

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

2008 ENGINE**Engine Mechanical - 2.0L - Cobalt****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS**

Application	Specification	
	Metric	English
A/C Compressor to Block Bolt	22 N.m	16 lb ft
Balance Shaft Adjustable Chain Guide Bolt	10 N.m	89 lb in
Balance Shaft Fixed Chain Guide Bolt	12 N.m	106 lb in
Balance Shaft Retaining Bolt	10 N.m	89 lb in
Block Coolant Plug	15 N.m	11 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 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
• Camshaft Timing Chain Tensioner	75 N.m	55 lb ft
• Exhaust Camshaft Position Actuator		
• First Pass	30 N.m	22 lb ft
• Final Pass	100 degrees	
• Intake Camshaft Position Actuator		
• First Pass	30 N.m	22 lb ft
• Final Pass	100 degrees	
Catalytic Converter Stud	50 N.m	37 lb ft
Catalytic Converter Nut	50 N.m	37 lb ft
Chain Guide Access Hole Plug	90 N.m	59 lb ft
Charger AIR Bypass Bolt	25 N.m	18 lb ft
Charger AIR Bypass Nut	25 N.m	18 lb ft
Connecting Rod Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Coolant Jacket Plug	35 N.m	26 lb ft

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Crankshaft Balancer Bolt

• First Pass	100 N.m	74 lb ft
• Final Pass	125 degrees	

Crankshaft Bearings - Lower Crankcase to Block - Bedplate

• First Pass	20 N.m	15 lb ft
• Final Pass	77 degrees	

Crankshaft Position Reluctor Ring	15 N.m	11 lb ft
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Crankshaft Position Sensor Bolt	10 N.m	89 lb in
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Cylinder Head Bolt

• First Pass	30 N.m	22 lb ft
• Final Pass	155 degrees	

Cylinder Head Front Chain Case Bolt	30 N.m	22 lb ft
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Cylinder Head Oil Gallery Plug	35 N.m	26 lb ft
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Cylinder Head Opening Plate Bolt	10 N.m	89 lb in
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Drive Belt Tensioner Bolt	45 N.m	33 lb ft
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Engine Coolant Temperature Sensor	20 N.m	15 lb ft
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Engine Lift Bracket Front Bolt	25 N.m	18 lb ft
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Engine Lift Bracket Rear Bolt	25 N.m	18 lb ft
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Engine Mount to Intermediate Bracket	65 N.m	48 lb ft
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Engine Mount to Midrail Nuts	100 N.m	74 lb ft
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Exhaust Manifold Heat Shield Bolt	25 N.m	18 lb ft
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Exhaust Manifold to Turbocharger Stud	10 N.m	89 lb in
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Exhaust Manifold to Cylinder Head Nut	14 N.m	10 lb ft
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Exhaust Manifold to Cylinder Head Stud	15 N.m	11 lb ft
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Flywheel Bolt - Automatic Transmission

• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	

Flywheel Bolt - Manual Transmission

• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	

Front Cover to Block Bolt	25 N.m	18 lb ft
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Fuel Pipe Bracket Bolt	10 N.m	89 lb in
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Fuel Pressure Dampener Bolt	10 N.m	89 lb in
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Fuel Pressure Sensor	33 N.m	24 lb ft
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Fuel Pump Bolt - High Pressure	15 N.m	11 lb ft
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Fuel Pump - High Pressure Line	30 N.m	22 lb ft
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Fuel Pump - Low Pressure Line	30 N.m	22 lb ft
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Fuel Pump Cover	10 N.m	89 lb in
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Fuel Rail Bolts	22 N.m	16 lb ft
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2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Generator to Block Bolt	22 N.m	16 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Intake Manifold Brace Bolt	22 N.m	16 lb ft
Intake Manifold to Cylinder Head Bolt	22 N.m	16 lb ft
Intake Manifold to Cylinder Head Nut	22 N.m	16 lb ft
Intake Manifold to Cylinder Head Stud	15 N.m	11 lb ft
Knock Sensor Bolt	25 N.m	18 lb ft
Lower Crankcase to Block Perimeter Bolt	25 N.m	18 lb ft
Oil Cooler Bolts	22 N.m	16 lb ft
Oil Filter Adapter Cover	22 N.m	16 lb ft
Oil Gallery Gerotor Cover - Rear Bolt	6 N.m	53 lb in
Oil Gallery Plug - Cylinder Head	35 N.m	26 lb ft
Oil Gallery Plug - Rear - Block	60 N.m	44 lb ft
Oil Level Indicator Tube Bolt	10 N.m	89 lb in
Oil Pan Baffle Bolt	14 N.m	10 lb ft
Oil Pan Bolts	25 N.m	18 lb ft
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pressure Switch	26 N.m	19 lb ft
Oil Pump Gerotor 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 Squirter	15 N.m	11 lb ft
Power Steering Pump Bolt	25 N.m	18 lb ft
Power Steering Tensioner Bolt	22 N.m	16 lb ft
Spark Plug	20 N.m	15 lb ft
Starter Motor to Block Bolt	53 N.m	39 lb ft
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
Timing Chain Adjustable Guide Bolt	10 N.m	89 lb in
Timing Chain Fixed Guide Bolt	12 N.m	106 lb in
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Timing Chain Tensioner Bolt	10 N.m	89 lb in
Timing Chain Upper Guide Bolt	10 N.m	89 lb in
Turbocharger Air Bypass Valve Cover Bolt/Screw	7 N.m	62 lb in
Turbocharger Air Cooler Outlet Pipe Bolts	25 N.m	18 lb ft
Turbocharger Brace Bracket Bolt	22 N.m	16 lb ft
Turbocharger Brace Bracket Bolt	50 N.m	37 lb ft
Turbocharger Brace Bracket Stud	25 N.m	18 lb ft
Turbocharger Brace Nut	50 N.m	37 lb ft
Turbocharger Bracket Bolt	58 N.m	43 lb ft

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	20 N.m	15 lb ft
Turbocharger Coolant Feed Pipe Mounting Bolt	10 N.m	89 lb in
Turbocharger Coolant Return Pipe Bolt	20 N.m	15 lb ft
Turbocharger Exhaust Pipe Heat Shield Bolt	10 N.m	89 lb in
Turbocharger Exhaust Pipe Nut	50 N.m	37 lb ft
Turbocharger Exhaust Pipe Stud	50 N.m	37 lb ft
Turbocharger Heat Shield Bolt	10 N.m	89 lb in
Turbocharger Nut	30 N.m	22 lb ft
Turbocharger Oil Feed Pipe Bolt	20 N.m	15 lb ft
Turbocharger Oil Return Pipe Bolt	10 N.m	89 lb in
Turbocharger Wastegate Regulator Solenoid Valve Bracket Bolt/Screw	7 N.m	62 lb in
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 Drain Plug	20 N.m	15 lb ft
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS**Engine Mechanical Specifications**

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.0 L	122 CID
• RPO	LDK, LNF	
• Liter (VIN)	LDK: E LNF A, M	
• Bore	85.992-86.008 mm	3.3880-3.3887 in
• Stroke	86 mm	3.388 in
• Compression Ratio	9.2:1	
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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

• 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	36.775-36.835 mm	1.4489-1.4512 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	85.992-86.008 mm	3.3880-3.3887 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	0.10 mm	0.0039 in
• Cylinder Head Deck Surface Flatness - Transverse	0.030 mm	0.0012 in
Camshaft		
• Camshaft End Play	0.040-0.307 mm	0.0016-0.0121 in
• Camshaft Journal Diameter	26.935-26.960 mm	1.0604-1.0614 in
• Camshaft Journal Diameter - Front	34.960-34.935 mm	1.3774-1.3764 in
• Camshaft Thrust Surface - with Camshaft Actuator Installed	30.020-30.175 mm	1.1828-1.1889 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	23.007-23.017 mm	0.9058-0.9062 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	49.000-49.014 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	55.994-56.008 mm	2.2045-2.2050 in
Cylinder Head		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

• Deck Straightness - in 150 mm (5.91 in)	0.05 mm	0.0019 in
• Deck Straightness - in 25 mm (0.985 in)	0.025 mm	0.0009 in
• Between Head Bolt Holes	0.030 mm	0.0011 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
Lubrication System		
• Oil Pressure - Minimum - @1000 RPM	344.75-551.60 kPa	50-80 psi
• Oil Capacity	LDK: 5.7L LNF: 4.8L	LDK: 6.0 quarts LNF: 5.0 quarts
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.20-0.35 mm	0.0078-0.0138 in
• Piston Ring End Gap - Second Compression Ring	0.35-0.55 mm	0.014-0.022 in
• Piston Ring End Gap - Oil Control Ring - Rails	0.25-0.75 mm	0.010-0.030 in
• Piston Ring to Groove Clearance - First Compression Ring	0.040-0.080 mm	0.0016-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.003-0.068 mm	0.0001-0.0027 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.024-0.176 mm	0.0009-0.0069 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	0.96-1.04 mm	0.0378-0.0409 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.009-0.023 mm	0.0004-0.0009 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.005-0.015 mm	0.0002-0.0006 in
• Pin - Piston Pin Diameter	22.995-23.000 mm	0.9053-0.9055 in
• Pin - Piston Pin End Play	0.320-1.278 mm	0.0126-0.0503 in
• Piston - Piston Diameter - @14.5 mm up	85.967-85.982 mm	3.3845-3.3851 in
• Piston - Piston Pin Bore Diameter	23.005-23.010 mm	0.9057-0.9059 in

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

• Piston - Piston Ring Groove Width - Oil Control	2.001-2.003 mm	0.0788-0.0789 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 Runout - Maximum	0.04 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.05 mm	0.0020 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 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 Lifters - Valve Lifter Diameter - Stationary Lash Adjuster	11.986-12.000 mm	0.0005-0.0020 in
• Valve Lifters - Valve Lifter-to-Bore Clearance - Stationary Lash Adjuster	0.013-0.051 mm	3.2210-3.2299 in
• Valve Springs - Valve Spring Load - Open - @22.5 mm	525.0-575.0 N. - Eng Spec.	
• Valve Springs - Valve Spring Load - Closed - @32.5 mm	245.0-271.0 N. - Eng Spec.	

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
# 6 Intake Rear Camshaft 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 Level Indicator Tube O-ring	Lubricant	12345501	992704
Fuel Injector O-rings	Engine Oil	12345610	993193
Fuel Injector Tip Insulators	Engine Oil	12345610	993193
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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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
Stationary Hydraulic Lash Adjusters	Lubricant	12345501	992704
Timing Chain Guide Bolt Access Hole Plug	Sealant	12345382	10953489
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

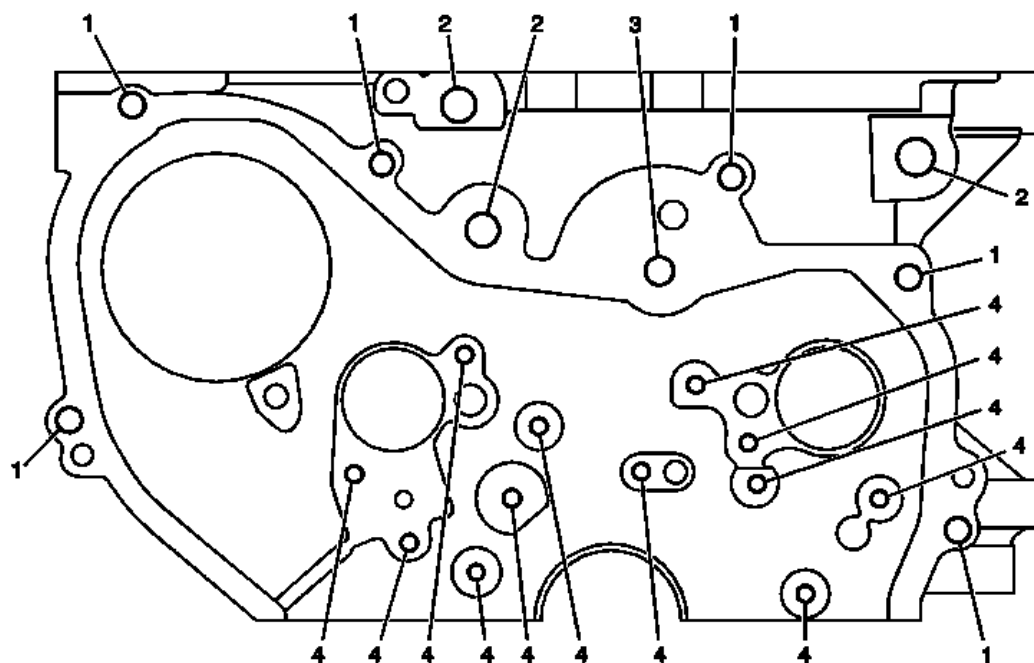


Fig. 1: Identifying Bolt Size & Locations On Engine Block - Front View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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

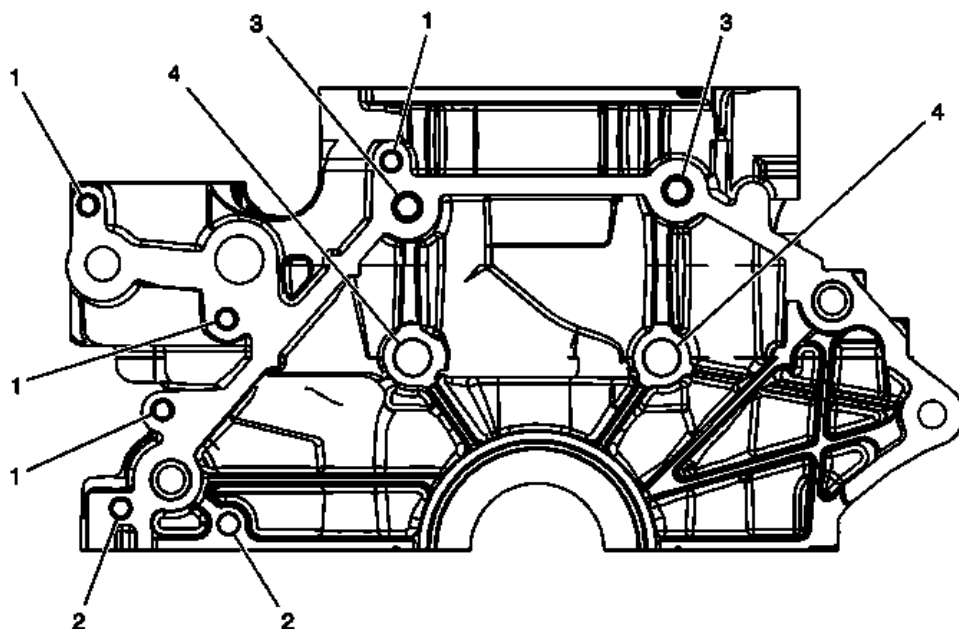


Fig. 2: Identifying Bolt Size & Locations On Engine Block - Back View
 Courtesy of GENERAL MOTORS CORP.

Engine Block - 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	24	0.945	THRU	
2	M10 x 1.5	215	211	212	213	214	29	1.161	THRU	
3	M12 x 1.75	855	856	857	858	859	39	1.535	33.5	1.32
4	M16 x 1.5	860	861	862	863	864	21	0.827	15	0.59

Engine Block - Right Side View

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

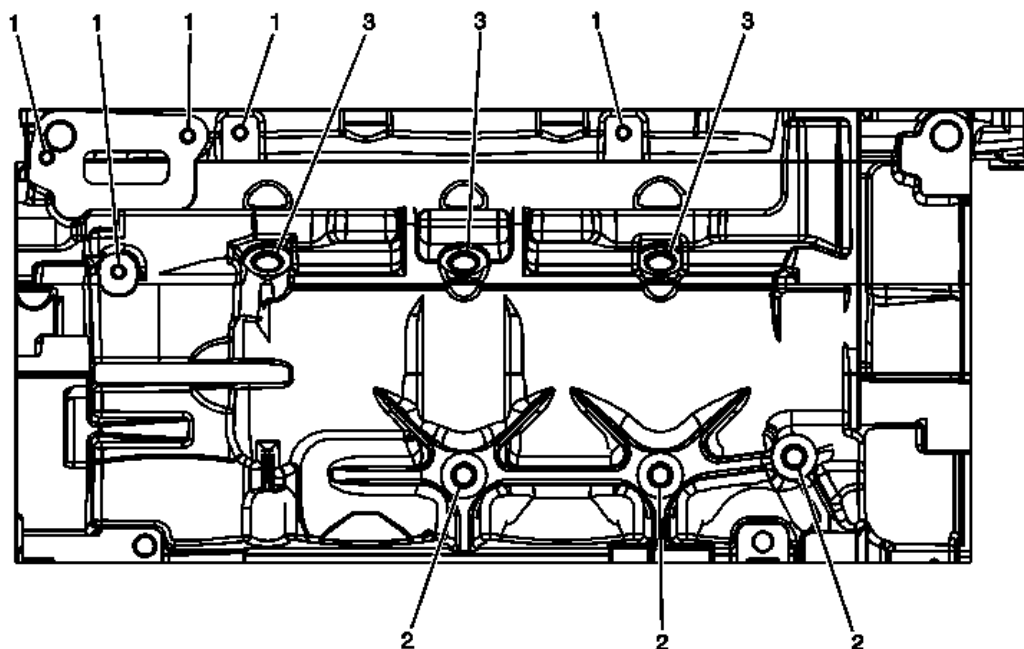


Fig. 3: Identifying Bolt Size & Locations On Engine Block - Right Side View
Courtesy of GENERAL MOTORS CORP.

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	22.5	0.886	16	0.63
2	M10 x 1.5	215	211	212	213	214	34	1.339	27	1.063
3	M12 x 1.75	865	856	857	858	859	19.5	0.768	12.5	0.49

Engine Block - Bottom View

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

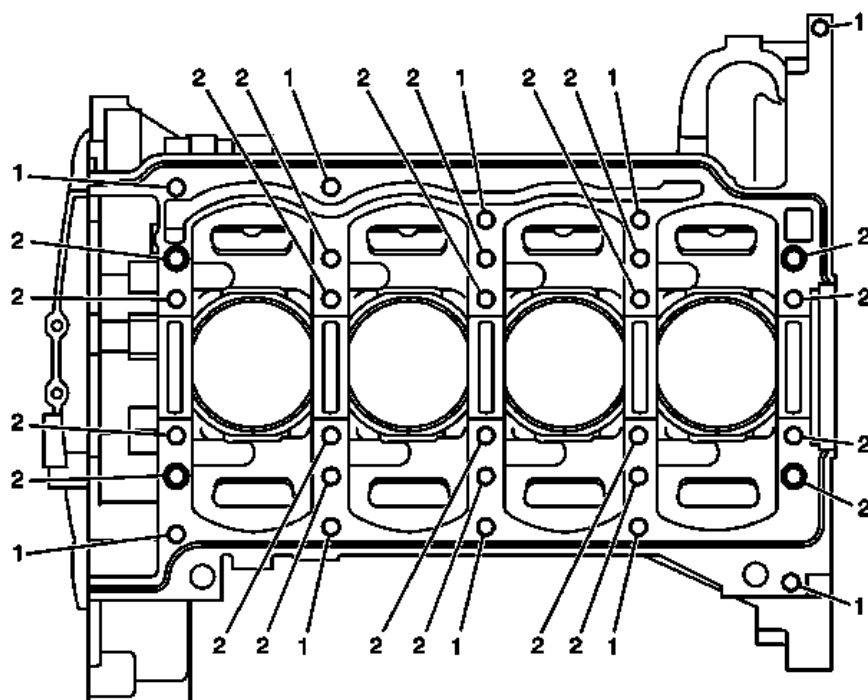


Fig. 4: Identifying Bolt Size & Locations On Engine Block - Bottom
Courtesy of GENERAL MOTORS CORP.

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 - Left Side View

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

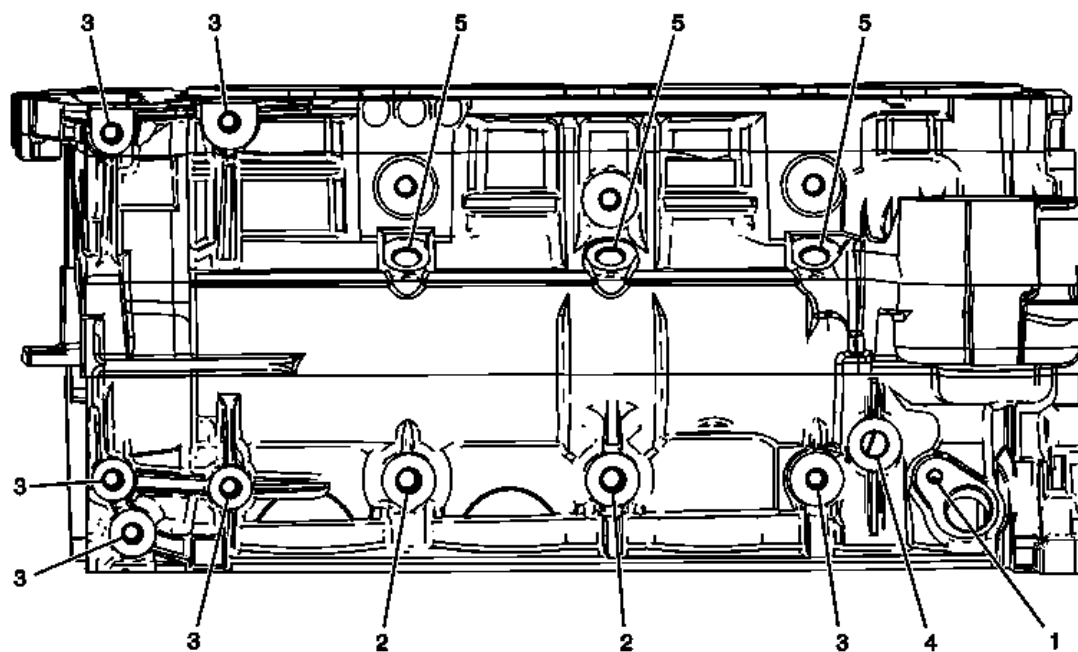


Fig. 5: Identifying Bolt Size & Locations On Engine Block - Left Side View
Courtesy of GENERAL MOTORS CORP.

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	207	208	209	30.5	1.201	22.5	0.89
4	M12 x 1.75	865	856	857	858	859	15.5	0.61	12.5	0.49
5	M12 x 1.75	865	856	857	858	859	19.5	0.778	12.5	0.49

Engine Block - Top View

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

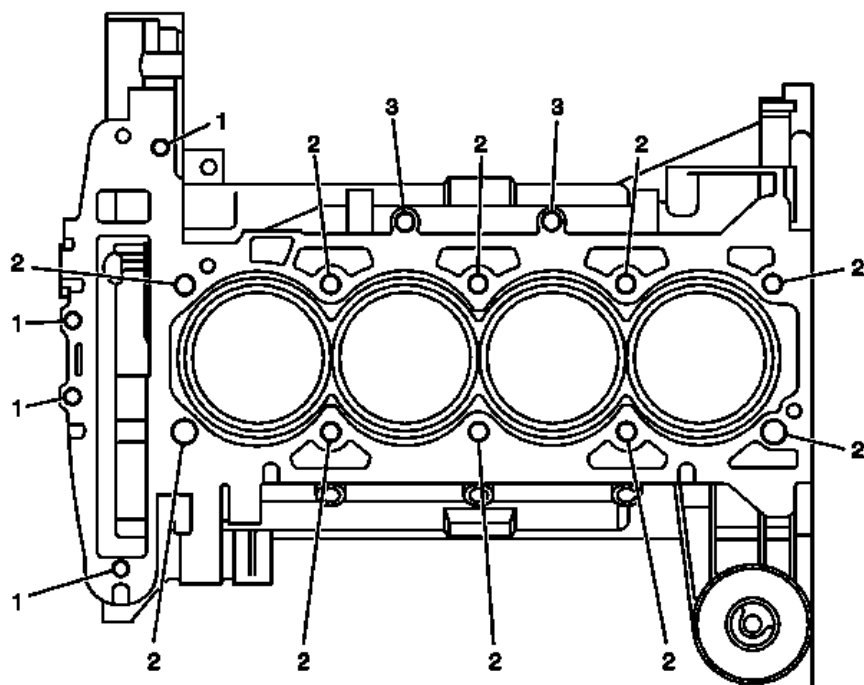


Fig. 6: Identifying Bolt Size & Locations On Engine Block - Top
Courtesy of GENERAL MOTORS CORP.

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	77.5	3.053	70	2.758
3	M12 x 1.75	865	856	857	858	859	13.5	0.531	12.5	0.49

Lower Crankcase - Front View

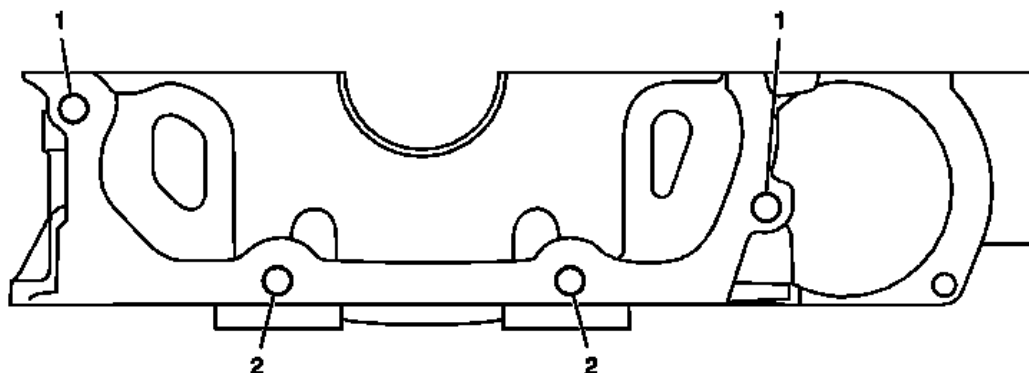


Fig. 7: Identifying Bolt Size & Locations On Lower Crankcase - Front
Courtesy of GENERAL MOTORS CORP.

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

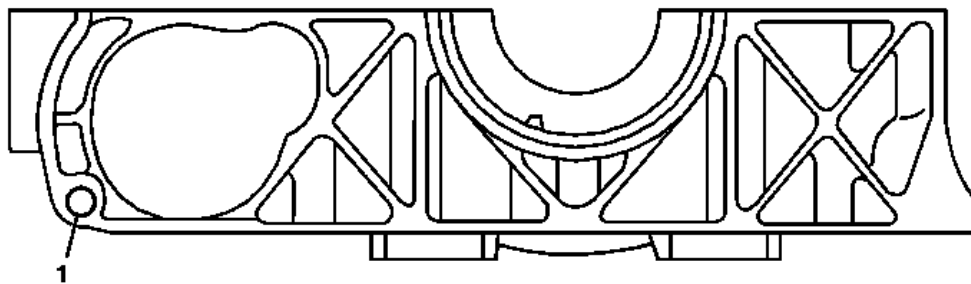


Fig. 8: Identifying Bolt Size & Locations On Lower Crankcase - Back
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum	Tap Depth Maximum
1	M8 x 1.25	210	206	207	208	209	23.5	18.5

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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

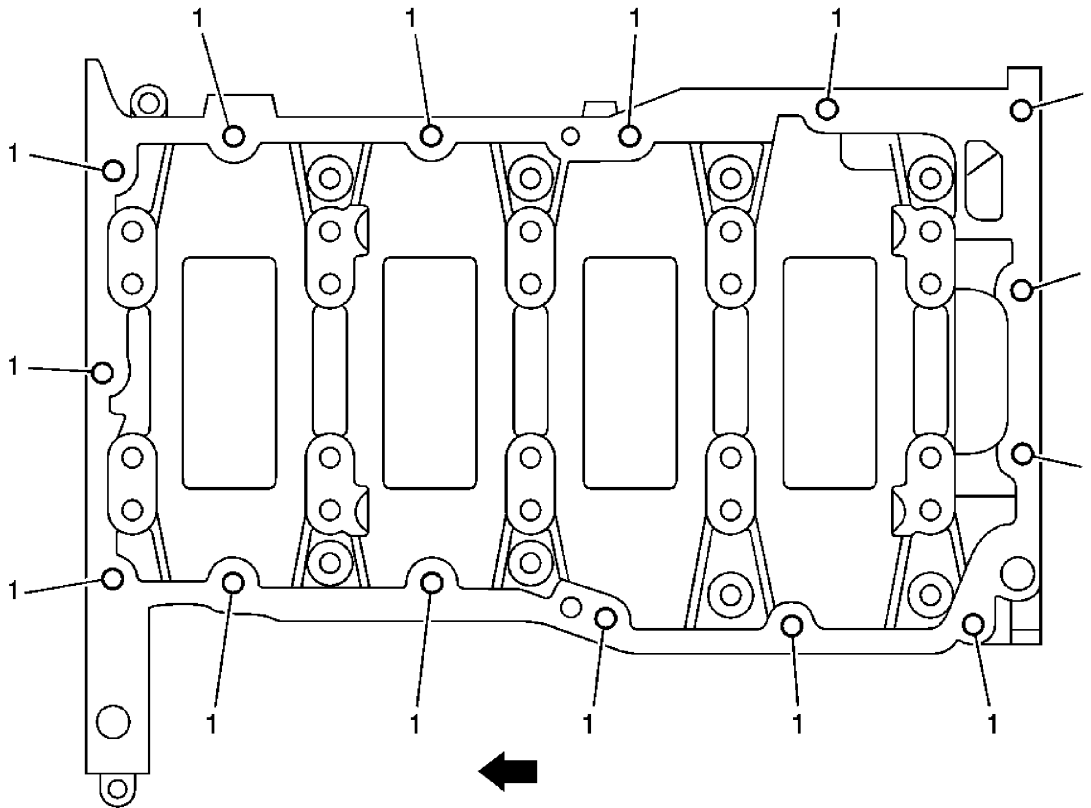


Fig. 9: Identifying Bolt Size & Locations On Lower Crankcase - Bottom
Courtesy of GENERAL MOTORS CORP.

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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

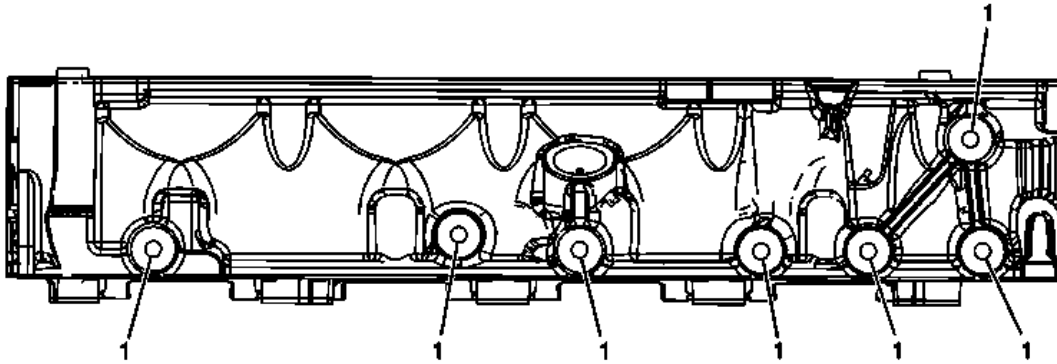


Fig. 10: Identifying Bolt Size & Locations On Lower Crankcase - Right
Courtesy of GENERAL MOTORS CORP.

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

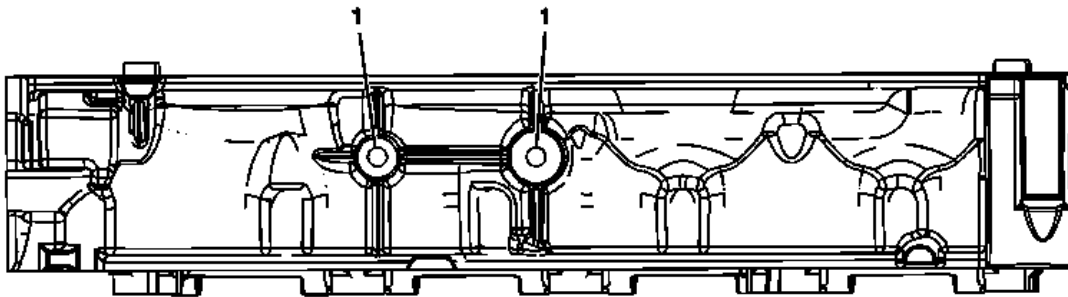


Fig. 11: Identifying Bolt Size & Locations On Lower Crankcase - Left
Courtesy of GENERAL MOTORS CORP.

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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

1	M8 x 1.25	210	211	212	213	214	34	1.339	27	1.063
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Cylinder Head - Top View

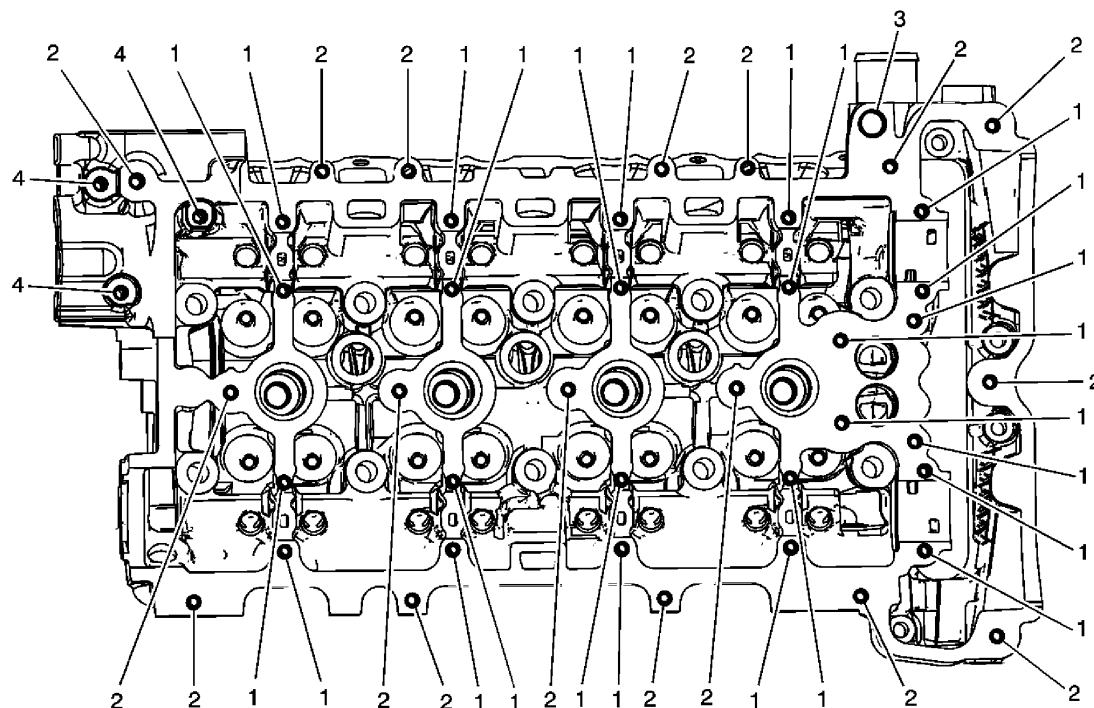


Fig. 12: Identifying Bolt Size & Locations On Cylinder Head - Top
Courtesy of GENERAL MOTORS CORP.

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	23	0.906	19	0.748
2	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
3	M14 x 1.75	856	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

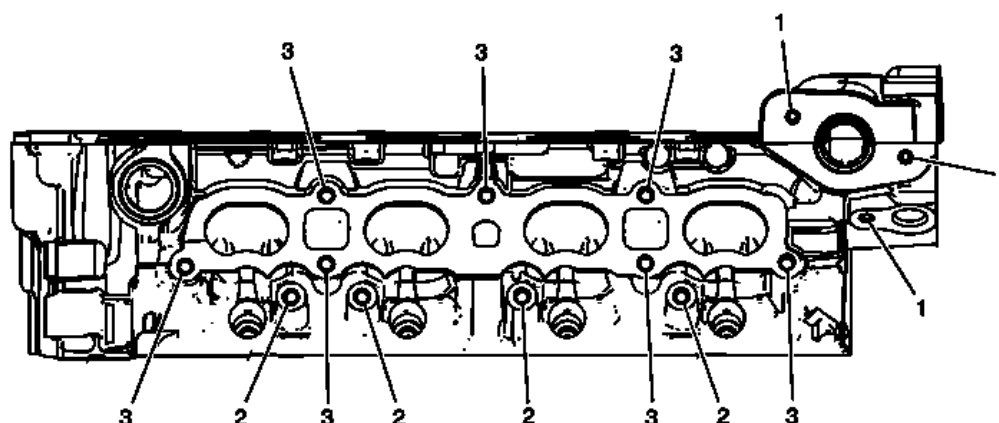


Fig. 13: Identifying Bolt Size & Locations On Cylinder Head - Intake Manifold Deck
Courtesy of GENERAL MOTORS CORP.

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

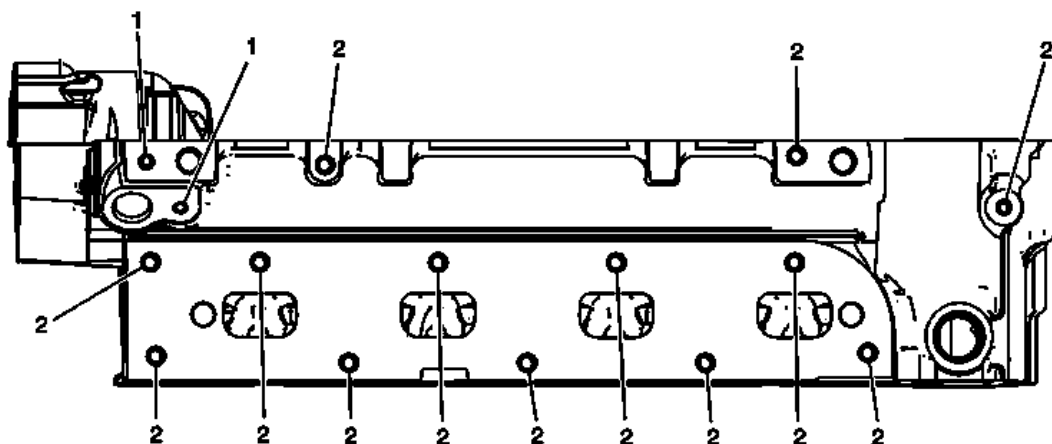


Fig. 14: Identifying Bolt Size & Locations On Cylinder Head - Exhaust Manifold Deck
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Exhaust Manifold Deck View

Service										
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2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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

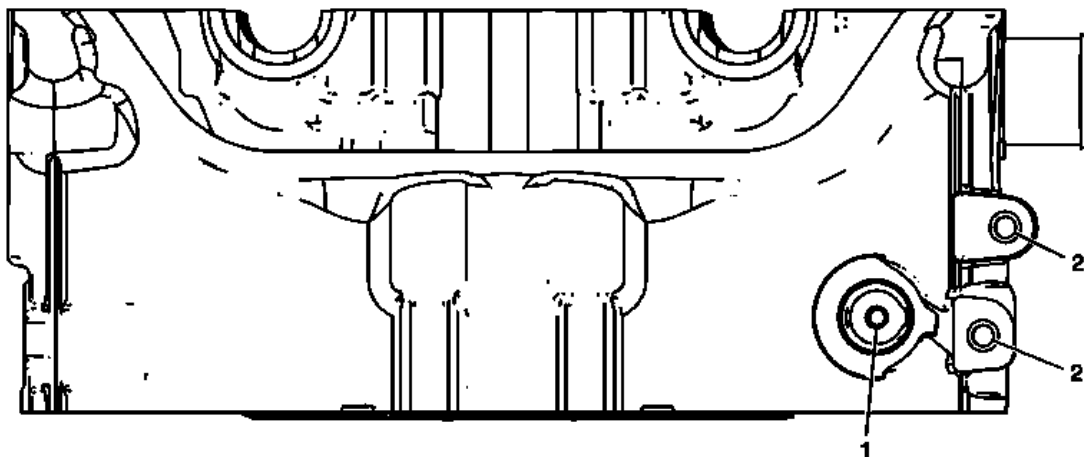


Fig. 15: Identifying Bolt Size & Locations On Cylinder Head - Front
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Head - Back View

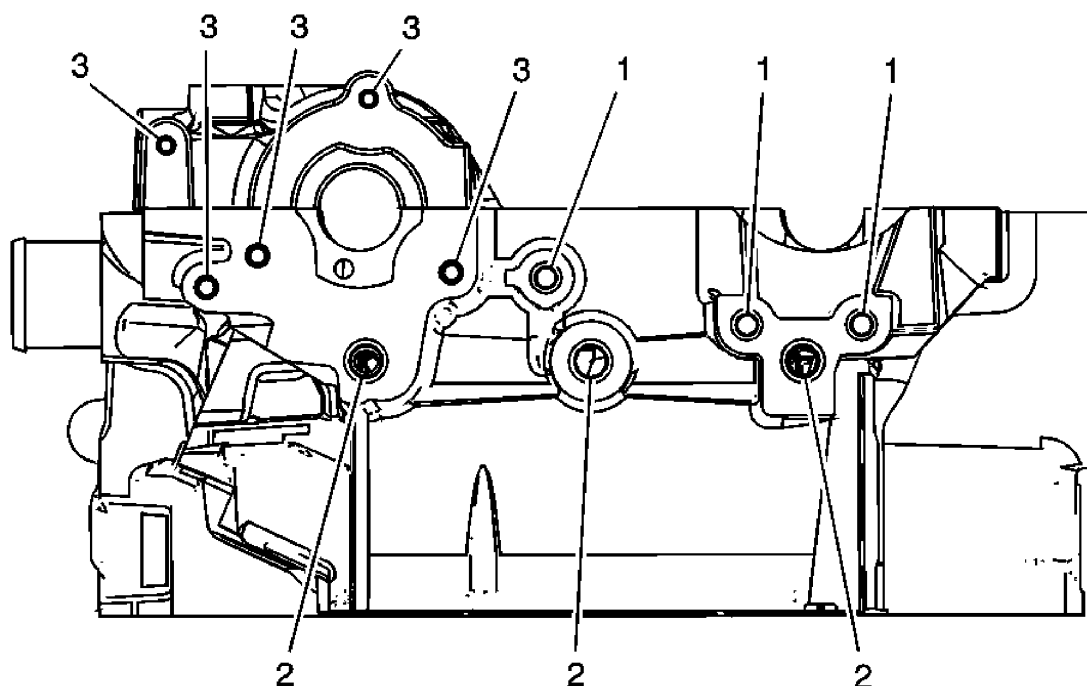


Fig. 16: Identifying Bolt Size & Locations On Cylinder Head - Back

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	
J 42385-850							MM	IN	MM	IN
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

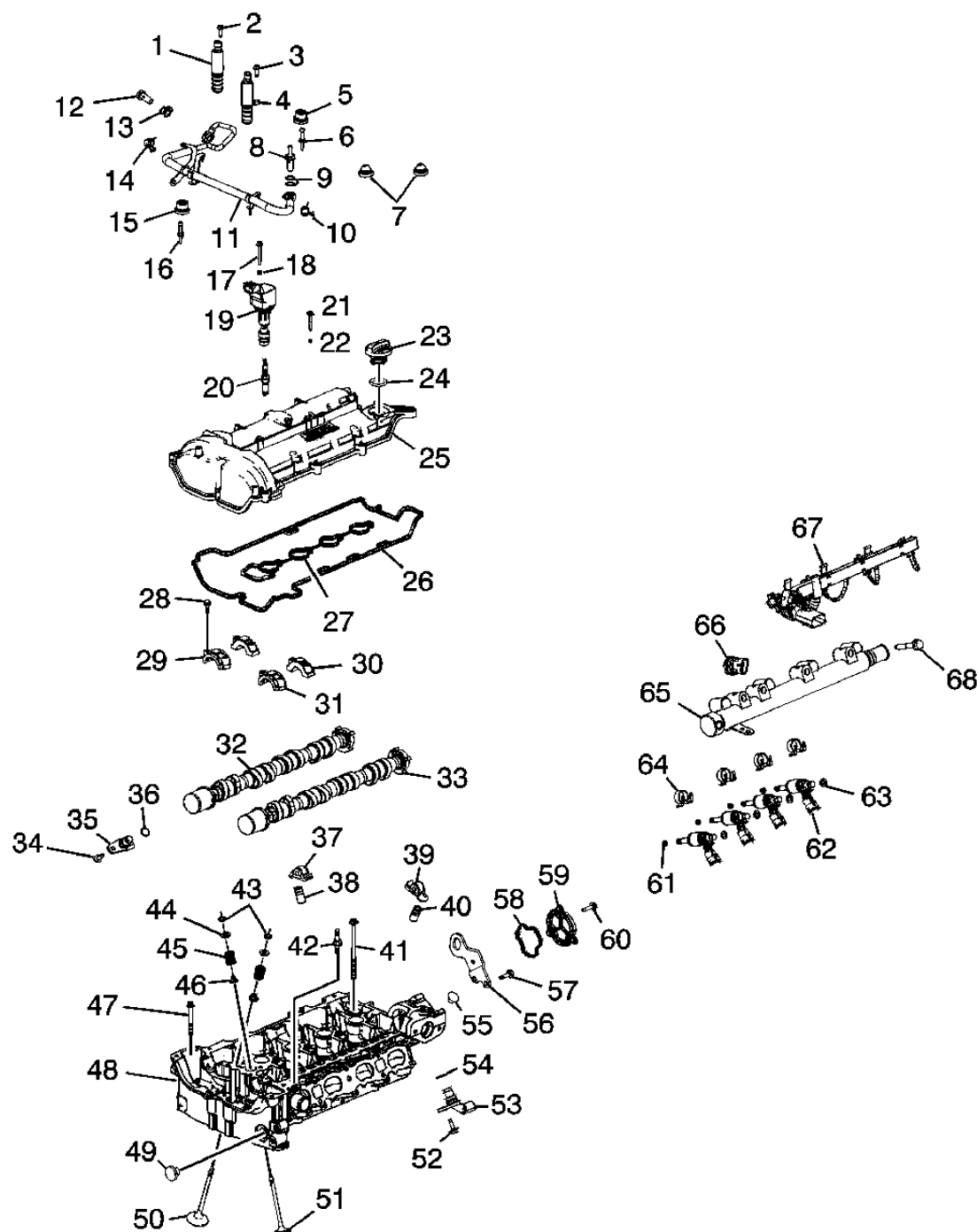


Fig. 17: Cylinder Head and Components
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve - Intake
2	Camshaft Position Actuator Solenoid Valve Bolt

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

3	Camshaft Position Actuator Solenoid Valve Bolt
4	Camshaft Position Actuator Solenoid Valve - Exhaust
5	Upper Intake Manifold Sight Shield Grommet
6	Ball Stud
7	Upper Intake Manifold Sight Shield Grommet
8	Turbocharger Coolant Feed Pipe Fitting
9	Turbocharger Coolant Feed Hose Gasket
10	Turbocharger Coolant Feed Hose Clamp
11	Turbocharger Coolant Feed Hose
12	Turbocharger Coolant Feed Hose Bolt
13	Turbocharger Coolant Feed Hose Gasket
14	Turbocharger Coolant Feed Hose Clamp
15	Upper Intake Manifold Sight Shield Grommet
16	Ball Stud
17	Ignition Coil Bolt
18	Ignition Coil Bolt Retainer
19	Ignition Coil
20	Spark Plug
21	Camshaft Cover Bolt
22	Camshaft Cover Bolt Retainer
23	Oil Fill Cap
24	Oil Fill Cap Seal
25	Camshaft Cover
26	Camshaft Cover Seal
27	Camshaft Cover Seal
28	Camshaft Cap Bolt
29	Camshaft Cap
30	Camshaft Cap
31	Camshaft Cap
32	Exhaust Camshaft
33	Intake Camshaft
34	Camshaft Position Sensor Bolt
35	Camshaft Position Sensor
36	Camshaft Position Sensor O-Ring
37	Roller Finger Follower
38	Hydraulic Lash Adjuster
39	Roller Finger Follower
40	Hydraulic Lash Adjuster
41	Cylinder Head Bolt
42	Coolant Air Bleed Fitting
43	Valve Keys
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2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	Valve Spring Retainer
45	Valve Spring
46	Valve Stem Seal
47	Small Cylinder Head Bolt
48	Cylinder Head
49	Timing Chain Guide Bolt Access Hole
50	Exhaust Valve
51	Intake Valve
52	Camshaft Position Sensor Bolt
53	Camshaft Position Sensor - Intake
54	Camshaft Position Sensor O-Ring
55	Cylinder Head Gallery Plug
56	Rear Lift Bracket
57	Rear Lift Bracket Bolt
58	Cylinder Head Cover Plate Seal
59	Cylinder Head Cover Plate
60	Cylinder Head Cover Plate Bolt
61	Fuel Injector Seal
62	Fuel Injector
63	Fuel Injector O-Ring
64	Fuel Injector Hold Down Clamp
65	Fuel Rail
66	Fuel Rail Pressure Sensor
67	Fuel Injector Wiring Harness
68	Fuel Rail Bolt

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

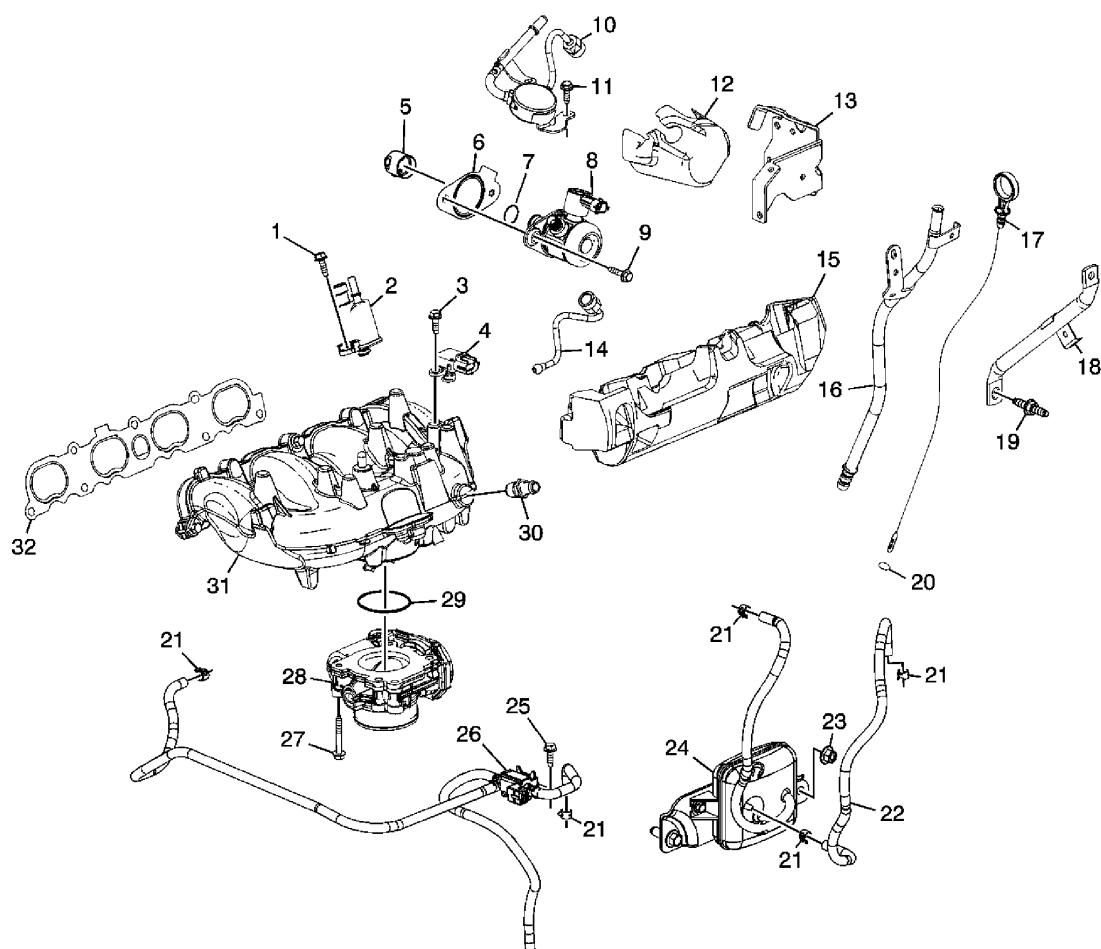


Fig. 18: Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Evaporative (EVAP) Emission Purge Solenoid Valve Bolt
2	EVAP Purge Solenoid Valve
3	Manifold Absolute Pressure (MAP) Sensor Bolt
4	MAP Sensor
5	Fuel Pump Lifter
6	High Pressure Fuel Pump Gasket
7	High Pressure Fuel Pump O-Ring
8	High Pressure Fuel Pump
9	High Pressure Fuel Pump Bolt
10	Fuel Feed Line
11	Fuel Feed Line Bolt
12	High Pressure Fuel Pump Insulator
13	High Pressure Fuel Pump Cover

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

14	High Pressure Fuel Line
15	Fuel Injector Insulator
16	Oil Indicator Tube
17	Oil Indicator
18	Intake Manifold Brace
19	Intake Manifold Brace Stud
20	Oil Indicator O-Ring
21	Charger AIR Bypass Tube Clamp
22	Charger AIR Bypass Tube Assembly
23	Charger AIR Bypass Valve Tank Assembly Nut
24	Charger AIR Bypass Valve Tank Assembly, Some Models
25	Charger AIR Bypass Valve Solenoid Bolt
26	Charger AIR Bypass Valve Solenoid
27	Throttle Body Bolt
28	Throttle Body
29	Throttle Body Seal
30	Power Brake Booster Fitting
31	Intake Manifold
32	Intake Manifold Gasket

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

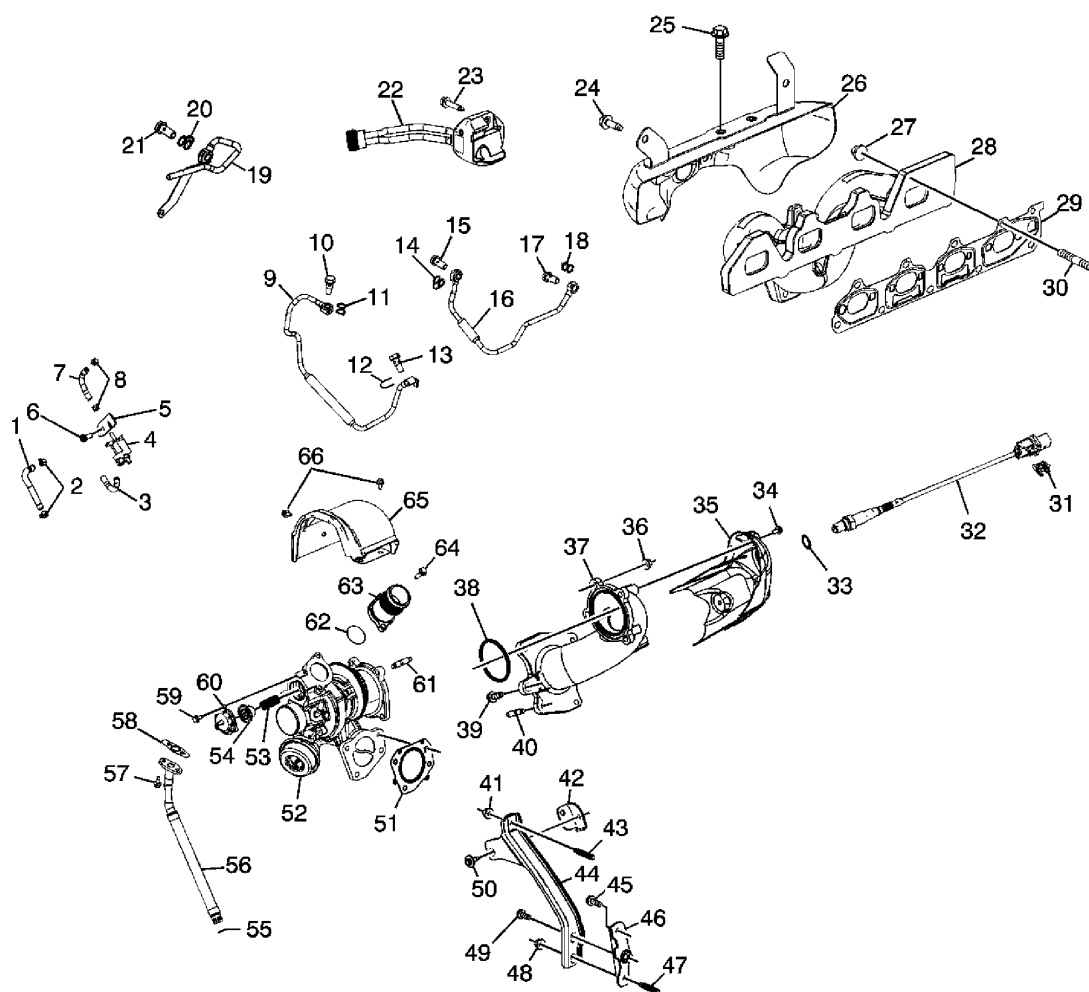


Fig. 19: Exhaust Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Turbocharger Wastegate Regulator Solenoid Hose
2	Turbocharger Wastegate Regulator Solenoid Hose Clamp
3	Turbocharger Wastegate Regulator Solenoid Hose
4	Turbocharger Wastegate Regulator Solenoid Valve Assembly
5	Turbocharger Wastegate Regulator Solenoid Valve Bracket
6	Turbocharger Wastegate Regulator Solenoid Valve Bracket Bolt/Screw
7	Turbocharger Wastegate Regulator Solenoid Hose
8	Turbocharger Wastegate Regulator Solenoid Hose Clamp
9	Turbocharger Oil Feed Pipe
10	Turbocharger Oil Feed Pipe Bolt
11	Turbocharger Oil Feed Pipe Gasket
12	Turbocharger Oil Feed Pipe Gasket

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

13	Turbocharger Oil Feed Pipe Bolt
14	Turbocharger Coolant Return Pipe Gasket
15	Turbocharger Coolant Return Pipe Bolt
16	Turbocharger Coolant Return Pipe
17	Turbocharger Coolant Return Pipe Bolt
18	Turbocharger Coolant Return Pipe Gasket
19	Turbocharger Coolant Feed Pipe
20	Turbocharger Coolant Feed Pipe Gasket
21	Turbocharger Coolant Feed Pipe Bolt
22	Engine Coolant Heater
23	Engine Coolant Heater Bolt
24	Exhaust Manifold Heat Shield Bolt
25	Exhaust Manifold Heat Shield Bolt
26	Exhaust Manifold Heat Shield
27	Exhaust Manifold Nut
28	Exhaust Manifold
29	Exhaust Manifold Gasket
30	Exhaust Manifold Stud
31	Oxygen Sensor Fastener
32	Oxygen Sensor
33	Oxygen Sensor Gasket
34	Turbocharger Exhaust Pipe Heat Shield Bolt
35	Turbocharger Exhaust Pipe Heat Shield
36	Turbocharger Exhaust Pipe Nut
37	Turbocharger Exhaust Pipe
38	Turbocharger Exhaust Pipe Seal
39	Turbocharger Exhaust Pipe Bolt
40	Turbocharger Exhaust Pipe Stud
41	Turbocharger Brace Nut
42	Turbocharger Brace Bracket
43	Turbocharger Brace Stud
44	Turbocharger Brace
45	Turbocharger Brace Bracket Bolt
46	Turbocharger Brace Bracket
47	Turbocharger Brace Bracket Stud
48	Turbocharger Brace Nut
49	Turbocharger Brace Bracket Bolt
50	Turbocharger Brace Bracket Bolt
51	Turbocharger Gasket
52	Turbocharger
53	Turbocharger Air Bypass Valve Spring

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	Turbocharger Air Bypass Diaphragm Assembly
55	Turbocharger Oil Return Pipe O-Ring
56	Turbocharger Oil Return Pipe
57	Turbocharger Oil Return Pipe Bolt
58	Turbocharger Oil Return Pipe Gasket
59	Turbocharger Air Bypass Valve Cover Bolt
60	Turbocharger Air Bypass Valve Cover
61	Turbocharger Exhaust Pipe Stud
62	Turbocharger Air Cooler Outlet Pipe Seal
63	Turbocharger Air Cooler Outlet Pipe
64	Turbocharger Air Cooler Outlet Pipe Bolt
65	Turbocharger Heat Shield
66	Turbocharger Heat Shield Bolts

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

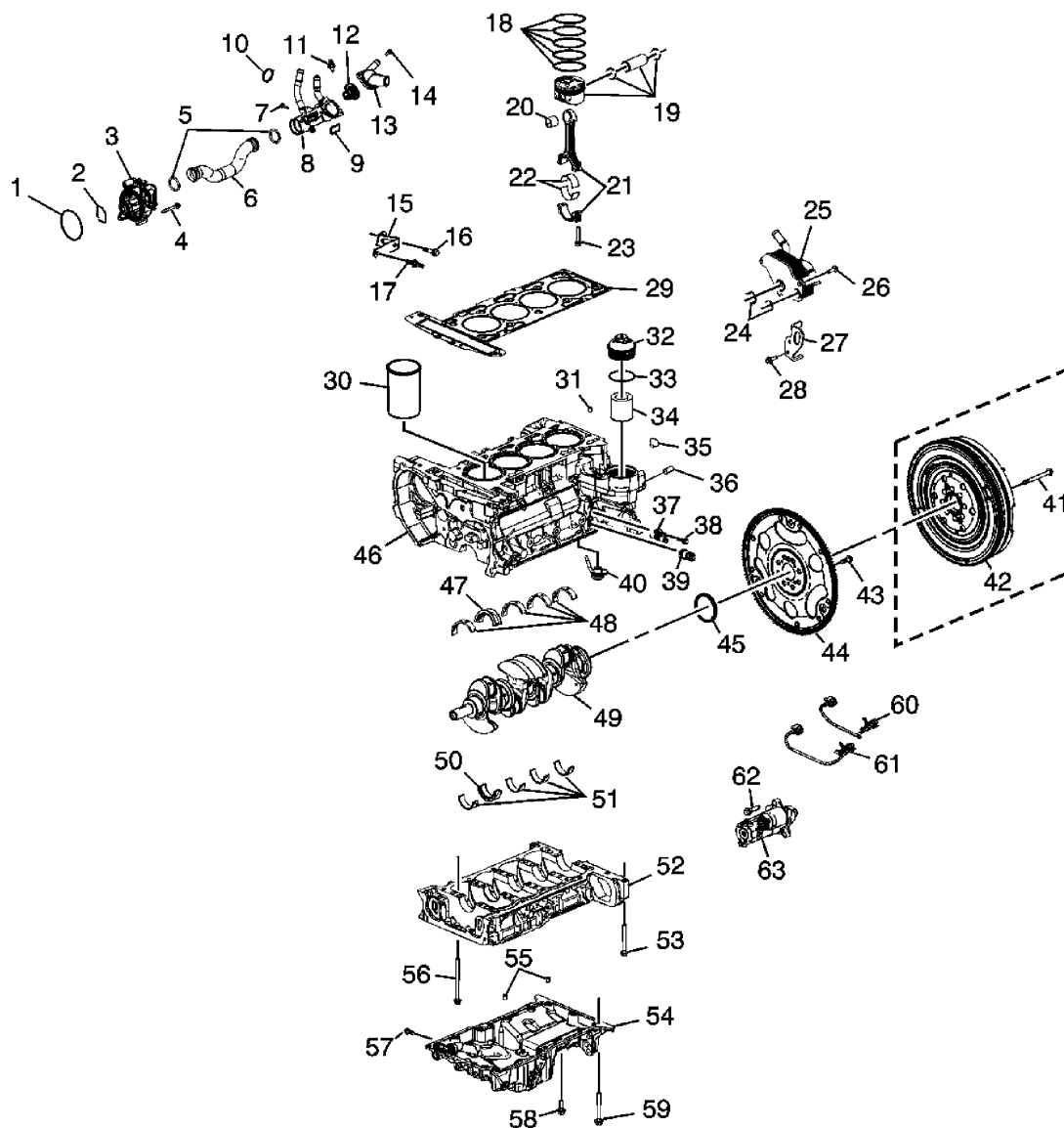


Fig. 20: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Water Pump to Engine Block Seal
2	Water Pump Seal
3	Water Pump
4	Water Pump Bolt
5	Outlet Pipe O-rings
6	Outlet Pipe
7	Coolant Thermostat Housing Bolt
8	Coolant Thermostat Housing

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

9	Thermostat Housing to Block Gasket
10	Coolant Thermostat Housing Seal
11	Coolant Temperature Sensor
12	Thermostat
13	Coolant Inlet
14	Coolant Inlet Bolt
15	Water Pipe Support Bracket
16	Water Pipe Support Bracket Bolt
17	Water Pipe Support Bracket Bolt Stud
18	Piston Ring Assembly
19	Piston Assembly
20	Connecting Rod Bushing
21	Connecting Rod
22	Connecting Rod Bearing
23	Connecting Rod Cap Bolt
24	Oil Cooler O-ring
25	Oil Cooler
26	Oil Cooler Bolt
27	Front Lift Bracket
28	Front Lift Bracket Bolt
29	Cylinder Head Gasket
30	Cylinder Bore Liner
31	Cylinder Head Alignment Pin
32	Oil Filter Cap
33	Oil Filter Cap O-ring
34	Oil Filter
35	Engine Block Gallery Plug
36	Engine Block to Transaxle Alignment Pin
37	Crankshaft Position Sensor
38	Crankshaft Position Sensor Bolt
39	Oil Pressure Switch
40	Piston Oil Nozzle Assembly
41	Manual Transaxle Flywheel to Crankshaft Bolt
42	Flywheel - Manual Transaxle
43	Automatic Transaxle Flywheel to Crankshaft Bolt
44	Flywheel - Automatic Transaxle
45	Crankshaft Rear Seal
46	Engine Block
47	Crankshaft Thrust Bearing - Upper
48	Crankshaft Bearing - Upper
49	Crankshaft
50	

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	Crankshaft Thrust Bearing - Lower
51	Crankshaft Bearing - Lower
52	Lower Crankcase Main Bearing Bolt
53	Lower Crankcase Perimeter Bolt
54	Engine Oil Pan
55	Engine Oil Pan Alignment Pins
56	Lower Crankcase Main Bearing Bolt
57	Engine Oil Pan Drain Plug
58	Engine Oil Pan Bolt
59	Engine Oil Pan Long Bolt
60	Knock Sensor - Rear
61	Knock Sensor - Front
62	Starter Bolt
63	Starter

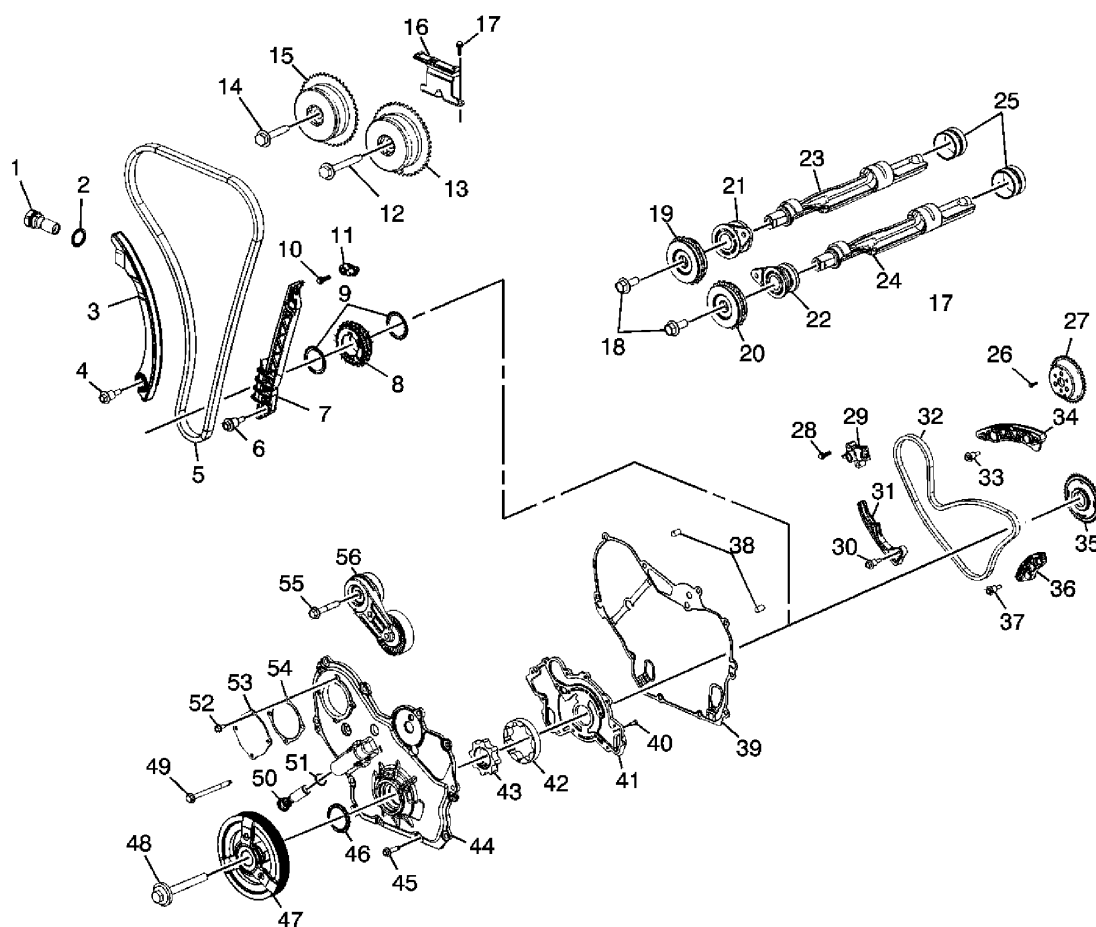


Fig. 21: Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Callout	Component Name
1	Timing Chain Tensioner Body
2	Timing Chain Tensioner Seal
3	Adjustable Timing Chain Guide
4	Adjustable Timing Chain Guide Bolt
5	Timing Chain
6	Fixed Timing Chain Guide Bolt
7	Fixed Timing Chain Guide
8	Timing Chain Drive Sprocket
9	Friction Washers
10	Timing Chain Oil Nozzle Bolt
11	Timing Chain Oil Nozzle
12	Camshaft Position Actuator Bolt
13	Intake Camshaft Position Actuator
14	Camshaft Position Actuator Bolt
15	Exhaust Camshaft Position Actuator
16	Upper Timing Chain Guide
17	Upper Timing Chain Guide Bolt
18	Balance Shaft Drive Sprocket Bolts
19	Exhaust Balance Shaft Drive Sprocket
20	Intake Balance Shaft Drive Sprocket
21	Exhaust Balance Shaft Bearing Carrier
22	Intake Balance Shaft Bearing Carrier
23	Exhaust Balance Shaft
24	Intake Balance Shaft
25	Balance Shaft Rear Bearing
26	Water Pump Drive Sprocket Bolt
27	Water Pump Drive Sprocket
28	Balance Shaft Drive Chain Tensioner Assembly Bolt
29	Balance Shaft Drive Chain Tensioner Assembly
30	Adjustable Balance Shaft Drive Chain Guide Bolt
31	Adjustable Balance Shaft Drive Chain Guide
32	Balance Shaft Drive Chain
33	Balance Shaft Drive Chain Guide Bolt
34	Balance Shaft Drive Chain Guide
35	Balance Shaft Drive Sprocket
36	Balance Shaft Drive Chain Guide
37	Balance Shaft Drive Chain Guide Bolt
38	Engine Front Cover Alignment Pins
39	Engine Front Cover Gasket
40	Oil Pump Cover Bolt
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2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	Oil Pump Cover
42	Oil Pump Gear
43	Oil Pump Inner Rotor
44	Engine Front Cover
45	Engine Front Cover Bolt
46	Crankshaft Front Oil Seal
47	Crankshaft Balancer
48	Crankshaft Balancer Bolt
49	Engine Front Cover Bolt
50	Oil Pressure Relief Valve
51	Oil Pressure Relief Valve O-Ring
52	Water Pump Sprocket Access Cover Bolt
53	Water Pump Sprocket Access Cover
54	Water Pump Sprocket Access Cover Gasket
55	Belt Tensioner Bolt
56	Belt Tensioner

ENGINE IDENTIFICATION

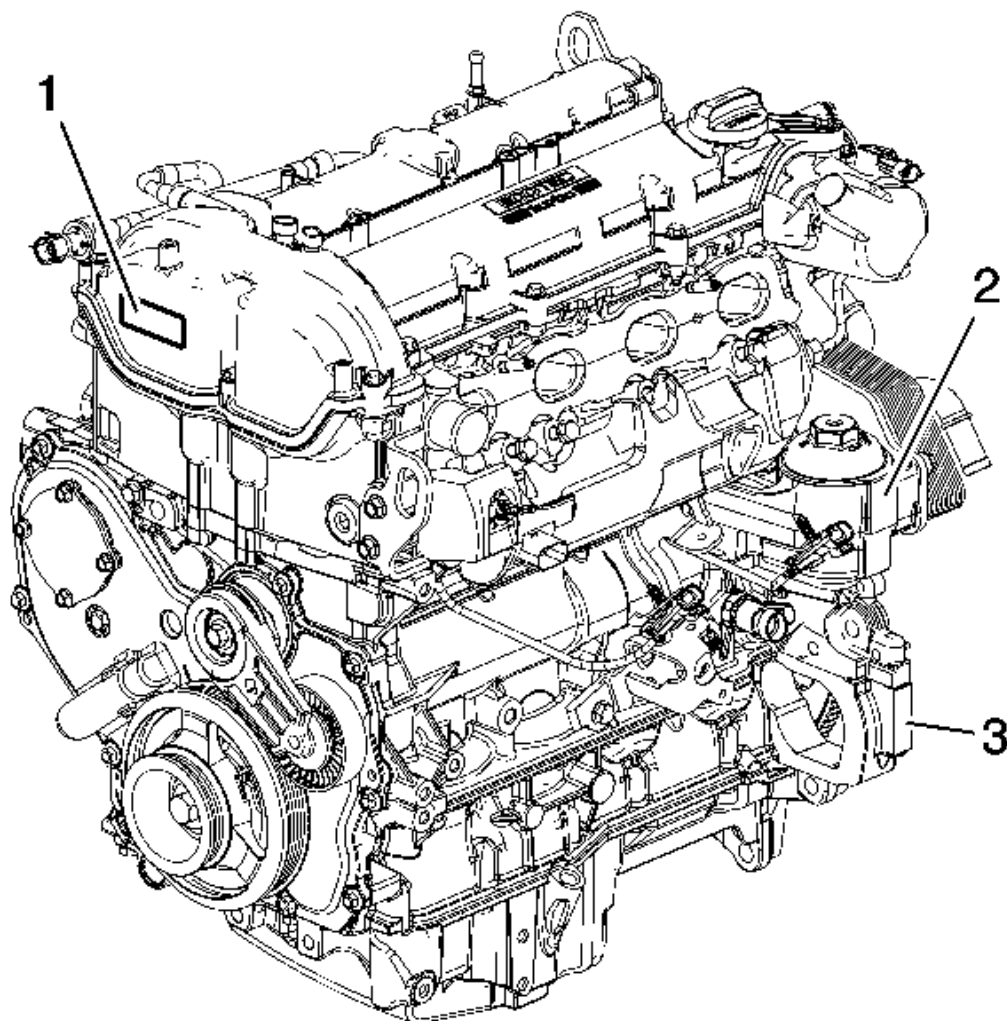


Fig. 22: Locating Engine Identification Numbers
Courtesy of GENERAL MOTORS CORP.

Identification can be made through the use of the broadcast code label (1) on the engine front cover and the use of the partial vehicle identification number (VIN) etched on the oil filter bowl (2).

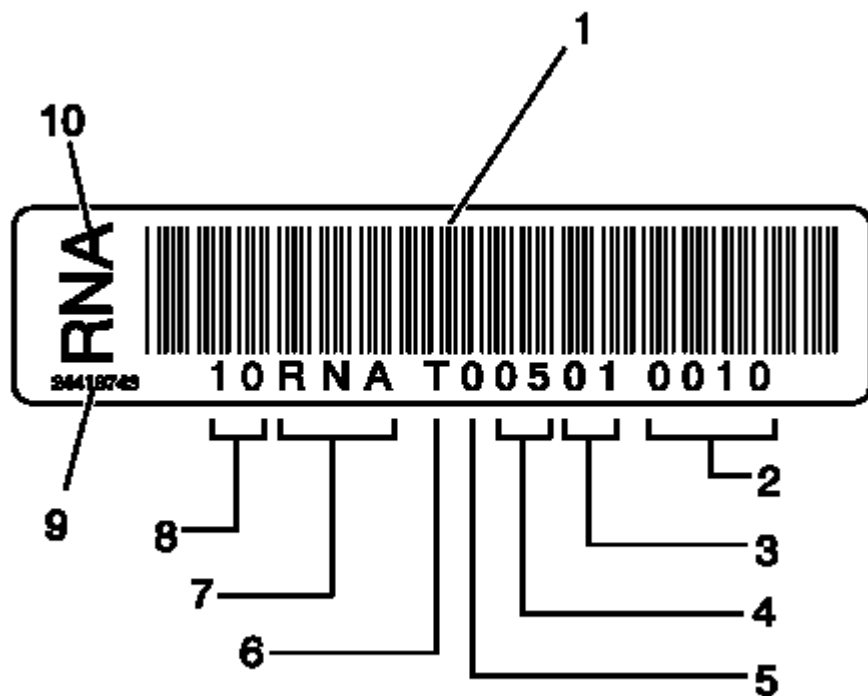


Fig. 23: View Of Broadcast Code Label
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Barcode
2	Sequence Number
3	Day
4	Month
5	Year
6	Engine Assembly Plant
7	Broadcast Code
8	Part Designation
9	Engine Assembly Number
10	Broadcast Code

The partial VIN identifies the specific vehicle by sequence number.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the **Diagnostic System Check - Vehicle** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **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.
- Inspect for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and ensure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

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

- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Coolant in Combustion Chamber
- Coolant in Engine Oil
- Turbocharger Whine Noise
- Turbocharger Hissing Noise
- Turbocharger Oil Leak From Compressor Seal
- Turbocharger Oil Leak From Turbine Seal
- Turbocharger Lack of Oil Supply
- Engine Compression Test
- Cylinder Leakage Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Crankcase Ventilation System Inspection/Diagnosis
- Drive Belt Chirping, Squeal, and Whine Diagnosis
- Drive Belt Rumbling and Vibration Diagnosis
- Drive Belt Falls Off and Excessive Wear Diagnosis
- Drive Belt Tensioner Diagnosis

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
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	Repair or replace, as required.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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.	
Improperly installed or damaged vacuum hoses	Repair or replace, as required.
Improperly installed or leaking charge air cooler tube	Repair or replace, as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body, as required.
Improperly installed or damaged manifold absolute pressure (MAP) sensor or intake air pressure temp (TMAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor and/or the TMAP 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 lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	1. Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. 2. Inspect the cylinder heads, engine block, and/or head gaskets. 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. 2. Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. 3. Perform cylinder leak down and compression testing to identify the cause. 4. Repair or replace, as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.	Replace the sensor and/or crankshaft, as required.

- Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position.
- Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set.
- Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and affect fuel and spark delivery to the point of generating a DTC P0300 or P0336.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, 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.	1. Inspect the components. 2. Repair or replace the components, 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.	1. Inspect the spark plugs for oil deposits. 2. Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace, as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft, and create a DTC	Replace the crankshaft and bearings, as required.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

without an actual misfire condition.

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.

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	1. Inspect the spark plugs for oil deposits. 2. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. 2. Inspect the cylinders for a loss of compression. Refer to <u>Engine Compression Test</u>. 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace, as required.

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

Cause	Correction

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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. The result is camshaft actuator locking pin does not lock	1. Verify correct engine oil viscosity by changing the engine oil and filter. Reevaluate the concern. 2. Isolate the noise to a specific camshaft position actuator. 3. Replace the camshaft actuator, oil and filter.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm stud, nut, or bolt. 2. 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 lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn, damaged, or faulty timing chain tensioners	Replace the timing chain tensioners.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft and valve lifters, as

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	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	1. Perform an oil pressure test. Refer to <u>Oil Pressure Diagnosis and Testing</u>. 2. 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.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	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:

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

- The crankshaft bearings
- The crankshaft journals
- The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 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	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	• Inspect cylinder for damaged components and/or foreign materials. • Inspect for fallen cylinder wall. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Inspect for fallen cylinder wall. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Broken crankshaft

- Inspect crankshaft.
- Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition which may cause engine component damage.	
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. 2 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. 2 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>.	

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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.

TURBOCHARGER WHINE NOISE

Condition	Action
Some whine noise is normal. Compare to a known good vehicle.	
Worn turbocharger bearings	Visually inspect for evidence of compressor wheel to housing contact. Inspect for worn or damaged turbocharger bearings. Inspect for end play causing compressor wheel to housing contact.

TURBOCHARGER HISSING NOISE

Condition	Action
Air inlet leaks or obstructions	Inspect for leaks or obstructions in the turbocharger inlet.
Leaking or restricted exhaust system	1. Inspect for a leak in the exhaust system. 2. Inspect for a restricted exhaust system.
Intake system leaks or obstructions	1. Inspect for leaks. 2. Inspect for obstructions.

TURBOCHARGER OIL LEAK FROM COMPRESSOR SEAL

Condition	Action
Restricted air system	Inspect for a clogged air filter element or restricted air inlet system.
Restricted exhaust system	Inspect for a restricted exhaust.
Leaking exhaust system	Inspect for exhaust manifold leaks.
Poor oil drainage from turbocharger	Inspect for a restricted turbocharger oil drain pipe.
Restricted crankcase ventilation system	Inspect for a restricted crankcase ventilation system.
Worn internal engine components	Inspect for excessive blowby or engine oil consumption.

TURBOCHARGER OIL LEAK FROM TURBINE SEAL

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Condition	Action
Poor oil drainage from turbocharger	Inspect for a restricted turbocharger oil drain pipe.
Restricted crankcase ventilation system	Inspect for a restricted crankcase ventilation system.
Worn internal engine components	Inspect for excessive blowby or engine oil consumption.

TURBOCHARGER LACK OF OIL SUPPLY

Condition	Action
Restricted oil supply hose	Inspect for a restricted or damaged turbocharger oil supply hose.

ENGINE COMPRESSION TEST

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

Tools Required

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

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

- Worn or burnt valves
- Broken valve springs
- Stuck valve lifters
- 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

CAUTION: 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.

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

IMPORTANT: 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** and adjust according to the manufacturers instructions. See Special Tools.
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

1. With the vehicle on a level surface, allow adequate drain down time of 2-3 minutes and measure for a low oil level.
2. Add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine, and verify low, or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
 - Oil diluted by moisture or unburned fuel mixtures
 - Improper oil viscosity for the expected temperature

- Incorrect or malfunctioning oil pressure sender
 - Incorrect or malfunctioning oil pressure gage
 - Plugged oil filter
 - Malfunctioning oil bypass valve
6. Remove the oil pressure sender or another engine block oil gallery plug.
 7. Install an oil pressure gage and measure the engine oil pressure.
 8. Compare the readings to the specifications. Refer to **Engine Mechanical Specifications**.
 9. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:

- Oil pump worn or dirty

Refer to **Oil Pump 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.		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	4. Inspect for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 4
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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, 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.		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 8
8	Use the J 28428-E high-intensity black light kit in order to identify the type of fluid, and the approximate location of the leak. 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. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special 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		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	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 replace all damaged or modified components, as necessary?	Go to Step 1	-

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS**Special Tools****J 23951** Valve Manometer

1. Verify clean air cleaner.
2. Verify oil fill cap is in place.
3. Verify oil level indicator is installed.
4. Remove the oil level indicator. Install a manometer **J 23951** , or equivalent, into the oil level indicator tube.
5. Start the engine.
6. The vacuum of the column of water at idle should be from 3-4 1/2 inches column height.
7. If vacuum is higher inspect and verify the clean air hose from cam cover to air inlet is not blocked or kinked, and the check valve on the clean air hose is open when vacuum from the engine is applied.
8. The hose from valve cover to the turbo is also for the positive crankcase ventilation (PCV) and is used for PCV flow under normal operation and only PCV flow during turbo boost conditions. If the hose is plugged, this will raise vacuum. Diagnosis can be done by removing the turbo side of the hose and start the engine for a few seconds. This should create a large air leak and erratic idle showing there is air flow. If the hose is blocked manually, vacuum will increase.
9. If vacuum is in 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 to approximately 5 inches on the manometer. If held too long, damage could result to the sealing system.
10. If vacuum does not increase, the orifice with check valve in the center of the intake manifold face could be plugged.
11. If there is zero vacuum or pressure, verify compression of the engine.
12. If compression is normal, check for a blocked orifice with check valve at the intake manifold clean orifice.

Concern	Action
External oil leak	Inspect for any of the following conditions:

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	• Plugged air intake system • Plugged positive crankcase ventilation (PCV) orifice/check valve in the intake manifold • Plugged or kinked PCV hoses • Damaged or incorrectly installed PCV hoses • Excessive crankcase pressure • Plugged PCV hose from cam cover to turbo
Rough idle	Inspect for any of the following conditions: • Plugged or incorrectly installed air intake system • Plugged PCV orifice/check valve in the intake manifold • Plugged or kinked PCV hoses • Leaking or damaged PCV hoses • Leaking PCV hose from cam cover to turbo
Stalling or slow idle speed	Inspect for any of the following conditions: • Plugged air intake system • Plugged PCV orifice in the intake manifold • Plugged or kinked PCV hoses • Leaking or damaged PCV hoses • Leaking PCV hose from cam cover to turbo
High idle speed	Inspect for any of the following conditions: • Air inlet system properly connected • Leaking or damaged PCV hoses
Sludge in the engine	Inspect for any of the following conditions: • Plugged or incorrectly installed air intake system • Plugged PCV orifice in the intake manifold • Plugged or kinked PCV hoses • Plugged PCV hose from cam cover to turbo

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.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</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 <u>Diagnostic Aids</u>
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
	Clean the drive belt pulleys with a suitable wire brush.		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

5	Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	NOTE: Refer to <u>Fastener Notice</u> . 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 <u>Diagnostic Aids</u> . 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 <u>Diagnostic Aids</u>
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 <u>Diagnostic Aids</u>
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

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

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

4: Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt 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
NOTE: Refer to <u>Belt Dressing Notice</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 <u>Diagnostic Aids</u>
3	IMPORTANT: 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. 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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	NOTE: Refer to <u>Fastener Notice</u> . 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 (LNF)</u> . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to <u>Diagnostic Aids</u>
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.

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

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

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

Step	Action	Yes	No
NOTE: Refer to <u>Belt Dressing Notice</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.		

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

	Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	NOTE: Refer to <u>Fastener Notice</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 Replacement</u>. Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to <u>Diagnostic Aids</u>
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 <u>Diagnostic Aids</u>
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. 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
	1. Use a torque wrench in order to measure the torque		

3	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. Refer to <u>Drive Belt Tensioner Replacement</u> . Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT

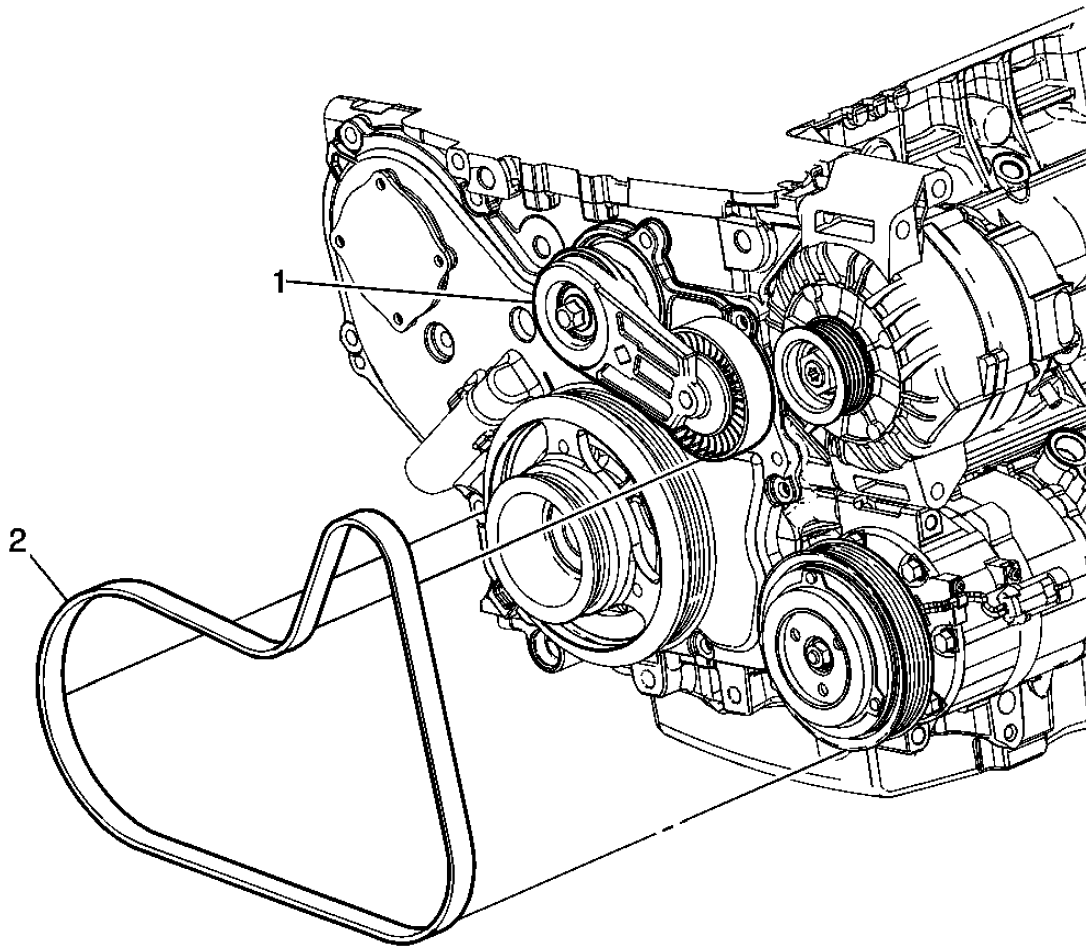


Fig. 24: View Of Drive Belt Routing (With A/C)
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedures	
1. Remove the air cleaner assembly. Refer to <u>Air Cleaner Assembly Replacement</u> .	
2. Lower the vehicle.	
1	Accessory Drive Belt

DRIVE BELT TENSIONER REPLACEMENT

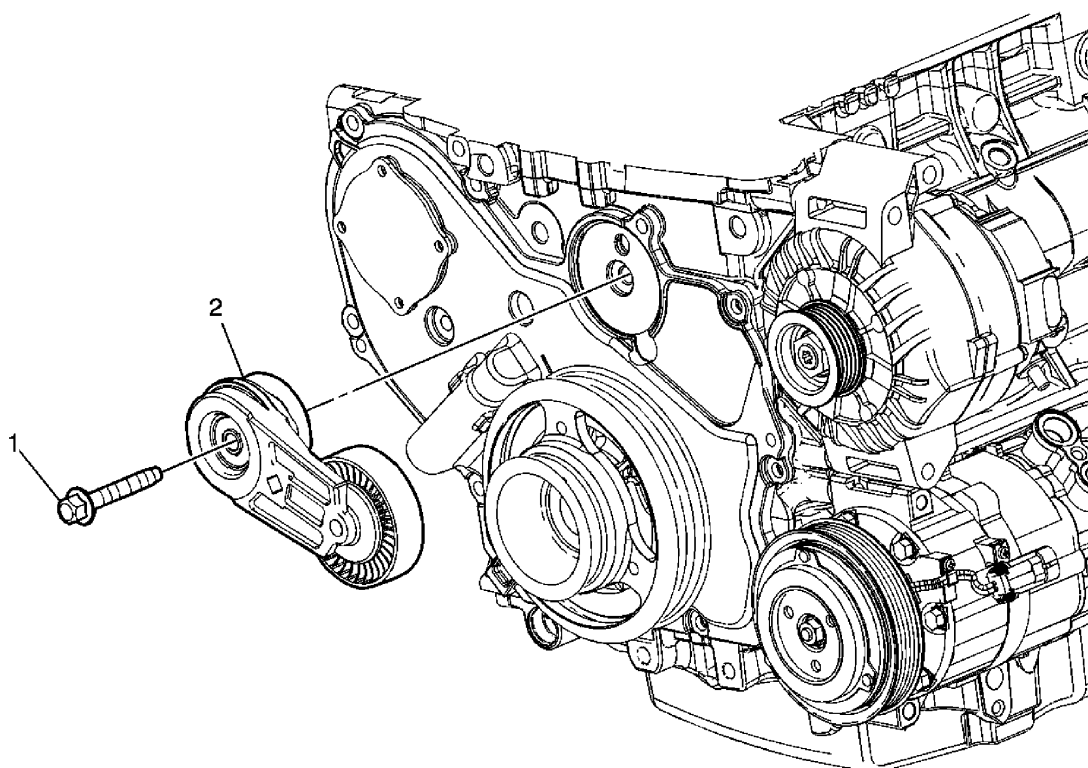


Fig. 25: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
Preliminary Procedure: Remove the drive belt. Refer to <u>Drive Belt Replacement</u> .	
1	Drive Belt Tensioner Bolt NOTE: Refer to <u>Fastener Notice</u> . Tighten: 45 N.m (33 lb ft)
2	Drive Belt Tensioner

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT**Removal Procedure**

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection**.
2. Disconnect the engine oil pressure sensor electrical connector.

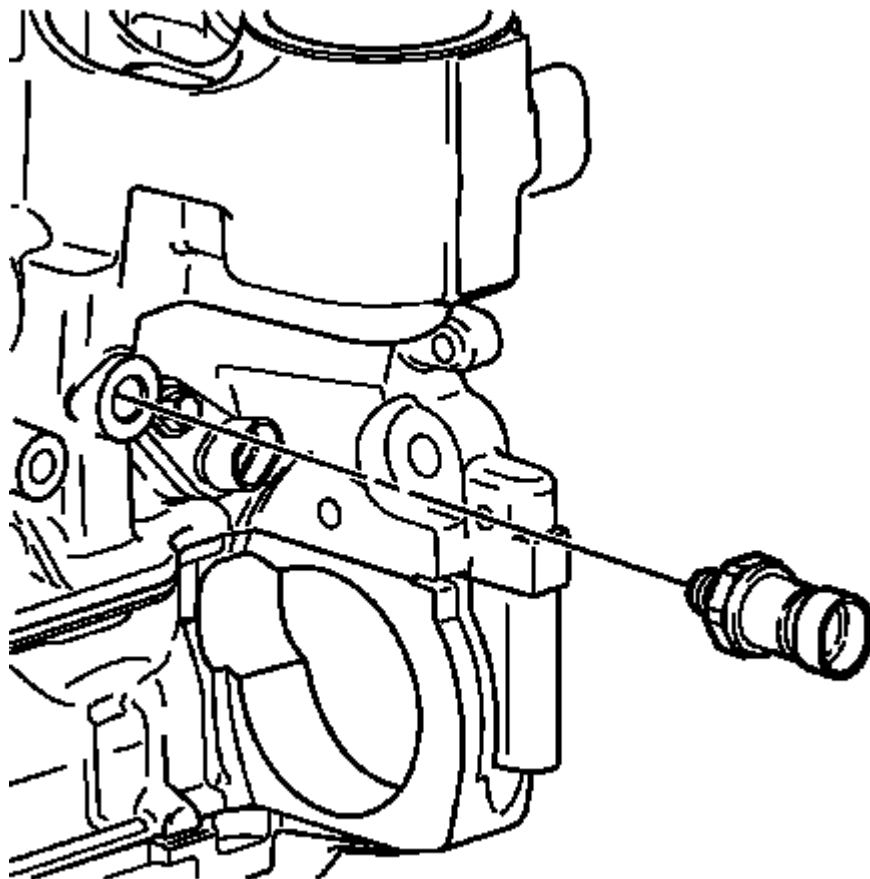


Fig. 26: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure sensor from the engine oil cooler assembly.

Installation Procedure

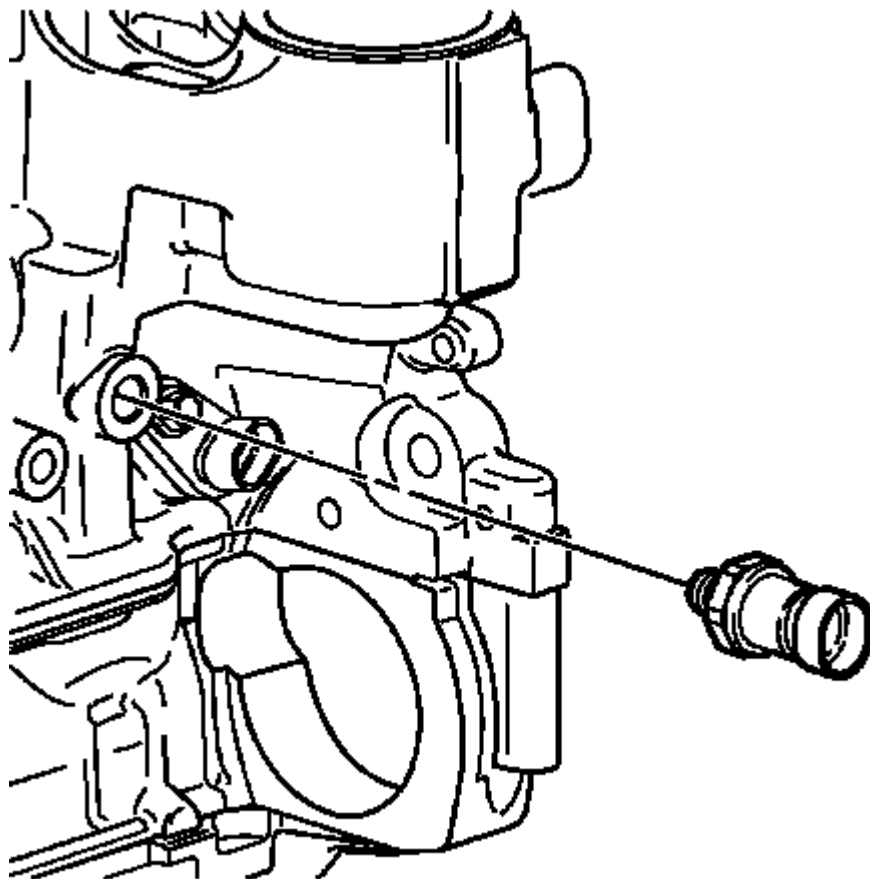


Fig. 27: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the engine oil pressure sensor to the engine oil cooler assembly.

Tighten: Tighten the oil pressure sensor to 22 N.m (16 lb ft).

2. Connect the engine oil pressure sensor electrical connector.
3. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection .

ENGINE MOUNT INSPECTION

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

1. Install the engine support fixture. Refer to Engine Support Fixture.
2. 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**.

ENGINE MOUNT BRACKET REPLACEMENT

Removal Procedure

1. Remove the engine mount. Refer to **Engine Mount Replacement** .

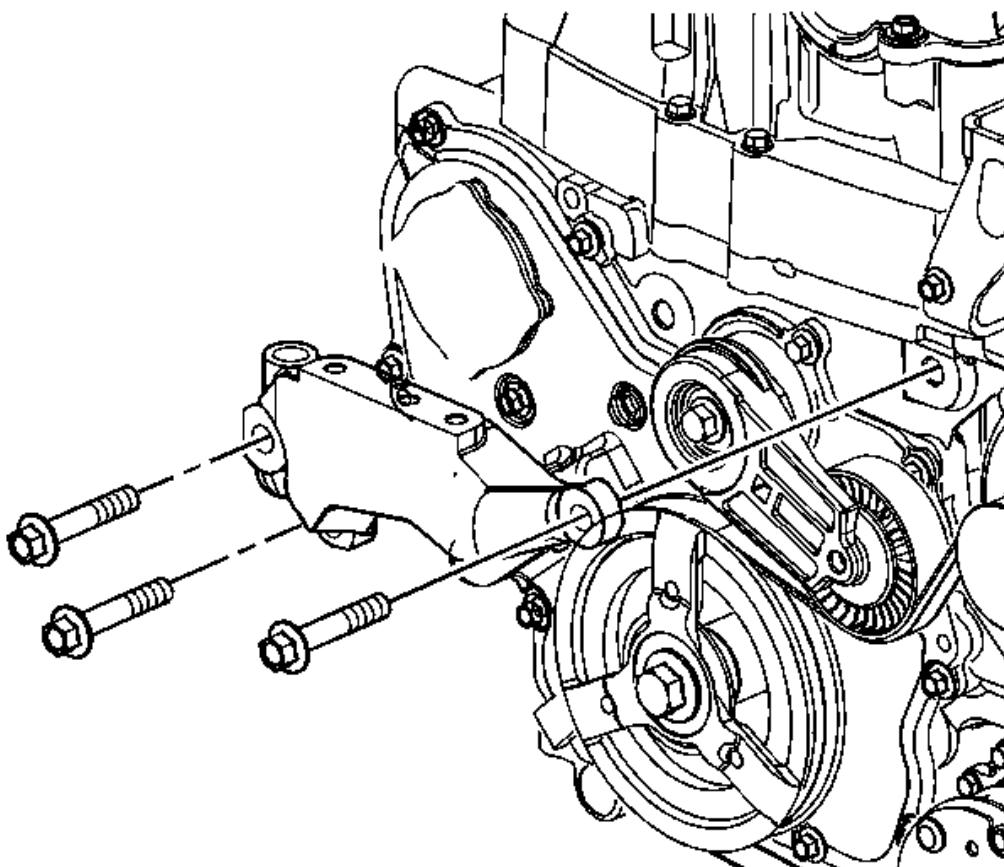


Fig. 28: View Of Intermediate Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the intermediate bracket to engine bolts.
3. Remove the intermediate bracket from the engine.

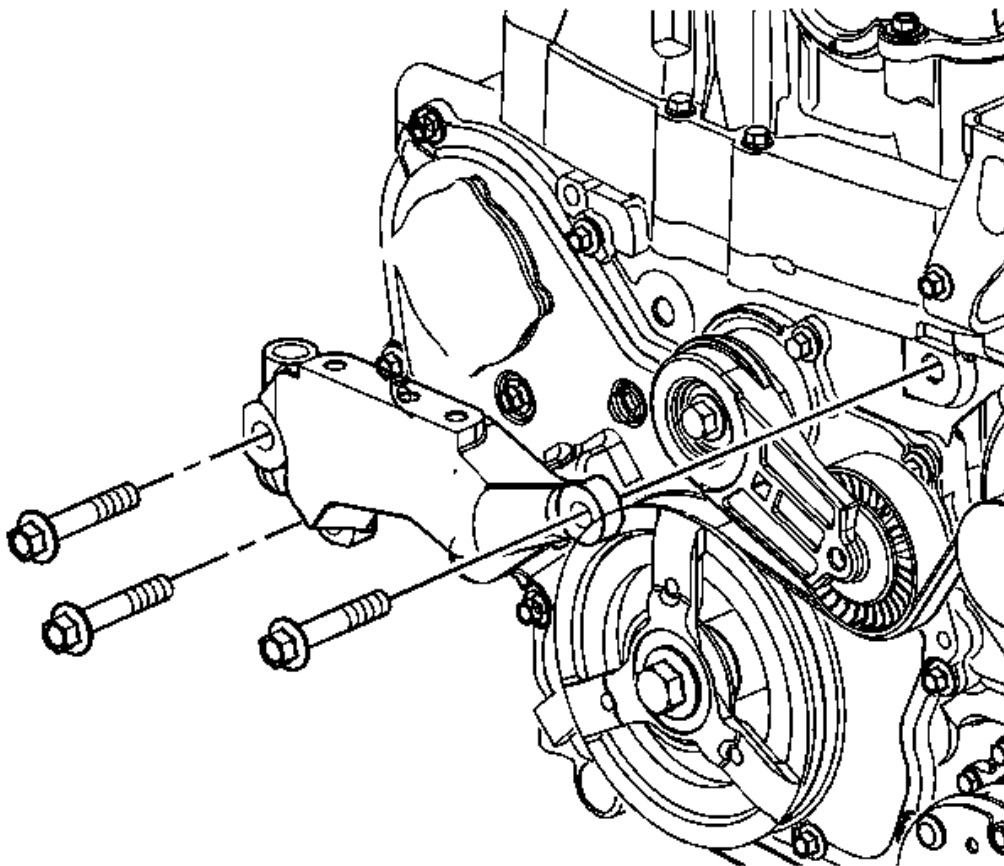
Installation Procedure

Fig. 29: View Of Intermediate Bracket
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice .

3. Tighten the intermediate bracket bolts.

Tighten: Tighten the bolts to 100 N.m (74 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement** .

ENGINE MOUNT REPLACEMENT

Removal Procedure

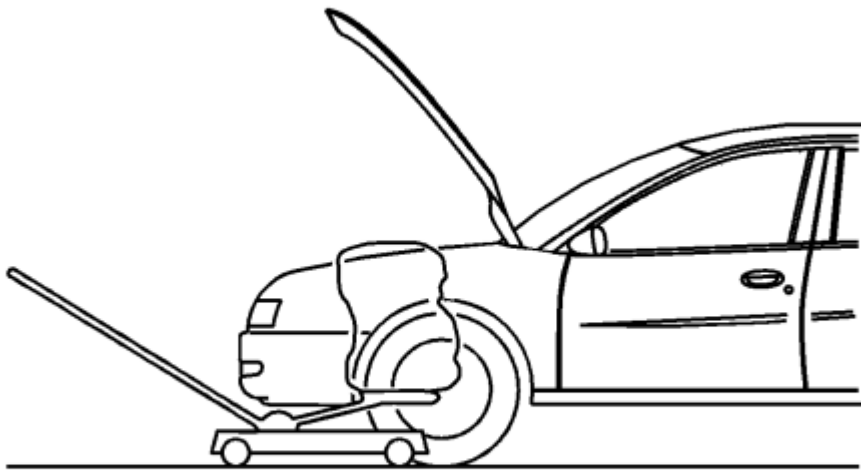


Fig. 30: Supporting Engine/Transmission With Hydraulic Floor Jack
Courtesy of GENERAL MOTORS CORP.

1. Support the engine with a hydraulic floor jack. Use a piece of wood between the jack and the oil pan.

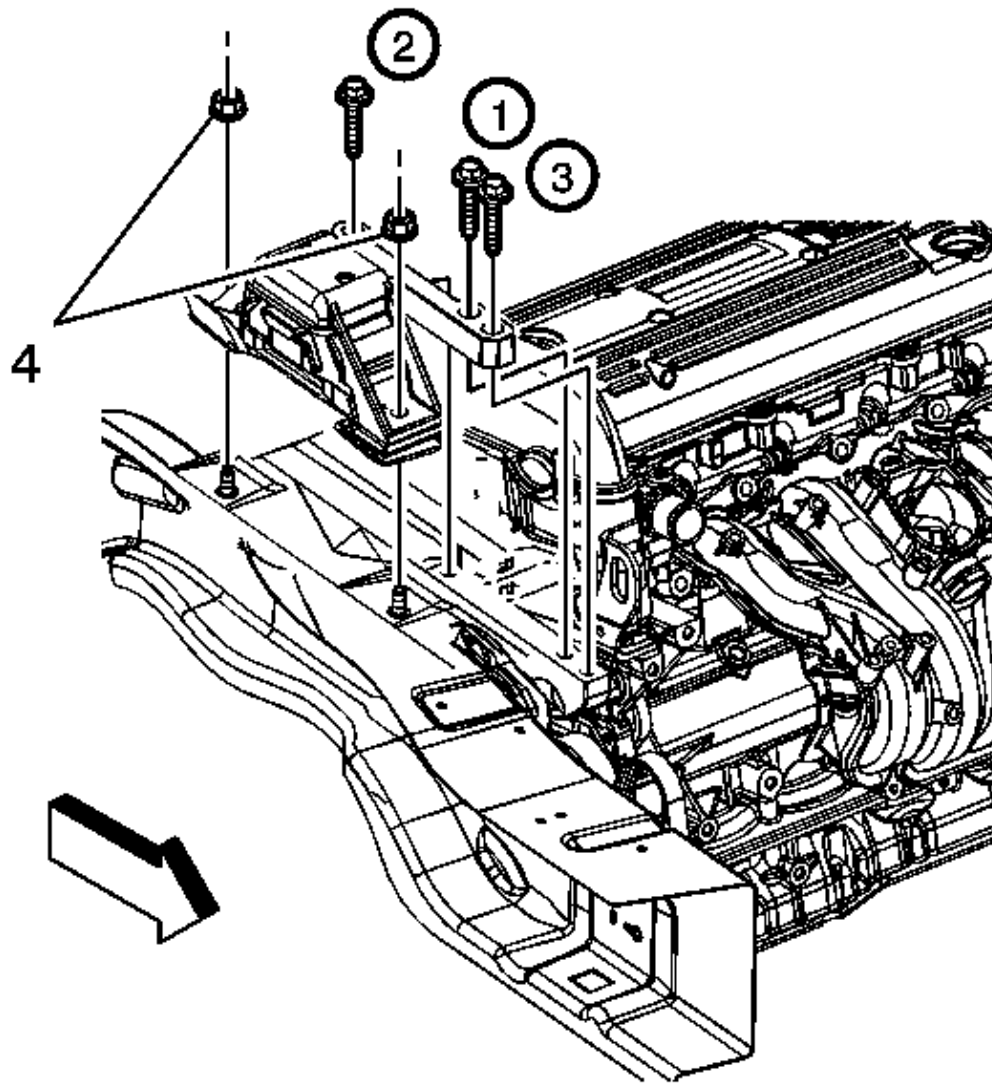


Fig. 31: Identifying Engine Mount To Intermediate Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine mount to intermediate bracket bolts.
3. Remove the engine mount to midrail nuts (4).
4. Remove the engine mount from the engine compartment.

Installation Procedure

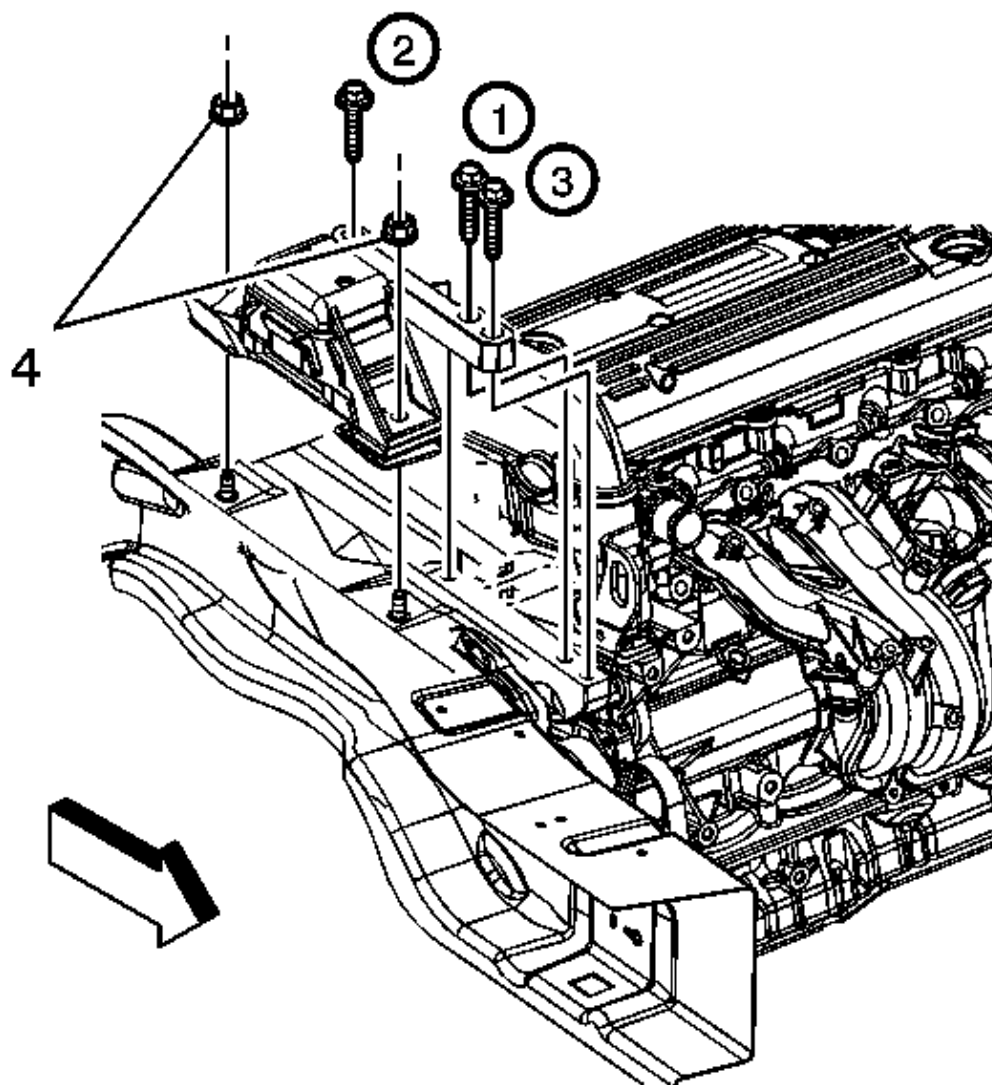


Fig. 32: Identifying Engine Mount To Intermediate Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Place the engine mount onto the midrail and hand start the nuts.

NOTE: Refer to Fastener Notice .

2. Tighten the engine mount to midrail nuts (4).

Tighten: Tighten the nuts to 100 N.m (74 lb ft).

IMPORTANT: The engine mount to intermediate bracket bolts must be hand started. Do not pry the engine mount to align the holes.

3. Hand start the engine mount to intermediate bracket bolts.

IMPORTANT: The engine mount bracket bolts must be torqued in a mandatory torque sequence as shown.

4. Tighten the engine mount to intermediate bracket bolts.

Tighten: Tighten the bolts to 65 N.m (48 lb ft).

5. Remove the hydraulic floor jack.

ENGINE SUPPORT FIXTURE

Tools Required

- **J 28467-B** Universal Engine Support Fixture
- **J 28467-500** Engine Support Fixture

Installation Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Place the engine support fixture legs (1) from the **J 28467-B** across the engine compartment.
3. Install the engine support fixture legs (1) from the **J 28467-500** on the engine support fixture long bar (2).

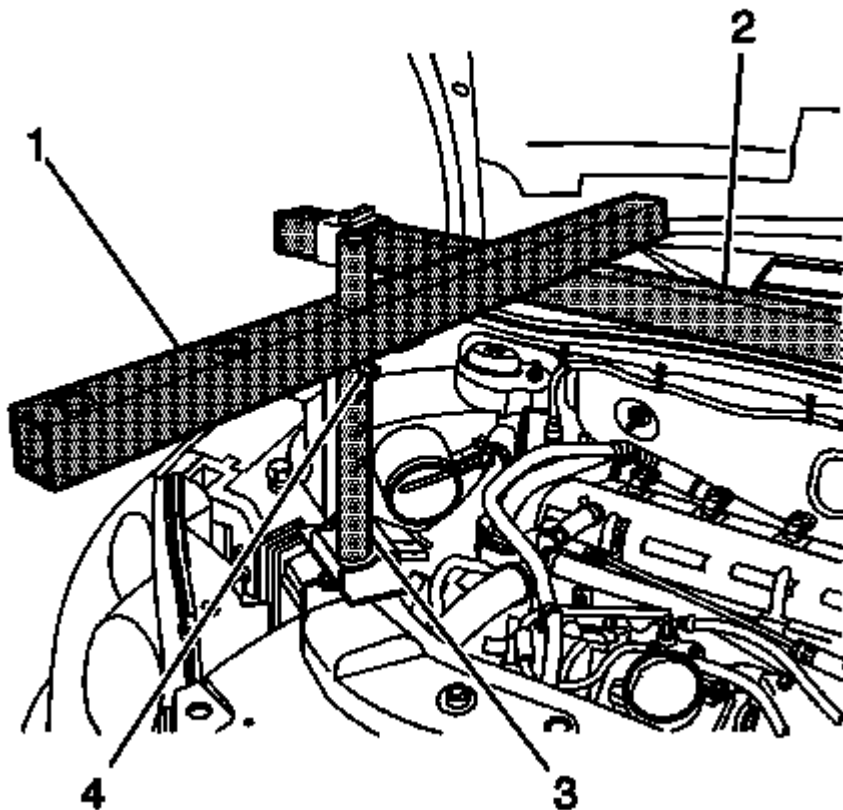


Fig. 33: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

4. 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.
5. 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.
6. Locate the J-28467-4A front support assembly to the upper tie bar.
7. 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.

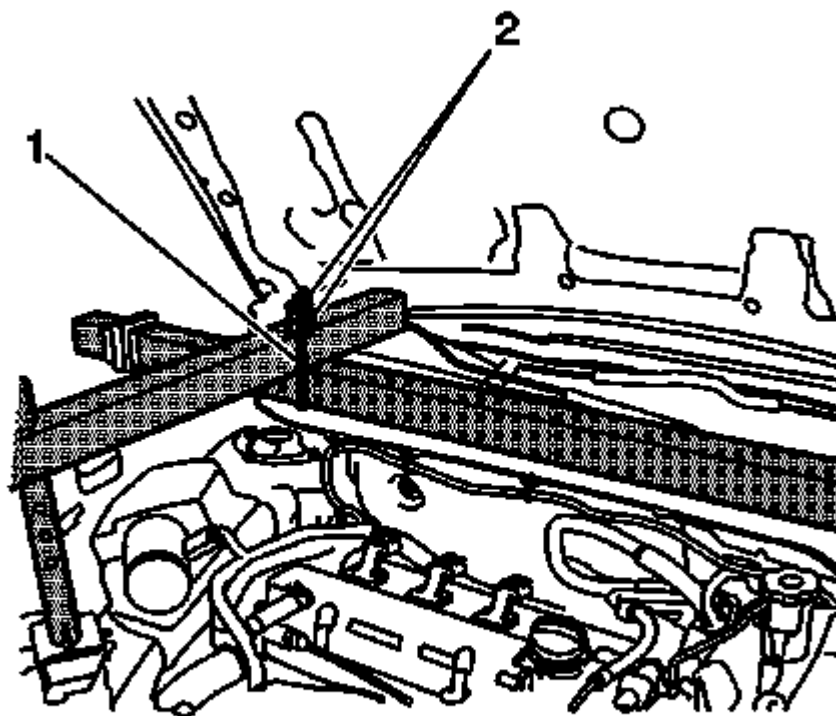


Fig. 34: View Of Engine Support Fixture & Cross Bracket
Courtesy of GENERAL MOTORS CORP.

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

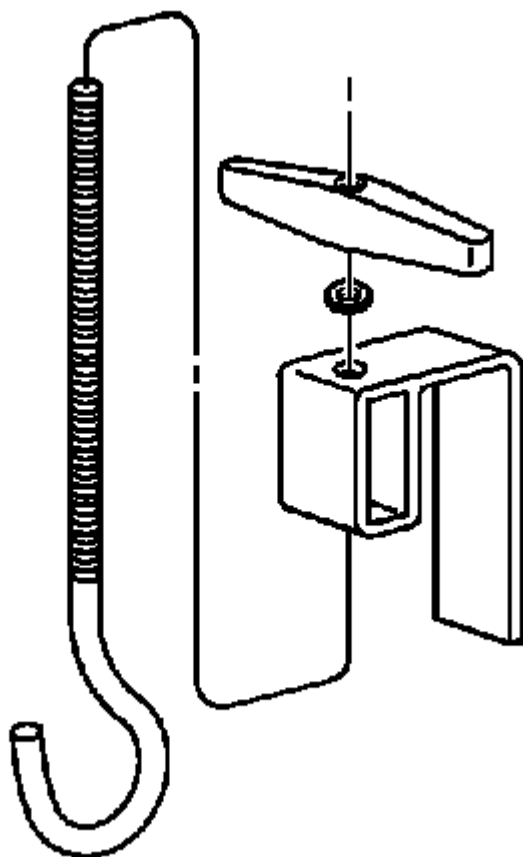


Fig. 35: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

10. Install the J-28467-7A bolt hook through the J-28467-6A bracket.
11. Install the J-28467-34 lift hook wing nut and washer to the J-28467-7A lift hook.
12. Repeat the previous 2 steps in order to assemble 2 lift hooks and brackets.

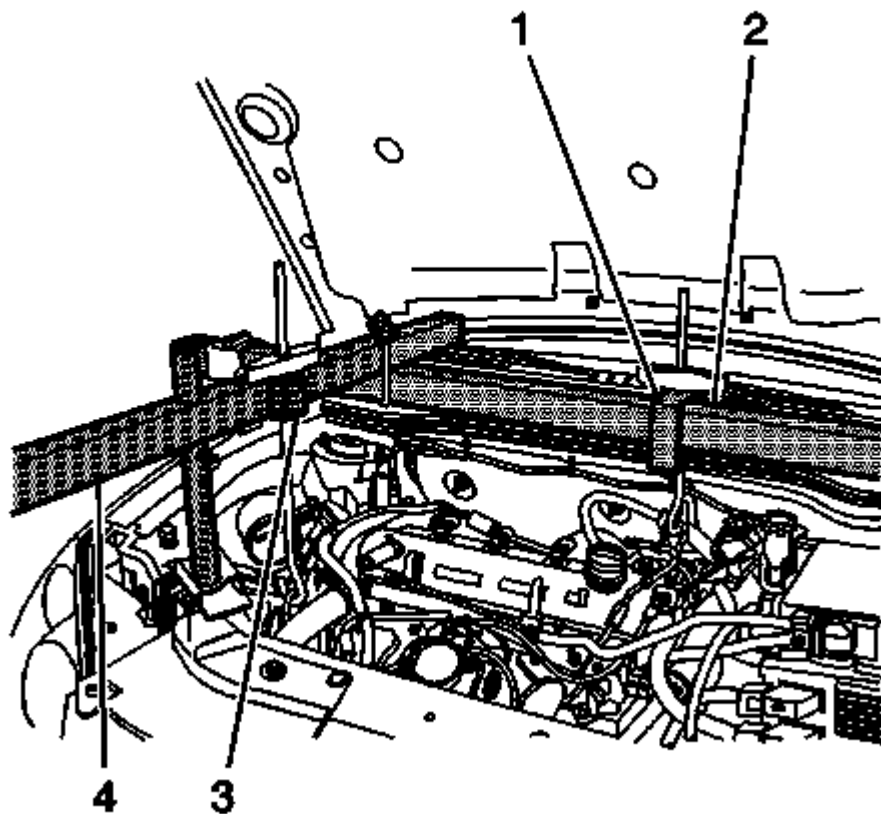


Fig. 36: Identifying Engine Support Fixture & Cross Bracket
Courtesy of GENERAL MOTORS CORP.

13. Install one of the lift hook and bracket assemblies (1) to the engine support fixture long bar (2).
14. Install the other lift hook and bracket assembly (3) to the J-28467-2A radiator shelf tube (4) above the engine front lift bracket.

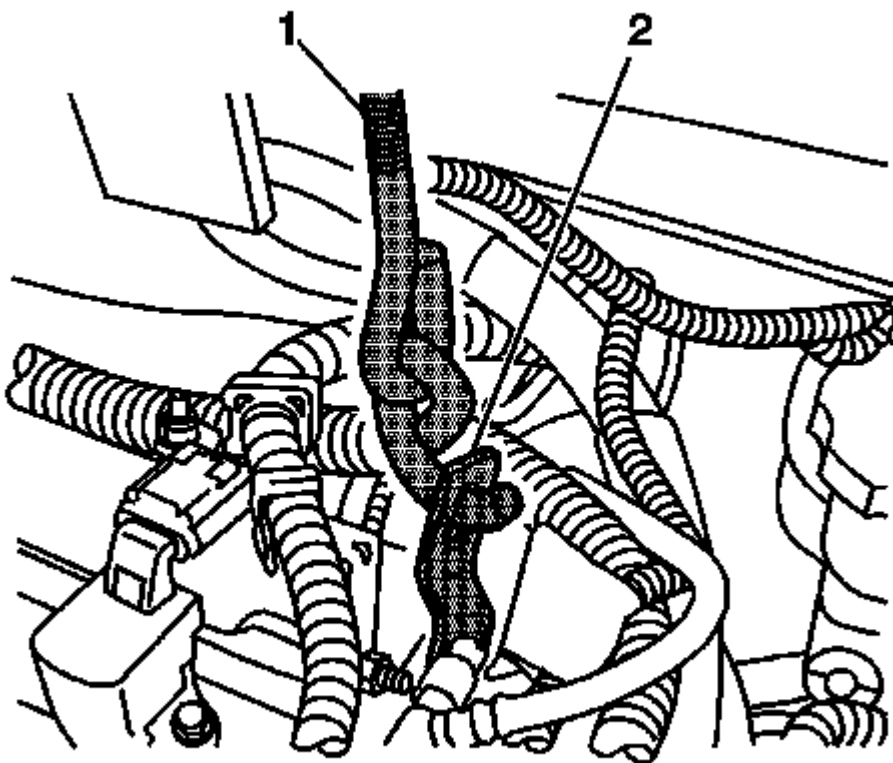


Fig. 37: Inserting Lift Hook Through Engine Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

15. Install the lift hook J-28467-7A through the engine rear lift bracket (2).

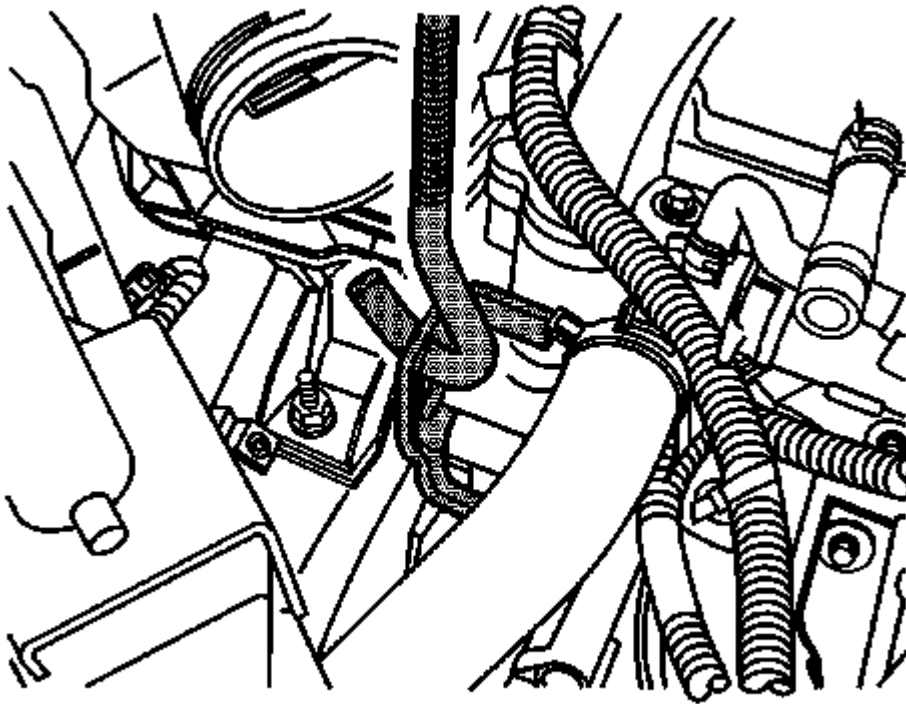


Fig. 38: Inserting Lift Hook Through Engine Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

16. Install the lift hook J-28467-7A (3) through the engine front lift bracket (4).
17. Hand tighten the lift hook wing nuts J-28467-34 (5) in order to remove all slack from the engine support fixture assembly.

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure

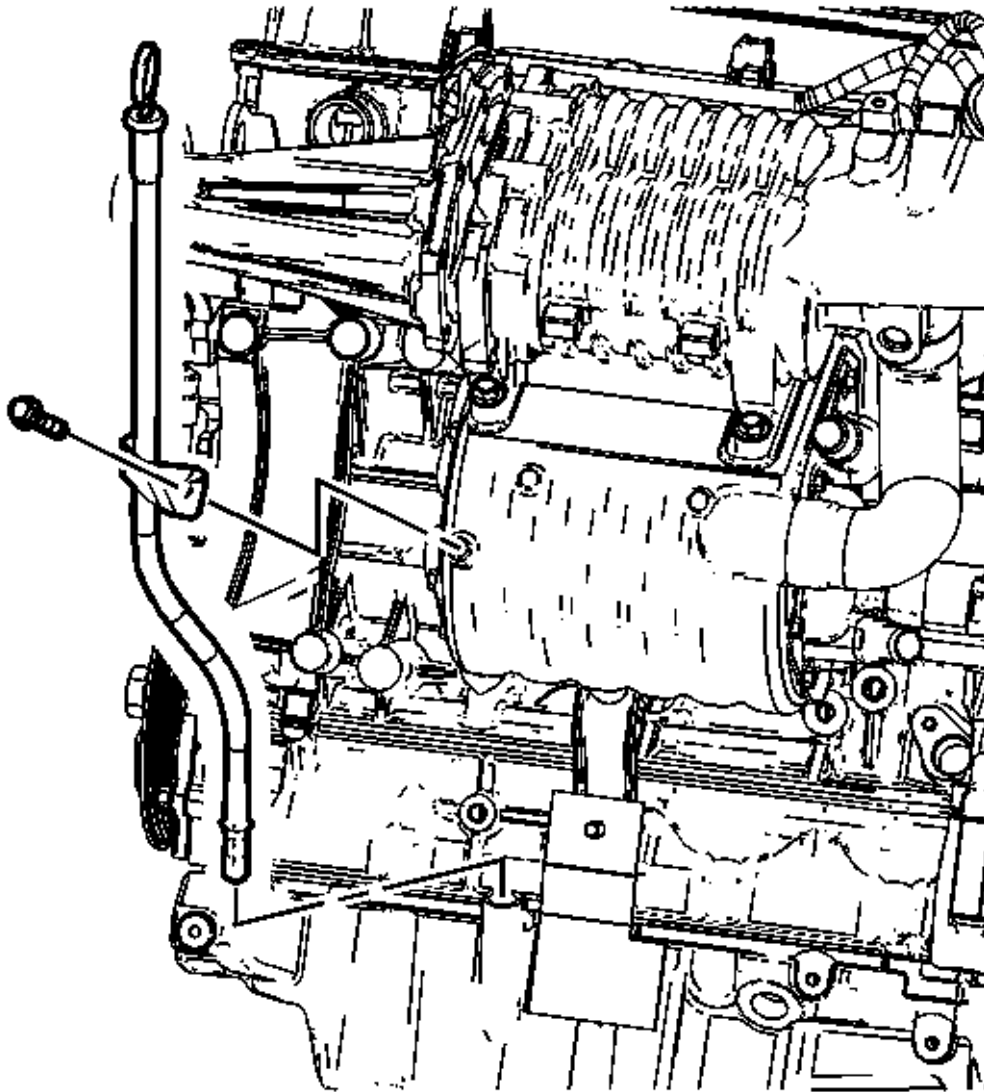


Fig. 39: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Unclip the electrical wiring harness from the oil level indicator tube.
3. Lower the vehicle.
4. Remove the oil level indicator tube bolt and unclip the upper wiring harness.
5. Remove the oil level indicator tube.

6. Remove the oil level indicator tube seal.

Installation Procedure

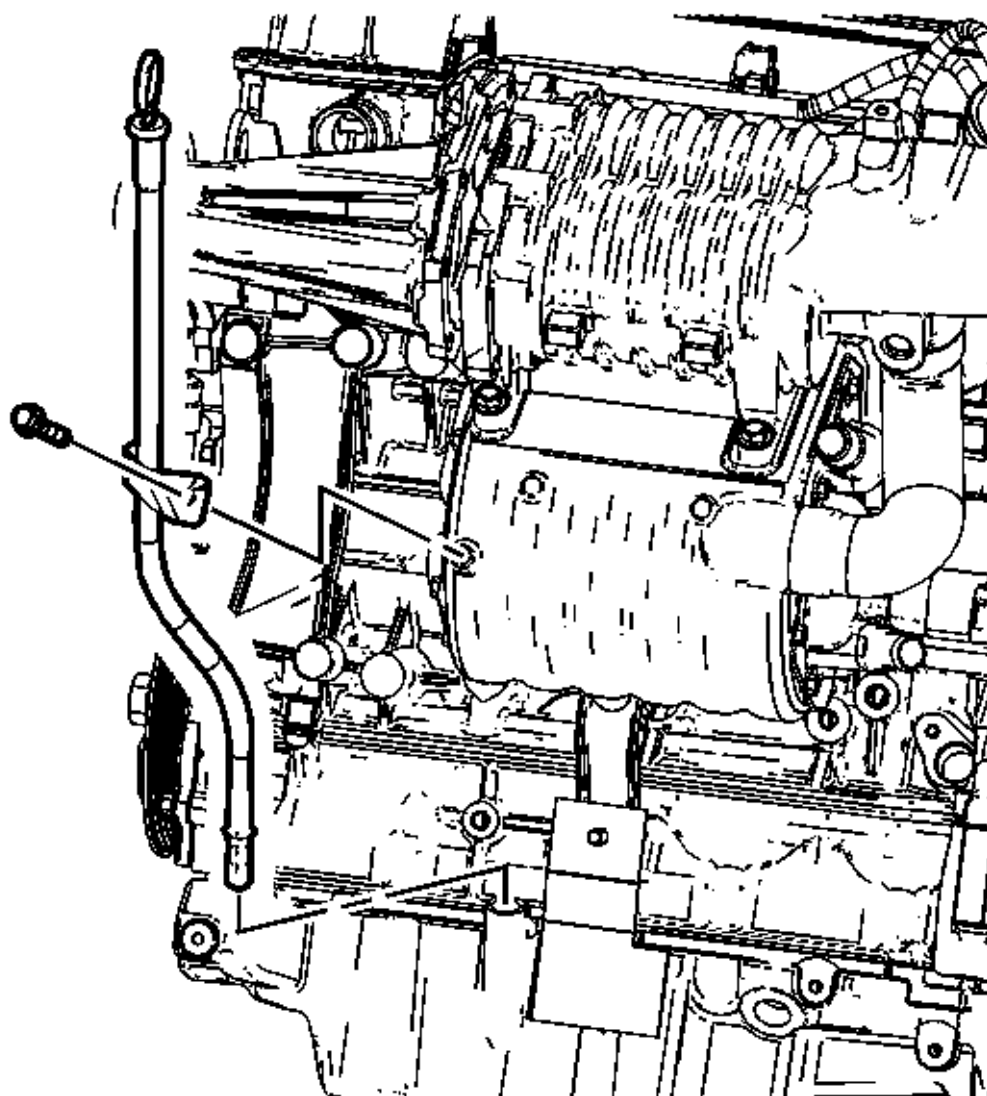


Fig. 40: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Install the oil level indicator tube seal.
2. Install the oil level indicator tube.

3. Clip the upper electrical wiring harness to the oil level indicator tube.

NOTE: Refer to **Fastener Notice** .

4. Install the oil level indicator tube bolt.

Tighten: Tighten the oil level indicator tube bolt to 10 N.m (89 lb in).

5. Raise the vehicle.
6. Clip the lower wiring harness.
7. Lower the vehicle.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

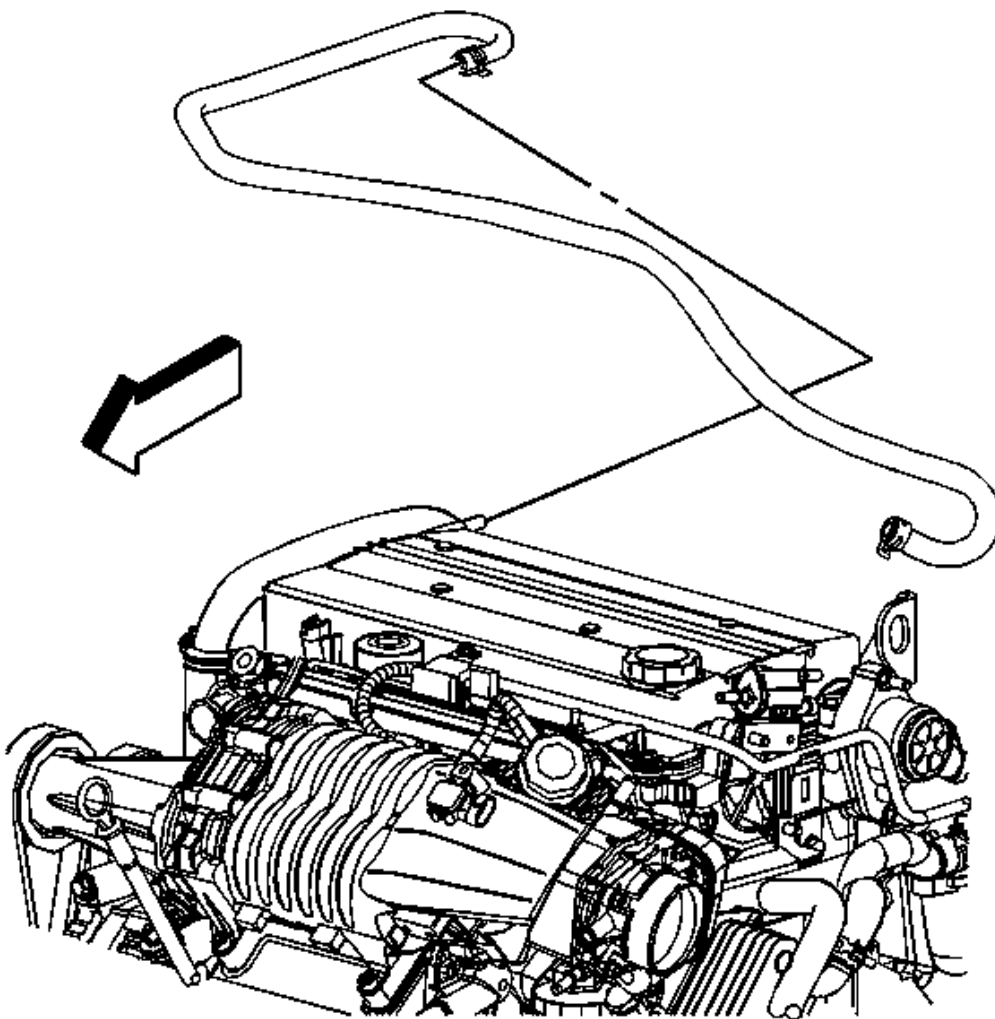


Fig. 41: View Of Crankcase Ventilation Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the crankcase ventilation hose from the camshaft cover.
2. Disconnect the crankcase ventilation hose from the air cleaner outlet duct.

Installation Procedure

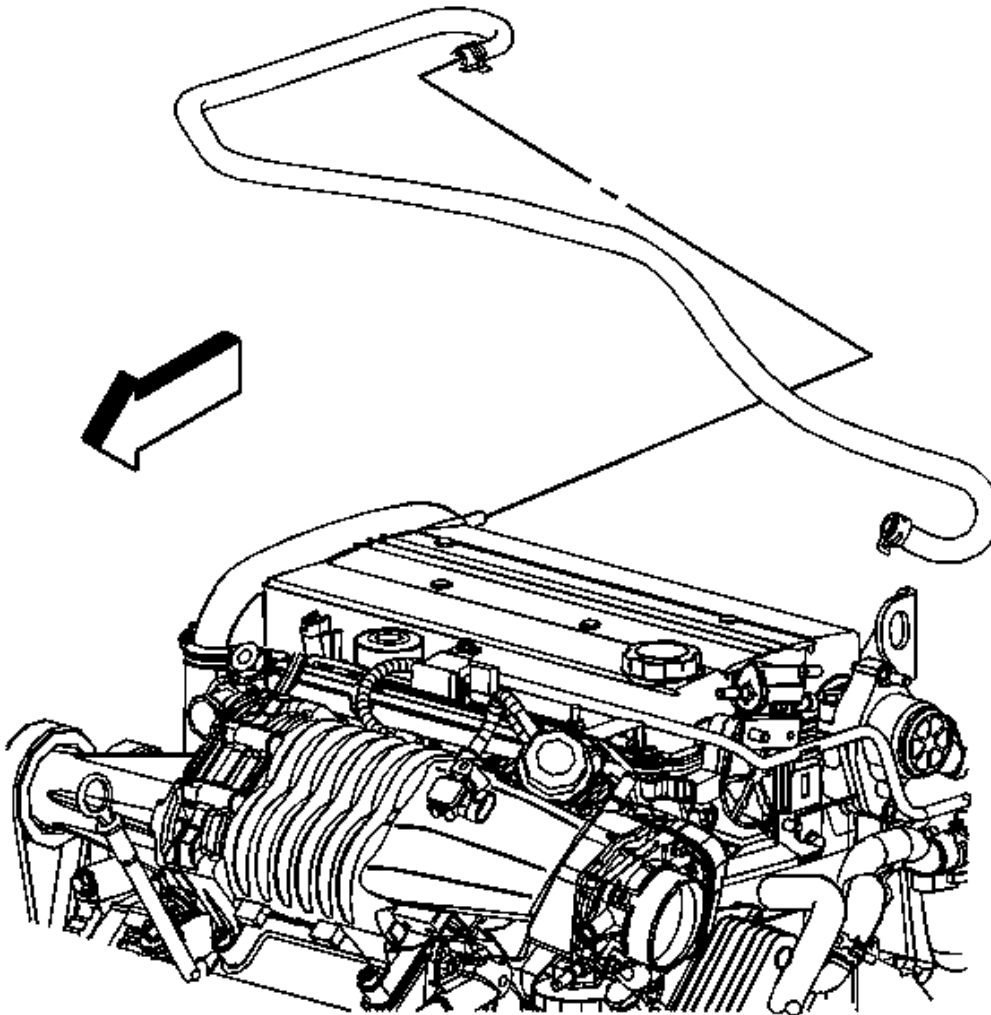


Fig. 42: View Of Crankcase Ventilation Hose
Courtesy of GENERAL MOTORS CORP.

1. Connect the crankcase ventilation hose to the camshaft cover.
2. Connect the crankcase ventilation hose to the air cleaner outlet duct.

TURBOCHARGER REPLACEMENT

Removal Procedure

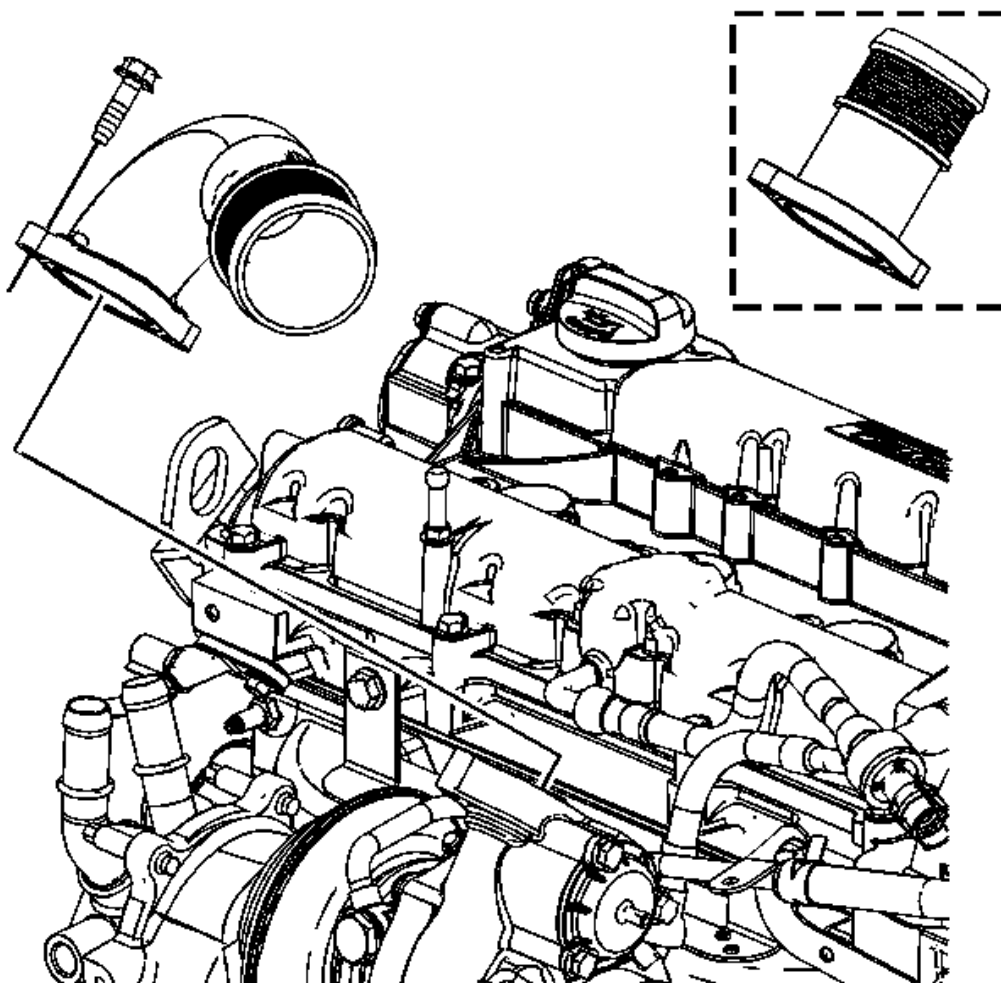


Fig. 43: Identifying Charge Air Cooler Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (GE 47716 Fill)** or **Cooling System Draining and Filling (Static Fill LNF)** .
2. Remove the charge air cooler inlet pipe. Refer to **Charge Air Cooler Inlet Pipe Replacement** .
3. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
4. Remove the charge air cooler pipe bolts at the turbocharger.
5. Remove the charge air cooler pipe from the turbocharger.

