

2010 ENGINE

Engine Mechanical - 2.2L or 2.4L - Equinox & Terrain

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
A/C Compressor to Block Bolt	20 N.m	15 lb ft
Air Pump Assembly Bolt	22 N.m	16 lb ft
Balance Shaft Bearing Carrier to Block Bolt	10 N.m	89 lb in
Balance Shaft Chain Guide Bolt, Adjustable	10 N.m	89 lb in
Balance Shaft Chain Guide Bolt, Fixed	12 N.m	106 lb in
Balance Shaft Chain Tensioner	10 N.m	89 lb in
Block Core Plug	35 N.m	26 lb ft
Block Heater Bolt	10 N.m	89 lb in
Cam Cover to Cylinder Head Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Stud	10 N.m	89 lb in
Camshaft		
• Camshaft Bearing Cap Bolt	10 N.m	89 lb in
• Camshaft Position Actuator Solenoid Valve Bolt	10 N.m	89 lb in
• Camshaft Position Sensor Bolt	10 N.m	89 lb in
• Exhaust Camshaft Position Actuator - First Pass	30 N.m	22 lb ft
• Exhaust Camshaft Position Actuator - Final Pass	100 degrees	
• Intake Camshaft Position Actuator - First Pass	30 N.m	22 lb ft
• Intake Camshaft Position Actuator - Final Pass	100 degrees	
• Intake Camshaft Rear Cap Bolt	10 N.m	89 lb in
Connecting Rod Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Crankshaft Balancer Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	125 degrees	
Crankshaft Position Reluctor Ring	15 N.m	11 lb ft
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Cylinder Head Bolt		

• First Pass	30 N.m	22 lb ft
• Final Pass	155 degrees	
Cylinder Head Front Chaincase Bolt	35 N.m	26 lb ft
Cylinder Head Oil Gallery Plug	35 N.m	26 lb ft
Drive Belt Tensioner Bolt	45 N.m	33 lb ft
Engine Block Oil Gallery Plug	60 N.m	44 lb ft
Engine Coolant Air Bleed Fitting	15 N.m	11 lb ft
Engine Coolant Temperature Sensor	20 N.m	15 lb ft
Engine Lift Bracket Bolt, Front	25 N.m	18 lb ft
Engine Lift Bracket Bolt, Rear	25 N.m	18 lb ft
Engine Lift Bracket Stud	25 N.m	18 lb ft
Engine Mount Bracket to Body Bolts	62 N.m	46 lb ft
Engine Mount Bracket to Engine Bolts	100 N.m	74 lb ft
Engine to Transmission Bolts	75 N.m	55 lb ft
EVAP Canister Valve Bolt	25 N.m	18 lb ft
Exhaust Manifold Heat Shield Bolt	25 N.m	18 lb ft
Exhaust Manifold to Cylinder Head Nut - 2 passes	14 N.m	124 lb in
Exhaust Manifold to Cylinder Head Stud	15 N.m	11 lb ft
Flywheel Bolt - Automatic Transmission		
• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	
Front Cover to Block Bolt	25 N.m	18 lb ft
Front Lift Bracket Bolt	25 N.m	18 lb ft
Fuel Feed Intermediate Pipe	30 N.m	22 lb ft
Fuel Pipe Bracket Bolt	10 N.m	89 lb in
Fuel Pump Cover Nut	10 N.m	89 lb in
Fuel Rail Assembly Bolt	25 N.m	18 lb ft
Fuel Rail Harness Connector Bracket Bolt	10 N.m	89 lb in
Generator to Block Bolt	23 N.m	17 lb ft
Generator Wiring Harness Nut	20 N.m	15 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Intake Manifold Insulator Bolt	10 N.m	89 lb in
Intake Manifold to Cylinder Head Bolt	10 N.m	89 lb in
Intake Manifold to Cylinder Head Nut	10 N.m	89 lb in
Intake Manifold to Cylinder Head Stud	6 N.m	53 lb in
Knock Sensor Bolt	25 N.m	18 lb ft
Lower Crankcase Bolts		
• Crankshaft Bearings - Lower Crankcase to Block - Bedplate		
• First Pass	20 N.m	15 lb ft
	70 Degrees	

• Final Pass		
• Lower Crankcase Perimeter Bolt	25 N.m	18 lb ft
Manifold Absolute Pressure (MAP) Sensor Bolt	4 N.m	35 lb in
Oil Filter Cap	22 N.m	16 lb ft
Oil Gallery Gerotor Cover - Rear Bolt	6 N.m	53 lb in
Oil Level Indicator Tube to Intake Manifold Bolt	10 N.m	89 lb in
Oil Pan Baffle	14 N.m	124 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan to Block Bolts	25 N.m	18 lb ft
Oil Pressure Switch	26 N.m	19 lb ft
Oil Pump Cover Bolt	6 N.m	53 lb in
Oil Pump Pressure Relief Valve Plug	40 N.m	30 lb ft
Oxygen Sensor	42 N.m	31 lb ft
Piston Oil Nozzle Assembly	15 N.m	11 lb ft
Positive Battery Cable to Starter Motor	9 N.m	80 lb in
Spark Plug	20 N.m	15 lb ft
Starter Motor to Block Bolt	53 N.m	39 lb ft
Starter Motor Wiring Harness Nut	3 N.m	27 lb in
Thermostat Housing to Block Bolts	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Nut	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
Timing Chain Guide Bolt, Adjustable	10 N.m	89 lb in
Timing Chain Guide Bolt, Fixed	12 N.m	106 lb in
Timing Chain Guide Bolt, Upper	10 N.m	89 lb in
Timing Chain Guide Bolt Access Hole Plug	90 N.m	59 lb ft
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Timing Chain Tensioner	75 N.m	55 lb ft
Transmission to Engine Brace Bolts	50 N.m	37 lb ft
Transmission Torque Converter to Flywheel Bolt	62 N.m	46 lb ft
Vent Tube to Cylinder Head	15 N.m	11 lb ft
Water Jacket Drain Plug	20 N.m	15 lb ft
Water Pipe Support Bracket Bolt	10 N.m	89 lb in
Water Pump Access Cover Bolt	10 N.m	89 lb in
Water Pump/Balance Shaft Chain Tensioner Bolt	10 N.m	89 lb in
Water Pump Bolts	25 N.m	18 lb ft
Water Pump Cover Stud	10 N.m	89 lb in
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.4 L	146 CID
• RPO	LAF	
• Liter (VIN)	Passenger Car: C Truck: W	
• Bore	87.992-88.008 mm	3.4668-3.4675 in
• Stroke	98 mm	3.861 in
• Compression Ratio	10:01	
Balance Shaft		
• Bearing Clearance	0.030-0.060 mm	0.0012-0.0024 in
• Bearing Diameter - Inside - Carrier	20.050-20.063 mm	0.7894-0.7899 in
• Bearing Diameter - Outside - Carrier	41.975-41.995 mm	1.6526-1.6534 in
• Bearing Journal Diameter	20.000-20.020 mm	0.7874-0.7882 in
• Bushing Clearance	0.033-0.102 mm	0.0013-0.0040 in
• Bushing Diameter - Inside	36.776-36.825 mm	1.4479-1.4498 in
• Bushing Journal Diameter	36.723-36.743 mm	1.4458-1.4466 in
• End Play	0.050-0.300 mm	0.0020-0.0118 in
Block		
• Balance Shaft Bearing Bore Diameter - Carrier	42.000-42.016 mm	1.6535-1.6542 in
• Balance Shaft Bushing Bore Diameter	40.763-40.776 mm	1.6048-1.6054 in
• Crankshaft Main Bearing Bore Diameter	64.068-64.082 mm	2.5224-2.5229 in
• Cylinder Bore Diameter	87.992-88.008 mm	3.4668-3.4675 in
• Cylinder Bore Out-of-Round - Maximum	0.010 mm	0.0004 in
• Cylinder Bore Taper - Maximum	0.010 mm	0.0004 in
• Cylinder Head Deck Surface Flatness - Longitude	0.050 mm	0.002 in
• Cylinder Head Deck Surface Flatness - Overall	0.08 mm	0.0031 in
• Cylinder Head Deck Surface Flatness - Transverse	0.030 mm	0.0012 in
Camshaft		
• Camshaft End Play	0.040-0.144 mm	0.0016-0.0057 in
• Camshaft Journal Diameter	26.935-26.960 mm	1.0604-1.0614 in
• Camshaft Thrust Surface	21.000-21.052 mm	0.8268-0.8252 in
Connecting Rod		

• Connecting Rod Bearing Clearance	0.029-0.073 mm	0.0011-0.0029 in
• Connecting Rod Bore Diameter - Bearing End	52.118-52.134 mm	2.0519-2.05252 in
• Connecting Rod Bore Diameter - Pin End	20.007-20.017 mm	0.7877-0.7881 in
• Connecting Rod Side Clearance	0.070-0.370 mm	0.0028-0.0146 in
• Connecting Rod Straightness - Bend - Maximum	0.021 mm	0.0083 in
• Connecting Rod Straightness - Twist - Maximum	0.04 mm	0.0157 in
Crankshaft		
• Connecting Rod Journal Diameter	48.999-49.015 mm	1.9291-1.9297 in
• Crankshaft End Play	0.050-0.380 mm	0.0012-0.0150 in
• Crankshaft Main Bearing Clearance	0.031-0.067 mm	0.0012-0.0026 in
• Crankshaft Main Journal Diameter	55.993-56.009 mm	2.2044-2.2051 in
Cylinder Head		
• Overall Height - Minimum	128.9 mm	5.07 in
• Surface Flatness - Block Deck - Longitude	0.050 mm	0.002 in
• Surface Flatness - Block Deck - Overall	0.1 mm	0.004 in
• Surface Flatness - Block Deck - Transverse	0.030 mm	0.0012 in
• Valve Guide Bore - Exhaust	6.000-6.012 mm	0.2362-0.2367 in
• Valve Guide Bore - Intake	6.000-6.012 mm	0.2362-0.2367 in
• Valve Lifter Bore Diameter - Stationary Lash Adjusters	12.013-12.037 mm	0.4730-0.4739 in
• Valve Seat Angle - Relief Surface	30 Degrees	
• Valve Seat Angle - Seating Surface	45 Degrees	
• Valve Seat Angle - Undercut Surface	60 Degrees	
• Valve Seat Roundness - Maximum	0.025 mm	0.0010 in
• Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valve Seat Width - Exhaust Seating Surface	1.600 mm	0.0630 in
• Valve Seat Width - Intake Seating Surface	1.200 mm	0.0472 in
Lubrication System		
• Oil Pressure - Minimum - @1000 RPM @ 90°C (194°F)	206.84-482.63 kPa	30-70 psi
• Oil Capacity	4.7L	5.0 quarts
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.15-0.30 mm	0.006-0.012 in
• Piston Ring End Gap - Second Compression Ring	0.20-0.45 mm	0.008-0.018 in

• Piston Ring End Gap - Oil Control Ring - Rails	0.15-0.65 mm	0.006-0.026 in
• Piston Ring to Groove Clearance - First Compression Ring	0.04-0.08 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.030-0.070 mm	0.0012-0.0030 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.058-0.207 mm	0.0023-0.0081 in
• Piston Ring Thickness - First Compression Ring	1.170-1.190 mm	0.0461-0.0469 in
• Piston Ring Thickness - Second Compression Ring	1.471-1.490 mm	0.0579-0.0587 in
• Piston Ring Thickness - Oil Control Ring - Rail - Maximum	0.473 mm	0.0186 in
• Piston Ring Thickness - Oil Control Ring - Spacer - Rail	0.929-1.006 mm	0.0366-0.0396 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.007-0.020 mm	0.0003-0.0008 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.004-0.012 mm	0.0002-0.0005 in
• Pin - Piston Pin Diameter	19.997-20.000 mm	0.7873-0.7874 in
• Pin - Piston Pin End Play	0.410-1.266 mm	0.0161-0.0498 in
• Piston - Piston Diameter - @14.5 mm up	87.967-87.982 mm	3.4633-3.4638 in
• Piston - Piston Pin Bore Diameter	20.004-20.009 mm	0.7876-0.7878 in
• Piston - Piston Ring Groove Width - Oil Control	2.01-2.03 mm	0.0791-0.0799 in
• Piston - Piston Ring Groove Width - Second	1.52-1.54 mm	0.0598-0.0606 in
• Piston - Piston Ring Groove Width - Top	1.23-1.25 mm	0.0484-0.0492 in
• Piston - Piston to Bore Clearance	0.010-0.041 mm	0.0004-0.0016 in
Valve System		
• Valves - Valve Face Angle	45 Degrees	
• Valves - Valve Face Runout - Maximum	0.040 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valves - Valve Face Seat Width - Exhaust	1.6000 mm	0.06299 in
• Valves - Valve Face Seat Width - Intake	1.2000 mm	0.04724 in
• Valves - Valve Head Diameter - Exhaust	29.950-30.250 mm	1.1791-1.1909 in
• Valves - Valve Head Diameter - Intake	34.950-35.250 mm	1.3760-1.4154 in
• Valves - Valve Head O.D. and Chamfer Height - Exhaust	1.1174 mm	0.04399 in
• Valves - Valve Head O.D. and Chamfer Height - Intake	1.0526 mm	0.04144 in

• Valves - Valve Stem Diameter - Exhaust	5.935-5.950 mm	0.2337-0.2343 in
• Valves - Valve Stem Diameter - Intake	5.955-5.970 mm	0.2344-0.2355 in
• Valves - Valve Stem Height - Closed	32.500 mm	1.2795 in
• Valves - Valve Stem to Guide Clearance - Exhaust	0.050-0.077 mm	0.0020-0.0026 in
• Valves - Valve Stem to Guide Clearance - Intake	0.030-0.057 mm	0.0012-0.0022 in
• Valve Lash Adjusters - Valve Lash Adjuster Diameter - Stationary Lash Adjuster	11.986-12.000 mm	0.0005-0.0020 in
• Valve Lash Adjusters - Valve Lash-Adjuster-to-Bore Clearance - Stationary Lash Adjuster	0.013-0.051 mm	3.2210-3.2299 in
• Valve Rocker Arms - Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arms - Rocker Arm Roller Diameter	17.740-17.800 mm	0.6987-0.7008 in
• Valve Springs - Valve Spring Free Length	41.400-44.200 mm	1.6299-1.7402 in
• Valve Springs - Valve Spring Installed Height - Closed	32.500 mm	1.2795 in
• Valve Springs - Valve Spring Installed Height - Open	22.500 mm	0.8858 in
• Valve Springs - Valve Spring Load - Closed - @32.5 mm	245.0-271.0 N	55-61 lb
• Valve Springs - Valve Spring Load - Open - @22.5 mm	525.0-575.0 N	118-129 lb

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
# 6 Intake Camshaft Rear Cap	Sealant	12378521	88901148
Balance Shaft Bearings	Engine Oil	12345610	993193
Cam Lobes	Engine Oil	12345610	993193
Crank Sensor O-ring	Engine Oil	12345610	993193
Cylinder Bores	Engine Oil	12345610	993193
Cylinder Head Plugs	Sealant	12345382	10953489
Engine Block Threaded Plugs	Sealant	12346004	10953480
Engine Block to Bedplate	Sealant	12378521	88901148
Engine Oil	Engine Oil	12345610	993193
Fuel Injector O-rings	Engine Oil	12345610	993193
Hydraulic Lash Adjusters	Lubricant	12345501	992704
Intake and Exhaust Valve Stems	Lubricant	12345501	992704
Main Bearings	Lubricant	12345501	992704
Oil Filter Cap - Threads and O-ring Lead-in Chamfers	Engine Oil	12345610	993193

Oil Level Indicator Tube O-ring	Lubricant	12345501	992704
Oil Pan to Bedplate Joint	Sealant	12378521	88901148
Oil Pump - Pump Elements	Engine Oil	12345610	993193
Oxygen Sensor Threads	Anti-seize	12397953	-
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	Engine Oil	12345610	993193
Rod Bearings - Rod Pins of Crankshaft	Engine Oil	12345610	993193
Thread Repair	Cutting Fluid	1052864	992881
	Cleaner	12346139	10953463
		12377981	
Timing Chain Guide Bolt Access Hole Plug	Sealant	12345382	10953489
Valves	Parts Immersion Solvent	12345368	10953514
Valve Rocker Arm/Valve Tip	Lubricant	12345501	992704
Water Feed Tube O-rings	Lubricant	12345579	1974984
Water Pump Drain Plug	Sealant	12346004	10953480

THREAD REPAIR SPECIFICATIONS

Engine Block - Front View

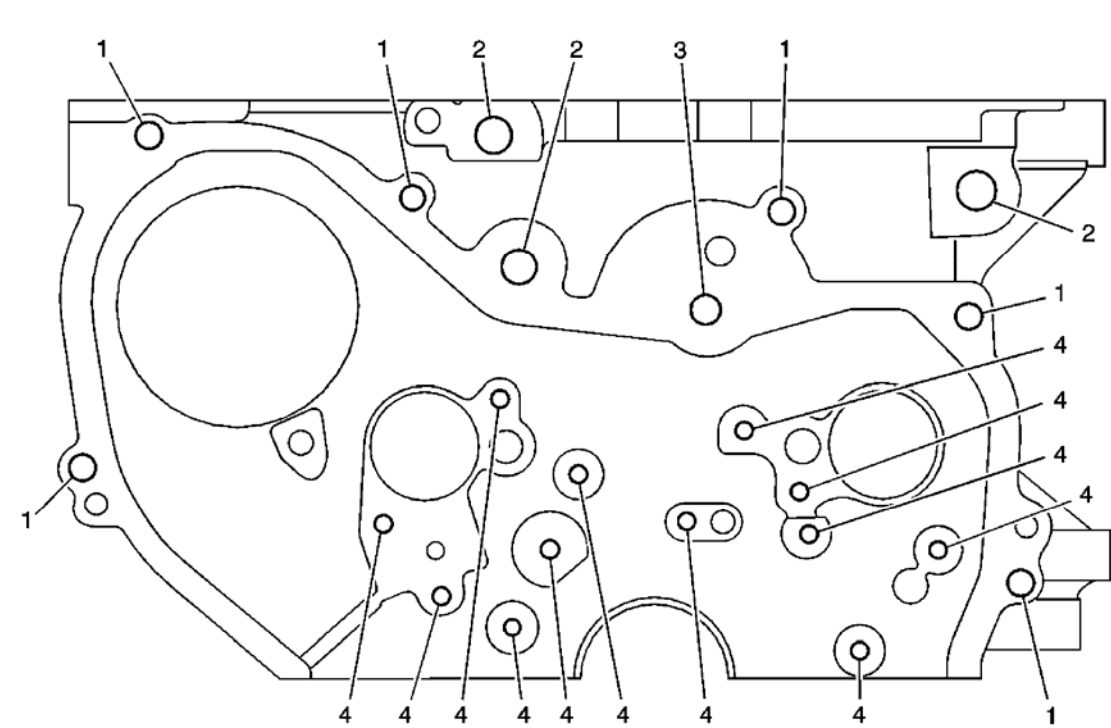


Fig. 1: Locating Bolts On Engine Block - Front View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
2	M12 x 1.75	855	856	857	858	859	33.5	1.32	26.5	1.04
3	M10 x 1.5	215	211	212	213	214	24.5	0.96	19.5	0.77
4	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

Engine Block - Back View

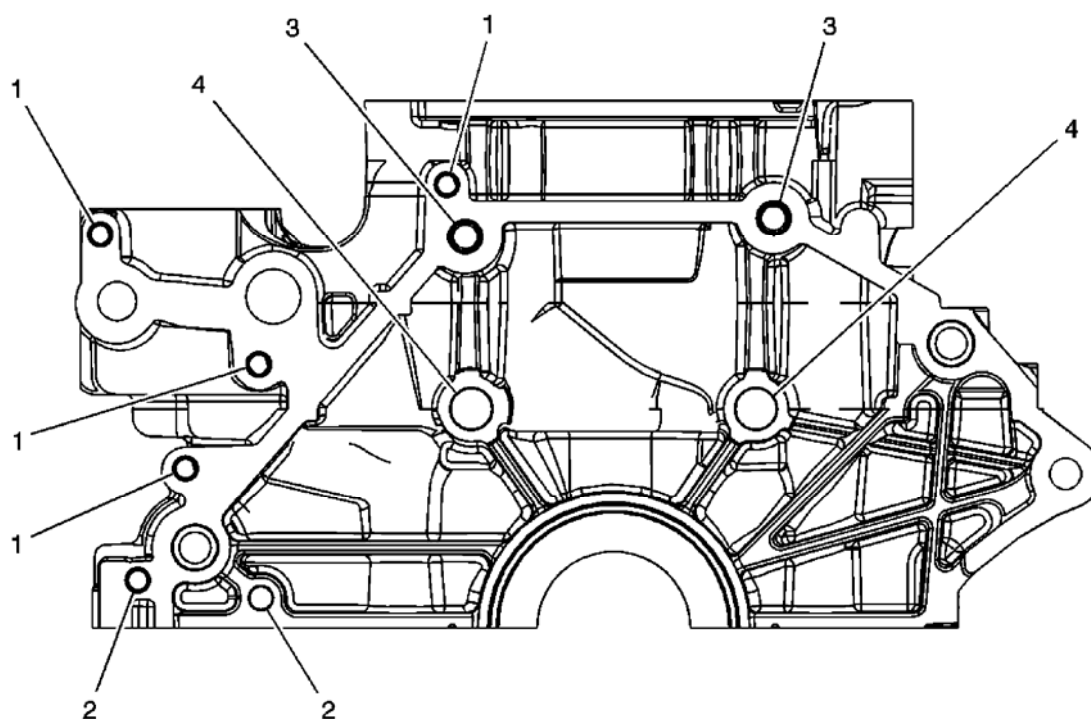


Fig. 2: Locating Bolts On Engine Block - Back View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Back View

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4	M16 x 1.5	860	861	862	863	864	21	0.827	15	0.59
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Engine Block - Right Side View

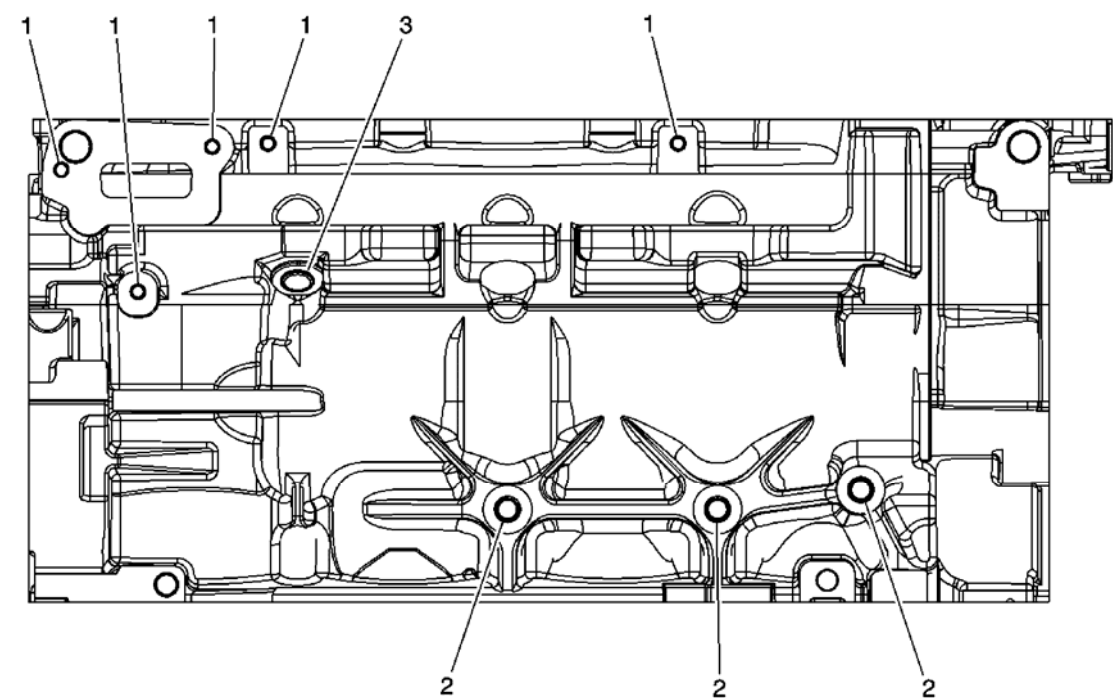


Fig. 3: Locating Bolts On Engine Block - Right Side View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20.5	0.807	16	0.63
2	M10 x 1.5	215	211	212	213	214	23.5	0.925	18.5	0.73
3	M12 x 1.75	865	856	857	858	859	19.5	0.768	12.5	0.49

Engine Block - Left Side View

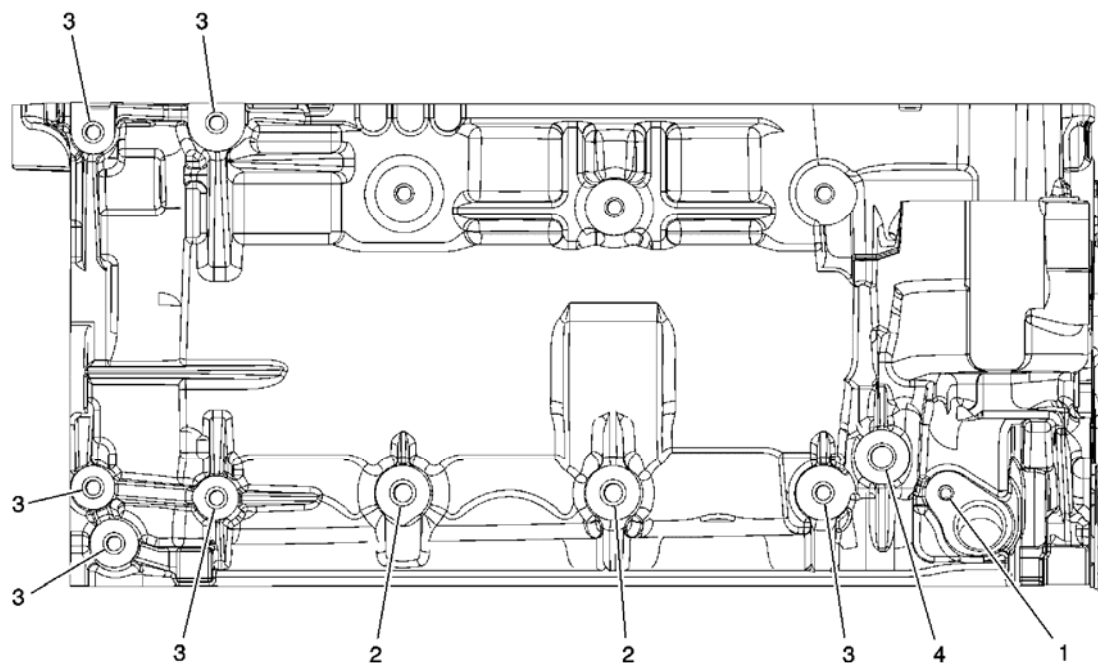


Fig. 4: Locating Bolts On Engine Block - Left Side View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20.5	0.807	16.5	0.65
2	M10 x 1.5	215	211	212	213	214	23.5	0.925	18	0.71
3	M8 x 1.25	210	206	2047	208	209	30.5	1.201	22.5	0.89
4	M12 x 1.75	865	856	857	858	859	15.5	.061	12.5	0.49

Engine Block - Bottom View

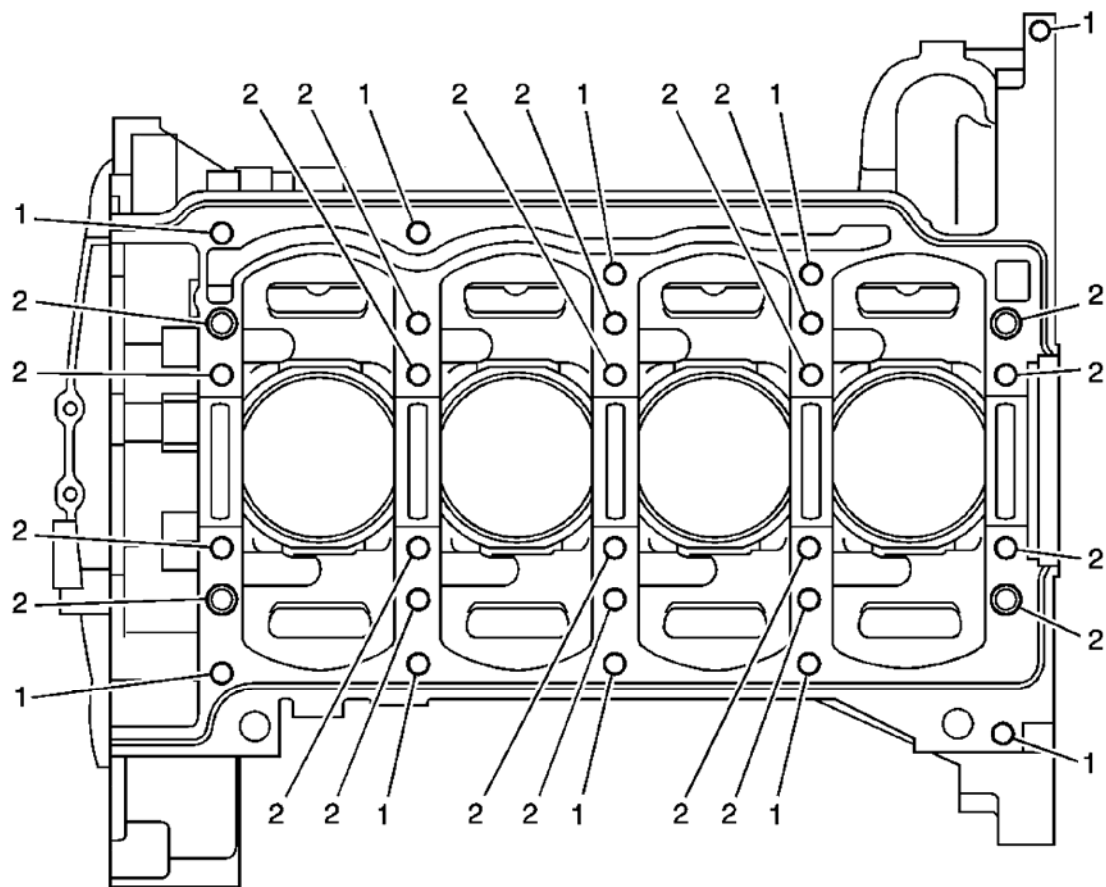


Fig. 5: Locating Bolts On Engine Block - Bottom View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
2	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11

Engine Block - Top View

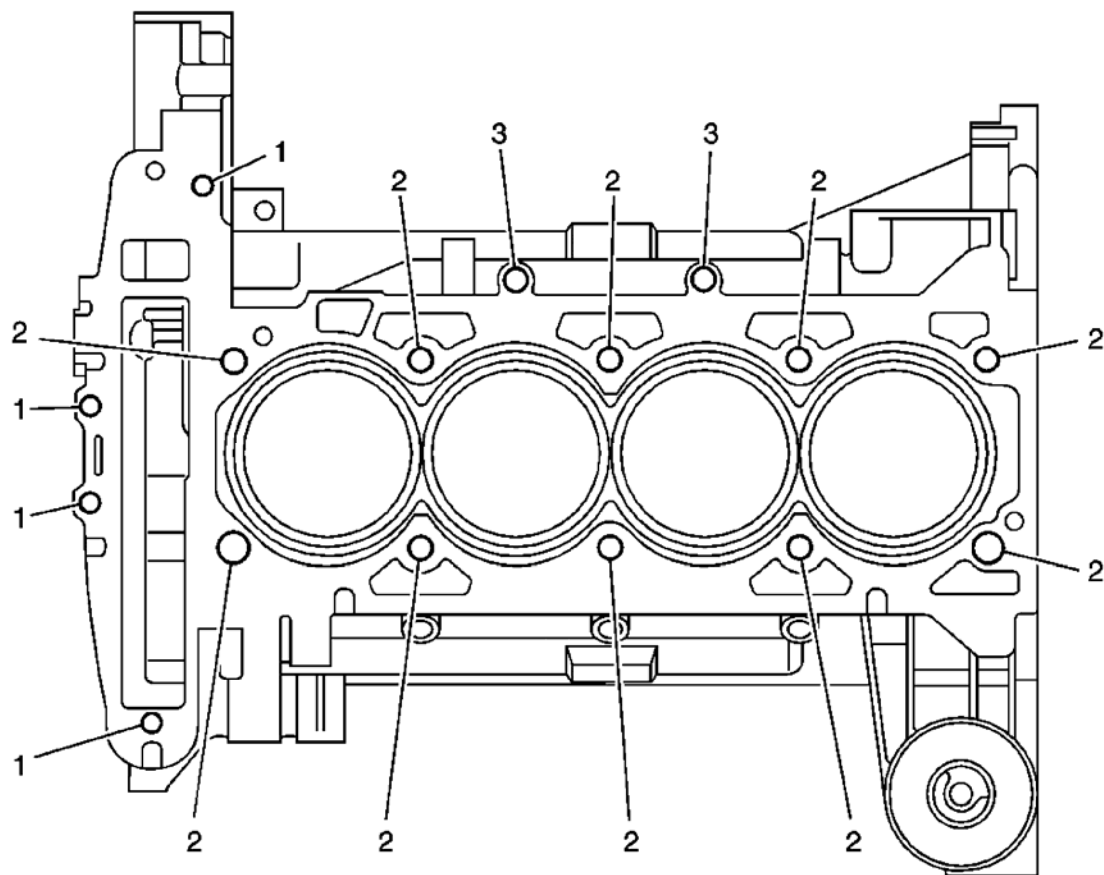


Fig. 6: Locating Bolts On Engine Block - Top View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73
2	M11 x 1.5	507	504	N/A	505	506	113.3	4.461	107.3	4.22
3	M12 x 1.75	865	856	857	858	859	13.5	0.531	12.5	0.49

Lower Crankcase - Front View

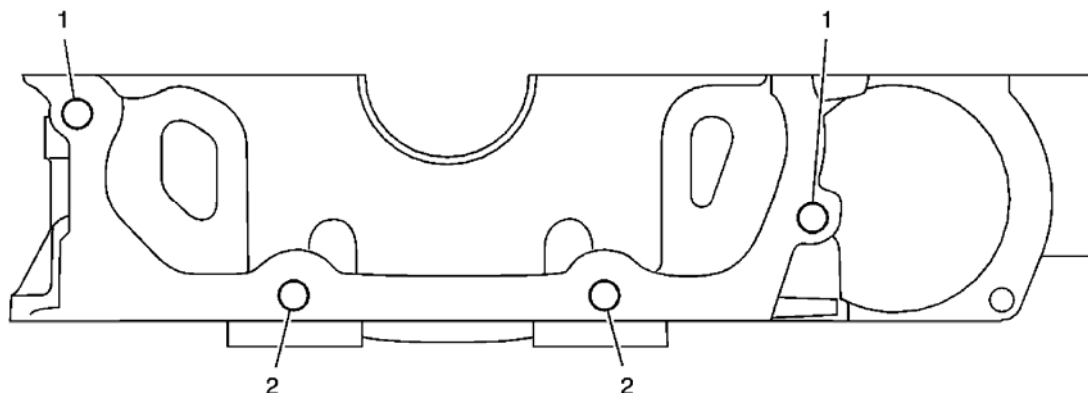


Fig. 7: Locating Bolts On Lower Crankcase -- Front View
 Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73
2	M8 x 1.25	210	206	207	208	209	30.5	1.201	25.5	1.00

Lower Crankcase - Back View

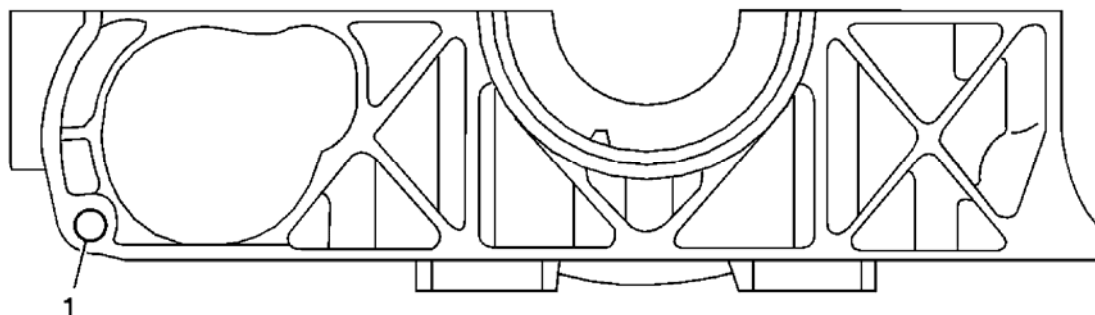


Fig. 8: Locating Bolt On Lower Crankcase - Back View
 Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	29.5	1.161	THRU	

Lower Crankcase - Bottom View

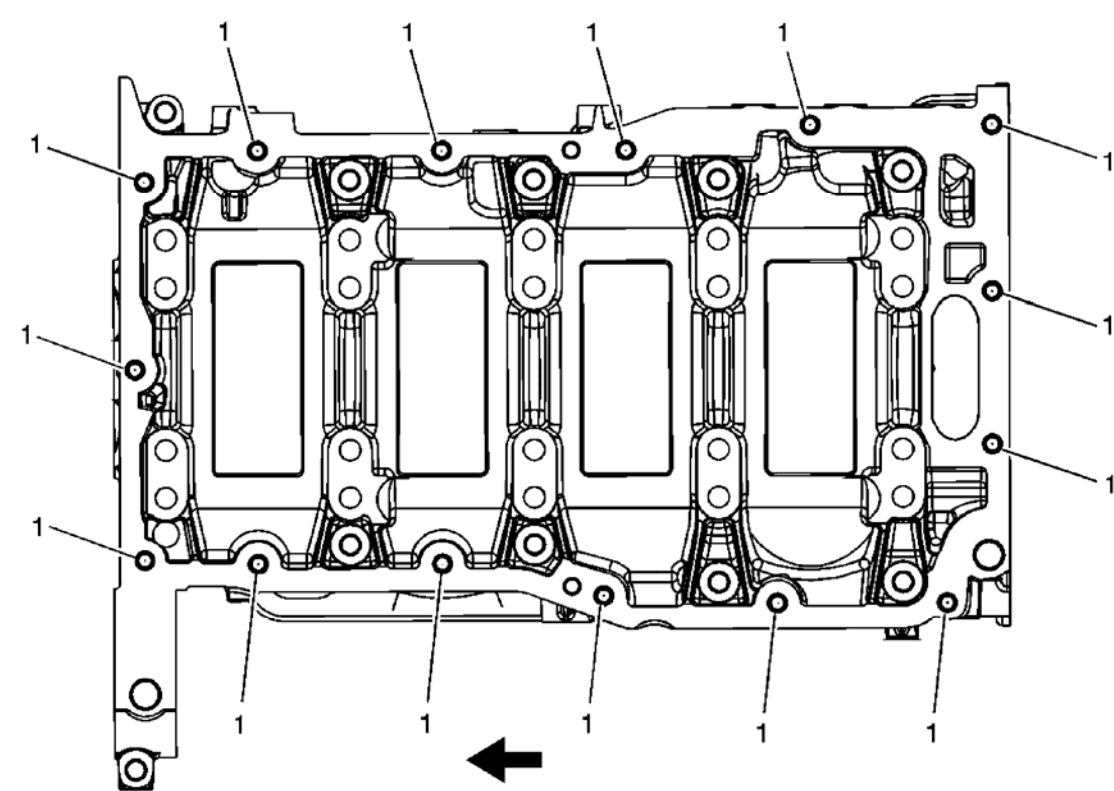


Fig. 9: Locating Bolt On Lower Crankcase - Bottom View
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73

Lower Crankcase - Right View

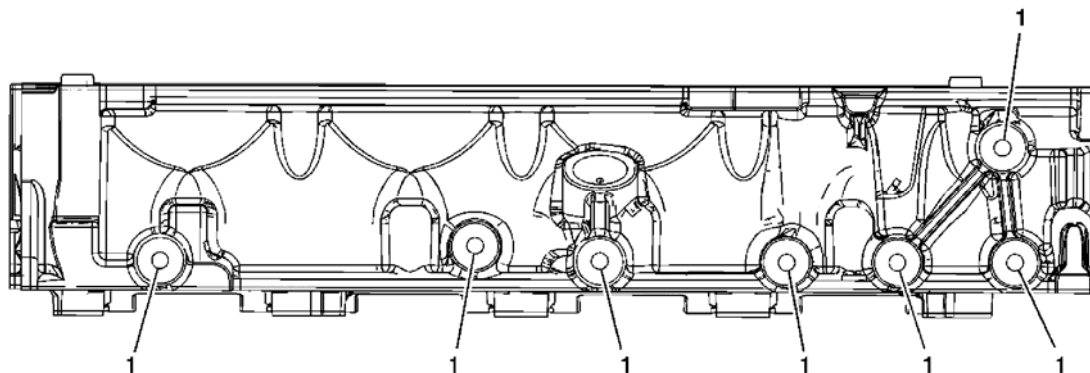


Fig. 10: Locating Bolts On Lower Crankcase - Right View
 Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Right View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	34	1.339	27	1.063

Lower Crankcase - Left View

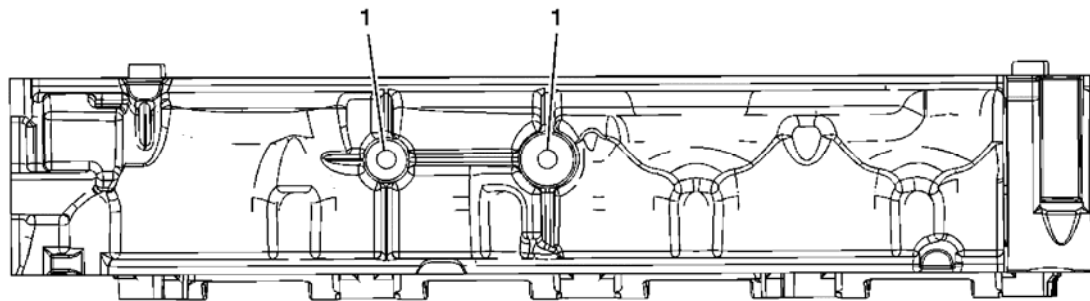


Fig. 11: Locating Bolts On Lower Crankcase - Left View
 Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Left View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	211	212	213	214	34	1.339	27	1.063

Cylinder Head - Top View

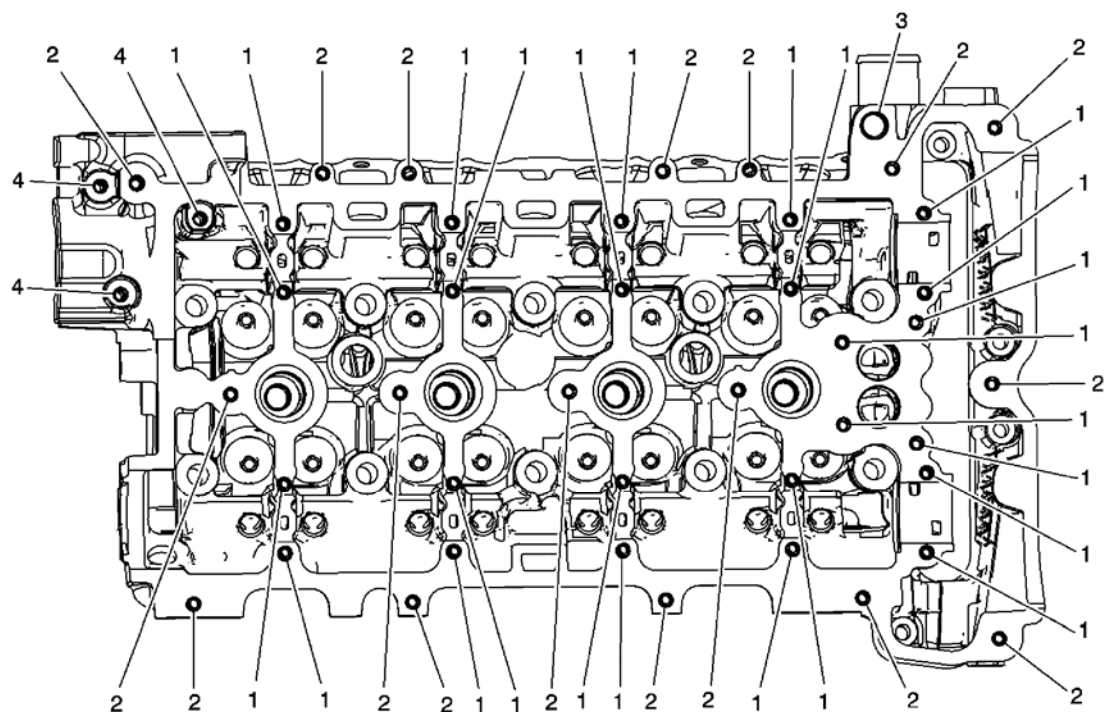


Fig. 12: Locating Bolts On Cylinder Head - Top View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	852	N/A	203	204	24	0.945	20	0.787
2	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
3	M14 x 1.75	854	857	N/A	858	859	THRU		THRU	
4	M8 x 1.25	854	853	N/A	208	209	30	1.182	27	1.063

Cylinder Head - Intake Manifold Deck View

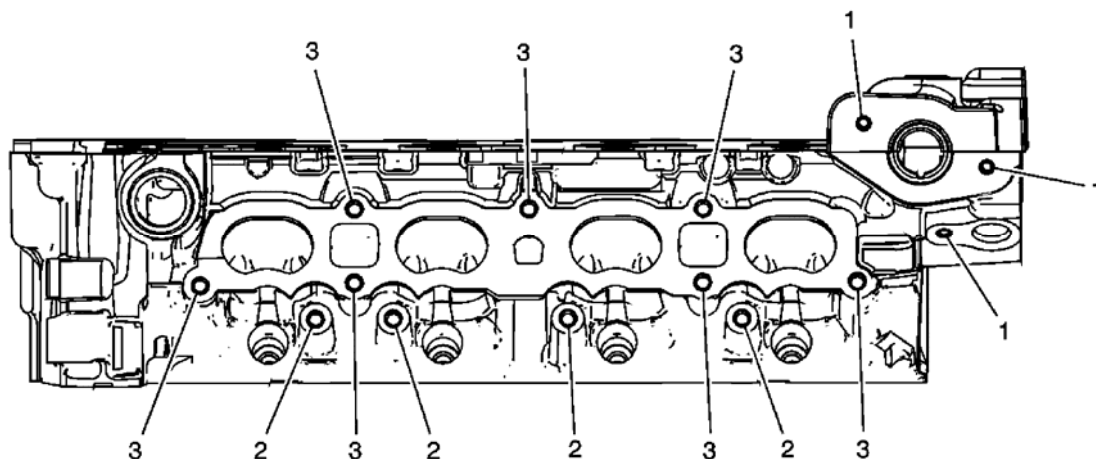


Fig. 13: Locating Bolts On Cylinder Head - Intake Manifold Deck
 Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake Manifold Deck View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
J 42385-850							MM	IN	MM	IN
1	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
2	M8 x 1.25	210	206	207	208	209	20	0.787	16	0.63
3	M8 x 1.25	205	201	202	203	204	16	0.630	12	0.473

Cylinder Head - Exhaust Manifold Deck View

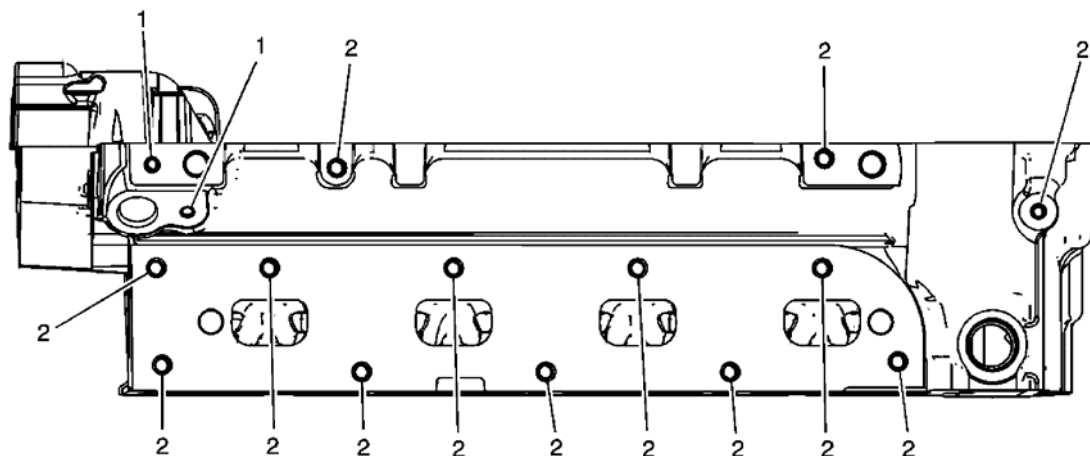


Fig. 14: Locating Bolts On Cylinder Head - Exhaust Manifold Deck
 Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Exhaust Manifold Deck View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20	0.78	16	0.63
2	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78

Cylinder Head - Front View

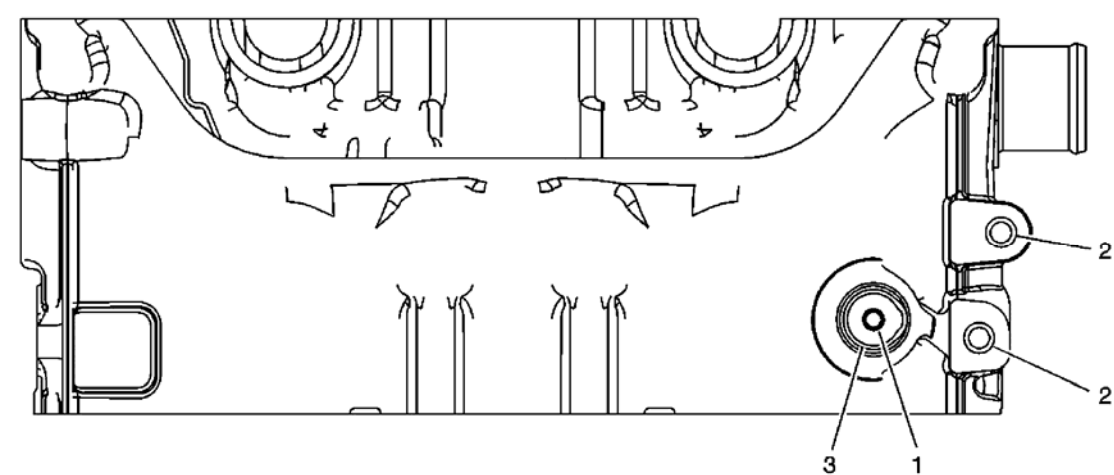


Fig. 15: Locating Bolts On Cylinder Head - Front View
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
2	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
3	M22 x 1.5	No Service Tools Available					THRU		THRU	

Cylinder Head - Back View

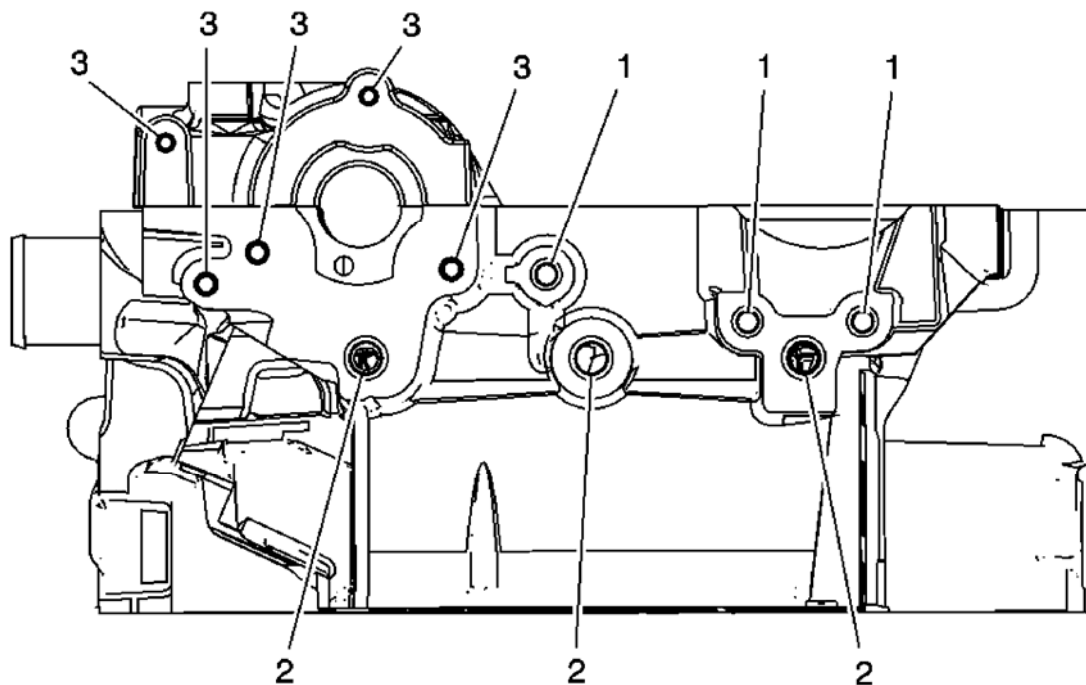


Fig. 16: Locating Bolts On Cylinder Head - Back View
 Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
							MM	IN	MM	IN
J 42385-850										
1	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
2	M12 x 1.75	865	856	857	858	859	18	0.709	14	0.551
3	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

COMPONENT LOCATOR

DISASSEMBLED VIEWS

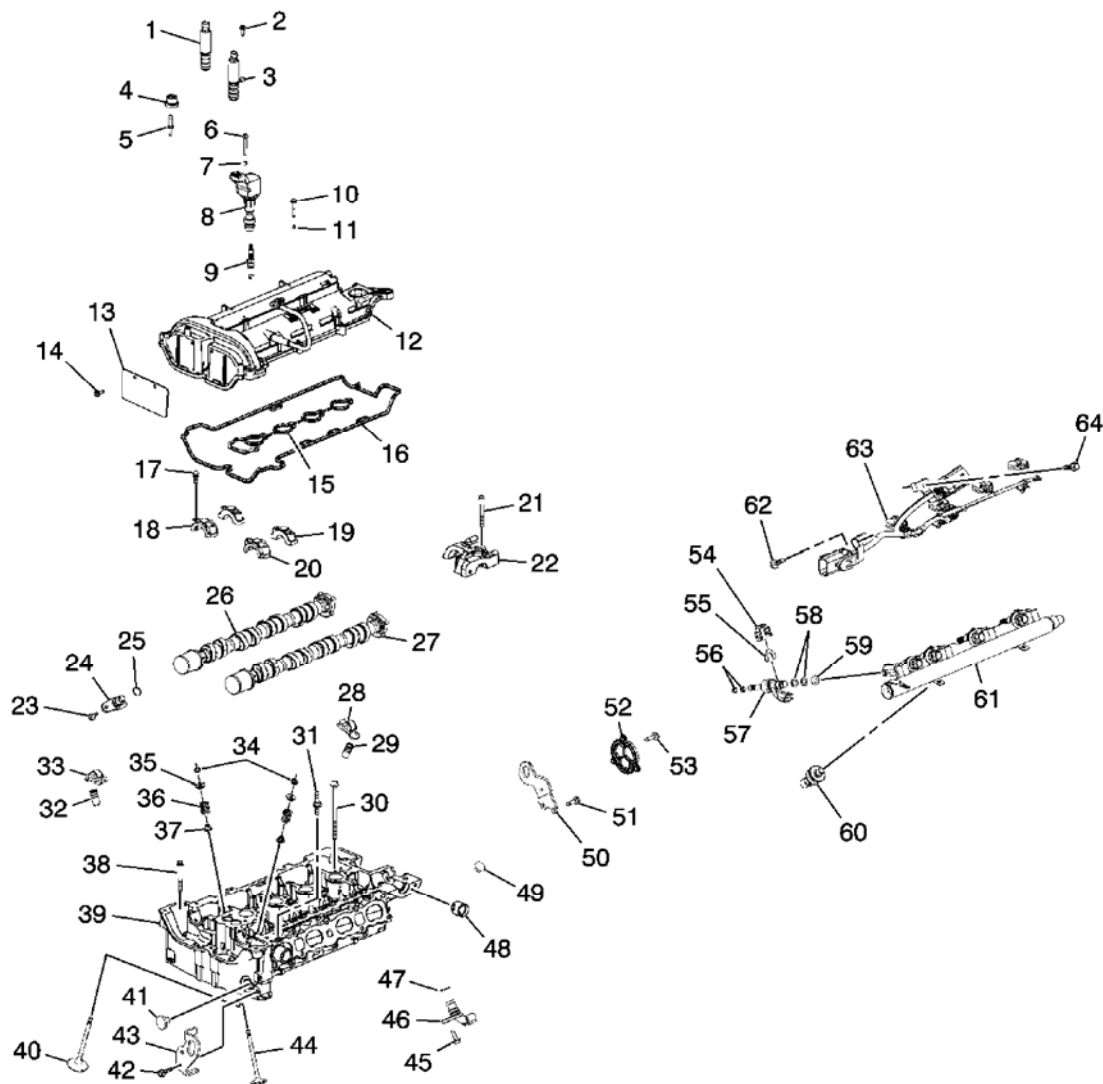


Fig. 17: Cylinder Head and Components
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve - Exhaust
2	Camshaft Position Actuator Solenoid Valve Bolt
3	Camshaft Position Actuator Solenoid Valve - Intake
4	Upper Intake Manifold Sight Shield Grommet
5	Ball Stud
6	Ignition Coil Bolt
7	Ignition Coil Bolt Retainer
8	Ignition Coil
9	Spark Plug

10	Camshaft Cover Bolt
11	Camshaft Cover Bolt Retainer
12	Camshaft Cover
13	Camshaft Housing Cover Insulator
14	Camshaft Housing Cover Insulator Bolt
15	Camshaft Cover Seal
16	Camshaft Cover Seal
17	Camshaft Bearing Cap Bolt
18	Camshaft Bearing Front Cap
19	Camshaft Bearing Cap
20	Camshaft Bearing Front Cap
21	Camshaft Rear Cap Bolt
22	Intake Camshaft Rear Cap
23	Camshaft Position Sensor Bolt
24	Camshaft Position Sensor
25	Camshaft Position Sensor O-Ring
26	Exhaust Camshaft
27	Intake Camshaft
28	Roller Finger Follower
29	Hydraulic Lash Adjuster
30	Cylinder Head Bolt
31	Engine Coolant Air Bleed Fitting
32	Hydraulic Lash Adjuster
33	Roller Finger Follower
34	Valve Keys
35	Valve Spring Retainer
36	Valve Spring
37	Valve Stem Seal
38	Small Cylinder Head Bolt
39	Cylinder Head
40	Valve
41	Timing Chain Guide Bolt Access Hole Plug
42	Front Lift Bracket Bolt
43	Front Lift Bracket
44	Valve
45	Camshaft Position Sensor Bolt
46	Camshaft Position Sensor
47	Camshaft Position Sensor O-Ring
48	High Pressure Fuel Pump Roller Lifter
49	Cylinder Head Gallery Plug
50	Rear Lift Bracket

Callout	Component Name
1	Oil Fill Cap
2	Intake Manifold Cover
3	Oil Fill Tube Assembly
4	Oil Fill Cap O-Ring
5	Fuel Pump Housing Seal
6	Fuel Pump Gasket
7	Fuel Pump Assembly
8	Fuel Pump Insulator
9	Fuel Pump Cover
10	Fuel Pump Cover Nut
11	Fuel Feed Intermediate Pipe
12	Low Pressure Fuel Pipe Assembly, model dependent
13	Low Pressure Fuel Pipe Assembly Bolt
14	Manifold Absolute Pressure (MAP) Sensor Bolt
15	MAP Sensor
16	MAP Sensor O-Ring
17	Intake Manifold Nut
18	Throttle Body
19	Intake Manifold Stud
20	Intake Manifold Insulator Bolt
21	Intake Manifold Insulator
22	Oil Indicator Tube
23	Oil Indicator Tube Bolt
24	Oil Indicator Tube O-Ring
25	Oil Indicator
26	Oil Indicator O-Ring
27	Intake Manifold
28	Evaporative (EVAP) Emission Canister Purge Tube Assembly
29	EVAP Emission Canister Purge Solenoid Valve

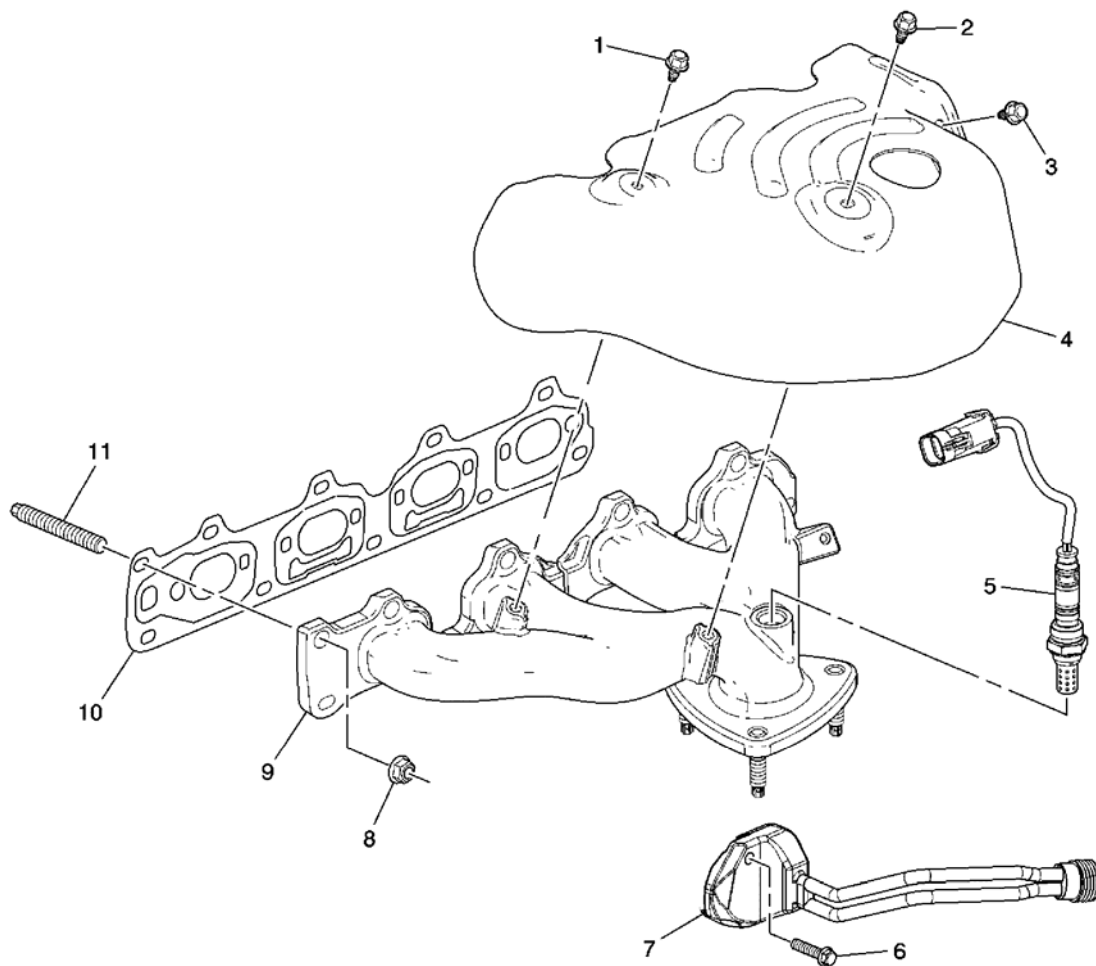


Fig. 19: Exhaust Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Exhaust Manifold Heat Shield Bolt
2	Exhaust Manifold Heat Shield Bolt
3	Exhaust Manifold Heat Shield Bolt
4	Exhaust Manifold Heat Shield
5	Oxygen Sensor
6	Block Heater Bolt
7	Block Heater
8	Exhaust Manifold Nut
9	Exhaust Manifold
10	Exhaust Manifold Gasket
11	Exhaust Manifold Stud

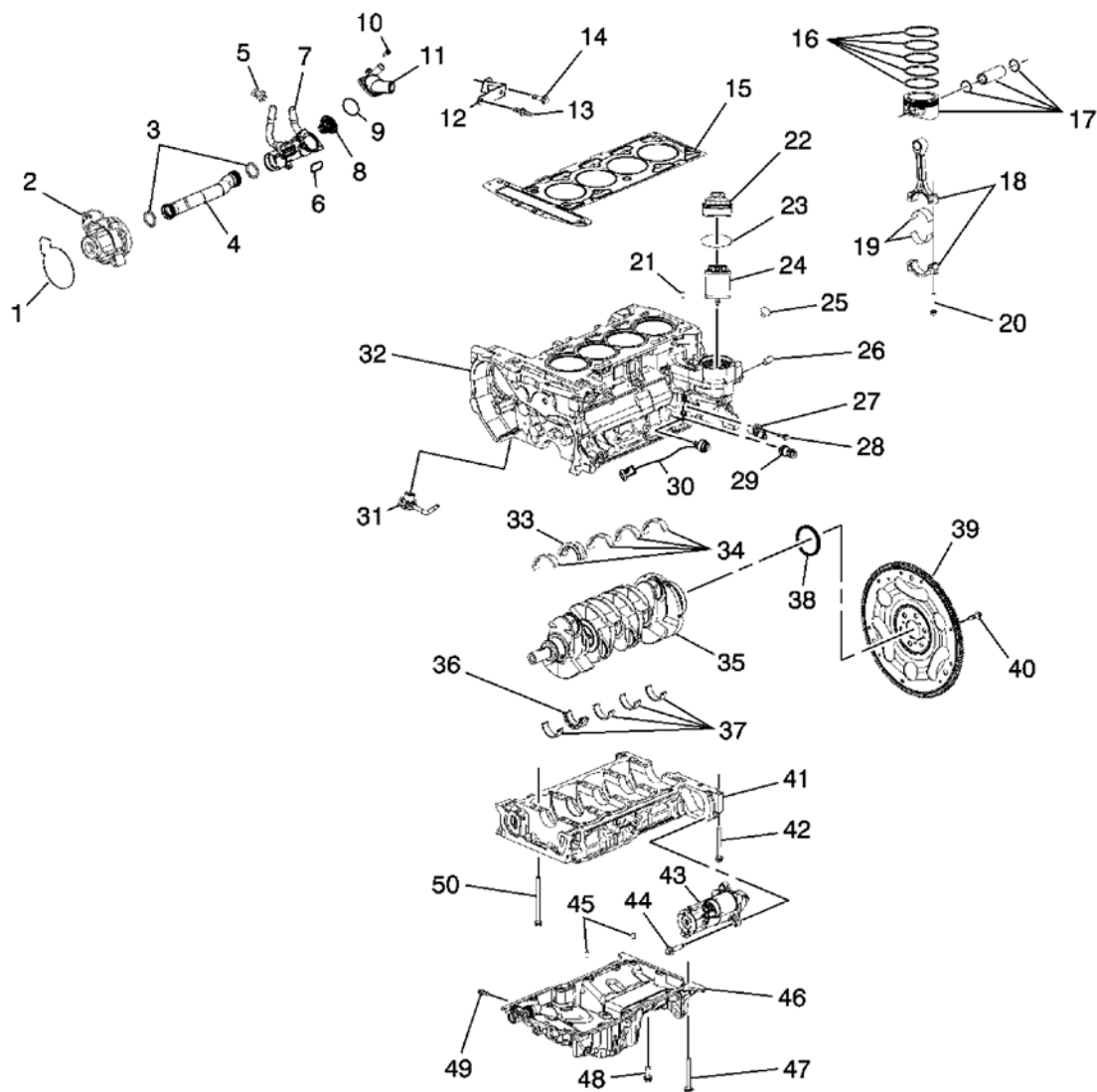


Fig. 20: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Water Pump to Engine Block Seal
2	Water Pump
3	Water Transfer Pipe O-ring Seals
4	Water Transfer Pipe
5	Coolant Temperature Sensor
6	Thermostat Housing to Block Gasket
7	Thermostat Housing
8	Thermostat
9	Thermostat Gasket

10	Thermostat Housing Cap Bolt
11	Thermostat Housing Cap
12	Water Pipe Support Bracket
13	Water Pipe Support Bracket Bolt Stud
14	Water Pipe Support Bracket Bolt
15	Cylinder Head Gasket
16	Piston Ring Assembly
17	Piston Assembly
18	Connecting Rod
19	Connecting Rod Bearing
20	Connecting Rod Cap Bolt
21	Cylinder Head Alignment Pin
22	Oil Filter Cap
23	Oil Filter Cap O-Ring
24	Oil Filter
25	Engine Block Gallery Plug
26	Engine Block to Transaxle Alignment Pin
27	Crankshaft Position Sensor
28	Crankshaft Position Sensor Bolt
29	Oil Pressure Switch
30	Knock Sensor
31	Piston Oil Nozzle
32	Engine Block
33	Crankshaft Thrust Bearing - Upper
34	Crankshaft Bearing - Upper
35	Crankshaft
36	Crankshaft Thrust Bearing - Lower
37	Crankshaft Bearing - Lower
38	Crankshaft Rear Seal
39	Flywheel
40	Flywheel to Crankshaft Bolt
41	Lower Crankcase
42	Lower Crankcase Perimeter Bolt
43	Starter
44	Starter Bolt
45	Engine Oil Pan Alignment Pins
46	Engine Oil Pan
47	Engine Oil Pan Long Bolt
48	Engine Oil Pan Bolt
49	Engine Oil Pan Drain Plug
50	Lower Crankcase Main Bearing Bolt

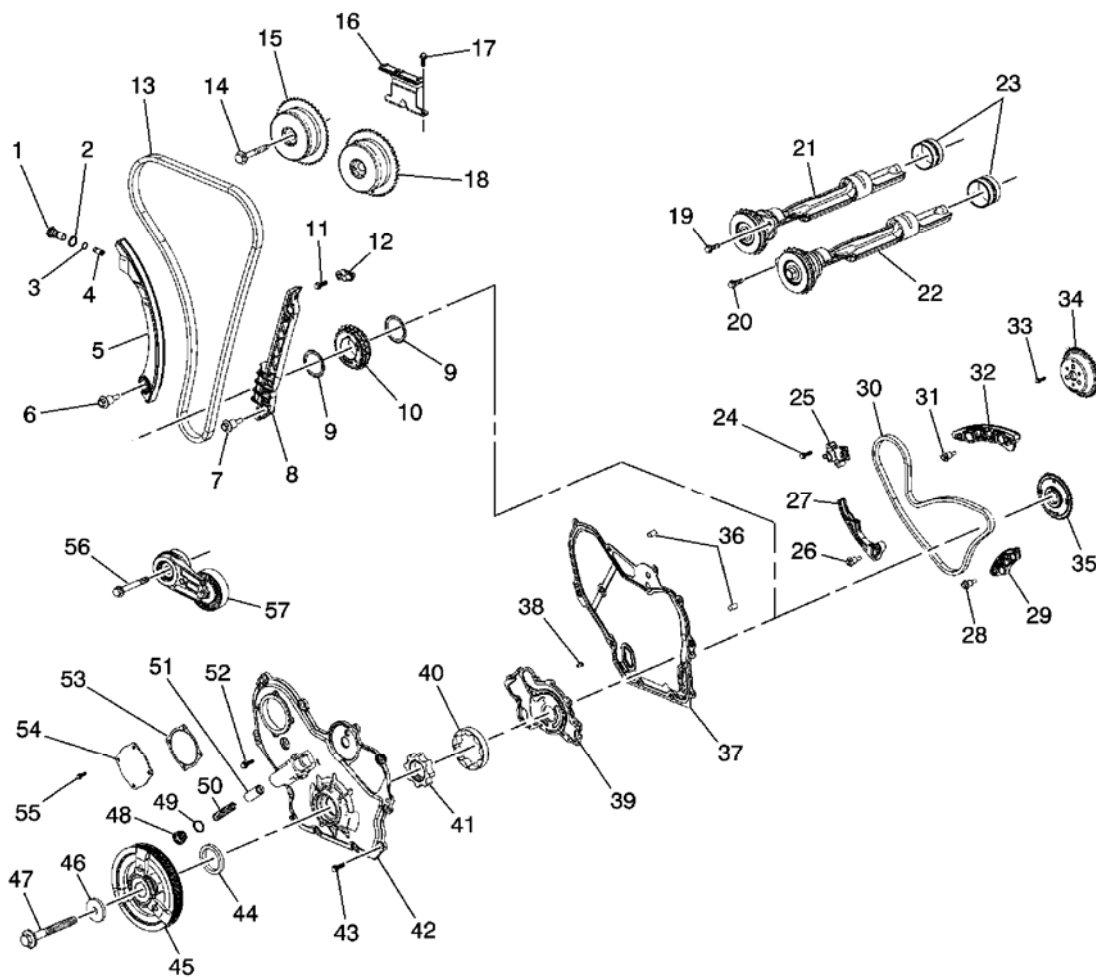


Fig. 21: Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Timing Chain Tensioner Body
2	Timing Chain Tensioner Washer
3	Timing Chain Tensioner O-Ring Seal
4	Timing Chain Tensioner Plunger
5	Adjustable Timing Chain Guide
6	Adjustable Timing Chain Guide Bolt
7	Fixed Timing Chain Guide Bolt
8	Fixed Timing Chain Guide
9	Friction Washer
10	Timing Chain Drive Sprocket
11	Timing Chain Oil Nozzle Bolt
12	Timing Chain Oil Nozzle

13	Timing Chain
14	Camshaft Position Actuator Bolt
15	Exhaust Camshaft Position Actuator
16	Upper Timing Chain Guide
17	Upper Timing Chain Guide Bolt
18	Intake Camshaft Position Actuator
19	Exhaust Balance Shaft Assembly Bolt
20	Intake Balance Shaft Assembly Bolt
21	Exhaust Balance Shaft Assembly
22	Intake Balance Shaft Assembly
23	Balance Shaft Rear Bearing
24	Balance Shaft Drive Chain Tensioner Assembly Bolt
25	Balance Shaft Drive Chain Tensioner Assembly
26	Adjustable Balance Shaft Drive Chain Guide Bolt
27	Adjustable Balance Shaft Drive Chain Guide
28	Balance Shaft Drive Chain Guide Bolt
29	Balance Shaft Drive Chain Guide
30	Balance Shaft Drive Chain
31	Balance Shaft Drive Chain Guide Bolt
32	Balance Shaft Drive Chain Guide
33	Water Pump Drive Sprocket Bolt
34	Water Pump Drive Sprocket
35	Balance Shaft Drive Sprocket
36	Engine Front Cover Alignment Pins
37	Engine Front Cover Gasket
38	Oil Pump Cover Bolt
39	Oil Pump Cover
40	Oil Pump Outer Gerotor
41	Oil Pump Inner Gerotor
42	Engine Front Cover
43	Engine Front Cover Bolt
44	Crankshaft Front Seal
45	Crankshaft Balancer
46	Crankshaft Balancer Washer
47	Crankshaft Balancer Bolt
48	Oil Pressure Relief Valve Plug
49	Oil Pressure Relief Valve O-Ring Seal
50	Oil Pressure Relief Valve Spring
51	Oil Pressure Relief Valve Plunger
52	Water Pump Bolt
53	Engine Front Cover Access Plate Gasket

	Engine Front Cover Access Plate
55	Engine Front Cover Access Plate Bolt
56	Belt Tensioner Bolt
57	Belt Tensioner

ENGINE IDENTIFICATION

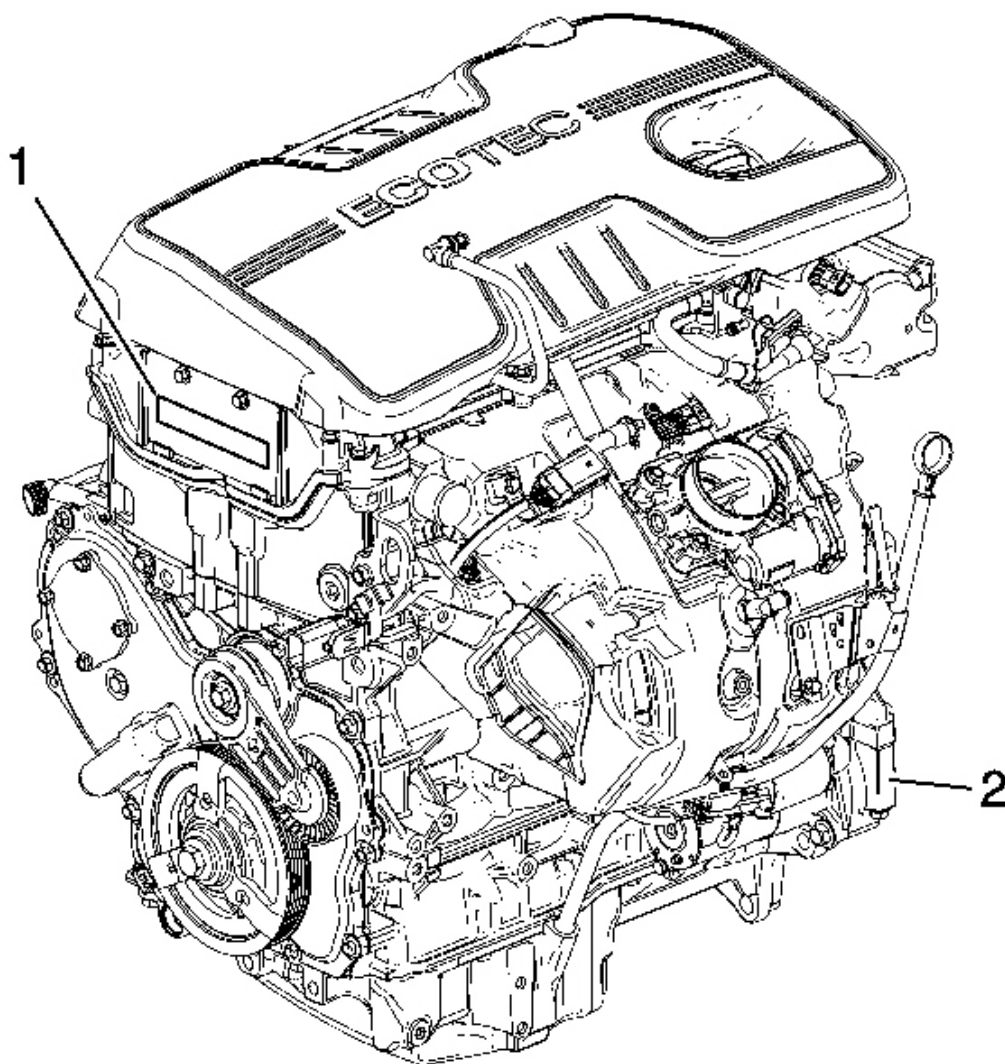


Fig. 22: Engine Identification

Courtesy of GENERAL MOTORS CORP.

Identification can be made through the use of the Broadcast Code label on the engine (1) and the use of the partial VIN etched in one of two places - the primary location is on the starter motor flange (2). The secondary location is the oil filter bowl.

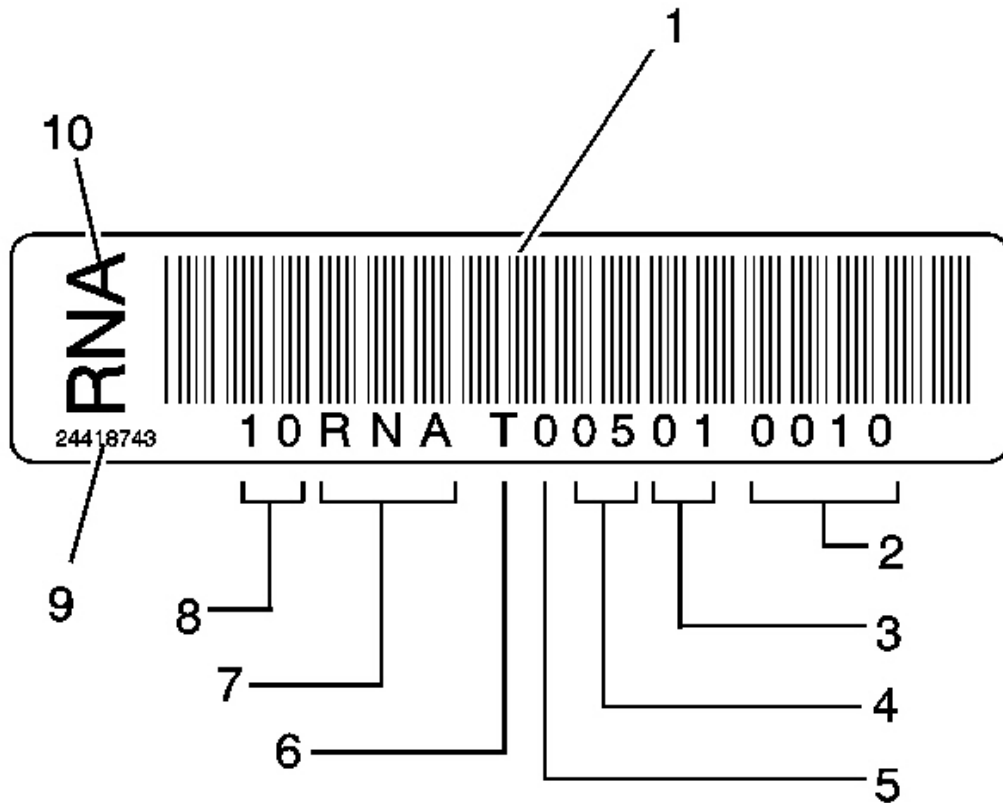


Fig. 23: Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

- Barcode (1)
- Sequence Number (2)
- Day (3)
- Month (4)
- Year (5)
- Engine Assembly Plant (6)
- Broadcast Code (7)
- Part Designation (8)
- Engine Assembly Number (9)

- Broadcast Code (10)

The partial VIN identifies the specific vehicle by sequence number.

DIAGNOSTIC INFORMATION AND PROCEDURES

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**, and **Lubrication Description**.

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

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**

- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Engine Compression Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- 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
Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
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.
A loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.

Damage to the MAP sensor housing	Replace the intake manifold.
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.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
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 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 P0300 DTC may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, 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.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft, and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly.	Replace the valve rocker arms as required.
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 lash adjusters.
Sticking lifters	Replace as required.

Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to <u>Camshaft Position Intake Actuator Replacement</u> or <u>Camshaft Position Exhaust Actuator Replacement</u>.
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BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gasket and/or cracking, or other damage to the cylinder head and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Perform a cylinder leak down test. • Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil.

	2. Install the correct viscosity oil.
High valve lash adjuster leak down rate	Replace the lash adjusters as required.
Worn crankshaft thrust bearing	1. Inspect the thrust bearing and crankshaft. 2. Repair or replace as required.
Damaged or faulty oil filter by-pass valve	1. Inspect the oil filter by-pass valve for proper operation. 2. Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to <u>Camshaft Position Intake Actuator Replacement</u> or <u>Camshaft Position Exhaust Actuator Replacement</u>.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm stud, nut or bolt. • Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty valve lash adjusters	Replace the valve lash adjusters.
Stretched or broken timing chain and/or damaged	Replace the timing chain and sprockets.

sprocket teeth	
Worn, damaged, or faulty timing chain tensioners	Replace tensioners
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lash adjusters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. • Repair or replace damaged components as required.
Worn accessory drive components - abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to <u>Symptoms - Engine Controls</u> .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen - an oil pan that has been damaged, may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore.

	2. Repair as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin, and connecting rod installation - pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. Refer to <u>Symptoms - Engine Controls</u> .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair as required.
Cracked flywheel, automatic transmission	1. Inspect the flywheel bolts and flywheel. 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
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to <u>Camshaft Position Intake Actuator Replacement</u> or <u>Camshaft Position Exhaust Actuator Replacement</u>.

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. 5. Inspect for cracked cylinder wall.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	1. Inspect timing chain and gears. 2. Repair as required.
Seized balance shaft	1. Inspect balance shaft.

	2. Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	1. Inspect cylinder for damaged components and/or foreign materials. 2. Inspect for fallen cylinder wall. 3. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Inspect for fallen cylinder wall. 3. Repair as required.
Bent or broken connecting rod	1. Inspect connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect crankshaft. 2. Repair as required.

COOLANT IN COMBUSTION CHAMBER

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

ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gauge at zero and crank the engine through 4 compression strokes, 4 puffs.
8. Measure the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Measure the compression again and record the reading.
10. The minimum compression in any 1 cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1\ 035 \times 70\% = 725$) ($150 \times 70\% = 105$).
 - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
 - Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.

- Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
- If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

CYLINDER LEAKAGE TEST

Special Tools

J 35667-A: Cylinder Head Leakdown Tester

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

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

- Worn or burnt valves
- Broken valve springs
- Stuck valve lash adjusters
- Incorrect valve lash/adjustment
- 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: Unless directed otherwise, the ignition and start switch must be in the OFF or LOCK position, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStar® (UE1) with Back Up Battery: The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power (RAP) should be allowed to time out or be disabled (simply opening the driver door should disable RAP) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with RAP activated may cause activation of the

OnStar® Back-Up Battery (BUB) system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The BUB is not rechargeable and once activated the BUB must be replaced.

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 engine 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 sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
 - Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
 - Air leakage sounds 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

Excessive oil consumption, not due to leaks, is the use of 0.9 L (1 qt) or greater of engine oil within 3 200 kilometers (2,000 miles). The causes of excessive oil consumption include the following conditions:

- External oil leaks

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

- Incorrect oil level or improper reading of oil level indicator

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

- Improper oil viscosity

Use recommended SAE viscosity for the prevailing temperatures.

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

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

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

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

- Piston improperly installed or mis-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

EN-21867-850: Oil Pressure Gauge Adapter

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

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

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

- Run the engine, and verify low, or no oil pressure on the vehicle gauge or light.

Listen for a noisy valve train or a knocking noise.

- Inspect for the following:
 - Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
 - Oil diluted by moisture or unburned fuel mixtures
 - Improper oil viscosity for the expected temperature
 - Incorrect or malfunctioning oil pressure sender
 - Incorrect or malfunctioning oil pressure gauge
 - Plugged oil filter
 - Malfunctioning oil bypass valve
- Remove the oil pressure sender or another engine block oil gallery plug.
- Install **EN-21867-850:** adapter and an oil pressure gauge and measure the engine oil pressure.
- Compare the readings to specifications. Refer to **Engine Mechanical Specifications**.
- If the engine oil pressure is below specifications, inspect the engine for one or more of the following:

- Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
- Oil pump worn or dirty

Refer to **Oil Pump Disassemble** .

- Oil pump-to-engine front cover bolts loose

Refer to **Engine Front Cover and Oil Pump Installation** .

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Malfunctioning oil pump pressure regulator valve
- Excessive bearing clearance

Refer to **Crankshaft and Bearing Cleaning and Inspection** .

- Cracked, porous or restricted oil galleries
- Oil gallery plugs missing or incorrectly installed

Refer to **Engine Block Assemble** .

- Broken lash adjusters

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
DEFINITION: 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. Refer to <u>Engine Mechanical Specifications</u> . 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3
	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations:		

3	• 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 miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, for example, baby powder or foot powder, to the suspected area. 3. Operate the vehicle for several 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
	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations:		

7	• 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 J 28428-E, Dye and Light Kit in order to identify the type of fluid, and the approximate location of the leak. See Special Tools. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK

11	Repair or replace all damaged or modified components. Did you complete the repair?	Go to Step 1	-
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CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS (WITHOUT TURBOCHARGER)

Special Tools

J 23951 Valve Manometer. See **Special Tools**.

1. Remove the oil level indicator. Install a **J 23951** or equivalent. See **Special Tools**.
2. Start the engine.
3. Check for slight vacuum. The vacuum level should be less than 3.377 kPa (1 in Hg).
4. If vacuum is higher, inspect and verify that the clean air hose from cam cover to air intake is not blocked or kinked.
5. If vacuum is in the normal range, block or pinch off the clean air hose. The clean air hose is the hose between the cam cover and air intake system. Vacuum should increase on the manometer. If held too long, vacuum will be drawn through the crankshaft seals creating a sucking sound.
6. If vacuum does not increase, the orifice in the intake manifold could be plugged.
7. If there is zero vacuum or pressure, verify compression of the engine.
8. If compression is normal, check for a blocked orifice at the intake manifold. Clean the orifice.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

- 2:** The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
- 3:** The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the

water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

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

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

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

11	1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. 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 <u>Drive Belt Tensioner Diagnosis</u> . Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19
19	Replace the drive belt. Refer to <u>Drive Belt Replacement</u> . 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 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 plies of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.
- 5: Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.
- 9: Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.
- 11: This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump 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 <u>Belt Dressing Caution</u> .			
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 <u>Symptoms - Engine Mechanical</u>

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	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 rumbling or vibration still exist?	Go to <u>Symptoms - Engine Mechanical</u> or Go to <u>Vibration Analysis - Engine</u>	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to <u>Drive Belt Replacement</u>. Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to <u>Drive Belt Replacement</u> . 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	1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u>. 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 <u>Water Pump Replacement (LF1)</u> or <u>Water Pump Replacement (LAF)</u> . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets.		Go to Diagnostic

	Did you find and correct the condition?	Go to Step 13	Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will 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: Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing. loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

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

14: The installation of a drive belt that is two wide or two narrow will cause wear on the drive belt. The

drive belt ribs should match all of the grooves on all of the pulleys.

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 <u>Belt Dressing Caution</u> .			
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 <u>Symptoms - Engine Mechanical</u>
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 <u>Drive Belt Replacement</u> . 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 <u>Fastener Caution</u> . 1. Tighten any loose fasteners. Refer to <u>Fastener Tightening Specifications</u> . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to <u>Drive Belt Tensioner Diagnosis</u> . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to <u>Drive Belt Tensioner Replacement</u> . Does the drive belt continue to fall off?	Go to Step 11	System OK
	Inspect for failed drive belt idler and drive belt		

11	tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to <u>Drive Belt Replacement</u> . 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 <u>Drive Belt Replacement</u> . 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 and 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 percent of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

INTAKE MANIFOLD COVER REPLACEMENT

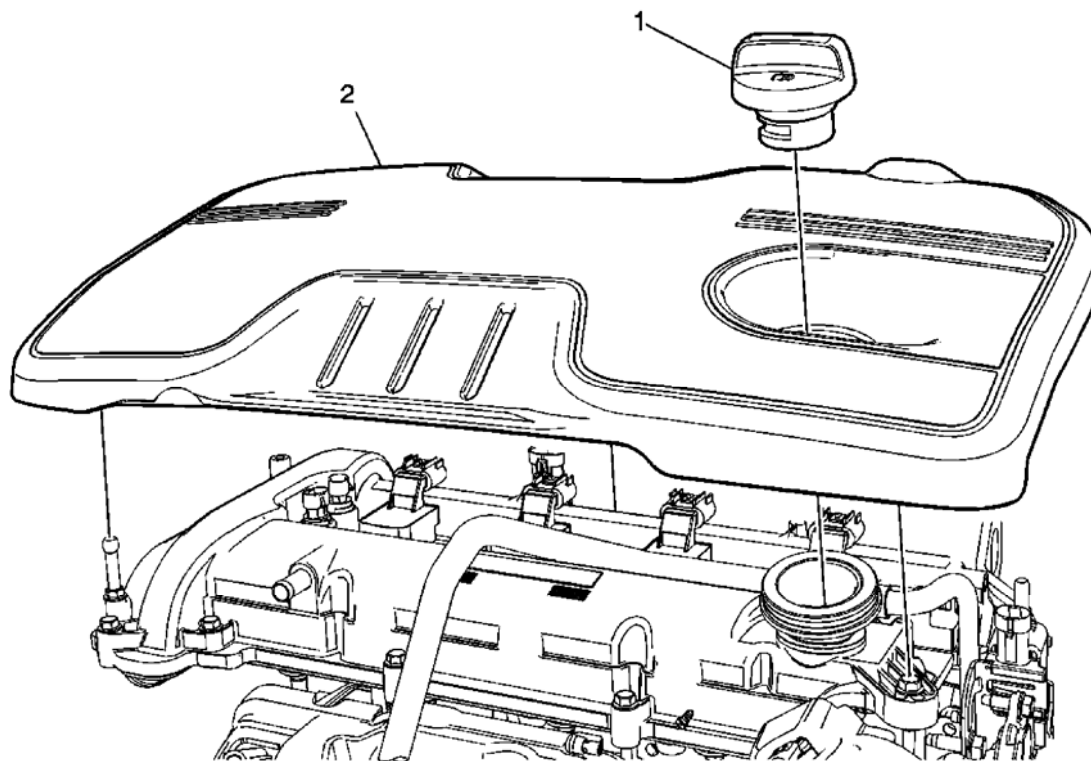


Fig. 24: Intake Manifold Cover

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove Air Cleaner Outlet Resonator. Refer to <u>Air Cleaner Outlet Resonator Replacement</u>	
1	Oil Cap Procedure: Remove oil cap to remove intake manifold cover.
2	Intake Manifold Cover Procedure: Transfer components as necessary.

DRIVE BELT REPLACEMENT

Tools Required

J 44811 Accessory Belt Tensioner Unloader. See **Special Tools**.

Removal Procedure

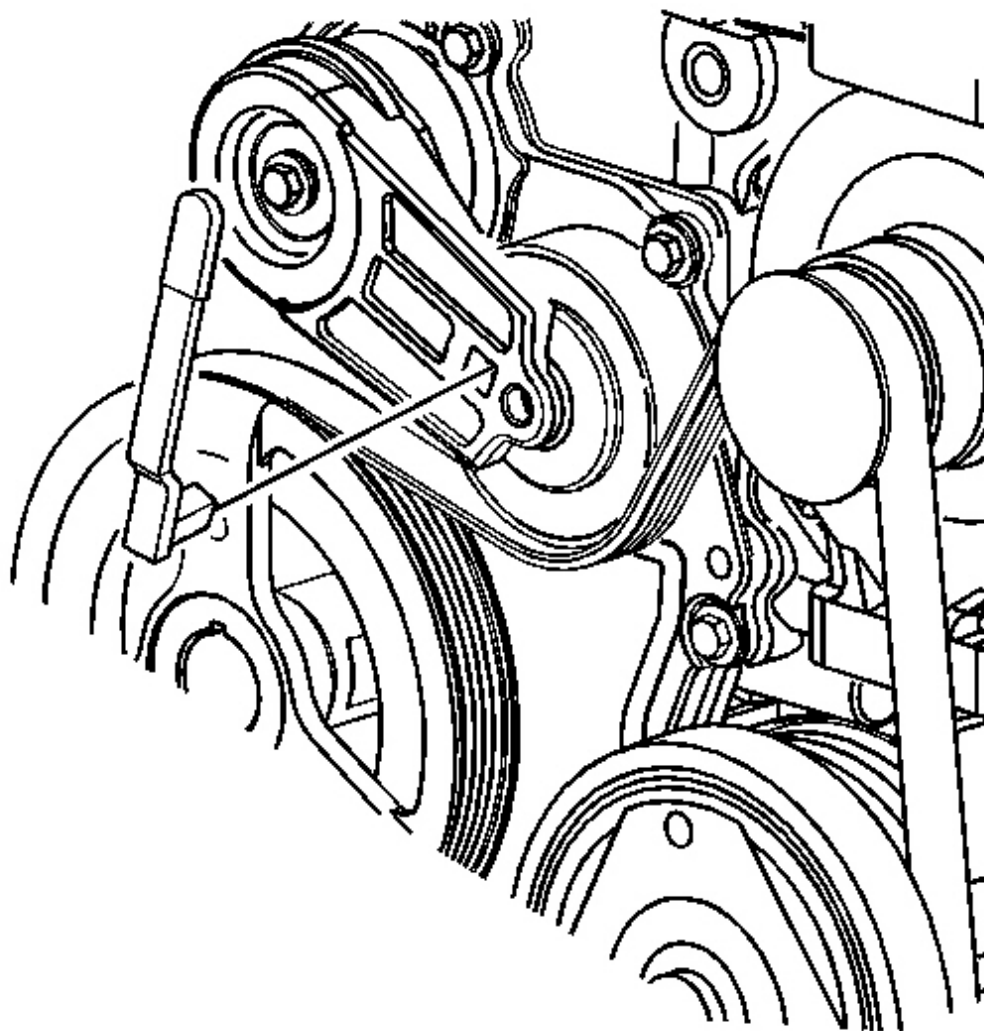


Fig. 25: View Of Drive Belt Tensioner & Special Tool
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .
2. Install the **J 44811** to the drive belt tensioner. See **Special Tools**.
3. Using the **J 44811** , rotate the tensioner counterclockwise in order to release the tensioner from the drive belt. See **Special Tools**.

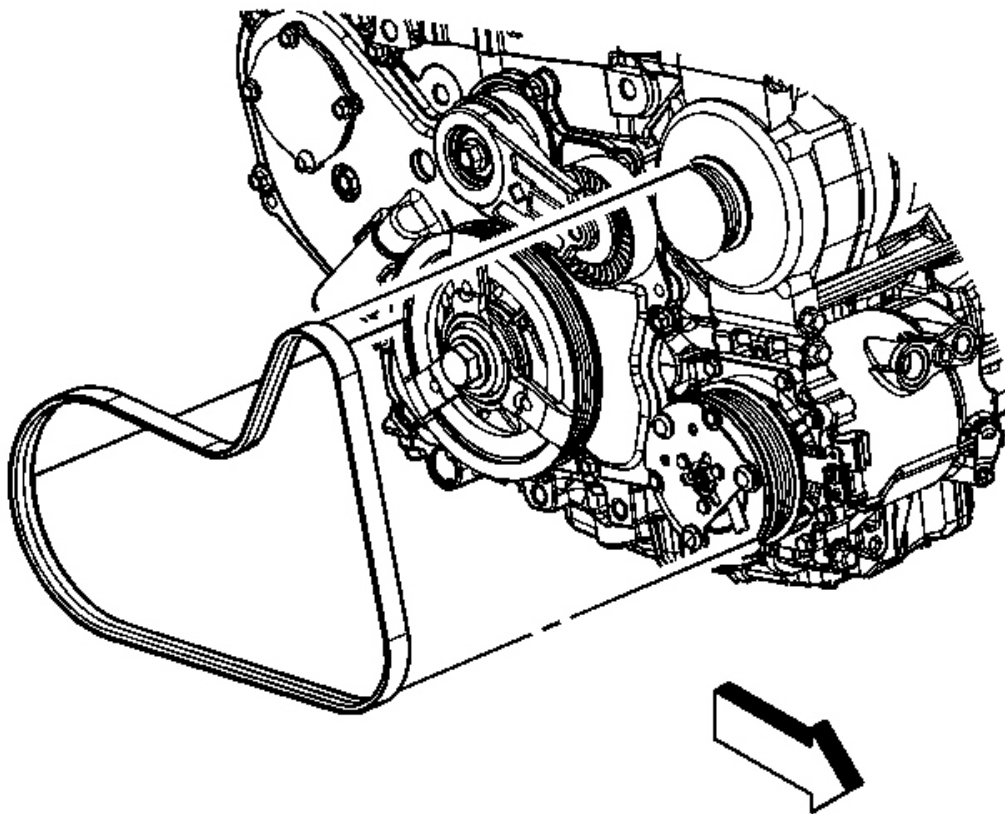


Fig. 26: Drive Belt

Courtesy of GENERAL MOTORS CORP.

4. Remove the drive belt.
5. Slowly rotate the **J 44811** and the tensioner clockwise in order to allow the tensioner to rest. See **Special Tools**.
6. Remove the **J 44811** from the drive belt tensioner. See **Special Tools**.

Installation Procedure

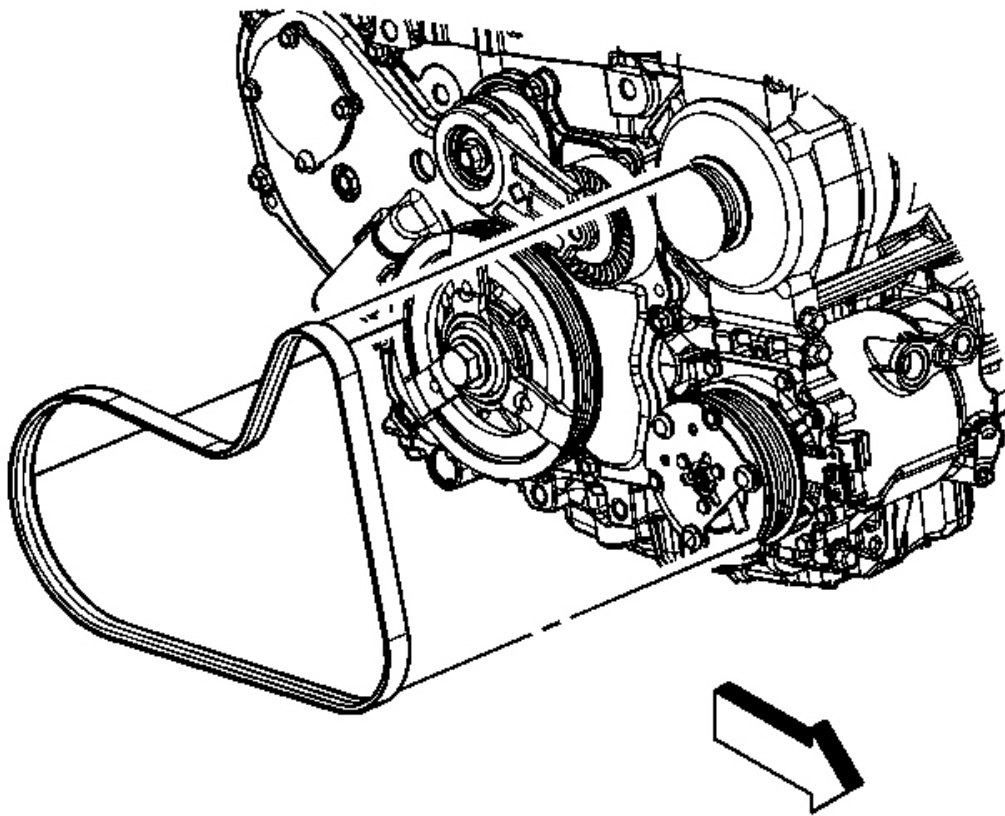


Fig. 27: Drive Belt

Courtesy of GENERAL MOTORS CORP.

1. Install and position the drive belt around all of the pulleys except for the drive belt tensioner.
2. Install the **J 44811** to the drive belt tensioner. See **Special Tools**.
3. Using the **J 44811** , rotate the tensioner counterclockwise. See **Special Tools**.
4. Position the drive belt under the tensioner pulley.

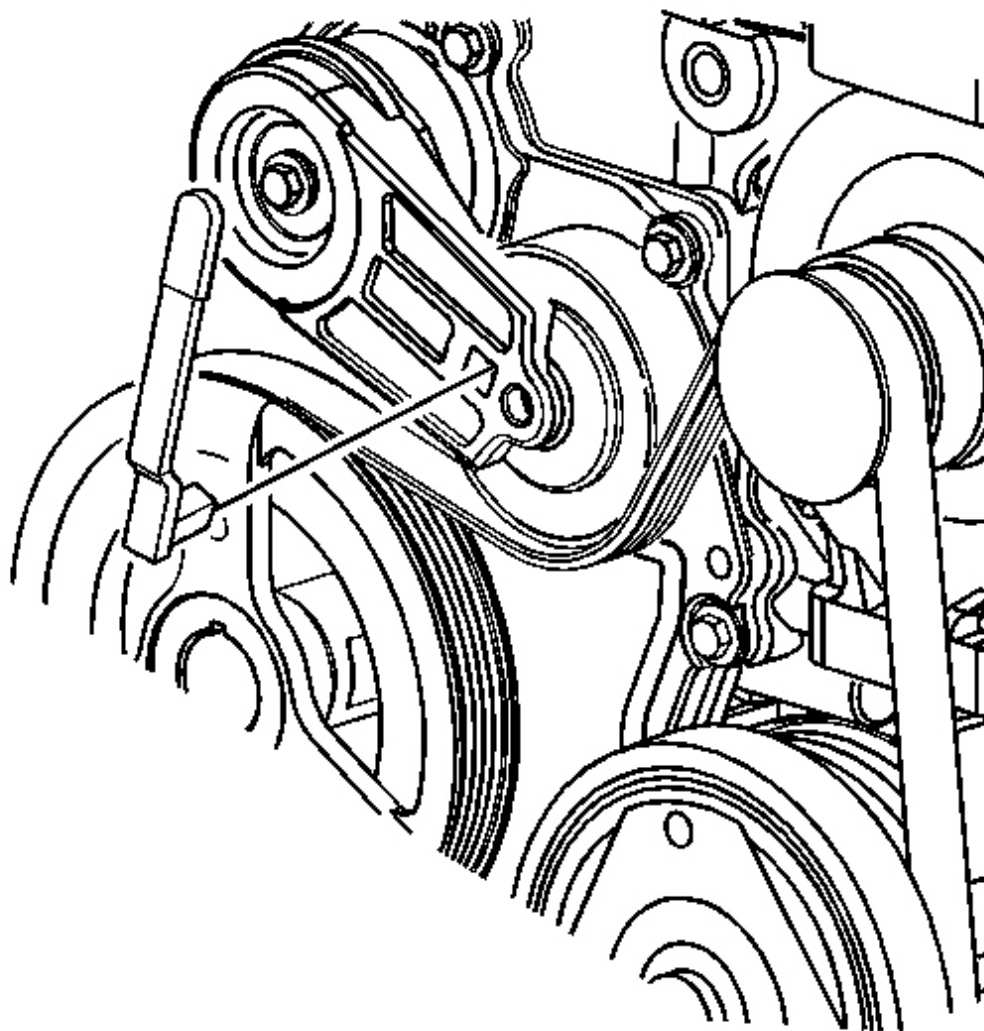


Fig. 28: View Of Drive Belt Tensioner & Special Tool
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 44811** , rotate the tensioner clockwise in order to seat the tensioner pulley onto the drive belt. See **Special Tools**.
6. Install the engine splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

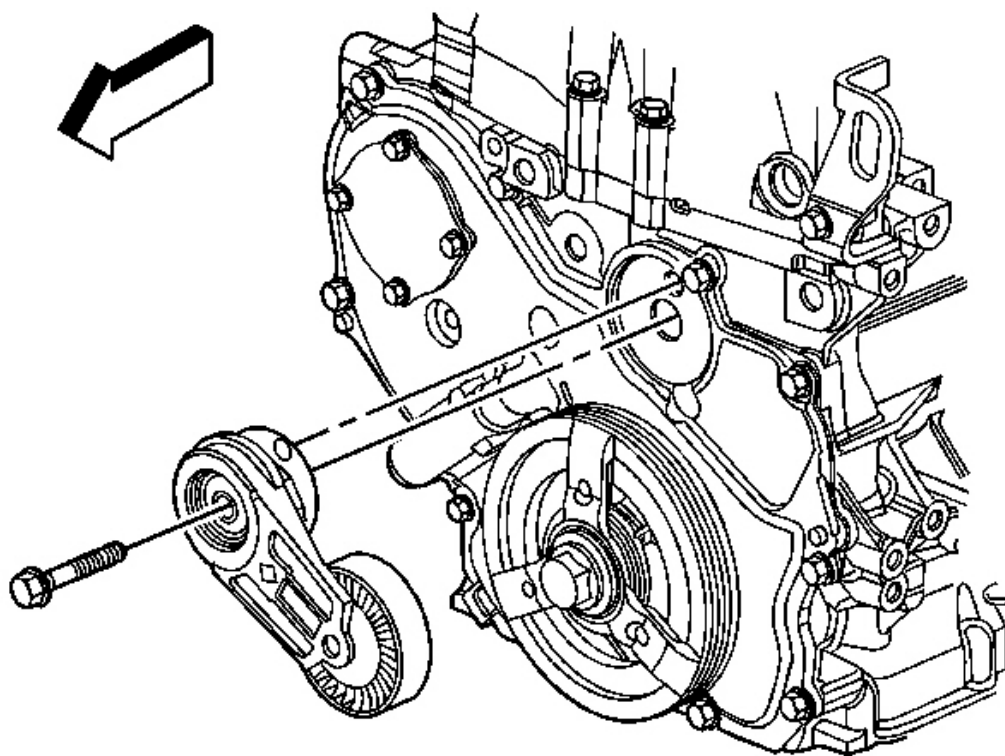


Fig. 29: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

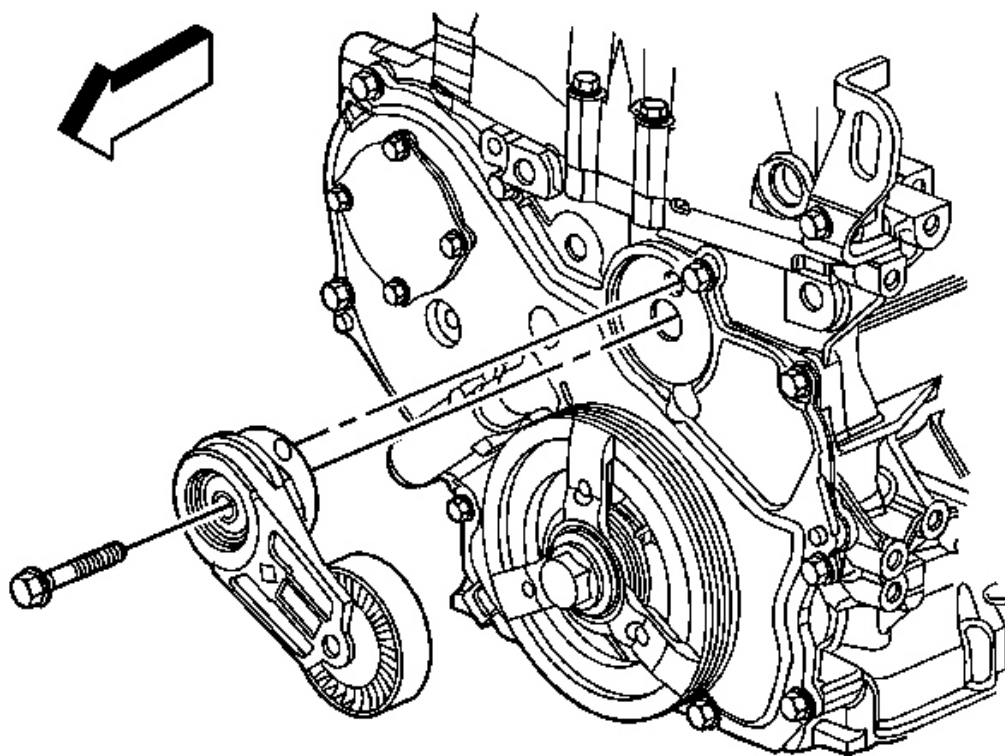


Fig. 30: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner.

CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).
3. Install the drive belt. Refer to **Drive Belt Replacement**.

ENGINE OIL PRESSURE SWITCH REPLACEMENT

Removal Procedure

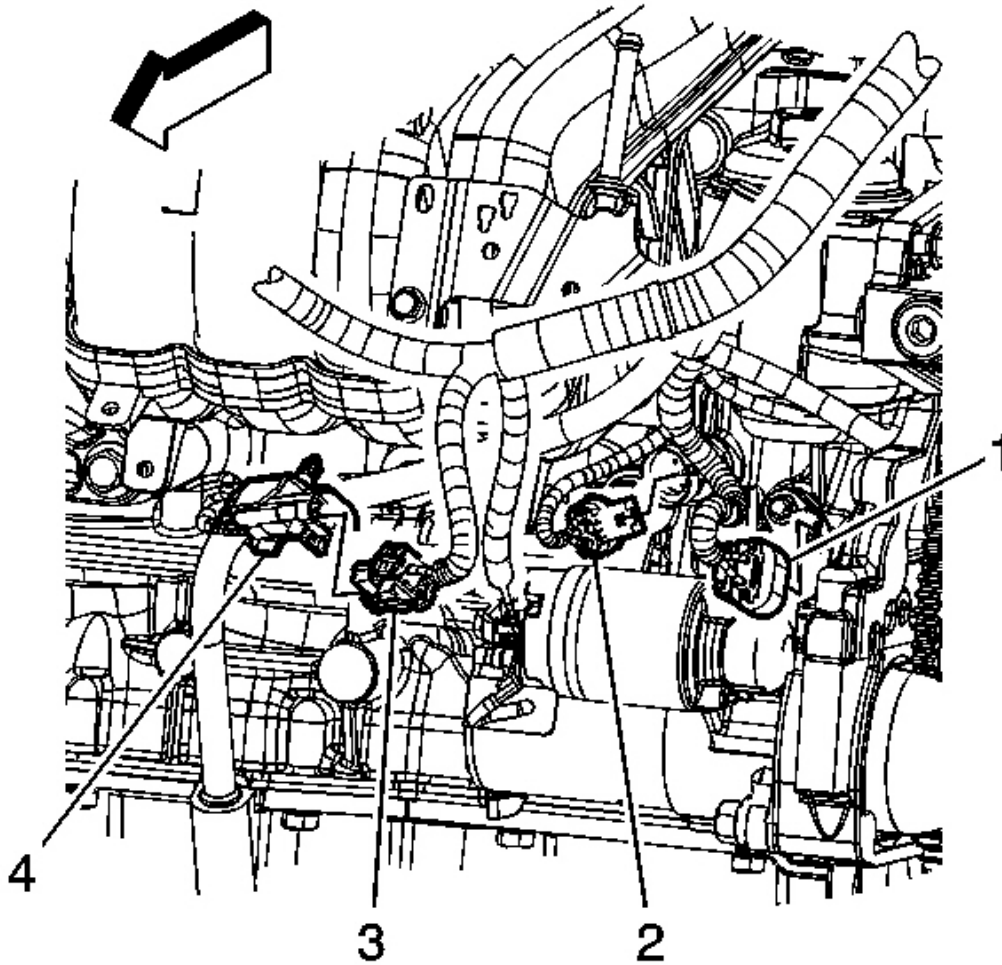


Fig. 31: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)**.
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch.

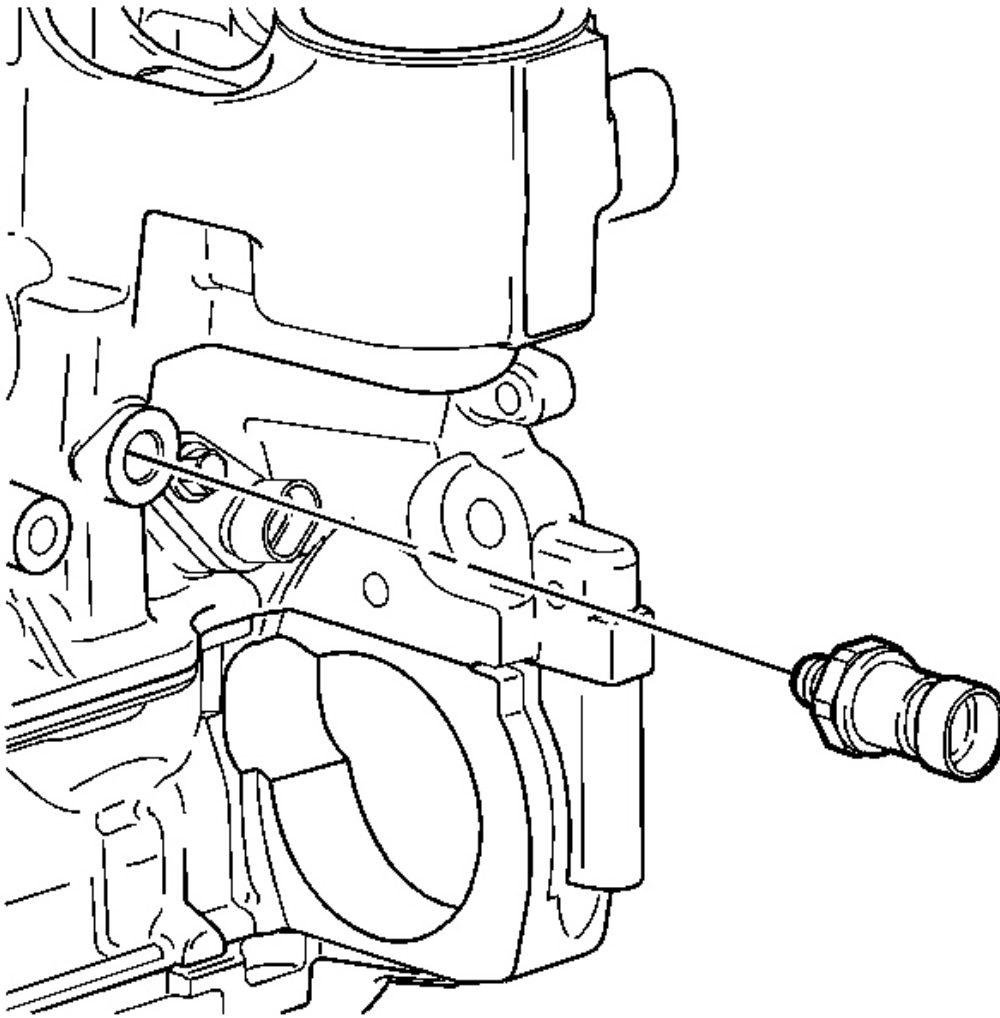


Fig. 32: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch.

Installation Procedure

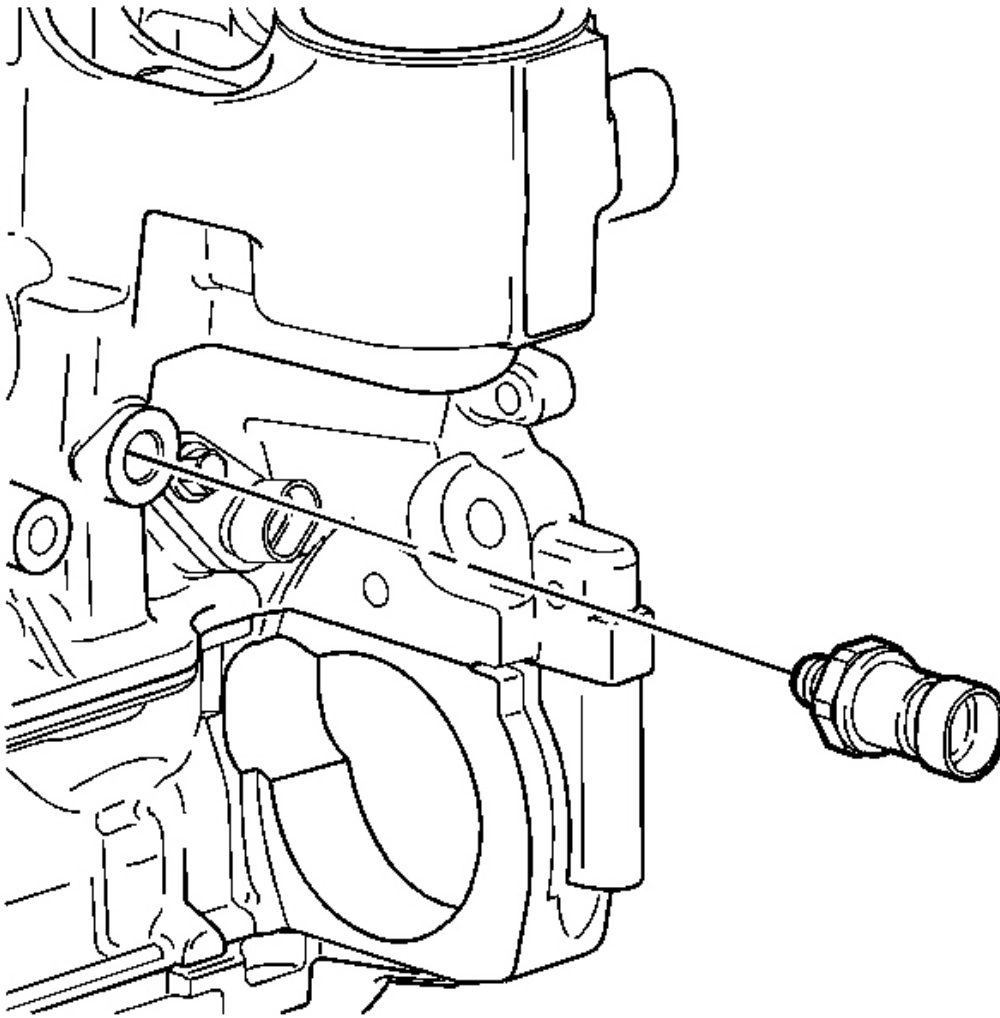


Fig. 33: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil pressure switch. Tighten the switch to 22 N.m (16 lb ft).

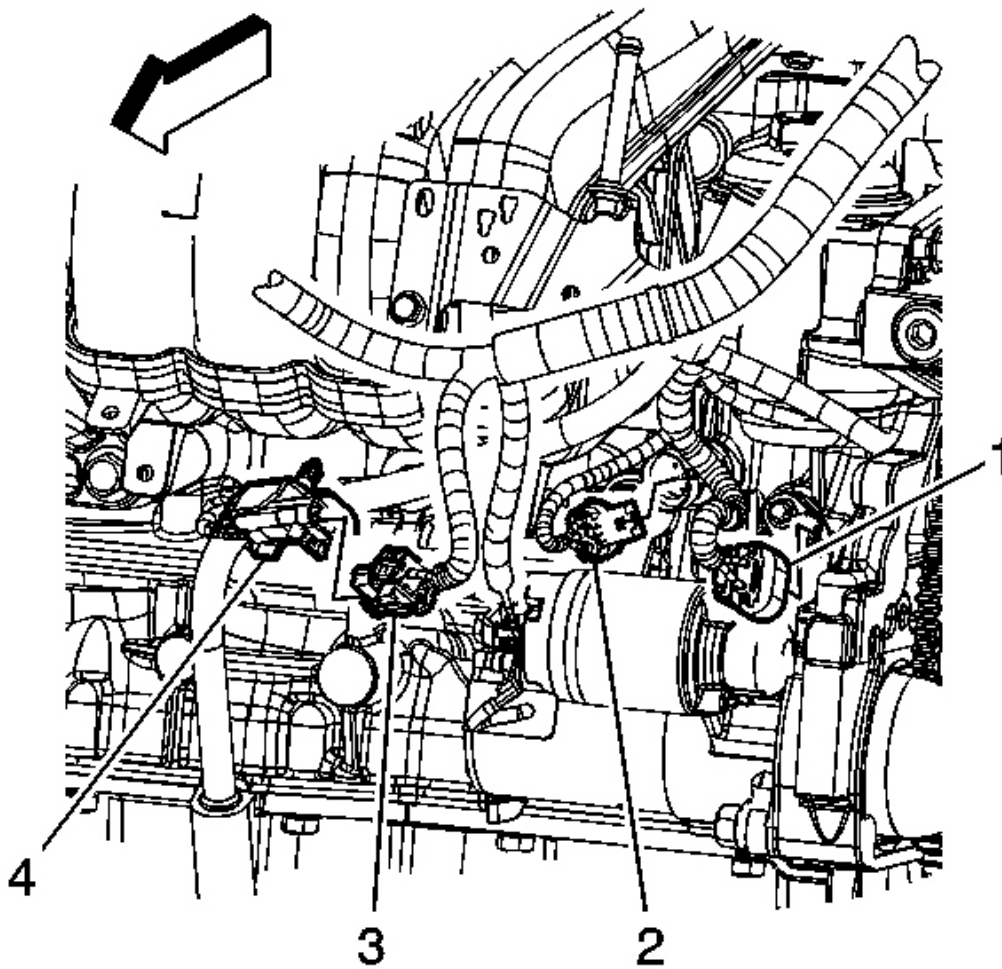


Fig. 34: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness electrical connector (2) to the oil pressure switch.
3. Install the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)** .

ENGINE MOUNT INSPECTION

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

1. Install the engine support fixture. Refer to **Engine Support Fixture** .

2. Observe the engine mount while raising the engine. Raising the engine removes the weight from the engine mount and creates slight tension on the rubber.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber is covered with heat check cracks.
 - The rubber is separated from the metal plate of the engine mount.
 - The rubber is split through the center of the engine mount.
 - The engine mount itself is leaking fluid.
4. For engine mount replacement. Refer to **Engine Mount Replacement - Right Side**.

ENGINE MOUNT BRACKET REPLACEMENT

Removal Procedure

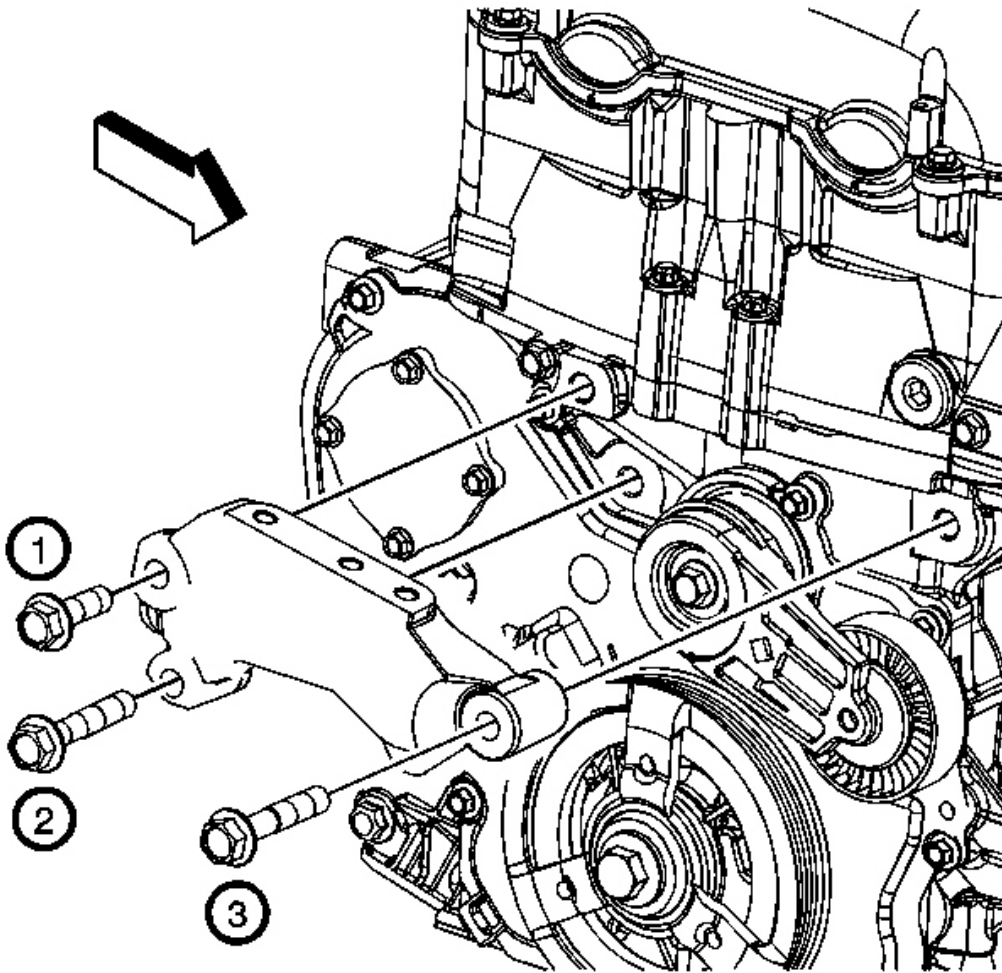


Fig. 35: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

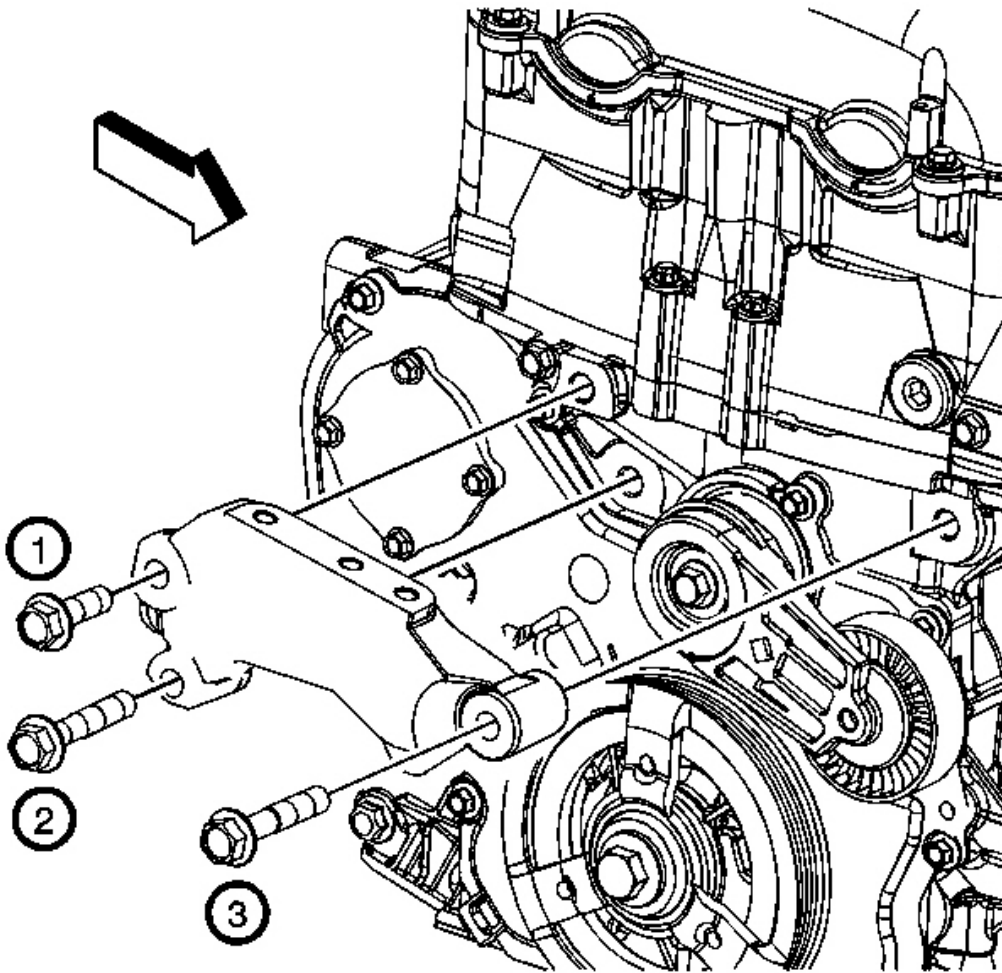


Fig. 36: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket to the engine.
2. Install the engine mount bracket bolts in the following locations:
 - The long bolts in the forward and lower Rear holes
 - The short bolt in the upper rear hole

CAUTION: Refer to Fastener Caution .

3. Tighten the engine mount bracket bolts in the sequence shown to 100 N.m (74 lb ft)

4. Install the engine mount. Refer to Engine Mount Replacement - Right Side.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

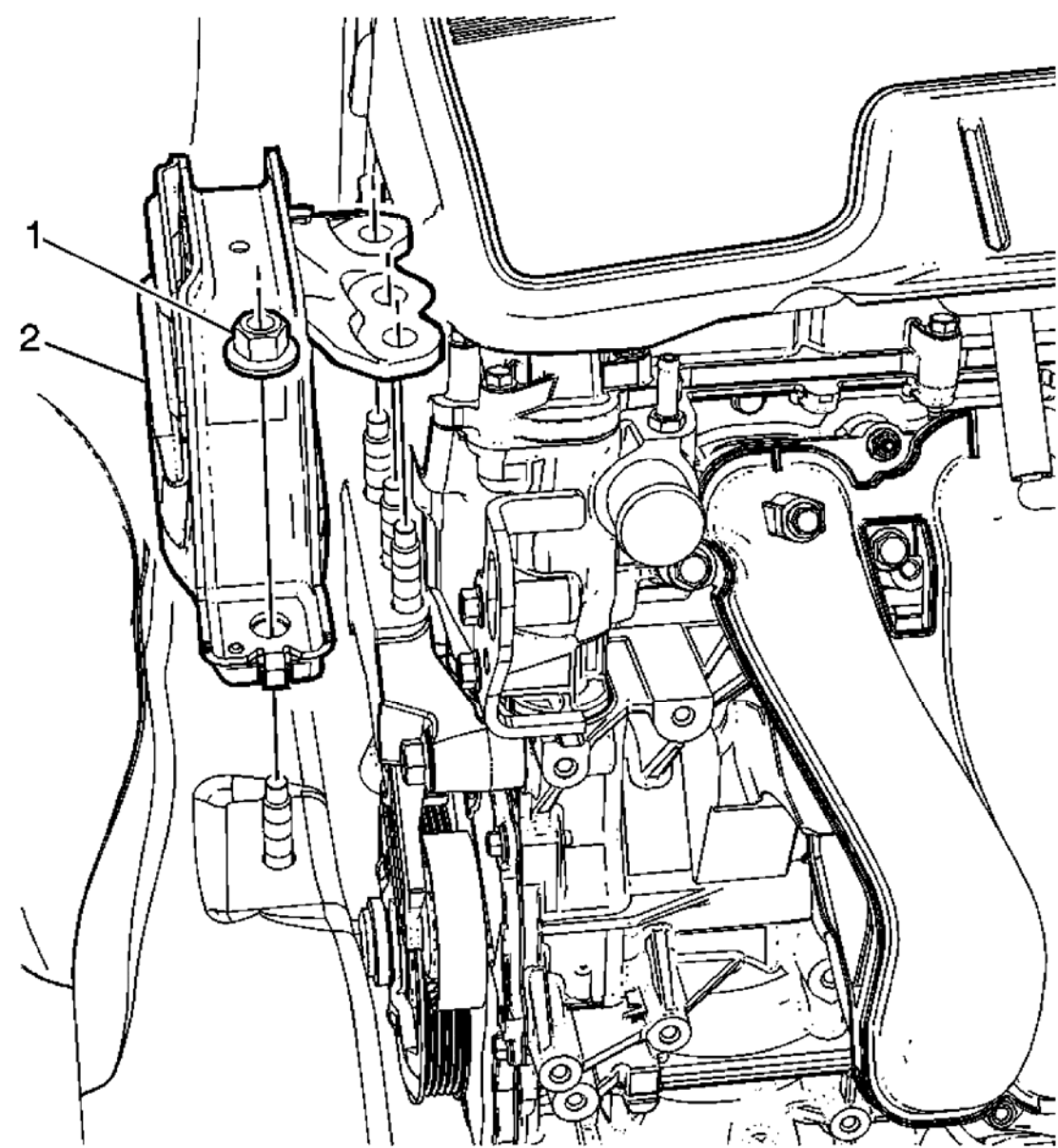


Fig. 37: Engine Mount - Right Side
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure	
1. Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u>	

2. Install engine support fixture. Refer to <u>Engine Support Fixture</u>	
1	Engine Mount Fastener (Qty, 5) CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 50 N.m (37 lb ft)
2	Engine Mount Procedure: Transfer components as necessary.

ENGINE SUPPORT FIXTURE

Special Tools

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools**.
- **J 28467-501** Engine Support Fixture Adapters
- **J 36857** Engine Lift Bracket

Installation Procedure

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the right headlamp. Refer to **Headlamp Replacement (Equinox)** or **Headlamp Replacement (Terrain)** .

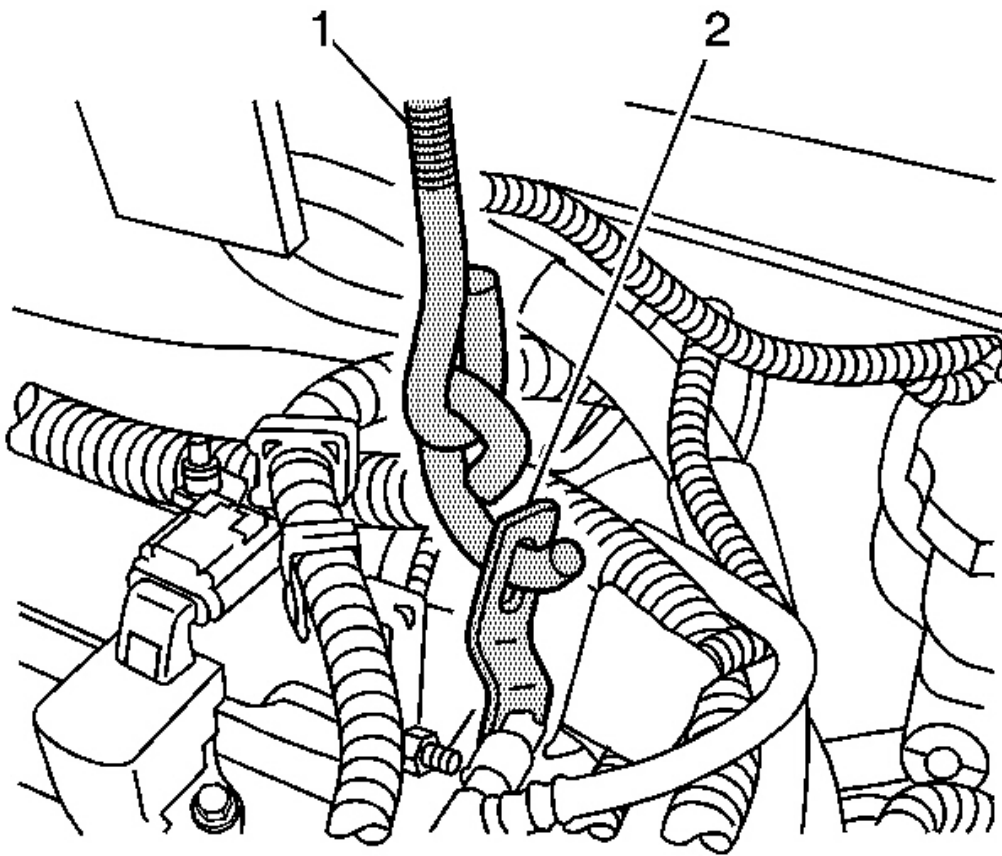


Fig. 38: Inserting Lift Hook Through Engine Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. J-36857: engine rear lift bracket

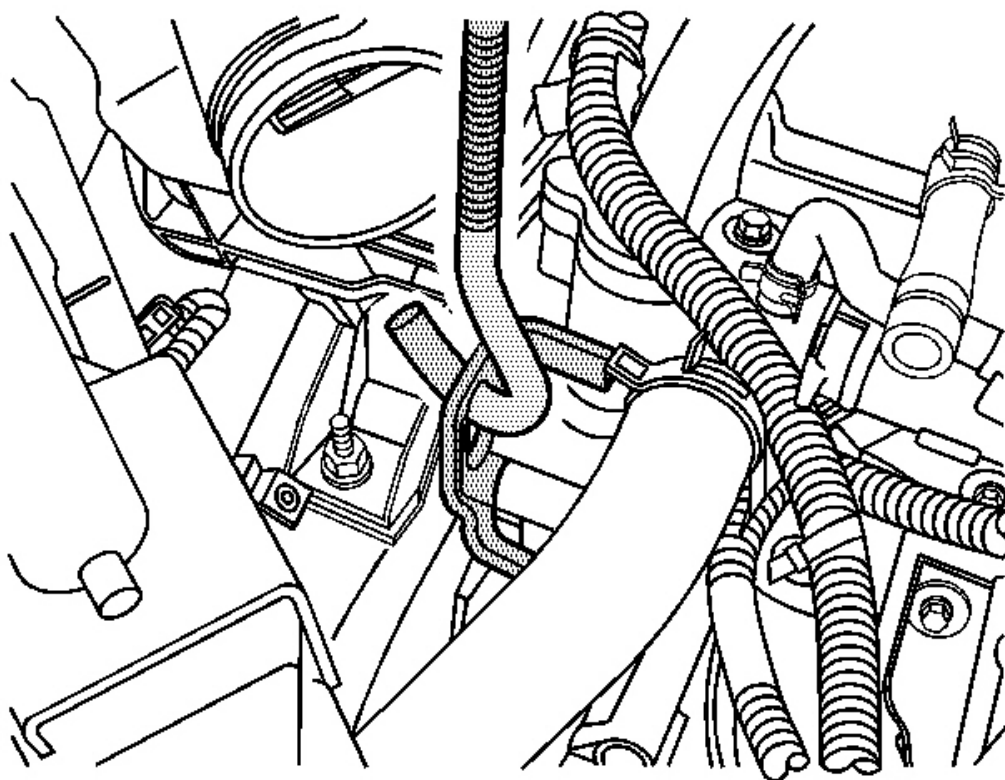


Fig. 39: Inserting Lift Hook Through Engine Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

4. J-36857: engine front lift bracket

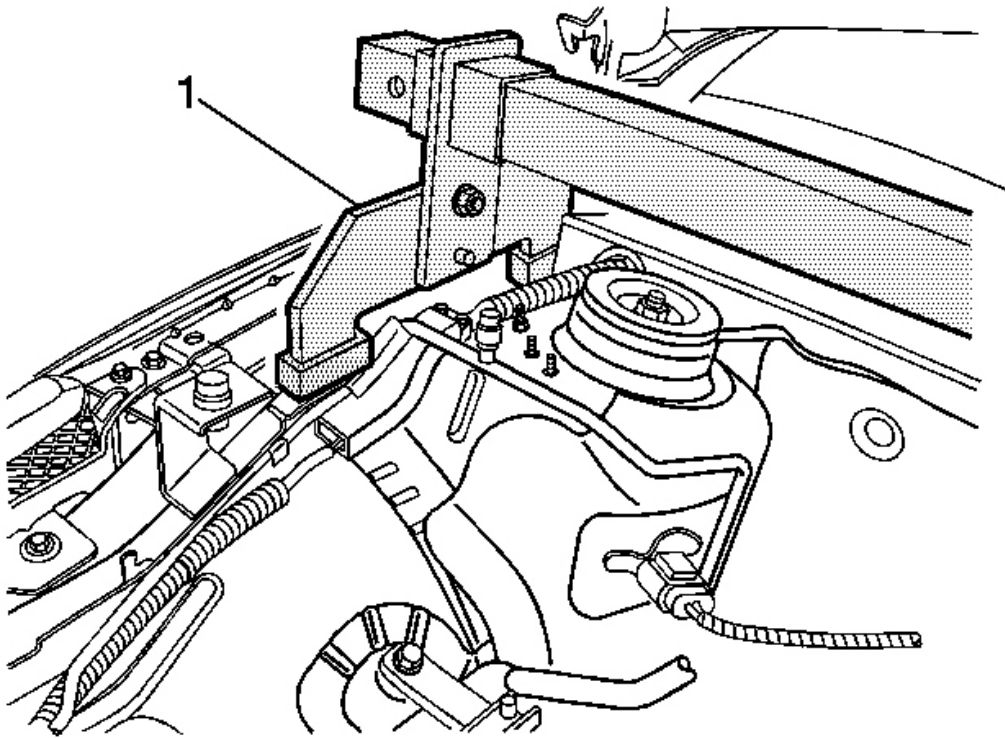


Fig. 40: Special Tool
Courtesy of GENERAL MOTORS CORP.

5. Loosen the **J 28467-501** adjusting nut.
6. Assemble the **J 28467-501** legs to the vehicle and install the **J 28467-B** cross bar and place across the engine compartment. See **Special Tools**.
7. Tighten the adjusting nuts on the **J 28467-501** legs until snug, then back the nut off 1/4 turn.

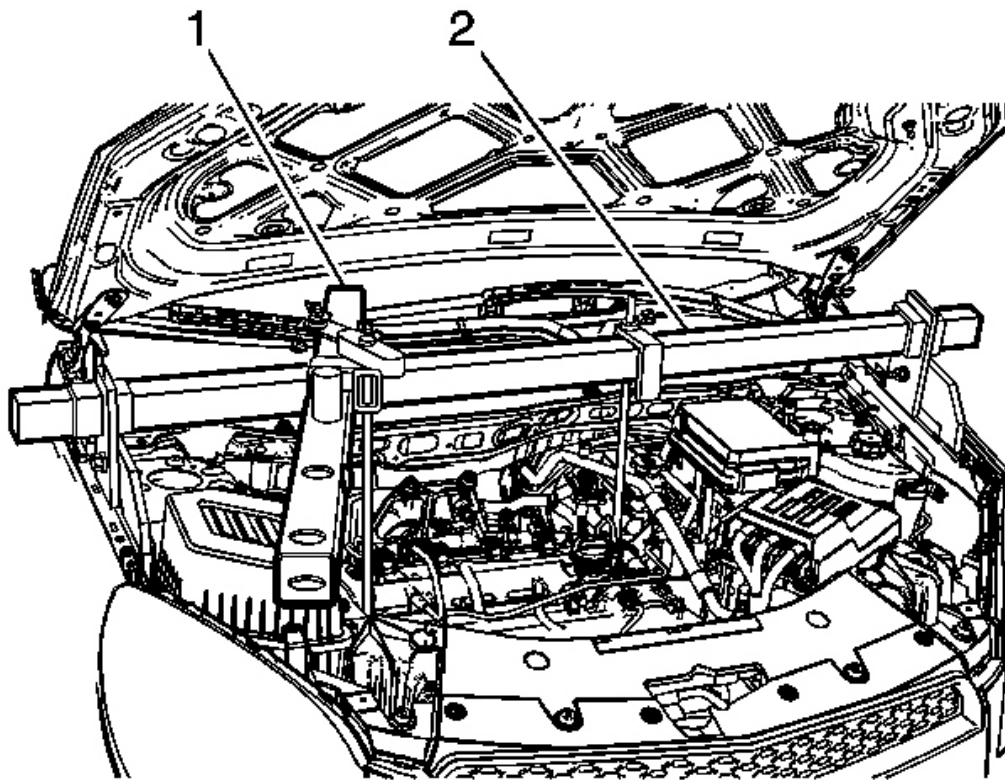


Fig. 41: Engine Support Fixture Components
Courtesy of GENERAL MOTORS CORP.

8. From the **J 28467-B** universal engine support fixture, install the radiator shelf tube J-28467-2A (1) on top of the strut tower tube J-28467-3 (2) above the engine front (right back) lift hook bracket. See **Special Tools**.
9. Install the round tube of the front support assembly J-28467-4A (3) through the large hole in the radiator shelf tube J-28467-2A.
10. Locate the J-28467-4A front support assembly to the upper tie bar.
11. Install the J-28467-9 7/16 inch x 2.0 inch quick-release pin (4) through the top hole in the J-28467-4A front support assembly.

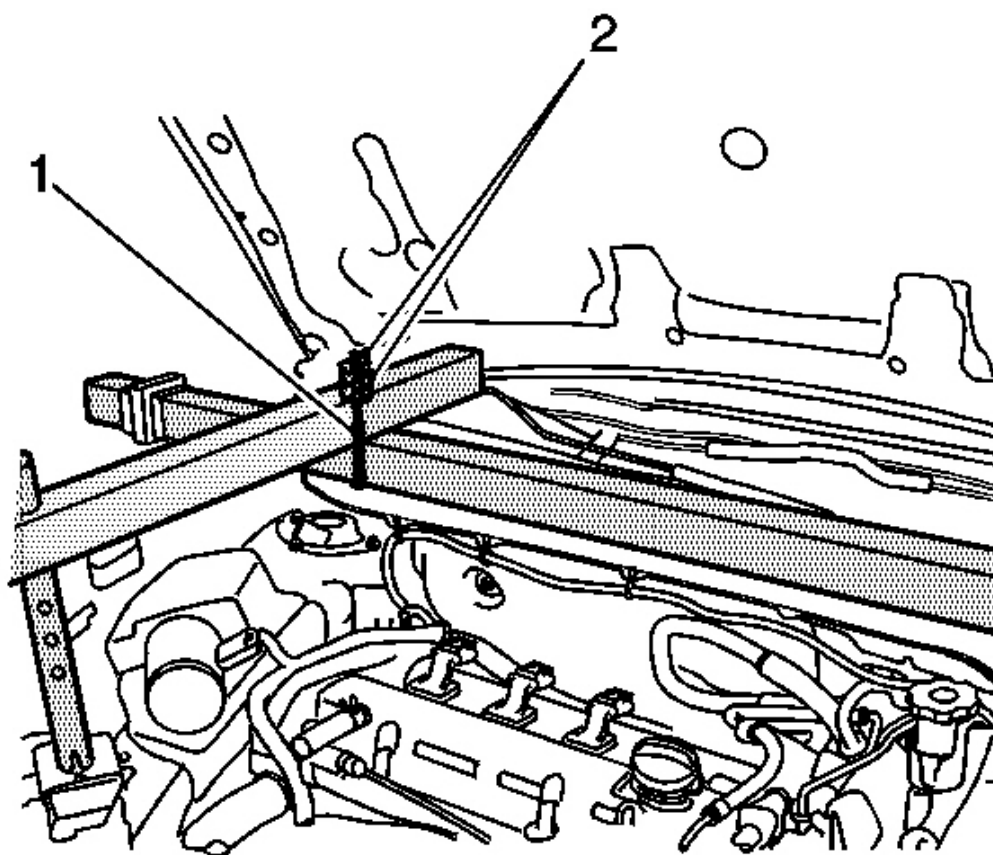


Fig. 42: Cross Bracket Assembly & Wing Nuts
Courtesy of GENERAL MOTORS CORP.

12. Install the J-28467-1A cross bracket assembly (1).
13. Hand tighten the J-28467-1A cross bracket wing nuts (2).

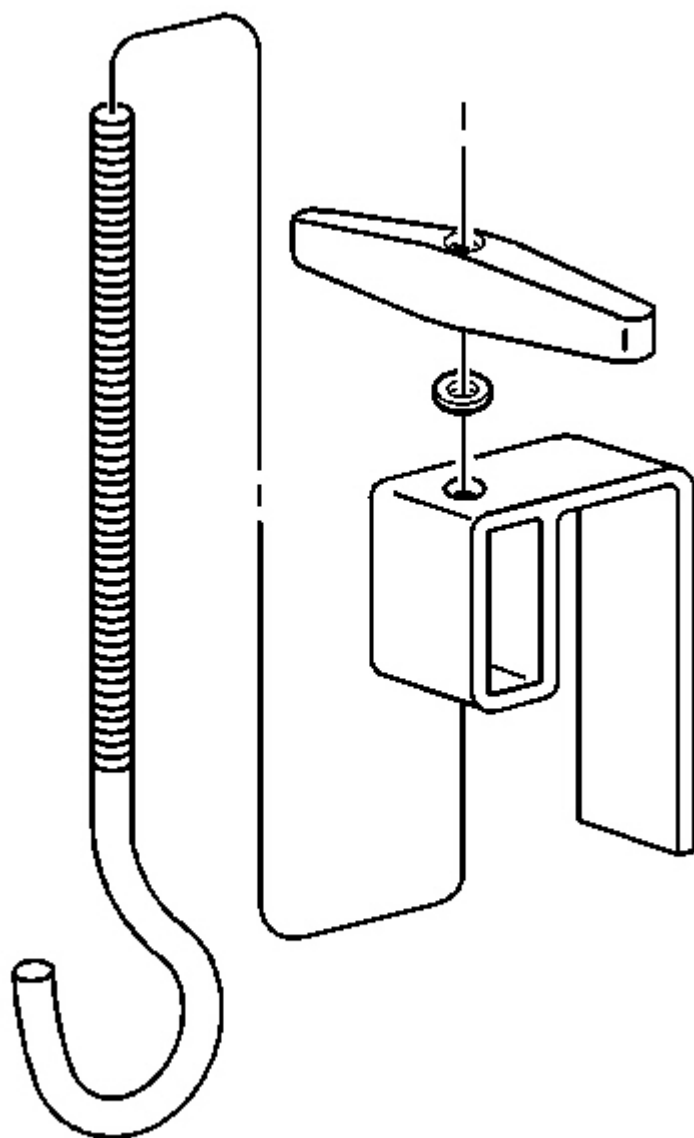


Fig. 43: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

14. Install the J-28467-7A bolt hook through the J-28467-6A bracket.
15. Install the J-28467-34 lift hook wing nut and washer to the J-28467-7A lift hook.

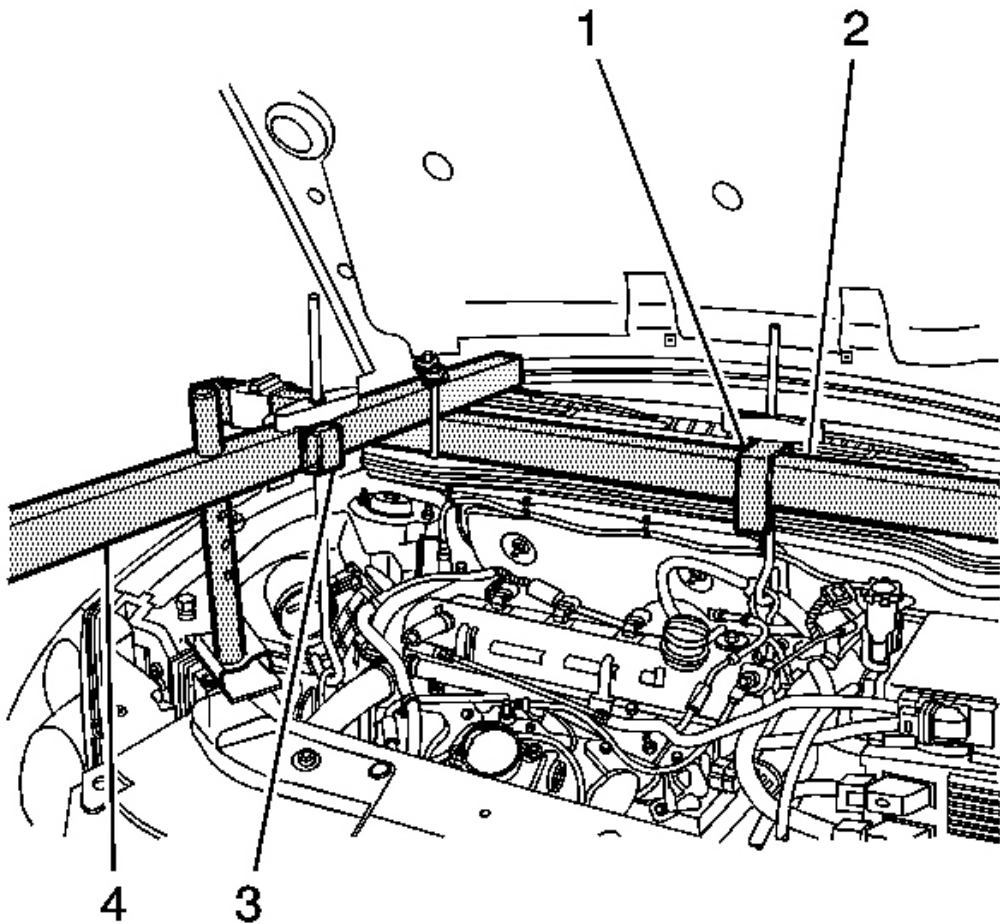


Fig. 44: Identifying Engine Support Fixture Components
Courtesy of GENERAL MOTORS CORP.

16. Install one of the lift hook and bracket assemblies (1) to the engine support fixture long bar (2).
17. Install the other lift hook and bracket assembly (3) to the J-28467-2A radiator shelf tube (4) above the engine front lift bracket.
18. Install the lift hook J-28467-7A through the engine rear lift bracket.
19. Install the lift hook J-28467-7A (3) through the engine front lift bracket.
20. Hand tighten the lift hook wing nuts J-28467-34 in order to remove all slack from the engine support fixture assembly.

OIL LEVEL INDICATOR TUBE REPLACEMENT

Removal Procedure

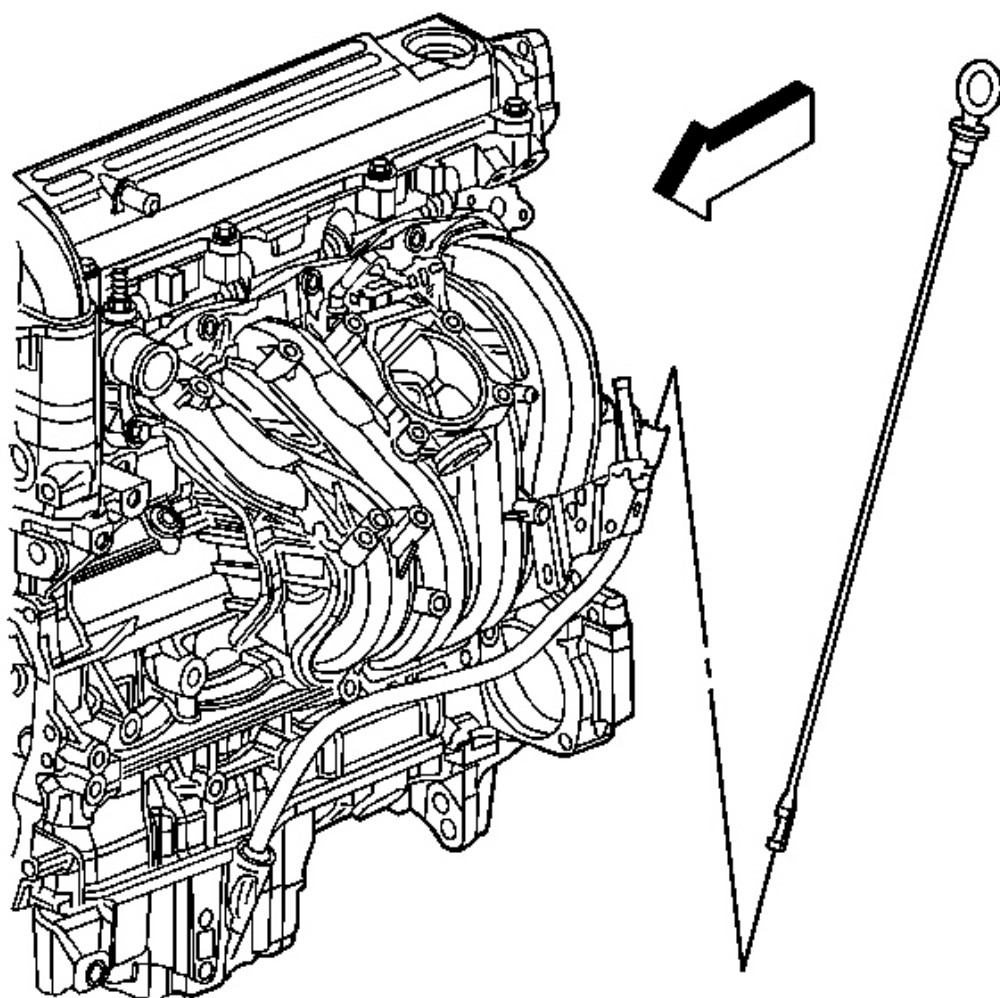


Fig. 45: Oil Level Indicator

Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the oil level indicator.

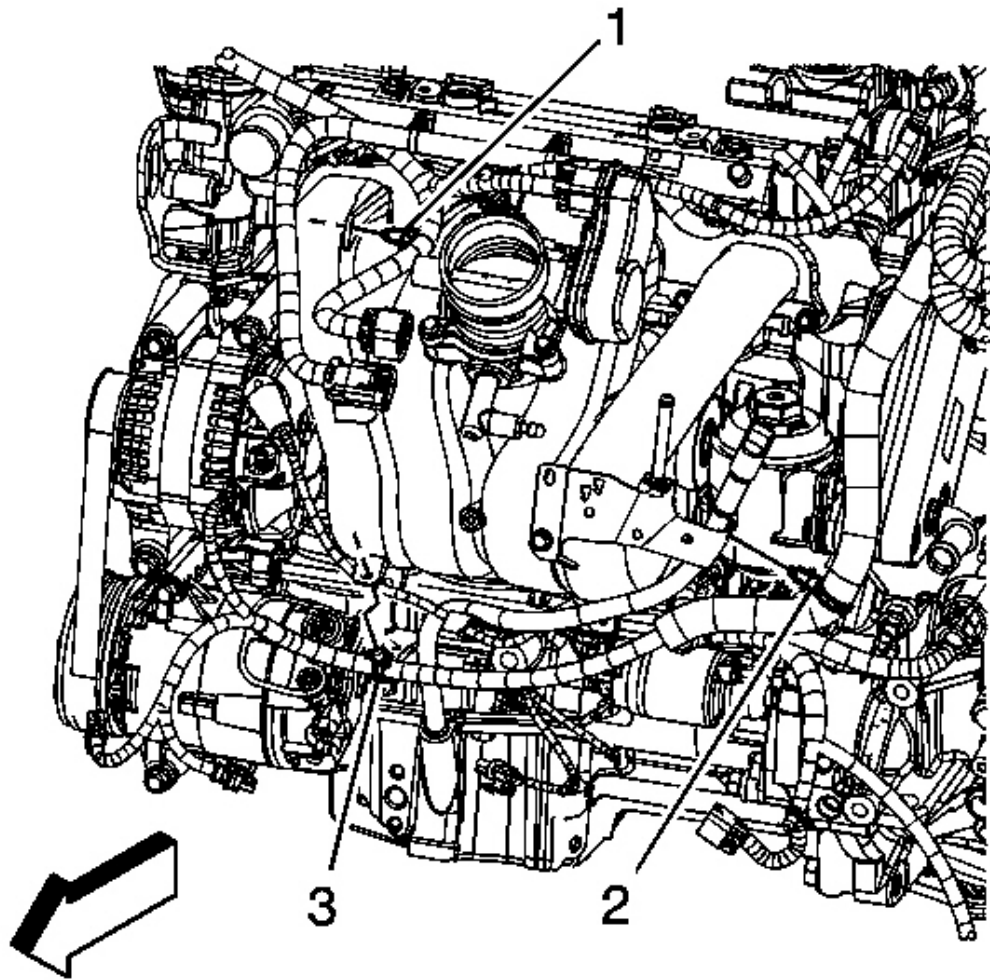


Fig. 46: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine harness clip (2) from the oil level indicator tube bracket.

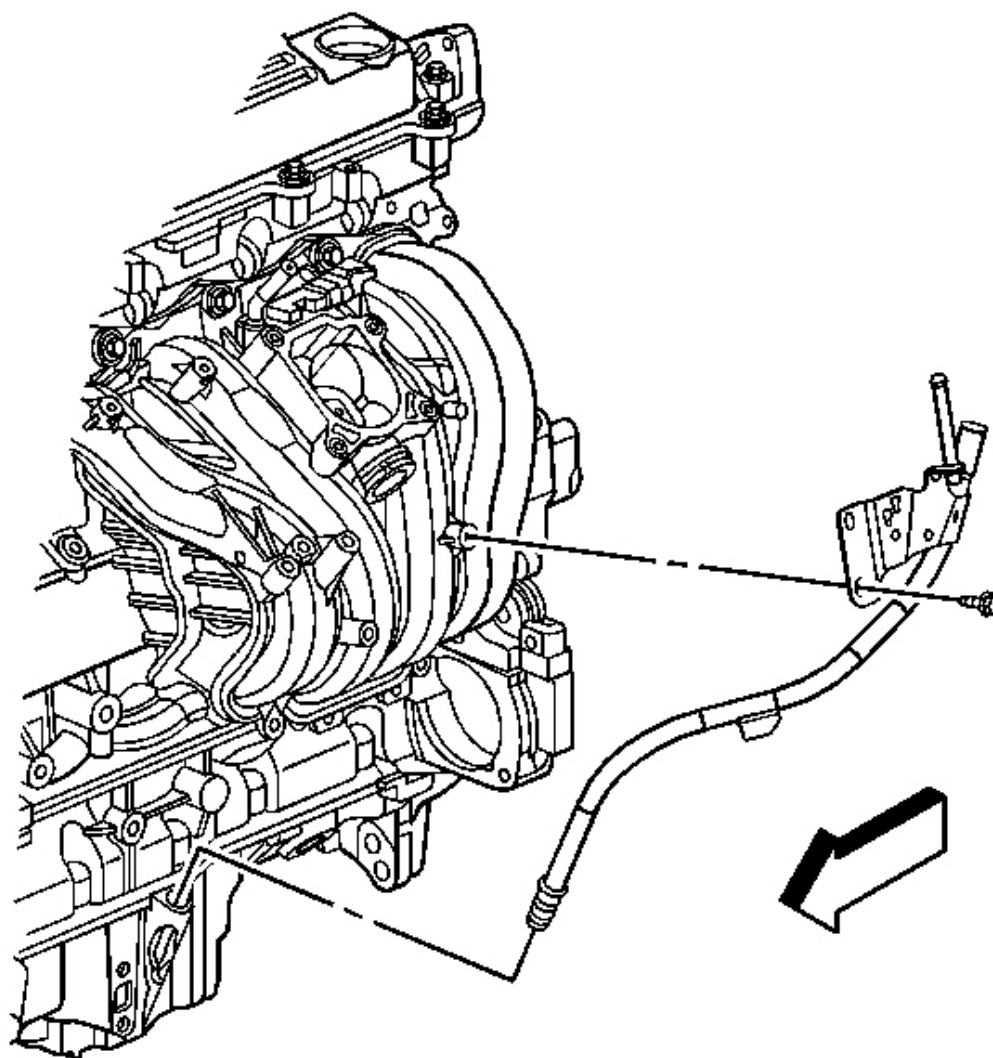


Fig. 47: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level indicator tube bolt.
5. Remove the oil level indicator tube.
6. Remove the oil level indicator tube O-ring seals, if necessary.
7. Disconnect electrical connector as needed.
8. Disconnect the brake vacuum pump connectors
9. A section of wire will be removed with the oil level indicator tube and will need to be transferred if the

oil indicator pipe is being replaced

Installation Procedure

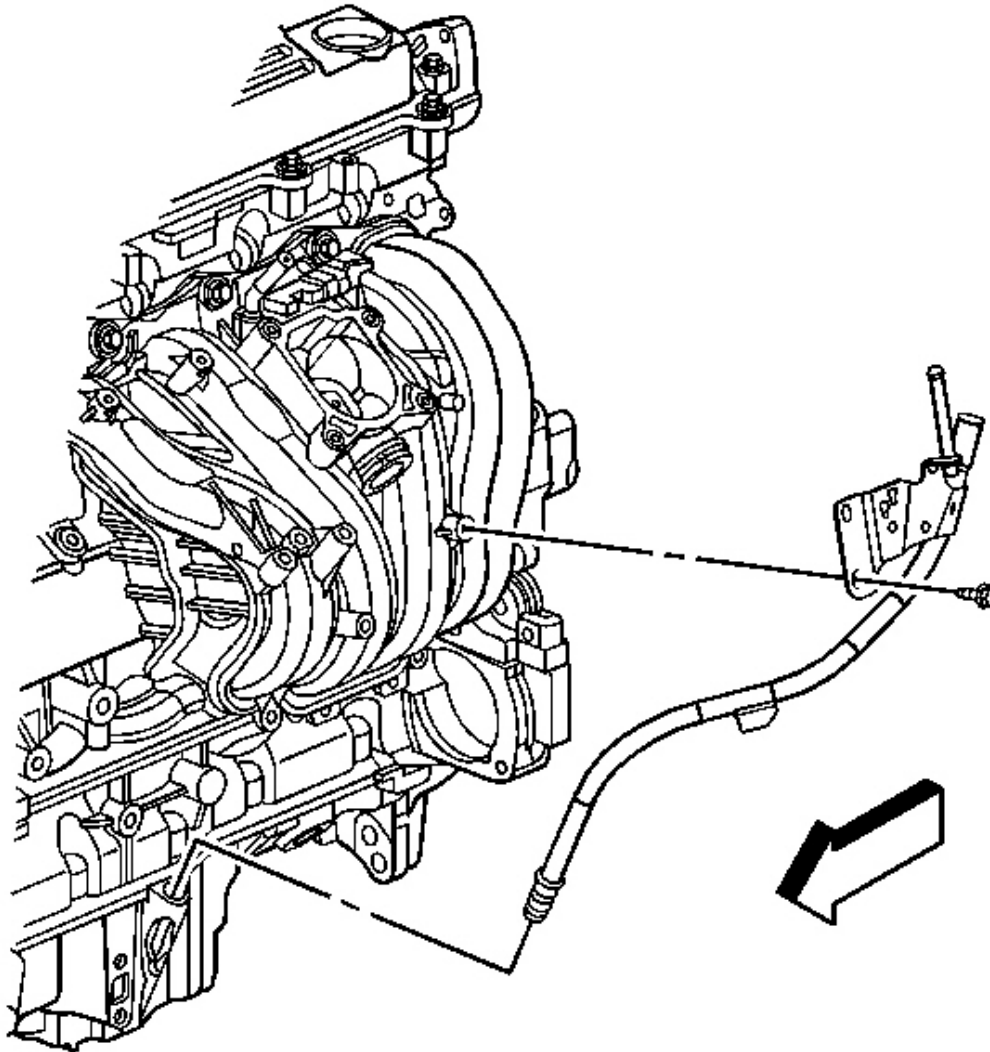


Fig. 48: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Install NEW oil level indicator tube O-ring seals, if necessary.
2. Install the oil level indicator tube.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bolt and tighten to 10 N.m (89 lb in).

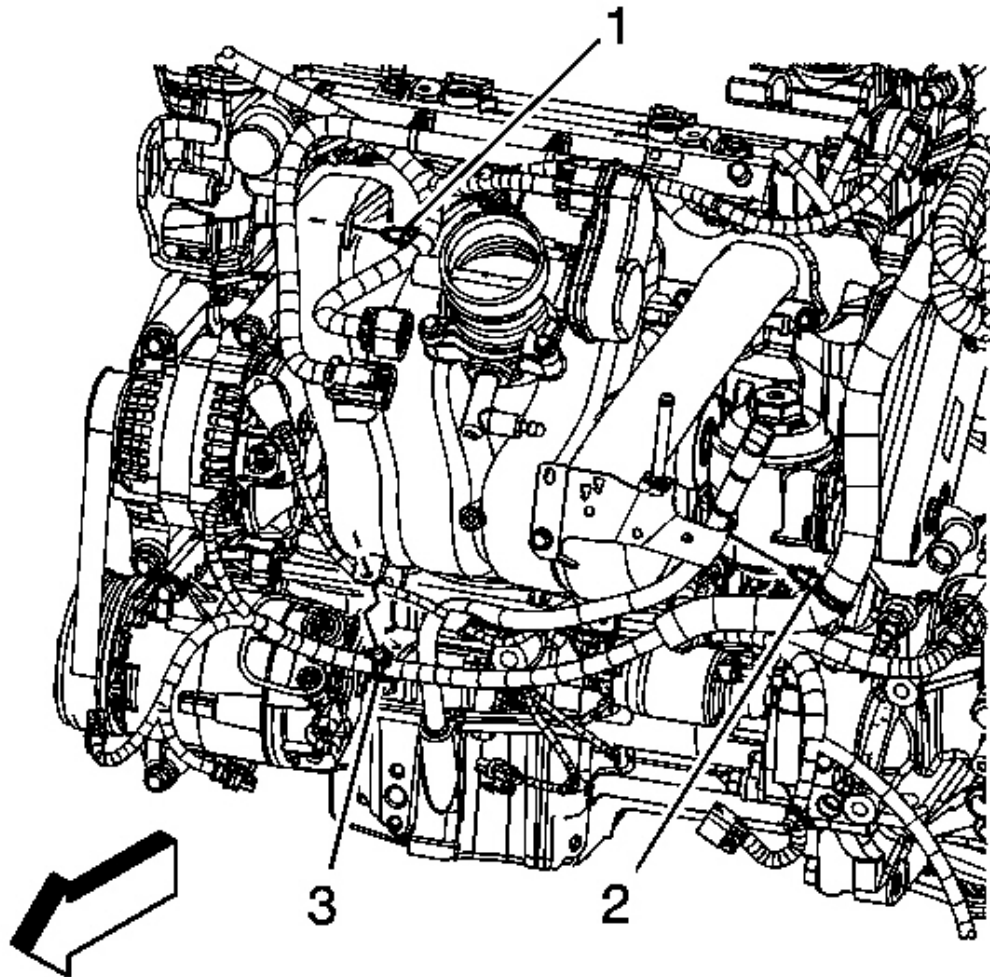


Fig. 49: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

4. Install the engine harness clip (1) to the oil level indicator tube bracket.

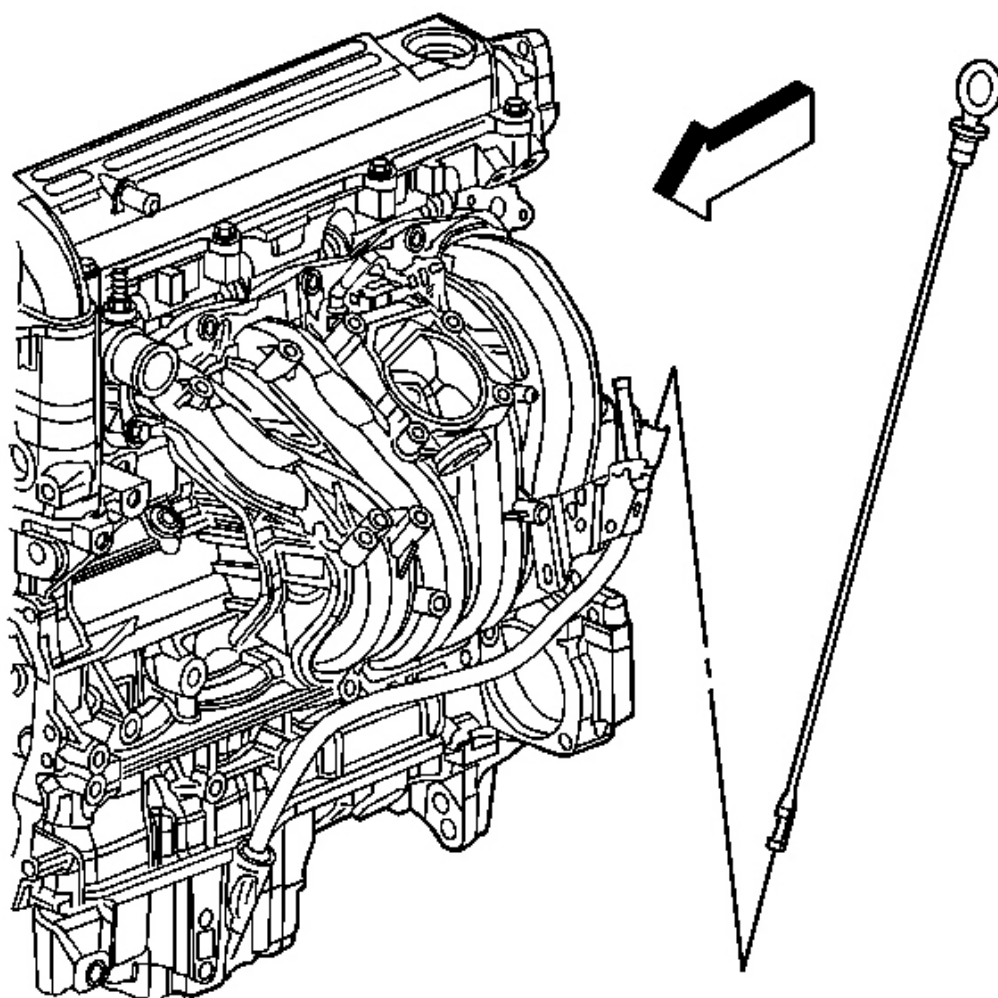


Fig. 50: Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

5. Install the oil level indicator.
6. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
7. connect electrical connector as needed.
8. Reconnect the brake vacuum pump connectors

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

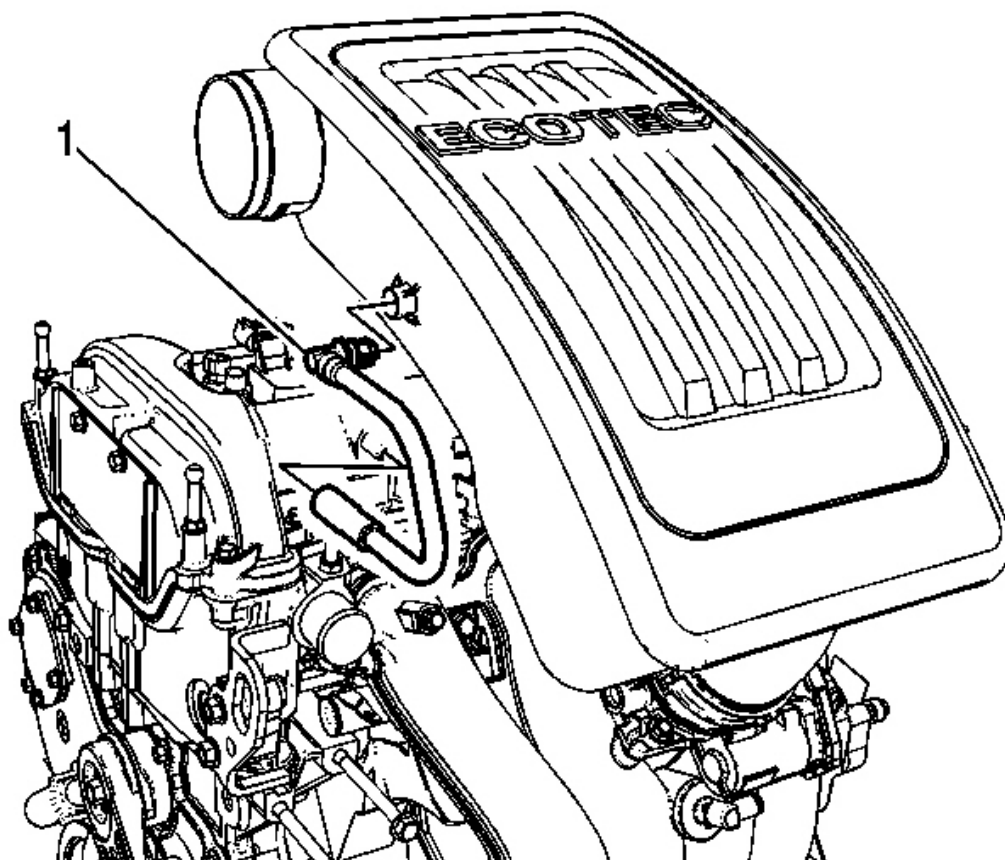


Fig. 51: Positive Crankcase Ventilation Hose/Pipe/Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the PCV hose (1) from the camshaft cover.

Installation Procedure

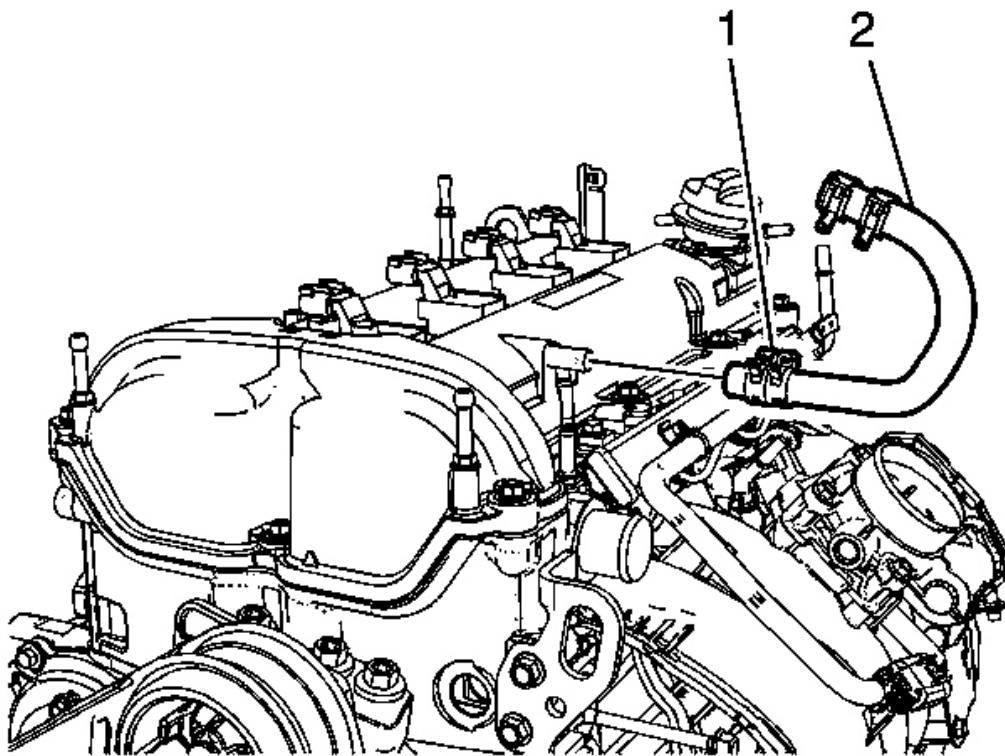


Fig. 52: PCV Hose

Courtesy of GENERAL MOTORS CORP.

1. Install the PCV hose (1) to the camshaft cover.
2. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Disconnect the evaporative emission canister purge tube at the intake manifold side only. Refer to **Evaporative Emission Canister Purge Tube Replacement**
2. Remove the manifold absolute pressure sensor. Refer to **Manifold Absolute Pressure Sensor Replacement**
3. Remove the fuel pump. Refer to **Fuel Pump Replacement**
4. Remove the throttle body. Refer to **Throttle Body Assembly Replacement**
5. Reposition the brake booster vacuum hose clamp at the intake manifold. Refer to **Power Brake Booster Vacuum Check Valve and Hose Replacement (2.4L)**

6. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**

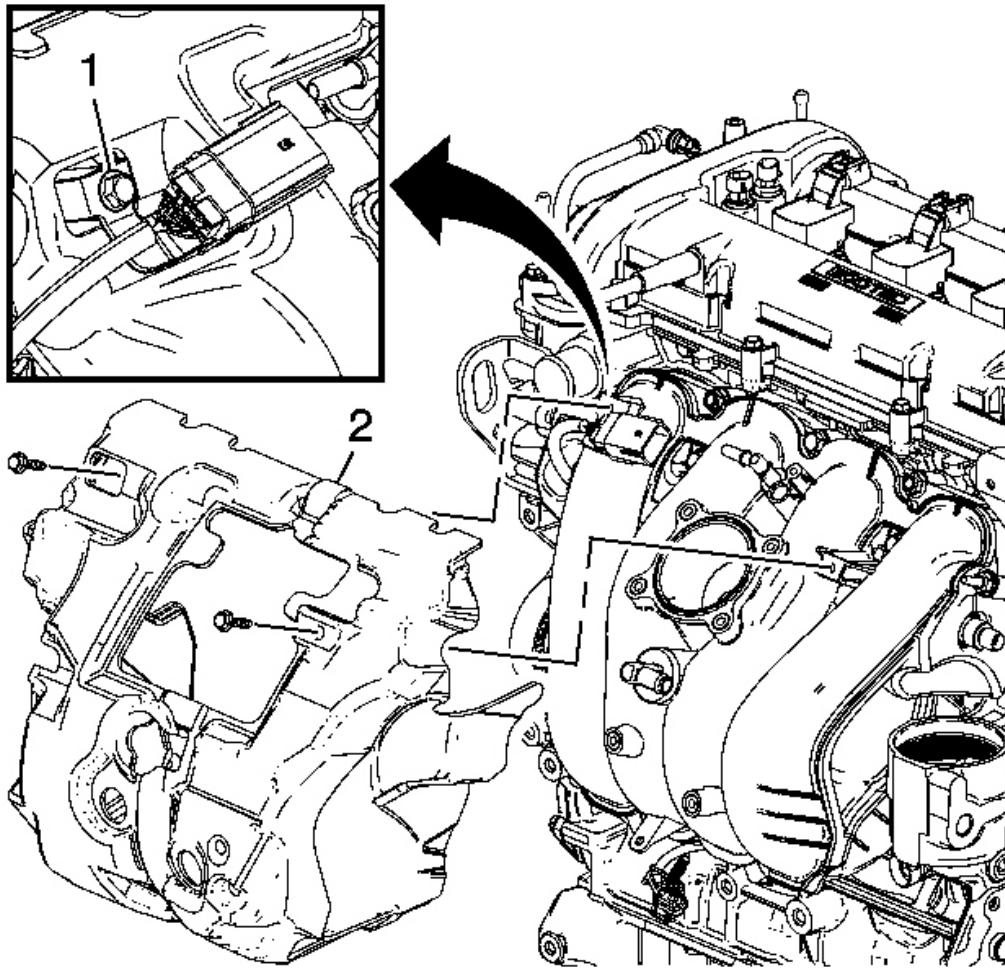


Fig. 53: Fuel Rail Harness Connector Bracket Bolt & Intake Manifold Insulator
Courtesy of GENERAL MOTORS CORP.

7. Remove the fuel rail harness connector bracket bolt (1) and intake manifold insulator bolt.
8. Remove the intake manifold insulator (2).
9. Discharging the A/C system. Refer to **Refrigerant Recovery and Recharging** .

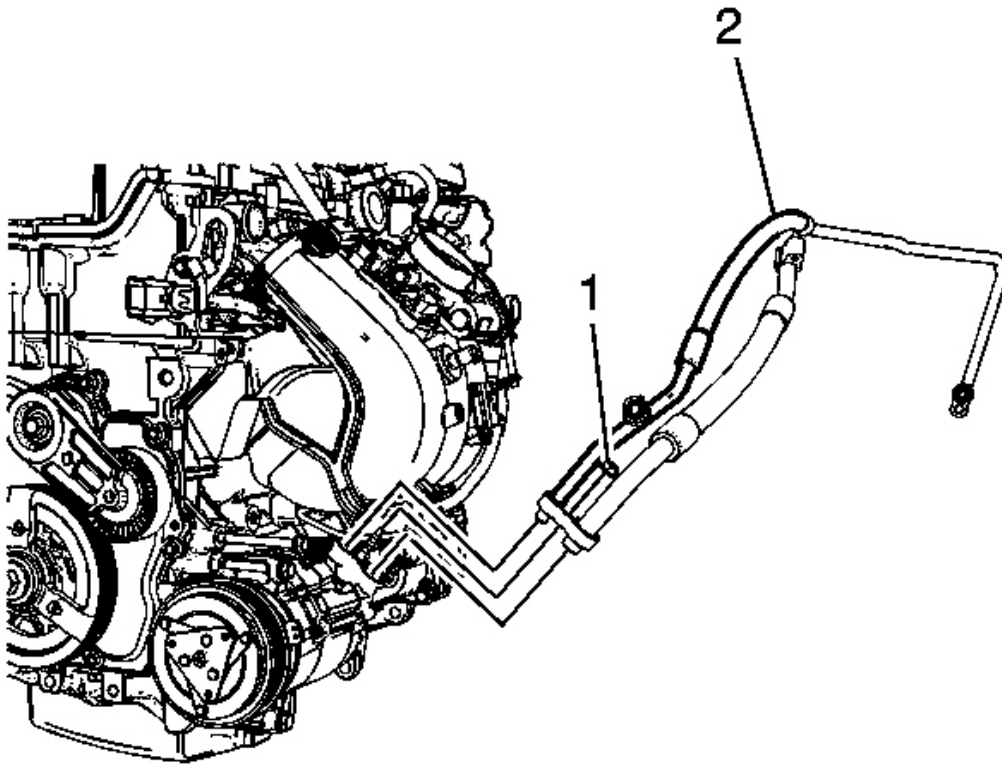


Fig. 54: A/C Line Components
Courtesy of GENERAL MOTORS CORP.

10. Remove the A/C line nut (1) and line (2) from the compressor and reposition the line to the side.

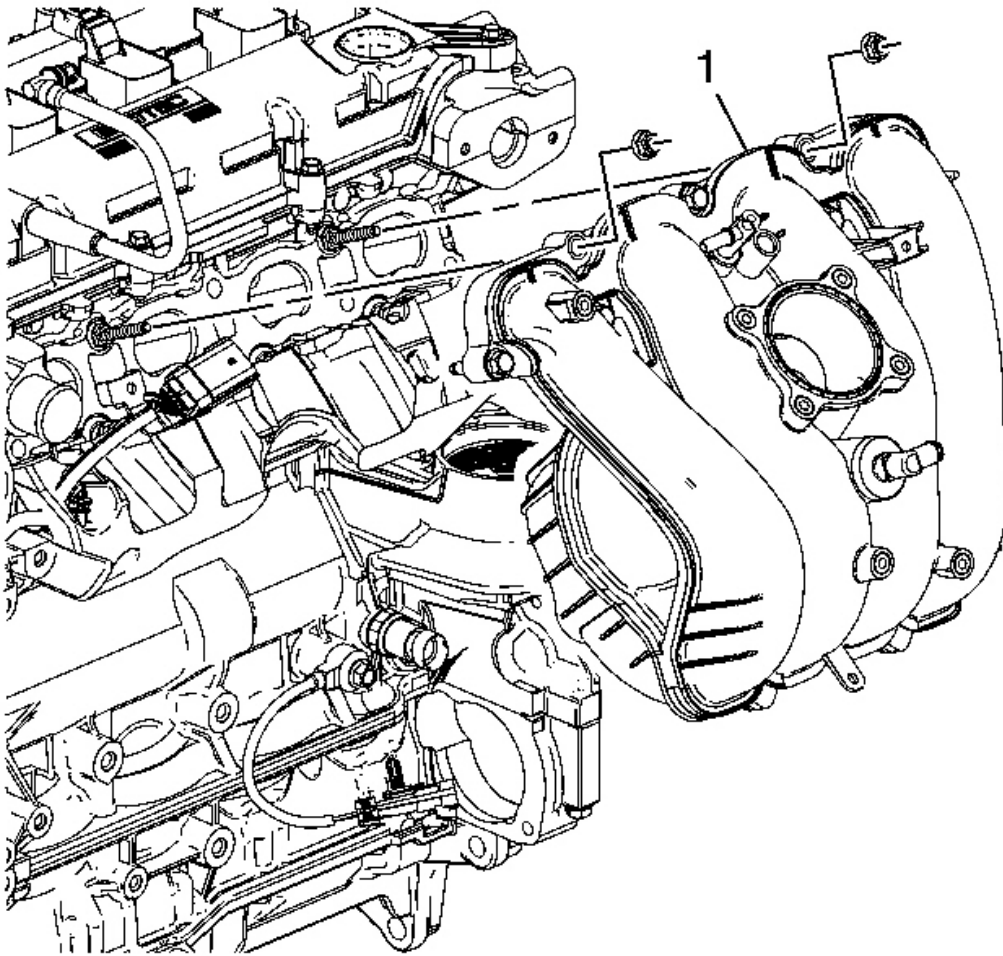


Fig. 55: Intake Manifold

Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold retaining nuts and bolts
12. Remove the intake manifold (1).

NOTE: **The intake manifold gasket is reusable. Only replace the gasket if damage has occurred.**

13. Disconnect electrical connectors as necessary.
14. Transfer parts as necessary.
15. Cleaning and inspection intake manifold. Refer to **Intake Manifold Cleaning and Inspection**

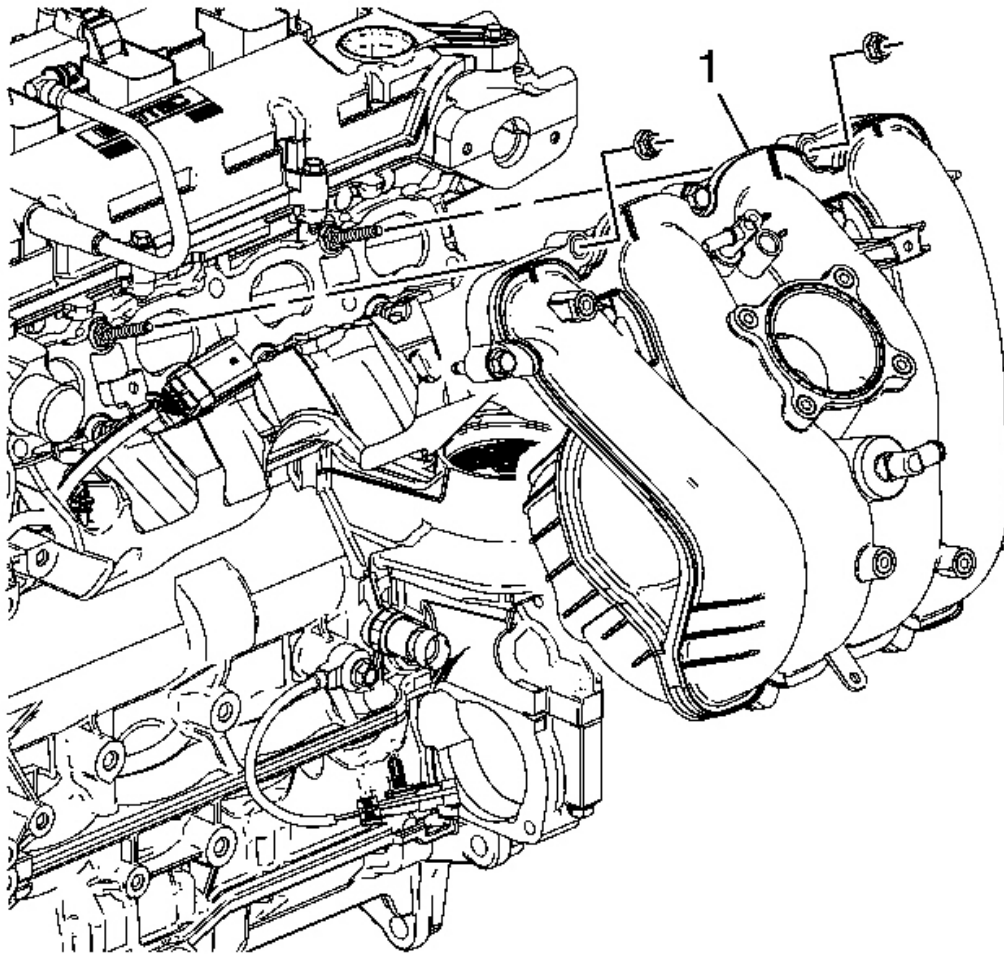


Fig. 56: Intake Manifold

Courtesy of GENERAL MOTORS CORP.

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

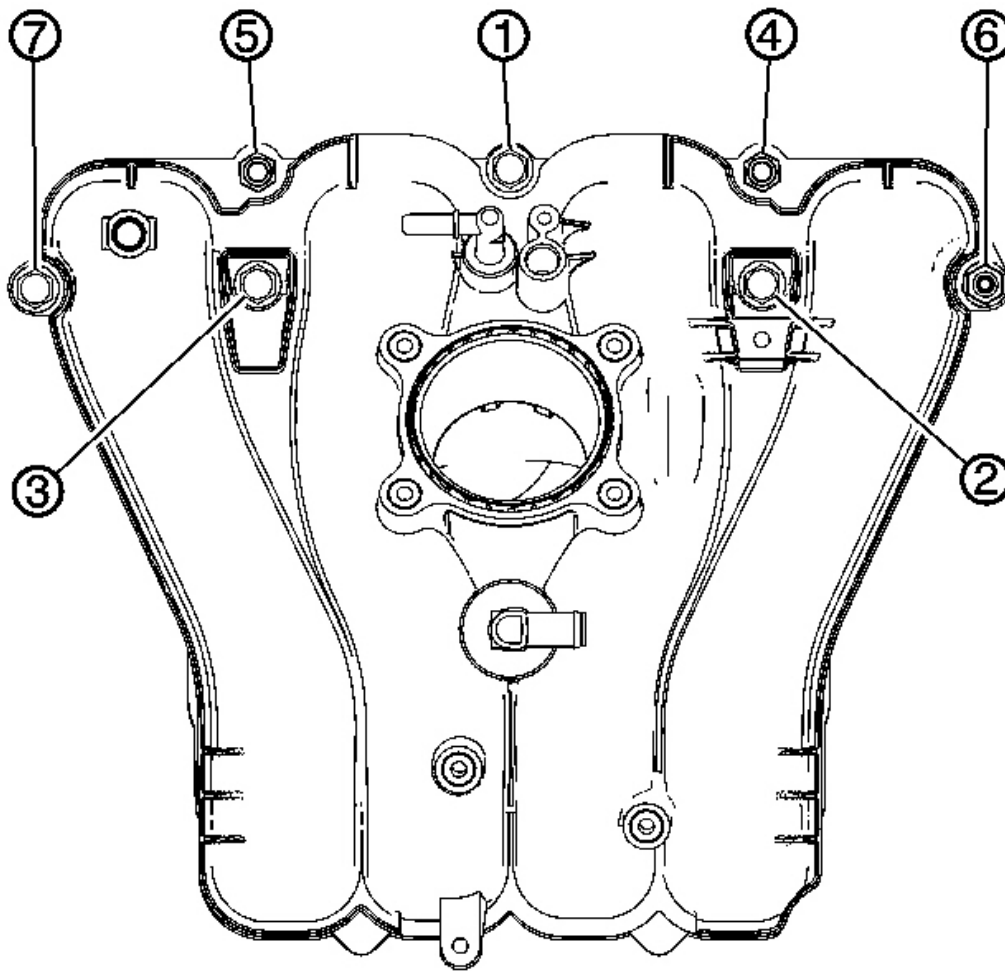


Fig. 57: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution Fastener Caution.

2. Install the intake manifold bolts and nuts and tighten to 10 N.m (89 lb in).

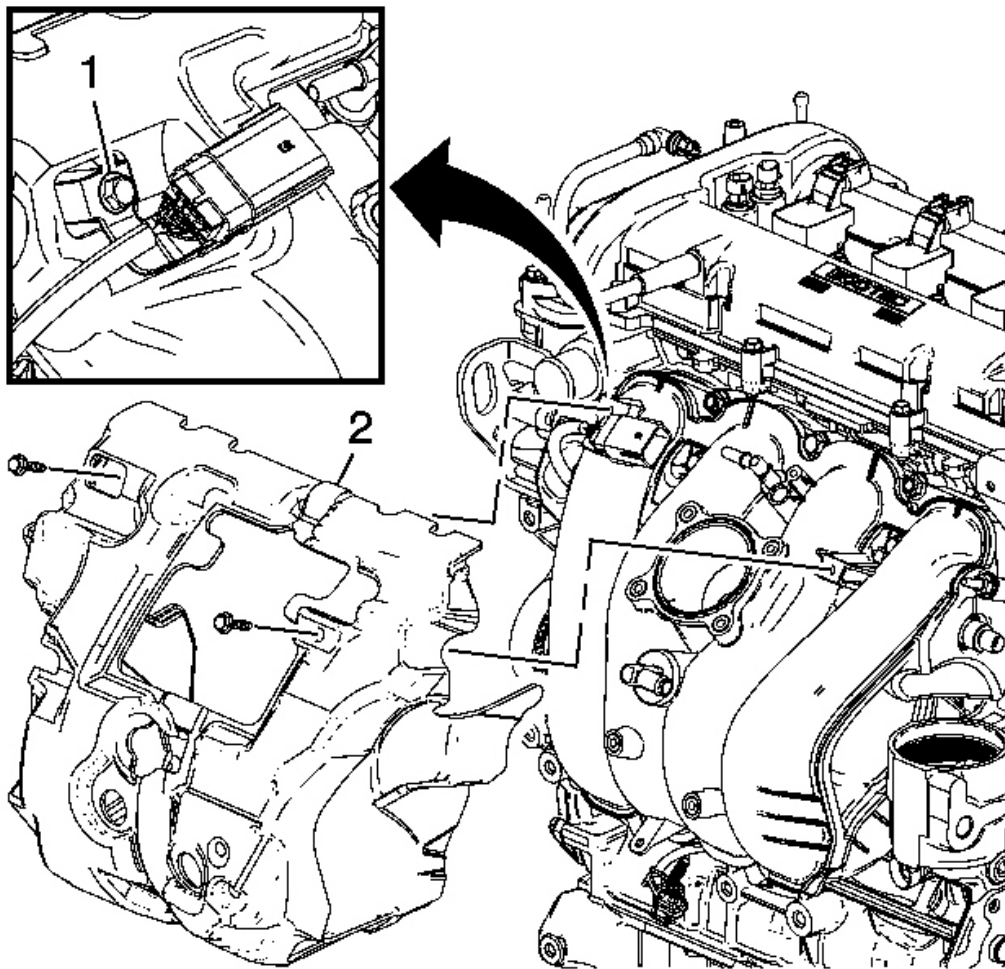


Fig. 58: Fuel Rail Harness Connector Bracket Bolt & Intake Manifold Insulator
Courtesy of GENERAL MOTORS CORP.

3. Install the intake manifold insulator (2).
4. Install the insulator bolt and tighten to 10 N.m (89 lb in).
5. Install the fuel rail harness connector bracket (1) to the intake manifold. Tighten the bracket bolt to 10 N.m (89 lb in).
6. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
7. Connect the brake booster vacuum hose clamp at the intake manifold. Refer to **Power Brake Booster Vacuum Check Valve and Hose Replacement (2.4L)**.
8. Install the throttle body. Refer to **Throttle Body Assembly Replacement**.
9. Install the fuel pump. Refer to **Fuel Pump Replacement**.

10. Install the manifold absolute pressure sensor. Refer to **Manifold Absolute Pressure Sensor Replacement**
11. Connect the evaporative emission canister purge tube at the intake manifold side only. Refer to **Evaporative Emission Canister Purge Tube Replacement** .

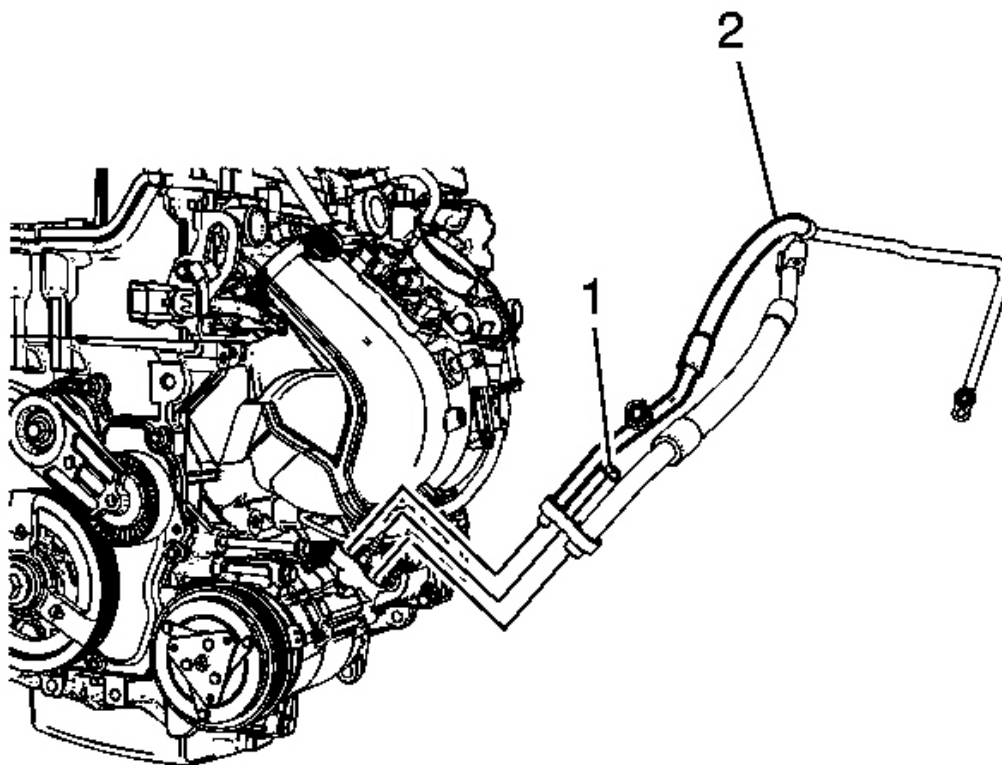


Fig. 59: A/C Line Components

Courtesy of GENERAL MOTORS CORP.

12. Install new seal washers to the compressor hose. Refer to **Air Conditioning System Seal Replacement**
13. Install the compressor hose (2) to the compressor.
14. Install the compressor hose nut (1) to the compressor and tighten the nut to 22 N.m (16 lb ft).
15. Connect the engine harness electrical connector as necessary.
16. Recharging the A/C system. Refer to **Refrigerant Recovery and Recharging** .

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **J 38122-A** Harmonic Balancer Holder. See Special Tools.
- **J 45059** Angle Meter

Removal Procedure

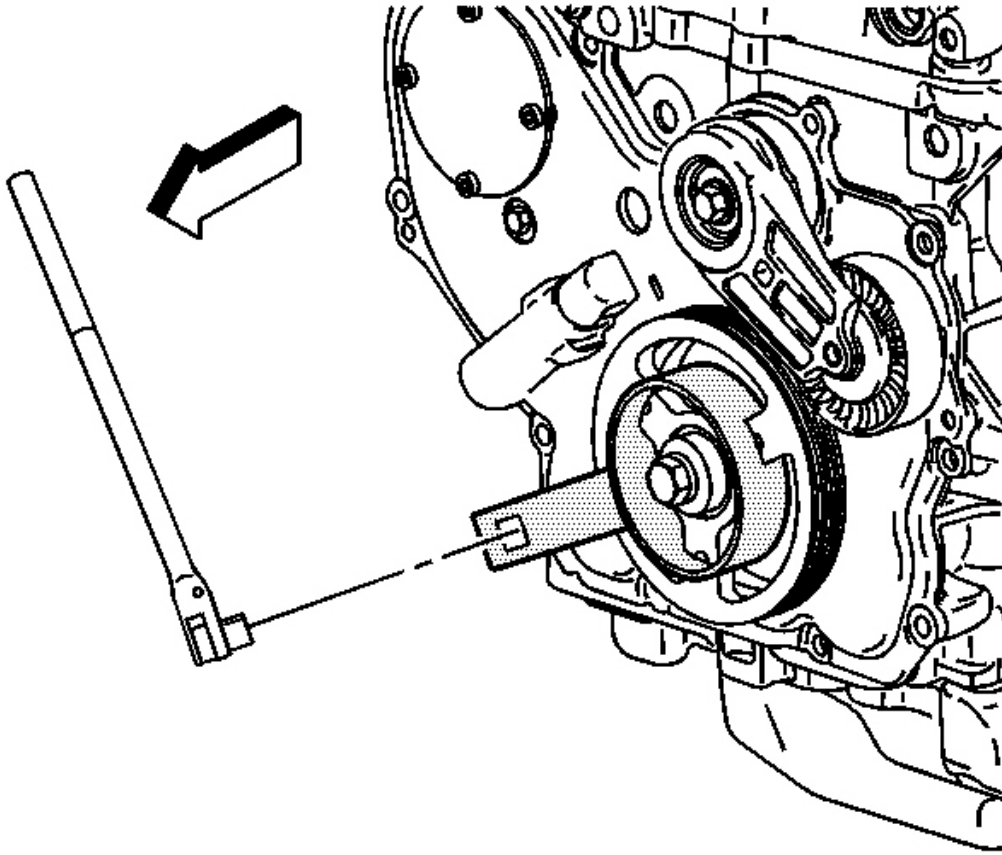


Fig. 60: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to Drive Belt Replacement.
2. Use **J 38122-A** to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt. See Special Tools.
3. Remove and discard the crankshaft balancer bolt.

