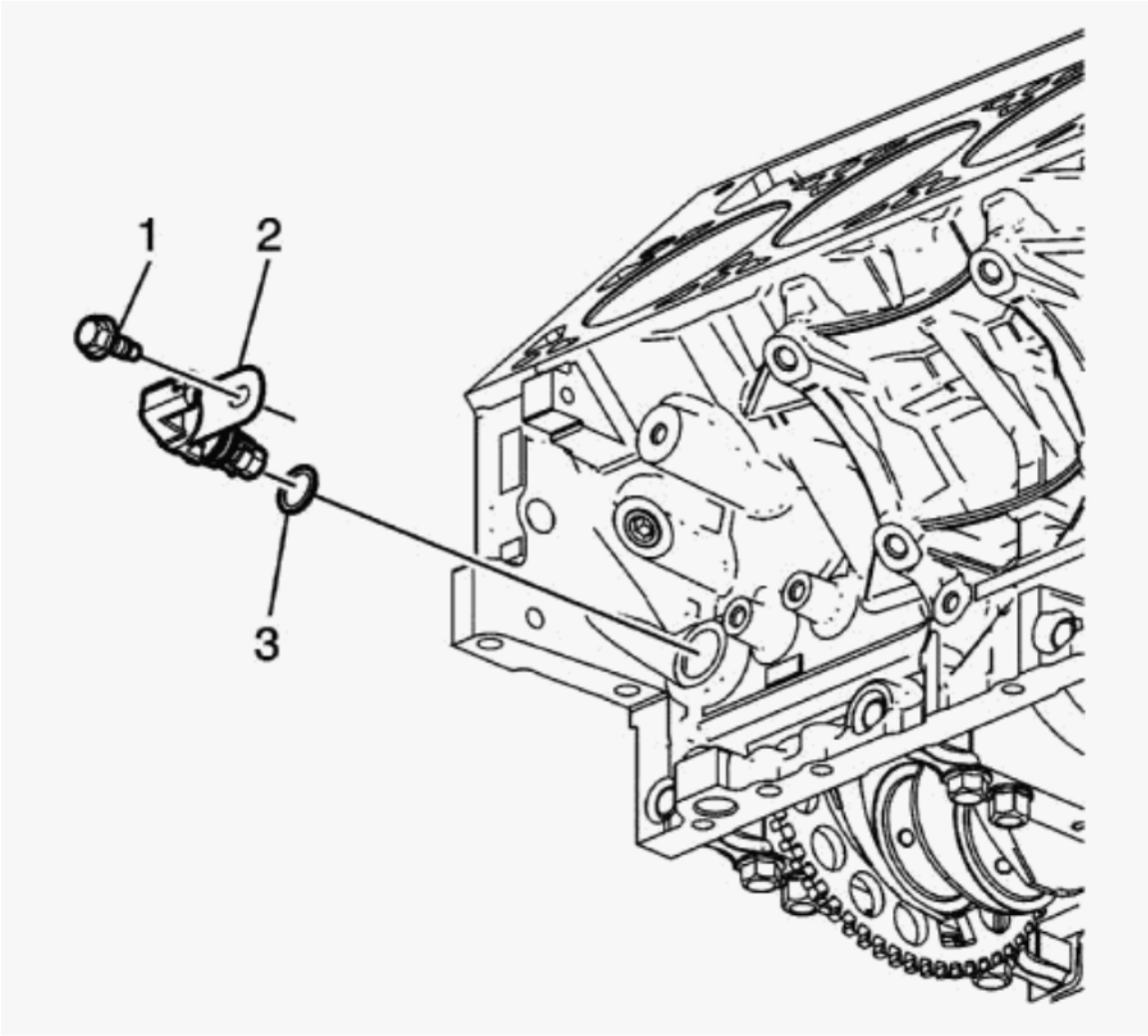

Fig. 507: O-ring, CKP Sensor And Crankshaft Position (CKP) Sensor Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Install the CKP sensor (2).
    1. Inspect the CKP sensor O-ring seal (3). If the O-ring seal is not cut or damaged, it may be used again.
    2. Coat the O-ring seal (3) with clean engine oil.
    3. Install the O-ring seal (3) onto the sensor.
    4. Install the sensor (2). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.
    5. Install the sensor bolt (1) and tighten to 25 N.m (18 lb ft).

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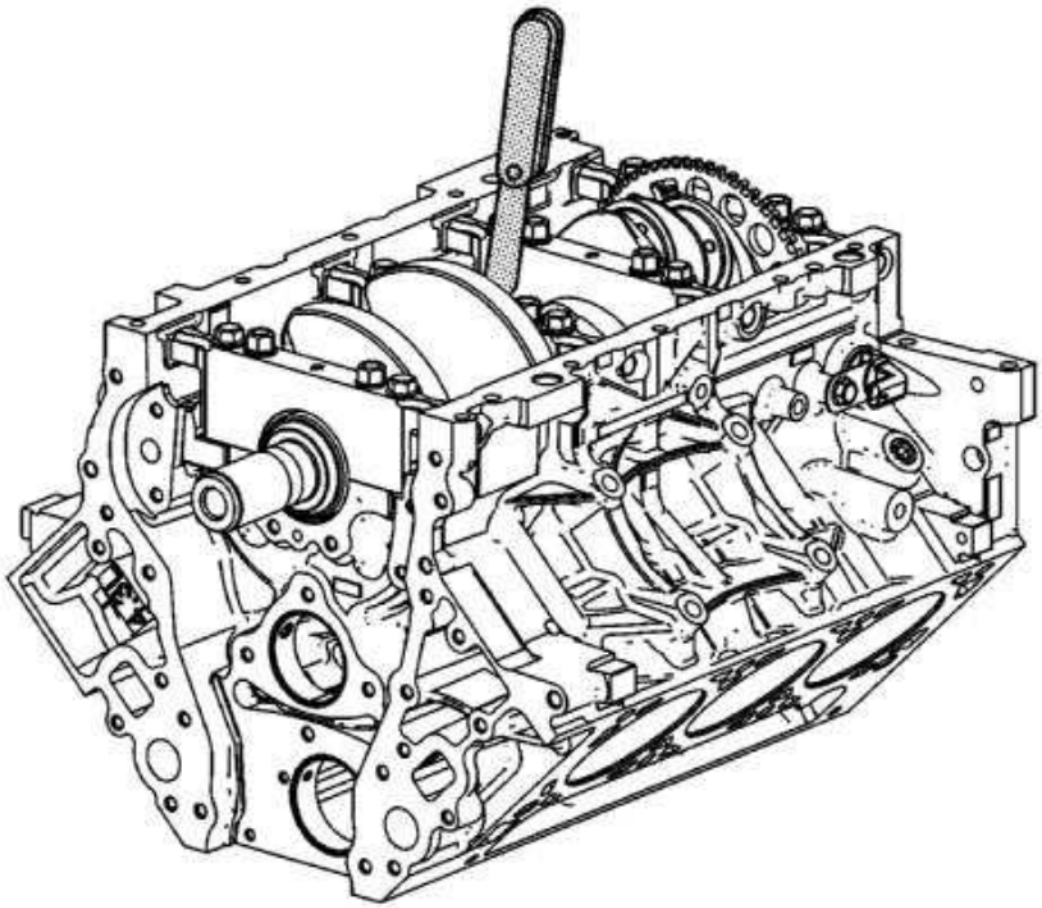

Fig. 508: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS COMPANY

12. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gauge 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

Special Tools

- **EN-8087** Cylinder Bore Gauge
- **EN-41556** Connecting Rod Guide
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Piston Selection

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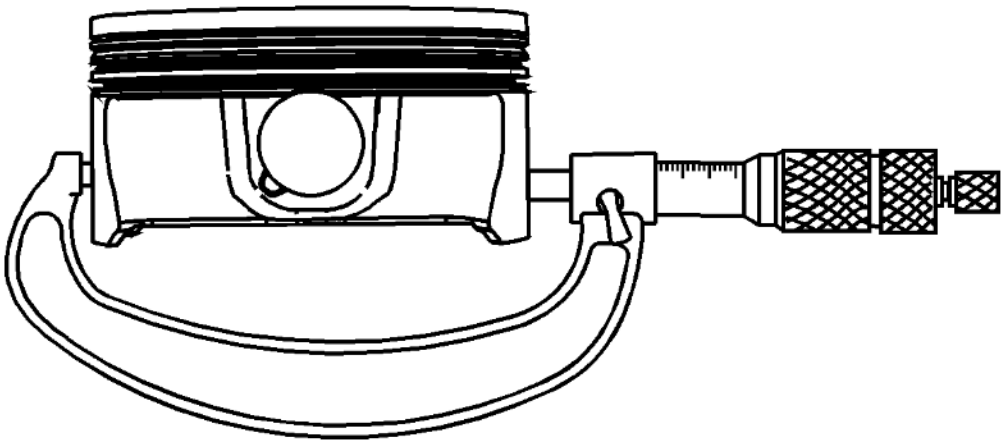

Fig. 509: Measuring Piston Outside Diameter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **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.

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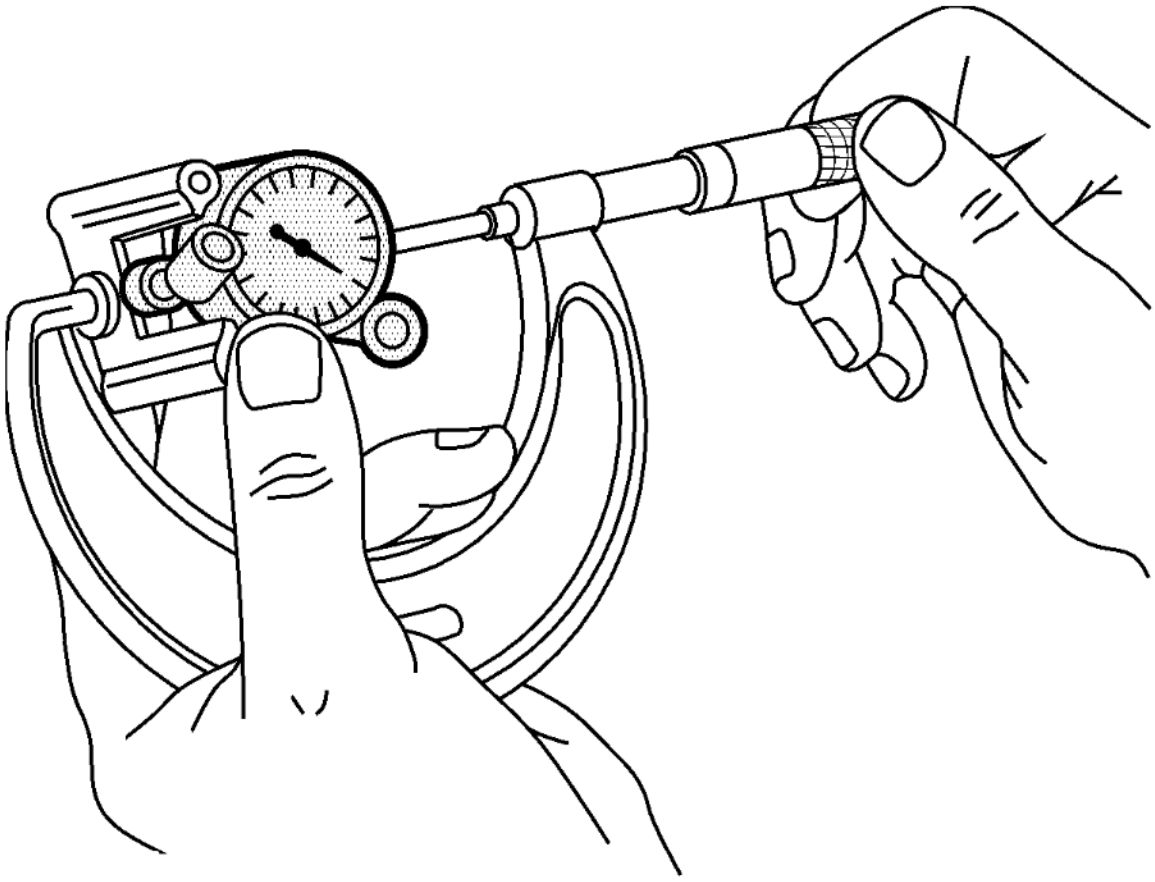

Fig. 510: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS COMPANY

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **EN-8087** bore gauge into the micrometer and zero the gauge dial.

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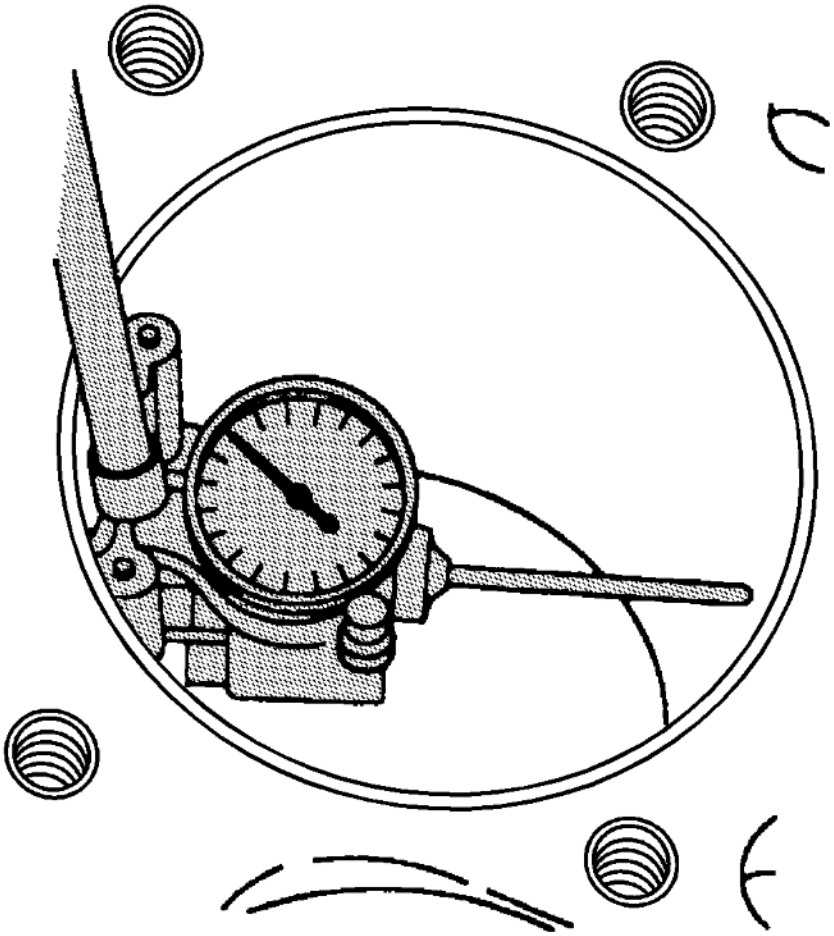

Fig. 511: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

5. Using the **EN-8087** bore gauge , 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 in order to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston and pin assembly and measure the clearances again. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

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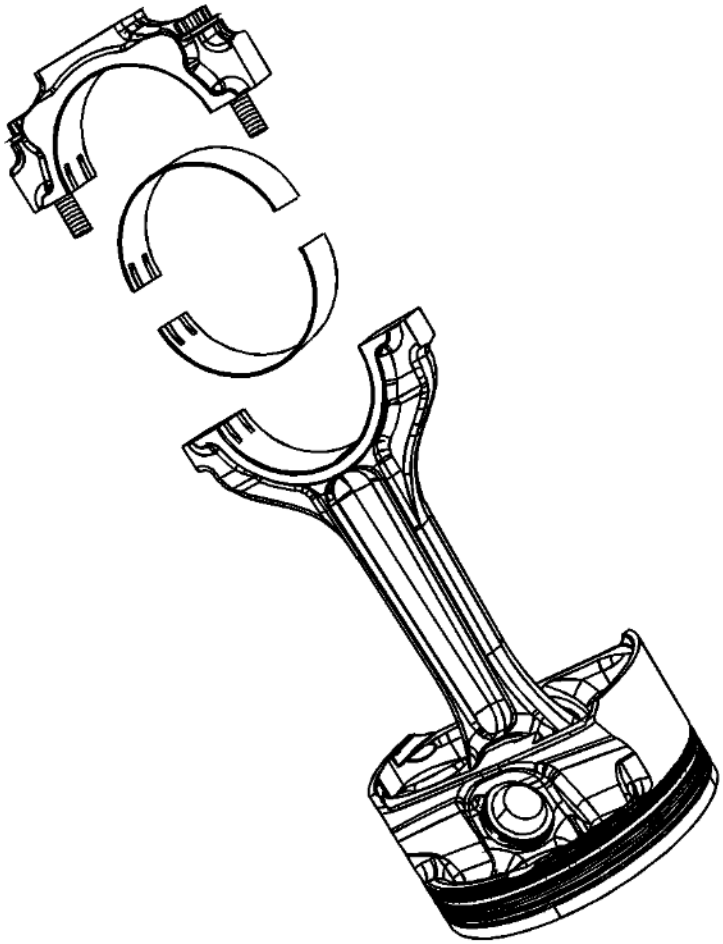

Fig. 512: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the following components with clean engine oil:
    - Piston
    - Piston rings
    - Cylinder bore
    - Bearings and bearing surfaces
2. Install the bearings to the connecting rod and cap.
3. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
4. Position the compression ring end gaps 180 degrees opposite each other.

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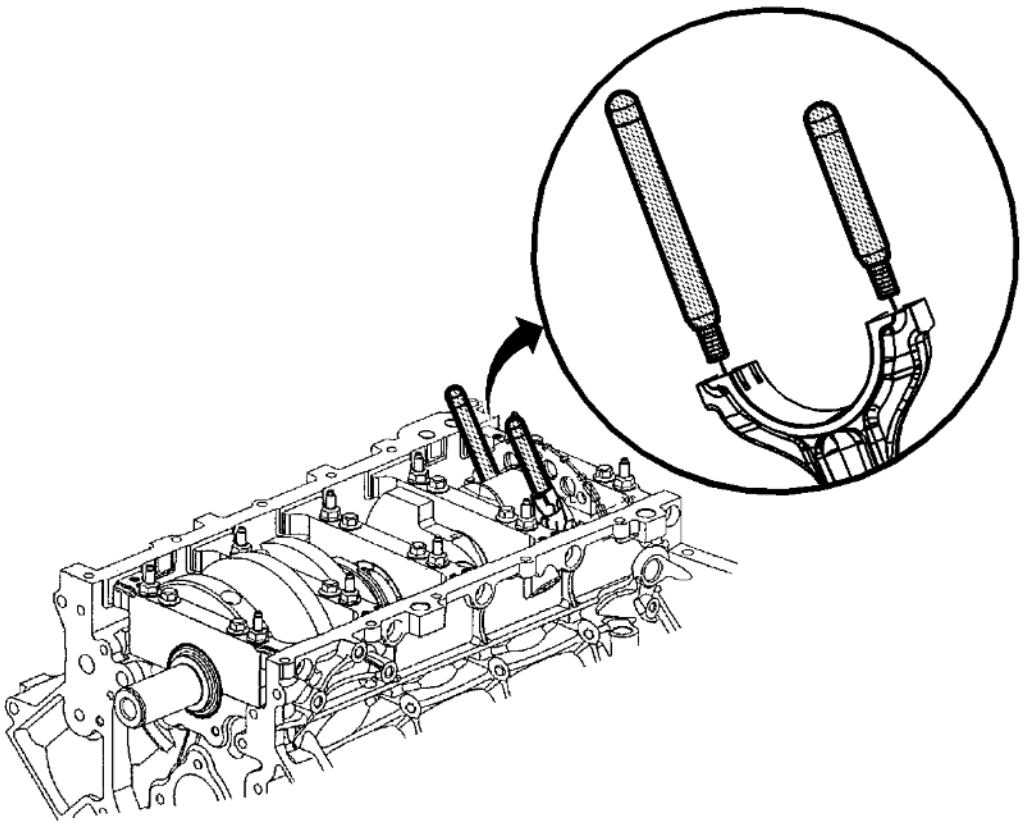

Fig. 513: Crankshaft Protector Pins Installed in Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-41556** rod guide to the connecting rod.

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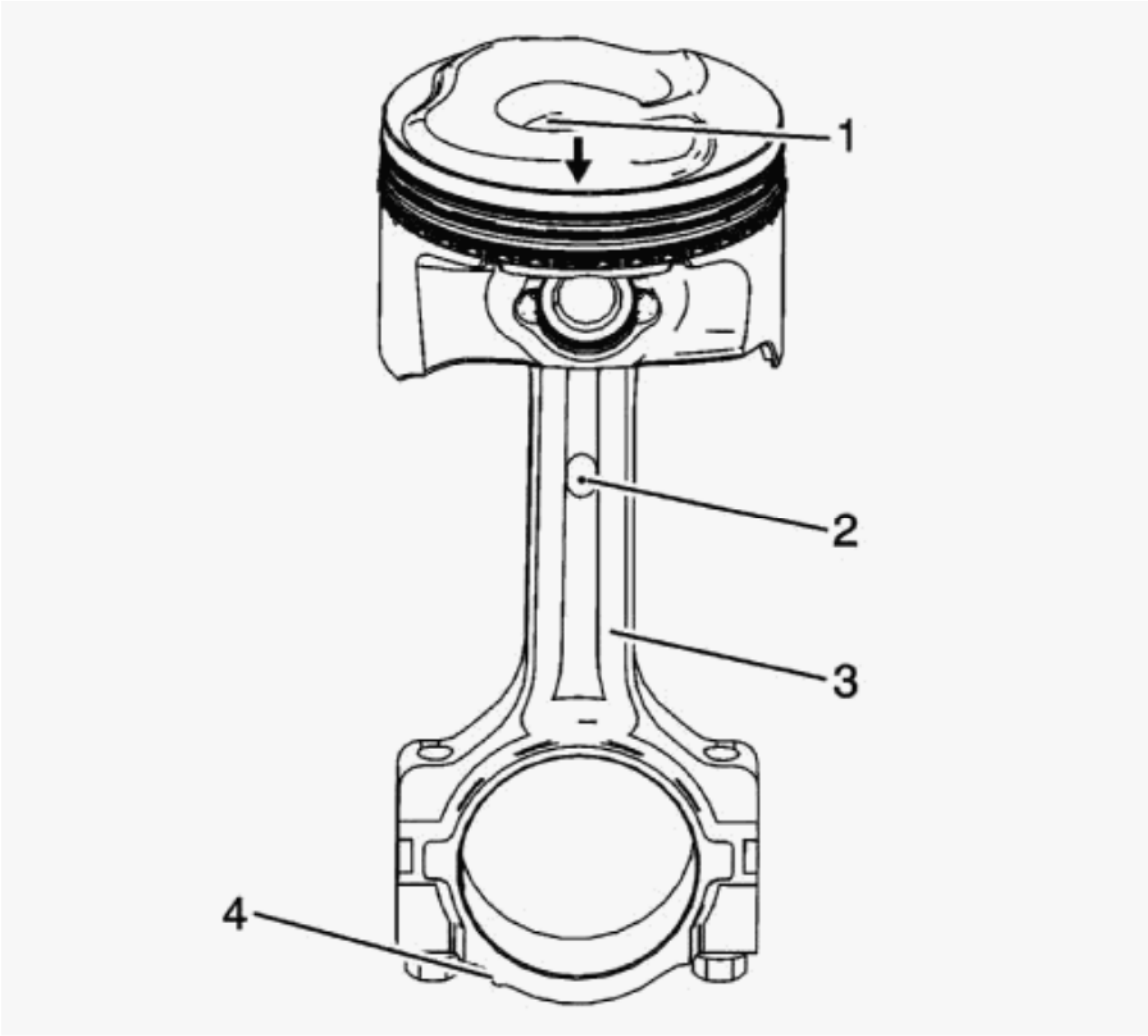

Fig. 514: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

6. Identify the proper installation direction of the piston and connecting rod assembly. The right and left side are assembled differently. Right Side: The arrow on top of the piston and the dimple (2) on the rod face the same direction. When installing the right side piston and rod (3) assemblies, the arrow on top of the piston and the dimple (2) on the rod face the front of the engine. the raised bump (4) on the bottom of the rod (3) will be closest to the outside of the engine. The deepest part of the fuel bowl (1) must face the outside of the engine.

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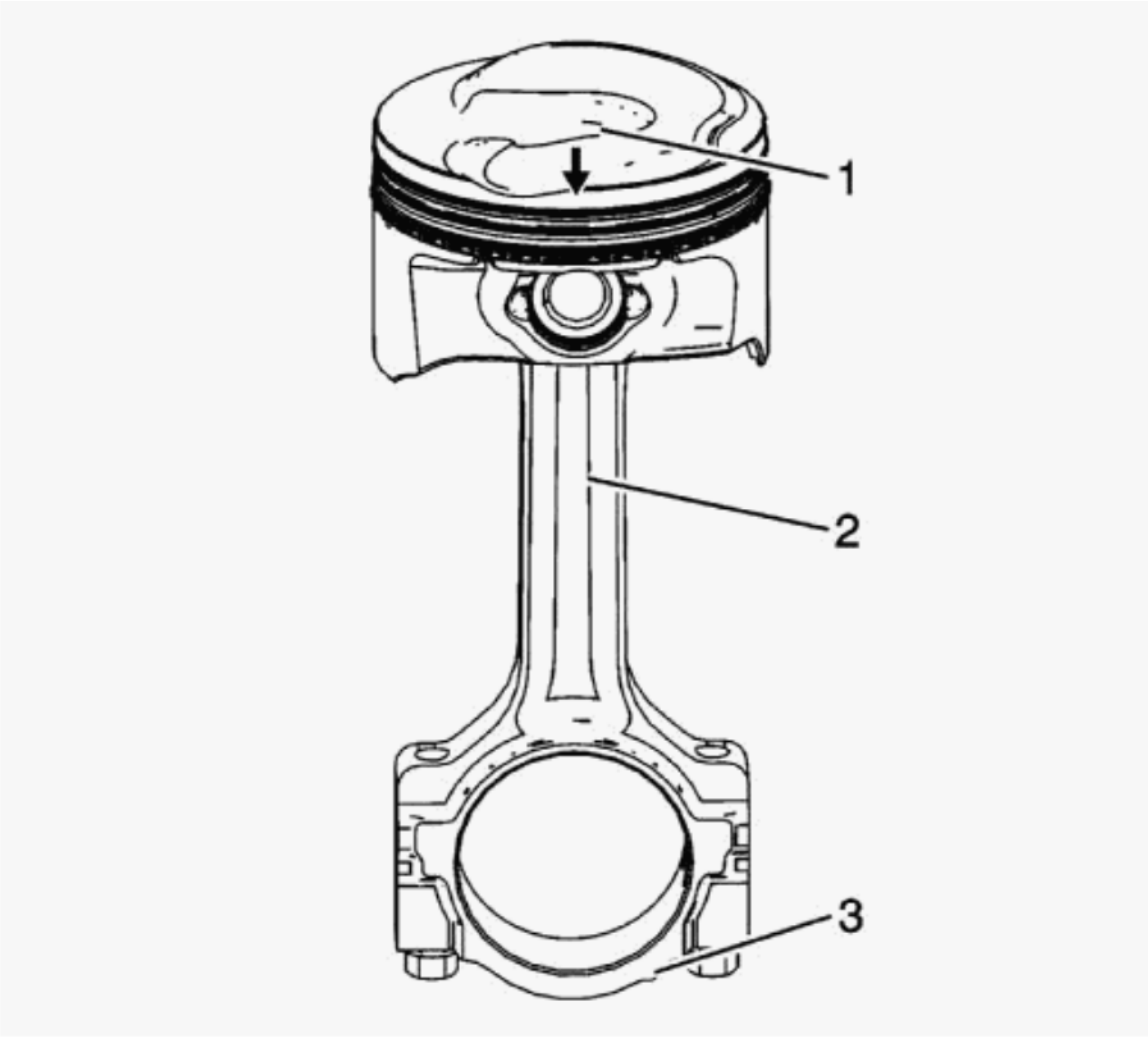

Fig. 515: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

7. Left Side: the arrow on top of the piston and the dimple on the rod face the opposite direction. When installing the left side piston and rod (2) assemblies, the arrow on top of the piston faces the front of the engine and the dimple on the rod faces the rear of the engine. The raised bump (3) on the bottom of rod will be closest to the outside of engine. The deepest part of the fuel bowl (1) must face the outside of the engine.

NOTE: **When installing a piston into a cylinder, use a ring compressor sleeve or equivalent for best results. The following features should be looked for when selecting a ring compressor sleeve.**

- **Hard anodized and Teflon coated for low friction and prolonged wear resistance.**
- **Smooth radius that tapers down to the specific bore size.**
- **Sleeve should compress the piston rings smoothly and evenly.**
- **Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.**

If a ring compressor sleeve is unavailable, a universal ring compressor will work, but is more difficult to use.

8. Compress the piston rings using a ring compressor sleeve or equivalent.

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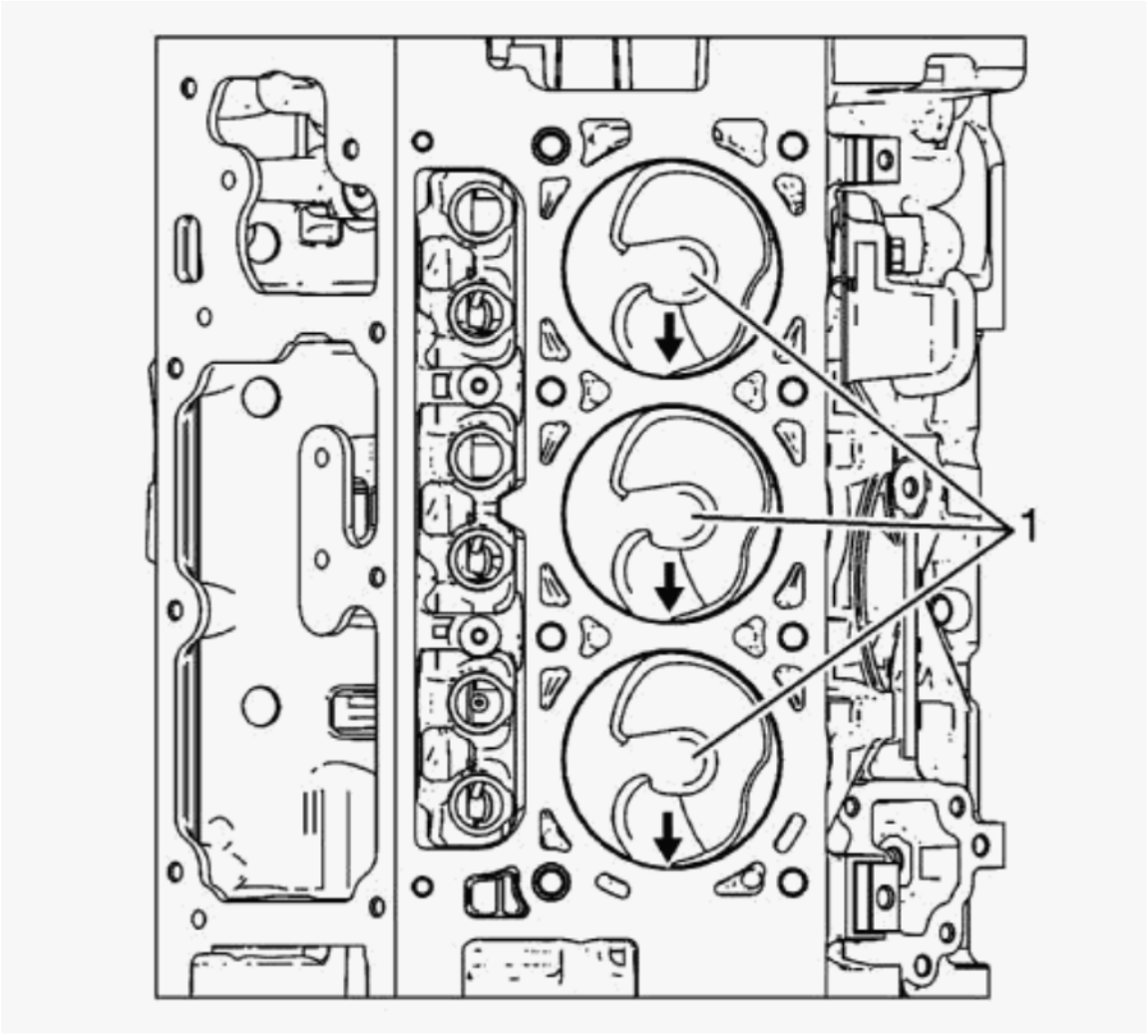

Fig. 516: Deepest Portion Of Fuel Bowls Must Be Toward Outside Of Engine
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The arrow on the top of the piston MUST face the front of the engine block. The deepest portion of the fuel bowls (1) must be toward the outside of the engine.**

9. Install the piston, pin, and connecting rod assembly into the cylinder bore. Tap the piston into the bore with a wooden hammer handle. Guide the connecting rod to the crankshaft journal using the **J-41556** rod guide while gently tapping the piston into place. Hold the ring compressor sleeve or equivalent against the engine block until all rings have entered the cylinder bore.
10. Remove the **EN-41556** rod guide from the connecting rod.

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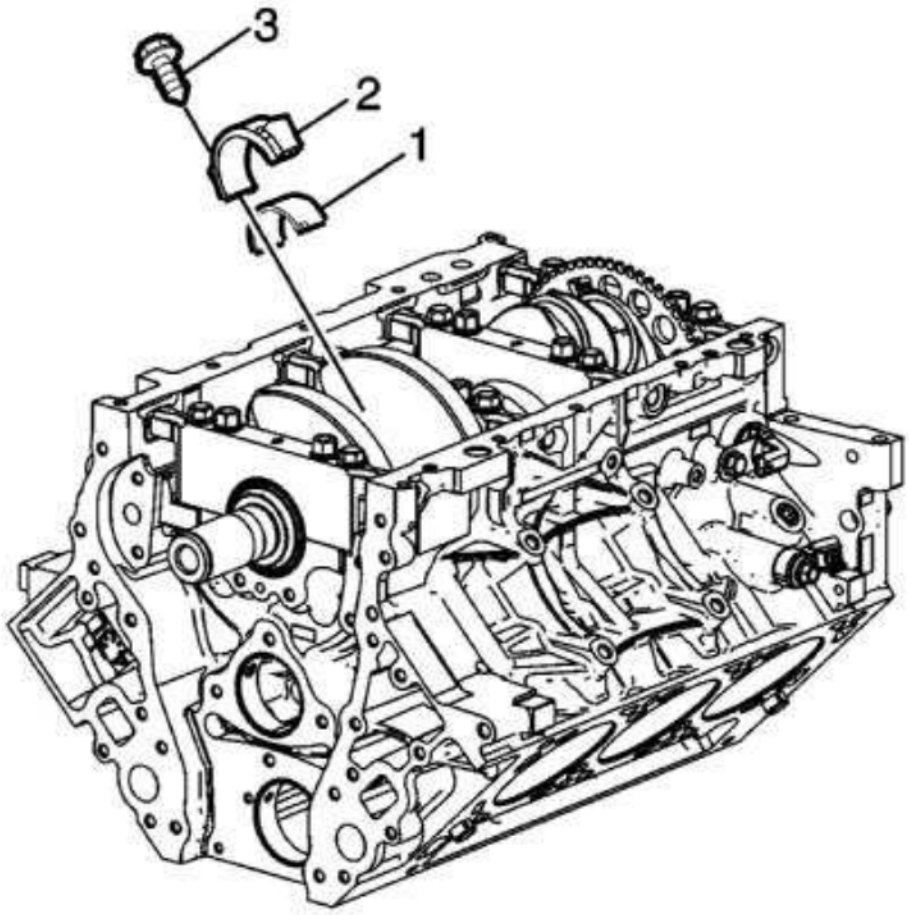

Fig. 517: Connecting Rod Bolts, Cap And Bearing
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

CAUTION: **Refer to Fastener Caution .**

NOTE:

- **The connecting rod and cap must be assembled with the mating surfaces properly aligned.**
- **If re-using connecting rods, DO NOT re-use connecting rod fasteners. During an installation procedure, the new connecting rod bolts can be re-tightened a maximum of 3 times.**

11. Install the bearing (1), bearing cap (2), and bolts (3).
    1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
    2. Tighten the bolts a final pass to 85 degrees using the **EN-45059** angle meter.

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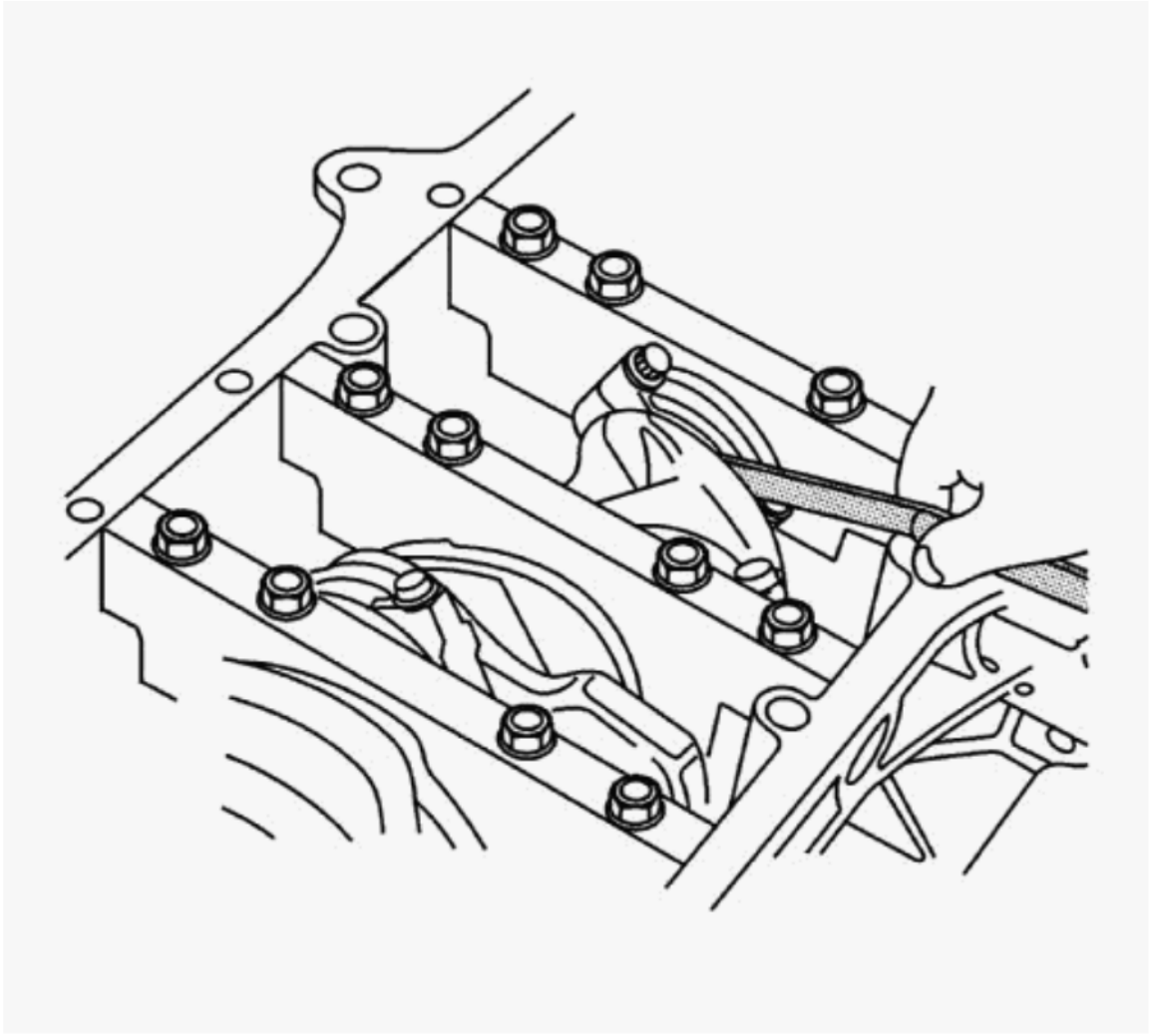

Fig. 518: Measuring Connecting Rods For Proper Side Clearance
Courtesy of GENERAL MOTORS COMPANY

12. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications**.

CAMSHAFT INSTALLATION

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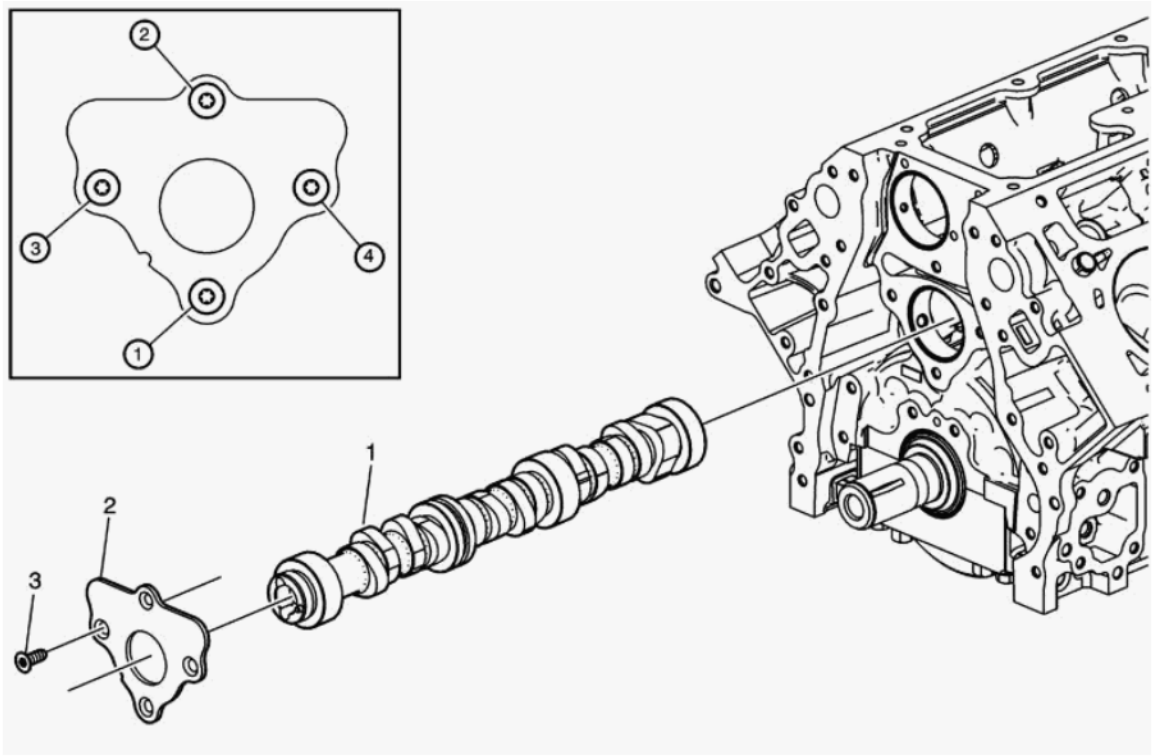

Fig. 519: Camshaft Retainer And Bolts
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Assembly
2	Camshaft Retainer
3	Camshaft Retainer Bolt (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Clean the threads of the cam retainer bolts and apply a sealant.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the retainer bolts in the sequence shown. **Tighten** 15 (11 lb ft)

VALVE LIFTER INSTALLATION

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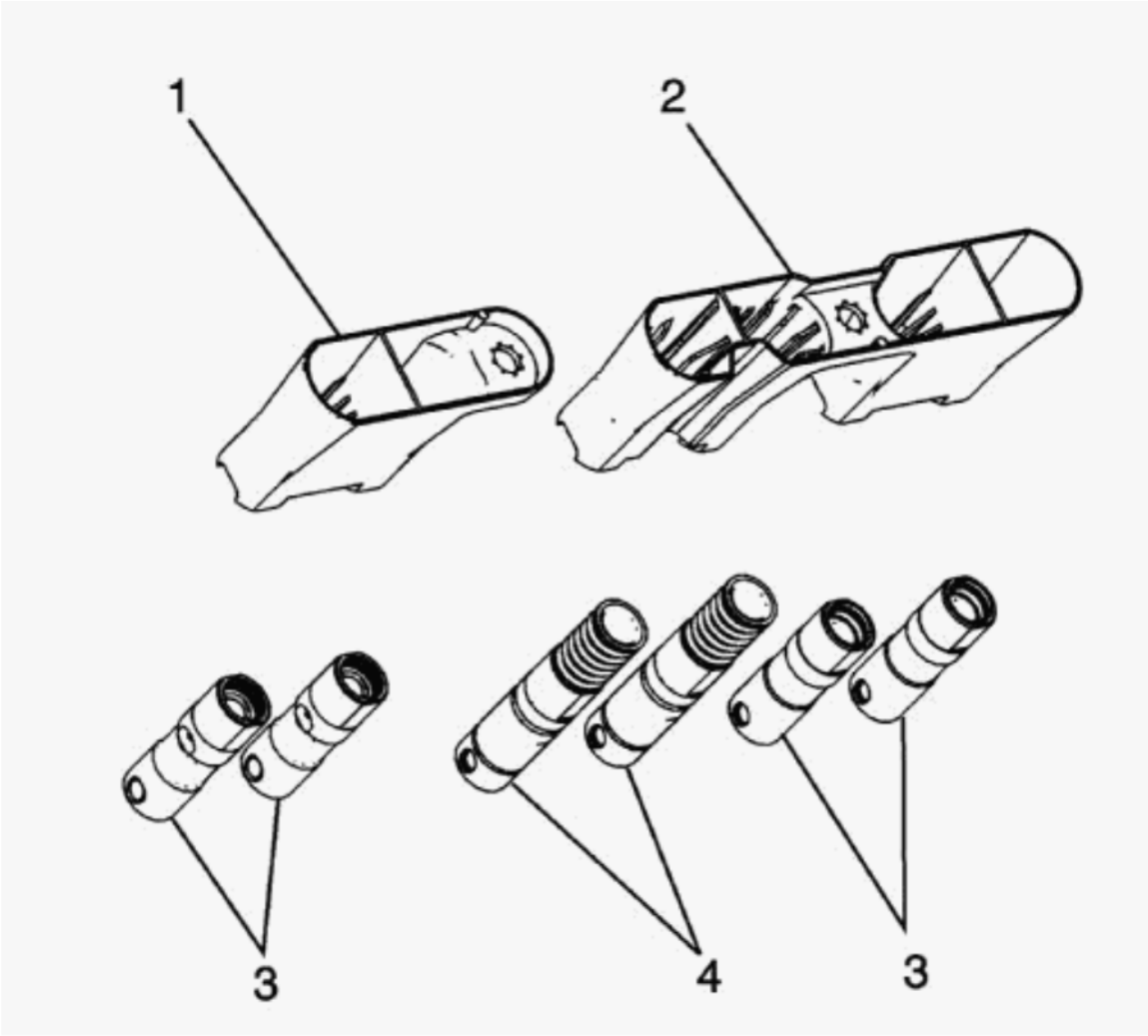

Fig. 520: Valve Lifters And Guides
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the 2 front valve guide assemblies will contain 2 non-active fuel management valve lifters. Each of the 2 rear valve guide assemblies will contain 2 active fuel management valve lifters and 2 non-active fuel management valve lifters.**
- **With the lifters and guides properly installed, cylinders 3 and 6 lifter bores will each contain 2 active fuel management valve lifters.**

1. Lubricate the valve lifters (3 and 4) and engine block valve lifter bores with clean engine oil.

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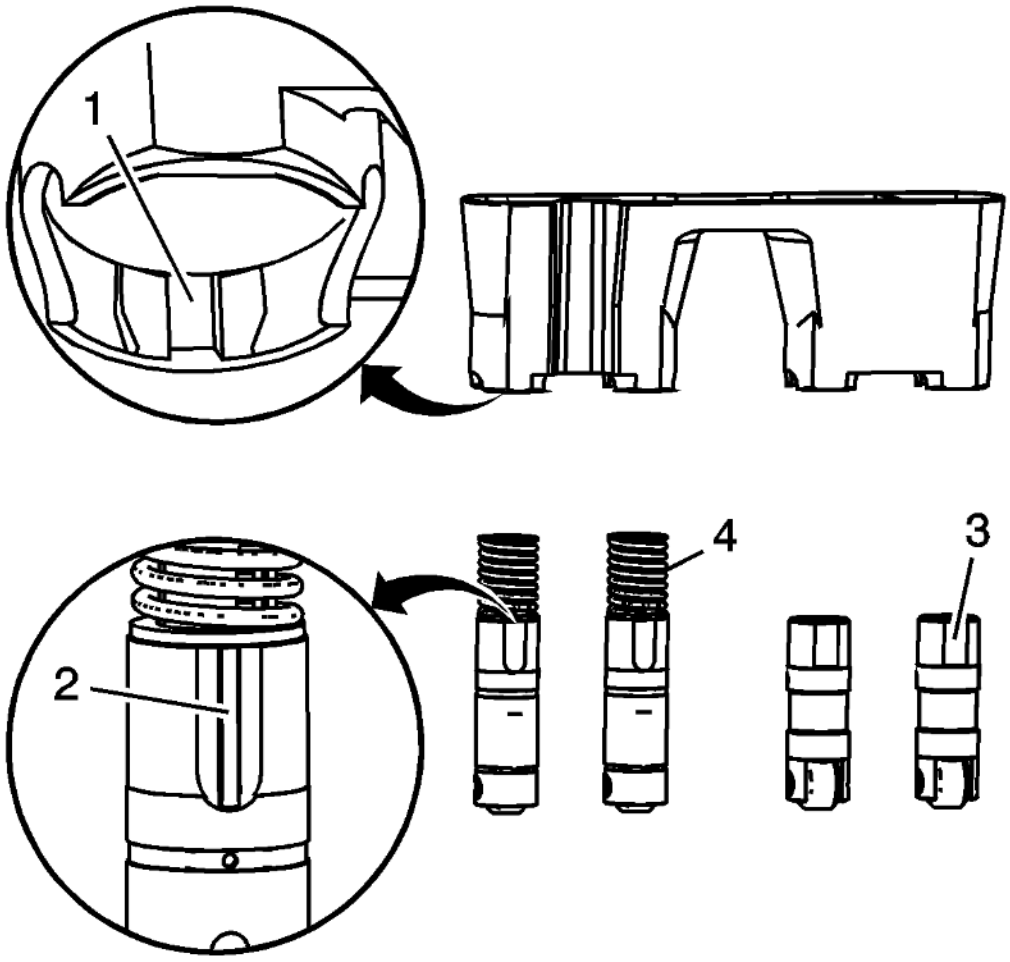

Fig. 521: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

2. Insert the valve lifters into the lifter guides.
    - Align the flat area (3) on the top of the non-active fuel management lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
    - The active fuel management lifters (4) are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.

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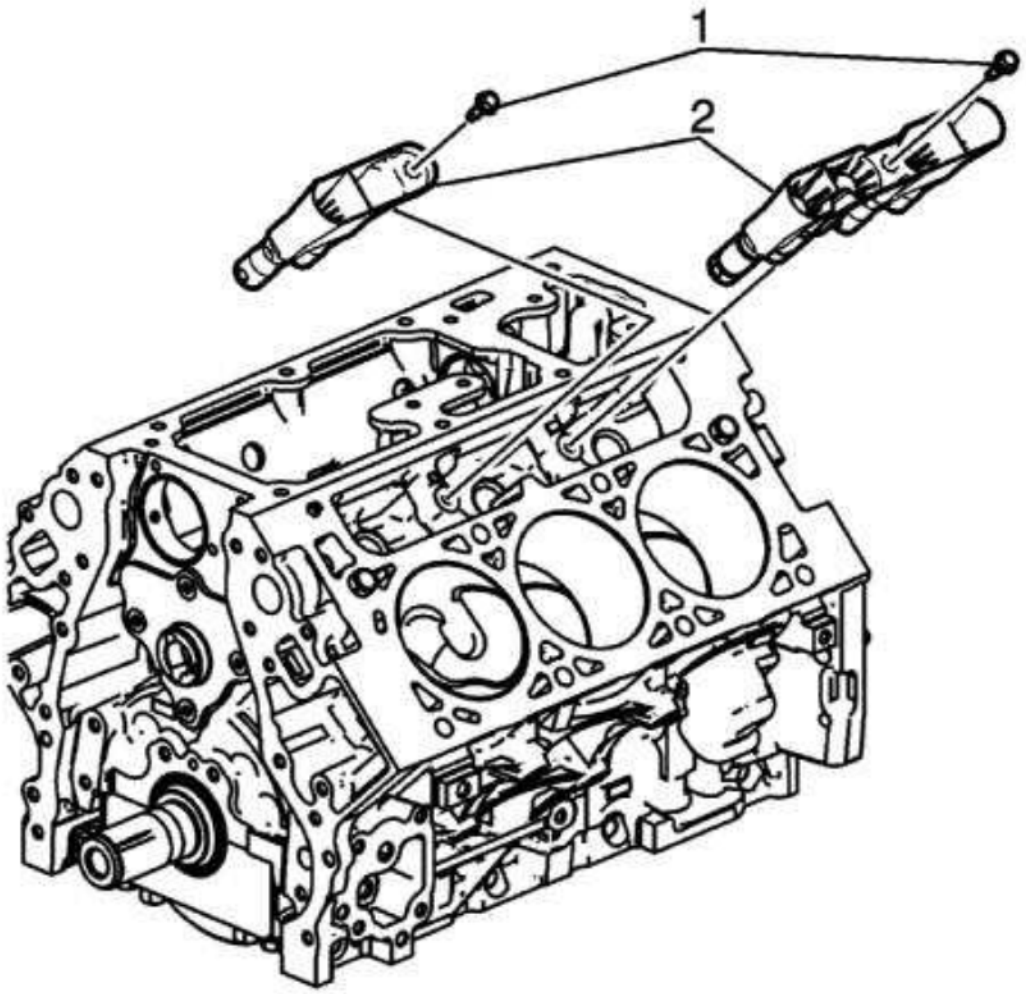

Fig. 522: Guides With Lifters And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the valve lifters and guide assembly (2) to the engine block.

CAUTION: **Refer to Fastener Caution .**

4. Install the valve lifter guide bolts (1) and tighten to 12 N.m (106 lb in).

VALVE LIFTER FOLLOWER GUIDE INSTALLATION

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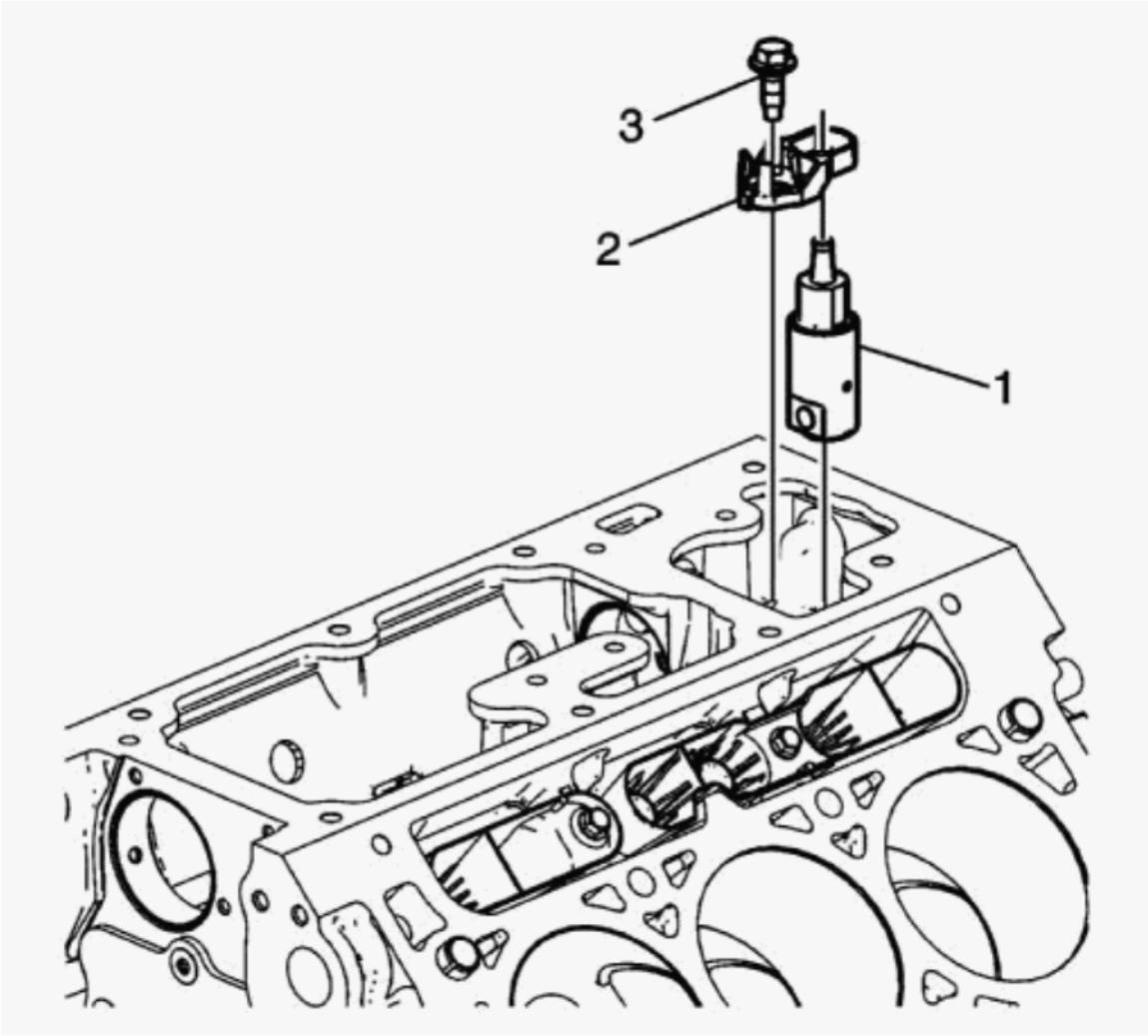

Fig. 523: Valve Lifter Follower Guide And Valve Filter Follower
Courtesy of GENERAL MOTORS COMPANY

1. Install the valve lifter follower (1).
2. Install the valve lifter follower guide (2).

CAUTION: Refer to Fastener Caution .

3. Install the valve lifter follower guide bolt (3). Tighten to 12 N.m (10 lb in).

VALVE LIFTER OIL MANIFOLD INSTALLATION

For installation of the Valve Lifter Oil Manifold Assembly. Refer to **Balancer Shaft and Timing Chain Assembly Installation**.

Valve Lifter Oil Manifold Assemble

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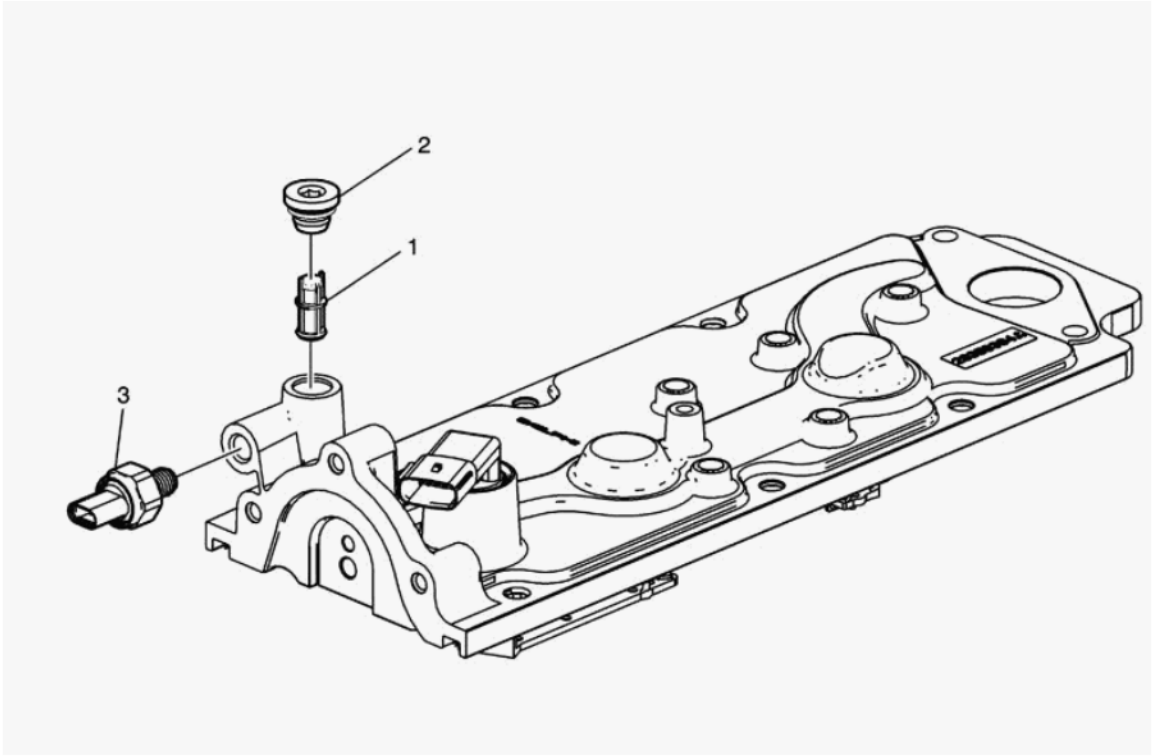

Fig. 524: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Assemble

Callout	Component Name
1	Balance Shaft Driven Sprocket
2	Balance Shaft Driven Sprocket Bolt **Tighten** 58 N.m (43 lb ft)
3	Valve Lifter Oil Filter
4	Valve Lifter Oil Manifold Plug **CAUTION:** **Refer to** **Fastener Caution** . **Procedure** Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten** 30 N.m (22 lb ft)
5	Oil Pressure Sensor **Tighten** 35 N.m (26 lb ft)

ENGINE BLOCK VALLEY COVER INSTALLATION

For installation of the Engine Block Valley Cover. Refer to **Balancer Shaft and Timing Chain Assembly**

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Installation.