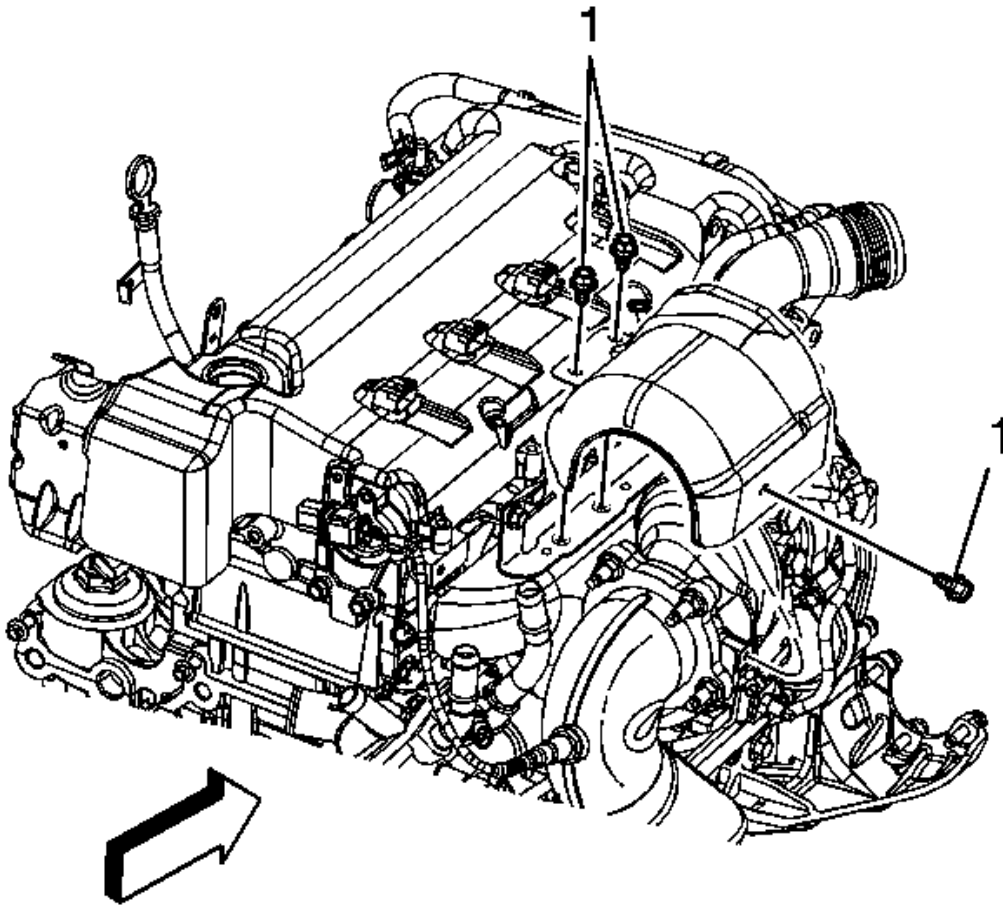


Fig. 44: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the turbocharger heat shield bolts (1) and shield.
7. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (LNF)** .
8. Remove the heated oxygen sensor. Refer to **Heated Oxygen Sensor 1 Replacement** .

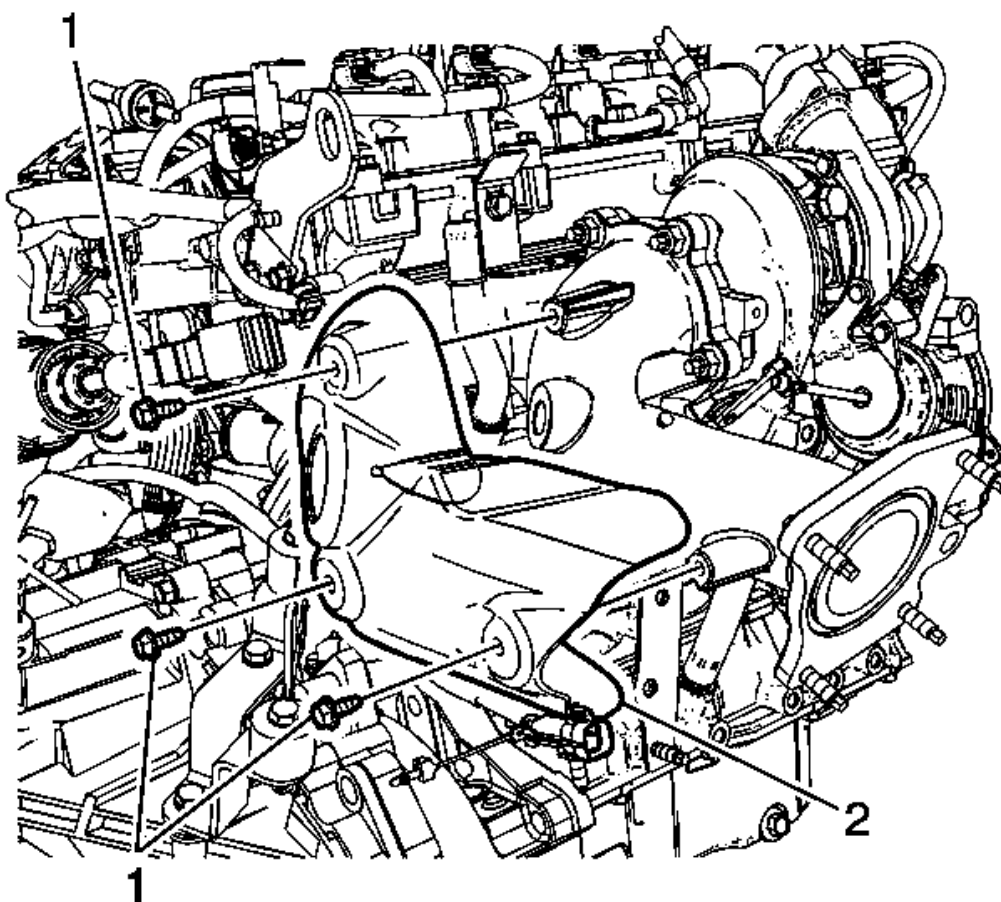


Fig. 45: Identifying Turbocharger Exhaust Pipe Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the turbocharger exhaust pipe heat shield bolts (1).
10. Remove the turbocharger exhaust pipe heat shield (2).

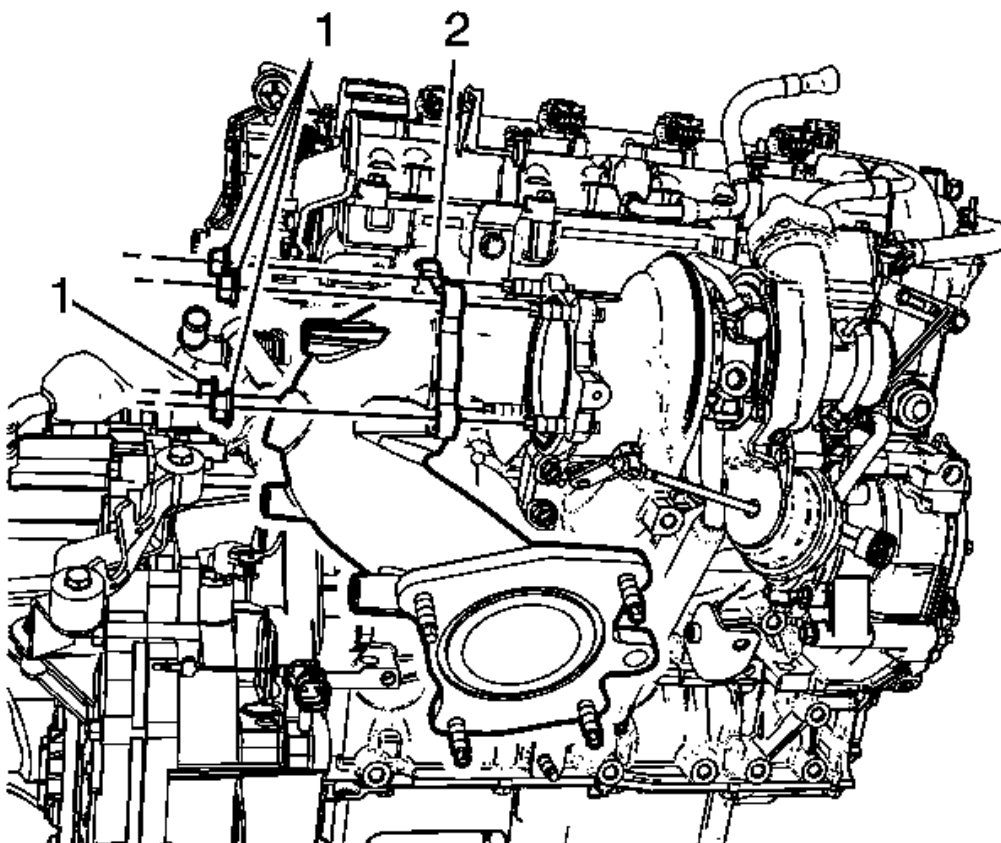


Fig. 46: Identifying Turbocharger Exhaust Pipe Heat Shield Nuts
Courtesy of GENERAL MOTORS CORP.

11. Remove the turbocharger exhaust pipe nuts (1).
12. Remove the turbocharger exhaust pipe (2).

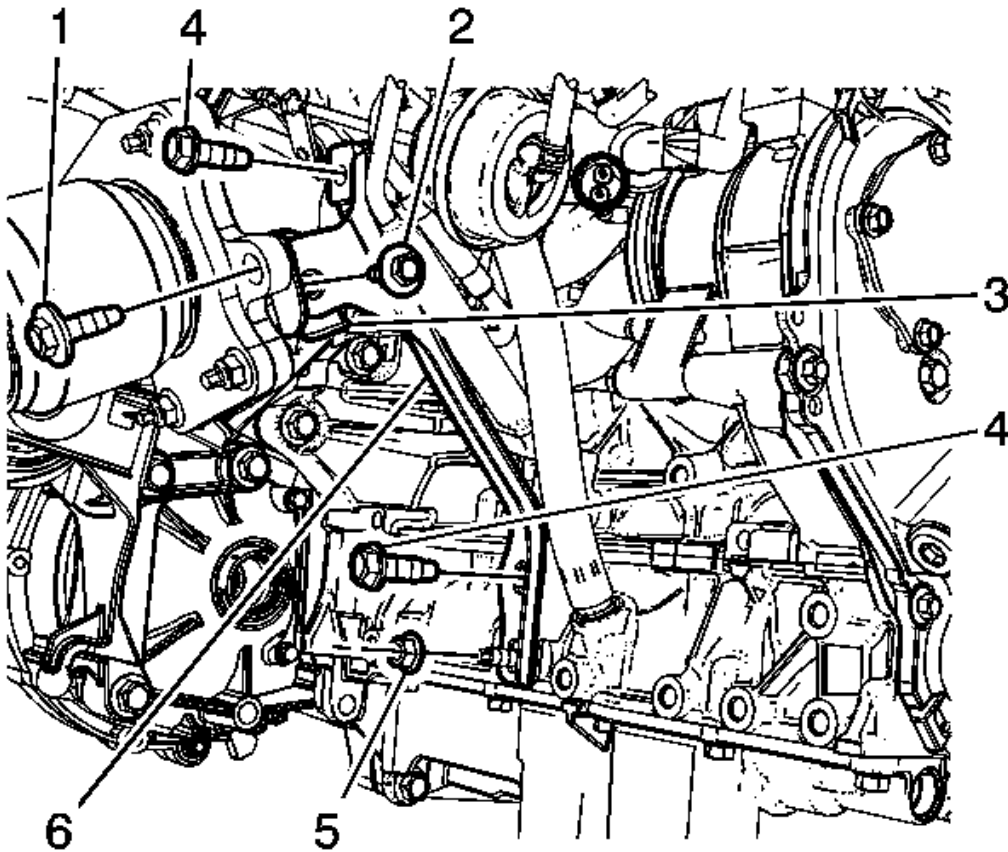


Fig. 47: Identifying Turbocharger Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the turbocharger bracket bolt (1).
14. Remove the turbocharger bracket bolt (2) and bracket (3).
15. Remove the turbocharger brace bolts (4).
16. Remove the turbocharger brace nut (5) and brace (6).
17. Lower the vehicle.

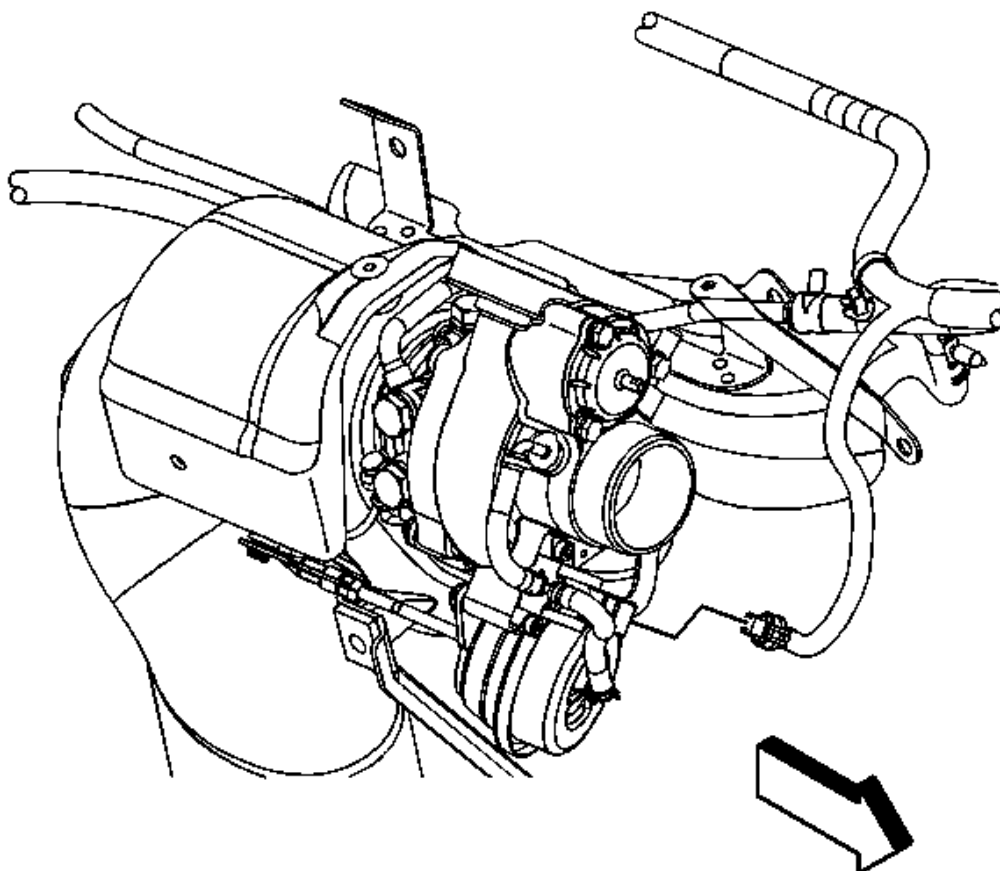


Fig. 48: Locating turbocharger wastegate solenoid valve Harness & Connector
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the engine wiring harness electrical connector from the turbocharger wastegate solenoid valve.

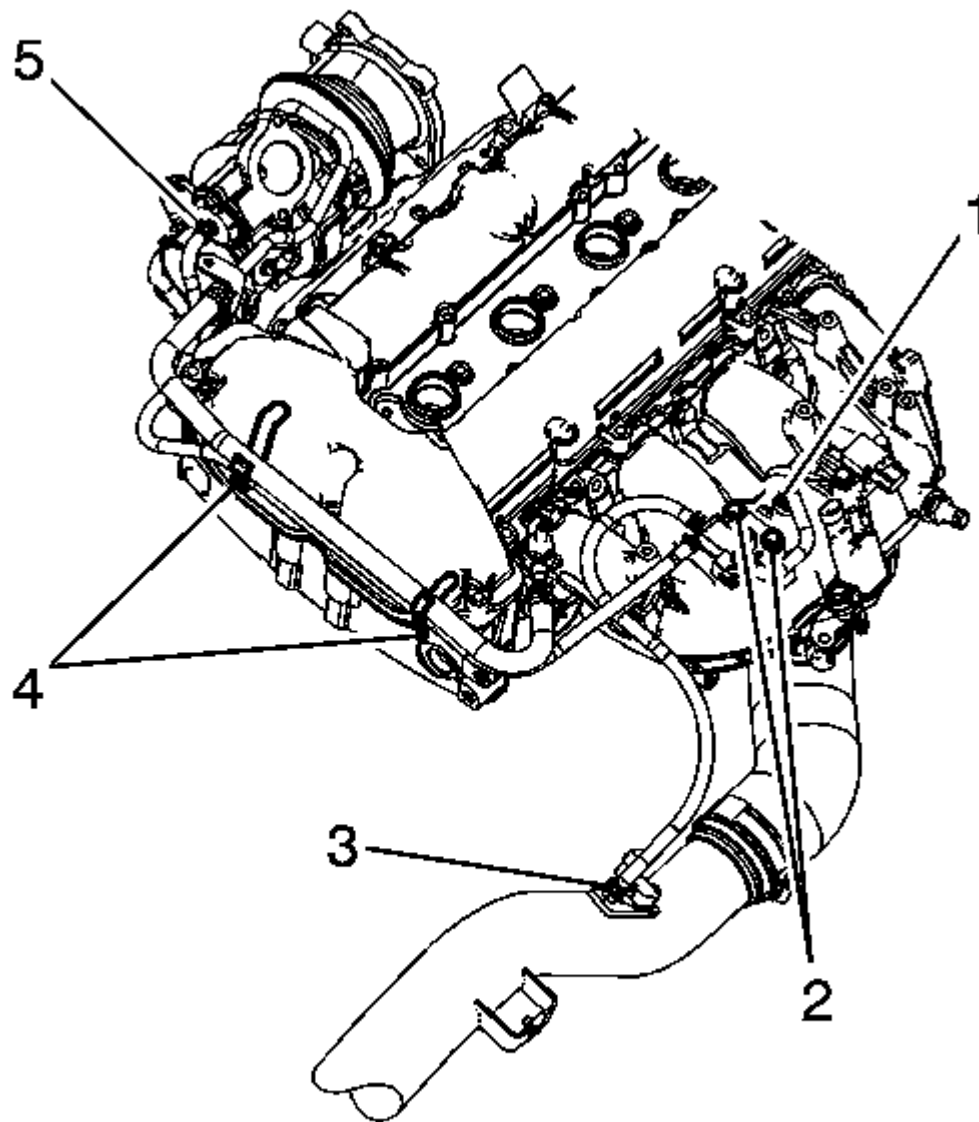


Fig. 49: View Of Turbocharger Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

19. Reposition the vacuum hose clamp (5) at the turbocharger.
20. Remove the vacuum hose from the turbocharger.

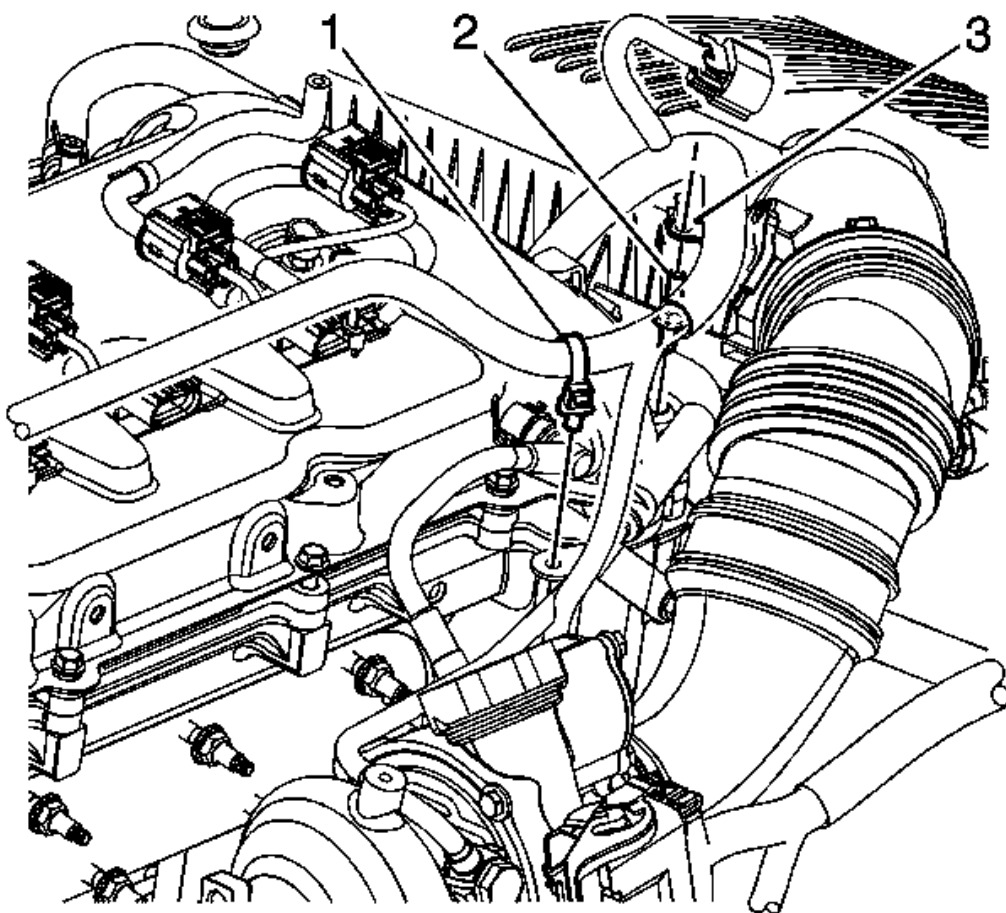


Fig. 50: Turbocharger Coolant Feed Pipe Clip
Courtesy of GENERAL MOTORS CORP.

21. Remove the engine wiring harness clip (1) from the turbocharger coolant feed pipe.

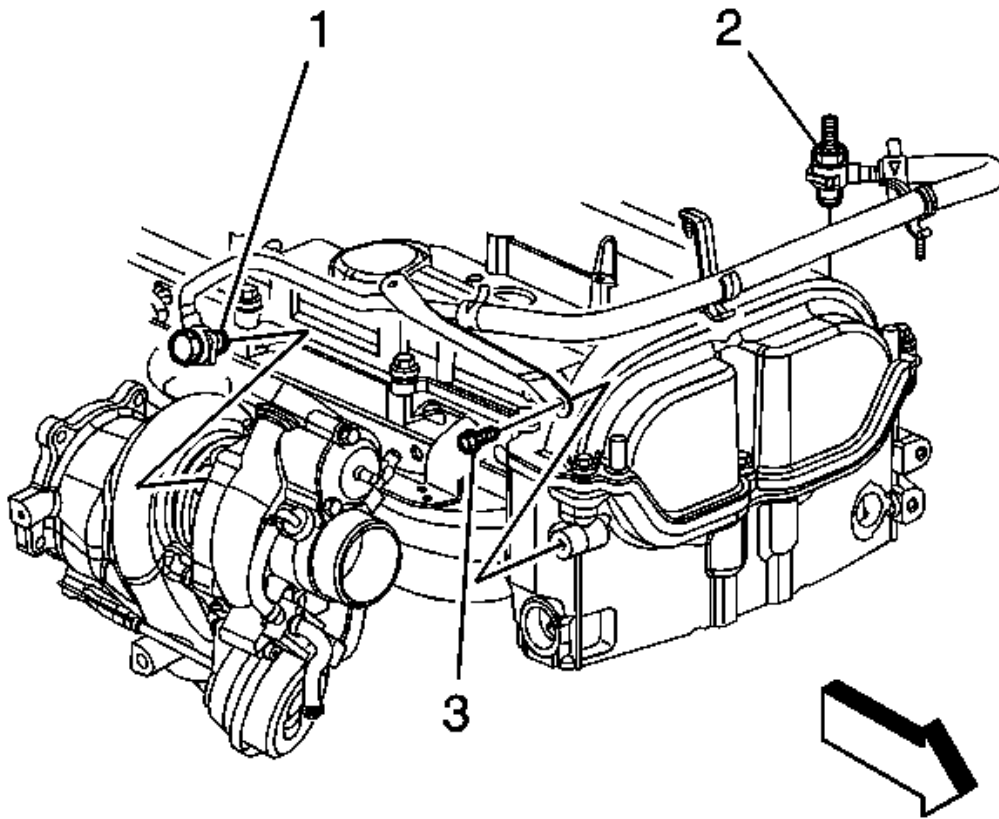


Fig. 51: Turbocharger Coolant Feed Pipe Bolt
Courtesy of GENERAL MOTORS CORP.

22. Remove the turbocharger coolant feed pipe bolt (1) at the turbocharger.
23. Remove and discard the turbocharger coolant feed pipe gasket.
24. Remove the turbocharger coolant feed pipe bolt (3) from the cylinder head.
25. Reposition the turbocharger coolant feed pipe out of the way.

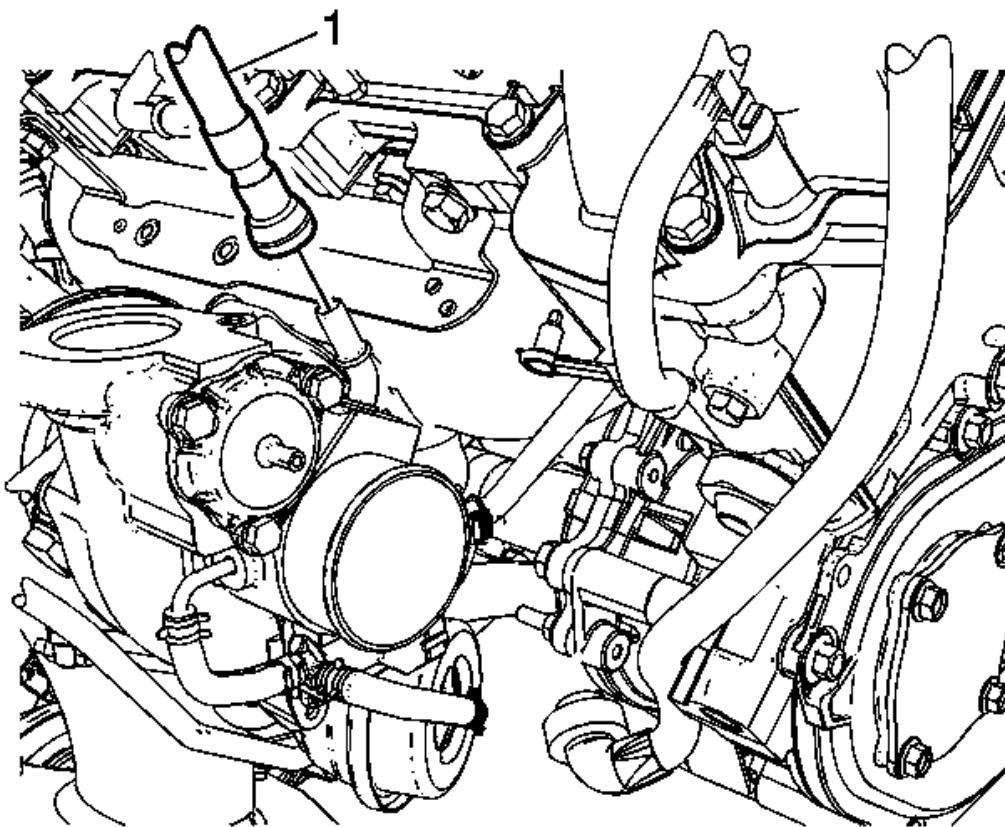


Fig. 52: Identifying Positive Crankcase Ventilation (PCV) Pipe
Courtesy of GENERAL MOTORS CORP.

26. Remove the positive crankcase ventilation (PCV) pipe (1) from the turbocharger. Reposition the PCV pipe (with fitting) out of the way.

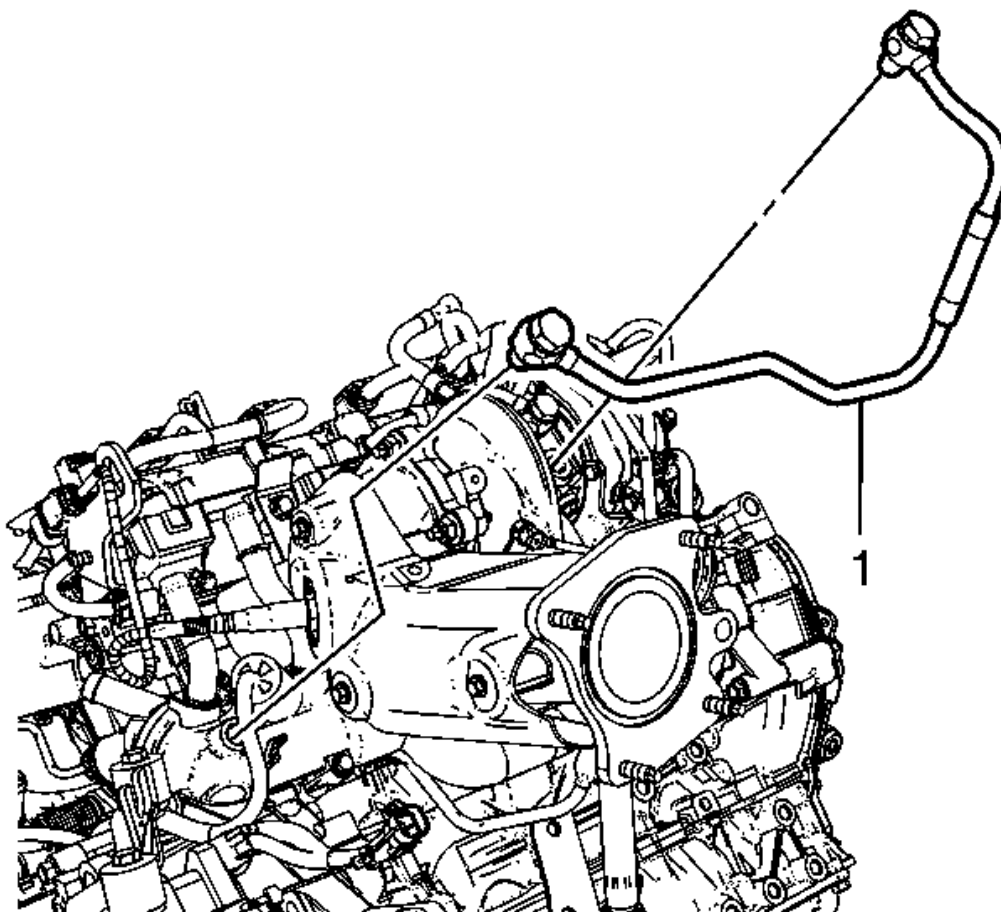


Fig. 53: Identifying Turbocharger Coolant Return Pipe
Courtesy of GENERAL MOTORS CORP.

27. Remove the turbocharger coolant return pipe bolts and pipe (1).
28. Remove and discard the turbocharger coolant return pipe gaskets.

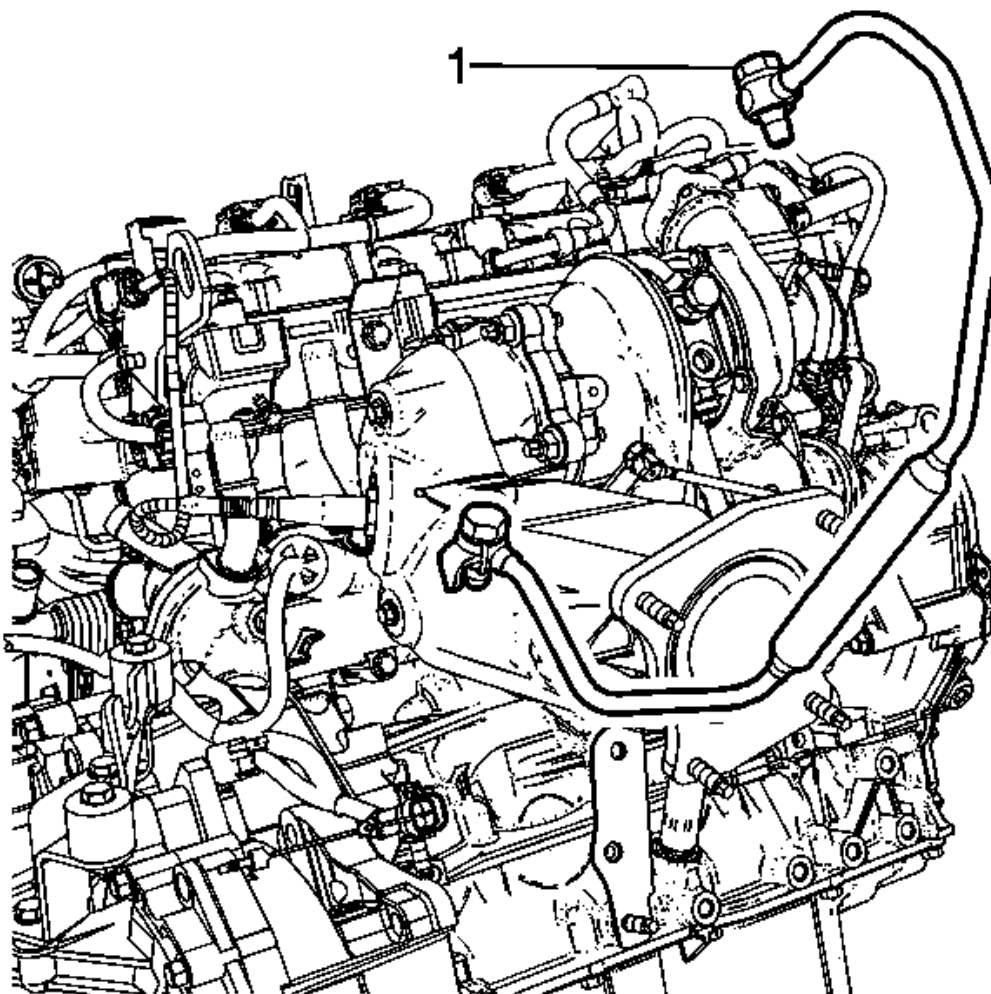


Fig. 54: Identifying Turbocharger Oil Feed Pipe & Fittings
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

29. Remove the turbocharger oil feed pipe bolts and pipe (1).
30. Remove and discard the turbocharger oil feed pipe gaskets.

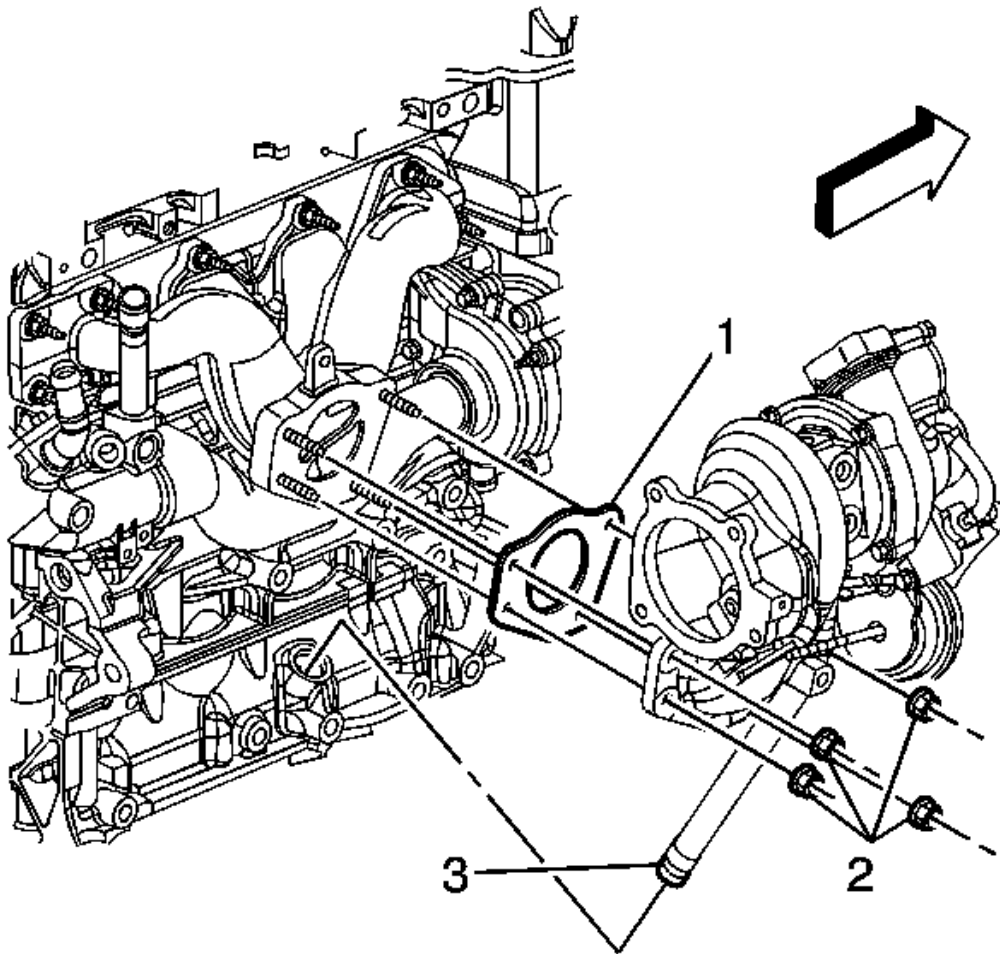


Fig. 55: View Of Turbocharger Nuts
Courtesy of GENERAL MOTORS CORP.

31. Remove the turbocharger nuts (2).
32. Remove the turbocharger from the exhaust manifold studs while also removing the turbocharger oil return hose from the engine block.
33. Remove and discard the turbocharger gasket (1) and oil return hose O-ring seal (3).

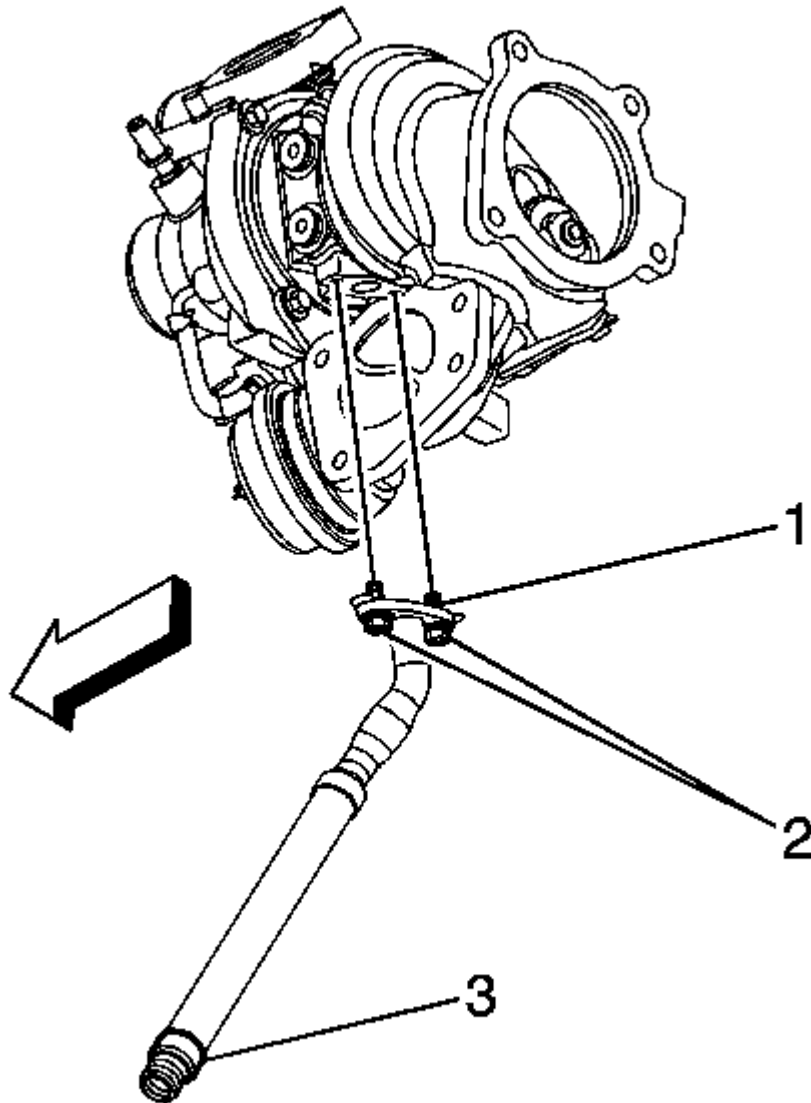


Fig. 56: Identifying Turbocharger Oil Return Hose
Courtesy of GENERAL MOTORS CORP.

34. If replacing the turbocharger, perform the following steps otherwise proceed to the step 7 in the Installation Procedure.
35. Remove the turbocharger oil return hose bolts (2) and hose from the turbocharger.
36. Remove and discard the turbocharger oil return hose gasket (1).

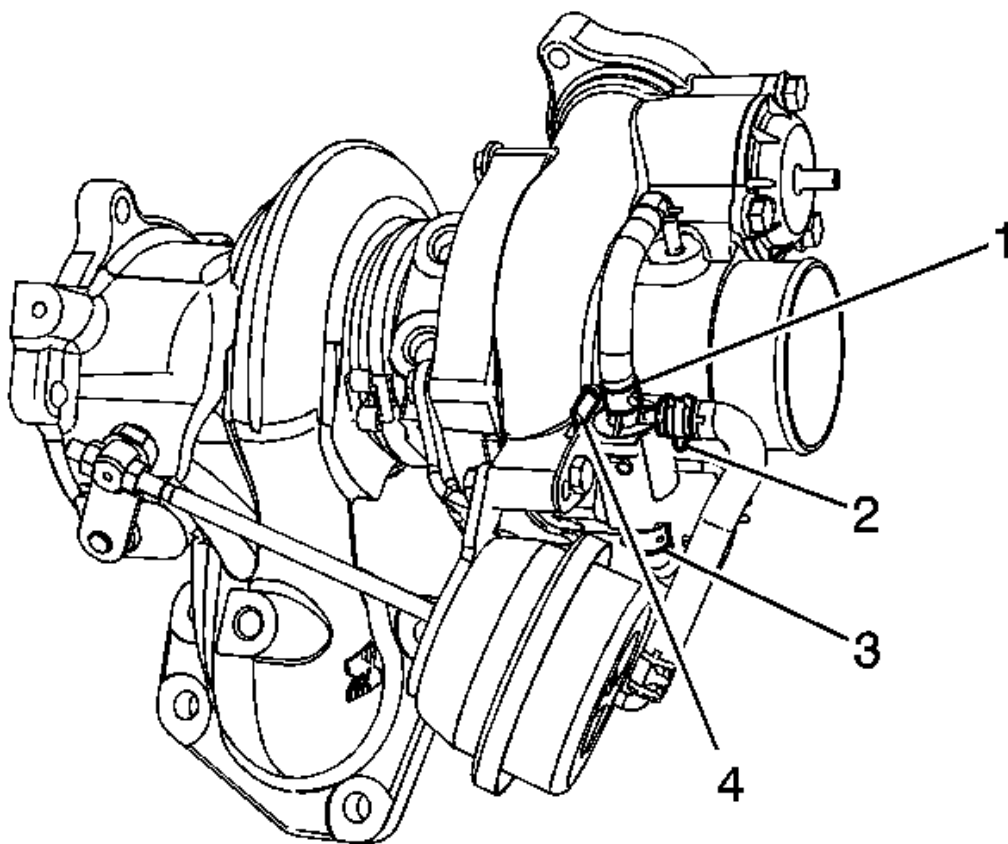


Fig. 57: Vacuum Hose Clamps & Boost Sensor Retainer
Courtesy of GENERAL MOTORS CORP.

37. Reposition the vacuum hose clamps (1, 2, and 3) at the turbocharger wastegate solenoid valve.
38. Remove the vacuum hoses from the turbocharger wastegate solenoid valve.
39. Gently push back the turbocharger wastegate solenoid valve retainer (4) and remove the turbocharger wastegate solenoid valve from the bracket.

Installation Procedure

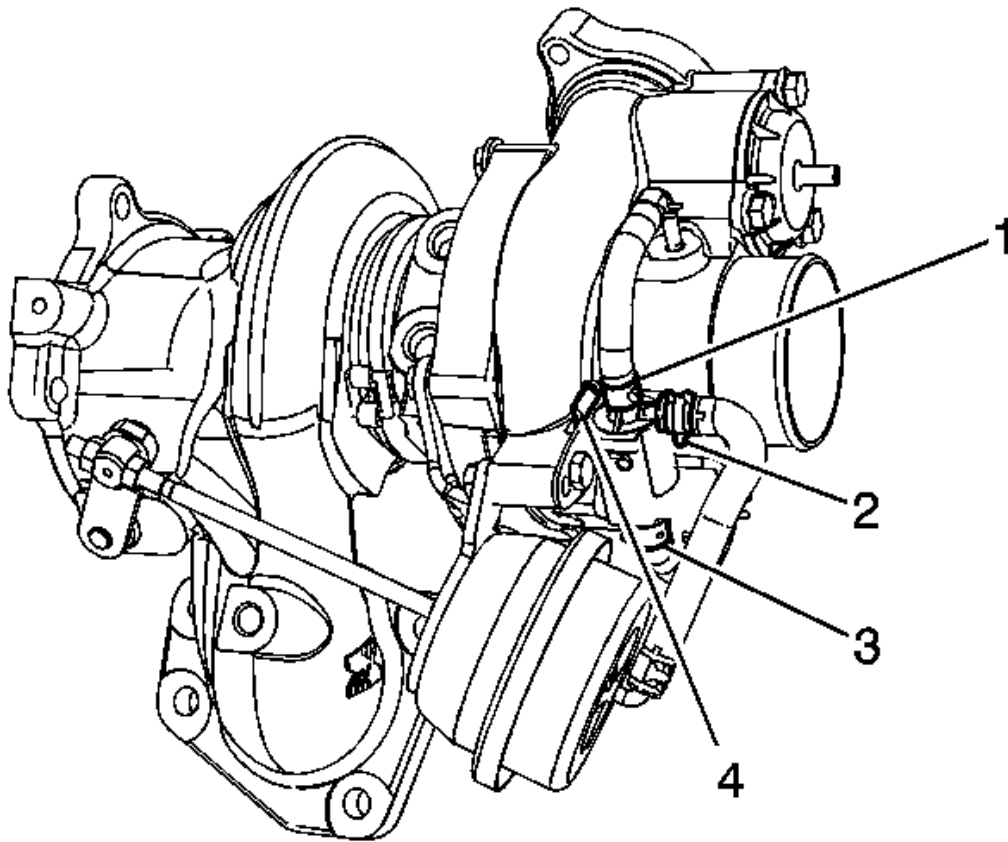


Fig. 58: Vacuum Hose Clamps & Boost Sensor Retainer
Courtesy of GENERAL MOTORS CORP.

1. If replacing the turbocharger, perform the following steps otherwise proceed to step 7.
2. Install the turbocharger wastegate solenoid valve to the bracket until the retainer (4) clips into place.
3. Install the vacuum hoses to the turbocharger wastegate solenoid valve.
4. Position the vacuum hose clamps (1, 2, and 3) at the turbocharger wastegate solenoid valve.

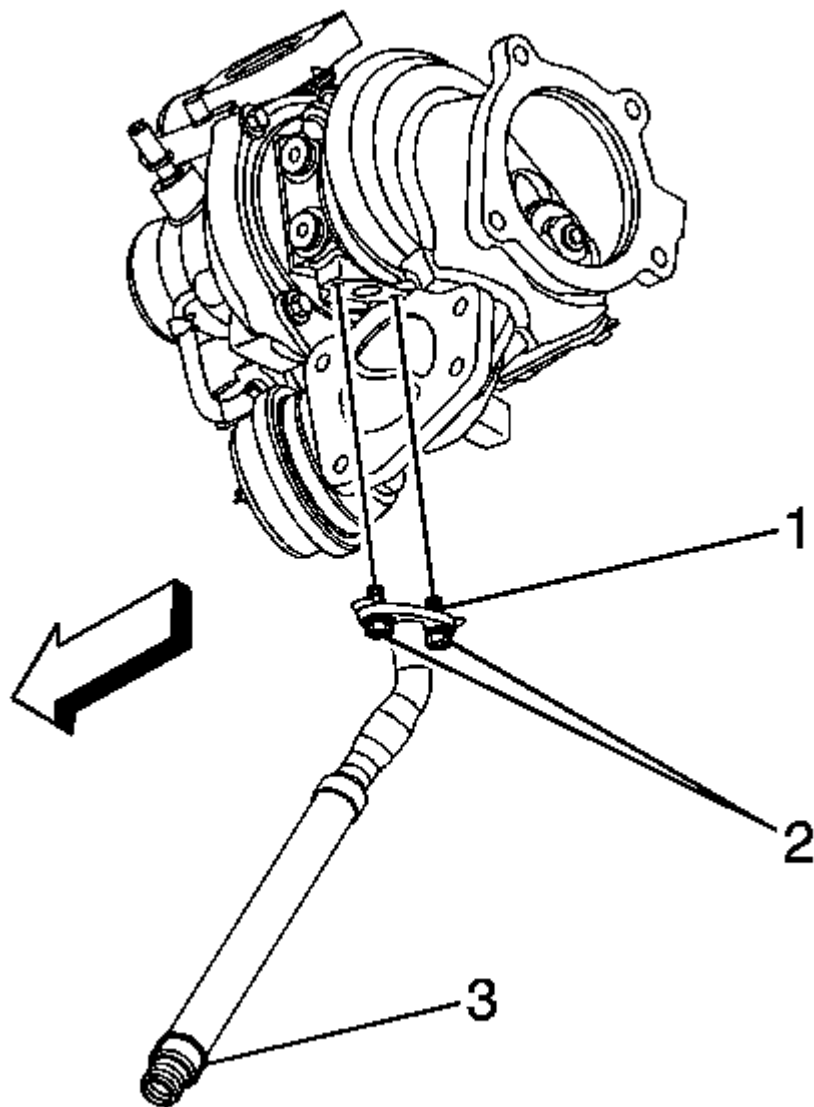


Fig. 59: Identifying Turbocharger Oil Return Hose
Courtesy of GENERAL MOTORS CORP.

5. Position a NEW turbocharger oil return hose gasket (1) on the turbocharger oil return hose.

NOTE: Refer to Fastener Notice .

6. Install the turbocharger oil return hose and bolts (2).

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

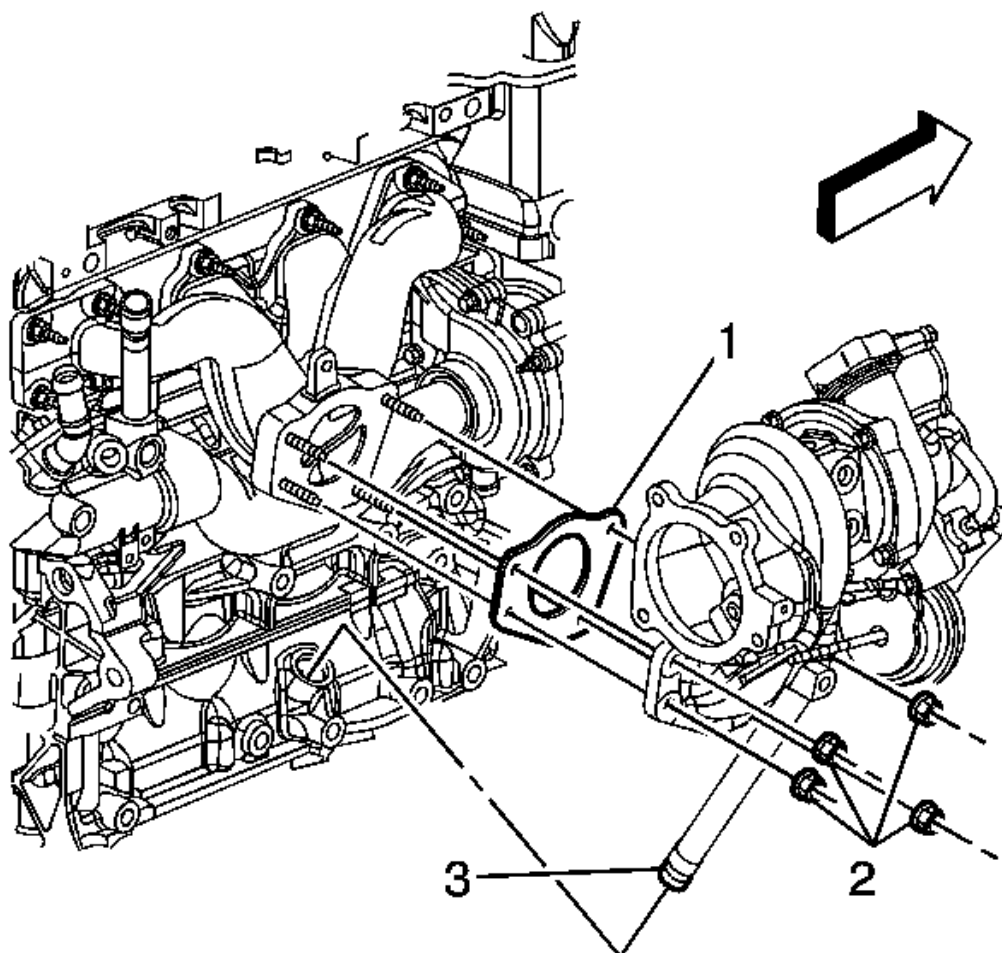


Fig. 60: View Of Turbocharger Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install a NEW turbocharger gasket (1) onto the exhaust manifold studs.
8. Lubricate and install a NEW turbocharger oil return hose O-ring seal (3).
9. Install the turbocharger oil return hose to the engine block while also installing the turbocharger to the exhaust manifold studs.
10. Install the turbocharger nuts (2).

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

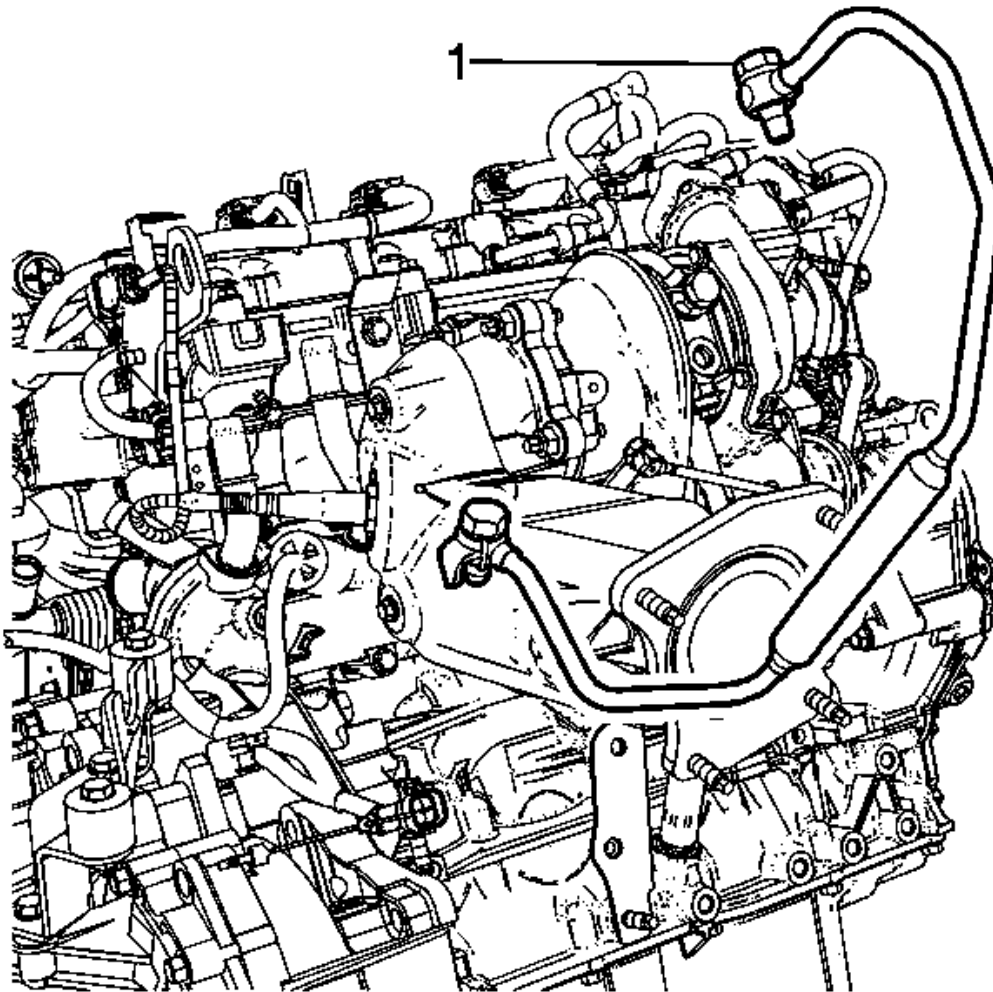


Fig. 61: Identifying Turbocharger Oil Feed Pipe & Fittings
Courtesy of GENERAL MOTORS CORP.

11. Install NEW gaskets onto the turbocharger oil feed pipe fittings.
12. Install the turbocharger oil feed pipe (1) and bolts.

Tighten: Tighten the bolts to 32 N.m (24 lb ft).

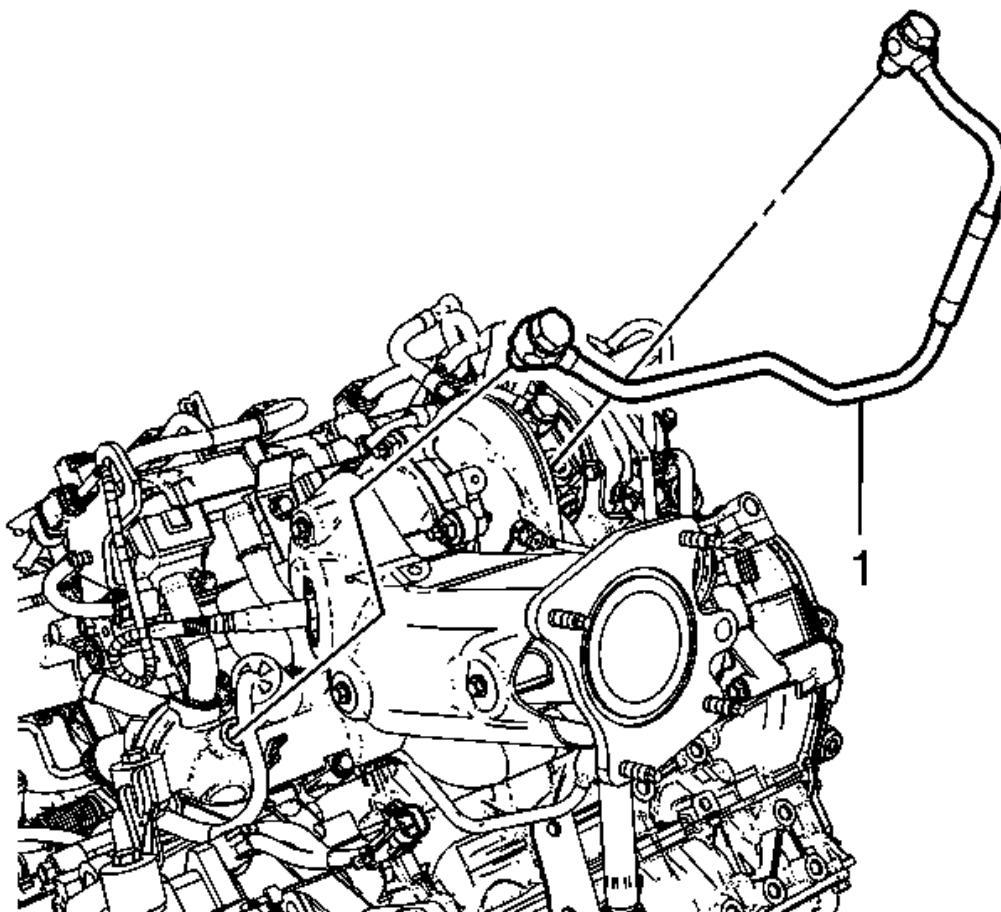


Fig. 62: Identifying Turbocharger Coolant Return Pipe
Courtesy of GENERAL MOTORS CORP.

13. Install NEW gaskets onto the turbocharger coolant return pipe fittings.
14. Install the turbocharger coolant return pipe (1) and bolts.

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

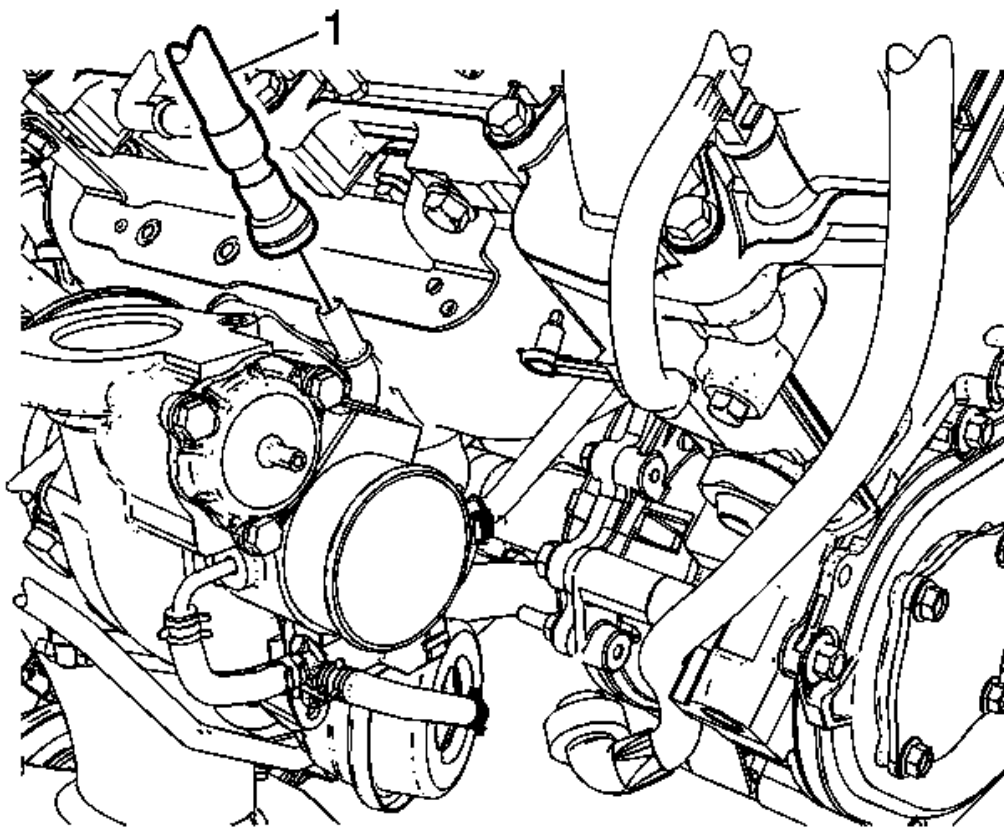


Fig. 63: Identifying Positive Crankcase Ventilation (PCV) Pipe
Courtesy of GENERAL MOTORS CORP.

15. Position the PCV pipe (with fitting) and install the PCV fitting to the turbocharger.

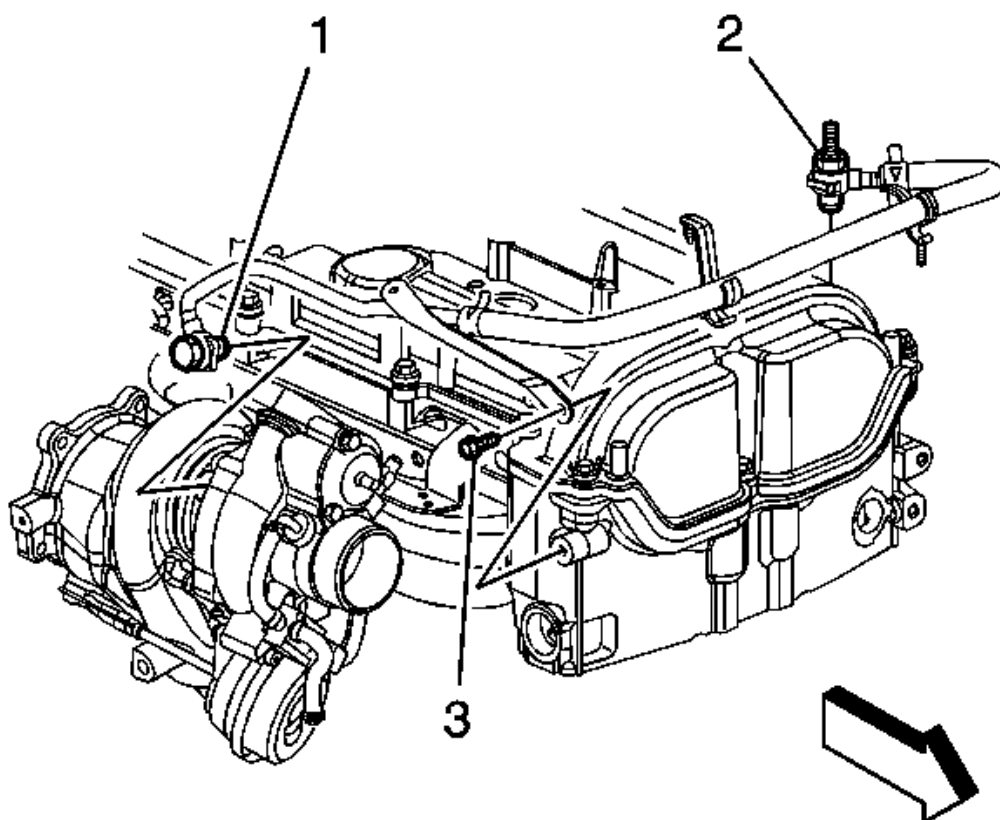


Fig. 64: Turbocharger Coolant Feed Pipe Bolt
Courtesy of GENERAL MOTORS CORP.

16. Position the turbocharger coolant feed pipe to the turbocharger.
17. Install NEW gaskets onto the turbocharger coolant feed pipe fitting.
18. Install the turbocharger coolant feed pipe bolt (1) at the turbocharger.

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

19. Install the turbocharger coolant feed pipe bolt (3) to the cylinder head.

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

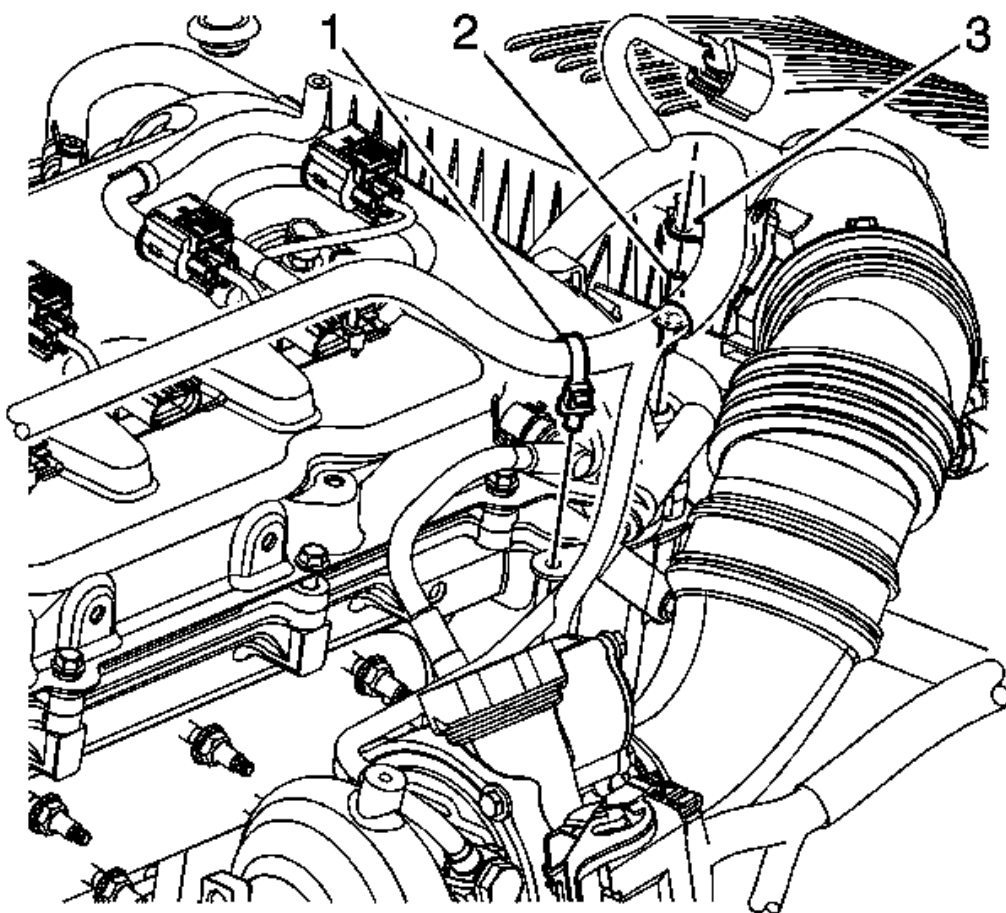


Fig. 65: Turbocharger Coolant Feed Pipe Clip
Courtesy of GENERAL MOTORS CORP.

20. Install the engine wiring harness clip (1) to the turbocharger coolant feed pipe.

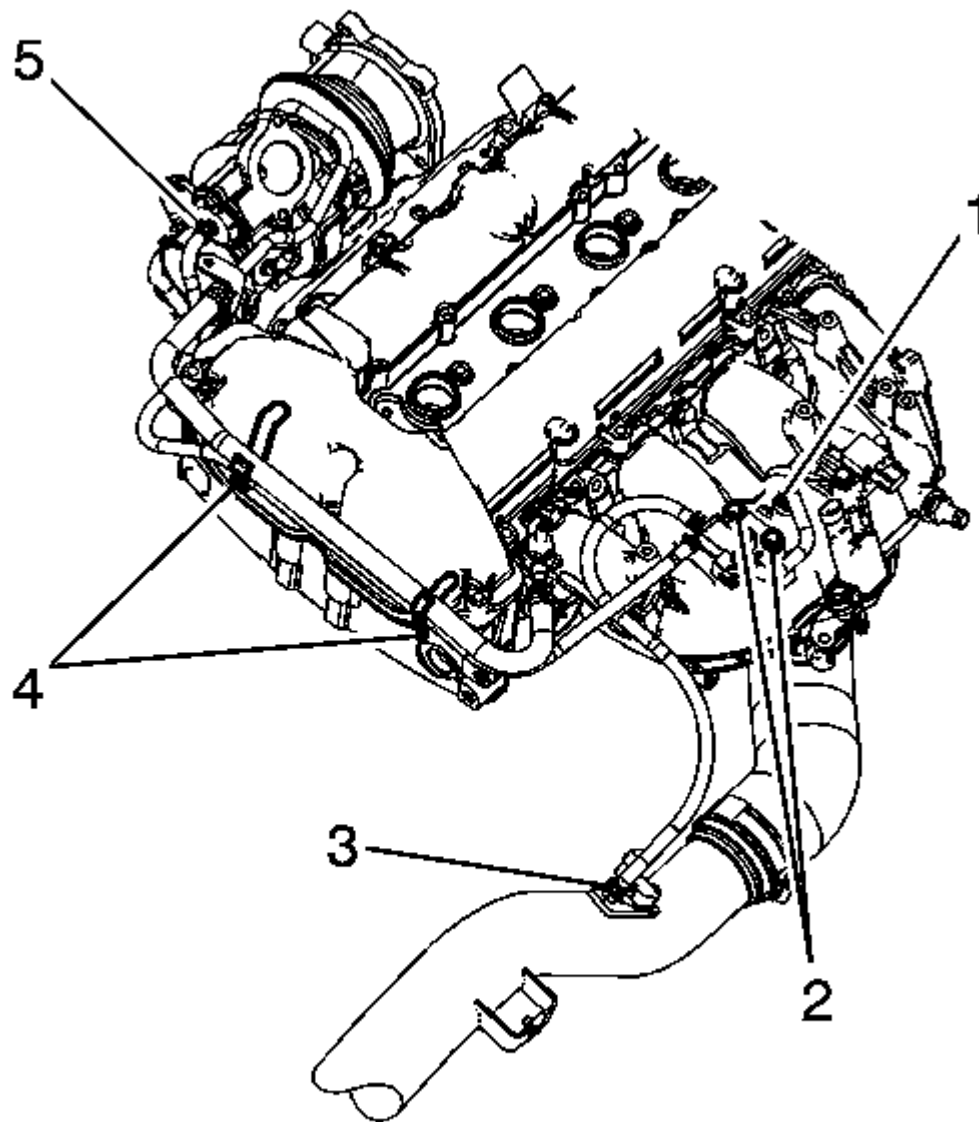


Fig. 66: View Of Turbocharger Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

21. Install the vacuum hose to the turbocharger.
22. Position the vacuum hose clamp (5) at the turbocharger.

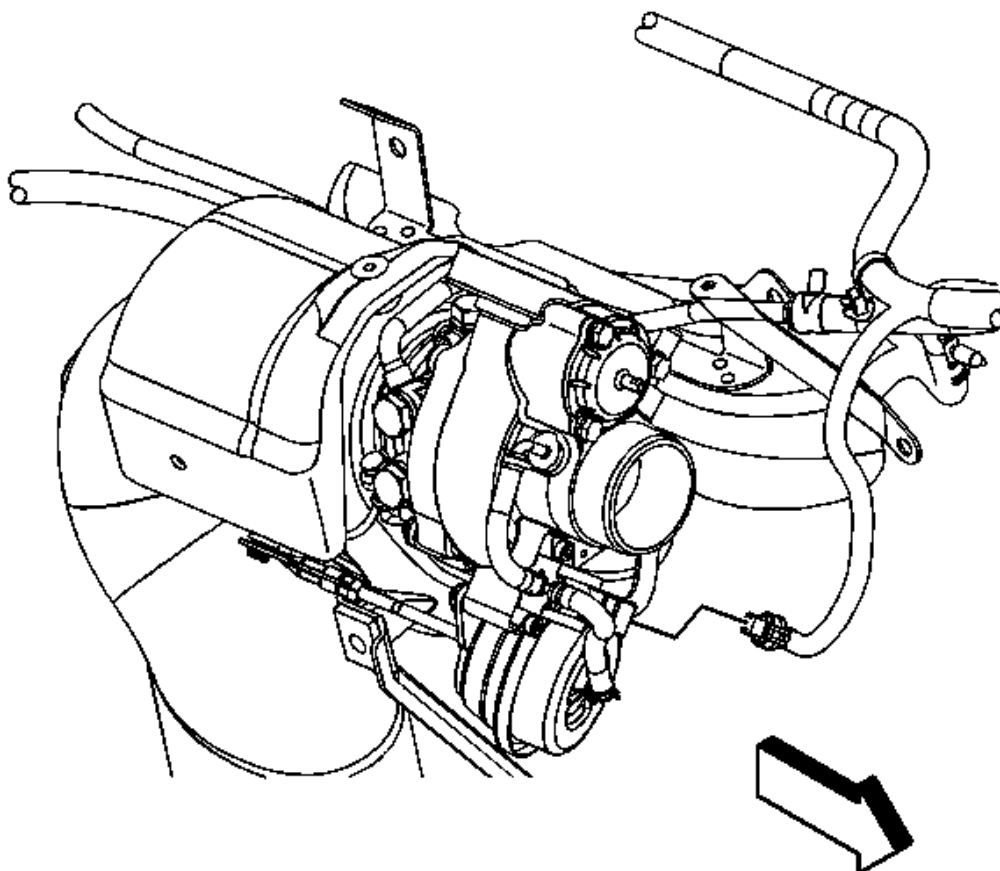


Fig. 67: Locating turbocharger wastegate solenoid valve Harness & Connector
Courtesy of GENERAL MOTORS CORP.

23. Connect the engine wiring harness electrical connector to the turbocharger wastegate solenoid valve.

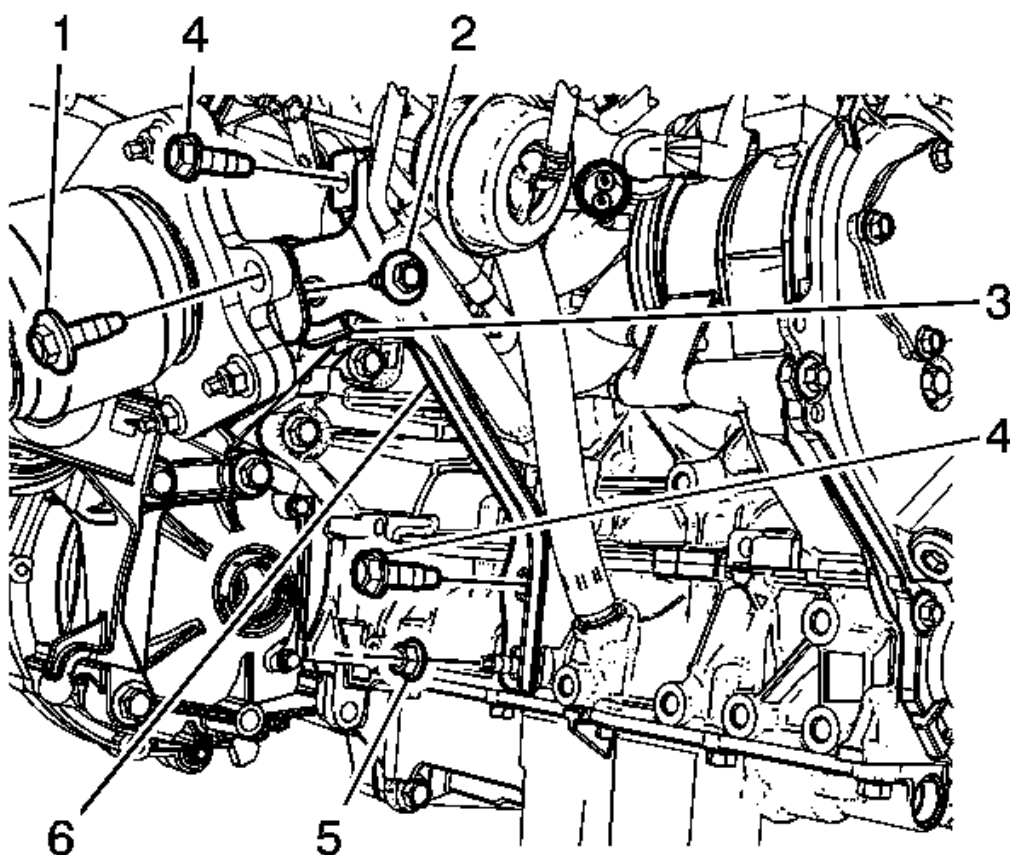


Fig. 68: Identifying Turbocharger Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

24. Install the turbocharger brace (6) and brace nut (5).

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

25. Install the turbocharger brace bolts (4).

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

26. Install the turbocharger bracket (3) and bracket bolt (2).

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

27. Install the turbocharger bracket bolt (1).

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

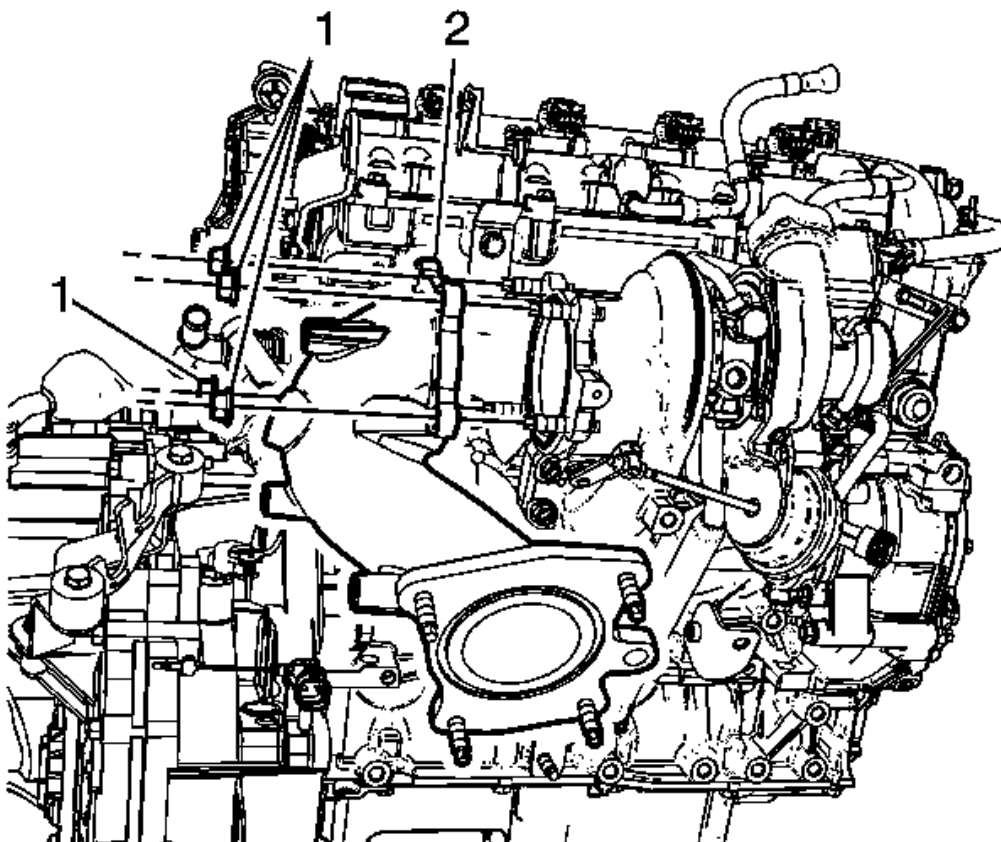


Fig. 69: Identifying Turbocharger Exhaust Pipe Heat Shield Nuts
Courtesy of GENERAL MOTORS CORP.

28. Install the turbocharger exhaust pipe (2).
29. Install the turbocharger exhaust pipe nuts (1).

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

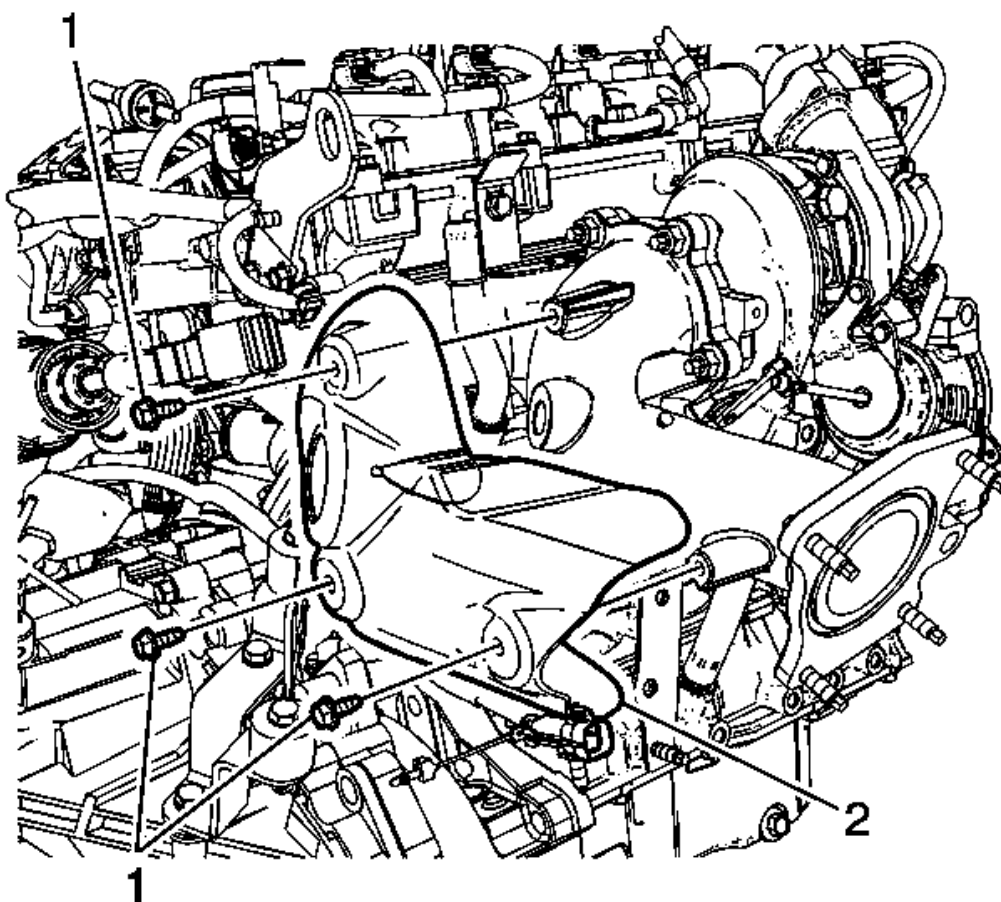


Fig. 70: Identifying Turbocharger Exhaust Pipe Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

30. Install the turbocharger exhaust pipe heat shield (2).
31. Install the turbocharger exhaust pipe heat shield bolts (1).

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

32. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
33. Install the heated oxygen sensor. Refer to **Heated Oxygen Sensor 1 Replacement** .
34. Install the catalytic converter. Refer to **Catalytic Converter Replacement (LNF)** .

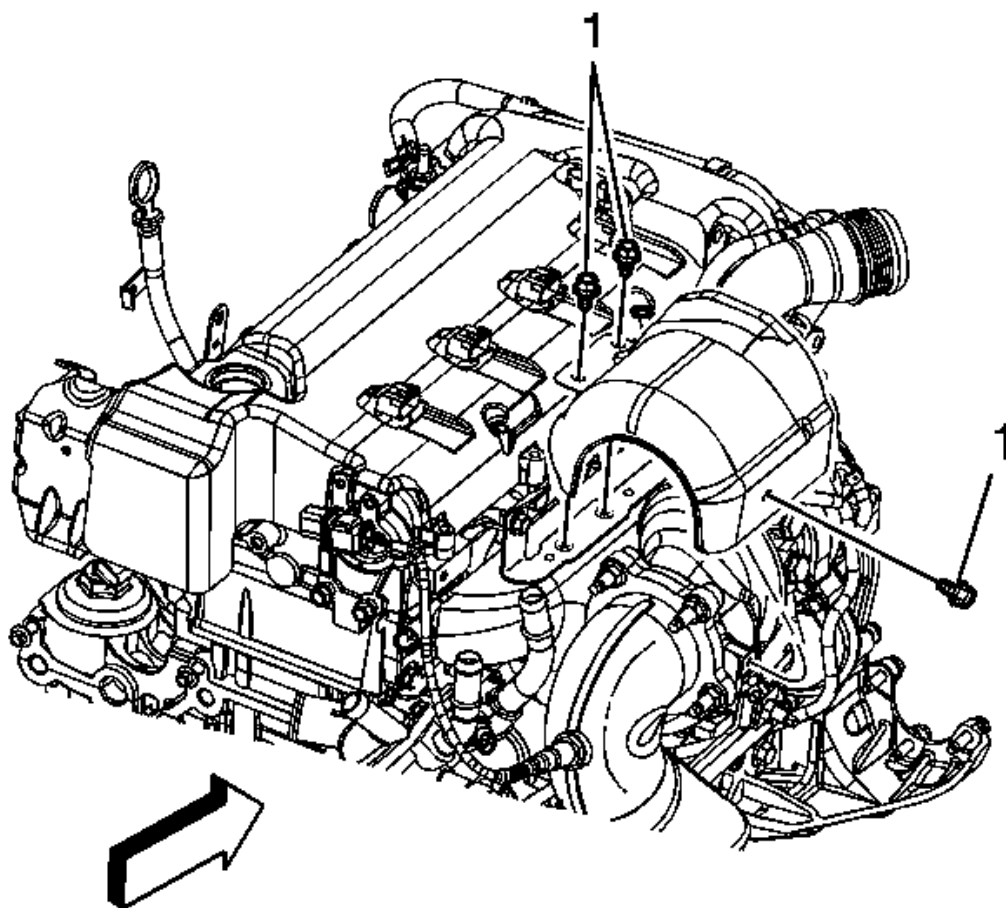


Fig. 71: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

35. Lower the vehicle.
36. Install the turbocharger heat shield and bolts (1).

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

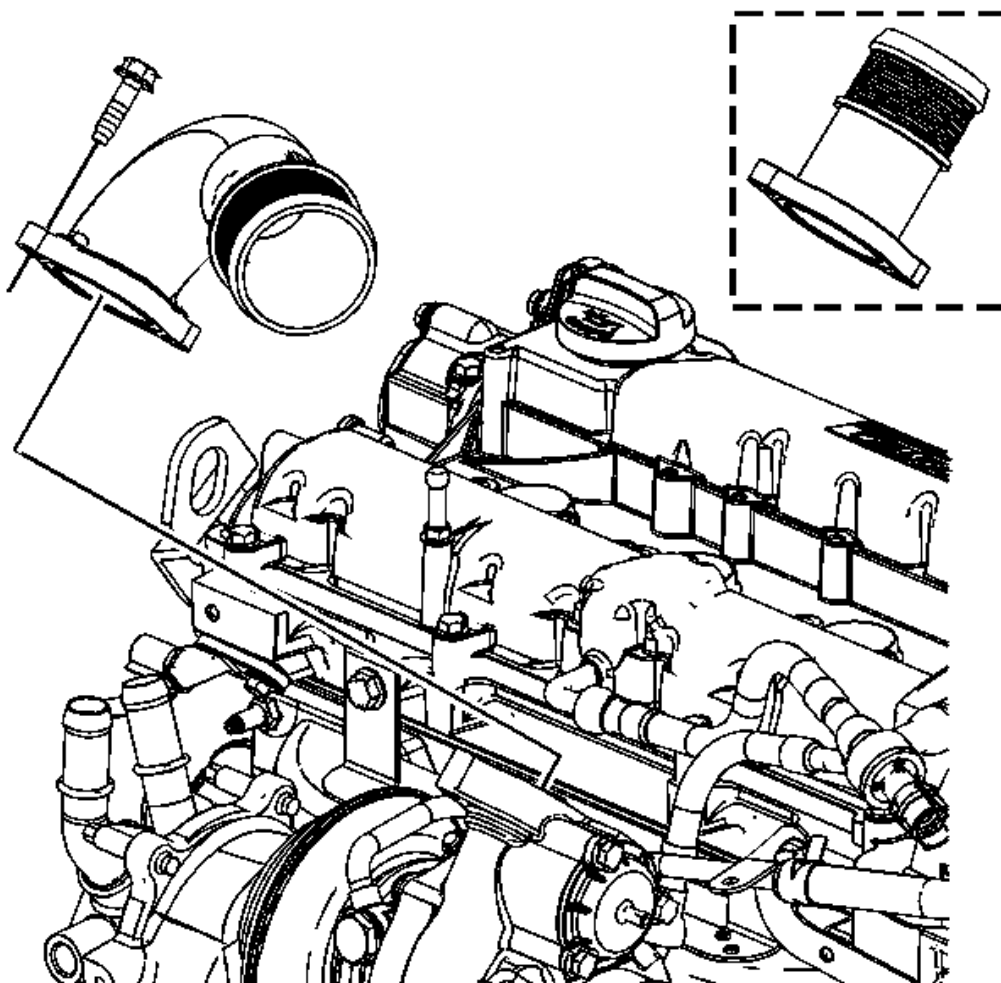


Fig. 72: Identifying Charge Air Cooler Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

37. Install the charge air cooler pipe and gasket to the turbocharger.
38. Install the charge air cooler pipe bolts at the turbocharger.

Tighten: Tighten the bolts to 22 N.m (16 lb ft).

39. Install the air cleaner outlet duct. Refer to [Air Cleaner Outlet Duct Replacement](#) .
40. Install the charge air cooler inlet pipe. Refer to [Charge Air Cooler Inlet Pipe Replacement](#) .
41. Fill the cooling system. Refer to [Cooling System Draining and Filling \(GE 47716 Fill\)](#) or [Cooling System Draining and Filling \(Static Fill LNF\)](#) .

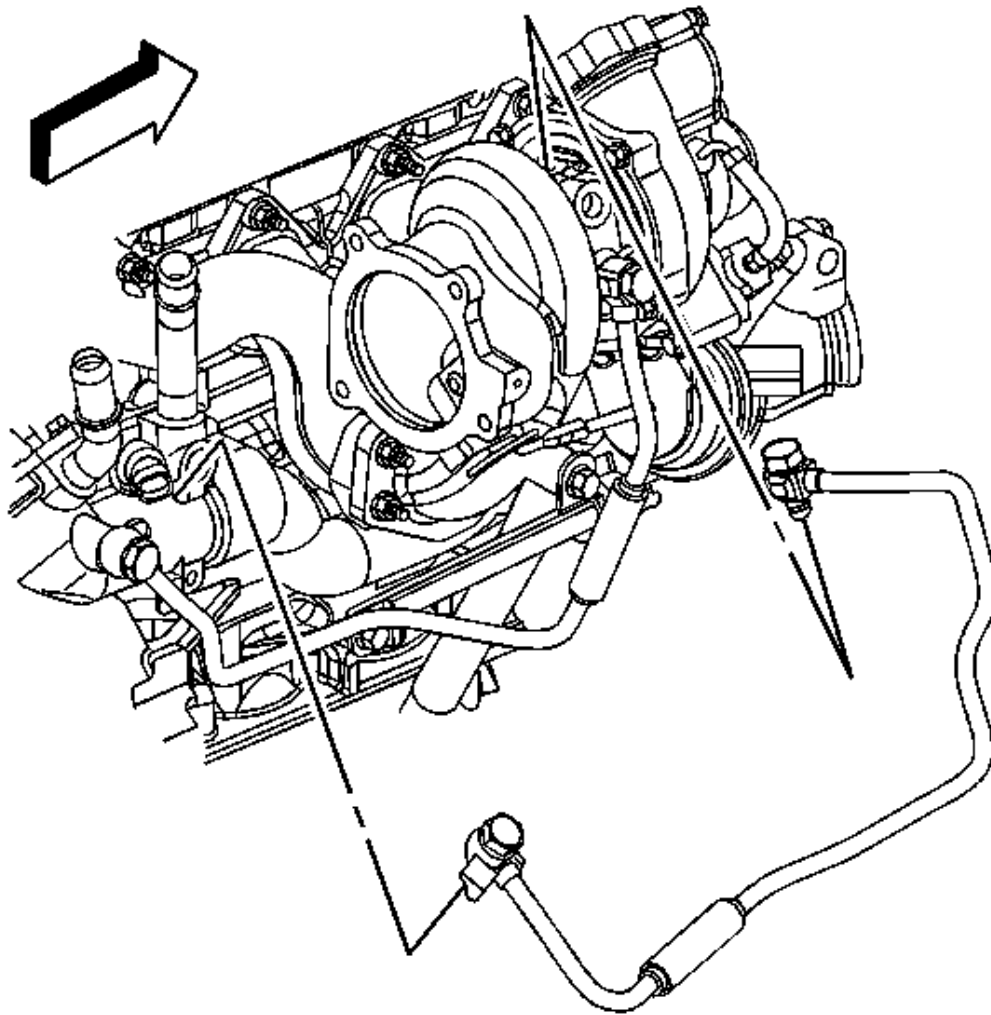
TURBOCHARGER OIL FEED PIPE REPLACEMENT**Removal Procedure**

Fig. 73: View Of Turbocharger Oil Feed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the catalytic converter. Refer to or **Catalytic Converter Replacement (LNF)** .
2. Remove the turbocharger oil feed pipe bolts and pipe.
3. Remove and discard the turbocharger oil feed pipe gaskets.

Installation Procedure

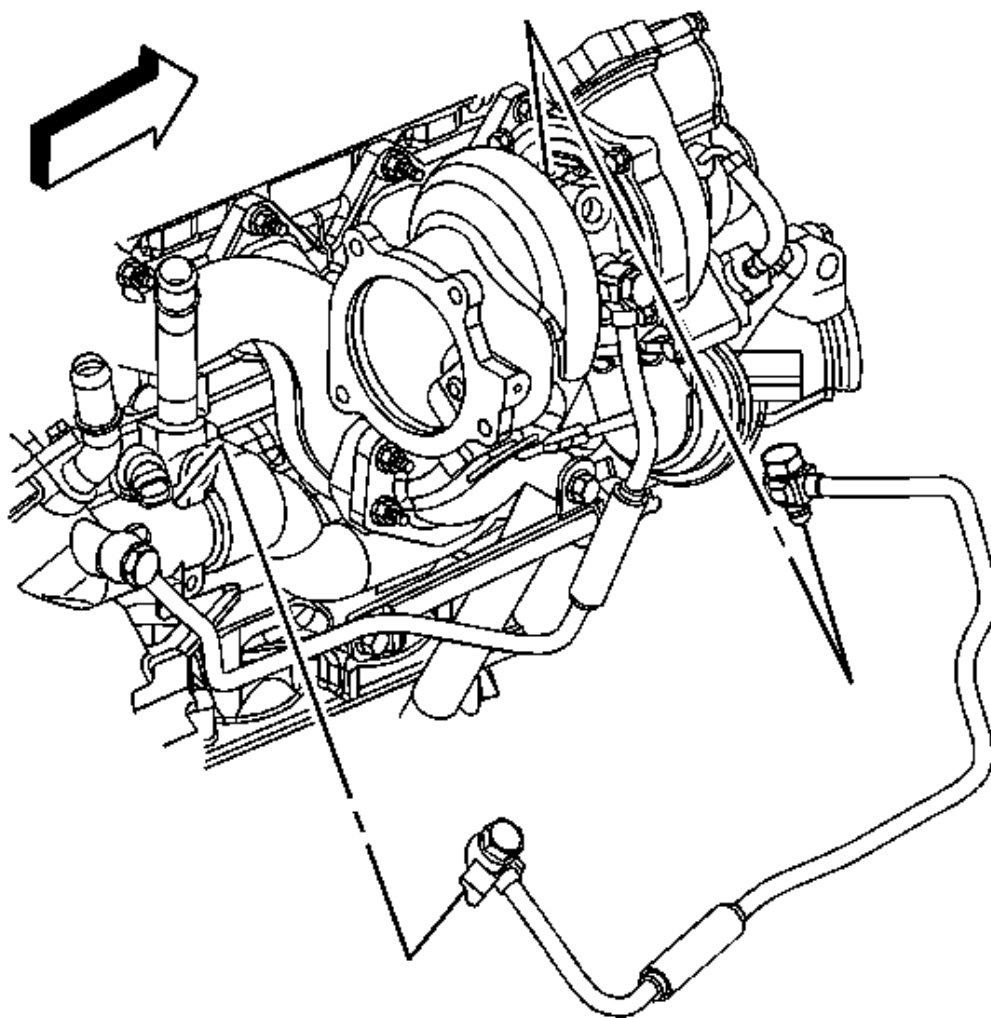


Fig. 74: View Of Turbocharger Oil Feed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install NEW gaskets onto the turbocharger oil feed pipe fittings.

NOTE: Refer to Fastener Notice .

2. Install the turbocharger oil feed pipe and bolts.

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

3. Install the catalytic converter. Refer to **Catalytic Converter Replacement (LNF)** .

TURBOCHARGER OIL RETURN PIPE REPLACEMENT

Removal Procedure

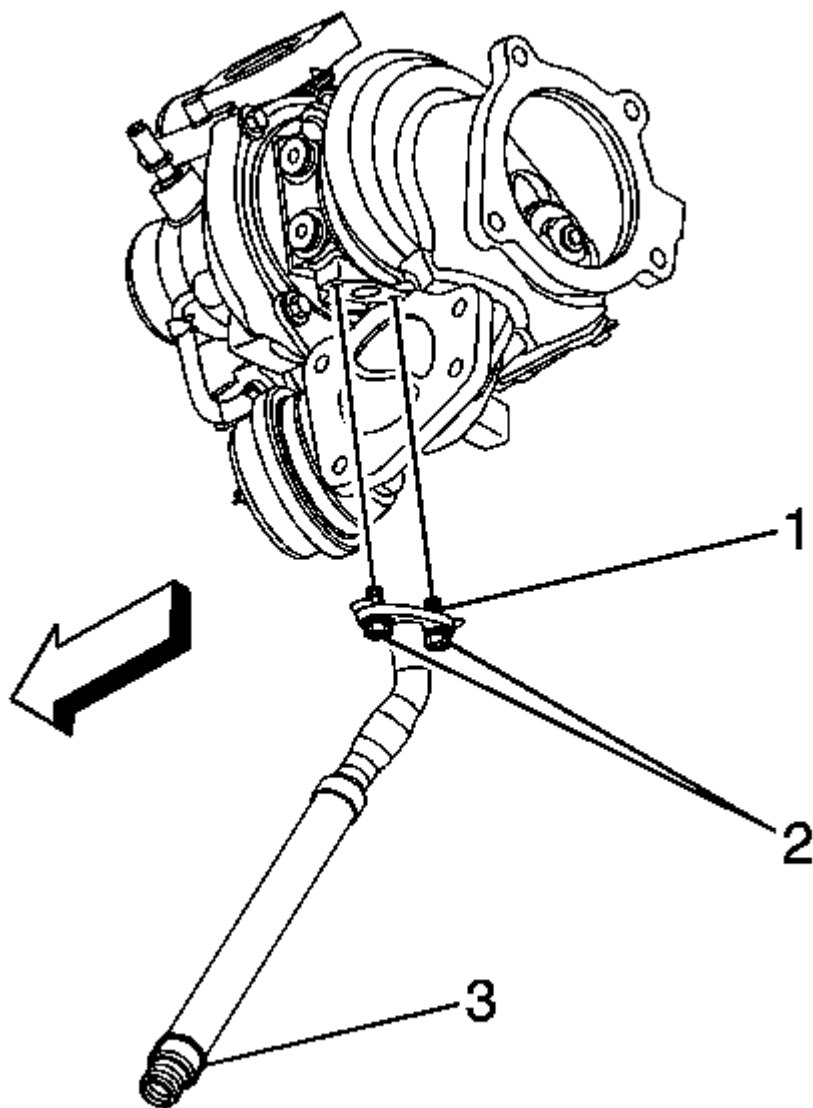


Fig. 75: Identifying Turbocharger Oil Return Hose

Courtesy of GENERAL MOTORS CORP.

1. Remove the turbocharger. Refer to **Turbocharger Replacement**.
2. Remove the turbocharger oil return hose bolts (2) and hose from the turbocharger.
3. Remove and discard the turbocharger oil return hose gasket (1).

Installation Procedure

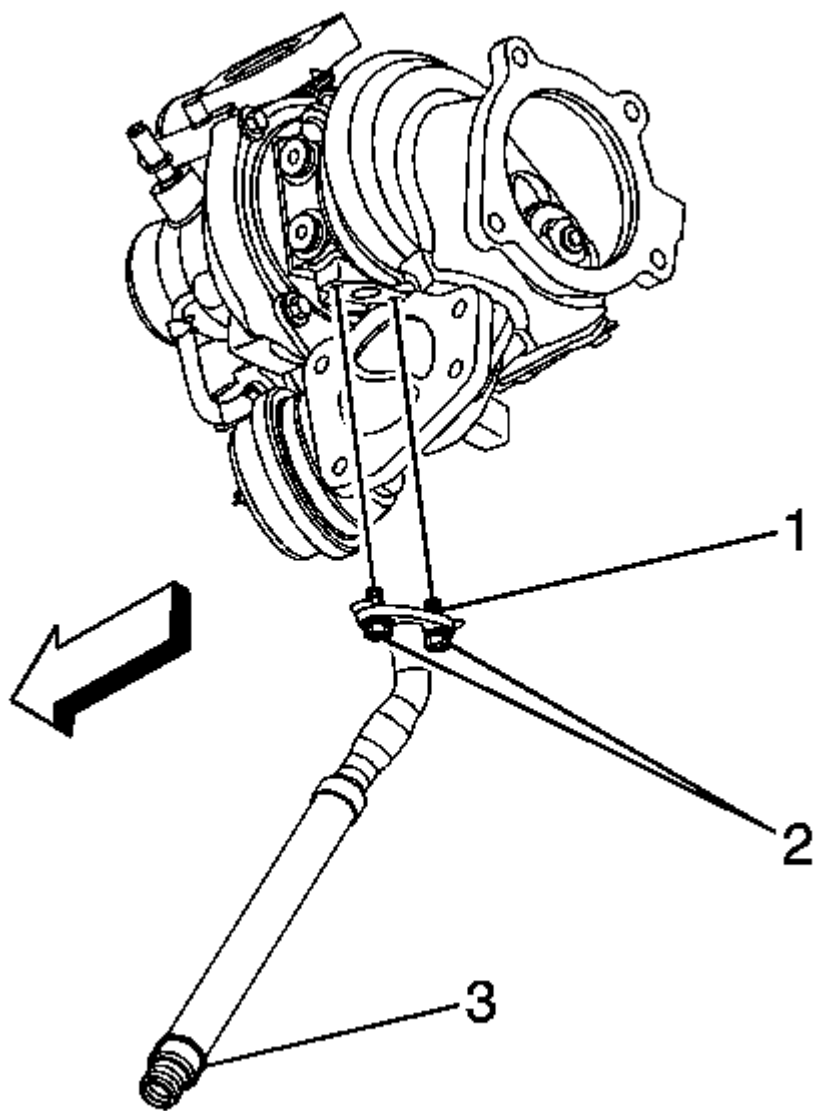


Fig. 76: Identifying Turbocharger Oil Return Hose
Courtesy of GENERAL MOTORS CORP.

1. Lubricate and install a NEW turbocharger oil return hose O-ring seal (3).
2. Position a NEW turbocharger oil return hose gasket (1) on the turbocharger oil return hose.

NOTE: Refer to **Fastener Notice** .

3. Install the turbocharger oil return hose and bolts (2).

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

4. Install the turbocharger. Refer to **Turbocharger Replacement**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

NOTE: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.

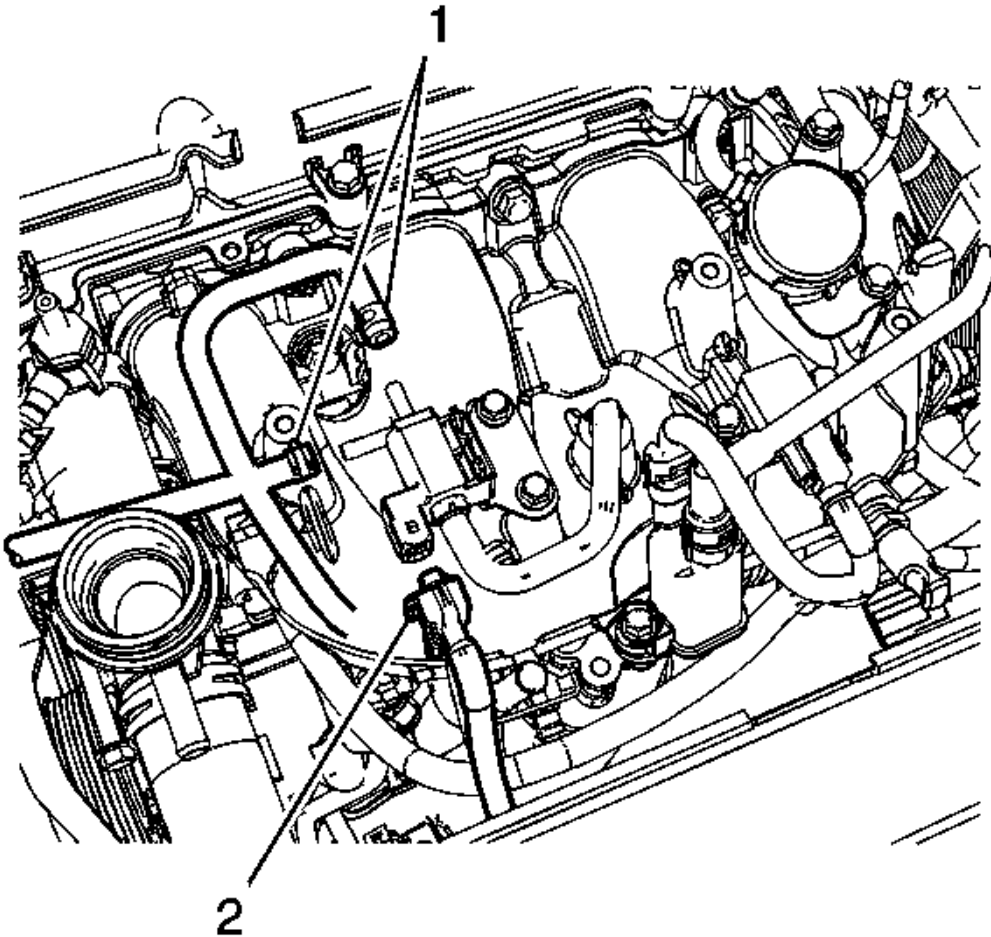


Fig. 77: Identifying Intake Manifold Vacuum Lines & Air Valve Solenoid Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Remove the charge air cooler inlet pipe. Refer to **Charge Air Cooler Inlet Pipe Replacement** .
3. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
4. Disconnect the fuel feed line quick connect fitting to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
5. Disconnect the charge air valve solenoid vacuum lines (1).
6. Disconnect the charge air valve solenoid vacuum electrical connector (2).

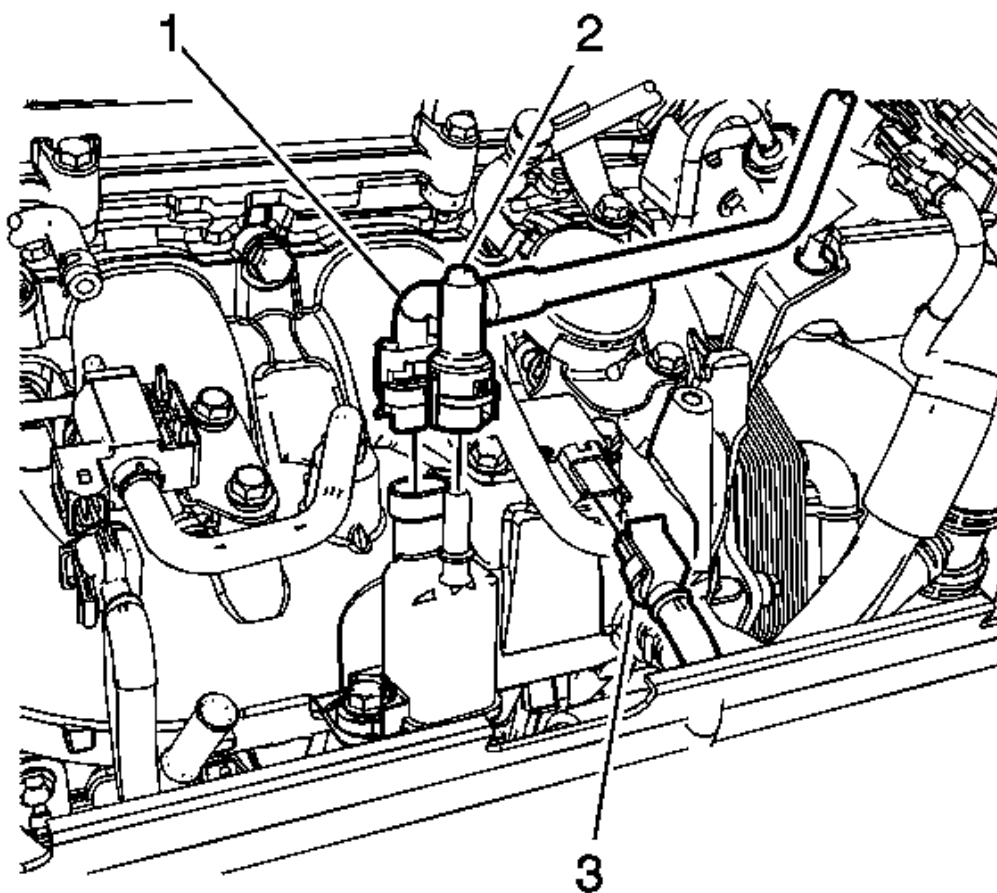


Fig. 78: Locating EVAP Line Connector & MAP Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the evaporative emission (EVAP) electrical connector (1) from the EVAP purge solenoid.
8. Disconnect the evaporative emission (EVAP) line quick connect fitting (2) from the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service**.
9. Disconnect the manifold absolute pressure (MAP) sensor electrical connector (3).

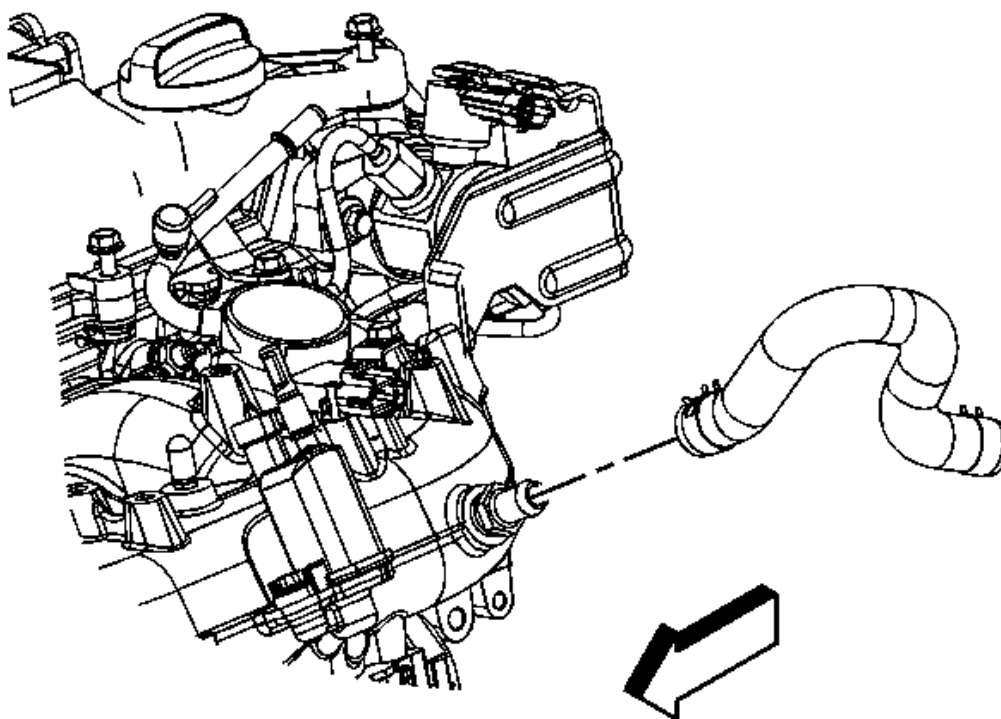


Fig. 79: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

10. Reposition the brake booster vacuum hose clamp at the intake manifold.
11. Remove the brake booster hose from the intake manifold.

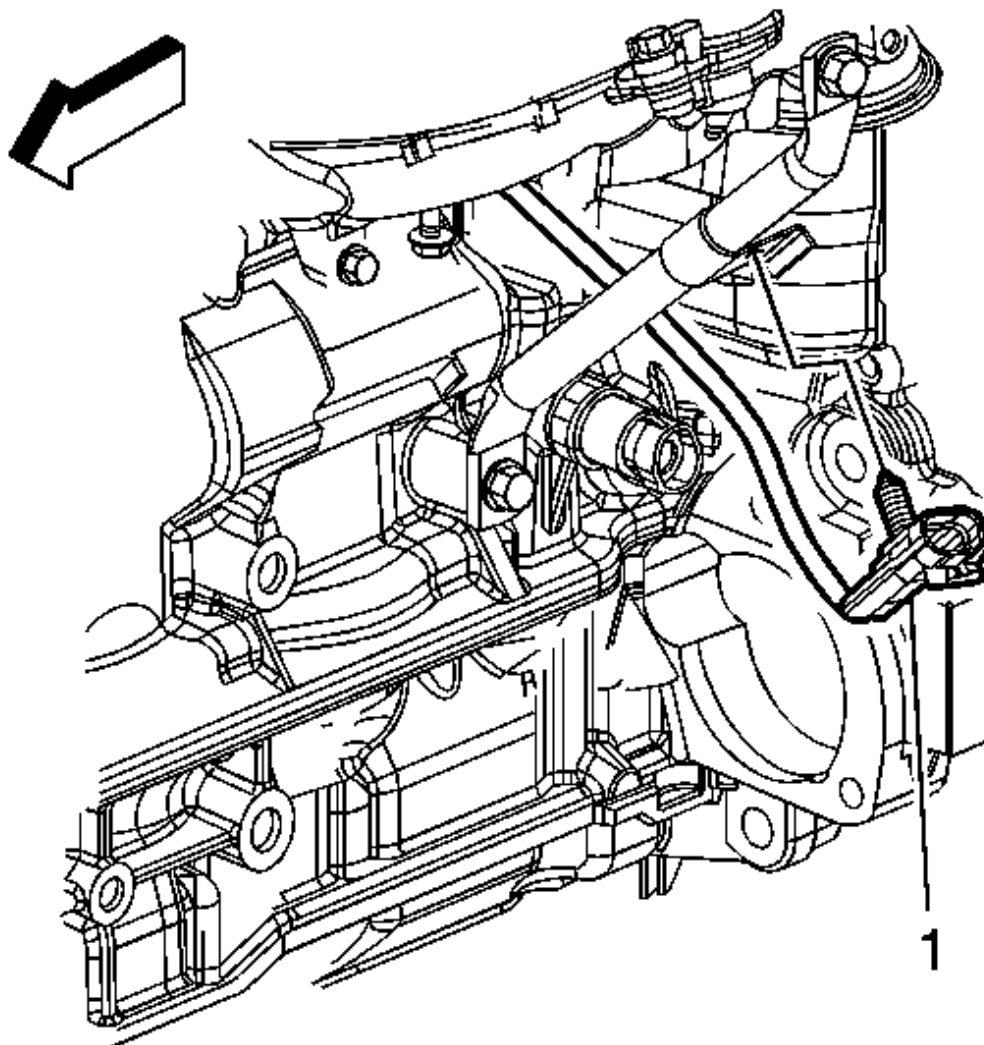


Fig. 80: Locating Knock Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

12. Remove the knock sensor electrical connector (1) clip from the intake manifold brace.

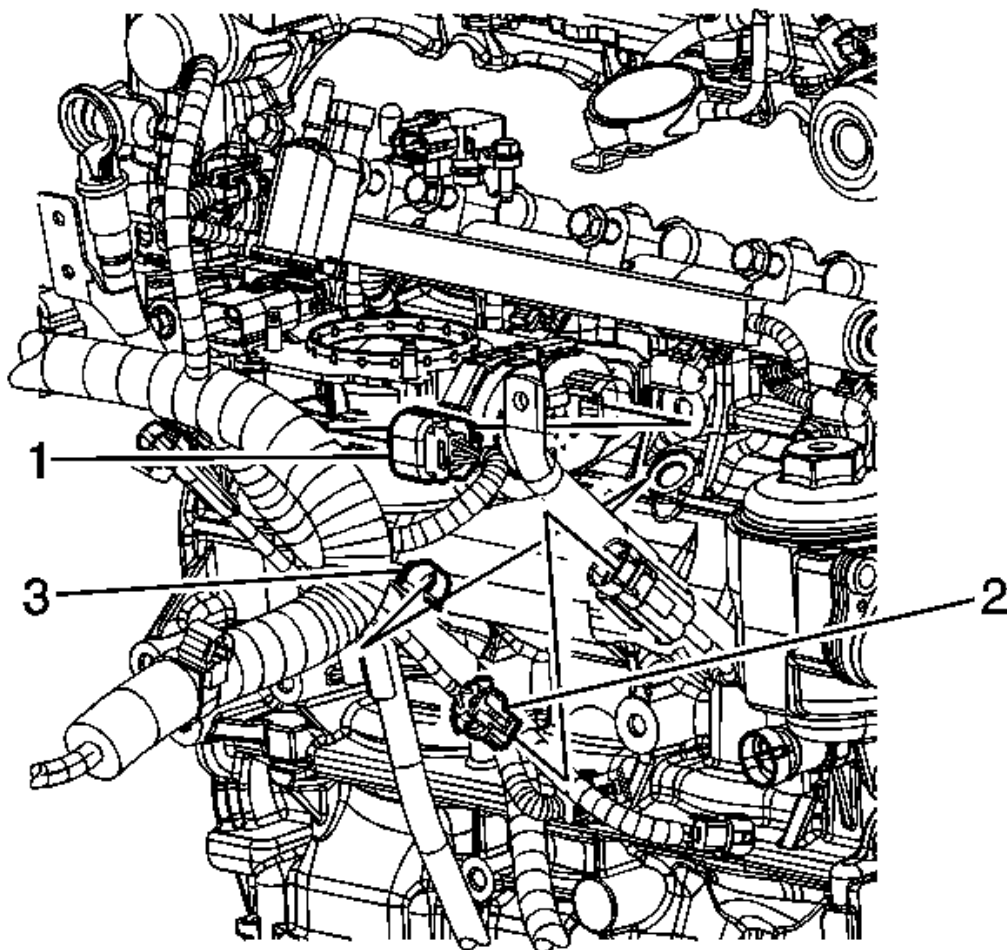


Fig. 81: Identifying Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the engine wiring harness electrical connector (1) from the throttle actuator control (TAC) module.
14. Remove the engine wiring harness clip (3) from the intake manifold brace.

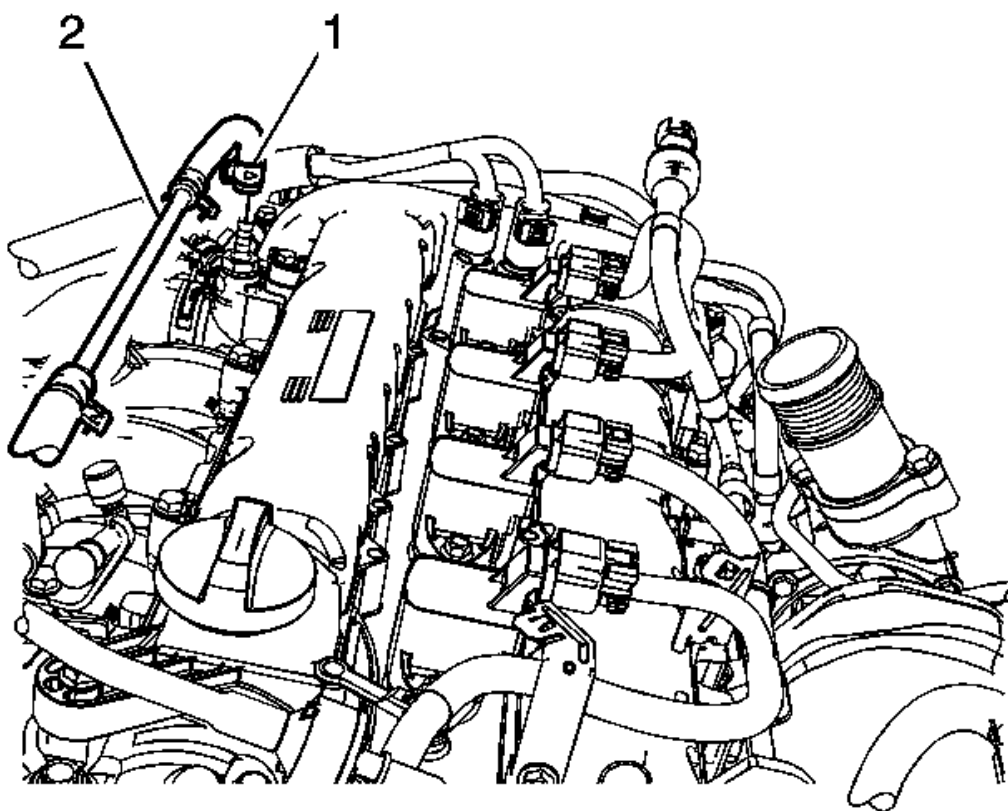


Fig. 82: Identifying Surge Tank Air Bleed Hose
Courtesy of GENERAL MOTORS CORP.

15. Reposition the surge tank air bleed hose clamp at the engine (1).
16. Remove the surge tank air bleed hose (2) from the engine.
17. Reposition the surge tank air bleed hose out of the way.

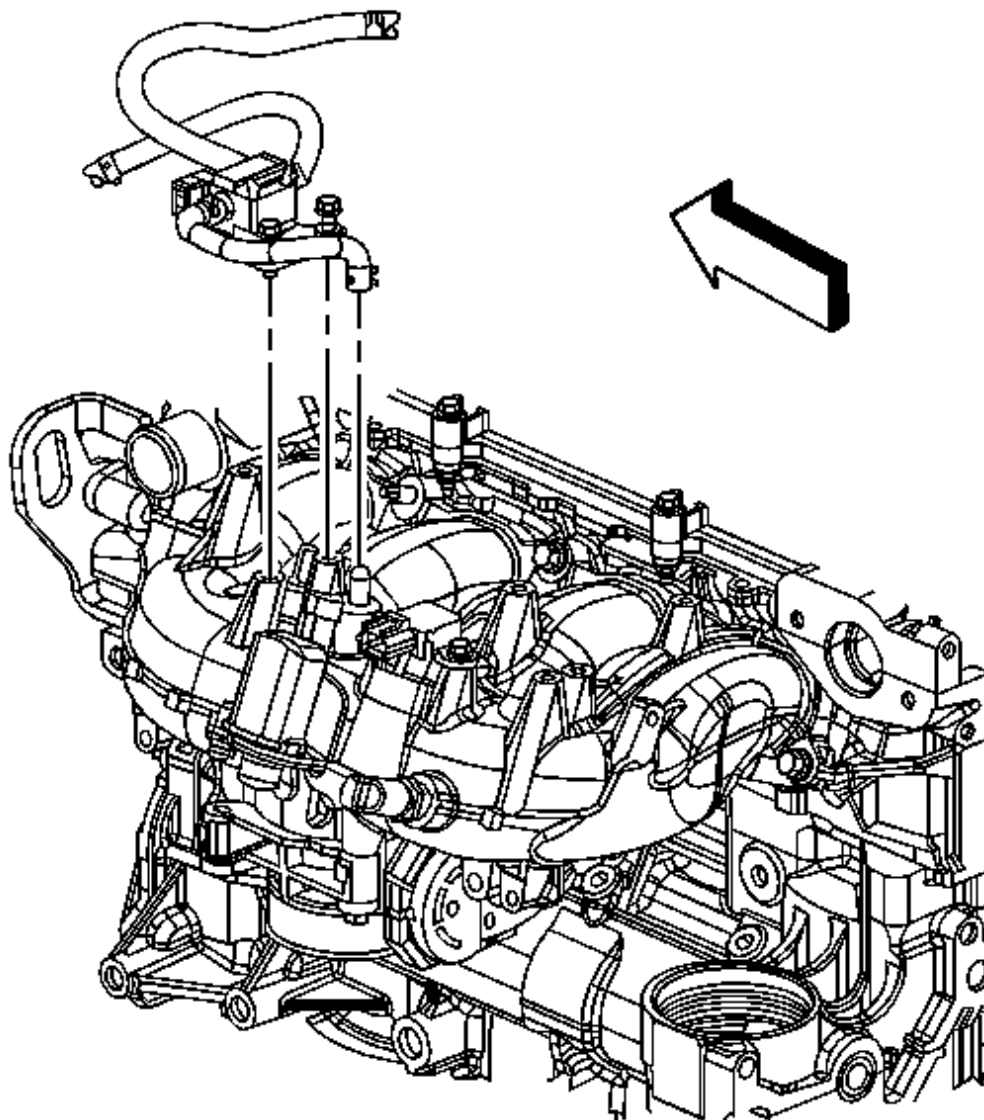


Fig. 83: Identifying Charge Air Bypass Valve Solenoid Assembly
Courtesy of GENERAL MOTORS CORP.

18. Reposition the charge air bypass valve vacuum hose clamp at the intake manifold.
19. Remove the charge air bypass valve vacuum hose from the intake manifold.
20. Remove the charge air bypass valve solenoid bolts.
21. Reposition the charge air bypass valve solenoid assembly out of the way.

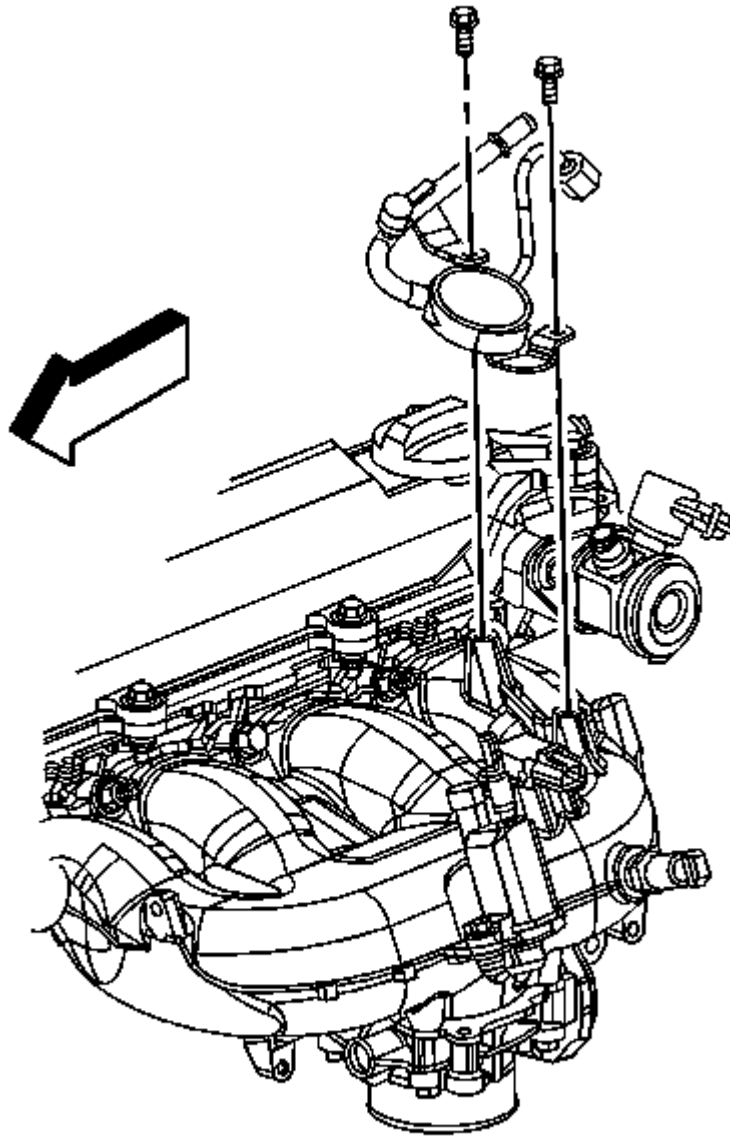


Fig. 84: Identifying Fuel Feed Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

22. Disconnect the metal quick connect fitting from the fuel feed pip. Refer to **Metal Collar Quick Connect Fitting Service** .
23. Disconnect the fuel feed pipe fitting from the fuel pump.
24. Remove the fuel feed pipe bolts.

25. Remove the fuel feed pipe.
26. Inspect the fuel feed pipe nut for damaged threads.
27. Inspect the fuel feed pipe sealing bail for damage or debris.
28. Replace the fuel feed pipe if any damage is found.
29. Remove the charge air bypass valve vacuum tank. Refer to **Charge Air Bypass Valve Vacuum Tank Replacement** .

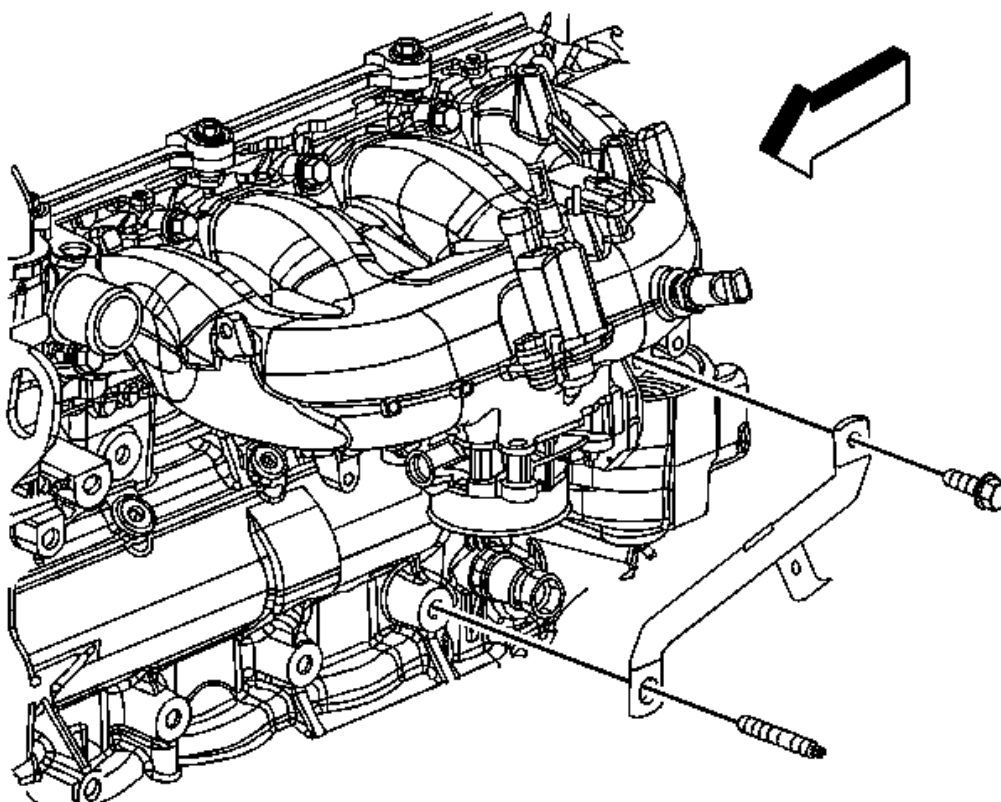


Fig. 85: View Of Intake Manifold Brace
Courtesy of GENERAL MOTORS CORP.

30. Remove the intake manifold brace bolt.
31. Remove the intake manifold brace.

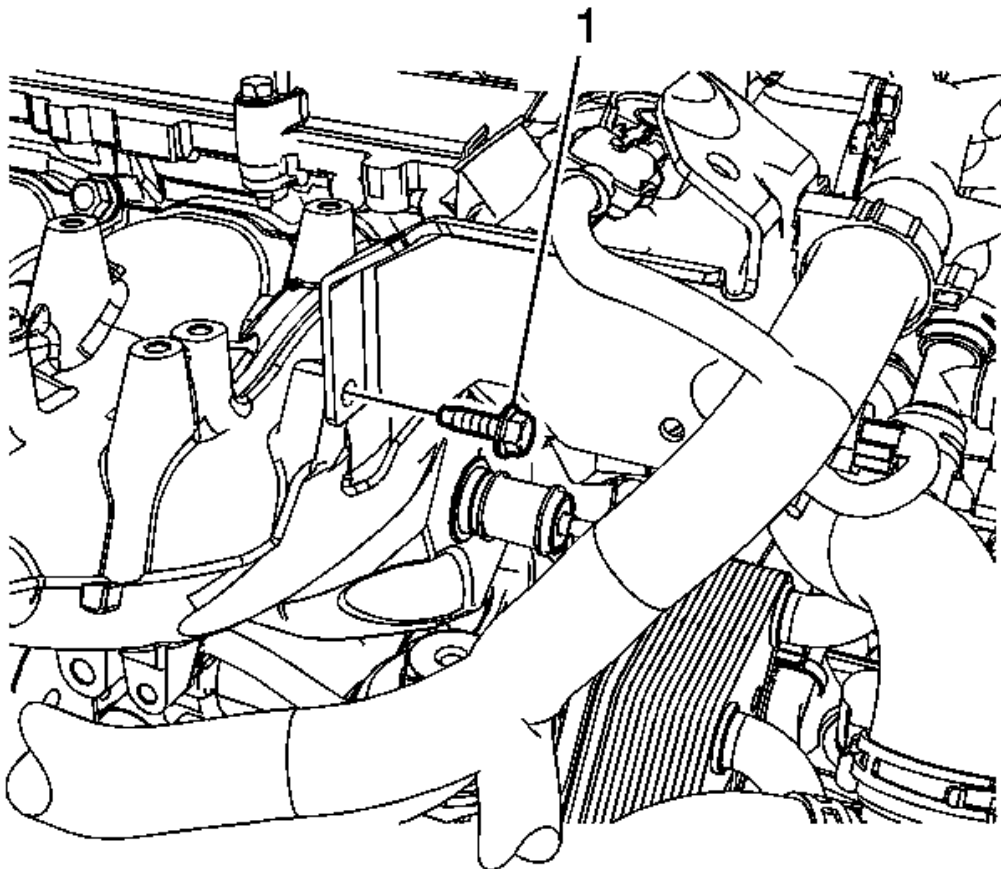


Fig. 86: Identifying Fuel Pump Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

32. Remove the fuel pump bracket bolt (1).

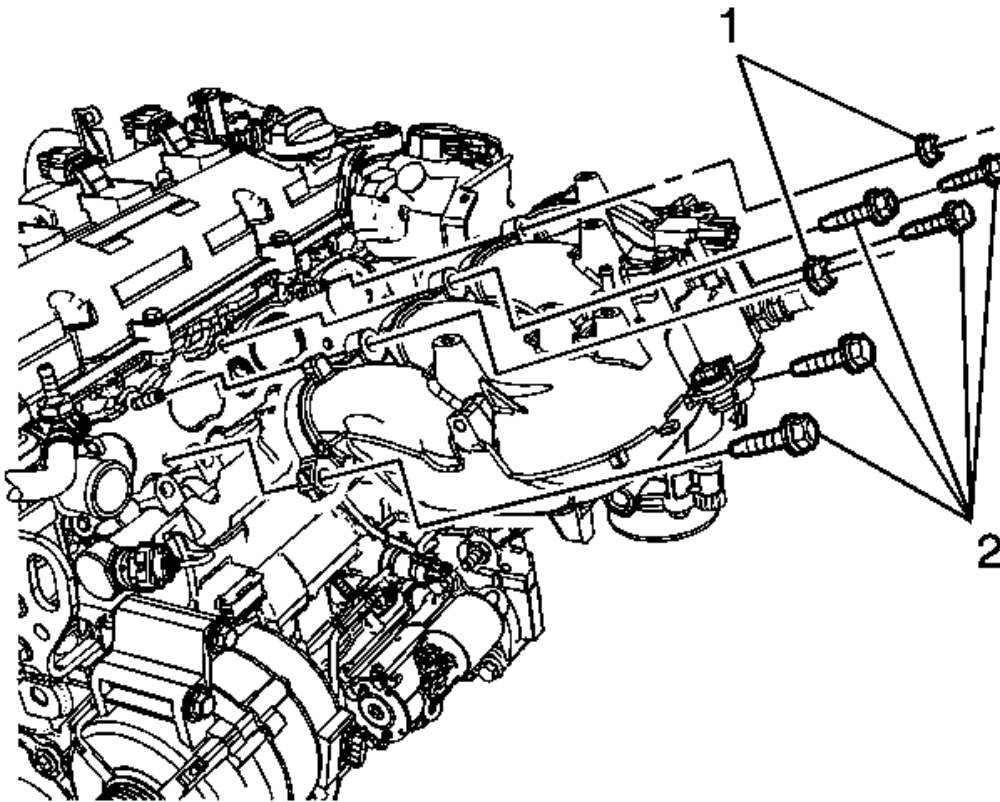


Fig. 87: View Of Intake Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

33. Remove the intake manifold nuts (1) and bolts (2).
34. Remove the intake manifold and place on a clean work surface.

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

35. Remove the intake manifold gasket, if necessary.

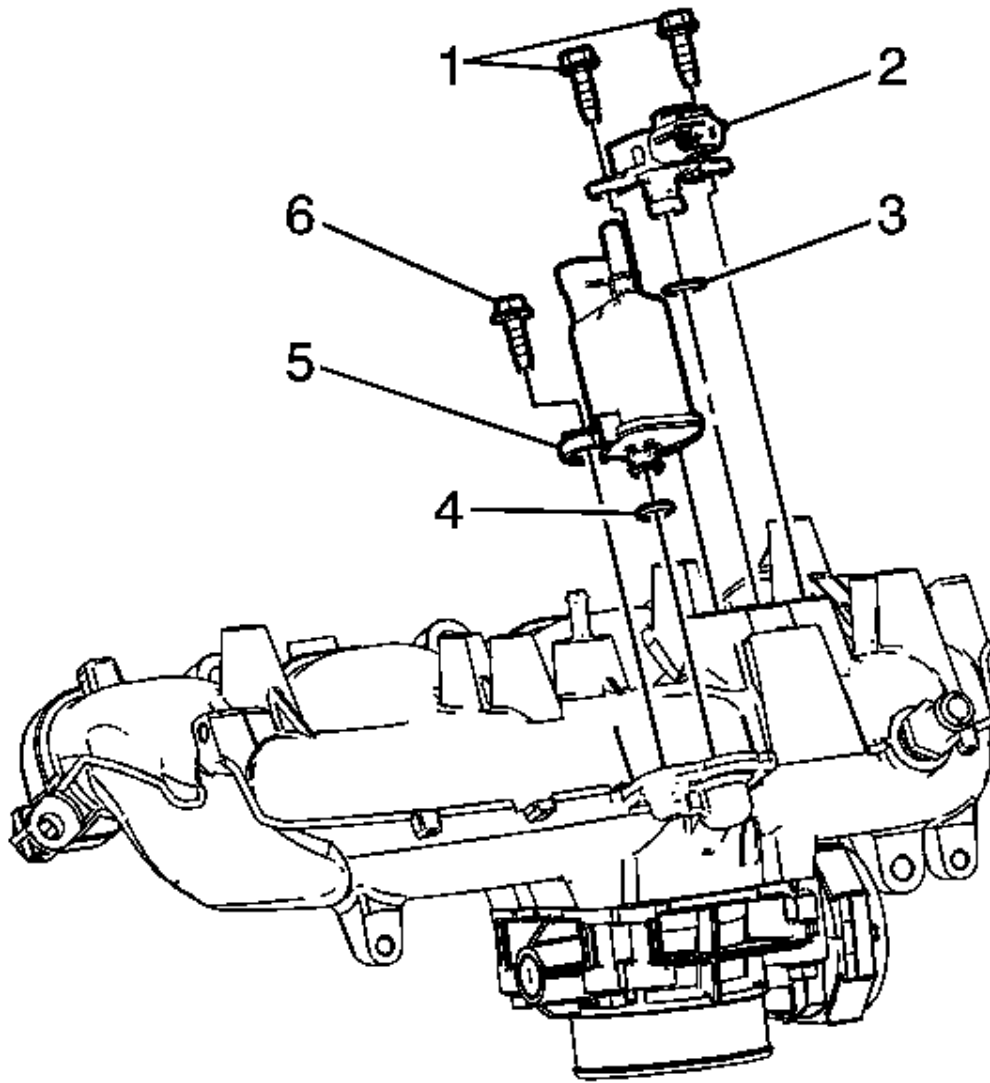


Fig. 88: View Of EVAP Canister Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

36. If replacing the intake manifold perform the following steps, otherwise proceed to step 11 in the installation procedure.
37. Remove the MAP sensor bolts (1).
38. Remove the MAP sensor (2), ensure that the O-ring seal (3) is still attached on the sensor, if not remove the O-ring seal from the intake manifold.
39. Remove the EVAP purge solenoid bolt (6).