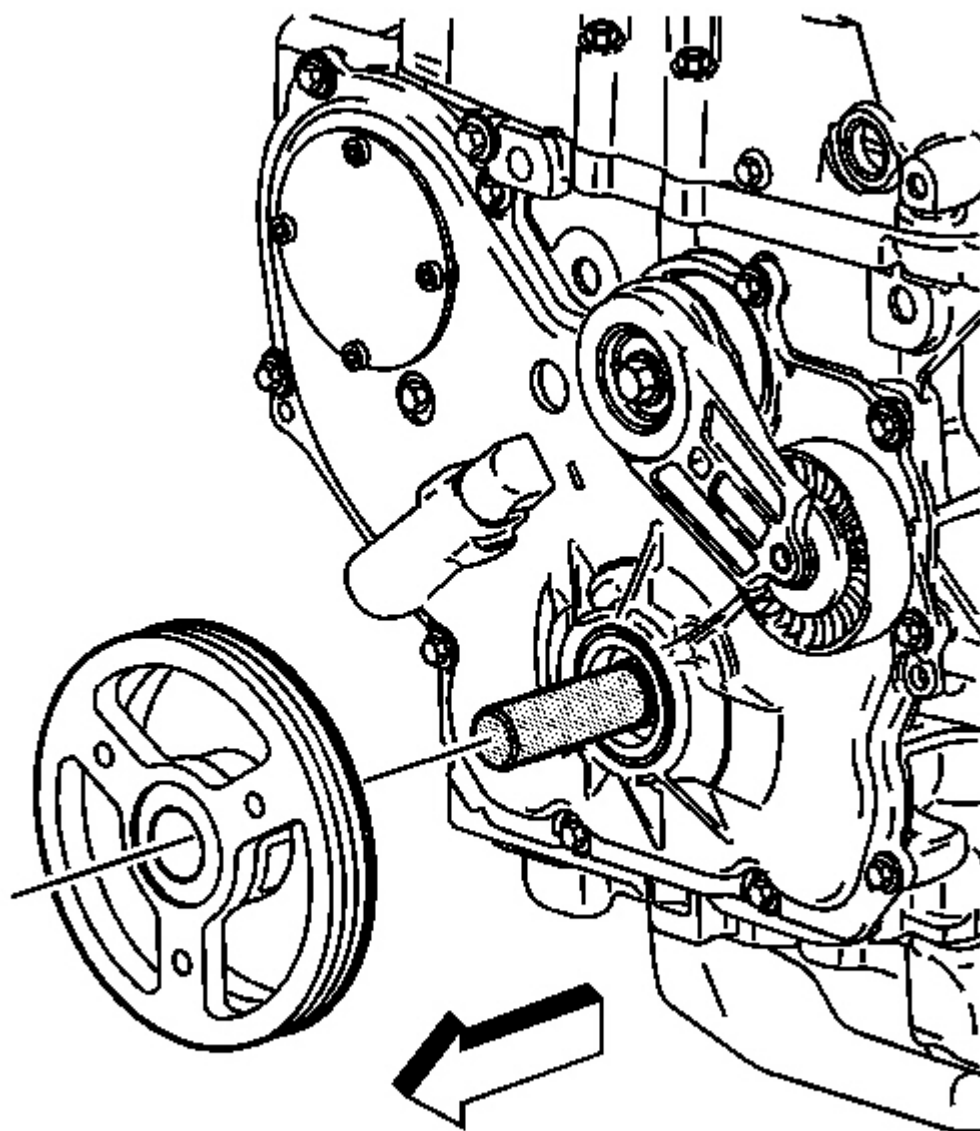


Fig. 61: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

Installation Procedure

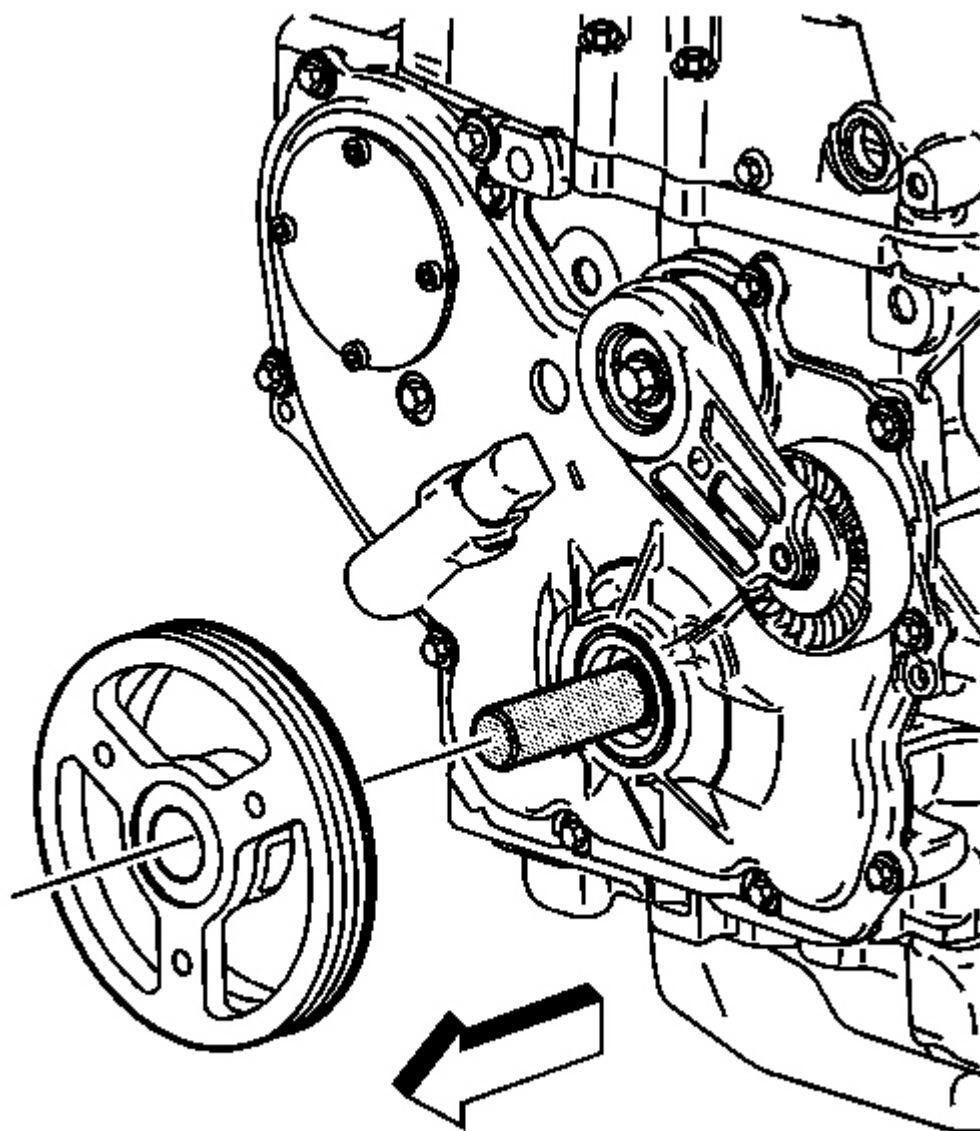


Fig. 62: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer.
2. Install a NEW crankshaft balancer bolt.

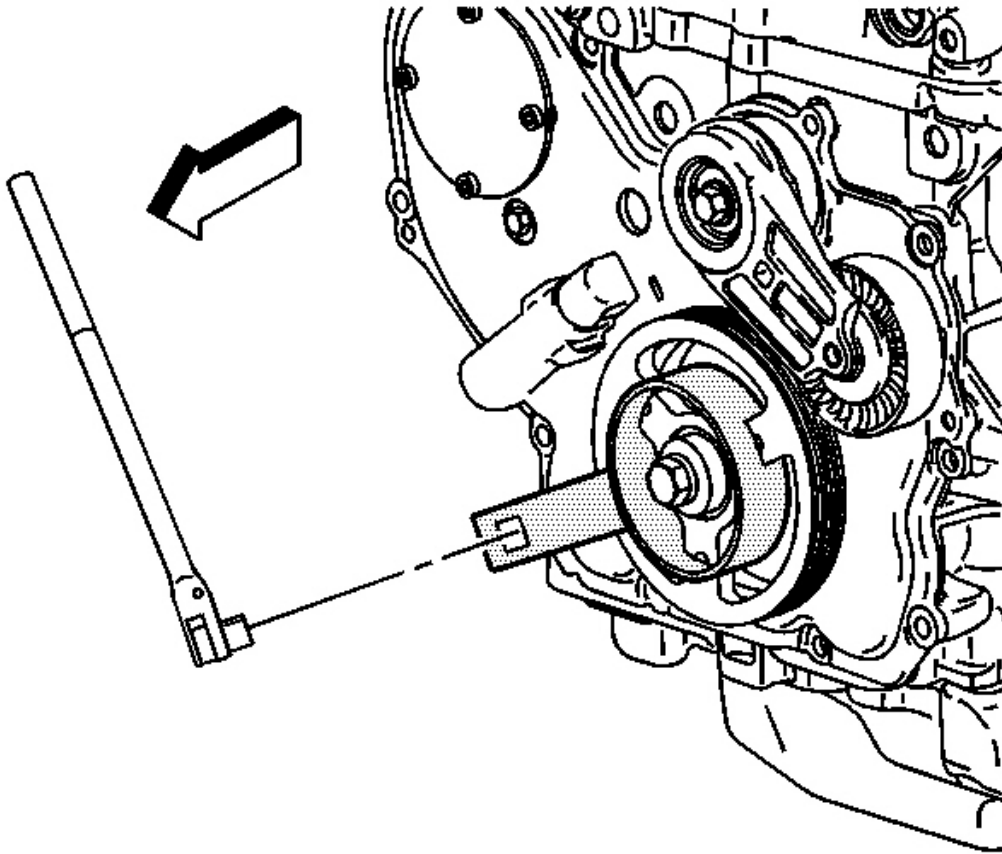


Fig. 63: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 38122-A** to hold the crankshaft balancer in order to prevent the balancer from rotating while tightening the bolt. See **Special Tools**.

CAUTION: Refer to Fastener Caution .

4. Tighten the crankshaft balancer bolt to 100 N.m (74 lb ft) plus an additional 125 degrees using the **J 45059** .
5. Install the drive belt. Refer to **Drive Belt Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

J 35268-A Camshaft/Front Main Seal Installer. See **Special Tools**.

Removal Procedure

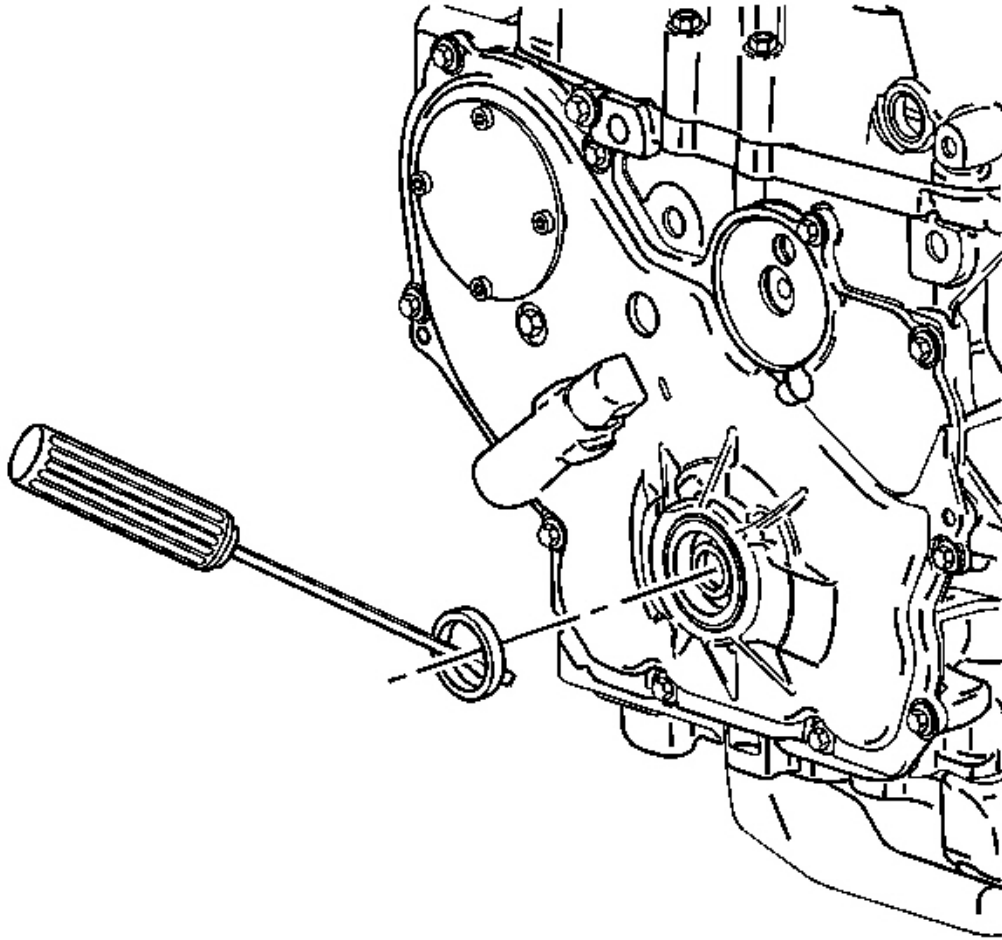


Fig. 64: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Use a flat-bladed tool to remove the seal from the front cover.

Installation Procedure

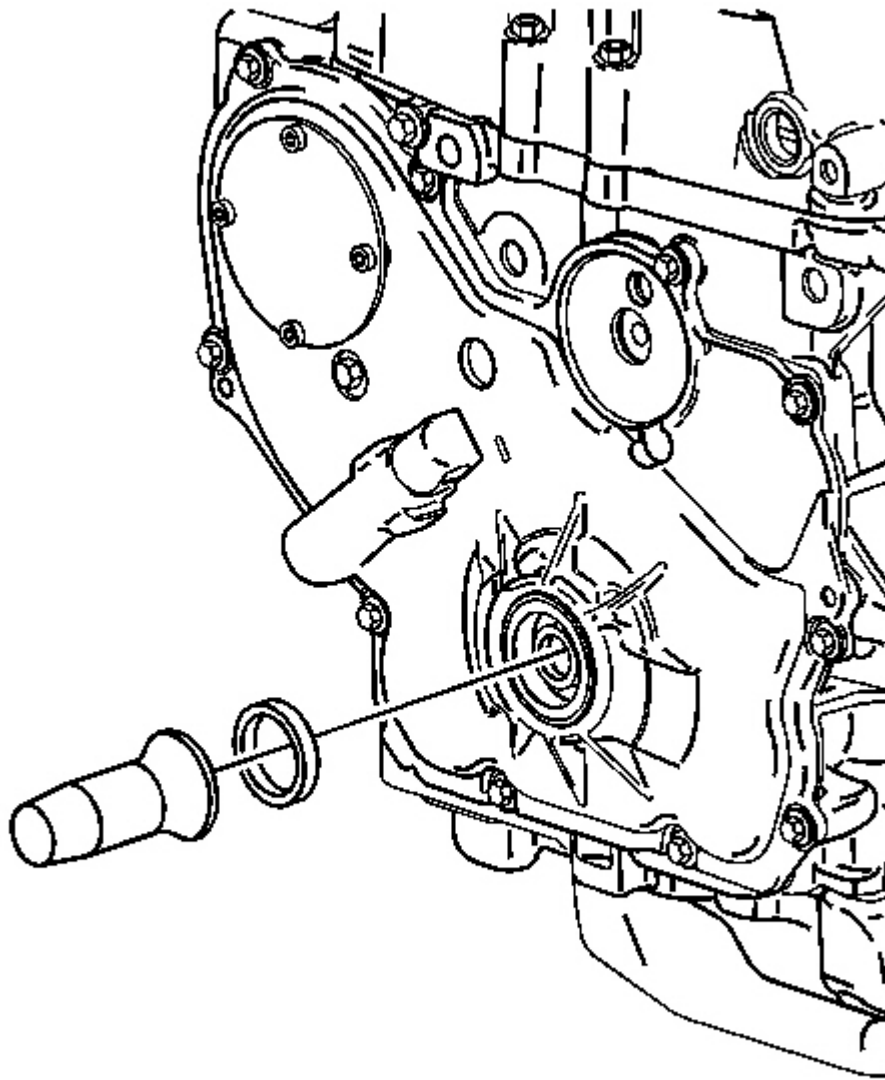


Fig. 65: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 35268-A** in order to install the crankshaft front oil seal to the engine front cover. See **Special Tools**.
2. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Removal Procedure

1. Remove the drive belt tensioner. Refer to [Drive Belt Tensioner Replacement](#).
2. Remove the crankshaft balancer. Refer to [Crankshaft Balancer Replacement](#).
3. Install the engine support fixture. Refer to [Engine Support Fixture](#).
4. Remove the engine mount and bracket. Refer to [Engine Mount Bracket Replacement](#).

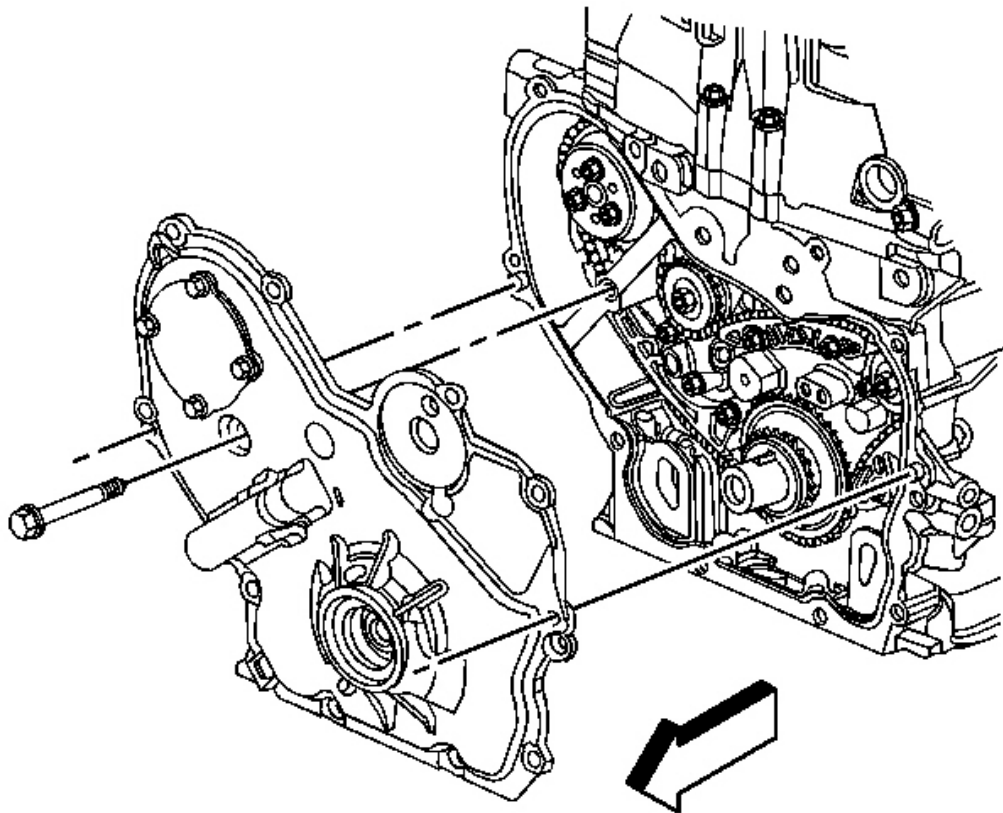


Fig. 66: Engine Front Cover To Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine front cover to water pump bolt.

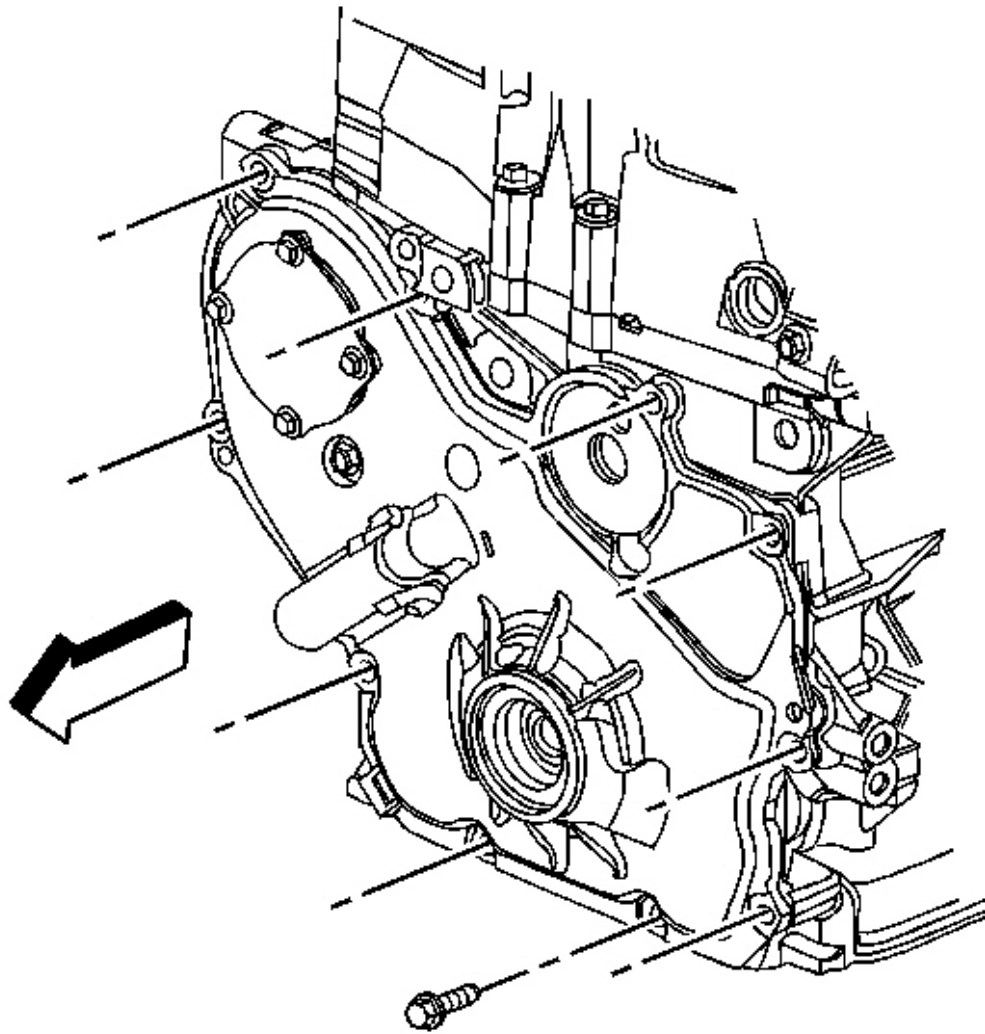


Fig. 67: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

6. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
7. Remove the engine front cover bolts.
8. Remove the engine front cover.

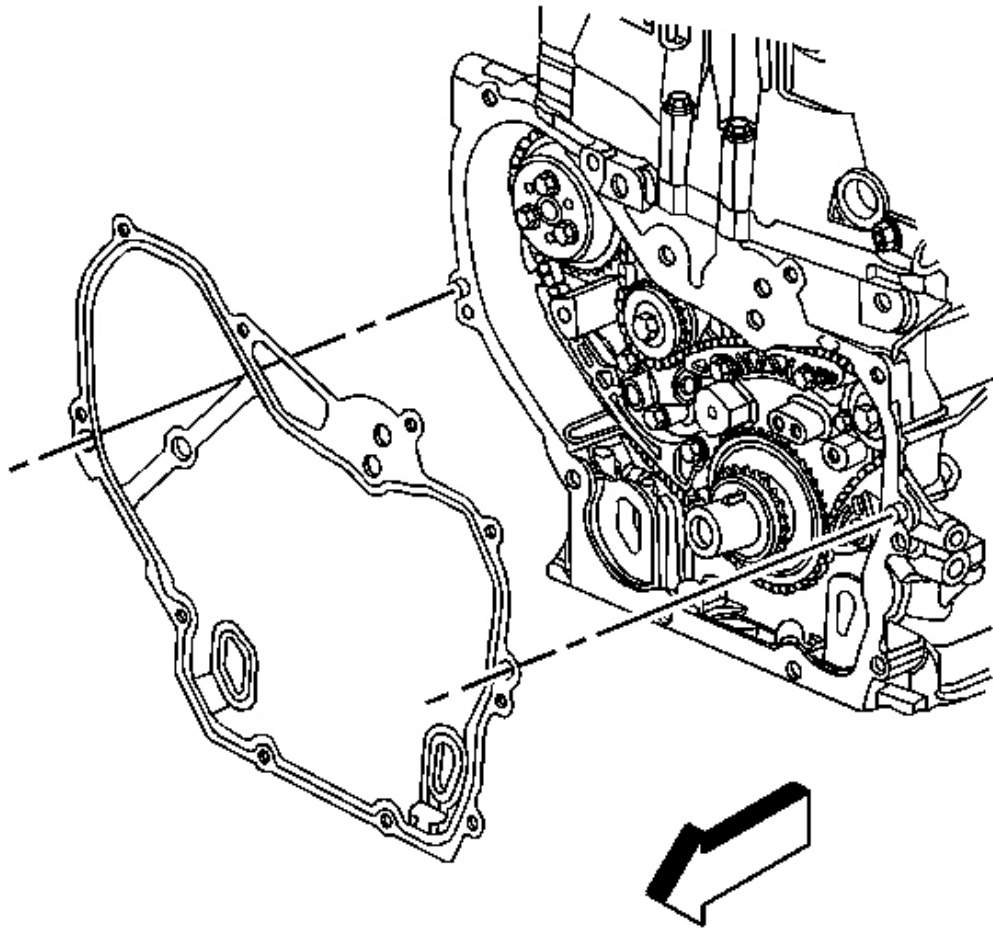


Fig. 68: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the engine front cover gasket.

Installation Procedure

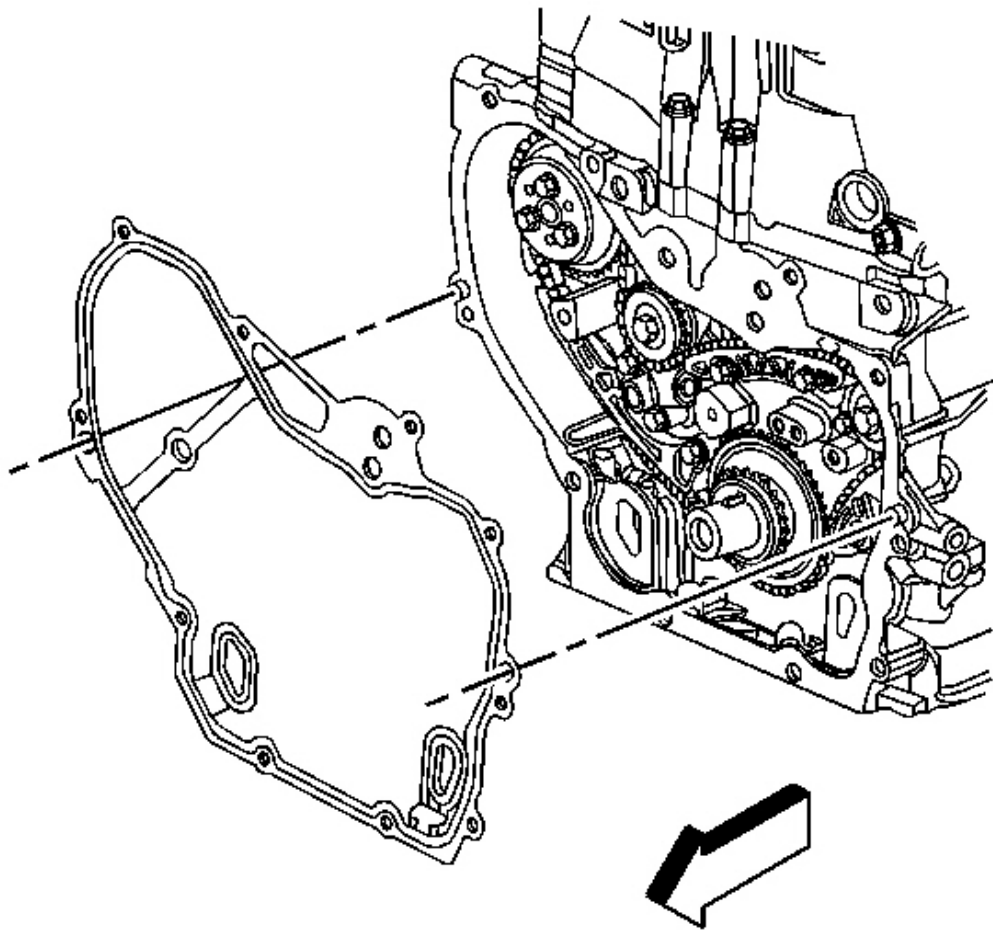


Fig. 69: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW engine front cover gasket to the dowel pins.
2. Install the engine front cover.

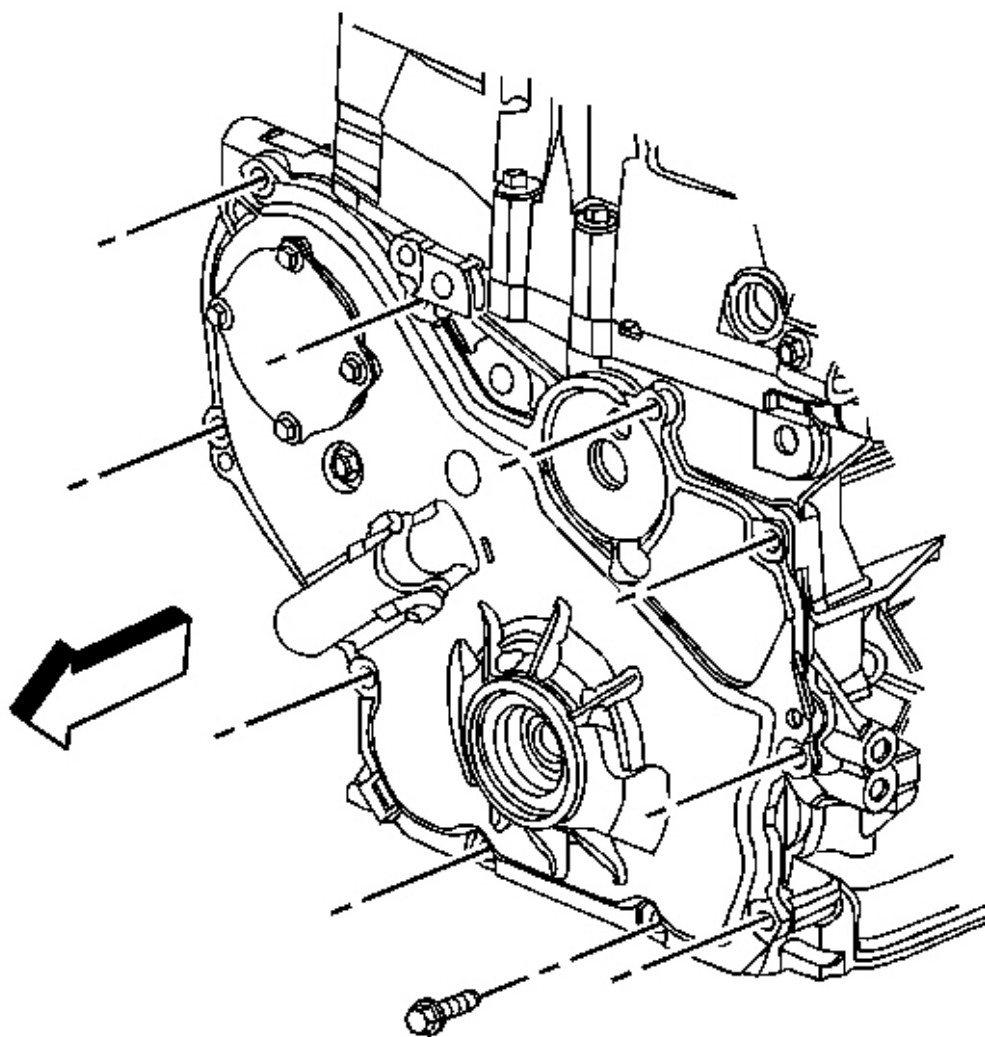


Fig. 70: Engine Front Cover

Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
4. Lower the vehicle.

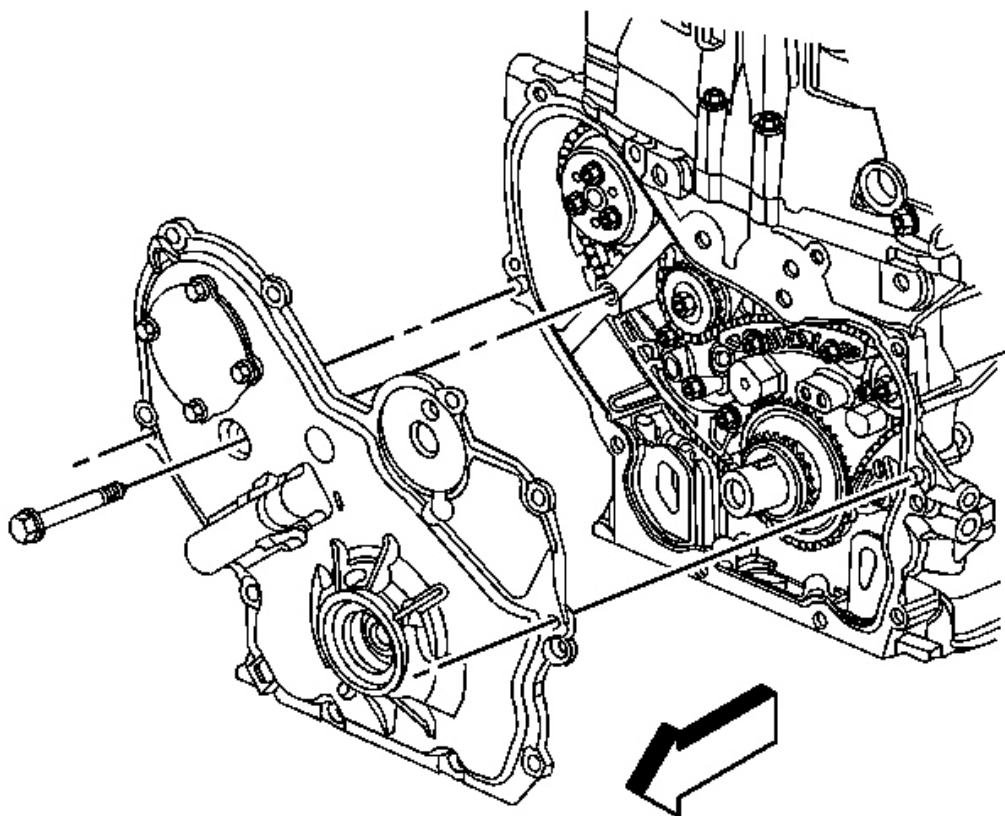


Fig. 71: Engine Front Cover To Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover to water pump bolt and tighten to 25 N.m (18 lb ft).

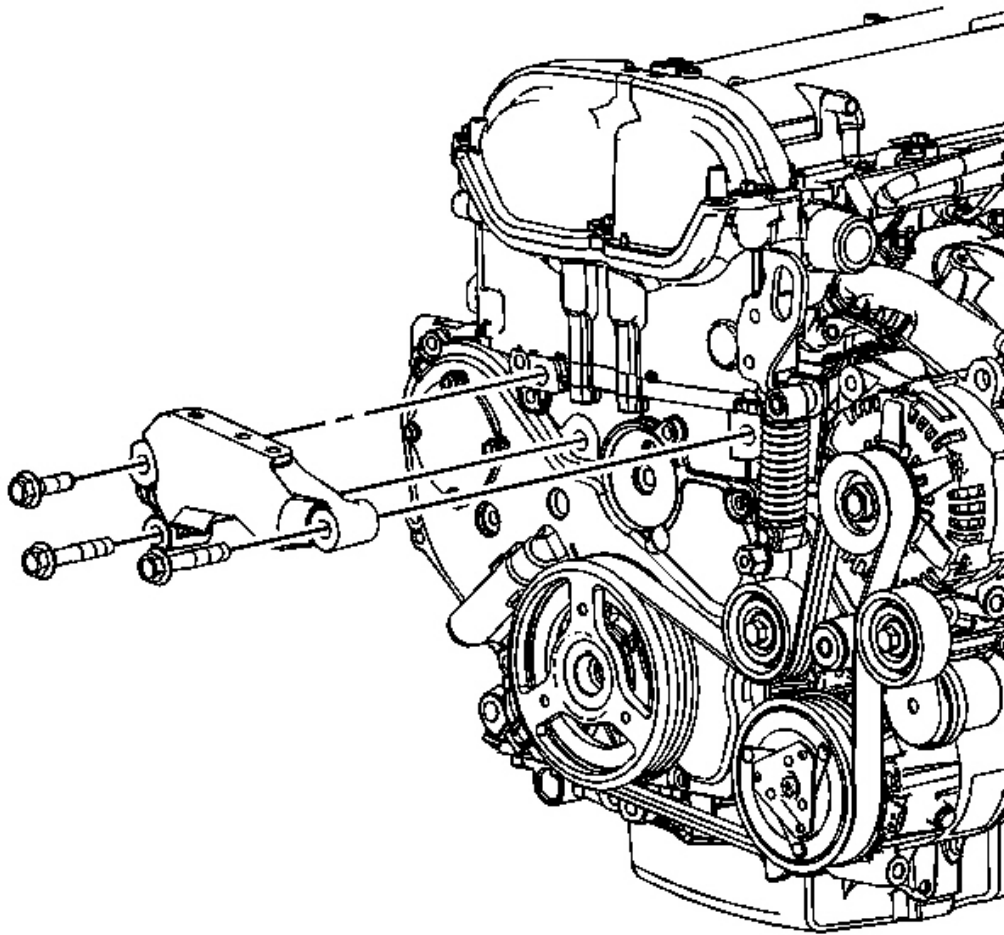


Fig. 72: Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

6. Position the engine mount and bracket. Refer to **Engine Mount Bracket Replacement**.
7. Remove the engine support fixture. Refer to **Engine Support Fixture**.
8. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
9. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

Special Tools

- **EN-45027: Tensioner Tool**

- **EN-45059:** Angle Meter

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

Removal Procedure

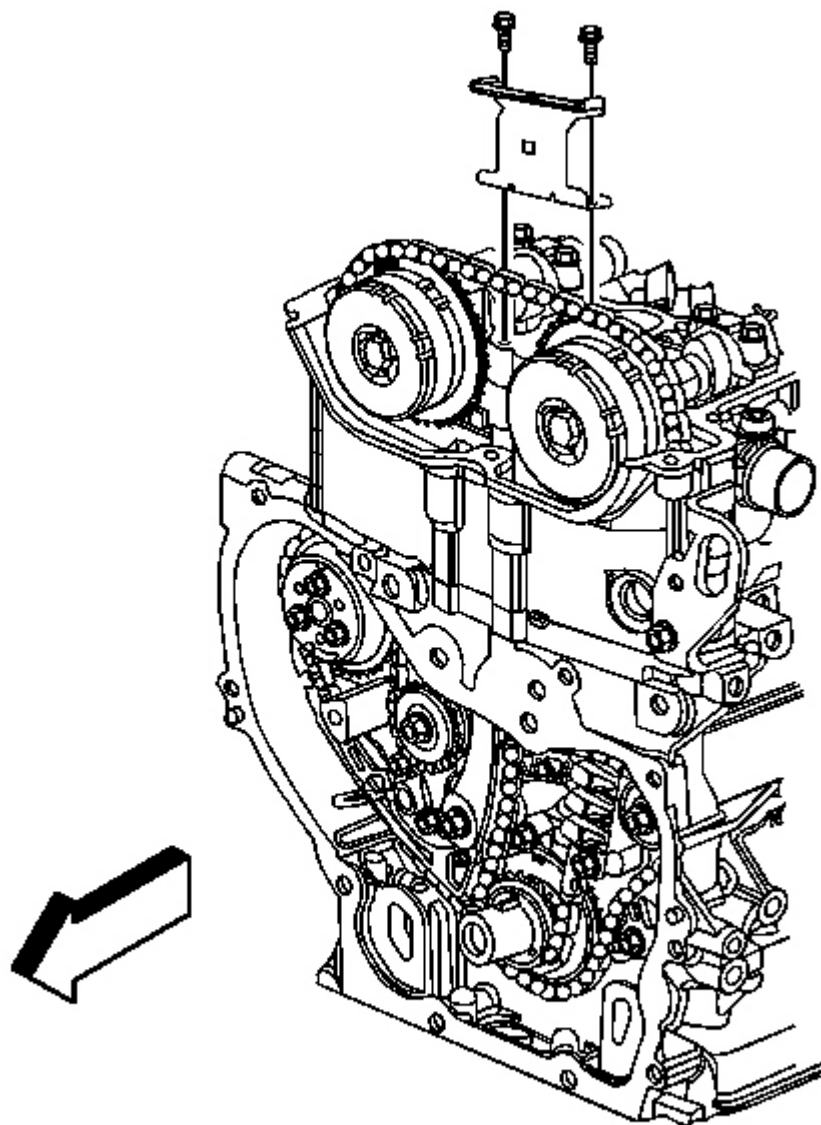


Fig. 73: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the number 1 cylinder spark plug. Refer to **Spark Plug Replacement** .
2. Rotate the crankshaft in the engine rotational direction clockwise, until the number 1 piston is at top dead center (TDC) on the exhaust stroke.
3. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
4. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Remove the upper timing chain guide bolts and guide.

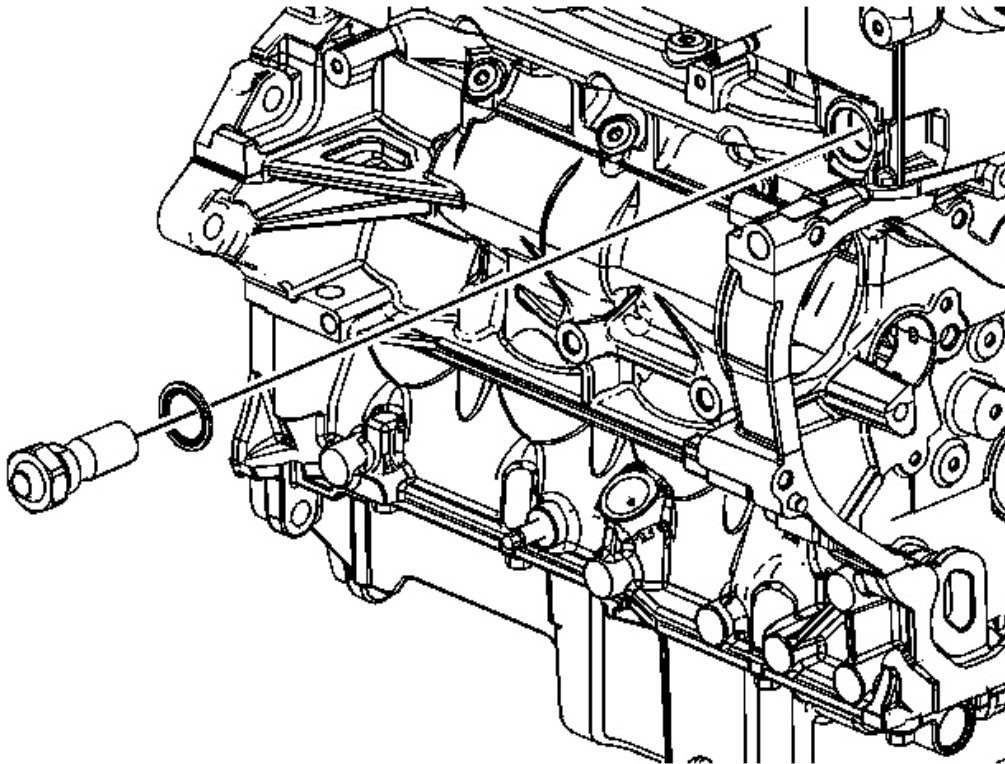


Fig. 74: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

6. Remove the timing chain tensioner.

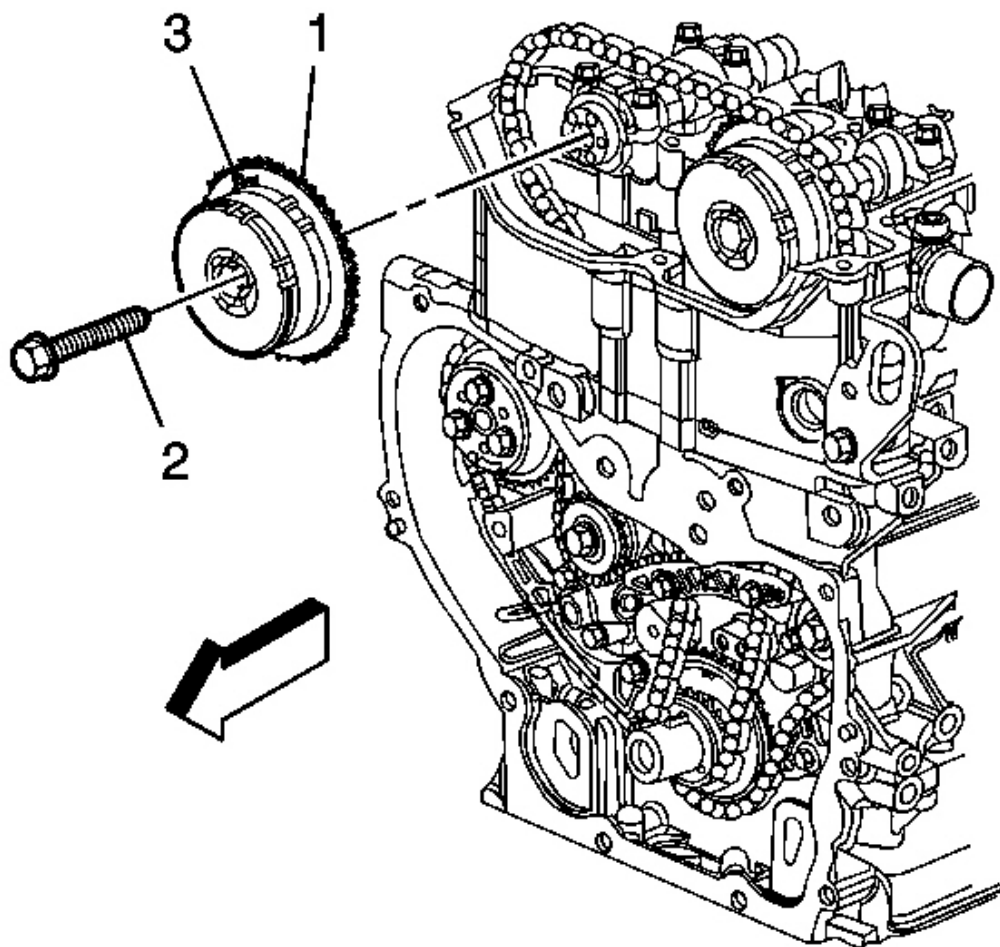


Fig. 75: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

7. Install a 24 mm wrench on the hex on the exhaust camshaft in order to hold the camshaft.
8. Remove and discard the exhaust camshaft actuator bolt (2).
9. Remove the exhaust camshaft actuator (1, 3) from the camshaft and timing chain.

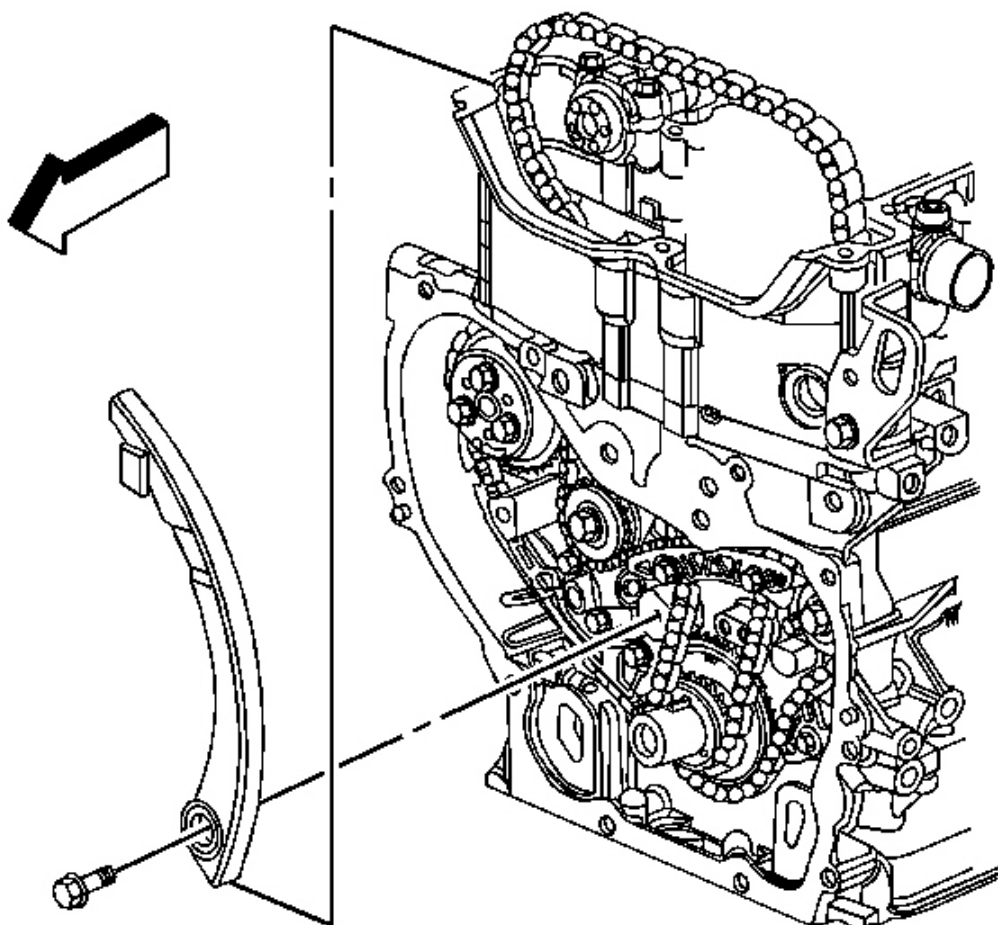


Fig. 76: Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner guide bolt and guide.

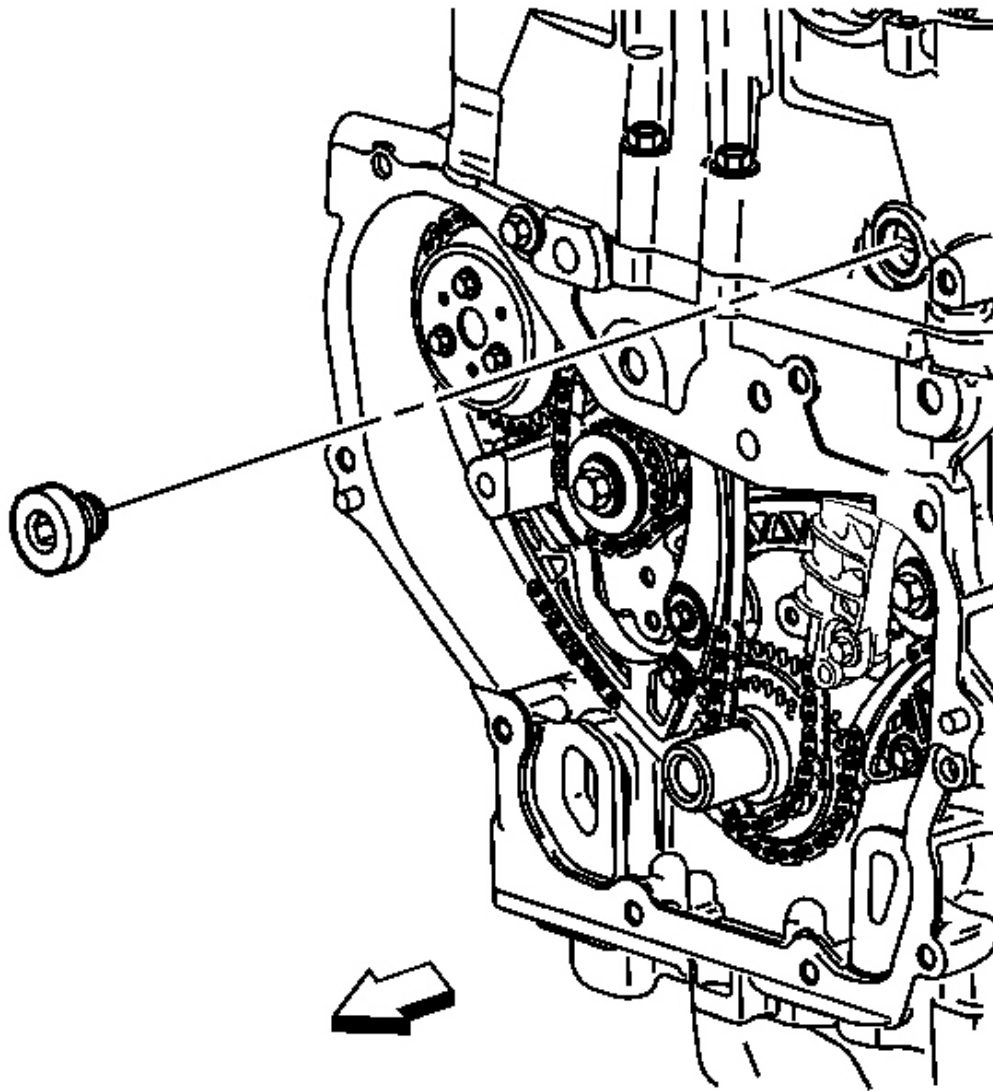


Fig. 77: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

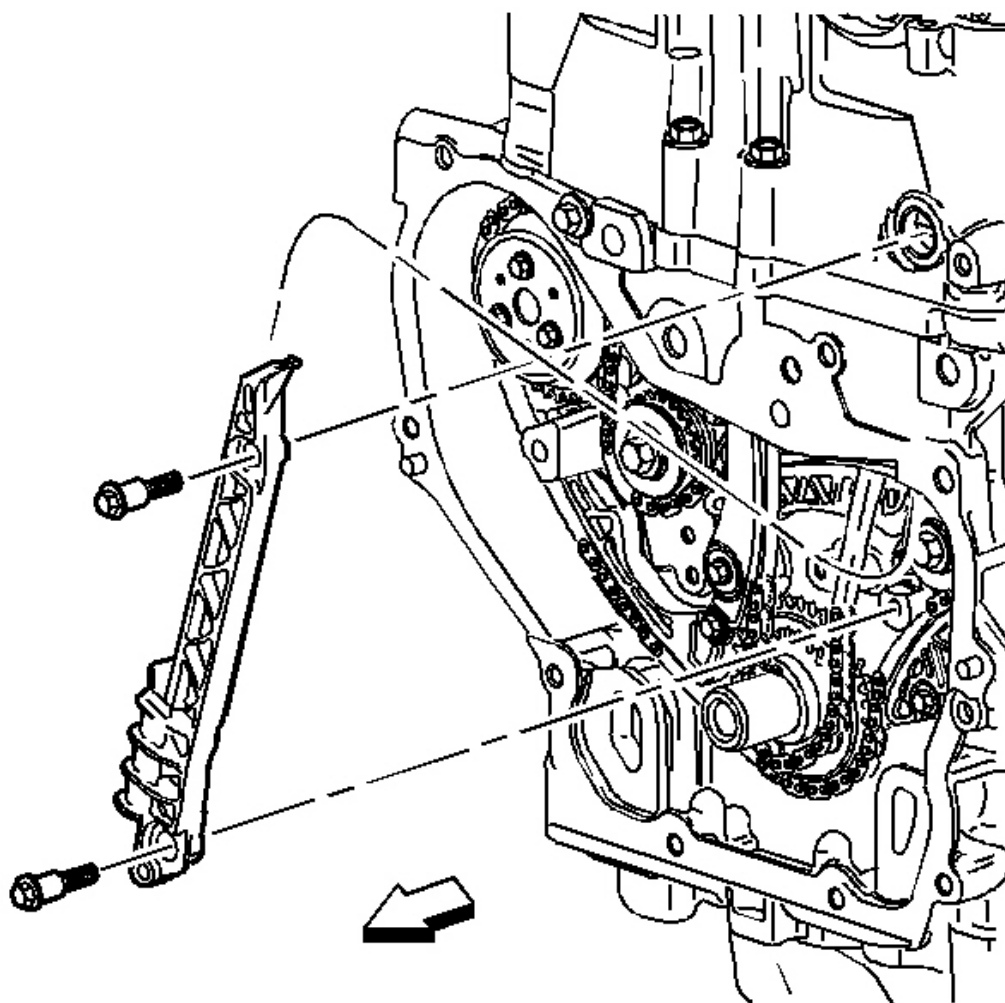


Fig. 78: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Remove the fixed timing chain guide bolts and guide.

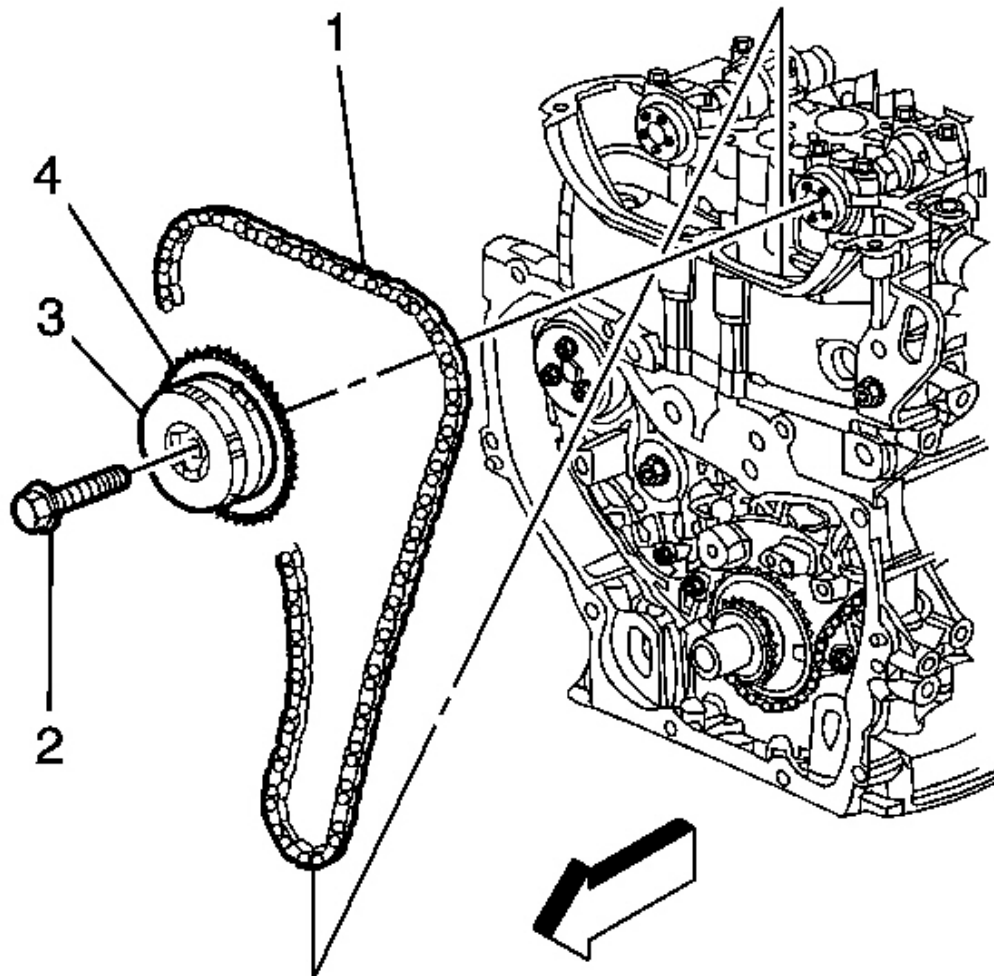


Fig. 79: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Install a 24 mm wrench on the hex on the intake camshaft in order to hold the camshaft.
14. Remove and discard the intake camshaft actuator bolt (2).
15. Remove the intake camshaft actuator (3), and the timing chain through the top of the cylinder head.

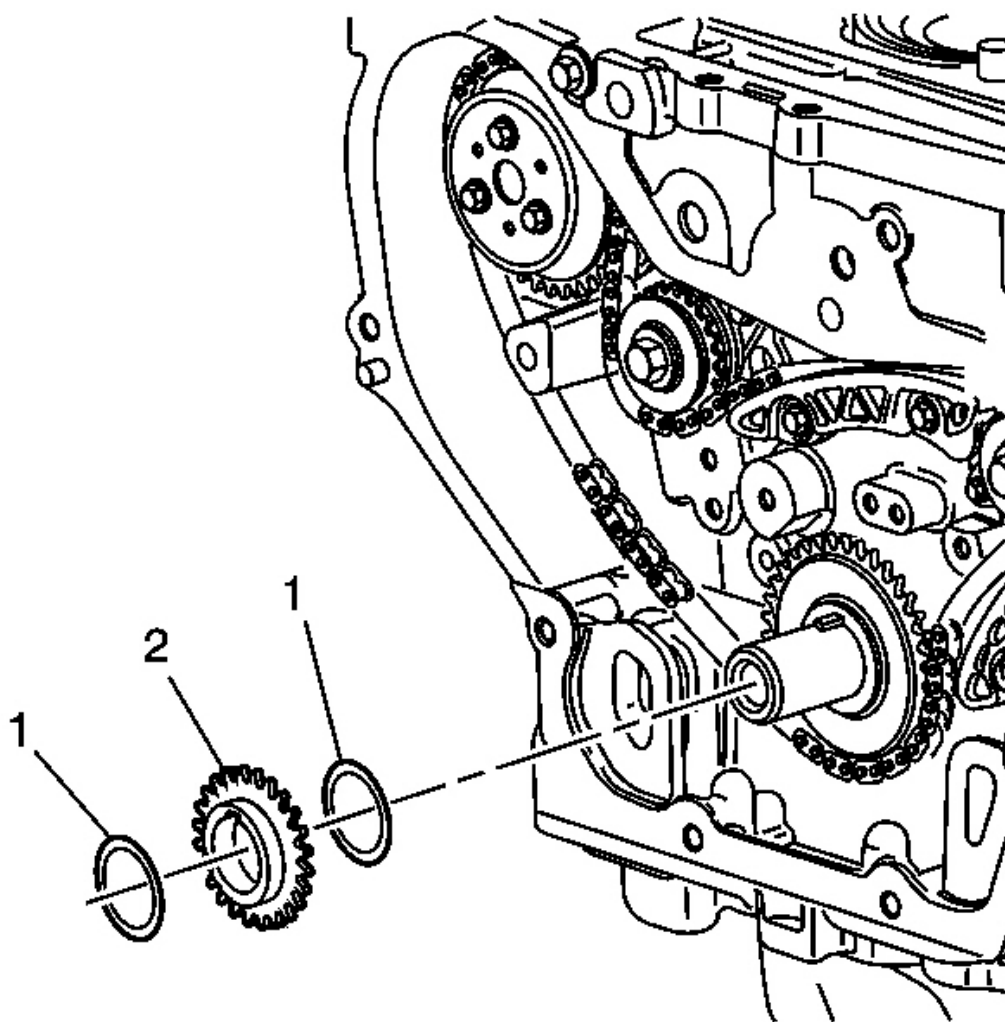


Fig. 80: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Remove the crankshaft sprocket (2) and friction washers (1), if equipped.

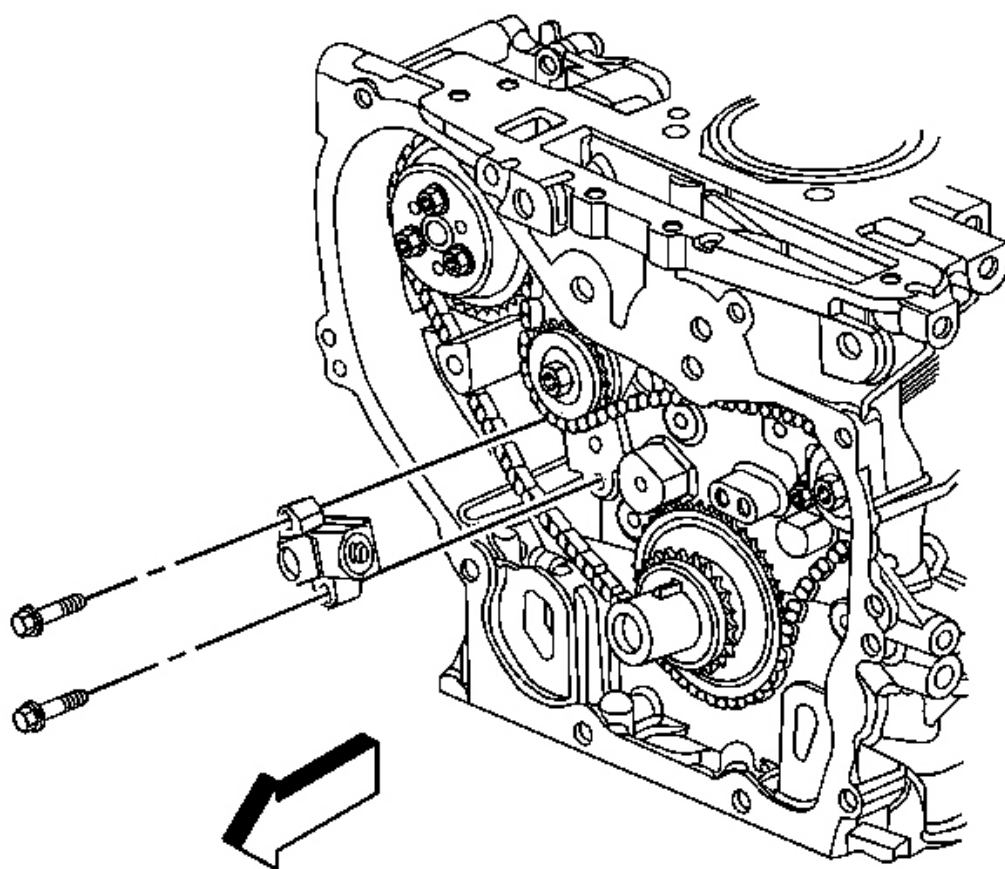


Fig. 81: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

17. If replacing the balance shaft timing chain and sprocket, perform the following steps, if not proceed to step 10 in the installation procedure.
18. Remove the balance shaft drive chain tensioner bolts and tensioner.

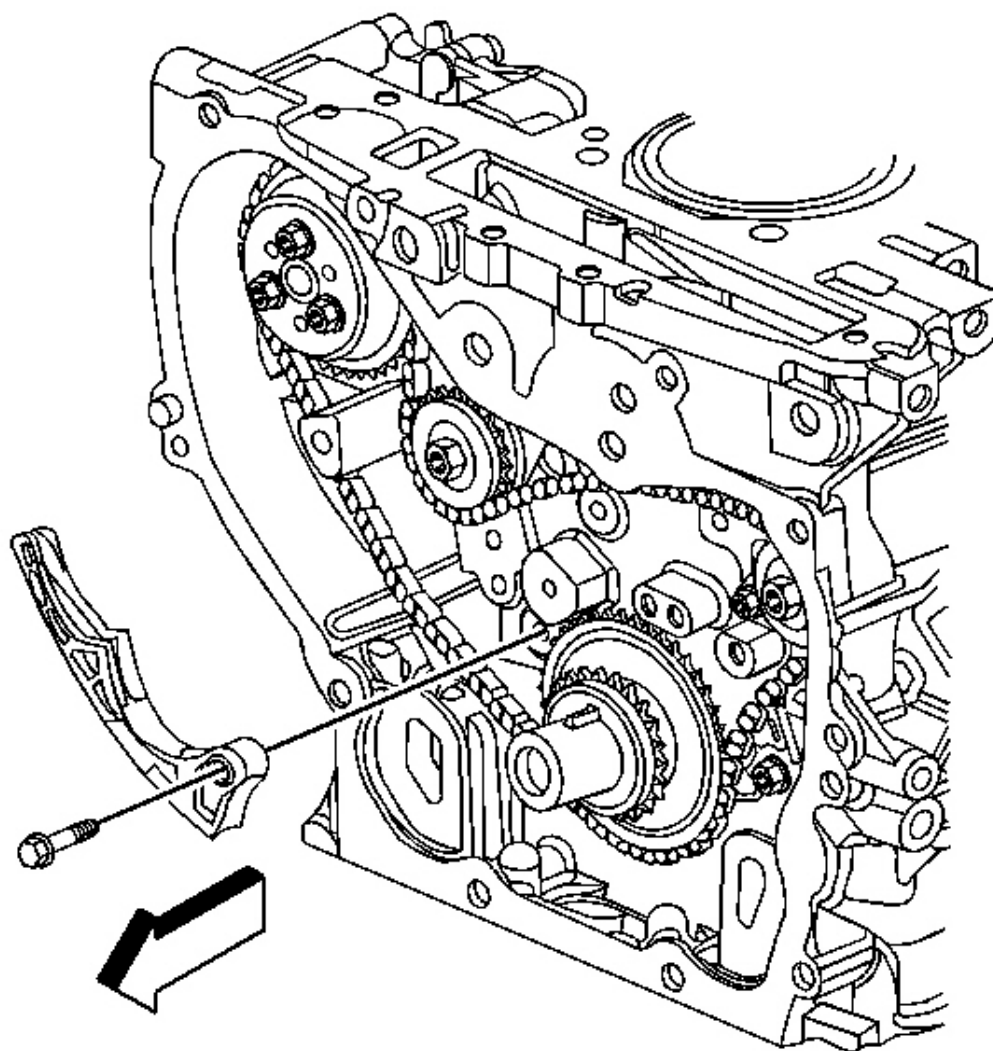


Fig. 82: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

19. Remove the adjustable balance shaft chain guide bolt and guide.

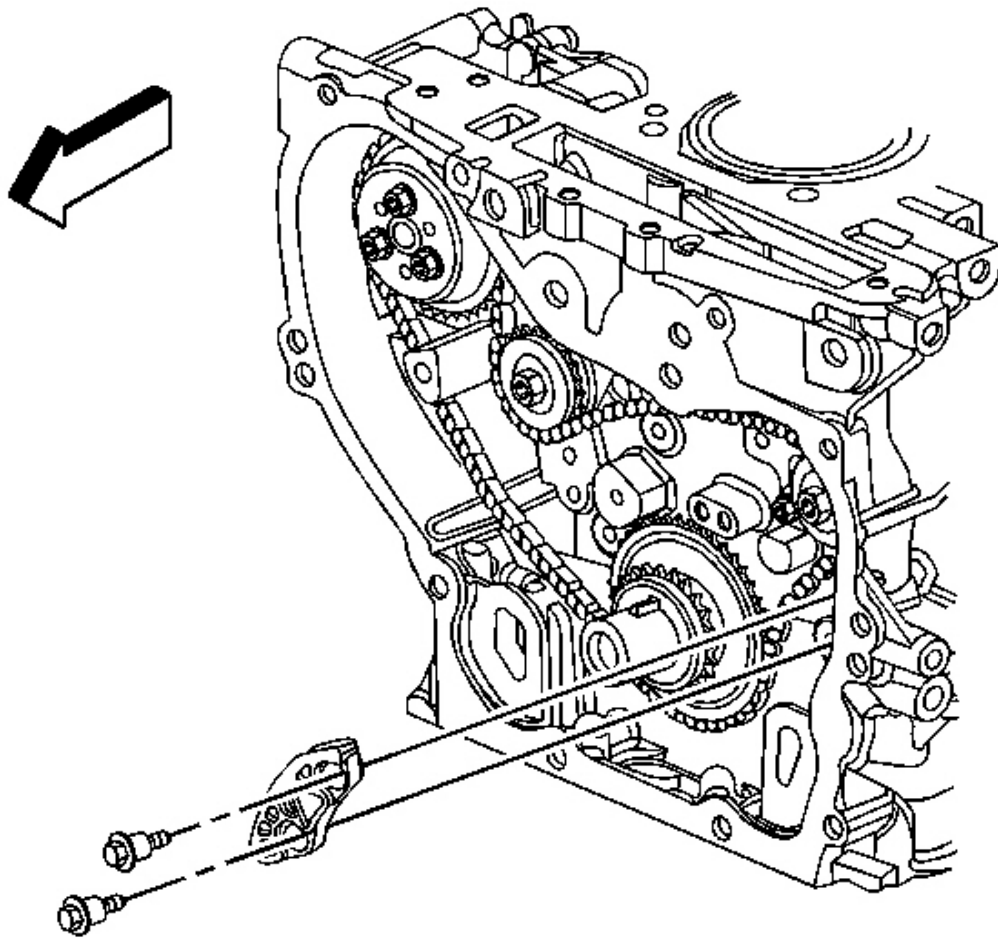


Fig. 83: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Remove the small balance shaft drive chain guide bolts and guide.

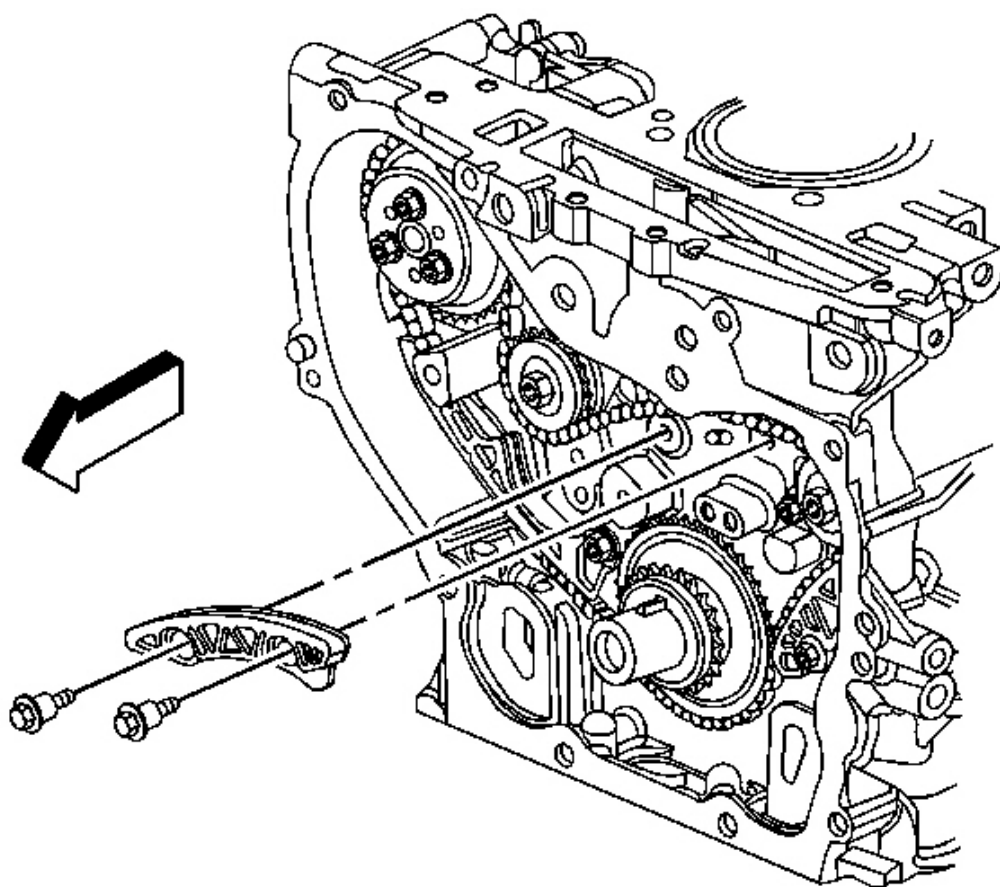


Fig. 84: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

21. Remove the upper balance shaft drive chain guide bolts and guide.

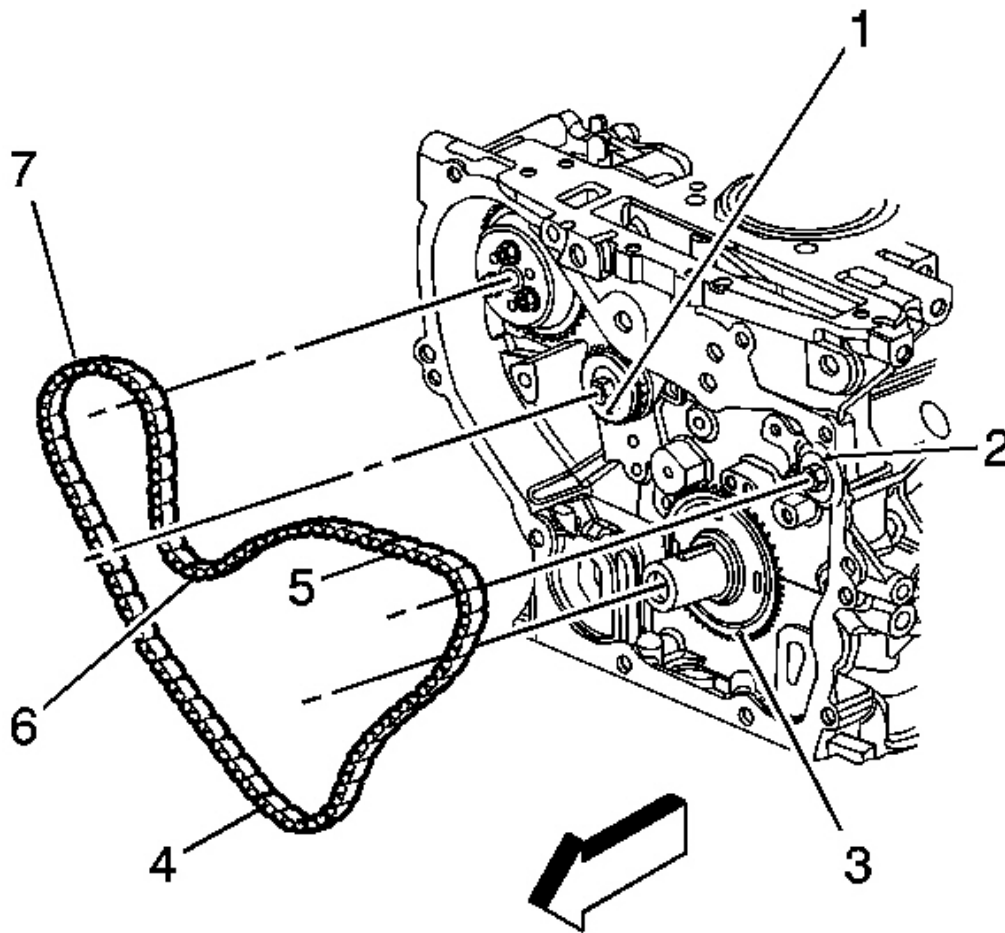


Fig. 85: Balance Shaft Drive Chain

Courtesy of GENERAL MOTORS CORP.

NOTE: It may ease removal of the balance shaft drive chain to get all the slack in the chain between the crankshaft and water pump sprockets.

22. Remove the balance shaft drive chain (7).
23. Remove the balance shaft drive sprocket.

Installation Procedure

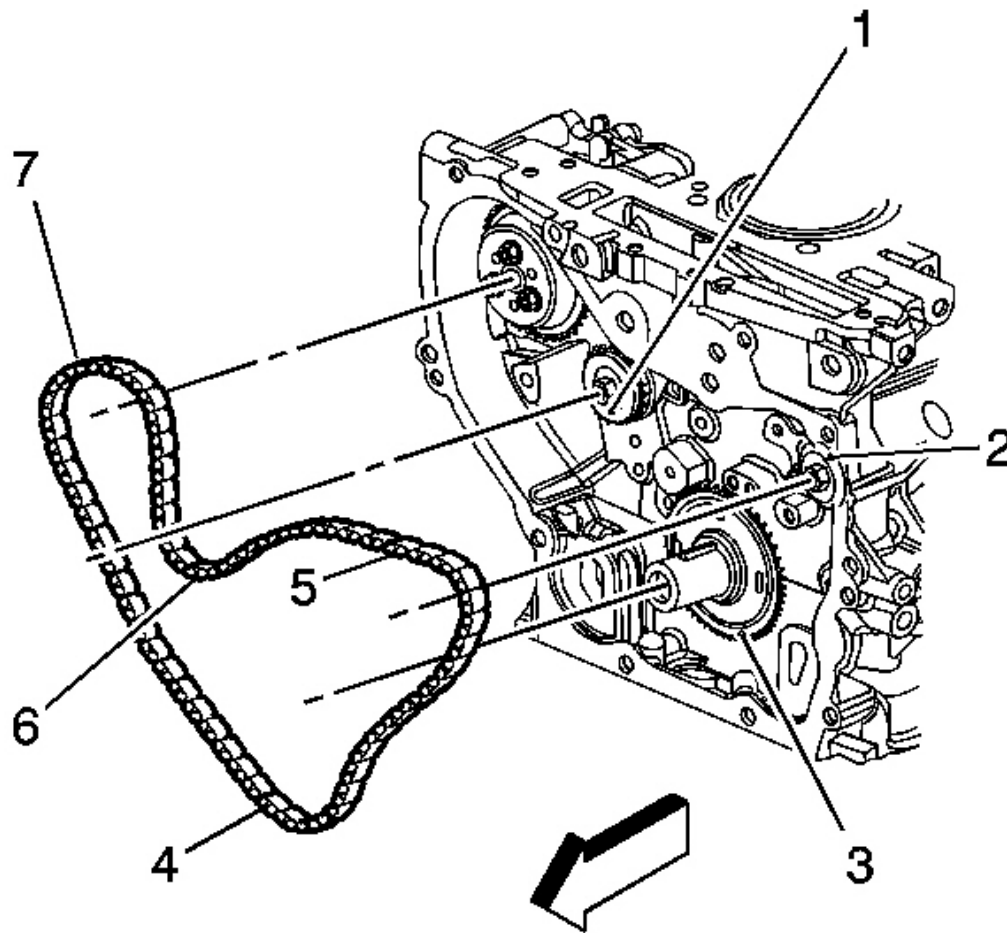


Fig. 86: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. If replacing the balance shaft timing chain, perform the following steps, if not proceed to step 10.
2. Install the balance shaft drive sprocket.

NOTE: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

3. Install the balance shaft drive chain (7) with the colored link lined up with the marks on the balance shaft sprockets and the balance shaft drive sprocket. There are 3 colored links on the chain. Two are chrome and one is copper. Use the following steps in order to line up the links with the sprockets.
 1. Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft

sprocket.

2. Working clockwise around the chain, place the chrome link (4) in line with the timing mark (3) on the balance shaft drive sprocket (approximately 6 o'clock position on the sprocket).
3. Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
4. Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

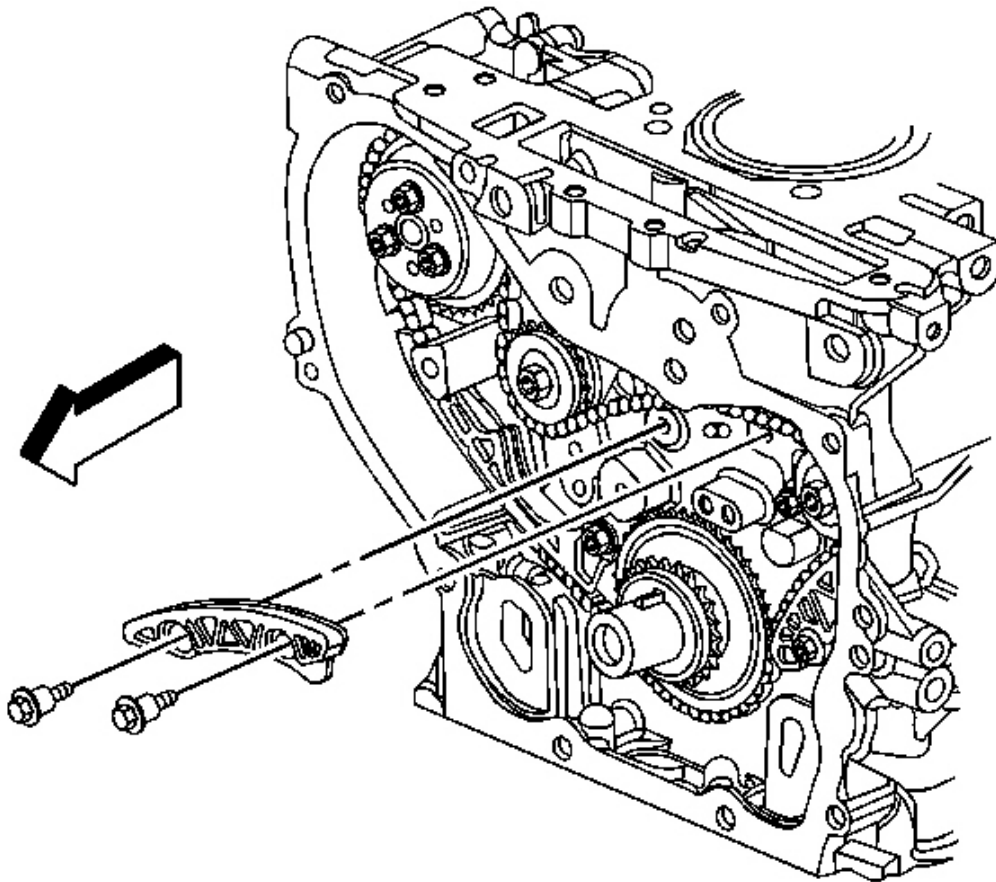


Fig. 87: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the upper balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

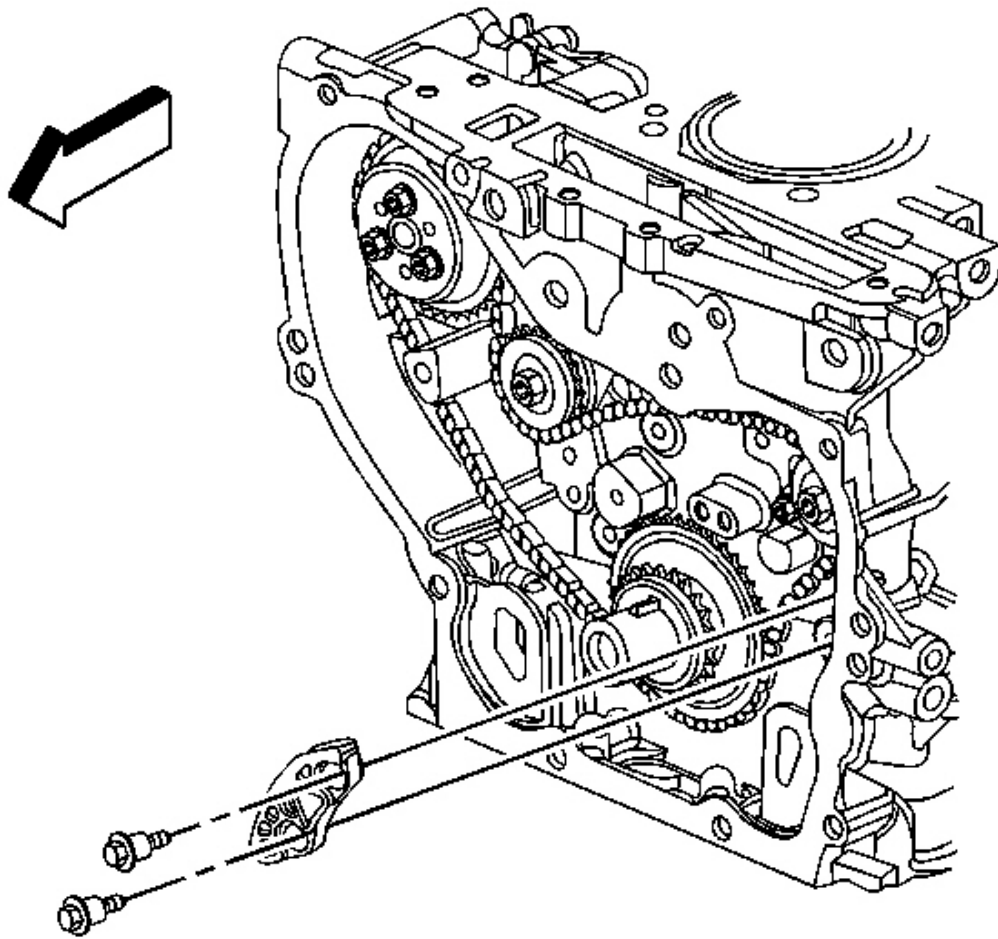


Fig. 88: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

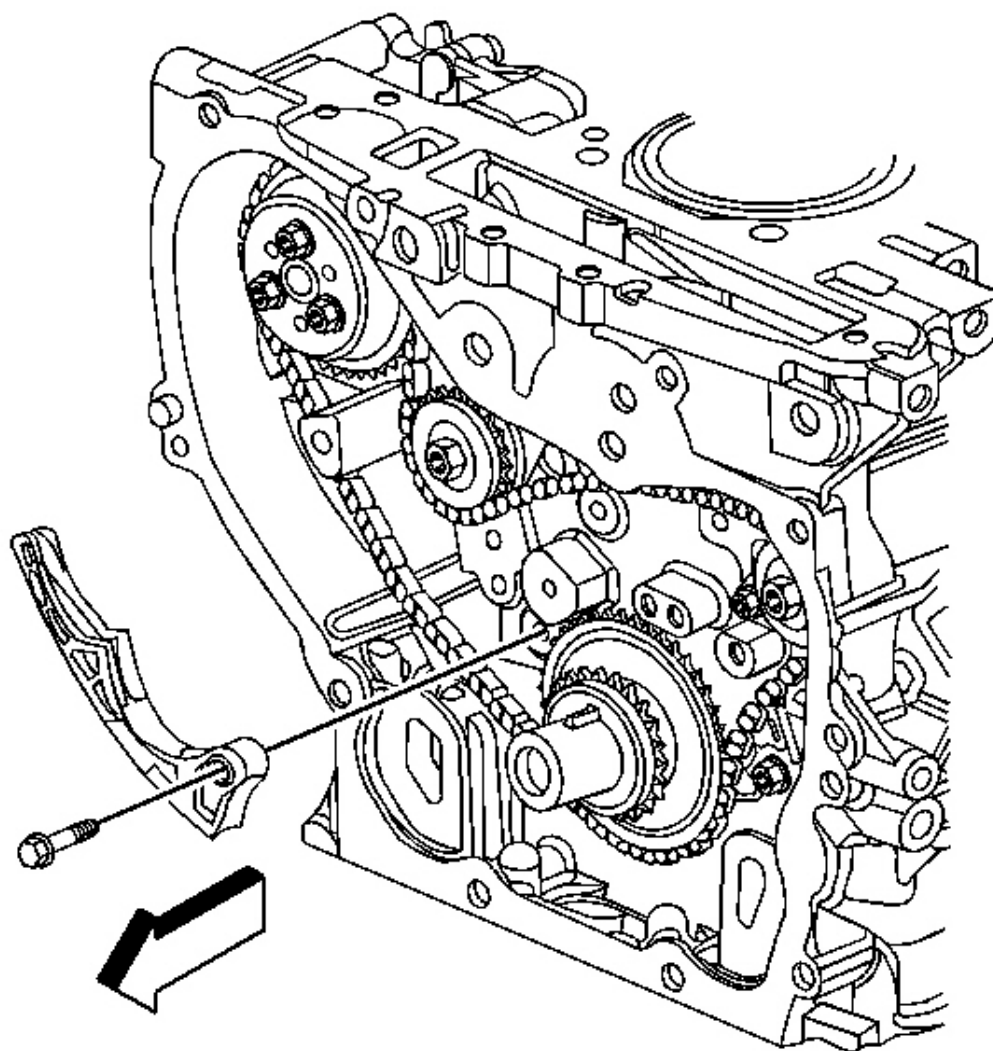


Fig. 89: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt and tighten to 10 N.m (89 lb in).

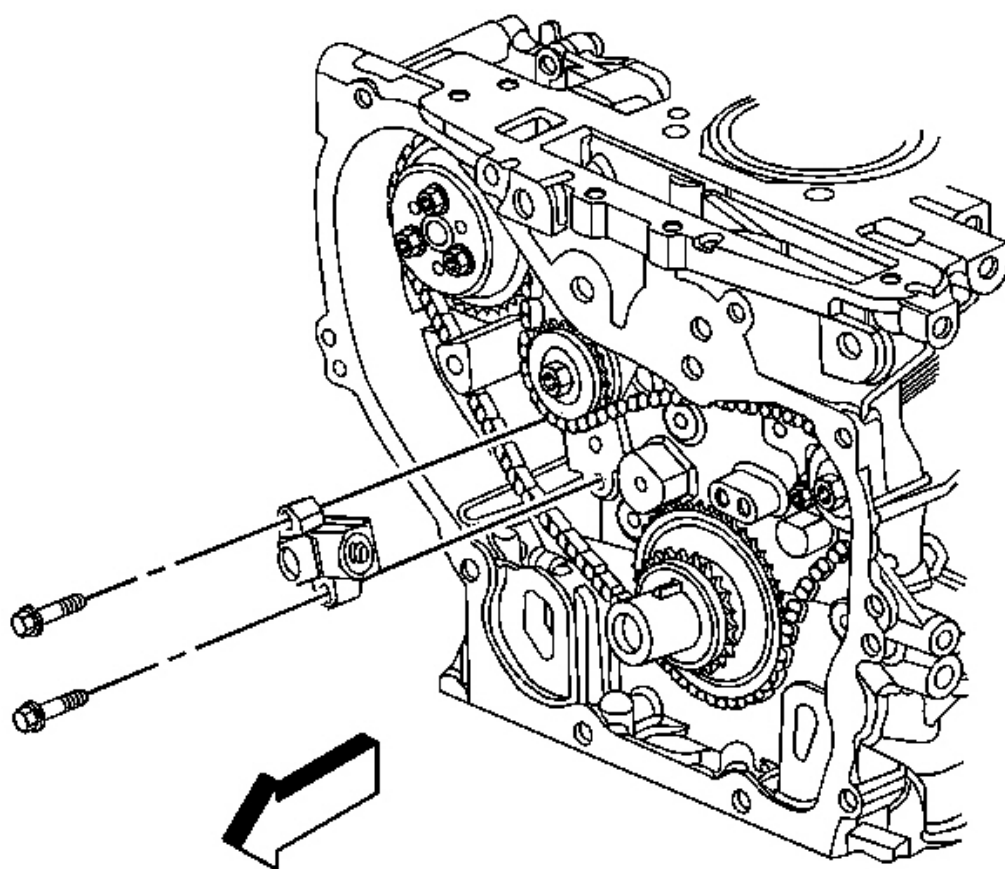


Fig. 90: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Reset the timing chain tensioner by performing the following steps:
 1. Rotate the tensioner plunger 90 degrees in its bore and compress the plunger.
 2. Rotate the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hose in the tensioner plunger.
8. Install the balance shaft drive chain tensioner and bolts and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

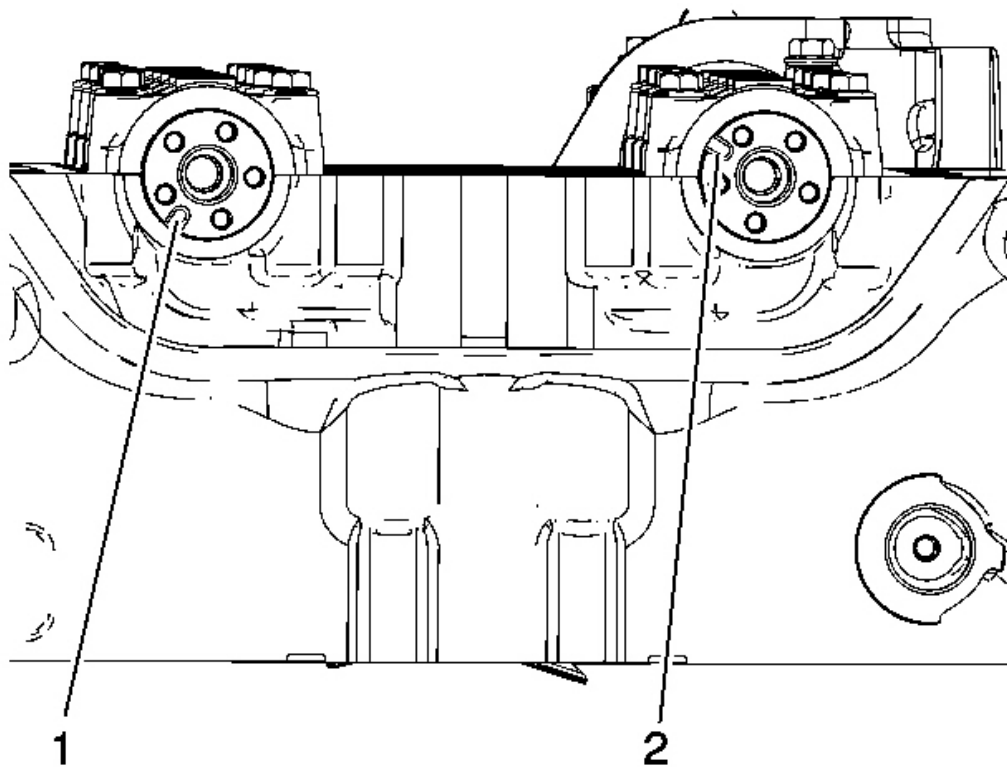


Fig. 91: Camshaft Notches (2.2L)
Courtesy of GENERAL MOTORS CORP.

10. On 2.2L engines, ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

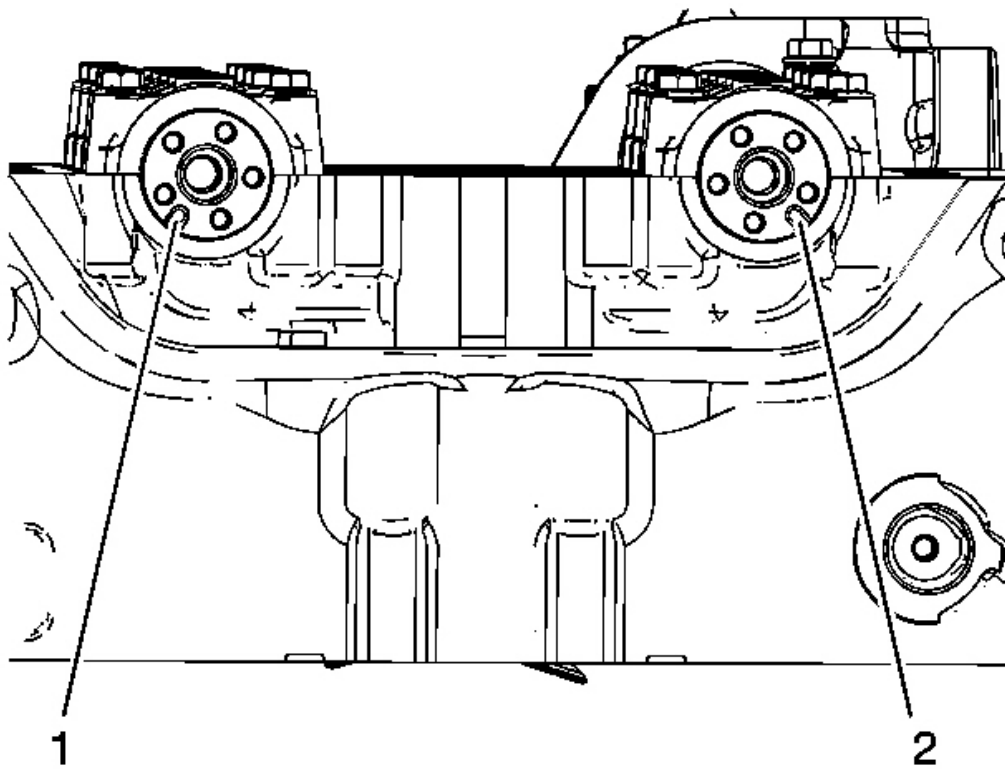


Fig. 92: Camshaft Notches (2.4L)
Courtesy of GENERAL MOTORS CORP.

11. On 2.4L engines, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

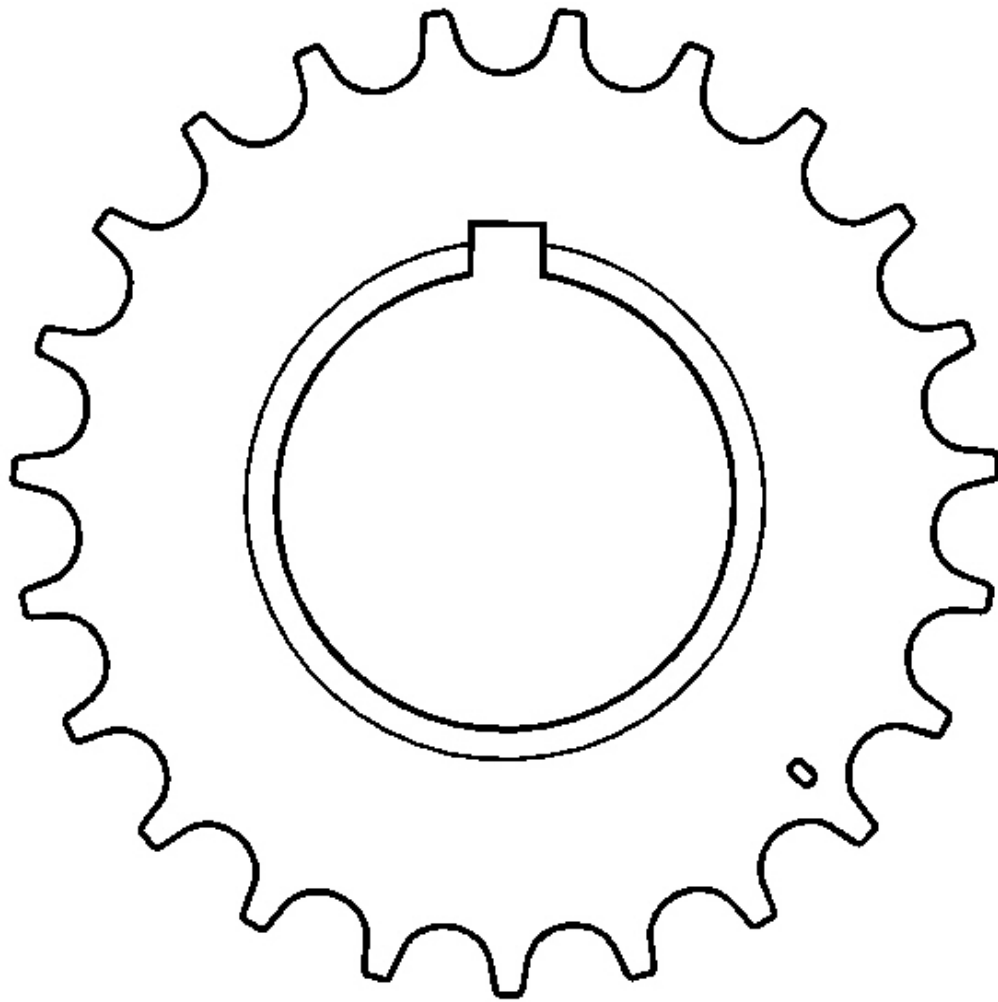


Fig. 93: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Install the friction washer, if applicable.
13. Install the timing chain drive sprocket to the crankshaft with the timing mark in the 5 o'clock position and the front of the sprocket facing.

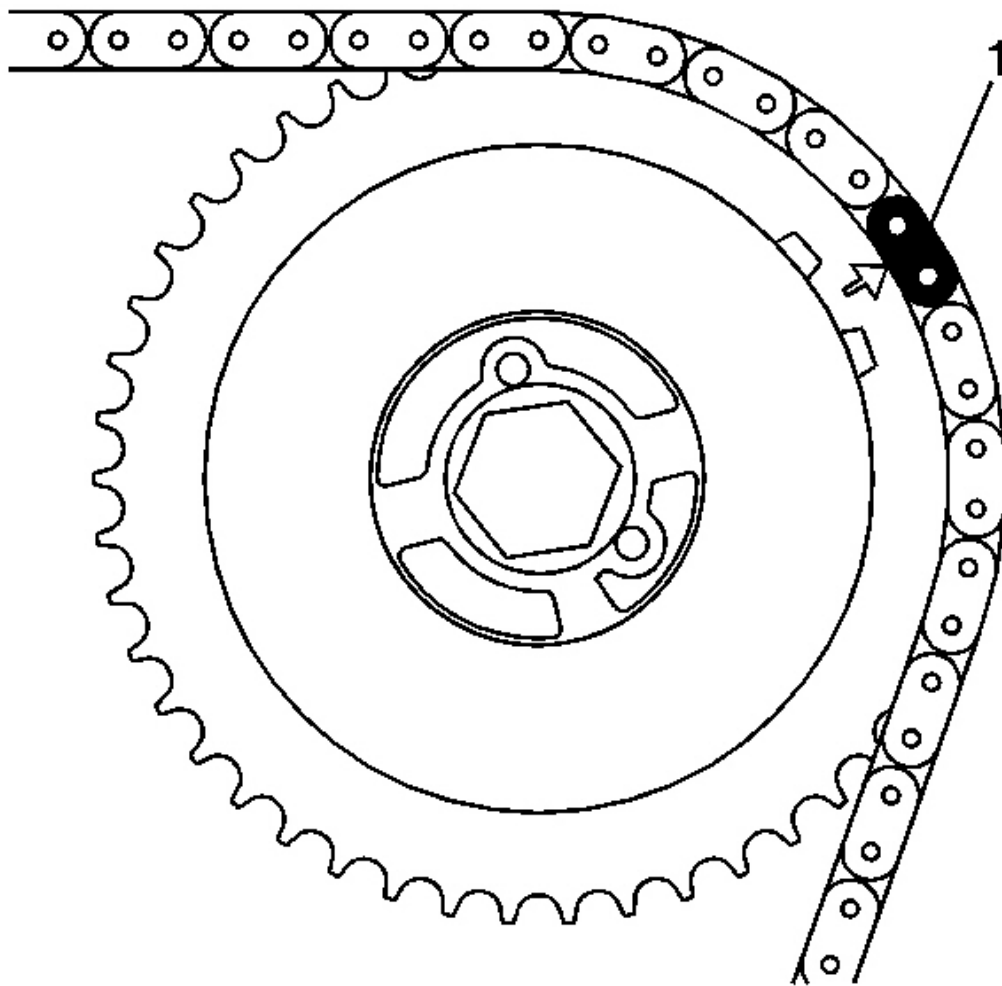


Fig. 94: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE:

- There are 3 colored links on the timing chain. Two links are of matching color, and 1 link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.
- Always use new actuator bolts.

14. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).

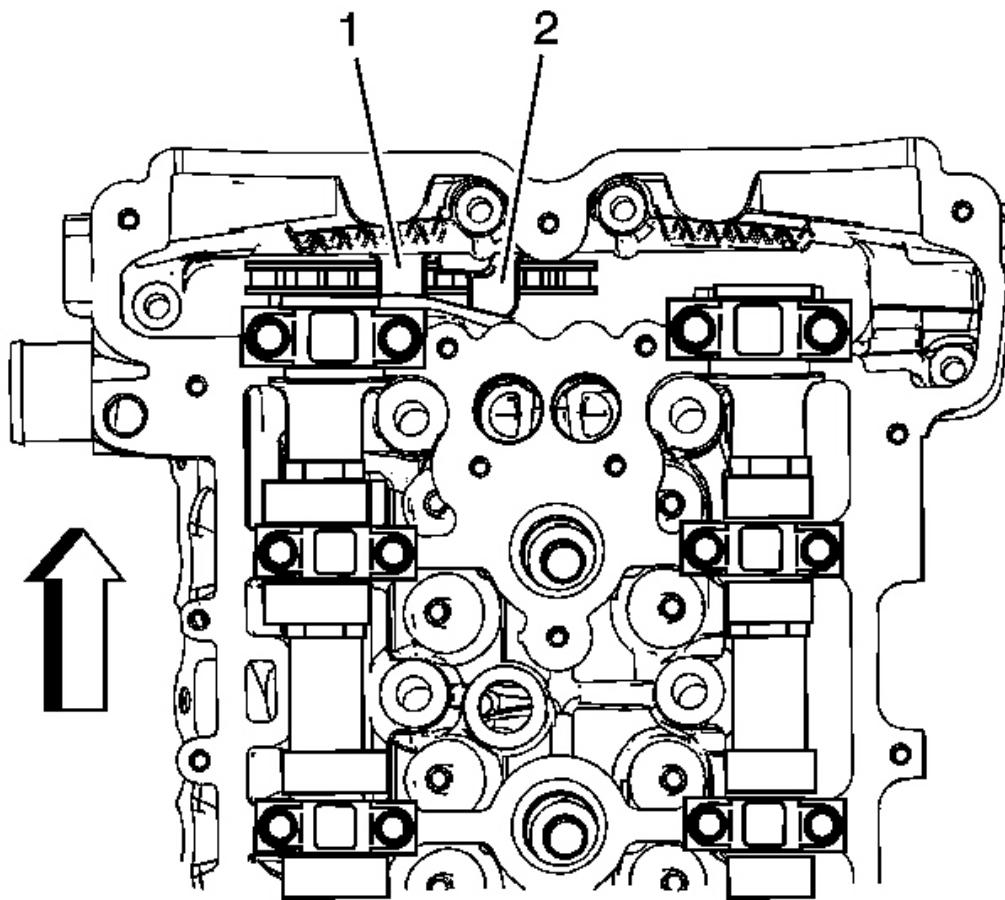


Fig. 95: Identifying Cylinder Block Bosses

Courtesy of GENERAL MOTORS CORP.

15. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).
16. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
17. Hand tighten the new intake camshaft actuator bolt.

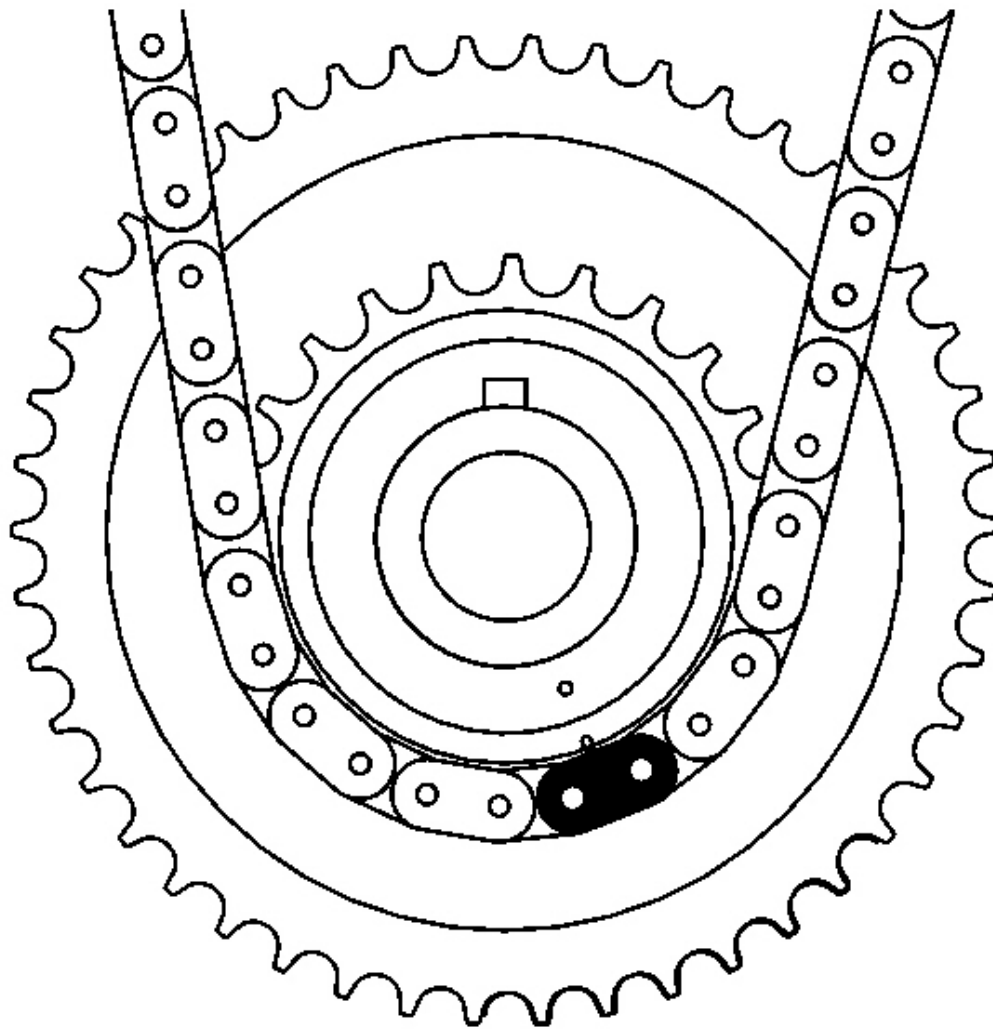


Fig. 96: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

18. Route the timing chain around the crankshaft sprocket and line up the first matching colored link with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.
19. Install the friction washer, if applicable.

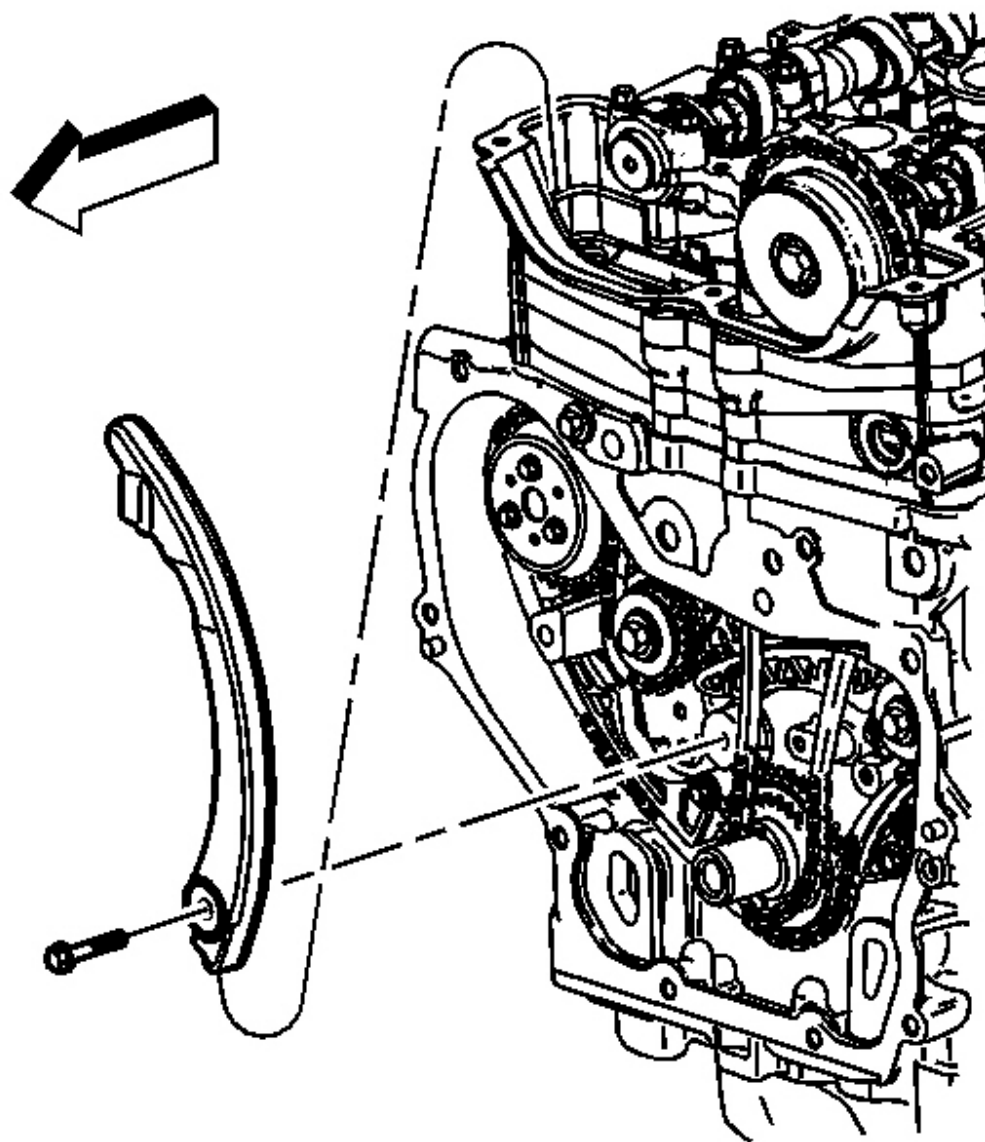


Fig. 97: Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.
21. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt. Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

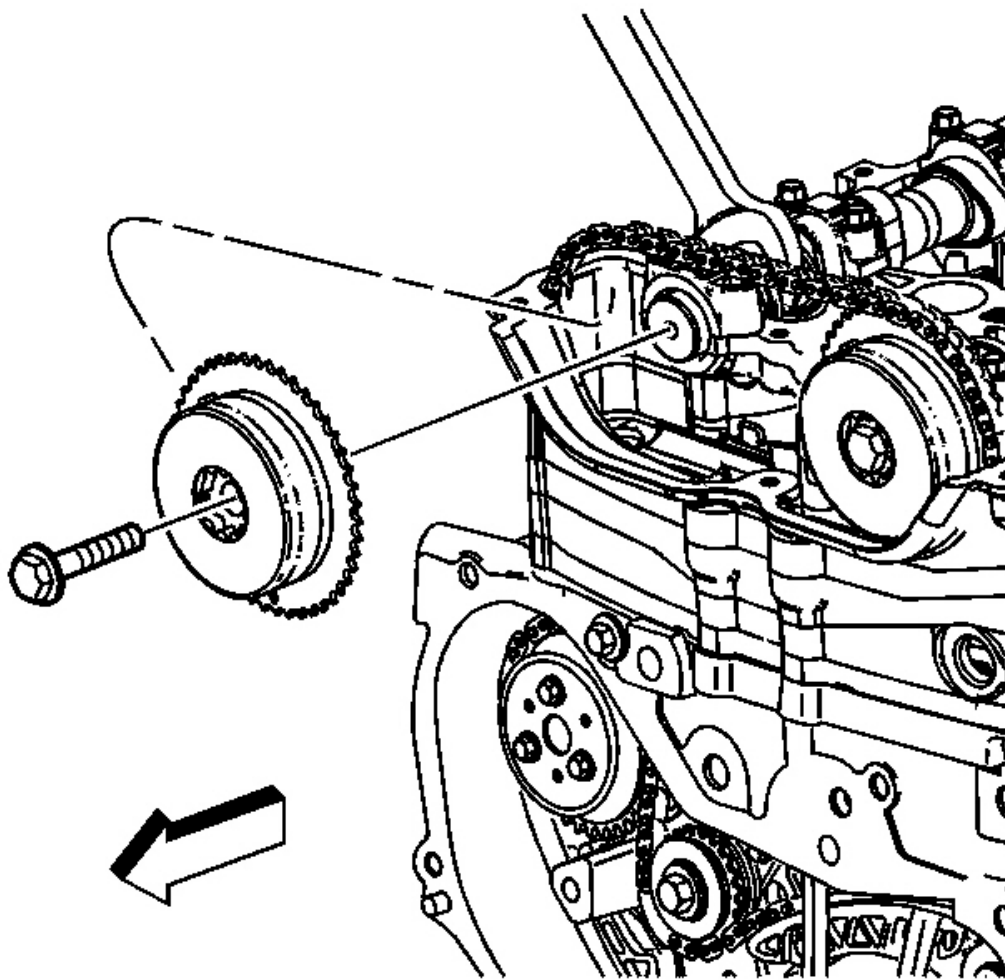


Fig. 98: Camshaft Actuator

Courtesy of GENERAL MOTORS CORP.

NOTE: Always install **NEW** actuator bolts.

22. Install the exhaust camshaft actuator into the timing chain with the timing mark lined up with the second matching colored link.

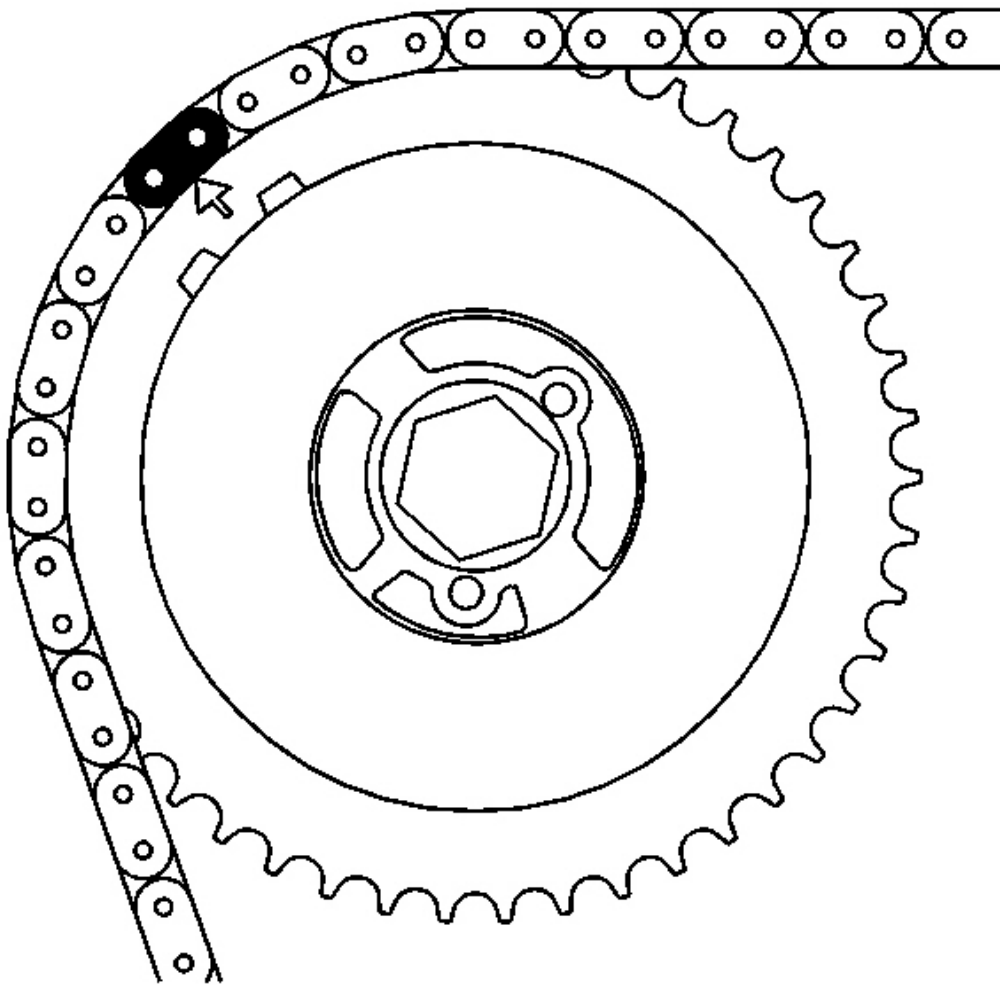


Fig. 99: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

23. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
24. use 24 mm open ended wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

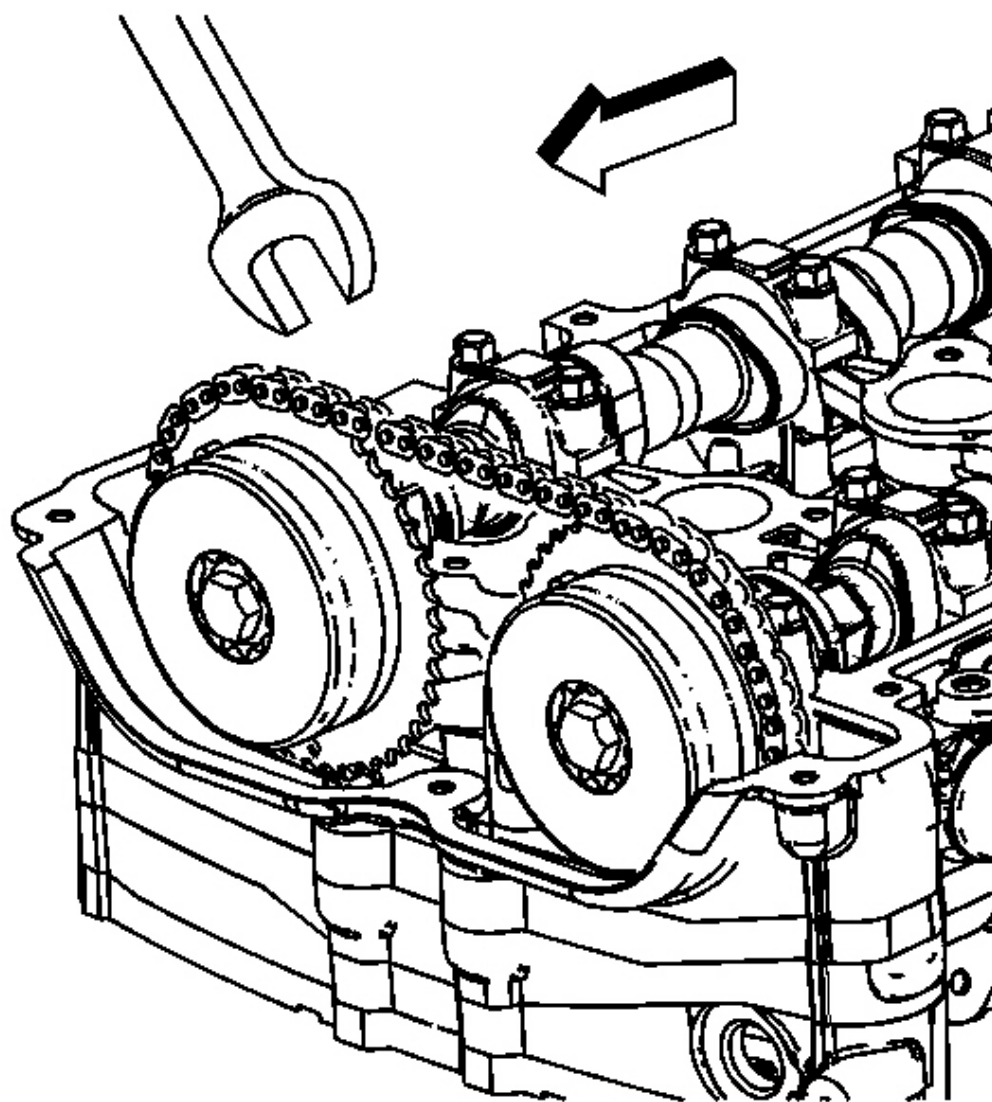


Fig. 100: Rotating Camshaft
Courtesy of GENERAL MOTORS CORP.

25. When the actuator seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.

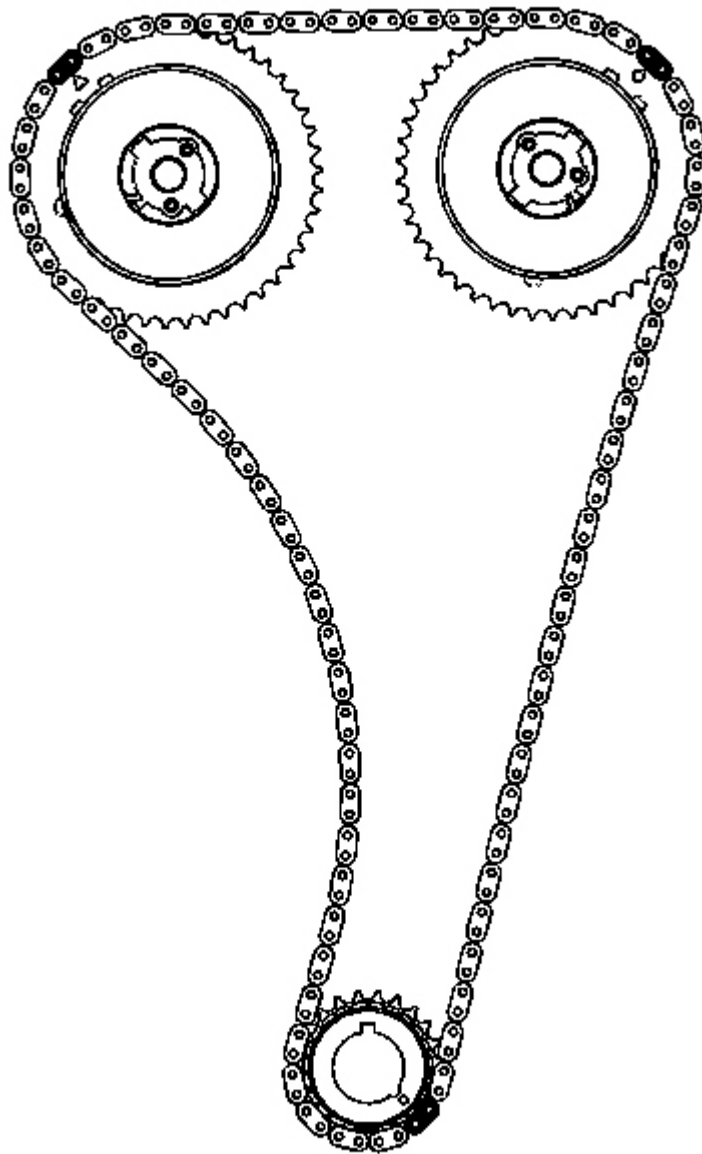


Fig. 101: Identifying Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

26. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not aligned, repeat the portion of the procedure necessary to align the timing marks.

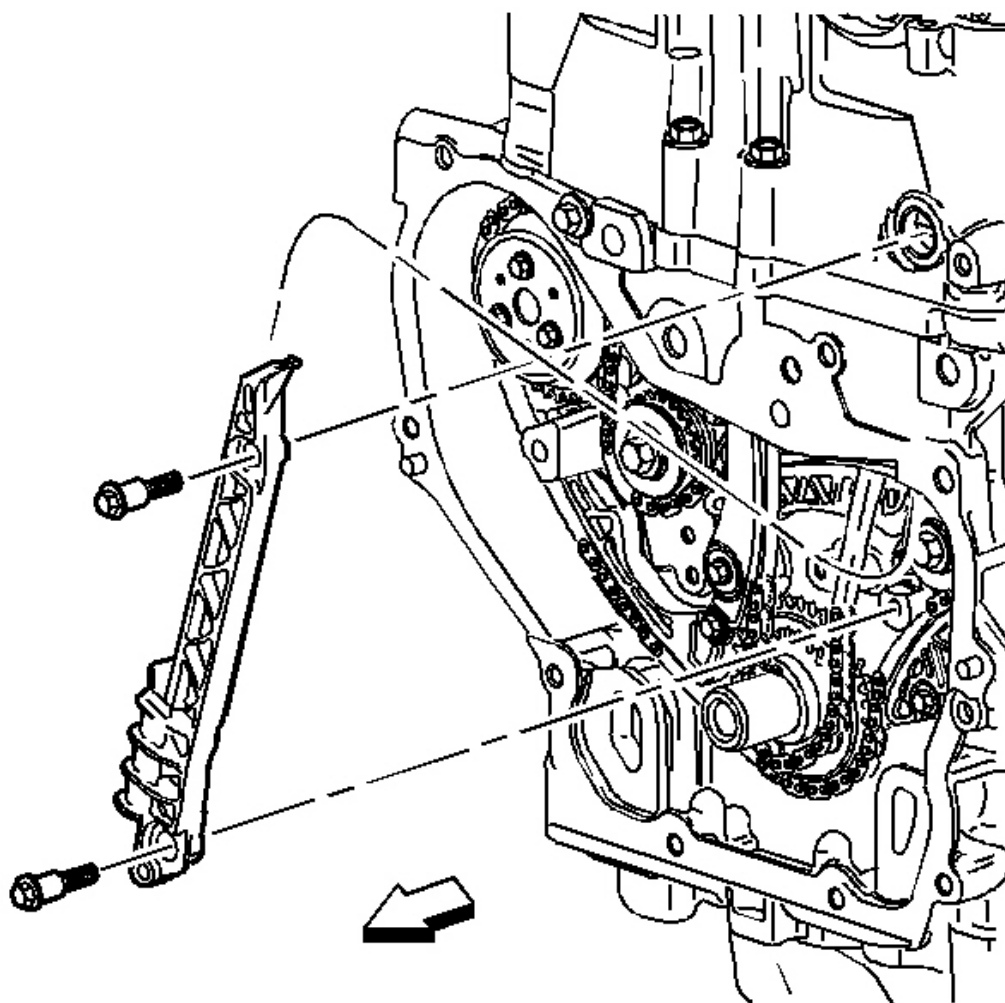


Fig. 102: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

27. Install the fixed timing chain guide and bolts. Tighten the fixed timing chain guide bolts to 12 N.m (106 lb in).

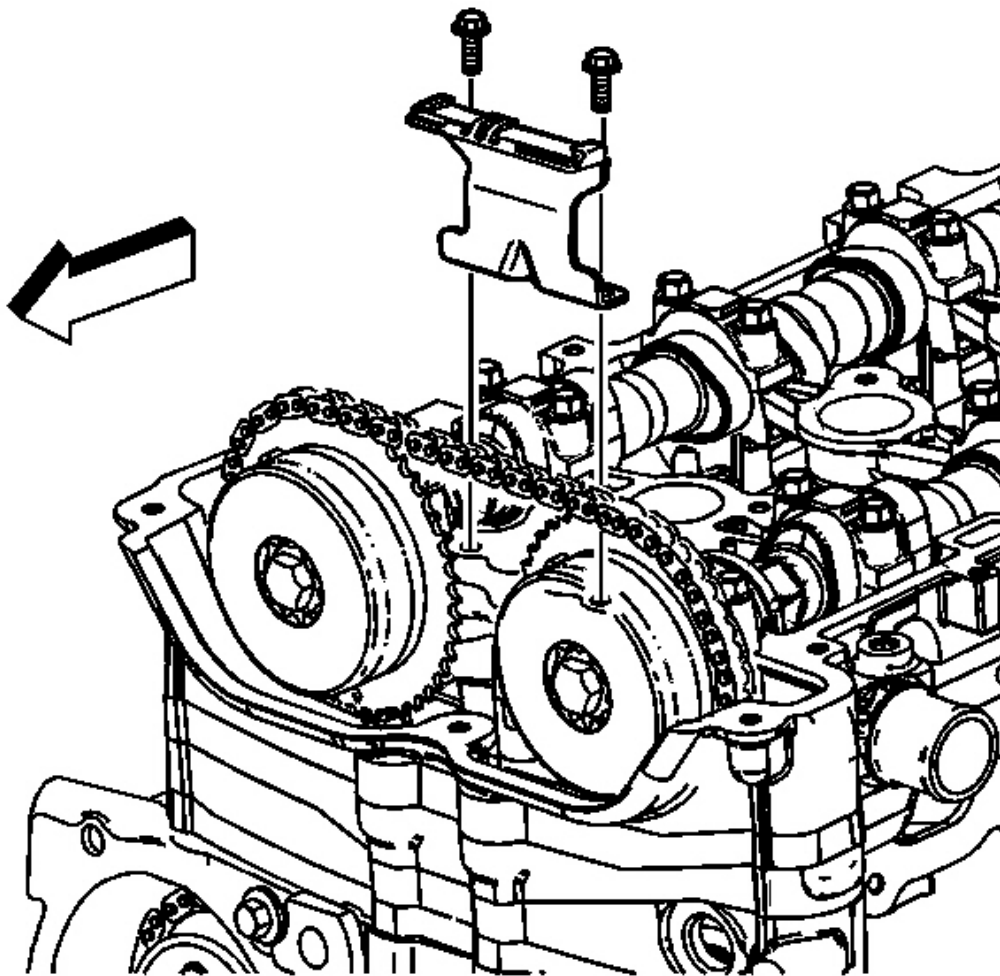


Fig. 103: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

28. Install the upper timing chain guide and bolts. Tighten the upper timing chain guide bolts to 10 N.m (89 lb in).

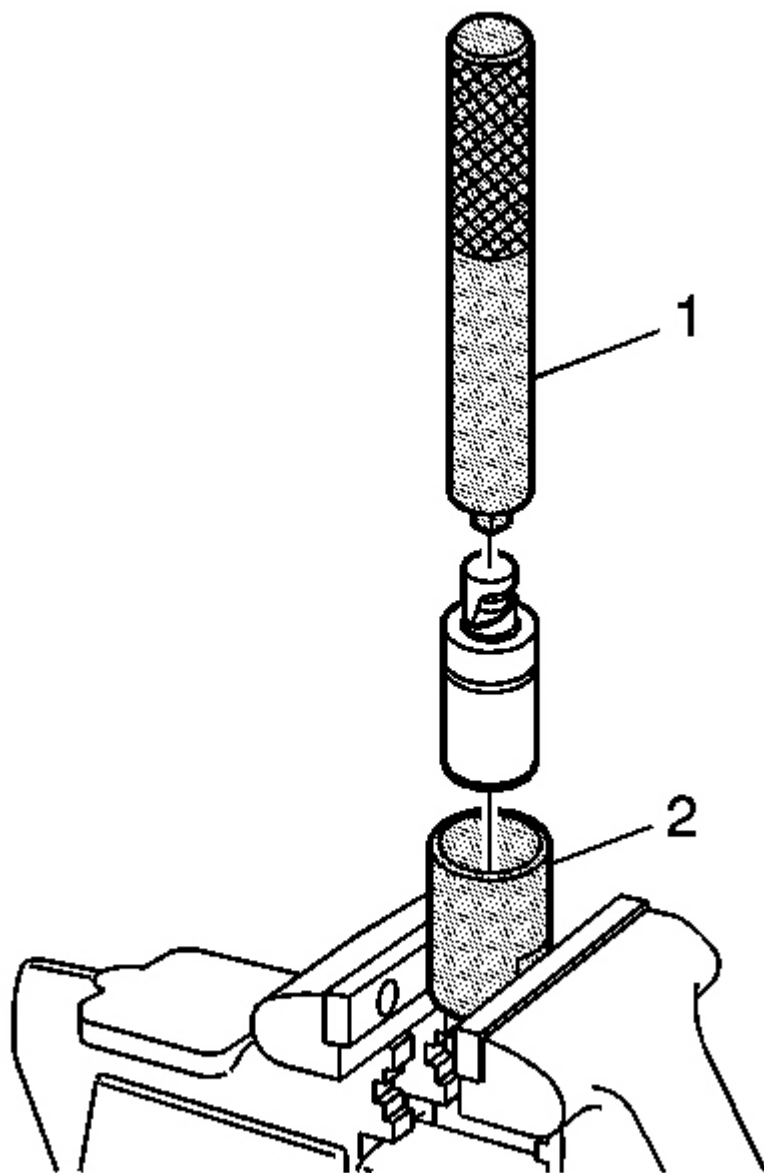


Fig. 104: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

29. Reset the timing chain tensioner by performing the following steps:
1. Remove the snap ring.
 2. Remove the piston assembly from the body of the timing chain tensioner.

3. Install the **EN-45027-2:** tool (2) into a vise.
4. Install the notch end of the piston assembly into the **EN-45027-2:** tool (2).
5. Using the **EN-45027-1:** tool (1), turn the ratchet cylinder into the piston.
6. Reinstall the piston assembly into the body of the tensioner.
7. Install the snap ring.

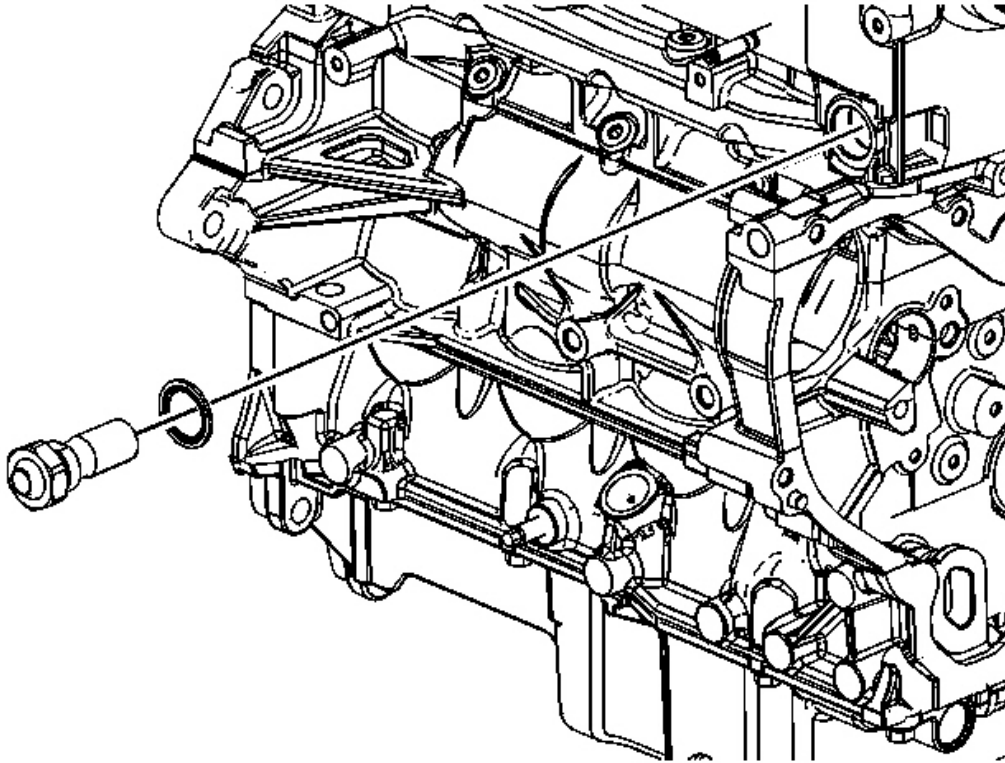


Fig. 105: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

30. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
31. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

NOTE: **Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.**

32. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).

33. The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.

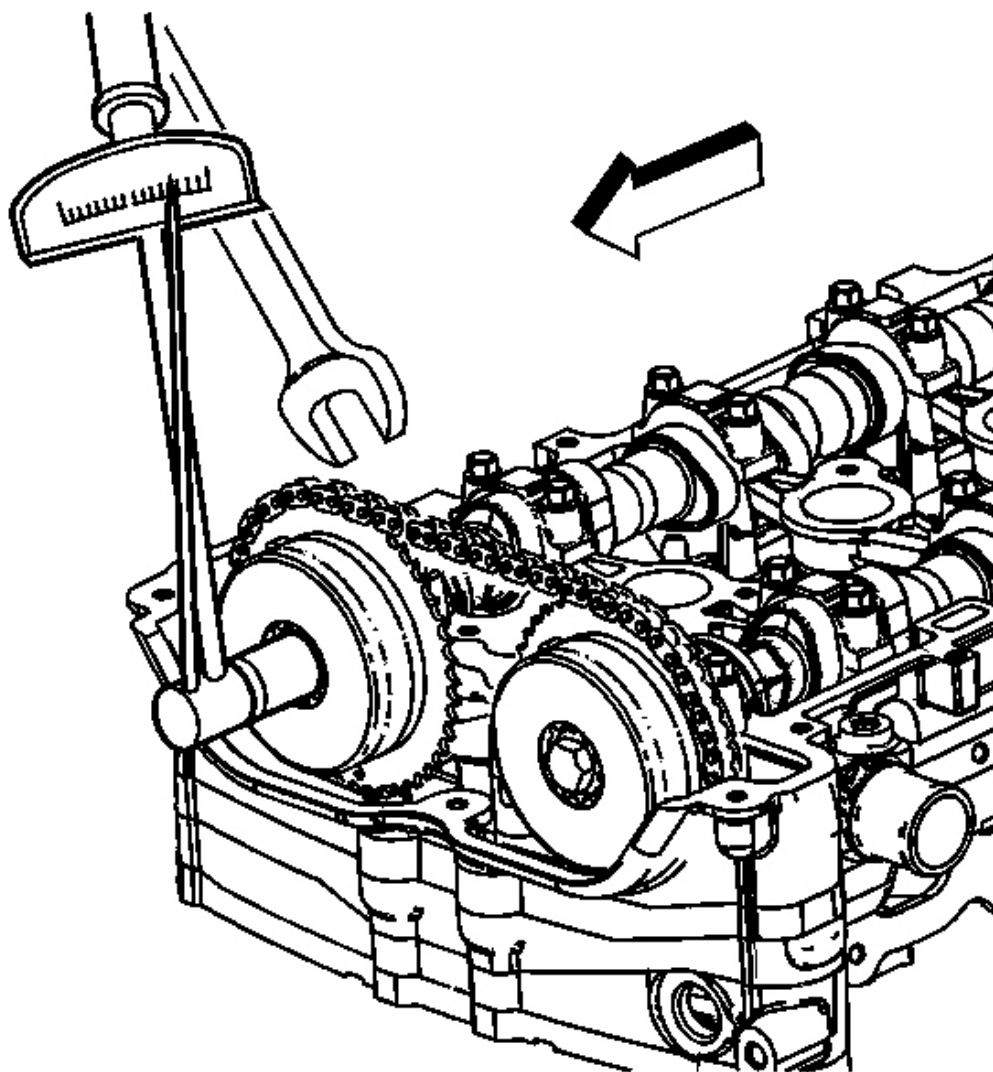


Fig. 106: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

34. Using a 24 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100

degrees using the **EN-45059**: meter.

35. Using a 24 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059**: meter.

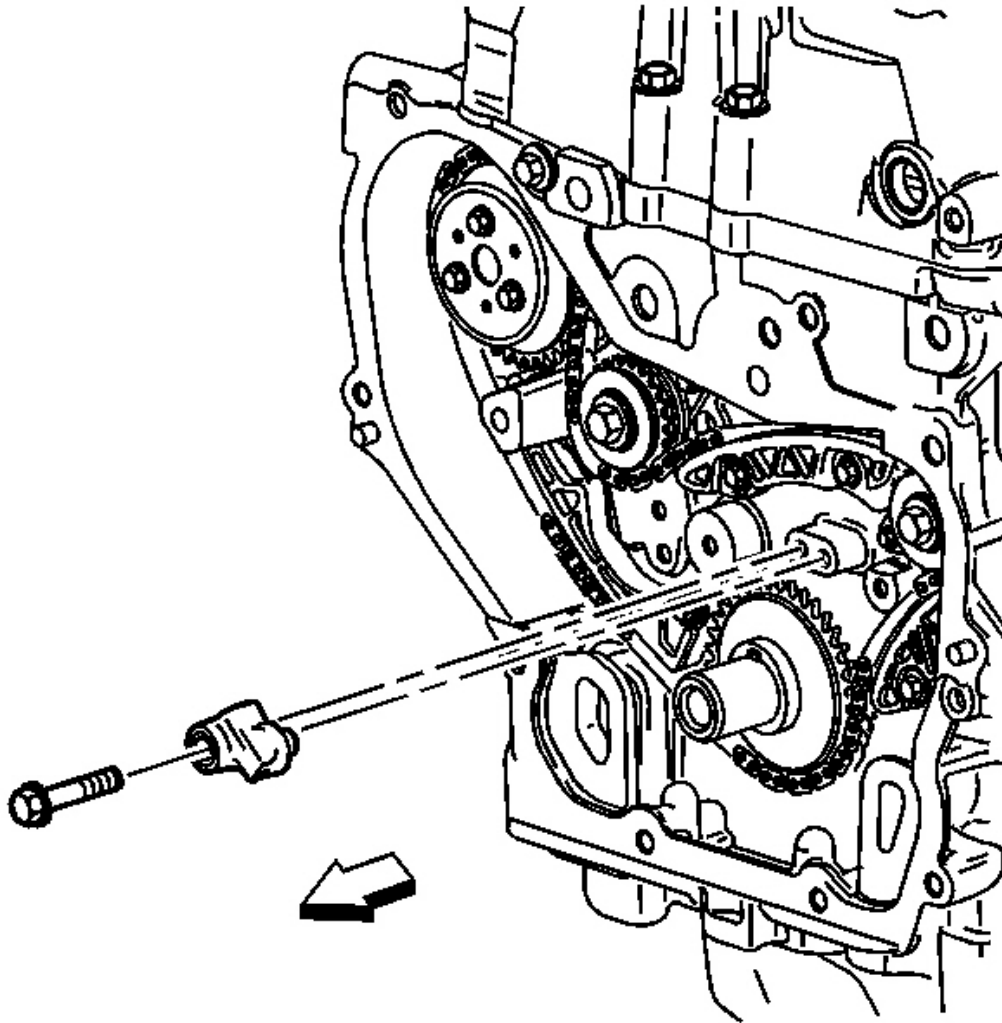


Fig. 107: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

36. Install the timing chain oiling nozzle. Tighten the timing chain oiling nozzle bolt to 10 N.m (89 lb in).

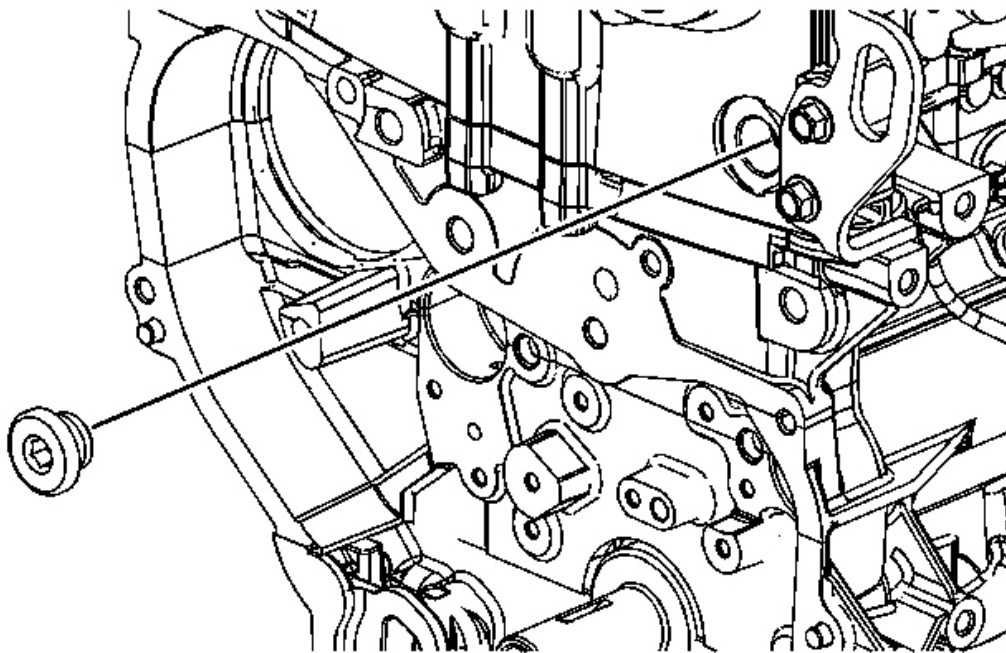


Fig. 108: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

37. Apply sealant compound to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended sealant.
38. Install the timing chain guide bolt access hole plug. Tighten the access hole plug to 90 N.m (66 lb ft).
39. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
40. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
41. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement**.

CAMSHAFT COVER REPLACEMENT

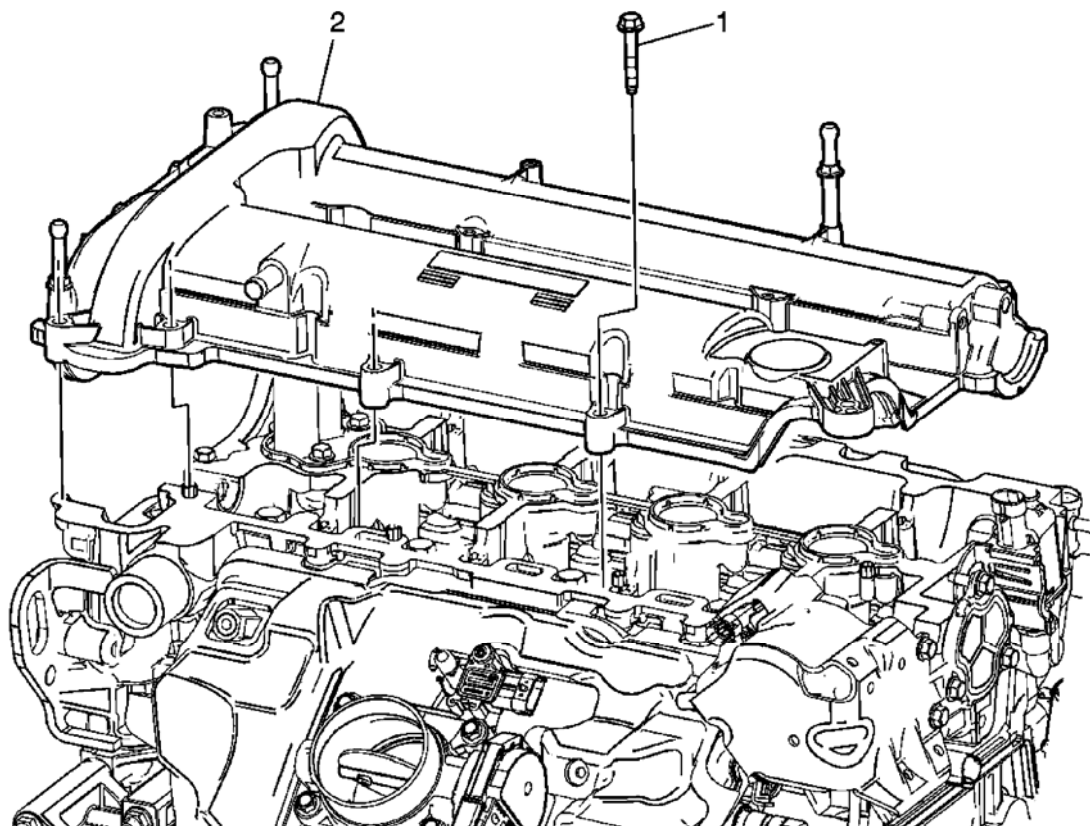


Fig. 109: Camshaft Cover
 Courtesy of GENERAL MOTORS CORP.

Callous	Component Name
Preliminary Procedures 1. Remove the air cleaner outlet duct. Refer to <u>Air Cleaner Outlet Resonator Replacement</u> . 2. Remove the ignition coils. Refer to <u>Ignition Coil Replacement</u> . 3. Remove the Camshaft Position Sensor intake. Refer to <u>Camshaft Position Sensor Replacement - Intake</u> 4. Remove the Camshaft Position Sensor Exhaust. Refer to <u>Camshaft Position Sensor Replacement - Exhaust</u>	
1	Camshaft Cover Fastener (Qty: 11) CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 10 N.m (89 lb in)
	Camshaft Cover

	Procedure
2	1. Do not reuse camshaft gasket. Also use a new gasket when removing or replacing camshaft cover. 2. Remove ignition coil wiring harness clips from the camshaft cover. 3. Remove the fuel line bracket from the camshaft cover. 4. Transfer components as necessary.

TIMING CHAIN TENSIONER REPLACEMENT

Special Tools

EN-45027: Tensioner Tool

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

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

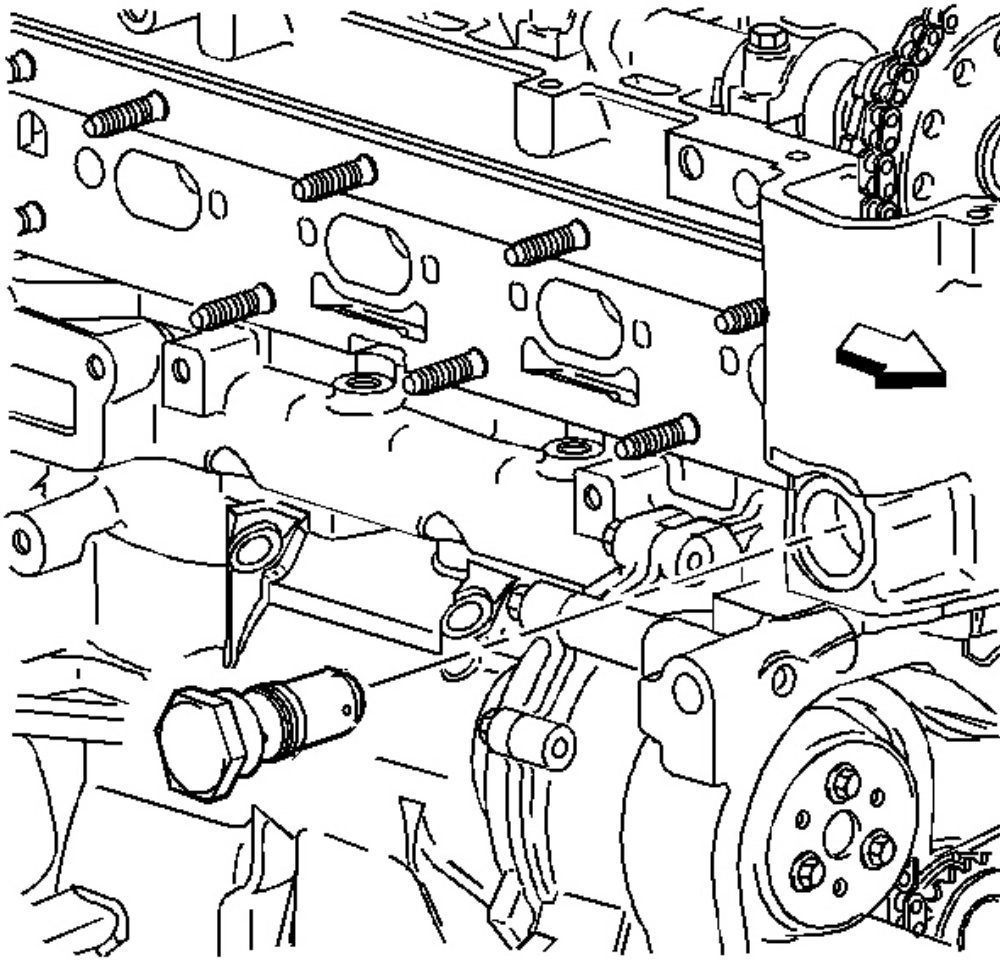


Fig. 110: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain tensioner.
4. Remove the seal from the tensioner.

Installation Procedure

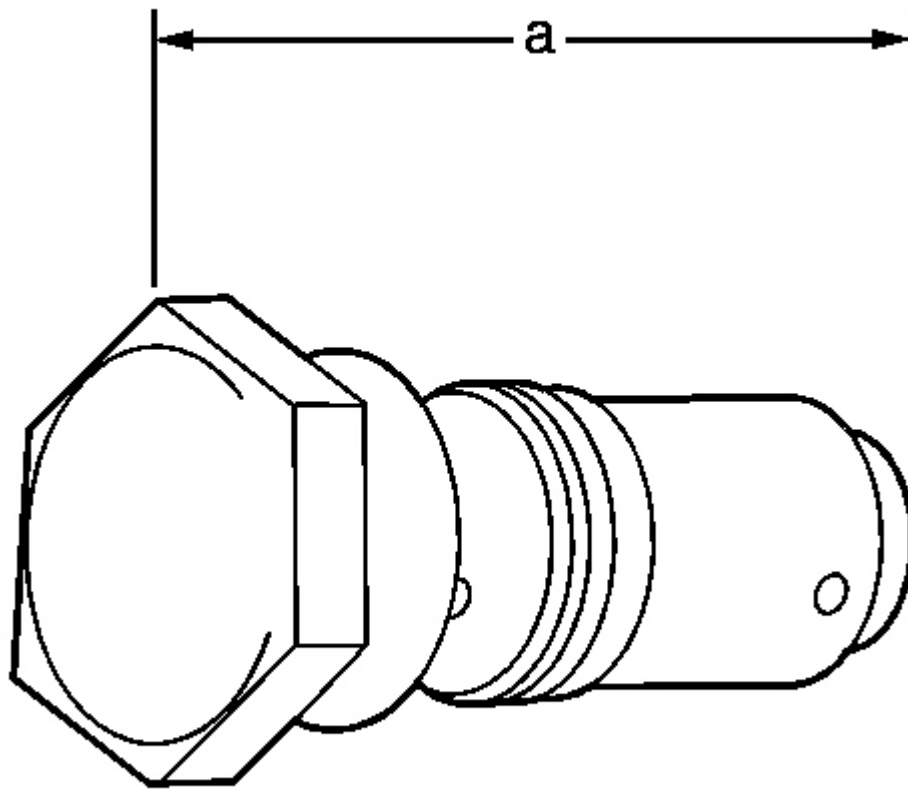


Fig. 111: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner or O-ring seal as applicable.
2. Measure the timing chain tensioner assembly from end to end. If the timing chain tensioner is to be replaced, a new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

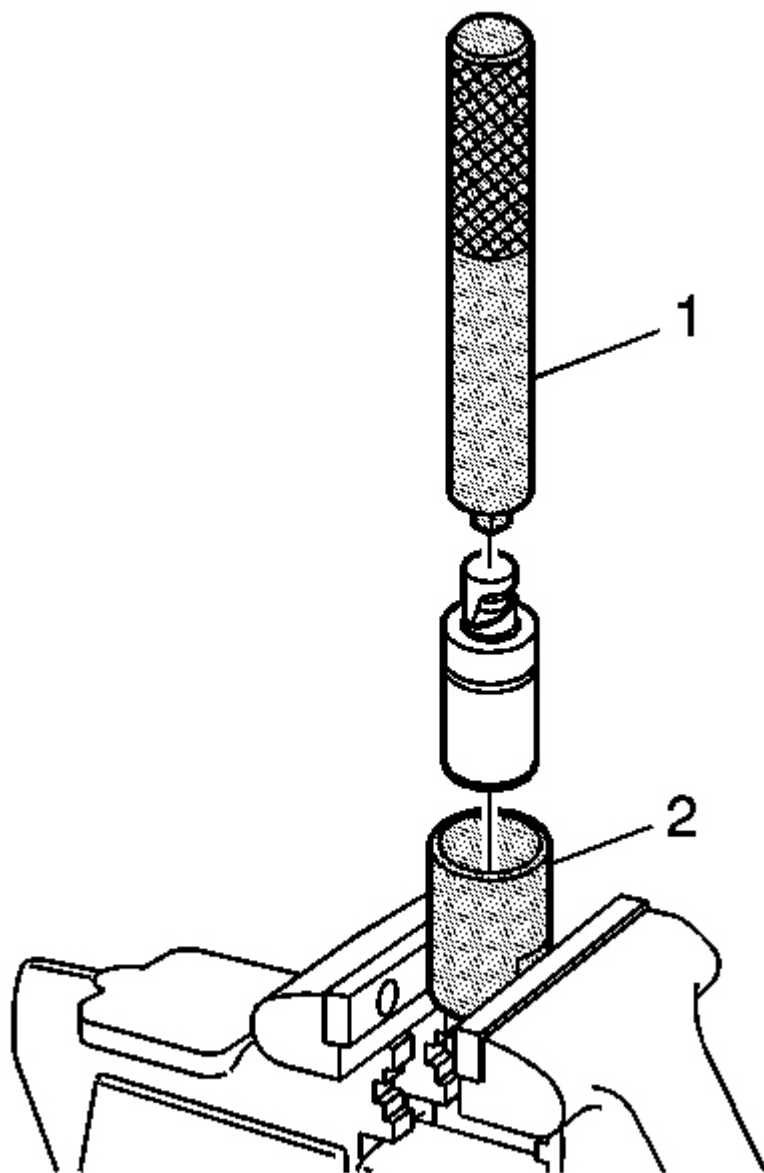


Fig. 112: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. If the timing chain tensioner is not in the compressed state, perform the following steps:
 1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
 2. Install the **EN-45027-2**: tool (2) into a vise.

3. Install the notch end of the piston assembly into the **EN-45027-2:** tool (2).
4. Using the **EN-45027-1:** tool (1), turn the ratchet cylinder into the piston.

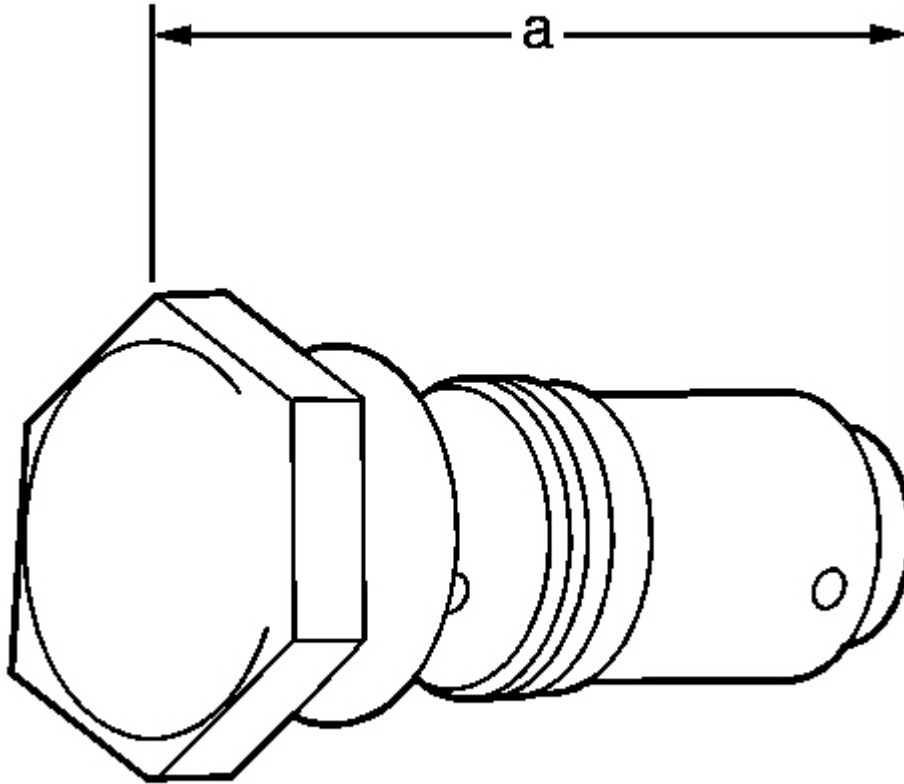


Fig. 113: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

4. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris out with a lint-free cloth.
5. Install the compressed piston assembly back into the timing chain tensioner body until it stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, it will activate the tensioner, which will then need to be reset again.
6. At this point the tensioner should measure approximately 72 mm (2.83 in) (a) from end to end. If the tensioner does not read 72 mm (2.83 in) (a) from end to end, repeat steps 3-5.

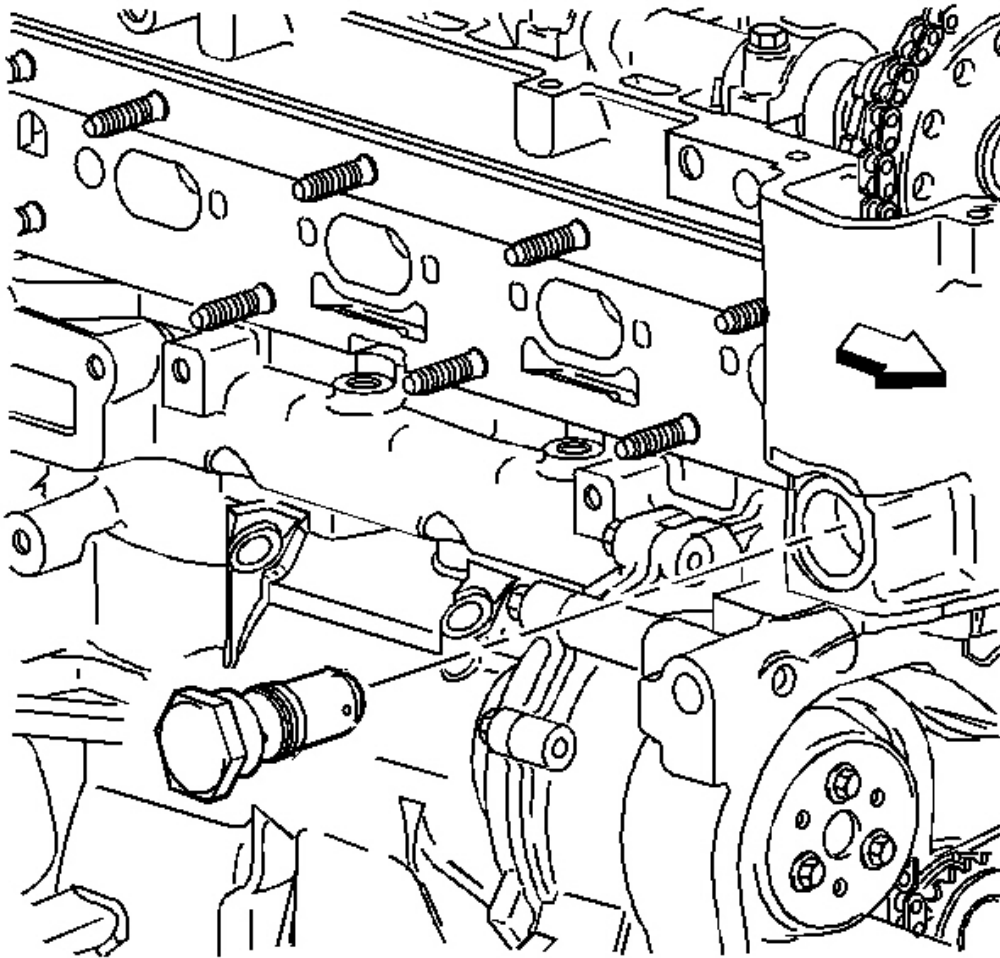


Fig. 114: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

CAUTION: Refer to Fastener Caution .

NOTE: **Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.**

8. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).

9. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.
10. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
11. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.

INTAKE CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

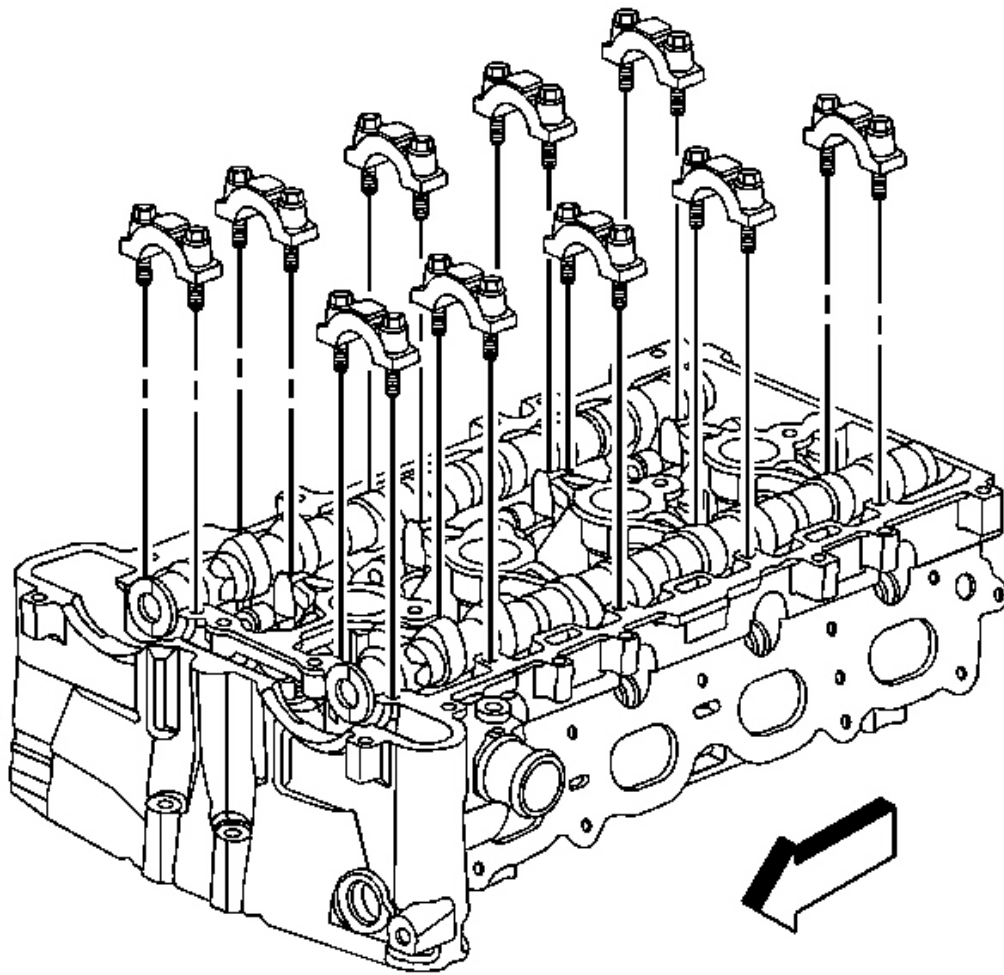


Fig. 115: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

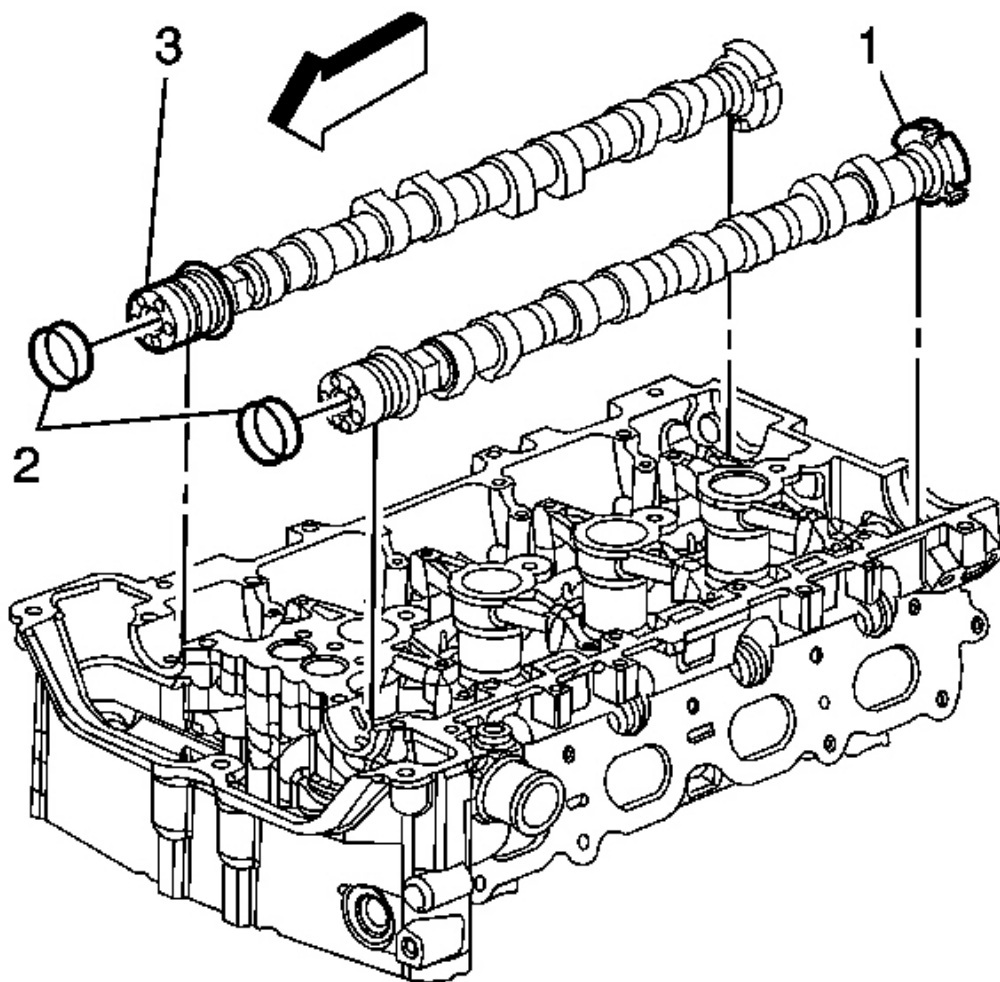


Fig. 116: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake camshaft (1).

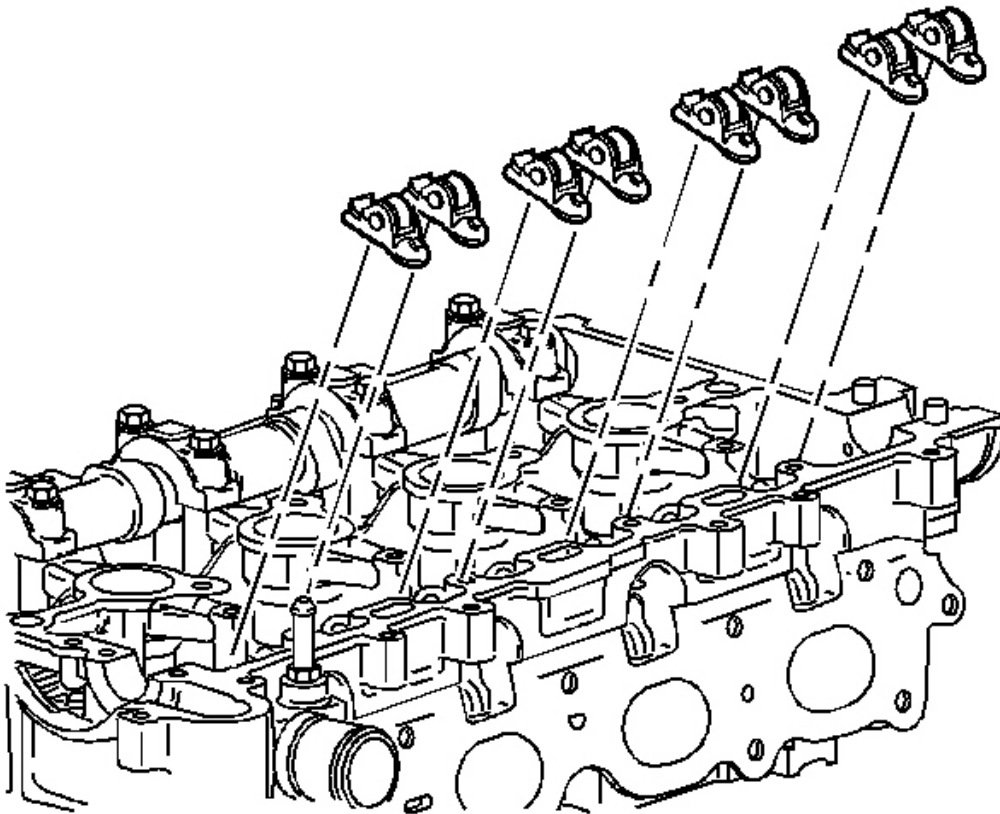


Fig. 117: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

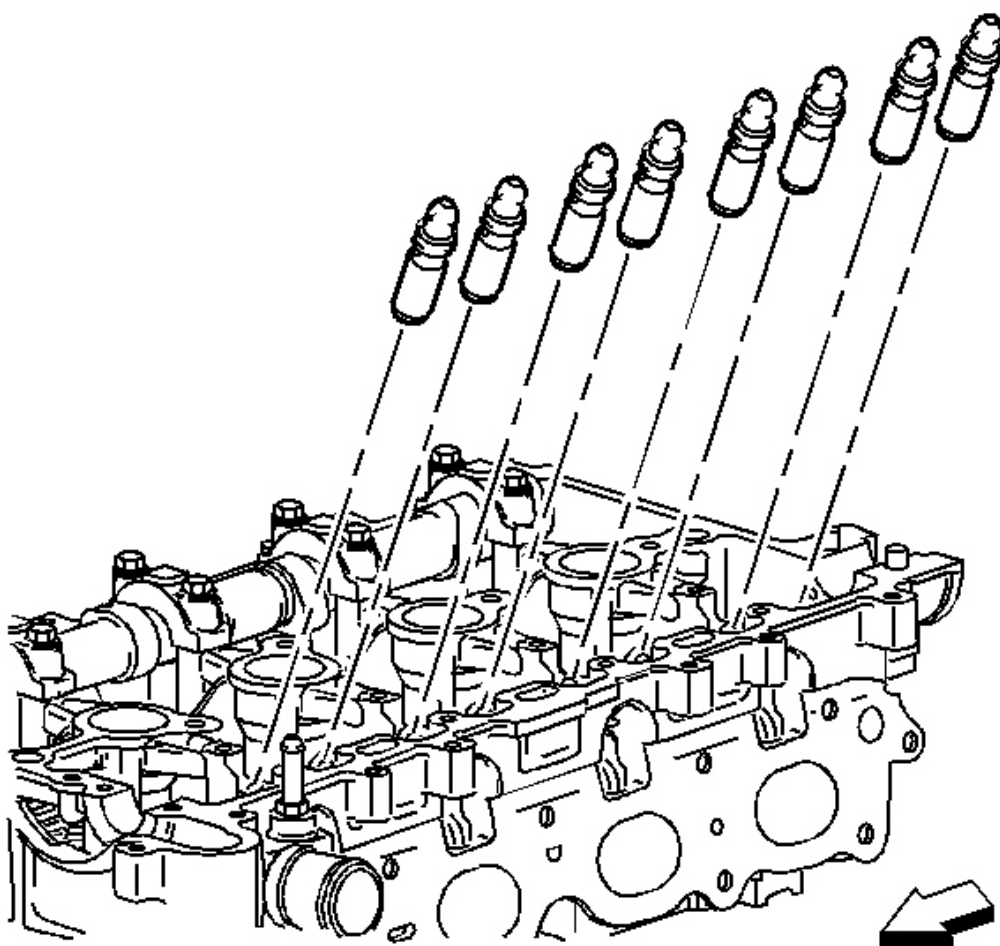


Fig. 118: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

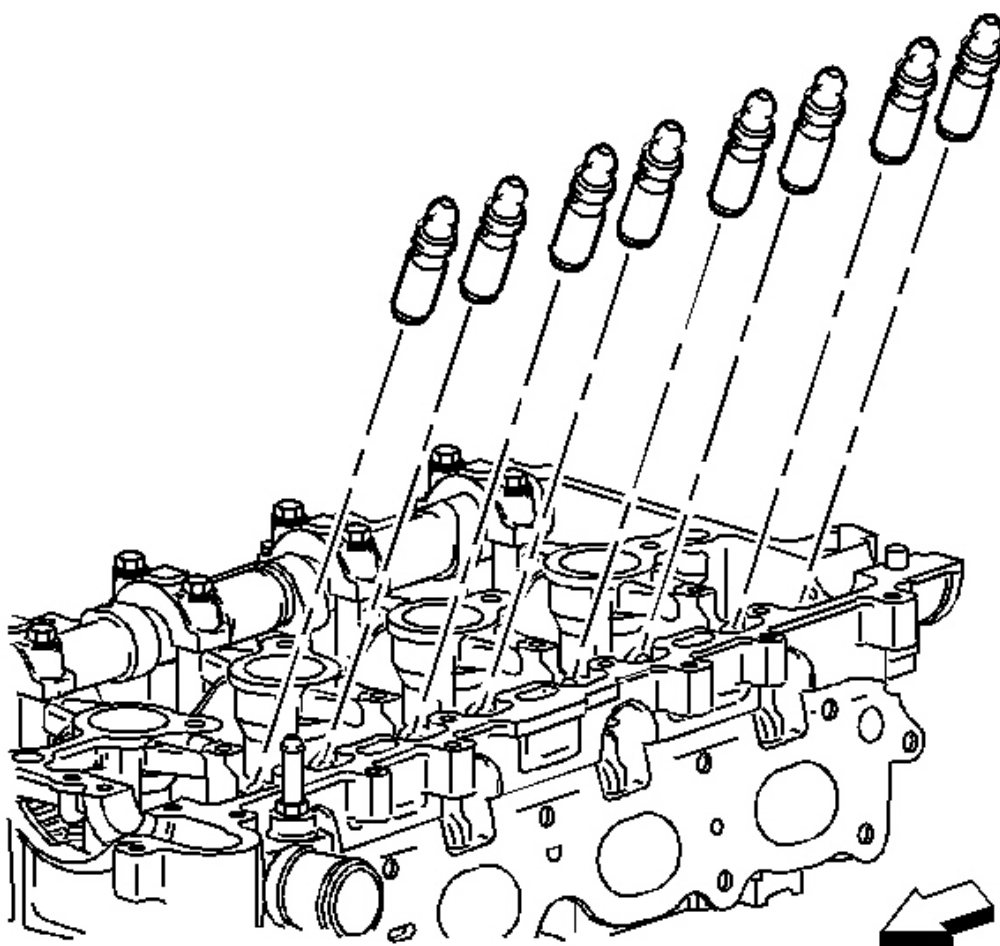


Fig. 119: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

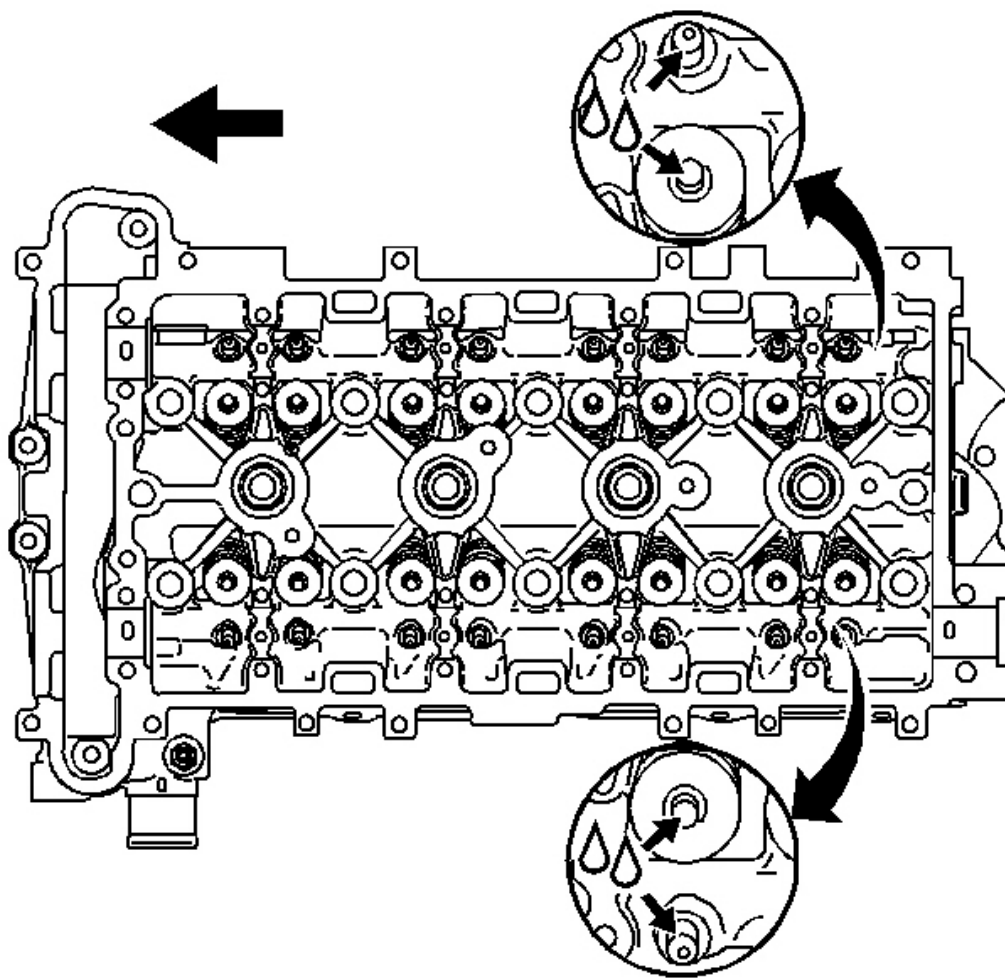


Fig. 120: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

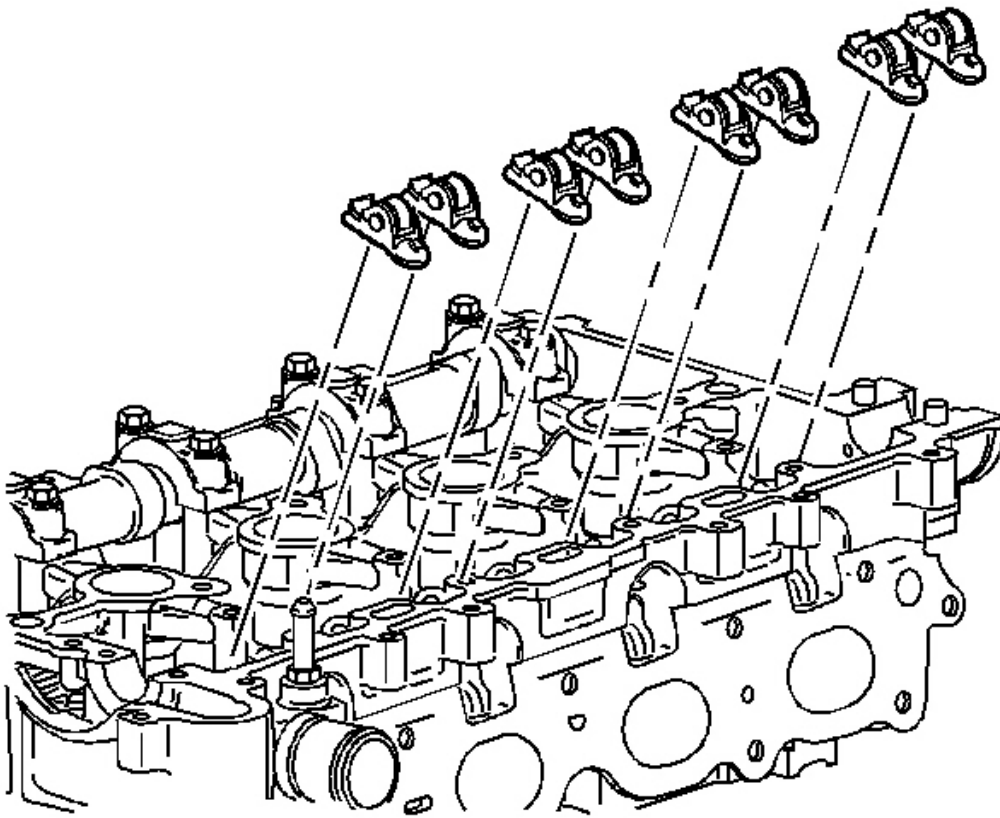


Fig. 121: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers **MUST** be returned to their original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the camshaft roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

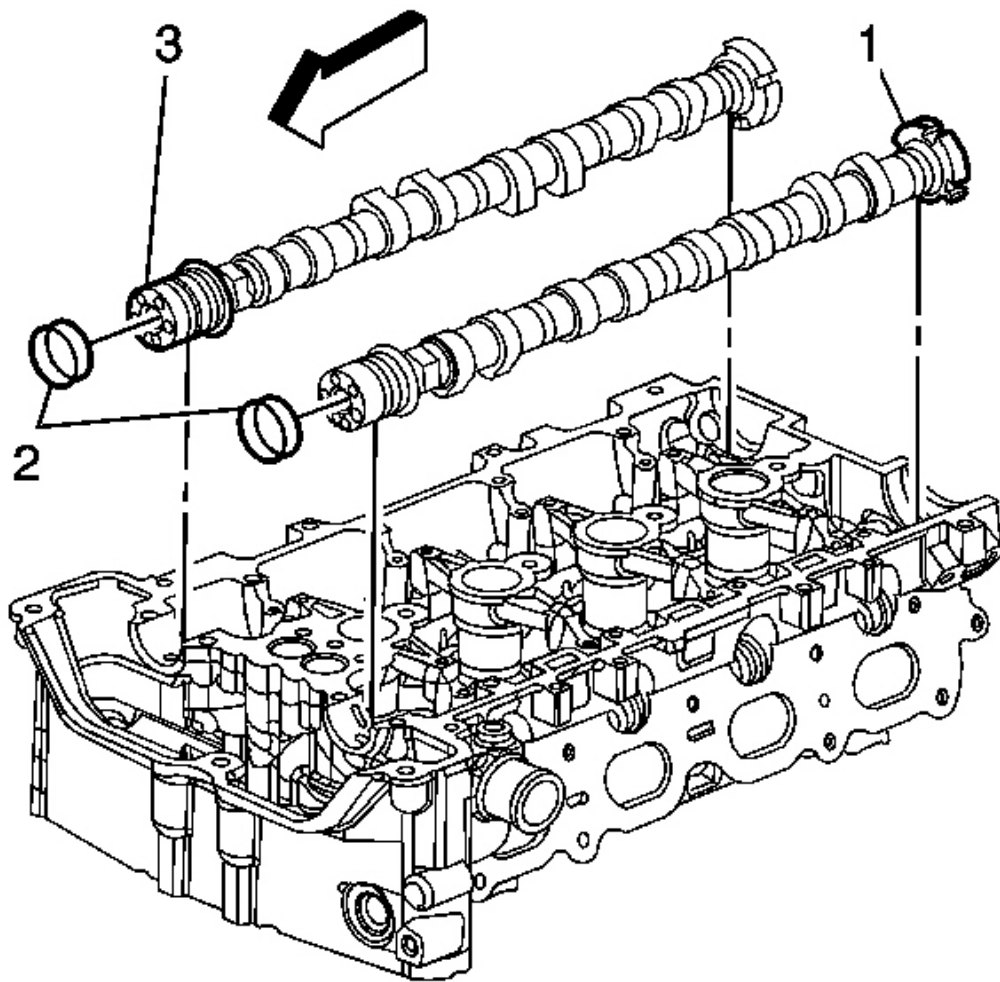


Fig. 122: Intake/Exhaust Camshaft

Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft (1) and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

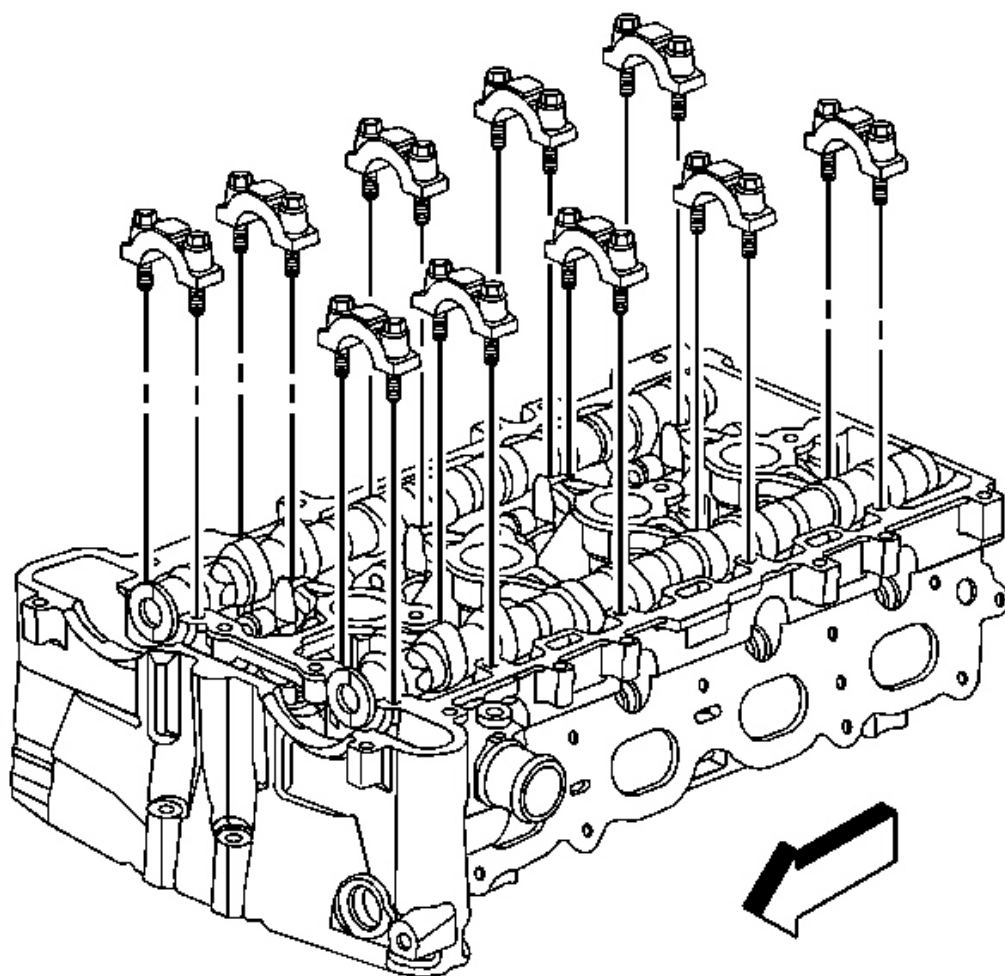


Fig. 123: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

EXHAUST CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

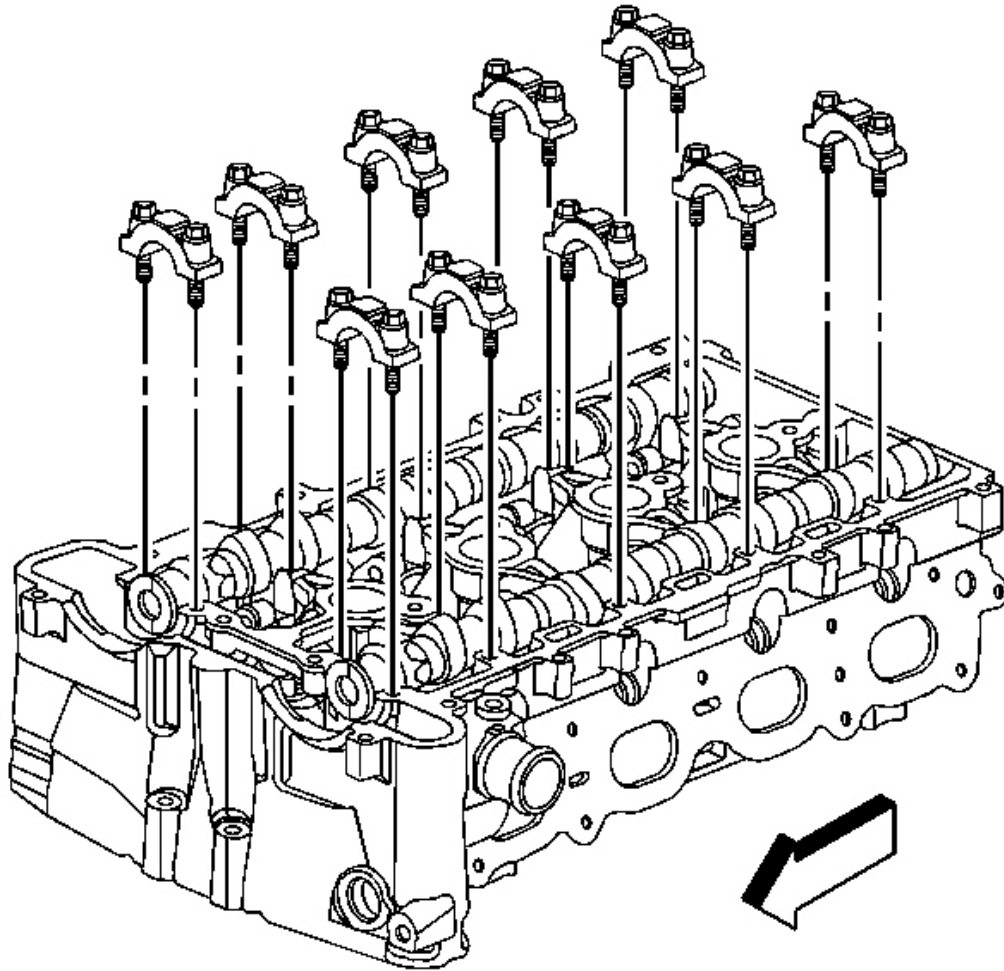


Fig. 124: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

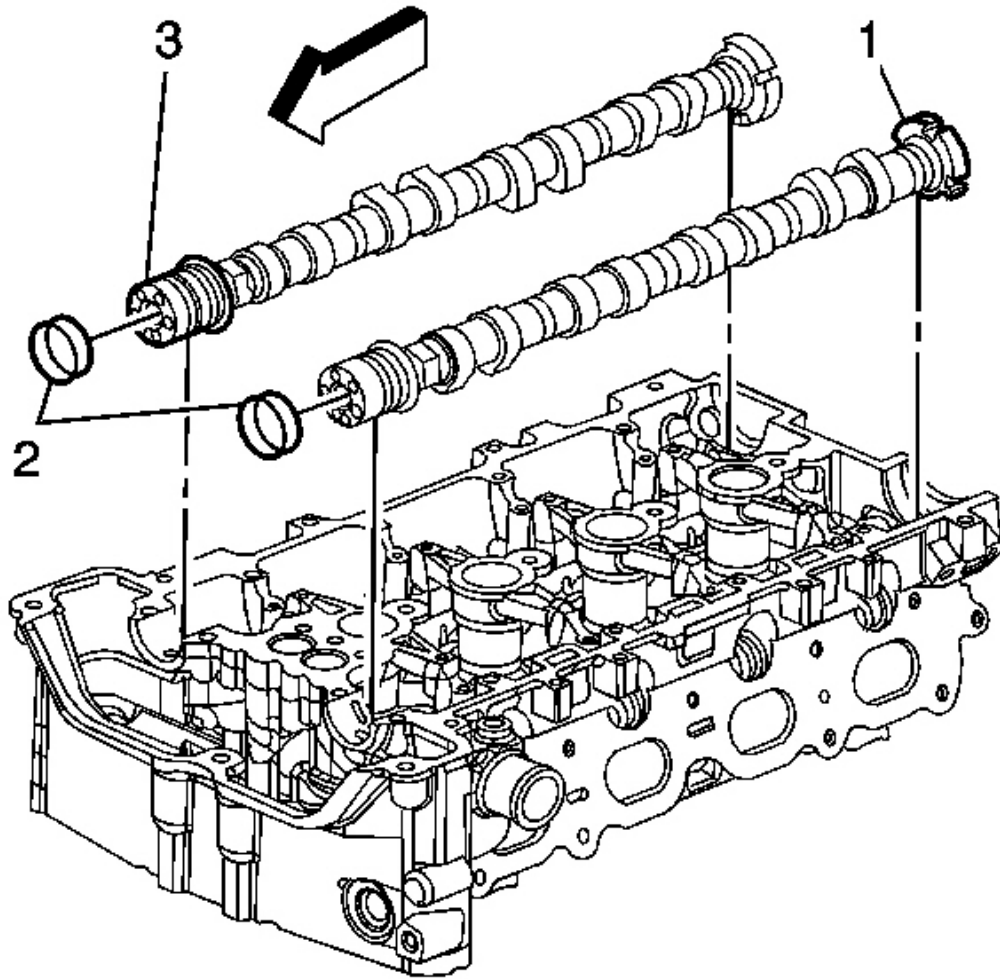


Fig. 125: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft (3).