Engine Block Valley Cover Assemble

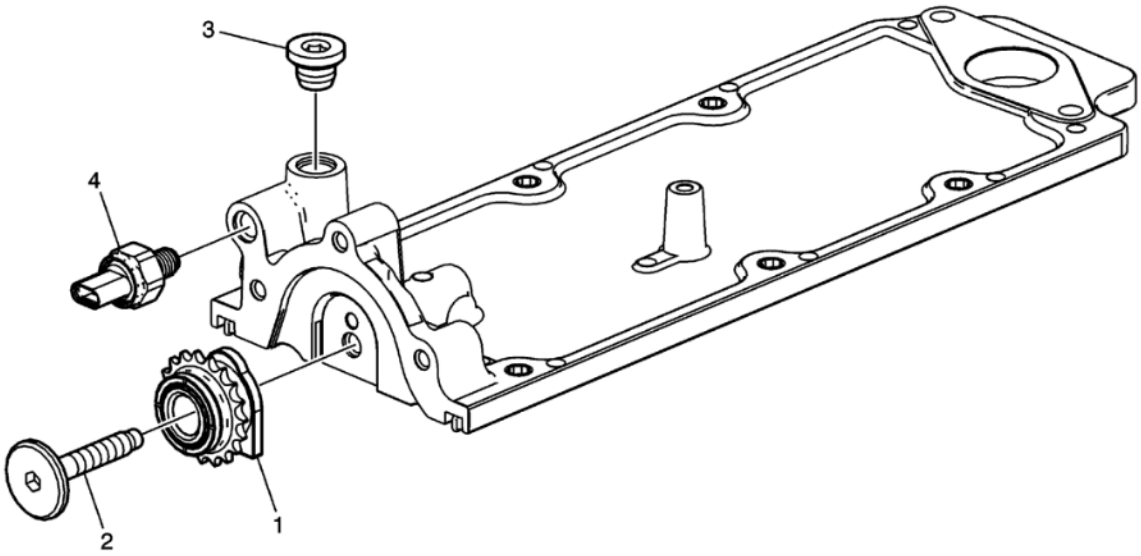

Fig. 525: Engine Block Valley Cover
Courtesy of GENERAL MOTORS COMPANY

Engine Block Valley Cover Assemble

Callout	Component Name
1	Balance Shaft Driven Sprocket
2	Balance Shaft Driven Sprocket Bolt **Tighten** 58 N.m (43 lb ft)
3	Oil Pressure Sensor **Procedure** Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten** 35 N.m (26 lb ft)
4	Engine Block Valley Cover Plug **CAUTION:** **Refer to Fastener Caution** . **Procedure** Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten**

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Callout	Component Name
	30 N.m (22 lb ft)

BALANCER SHAFT AND TIMING CHAIN ASSEMBLY INSTALLATION

Special Tools

- **EN-42386-A** Flywheel Holding Tool
- **EN-46330** Tension Pin
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

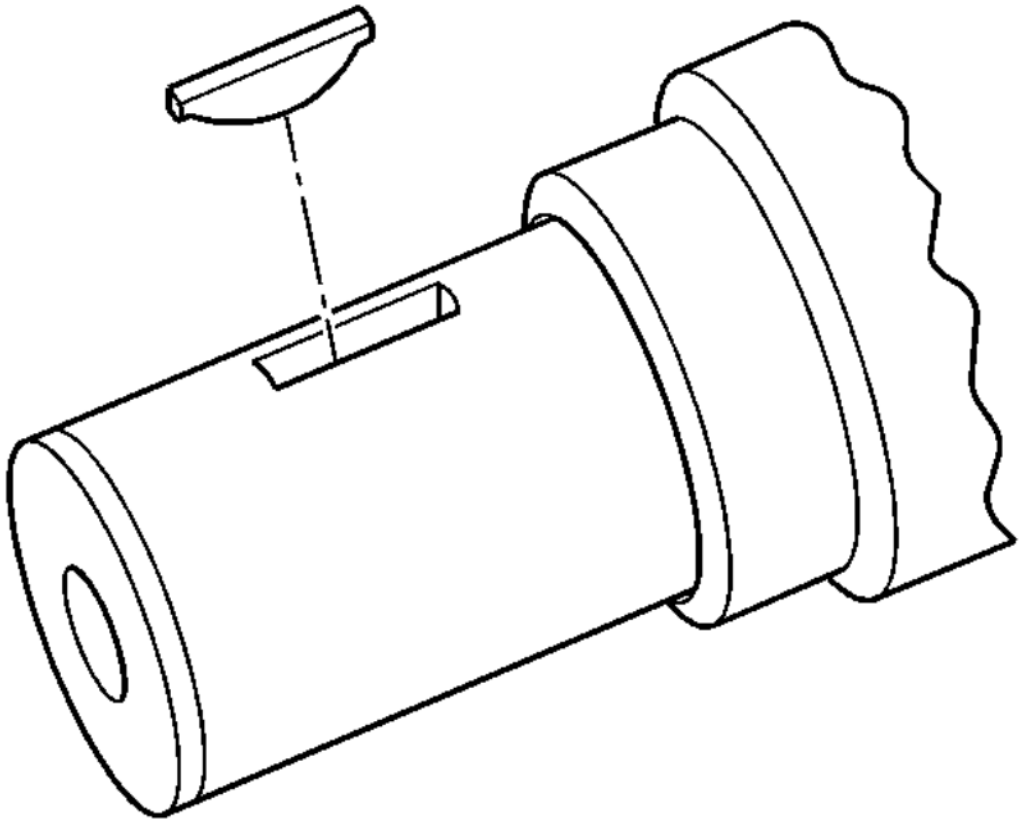

Fig. 526: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS COMPANY

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

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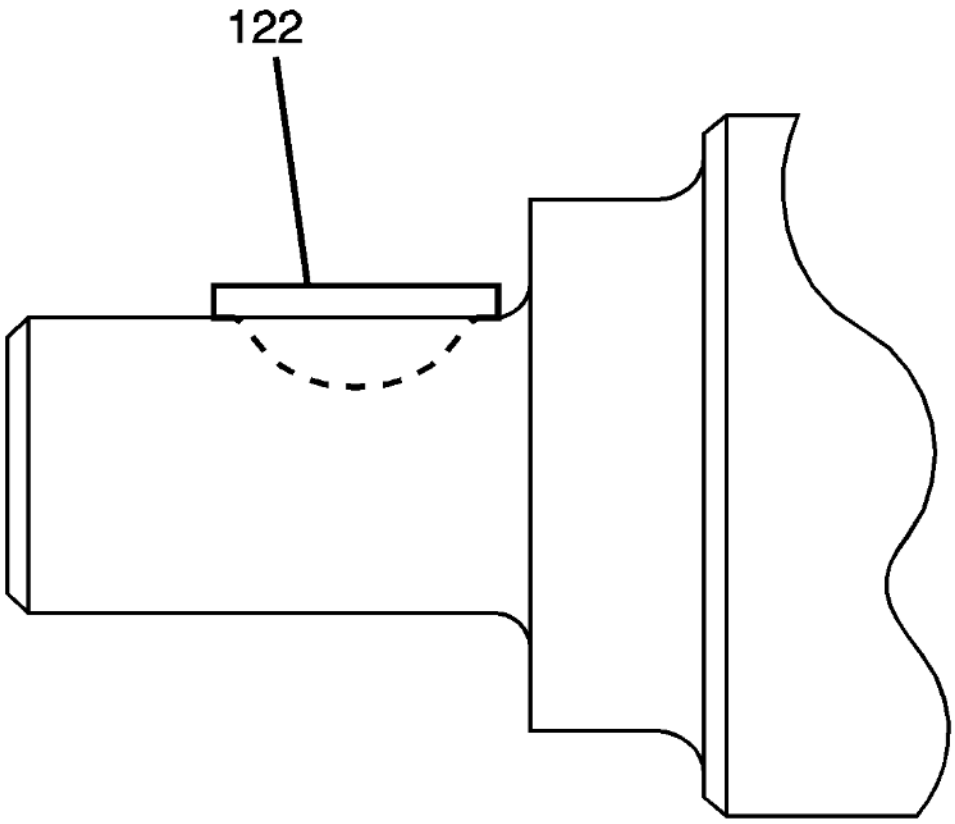

Fig. 527: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS COMPANY

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

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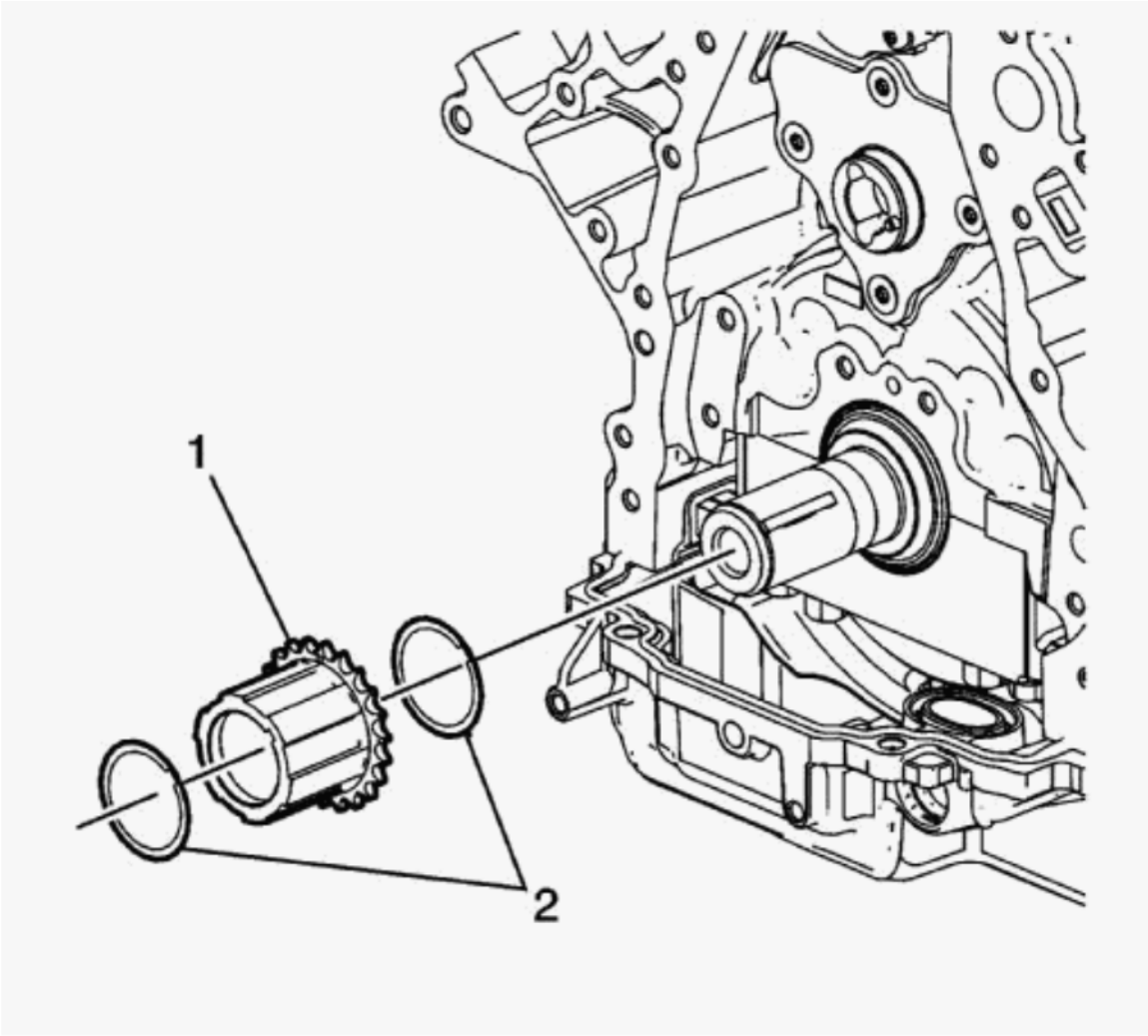

Fig. 528: Crankshaft Sprocket Washers And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft sprocket (1). Align the crankshaft key with the crankshaft sprocket keyway.

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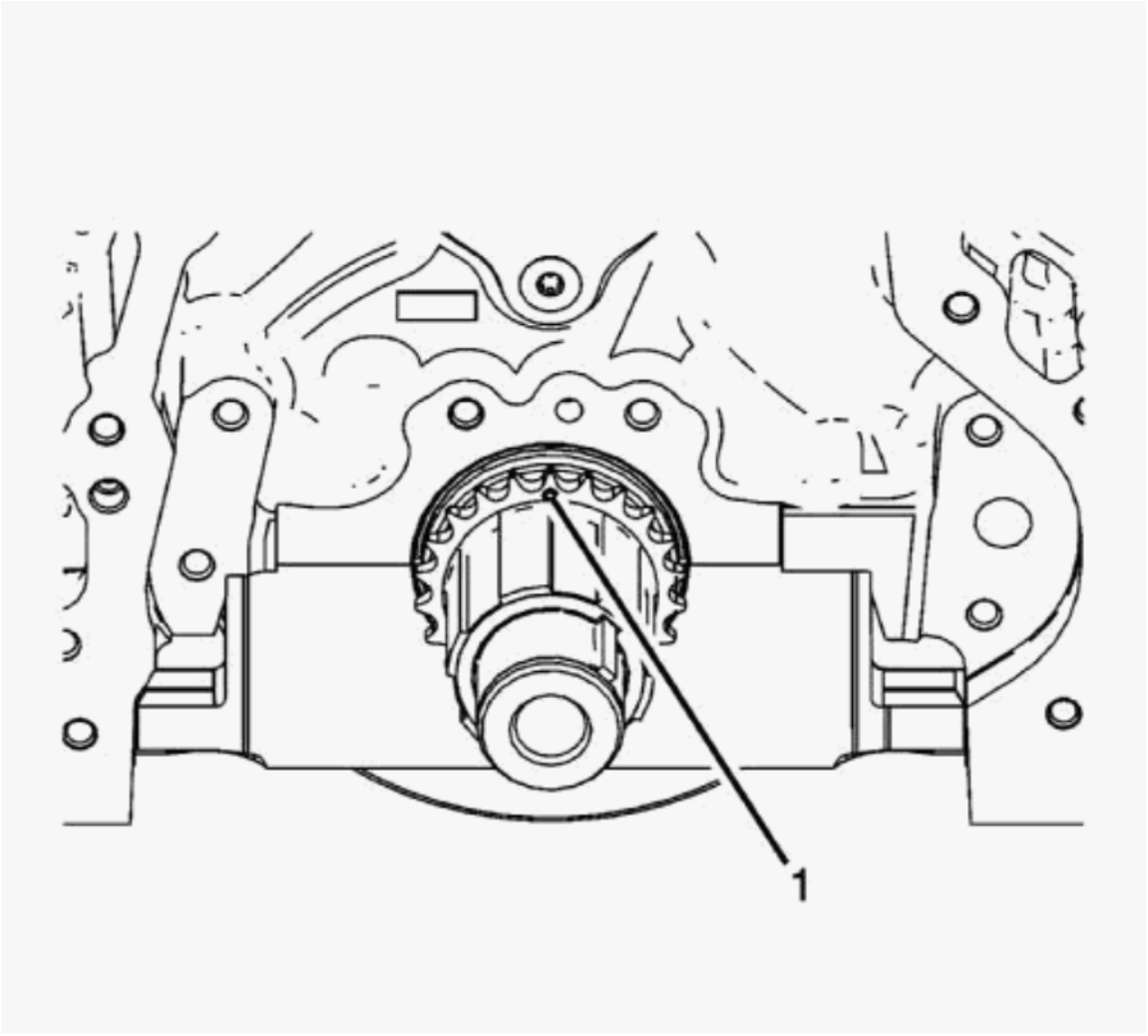

Fig. 529: Rotating Crankshaft Until Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft until the sprocket alignment mark (1) is in the 12 o'clock position.

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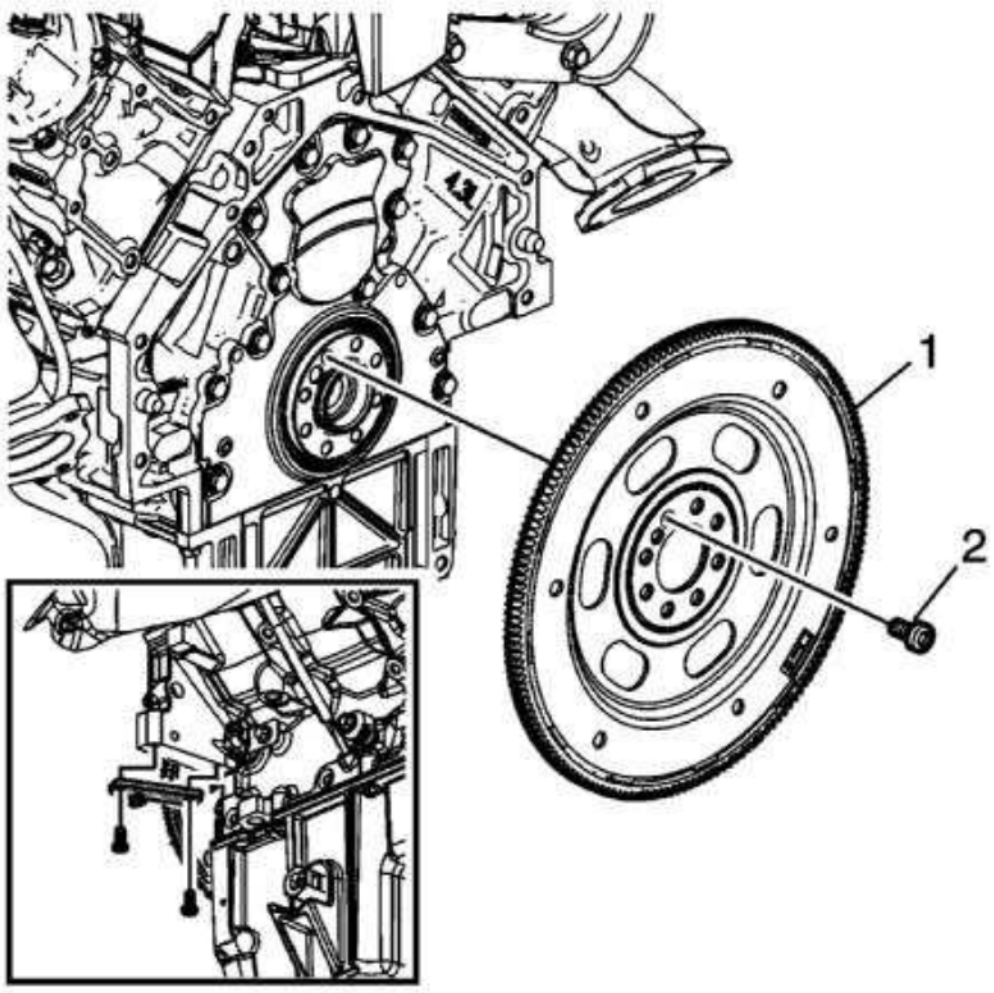

Fig. 530: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

5. Temporarily install the flex plate (1) and bolts (2). Tighten the bolts (2) hand tight.
6. Lock the flex plate using the **EN-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft).

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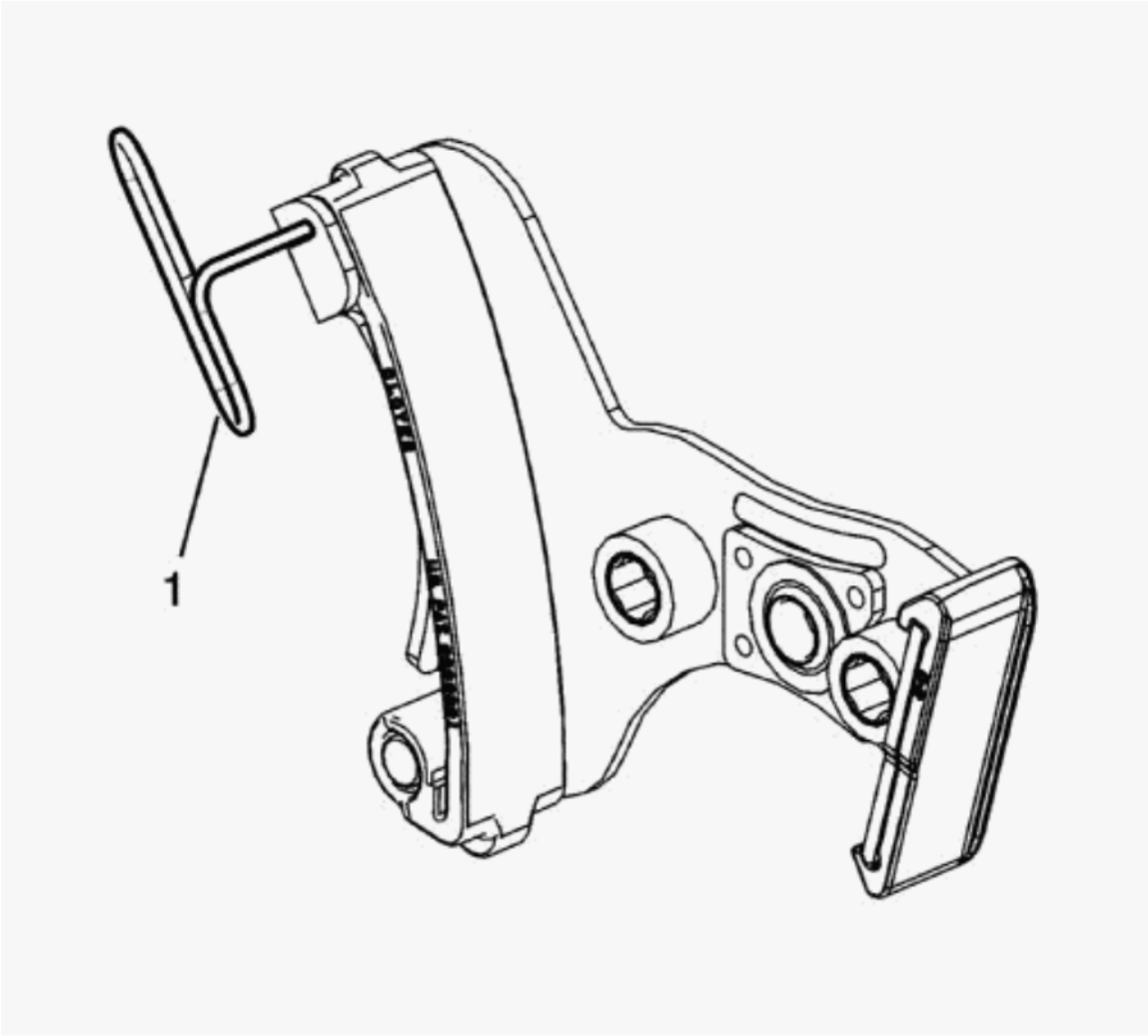

Fig. 531: Timing Chain Tensioner Guide And Pin
Courtesy of GENERAL MOTORS COMPANY

7. Compress the timing chain tensioner guide and install the **EN-46330** tension pin (1).

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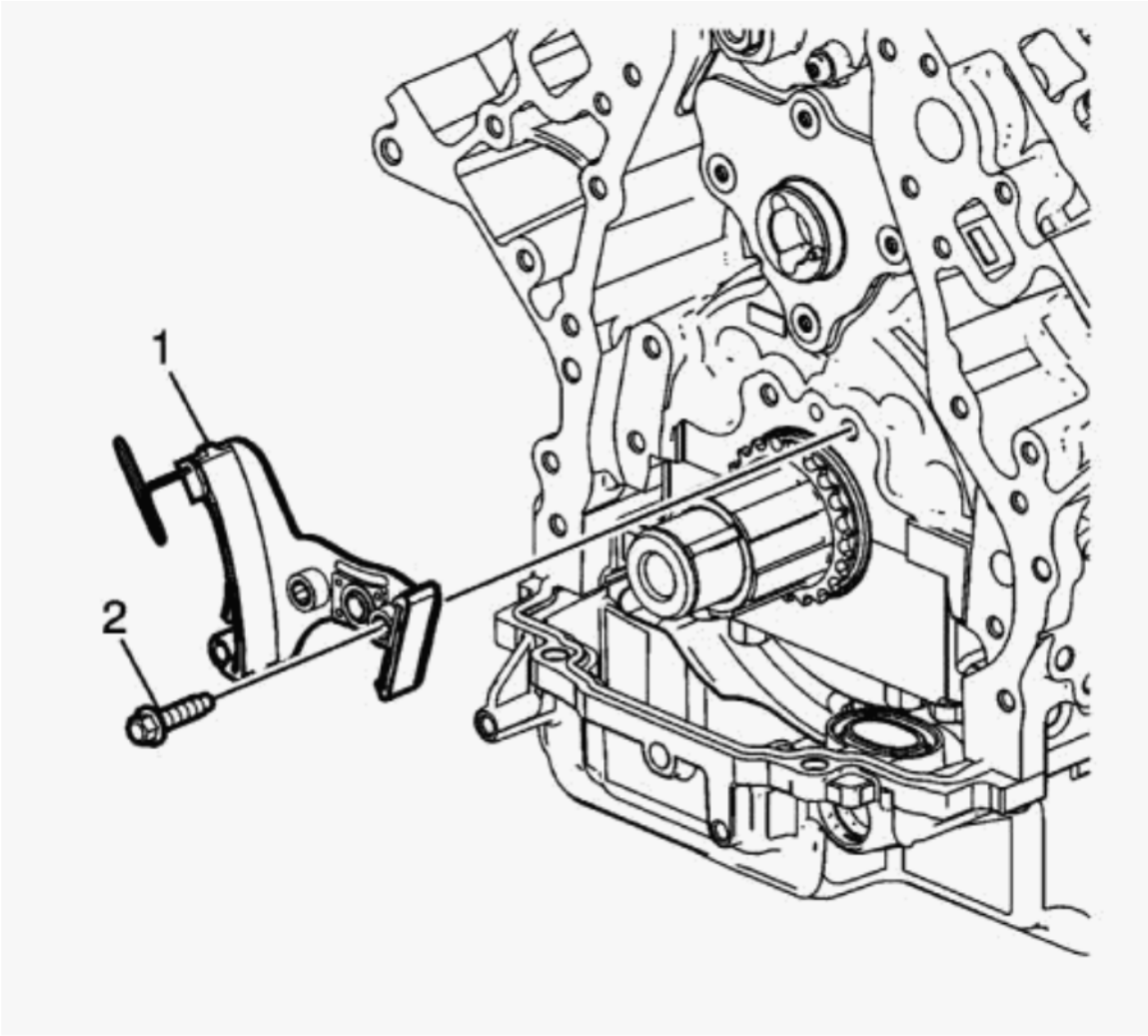

Fig. 532: Timing Chain Tensioner And Left Side Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Install the timing chain tensioner and right side bolt (1) hand tight. Do not install the left side bolt at this time. The left side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.

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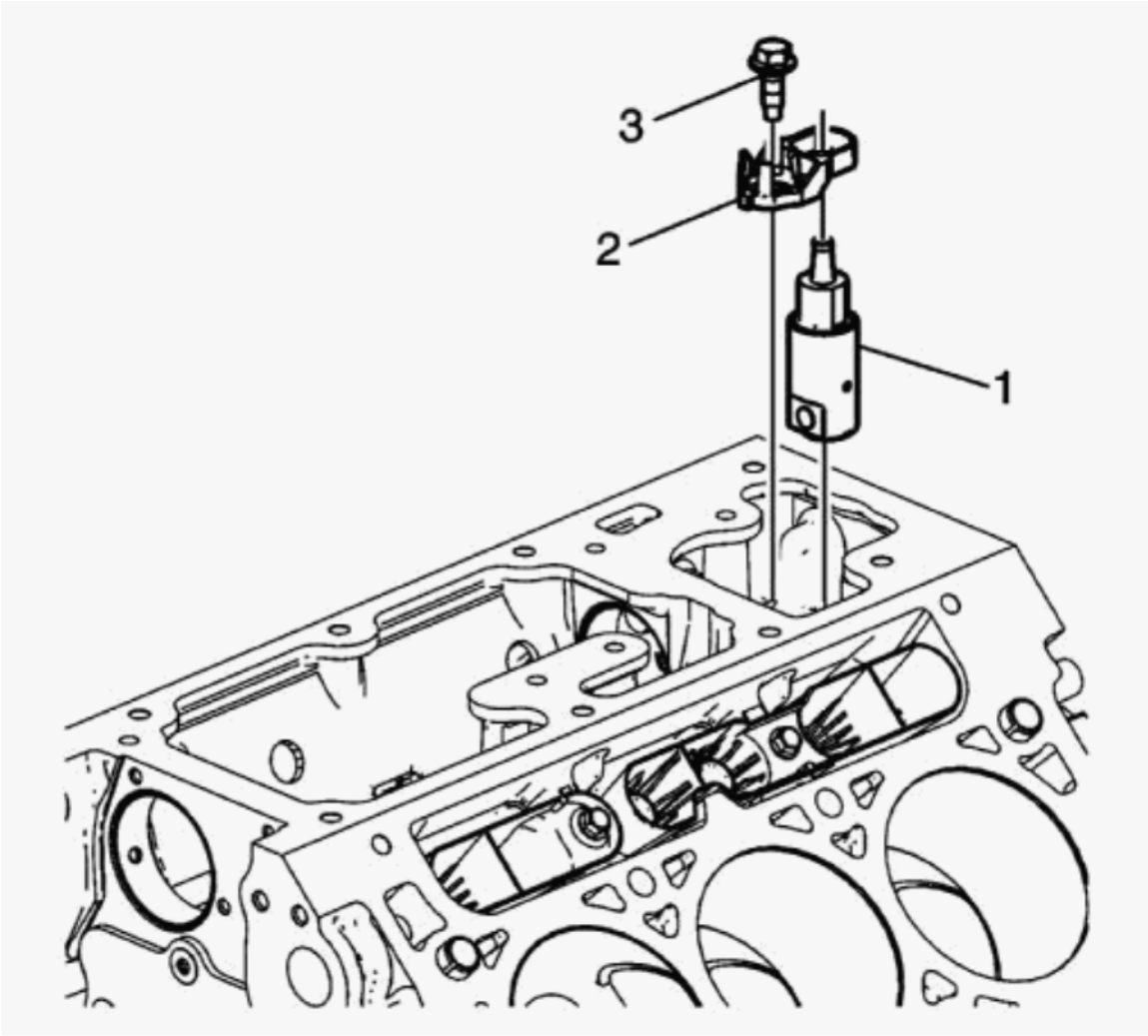

Fig. 533: Valve Lifter Follower Guide And Valve Filter Follower
Courtesy of GENERAL MOTORS COMPANY

9. Install the valve lifter follower guide (1) and bolt (2). Tighten bolt to 12 N.m (106 lb in).

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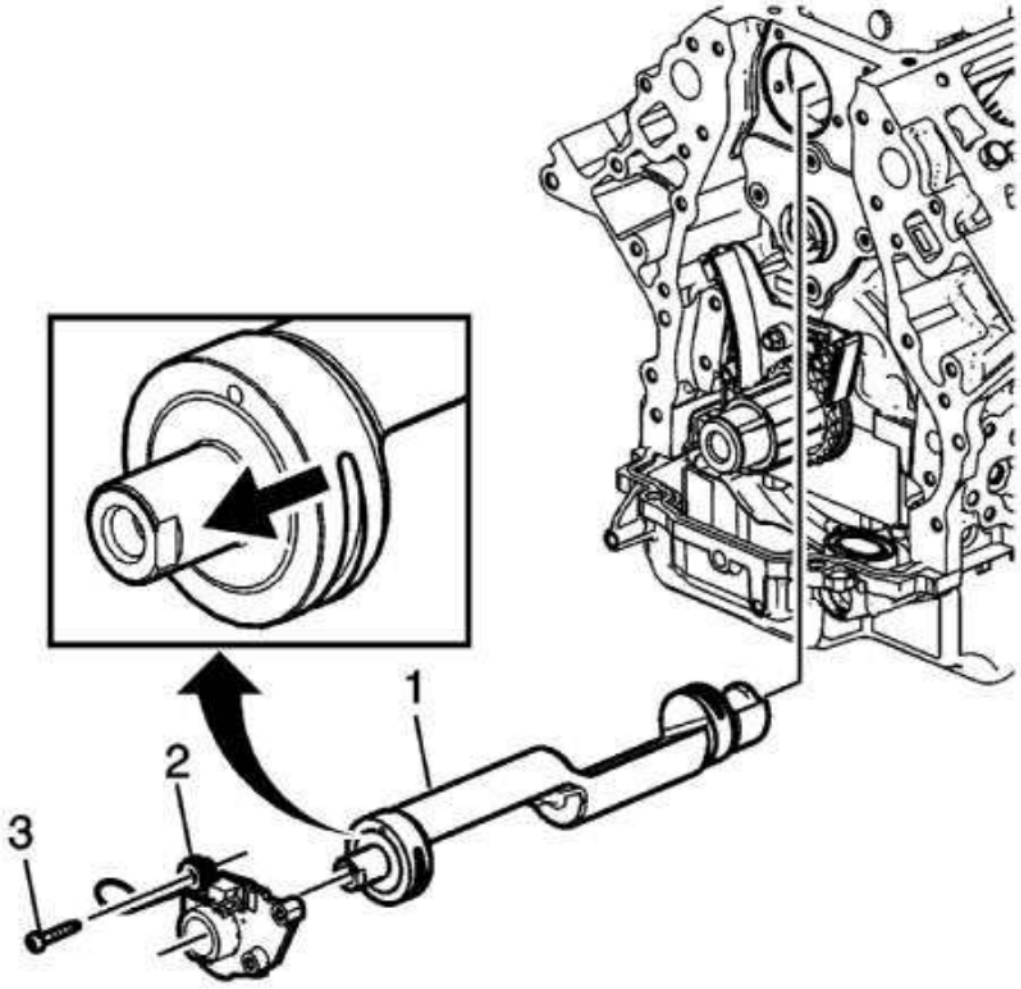

Fig. 534: Balancer Shaft And Balancer Shaft Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the balancer shaft (1) is installed with the flat spot facing the 3 o'clock position.**

10. Install the balancer shaft (1) and the balancer shaft retainer (2) with **EN-46330** tension pin installed.
11. Install the 11 o'clock position balancer shaft retainer bolt (3) hand tight.

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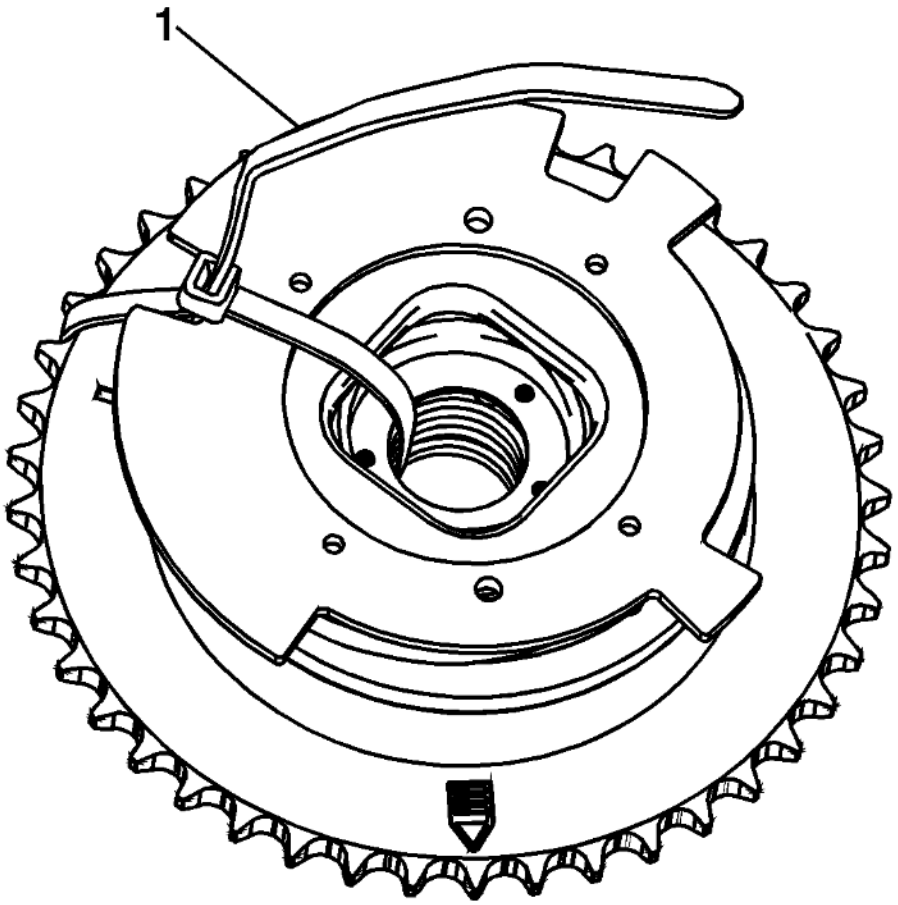

Fig. 535: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Camshaft Position Actuator Removal and Installation Warning .**

12. Remove the tie strap (1) from the actuator.

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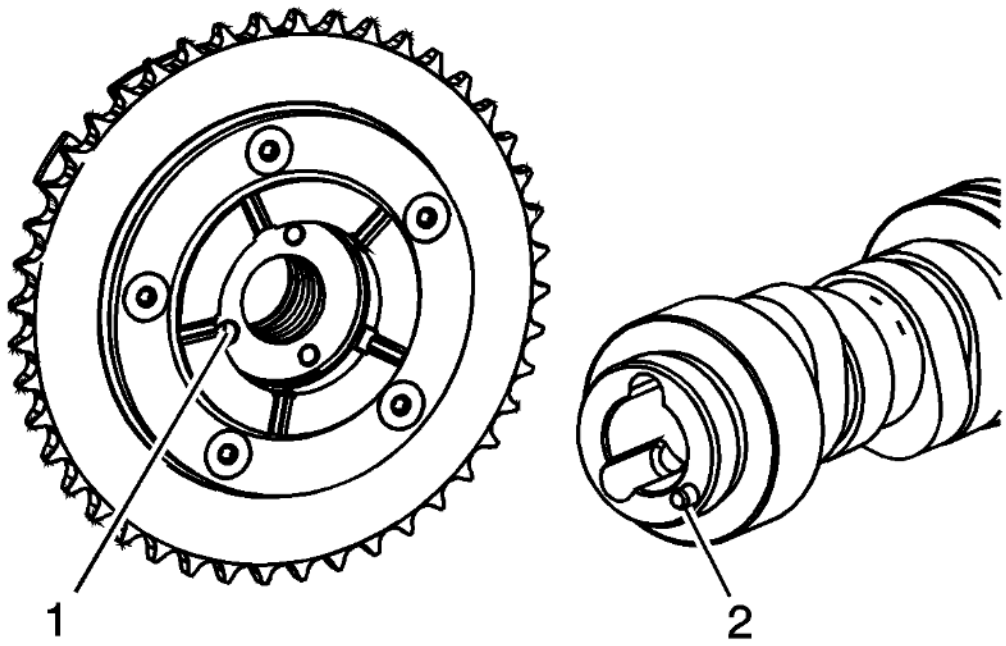

Fig. 536: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh**
- **The camshaft and the sprocket alignment marks MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW valve during assembly.**

13. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

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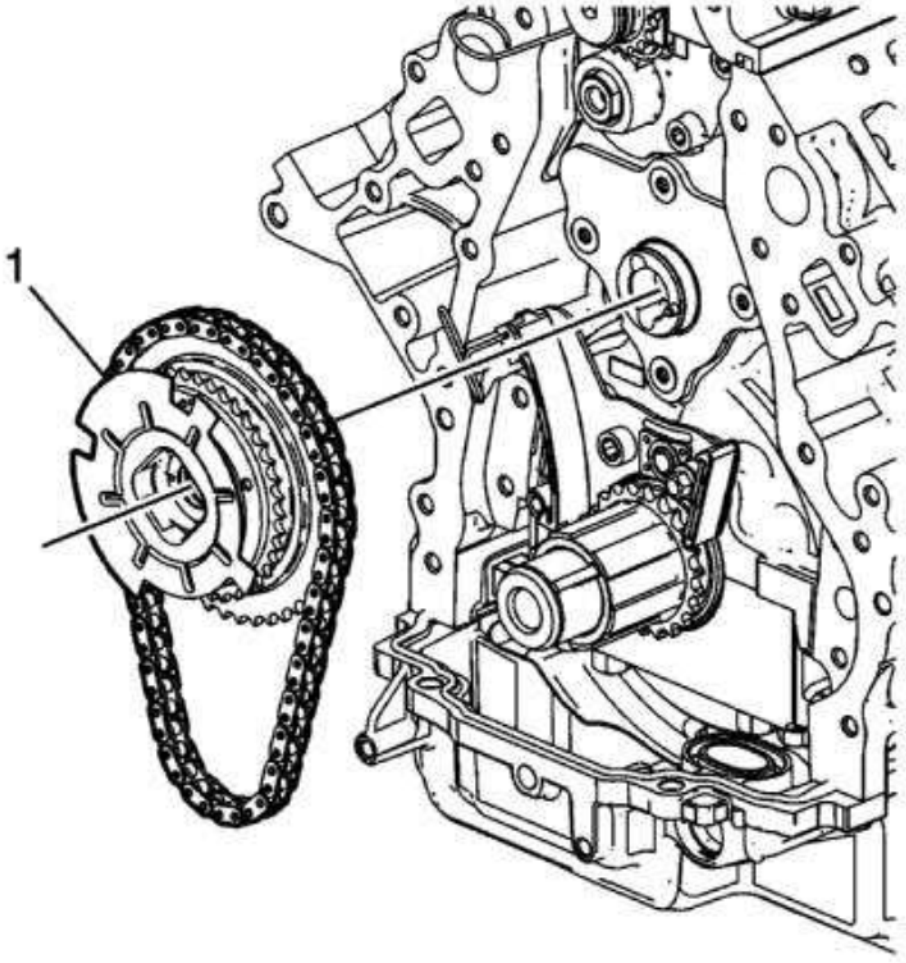

Fig. 537: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

14. Install the CMP actuator and timing chain (1). Use care to install the actuator completely onto the front of the camshaft. Position fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

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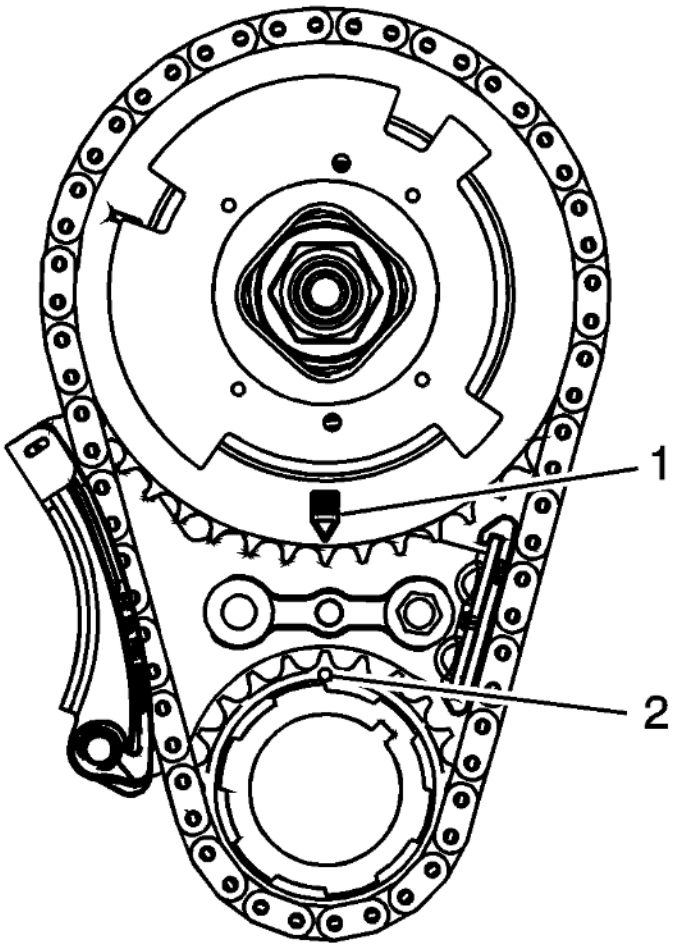

Fig. 538: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

15. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be in the 6 o'clock position and the mark on the crankshaft sprocket (2) should be located in the 12 o'clock position.

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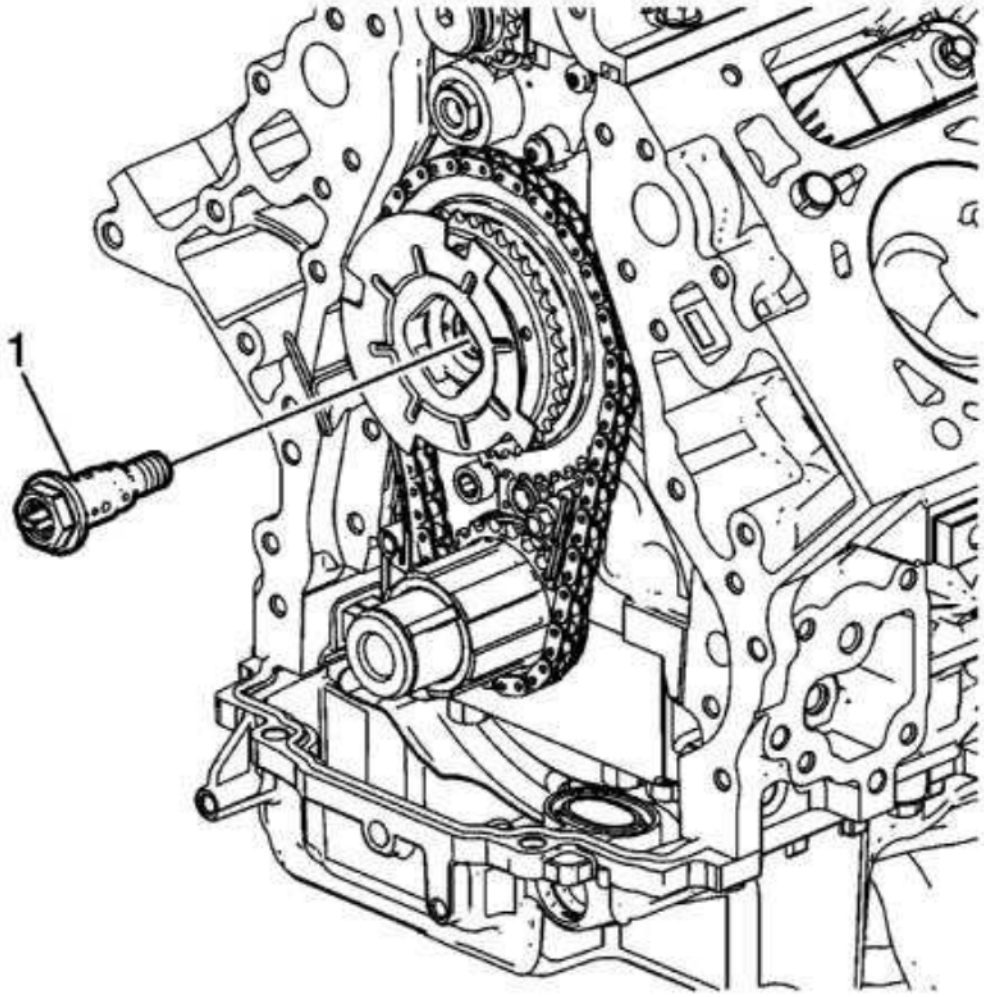

Fig. 539: NEW CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

16. Install a NEW CMP actuator solenoid valve (1). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid valve can be threaded completely into the camshaft using light hand pressure.
    1. Tighten a first pass to 65 N.m (48 lb ft)
    2. Tighten a final pass an additional 90 degrees using **EN-45059** angle meter.

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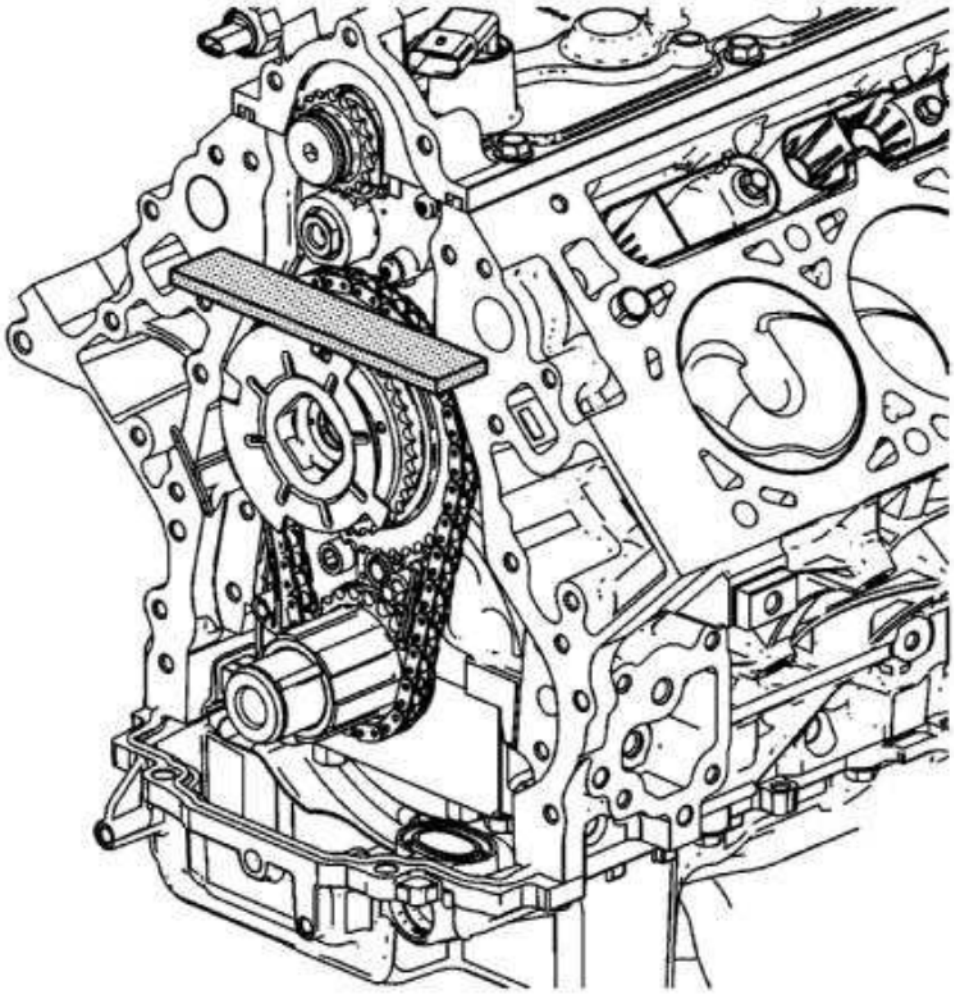

Fig. 540: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is possible to push the camshaft rearward when installing the CMP actuator. Verify that the camshaft lobes are centered in the valve lifter bores after the CMP actuator is installed.**

17. Locate a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of the camshaft, the timing chain will not protrude beyond the front face of the engine block.

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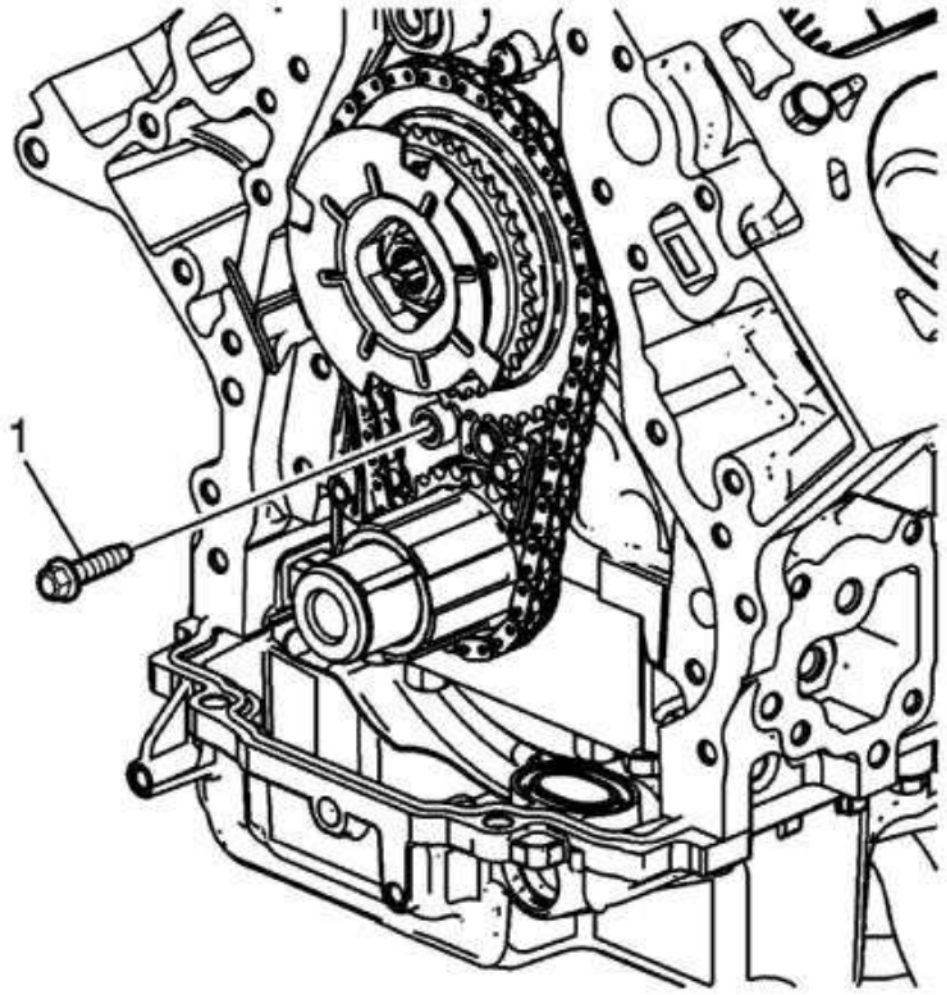

Fig. 541: Left Side Bolt And Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

18. Install the left side bolt (1) onto the timing chain tensioner. Tighten both bolts to 25 N.m (18 lb ft).

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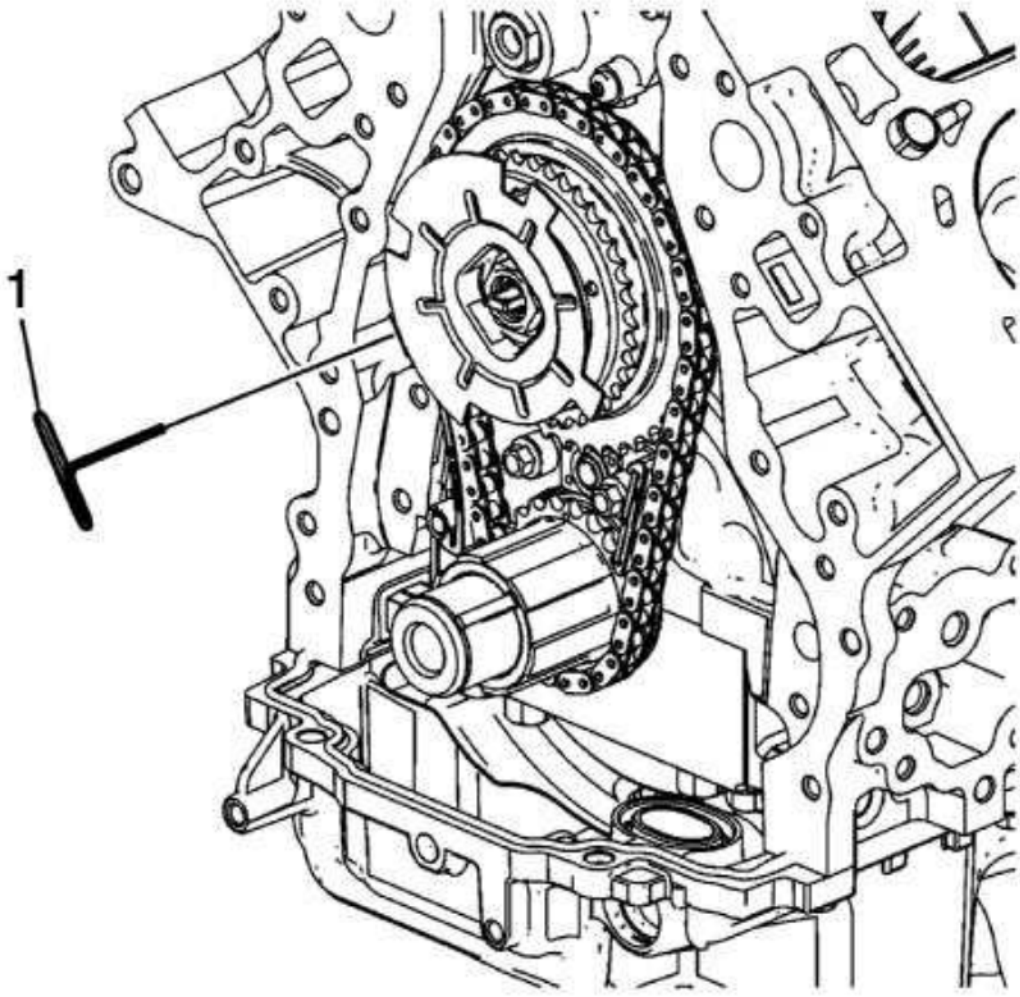

Fig. 542: Tension Pin
Courtesy of GENERAL MOTORS COMPANY

19. Remove the **EN-46330** tension pin.

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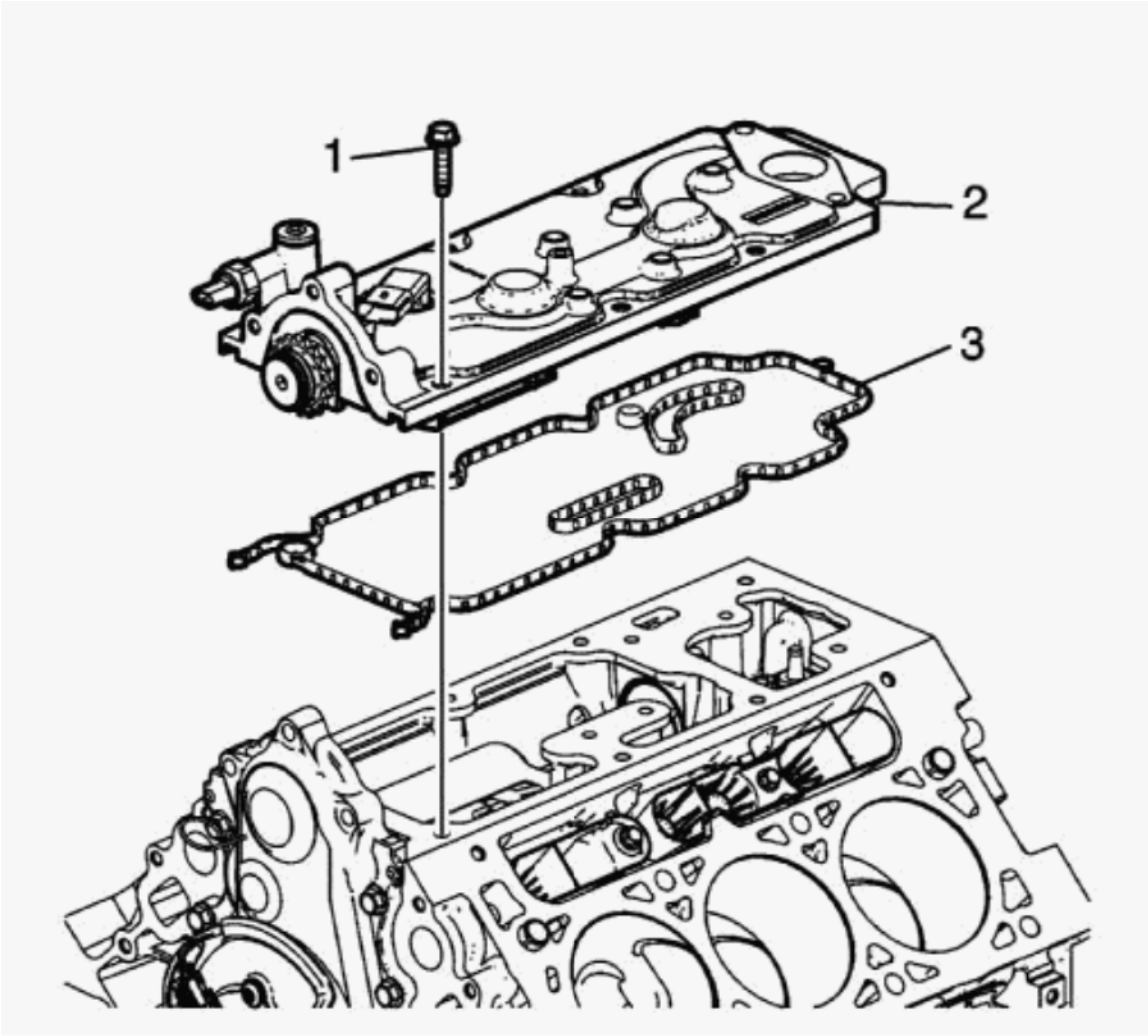

Fig. 543: Valve Lifter Oil Manifold Assembly Gaskets
Courtesy of GENERAL MOTORS COMPANY

20. Install the valve lifter oil manifold assembly gaskets (3) and the valve lifter oil manifold assembly (2).

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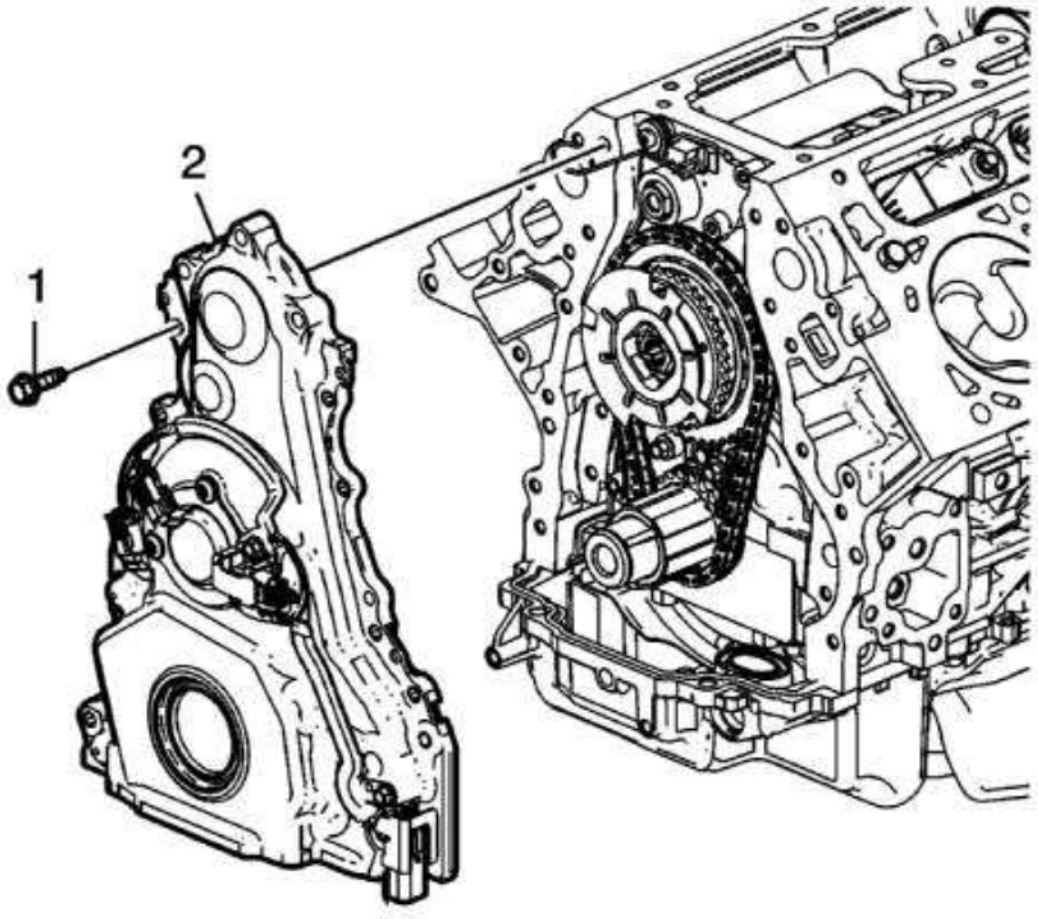

Fig. 544: Clean Engine Front Cover And Bolts
Courtesy of GENERAL MOTORS COMPANY

21. Temporarily install the clean engine front cover (2) and bolts (1) as an assembly guide so the valve lifter oil manifold assembly will be assembled flush with the front face of the cylinder block. Make sure the front cover is clean of RTV and debris. Tighten bolts (1) to 25 N.m (18 lb ft).