40. Remove the EVAP purge solenoid (5), ensure that the O-ring seal (4) is still attached on the sensor, if not remove the O-ring seal from the intake manifold.

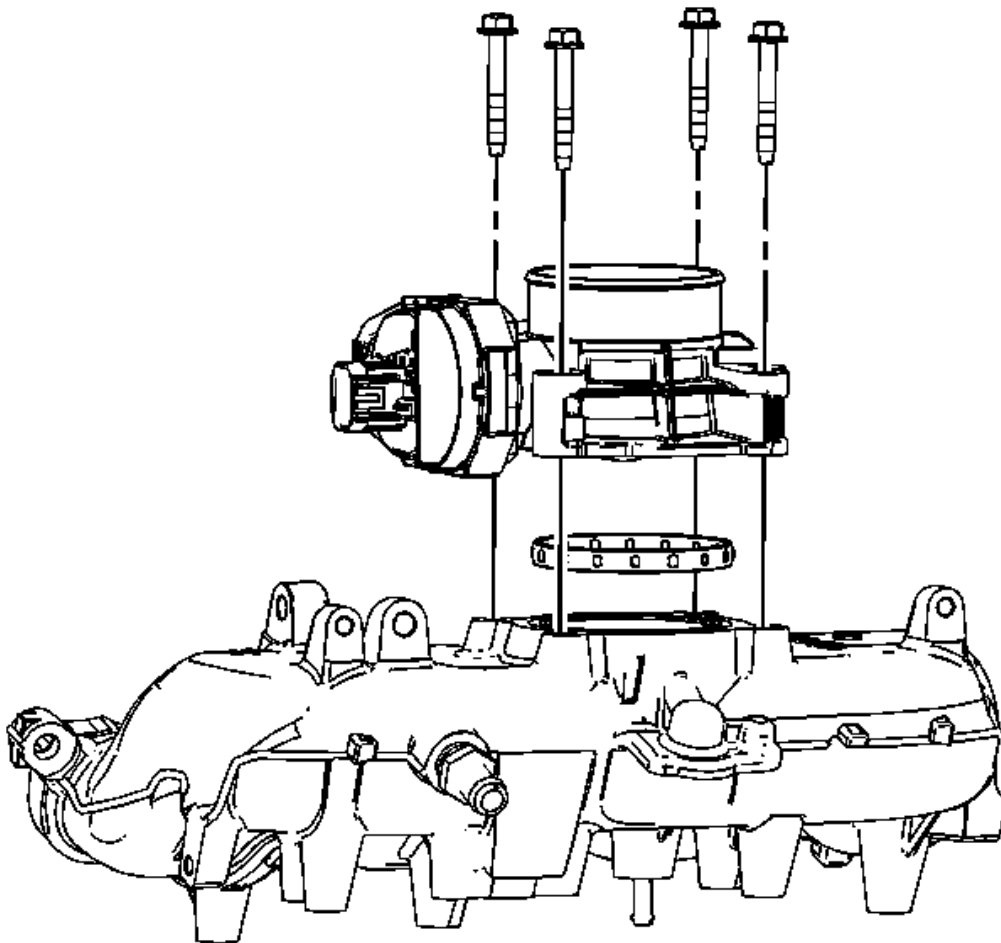


Fig. 89: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

41. Turn the intake manifold up side down.
42. Remove the throttle body bolts.
43. Remove the throttle body and seal.

Installation Procedure

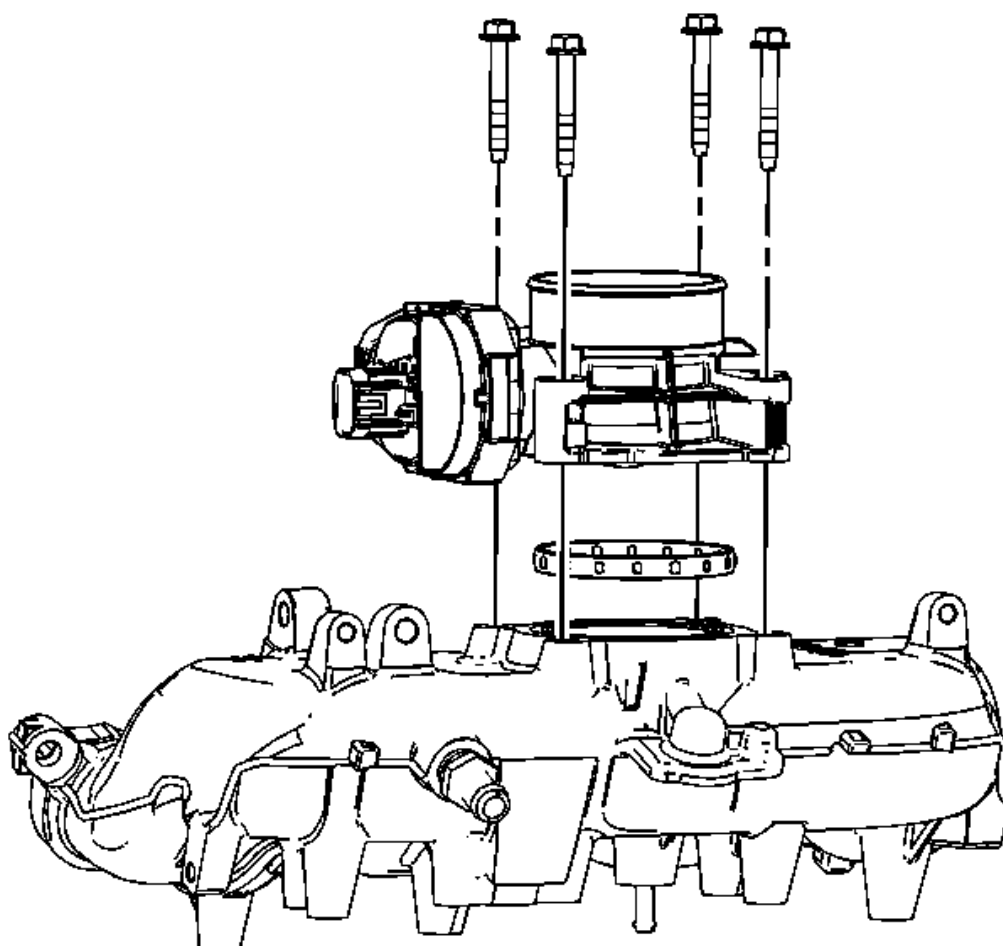


Fig. 90: View Of Throttle Body

Courtesy of GENERAL MOTORS CORP.

1. If replacing the intake manifold perform the following steps, otherwise proceed to step 11.
2. Inspect the throttle body seal and replace if necessary.
3. Install the throttle body seal and position the throttle body.

NOTE: Refer to **Fastener Notice** .

4. Install the throttle body bolts.

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

5. Turn the intake manifold right side up.

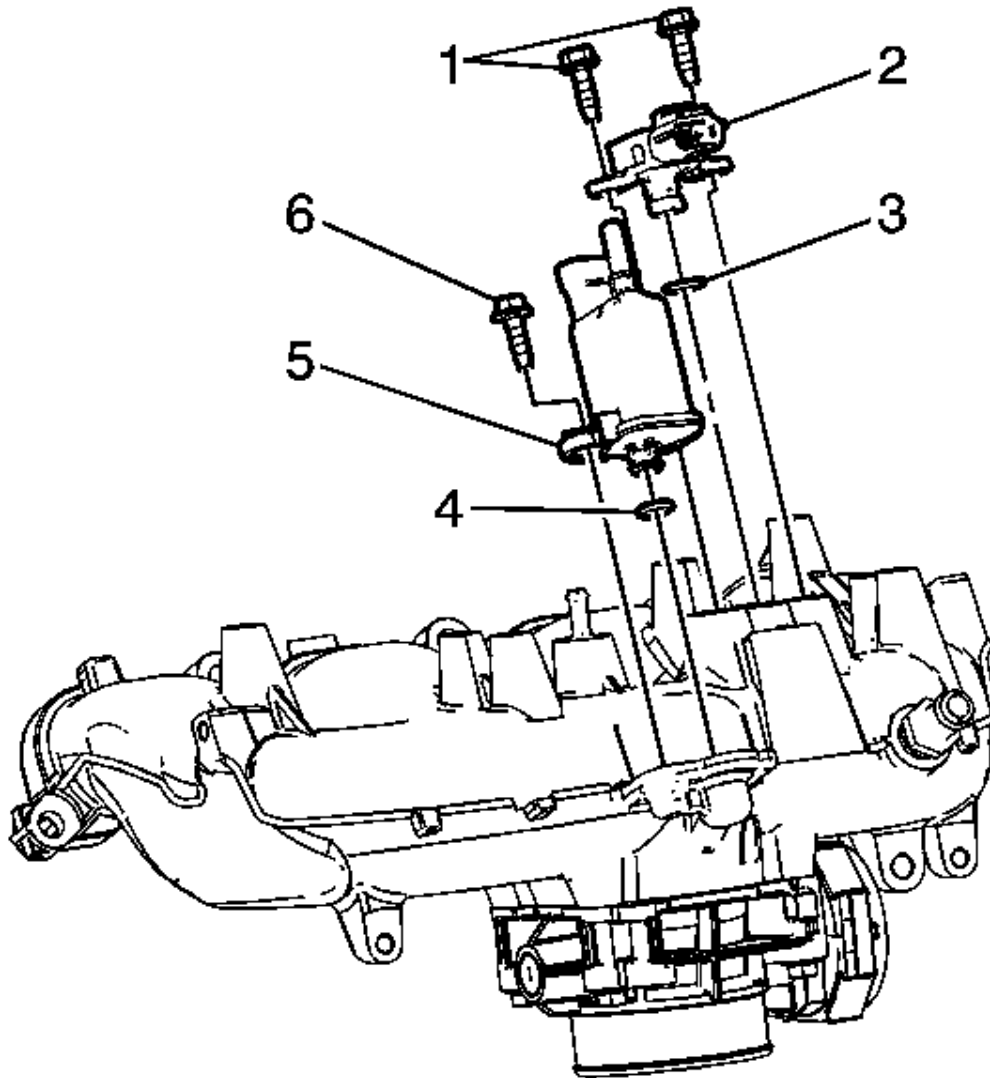


Fig. 91: View Of EVAP Canister Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

6. Inspect the EVAP purge solenoid and MAP sensor O-ring seals, replace if necessary.
7. Ensure that the EVAP purge solenoid O-ring seal (4) is installed on the EVAP purge solenoid (5).
8. Install the EVAP purge solenoid (5) and bolt (6).

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

9. Ensure that the MAP sensor O-ring seal (3) is installed on the MAP sensor (2).
10. Install the MAP sensor (2) and bolts (1).

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

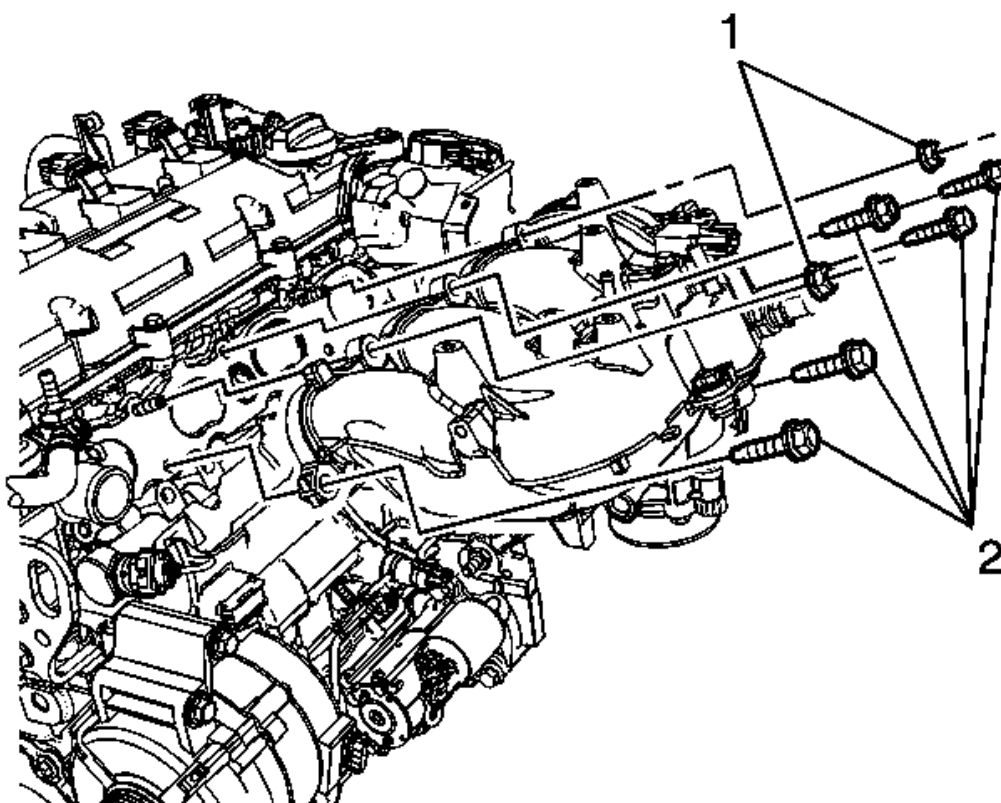


Fig. 92: View Of Intake Manifold, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the intake manifold gasket, if necessary.
12. Install the intake manifold to the studs.
13. Install the intake manifold nuts (1) and bolts (2).

Tighten

- Tighten the bolts (2) to 25 N.m (18 lb ft).

- Tighten the nuts (1) to 20 N.m (15 lb ft).

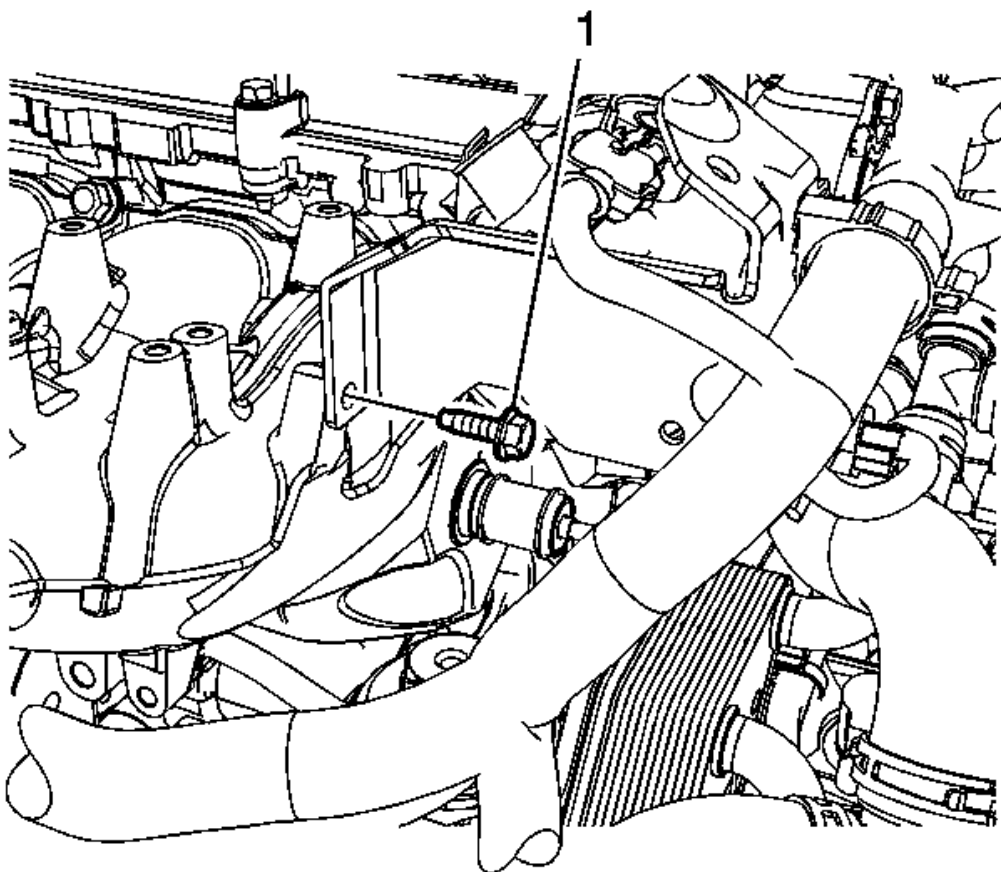


Fig. 93: Identifying Fuel Pump Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the fuel pump bracket bolt (1).

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

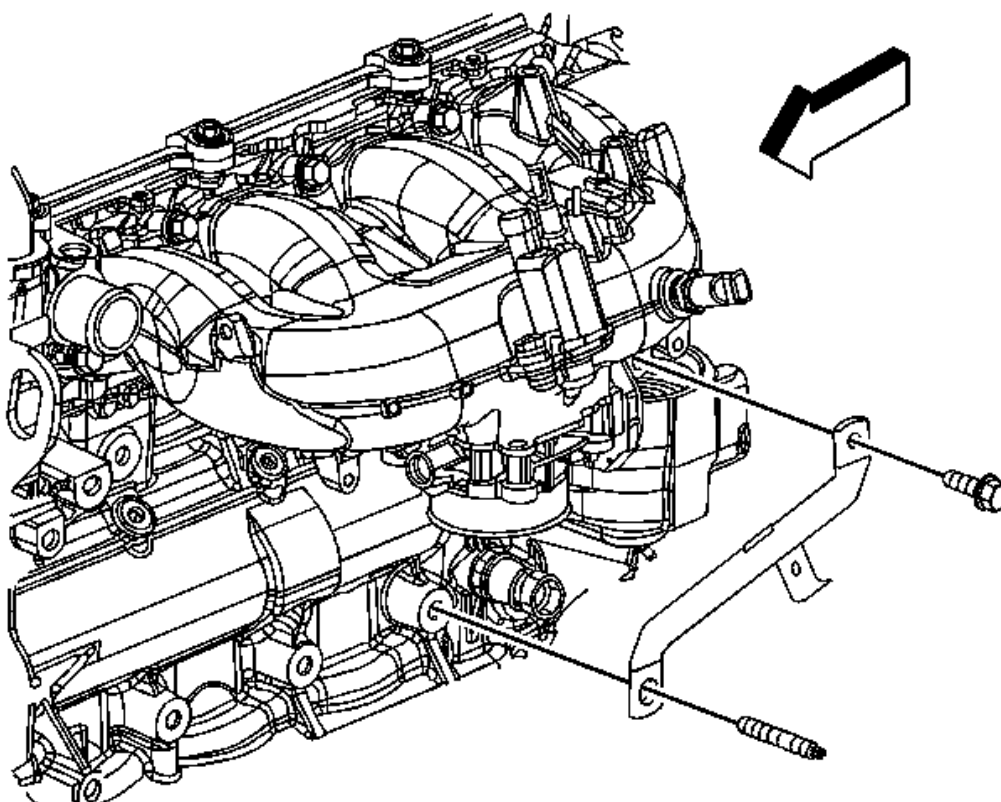


Fig. 94: View Of Intake Manifold Brace
Courtesy of GENERAL MOTORS CORP.

15. Install the intake manifold brace.
16. Loosely install the intake manifold brace bolt.
17. Tighten the intake manifold brace bolt.

Tighten: Tighten the bolt to 22 N.m (16 lb ft).

18. Install the charge air bypass valve vacuum tank. Refer to **Charge Air Bypass Valve Vacuum Tank Replacement**.

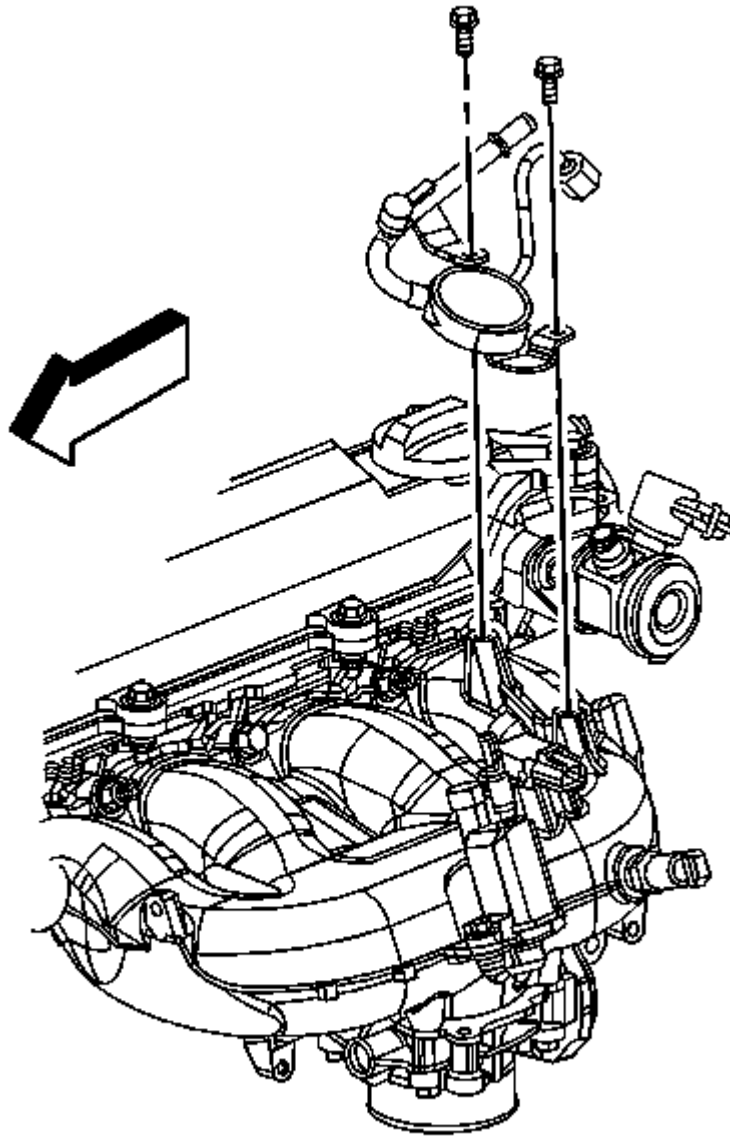


Fig. 95: Identifying Fuel Feed Pipe & Bolts
Courtesy of GENERAL MOTORS CORP.

19. Lubricate the high pressure fuel pump fuel feed pipe connection threads with silicon free engine oil GM P/N 12345610 (Canadian P/N 993193) or equivalent.
20. Place the fuel feed pipe on top of the intake manifold.
21. Connect the fuel feed pipe fitting to the high pressure fuel pump.

22. Install the fuel feed pipe bolts.

Tighten:

- Tighten the bolts to 10 N.m (89 lb in).
- Tighten the fitting to 30 N.m (22 lb ft).

23. Connect the metal quick connect fitting to the fuel feed pip. Refer to **Metal Collar Quick Connect Fitting Service** .

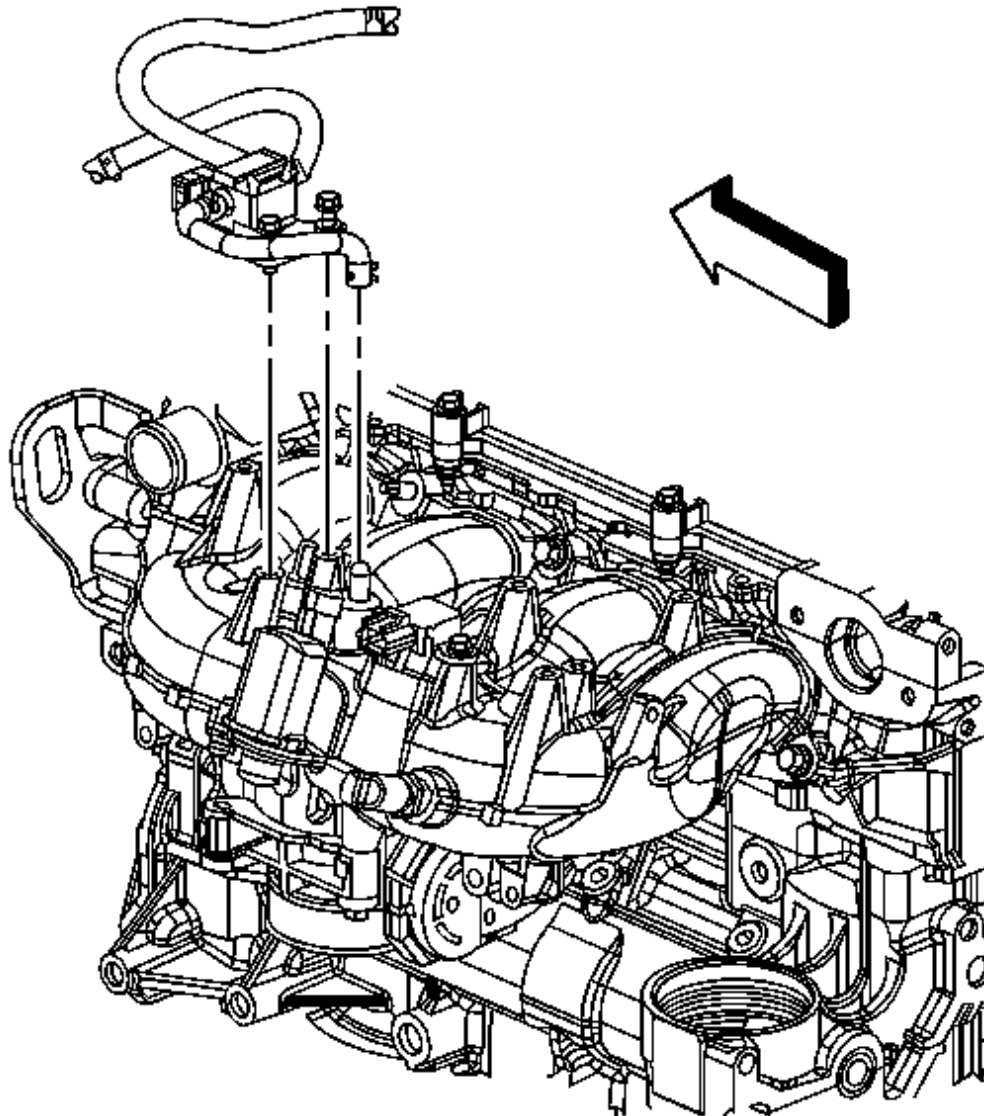


Fig. 96: Identifying Charge Air Bypass Valve Solenoid Assembly
Courtesy of GENERAL MOTORS CORP.

24. Position the charge air bypass valve solenoid assembly to the intake manifold.
25. Install the charge air bypass valve solenoid bolts.

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

26. Install the charge air bypass valve vacuum hose to the intake manifold.
27. Position the charge air bypass valve vacuum hose clamp at the intake manifold.

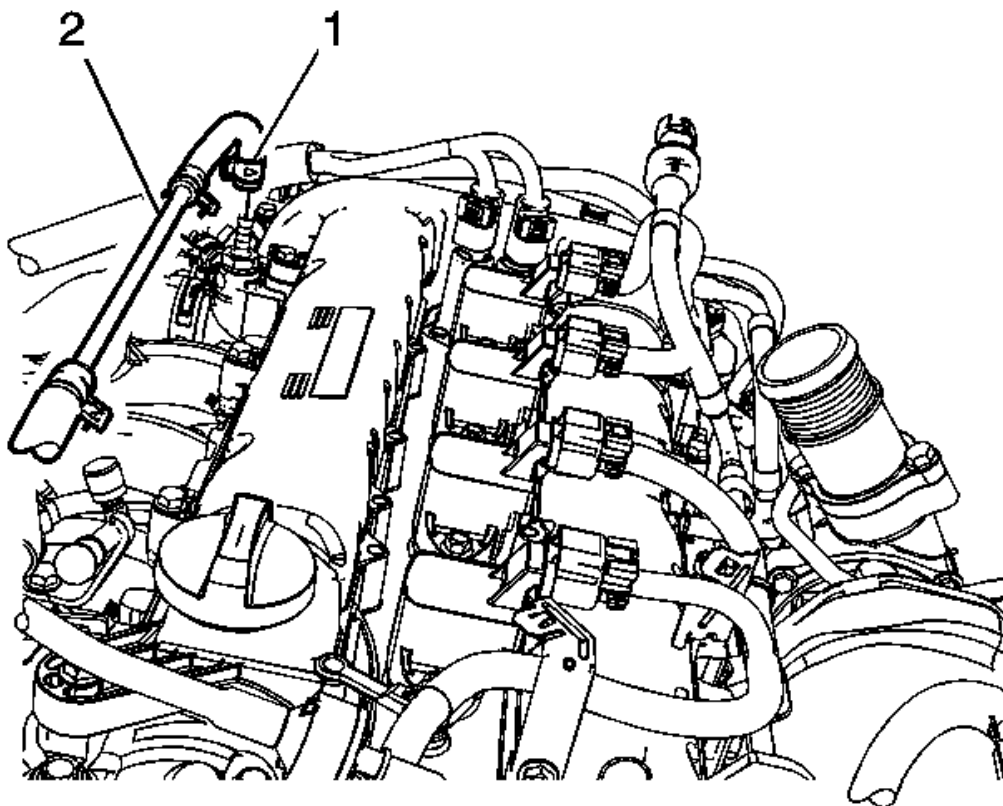


Fig. 97: Identifying Surge Tank Air Bleed Hose
Courtesy of GENERAL MOTORS CORP.

28. Position the surge tank air bleed hose to the engine.
29. Install the surge tank air bleed hose (2) to the engine.
30. Position the surge tank air bleed hose clamp at the engine (1).

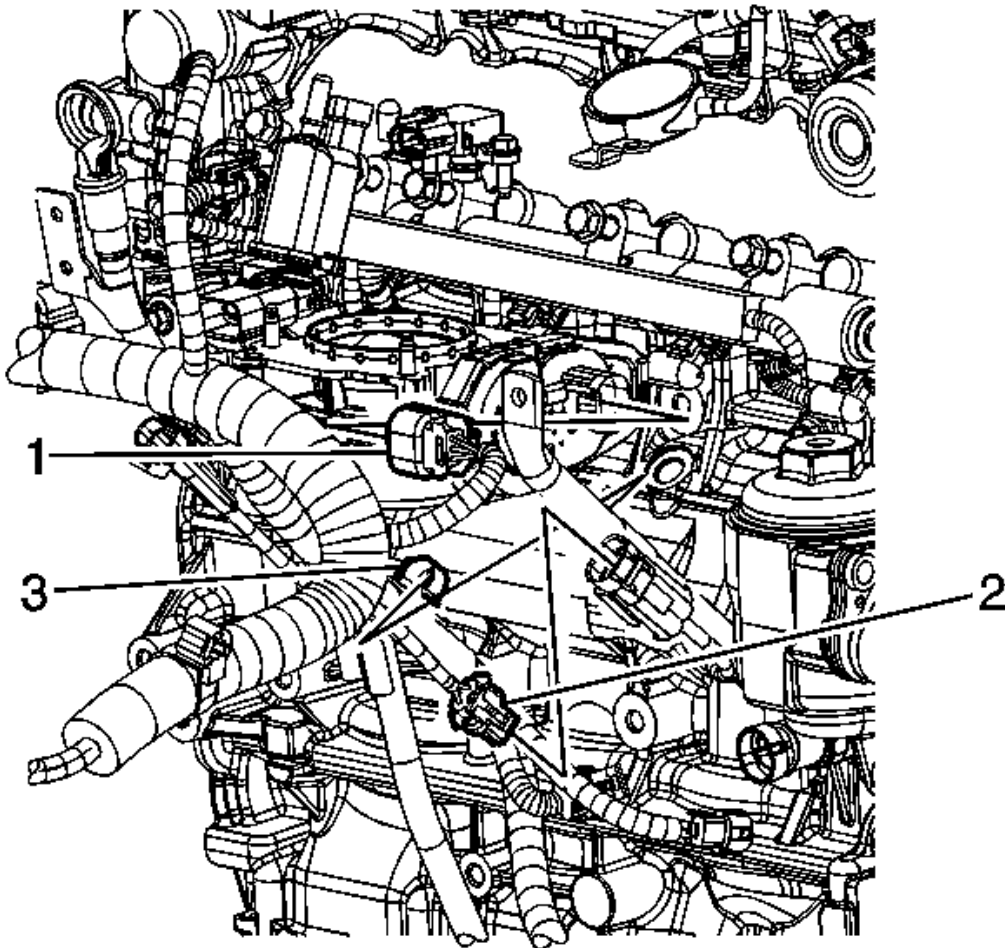


Fig. 98: Identifying Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

31. Connect the engine wiring harness electrical connector (1) to the TAC module.
32. Install the engine wiring harness clip (3) to the intake manifold brace.

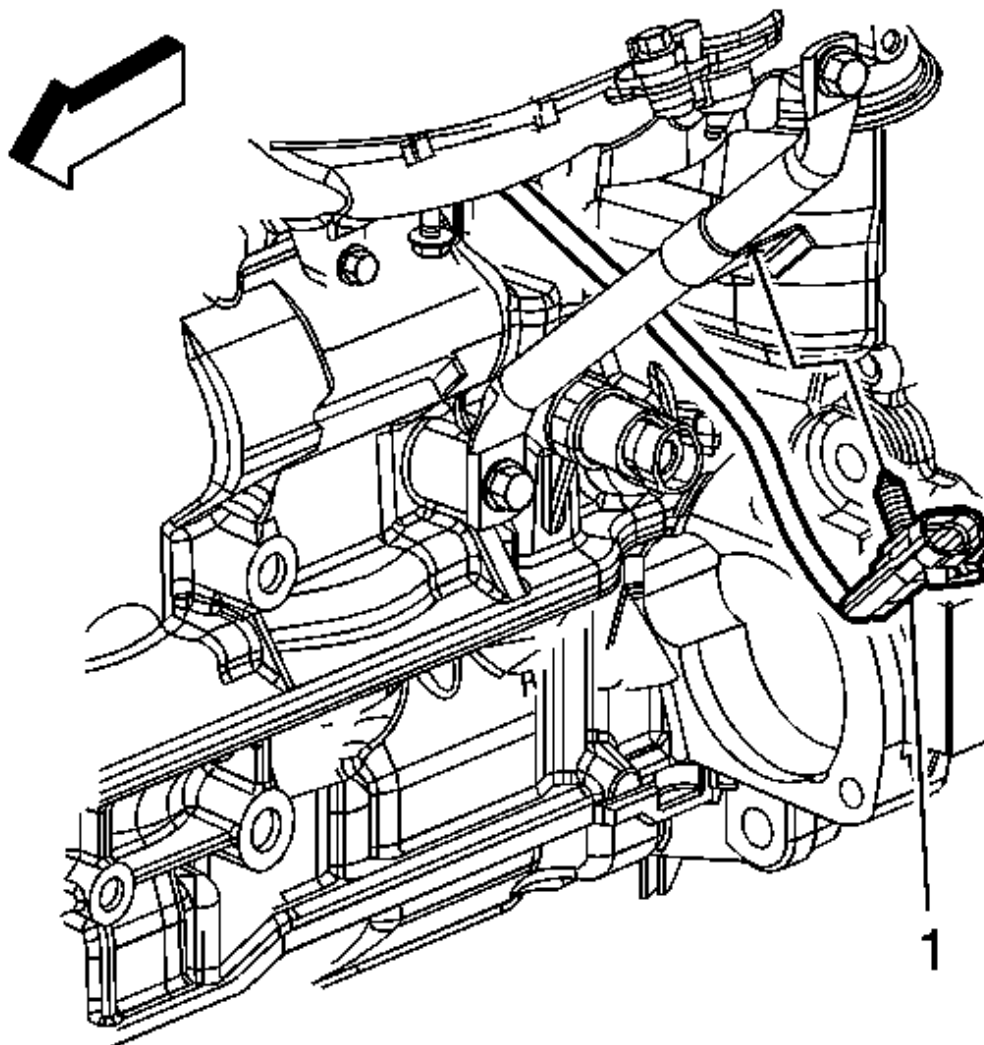


Fig. 99: Locating Knock Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

33. Install the knock sensor electrical connector (1) clip to the intake manifold brace.

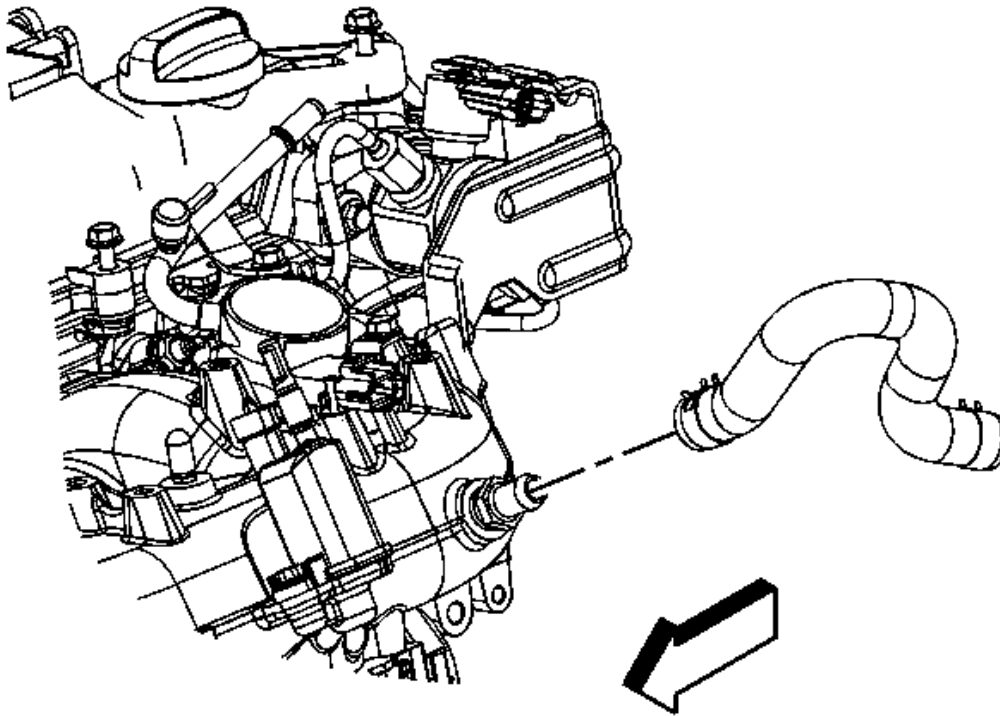


Fig. 100: View Of Brake Booster Vacuum Hose

Courtesy of GENERAL MOTORS CORP.

34. Install the brake booster hose to the intake manifold.
35. Position the brake booster vacuum hose clamp at the intake manifold.
36. Connect the EVAP line quick connect fitting (2) to the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

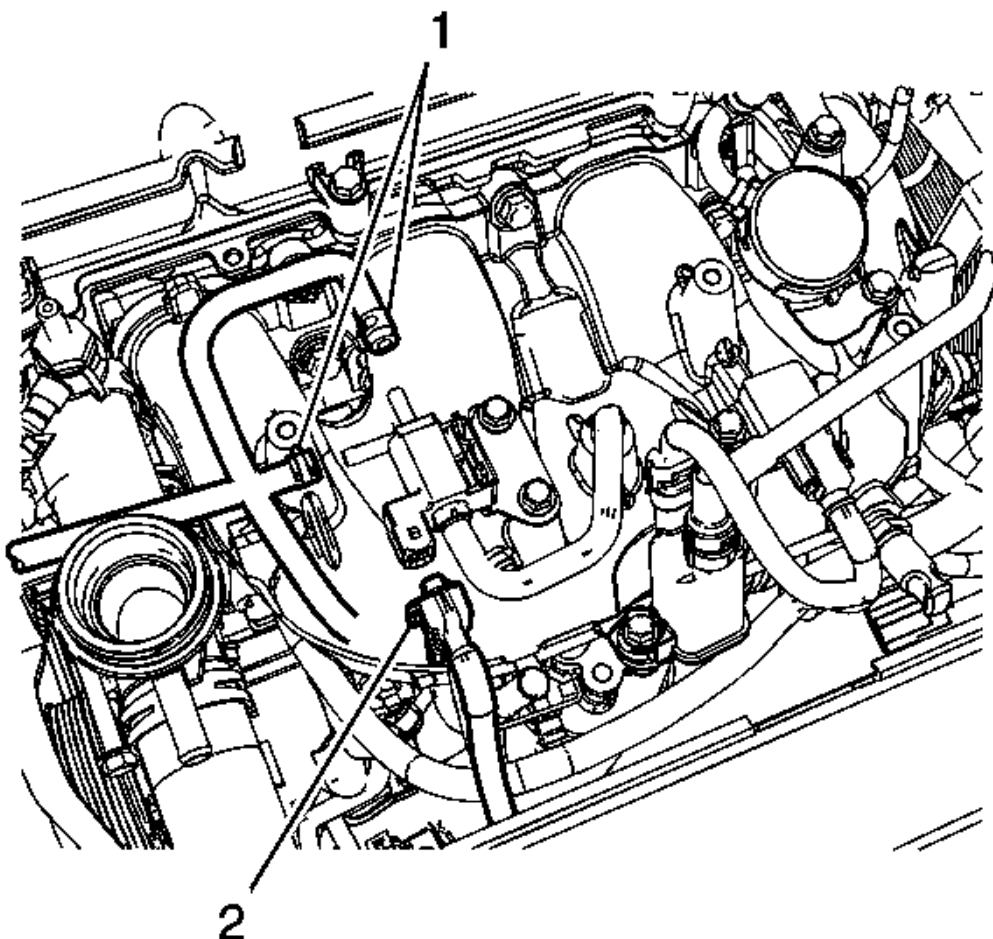


Fig. 101: Identifying Intake Manifold Vacuum Lines & Air Valve Solenoid Electrical Connectors
 Courtesy of GENERAL MOTORS CORP.

37. Connect the charge air valve solenoid vacuum electrical connector (2).
38. Connect the charge air valve solenoid vacuum lines (1).
39. Connect the fuel feed line quick connect fitting to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
40. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
41. Install the charge air cooler inlet pipe. Refer to **Charge Air Cooler Inlet Pipe Replacement** .
42. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

CRANKSHAFT BALANCER REPLACEMENT

Tools Required**J 38122-A** Harmonic Balancer Holder**Removal Procedure**

1. Remove the engine drive belt. Refer to **Drive Belt Replacement**.

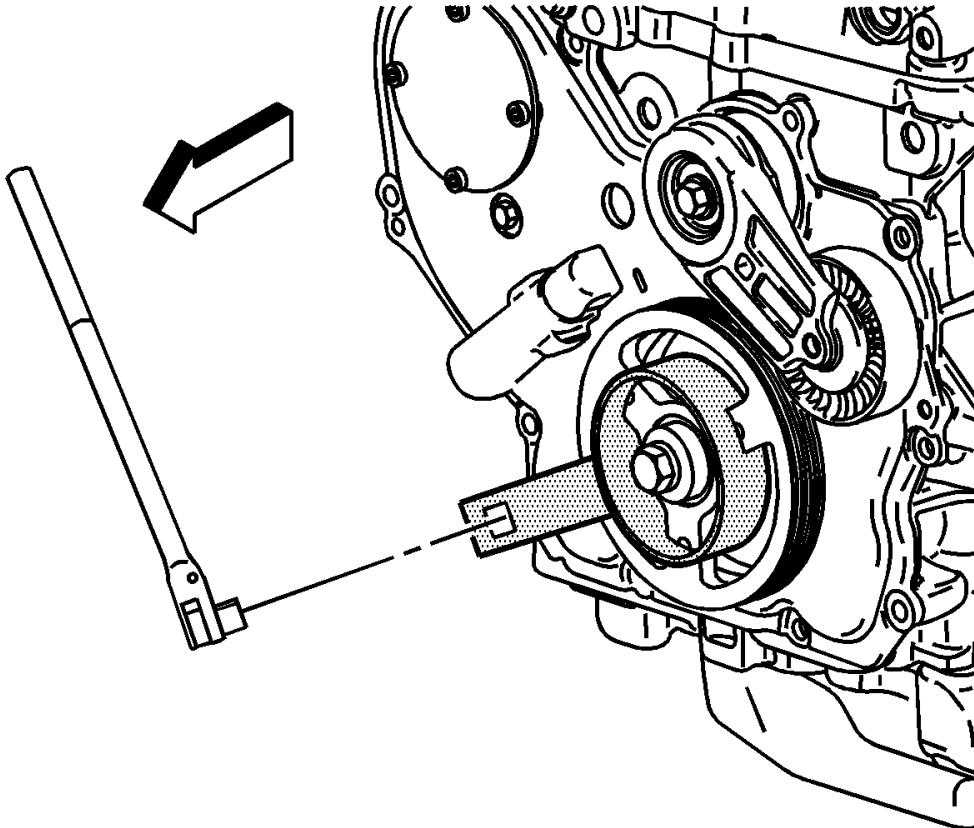


Fig. 102: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Use **J 38122-A** to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt.
3. Remove the crankshaft balancer bolt. Discard the bolt.

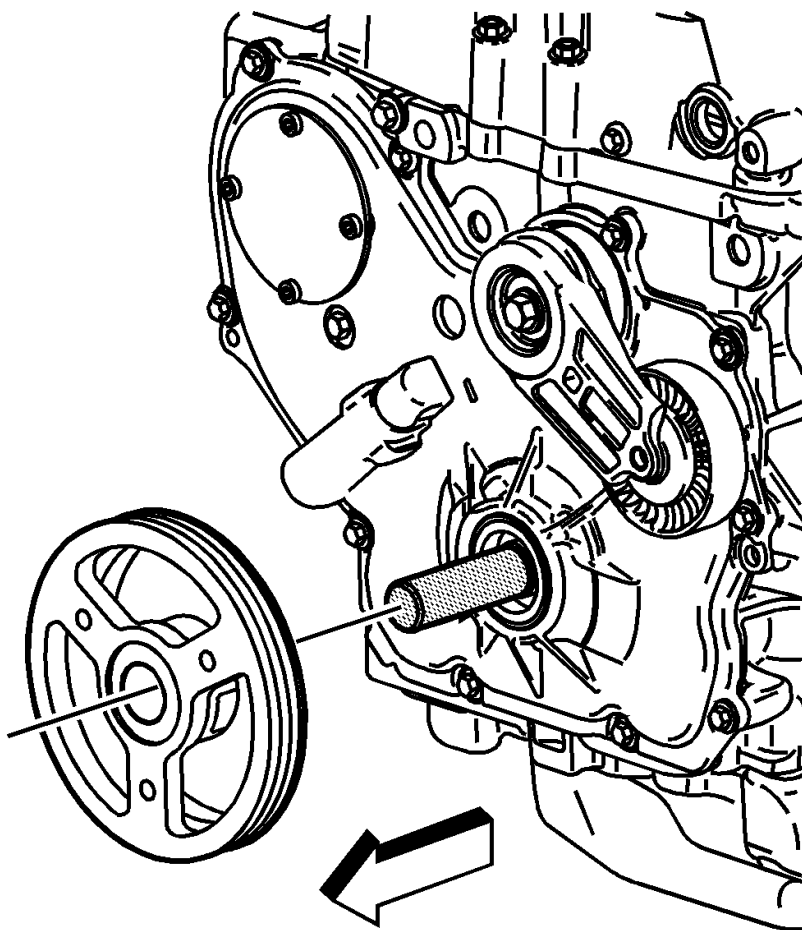


Fig. 103: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

Installation Procedure

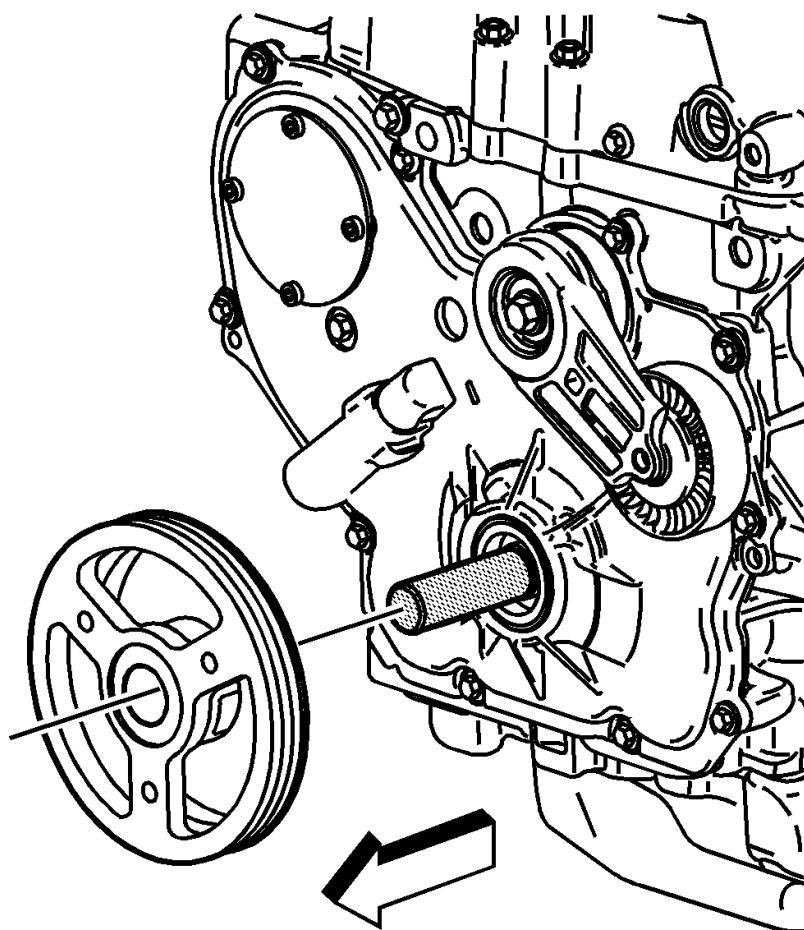


Fig. 104: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

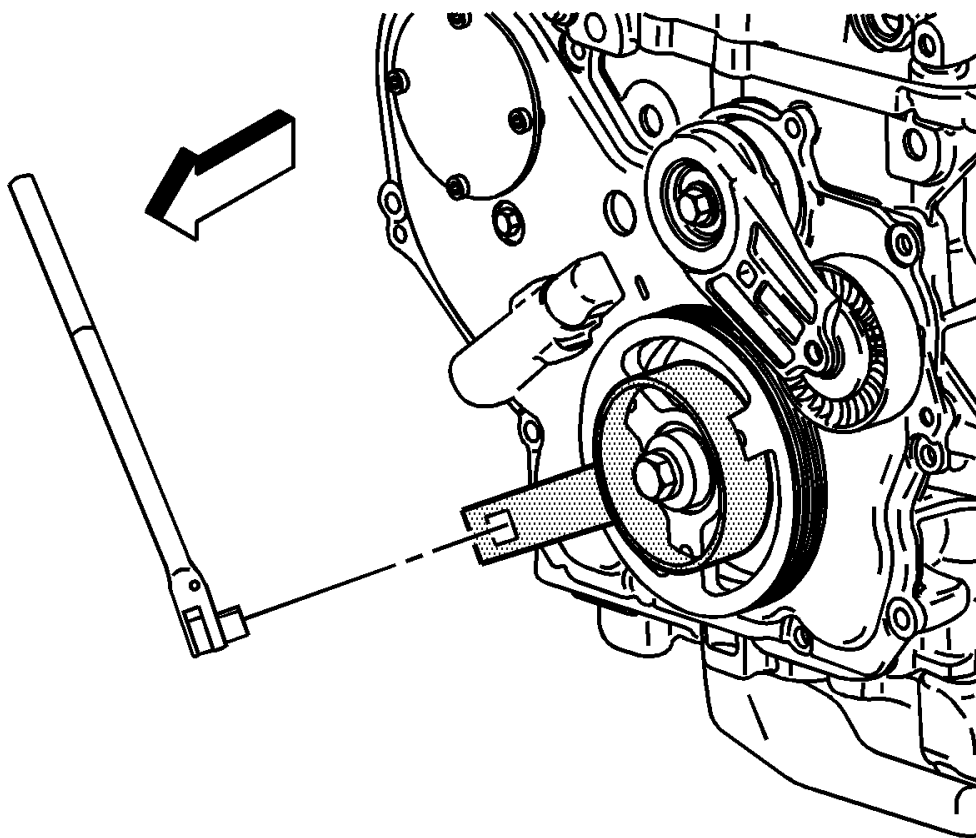


Fig. 105: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Use **J 38122-A** to prevent the crankshaft from rotating while tightening the crankshaft balancer bolt.

Tighten: Tighten the bolt to 100 N.m (74 lb ft) plus 75 degrees.

4. Install the engine drive belt. Refer to Drive Belt Replacement.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Tools Required

J 35268-A Camshaft/Front Main Seal Installer

Removal Procedure

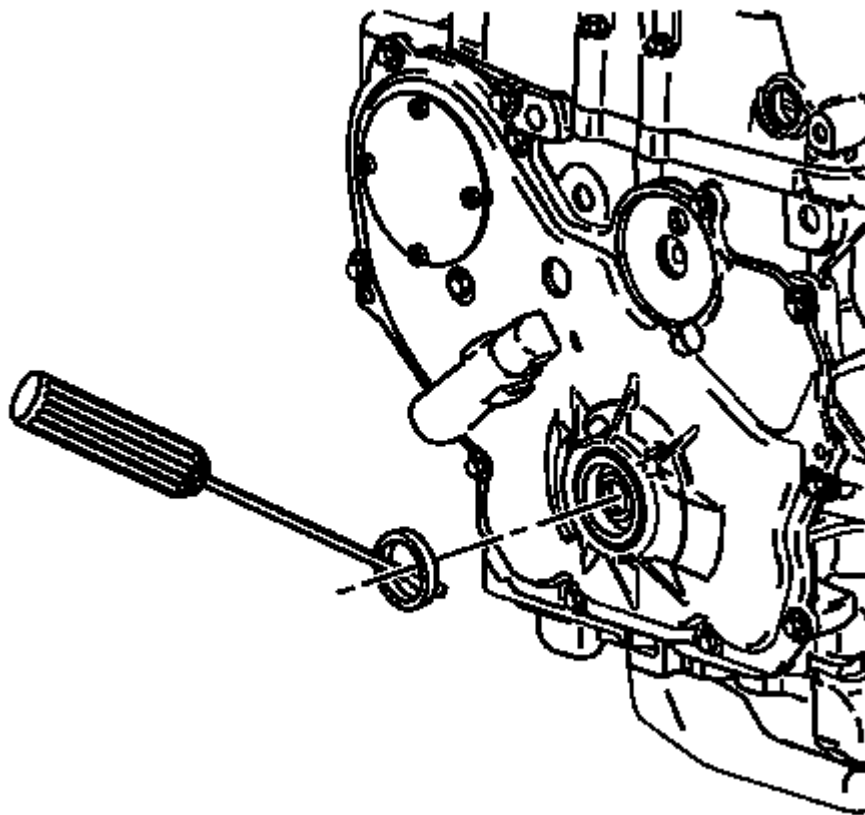


Fig. 106: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

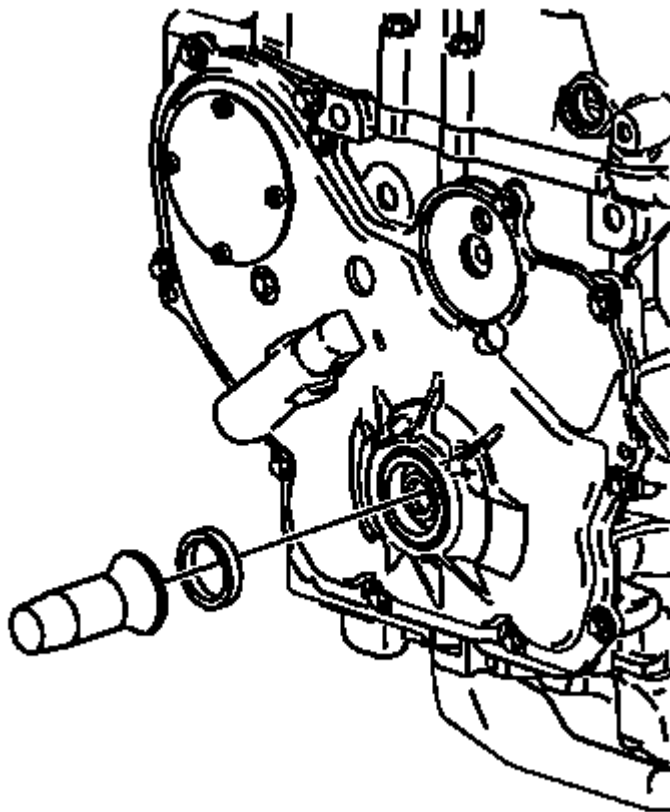


Fig. 107: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

ENGINE FRONT COVER REPLACEMENT

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

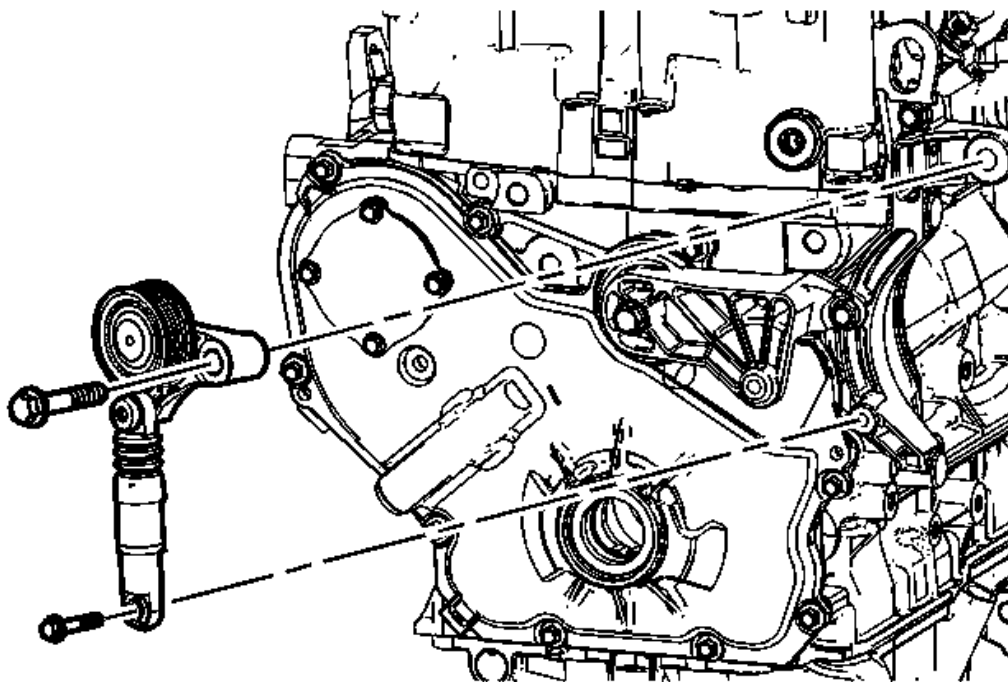


Fig. 108: Identifying Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt tensioner.

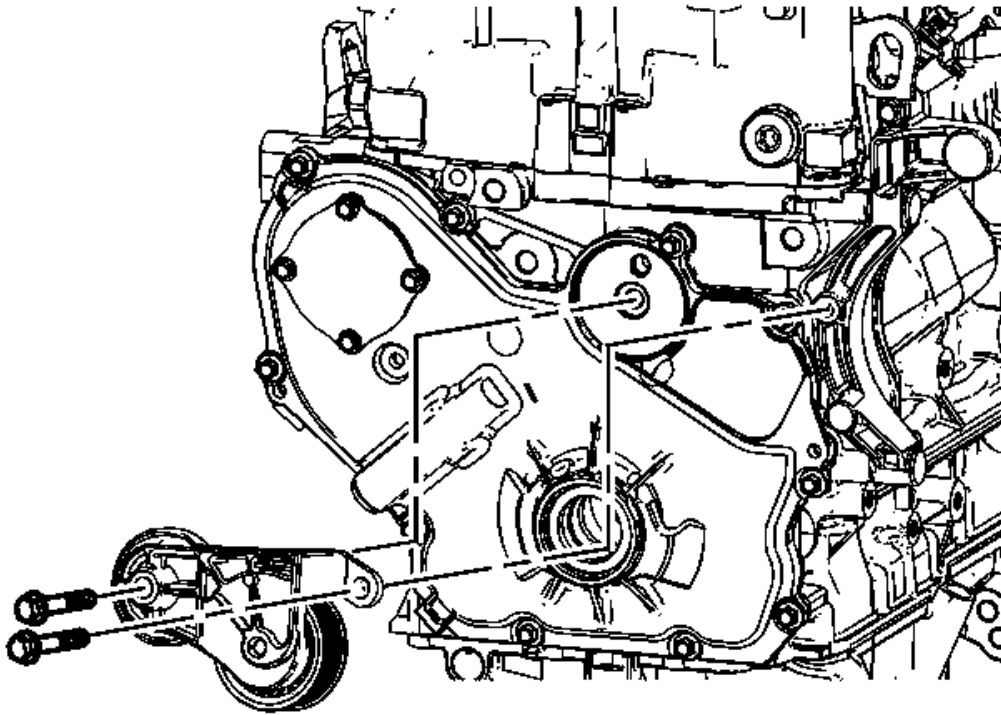


Fig. 109: View Of Idler Pulley
Courtesy of GENERAL MOTORS CORP.

3. Remove the idler pulley.

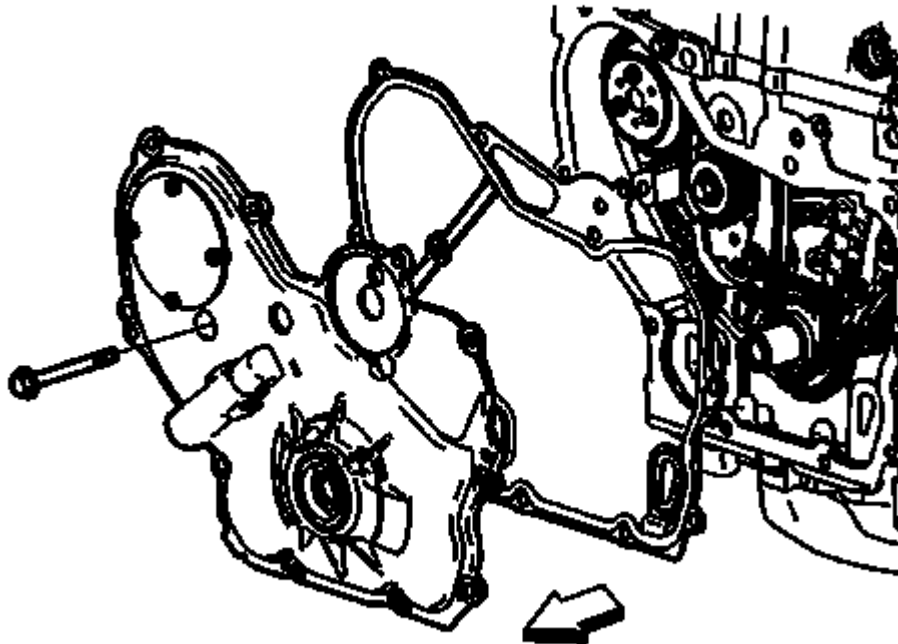


Fig. 110: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

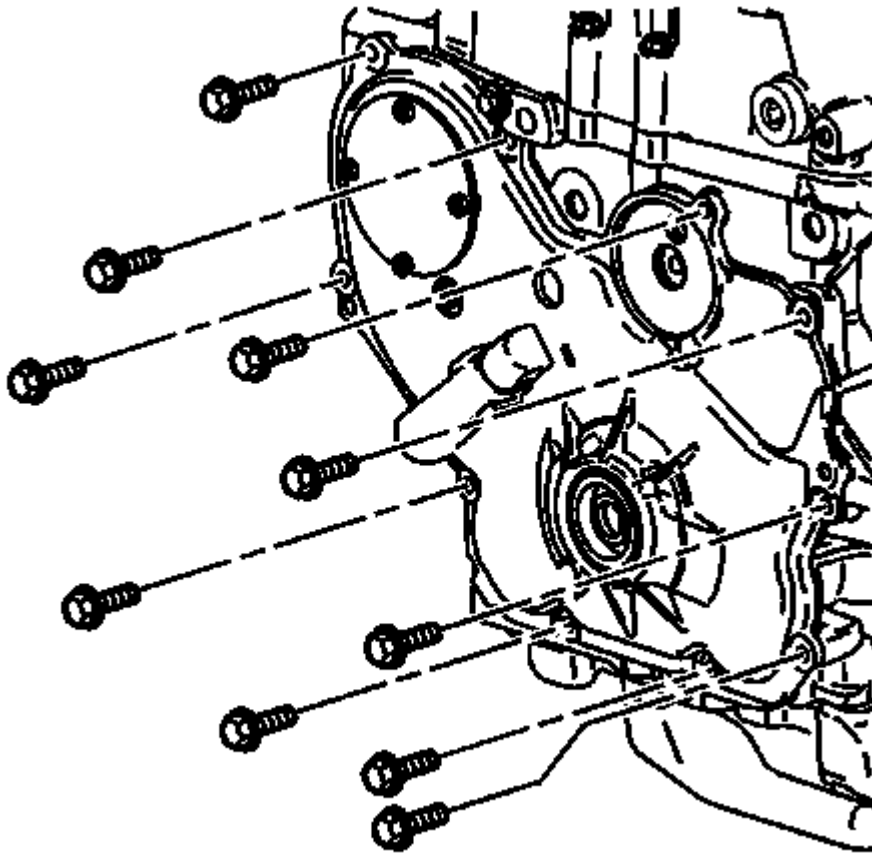


Fig. 111: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the remaining engine front cover bolts.
6. Remove the engine front cover.
7. If the engine front cover gasket is damaged, remove the front engine mount. Refer to **Engine Mount Replacement**.

Installation Procedure

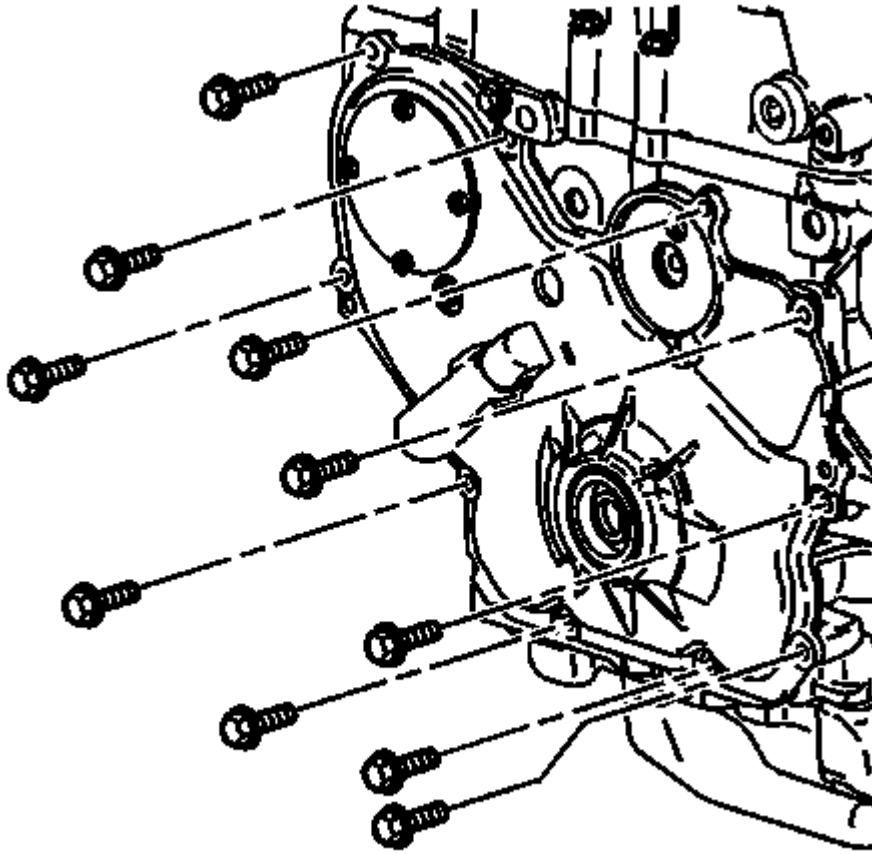


Fig. 112: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. If removed, install a new engine front cover gasket.
2. Install the front engine mount. Refer to Engine Mount Replacement.
3. Install the engine front cover.

NOTE: Refer to Fastener Notice .

4. Install the engine front cover bolts.

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

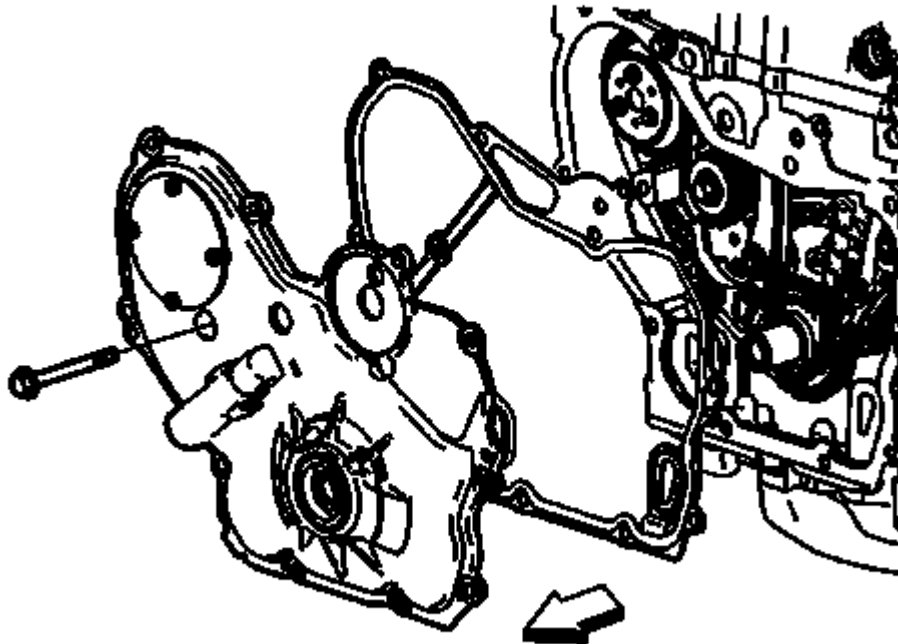


Fig. 113: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the water pump bolt.

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

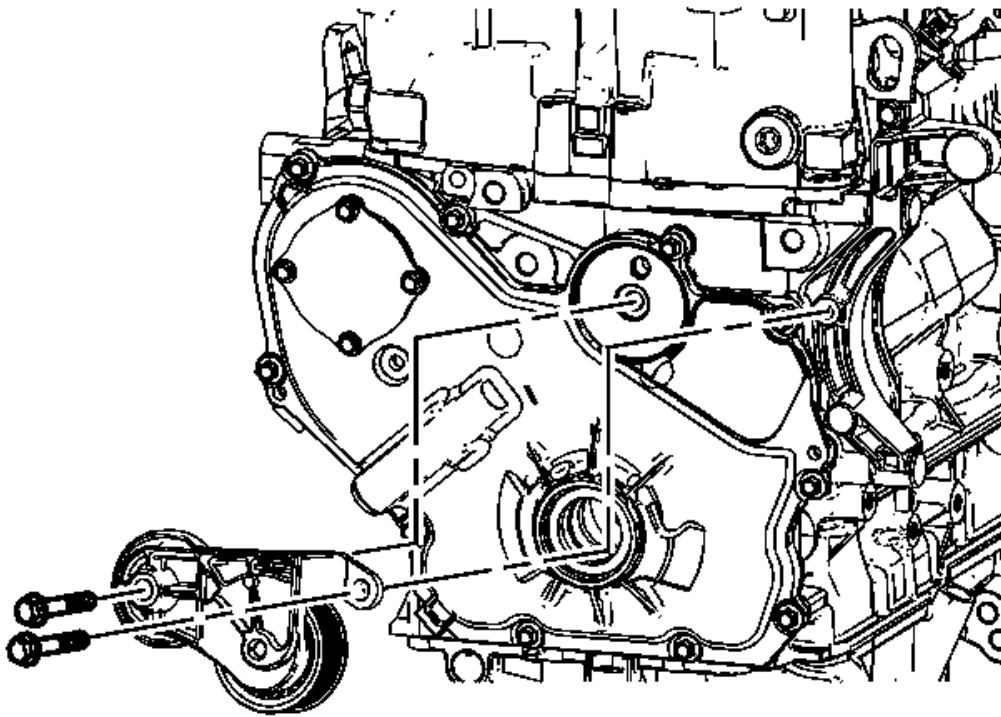


Fig. 114: View Of Idler Pulley
Courtesy of GENERAL MOTORS CORP.

6. Install the idler pulley.

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

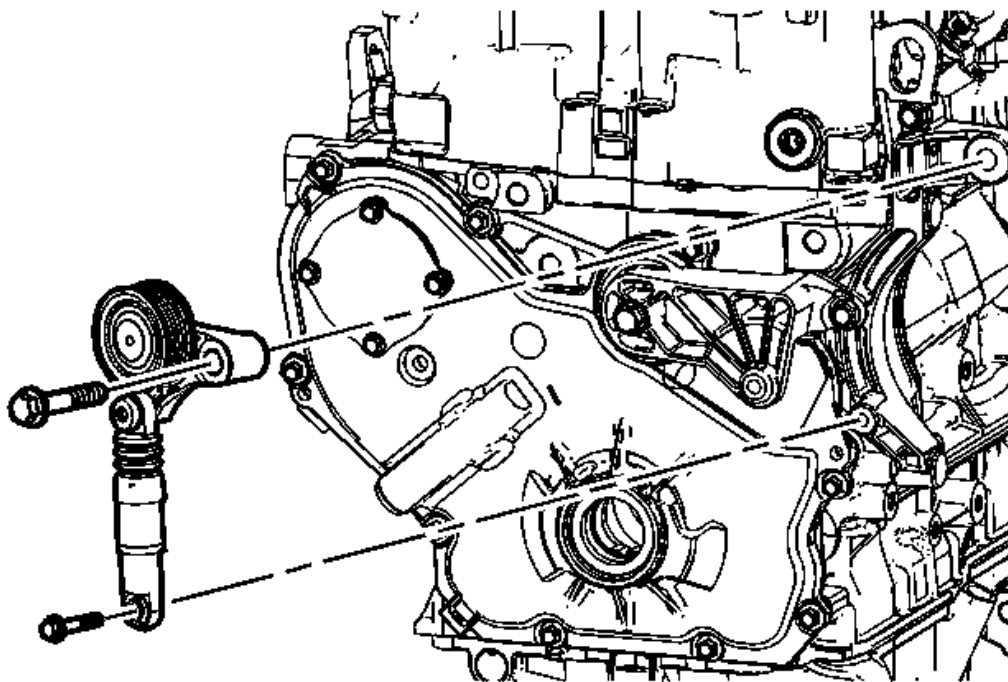


Fig. 115: Identifying Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Install the drive belt tensioner.
8. Install the drive belt tensioner bolts.

Tighten: Tighten the drive belt tensioner bolts to 45 N.m (33 lb ft).

9. Install the crankcase balancer. Refer to **Crankshaft Balancer Replacement**.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

Special Tools

- **J 45027** Tensioner Tool. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

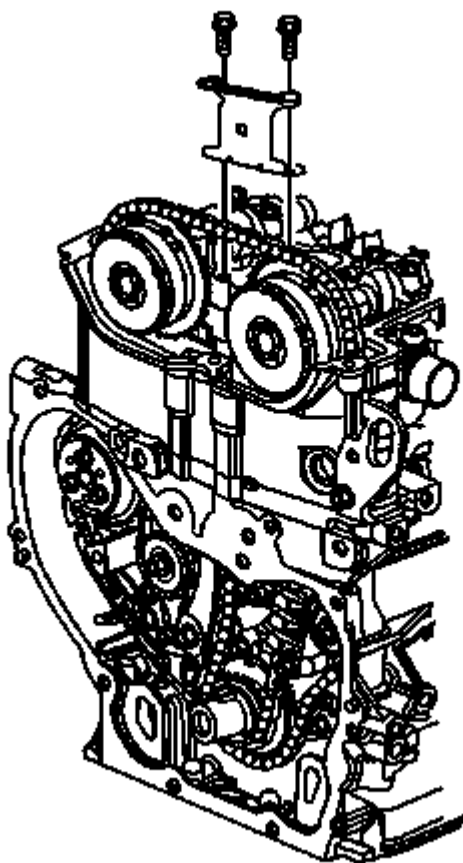


Fig. 116: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

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 compression 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.

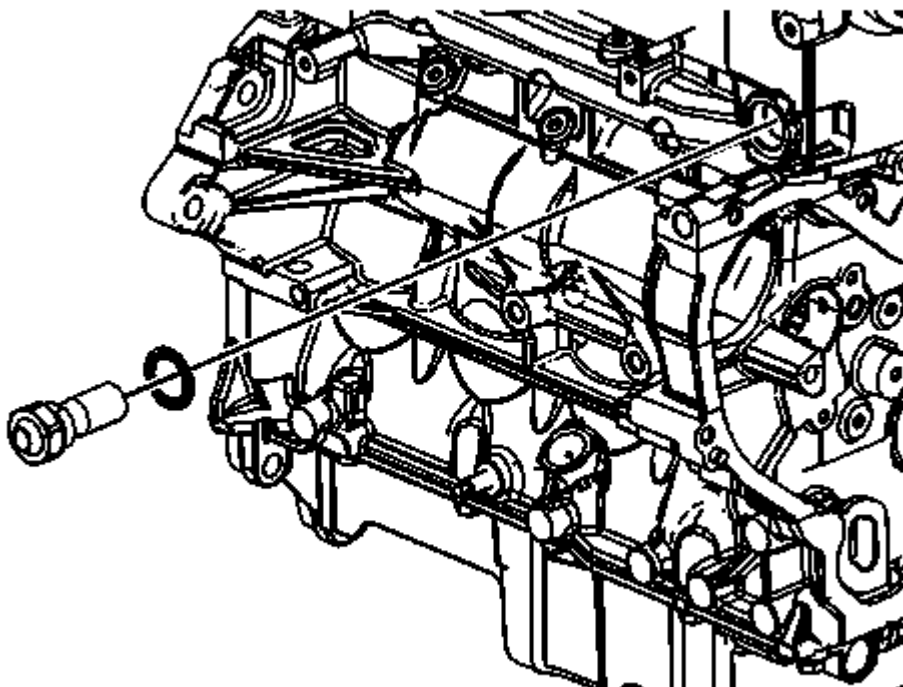


Fig. 117: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

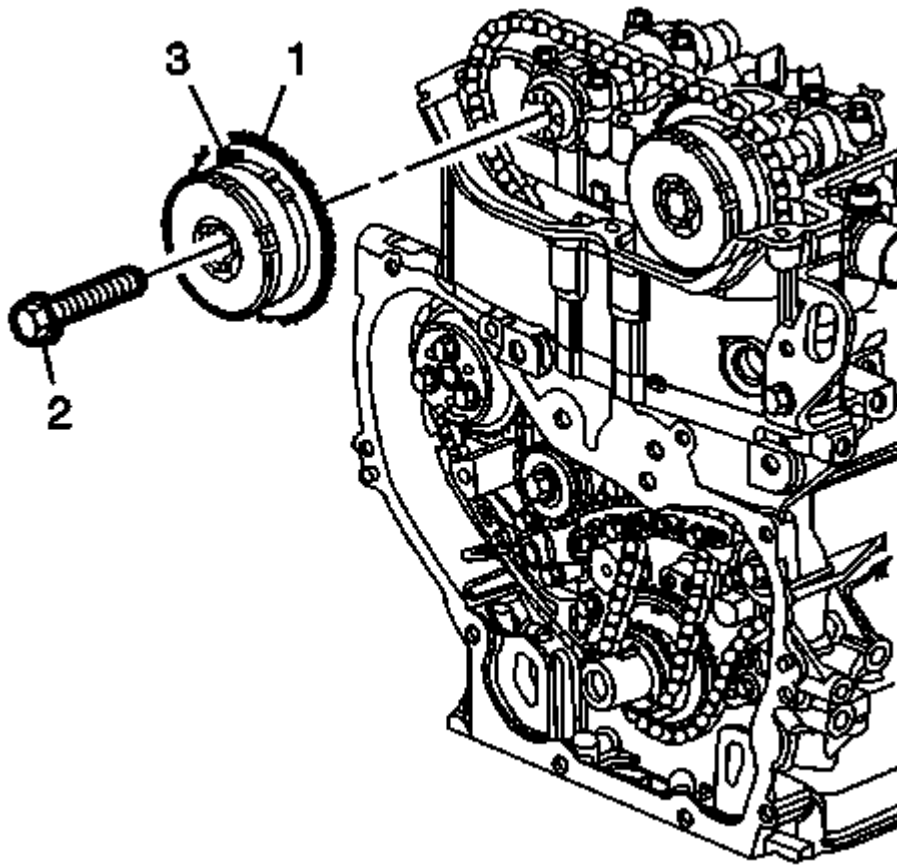


Fig. 118: Identifying Exhaust Camshaft Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

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.

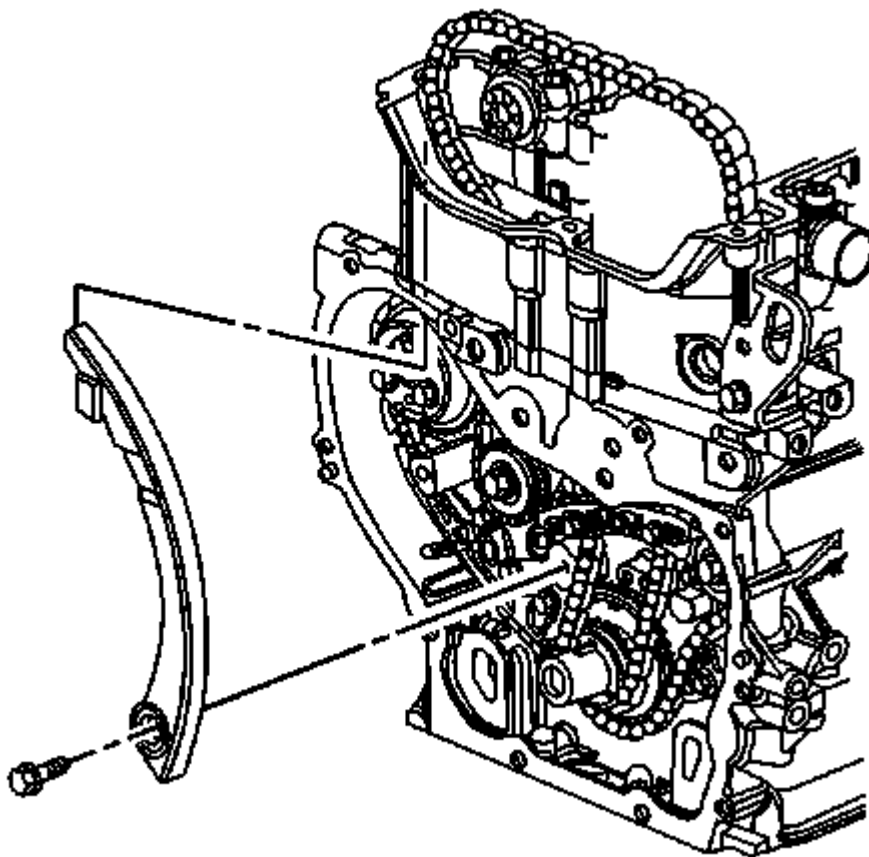


Fig. 119: Identifying Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

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

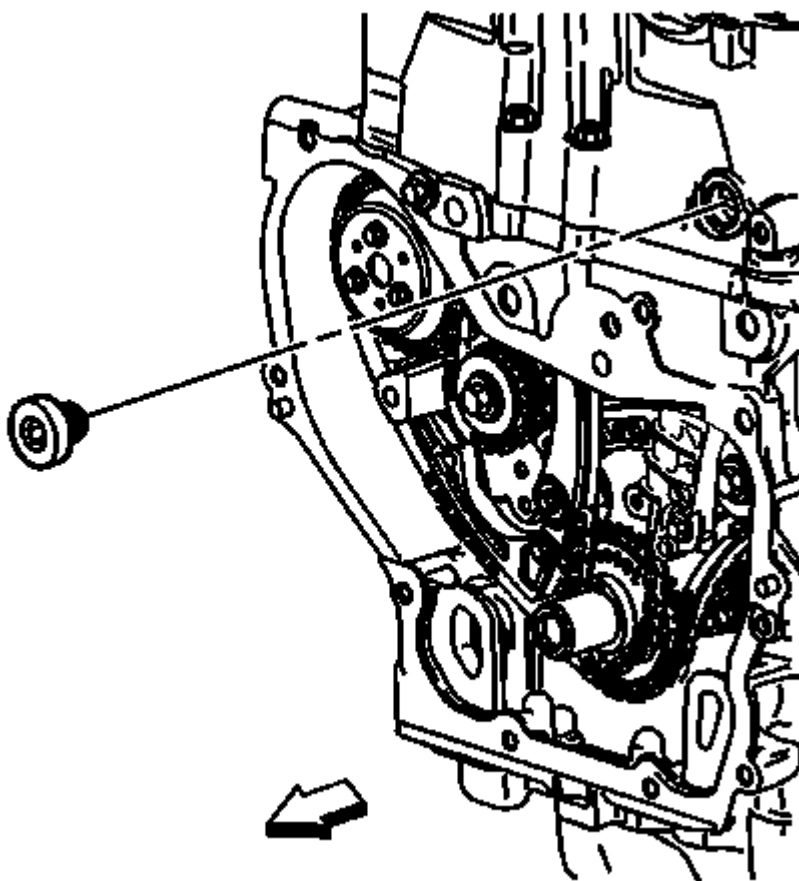


Fig. 120: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

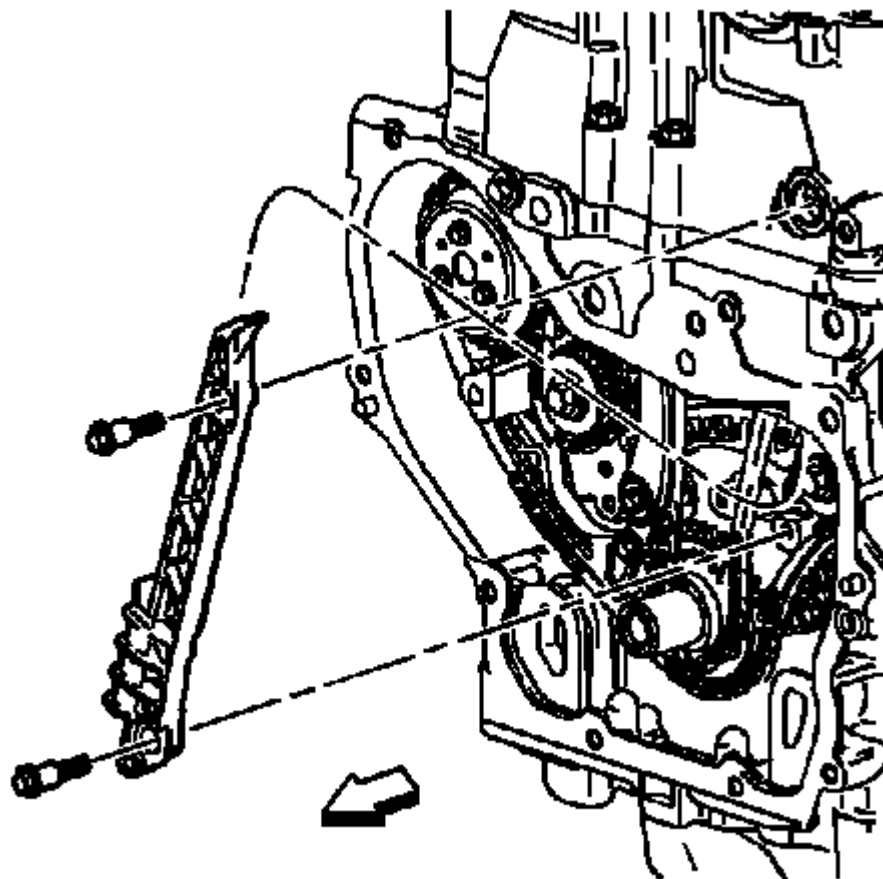


Fig. 121: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

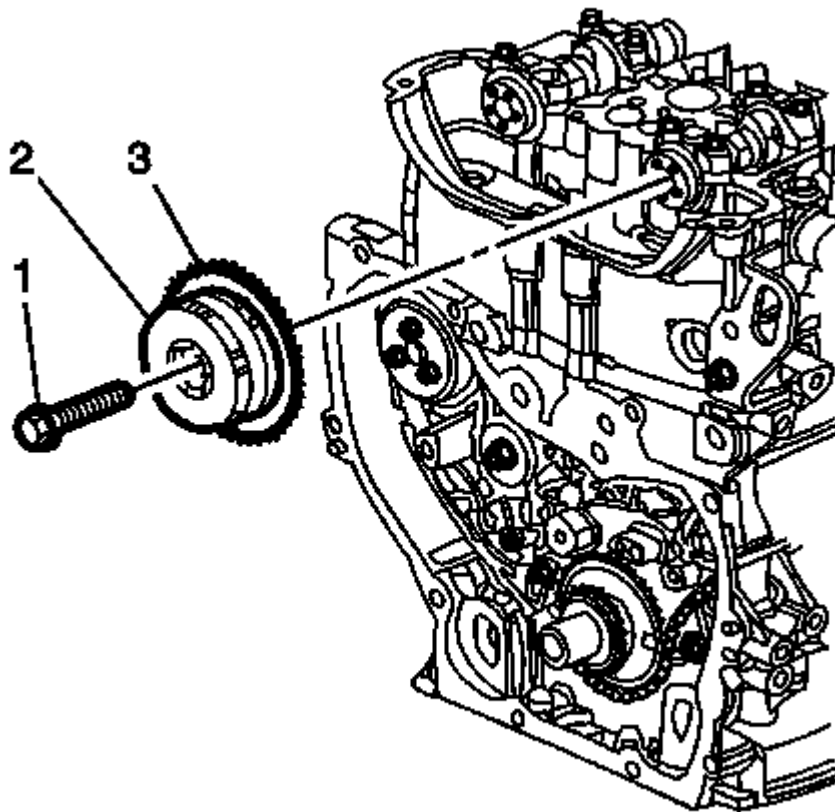


Fig. 122: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

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.

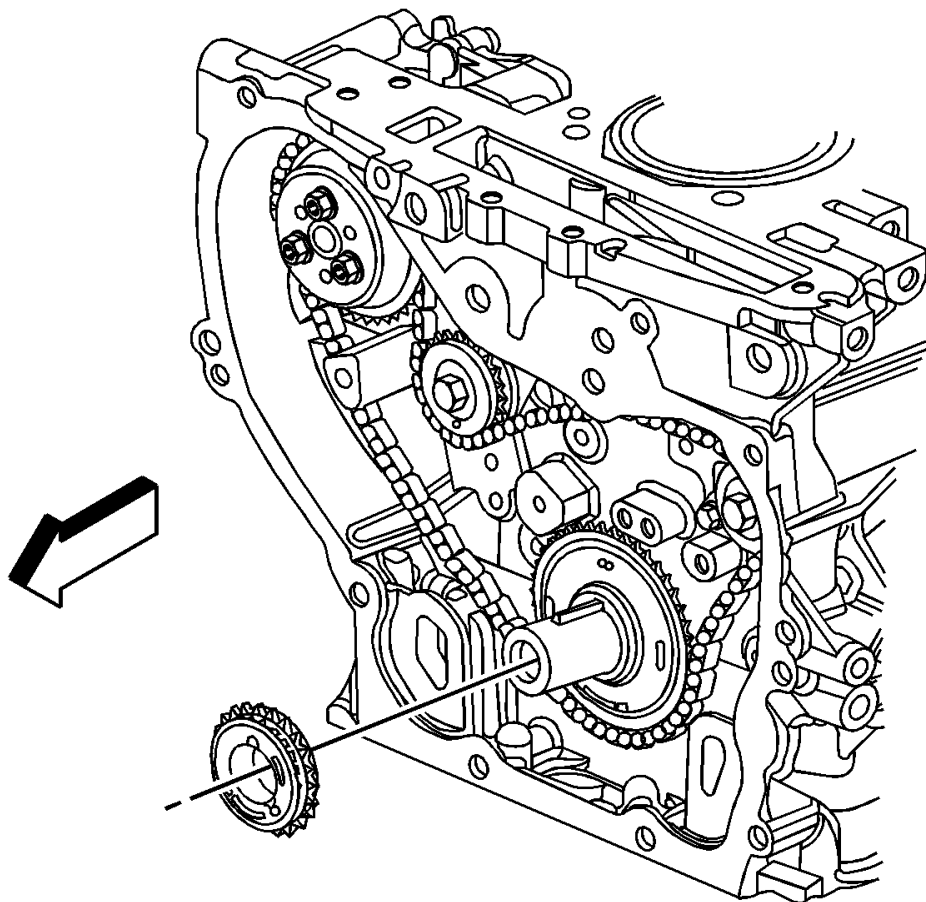


Fig. 123: Identifying Timing Chain Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Remove the timing chain crankshaft sprocket.

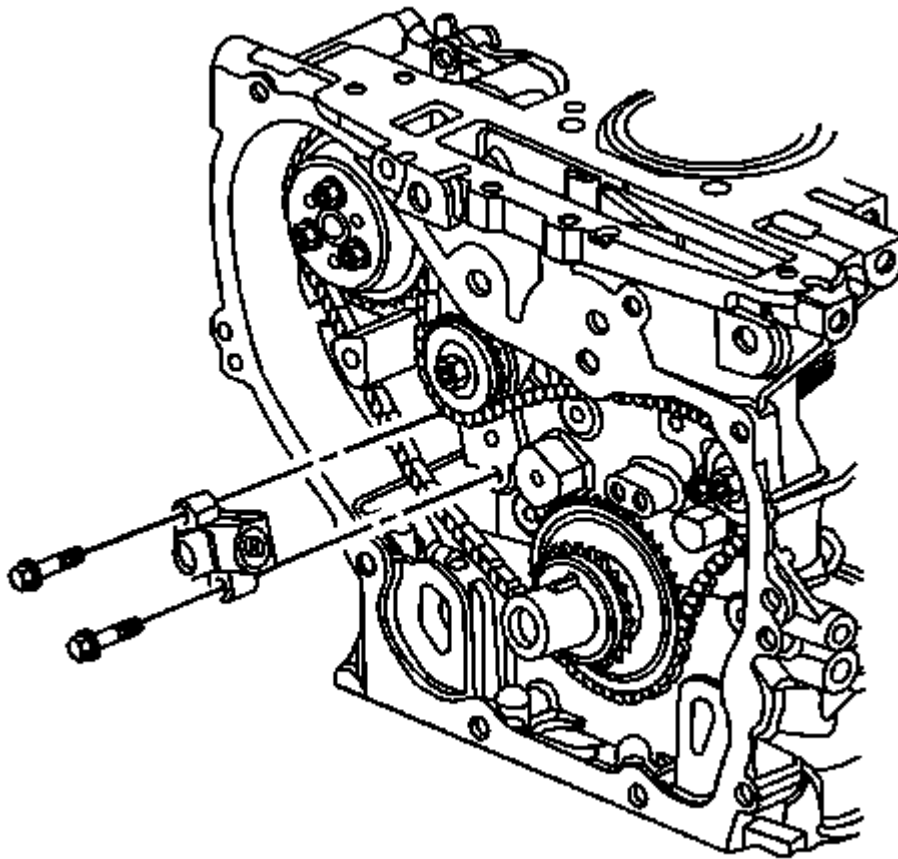


Fig. 124: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

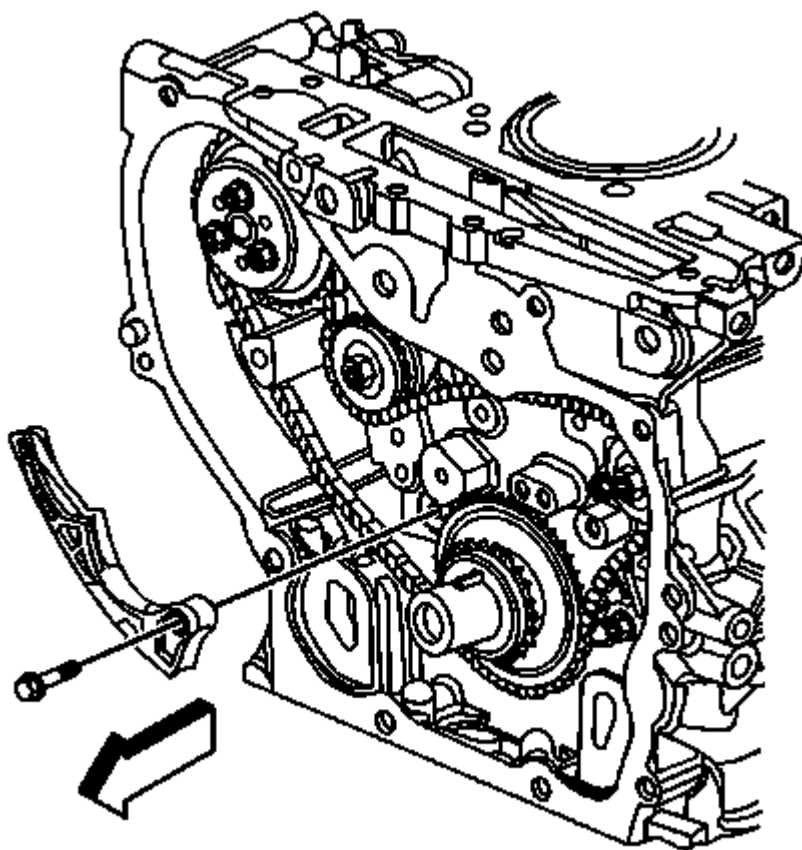


Fig. 125: Identifying Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

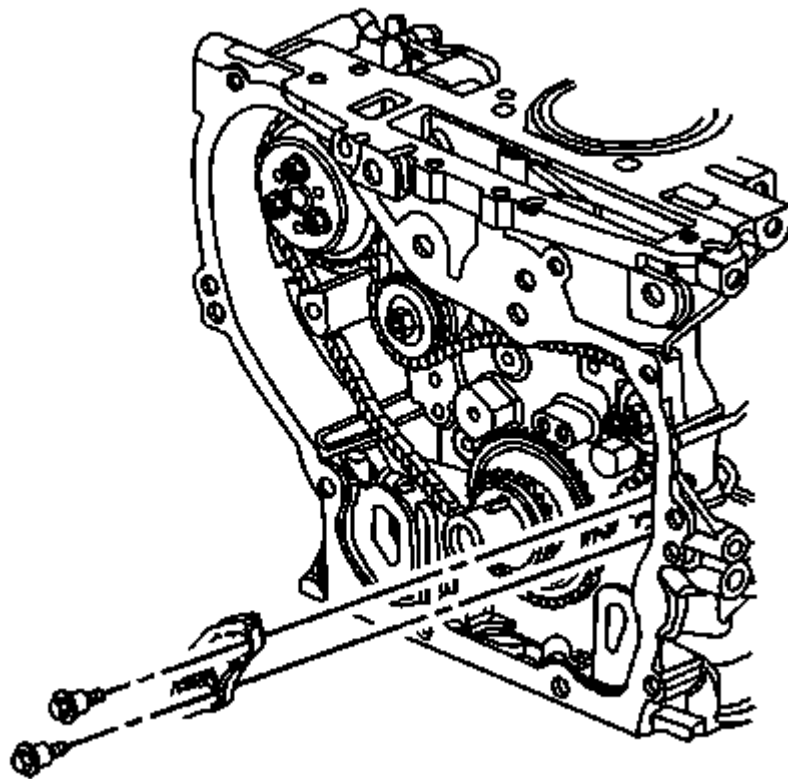


Fig. 126: Identifying Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

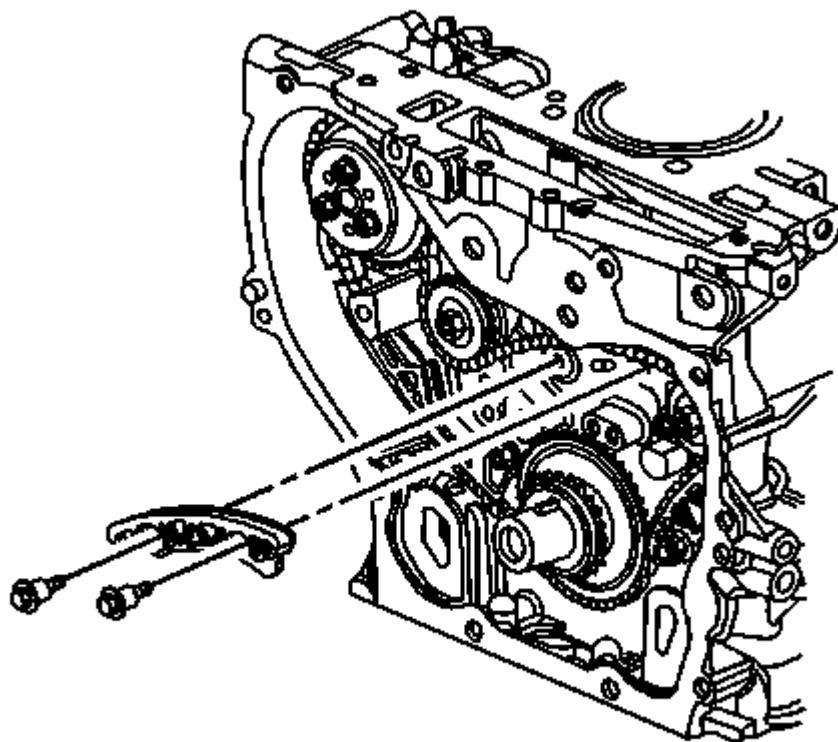


Fig. 127: Identifying Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

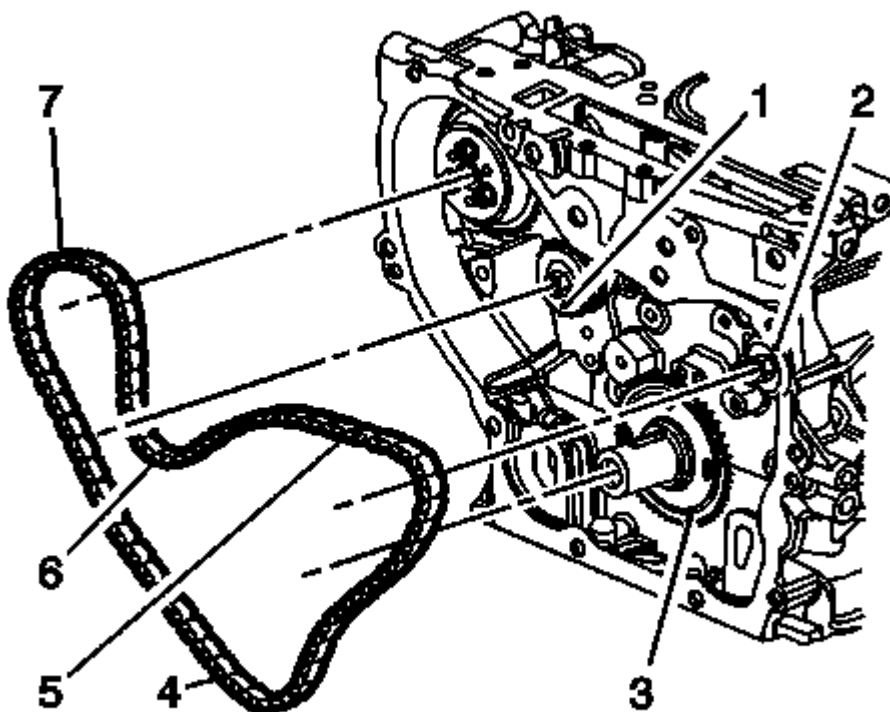


Fig. 128: Identifying Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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

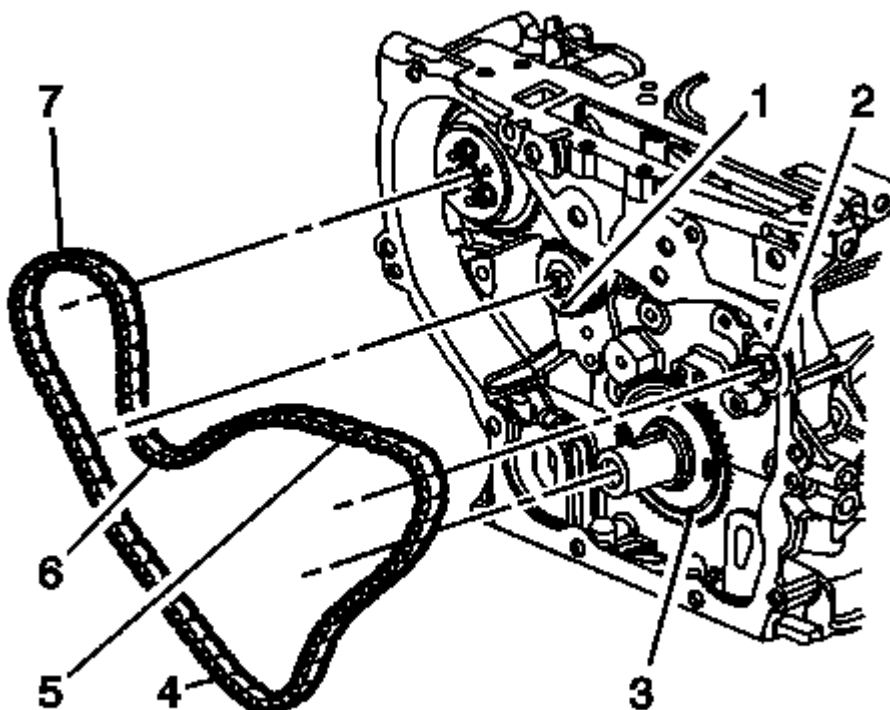


Fig. 129: Identifying Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: 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 (1) with the colored link lined up with the marks on the balance shaft sprockets and the balance shaft drive sprocket. There are three 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.
 - Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft sprocket.
 - 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).
 - Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
 - Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

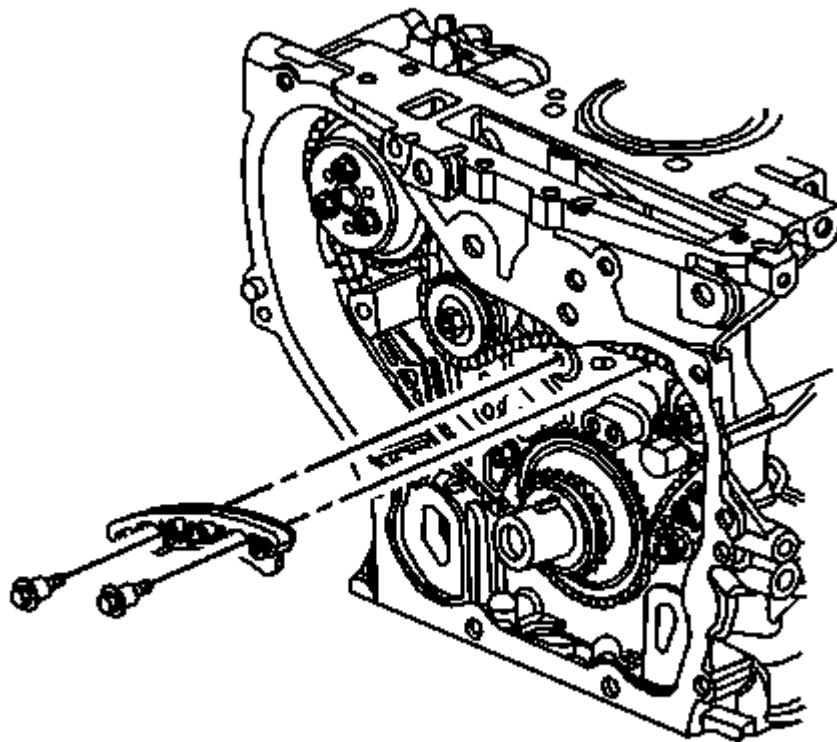


Fig. 130: Identifying Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the upper balance shaft drive chain guide and bolts.

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

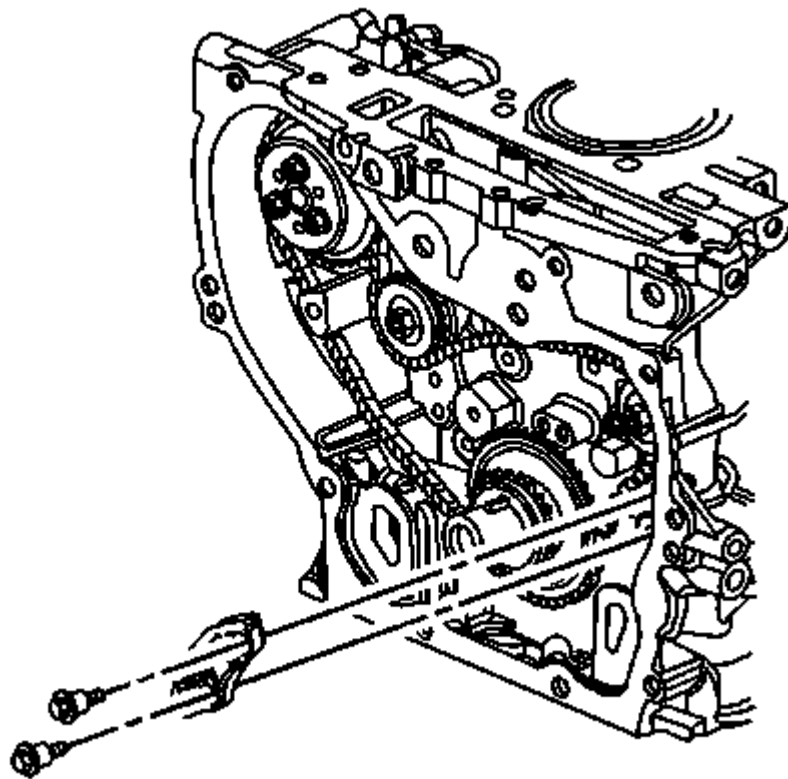


Fig. 131: Identifying Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts.

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

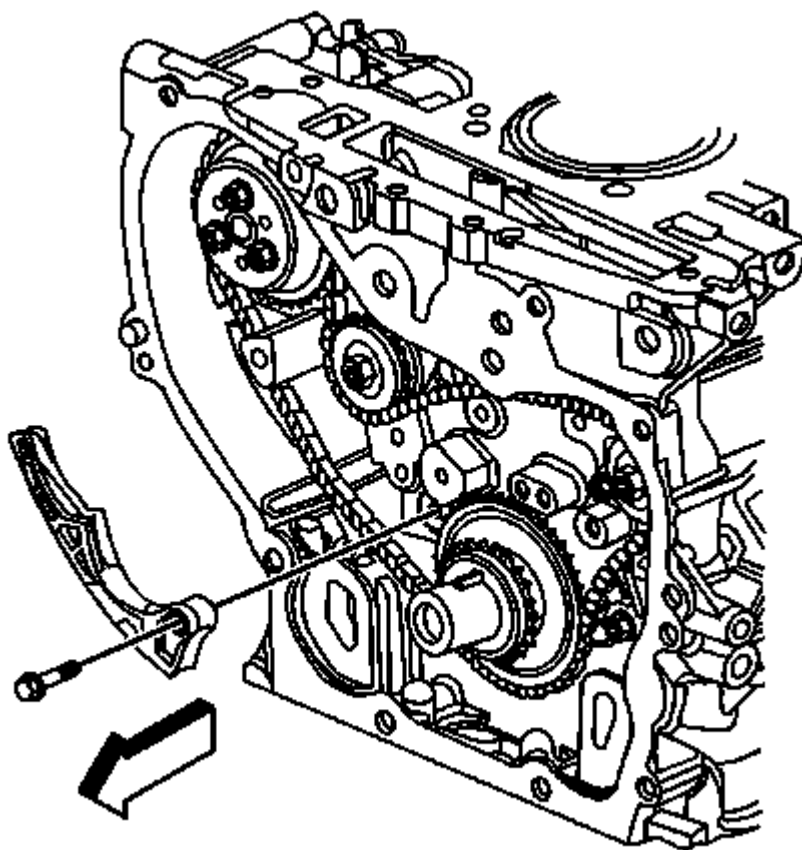


Fig. 132: Identifying Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt.

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

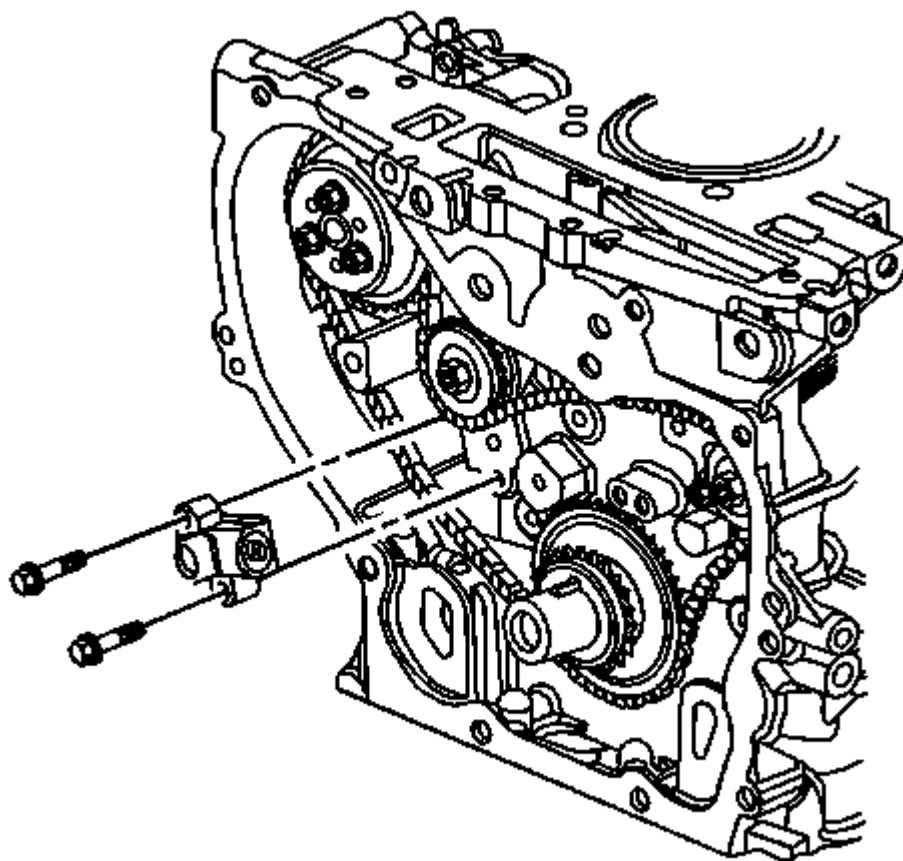


Fig. 133: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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.

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

9. Remove the paper clip from the balance shaft drive chain tensioner.

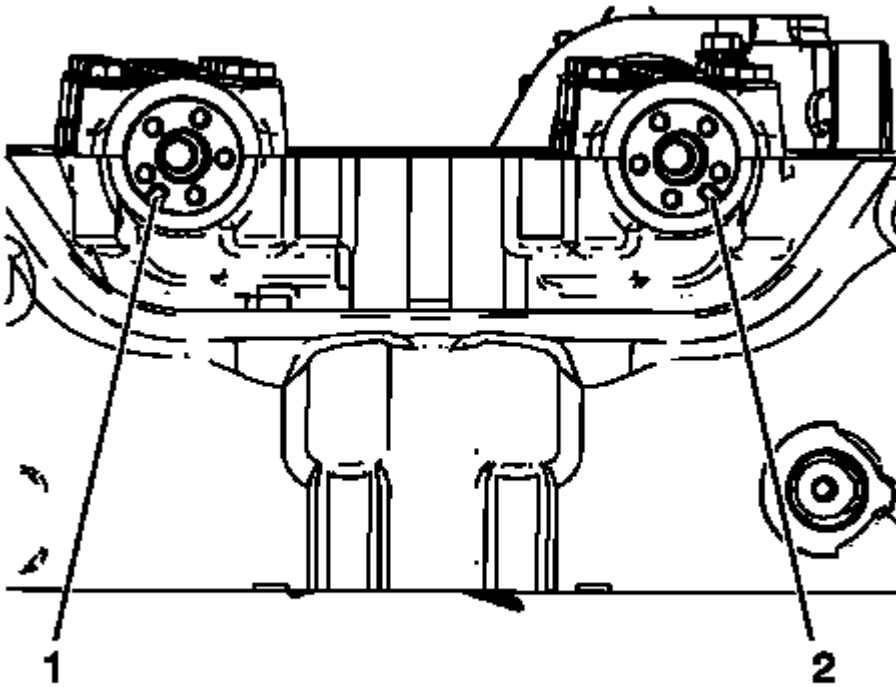


Fig. 134: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

10. 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.

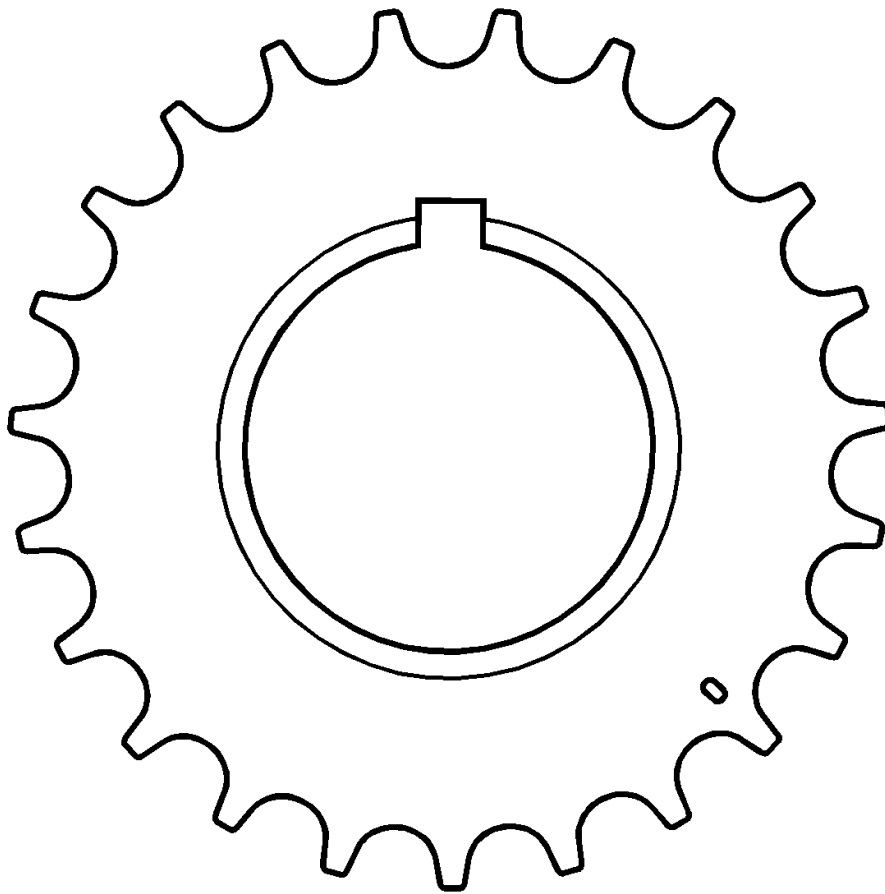


Fig. 135: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

11. 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 out.

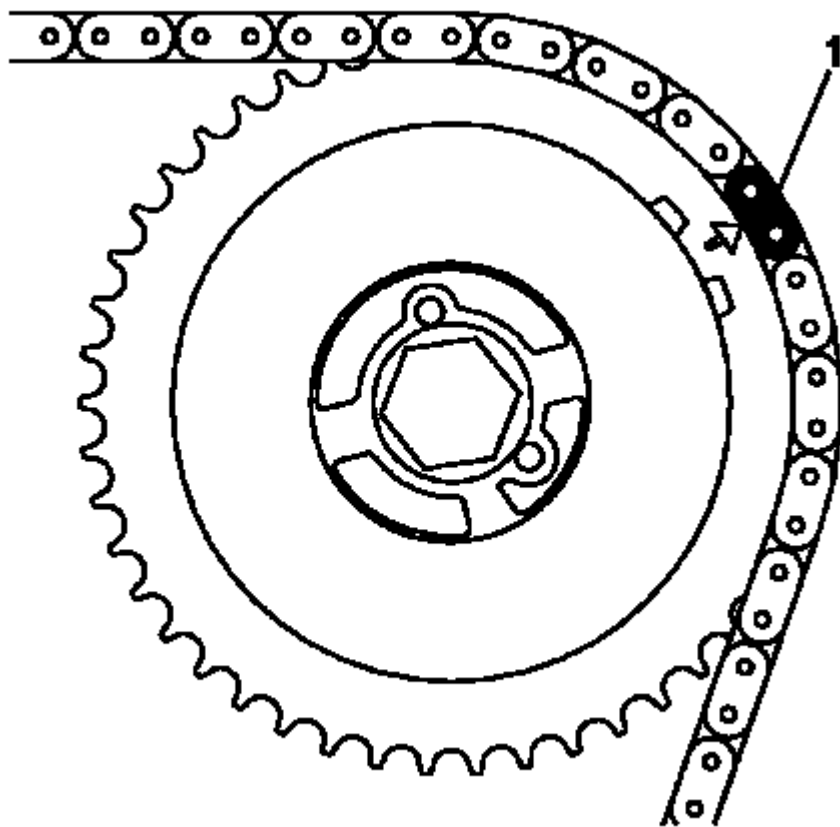


Fig. 136: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- There are 3 colored links on the timing chain. 2 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.

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

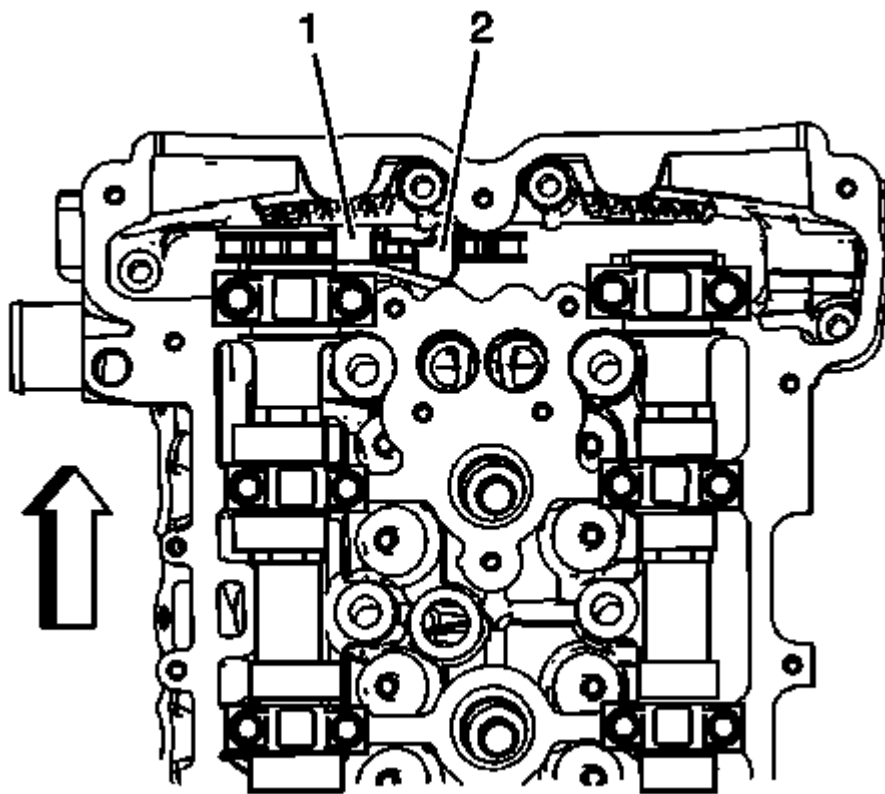


Fig. 137: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

13. 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).
14. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
15. Hand tighten the new intake camshaft actuator bolt.

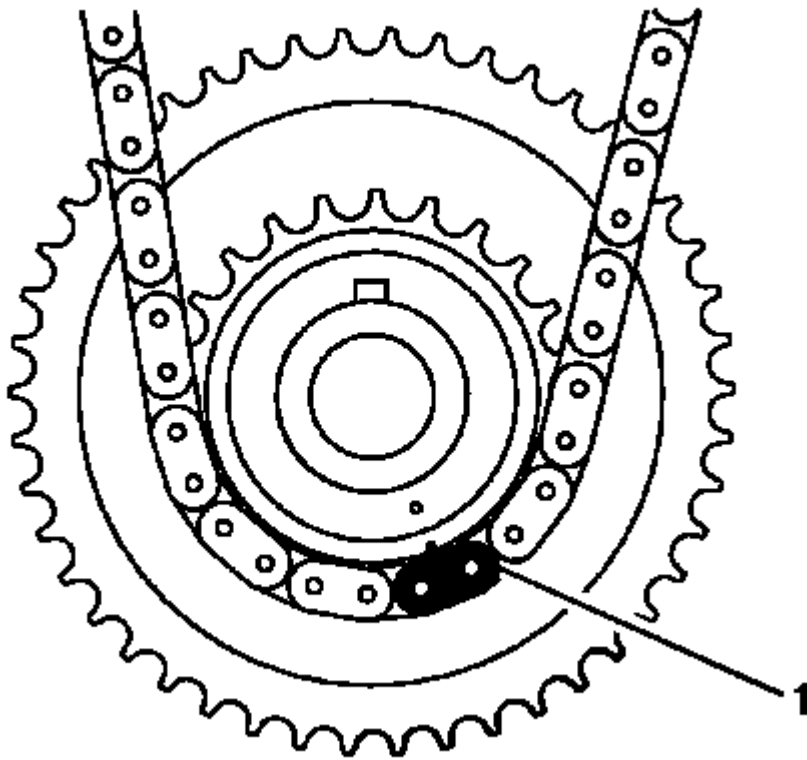


Fig. 138: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. 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.

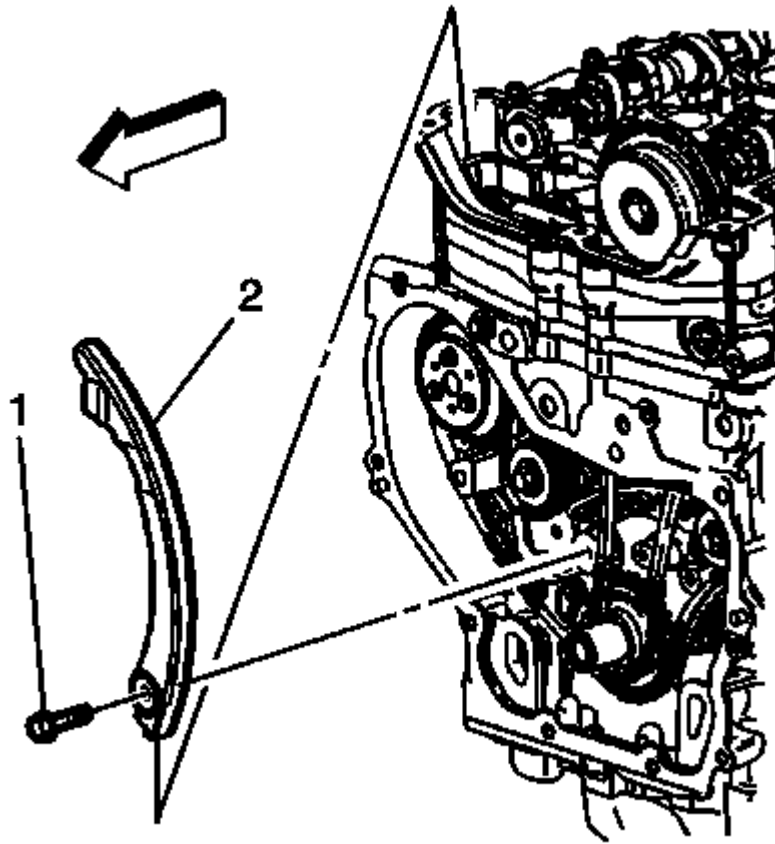


Fig. 139: Identifying Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

17. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.
18. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt.

Tighten: Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

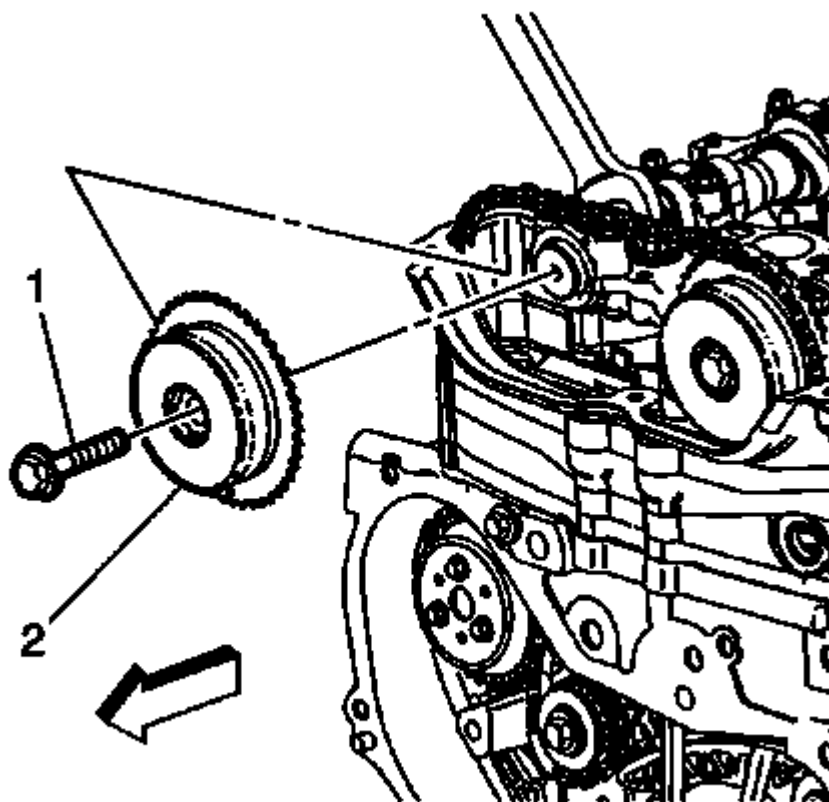


Fig. 140: Locating Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install NEW actuator bolts.

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

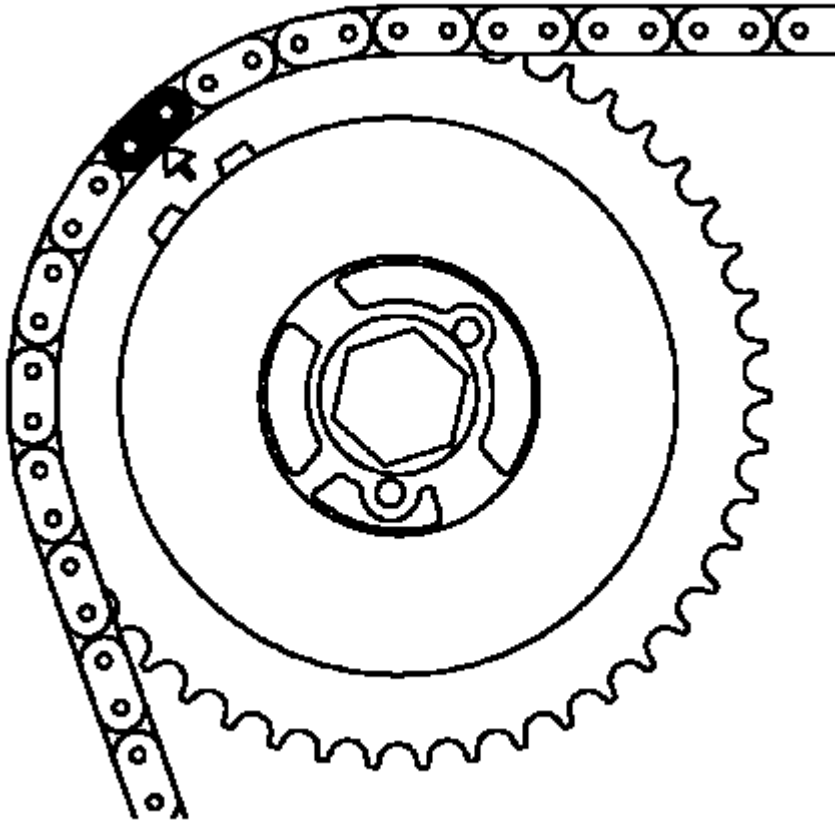


Fig. 141: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

20. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
21. Using a 23 mm open end wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

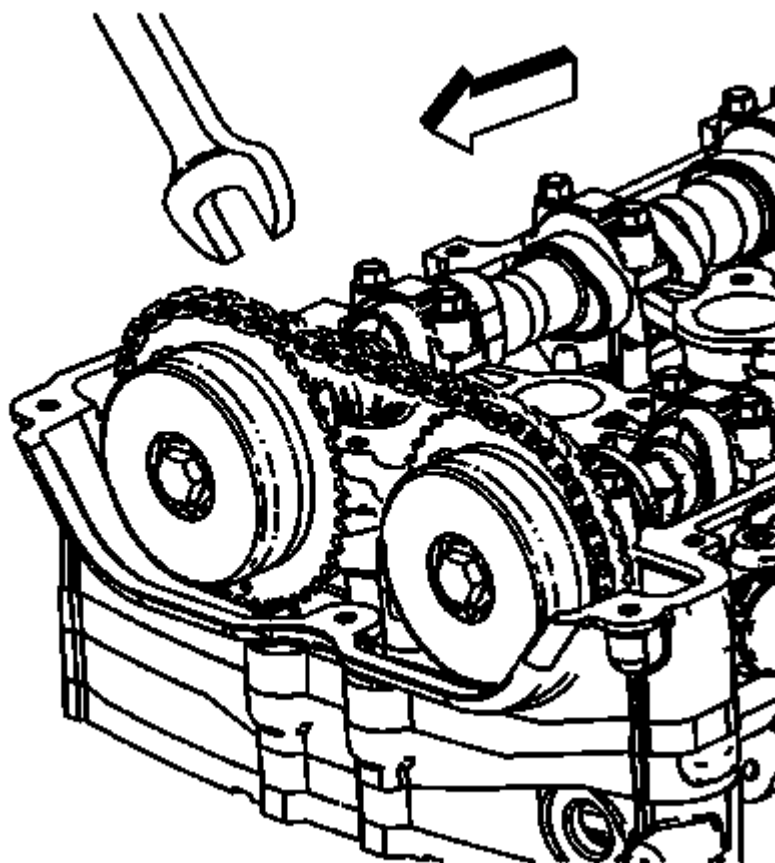


Fig. 142: Using 24mm Wrench To Align Camshaft
Courtesy of GENERAL MOTORS CORP.

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

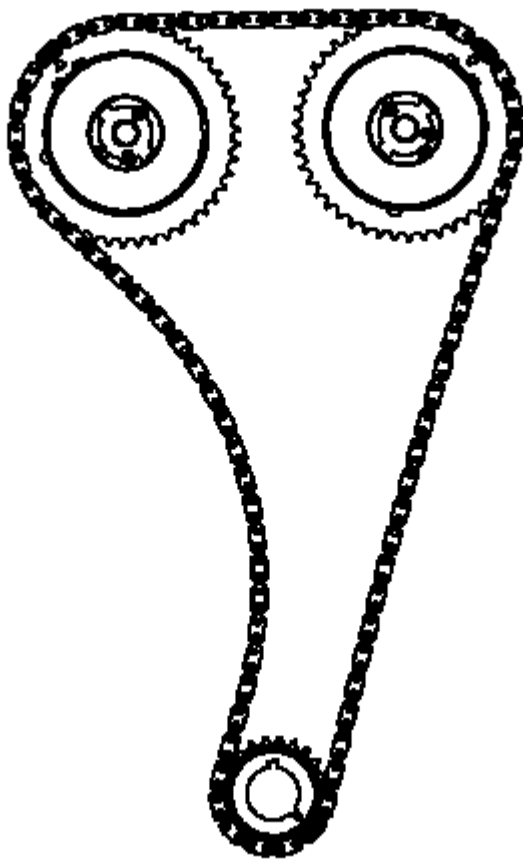


Fig. 143: Identifying Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

23. 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.

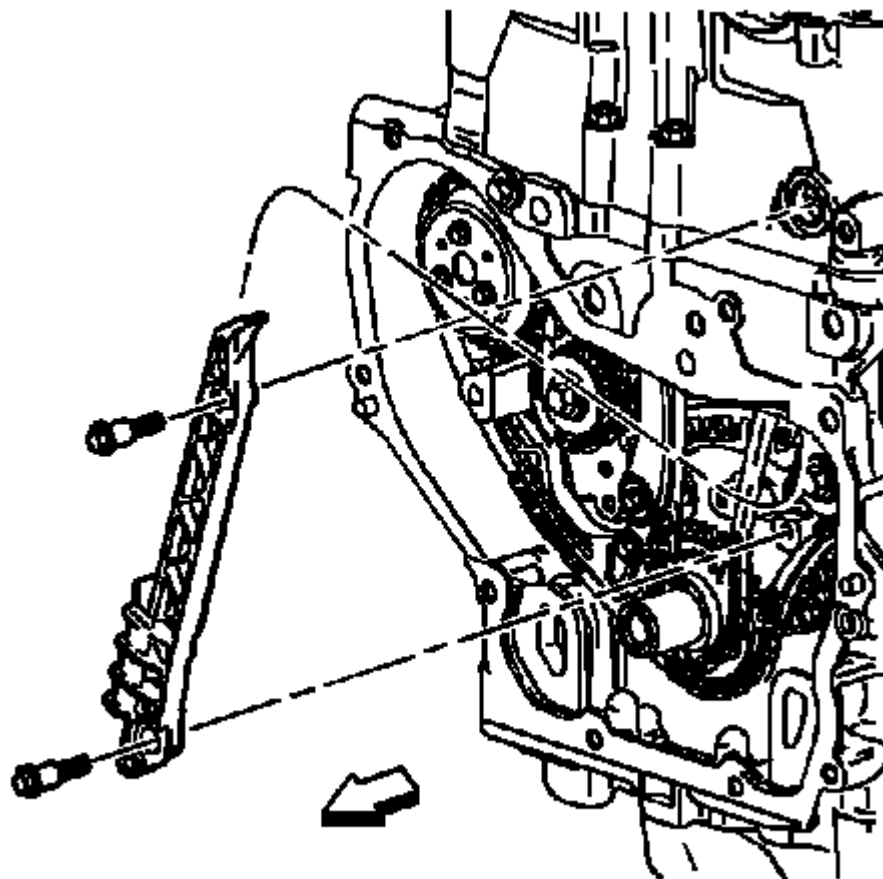


Fig. 144: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

24. Install the fixed timing chain guide and bolts.

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

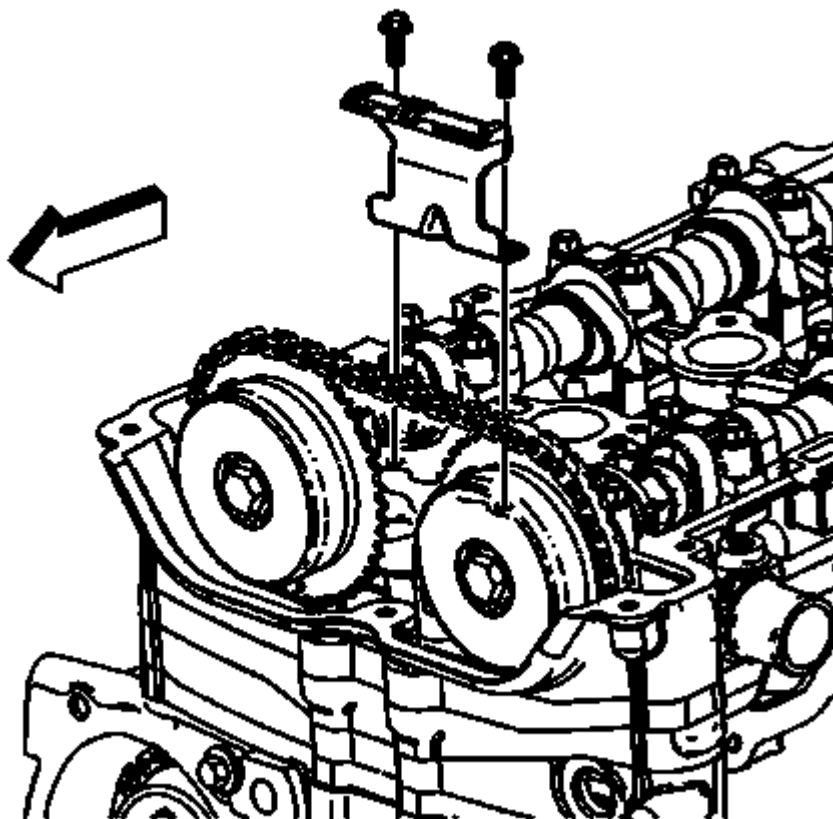


Fig. 145: Locating Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the upper timing chain guide and bolts.

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

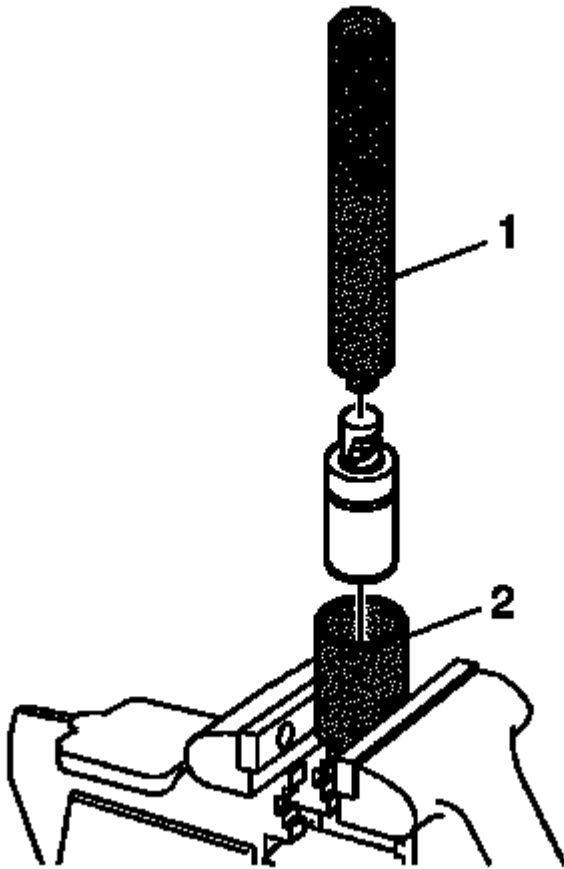


Fig. 146: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

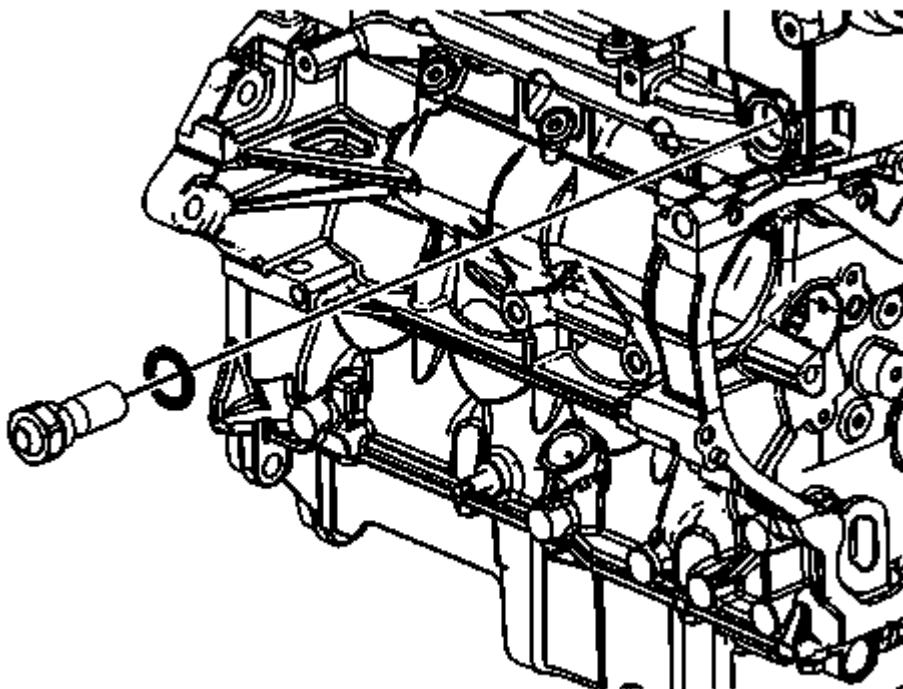


Fig. 147: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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

29. Install the timing chain tensioner assembly.

Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

30. 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.