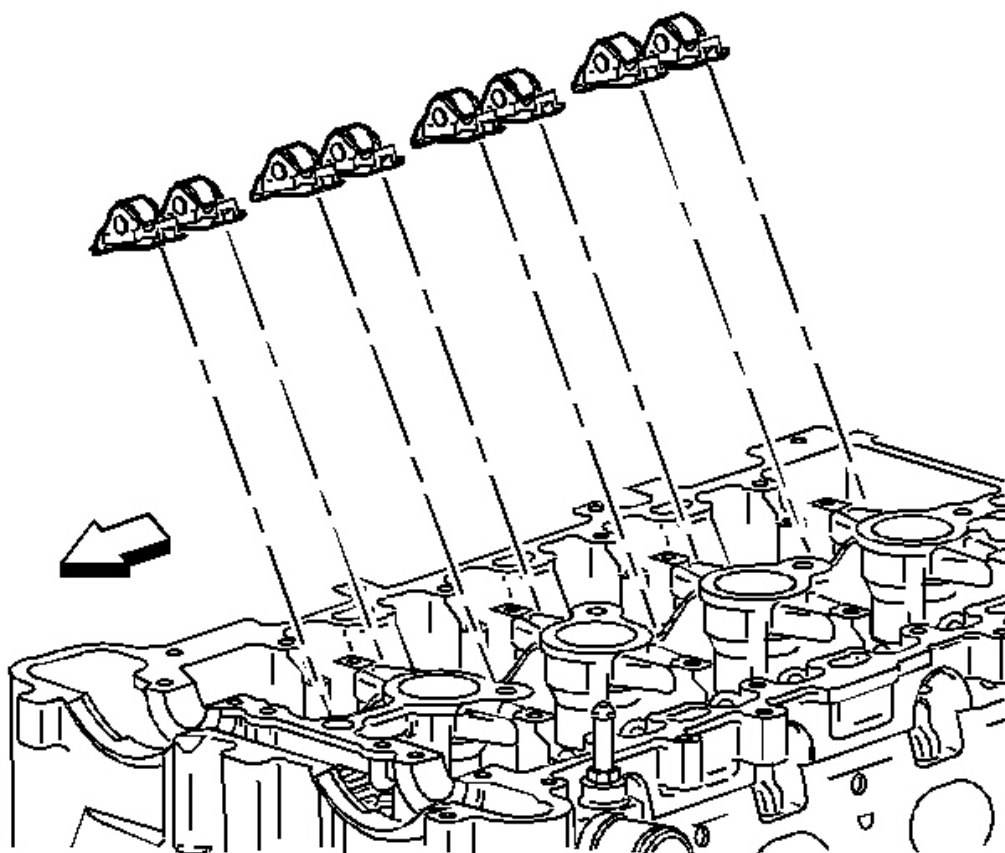


Fig. 126: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

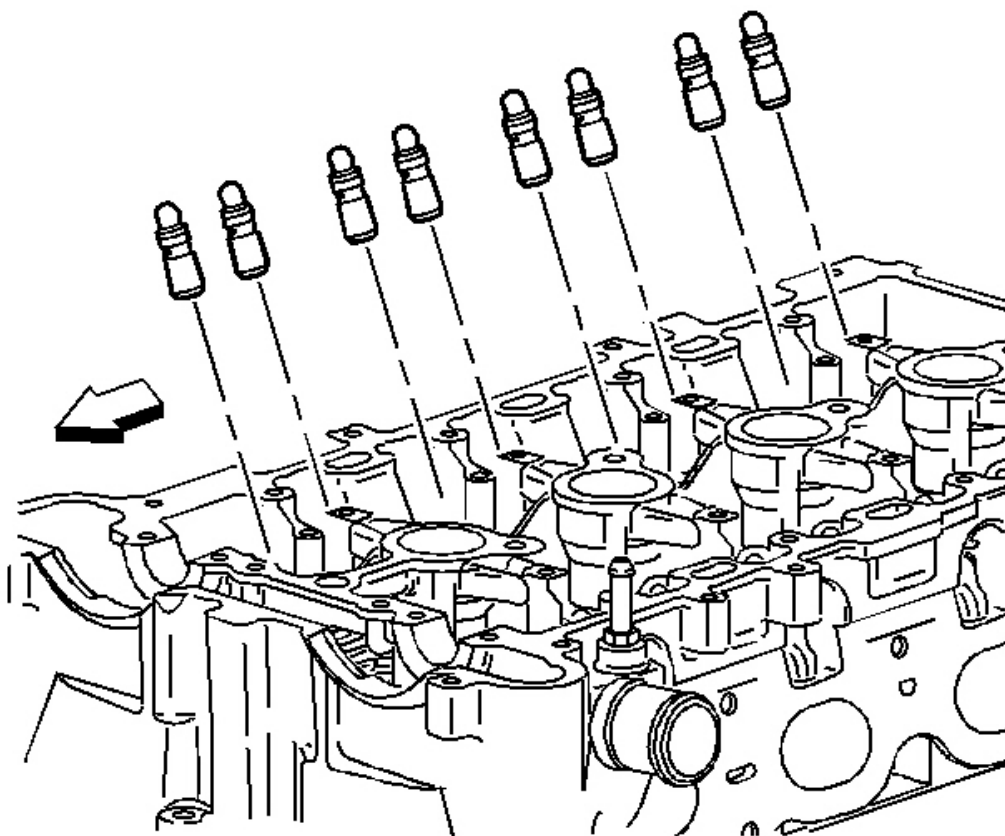


Fig. 127: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

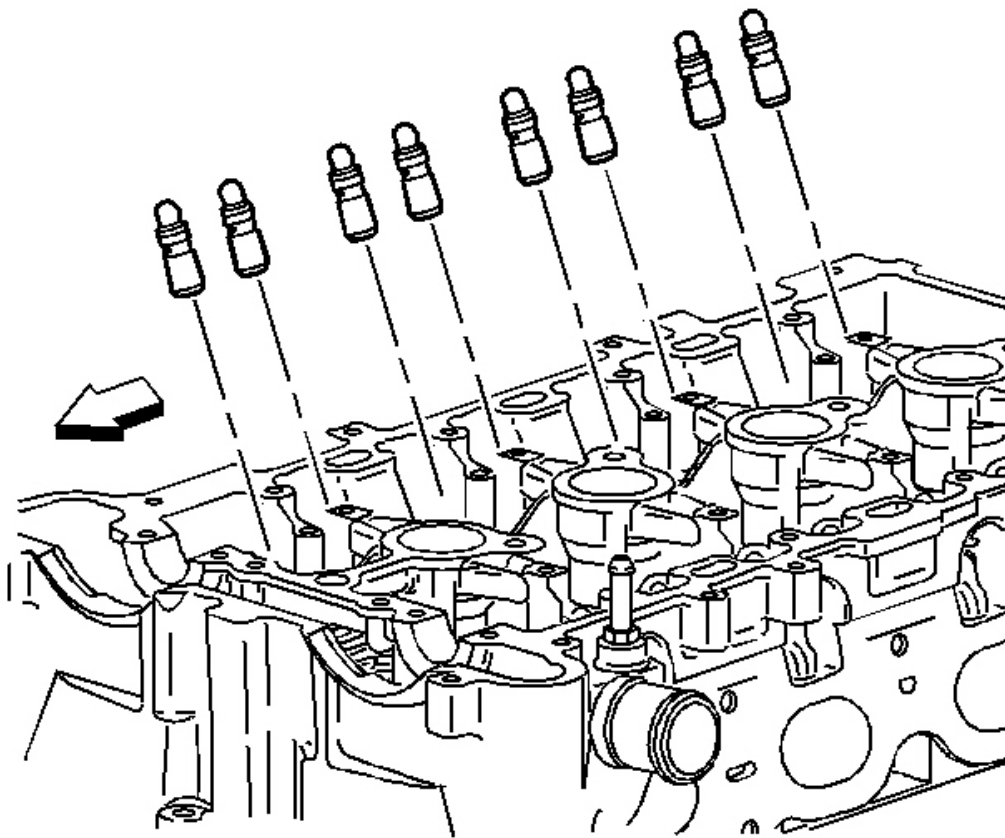


Fig. 128: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

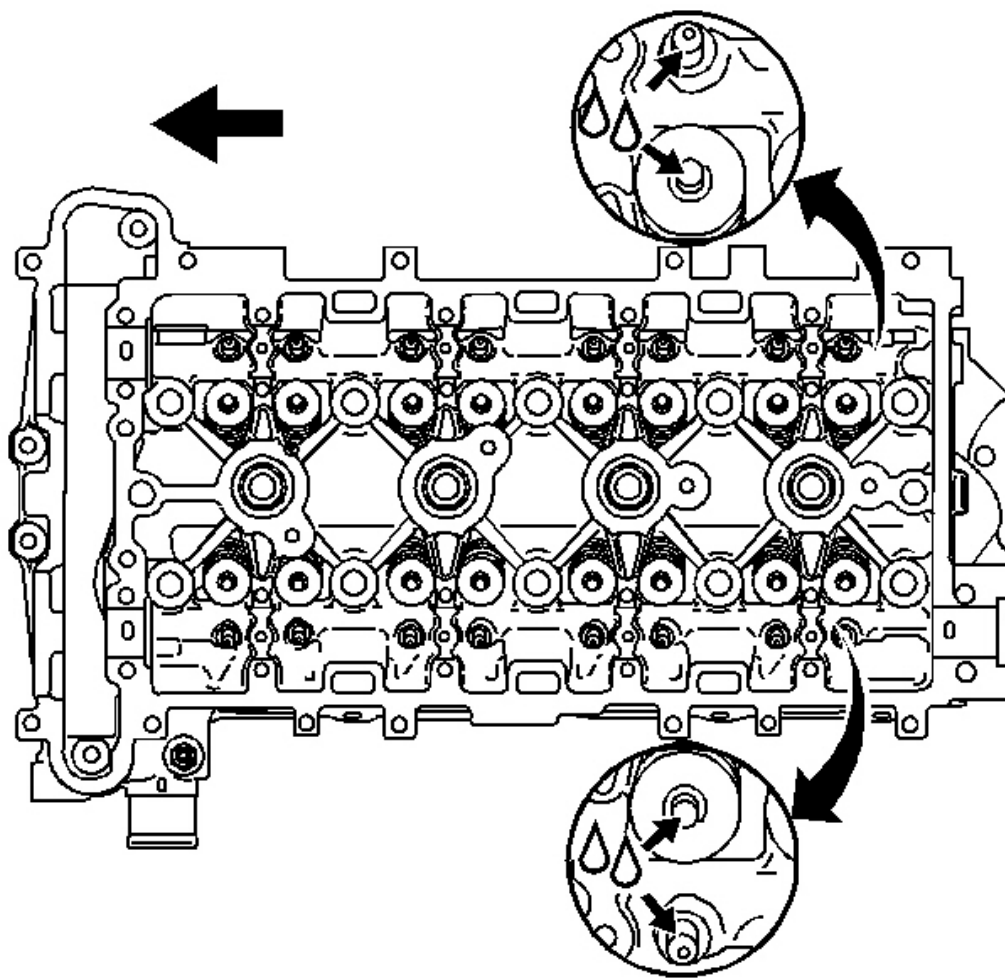


Fig. 129: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with Adhesives, Fluids, Lubricants, and Sealers.

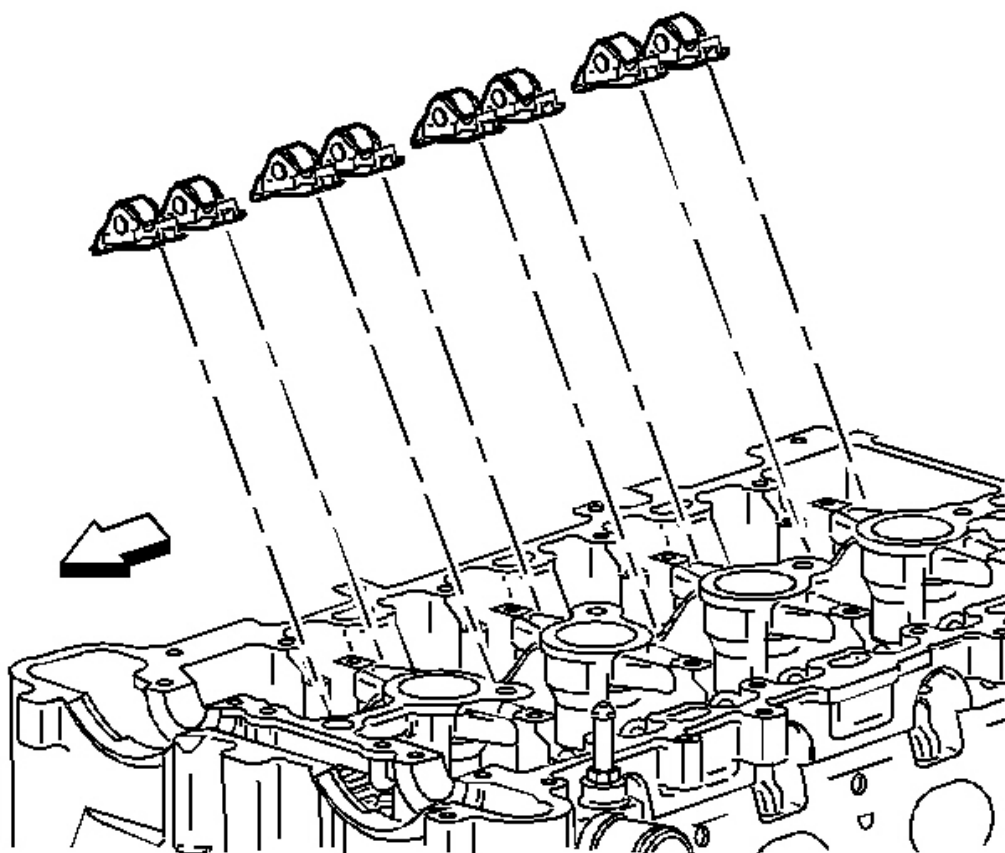


Fig. 130: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers **MUST** be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

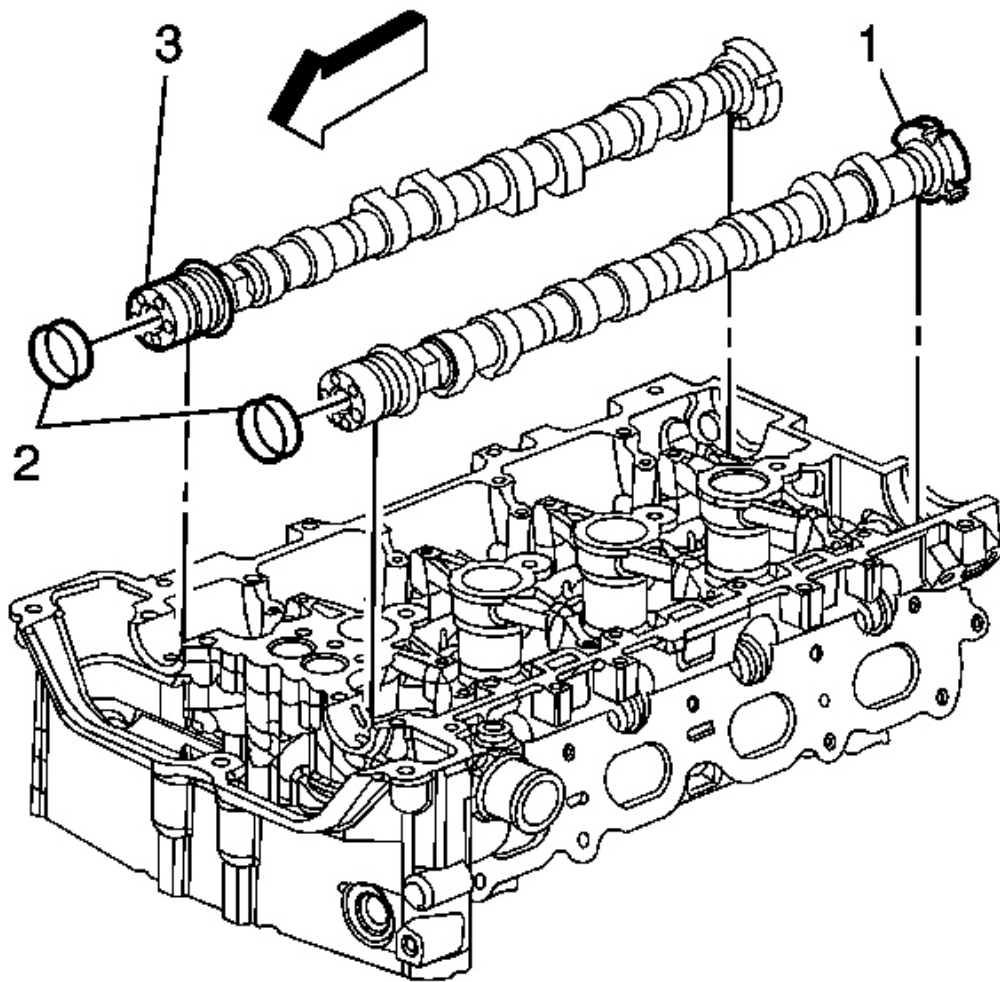


Fig. 131: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft (3). Lubricate with **Adhesives, Fluids, Lubricants, and Sealers**.

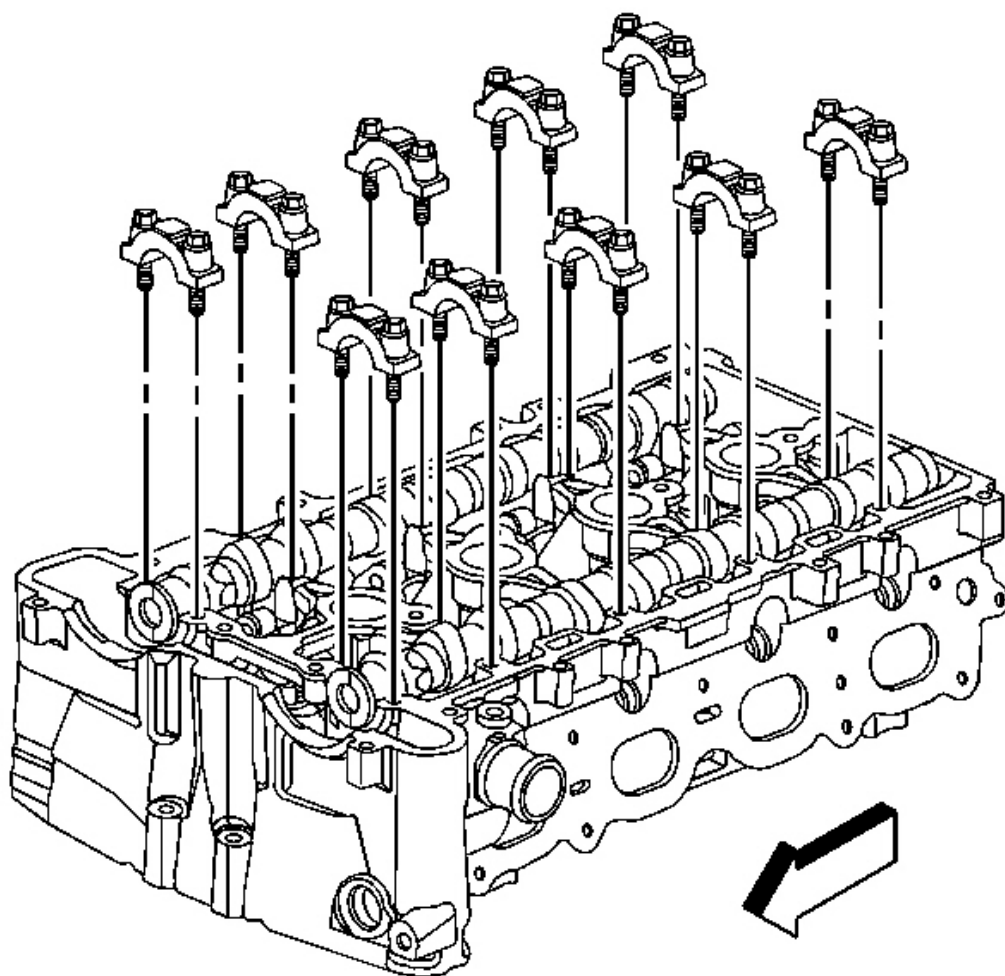


Fig. 132: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

CAMSHAFT POSITION INTAKE ACTUATOR REPLACEMENT

Special Tools

- **EN-45059:** Angle Meter
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

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

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement**.

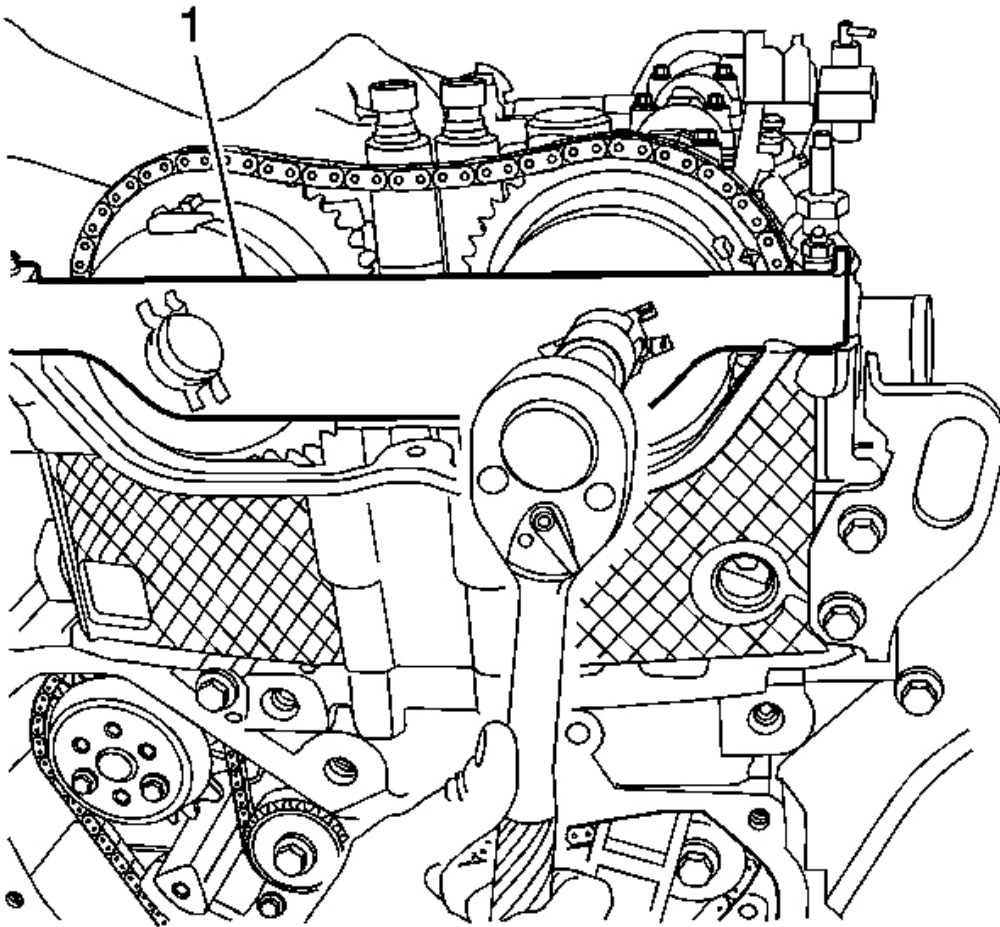


Fig. 133: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953**: retention tool (1).

CAUTION: Refer to **Fastener Caution** .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but DO NOT remove the intake camshaft actuator bolt.
6. Remove the **EN-48953**: locking tool (1).
7. Clean the timing chain and gears with solvent.

NOTE: Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

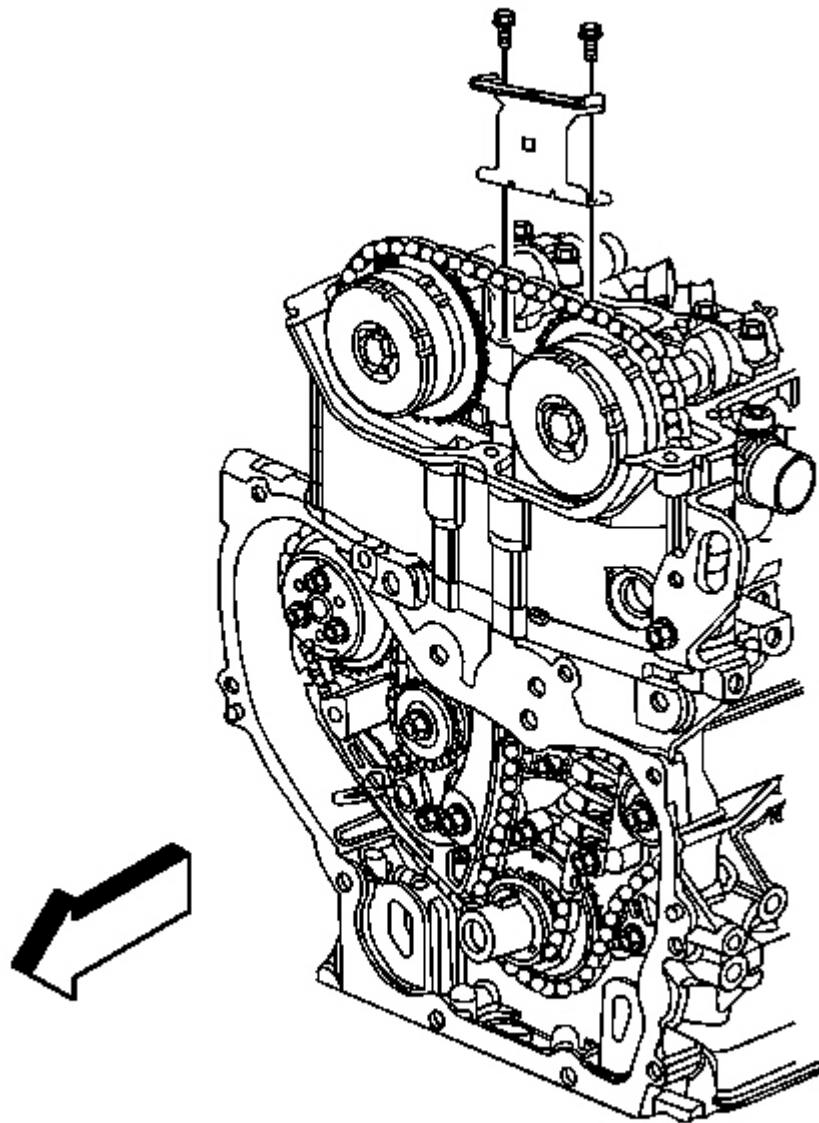


Fig. 134: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

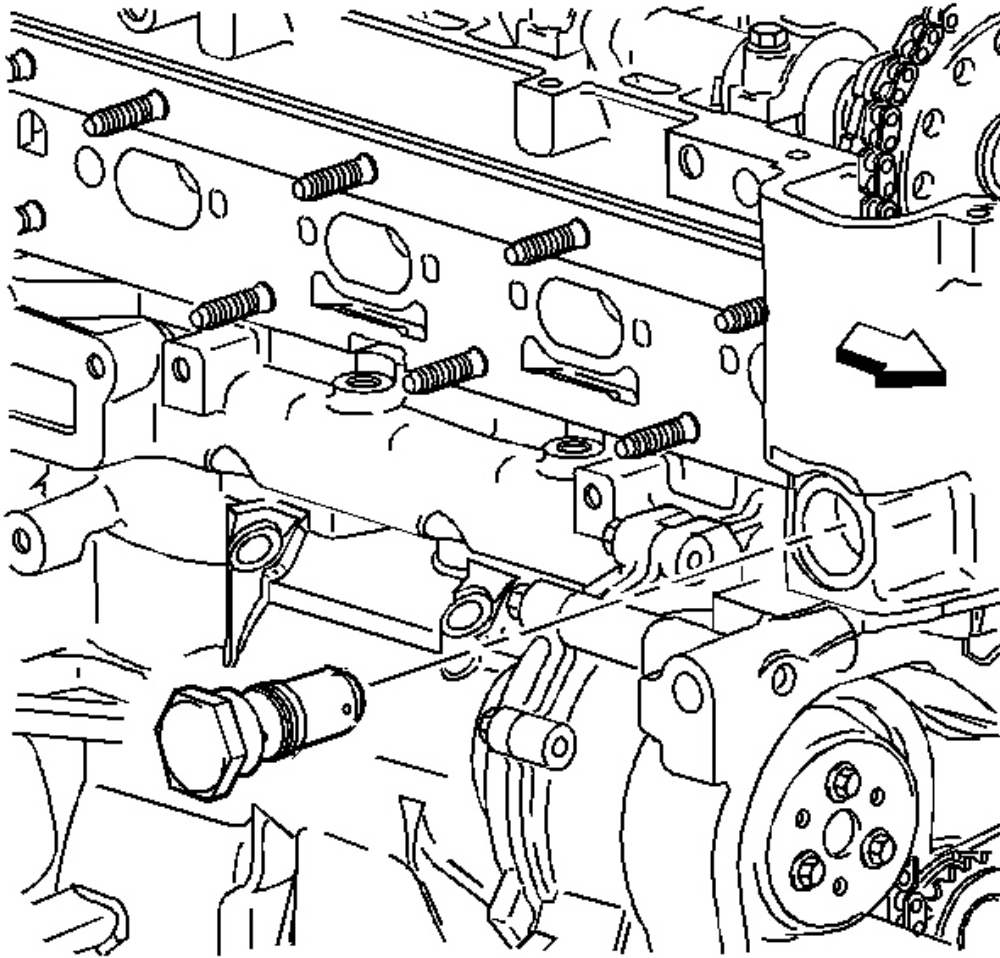


Fig. 135: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

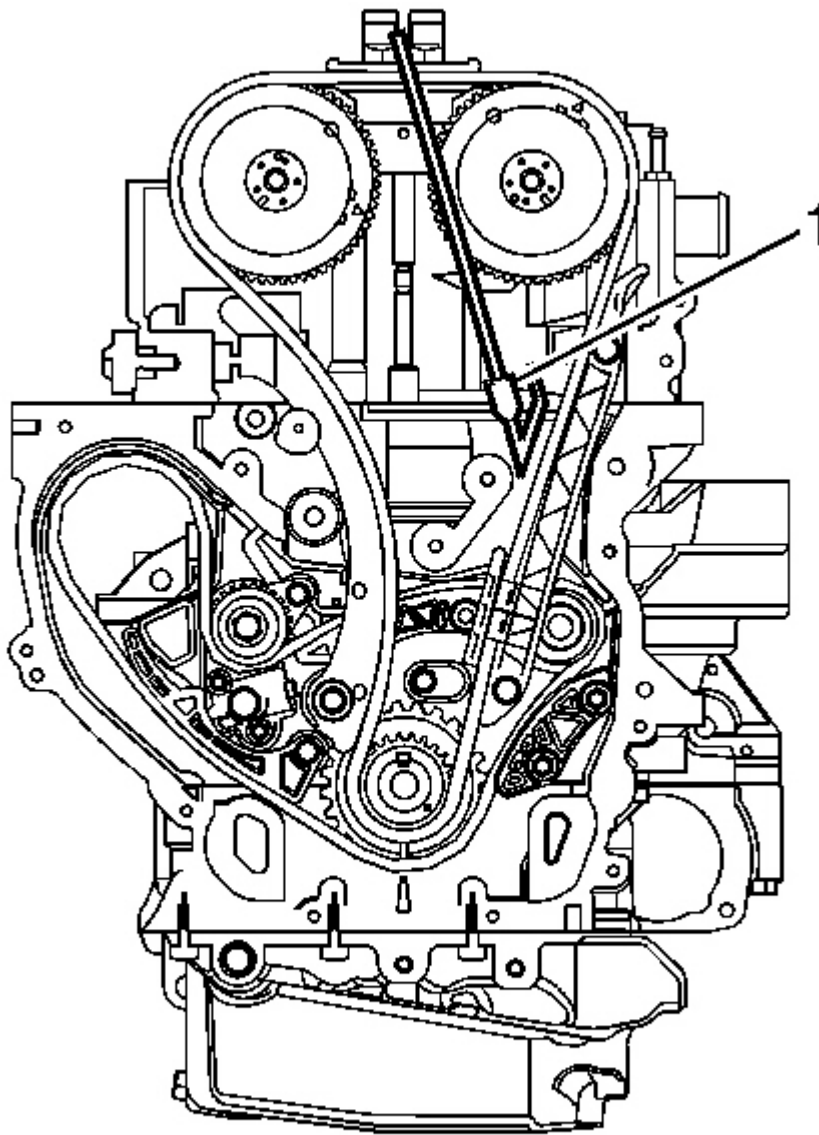


Fig. 136: Identifying Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The intake camshaft actuator should not rotate during the removal or installation.
- Ensure the tips of the tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to

ensure the teeth from the retention tool are engaged.

11. Install the **EN-48749**: retention tool (1) to the intake side of the timing chain.

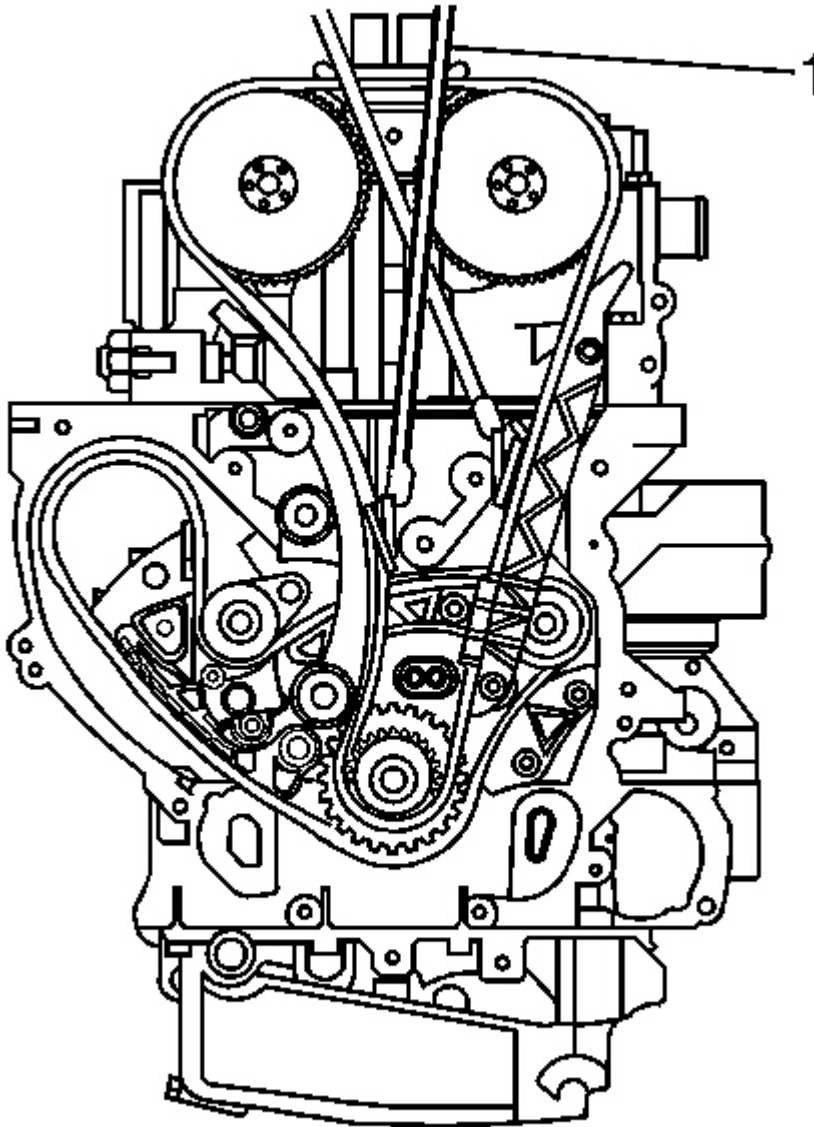


Fig. 137: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN-48749**: retention tool (1) to the exhaust side of the timing chain.

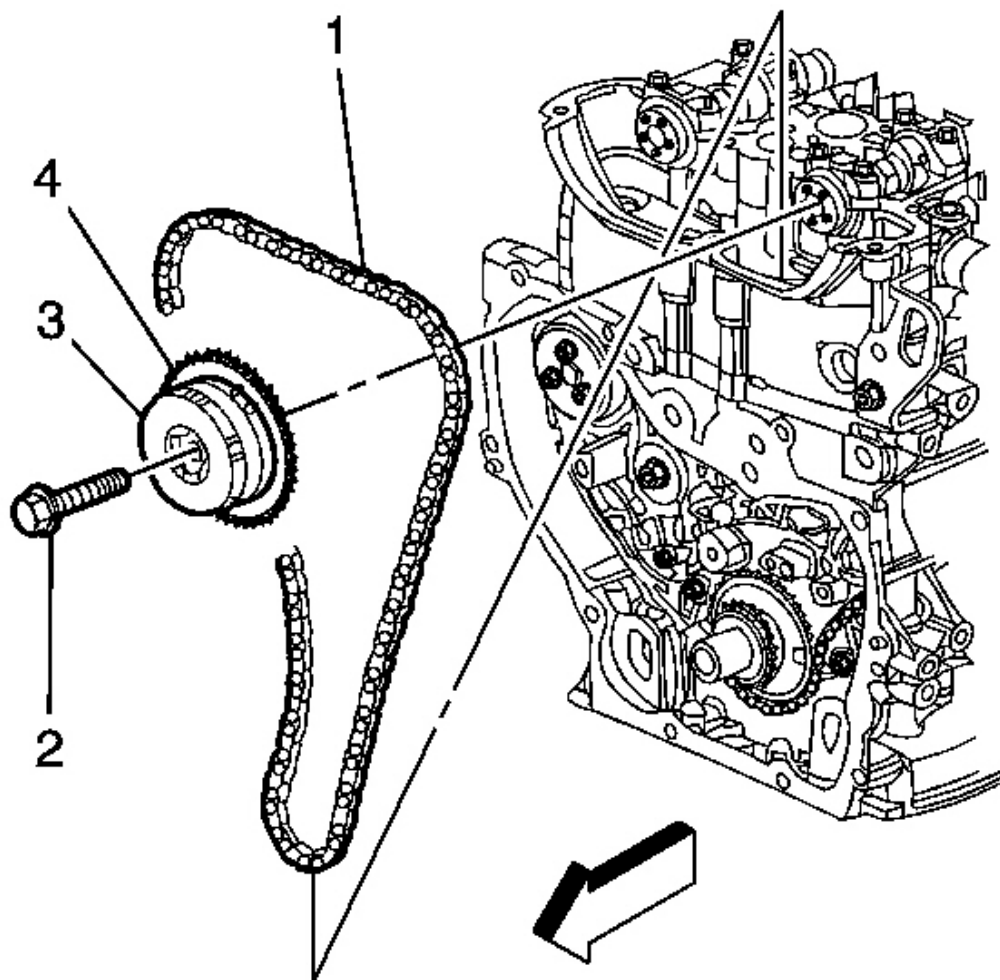


Fig. 138: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the intake camshaft actuator bolt (2).
14. Rotate the exhaust camshaft clockwise slightly to take the tension off of the timing chain on the intake actuator.
15. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

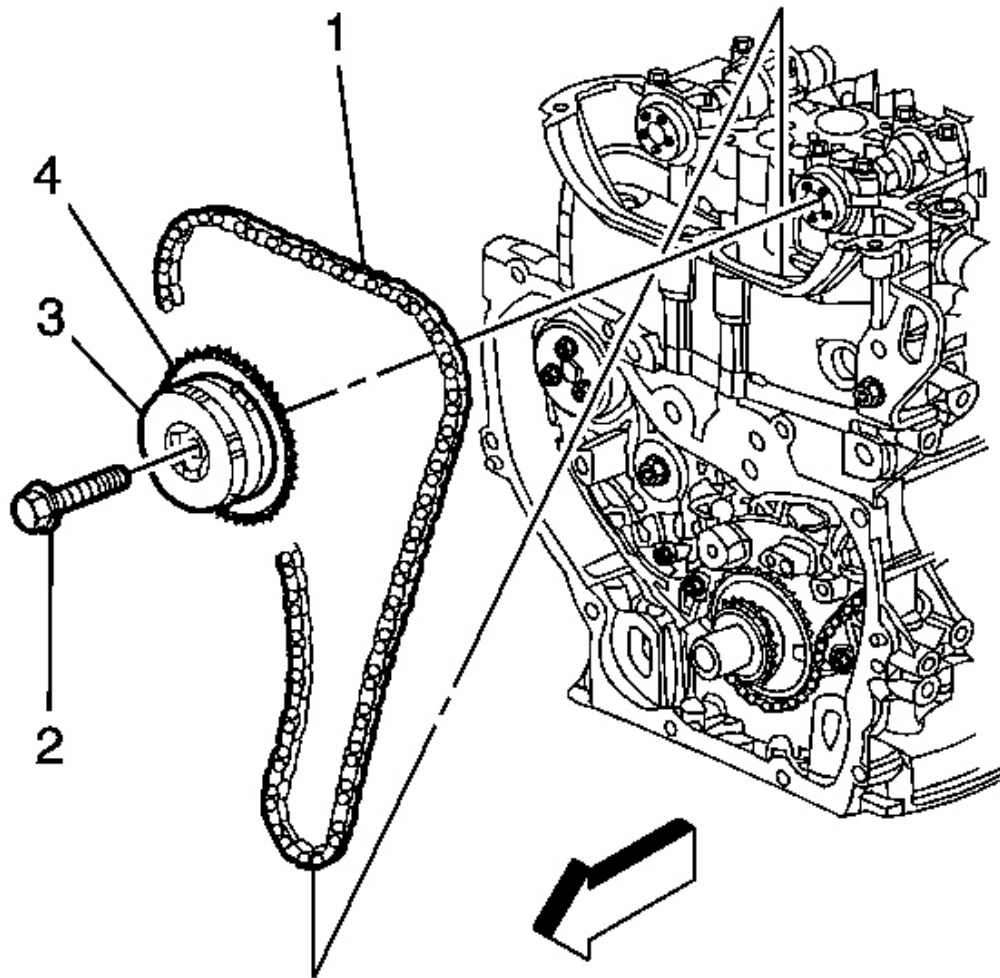


Fig. 139: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

1. Install the timing chain onto the intake camshaft actuator.
2. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft rotating the exhaust camshaft clockwise, if required.
3. Install a NEW intake camshaft actuator bolt (2) until snug.

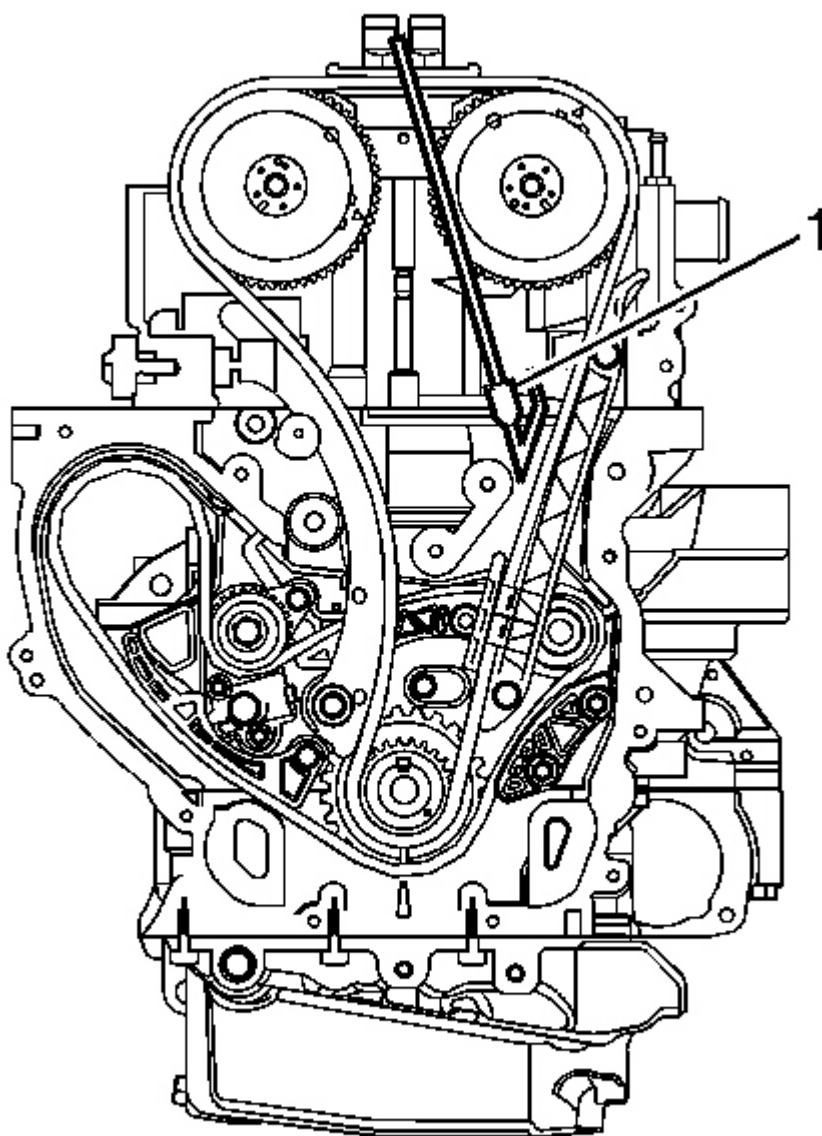


Fig. 140: Identifying Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain retention tool (1) from the intake side of the timing chain.

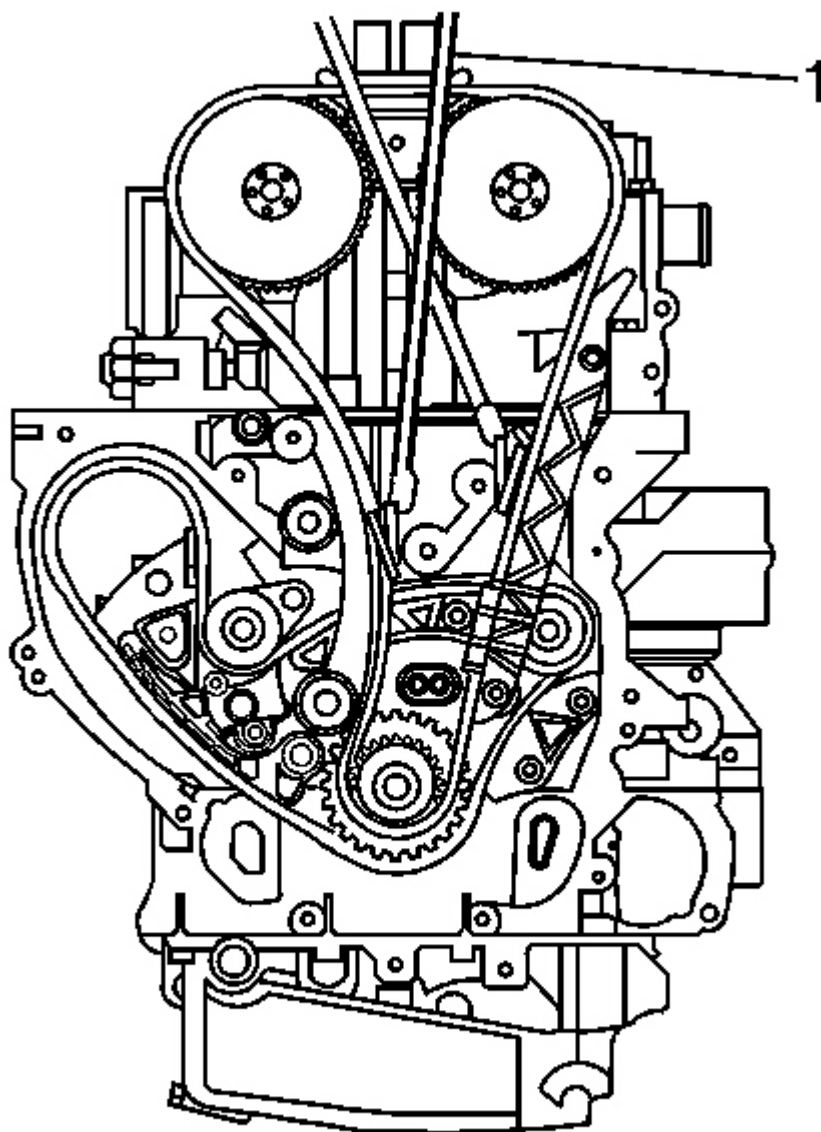


Fig. 141: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the intake camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

5. Remove the timing chain retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend, limiting the timing chain life.

6. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

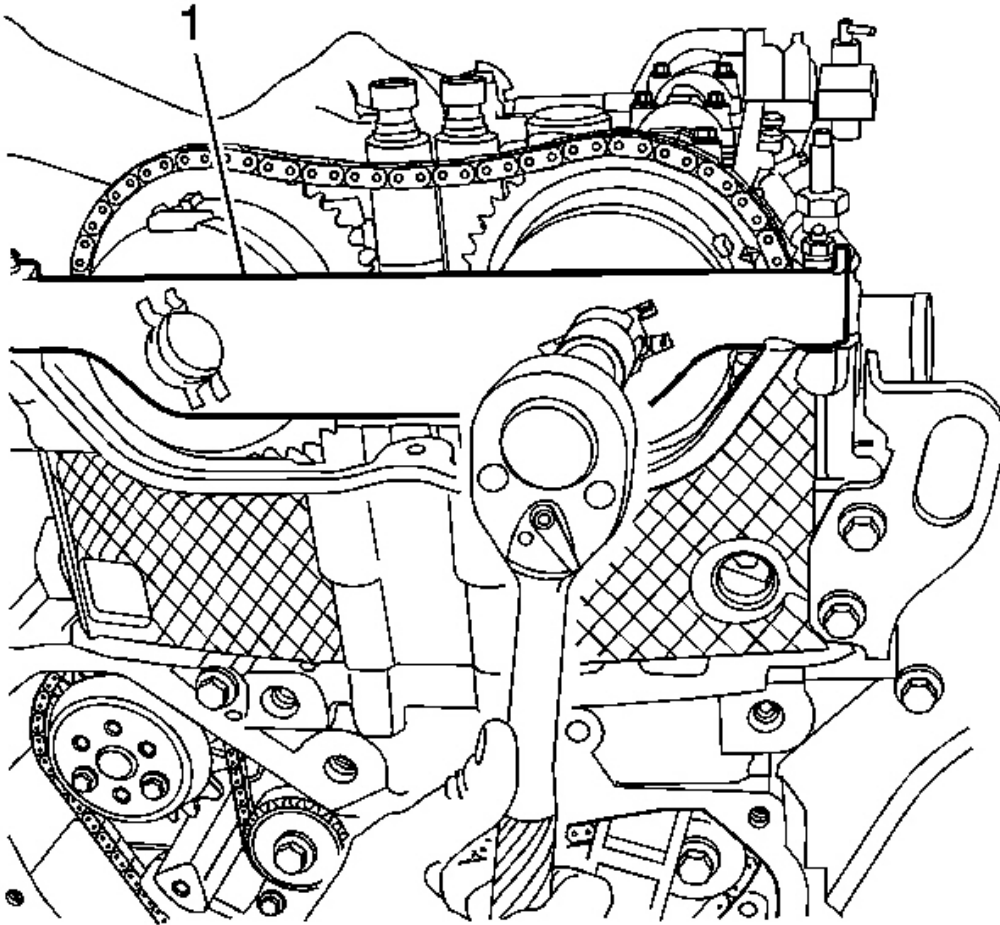


Fig. 142: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the **EN-48953**: retention tool (1).
8. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
9. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059**: meter.

NOTE: You must have the **EN-48953: retention tool** installed to perform this procedure.

10. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft)..
11. Remove the **EN-48953: retention tool** (1).

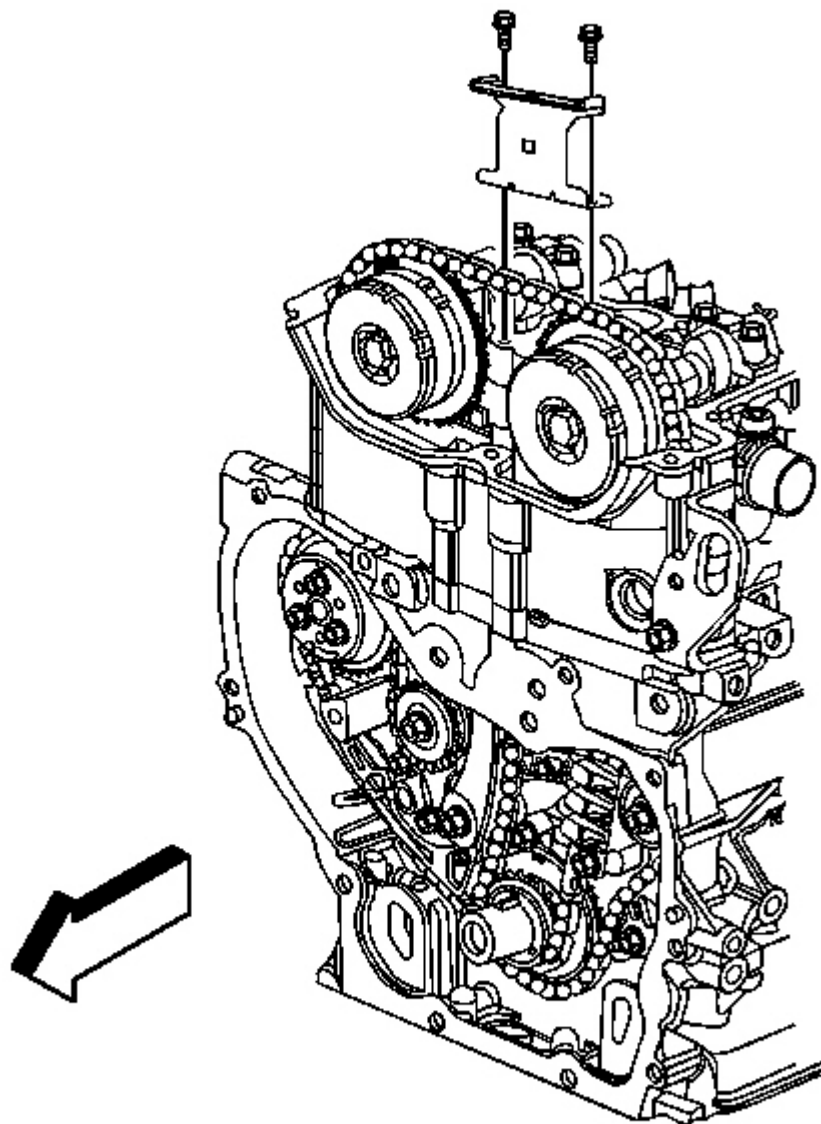


Fig. 143: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

Special Tools

- **EN-45059:** Angle Meter
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

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

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

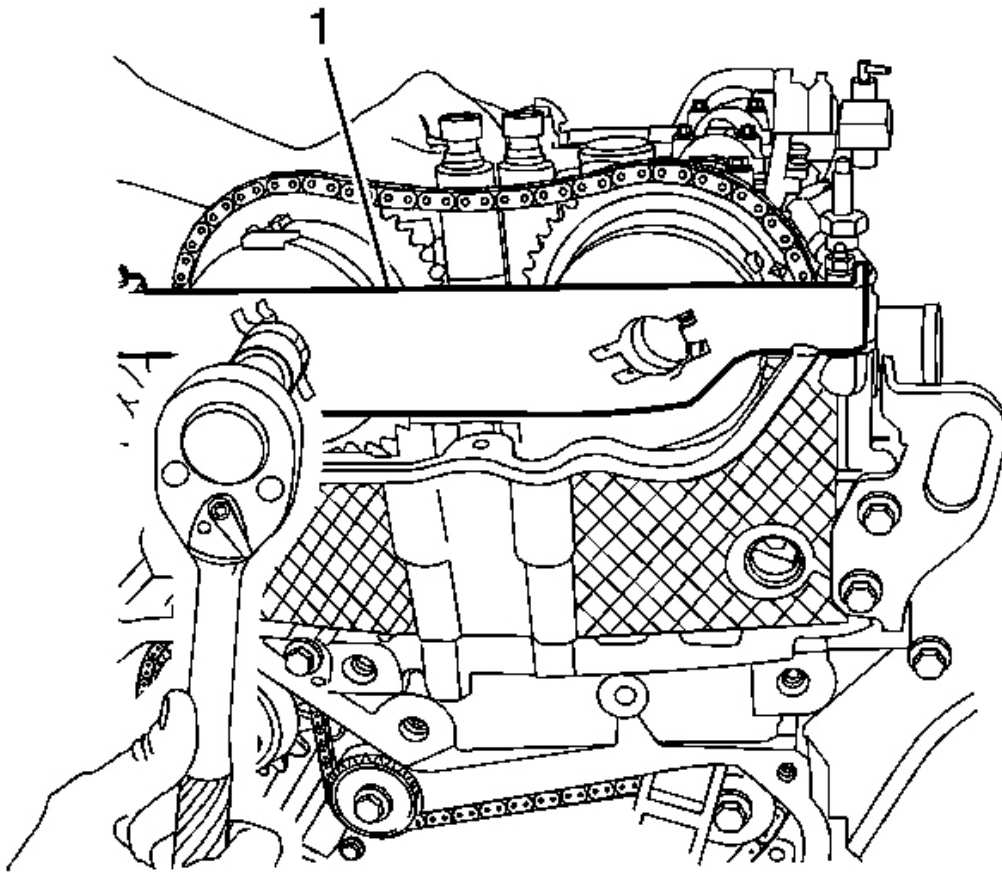


Fig. 144: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953**: retention tool (1).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but do not remove the exhaust camshaft actuator bolt.
6. Clean the timing chain and gears with solvent.

NOTE: **Ensure the timing chain and the camshaft position actuators are marked for proper assembly.**

7. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

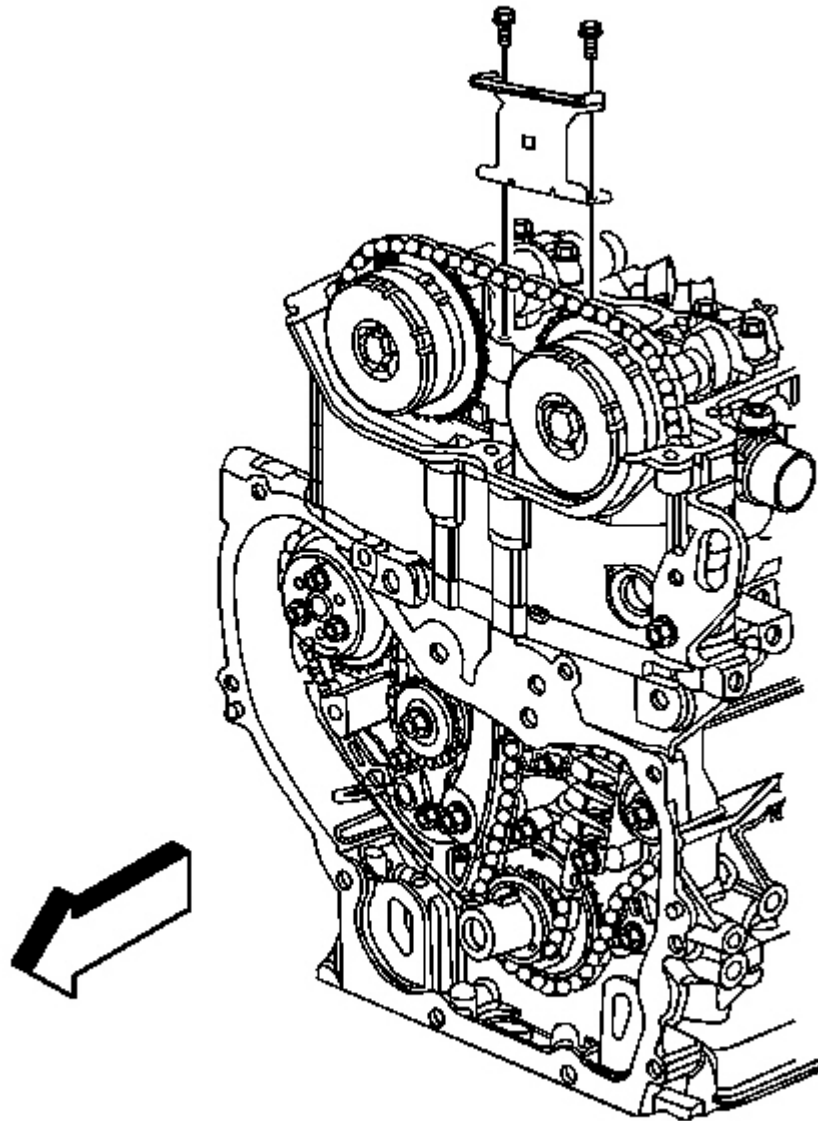


Fig. 145: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the upper timing chain guide bolts and guide.

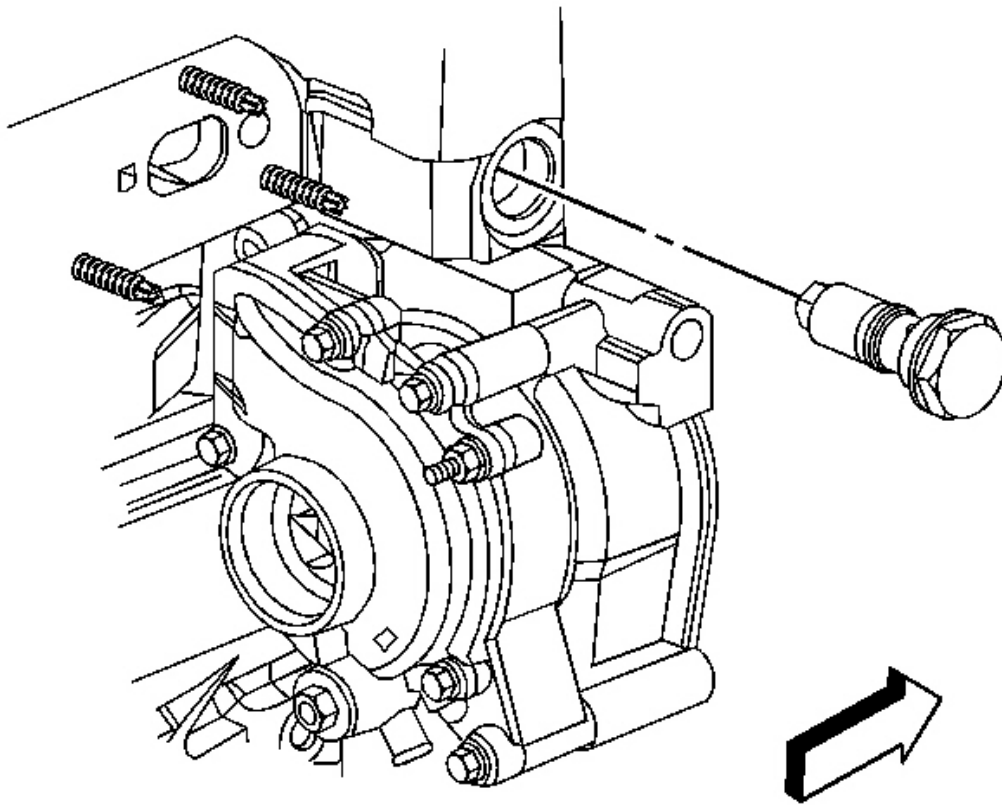


Fig. 146: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

9. Remove the timing chain tensioner.

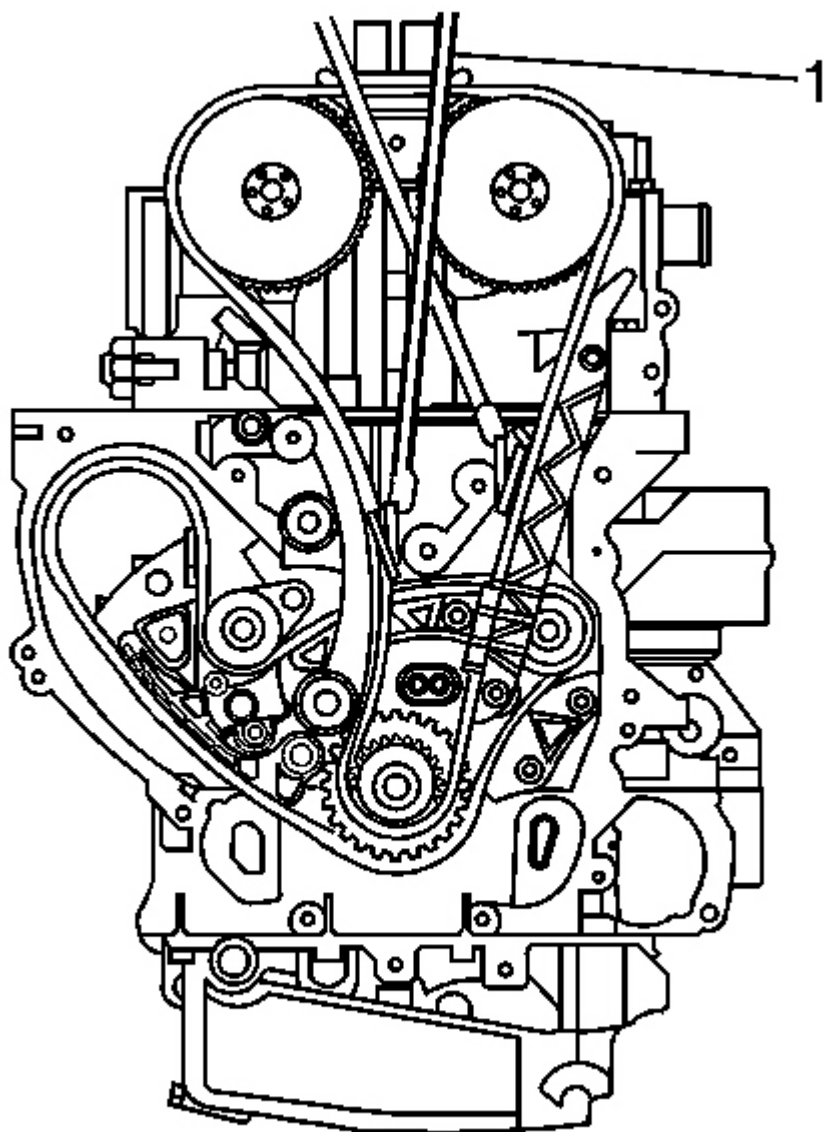


Fig. 147: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The camshaft actuators should not rotate during the removal or installation.
- Ensure the tips of the EN-48749: retention tool are fully engaged into the timing chain. The retention tool rod can be used on the back side

of the chain to ensure the teeth from the retention tool are engaged.

10. Install the **EN-48749**: retention tool (1) to the exhaust side of the timing chain.

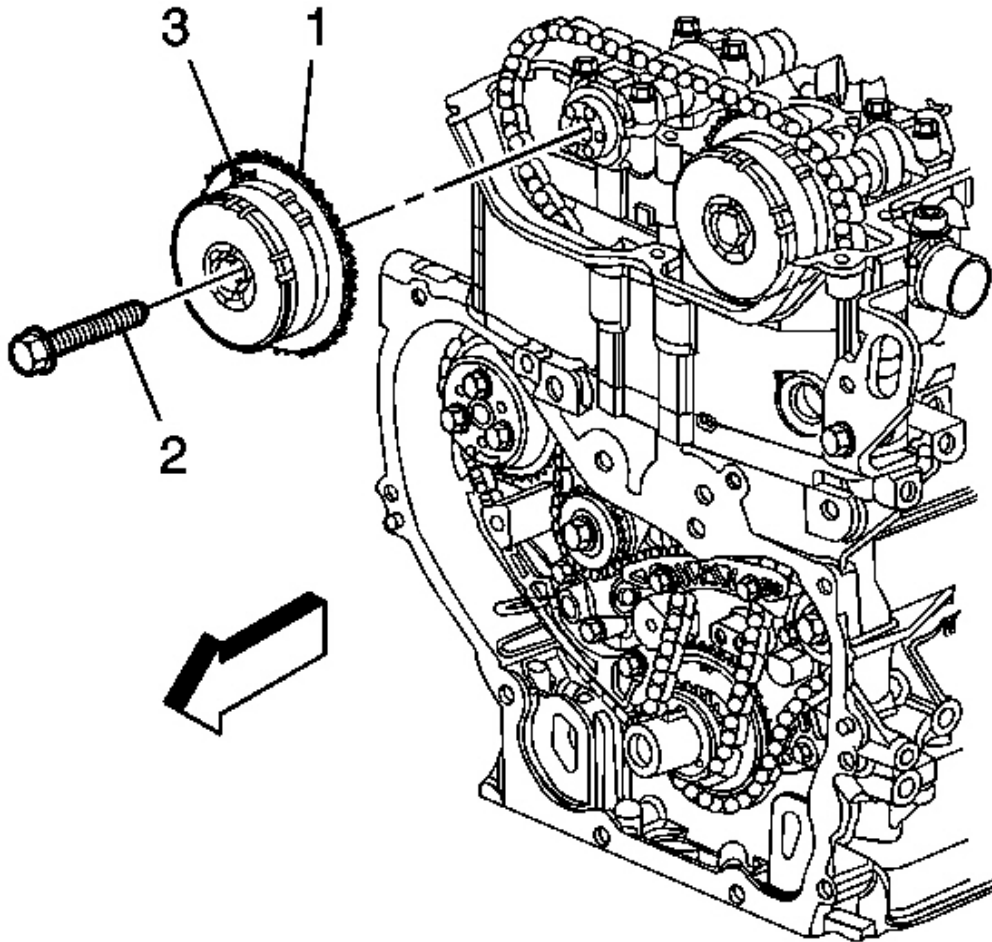


Fig. 148: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the exhaust camshaft actuator bolt (2).
12. Remove the exhaust camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

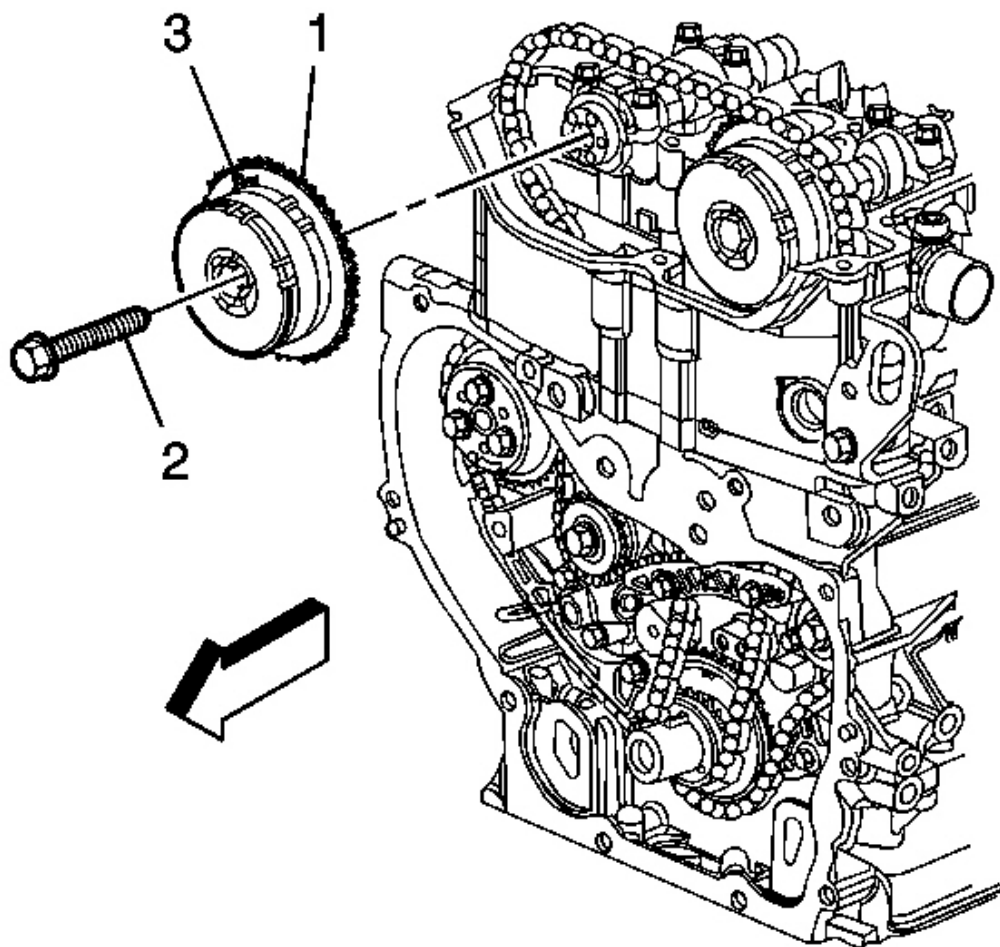


Fig. 149: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.
- The exhaust camshaft may need to be rotated clockwise to fully set the camshaft actuator.

1. Install the timing chain onto the exhaust camshaft actuator.
2. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.

3. Install a NEW exhaust camshaft actuator bolt (2) until snug.

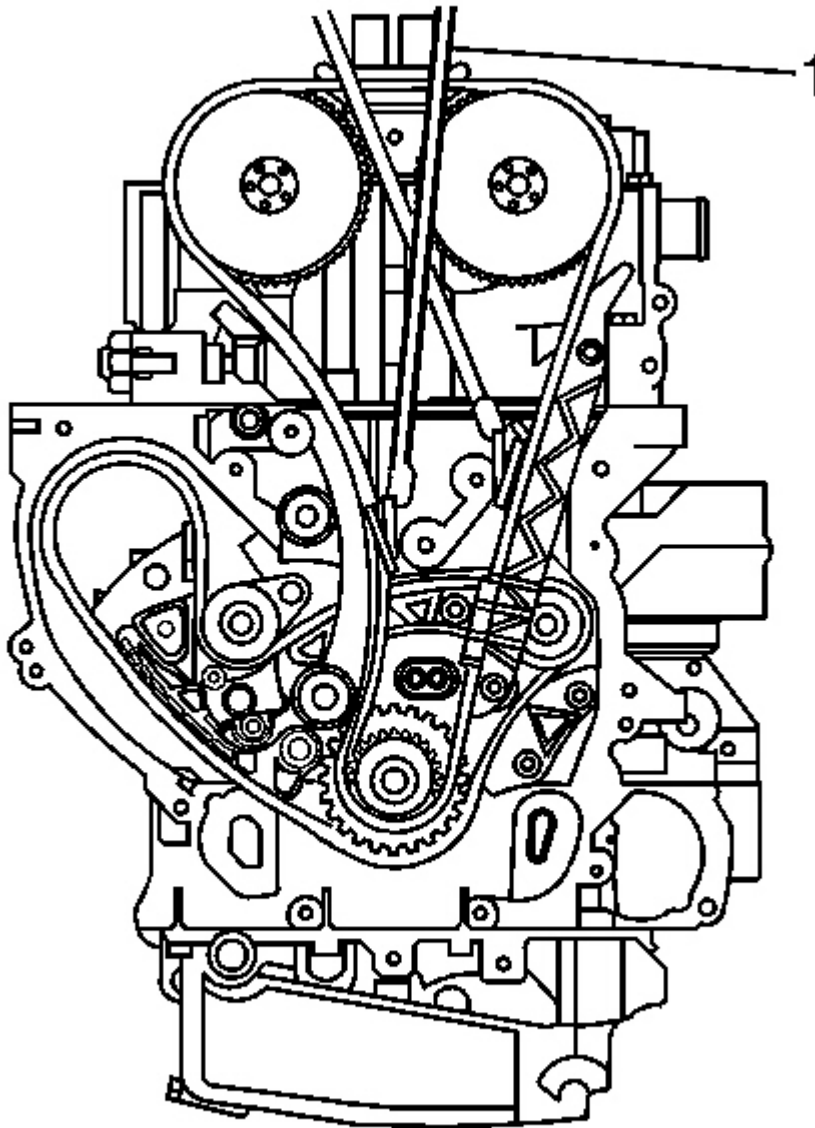


Fig. 150: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the exhaust camshaft actuator is still aligned properly with the timing chain. If the mark made

previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

4. Remove the **EN-48749**: retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend, limiting the timing chain life.

5. Reset and install the timing chain tensioner. Refer to Timing Chain Tensioner Replacement.

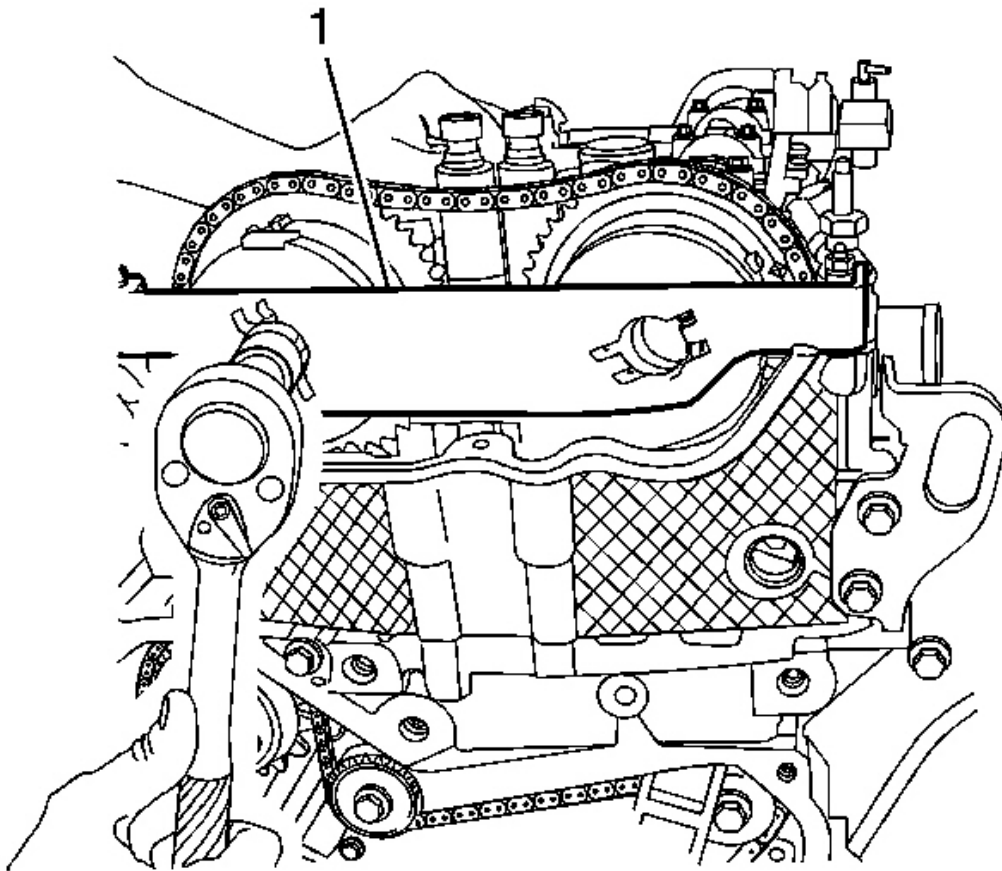


Fig. 151: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

6. Install the intake camshaft actuator retainer (1).
7. Install the camshaft actuator retainer bolts and tighten 10 N.m (89 lb in).

8. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059**: meter.

NOTE: You must have the **EN-48953**: locking tool installed to perform this procedure.

9. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).

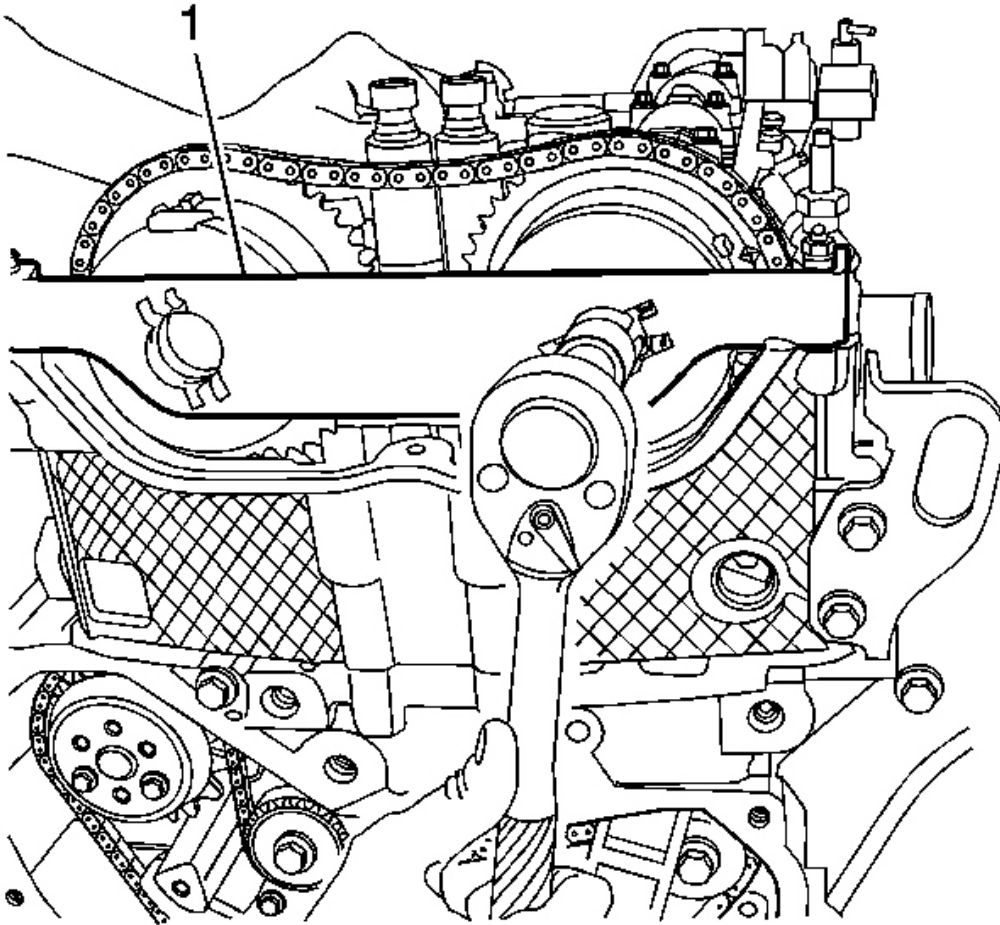


Fig. 152: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft actuator retainer **EN-48953**: retention tool (1).

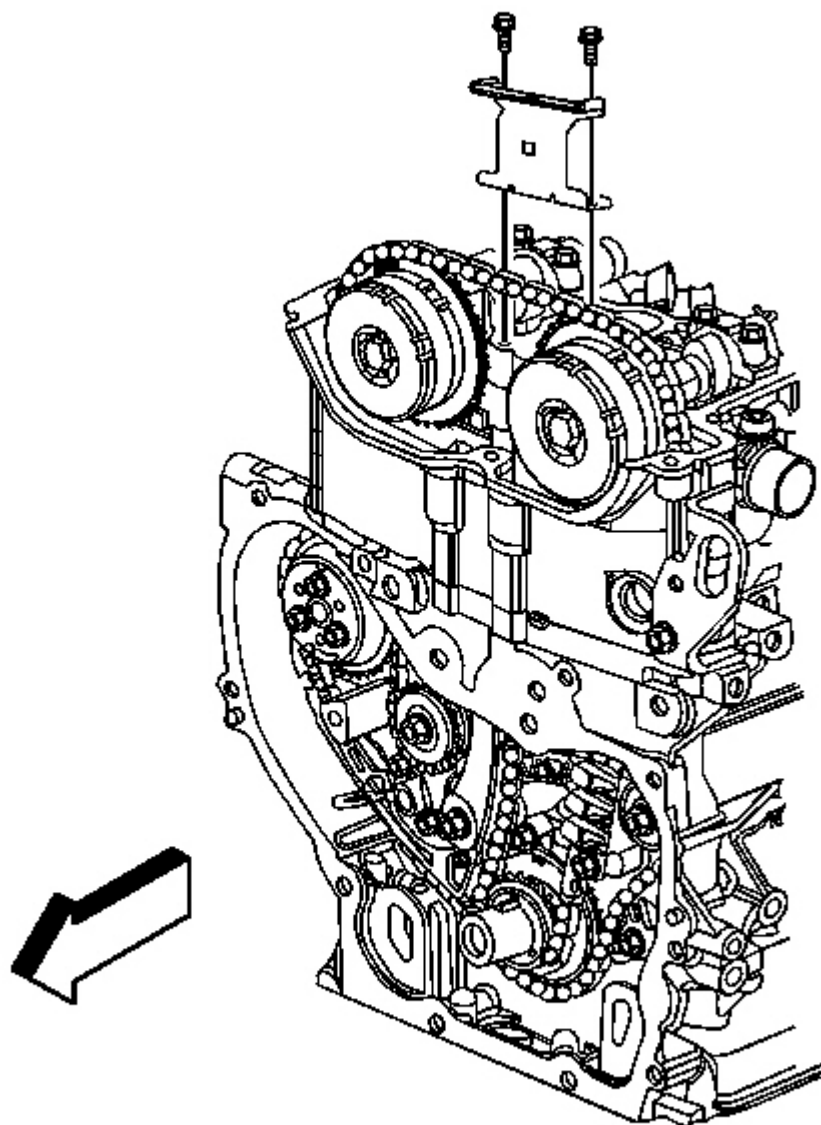


Fig. 153: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
12. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
13. Install the spark plugs. Refer to **Spark Plug Replacement**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **EN-36017:** Valve Guide Seal Remover
- **EN-43649:** Valve Spring Compressor
- **EN-43649-10:** Valve Spring Compressor Adaptor Set
- **EN-43653:** Flywheel Holding Tool

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

Removal Procedure

IMPORTANT: Prevent the crankshaft from rotating clockwise or counter-clockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-43653: Flywheel Holding Tool.

1. If equipped, with a manual transmission leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped, with an automatic transmission, remove the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)** .
3. Install **EN-43653:** flywheel holding tool.
4. Remove the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.

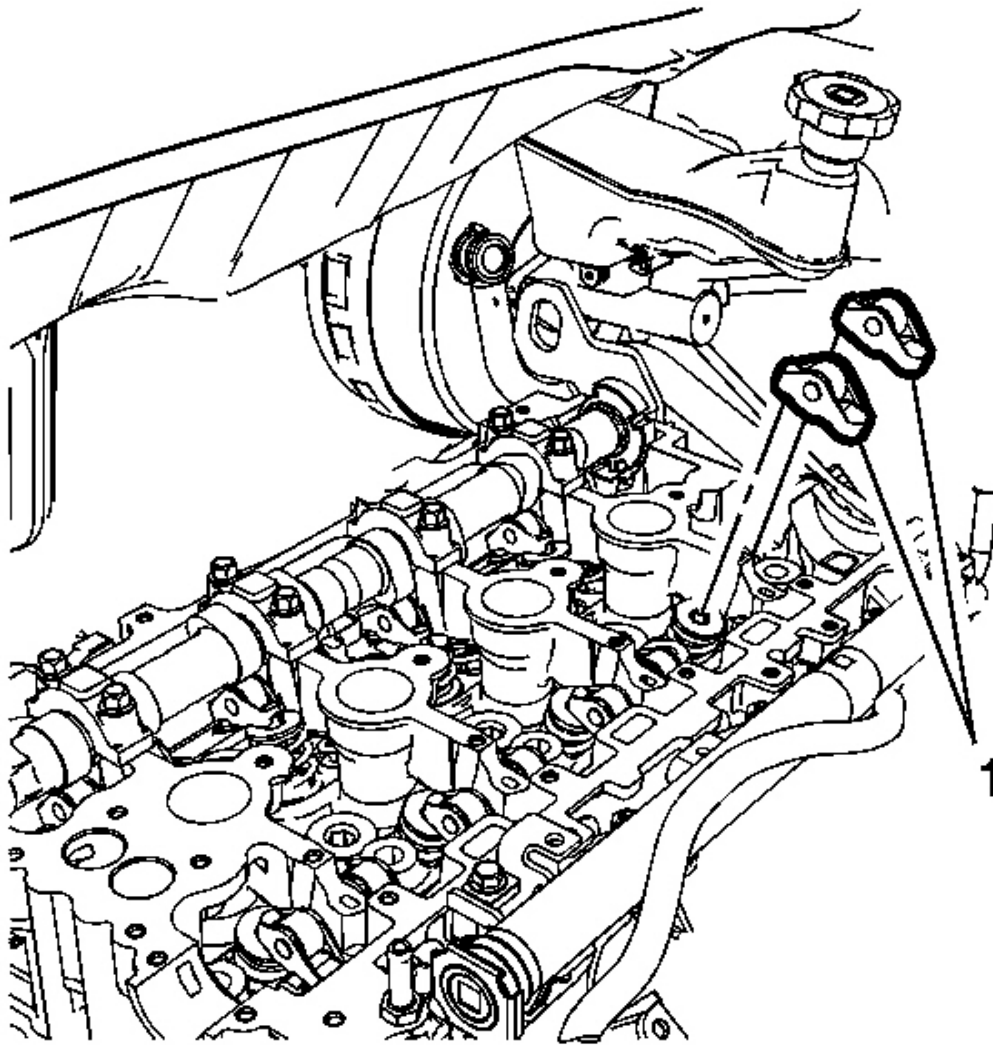


Fig. 154: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft roller followers (1).

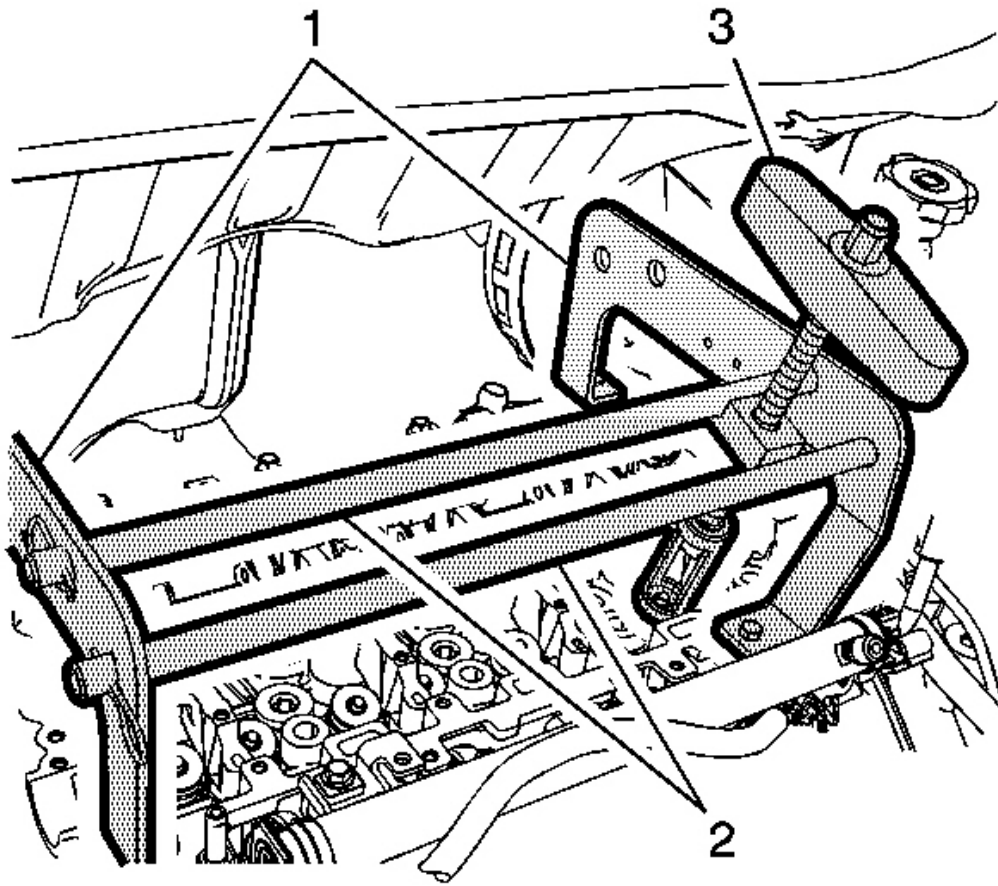


Fig. 155: Valve Spring Compressor Adaptor Set
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-43649-10:** valve spring compressor adaptor set (1) to the front and rear of the cylinder head.
7. Install the cross bars and locks (2) of the **EN-43649:** valve spring compressor to the valve spring compressor adaptors.
8. Remove the spark plugs. Refer to **Spark Plug Replacement** .
9. Install an air hose adapter into the spark plug hole.
10. Attach an air hose to the adapter and pressurize the cylinder to 690 kPa (100 psi)
11. Compress the valve spring using the valve spring compressor (3).

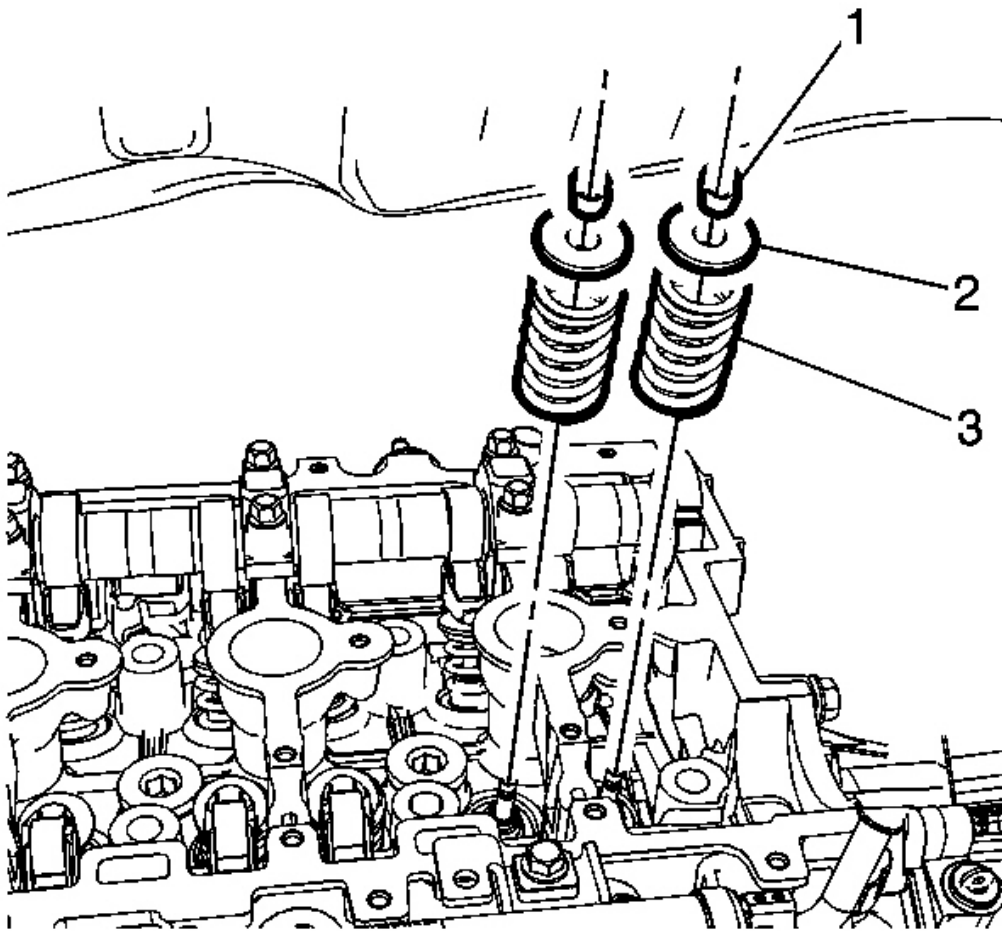


Fig. 156: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve spring keepers (1).
13. Remove the valve spring (3) and retainer (2).

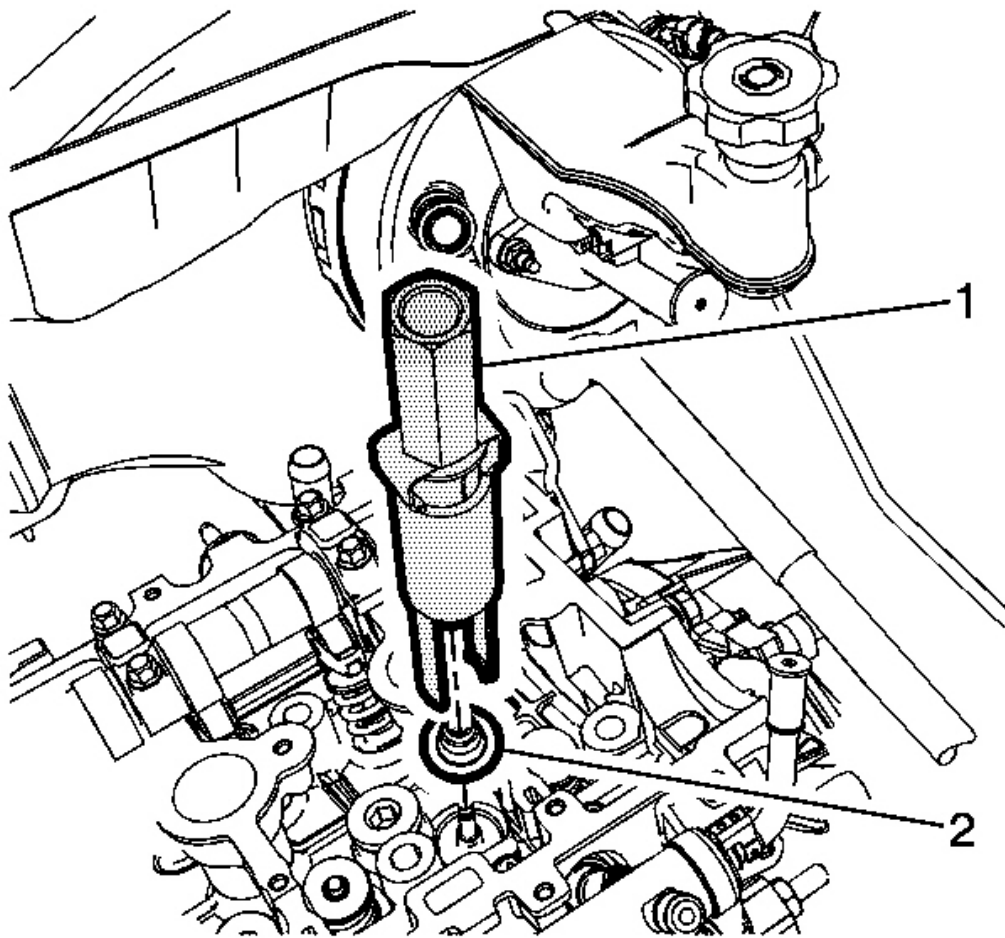


Fig. 157: Valve Guide Seal Remover
Courtesy of GENERAL MOTORS CORP.

14. Use the **EN-36017**: valve guide seal remover (1) to remove the valve seal.

Installation Procedure

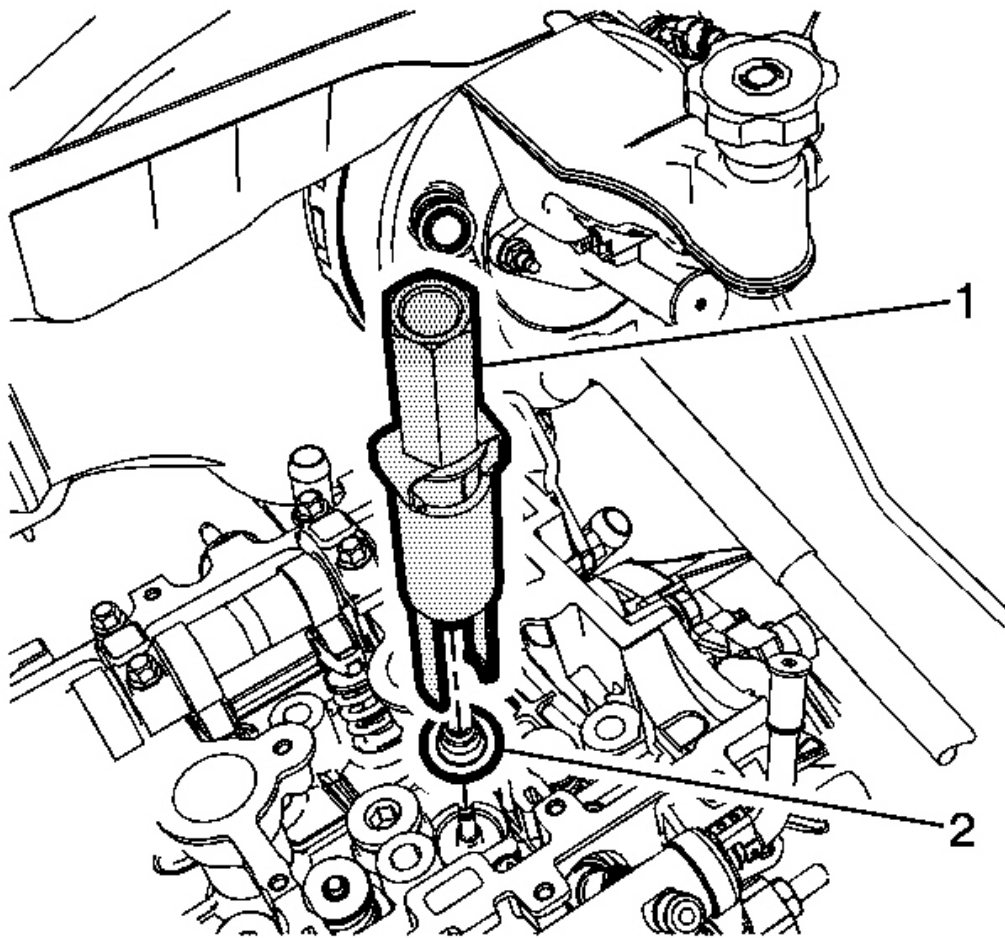


Fig. 158: Valve Guide Seal Remover
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-36017**: valve guide seal remover (1) install the NEW valve seal. Fully seat the seal onto the valve guide.

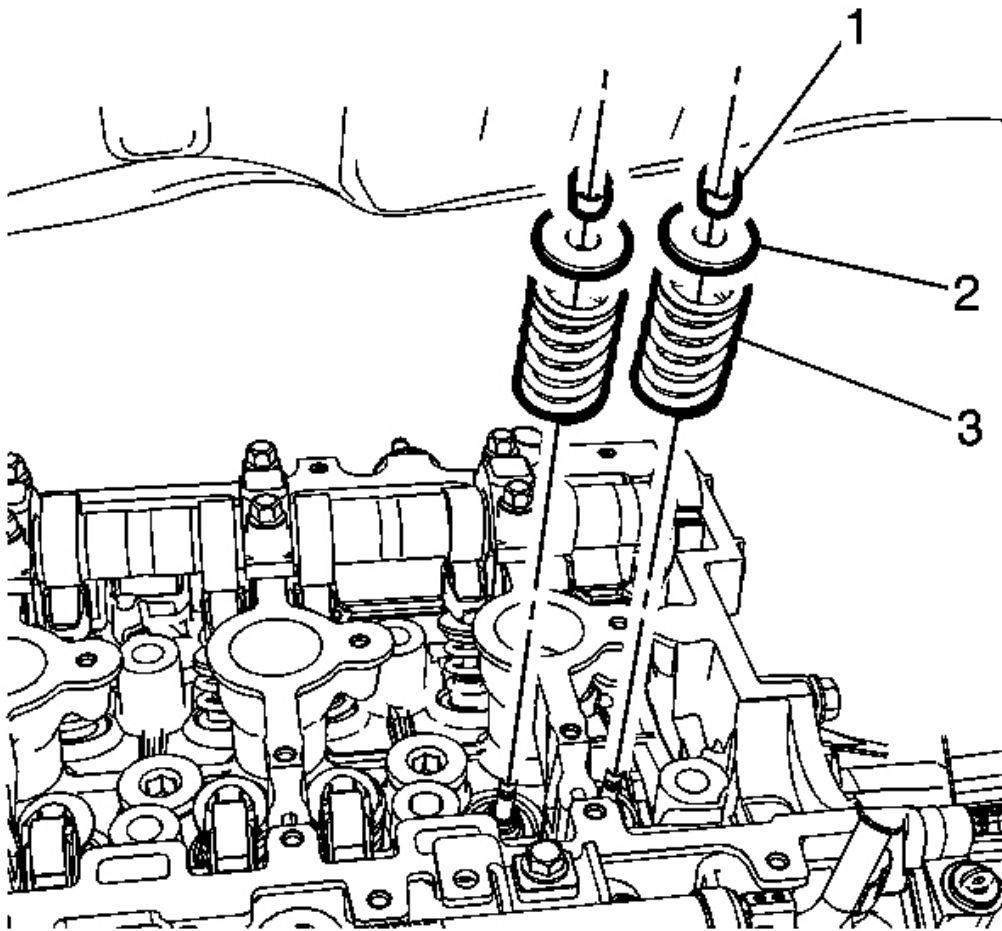


Fig. 159: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (3) and Retainer (2).
3. Compress the valve spring using the valve spring compressor.
4. Install the valve spring keepers (1).
5. Disconnect the air hose and air hose adapter.

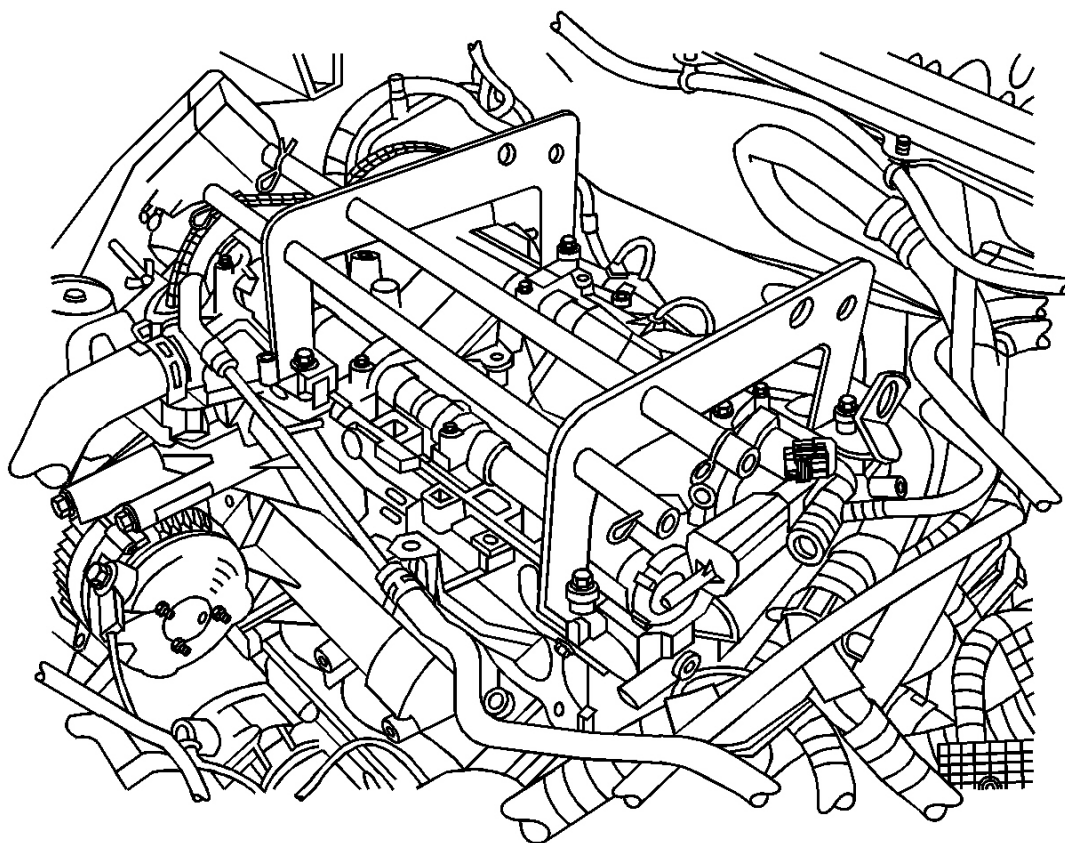


Fig. 160: Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN-43649:** valve spring compressor and **EN-43649-10:** valve spring compressor adaptor set from the cylinder head.
7. Install the spark plugs. Refer to **Spark Plug Replacement** .

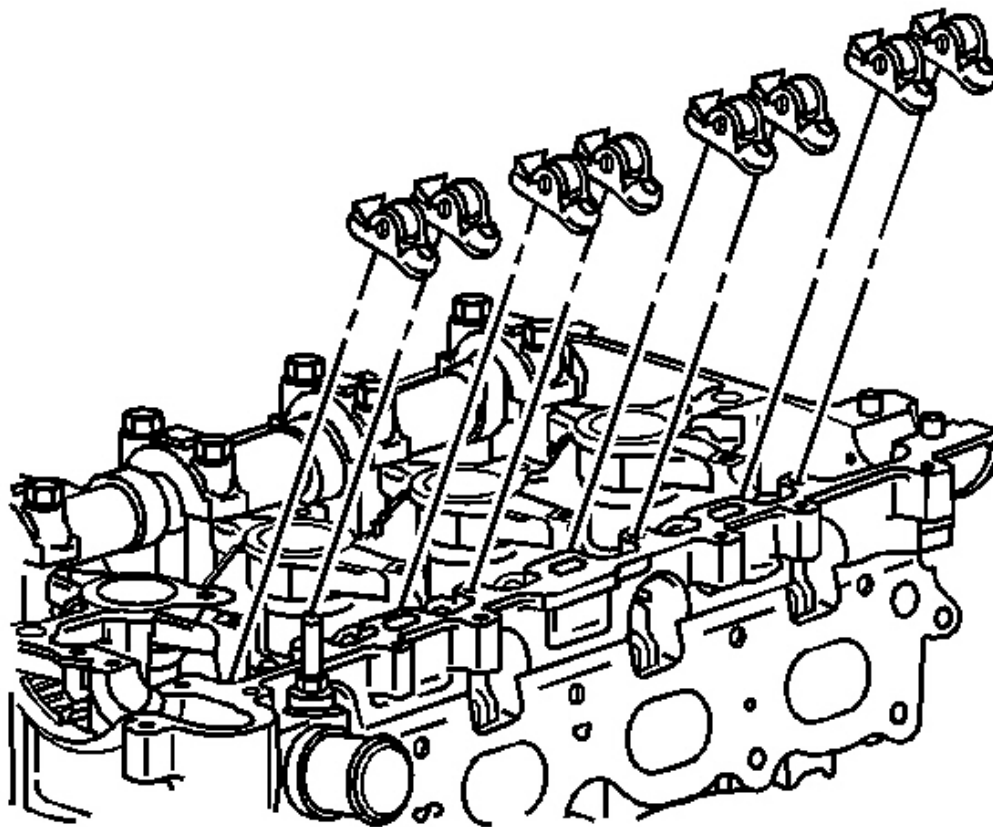


Fig. 161: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers (1).
9. Install the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.
10. If used, remove the **EN-43653**: flywheel holding tool.
11. If removed, install the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)** .

CYLINDER HEAD REPLACEMENT

Special Tools

- **J 38185** Hose Clamp Pliers
- **J 45059** Angle Meter
- **EN-48749** Timing Chain Retention Tool Kit. See **Special Tools**.

- **EN-48953** Camshaft Actuator Locking Tool. See **Special Tools**.

Removal Procedure

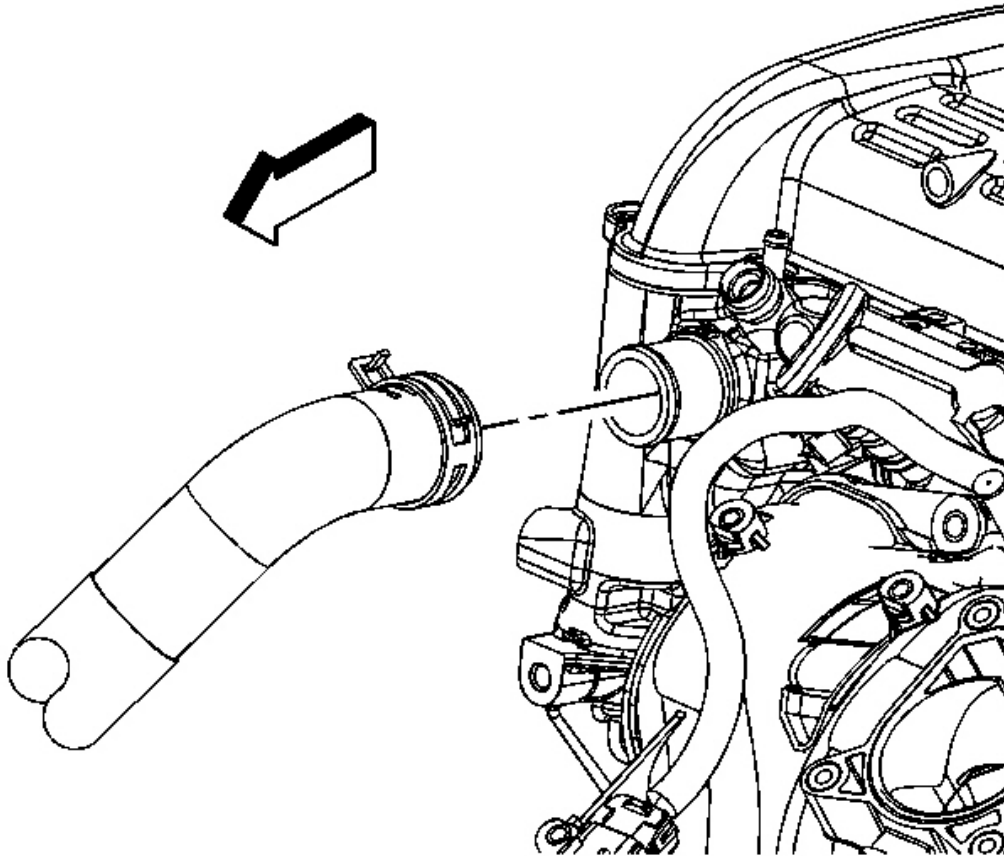


Fig. 162: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static)** or **Cooling System Draining and Filling (GE 47716)** .
2. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement (LAF)** .
3. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
4. Reposition the radiator surge tank air bleed hose clamp.
5. Remove the radiator surge tank air bleed hose from the cylinder head.
6. Reposition the radiator inlet hose clamp using the **J 38185** .
7. Remove the radiator inlet hose from the cylinder head.

8. Disconnect all electrical connectors as necessary.
9. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

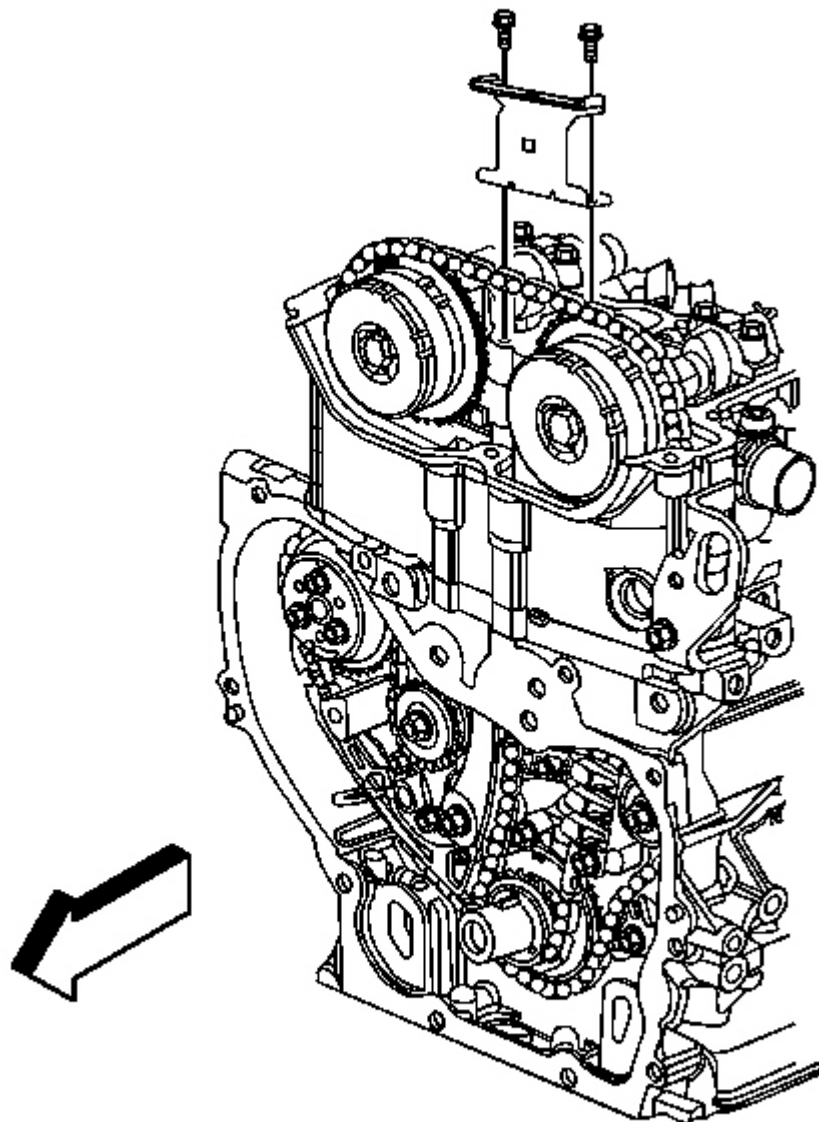


Fig. 163: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the upper timing chain guide bolts and guide.

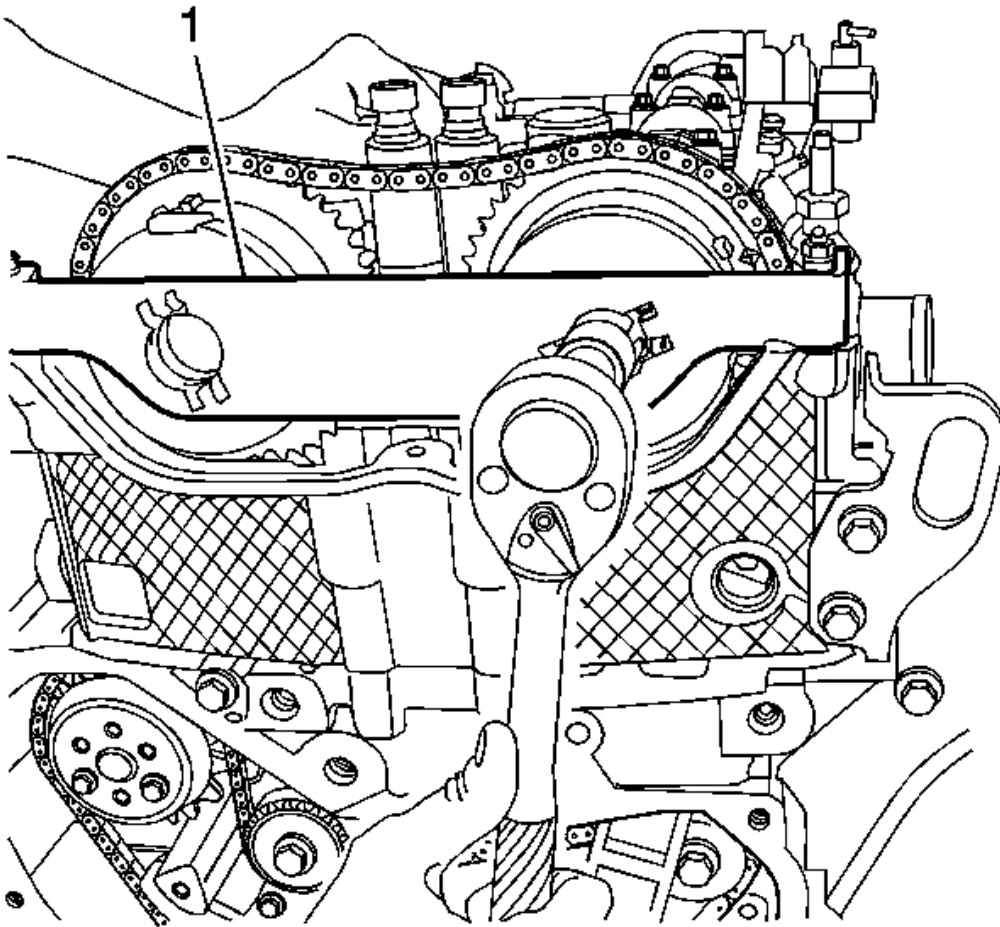


Fig. 164: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE:

- If the intake camshaft actuator is moving independently of the camshaft, this means the camshaft is not locked to the actuator. Rotate the camshaft counterclockwise while the holding tool is installed and this will lock the camshaft to the actuator.
- Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

11. Rotate the intake camshaft clockwise and install the **EN-48953 (1)** to the actuators. See **Special Tools**.

CAUTION: Refer to **Fastener Caution** .

12. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
13. Clean the timing chain and gears with solvent.
14. Mark the timing gear sprockets and the timing chain. It is recommended that the paint marks are located in the 12 o'clock position.
15. Loosen, but do not remove the intake and exhaust camshaft actuator bolts.
16. Remove the camshaft actuator locking tool, **EN-48953** . See **Special Tools**.

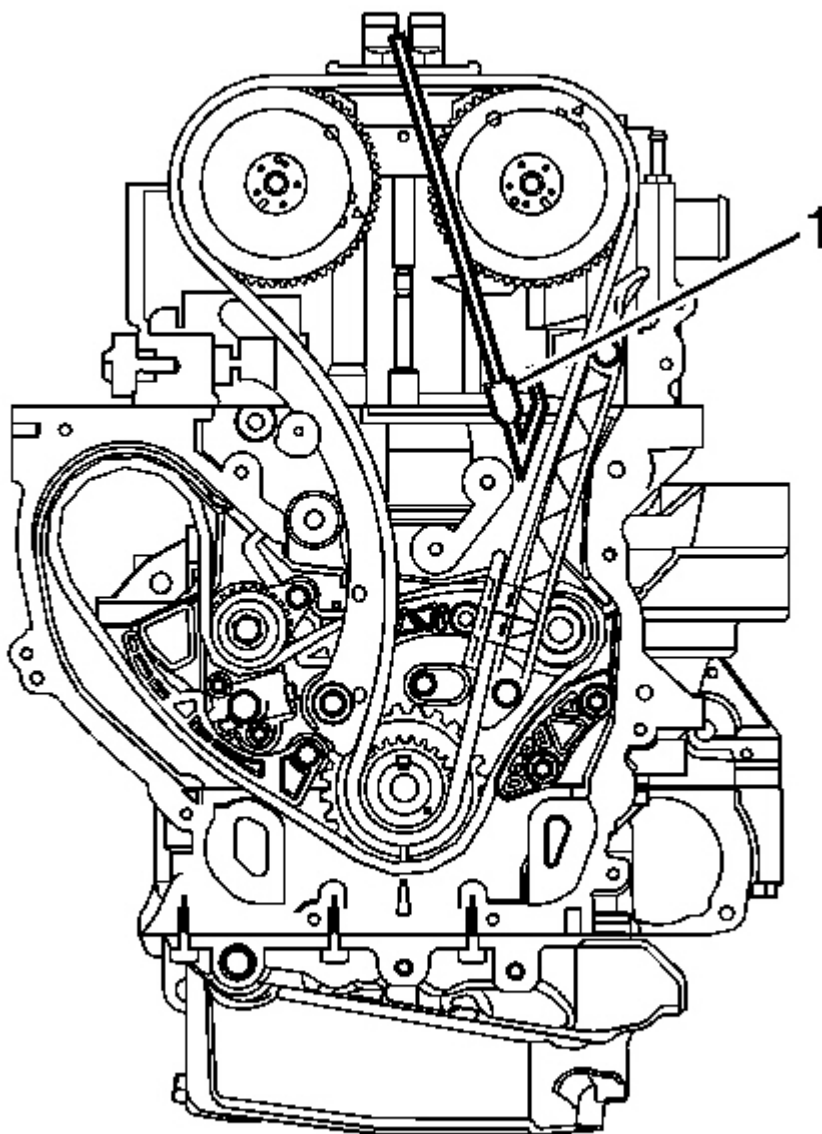


Fig. 165: Identifying Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the tips of the EN-48749 are fully engaged into the timing chain. See Special Tools. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.

17. Install the timing chain retention tool **EN-48749** (1) to the intake side of the timing chain. See **Special Tools**.

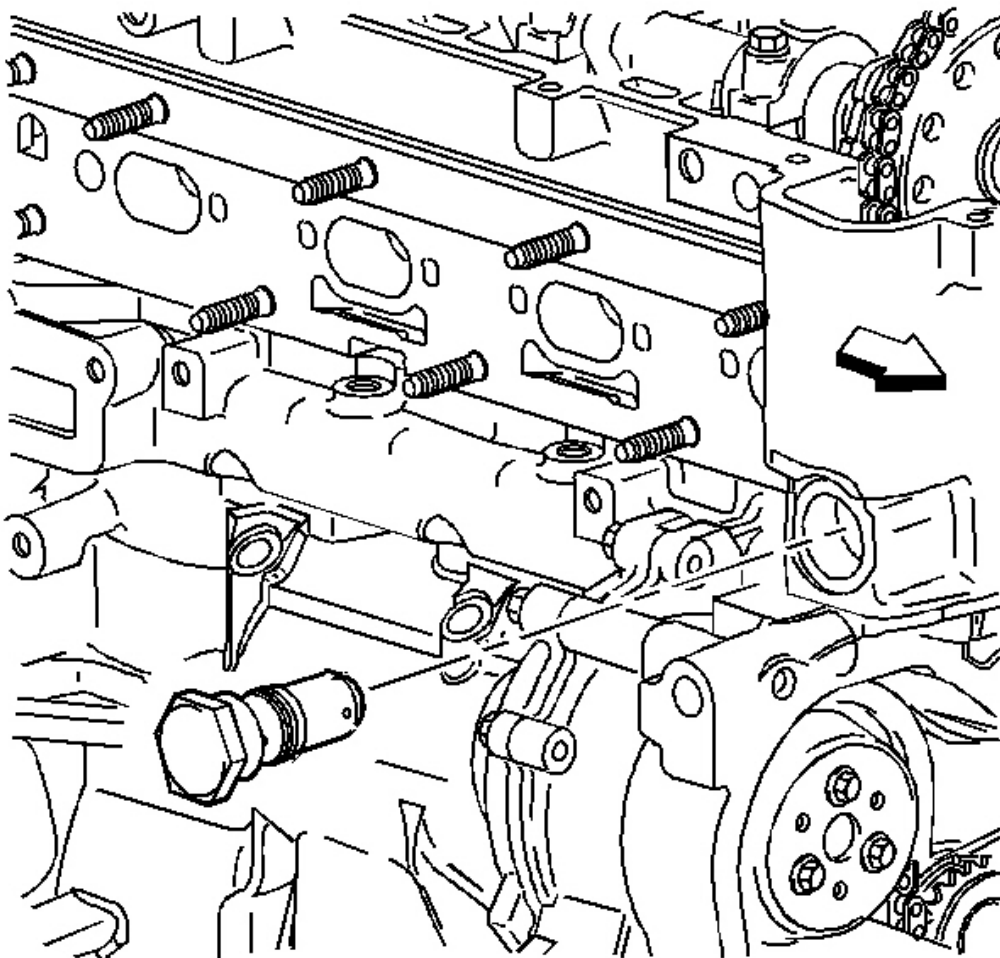


Fig. 166: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

18. Remove the timing chain tensioner.

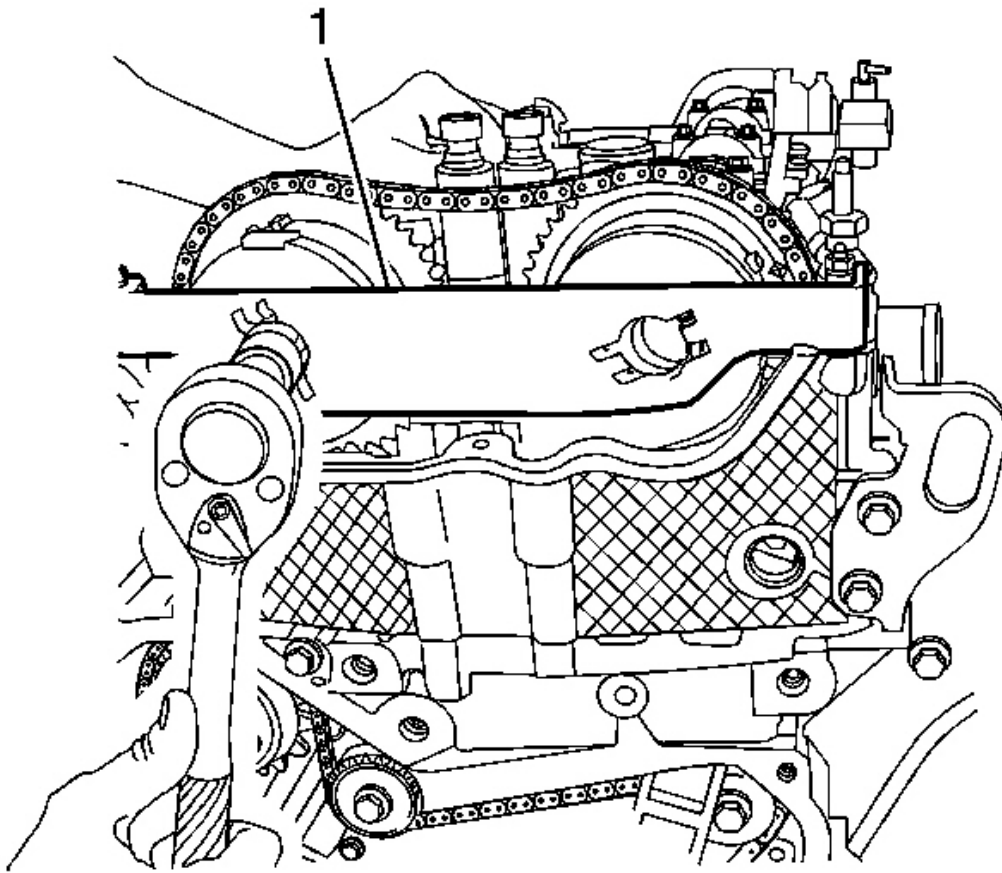


Fig. 167: View of Camshaft Actuator Retainer

Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft actuators should not rotate during the removal of installation.

19. Install the timing chain retention tool **EN-48749** (1) to the exhaust side of the timing chain. See **Special Tools**.

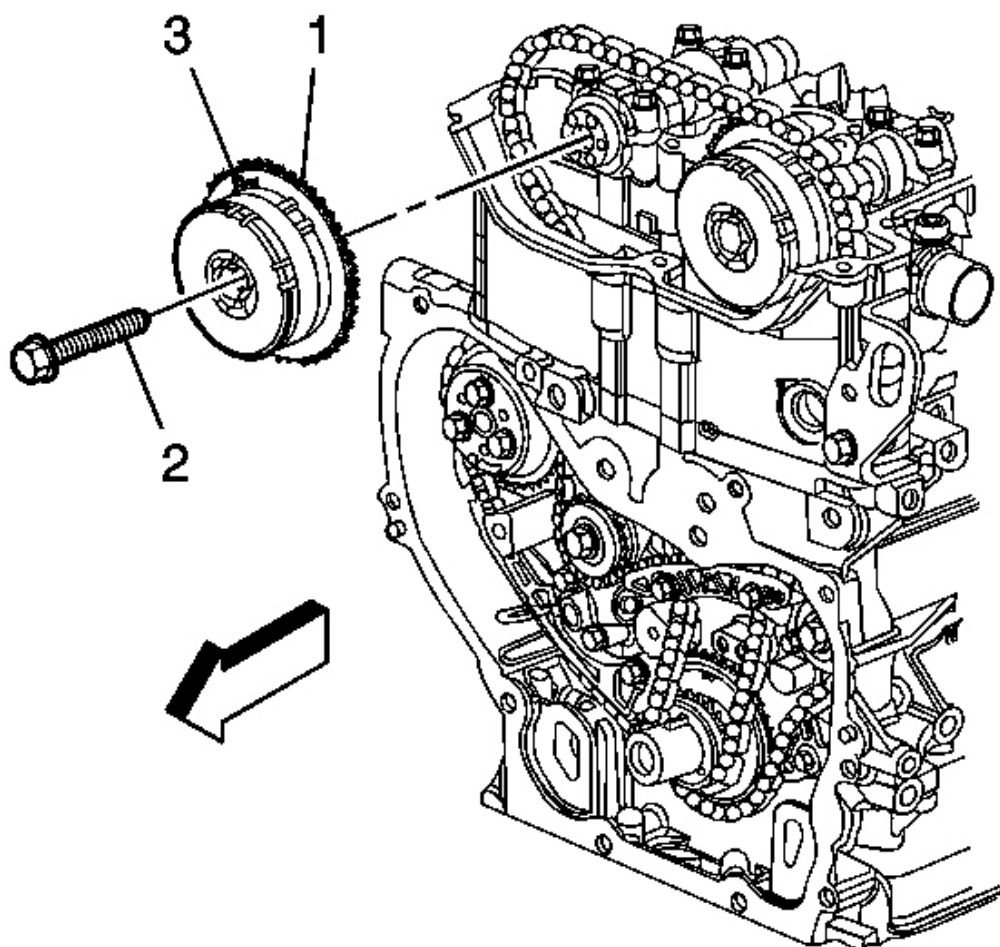


Fig. 168: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

20. Remove and discard the exhaust camshaft actuator bolt (2).

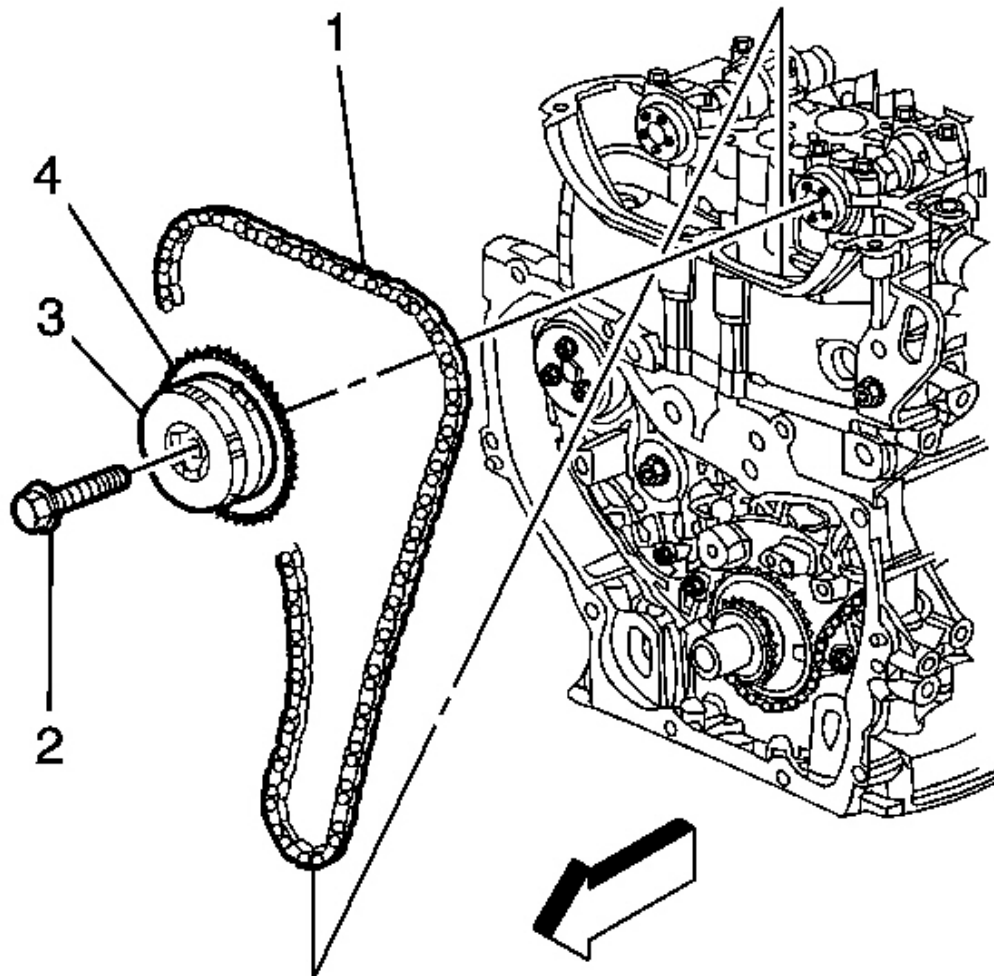


Fig. 169: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

21. Remove and discard the intake camshaft actuator bolt (2).
22. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

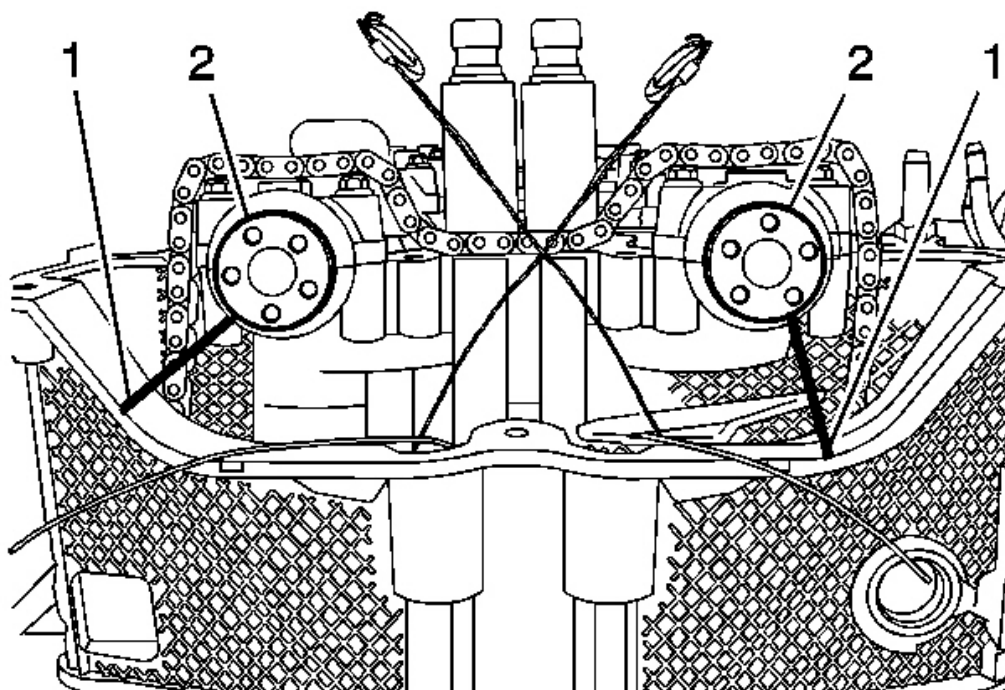


Fig. 170: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

23. Mark the cylinder head (1) in relationship to the camshaft actuator notch is on the camshaft (2).

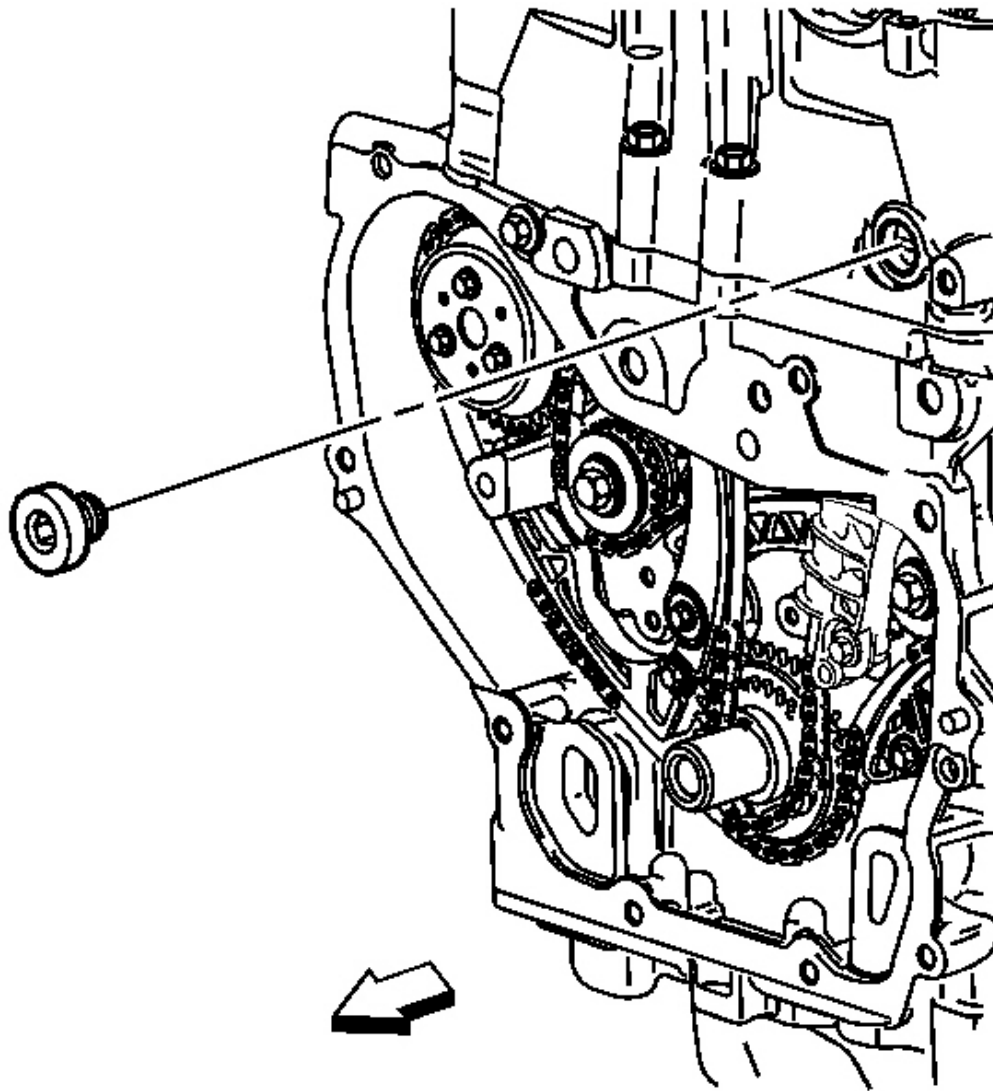


Fig. 171: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

24. Remove the fixed timing chain guide access plug.

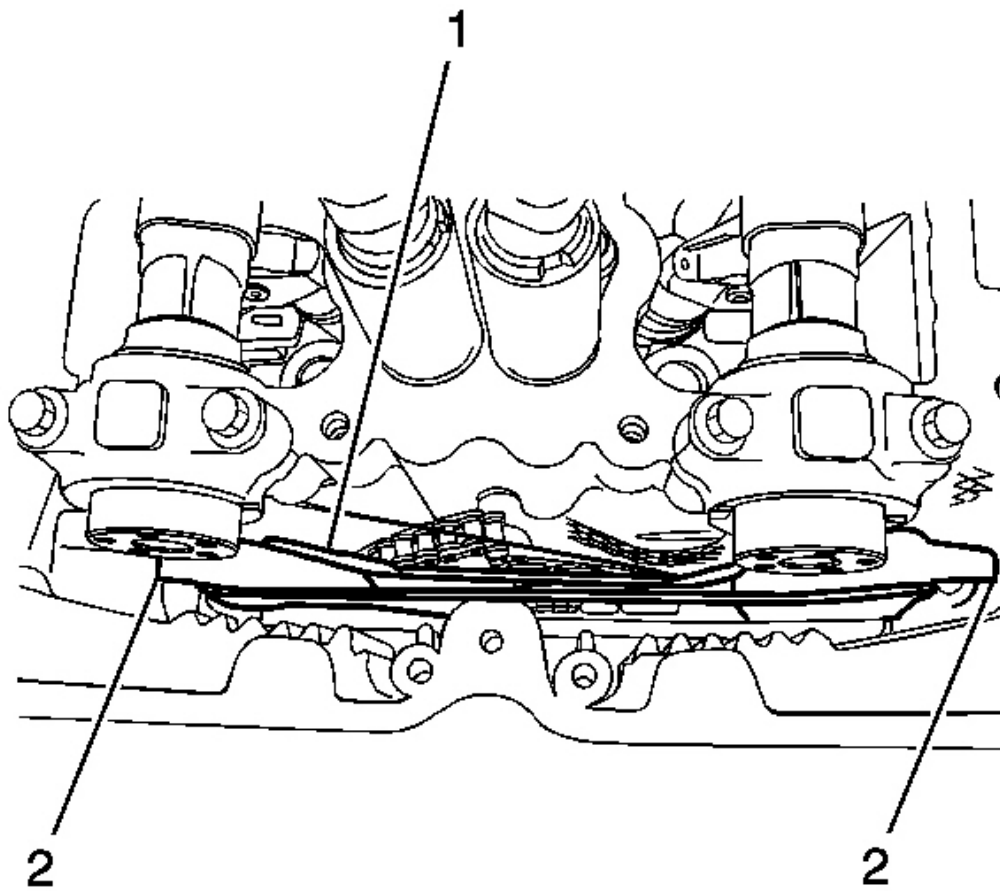


Fig. 172: Pulling Guides Together
Courtesy of GENERAL MOTORS CORP.

NOTE: The threaded rod from the timing chain retention tool can be used to help feed the rubber band around the chain guides.

25. Install a rubber band (1) around the top of the upper timing chain guides (2) in order to pull the guides together.

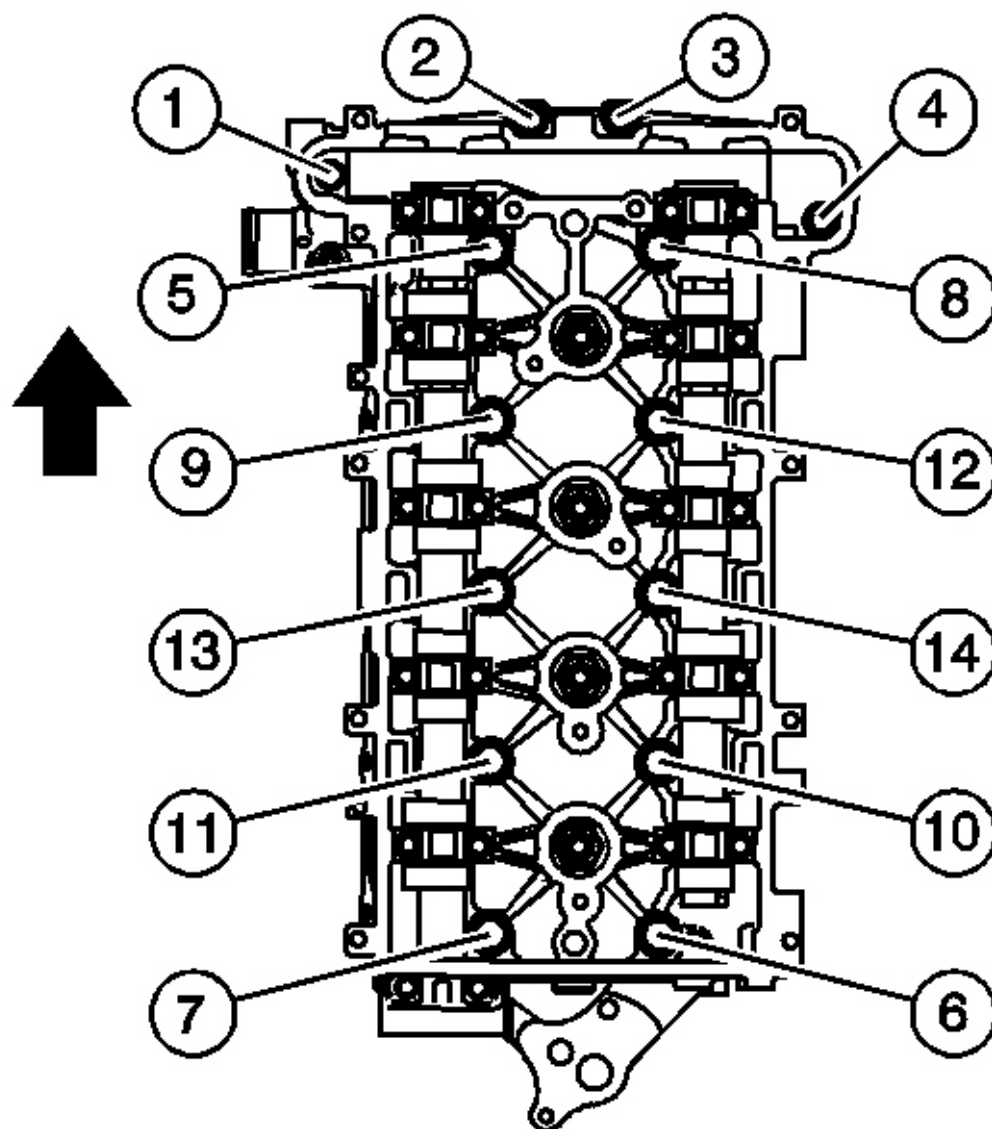


Fig. 173: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

26. Remove the cylinder head bolts in the sequence shown. Discard the bolts.

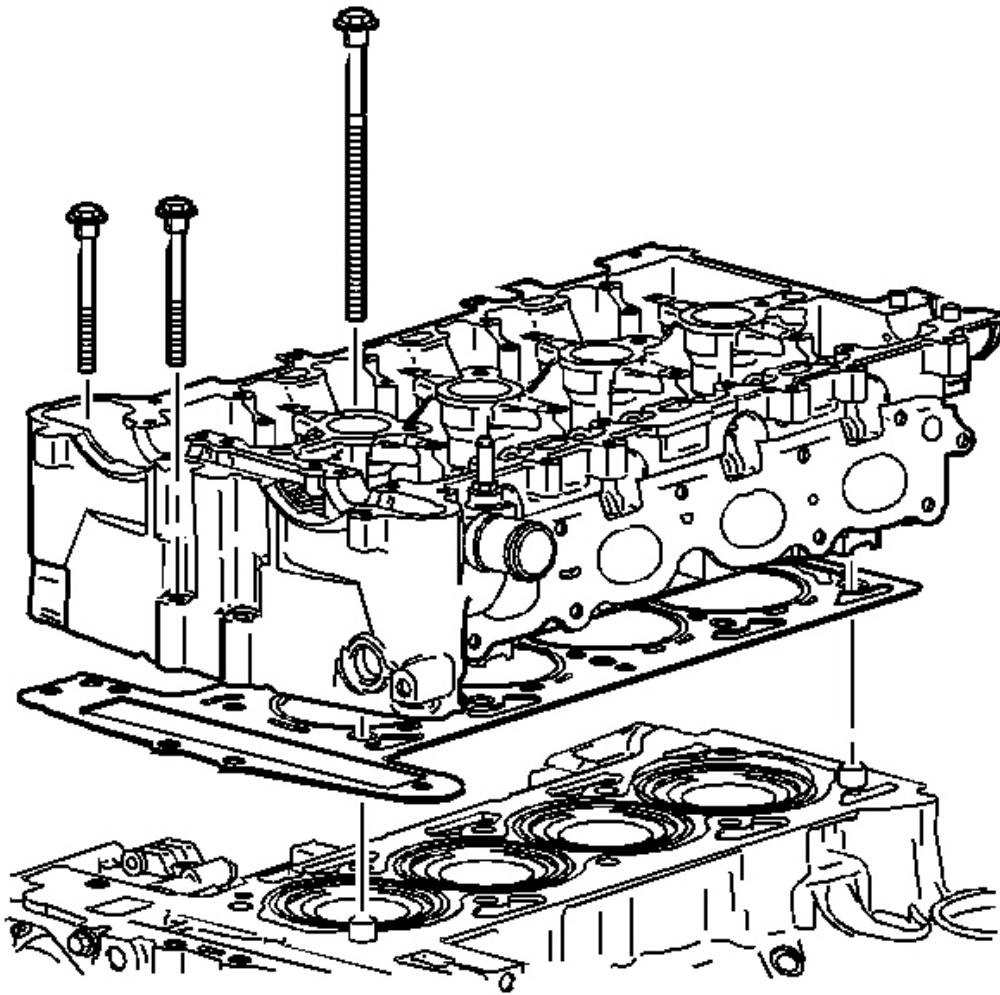


Fig. 174: View Of Cylinder Head & Gasket
Courtesy of GENERAL MOTORS CORP.

27. Remove the cylinder head.
28. Remove the cylinder head gasket.
29. Clean all of the gasket surfaces.
30. Use the following steps when cleaning the cylinder head and cylinder block surfaces:
 - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge either surface.

NOTE: **DO NOT** use any other method or technique to clean these gasket

surfaces.

- Use a NEW razor blade on the cylinder head and a NEW blade on the cylinder block.

NOTE: Be careful not to gouge or scratch the gasket surfaces. DO NOT gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the NEW gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

31. Clean the old sealer/lube and any dirt from around the bolt holes.

NOTE: DO NOT use a tap to clean the cylinder head bolt holes.

32. Clean the bolts holes with a nylon bristle brush.

33. When cleaning the cylinder head bolt holes use suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun in order to reach the bottom of the holes.

34. If replacing the cylinder head, transfer all parts as necessary.

Installation Procedure

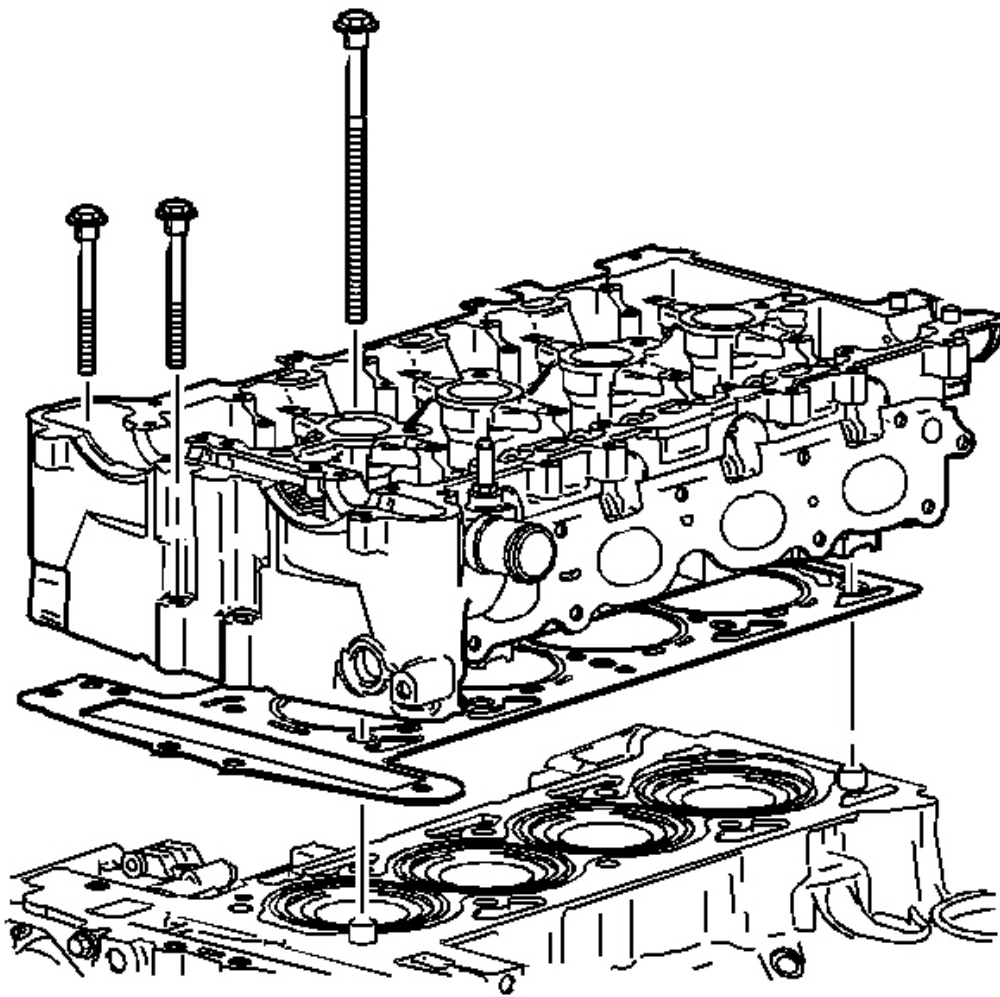


Fig. 175: View Of Cylinder Head & Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT** use any sealing material.

1. Install the cylinder head gasket.
2. Install the cylinder head.
3. Install NEW cylinder head bolts.

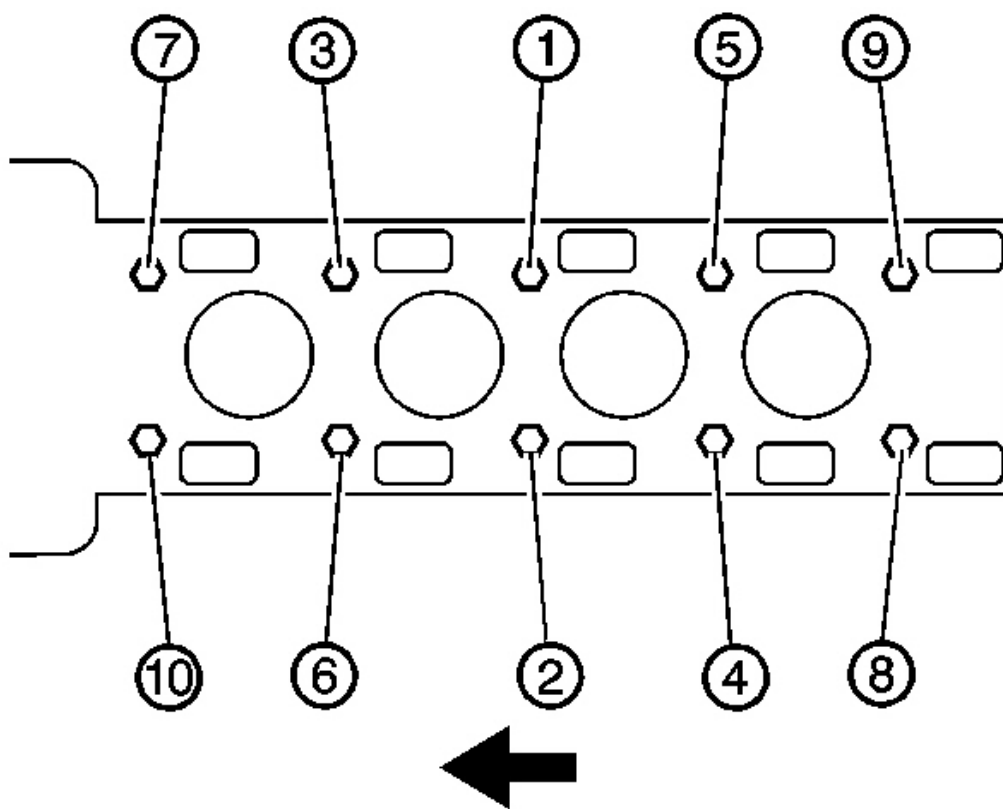


Fig. 176: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown. Tighten the bolts to 30 N.m (22 lb ft) plus an additional 155 degrees using the **J 45059**.

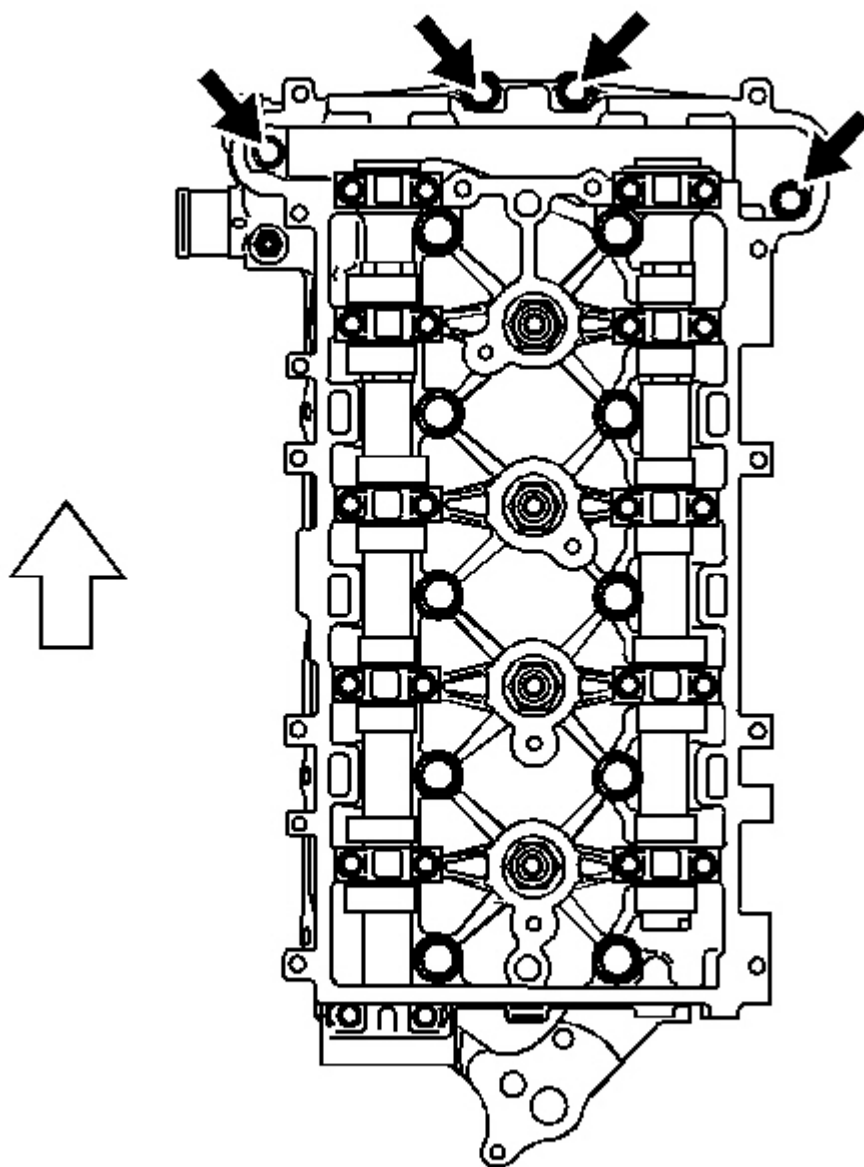


Fig. 177: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts and tighten to 35 N.m (26 lb ft).

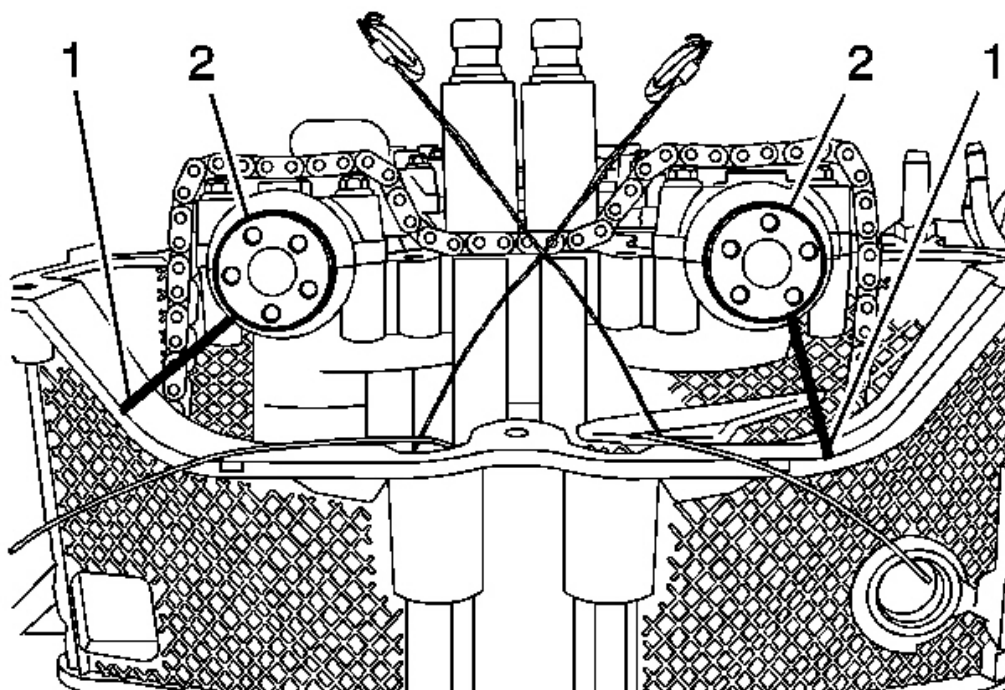


Fig. 178: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

6. Ensure the cylinder head (1) and the camshaft (2) are correctly aligned.

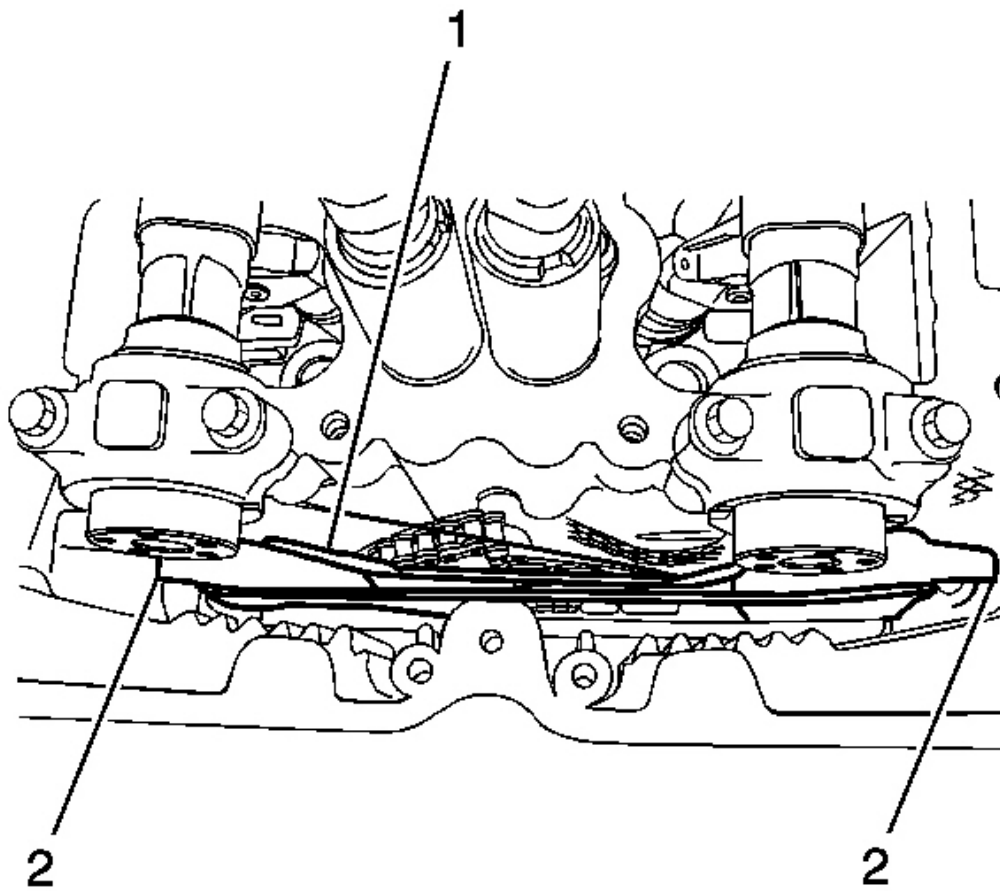


Fig. 179: Pulling Guides Together
Courtesy of GENERAL MOTORS CORP.

7. Remove the rubber band (1) from around the top of the upper timing chain guides (2).
8. Install the fixed guide bolt into the cylinder bolt and tighten to 12 N.m (106 lb in).

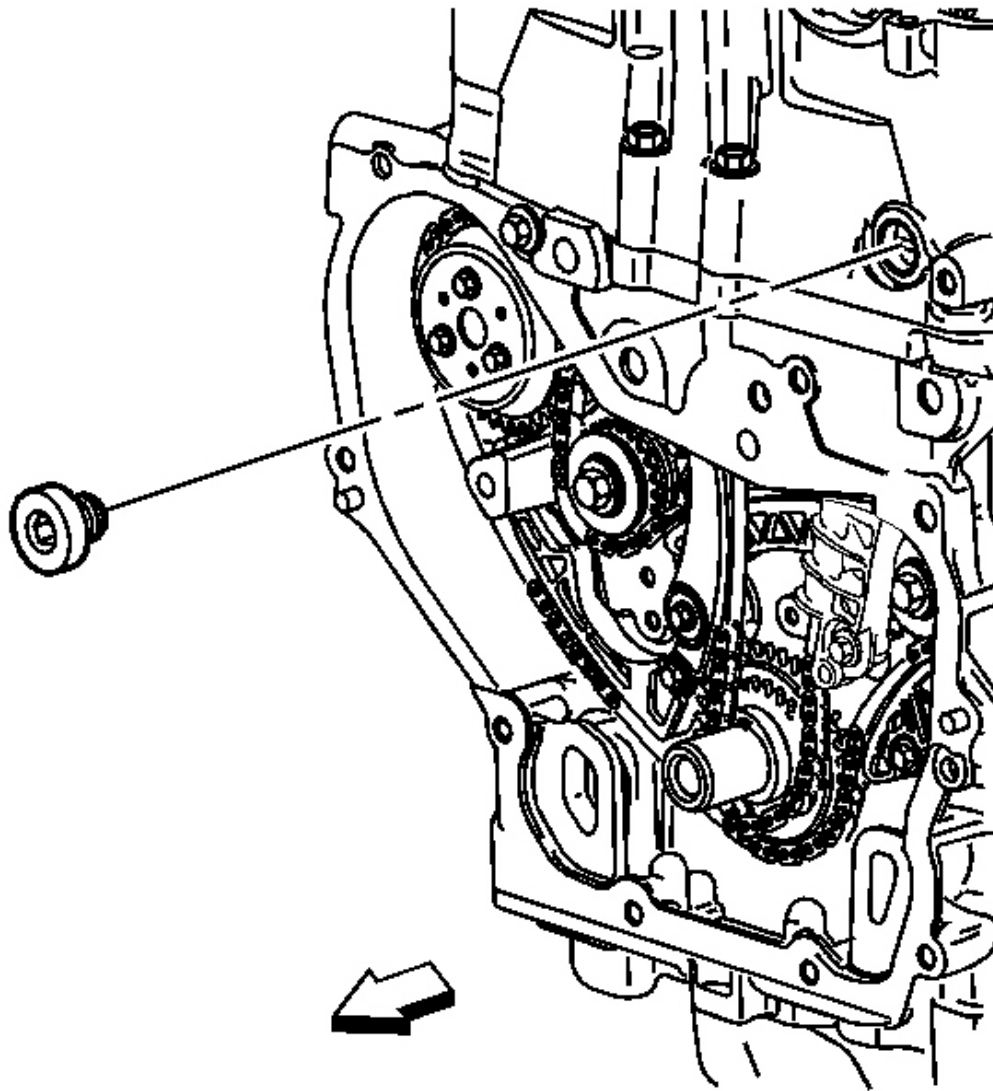


Fig. 180: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant compound to thread and install the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
10. Install the fixed timing chain guide access plug. Tighten the chain guide plug to 90 N.m (59 lb ft).

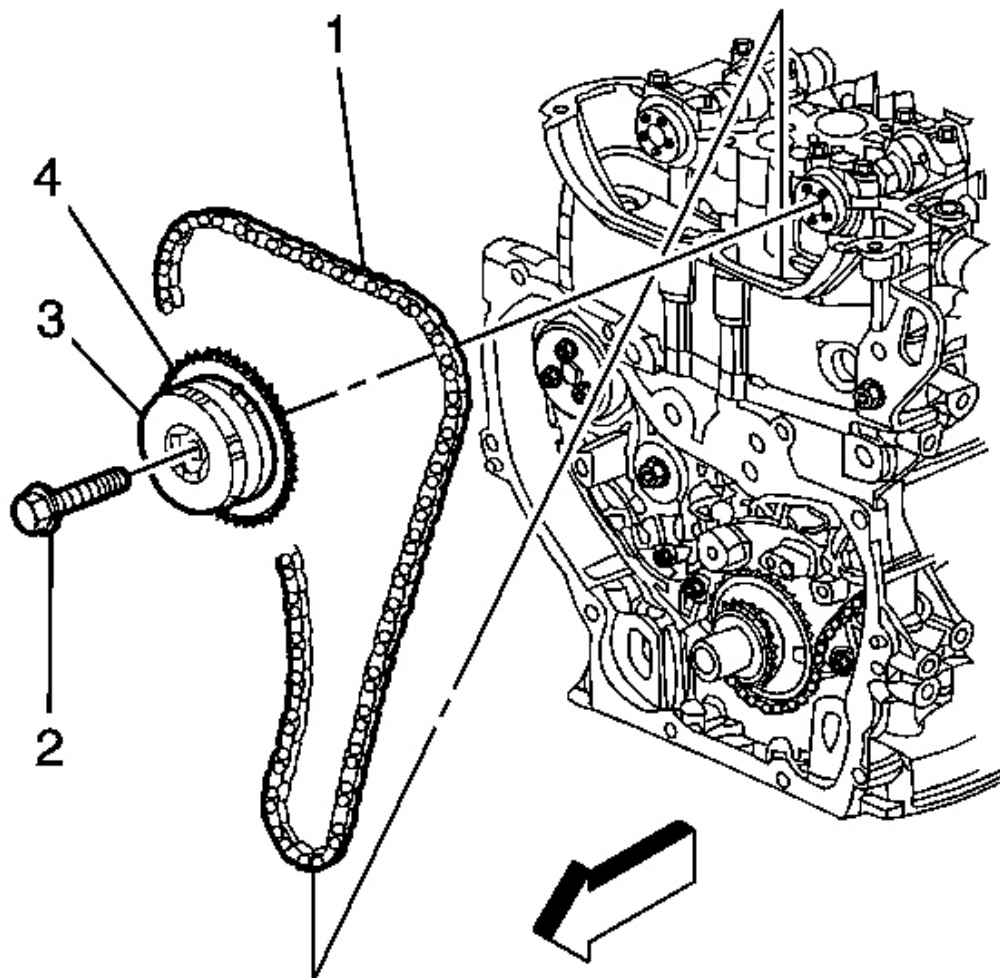


Fig. 181: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the exhaust camshaft actuator is still aligned properly with the mark on the timing chain.

11. Install the timing chain onto the intake camshaft actuator.
12. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
13. Install a NEW intake camshaft actuator bolt (2) until snug.

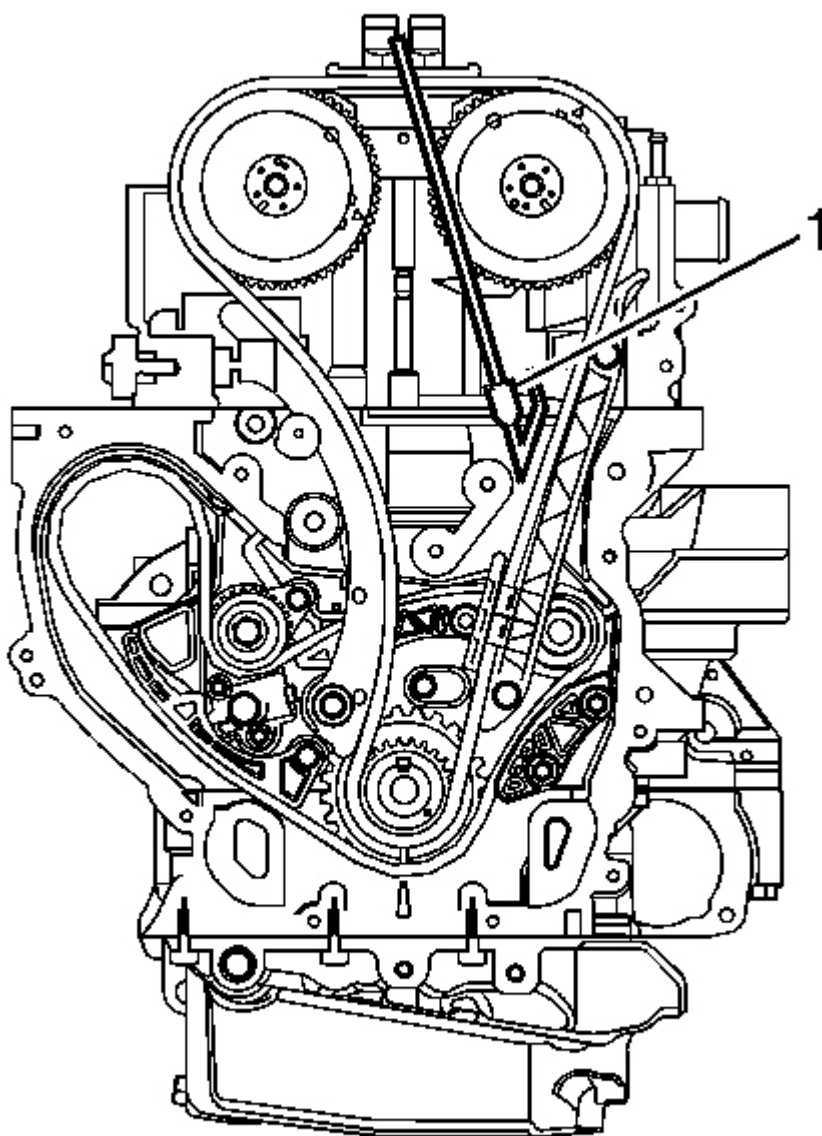


Fig. 182: Identifying Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

14. Remove the timing chain retention tool **EN-48749** (1) from the intake side of the timing chain. See **Special Tools**.

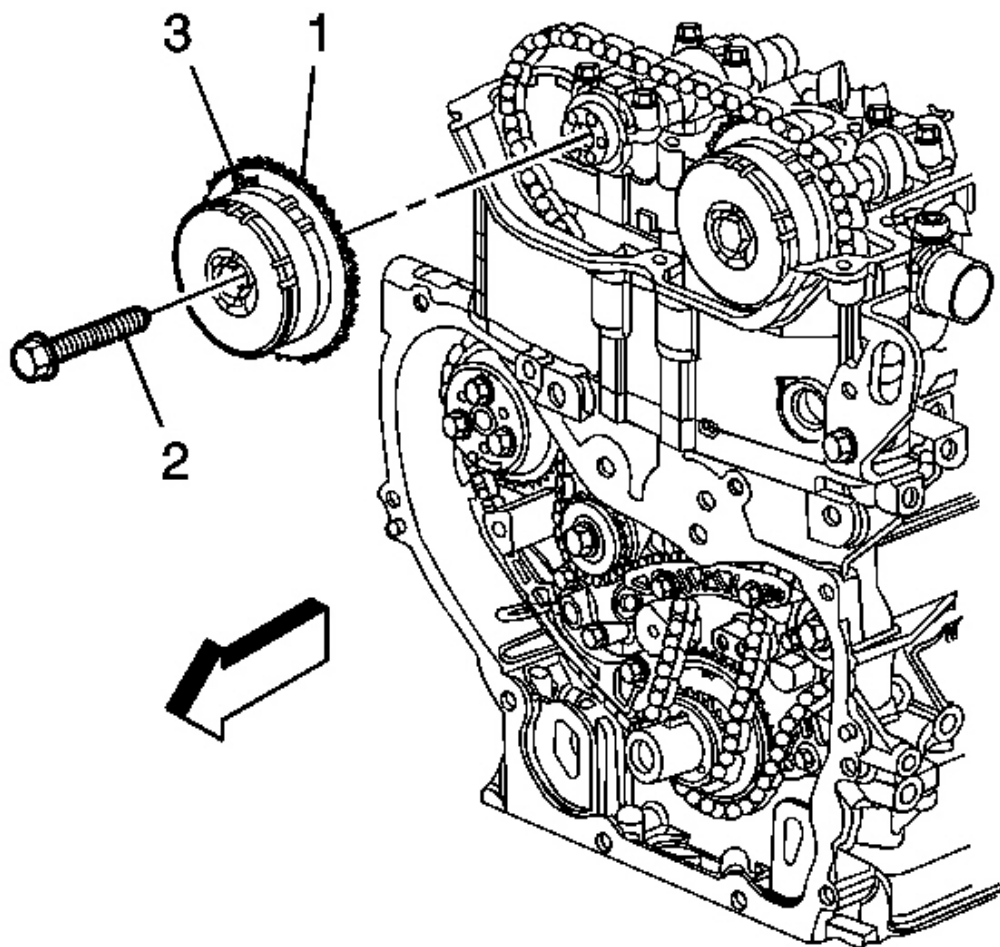


Fig. 183: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

15. Install the timing chain onto the exhaust camshaft actuator.
16. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
17. Install a NEW exhaust camshaft actuator bolt (2) until snug.

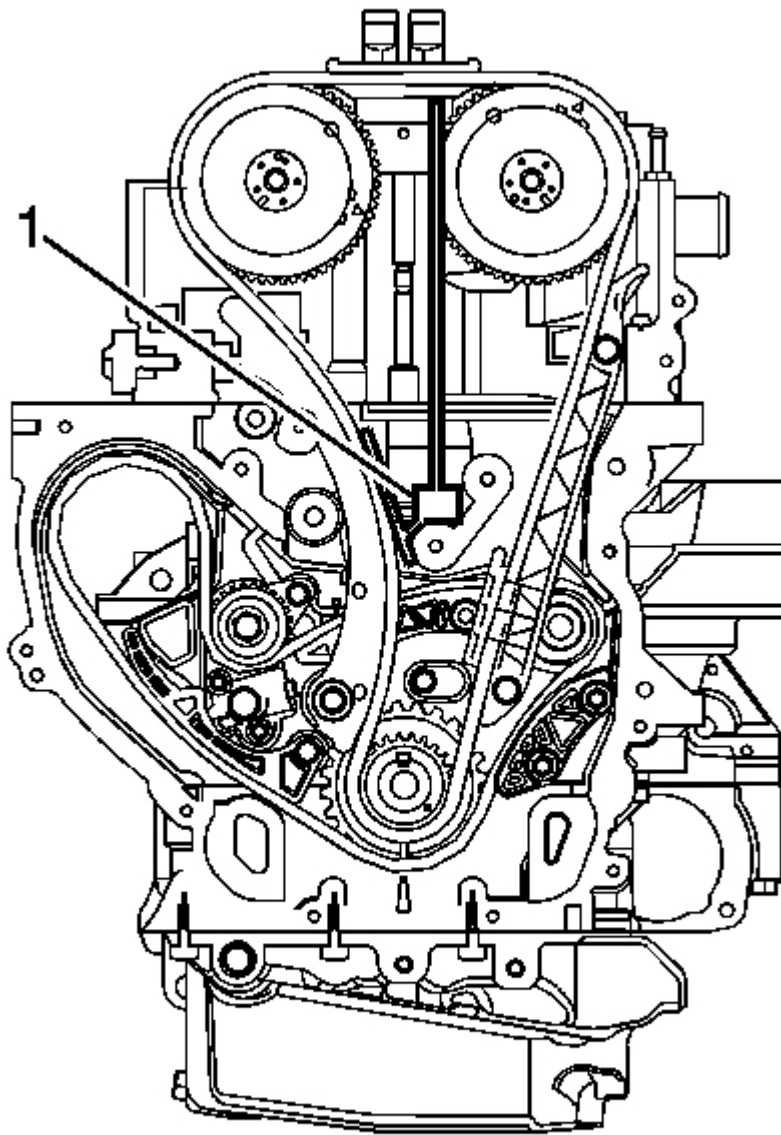


Fig. 184: View Of Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

18. Remove the timing chain retention tool **EN-48749** (1) from the exhaust side of the timing chain. See **Special Tools**.
19. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

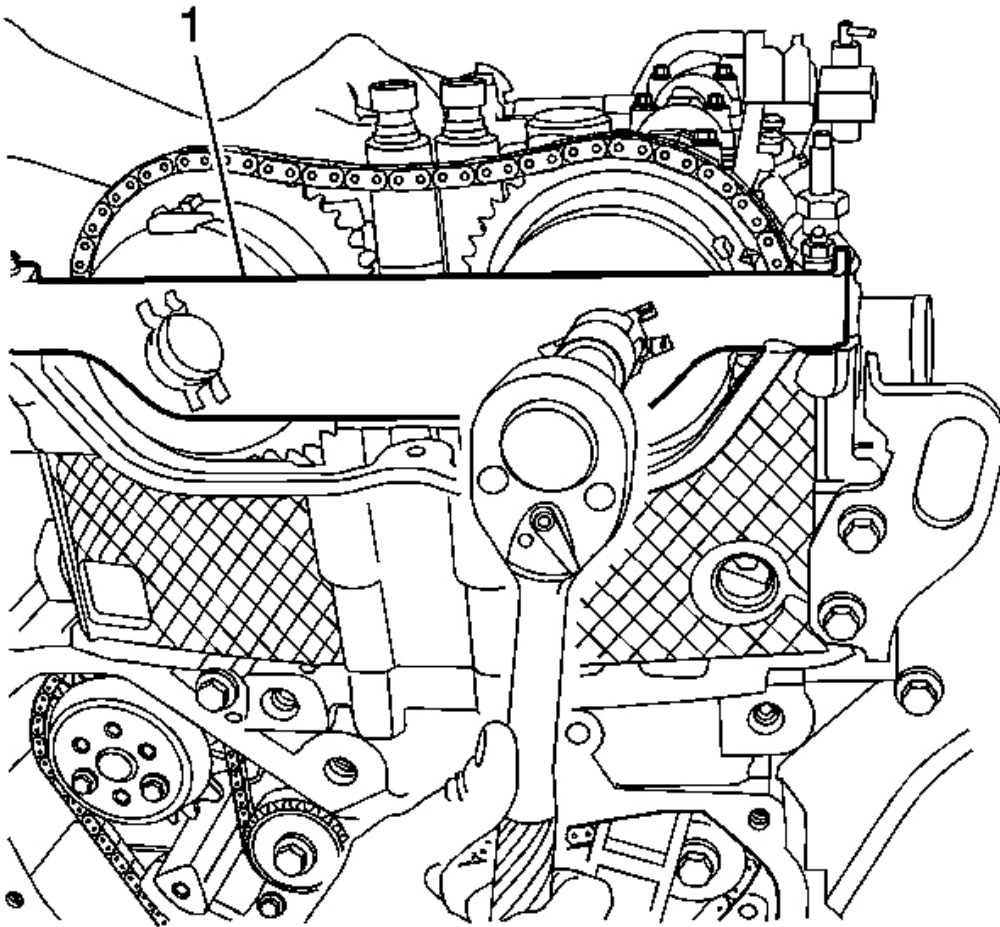


Fig. 185: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

20. Install the **EN-48953** (1) to the actuators. See **Special Tools**.
21. Install the camshaft actuator locking tool bolts and tighten to 10 N.m (89 lb in).
22. Release the tensioner by applying a counterclockwise torque on the harmonic balancer bolt and tighten the bolt to 45 N.m (33 lb ft).
23. Tighten the NEW camshaft actuator bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059**.
24. Remove the camshaft actuator locking tool, **EN-48953**. See **Special Tools**.

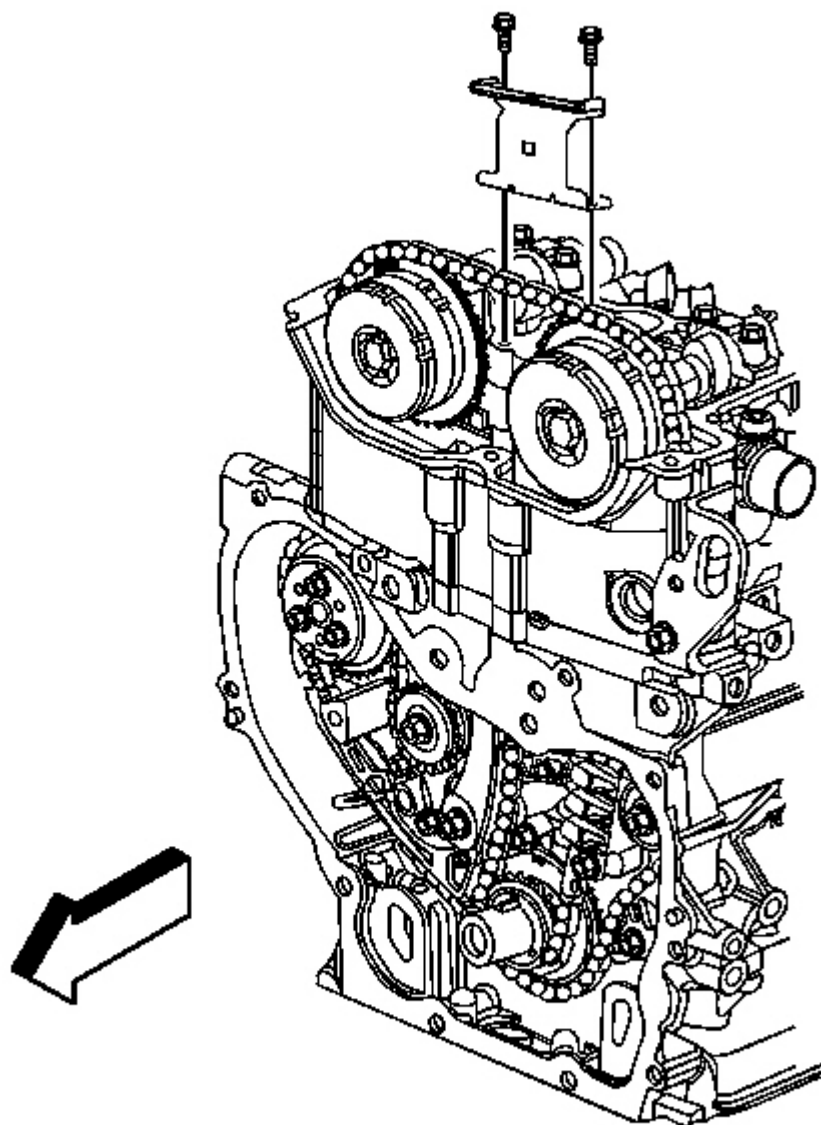


Fig. 186: View Of Upper Timing Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the upper timing chain guide bolts and guide. Tighten the bolts to 10 N.m (89 lb in).
26. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

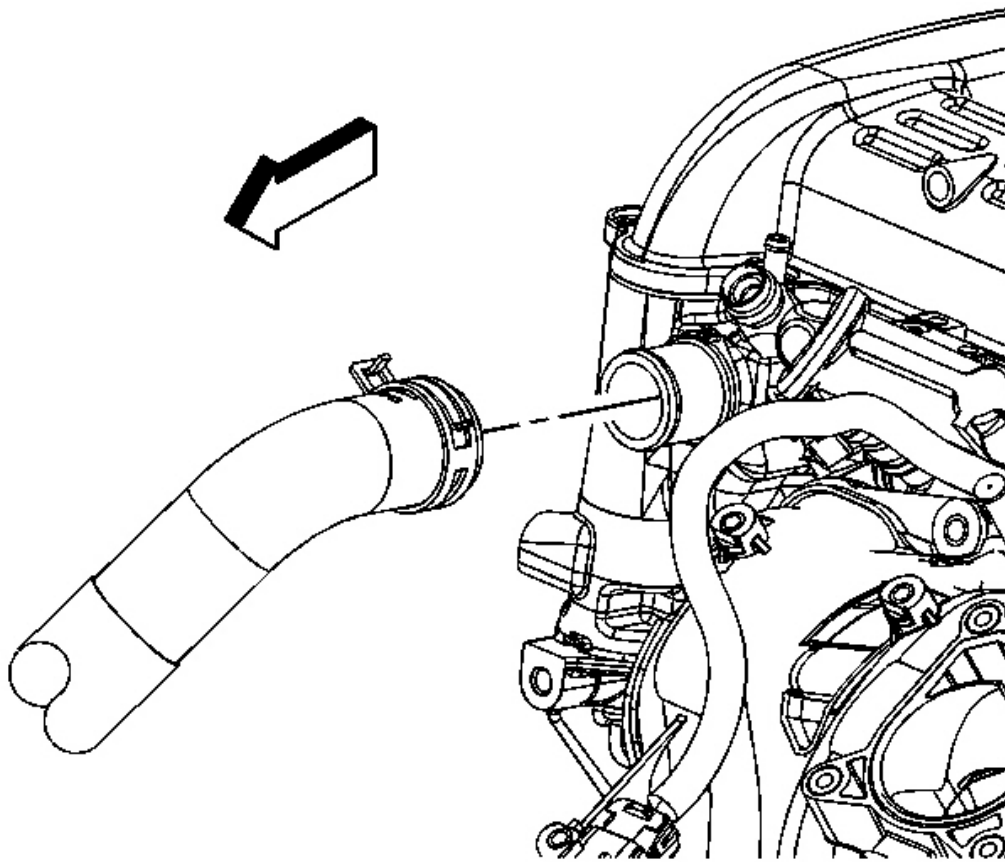


Fig. 187: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

27. Connect all electrical connectors as necessary.
28. Install the radiator inlet hose to the cylinder head.
29. Position the radiator inlet hose clamp using the **J 38185** .
30. Install the radiator surge tank air bleed hose to the cylinder head.
31. Position the radiator surge tank air bleed hose clamp.
32. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (LAF)** .
33. Install the intake manifold. Refer to **Intake Manifold Replacement**.
34. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static)** or **Cooling System Draining and Filling (GE 47716)** .

OIL PAN REPLACEMENT

Removal Procedure

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**.

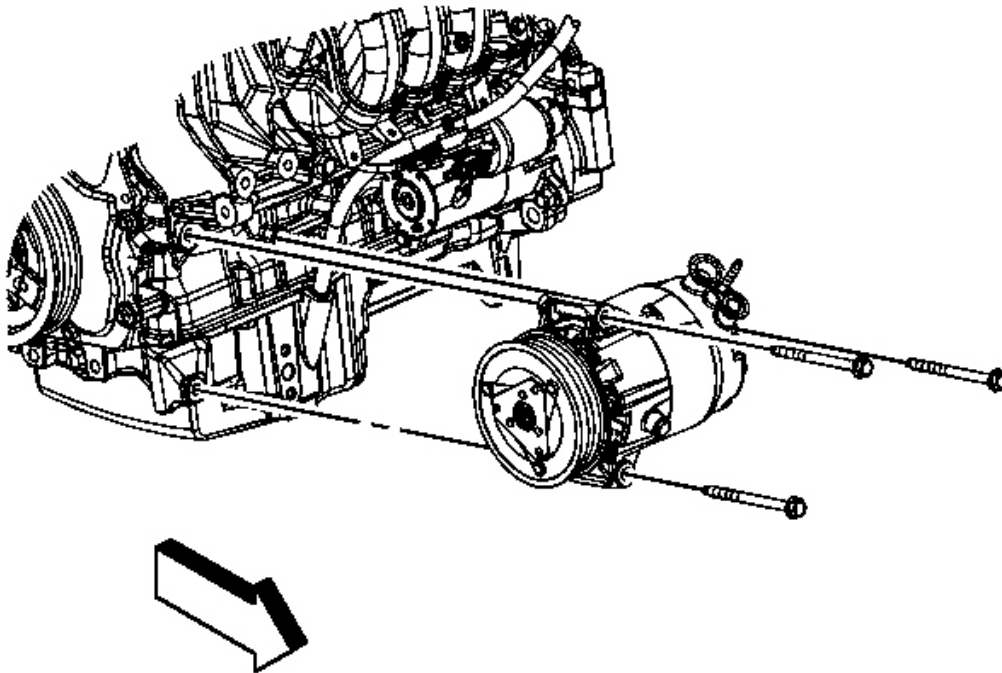


Fig. 188: Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

4. Loosen the upper air conditioning (A/C) compressor bolts.
5. Remove the lower A/C compressor bolt.

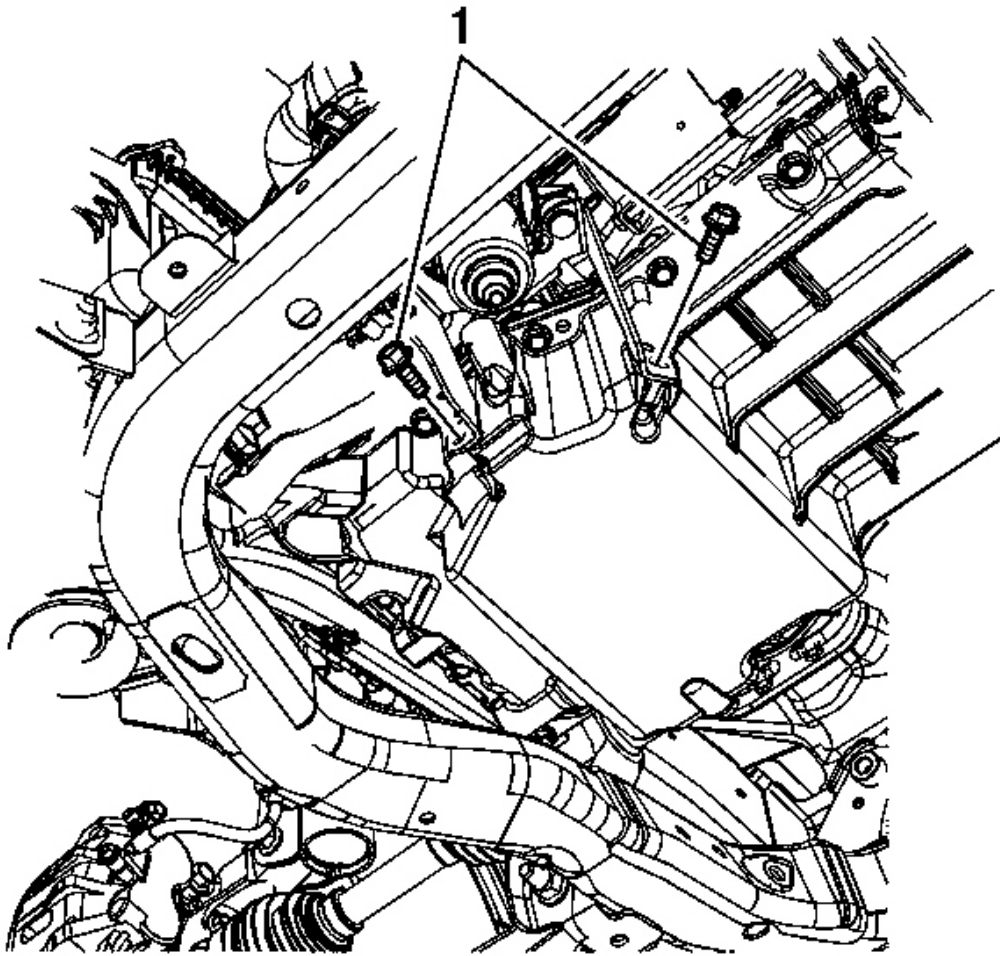


Fig. 189: Power Brake Booster Pump Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the lower 2 power brake booster pump bolts (1).
7. Reposition the pump away from the oil pan.

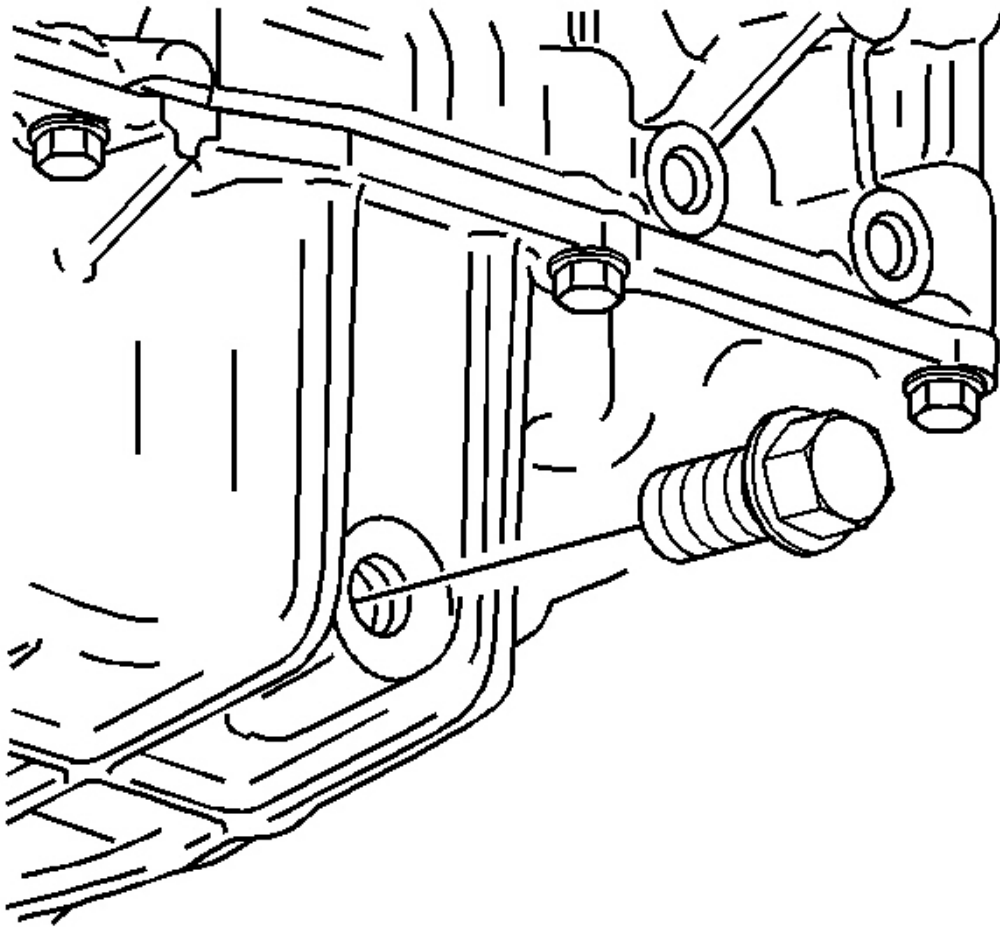


Fig. 190: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

8. Place a suitable drain pan under the oil pan drain plug.
9. Remove the oil pan drain plug.
10. Drain the engine oil.
11. Reinstall the oil pan drain plug until snug.

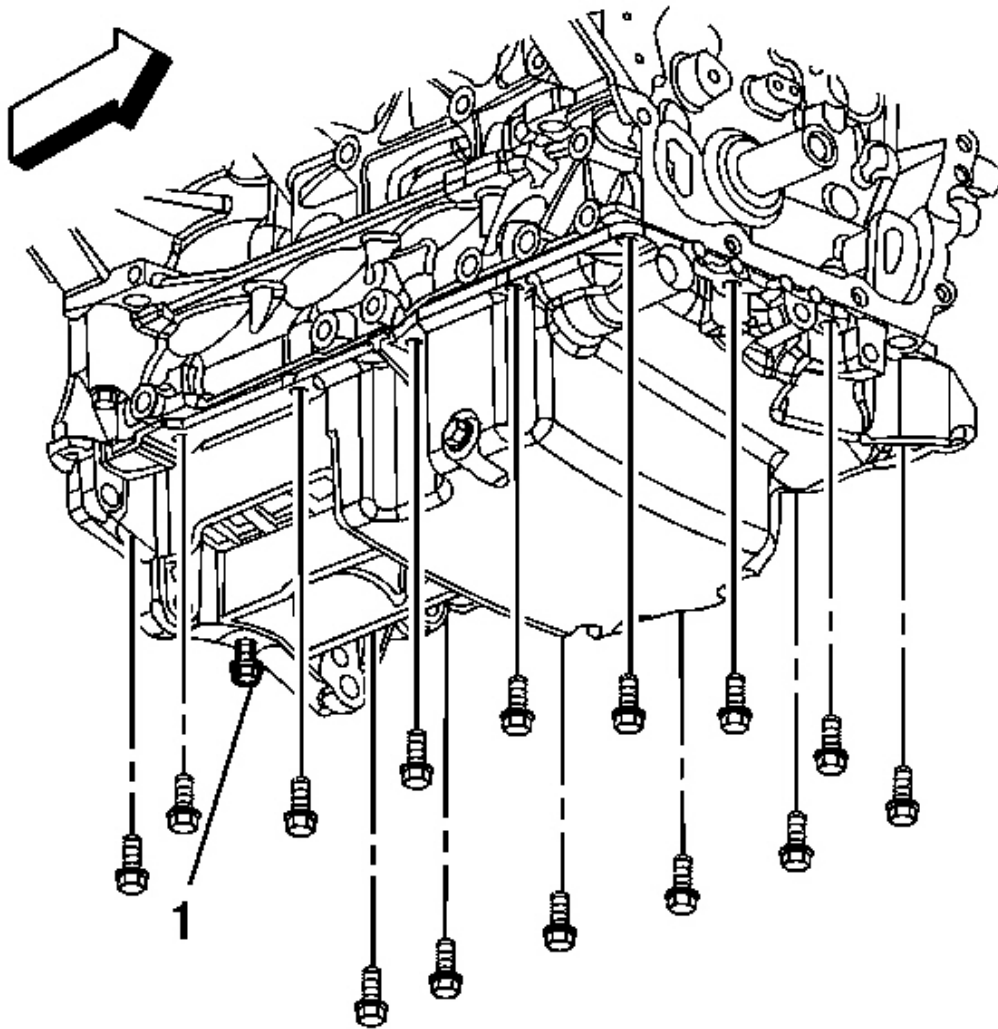


Fig. 191: Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the 4 oil pan to transaxle bolts.
13. Remove the oil pan bolts.

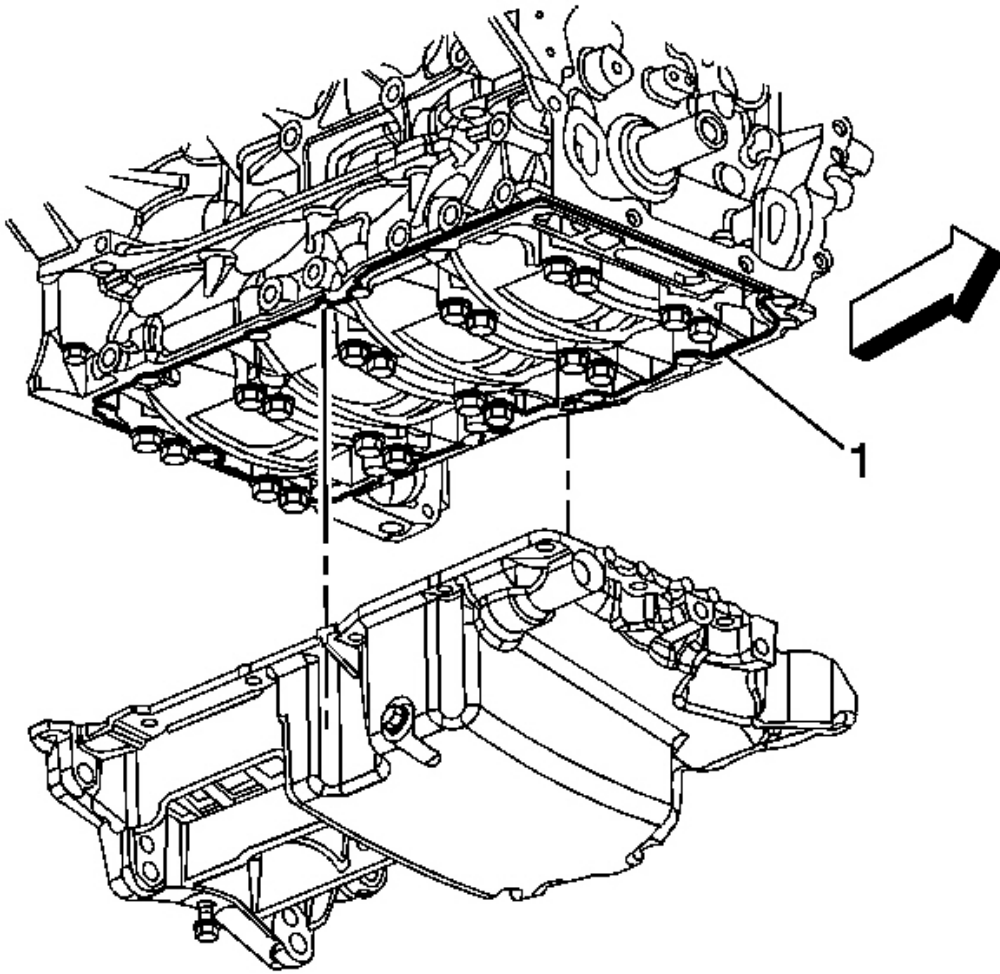


Fig. 192: Locating Oil Pan Sealant
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil pan
15. Remove any old oil pan sealant (1).

Installation Procedure

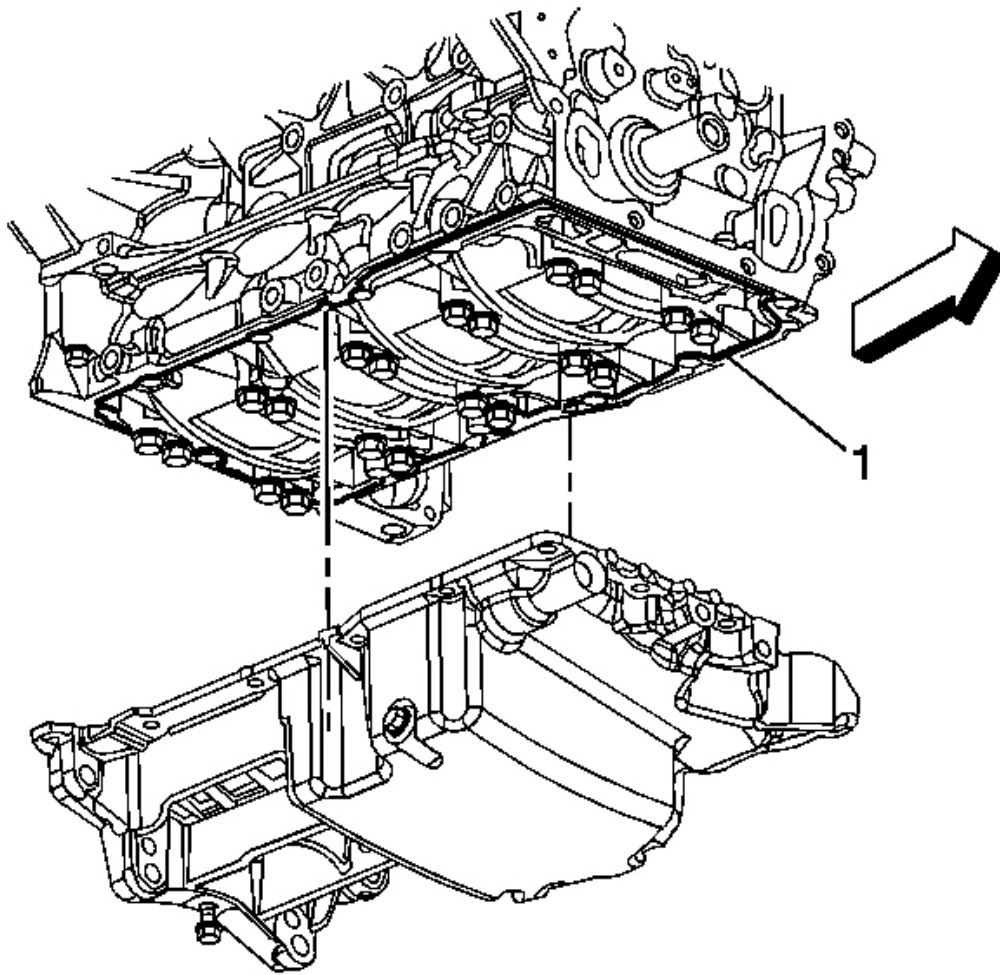


Fig. 193: Locating Oil Pan Sealant
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the oil pan and the sealing surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of sealant (1) around the perimeter of the oil pan and the oil suction port opening. DO NOT over apply the sealant. More than a 2 mm bead is not required. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
3. Install the oil pan.