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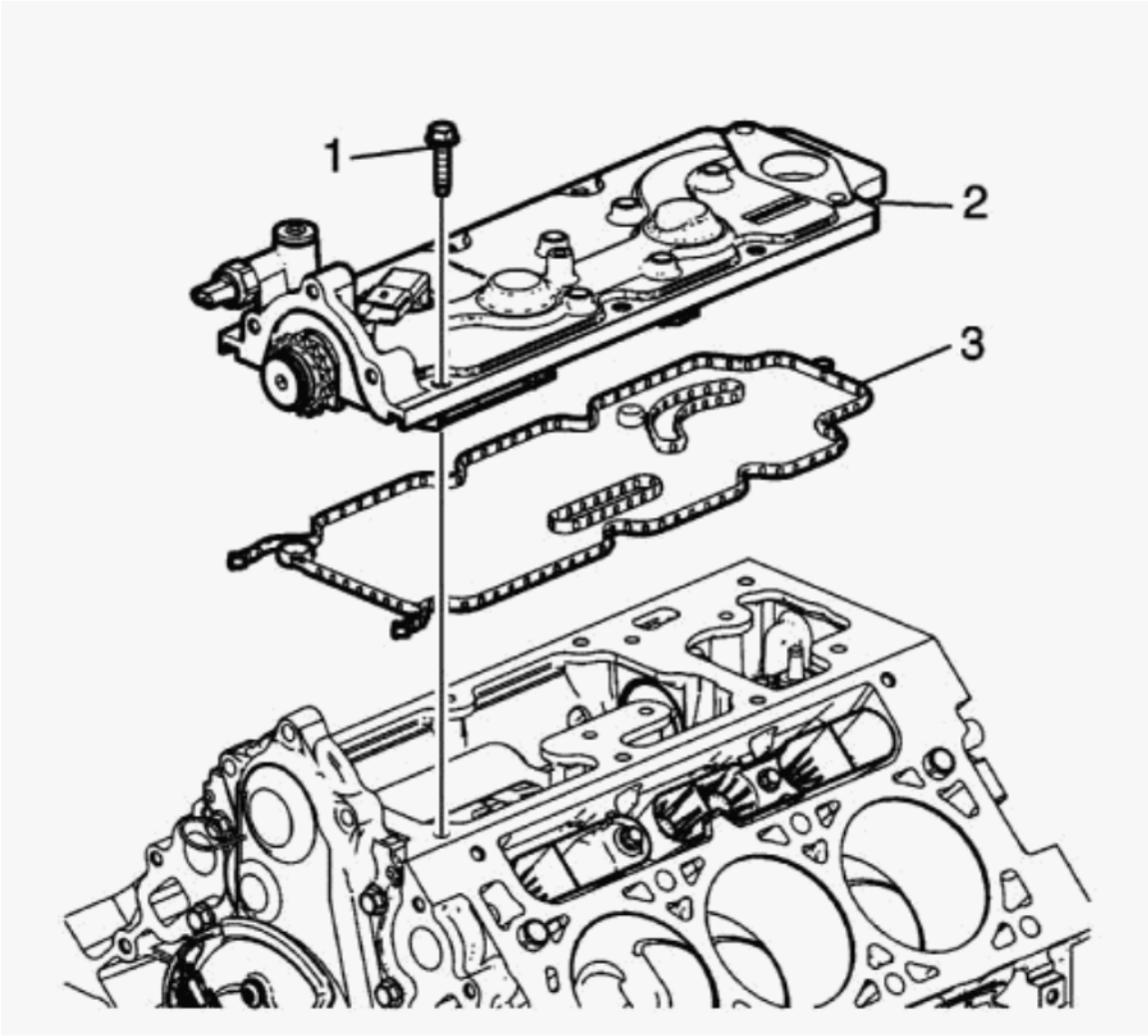

Fig. 545: Valve Lifter Oil Manifold Assembly Gaskets
Courtesy of GENERAL MOTORS COMPANY

22. Install the valve lifter oil manifold assembly bolts (1).

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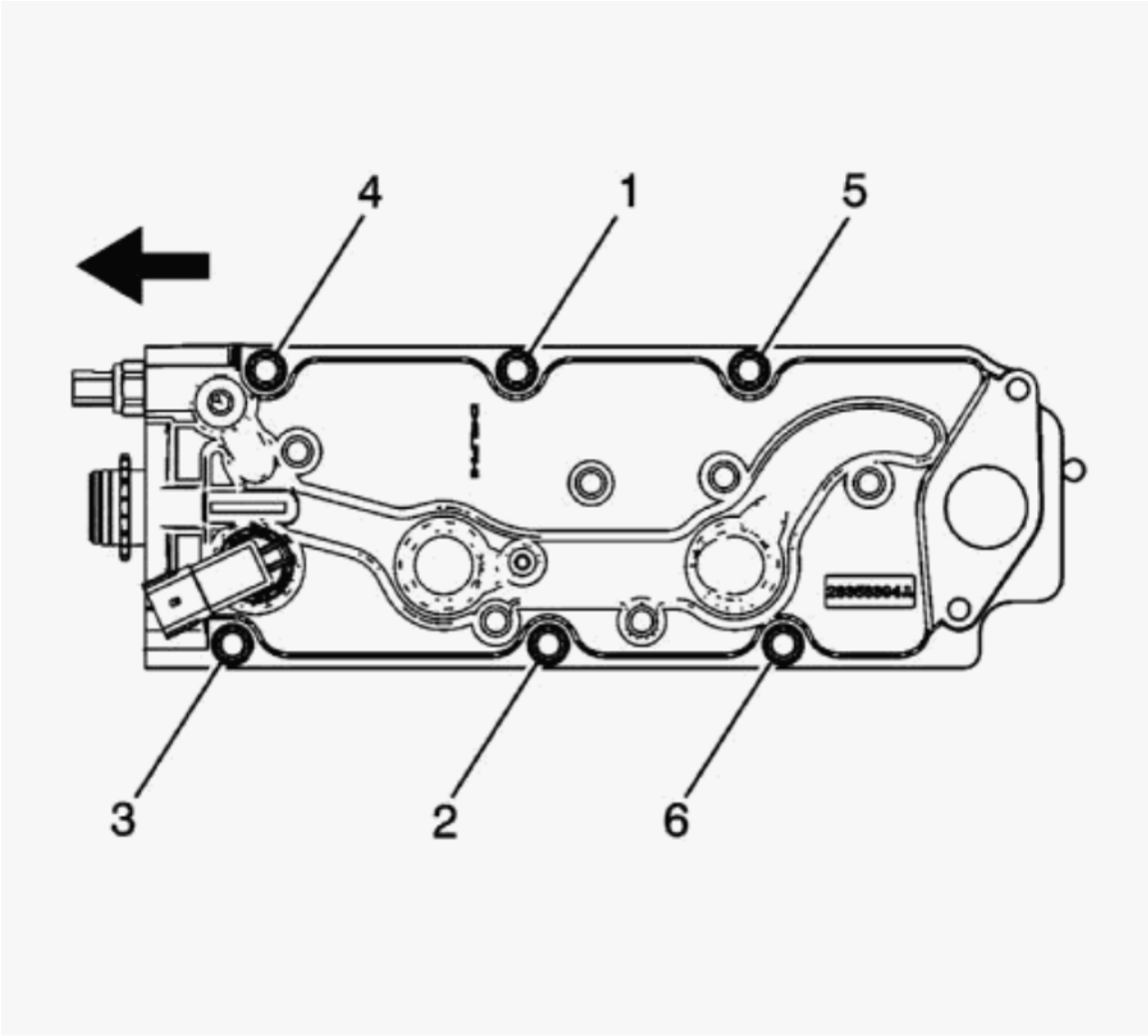

Fig. 546: Valve Lifter Oil Manifold Assembly Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

23. Tighten the valve lifter oil manifold assembly bolts.
    1. First pass in sequence to 15 N.m (11 lb ft)
    2. Final pass in sequence to 30 N.m (22 lb ft)

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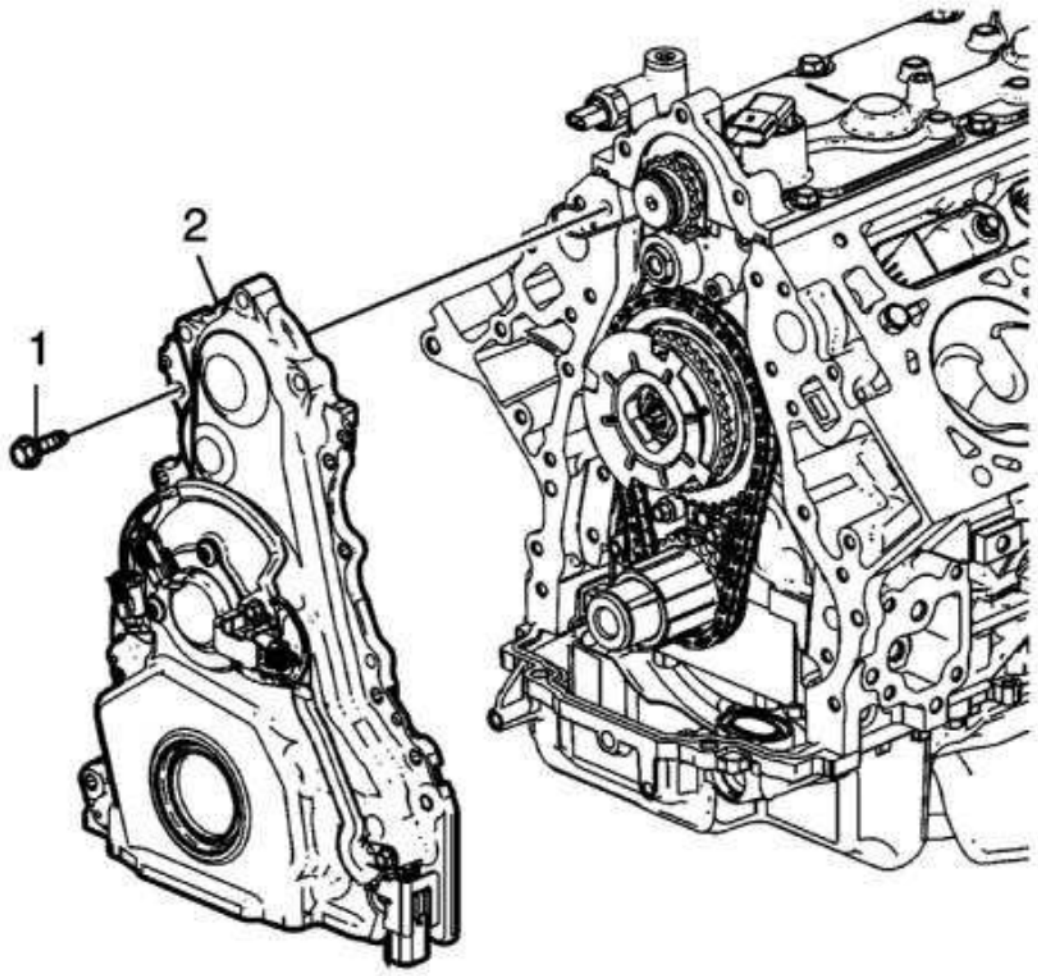

Fig. 547: Engine Front Cover Bolts And Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

24. Remove the engine front cover bolts (1) and the engine front cover (2).

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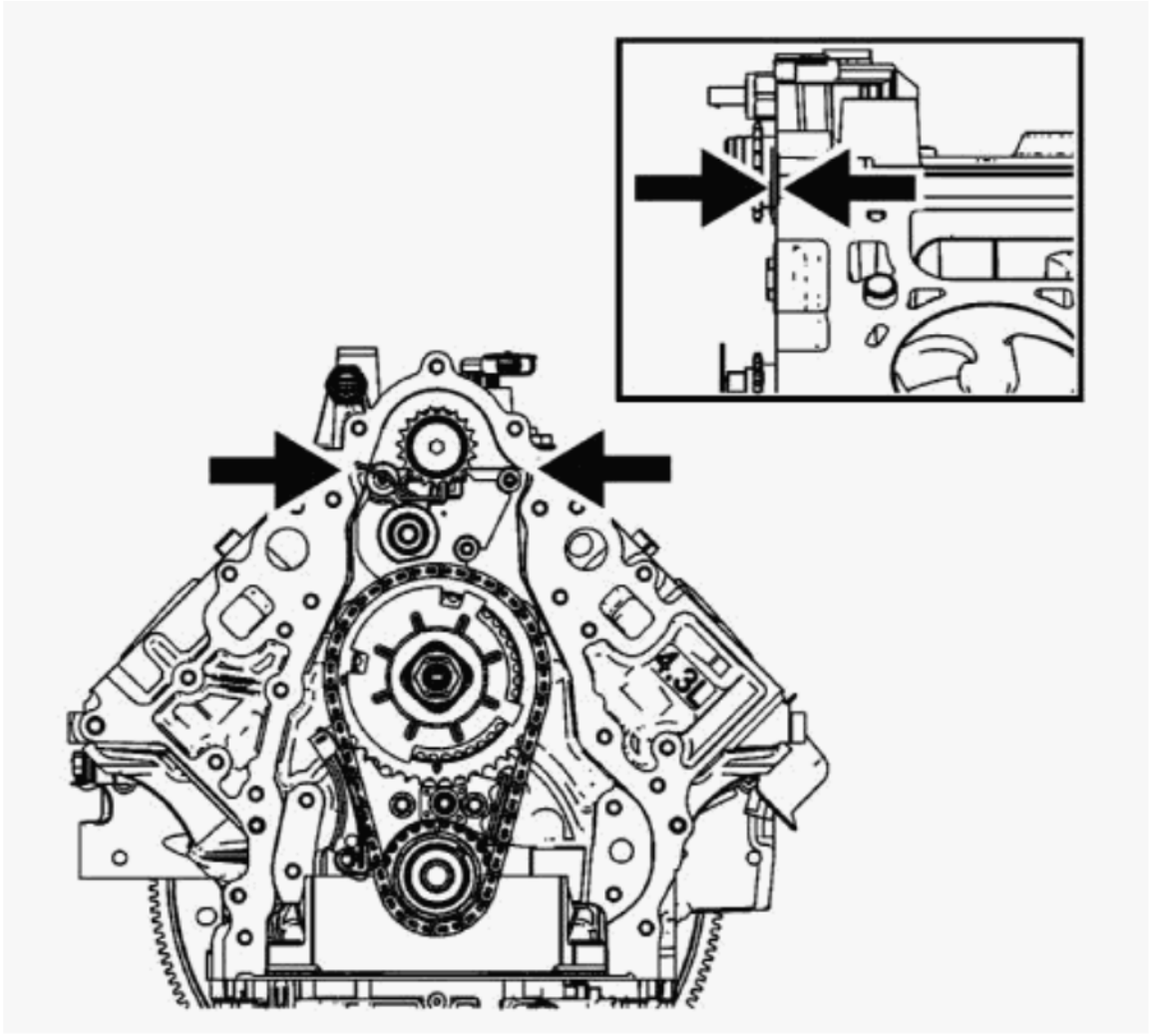

Fig. 548: Valve Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

25. The valve lifter oil manifold assembly should be flush with the face of the block. A tolerance allows that the valve lifter oil manifold assembly can be up to 0.3 mm (0.019 in) shy (rearward) from the front face of the block.

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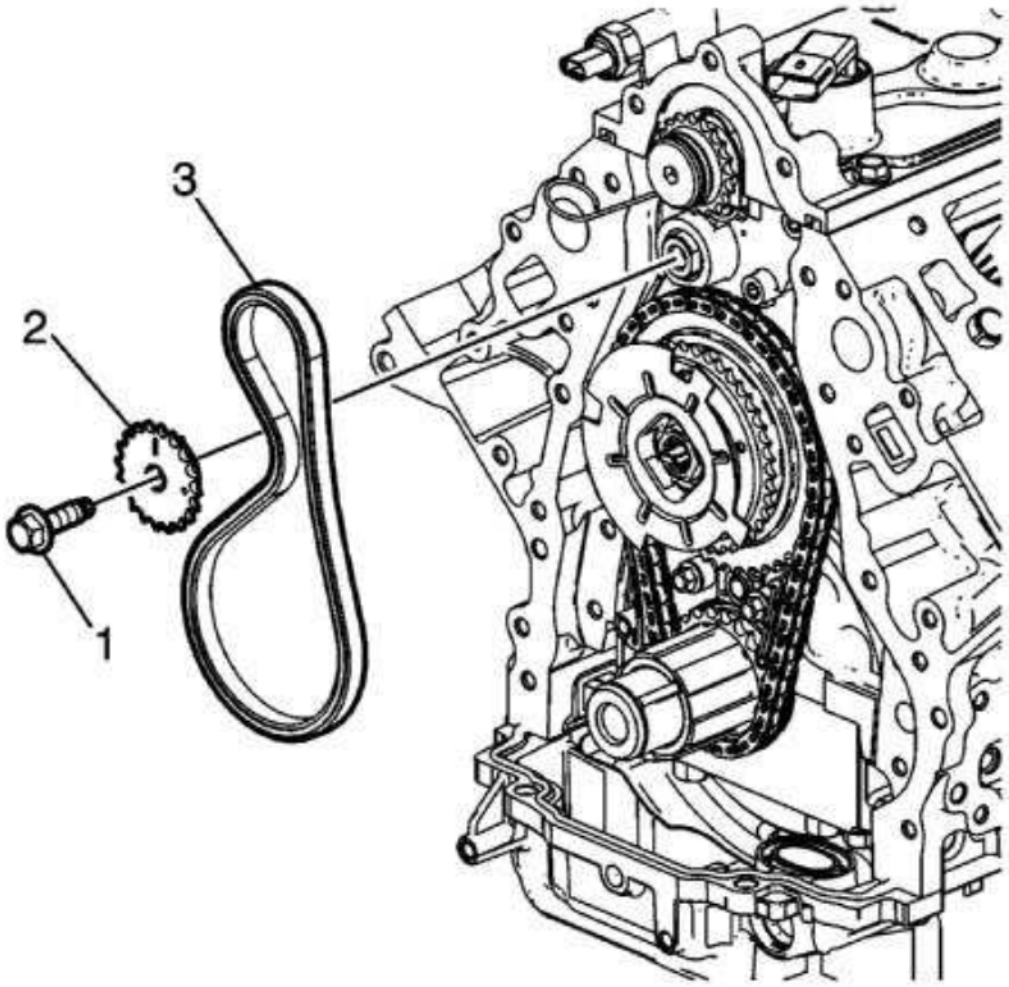

Fig. 549: Balancer Chain And Driven Sprocket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the balancer shaft (1) is installed with the flat spot facing the 3 o'clock position.**

26. Install the balancer chain (3) by wrapping it around the camshaft actuator and the balancer shaft idler sprocket.
27. Install the driven sprocket (2), and driven sprocket bolt (1) hand tight.

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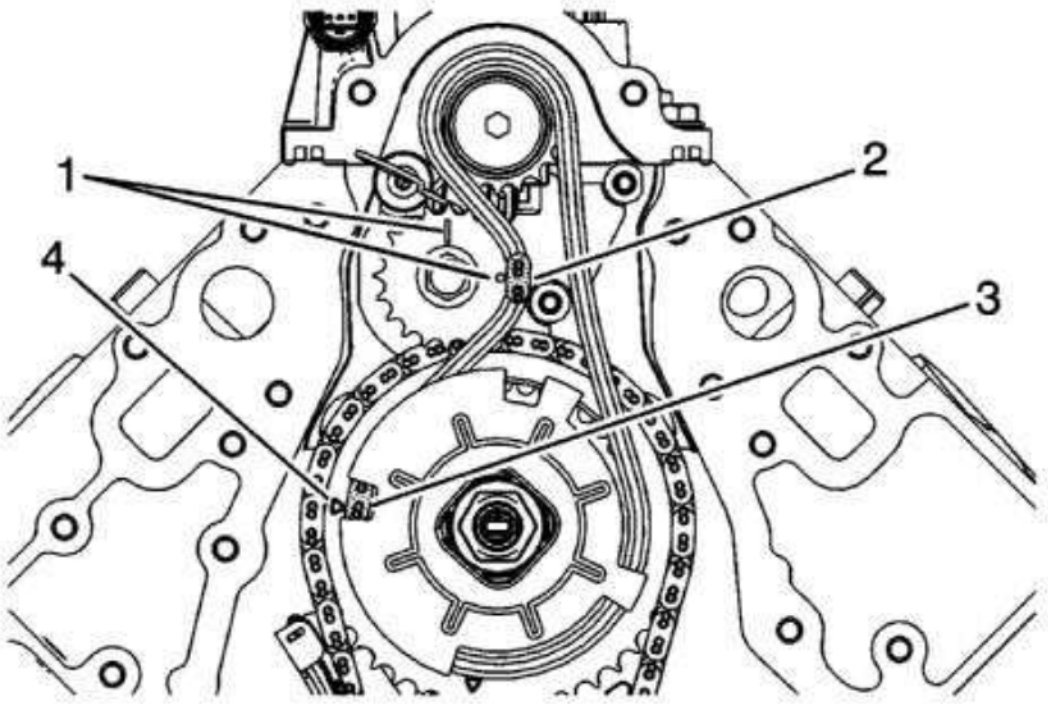

Fig. 550: Blue Link Plate And Camshaft Actuator Triangle Mark
Courtesy of GENERAL MOTORS COMPANY

28. The lower blue link plate (3) of the balancer chain must align with the camshaft actuator triangle mark (4).
29. The upper blue link plate (2) of the balancer chain must alight with the dot (1) on balancer driven sprocket. The 20 tooth driven sprocket will also have a molded in vertical line (1) pointing at 12 o'clock.

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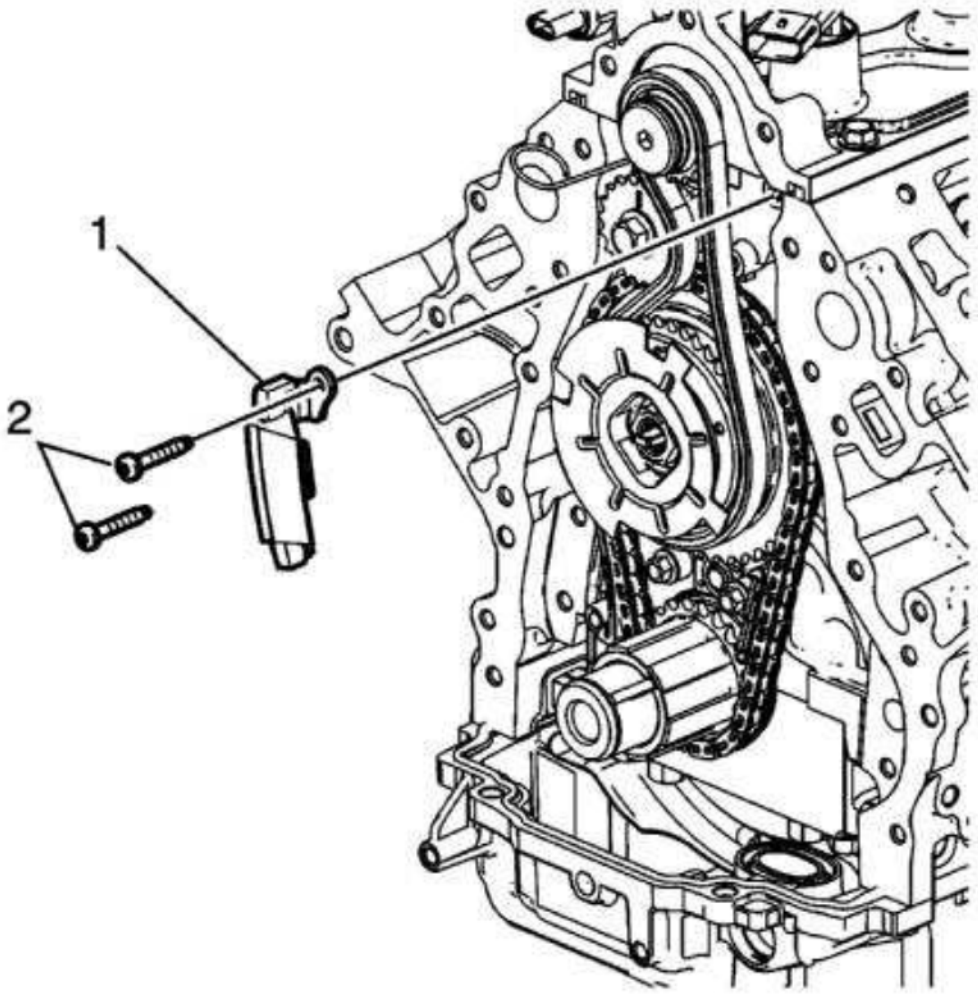

Fig. 551: Balancer Chain Guide With Shim And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If plastic shim is not available, a 1.1 mm (0.04 in) size shim will need to be placed between the balancer chain and guide during installation.**

30. Install the balancer chain guide with shim (1) and bolts (2).
31. Tighten the 2 o'clock, 11:00 o'clock, and 3:30 o'clock position guide bolts (2) to 10 N.m (88 lb in).

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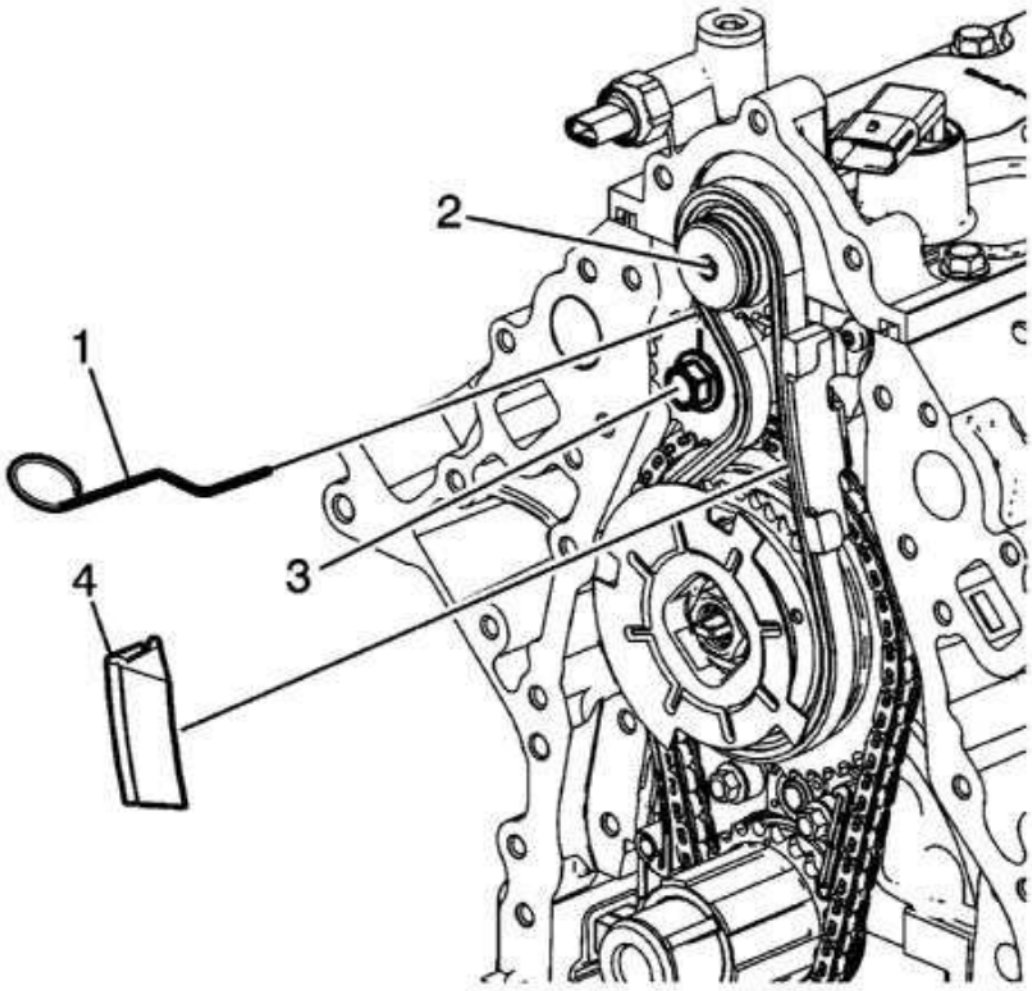

Fig. 552: Driven Sprocket Bolt And Idler Sprocket
Courtesy of GENERAL MOTORS COMPANY

32. Tighten the driven sprocket bolt (3) to 58 N.m (43 lb ft).
33. With the idler sprocket (2) free to slide up and down, pull (remove) the **EN-46330** tension pin (1).
34. Tighten the idler sprocket bolt (2) to 58 N.m (43 lb ft).
35. The chain should now be tight. Remove the shim (4) from between the balancer guide and the chain. The chain should now be slightly loose.

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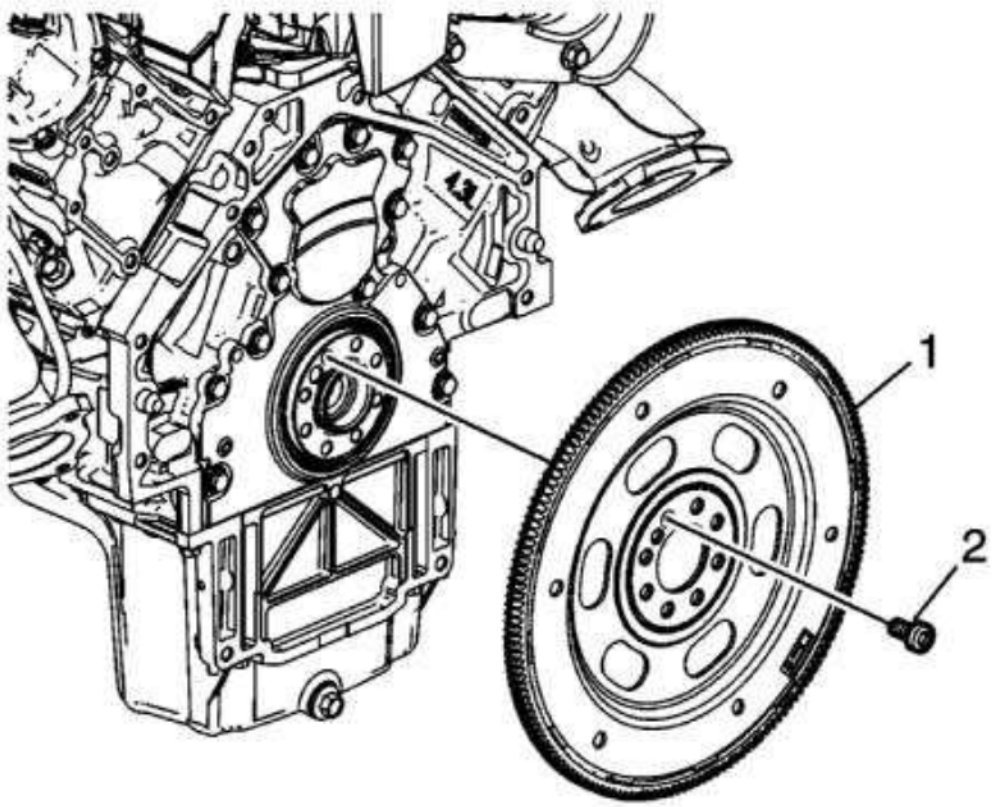

Fig. 553: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

36. Remove the flex plate (1) and bolts (2).

OIL PUMP INSTALLATION

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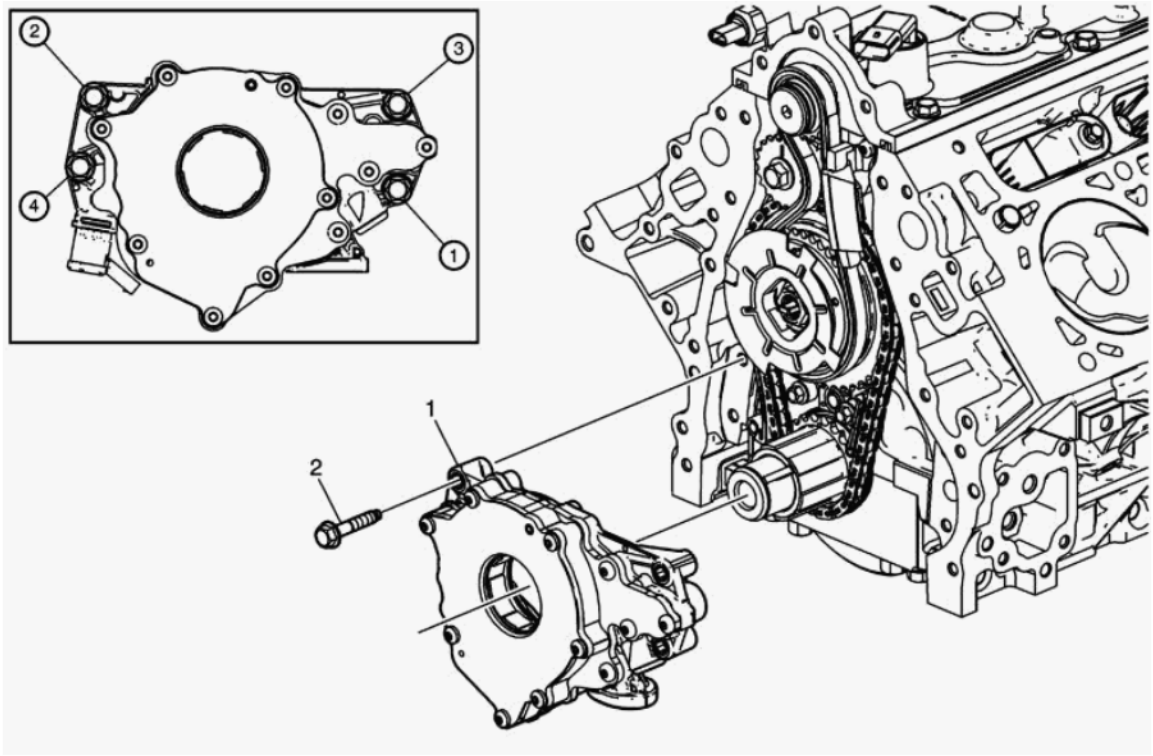

Fig. 554: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If oil pump is removed to perform a different repair and is going to be REUSED, the alignment tool **EN-51267** oil pump alignment tool MUST be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If **EN-51267** oil pump alignment tool IS NOT installed prior the oil pump being removed AND left in place while other repairs are performed, a NEW oil pump MUST be installed.	
1	Oil Pump Assembly **NOTE:** **Prior to installing the oil pump, ensure that oil pump housing gasket is fully installed in the timing chain tensioner assembly and is not damaged. If the gasket is missing or**

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Callout	Component Name
	damaged, replace the tensioner assembly.
2	Oil Pump Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the oil pump bolts in the sequence shown. **NOTE:** **Upward pressure must be applied to the oil pump while tightening the fasteners. Contact between the oil pump housing and the oil pump alignment tool must be maintained while oil pump bolts are tightened. Prior to removing the oil pump alignment tool, ensure that there is no gap between the oil pump housing and the tool. If there is a gap, the oil pump bolts**

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Callout	Component Name
	need to be loosened and the installation procedure repeated. **Tighten** 25 N.m (18 lb ft) **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.

CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION

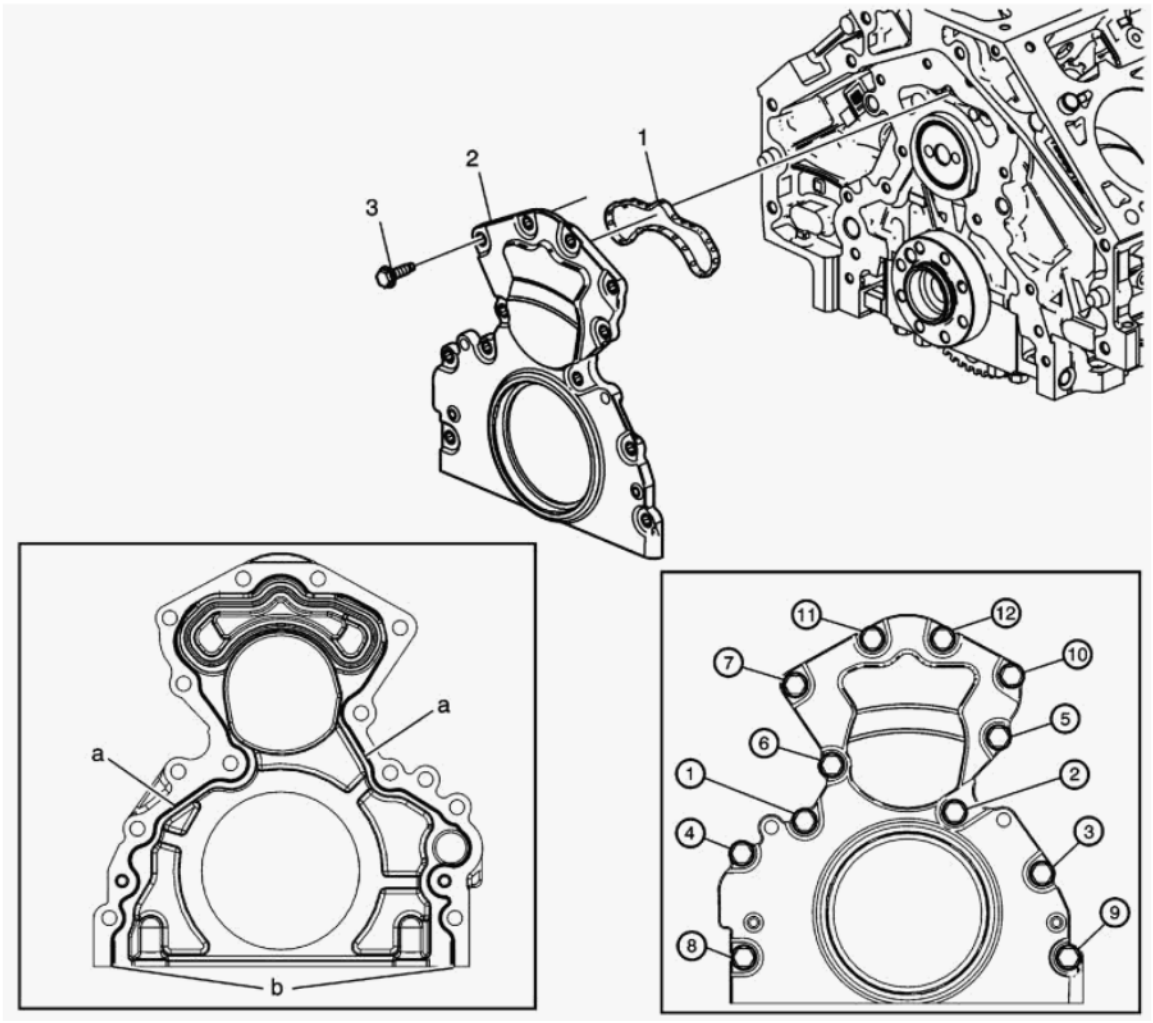

Fig. 555: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Gasket

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Callout	Component Name
	NOTE:
1	Crankshaft Rear Oil Seal Housing **Must use a NEW gasket when installing the rear housing.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended sealant.
2	Crankshaft Rear Oil Seal Housing Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the rear oil seal housing bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

- **EN-41479** Crankshaft Rear Oil Seal Installer
- **EN-41479-2A** Crankshaft Rear Oil Seal Installation Guide
- **EN-41479-10** Crankshaft Rear Oil Seal Installer Adapter

For equivalent regional tools, refer to **Special Tools**.

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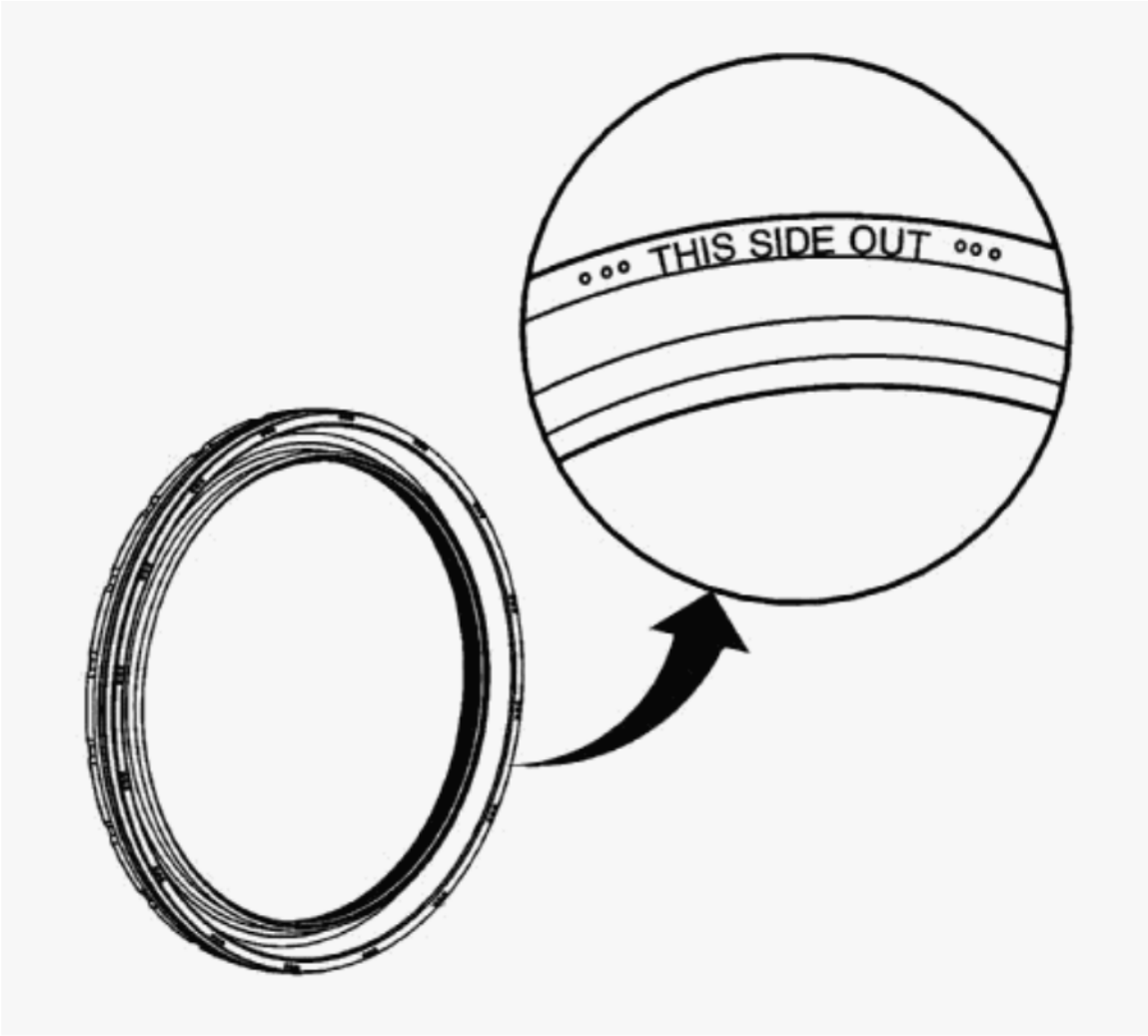

Fig. 556: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

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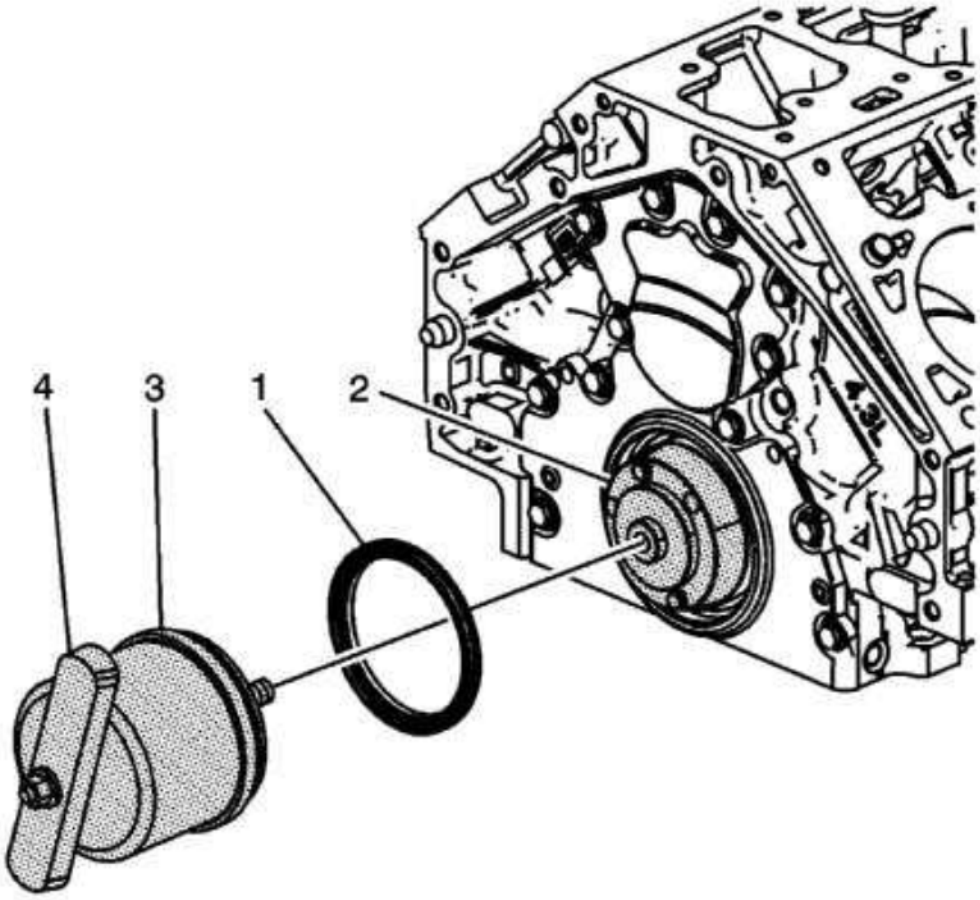

Fig. 557: Crankshaft Rear Oil Seal Installation Guide Cone
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41479-2A** crankshaft rear oil seal installation guide cone (2) and bolts onto the rear of the crankshaft.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal (1) onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with "THIS SIDE OUT" facing away from the engine.
5. Install the **EN-41479-10** crankshaft rear oil seal installer adapter (3) onto **EN-41479** crankshaft rear oil seal installer (4).
6. Thread the **EN-41479** crankshaft rear oil seal installer threaded rod into the tapered cone until the tool contacts the oil seal.
7. Align the oil seal (1) onto the tool.
8. Rotate the handle of the tool clockwise until the seal enters the rear housing and bottoms into the seal bore.
9. Remove the tool.

ENGINE FRONT COVER INSTALLATION

Oil Pump Flow Control Valve Harness Installation

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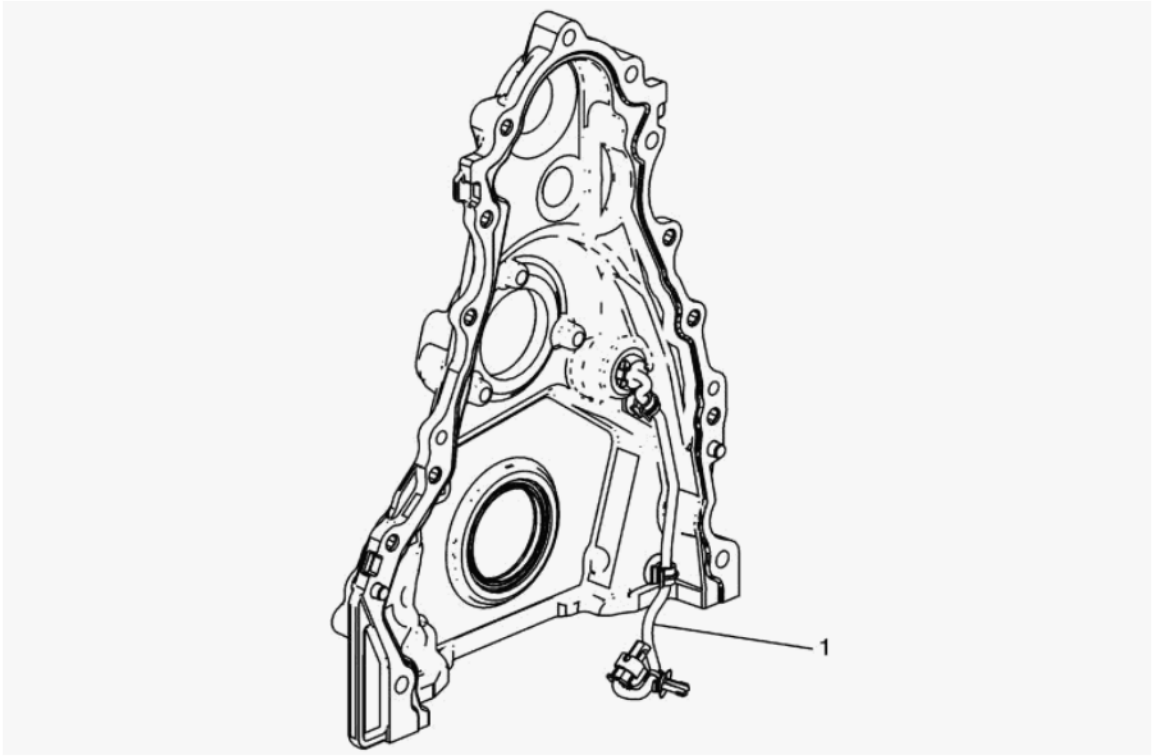

Fig. 558: Oil Pump Flow Control Valve Harness
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Harness Installation

Callout	Component Name
1	Oil Pump Flow Control Valve Harness **Procedure** 1. Install the harness through the front of the engine front cover and push connector into engine front cover until it clicks. 2. Install the wire into the 2 retainer clips.

Front Cover Installation

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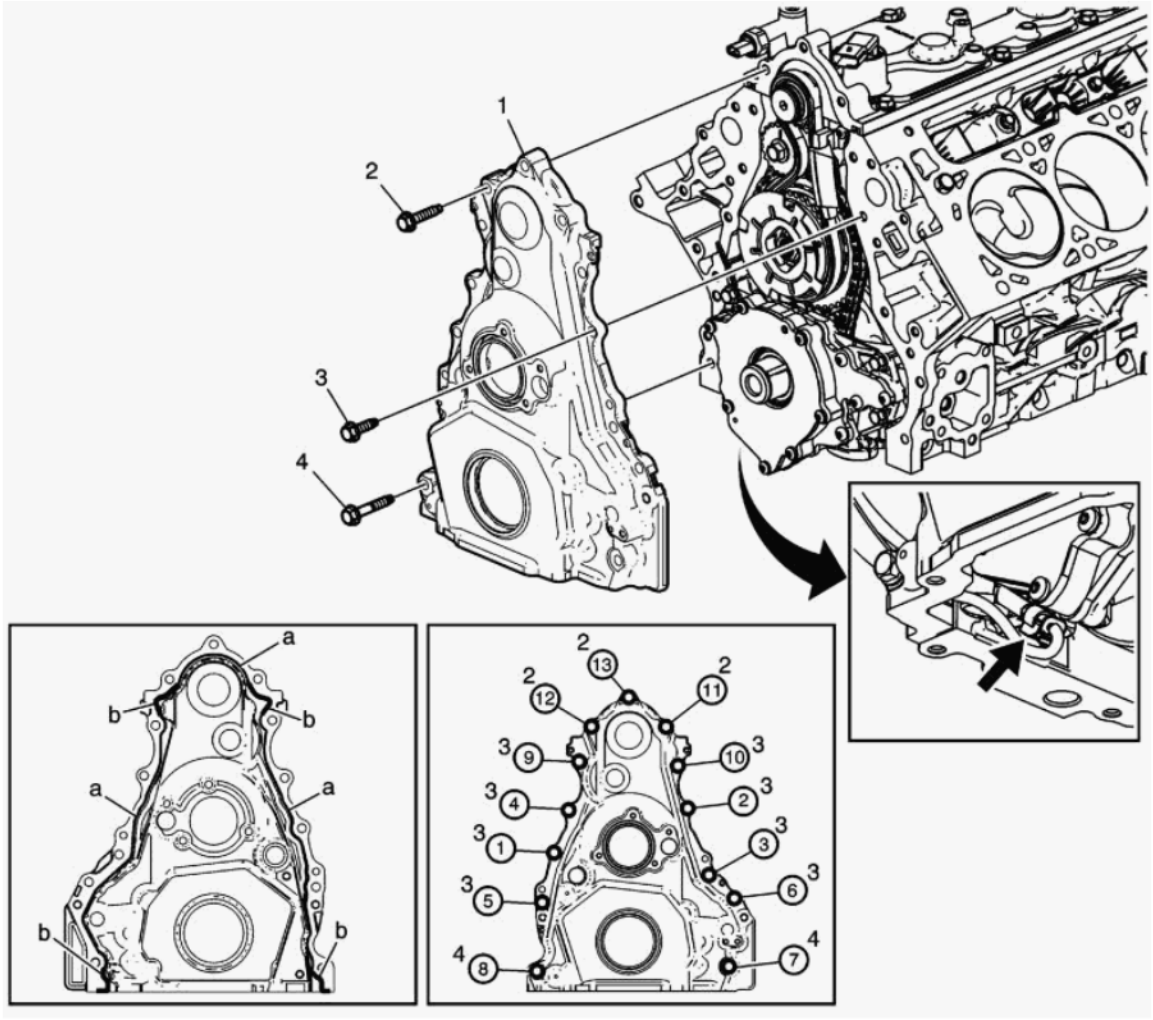

Fig. 559: Front Cover
Courtesy of GENERAL MOTORS COMPANY

Front Cover Installation

Callout	Component Name
1	Engine Front Cover **NOTE:** **Install and align the front cover within 10 minutes of applying the sealer.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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Callout	Component Name
	3. The oil pump flow control valve harness must be connected before installing the engine front cover.
2	Engine Front Cover Bolt **CAUTION:** **Refer to** **Fastener Caution .** **Procedure** Tighten the front cover bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
3	Engine Front Cover Bolt **Procedure** Tighten the front cover bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
4	Engine Front Cover Bolt **Procedure** Tighten the front cover bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Installation

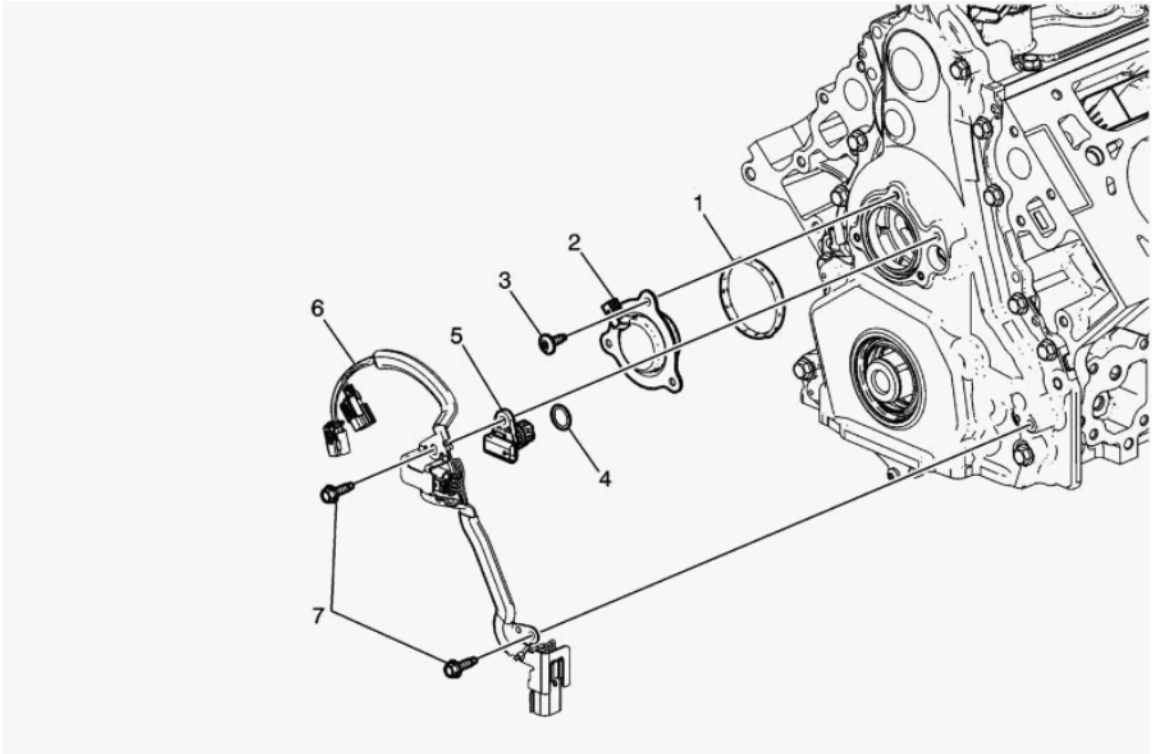

Fig. 560: Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

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Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Installation

Callout	Component Name
1	Camshaft Actuator Magnet Gasket **NOTE:** **Must use a NEW gasket.**
2	Camshaft Actuator Magnet
3	Camshaft Actuator Magnet Bolts **Tighten** 10 N.m (88 lb in)
4	Camshaft Position Sensor Seal **NOTE:** **Must use a NEW seal.**
5	Camshaft Position Sensor
6	Camshaft Position Sensor Harness
7	Camshaft Position Sensor Harness Bolts **Tighten** 10 N.m (88 lb in)

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

- **J-41478-A** Crankshaft Front Oil Seal Installer
- **EN-51091** Crankshaft Front Oil Seal Installer

For equivalent regional tools, refer to **Special Tools**

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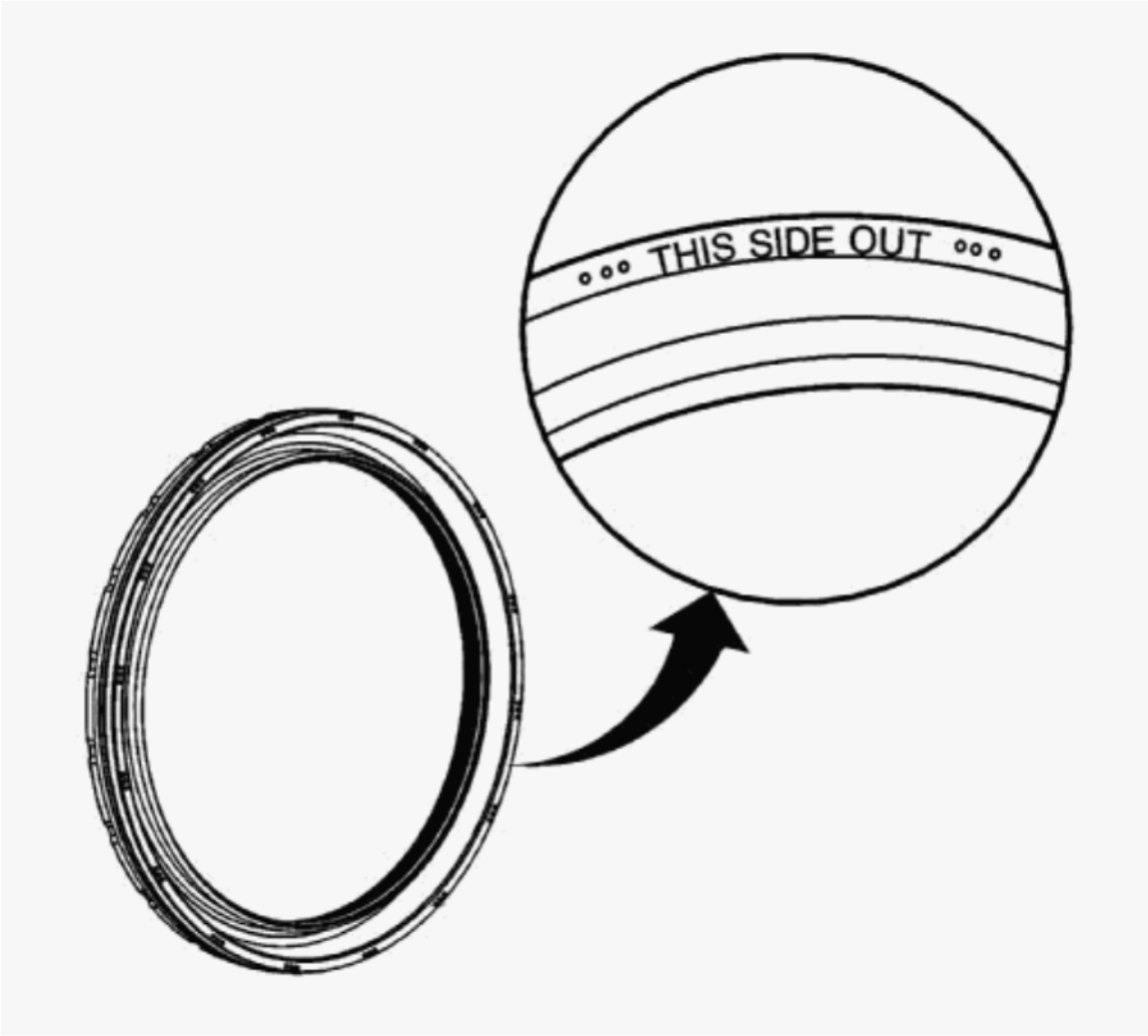