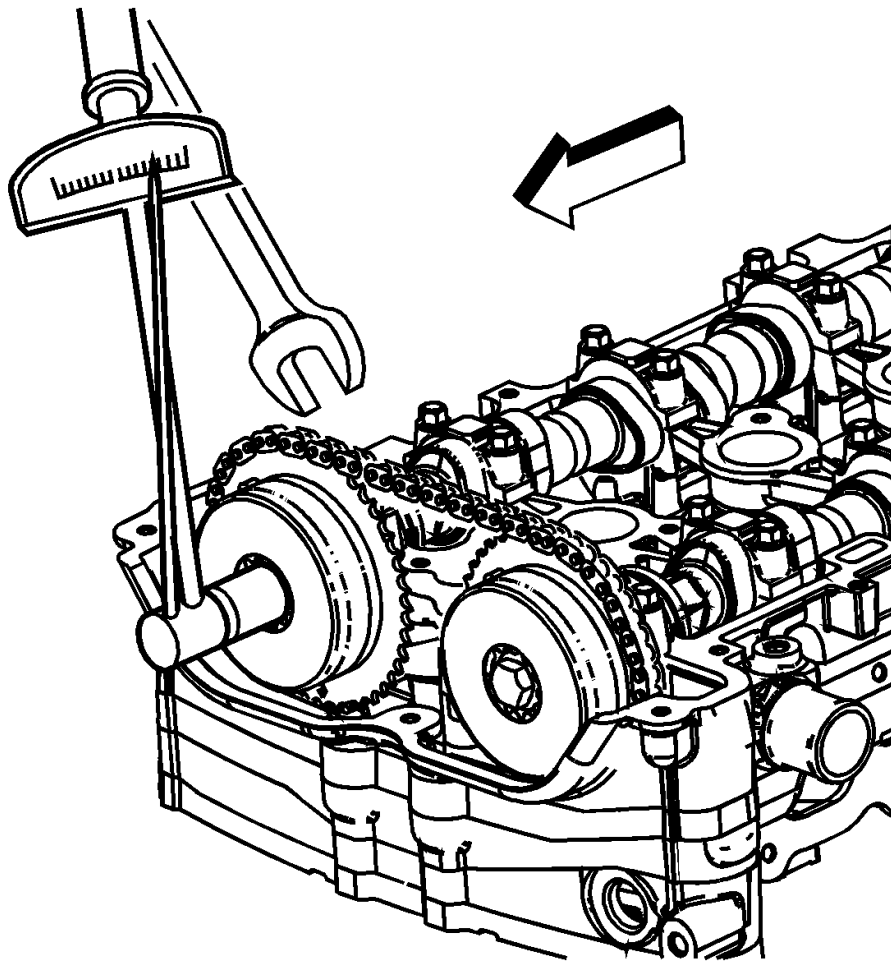


Fig. 148: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

31. Using a 23 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt.

Tighten: Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** . See **Special Tools**.

32. Using a 23 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt.

Tighten: Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** . See **Special Tools**.

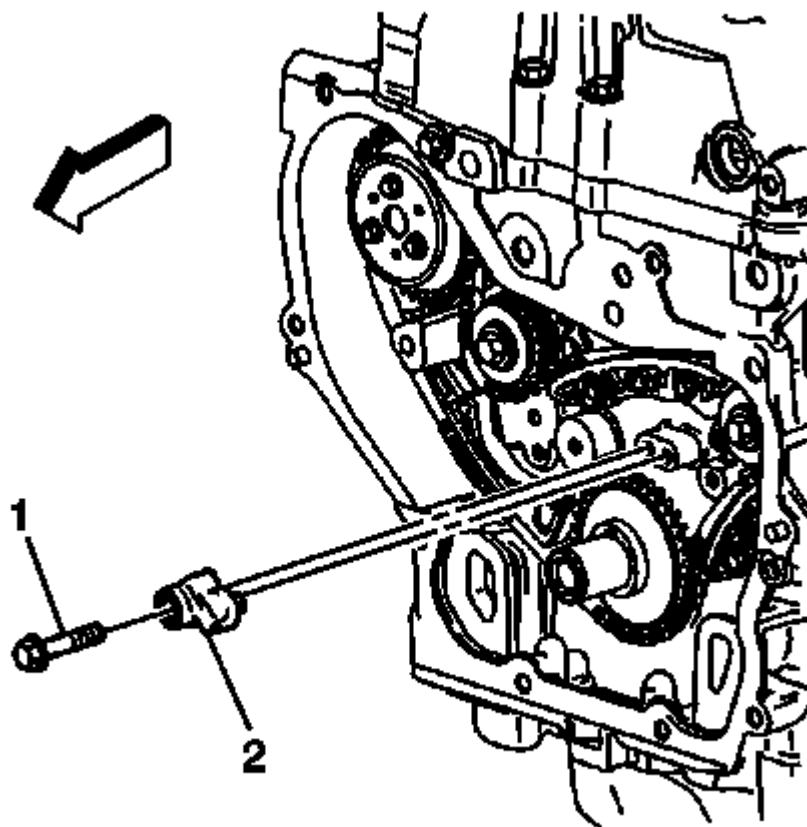


Fig. 149: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

33. Install the timing chain oiling nozzle.

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

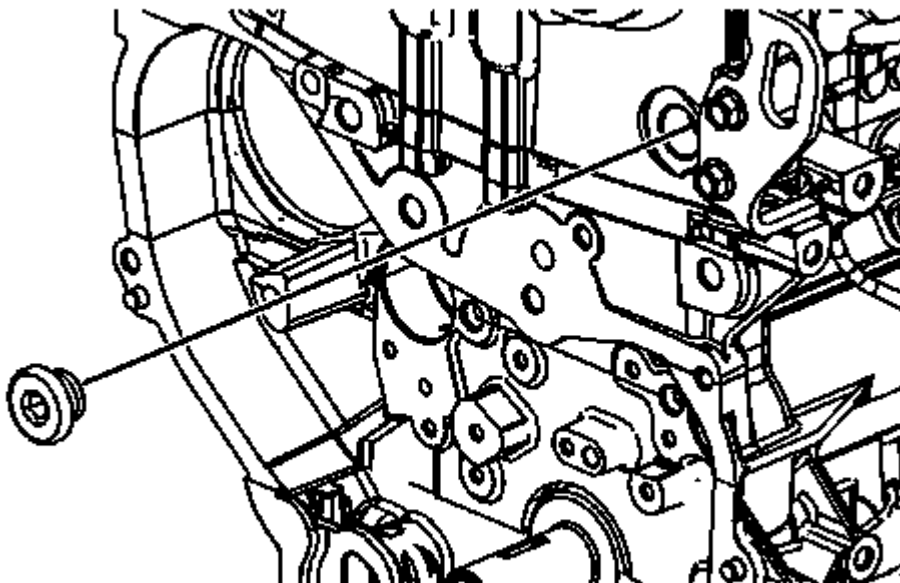


Fig. 150: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

34. Apply sealant compound GM P/N 12345382 (Canadian P/N 10953489) to the thread of the timing chain guide bolt access hole plug.
35. Install the timing chain guide bolt access hole plug.

Tighten: Tighten the access hole plug to 90 N.m (66 lb ft).

36. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
37. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
38. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement**.

CAMSHAFT COVER REPLACEMENT

Removal Procedure

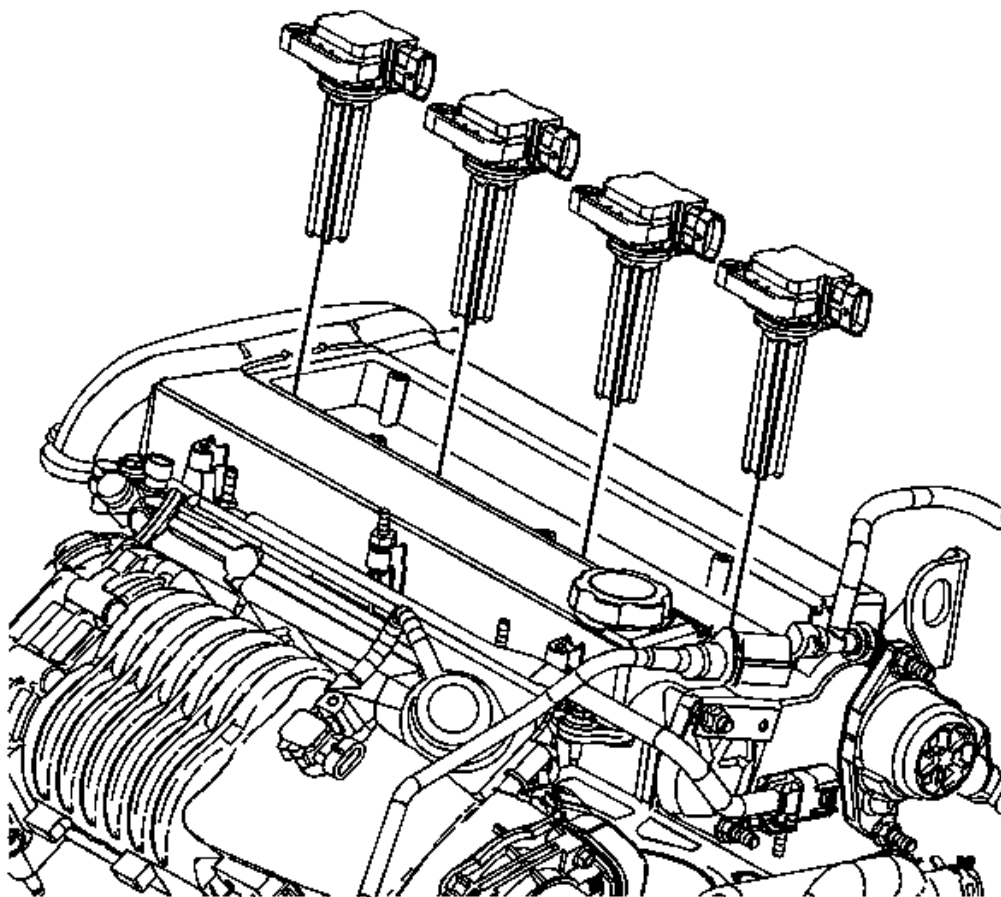


Fig. 151: View OF Ignition Coils
Courtesy of GENERAL MOTORS CORP.

1. Remove the ignition coils. Refer to **Ignition Coil Replacement** .
2. Remove the ground strap and stud.
3. Disconnect the positive crankcase ventilation (PCV) hose from the cam cover.

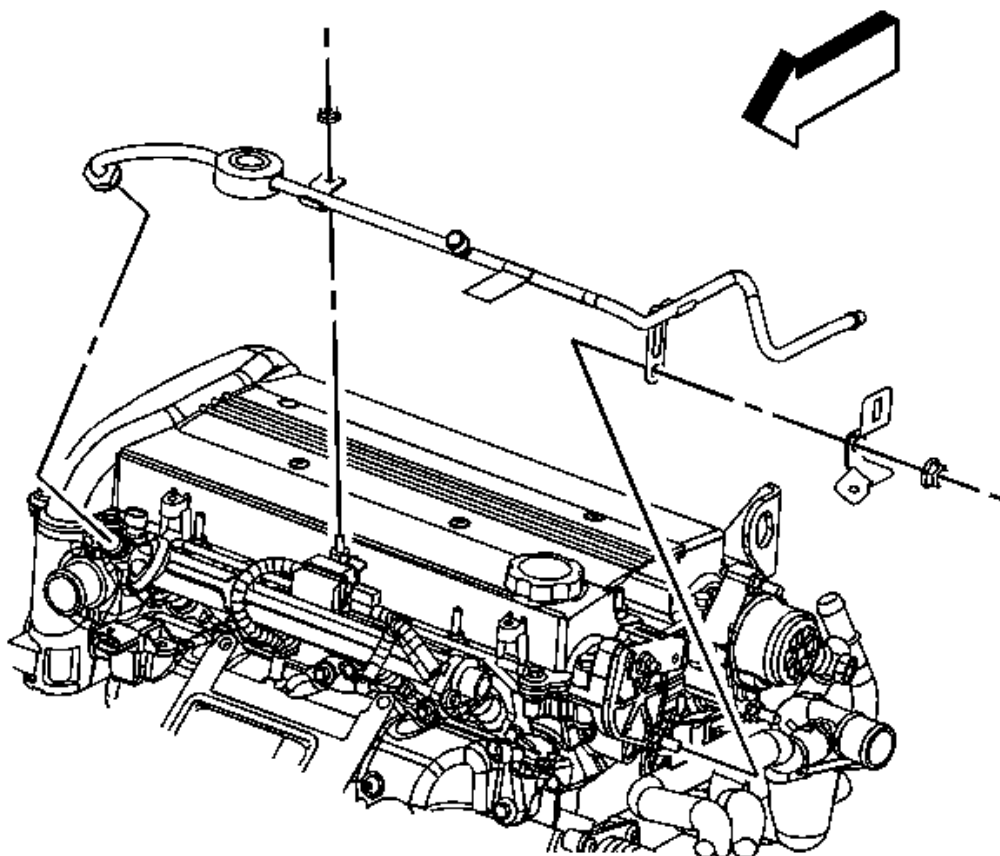


Fig. 152: View Of Fuel Line

Courtesy of GENERAL MOTORS CORP.

4. Disconnect the fuel feed pipe from the fuel rail.

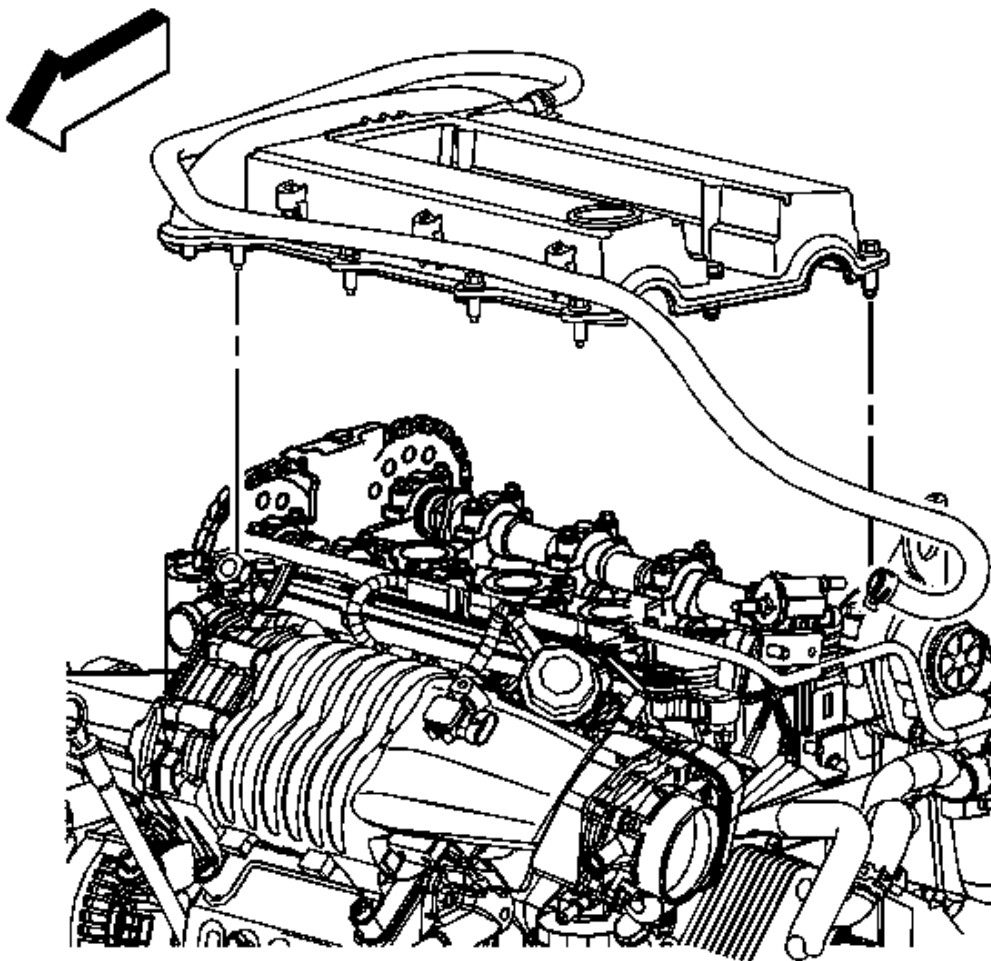


Fig. 153: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft cover bolts.
6. Remove the camshaft cover.

Installation Procedure

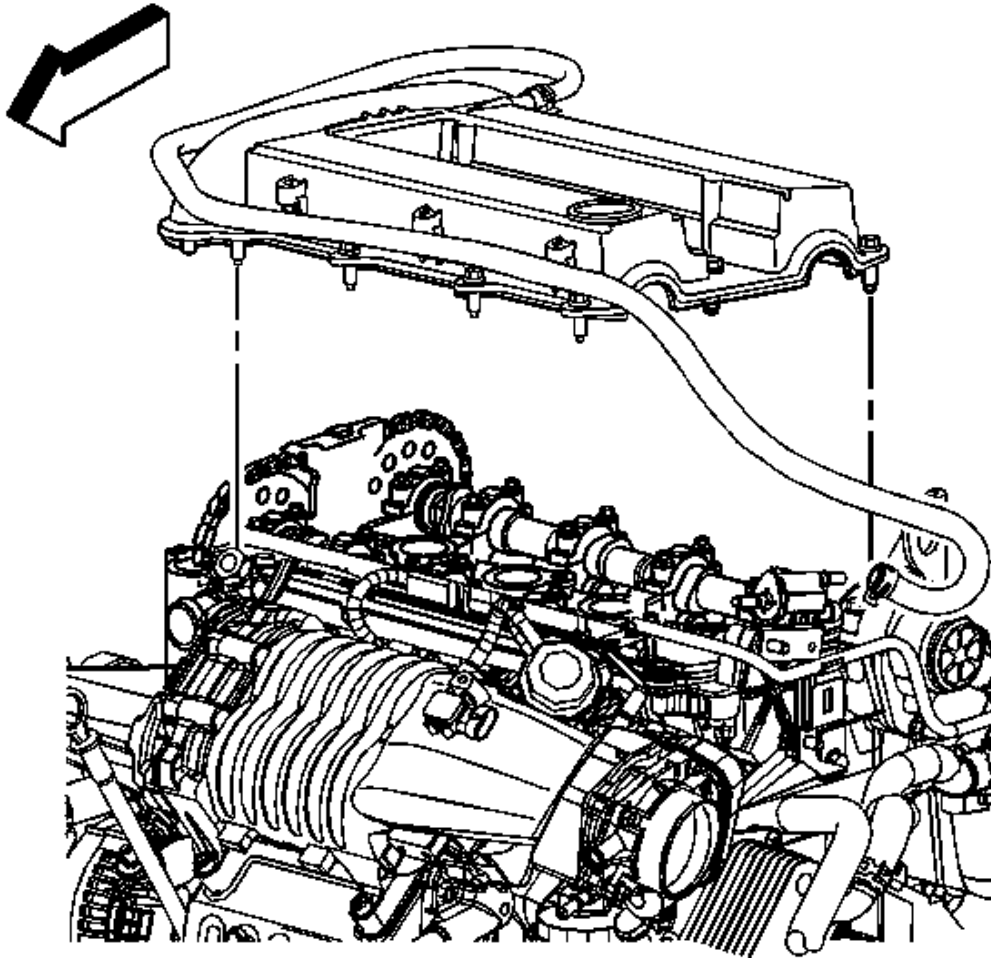


Fig. 154: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the camshaft cover and bolts.

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

2. Install the ground strap to the camshaft cover.

Tighten: Tighten the ground strap stud to 10 N.m (89 lb in).

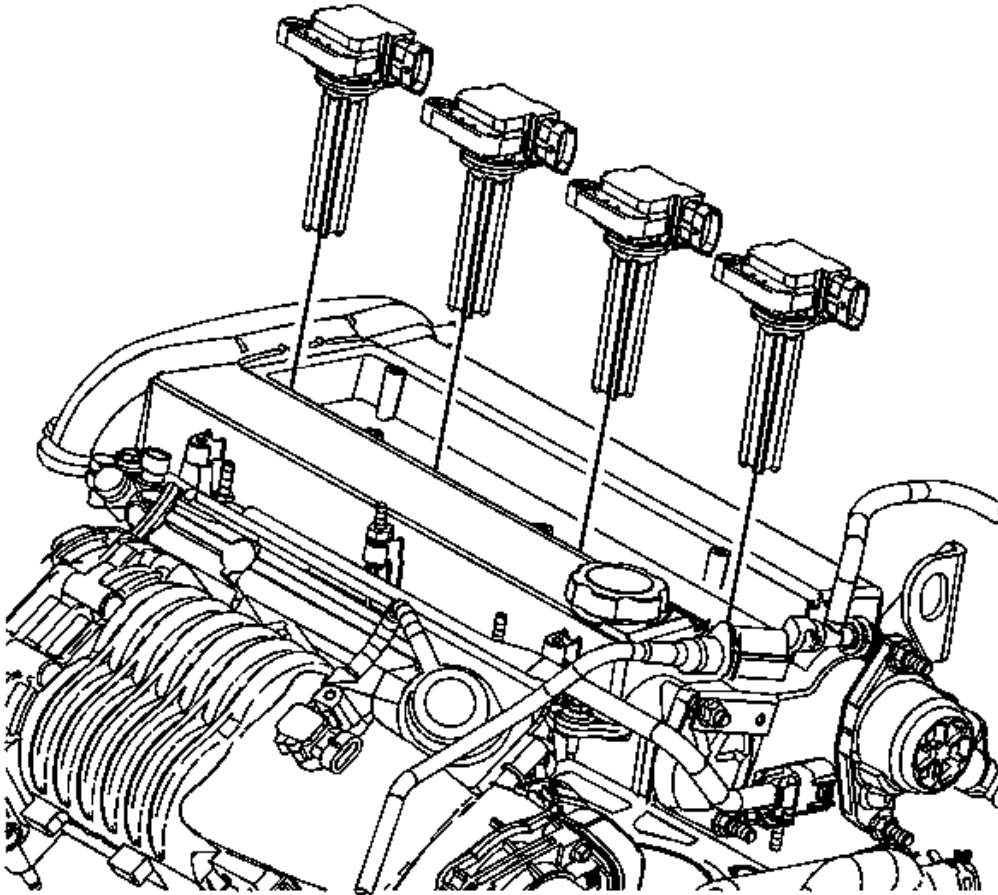


Fig. 155: View OF Ignition Coils
Courtesy of GENERAL MOTORS CORP.

3. Install the ignition coils. Refer to **Ignition Coil Replacement** .
4. Connect the fuel feed pipe to the fuel rail.
5. Install the fuel pipe bracket.

Tighten: Tighten the fuel pipe bracket bolt to 10 N.m (89 lb in).

6. Connect the PCV hose to the cam cover.

INTAKE CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

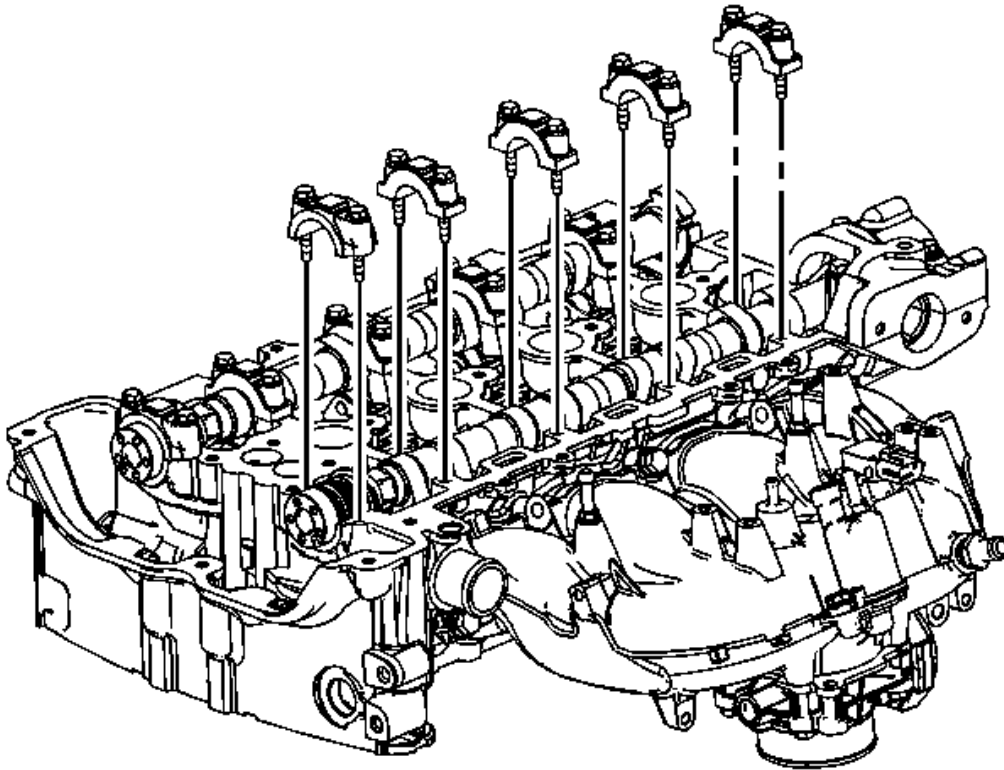


Fig. 156: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position intake actuator. Refer to **Camshaft Position Intake Actuator Replacement**.
2. Remove the high pressure fuel pump. Refer to **High Pressure Fuel Pump Replacement**.

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

3. Mark the camshaft bearing caps to ensure they are installed in the same position.
4. Remove the camshaft bearing cap bolts and caps.

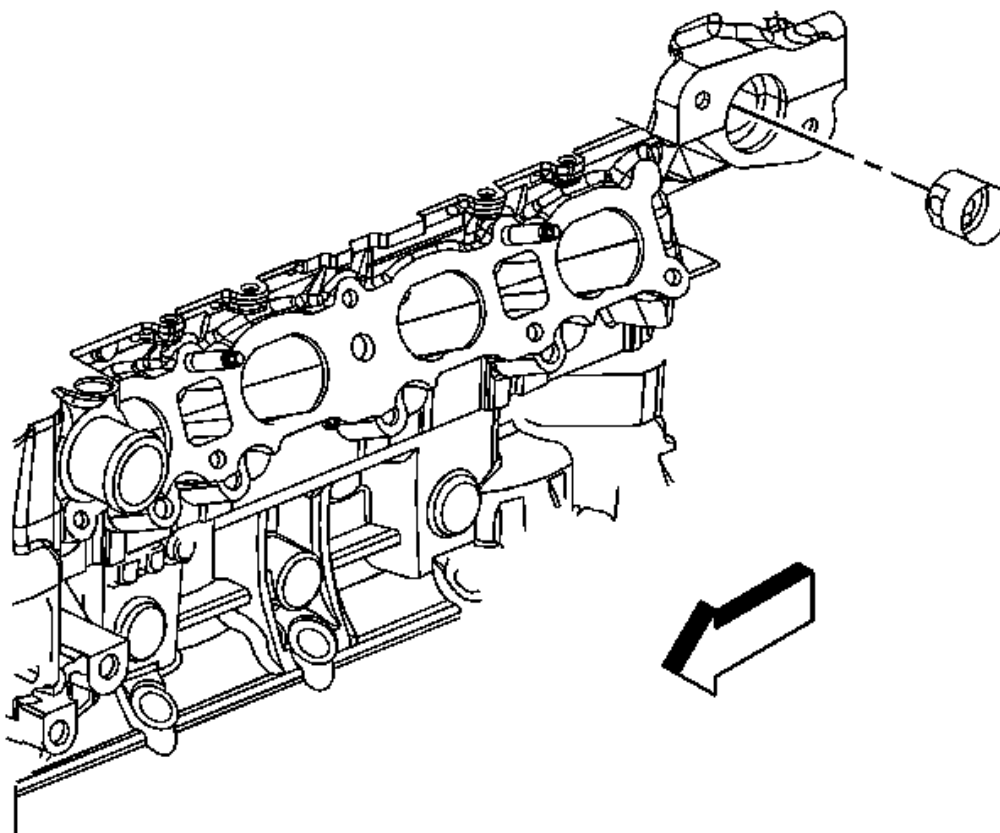


Fig. 157: View Of Valve Lifter Follower
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve lifter follower.

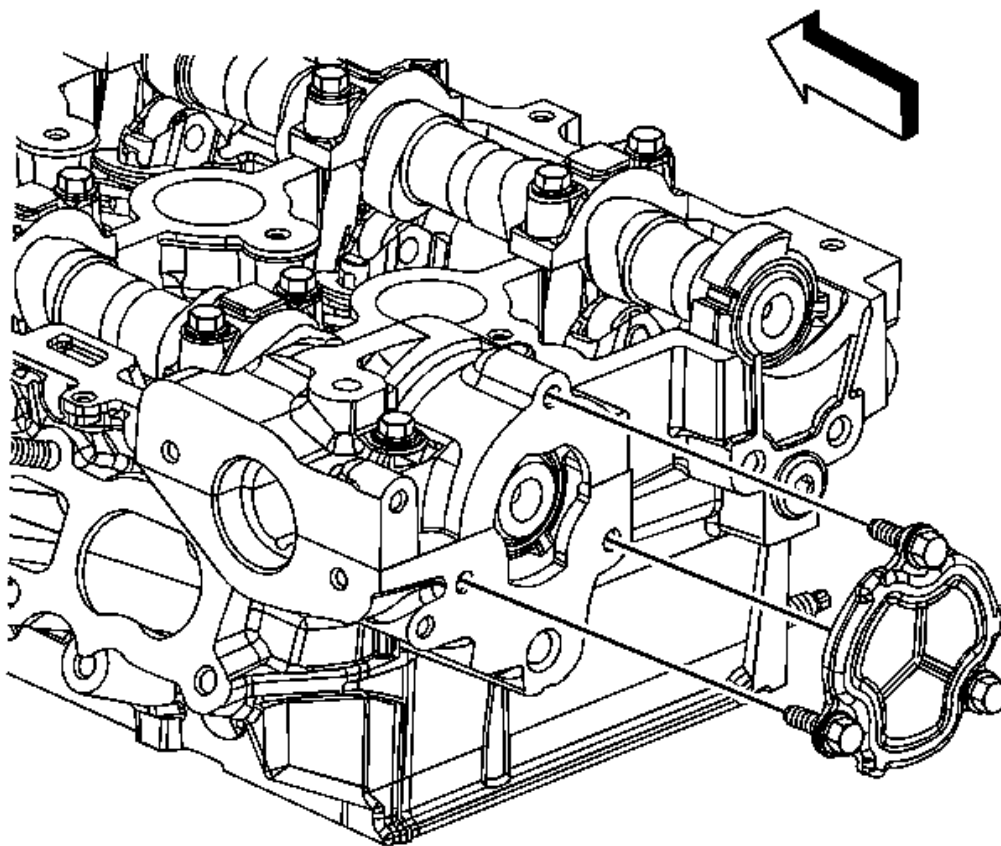


Fig. 158: Identifying Cylinder Head Opening Plate
Courtesy of GENERAL MOTORS CORP.

6. Remove the cylinder head opening plate bolts and plate.

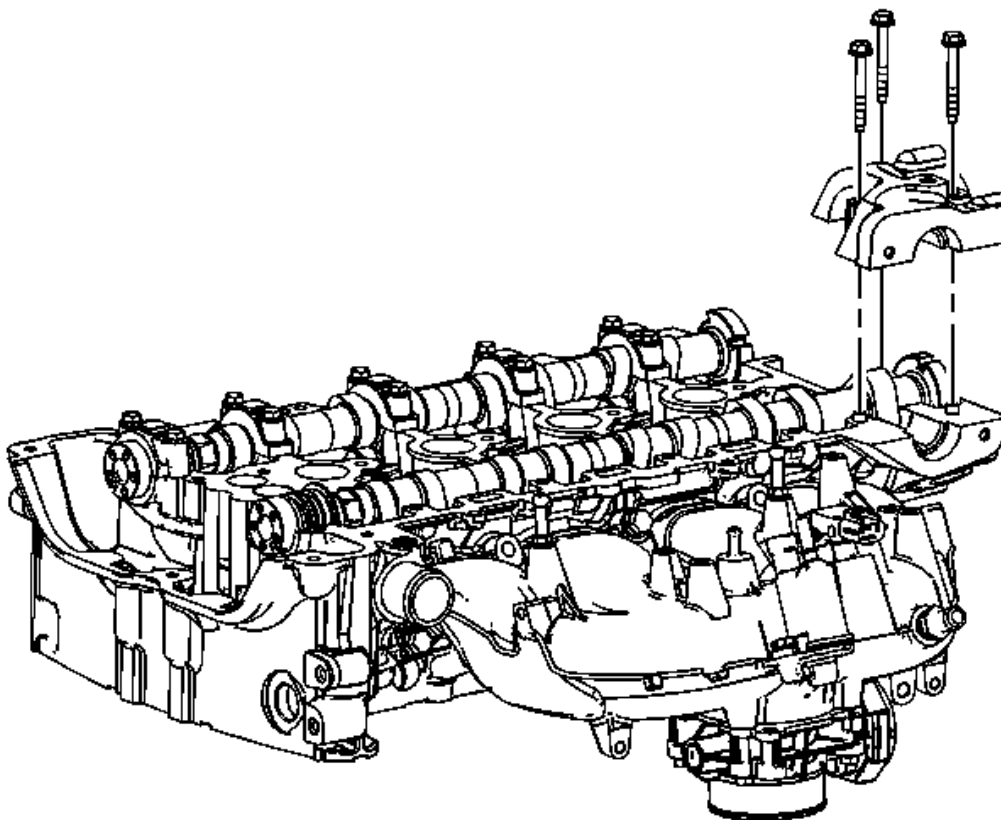


Fig. 159: Identifying Rear Bearing Cap
Courtesy of GENERAL MOTORS CORP.

7. Remove the rear bearing cap bolts and cap.

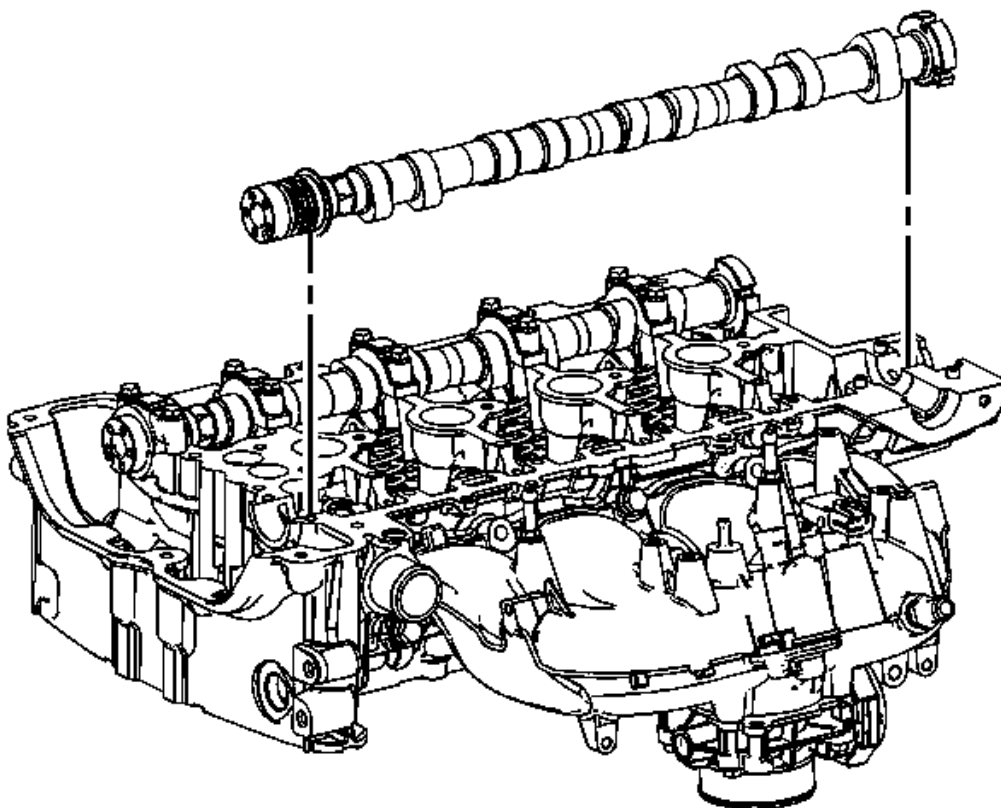


Fig. 160: Identifying Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

8. Remove the intake camshaft.

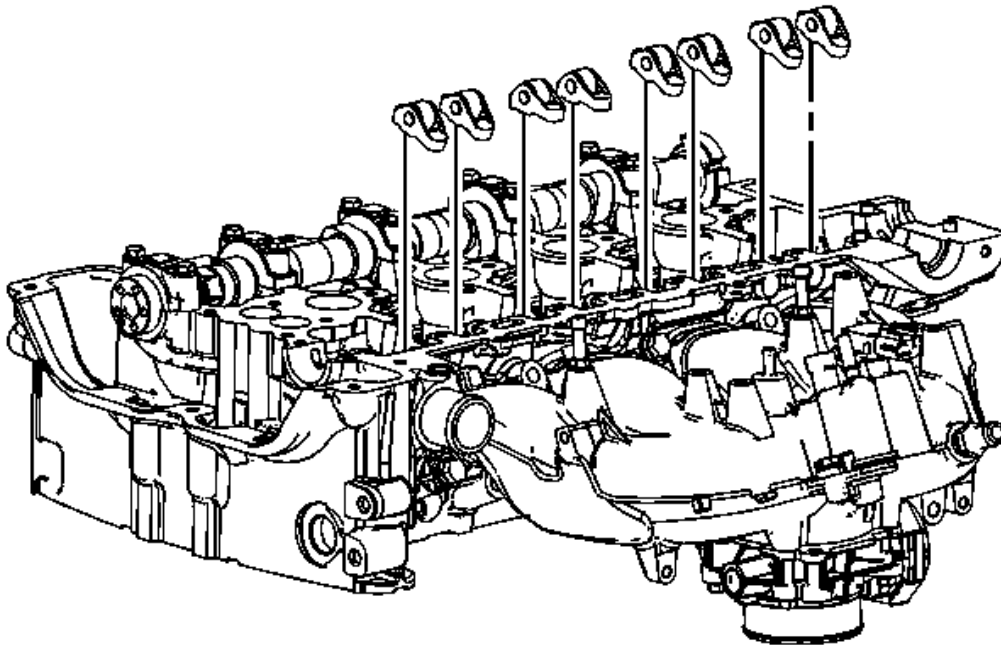


Fig. 161: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

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

9. Remove the valve rocker arms.

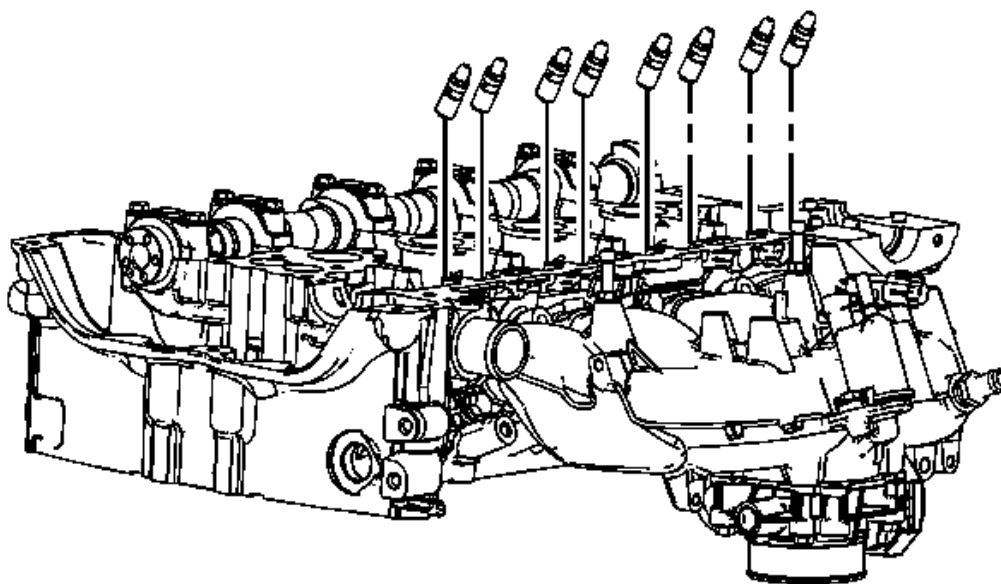


Fig. 162: Locating Hydraulic Valve Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

10. Remove the hydraulic valve lash adjusters.

Installation Procedure

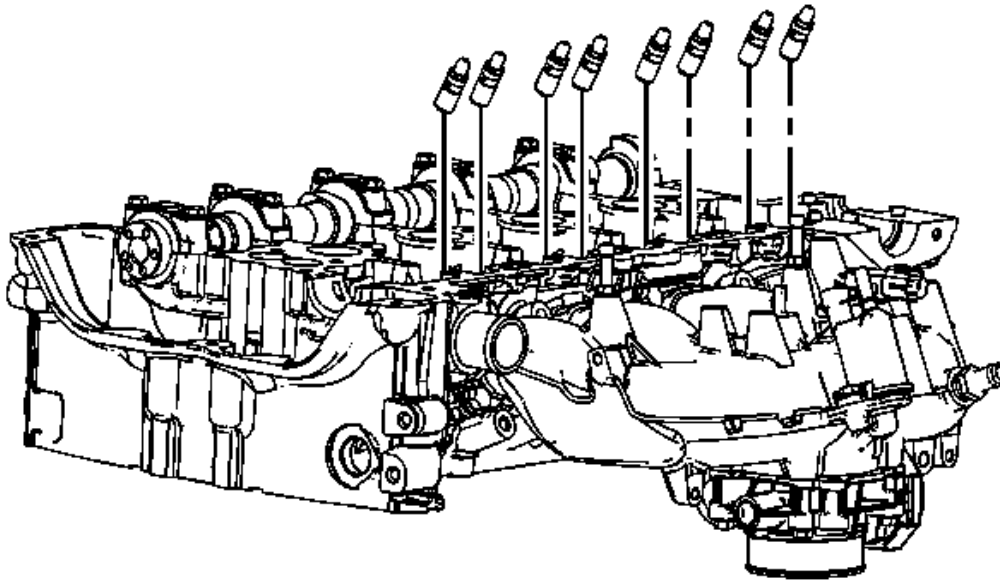


Fig. 163: Locating Hydraulic Valve Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

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

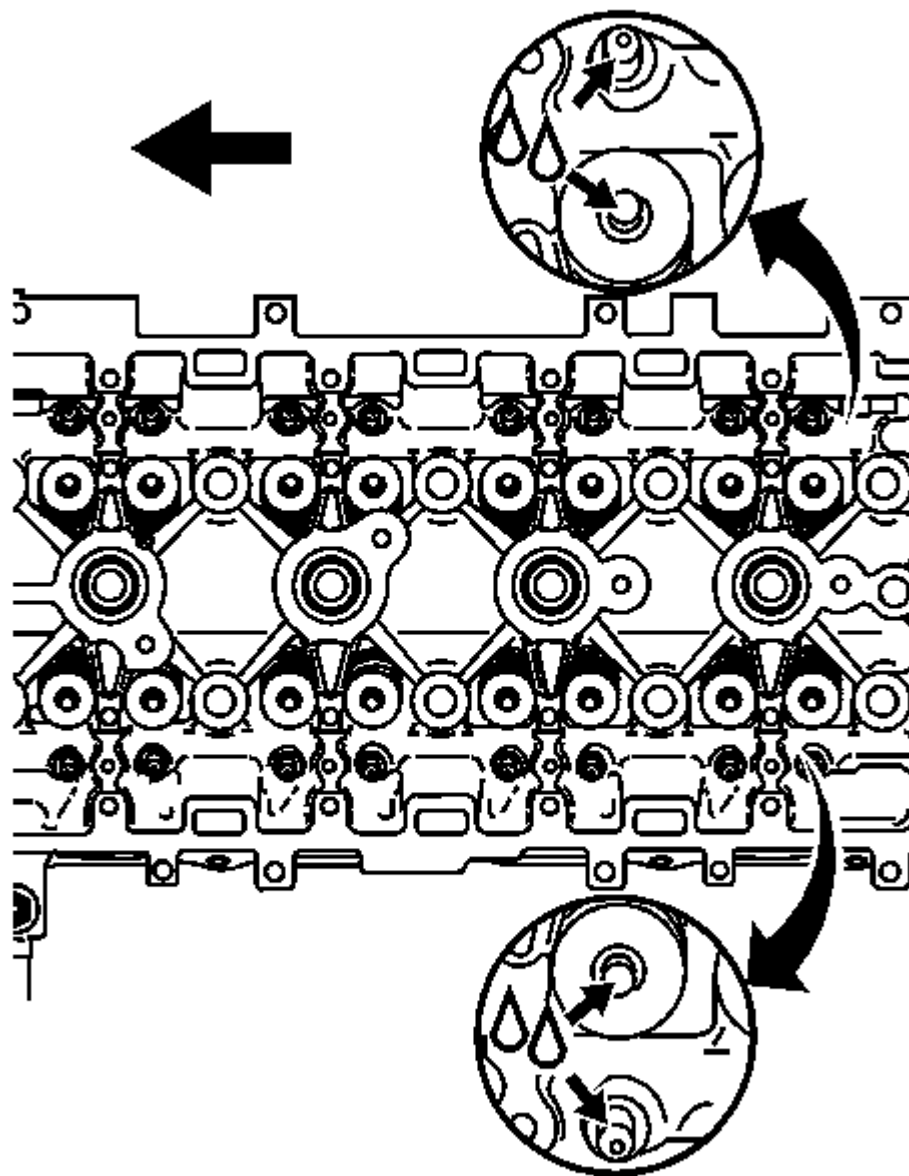


Fig. 164: Lubricating valve tips

Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

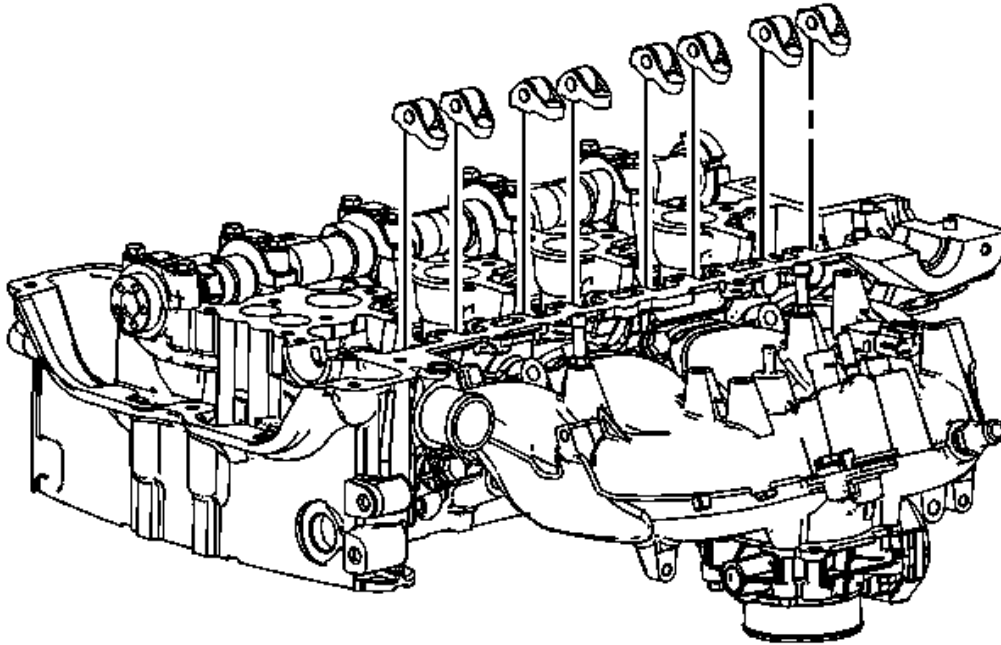


Fig. 165: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used valve rocker arms **MUST** be returned to their original position on the camshaft. If the camshaft is being replaced, the rocker arms **MUST** also be replaced.

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

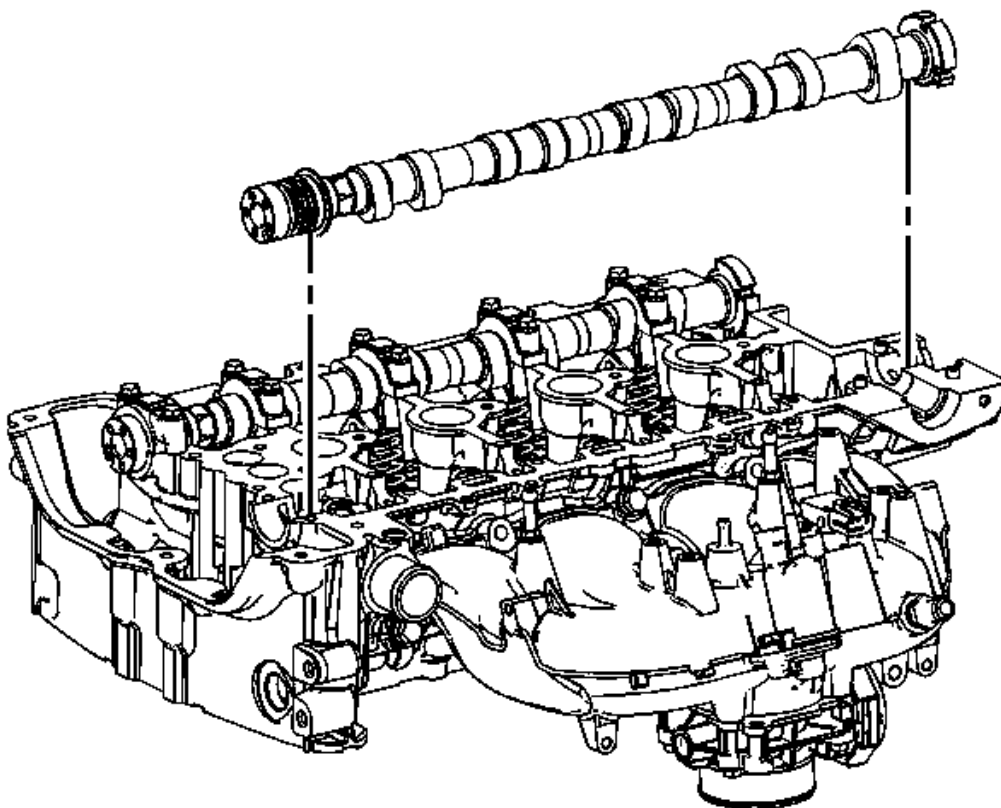


Fig. 166: Identifying Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft. Lubricate the camshaft. Refer to **Adhesives, Fluids, Lubricants, and Sealers.**

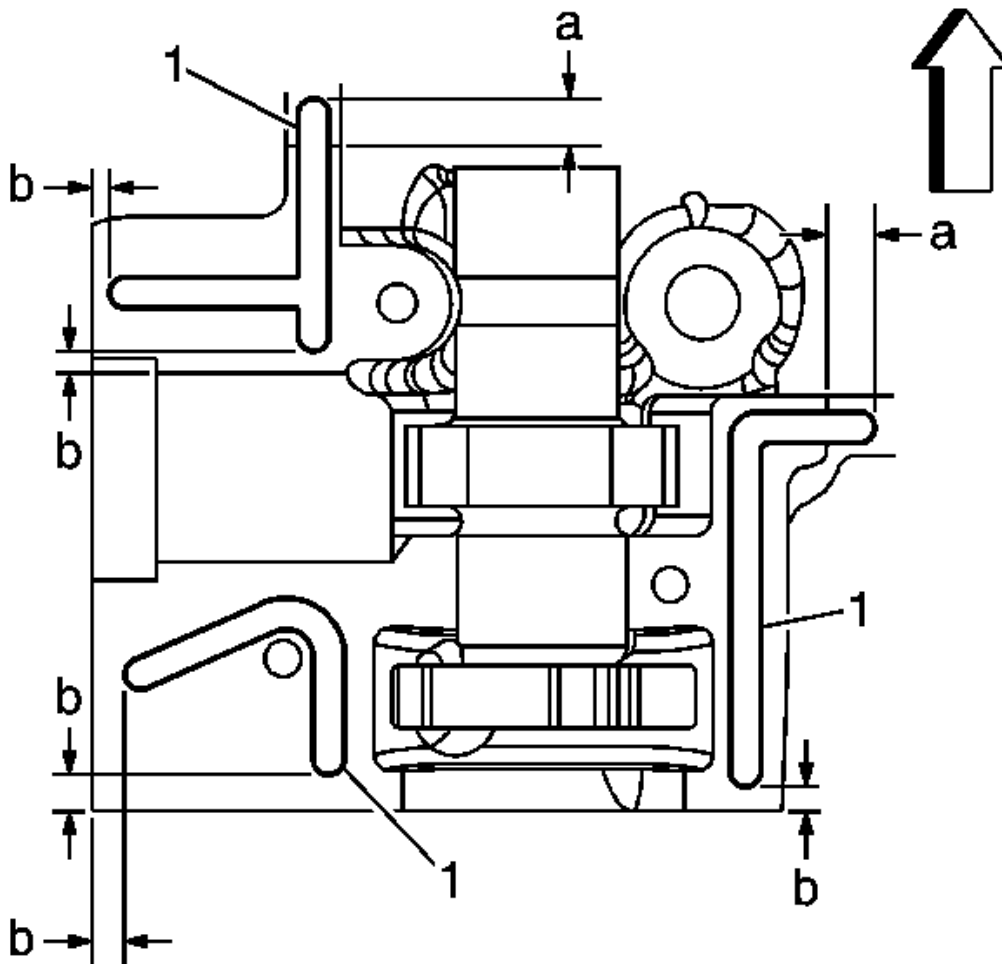


Fig. 167: Locating Head Sealer Application Areas
Courtesy of GENERAL MOTORS CORP.

6. Apply a 3.5 mm (0.138 in) bead of sealer (1) to the cylinder head. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. In areas where the rear bearing cap ends on the perimeter rail, extend the bead of sealer 4.0 mm (0.1575 in) beyond the edge of the cap (a).
8. Run the bead of sealer to within 4.0 mm (0.1575 in) of end points (b).

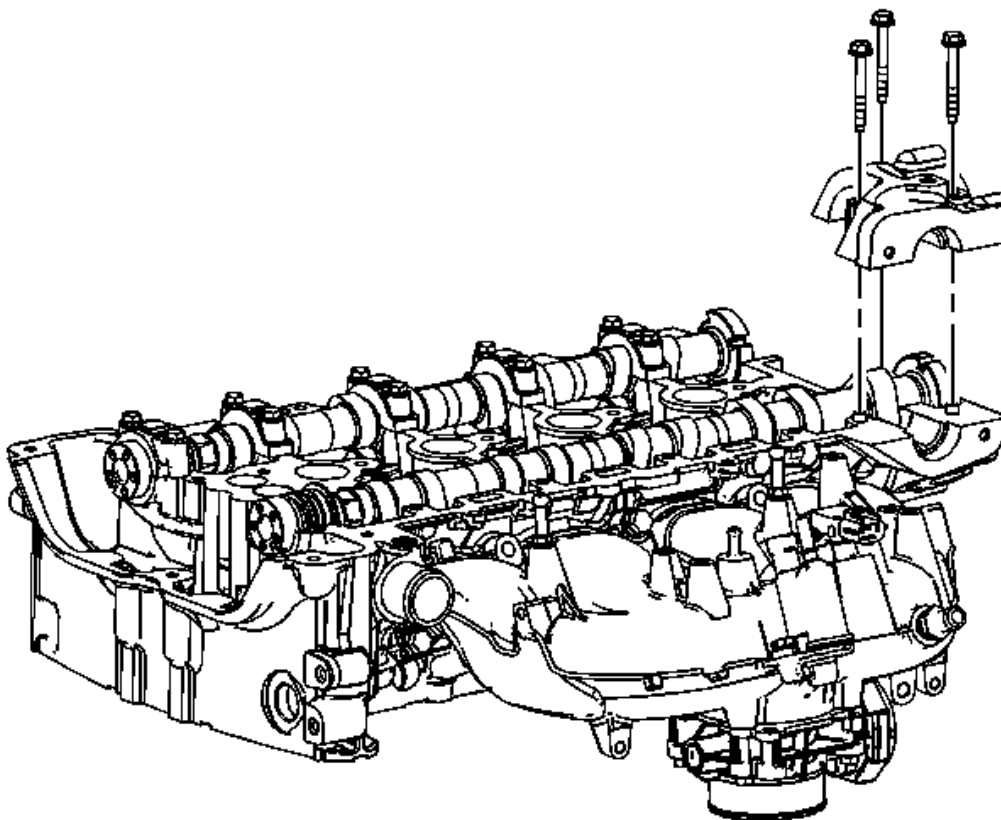


Fig. 168: Identifying Rear Bearing Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Install the rear bearing cap and bolts.

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

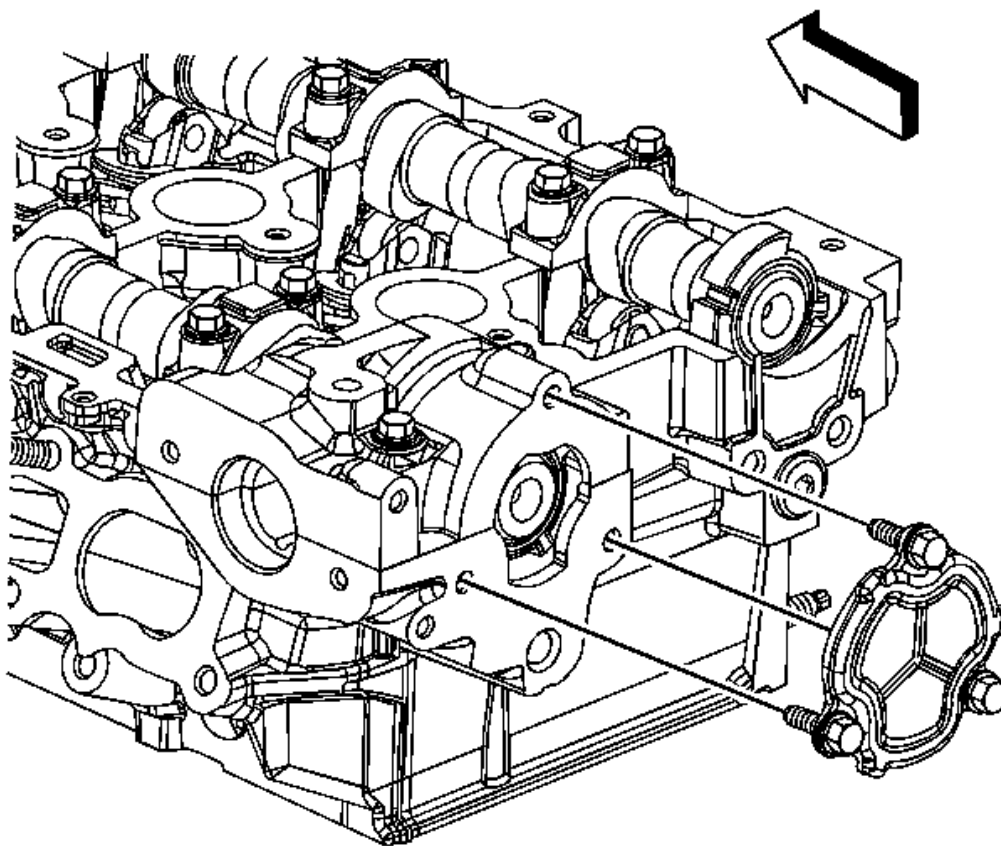


Fig. 169: Identifying Cylinder Head Opening Plate
Courtesy of GENERAL MOTORS CORP.

10. Install the cylinder head opening plate and bolts.

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

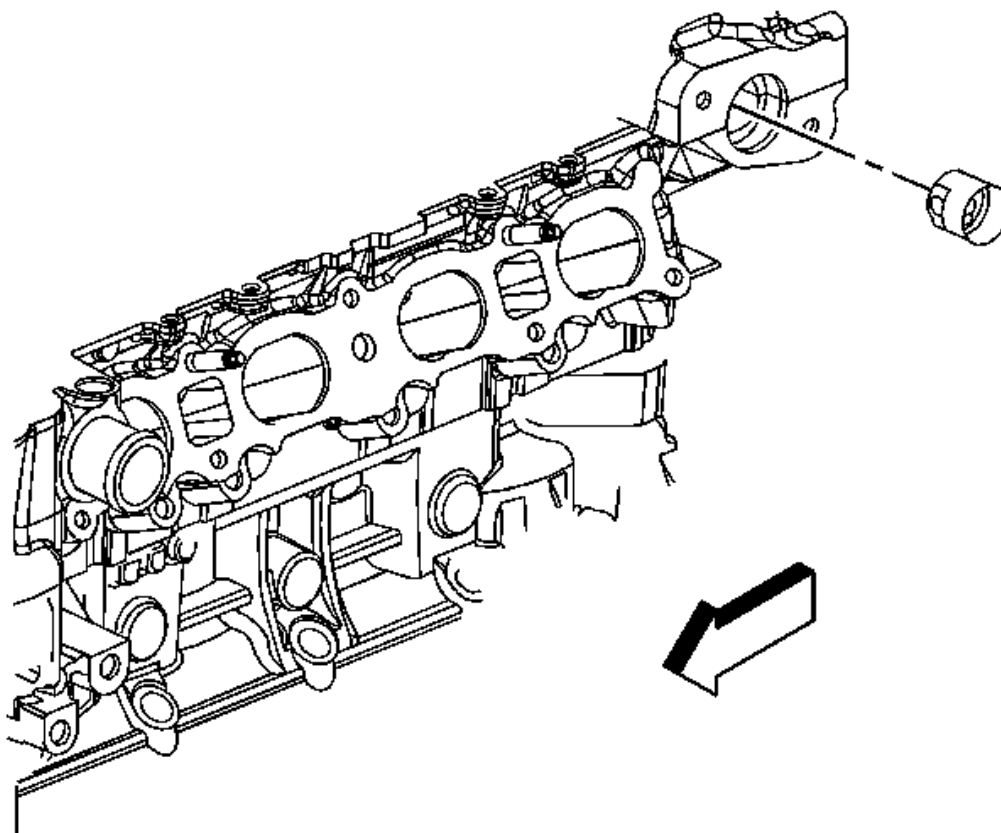


Fig. 170: View Of Valve Lifter Follower
Courtesy of GENERAL MOTORS CORP.

11. Install the valve lifter follower.

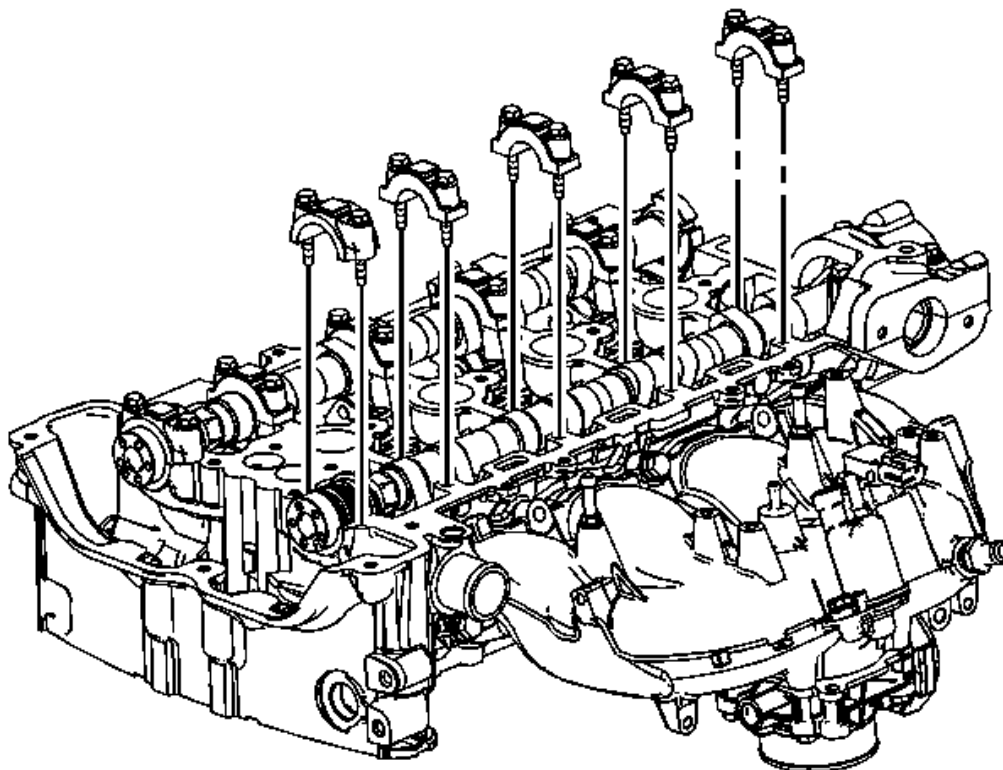


Fig. 171: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The caps should be installed on the cylinder head in sequence as shown on top of the bearing caps.

12. Position the camshaft bearing caps. Install the bearing cap bolts hand tight.
13. Tighten the bearing cap bolts in increments of 3 turns until they are seated.

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

14. Install the high pressure fuel pump. Refer to **High Pressure Fuel Pump Replacement** .
15. Install the camshaft position intake actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

EXHAUST CAMSHAFT AND VALVE LIFTER REPLACEMENT

Removal Procedure

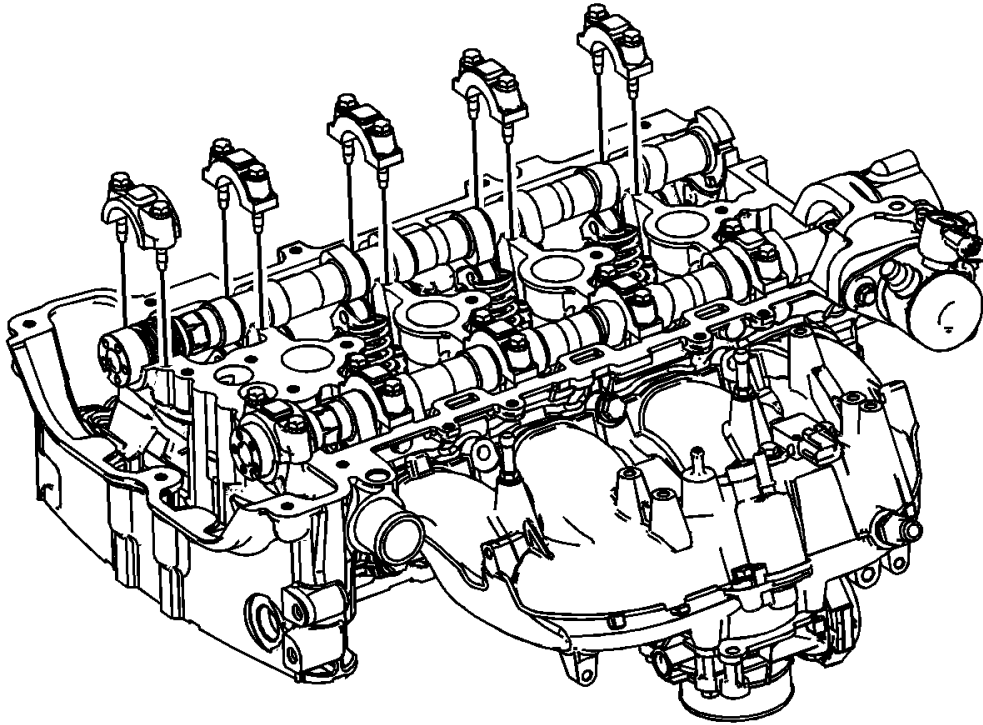


Fig. 172: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

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

2. Mark the camshaft bearing caps to ensure they are installed in the same position.
3. Remove the camshaft bearing cap bolts and cap.

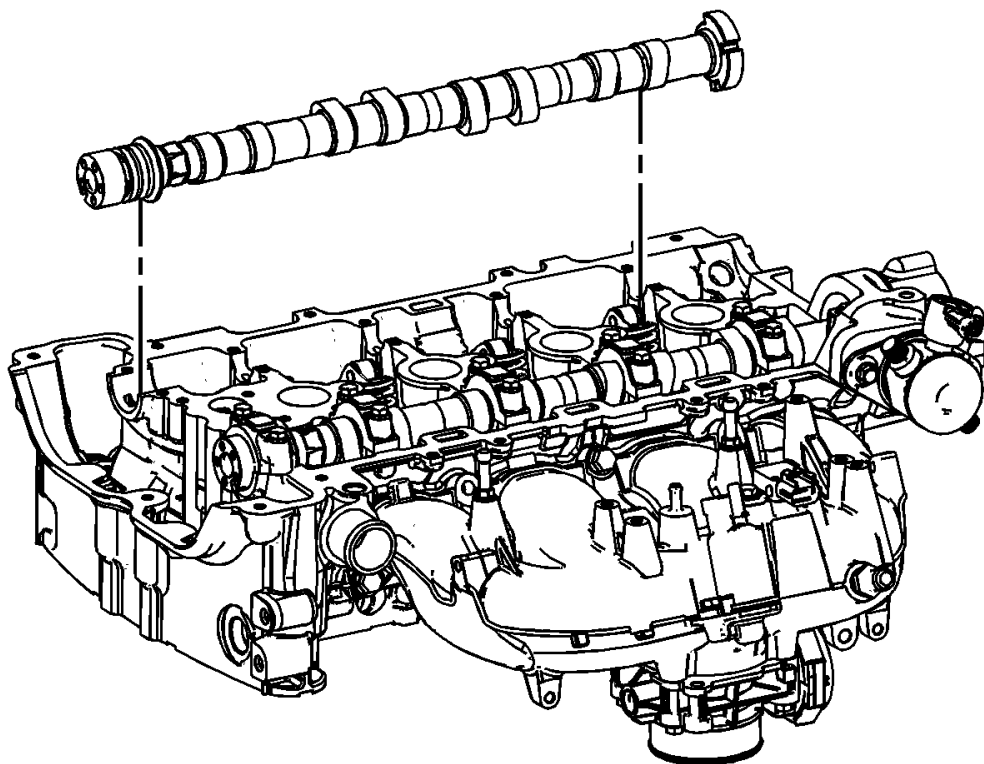


Fig. 173: Identifying Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust camshaft.

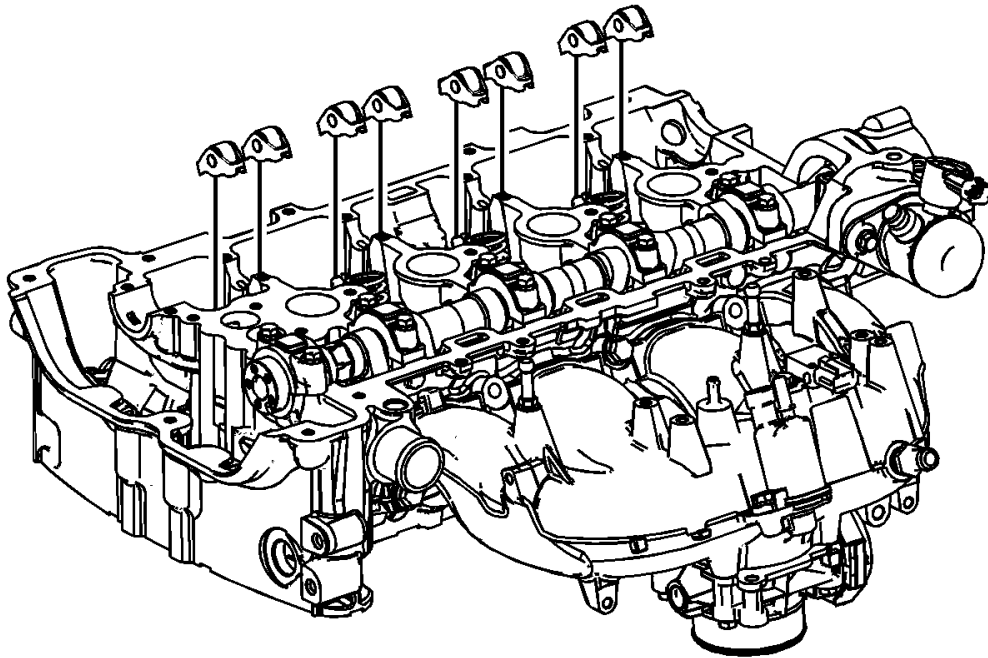


Fig. 174: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep all of the rocker arms and hydraulic valve lash adjusters in order so that they can be reinstalled in their respective locations.

5. Remove the valve rocker arms.

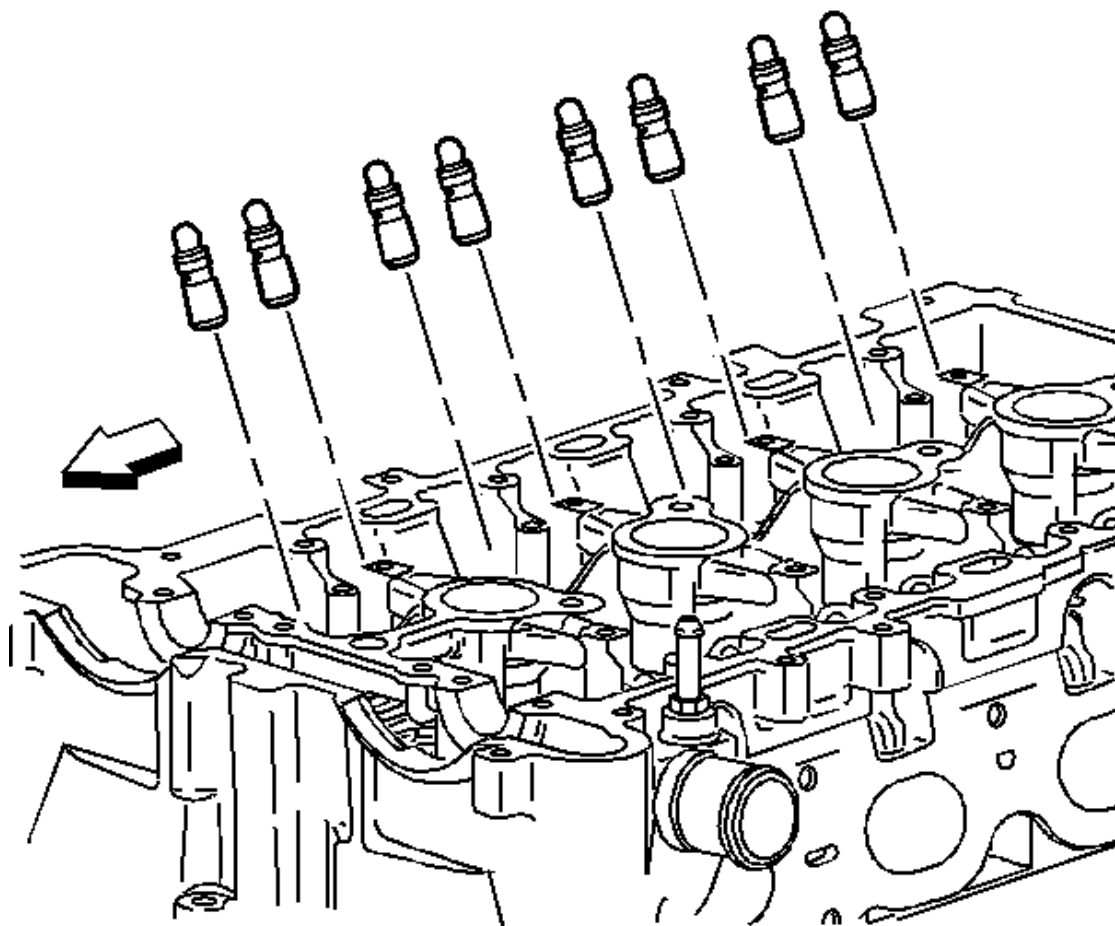


Fig. 175: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic valve lash adjusters.

Installation Procedure

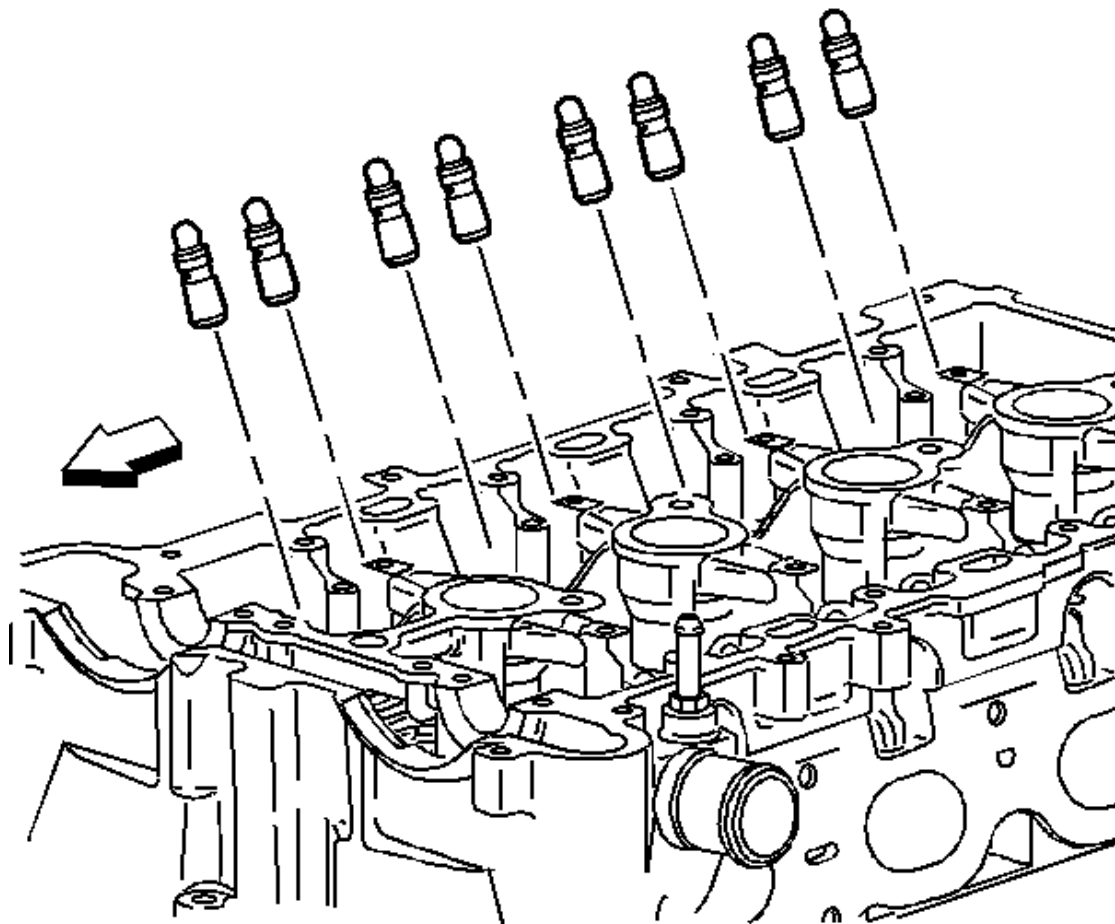


Fig. 176: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

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

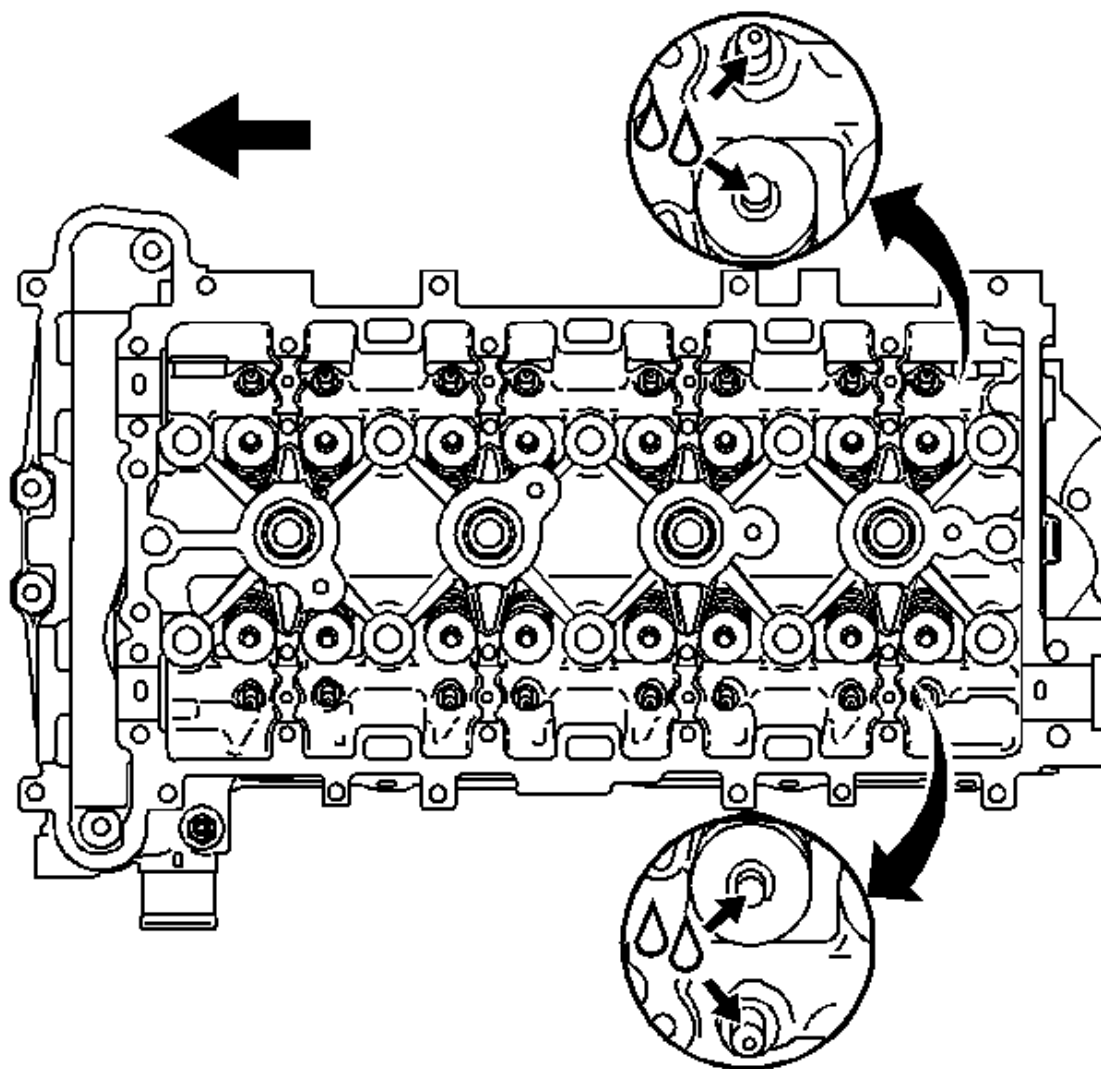


Fig. 177: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

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

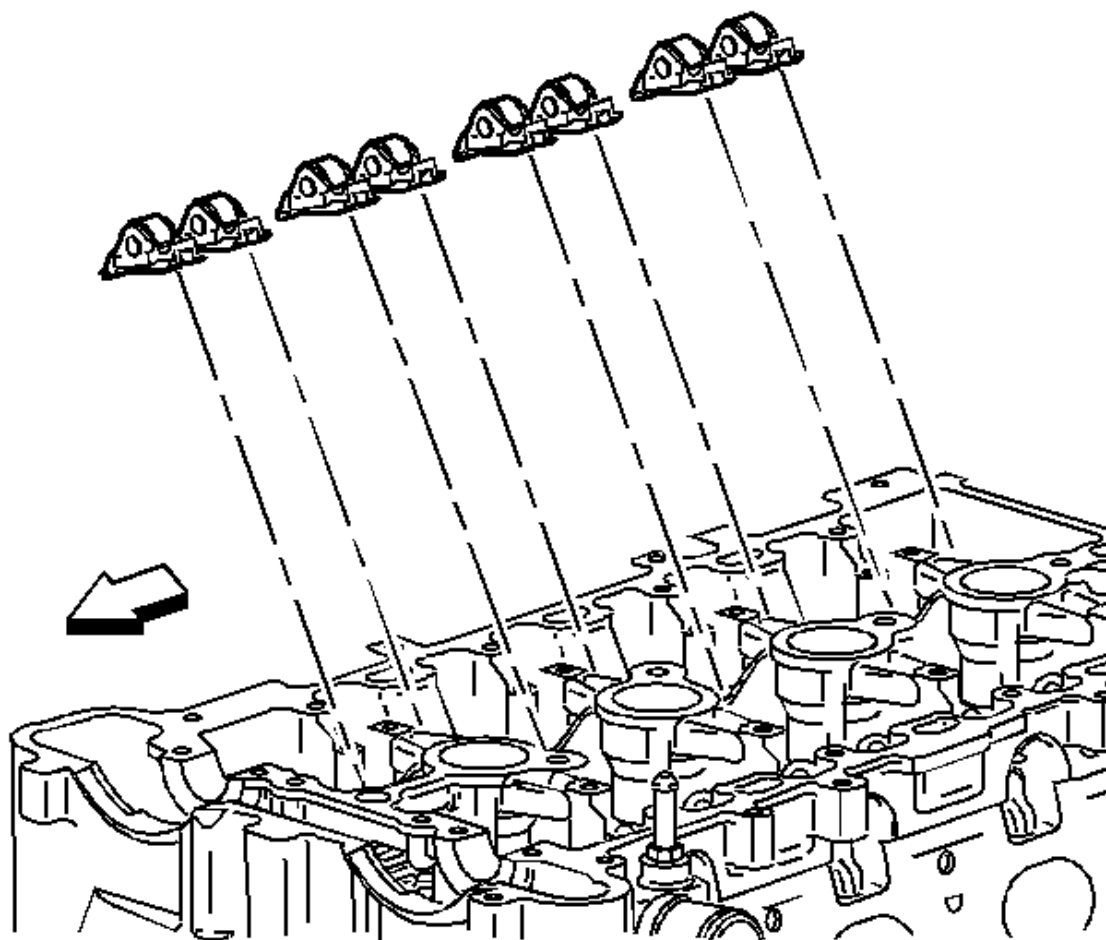


Fig. 178: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used rocker arms **MUST** be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms **MUST** also be replaced.

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

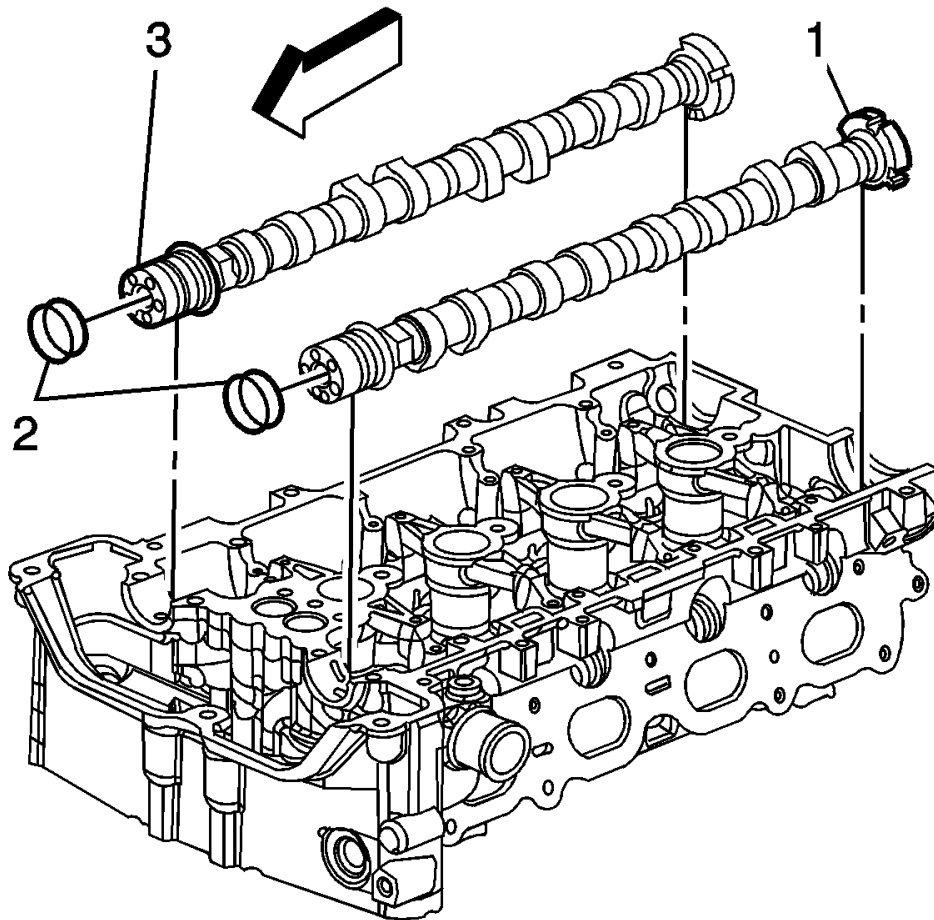


Fig. 179: Identifying Intake/Exhaust Camshafts
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft. Lubricate the camshaft. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

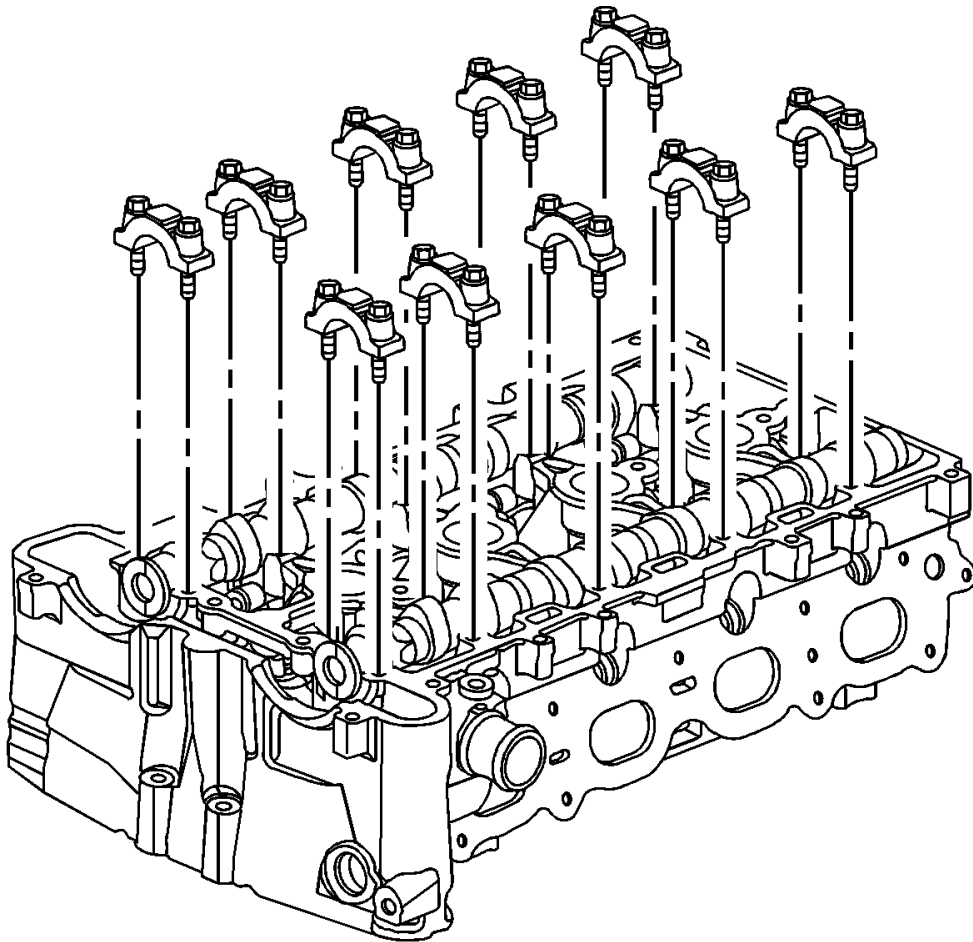


Fig. 180: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The caps should be installed on the cylinder head in sequence as shown on top of the bearing caps.

6. Position the camshaft bearing caps. Install the bearing cap bolts hand tight.

NOTE: Refer to Fastener Notice .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated.

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

8. Install the camshaft position exhaust actuator. Refer to Camshaft Position Exhaust Actuator Replacement.

CAMSHAFT POSITION INTAKE ACTUATOR REPLACEMENT

Special Tools

- **EN-48749** Timing Chain Retention Tool Kit
- **EN-48953** Camshaft Actuator Locking Tool
- **J 45059** Angle Meter. See **Special Tools**.

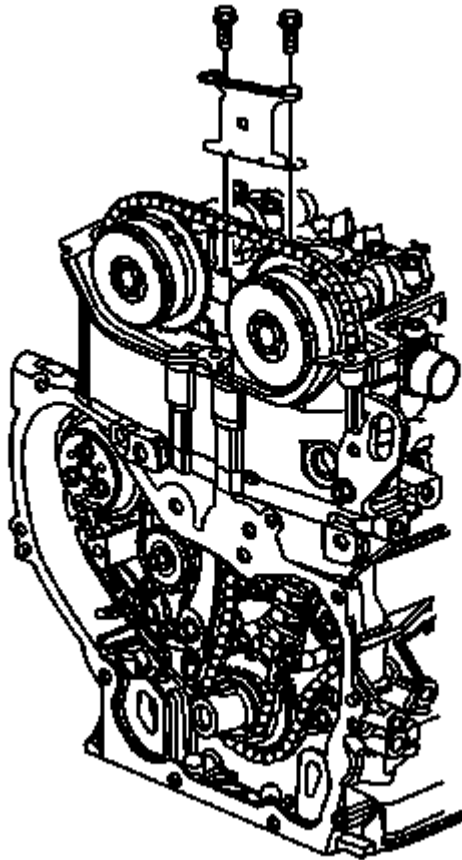
Removal Procedure

Fig. 181: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement** .
2. Remove the upper timing chain guide bolts and guide.

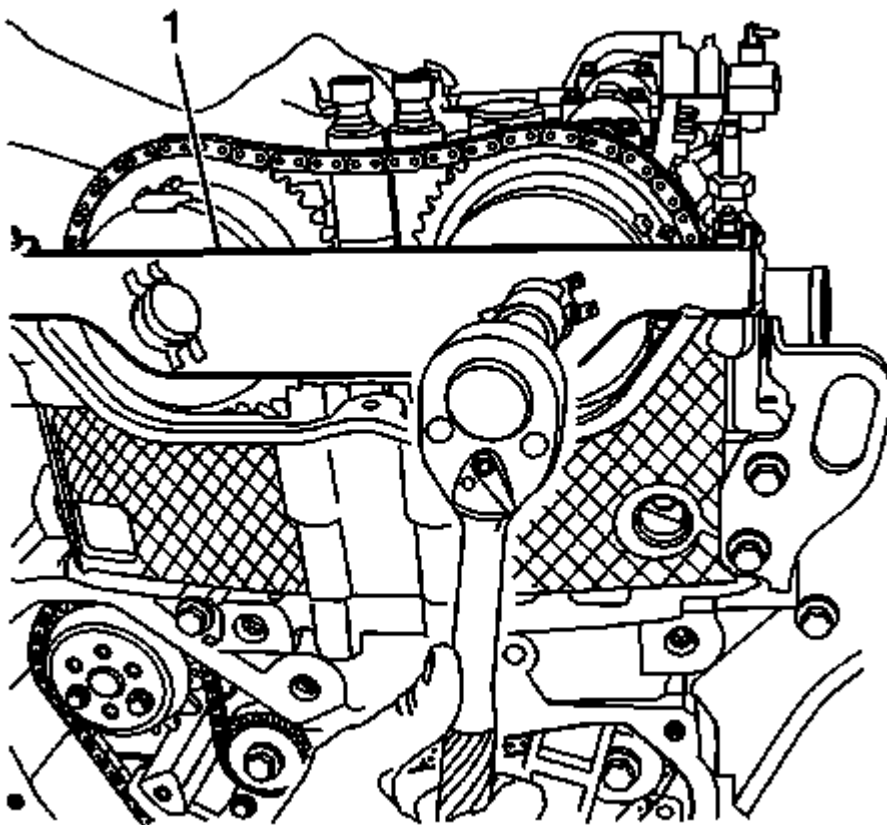


Fig. 182: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install a 24 mm wrench onto the hex on the camshaft in order to rotate the camshafts clockwise and install the camshaft actuator retainer **EN-48953** (1).
4. Install the camshaft actuator retainer bolts.

NOTE: Refer to **Fastener Notice** .

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

5. Loosen, but DO NOT remove the intake camshaft actuator bolt.
6. Remove the camshaft actuator locking tool, **EN-48953** (1).

IMPORTANT: 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.

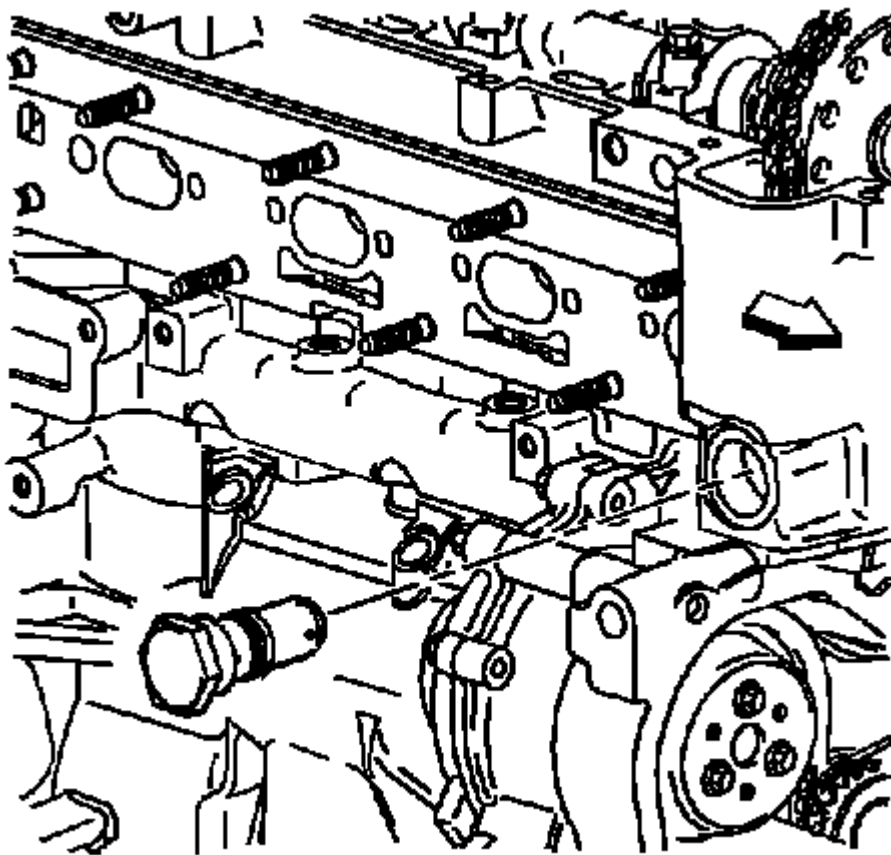


Fig. 183: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

8. Remove the timing chain tensioner.

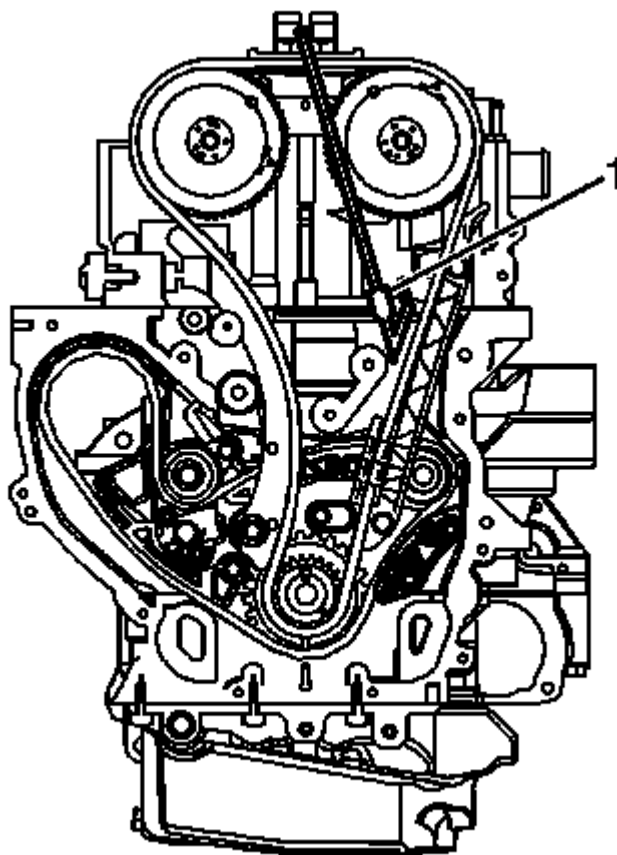


Fig. 184: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft actuators should not rotate during the removal or installation.

IMPORTANT: Ensure the tips of the 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.

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

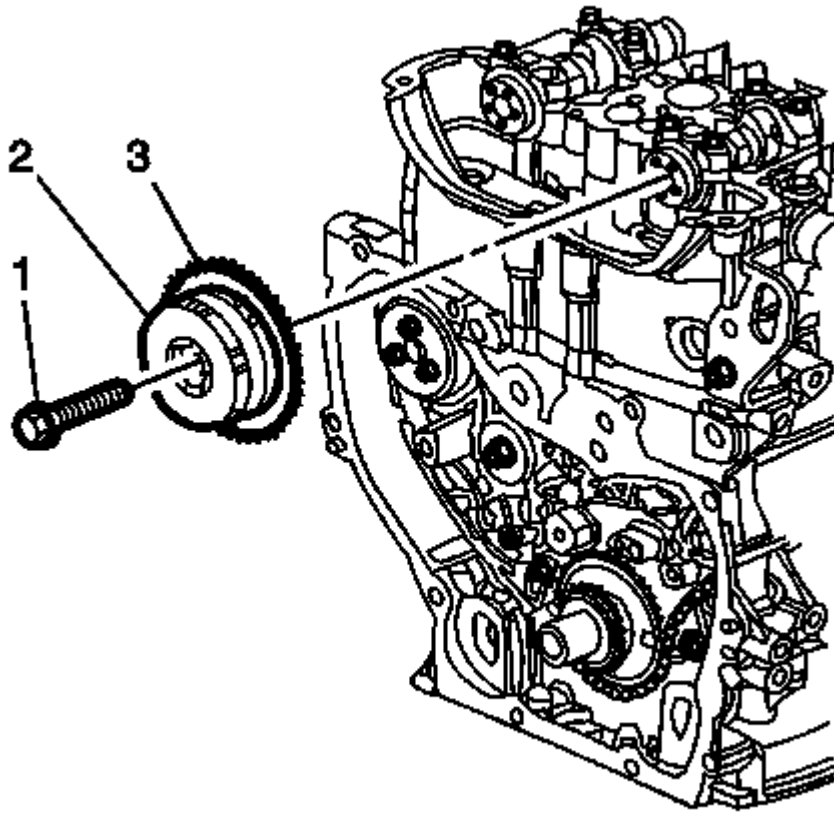


Fig. 185: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

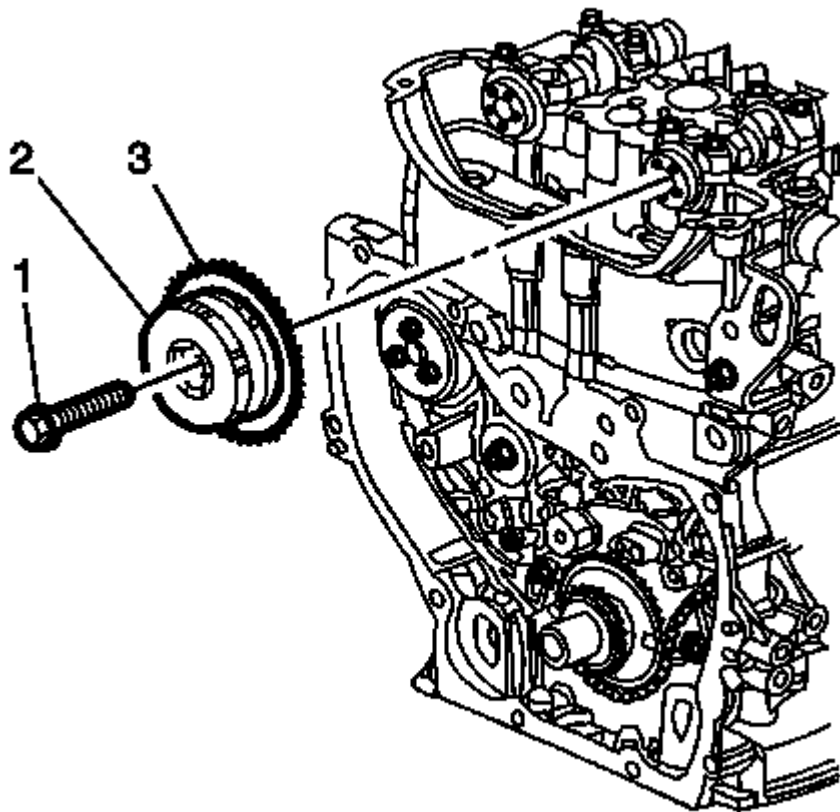


Fig. 186: Identifying Timing Chain & Camshaft Position Actuator
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the alignment mark made previously on the exhaust 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.
3. Install a NEW intake camshaft actuator bolt (2) until snug.

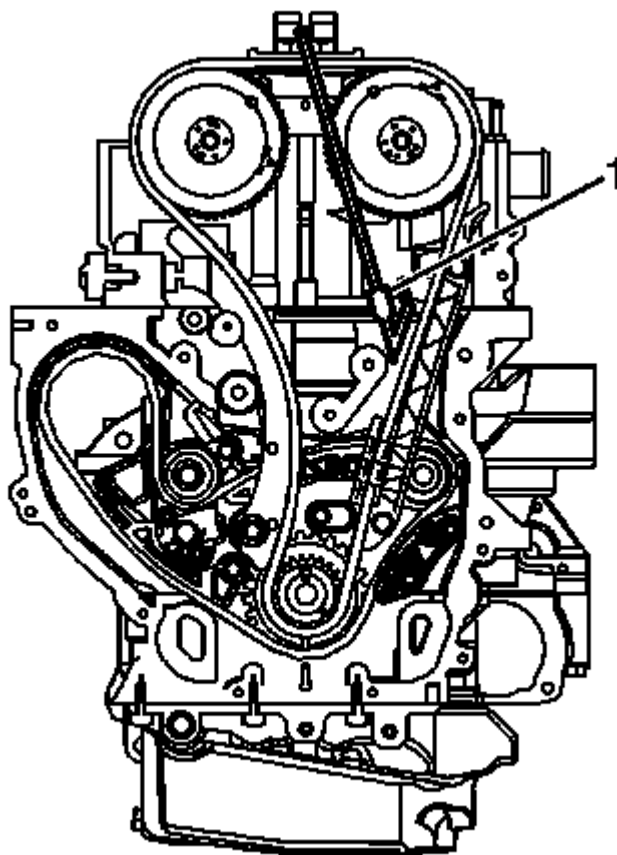


Fig. 187: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

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

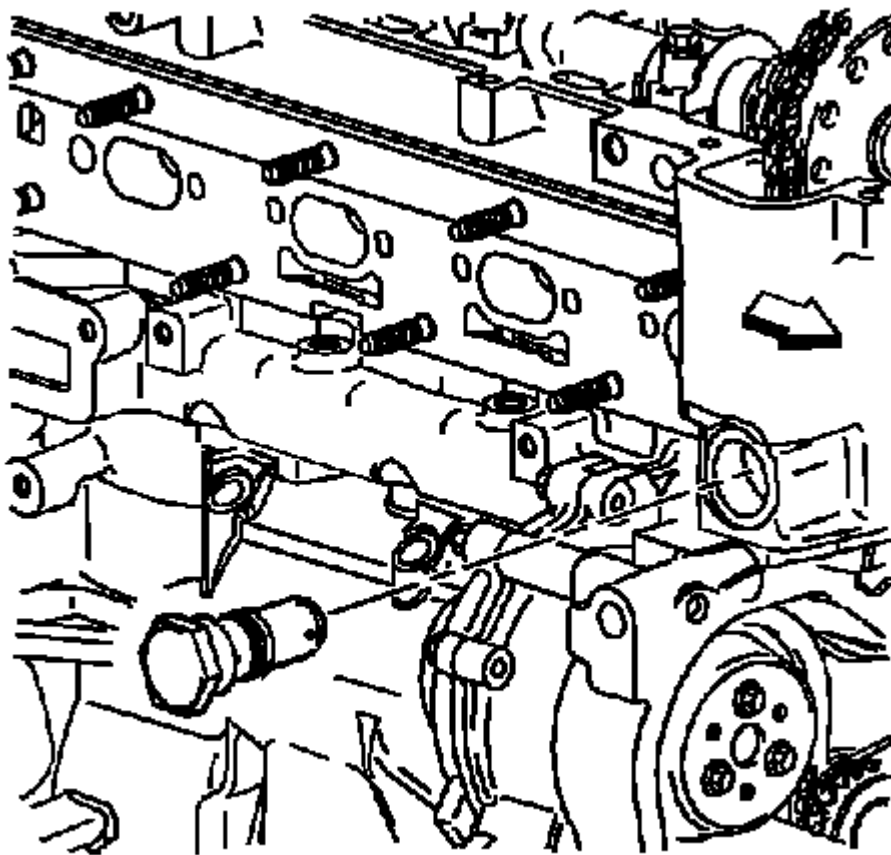


Fig. 188: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain tensioner.

Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

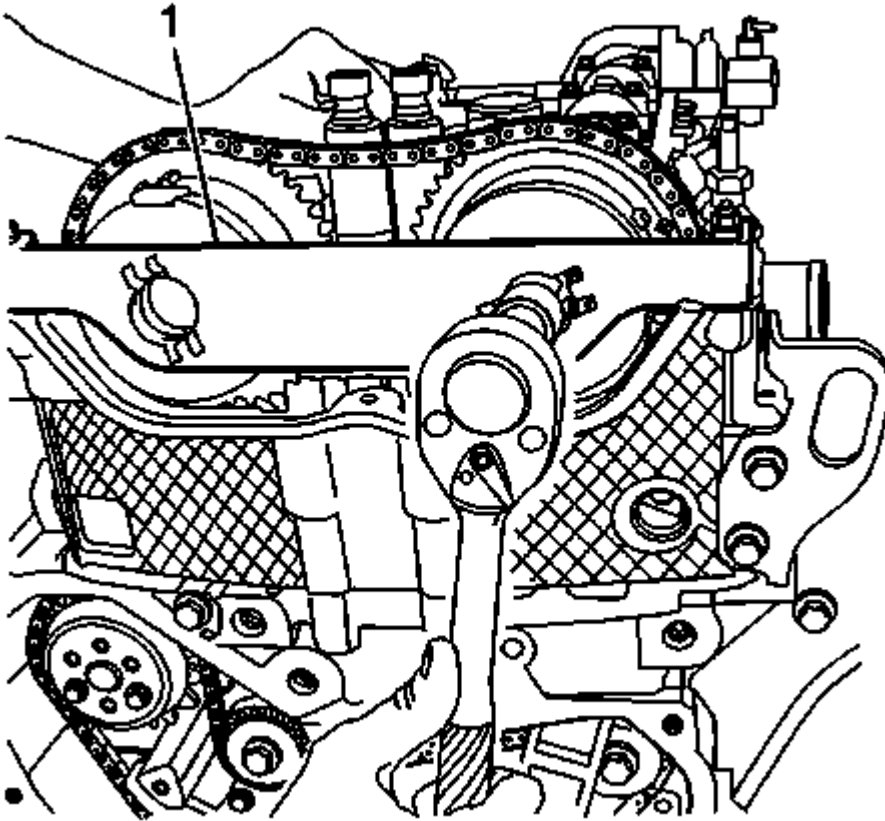


Fig. 189: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft actuator retainer (1).
7. Install the camshaft actuator retainer bolts.

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

8. Tighten the NEW camshaft actuator bolt.

Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059** . See **Special Tools**.

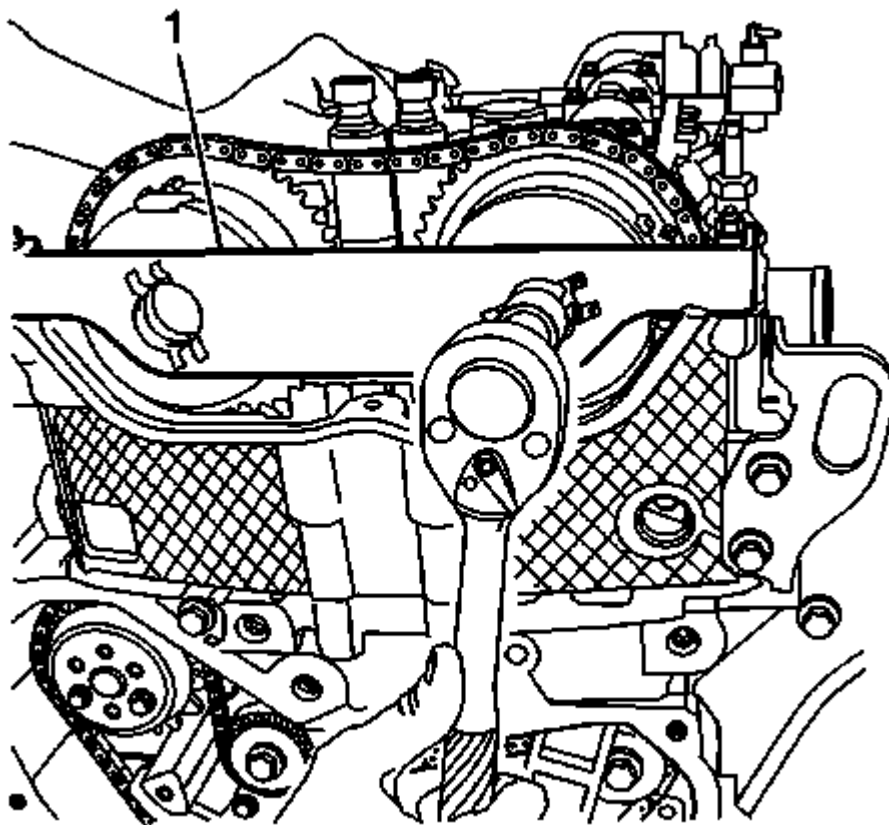


Fig. 190: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft actuator retainer **EN-48953** (1).
10. Release the tensioner by rotating the crankshaft balancer counter clockwise.

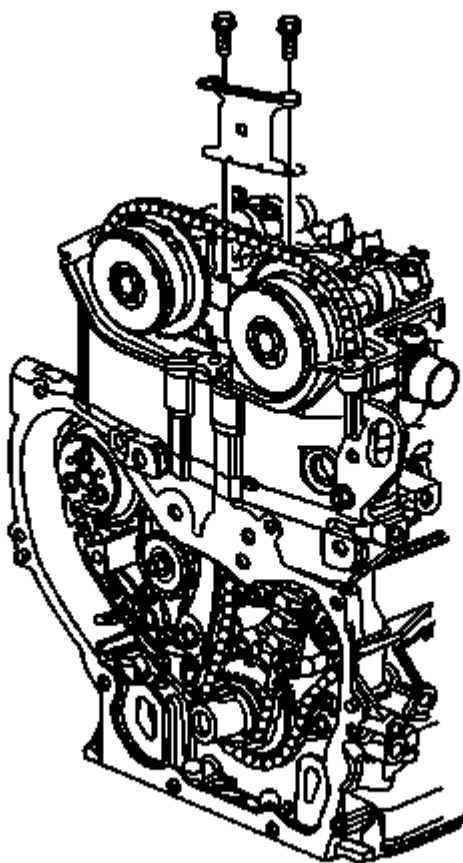


Fig. 191: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts.

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

12. Install the camshaft cover. Refer to Camshaft Cover Replacement .

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

Special Tools

- EN-48749
- EN-48953
- J 45059 Angle Meter. See Special Tools.

Removal Procedure

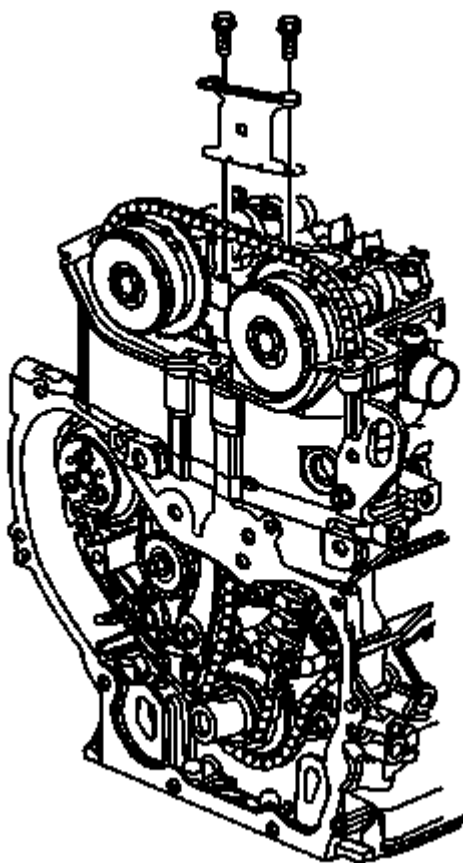


Fig. 192: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement** .
2. Remove the upper timing chain guide bolts and guide.

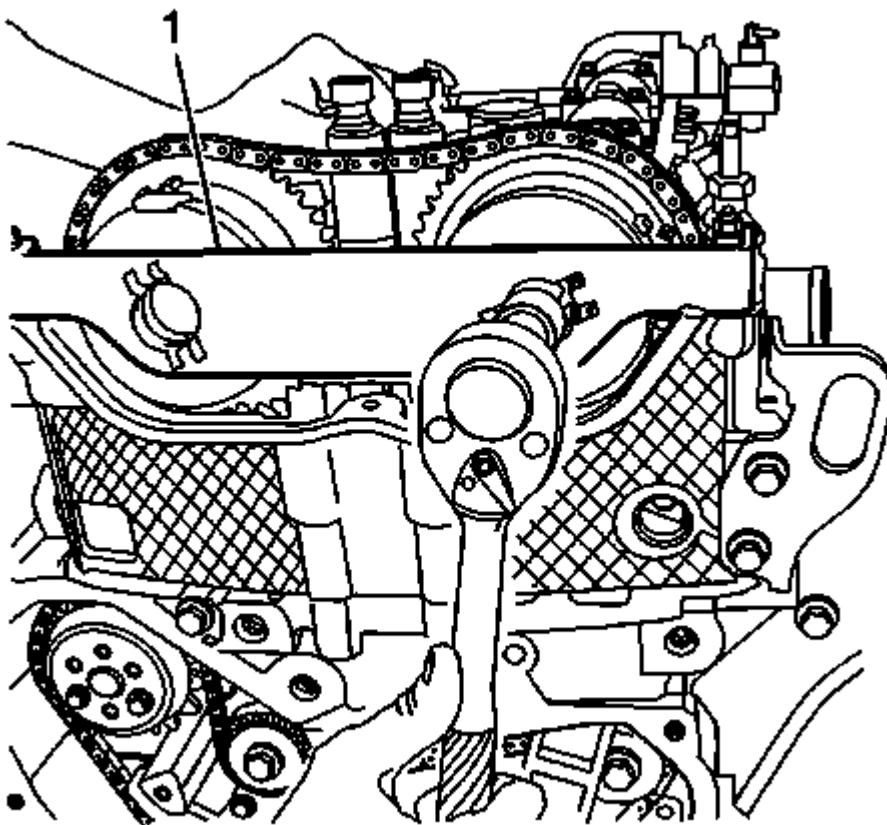


Fig. 193: Loosening/Tightening Camshaft Actuator Retainer Bolts
 Courtesy of GENERAL MOTORS CORP.

3. Install a 24 mm wrench onto the hex on the camshaft in order to rotate the camshafts clockwise and install the camshaft actuator retainer **EN-48953** (1).
4. Install the camshaft actuator retainer bolts.

NOTE: Refer to **Fastener Notice** .

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

5. Loosen, but do not remove the intake and exhaust camshaft actuator bolts.

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

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

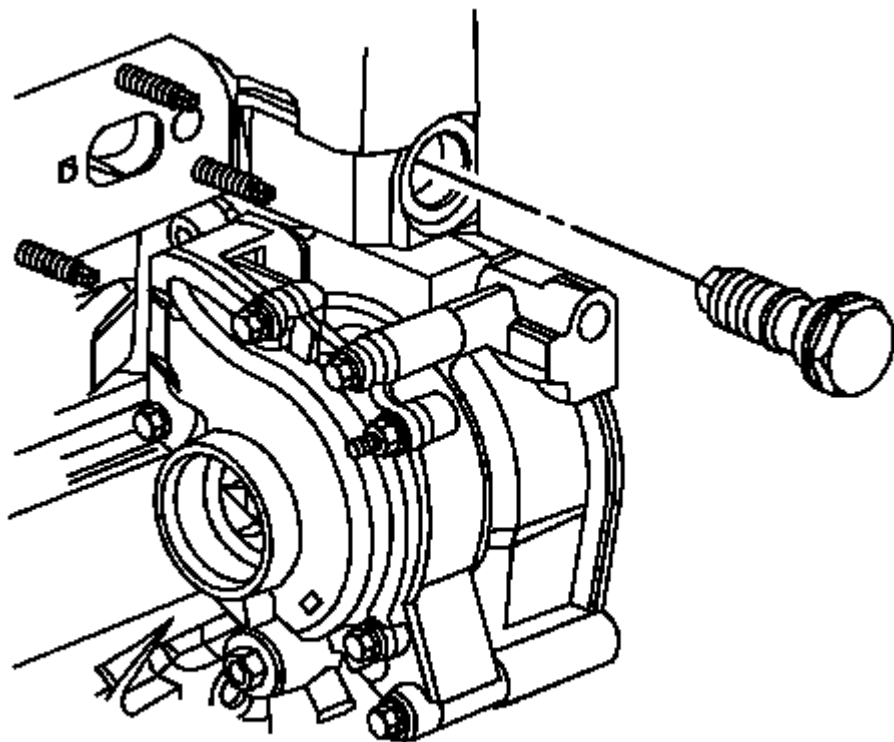


Fig. 194: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Remove the timing chain tensioner.

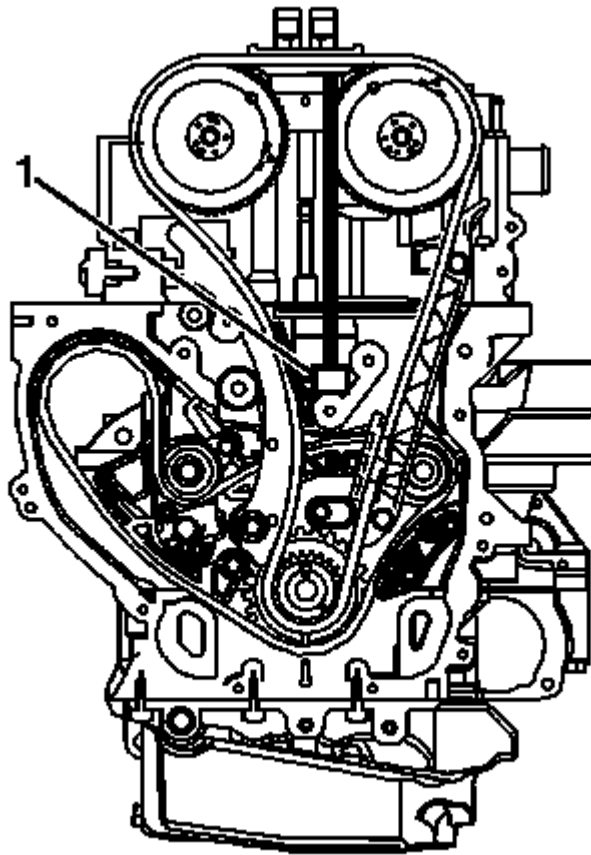


Fig. 195: View Of Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft actuators should not rotate during the removal or installation.

IMPORTANT: Ensure the tips of the EN-48749 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.

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

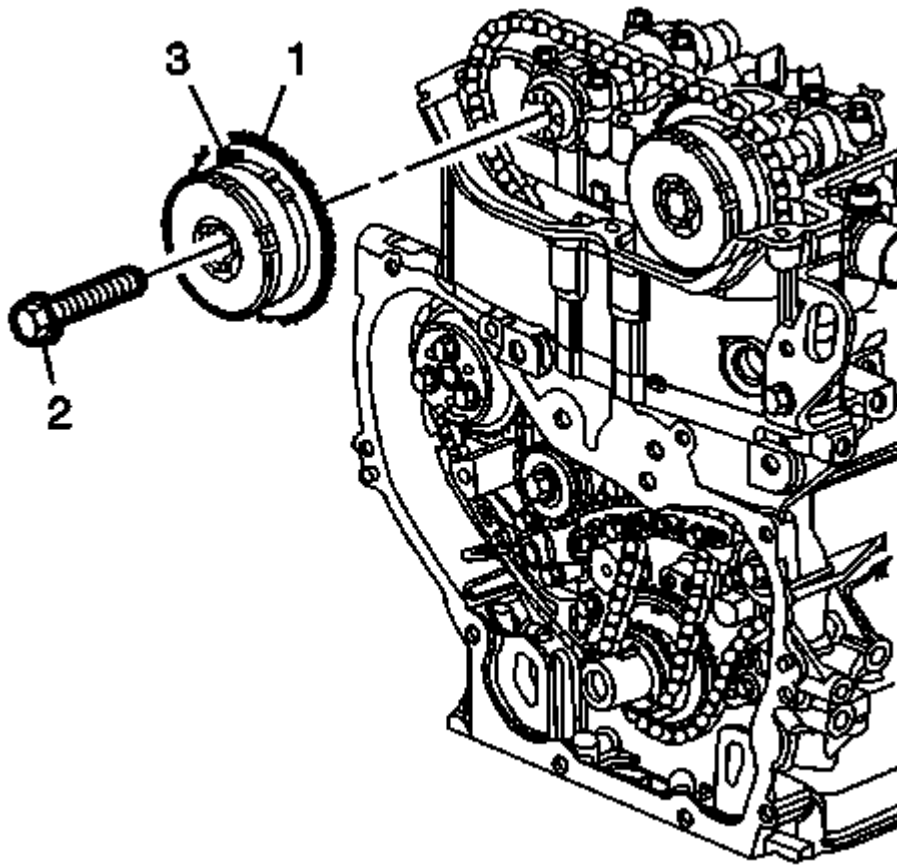


Fig. 196: Identifying Exhaust Camshaft Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

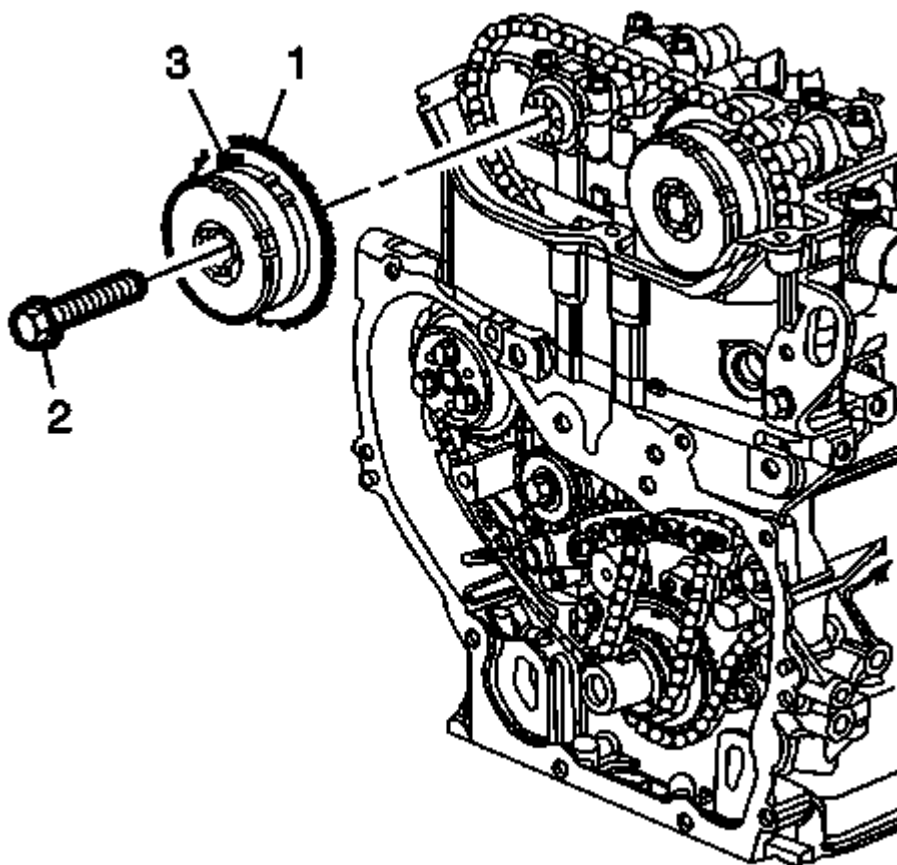


Fig. 197: Identifying Exhaust Camshaft Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: 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.

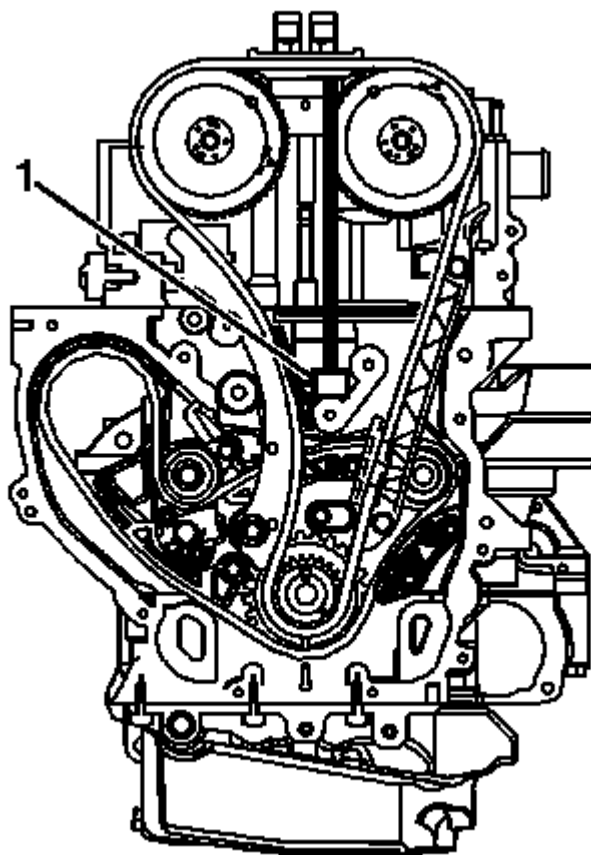


Fig. 198: View Of Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

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

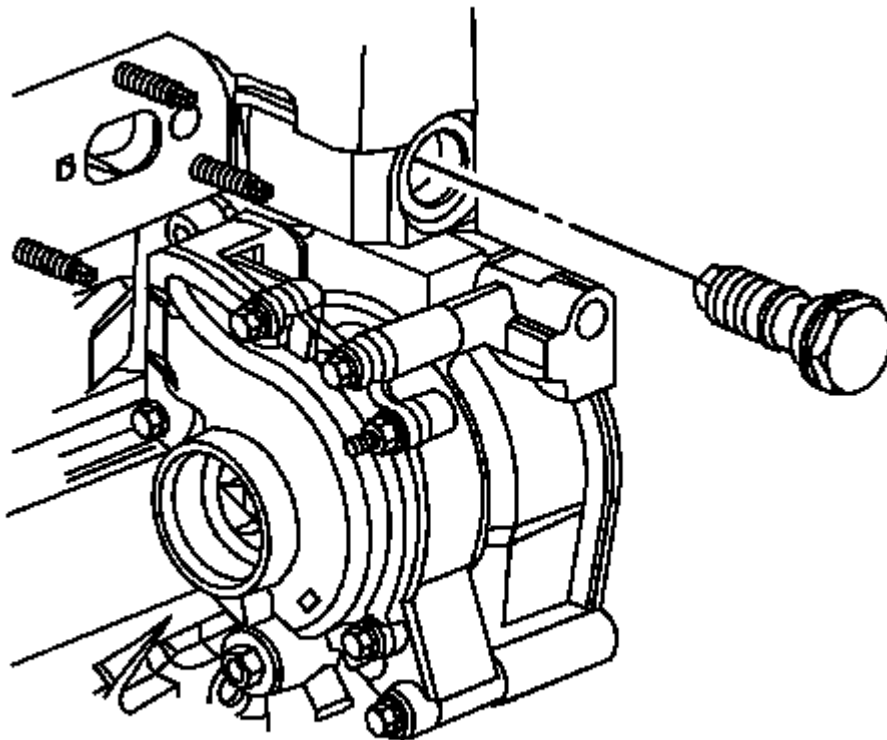


Fig. 199: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain tensioner.

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

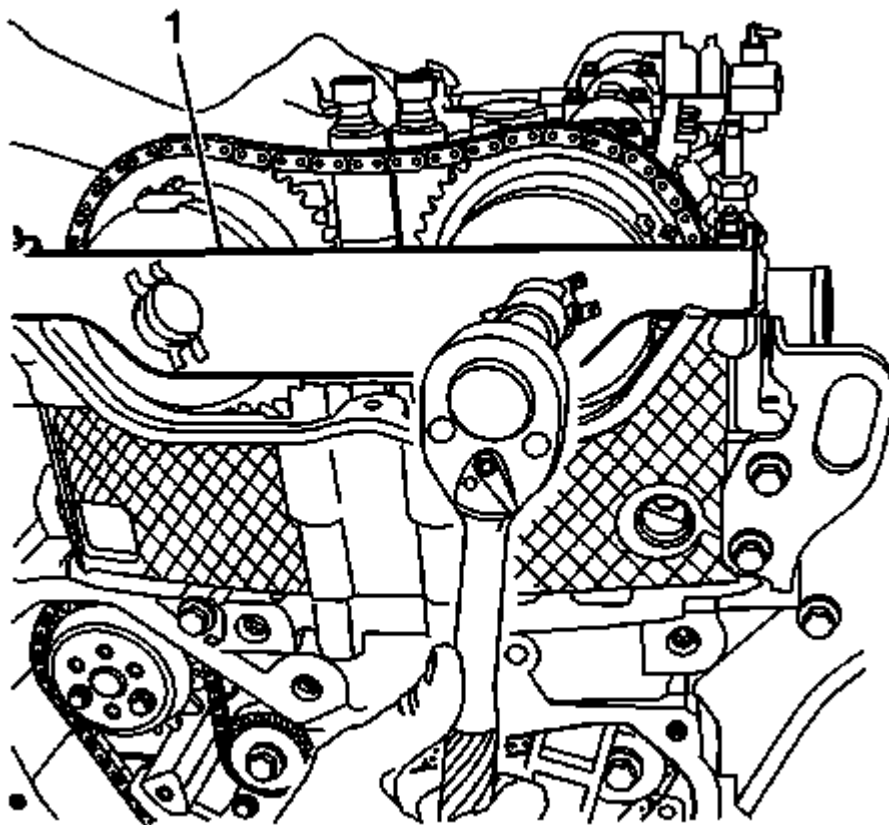


Fig. 200: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft actuator retainer (1).
7. Install the camshaft actuator retainer bolts.

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

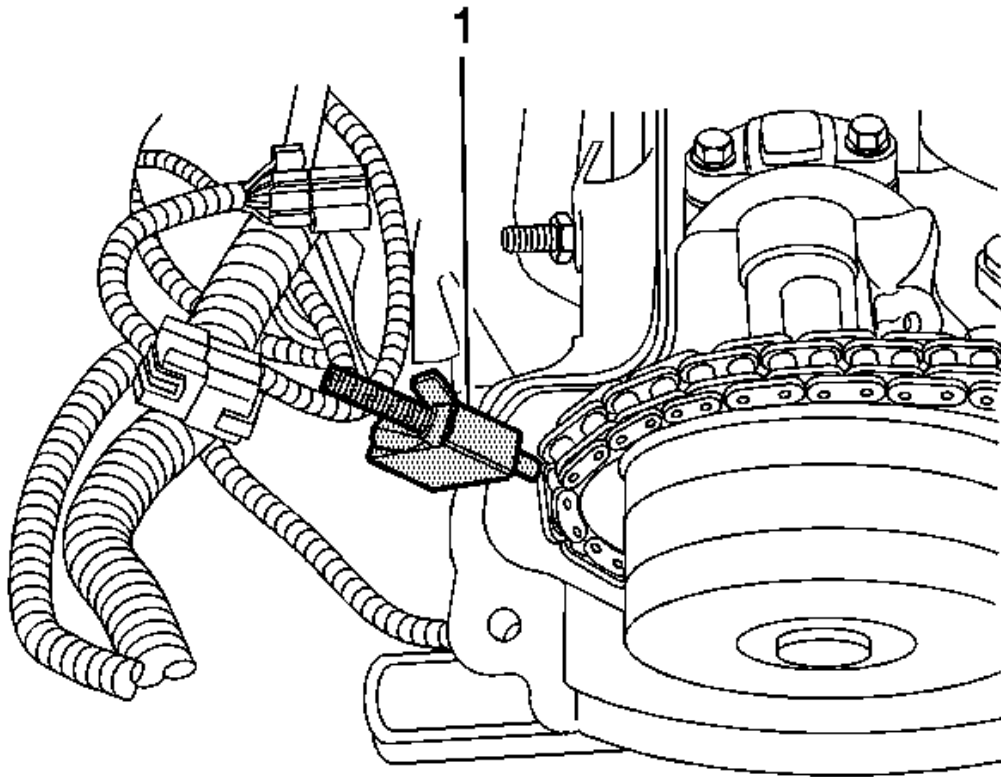


Fig. 201: Identifying J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

8. Remove the tool (1) from the exhaust camshaft side of the timing chain assembly.
9. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.
10. Tighten the NEW camshaft actuator bolt.

Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059** . See **Special Tools**.

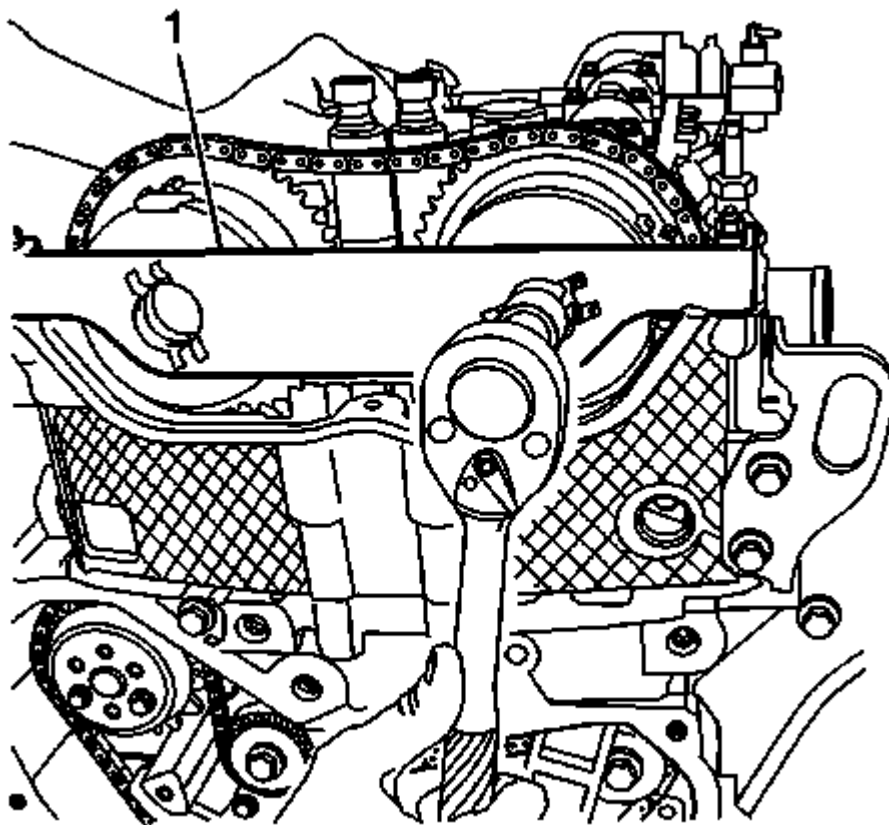


Fig. 202: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

11. Remove the camshaft actuator retainerEN-48953 (1).
12. Release the tensioner by rotating the crankshaft balancer counter clockwise.

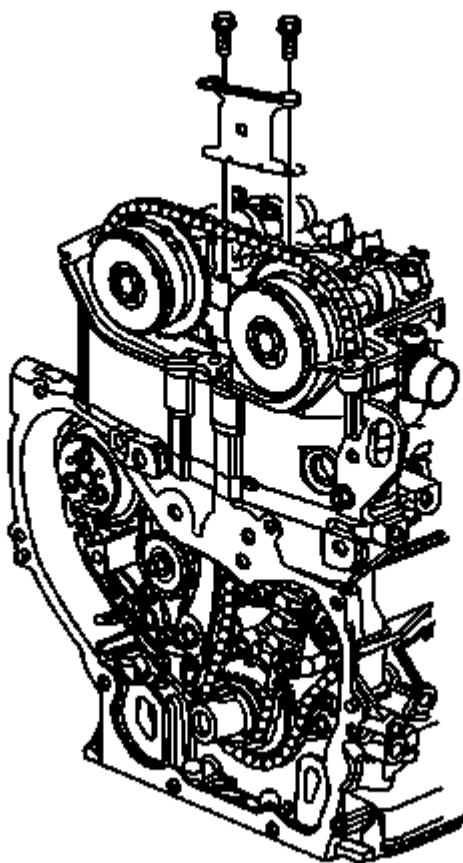


Fig. 203: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

13. Install the upper timing chain guide and bolts.

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

14. Install the camshaft cover. Refer to Camshaft Cover Replacement .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **J 43649** Valve Spring Compressor. See Special Tools.
- **J 36017** Valve Guide Seal Remover. See Special Tools.
- **J 43653** Flywheel Holding Tool

Removal Procedure

IMPORTANT: Prevent the crankshaft from rotating clockwise or counterclockwise before using compressed air in the cylinder. Rotation of the crankshaft

may cause damage to the J 43653 .

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 Motor Replacement** .
3. Install the J 43653 .
4. Remove the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.

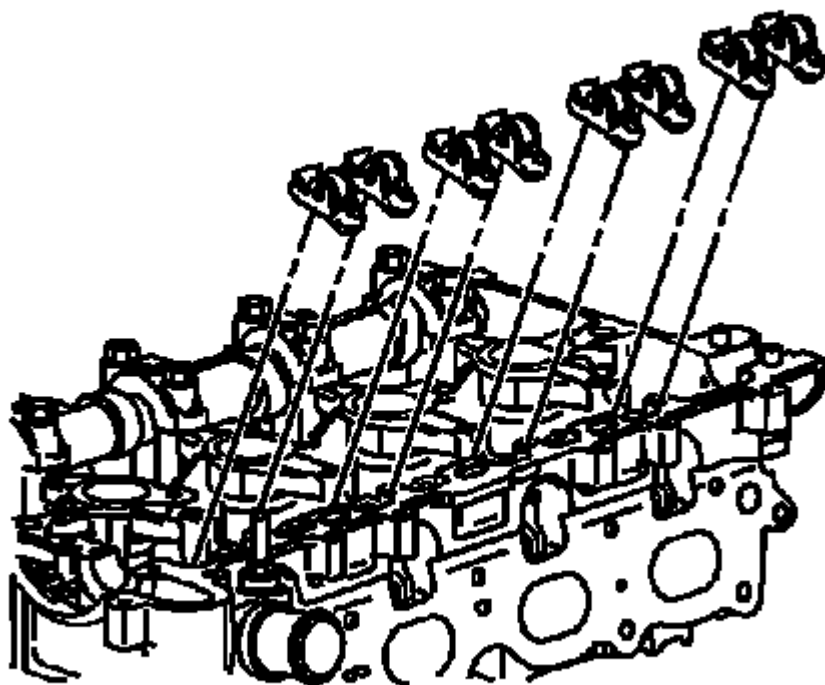


Fig. 204: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft roller followers.