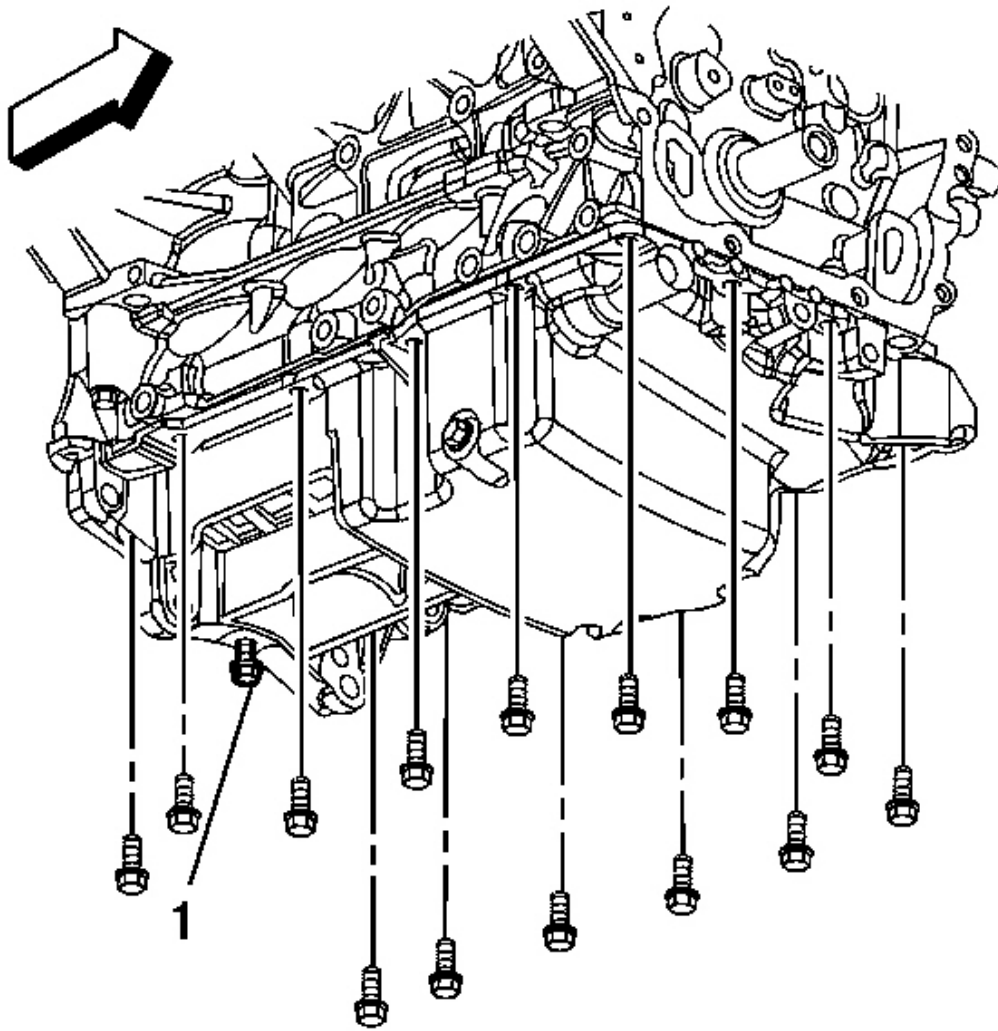


Fig. 194: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

CAUTION: Refer to Fastener Caution .

5. Install the 4 oil pan to transaxle bolts and tighten to 75 N.m (55 lb ft).

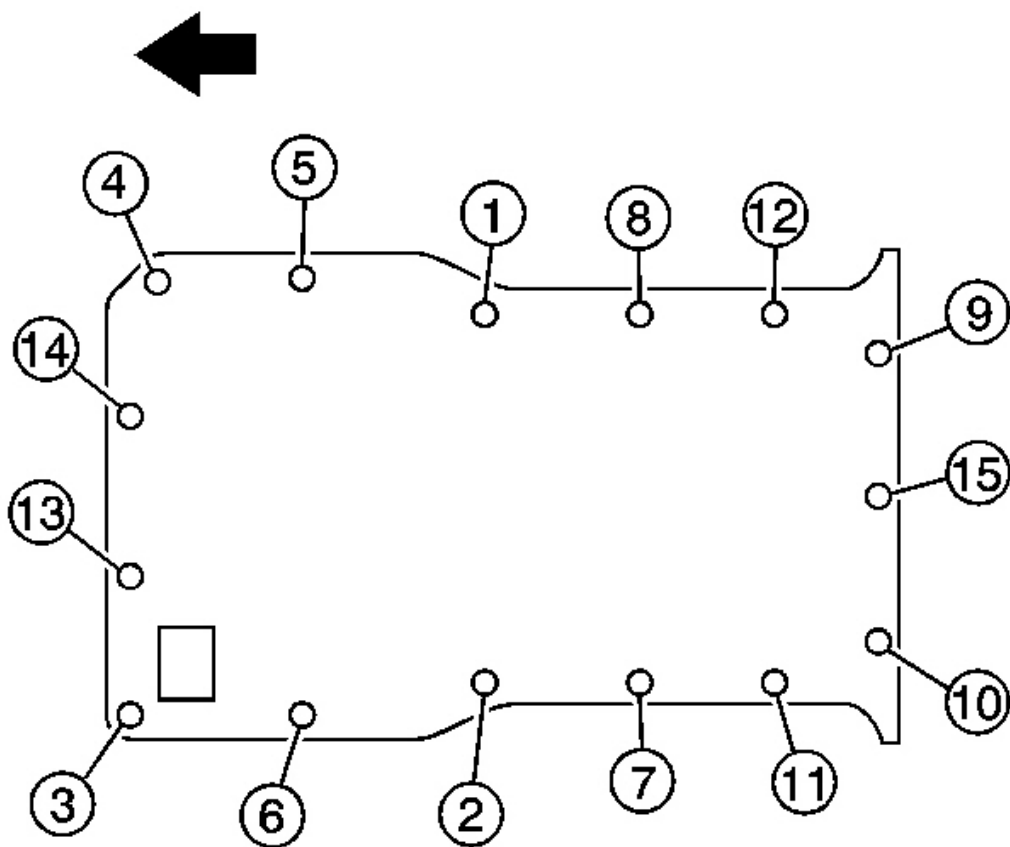


Fig. 195: Identifying Oil Pan Bolt Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

6. Tighten the oil pan bolts in the sequence shown to 25 N.m (18 lb ft).

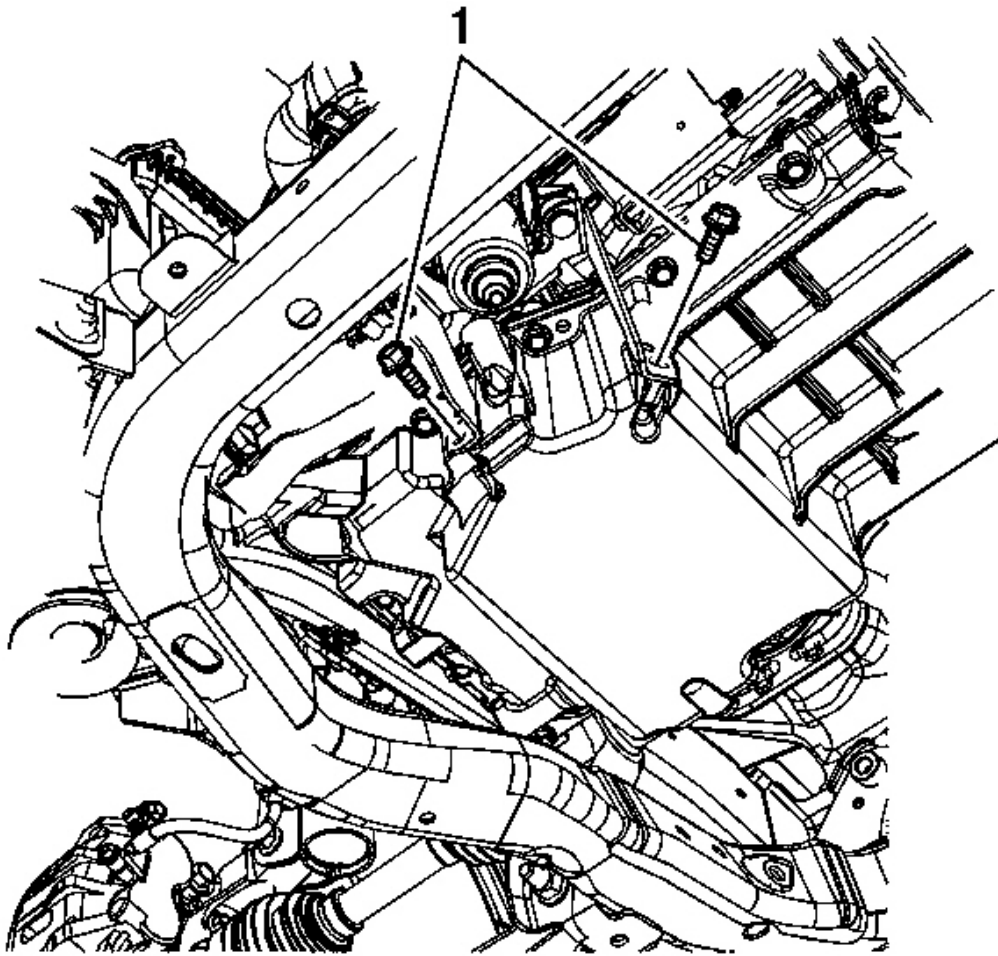


Fig. 196: Power Brake Booster Pump Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the power brake booster pump bolts (1).
8. Tighten the power brake booster pump M8 bolt to 22 N.m (16 lb ft).
9. Tighten the power brake booster pump M10 bolt to 50 N.m (37 lb ft).

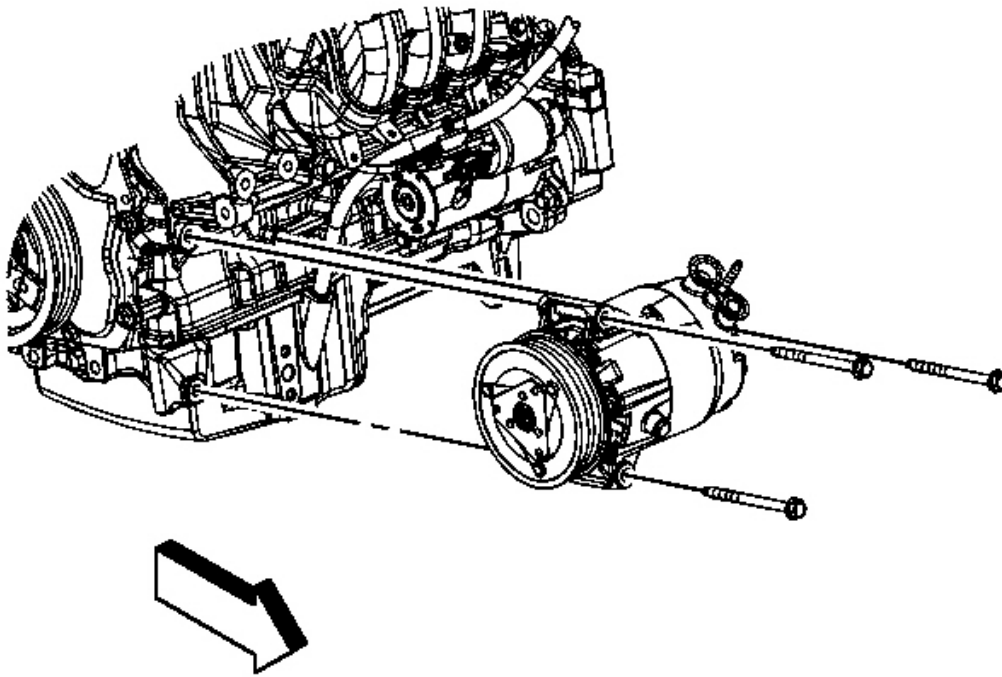


Fig. 197: Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the A/C Compressor bolts tighten bolt to 20 N.m (15 lb.ft)
11. Lower the vehicle.
12. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
13. Install the drive belt. Refer to **Drive Belt Replacement**.
14. Fill the engine oil to the proper level.

PISTON OIL NOZZLE REPLACEMENT

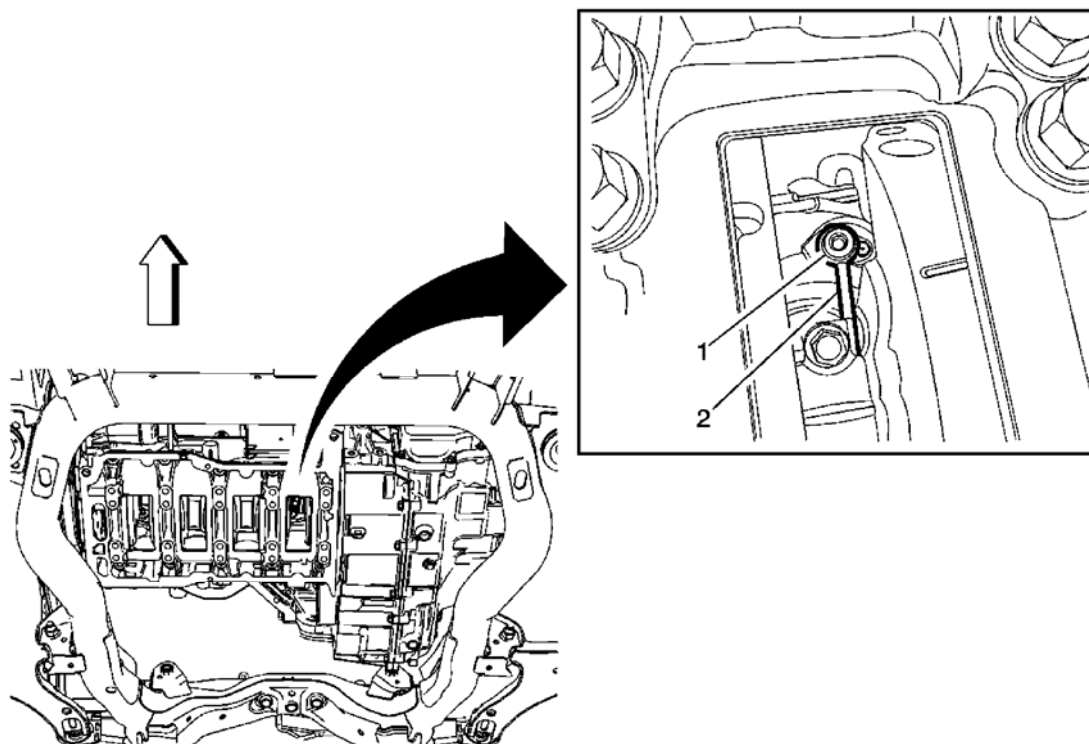


Fig. 198: Piston Oil Nozzle

Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove the oil pan. Refer to <u>Oil Pan Replacement</u>	
1	Piston Oil Nozzle Fastener CAUTION: Refer to <u>Fastener Caution</u> . Tighten: 15 N.m (11 lb ft) Procedure: Rotate the crankshaft as necessary to gain access to piston oil nozzles bolts.
2	Piston Oil Nozzle Procedure: Transfer part as necessary.

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT

Special Tools

- **J 8037** Ring Compressor. See **Special Tools**.
- **J 24270** Cylinder Bore Ridge Reamer
- **J-43966-1** Connecting Rod Guides. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the cylinder head. Refer to **Cylinder Head Replacement**.

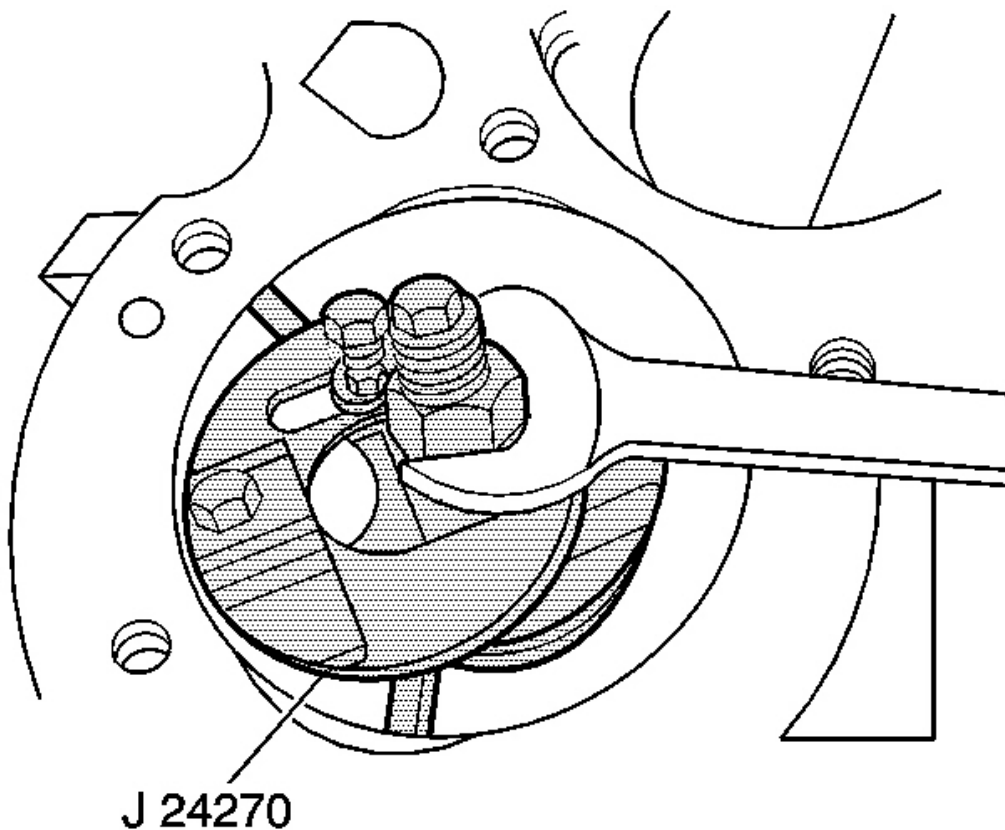


Fig. 199: Removing Cylinder Bore Ring Ridge
 Courtesy of GENERAL MOTORS CORP.

3. If a ring ridge is present, remove the ring ridge as follows:
 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 a **J 24270** to remove the ring ridge.
4. Turn the crankshaft so the piston is at top of the stroke.
5. Remove the cloth and cutting debris.

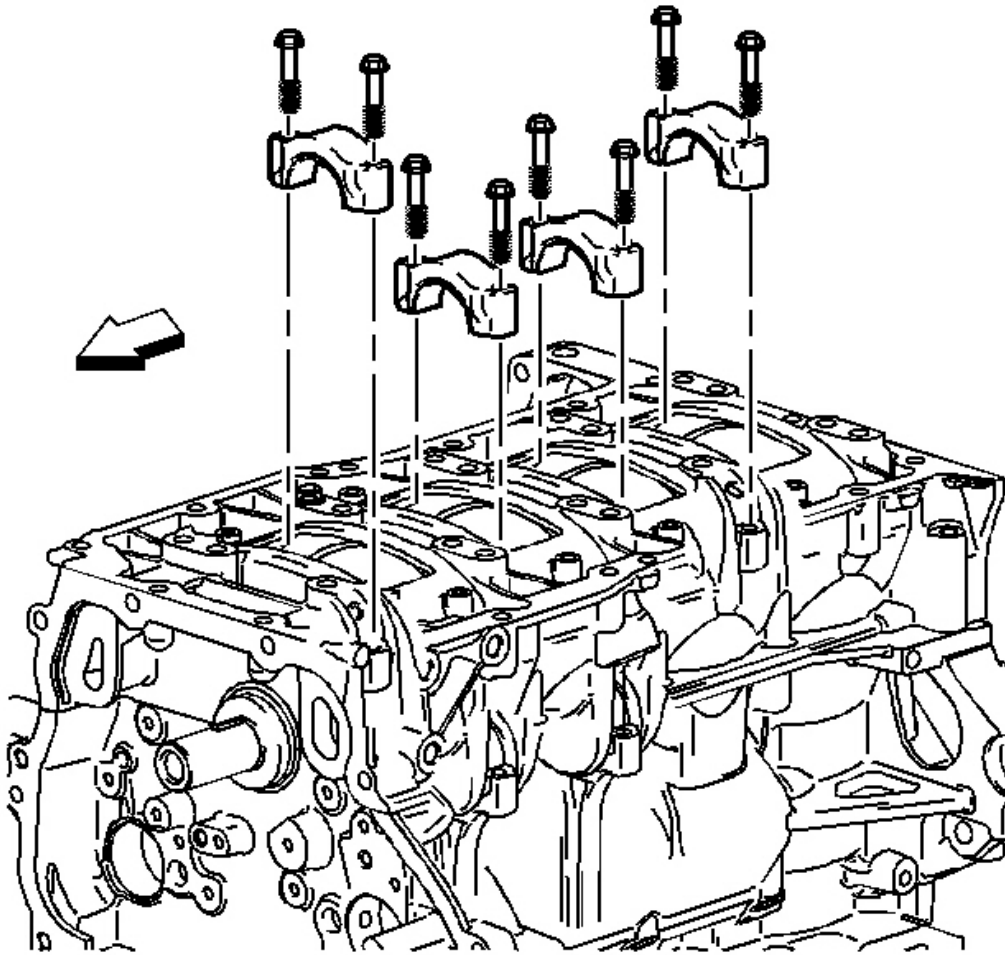


Fig. 200: View Of Connecting Rods, Nuts & Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Place the numbers on connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

4. Remove the connecting rod nuts and the connecting rod cap.

Discard the bolts and nuts.

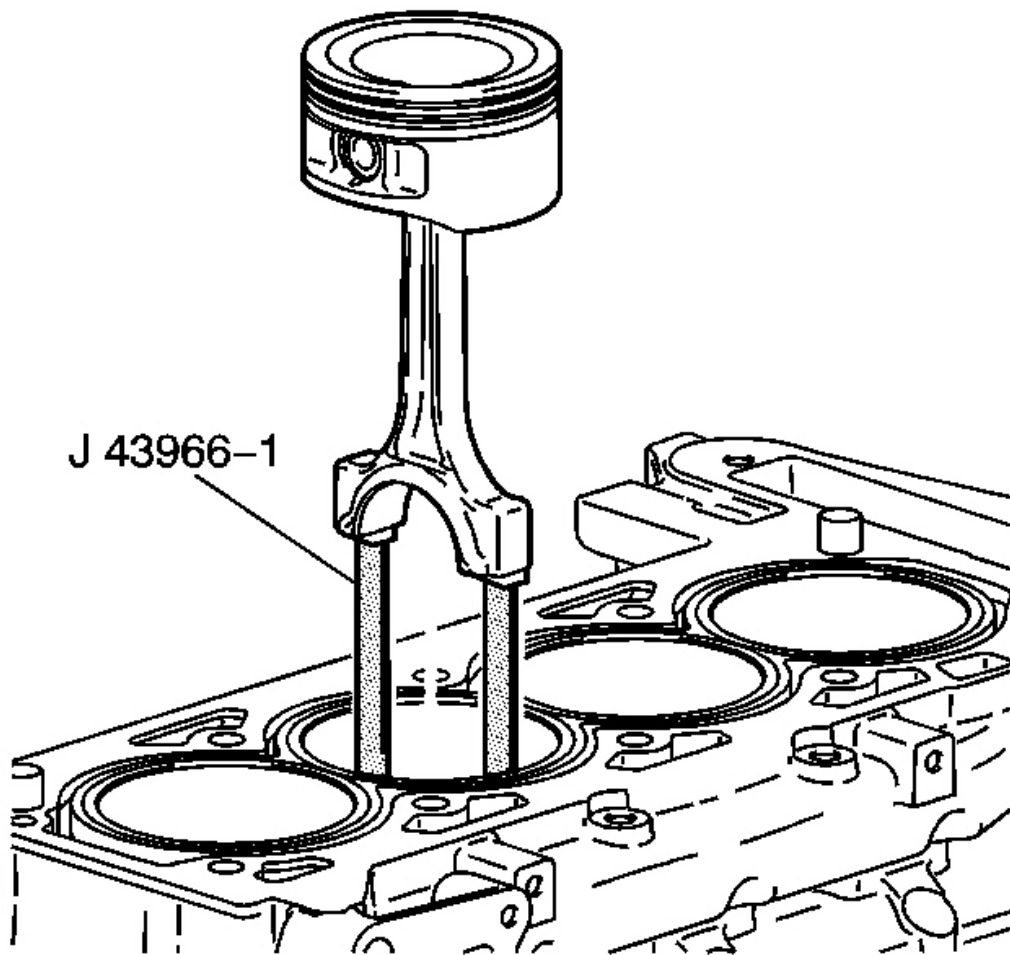


Fig. 201: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

5. Remove the connecting rod and the piston out of the top of the engine block using the **J-43966-1** . See **Special Tools**.
6. Clean the cylinder bores with hot water and detergent or with a light honing.
7. Swab the bores with the engine oil and a clean, dry cloth.

Installation Procedure

1. Coat the following parts with engine oil:
 - The piston
 - The piston rings

- The cylinder bore
- The bearing surfaces

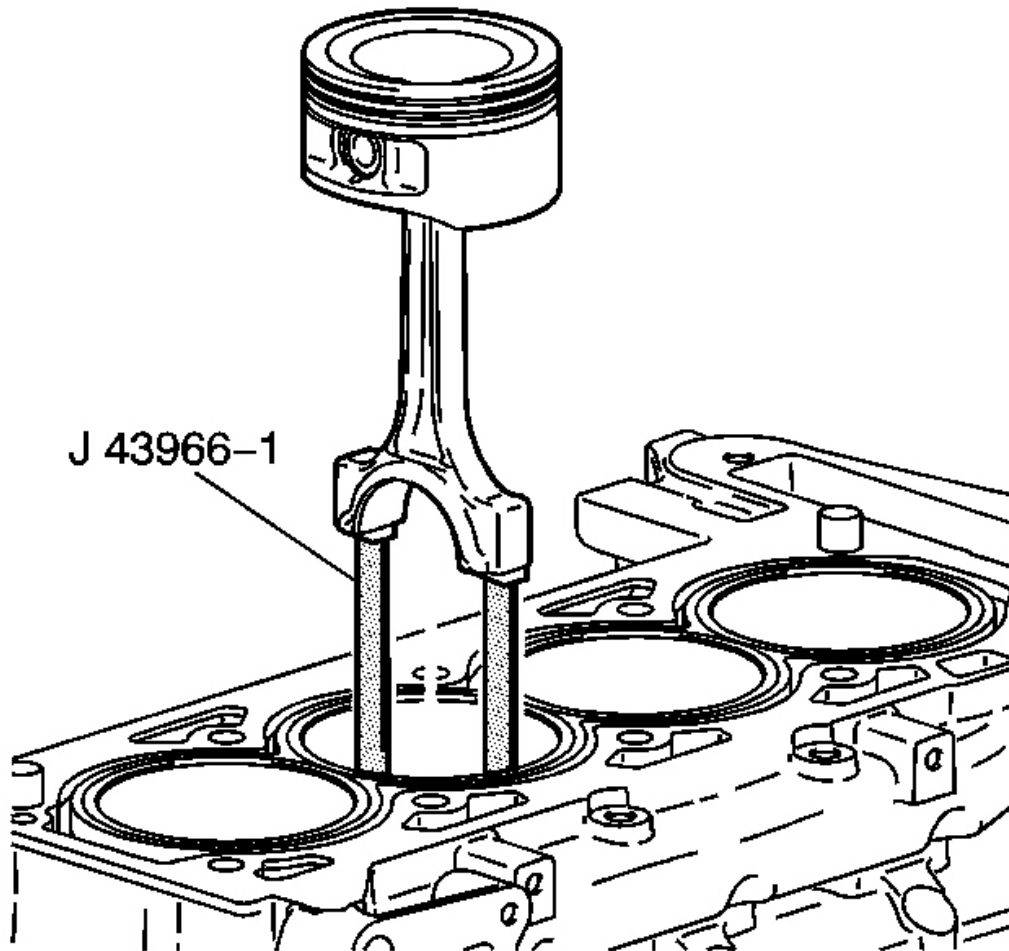


Fig. 202: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

2. Install the piston into its original bore using the J-43966-1 . See **Special Tools**.

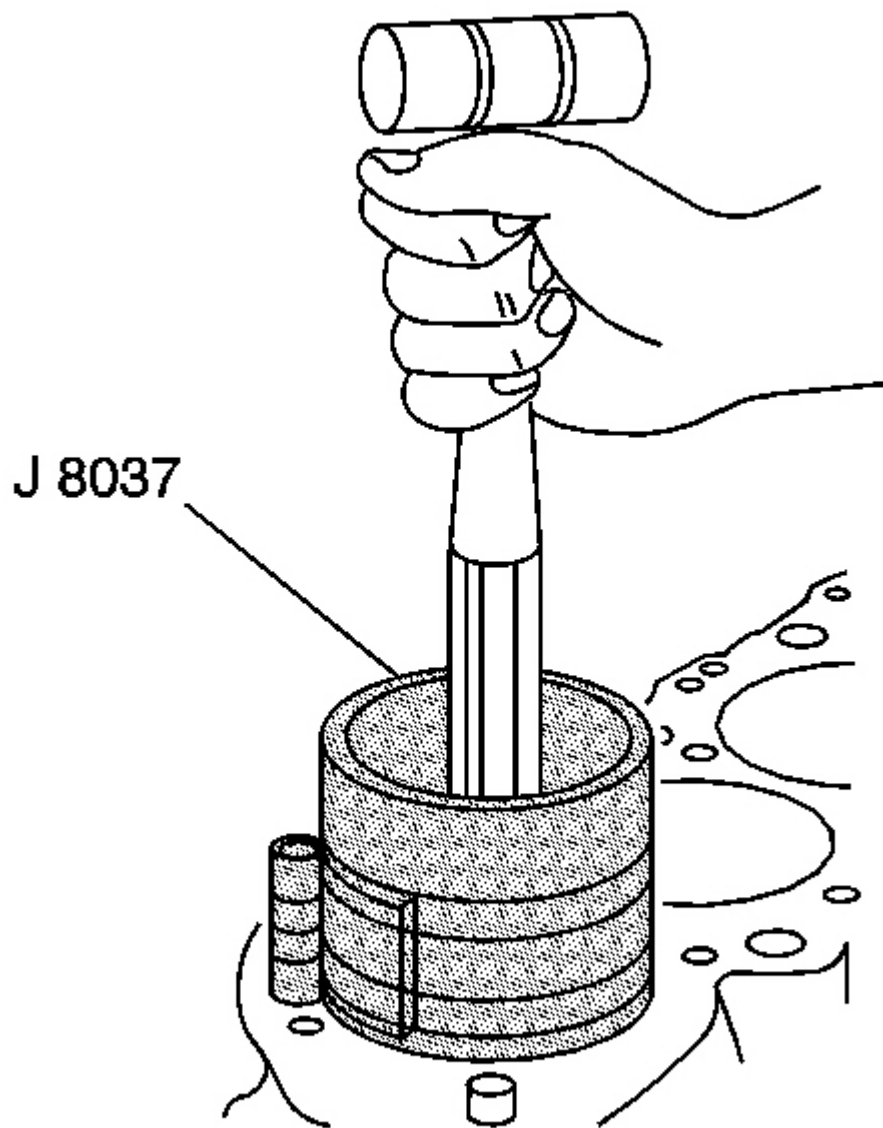


Fig. 203: Installing Piston & Connecting Rod Assembly Into Engine
Courtesy of GENERAL MOTORS CORP.

3. Lightly tap the top of the piston with a wooden hammer handle.
4. When installing the piston and the connecting rod, the stamped mark on the piston must point to the front of the engine.
5. Hold the **J 8037** firmly against the engine block until all the piston rings have entered the cylinder bore.

See **Special Tools**.

6. Install the connecting rod caps onto their original connecting rods.
7. Align the numbers placed on the connecting rod and the connecting rod cap during removal.

CAUTION: Refer to Fastener Caution .

8. Install the new connecting rod bolts and nuts.
 - On the first pass, tighten the nuts evenly to 25 N.m (18 lb ft).
 - On the final pass, use the **J 45059** in order to tighten the nuts an additional 100 degrees.

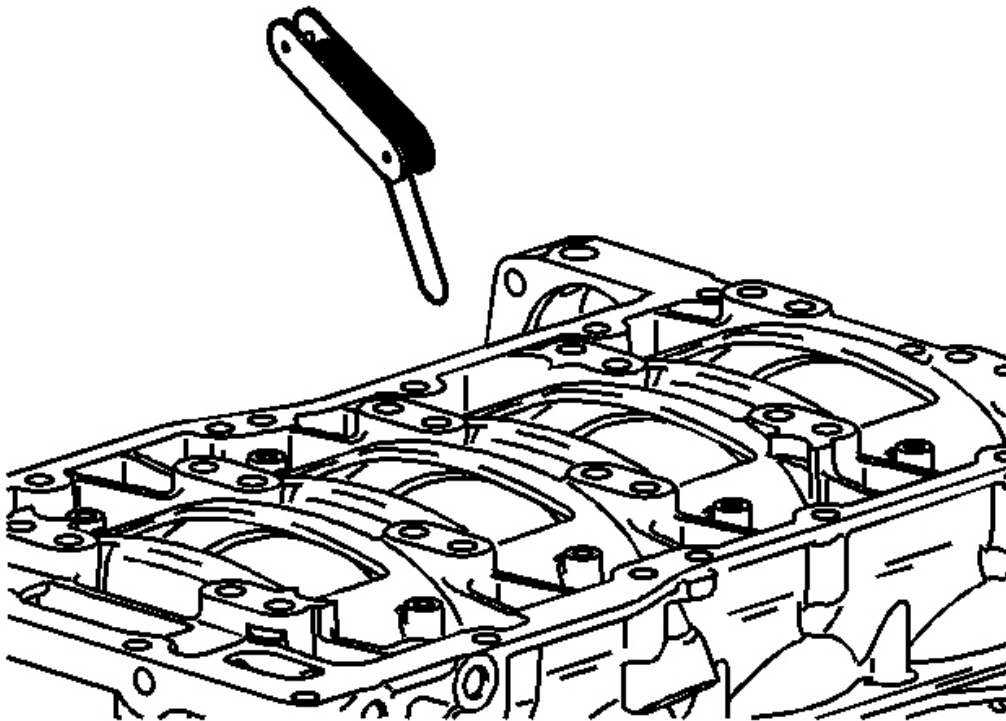


Fig. 204: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

9. Measure the connecting rod side clearance with a feeler gauge.

The correct clearance is 0.070-0.370 mm (0.0027-0.0145 in).

10. Install the cylinder head. Refer to **Cylinder Head Replacement**.

11. Install the oil pan. Refer to Oil Pan Replacement.

ENGINE FLYWHEEL REPLACEMENT

Special Tools

- **EN-43653:** Flywheel Holding Tool
- **EN-45059:** Angle Meter

For equivalent regional tools, refer to Special Tools

Removal Procedure

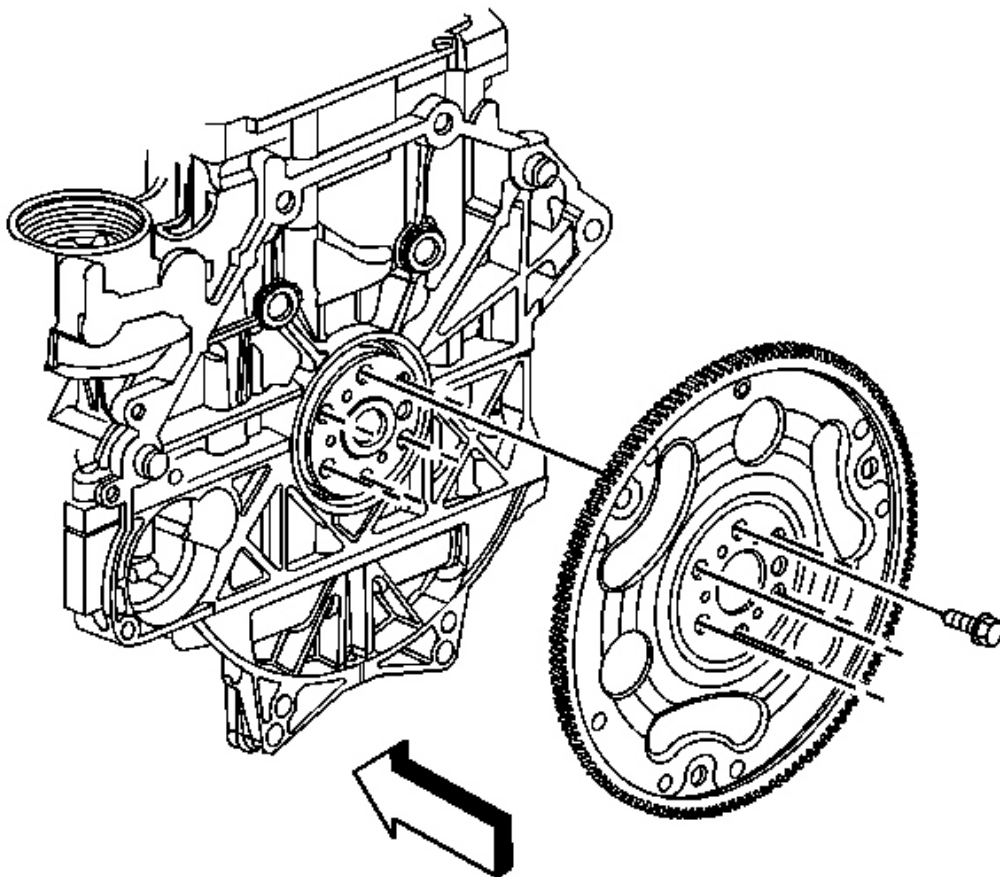


Fig. 205: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Remove the transaxle. Refer to **Transmission Replacement** .
2. Install the **EN-43653**: tool in order to prevent the flywheel from rotating when loosening the flywheel bolts.

NOTE: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full engagement on the thin-headed flywheel bolts.

3. Loosen, remove and discard the flywheel bolts.

NOTE: Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

4. Remove the flywheel.
5. Remove the **EN-43653**: tool.
6. Clean the thread adhesive from the flywheel bolt holes. Use a nylon bristle brush to clean the holes in the crankshaft.

Installation Procedure

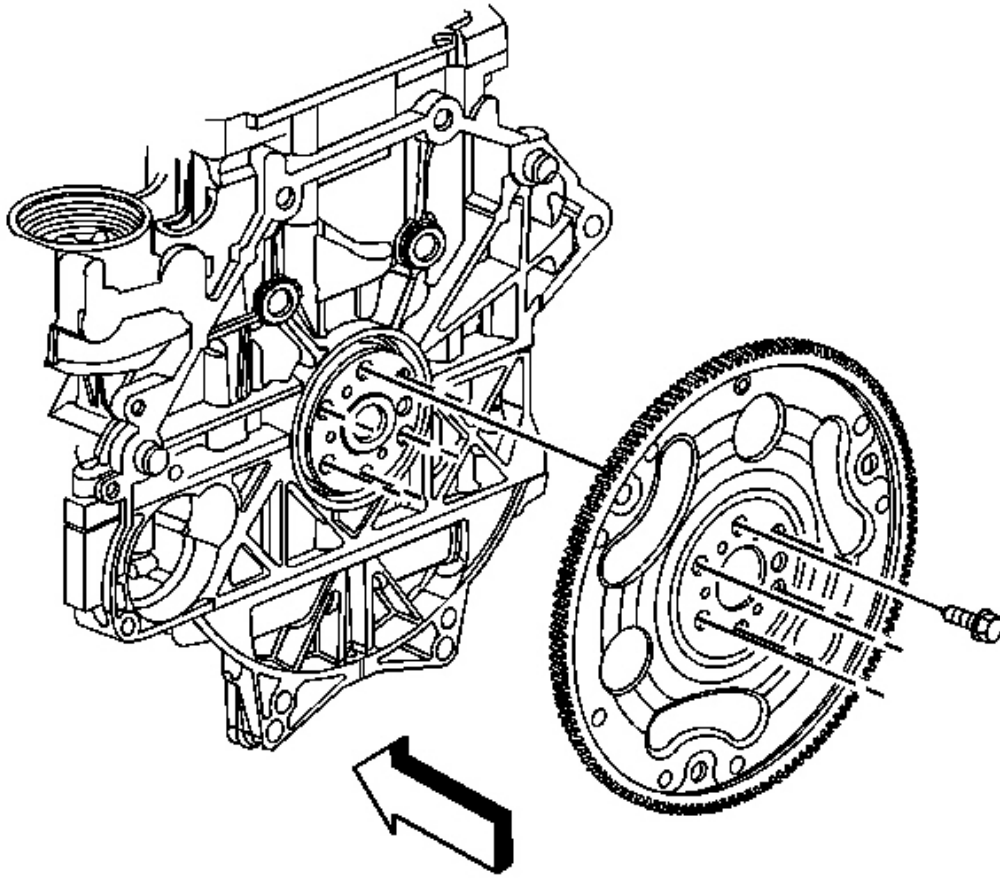


Fig. 206: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel to the crankshaft.
2. Install the NEW flywheel bolts until snug.
3. Install the **EN-43653**: tool in order to prevent the flywheel from rotating when tightening the flywheel bolts.

CAUTION: Refer to Fastener Caution .

4. Tighten the flywheel bolts to 53 N.m (39 lb ft) plus an additional 25 degrees using the **EN-45059**: meter.
5. Remove the **EN-43653**: tool.
6. Install the transaxle. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

EN-42067: Rear Main Seal Installer

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

Removal Procedure

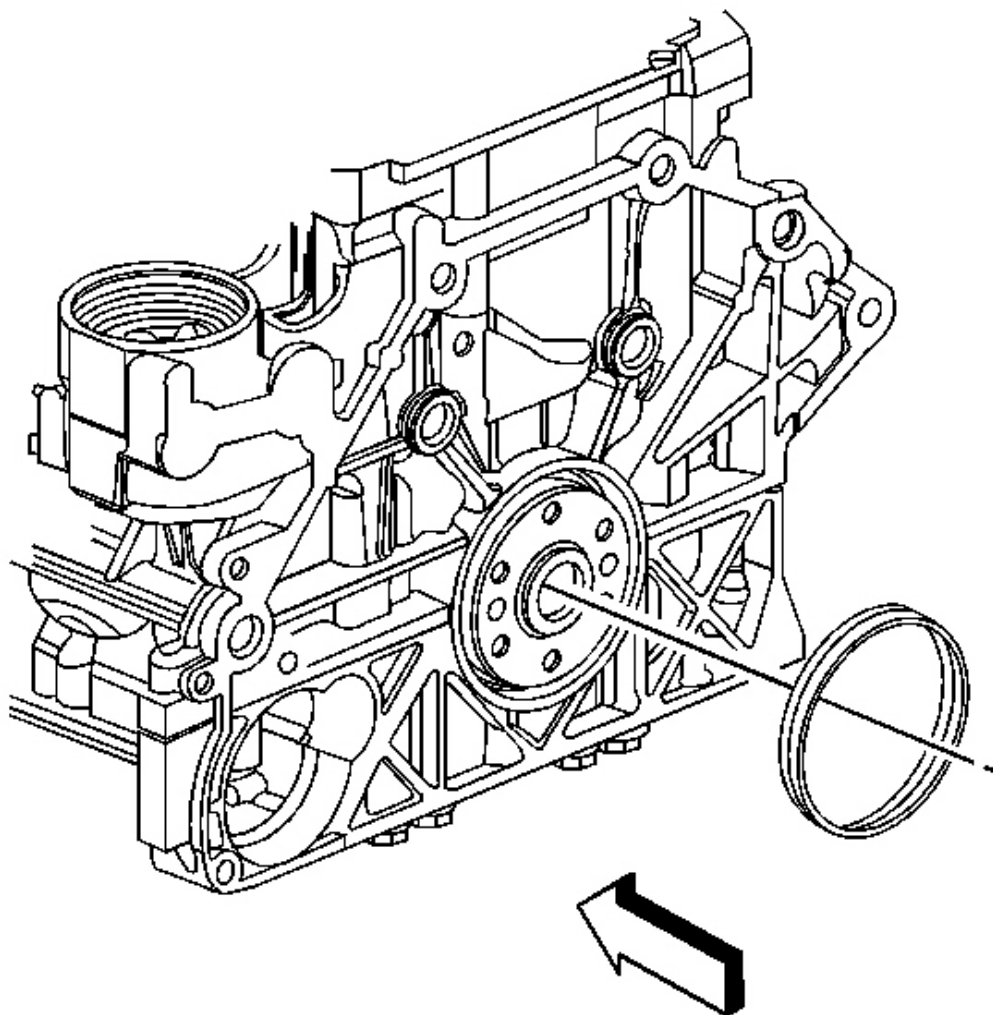


Fig. 207: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

NOTE: Do not damage the outside diameter of the crankshaft or chamber with any tool.

2. Pry out the crankshaft rear oil seal using a flat-bladed tool.

Installation Procedure

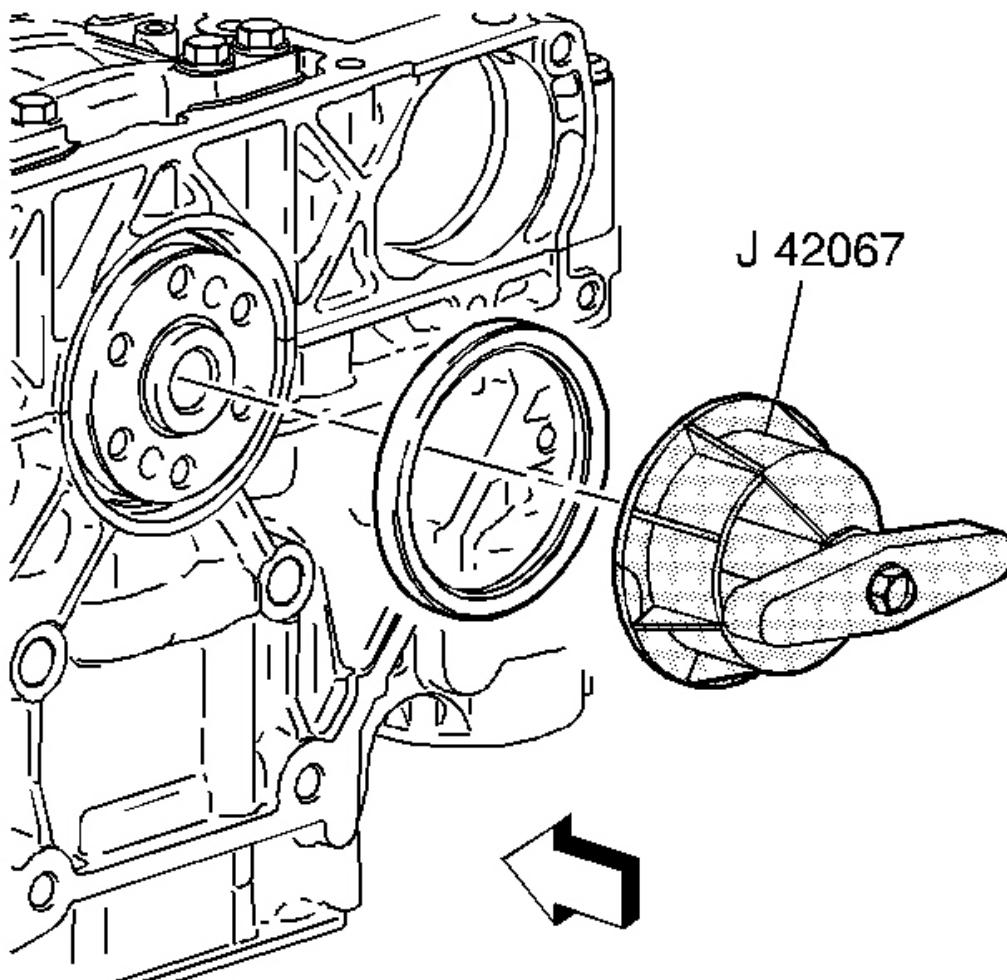


Fig. 208: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-42067**: installer, install a NEW crankshaft rear oil seal.

2. Install the flywheel. Refer to **Engine Flywheel Replacement**.

ENGINE REPLACEMENT

Removal Procedure

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static)** or **Cooling System Draining and Filling (GE 47716)**
2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**
3. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**
4. Remove the battery and battery tray. Refer to **Battery Tray Replacement**

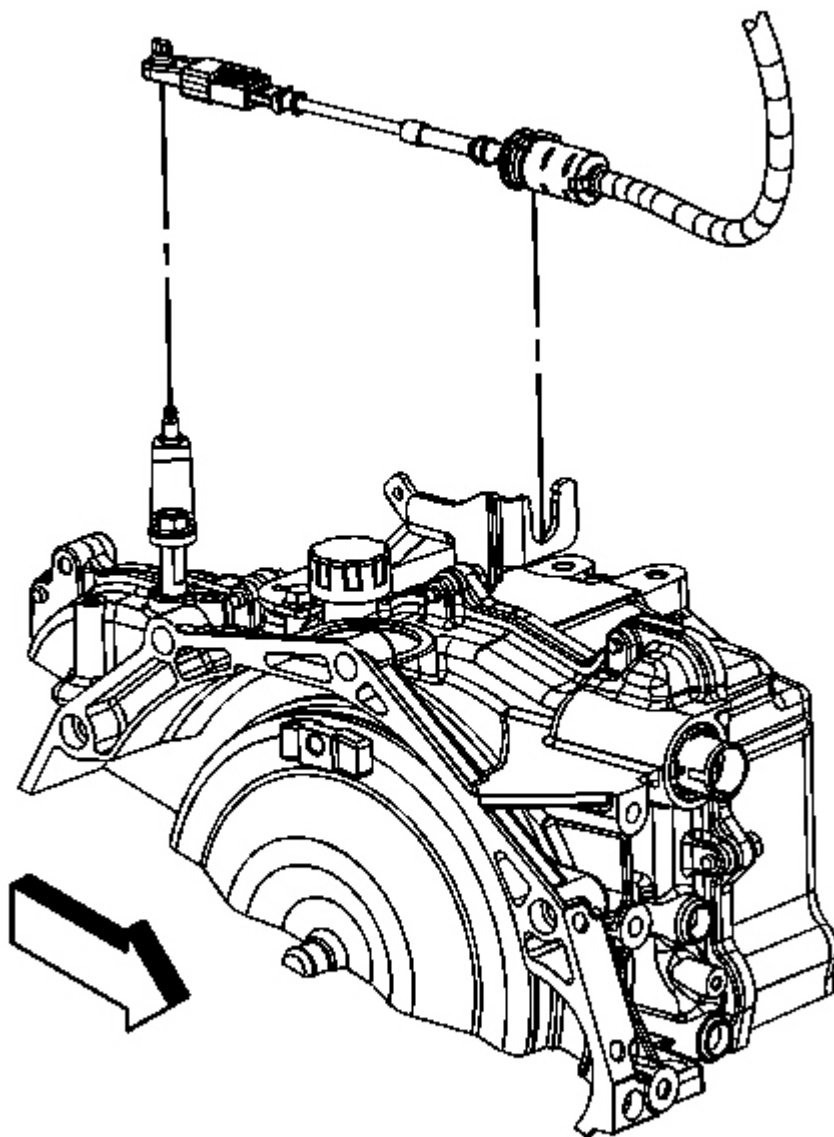


Fig. 209: Transaxle Shift Cable & Range Select Lever
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the transmission shifter cable from the level and the bracket.
6. Disconnect the radiator outlet hose from the engine. Refer to **Radiator Outlet Hose Replacement (LAF)** or **Radiator Outlet Hose Replacement (LF1)**
7. Disconnect the radiator inlet hose from the engine. Refer to **Radiator Inlet Hose Replacement (LAF)** or

Radiator Inlet Hose Replacement (LF1)

8. Secure the cooling module to the upper body structure
9. Remove the generator. Refer to **Generator Replacement (LAF)** or **Generator Replacement (LF1)**

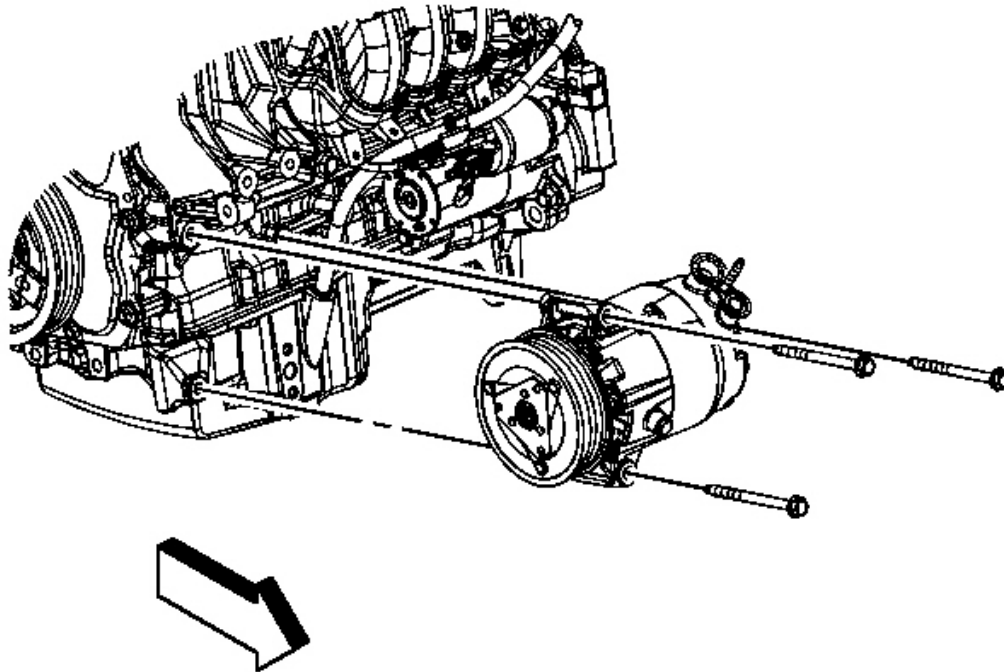


Fig. 210: Compressor Bolts

Courtesy of GENERAL MOTORS CORP.

10. Disconnect A/C electrical connector.
11. Remove the A/C compressor. DO NOT discharge the A/C system. Support the compressor. Refer to **Air Conditioning Compressor Replacement (LAF)** or **Air Conditioning Compressor Replacement (LF1)**
12. Disconnect the coolant reservoir hose from the engine to reservoir.
13. Relieve the fuel pressure. Refer to **Fuel Pressure Relief**
14. Disconnect the fuel feed pipe at the reposition. Refer to **Metal Collar Quick Connect Fitting Service**
15. Disconnect the fuel evaporative emission (EVAP) line.
16. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
17. Remove the lower transaxle-to-engine bolts.
18. Remove the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)**
19. Mark the relationship of the flywheel to the torque converter for reassembly.
20. Remove the torque converter to flywheel bolts.

21. If equipped with AWD, remove the propeller shaft completely from the vehicle. Refer to **Propeller Shaft Replacement**
22. If equipped remove the transfer case. Refer to **Transfer Case Assembly Replacement**
23. Remove the front wheels. Refer to **Tire and Wheel Removal and Installation**
24. Disconnect the Transmission Fluid Cooler Inlet Pipe. Refer to **Transmission Fluid Cooler Inlet Pipe Replacement**
25. Disconnect the Transmission Fluid Cooler Outlet Pipe. Refer to **Transmission Fluid Cooler Outlet Pipe Replacement**
26. Remove the left and right tie rod ends from the steering knuckles. Refer to **Steering Linkage Outer Tie Rod Replacement**
27. Remove the left and right stabilizer bar links. Refer to **Stabilizer Shaft Link Replacement**
28. Disconnect the left and right lower ball joints. Refer to **Lower Control Arm Replacement**
29. Remove the left and right axle shaft nuts. Refer to **Front Wheel Drive Shaft Replacement**

NOTE: In order to prevent possible SIR system deployment, do not attempt to rotate the steering shaft.

30. Disconnect the steering shaft coupling from the steering gear. Refer to **Intermediate Steering Shaft Replacement**
31. Remove the Catalytic Converter. Refer to **Catalytic Converter Replacement (LAF)**
32. Install block of wood between the Crankshaft Balancer and the frame
33. Remove the engine splash shield - Right Side. Refer to **Engine Splash Shield Replacement - Right Side**
34. Remove the engine splash shield-left side. Refer to **Engine Splash Shield Replacement - Left Side**
35. Remove the right engine mount. Refer to **Engine Mount Replacement - Right Side**
36. Remove the left transmission mount. Refer to **Transmission Mount Replacement - Left Side**

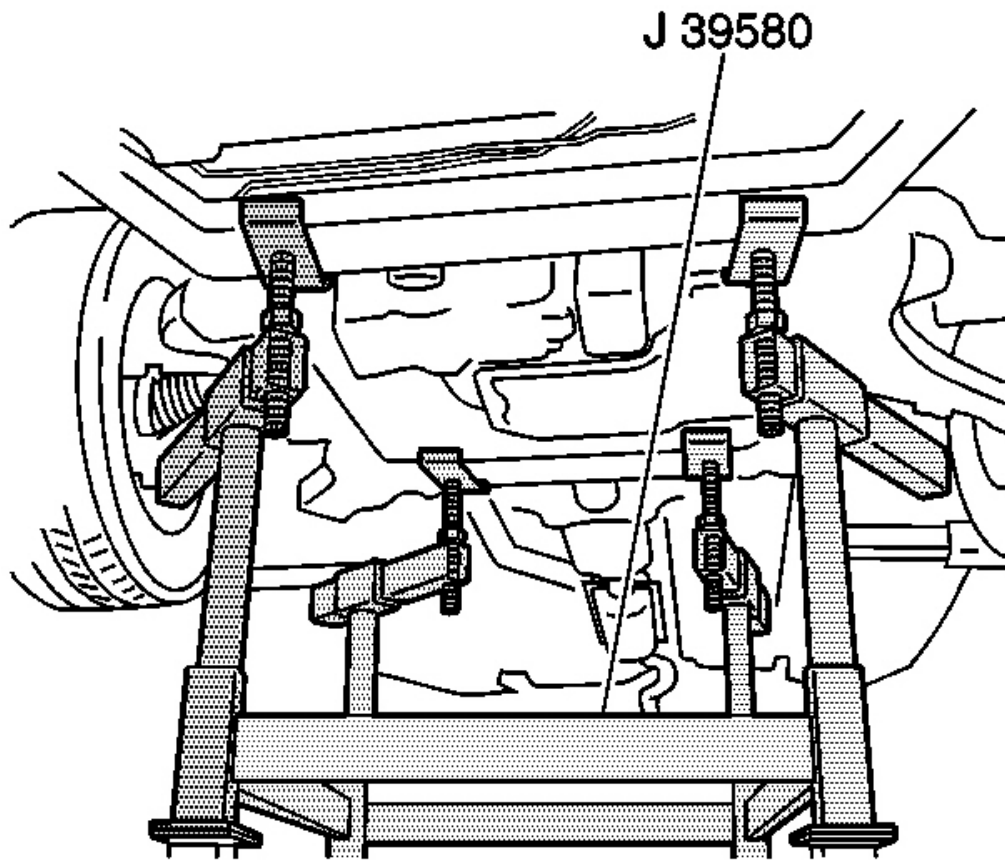


Fig. 211: Identifying Utility Stand
Courtesy of GENERAL MOTORS CORP.

37. Position the engine support table under the powertrain assembly.
38. With the table positioned, fully raise the table to contact with the powertrain assembly.
39. Remove the cradle bolts.

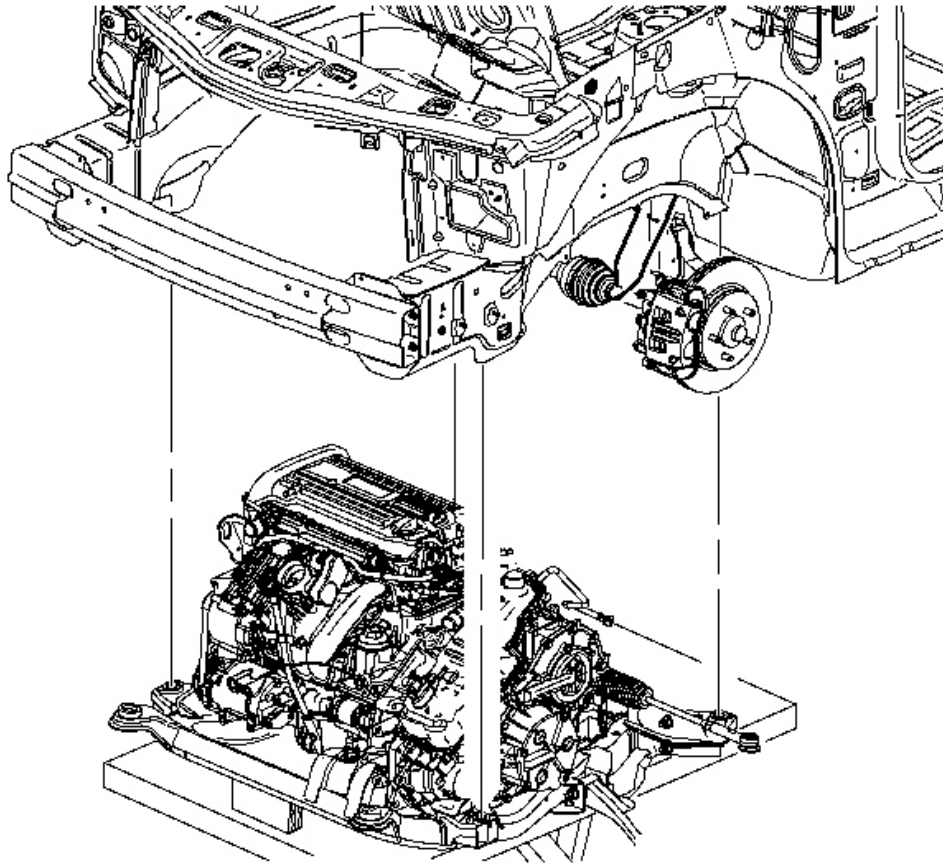


Fig. 212: Raising/Lowering Powertrain Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: During the powertrain removal, support the vehicle body by placing a jack at the rear of the vehicle.

40. Slowly raise the vehicle until the powertrain assembly is clear of the vehicle.
41. Remove the front transmission mount from the engine. Refer to **Transmission Front Mount Replacement**
42. Install the engine lift to powertrain assembly.
43. Separate the engine from the transmission on the floor.
44. Lift engine assembly from the cradle and place on the floor

45. Transfer parts as needed.

Installation Procedure

1. Align the engine to the transmission.

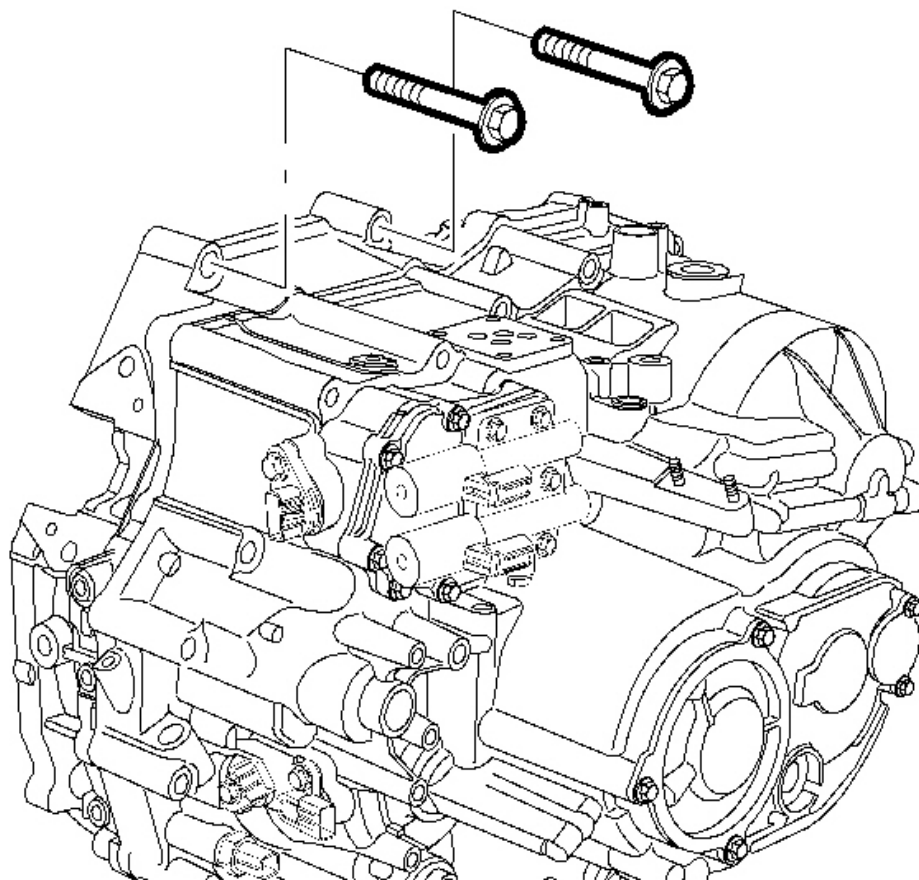


Fig. 213: View Of Transmission-To-Engine Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution

2. Install the upper transmission-to-engine mounting bolts. Tighten the bolts to 75 N.m (55 lb ft).

3. Install the front transmission mount to the engine. Refer to **Transmission Front Mount Replacement**
4. Install wood blocks between the engine and cradle.

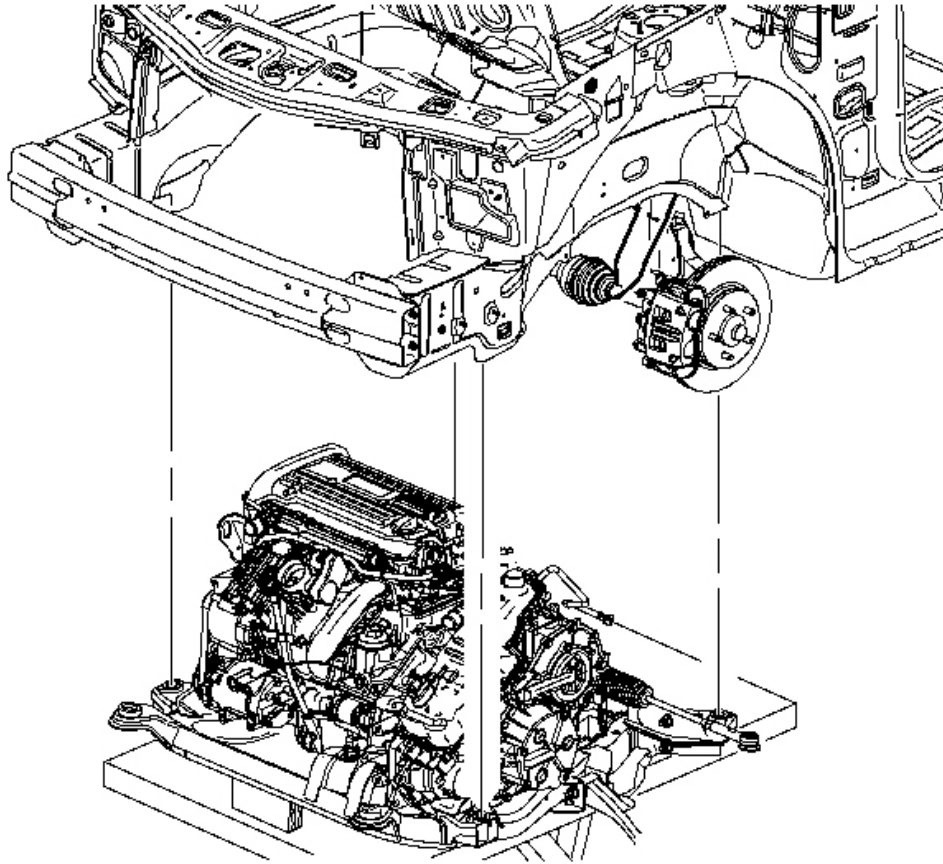


Fig. 214: Raising/Lowering Powertrain Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the powertrain assembly to the vehicle.
6. Install the cradle bolts. Refer to **Drivetrain and Front Suspension Frame Replacement**
7. Install left engine splash shield-left side. Refer to **Engine Splash Shield Replacement - Left Side**
8. Install the engine splash shield - Right Side. Refer to **Engine Splash Shield Replacement - Right Side**
9. Remove the engine support table.
10. Install the right engine mount. Refer to **Engine Mount Replacement - Right Side**

11. Install the left transmission mount bolts. Refer to **Transmission Mount Replacement - Left Side**
12. Remove the wood blocks from the cradle
13. Install the lower transaxle-to-engine bolts and tighten to 75 N.m (55 lb ft).
14. Install the torque convertor-to-flywheel bolts and tighten to 62 N.m (46 lb ft).
15. If equipped with AWD, Install the propeller shaft completely from the vehicle. Refer to **Propeller Shaft Replacement**
16. If equipped install the transfer case. Refer to **Transfer Case Assembly Replacement**
17. Install the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)**
18. Install the starter. Refer to **Starter Replacement (LAF)** or **Starter Replacement (LF1)**
19. Install the Intermediate Steering Shaft. Refer **Intermediate Steering Shaft Replacement**
20. Install the Catalytic Converter. Refer to **Catalytic Converter Replacement (LAF)**
21. Connect the steering shaft coupling from the steering gear. Refer to **Intermediate Steering Shaft Replacement**
22. Install the left and right axle shaft nuts to the steering knuckles. Refer to **Front Wheel Drive Shaft Replacement**
23. Connect the left and right lower ball joints. Refer to **Lower Control Arm Replacement**
24. Install the left and right stabilizer bar links. Refer to **Stabilizer Shaft Link Replacement**
25. Install the left and right tie rod ends to the steering knuckles. Refer to **Steering Linkage Outer Tie Rod Replacement**
26. Connect the transmission cooler lines to the transmission.
27. Connect the Transmission Fluid Cooler Inlet Pipe. Refer to **Transmission Fluid Cooler Inlet Pipe Replacement**
28. Connect the Transmission Fluid Cooler Outlet Pipe. Refer to **Transmission Fluid Cooler Outlet Pipe Replacement**
29. Install the A/C compressor. Refer to **Air Conditioning Compressor Replacement (LAF)** or **Air Conditioning Compressor Replacement (LF1)**
30. Install the front tires. Refer to **Tire and Wheel Removal and Installation**
31. Lower the vehicle.
32. Connect the fuel feed pipe at the reposition. Refer to **Metal Collar Quick Connect Fitting Service**
33. Connect the fuel evaporative emission (EVAP) line.
34. Connect the coolant reservoir hose from the engine to reservoir.
35. Connect the A/C high pressure switch harness.
36. Connect the generator positive cable and nut and tighten to 12 N.m (106 lb in).
37. Connect the radiator outlet hose from the engine. Refer to **Radiator Outlet Hose Replacement (LAF)** or **Radiator Outlet Hose Replacement (LF1)**
38. Connect the radiator inlet hose from the engine. Refer to **Radiator Inlet Hose Replacement (LAF)** or **Radiator Inlet Hose Replacement (LF1)**
39. Fill the vehicle with coolant. Refer to **Cooling System Draining and Filling (Static)** or **Cooling System Draining and Filling (GE 47716)**
40. Fill the vehicle with engine oil. Refer to **Engine Oil and Oil Filter Replacement**

41. Connect the wiring harness to the underhood junction block.

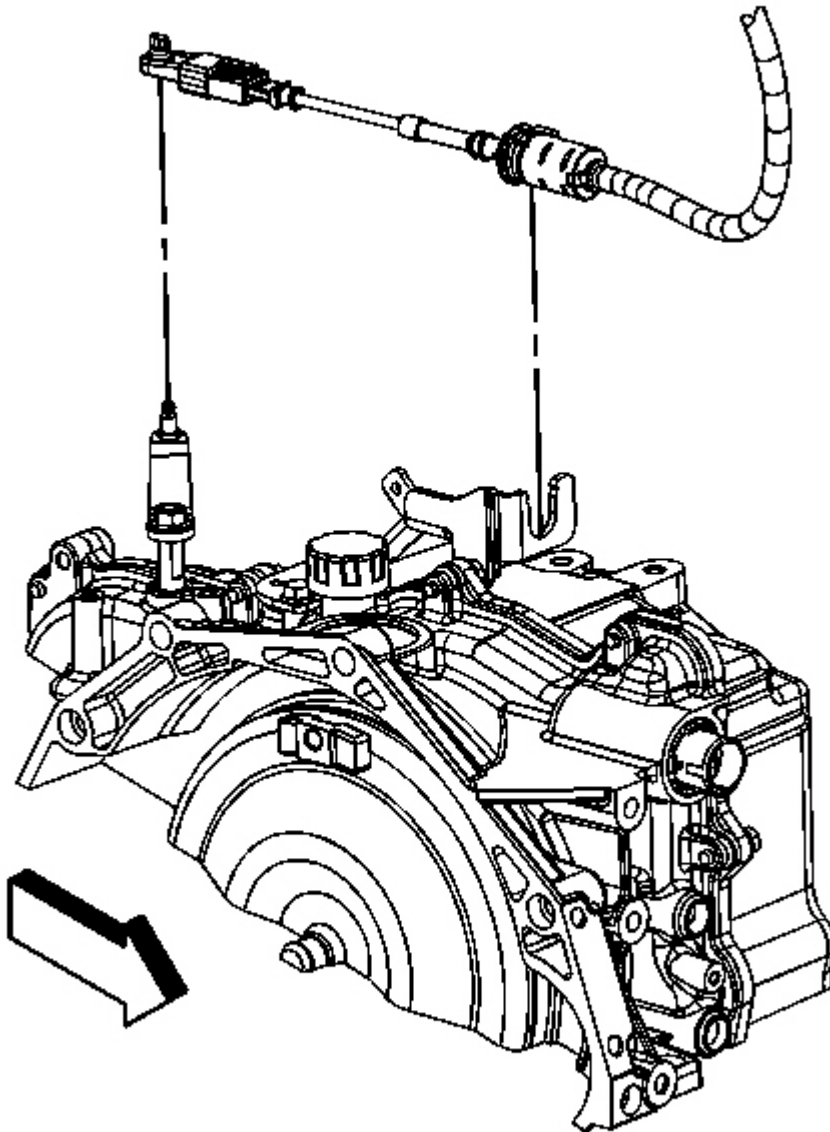


Fig. 215: Transaxle Shift Cable & Range Select Lever
Courtesy of GENERAL MOTORS CORP.

42. Connect the transmission shifter cable.
43. Install the battery tray and battery. Refer to **Battery Tray Replacement**

44. Remove the cooling module support.
45. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**
46. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**
47. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**
48. Perform the throttle learn procedure. Refer to **Throttle/Idle Learn**

ENGINE OIL AND OIL FILTER REPLACEMENT

Special Tools

EN-4487: Oil Filter Wrench

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

Removal Procedure

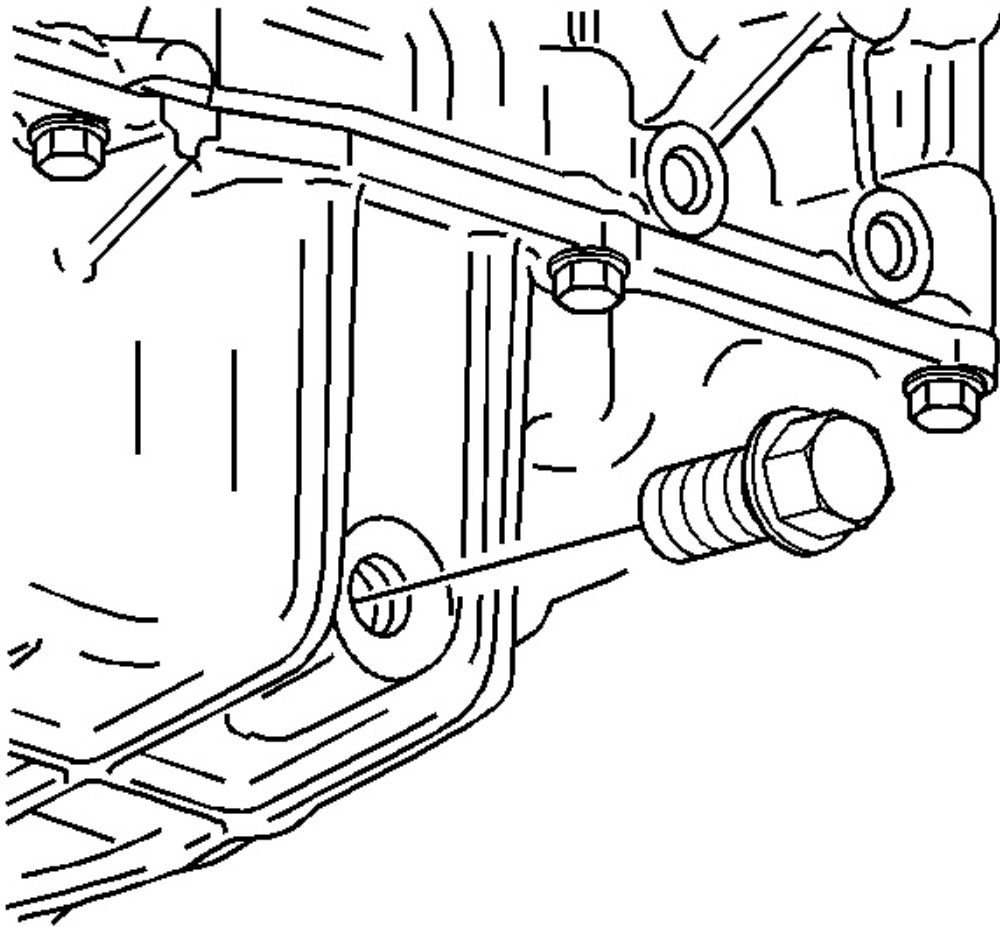


Fig. 216: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil drain plug.
3. Remove the oil pan drain plug.
4. Allow the oil to drain completely.

CAUTION: Refer to **Fastener Caution** .

5. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
6. Lower the vehicle.

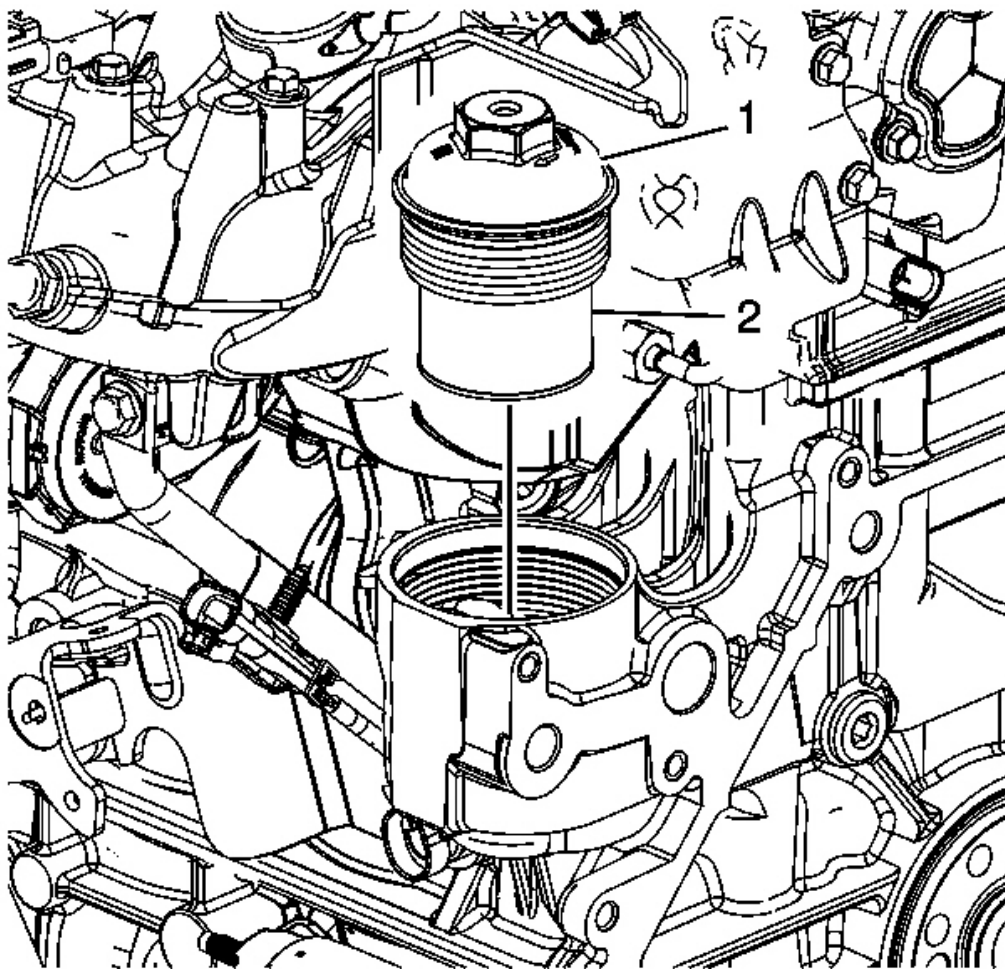


Fig. 217: Oil Filter & Cap

Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

7. Use an **EN-4487: Oil Filter Wrench** to loosen the oil filter cap (1).
8. Remove the oil filter cap (1) and filter (2).
9. Remove the filter from the cap.

Installation Procedure

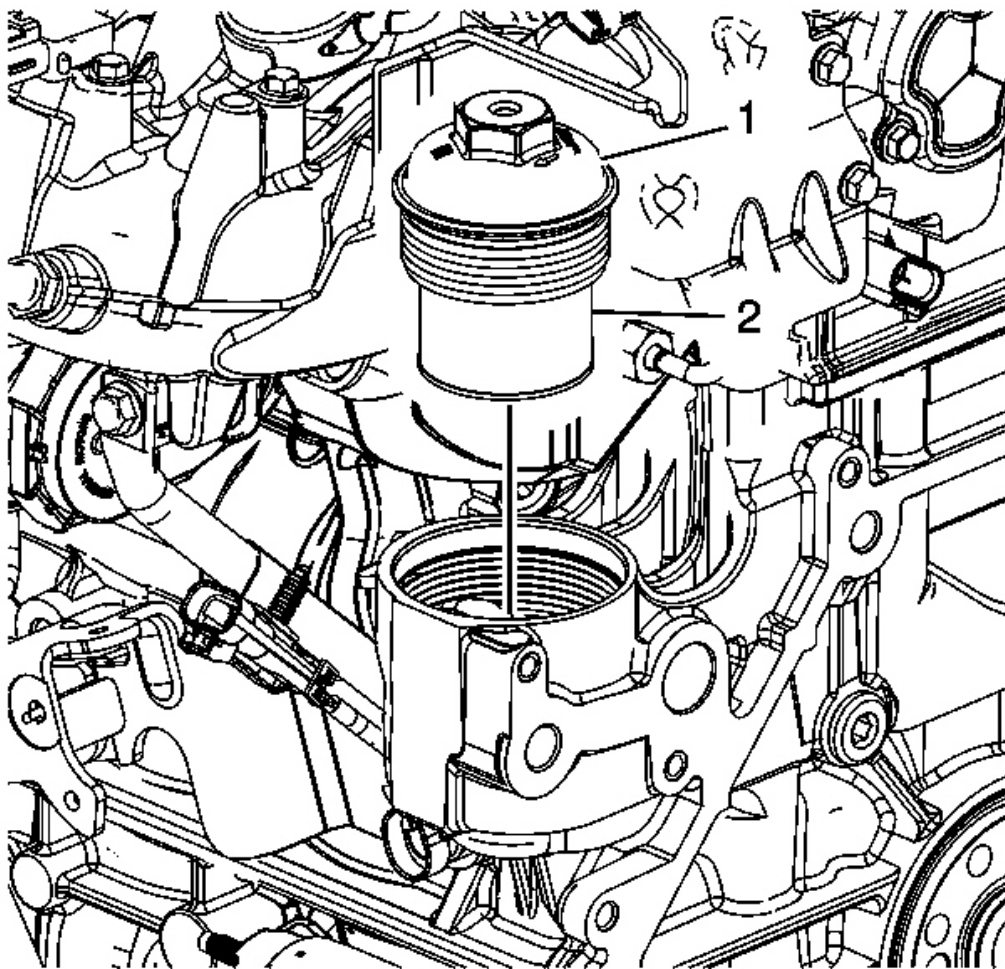


Fig. 218: Oil Filter & Cap

Courtesy of GENERAL MOTORS CORP.

1. Clean and lubricate the Oil-ring on the oil filter cap (1) with clean 5W30 engine oil.
2. Install the NEW oil filter (2) on the filter cap (1).
3. Install the oil filter cap and filter.

CAUTION: Over torquing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

4. Use an **EN-4487**: Oil Filter Wrench to install and tighten the oil filter cap (1) until fully seated. DO NOT exceed 25 N.m (18 lb ft).
5. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations (USA and Canada)** .

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

Special Tools

EN-44887: Oil Filter Wrench

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

Procedure

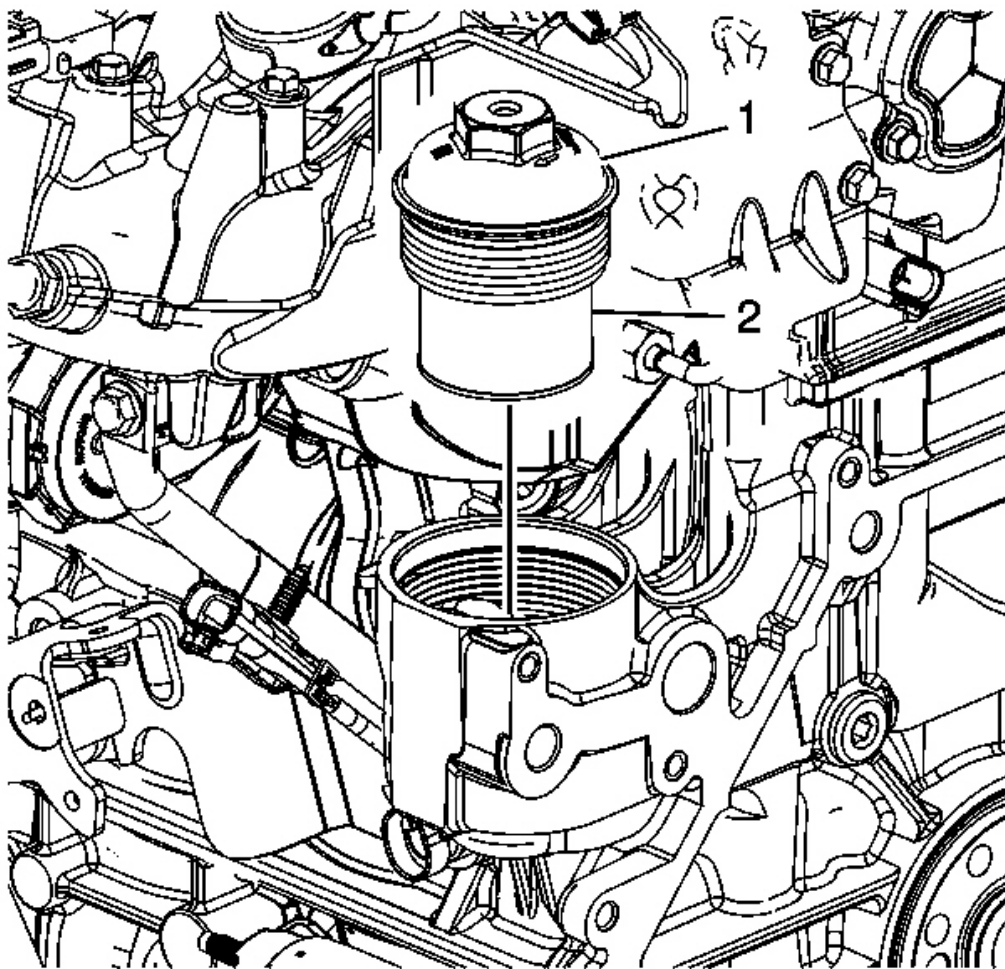


Fig. 219: Oil Filter & Cap

Courtesy of GENERAL MOTORS CORP.

1. Use **EN-44887**: wrench to remove the oil filter cap (1). Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter (2) from the cap and discard.
3. Clean the oil filter housing in the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).

5. Remove the water pump drain plug from the water pump and allow the coolant to drain from the water jacket.
6. Apply sealant to the water pump drain plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. Install the water pump drain plug and tighten to 20 N.m (15 lb ft).
8. If cleaning or repairing the engine block, it is not necessary to reinstall the plugs.

CRANKSHAFT BALANCER REMOVAL

Special Tools

EN 43653: Flywheel Holding Tool

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

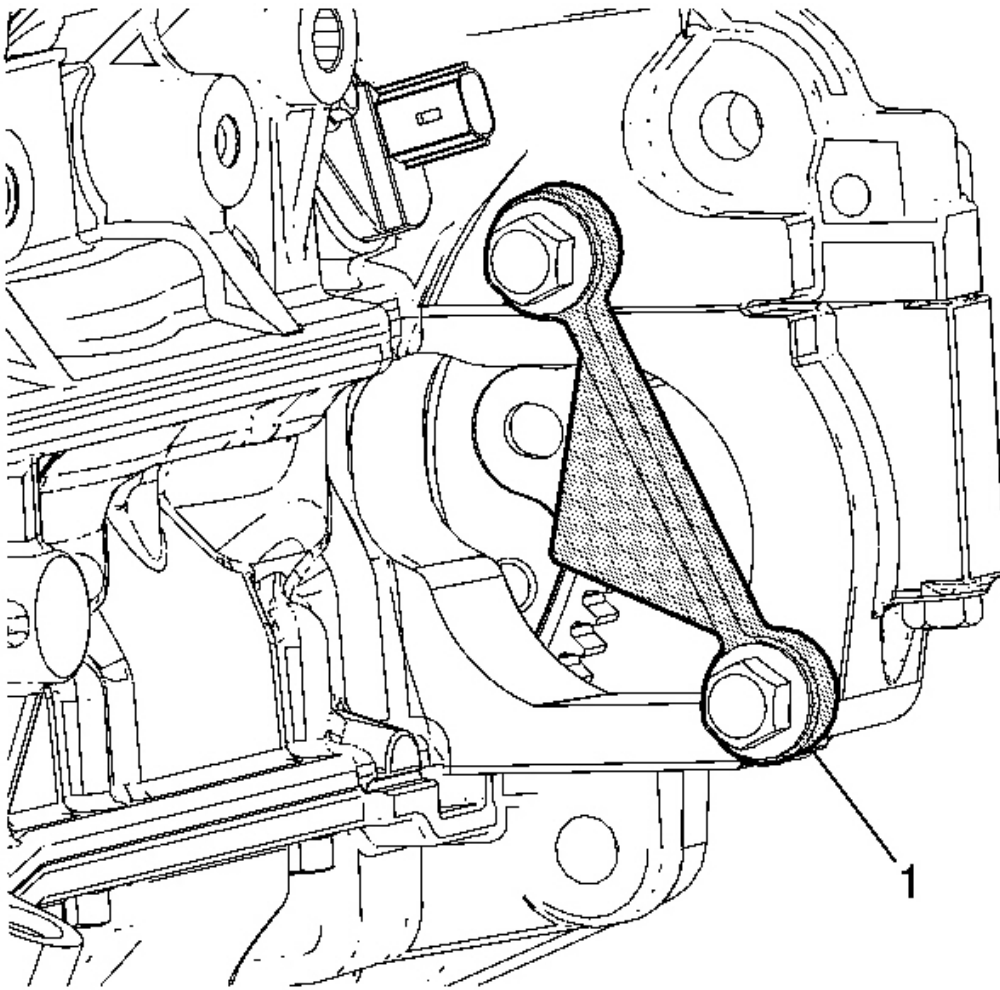


Fig. 220: View Of Crankshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

1. Install **EN 43653**: holding tool (1) in the starter assembly location, engaging the flywheel, in order to prevent crankshaft rotation.

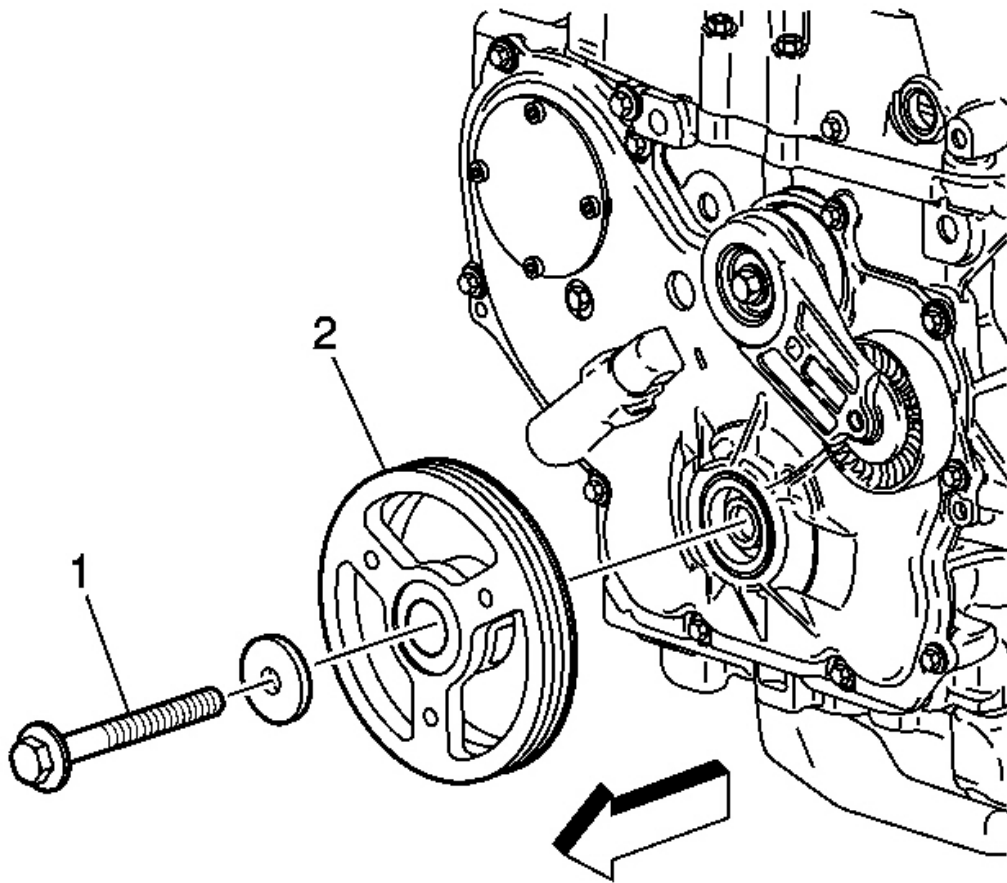


Fig. 221: Balancer & Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the balancer retaining bolt (1) and washer. Discard the bolt.
3. Remove the balancer (2) using a universal removal tool.

ENGINE FLYWHEEL REMOVAL

Special Tools

EN 43653: Flywheel Holding Tool

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

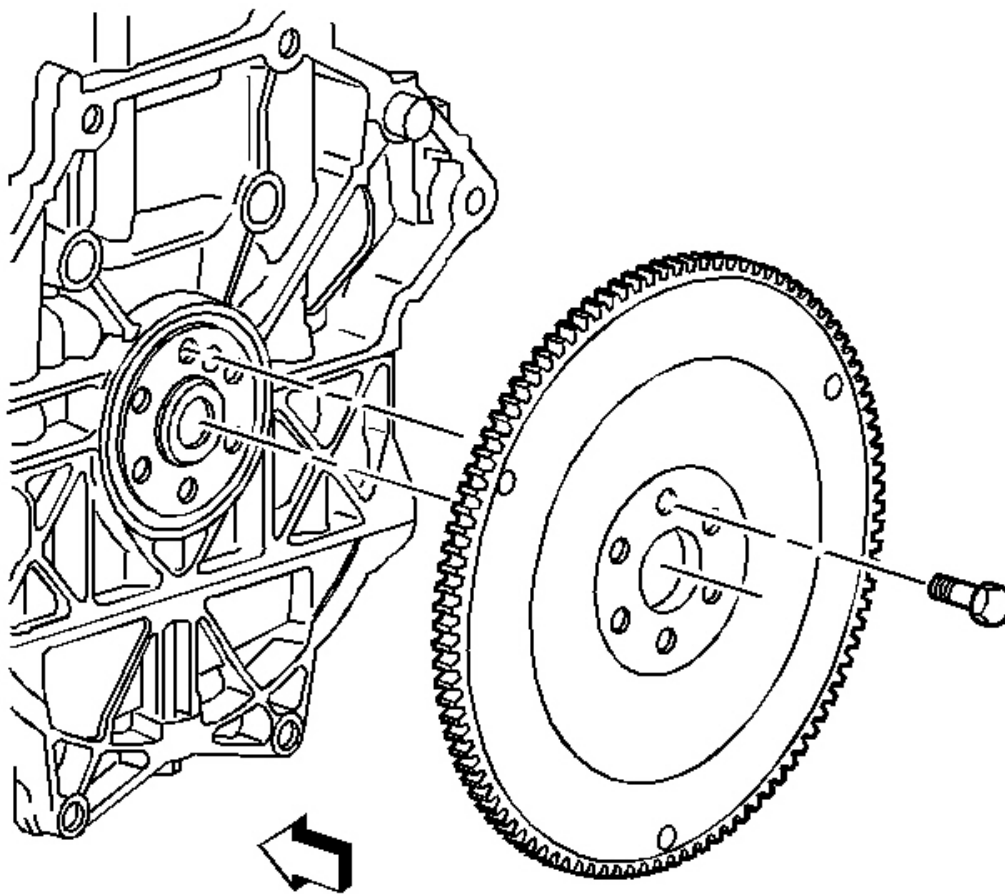


Fig. 222: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Ensure that **EN 43653**: tool is installed and engaging the flywheel to prevent crankshaft rotation.
2. Remove the flywheel attaching bolts.
3. Remove the flywheel.
4. Remove **EN 43653**: tool.

OIL LEVEL INDICATOR AND TUBE REMOVAL

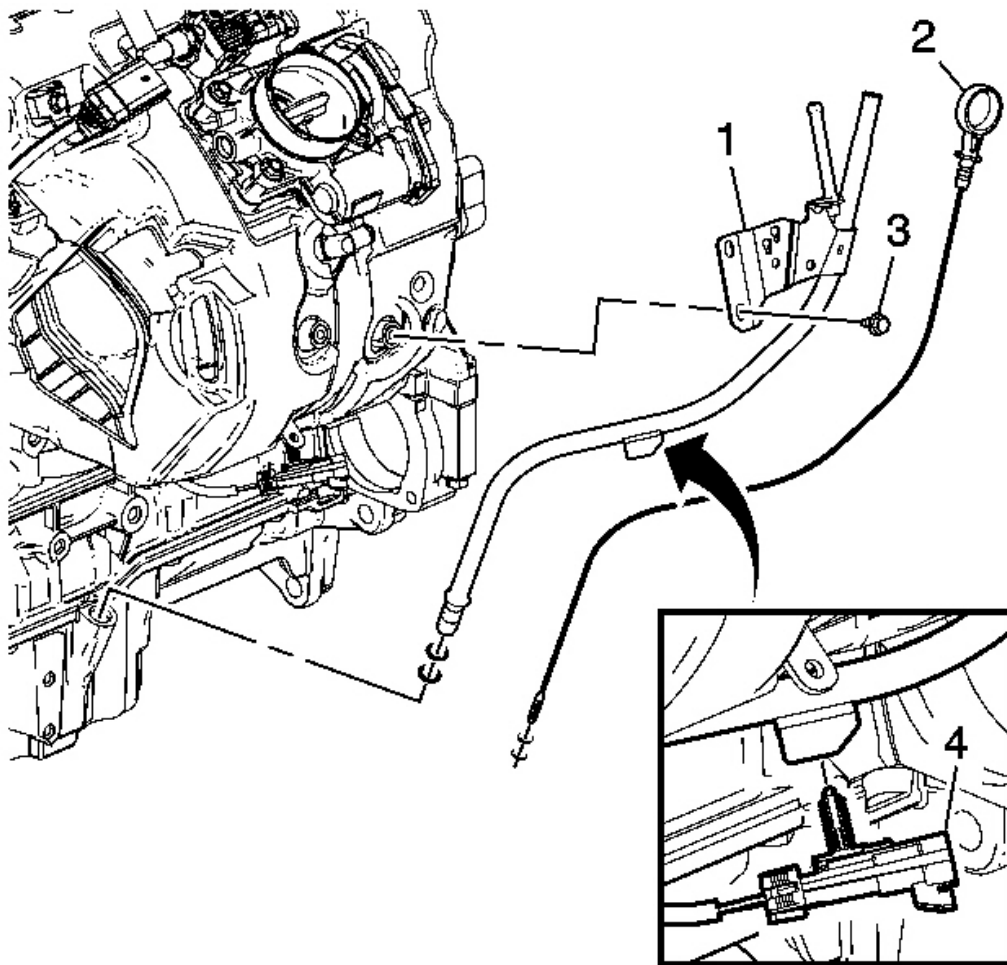


Fig. 223: Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove knock sensor connector (4) from the oil level indicator tube.
2. Remove the electrical wiring harness from the oil level indicator tube.
3. Remove the oil level indicator tube bracket bolt (3).
4. Remove the oil level indicator (2) and the oil level indicator tube (1) from the oil pan.
5. Inspect the O-ring and replace if necessary.

EXHAUST MANIFOLD REMOVAL

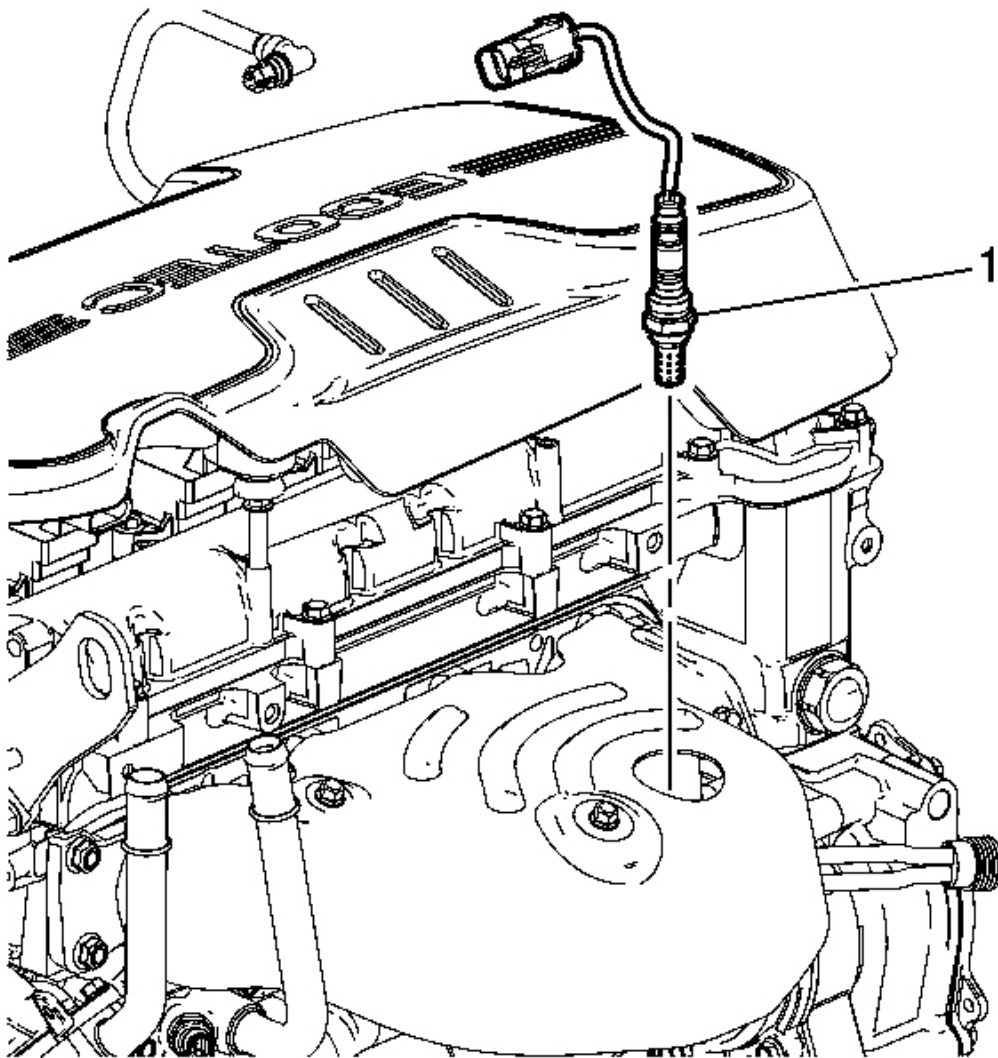


Fig. 224: Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the oxygen sensor (1).

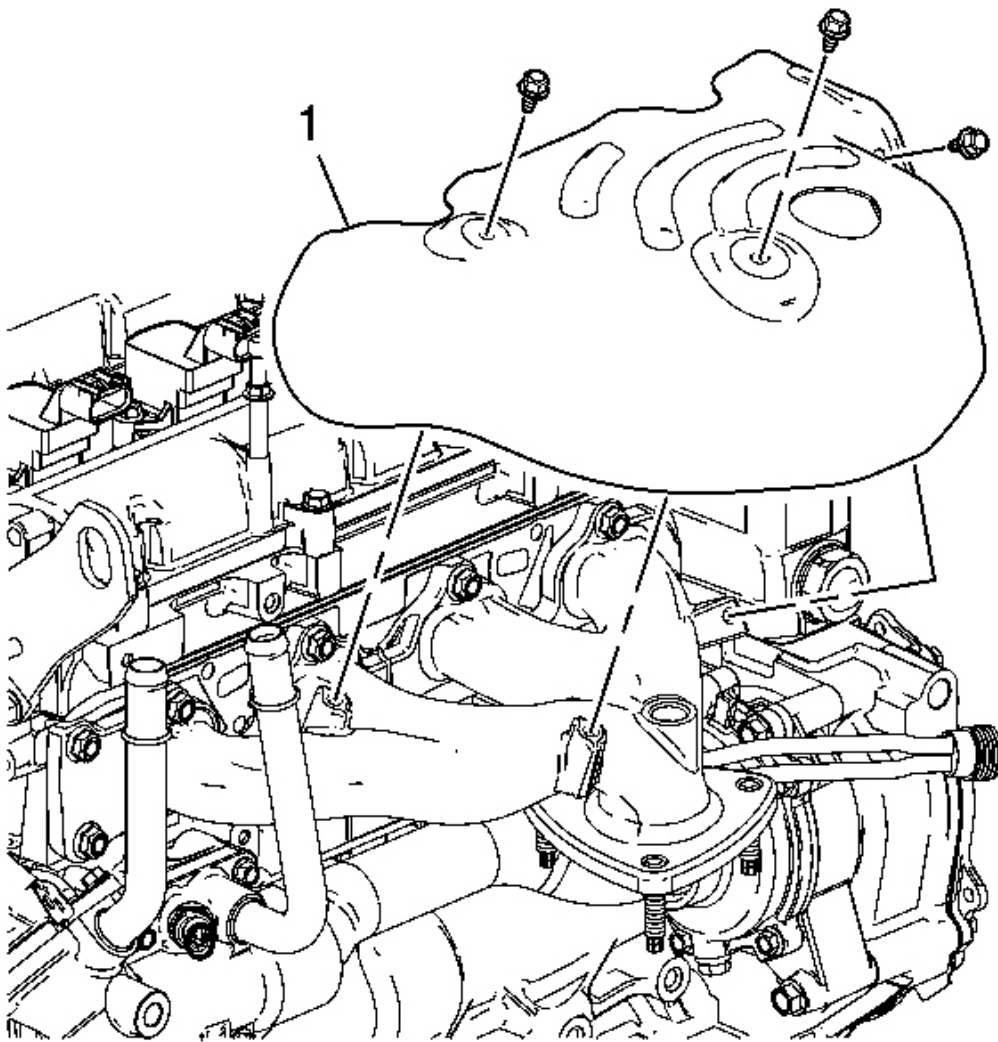


Fig. 225: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

2. Remove the exhaust manifold heat shield bolts.
3. Remove the exhaust manifold heat shield (1).

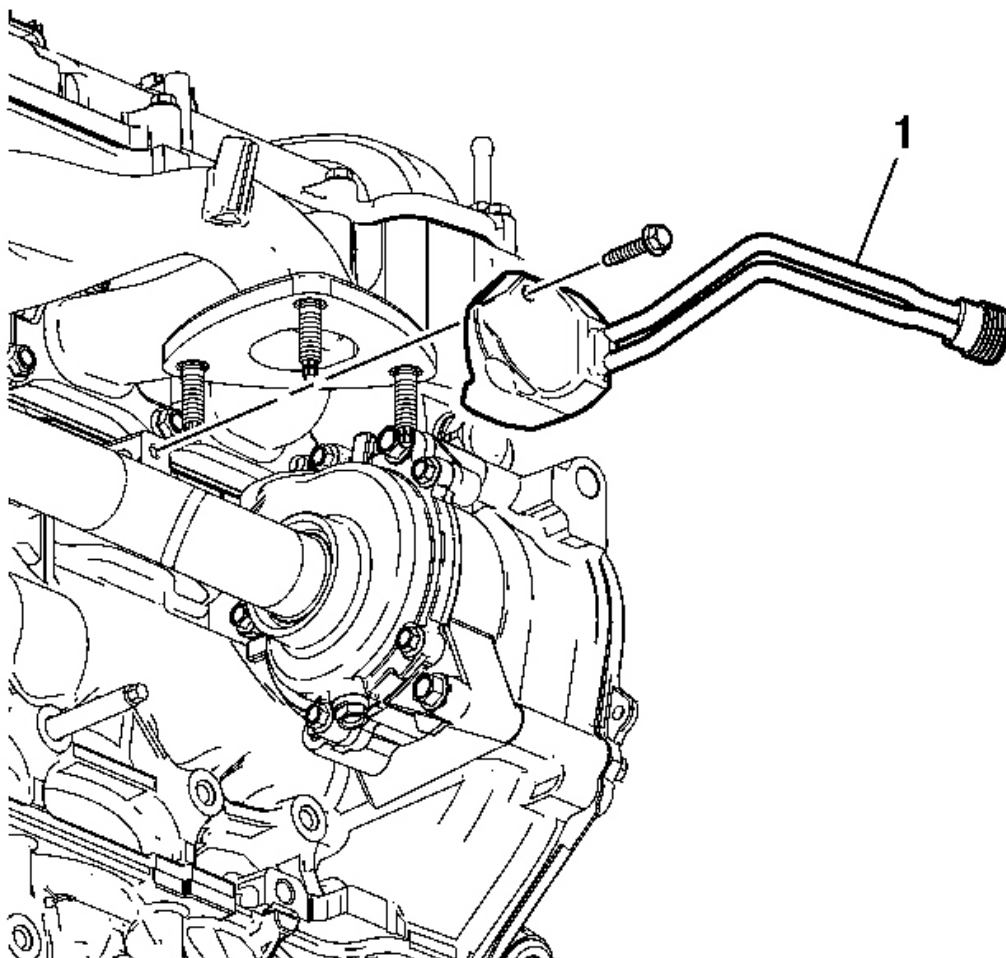


Fig. 226: Block Heater
Courtesy of GENERAL MOTORS CORP.

4. Remove the block heater (1), if equipped.

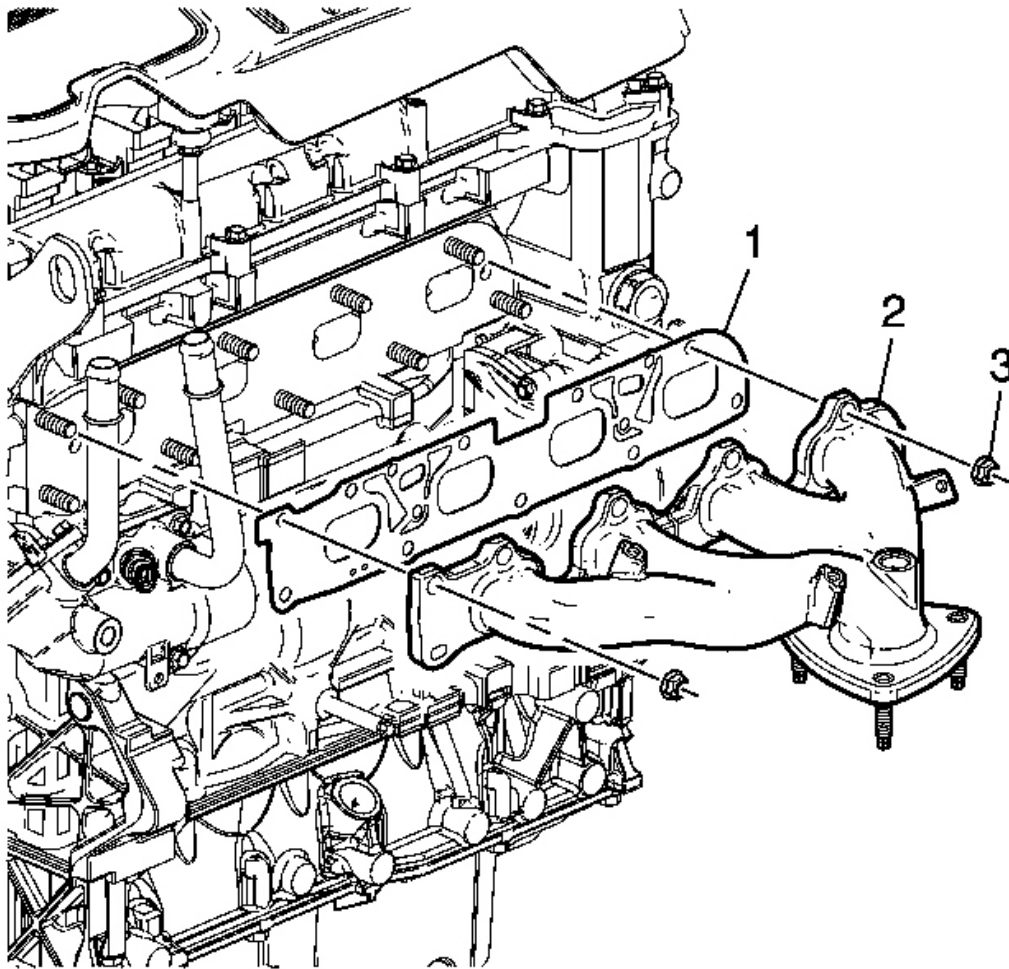


Fig. 227: Exhaust Manifold Components
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the exhaust manifold to cylinder head retaining nuts (1).
6. Remove the exhaust manifold (2).
7. Remove the exhaust manifold gasket (3).
8. Clean all of the sealing surfaces.
9. If the exhaust manifold is being replaced, transfer the following parts:
 - The exhaust manifold heat shield
 - The oxygen sensor

INTAKE MANIFOLD REMOVAL

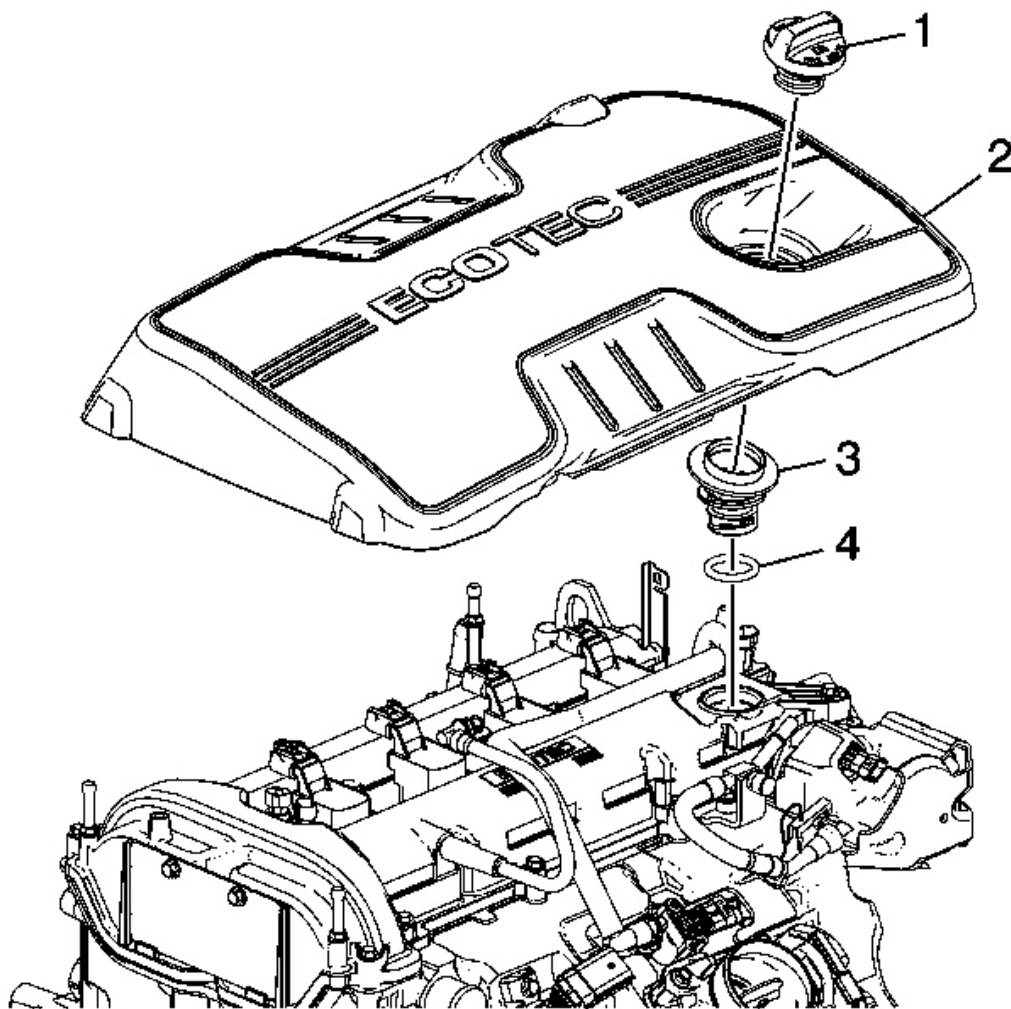


Fig. 228: Intake Manifold Cover Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold can be damaged if it is removed when the engine is hot.

1. Remove the oil fill cap (1).
2. Remove the intake manifold cover (2).
3. Remove the oil fill tube assembly (3) and O-ring (4).

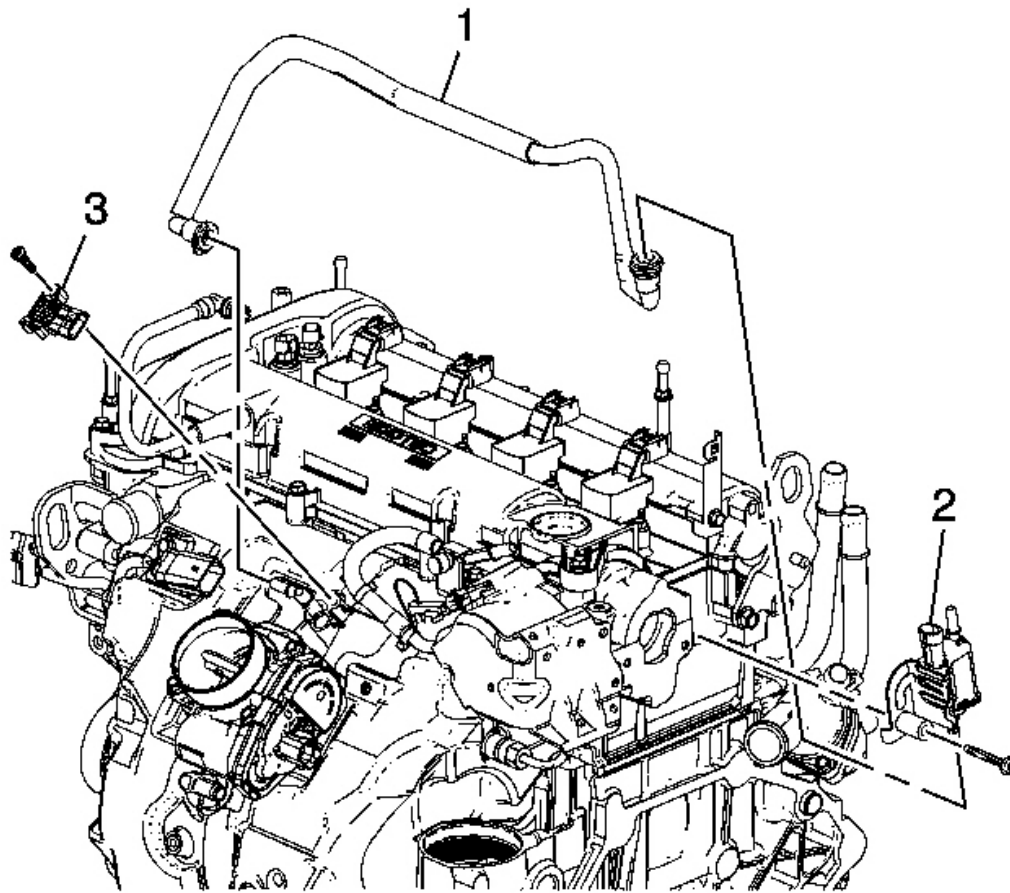


Fig. 229: EVAP Canister Valve, Tube & MAP Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the evaporative (EVAP) emission canister valve tube (1).
5. Remove the EVAP canister valve (2).
6. Remove the MAP sensor (3).

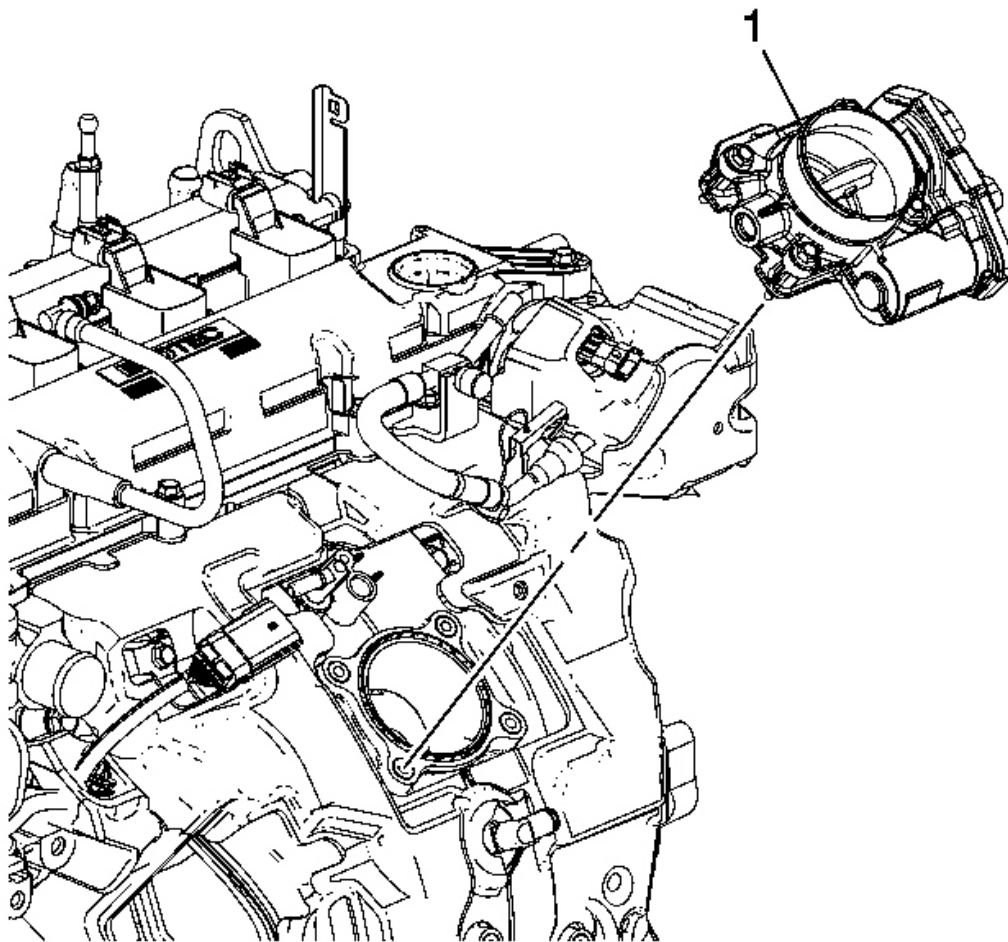


Fig. 230: Throttle Body
Courtesy of GENERAL MOTORS CORP.

7. Remove the throttle body (1).

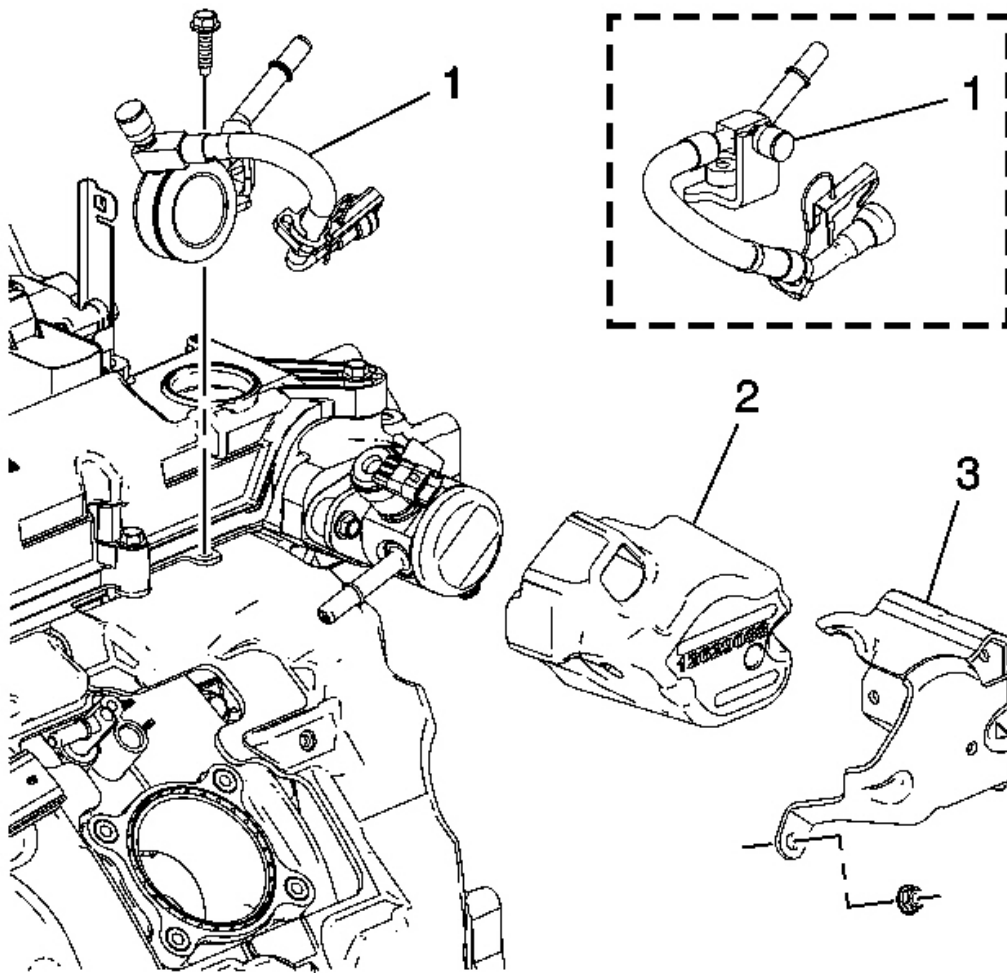


Fig. 231: Fuel Pump Components
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel pump cover nut and cover (3).

NOTE: The low pressure fuel pipe used is model dependent.

9. Remove the bracket bolt and low pressure fuel pipe assembly (1).
10. Remove the fuel pump insulator (2).

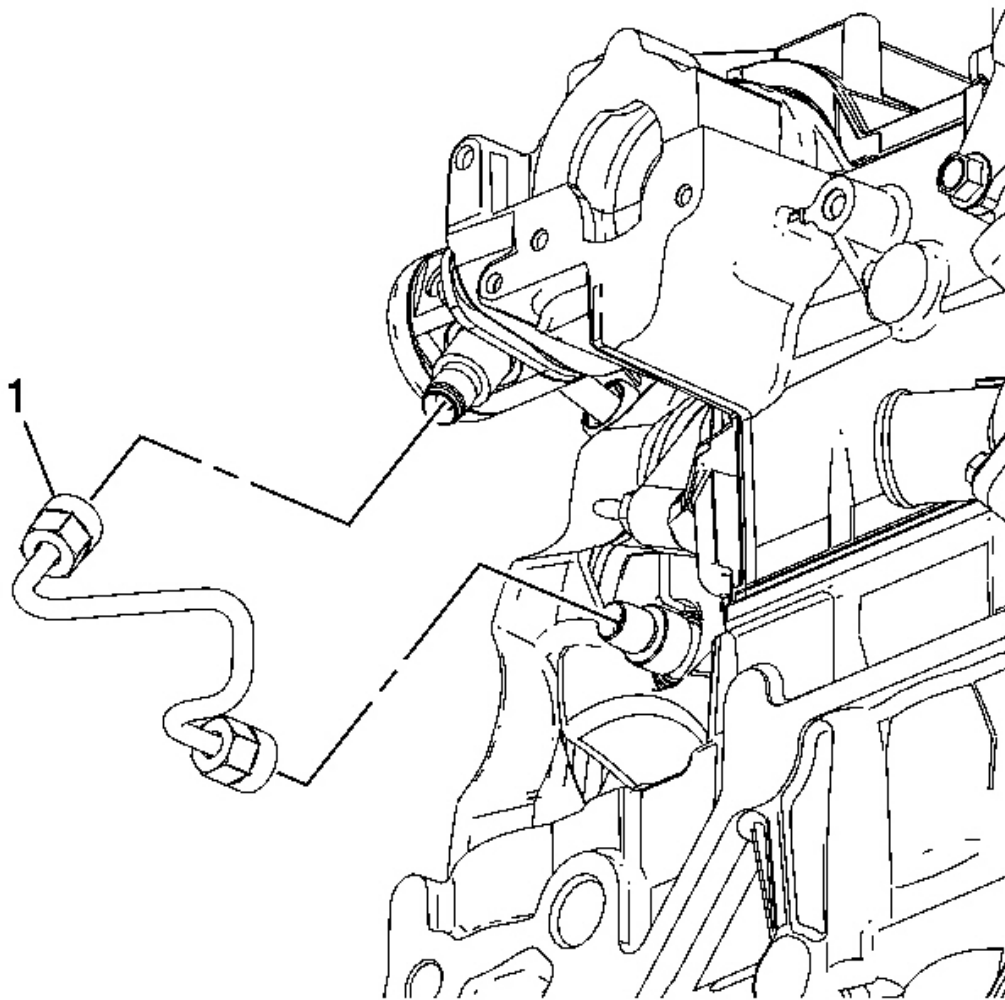


Fig. 232: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS CORP.

WARNING: Fuel that flows out at high pressure can cause serious injury to the skin and eyes. **ALWAYS** depressurize the fuel system before removing components that are under high fuel pressure.

11. Remove and discard the fuel feed intermediate pipe (1).

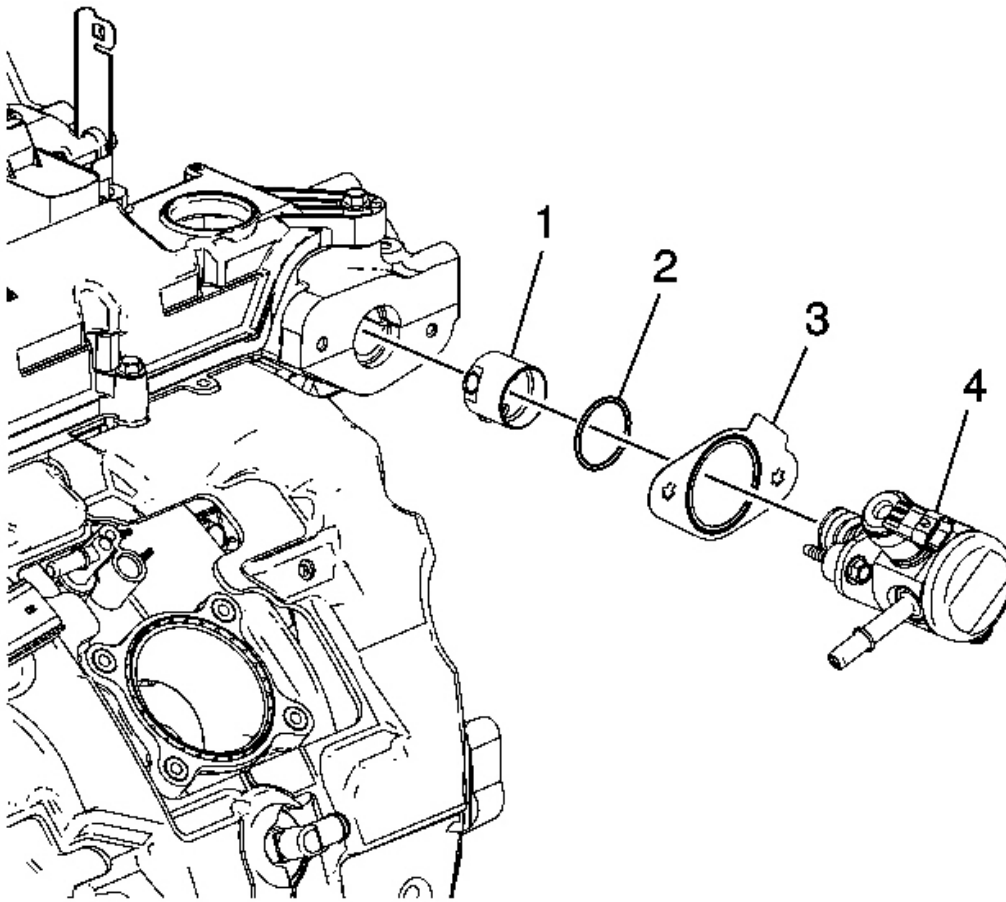


Fig. 233: Fuel Pump Assembly Components
Courtesy of GENERAL MOTORS CORP.

12. Remove the fuel pump assembly (4).
13. Remove and discard the fuel pump housing O-ring (2) and gasket (3).
14. Remove the fuel pump roller lifter (1).

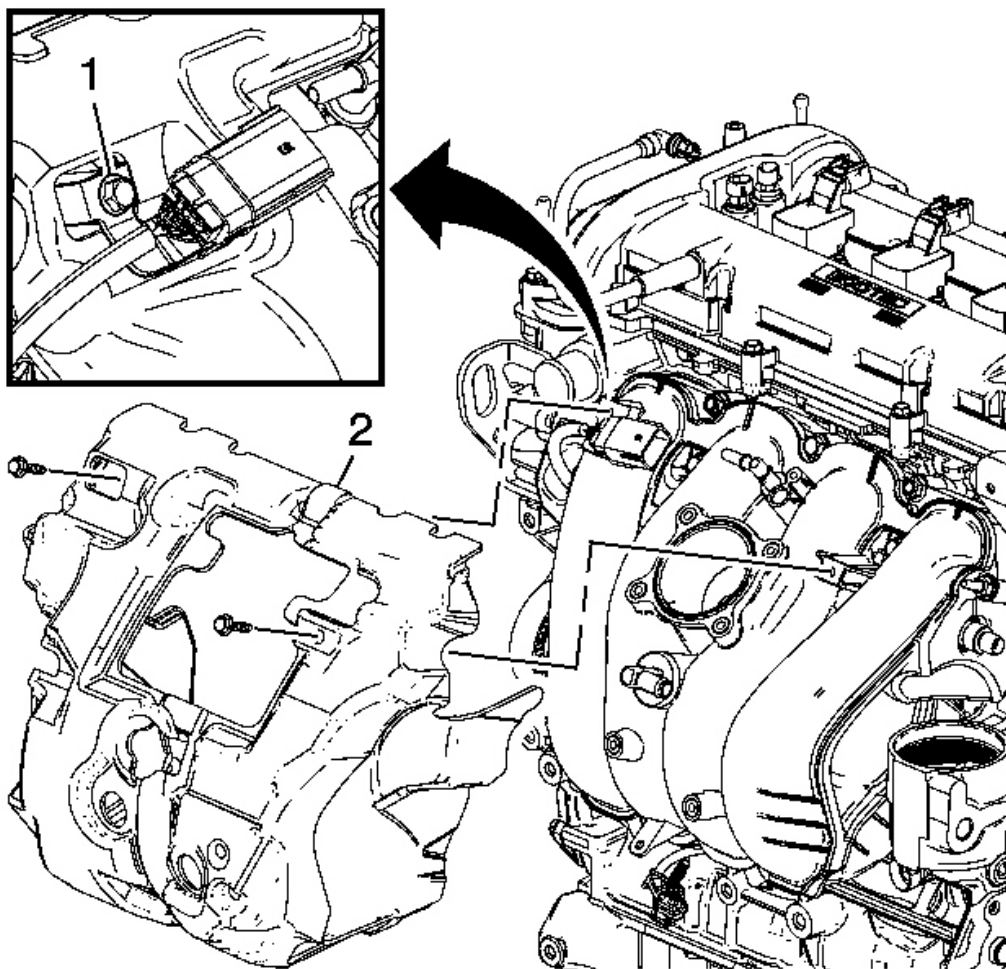


Fig. 234: Fuel Rail Harness Connector Bracket Bolt & Intake Manifold Insulator
Courtesy of GENERAL MOTORS CORP.

15. Remove the fuel rail harness connector bracket bolt (1) and intake manifold insulator bolt.
16. Remove the intake manifold insulator (2).

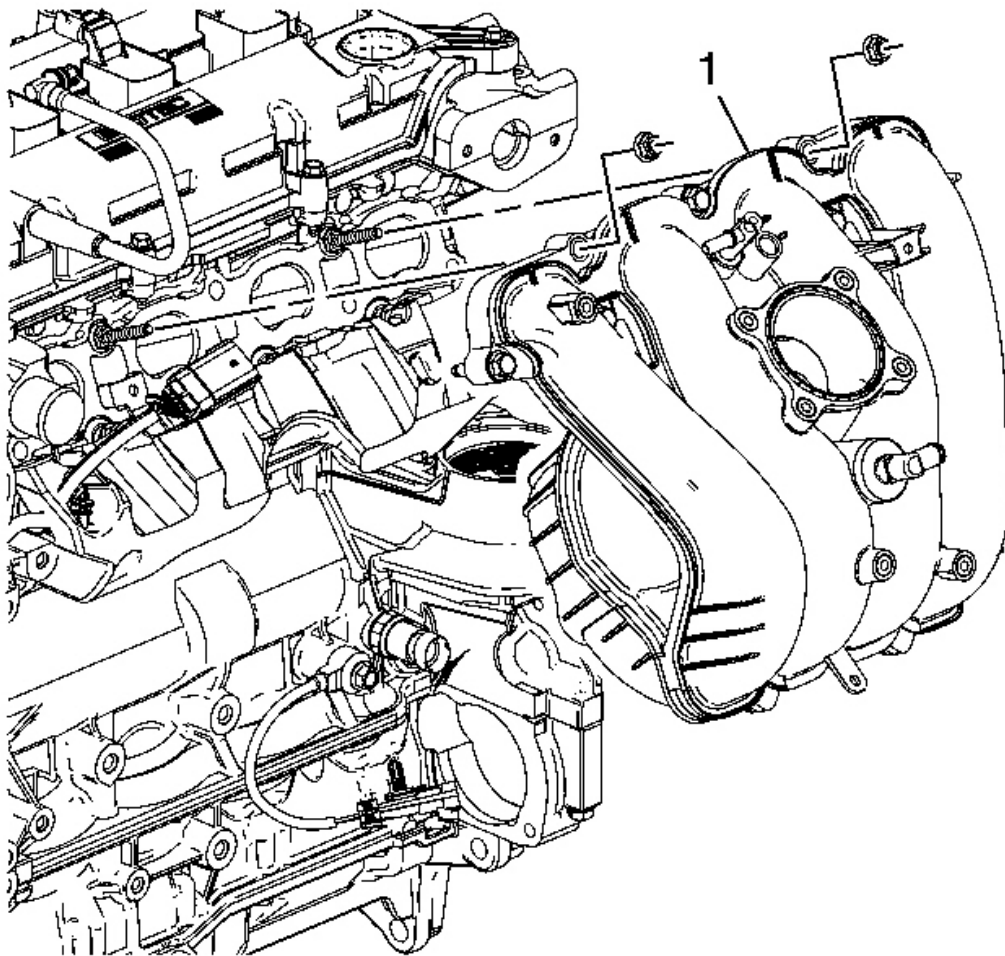


Fig. 235: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

17. Remove the intake manifold retaining nuts and bolts.
18. Remove the intake manifold (1).
19. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

FUEL RAIL AND INJECTORS REMOVAL

Special Tools

EN-49248: Fuel Rail Assembly Remover

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

Removal

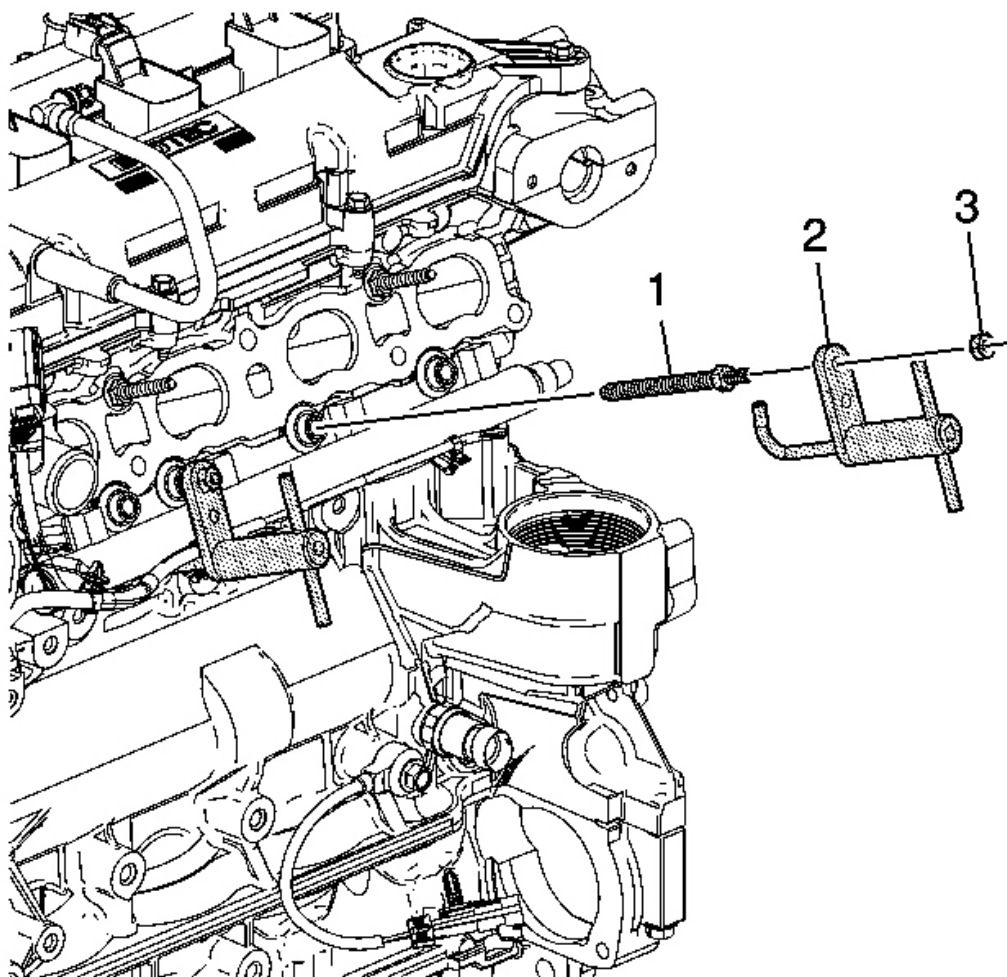


Fig. 236: Fuel Rail Remover

Courtesy of GENERAL MOTORS CORP.

1. Disconnect the electrical harness from the fuel rail harness connection.
2. Disconnect all 4 fuel injector electrical connections.
3. Remove the fuel rail assembly retaining bolts.

NOTE: Use care to avoid contact with the fuel rail harness during special tool installation and fuel rail removal.

4. Install **EN-49248**: studs (1) into the 2 center fuel rail assembly retaining bolt locations. Tighten the studs

to 22 N.m (16 lb ft).

5. Install **EN-49248**: remover (2) onto each stud, and engage the hooks to the fuel rail. Install the nuts (3) retaining the remover onto the studs and tighten until snug.

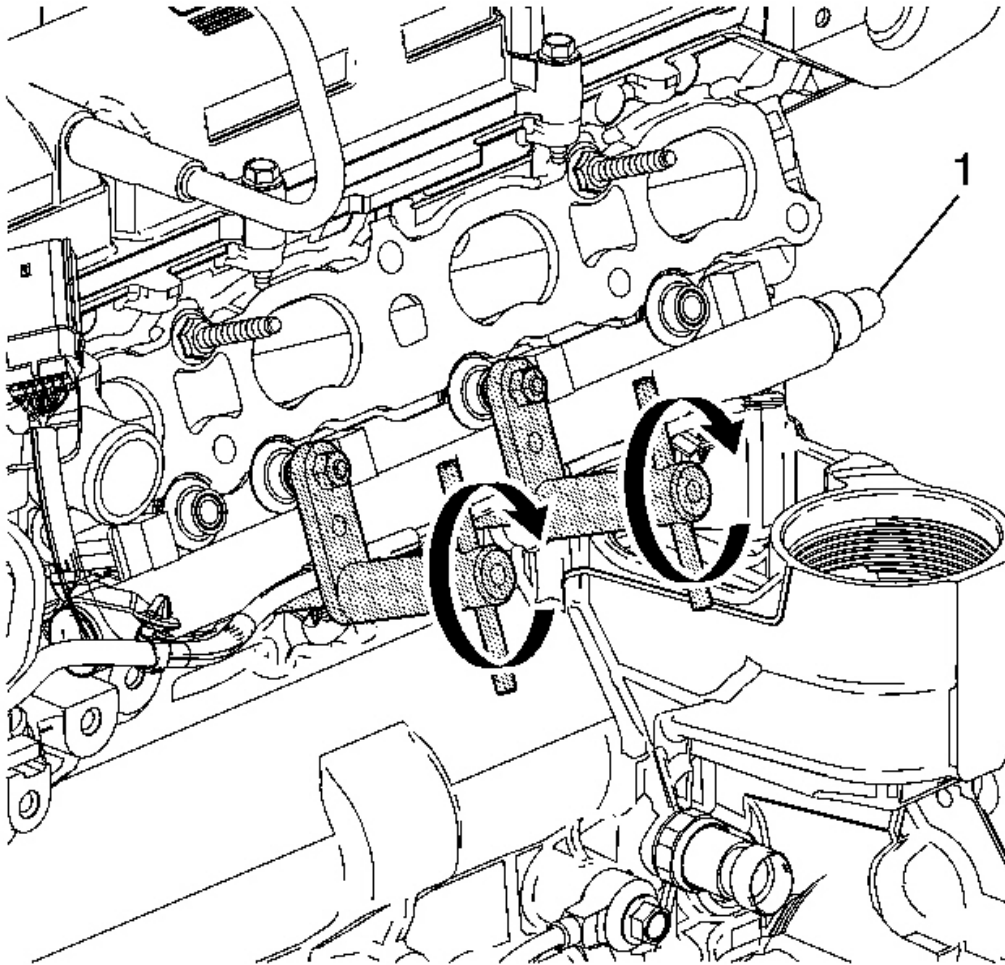


Fig. 237: Removing Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: EN-49248 will assist in the proper removal of the fuel rail assembly. Ensure that the following conditions are met:

- Turn the handles simultaneously in order to pull the fuel rail straight out along the fuel injector axis.
- DO NOT twist when pulling out on the fuel rail and injector assembly.

6. Using **EN-49248**: remover, remove the fuel rail assembly (1).

CAMSHAFT COVER REMOVAL

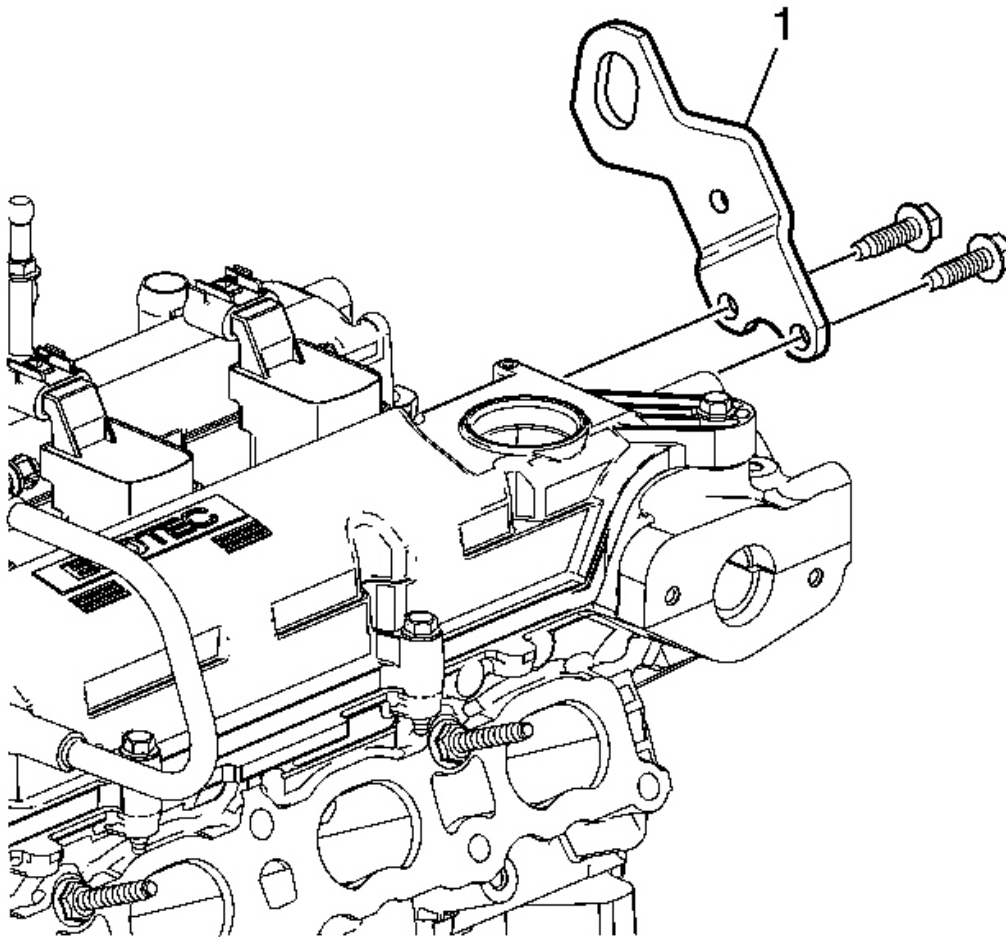


Fig. 238: Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the rear lift bracket (1).

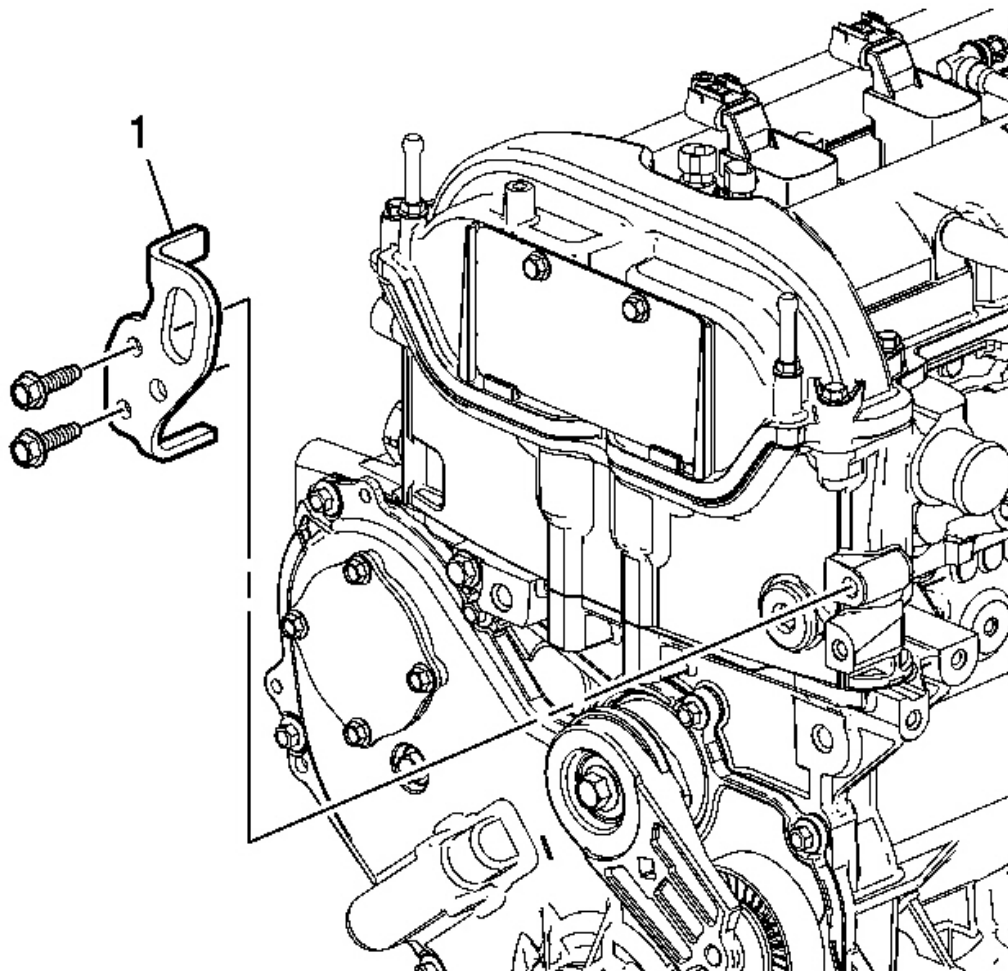


Fig. 239: Front Lift Bracket

Courtesy of GENERAL MOTORS CORP.

2. Remove the front lift bracket (1).

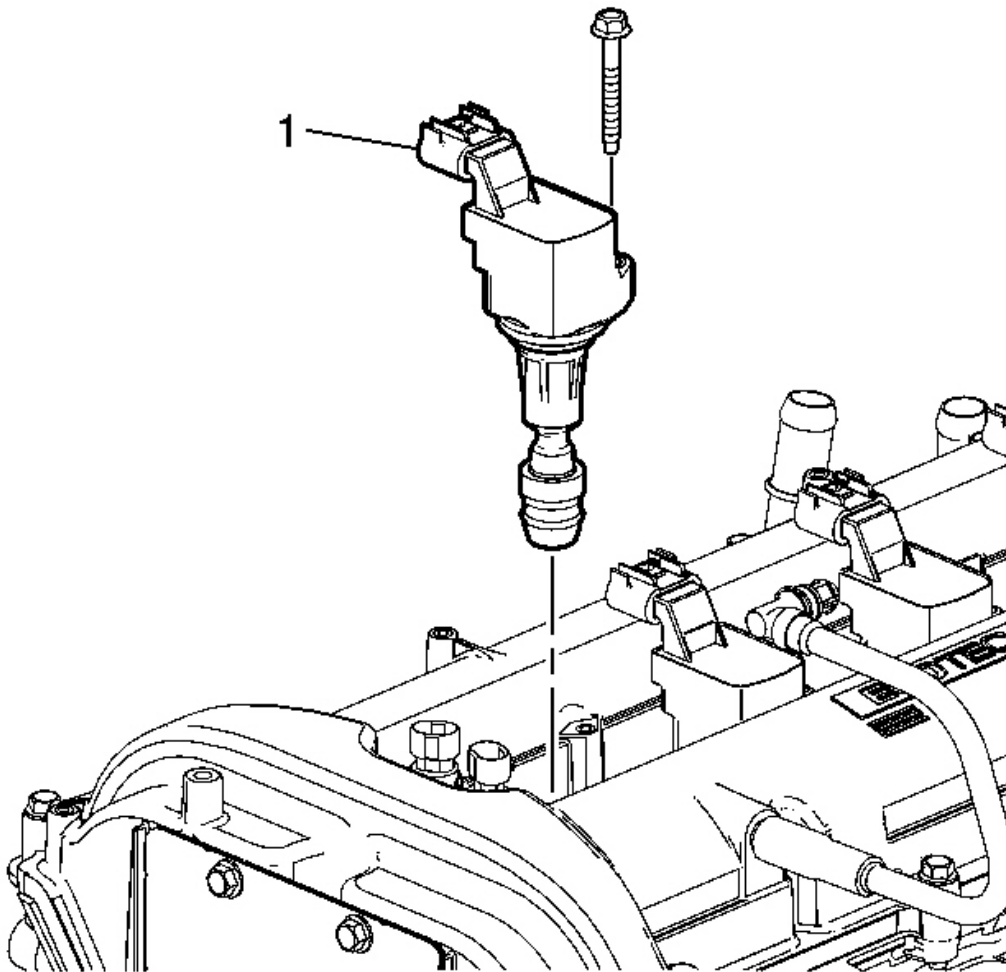


Fig. 240: Ignition Coil
Courtesy of GENERAL MOTORS CORP.

3. Remove the ignition coil (1).

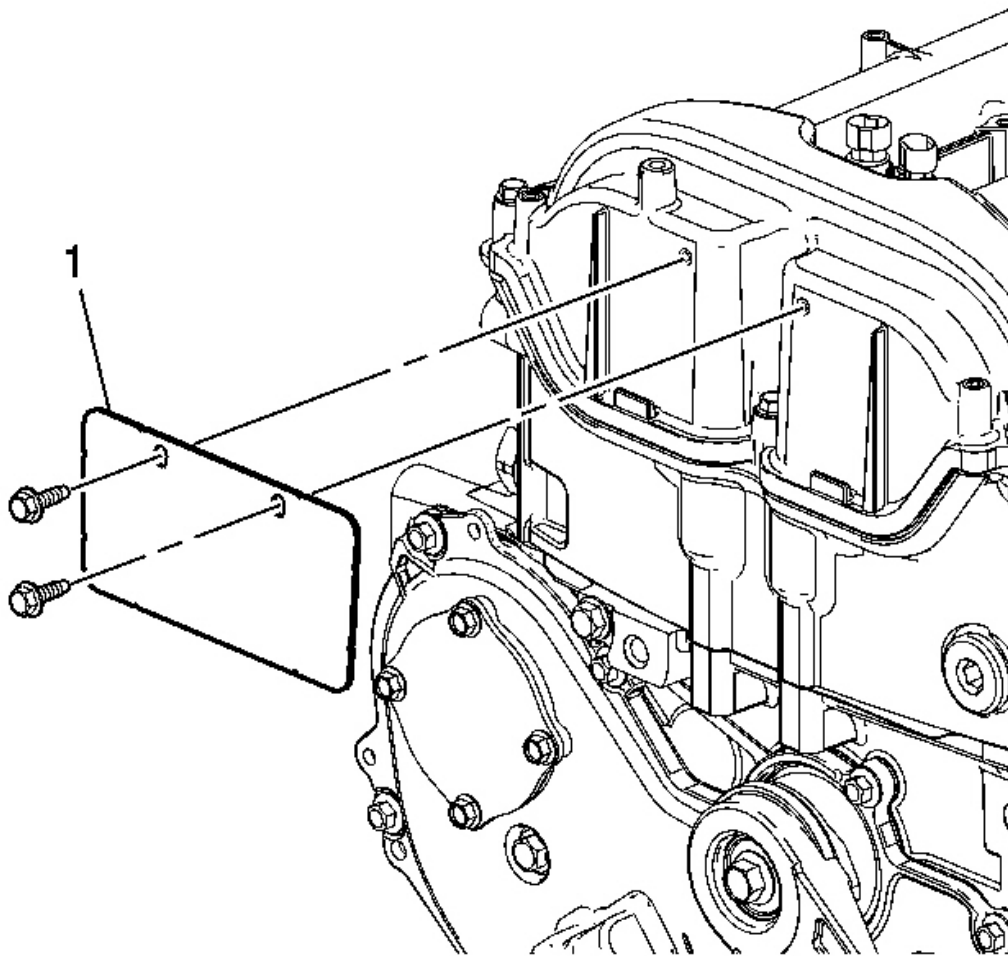


Fig. 241: Camshaft Housing Cover Insulator
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft housing cover insulator (1).

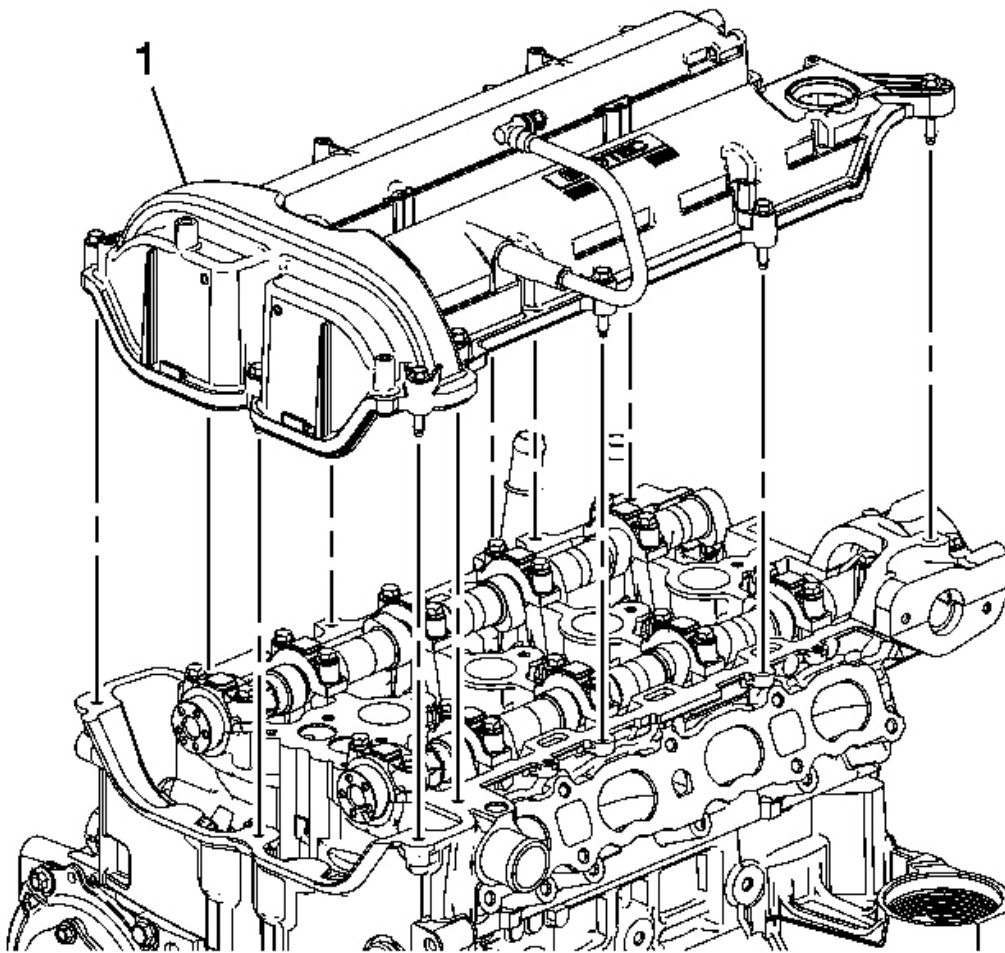


Fig. 242: Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: **DO NOT** remove the PCV hose from the camshaft cover. If damage to the hose or connectors is present, the cover must be replaced.

5. Remove the camshaft cover assembly (1).
6. Remove and discard the camshaft cover gasket, camshaft cover grommets, and camshaft cover bolts if they are serviced with the grommet.

ENGINE FRONT COVER AND OIL PUMP REMOVAL

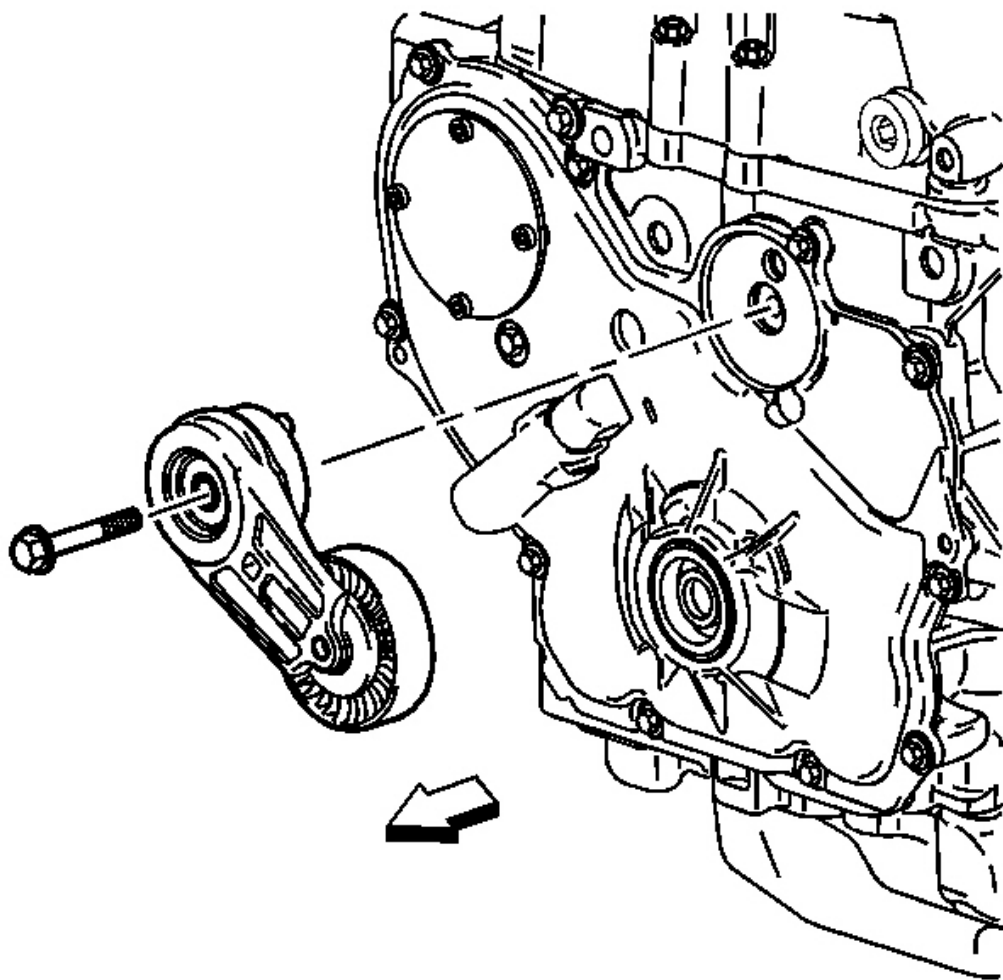


Fig. 243: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt tensioner bolt.
2. Remove the accessory drive belt tensioner.

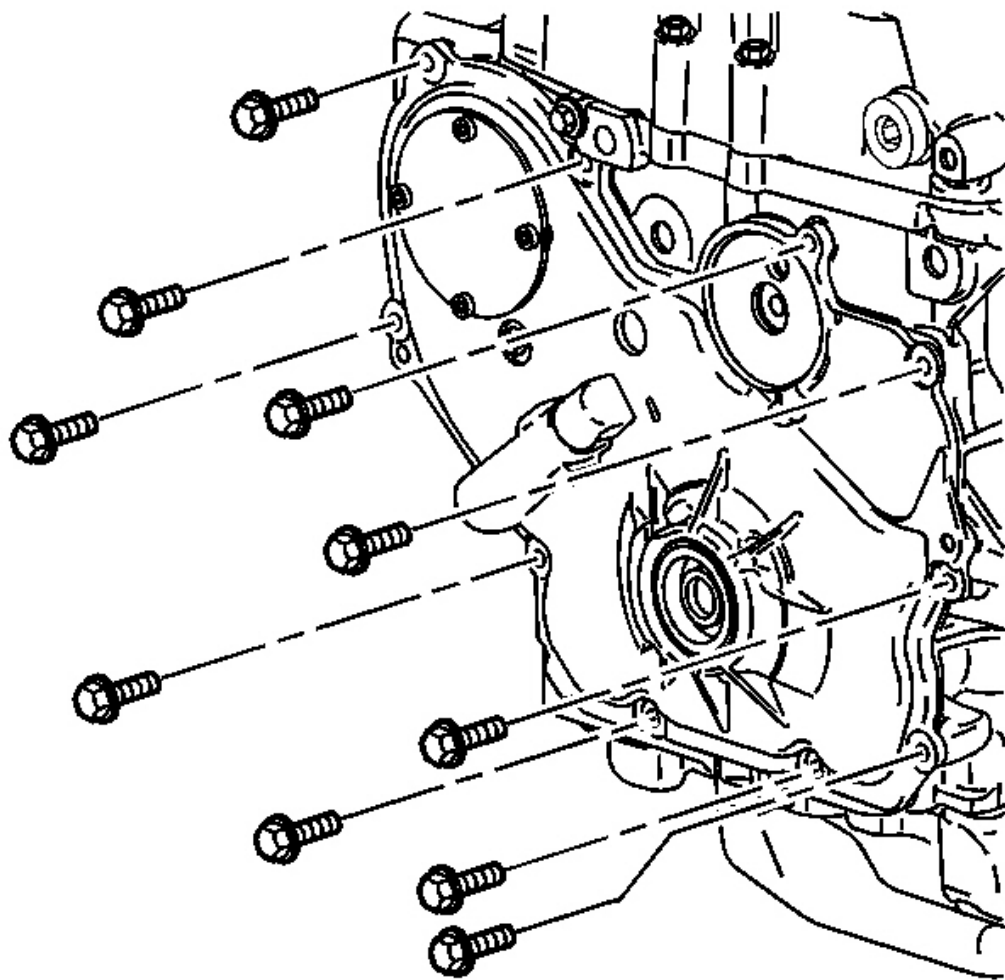


Fig. 244: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

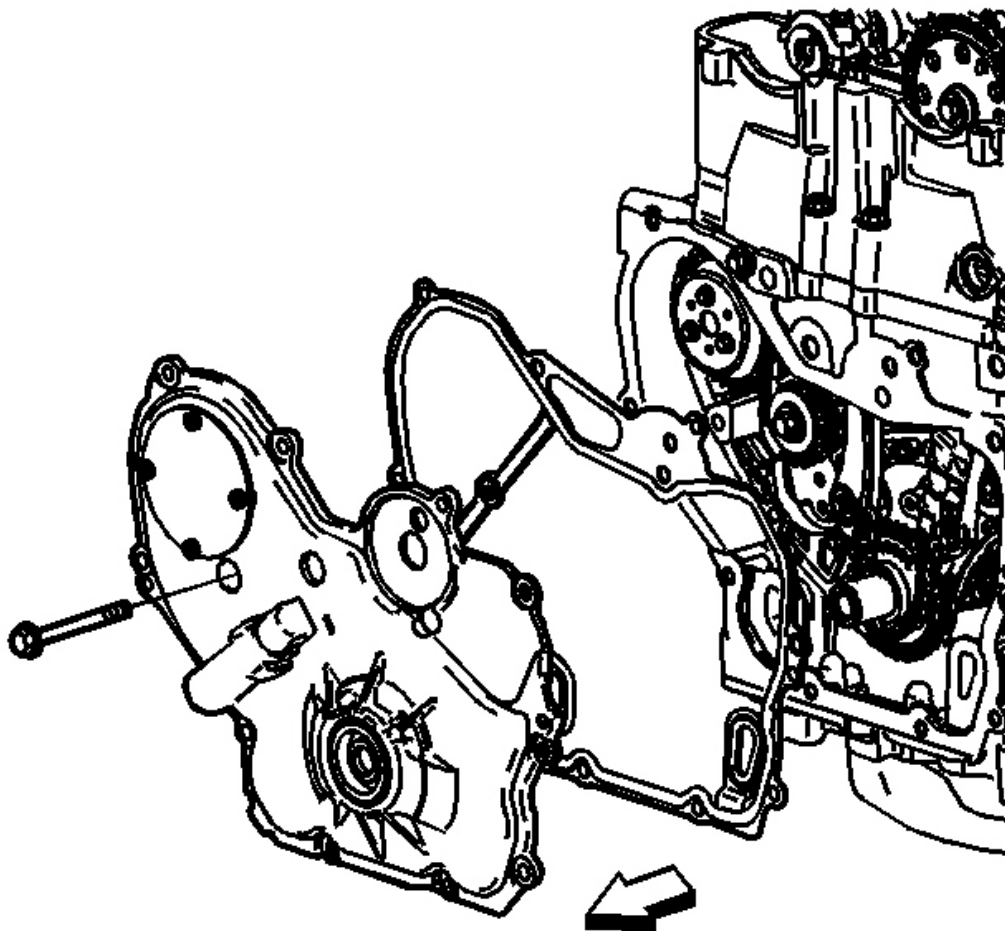


Fig. 245: View Of Engine Front Cover & Seal
Courtesy of GENERAL MOTORS CORP.

4. Remove the long water pump bolt.
5. Remove the engine front cover and gaskets.
6. Remove the crankshaft front cover oil seal with an appropriate tool.

TIMING CHAIN AND TENSIONER REMOVAL

Special Tools

EN-48953: Camshaft Actuator Locking Tool

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

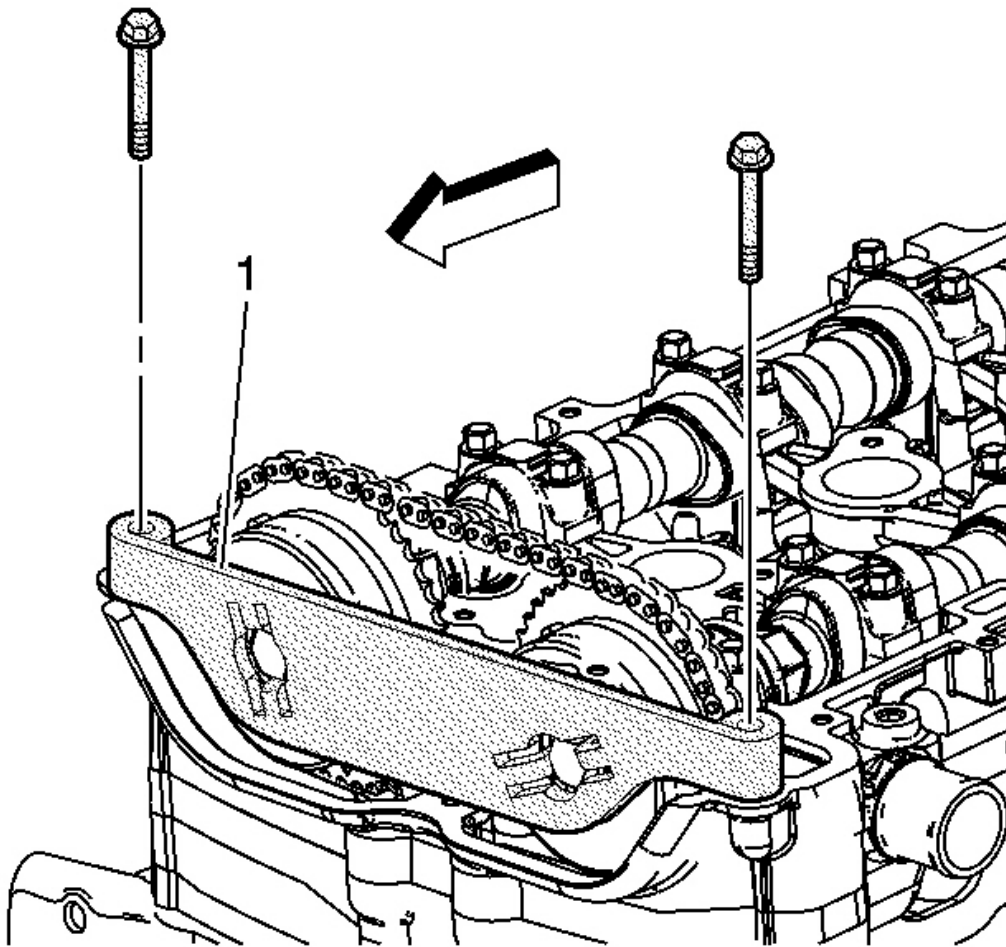


Fig. 246: View Locking Tool

Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft to install **EN-48953**: locking tool (1).

NOTE: Marking the chain and actuators is crucial to procedures operation. The camshaft actuator and timing chain must have oil removed from the surface prior to marking both actuators and chain.

2. Install **EN-48953**: locking tool onto the cylinder head and tighten to 10 N.m (89 lb in). If the intake camshaft actuator is moving independent of cam and is not locked, rotate the intake camshaft counterclockwise and the tool will hold the actuator, locking the actuator to the cam.
3. Loosen the intake camshaft actuator bolt.
4. Loosen the exhaust camshaft actuator bolt.

5. Remove **EN-48953**: locking tool.

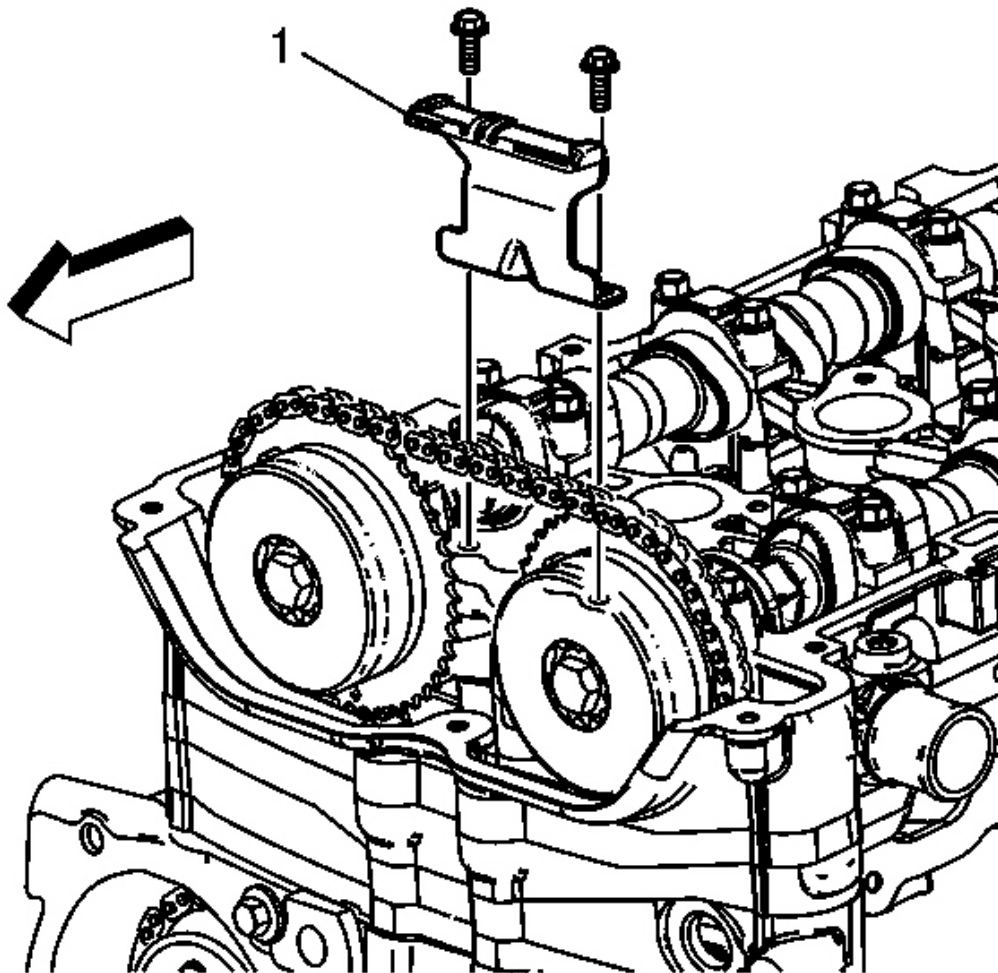


Fig. 247: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the upper timing chain guide bolts.
7. Remove the upper timing chain guide (1).

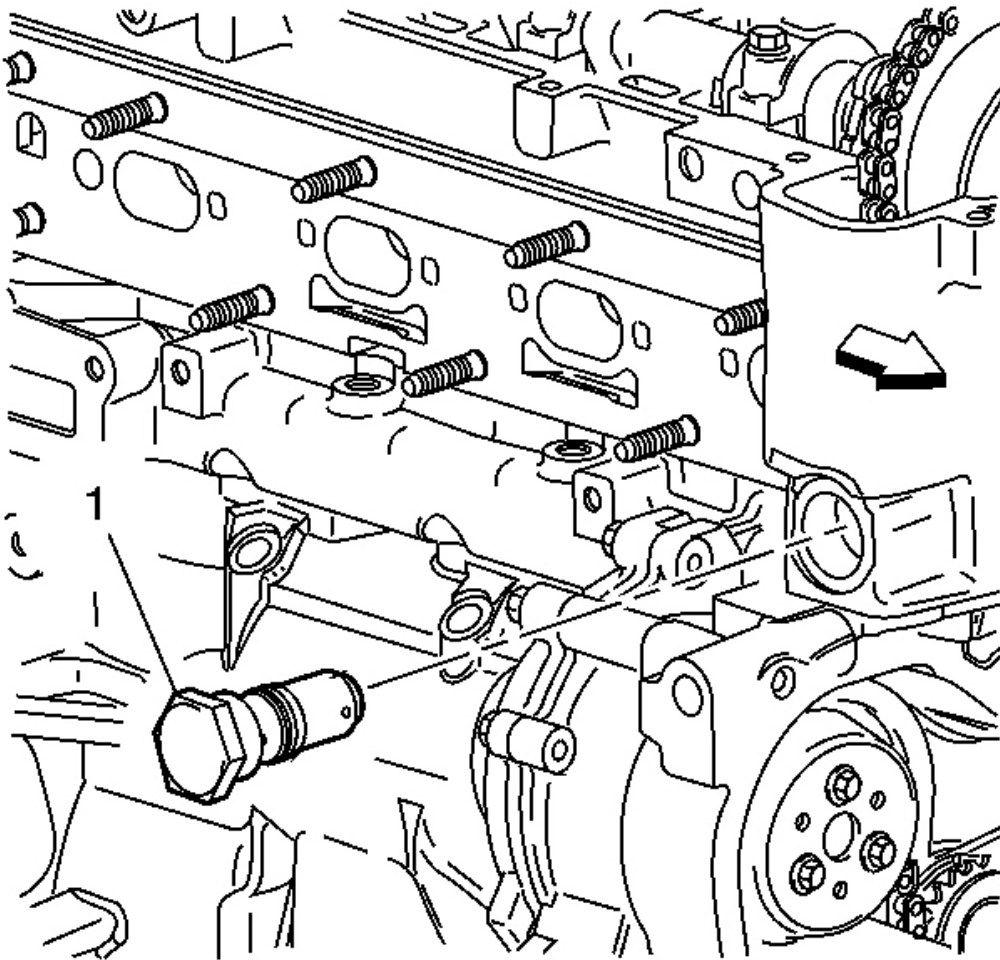


Fig. 248: Timing Chain Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

NOTE: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed.

8. Remove the timing chain tensioner plunger (1).

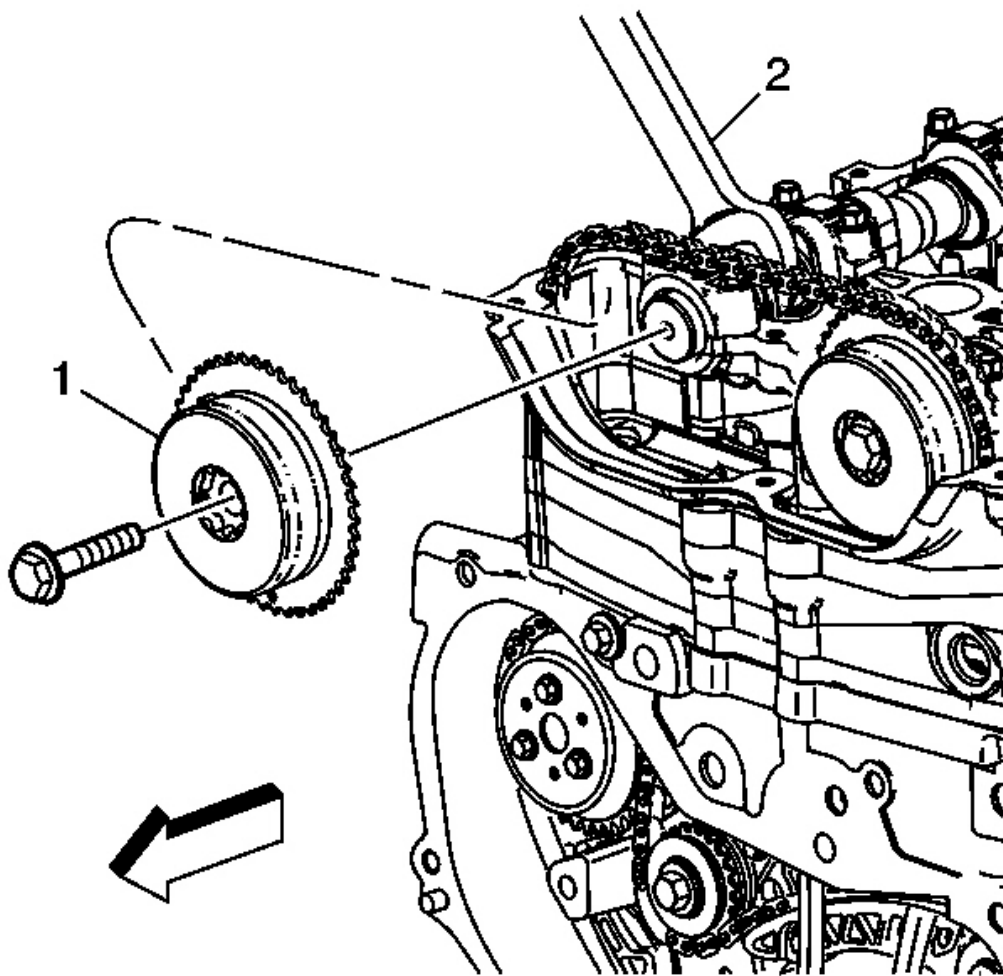


Fig. 249: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

9. Locate hex on the exhaust camshaft and hold with a wrench (2).
10. Remove the exhaust camshaft bolt and the exhaust camshaft actuator (1). Discard the bolt.

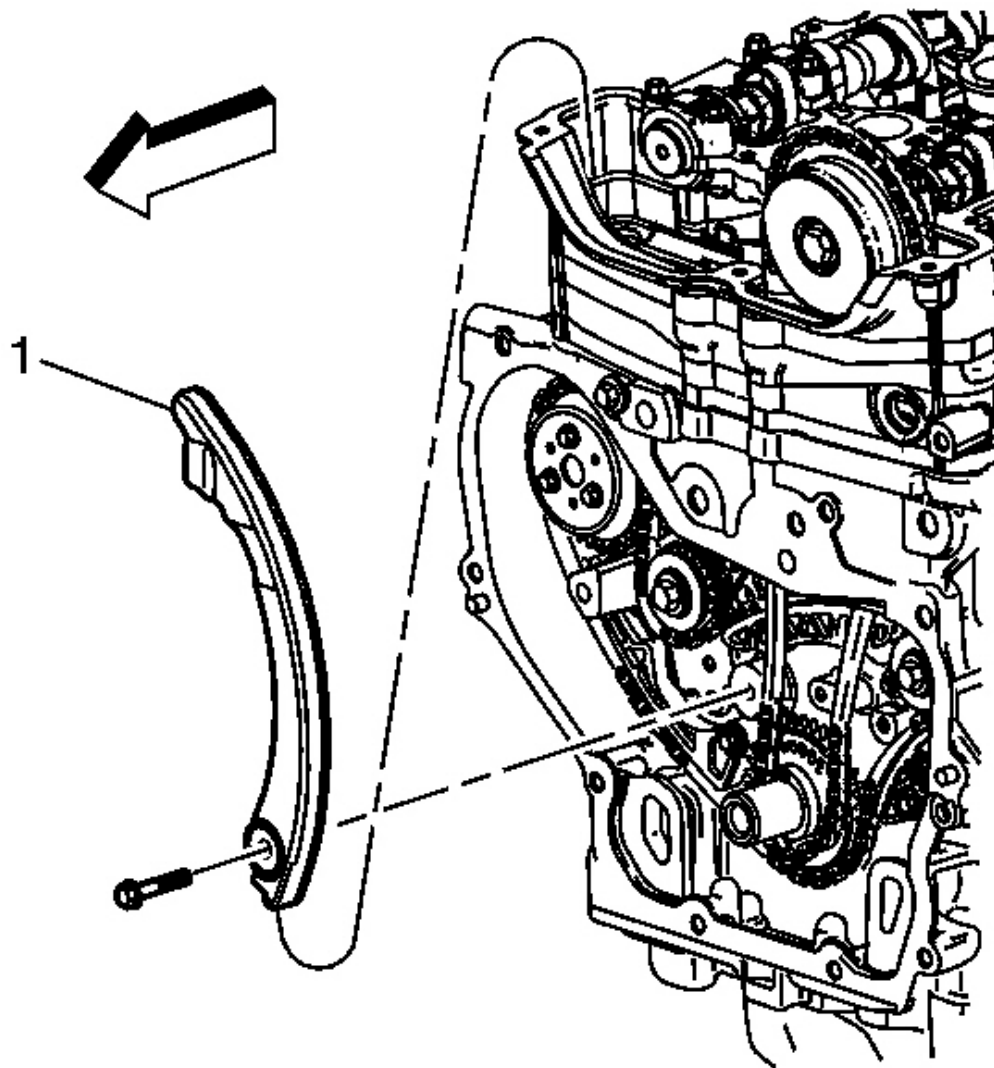


Fig. 250: Adjustable Timing Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the adjustable timing chain guide bolt.
12. Remove the adjustable timing chain guide (1).

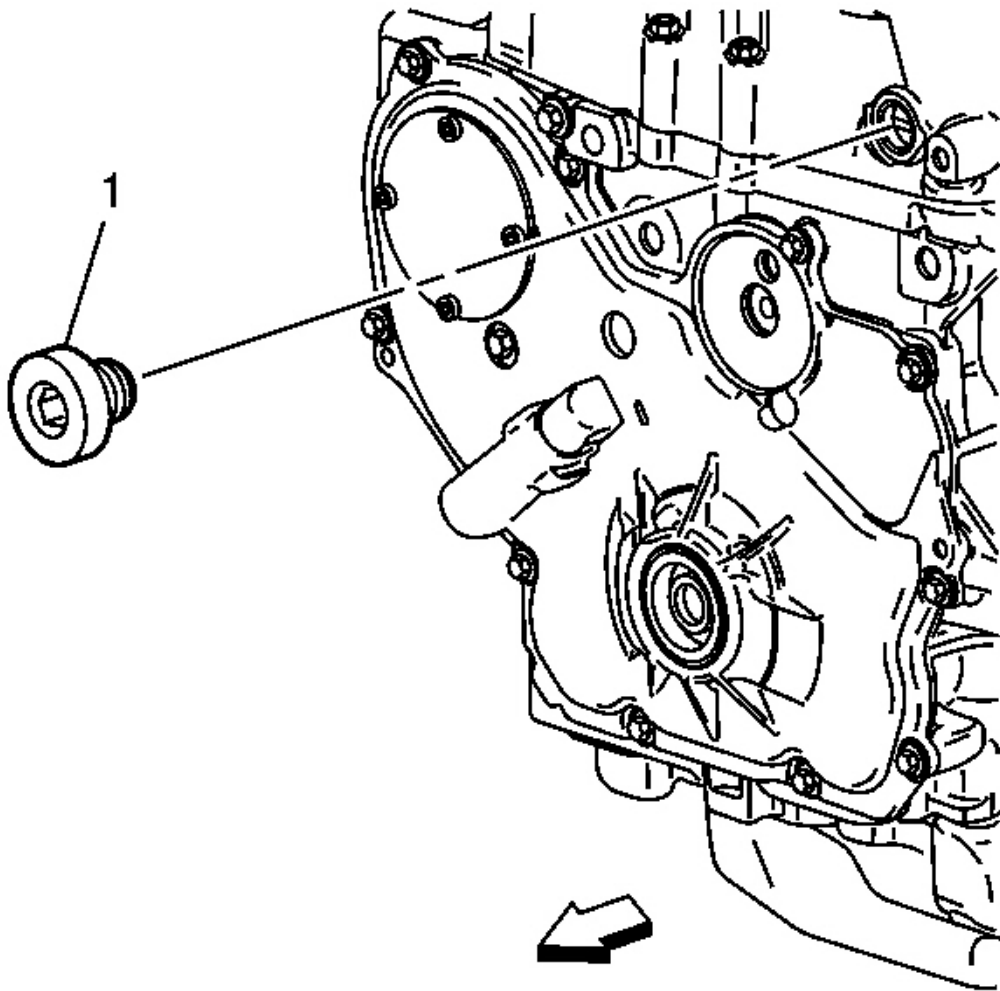


Fig. 251: Fixed Timing Chain Guide Bolt Plug
Courtesy of GENERAL MOTORS CORP.

13. Remove the plug (1) to gain access to the fixed timing chain guide bolt.

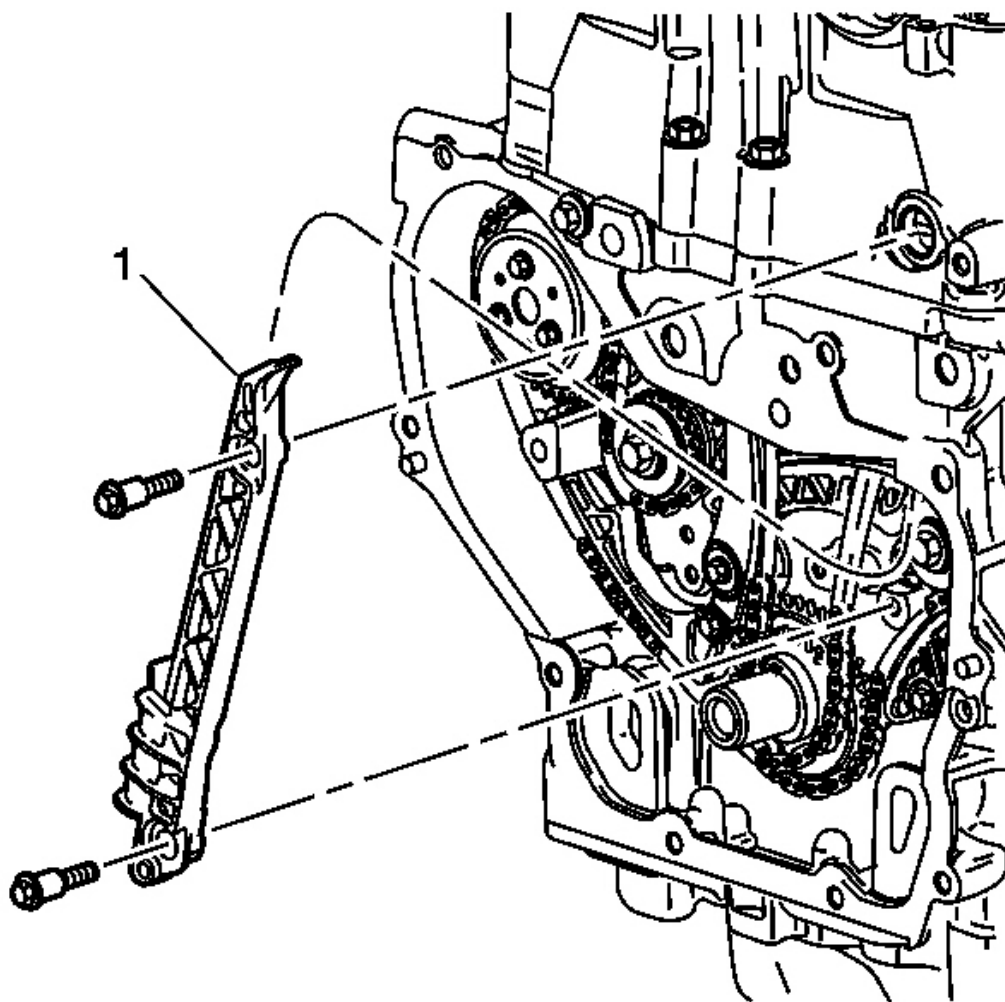


Fig. 252: View of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

14. Remove the fixed timing chain guide bolts.
15. Remove the fixed timing chain guide (1).

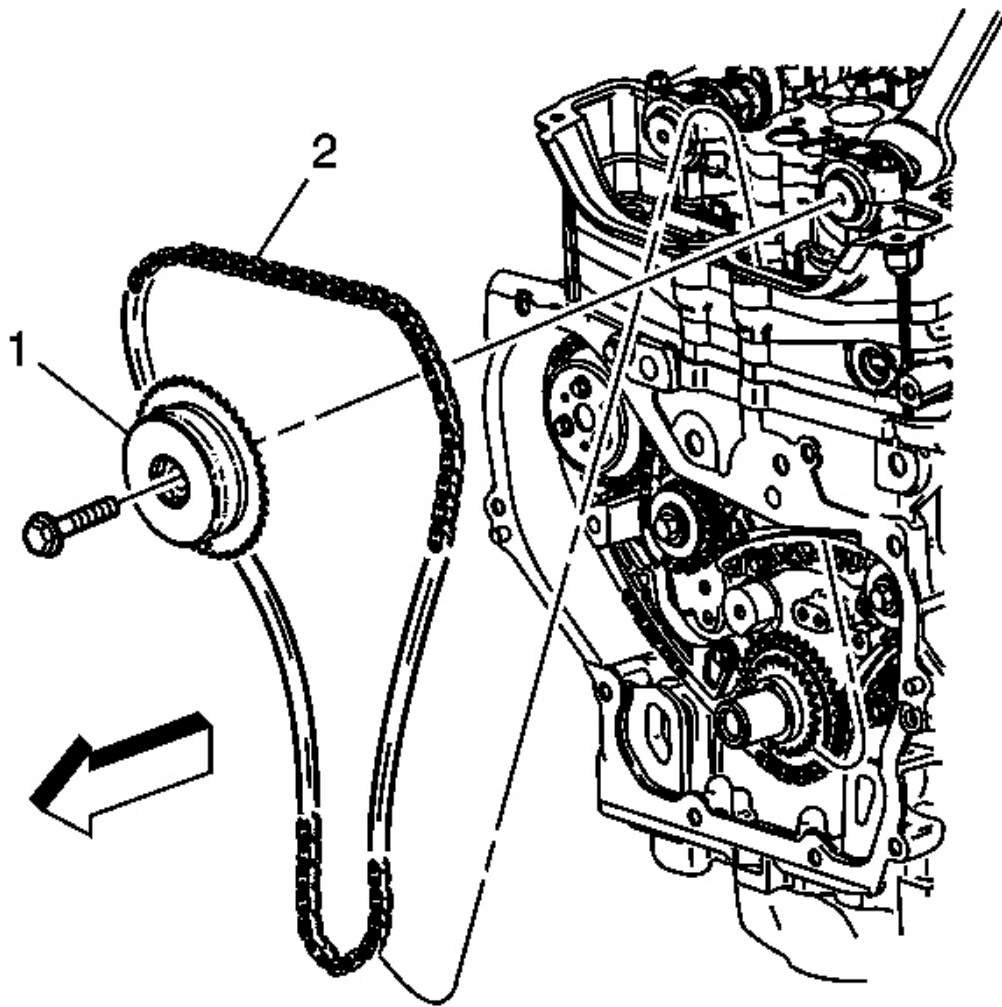


Fig. 253: Intake Camshaft Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

16. Locate hex on the intake camshaft and hold with a wrench.
17. Remove the intake camshaft actuator bolt, the intake camshaft actuator (1) and the timing chain (2) through the top of the cylinder head. Discard the bolt.

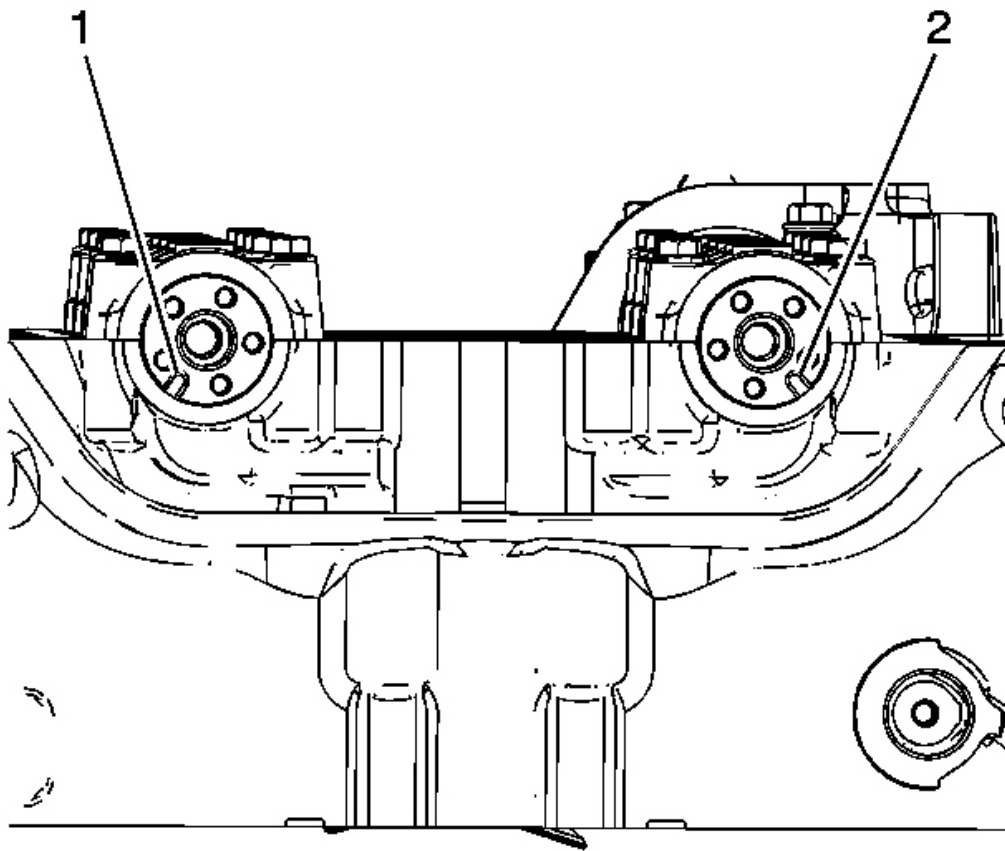


Fig. 254: Identifying Position Of Camshafts
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The number 3 exhaust valves are open.
- Note the position and direction of the camshafts before removal. Mark the cylinder head in relation to the locking notches before component removal.

18. Mark the cylinder head where the exhaust camshaft actuator locking notch (1) and intake camshaft locking notch (2) are lined up with the cylinder head.