Fig. 561: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

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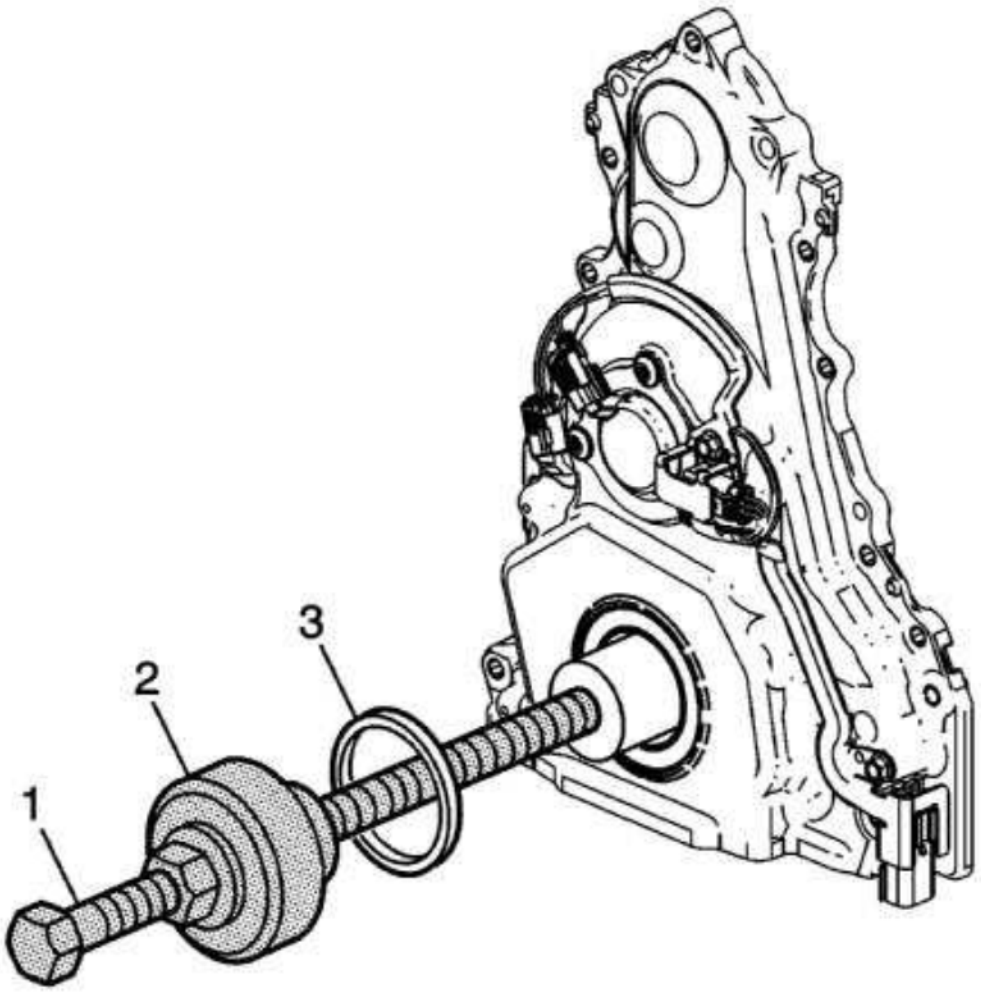

Fig. 562: Crankshaft Front Oil Seal And Crankshaft Front Oil Seal Installer
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not lubricate the oil seal sealing surface.**
- **Do not use the crankshaft front oil seal again.**

2. Install the crankshaft front oil seal (3) onto the threaded rod, nut and washer from **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2).
3. Install the **J-41478-A** crankshaft front oil seal installer threaded rod, nut and washer (1) and **EN-51091** crankshaft front oil seal installer (2) and oil seal (3), into the end of the crankshaft.
4. Use the **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2) in order to install the oil seal (3) 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

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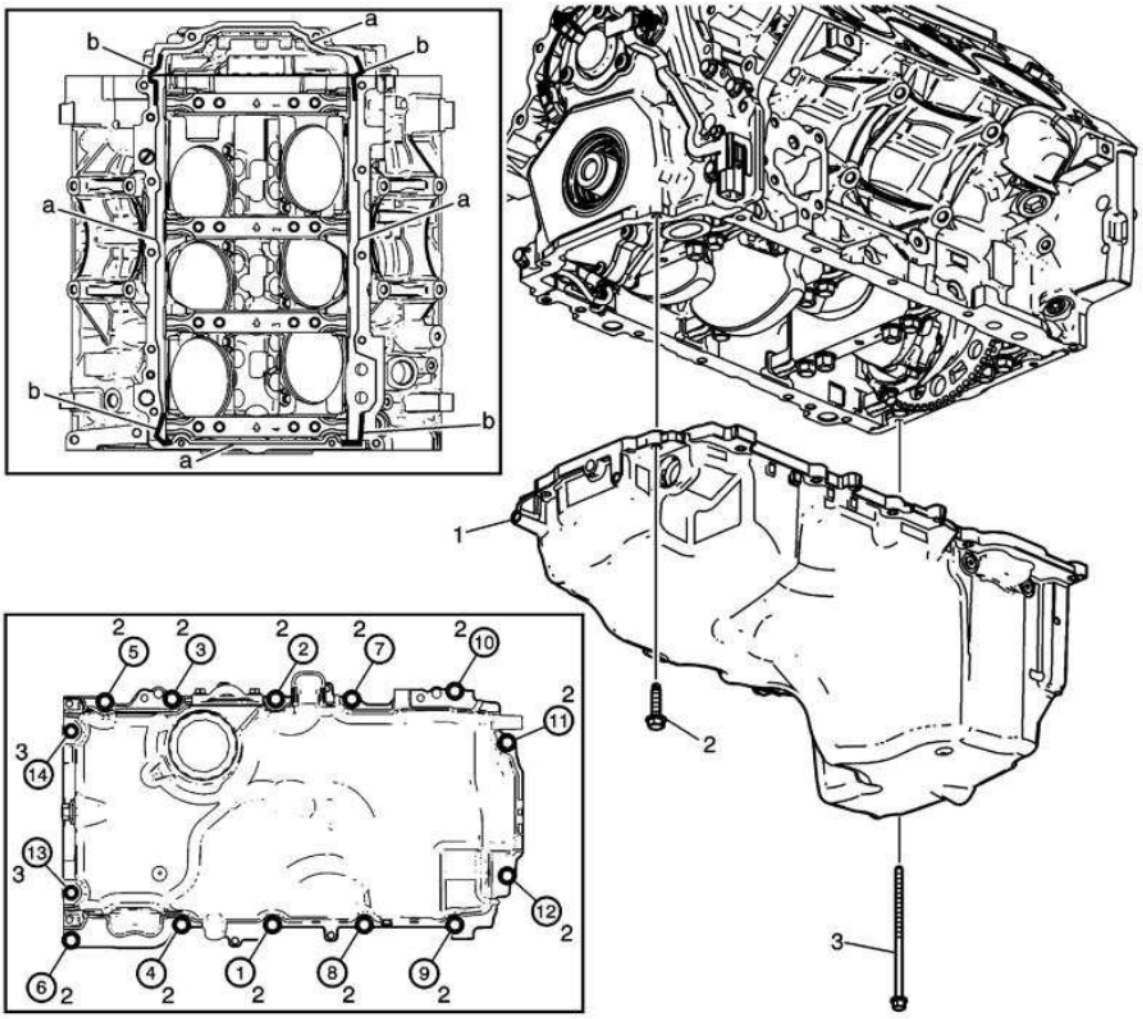

Fig. 563: Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan **NOTE:** **Install and align the oil pan within 10 minutes of applying the sealer.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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Callout	Component Name
2	Oil Pan Bolt **CAUTION:** **Refer to** **Fastener Caution** . **Procedure** Tighten the oil pan bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
3	Oil Pan Bolt **Procedure** Tighten the oil pan bolts in the sequence shown. **Tighten** 12 N.m (106 lb in)

OIL FILTER INSTALLATION

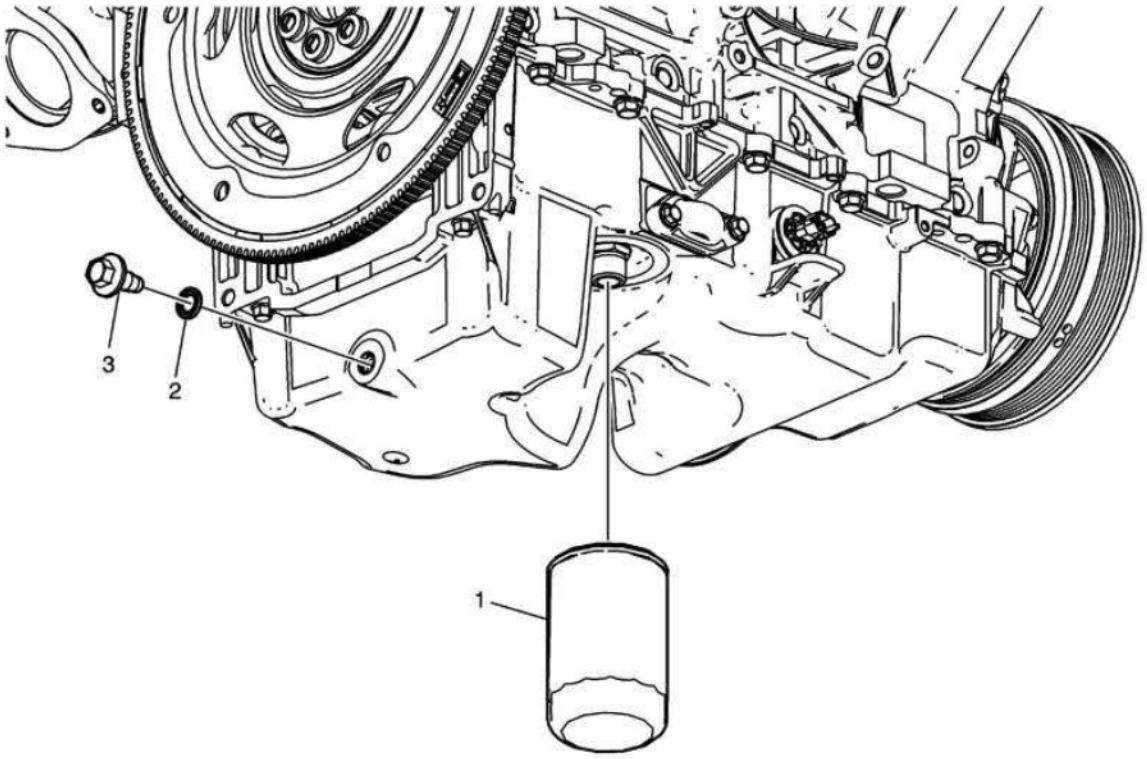

Fig. 564: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Filter Assembly **CAUTION:**

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Callout	Component Name
	Refer to Fastener Caution . **Tighten** 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange
2	Oil Pan Drain Plug Seal
3	Oil Pan Drain Plug **Tighten** 25 N.m (18 lb ft)

CYLINDER HEAD INSTALLATION - LEFT SIDE

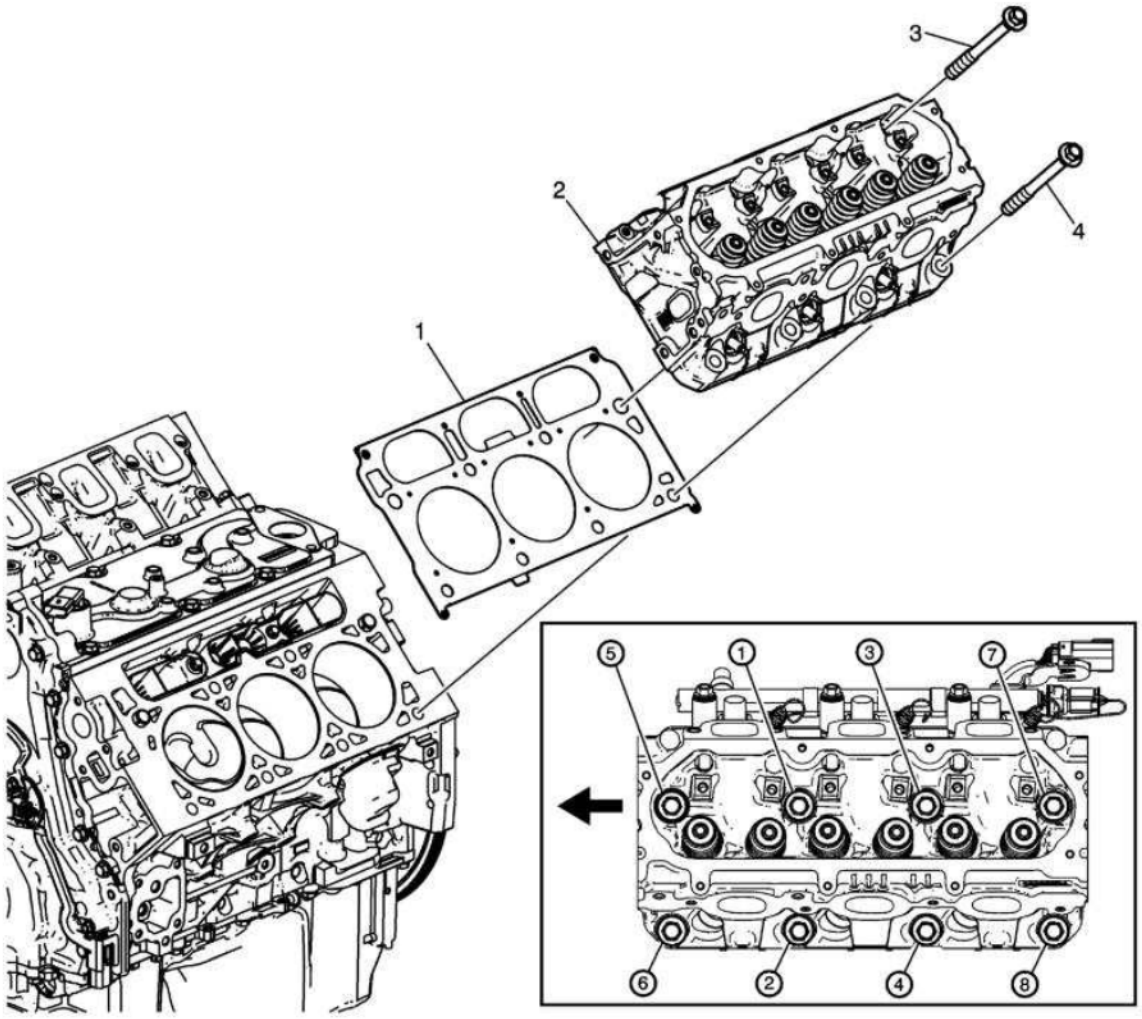

Fig. 565: Cylinder Head - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.	
1	Cylinder Head Gasket

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Callout	Component Name
2	Cylinder Head Assembly
3	Cylinder Head Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.** **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the cylinder head bolts each pass in the sequence shown. **Tighten** 80 N.m (59 lb ft) + 90Â° + 60Â°
4	Cylinder Head Bolt **Procedure** Tighten the cylinder head bolts each pass in the sequence shown. **Tighten** 80 N.m (59 lb ft) + 90Â° + 60Â°

CYLINDER HEAD INSTALLATION - RIGHT SIDE

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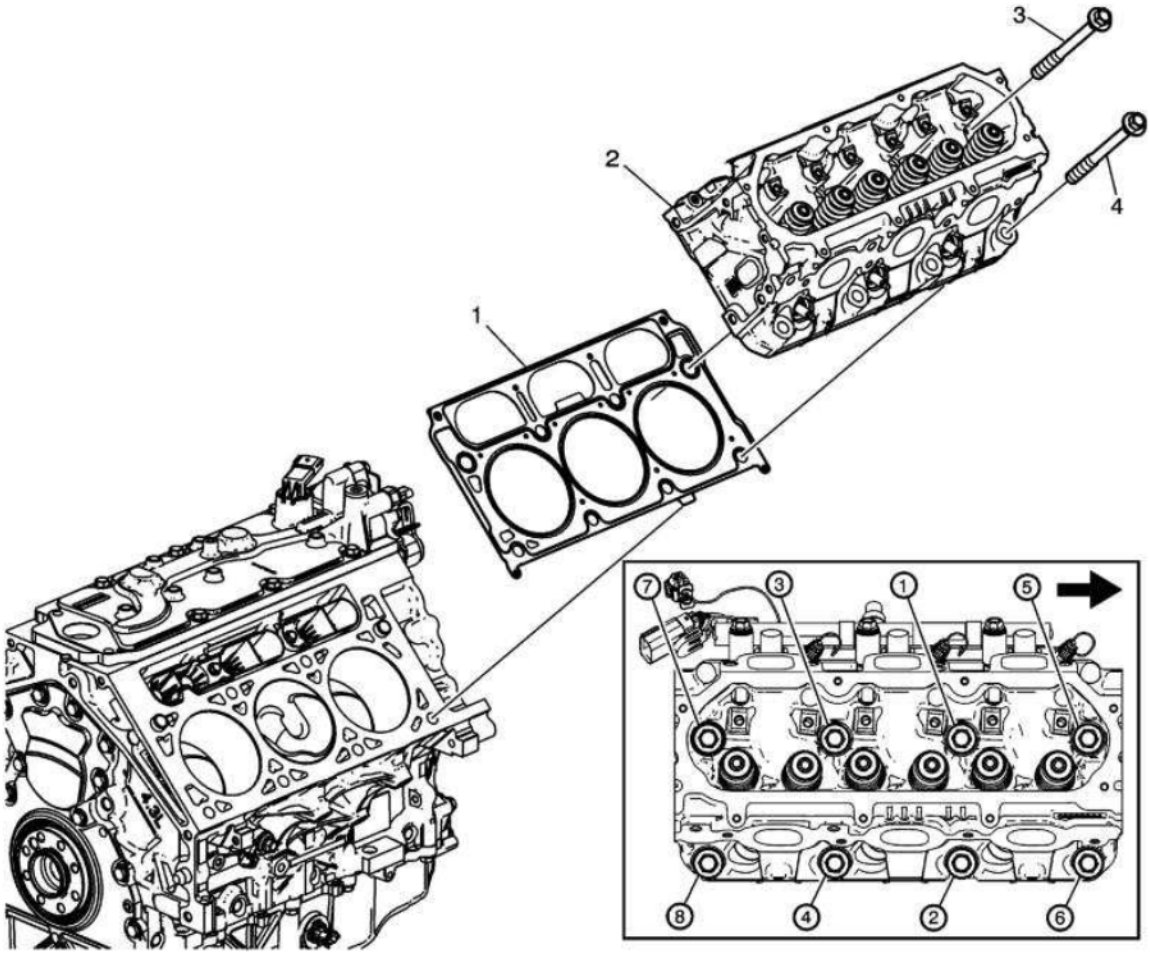

Fig. 566: Cylinder Head - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.	
1	Cylinder Head Gasket
2	Cylinder Head Assembly
3	Cylinder Head Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener**

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Callout	Component Name
	when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the cylinder head bolts each pass in the sequence shown. **Tighten** 80 N.m (59 lb ft) + 90Â° + 60Â°
4	Cylinder Head Bolt **Procedure** Tighten the cylinder head bolts each pass in the sequence shown. **Tighten** 80 N.m (59 lb ft) + 90Â° + 60Â°

VALVE ROCKER ARM AND PUSH ROD INSTALLATION

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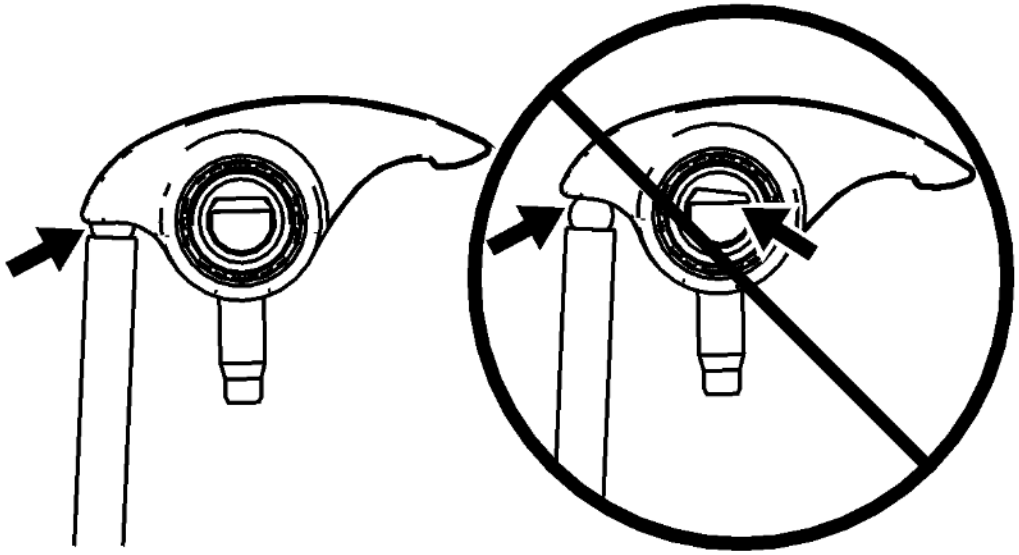

Fig. 567: Proper Seating Of Push Rod
Courtesy of GENERAL MOTORS COMPANY

1. Ensure the pushrods seat properly to the ends of the rocker arms.

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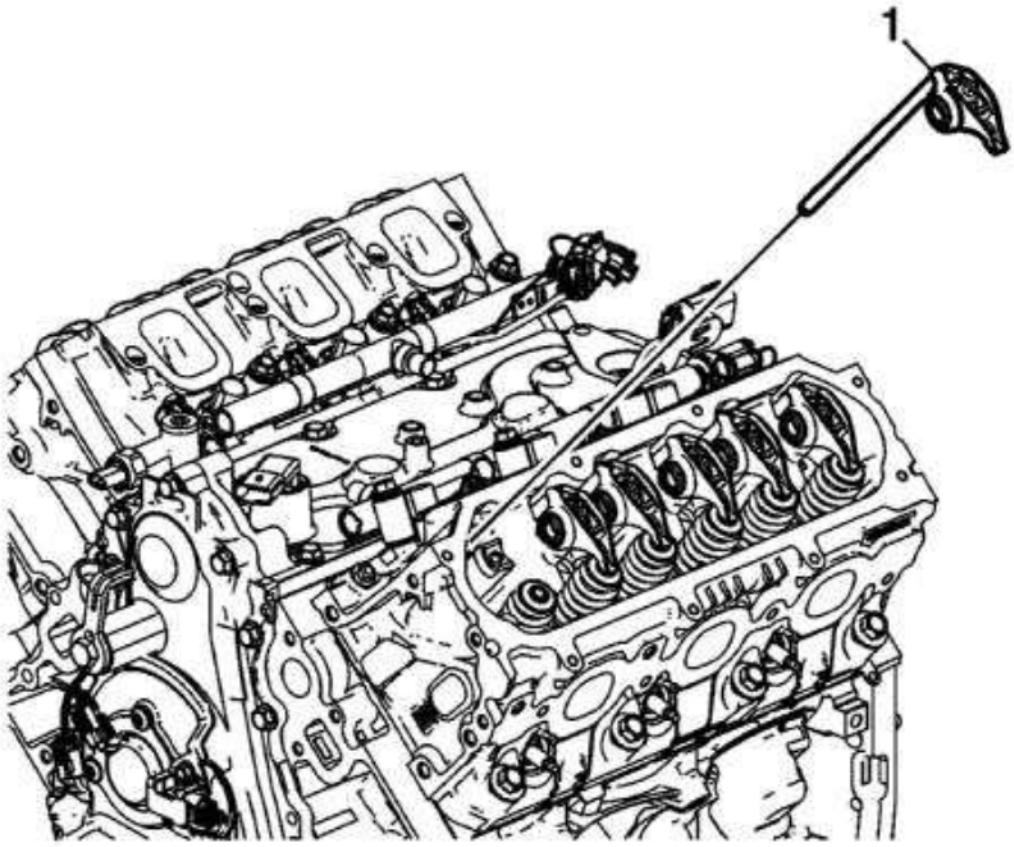

Fig. 568: Valve Rocker Arm And Pushrod Assemblies
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **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.**
- **Lubricate the flange of the valve rocker arm bolts with clean engine oil.**
- **Lubricate the valve rocker arms and pushrods with clean engine oil.**
- **Ensure the pushrods seat properly to the valve lifter sockets.**
- **DO NOT tighten the rocker arm bolts at this time.**

2. Install the valve rocker arm and pushrod assemblies (1).

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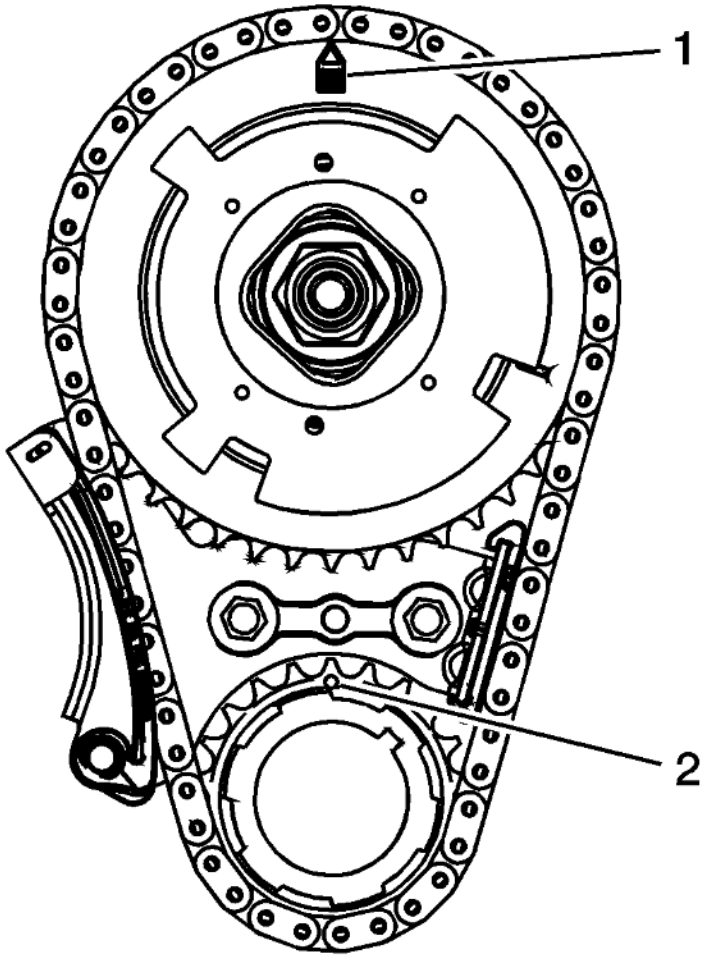

Fig. 569: View Of Camshaft & Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

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

   Cylinders 1, 3, and 5 are left bank.

   Cylinders 2, 4, and 6 are right bank.

   CAUTION: Refer to Fastener Caution

4. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
   1. Tighten the exhaust valve rocker arm bolts 1, 5, and 6 to 30 N.m (22 lb ft).
   2. Tighten the intake valve rocker arm bolts 1, 3, and 2 to 30 N.m (22 lb ft).
5. Rotate the crankshaft 360 degrees.
6. Tighten the following valve rocker arm bolts:

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

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

Valve Rocker Arm Cover Assemble - Left Side

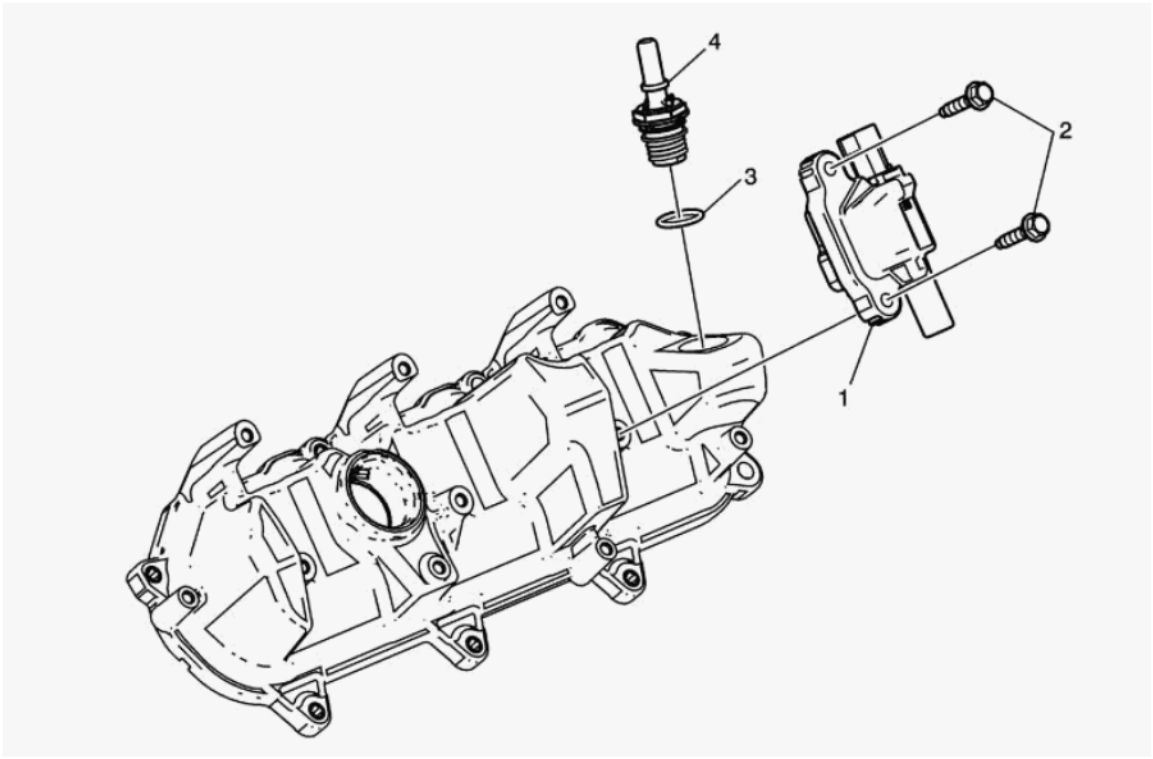

Fig. 570: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Assemble - Left Side

Callout	Component Name
1	Ignition Coil
2	Ignition Coil Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (88 lb in)
3	PCV Fitting Seal **NOTE:** **Must use a NEW seal.**
4	PCV Fitting **Tighten**

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Callout	Component Name
	6 N.m (53 lb in)

Valve Rocker Arm Cover Installation - Left Side

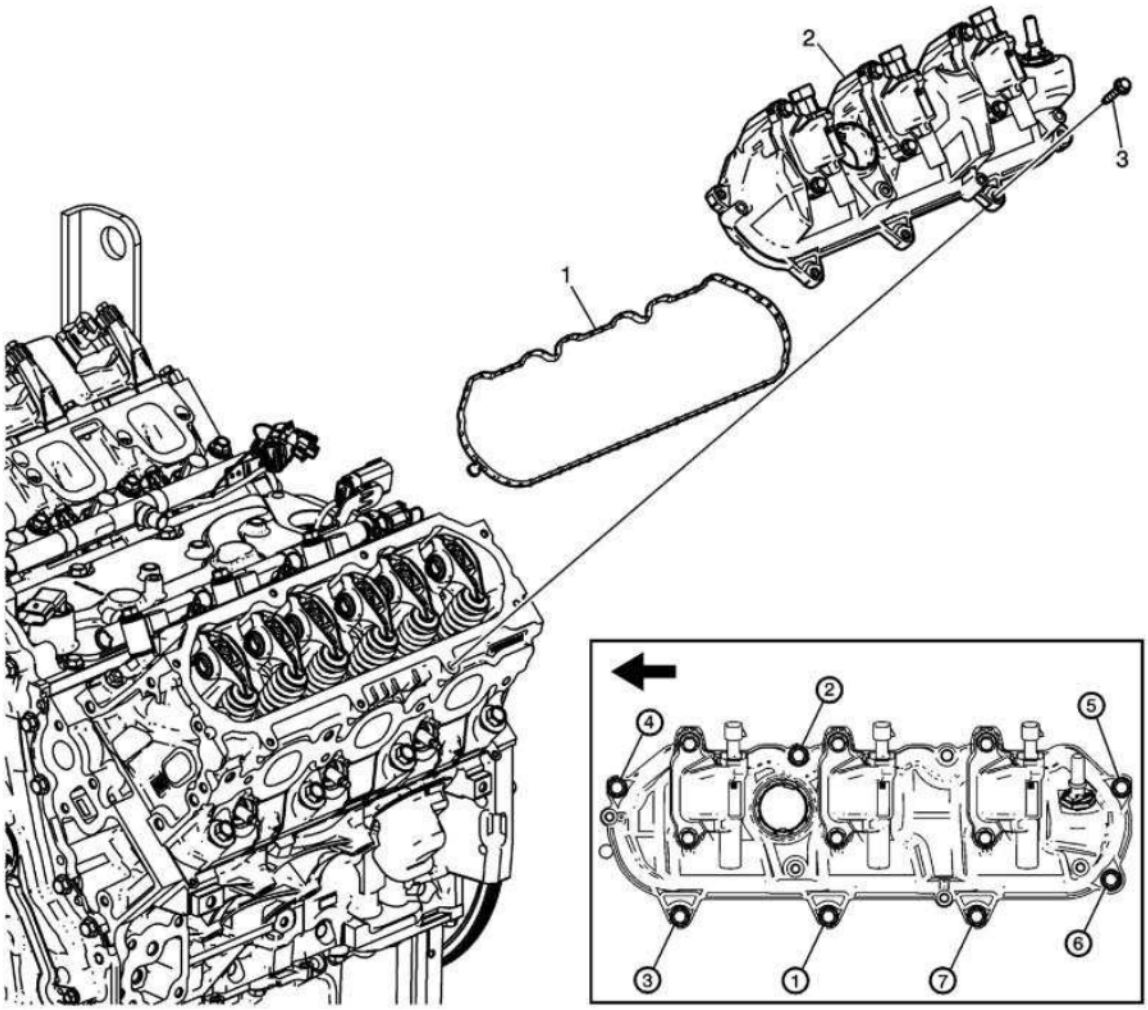

Fig. 571: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Installation - Left Side

Callout	Component Name
1	Valve Rocker Arm Cover Gasket **NOTE:** **Must use a NEW gasket.**
2	Valve Rocker Arm Cover - Left Side
3	Valve Rocker Arm Cover Bolt **Procedure** Tighten the valve rocker arm cover bolts in the sequence shown. **Tighten** 10 N.m (88 lb in)

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

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Valve Rocker Arm Cover Assemble - Right Side

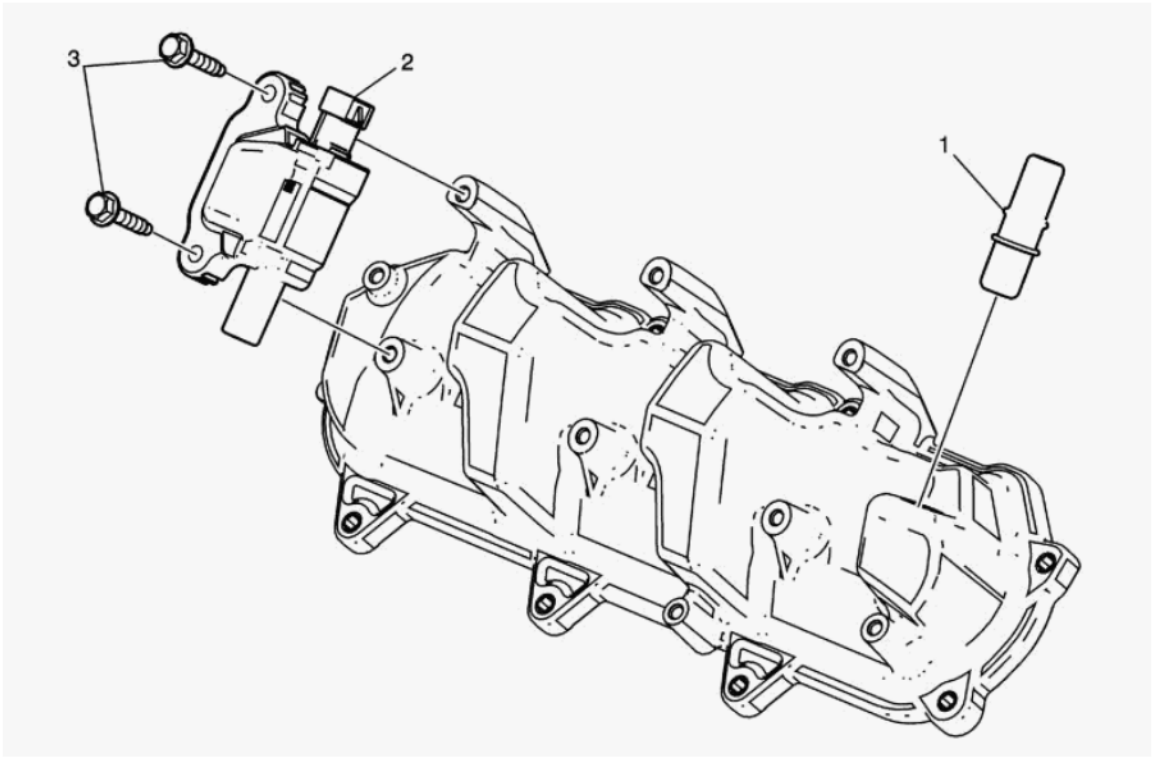

Fig. 572: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Assemble - Right Side

Callout	Component Name
1	Ignition Coil
2	Ignition Coil Bolt **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 10 N.m (88 lb in)

Valve Rocker Arm Cover Installation - Right Side

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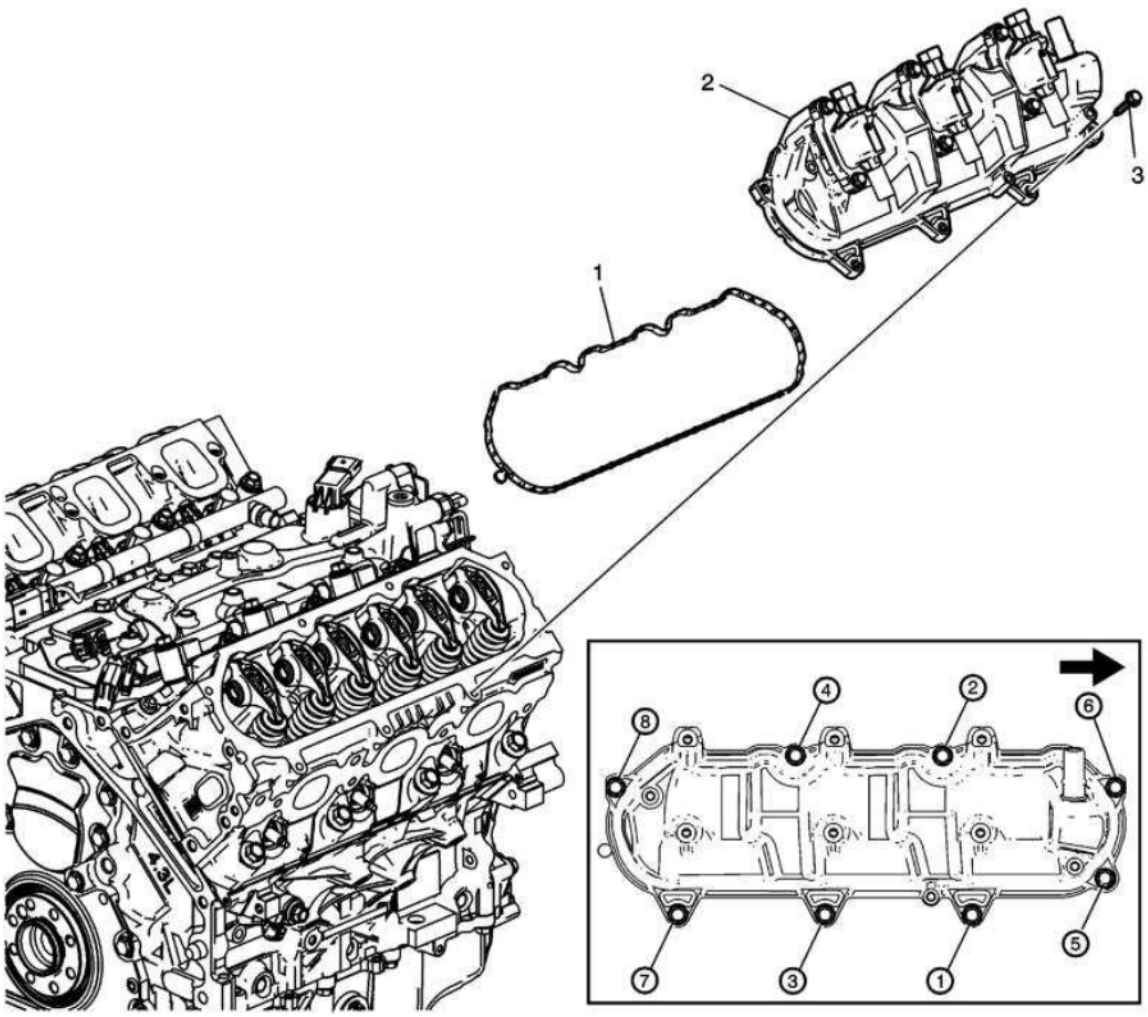

Fig. 573: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Installation - Right Side

Callout	Component Name
1	Valve Rocker Arm Cover Gasket **NOTE:** **Must use a NEW gasket.**
2	Valve Rocker Arm Cover - Right Side
3	Valve Rocker Arm Cover Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the valve rocker arm cover bolts in the sequence shown. **Tighten** 10 N.m (88 lb in)

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VALVE LIFTER OIL FILTER INSTALLATION

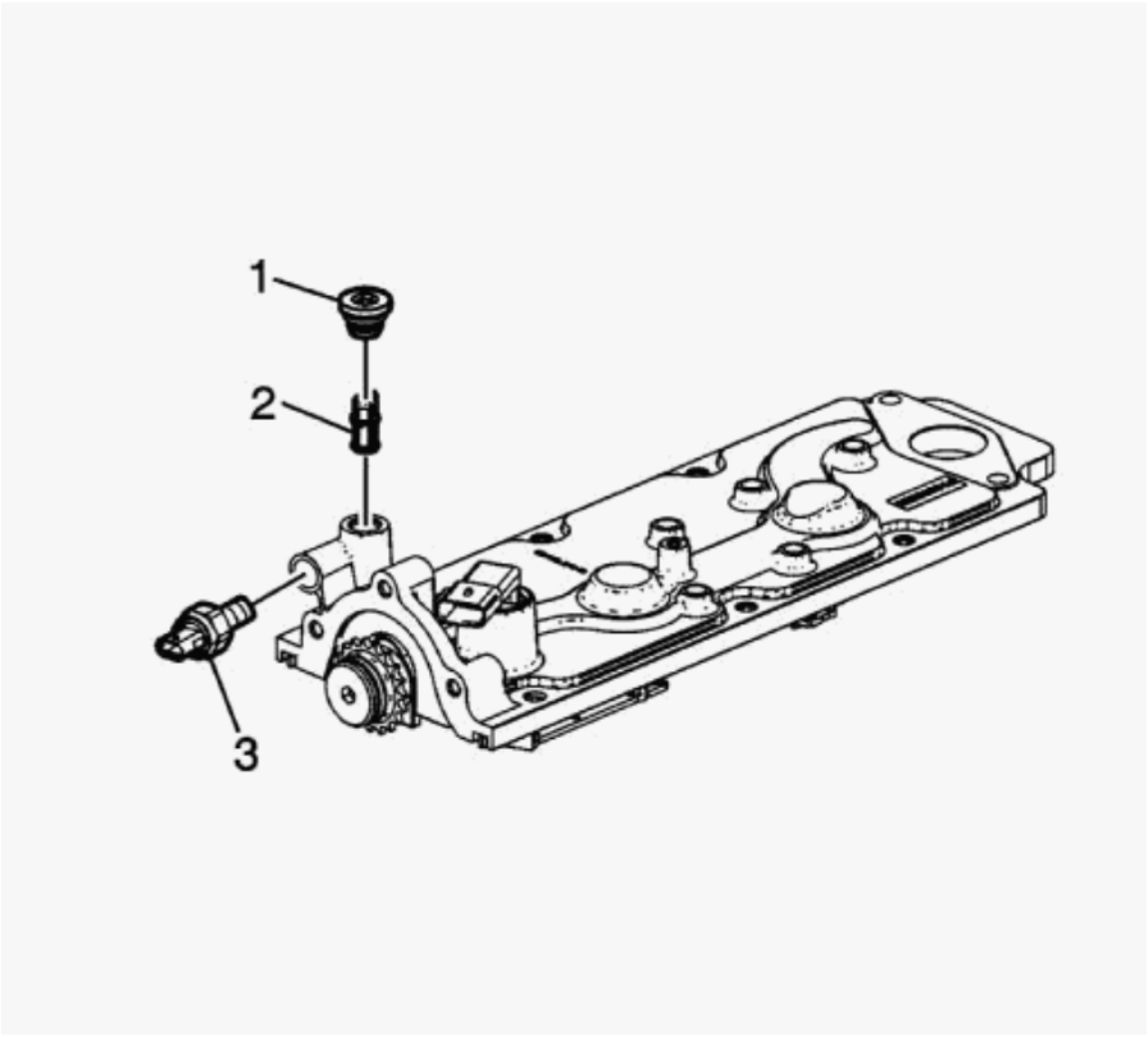

Fig. 574: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

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

1. Install a NEW oil filter (2).
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor (3). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

CAUTION: **Refer to Fastener Caution .**

3. Install the valve lifter oil manifold plug (1). Tighten to 30 N.m (22 lb ft).
4. Install the oil pressure sensor (3). Tighten the oil pressure sensor to 35 N.m (26 lb ft).

FUEL PUMP INSTALLATION

Special Tools

EN-51092 Fuel Pump Installation Gauge

For equivalent regional tools, refer to **Special Tools**.

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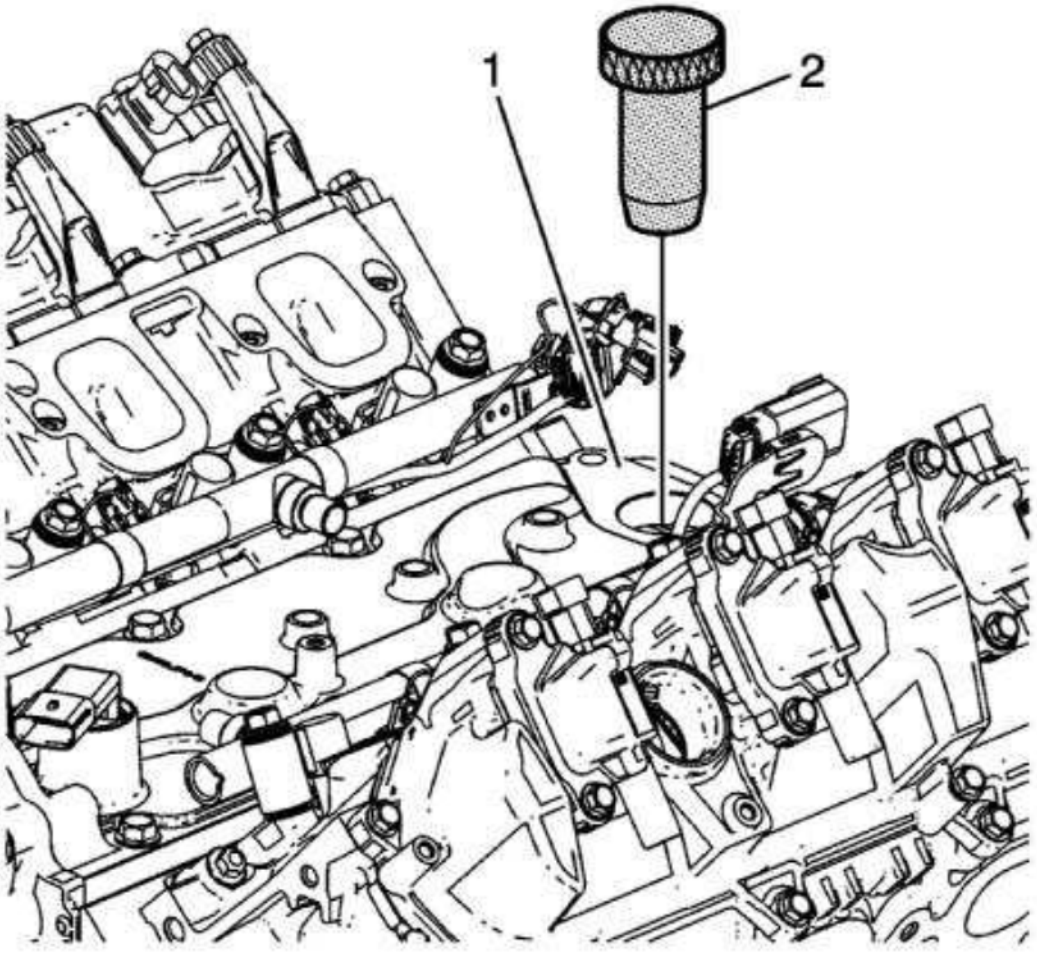

Fig. 575: EN-51092 Alignment Gauge And Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The camshaft must be in the base circle position before the high pressure fuel pump is installed.**

1. Use the **EN-51092** alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the top surface of the Lifter Oil Manifold Assembly (1).

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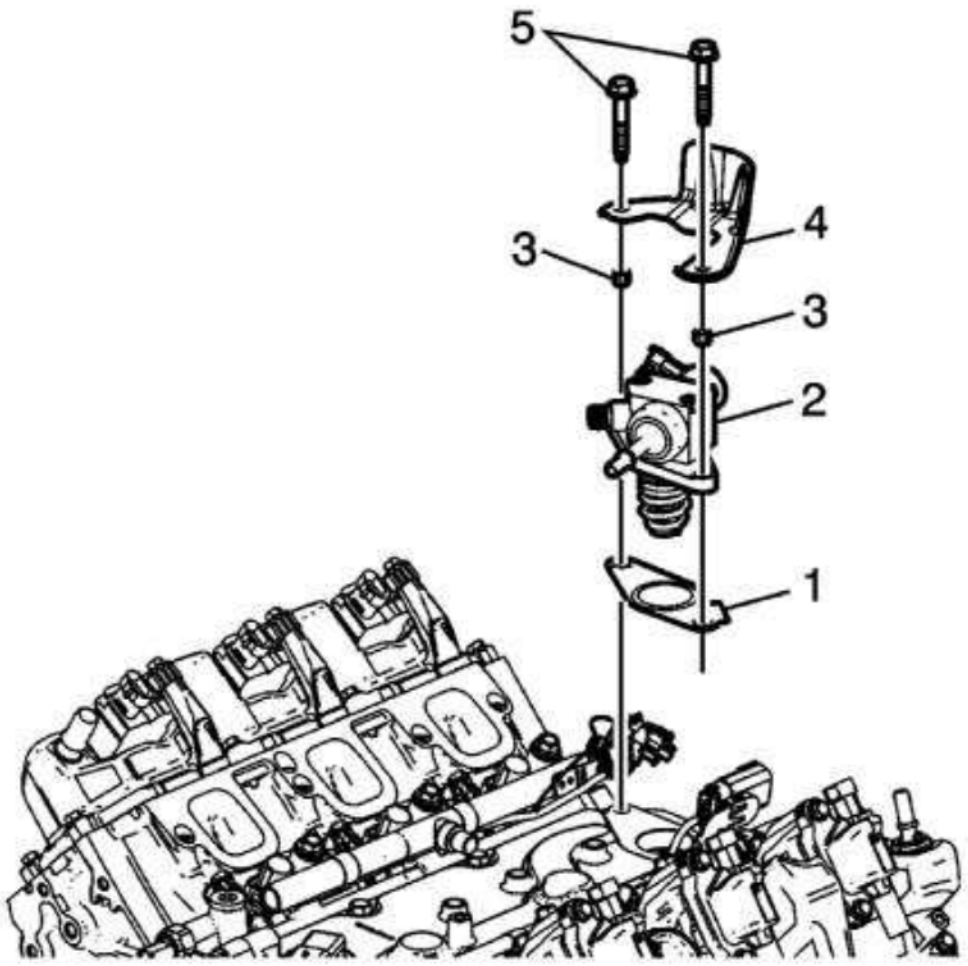

Fig. 576: NEW High Pressure Fuel Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.**

NOTE: **Ensure the plastic bolt retainers (3) are installed in the high pressure fuel pump mounting holes before installing.**

2. Install a NEW high pressure fuel pump gasket (1).
3. Install the high pressure fuel pump (2) and high pressure fuel pump cover (4).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.**

4. Start and hand-tighten the high pressure fuel pump bolts (5) evenly and tighten the high pressure fuel pump bolts to 25 N.m (18 lb ft).

FUEL RAIL AND INJECTORS INSTALLATION

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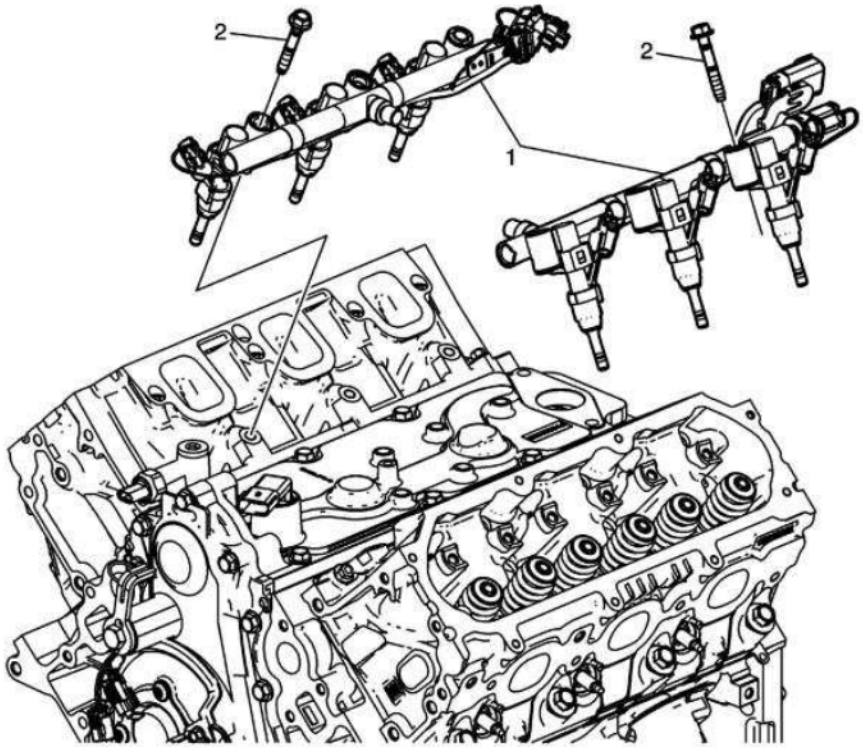

Fig. 577: Fuel Rail And Injectors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Rail Insulator
2	Direct Fuel Injection Fuel Rail Assembly **CAUTION:** **Make sure the fuel injectors are free from debris and lubricant. Lubricant can burn and ruin the fuel injector seals.** • **CAUTION:** **The fuel rail assemblies must be drawn down evenly before final torque.**

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Callout	Component Name
	Failure to draw down the fuel rail assemblies evenly may result in scoring of the lifter bores. • **NOTE:** • **If re-using injectors be sure to replace lower compression seals.** • **Do not lubricate the combustion seals when replacing.** • **Clean the holes in the cylinder head of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.** Refer to **Fuel Rail and Injectors Cleaning and Inspection**.
3	Fuel Injection Fuel Rail Bolt **CAUTION:**

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Callout	Component Name
	Refer to Fastener Caution . **NOTE:** Clean the threads and apply a threadlocker. Refer to Adhesives, Fluids, Lubricants, and Sealers. **Tighten** 25 N.m (18 lb ft)

FUEL PUMP INSULATOR AND FUEL FEED PIPES INSTALLATION

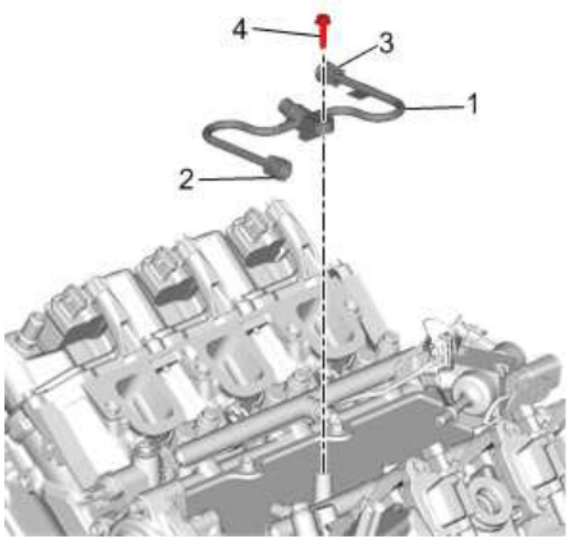

Fig. 578: Fuel Pump Insulator and Fuel Feed Pipes
Courtesy of GENERAL MOTORS COMPANY

WARNING: Avoid unnecessary contact between the fuel feed intermediate pipes and any other parts. This could cause damage to the mating joints. Damage to the mating joints may cause a fuel leak. A fuel leak could cause an engine fire resulting in catastrophic engine and vehicle damage, and possible injury or death.

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

CAUTION: Fuel feed intermediate pipes will be delivered with shipping caps that are meant to protect the mating joint threads. Do NOT remove shipping caps until the pipe is to be installed and joints are to be secured. Failure to do so could result in damage to the mating threads.

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NOTE:

- **DO NOT reuse the fuel feed intermediate pipe - position 1 (1). If the fuel feed intermediate pipe fittings are loosened or the pipes are removed, the pipes must be replaced.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

1. Install the NEW fuel feed intermediate pipe - position 1 (1) by starting both fuel feed intermediate pipe - position 1 fitting nuts (2 and 3) to finger-tight only. For each end, begin by sliding the nut back along the pipe to reveal the sphere. Carefully seat the sphere in the mating socket and hold the sphere firmly in the socket while finger tightening the nut. This will avoid dislodging any wax from the pipe nut threads and ensure a proper seal.
2. Install the fuel feed pipe bolt (4) and hand tighten only.
3. Tighten the LH fuel feed intermediate pipe fitting nut (2) to 30 N.m (22 lb ft).
4. Tighten the RH fuel feed intermediate pipe fitting nut (3) to 30 N.m (22 lb ft).
5. Tighten the fuel feed pipe bolt (4) to 10 N.m (89 lb in).

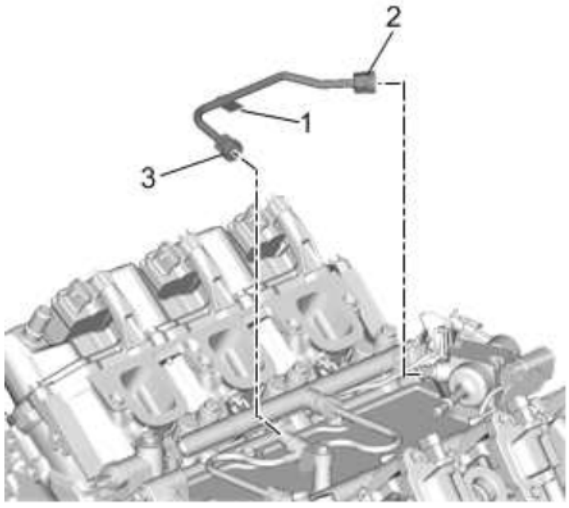

Fig. 579: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Avoid unnecessary contact between the fuel feed intermediate pipes and any other parts. This could cause damage to the mating joints. Damage to the mating joints may cause a fuel leak. A fuel leak could cause an engine fire resulting in catastrophic engine and vehicle damage, and possible injury or death.**

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

CAUTION: **Fuel feed intermediate pipes will be delivered with shipping caps that are meant to protect the mating joint threads. Do NOT remove shipping caps until the pipe is to be installed and joints are to be secured. Failure to do so could result in damage to the mating threads.**

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NOTE:

- **DO NOT reuse the fuel feed intermediate pipe - position 2 (1). If the fuel feed intermediate pipe fittings are loosened or the pipes are removed, the pipes must be replaced.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

6. Install the NEW fuel feed intermediate pipe - position 2 (1). Hold the pipe in install position and first, finger-tighten fuel pipe fitting nut (2). Begin by sliding the nut back along the pipe to reveal the sphere. Carefully seat the sphere in the mating socket on the fuel pump and hold the sphere firmly in the socket while finger tightening the nut. This will avoid dislodging any wax from the pipe nut threads and ensure a proper seal.
7. Finger-tighten fuel pipe fitting nut (3). Begin by sliding the nut back along the pipe to reveal the sphere. Carefully seat the sphere in the mating socket on the fuel pump and hold the sphere firmly in the socket while finger tightening the nut. This will avoid dislodging any wax from the pipe nut threads and ensure a proper seal.
8. Tighten the fuel feed intermediate pipe - position 2 fitting at the fuel pump (2) to 30 N.m (22 lb ft).
9. Tighten the remaining fuel feed intermediate pipe - position 2 fitting (3) to 30 N.m (22 lb ft).

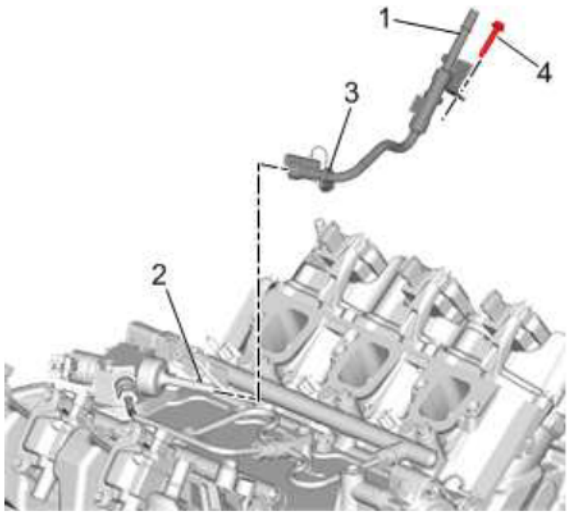

Fig. 580: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

10. Install fuel feed pipe (1) to the fuel pump (2). Press fuel pipe until an audible click is heard. Install redundant clip (3).
11. Install fuel feed pipe to LH rocker cover. Tighten fuel feed bolt (4) to 10 N.m (89 lb in).