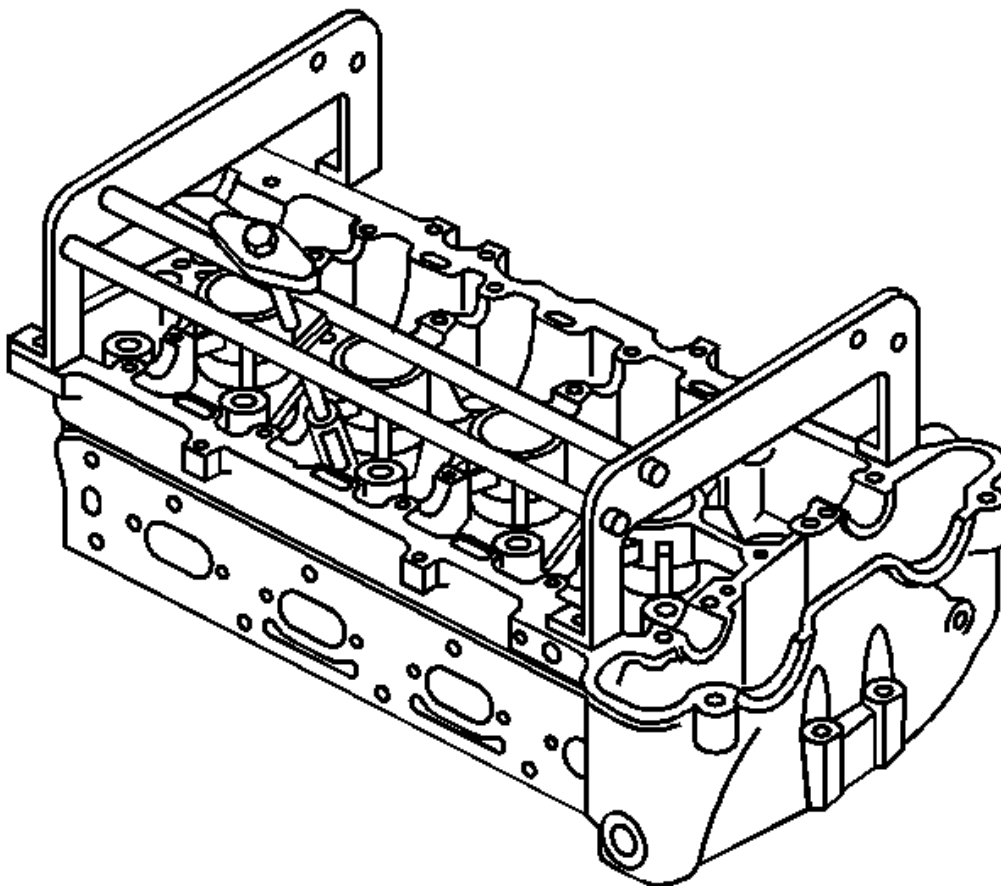


Fig. 205: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 43649** to the cylinder head. See **Special Tools**.
7. Remove the spark plugs. Refer to **Spark Plug Replacement**.

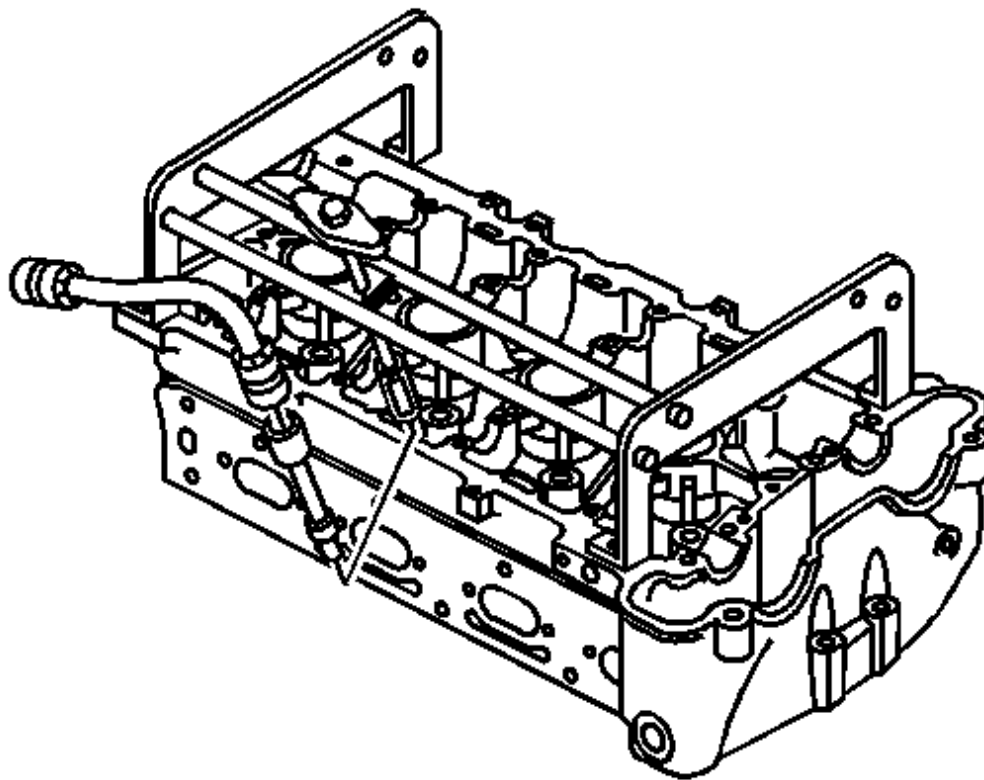


Fig. 206: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

8. Install an air hose adaptor into the spark plug hole.
9. Pressurize the cylinder to 690 kPa (100 psi).
10. Compress the valve spring.
11. Remove the valve spring keepers.
12. Remove the valve spring.

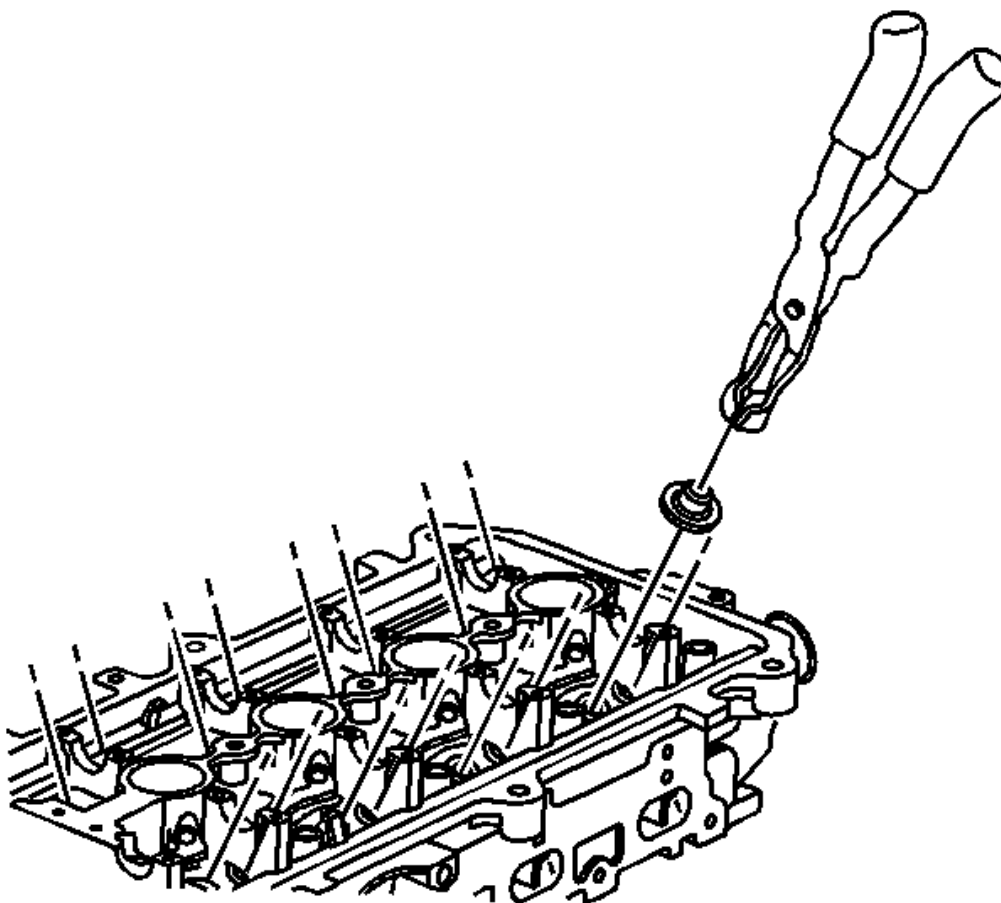


Fig. 207: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

13. Using the **J 36017** , remove the valve seal. See **Special Tools**.

Installation Procedure

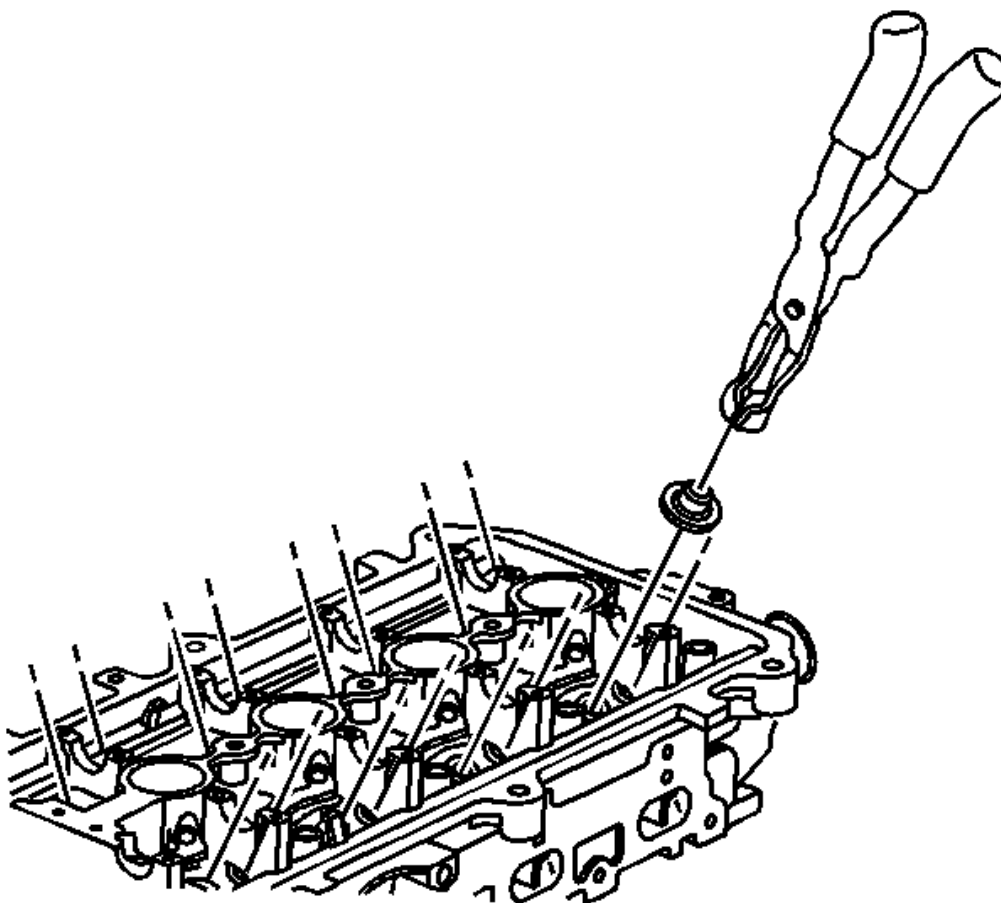


Fig. 208: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 36017** , install the valve seal. See **Special Tools**.

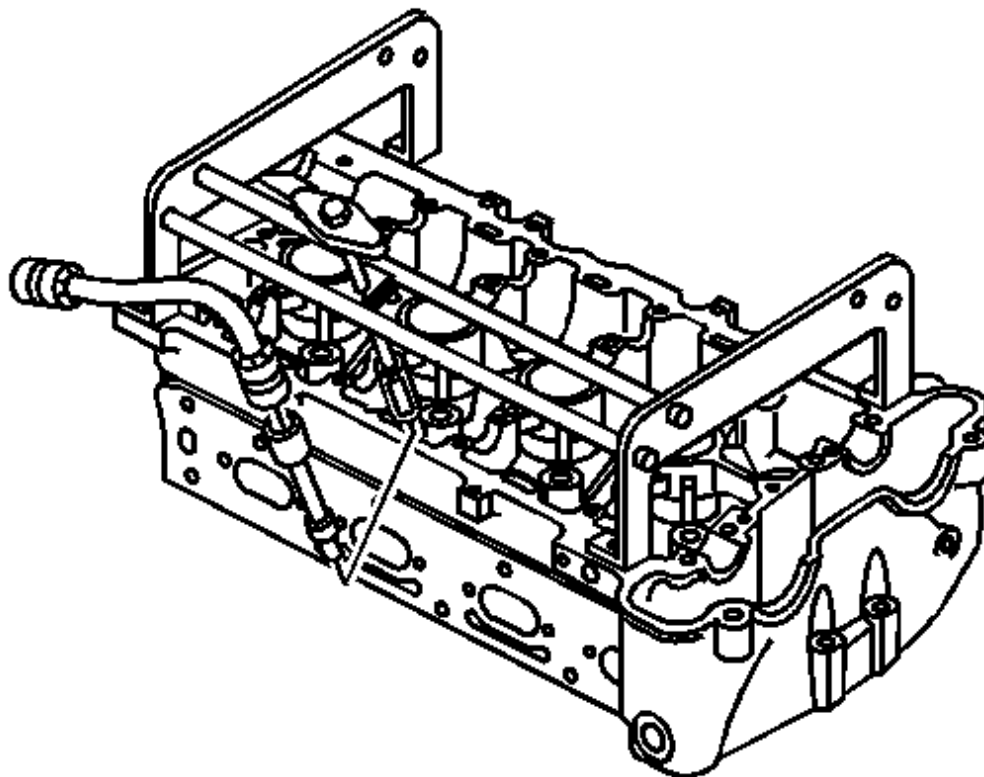


Fig. 209: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring.
3. Compress the valve spring.
4. Install the valve spring keepers.
5. Remove the air hose adaptor from the spark plug hole.

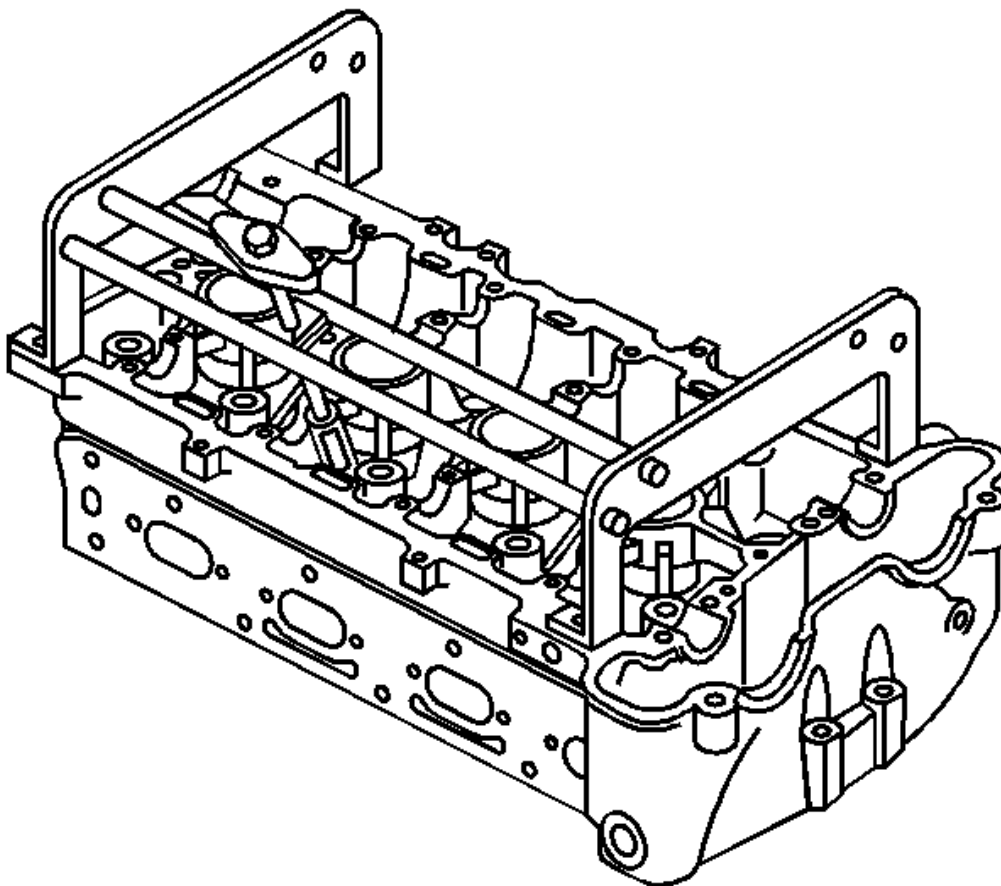


Fig. 210: View Of Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

6. Remove the **J 43649** from the cylinder head. See **Special Tools**.
7. Install the spark plugs. Refer to **Spark Plug Replacement**.

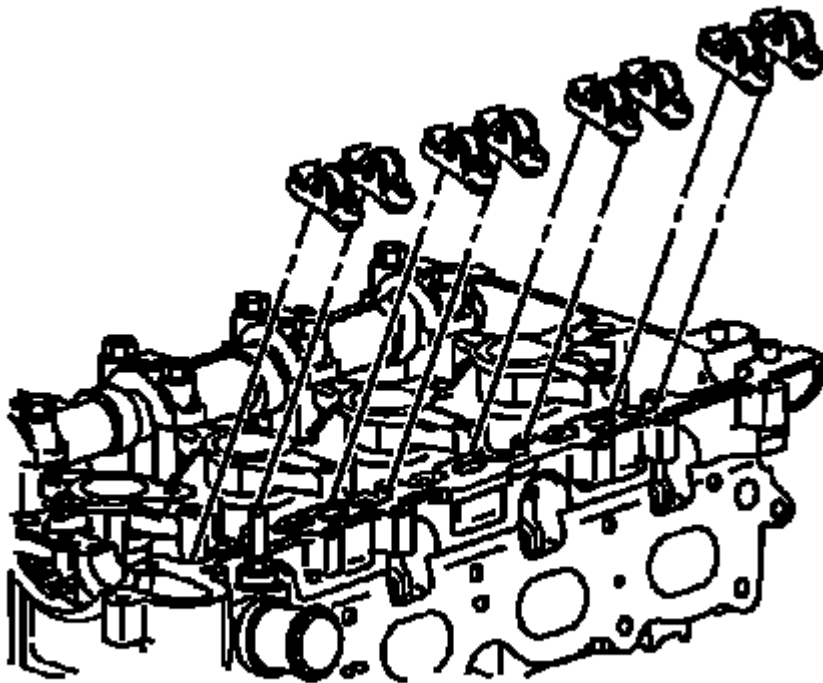


Fig. 211: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers.
9. Install the camshaft. Refer to Intake Camshaft and Valve Lifter Replacement or Exhaust Camshaft and Valve Lifter Replacement.
10. If removed, install the starter. Refer to Starter Motor Replacement.
11. If used, remove the **J 43653**.

CYLINDER HEAD REPLACEMENT

Special Tools

- **J 38185** Hose Clamp Pliers
- **J 45059** Angle Meter. See Special Tools.
- **EN-48953** Camshaft Actuator Locking Tool
- **EN 46101** Spark Plug Tube Seal Guide

Removal Procedure

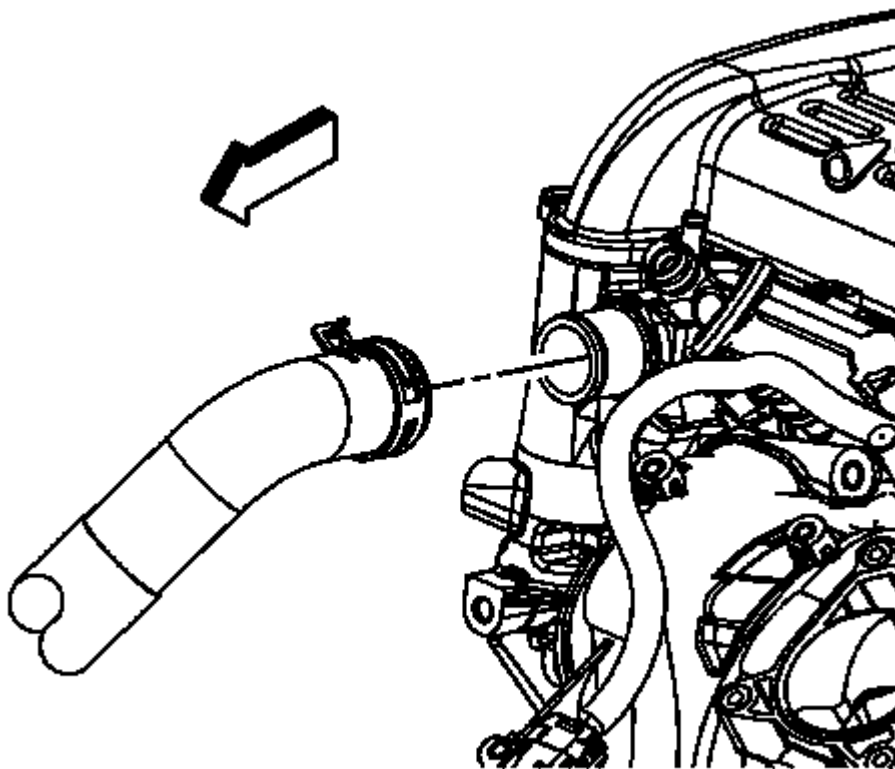


Fig. 212: View Of Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to Cooling System Draining and Filling (GE 47716 Fill) or Cooling System Draining and Filling (Static Fill LNF).
2. Remove the exhaust manifold. Refer to Exhaust Manifold Replacement (LNF).
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.

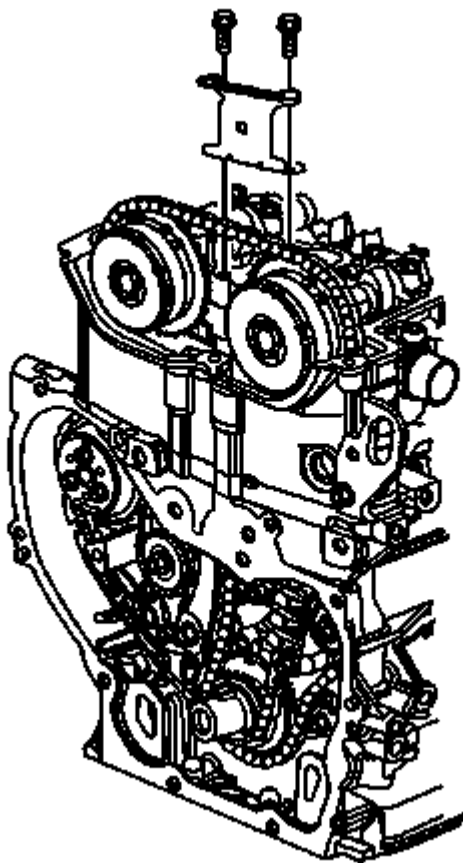


Fig. 213: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

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

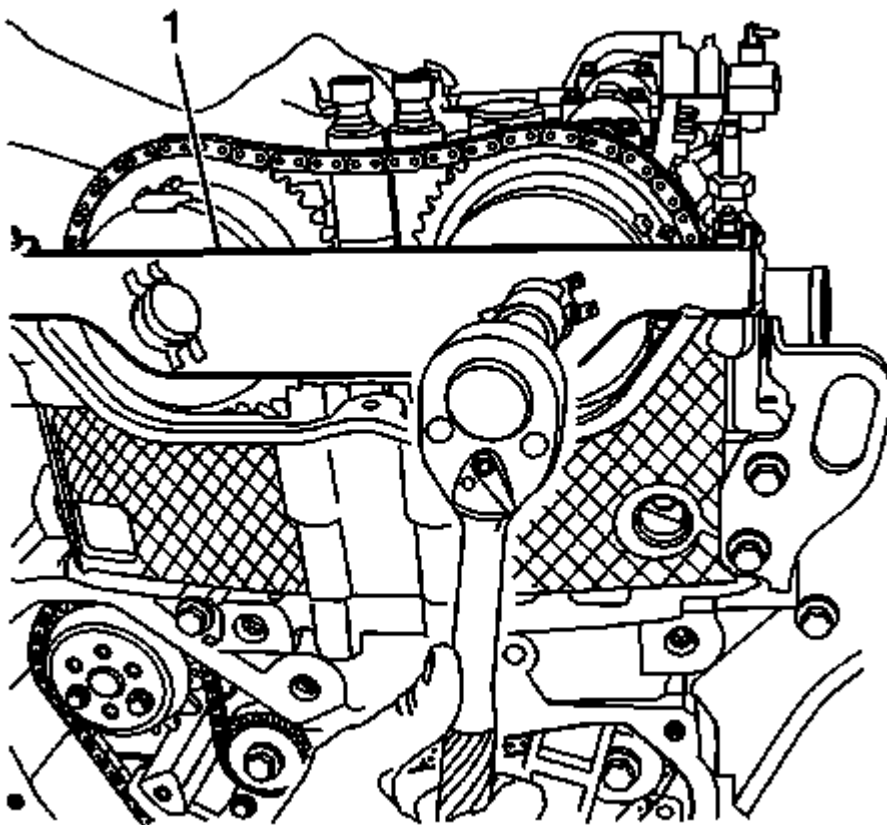


Fig. 214: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the intake camshaft actuator is moving independently of the camshaft, this means the camshaft is not locked to the actuator. Rotate the camshaft counter-clockwise while the holding tool is installed and this will lock the camshaft to the actuator.

IMPORTANT: 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.
12. Install the camshaft actuator retainer bolts.

NOTE: Refer to **Fastener Notice** .

Tighten: Tighten the bolts 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 .

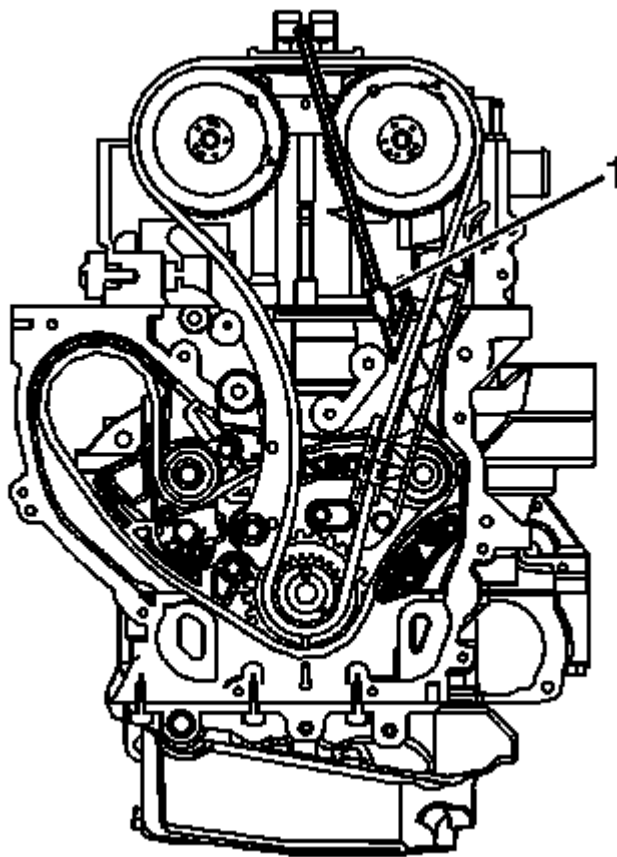


Fig. 215: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the tips of the EN-48749 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.

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

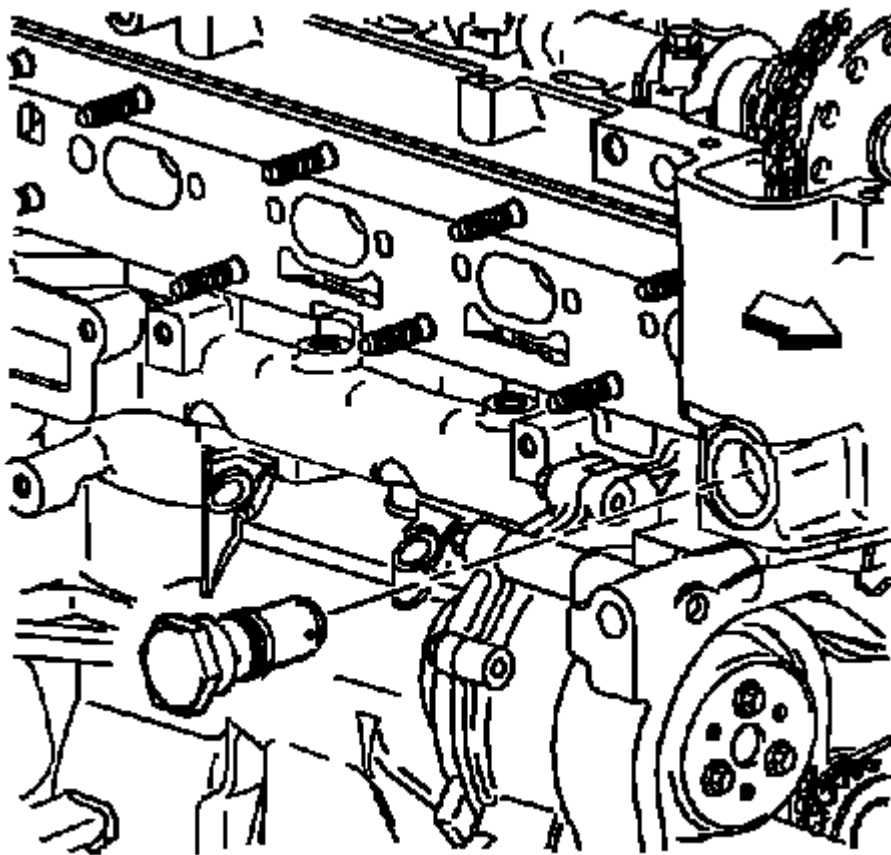


Fig. 216: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

18. Remove the timing chain tensioner.

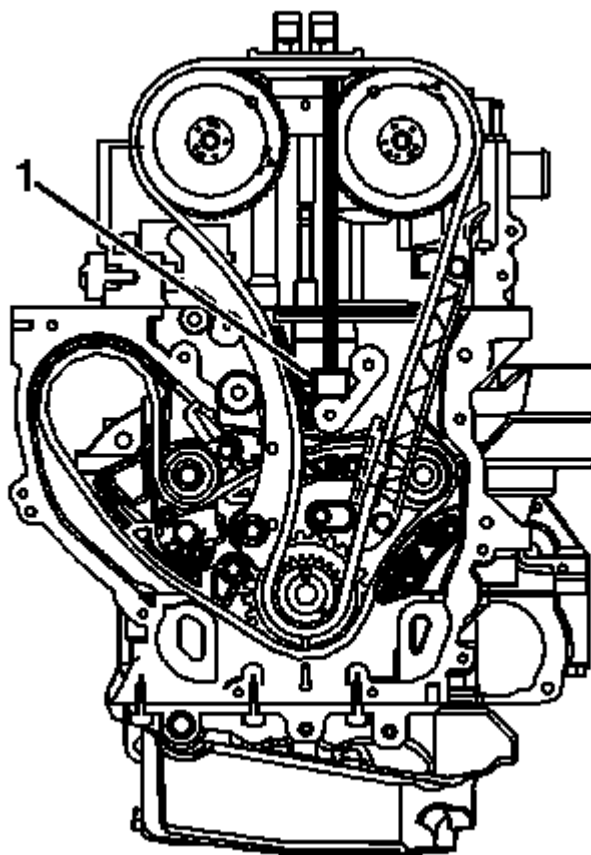


Fig. 217: View Of Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

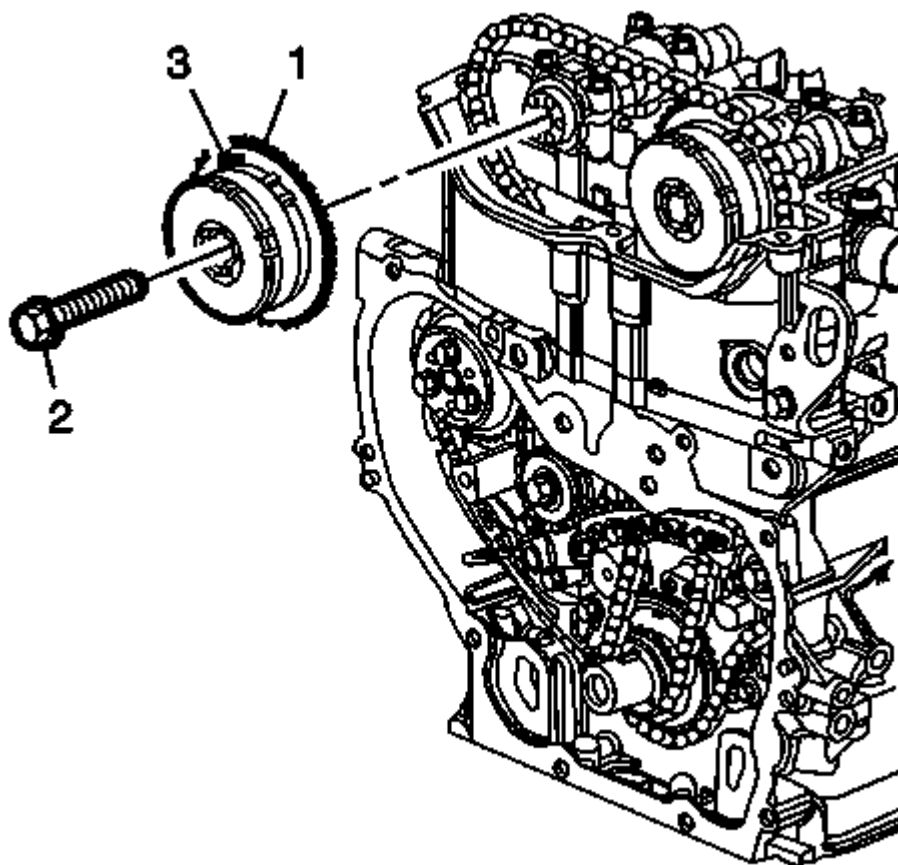


Fig. 218: Identifying Exhaust Camshaft Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

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

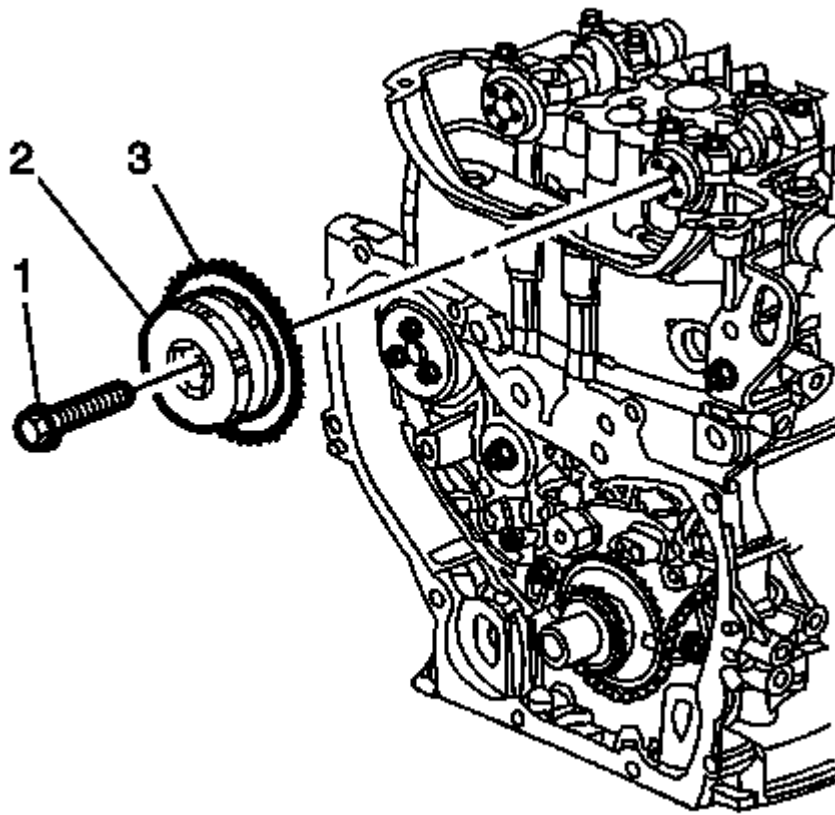


Fig. 219: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

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.

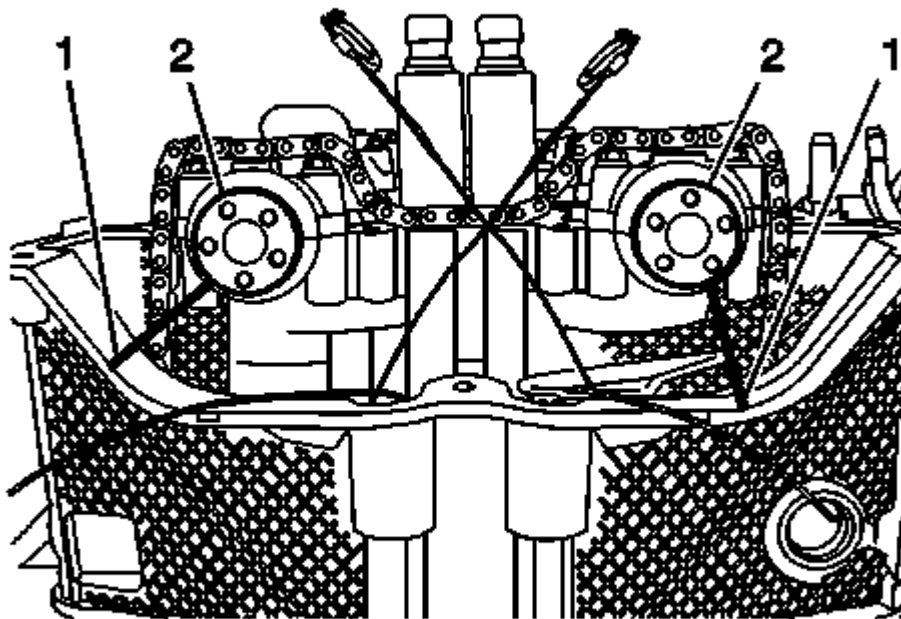


Fig. 220: Aligning Mark On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

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

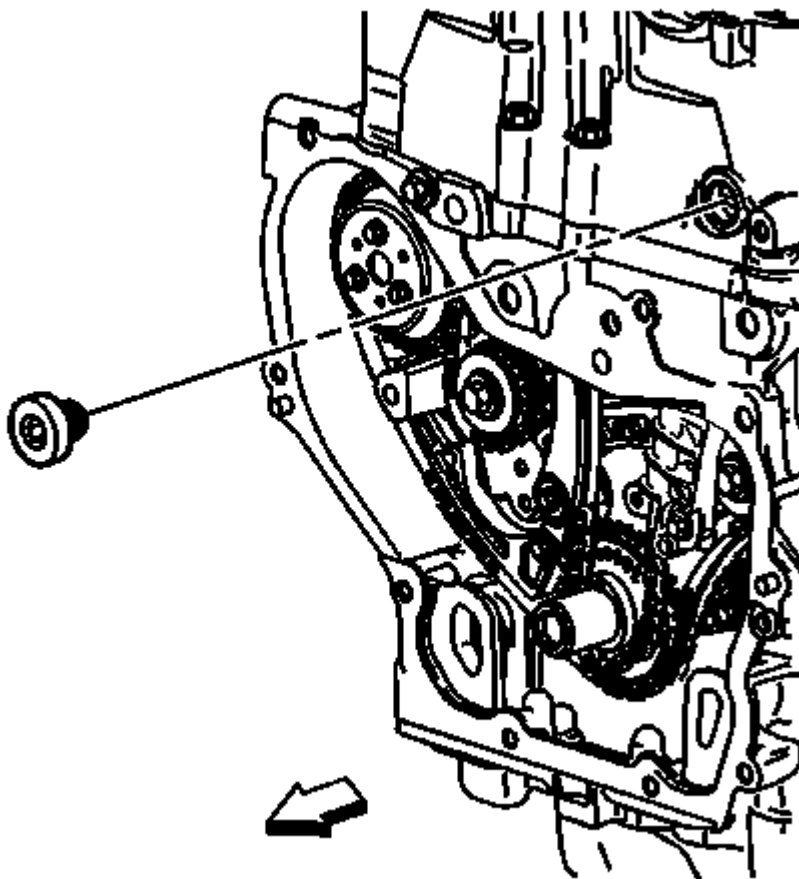


Fig. 221: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

24. Remove the fixed timing chain guide access plug.

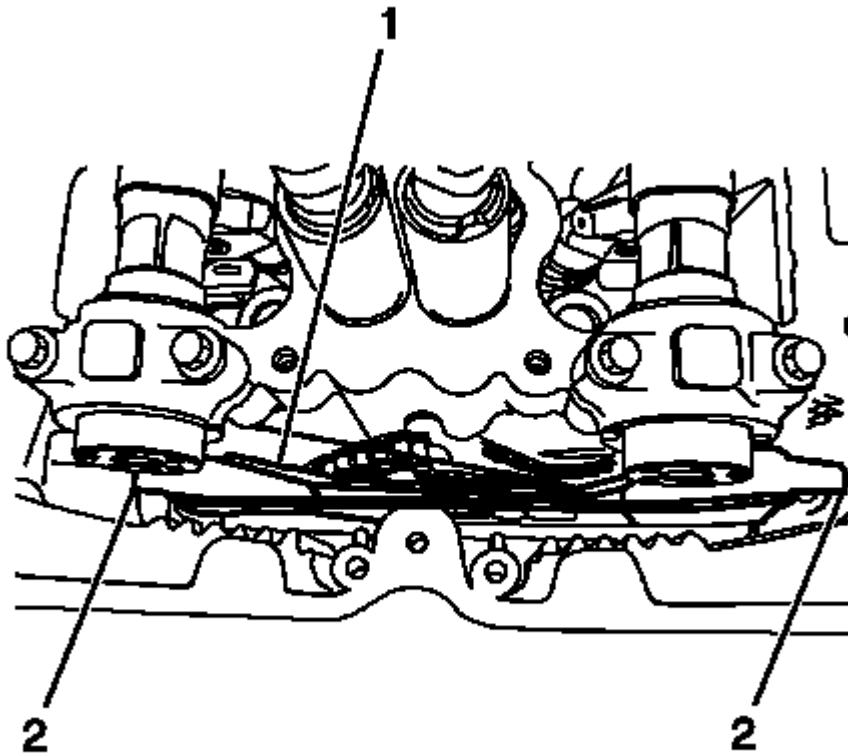


Fig. 222: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

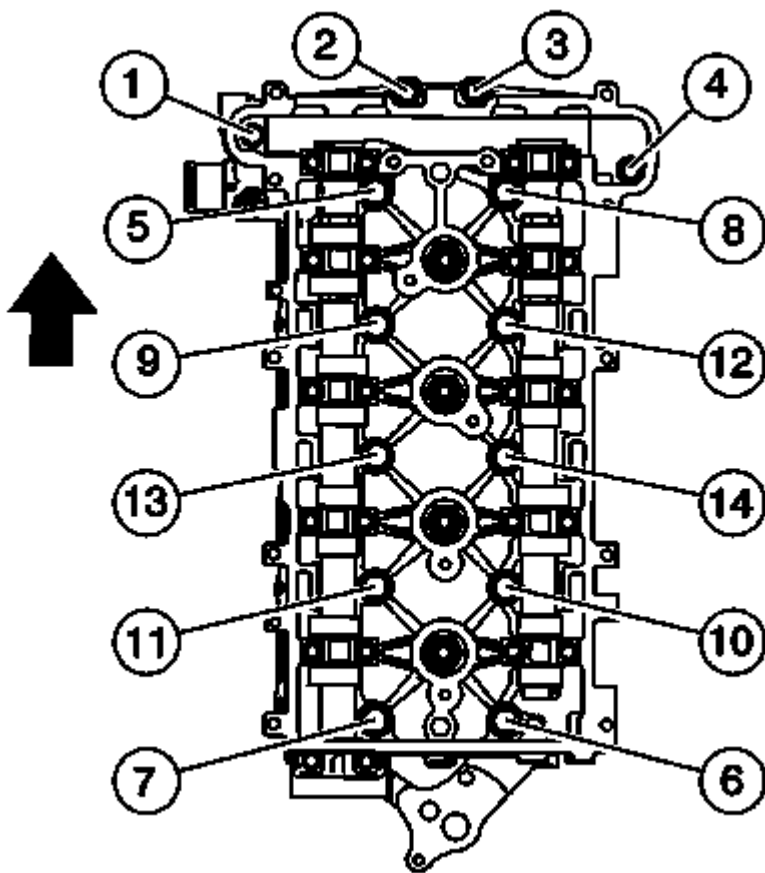


Fig. 223: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

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

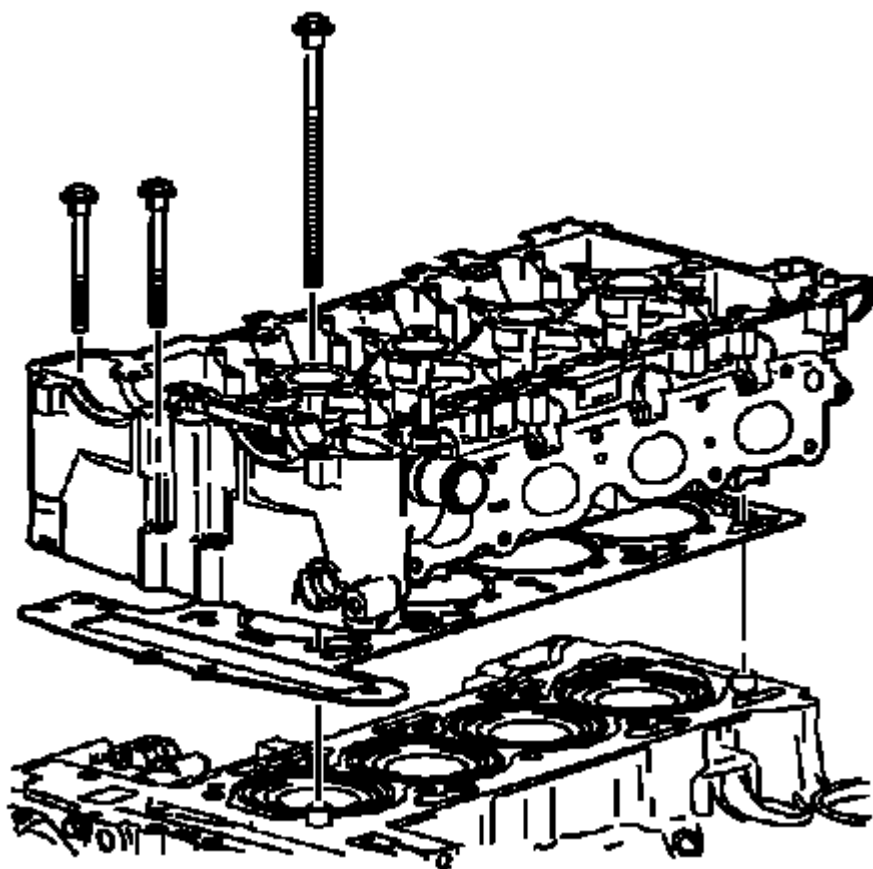


Fig. 224: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: 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.

IMPORTANT: 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.

IMPORTANT: 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

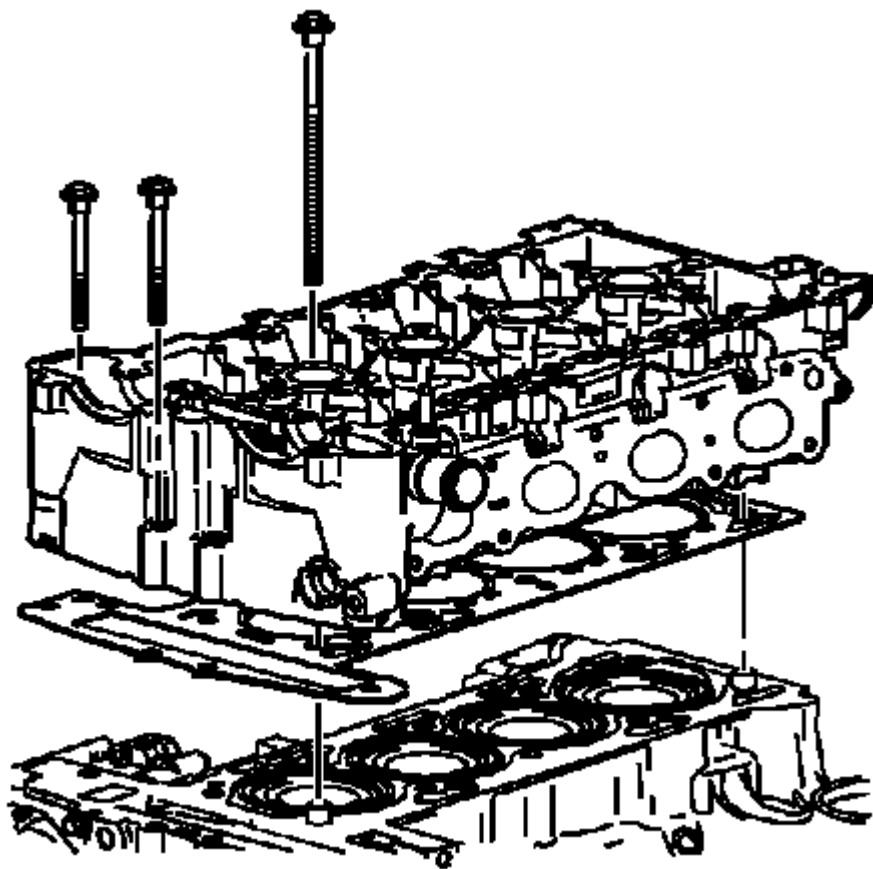


Fig. 225: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use any sealing material.

1. Install the cylinder head gasket.

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

NOTE: Refer to Fastener Notice .

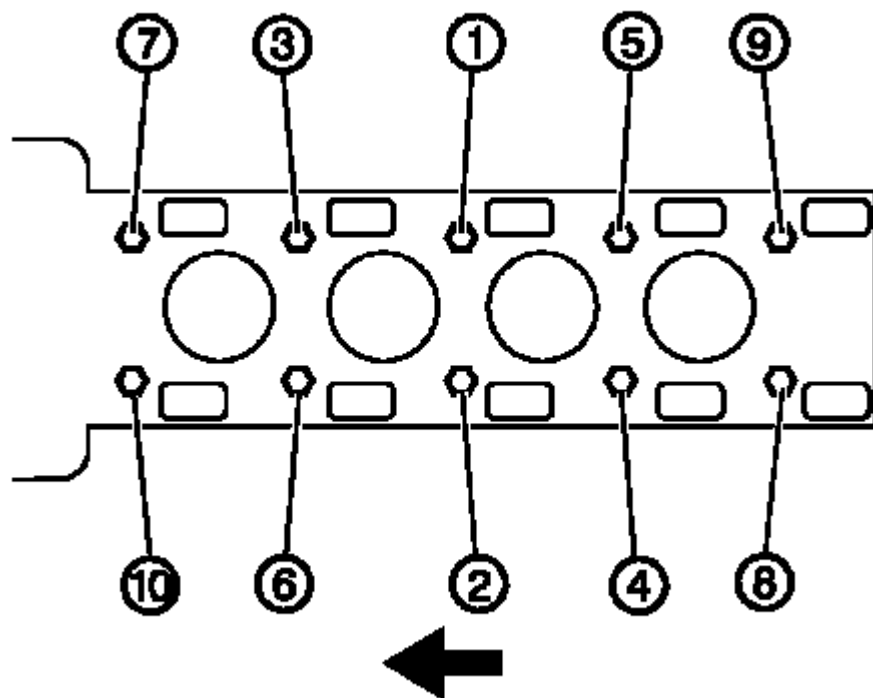


Fig. 226: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown.

Tighten: Tighten the bolts to 30 N.m (22 lb ft) plus an additional 155 degrees using the **J 45059** . See Special Tools.

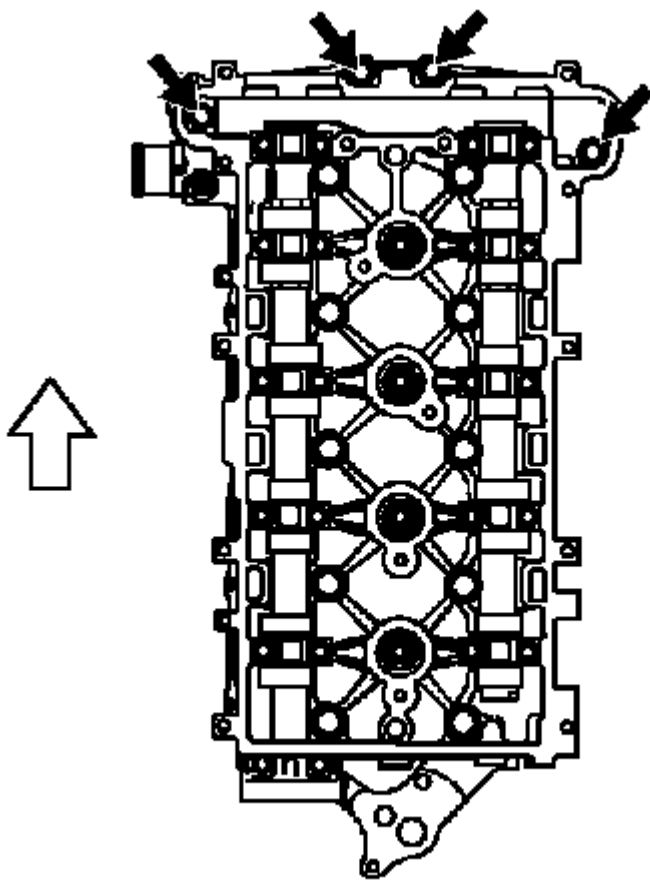


Fig. 227: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts.

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

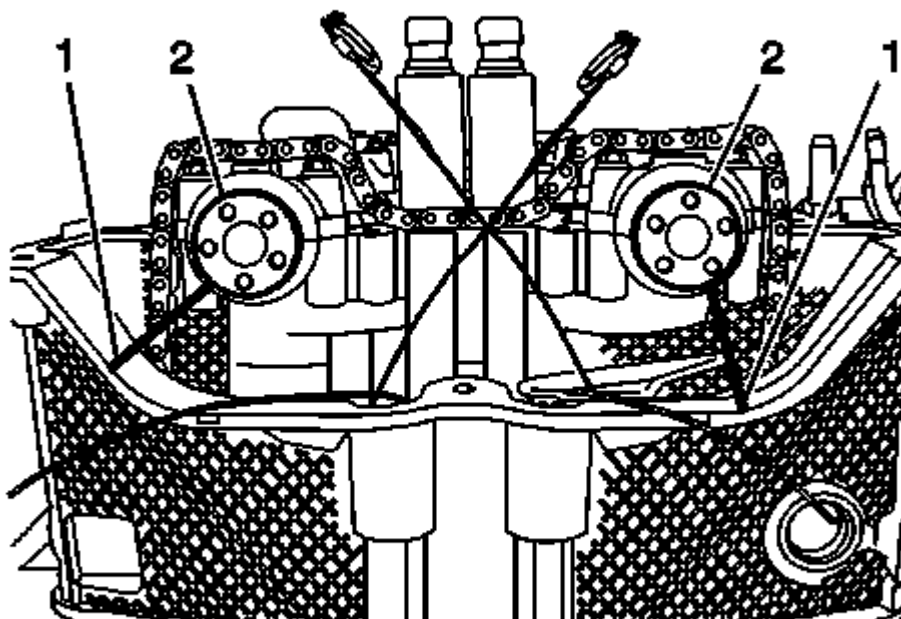


Fig. 228: Aligning Mark On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

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

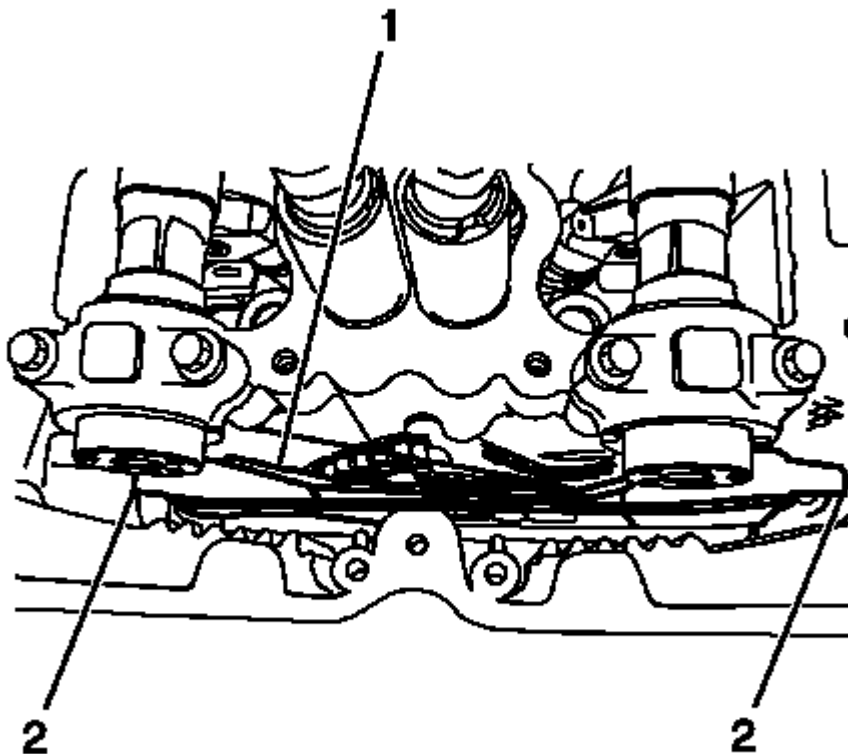


Fig. 229: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

7. Remove the rubber band (1) from around the top of the upper timing chain guides (2).

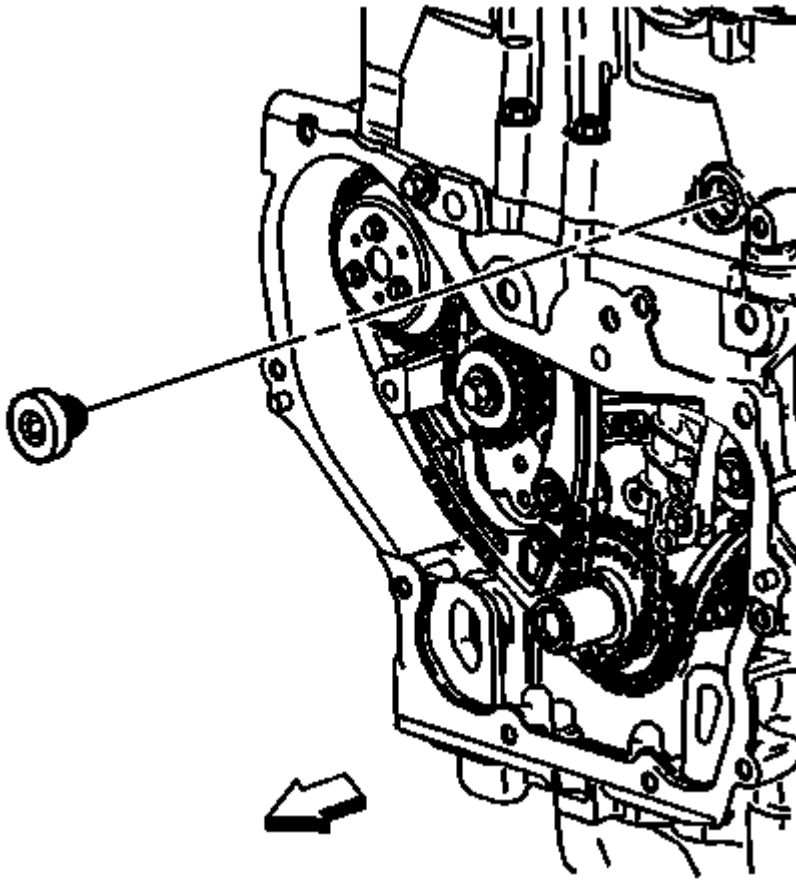


Fig. 230: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

8. 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.
9. Install the fixed timing chain guide access plug.

Tighten: Tighten the chain guide plug to 90 N.m (59 lb ft).

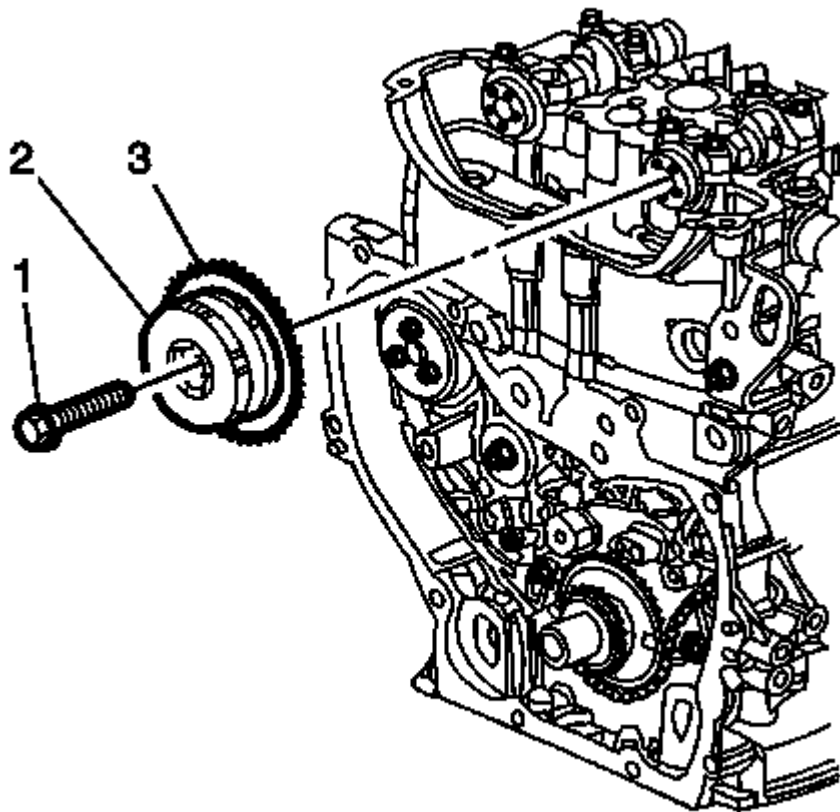


Fig. 231: Identifying Timing Chain & Camshaft Position Actuator
 Courtesy of GENERAL MOTORS CORP.

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

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

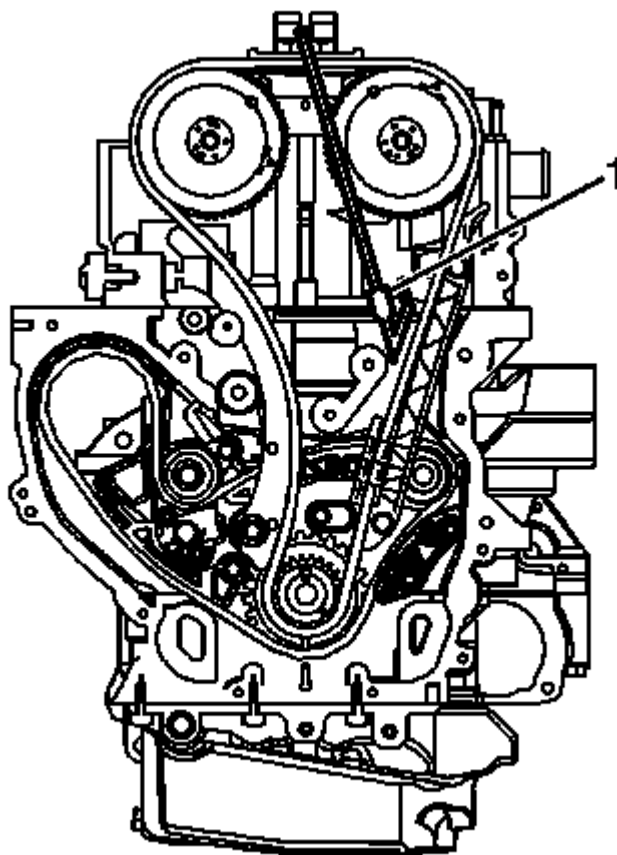


Fig. 232: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

13. Remove the timing chain retention tool EN-48749 (1) from the intake side of the timing chain.

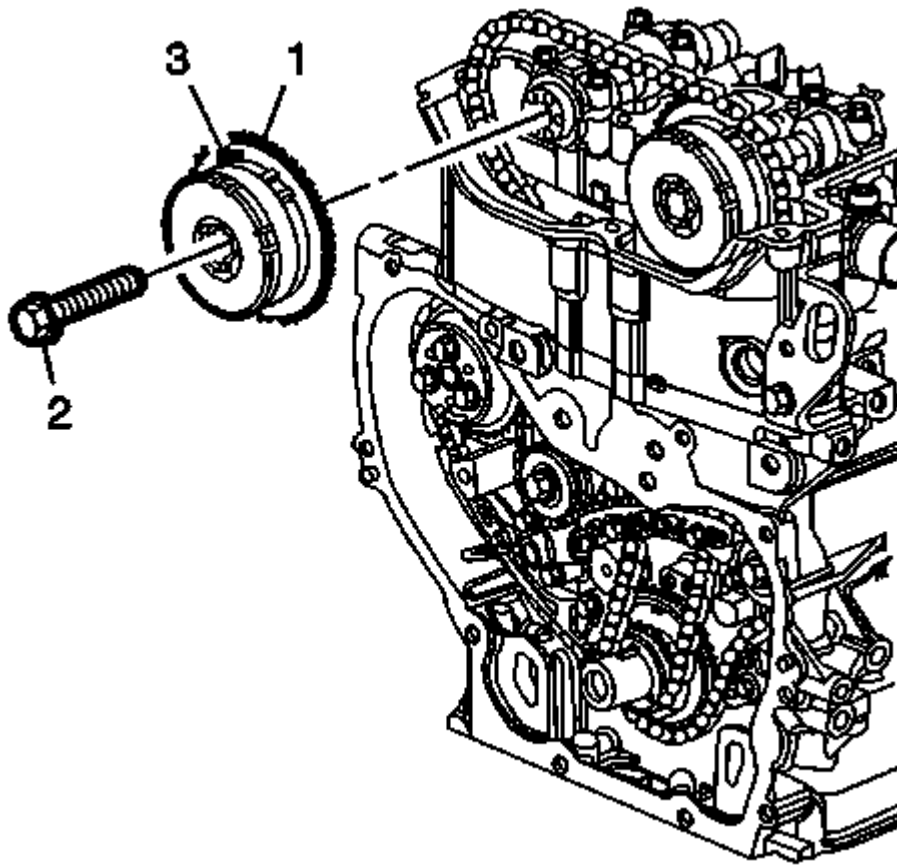


Fig. 233: Identifying Exhaust Camshaft Actuator & Bolt
Courtesy of GENERAL MOTORS CORP.

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

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

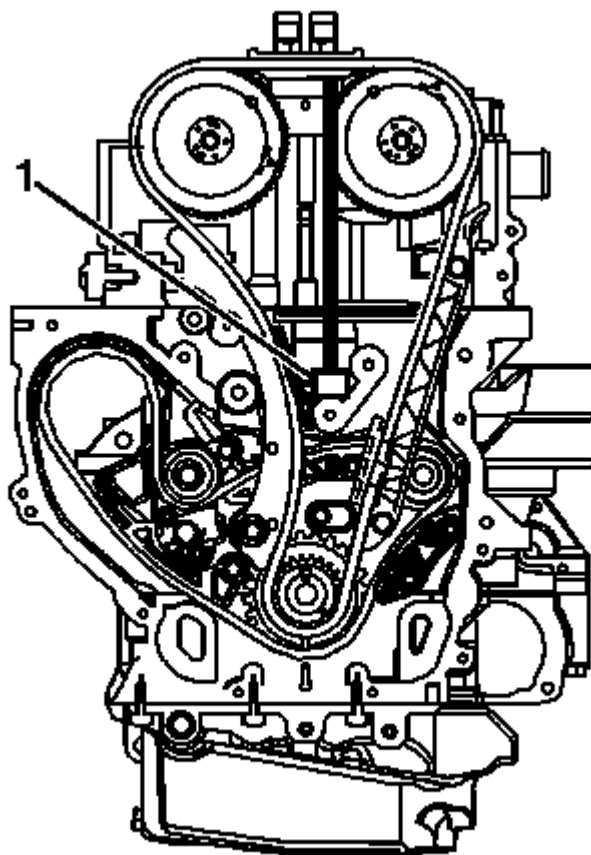


Fig. 234: View Of Timing Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

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

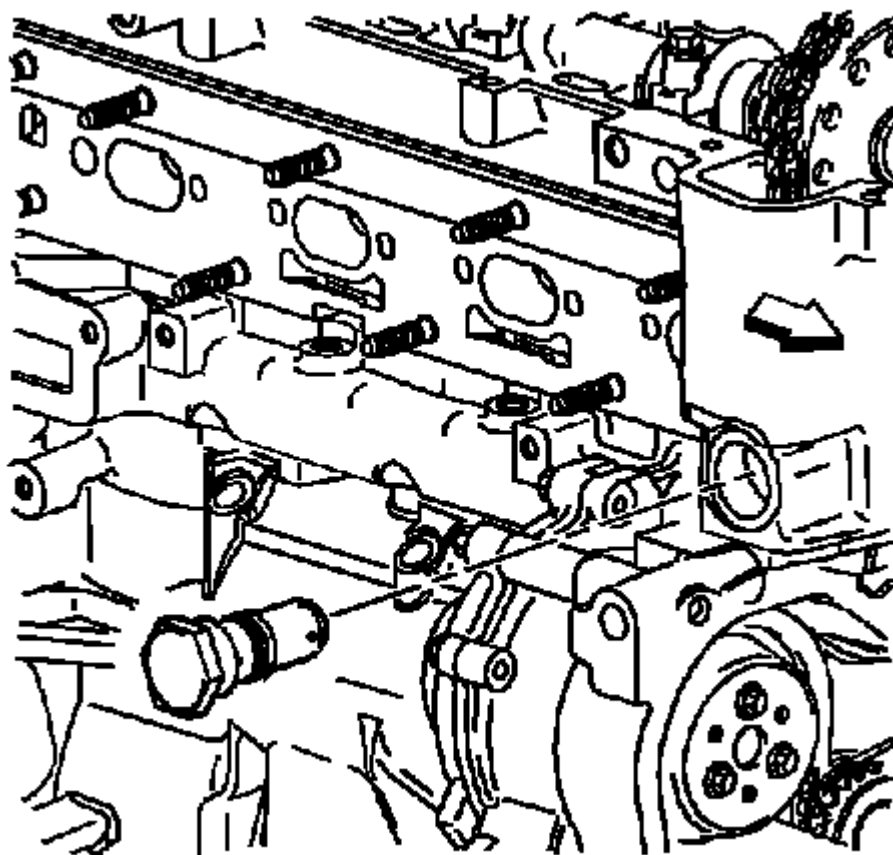


Fig. 235: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

18. Install the timing chain tensioner.

Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

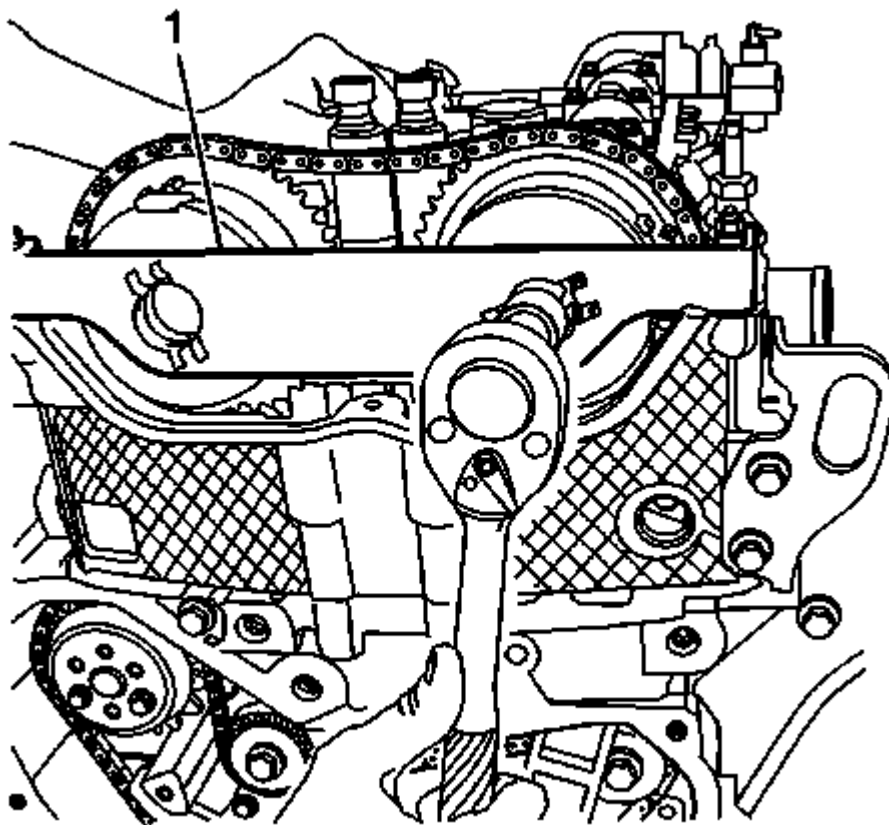


Fig. 236: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

19. Install the **EN-48953** (1) to the actuators.
20. Install the camshaft actuator locking tool bolts.

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

21. Tighten the NEW camshaft actuator bolt.

Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059** . See **Special Tools**.

22. Remove the camshaft actuator locking tool, **EN-48953** .

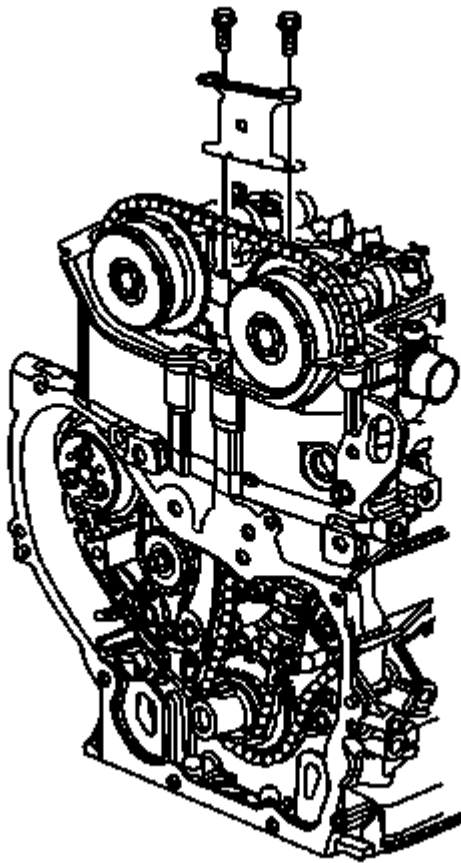


Fig. 237: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

23. Install the upper timing chain guide bolts and guide.

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

24. Install the camshaft cover. Refer to **Camshaft Cover Replacement** .

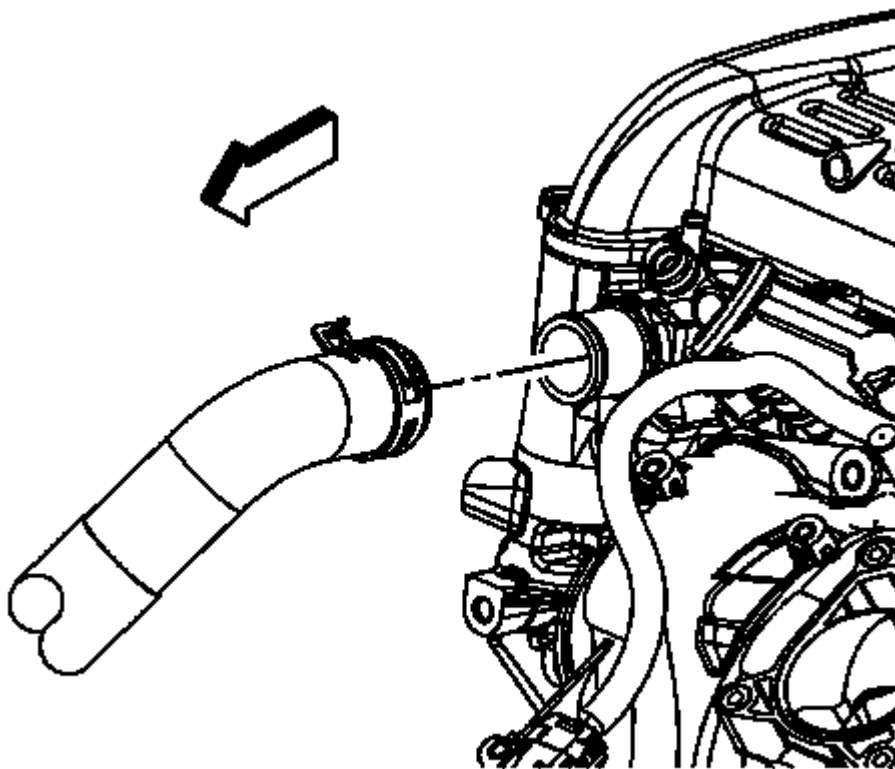


Fig. 238: View Of Radiator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

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

ENGINE OIL COOLER REPLACEMENT

Removal Procedure

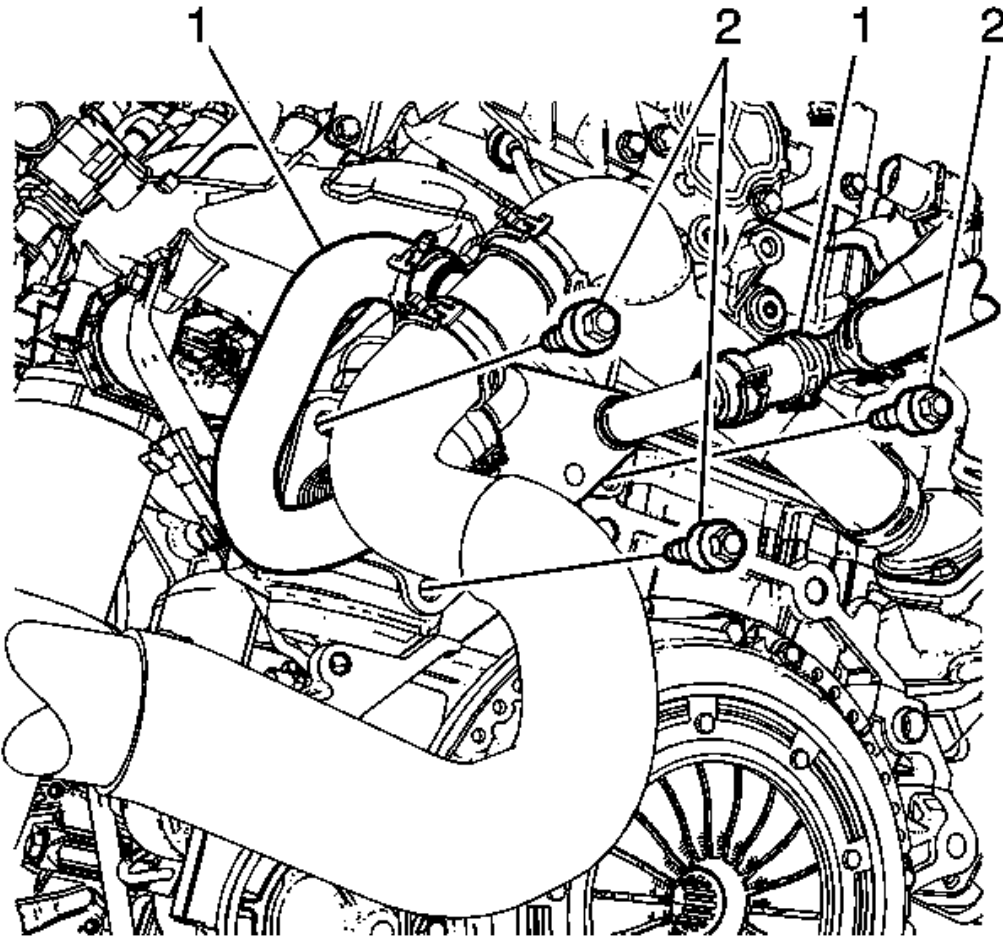


Fig. 239: Identifying Oil Cooler Hoses & Bolts

Courtesy of GENERAL MOTORS CORP.

1. Drain the charged air cooling system. Refer to Cooling System Draining and Filling (GE 47716 Fill) or Cooling System Draining and Filling (Static Fill LNF) .
2. Disconnect the oil cooler hoses (1).
3. Remove the oil cooler bolts (2).
4. Remove the oil cooler.

Installation Procedure

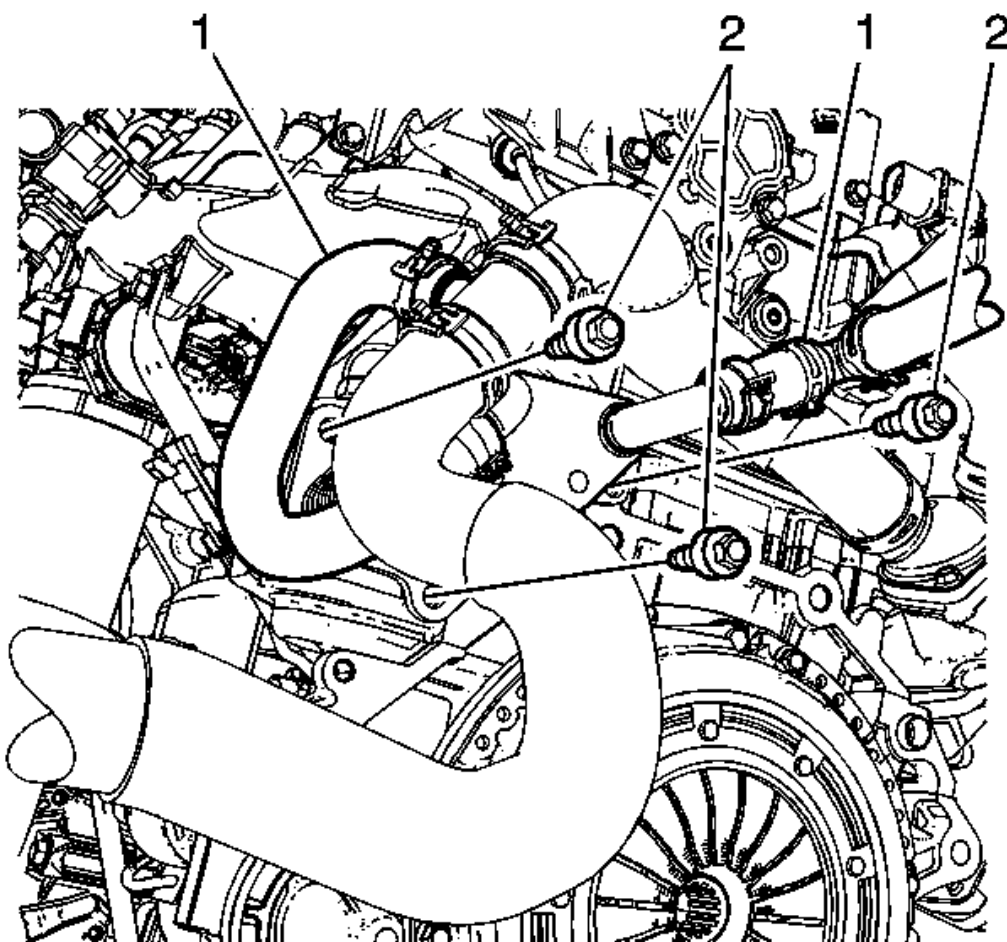


Fig. 240: Identifying Oil Cooler Hoses & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the oil cooler.

NOTE: Refer to Fastener Notice .

2. Install the oil cooler bolts (2).

Tighten: Tighten the bolts and stud to 22 N.m (16 lb ft).

3. Connect the oil cooler hoses (1).
4. Fill the charged air cooling system. Refer to Cooling System Draining and Filling (GE 47716 Fill) or Cooling System Draining and Filling (Static Fill LNF) .

SEALANT REPLACEMENT - LOWER CRANKCASE TO ENGINE BLOCK**Special Tools**

J 45059 Angle Meter. See Special Tools.

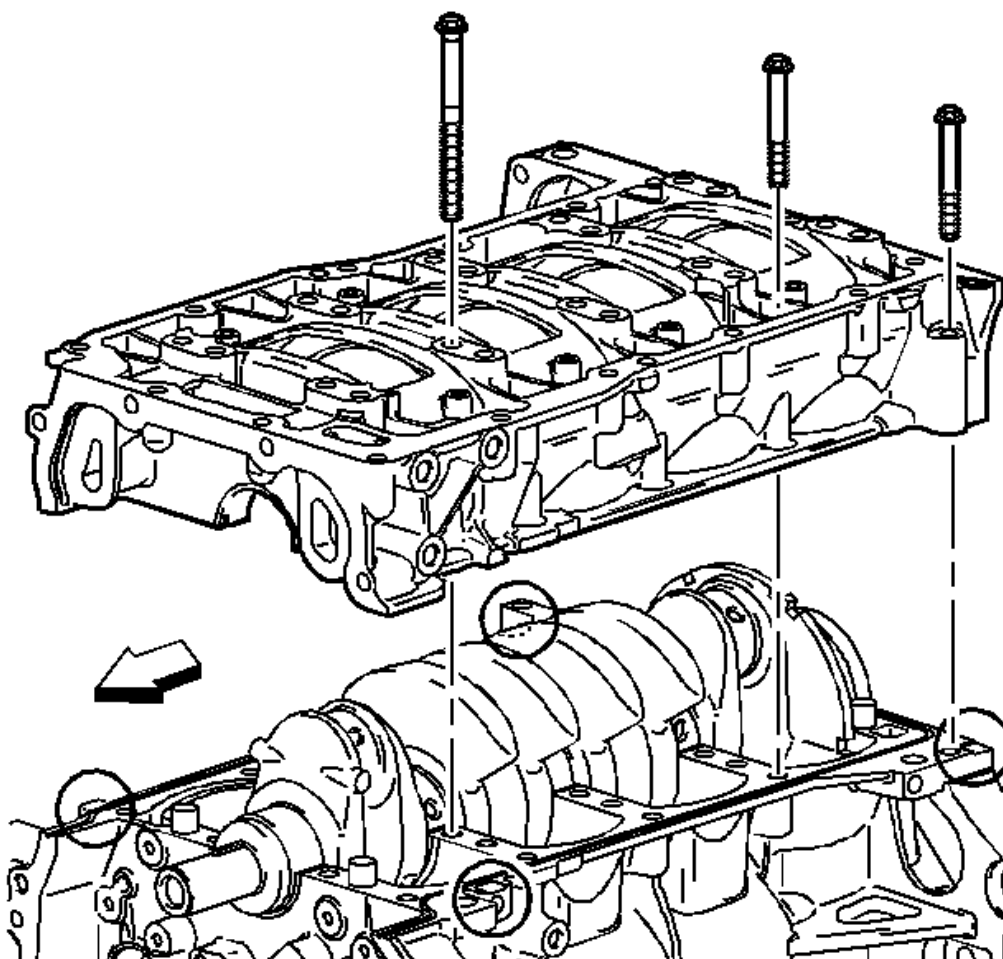
Removal Procedure

Fig. 241: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine from the vehicle. Refer to Engine Replacement.
2. Remove the crankshaft balancer. Refer to Crankshaft Balancer Removal.
3. Remove the engine front cover. Refer to Engine Front Cover and Oil Pump Removal.

4. Remove the engine oil pan. Refer to **Oil Pan Removal**.
5. Remove the 3 perimeter bolts.

IMPORTANT: Do not forget the 2 outside rear bolts.

6. Remove and discard the crankshaft bearing bolts.

IMPORTANT: Keep the bearing halves in order upon removal for proper installation.

7. Using the pry points and an appropriate prying tool, gently separate the upper and lower crankcase.
8. Clean the sealing material from the engine block and lower the crankcase.

Installation Procedure

1. Apply oil to the crankshaft bearing surfaces.

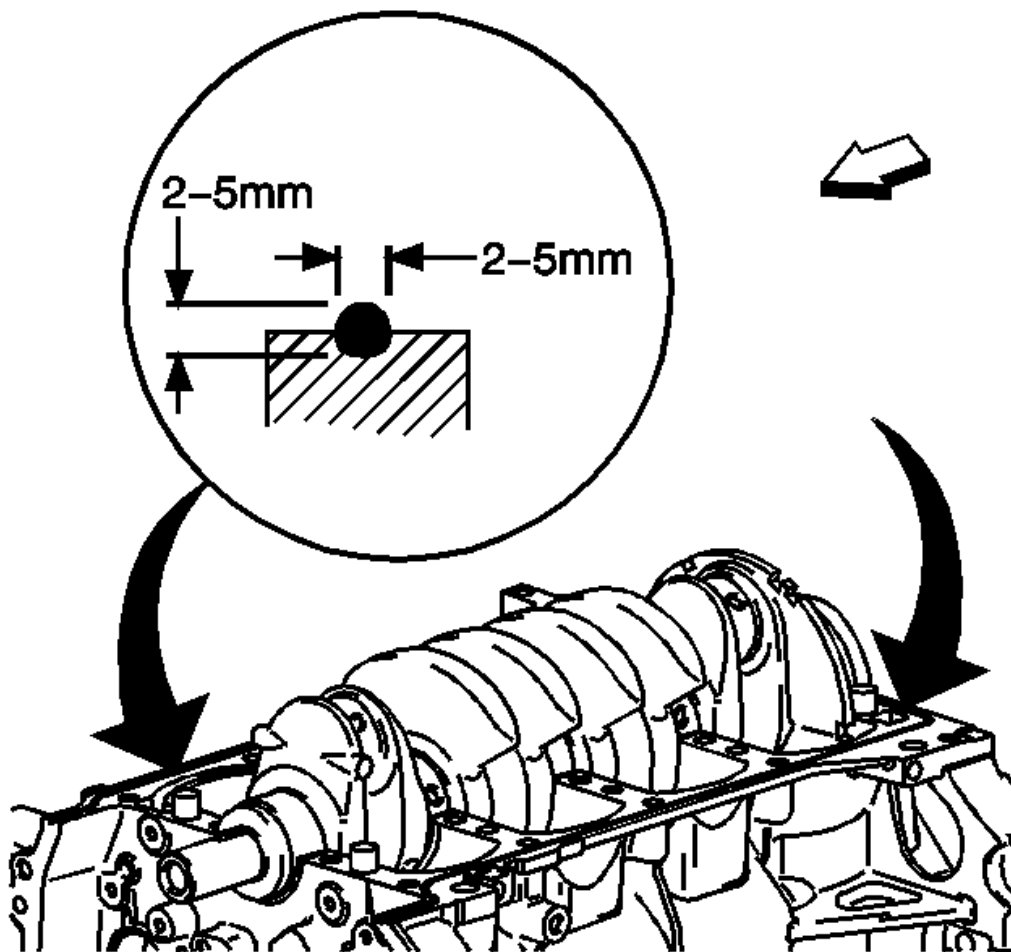


Fig. 242: Applying Sealer To Surfaces Of Engine Block To Bedplate Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

2. Apply a 2-5 mm (0.08-0.20 in) bead (a) of sealer GM P/N 12378521 (Canadian P/N 88901148) to the surface of the engine block-to-lower crankcase mating surface.

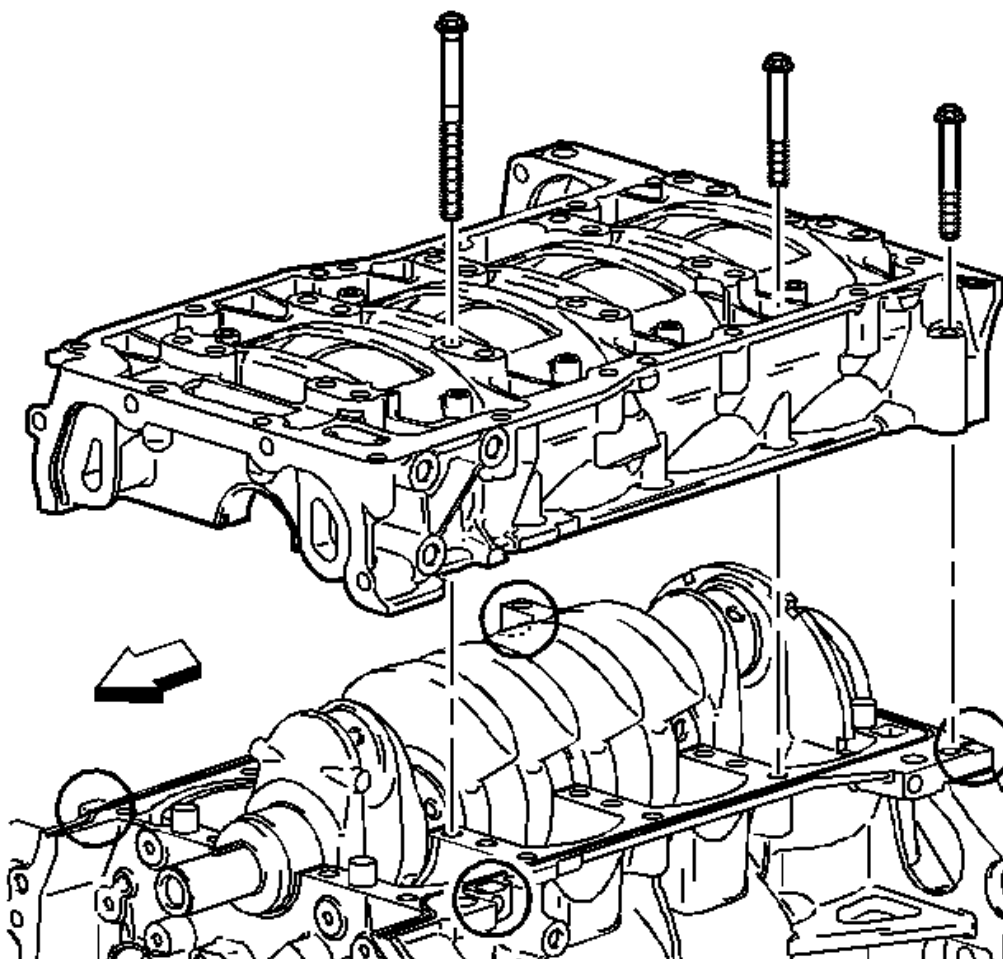


Fig. 243: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the lower crankcase.

Tap gently into place with a suitable tool, if necessary. Ensure it is aligned properly on the dowels.

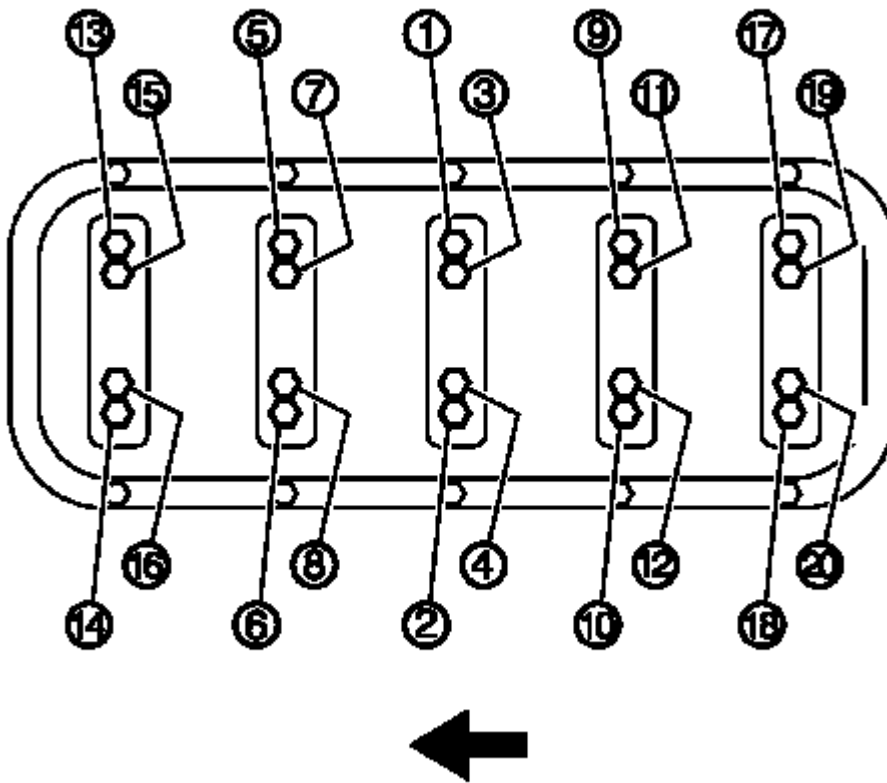


Fig. 244: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the NEW crankshaft bearing bolts in sequence finger tight.
 1. Tighten the crankshaft bearing bolts in sequence.

Tighten: Tighten the crankshaft bearing bolts to 20 N.m (15 lb ft).

2. Tighten the crankshaft bearing bolts in sequence using the **J 45059** . See Special Tools.

Tighten: Tighten the crankshaft bearing bolts to 70 degrees using the **J 45059** . See Special Tools.

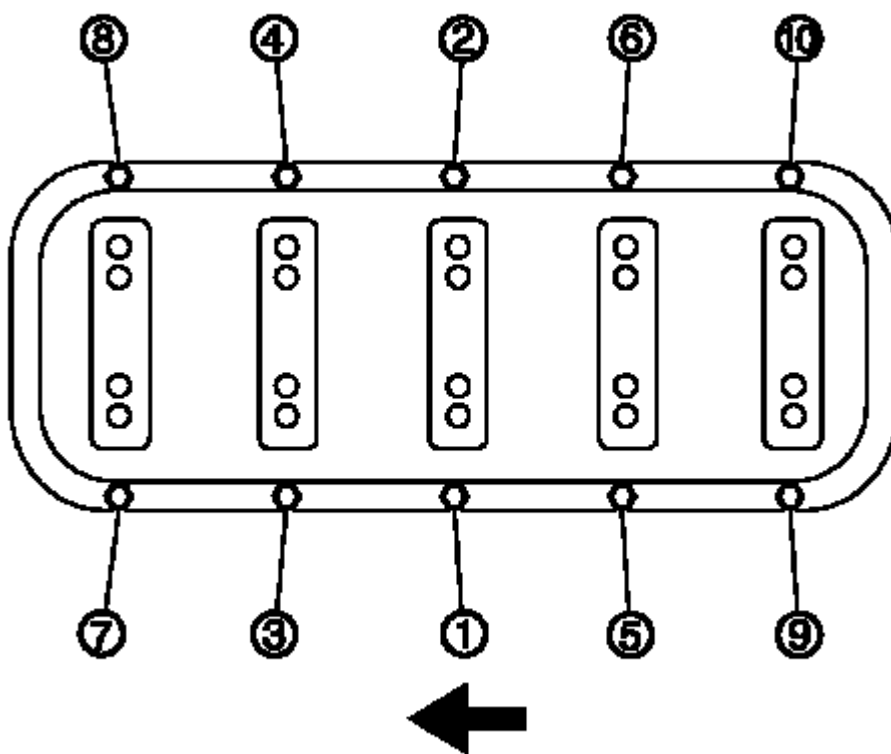


Fig. 245: Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the lower crankcase perimeter bolts in sequence.

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

6. Install the engine front cover. Refer to **Engine Front Cover and Oil Pump Installation** .
7. Install the crankshaft balancer. Refer to **Crankshaft Balancer Installation**
8. Install the engine oil pan. Refer to **Oil Pan Installation** .
9. Install the engine. Refer to **Engine Replacement**.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

J 42067 Rear Main Seal Installer. See **Special Tools**.

Removal Procedure

1. Remove the transmission. Refer to **Transmission Replacement** .

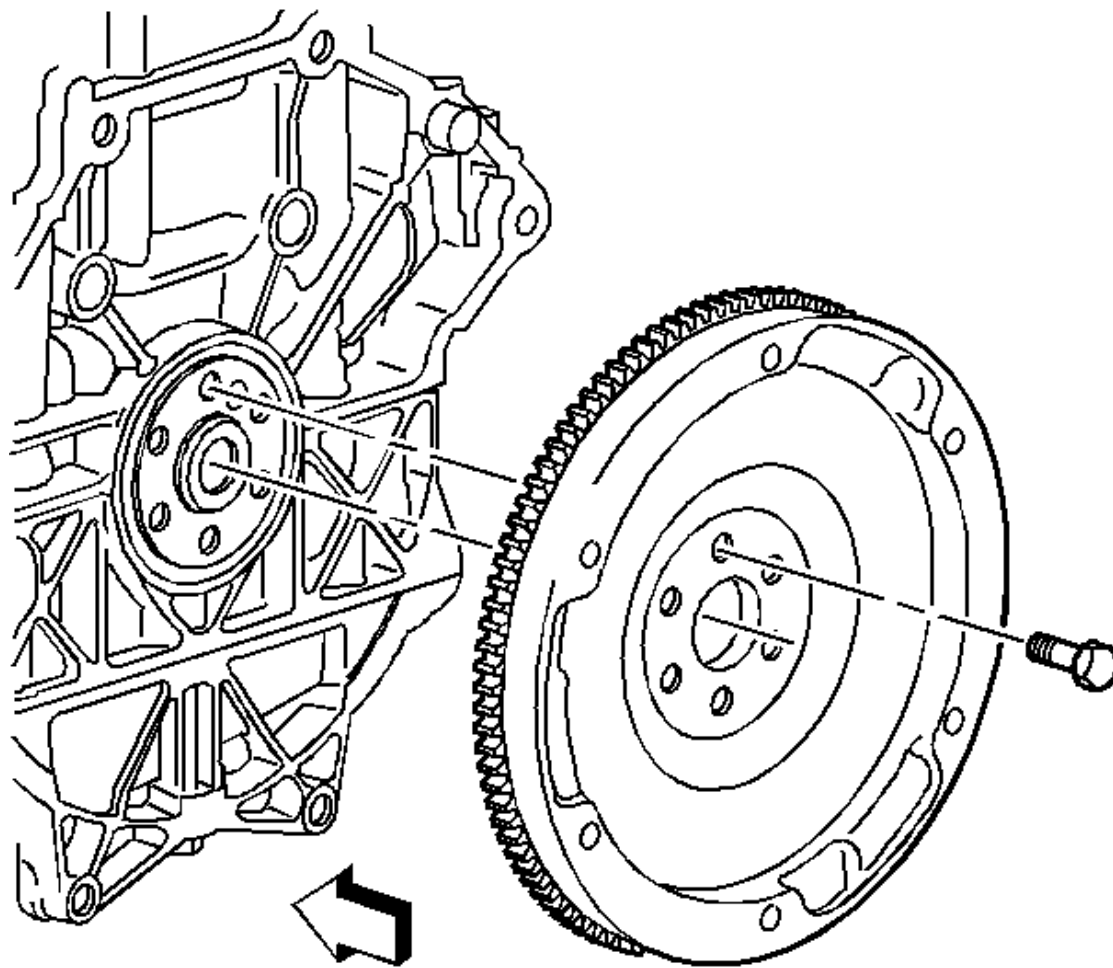


Fig. 246: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel.

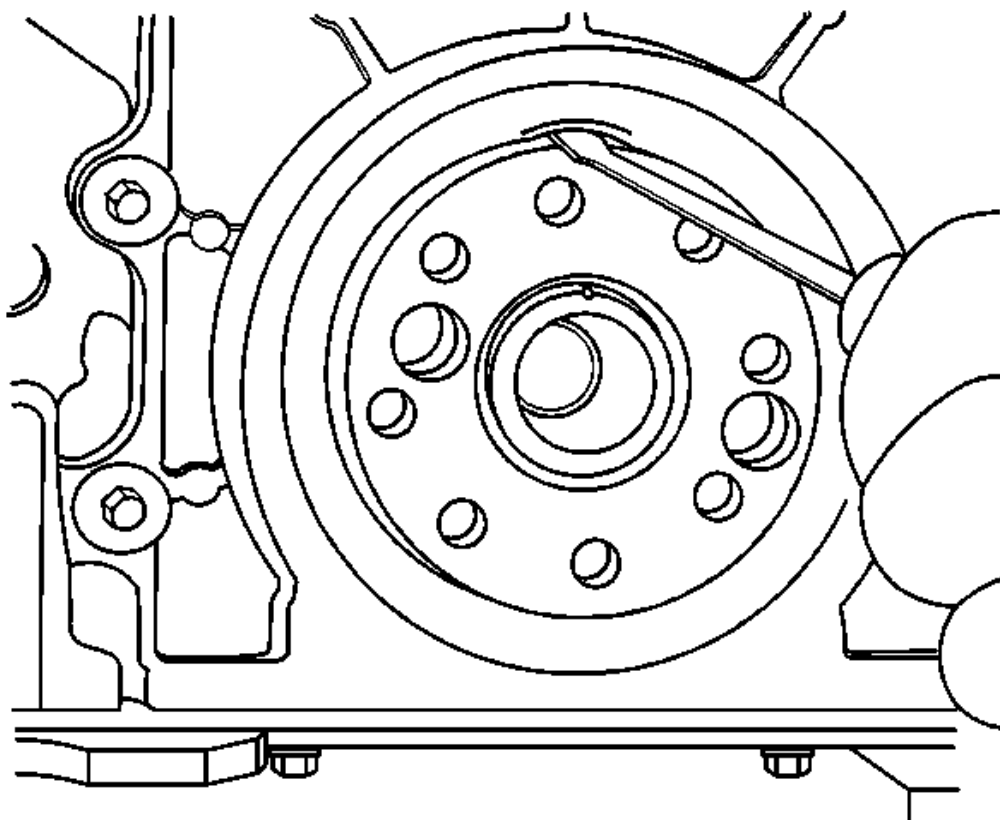


Fig. 247: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

3. Pry the crankshaft rear oil seal with a flat-bladed tool.

Installation Procedure

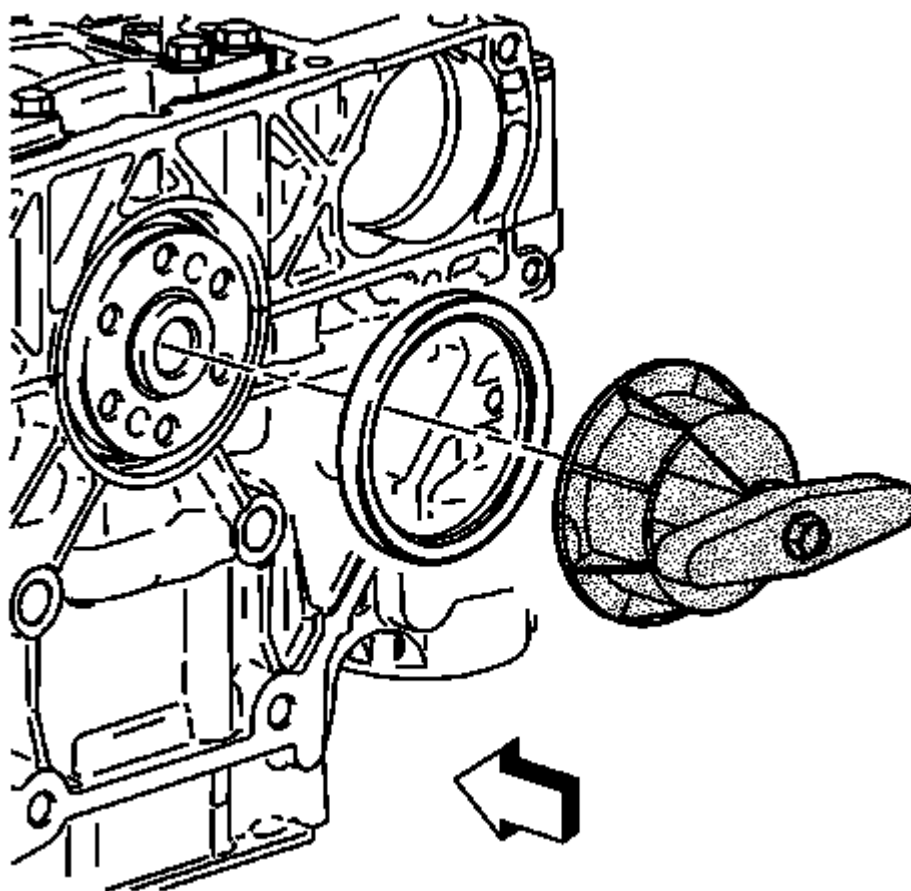


Fig. 248: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 42067** and install the seal. See **Special Tools**.

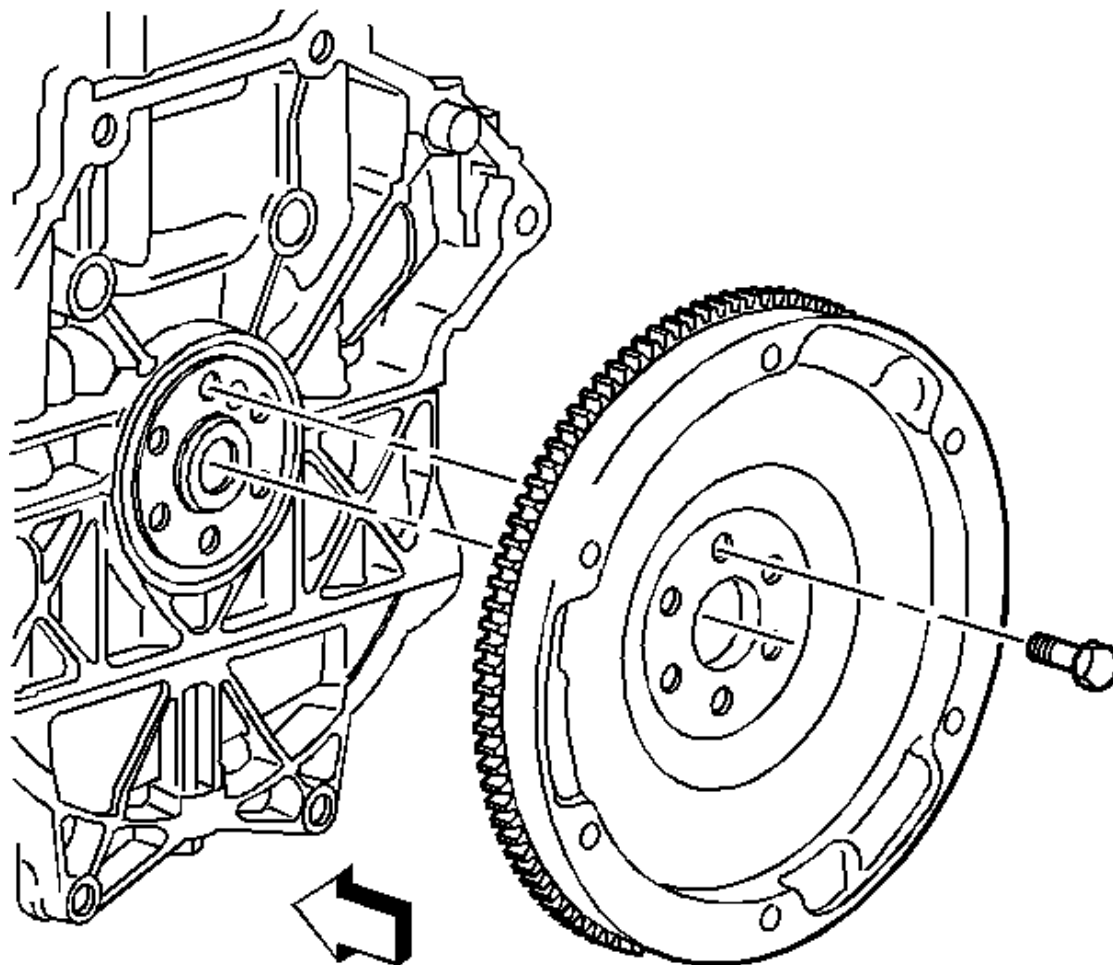


Fig. 249: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the flywheel.

Tighten: Tighten the flywheel bolts to 53 N.m (39 lb ft) plus 25 degrees.

3. Install the transmission. Refer to Transmission Replacement .

ENGINE FLYWHEEL REPLACEMENT

Removal Procedure

1. Remove the transmission. Refer to Transmission Replacement .

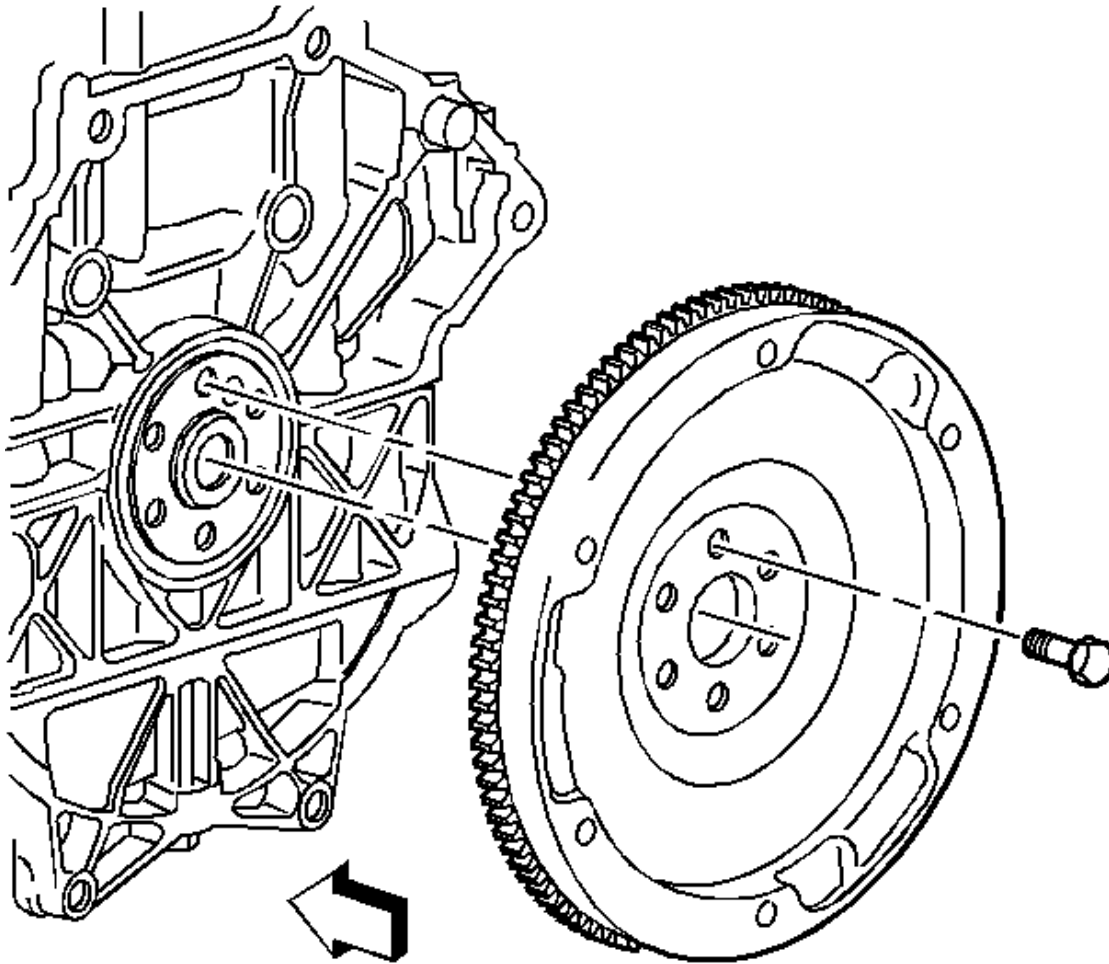


Fig. 250: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel bolts, and note the position of the flywheel to the crank shaft.
3. Remove the flywheel.

Installation Procedure

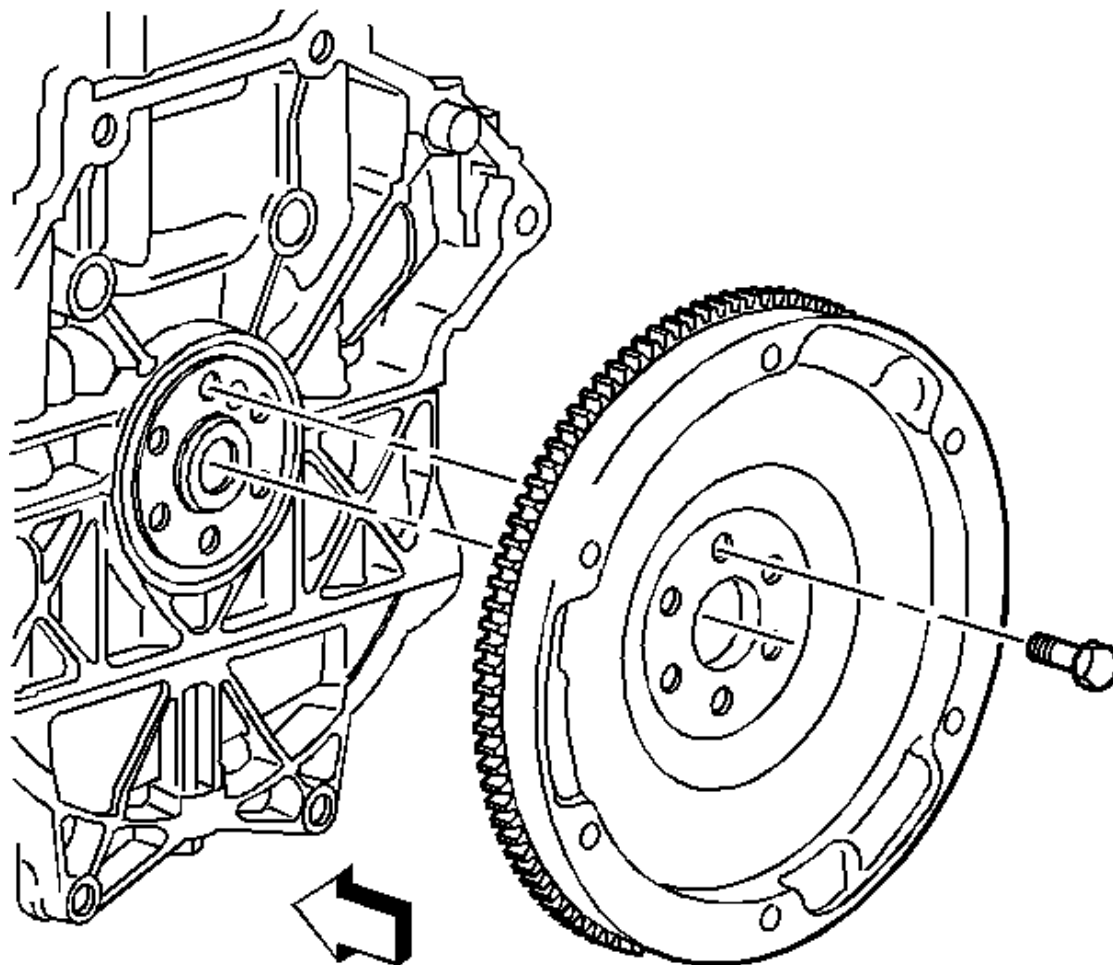


Fig. 251: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel on the crankshaft as previously noted.

NOTE: Refer to Fastener Notice .

2. Install the flywheel bolts.

Tighten: Tighten the flywheel bolts to 53 N.m (39 lb ft) plus 25 degrees.

3. Install the transmission. Refer to Transmission Replacement .

ENGINE REPLACEMENT

Removal Procedure

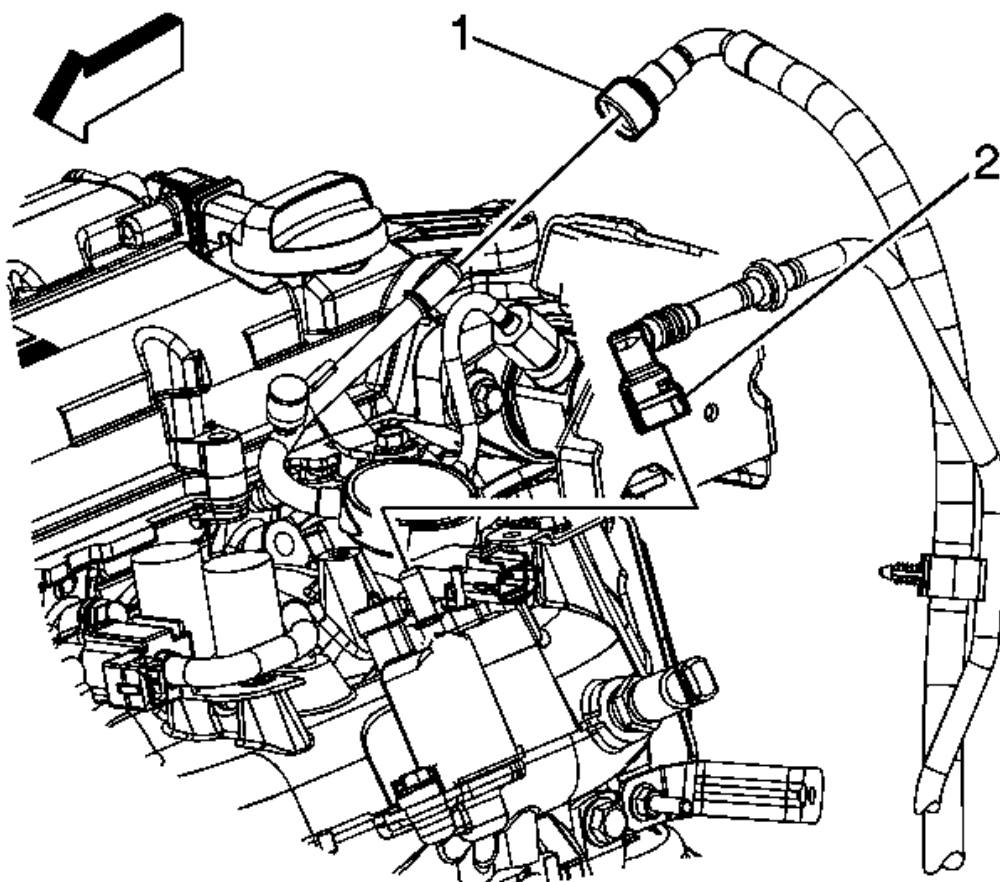


Fig. 252: Identifying Feed Pipe & EVAP Canister Purge Solenoid Tube
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Remove the charge air cooler inlet and outlet pipes. Refer to **Charge Air Cooler Inlet Pipe Replacement** and **Charge Air Cooler Outlet Pipe Replacement** .
4. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief (Without CH 48027)** or **Fuel Pressure Relief (With CH 48027)** or **Fuel Pressure Relief (High Pressure Side)** .
5. Disconnect the evaporative emission (EVAP) canister purge solenoid tube from the valve (2). Refer to **Plastic Collar Quick Connect Fitting Service** .
6. Disconnect the fuel feed pipe (1) from the fuel line. Refer to **Metal Collar Quick Connect Fitting Service** .

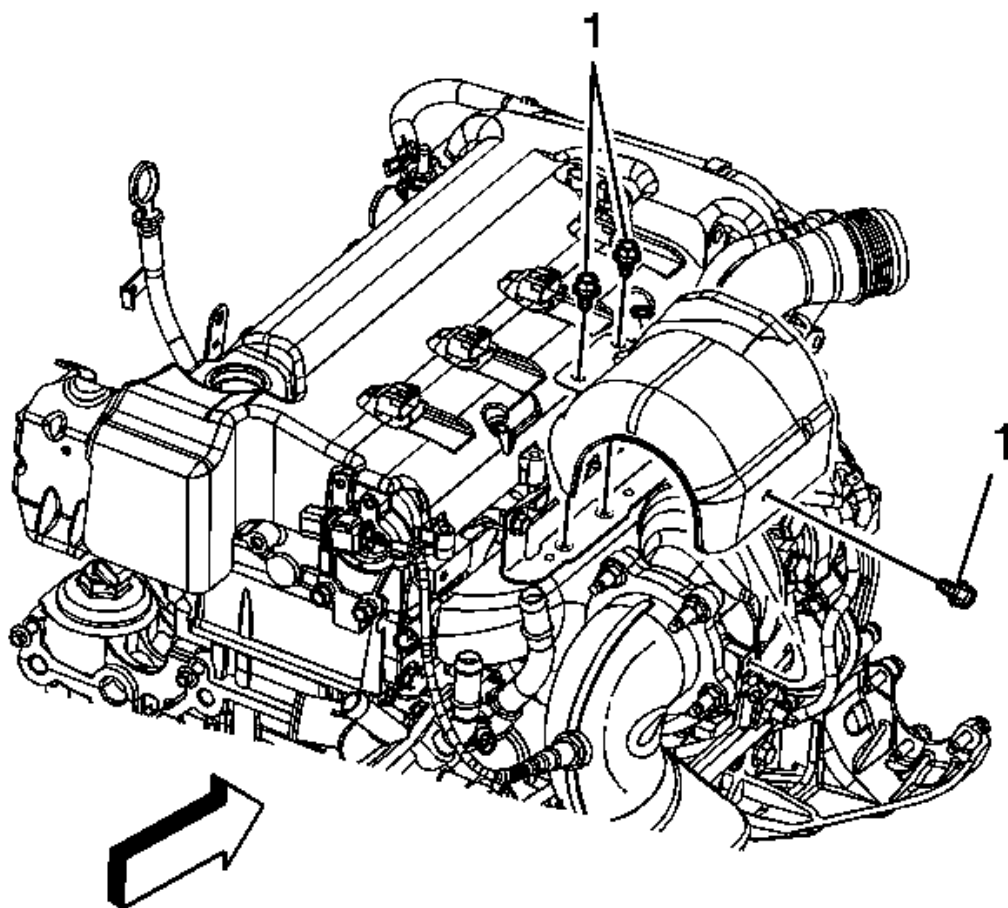


Fig. 253: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the turbocharger heat shield bolts (1) and shield.

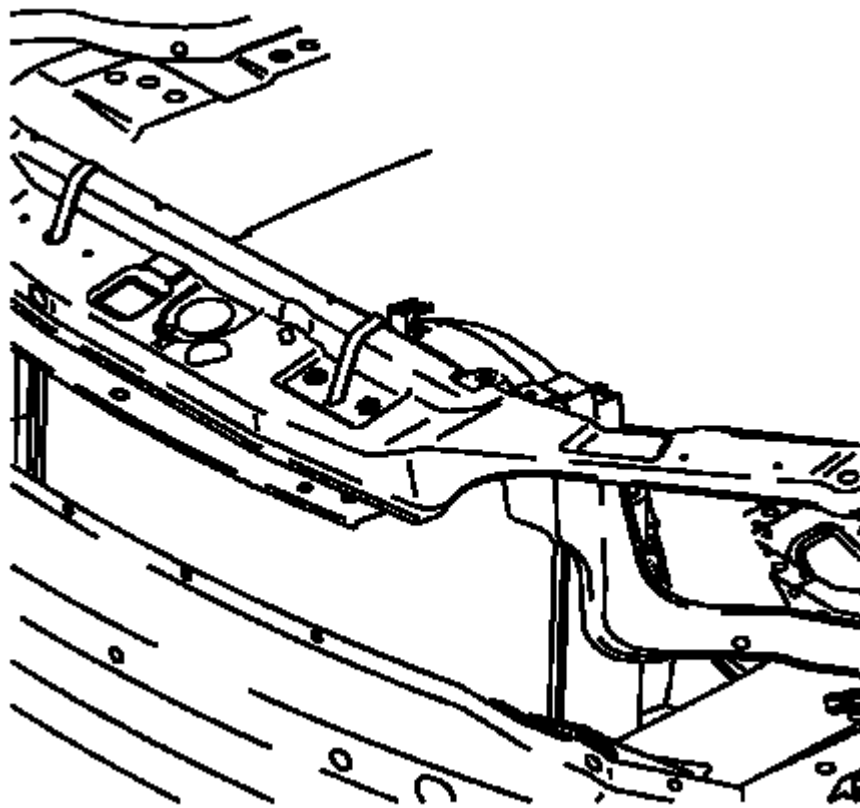


Fig. 254: Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

8. Secure the cooling module to the upper body structure.
9. Remove the engine drive belt. Refer to **Drive Belt Replacement** .

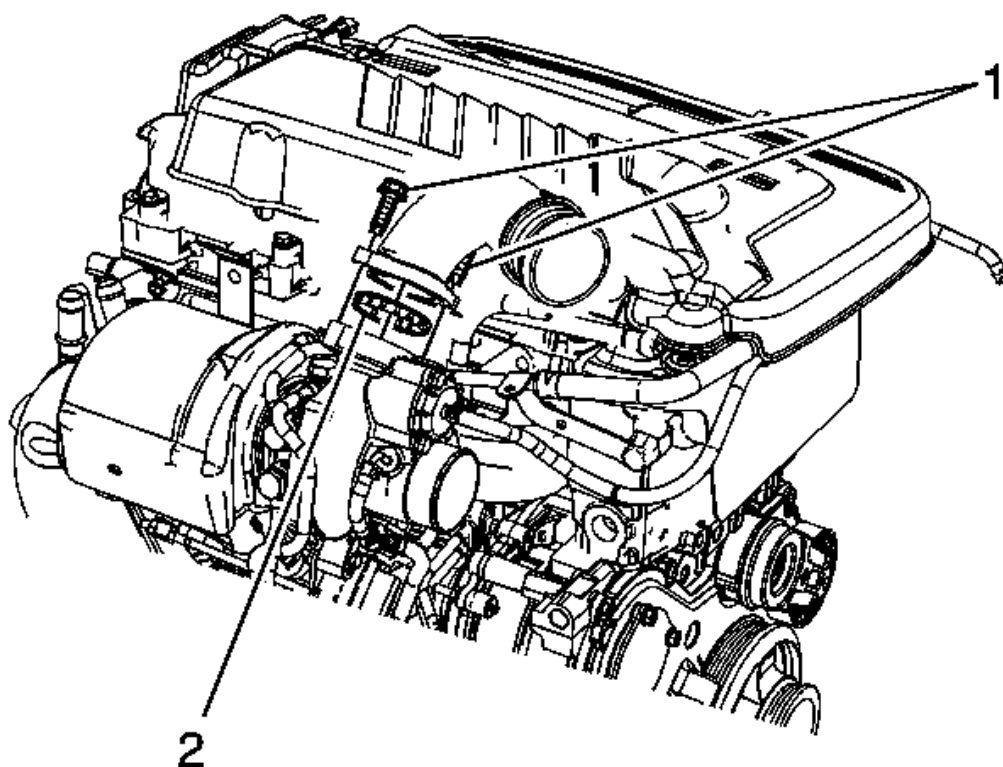


Fig. 255: Locating Charge Air Cooler Pipe
Courtesy of GENERAL MOTORS CORP.

10. Remove the charge air cooler pipe to turbocharger bolts (1).
11. Remove the charge air cooler pipe and gasket (2) from the turbocharger.
12. Cap or plug the turbocharger opening.
13. Remove the radiator inlet hose. Refer to **Radiator Inlet Hose Replacement (LNF)** .
14. Remove the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LNF)** .
15. Lower the vehicle.

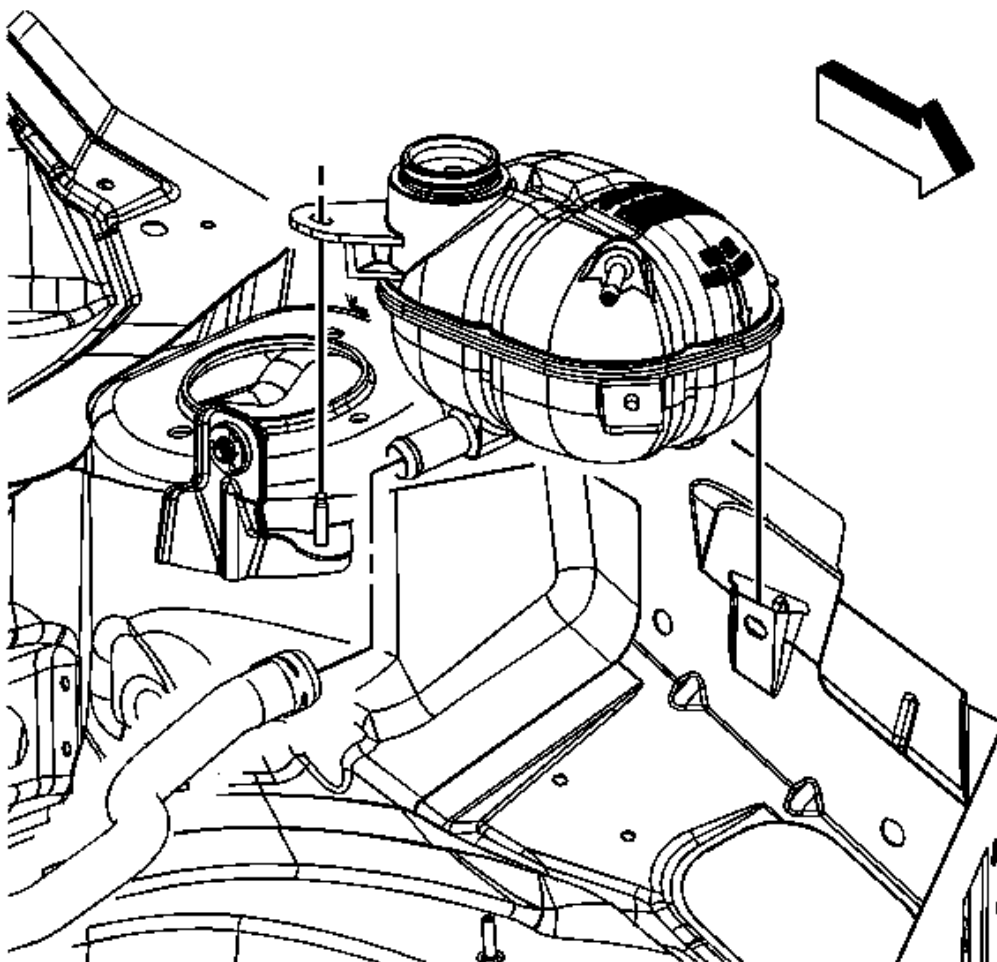


Fig. 256: View Of Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

16. Reposition the surge tank outlet hose clamp at the surge tank.
17. Remove the surge tank outlet hose from the surge tank.

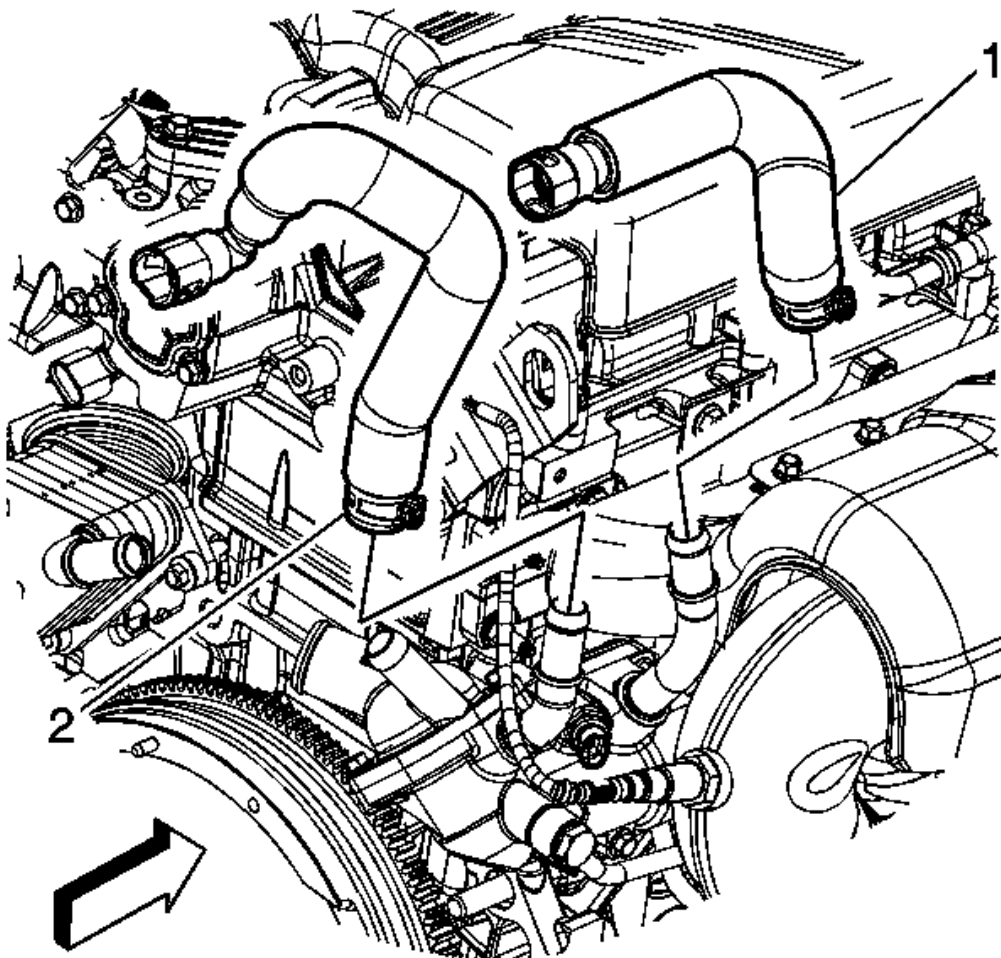


Fig. 257: Identifying Heater Inlet & Outlet Hoses & Clamps
Courtesy of GENERAL MOTORS CORP.

18. Reposition the heater inlet and outlet hose clamps at the thermostat housing.
19. Remove the heater inlet (1) and outlet (2) hoses from the thermostat housing.

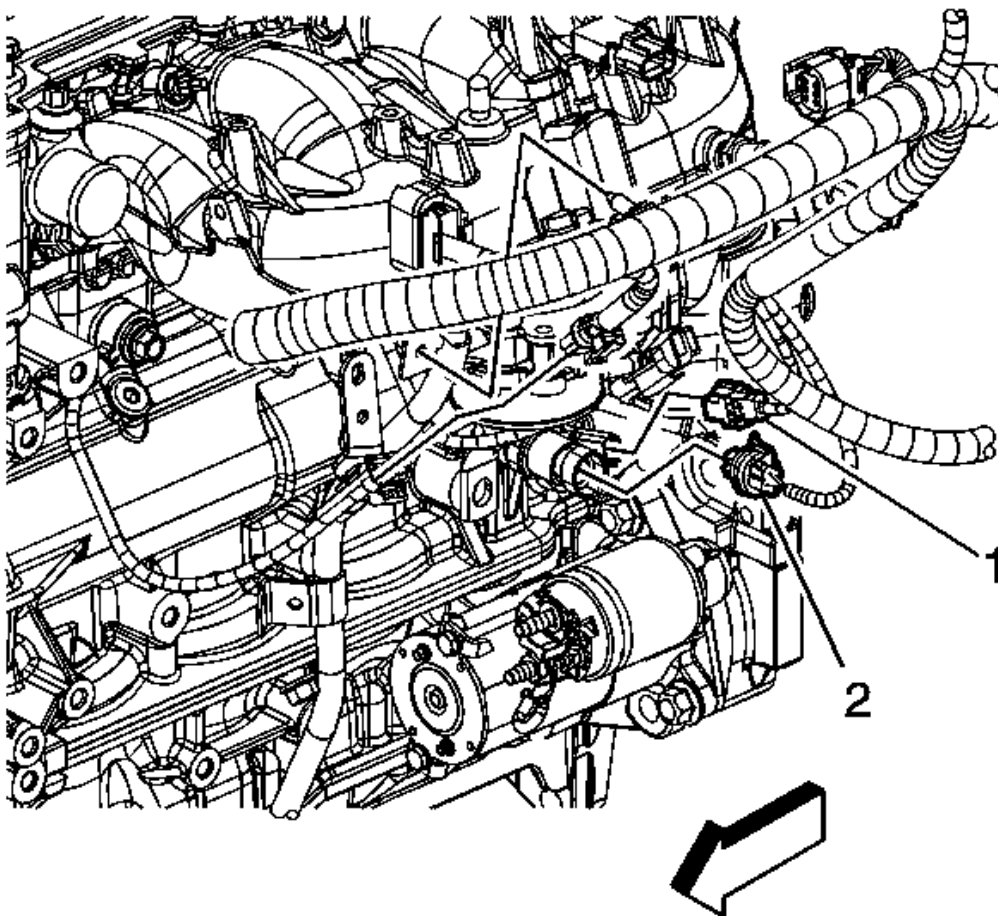


Fig. 258: Locating CKP Sensor & Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

20. Disconnect the engine wiring harness electrical connector (1) from the crankshaft position (CKP) sensor.
21. Disconnect the engine wiring harness electrical connector (2) from the oil pressure sensor.