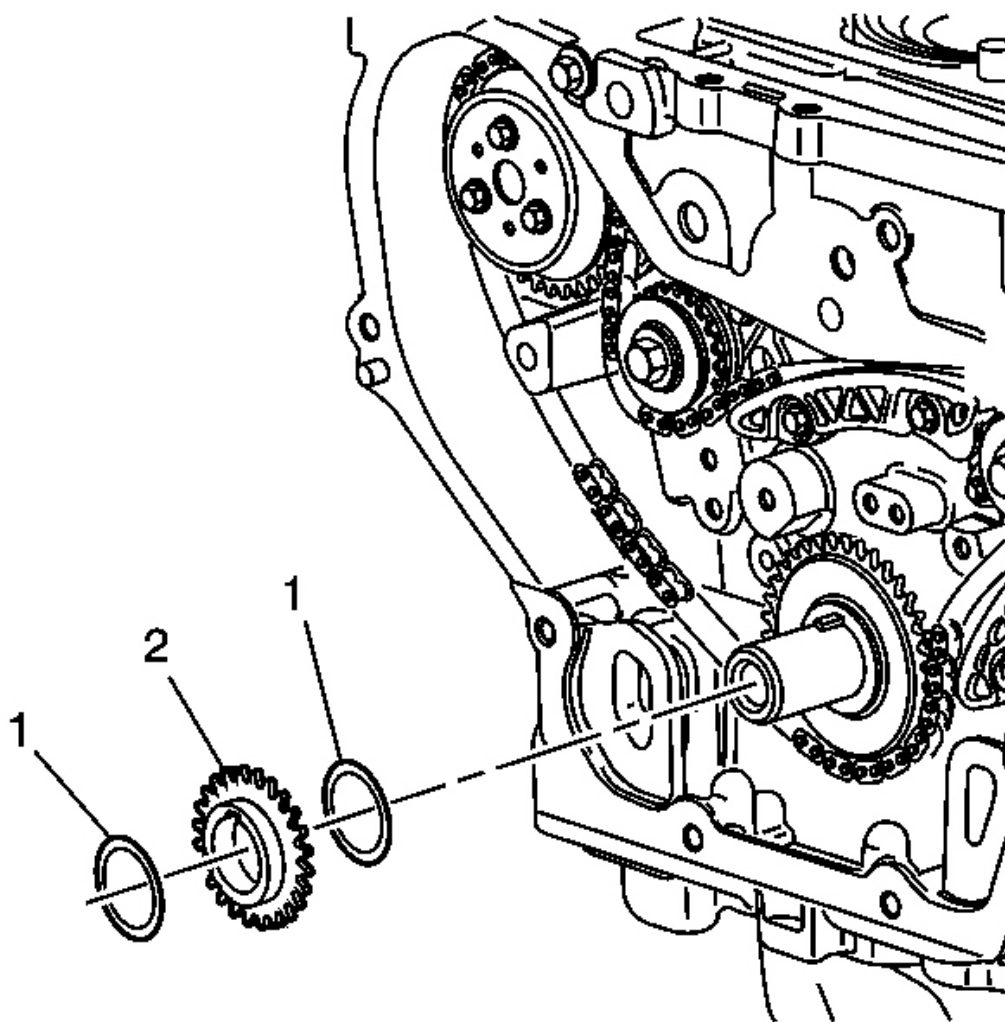


Fig. 255: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

19. Remove the crankshaft sprocket (2) and friction washers (1), if equipped.

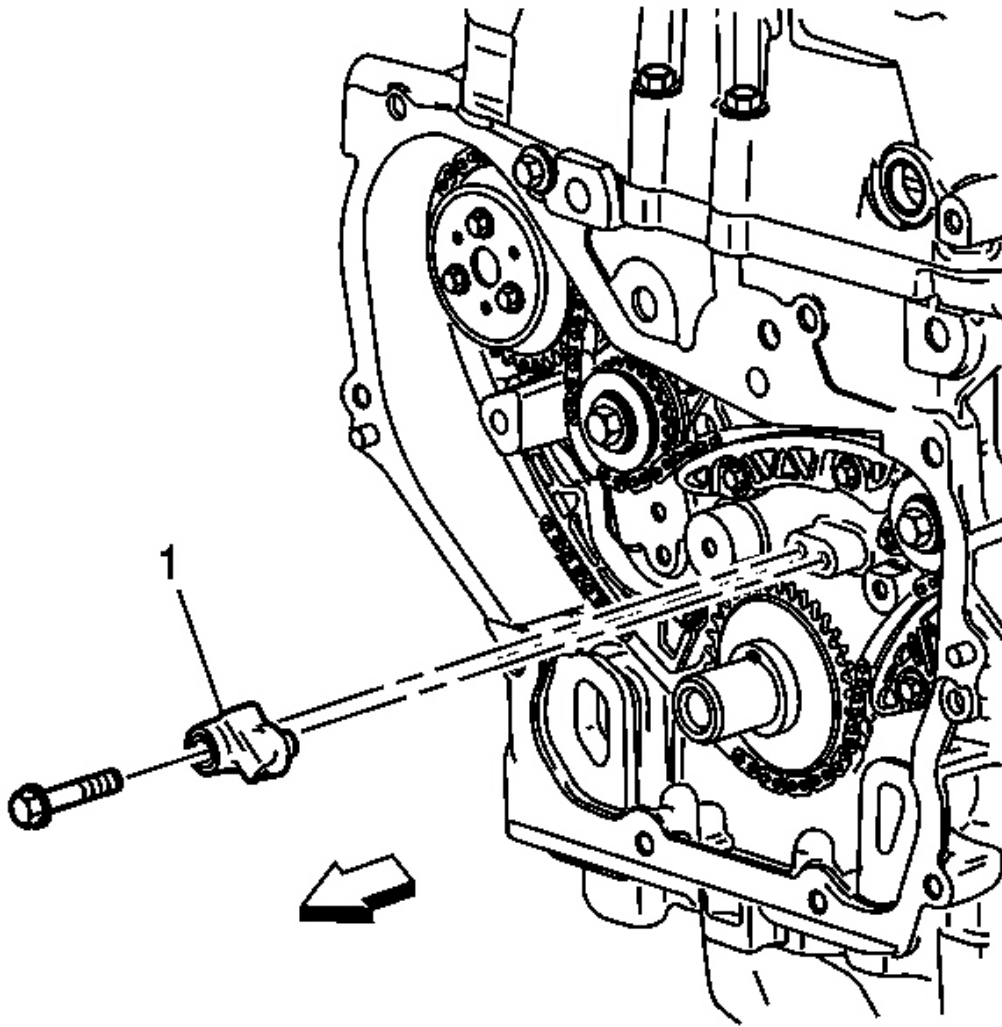


Fig. 256: View of Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

20. Remove the timing chain oil nozzle bolt.
21. Remove the timing chain oil nozzle (1).

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

Intake Camshaft and Components Removal

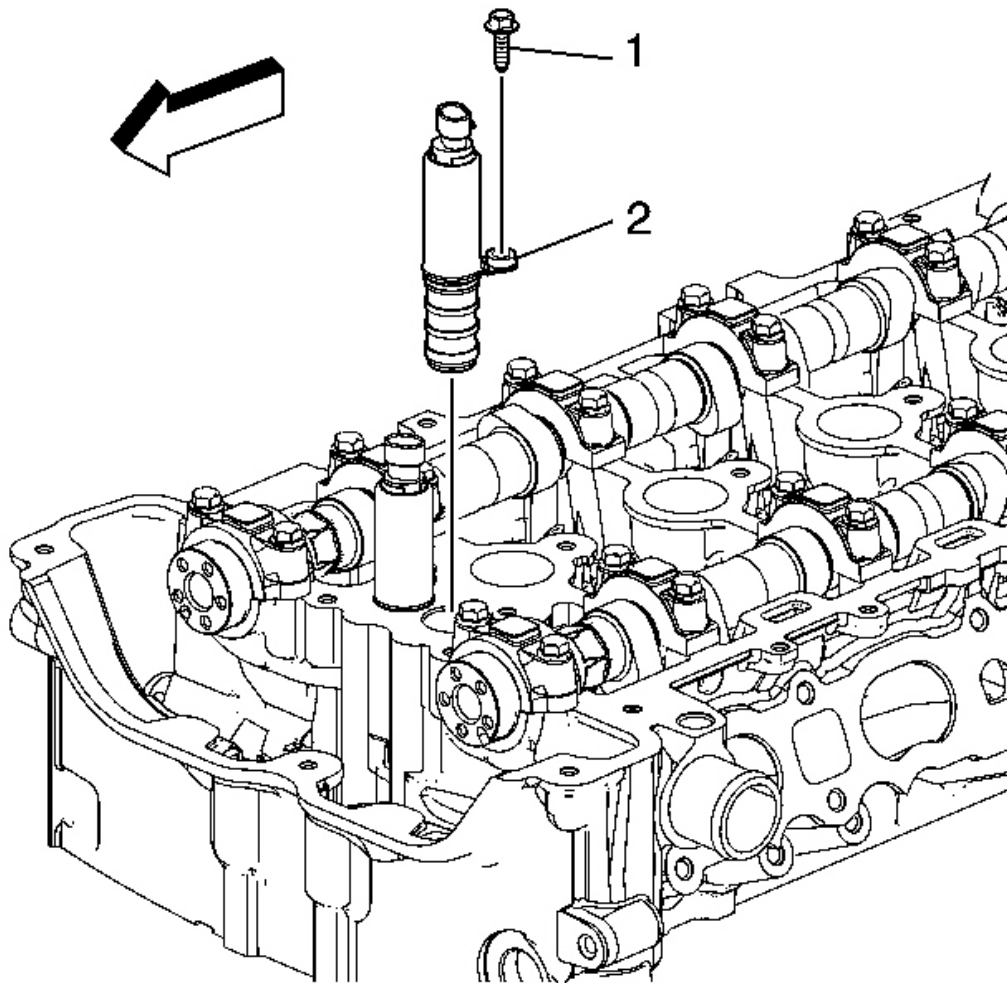


Fig. 257: Intake Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position actuator solenoid valve bolt (1) and valve (2).

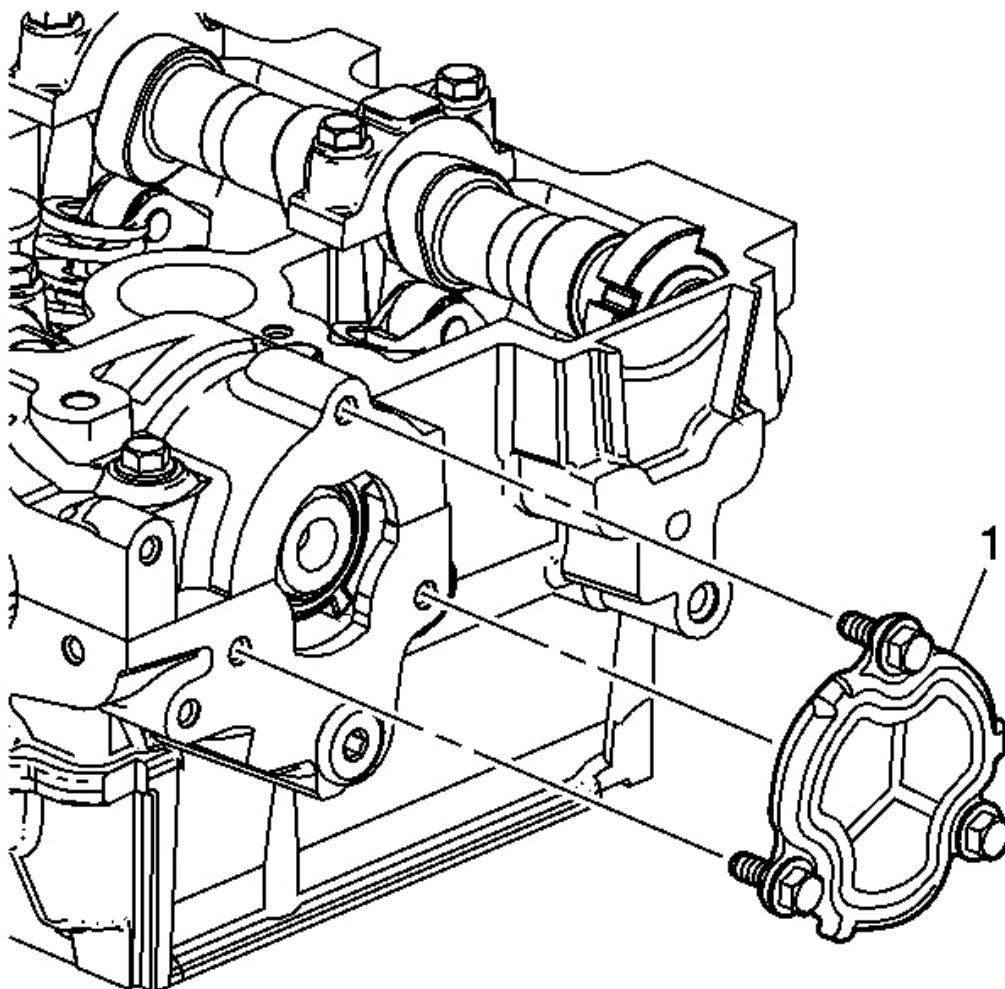


Fig. 258: Rear Cylinder Head Cover Plate
Courtesy of GENERAL MOTORS CORP.

2. Remove the rear cylinder head cover plate (1).

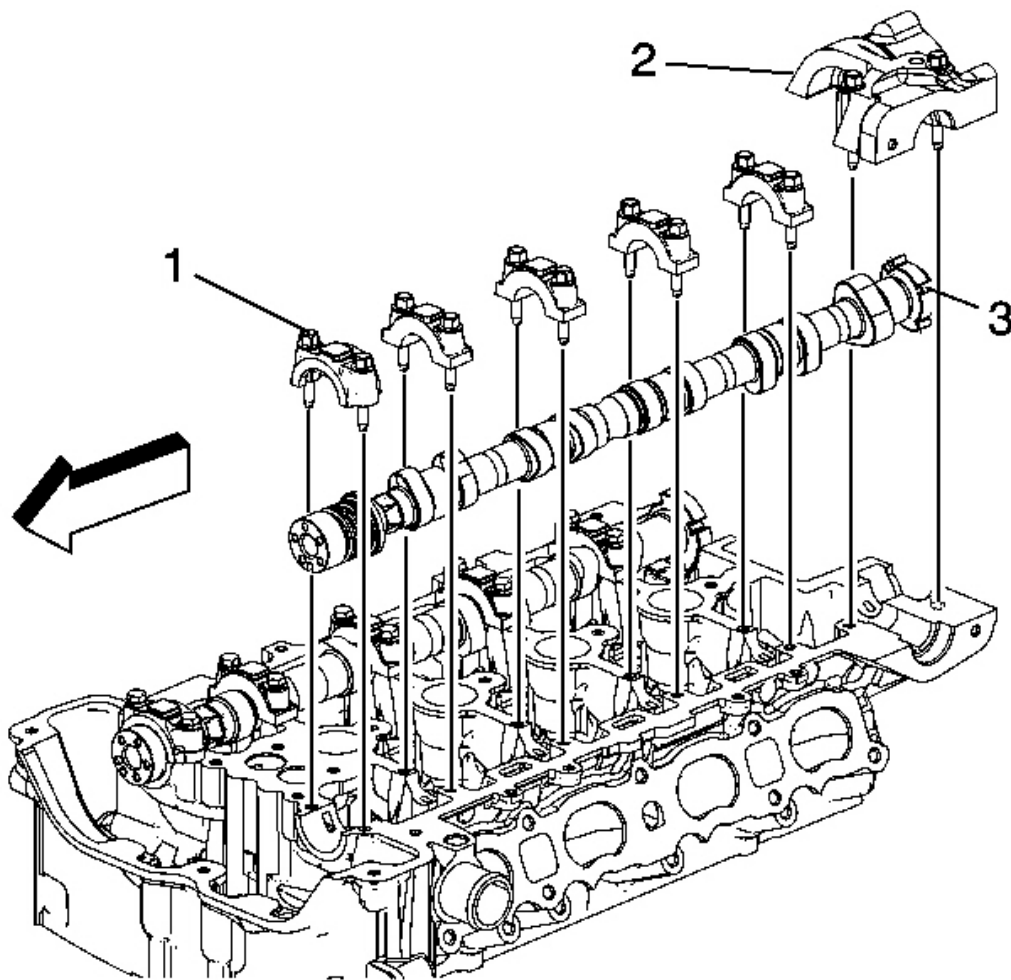


Fig. 259: Intake Camshaft Bearing Rear Cap Bolts & Cap
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake camshaft bearing rear cap bolts and cap (2).

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

4. Mark camshaft caps to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts.
6. Remove the camshaft caps (1).
7. Remove the intake camshaft (3).

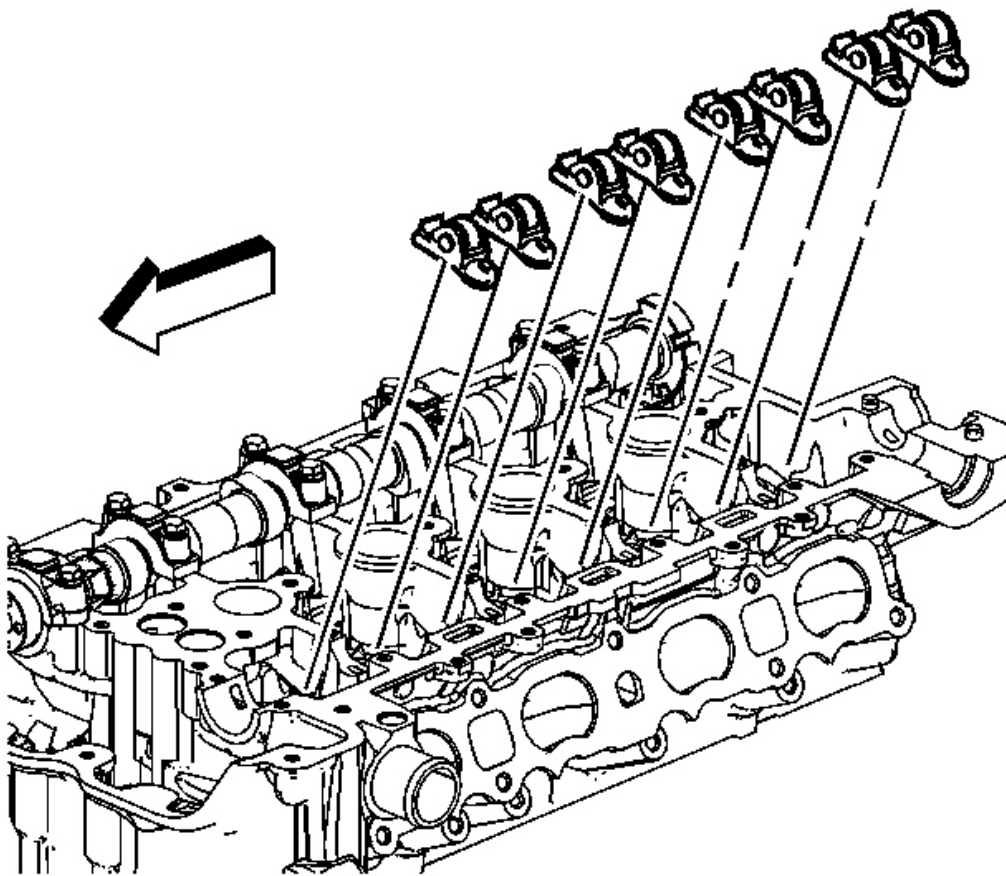


Fig. 260: Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

8. Remove the intake camshaft roller finger followers.

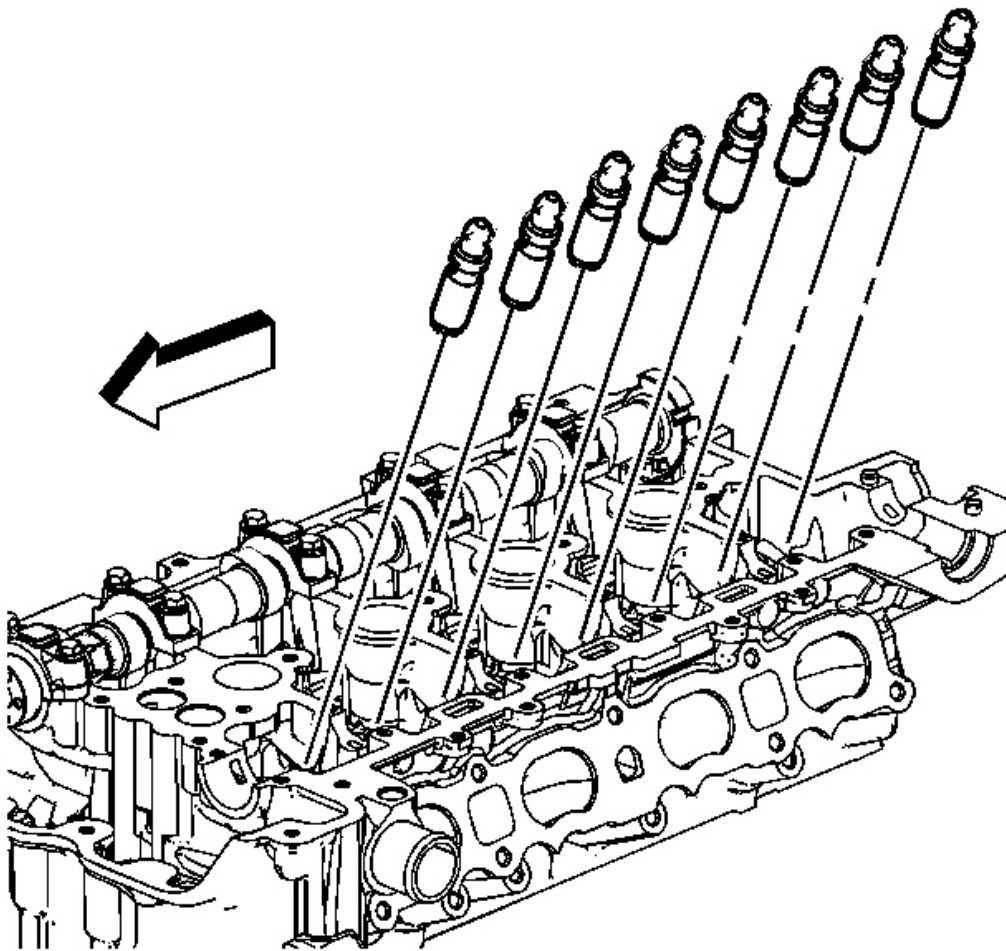


Fig. 261: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

9. Remove the hydraulic lash adjusters.

Exhaust Camshaft and Components Removal

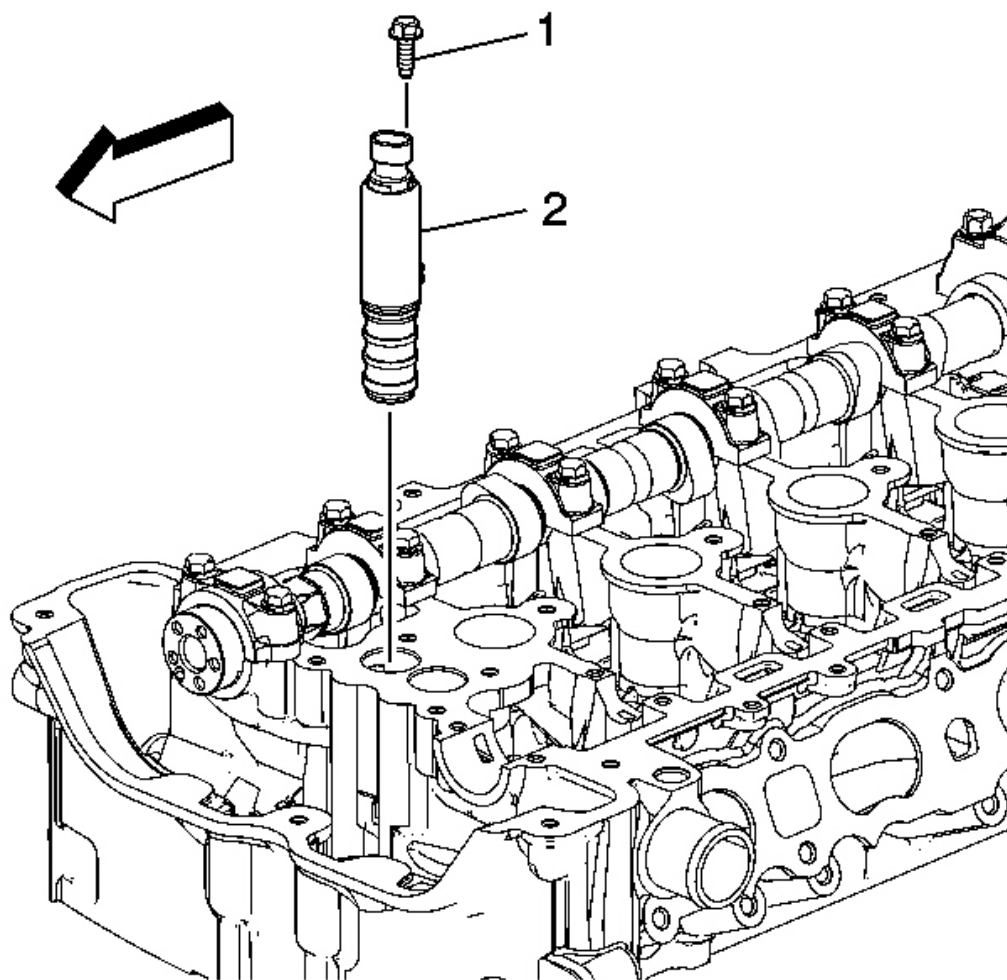


Fig. 262: Exhaust Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator solenoid valve bolt (1) and valve (2).

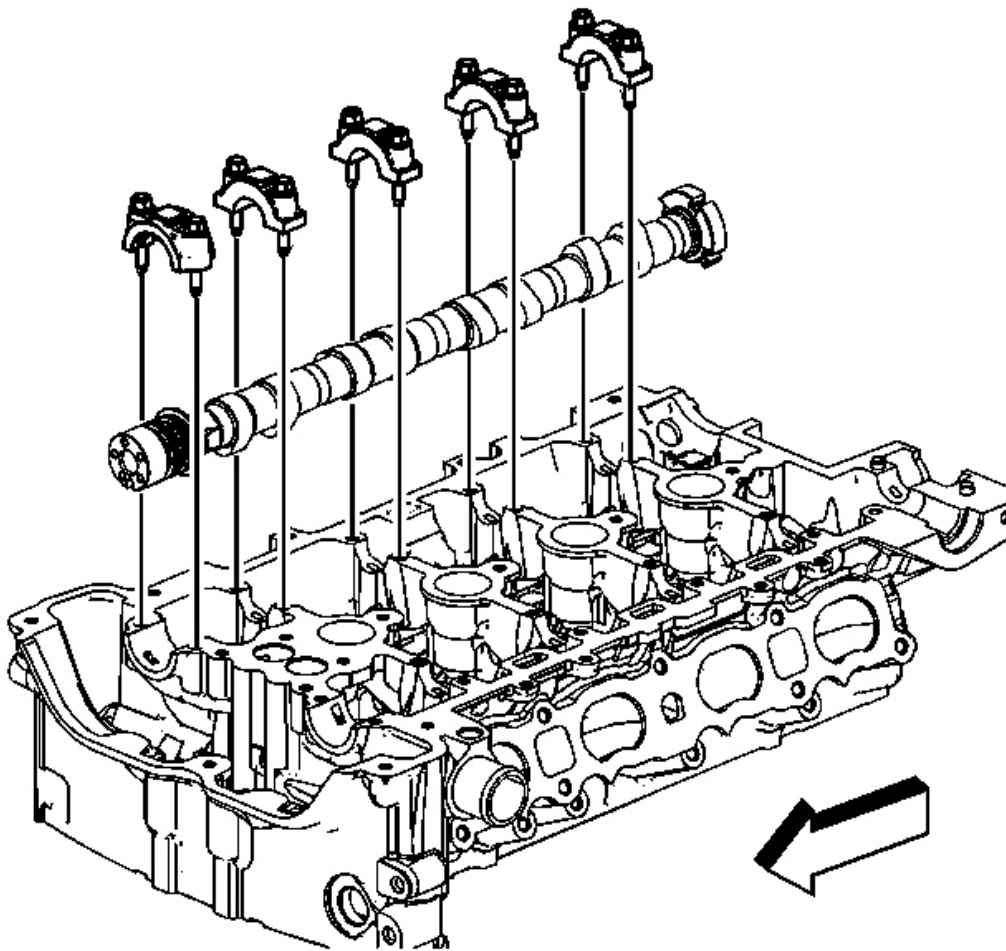


Fig. 263: Exhaust Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark camshaft caps to ensure they are installed in the same position.
3. Remove the exhaust camshaft cap bolts.
4. Remove the camshaft caps ensuring they are marked and refitted in same position on assembly.
5. Remove the exhaust camshaft.

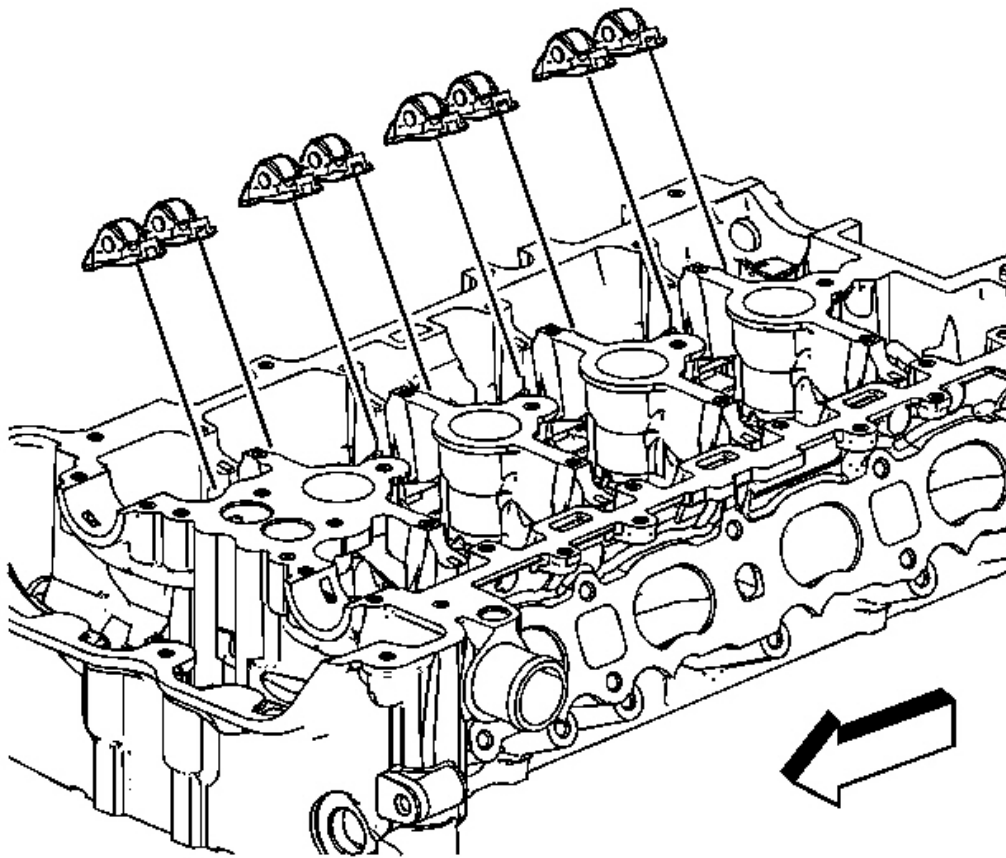


Fig. 264: Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the exhaust camshaft roller finger followers.

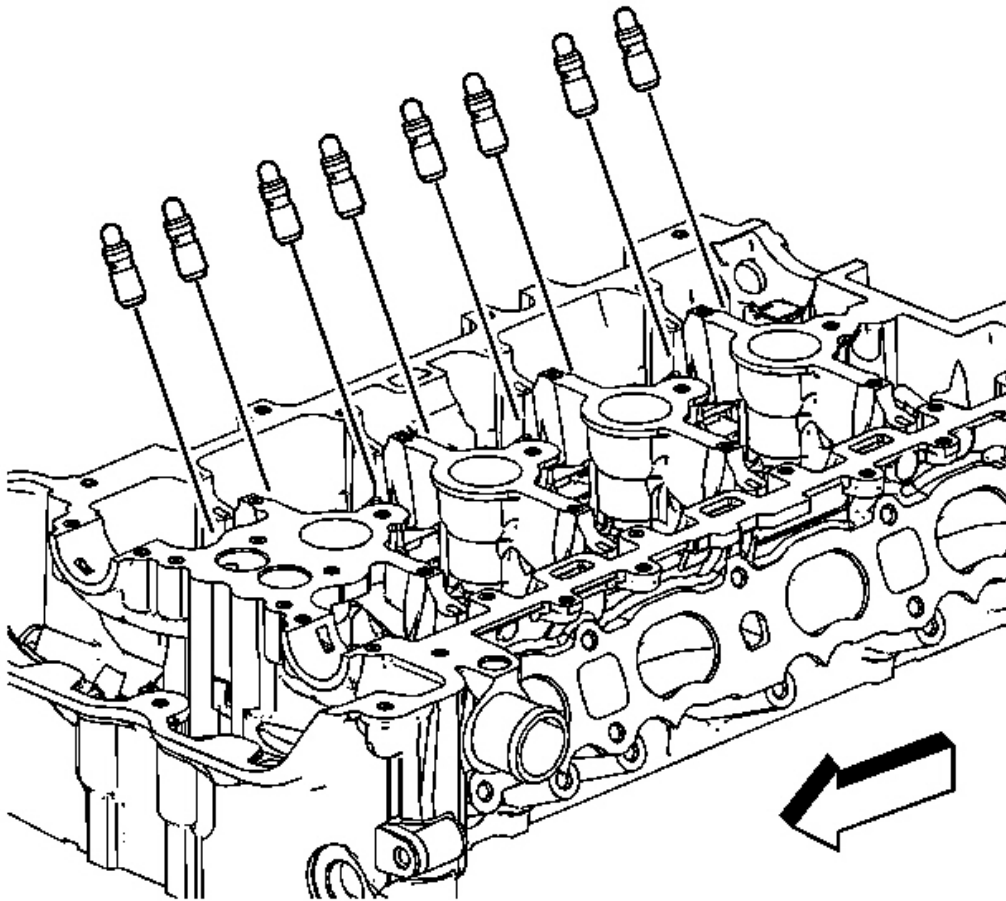


Fig. 265: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic lash adjusters.

WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER REMOVAL

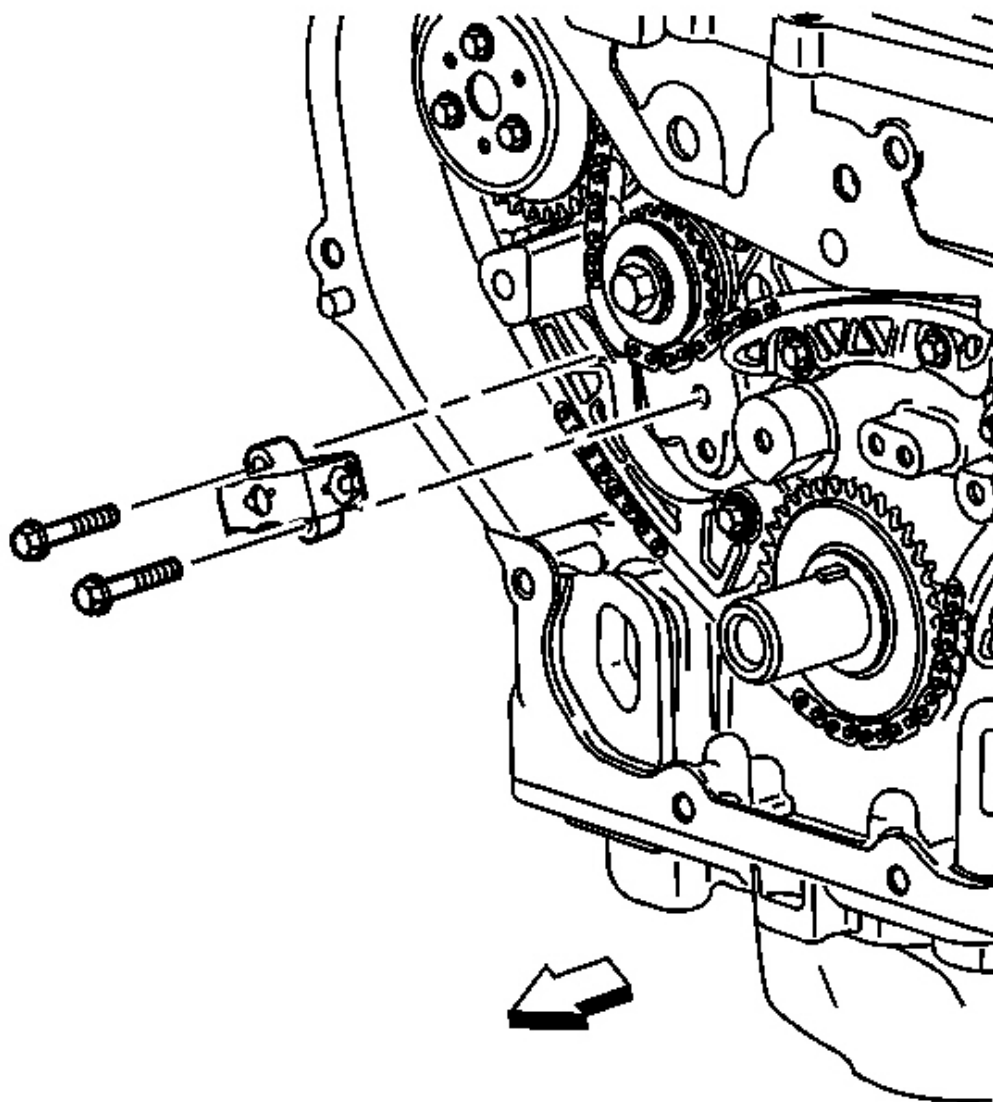


Fig. 266: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft drive chain tensioner bolts.
2. Remove the balance shaft drive chain tensioner.

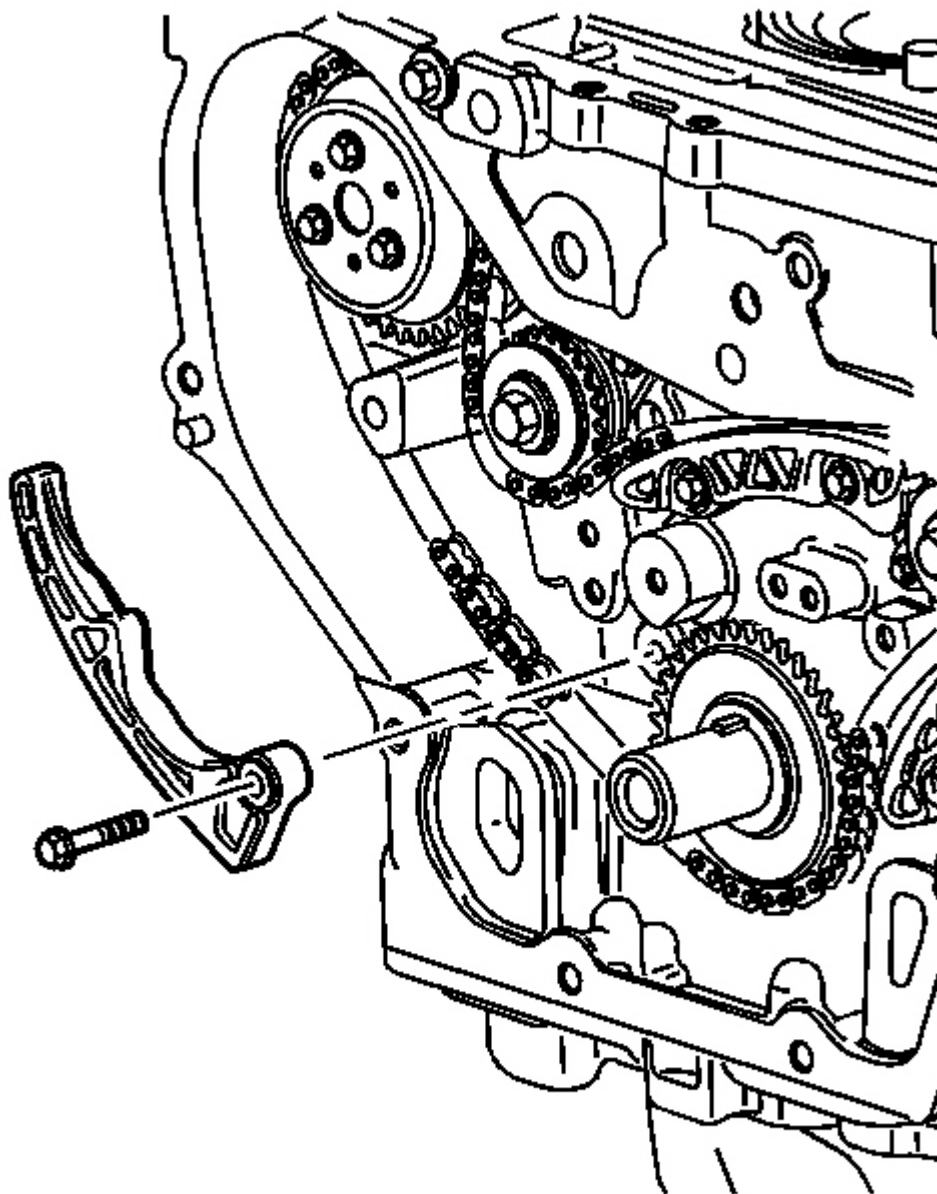


Fig. 267: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide.

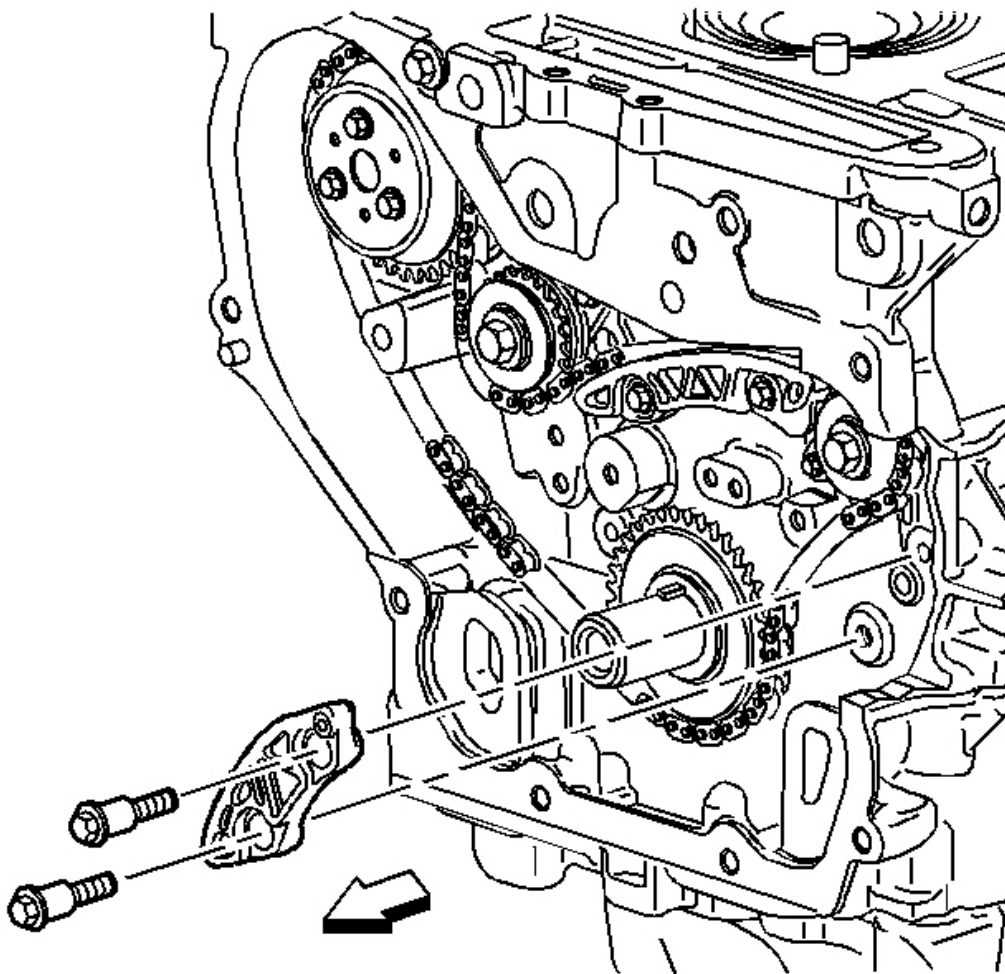


Fig. 268: View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide.

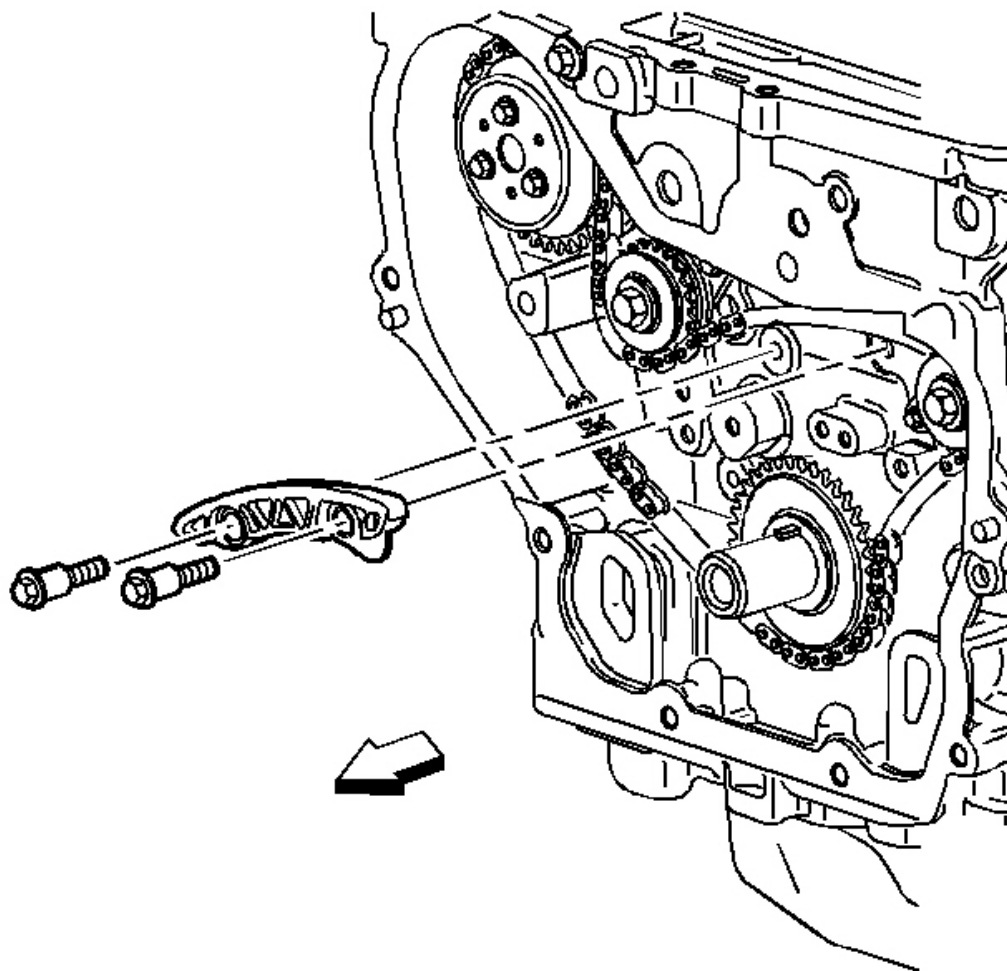


Fig. 269: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide.

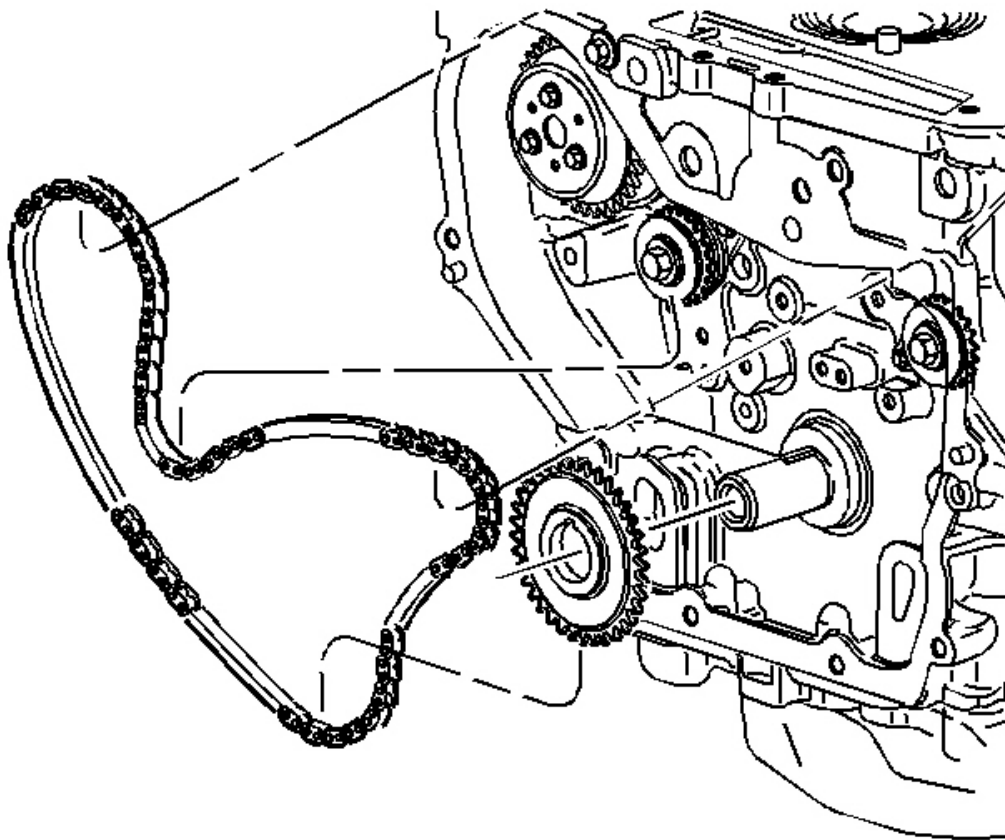


Fig. 270: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may ease removal of the balance shaft drive chain to get all of the slack in the chain between the crankshaft and water pump sprockets.

9. Remove the balance shaft drive chain.
10. Remove the balance shaft drive sprocket.

BALANCE SHAFT REMOVAL

Special Tools

EN-43650: Balancer Shaft Bearing Remover and Installer

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

Removal

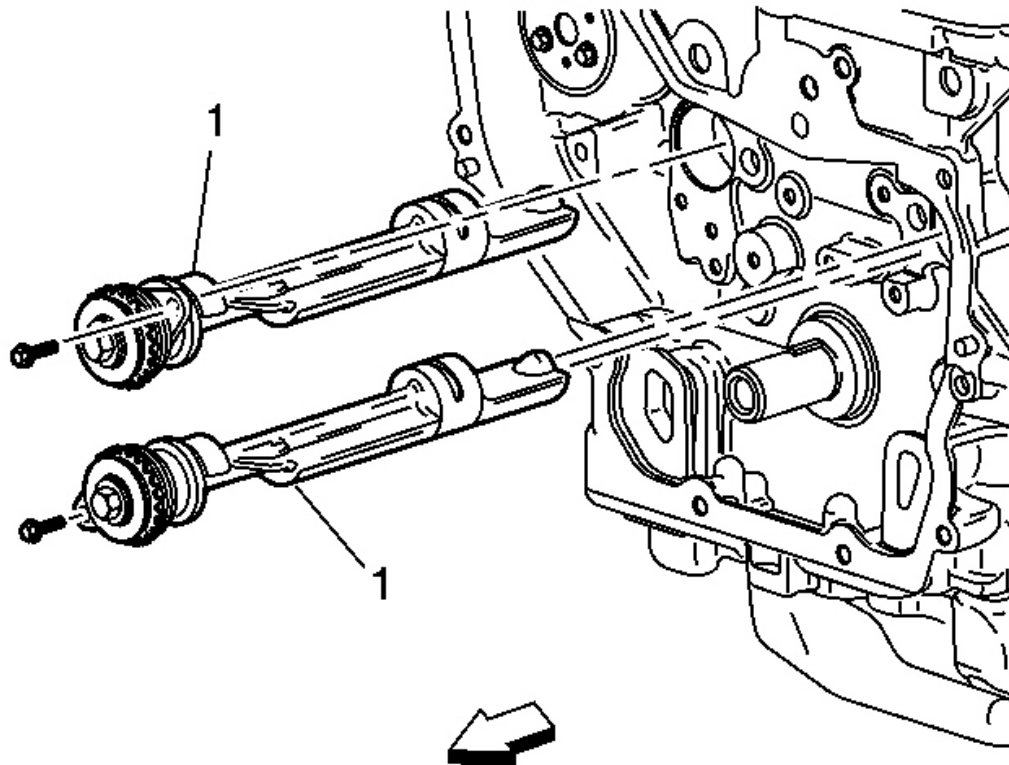


Fig. 271: Balance Shaft Bolts

Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

NOTE:

- It is possible to install the intake side balance shaft into the exhaust side and vice versa. Please use care not to install the balance shafts into the wrong bores. Engine vibration will result.
- Do not remove the bolt holding the sprocket.

2. Remove the balance shaft assemblies (1).

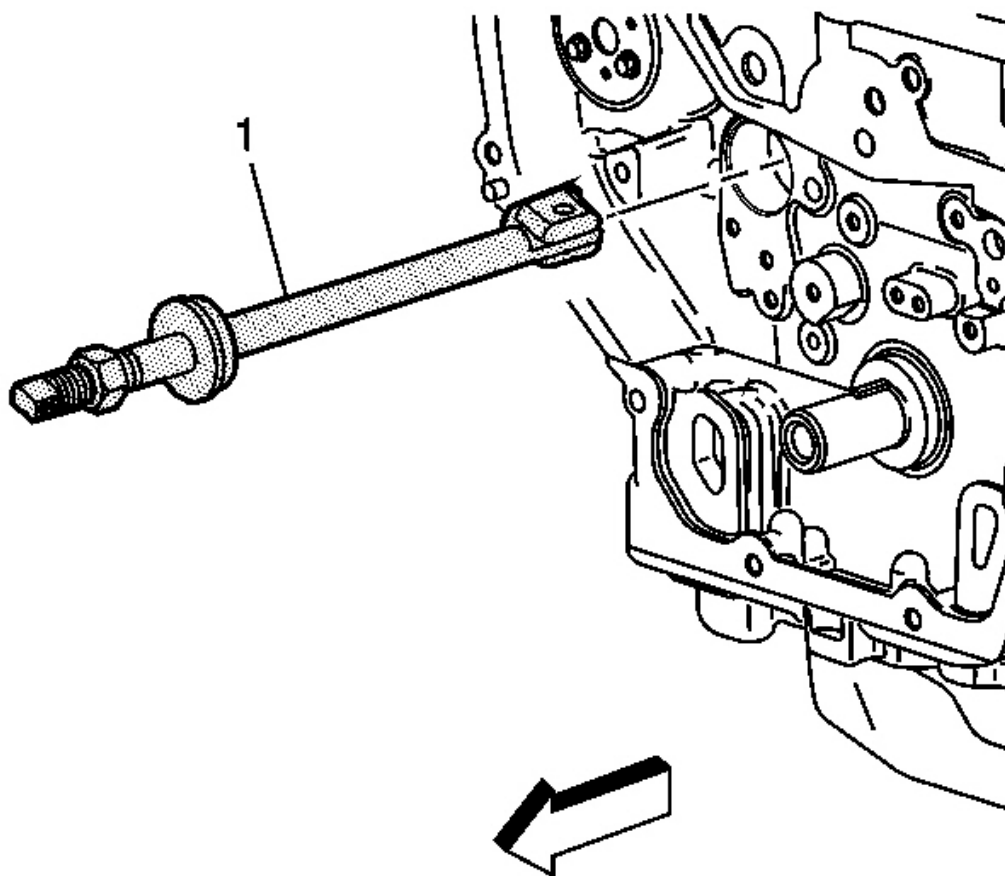


Fig. 272: Identifying Balancer Shaft Bearing Remover/Installer

Courtesy of GENERAL MOTORS CORP.

CAUTION: Proper centering of the tool is required on the balance shaft bushing. If the tool is not properly centered then damage to the bearing bore and block will occur.

3. Install the **EN-43650**: remover (1) into the balance shaft hole. Insert the tool with the foot parallel to the shaft.

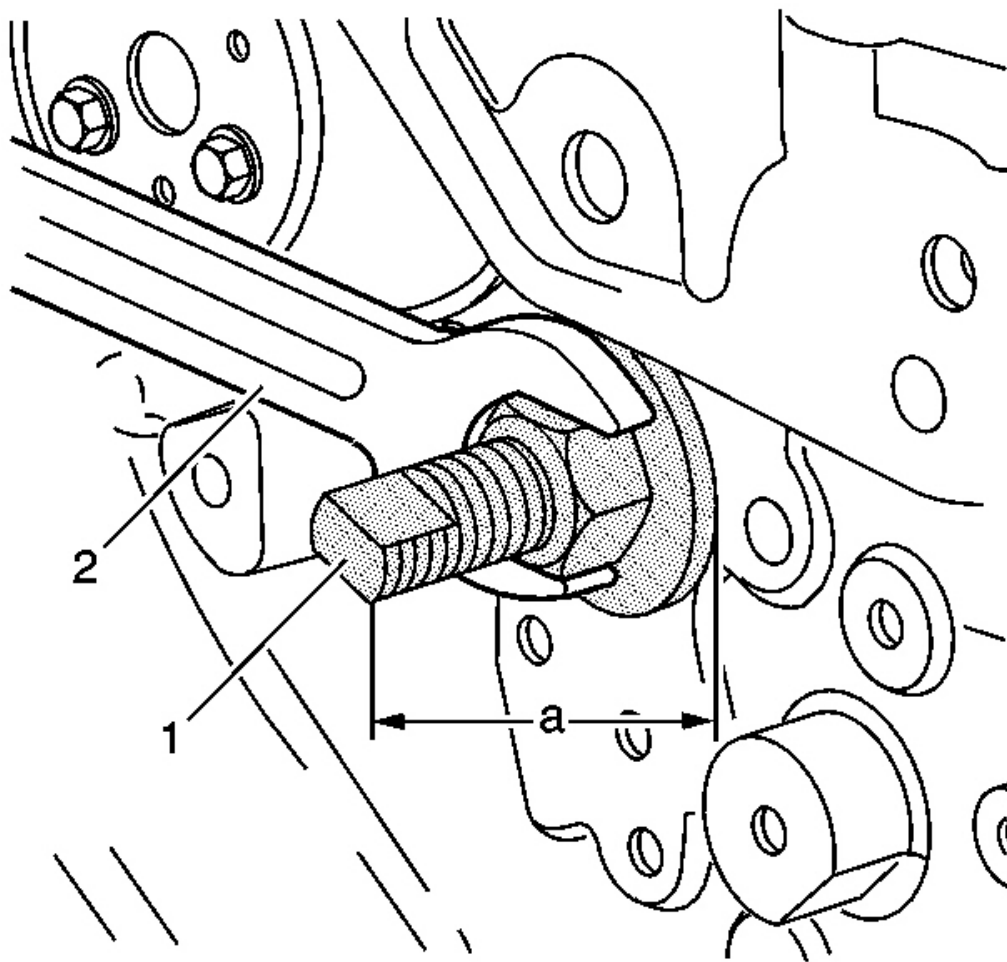


Fig. 273: Aligning Balance Shaft Bushing Remover
Courtesy of GENERAL MOTORS CORP.

4. When the **EN-43650:** remover (1) is inserted in the block turn the **EN-43650:** remover so that the foot becomes perpendicular to the shaft.
5. Center the foot of the **EN-43650:** remover on the balance shaft bushing.
6. Once the **EN-43650:** remover is centered on the balance shaft bushing, then insert the centering guide into the front balance shaft bore and tighten the nut with an appropriate wrench (2).

When the **EN-43650:** remover is properly installed, before removing the bushing, the end of the tool should be 116 mm (4.6 in) (a) from the block face.

If the **EN-43650:** remover is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.

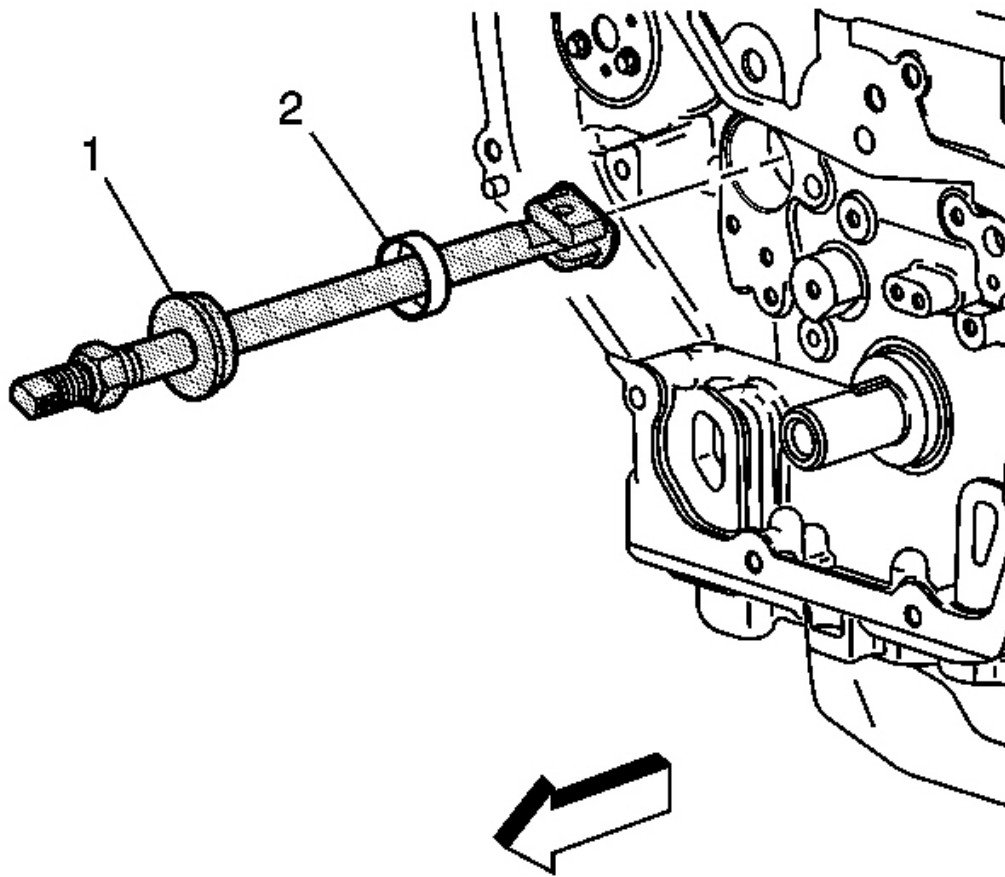


Fig. 274: Remover & Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **EN-43650**: remover (1) until the tension releases. When the tension releases, remove the **EN-43650**: remover and the balance shaft bushing (2).

WATER PUMP REMOVAL

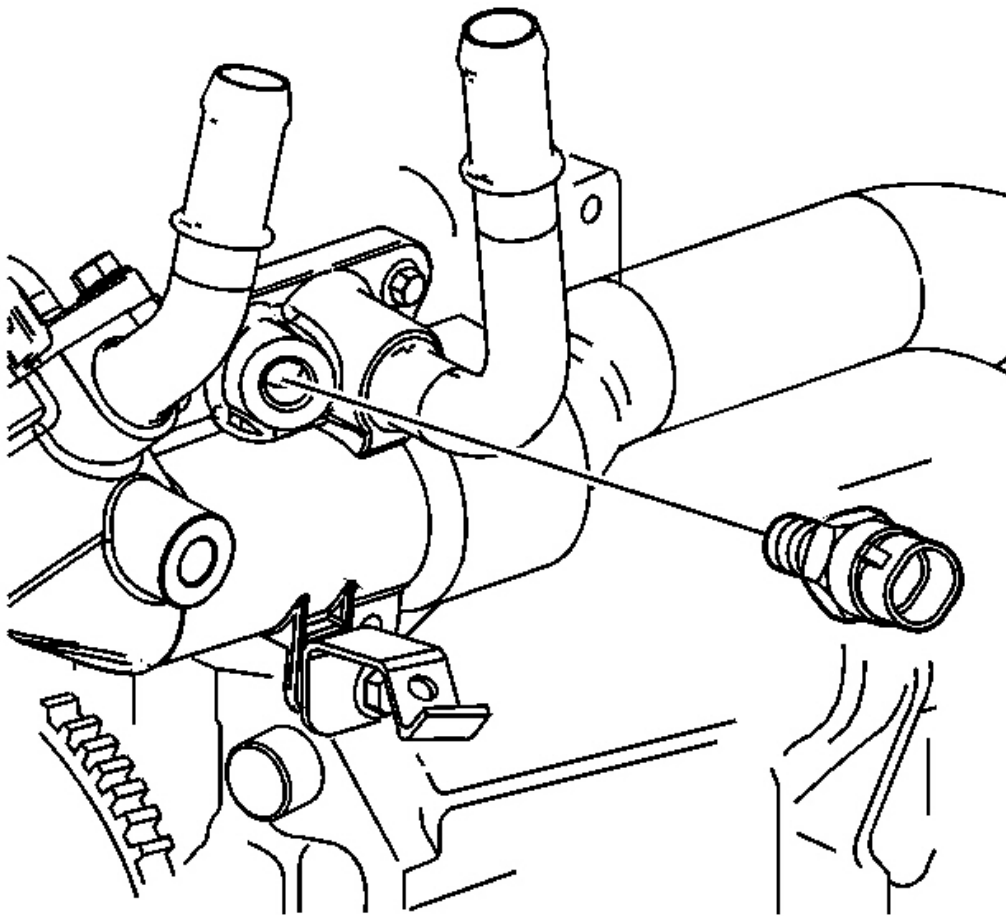


Fig. 275: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

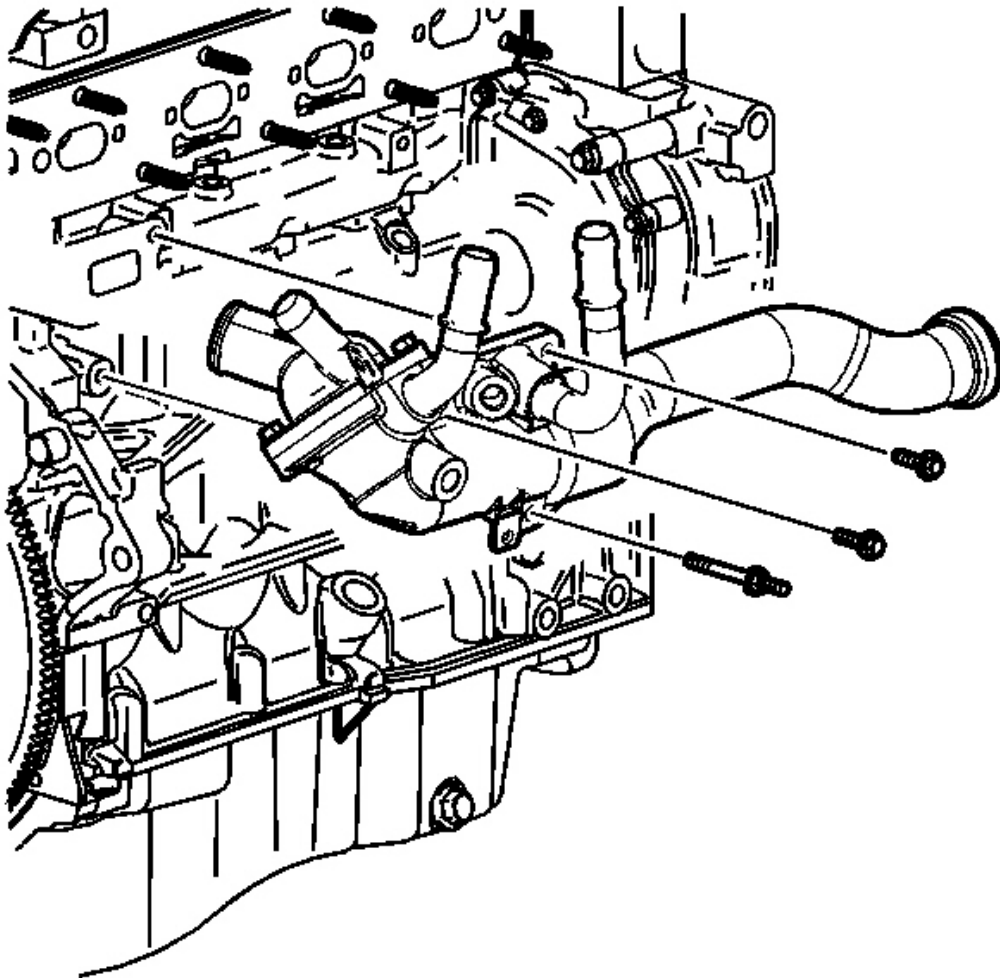


Fig. 276: View Of Thermostat & Water Feed Pipe Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the thermostat and water feed pipe retaining bolts.

IMPORTANT: Twist the water feed pipe while pulling to remove it from the water pump cover.

3. Remove the thermostat housing and water feed pipe from the water pump cover.

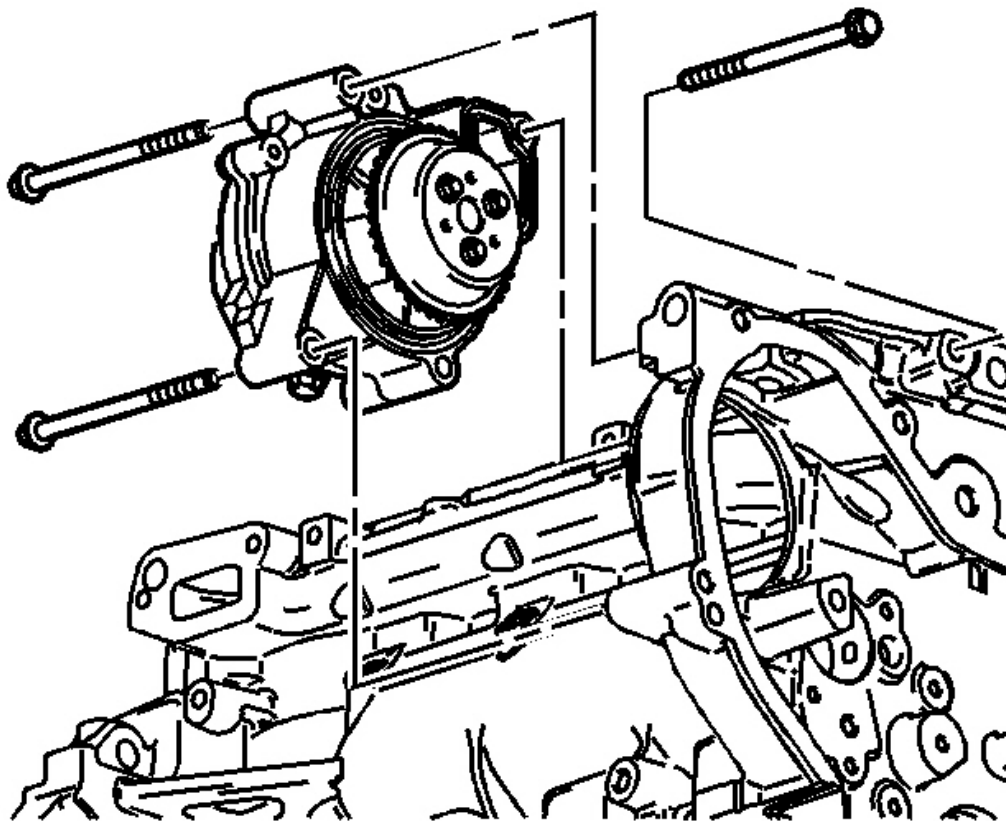


Fig. 277: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the water pump retaining bolts. Be sure to remove the bolt that goes through the front of the engine block.
5. Remove the water pump assembly.

CYLINDER HEAD REMOVAL

Special Tools

EN 38188: Cylinder Head Broken Bolt Extractor Kit

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

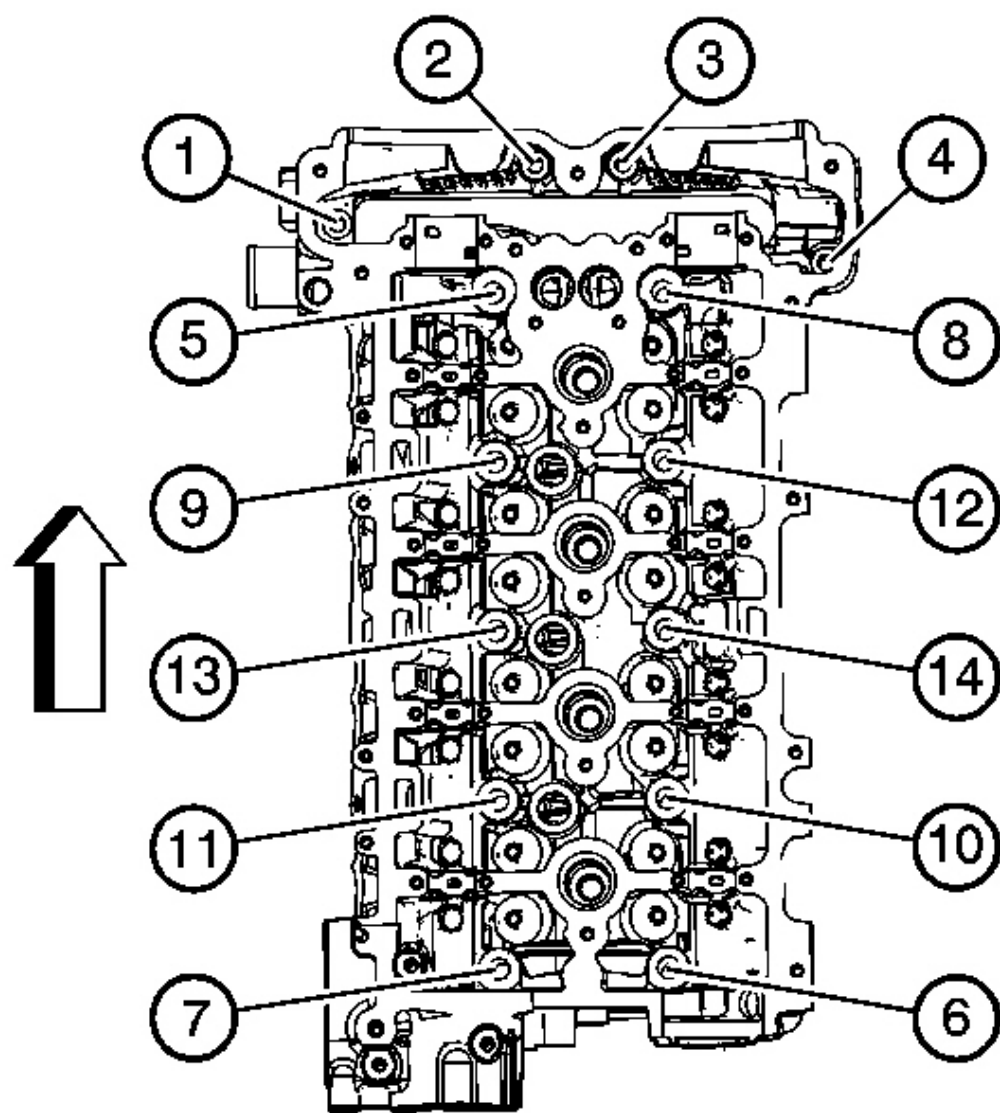


Fig. 278: Cylinder Head-To-Block Bolt Sequence
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head to the block bolts in sequence.

Discard the bolts.

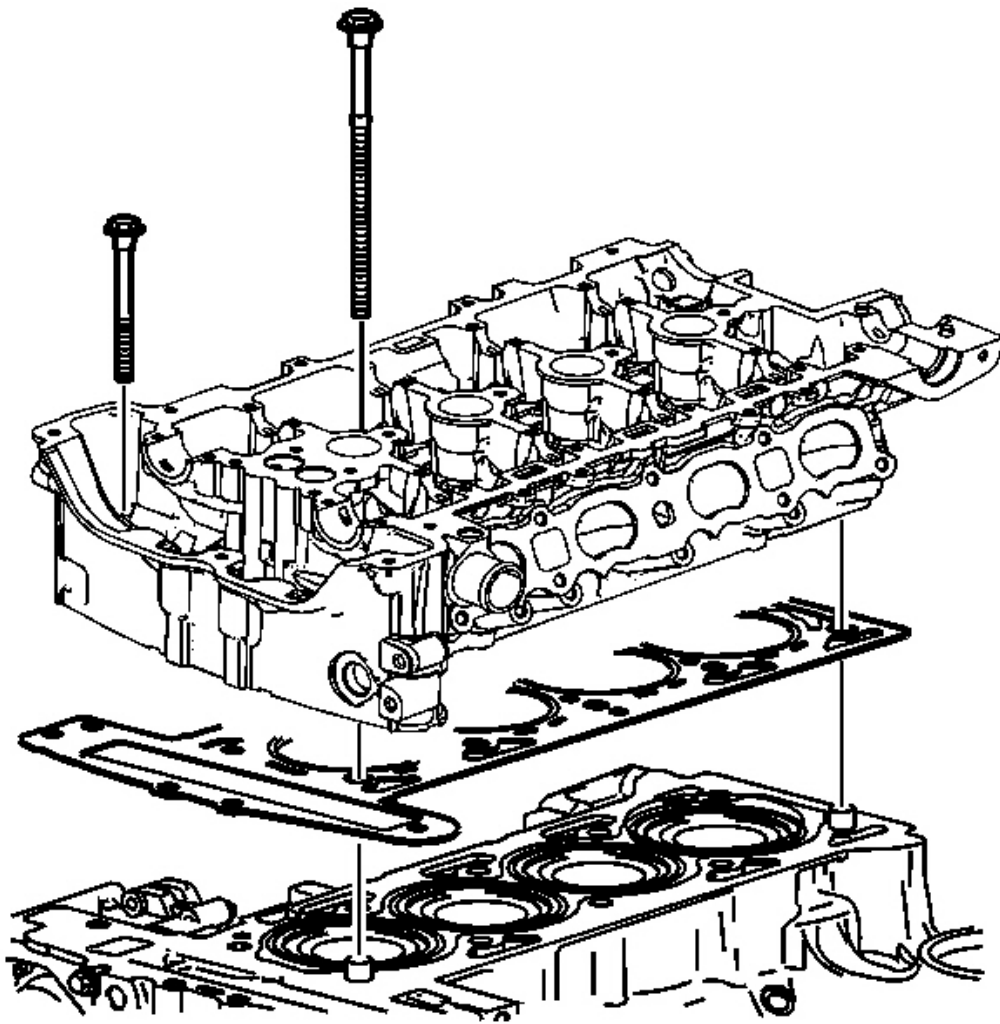


Fig. 279: Cylinder Head

Courtesy of GENERAL MOTORS CORP.

CAUTION: In order to prevent damage to the valves and injectors during cylinder head removal, set the cylinder head on blocks.

2. Remove the cylinder head.
3. Remove the cylinder head gasket.
4. Clean all of the gasket surfaces.
5. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:

- Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

NOTE: **Do not use any other method or technique to clean these gasket surfaces.**

- Use a new razor blade for each cylinder head and cylinder block.

NOTE: **Be careful not to gouge or scratch the gasket surfaces. Do not gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the new gasket.**

- Hold the razor blade as parallel to the gasket surface as possible.

NOTE: **Do not use a tap to clean the cylinder head bolt holes.**

6. Clean the old sealer/lube and dirt from the bolt holes.
7. Clean the bolt holes with a nylon bristle brush.

WARNING: **Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.**

8. When cleaning the cylinder head bolt holes use a suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun to reach the bottom of the holes.
9. Remove any broken long cylinder head bolts using the **EN 38188:** kit.

OIL PAN REMOVAL

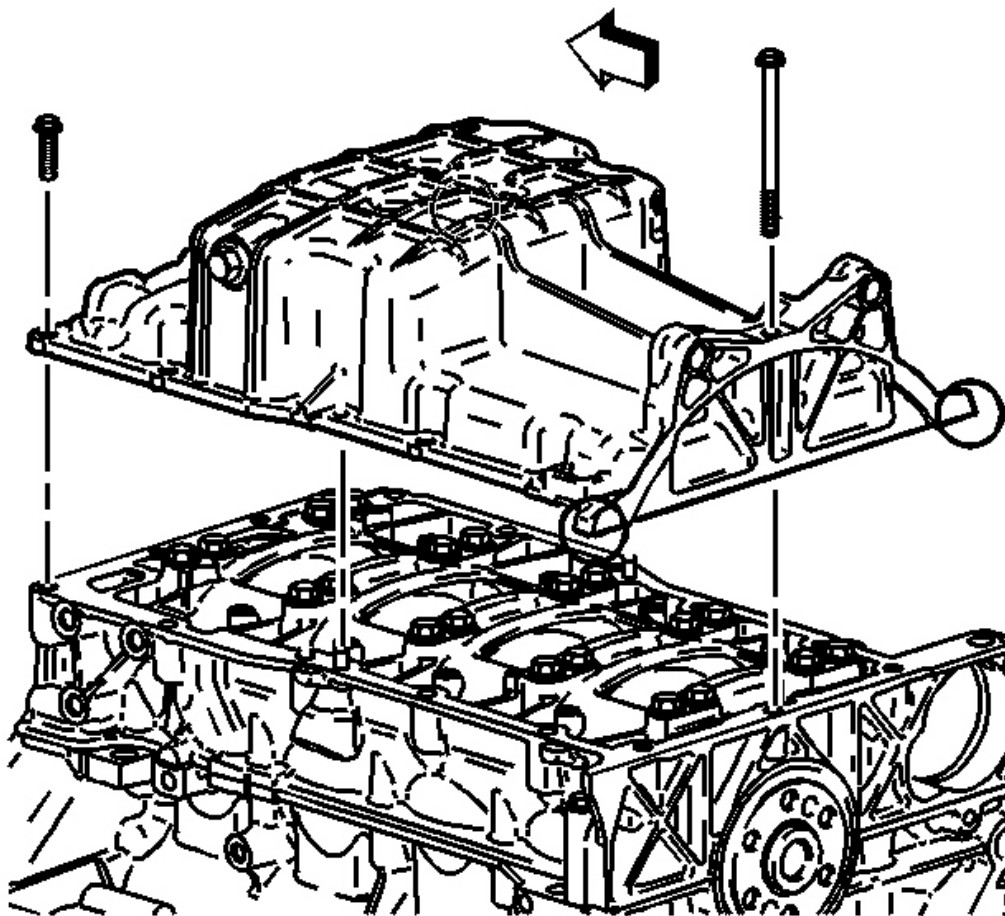


Fig. 280: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

EN 43966: Connecting Rod Guides

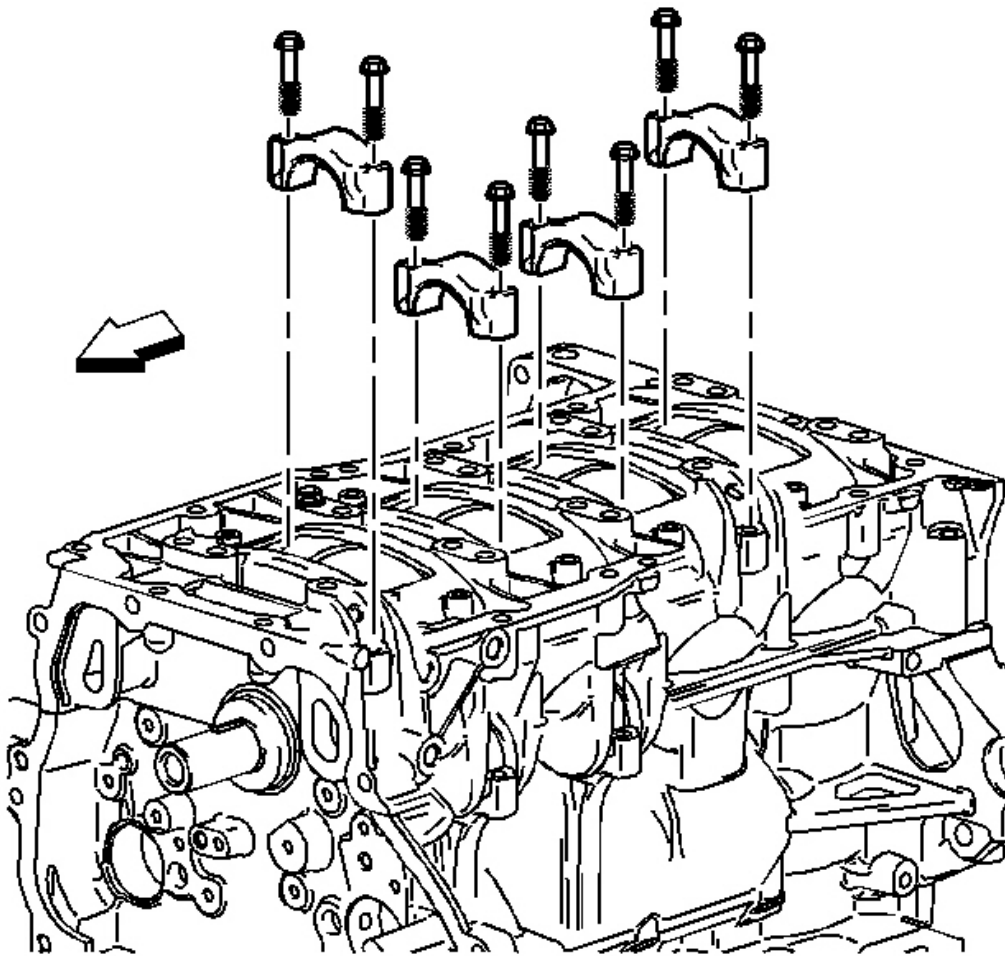


Fig. 281: View Of Connecting Rod Nuts & Caps
Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.

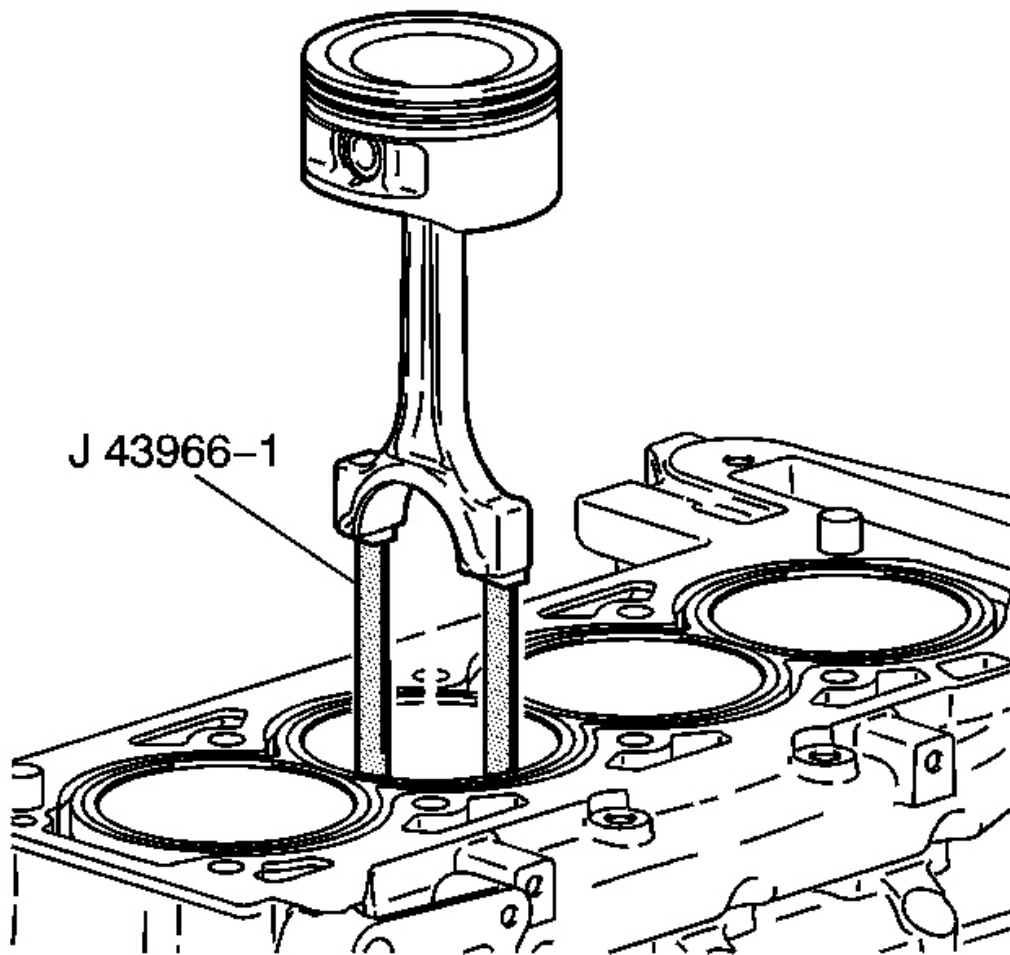


Fig. 282: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

6. Install **EN 43966**: guides on the connecting rod bolts before removing the piston and connecting rod assembly.
7. Remove the piston and connecting rod assembly.

LOWER CRANKCASE REMOVAL

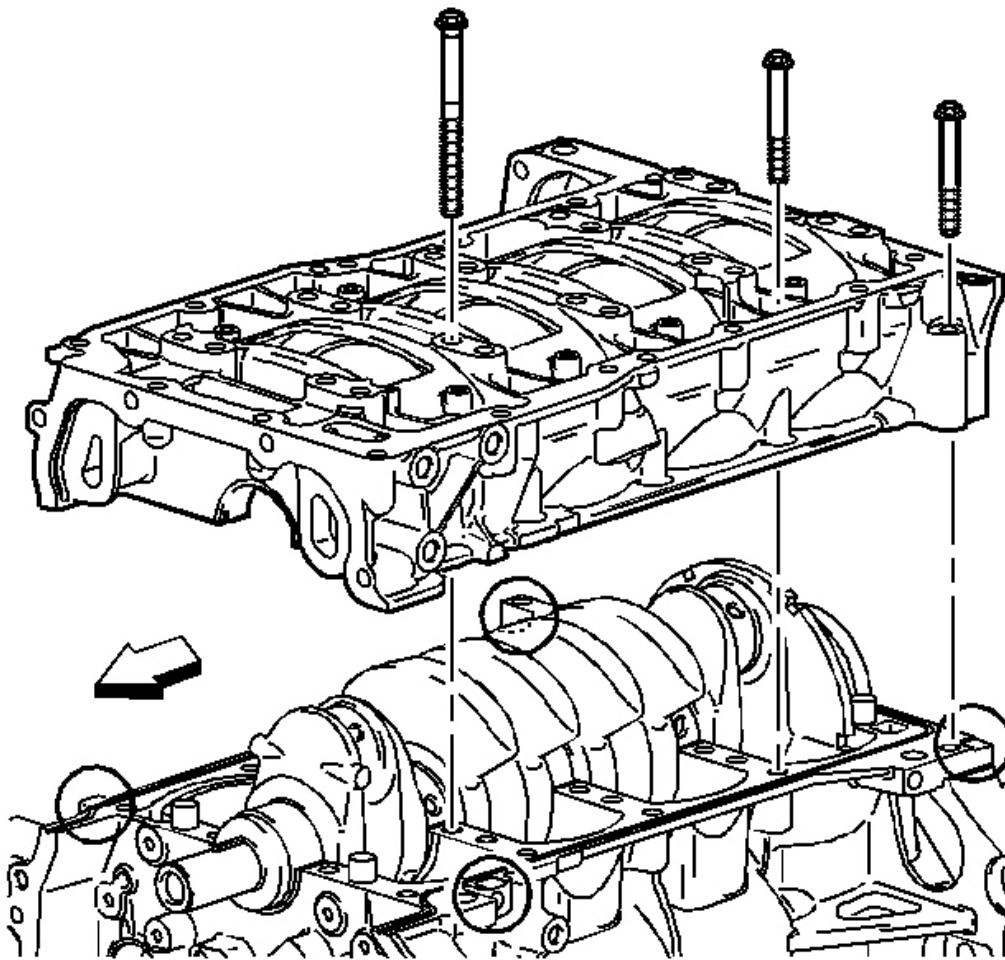


Fig. 283: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor.
2. Inspect the crankshaft position sensor for damage and replace, if necessary.
3. Remove the bedplate perimeter bolts.

IMPORTANT: Do not forget the 2 outside rear bolts.

4. Remove and discard the crankshaft bearing bolts.
5. Using the pry-points and an appropriate prying tool, gently separate the upper and lower crankcase.

CRANKSHAFT AND BEARING REMOVAL

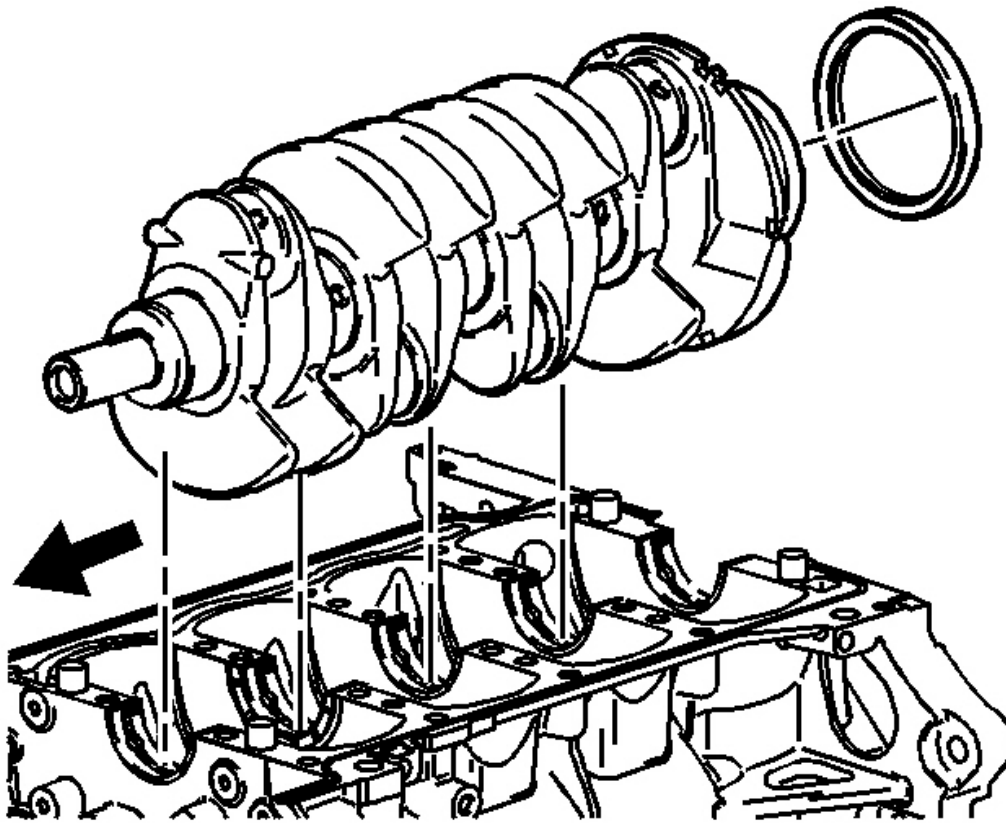


Fig. 284: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft from the block.
2. Remove the crankshaft rear oil seal from the block.

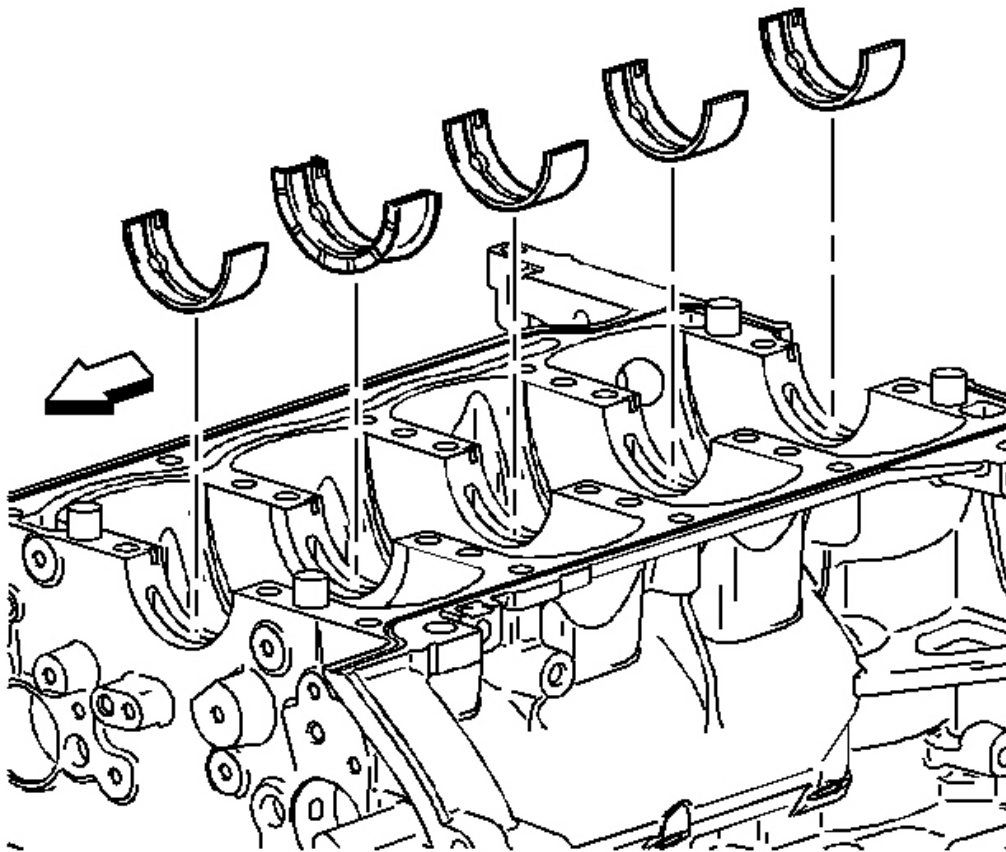


Fig. 285: View Of Block Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

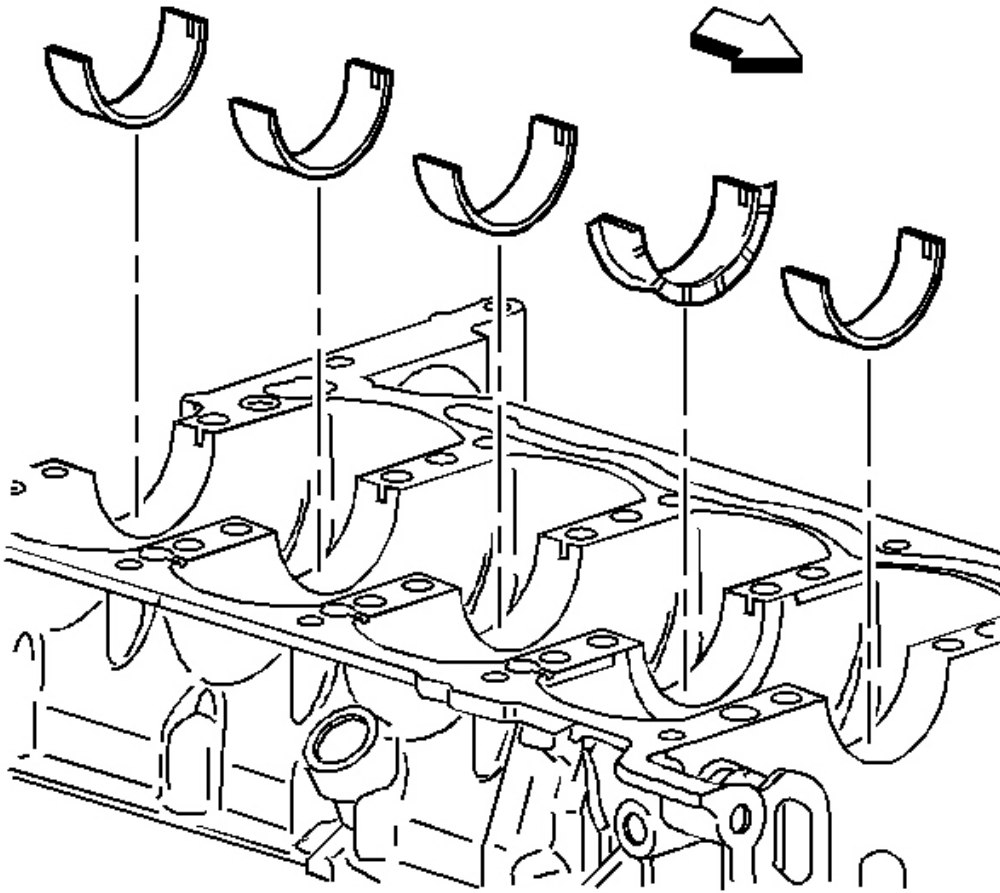


Fig. 286: View Of Bed Plate Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bearing inserts from the bed plate.
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves

- Overheating (discoloration)
9. Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

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

10. Measure the crankshaft journals. Use a micrometer or dial indicator to measure the taper and runout. Note the result for the later selection of bearing inserts. If not within limits the crankshaft must be replaced.

Note the location of the main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

ENGINE BLOCK DISASSEMBLE

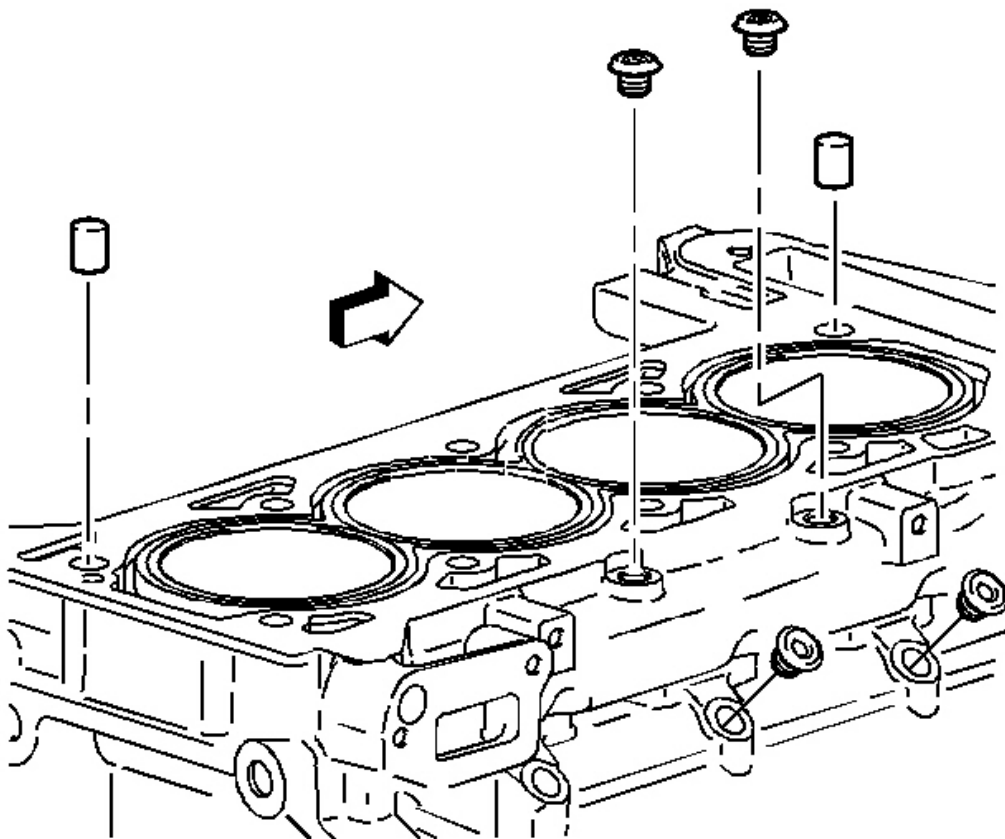


Fig. 287: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block coolant drain plug.
2. Remove the rear oil passage plug.
3. Remove the 6 oil passage plugs on the sides of the block.
4. Remove the 2 water passage plugs on the top of the block.
5. Remove the 2 front oil passage plugs.

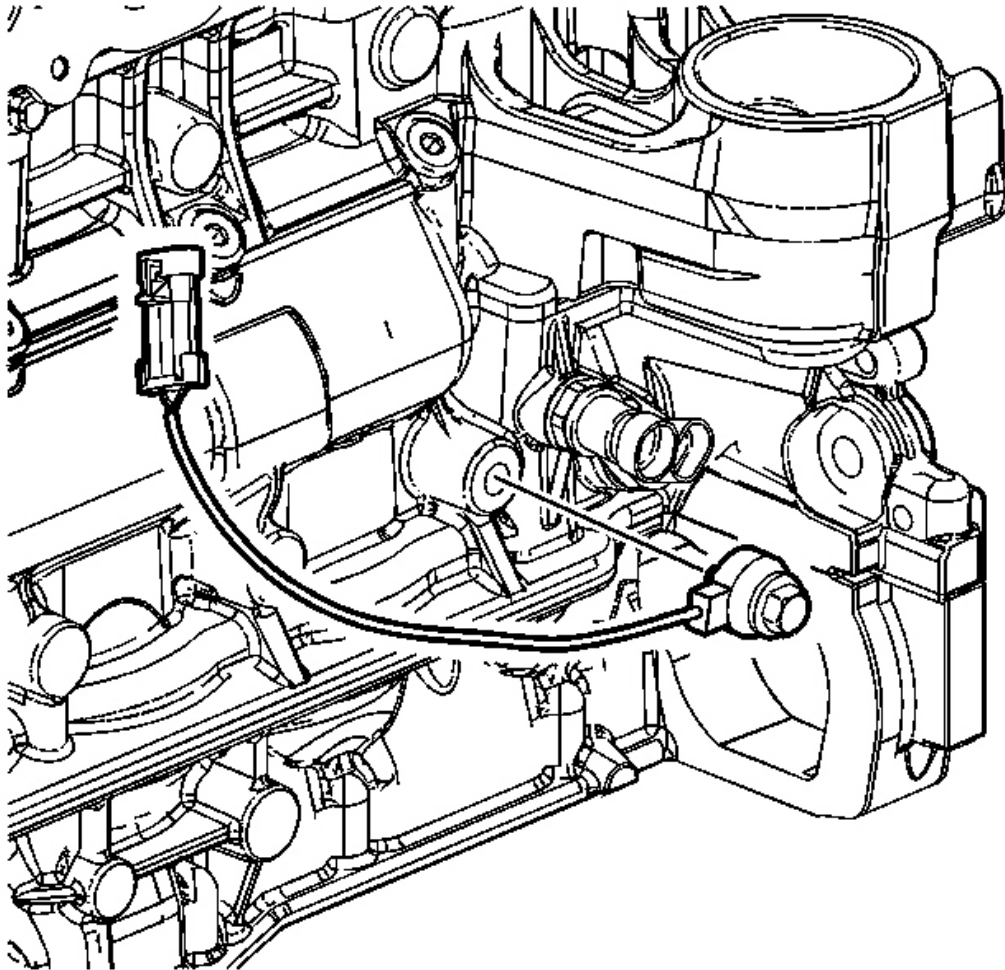


Fig. 288: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the knock sensor and bolt.

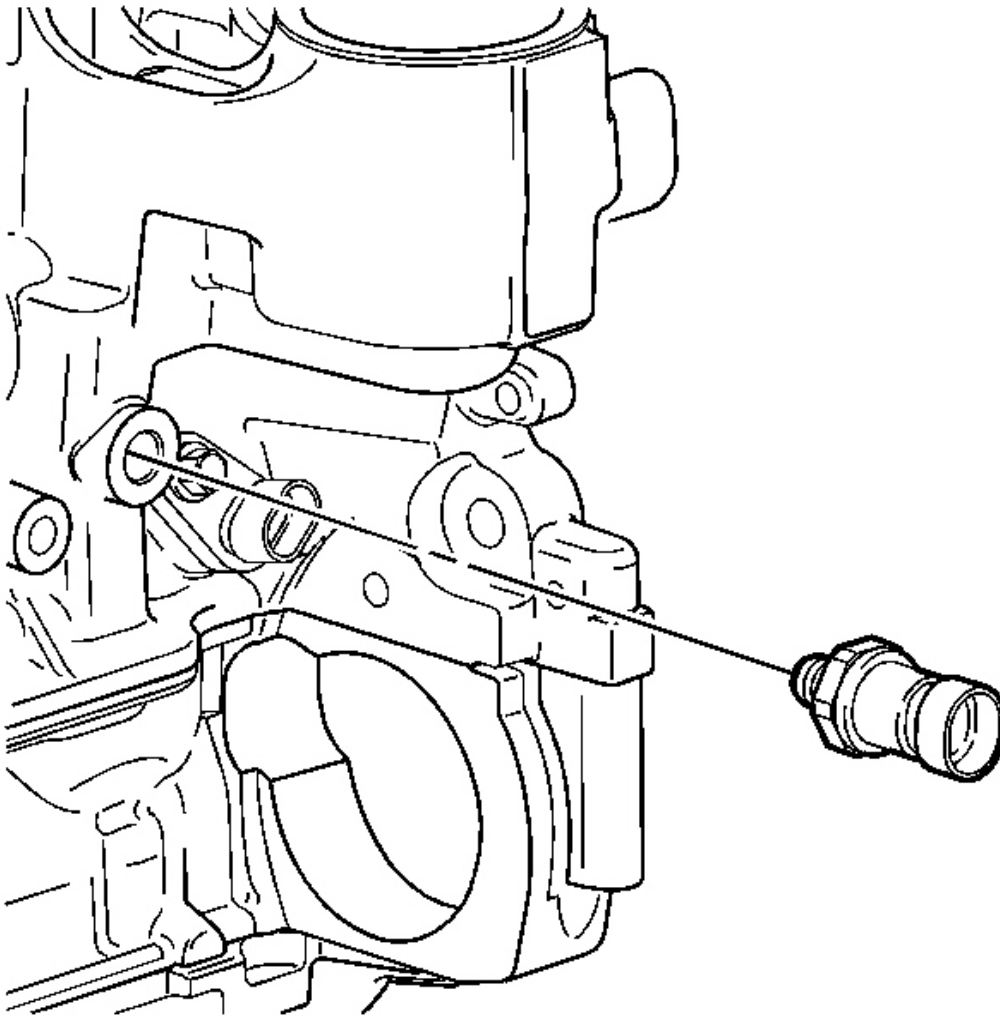


Fig. 289: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pressure switch.

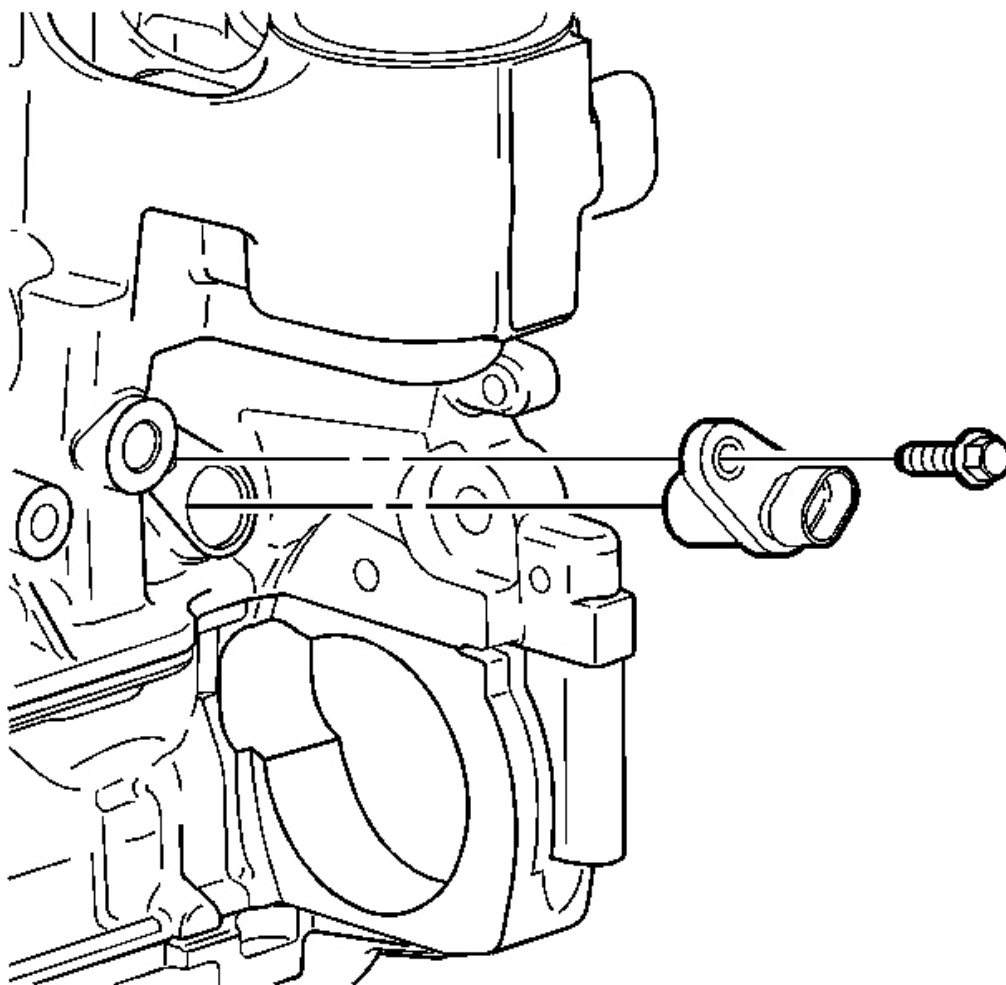


Fig. 290: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft position (CKP) sensor and bolt.

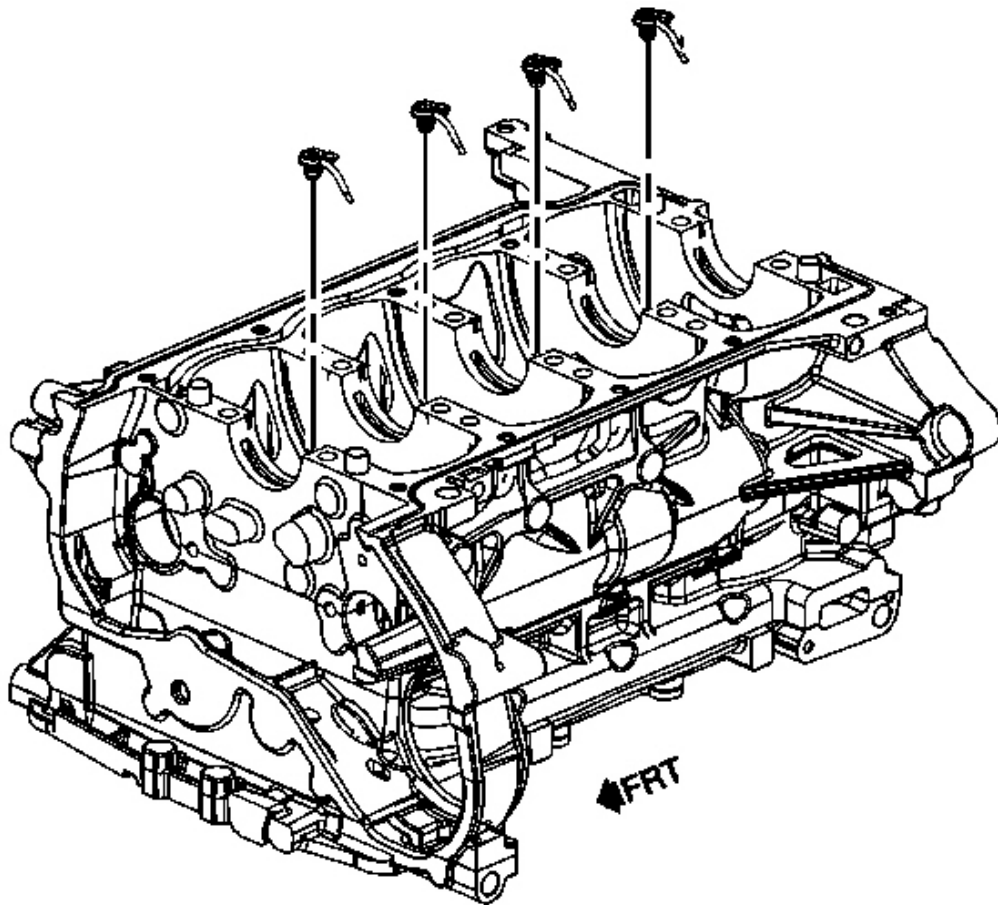


Fig. 291: View Of Piston Oil Nozzle Assembly
Courtesy of GENERAL MOTORS CORP.

9. If equipped, loosen the piston oil nozzle assembly bolt and remove the piston oil nozzle assembly.

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **EN-8087:** Cylinder Bore Gauge
- **GE-7872:** Magnetic Base Dial Indicator

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

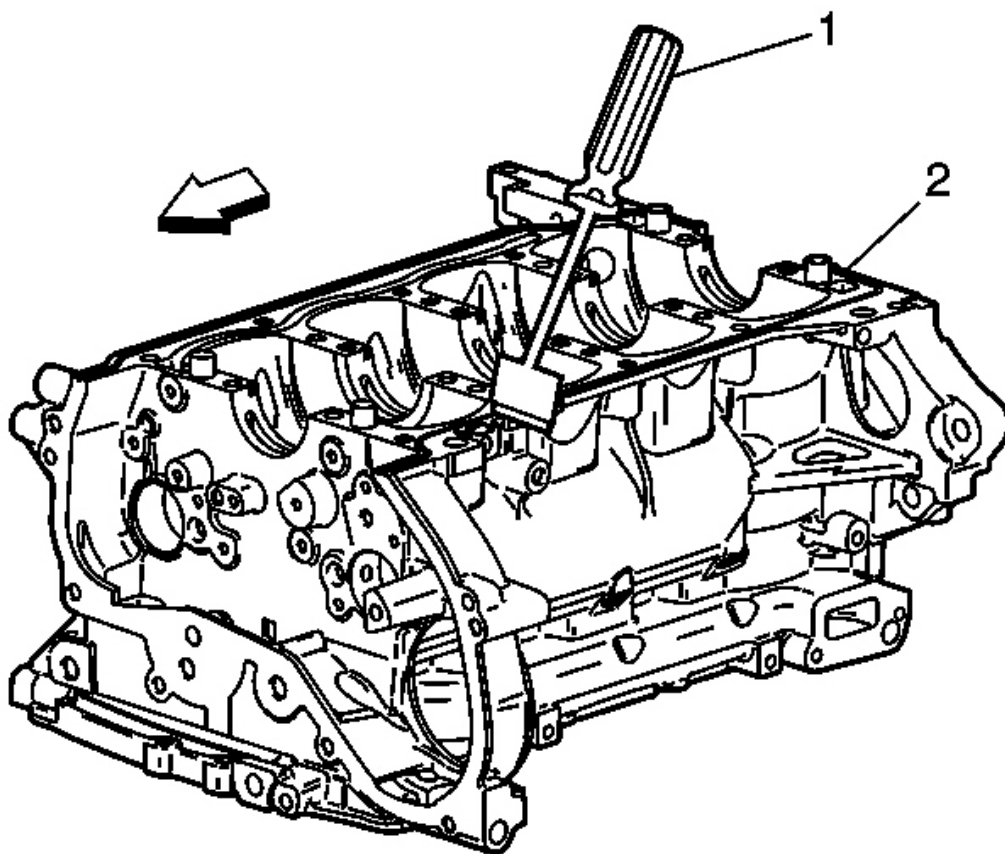


Fig. 292: Cleaning Sealing Material From Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces (2) with a suitable tool (1).
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Inspect the cylinder bores for glazing. If the bore is glazed but otherwise serviceable, refer to Deglazing Procedure in **Cylinder Boring and Honing**.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair**.

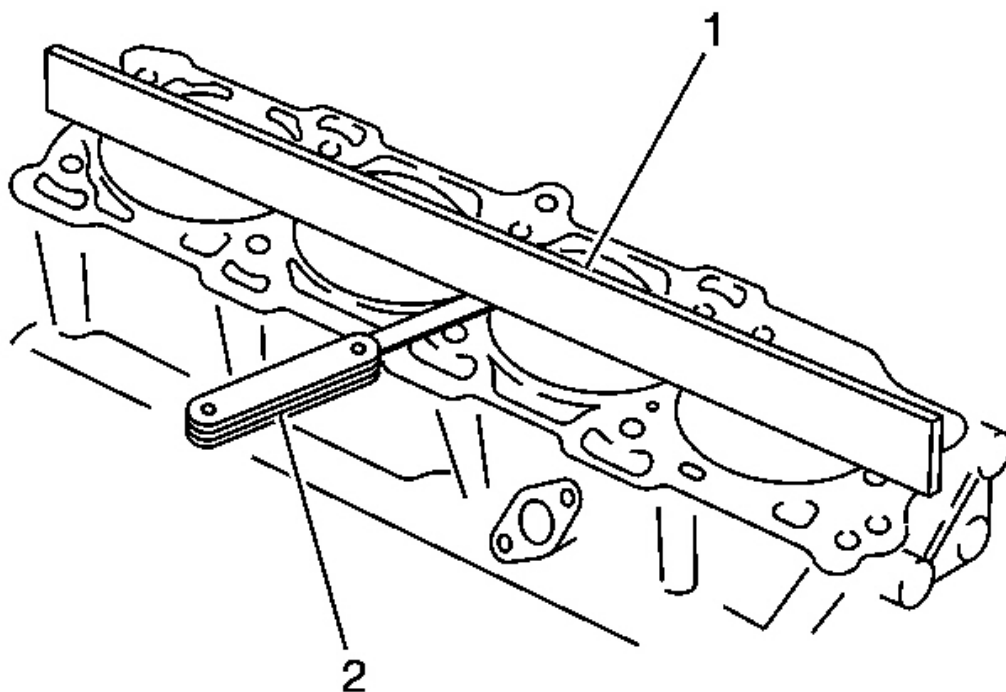


Fig. 293: Checking Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

9. Use a straight edge (1) and a feeler gauge (2) to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

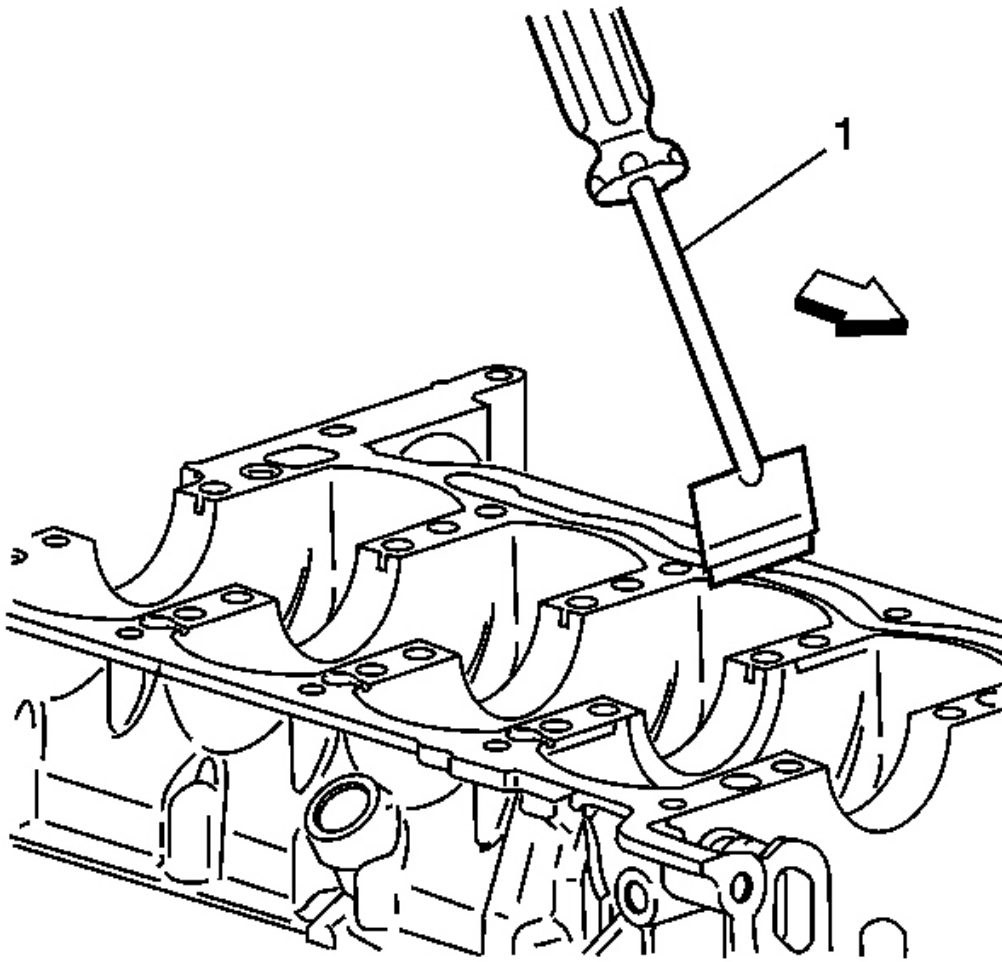


Fig. 294: Cleaning Sealing Material From Gasket Mating Surfaces On Lower Crankcase Engine Block Side

Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side with a suitable tool (1).

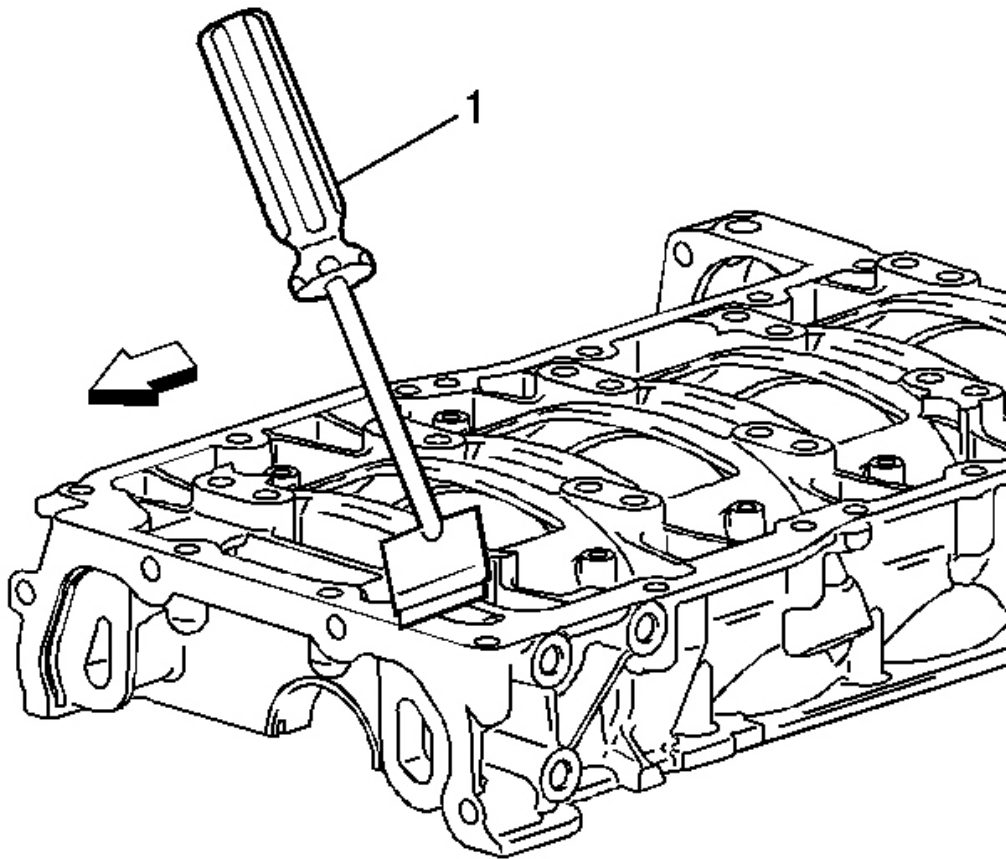


Fig. 295: Cleaning Sealing Material From Gasket Mating Surfaces On Lower Crankcase Oil Pan Side

Courtesy of GENERAL MOTORS CORP.

12. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side with a suitable tool (1).

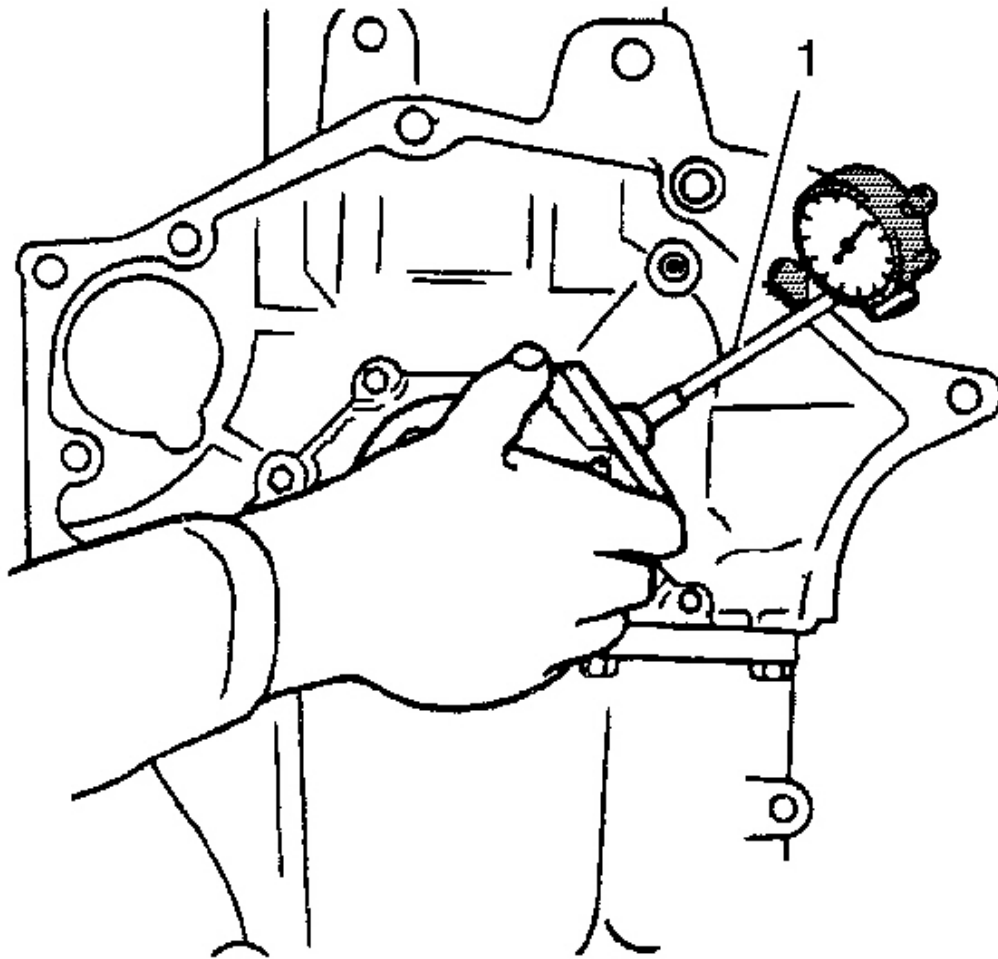


Fig. 296: Inspecting Mating Surfaces Of Transmission Face
Courtesy of GENERAL MOTORS CORP.

13. Inspect the mating surfaces of the transmission face.

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

14. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
 1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **GE-7872**: dial indicator (1)

2. Hold the gauge plate flat against the crankshaft flange.
3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.203 mm (0.008 in).
5. Recheck the crankshaft flange runout if the readings vary more than 0.203 mm (0.008 in).
6. Remove the crankshaft and bearings.

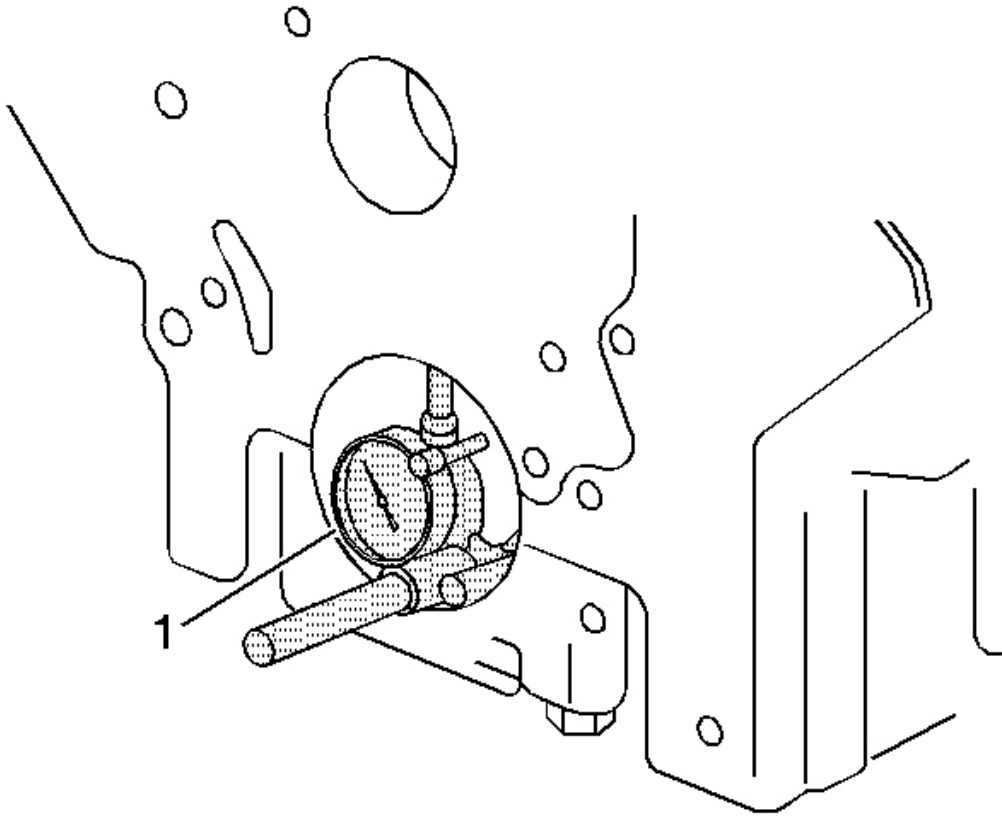


Fig. 297: Measuring Bearing Bore
Courtesy of GENERAL MOTORS CORP.

15. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
16. Inspect the crankshaft main bearing bores. Use the **EN-8087**: gauge (1) to measure the bearing bore concentricity and alignment. Refer to **Engine Mechanical Specifications**.
17. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
18. Remove the bed plate.

Measuring Cylinder Bore Diameter

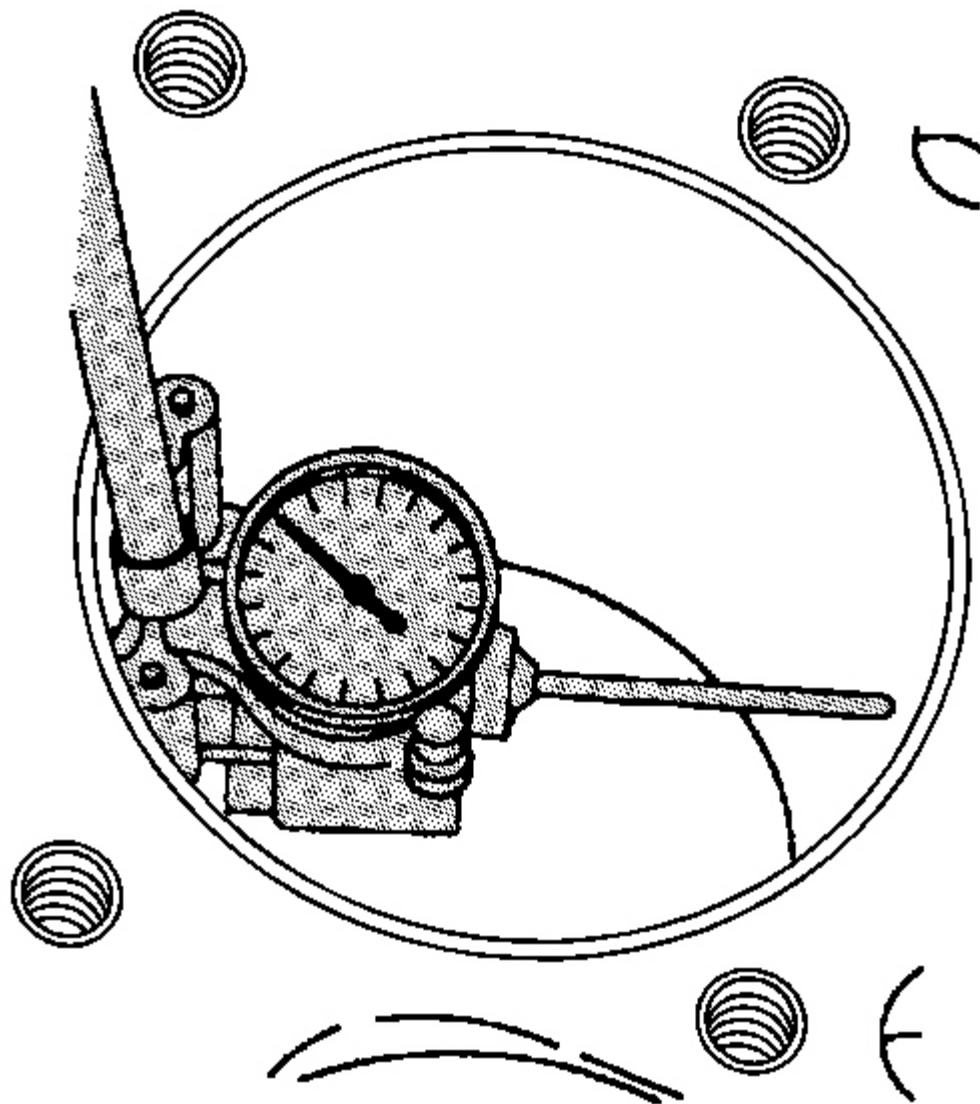


Fig. 298: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **EN-8087**: gauge.
2. Compare your results with the **Engine Mechanical Specifications**. If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of

oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing**.

Measuring Cylinder Bore Taper

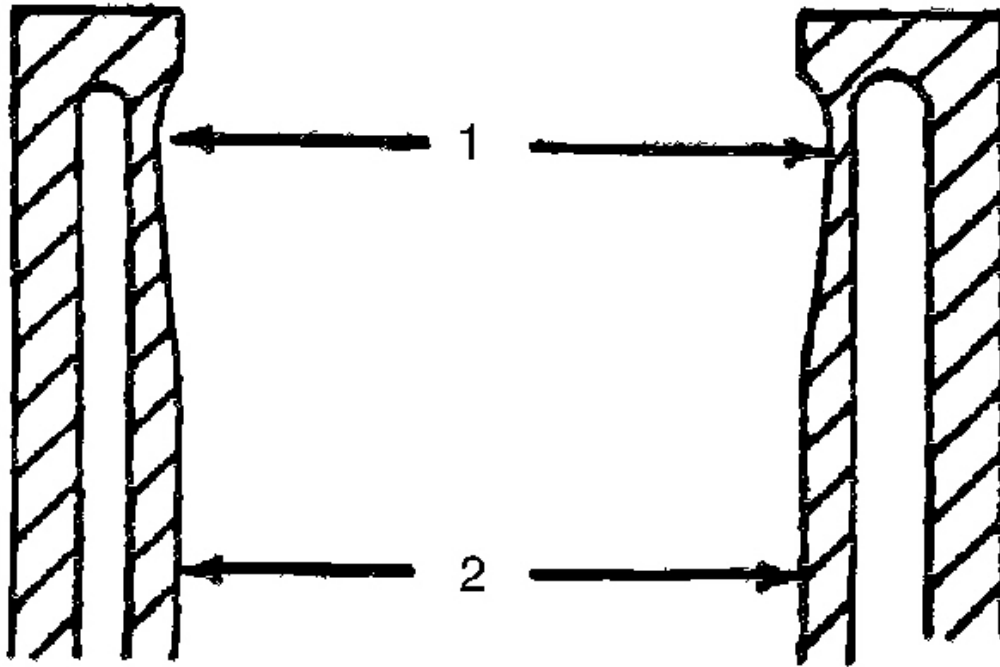


Fig. 299: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 13 mm (0.510 in) below the deck surface (1) and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.938 in) below the deck surface (2) and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications**. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing**.

Measuring Cylinder Bore Out-of-Round

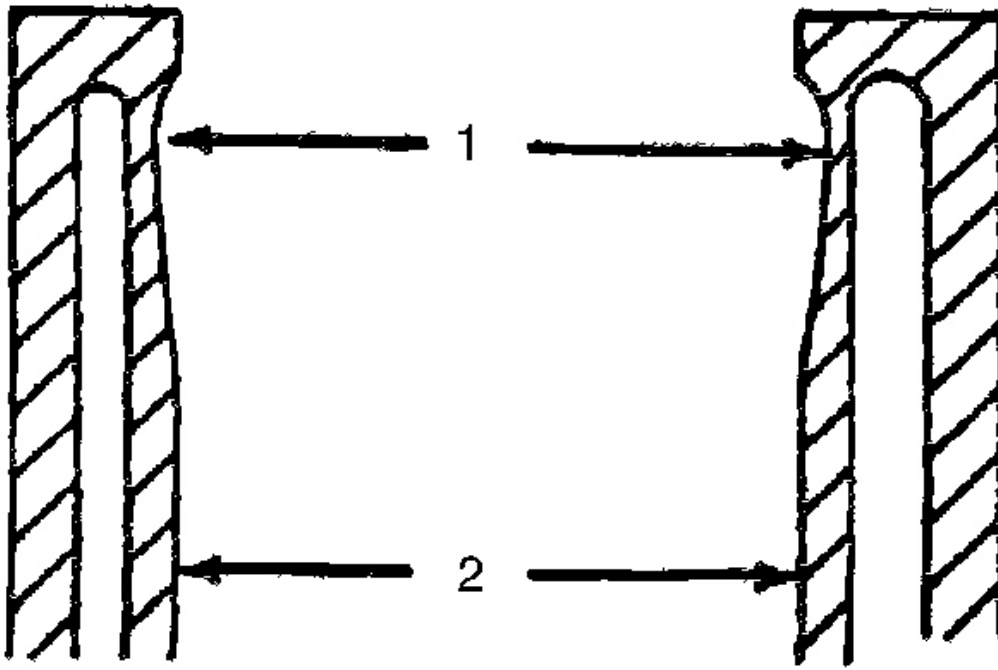


Fig. 300: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. Measure both the thrust and non-thrust cylinder diameter at 13 mm (0.510 in) below the deck surface (1). Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.938 in) below the deck surface (2). Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications**. If the cylinders exceed these specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service. Refer to **Cylinder Boring and Honing**.

CYLINDER BORING AND HONING

Boring Procedure

1. Measure all pistons with a micrometer to determine the cylinder bore diameter. Refer to **Engine Block Cleaning and Inspection**.

2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block, removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

Honing Procedure

NOTE: **Fine vertical scratches made by the ring ends do not, by themselves, cause excessive oil consumption. Do not hone the cylinder in order to remove these scratches.**

1. When honing the cylinders, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.

NOTE: **All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.**

2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly check the cylinder bore for fit with the selected piston.
3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100-grit stone.

NOTE: **A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.**

4. Perform final cylinder honing with a 240-grit stone and obtain a 45 degree cross hatch pattern.
5. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
6. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
7. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.
8. Perform final measurements of the piston and the cylinder bore.

9. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure

1. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. Refer to **Piston, Connecting Rod, and Bearing Installation (LAF, LAT, LE5, LE9)**.

NOTE: **A 240-grit stone is preferred for final honing. If a 240-grit stone is not available, a 220-grit stone may be used as a substitute.**

2. Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240-grit stone of silicone carbide, or equivalent, material when performing the deglazing procedure.
 1. The honing stones must be clean, sharp, and straight.
 2. Move the hone slowly up and down to produce a 45 degree cross-hatch pattern.
 3. Clean the bore thoroughly with soap and water.
 4. Dry the bore.
 5. Rub clean engine oil in the bore.
 6. Re-measure the bore.
3. If the cylinder bore is out of specification, the cylinder bore may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.
4. If honing is not required, clean the cylinder bores with hot water and detergent. Apply clean engine oil to the bore after washing and drying the bore.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

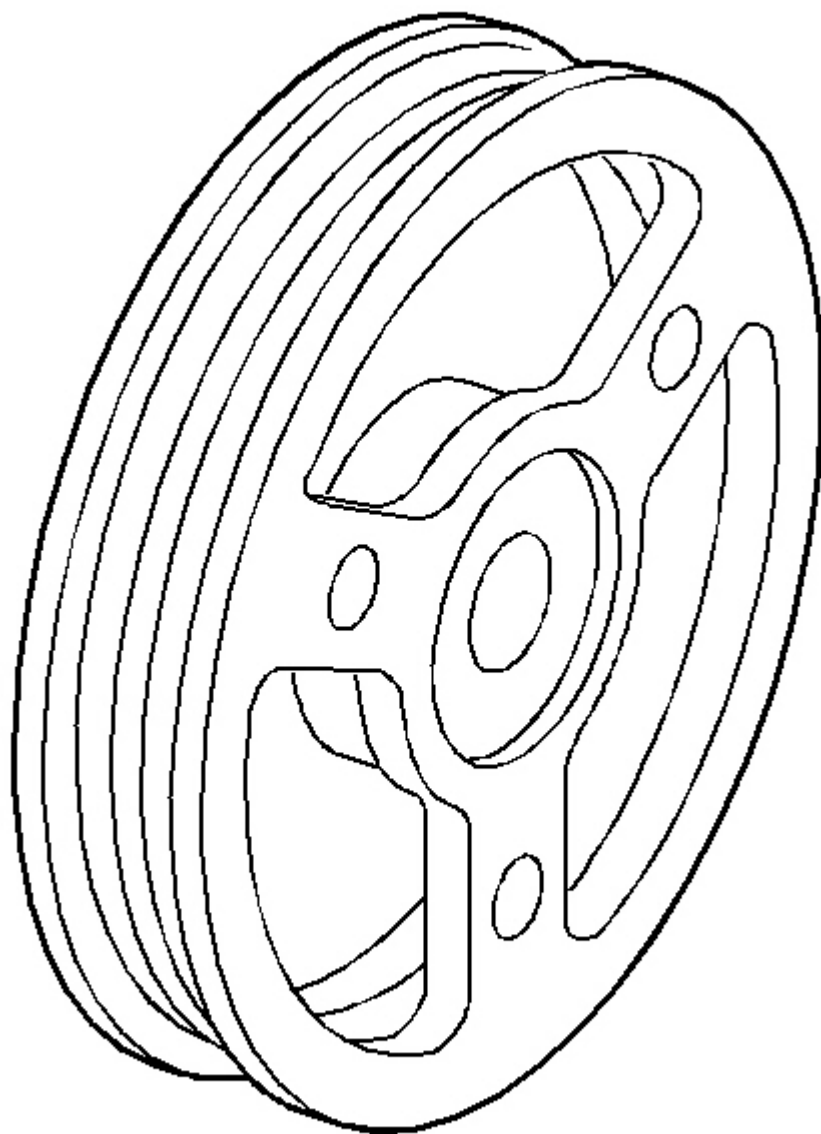


Fig. 301: Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer.
2. Clean the belt grooves of all dirt or debris with a wire brush.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:
 - Worn, grooved, or damaged hub seal surface

A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

NOTE: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves

The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

Minor imperfections may be removed with a fine file.

- Worn, chunking or deteriorated rubber between the hub and pulley

ENGINE FLYWHEEL CLEANING AND INSPECTION

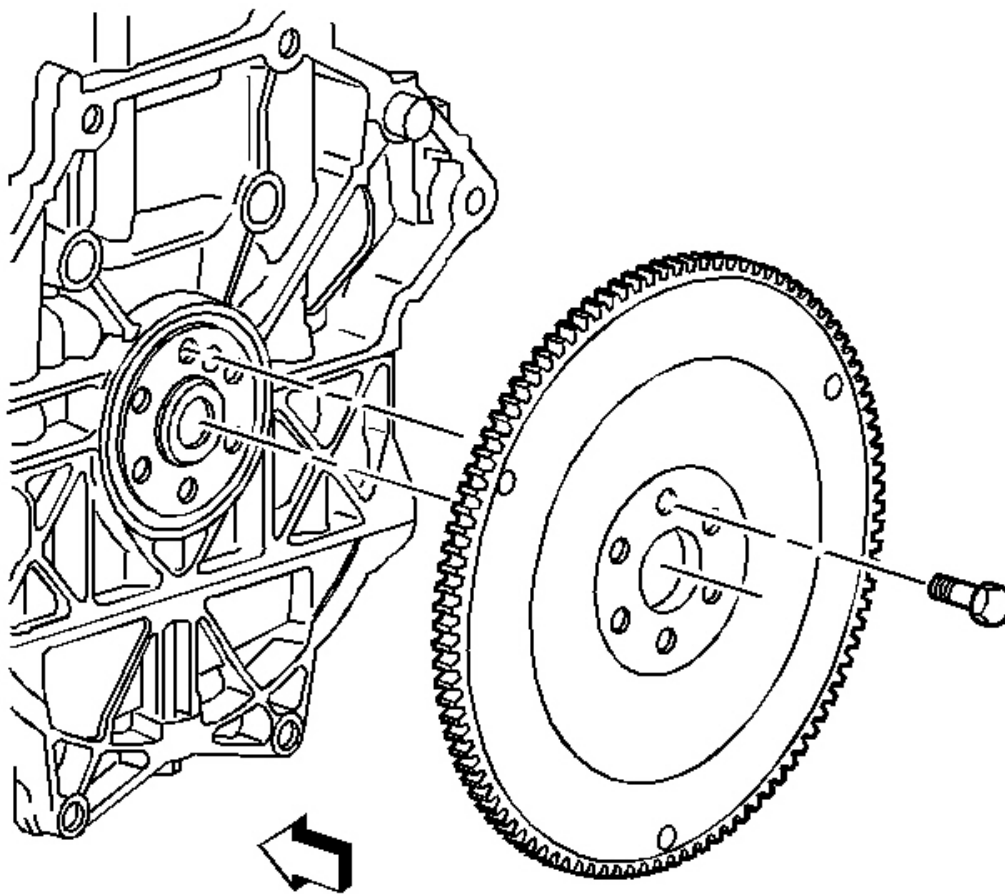


Fig. 302: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following:
 - Damaged ring gear teeth
 - Stress cracks around the flywheel-to-crankshaft bolt hole locations
 - Weight saving holes

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

GE-7872: Magnetic Base Dial Indicator Set

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

CLEANING AND INSPECTION

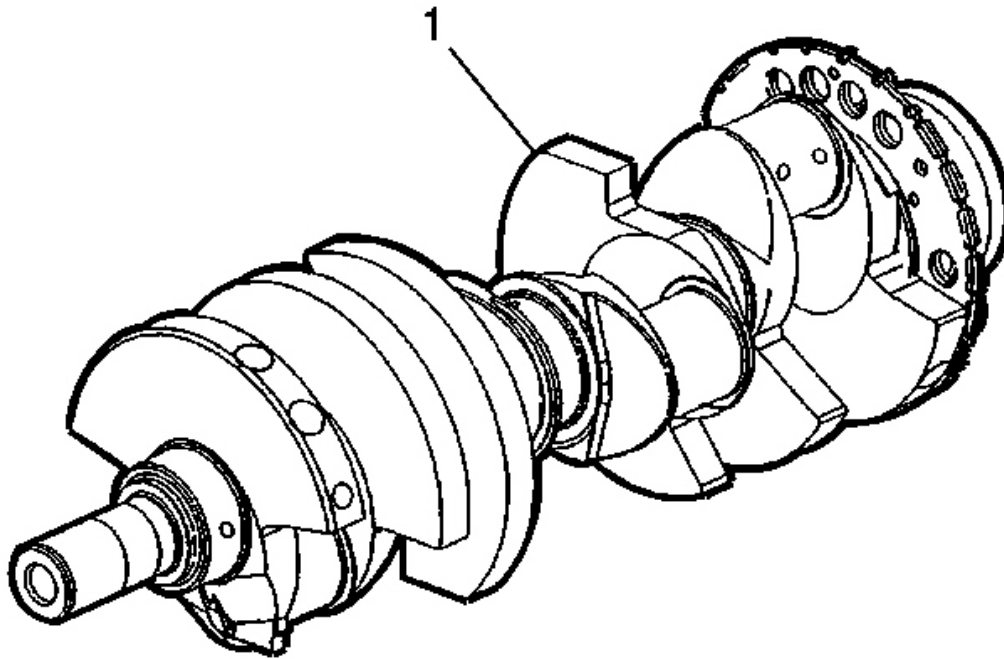


Fig. 303: Crankshaft

Courtesy of GENERAL MOTORS CORP.

NOTE: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may affect on-board diagnostic (OBD) II system performance.

1. Clean the crankshaft (1) with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

NOTE: Reluctor ring teeth should not have imperfections on the rising or falling edges.
Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.

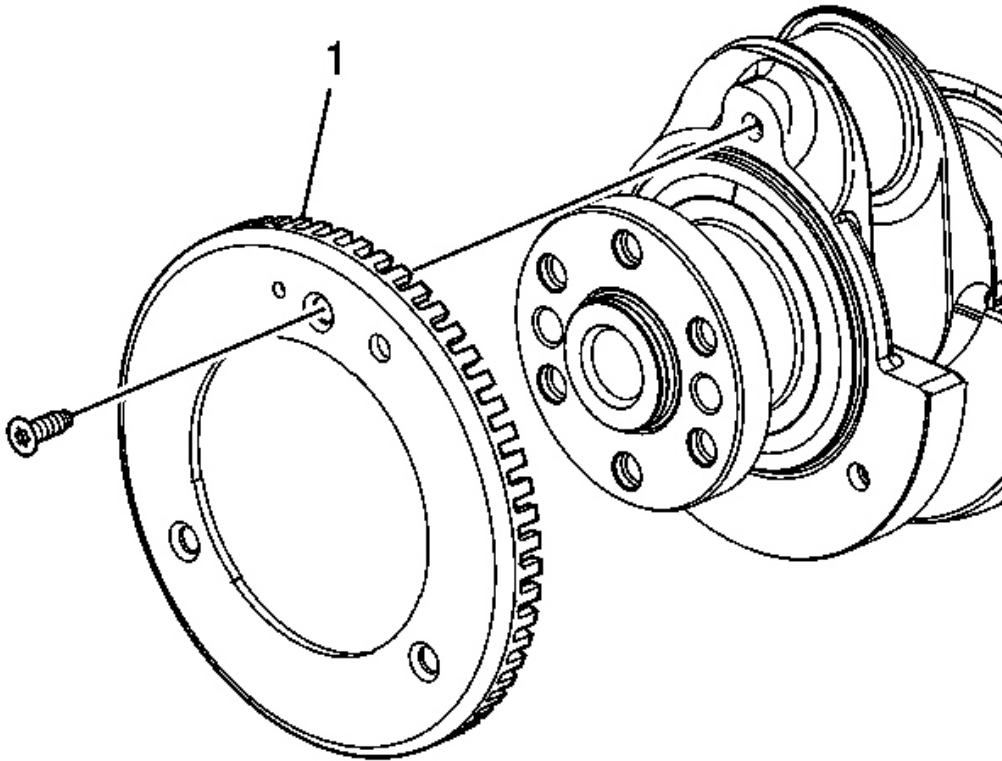


Fig. 304: Crankshaft Position Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft position reluctor ring (1) may be replaced if damaged. Tighten the crankshaft position reluctor ring bolts to 15 N.m (11 lb ft).

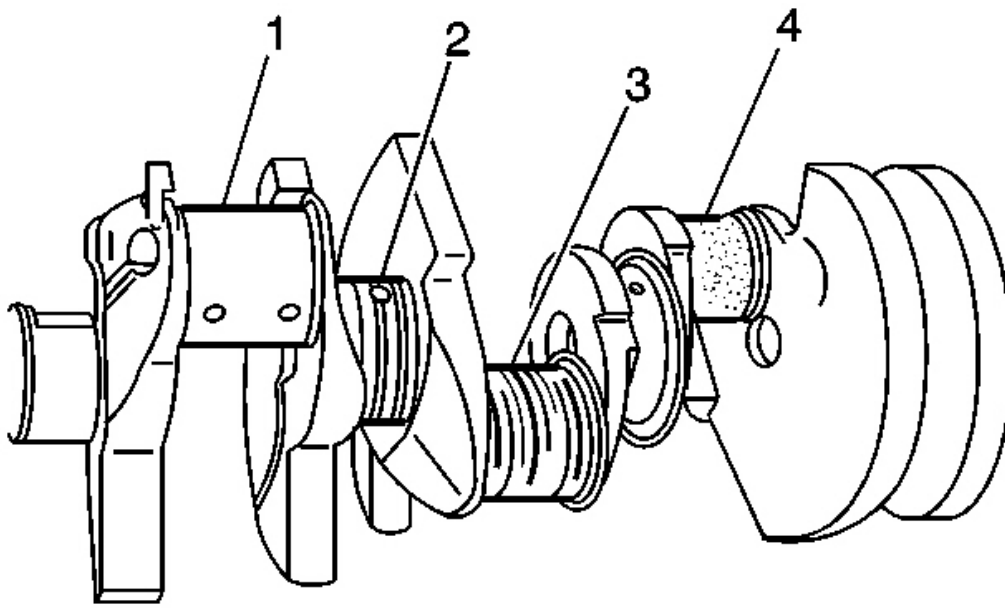


Fig. 305: Identifying Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

6. Inspect the crankshaft journals for wear (1). The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring (2).
8. Inspect the crankshaft journals for scratches or wear (3).
9. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

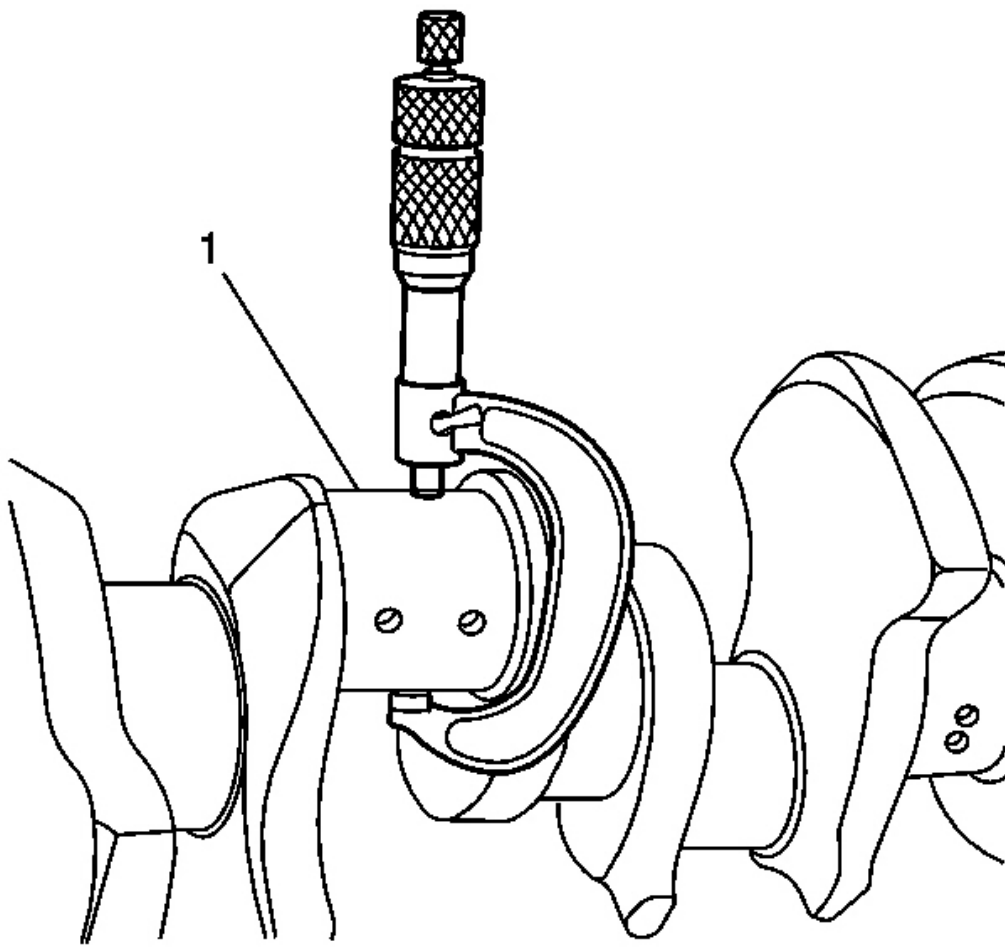


Fig. 306: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft journals (1) for out-of-round.
11. Measure the crankshaft journals for taper.

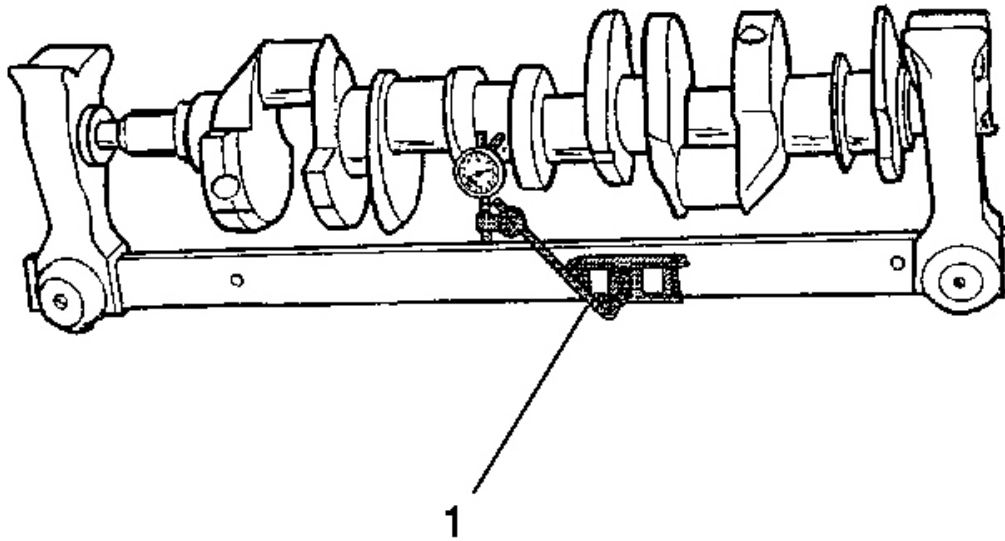


Fig. 307: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **GE-7872:** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **GE-7872:** indicator in order to measure the runout of the crankshaft rear flange.
15. Replace the crankshaft if the measurements are not within specifications.

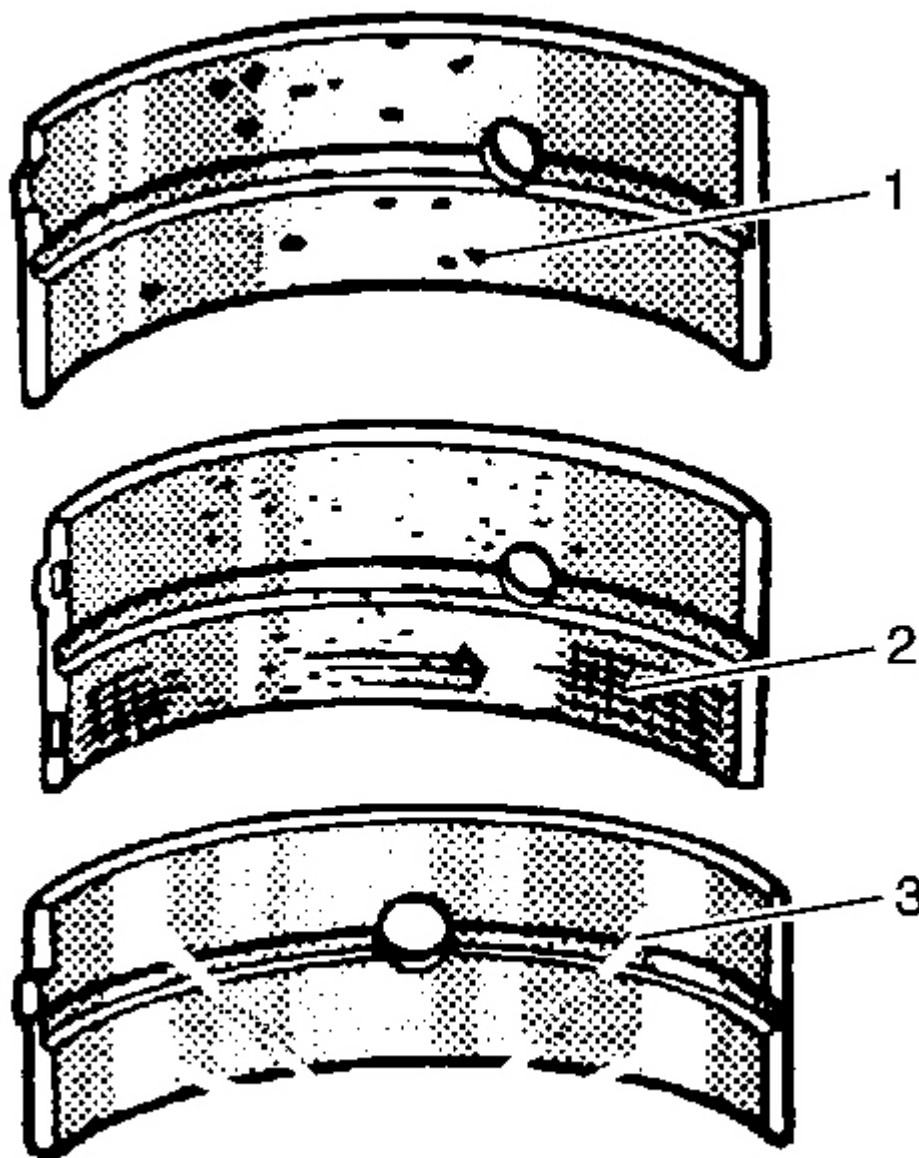


Fig. 308: Identifying Crankshaft Bearing Damage
Courtesy of GENERAL MOTORS CORP.

16. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.
17. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

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.

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

EN-46745: Piston Pin Retainer Remover and Installer

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

Disassemble

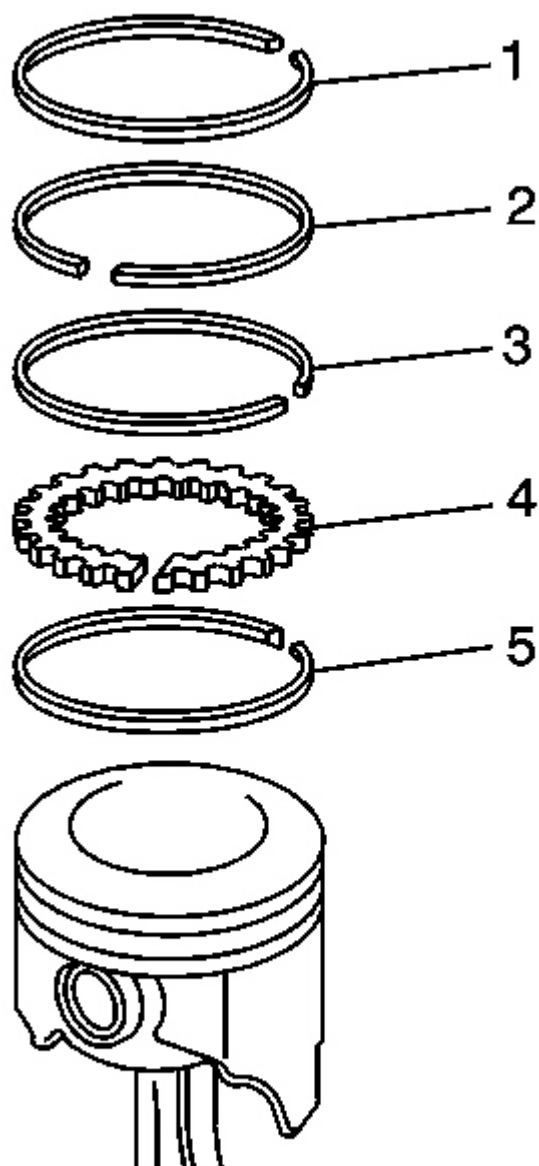


Fig. 309: Identifying Piston Rings
Courtesy of GENERAL MOTORS CORP.

WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.

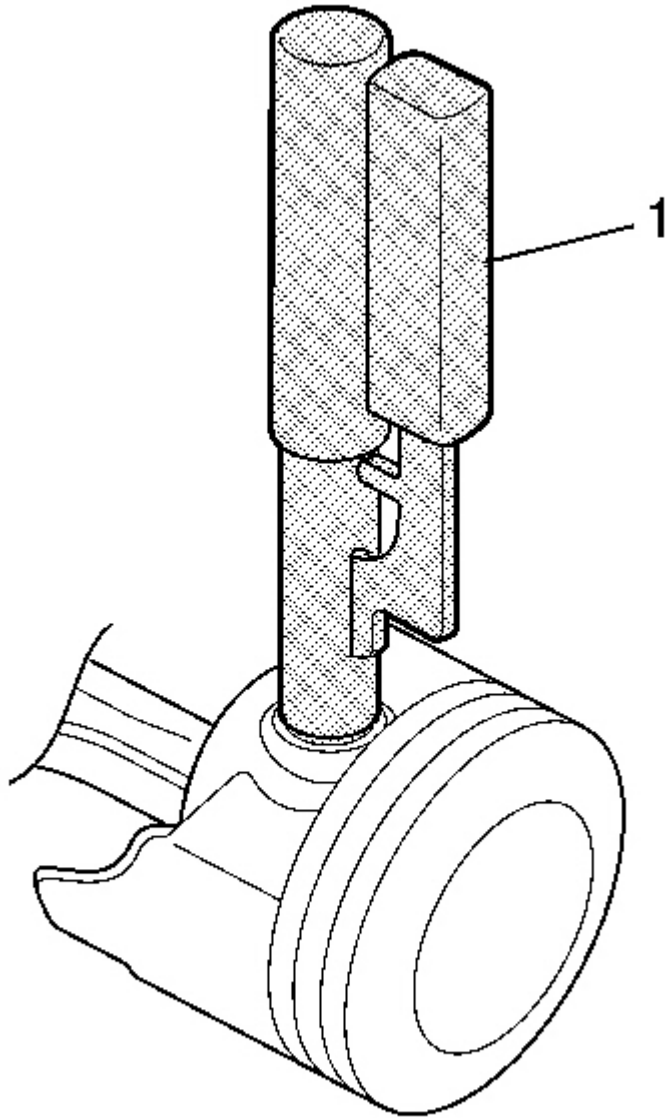


Fig. 310: Piston Pin Retainer Remover
Courtesy of GENERAL MOTORS CORP.

NOTE: Two retainers hold the piston pins in place. No special tools are required to remove the piston pins. Ensure that the piston pin is not damaged. Do

not reuse the retainers.

2. Remove the piston pin retainers using the **EN-46745**: remover (1).

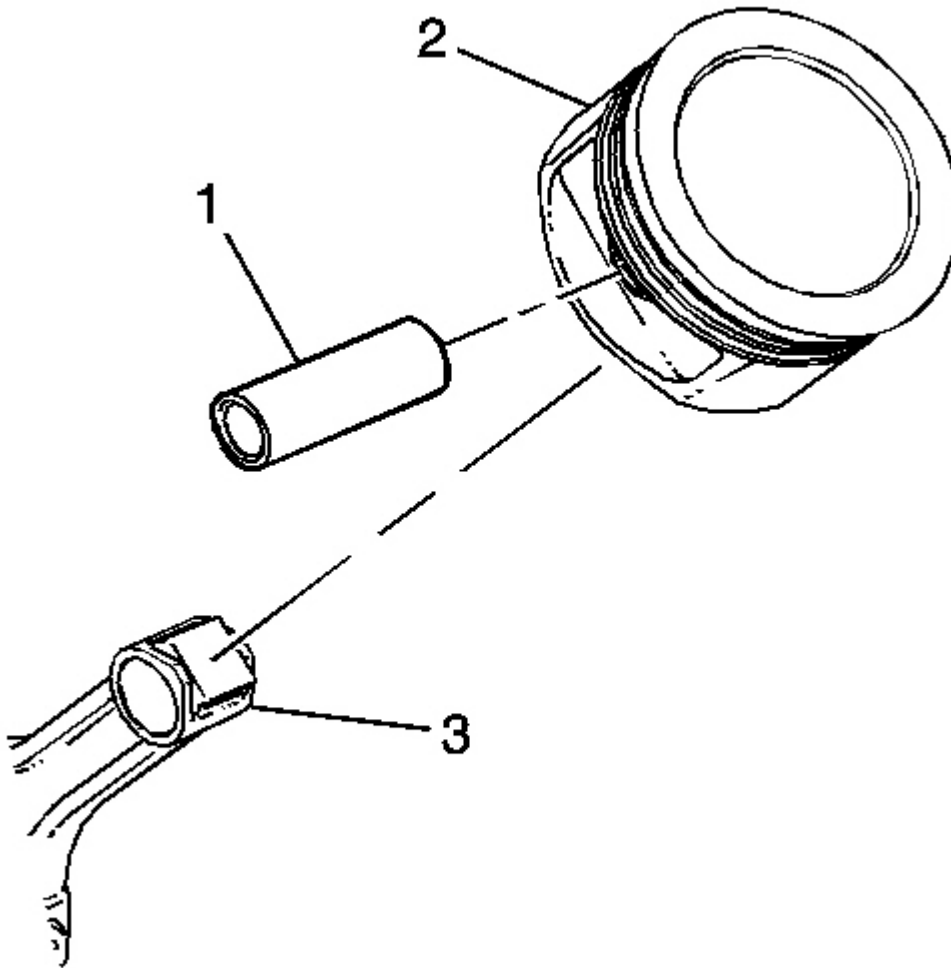


Fig. 311: Identifying Piston Pin, Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin (1) and the connecting rod (3) from the piston (2).

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

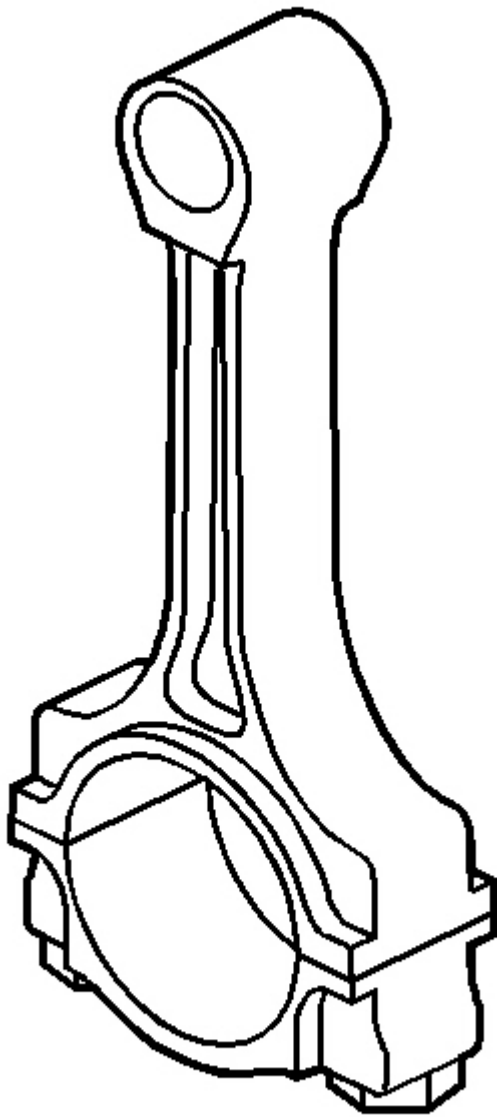


Fig. 312: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean the connecting rods in solvent and dry with compressed air.
2. Inspect the connecting rods for the following:
 - Signs of being twisted, bent, nicked, or cracked
 - Scratches or abrasion on the rod bearing seating surface

3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT scrape the rod or rod cap.
4. If the beam of the rod is scratched or has other damage replace the connecting rod.
5. Measure the piston pin to connecting rod bore using the following procedure:
 1. Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
 2. Using an inside micrometer, measure the connecting rod piston pin bore.
 3. Subtract the piston pin diameter from the piston pin bore diameter.
 4. The clearance should not be more than 0.021 mm (0.0008 in).
6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

Piston Measurement

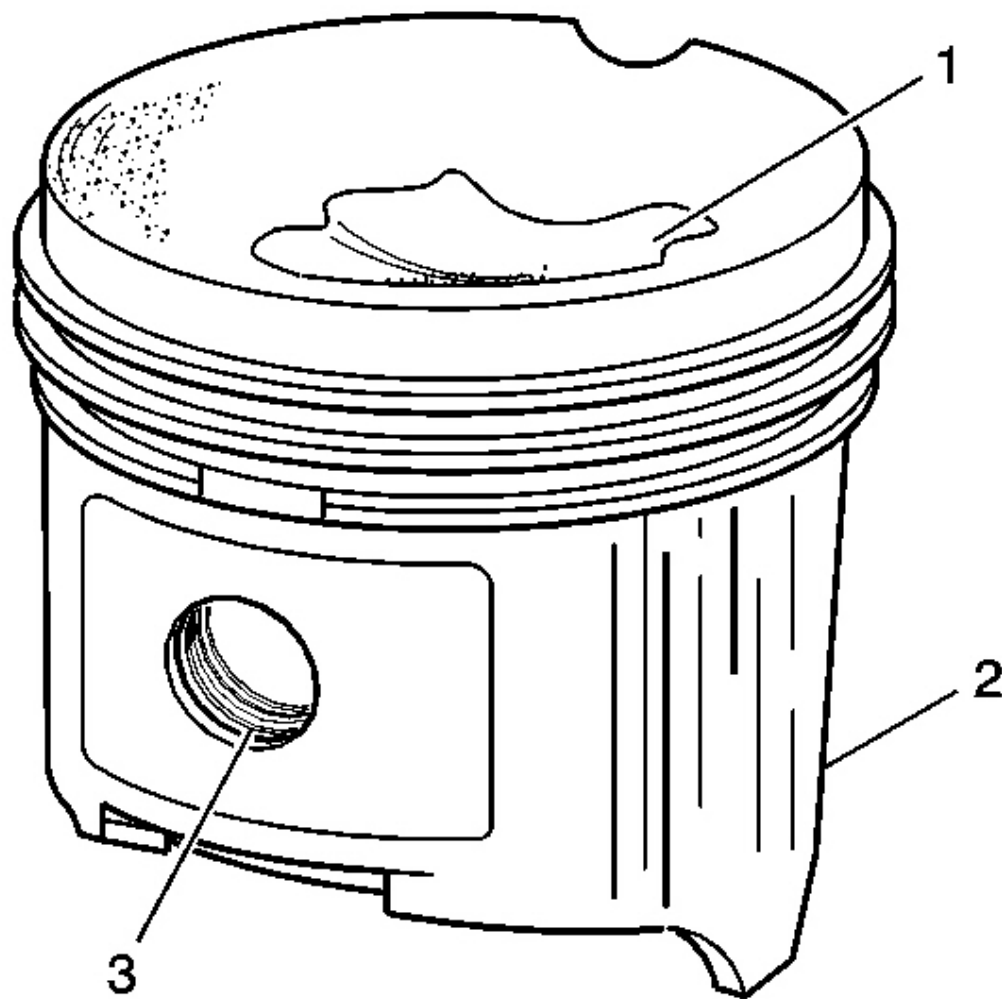


Fig. 313: Identifying Piston Damage
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts, or pin bosses
 - Ring grooves for nicks, burrs that may cause binding
 - Warped or worn ring lands
 - Eroded areas at the top of the piston (1)

- Scuffed or damaged skirts (2)
 - Worn piston pin bores (3)
4. Replace pistons that show any signs or damage or excessive wear.
 5. Measure the piston pin bore to piston pin clearances using the following procedure:
 1. Piston pin bores and pins must be free of varnish or scuffing.
 2. Use an outside micrometer to measure the piston pin in the piston contact areas.
 3. Using an inside micrometer, measure the piston pin bore.
 4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002-0.012 mm (0.00007-0.00047 in).
 5. If the clearance is excessive, determine which component is out of specification.

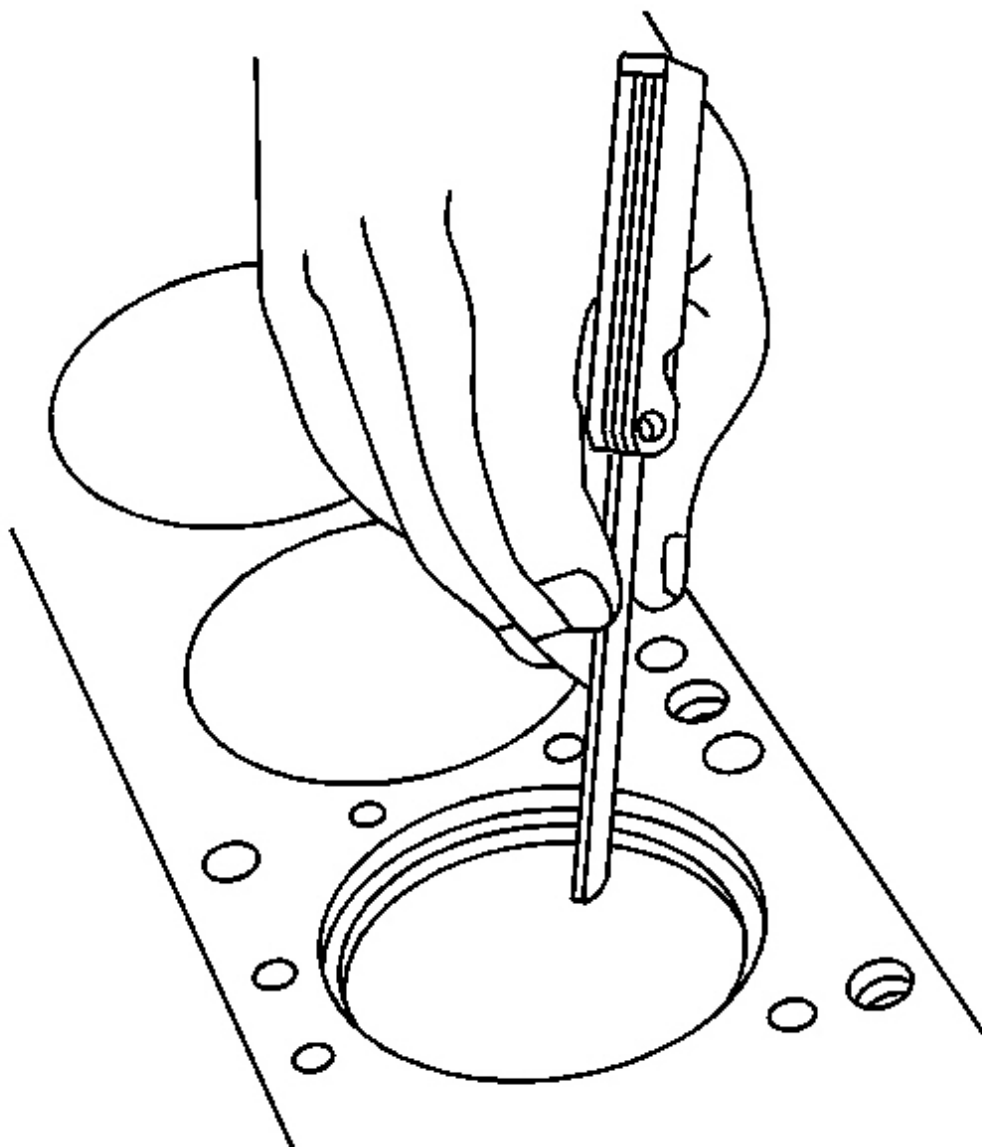


Fig. 314: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

6. Measure the piston ring end gap using the following procedure:
 1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.

2. Measure the end gap of the piston ring with feeler gauges. Compare the measurements with those provided below:
 - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
 - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
 - The oil ring end gap should be 0.25-0.76 mm (0.0098-0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

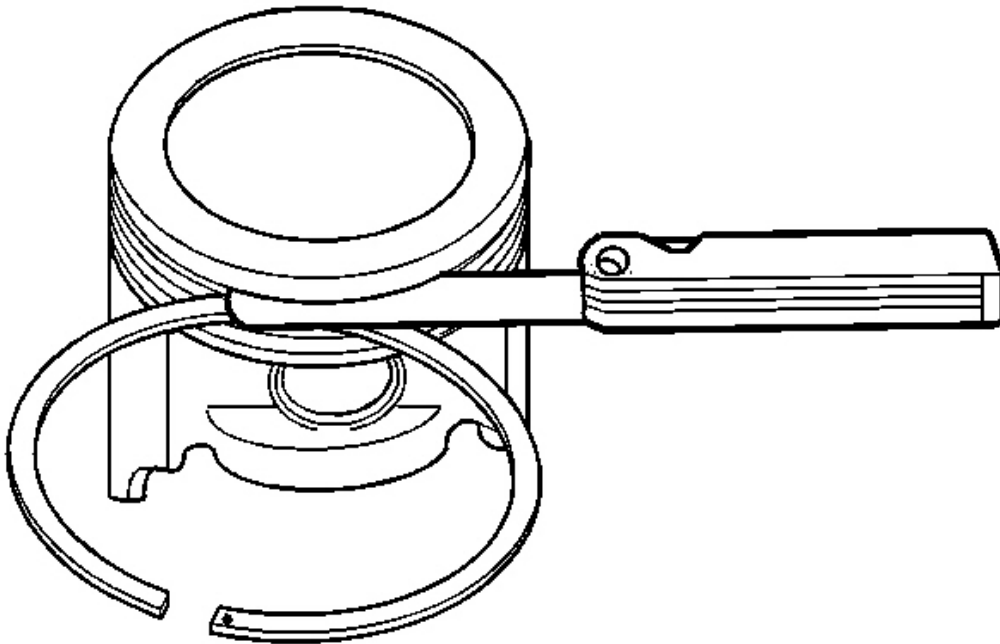


Fig. 315: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance using the following procedure:
 1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
 2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
 3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
 4. If the clearance is greater than specifications, replace the piston ring.
 5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.

8. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.
9. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
10. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.

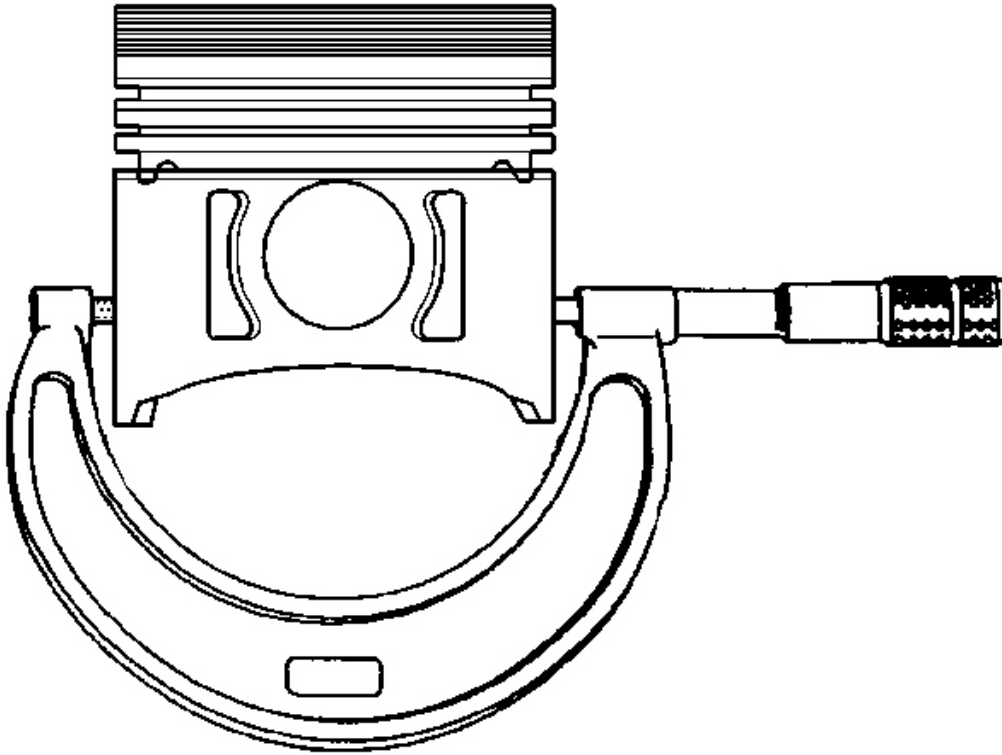


Fig. 316: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

11. Measure piston width using the following procedure:
 1. Using an outside micrometer, measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
 2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
 3. The proper clearance specification for the piston is 0.010-0.041 mm (0.0006-0.0016 in).
12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston.

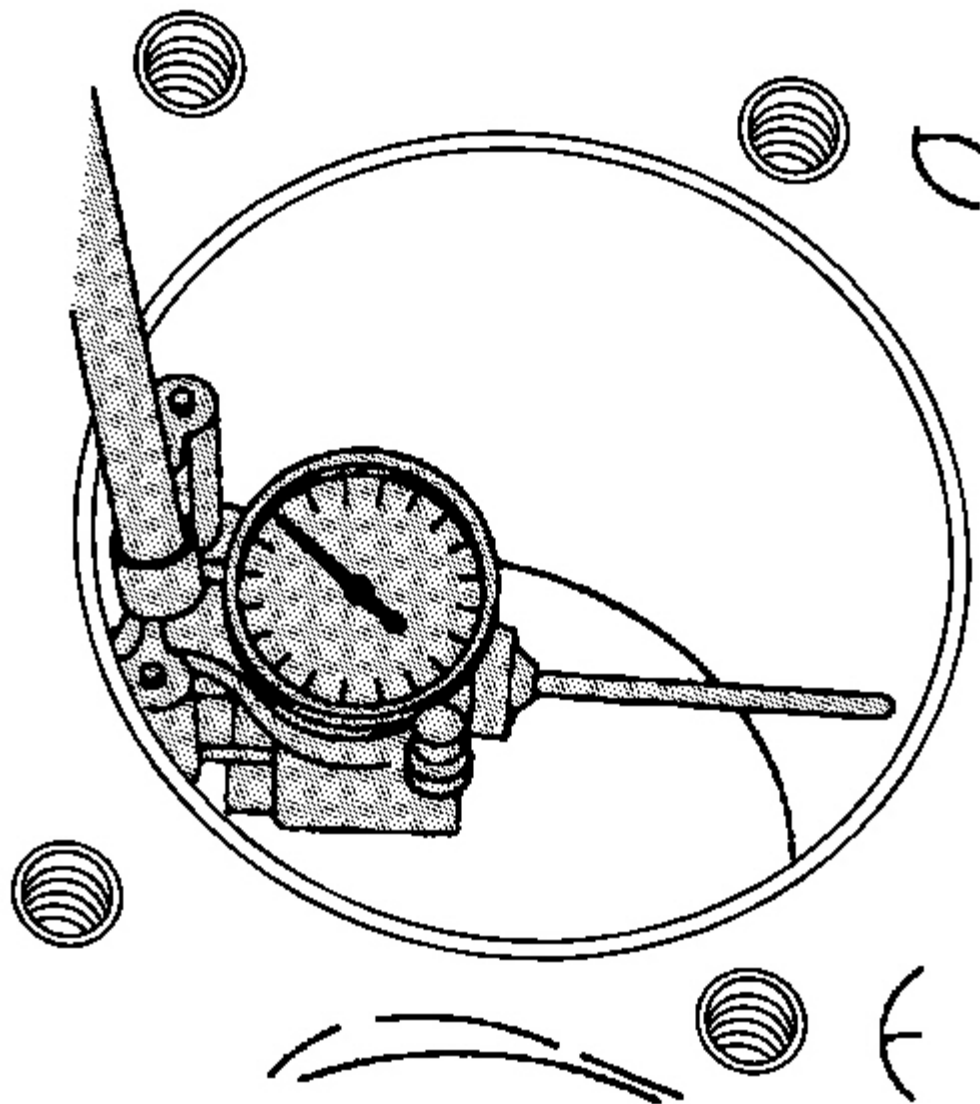


Fig. 317: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.
For proper piston fit, the engine block cylinder bores must not have

excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

1. Inspect the engine block cylinder bore. Refer to **Engine Block Cleaning and Inspection.**
2. Inspect the piston and the piston pin. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection.**
3. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

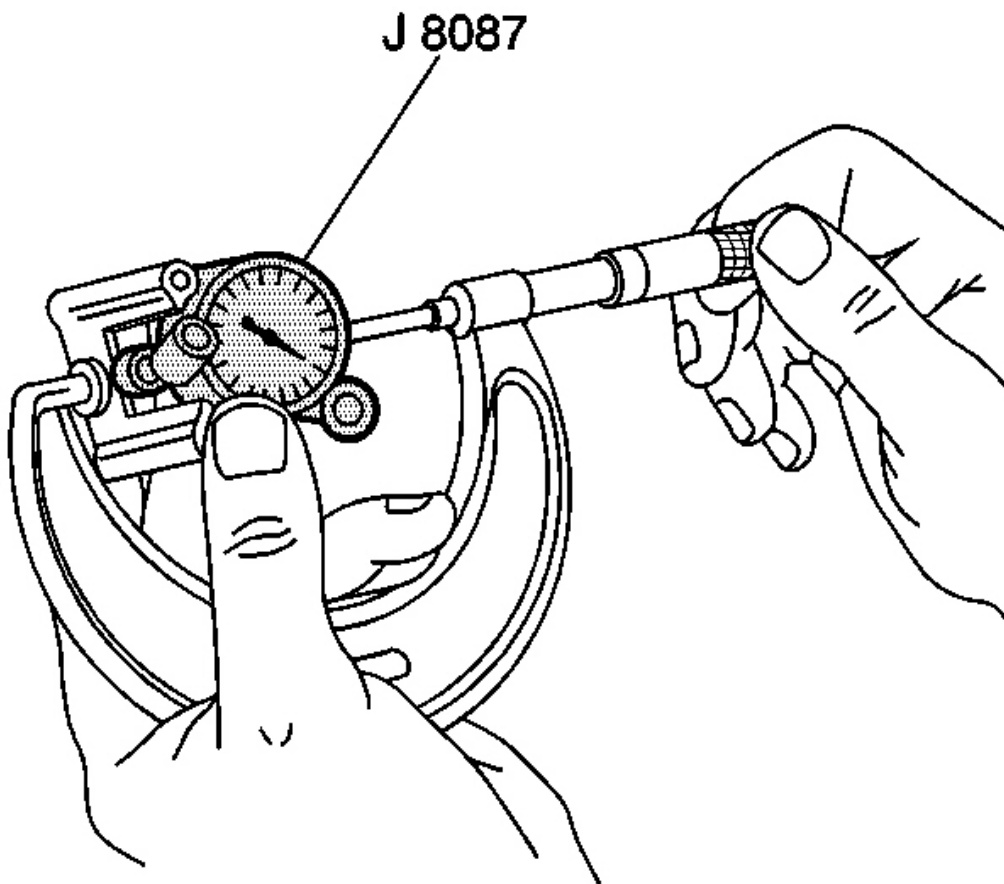


Fig. 318: Measuring Bore Gauge
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gauge with a micrometer and record the reading.

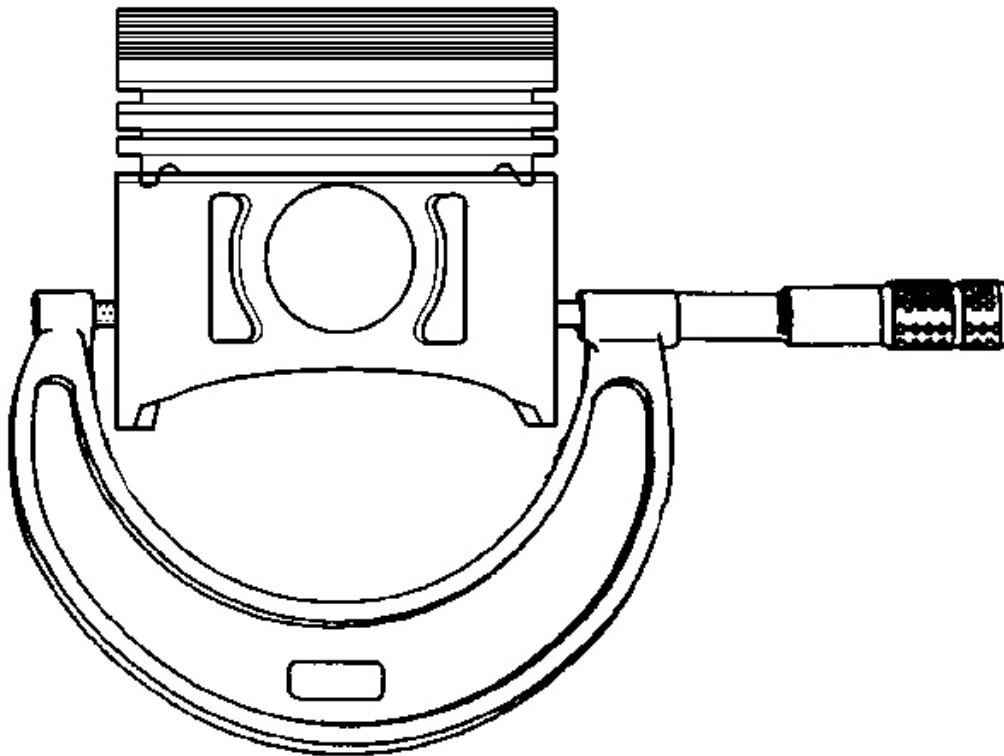


Fig. 319: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

5. With a micrometer or caliper at a right angle to the piston, measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to **Separating Parts**.

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

EN-46745: Piston Pin Retainer Remover and Installer

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

Assemble

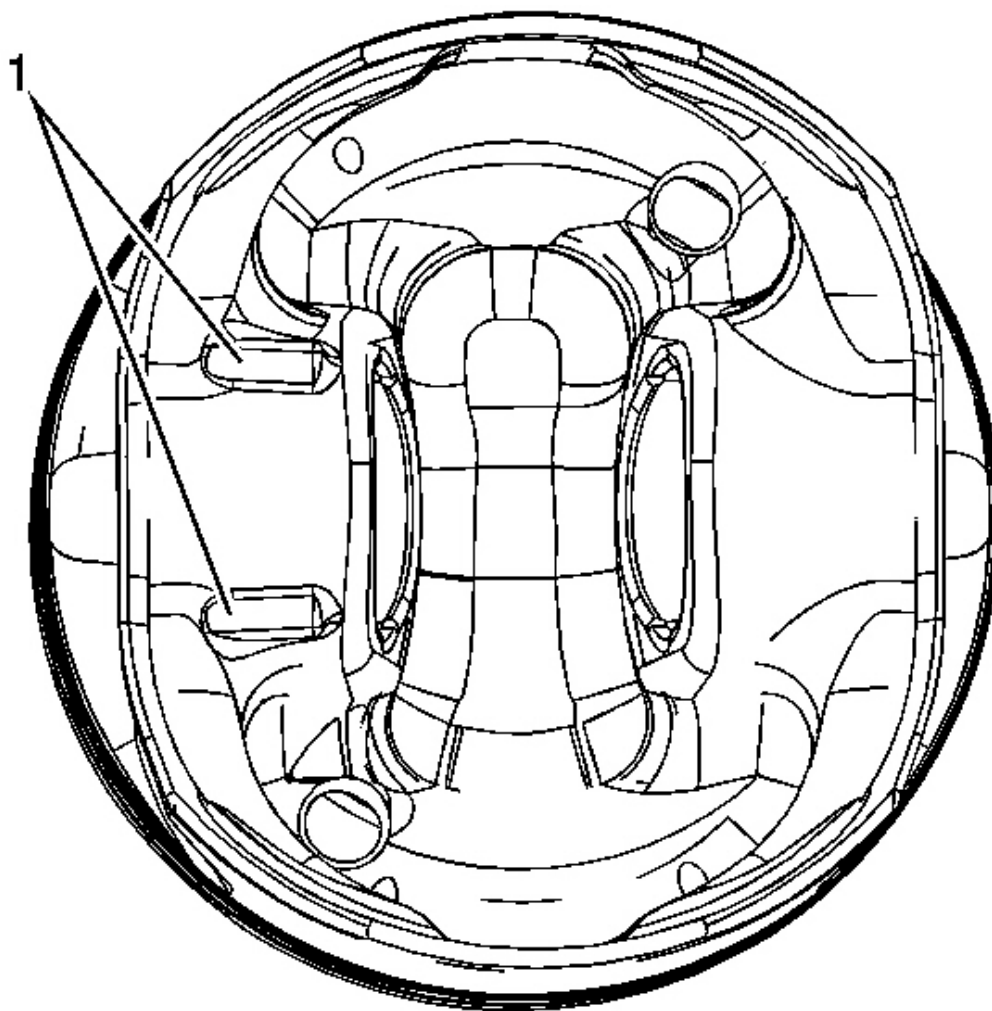


Fig. 320: Locating "Cast Boss" On Underside of Piston
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the piston onto the connecting rod with the arrow on top of the piston toward the front oriented toward the front of the engine.

NOTE: The cast boss (1) can be in either or both locations depending on

displacement.

1. The cast boss (1), on the underside of the piston, must go to the rear of the block.

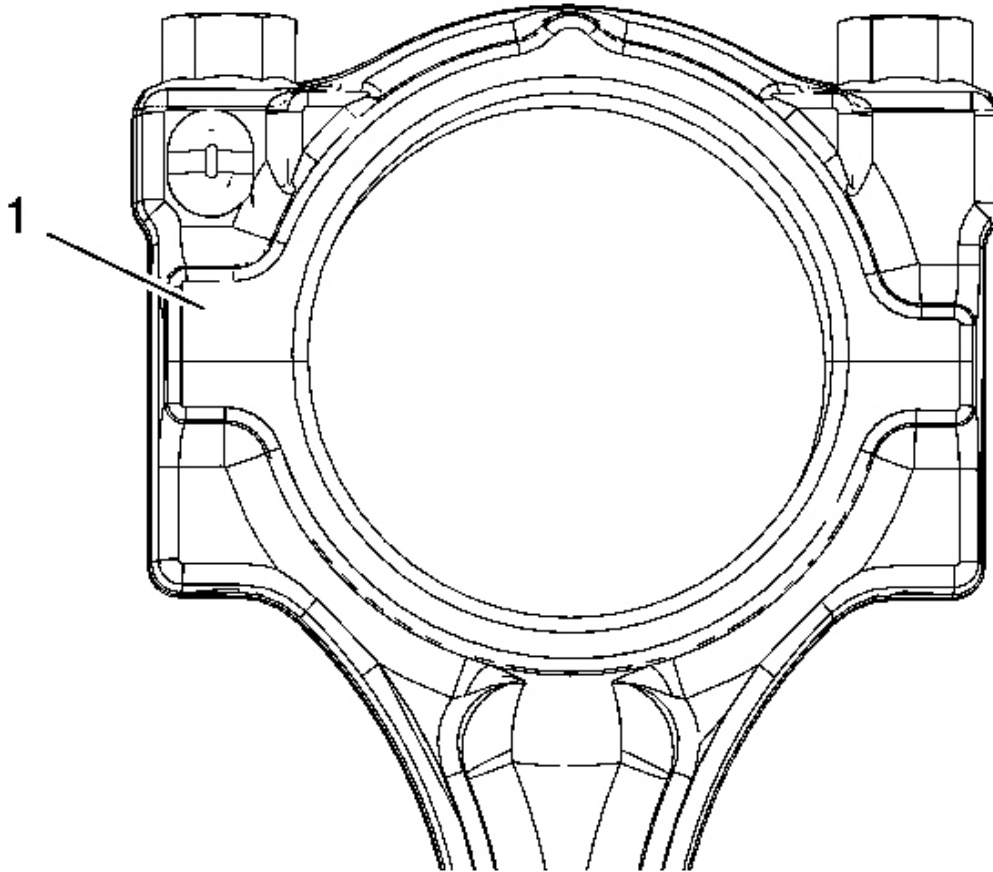


Fig. 321: Identifying Larger Feature Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

2. The larger feature (1), at the split line located on one side of the connecting rod, must go to the front of the block.

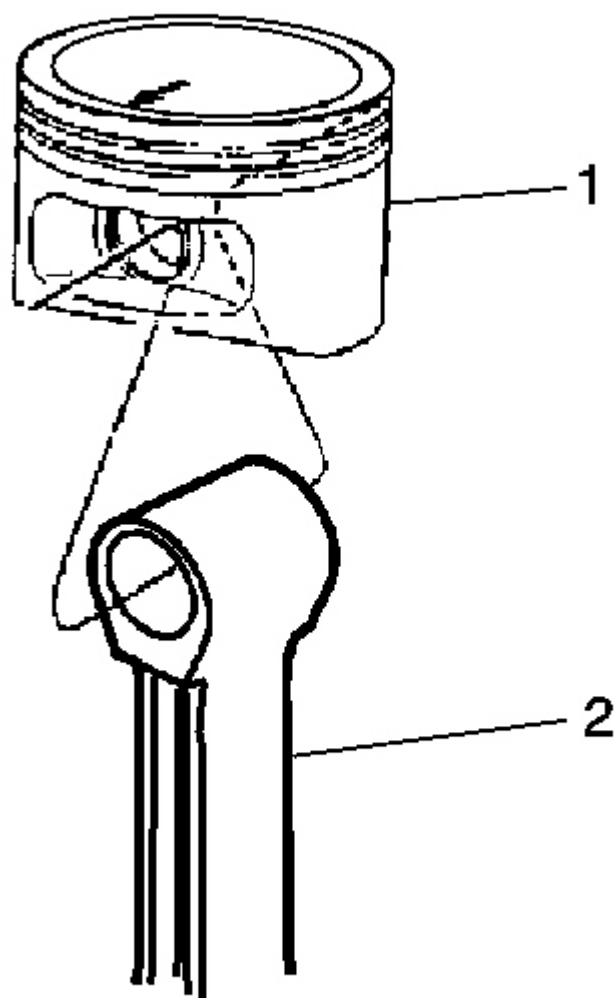


Fig. 322: Identifying Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

3. Assemble the connecting rod (2) and the piston (1).

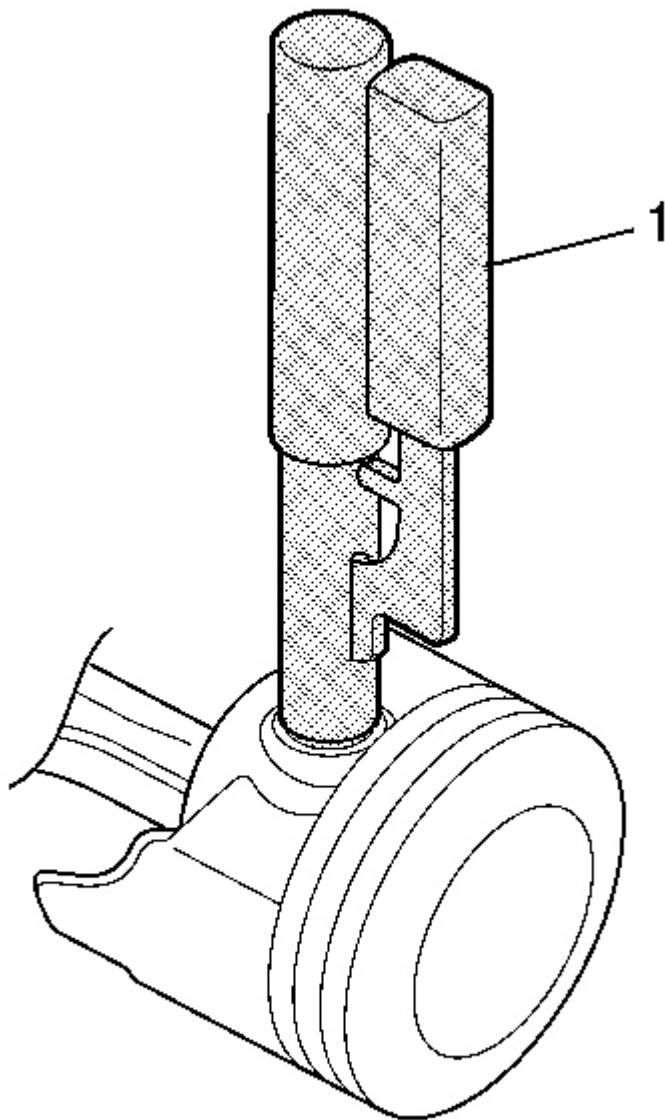


Fig. 323: Piston Pin Retainer Remover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

4. Use the following procedure to assemble the piston pin and the retainer:

1. Coat the piston pin with oil.
2. Install one side of one piston pin retainer into the retaining groove using **EN-46745:** installer. Rotate the retainer until it is fully seated in the groove.
3. Install the connecting rod and the piston pin.

Push the piston pin until it bottoms in the previously installed retainer.

4. Install the second piston pin retainer, using **EN-46745:** installer (1) .
5. Ensure that the piston moves freely.

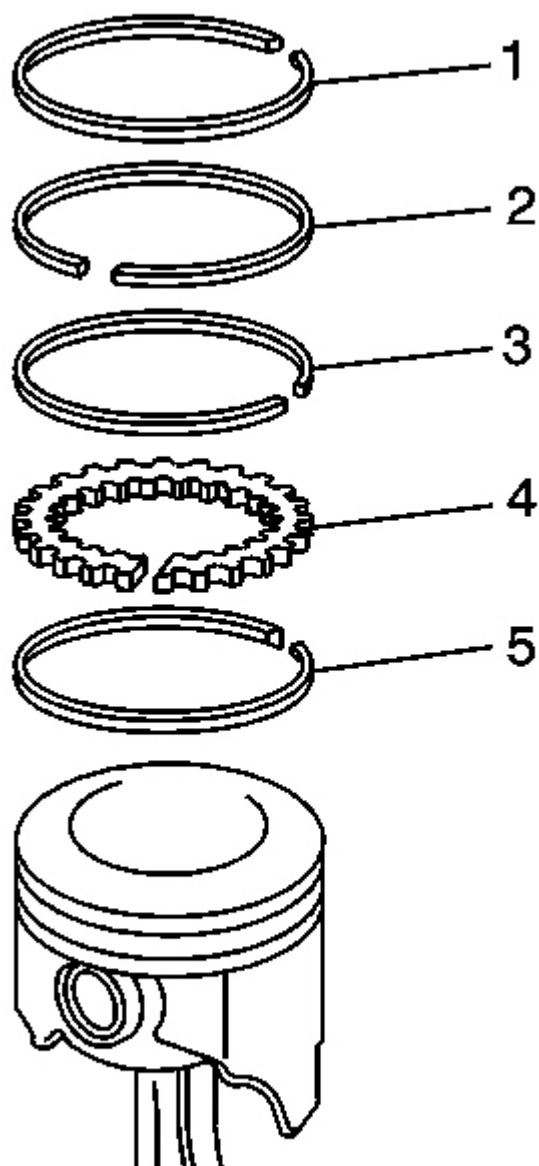


Fig. 324: Identifying Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

5. Install the following components of the oil control ring assembly (bottom ring):
 1. The expander (5)
 2. The lower oil control ring (4)
 3. The upper control ring (3)
6. Install the lower compression ring (2). Place the manufacturer's mark facing up.
7. Install the upper compression ring (1).