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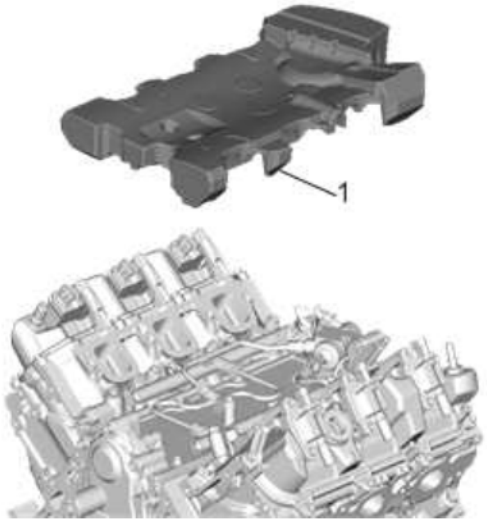

Fig. 581: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

WARNING: **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.**

12. Install the fuel pump insulator (1).

INTAKE MANIFOLD INSTALLATION

Intake Manifold Installation

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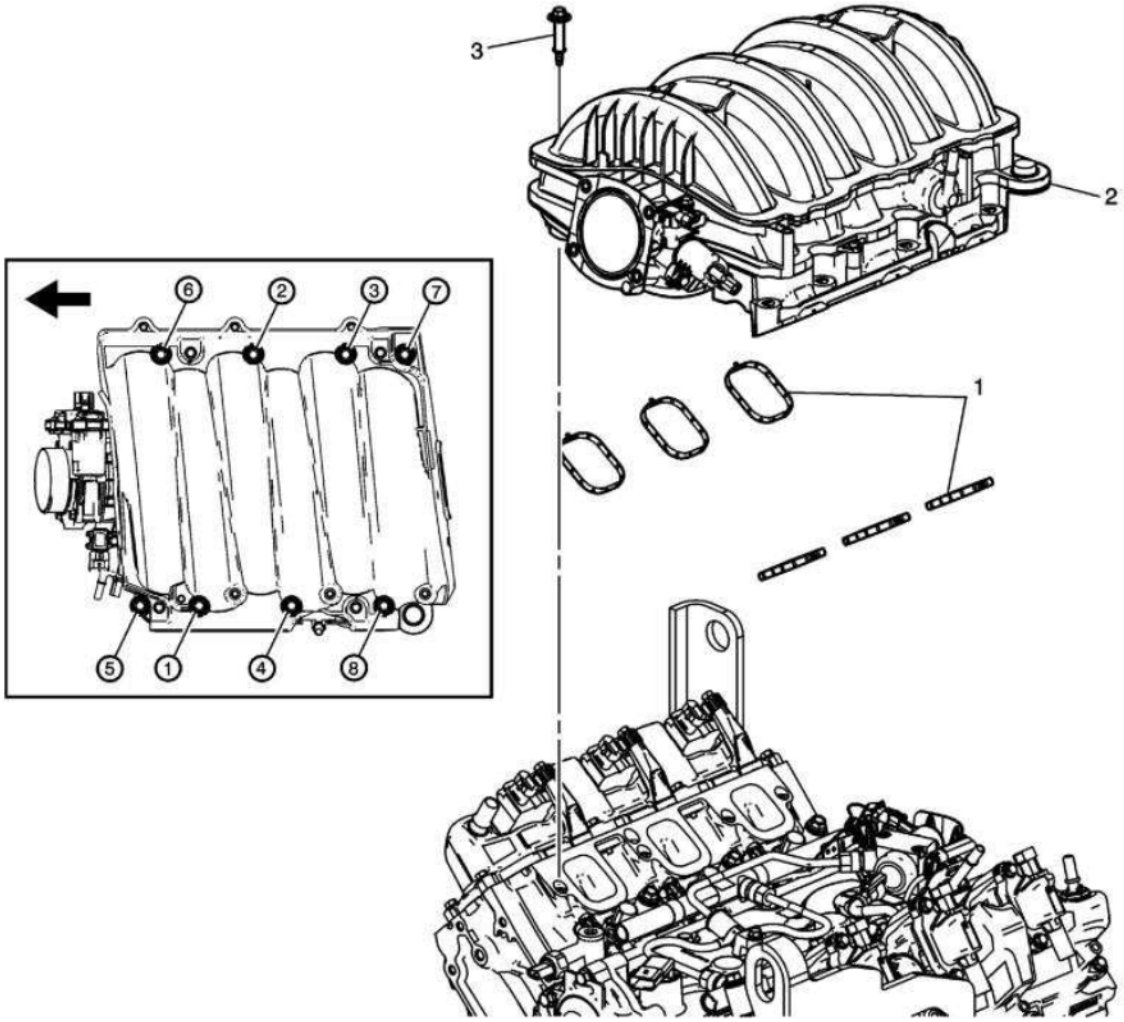

Fig. 582: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Installation

Callout	Component Name
1	Intake Manifold Gasket **NOTE:** **A NEW gasket must be used when installing the intake manifold assembly.**
2	Intake Manifold Assembly

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Callout	Component Name
3	Intake Manifold Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten:** • Tighten the bolts a first pass in the sequence shown to 5 N.m (44 lb in). • Tighten the bolts a final pass in the sequence shown to 10 N.m (89 lb in).

Intake Manifold Cover Installation

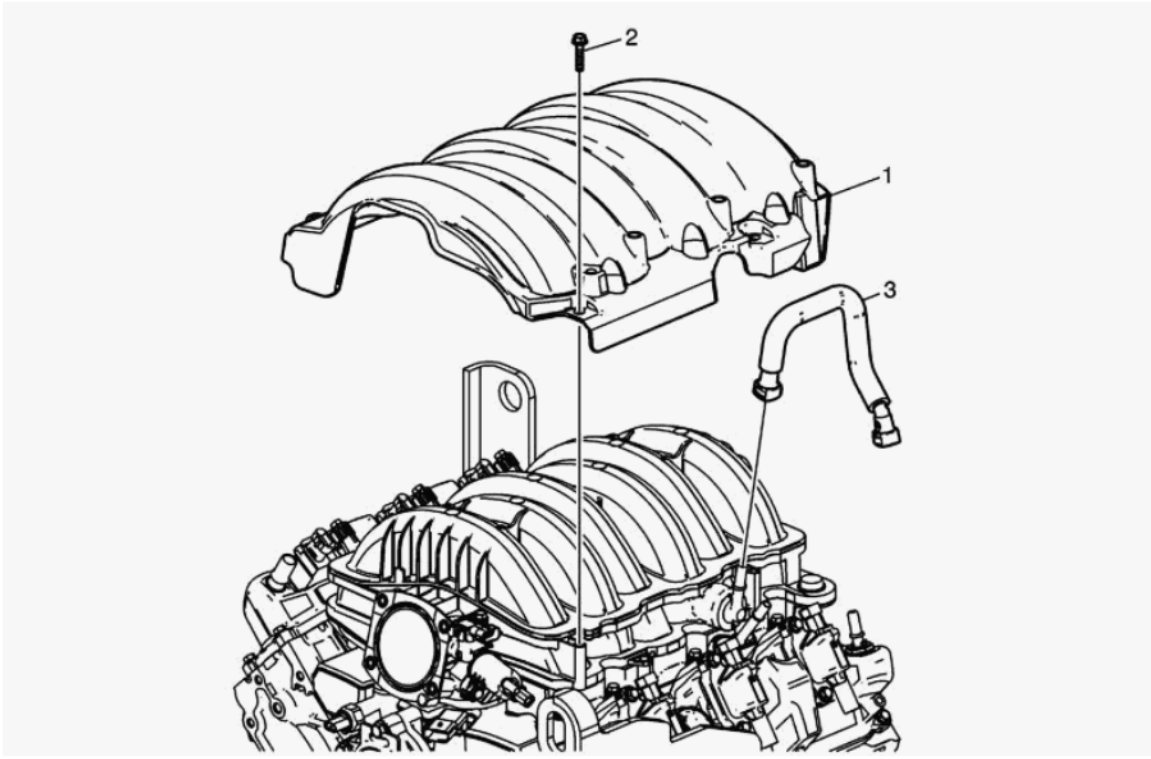

Fig. 583: Intake Manifold Cover
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Cover Installation

Callout	Component Name
1	Intake Manifold Cover Assembly
2	Intake Manifold Cover Bolt **CAUTION:** **Refer to Fastener Caution .**

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Callout	Component Name
	Tighten 4.5 N.m (40 in lb)
3	PCV Tube Assembly **Procedure** 1. The PCV tube is connected to the intake manifold and the engine via a plastic collar quick connect fitting. 2. To install the PCV tube, refer to **Plastic Collar Quick Connect Fitting Service** .

THROTTLE BODY ASSEMBLY INSTALLATION

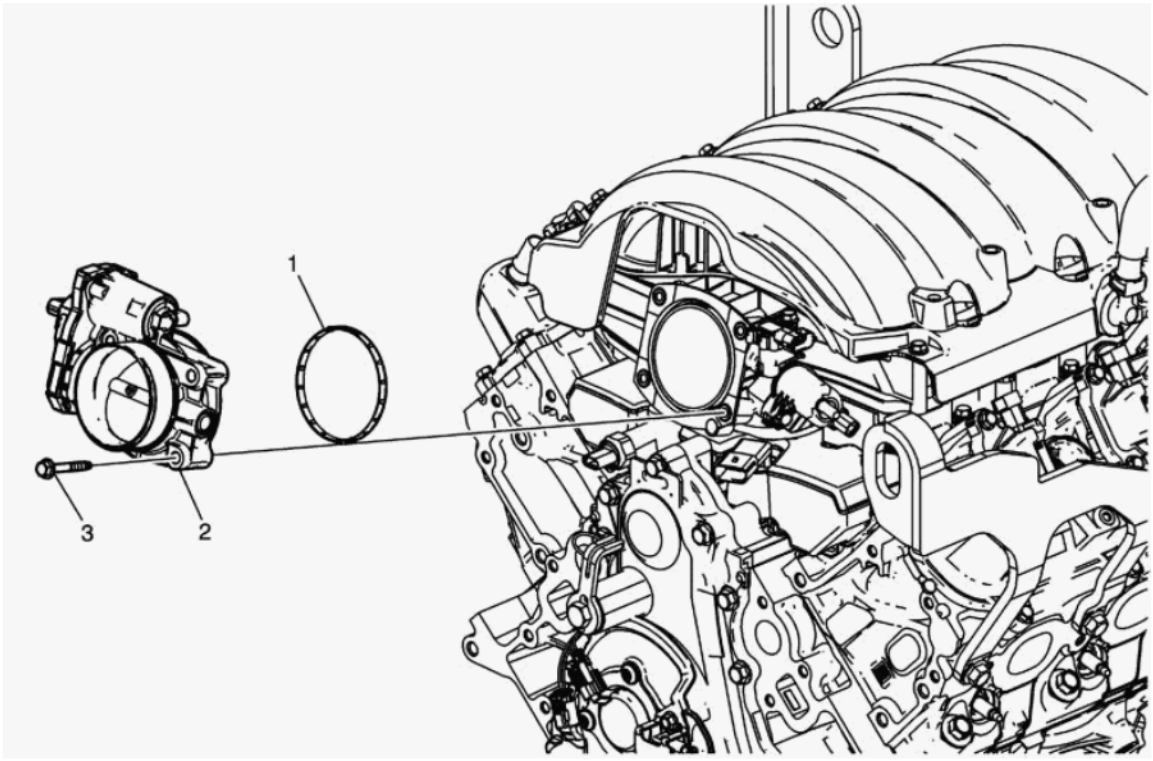

Fig. 584: Throttle Body Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Gasket **NOTE:** **A NEW gasket must be used when installing the throttle body assembly.**
2	Throttle Body Assembly

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Callout	Component Name
3	Throttle Body Bolt **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 10 N.m (88 lb in)

ENGINE COOLANT MANIFOLD INSTALLATION

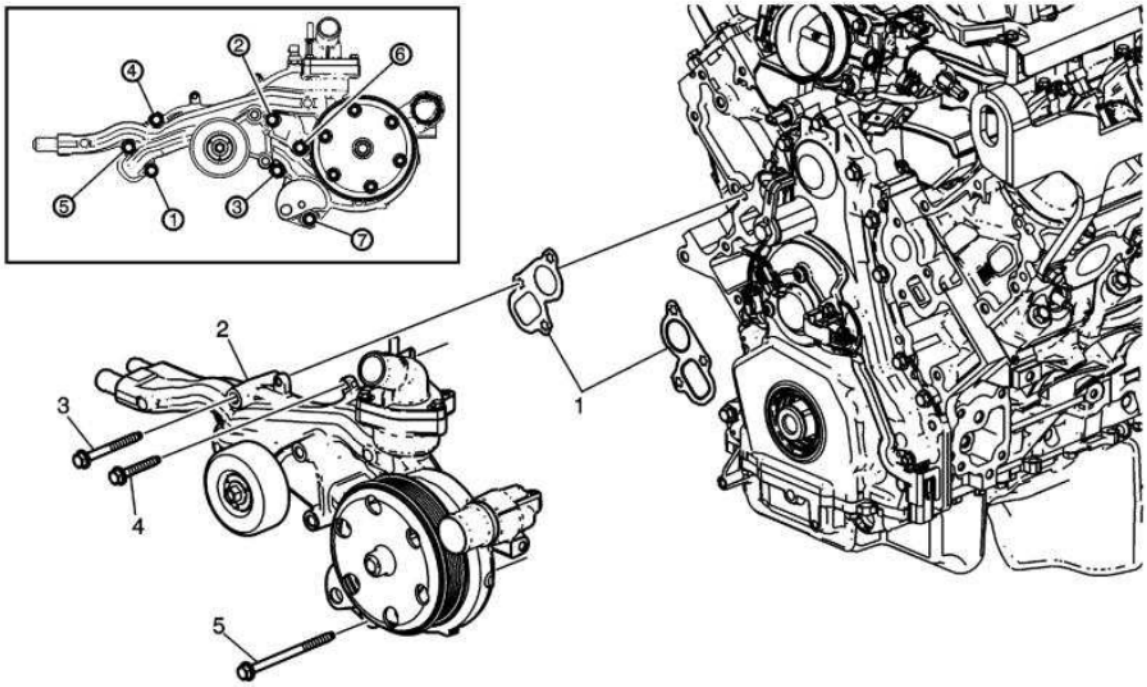

Fig. 585: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Manifold Gasket **NOTE:** **Must use a NEW gasket.**
2	Engine Coolant Manifold Assembly
3	Engine Coolant Manifold Bolt **CAUTION:** **Refer to** **Fastener Caution .**

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Callout	Component Name
	NOTE: **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
4	Engine Coolant Manifold Bolt **NOTE:** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
5	Engine Coolant Manifold Bolt **NOTE:** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

OIL LEVEL INDICATOR AND TUBE INSTALLATION

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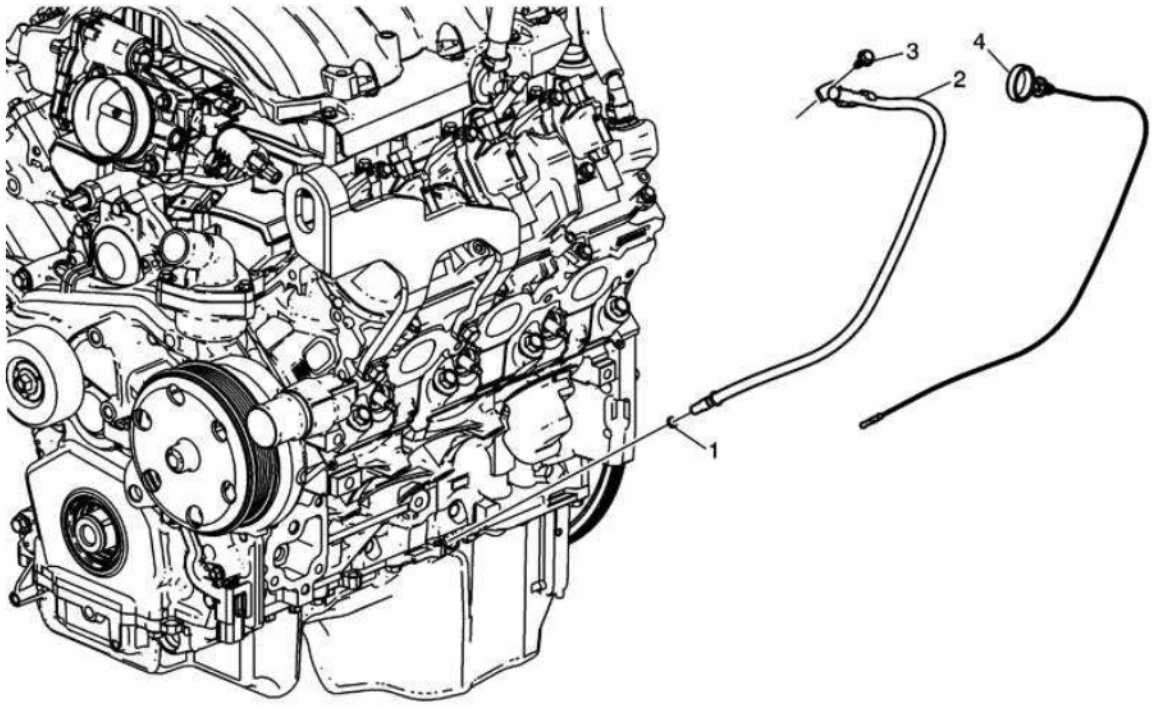

Fig. 586: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube Seal
2	Oil Level Indicator Tube
3	Oil Level Indicator Tube Bracket Bolt **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 10 N.m (88 lb in)
4	Oil Level Indicator

VACUUM PUMP INSTALLATION

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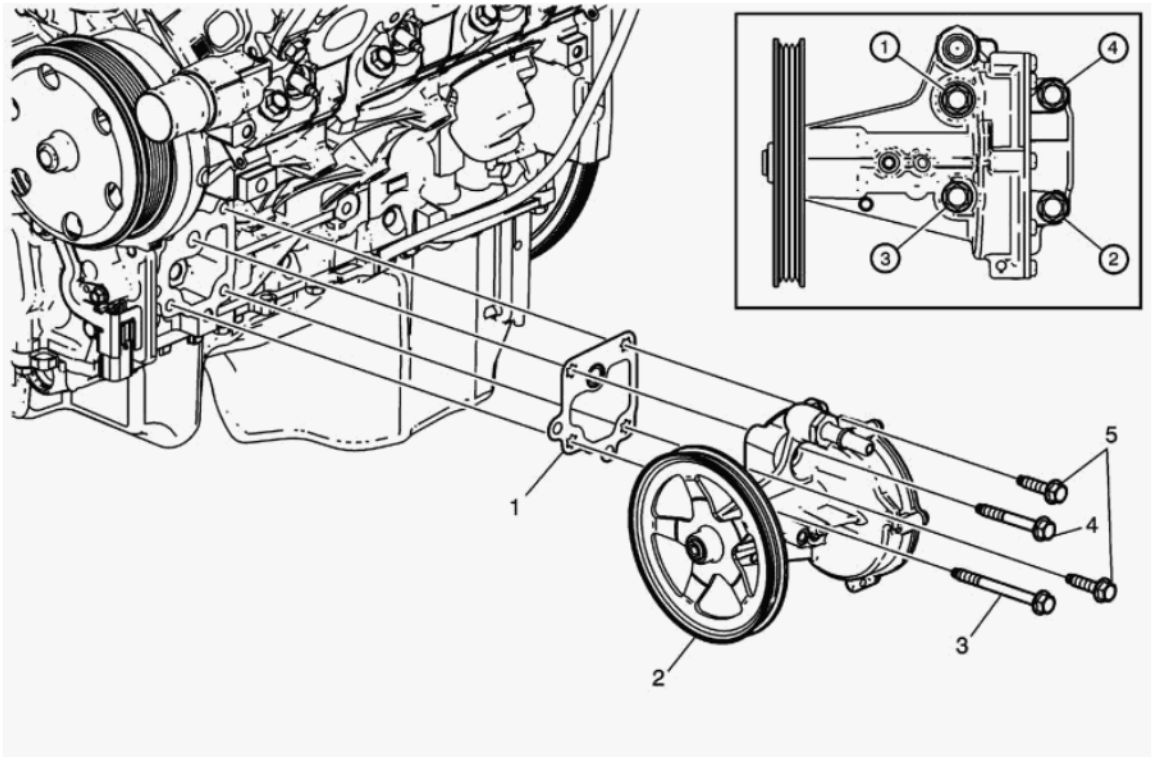

Fig. 587: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Gasket **NOTE:** **Must use NEW gasket when installing vacuum pump.**
2	Vacuum Pump Assembly
3	Vacuum Pump Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
4	Vacuum Pump Bolt **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten**

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Callout	Component Name
	25 N.m (18 lb ft)
5	Vacuum Pump Bolt **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

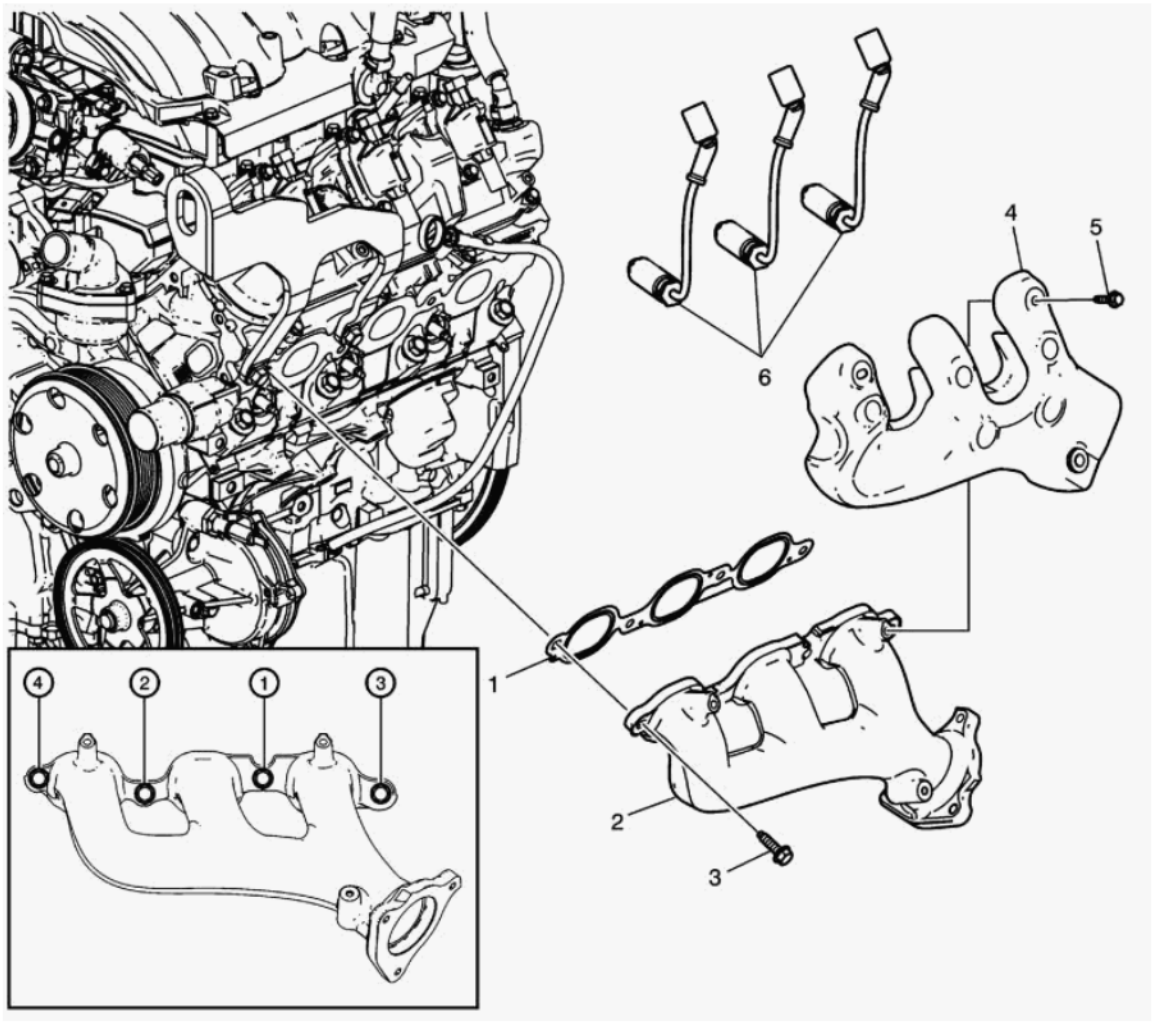

Fig. 588: Exhaust Manifold - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Gasket **NOTE:** **Must use a NEW gasket.**
2	Exhaust Manifold
3	Exhaust Manifold Bolt

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Callout	Component Name
	CAUTION: **Refer to Fastener Caution.** **Procedure** Tighten the exhaust manifold bolts in the sequence shown. 1. If installing on existing cylinder head - Tighten the bolts to 23 N.m (17 lb ft). 2. If installing on NEW cylinder head - Tighten bolts to 27 N.m (20 lb ft)
4	Heat Shield
5	Heat Shield Bolt **Tighten** 12 N.m (106 in lb)
6	Spark Plug Wire **Procedure** Inspect the inside of the spark plug wire boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: **NOTE:** • **Only apply dielectric grease to the spark plug side of the spark plug wire boot.** • **When installing the wires, one audible click should be heard at the spark plug end and two audible clicks should be heard at the ignition coil end.**

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Callout	Component Name
	1. Apply a thin coating of dielectric grease evenly to the inside of the spark plug wire boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

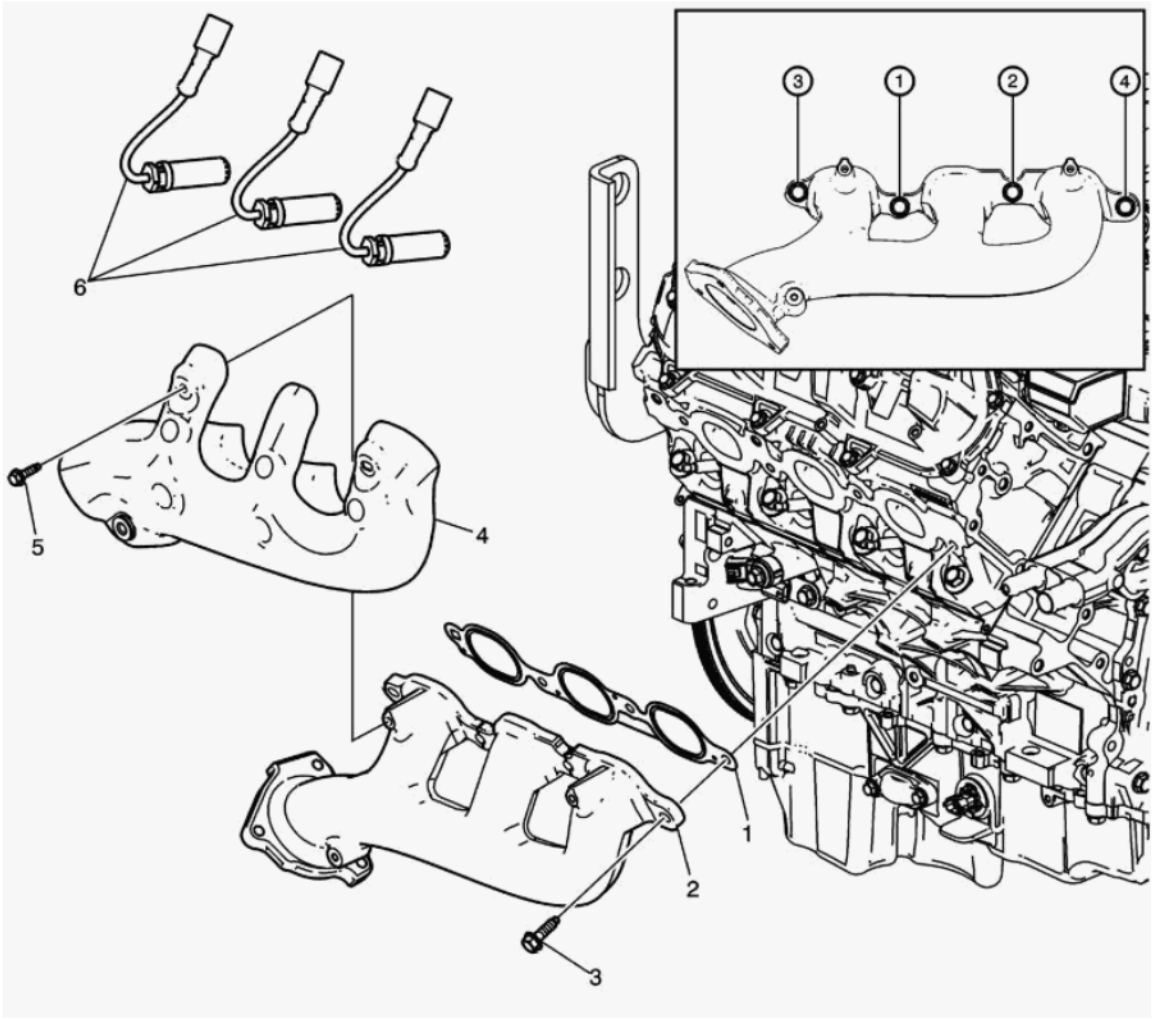

Fig. 589: Exhaust Manifold - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Gasket **NOTE:** **Must use a NEW gasket.**
2	Exhaust Manifold
3	Exhaust Manifold Bolt **CAUTION:**

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Callout	Component Name
	Refer to Fastener Caution . **Procedure** Tighten the exhaust manifold bolts in the sequence shown. 1. If installing on existing cylinder head - Tighten the bolts to 23 N.m (17 lb ft). 2. If installing on NEW cylinder head - Tighten bolts to 27 N.m (20 lb ft)
4	Exhaust Manifold Heat Shield
5	Heat Shield Bolt **Tighten** 12 (106 in lb)
6	Spark Plug Wire **Procedure** Inspect the inside of the spark plug wire boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: **NOTE:** • **Only apply dielectric grease to the spark plug side of the spark plug wire boot.** • **When installing the wires, one audible click should be heard at the spark plug end and two audible clicks should be heard at the**

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Callout	Component Name
	ignition coil end. 1. Apply a thin coating of dielectric grease evenly to the inside of the spark plug wire boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers** . 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

CLUTCH PILOT BEARING INSTALLATION

Special Tools

- **GE-8433** Two Jaw Puller
- **EN-45949** Pilot Bearing and Flywheel Locator Installer

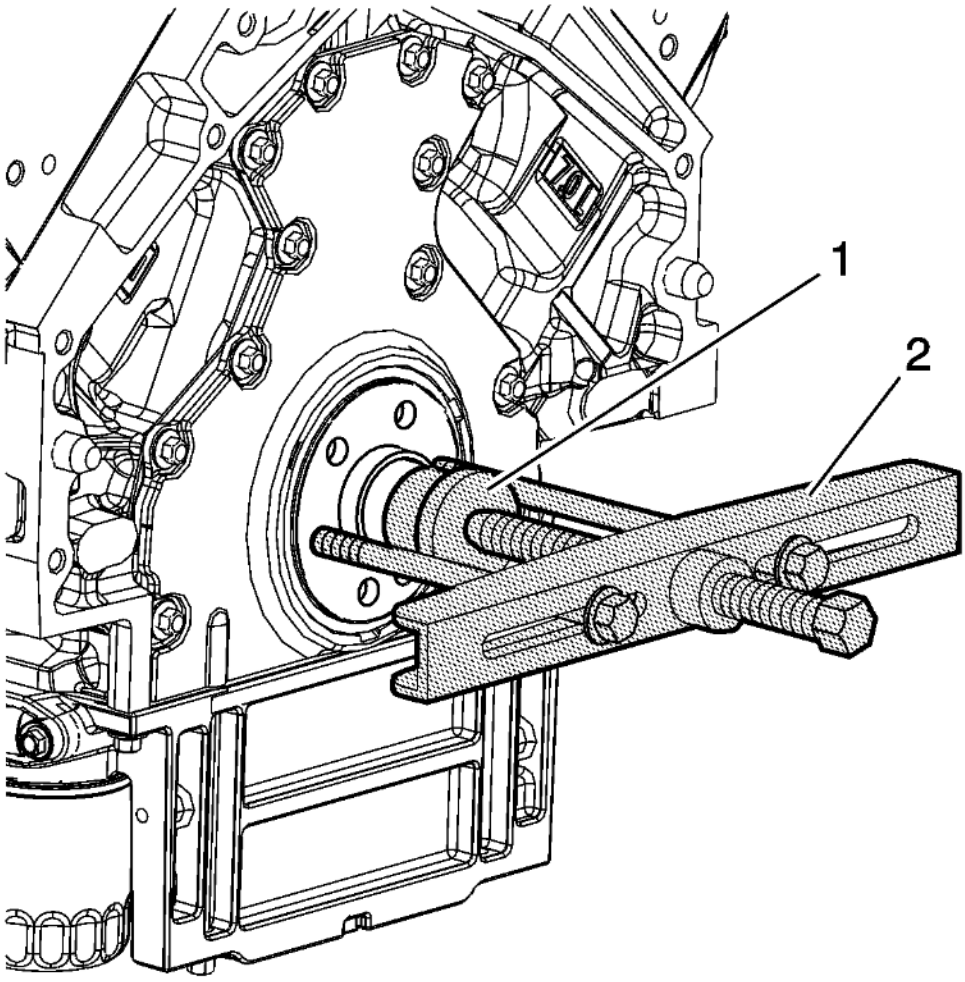

Fig. 590: Identifying Special Tools
Courtesy of GENERAL MOTORS COMPANY

1. Position the bearing to the rear of the crankshaft.
2. Assemble the **GE-8433** two jaw puller (2), the **EN-45949** pilot bearing and flywheel locator installer (1) and

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bolts to the rear of the crankshaft.

Tighten the bolts until snug.

3. Rotate the bolt of the **GE-8433** two jaw puller (2) until the bearing is seated in the bore of the crankshaft.
4. Remove the tools.

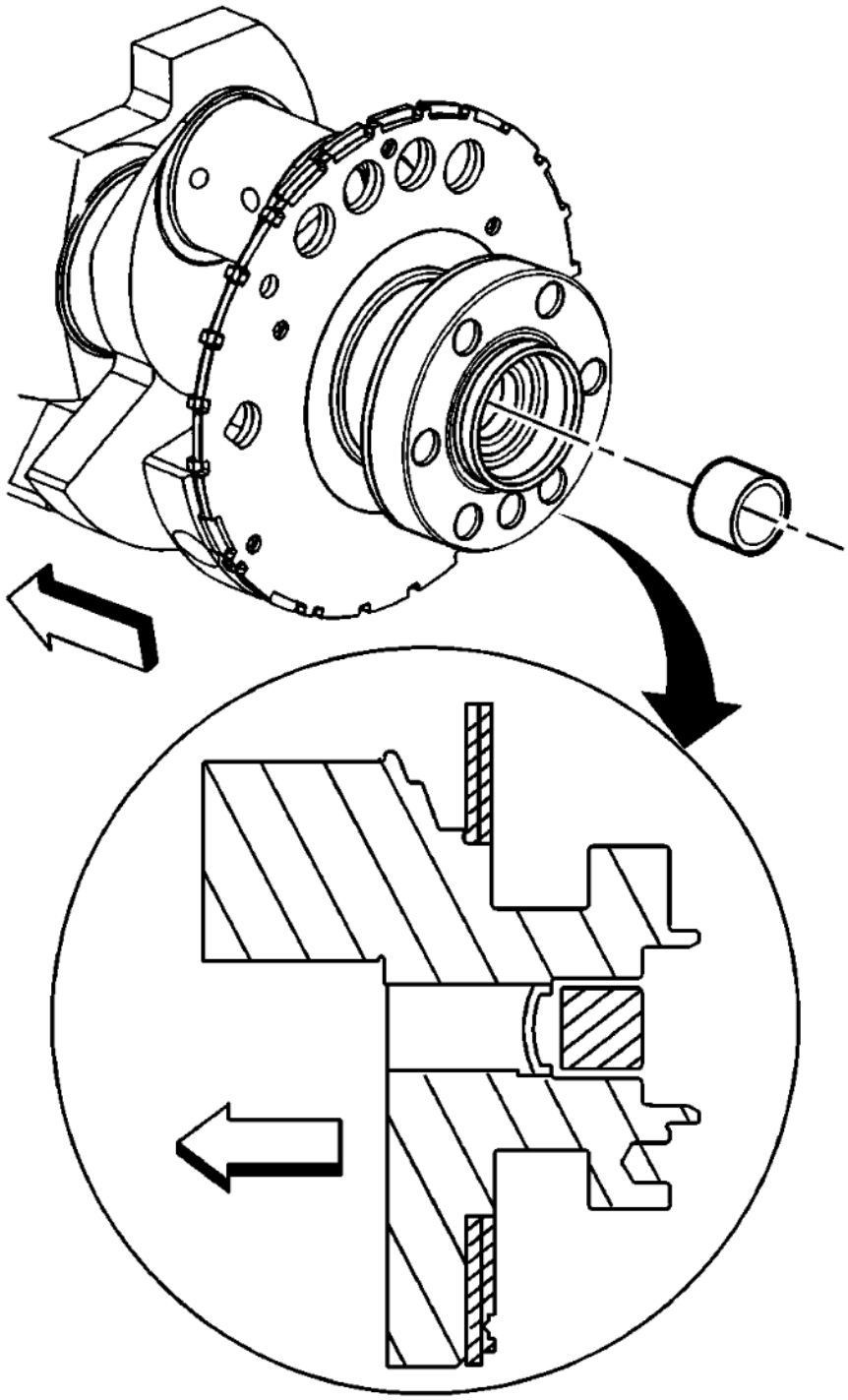

Fig. 591: Locating Clutch Pilot Bearing
Courtesy of GENERAL MOTORS COMPANY

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5. Inspect the clutch pilot bearing for proper installation.

ENGINE FLYWHEEL INSTALLATION

Special Tools

J-42386-A Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**.

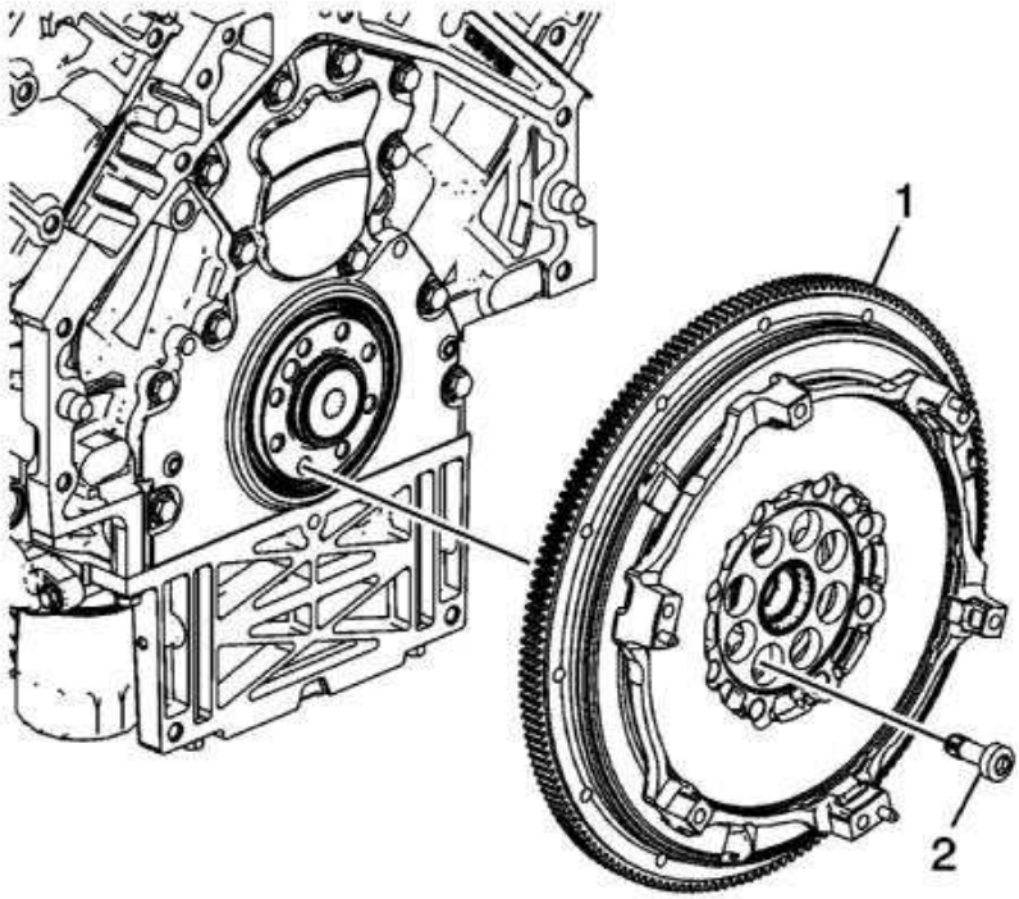

Fig. 592: Manual Transmission Flywheel
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE: **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.**

1. Install the flywheel (1) to the crankshaft.

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CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

2. Install and hand tighten the NEW flywheel bolts (2).

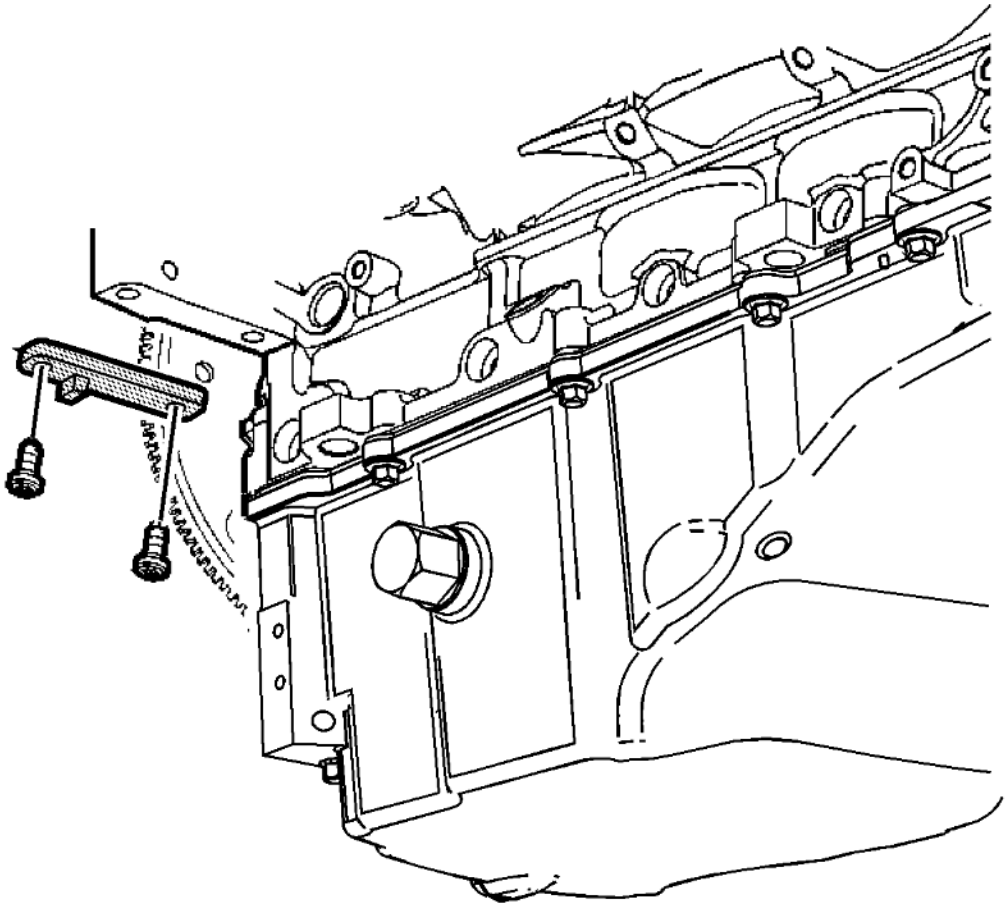

Fig. 593: Flywheel Holder
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

3. Install the **J-42386-A** flywheel holding tool and bolts.

   Use 1 M10 -1.5 x 120 mm and 1 M10 -1.5 x 45 mm bolt for proper tool operation.

   Tighten the **J-42386-A** flywheel holding tool and bolts to 50 N.m (37 lb ft).

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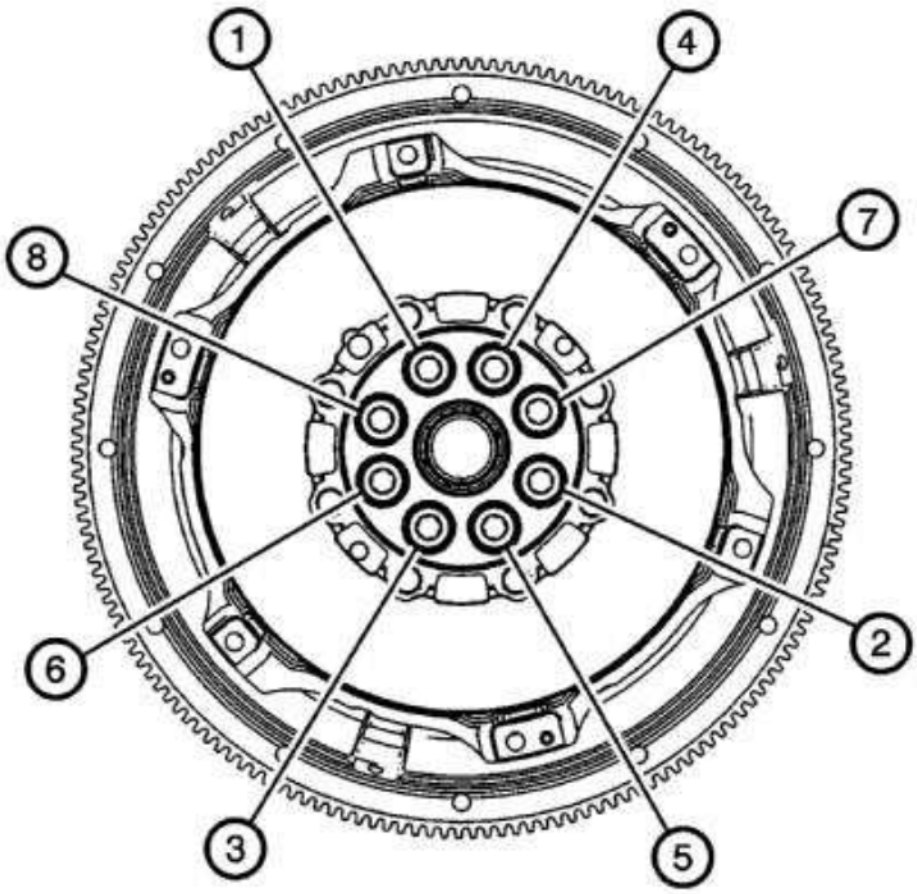

Fig. 594: Tightening Flywheel Bolts In Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Tighten the flywheel bolts (1).
    1. Tighten the bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).
    2. Tighten the bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
    3. Tighten the bolts (1-8) a final pass in sequence an additional 30 degrees using **EN-45059** angle meter.
5. Remove the **J-42386-A** flywheel holding tool.

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to **Special Tools**.

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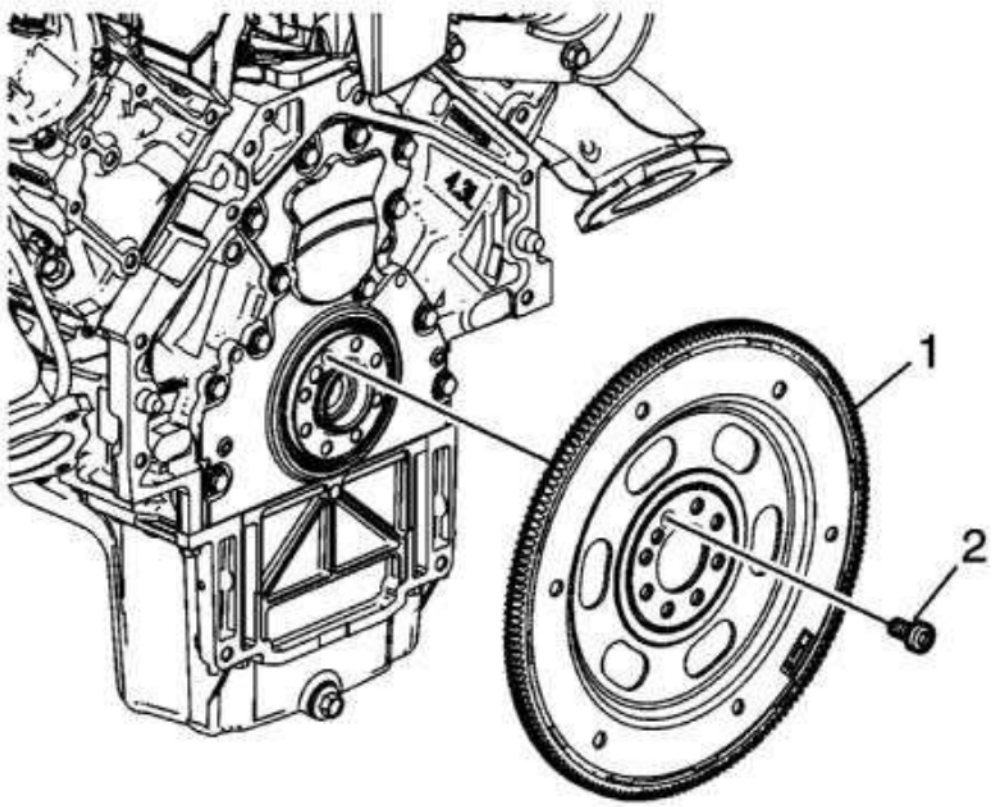

Fig. 595: Flex Plate And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.**

1. Install the flex plate (1) to the crankshaft.

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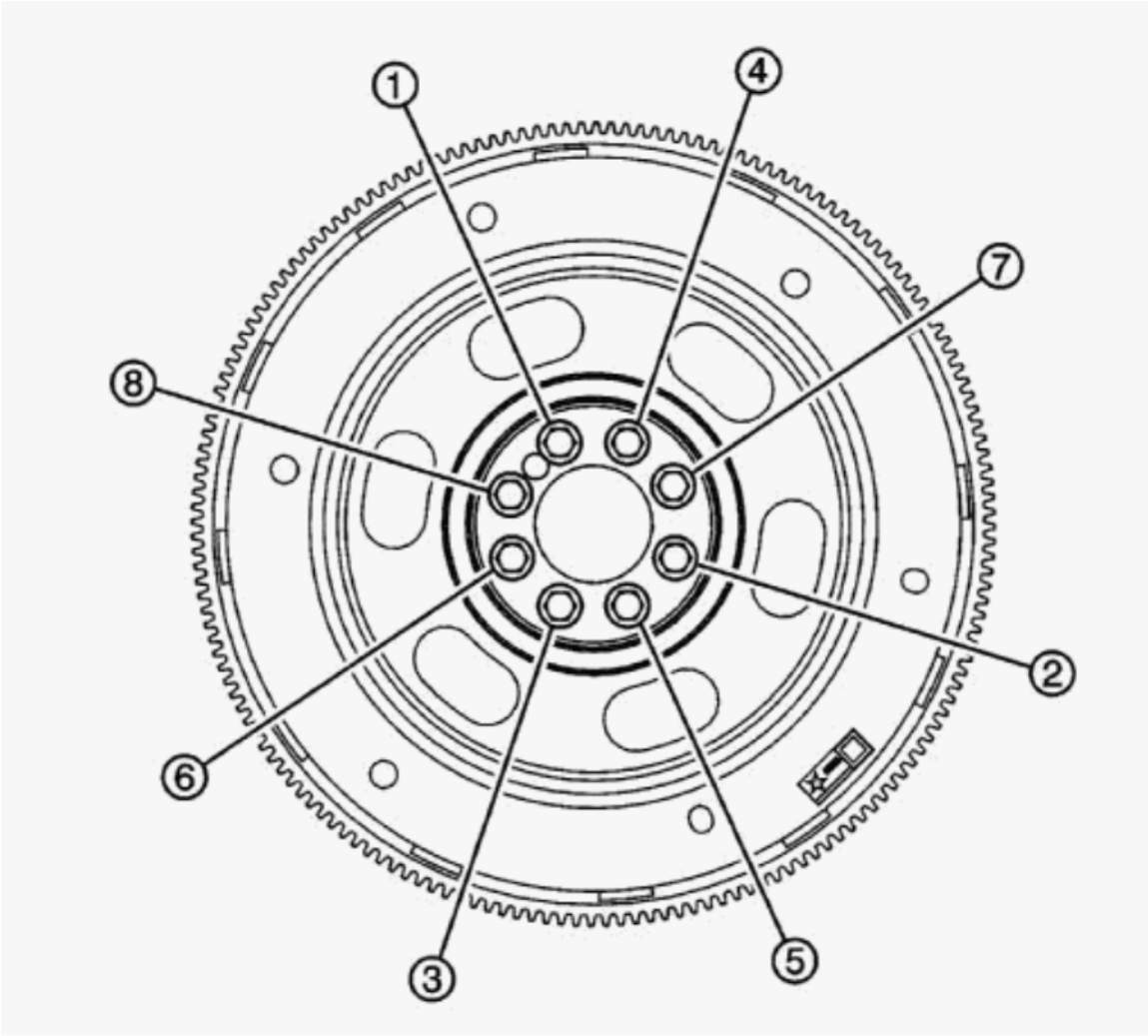

Fig. 596: NEW Engine Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

CAUTION: **Refer to Fastener Caution .**

NOTE: **Must use NEW bolts.**

2. Install the NEW engine flex plate bolts (2).
    1. Tighten the engine flex plate bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).
    2. Tighten the engine flex plate bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
    3. Tighten the engine flex plate bolts (1-8) a final pass in sequence an additional 45 degrees using **EN-45059** angle meter.

CRANKSHAFT BALANCER INSTALLATION

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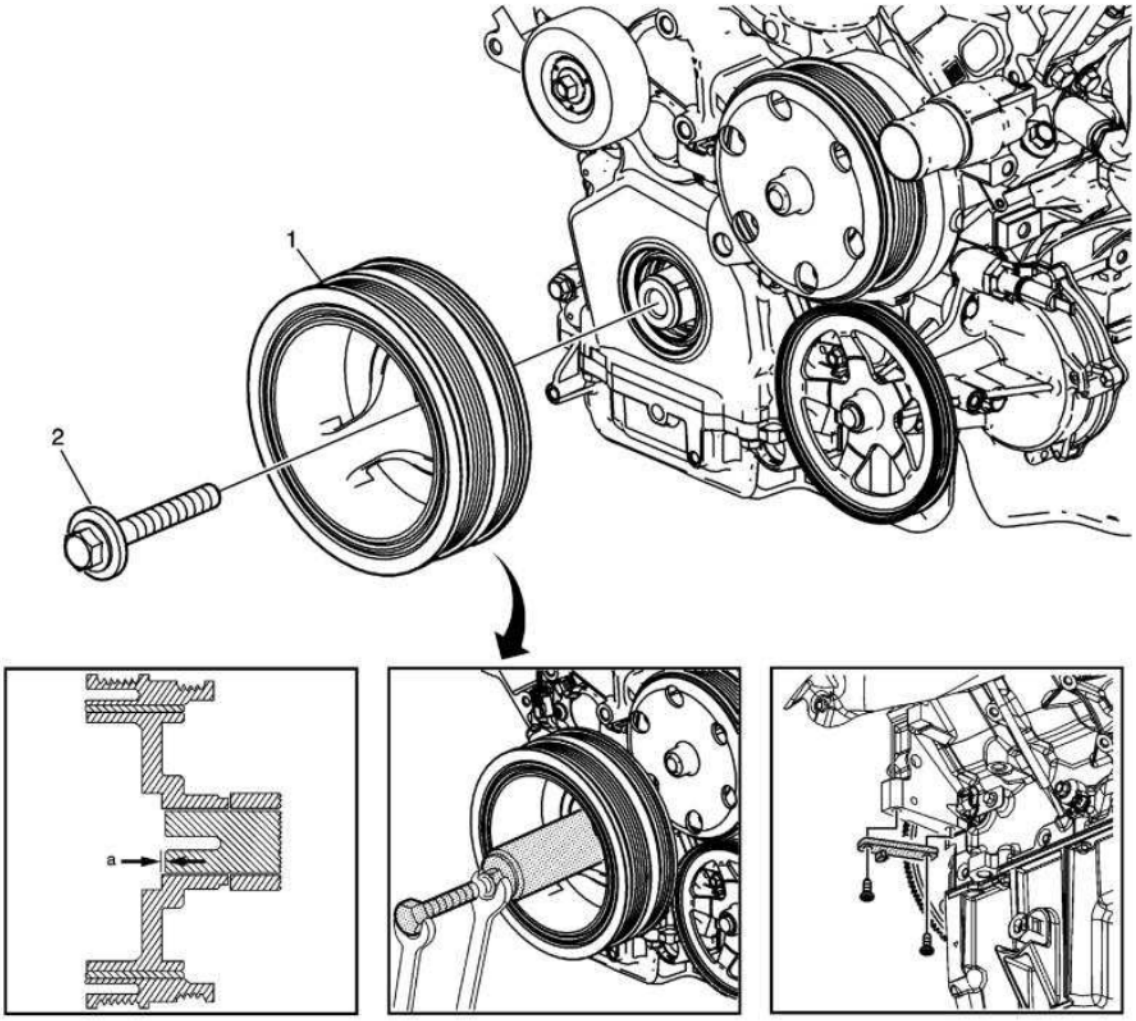

Fig. 597: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Assembly **CAUTION:** **Refer to Fastener Caution .** **NOTE:** • **Ensure the teeth of the tool engage the engine flywheel teeth.** • **The used crankshaft balancer**

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Callout	Component Name
	bolt is used only during the installation procedure. Install a NEW crankshaft balancer bolt during final assembly. **Procedure** 1. Install the **EN-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft). 2. Assemble the **EN-41478** installer threaded rod, nut, washer and the **EN-41665** installer. 3. Insert the smaller end of the installer into the front of the balancer. Use a wrench and hold the hex end of the threaded rod. 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. Use wrench and hold the hex end of the threaded rod. Use a second wrench and rotate the nut clockwise until the balancer is installed onto the crankshaft. 5. Remove the balancer installation tools. **Special Tools** • **EN-41478** Crankshaft Front Oil Seal Installer • **EN-41665** Crankshaft Balancer and Sprocket Installer • **EN-42386-A** Flywheel Holding Tool For equivalent regional tools, refer to **Special Tools**.
2	Crankshaft Balancer Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener**

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Callout	Component Name
	when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. **NOTE:** **The nose of the crankshaft (a) should be recessed 2.40-4.48 mm (0.094-0.176 in) into the balancer bore.** **Procedure** 1. Install the used crankshaft balancer bolt and tighten to 330 N.m (240 lb ft) to fully seat the balancer. 2. Remove the used crankshaft balancer bolt. 3. Measure for correctly installed balancer. If the balancer is not installed to proper dimensions, install the **EN-41665** installer and repeat the installation procedure. 4. Install the NEW crankshaft balancer bolt: 1. Tighten the crankshaft balancer bolt to 120 N.m (110 lb ft). 2. Loosen the crankshaft balancer bolt 360 degrees. 3. Tighten the crankshaft balance bolt to 80 N.m (59 lb ft). 4. Tighten the crankshaft balancer bolt a final pass to: • Balancer bolt with flanged head tighten to 125 degrees using the **EN-45059** angle meter. • Balancer bolt with retained rotating washer tighten to 200 degrees using the **EN-45059** angle meter. 5. Remove the **EN-42386-A** flywheel holding tool. **Special Tools**

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Callout	Component Name
	• **EN-41665** Crankshaft Balancer and Sprocket Installer • **EN-42386-A** Flywheel Holding Tool • **EN-45059** Angle Meter For equivalent regional tools, refer to **Special Tools**.

ENGINE PRELUBING

Special Tools

J 45299 Engine Preluber

For equivalent regional tools, refer to **Special Tools**

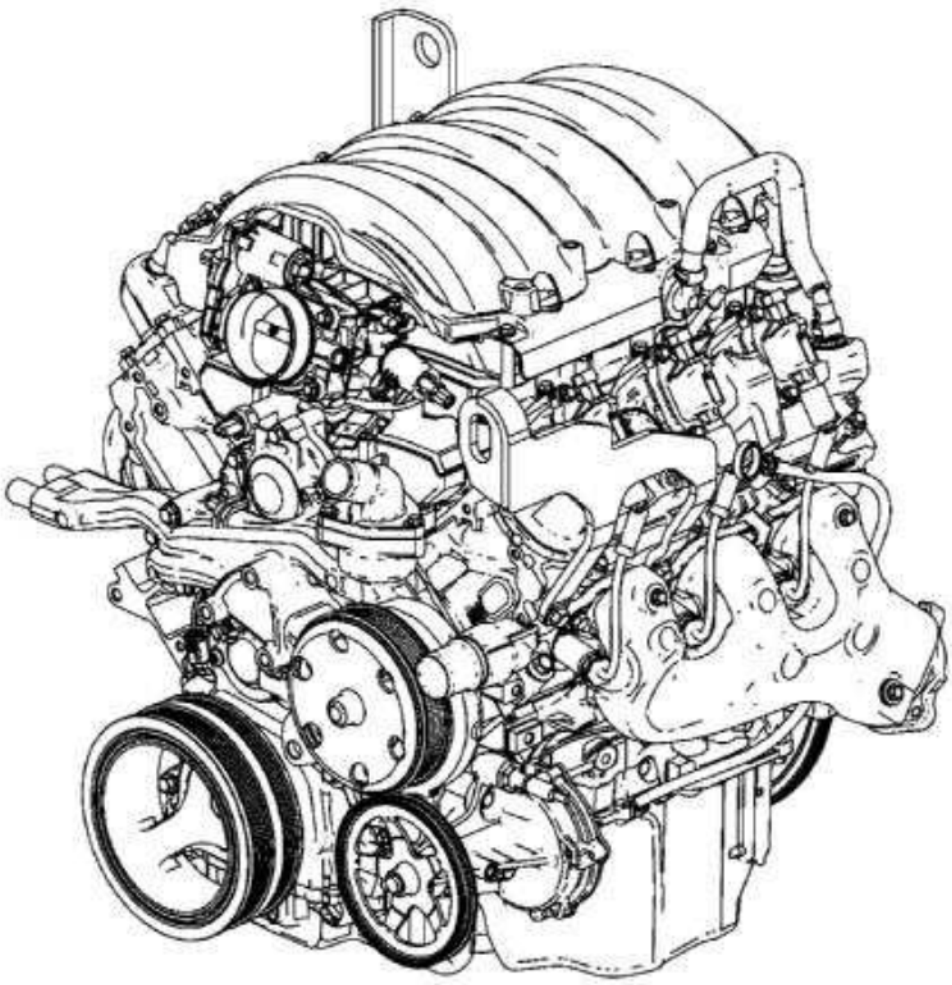

Fig. 598: Engine Oil Filter And Fill With Clean Engine Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Use an approved engine oil as specified in the owners manual.**

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1. Remove the engine oil filter and fill with clean engine oil.