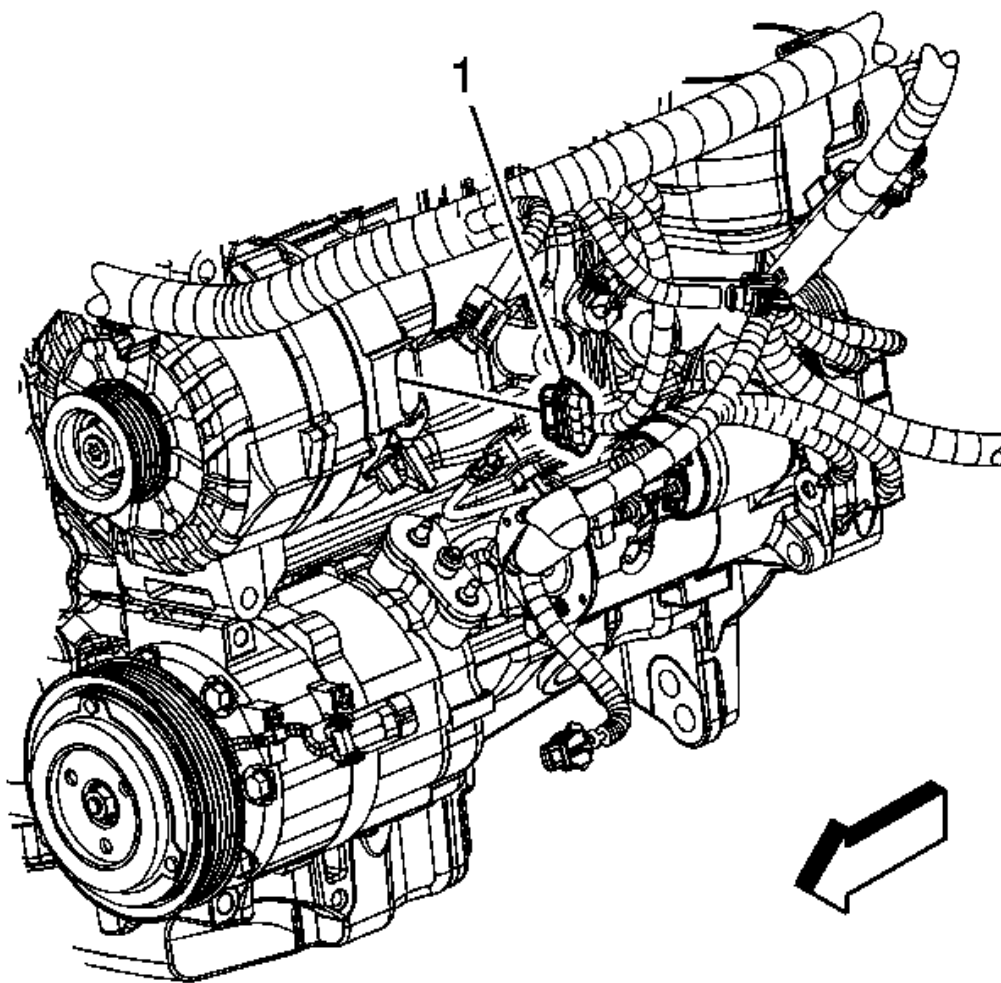


Fig. 259: Identifying Generator Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

22. Disconnect the engine wiring harness electrical connector (1) from the generator.

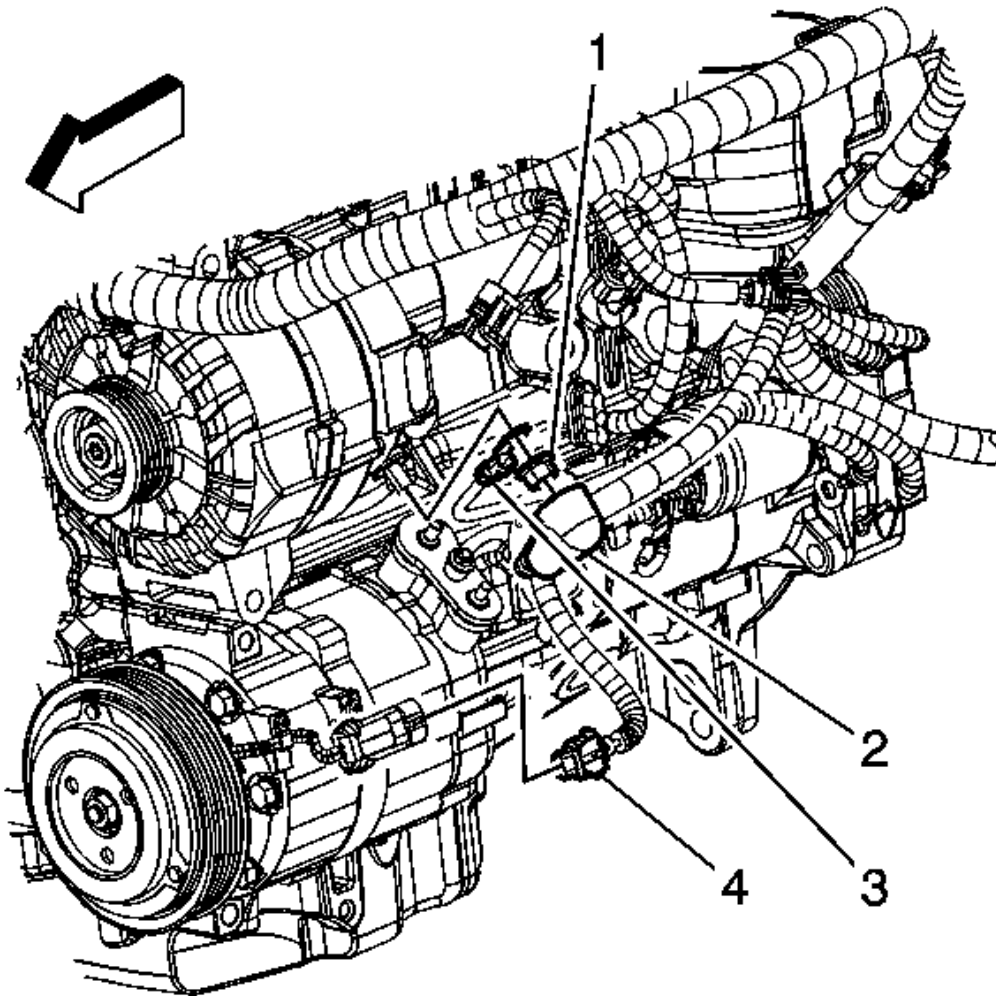


Fig. 260: Identifying Generator
Courtesy of GENERAL MOTORS CORP.

23. Reposition the positive battery cable terminal boot (2).
24. Remove the generator terminal nut (1).
25. Remove the positive battery cable terminal (3) from the generator.
26. Disconnect the engine wiring harness electrical connector (4) from the A/C compressor.

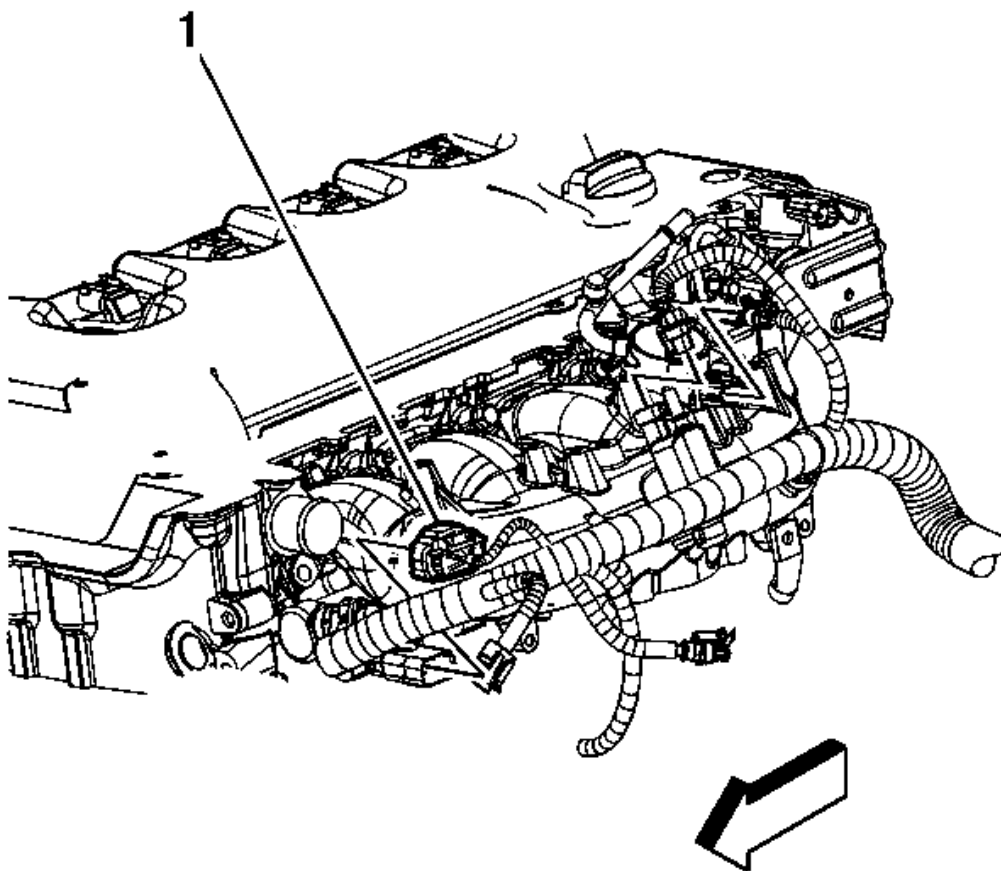


Fig. 261: Locating Fuel Injector Jumper Electrical Connector
Courtesy of GENERAL MOTORS CORP.

27. Disconnect the engine wiring harness electrical connector (1) from the fuel injector jumper electrical connector.

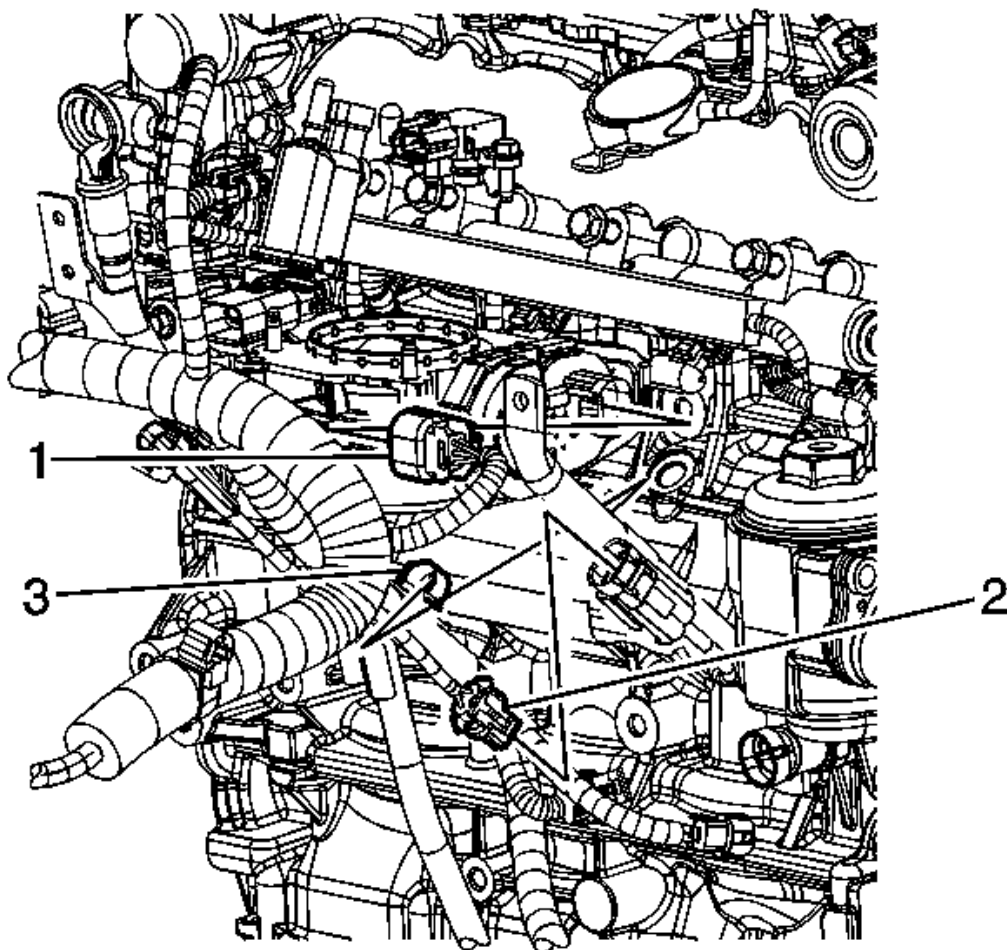


Fig. 262: Identifying Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

28. Disconnect the engine wiring harness electrical connector (2) from the knock sensor.

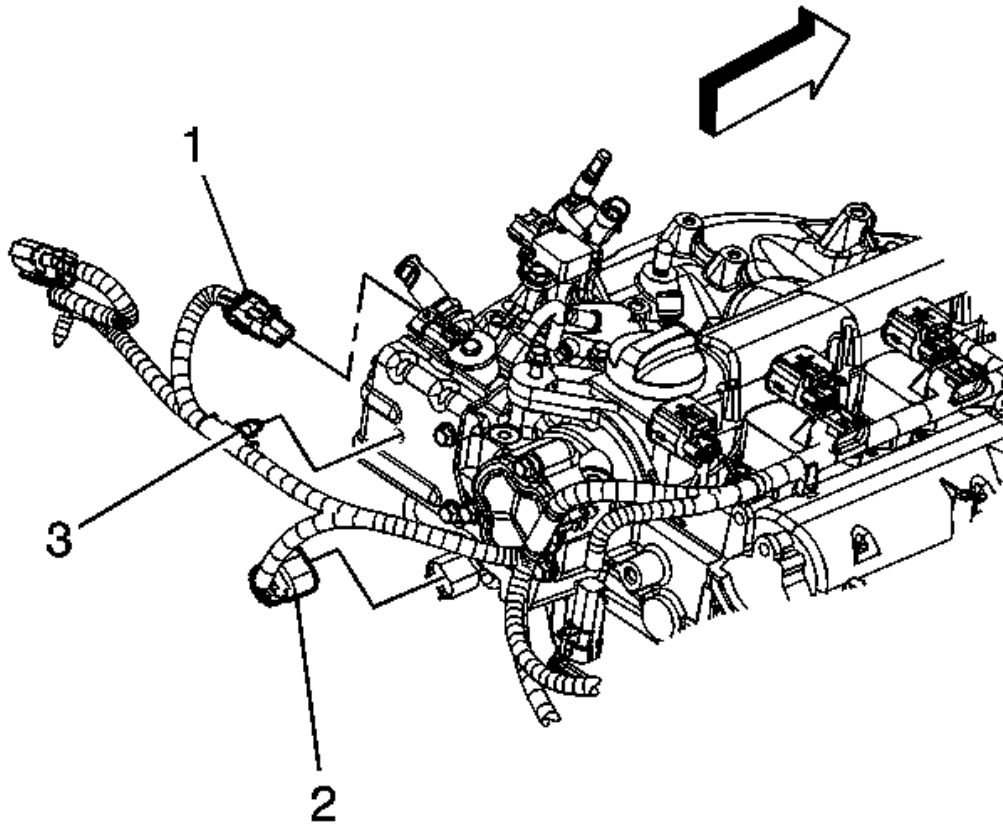


Fig. 263: View Of Engine Wiring Harness Connector & High Pressure Fuel Pump
Courtesy of GENERAL MOTORS CORP.

29. Disconnect the engine wiring harness electrical connector (2) from the intake camshaft position (CMP) sensor.
30. Disconnect the engine wiring harness electrical connector (1) from the high pressure fuel pump.
31. Remove the engine wiring harness clip (3) from the high pressure fuel pump bracket.

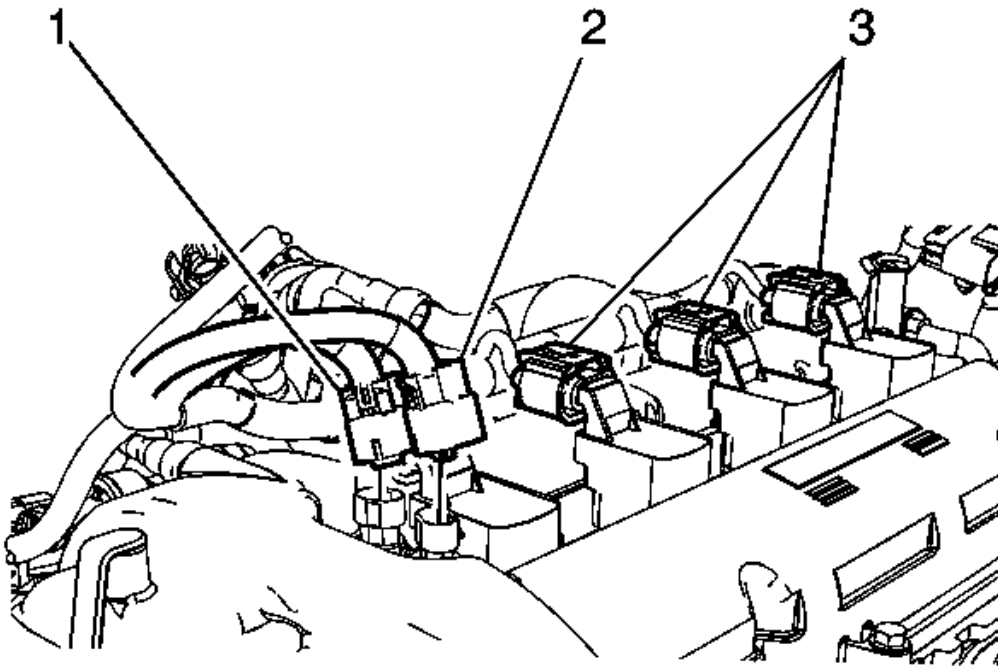


Fig. 264: Identifying Intake & Exhaust CMP Actuators
Courtesy of GENERAL MOTORS CORP.

32. Disconnect the engine wiring harness electrical connector (2) from the intake CMP actuator.
33. Disconnect the engine wiring harness electrical connector (1) from the exhaust CMP actuator.
34. Disconnect the ignition coil electrical connectors (3) from the ignition coils.

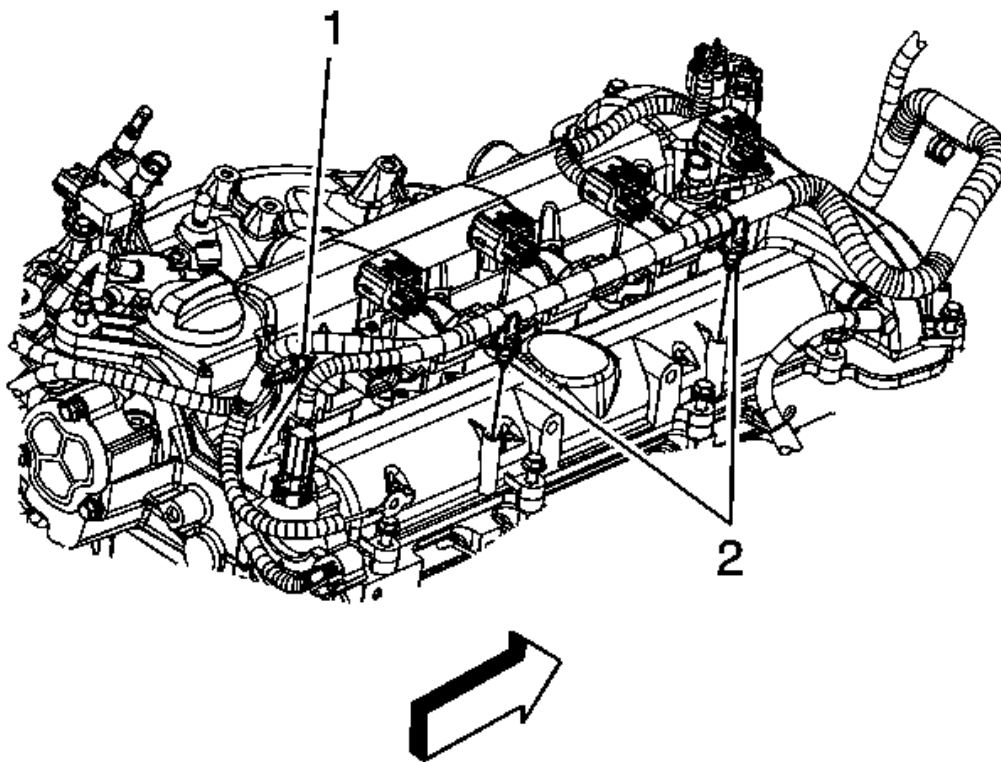


Fig. 265: Identifying Engine Wiring Harness Clips At Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

35. Disconnect the engine harness clips (2) from the camshaft cover.
36. Disconnect the engine harness clip (1) from the camshaft cover.

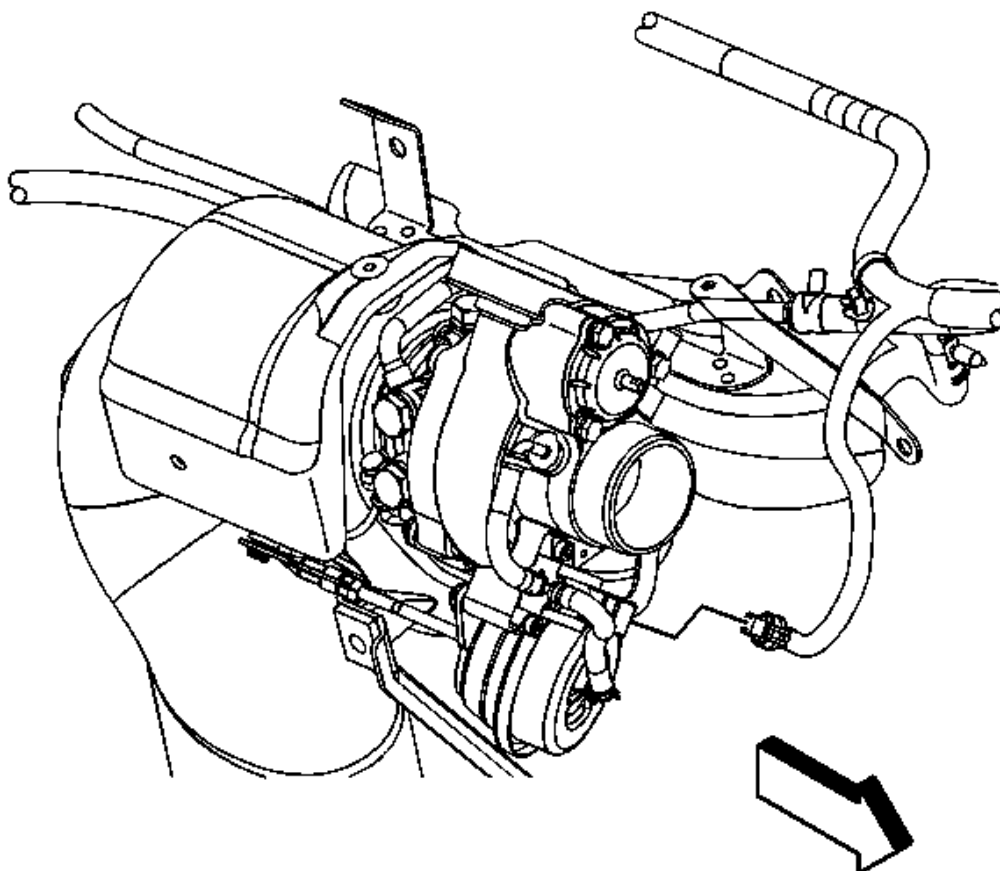


Fig. 266: Locating turbocharger wastegate solenoid valve Harness & Connector
Courtesy of GENERAL MOTORS CORP.

37. Disconnect the engine wiring harness electrical connector from the boost sensor.

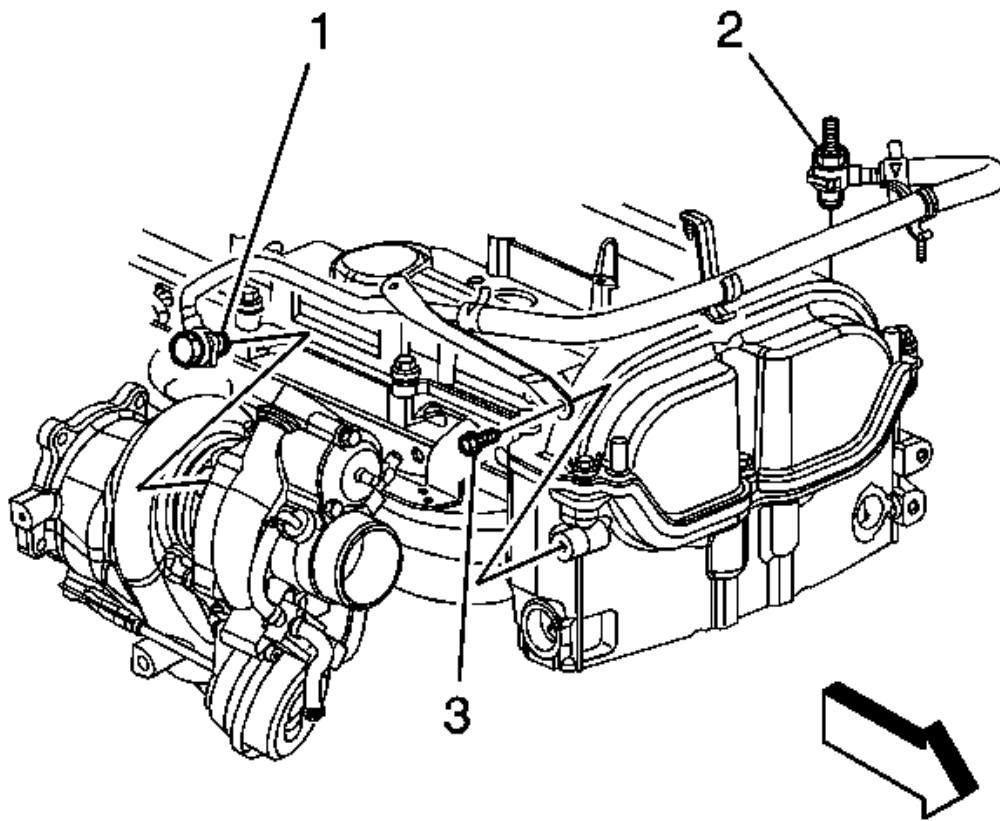


Fig. 267: Turbocharger Coolant Feed Pipe Bolt
Courtesy of GENERAL MOTORS CORP.

38. Remove the turbocharger coolant feed pipe bolt (1) at the turbocharger.
39. Remove the turbocharger coolant feed pipe fitting (2) from the cylinder head.
40. Remove the turbocharger coolant feed pipe bracket bolt from the cylinder head.
41. Remove the turbocharger coolant feed pipe bracket from the vehicle.

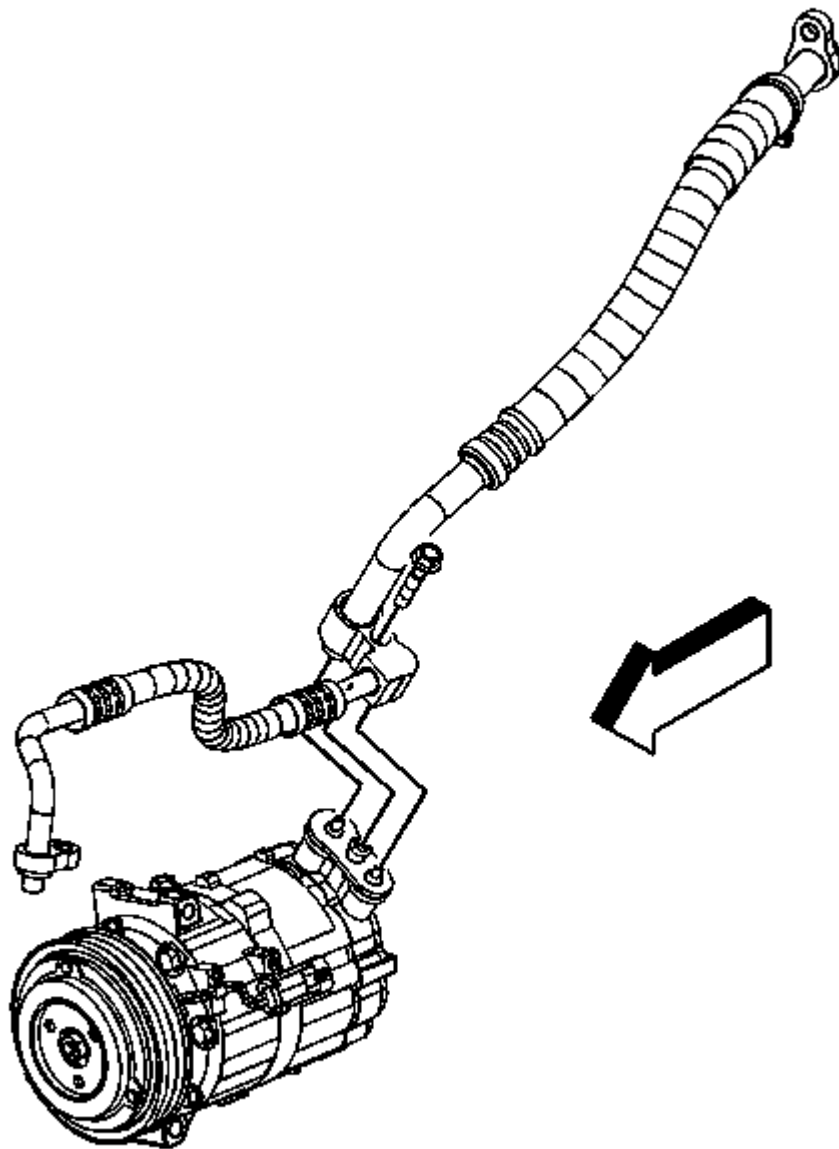


Fig. 268: A/C Compressor Line
Courtesy of GENERAL MOTORS CORP.

42. Remove the A/C compressor line bolt and reposition the line off to the side.

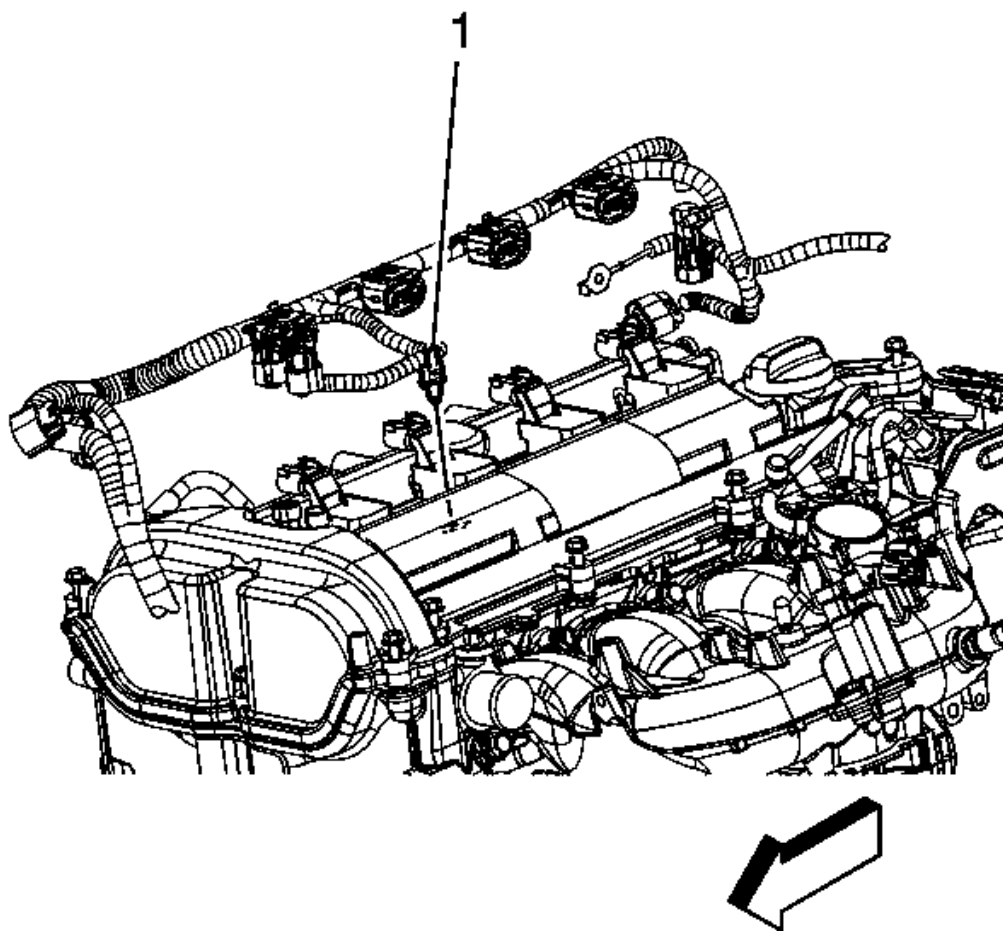


Fig. 269: Identifying Engine Wiring Harness Clips At Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

43. Remove the engine harness clip (1) from the camshaft cover.
44. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
45. Drain the engine oil.

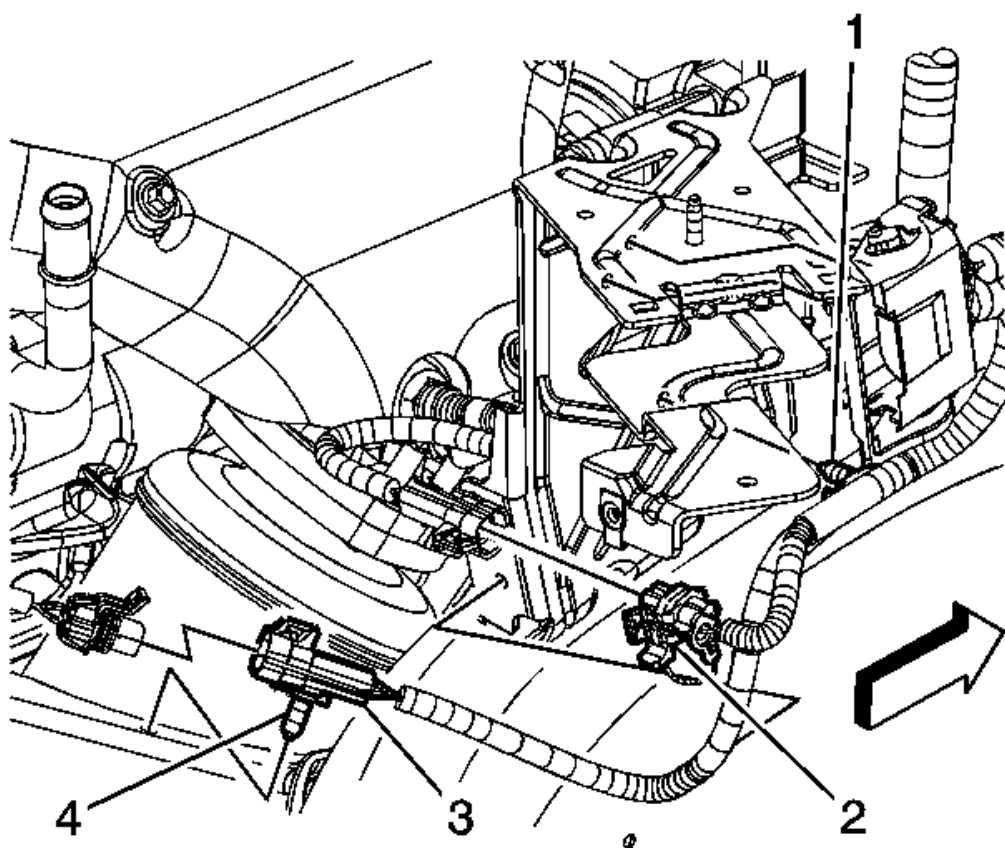


Fig. 270: Identifying CPA Retainer & HO2S Electrical Connector
Courtesy of GENERAL MOTORS CORP.

46. Disconnect the engine wiring harness electrical connector (1) from the heated oxygen sensor (HO2S) (3).

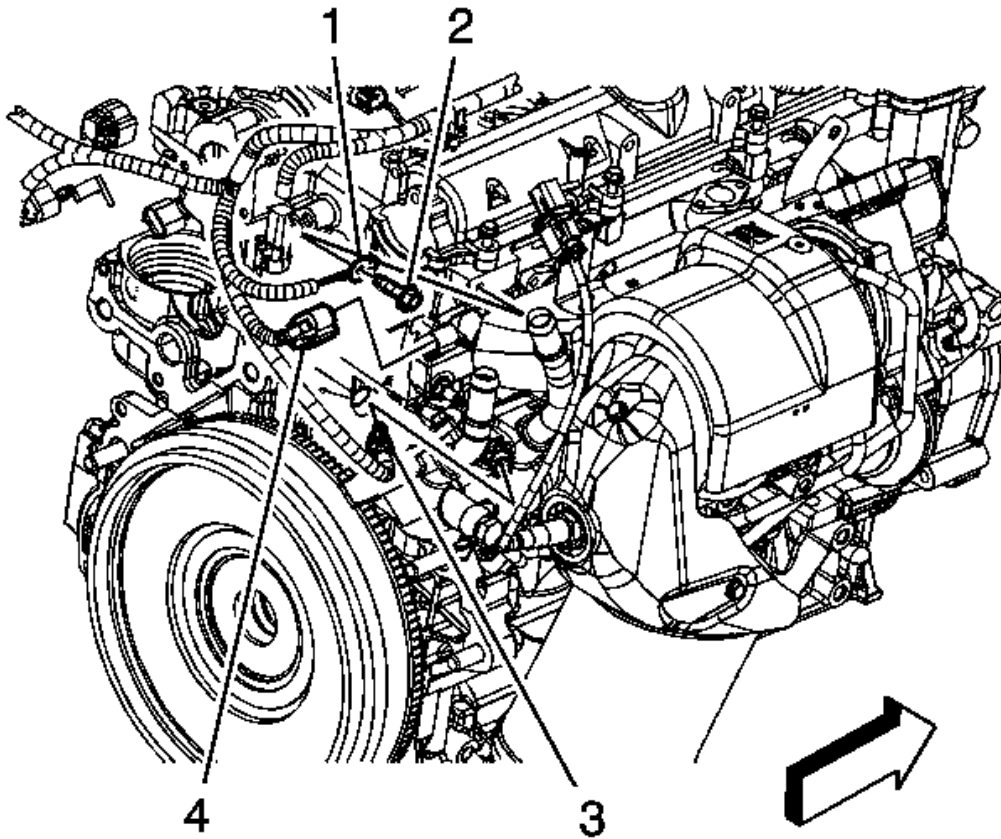


Fig. 271: View Of Engine Wiring Harness Electrical Connector & ECT Sensor
Courtesy of GENERAL MOTORS CORP.

47. Disconnect the engine wiring harness electrical connector (4) from the exhaust CMP sensor.
48. Remove the engine harness ground terminal bolt (2) and reposition the engine harness ground terminal (1).
49. Disconnect the engine wiring harness electrical connector (3) from the engine coolant temperature (ECT) sensor.

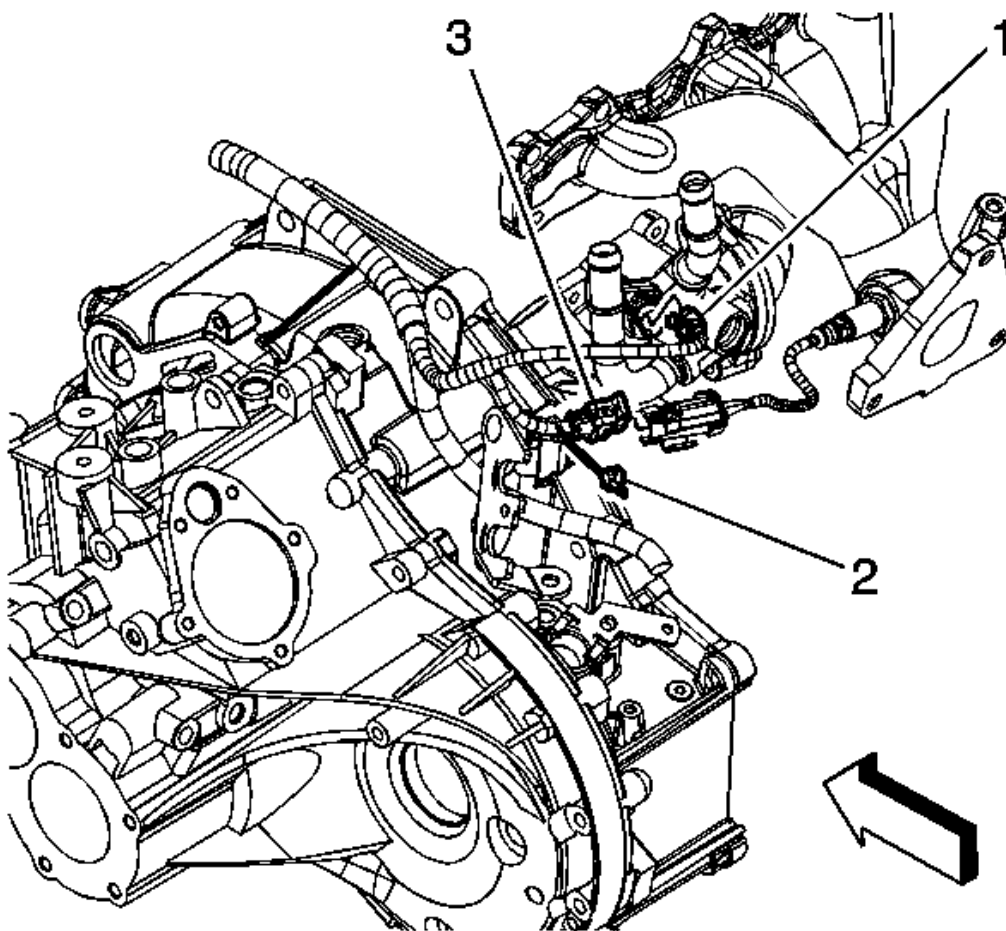


Fig. 272: ECT Sensor Electrical Connector (M/T)
Courtesy of GENERAL MOTORS CORP.

50. Disconnect the ECT sensor electrical connector (1).
51. Remove the CPA retainer (2).
52. Disconnect the engine harness electrical connector (3) from the HO2S.

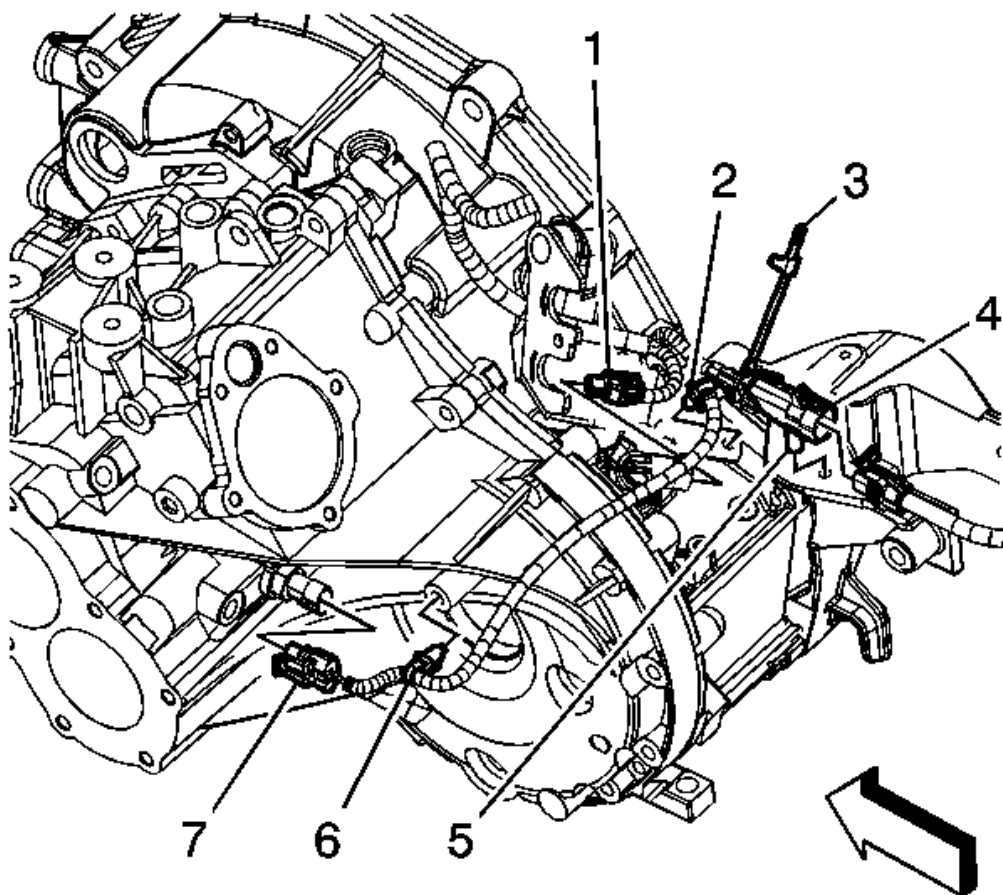


Fig. 273: View Of Engine/Transaxle Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

53. Disconnect the engine harness electrical connector (1) from the VSS.
54. Remove the engine harness clip (2) from the transaxle.
55. Remove the CPA retainer (3).
56. Remove the engine harness electrical connector clip (5) from the transaxle rear mount bracket.
57. Disconnect the engine harness electrical connector (4) from the HO2S.
58. Disconnect the engine harness electrical connector (7) from the back up lamp switch.
59. Remove the engine harness clip (6) from the transaxle.
60. Gather all engine harness branches and reposition the harness off to the side, out of the way.

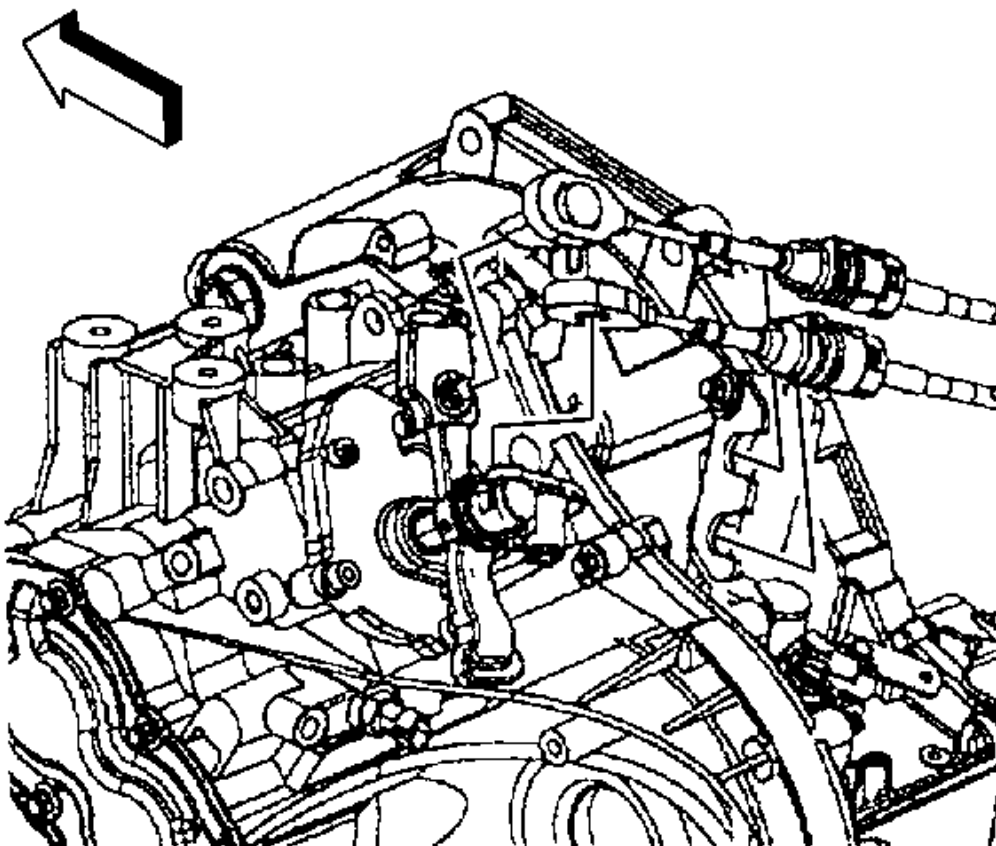


Fig. 274: View Of Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

61. Disconnect the range selector and shift lever cables from the transaxle levers.
62. Remove the range selector and shift lever cables from the transaxle bracket.
63. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (LNF)** .
64. Lower the vehicle.
65. Insert blocks of wood between the powertrain and the frame, in order to support the powertrain.
66. Remove the engine mount. Refer to **Engine Mount Replacement**.

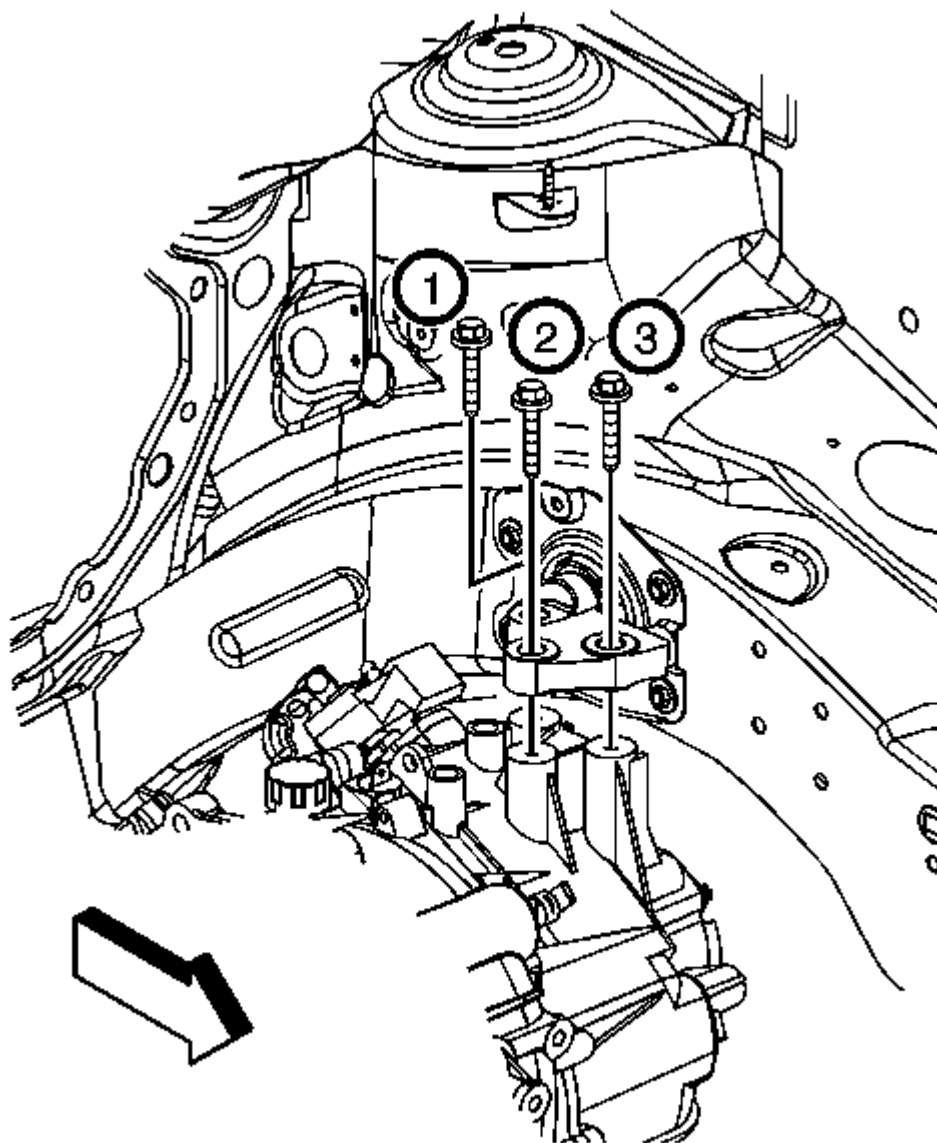


Fig. 275: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

67. Remove the transaxle mount to transaxle bolts.
68. Raise the vehicle.
69. Disconnect the stabilizer links from the stabilizer bar. Refer to **Stabilizer Shaft Link Replacement**.
70. Disconnect the outer tie rod ends from the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod**.

End Replacement .

71. Disconnect the intermediate shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
72. Disconnect the lower control arms from the steering knuckles. Refer to **Lower Control Arm Replacement** .

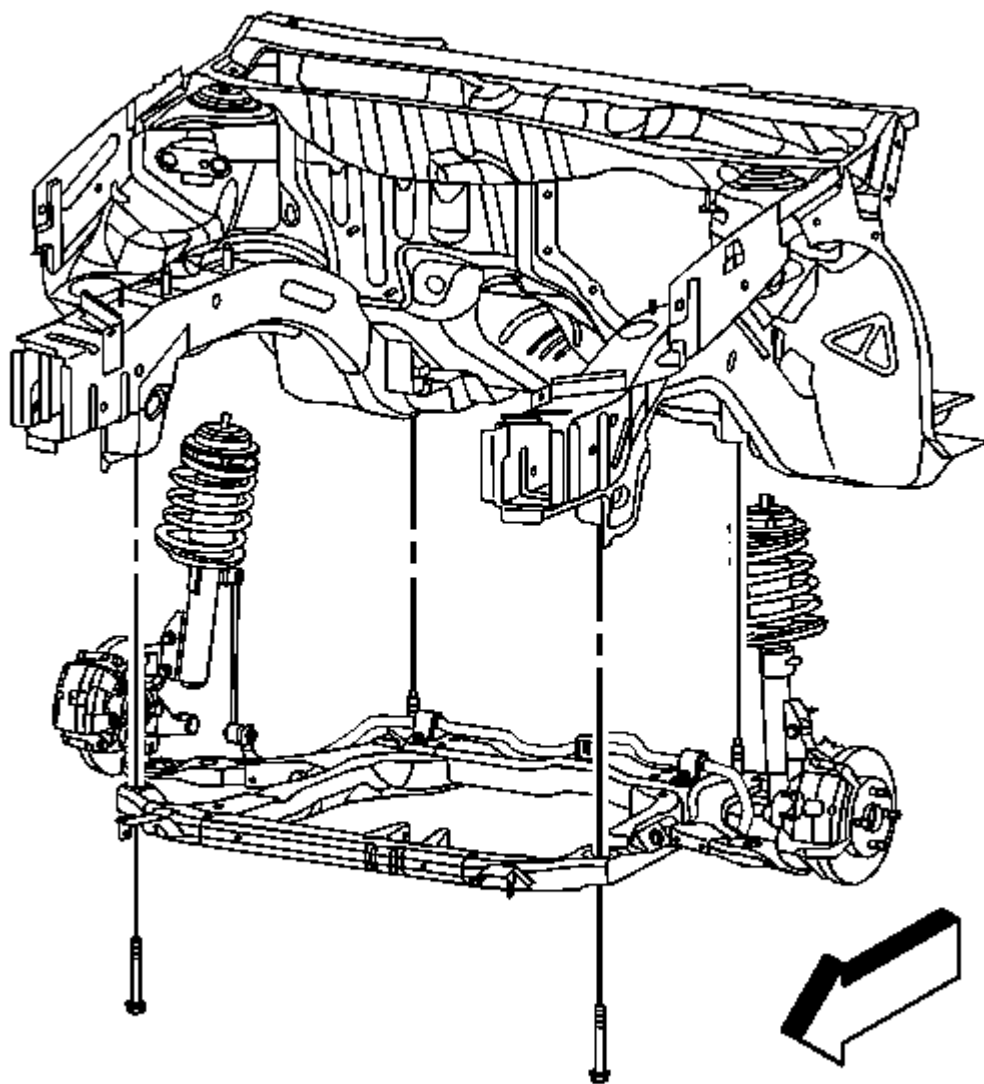


Fig. 276: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

73. Using a paint pen or magic marker, mark the frame to body position.
74. Lower the vehicle to about 3 feet off the ground.
75. Position a engine lift table under the frame.
76. Place wood blocks on top of the lift table between the table and the frame.
77. Lower the vehicle until the frame is resting on the blocks of wood.
78. Slowly loosen/remove the frame bolts using the following sequence:
 1. Loosen/remove the front frame bolts.
 2. Loosen/remove the rear frame bolts.
79. Slowly raise the vehicle away from the powertrain assembly.
80. Slide the lift table out from under the vehicle.
81. Attach the engine lift hoist to the engine lift hooks.
82. Remove the starter. Refer to **Starter Removal**.

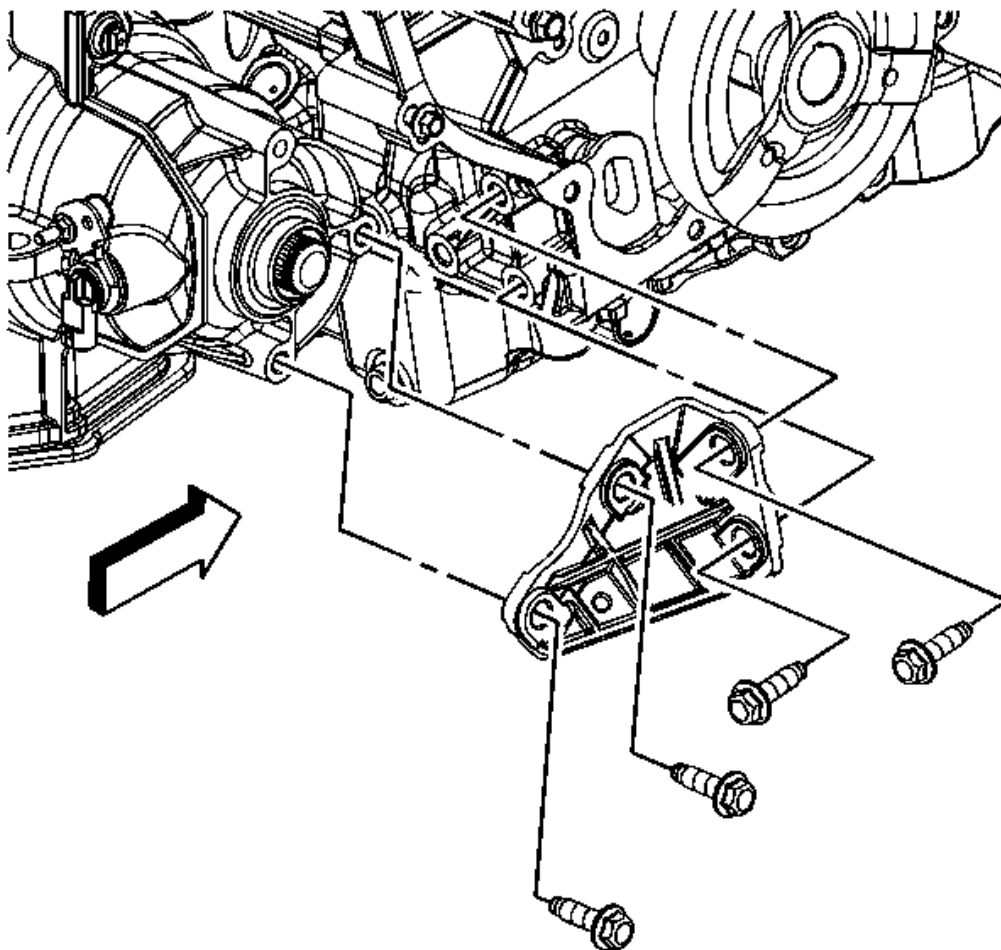


Fig. 277: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

83. Remove the transaxle brace bolts and brace.

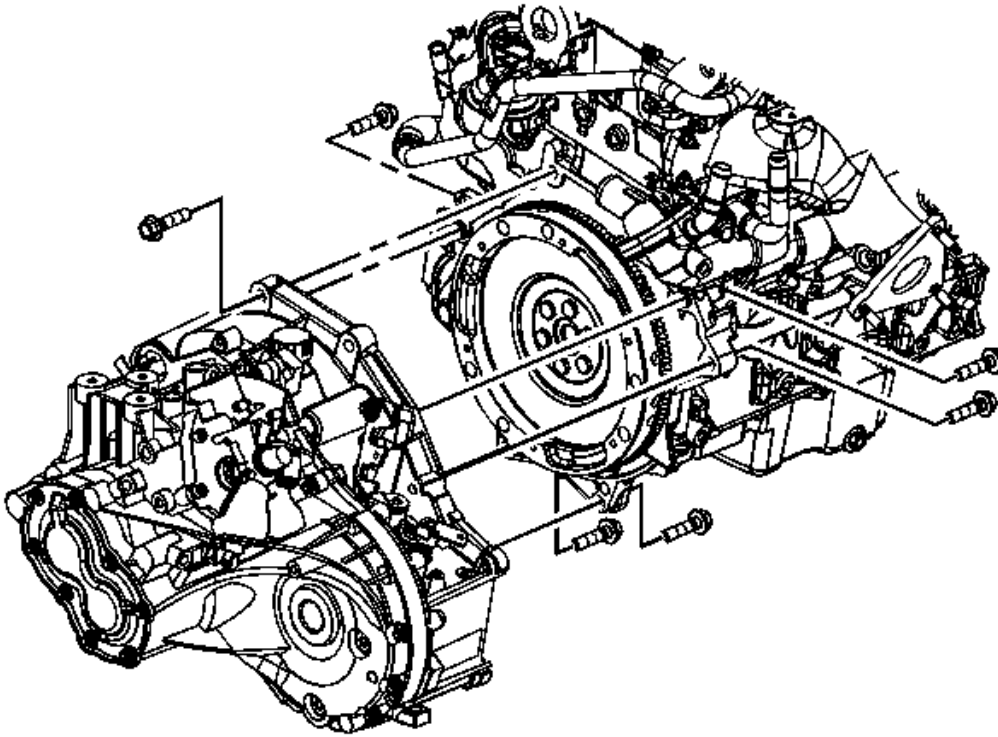


Fig. 278: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

84. Remove the transaxle to engine bolts/stud.
85. Remove the clutch pressure plate and disc. Refer to **Clutch Pressure and Driven Plate Replacement (MU3)**.
86. Remove the following components:
 - The engine mount bracket
 - The engine block heater
 - The generator
87. Using a engine hoist, install the engine to a engine stand.

Installation Procedure

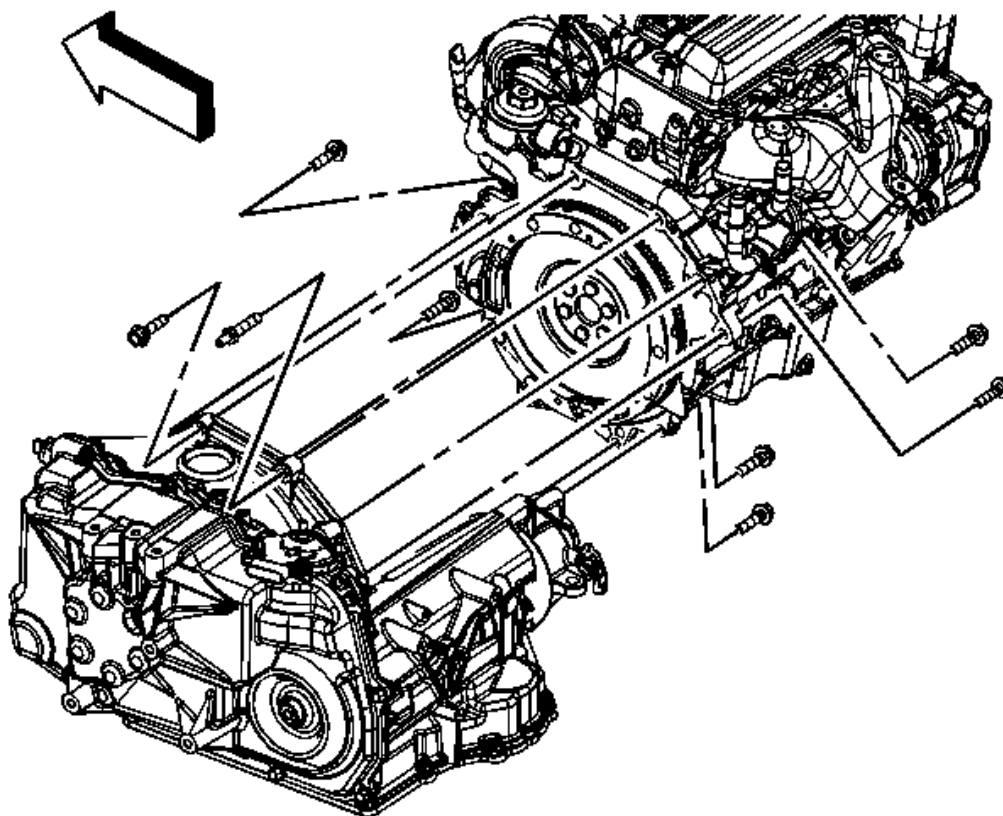


Fig. 279: Identifying Engine/Transaxle Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

1. Using a engine hoist, remove the engine from the engine stand.
2. Install the following components:
 - The engine mount bracket
 - The engine block heater
 - The generator
3. Install the clutch pressure plate and disc. Refer to **Clutch Pressure and Driven Plate Replacement (MU3)**.
4. Install the engine to the transaxle.

NOTE: Refer to **Fastener Notice**.

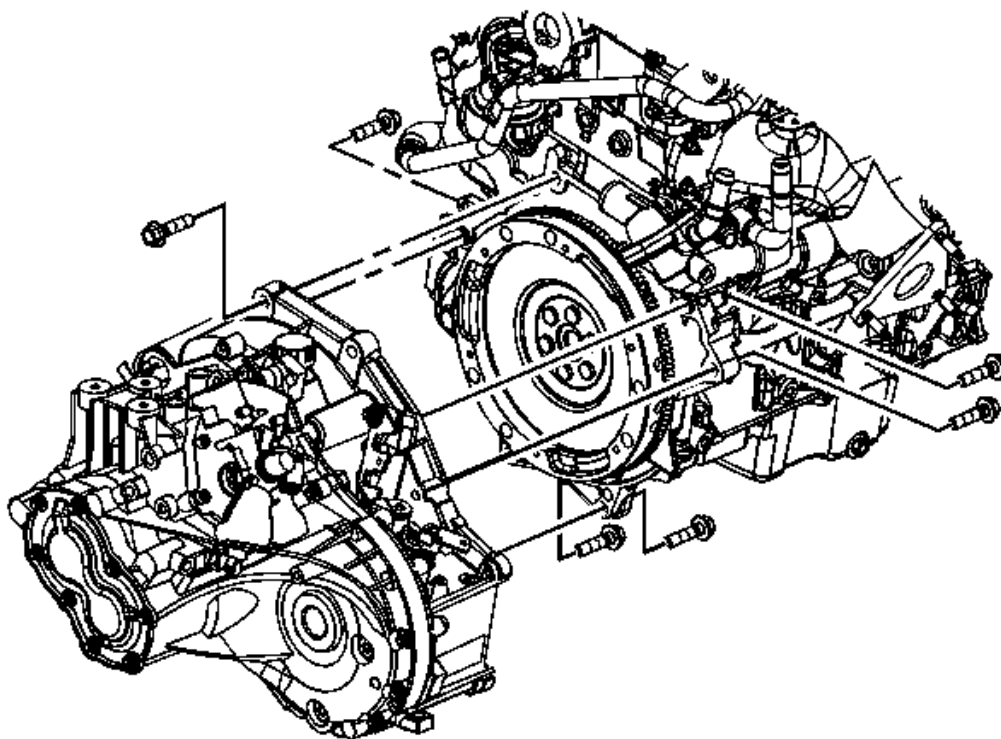


Fig. 280: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

5. Install the transaxle to engine bolts/stud.

Tighten: Tighten the bolts/stud to 75 N.m (55 lb ft).

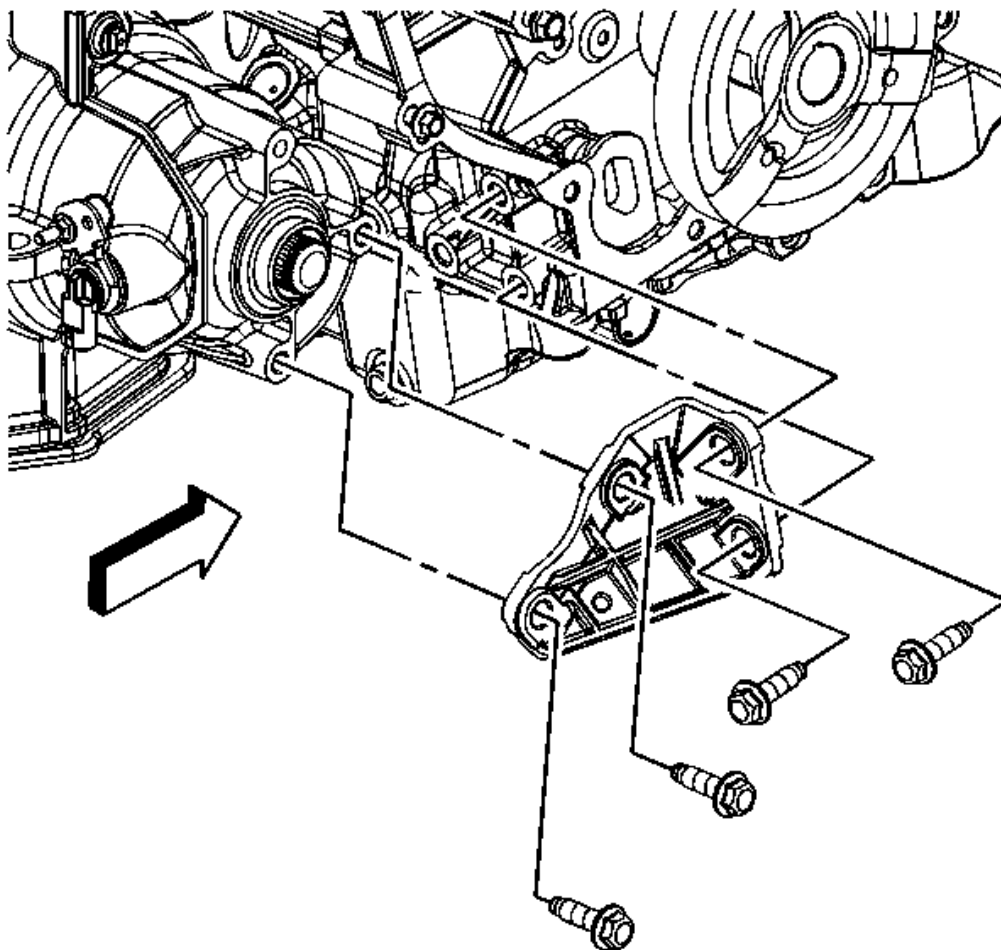


Fig. 281: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the transaxle brace and bolts.

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

7. Install the starter. Refer to **Starter Installation**.

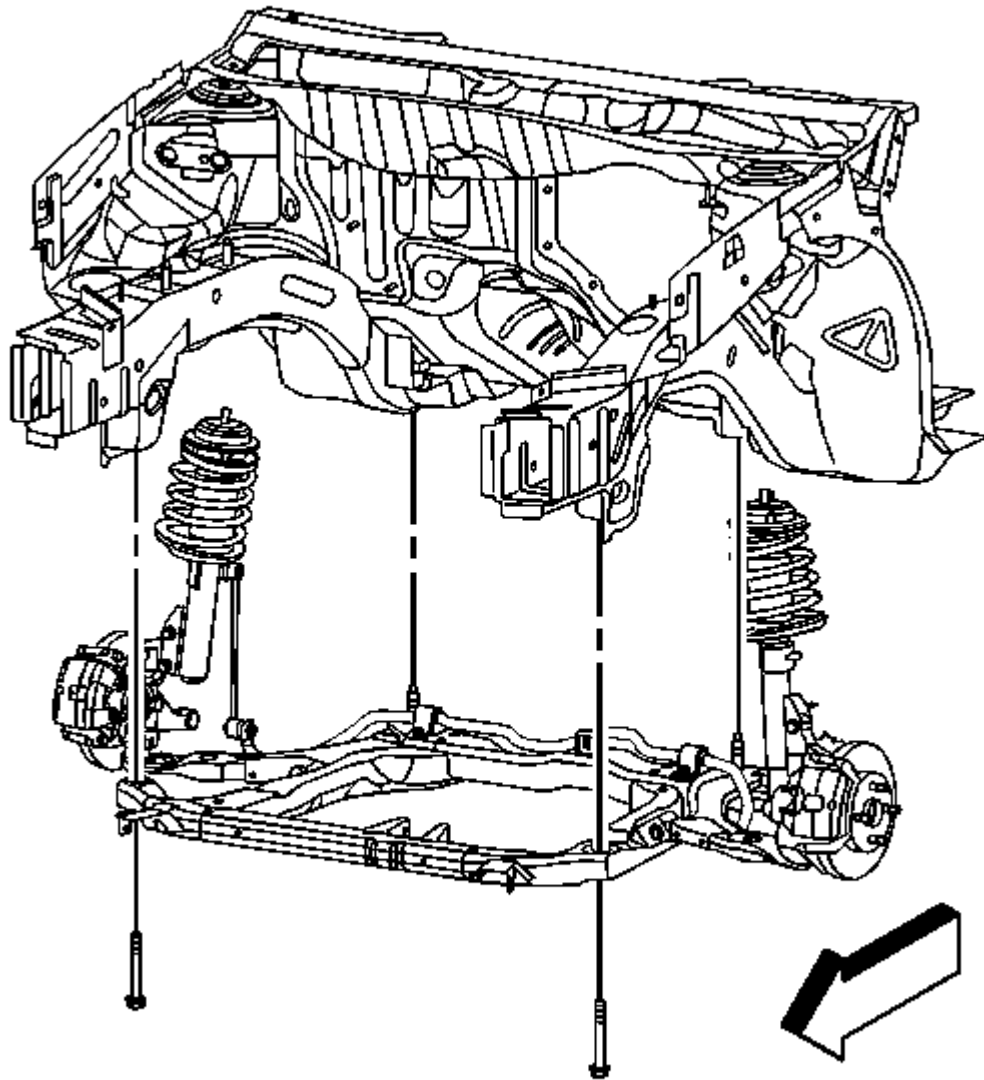


Fig. 282: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine lift hoist from the engine lift hooks.
9. Slide the lift table under the vehicle.
10. Slowly lower the vehicle until it aligns with the alignment marks made during the removal.
11. Tighten/install the frame bolts.

Tighten: Tighten the bolts to 100 N.m (74 lb ft) plus and additional 180 degrees.

12. Raise the vehicle until the lift table can be removed from under the vehicle.
13. Remove the lift table.

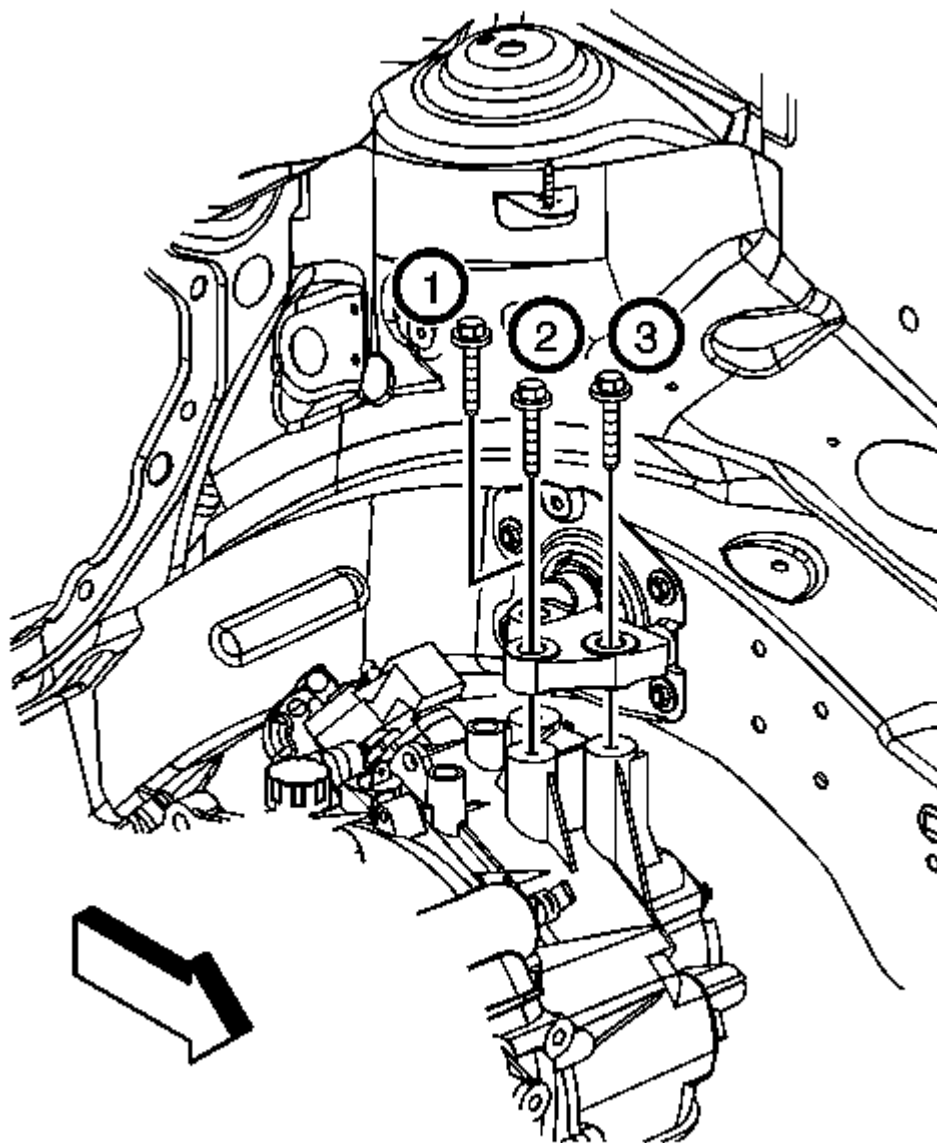


Fig. 283: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

14. Connect the lower control arms to the steering knuckles. Refer to [Lower Control Arm Replacement](#) .
15. Connect the intermediate shaft to the steering gear. Refer to [Intermediate Steering Shaft Replacement](#) .
16. Connect the outer tie rod ends to the steering knuckles. Refer to [Rack and Pinion Outer Tie Rod End Replacement](#) .
17. Connect the stabilizer links to the stabilizer bar. Refer to [Stabilizer Shaft Link Replacement](#) .
18. Lower the vehicle.
19. Install the transaxle mount to transaxle bolts.

Tighten: Tighten the bolts to 45 N.m (33 lb ft).

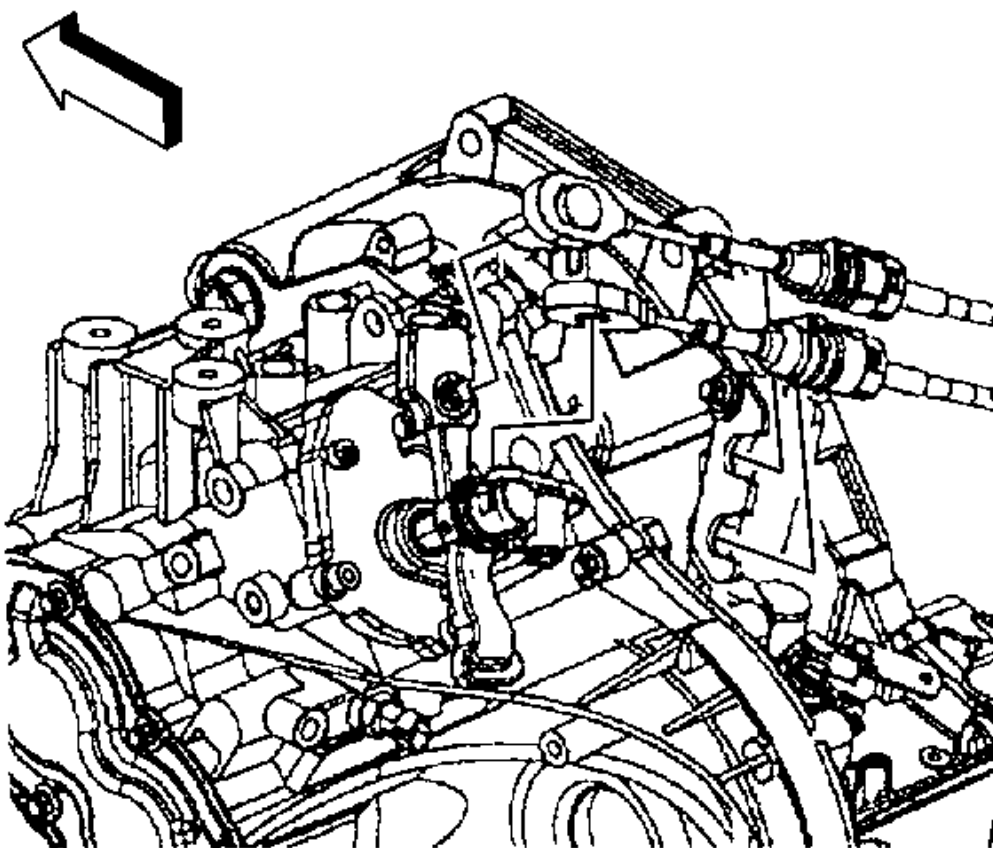


Fig. 284: View Of Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

20. Install the engine mount. Refer to [Engine Mount Replacement](#).
21. Remove the blocks of wood from between the powertrain and the frame.

22. Install the catalytic converter. Refer to Catalytic Converter Replacement (LNF) .
23. Lower the vehicle.

IMPORTANT: Ensure that the black cable is installed in the top notch of the transaxle bracket and the white cable is installed in the bottom notch of the transaxle bracket.

24. Install the range selector and shift lever cables to the transaxle bracket.
25. Connect the range selector and shift lever cables to the transaxle levers.

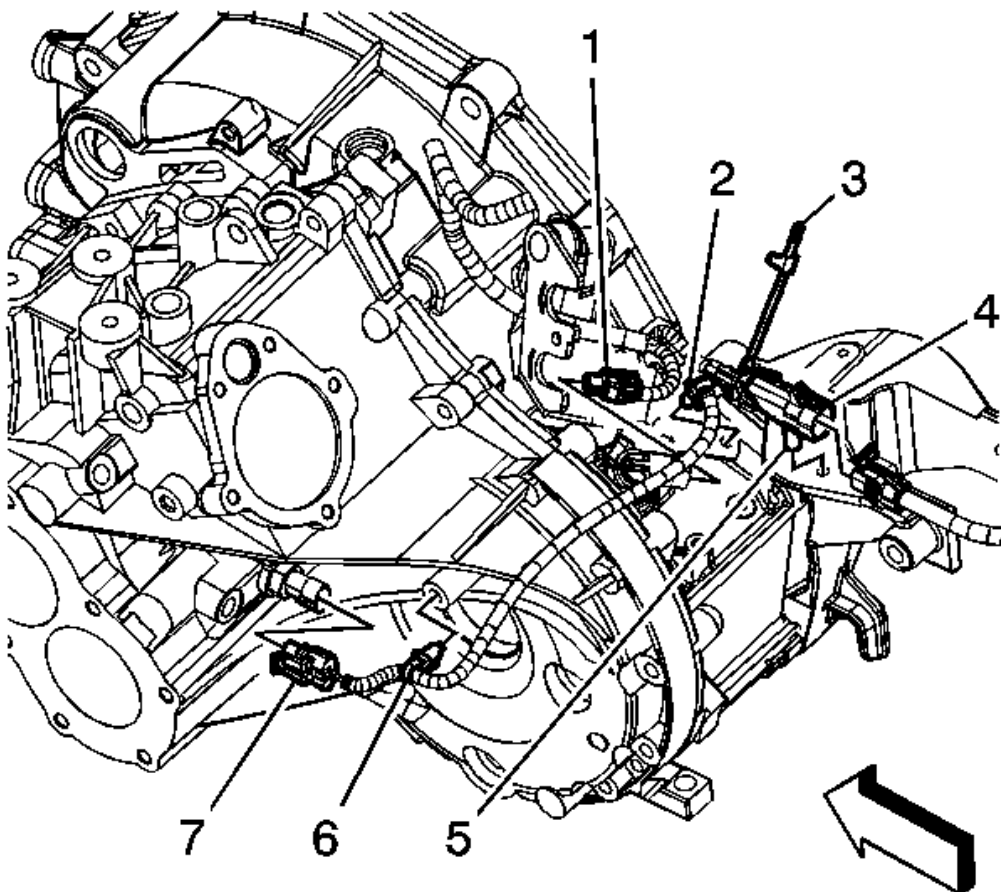


Fig. 285: View Of Engine/Transaxle Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

26. Gather all engine harness branches and position the harness over the engine.

27. Install the engine harness clip (6) to the transaxle.
28. Connect the engine harness electrical connector (7) to the back up lamp switch.
29. Connect the engine harness electrical connector (4) to the HO2S.
30. Install the engine harness electrical connector clip (5) to the transaxle rear mount bracket.
31. Install the engine harness clip (2) to the transaxle.
32. Install the CPA retainer (3).
33. Connect the engine harness electrical connector (1) to the VSS.

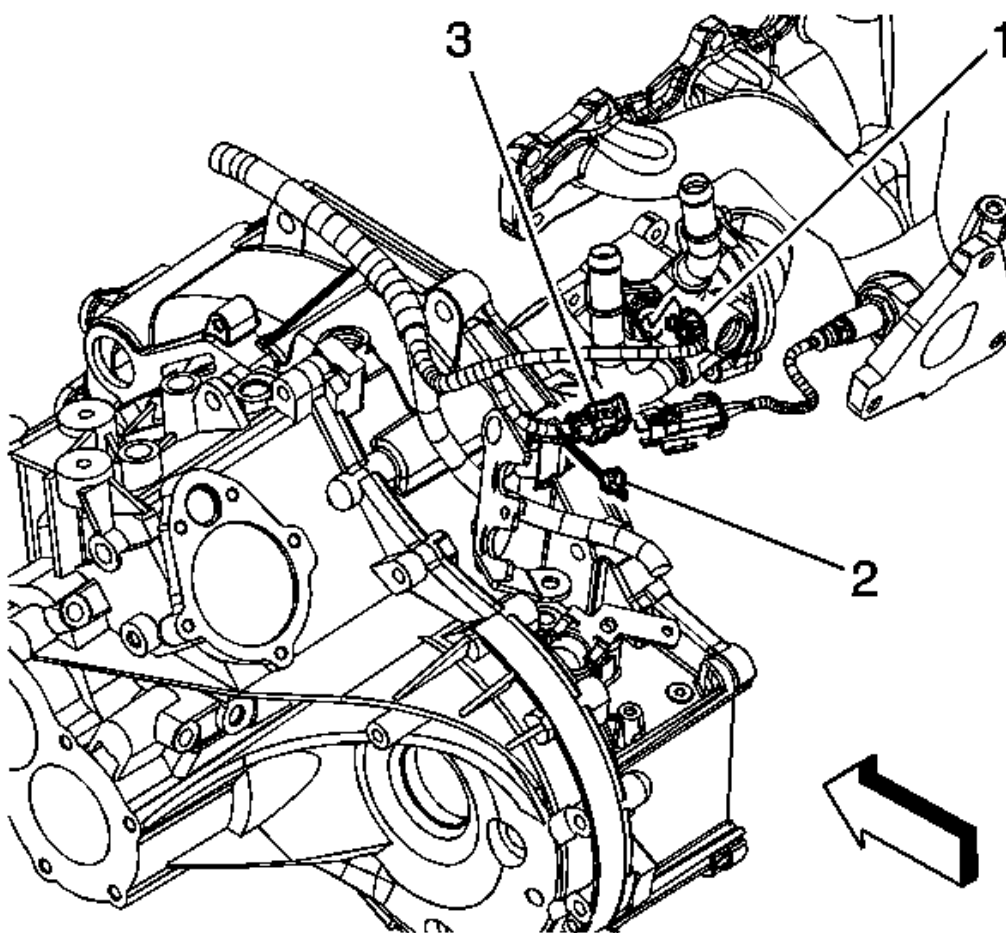


Fig. 286: ECT Sensor Electrical Connector (M/T)
Courtesy of GENERAL MOTORS CORP.

34. Connect the engine harness electrical connector (3) to the HO2S.

35. Install the CPA retainer (2).
36. Connect the ECT sensor electrical connector (1).

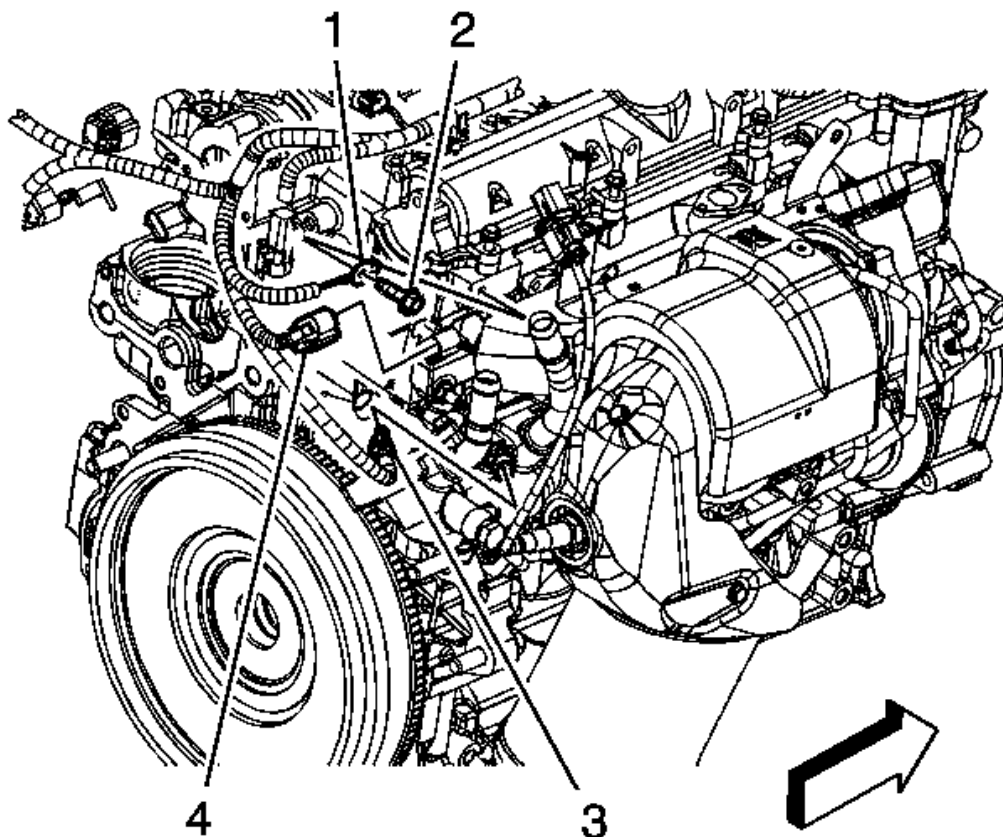


Fig. 287: View Of Engine Wiring Harness Electrical Connector & ECT Sensor
Courtesy of GENERAL MOTORS CORP.

37. Connect the engine wiring harness electrical connector (4) to the exhaust CMP sensor.
38. Connect the engine wiring harness electrical connector (3) to the ECT sensor.
39. Position the engine harness ground terminal (1) and install the engine harness ground terminal bolt (2).

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

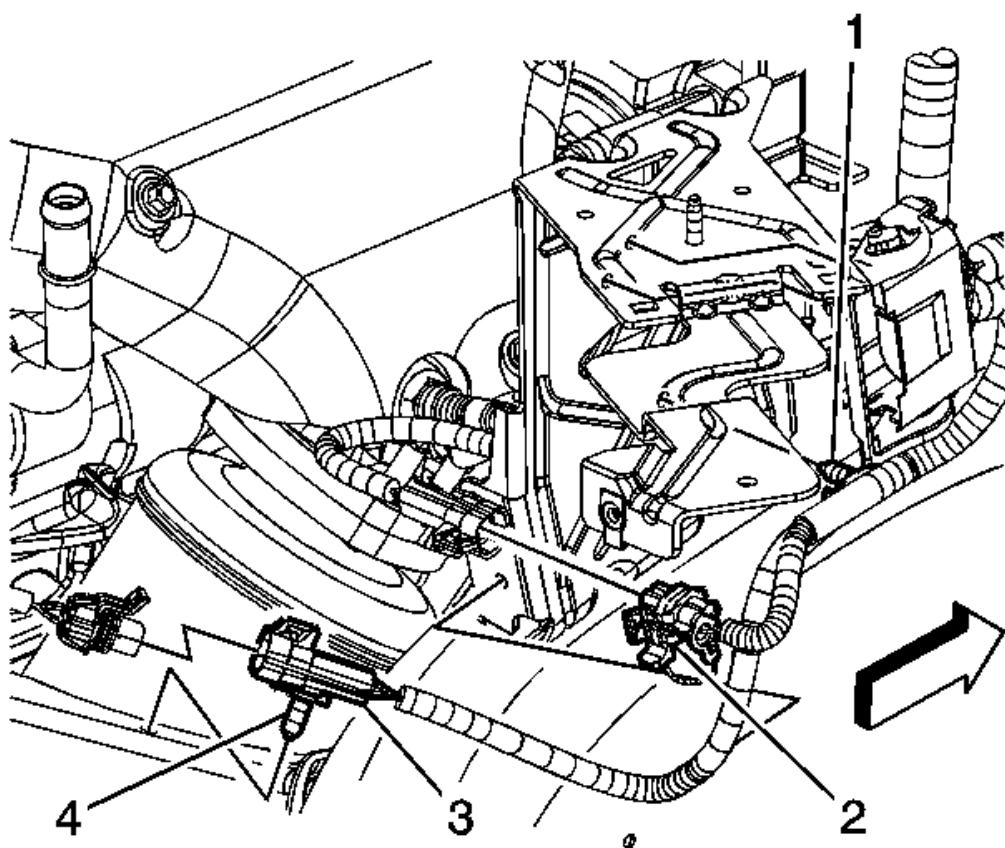


Fig. 288: Identifying CPA Retainer & HO2S Electrical Connector
Courtesy of GENERAL MOTORS CORP.

40. Connect the engine wiring harness electrical connector (1) to the HO2S (3).

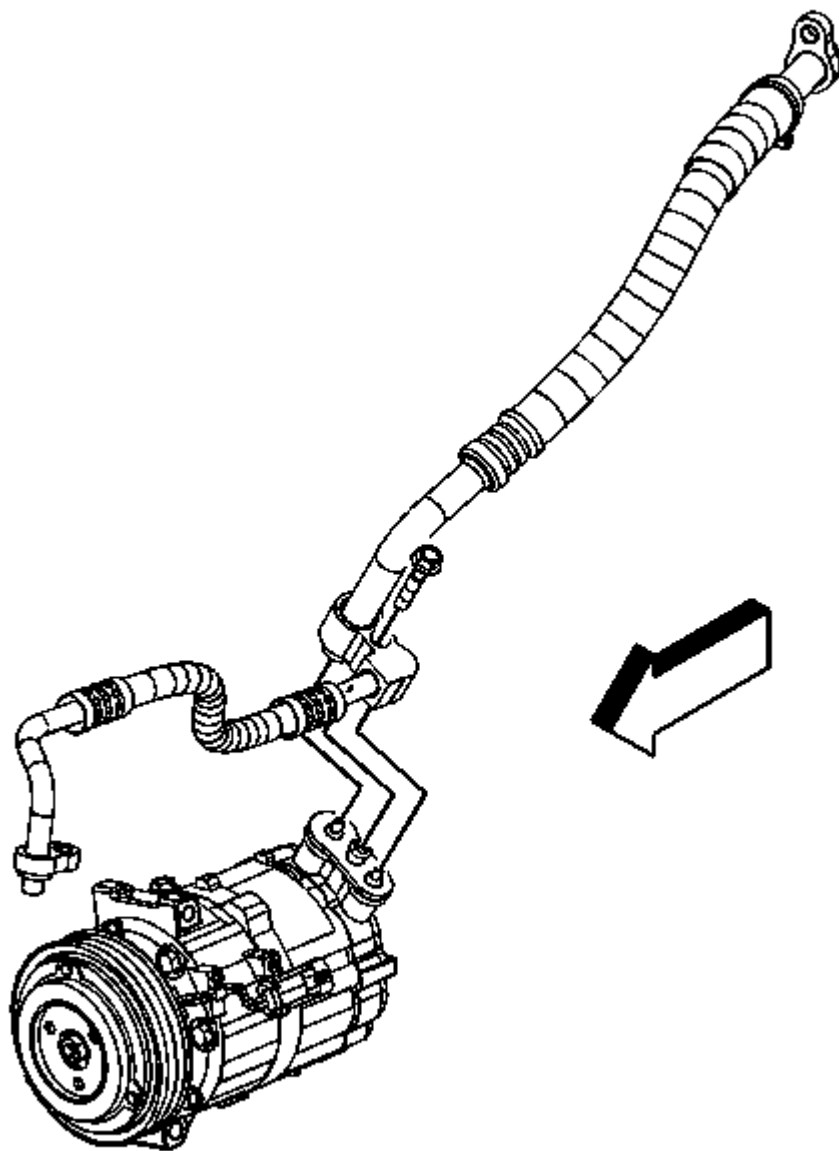


Fig. 289: A/C Compressor Line
Courtesy of GENERAL MOTORS CORP.

41. Position the A/C compressor line and install the bolt.

Tighten: Tighten the bolts to 22 N.m (16 lb ft).

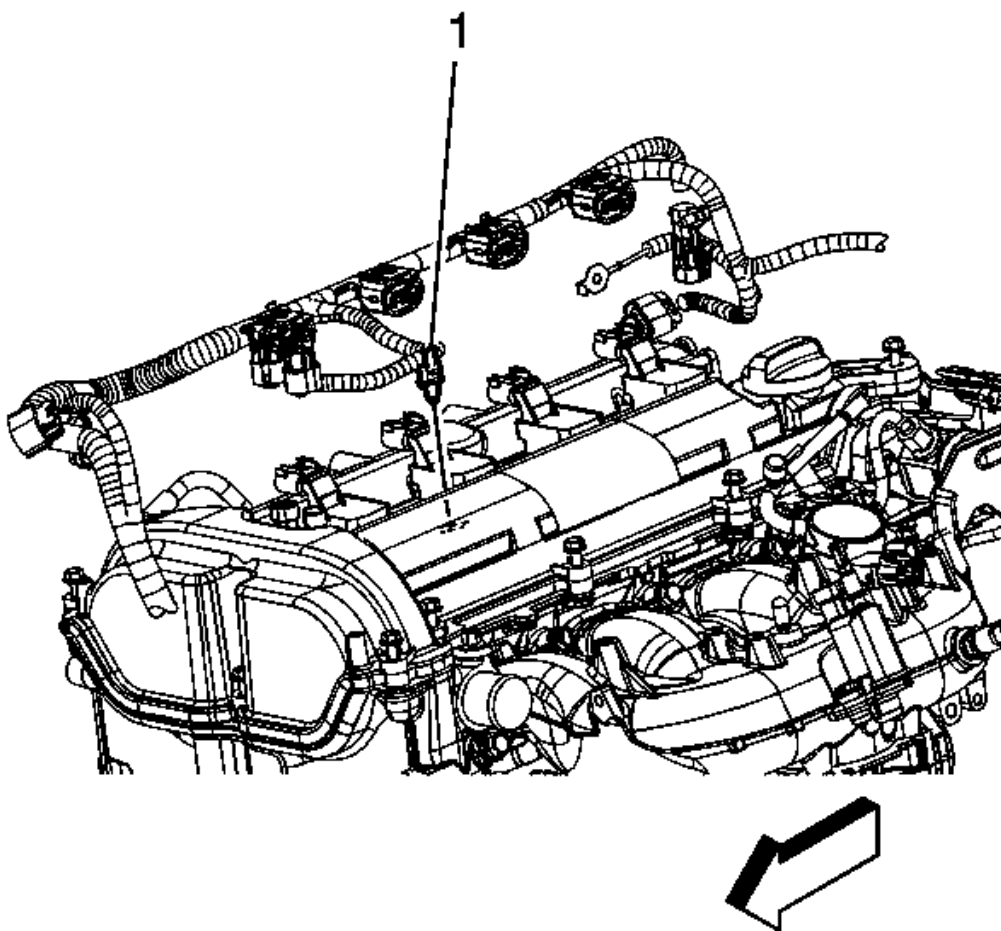


Fig. 290: Identifying Engine Wiring Harness Clips At Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

42. Lower the vehicle.
43. Install the engine harness clip (1) to the camshaft cover.

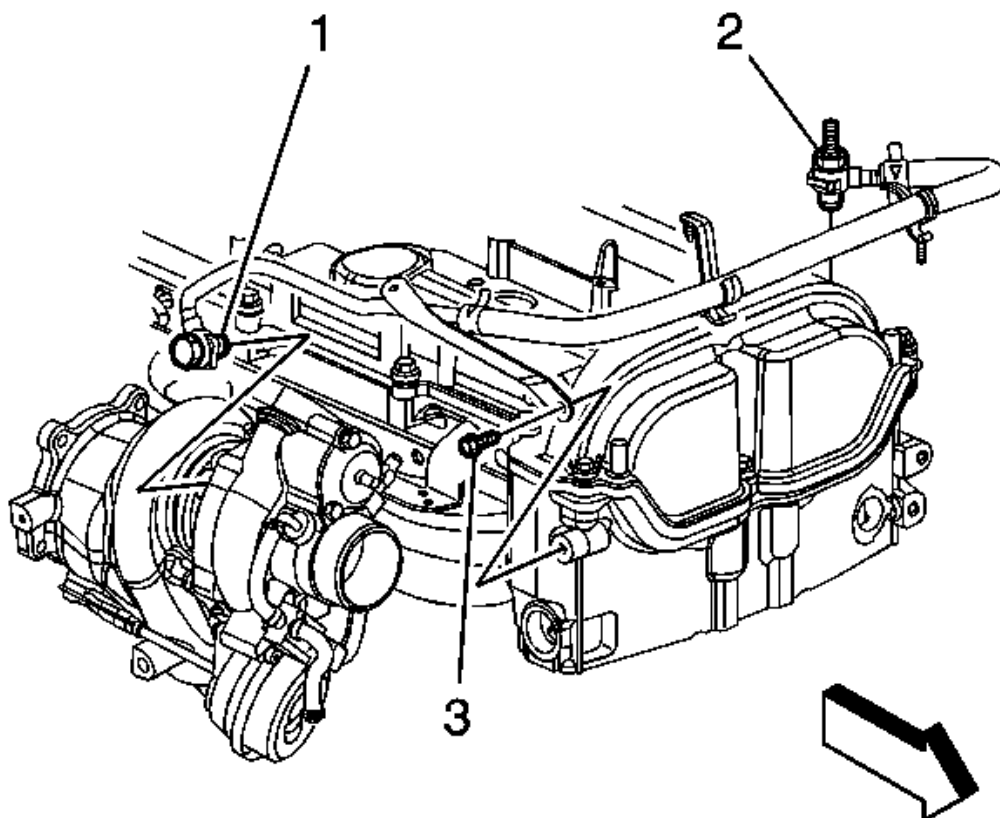


Fig. 291: Turbocharger Coolant Feed Pipe Bolt
Courtesy of GENERAL MOTORS CORP.

44. Position the turbocharger coolant feed pipe to the vehicle.
45. Install the turbocharger coolant feed pipe bracket bolt (3) to the cylinder head.

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

46. Install the turbocharger coolant feed pipe fitting (2) to the cylinder head.

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

47. Install the turbocharger coolant feed pipe bolt (1) at the turbocharger.

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

48. Install the charge air bypass valve vacuum solenoid.

49. Install the charge air bypass valve vacuum hose to the turbocharger coolant feed pipe clips.
50. Position the charge air bypass valve vacuum hose clamp at the turbocharger.
51. Place the charge air bypass valve solenoid out of the way.

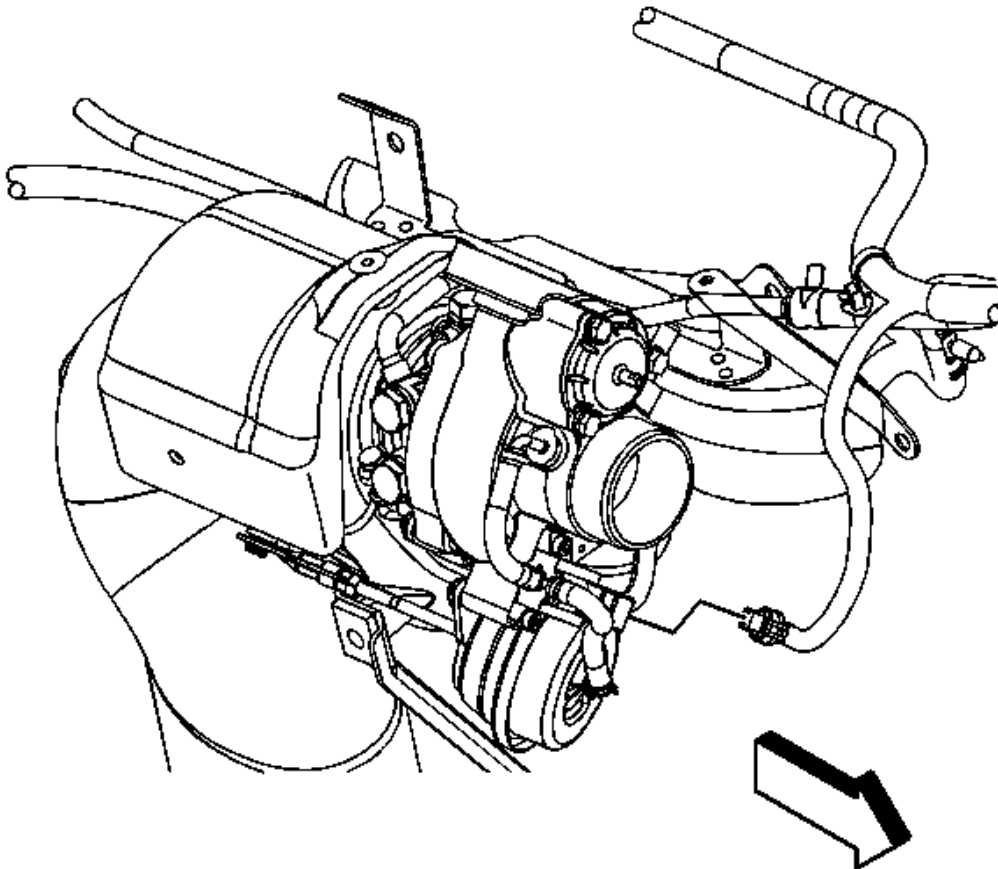


Fig. 292: Locating turbocharger wastegate solenoid valve Harness & Connector
Courtesy of GENERAL MOTORS CORP.

52. Connect the engine wiring harness electrical connector to the boost sensor.

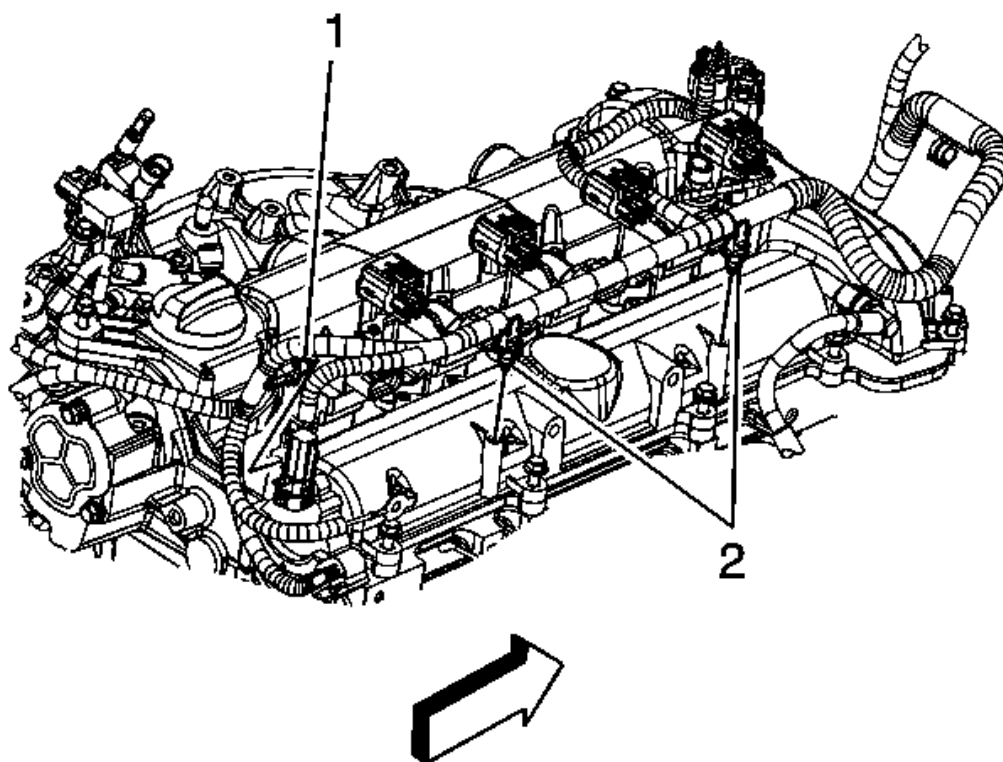


Fig. 293: Engine Wiring Harness Clips
Courtesy of GENERAL MOTORS CORP.

53. Connect the engine harness clips (2) to the camshaft cover.
54. Connect the engine harness clip (1) to the camshaft cover.

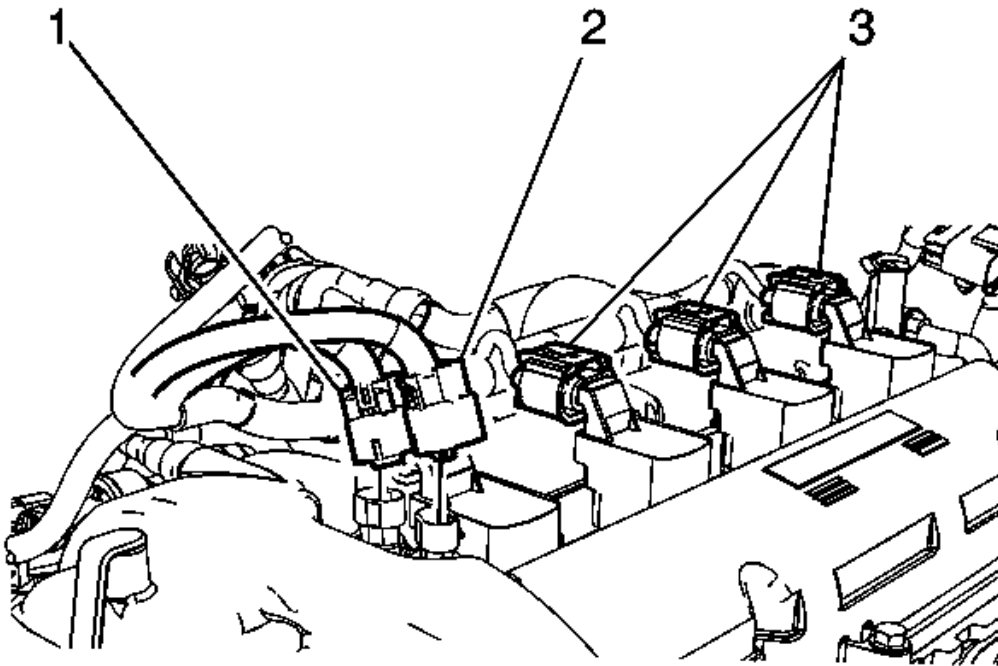


Fig. 294: Identifying Intake & Exhaust CMP Actuators
Courtesy of GENERAL MOTORS CORP.

55. Connect the engine wiring harness electrical connectors to the ignition coils.
56. Connect the engine wiring harness electrical connector (2) to the intake CMP actuator.
57. Connect the engine wiring harness electrical connector (1) to the exhaust CMP actuator.

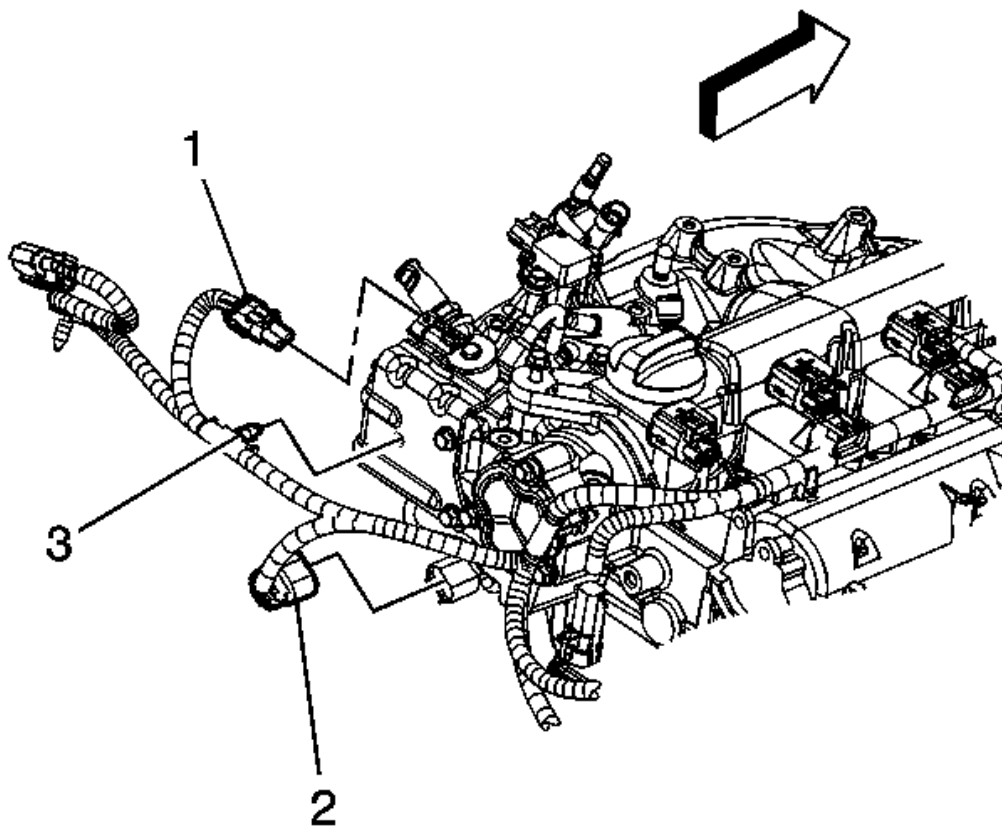


Fig. 295: View Of Engine Wiring Harness Connector & High Pressure Fuel Pump
Courtesy of GENERAL MOTORS CORP.

58. Connect the engine wiring harness electrical connector (1) to the high pressure fuel pump.
59. Install the engine wiring harness clip (3) to the high pressure fuel pump bracket.

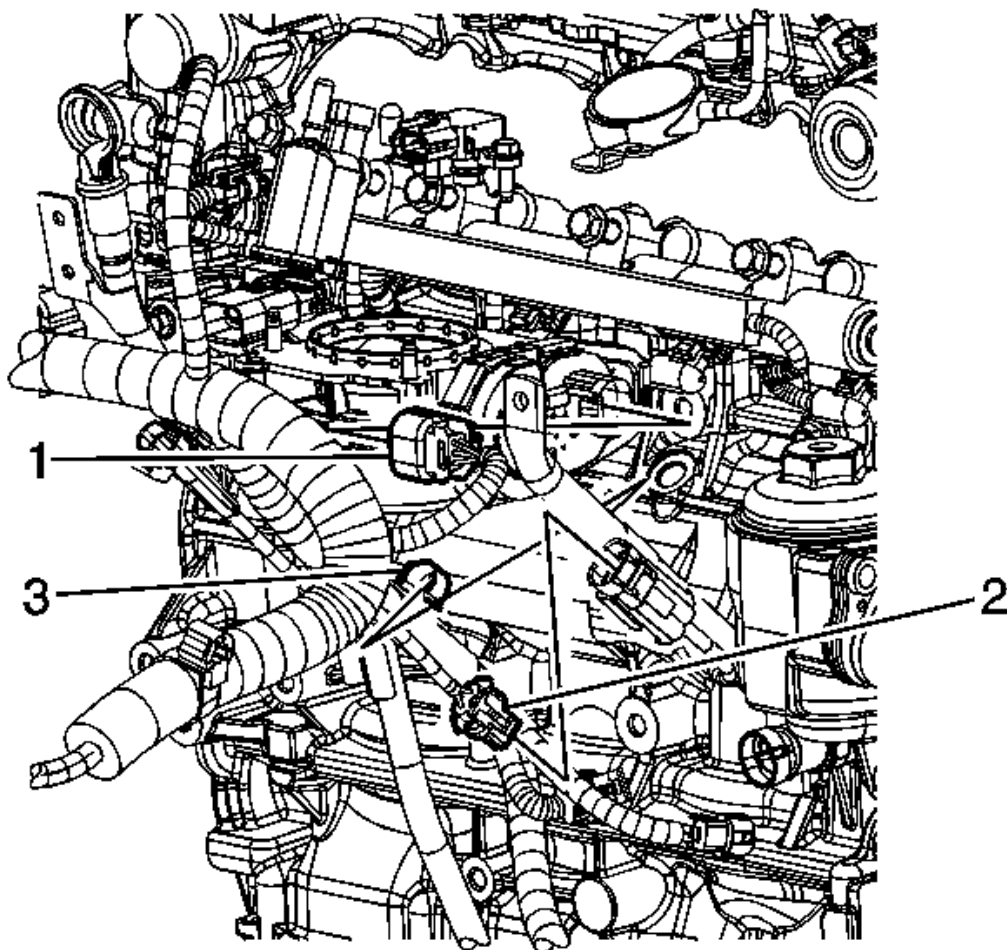


Fig. 296: Identifying Knock Sensor Connector
Courtesy of GENERAL MOTORS CORP.

60. Connect the engine wiring harness electrical connector (2) to the knock sensor.

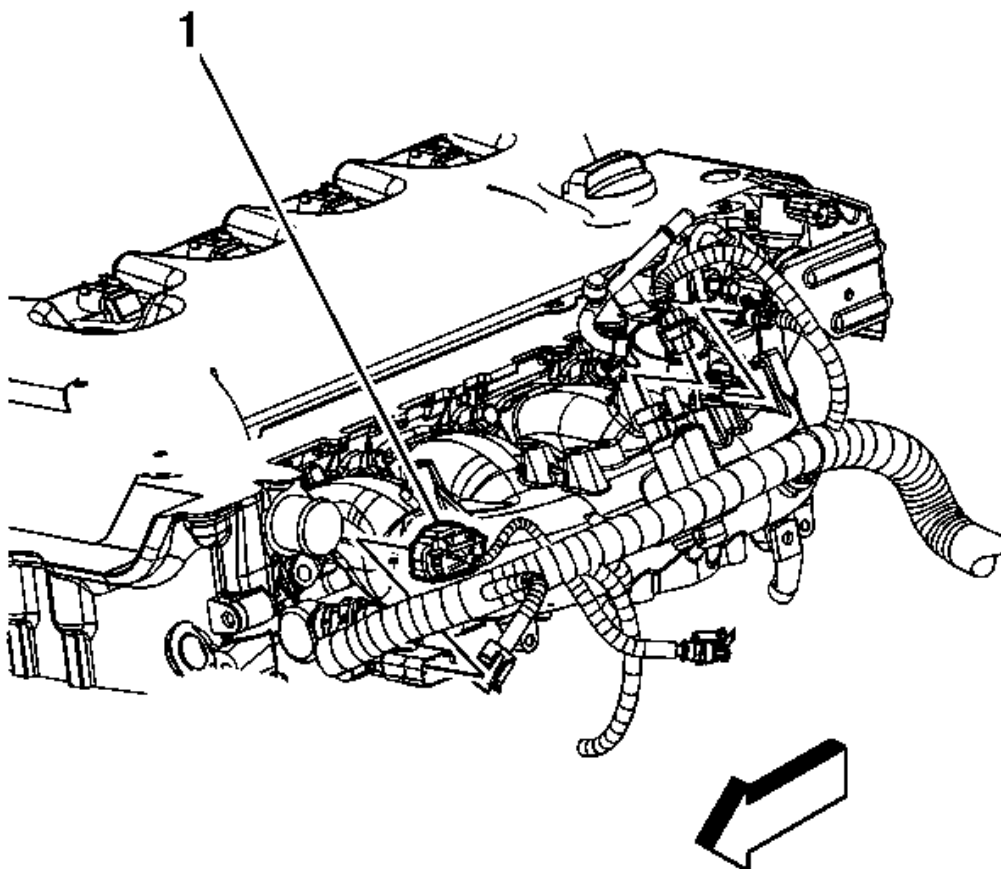


Fig. 297: Locating Fuel Injector Jumper Electrical Connector
Courtesy of GENERAL MOTORS CORP.

61. Connect the engine wiring harness electrical connector (1) to the fuel injector jumper electrical connector.

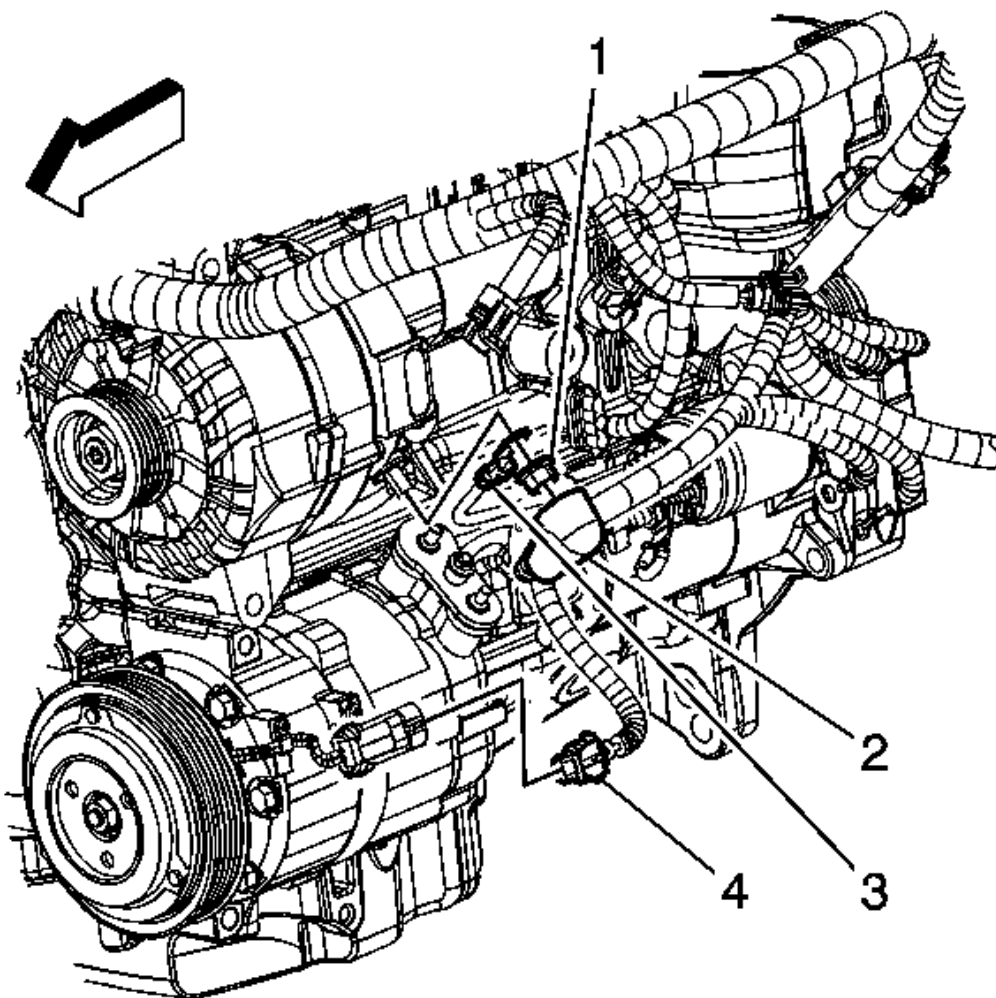


Fig. 298: Identifying Generator
Courtesy of GENERAL MOTORS CORP.

62. Install the positive battery cable terminal (3) to the generator.
63. Install the generator terminal nut (1).

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

64. Position the positive battery cable terminal boot (2).
65. Connect the engine wiring harness electrical connector (4) to the A/C compressor.

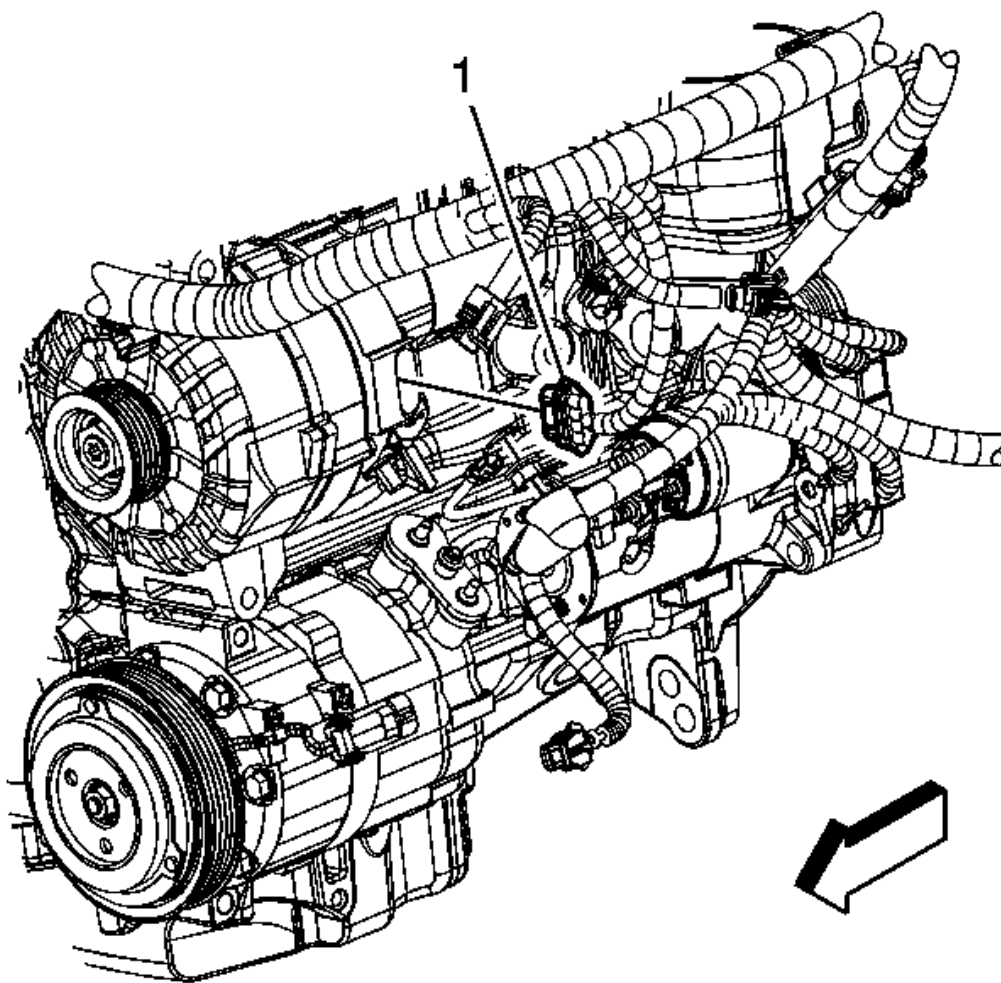


Fig. 299: Identifying Generator Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

66. Connect the engine wiring harness electrical connector (1) to the generator.

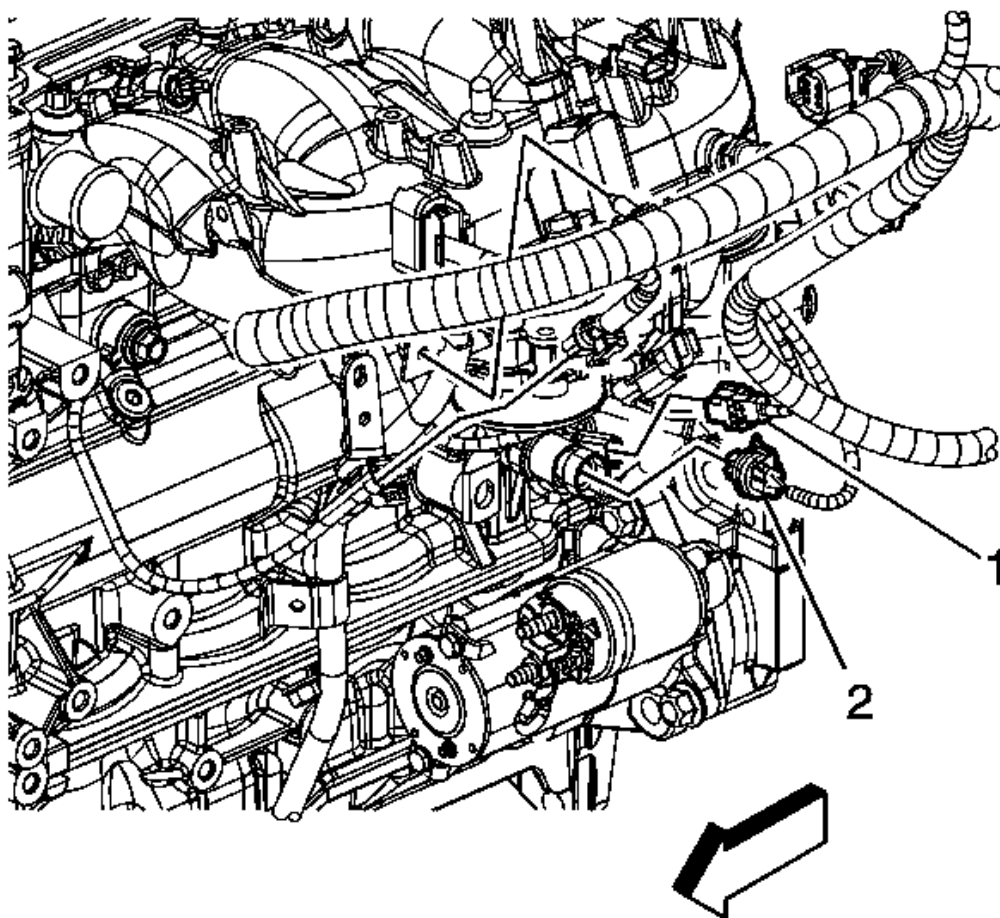


Fig. 300: Locating CKP Sensor & Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

67. Install the catalytic converter. Refer to **Catalytic Converter Replacement (LNF)** .
68. Connect the engine wiring harness electrical connector (1) to the CKP sensor.
69. Connect the engine wiring harness electrical connector (2) to the oil pressure sensor.
70. Lower the vehicle.

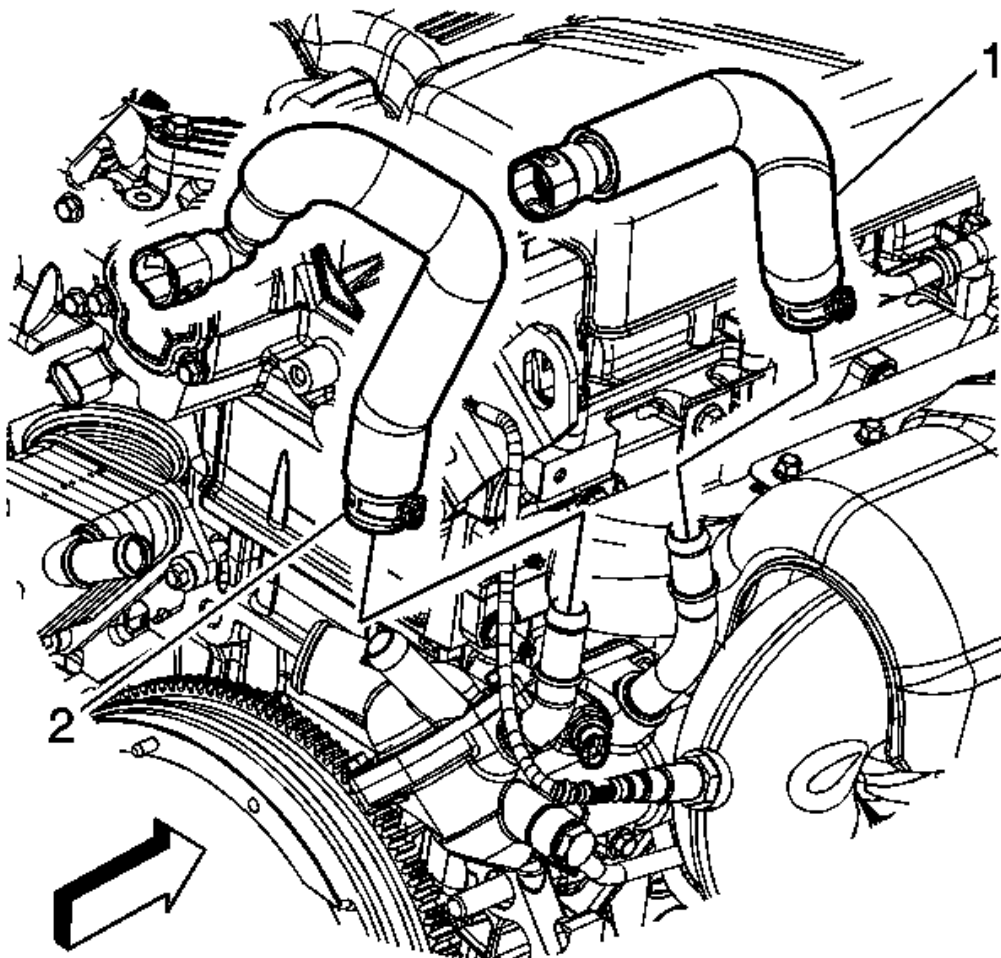


Fig. 301: Identifying Heater Inlet & Outlet Hoses & Clamps
Courtesy of GENERAL MOTORS CORP.

71. Install the heater inlet (1) and outlet (2) hoses to the thermostat housing.
72. Position the heater inlet and outlet hose clamps at the thermostat housing.

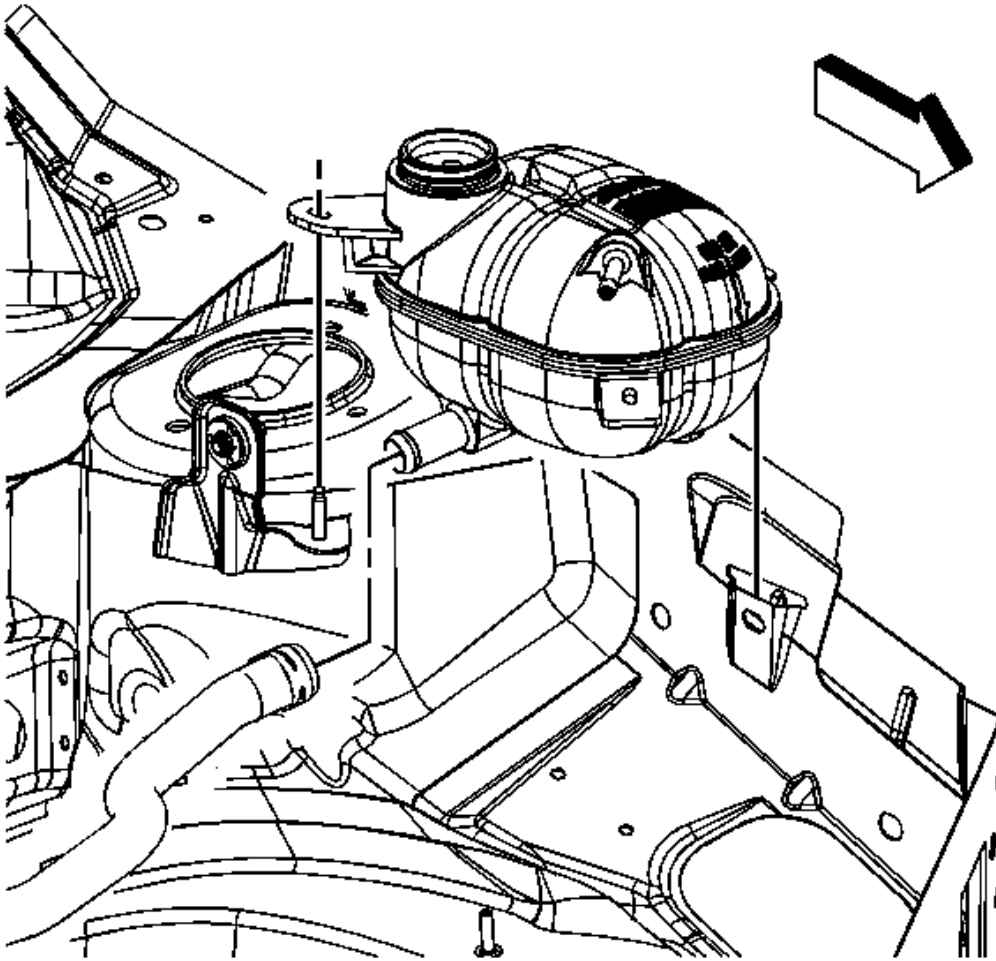


Fig. 302: View Of Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

73. Install the surge tank outlet hose to the surge tank.
74. Position the surge tank outlet hose clamp at the surge tank.
75. Install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LNF)** .
76. Install the radiator inlet hose. Refer to **Radiator Inlet Hose Replacement (LNF)** .

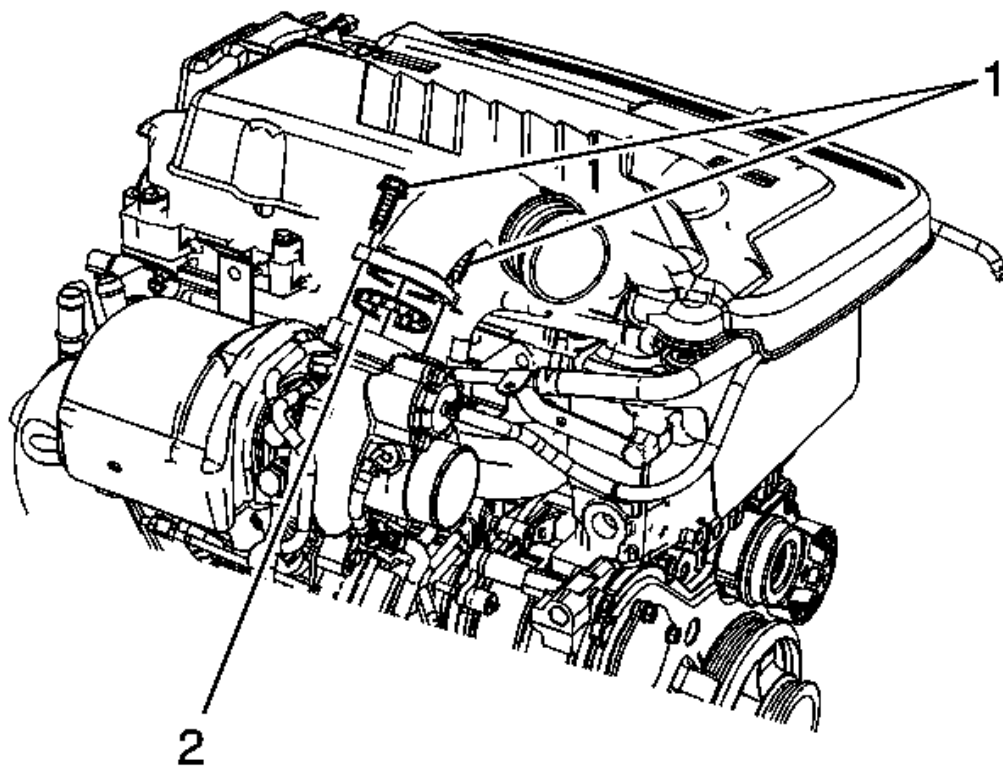


Fig. 303: Locating Charge Air Cooler Pipe
Courtesy of GENERAL MOTORS CORP.

- 77. Remove the cap or plug from the turbocharger opening.
- 78. Install the charge air cooler pipe to the turbocharger.
- 79. Install the charge air cooler pipe to turbocharger bolts (1).

Tighten: Tighten the bolts to 22 N.m (16 lb ft).

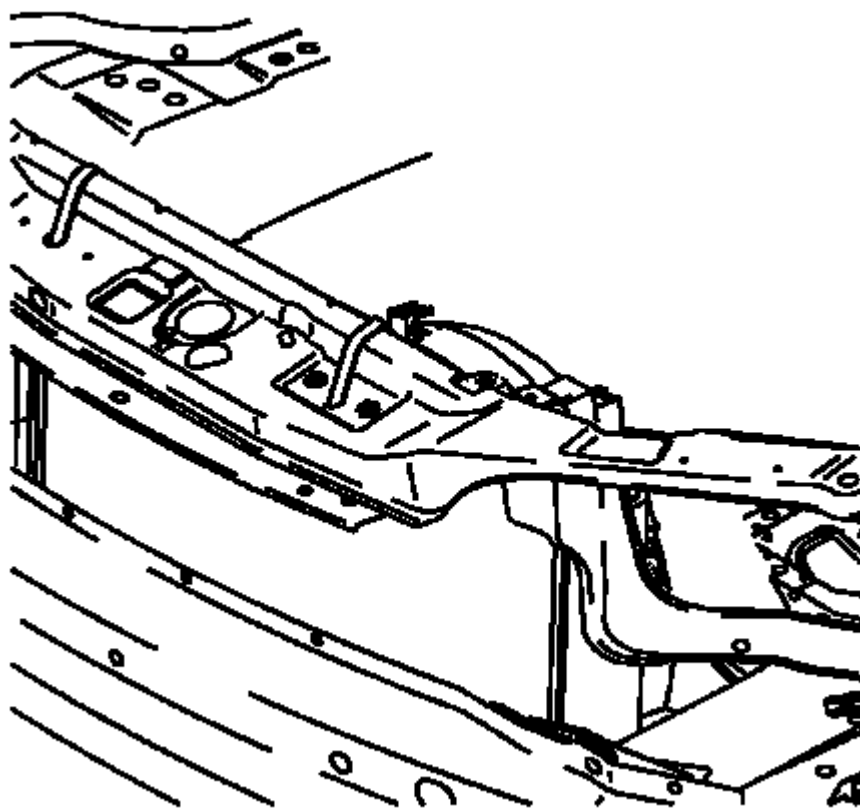


Fig. 304: Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

80. Install the engine drive belt. Refer to **Drive Belt Replacement** .
81. Unsecure the cooling module from the upper body structure.
82. Fill the cooling system. Refer to **Cooling System Draining and Filling (GE 47716 Fill)** or **Cooling System Draining and Filling (Static Fill LNF)** .

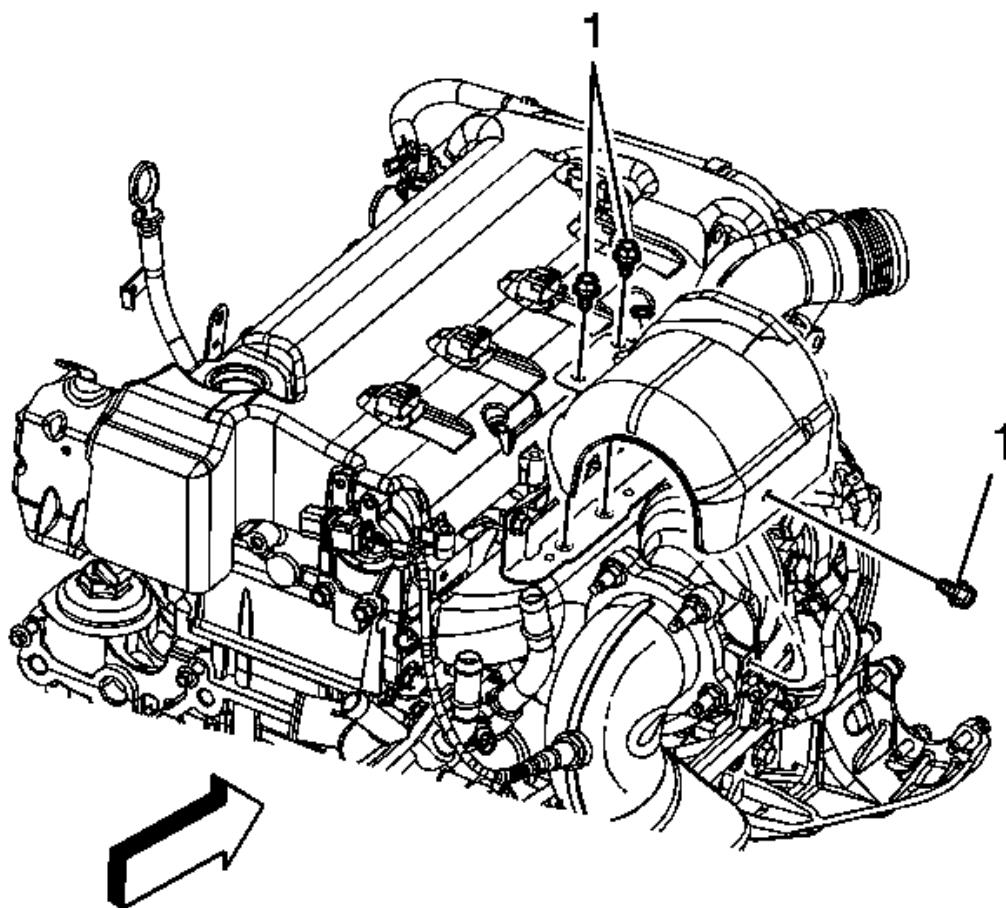


Fig. 305: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

83. Install the turbocharger heat shield and bolts (1).

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

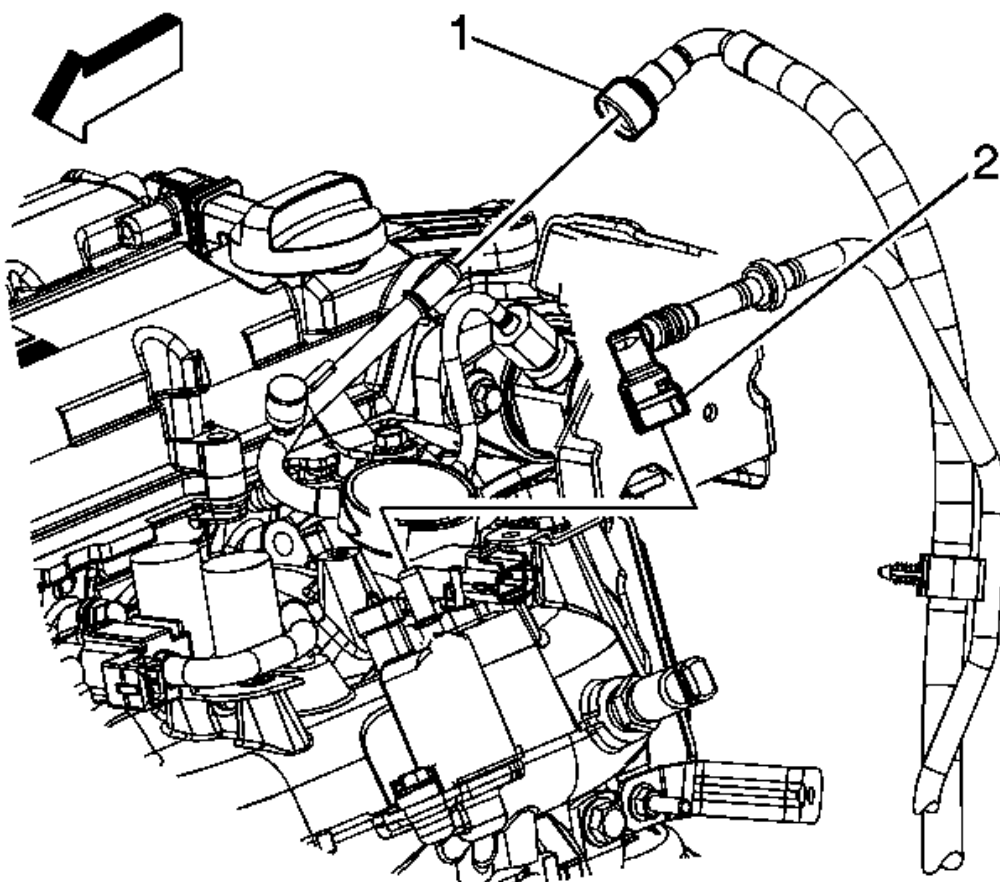


Fig. 306: Identifying Feed Pipe & EVAP Canister Purge Solenoid Tube
Courtesy of GENERAL MOTORS CORP.