CAMSHAFT CLEANING AND INSPECTION

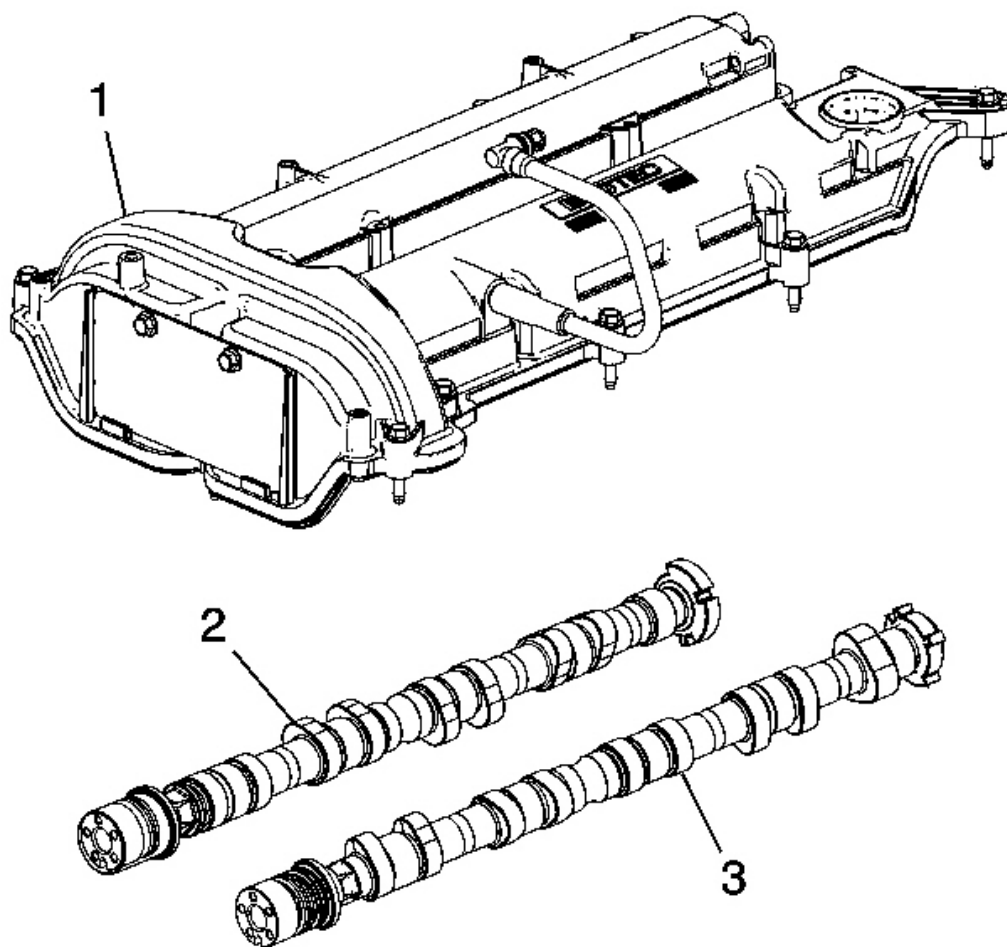


Fig. 325: Camshaft Cover & Camshafts
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft journals and lobes for wear or scoring.

2. Inspect the camshaft sprocket alignment notch for damage.
3. Inspect the camshaft cover (1) for damage or loose oil control baffles.
4. Clean the camshaft cover.
5. Wash the camshafts (2, 3) in solvent.
6. Oil the camshafts.
7. Inspect the camshaft cover for cracks or other signs of damage.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

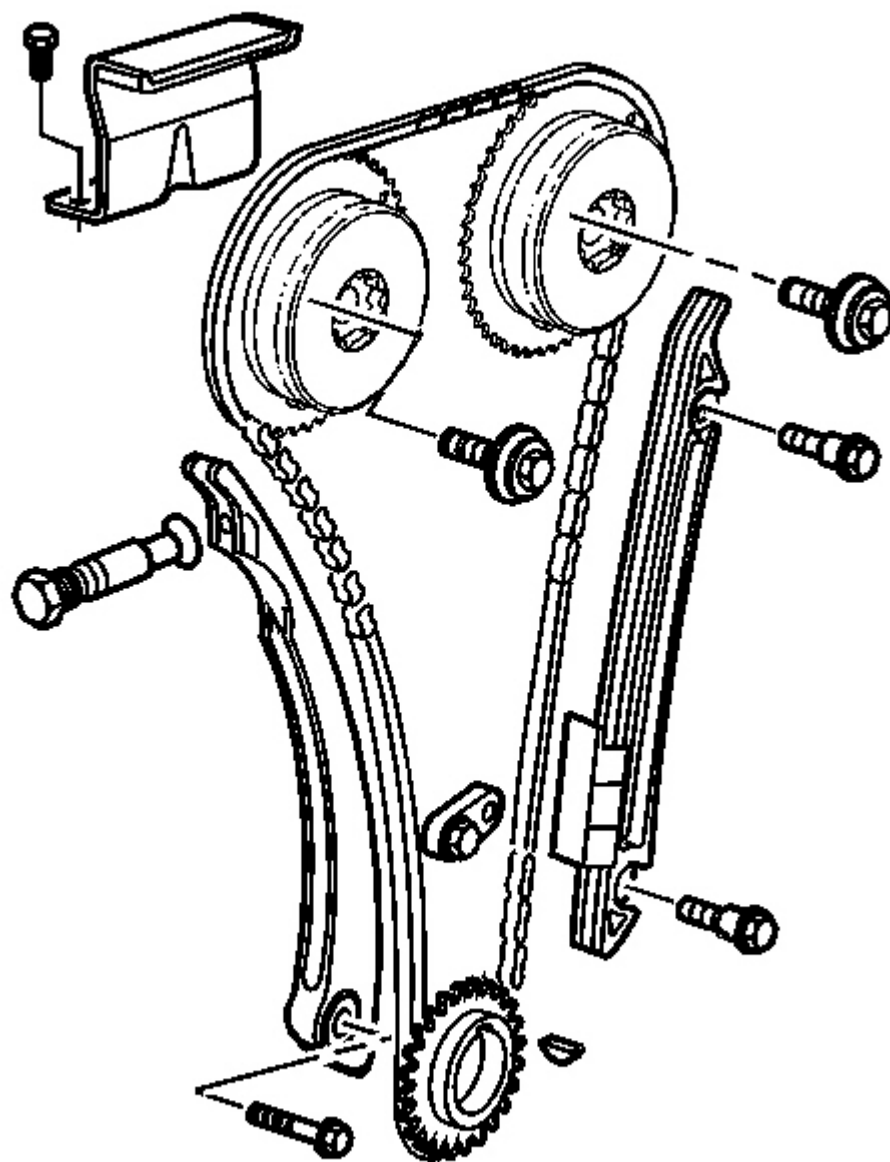


Fig. 326: Inspecting Timing Chain Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain guides for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner shoe for wear.

4. Replace the timing chain tensioner shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain and actuators for wear.
6. Inspect the camshaft actuator faces for signs of movement.
7. Inspect the camshaft actuator teeth and chain for signs of excessive wear, chipping, or seizure of the timing chain links.
8. Inspect the oil nozzle body for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged.
9. Verify oil nozzle oil flow with compressed air.
10. Inspect the timing chain tensioner for the scoring or free movement.
11. Inspect the timing chain tensioner washer and O-ring for damage. If damaged, replace the timing chain tensioner.

BALANCE SHAFT CLEANING AND INSPECTION

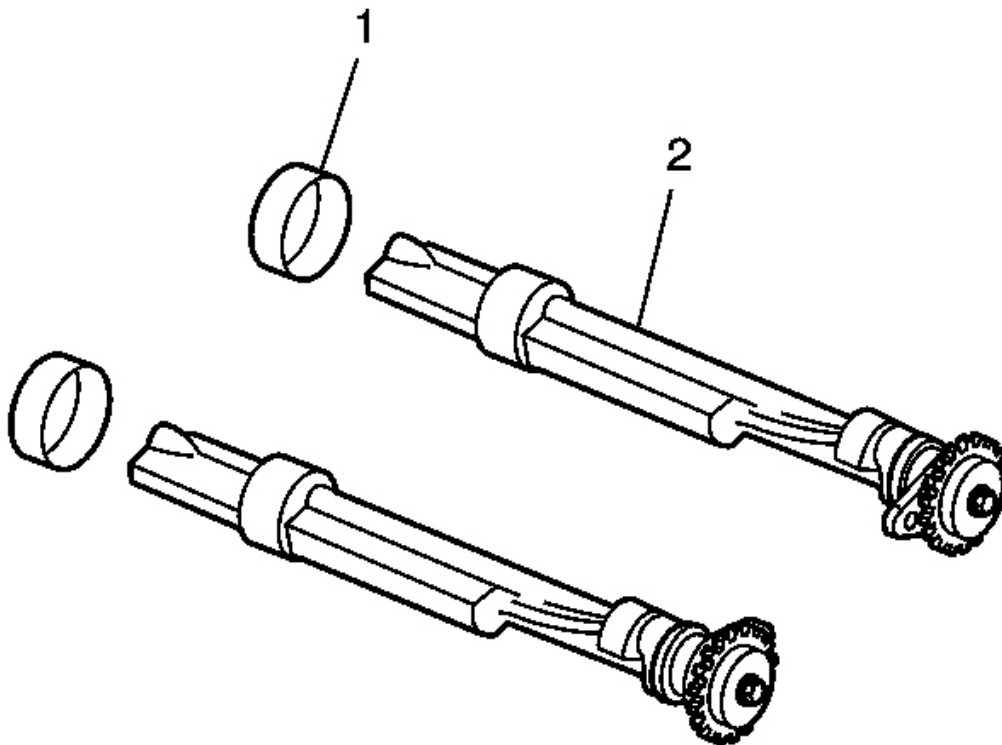


Fig. 327: Balance Shafts
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shafts (1) in solvent.
2. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.

NOTE: **Do not remove the balance shaft drive sprockets.**

3. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth.
4. Measure the rear bearing journals on the balance shafts, the journals should be 36.723-36.743 mm (1.4458-1.4466 in) in diameter.
5. Measure the front bearing journals on the balance shafts, the front bearing journals should be 20.020-20.000 mm (0.7881-0.7874 in) in diameter.
6. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

WATER PUMP AND BALANCE SHAFT CHAIN AND SPROCKET CLEANING AND INSPECTION

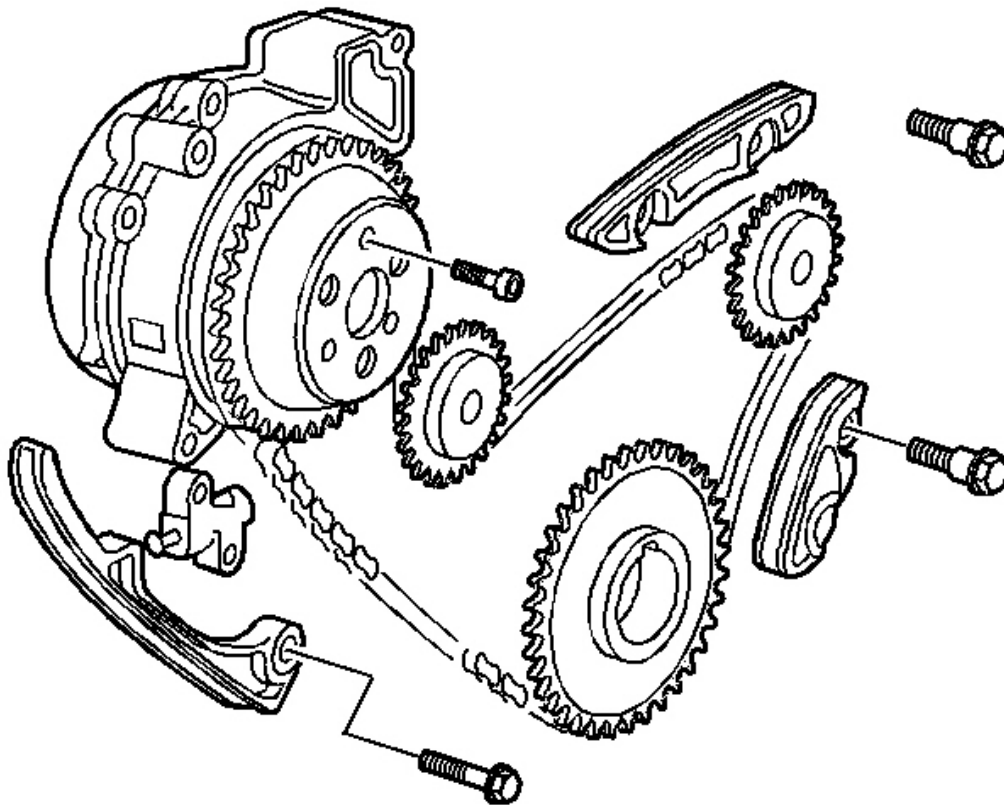


Fig. 328: Inspecting Balance Shaft Drive Chain & Sprockets

Courtesy of GENERAL MOTORS CORP.

1. Inspect the balance shaft drive chain guides for cracking or wear.
2. Replace the balance shaft drive chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the balance shaft drive chain tensioner guide shoe for wear.

Replace the balance shaft drive chain tensioner guide shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.

4. Inspect the balance shaft drive chain and sprockets for wear.
5. Inspect the crankshaft sprocket faces for signs of movement.
6. Inspect the alignment notch in the balance shaft for cracking or damage.
7. Inspect the water pump, crankshaft, and balance shaft sprocket teeth and chain for signs of excessive wear, chipping, or seizure of the balance shaft drive chain links.
8. Inspect the timing chain tensioner for damage or wear.

CYLINDER HEAD DISASSEMBLE

Special Tools

- **EN-8062:** Valve Spring Compressor
- **EN-36017:** Valve Seal Remover
- **EN-43963:** Valve Spring Compressor (off car)

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

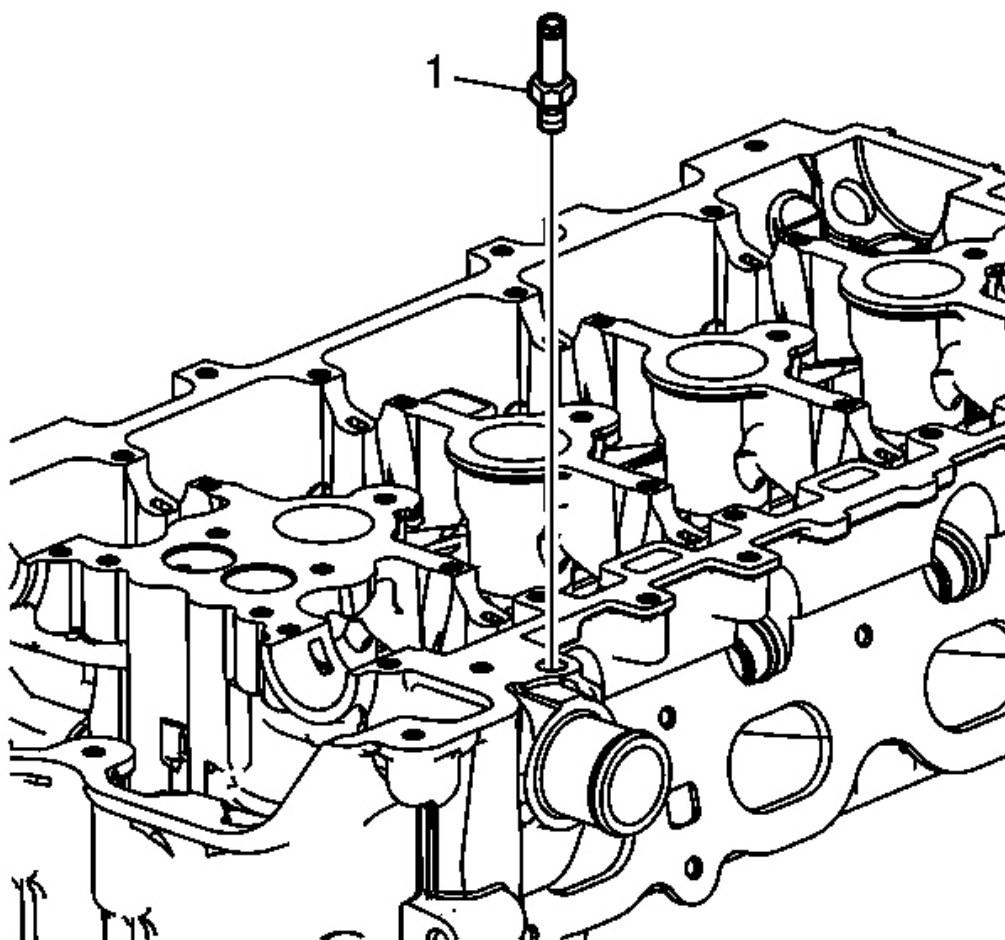


Fig. 329: Identifying the Coolant Air Bleed Hose Fitting
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant air bleed hose fitting (1).

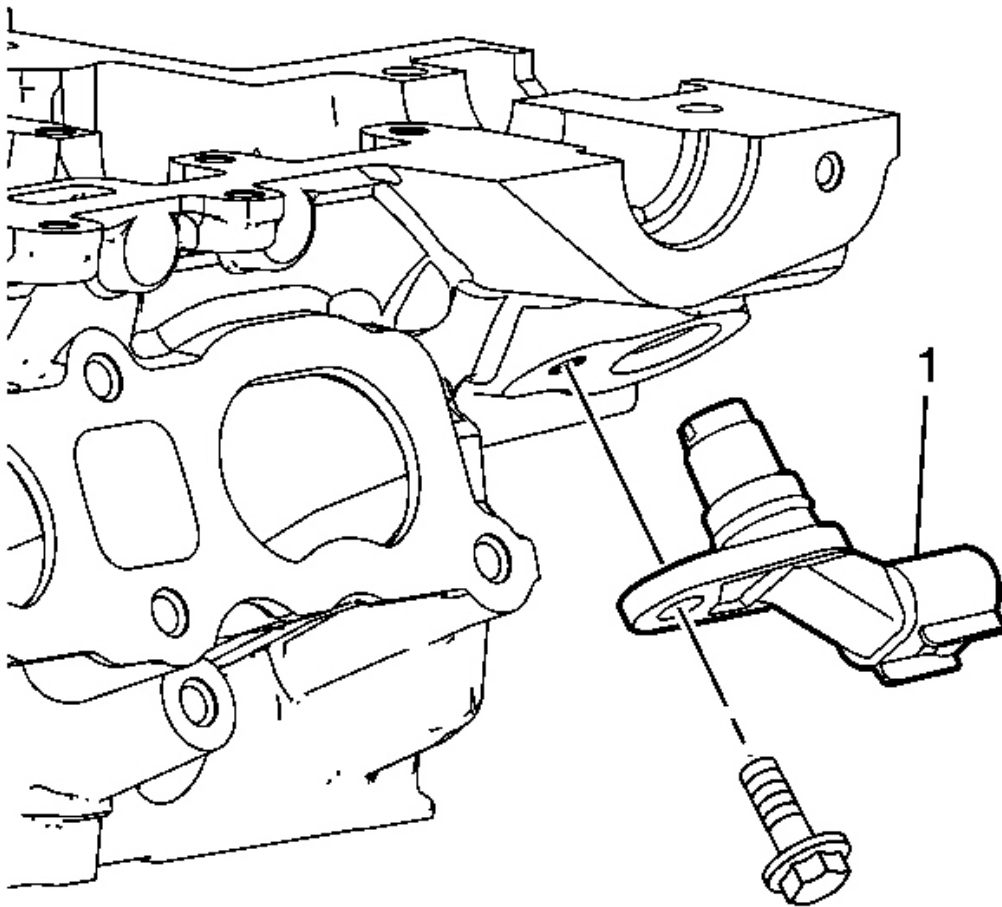


Fig. 330: Intake Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the intake camshaft position sensor (1) and bolt.

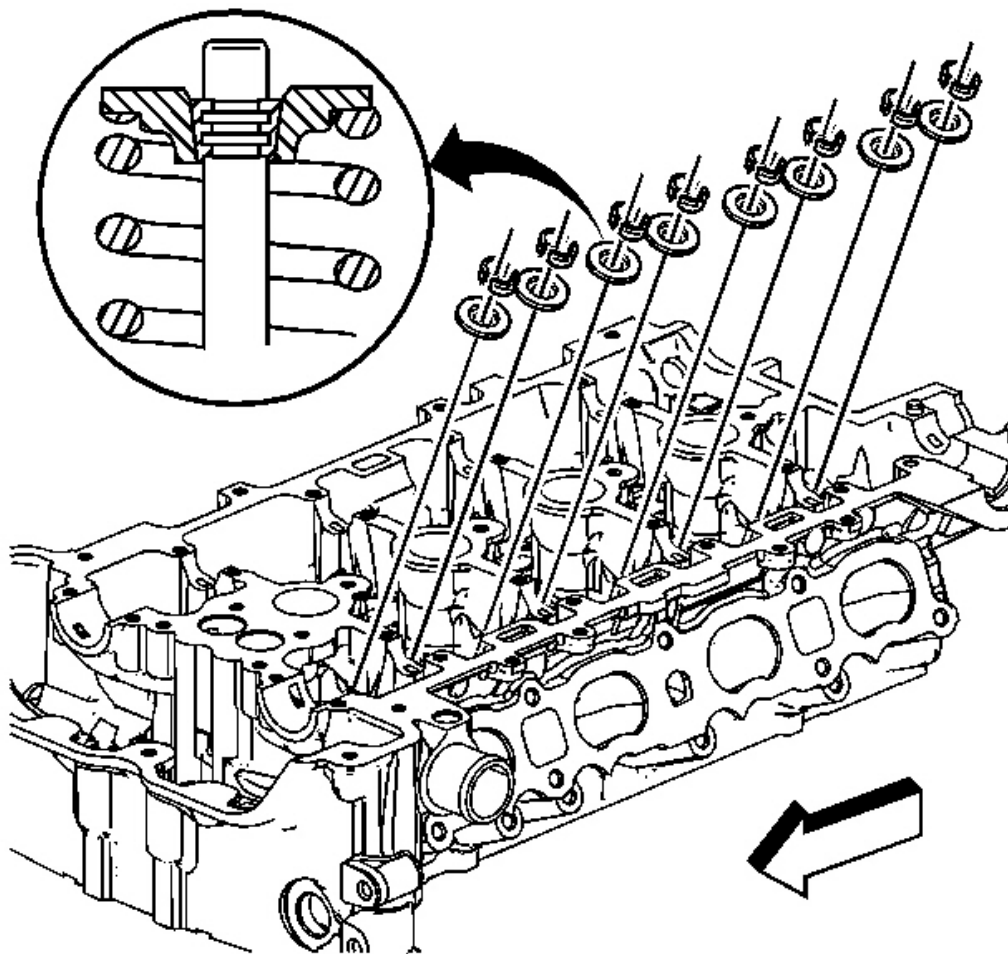


Fig. 331: Valve Train Components
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in).
Contact between the valve spring retainer and the valve stem oil seal

NOTE: Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

3. Perform the following procedure to remove the valve keys, springs, and retainers:
 1. Using the **EN-8062:** compressor and the **EN-43963:** compressor , compress the valve spring.
 2. Remove the valve keys.
 3. Slowly release the **EN-8062:** compressor and the **EN-43963:** compressor from the valve spring assembly.
 4. Remove the retainer.

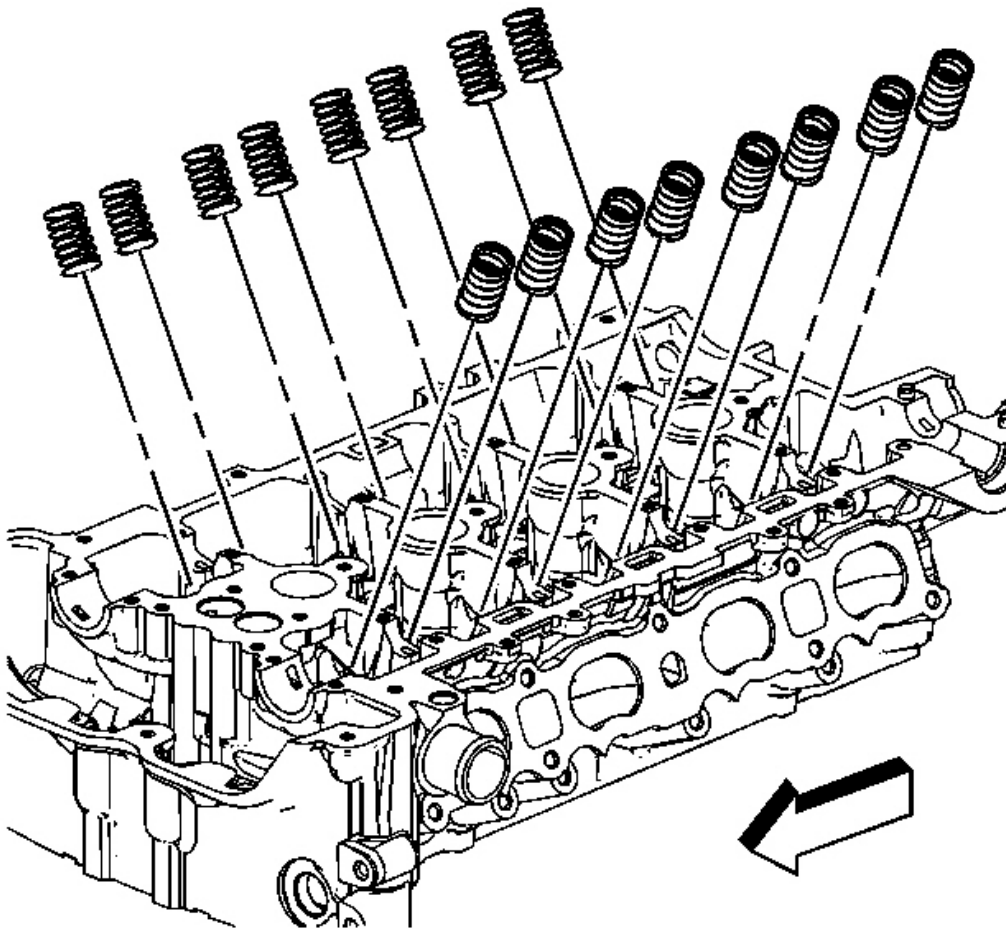


Fig. 332: Valve Springs

Courtesy of GENERAL MOTORS CORP.

4. Remove the springs.

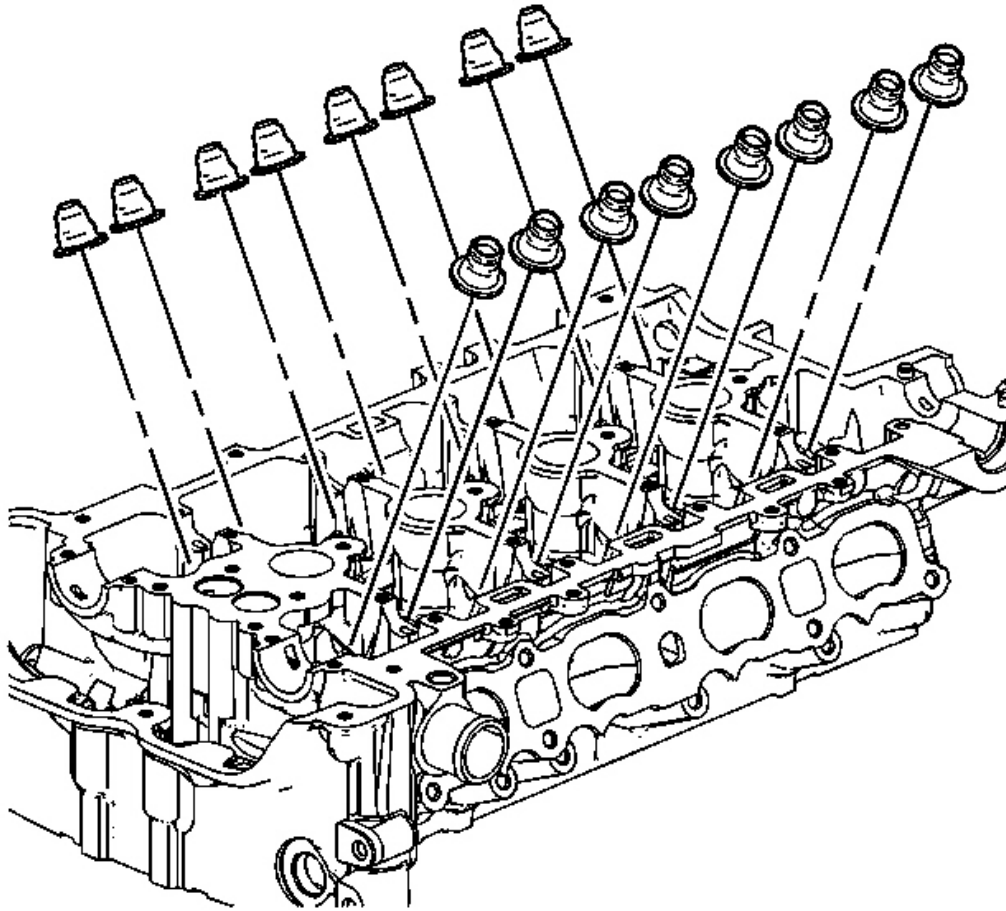


Fig. 333: Valve Guides

Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

5. Using **EN-36017**: remover, remove the valve seals. Discard the seals, do not reuse.

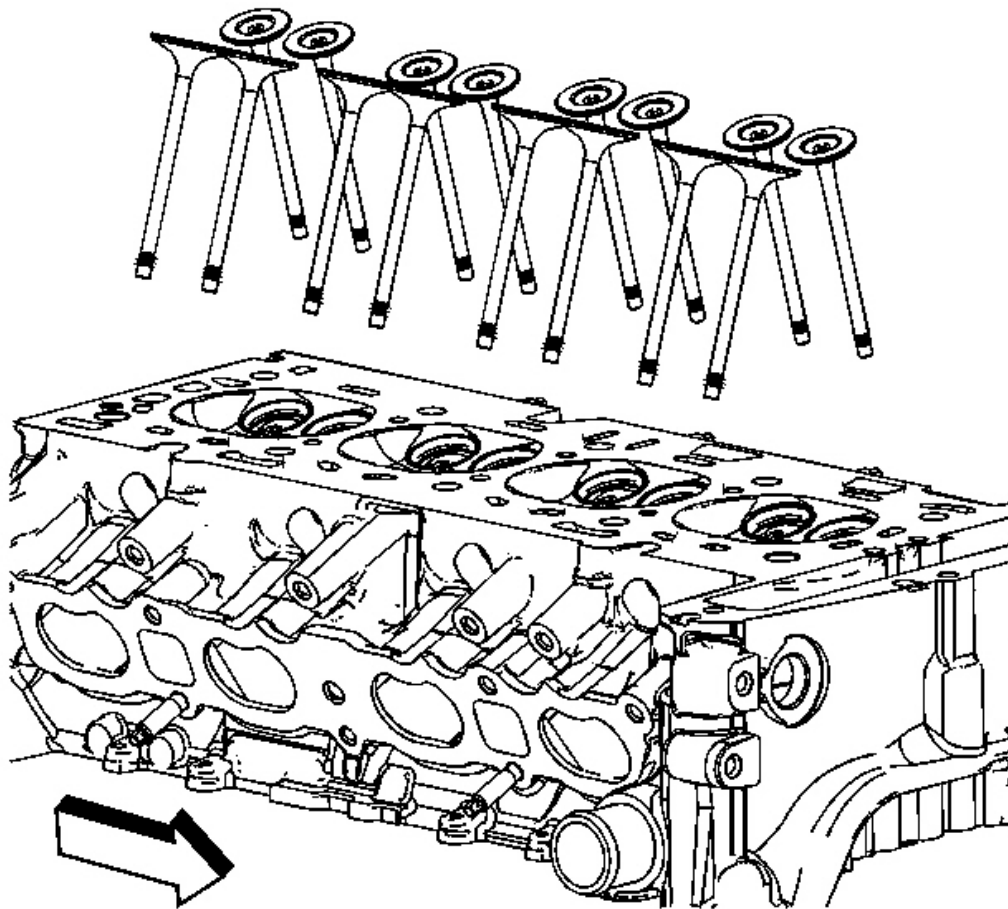


Fig. 334: Valves

Courtesy of GENERAL MOTORS CORP.

6. Remove the valves.

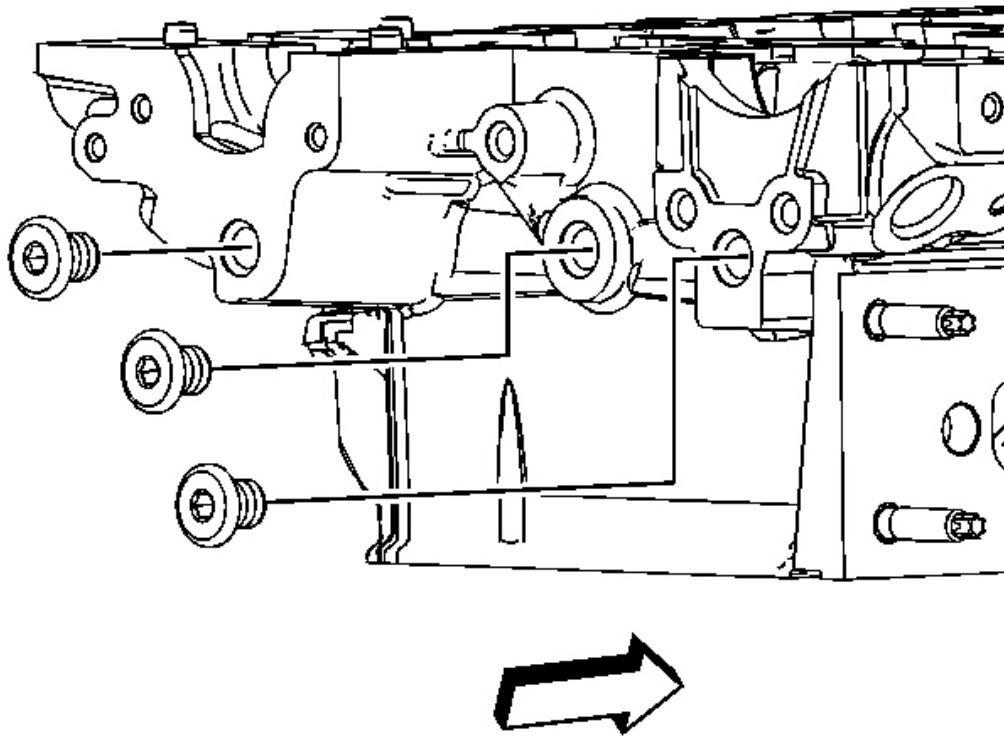


Fig. 335: Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head plugs.

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **EN-28410:** Gasket Remover
- **GE 7872:** Magnetic Base Dial Indicator
- **J 22738-B:** Valve Spring Tester

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

Valve Cleaning and Inspection

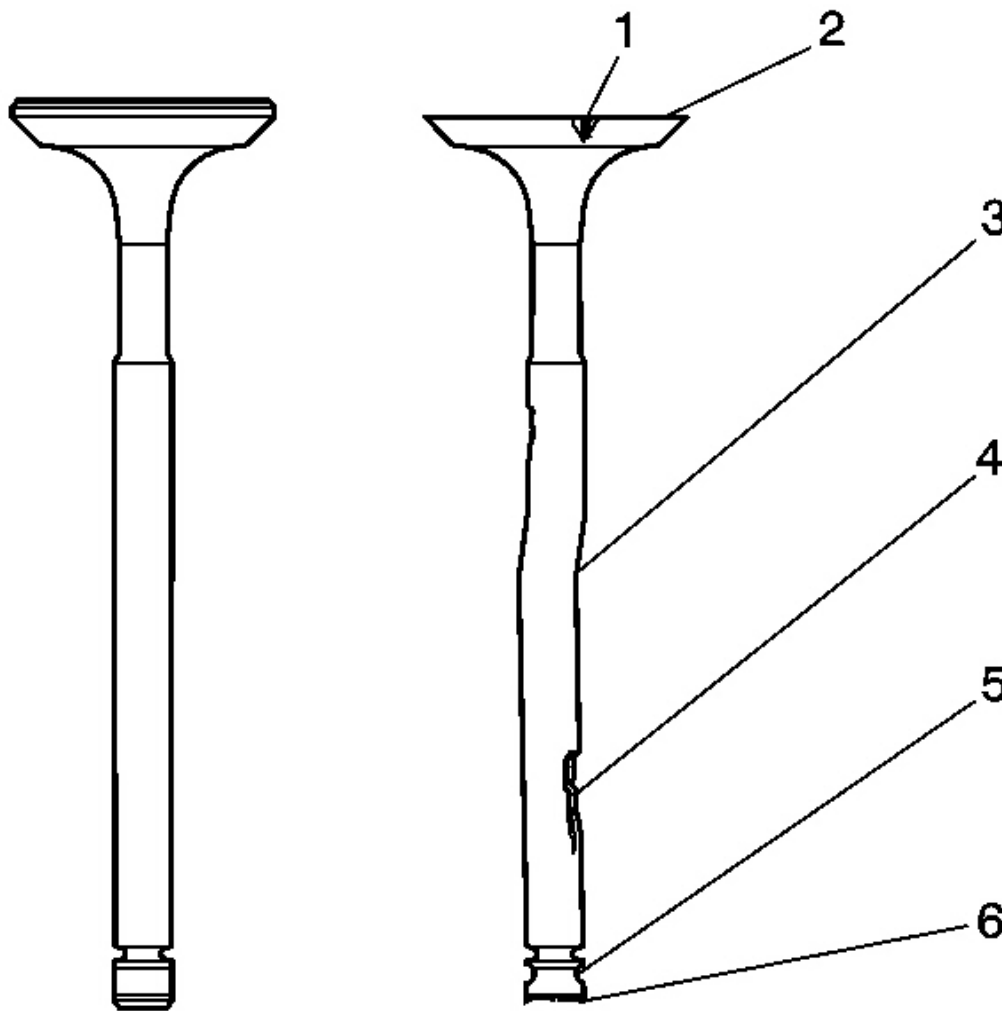


Fig. 336: Identifying Valve Flaws

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a wire brush on any part of the valve stem.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

1. Clean the valves of carbon, oil and varnish. Use a soft bristle wire brush to clean any carbon build-up from the valve head. Varnish can be removed by soaking in Parts Immersion Solvent. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

2. Clean the valve guides.
3. Inspect the valve stem for pitting or wear (4).
4. Inspect the valve key groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness (3) and the valve head for bending or distortion using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. Replace the valve if the valve head O.D. and chamfer (2) is worn or out of specification. Refer to **Valve and Seat Grinding**.
11. The valves may be lightly lapped to the valve seats.
12. Replace the valve if the valve tip (6) is worn.
13. If no apparent wear, pitting, grooving, or distortion is present, perform the valve measurement and reconditioning procedure to verify valve specification. Refer to **Valve and Seat Grinding**.

Valve Guide Measurement

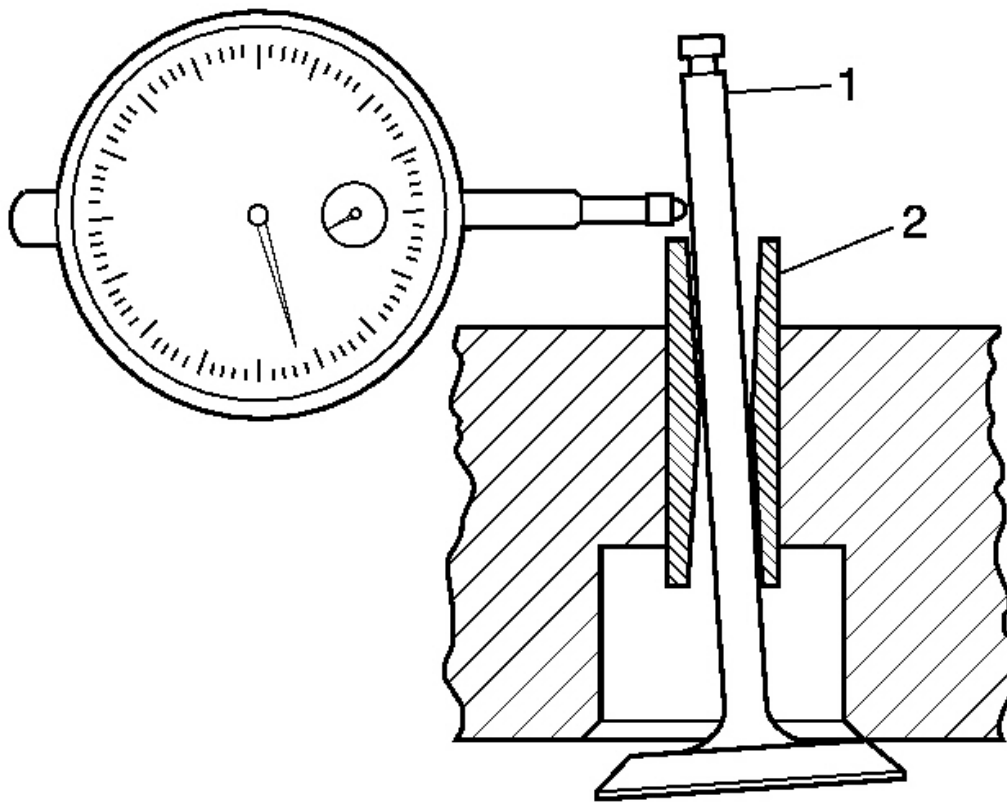


Fig. 337: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **GE 7872**: dial indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications** for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

1. Clean the valve springs in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

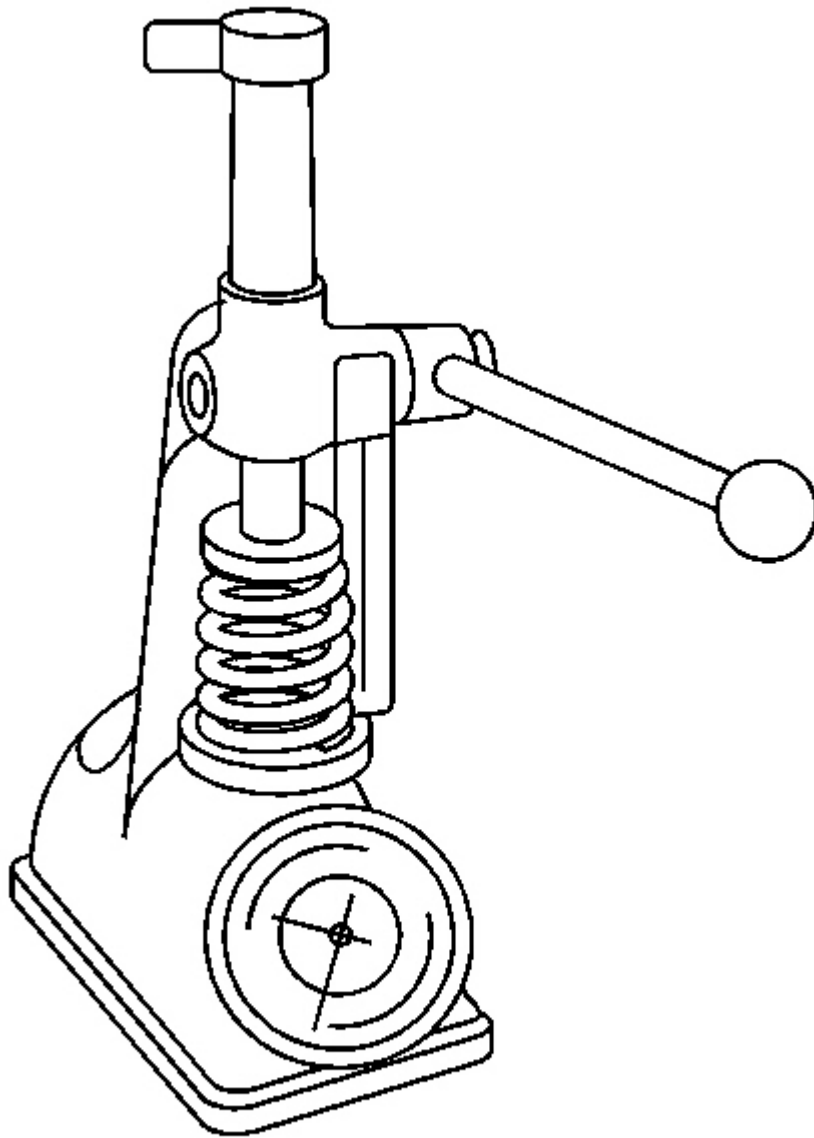


Fig. 338: View Of J 22738-B
Courtesy of GENERAL MOTORS CORP.

4. Measure the valve spring tension using the **J 22738-B**: tester. Refer to **Engine Mechanical Specifications**
5. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

Valve Rocker Arm Cleaning and Inspection

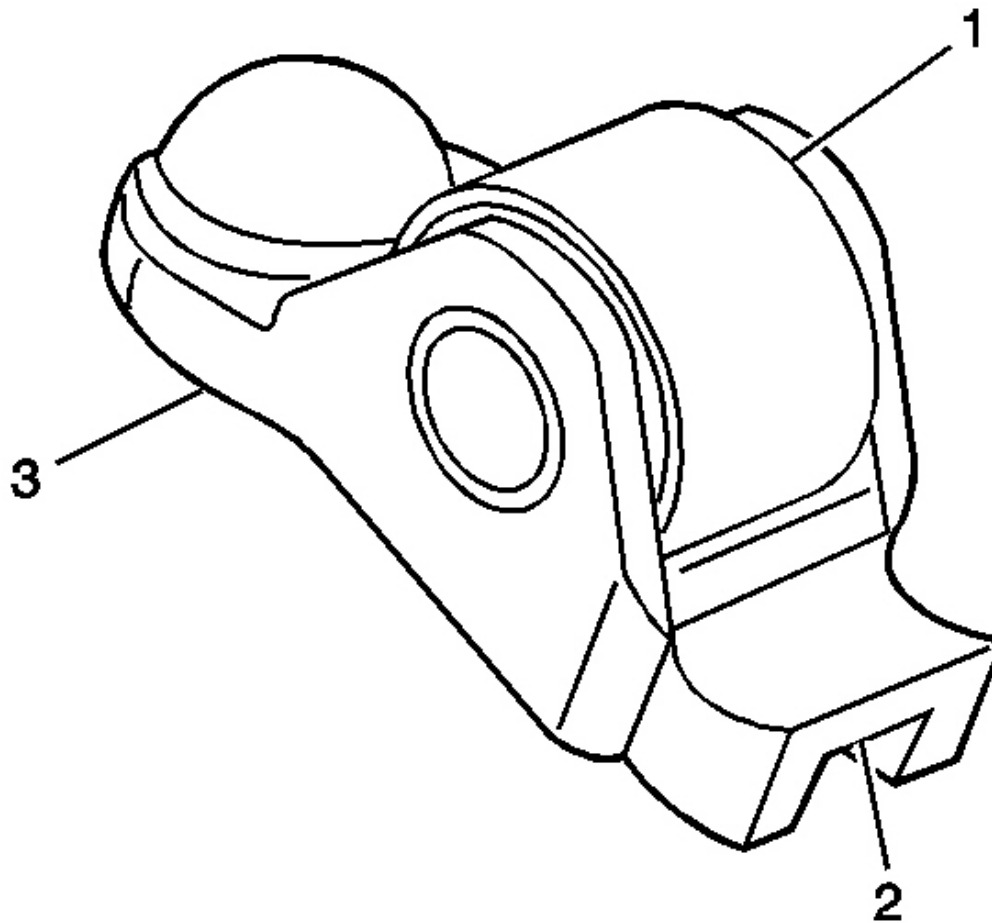


Fig. 339: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft follower roller (1) for the following:
 - Flat spots
 - Excessive scoring and pitting
 - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

Cylinder Head and Gasket Surface Cleaning and Inspection

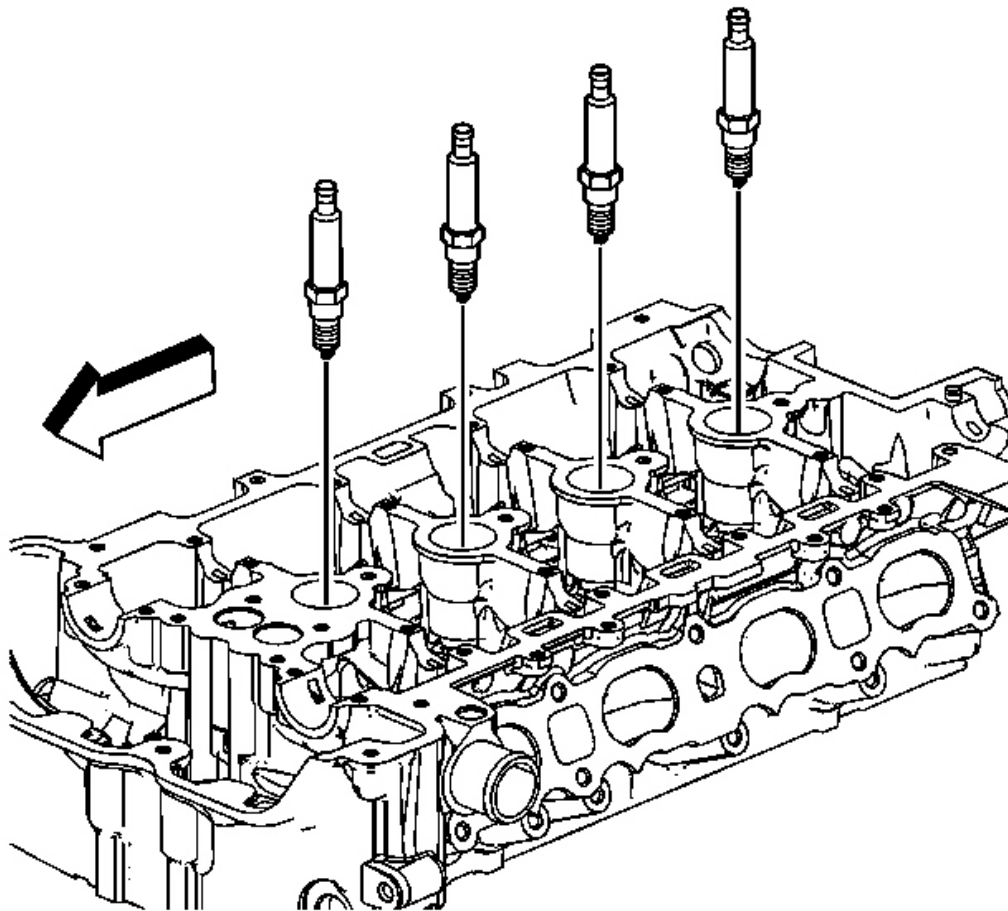


Fig. 340: Spark Plugs

Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.
2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:
 1. Improper installation
 2. Loose or warped cylinder head
 3. Missing, off location or not fully seated dowel pins
 4. Corrosion in the seal area around the coolant passages
 5. Chips or debris in the cylinder head bolt holes
 6. Bolt holes in the cylinder block not drilled or tapped deep enough

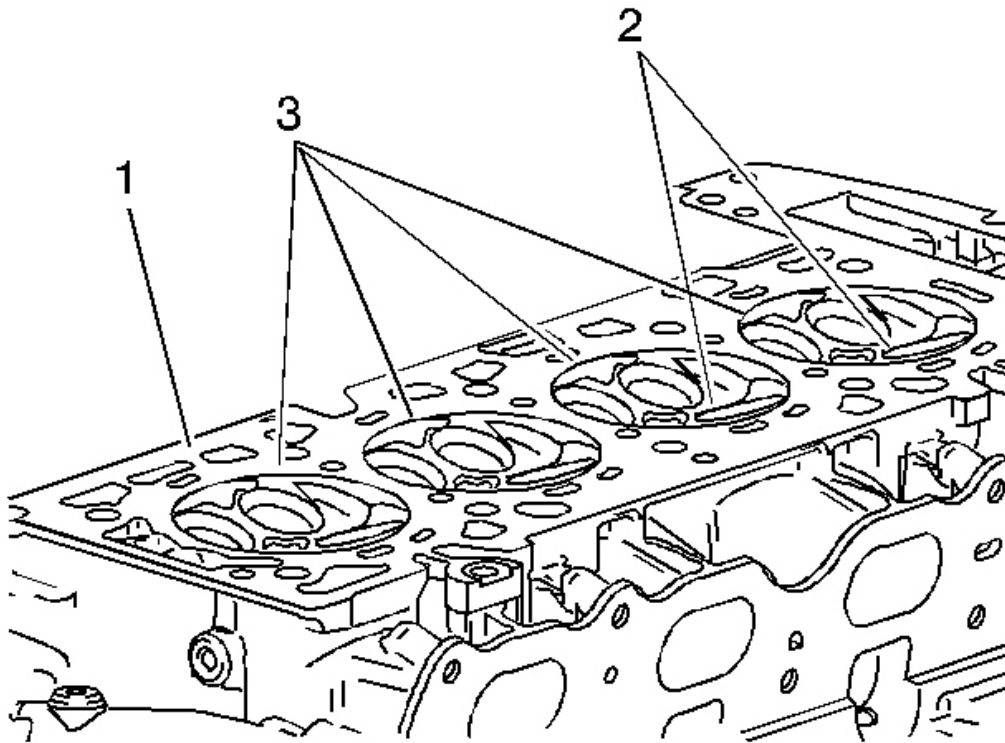


Fig. 341: Cylinder Head Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head gasket surface.
 - Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
 - Replace the cylinder head if the area between the valve seats is cracked (2).
 - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).

4. Clean the cylinder head bolts.

NOTE: **Do not use a wire brush on any gasket sealing surface.**

5. Remove the sealant from the rear cap mating surface with **EN-28410:** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
6. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
7. Clean the valve guides.
8. Clean the threaded holes. Use a nylon bristle brush.

9. Clean the remains of the sealer from the plug holes.
10. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
11. Replace all suspect bolts.
12. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

NOTE: Do not attempt to weld the cylinder head, replace it.

13. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

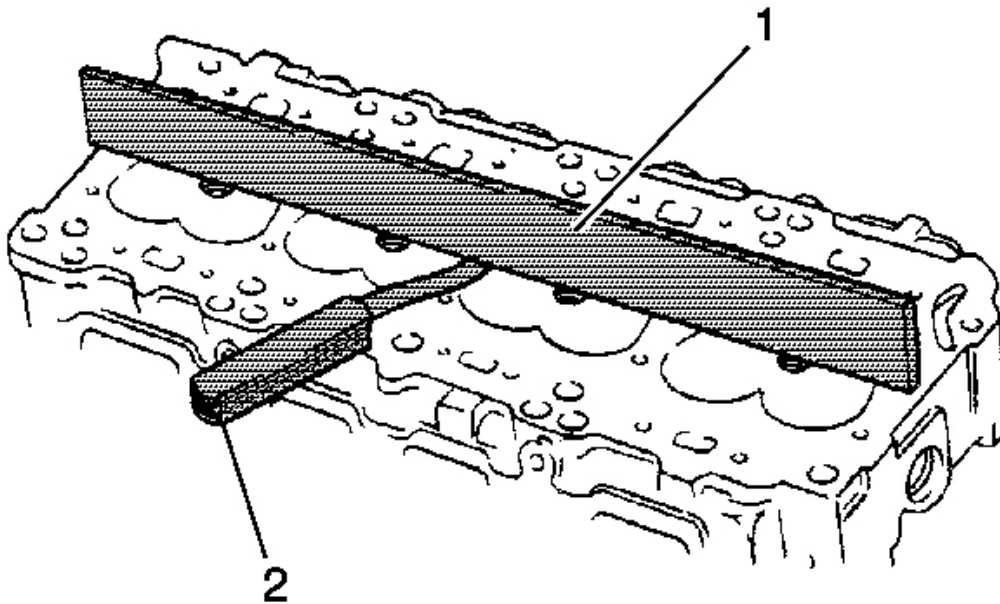


Fig. 342: Inspecting Cylinder Head Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

14. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications**. If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
15. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
16. Inspect the sealing surfaces.

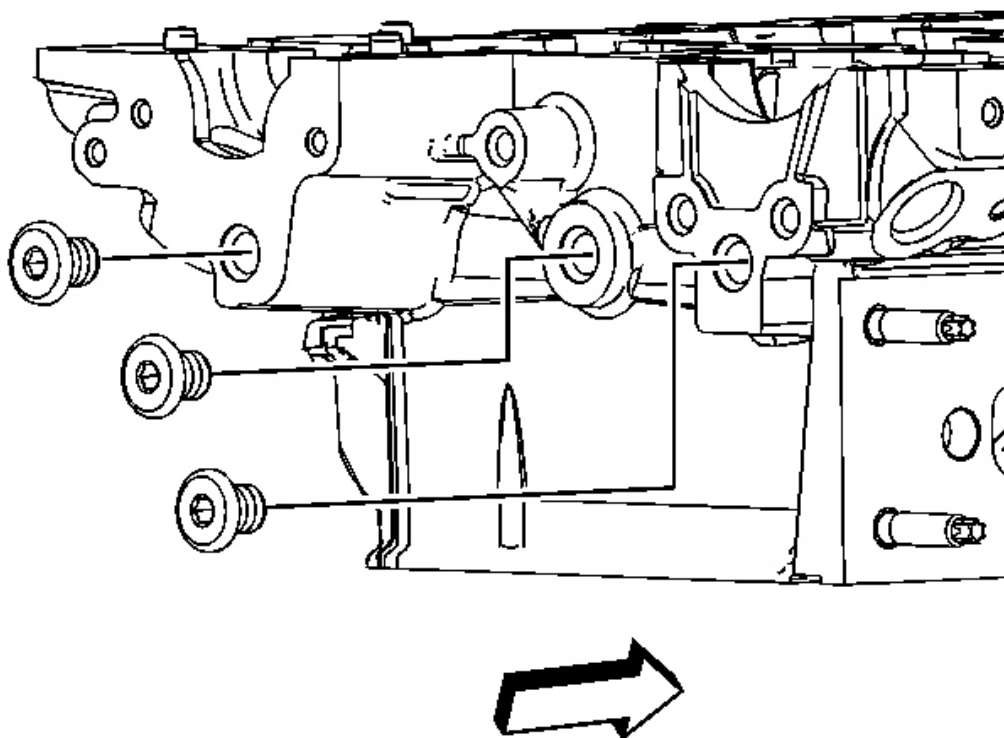


Fig. 343: Cylinder Head Plugs

Courtesy of GENERAL MOTORS CORP.

17. Inspect the cylinder head plugs and verify the oil orifice is clear and free of debris.

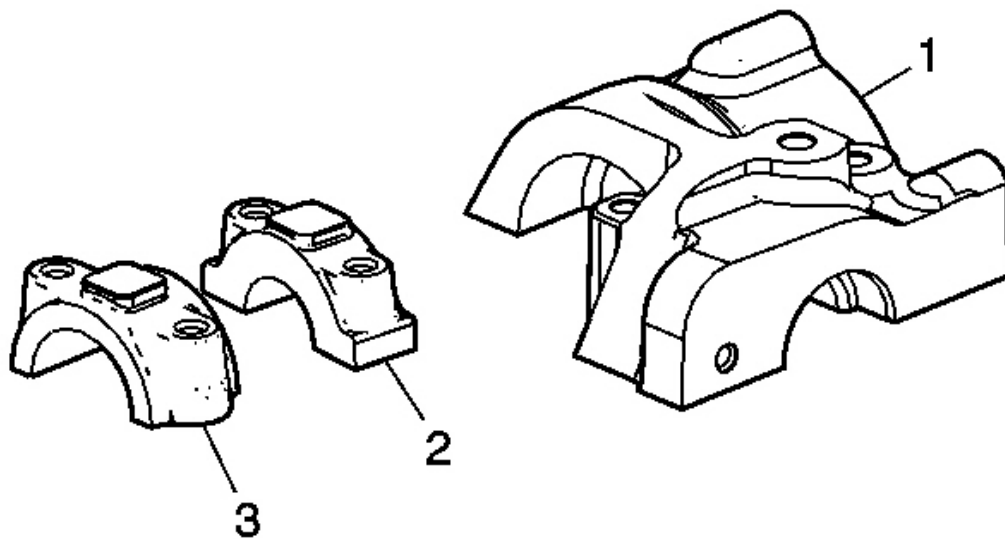


Fig. 344: Bearing Caps
Courtesy of GENERAL MOTORS CORP.

18. Clean the sealant from the rear cap mating surface with **EN-28410:** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
19. Inspect the intake camshaft bearing rear cap (1) for damage.
20. Inspect the rear bearing mating surfaces for damage.
21. Inspect the camshaft bearing caps (2) for damage.
22. Inspect the camshaft front bearing caps (3) for damage.

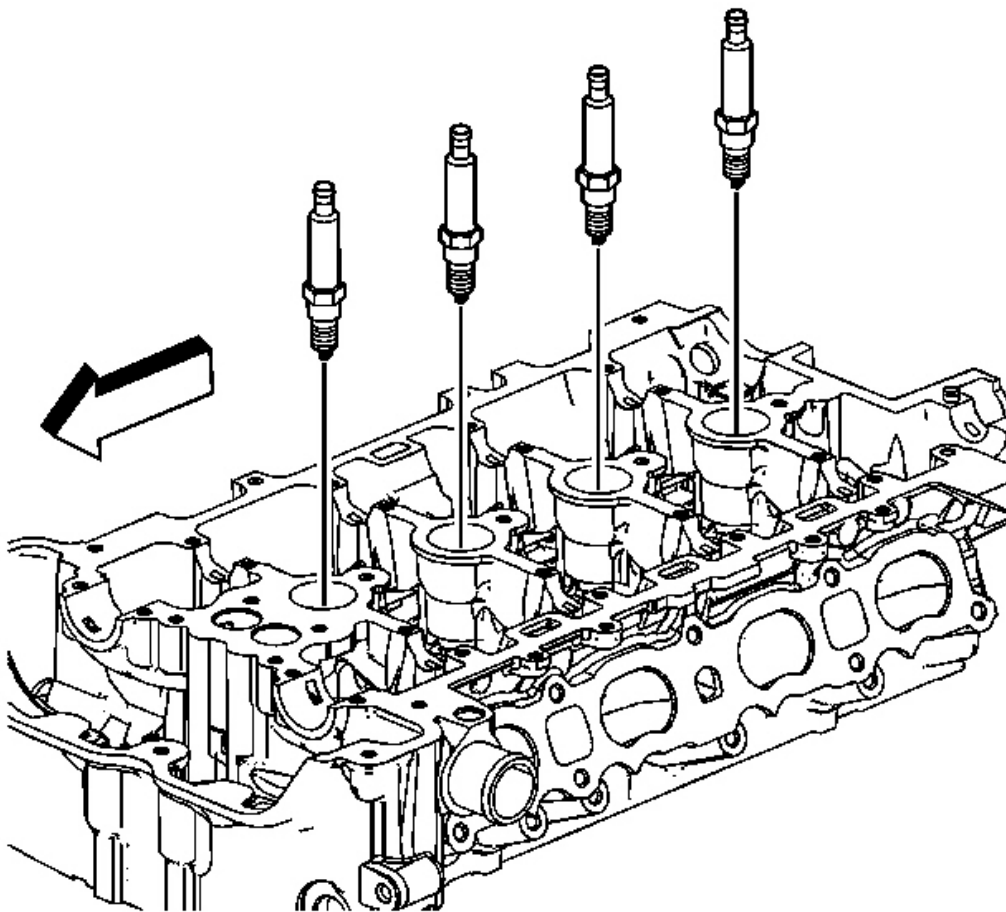


Fig. 345: Spark Plugs

Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Component Fastener Tightening Caution .

23. Install the spark plugs. Tighten the plugs to 20 N.m (15 lb ft).

VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.

- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure

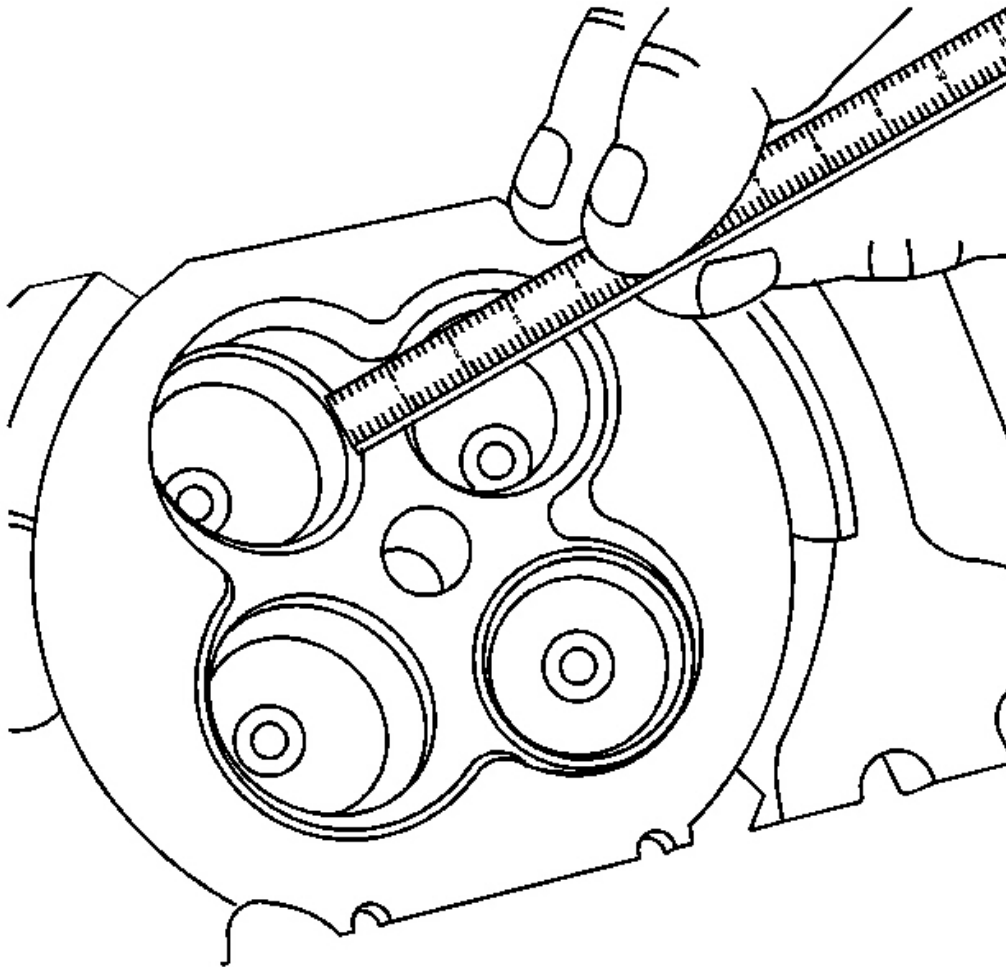


Fig. 346: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve seat width in the cylinder head using a proper scale.

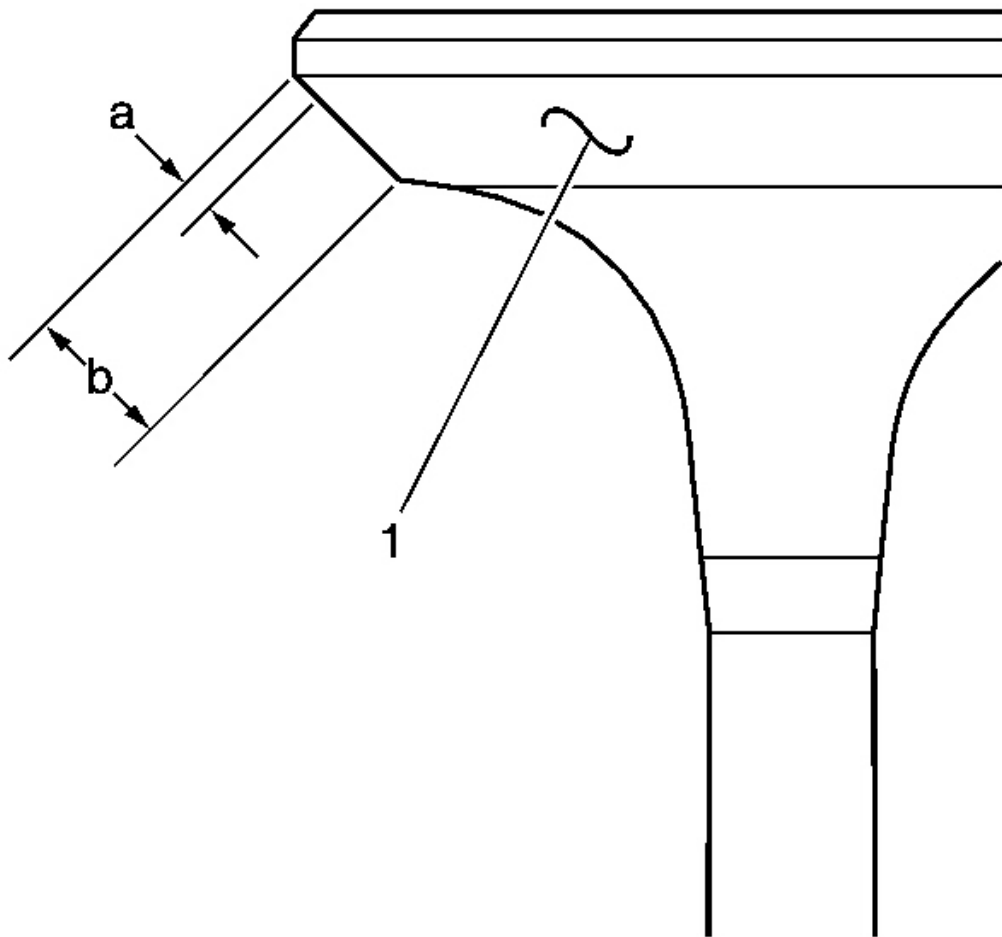


Fig. 347: Valve Face Seat width
Courtesy of GENERAL MOTORS CORP.

2. Measure the seat width (b) on the valve face (1) using a proper scale.

NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning

Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications**.
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Head O.D. and Chamfer Measurement Procedure

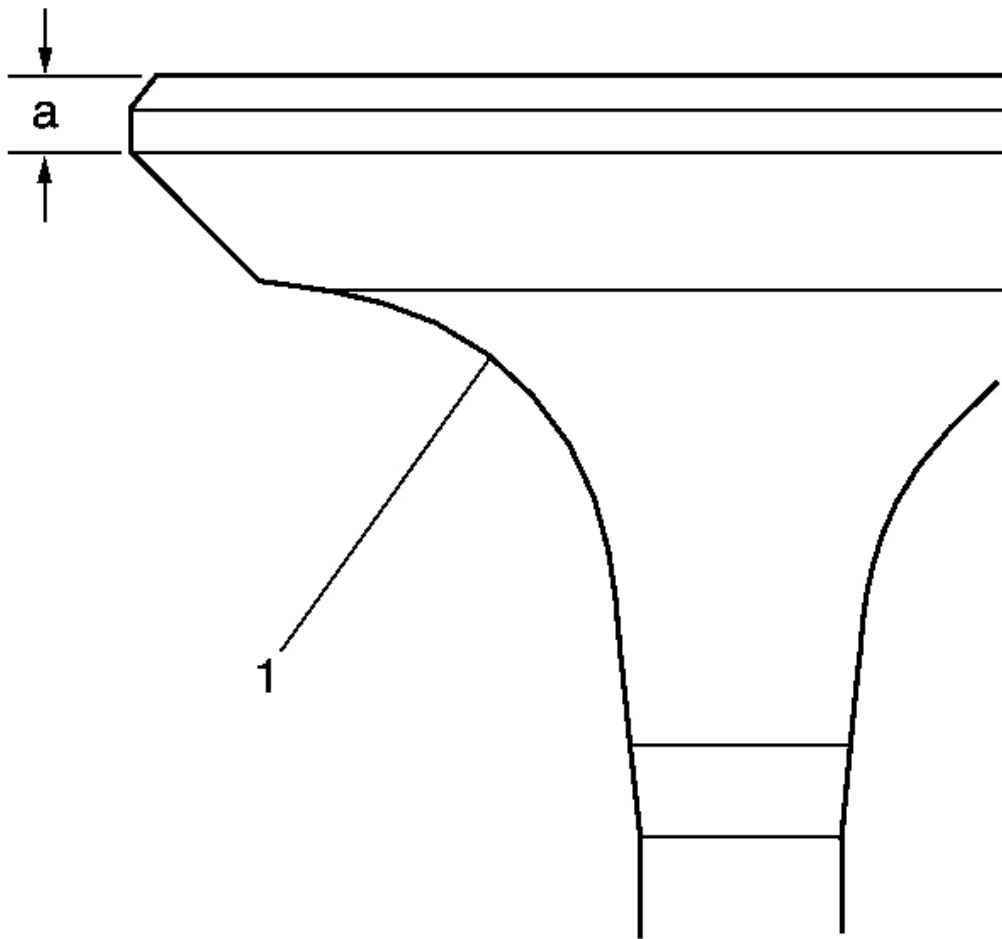


Fig. 348: Valve Head O.D. & Chamfer
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to **Engine Mechanical Specifications**.
2. If the valve head O.D. and chamfer is within specification, test the valve (1) for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure. Reinspect the valve head O.D. and chamfer after completing the concentricity measurement if valve seat reconditioning is performed.

Valve-to-Seat Concentricity Measurement Procedure

NOTE:

- **Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.**

- You must measure the valve face and the valve seat to ensure proper valve sealing.

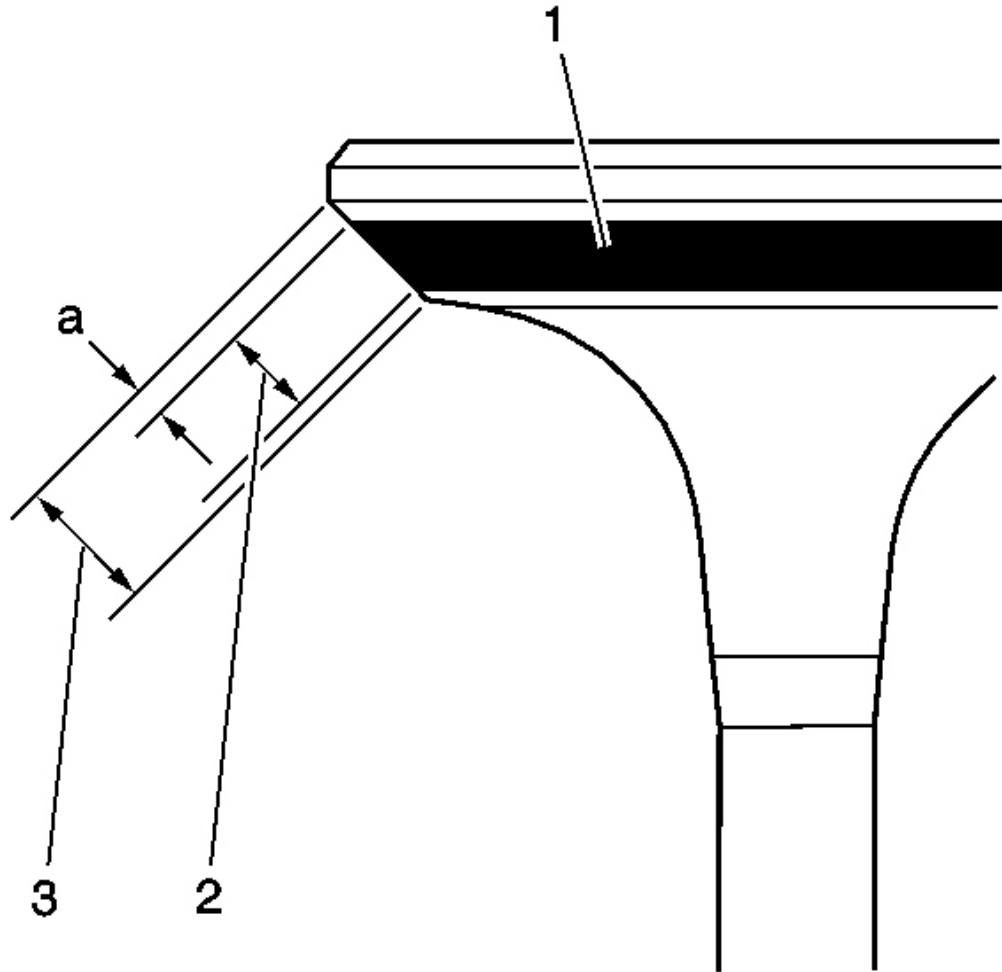


Fig. 349: Inspecting Valve Face
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve face (3) lightly with blue dye (1).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.

- If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

NOTE: The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

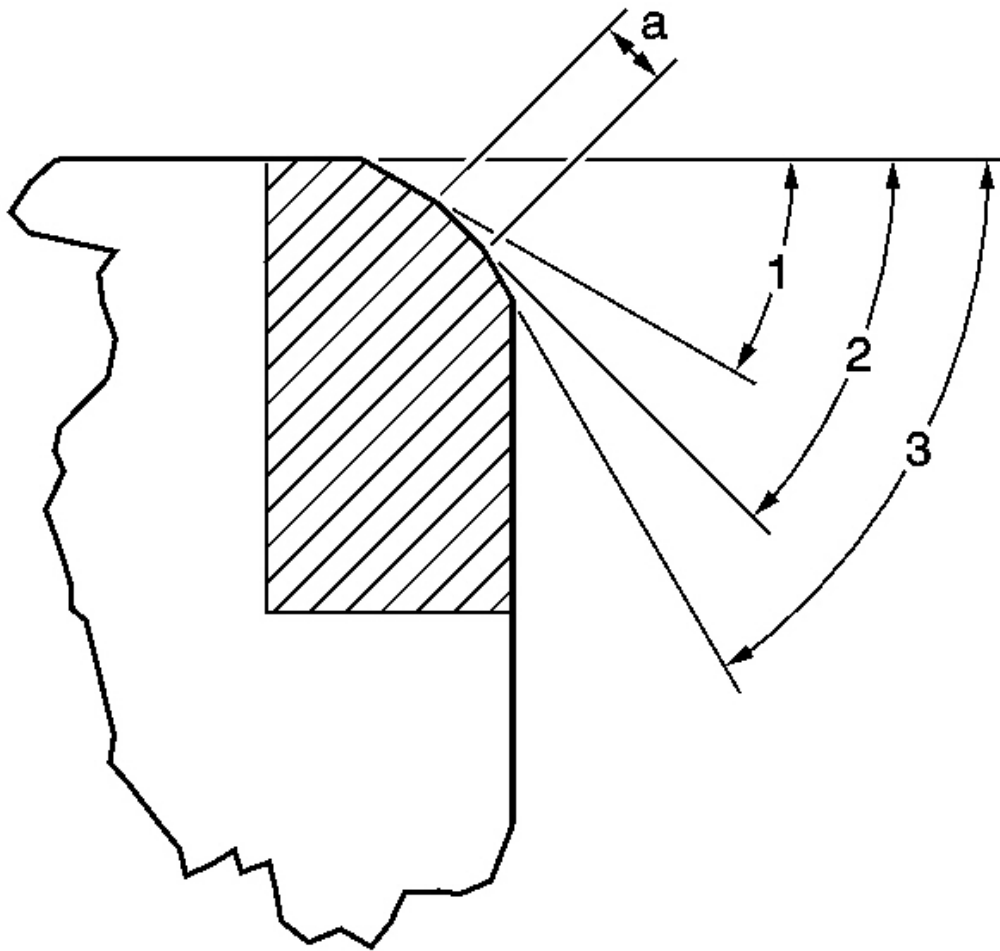


Fig. 350: Valve Seating Surface
Courtesy of GENERAL MOTORS CORP.

NOTE:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seating surface (a) to the proper angle specification (2) listed in **Engine Mechanical Specifications**.
2. Grind the valve relief surface to the proper angle specification (1) listed in **Engine Mechanical Specifications**, to correctly position the valve seating surface (a) to the valve.

3. Grind the valve undercut surface to the proper angle specification (3) listed in **Engine Mechanical Specifications**, to narrow the valve seating surface width (a) to the specifications listed in **Engine Mechanical Specifications**.

NOTE: **Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.**

4. Replace the intake valve if it is out of specification. Refer to **Engine Mechanical Specifications**.
5. If the original exhaust valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications**. Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
 - If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.
 - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

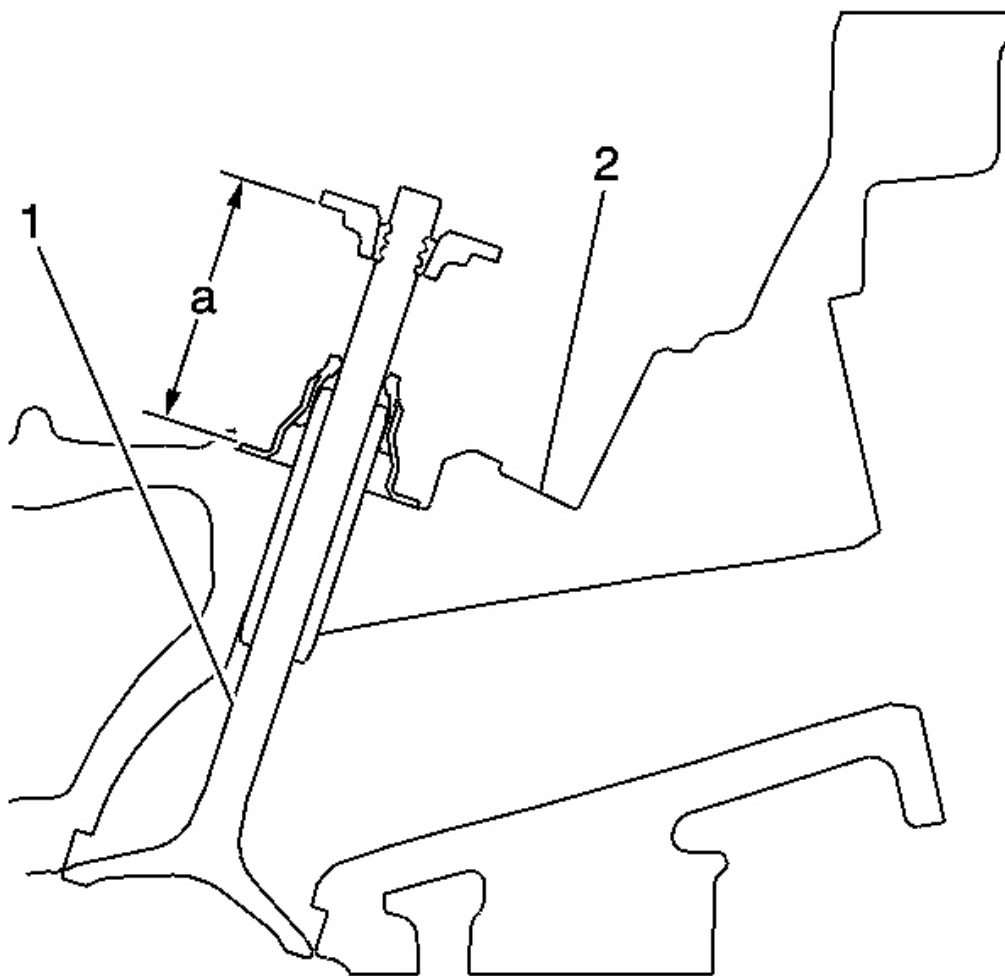


Fig. 351: Valve Stem Height Measurement
Courtesy of GENERAL MOTORS CORP.

NOTE: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve (1) into the valve guide in the cylinder head (2).
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (a) between the valve seal lip to the bottom of the valve spring retainer. Refer to **Engine Mechanical Specifications**.

6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

CAUTION: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

CAUTION: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-8062:** Valve Spring Compressor
- **EN-9666:** Valve Spring Tester
- **EN-43963:** Valve Spring Compressor (off car)

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

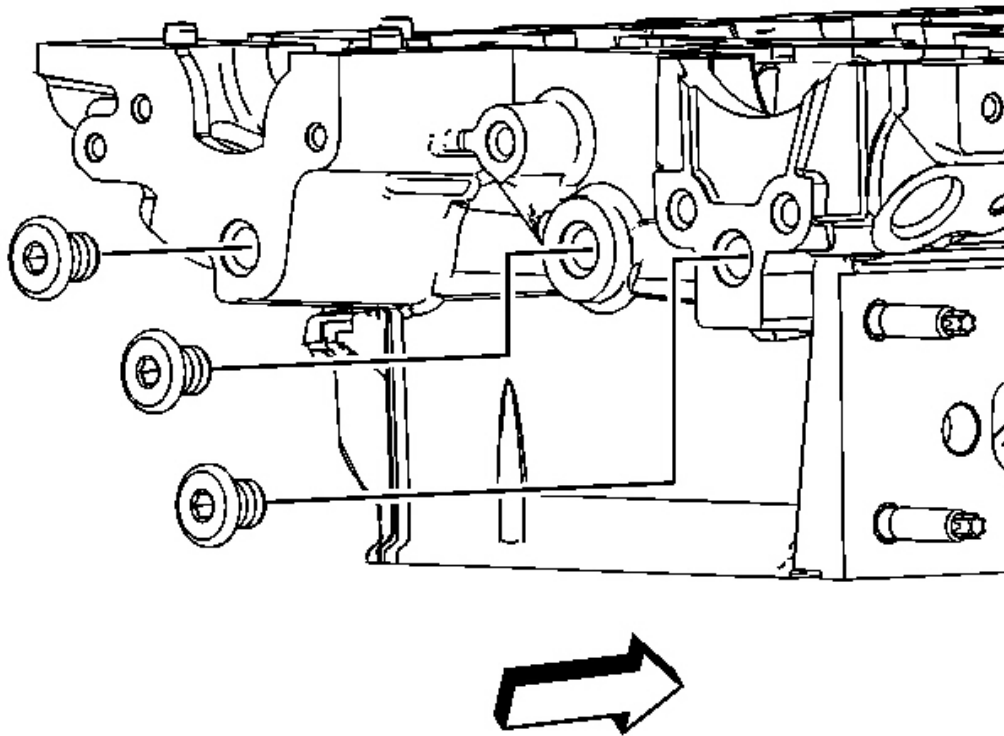


Fig. 352: Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

CAUTION: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

CAUTION: Refer to Component Fastener Tightening Caution .

1. Install NEW cylinder head plugs. Coat the plugs with sealer. Refer to Adhesives, Fluids, Lubricants, and Sealers.
2. Inspect the valve springs for the following conditions:
 - Expanded height
 - Unparallel spring ends
 - Spring tension using **EN-9666**: tester
 - Any distorted springs should be replaced

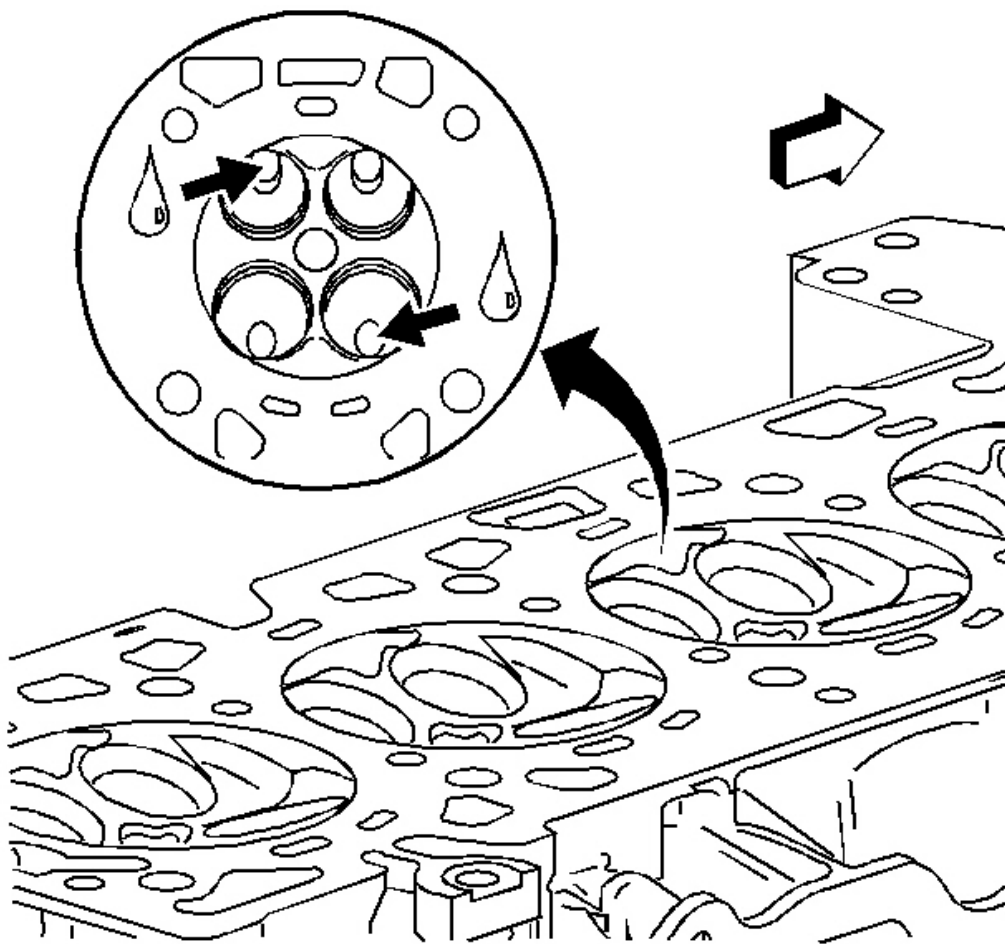


Fig. 353: Applying Prussian Blue
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valves and the valve seats. Refer to **Valve and Seat Grinding**.

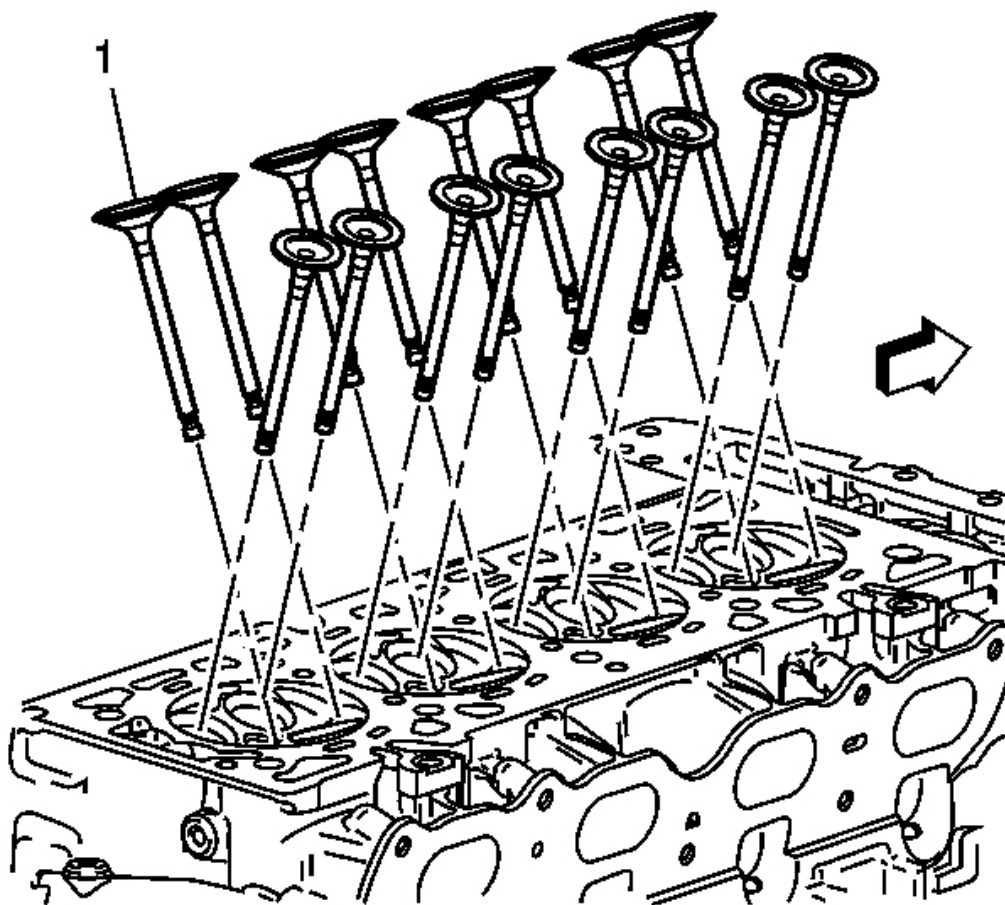


Fig. 354: View of Valves

Courtesy of GENERAL MOTORS CORP.

4. Install the valves (1). Replace the valves, if required.

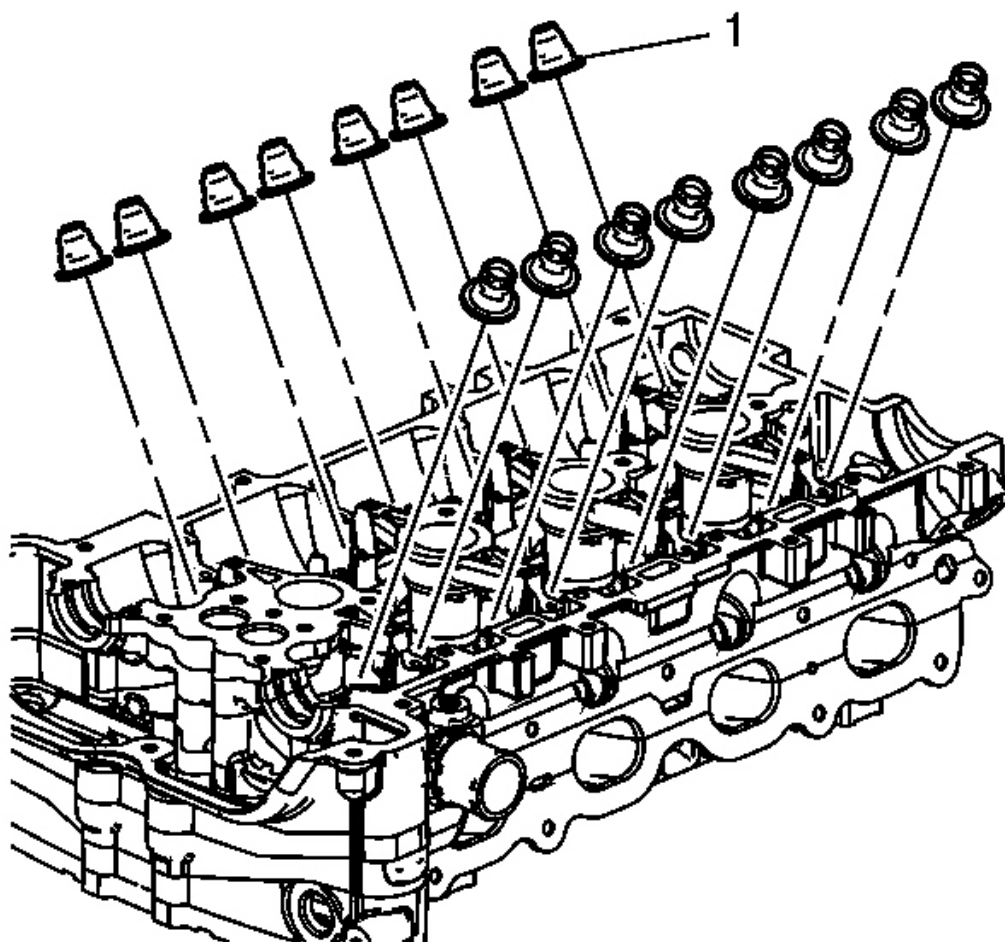


Fig. 355: View of Valve Seals

Courtesy of GENERAL MOTORS CORP.

NOTE: Always use **NEW** valve stem oil seals when assembling the cylinder head.

5. Install the NEW valve seals (1). Fully seat the seals on the valve guides.

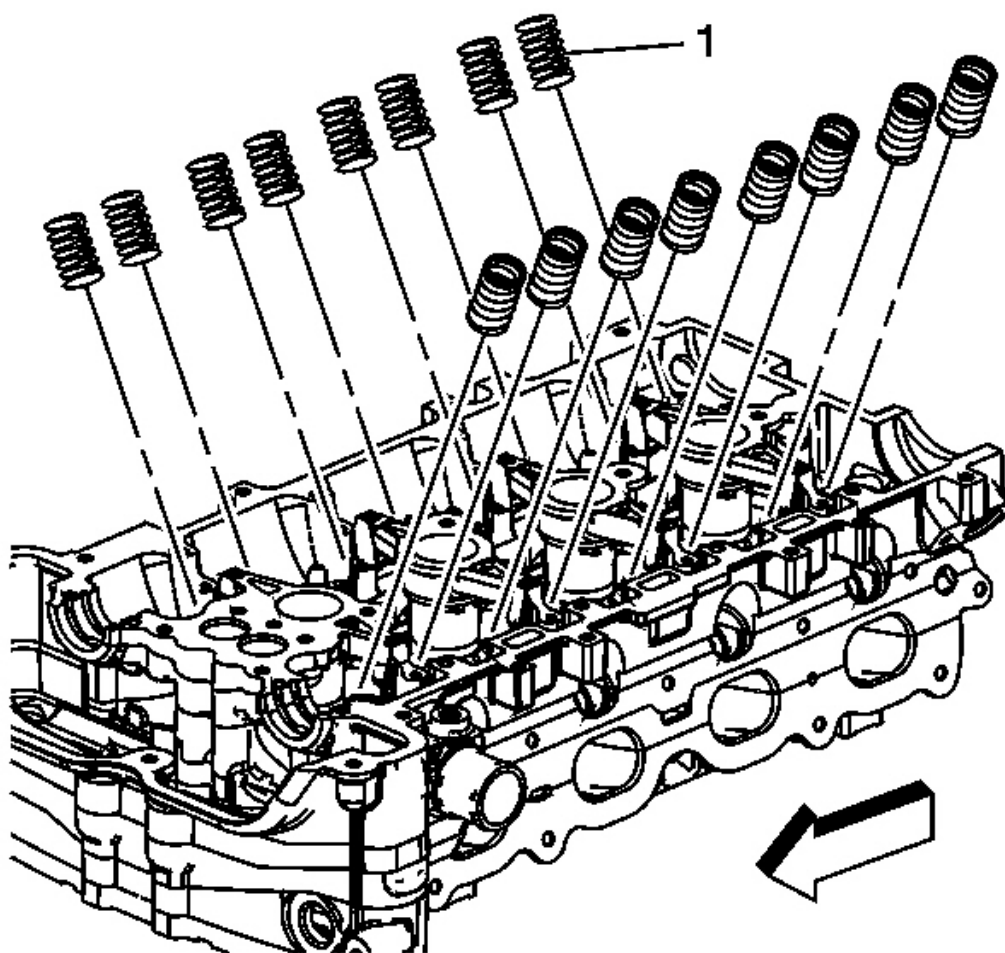


Fig. 356: View of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Install the springs (1).

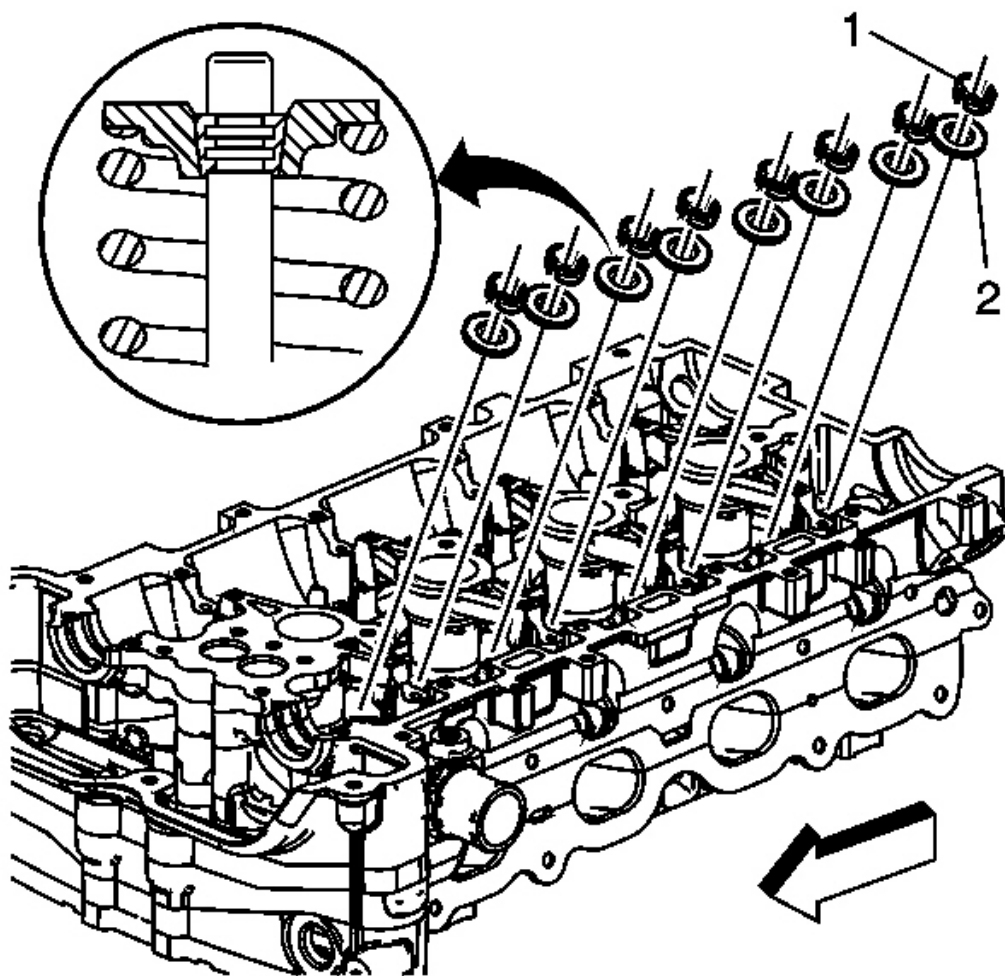


Fig. 357: Identifying Valve Keys & Retainer
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal

can cause potential valve stem oil seal damage.

7. Install the retainers and keys using the following procedure:
 1. Install the retainer (2).
 2. Using the **EN-8062**: compressor and the **EN-43963**: compressor , compress the valve spring.
 3. Install the valve keys (1).
 4. Slowly release the **EN-8062**: compressor and the **EN-43963**: compressor (off car) from the valve/spring assembly.
 5. Inspect for proper valve key seating.

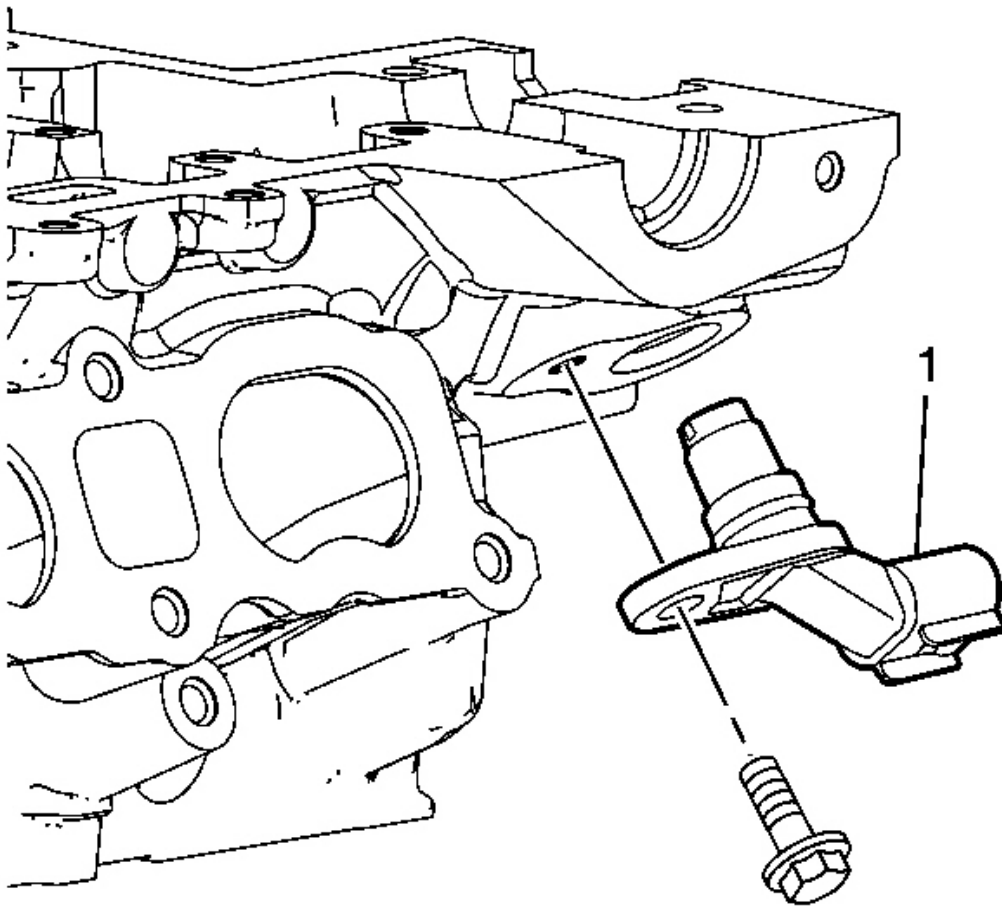


Fig. 358: Intake Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the camshaft position sensor O-ring with clean engine oil.

CAUTION: Refer to Fastener Caution .

9. Install the intake camshaft position sensor (1) and bolt. Tighten the bolt to 10 N.m (89 lb in).

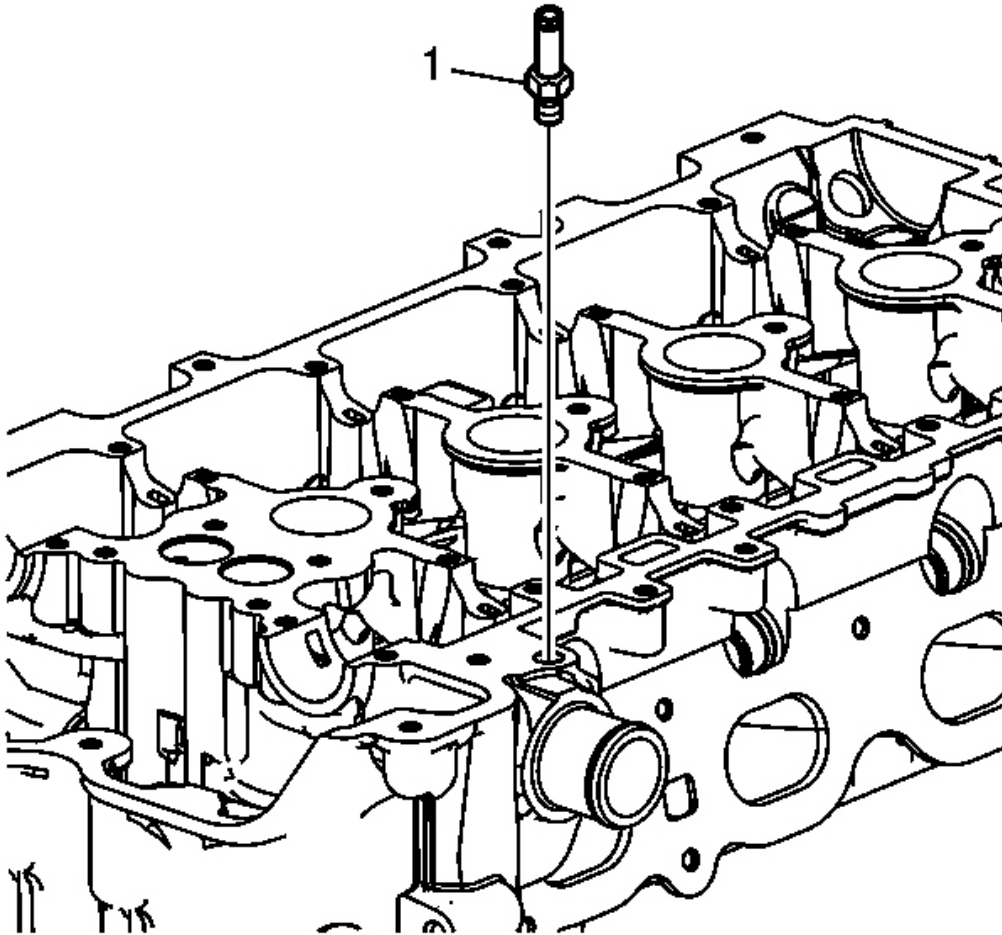


Fig. 359: Identifying the Coolant Air Bleed Hose Fitting
Courtesy of GENERAL MOTORS CORP.

10. Install the cylinder head air bleed tube (1) and tighten the tube to 15 N.m (11 lb ft).

OIL PUMP DISASSEMBLE

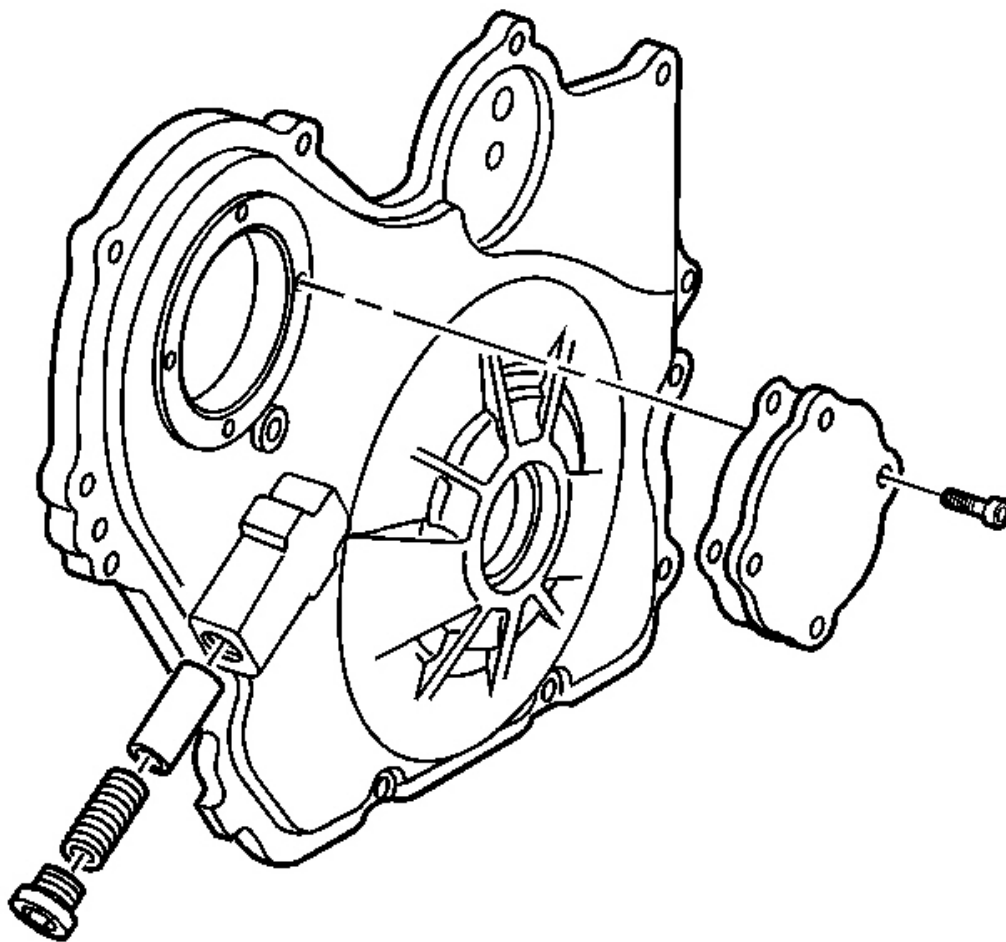


Fig. 360: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

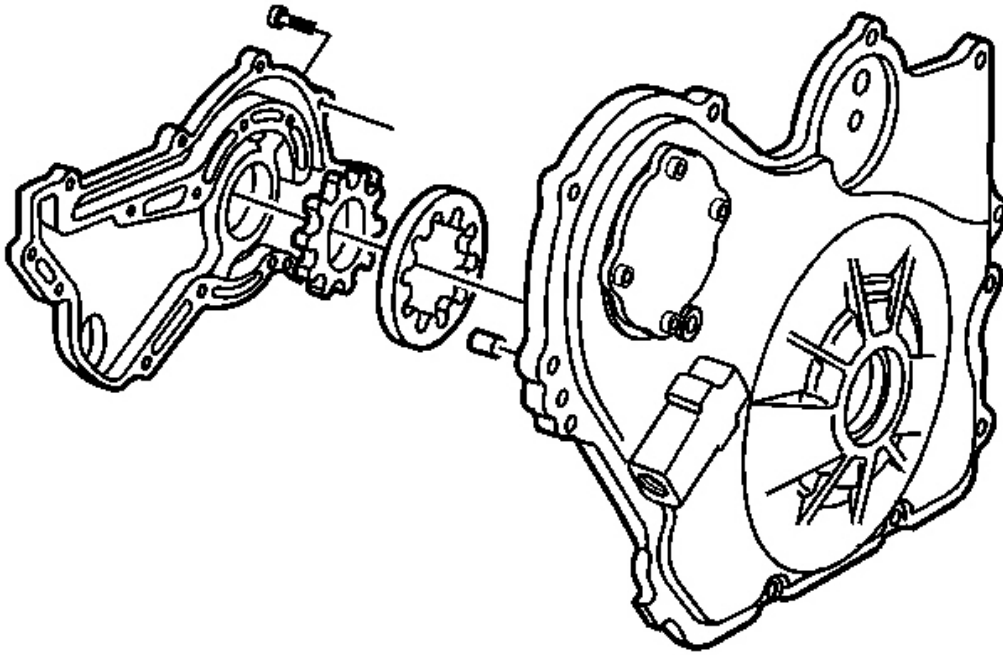


Fig. 361: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump gerotor cover and bolts.
3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump for wear and scoring. Insure that all components are within specifications. Refer to **Engine Mechanical Specifications**.

Replace the front cover and oil pump assembly if it is out of specification or damaged.

OIL PUMP ASSEMBLE

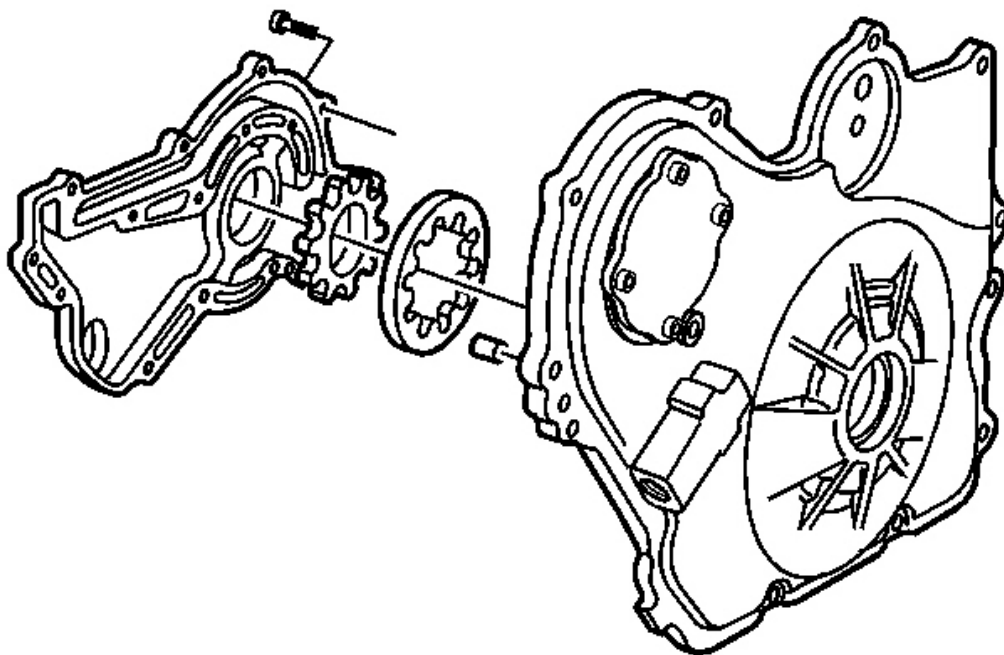


Fig. 362: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

NOTE: **If gears are improperly installed in the front cover, the gerotor cover will not bolt on.**

3. Install the gears together into the front cover with the hub of the center gear facing the front cover.

CAUTION: Refer to Fastener Caution .

4. Install the oil pump gerotor cover and bolts and tighten to 6 N.m (53 lb in).

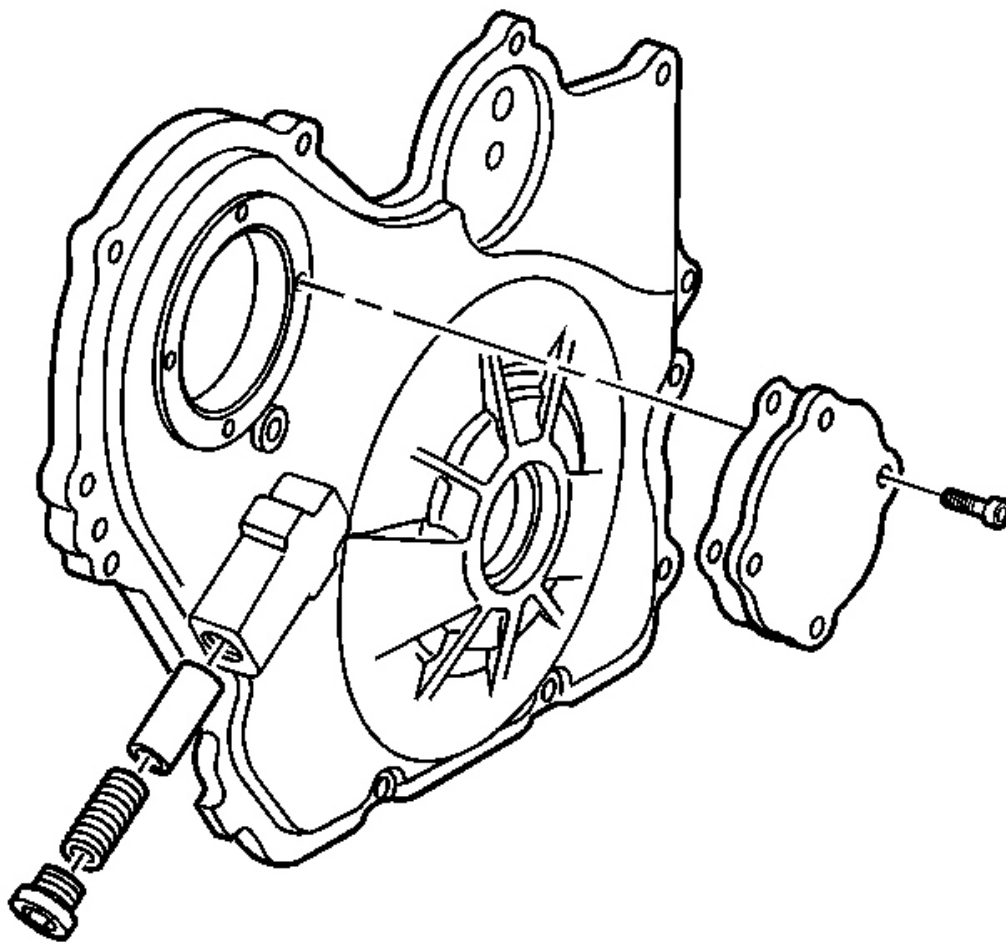


Fig. 363: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure relief valve piston.
6. Install the pressure relief valve spring.
7. Install and tighten the pressure relief valve plug to 40 N.m (30 lb ft).

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- **EN-49245:** Fuel Injector Seal Installer and Sizer
- **EN-49247:** Injector Retaining Clip Installer

For equivalent regional tools, refer to Special Tools.

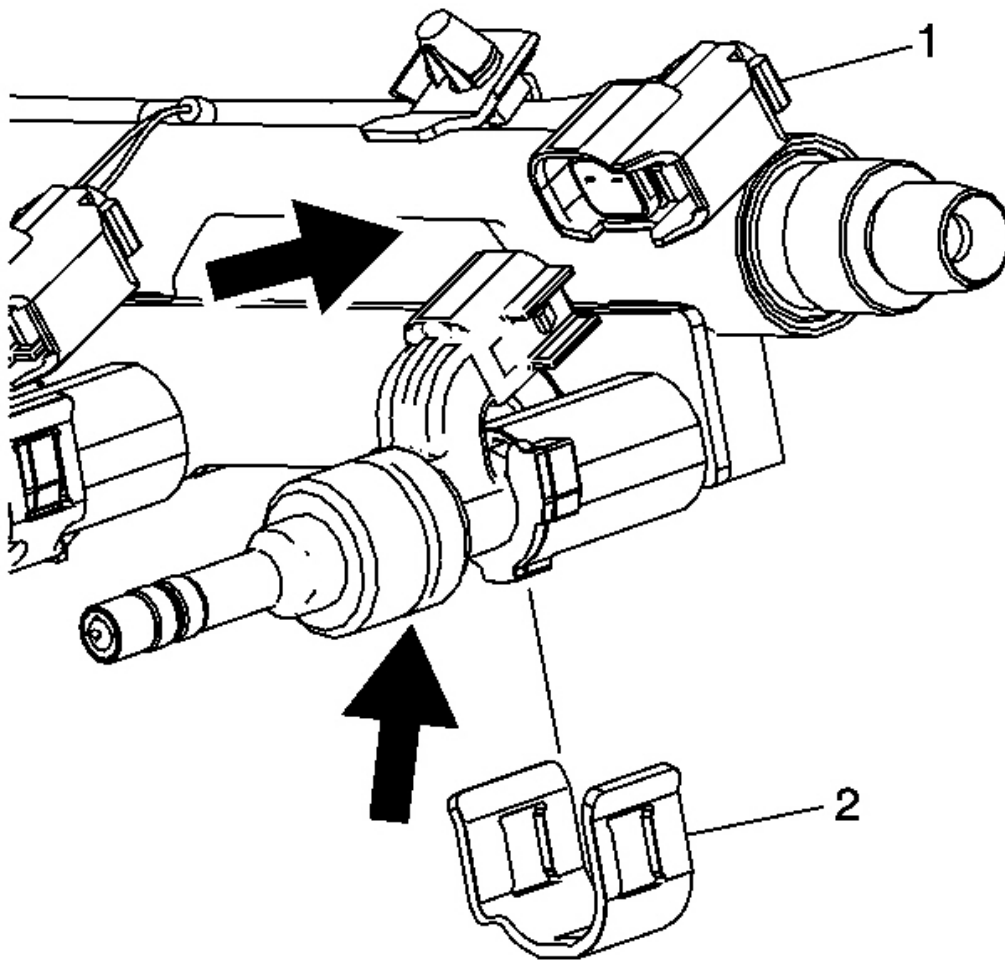


Fig. 364: Fuel Injectors & Retainers

Courtesy of GENERAL MOTORS CORP.

1. Disconnect the electrical connections from the fuel injectors (1).

NOTE: Support the fuel rail along the bottom, indicated by the arrow. Support the fuel injector at the widest point, indicated by the arrow. DO NOT support or hold the fuel injector by the tip or connector when removing the fuel injector retainer.

2. Remove and discard the fuel injector retainer (2).

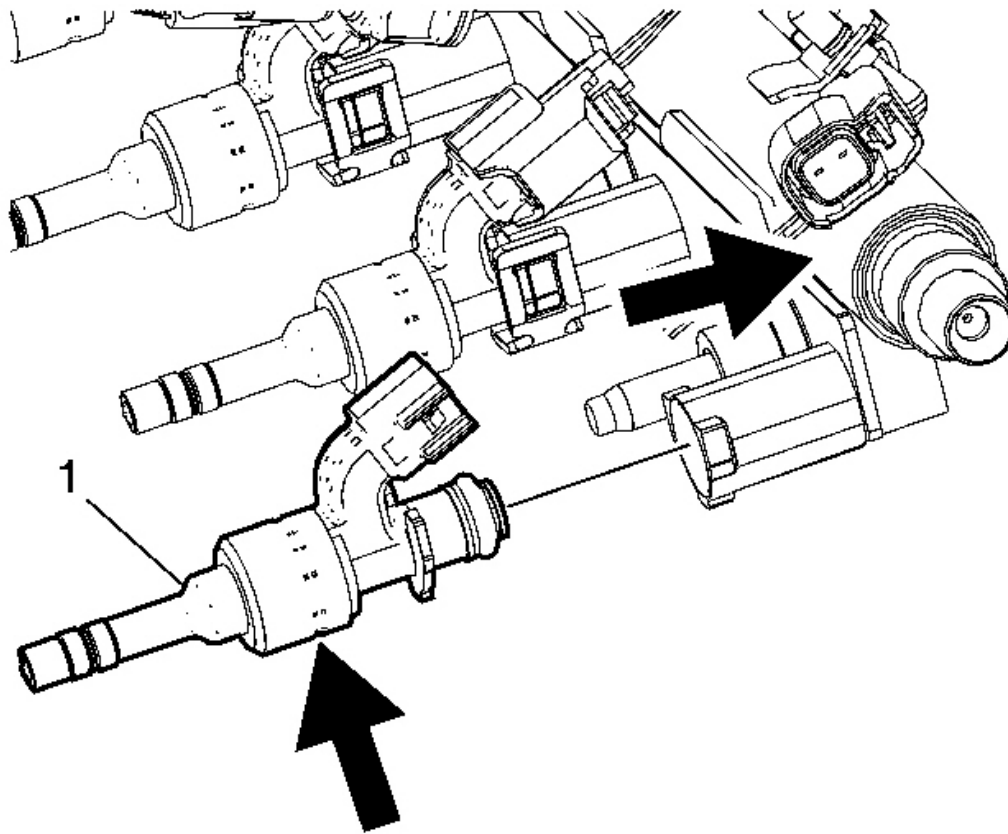


Fig. 365: Supporting Fuel Injector
Courtesy of GENERAL MOTORS CORP.

NOTE: Support the fuel injector at the widest point, indicated by the arrow.
 Support the fuel rail at the point indicated by the arrow.

- DO NOT support or hold the fuel injector by the tip or connector
- DO NOT tilt or excessively twist the injector during removal

3. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable.

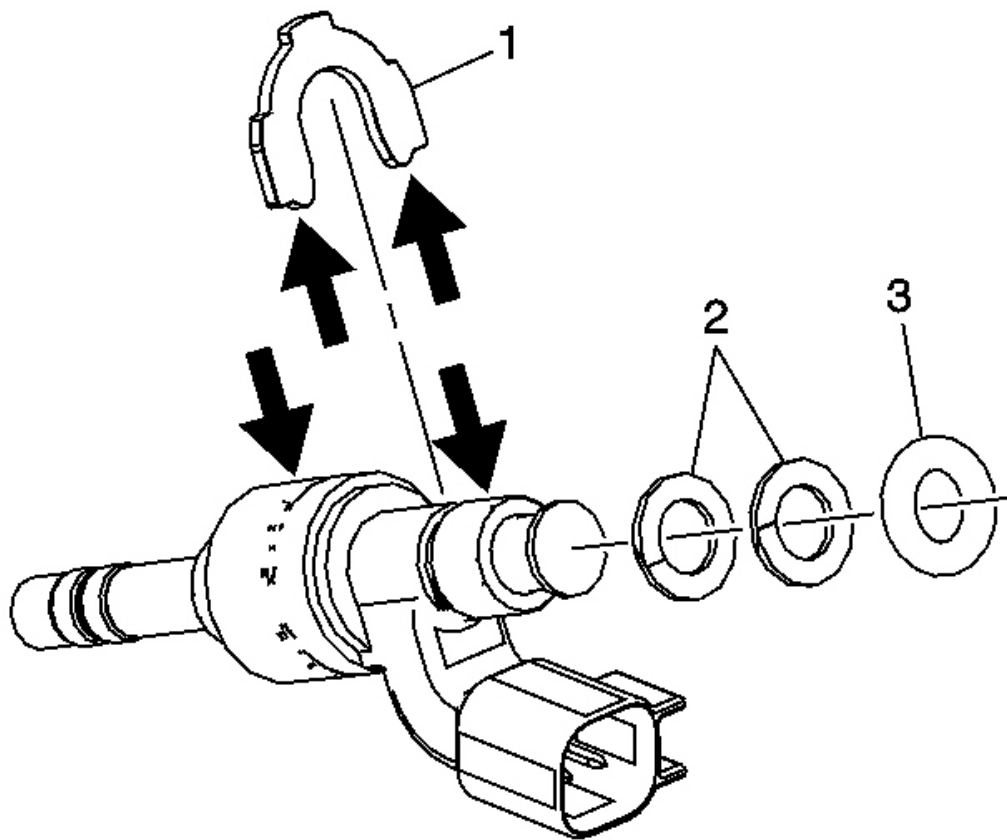


Fig. 366: Removing Fuel Injector Bushing
Courtesy of GENERAL MOTORS CORP.

NOTE: Support the fuel injector at the widest point, and directly behind the bushing location, indicated by the arrows. DO NOT support or hold the fuel injector by the tip or connector when removing the fuel injector bushing.

4. Using a suitable tool, remove the fuel injector bushing (1) by pushing straight off at the bushing tabs, indicated by the arrows. Discard the bushing.
5. Remove and discard the fuel injector O-ring (3) and plastic spacers (2).

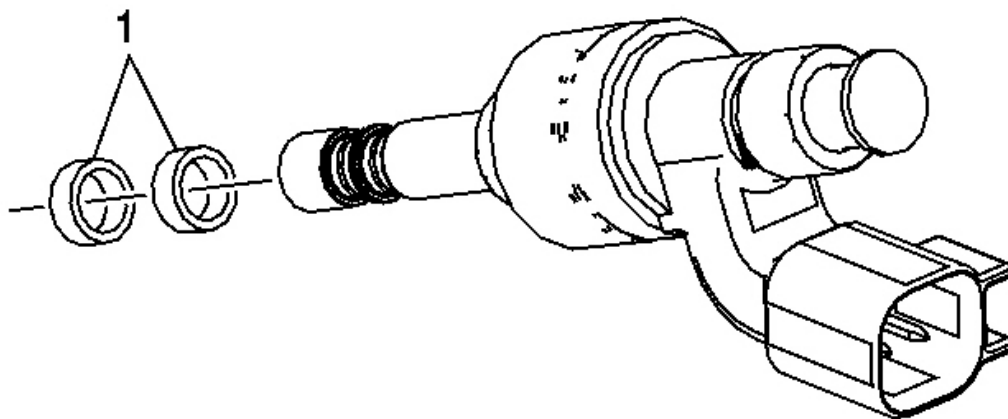


Fig. 367: Fuel Injector Seals

Courtesy of GENERAL MOTORS CORP.

6. Remove and discard the fuel injector seals (1).

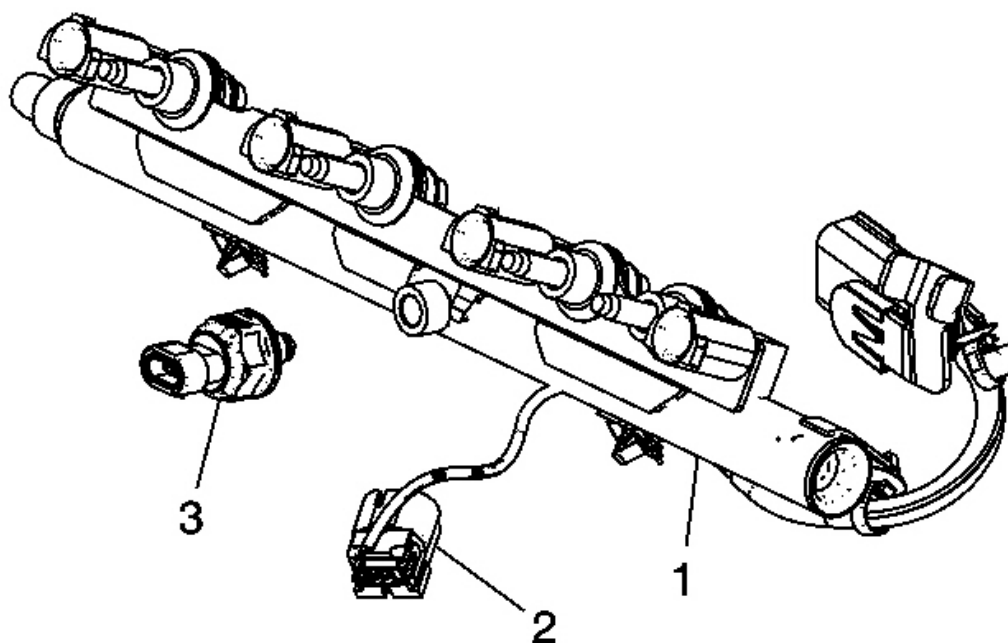


Fig. 368: Fuel Rail

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not soak or submerge the fuel rail or injectors in solvent.

7. Clean the exterior of the fuel rail (1) and injectors in solvent.
8. 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
 - Damage to the threads on the fuel rail fuel feed fitting
9. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

CAUTION: Refer to Fastener Caution .

10. Inspect the fuel pressure sensor (3) for damage.
 1. Disconnect the harness connector (2) from the fuel pressure sensor.
 2. Remove the fuel pressure sensor. Dry the fuel pressure sensor bore in the fuel rail with a lint free cloth. The bore should be free of fuel, debris, and burrs.
 3. Lubricate the fuel rail fuel pressure sensor bore with clean engine oil.
 4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
 5. Install the fuel pressure sensor hand tight.
 6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
 7. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft) .
 8. Connect the harness connector to the fuel pressure sensor.

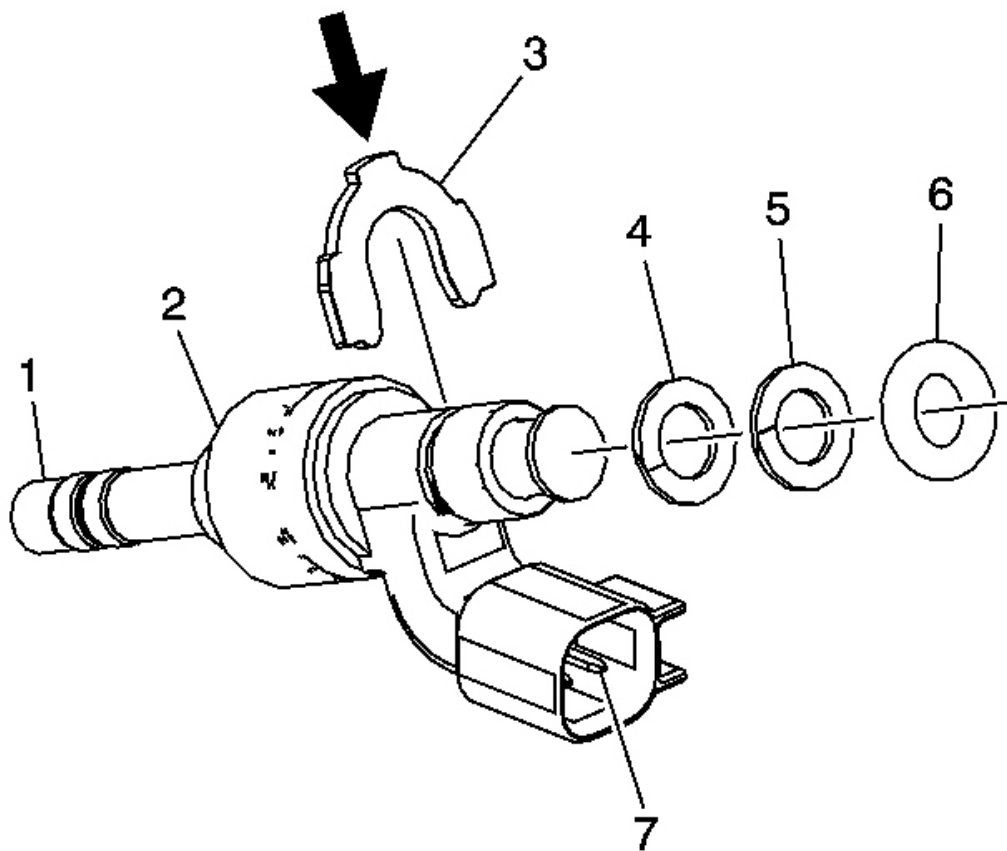


Fig. 369: Fuel Injector Components
Courtesy of GENERAL MOTORS CORP.

11. Inspect the fuel injectors for the following conditions:
 - Damage to the fuel injector connector (7)
 - Damage to the fuel injector harness connector
 - Damage to the fuel injector tip (1)
 - Damage to the tolerance ring (2)
12. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.
13. Install a new fuel injector bushing (3) onto the fuel injector. The bushing should seat with a distinct "snap" sound and feel.

NOTE: **DO NOT** reverse the order of the plastic spacers. Identify the correct order in which the new plastic spacers are installed by the color of the spacer.

14. Install the new white plastic spacer (4) on the fuel injector first.
15. Install the new brown plastic spacer (5) second.
16. Lubricate the new O-ring (6) with 5W30 engine oil.
17. Install the O-ring on the injector.

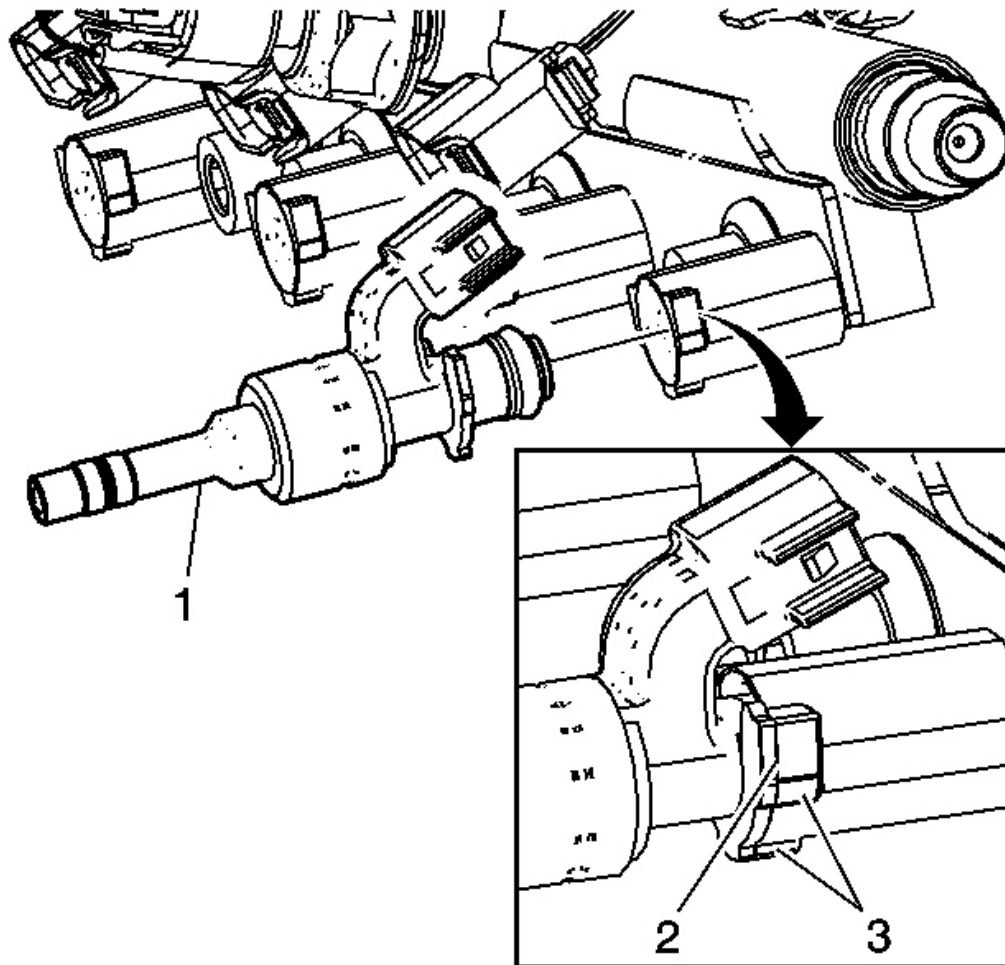


Fig. 370: Installing Fuel Injectors

Courtesy of GENERAL MOTORS CORP.

NOTE: The injector must be fully installed and properly aligned with the fuel rail in order to install the retainer.

18. Install the fuel injectors (1) into the fuel rail.

- Ensure the fuel injector is fully seated in the fuel rail, and no gaps are present (2).
- Ensure the injector and fuel rail flanges are aligned (3)

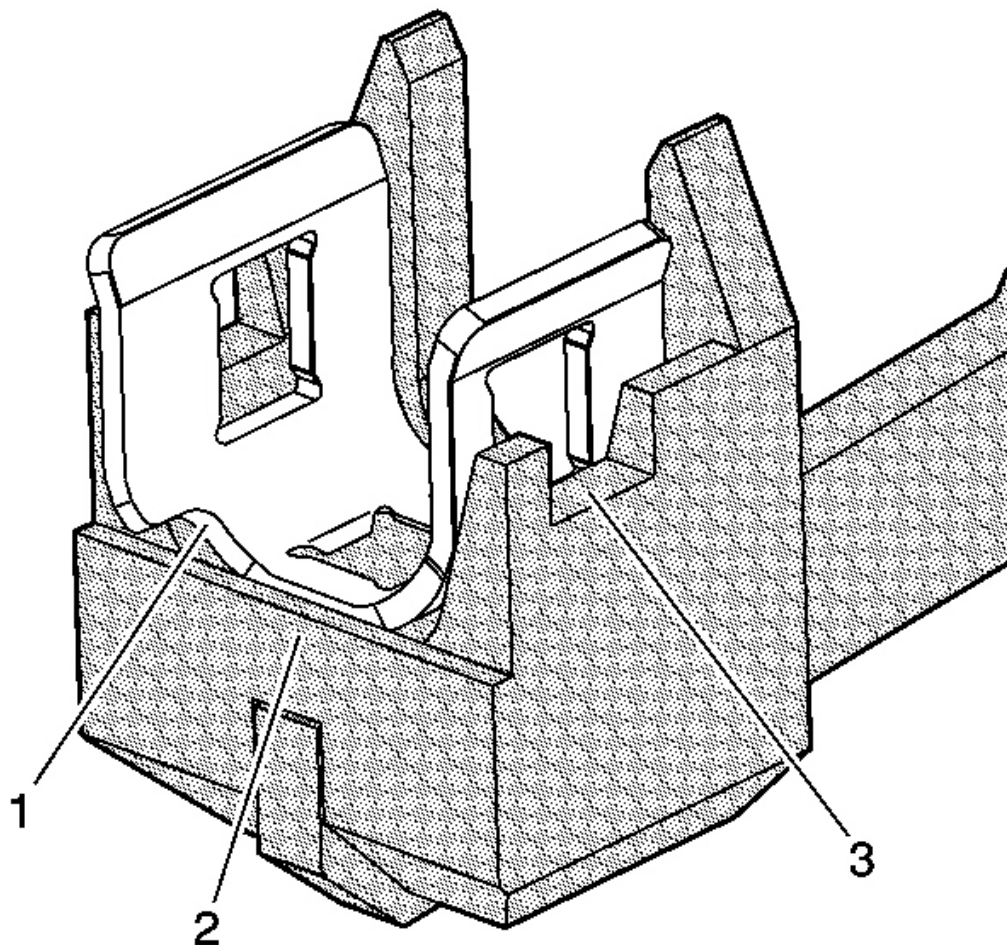


Fig. 371: Retainer Installer

Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the retainer is set properly into EN-49247: installer.

- The notch should always face forward (1)
- The retainer should be behind the plate (2)
- The tool windows allow for visual alignment (3)

19. Install the fuel injector retainer onto the **EN-49247**: installer.

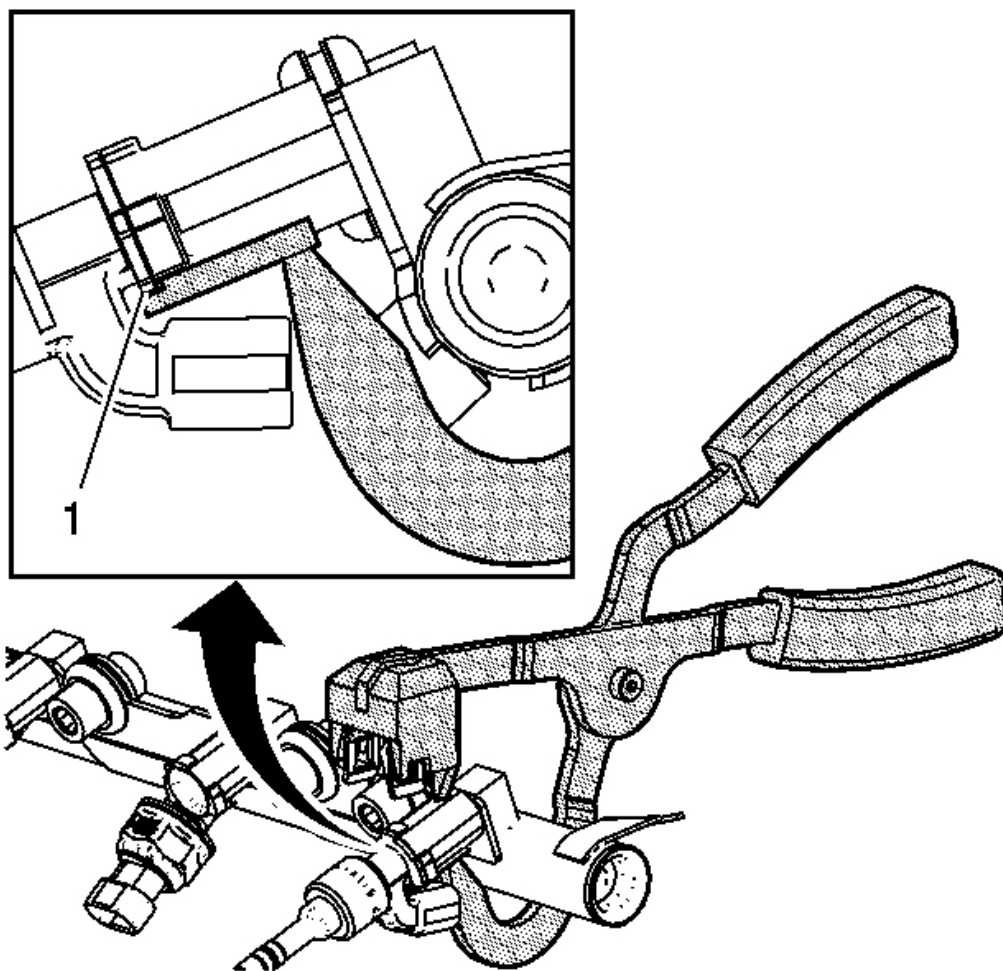


Fig. 372: Installing Fuel Injector Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the tool is resting on the flange of the injector bushing (1).

20. Using **EN-49247**: installer, install the fuel injector retainer.

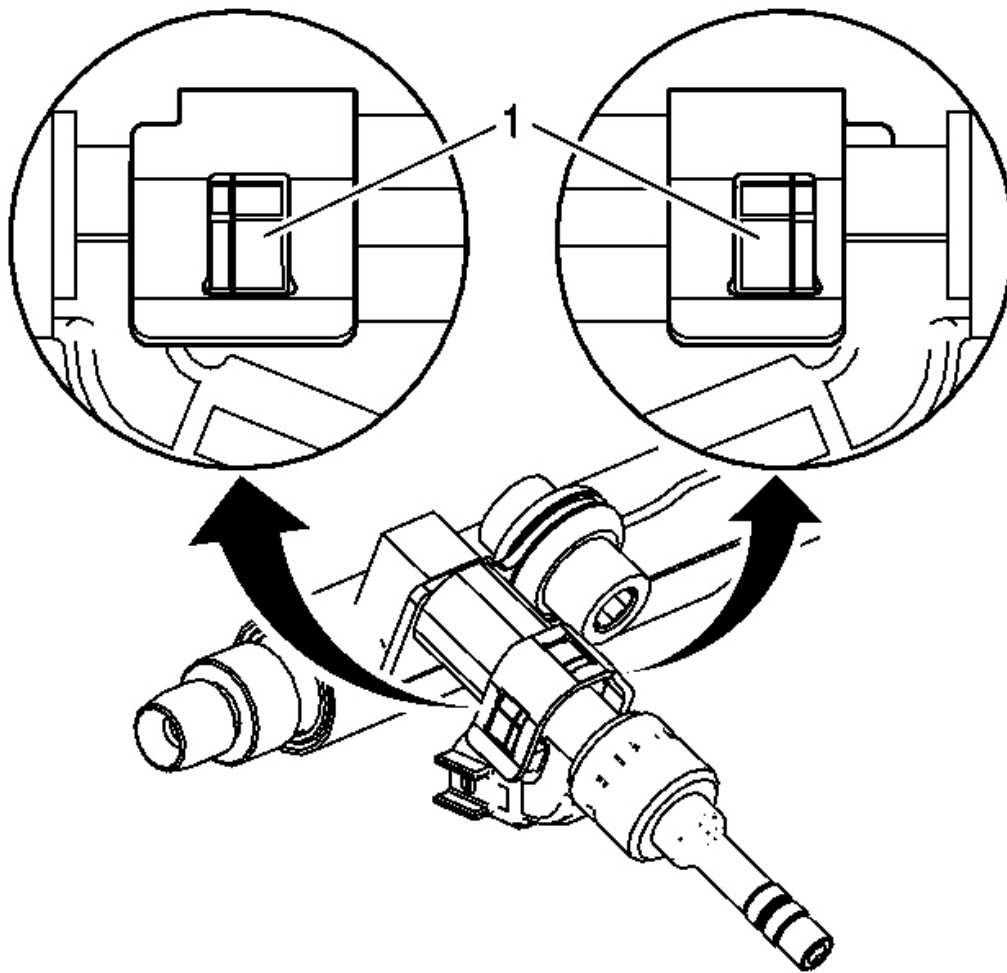


Fig. 373: Identifying Proper Injector Retainer Installation
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure the fuel injector retainer is properly installed. Failure to completely install the retainers may degrade fuel injection system performance or cause system malfunction.

21. Inspect each installed fuel injector retainer, and ensure the retainer is fully seated on the fuel rail and fuel injector bushing flanges (1). The flanges on each side and at the top of the fuel injector should seat completely into the window on the retainer.

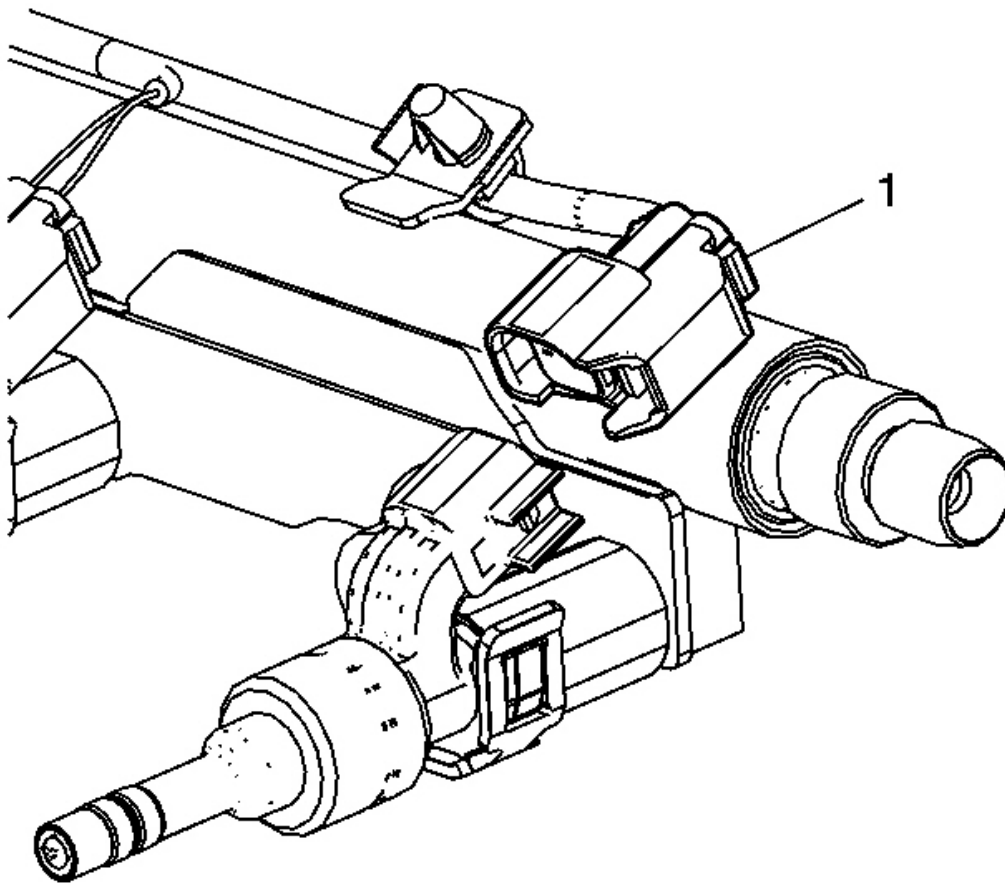


Fig. 374: Fuel Rail Harness Connector
Courtesy of GENERAL MOTORS CORP.

22. Connect the electrical connection to the fuel rail.
23. Connect the fuel rail harness connectors (1) to the fuel injectors.

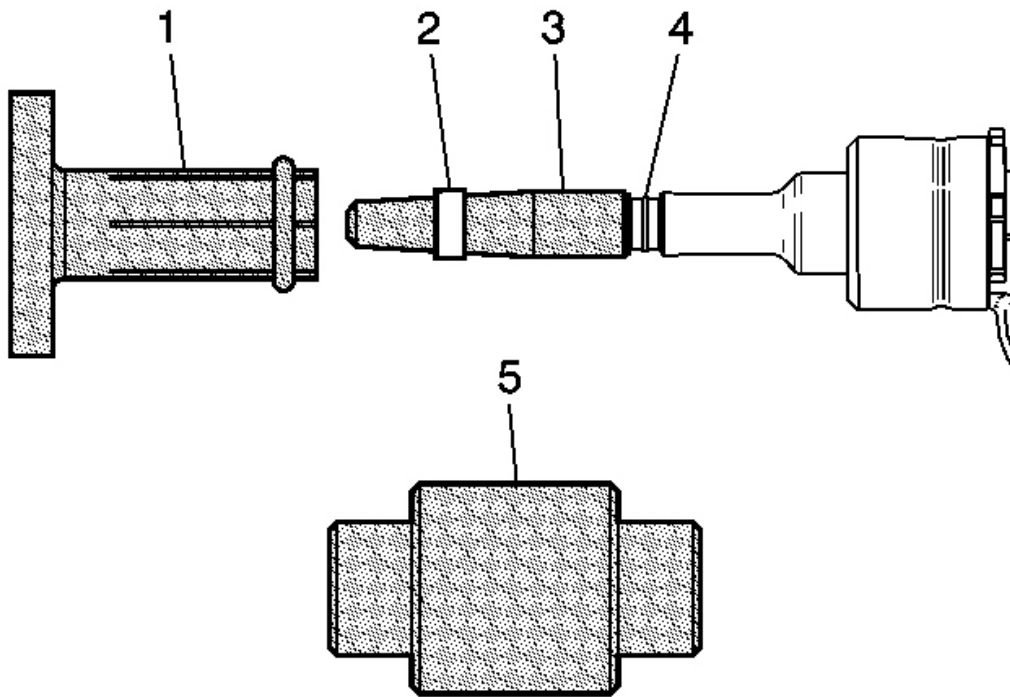


Fig. 375: Installing Seals

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

24. Install **EN-49245-1:** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on **EN-49245-1:** long protector.
25. 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.

26. Compress the seal with your fingers, then resize the seal using the **EN-49245-4:** sizer (5).

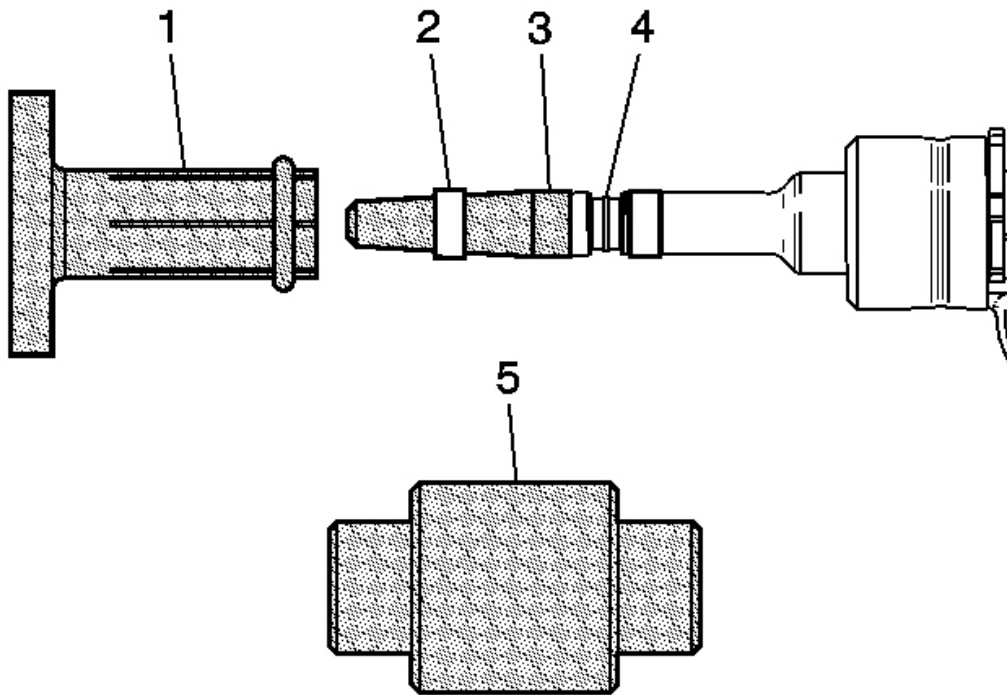


Fig. 376: Installing Seals

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector tip.

27. Install **EN-49245-2:** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-49245-2:** short protector.
28. 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.

29. Compress the seal with your fingers, then resize the seal using the **EN-49245-4:** sizer (5).

INTAKE MANIFOLD CLEANING AND INSPECTION

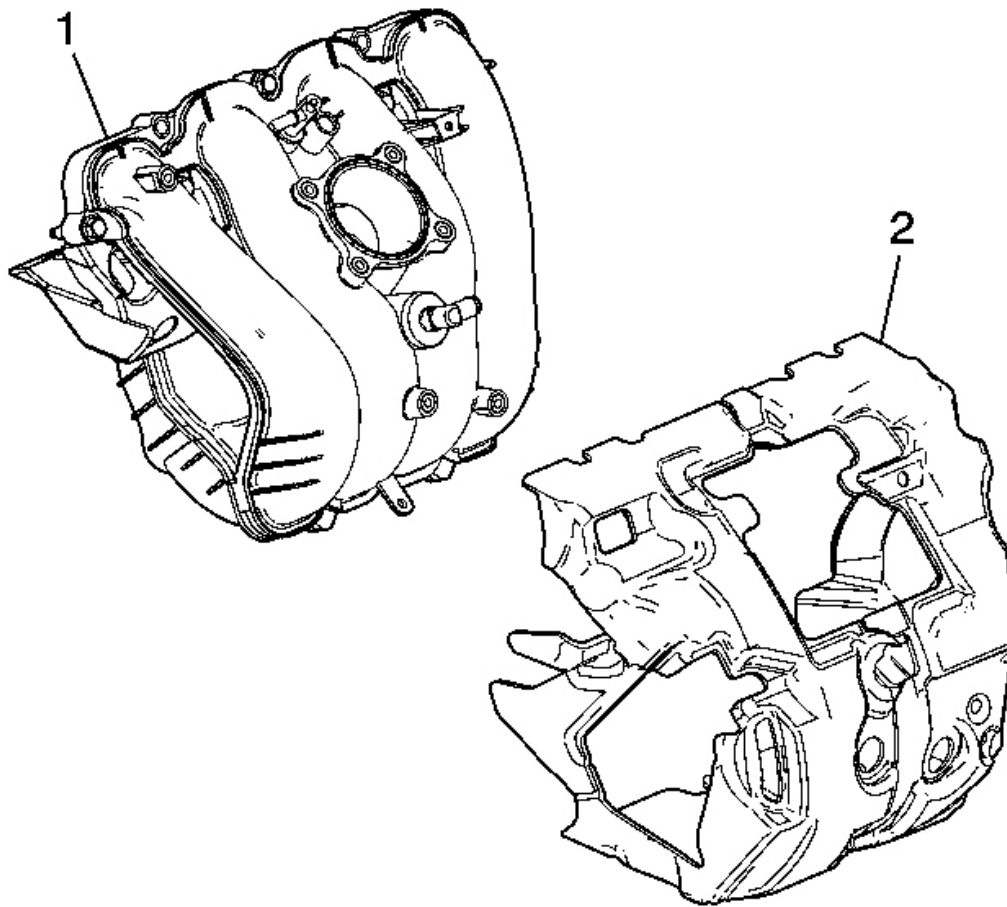


Fig. 377: Intake Manifold & Insulator
Courtesy of GENERAL MOTORS CORP.

1. Clean the intake manifold (1) mating surfaces.
2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.
4. Clean and inspect the intake manifold insulator (2) for damage.

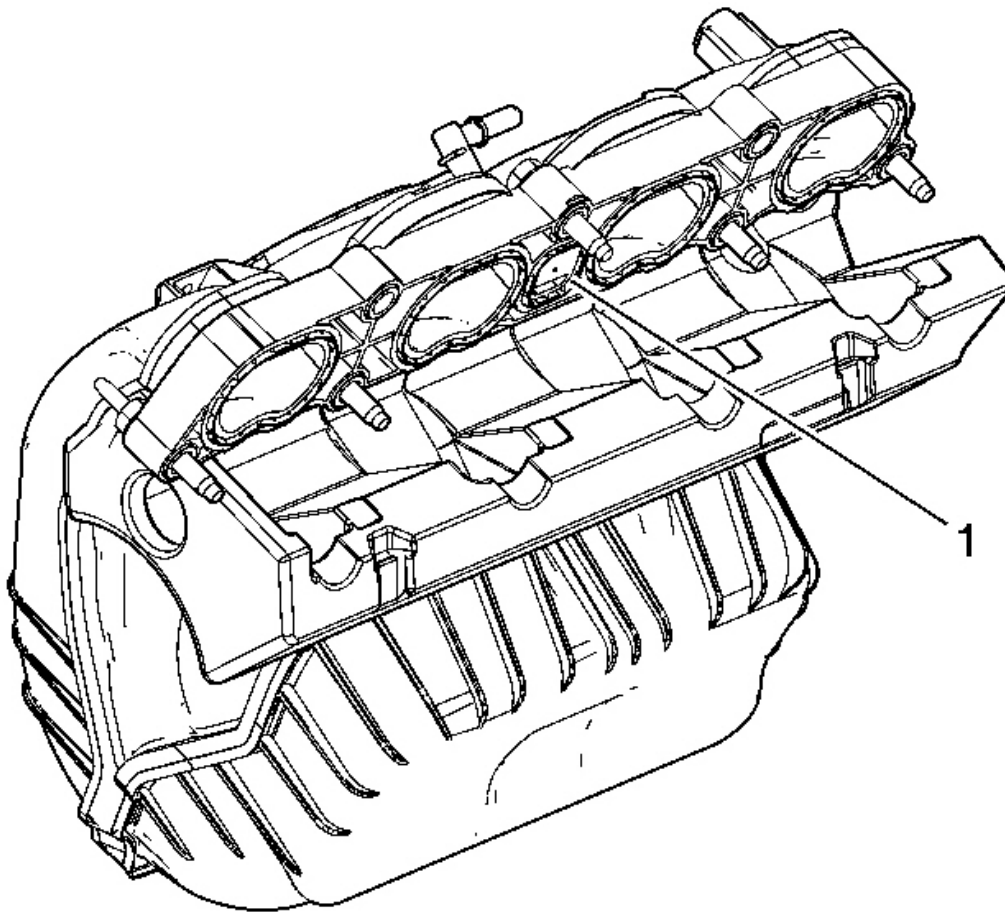


Fig. 378: Crankcase Ventilation Passages
Courtesy of GENERAL MOTORS CORP.

5. Inspect the crankcase ventilation passages (1) in the intake manifold face for blockage.

WARNING: Refer to Safety Glasses Warning .

6. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
7. Replace the intake manifold as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

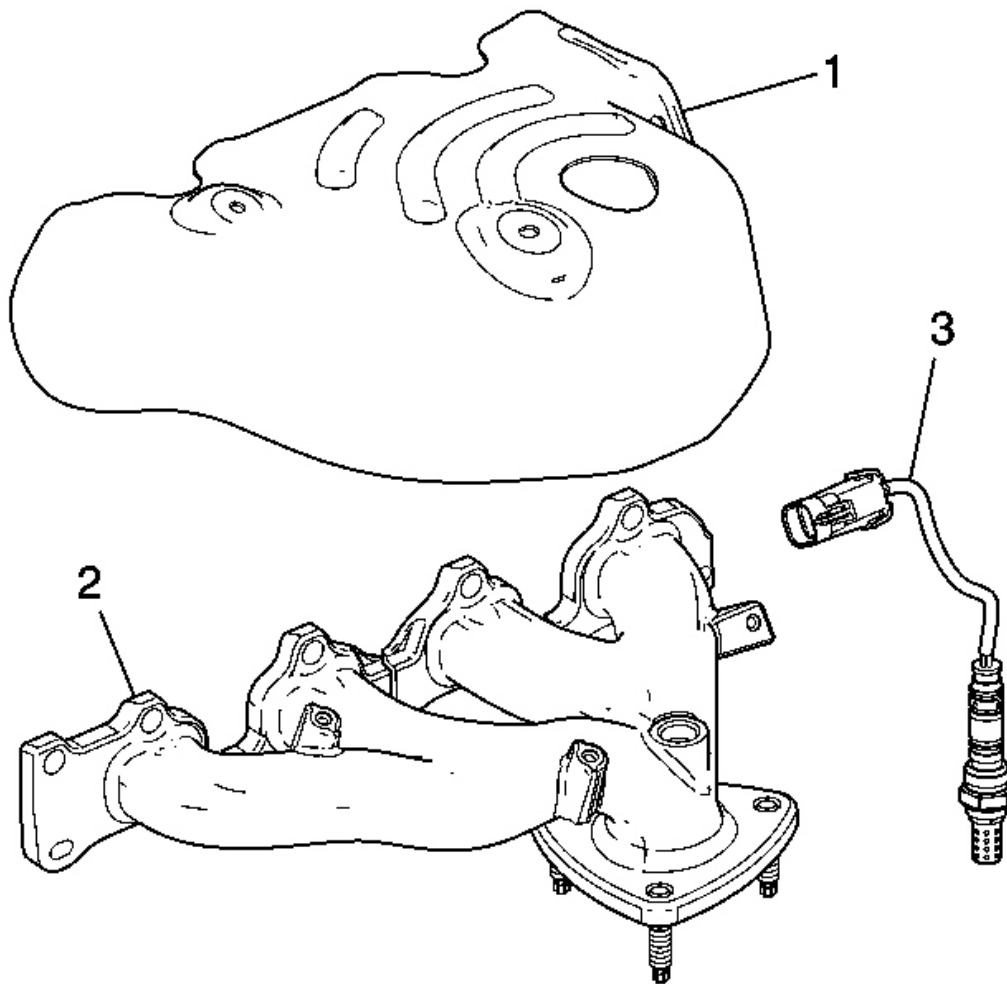


Fig. 379: Exhaust Manifold & Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE:

- Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.
- Remove the oxygen sensor prior to cleaning the manifold. Do not submerge the oxygen sensor in cleaning solvent.

1. Remove the oxygen sensor (3) from the manifold.
2. Clean the exhaust manifold (2) in solvent.

WARNING: Refer to Safety Glasses Warning .

3. Dry the exhaust manifold with compressed air.
4. Inspect the heat shield (1) for damage.

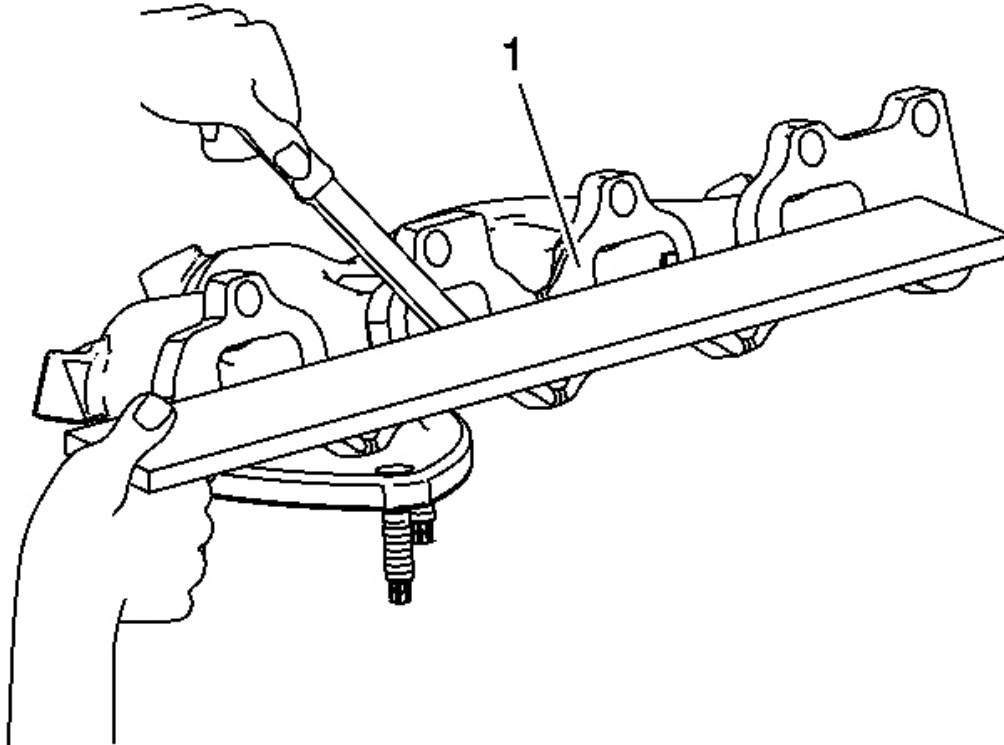


Fig. 380: Measuring Exhaust Manifold Mounting Face
Courtesy of GENERAL MOTORS CORP.

5. Use a straight edge and a feeler gauge and measure the exhaust manifold mounting face (1) for warpage.

An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

OIL PAN CLEANING AND INSPECTION

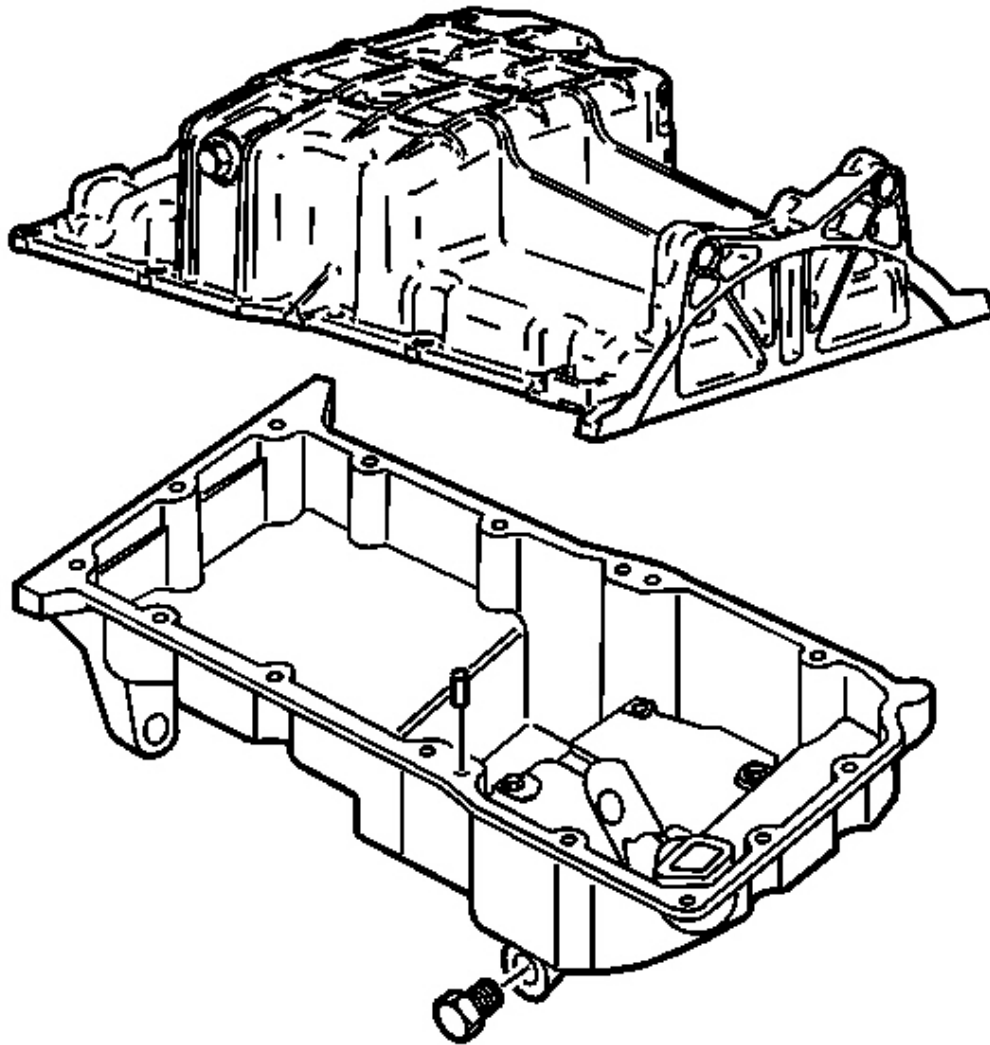


Fig. 381: Inspecting Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pan mating surface.
2. Clean the oil pan. Remove all the sludge and the oil deposits.
3. Inspect the threads for the engine oil drain plug.
4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
5. Inspect the oil pan for cracking resulting from impact or flying road debris.

IMPORTANT: The oil pan baffle and pickup screen are not removable from the oil pan.

6. Inspect the oil pan baffle and pickup screen.
7. Repair or replace the oil pan as necessary.

THREAD REPAIR

Special Tools

EN 42385-850: Thread Repair Kit

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

General Thread Repair

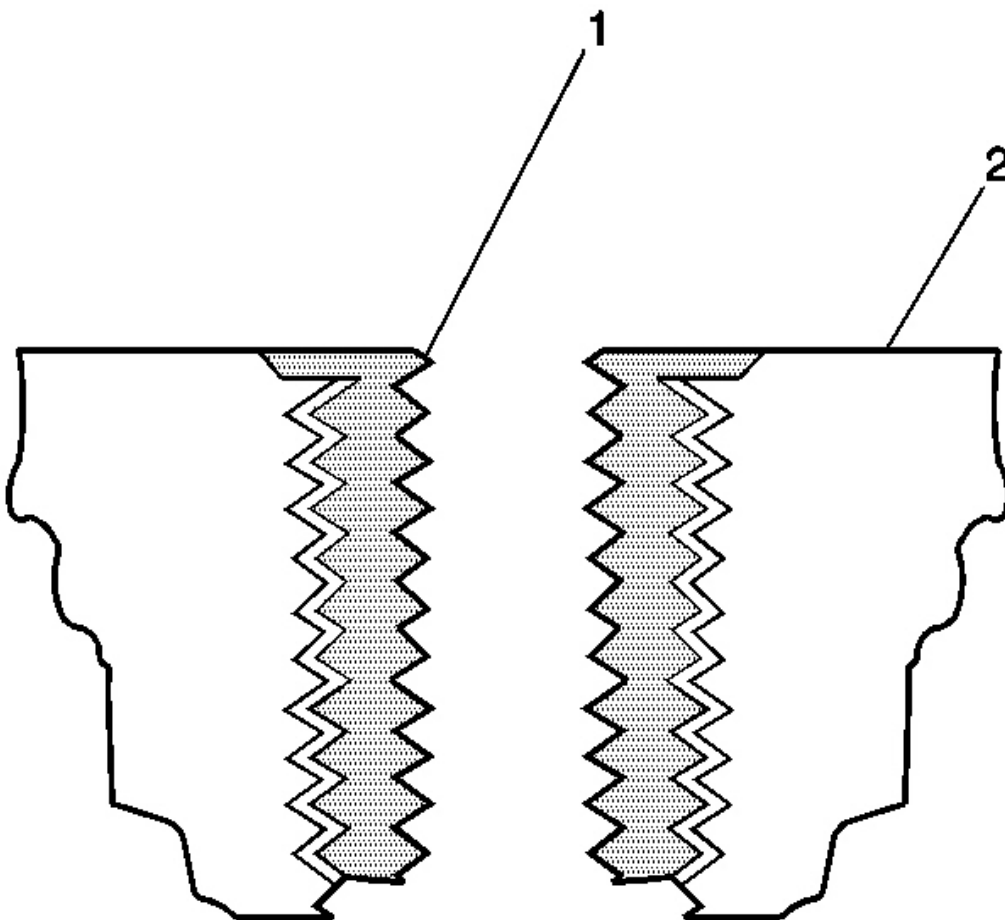


Fig. 382: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

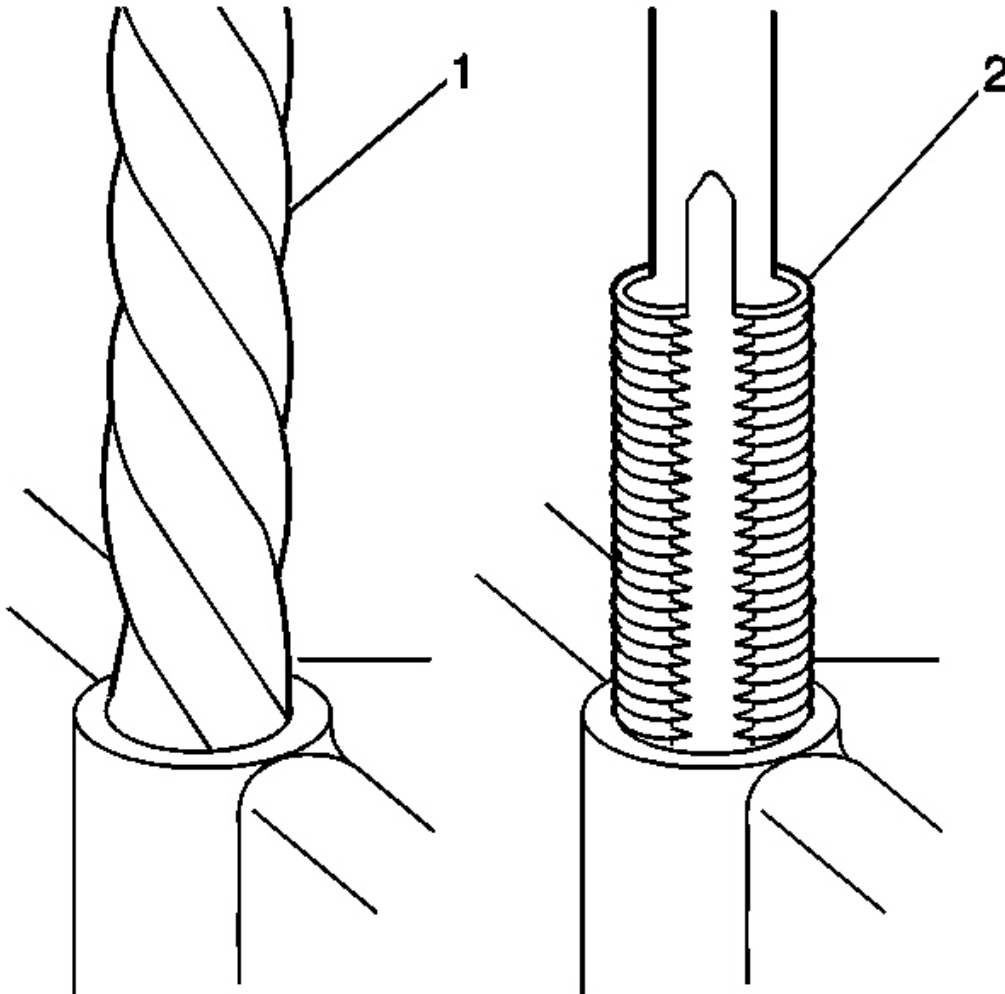


Fig. 383: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

NOTE: The use of a cutting fluid, WD 40®, or equivalent, is recommended when

performing the drilling, counterboring, and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.

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).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Using compressed air, clean out any chips.

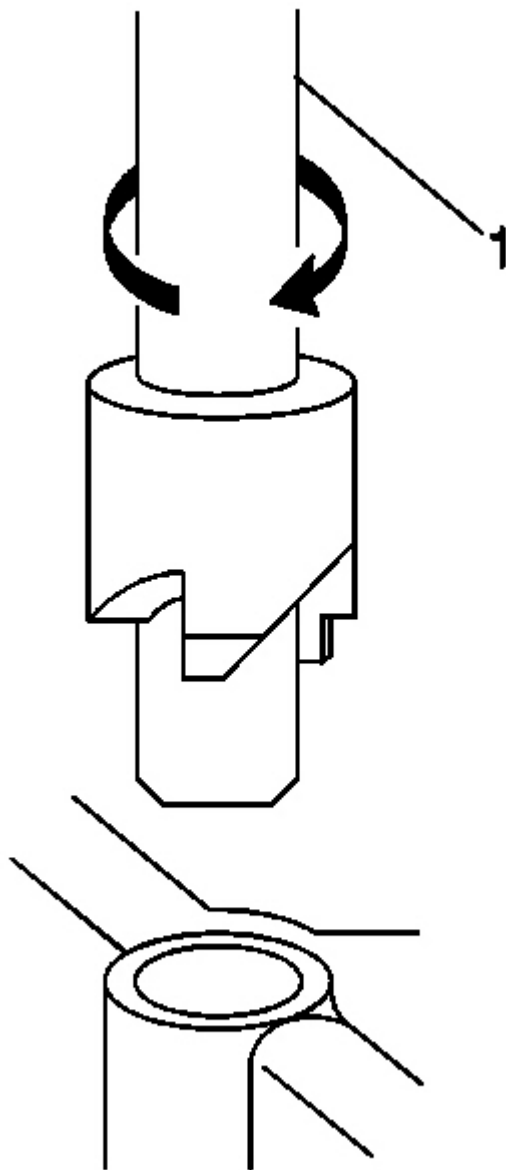


Fig. 384: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

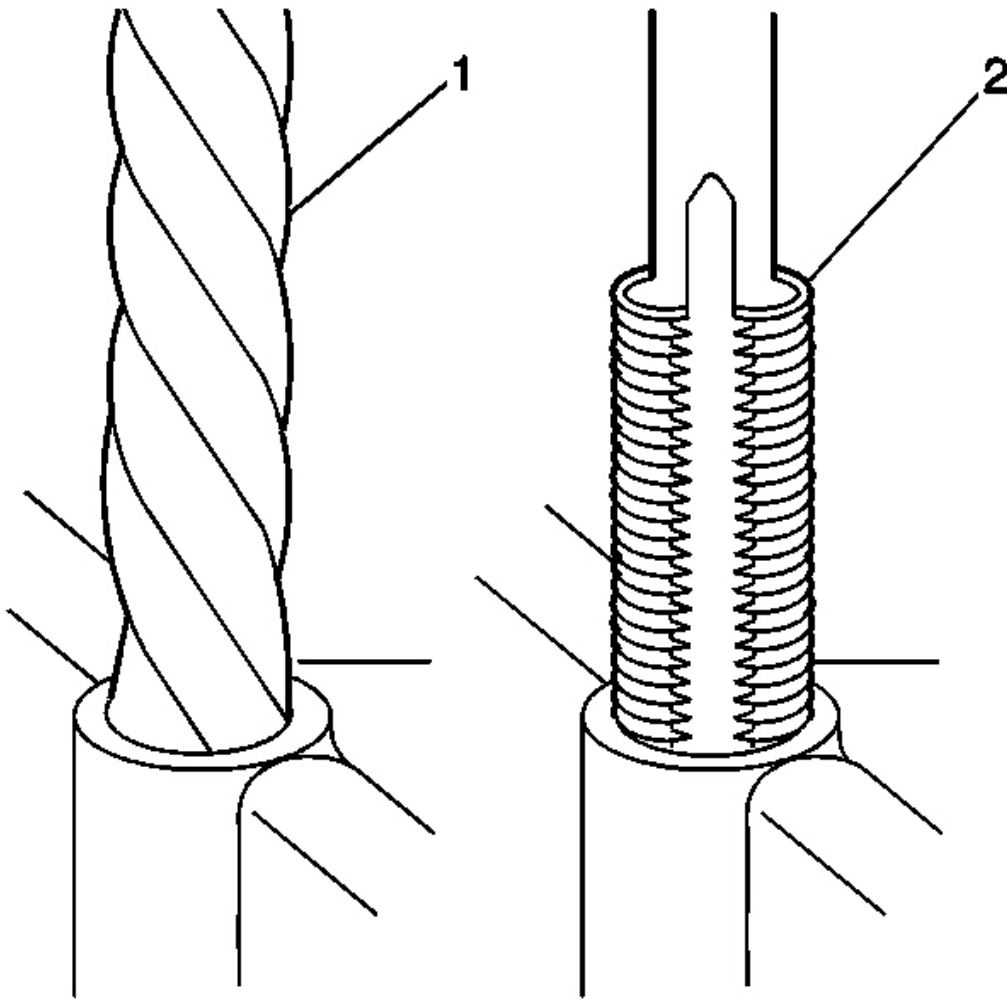


Fig. 385: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

6. Using compressed air, clean out any chips.
7. Spray cleaner into the hole. Refer to Adhesives, Fluids, Lubricants, and Sealers.
8. Using compressed air, clean any cutting oil and chips out of the hole.

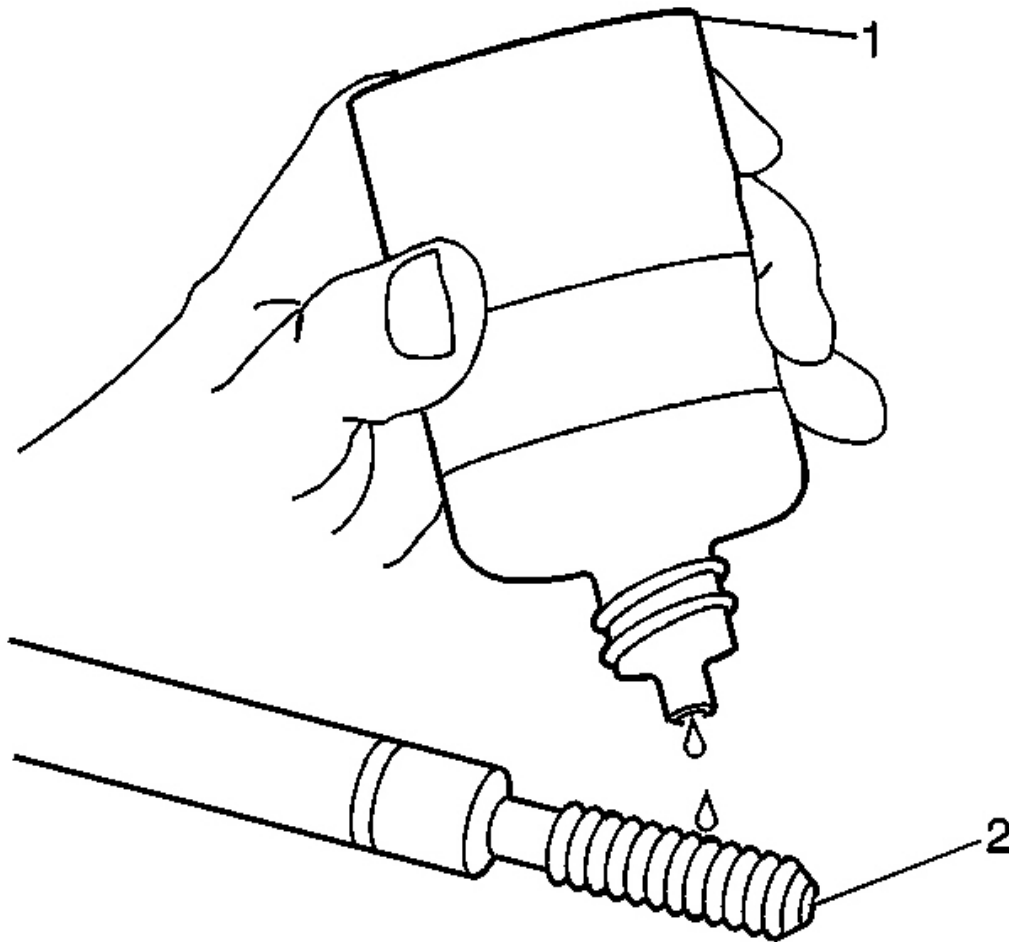


Fig. 386: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

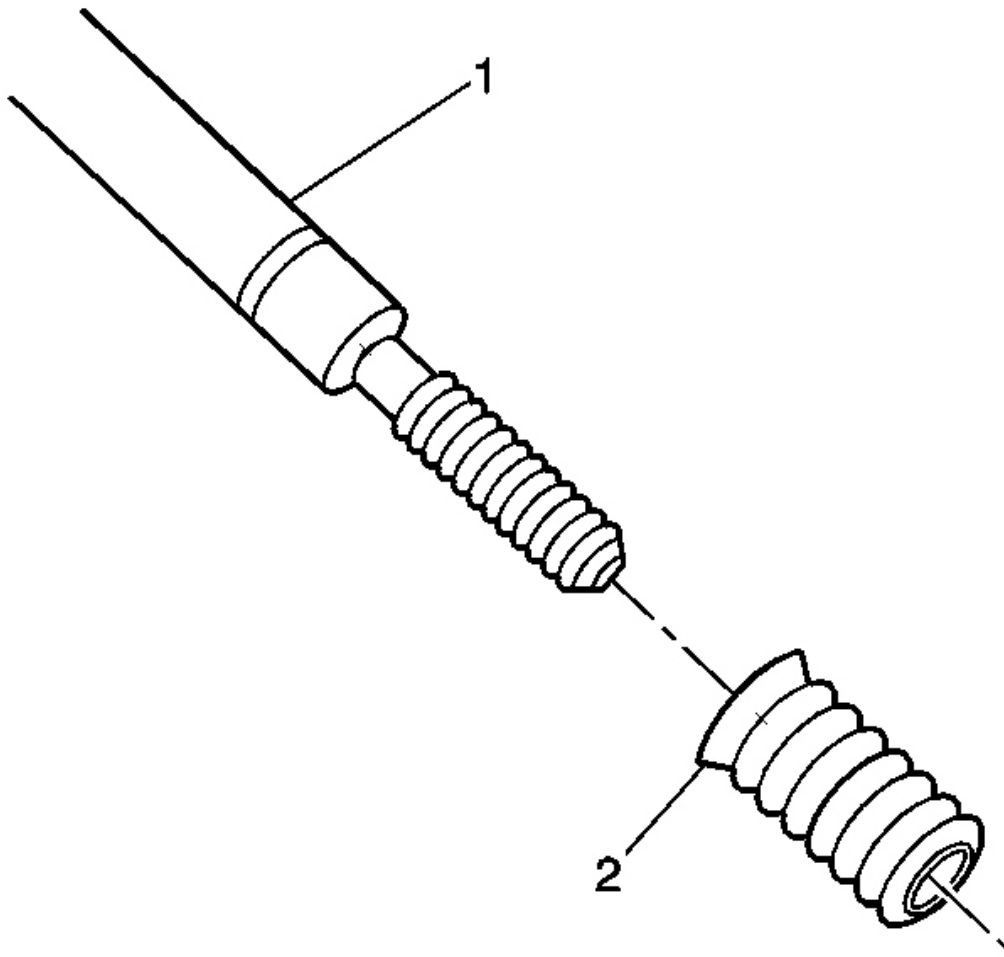


Fig. 387: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

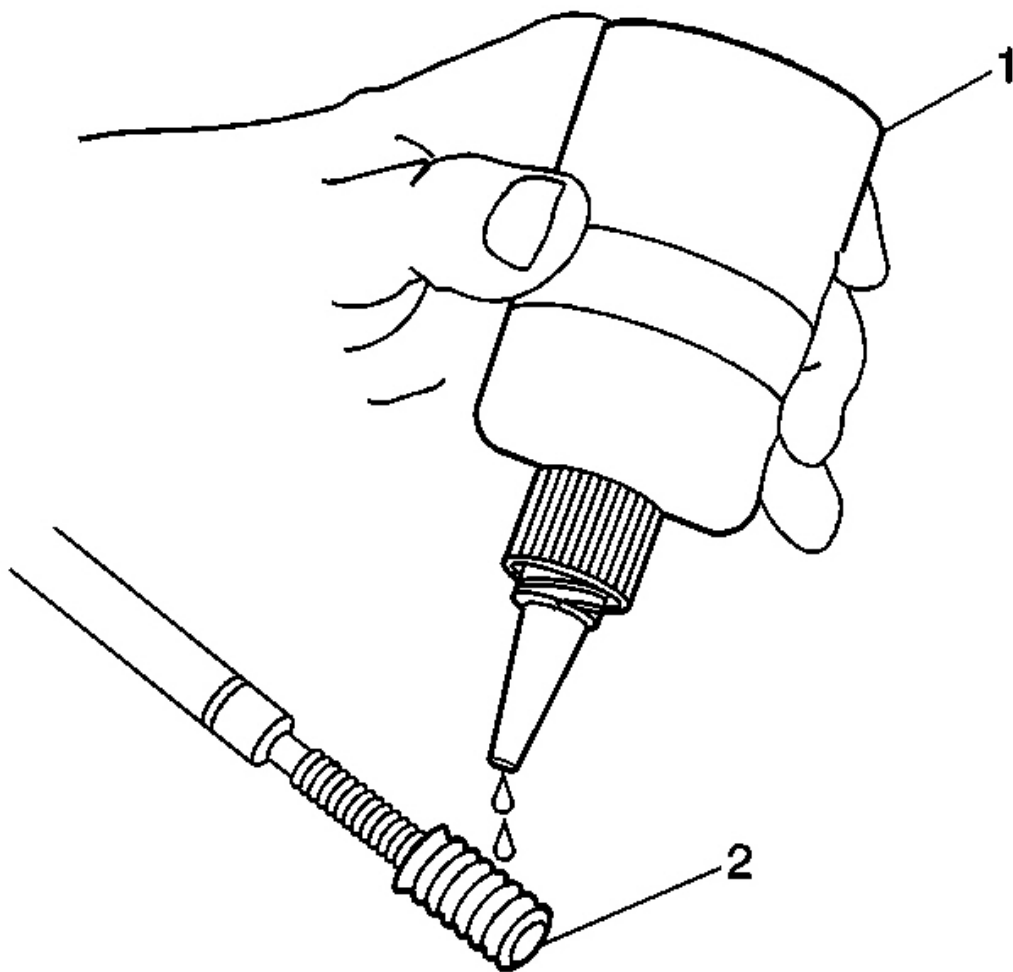


Fig. 388: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, EN 42385-109 (1): loctite, or equivalent to the insert OD threads (2).

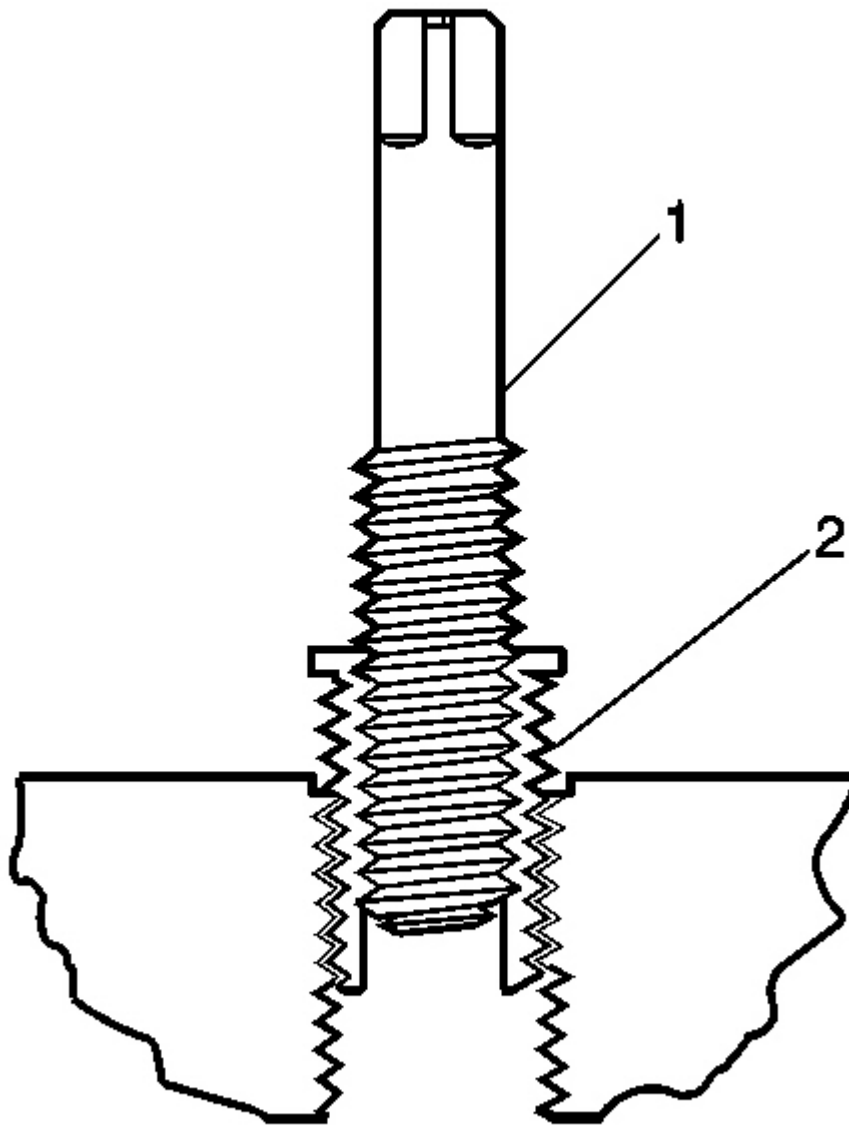


Fig. 389: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

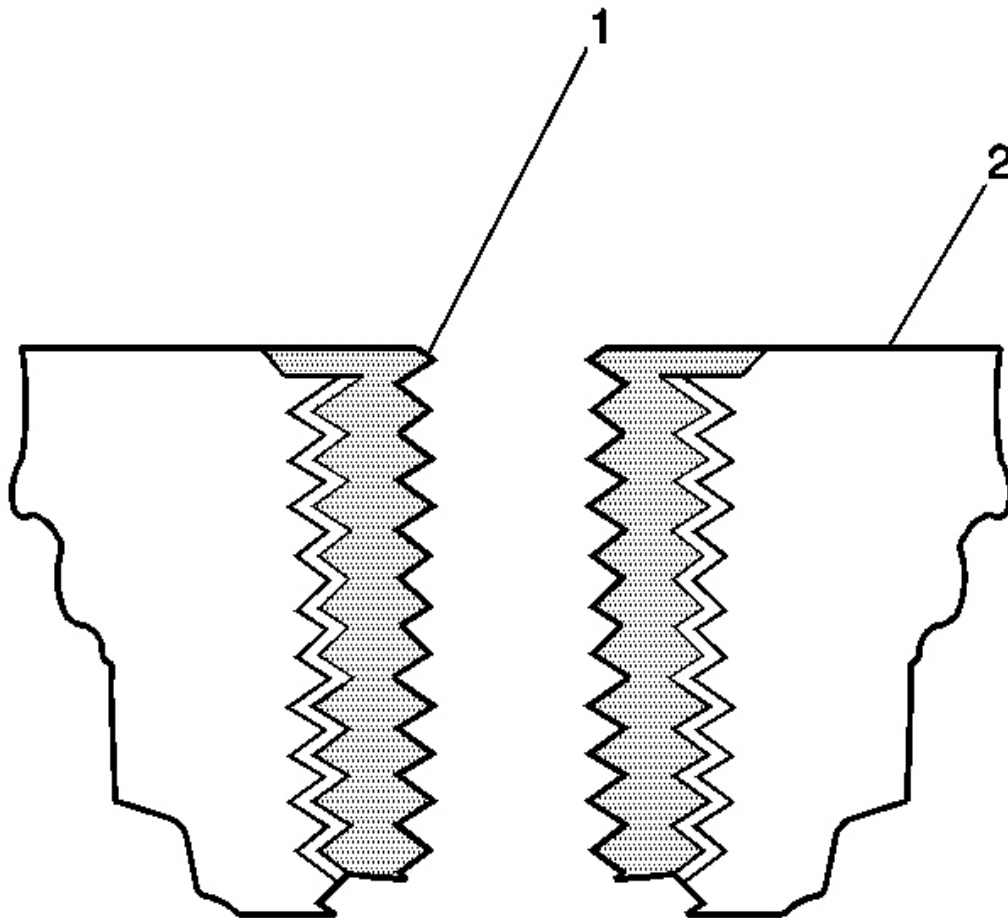


Fig. 390: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

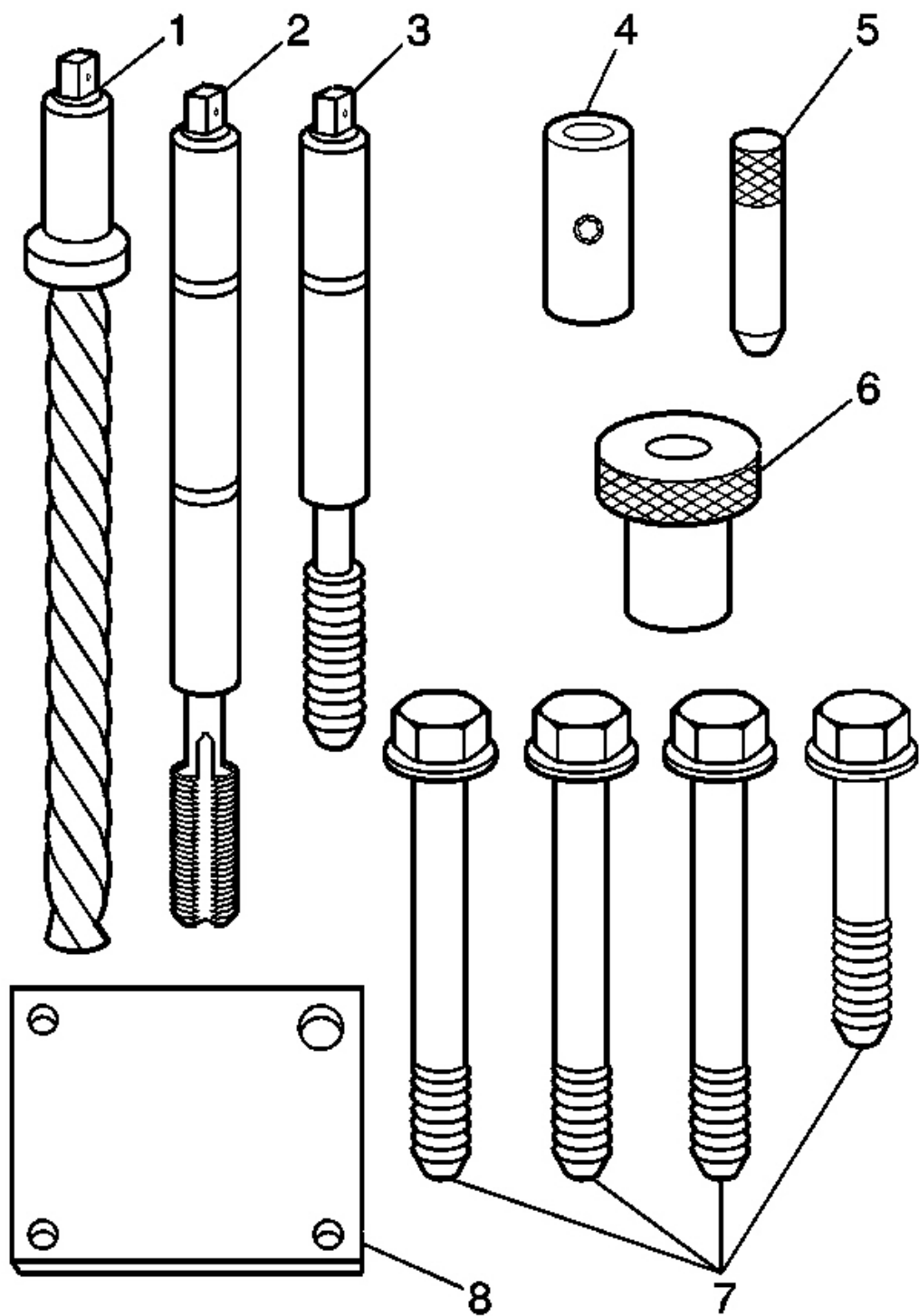


Fig. 391: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The cylinder head bolt hole thread repair kit consists of the following items:
 - Drill (1)
 - Tap (2)
 - Installer (3)
 - Sleeve (4)
 - Alignment Pin (5)
 - Bushing (6)
 - Bolts (7)
 - Fixture Plate (8)

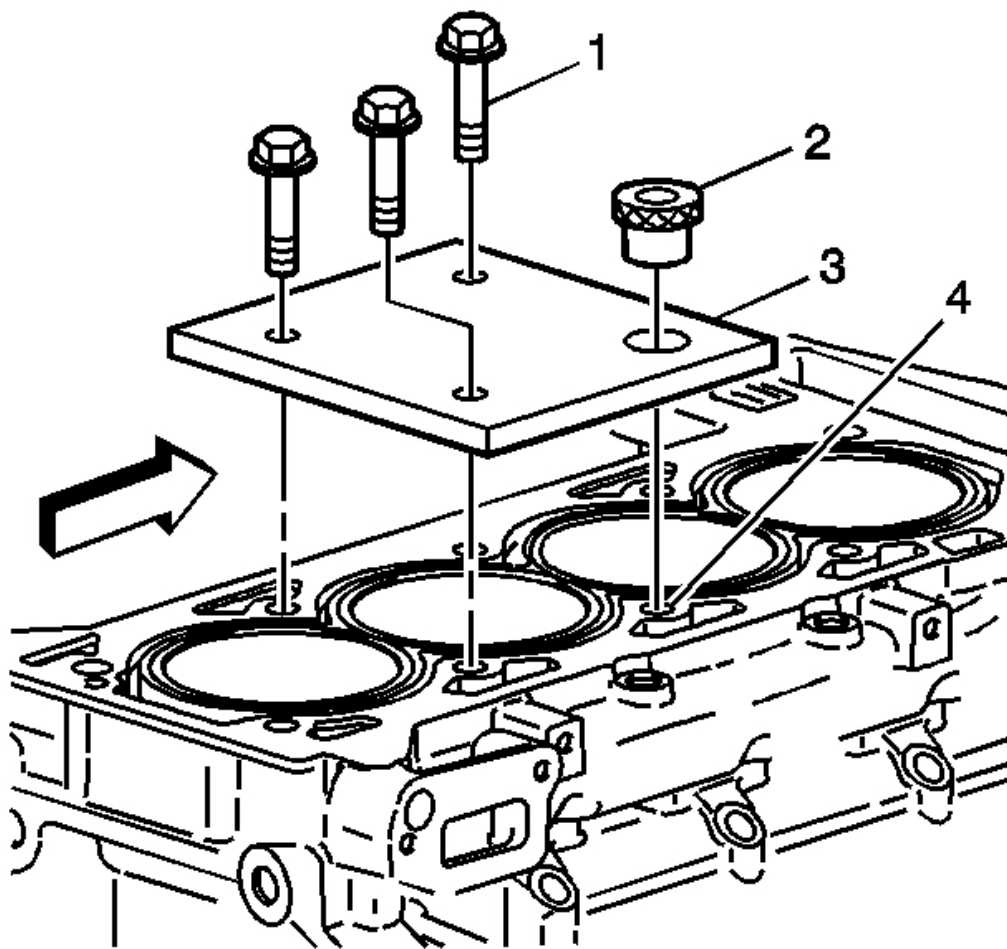


Fig. 392: Installing Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

NOTE: The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.
Driver oil **MUST** be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

Position the fixture plate and bushing over the hole that is to be repaired (4).