CAUTION: **Refer to Fastener Caution .**

2. Install the oil filter and tighten 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.
3. Ensure that the oil drain plug is installed and tightened to 25 N.m (18 lb ft)
4. Locate the engine block left rear oil gallery plug.
5. Install the M16 x 1.5 adapter P/N 509375.

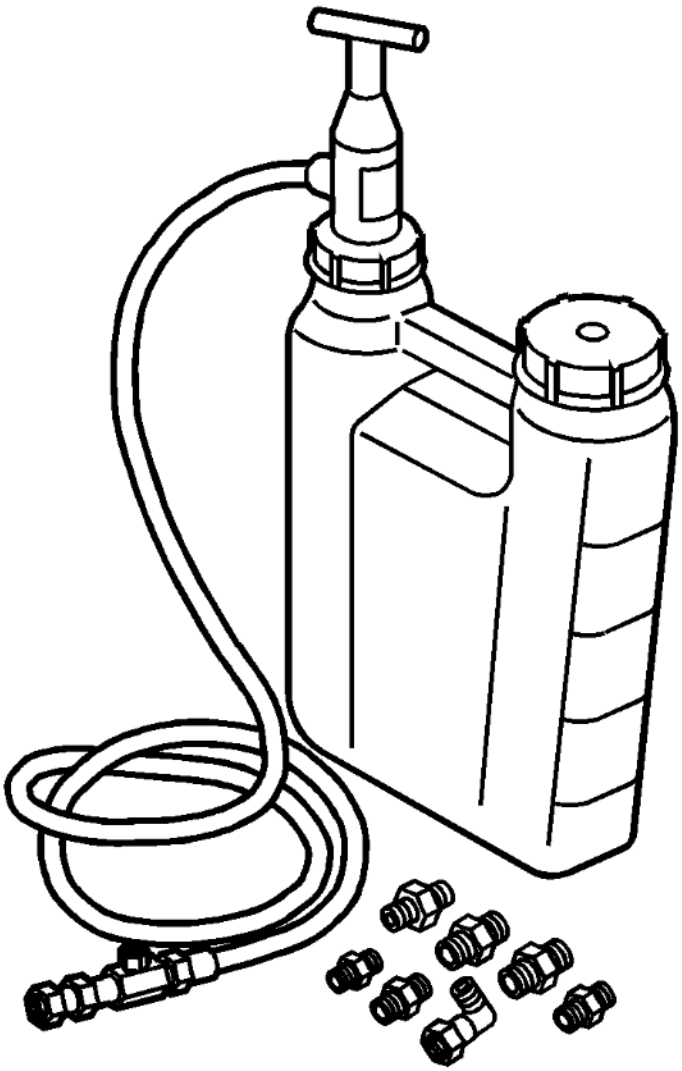

Fig. 599: Preluber Flexible Hose
Courtesy of GENERAL MOTORS COMPANY

6. Install the flexible hose to the adapter and open the valve.
7. Pump the handle on the **J 45299** preluber 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.
8. Close the valve and remove the flexible hose and adapter from the engine.
9. Install the gallery plug to the engine and tighten to 30 N.m (44 lb ft).
10. Top-off the engine oil to the proper level.

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DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

A closed crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from up-stream of the throttle blade to the front of the right rocker arm cover via a formed rubber hose. To reduce the potential of oil pullover into the throttle bore area due to back flow of the ventilation system, the fitting in the right rocker arm cover is shielded from the rocker arms. From there fresh air and gases are routed through the crankcase and up to the opposite rocker arm cover where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a hose to the intake manifold.

ENGINE COMPONENT DESCRIPTION

The 4.3 Liter V6 Engine

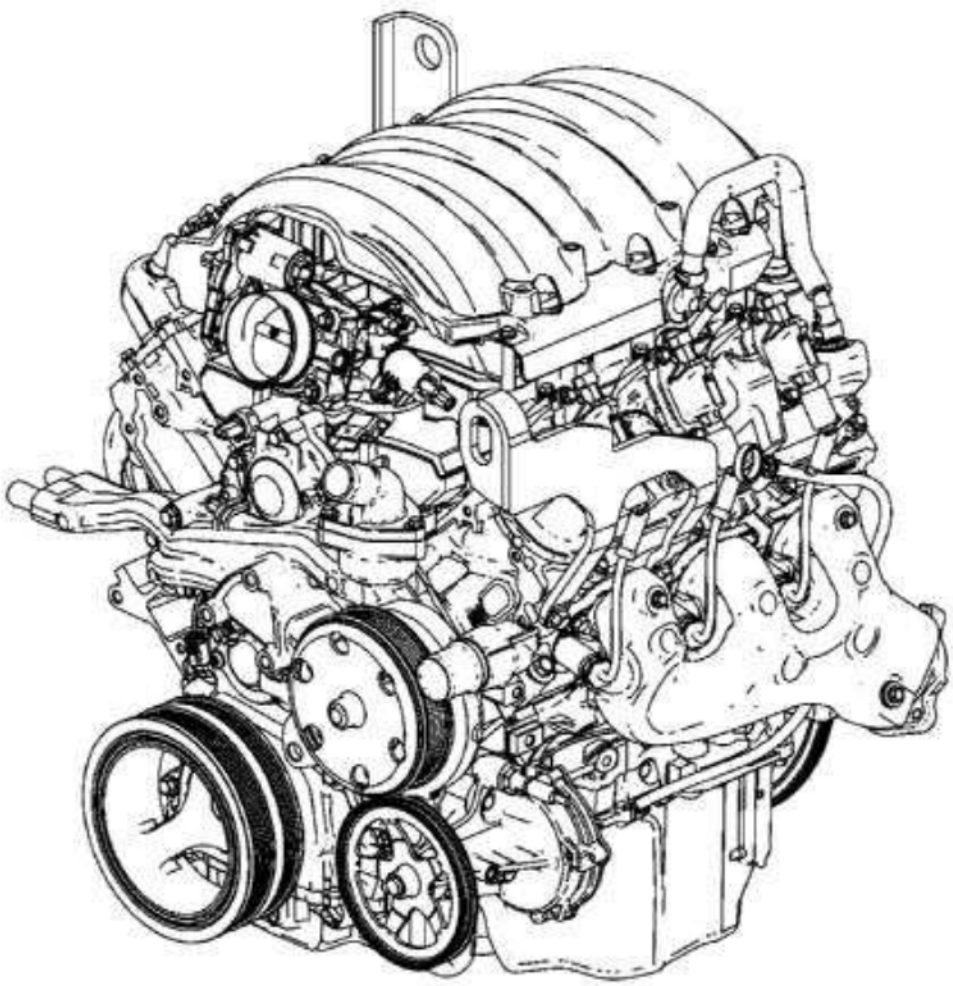

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Fig. 600: Engine Oil Filter And Fill With Clean Engine Oil
Courtesy of GENERAL MOTORS COMPANY

To assist in determining the applicable hardware and control system for each engine RPO, refer to **Engine Content Specifications**.

Camshaft and Drive System

A billet steel 1-piece camshaft is supported by 4 bearings pressed into the engine block. The camshaft has a tri-lobe forward of the rear journal for actuating the direct injection fuel pump. The CMP actuator is mounted to the front of the camshaft and retained by the CMP solenoid valve. The CMP actuator is driven by the crankshaft sprocket through the camshaft timing chain. The CMP sensor wheel is incorporated into the front face of the CMP actuator with the CMP sensor and CMP actuator magnet mounted in the engine front cover. A timing chain tensioner is mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location. Refer to **Camshaft Position Actuator and Solenoid Valve Description**.

Crankshaft

The crankshaft is made of hardened forged steel. The crankshaft is supported by 4 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 number 3 main journal is the thrust journal. A 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. The valve rocker arm covers are retained to the cylinder head by 8 perimeter mounted rocker arm cover bolts. Cylinder heads are a high-flow design with offset intake valve rocker arms.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V-configuration with 4 crankshaft bearing caps. The engine block is cast aluminum. The 4 crankshaft bearing caps each have 4 vertical M10 and 2 horizontal M8 mounting bolts. The camshaft is supported by 4 camshaft bearings pressed into the block. The left bank of cylinders are number 1-3-5 (#1 is front left) and the right bank of cylinders are 2-4-6 (#2 is front right) viewed from the flywheel end of the engine. The engine firing order is 1-6-5-4-3-2.

Exhaust Manifolds

The exhaust manifolds are a 1-piece cast iron design. The exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a 1-piece composite design that incorporates brass threaded inserts for mounting the throttle body, and wire harness studs. Each side of the intake manifold is sealed to the cylinder head by 6 silicone push in place gaskets. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a 1-piece push in place silicone gasket. The intake manifold covers the direct injected fuel rail assembly, fuel pipes and fuel pump. The manifold absolute pressure (MAP) sensor is installed and retained to the left front of the intake manifold behind the throttle body. The evaporative (EVAP) emission canister purge solenoid valve is mounted left front of the intake manifold below the MAP sensor.

Fuel System

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The fuel system consists of 6 separate direct injection fuel injectors, two high pressure fuel rails, a high pressure cross-over fuel pipe (connects the two fuel rails), a high pressure fuel feed pipe (connects the cross-over pipe to the high pressure fuel pump), a high pressure fuel pump and a low pressure fuel feed pipe. The injectors are each seated into their individual bores in the cylinder heads with two combustion seals to provide sealing. The high pressure fuel pump mounts to the rear of the Valve Lifter Oil Manifold in the engine valley. Motion is transmitted to the pump from a tri-lobe on the rear of the camshaft through a hydraulic roller lifter.

Oil Pan

The structural rear-sump oil pan is a cast aluminum pan . Incorporated into the design is the oil filter mounting boss, drain plug opening, baffle, oil deflector, oil pump screen, and oil level sensor, and oil filter center crossover tube. The oil filter bypass valve is in the oil filter assembly. The oil pan is sealed to the oil pump with a silicone push in place gasket and to the engine block with RTV sealant. Dowels are pressed into the pan for aid in alignment to the engine block during assembly

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a 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 assemblies. Incorporated into the left and right valve rocker arm covers are the positive crankcase ventilation (PCV) fresh air passages. Incorporated into the left cover is the oil fill tube.

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 are mounted on individual pedestals or pivot supports that are incorporated into the cylinder heads. Each rocker arm is retained by a bolt. Valve lash is net build. Cylinders 3 and 6 are active fuel management. The active fuel management is commanded by the valve lifter oil manifold (VLOMA) that uses 2 solenoids to deactivate AFM cylinders. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**. The balance shaft is made of forge steel with hardened journals. The balance shaft is supported by 2 balance shaft bearings. The balance shaft is driven by a chain attached to the camshaft sprocket.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

System Operation

General Motors Active Fuel Management engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy by deactivating 2 of the engines 6 cylinders. The engine will normally operate on 6 cylinders in V6 mode during starting, idling, and medium or heavy throttle conditions. When commanded ON, the engine control module (ECM) will direct the active fuel management system and deactivate cylinder 3 on the left bank and cylinder 6 on the right bank, forcing V4 mode. Refer to **Lubrication Description**, and **Cylinder Deactivation (Active Fuel Management) System Description** .

Valve Lifter Oil Manifold Assembly

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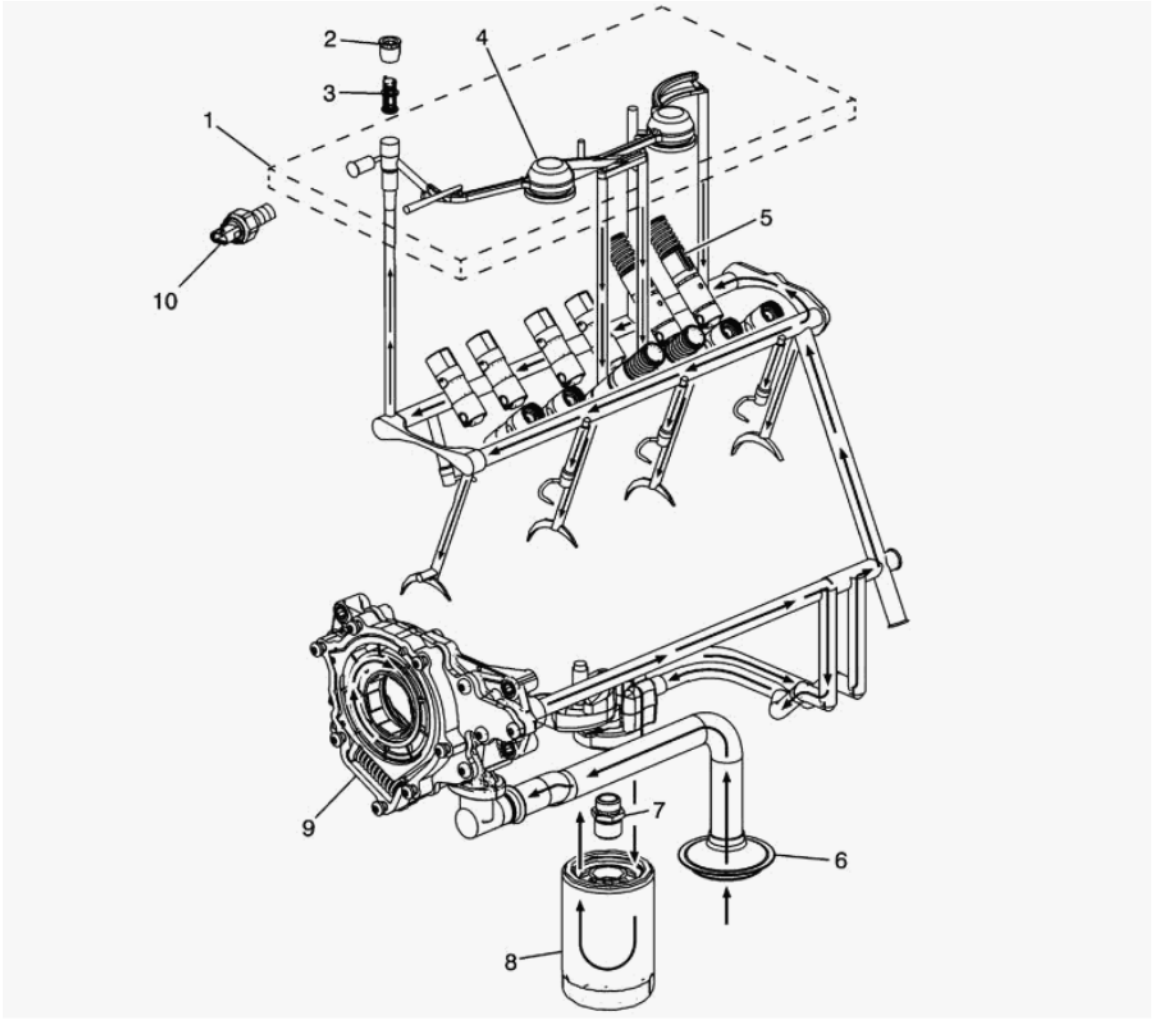

Fig. 601: Valve Lifter Oil Manifold Assembly And Exhaust Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

The valve lifter oil manifold assembly (1) is bolted to the top of the engine block beneath the intake manifold assembly. The oil manifold consists of 2 electrically operated and normally-closed solenoids (4). Each solenoid directs the flow of pressurized engine oil to the active fuel management intake and exhaust valve lifters (5).

When enabling conditions are met for active fuel management operation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the windings energized, the solenoid valves open and direct pressurized engine oil through the valve lifter oil manifold into 4 vertical passages in the engine block lifter valley. The 4 vertical passages, 2 per cylinder, direct pressurized oil to the valve lifter bores of the cylinders to be deactivated. When vehicle operating conditions require a return to V6 mode, the ECM will turn OFF the ground circuit for the solenoids, allowing the solenoid valves to close. When the solenoid valves are closed, remaining oil pressure is exhausted through the bleed passages of the valve lifter oil manifold into the engine block lifter valley. The housing of the oil manifold incorporates a vent orifice that continuously purges trapped air from the manifold.

To help control contamination within the active fuel management hydraulic system, a small replaceable oil filter (3) is located in the valve lifter oil manifold oil inlet passage. The oil pressure sensor (10) monitors engine oil pressure and provides information to the ECM.

Active Fuel Management Valve Lifters

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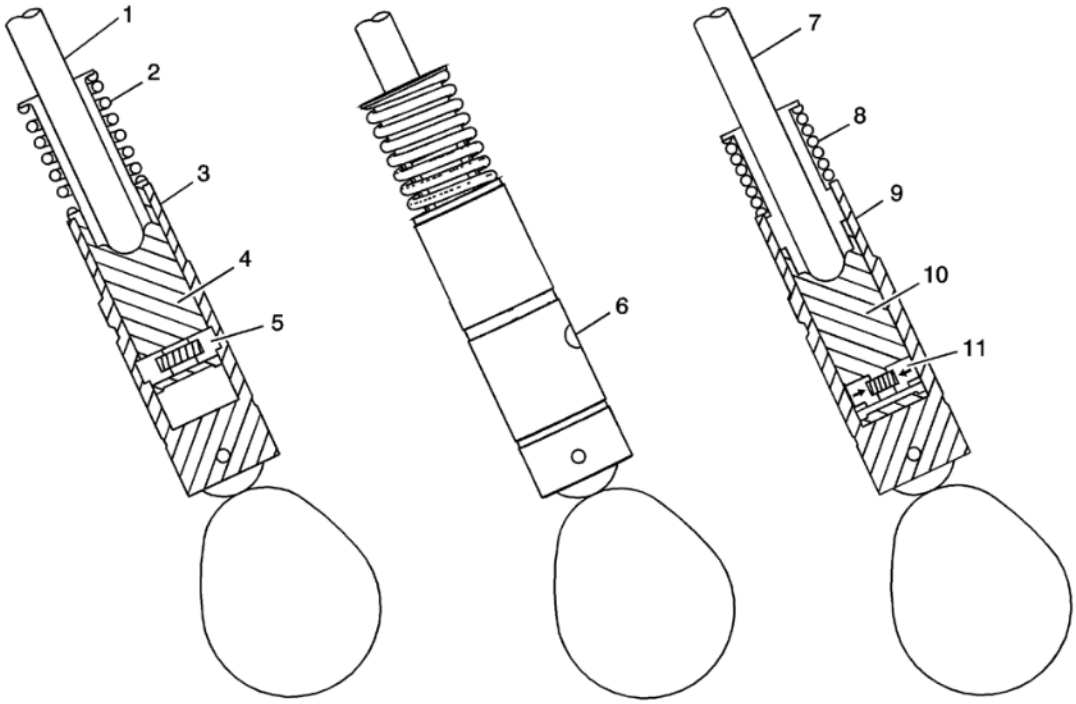

Fig. 602: Displacement On Demand Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

When operating in V6 mode, the active fuel management valve lifters function similar to the non-active fuel management valve lifters. The active fuel management oil manifold solenoids are in the closed position, with no pressurized oil directed to the valve lifters. The pushrod (1) travels upward and downward to actuate the rocker arm and valve. The spring loaded locking pins (5) of the lifter are extended outward and mechanically lock the pin housing (4) to the outer body of the valve lifter (3).

When the active fuel management system is commanded ON, the ECM will direct the solenoids of the oil manifold to open and direct pressurized oil to the valve lifters. Oil travels through the valve lifter oil manifold and engine block oil galleries and enters the inlet port (6) of the valve lifter.

When operating in V4 mode, pressurized oil forces the locking pins (11) inward. The pushrod (7) remains in a constant position and does not travel upward and downward. The outer body of the lifter (9) moves upward and downward independently from the pin housing (10). The valve lifter spring (8) retains tension on the valve train components to eliminate valve train noise.

When the active fuel management system is commanded OFF, the ECM directs the solenoids of the oil manifold to close, stopping the flow of pressurized oil to the valve lifters. The oil pressure within the lifter will decrease and the locking pins will move outward to mechanically lock the pin housing and outer body.

Engine Block

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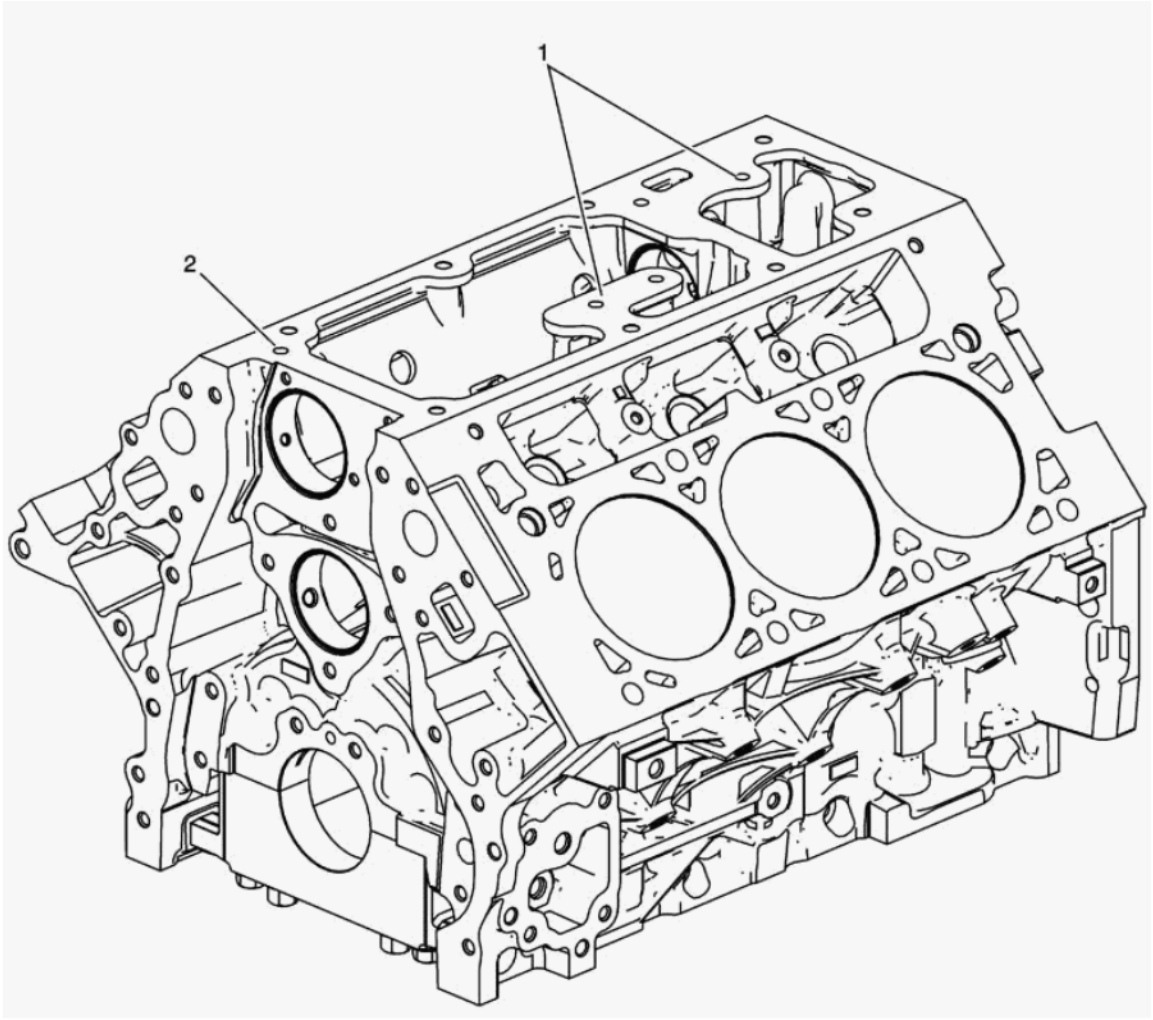

Fig. 603: Valve Lifter Oil Manifold Assembly And Cast-In-Block Oil Passages
Courtesy of GENERAL MOTORS COMPANY

The active fuel management engine block incorporates additional features to support active fuel management system operation. Engine oil pressure is routed to the valve lifter oil manifold assembly from an oil gallery (2) in the front of the cylinder block. Cylinders 3 and 6 each have 2 vertical, cast-in-block oil passages (1). The vertical oil passages permit oil flow from the manifold assembly to the valve lifter bores.

Engine Control Module (ECM)

Refer to **Cylinder Deactivation (Active Fuel Management) System Description** .

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DESCRIPTION

Camshaft

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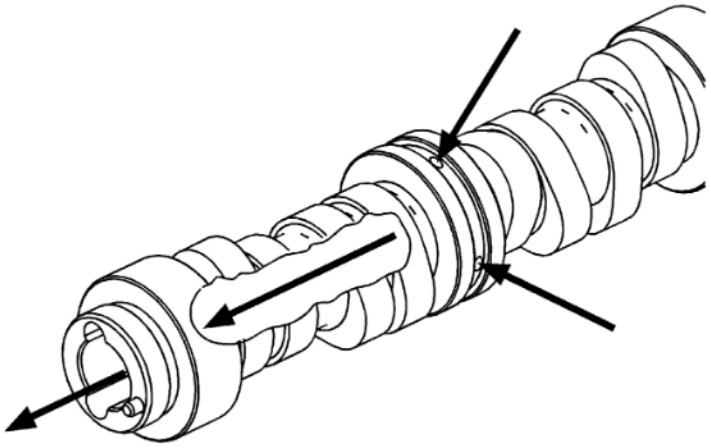

Fig. 604: Camshaft Lubrication Path
Courtesy of GENERAL MOTORS COMPANY

The camshaft is designed to provide a lubrication path for pressurized engine oil to flow to the camshaft position (CMP) actuator. Pressurized engine oil enters the camshaft at bearing journal location number 2. Oil travels through the camshaft, out the front, and into the CMP actuator solenoid valve.

CMP Actuator Solenoid Valve

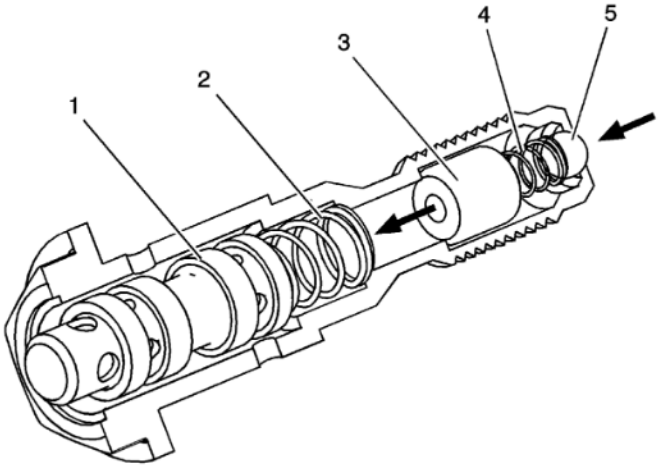

Fig. 605: CMP Actuator Solenoid Valve Components
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator solenoid valve consists of a housing, spool valve (1), spool return spring (2), oil filter (3), inlet check ball return spring (4), and inlet check ball (5). Pressurized engine oil enters the valve and travels through the filter to the spool. Spool position is controlled by the CMP magnet and engine control module (ECM). When the spool is moved to the proper position, oil flow is directed through the valve and into the CMP actuator assembly. The CMP solenoid valve is a torque-to-yield design and should be replaced each time it is removed.

CMP Actuator Magnet

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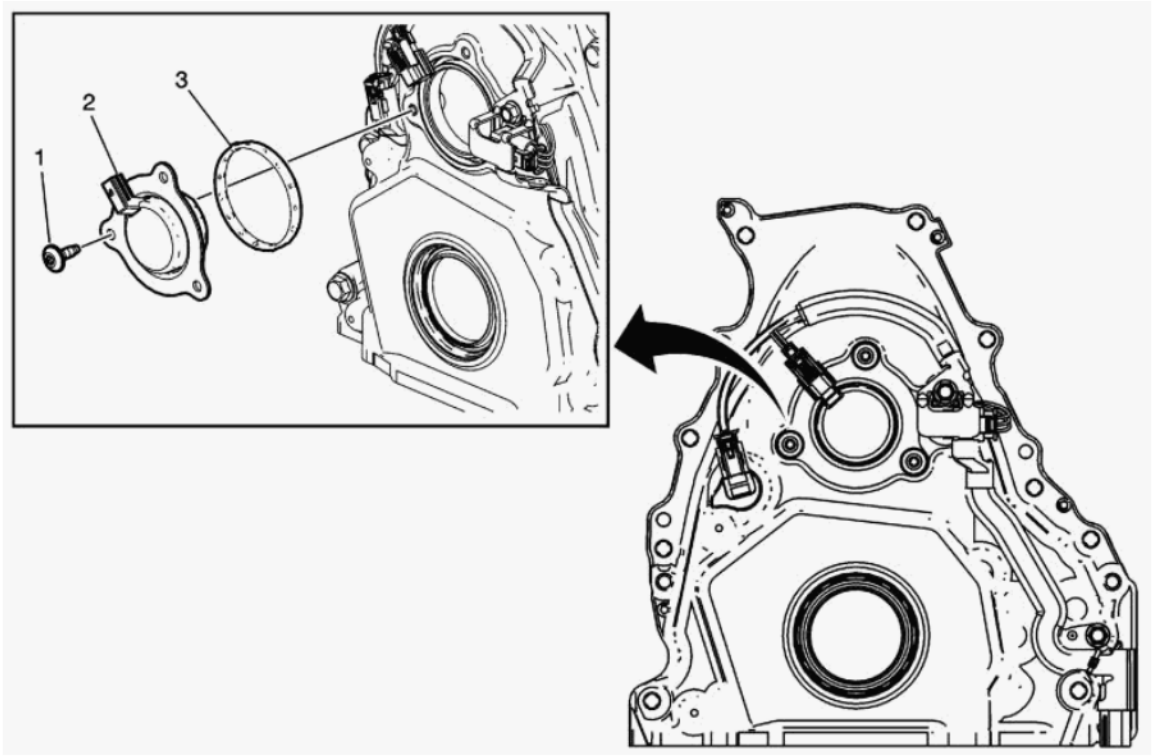

Fig. 606: CMP Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator magnet (2) is located in the engine front cover and is sealed by a press in place gasket (3). The CMP actuator magnet is controlled by a 12-volt 150 Hz pulse width 0-100 percent duty cycle signal from the ECM. When energized, the solenoid uses electromagnetic force on the magnet pintle to position the spool valve of the CMP solenoid valve.

CMP Actuator

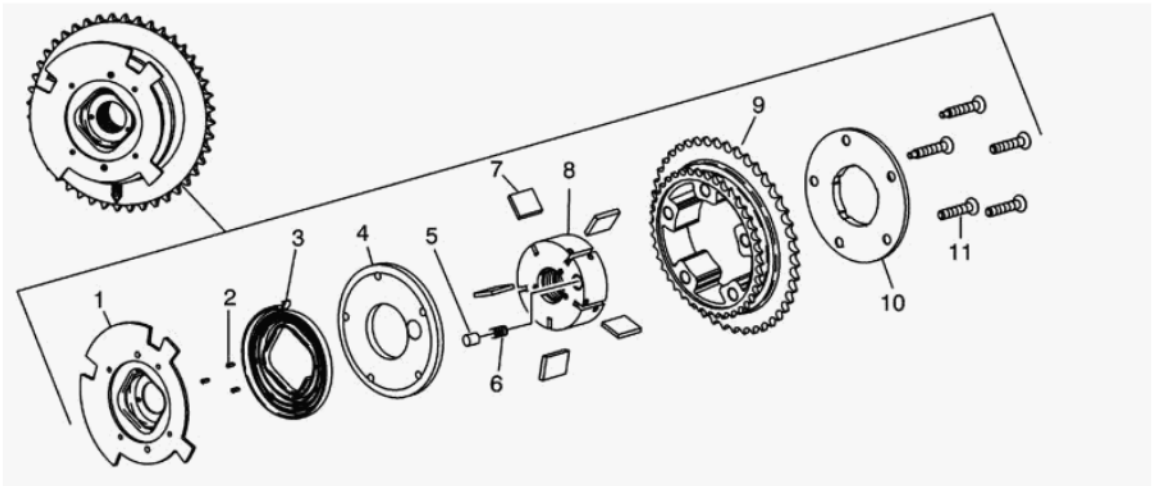

Fig. 607: CMP Reluctor Wheel, Wheel Retaining Pins And Return Spring
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator is a vane type design that hydraulically changes angle or timing of the camshaft relative to crankshaft position. The CMP actuator allows earlier or later intake and exhaust valve opening during the 4-stroke engine cycle. The CMP actuator cannot vary the duration of valve opening or valve lift. The CMP actuator is to be serviced as an assembly. For system operation, refer to **Camshaft Actuator System Description** .

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The CMP actuator consists of the CMP reluctor wheel (1), wheel retaining pins (2), return spring (3), front cover (4), park position pin (5), park position pin spring (6), vanes and vane springs (7), rotor (8), housing with chain sprockets (9), sealing cover/thrust plate (10), and bolts (11).

CMP System Operation

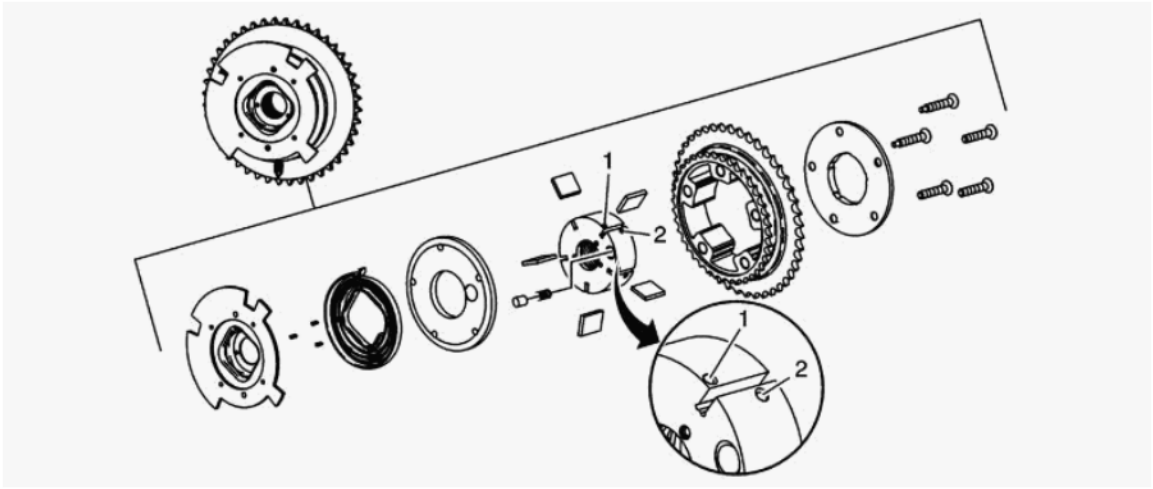

Fig. 608: Advance Cavities And Retard Cavities
Courtesy of GENERAL MOTORS COMPANY

A CMP actuator dynamically changes valve timing events relative to piston timing by controlling camshaft position. This is sometimes referred to as variable valve timing or camshaft phasing. Variable valve timing or camshaft phasing does not change duration or lift.

- By advancing camshaft timing, an improvement in low end torque can be achieved.
- By retarding camshaft timing slightly, an improvement in high end power can be achieved.
- By retarding camshaft timing significantly, an improvement in light load fuel economy can be achieved.

There are 5 cavities divided by vanes within the CMP actuator.

- When oil is directed to the advance cavities (1), the camshaft timing is advanced.
- When oil is directed to the retard cavities (2), the camshaft timing is retarded.
- When oil is directed to both cavities, the camshaft is held stationary.

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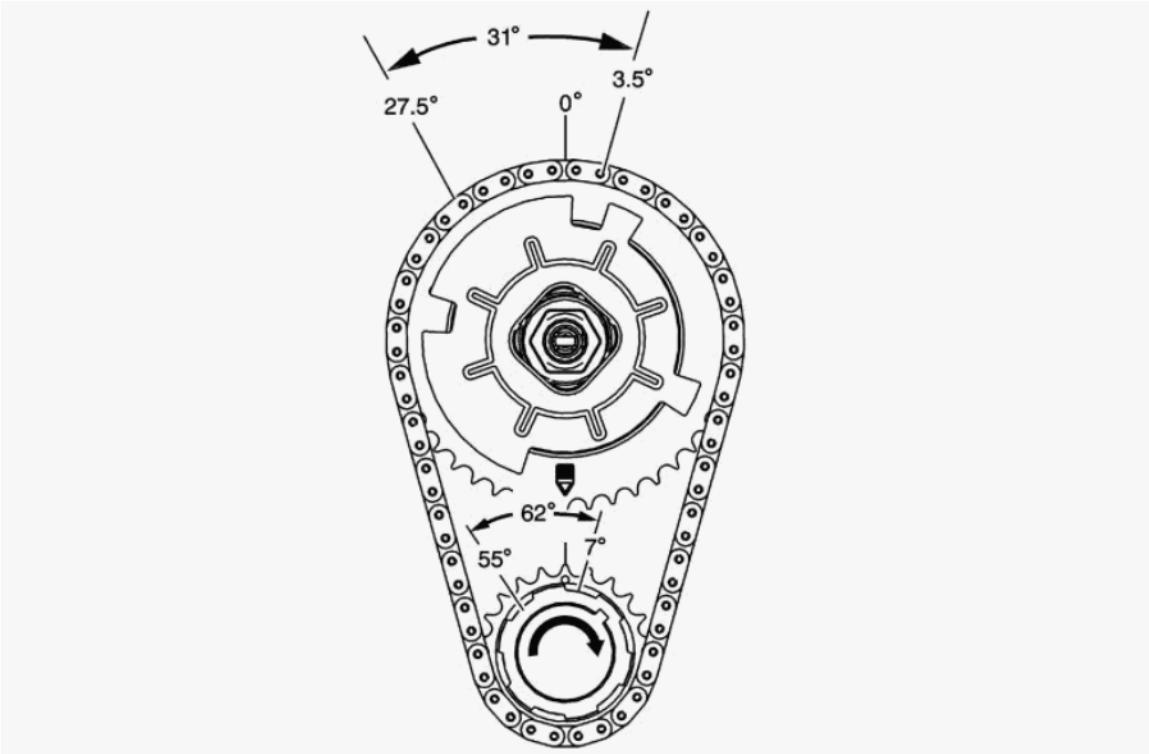

Fig. 609: Degree Range Of Authority At Crankshaft
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator has a 62 degree range of authority at the crankshaft (31 degrees at the camshaft). With the engine not running and no engine oil pressure to the CMP actuator, the high tension spring positions camshaft timing at the 7 degree advanced park position at the crankshaft (3.5 degrees at the camshaft). During normal engine operation, and based on performance requirements, the ECM may adjust camshaft timing, as required, within a range from 7 degrees advanced at the crankshaft (3.5 degrees at the camshaft) to 55 degrees retard at the crankshaft (27.5 degrees at the camshaft).

CMP System Lubrication Flow and Actuator Operation

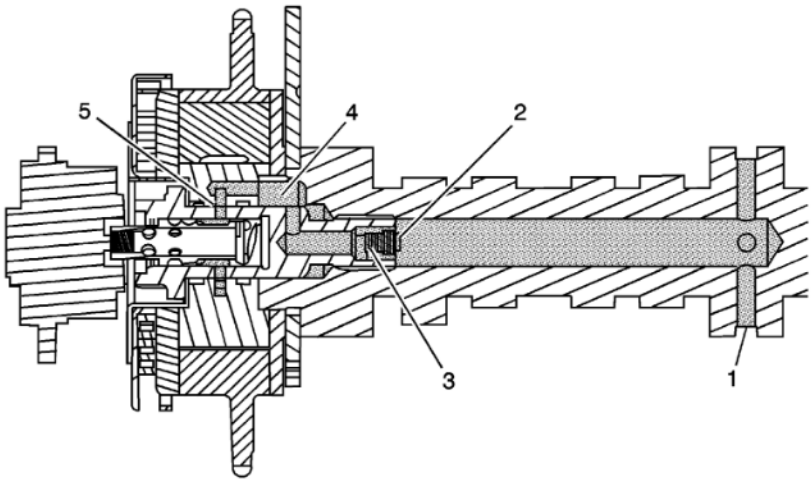

Fig. 610: Cutaway View Of Actuator
Courtesy of GENERAL MOTORS COMPANY

1. Oil enters the camshaft at the second main bearing journal (1).
2. Oil travels through the camshaft into the CMP actuator valve check ball (2) and filter (3).

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3. Oil exits the valve and travels through the internal passages of the camshaft (4).
4. Oil exits the camshaft and enters the actuator oil entry ports.
5. Oil travels through the actuator and is directed back into the valve (5).
6. Valve spool position directs oil to the advance or retard passages of the actuator.

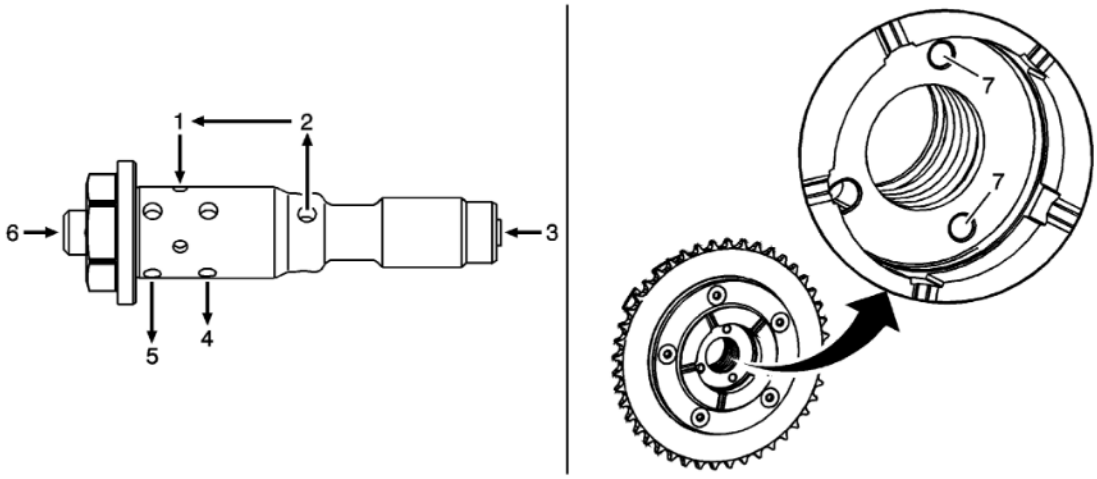

Fig. 611: Identifying Actuator Passages
Courtesy of GENERAL MOTORS COMPANY

1. Oil flows from the camshaft into the valve inlet (3) through the internal check ball and filter.
2. Oil exits the valve (2) and travels within the internal passages of the camshaft into the entry ports (7) of the actuator.
3. The center oil groove of the actuator is pressurized and oil reenters the valve (1).
4. Valve spool position directs oil out of the valve advance (5) or retard (4) ports to the actuator.

The valve may also, under certain conditions, be positioned in a neutral position with alternating low, balanced oil flow between the advance and retard passages of the actuator.

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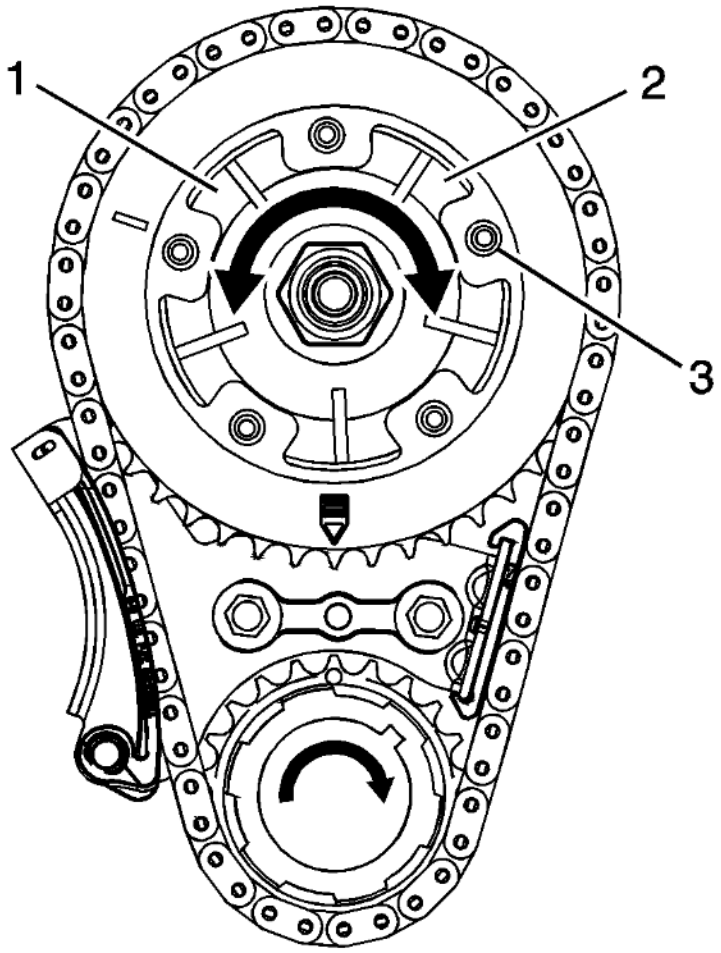

Fig. 612: View Of Advance And Retard Cavities
Courtesy of GENERAL MOTORS COMPANY

1. Pressurized oil enters the retard cavities (2) of the actuator and moves the park pin (3) from the locked position.
2. As pressure increases within the retard cavities (2), the rotor and camshaft rotate counter clockwise retarding valve timing.
3. As the duty cycle decreases, the spool is repositioned and oil is sent to the advance cavities (1), rotating the rotor and camshaft clockwise, advancing valve timing.
    - With a 0 percent duty cycle signal to the magnet, the spool is positioned in the fully extended position and there is full flow to the advance cavities of the actuator. As duty cycle increases to near 50 percent, flow to the advance cavities is decreased.
    - With a 50 percent duty cycle, the spool is positioned neutral, with no flow to either the advance and retard cavities.
    - With a 51-100 percent duty cycle, the spool is positioned to provide oil flow to retard cavities. As the duty cycle increases, the flow to retard cavities increases.
    - With a 100 percent duty cycle, there is full flow to the retard cavities of the actuator.
    - The above duty cycle percentage values are only a guideline, as the actual duty cycle values may vary based on engine oil temperature, solenoid magnet coil temperature, magnet coil resistance, and other specifics.

CMP Actuator Park Position Verification

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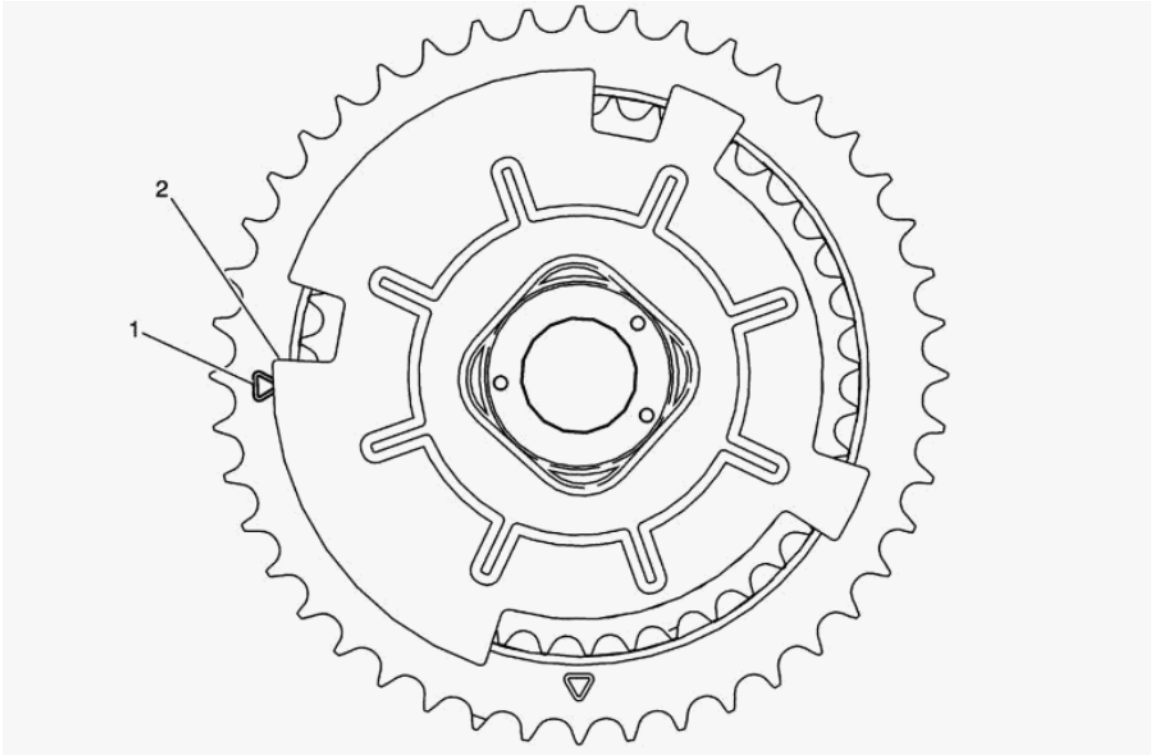

Fig. 613: CMP Actuator Park Position
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator can be visually inspected to determine if the tension spring has returned the reluctor wheel and rotor to the park position.

With the reluctor wheel returned to the proper parked position, the edge of the notched area of the wheel (2) aligns with the marking (1) on the camshaft sprocket.

CMP Actuator Handling Safety

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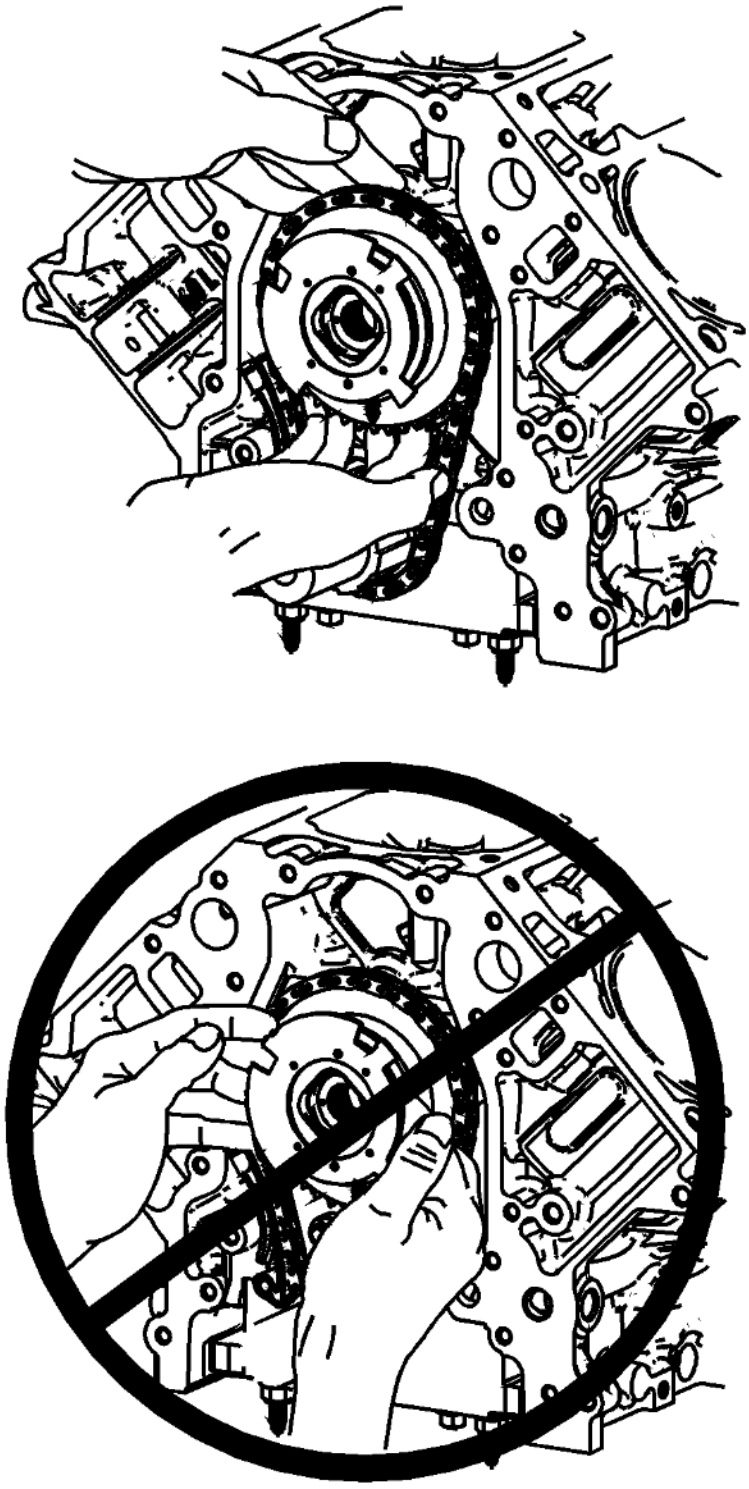

Fig. 614: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

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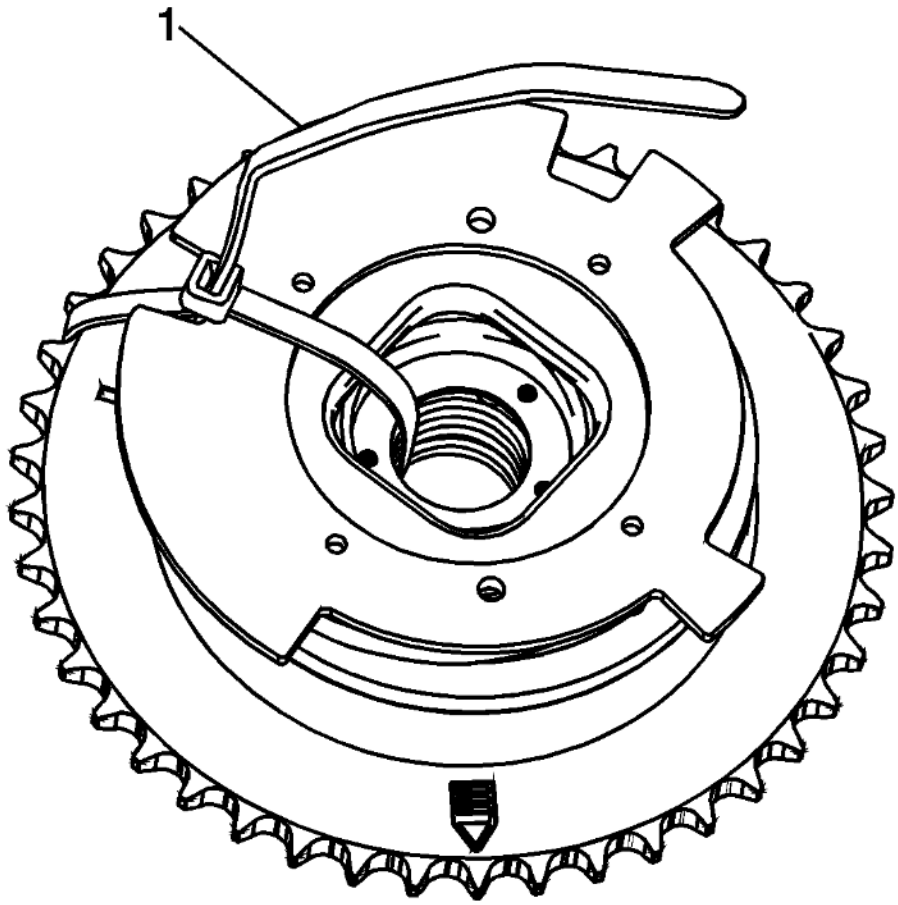

Fig. 615: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

Install tie wrap (1) to retain the reluctor wheel to the sprocket. The reluctor wheel is mounted to the actuator body with 3 roll pins.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight, or indicate, important product changes from the previous model year.

Changes may include 1 or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

Changed Engine Specifications

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A variety of specifications have been revised based on the new design LV3 engines. Refer to **Engine Mechanical Specifications**.

Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes on the LV3 engines utilize metric threads.
- Cylinder head, connecting rod, crankshaft balancer, camshaft sprocket, and main bearing cap bolts still apply a torque and angle tightening strategy.
- Certain fasteners should not be used again. Bolts, studs, or other fasteners that must be replaced, will be called out in the specific service procedure.

New Sealants and/or Adhesives

Sealers and adhesives, as required, are identified within the specific service procedures. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

Disassembly and Assembly Procedure Revisions

A variety of procedures have been revised based on the new design LV3 engines.

Engine Mechanical Diagnostic Procedure Revisions

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

New Special Tools Required

A variety of new special tools are required for the new design LV3 engines. Refer to **Special Tools**.

A Component Comparison from the Previous Year

The 4.3L LU3 VIN X Gen 1e engine is replaced by the 4.3 L LV3 VIN H Gen 5 engines. Refer to **Engine Component Description**.

LUBRICATION DESCRIPTION

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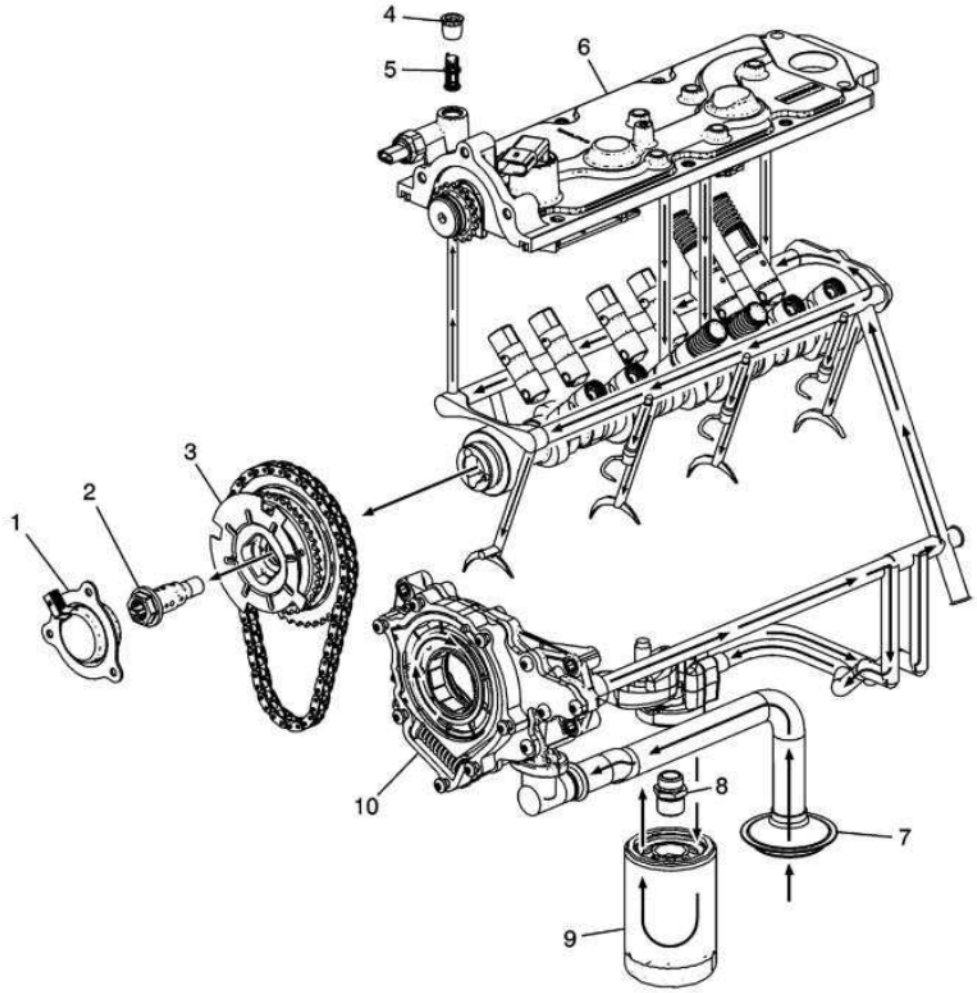

Fig. 616: Engine Lubrication Description
Courtesy of GENERAL MOTORS COMPANY

Engine lubrication is supplied by a variable displacement two-stage vane-type oil pump assembly (10). An oil control solenoid valve , controlled by the engine control module (ECM), mounted to the oil pump provides two stage functionality. The oil pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump rotor and vanes rotate and draw oil from the oil pan sump through a pick-up screen and pipe (7). The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery.

Pressurized oil is directed through the engine block lower oil gallery , through a center tube inside of the oil pan, and over to the full flow oil filter (9) where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted.

Oil is then directed from the filter to an external oil cooler in the radiator , back to the right side of the oil pan and back through the center tube. Oil is then directed to the upper main oil galleries and the valve lifter oil manifold assembly (7). Oil from the left upper oil gallery is directed to the balance shaft, crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor (4) is located at the top front of the engine.

An oil passage at camshaft bearing location 2 permits oil flow into the center of the camshaft. Oil enters the camshaft exiting at the front and into the camshaft position (CMP) actuator solenoid valve (2). The CMP valve spool position is controlled by the engine control module (ECM) and CMP magnet (1). When commanded by the ECM, the CMP magnet repositions the CMP actuator solenoid valve spool directing pressurized oil into the CMP actuator to control

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valve timing. Refer to **Camshaft Position Actuator and Solenoid Valve Description**.

With active fuel management activated, the ECM commands the 2 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 3 and 6.

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

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Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to **Special Tools**.

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** remover 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

CAUTION: Refer to Sealant Caution .

- 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 SEALANT

Cleaning Mating Part Surfaces for RTV Joints

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to ensure good adhesion over the life of the product.

CAUTION: When cleaning the sealing surfaces of engine components, DO NOT use bristle discs, abrasive pads, wire wheels or surface conditioning discs. These types of devices should not be used because they produce a very fine grit that is abrasive

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and known to cause internal engine damage. The bristle discs and pads are embedded with abrasive material and wear down as they clean, continually exposing fresh abrasive to the surface of the component.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover, cylinder head, engine block, oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area.