84. Connect the fuel feed pipe (1) to the fuel line. Refer to **Metal Collar Quick Connect Fitting Service** .
85. Connect the EVAP canister purge solenoid tube to the valve (2). Refer to **Plastic Collar Quick Connect Fitting Service** .
86. Install the charge air cooler inlet and outlet pipes. Refer to **Charge Air Cooler Inlet Pipe Replacement** and **Charge Air Cooler Outlet Pipe Replacement** .
87. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
88. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
89. Fill the engine with oil.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
2. Place a drain pan under the oil drain plug.

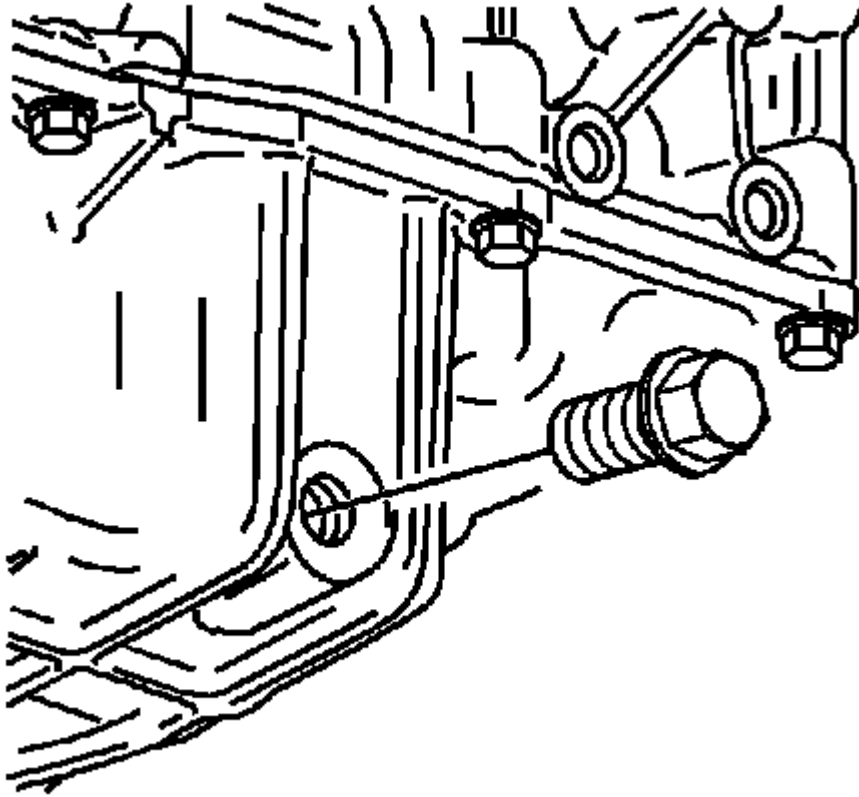


Fig. 307: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan drain plug.
4. Lower the vehicle.

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

5. Without supercharger - use a 32 mm socket with a long extension (1/2 to 3/8 reducer helps if available) and ratchet on the hex on the top of the oil filter cap.
6. With Supercharger - the oil filter is accessible by reaching under the supercharger. Use a 32 mm socket with the needed flex handle or box wrench.
7. Loosen the oil filter housing.
8. Remove the tools.

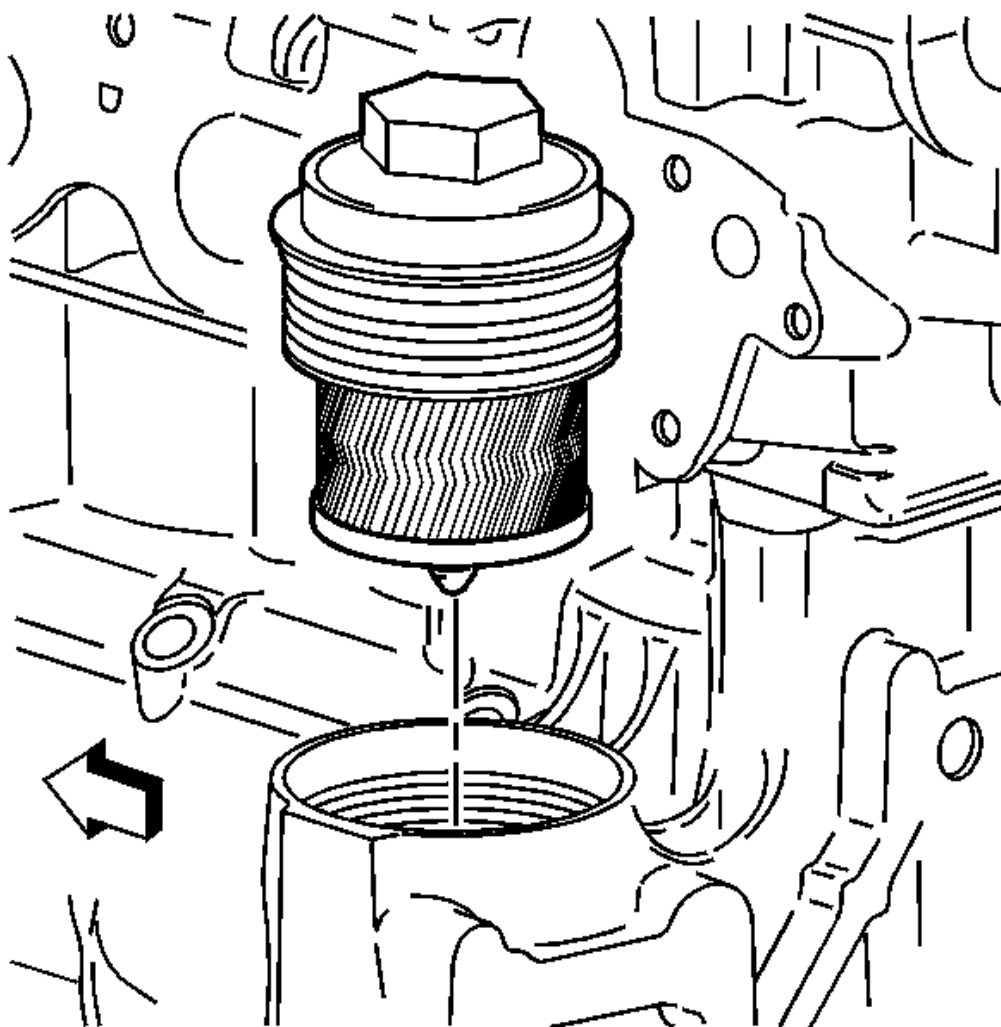


Fig. 308: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil filter and housing.
10. Remove the filter from the cap.

Installation Procedure

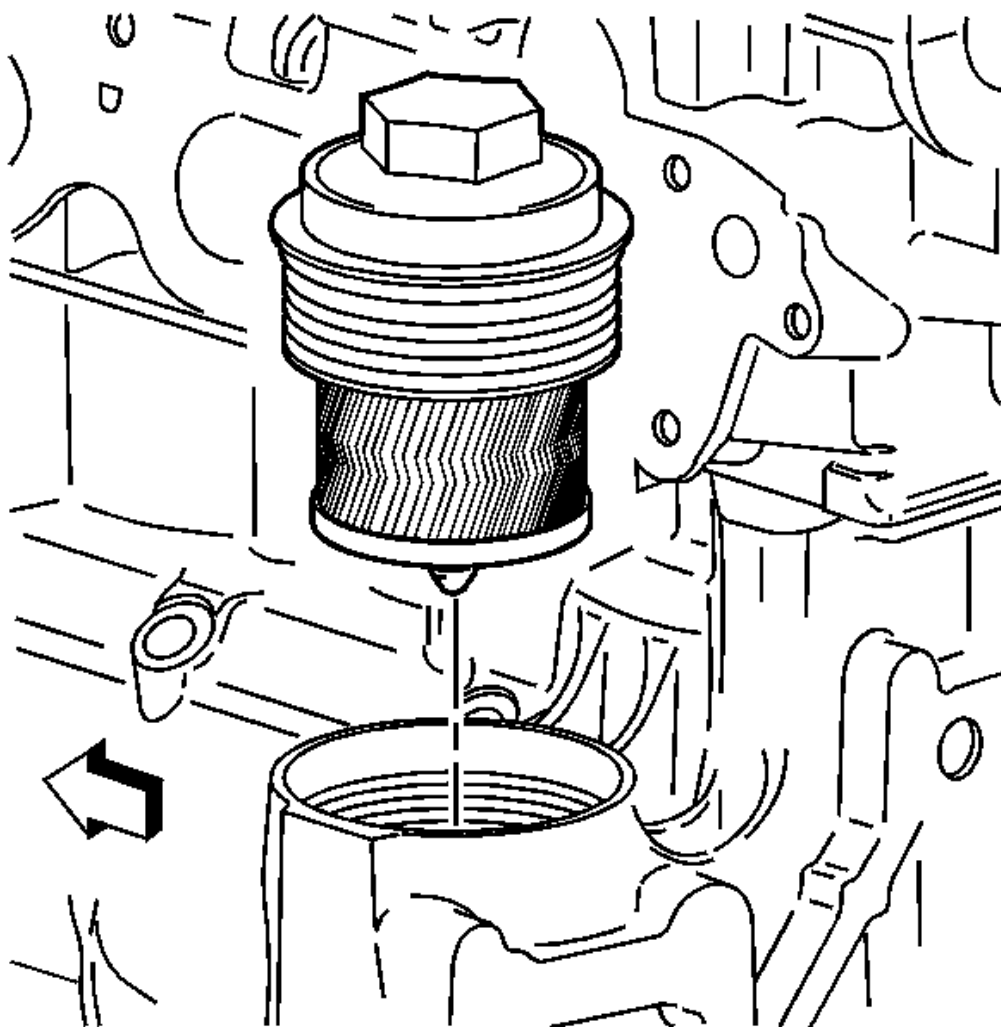


Fig. 309: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

1. Install the filter to the housing.
2. Install the oil filter cap with filter.
3. Install the oil filter to the housing.

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

NOTE: Refer to Fastener Notice .

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

4. Use a 32 mm socket with a long extension (1/2 to 3/8 reducer helps if available) and ratchet on the hex on the top of the oil filter cap.

Tighten: Tighten the oil filter cap until fully seated, DO NOT exceed 25 N.m (18 lb ft).

5. Raise the vehicle.

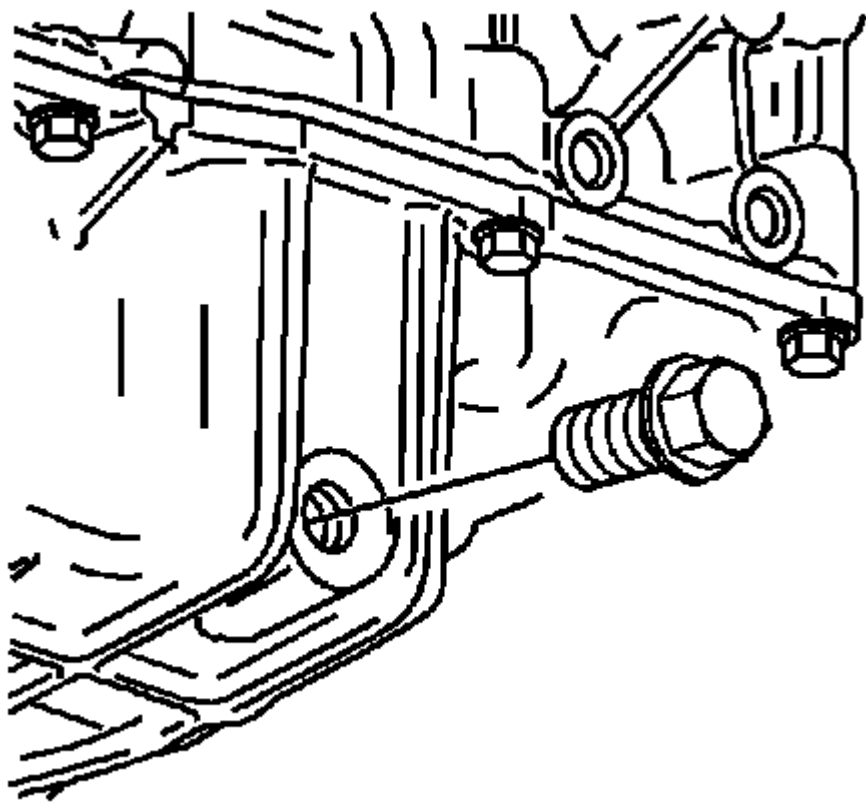


Fig. 310: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug.

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

7. Lower the vehicle.
8. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations** .

REPAIR INSTRUCTIONS - OFF VEHICLE

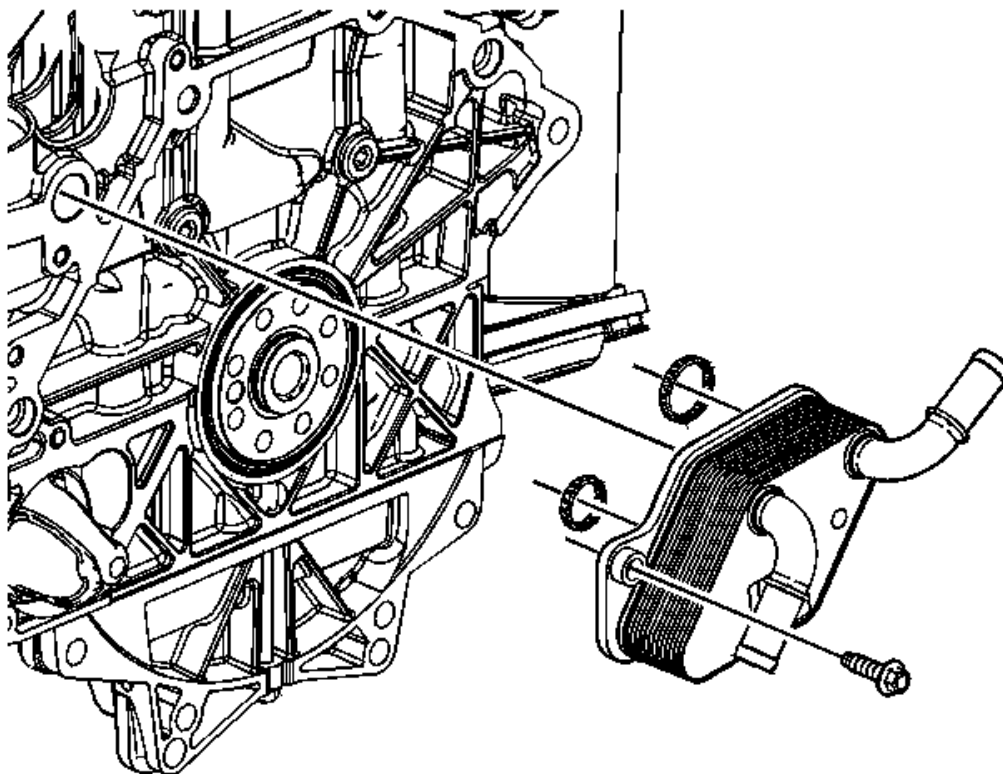
ENGINE OIL COOLER REMOVAL

Fig. 311: View Of Engine Oil Cooler
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil cooler bolt.
2. Remove the oil cooler.

DRAINING FLUIDS AND OIL FILTER REMOVAL**Tools Required**

J 44887 Oil Filter Wrench. See **Special Tools**.

Removal Procedure

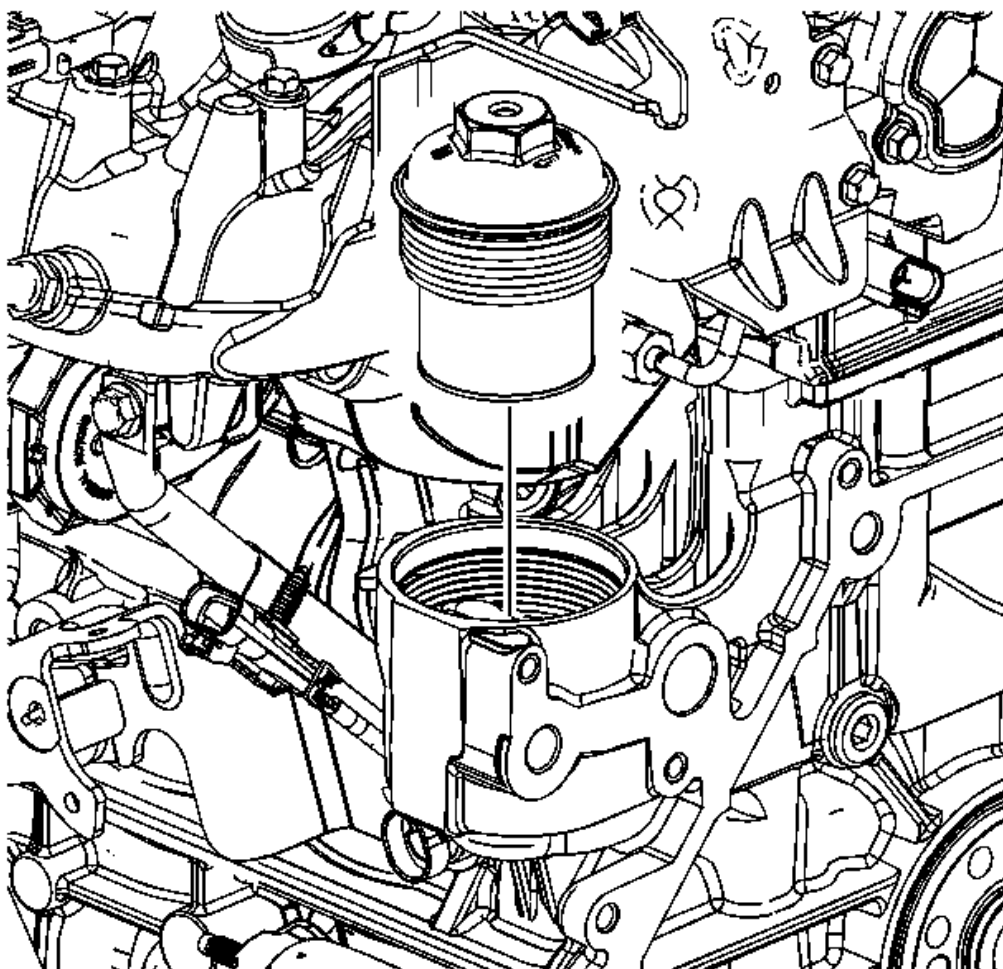


Fig. 312: View Of Oil Filter & Cap
Courtesy of GENERAL MOTORS CORP.

1. Use **J 44887** to remove the oil filter cap. See **Special Tools**. Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter from the cap and discard.
3. Clean the oil filter housing in the engine block.

NOTE: Refer to **FASTENER NOTICE** .

4. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain plug 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 GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the water pump drain plug.
7. Install the water pump drain plug.

Tighten: Tighten the water pump drain plug 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

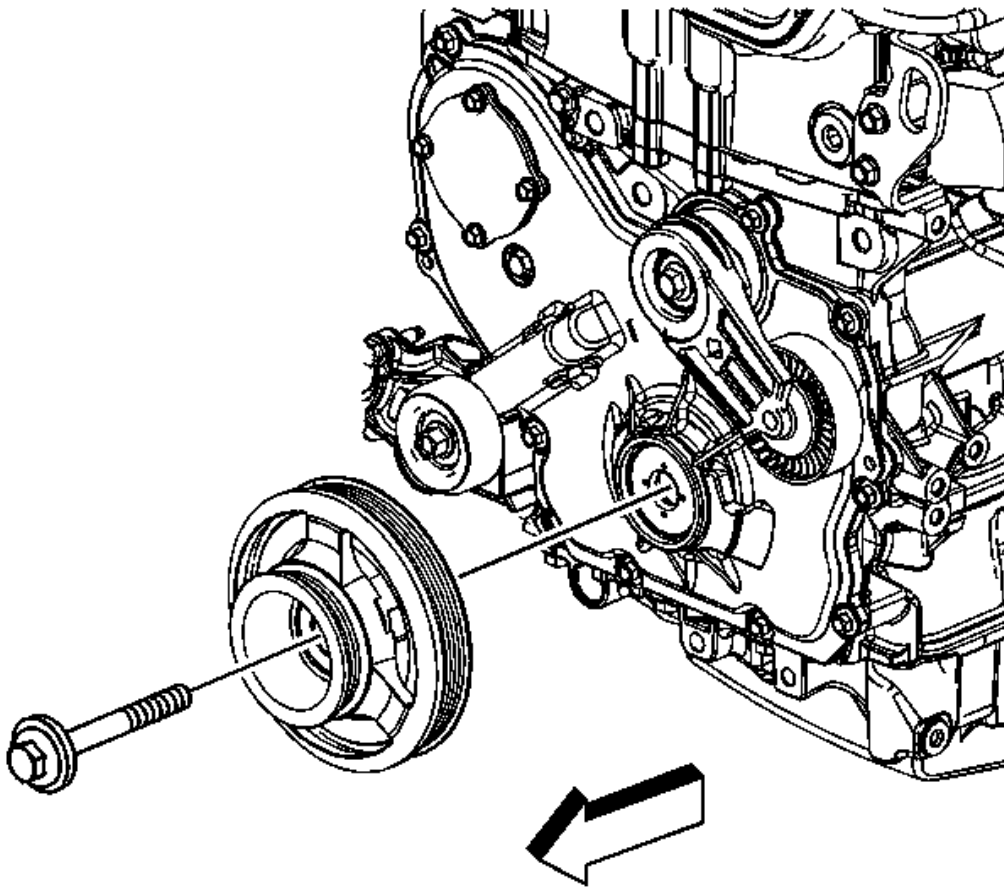


Fig. 313: View Of Crankshaft Balancer & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the balancer retaining bolt and washer. Discard the bolt.

2. Remove the balancer using a universal removal tool.

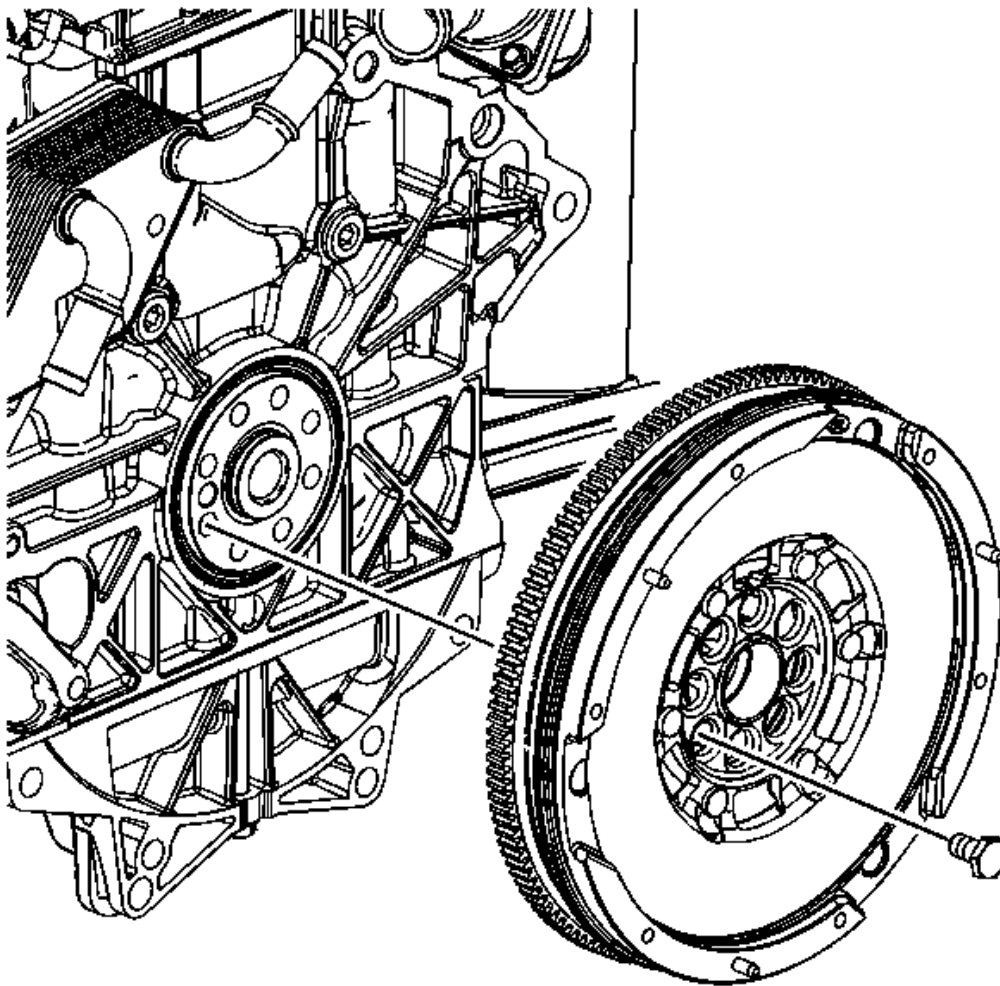
ENGINE FLYWHEEL REMOVAL

Fig. 314: Flywheel (M/T)

Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel attaching bolts.
2. Remove the flywheel, if the vehicle has a manual transmission.

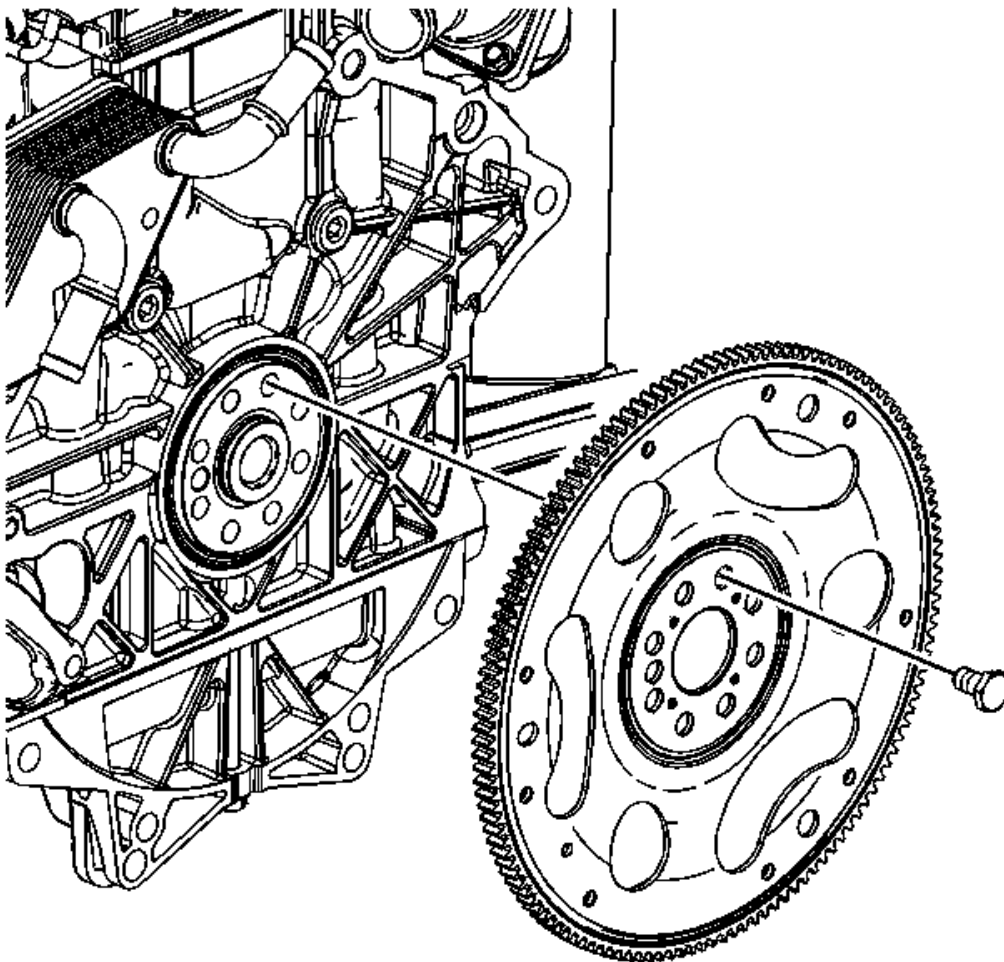


Fig. 315: Flywheel (A/T)

Courtesy of GENERAL MOTORS CORP.

3. Remove the flywheel attaching bolts.
4. Remove the flywheel, if the vehicle has an automatic transmission.

ENGINE MOUNTING TO STAND

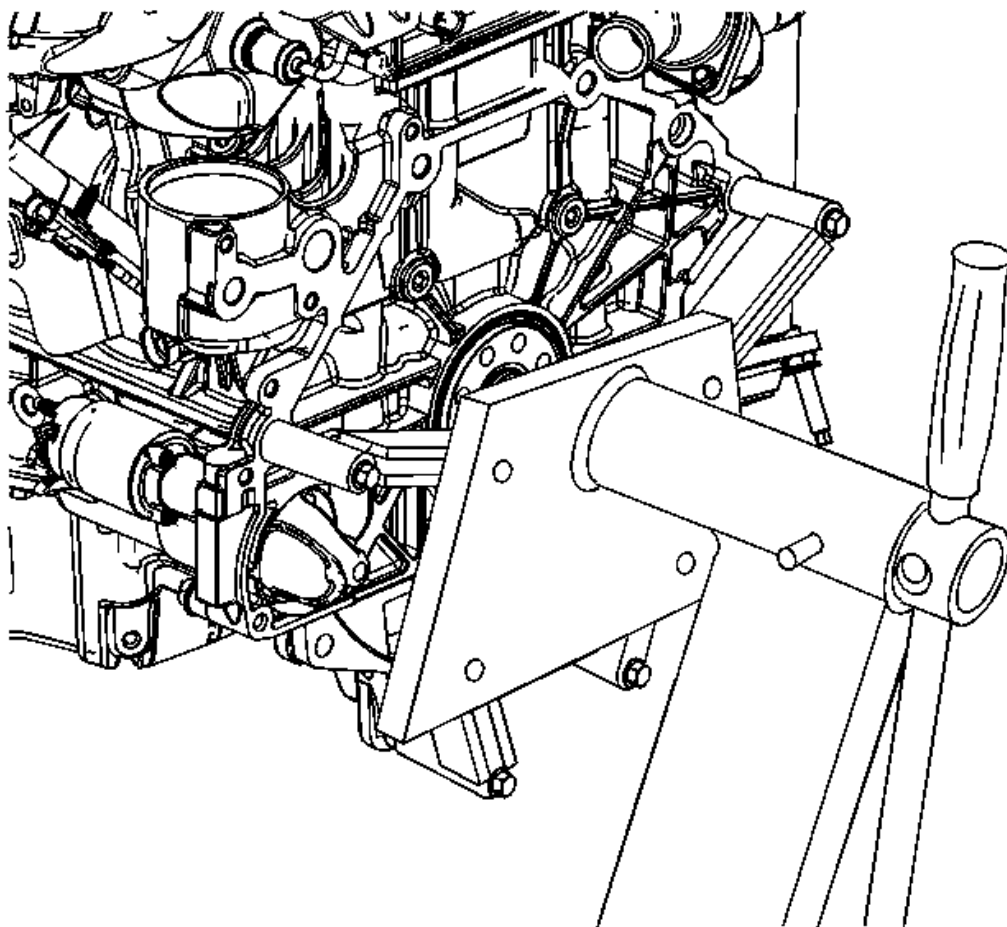


Fig. 316: Engine Block Mounted To Engine Stand
Courtesy of GENERAL MOTORS CORP.

After the flywheel housing has been removed, mount the engine block to a suitable engine stand.

OIL LEVEL INDICATOR AND TUBE REMOVAL

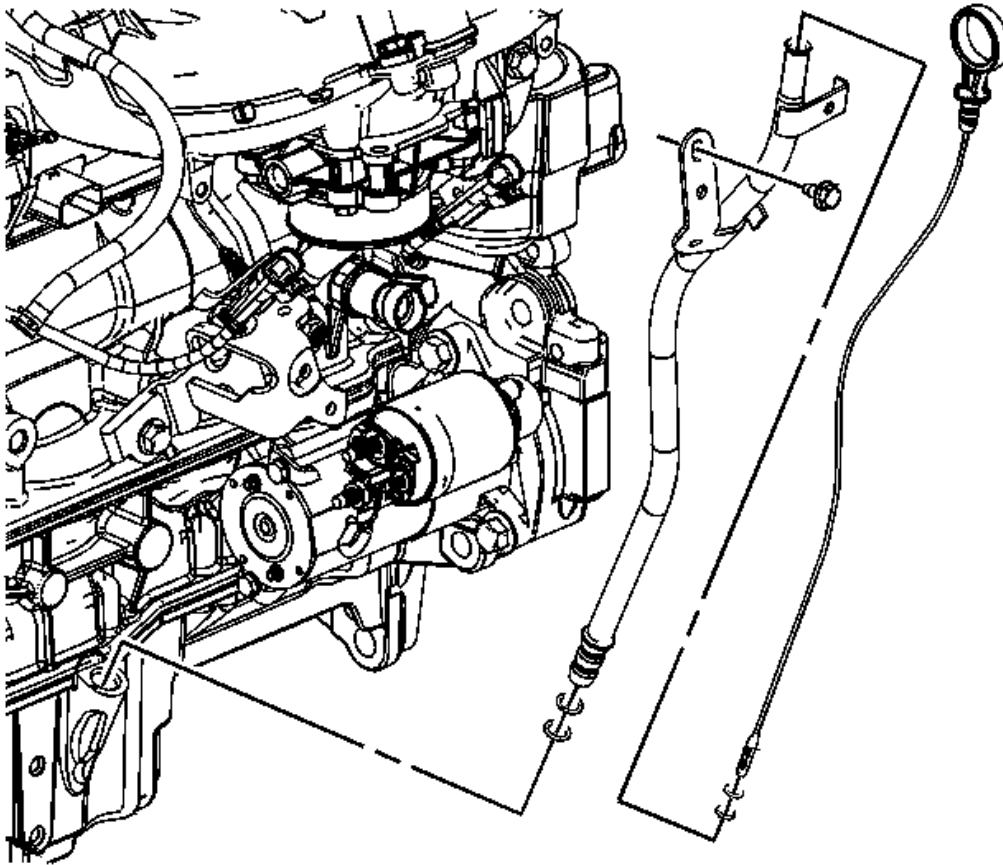


Fig. 317: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the knock sensor 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 to the intake manifold bolt.
4. Remove the oil level indicator and the oil level indicator tube from the oil pan.
5. Inspect the O-rings for damage. Replace if damaged.

STARTER REMOVAL

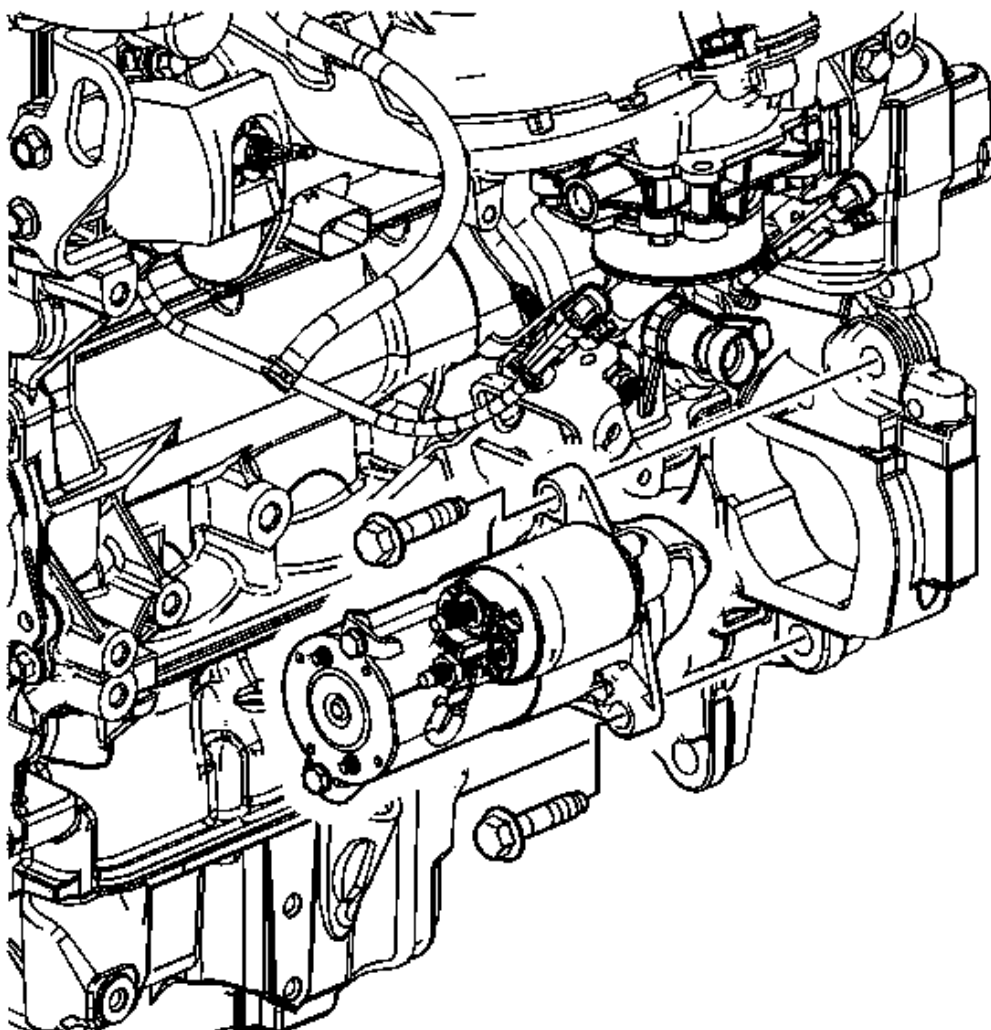


Fig. 318: View Of Starter

Courtesy of GENERAL MOTORS CORP.

1. Remove the starter bolts.
2. Remove the starter.

INTAKE MANIFOLD REMOVAL

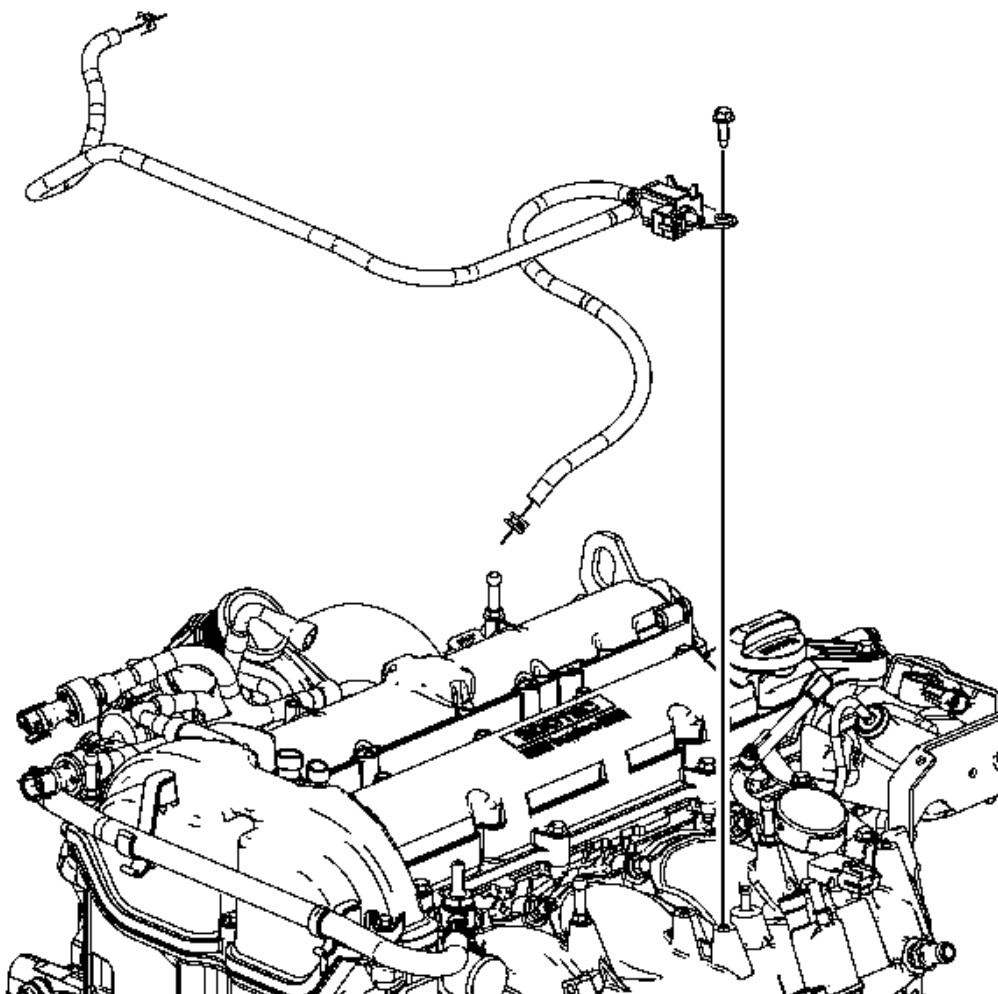


Fig. 319: View Of AIR Bypass Tube Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.

1. If the engine is equipped with a charger AIR bypass valve tank assembly, complete the following procedure:

IMPORTANT: The charger AIR bypass tube assembly connected from the charger

AIR bypass valve solenoid to the charger AIR bypass valve tank assembly is permanently attached to the tank assembly. Do not attempt to disconnect the charger AIR bypass tube assembly at the charger AIR bypass valve tank assembly.

1. Disconnect the charger AIR bypass tube with the retaining clip from the charger AIR bypass valve tank assembly.
2. Disconnect the remaining charger AIR bypass tubes at the turbocharger and vehicle.
3. Remove the charger AIR bypass valve solenoid bolts.
4. Remove the charger AIR bypass valve solenoid.

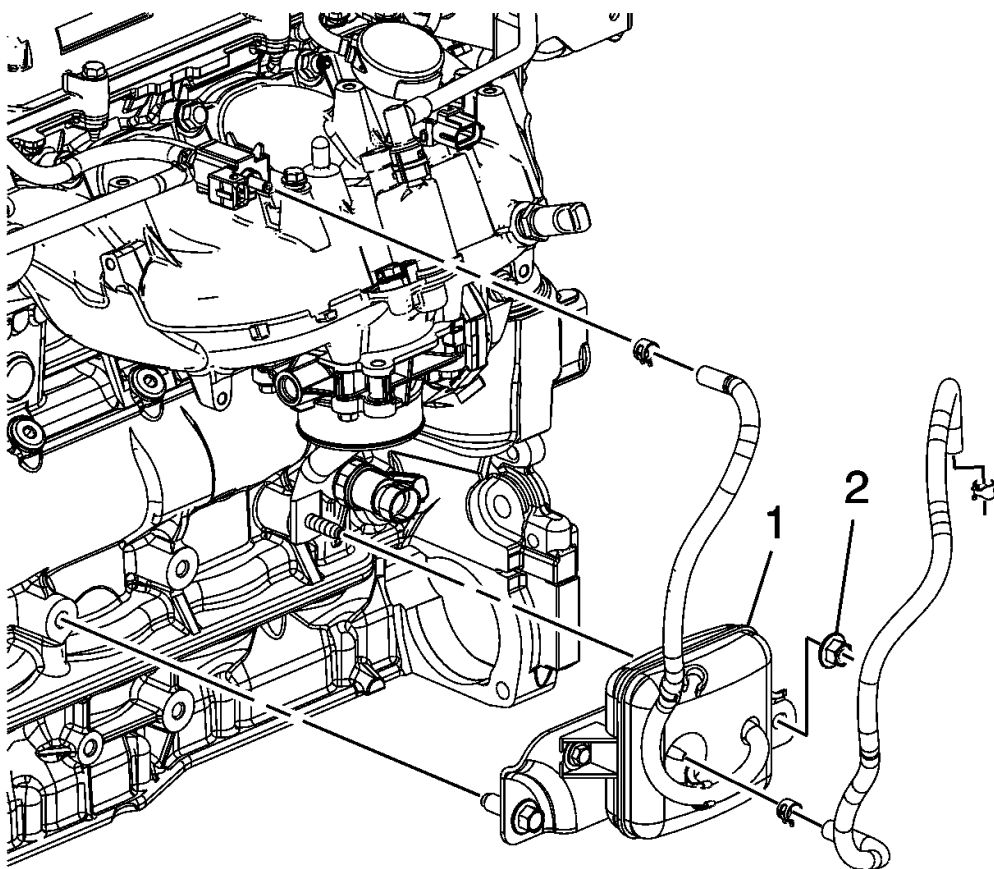


Fig. 320: Identifying AIR Bypass Valve Tank Assembly
Courtesy of GENERAL MOTORS CORP.

2. If the engine is equipped with a charger AIR bypass valve tank assembly, complete the following procedure:
 1. Disconnect the charger AIR bypass tube assembly from the intake manifold.

2. Remove the charger AIR bypass valve tank assembly nut.

IMPORTANT: The charger AIR bypass bolt is captured on the bracket and should not be removed from the bracket. Loosen the bolt only until it is no longer attached to the block when removing the charger AIR bypass valve tank assembly.

3. Loosen the charger AIR bypass valve tank assembly bolt.
4. Remove the charger AIR bypass valve tank assembly.

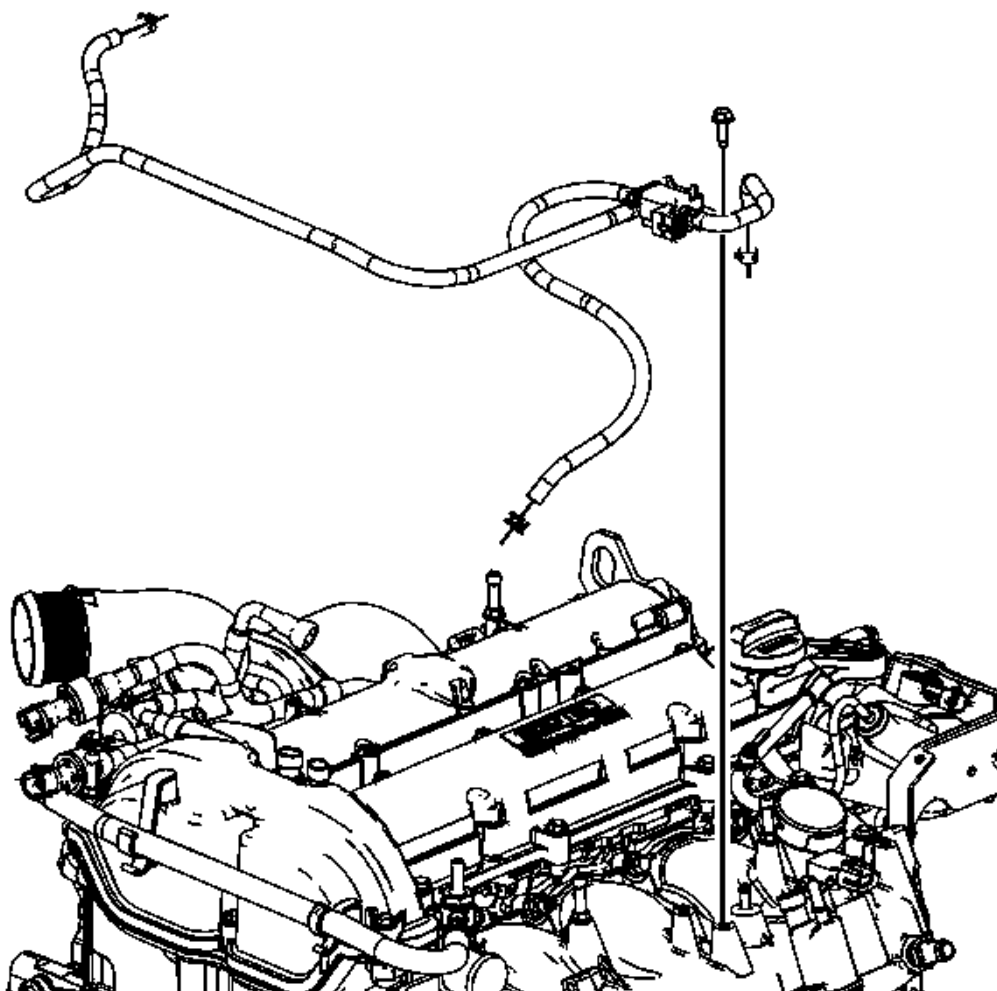


Fig. 321: Bypass Valve Solenoid Hoses
Courtesy of GENERAL MOTORS CORP.

NOTE: **Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.**

3. If the engine is not equipped with a charger AIR bypass valve tank assembly, complete the following procedure:
 1. Disconnect the charger AIR bypass valve solenoid tubes.
 2. Remove the charger AIR bypass valve solenoid bolts.
 3. Remove the charger AIR bypass valve solenoid with tubes.

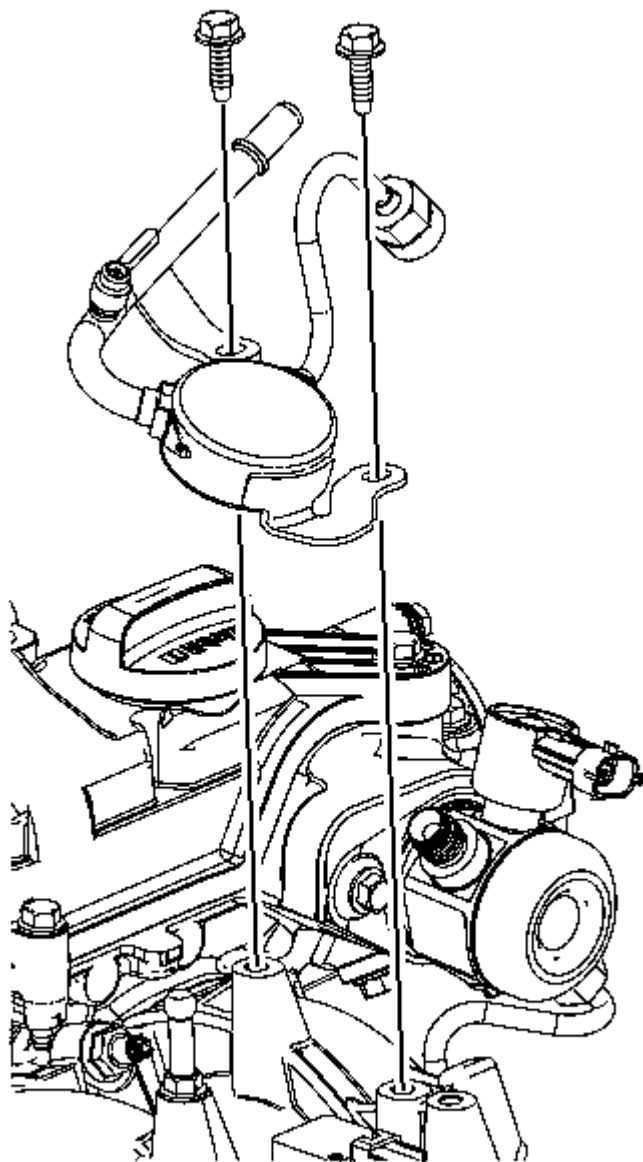


Fig. 322: Identifying Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

4. Loosen and disconnect the fuel feed line tube nut.
5. Remove the fuel feed line bolts.
6. Remove the fuel feed line.
7. Inspect the fuel feed line nut for damaged threads.
8. Inspect the fuel feed line sealing bail for damage or debris.
9. Replace the fuel feed line if any damage is found.

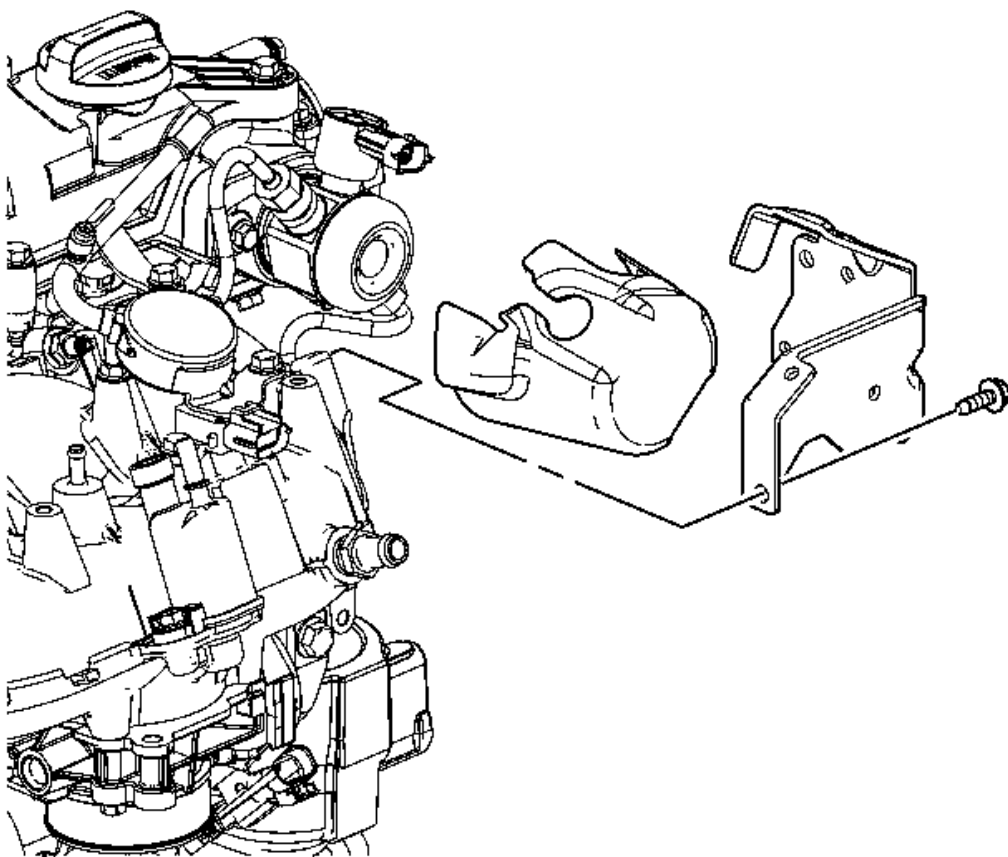


Fig. 323: View Of High Pressure Fuel Pump Cover
Courtesy of GENERAL MOTORS CORP.

10. Remove the high pressure fuel pump cover bolts.
11. Remove the high pressure fuel pump cover.
12. Remove the high pressure fuel pump noise insulator.

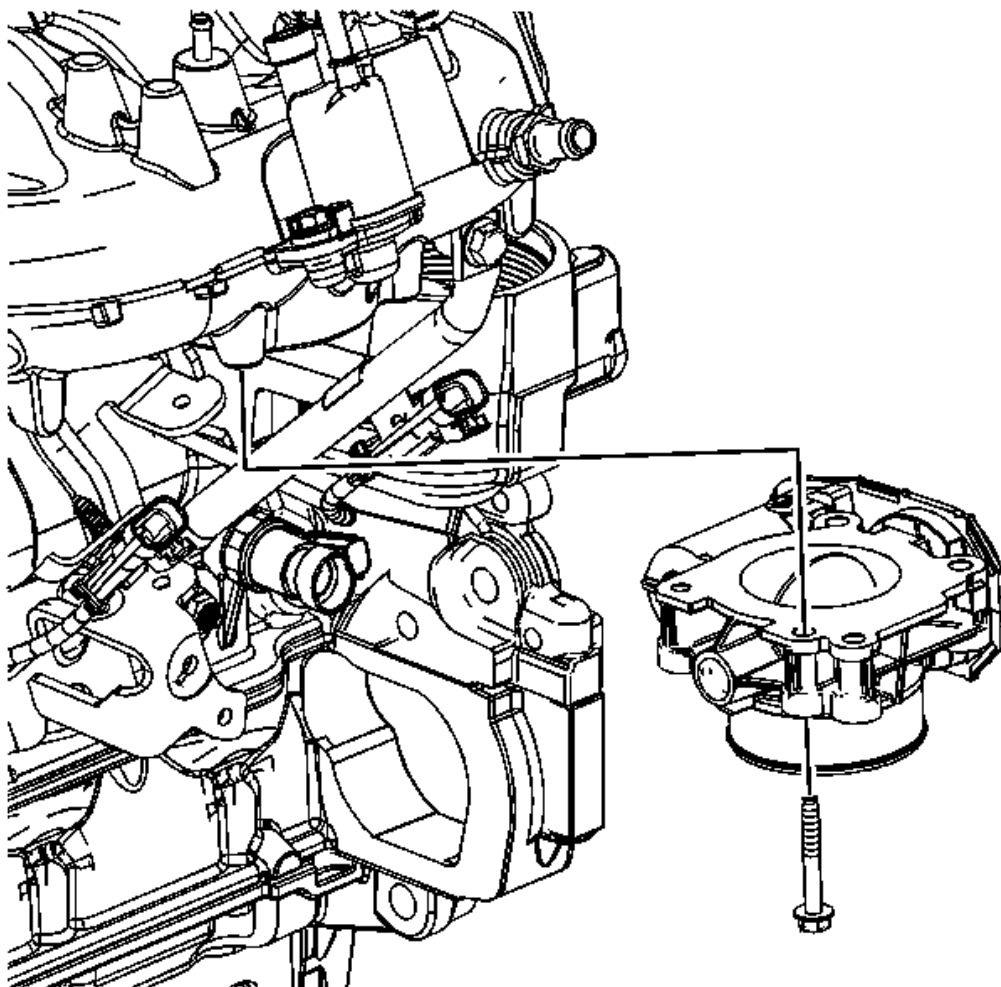


Fig. 324: View Of Throttle Body & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the throttle body bolts.
14. Remove the throttle body.

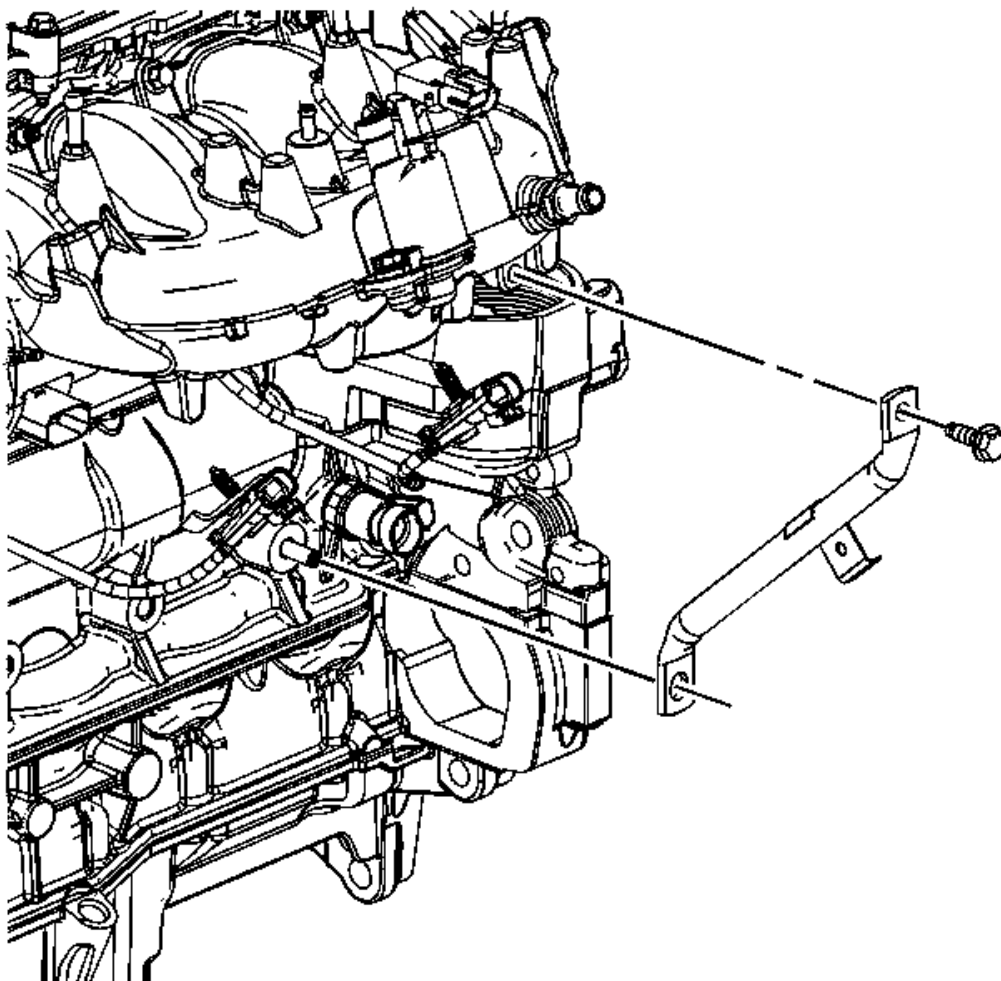


Fig. 325: Identifying Intake Manifold Brace
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the rear knock sensor from the intake manifold brace.
16. Remove the intake manifold brace bolt.
17. Remove the intake manifold brace.

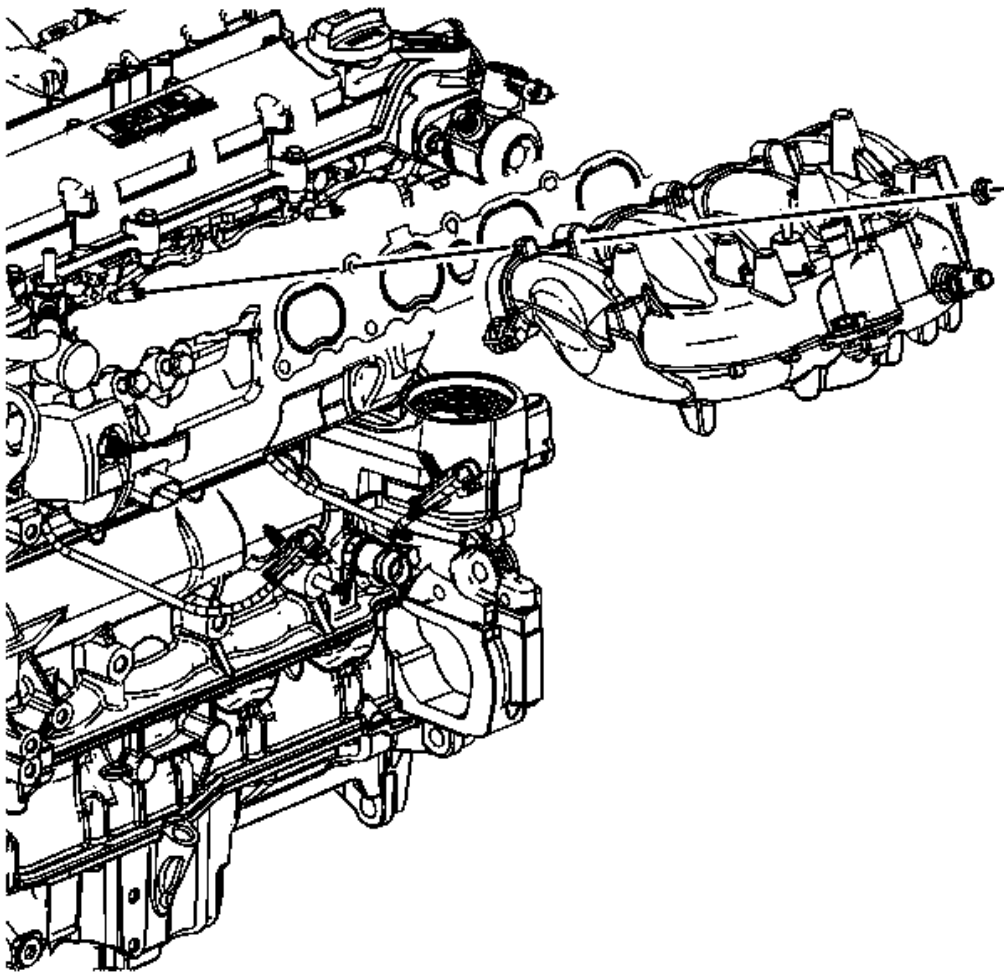


Fig. 326: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

18. Remove the intake manifold bolts and nuts.
19. Remove the intake manifold.
20. Remove the intake manifold gasket.

FUEL RAIL AND INJECTORS REMOVAL

Tools Required

- **J 2619-01** Slide Hammer
- **J-37281-A** Injector Remover

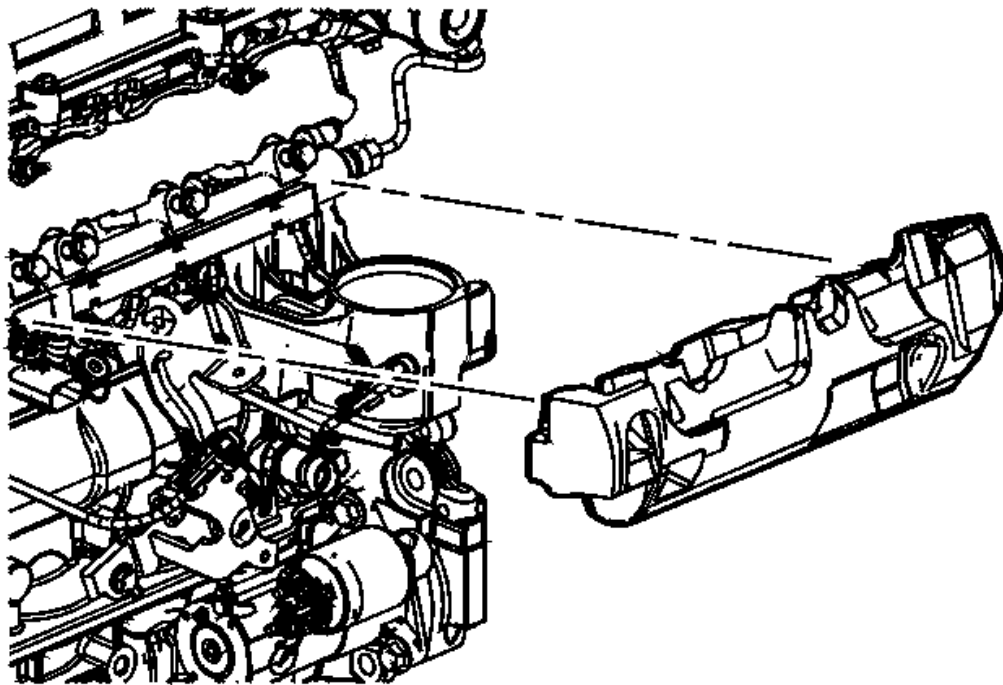


Fig. 327: View Of Fuel Injector Insulator
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the electrical harness from the fuel rail harness connection.
2. Remove the fuel injector noise insulator.

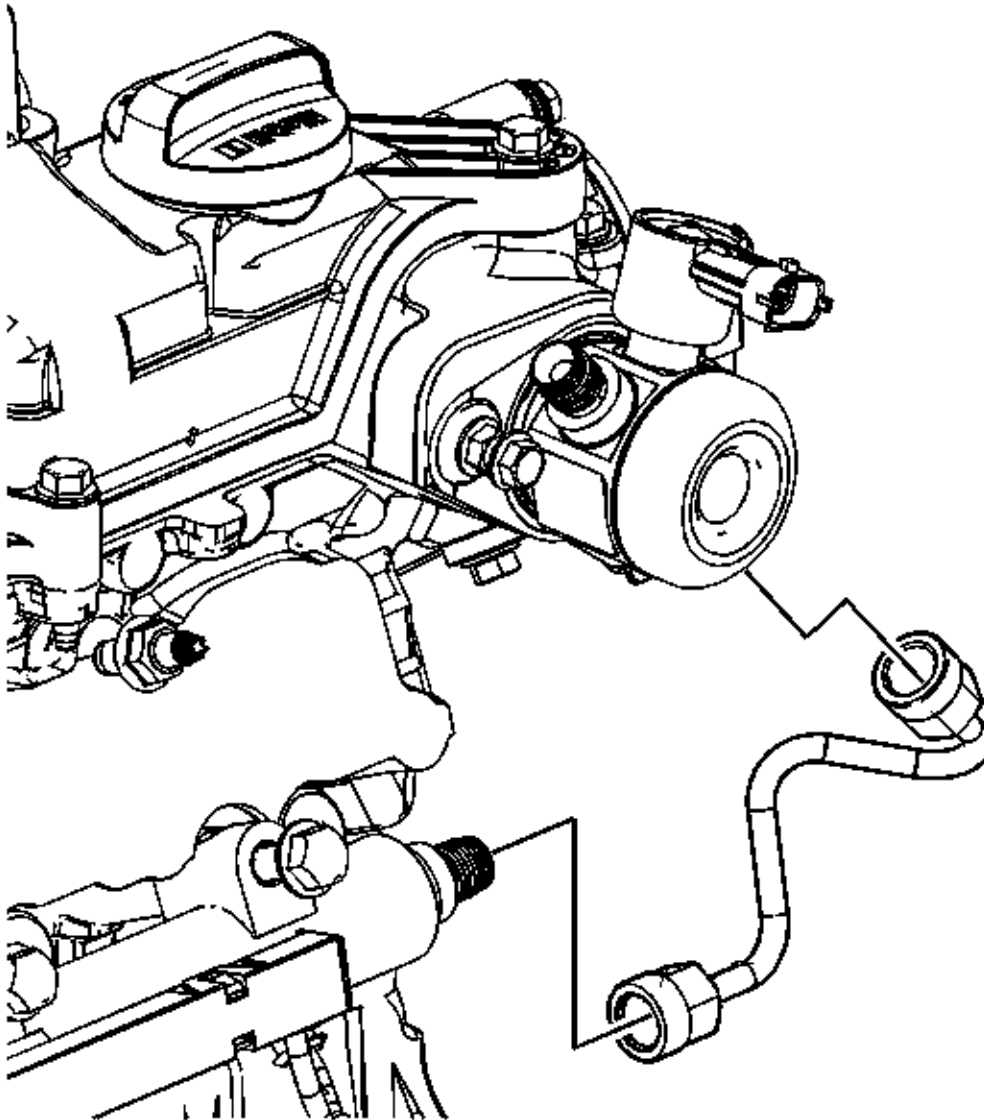


Fig. 328: Identifying High Pressure Fuel Line
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

3. Remove and discard the high pressure fuel line.

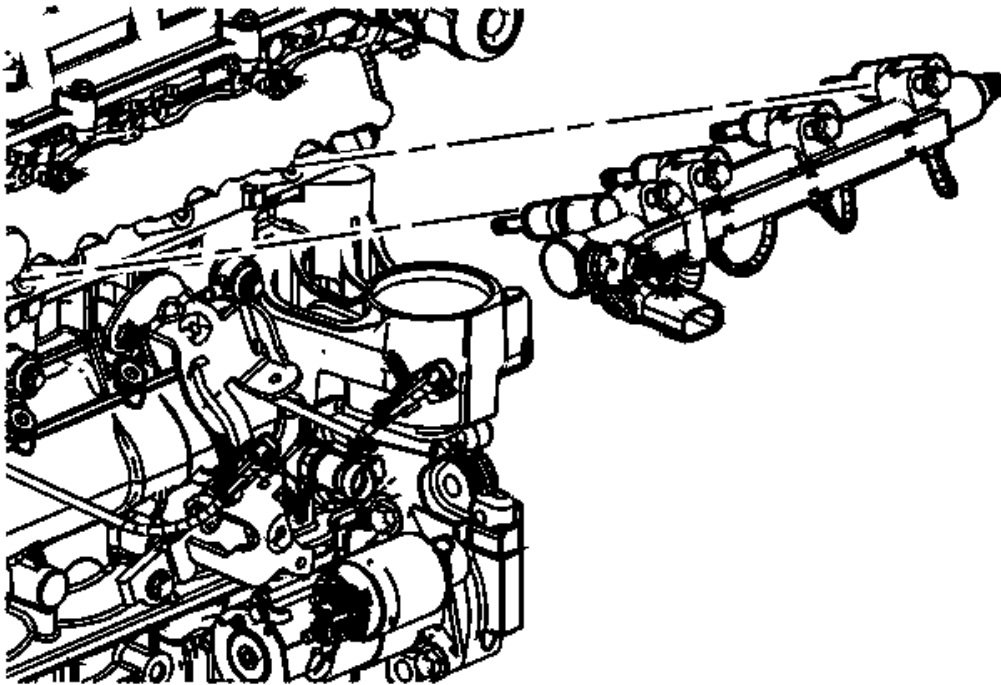


Fig. 329: View Of Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

4. Disconnect all 4 fuel injector electrical connections.
5. Remove the fuel rail bolts.
6. Remove the fuel rail and injectors.

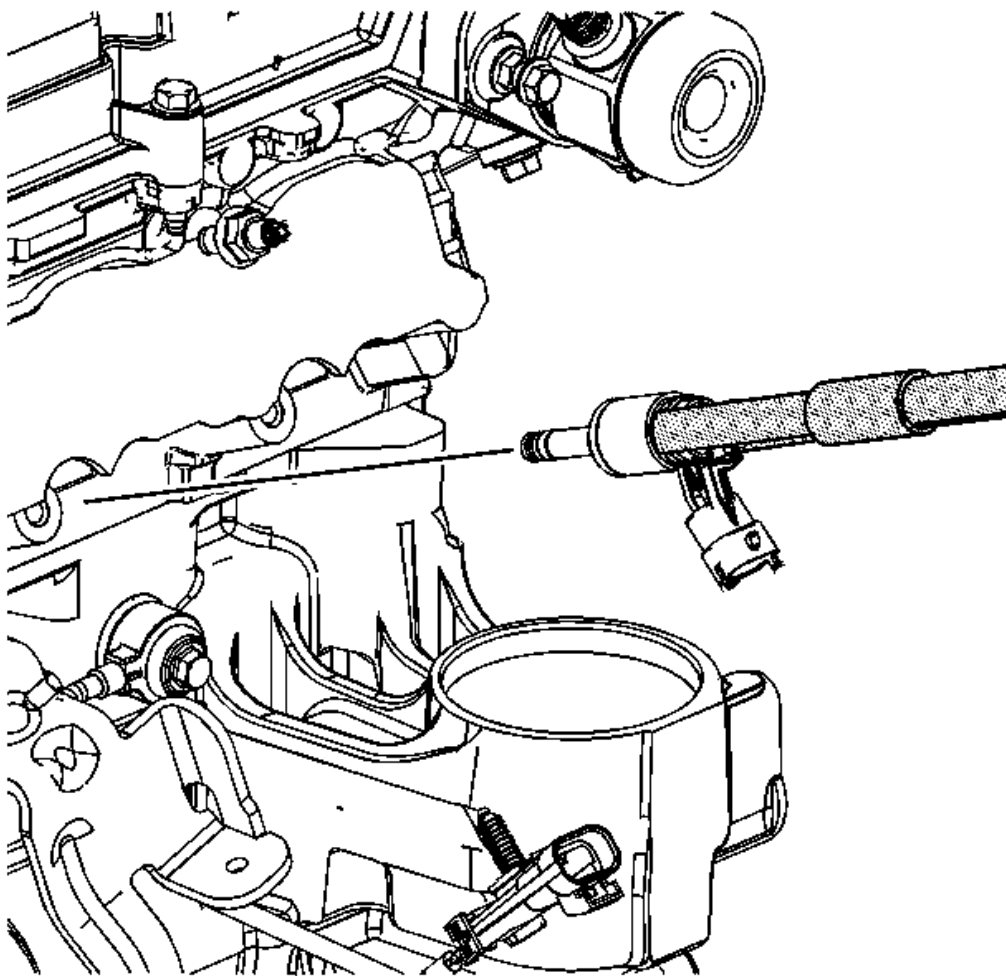


Fig. 330: Using J 2619-01 & J-37281-A
Courtesy of GENERAL MOTORS CORP.

7. The injectors may stay in the cylinder head. Remove the fuel injector hold-down clamp before removing the injector.
8. Use **J-37281-A** and **J 2619-01** to remove the injector.

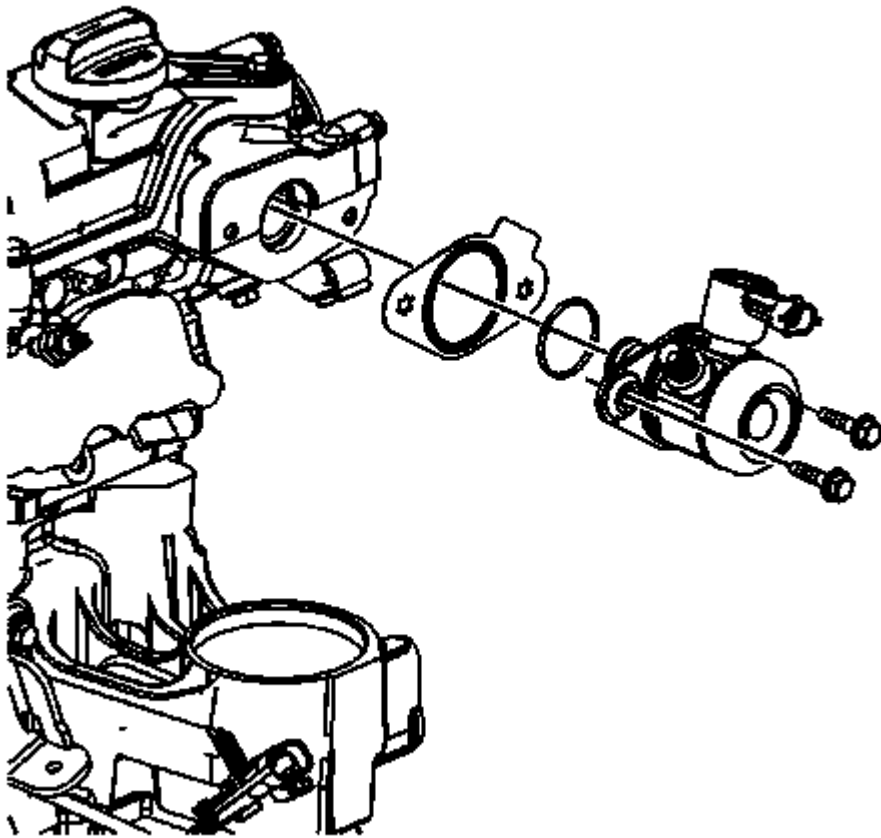


Fig. 331: Identifying High Pressure Fuel Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the high pressure fuel pump bolts.
10. Remove the high pressure fuel pump.
11. Remove and discard the high pressure fuel pump gasket.
12. Remove and discard the high pressure fuel pump O-ring.

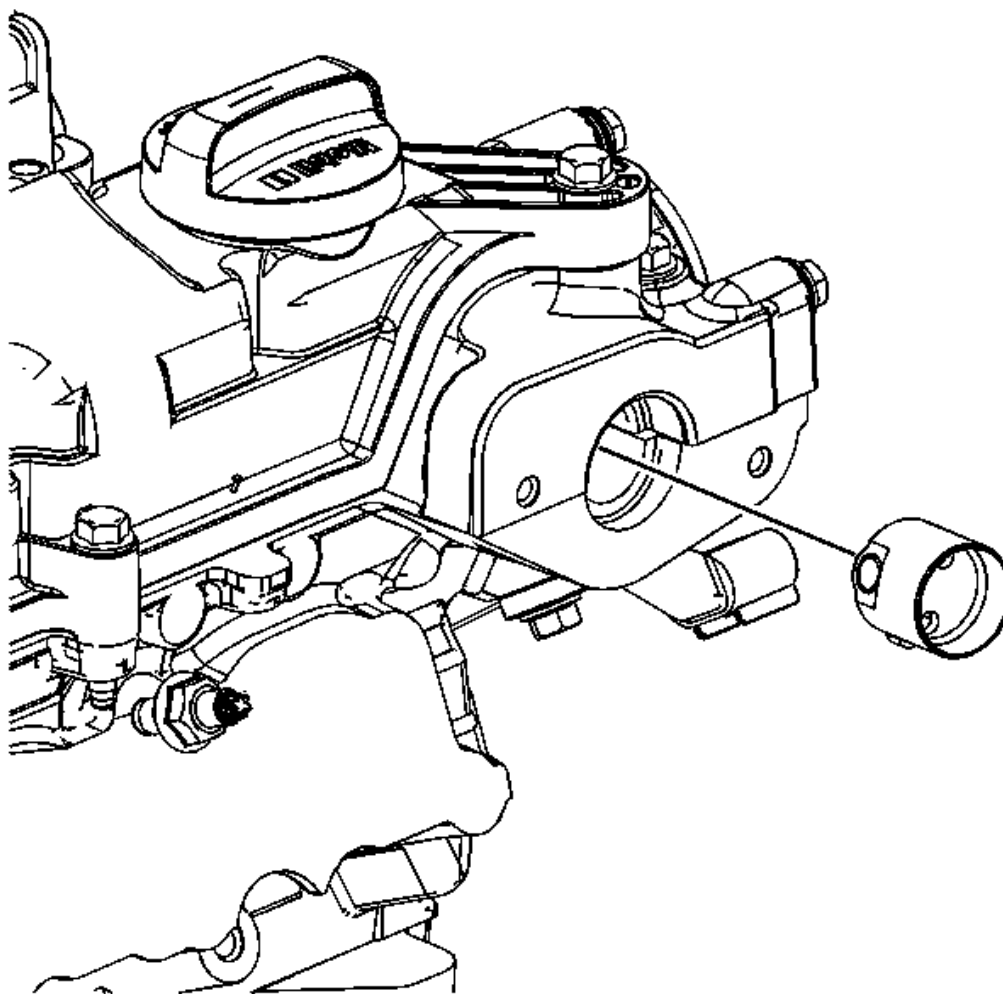


Fig. 332: View Of High Pressure Fuel Pump Roller Lifter
Courtesy of GENERAL MOTORS CORP.

13. Remove the high pressure fuel pump roller lifter.

TURBOCHARGER REMOVAL

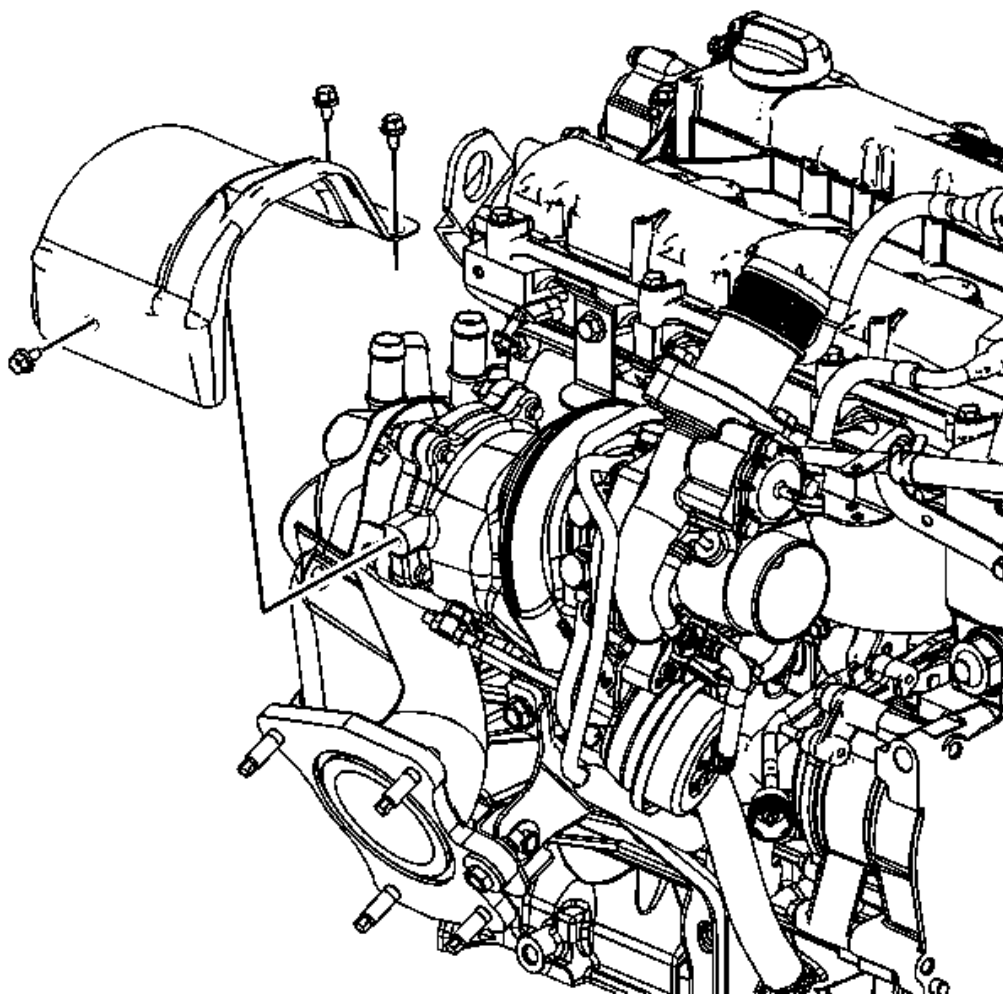


Fig. 333: Identifying Turbocharger Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the turbocharger heat shield bolts.
2. Remove the turbocharger heat shield.

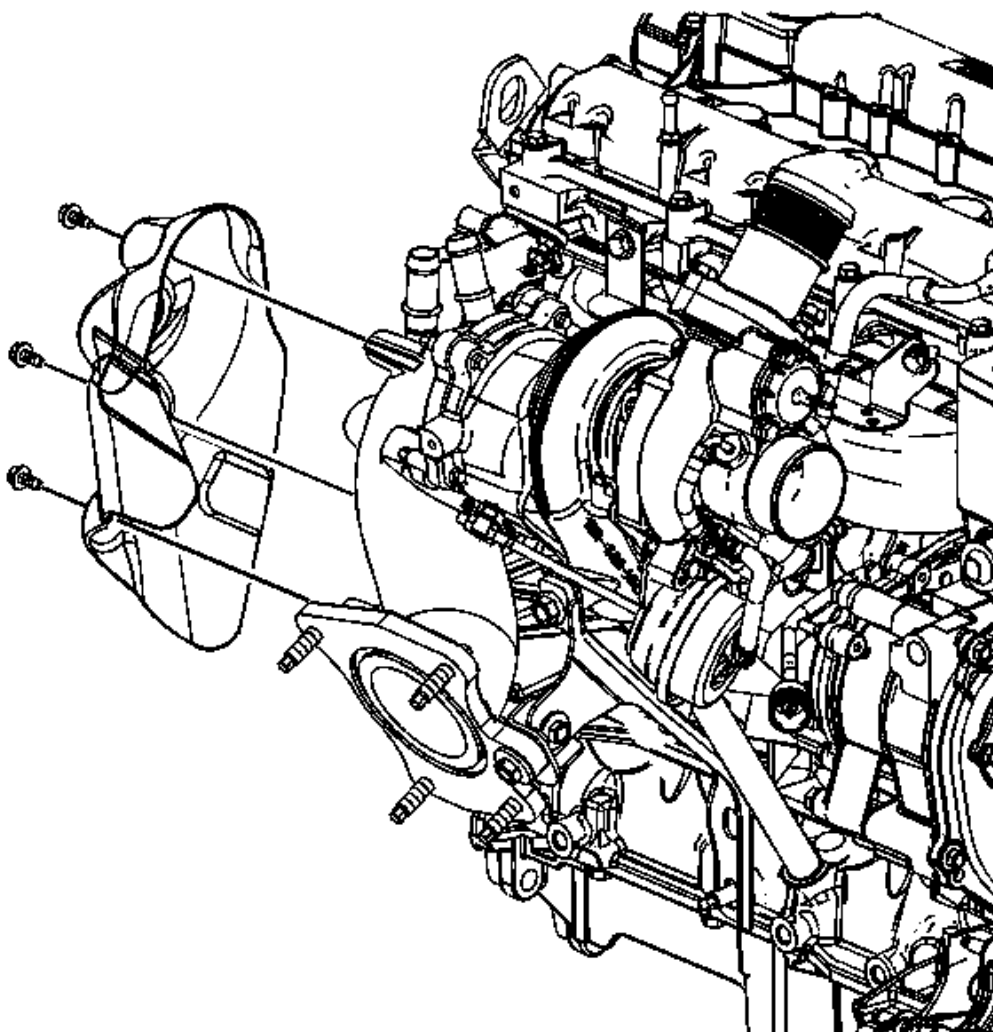


Fig. 334: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the turbocharger exhaust pipe heat shield bolts.
4. Remove the turbocharger exhaust pipe heat shield.

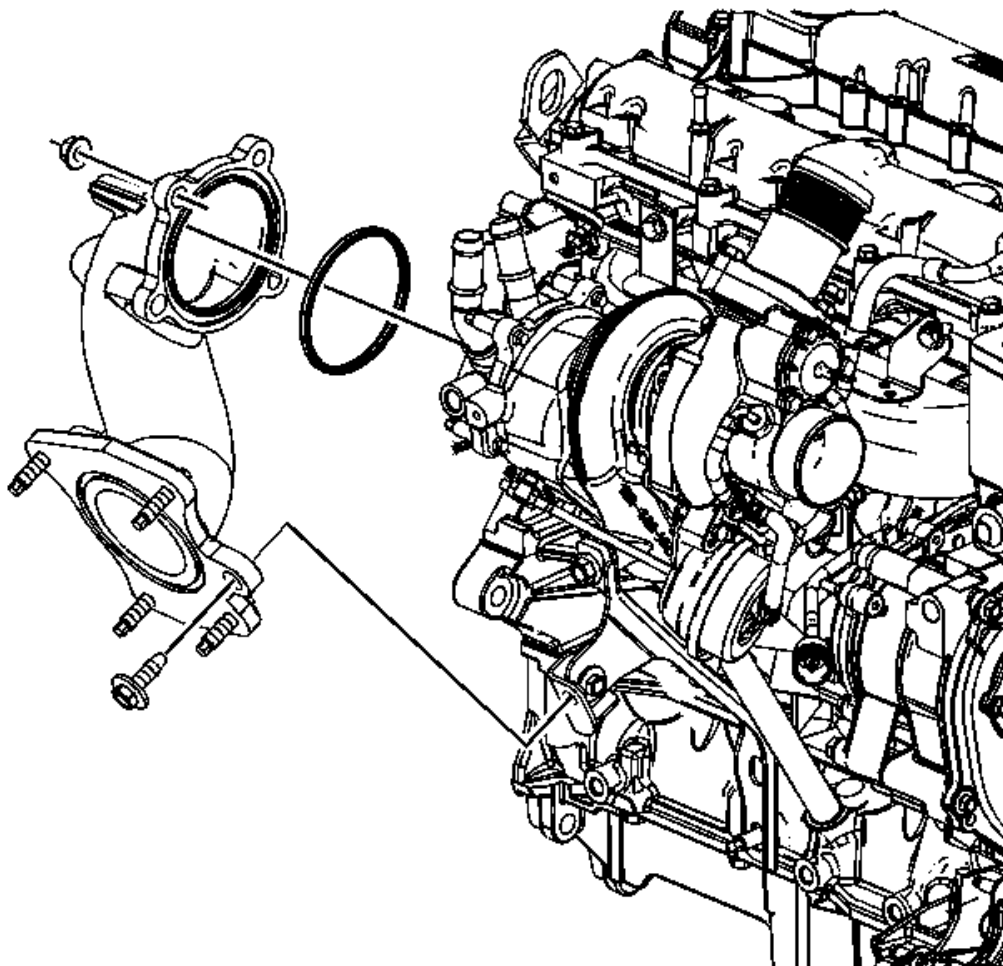


Fig. 335: Identifying Turbocharger Exhaust Pipe & Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove the turbocharger exhaust pipe nuts and bolt.
6. Remove the turbocharger exhaust pipe.
7. Remove the turbocharger exhaust pipe seal.

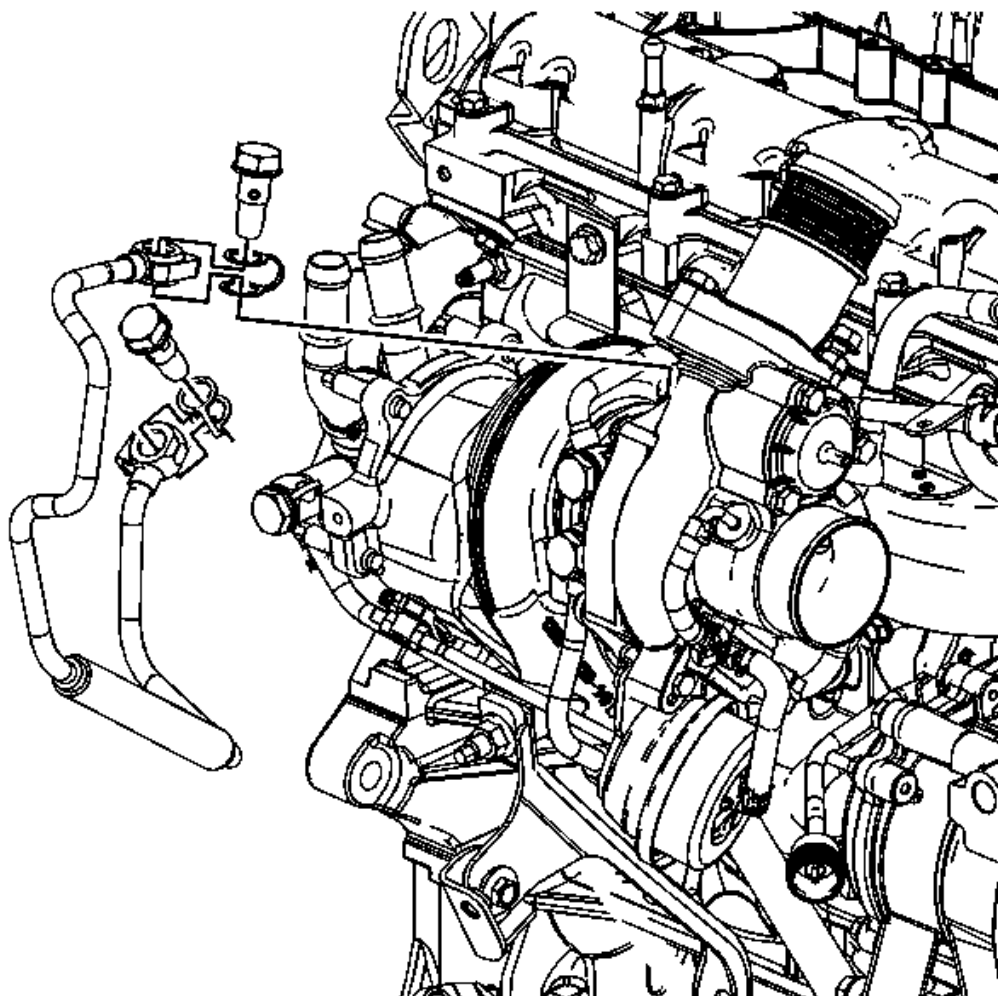


Fig. 336: Identifying Turbocharger Oil Feed Pipe

Courtesy of GENERAL MOTORS CORP.

NOTE: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

8. Remove the turbocharger oil feed pipe bolts.
9. Remove the turbocharger oil feed pipe gaskets.

10. Remove the turbocharger oil feed pipe.

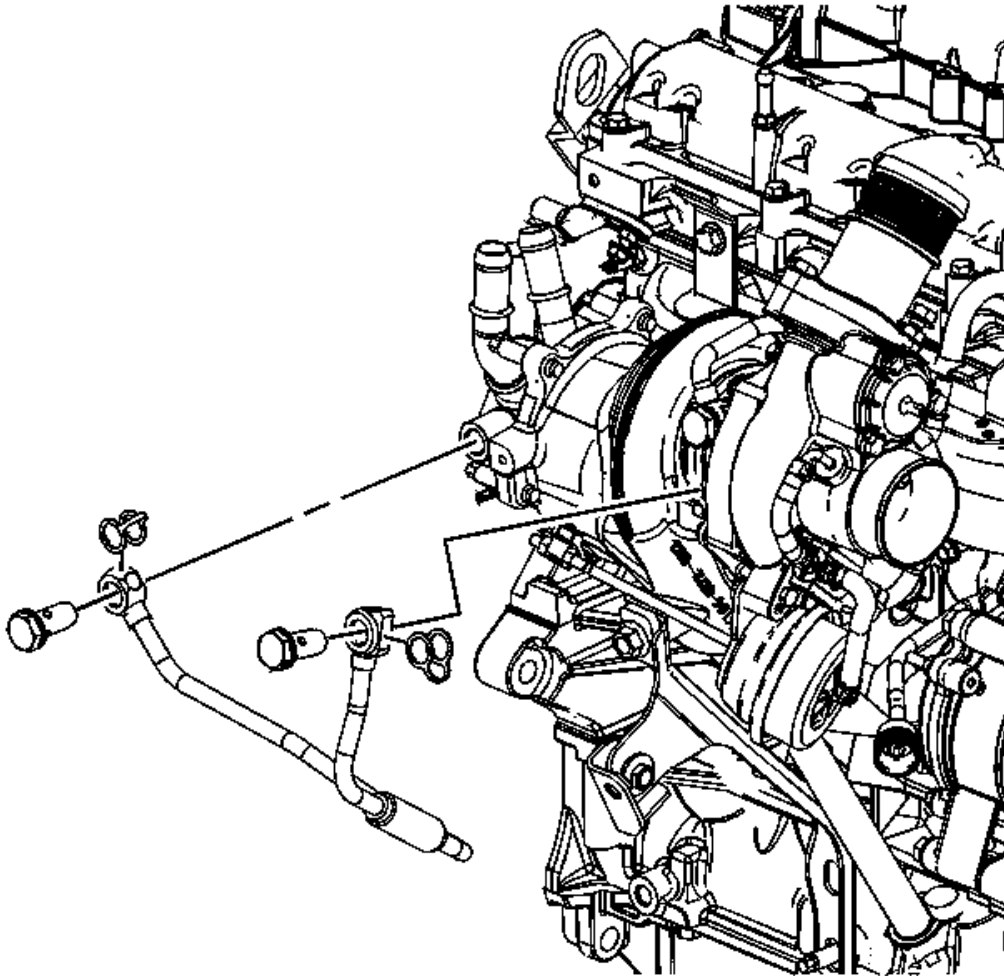


Fig. 337: View Of Turbocharger Coolant Return Pipe
Courtesy of GENERAL MOTORS CORP.

11. Remove the turbocharger coolant return pipe bolts.
12. Remove the turbocharger coolant return pipe gaskets.
13. Remove the turbocharger coolant return pipe.

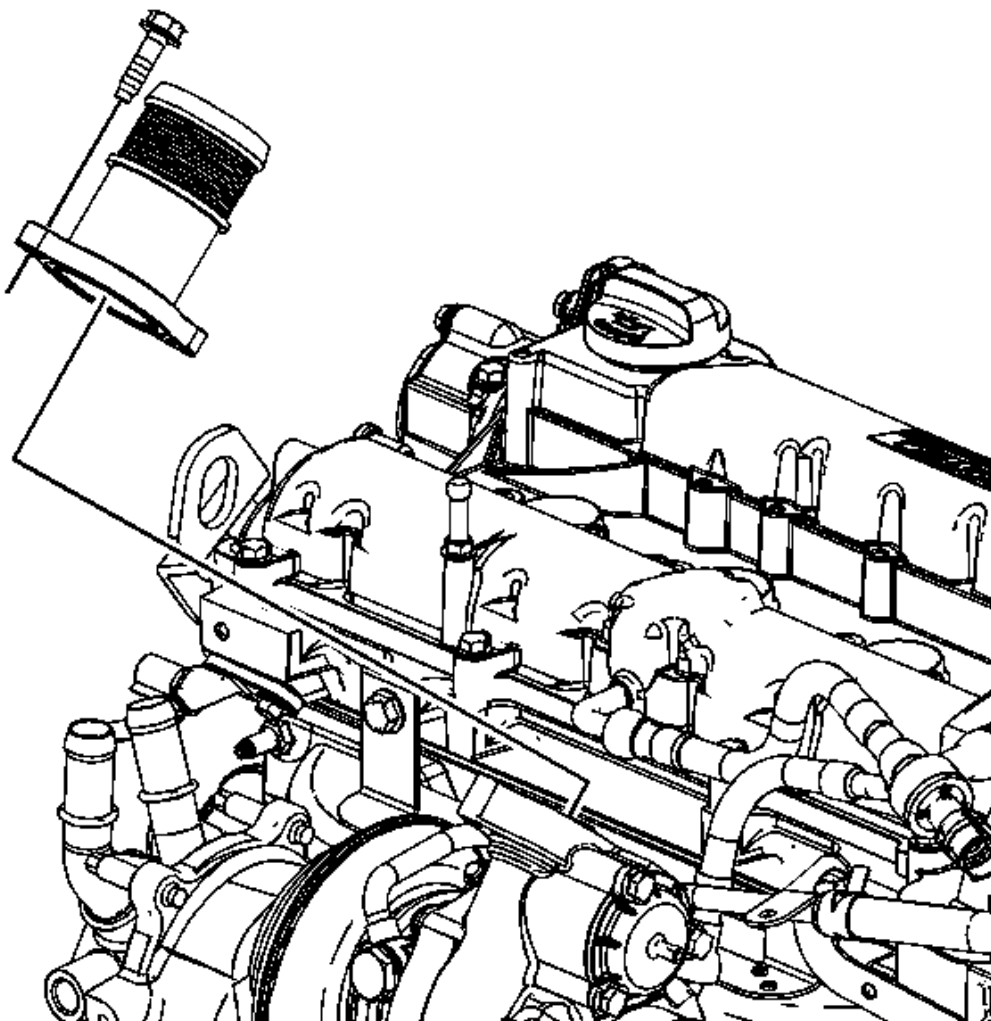


Fig. 338: View Of Turbocharger Coolant Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

14. Remove the turbocharger air cooler outlet pipe bolts.
15. Remove the turbocharger air cooler outlet pipe.

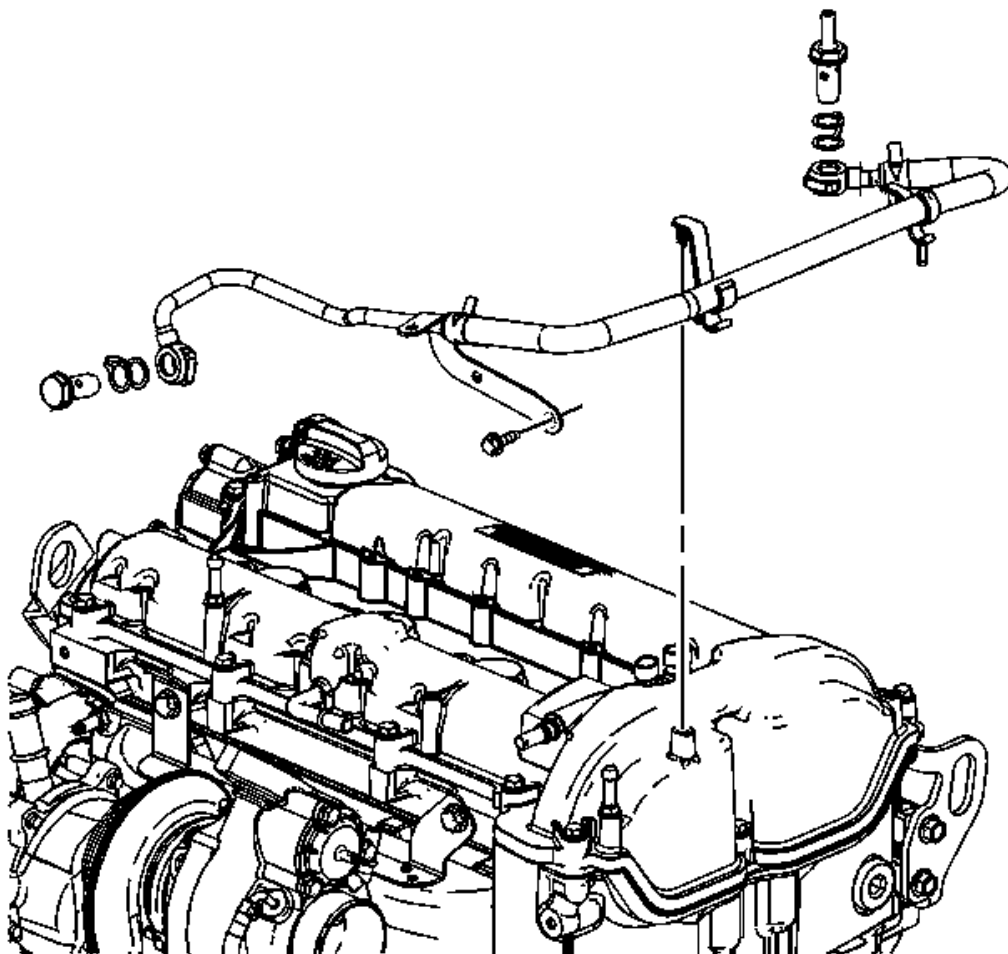


Fig. 339: Identifying Turbocharger Coolant Feed Pipe
Courtesy of GENERAL MOTORS CORP.

16. Remove the turbocharger coolant feed pipe bolts.
17. Remove the turbocharger coolant feed pipe gaskets.
18. Remove the turbocharger coolant feed pipe.

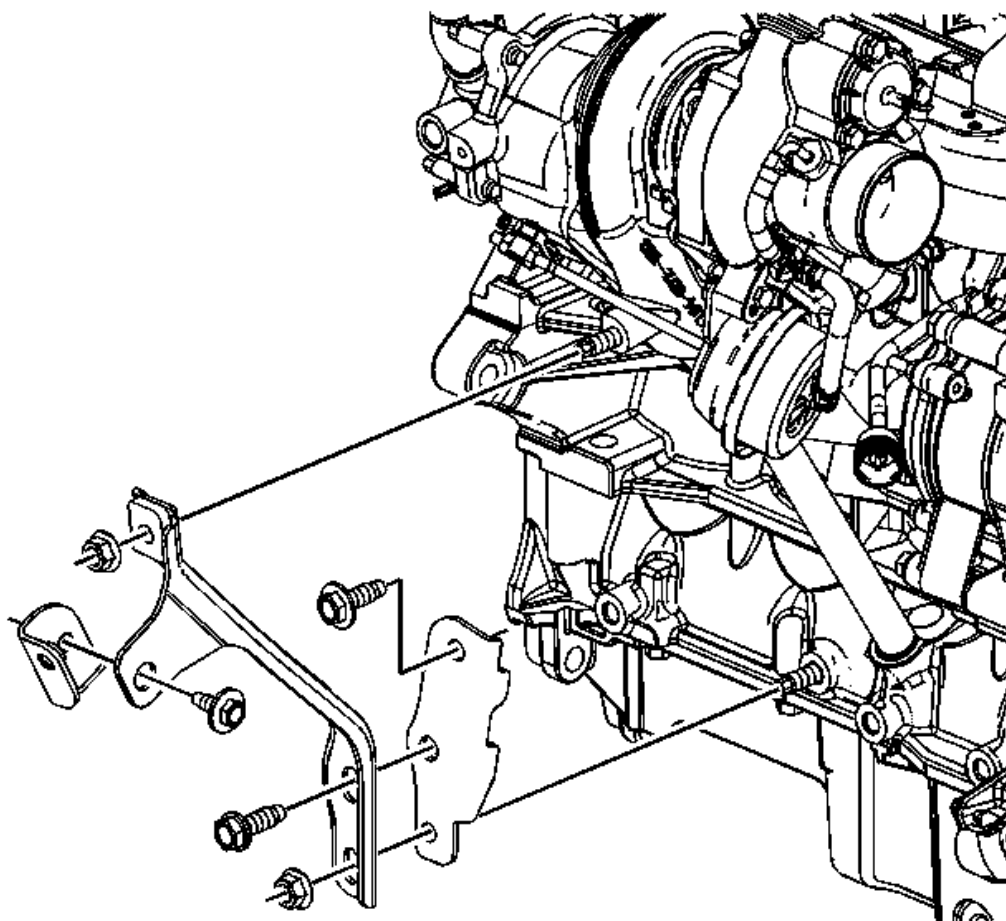


Fig. 340: View Of Turbocharger Brace Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

19. If necessary, remove the turbocharger brace bracket bolt and turbocharger brace bracket from the turbocharger brace.
20. Remove the turbocharger brace upper and lower nuts.
21. Remove the turbocharger brace bolt.
22. Remove the turbocharger brace.
23. Remove the turbocharger brace bracket bolt.
24. Remove the turbocharger brace bracket.

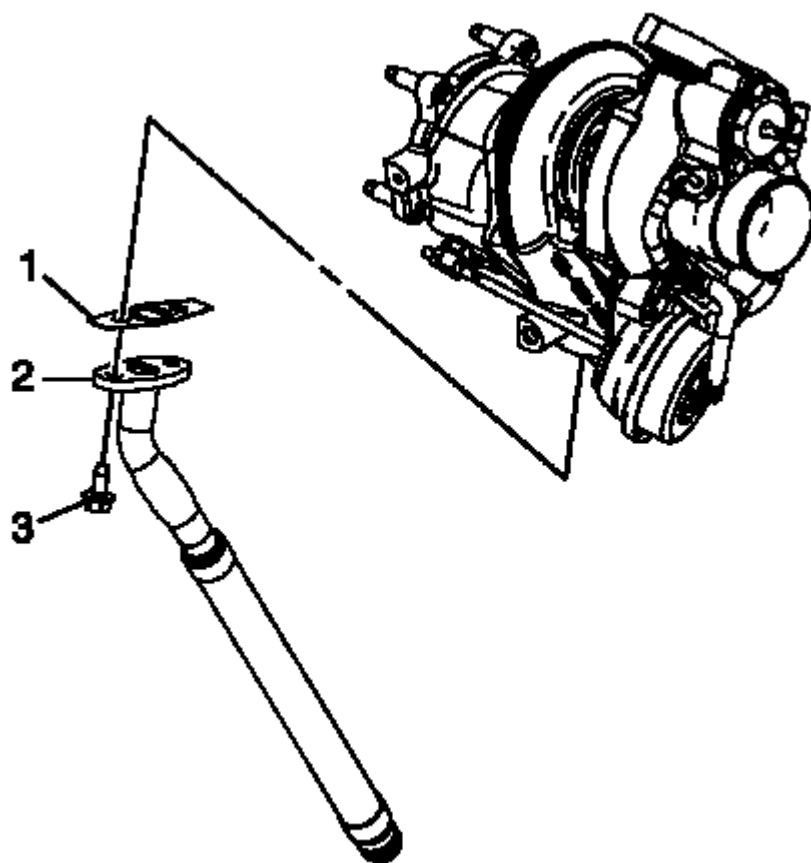


Fig. 341: View of Turbocharger Oil Return Pipe & Bolt
Courtesy of GENERAL MOTORS CORP.

25. Remove the turbocharger oil return pipe bolts.
26. Remove the turbocharger oil return pipe.
27. Remove and discard the turbocharger oil return pipe gasket.

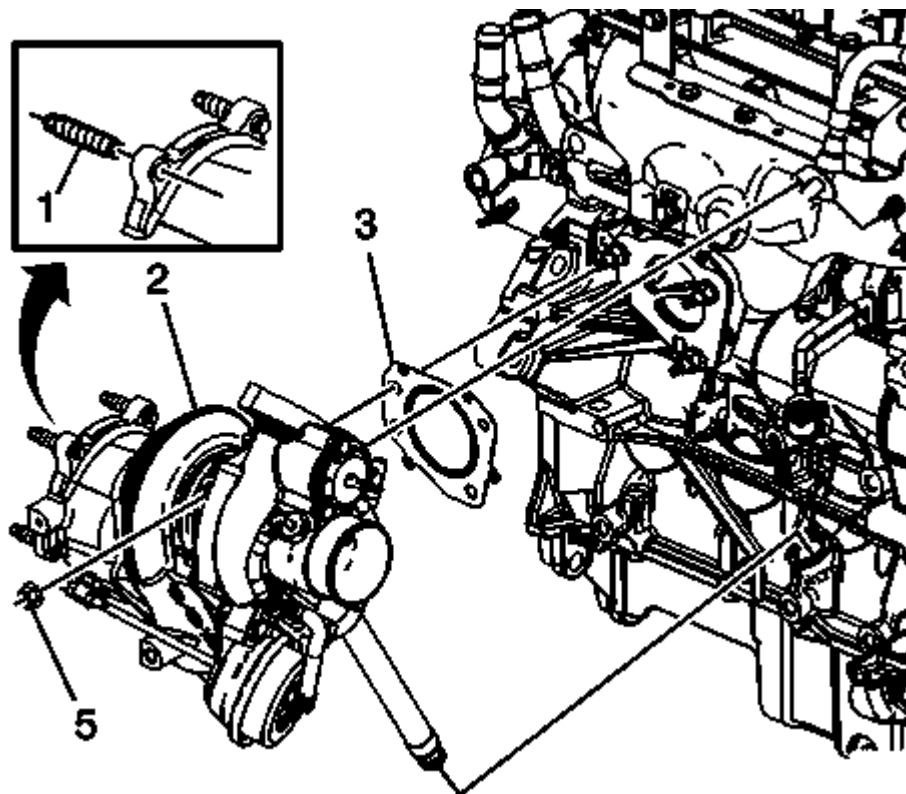


Fig. 342: Removing/Installing Turbocharger & Gasket
Courtesy of GENERAL MOTORS CORP.

28. Remove the PCV hose fitting bolt.
29. Remove the PCV hose fitting from the turbocharger with the hose still attached.
30. Remove the turbocharger nuts.
31. Remove the turbocharger.
32. Remove the turbocharger gasket.

EXHAUST MANIFOLD REMOVAL

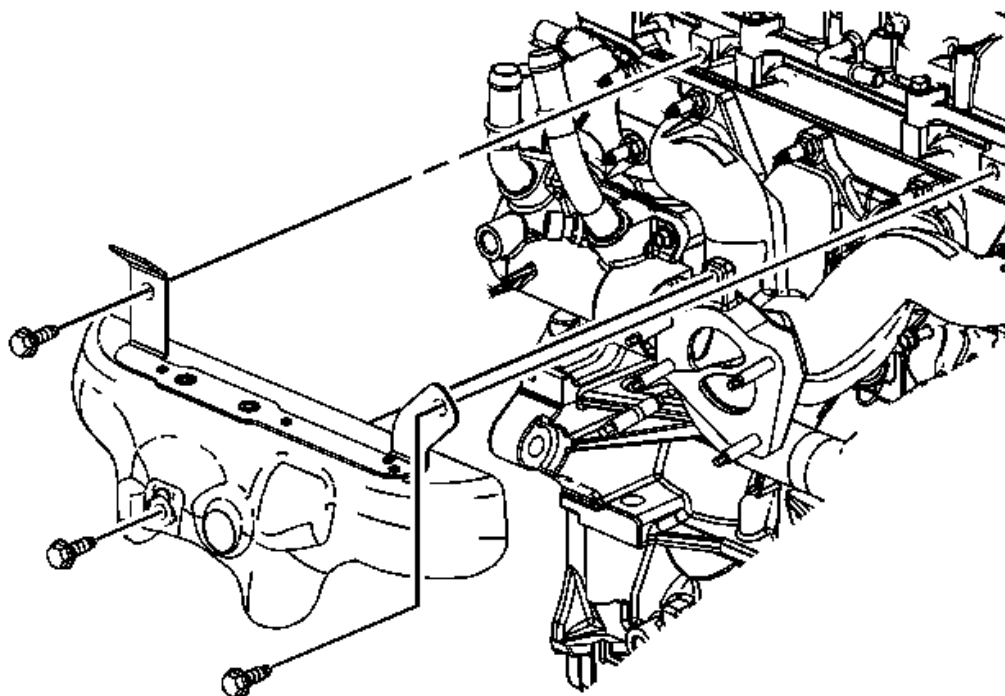


Fig. 343: View Of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust manifold heat shield bolts.
2. Remove the exhaust manifold heat shield.

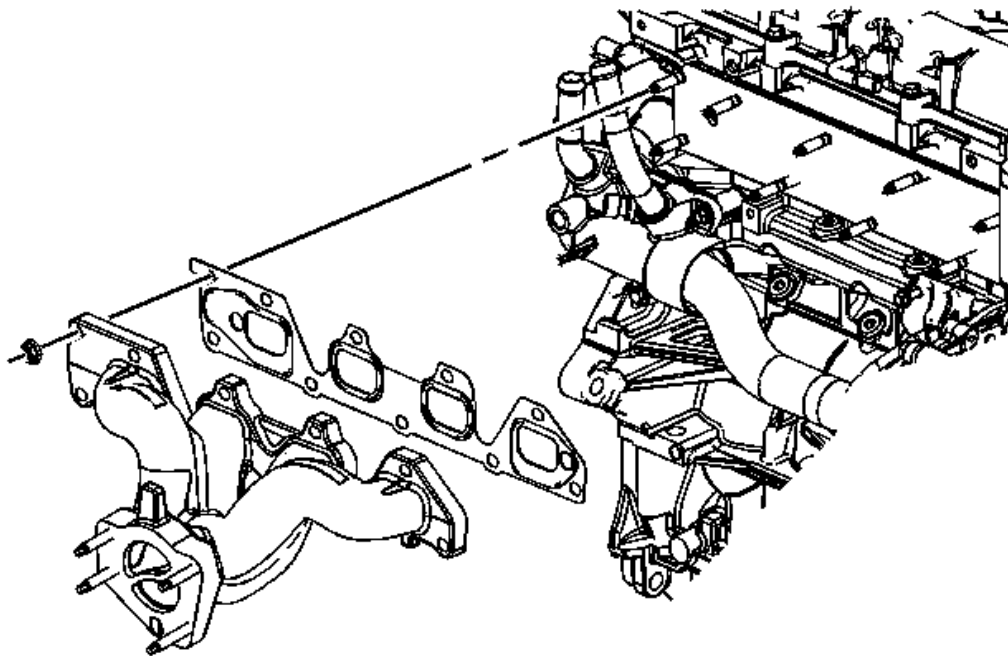


Fig. 344: View Of Exhaust Manifold, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the exhaust manifold nuts.
4. Remove the exhaust manifold.
5. Remove the exhaust manifold gasket.

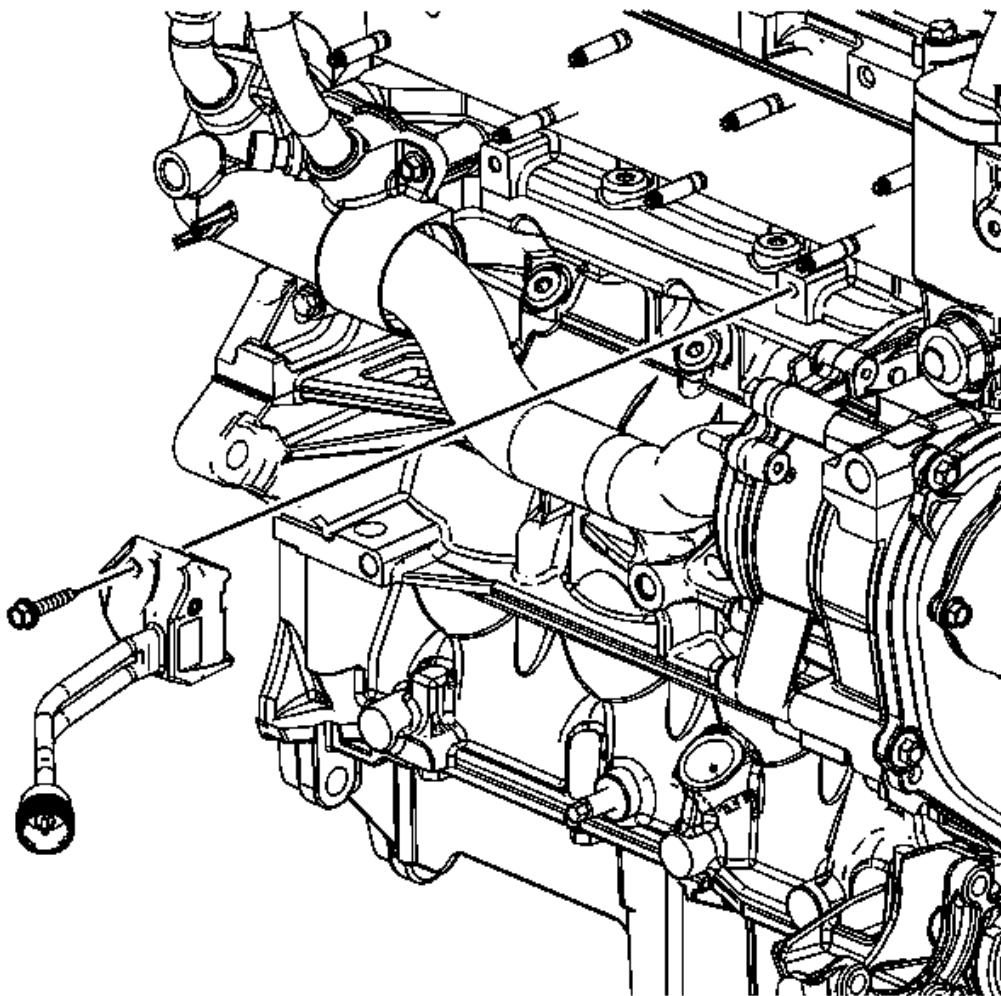


Fig. 345: Identifying Block Heater
Courtesy of GENERAL MOTORS CORP.

6. Remove the block heater bolt, if equipped.
7. Remove the block heater, if equipped.

CAMSHAFT COVER REMOVAL

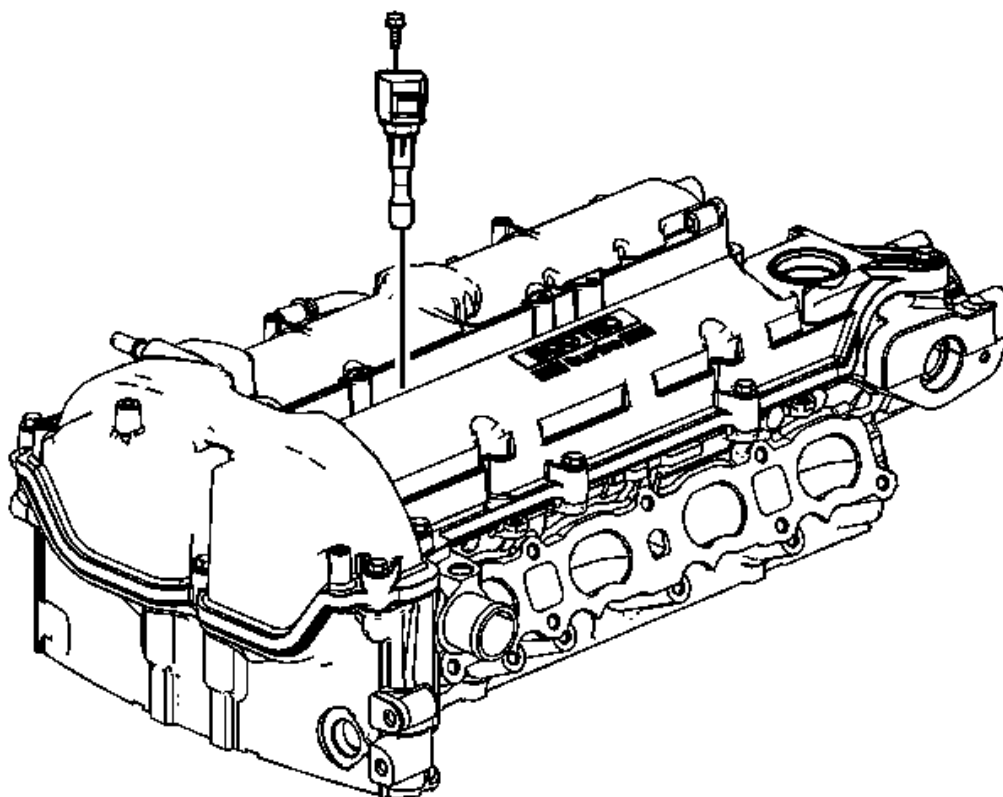


Fig. 346: Identifying Coil & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt and coil.

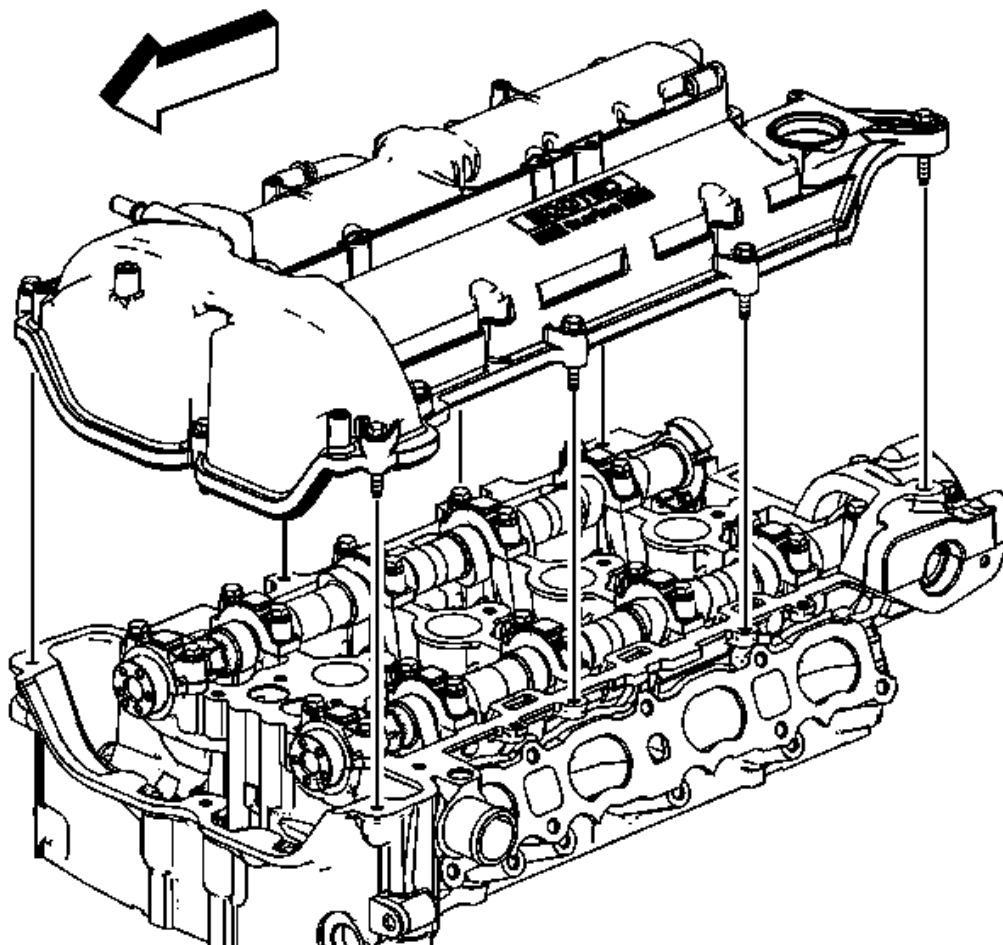


Fig. 347: View Of Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The PCV hose should not be disconnected from the camshaft cover as damage to the hose connection will result.

2. Remove the camshaft cover assembly.

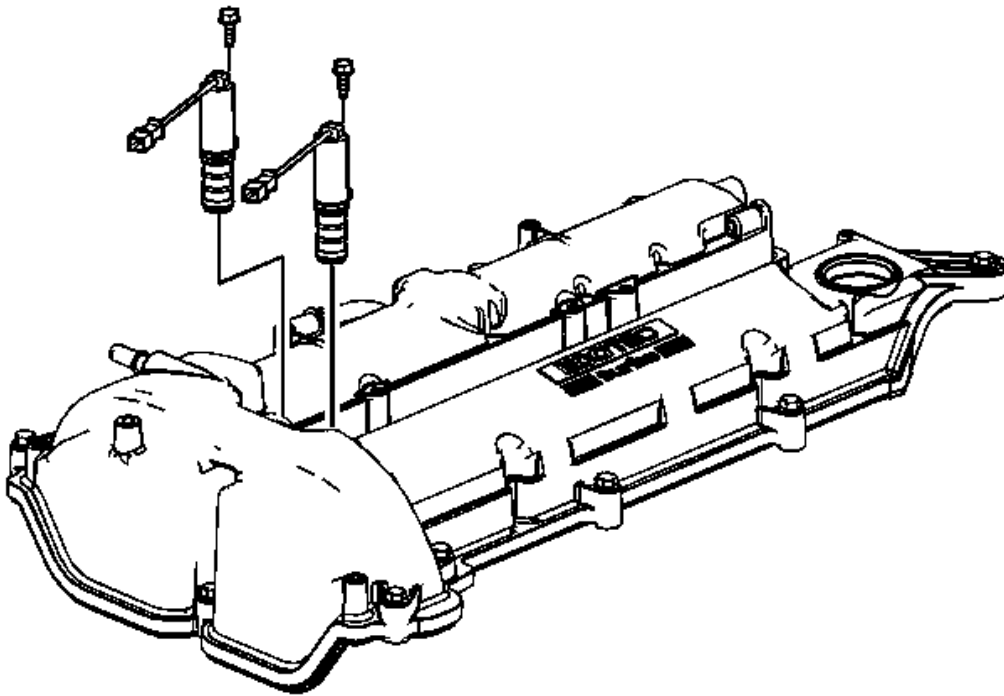


Fig. 348: Identifying Camshaft Position Actuator Solenoid Valves
Courtesy of GENERAL MOTORS CORP.

3. Remove the camshaft position actuator solenoid valve bolts.
4. Remove the camshaft position actuator solenoid valves.

ENGINE FRONT COVER AND OIL PUMP REMOVAL

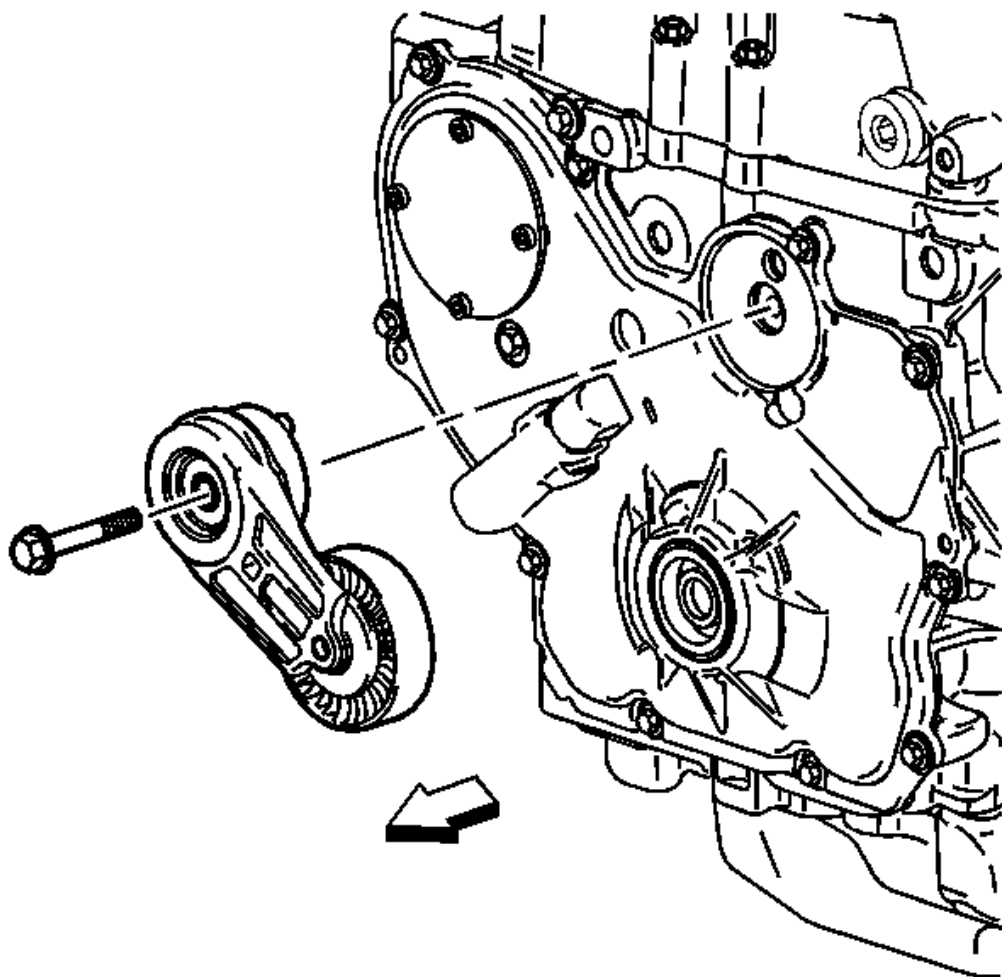


Fig. 349: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

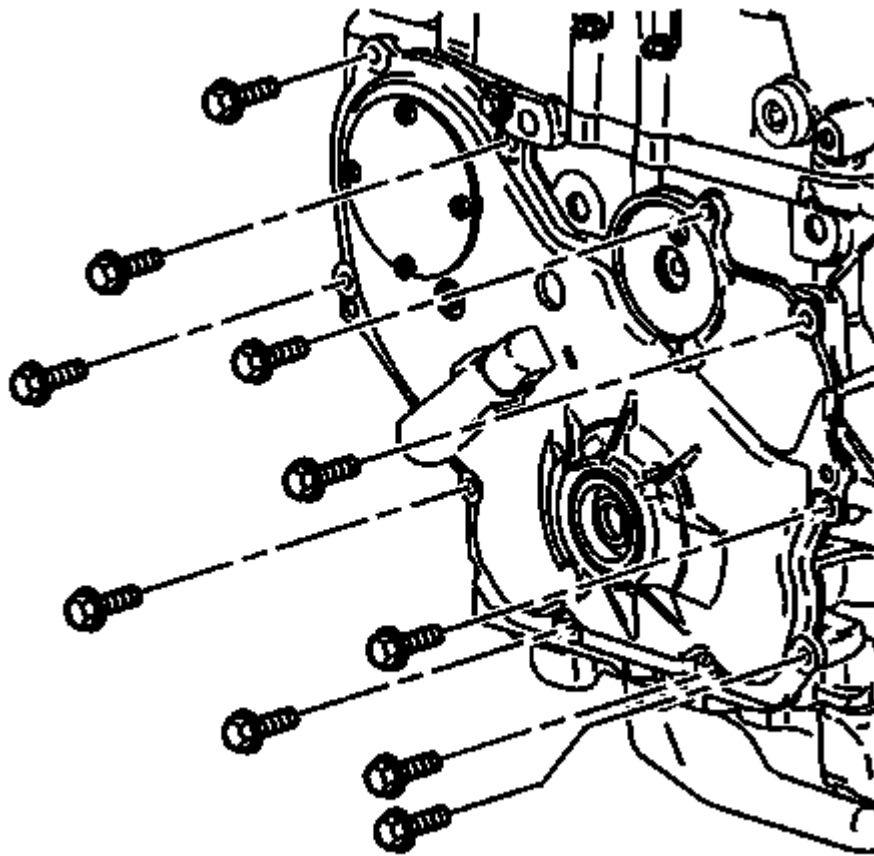


Fig. 350: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

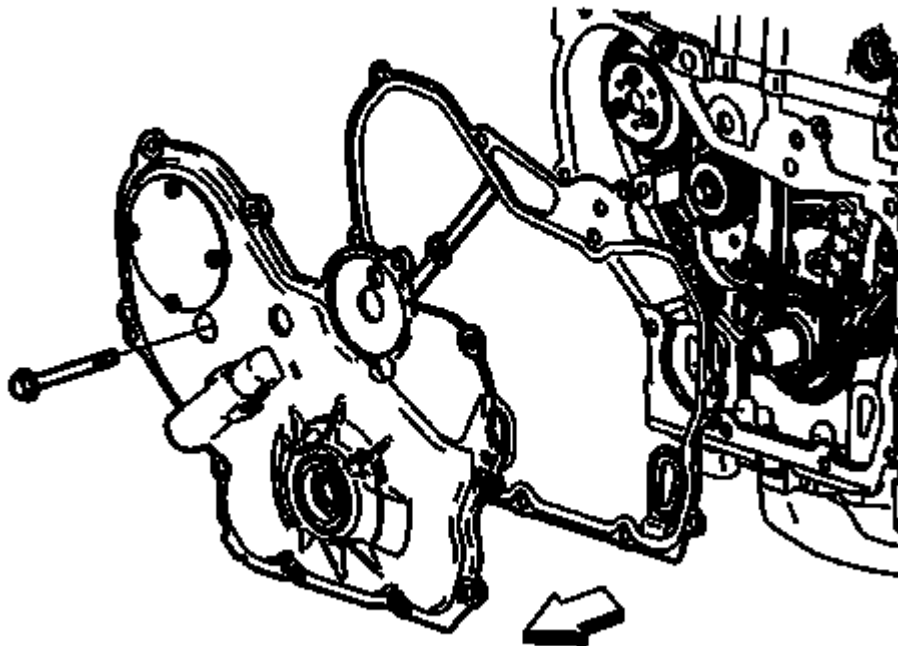


Fig. 351: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

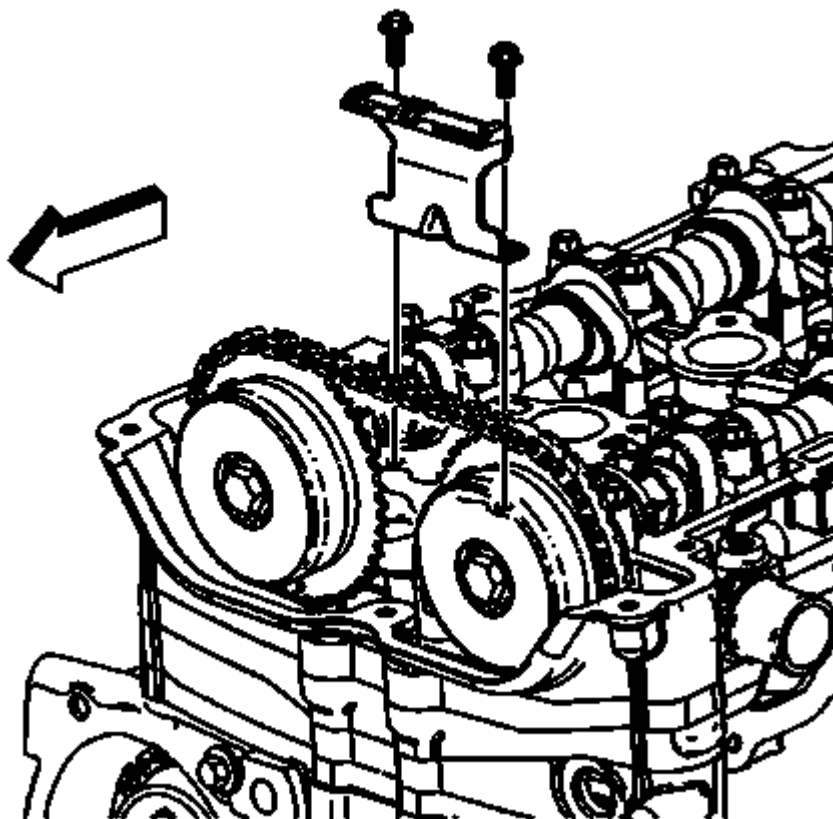


Fig. 352: Locating Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the upper timing chain guide bolts.
2. Remove the upper timing chain guide.

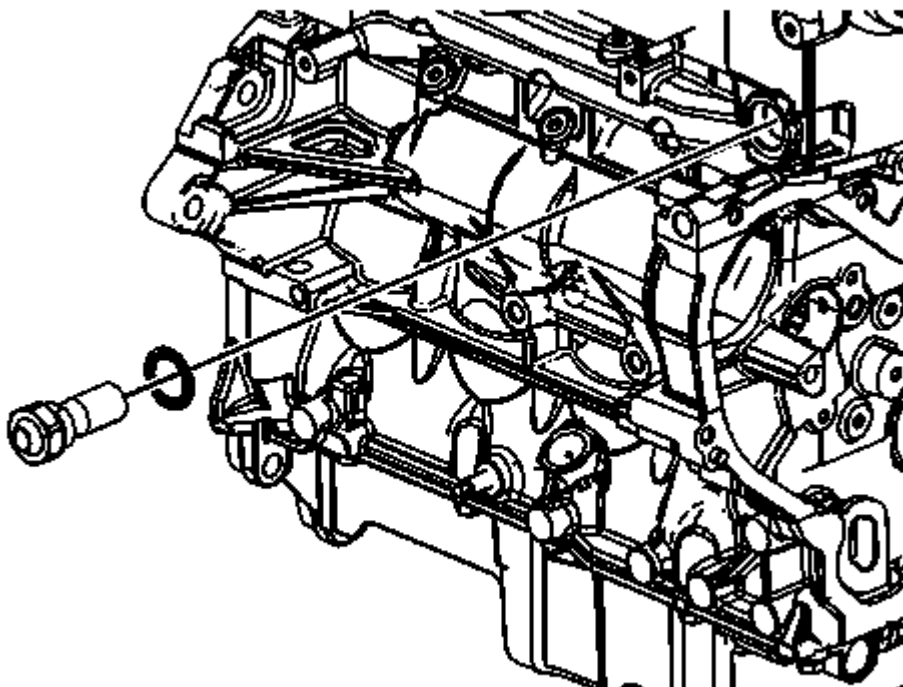


Fig. 353: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

3. Remove the timing chain tensioner.

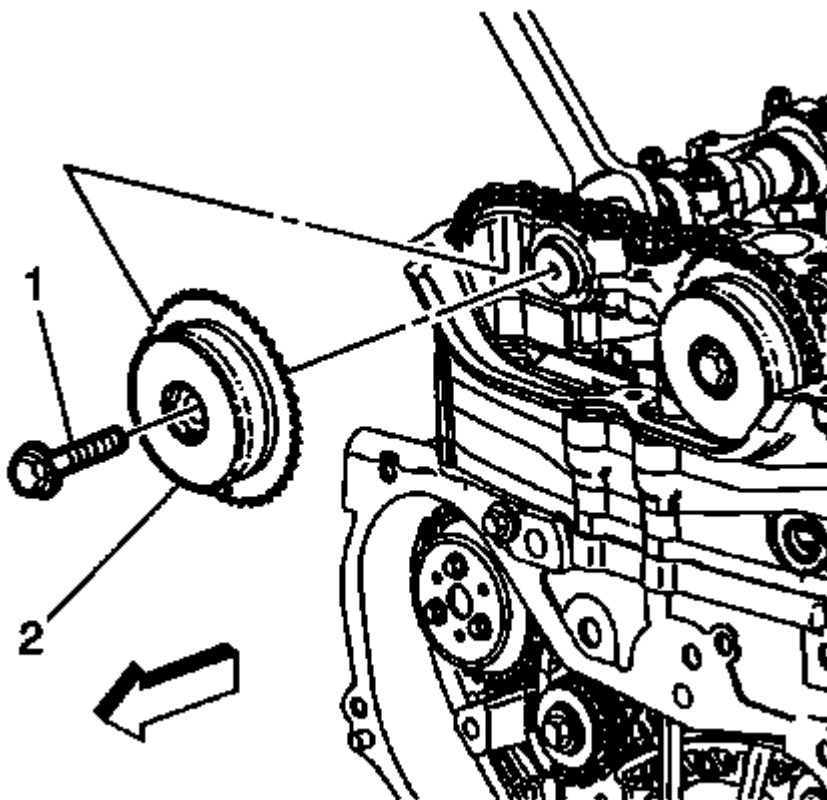


Fig. 354: Locating Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

4. Locate hex on the exhaust camshaft and hold with a wrench.
5. Remove the exhaust cam bolt and the exhaust cam actuator.