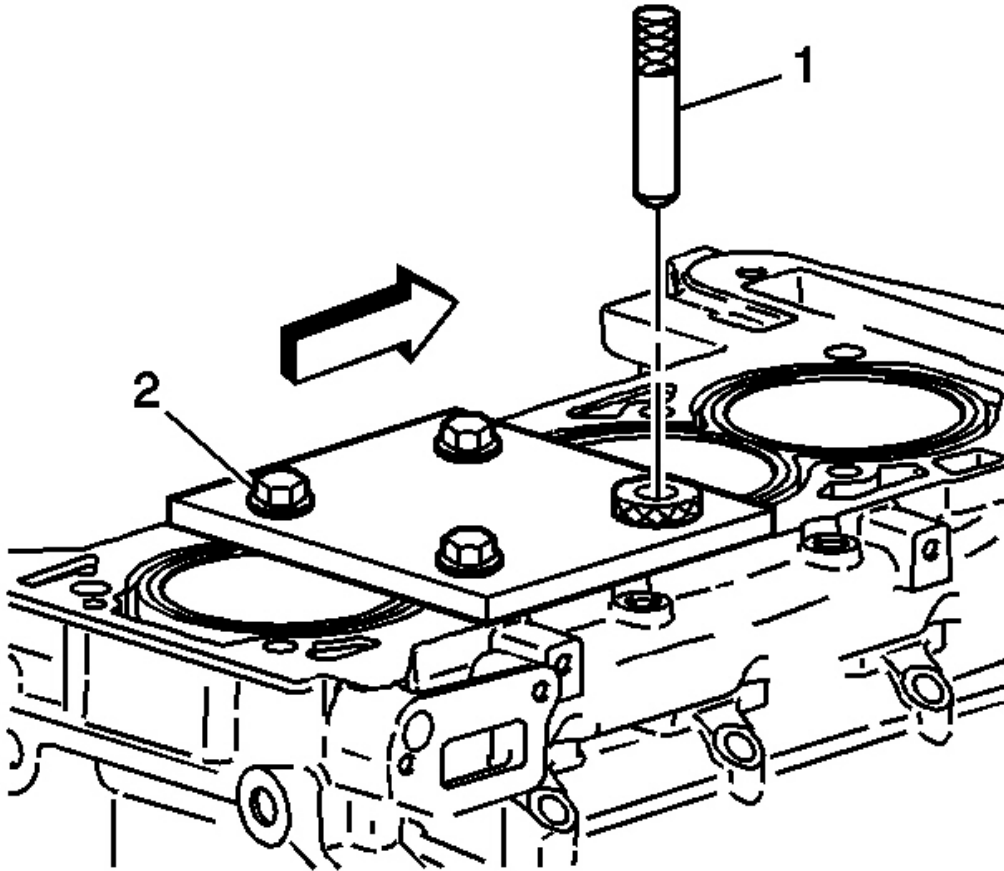


Fig. 393: Identifying Alignment Pin
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

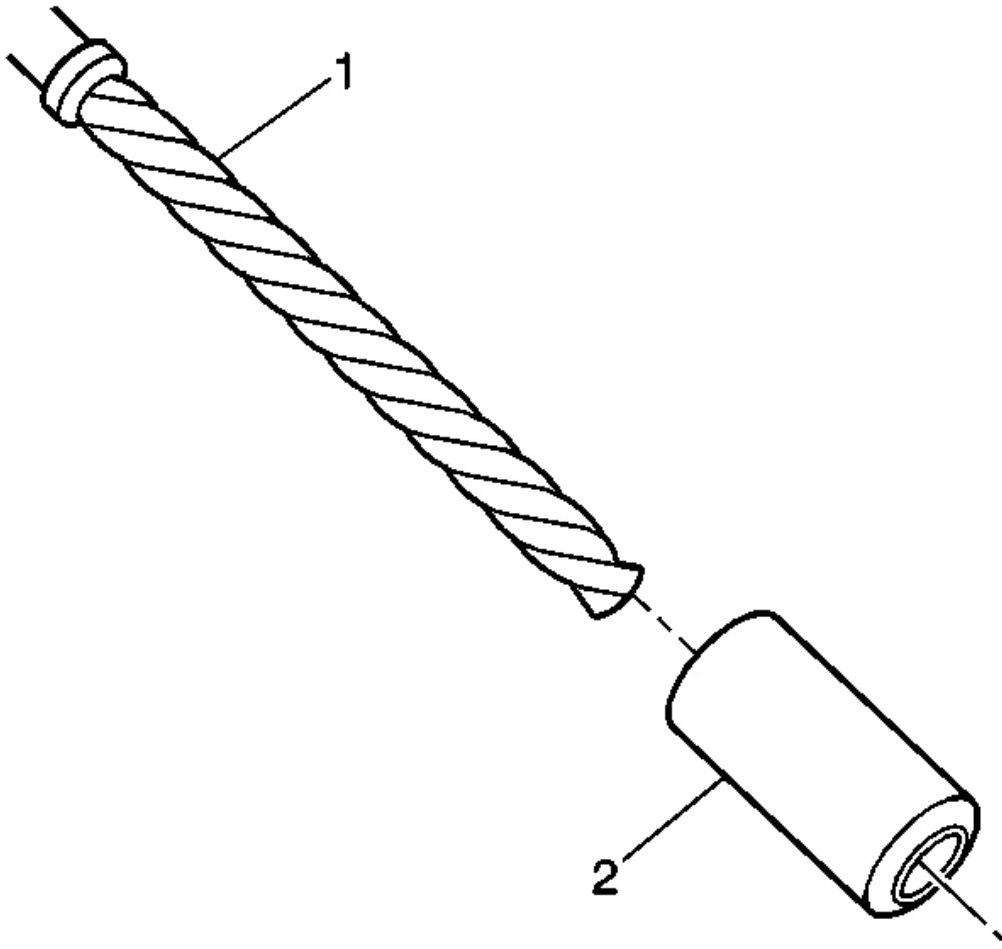


Fig. 394: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

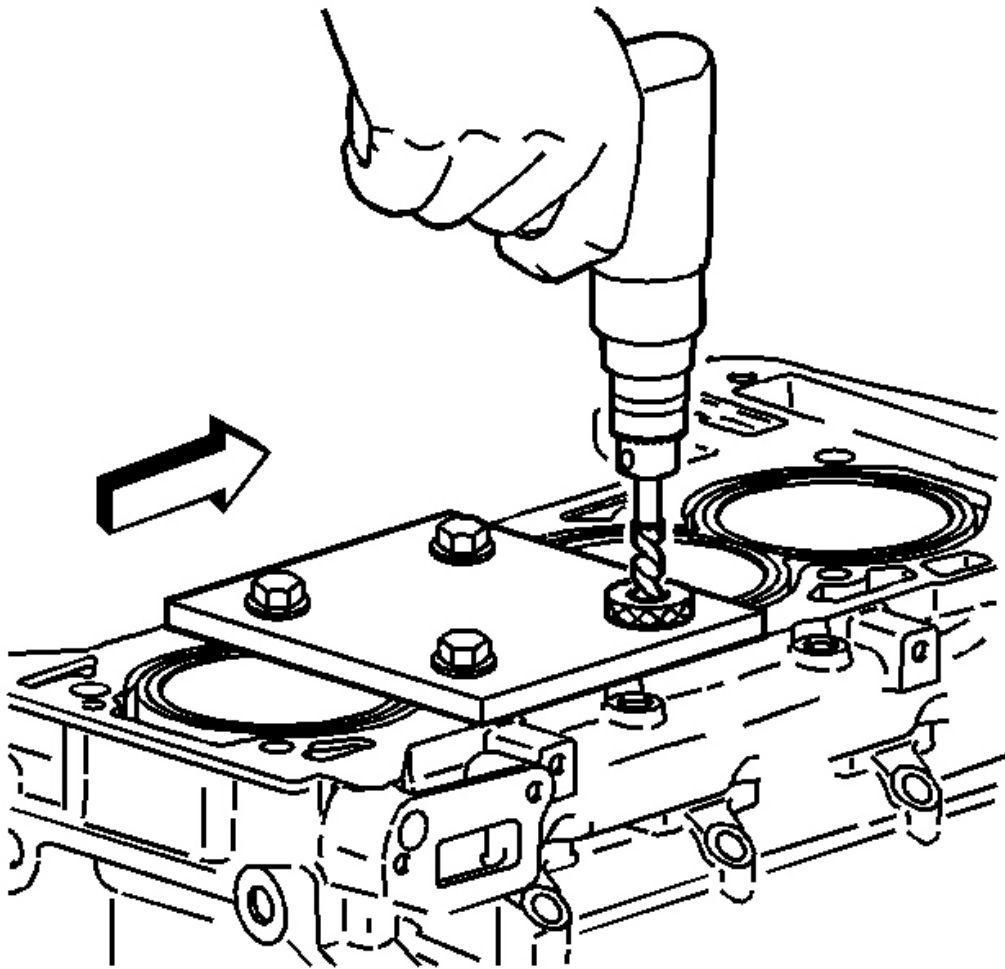


Fig. 395: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

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.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

8. Using compressed air, clean out any chips.

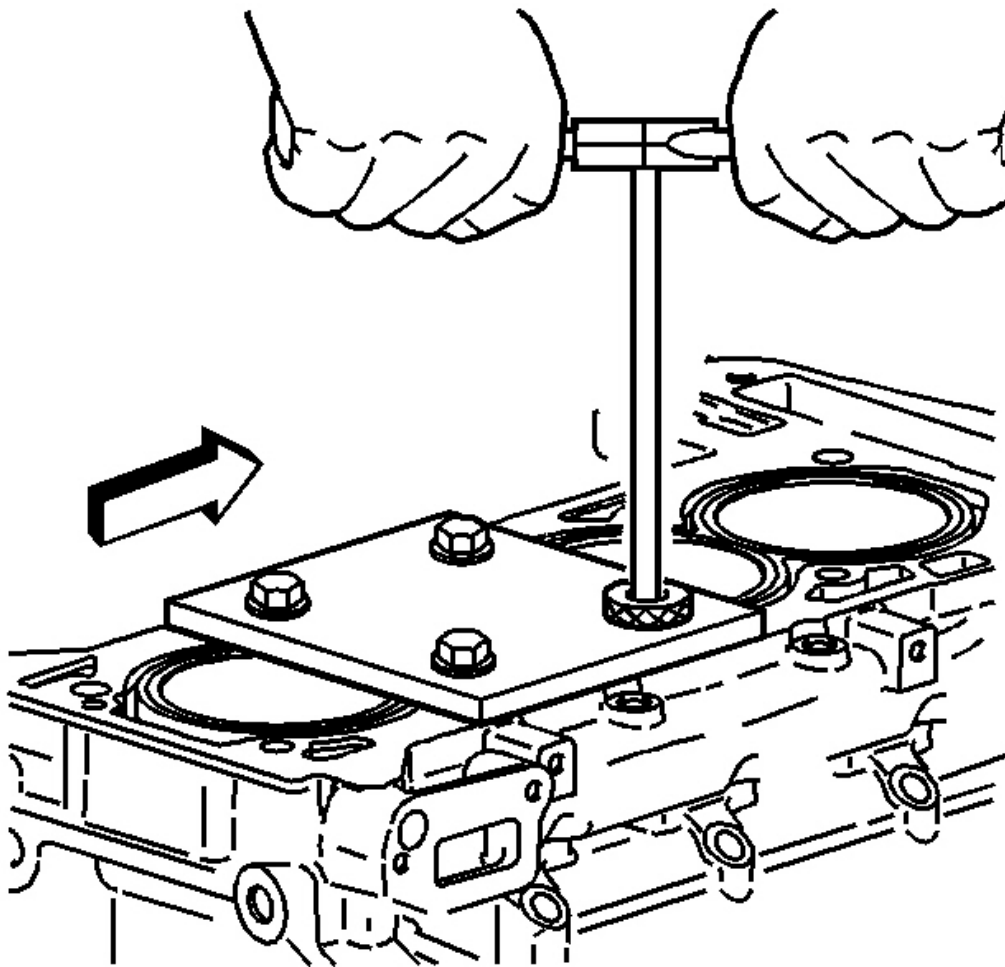


Fig. 396: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

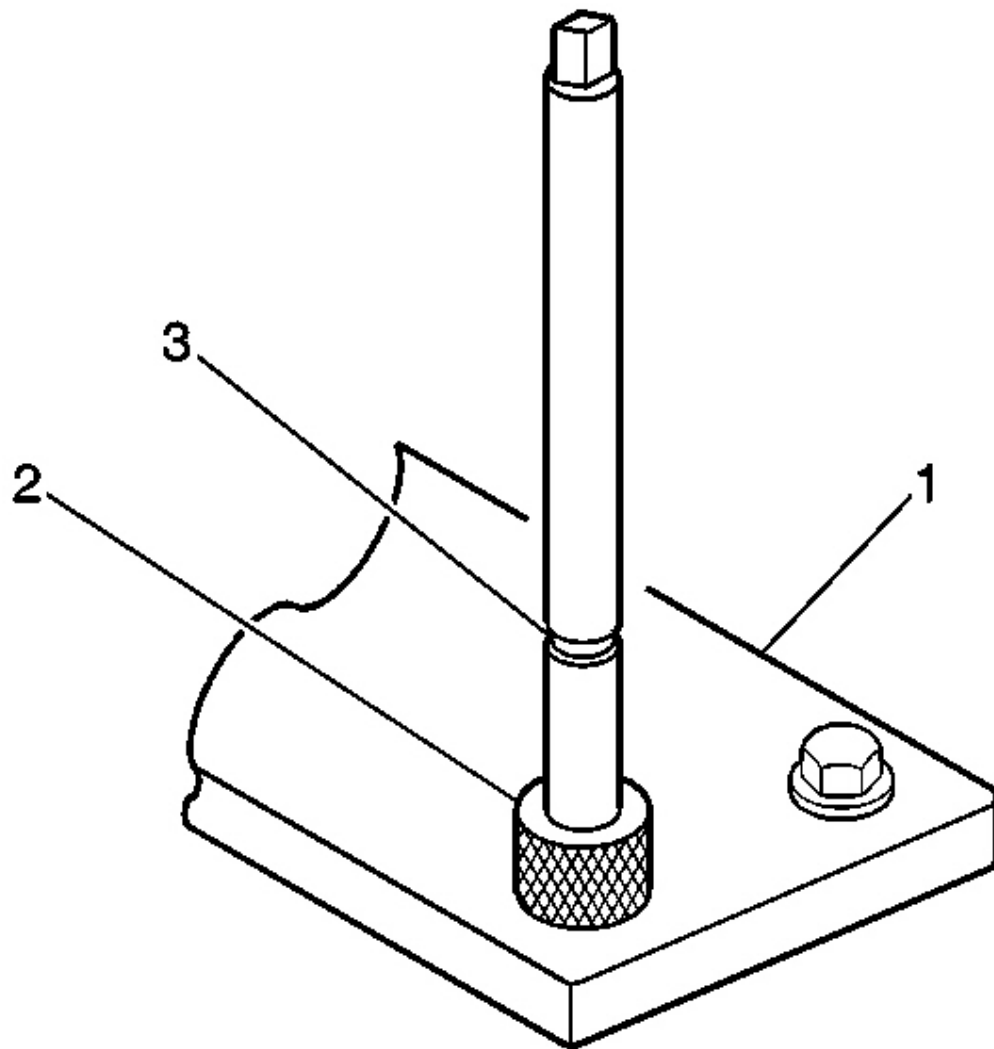


Fig. 397: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

10. 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 (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to Adhesives, Fluids, Lubricants, and Sealers.
14. Using compressed air, clean any cutting oil and chips out of the hole.

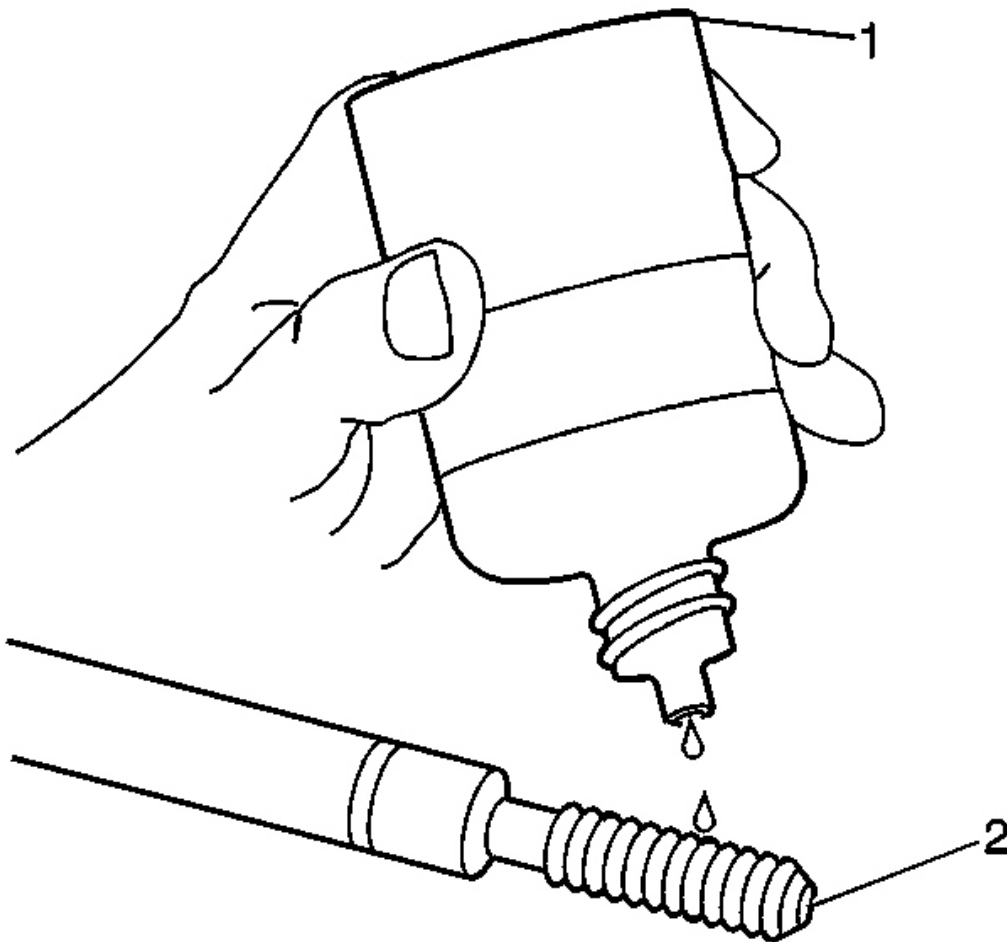


Fig. 398: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

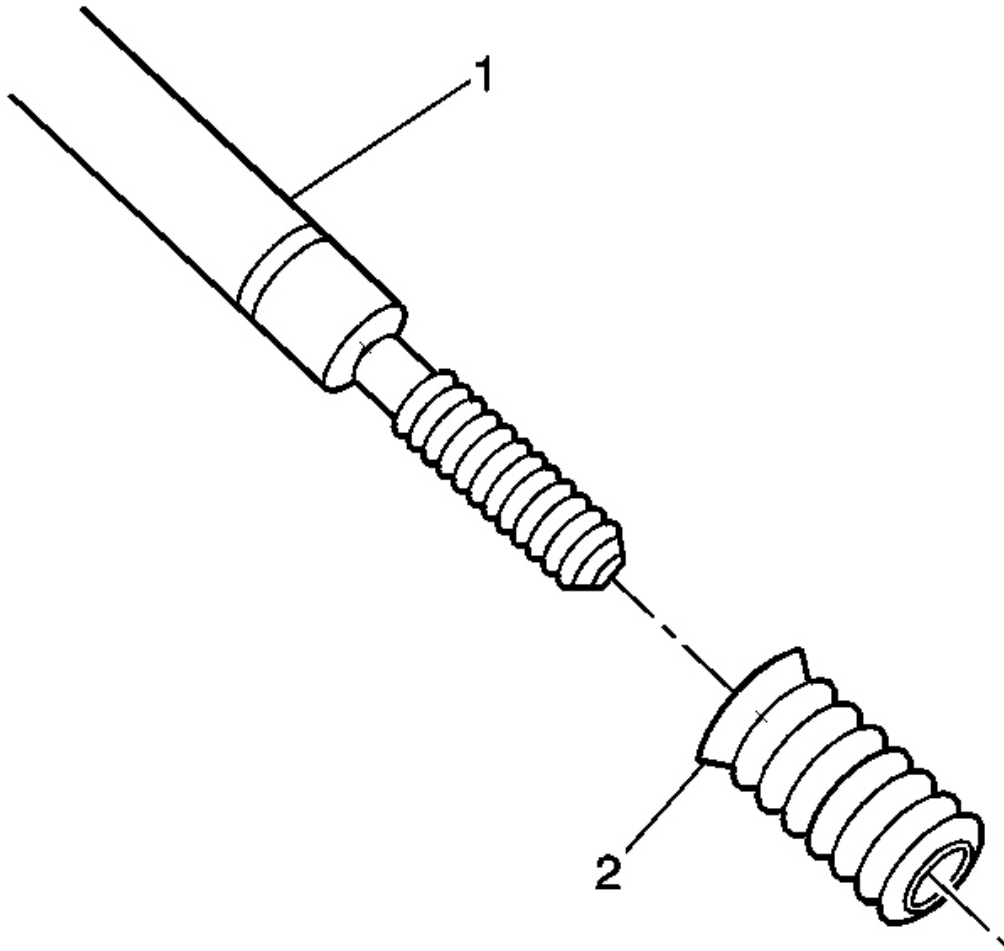


Fig. 399: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

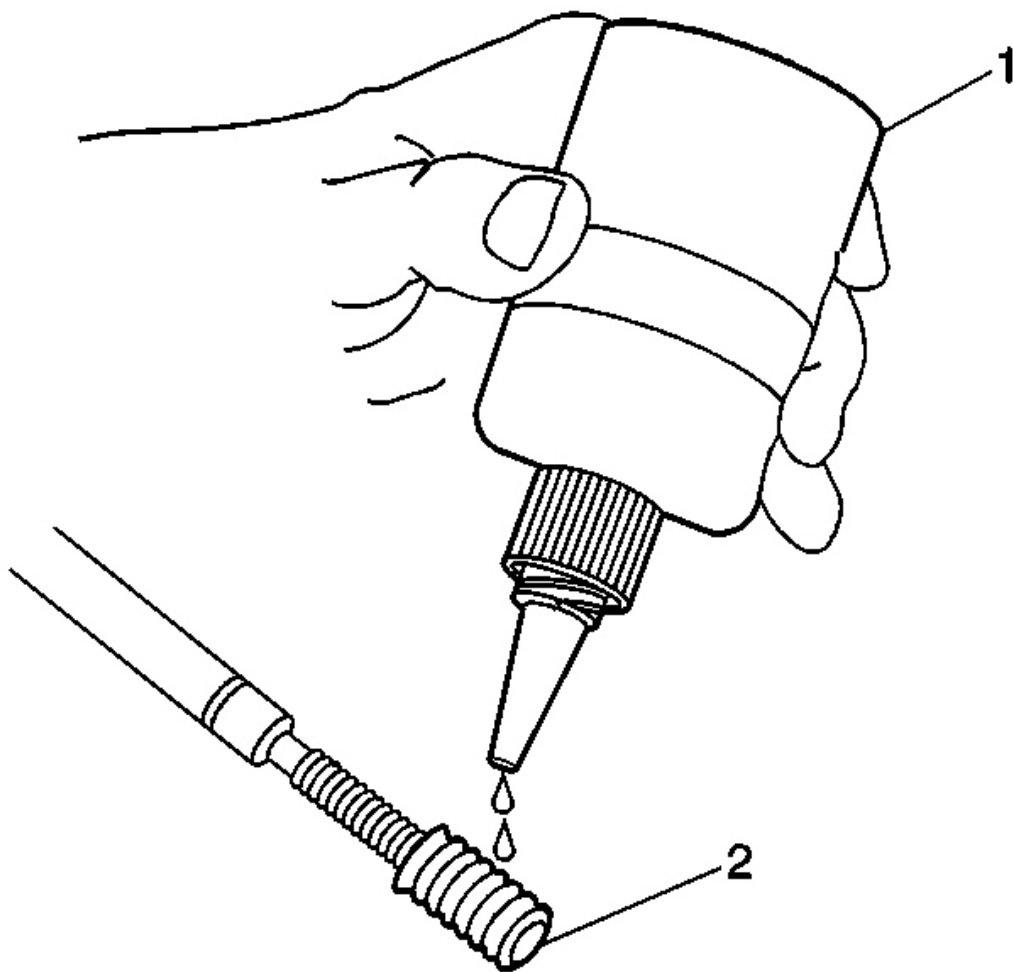


Fig. 400: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, **EN 42385-109:** loctite (1), or equivalent to the insert OD threads (2).

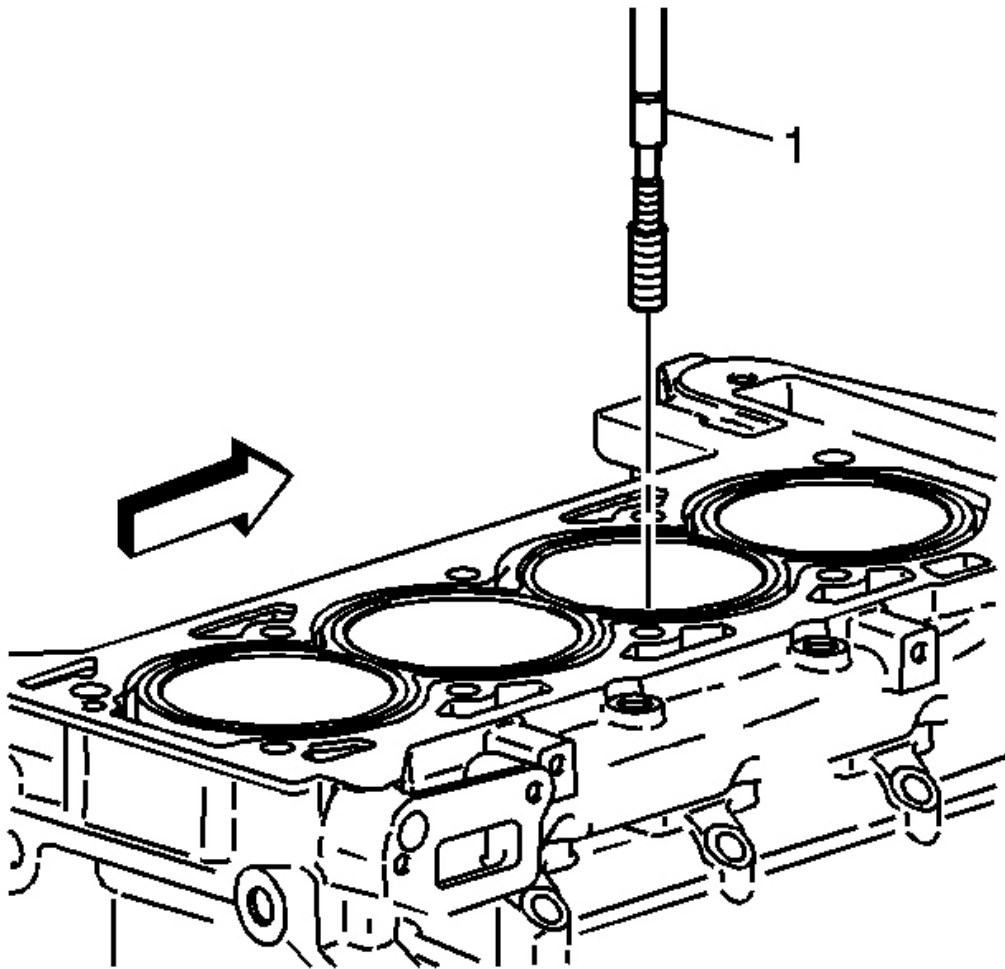


Fig. 401: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and driver (1) into the hole.

Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

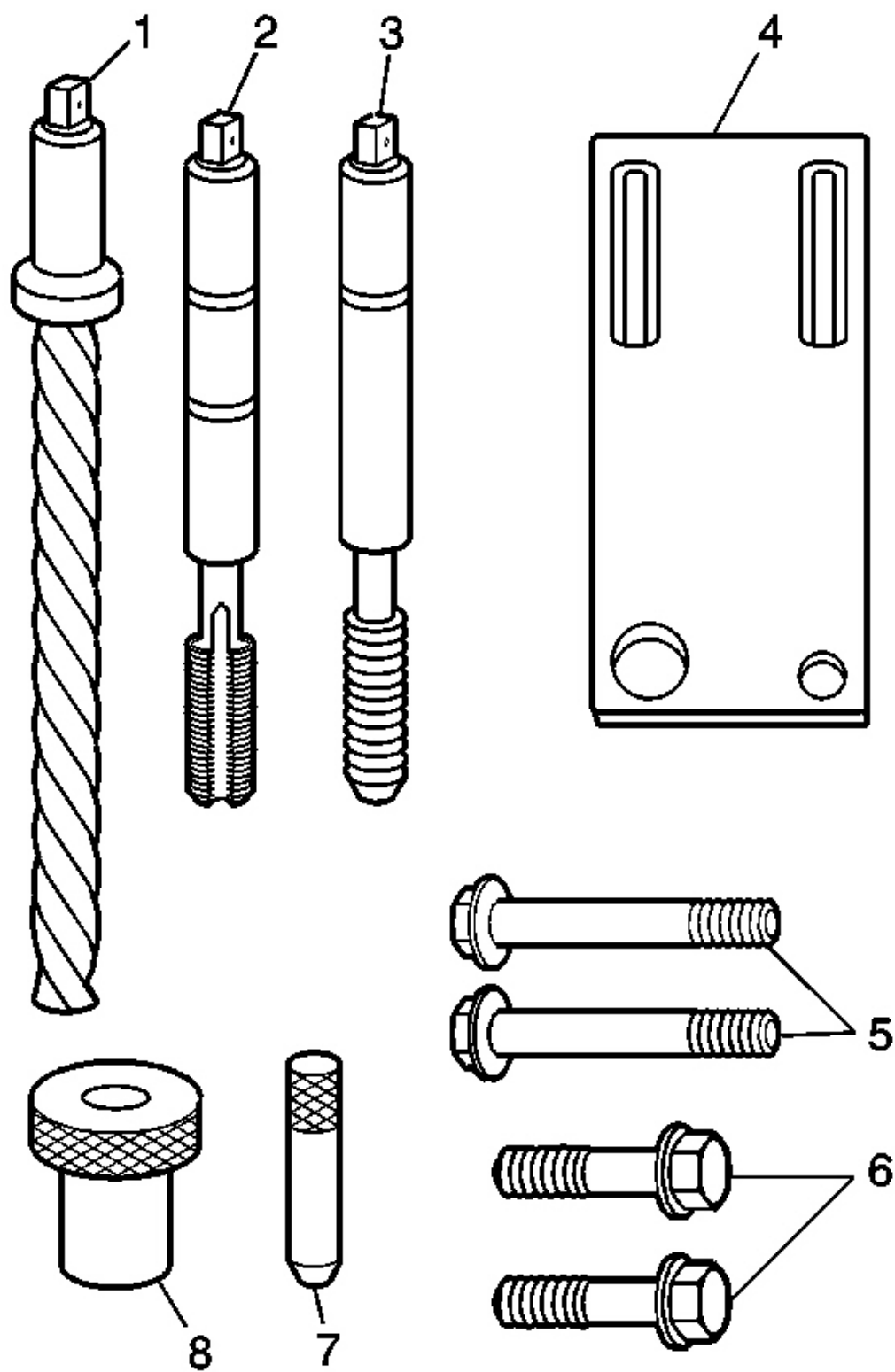


Fig. 402: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:

- Drill (1)
- Tap (2)
- Installer (3)
- Fixture Plate (4)
- Long Bolts (5)
- Short Bolts (6)
- Alignment Pin (7)
- Bushing (8)

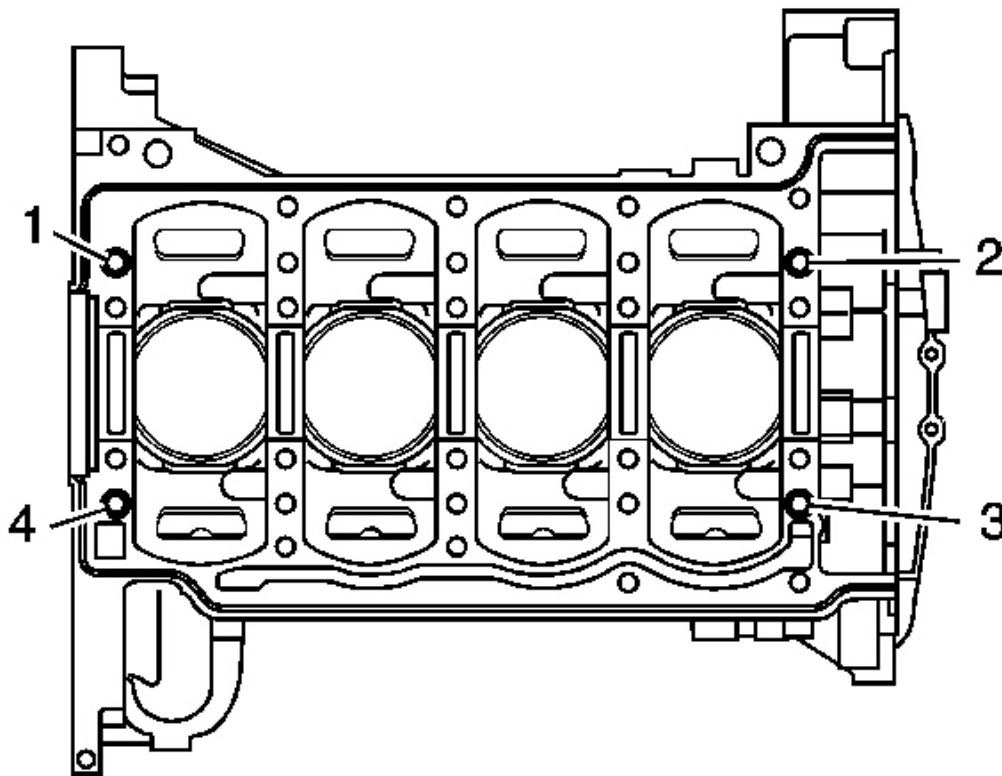


Fig. 403: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment dowel pins from the holes (1-4), if necessary.

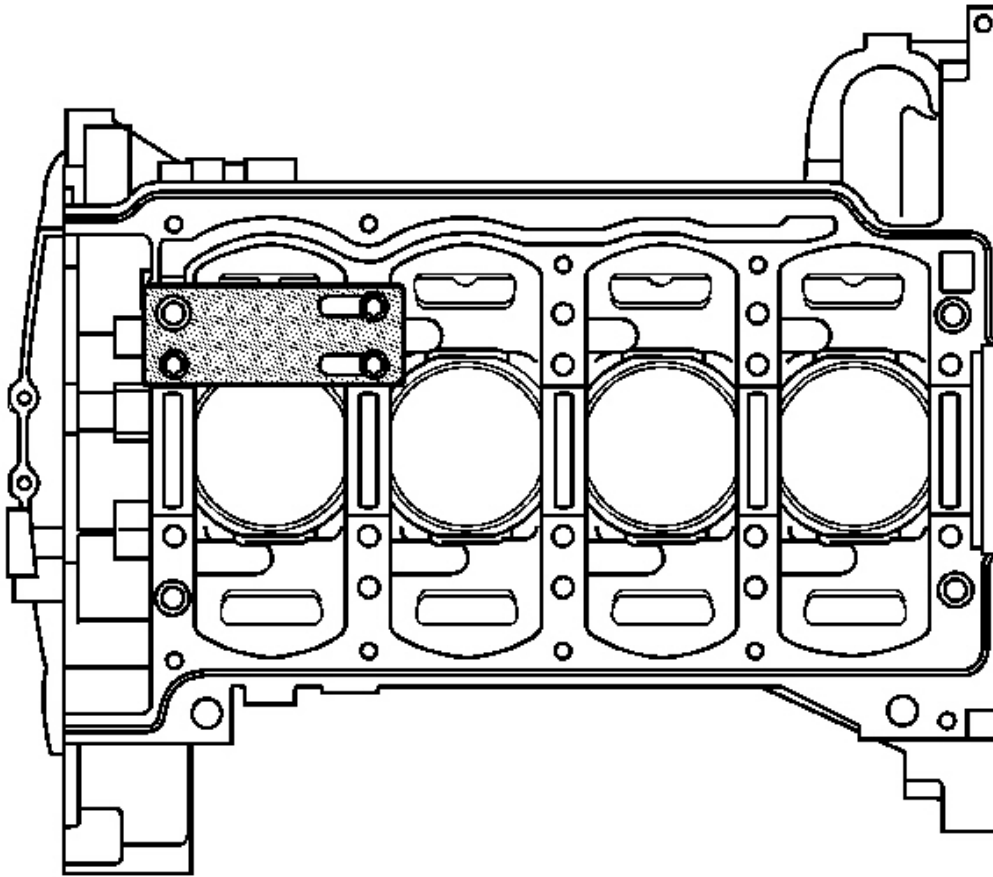


Fig. 404: Installing Fixture Plate, Bolt, & Bushing Onto Engine Block
Courtesy of GENERAL MOTORS CORP.

3. 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.

4. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.
5. Drill out the damaged hole.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

6. Using compressed air, clean out any chips.

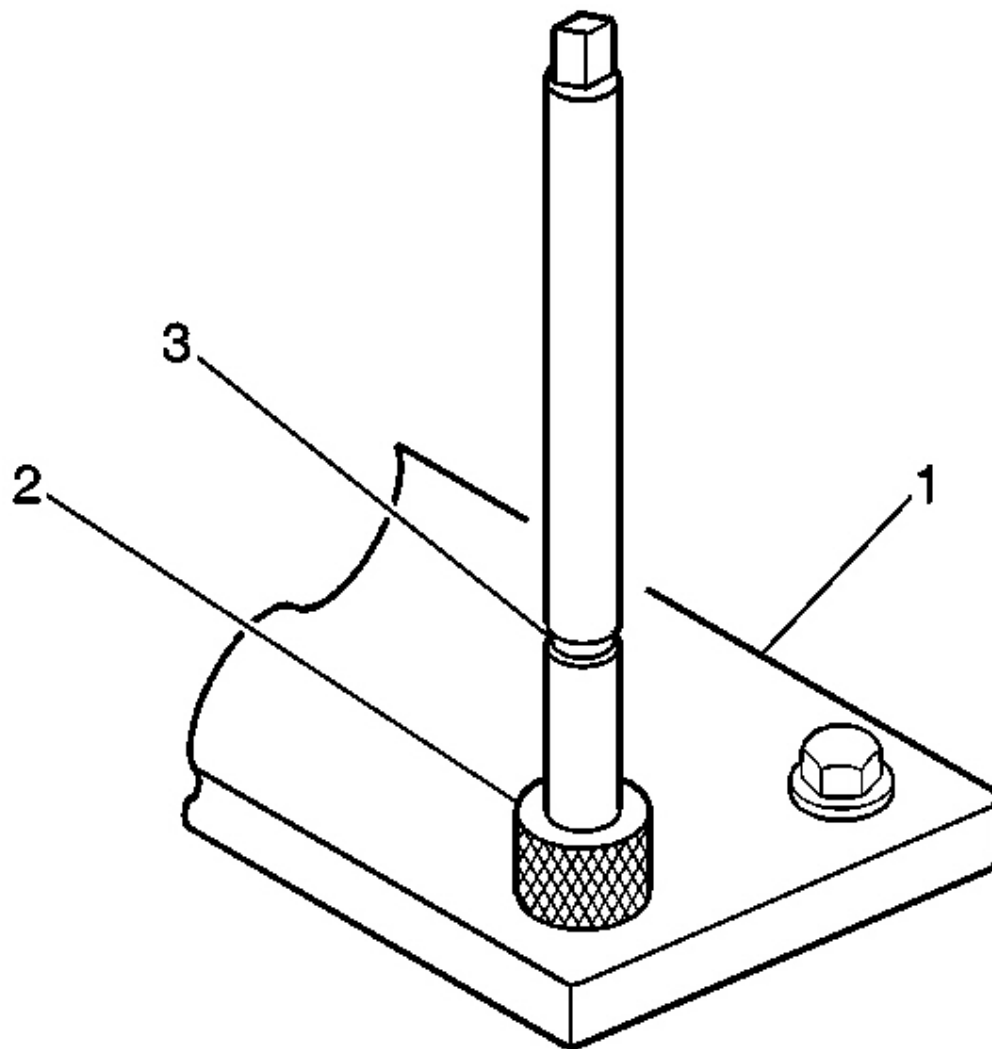


Fig. 405: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

7. 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 (3) on the tap aligns with the top of the bushing (2).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

8. Using compressed air, clean out any chips.
9. Spray cleaner into the hole. Refer to Adhesives, Fluids, Lubricants, and Sealers.
10. Using compressed air, clean any cutting oil and chips out of the hole.

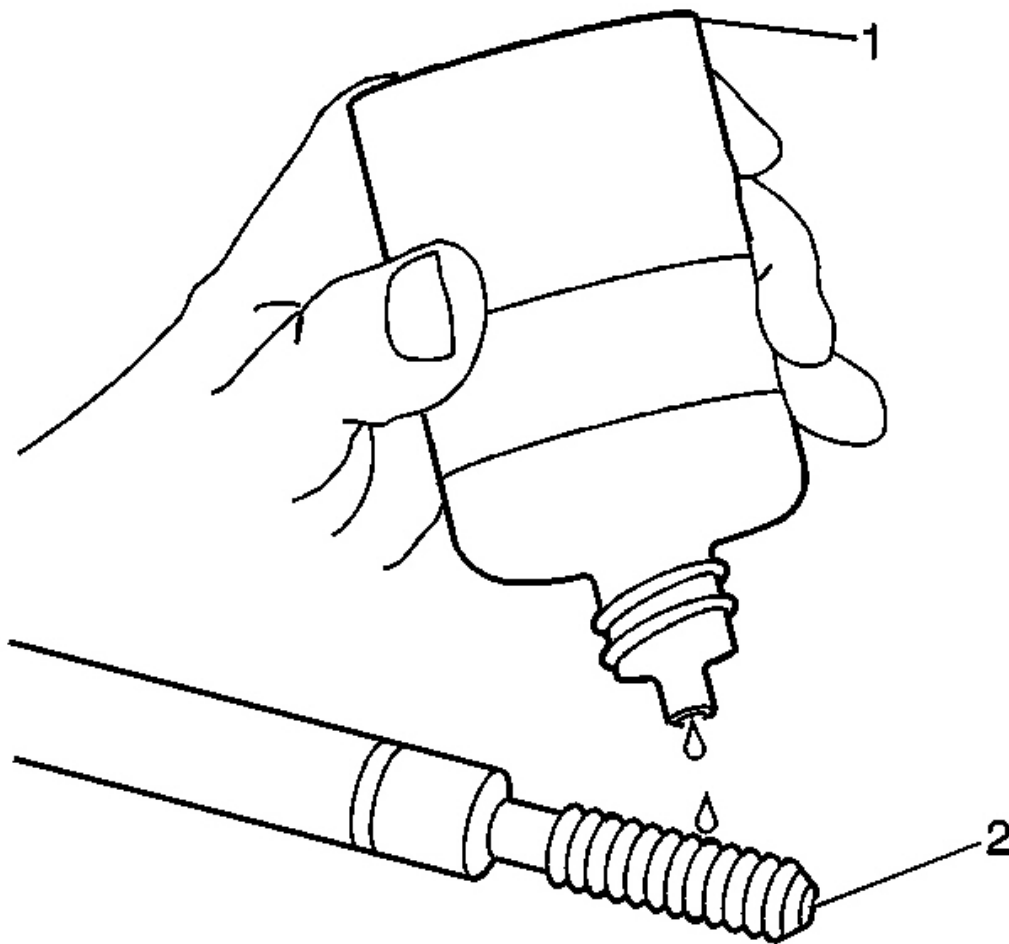


Fig. 406: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

11. Lubricate the threads of the installer tool (2) with the driver oil (1).

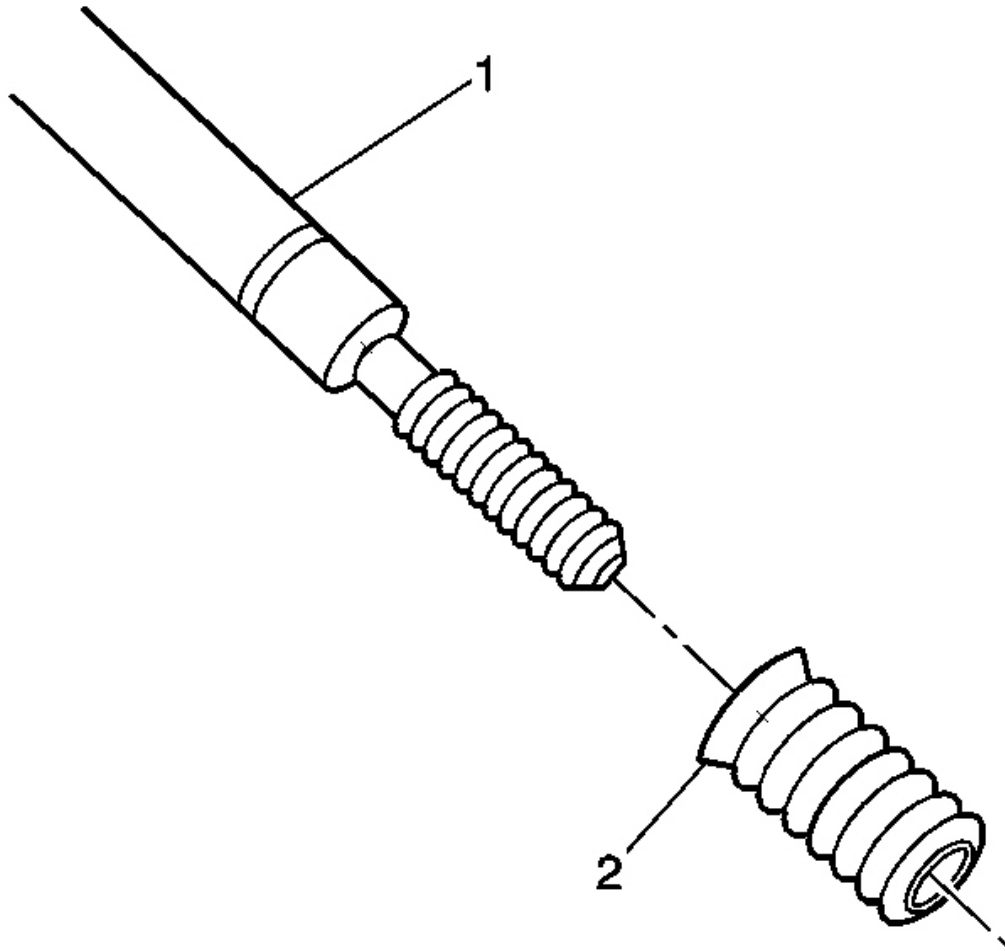


Fig. 407: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

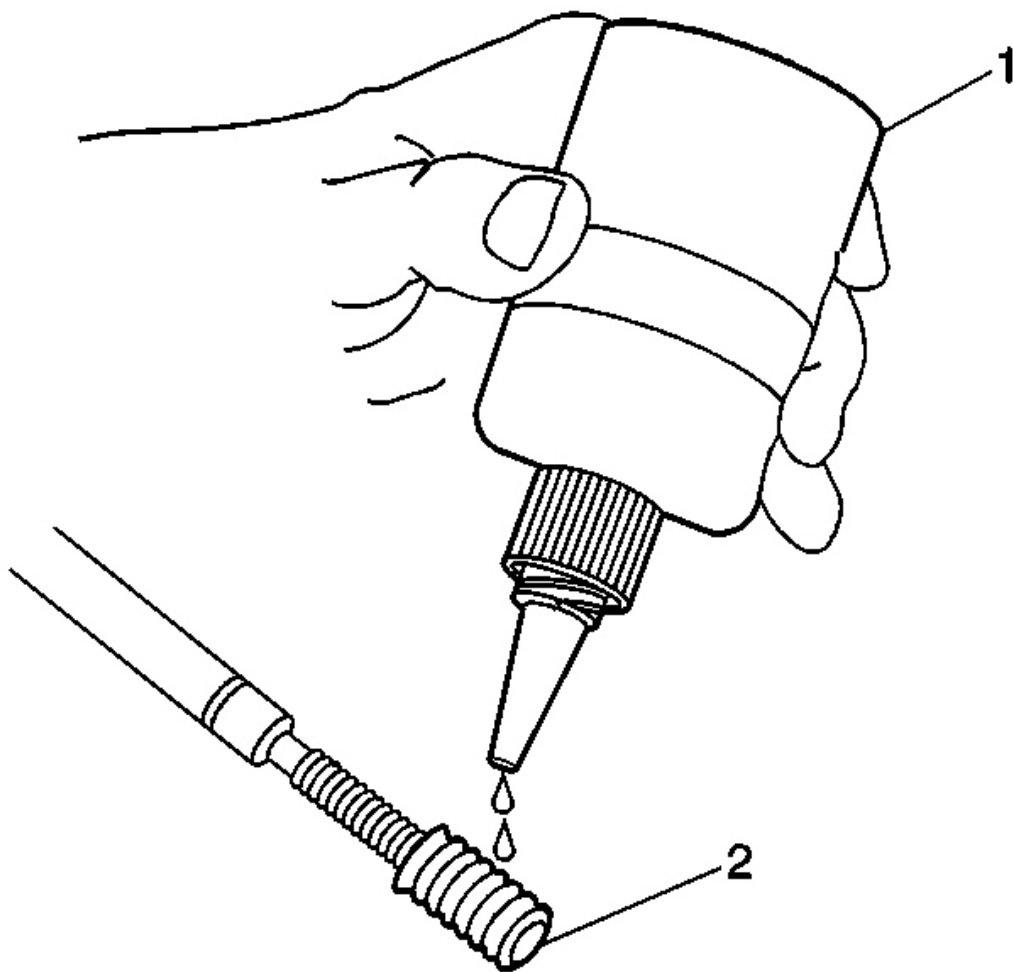


Fig. 408: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE™ 277, EN 42385-109 (1), or equivalent to the insert OD threads (2).

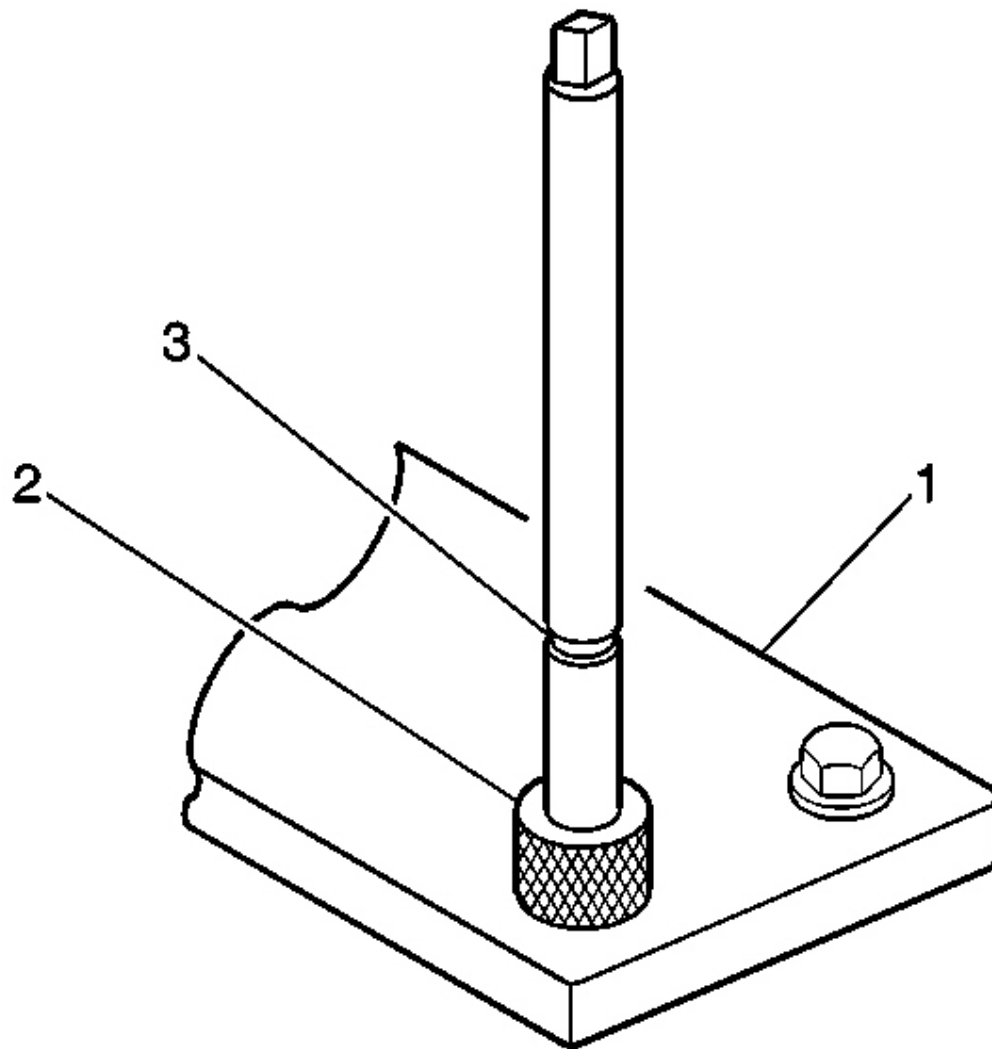


Fig. 409: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

NOTE: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

14. Install the insert and driver through the bushing (2), fixture plate (1) 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.

15. Remove the driver, bushing (2), fixture plate (1), and bolts.

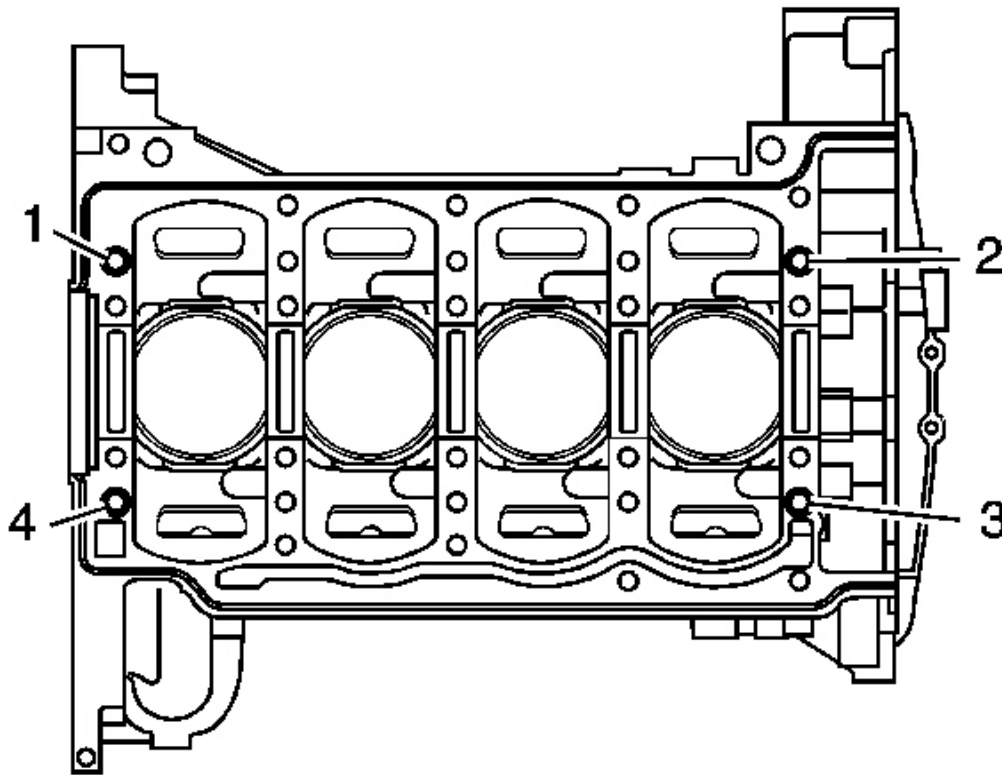


Fig. 410: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

16. Install the alignment dowel pins in holes (1-4), if necessary.

SERVICE PRIOR TO ASSEMBLY

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This

is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

ENGINE BLOCK ASSEMBLE

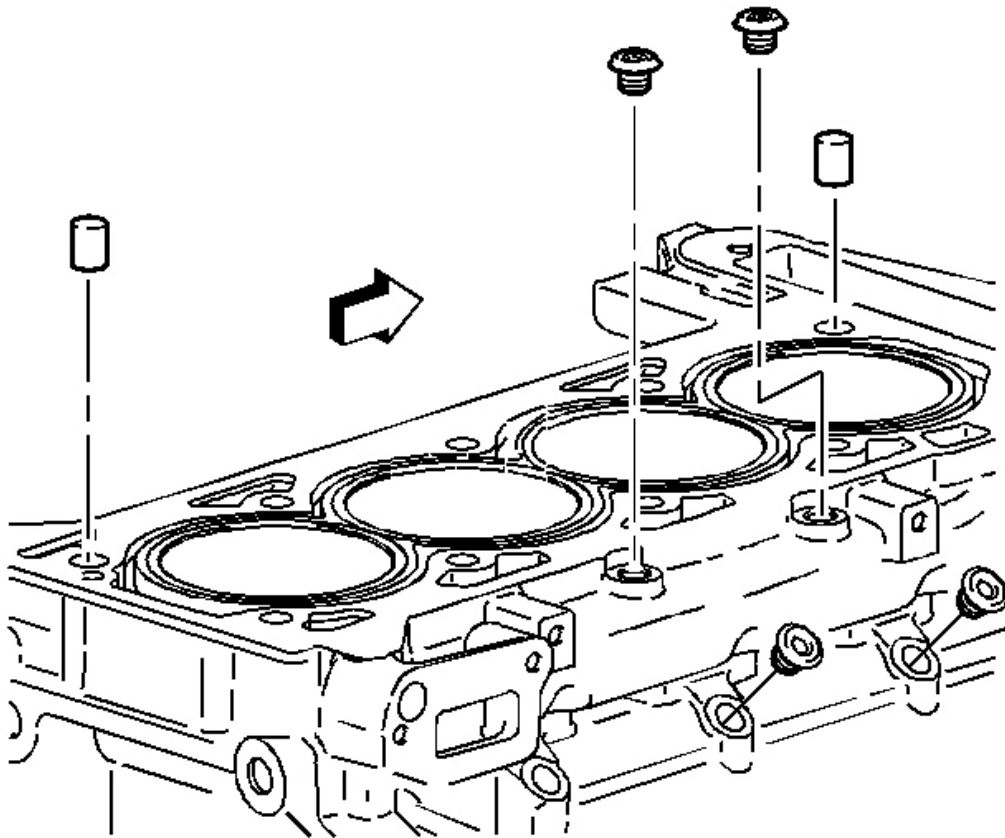


Fig. 411: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant to the plugs before installation. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Install the drain plug in the water pump.

CAUTION: Refer to Fastener Caution .

3. Install the coolant jacket plugs and tighten to 35 N.m (26 lb ft).
4. Install the rear oil passage plugs and tighten to 60 N.m (44 lb ft).
5. Install the other oil passage plugs and tighten to 35 N.m (26 lb ft).

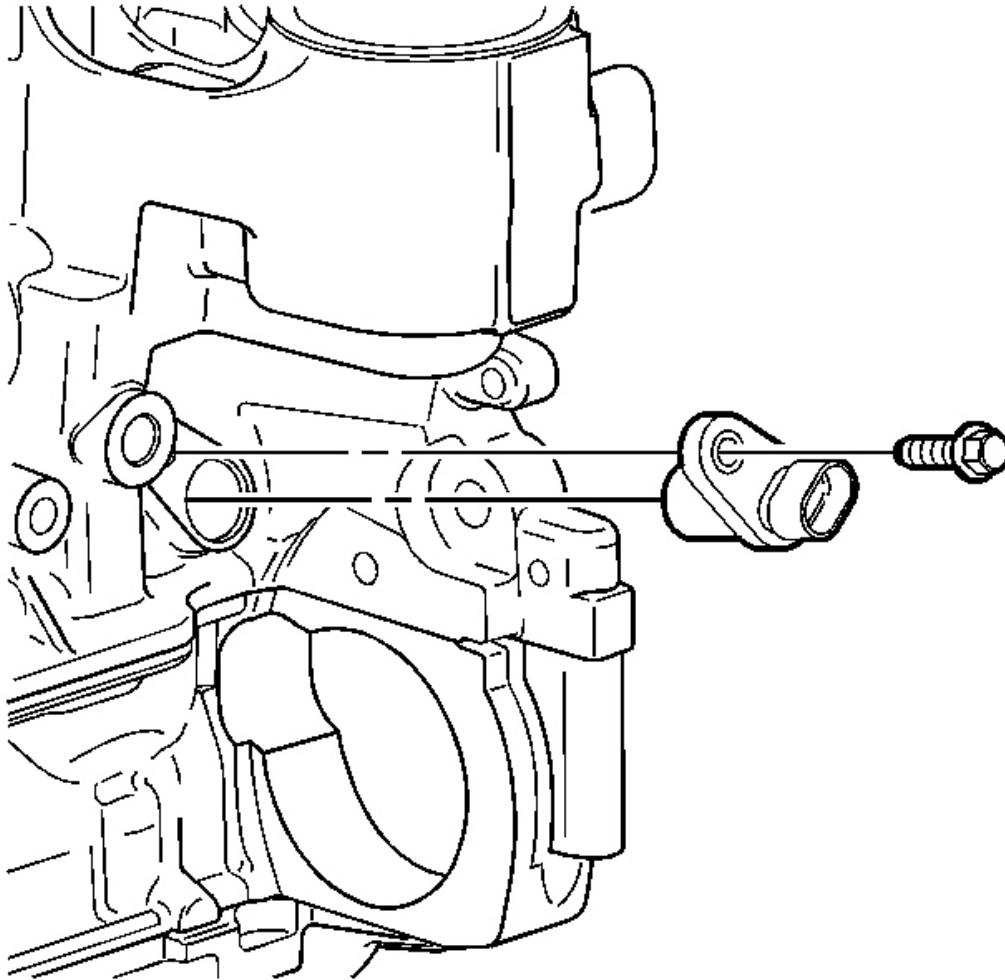


Fig. 412: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the crankshaft position sensor O-ring with engine oil.
7. Install the crankshaft position sensor and bolt and tighten to 10 N.m (89 lb in).

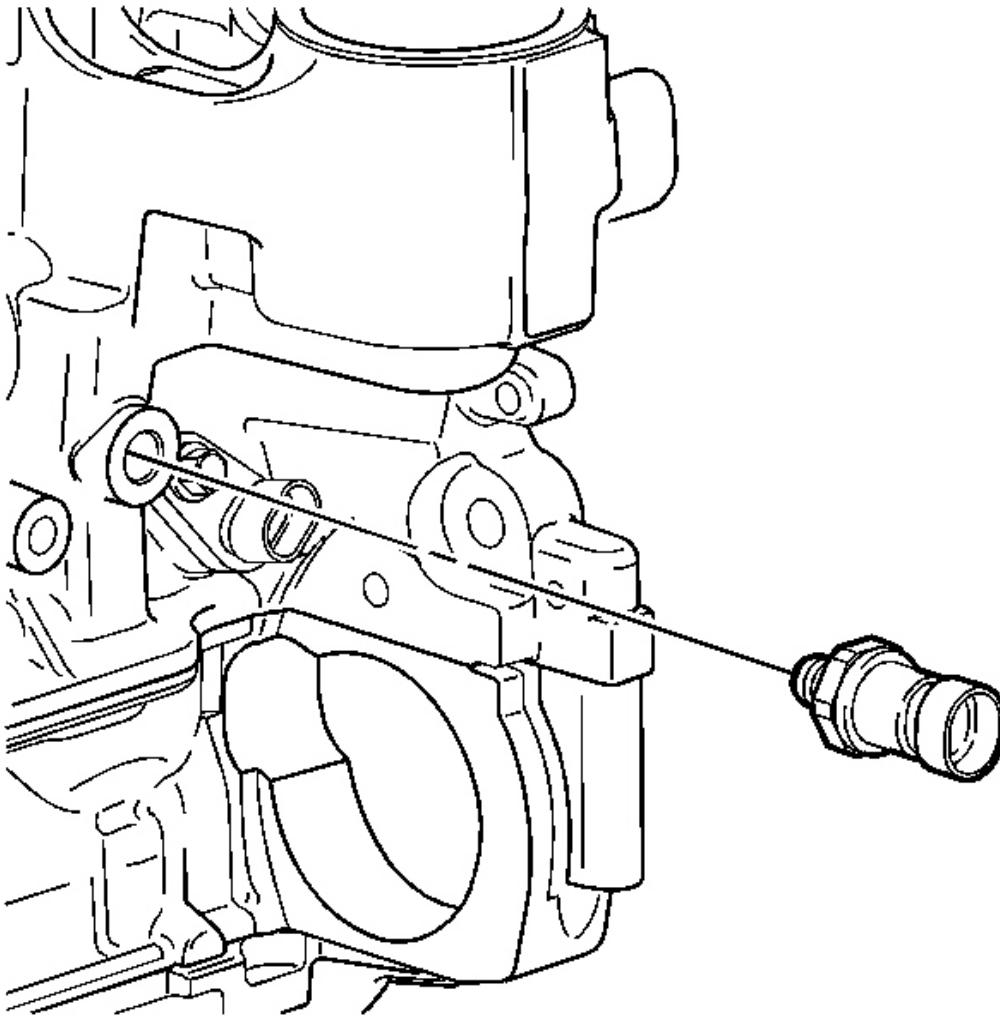


Fig. 413: Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

8. Install the oil pressure switch and tighten to 26 N.m (19 lb ft).

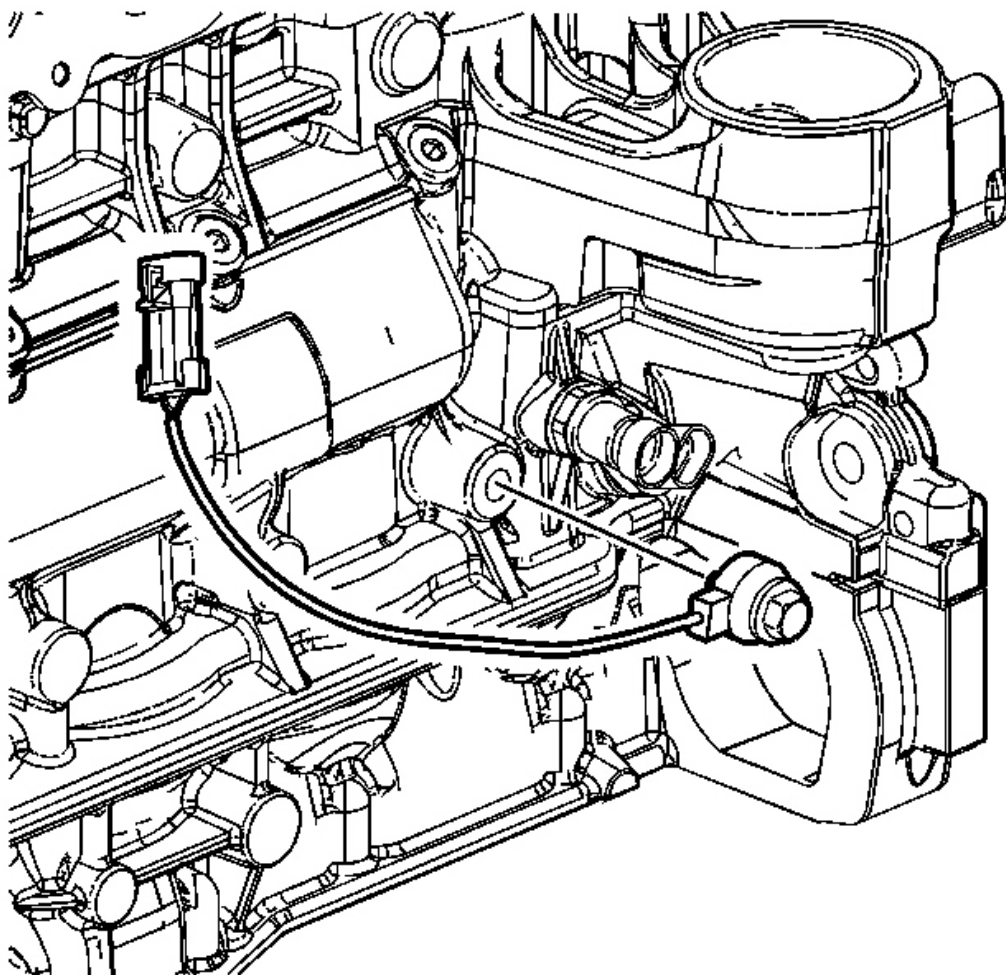


Fig. 414: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the knock sensor and bolt and tighten to 25 N.m (18 lb ft).

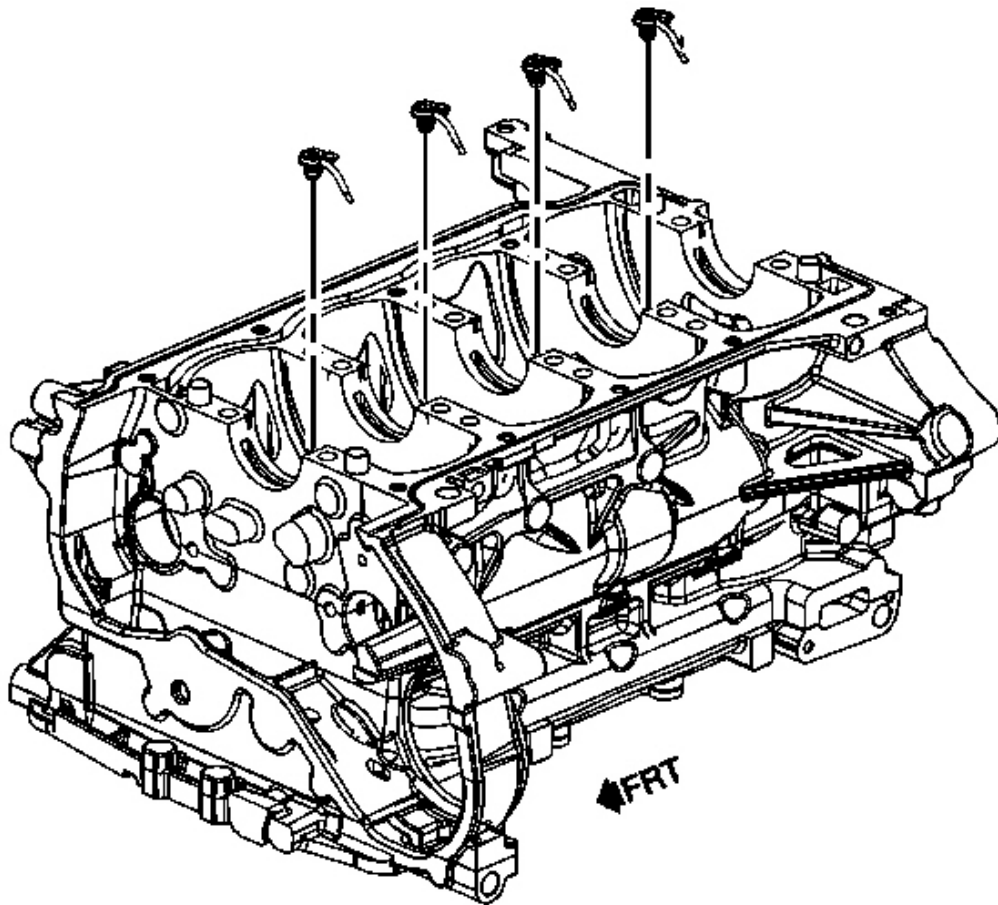


Fig. 415: View Of Piston Oil Nozzle Assembly
Courtesy of GENERAL MOTORS CORP.

10. Install the piston oil nozzle assemblies, if equipped.
11. Install the piston oil nozzle assembly bolts and tighten to 15 N.m (11 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **EN-8087:** Cylinder Bore Checking Gauge
- **EN 45059:** Angle Meter

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

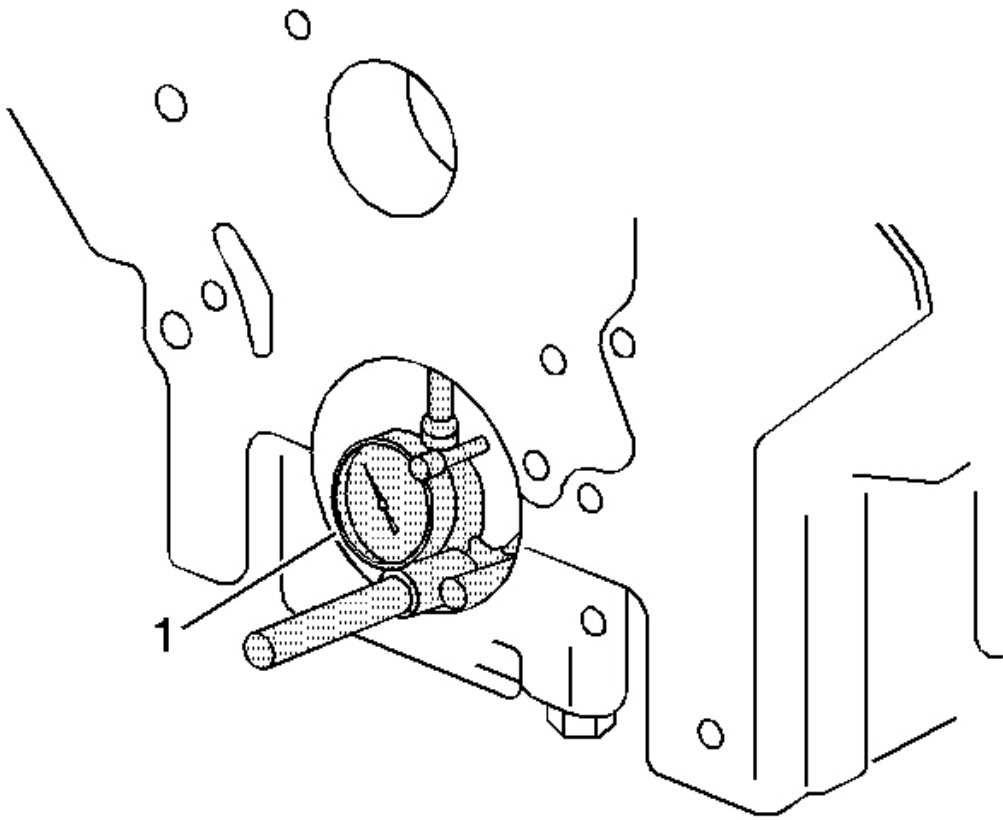


Fig. 416: Measuring Bearing Bore
Courtesy of GENERAL MOTORS CORP.

NOTE: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **EN 45059**: meter.
- Measure the bearing bore for taper and out-of-round using the **EN-8087**: gauge (1).
- No taper or out-of-round should exist.

Bearing Selection

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are 2 methods to measure bearing clearance. Method A gives more reliable results and is preferred.
 - Method A yields measurement from which the bearing clearance can be computed.

- Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

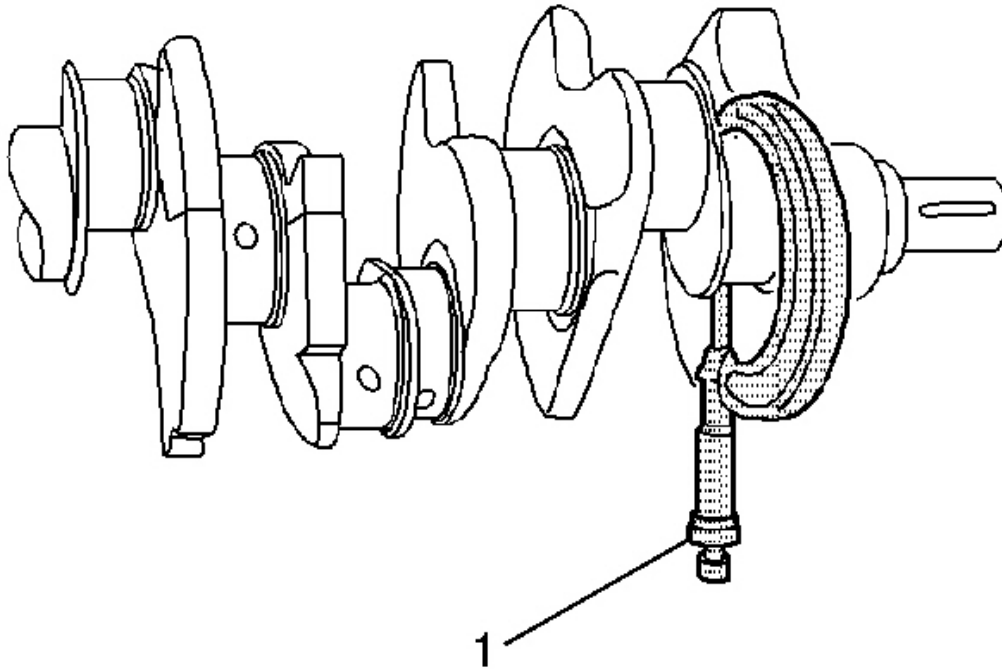


Fig. 417: Measuring Crankshaft Bearing Journal Using Method A
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
 1. Measure the crankshaft bearing journal diameter with a micrometer (1) in several places, 90 degrees apart. Average the measurements.
 2. Measure the crankshaft bearing journal taper and runout.
 3. Install the lower crankcase and tighten the bearing cap bolts to specification.
 4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
 5. Subtract journal measurement from bearing ID measurement to determine clearance.
 6. Determine whether clearance is within specification.
 7. If out of specification, choose different inserts.
 8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.

9. Measure the crankshaft main bearing inside diameter with an inside micrometer.

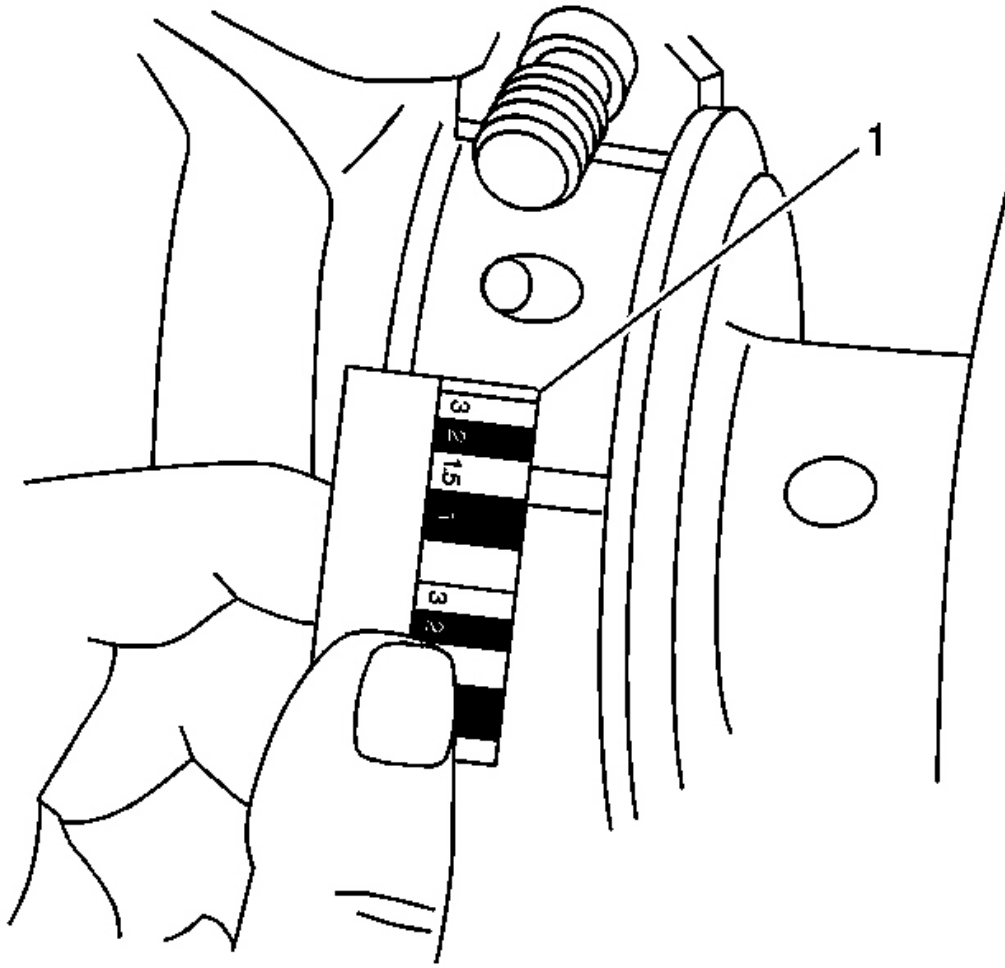


Fig. 418: Measuring Bearing Clearance Using Method B
Courtesy of GENERAL MOTORS CORP.

3. To measure bearing clearance using Method B, use the following procedure:
 1. Clean the used bearing inserts.
 2. Install the used bearing inserts.
 3. Place a piece of gaging plastic across the entire bearing width.
 4. Install the bearing caps.

CAUTION: In order to prevent the possibility of cylinder block or

crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

5. Install the bearing cap bolts to specification.

NOTE: **Do not rotate the crankshaft.**

6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale (1) printed on the gaging plastic package.
8. Remove the gaging plastic.

LOWER CRANKCASE INSTALLATION

Special Tools

EN 45059: Angle Meter

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

Installation

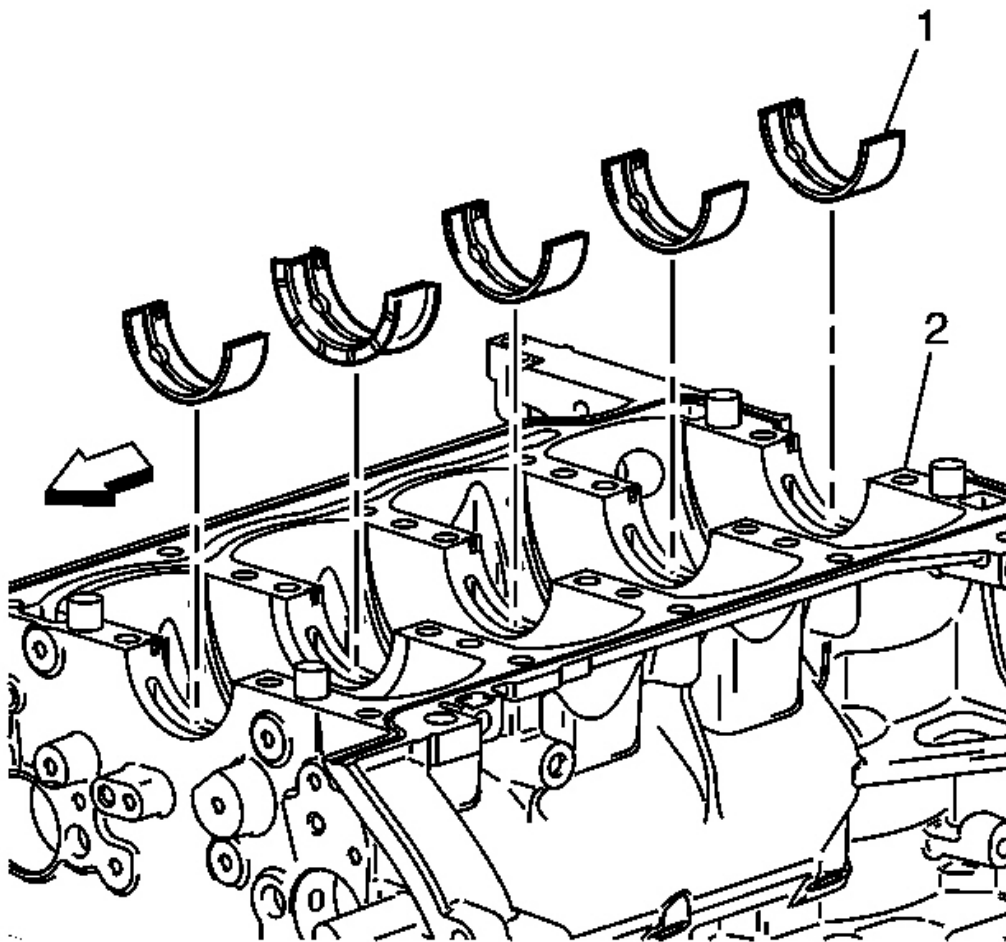


Fig. 419: View of Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.

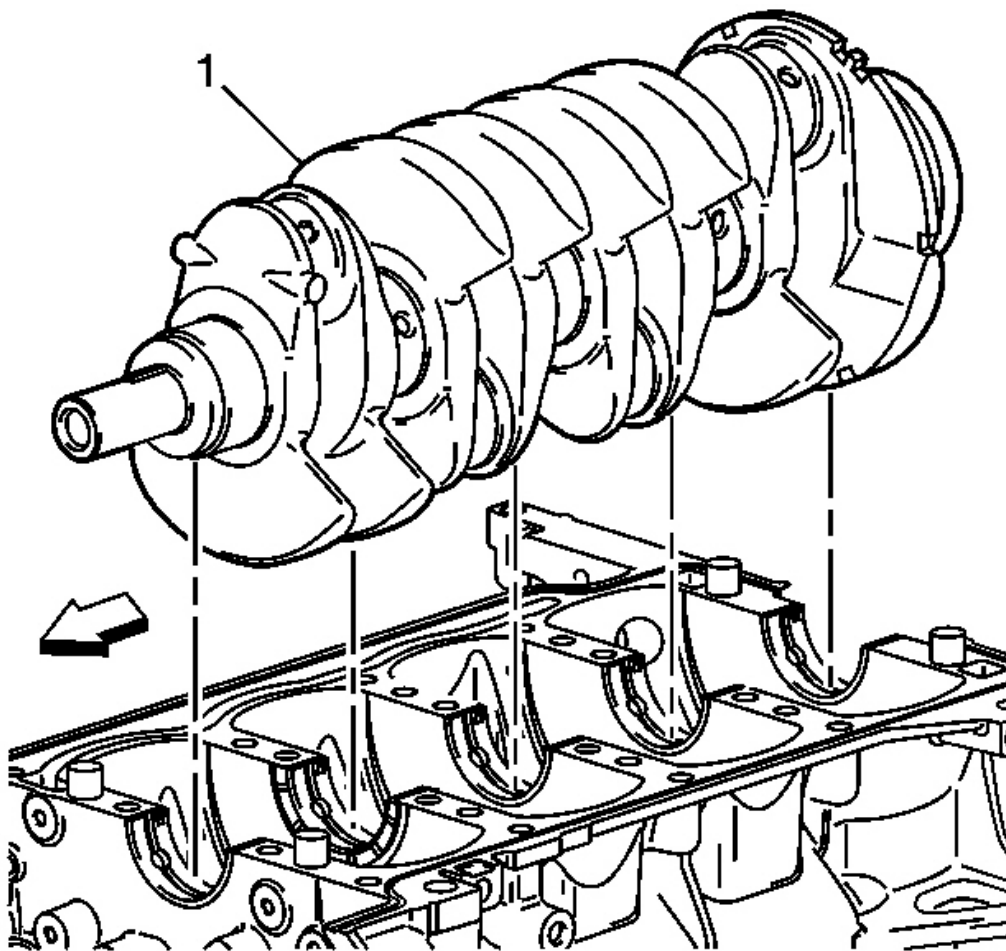


Fig. 420: View of Crankshaft

Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft (1) on the journals.

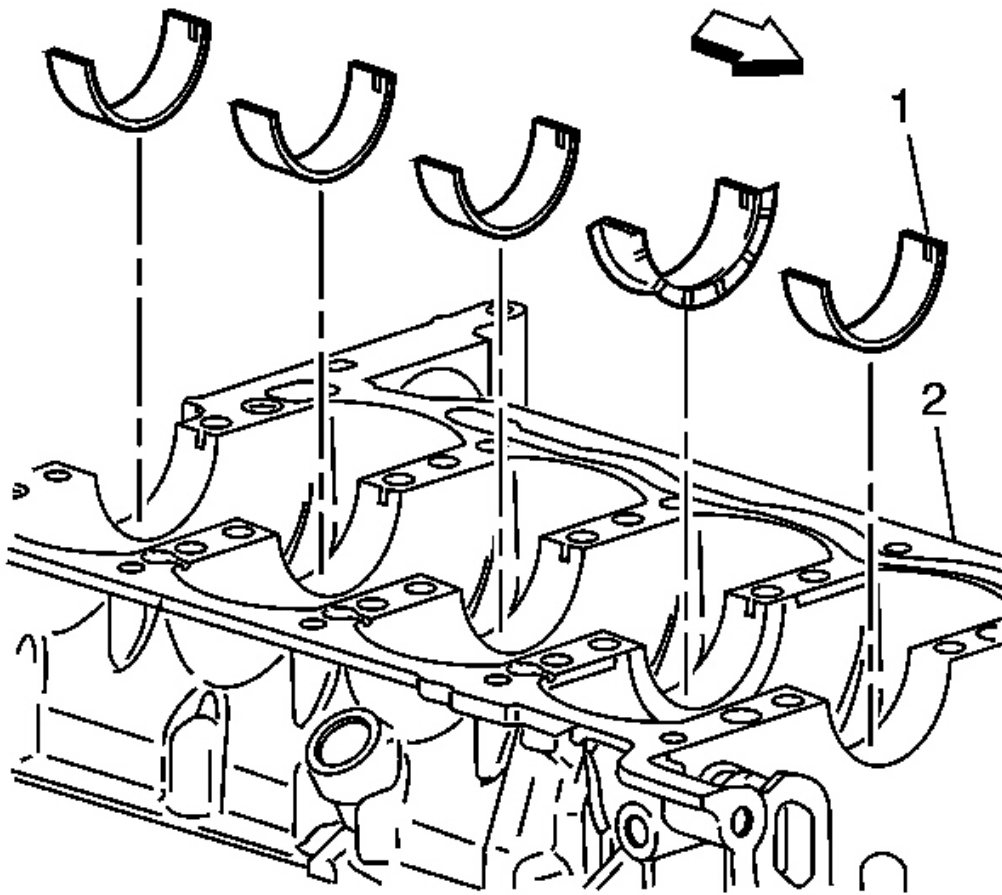


Fig. 421: View of Lower Bearing Halves
Courtesy of GENERAL MOTORS CORP.

3. Install the lower bearing halves (1), without grooves, into the lower crankcase. Apply oil to bearing surfaces.

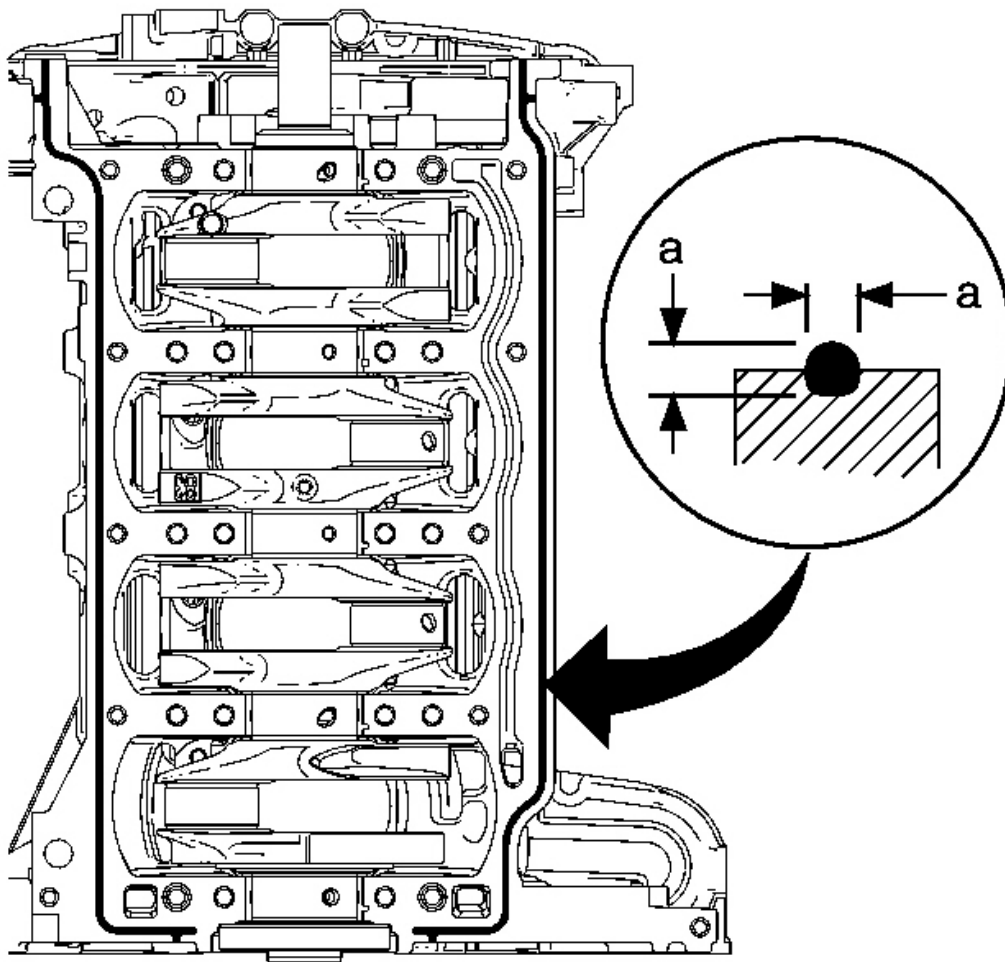


Fig. 422: View of Bead of Sealer on Bedplate Mating Surface
 Courtesy of GENERAL MOTORS CORP.

NOTE:

- The block assembly surface must be free of contamination prior to applying the sealer.
- Install and align the bedplate to block within 20 minutes of applying the sealer.
- The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.

4. Apply a 4.25 mm bead of sealer, dimension (a), directly in the groove of the block to bedplate mating surfaces. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

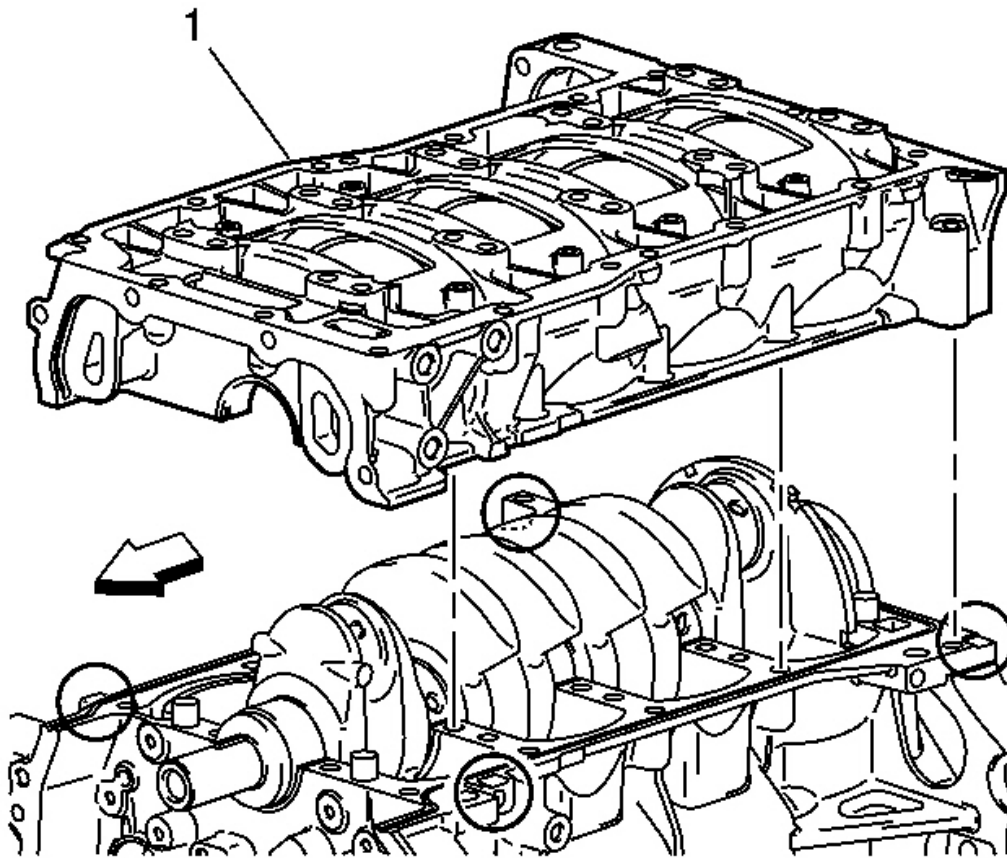


Fig. 423: Identifying Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase (1). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

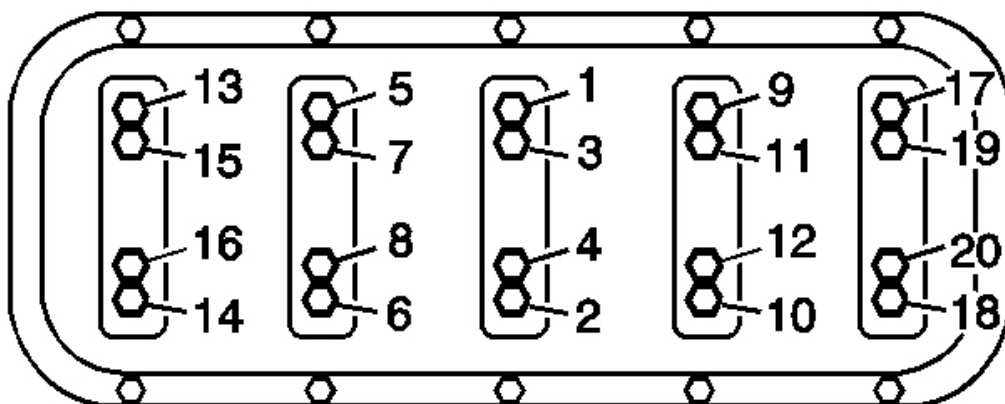


Fig. 424: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the NEW crankshaft bearing bolts in sequence finger tight.
 1. Tighten the crankshaft bearing bolts in sequence to 20 N.m (15 lb ft) .
 2. Tighten the crankshaft bearing bolts in sequence using the **EN 45059:** meter an additional 70 degrees.

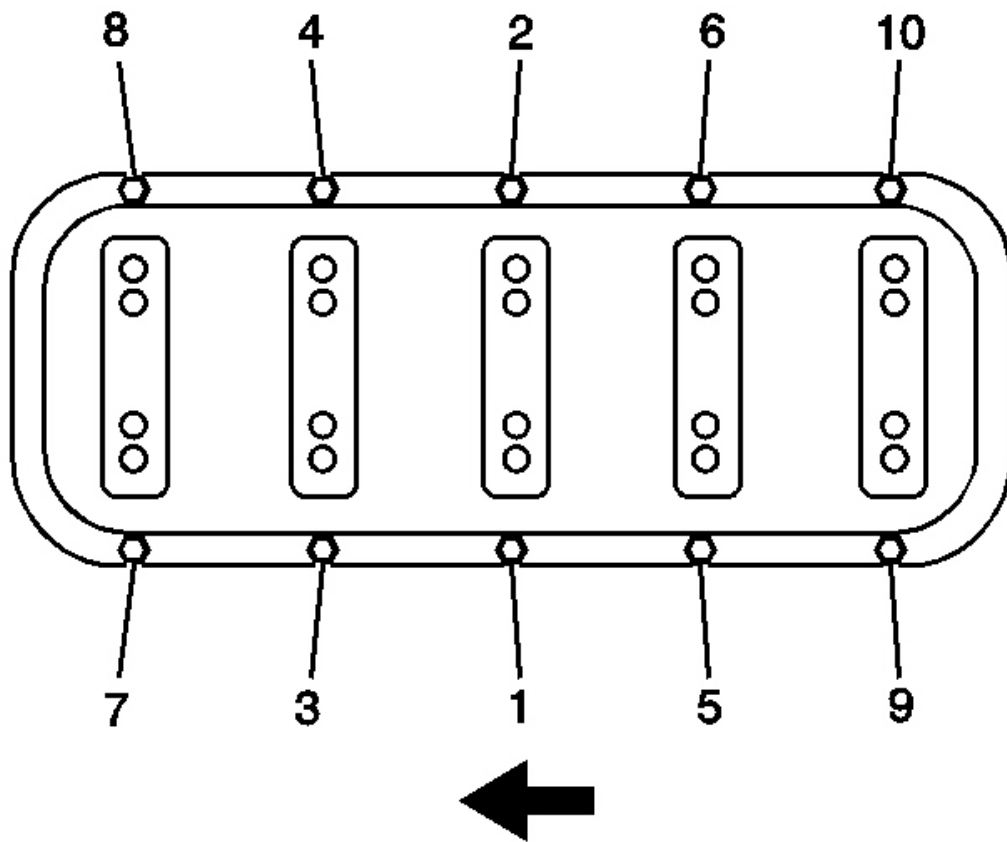


Fig. 425: Identifying Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

7. Tighten the lower crankcase perimeter bolts in sequence to 25 N.m (18 lb ft).

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

EN 42067: Rear Main Seal Installer

Installation

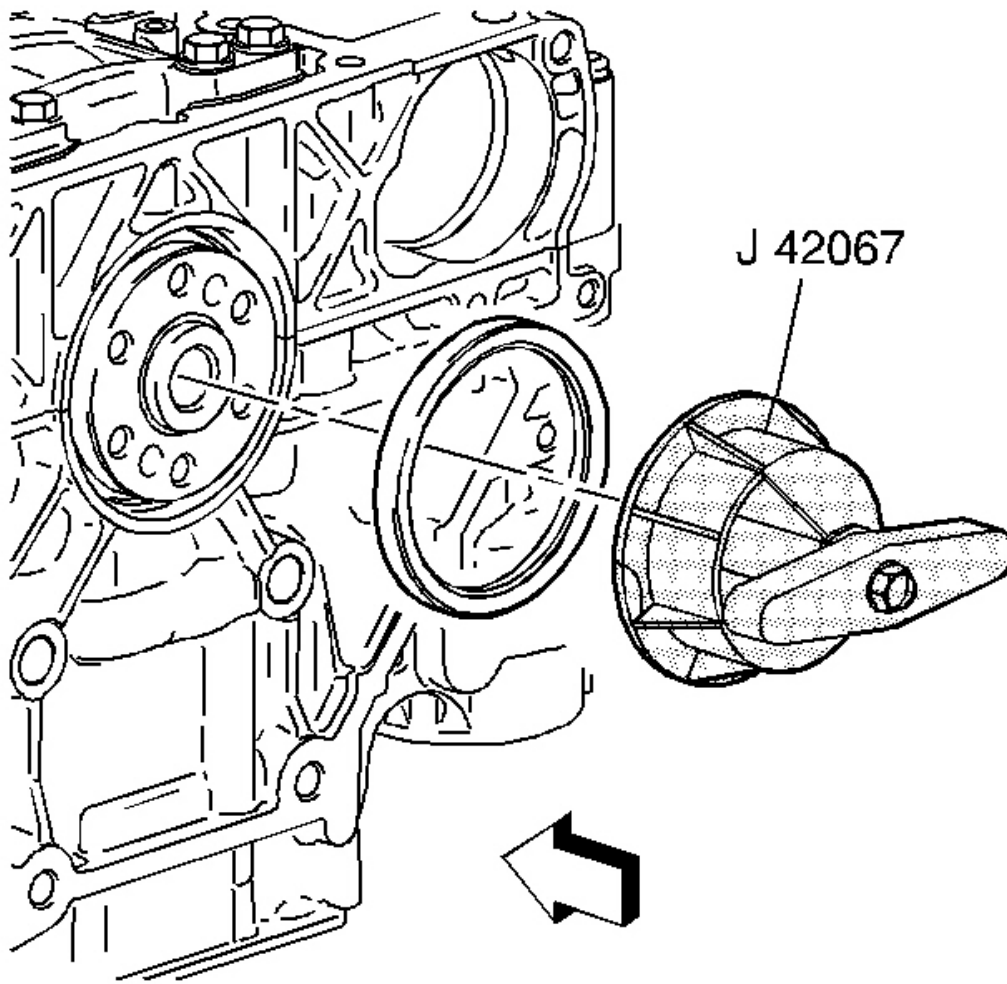


Fig. 426: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove excess sealer from seal recess.
2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **EN 42067**: installer, press the new crankshaft seal into the housing. The **EN 42067**: installer also establishes the depth of the seal in the crankshaft seal bore.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION (LAF, LAT, LE5, LE9)

Special Tools

- **EN-43966**: Connecting Rod Guides

- **EN 45059:** Angle Meter
- **EN-47836:** Piston Ring Compressor

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

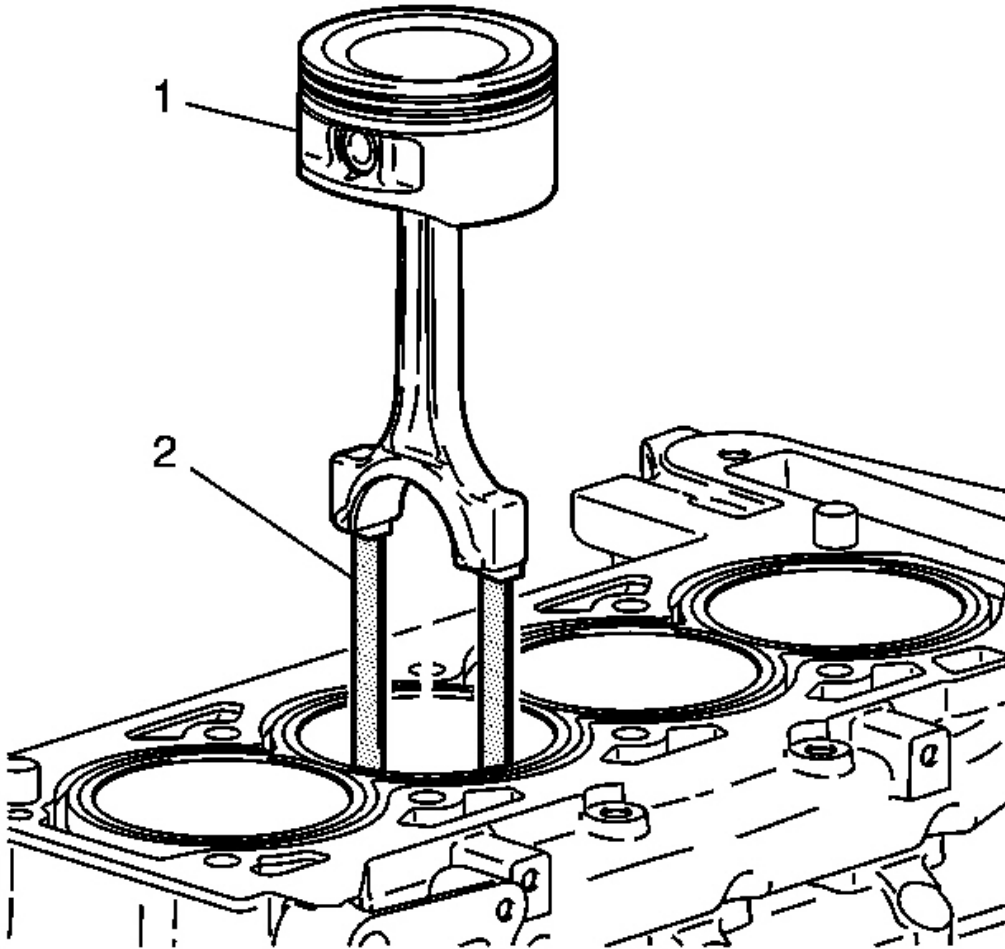


Fig. 427: Piston & Guides

Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod bearings. Use NEW bearings.
 1. Install the bearing inserts into the connecting rod and the connecting rod cap.
 2. Lubricate the connecting rod bearings with engine oil.
2. Install the **EN-43966-1**: guides (1) into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.

3. Install **EN-47836**: compressor, piston, and the connecting rod to the correct bore.
 1. Stagger each piston ring end gap equally around the piston.
 2. Lubricate the piston and the piston rings with engine oil.
 3. Do not disturb the piston ring end gap location.
 4. The piston must be installed so that the mark on the top of the piston faces the front of the engine.
 5. Place the piston in its matching bore.
 6. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
 7. Hold the **EN-47836**: compressor against the engine block until all the rings have entered the cylinder bore.
 8. Remove the connecting rod guides from the connecting rod bolt holes.

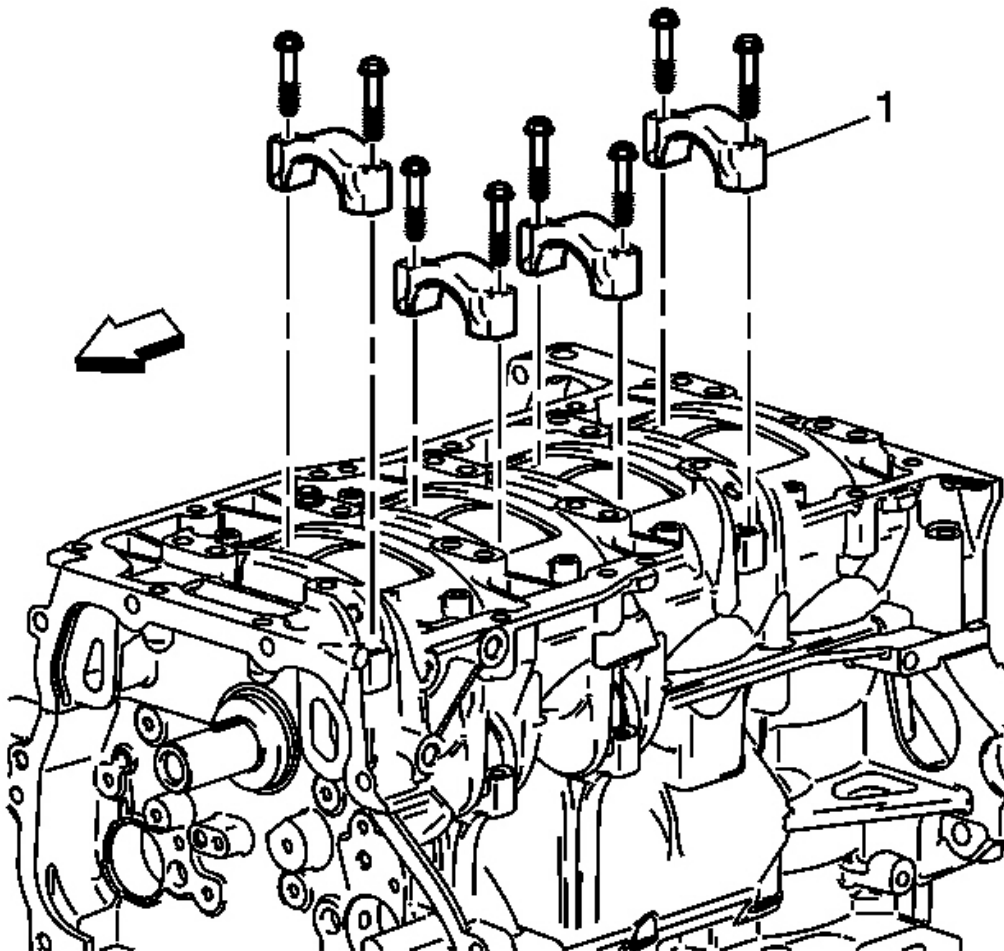


Fig. 428: Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap (1).

CAUTION: Refer to Fastener Caution .

5. Install the connecting rod bolts. Always use new bolts. Tighten the connecting rod bolts to 25 N.m (18 lb ft), plus 100 degrees using the **EN 45059**: meter.
6. Install the remaining connecting rods and piston assemblies.

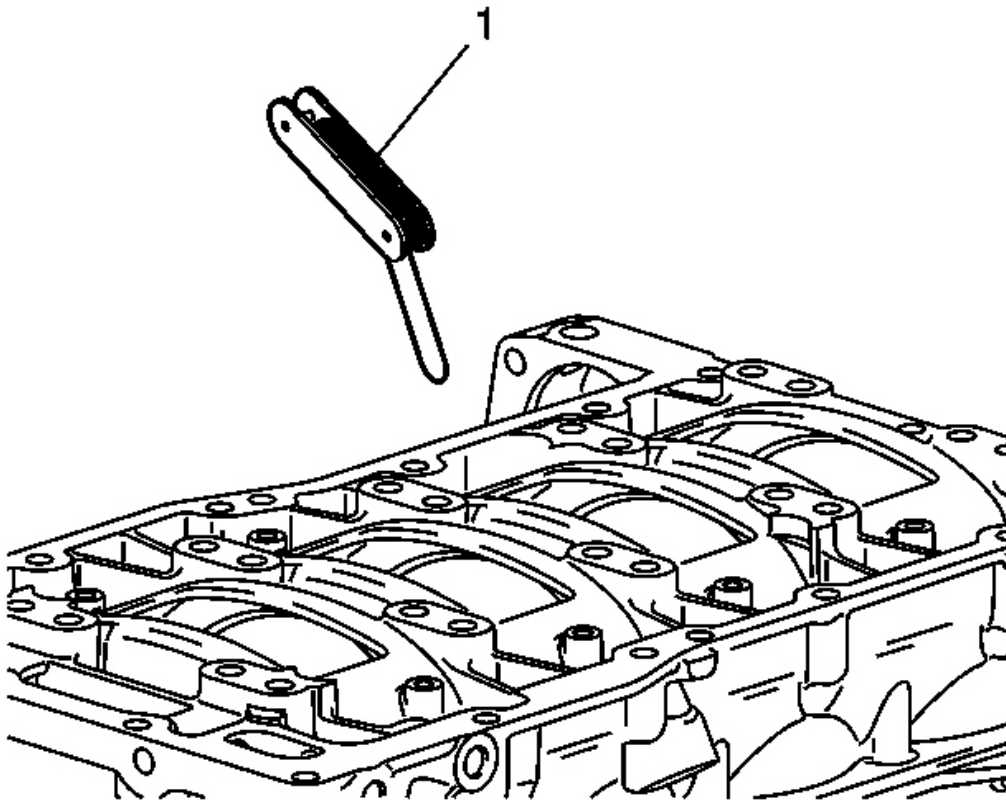


Fig. 429: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the connecting rod side clearance with a feeler gauge (1).

The correct clearance is 0.07-0.37 mm (0.0027-0.0145 in).

CYLINDER HEAD INSTALLATION

Special Tools

EN 45059: Angle Meter

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

Installation

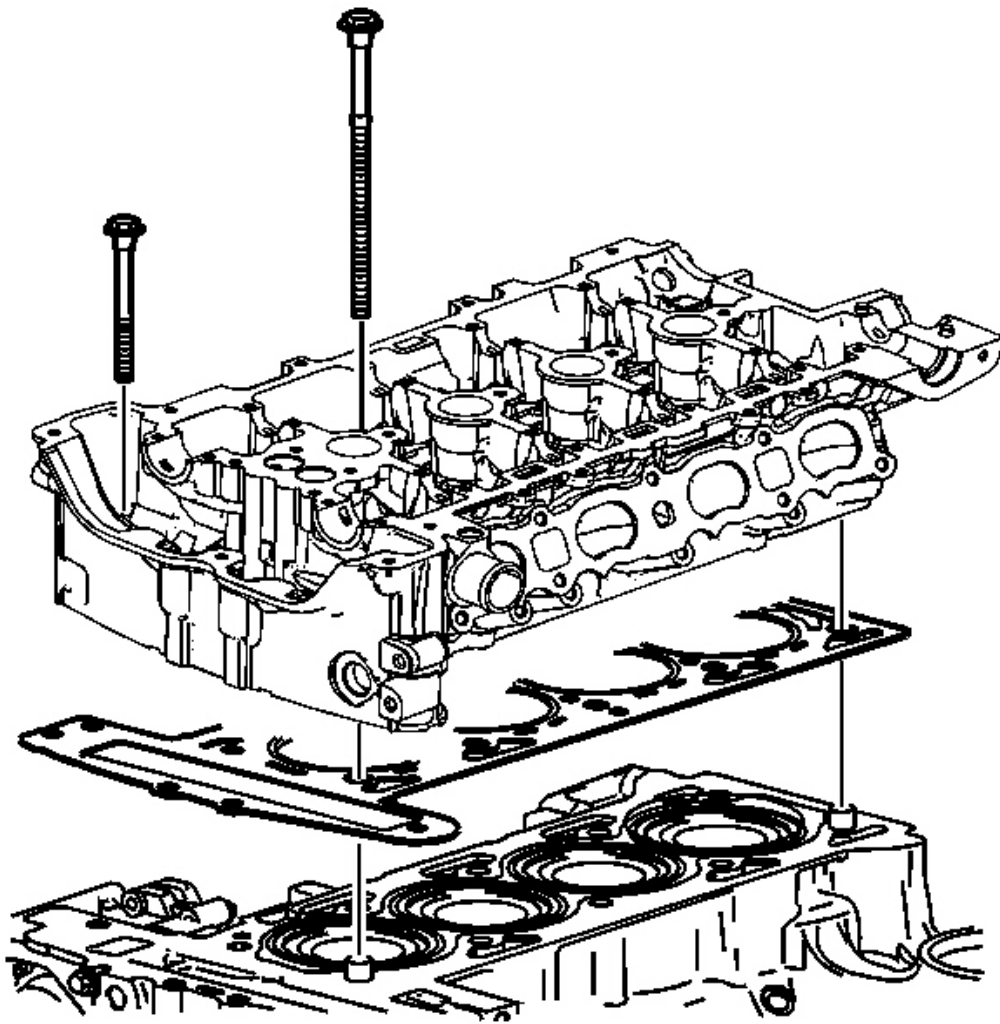


Fig. 430: Cylinder Head

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any sealing material.

1. Install the cylinder head gasket to the block.
2. Install the cylinder head. Ensure the number 1 cylinder is at top dead center (TDC). The key on the crankshaft should be on top in the 12 o'clock position.

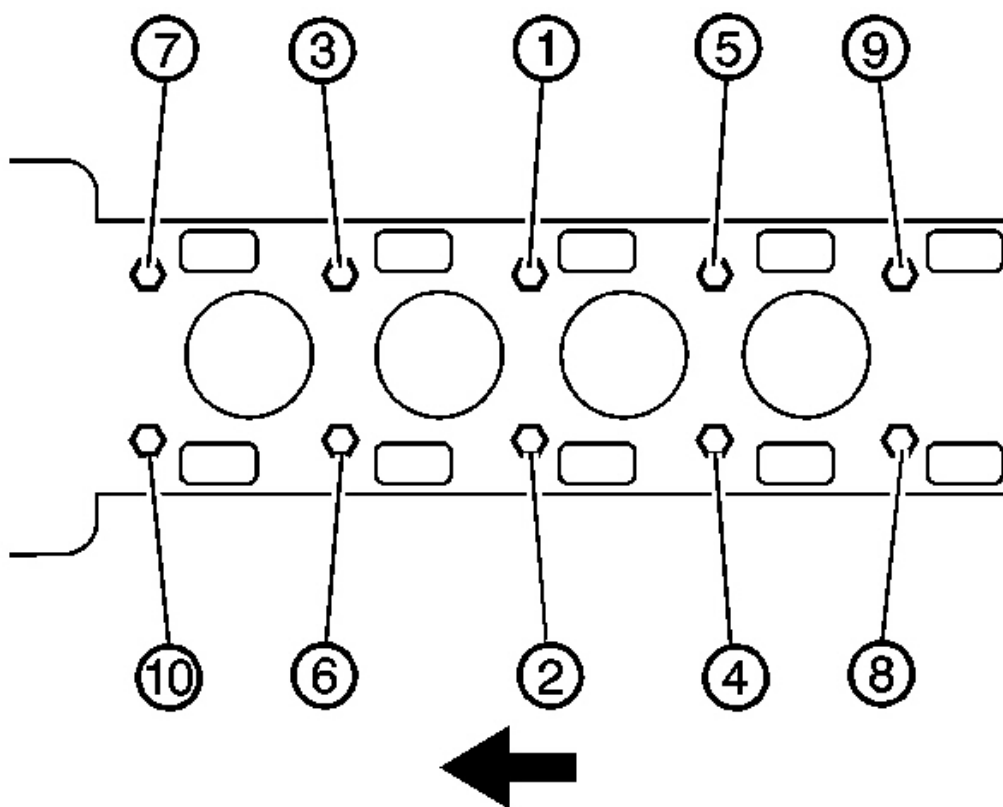


Fig. 431: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Always use **NEW** cylinder head bolts.

3. Install the cylinder head bolts.
 1. Tighten the bolts in sequence to 30 N.m (22 lb ft) .
 2. Tighten the bolts an additional 155 degrees in sequence using the **EN 45059:** meter .

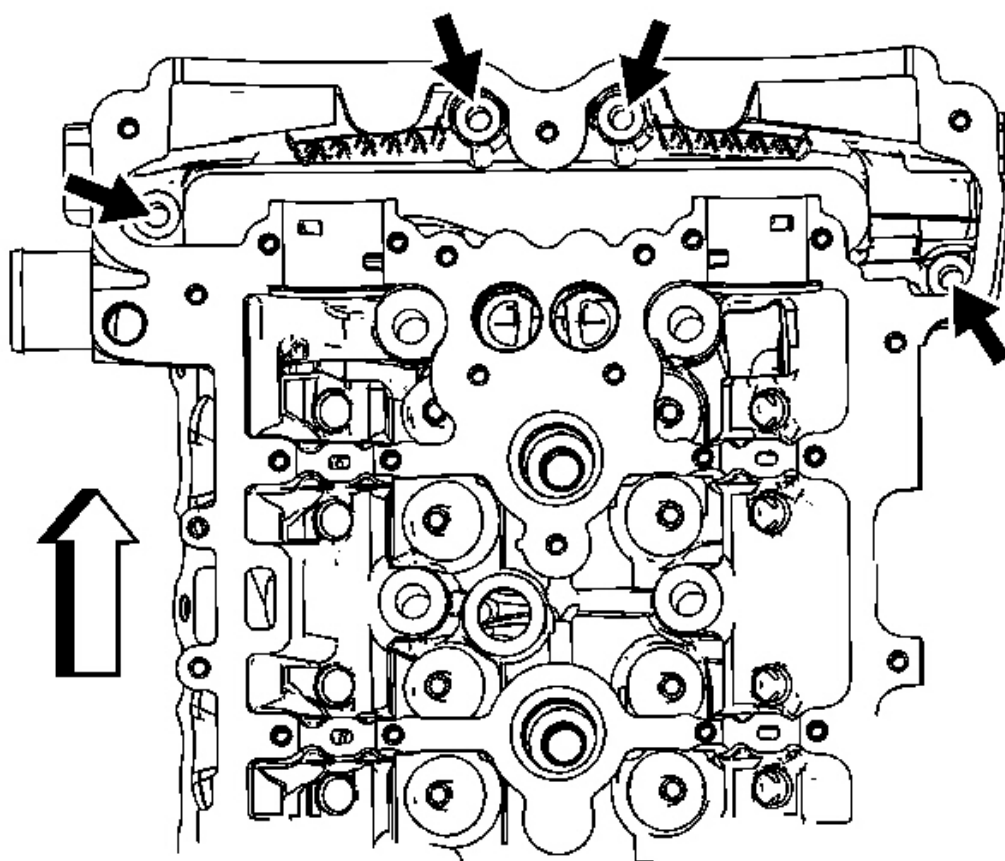


Fig. 432: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the front cylinder head bolts and tighten to 30 N.m (22 lb ft).

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

Exhaust Camshaft Installation

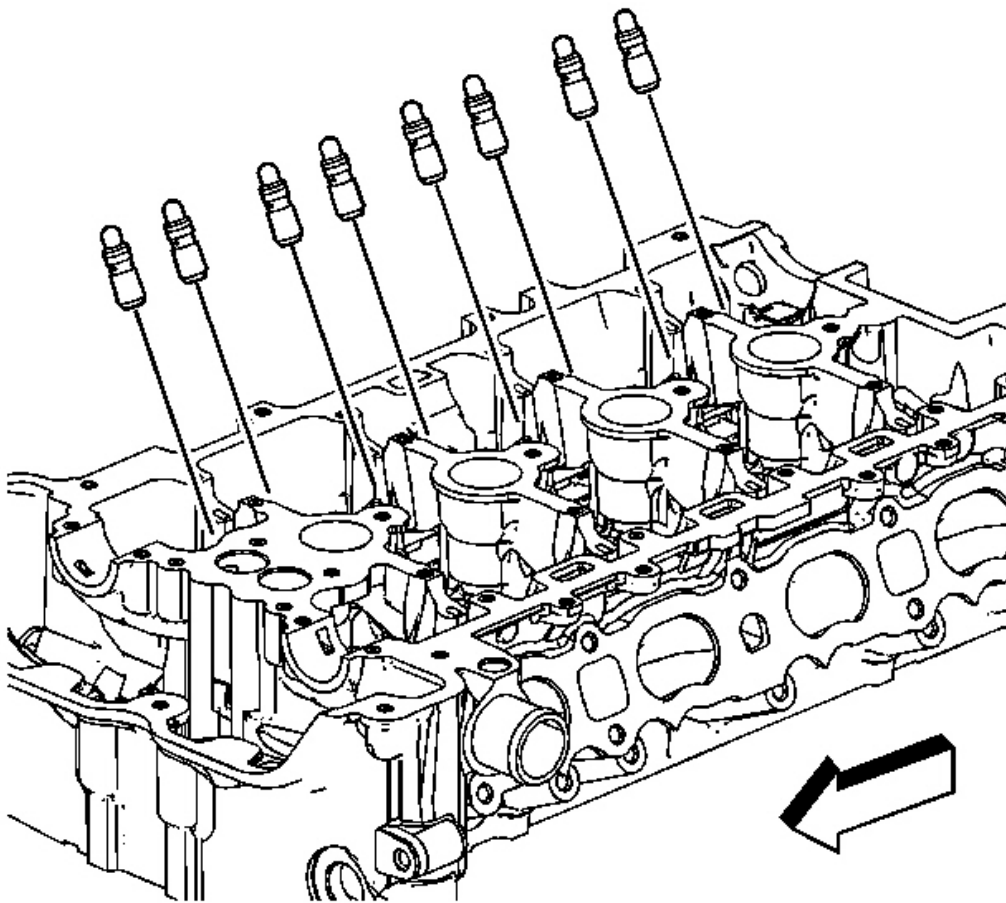


Fig. 433: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

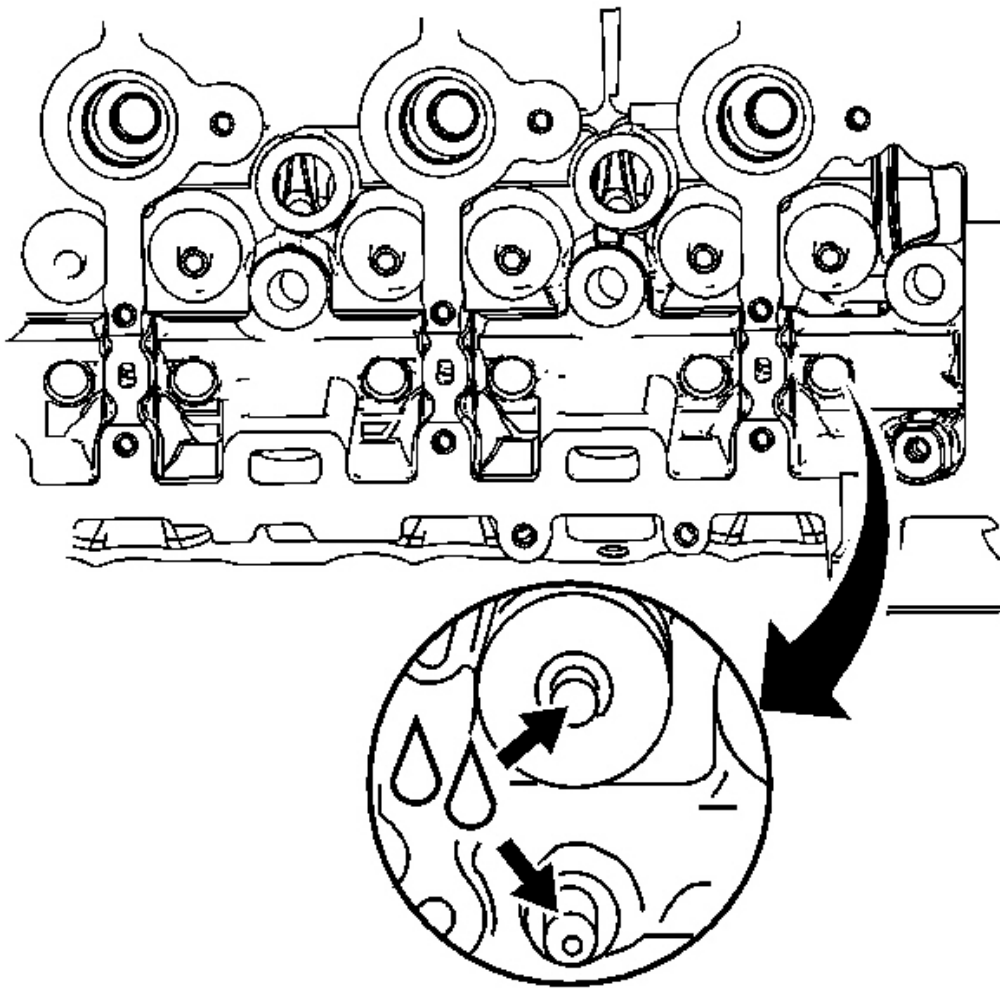


Fig. 434: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers.

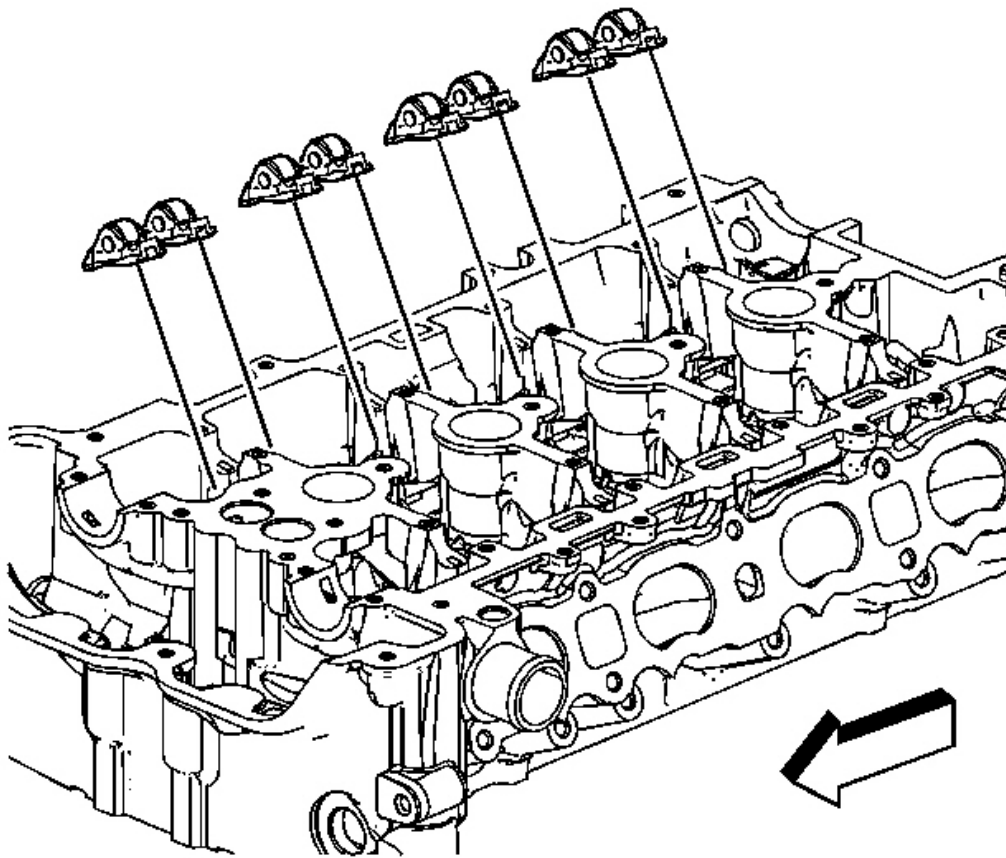


Fig. 435: Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers must be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

3. Position the roller followers on the tip of the valve stem and on the lash adjuster and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

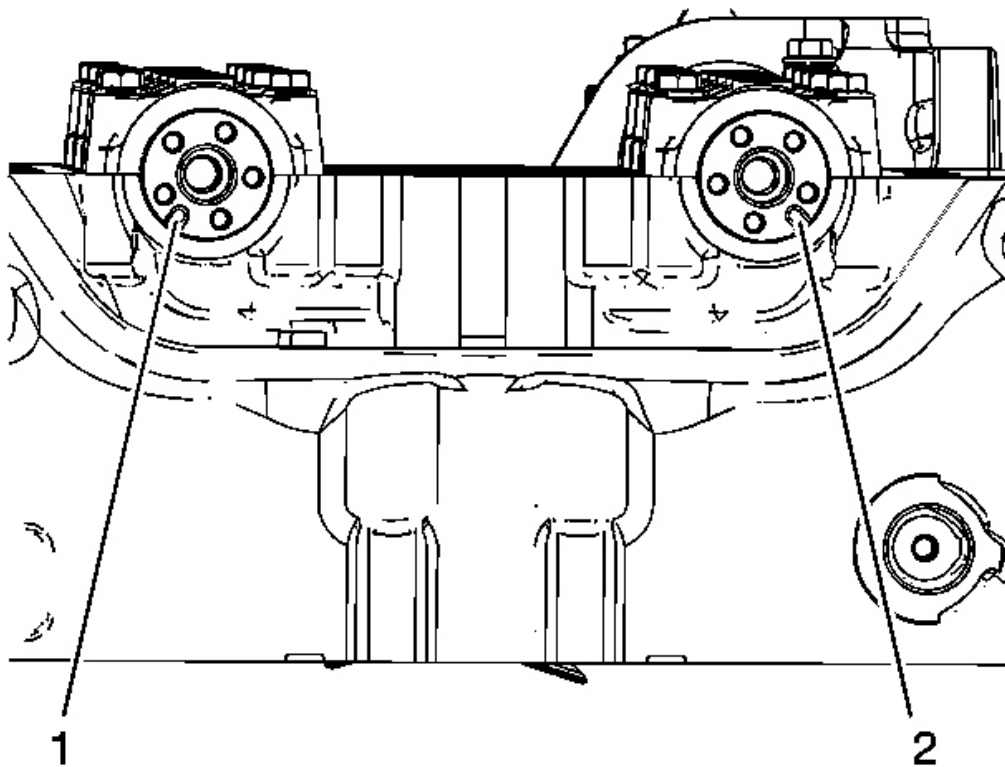


Fig. 436: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

4. When installing the camshafts, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

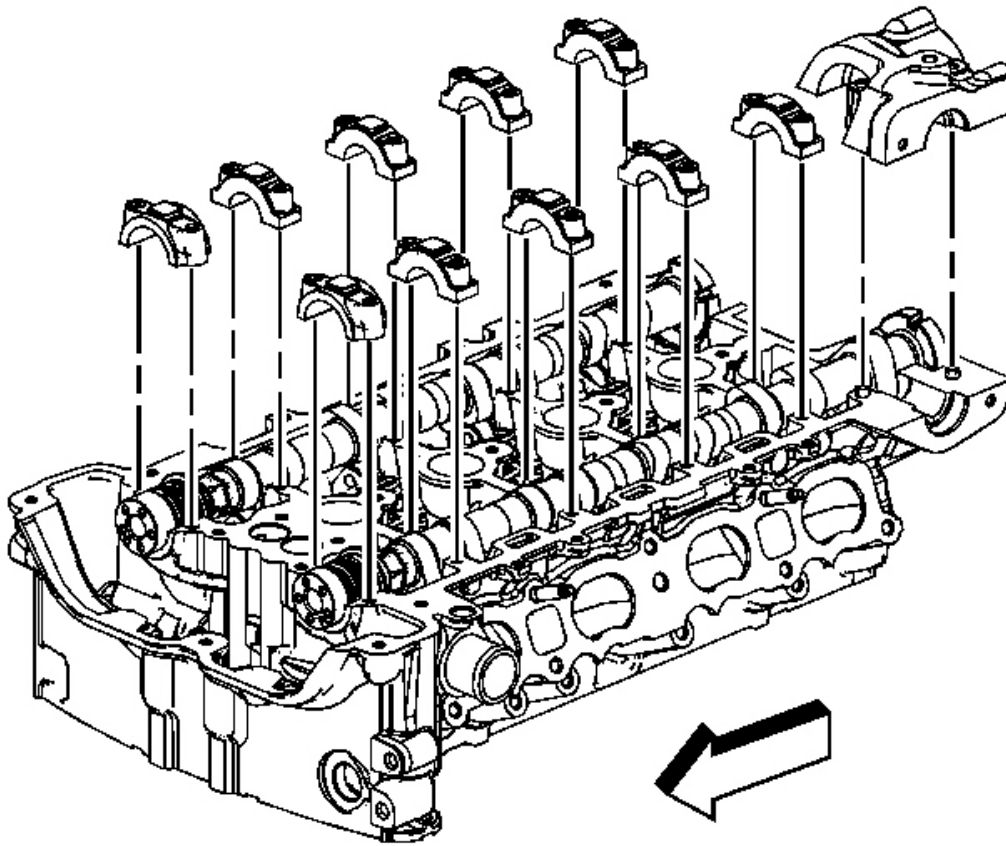


Fig. 437: Intake Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to Adhesives, Fluids, Lubricants, and Sealers.

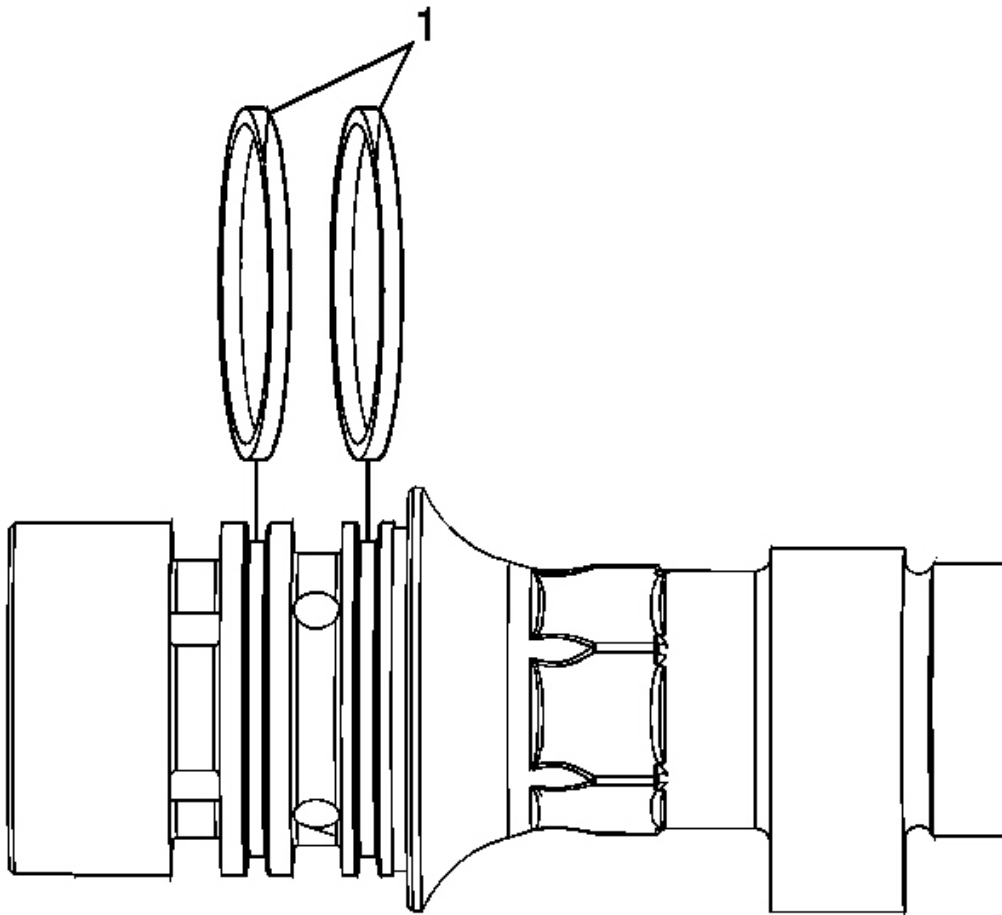


Fig. 438: Oil Seals

Courtesy of GENERAL MOTORS CORP.

6. Rotate the oil seal in the groove of the number one camshaft journal so the split line (1) is at approximately the 12:00 position before installing the camshaft caps.

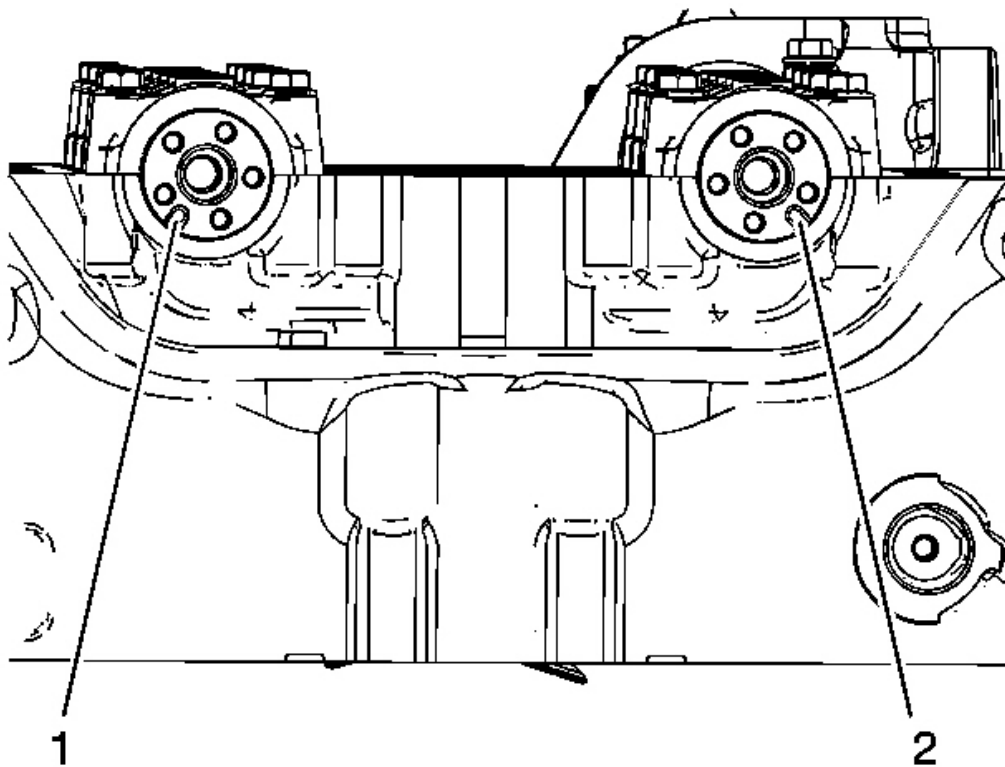


Fig. 439: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust camshaft with the notch on the front (1) at approximately the 7 o'clock position.
8. Install the camshaft caps and hand start the camshaft cap bolts.

CAUTION: Refer to Fastener Caution .

9. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).

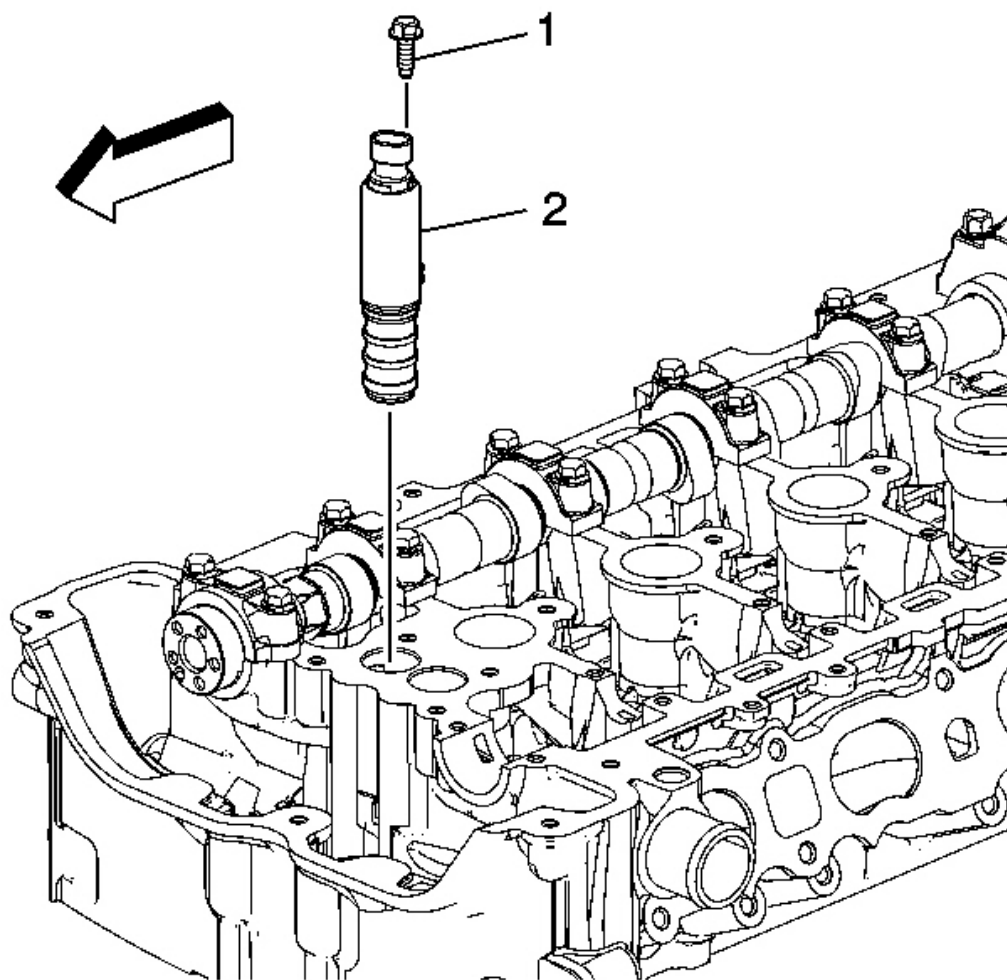


Fig. 440: Exhaust Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

10. Install the exhaust camshaft position actuator solenoid valve (2). Tighten the solenoid valve bolt (1) to 10 N.m (89 lb in).

Intake Camshaft Installation

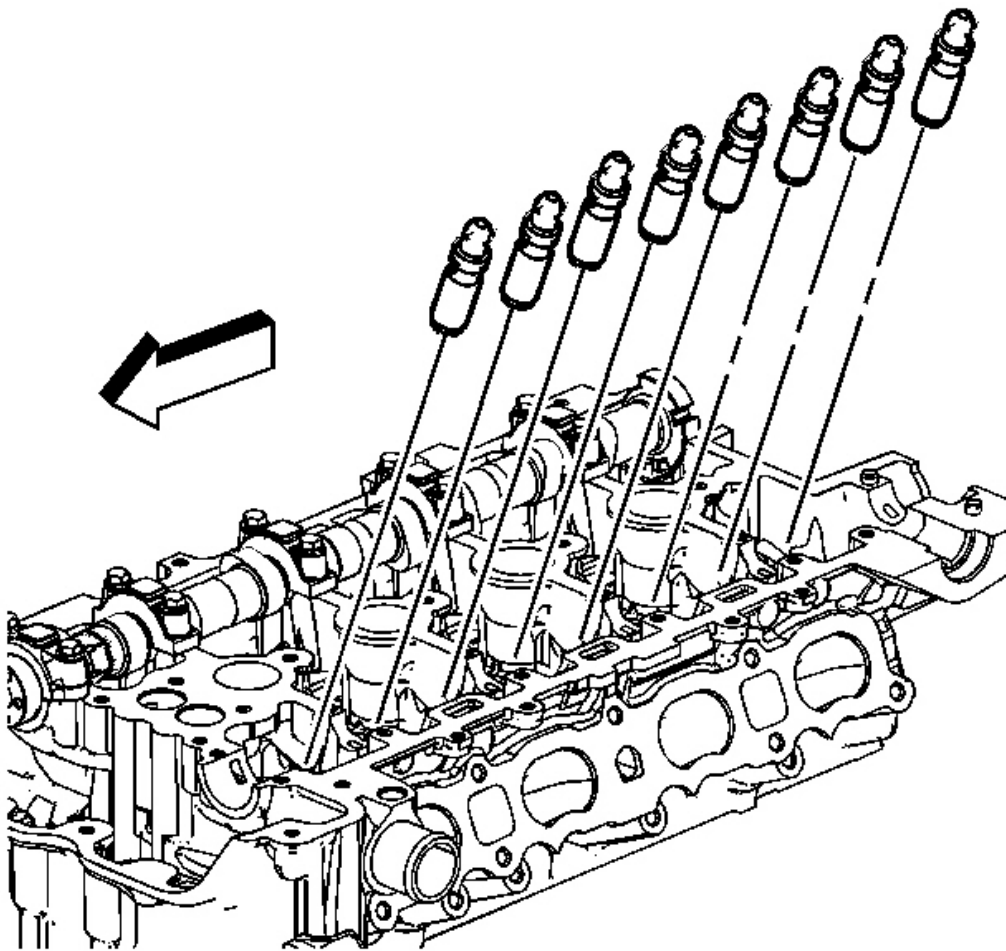


Fig. 441: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

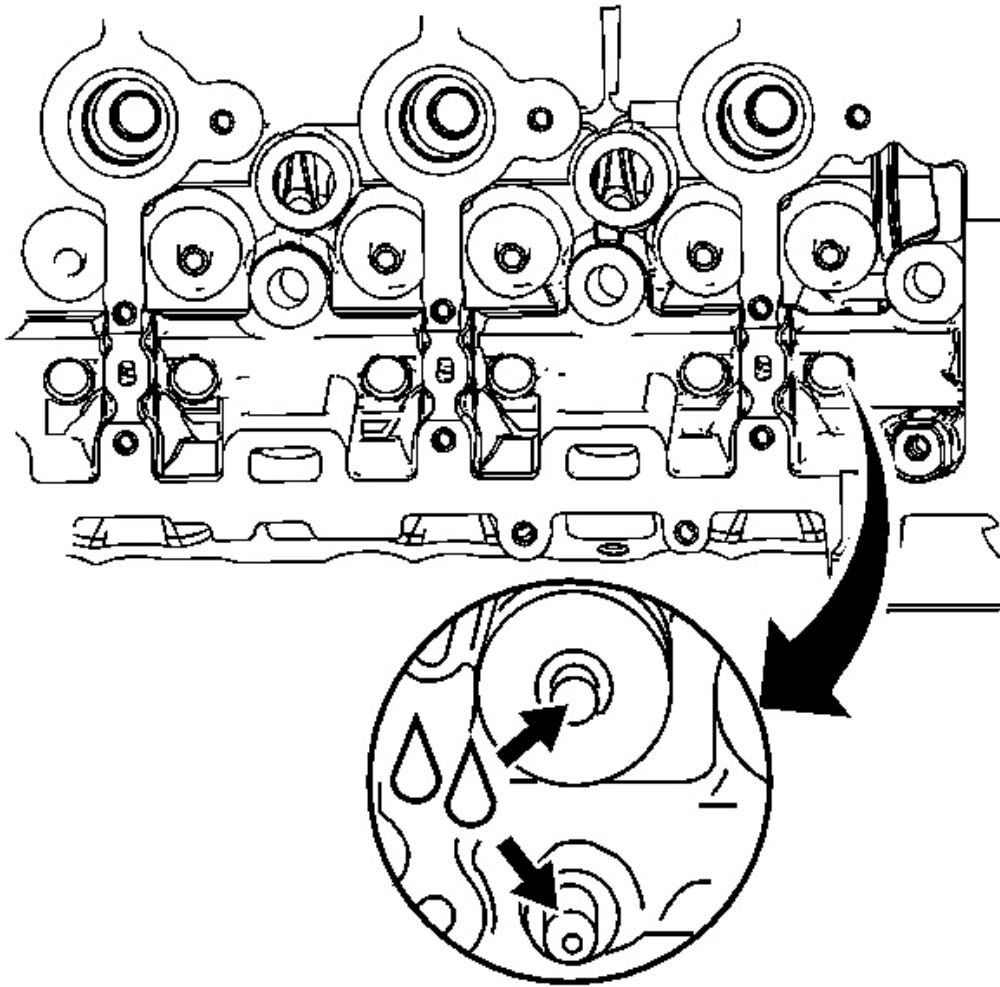


Fig. 442: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to Adhesives, Fluids, Lubricants, and Sealers.

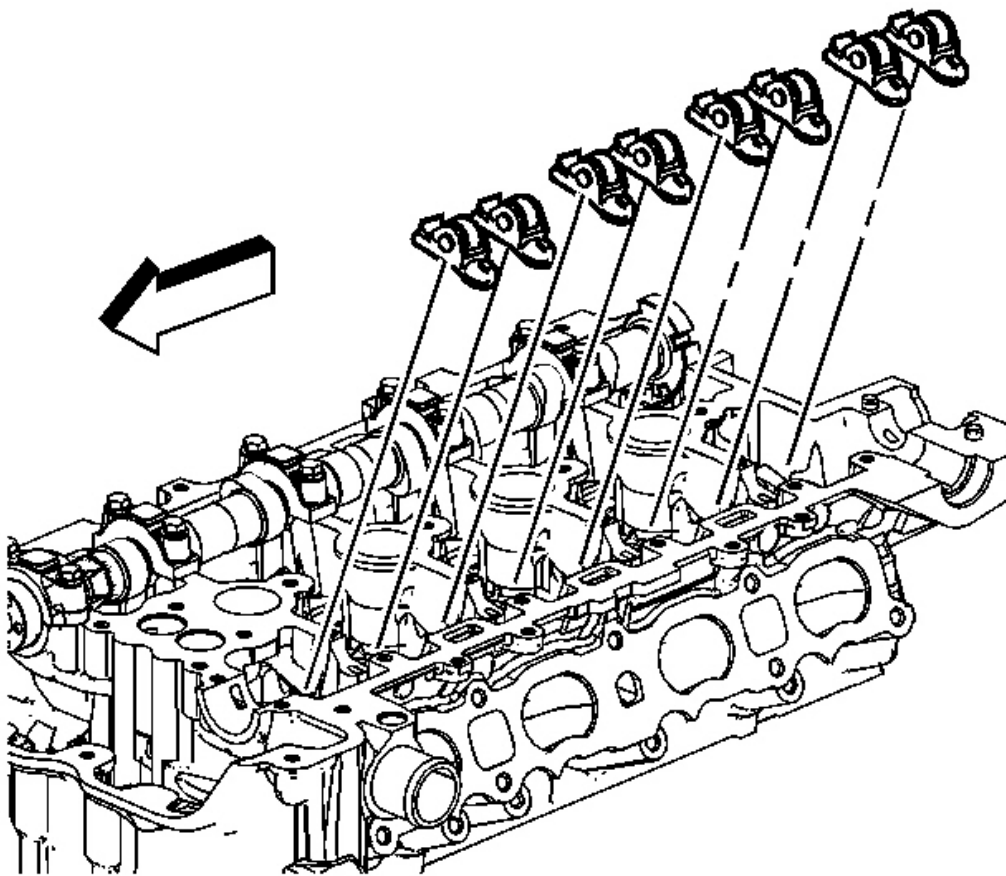


Fig. 443: Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers must be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Lubricate roller followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

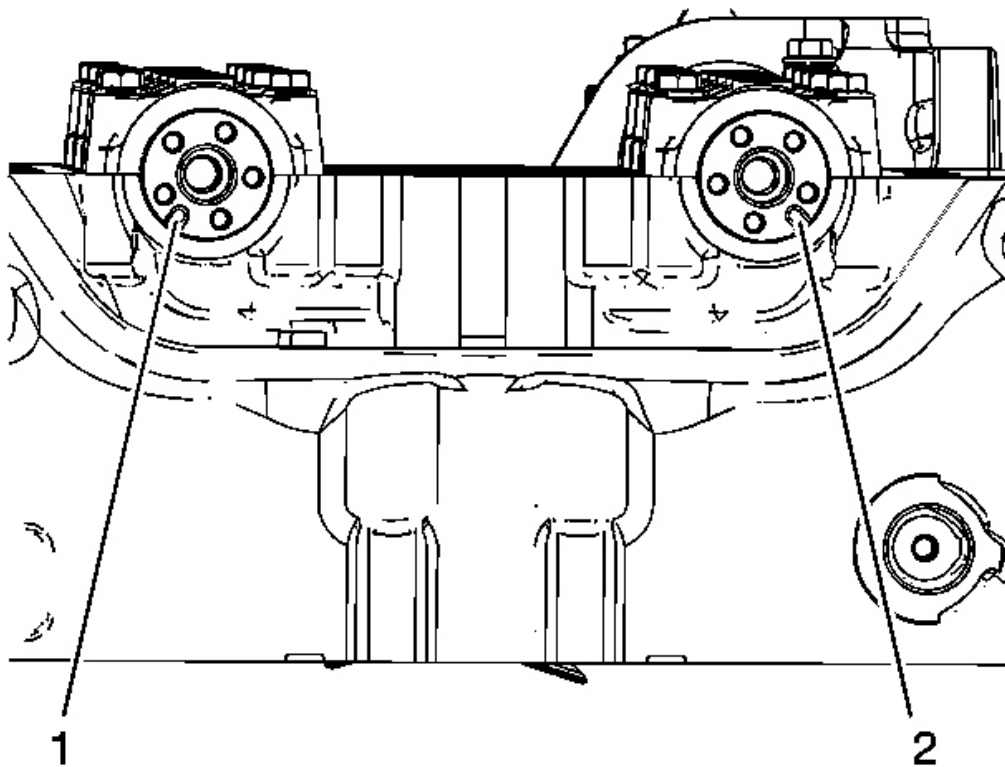


Fig. 444: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

5. When installing the camshafts, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

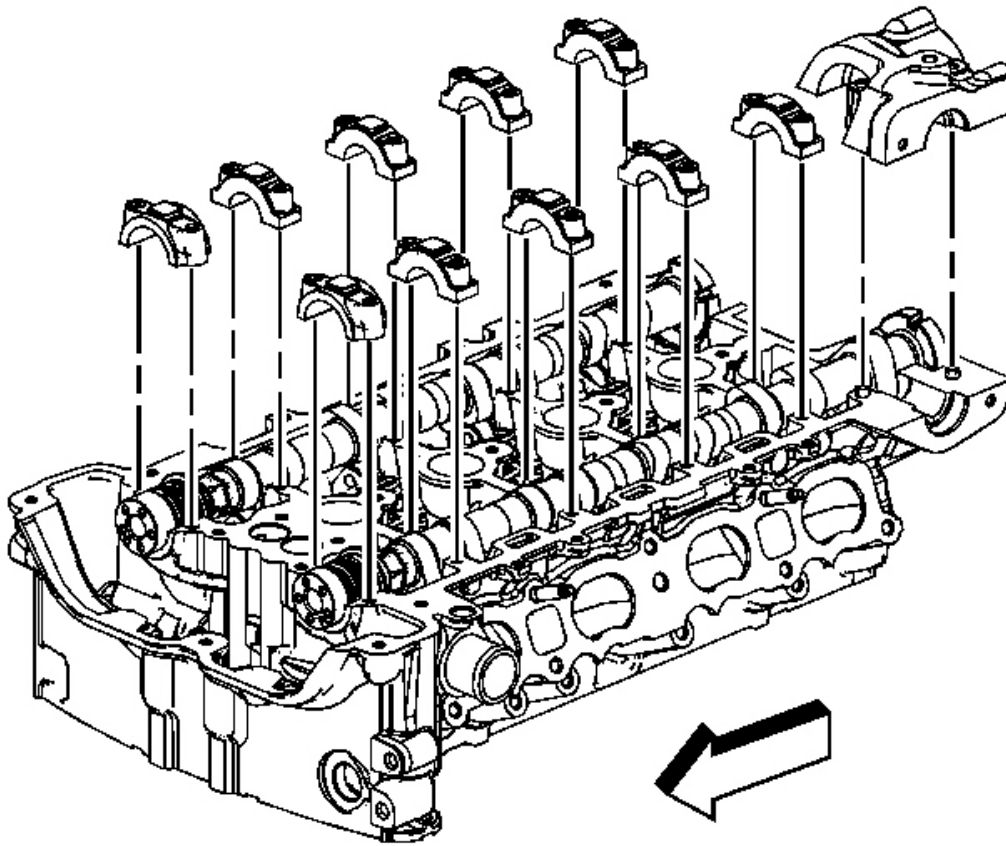


Fig. 445: Intake Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

6. Set the intake camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

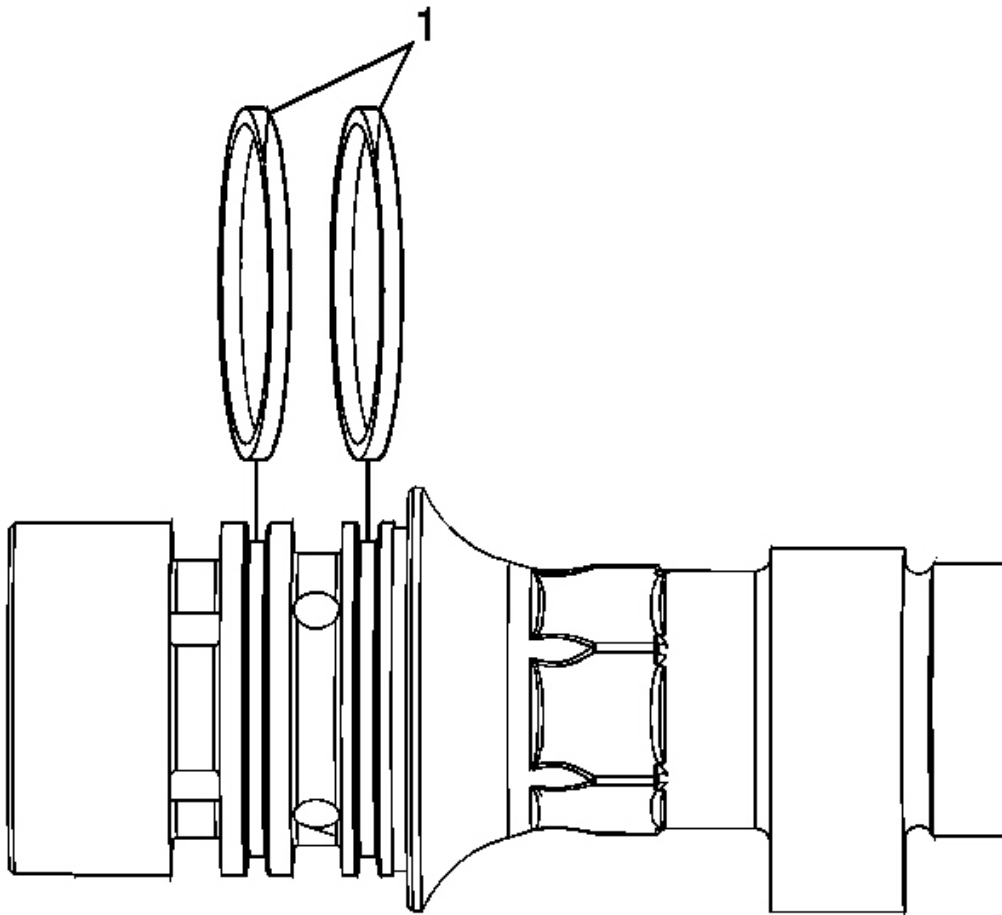


Fig. 446: Oil Seals

Courtesy of GENERAL MOTORS CORP.

7. Rotate the oil seal in the groove of the number one camshaft journal so the split line (1) is at approximately the 12:00 position before installing the camshaft caps.

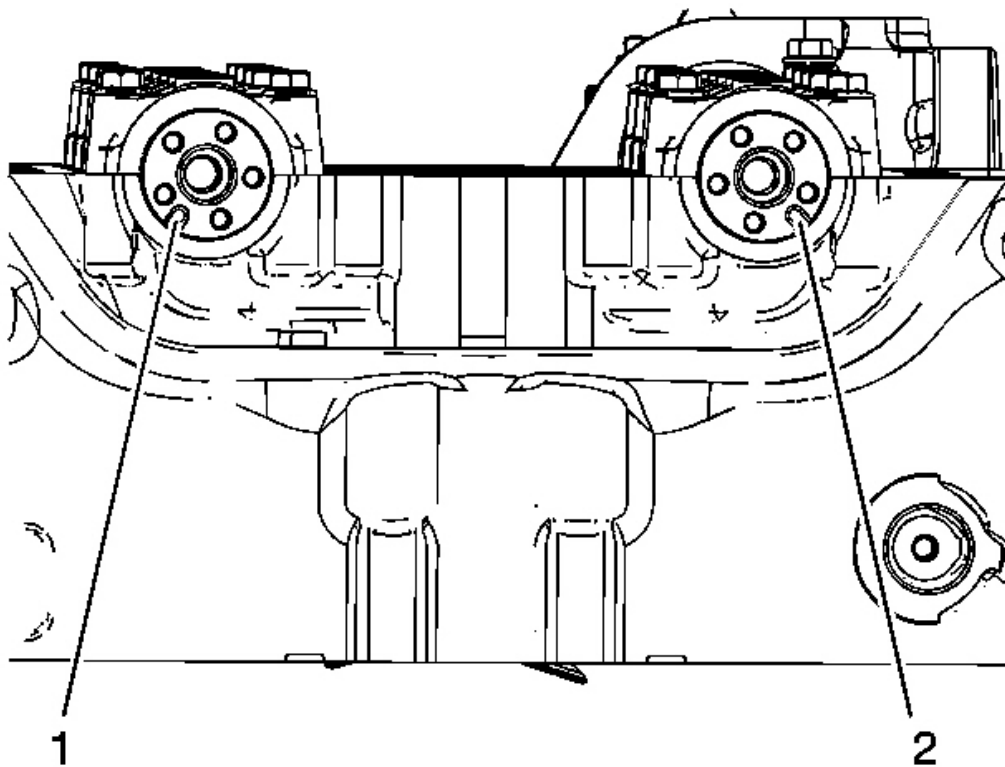


Fig. 447: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: **The number 1 cylinder must be at top dead center (TDC), crankshaft keyway at the 12 o'clock position.**

8. Install the intake camshaft with the notch on the front at approximately the 5 o'clock position (2).
9. Install the camshaft caps and hand start the camshaft cap bolts.
10. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).

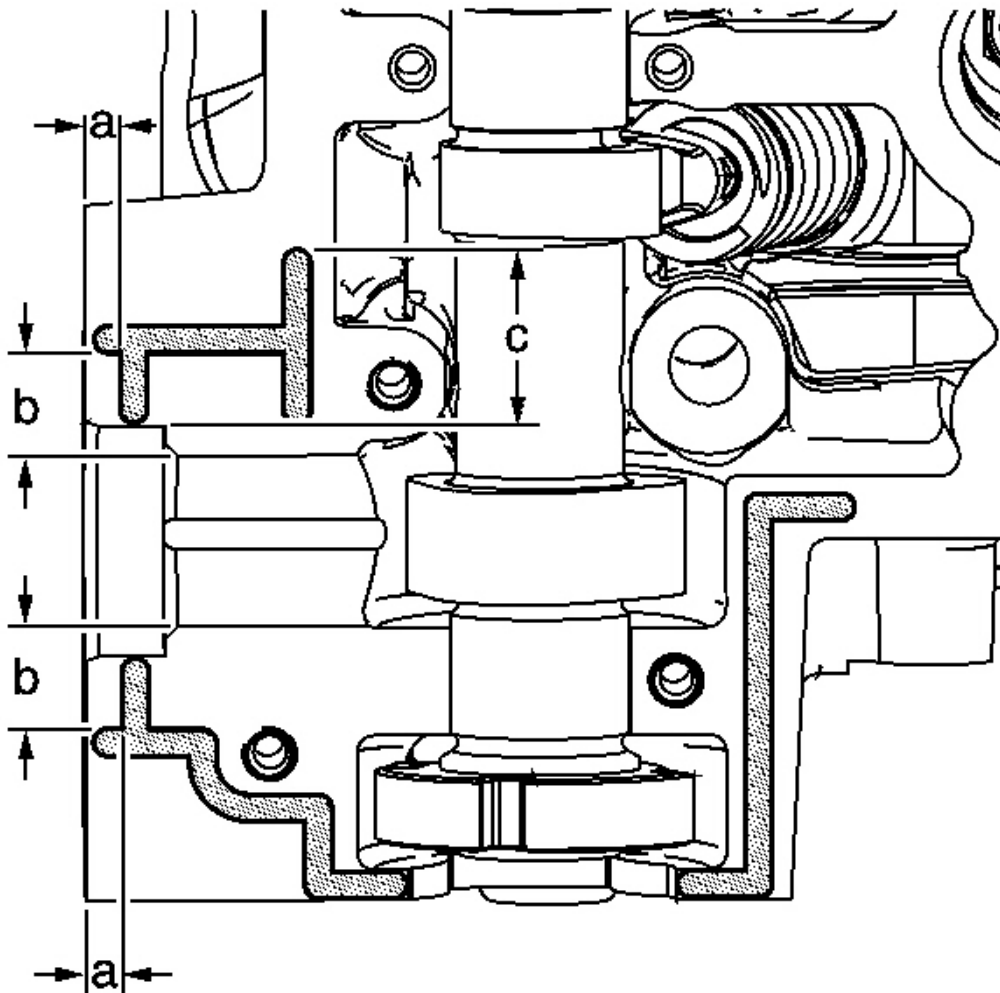


Fig. 448: Sealer Application Areas
Courtesy of GENERAL MOTORS CORP.

- NOTE:** It is critical during installation to ensure the bearing rear cap and cylinder head alignment is correct and the mating surfaces are flush.
- Ensure that all sealing material has been removed from the components, and the sealing surfaces are clean and free of contamination prior to applying the sealer.
 - Install and align the rear cap within 20 minutes of applying the sealer.

NOTE: Apply the sealer to all locations centrally locating the bead on the rail.

- Run bead to 5.0 mm, dimension a, as shown.
- Where the cap ends on the perimeter rail, extend bead approximately 4.0 mm beyond edge of cap.
- Run bead, dimension c, 32 mm from the edge of the cylinder head as shown.
- Run beads, dimension b, 20 mm from edge of cylinder head as shown.

11. Apply a 2.5 mm bead of sealer to the cylinder head at the number 6 intake camshaft rear cap mating surface. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
12. Install the number 6 intake camshaft rear cap.
 1. Tighten the cap bolts evenly to 5 N.m (44 lb in).
 2. Tighten the cap bolts evenly to 10 N.m (89 lb in).
 3. Back the cap bolts out 120 degrees.
 4. Tighten the cap bolts evenly a final pass to 10 N.m (89 lb in).

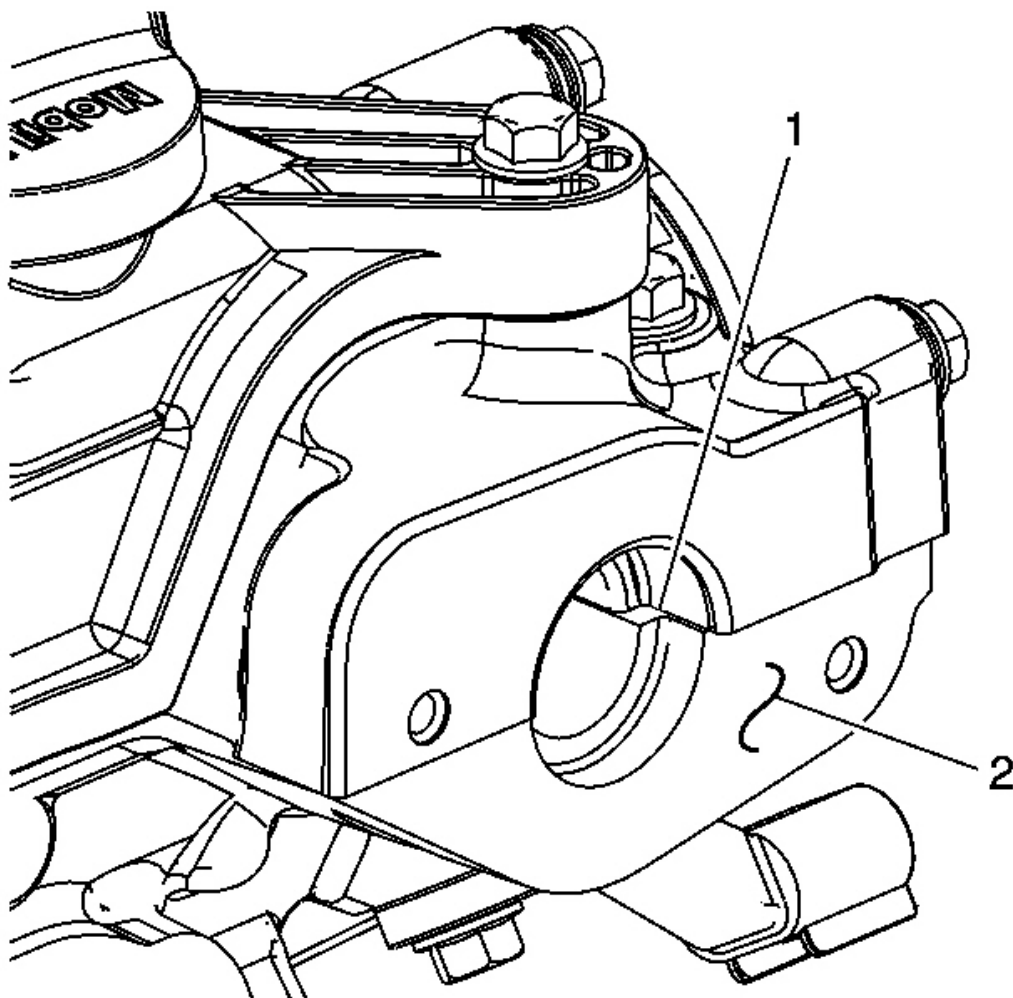


Fig. 449: Fuel Pump Roller Lifter Bore & Fuel Pump Assembly Sealing Surface
Courtesy of GENERAL MOTORS CORP.

13. Remove all excess sealing material from the fuel pump roller lifter bore (1), and ensure the bore is free of debris. Do not allow any excess sealing material to remain within the cylinder head or on any sealing surface.
14. Remove all excess sealing material from the fuel pump assembly sealing surface (2).

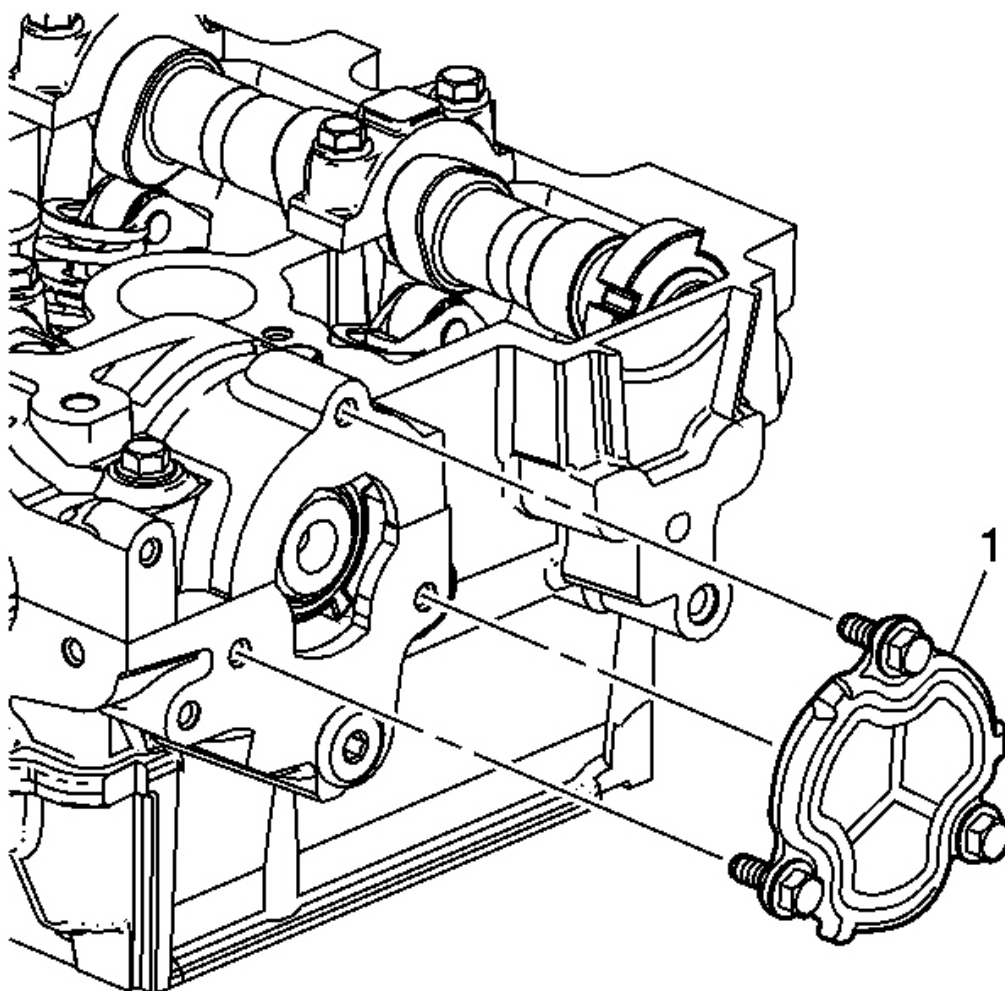


Fig. 450: Rear Cylinder Head Cover Plate
Courtesy of GENERAL MOTORS CORP.

15. Verify the seal on the cylinder head cover plate (1) is intact and in good condition.
16. Ensure that the opening plate sealing surface is clean and free of excess sealing material. Install the rear cylinder head opening plate (1) and tighten the bolts to 10 N.m (89 lb in).

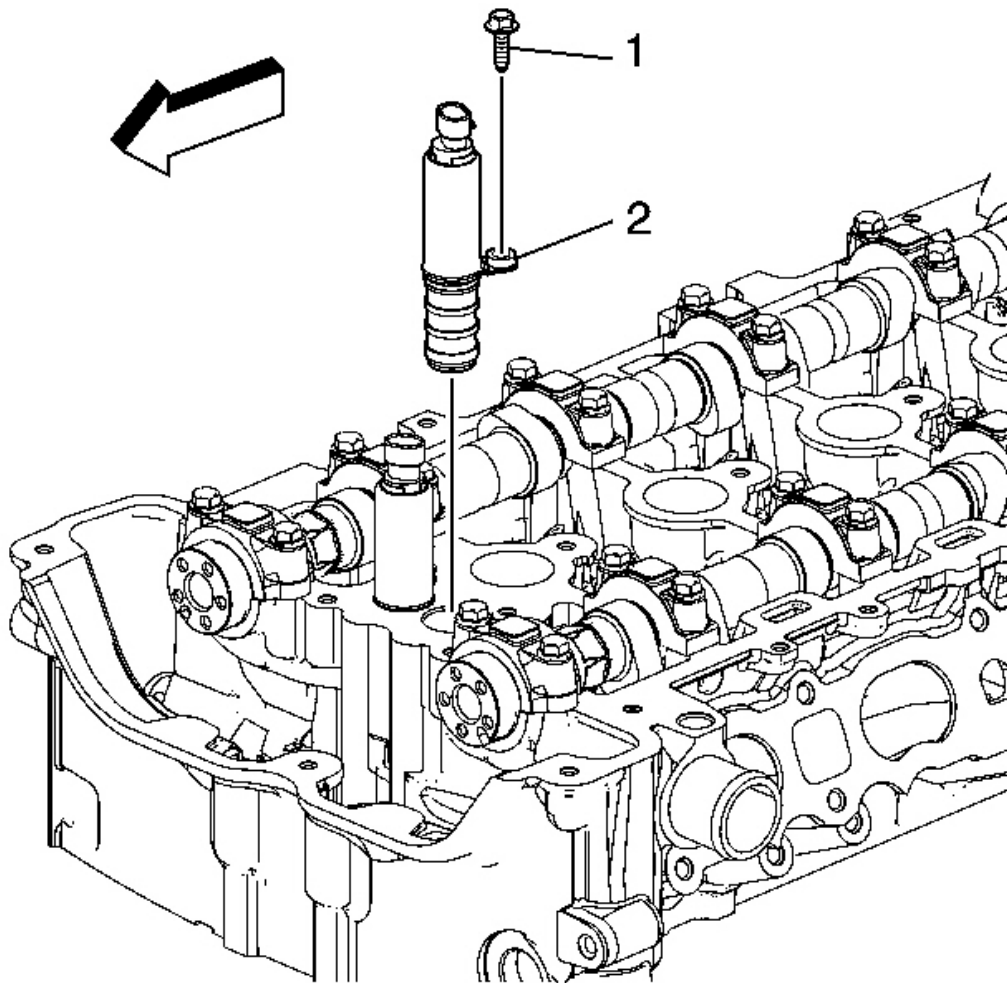


Fig. 451: Intake Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

17. Install the intake camshaft position actuator solenoid valve (2). Tighten the solenoid valve bolt (1) to 10 N.m (89 lb in).

BALANCE SHAFT INSTALLATION

Special Tools

EN-43650: Balance Shaft Bushing Remover/Installer

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

Installation

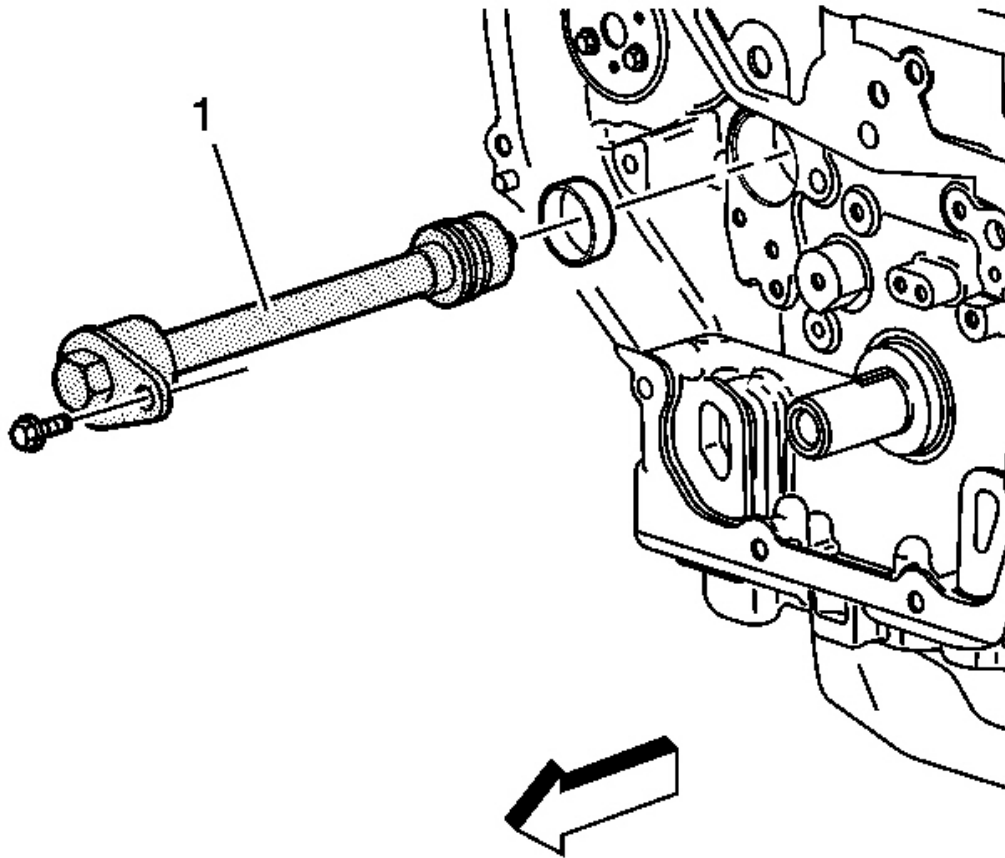


Fig. 452: Installing Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft bushing using the **EN-43650**: installer (1).

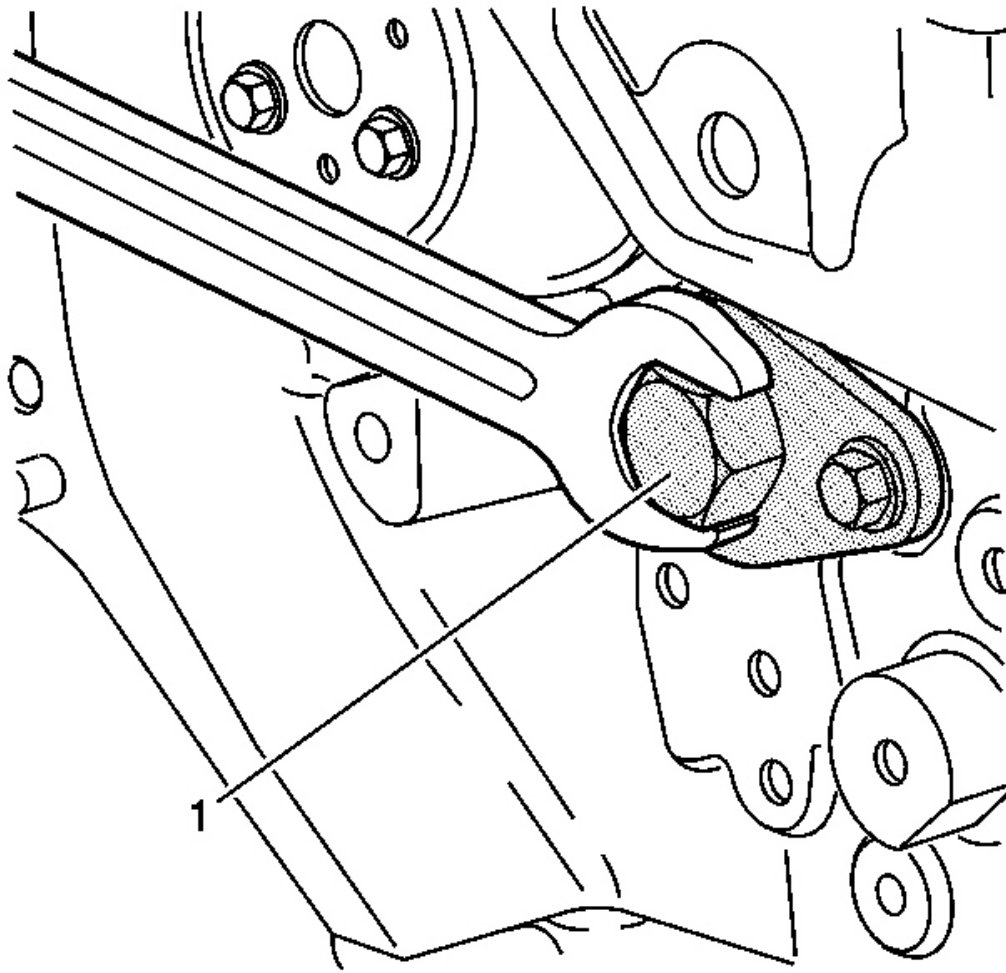


Fig. 453: Seating Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

2. Seat the balance shaft bushing into the bore using the **EN-43650**: installer (1) and a wrench.
3. When the **EN-43650**: installer is fully seated in the engine block, remove it with a wrench.

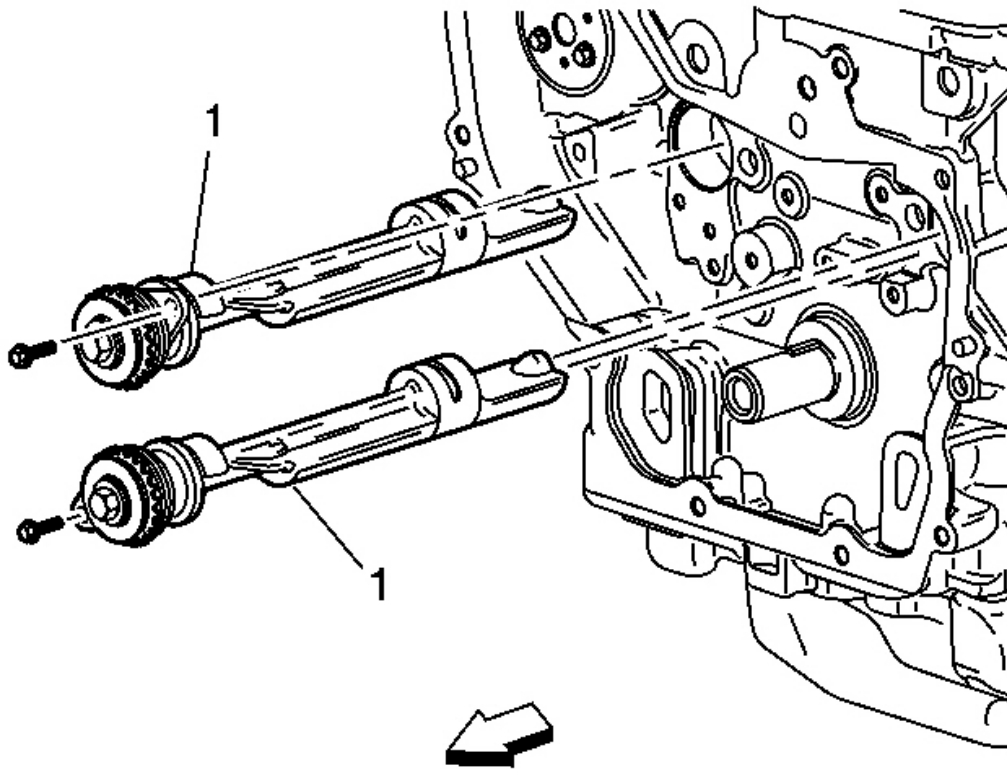


Fig. 454: Balance Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

4. Place the number one piston at top dead center (TDC).
5. Lubricate the balance shaft lobes with engine oil.
6. Install the balance shafts (1) into their bores.

CAUTION: Refer to Fastener Caution .

7. Install the balance shaft retaining bolts and tighten to 10 N.m (89 lb in).

WATER PUMP INSTALLATION

Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to

ensure proper sealing.

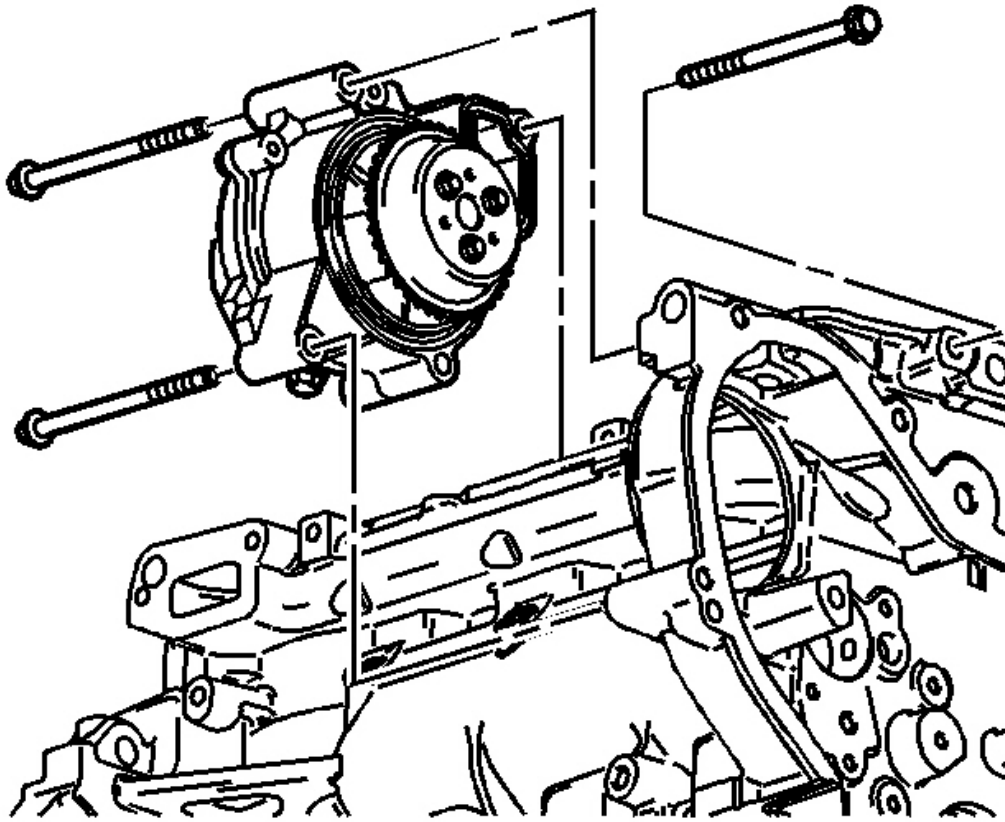


Fig. 455: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump assembly.
2. Install the water pump bolts. Finger tighten the bolts.

CAUTION: Refer to Fastener Caution .

3. Tighten the water pump bolts to 25 N.m (18 lb ft).
4. Apply sealant to the water pump drain plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
5. Install the water pump drain plug, if necessary. Tighten to 20 N.m (15 lb ft).

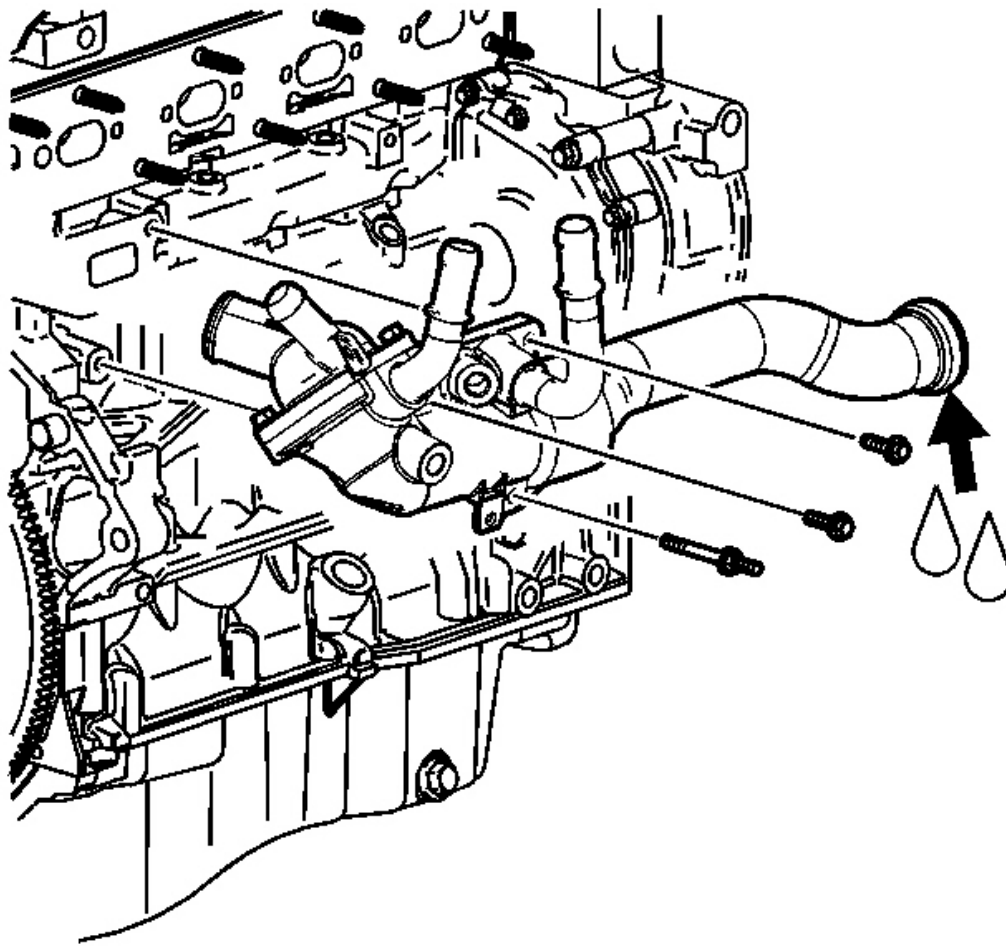


Fig. 456: View Of Water Feed Tube
Courtesy of GENERAL MOTORS CORP.

6. Install the water feed tube.
7. Lubricate the feed tube O-ring with antifreeze.
8. Install the water feed tube by twisting and pushing toward the water pump. Take care not to tear or damage the O-ring.
9. Install the thermostat housing to block bolts and stud and tighten to 10 N.m (89 lb in).

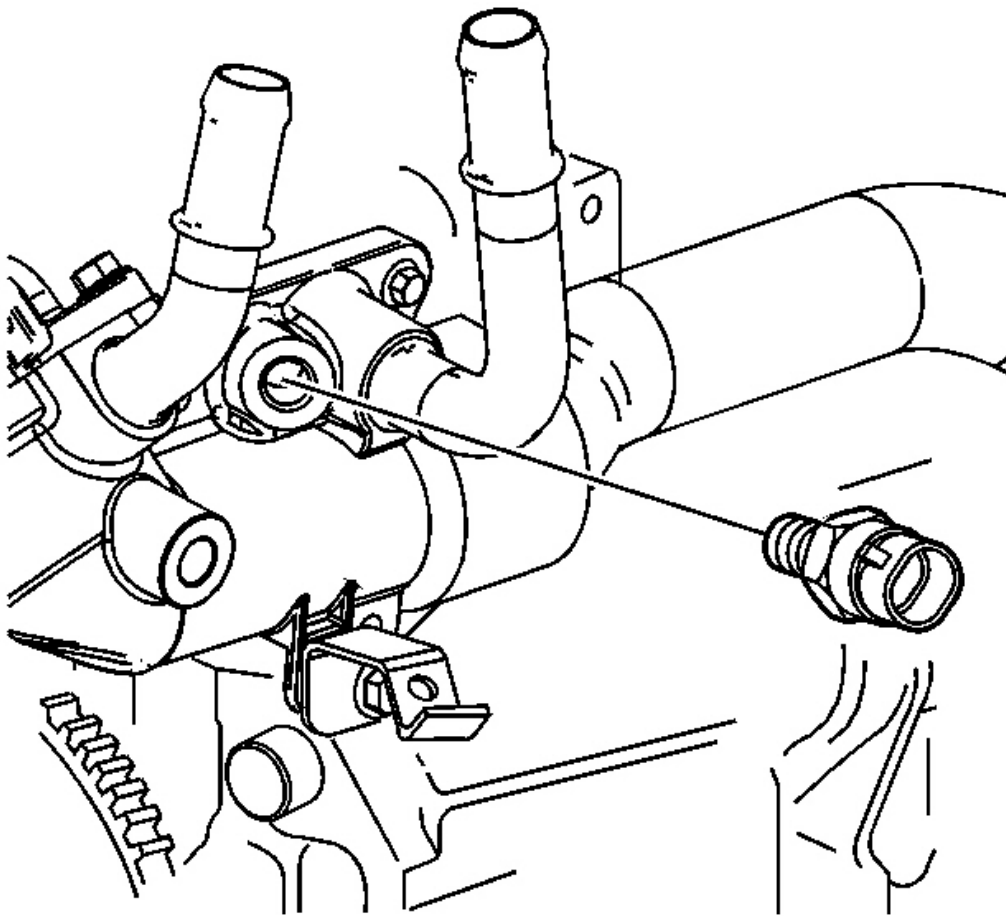


Fig. 457: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the engine coolant temperature sensor by hand.
11. Tighten the engine coolant temperature sensor and tighten to 20 N.m (15 lb ft).

BALANCE SHAFT TO ENGINE TIMING

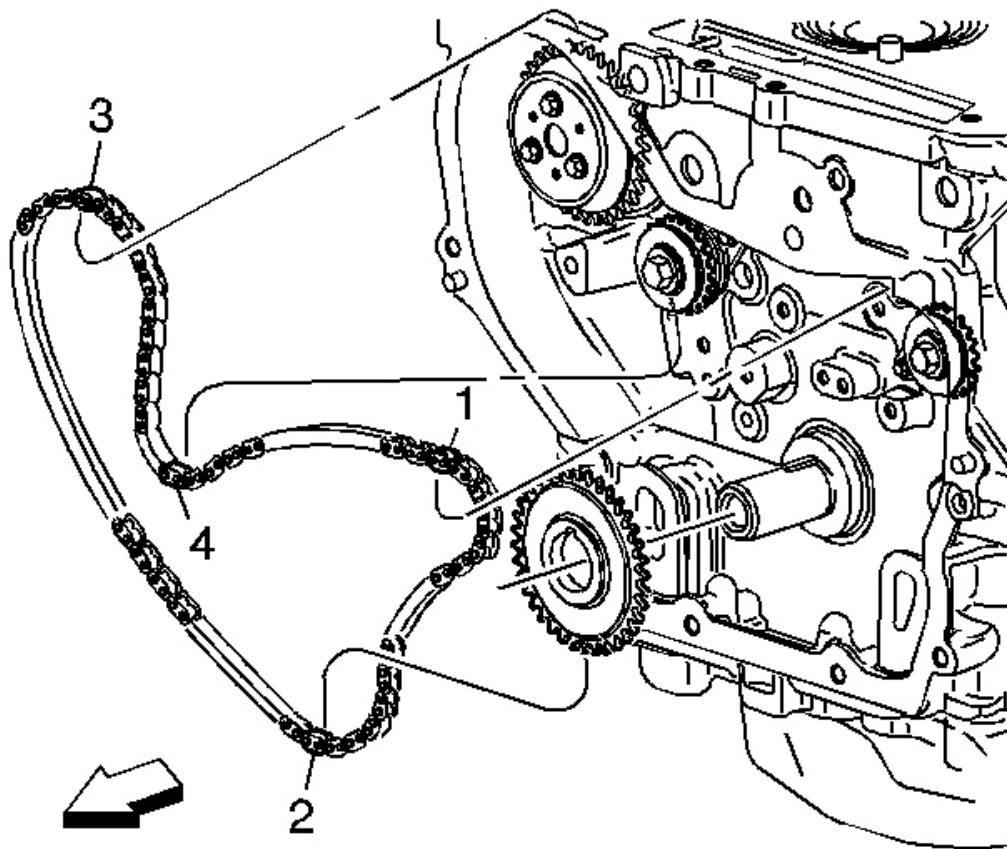


Fig. 458: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft drive sprocket.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three colored links on the chain. Two links are of matching colors, and one link is of a unique color. Use the following procedure to line up the links with the sprockets:

Orient the chain so that the colored links are visible.

3. Place the uniquely colored link (1) so that it lines up with the timing mark on the intake side balance shaft sprocket.

4. Working clockwise around the chain, place the first matching colored link (2) in line with the timing mark on the crankshaft drive sprocket. (approximately 6 o'clock position on the crank sprocket)
5. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
6. Align the last matching colored link (4) with the timing mark on the exhaust side balance shaft drive sprocket.

WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER INSTALLATION

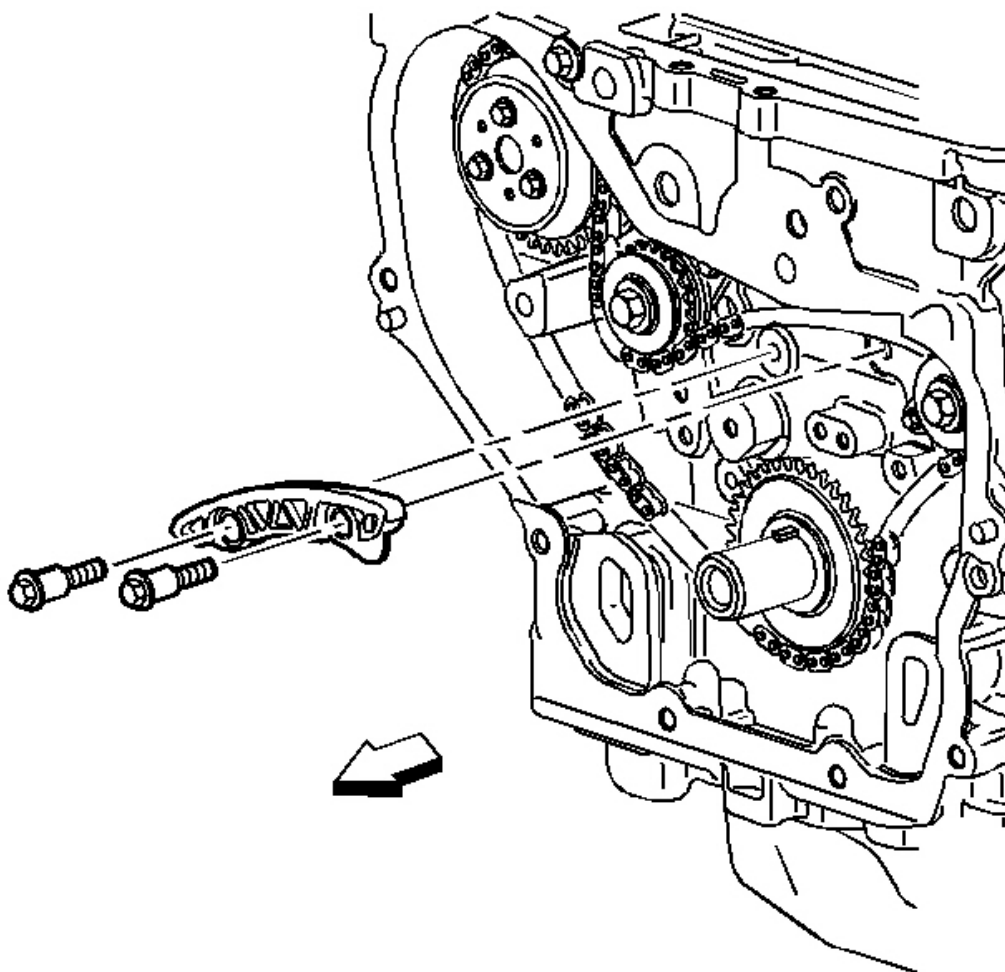


Fig. 459: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: If the balance shafts are not properly timed to the engine, the engine may vibrate and make noise.