When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1,600 km (1,000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

NOTE: **After the final cleaning with GM Low VOC Cleaner and before reassembly, DO NOT touch the cleaned surfaces with your hand. Oils from your skin WILL CONTAMINATE the surface and prevent proper bonding of the new RTV sealant.**

Typical Applications

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.

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- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover/rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/cam covers with press in place gaskets using RTV at corners or T-joints.

Materials Needed

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC -Free Cleaner & Degreaser

Procedure:

1. Identify the surfaces to which the RTV will come into contact in the assembled joint.
2. Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.
3. Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some discoloration of the cloth after wiping however a clean surface should produce the same level of discoloration with successive wiping with a clean cloth and solvent.
4. If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
5. Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
6. Do not touch the cleaned surface with anything prior to RTV application.
7. The surface is now prepared for RTV application.

Sealant Types

NOTE: **The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.**

The following two major types of sealant are commonly used in engines:

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:

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- Gasket Eliminator
- Pipe Sealant
- Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Do not use RTV sealant unless the ambient air temperature is at least 18Â°C (65Â°F) degrees or higher.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

CAUTION: **Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.**

NOTE: **The bead size is critical and is easier to maintain consistency and application with a RTV dispensing tool. This also helps to eliminate waste.**

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

NOTE: **Do not wait for the RTV sealant to skin over.**

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

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- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
- The surfaces to be sealed must be clean and dry.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.
  - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
  - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
  - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between two close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

NOTE:

- **Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where two parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.

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- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

NOTE: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section, with a complete listing at the end of the section. 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

Illustration	Tool Number/Description

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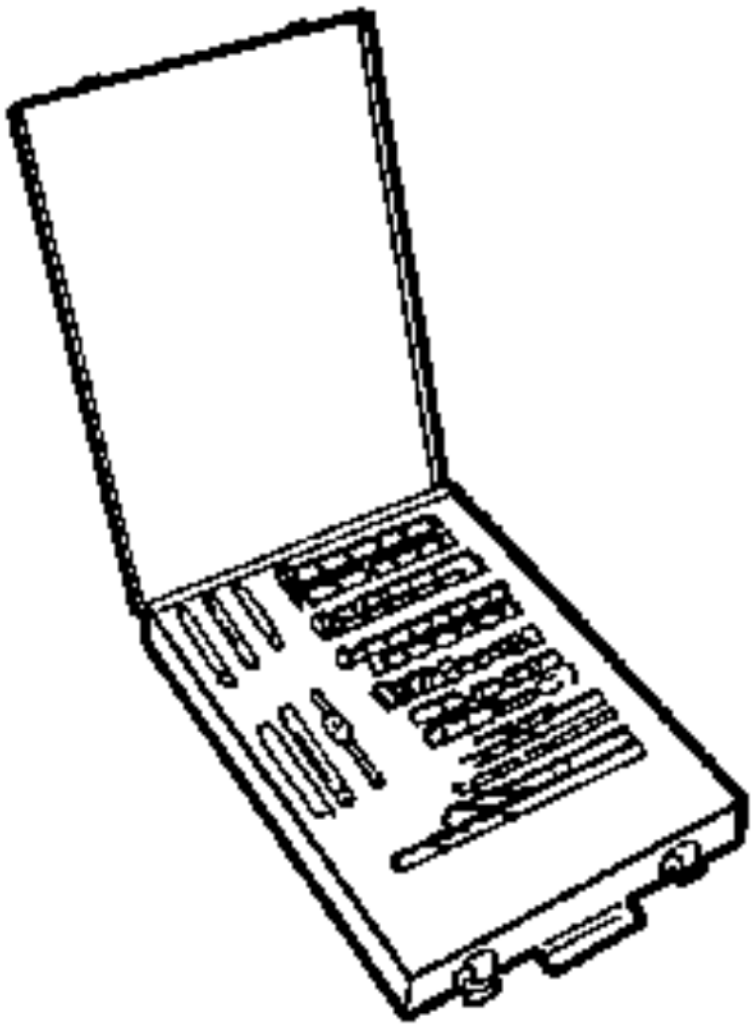
Illustration	Tool Number/Description
	EN-42385-50 Head/Main Bolt Thread Repair Kit

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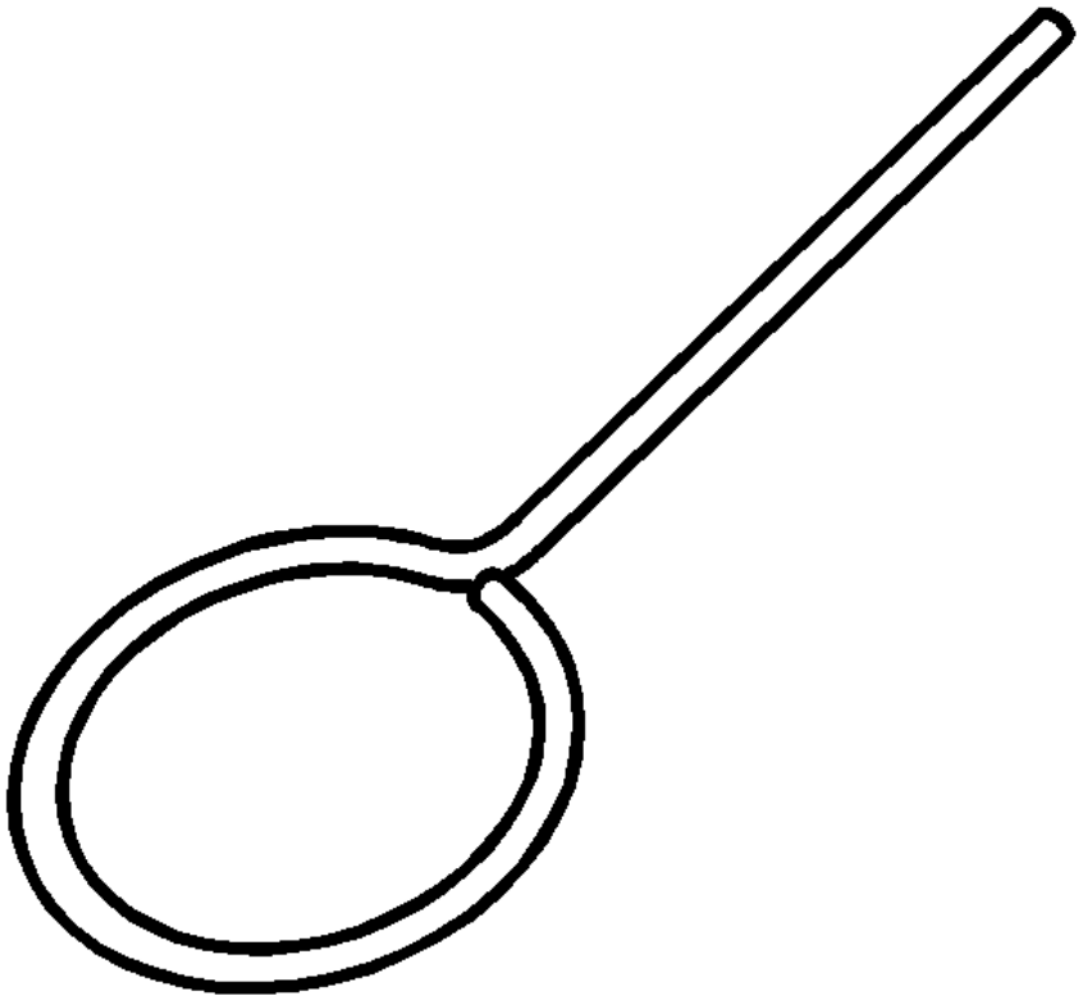
Illustration	Tool Number/Description
	EN-46330 Timing Belt Tensioner Retaining Pin

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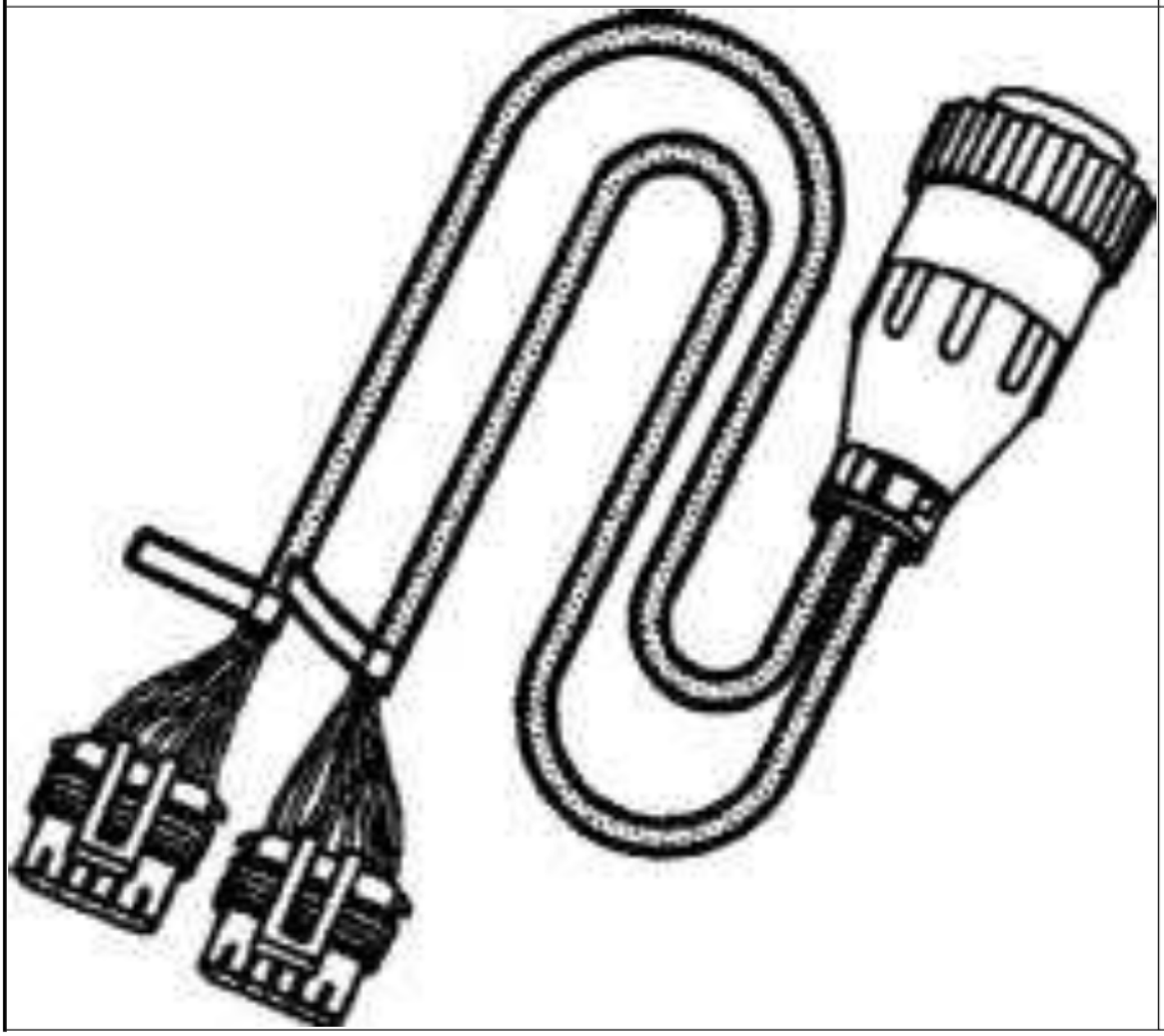
Illustration	Tool Number/Description
	EN-46999-15 Active Fuel Management Tester Harness - Small Block V6

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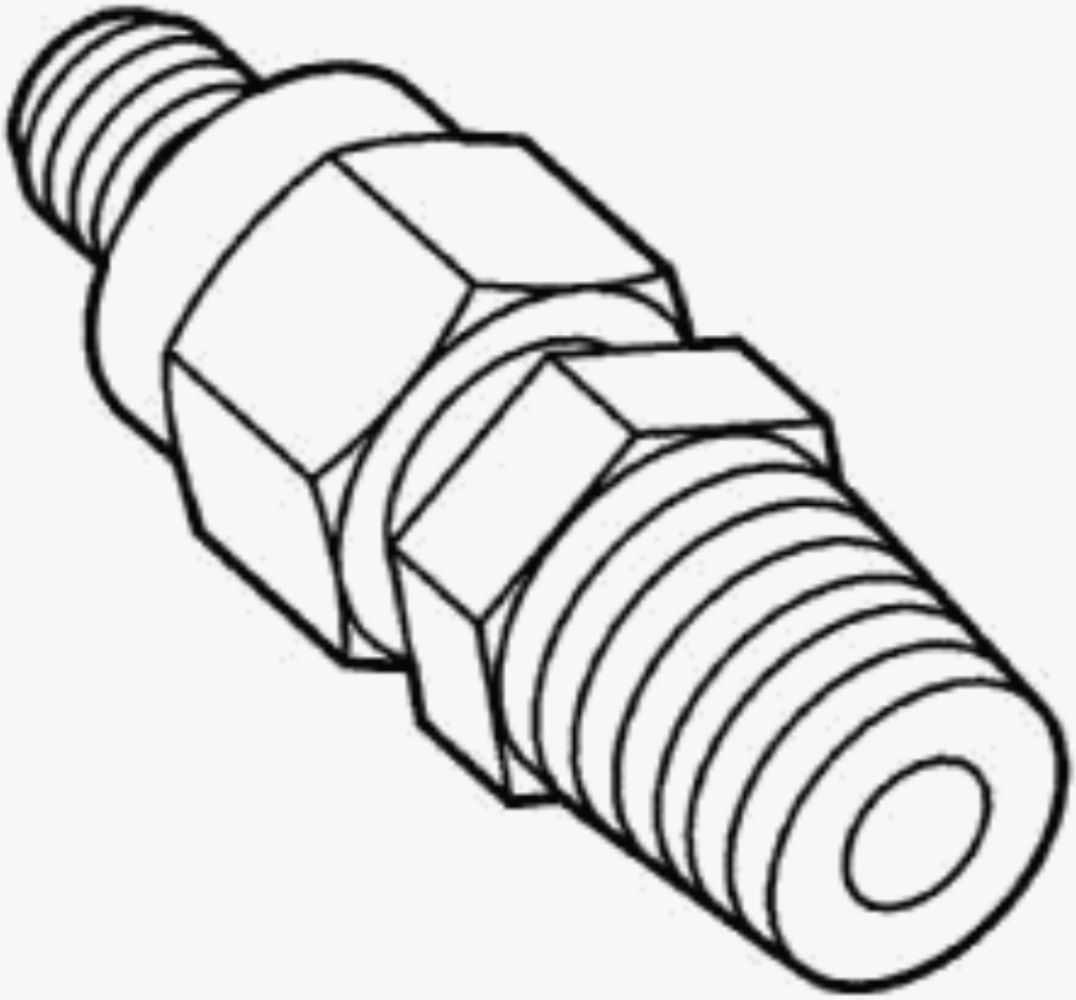
Illustration	Tool Number/Description
	EN-46999-18 Active Fuel Management Tester Air Adapter

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Illustration	Tool Number/Description
	EN-47971 Oil Pressure Gauge Adapter

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Illustration	Tool Number/Description
	EN-49245 Fuel Injection Seal Installer Sizer

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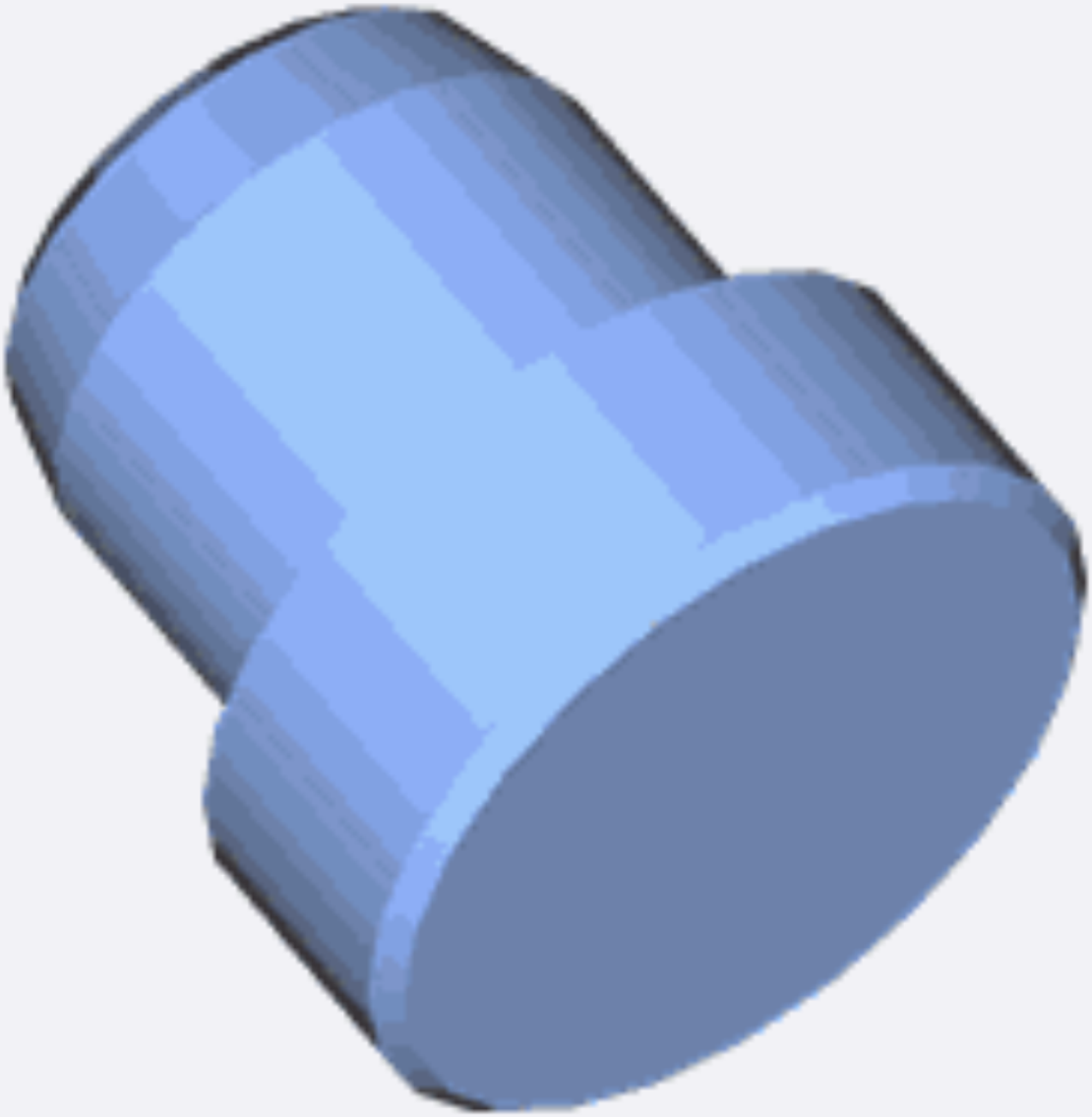
Illustration	Tool Number/Description
	EN-51092 Fuel Pump Installation Guage

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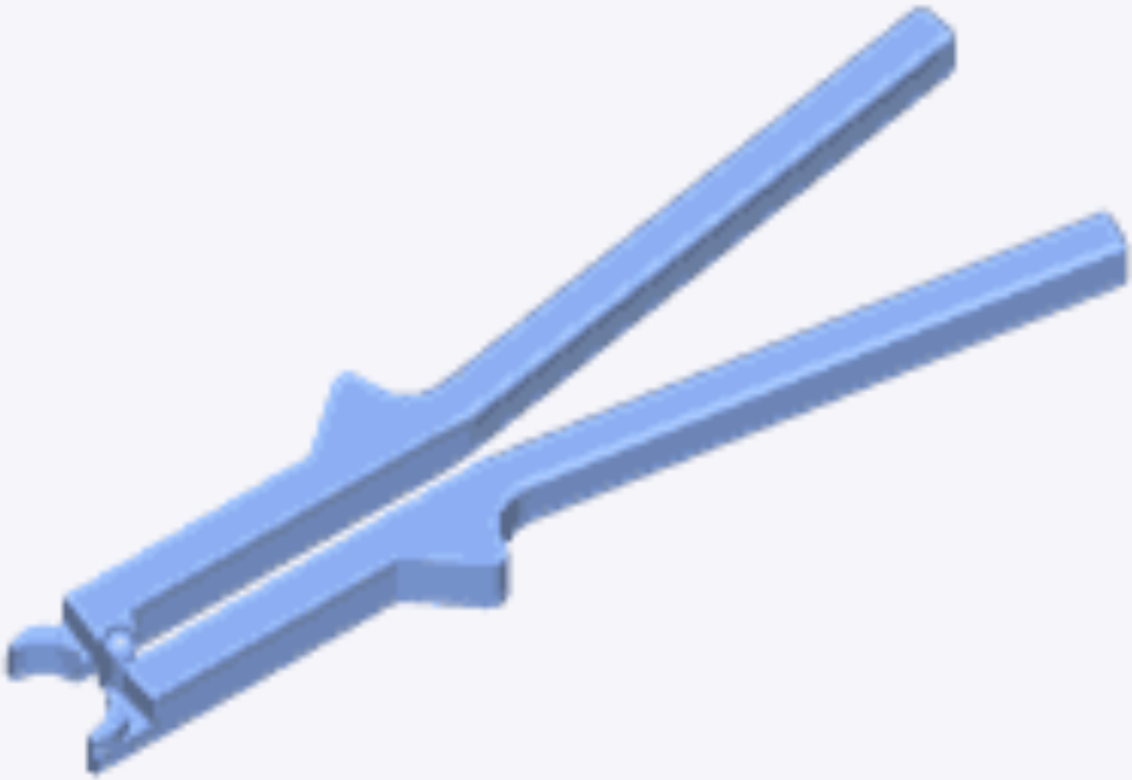
Illustration	Tool Number/Description
	EN-51097 Injector Retaining Clip Installer

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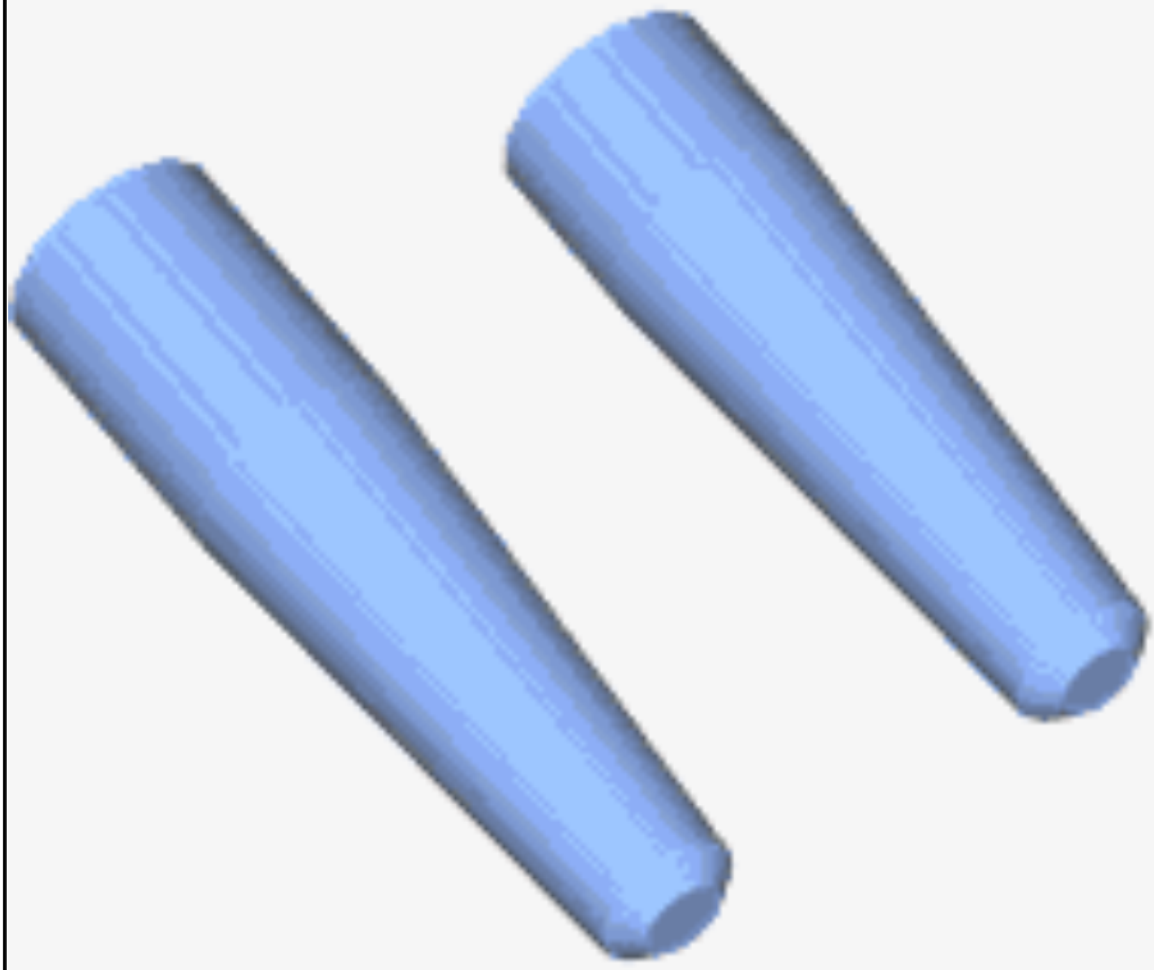
Illustration	Tool Number/Description
	EN-51105 Injector Seal Installer and Sizer

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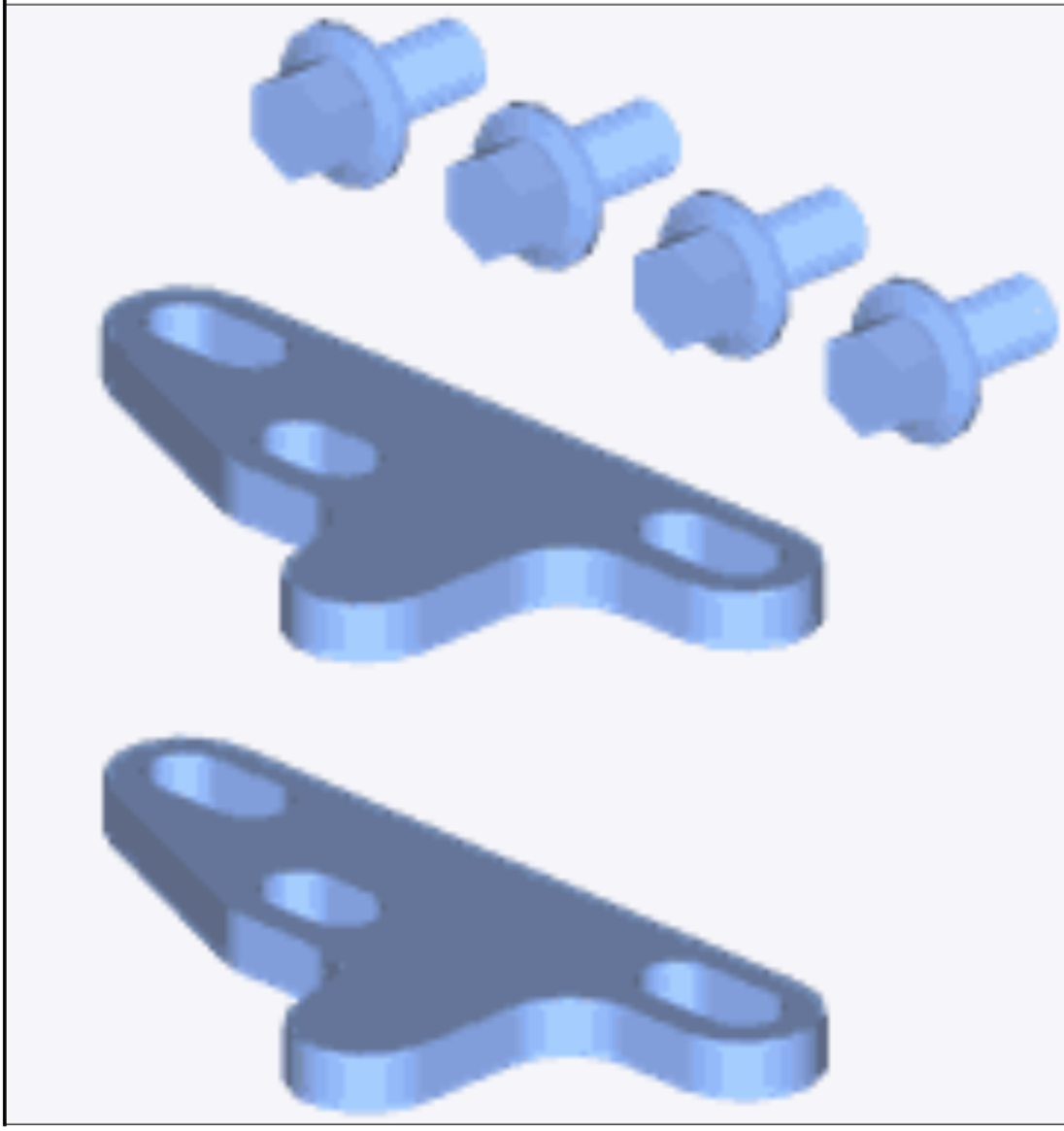	EN-51267 Oil Pump Alignment Tool

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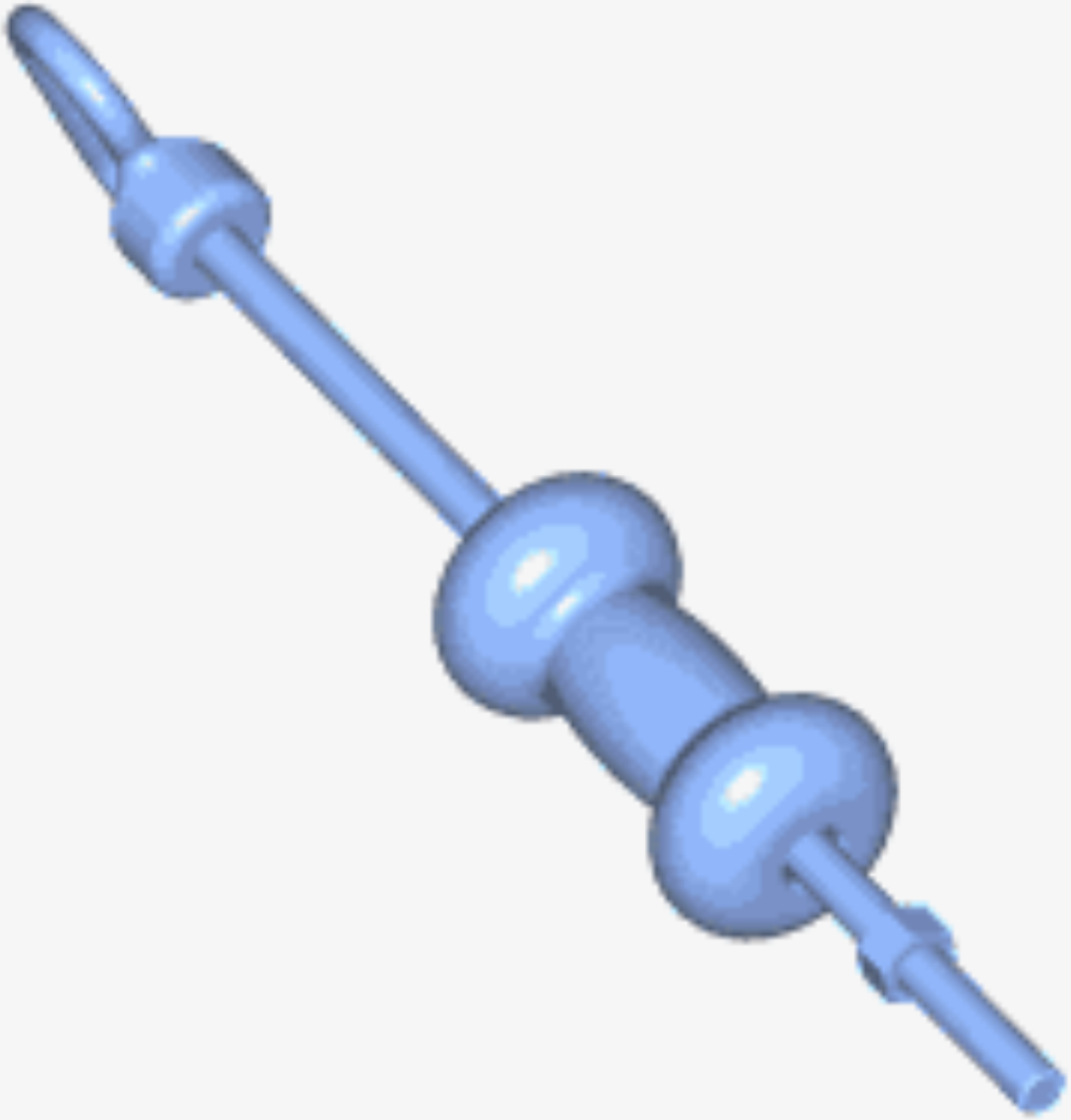
Illustration	Tool Number/Description
	GE-02619-A J-02619-A Slide Hammer

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Illustration	Tool Number/Description
	GE-6125-1B J-6125-1B Slide Hammer with Adapter

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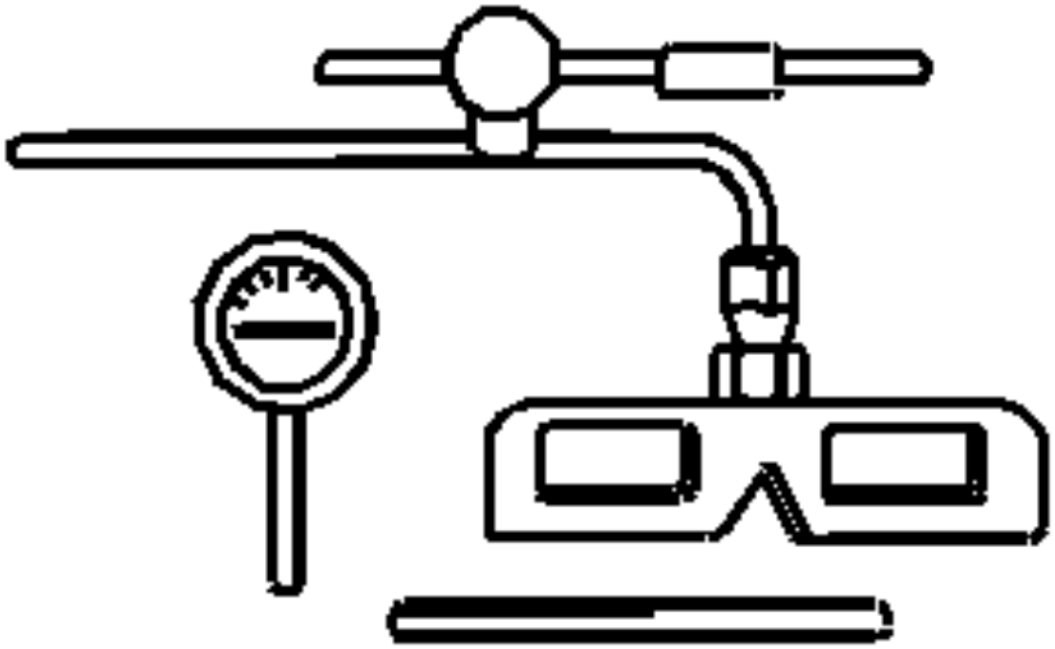
Illustration	Tool Number/Description
	GE-7872 J-7872 Magnetic Base Dial Indicator Set

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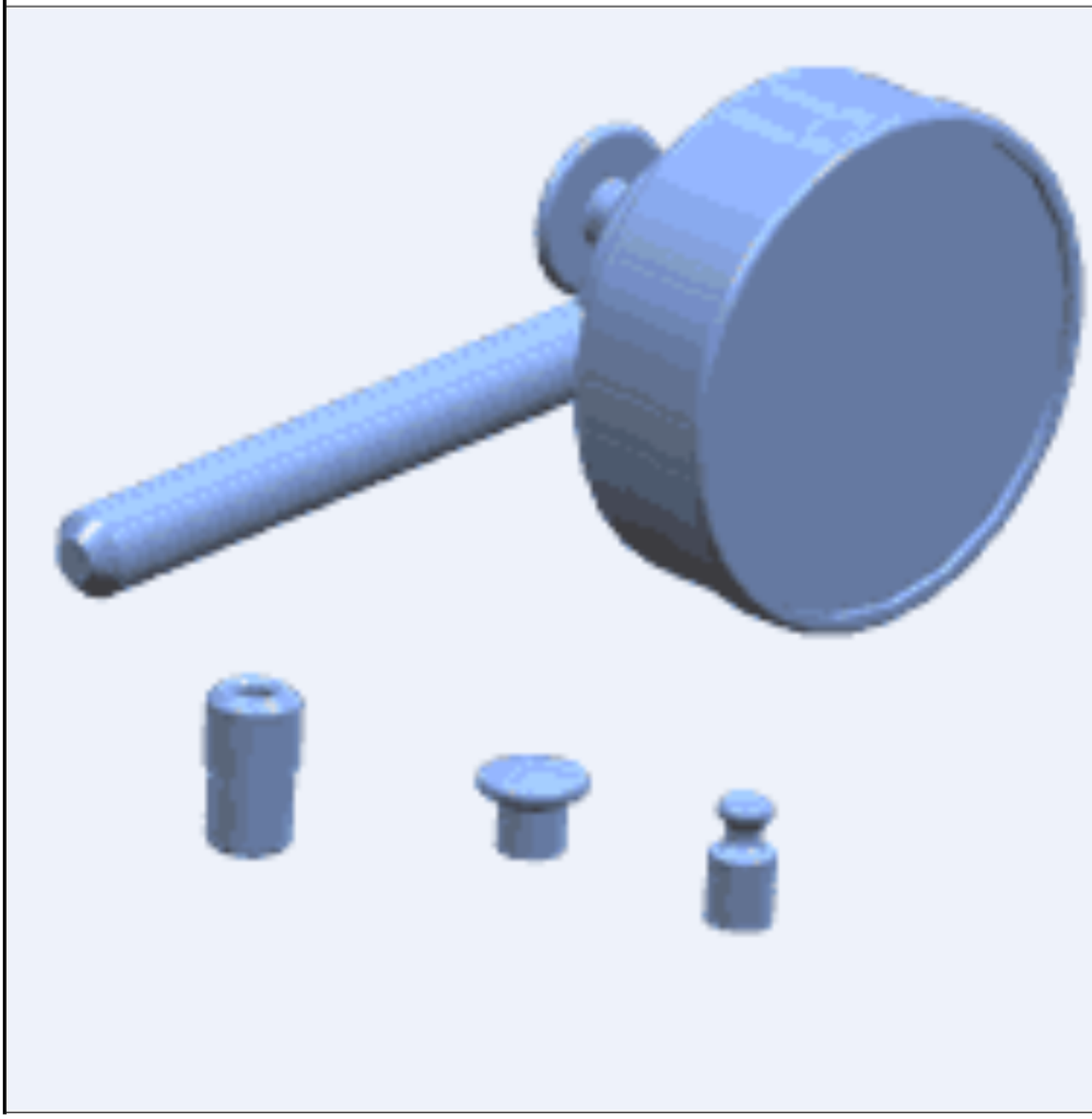
Illustration	Tool Number/Description
	GE-8001 J-8001 Dial Indicator Set

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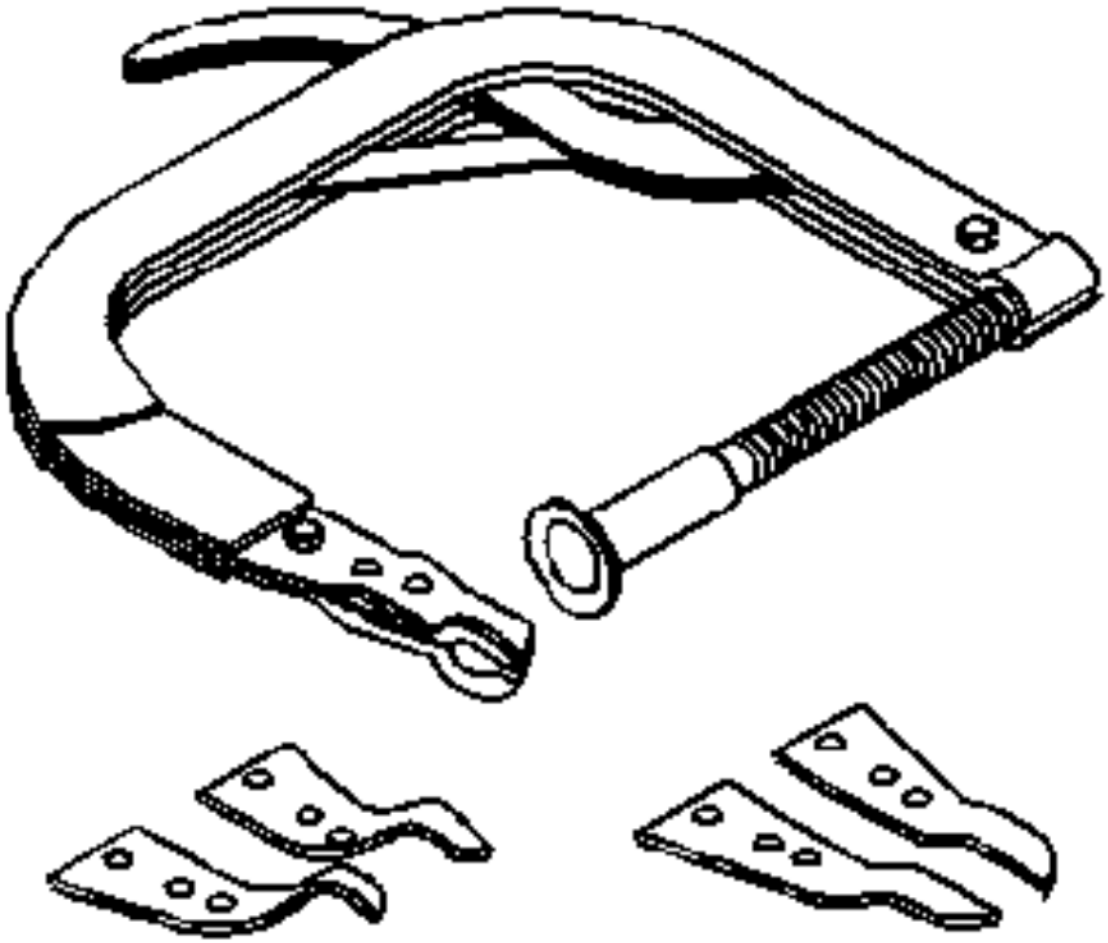
Illustration	Tool Number/Description
	EN-8062 J-8062 Valve Spring Compressor- Head Off

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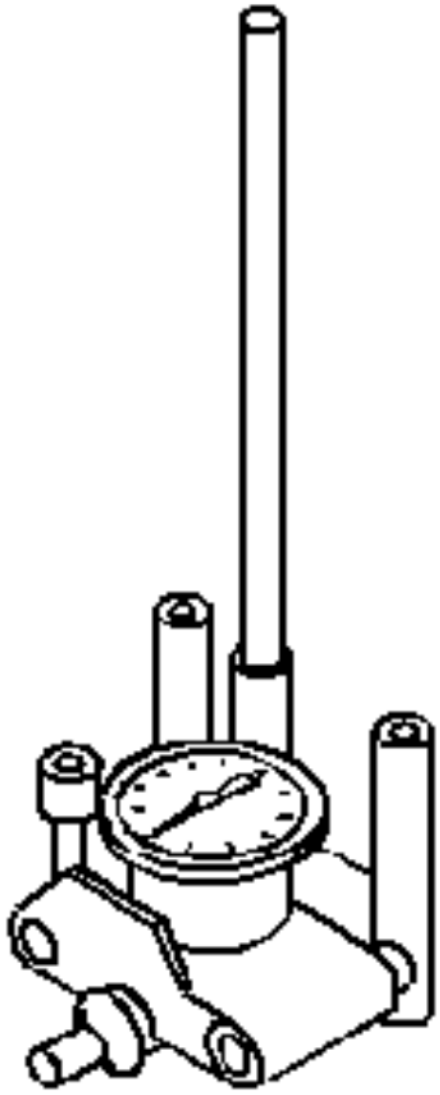
Illustration	Tool Number/Description
	EN-8087 J-8087 Cylinder Bore Gauge

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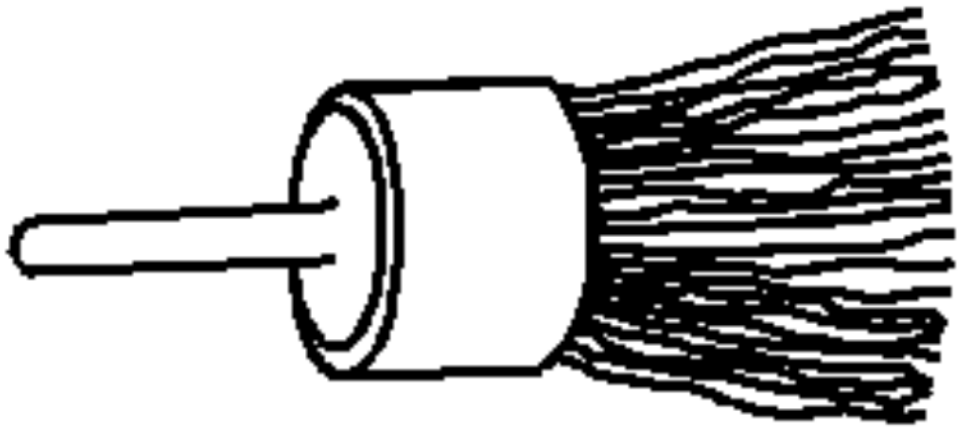
Illustration	Tool Number/Description
	EN-8089 J-8089 Carbon Removal Brush

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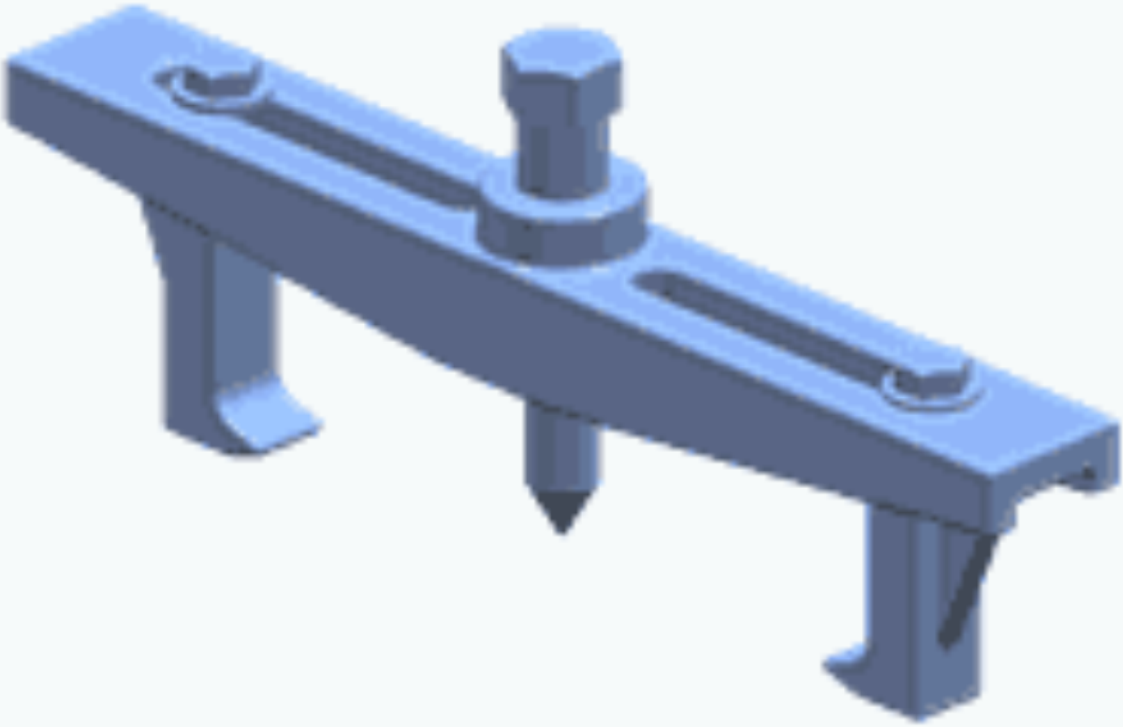
Illustration	Tool Number/Description
	GE-8433 J-8433 Two Jaw Puller

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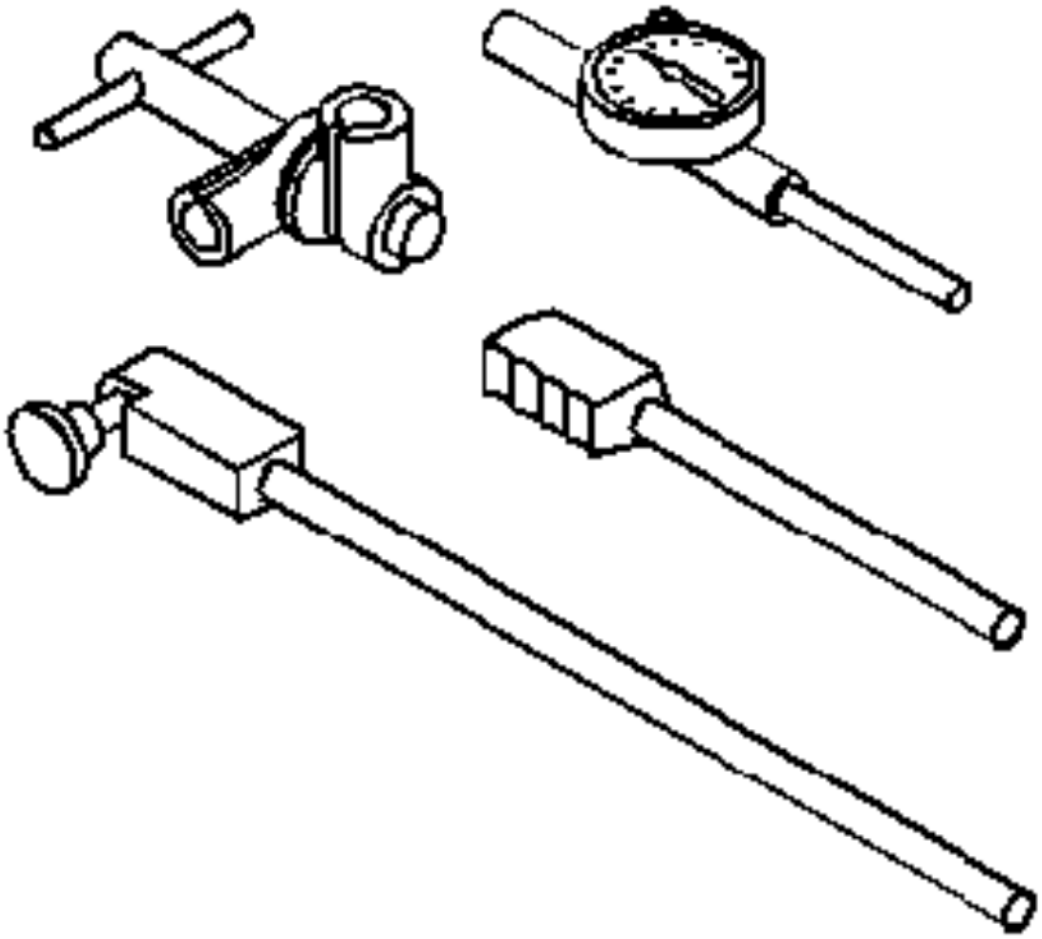
Illustration	Tool Number/Description
	EN-8520 J-8520 Cam Lobe Lift Indicator

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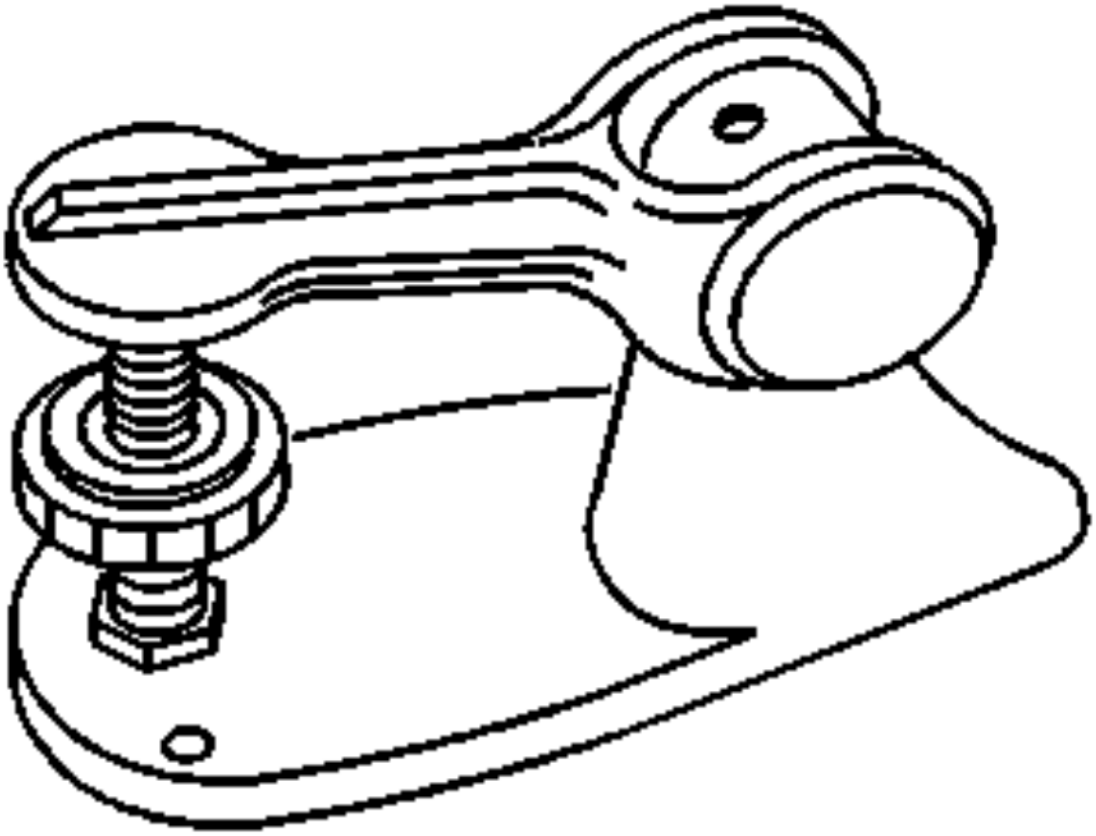
Illustration	Tool Number/Description
	EN-22738-B J-9666 Valve Spring Tester

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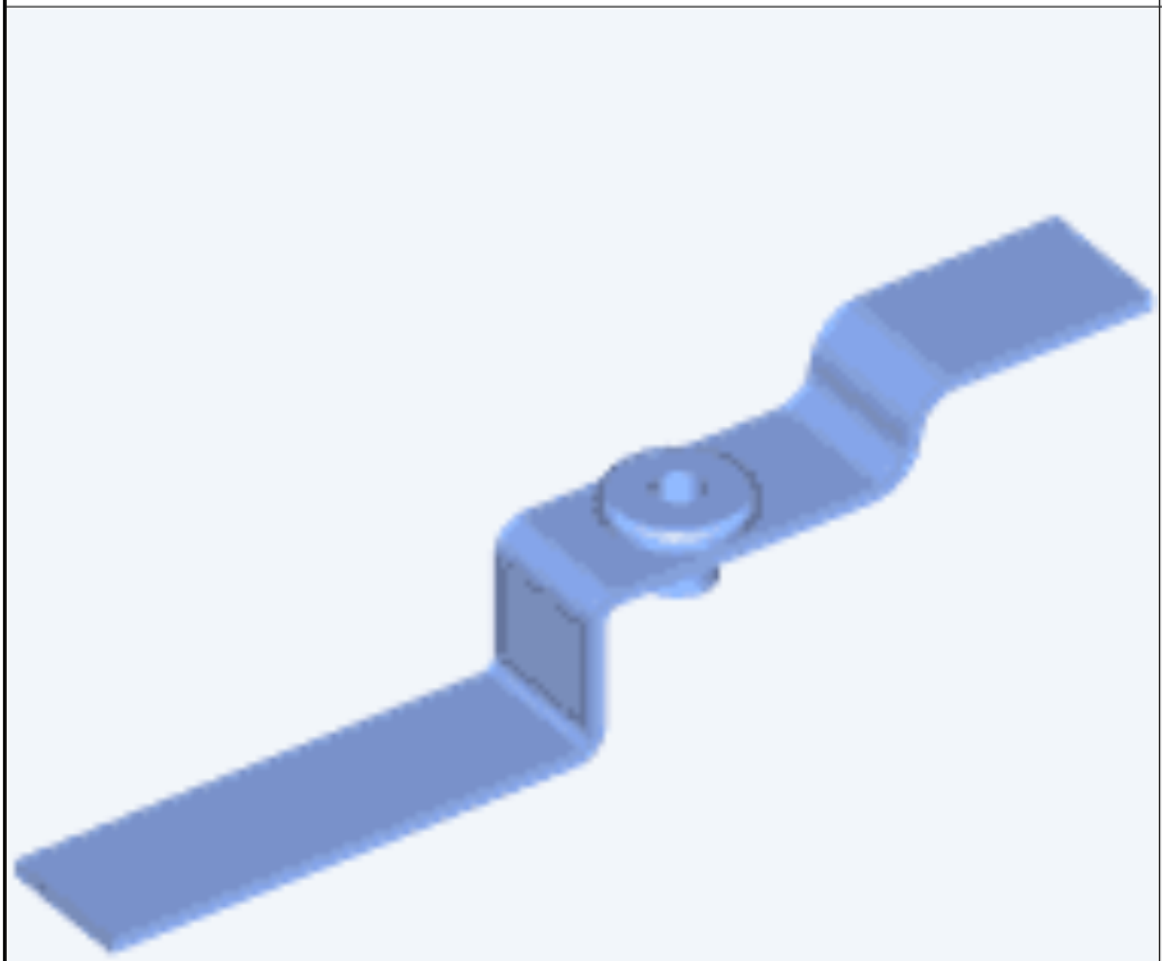
Illustration	Tool Number/Description
	DT-21366 J-21366 Converter Holding Strap

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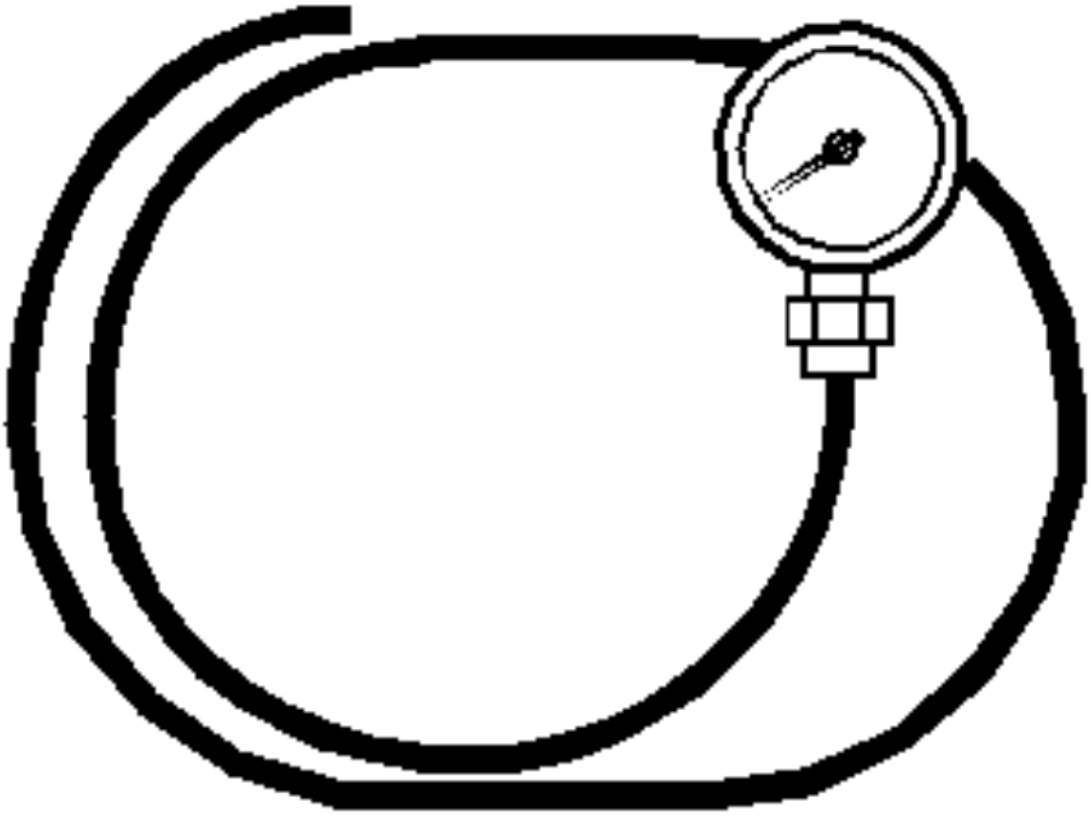
Illustration	Tool Number/Description
	GE-21867-A J-21867-A Pressure Gauge

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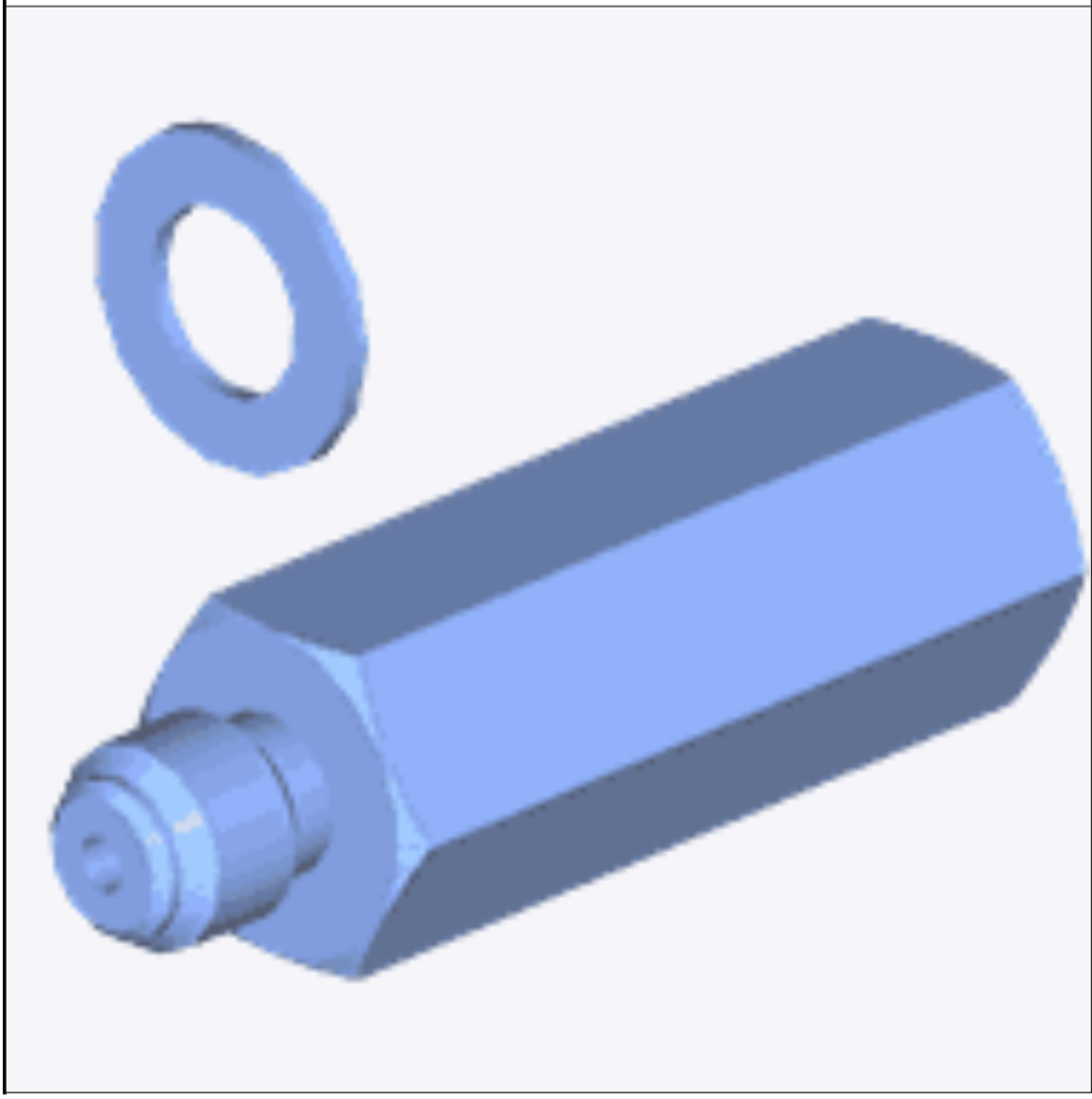
Illustration	Tool Number/Description
	J-21867-850 Oil Pressure Adapter

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Illustration	Tool Number/Description
	GE-2307-1 J-23907-1 Slide Hammer with Bearing Adapter

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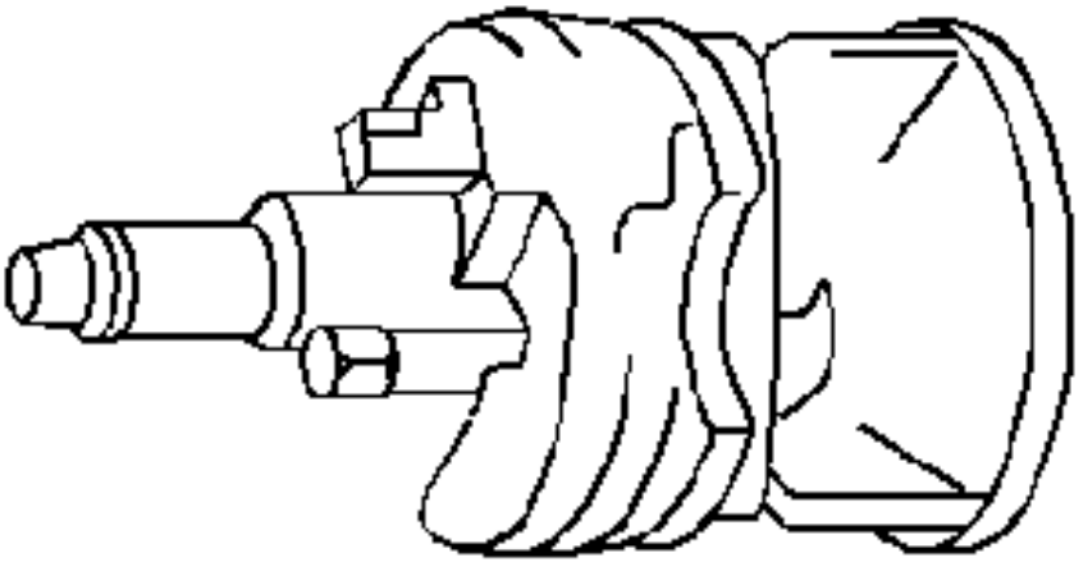
Illustration	Tool Number/Description
	EN-24270 J-24270 Cylinder Bore Ridge Reamer

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Illustration	Tool Number/Description
	EN-28410 J-28410 Gasket Remover

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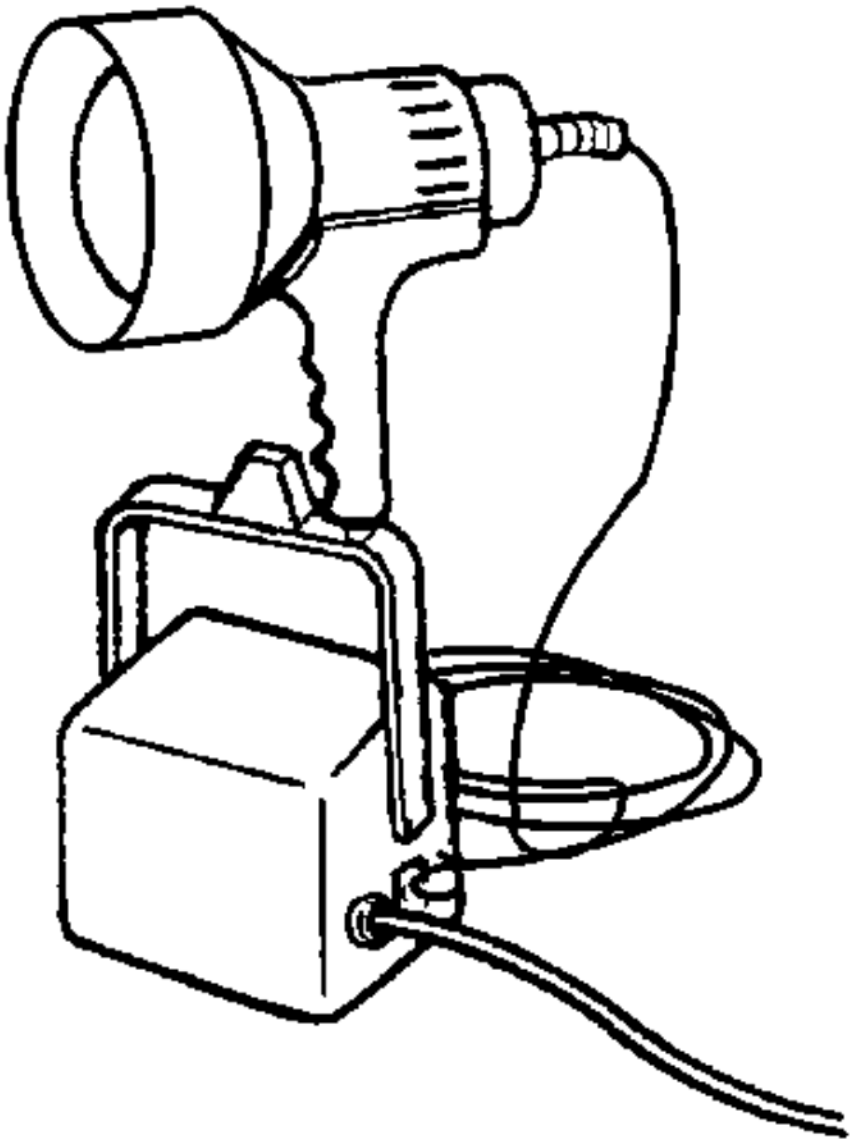
Illustration	Tool Number/Description
	GE-42220 J-28428-E High-Intensity Black Light Kit

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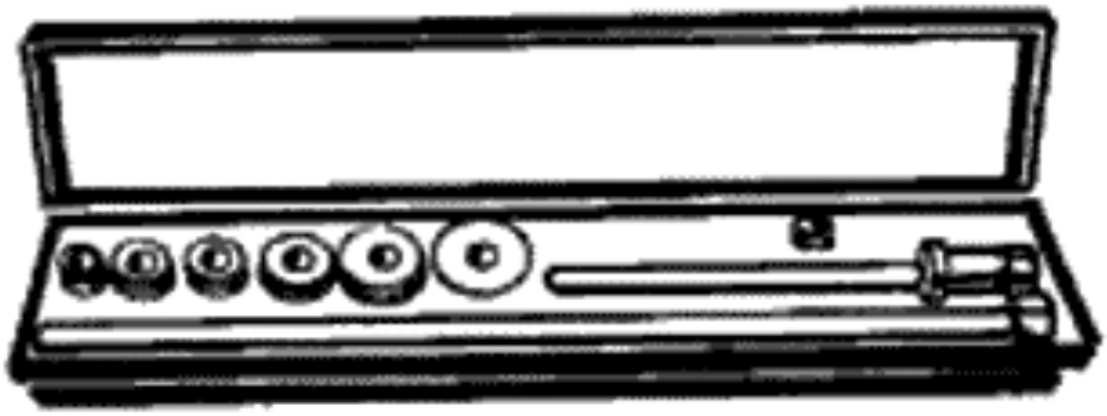
Illustration	Tool Number/Description
	EN-33049 J-33049 Camshaft Bearing Service Set

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Illustration	Tool Number/Description
	EN-35667-A J-35667-A Cylinder Head Leakdown Tester

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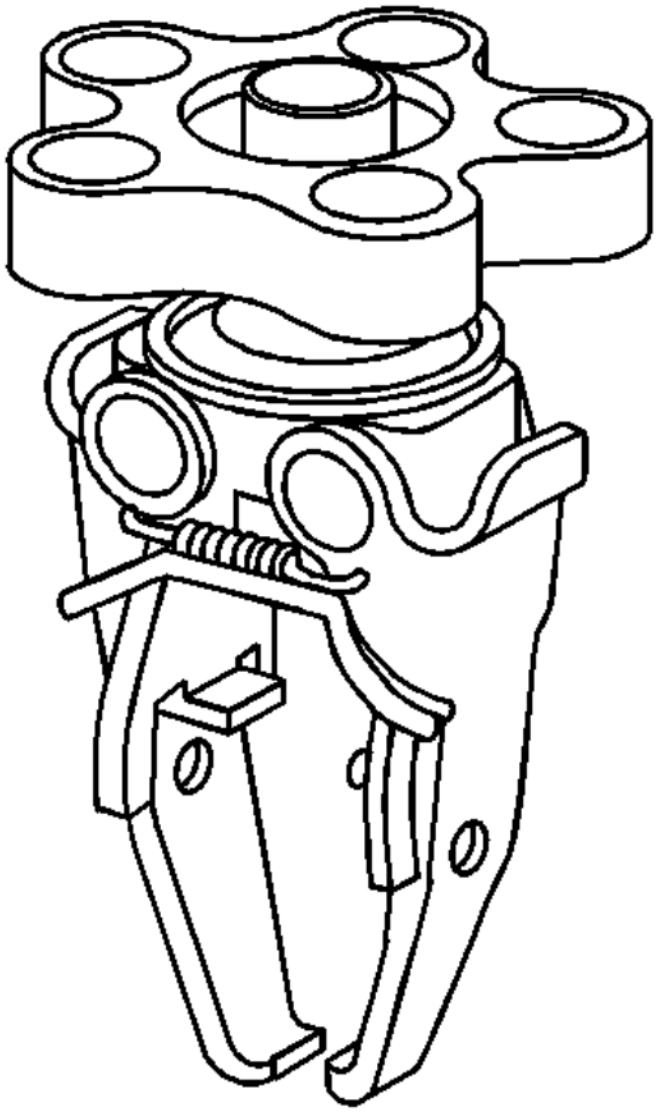
Illustration	Tool Number/Description
	EN-38606 J-38606 Valve Spring Compressor

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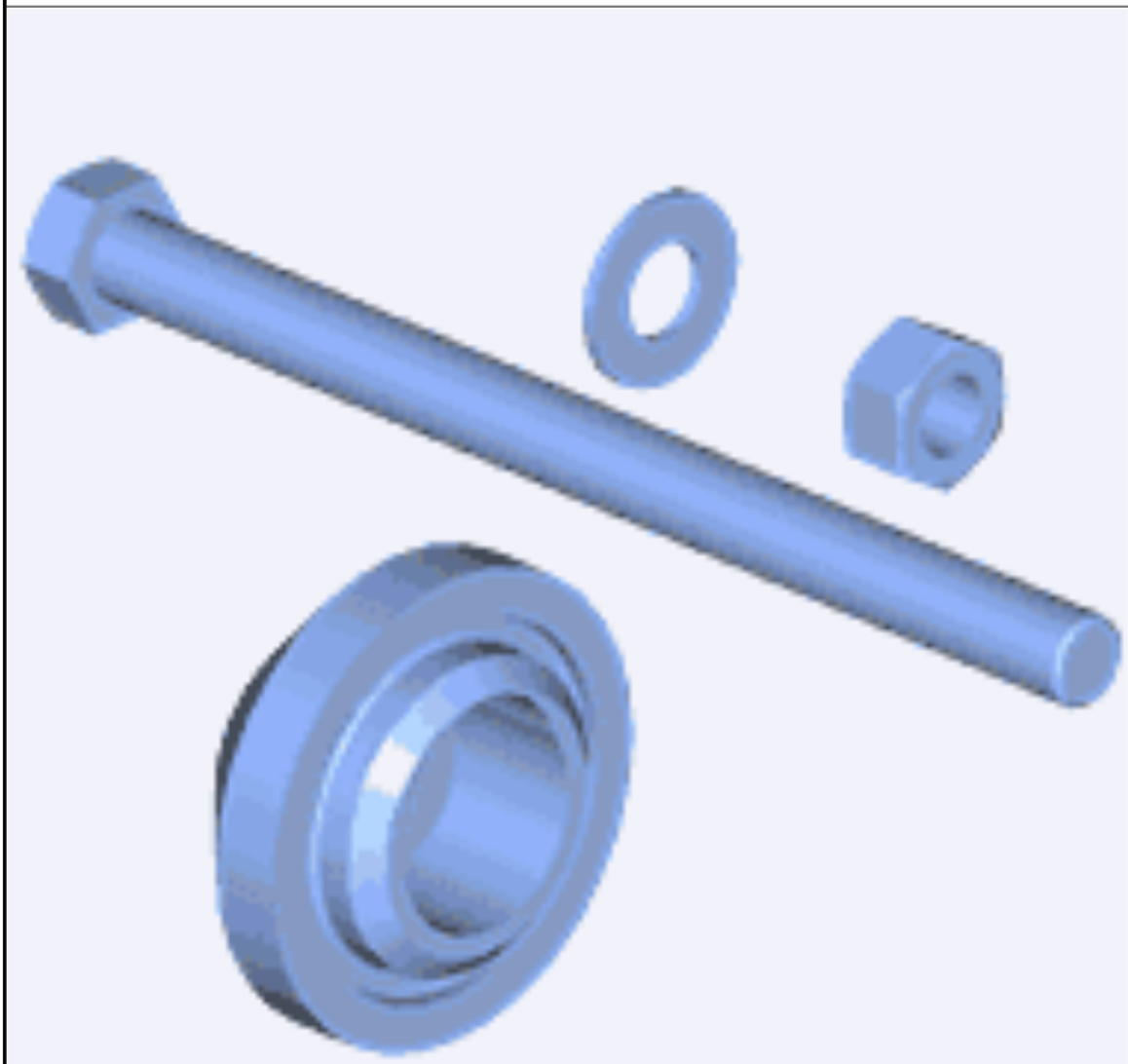
Illustration	Tool Number/Description
	EN-41478-A Crankshaft Front Oil Seal Installer

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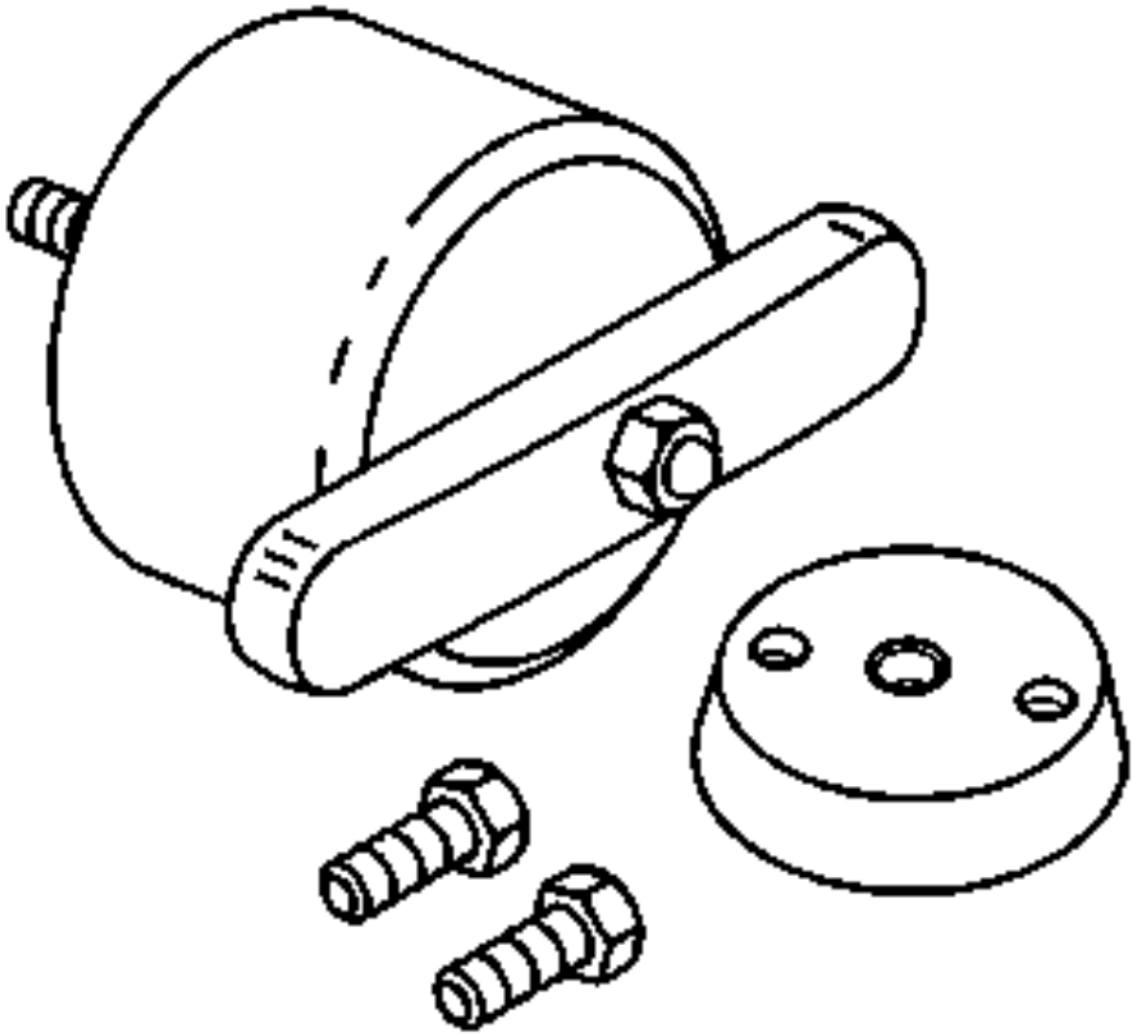
Illustration	Tool Number/Description
	EN-41479-B J-41479-B Crankshaft Rear Oil Seal Installer

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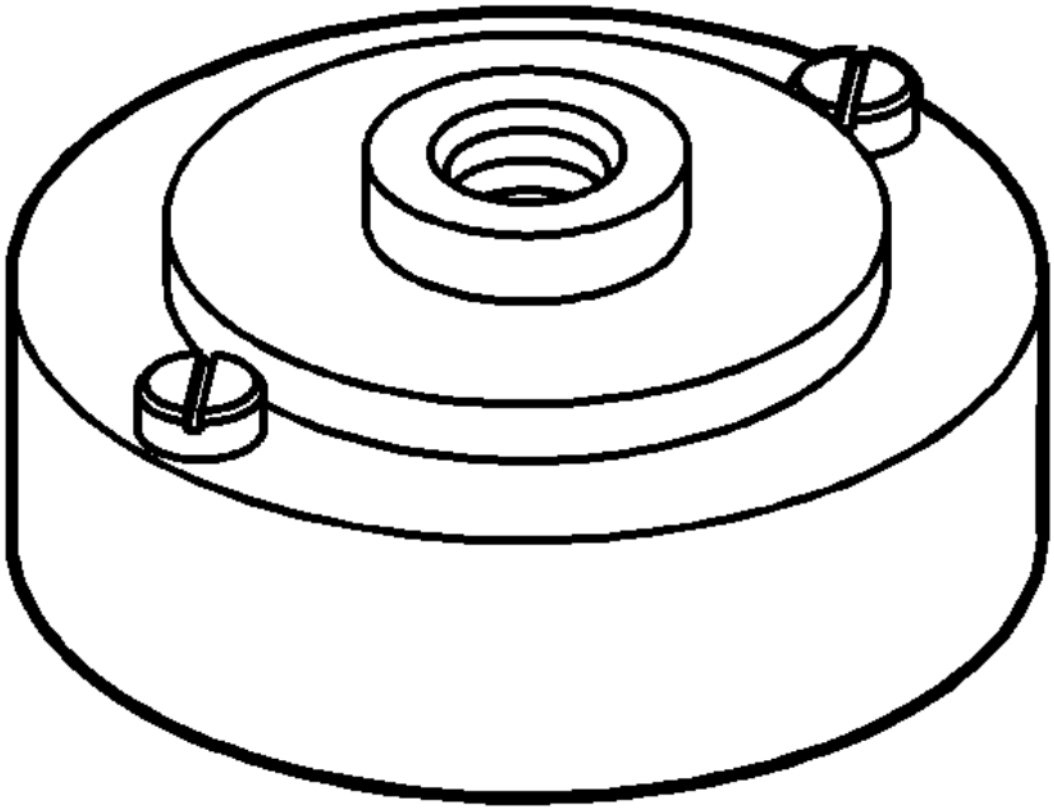
Illustration	Tool Number/Description
	EN-41479-2A J-41479-2A Crankshaft Rear Oil Seal Installation Guide

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Illustration	Tool Number/Description
	EN-41479-10 J-41479-10 Crankshaft Rear Oil Seal Installer Adapter

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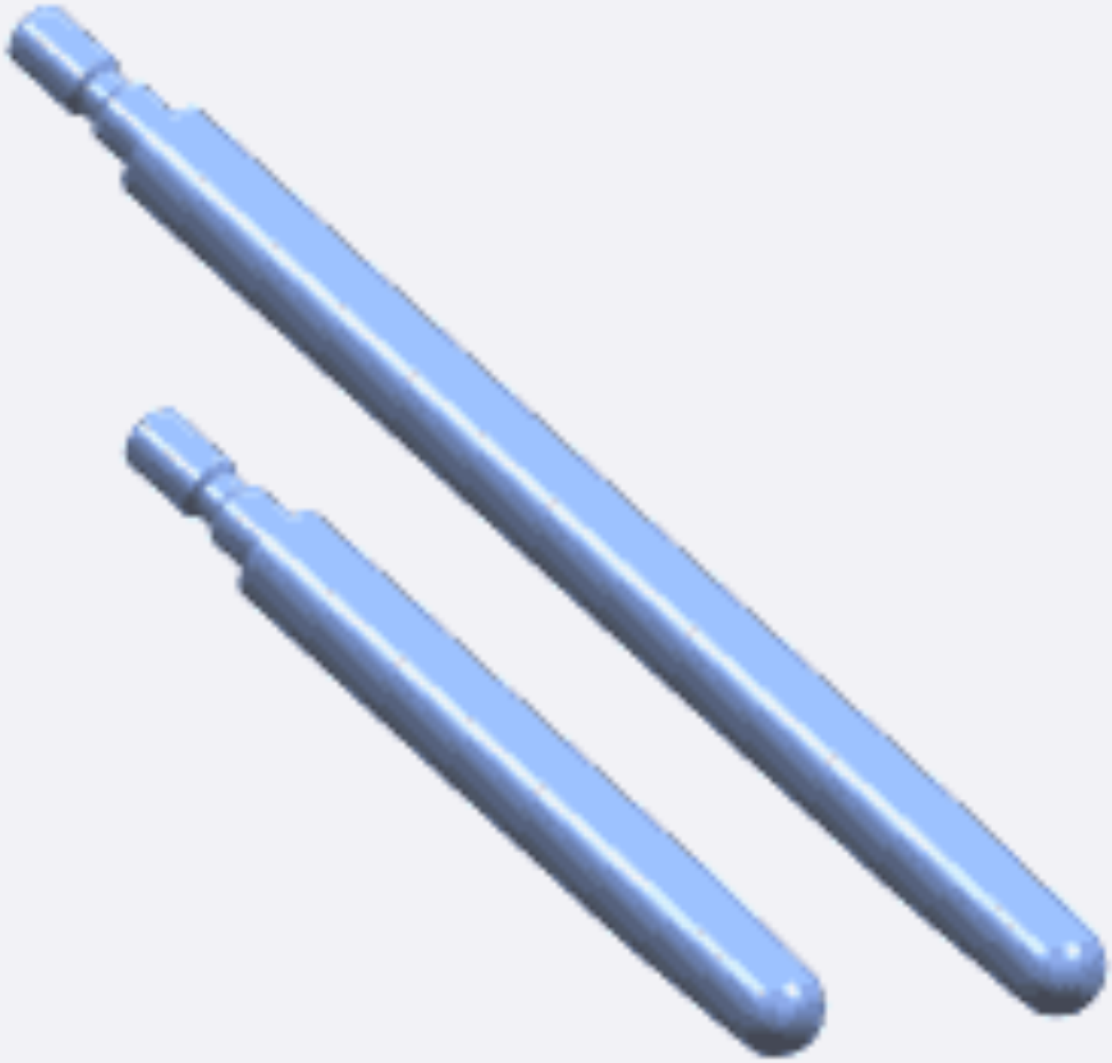
Illustration	Tool Number/Description
	EN-41556 J-41556 Connecting Rod Guide

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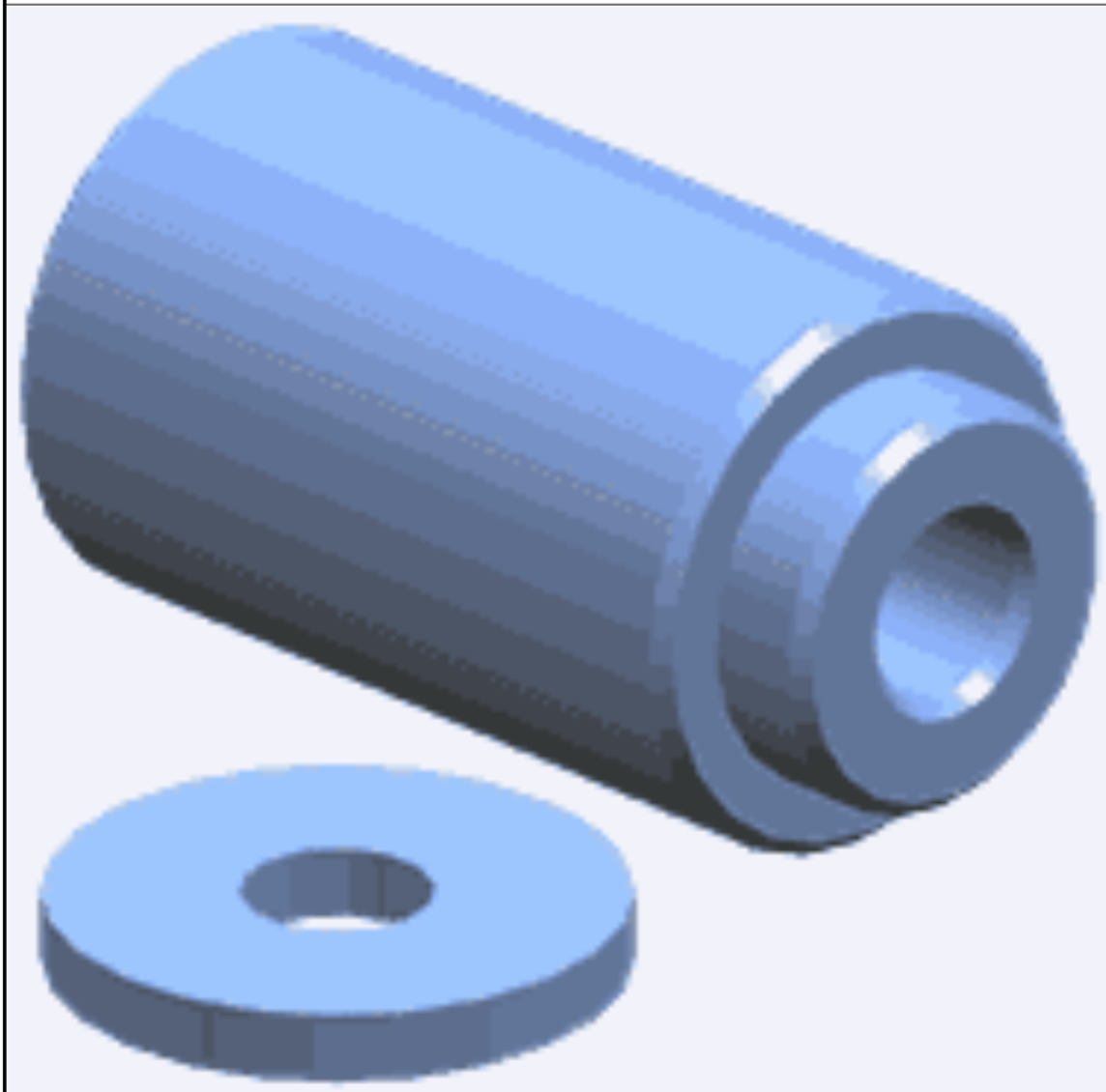
Illustration	Tool Number/Description
	EN-41665-A J-41665-A J-41665 Crankshaft Balancer and Sprocket Installer

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Illustration	Tool Number/Description
	EN-41816 J-41816 Crankshaft Balancer Remover

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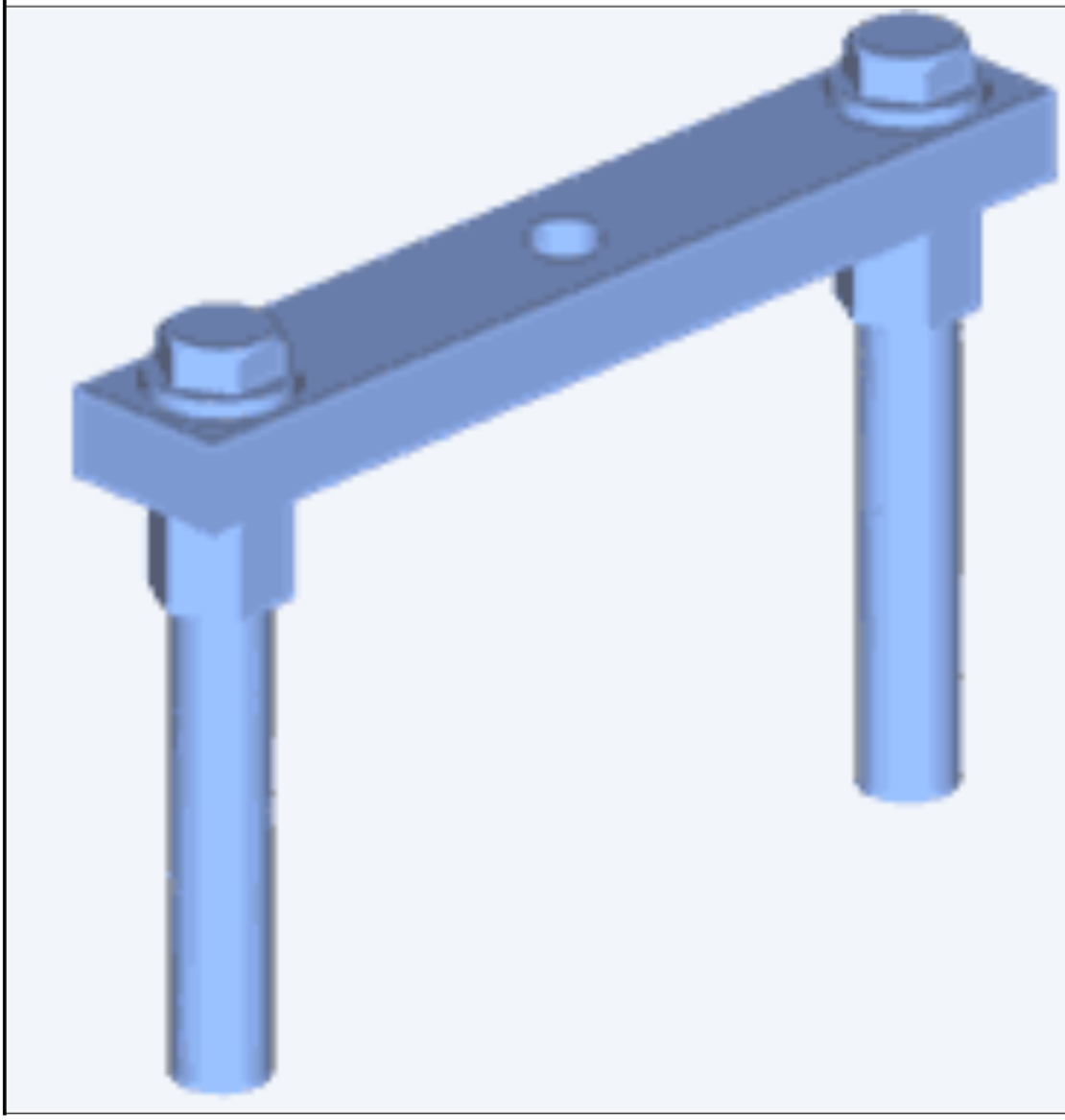
Illustration	Tool Number/Description
	EN-49102 J-41818 Crankshaft Bearing Cap Remover

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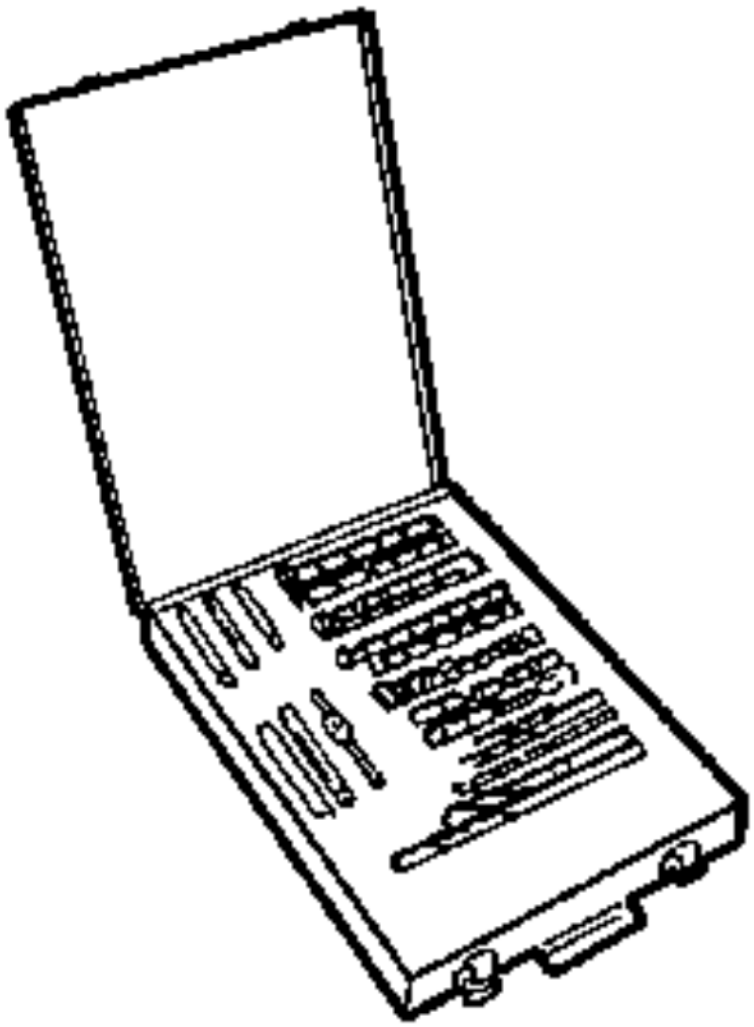
Illustration	Tool Number/Description
	EN-42385-100 J-42385-100 Head/Main Bolt Thread Repair Kit

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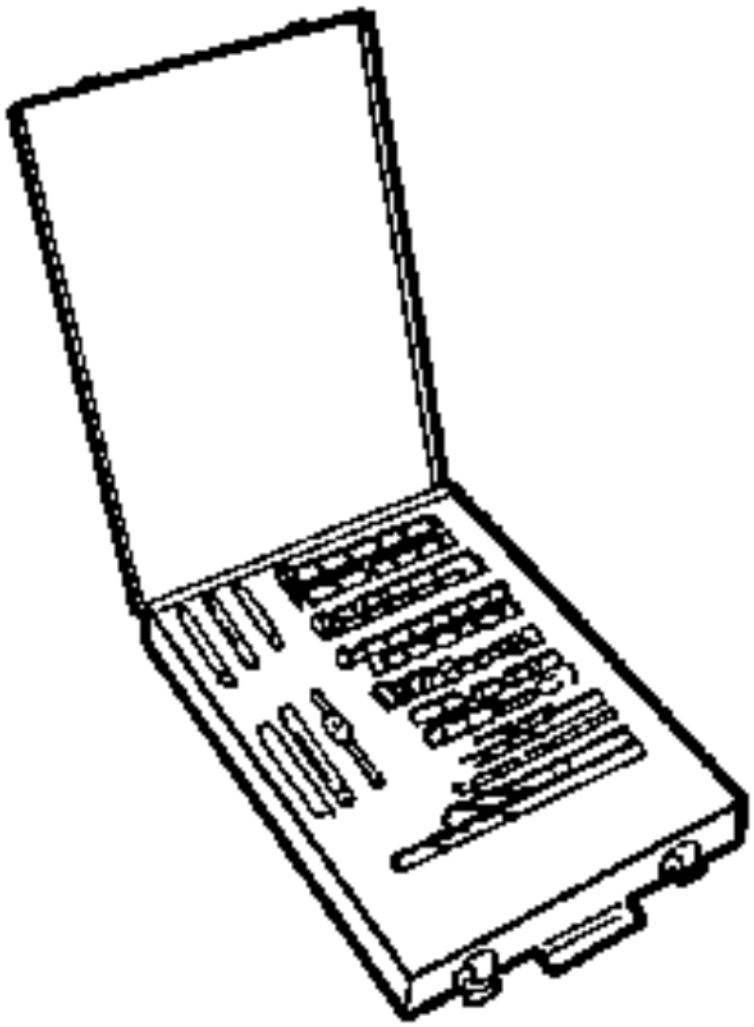
Illustration	Tool Number/Description
	EN-42385-200 J-42385-200 Common Thread Repair Kit

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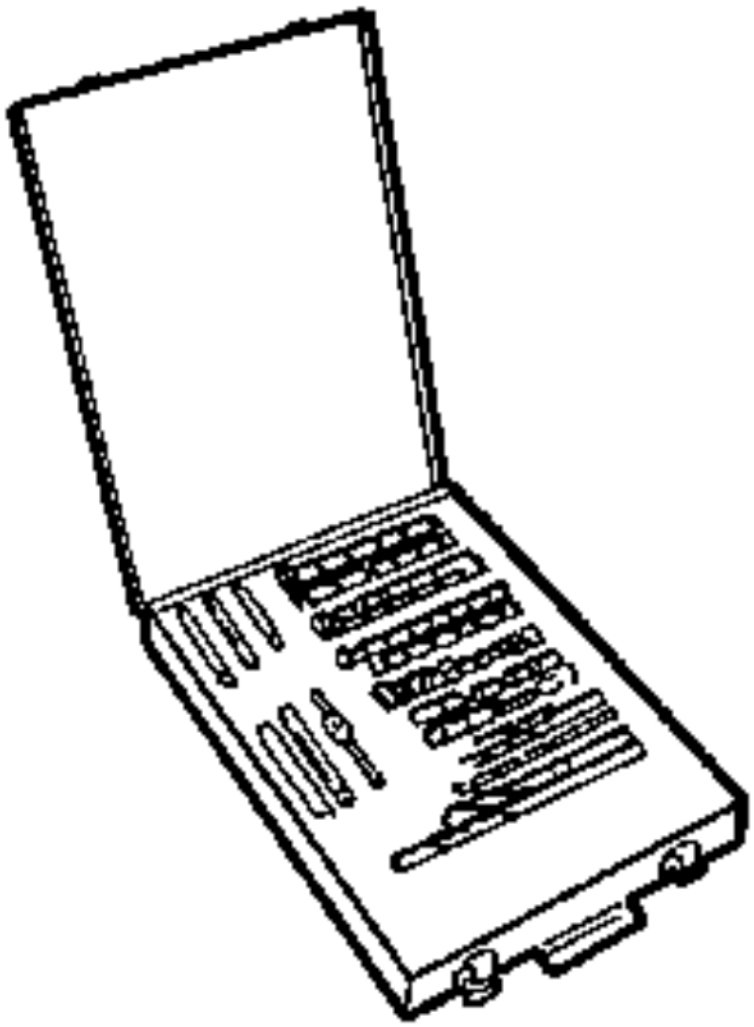
Illustration	Tool Number/Description
	EN-42385-300 J-42385-300 Fixtures and Hardware Kit

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Illustration	Tool Number/Description
	EN-42386-A J-42386-A Flywheel Holding Tool

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Illustration	Tool Number/Description
	EN-43690-A J-43690-A Rod Bearing Clearance Checking Tool

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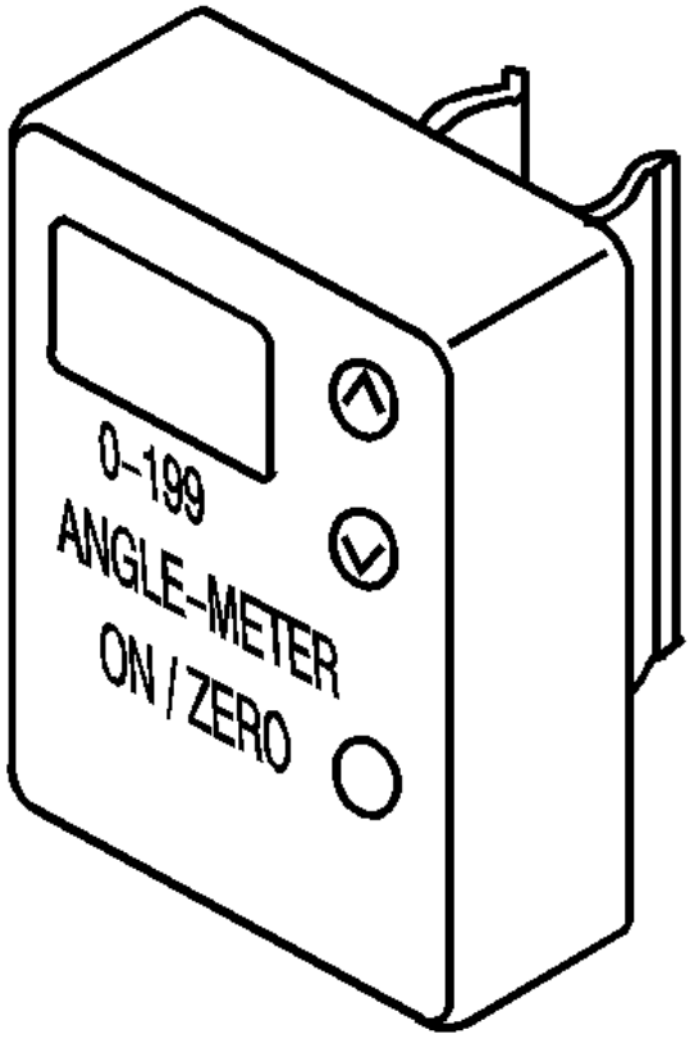
Illustration	Tool Number/Description
	EN-45059 J-45059 Angle Meter

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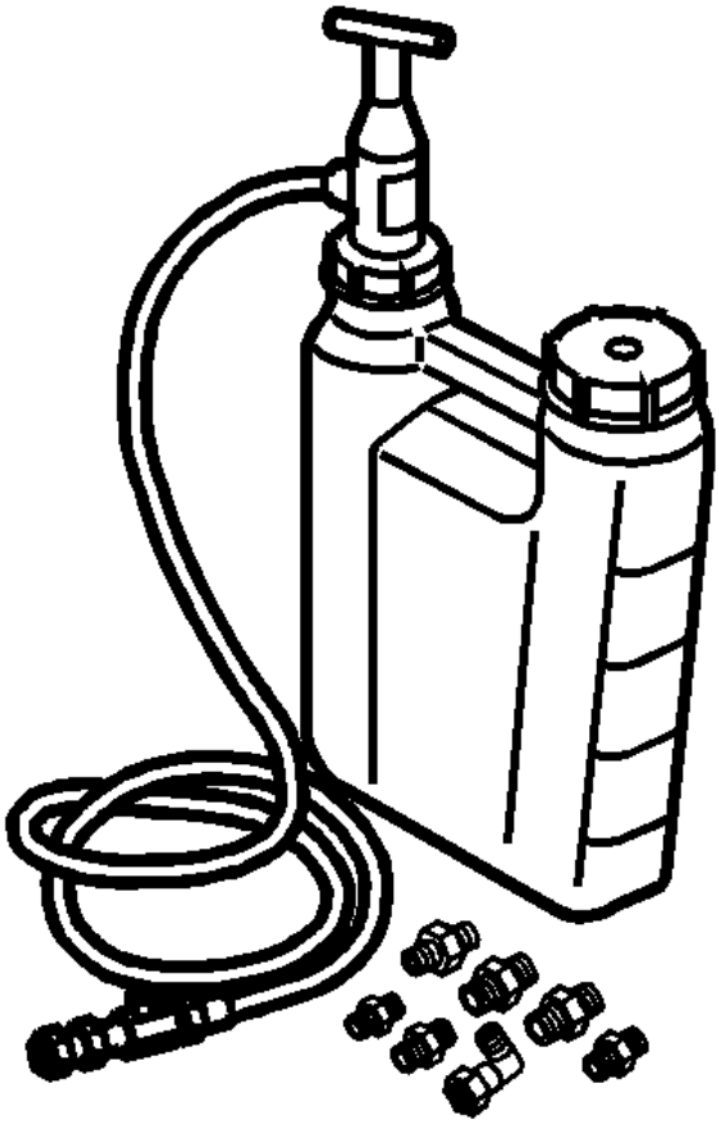
Illustration	Tool Number/Description
	EN-45299 J-45299 Engine Preluber

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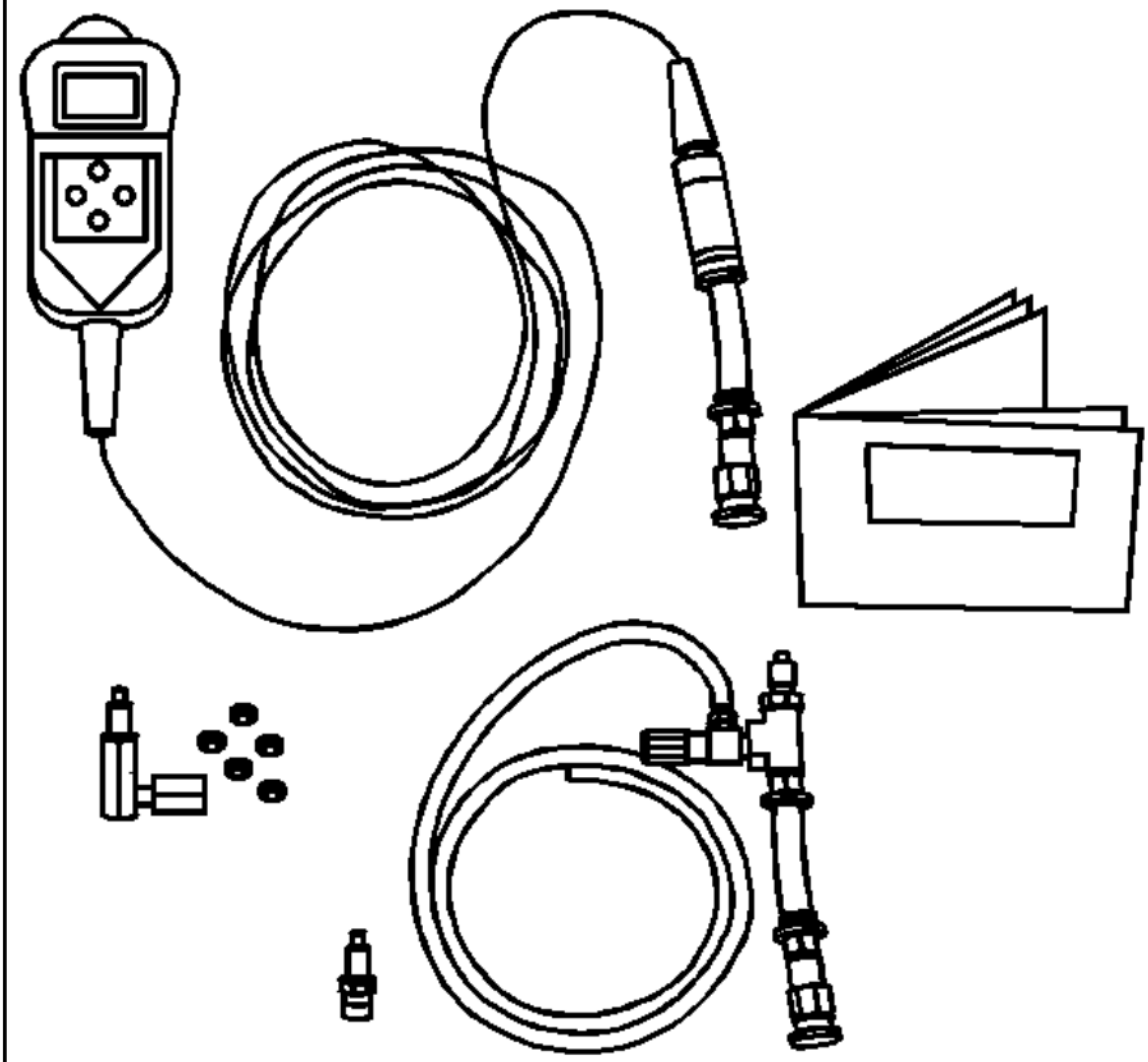
Illustration	Tool Number/Description
	CH-48027 Digital Pressure Gauge

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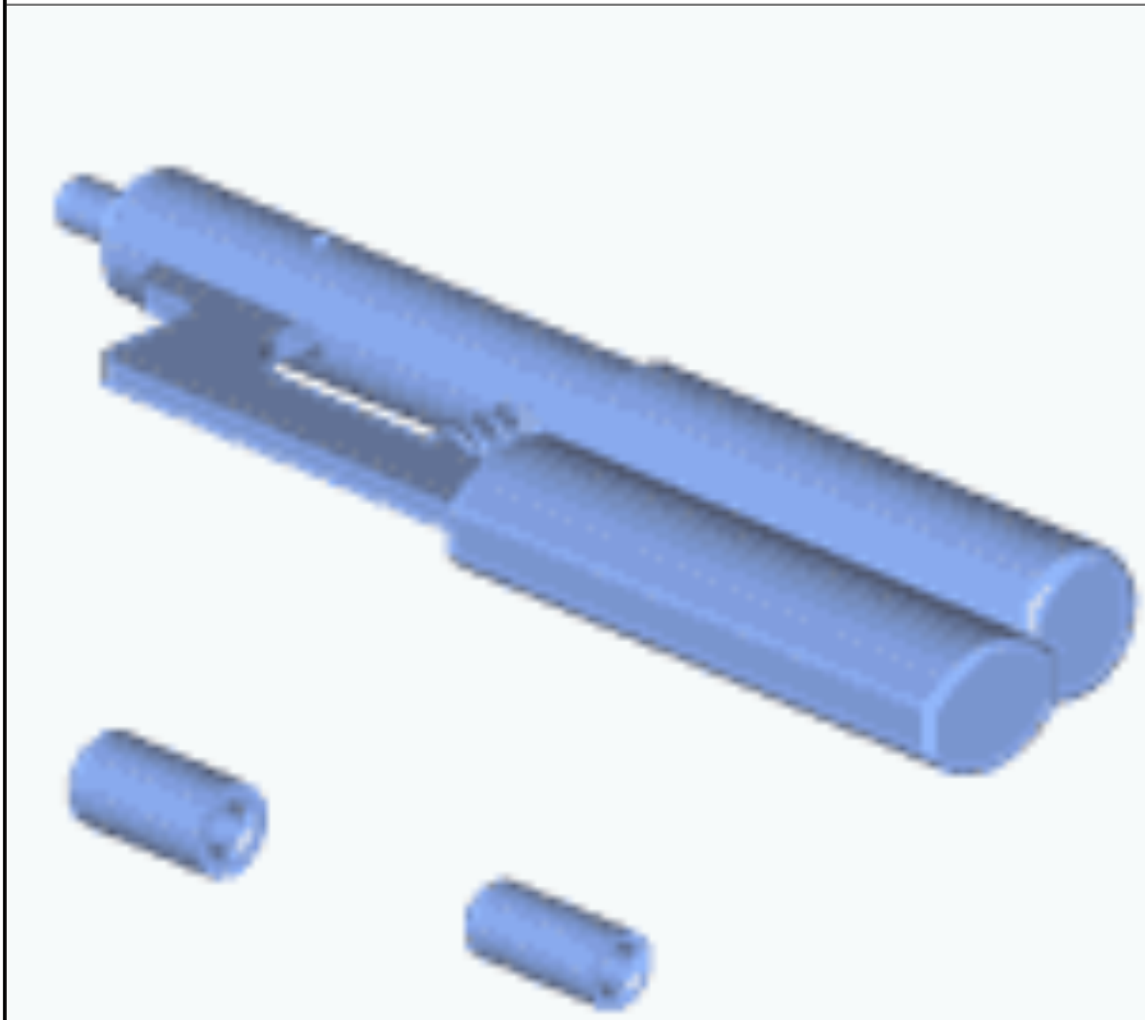
Illustration	Tool Number/Description
	EN-46745 J-46354 Piston Pin Clip Remover/Installer

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Illustration	Tool Number/Description
	EN-47909 Injector Bore and Sleeve Cleaning Kit

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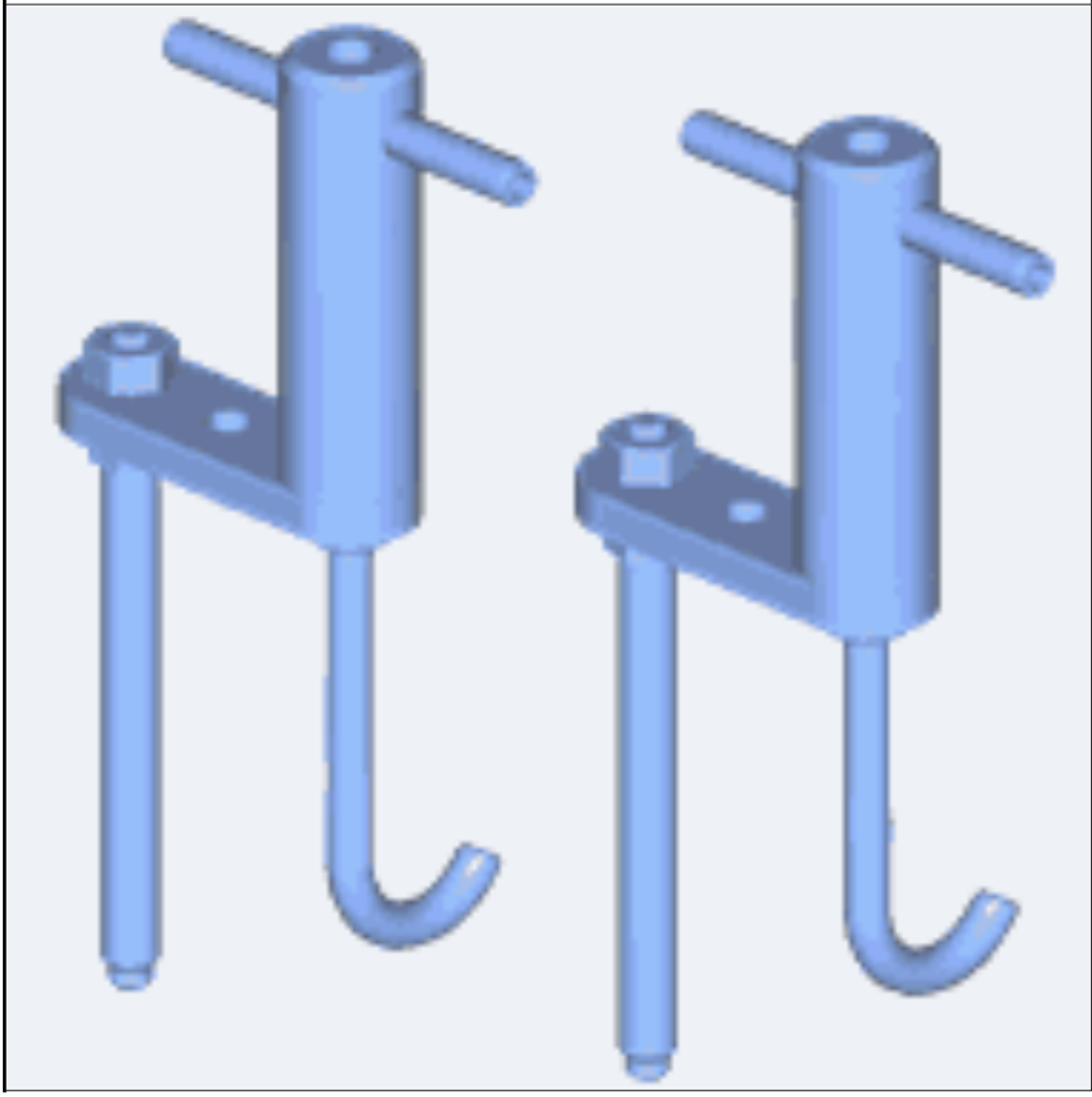
Illustration	Tool Number/Description
	EN-49248 Injector Rail Assembly Remover

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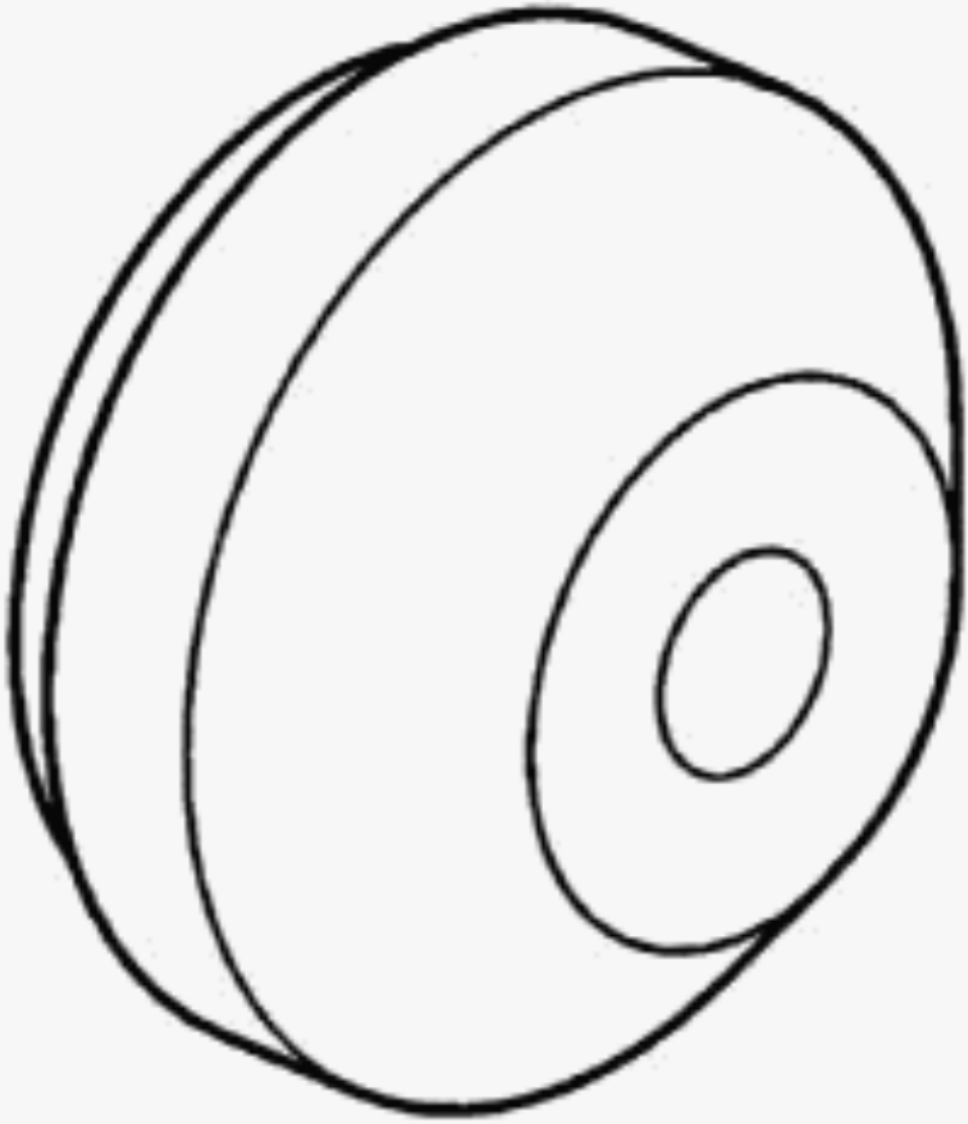
Illustration	Tool Number/Description
	EN-51091 Crankshaft Front Oil Seal Installer

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Illustration	Tool Number/Description
	EN-51096 Rear Main Seal Remover

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Illustration	Tool Number/Description
	EN-36857 J-36857 Engine Lift Bracket

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