1. Install the upper balance shaft chain guide and bolts and tighten to 15 N.m (11 lb ft).

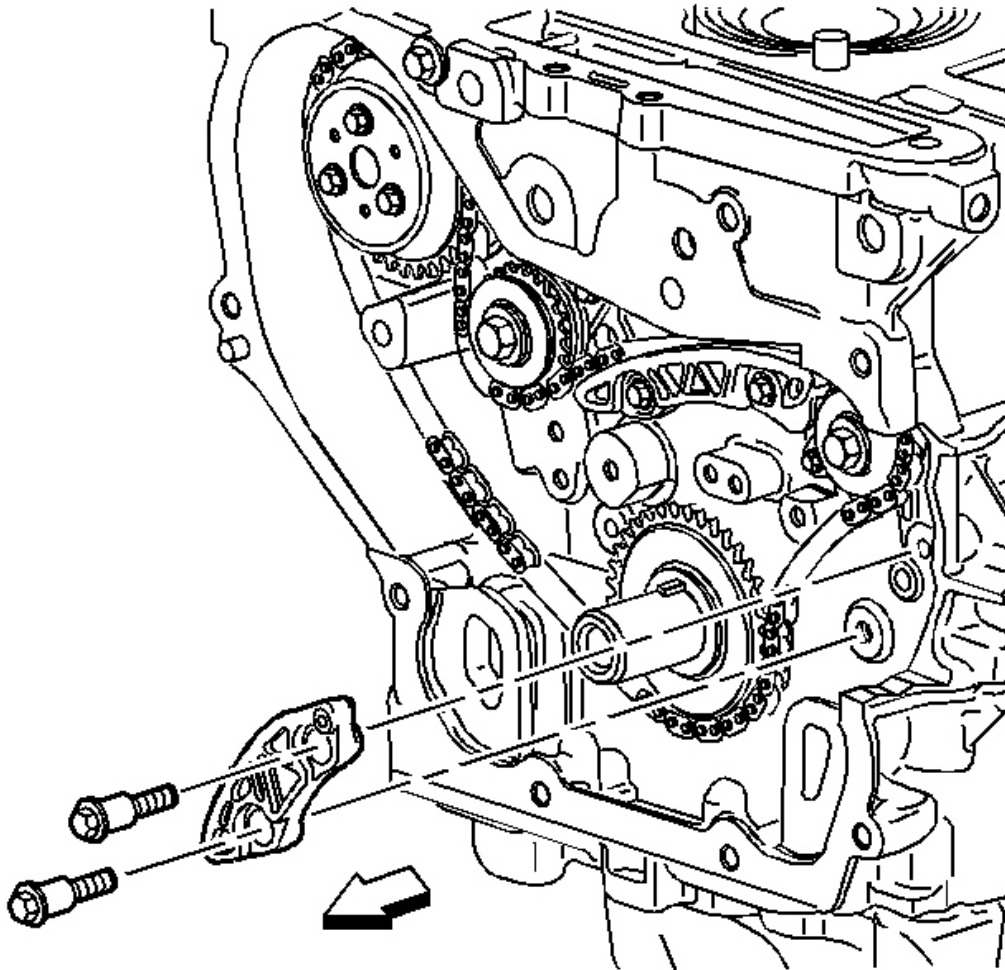


Fig. 460: View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts and tighten to 15 N.m (11 lb ft).

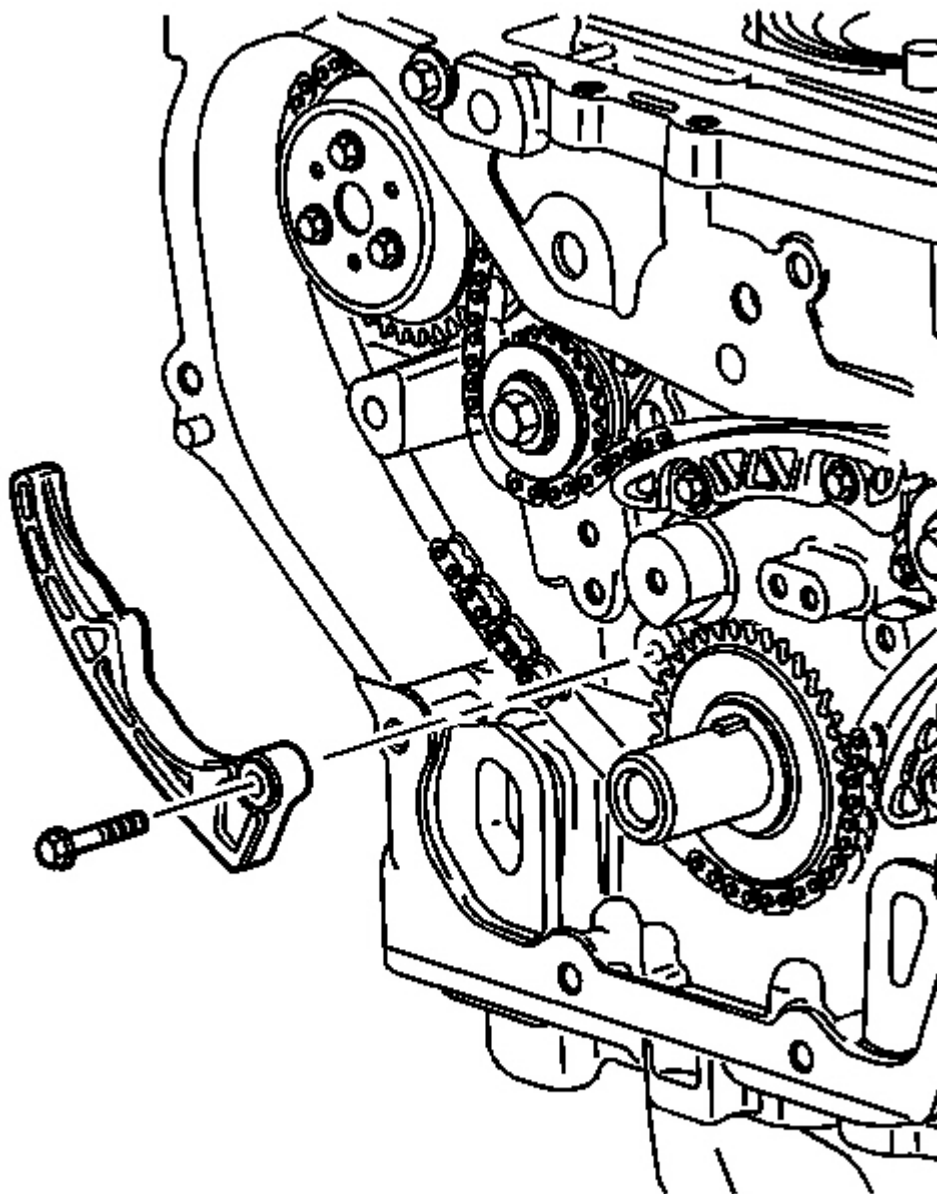


Fig. 461: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the adjustable balance shaft drive chain guide.
5. Install the adjustable balance shaft drive chain guide bolts and tighten to 10 N.m (89 lb in).

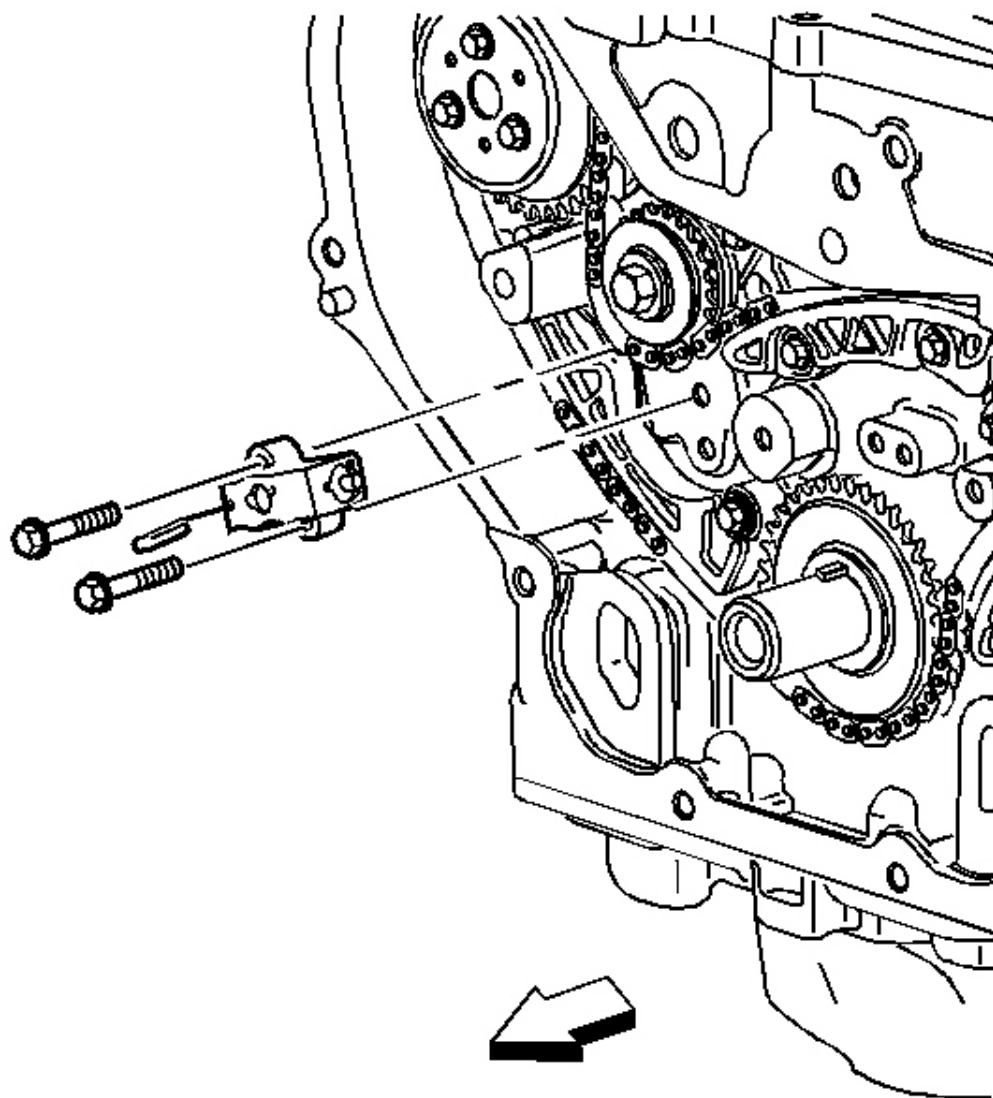


Fig. 462: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Reset the timing chain tensioner by performing the following steps:
 1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.
 2. Turn the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hole in the tensioner plunger.
7. Install the timing chain tensioner.

8. Install the chain tensioner bolts and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER INSTALLATION

Special Tools

- **EN-45027:** Tensioner Tool
- **EN 45059:** Angle Meter
- **EN-48953:** Camshaft Actuator Locking Tool

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

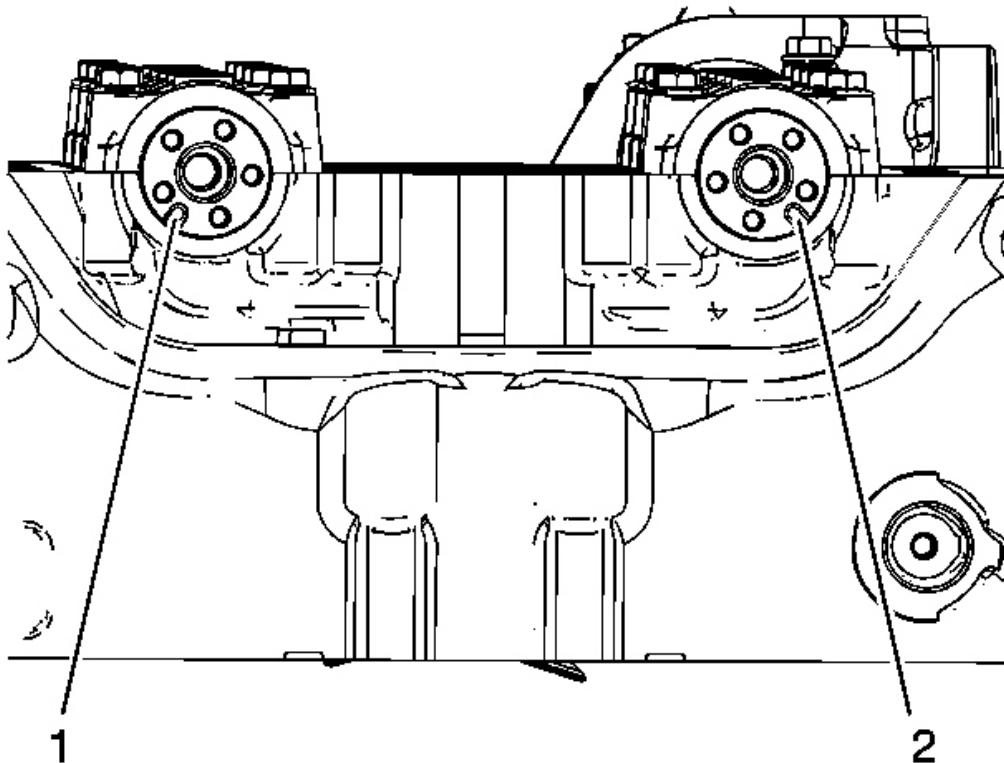


Fig. 463: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

1. Ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

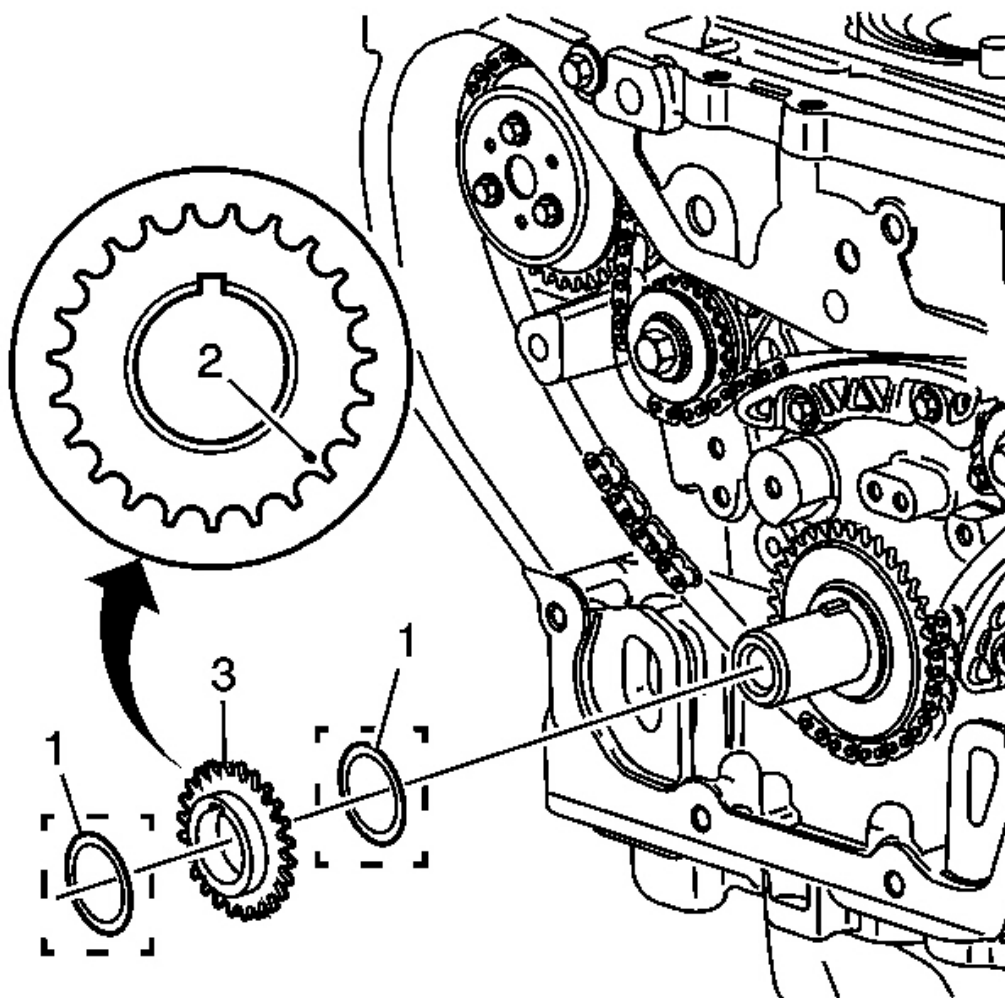


Fig. 464: Identifying Friction Washer, Timing Chain Drive Sprocket & Timing Mark
Courtesy of GENERAL MOTORS CORP.

2. Install a friction washer (1), if equipped.
3. Install the timing chain drive sprocket (3) to the crankshaft with the timing mark (2) in the 5 o'clock position and the front of the sprocket facing out.
4. Install a second friction washer (1), if equipped.

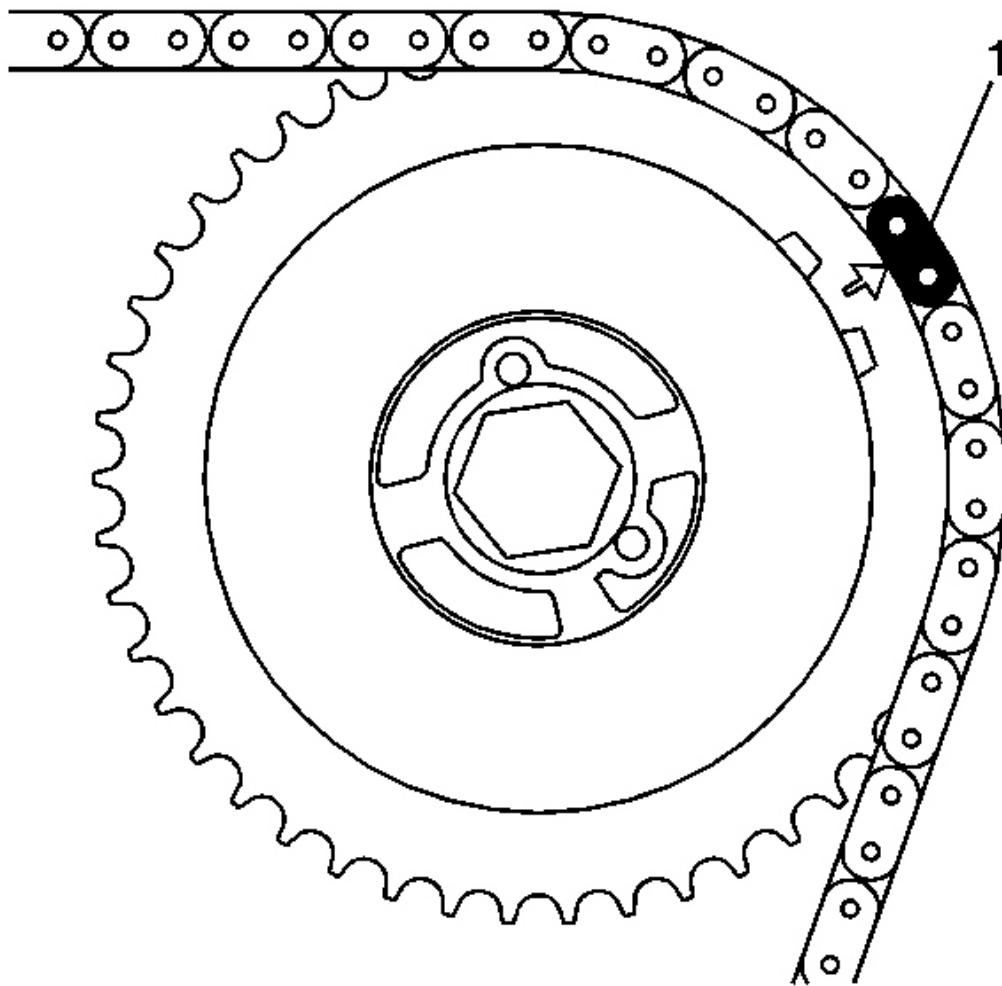


Fig. 465: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: There are three colored links on the timing chain. Two links are of matching color, and one link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

5. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).

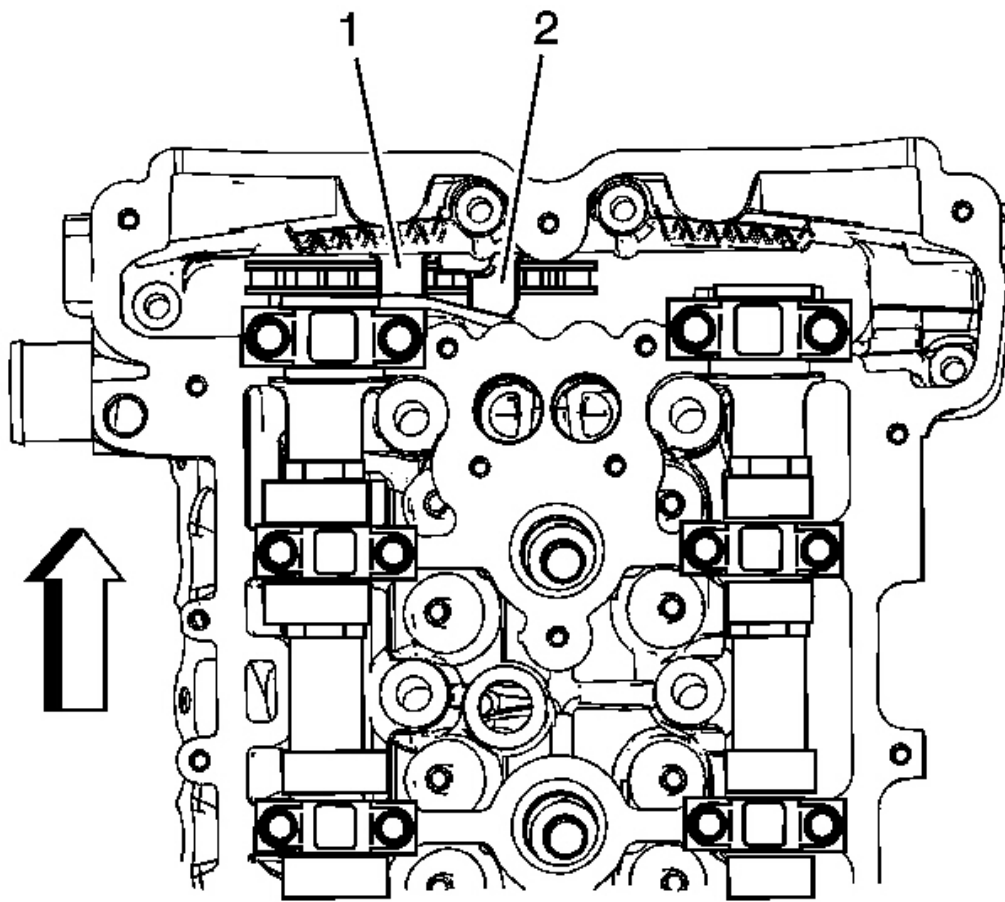


Fig. 466: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

6. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).
7. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.

NOTE: **Always use NEW actuator bolts.**

8. Hand tighten the new intake camshaft actuator bolt.

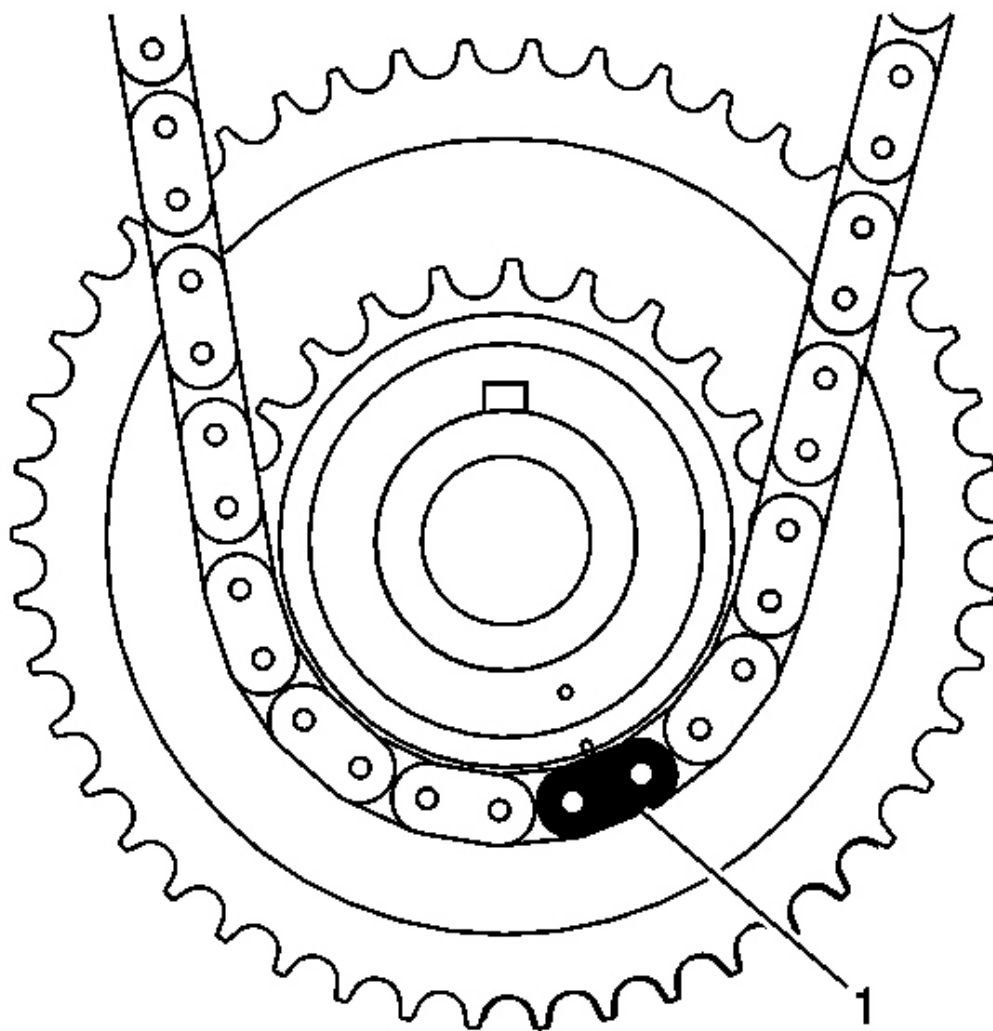


Fig. 467: Matching Colored Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

9. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (1) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

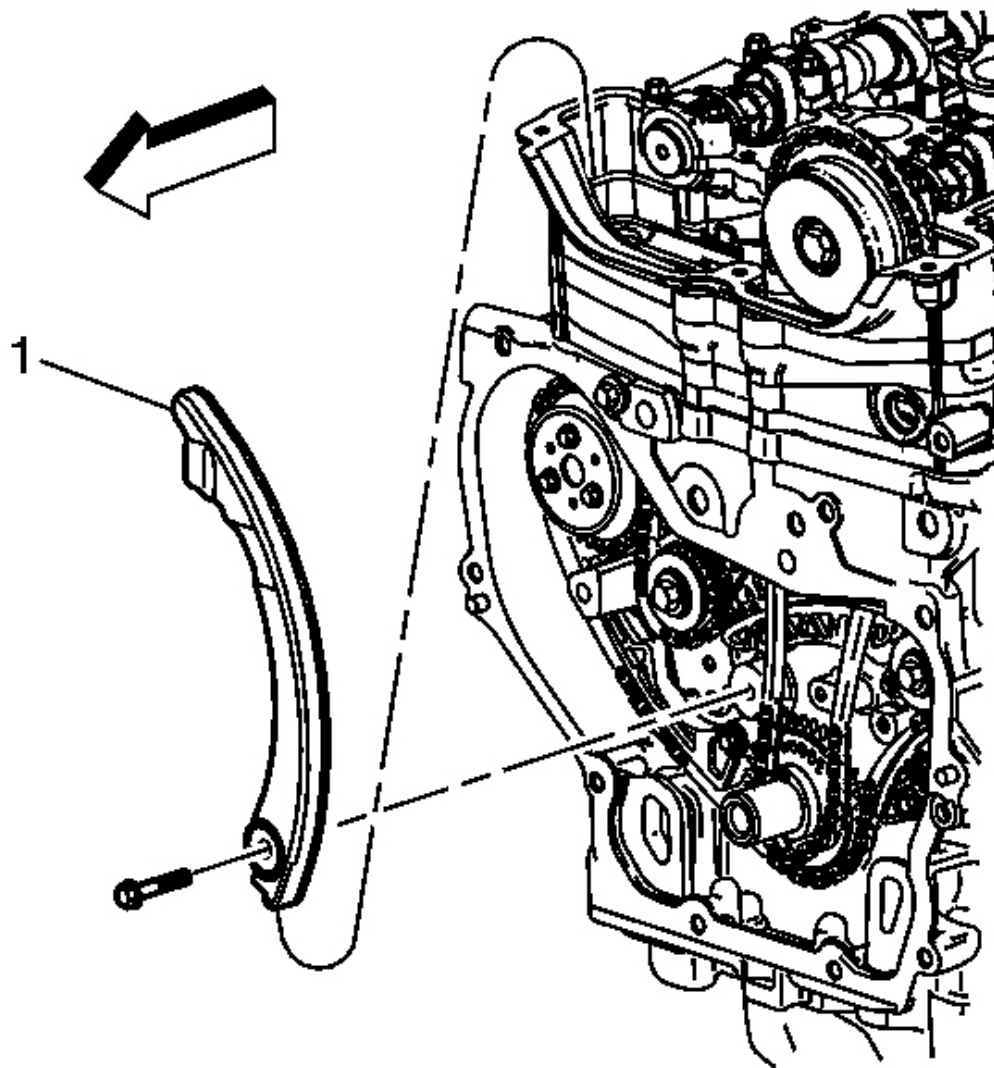


Fig. 468: Adjustable Timing Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

10. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.

CAUTION: Refer to Fastener Caution .

11. Install the adjustable timing chain guide (1) down through the opening in the cylinder head and install the

adjustable timing chain bolt and tighten to 10 N.m (89 lb in).

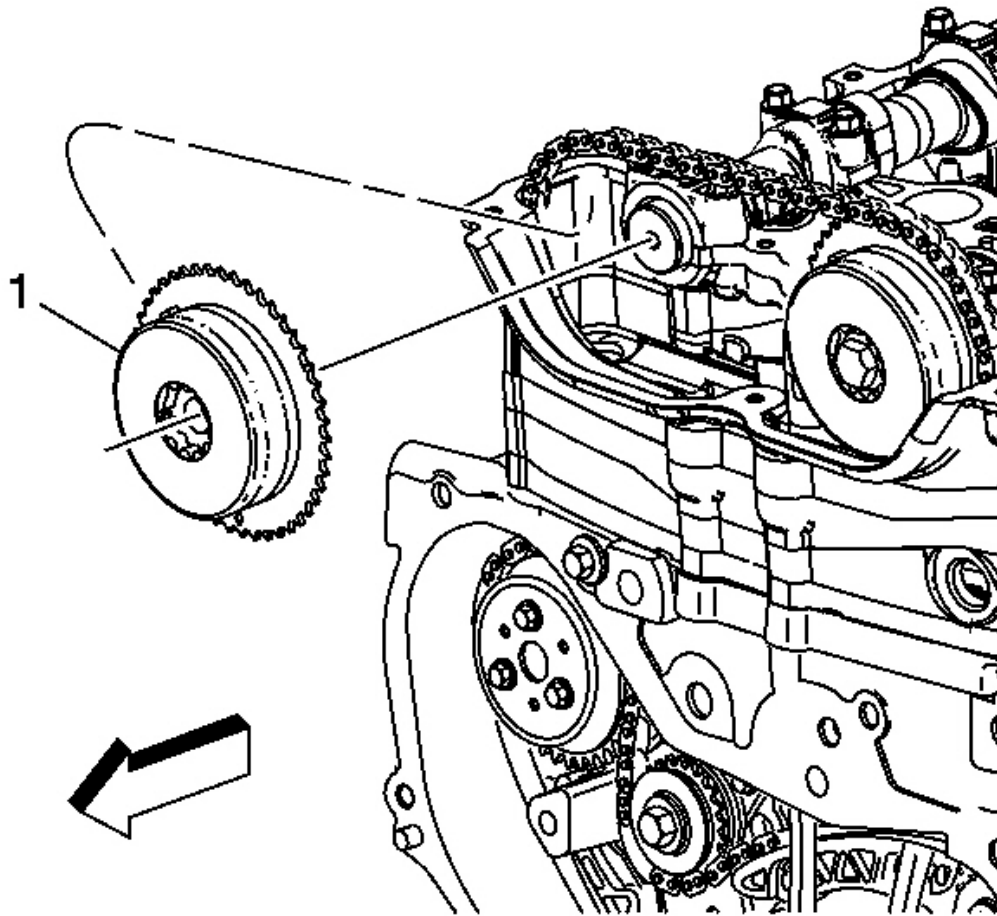


Fig. 469: View of Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

12. Install the exhaust camshaft actuator (1) into the timing chain with the timing mark lined up with the second matching colored link.

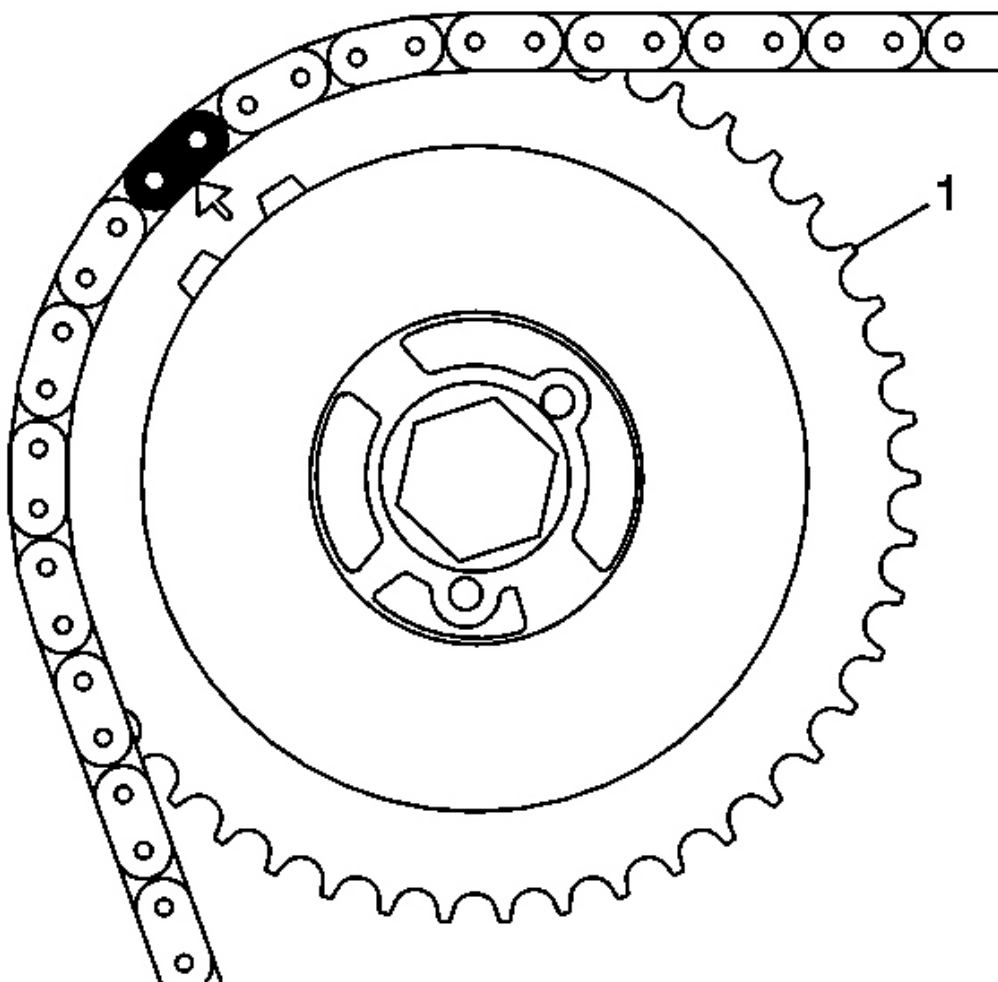


Fig. 470: Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install NEW actuator bolts.

13. Install the exhaust camshaft actuator (1) onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
14. Using a 23-24 mm open end wrench, rotate the exhaust camshaft clockwise until the dowel pin in the camshaft actuator goes into the camshaft slot.

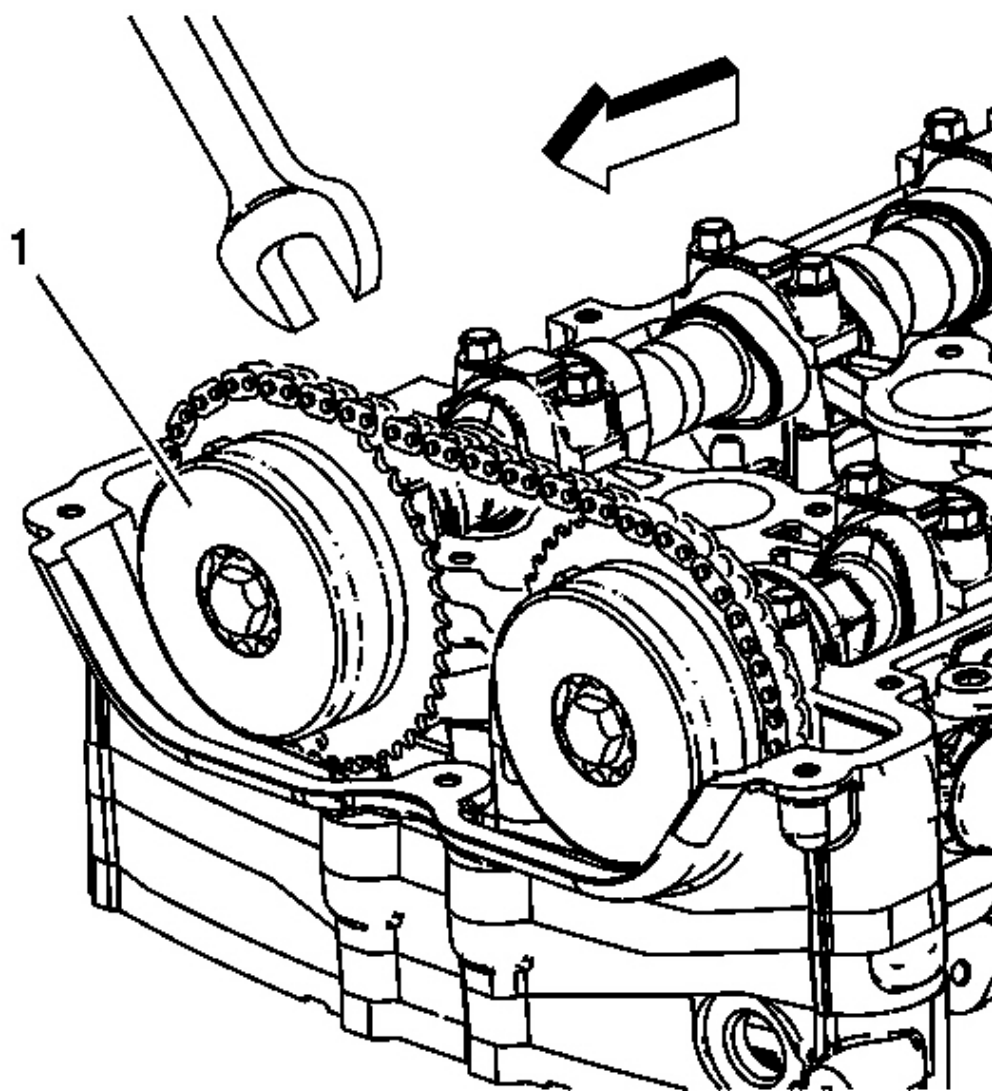


Fig. 471: View of Actuator

Courtesy of GENERAL MOTORS CORP.

15. When the actuator (1) seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.
16. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not, repeat the portion of the procedure necessary to align the timing marks.

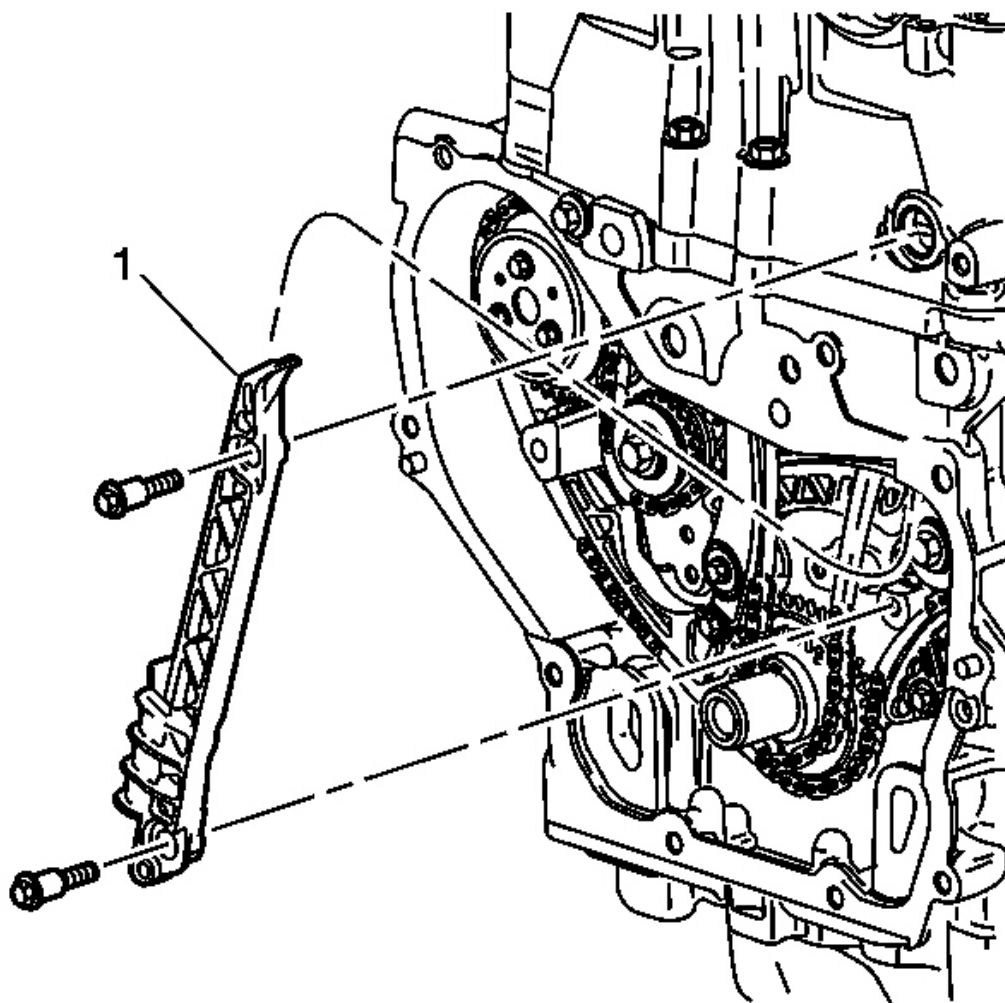


Fig. 472: View of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

17. Install the fixed timing chain guide (1) and bolts and tighten to 12 N.m (106 lb in).

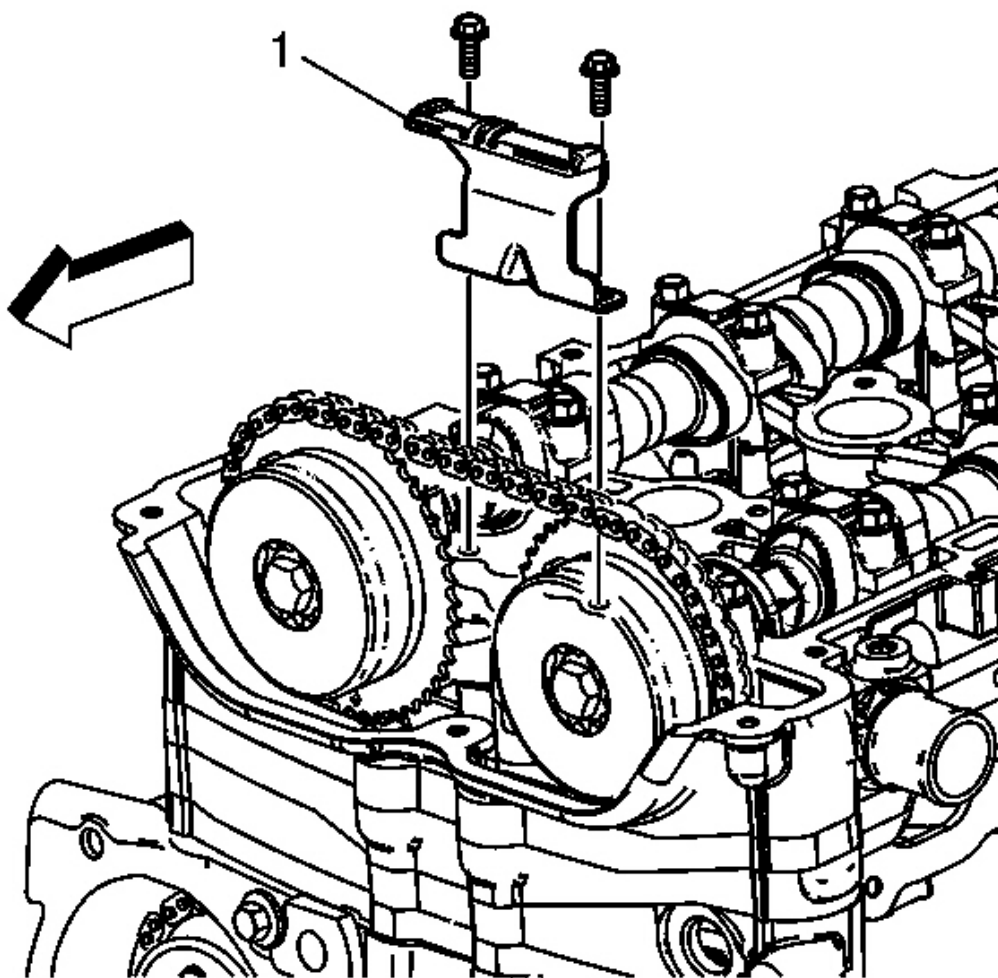


Fig. 473: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

18. Install the upper timing chain guide (1) and bolts and tighten to 10 N.m (89 lb in).

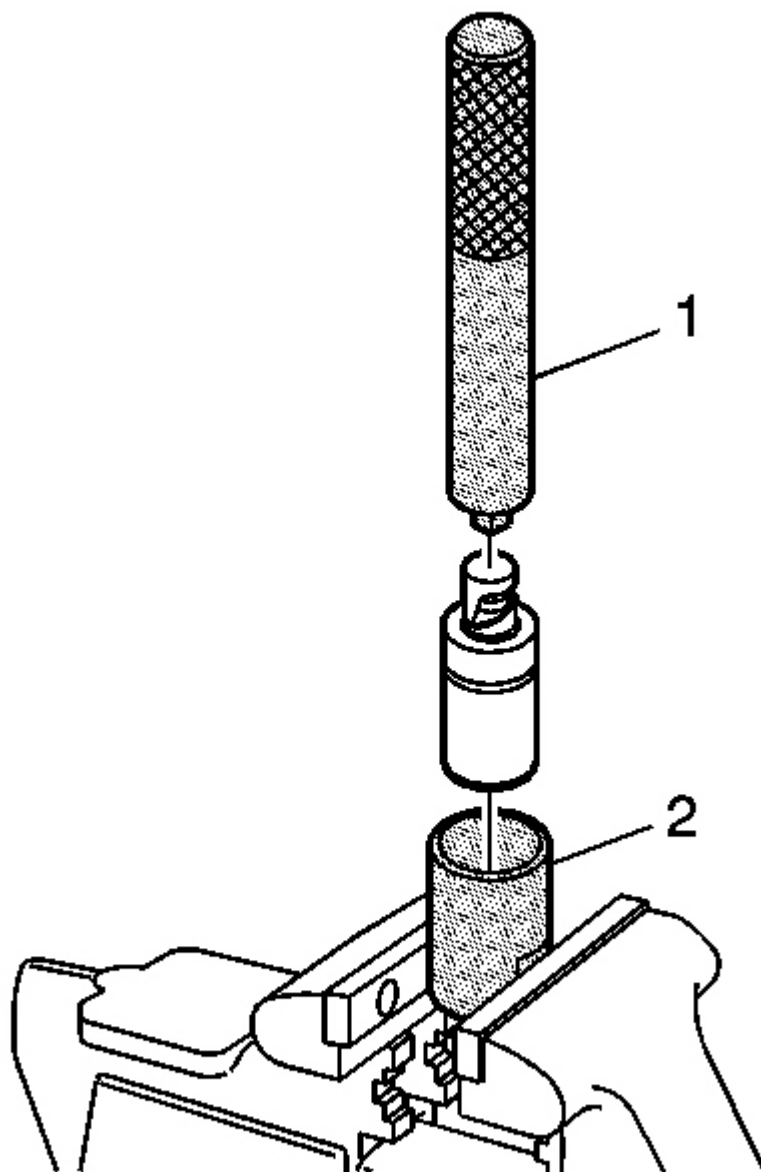


Fig. 474: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

19. Reset the timing chain tensioner by performing the following steps:
 1. Remove the snap ring.
 2. Remove the piston assembly from the body of the timing chain tensioner.

3. Install the **EN-45027-2 (2)**: tensioner into a vise.
4. Install the notch end of the piston assembly into the **EN-45027-2 (2)**: tensioner .
5. Using the **EN-45027-1 (1)**: tensioner , turn the ratchet cylinder into the piston.
6. Reinstall the piston assembly into the body of the tensioner.
7. Install the snap ring.

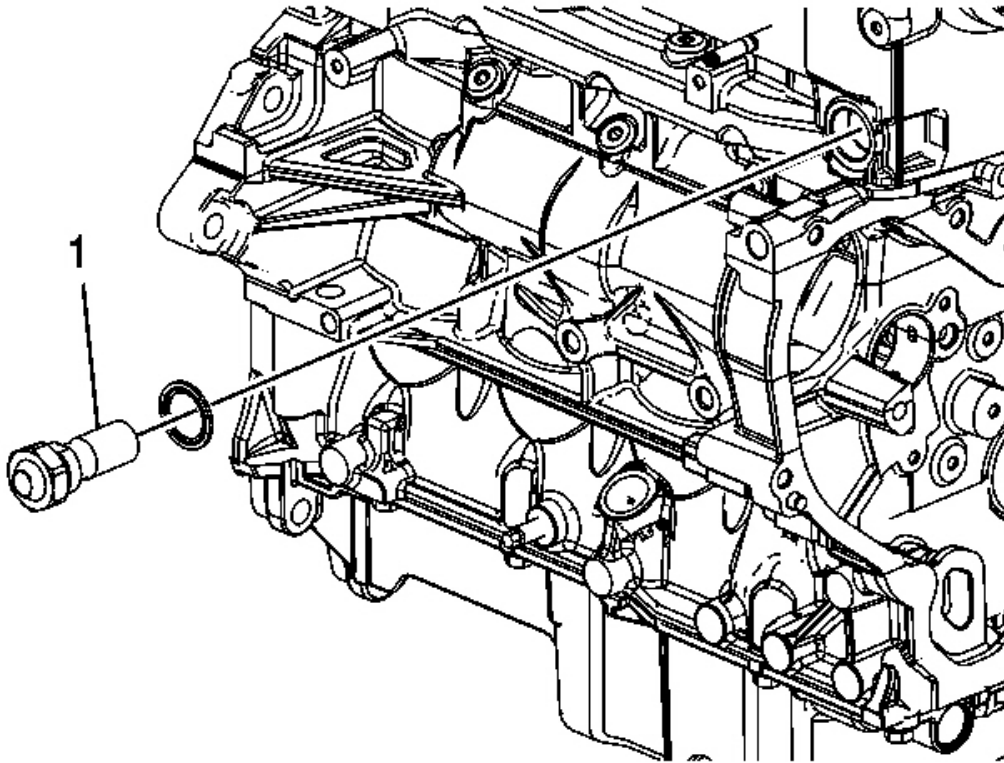


Fig. 475: Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

20. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
21. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

NOTE: **Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.**

22. Install the timing chain tensioner assembly (1) and tighten to 75 N.m (55 lb ft).

NOTE: The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet.

23. The crankshaft balancer must be installed in order to release the tensioner. Refer to **Crankshaft Balancer Installation**.

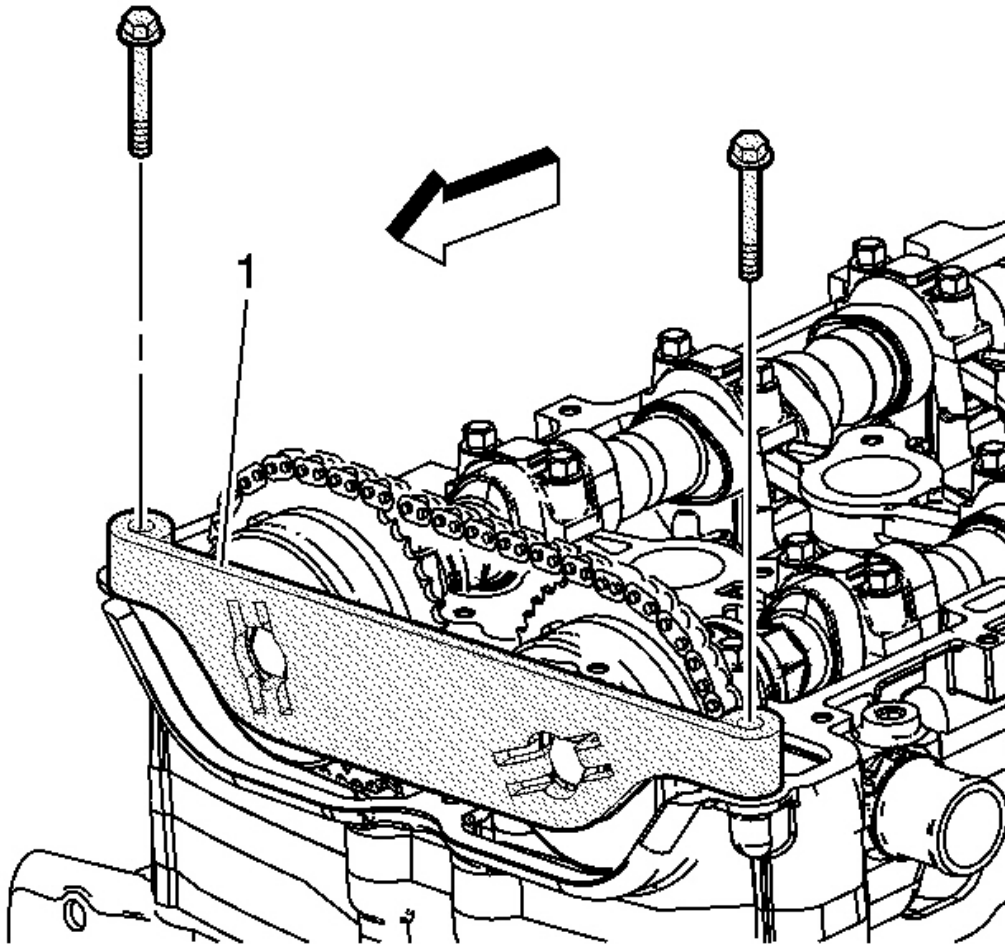


Fig. 476: View Locking Tool
Courtesy of GENERAL MOTORS CORP.

24. Install **EN-48953**: locking tool (1) and tighten the bolts into the cylinder head to 10 N.m (89 lb in).
25. Using a torque wrench, tighten the intake camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **EN 45059**: meter.
26. Using a torque wrench, tighten the exhaust camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **EN 45059**: meter.

27. Remove **EN-48953**: locking tool.

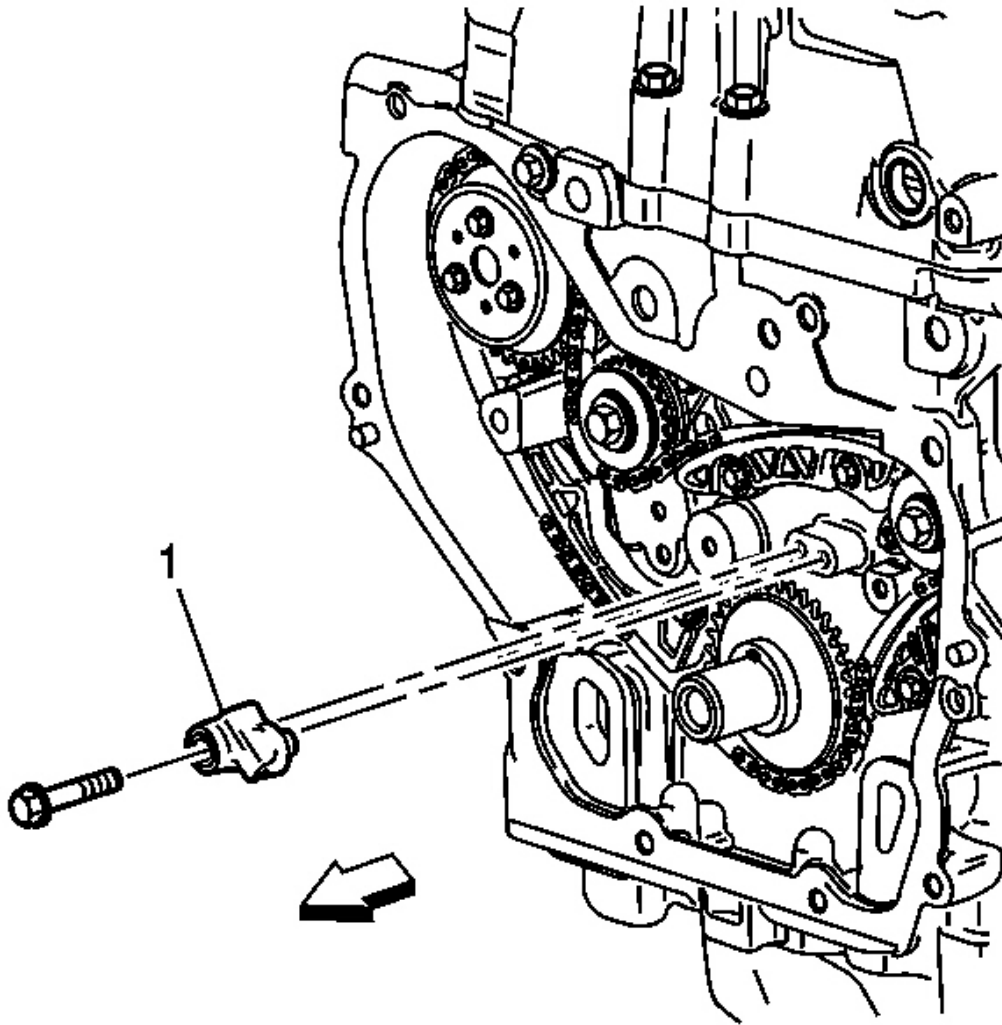


Fig. 477: View of Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

28. Install the timing chain oiling nozzle (1) and tighten the bolt to 10 N.m (89 lb in).

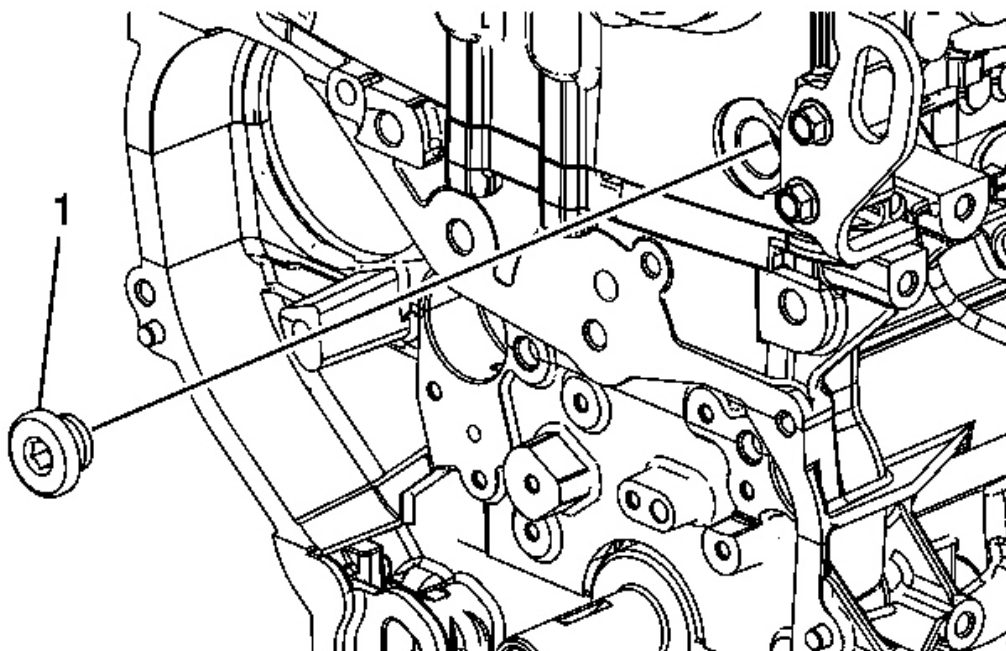


Fig. 478: View of timing Chain Guide Bolt Access Hole Plug
Courtesy of GENERAL MOTORS CORP.

29. Apply sealant to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
30. Install the timing chain guide bolt access hole plug (1) and tighten to 90 N.m (66 lb ft).

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

J 35268-A Camshaft/Front Main Seal Installer

Installation

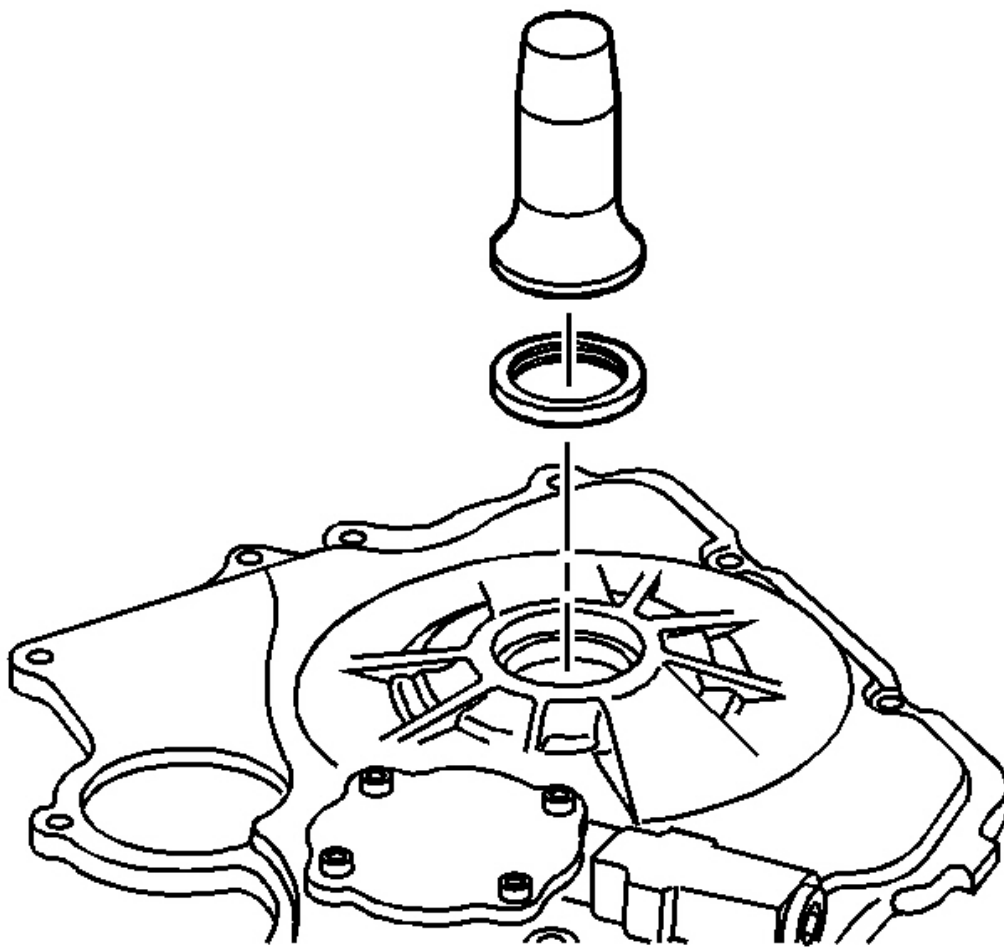


Fig. 479: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the seal into the front cover by driving it in from the timing chain side using **J 35268-A** .
2. Ensure that the engine front cover is properly supported when installing the seal.

ENGINE FRONT COVER AND OIL PUMP INSTALLATION

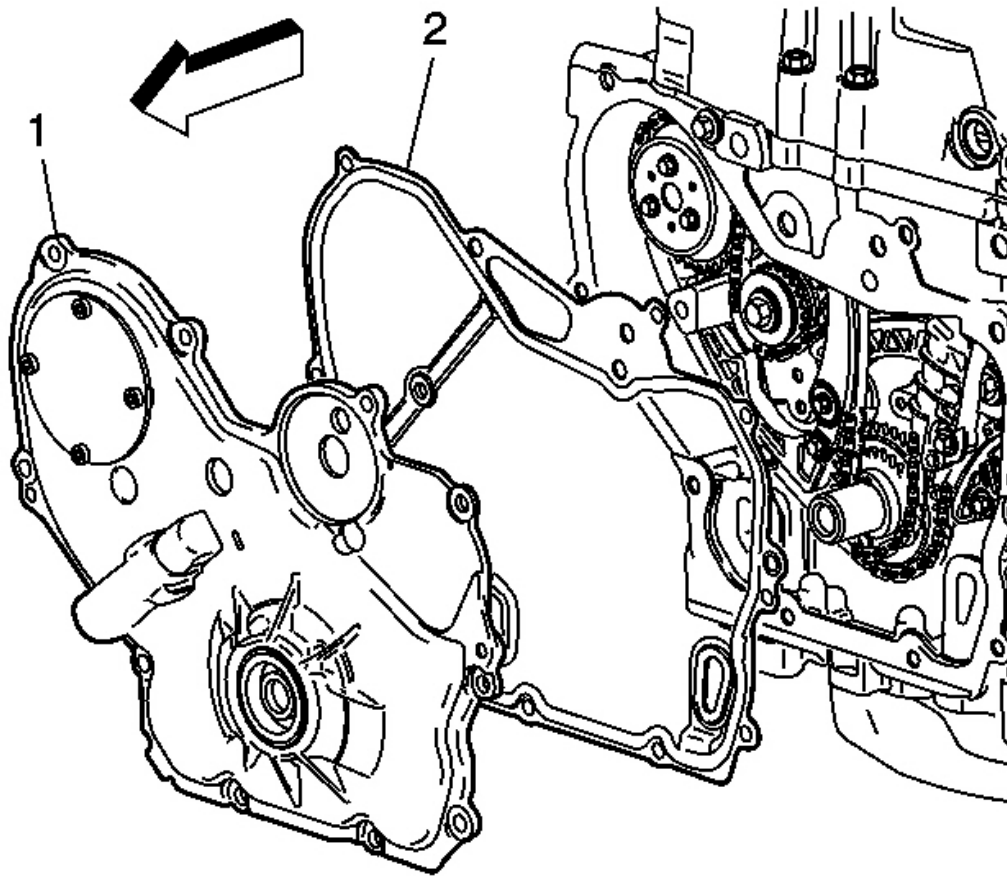


Fig. 480: Engine Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover (1) with a new gasket (2).

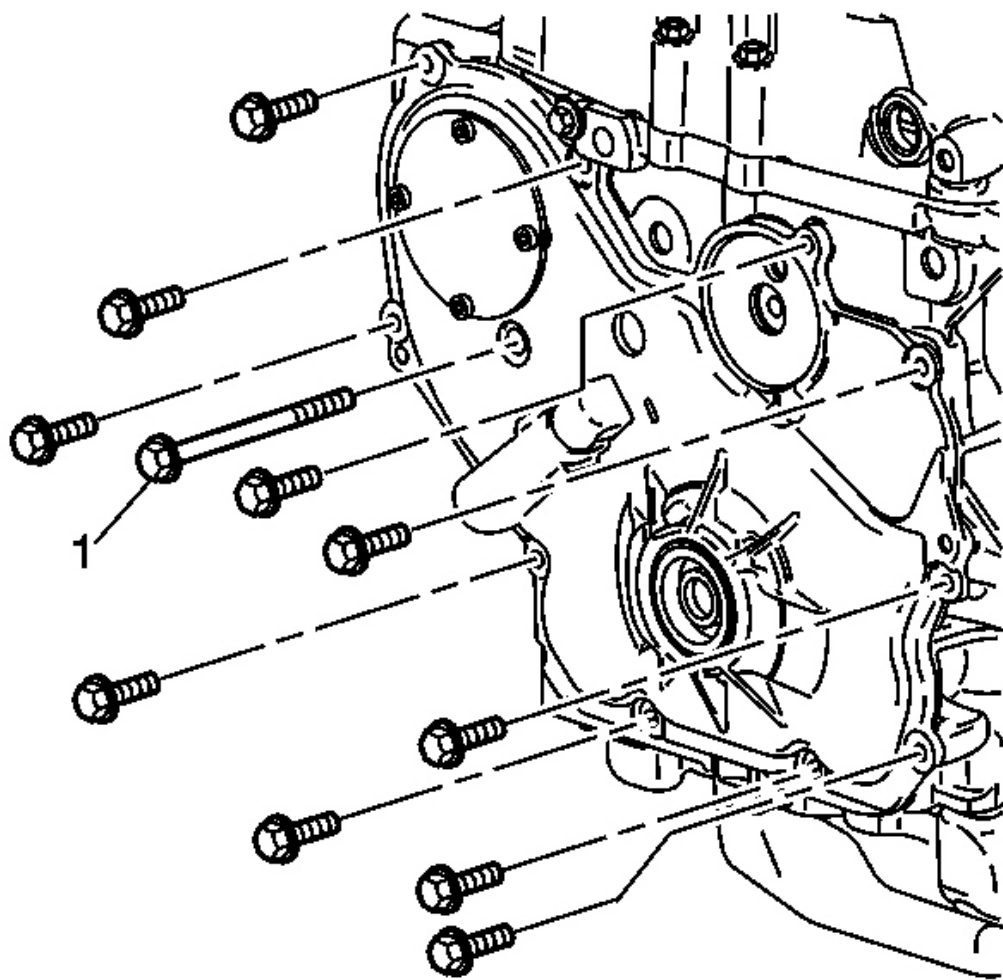


Fig. 481: Engine Front Cover Bolts & Long Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: The center bolt (1) should be tightened last.

2. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
3. Install the long water pump bolt (1) and tighten to 25 N.m (18 lb ft).

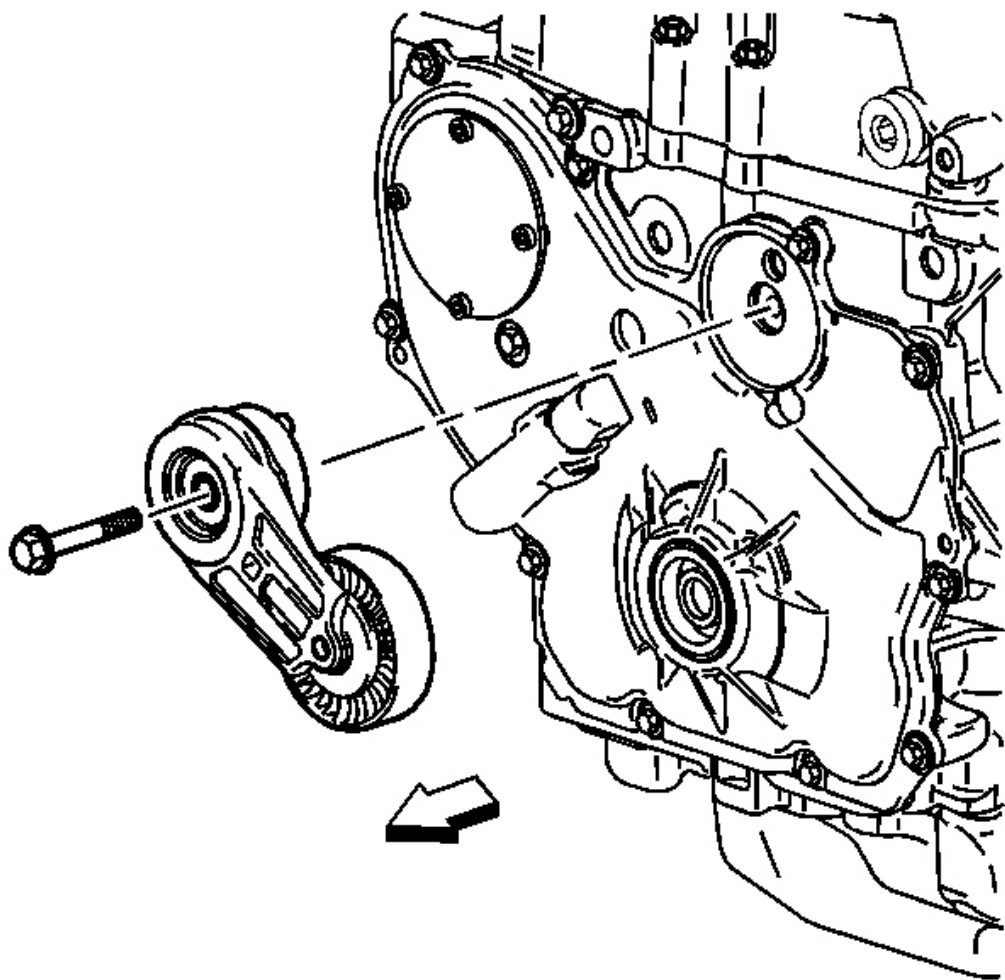


Fig. 482: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install the accessory drive belt tensioner.
5. Install the accessory drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).

OIL PAN INSTALLATION

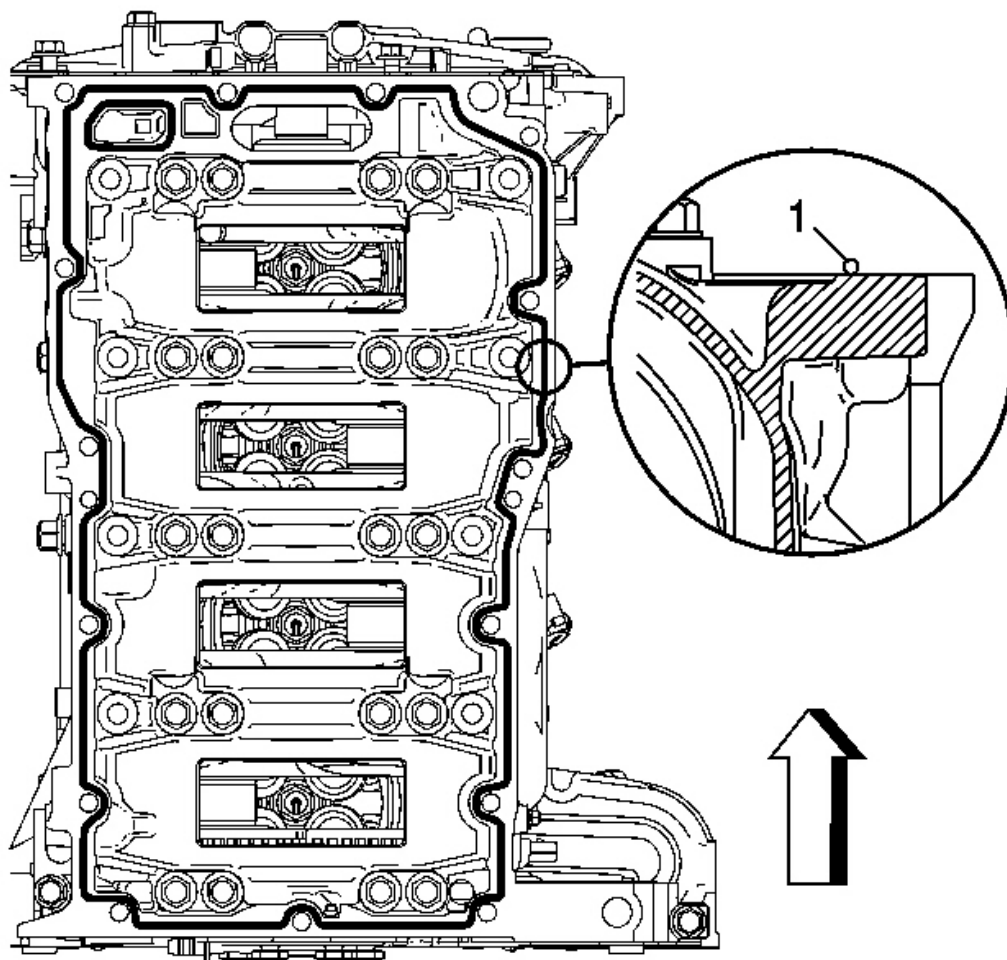


Fig. 483: Applying Sealer To Oil Pan
Courtesy of GENERAL MOTORS CORP.

NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 20 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

1. Apply a 2.25 mm bead of sealer (1) on the level part of the flange next to the chamfer around the perimeter of the oil pan and the oil suction port opening. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

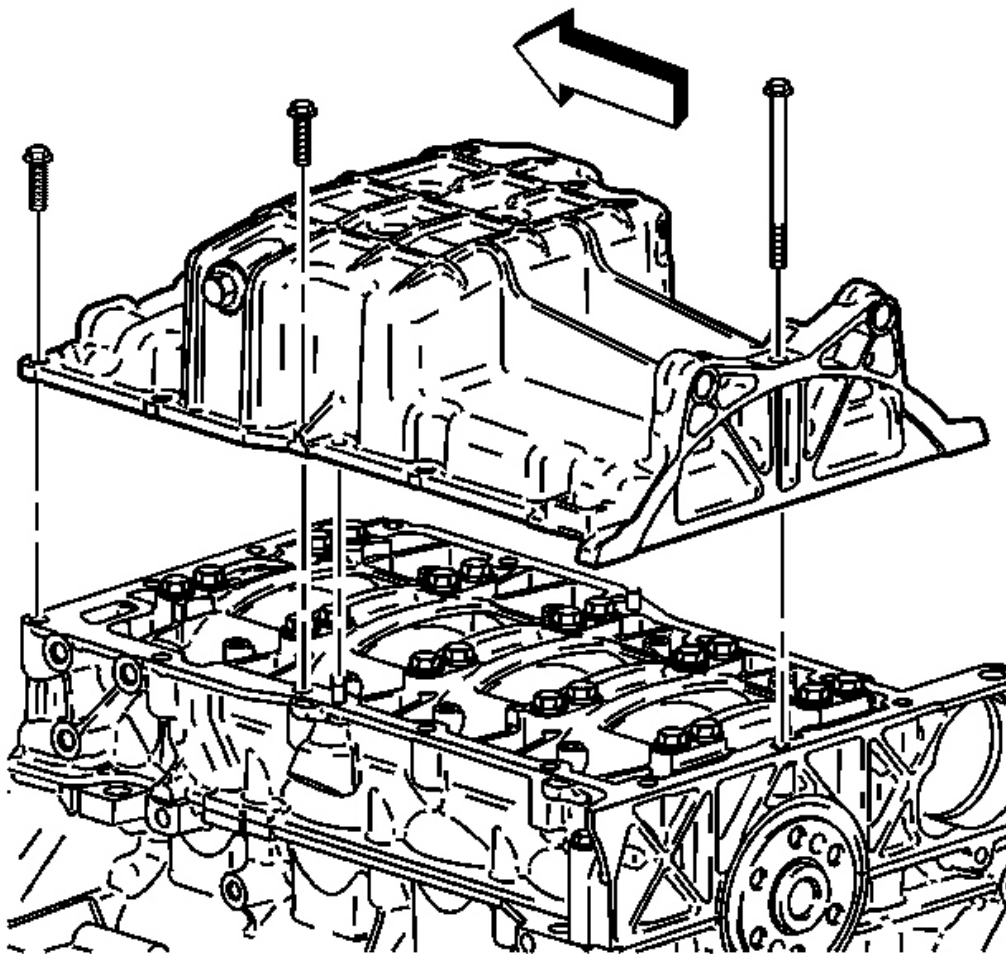


Fig. 484: Installing Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pan.

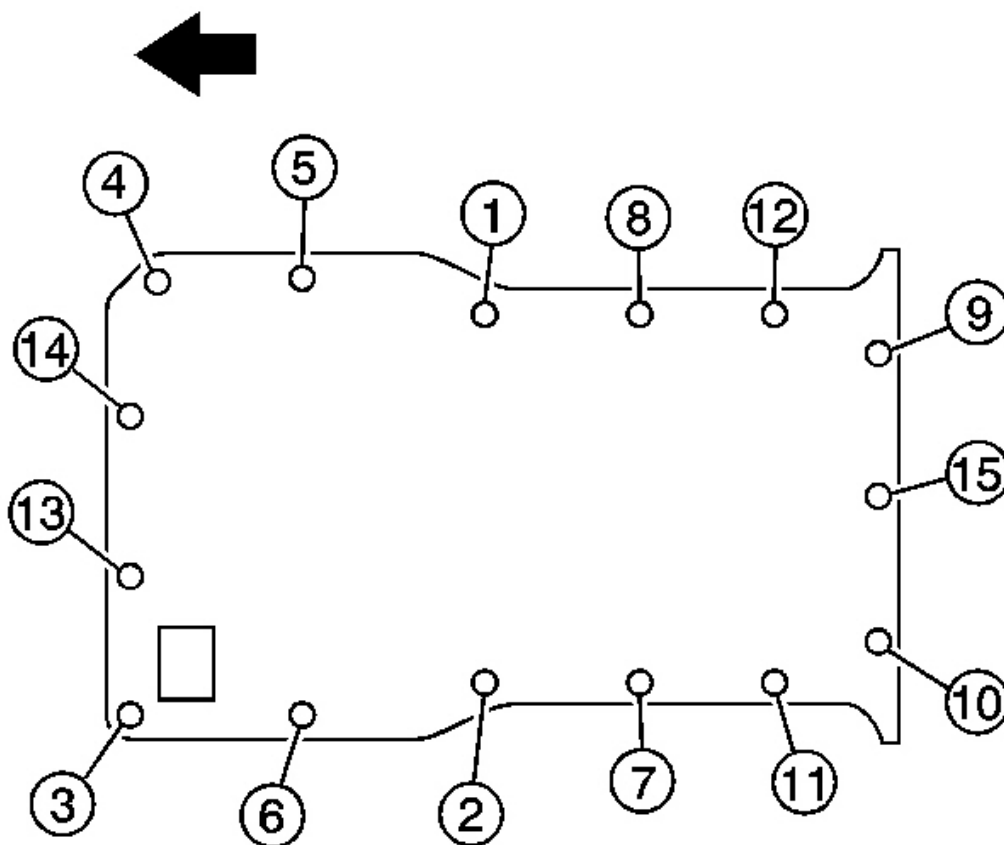


Fig. 485: Identifying Oil Pan Bolt Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the oil pan bolts and tighten to 25 N.m (18 lb ft) in sequence.

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **EN-48585:** Crankshaft Balancer Guide
- **EN-48953:** Camshaft Actuator Locking Tool
- **EN 38112-A:** Crankshaft Balancer Holder

- **EN 43653:** Flywheel Holding Tool
- **EN 45059:** Angle Meter

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

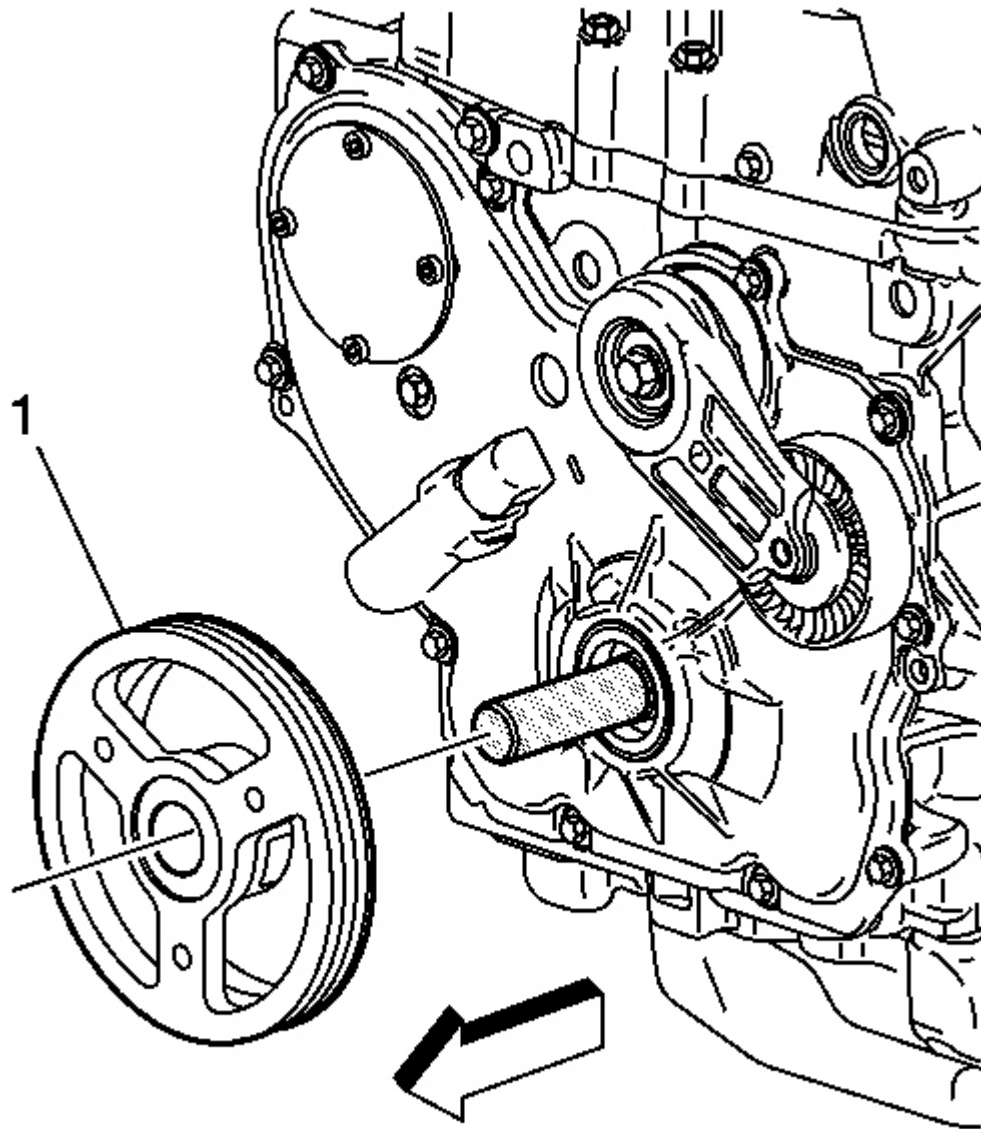


Fig. 486: Identifying Balancer
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the **EN 38112-A:** holder into the end of the crankshaft.
2. Install the balancer (1) onto the **EN-48585:** guide. Use care to properly align the keyway and flats on the balancer with the oil pump drive.

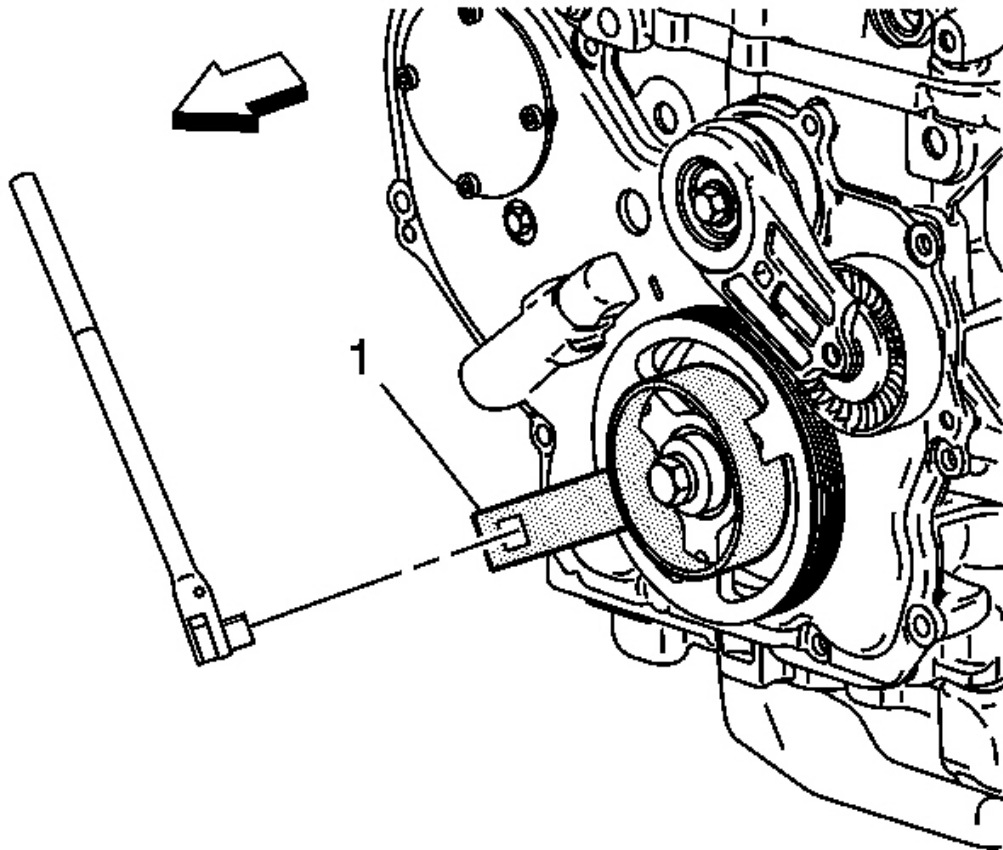


Fig. 487: Identifying J 38122-A
Courtesy of GENERAL MOTORS CORP.

NOTE: EN 43653: locking tool may be used instead of EN 38112-A: holder to prevent crankshaft rotation.

3. Install the **EN 38112-A:** holder (1).

CAUTION: Refer to Fastener Caution .

NOTE: Always install a new crankshaft balancer retaining bolt and washer.

4. Install a new retaining bolt and washer. Use the **EN 38112-A:** holder and a breaker bar to prevent the crankshaft from rotating when tightening the bolt. Tighten the bolt to 100 N.m (74 lb ft) plus 125 degrees using the **EN 45059:** meter.

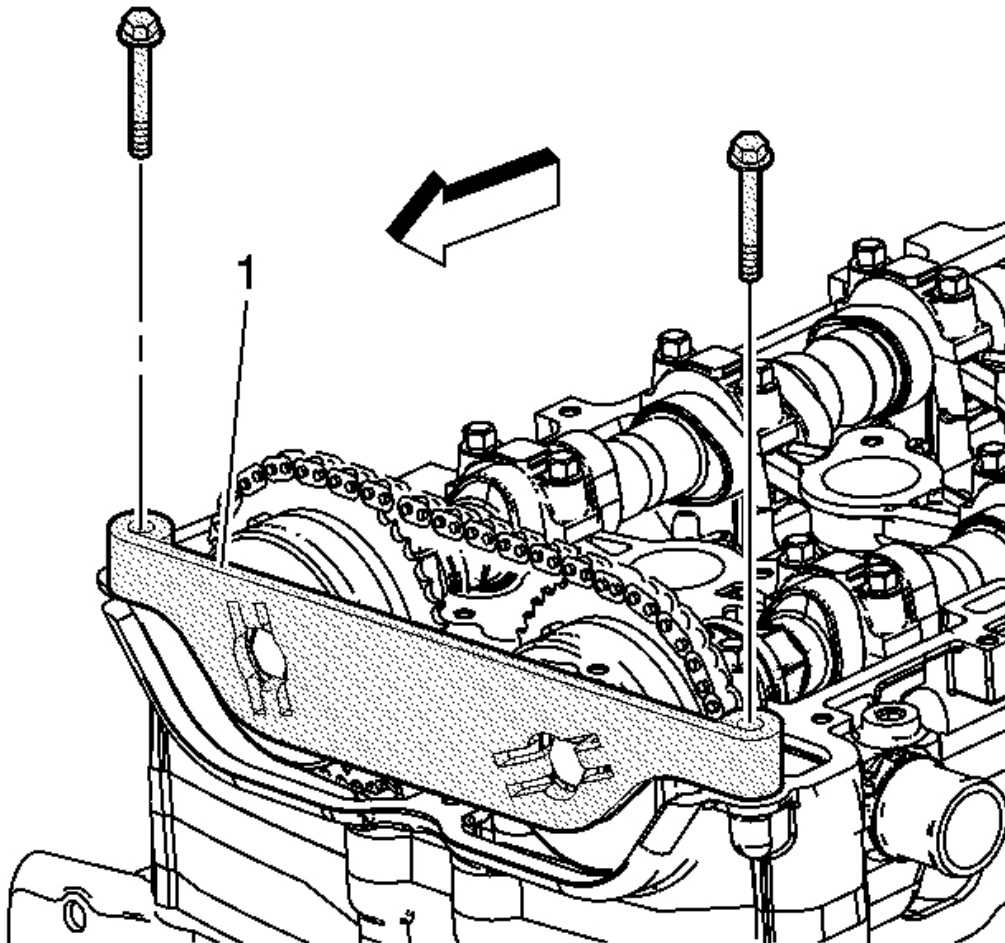


Fig. 488: View Locking Tool

Courtesy of GENERAL MOTORS CORP.

5. Install the **EN-48953:** locking tool (1) and tighten the bolts into the cylinder head. Tighten the **EN-48953:** locking tool retaining bolts to 10 N.m (89 lb in).

6. Release the timing chain tensioner by applying 45 N.m (33 lb ft) counterclockwise torque to the crankshaft balancer bolt.
7. Remove the **EN-48953**: locking tool.

CAMSHAFT COVER INSTALLATION

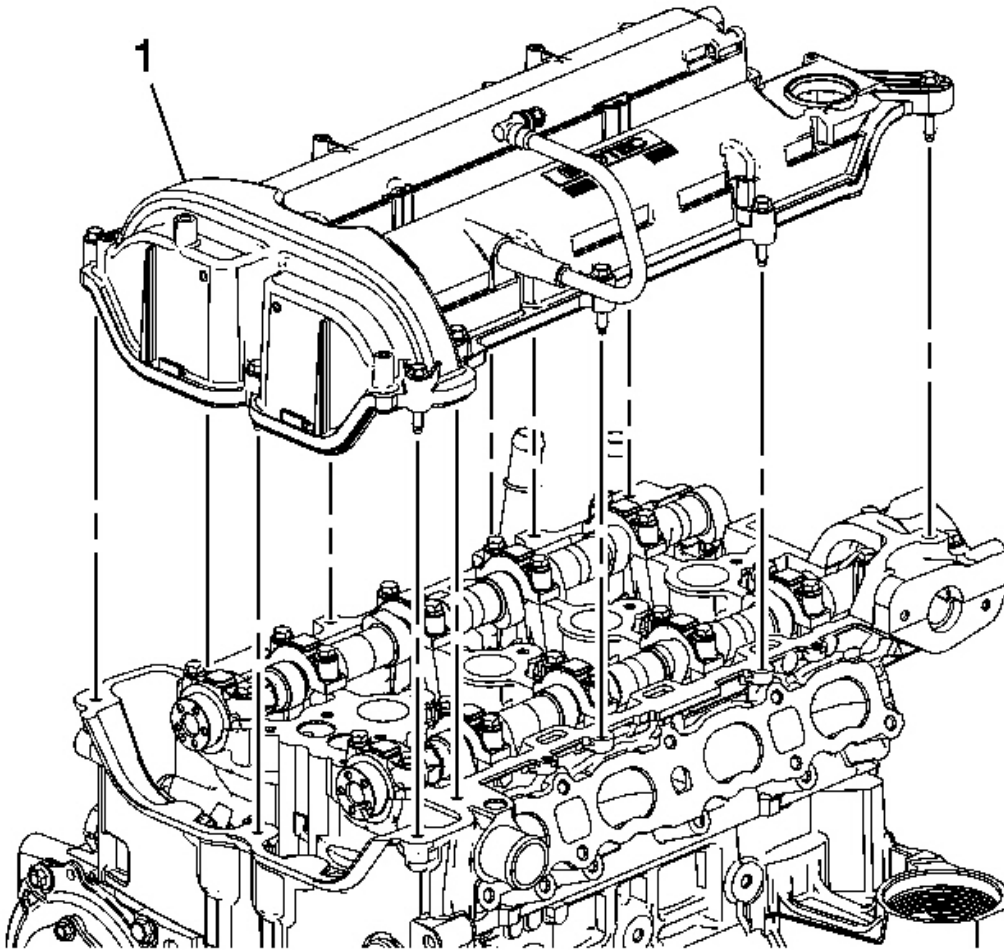


Fig. 489: Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install NEW camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.
2. Assemble the camshaft cover (1) and a NEW gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

CAUTION: Refer to Fastener Caution .

3. Install the cover on the cylinder head and hand start the bolts. Tighten the bolts to 10 N.m (89 lb in).

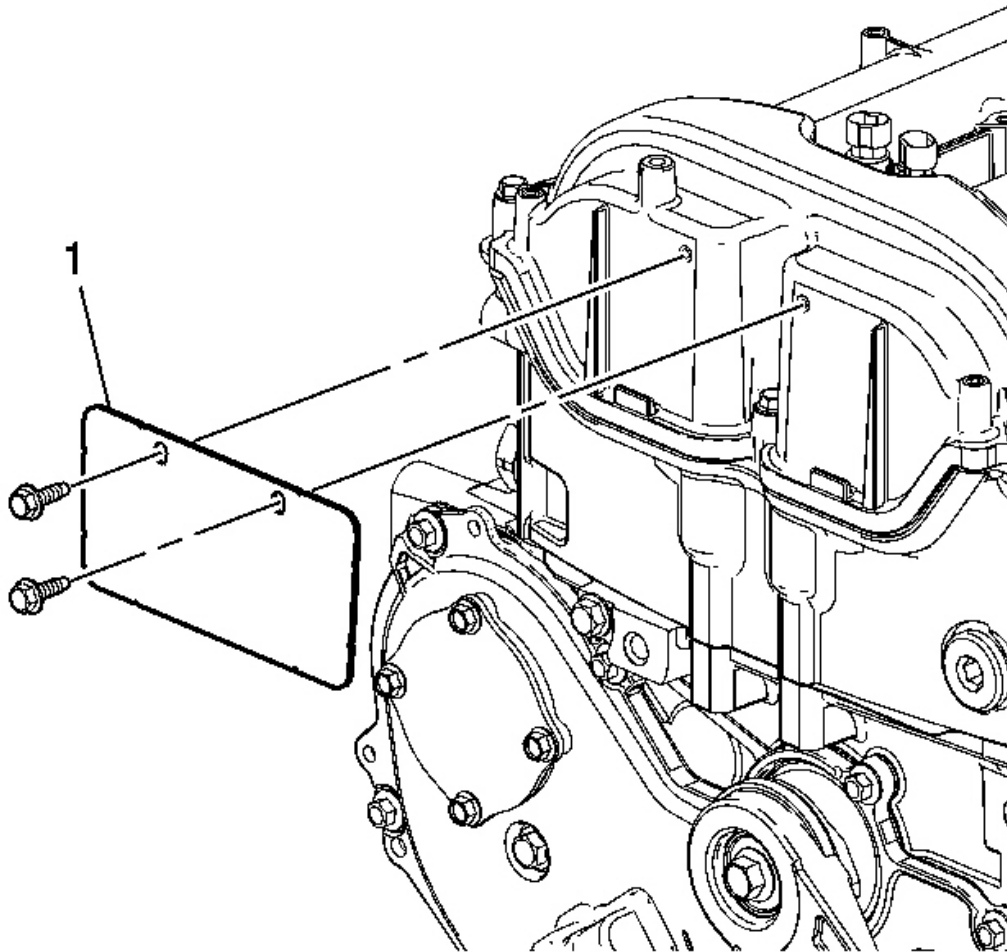


Fig. 490: Camshaft Housing Cover Insulator
Courtesy of GENERAL MOTORS CORP.

4. Install the camshaft housing cover insulator (1). Tighten the bolts to 10 N.m (89 lb in).

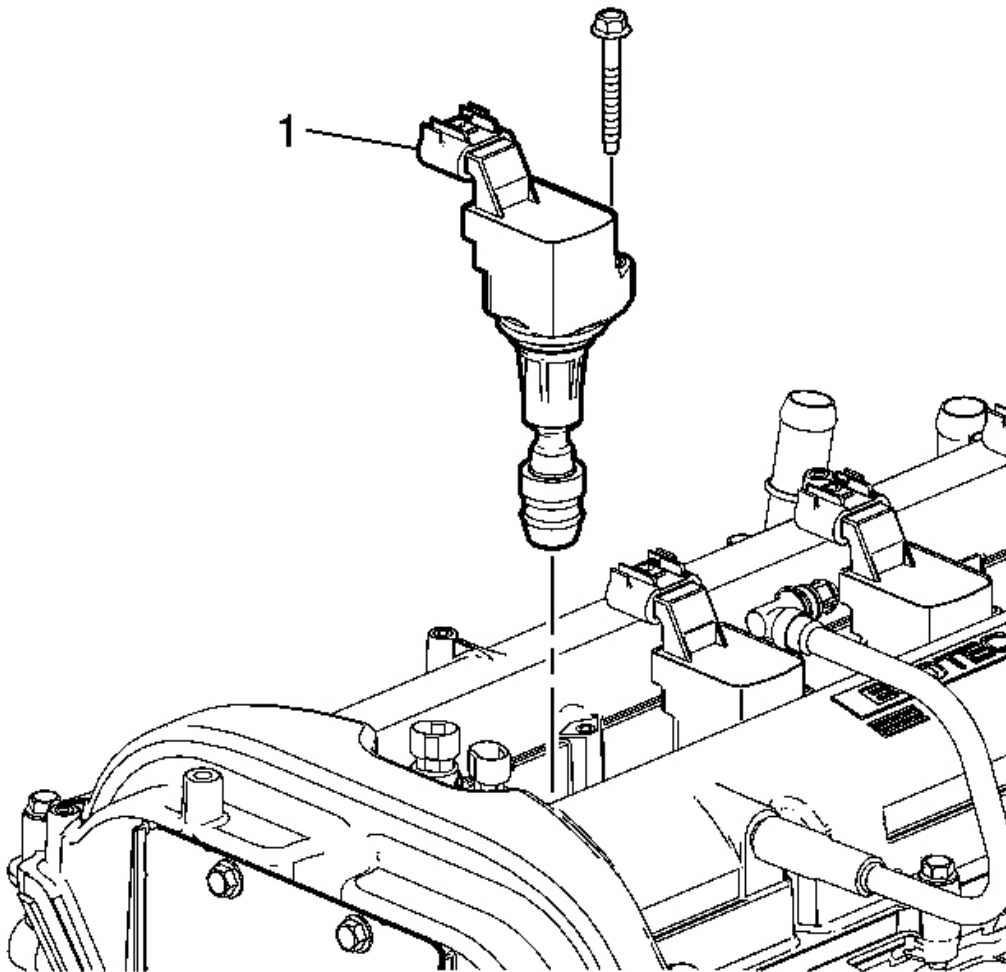


Fig. 491: Ignition Coil

Courtesy of GENERAL MOTORS CORP.

5. Install the ignition coil (1). Tighten the bolt to 10 N.m (89 lb in).

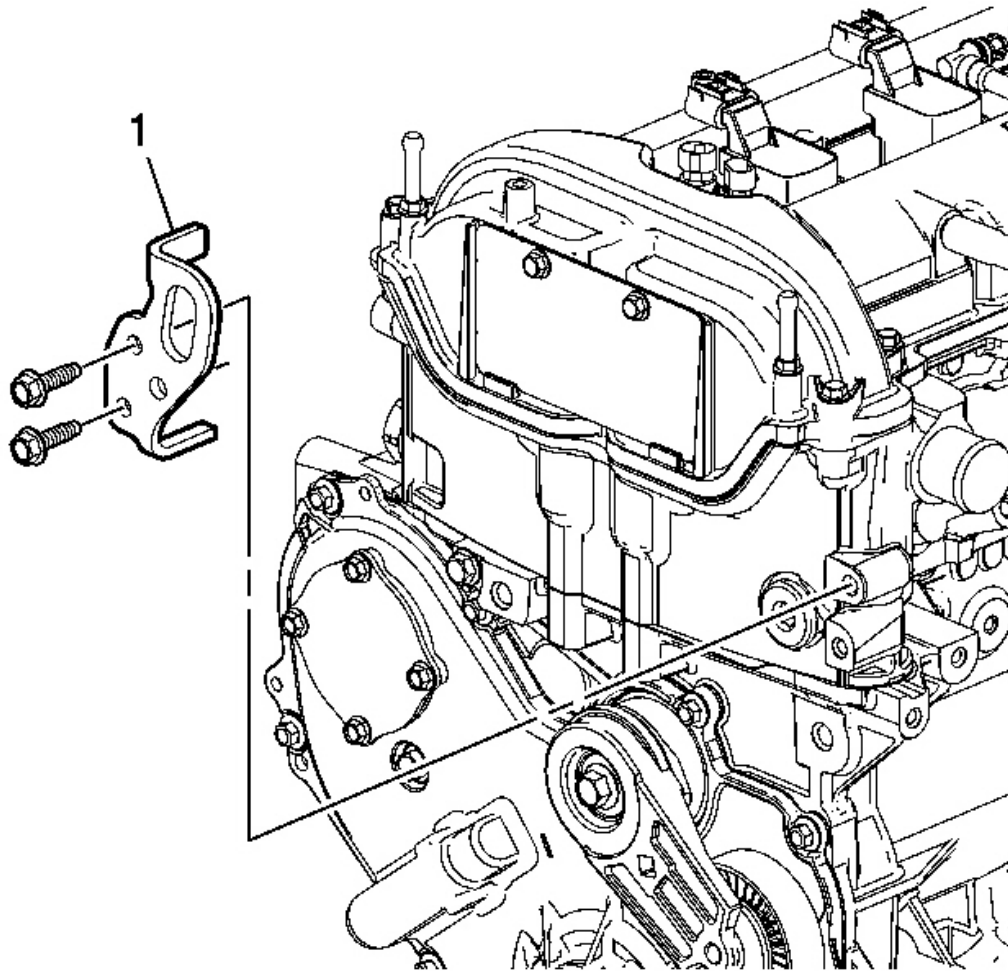


Fig. 492: Front Lift Bracket

Courtesy of GENERAL MOTORS CORP.

6. Install the front lift bracket (1).
7. Install the front lift bracket bolts and tighten to 25 N.m (18 lb ft).

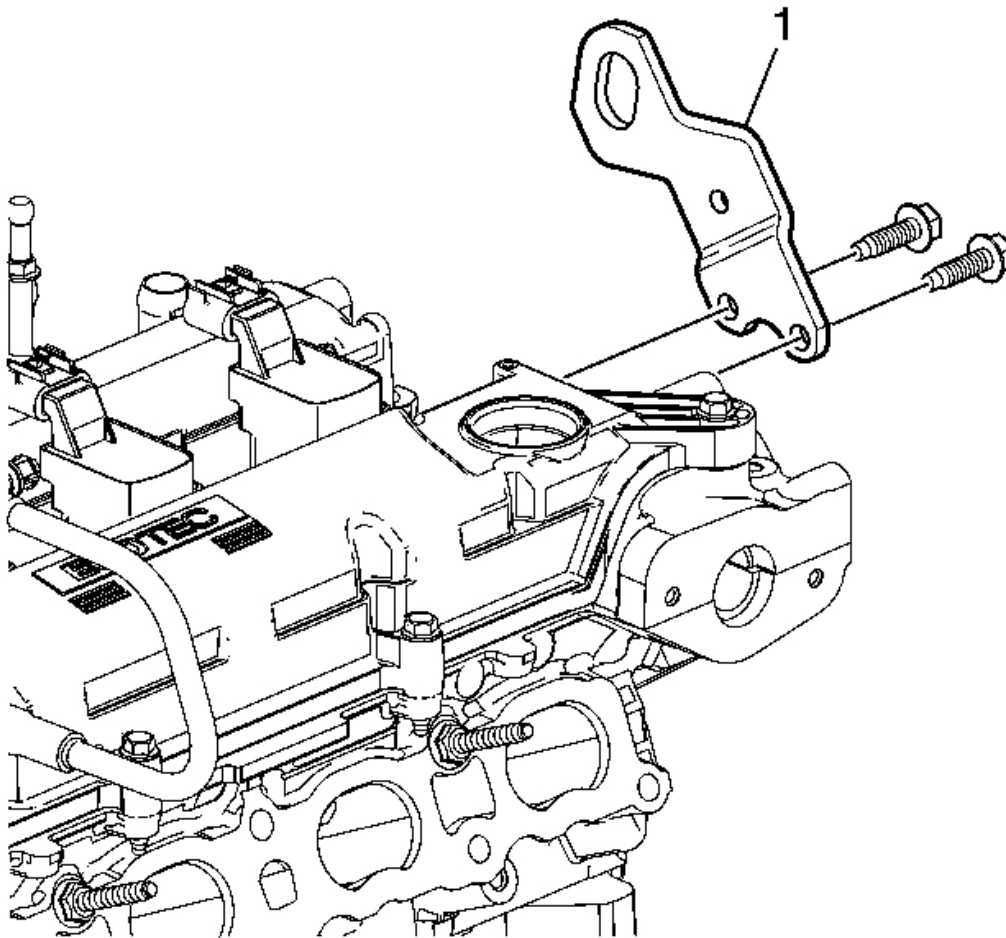


Fig. 493: Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the rear lift bracket (1).
9. Install the rear lift bracket bolts and tighten to 25 N.m (18 lb ft).

OIL FILTER WITH CAP AND SEAL INSTALLATION

Special Tools

EN-44887: Oil Filter Wrench

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

Installation

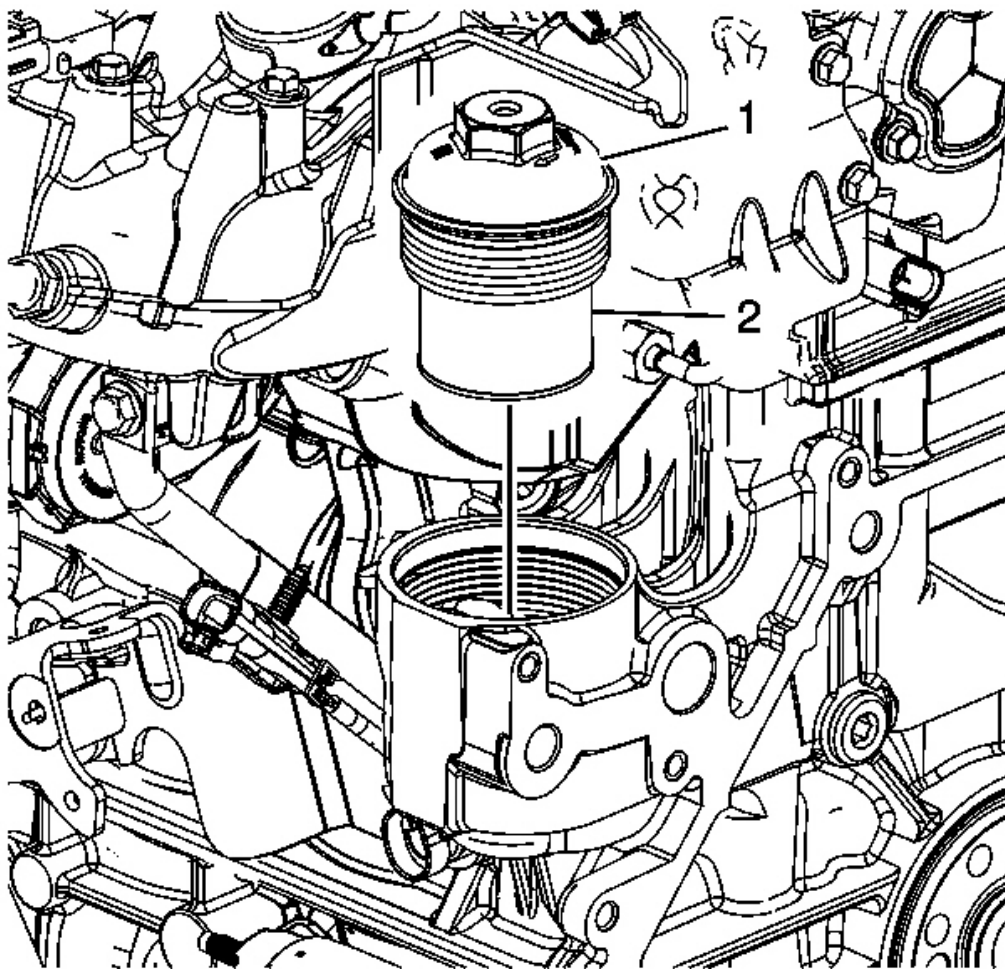


Fig. 494: Oil Filter & Cap

Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter (2) on the oil filter cap (1).
2. Lubricate the O-ring on the oil filter cap with 5W30 engine oil.

CAUTION: Refer to Fastener Caution .

3. Use **EN-44887**: wrench to install the oil filter cap. Tighten the oil filter cap to 22 N.m (16 lb ft).

FUEL RAIL AND INJECTORS INSTALLATION

Special Tools

EN-47909: Injector Bore and Sleeve Cleaning Kit

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

Installation

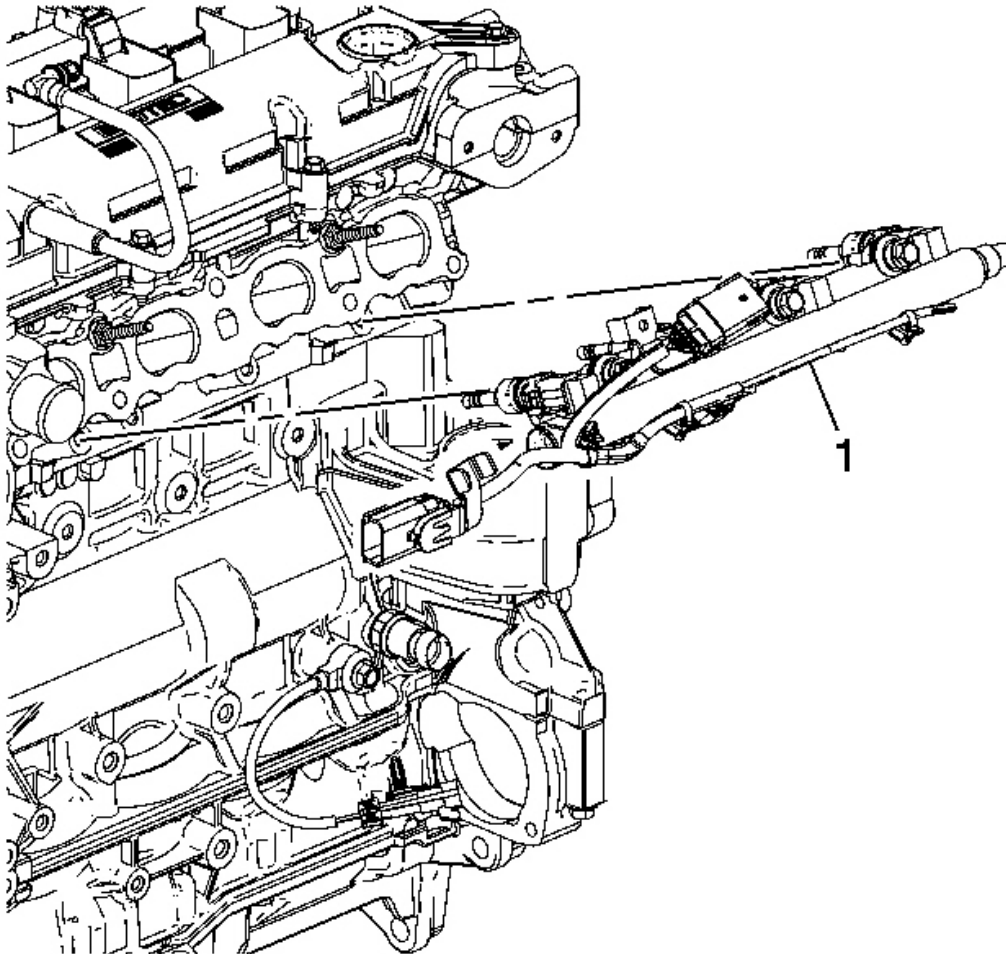


Fig. 495: Fuel Rail & Injectors

Courtesy of GENERAL MOTORS CORP.

1. Clean the fuel injector bore in the cylinder head using the **EN-47909**: kit.
2. Install the fuel rail (1) with injectors into the cylinder head evenly.
3. Hand tighten the 2 outer fuel rail bolts to seat the injector into the injector bores.

CAUTION: Refer to Fastener Caution .

4. Start and hand tighten the remaining fuel rail bolts. Tighten the bolts in sequence to final torque using the following procedure:
 1. Tighten first pass in sequence to 25 N.m (18 lb ft).
 2. Tighten final pass in sequence to 25 N.m (18 lb ft).
5. Connect the electrical harness to the fuel rail harness connections.

INTAKE MANIFOLD INSTALLATION

Special Tools

EN-48896: HP Fuel Pump Installation Alignment Gauge

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

Installation

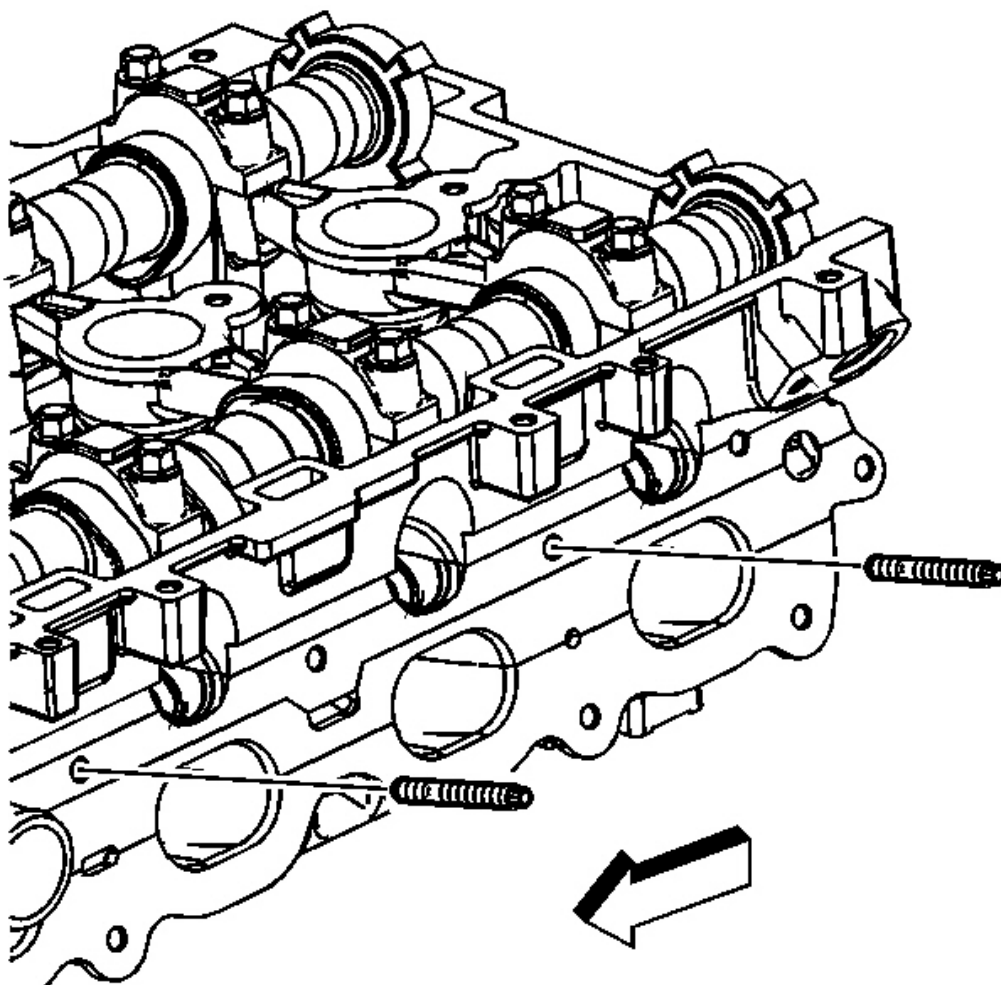


Fig. 496: Intake Manifold Studs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the intake manifold studs in the manifold face and tighten to 6 N.m (53 lb in).

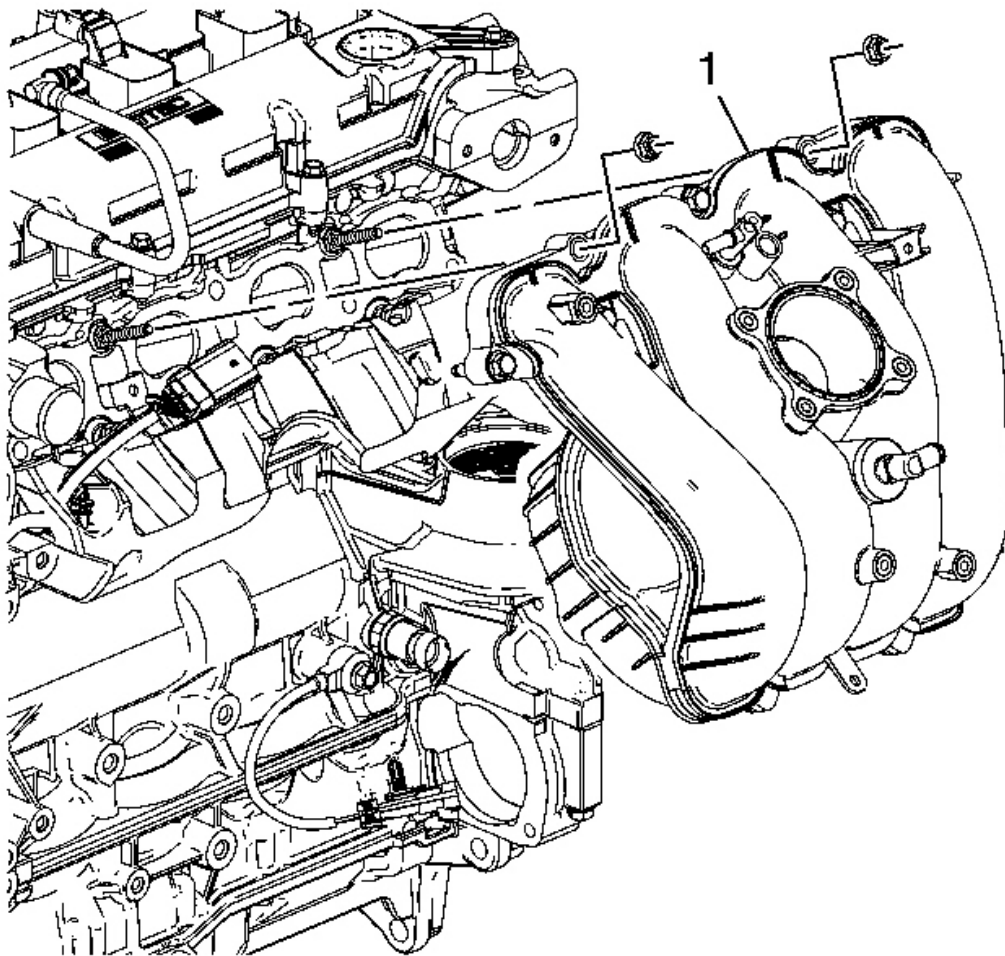


Fig. 497: Intake Manifold

Courtesy of GENERAL MOTORS CORP.

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

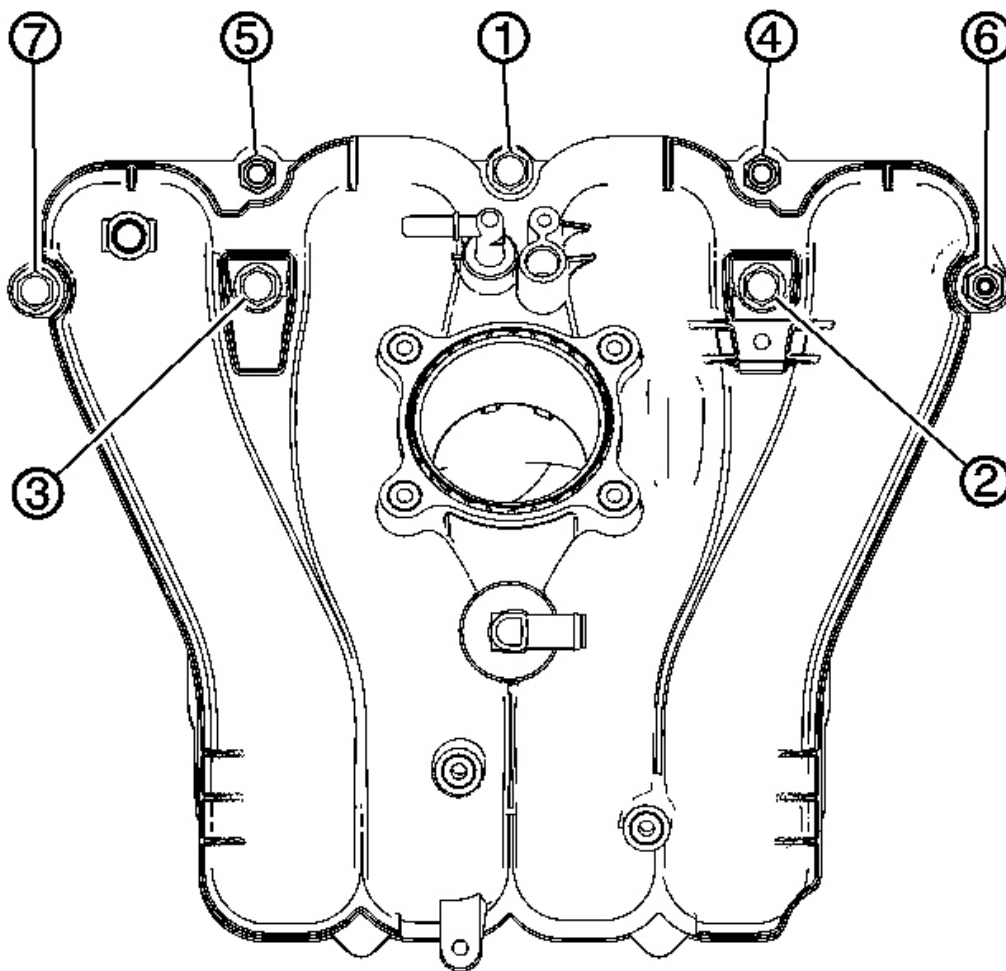


Fig. 498: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

3. Tighten the bolts and nuts in sequence to 10 N.m (89 lb in).

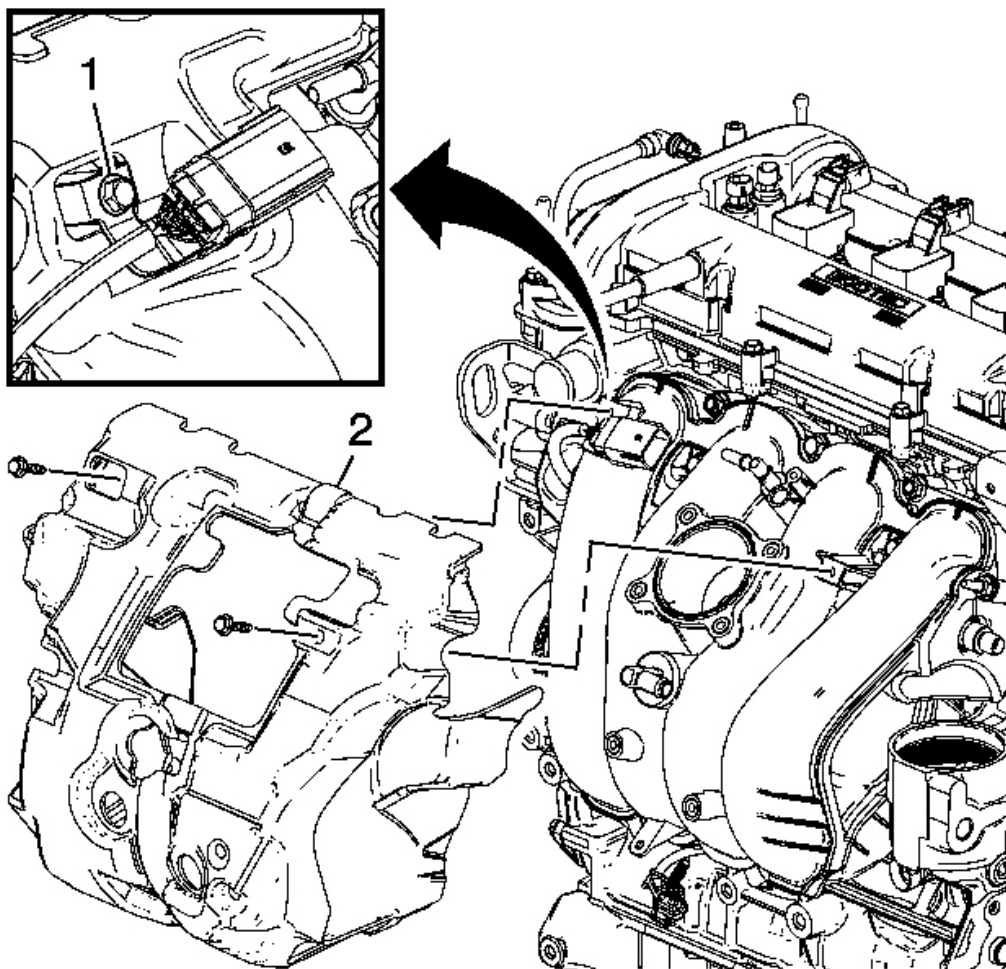


Fig. 499: Fuel Rail Harness Connector Bracket Bolt & Intake Manifold Insulator
Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold insulator (2).
5. Install the insulator bolt and tighten to 10 N.m (89 lb in).
6. Install the fuel rail harness connector bracket (1) to the intake manifold. Tighten the bracket bolt to 10 N.m (89 lb in).

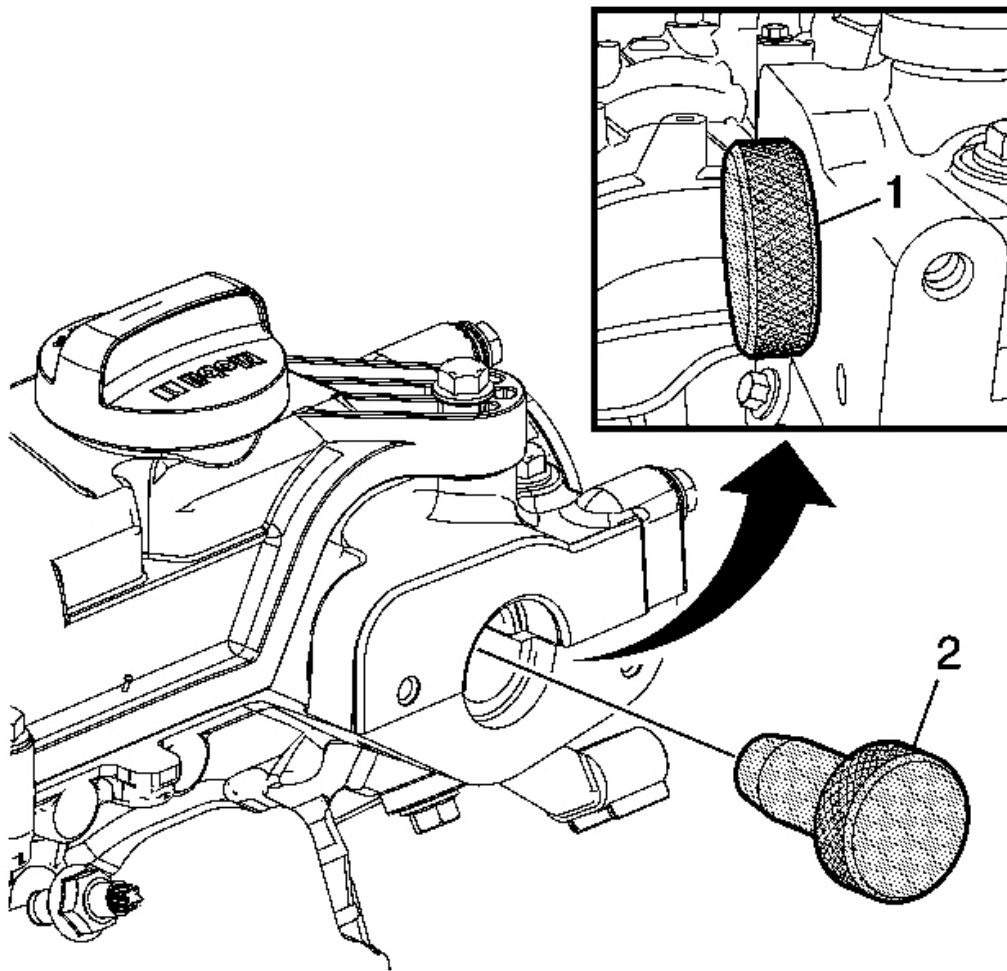


Fig. 500: Alignment Gauge

Courtesy of GENERAL MOTORS CORP.

NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed.

7. Use the **EN-48896**: 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 head (1).

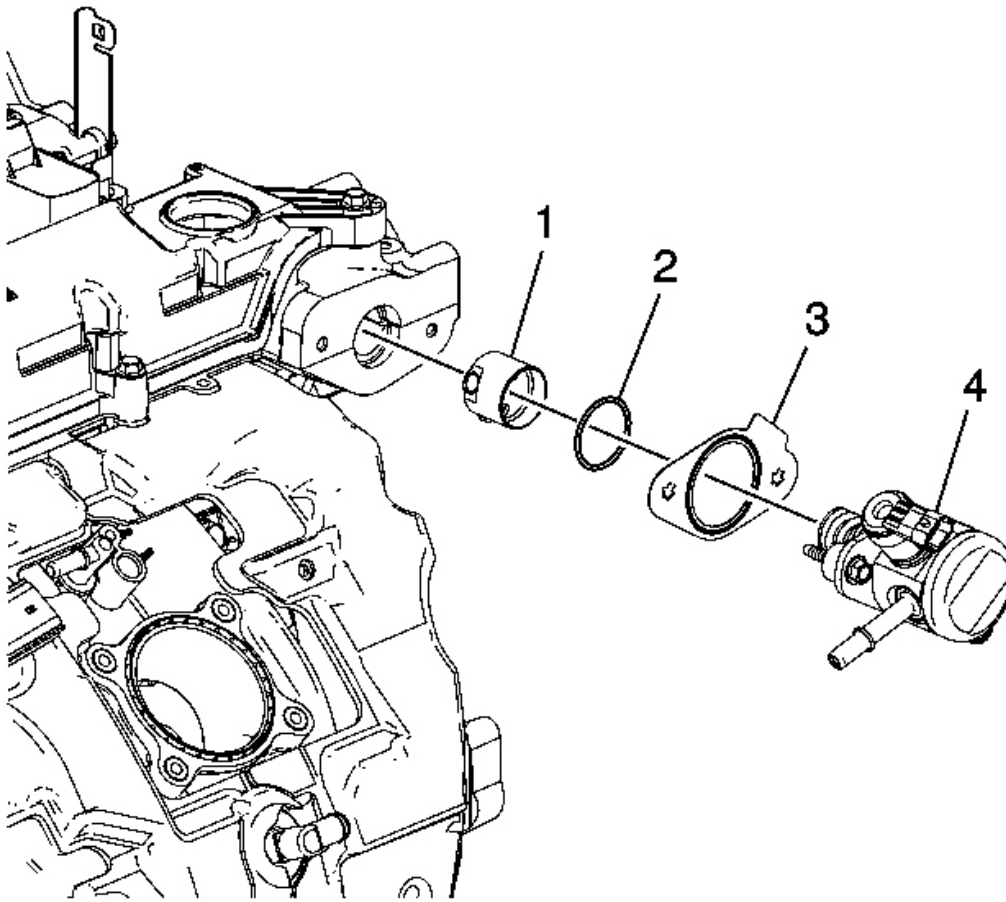


Fig. 501: Fuel Pump Assembly Components
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the high pressure fuel pump cylinder head bore with 5W30 engine oil.

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. The distance from the mounting flange surface to the camshaft at base circle should be 52 mm (2.05 in).

9. Lubricate the high pressure fuel pump roller lifter (1) with 5W30 engine oil and install into the cylinder head bore.
10. Install a NEW fuel pump housing O-ring (2) and gasket (3).

NOTE: Ensure the plastic bolt retainers are installed in the high pressure fuel

pump mounting holes before installing.

11. Install the fuel pump assembly (4).
12. Start and hand-tighten the fuel pump assembly bolts evenly. Tighten the fuel pump bolts evenly to 15 N.m (11 lb ft).

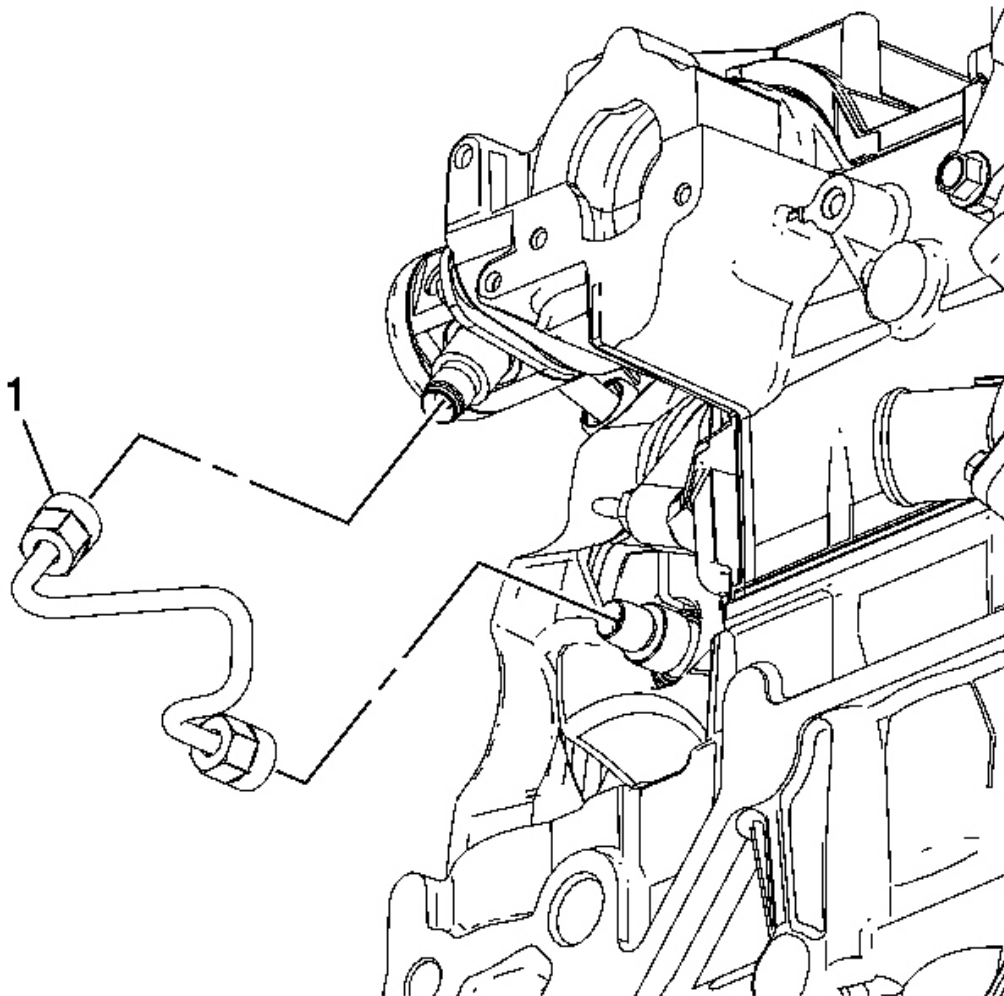


Fig. 502: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS CORP.

13. Install and hand-tighten both ends of the NEW high pressure fuel line (1). Tighten the high pressure fuel line fitting nuts to 30 N.m (22 lb ft).

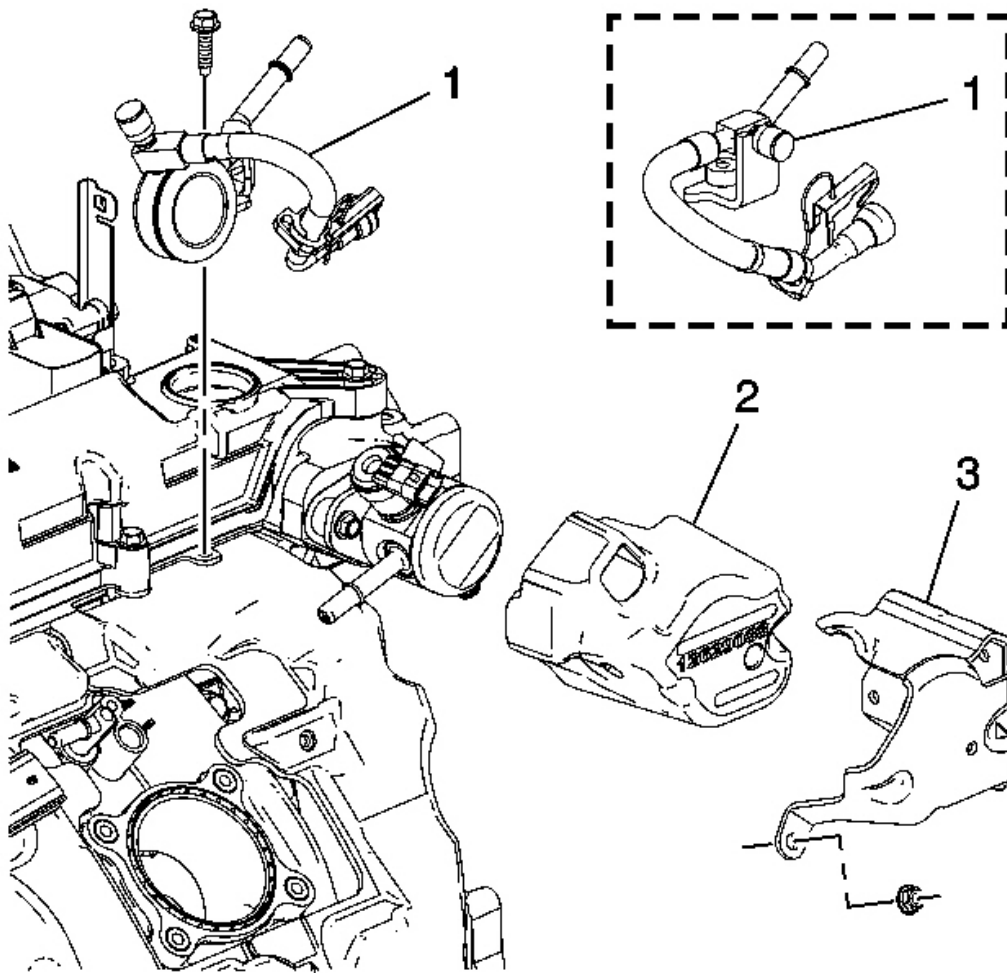


Fig. 503: Fuel Pump Components
Courtesy of GENERAL MOTORS CORP.

14. Install the fuel pump insulator (2).

NOTE: The low pressure fuel pipe used is model dependent.

15. Install the low pressure fuel pipe assembly (1).
16. Install the fuel pump cover (3) and nut. Tighten the nut to 10 N.m (89 lb in).

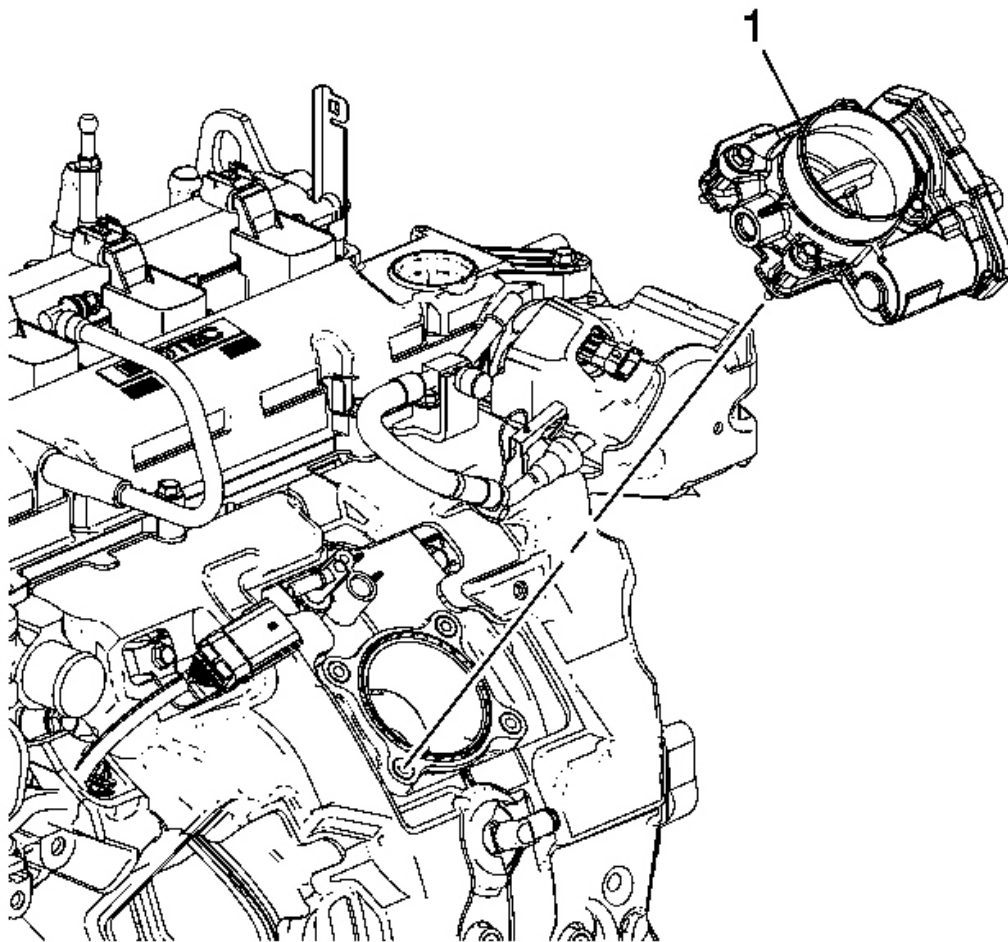


Fig. 504: Throttle Body

Courtesy of GENERAL MOTORS CORP.

17. Install a new throttle body gasket.
18. Install the throttle body (1).
19. Install the throttle body bolts and tighten to 10 N.m (89 lb in).

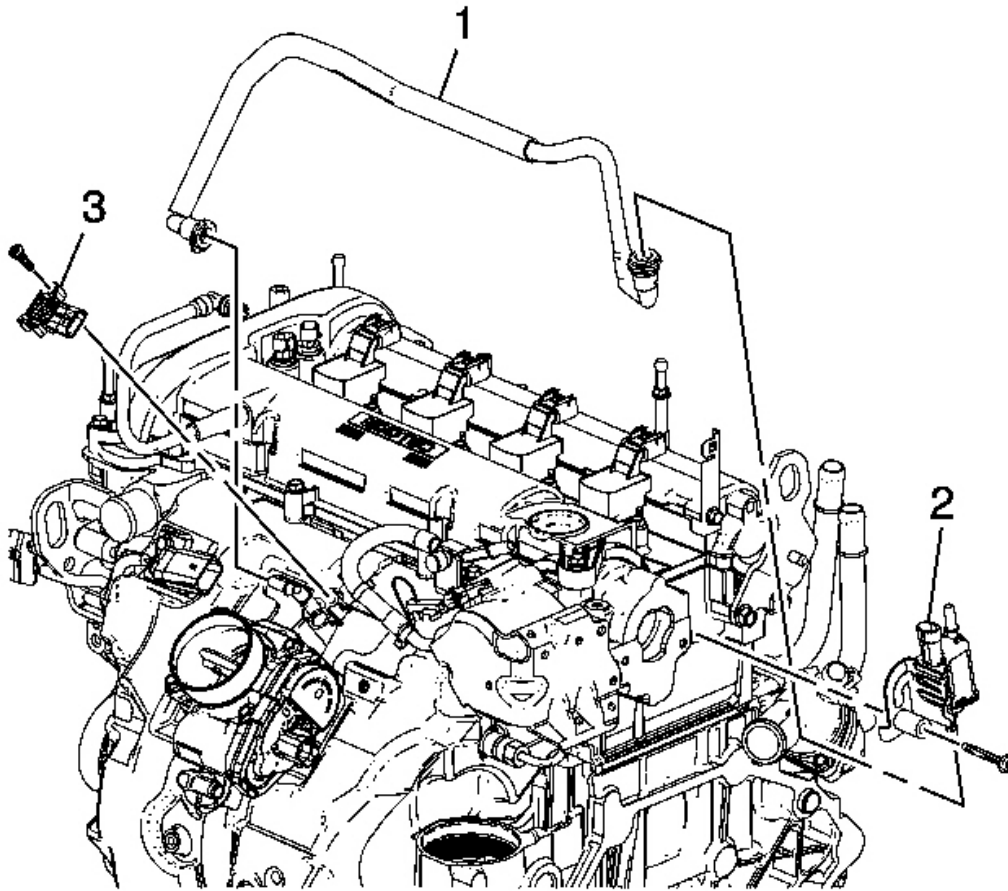


Fig. 505: EVAP Canister Valve, Tube & MAP Sensor
Courtesy of GENERAL MOTORS CORP.

20. Install the MAP sensor (3). Tighten the sensor bolt to 4 N.m (35 lb in).
21. Install the EVAP canister valve (2) and tighten to 25 N.m (18 lb ft).
22. Install the EVAP canister valve tube (1).

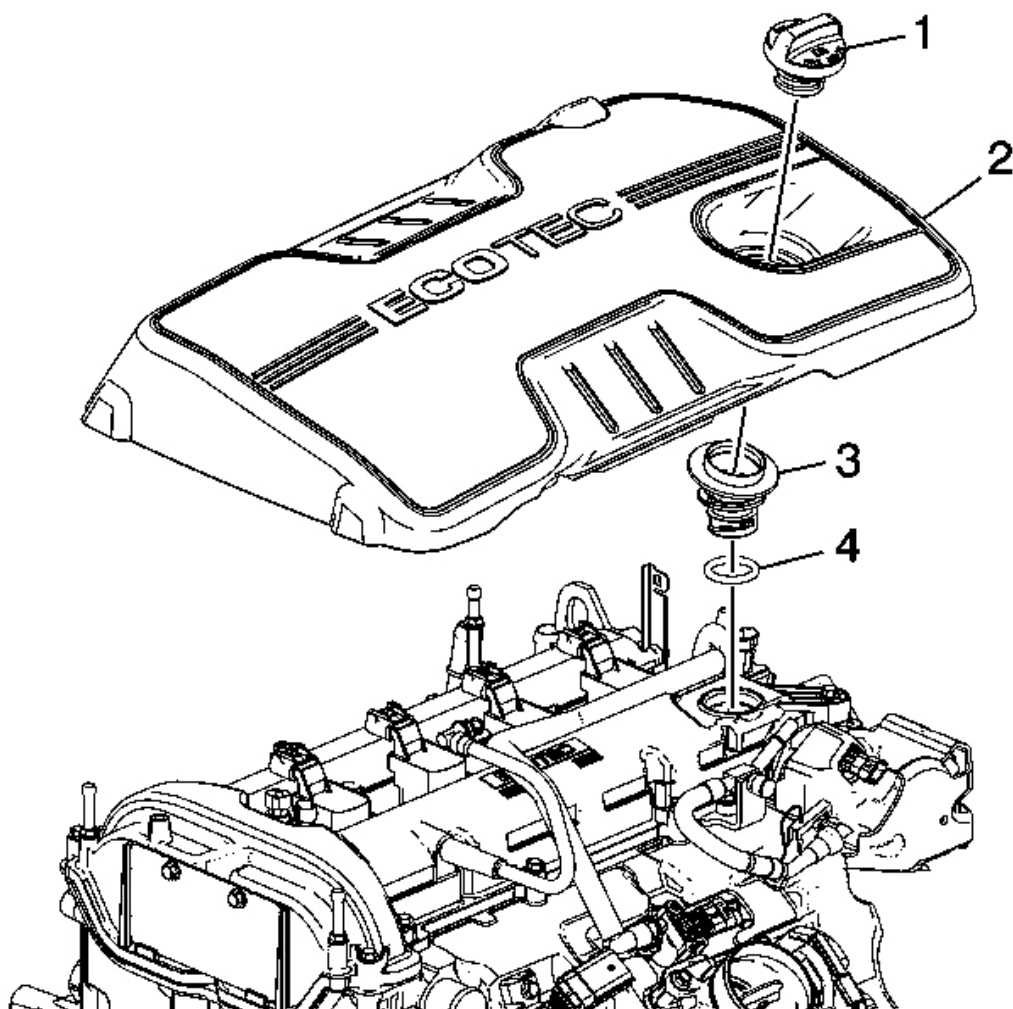


Fig. 506: Intake Manifold Cover Components
Courtesy of GENERAL MOTORS CORP.

23. Install the O-ring and oil fill tube assembly (3).
24. Install the intake manifold cover (2) onto the camshaft cover ball studs.
25. Install the oil fill cap (1).

EXHAUST MANIFOLD INSTALLATION

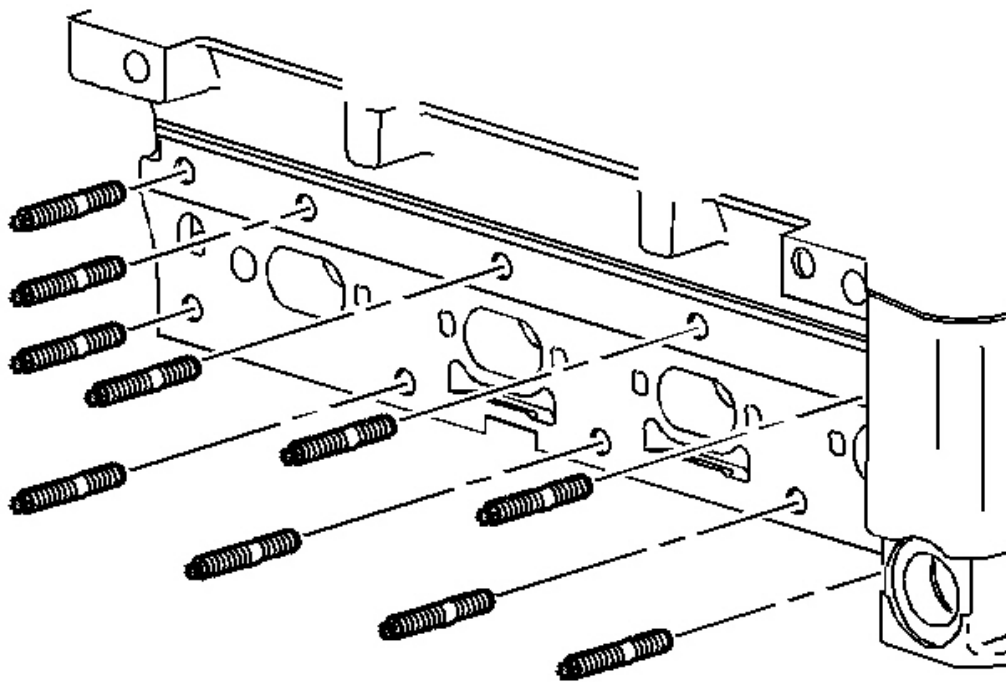


Fig. 507: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install new exhaust manifold studs and tighten to 10 N.m (89 lb in).

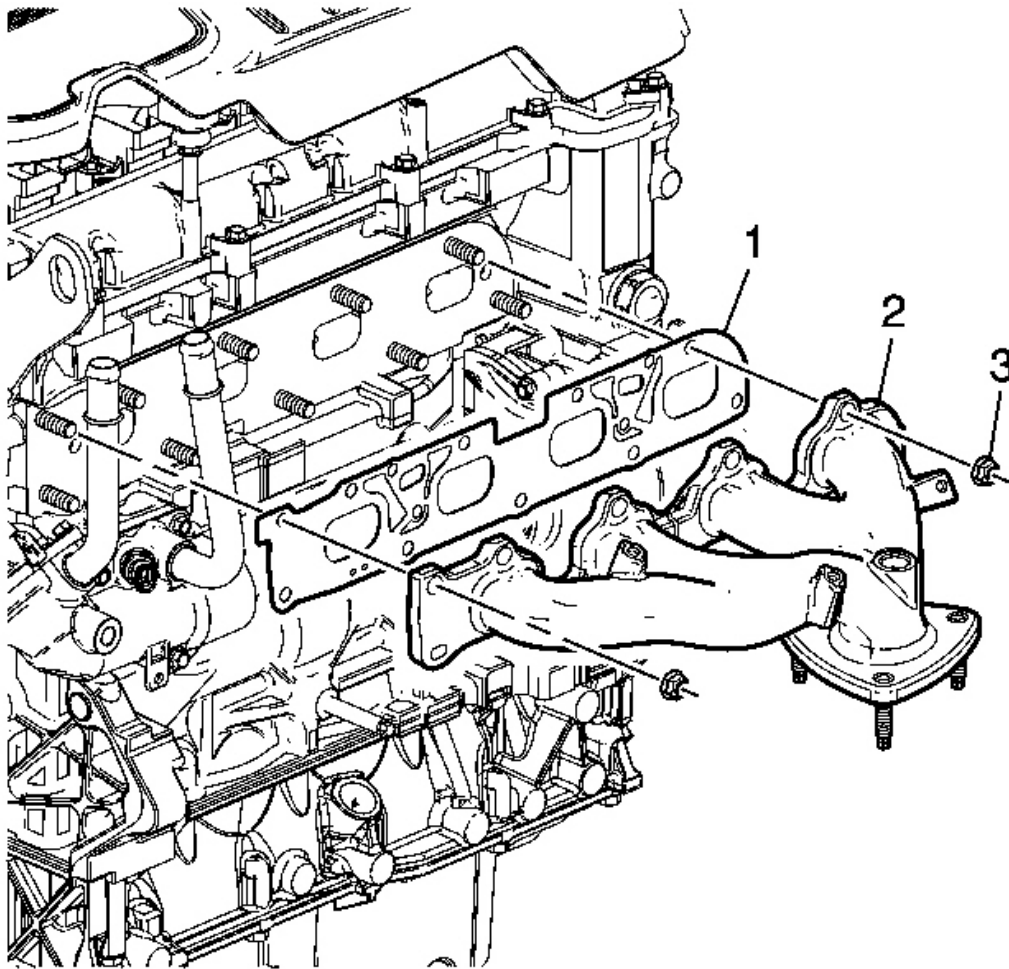


Fig. 508: Exhaust Manifold Components
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold gasket (3).
3. Install the exhaust manifold (2) to the cylinder head.
4. Install NEW exhaust manifold to cylinder head retaining nuts (1) finger tight.

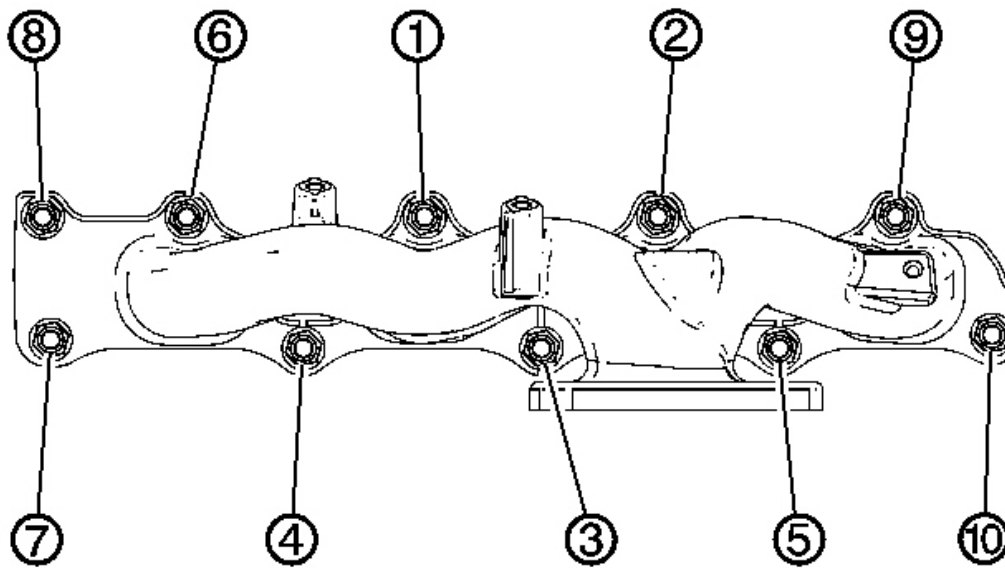


Fig. 509: Identifying Exhaust Manifold To Cylinder Head Retaining Nut Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the NEW exhaust manifold to cylinder head retaining nuts two passes in sequence:
 1. Tighten first pass in sequence to 14 N.m (124 lb in) .
 2. Tighten final pass in sequence to 14 N.m (124 lb in) .

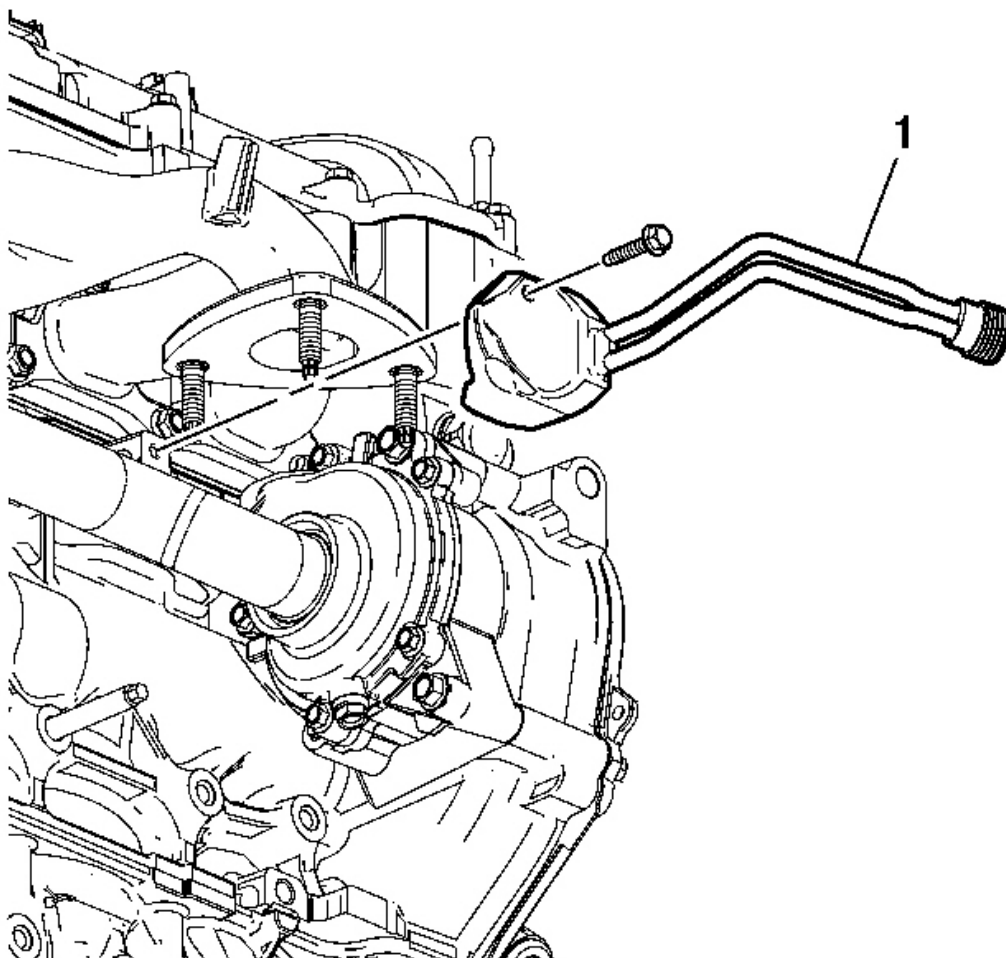


Fig. 510: Block Heater

Courtesy of GENERAL MOTORS CORP.

6. Install the block heater (1). Tighten the bolt to 10 N.m (89 lb in).

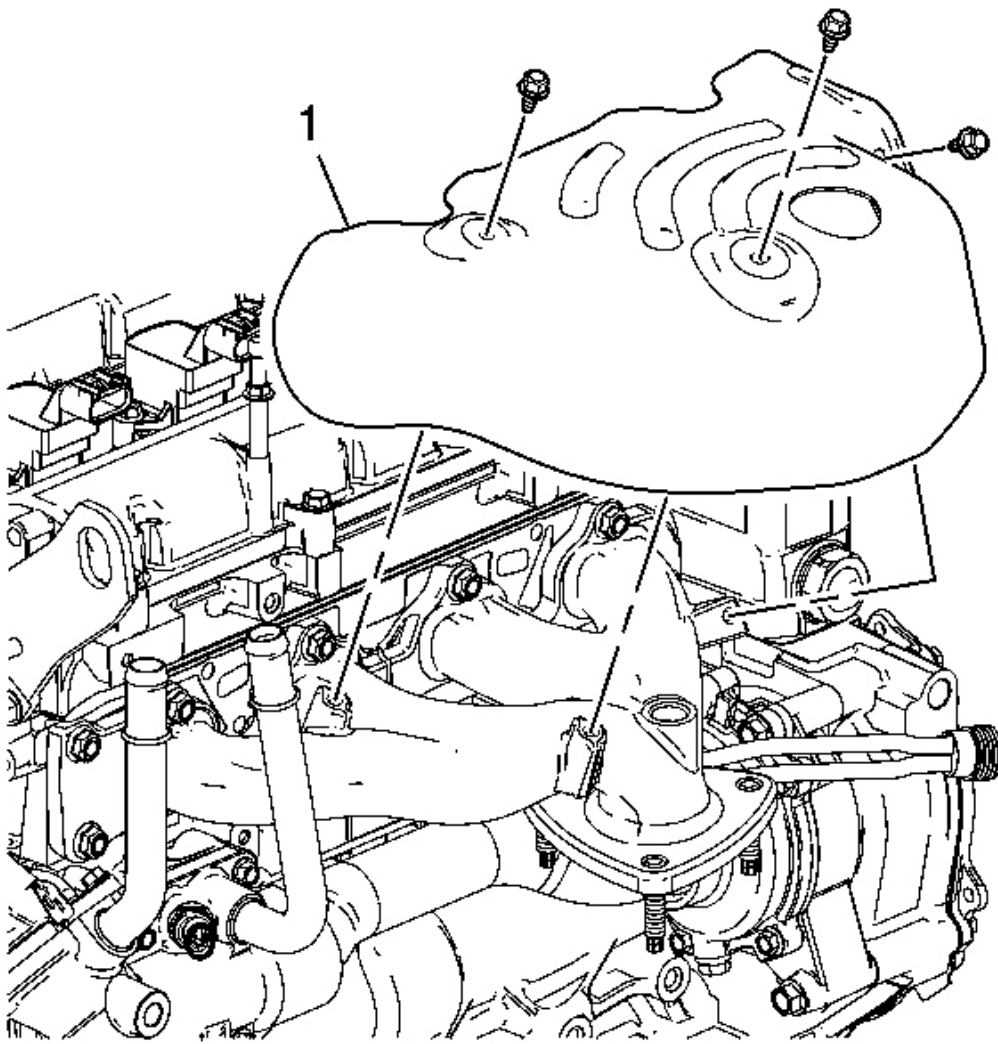


Fig. 511: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust manifold heat shield (1).
8. Install the exhaust manifold heat shield bolts and tighten to 25 N.m (18 lb ft).

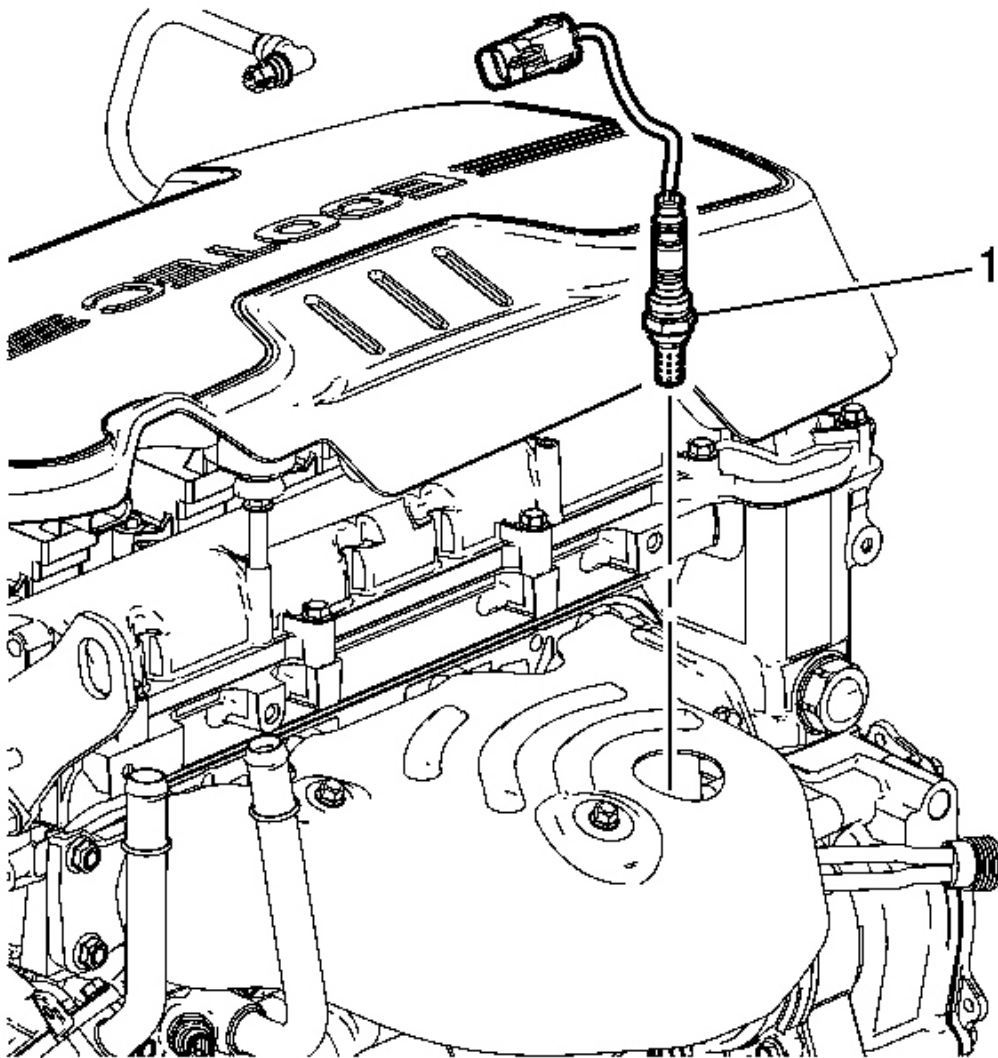


Fig. 512: Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: An equivalent antiseize may be used.

9. Coat the threads of the oxygen sensor (1) with antiseize GM P/N 12397953. Refer to **Adhesives, Fluids, Lubricants, and Sealers.**
10. Install the oxygen sensor and tighten to 42 N.m (31 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

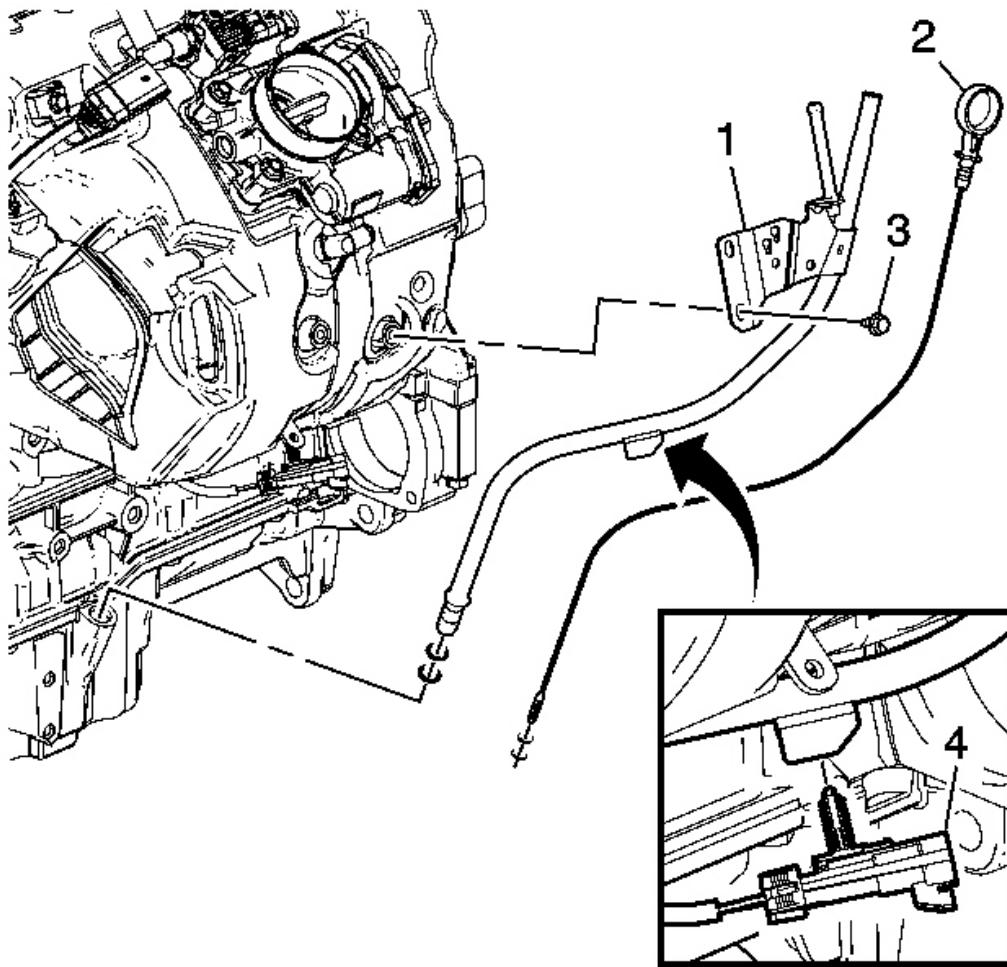


Fig. 513: Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Install the oil level indicator (2) and the oil level indicator tube (1) into the oil pan.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bracket bolt (3) to the intake manifold and tighten to 10 N.m (89 lb in).
4. Install the electrical wiring harness to the oil level indicator tube.
5. Install the knock sensor wiring clip (4) into the oil level indicator tube.

ENGINE FLYWHEEL INSTALLATION

Special Tools

- **EN-38122-A:** Crankshaft Balancer Holder
- **EN-43653:** Flywheel Holding Tool
- **EN-45059:** Angle Meter

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

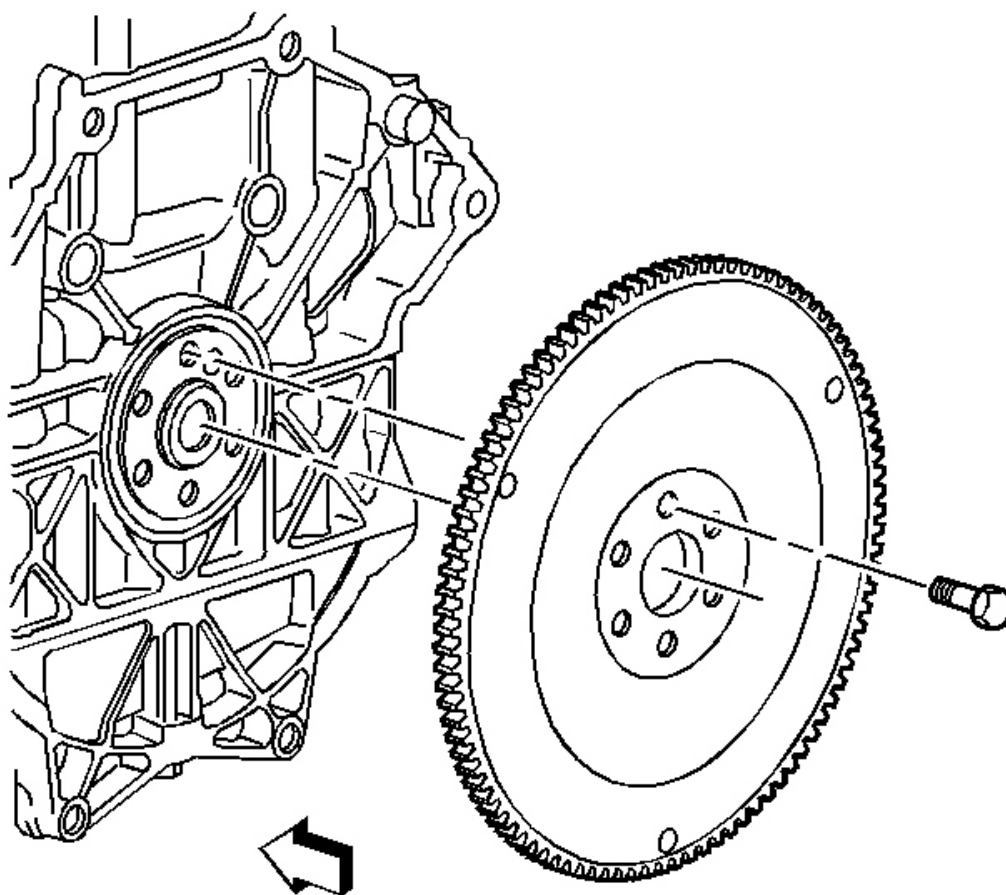


Fig. 514: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.
2. Install NEW bolts.

CAUTION: Refer to Fastener Caution .

NOTE: EN-43653: flywheel holding tool may be used instead of EN-38122-A: holder in order to prevent crankshaft rotation.

3. Holding the crankshaft balancer with **EN-38122-A:** holder, tighten the bolts evenly. Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the **EN-45059:** meter

ENGINE PRELUBING

Special Tools

EN-45299: Engine Preluber

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

Prelube

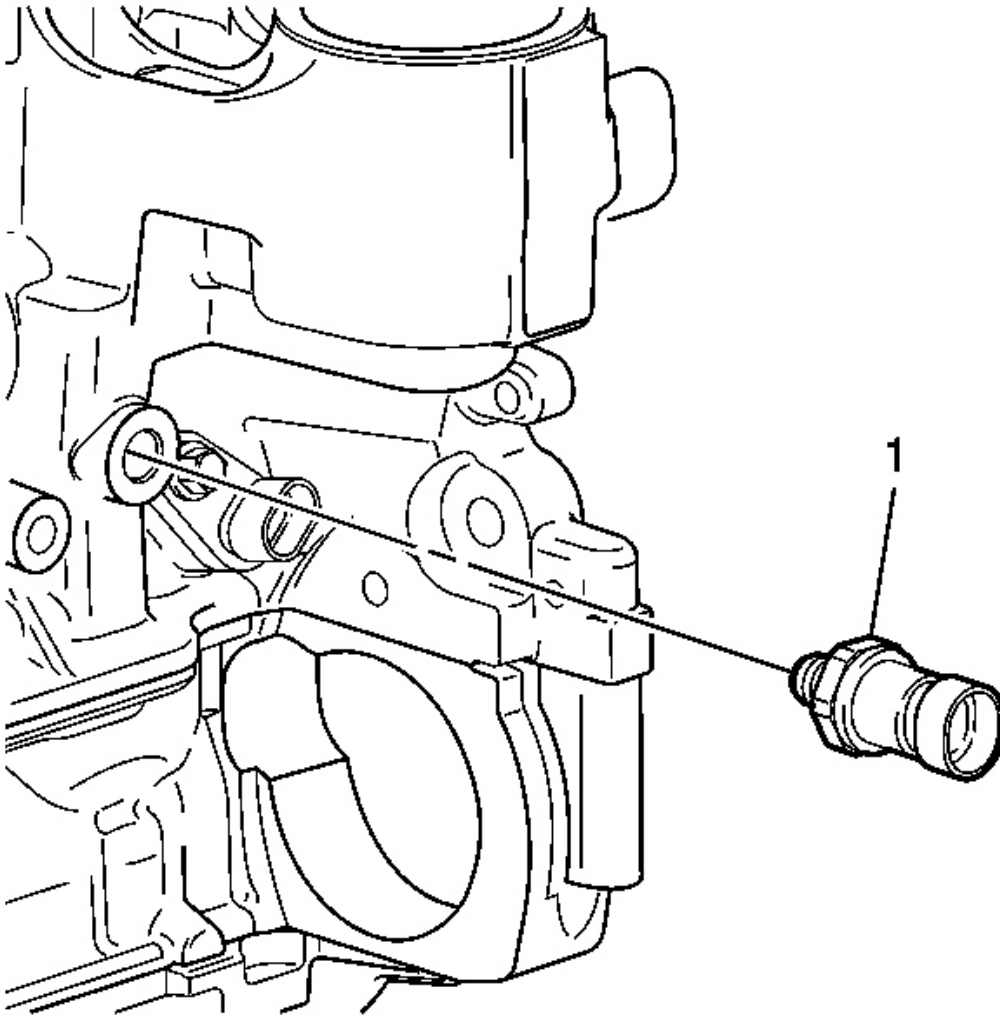


Fig. 515: Identifying the M12 x 1.75 Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

1. Remove the oil pressure switch.
2. Install the M12 x 1.75 adapter (1) P/N 509376.

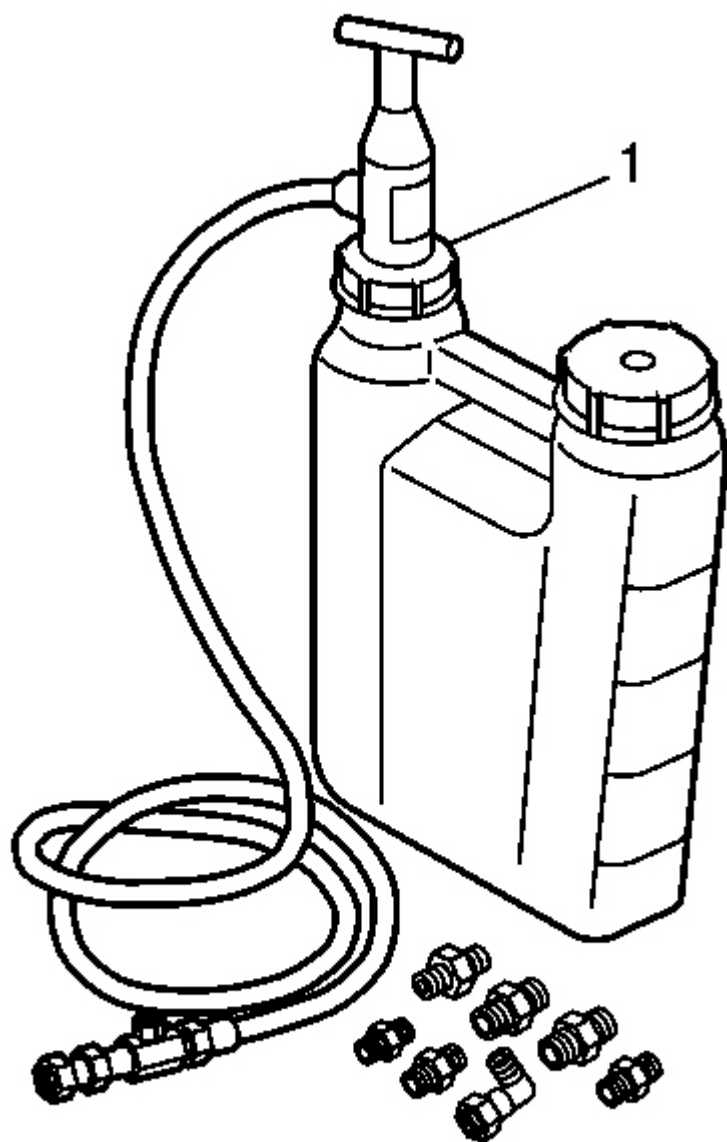


Fig. 516: View Of Preluber
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **EN-45299**: preluber (1) in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
5. Close the valve and remove the flexible hose and adapter from the engine.

CAUTION: Refer to Fastener Caution .

6. Install the oil pressure switch to the engine and tighten to 22 N.m (16 lb ft).
7. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation

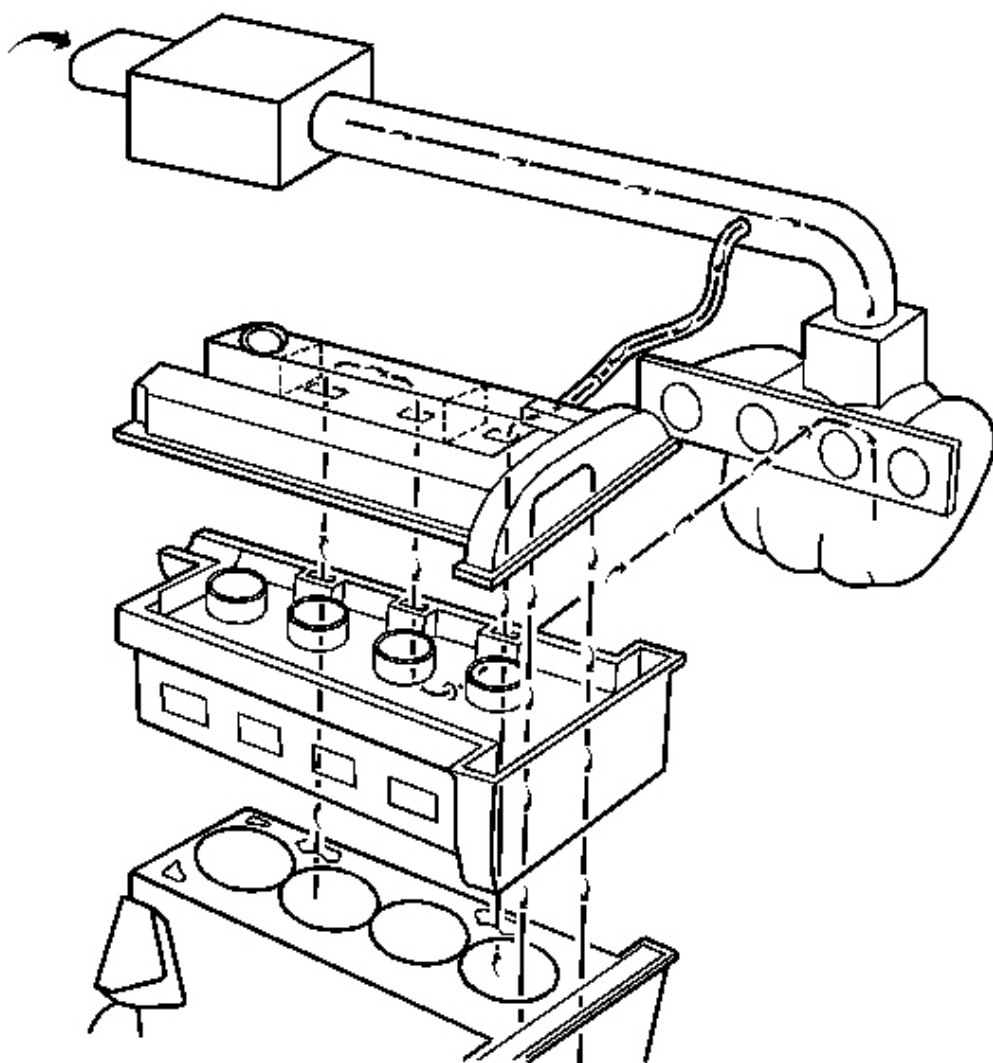


Fig. 517: Identifying Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the camshaft cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
 - The power steering pump, if belt driven
 - The generator
 - The A/C compressor, if equipped
 - The engine cooling fan, if belt driven
 - The water pump, if belt driven
 - The vacuum pump, if equipped
 - The air compressor, if equipped

The drive belt system may use one belt or two belts. The drive belt is thin so that it can bend backward and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubber (chloroprene or EPDM) and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is constructed of aluminum alloy by precision sand-casting with 4 cast-in-place iron cylinder liners arranged in-line. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the front of the engine. The cylinder block incorporates a bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

Crankshaft

The crankshaft is cast nodular iron with 8 counterweights. The number 8 counterweight is also the ignition system reluctor wheel. The main bearing journals are cross-drilled, and the upper bearings are grooved. The crankshaft has a slip fit balance shaft drive sprocket. Number 2 main bearing is the thrust bearing. The crankshaft balancer is used to control torsional vibration.

Connecting Rod and Piston

The connecting rods are powdered metal. The connecting rod incorporates the floating piston pin. The pistons are cast aluminum. The piston rings are of a low tension type to reduce friction. The top compression ring is ductile iron with a molybdenum facing and phosphate coated sides. The second compression ring is gray iron. The oil ring is a 3-piece spring construction with chromium plating.

Oil Pan

The oil pan is die cast aluminum. The oil pan includes an attachment to the transmission to provide additional structural support.

Balance Shaft Assembly

There are 2 block mounted balance shafts located on each side of the crankcase at the bottom of the cylinder bores. The balance shafts are driven by a single roller chain that also drives the water pump. The chain is tensioned by a hydraulic tensioner that is supplied pressure by the engine oil pump. This design promotes the maximum effectiveness of the balance shaft system and reduces noise and vibration.

Cylinder Head

The cylinder head is a semi-permanent mold. Pressed-in powdered metal valve guides and valve seat insets are used. The fuel injection nozzle is located in the intake port. The cylinder head incorporates camshaft journals and camshaft caps.

Valves

There are 2 intake and 2 exhaust valves per cylinder. Rotators are used on all of the intake valves. The rotators are located at the bottom of the valve spring to reduce valve train reciprocating mass. Positive valve stem seals are used on all valves.

Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron.

Valve Lash Adjusters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft Drive

A roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

Intake and Exhaust Manifold

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

LUBRICATION DESCRIPTION

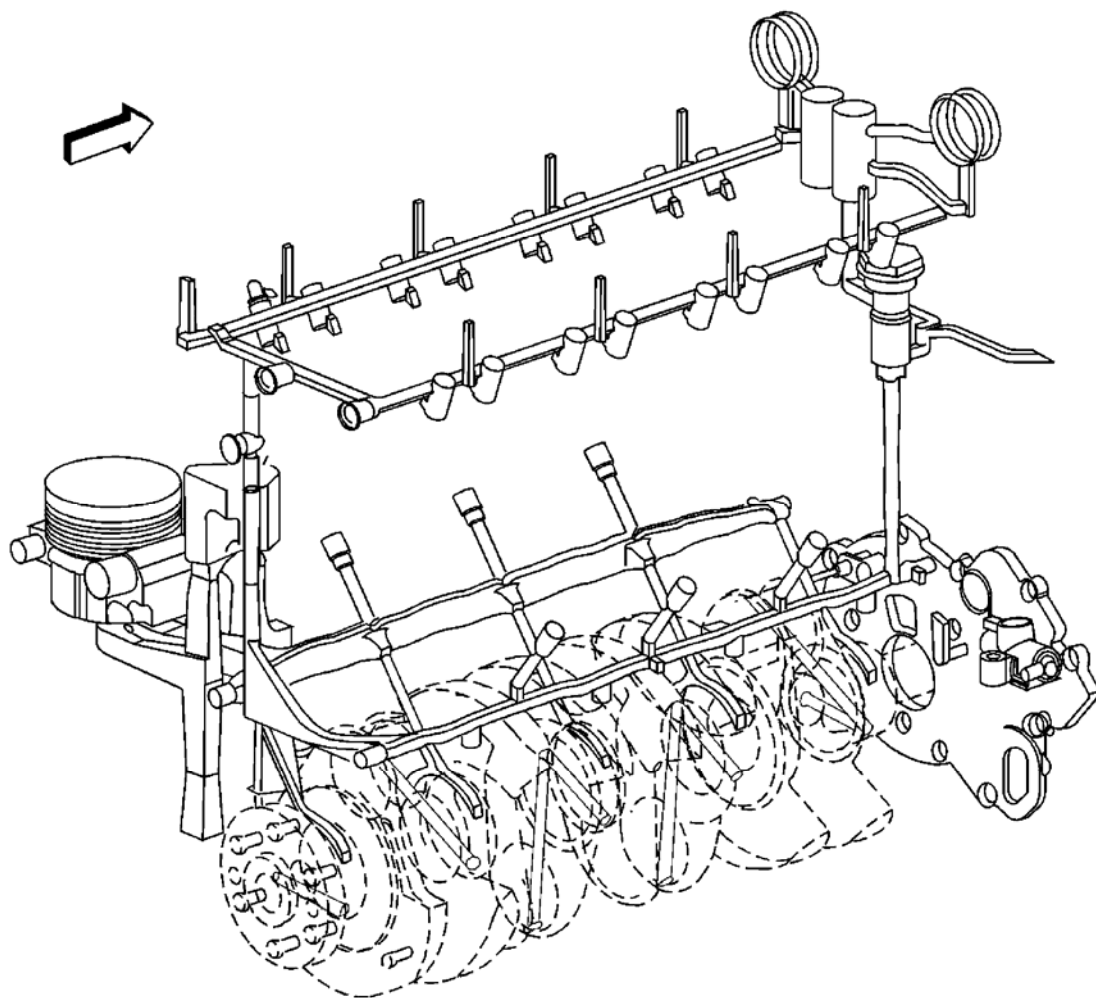


Fig. 518: Lubrication System

Courtesy of GENERAL MOTORS CORP.

Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, valve lash adjusters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the gerotor type oil pump through a fixed inlet screen. The oil pump is driven by the crankshaft. The oil pump body is within the engine front cover. The pressurized oil from the pump passes through the oil filter. The oil filter is located on the right (front) side of the engine block. The oil filter is housed in a casting that is integrated with the engine block. The oil filter is a disposable cartridge type. A by-pass valve in the filter cap allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

IMPORTANT:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **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 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 lash adjusters
- Valve lash adjusters, lash adjuster guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Special Tools

EN 28410: Gasket Remover

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless 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 **EN 28410**: gasket 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

- 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.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Pipe Joint Compound

IMPORTANT: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct

sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where 2 non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when the bolt is tightened.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- Room temperature vulcanizing (RTV) sealant hardens when exposed to air. This type sealer is used where 2 rigid parts, such as the lower crankcase and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet, within 3 minutes. Do not wait for RTV to skin over.
- Tighten bolts to specifications. Do not overtighten.

TOOLS AND EQUIPMENT

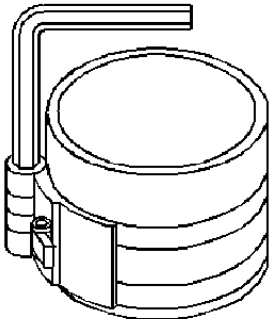
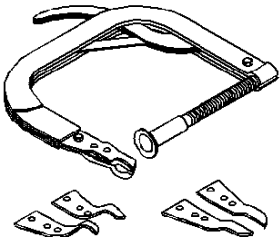
Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

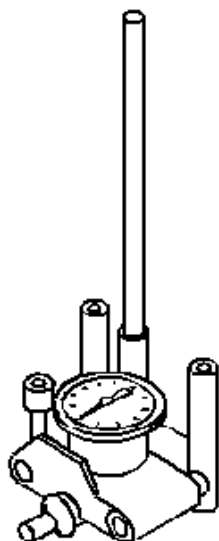
To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

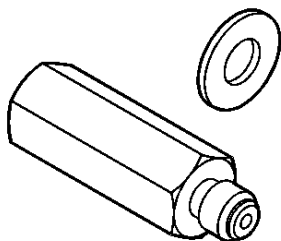
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

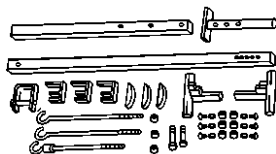
Illustration	Tool Number/Description
	EN-8037 J-8037 Ring Compressor
	EN-8062 J 8062 KM-348 09916-14510 Valve Spring Compressor - Head Off



EN-8087
J 8087
Cylinder Bore Gauge

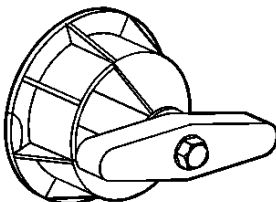
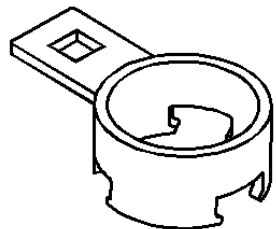
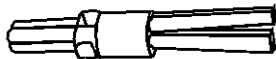
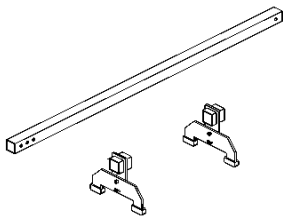


EN-21867-850
J-21867-850
KM-498-B
KM-6106
Oil Pressure Gauge Adapter



EN 28467-B
J 28467-B
Universal Engine Support Fixture

EN 28467-500B
J 28467-500B
Engine Support Fixture

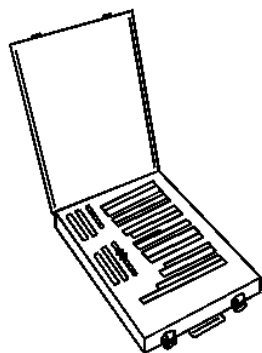


EN-36017
J 36017
KM-840 - Removal
KM-6152 - Installation
Valve Seal Remover

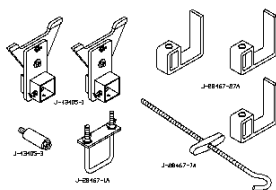
EN-38122-A
J 38122-A
KM-J-38122-A
KM-956-1
Crankshaft Balancer Holder

EN-38188
J 38188
Cylinder Head Broken Bolt Extractor Kit

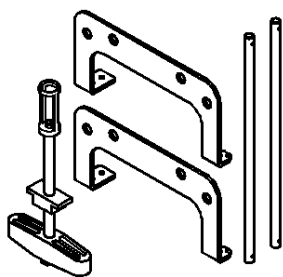
EN-48067
J 42067
KM-J-42067
Rear Main Seal Installer



EN-42385-850
J 42385-850
Thread Repair Kit

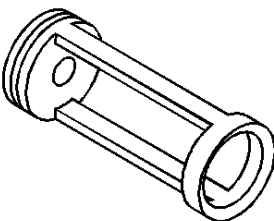
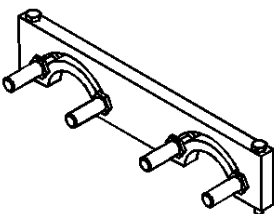
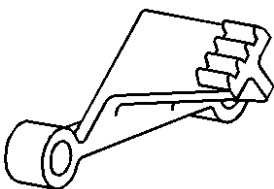
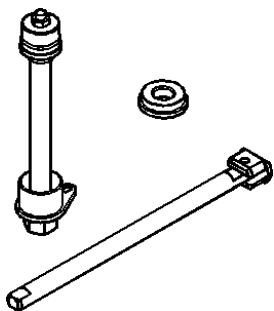


EN 43405
J 43405
Engine Support Fixture Adapter



EN-43649
J 43649
Valve Spring Compressor

EN-43650
J 43650
Balance Shaft Bearing Remover and Installer

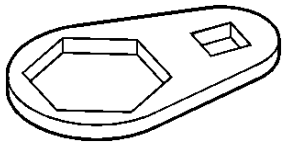
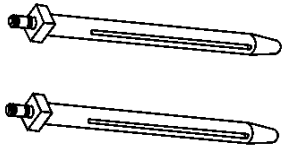


EN 43653
J 43653
KM-652
Flywheel Holding Tool

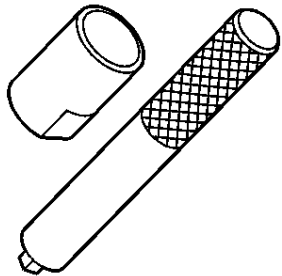
EN-43655
J 43655
KM-6148
Camshaft Sprocket Holding Tool

EN-43963
J 43963
KM-6149
Valve Spring Compressor (off car)

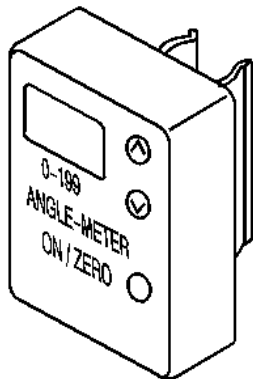
EN-43966
J 43966
Connecting Rod Guides



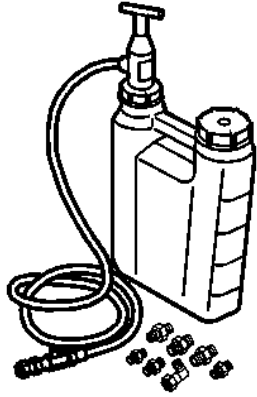
EN-44887
J 44887
KM-6150
Oil Filter Wrench



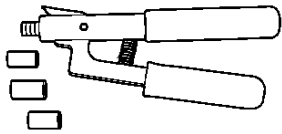
EN-45027
J 45027
Tensioner Tool



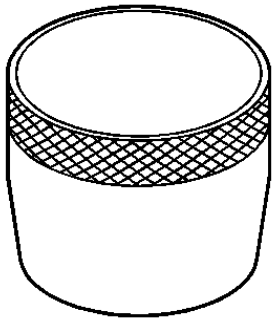
EN-45059
J 45059
KM-470-B
Angle Meter



EN-45299
J 45299
Engine Pre-Luber

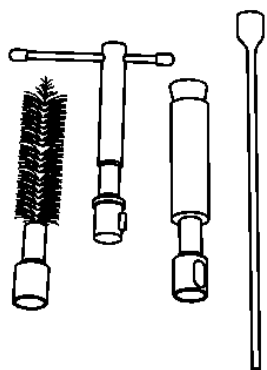


EN 46745
J 43654
Piston Pin Clip Remover/Installer

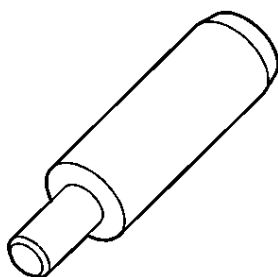


EN 47836
Piston Ring Compressor

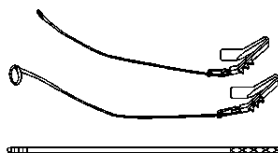
EN-47909
Injector Bore and Sleeve Cleaning Kit



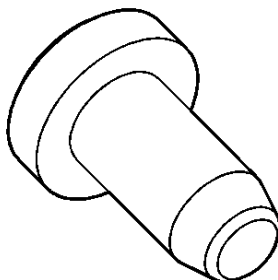
EN 48585
Crankshaft Balancer Guide

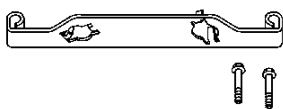


EN 48749
Timing Chain Retention Tool Kit

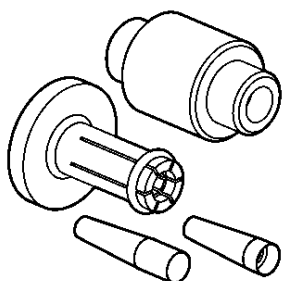


EN 48896
HP Fuel Pump Installation Alignment Gauge

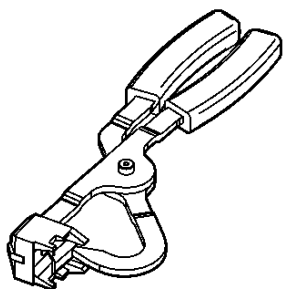




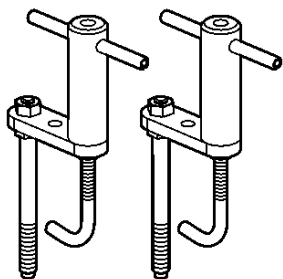
EN 48953
EN 48366
EN 48368
Camshaft Actuator Locking Tool



EN 49245
Fuel Injector Seal Installer/Sizer

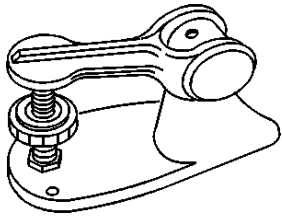


EN 49247
Injector Retaining Clip Installer

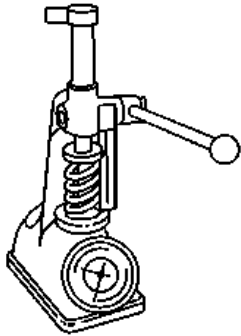


EN 49248
Fuel Rail Assembly Remover

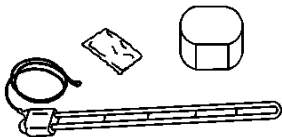
J 9666
Valve Spring Tester



J 22738-B
Valve Spring Tester



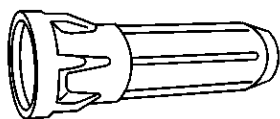
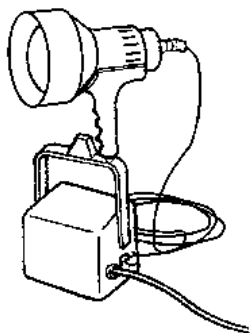
J 23951
Valve Manometer



J 28410
Gasket Remover



J 28428-E
High-Intensity Black Light Kit



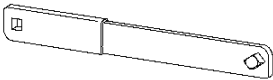
J 35268-A
Camshaft/Front Main Seal Installer

J 35667-A
Cylinder Head Leakdown Tester

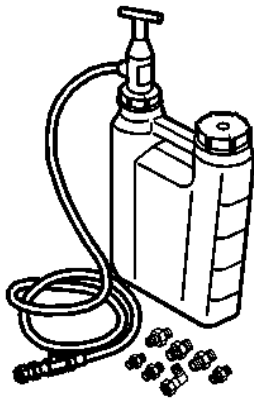
J 36462
Engine Support Adapter Leg



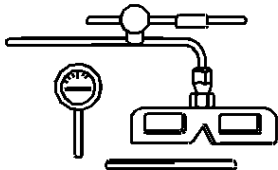
J 38122
Harmonic Balancer Holder



J 44811
Accessory Belt Tensioner Unloader



J 45299
Engine Pre-Luber



GE-7872
J 7872
Magnetic Base Dial Indicator Set