Discard the bolt.

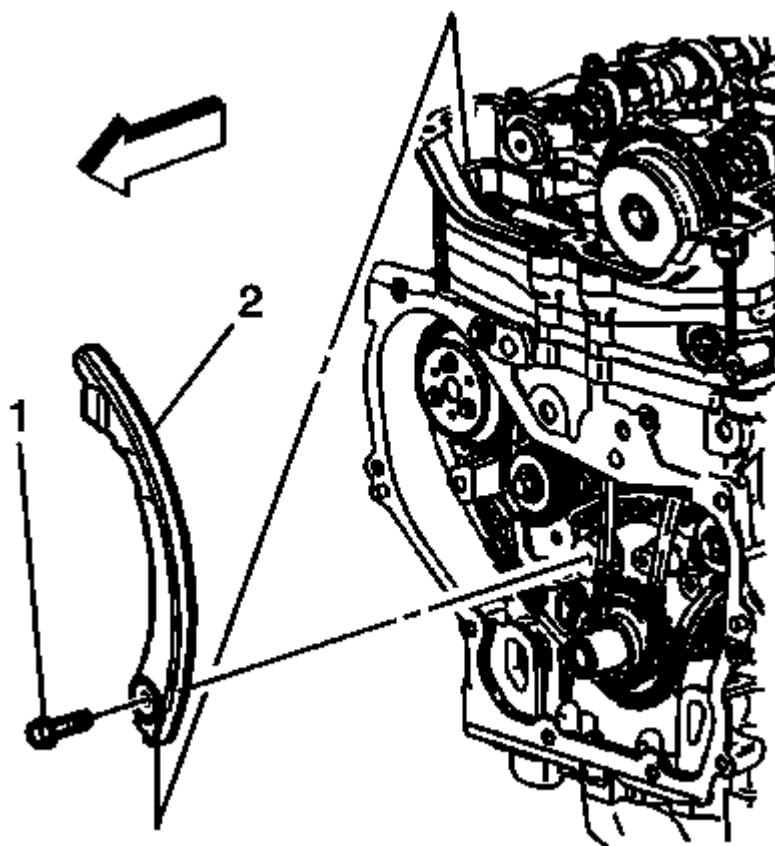


Fig. 355: Identifying Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the adjustable timing chain guide bolt.
7. Remove the adjustable timing chain guide.

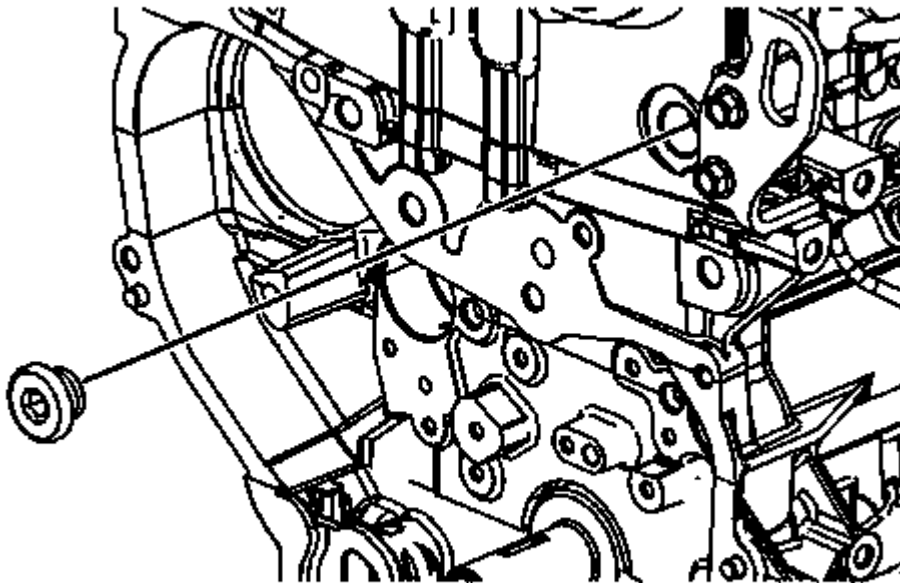


Fig. 356: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the plug to gain access to the fixed timing chain guide bolt.

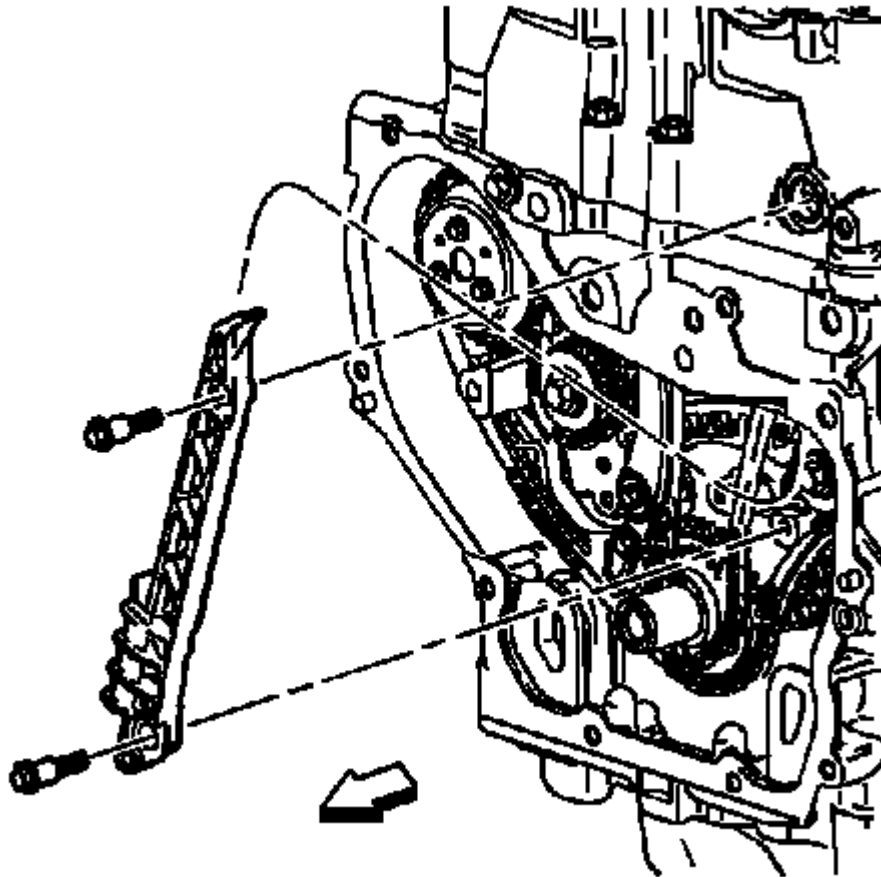


Fig. 357: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the fixed timing chain guide bolts.
10. Remove the fixed timing chain guide.

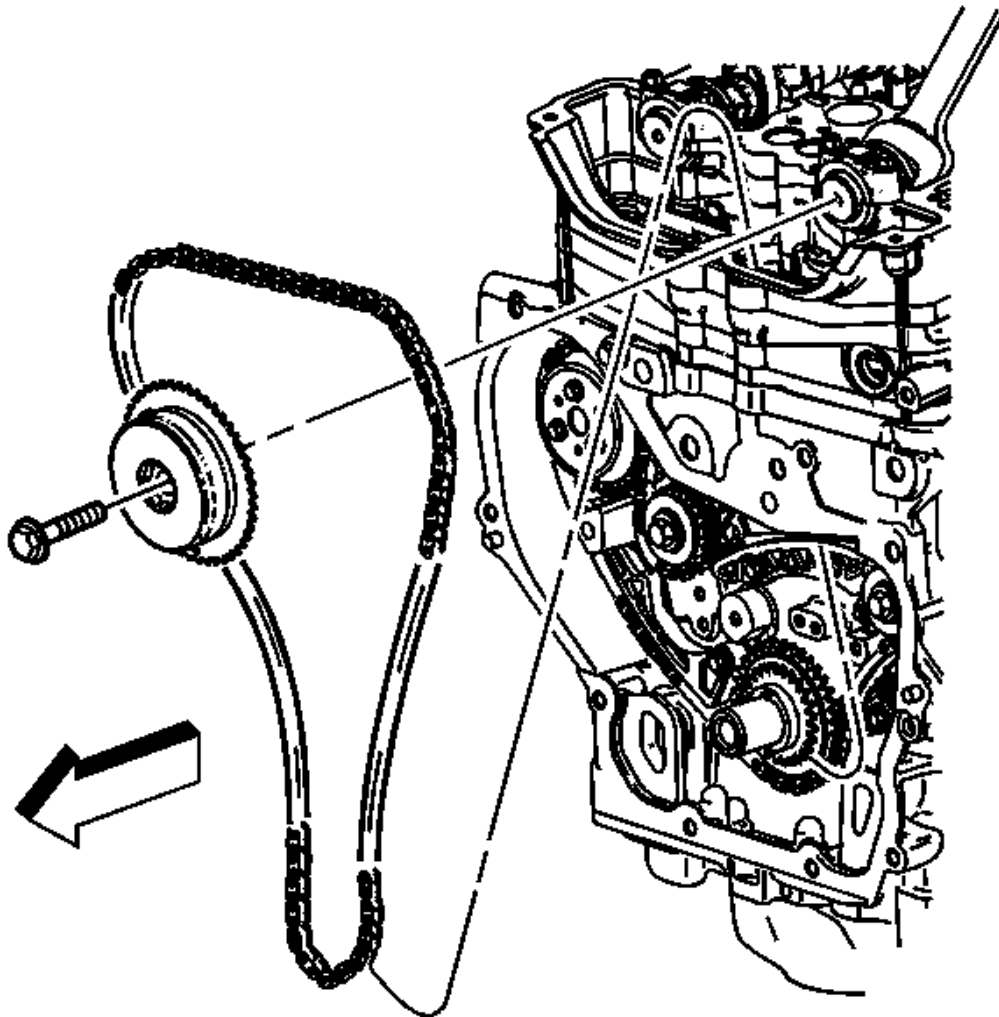


Fig. 358: Identifying Intake Cam Sprocket & The Timing Chain
Courtesy of GENERAL MOTORS CORP.

11. Locate hex on the intake camshaft and hold with a wrench.
12. Remove the intake cam sprocket bolt, the intake cam sprocket and the timing chain through the top of the cylinder head. Discard the bolt.

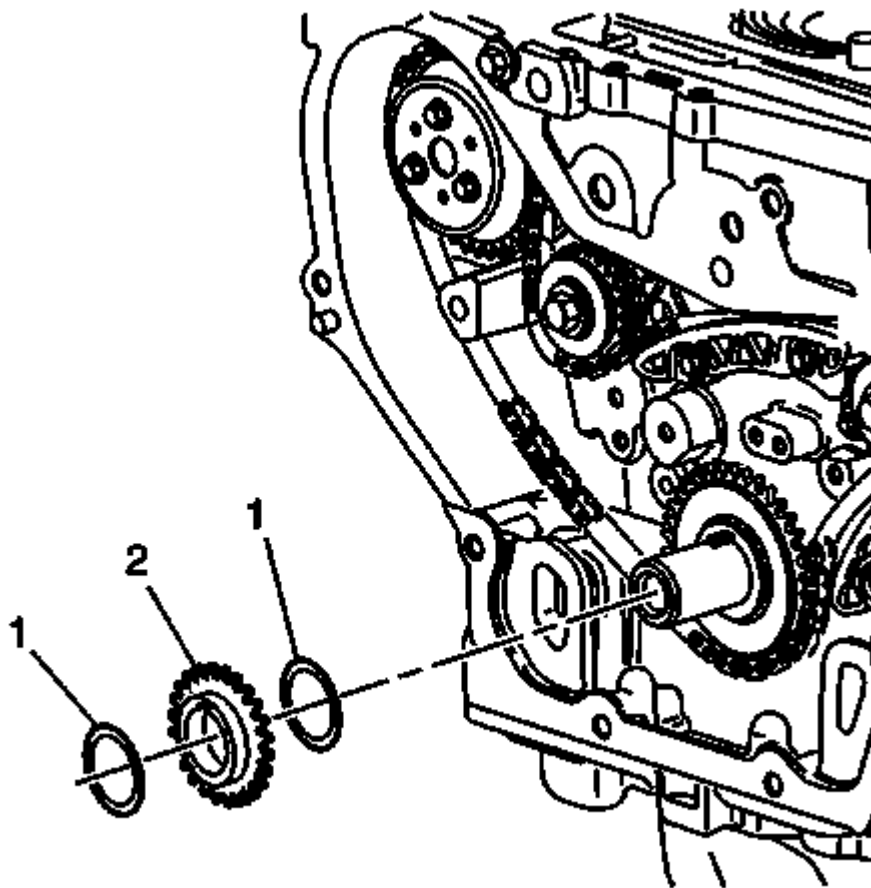


Fig. 359: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Remove the friction washers.
14. Remove the crankshaft sprocket.

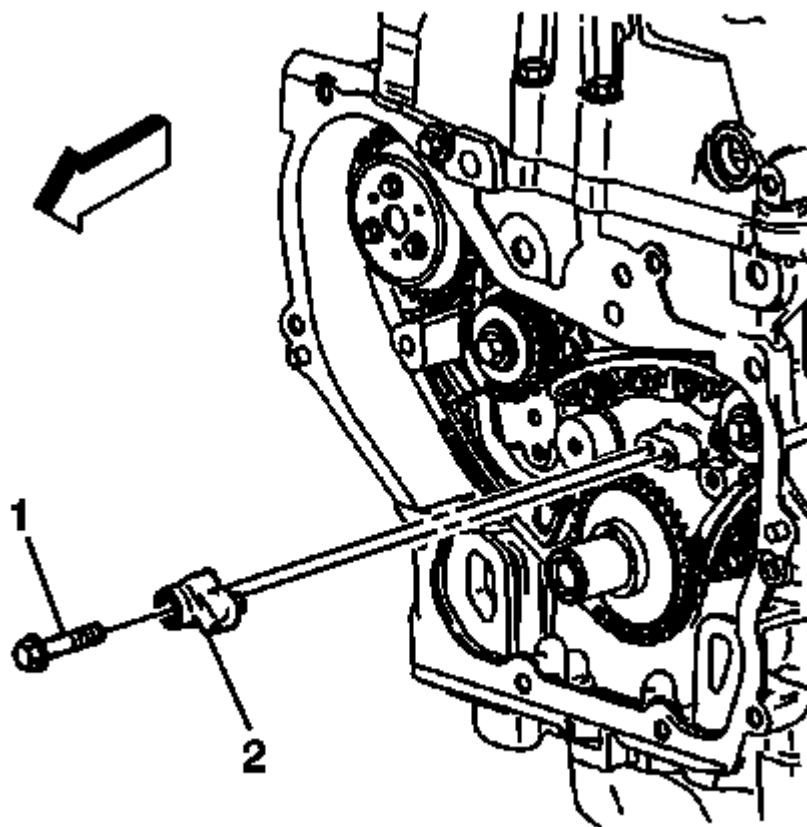


Fig. 360: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Remove the timing chain oil nozzle bolt.
16. Remove the timing chain oil nozzle.

INTAKE CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

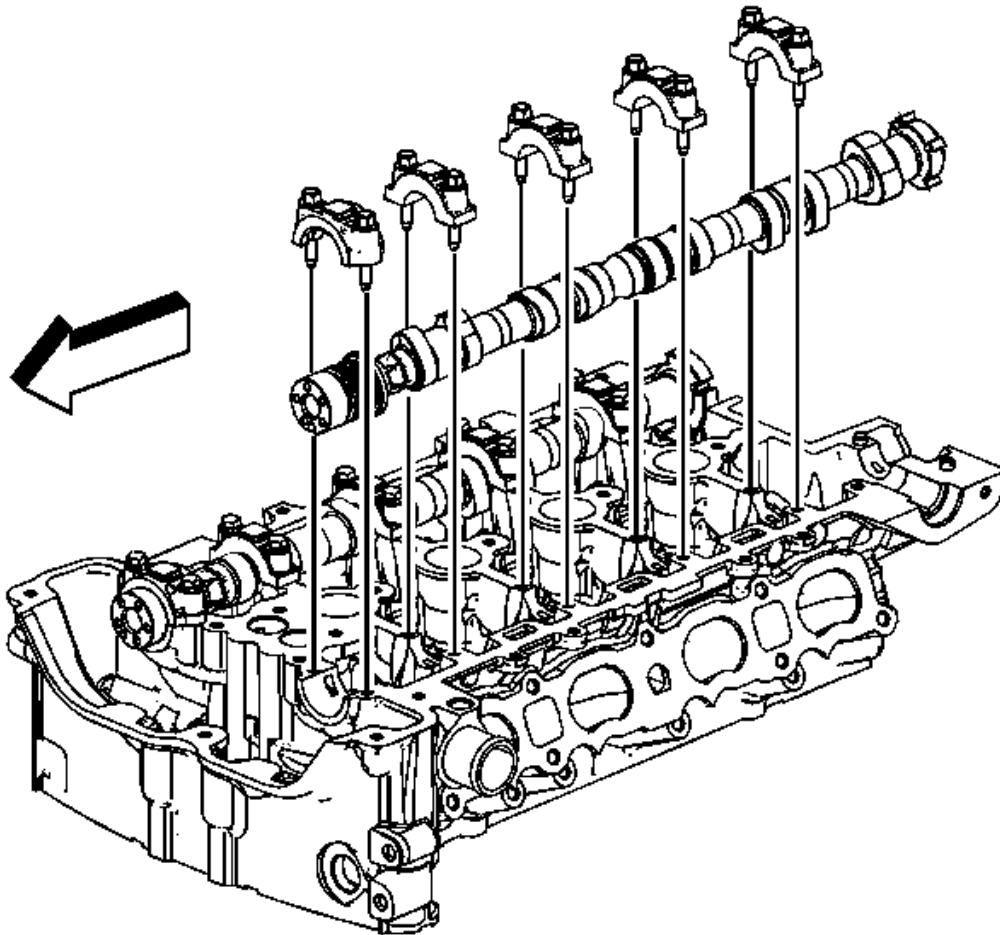


Fig. 361: View Of Intake Camshaft & Caps

Courtesy of GENERAL MOTORS CORP.

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

1. Mark camshaft caps to ensure they are installed in the same position.
2. Remove the intake camshaft cap bolts.
3. Remove the camshaft caps.
4. Remove the intake camshaft.

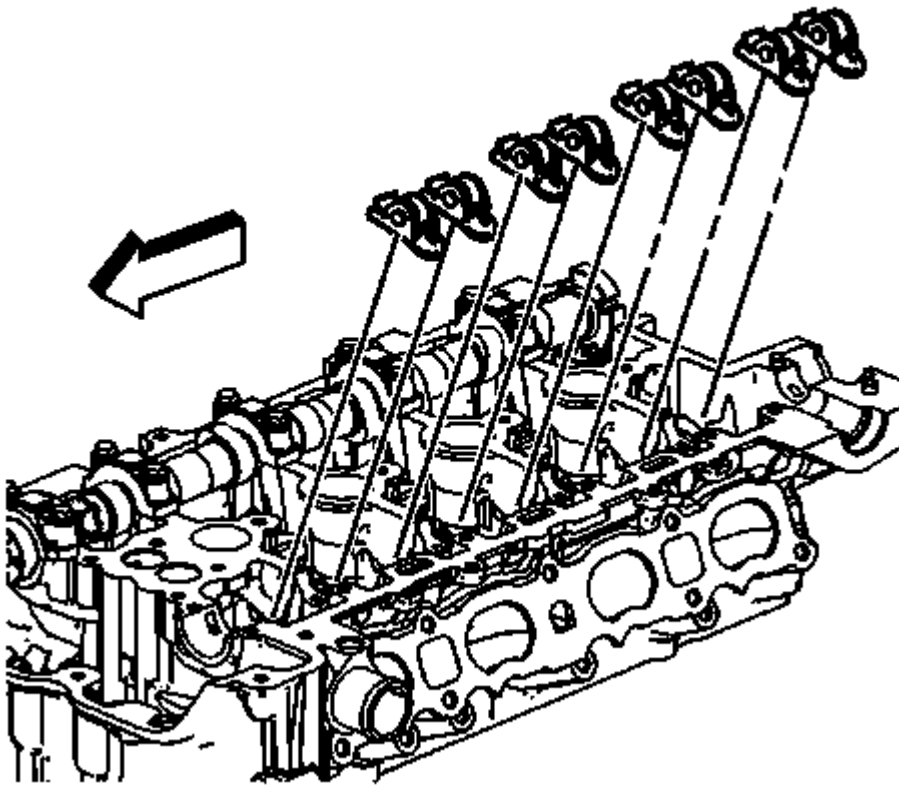


Fig. 362: View Of Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the intake camshaft roller finger followers.

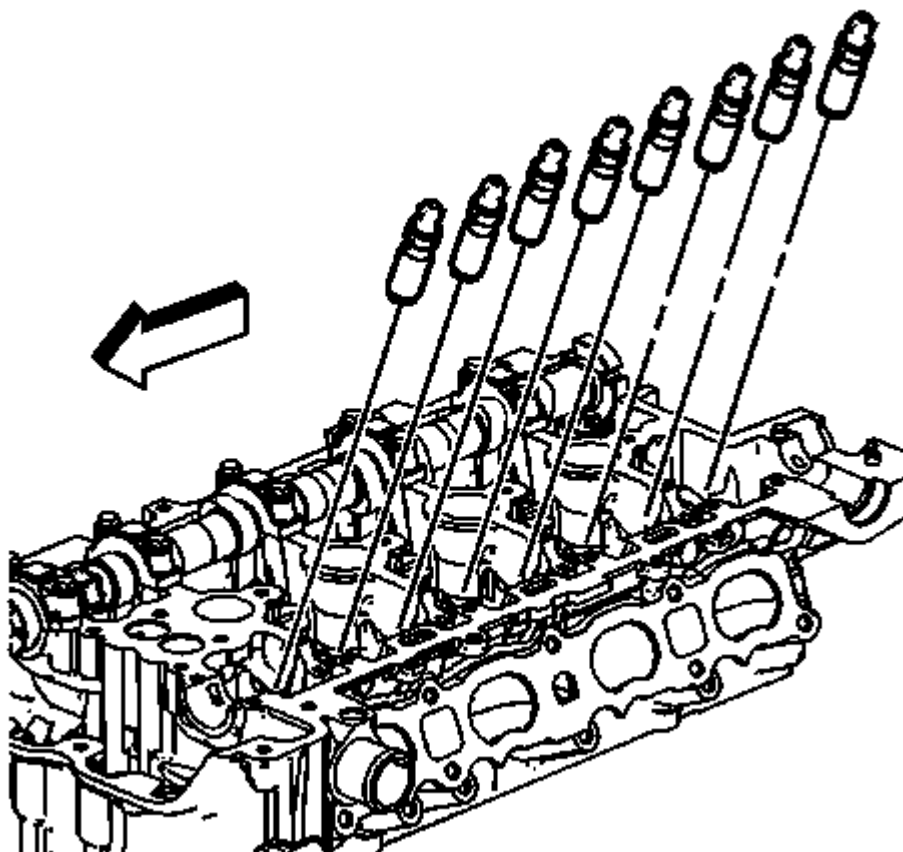


Fig. 363: View Of Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

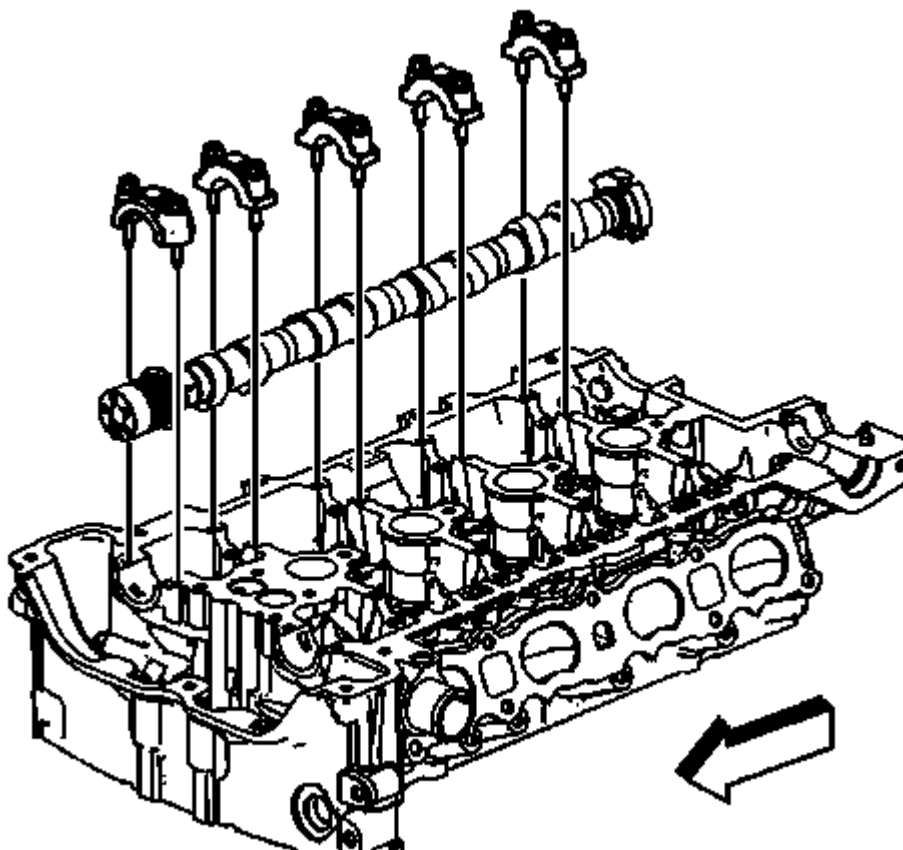


Fig. 364: View Of Exhaust Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

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

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

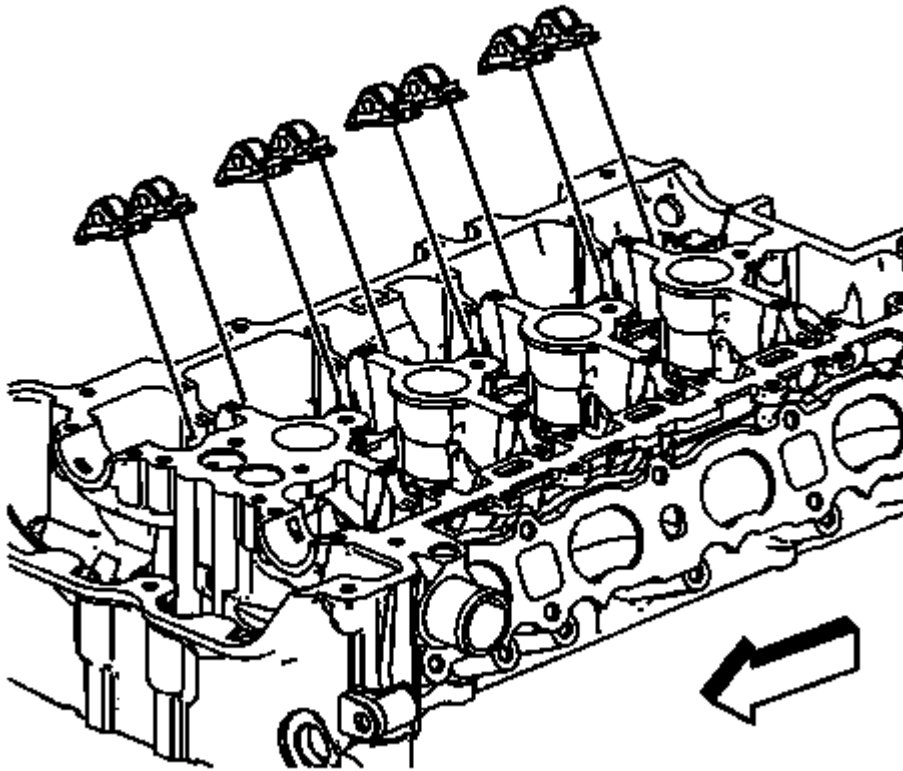


Fig. 365: View Of Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

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

5. Remove the exhaust camshaft roller finger followers.

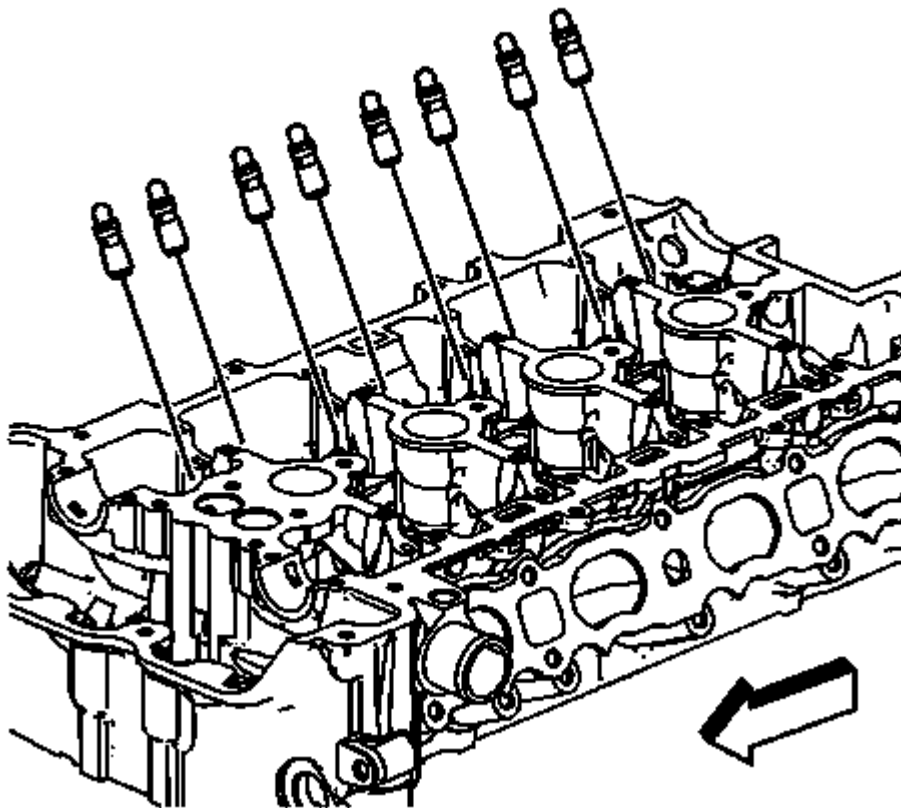


Fig. 366: View Of Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER REMOVAL

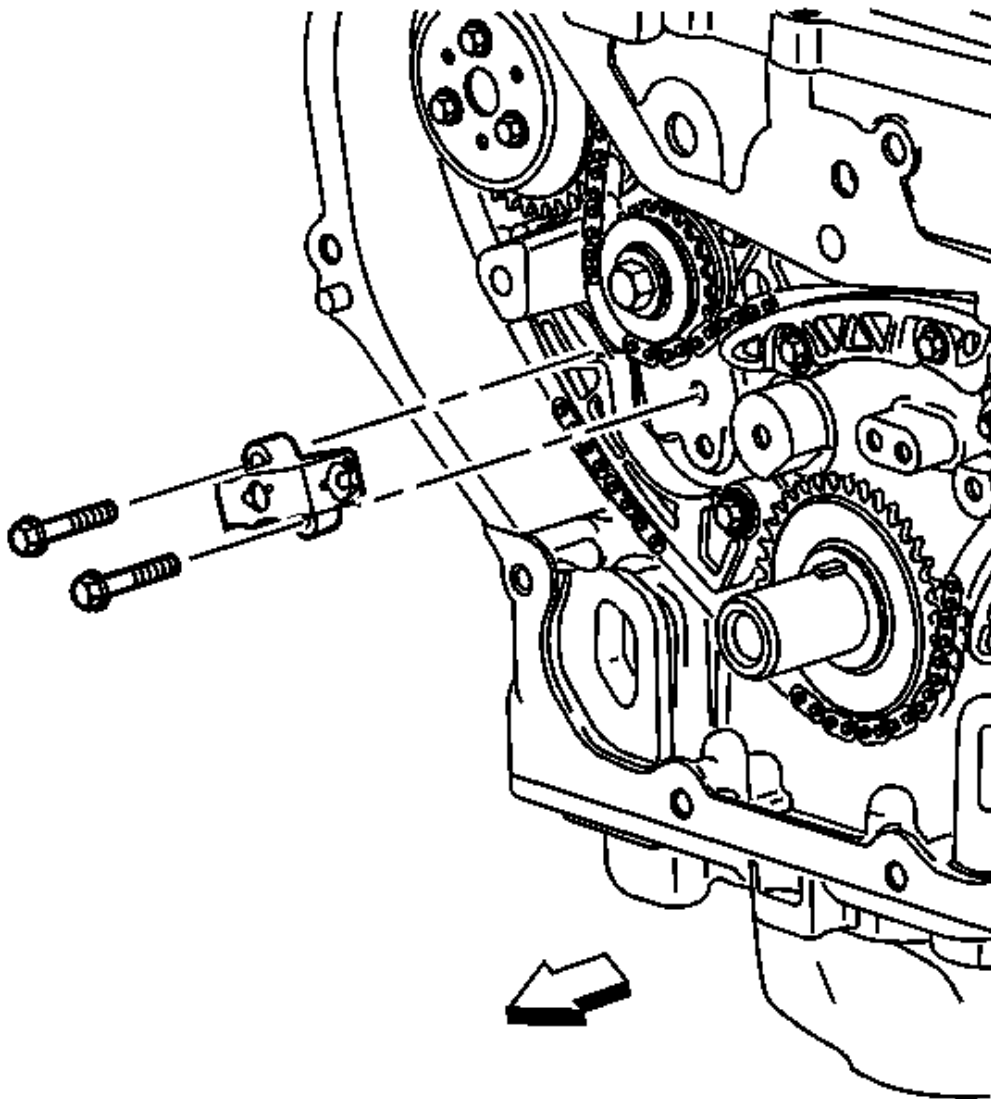


Fig. 367: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

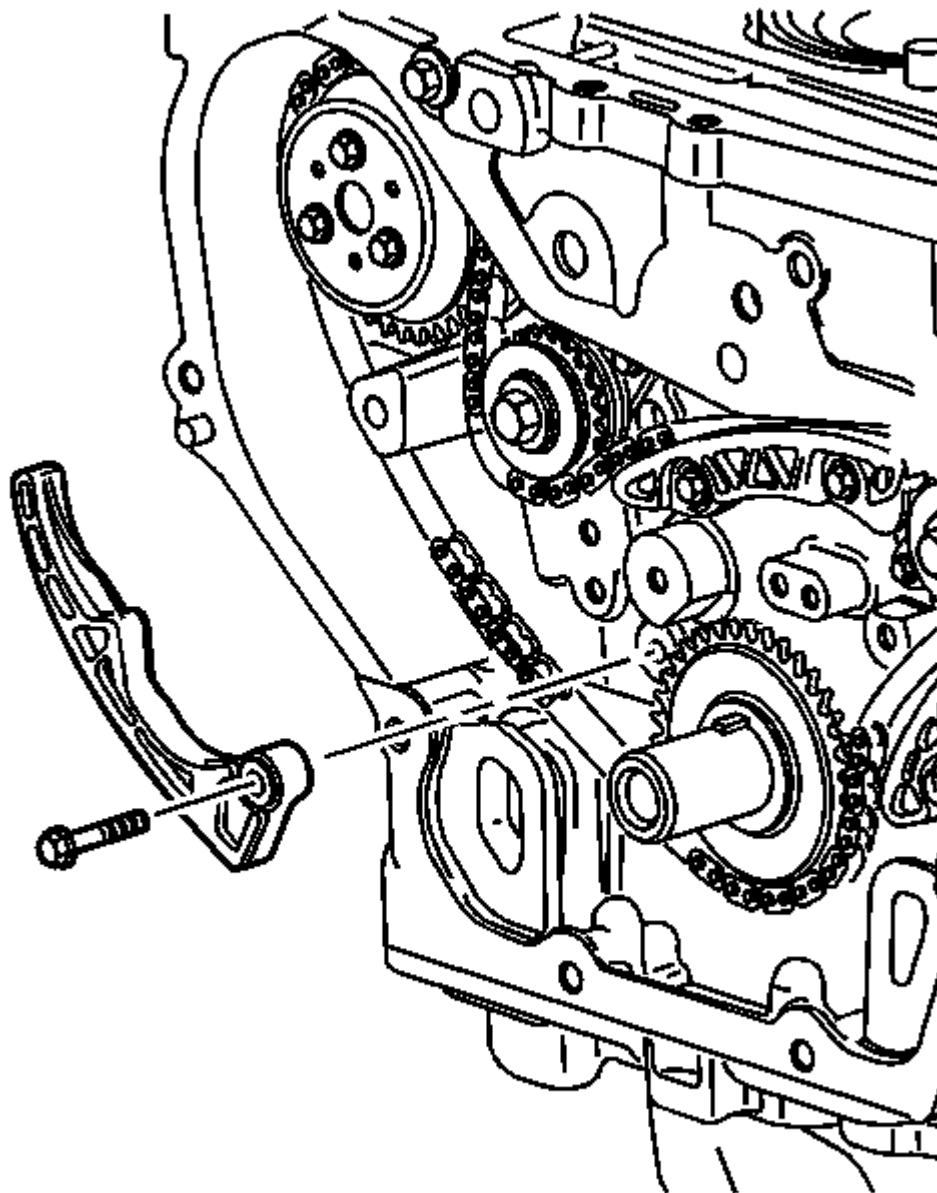


Fig. 368: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

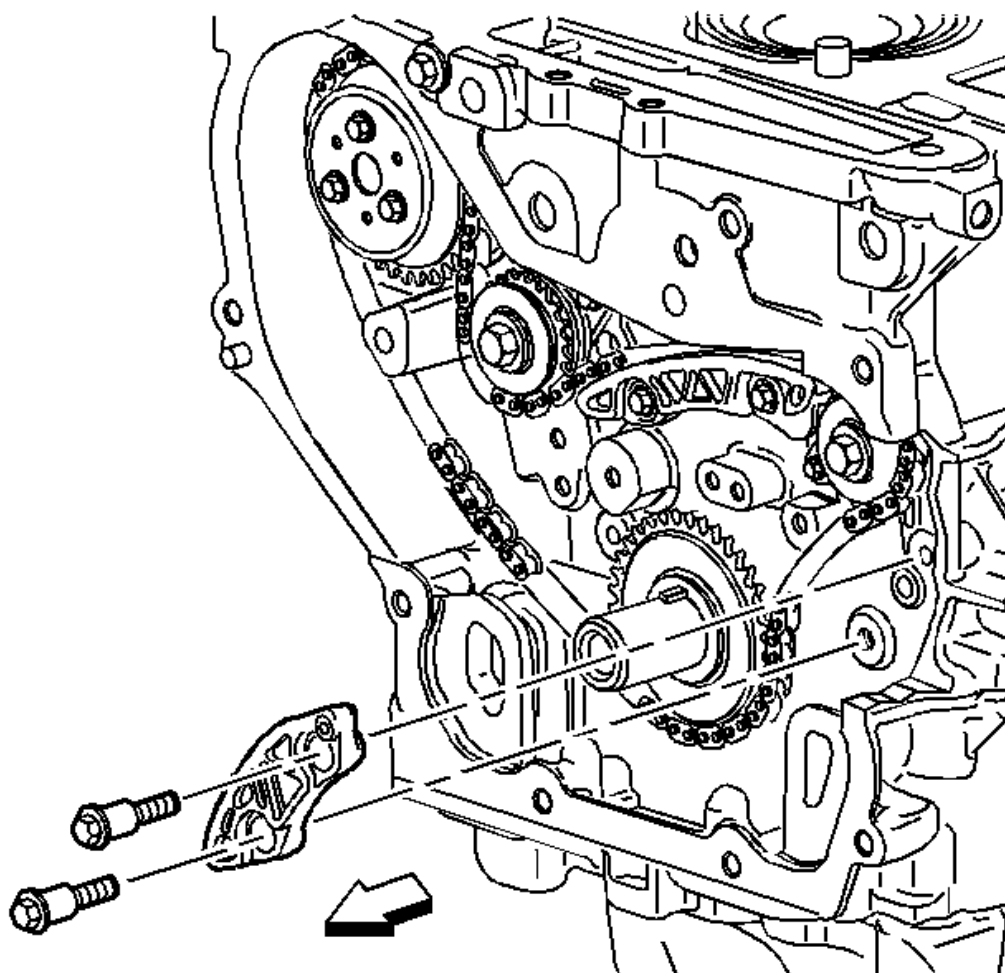


Fig. 369: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

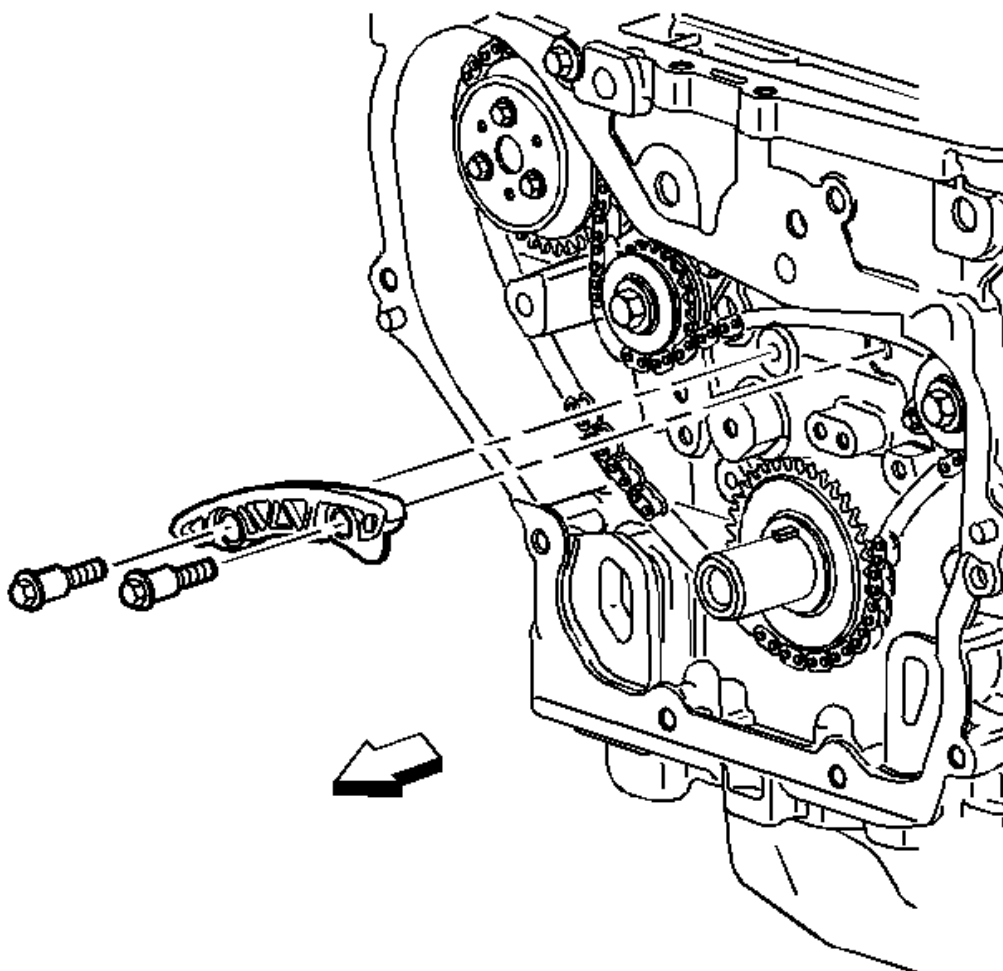


Fig. 370: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

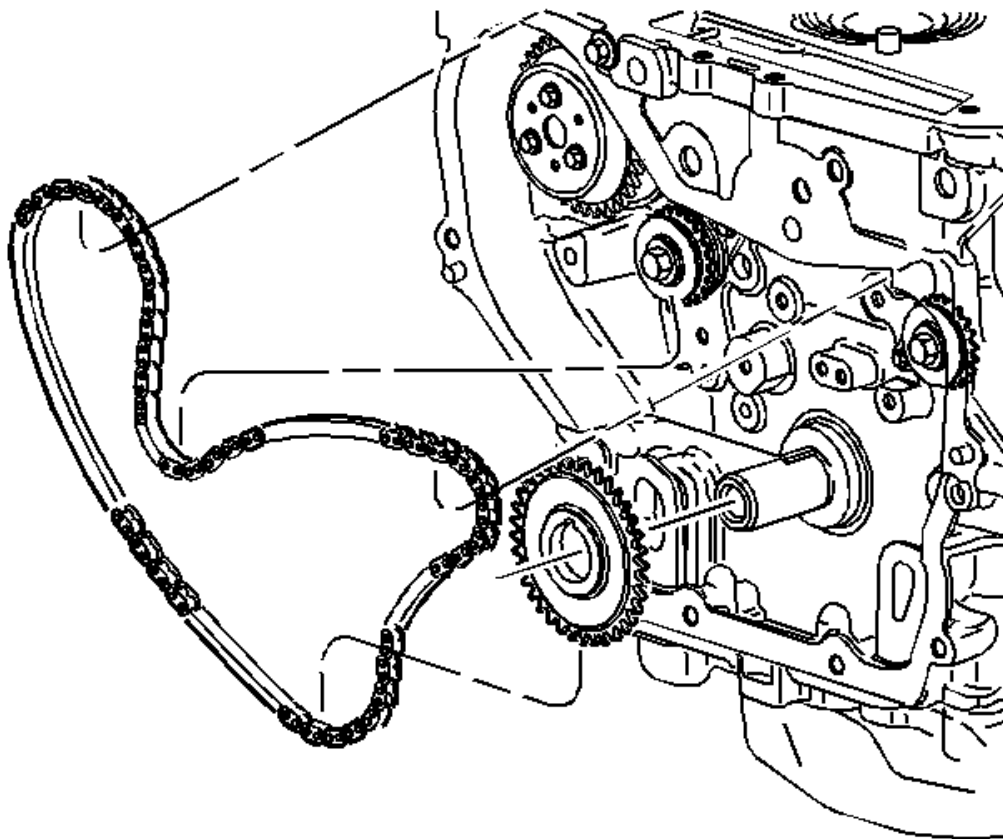


Fig. 371: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

J 43650 Balancer Shaft Bearing Remover and Installer. See **Special Tools**.

Removal Procedure

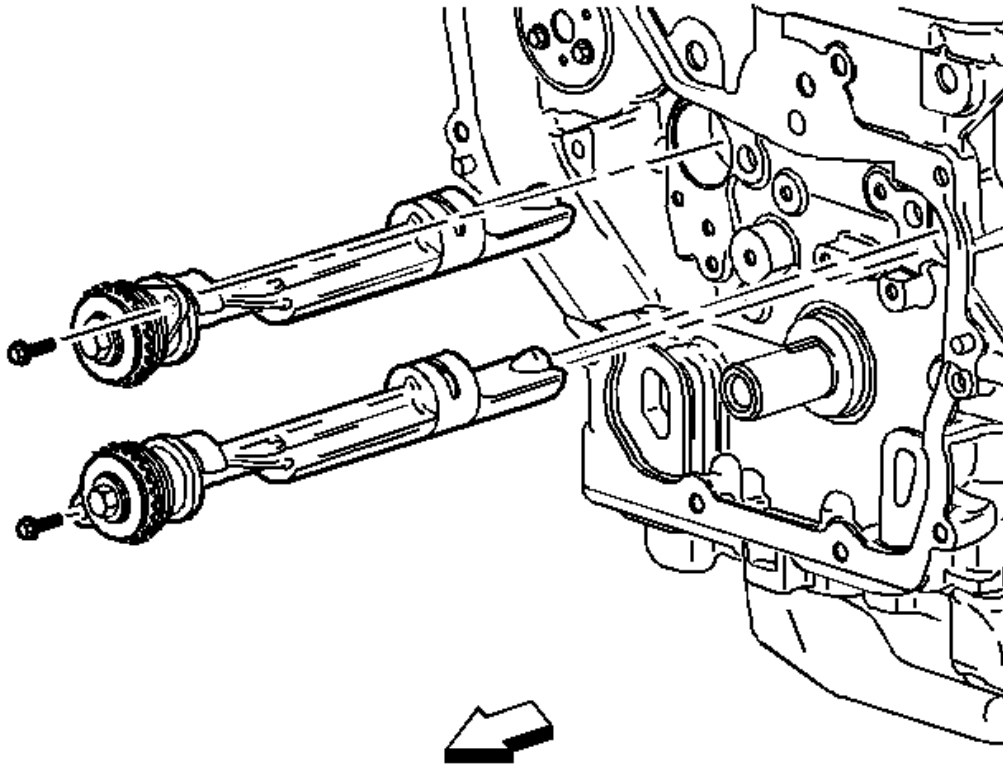


Fig. 372: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

IMPORTANT:

- 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.

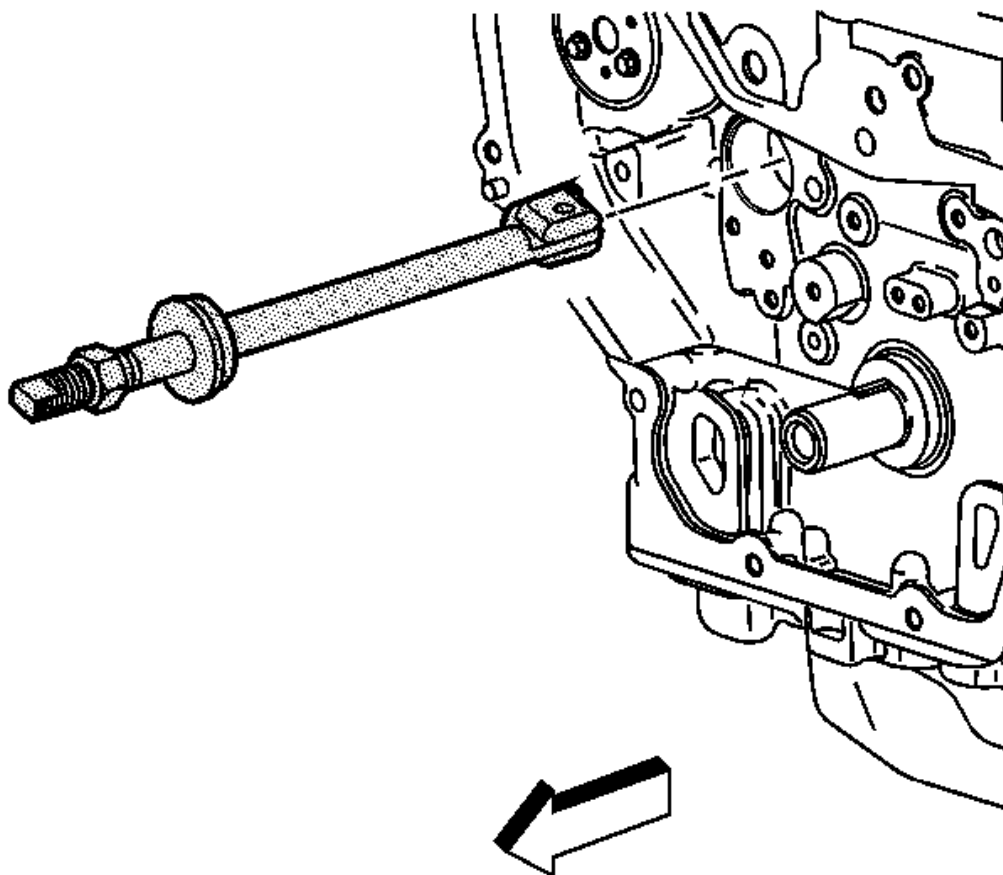


Fig. 373: Identifying J 43650

Courtesy of GENERAL MOTORS CORP.

NOTE: 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 **J 43650** into the balance shaft hole. See **Special Tools**. Insert the tool with the foot parallel to the shaft.

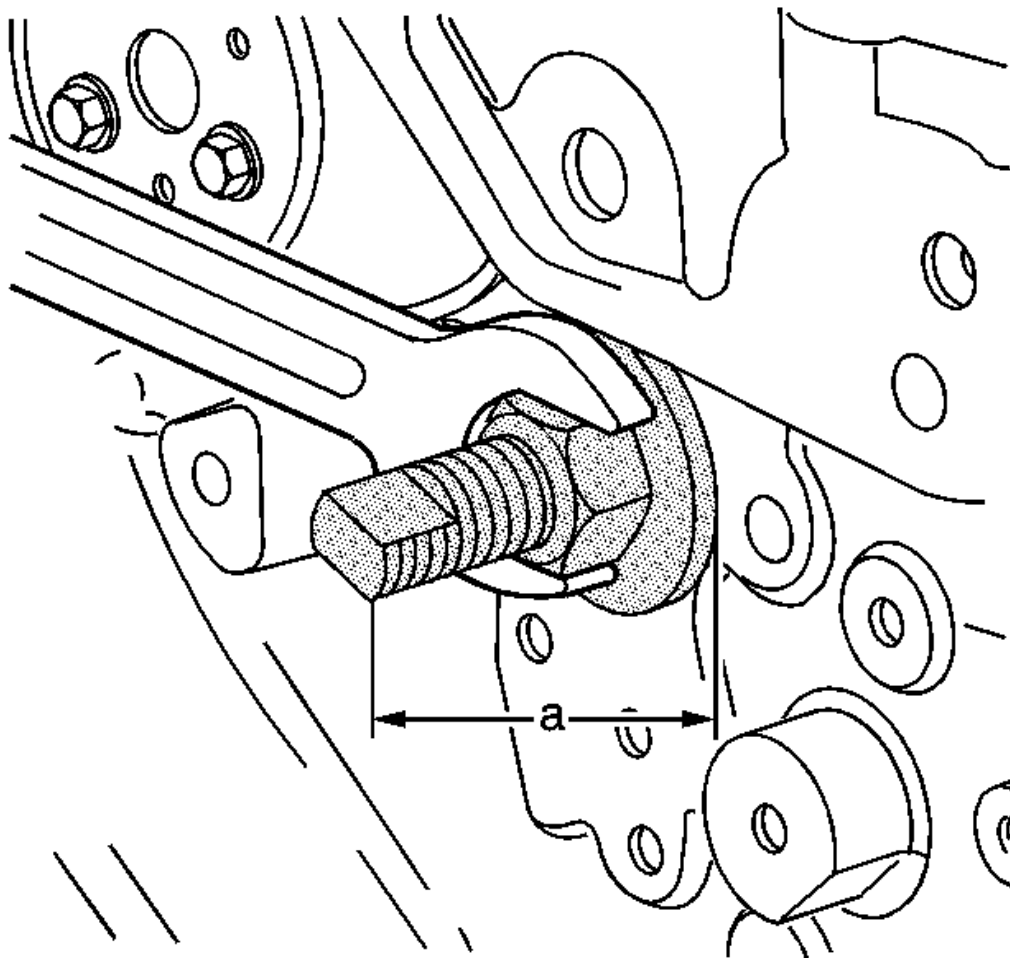


Fig. 374: Using J 43650

Courtesy of GENERAL MOTORS CORP.

4. When the **J 43650** is inserted in the block turn the **J 43650** so that the foot becomes perpendicular to the shaft. See **Special Tools**.
5. Center the foot of the **J 43650** on the balance shaft bushing. See **Special Tools**.
6. Once the **J 43650** 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. See **Special Tools**.

When the **J 43650** is properly installed, before removing the bushing, the end of the tool should be 116 mm (4. See **Special Tools**.6 in) (a) from the block face.

If the **J 43650** is less than approximately 114 mm (4. See **Special Tools**.5 in) (a), recheck the tool

alignment.

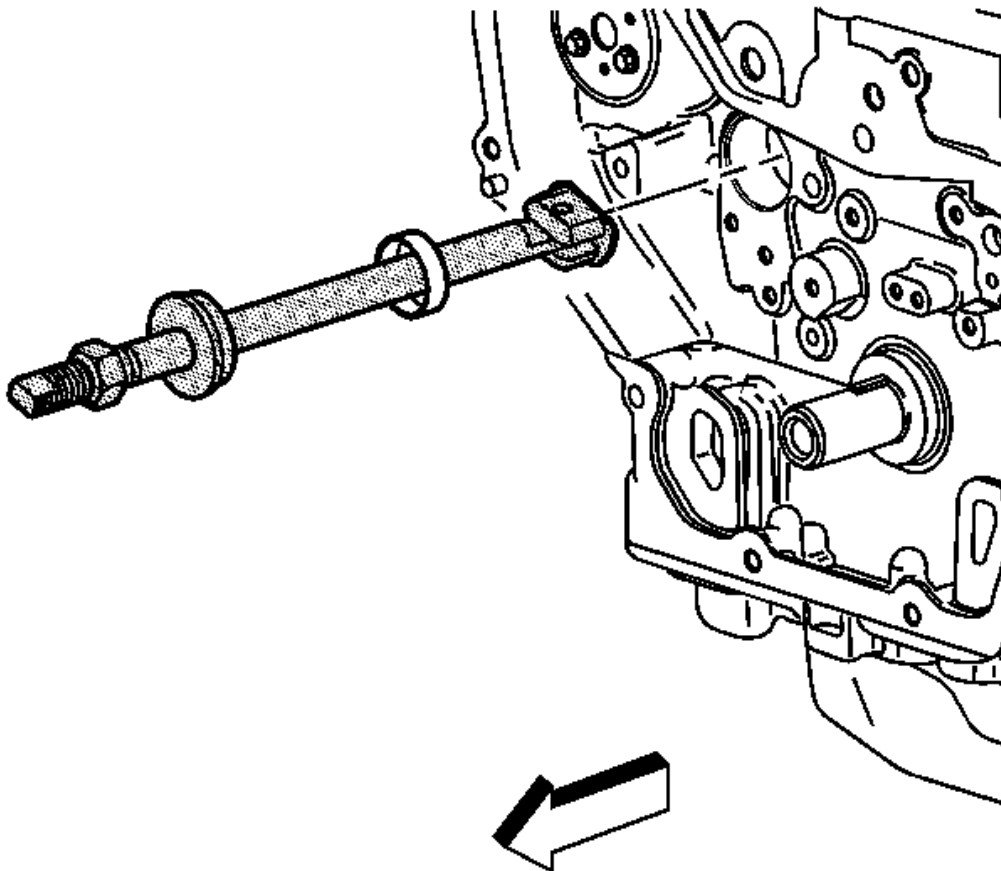


Fig. 375: Removing J 43650 & Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **J 43650** until the tension releases. See **Special Tools**. When the tension releases, remove the **J 43650** and the balance shaft bushing. See **Special Tools**.

WATER PUMP REMOVAL

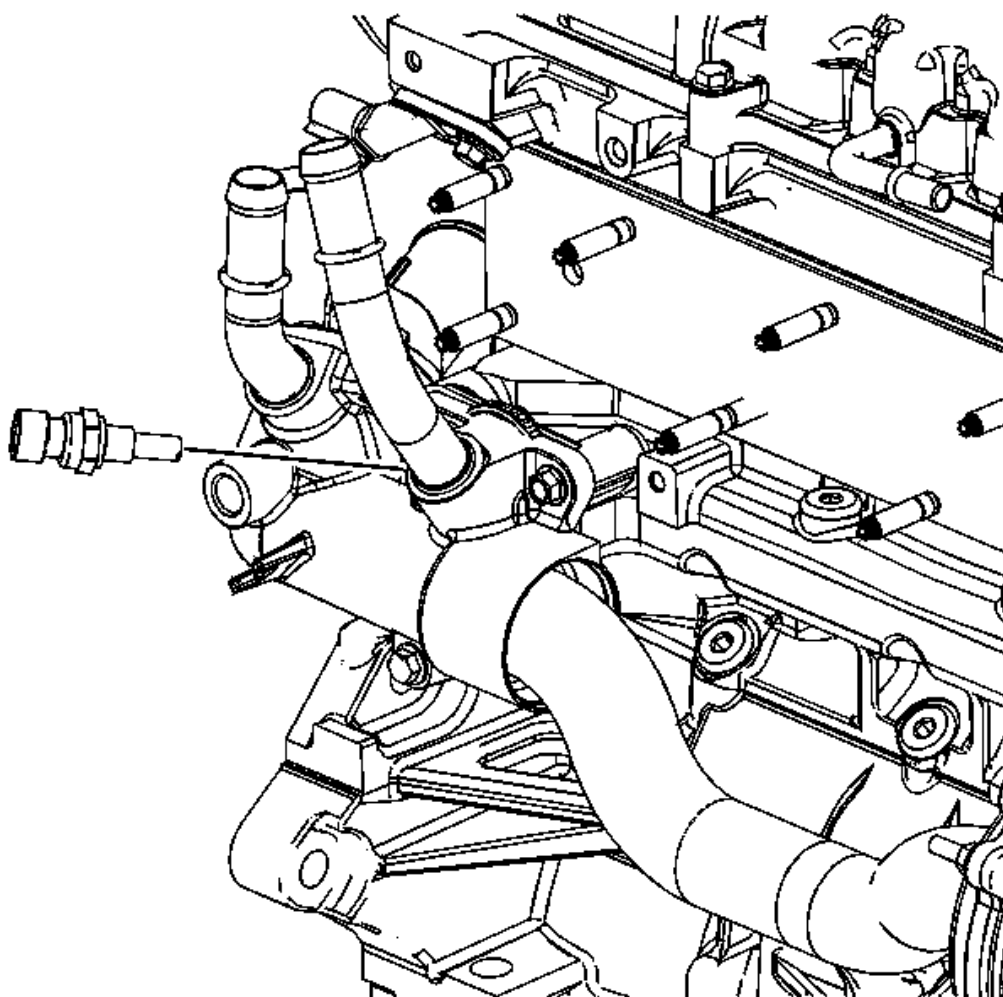


Fig. 376: Locating Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

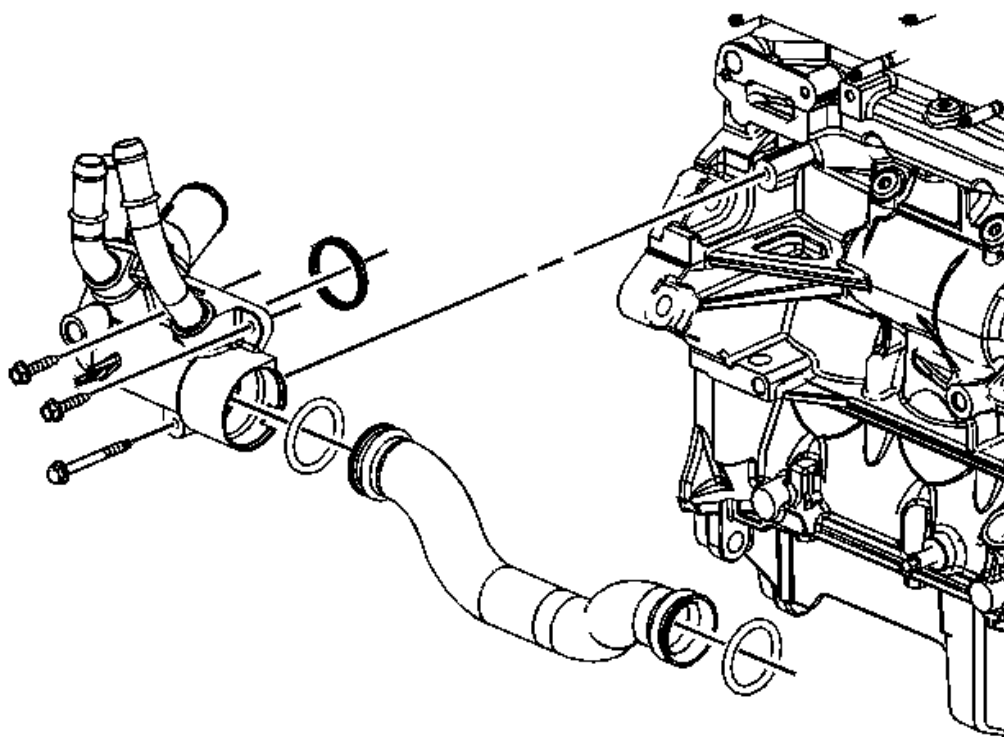


Fig. 377: Identifying Radiator Outlet Pipe

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.

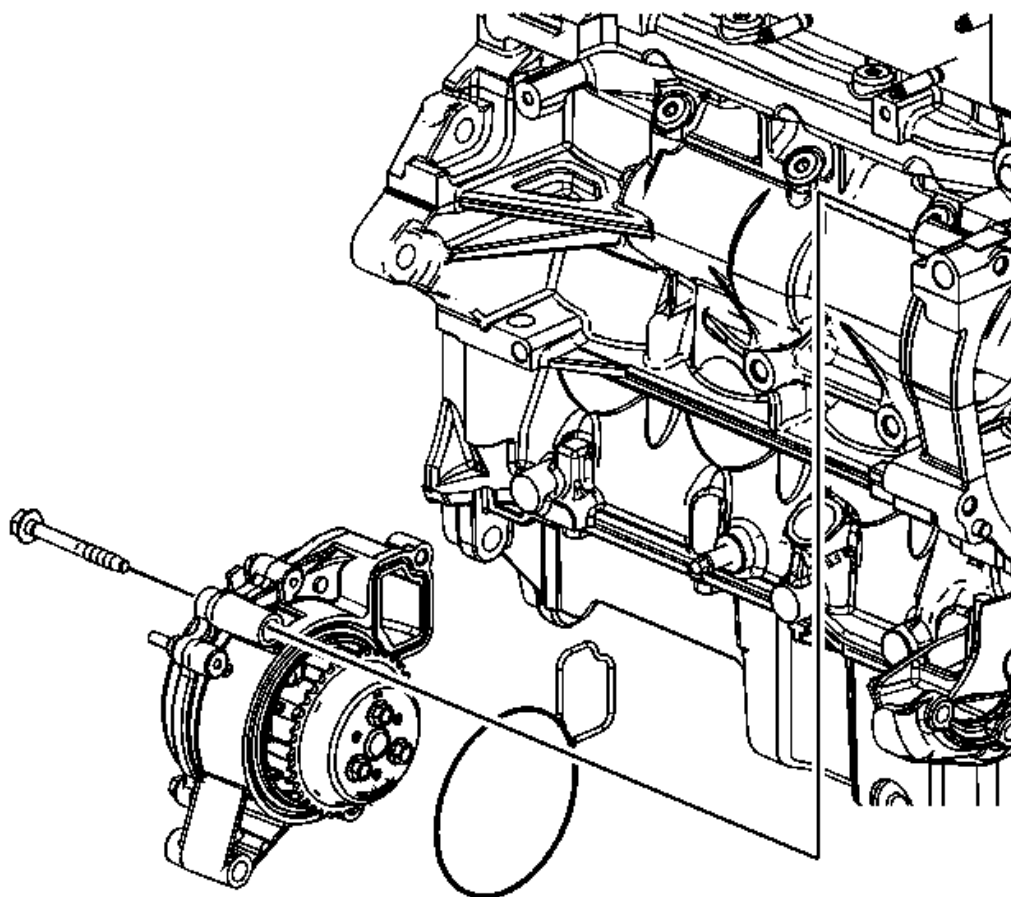


Fig. 378: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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

Tools Required

J 38188 Cylinder Head Broken Bolt Extractor Kit. See **Special Tools**.

Removal Procedure

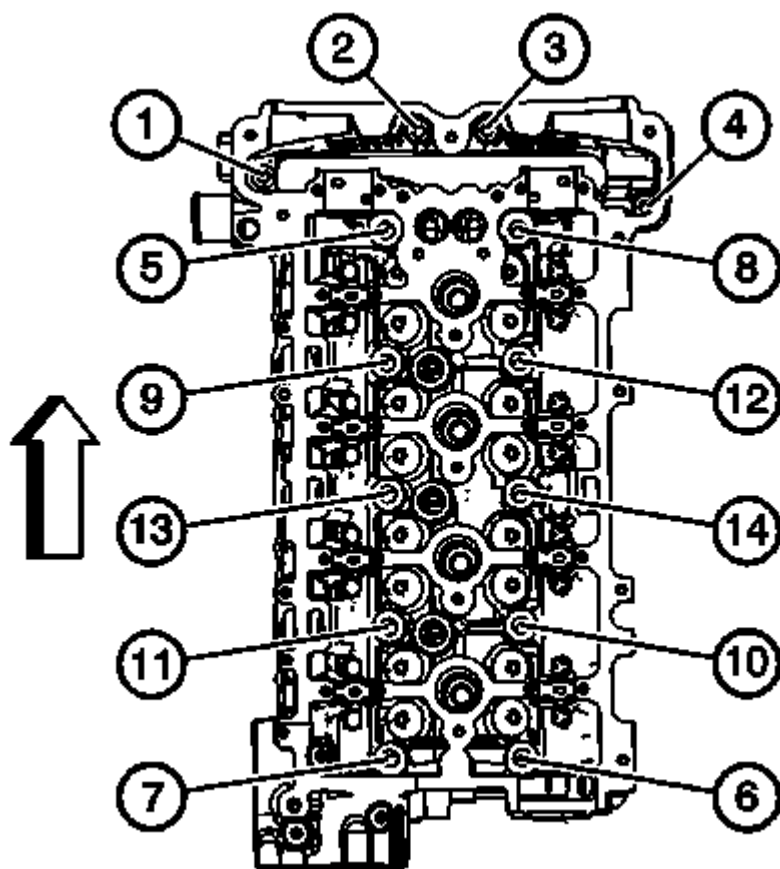


Fig. 379: Cylinder Head-To-Block Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

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

Discard the bolts.

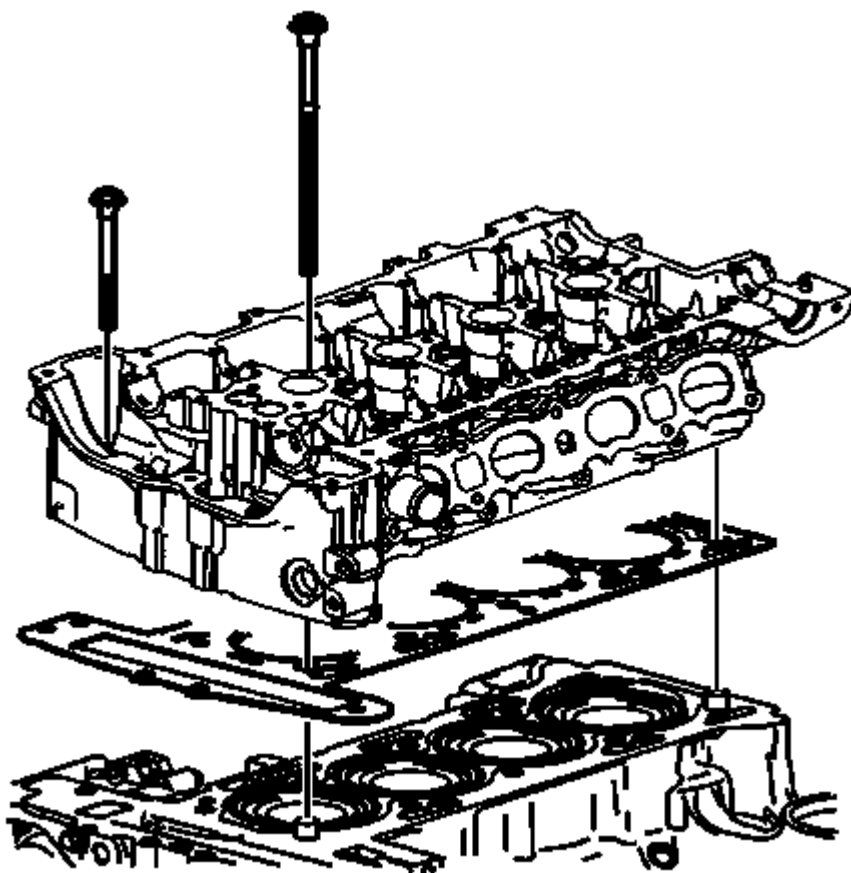


Fig. 380: View Of Cylinder Head, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

IMPORTANT: 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.

IMPORTANT: 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.

IMPORTANT: 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.

CAUTION: 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 **J 38188** . See Special Tools.

OIL PAN REMOVAL

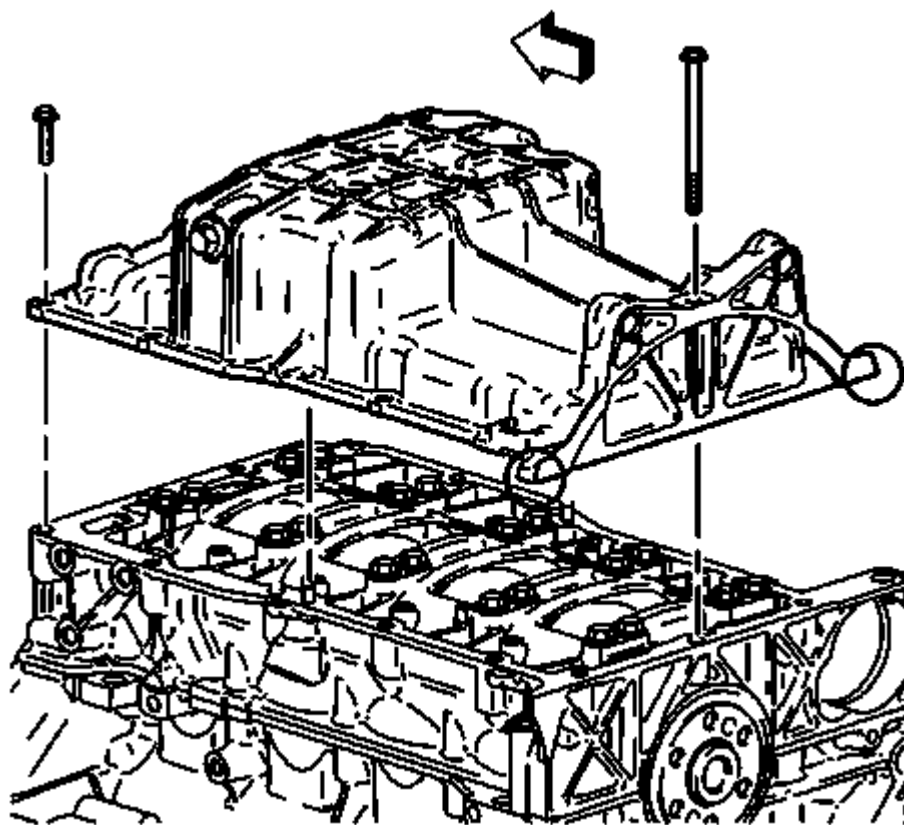


Fig. 381: View Of Oil Pan

Courtesy of GENERAL MOTORS CORP.

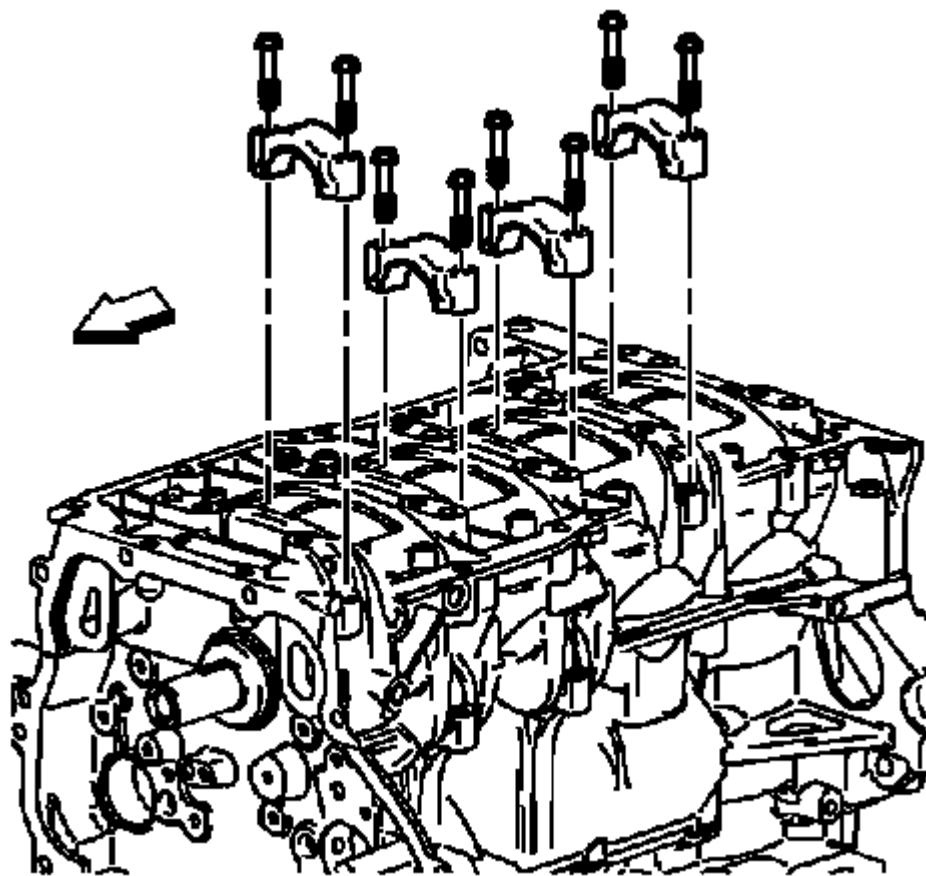
1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

J-43966-1 Connecting Rod Guides. See Special Tools.

Removal Procedure

**Fig. 382: View Of Connecting Rod Nuts And 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.

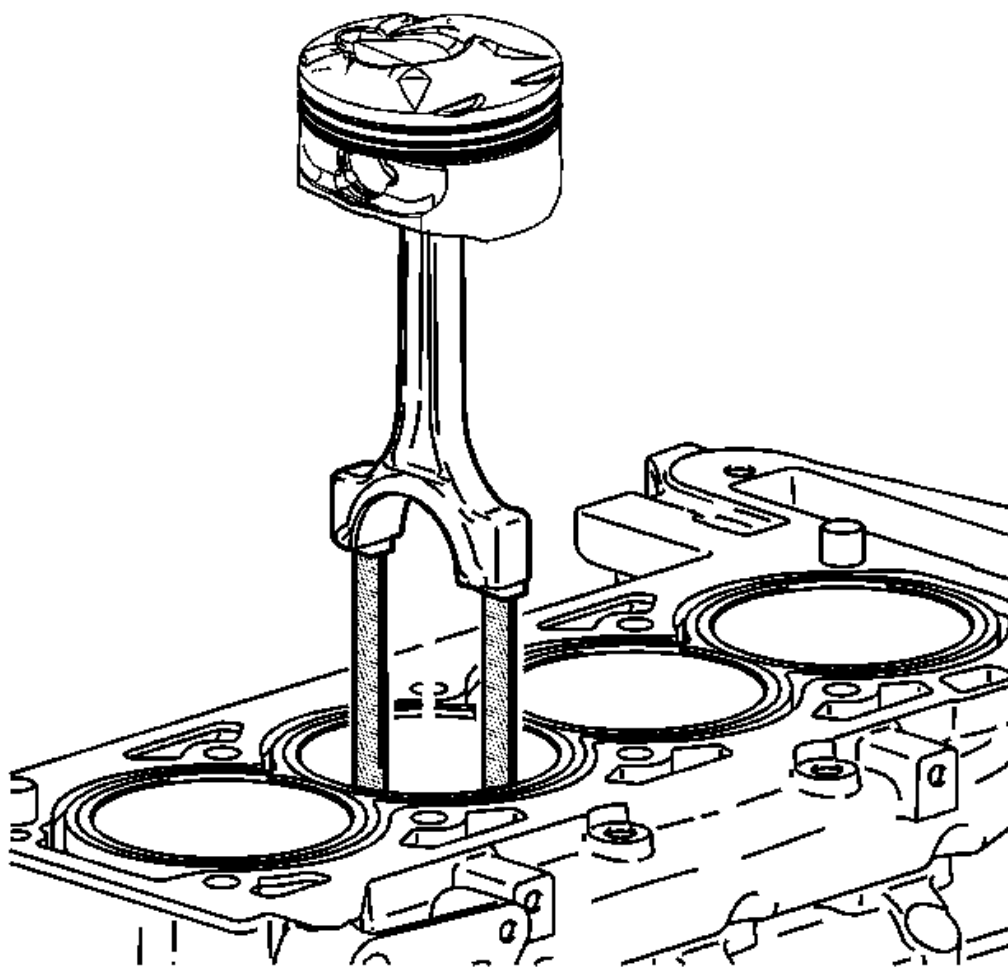


Fig. 383: View Of Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

6. Install **J-43966-1** on the connecting rod bolts before removing the piston and connecting rod assembly. See **Special Tools**.
7. Remove the piston and connecting rod assembly.

LOWER CRANKCASE REMOVAL

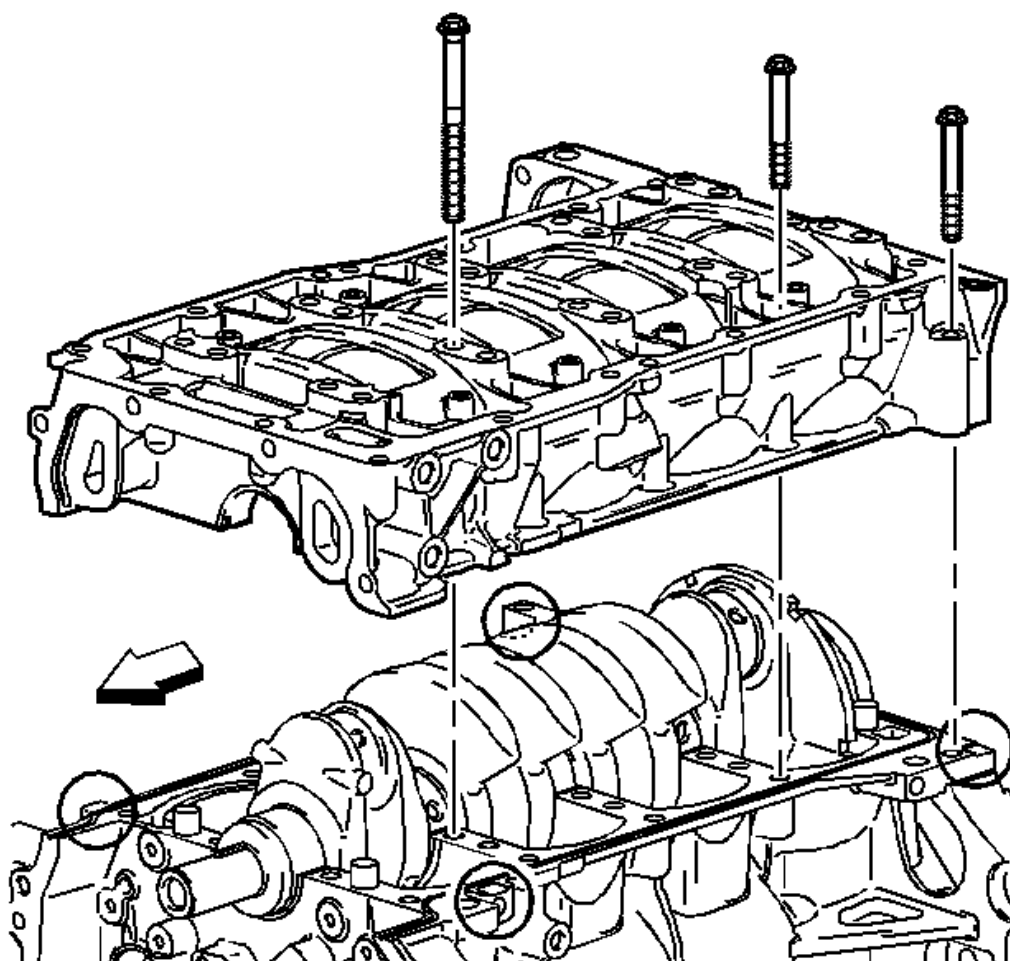


Fig. 384: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

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

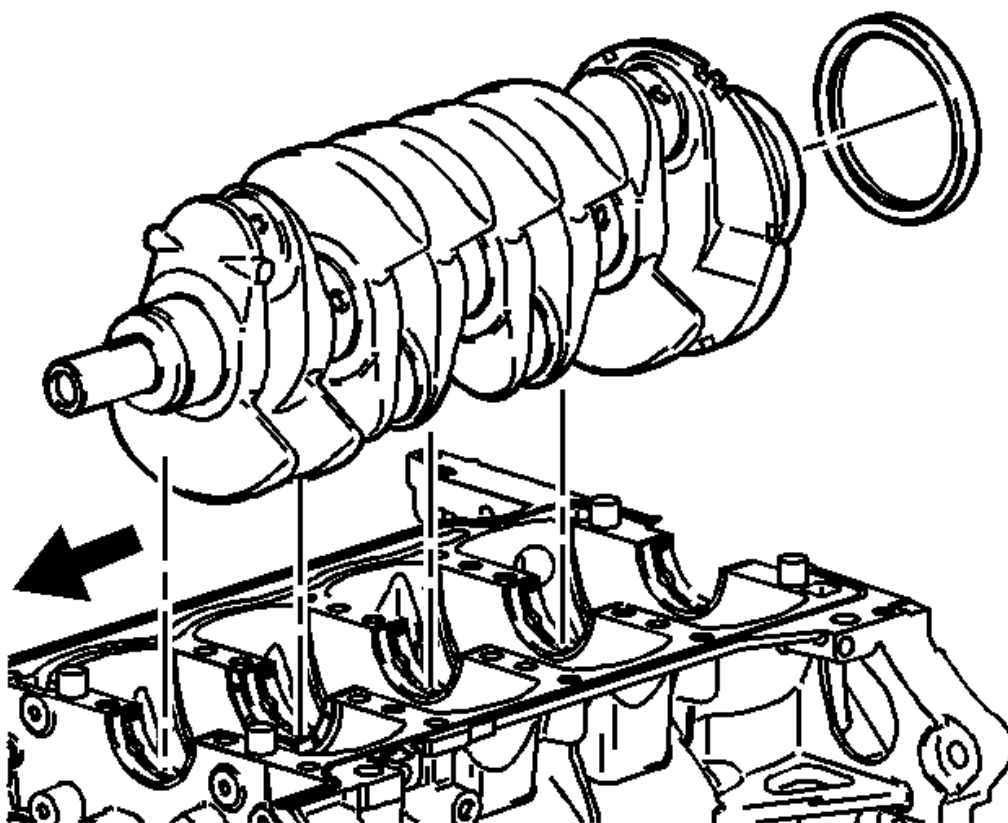


Fig. 385: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

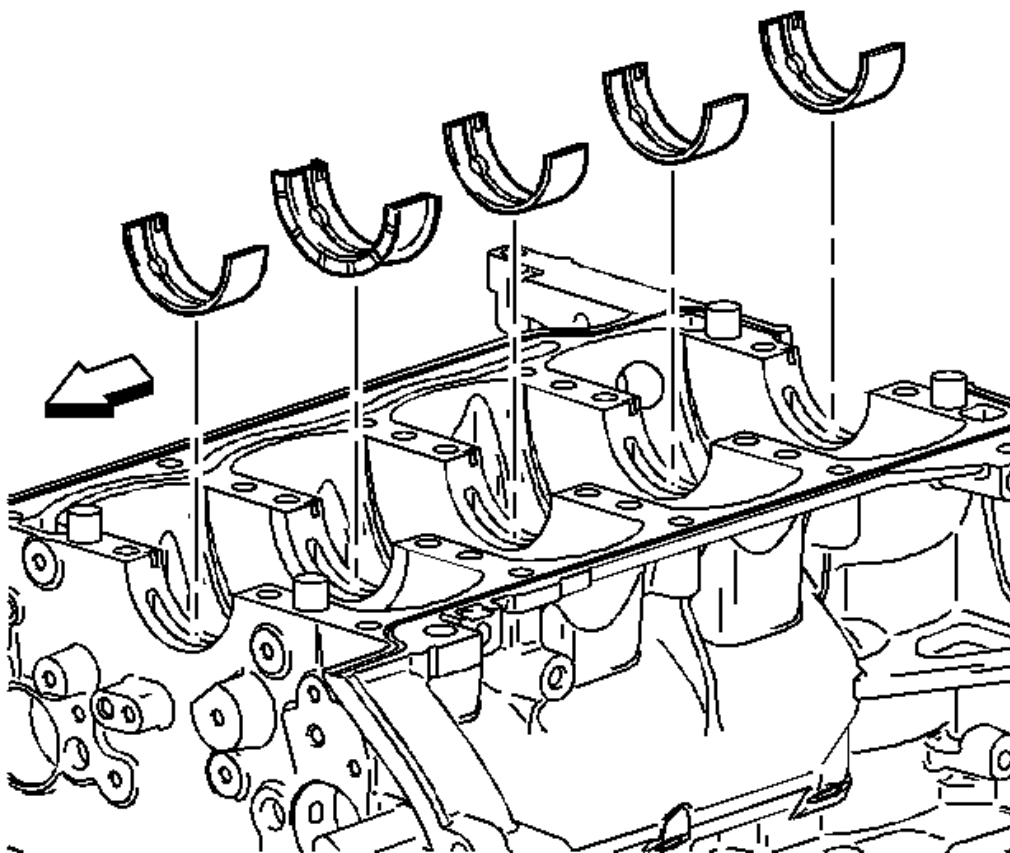


Fig. 386: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

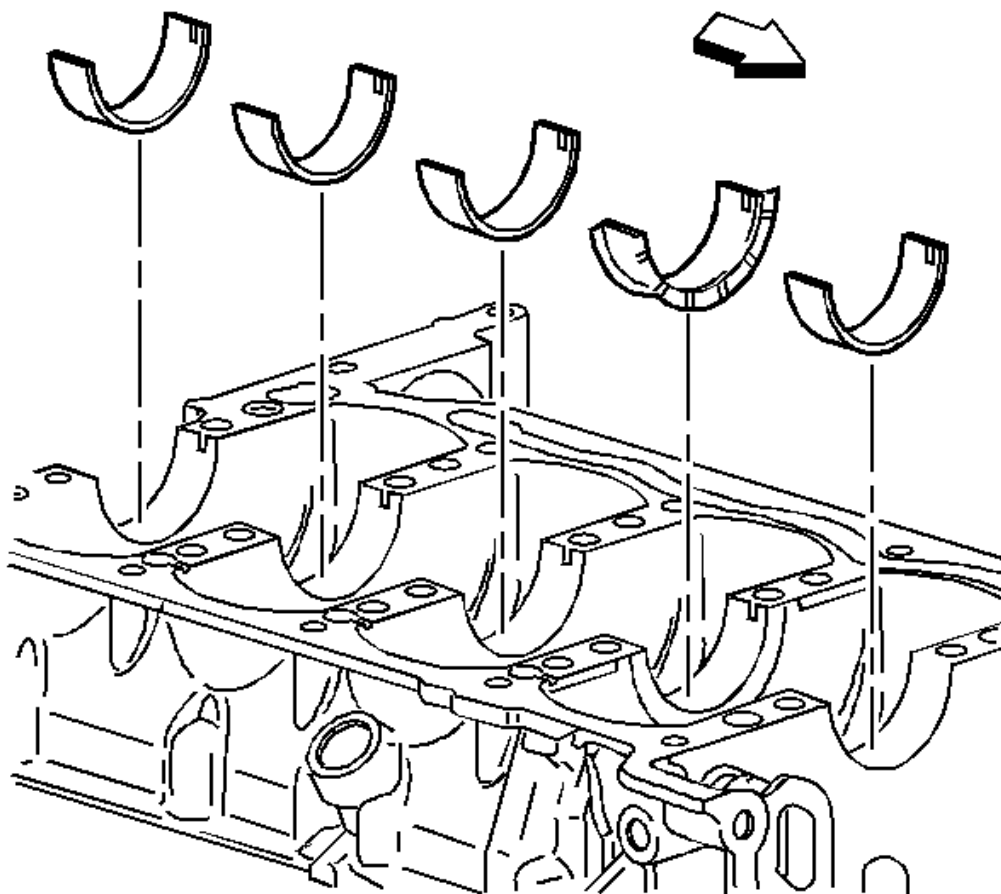


Fig. 387: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

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

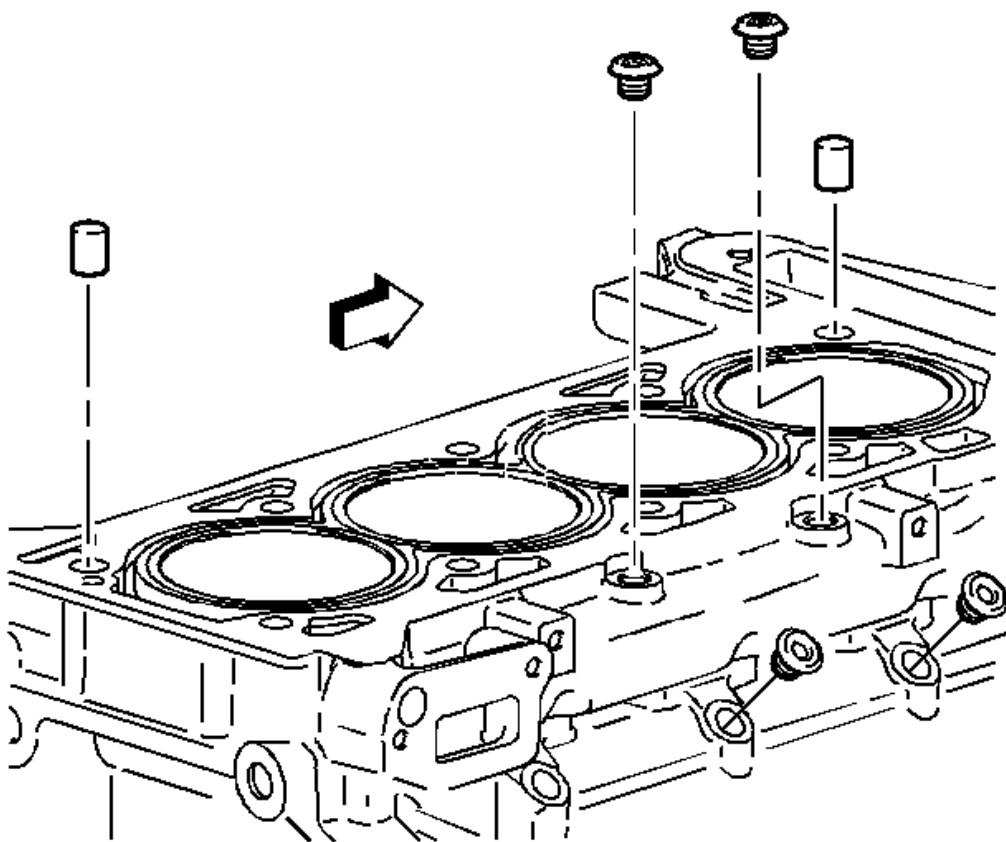


Fig. 388: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the water jacket drain plug.
2. Remove the oil flow check valve.
3. Remove the rear oil passage plug.
4. Remove the 6 oil passage plugs on the sides of the block.
5. Remove the 2 water passage plugs on the top of the block.
6. Remove the 2 front oil passage plugs.

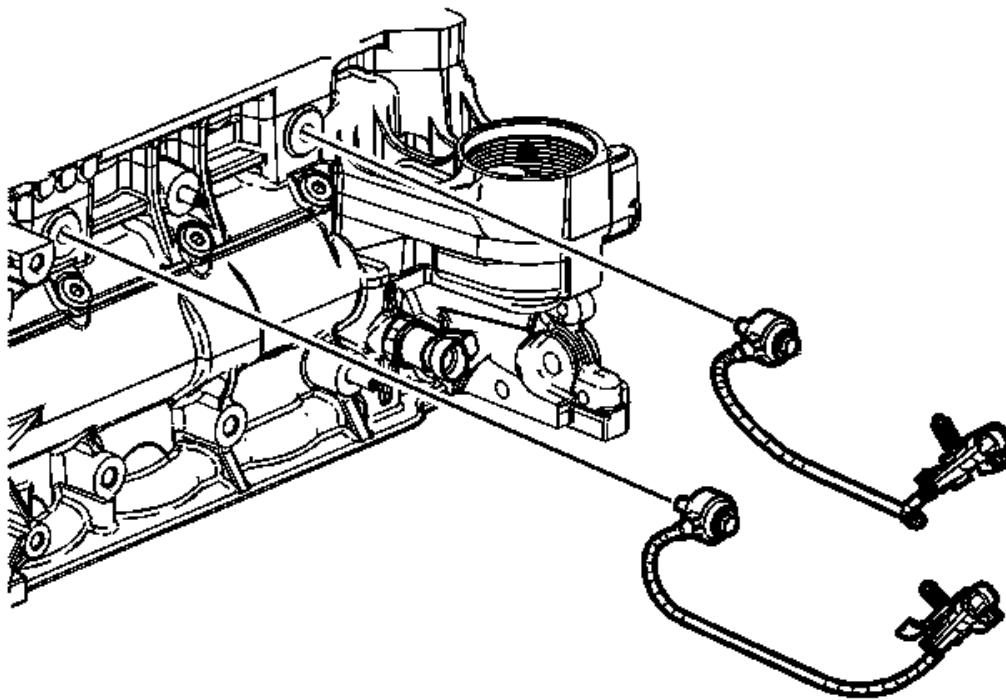


Fig. 389: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

7. Remove the knock sensors.

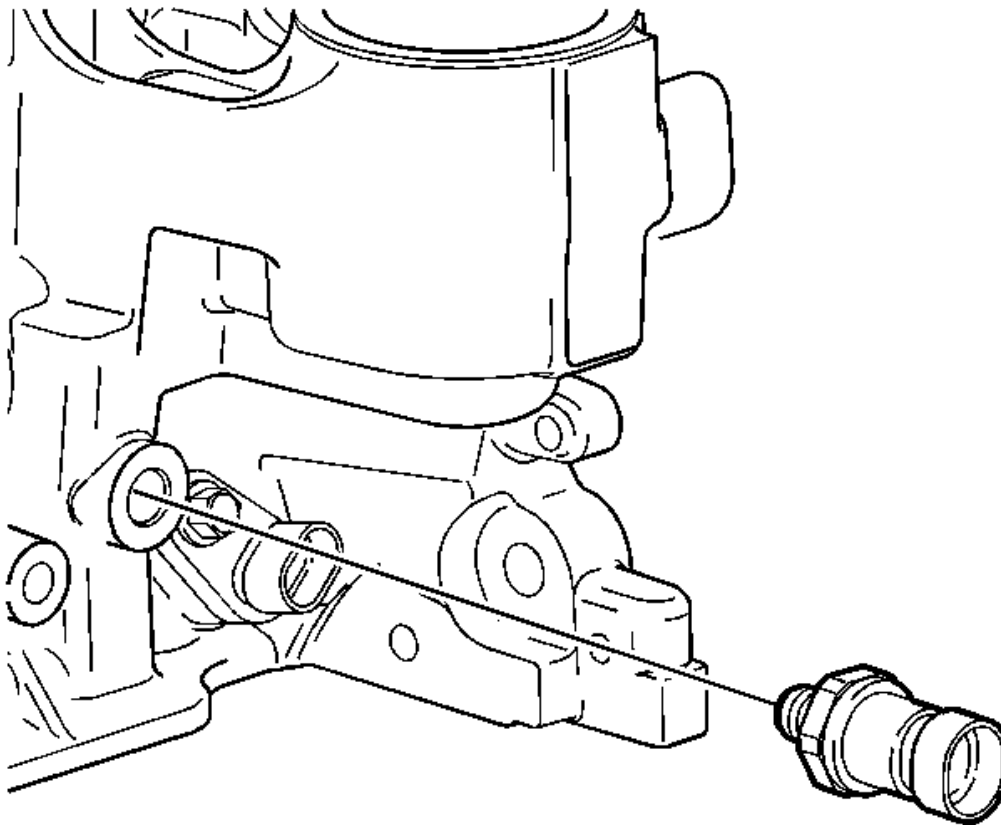


Fig. 390: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pressure switch.

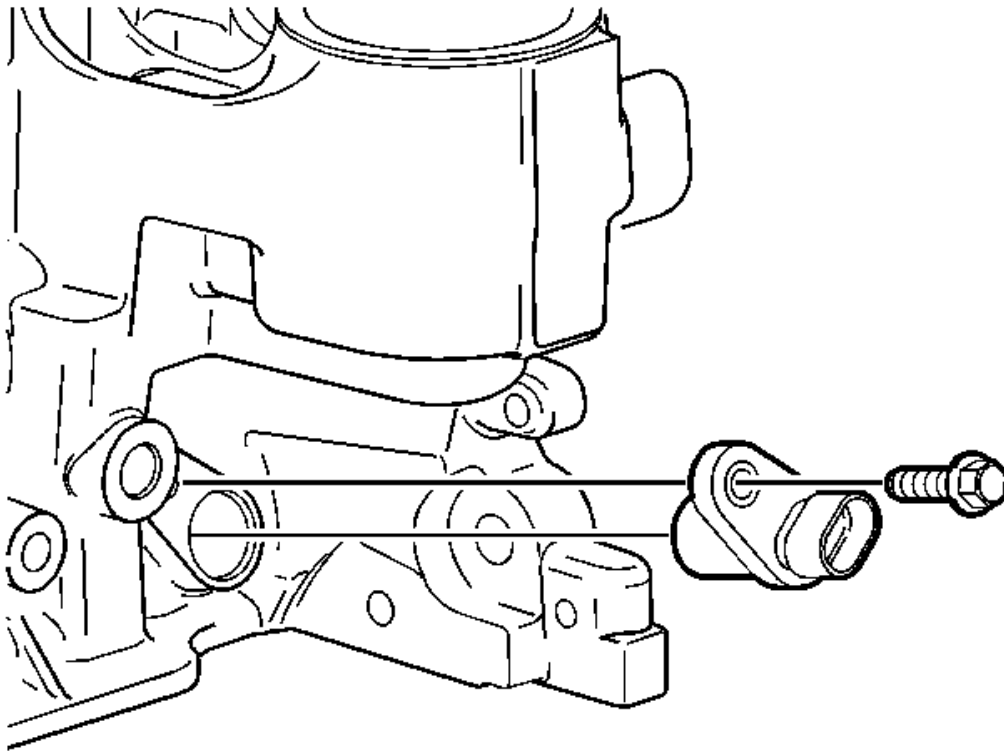


Fig. 391: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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

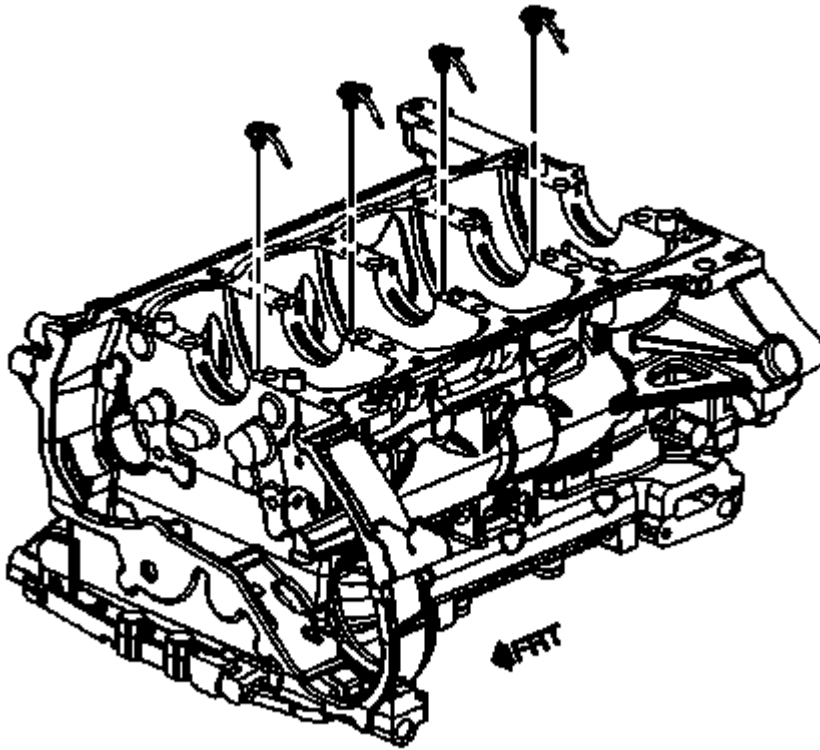


Fig. 392: Identifying Piston Oil Squirters
Courtesy of GENERAL MOTORS CORP.

10. Loosen the piston oil nozzle assembly captured bolts and remove the piston oil nozzle assemblies.

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

- **J 7872** Magnetic Base Dial Indicator. See **Special Tools**.
- **J 8087** Cylinder Bore Gage. See **Special Tools**.

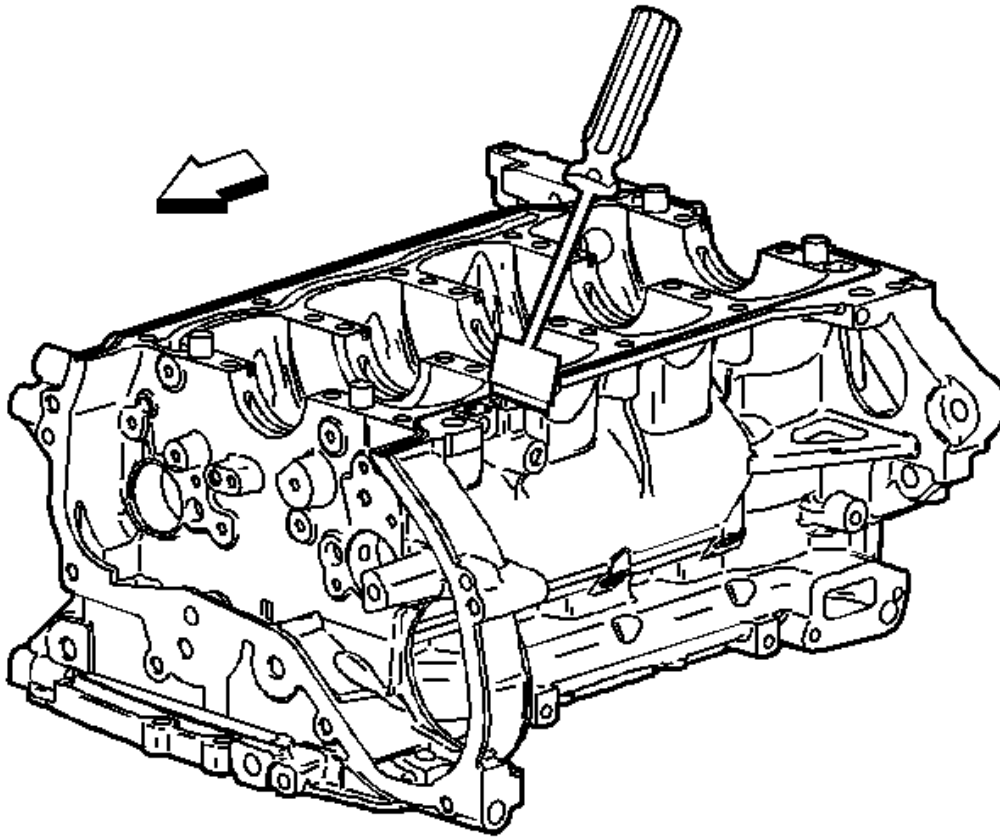


Fig. 393: Cleaning Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
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. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes.
8. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair**.

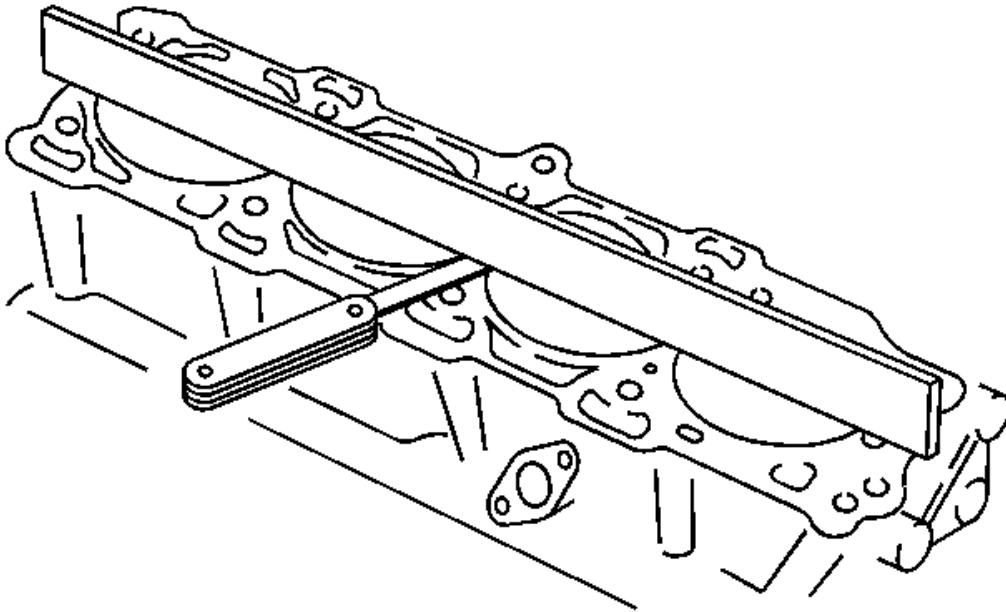


Fig. 394: Checking Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to machine the lower crankcase to engine block surfaces.

9. Use a straight edge and a feeler gage to inspect the deck surface for flatness. Carefully machine minor irregularities. Replace the block if greater 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.

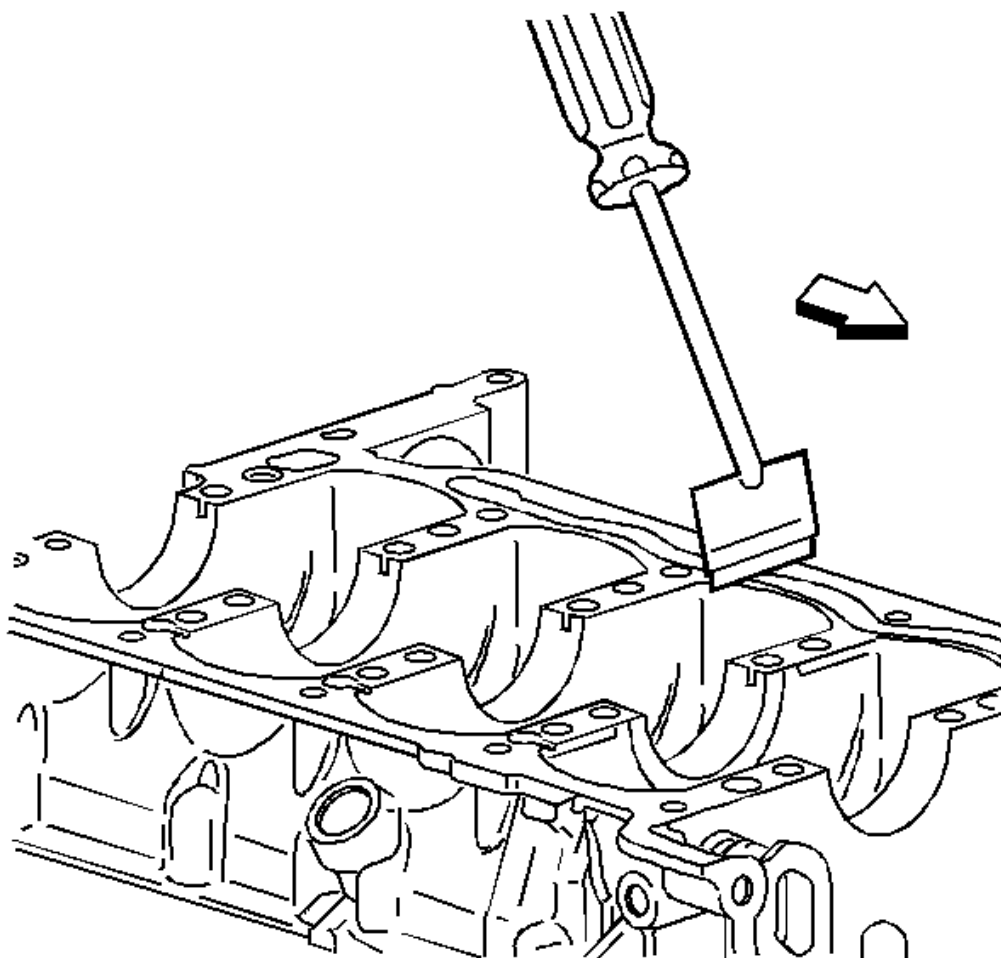


Fig. 395: Cleaning Sealing Material From Gasket Mating Surfaces - Engine Block Side
Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side.

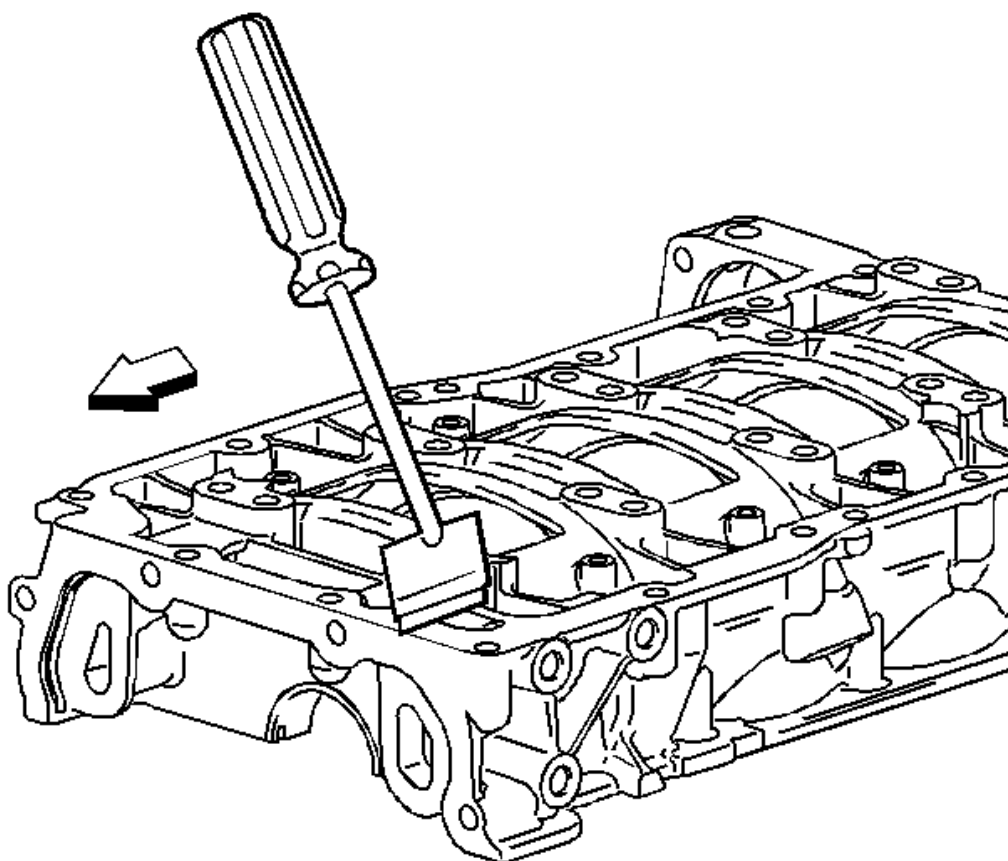


Fig. 396: Cleaning Sealing Material From Gasket Mating Surfaces - Oil Pan Side
Courtesy of GENERAL MOTORS CORP.

12. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side.

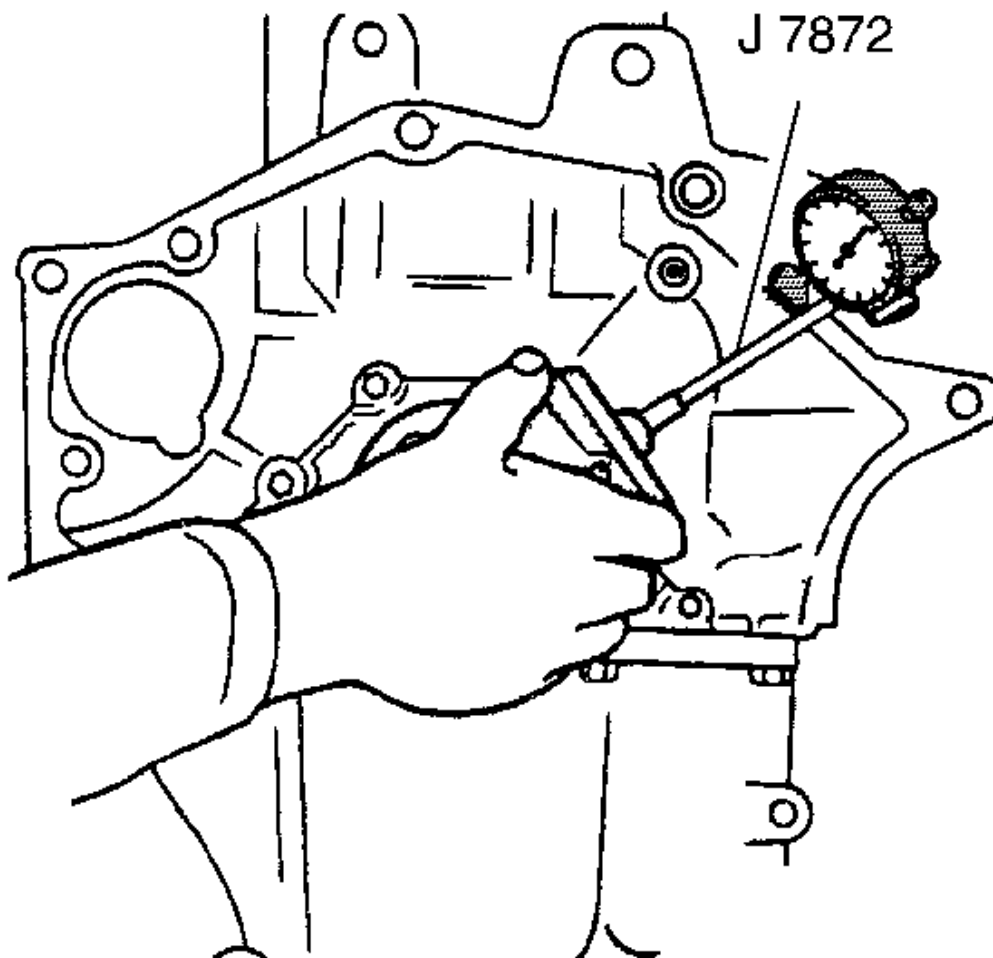


Fig. 397: Measuring Engine Block Flange Runout
Courtesy of GENERAL MOTORS CORP.

13. Inspect the mating surfaces of the transmission face.

NOTE: 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 **J 7872** . See **Special Tools**.
 2. Hold the gage 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. Check the crankshaft flange runout again if the readings vary greater than 0.203 mm (0.008 in).
6. Remove the crankshaft and bearings.

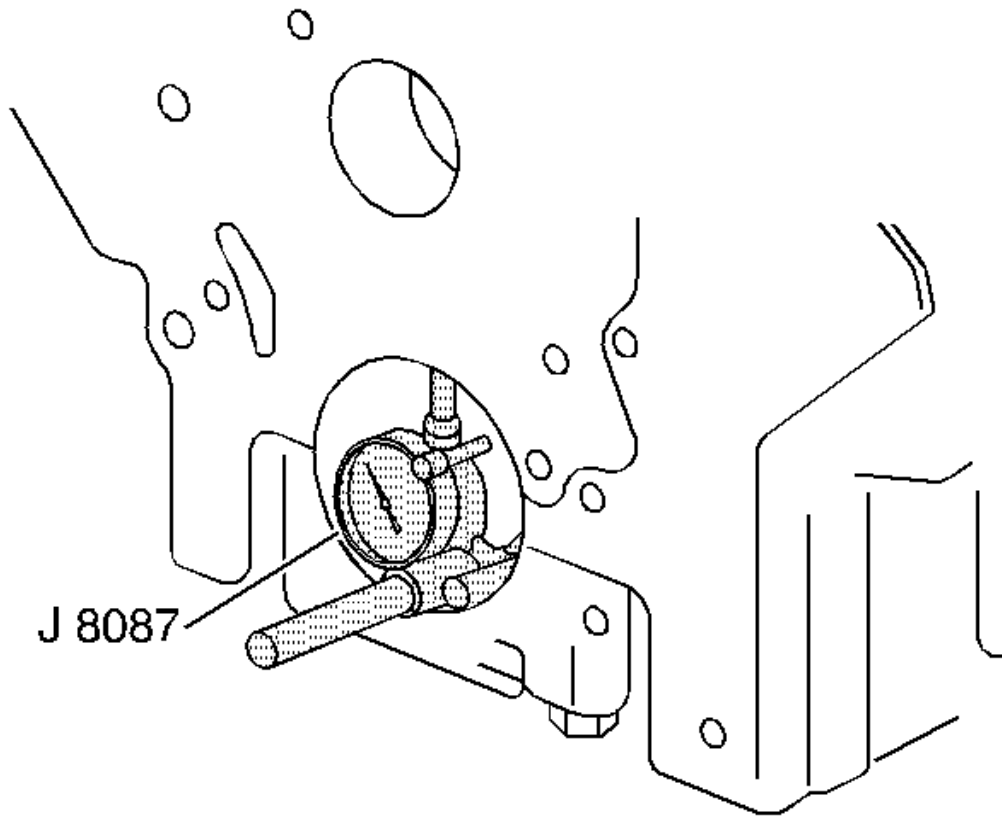


Fig. 398: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

15. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
16. Inspect the crankshaft main bearing bores. Use the **J 8087** to measure the bearing bore concentricity and alignment. See **Special Tools**. 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.

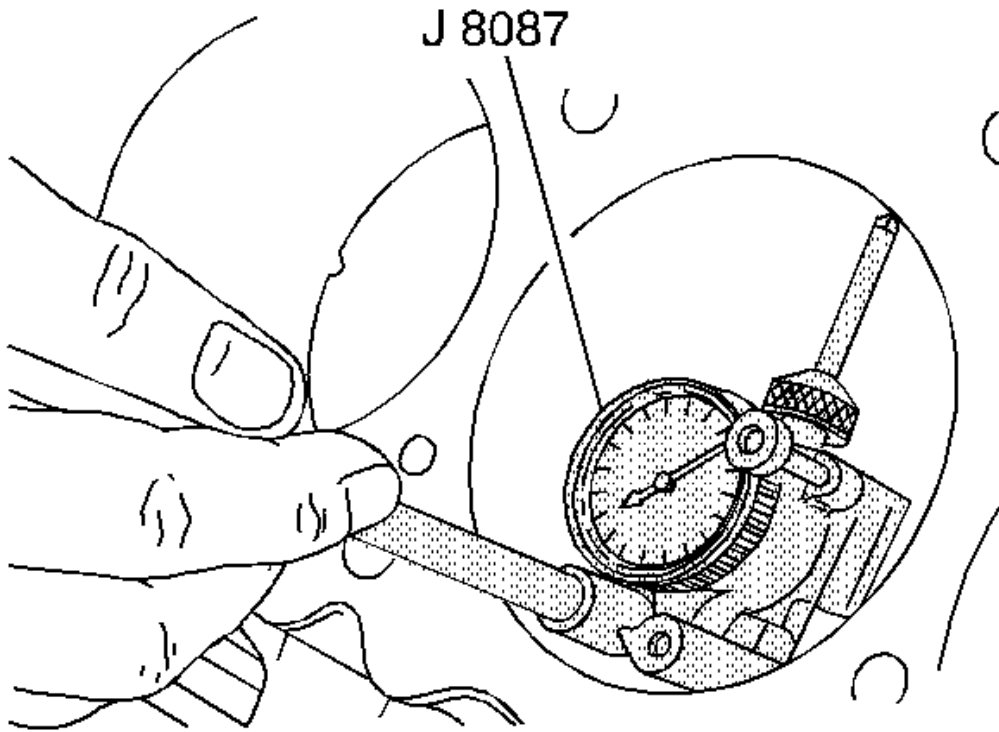


Fig. 399: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

19. Using the **J 8087** , inspect the cylinder bores for the following conditions:
 - Wear
 - Taper
 - Runout
 - Ridging
20. If the cylinder bores are out of specification, install a NEW cylinder bore sleeve. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.

CYLINDER HONING

Tools Required

J 8087 Cylinder Bore Gage. See **Special Tools**.

Honing Procedure

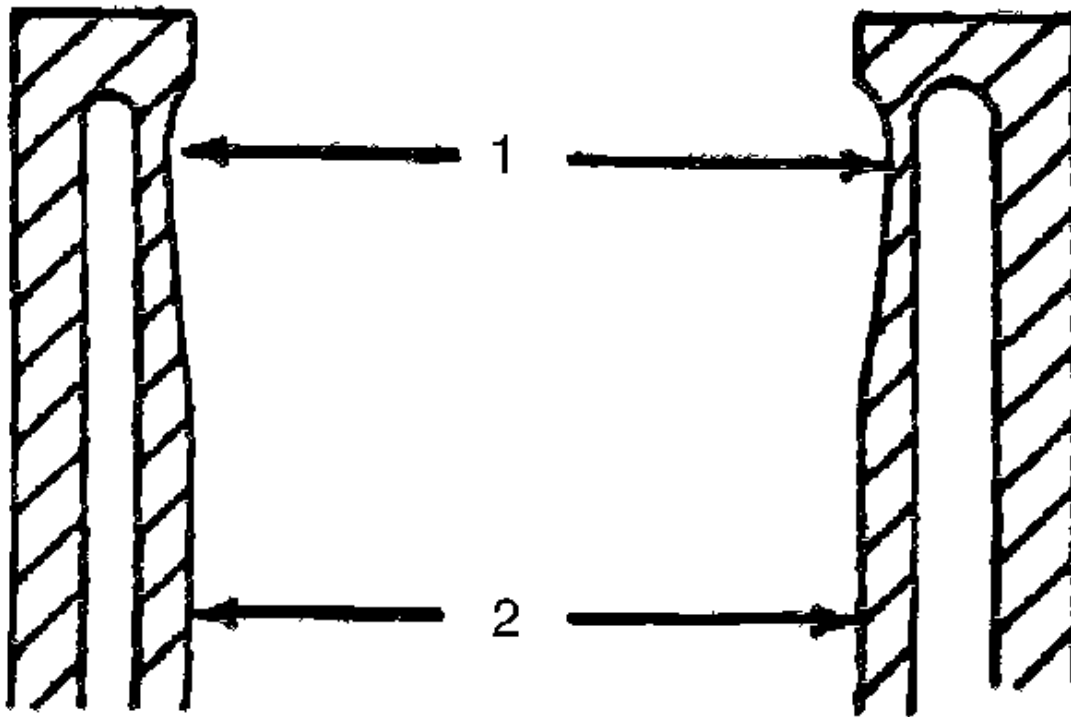


Fig. 400: Measuring Head Gasket Dimensions
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore for out-of-round and taper.
2. Measure the dimension (1) at 13 mm (0.5 in) below the head gasket surface. Measure the dimension (2) at 100 mm (4 in) below the head gasket surface.

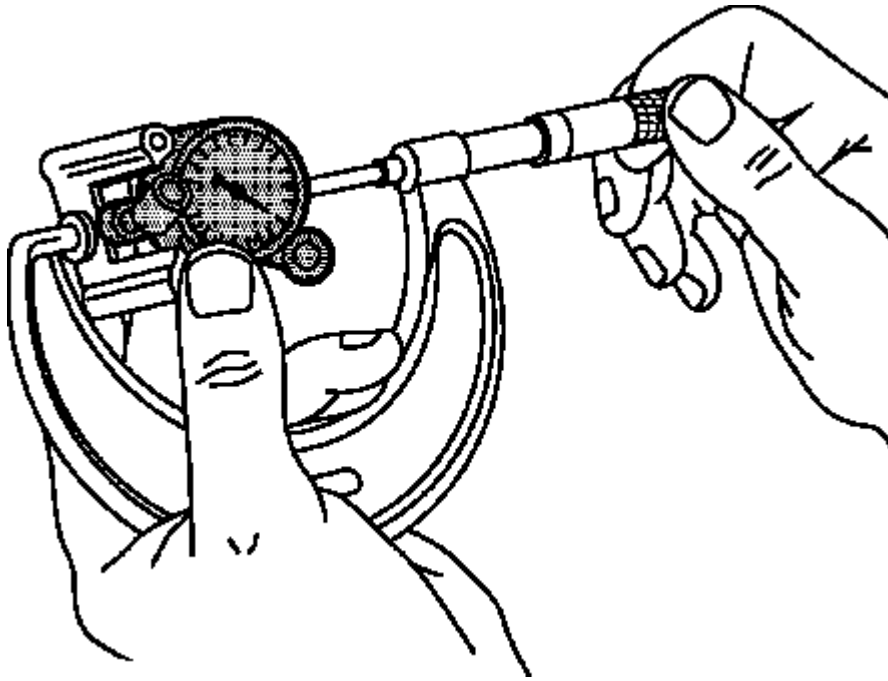


Fig. 401: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder bores by setting the **J 8087** dial at zero in the cylinder at the point of the desired measurement. See **Special Tools**. Lock the dial indicator at zero before removing the dial from the cylinder. Measure across the gage contact points with an outside micrometer, with the gage at the same zero setting as when the gage was removed from the cylinder.
4. 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.
5. 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**.
 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. Measure the bore again.
6. If the cylinder bore is out of specification, install a new cylinder bore sleeve. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.
7. 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.

CYLINDER SLEEVE REMOVAL

Tools Required

EN 45680-850 Cylinder Liner Removal and Installation Kit. See Special Tools.

Removal Procedure

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

NOTE: Do not damage the crankshaft connecting rod journals or reluctor ring or engine damage will occur.

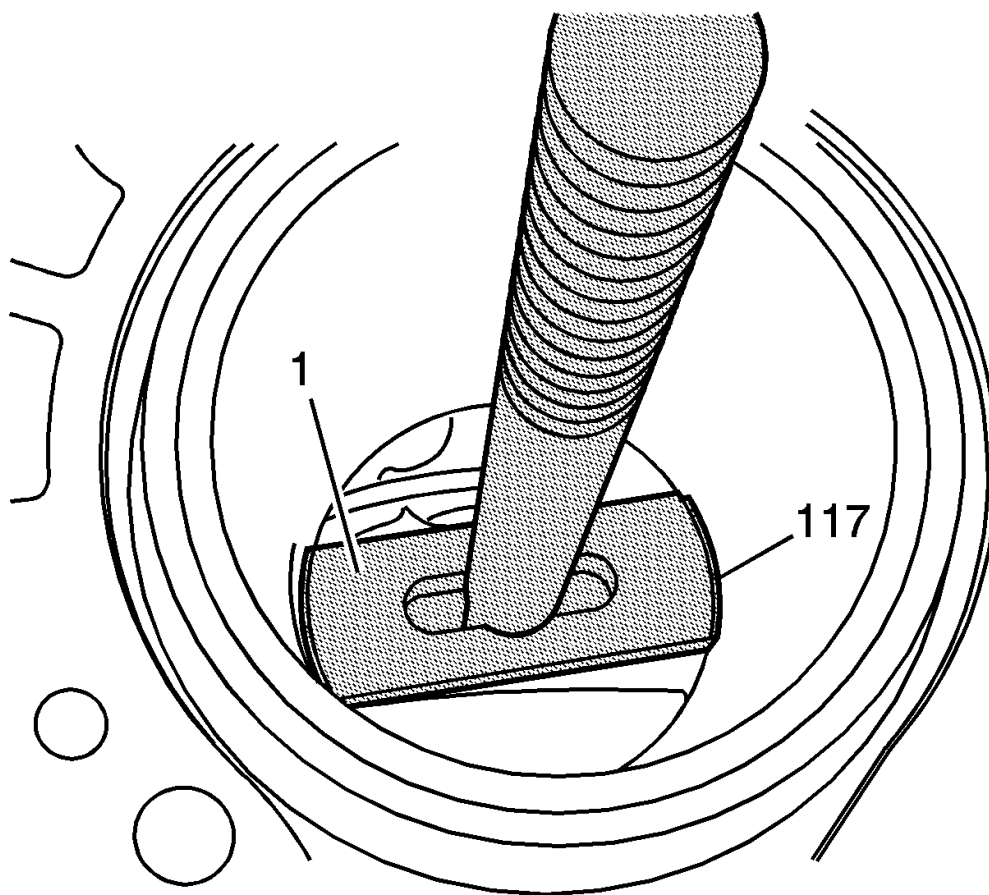


Fig. 402: View Of Cylinder Bore Liner Puller
Courtesy of GENERAL MOTORS CORP.

1. If the crankshaft is still installed, rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
2. Install the cylinder bore sleeve puller (1) through the cylinder bore.

NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore sleeve or damage to the cylinder bore sleeve puller will occur.

3. Align the shoe (1) of the cylinder bore sleeve puller to the bottom of the cylinder bore sleeve (117).

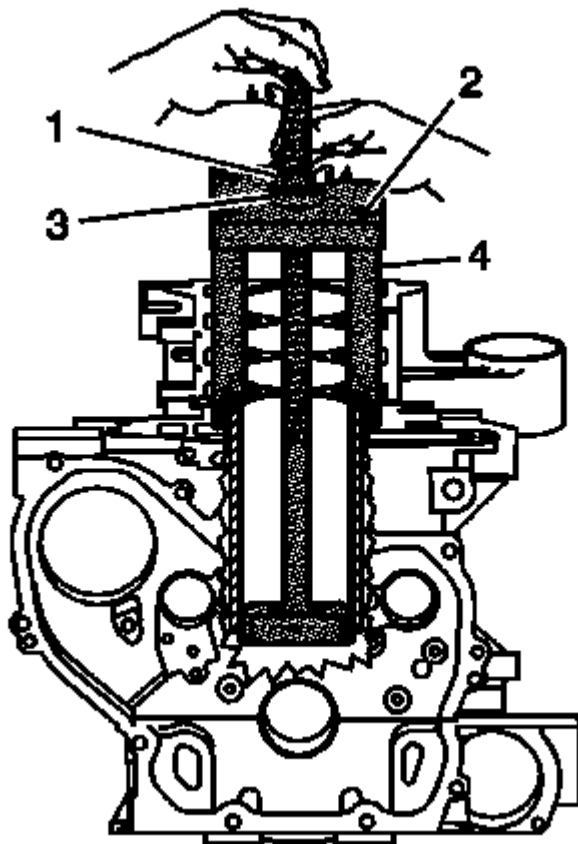


Fig. 403: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

4. Hold the threaded shaft of the cylinder bore sleeve puller upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.
5. Install the fixture (4) onto the threaded shaft of the cylinder bore sleeve puller and the engine block.
6. Install the bearing (3) and the nut (1).
7. Tighten the nut (1) to the bearing (3).

NOTE: Refer to Fastener Notice .

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

8. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block.

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

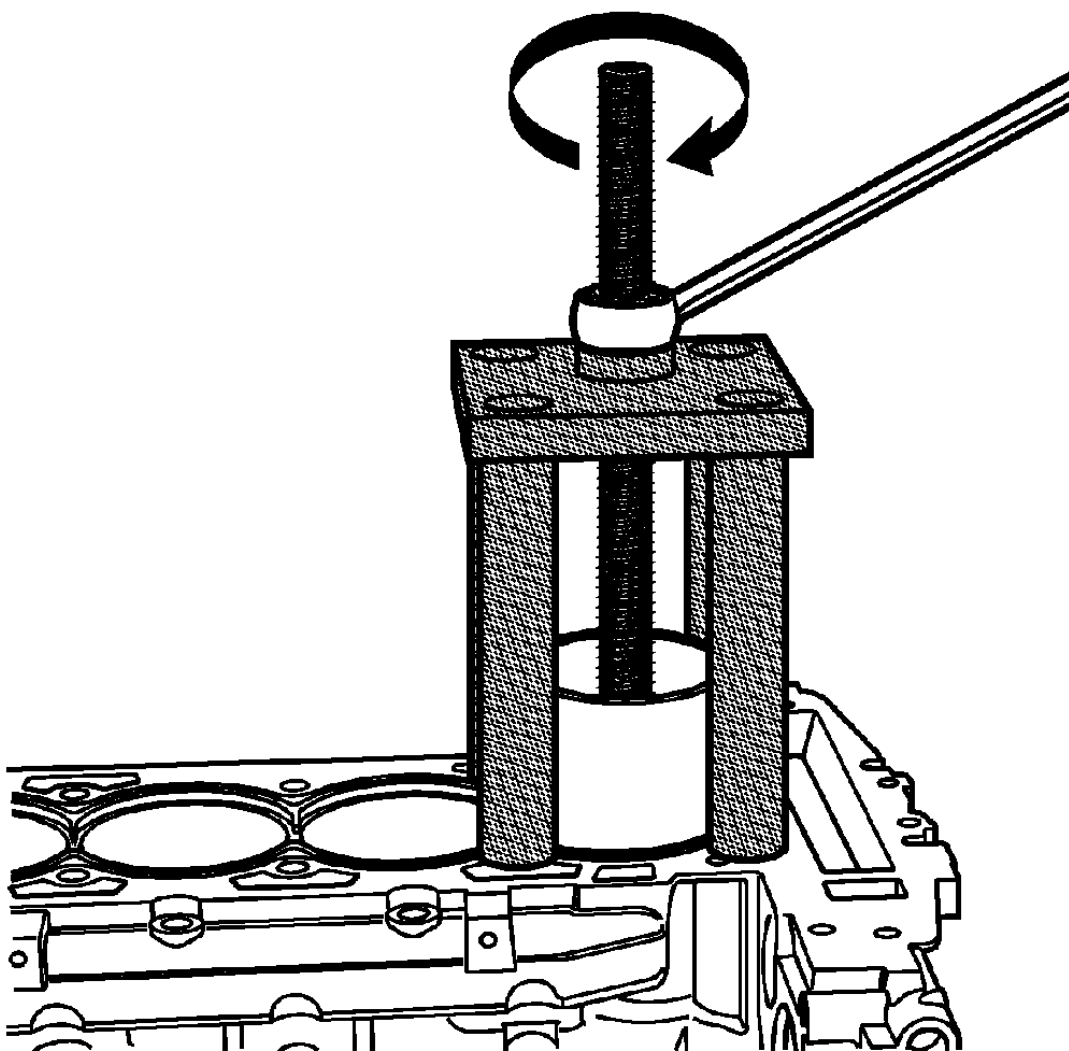


Fig. 404: Removing Cylinder Bore Sleeve By Rotating Nut
Courtesy of GENERAL MOTORS CORP.

9. Rotate the nut clockwise in order to remove the cylinder bore sleeve.

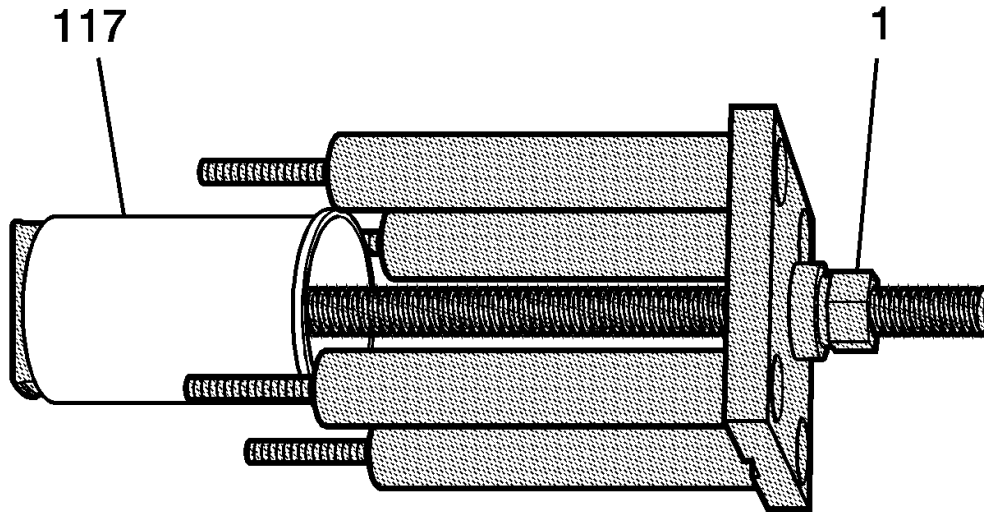


Fig. 405: Removing Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the cylinder block surface. Damage to the cylinder block surface can cause engine failure.

10. Remove the fixture, cylinder bore sleeve puller, and the cylinder bore sleeve (117) from the engine block.
11. Loosen the nut (1) to remove the cylinder bore sleeve (117).
12. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.
13. Inspect the piston, piston rings, and connecting rod for damage. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection.**

CYLINDER SLEEVE INSTALLATION

Special Tools

EN 45680-850 Cylinder Sleeve Removal and Installation Kit. See **Special Tools.**

Installation Procedure

NOTE: Do not use assembly aids or lubricants on the cylinder bore sleeve or the cylinder bore block when installing a new cylinder bore sleeve, or engine damage will occur. These items will not aid in the installation of the new cylinder bore sleeve.

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

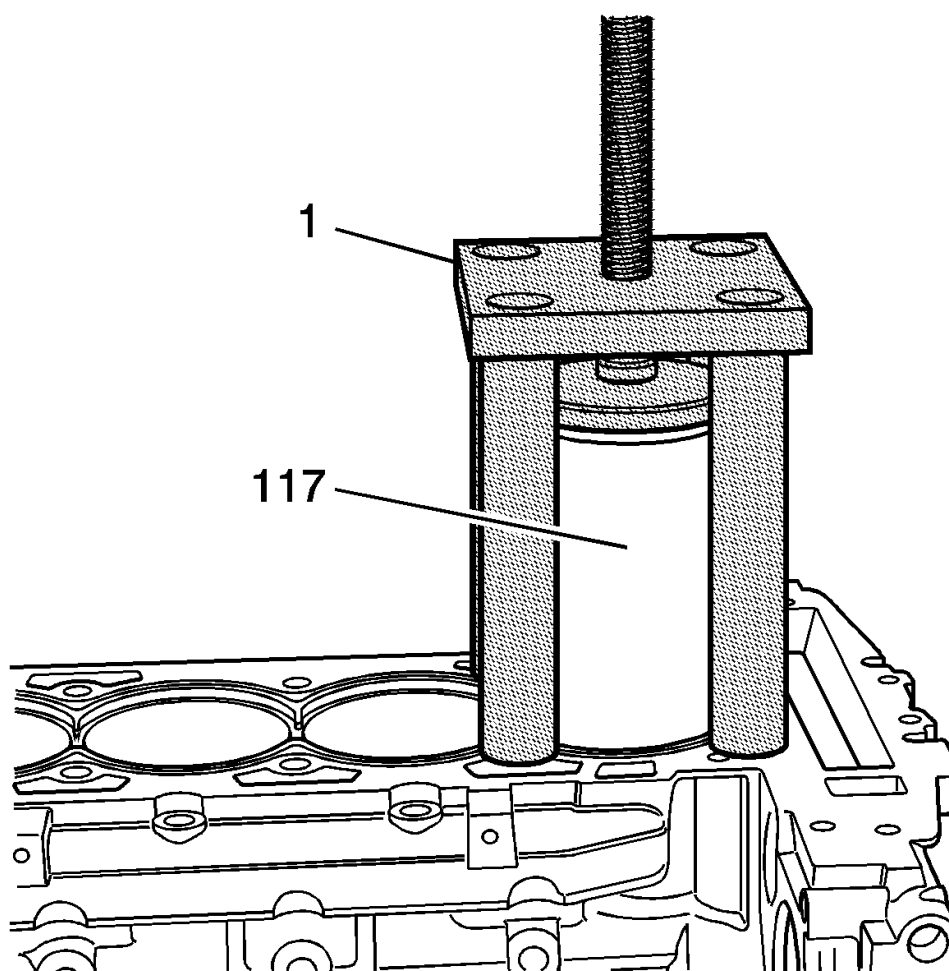


Fig. 406: View Of Cylinder Bore Sleeve Fixture
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install the fixture EN-45680-851 and the cylinder bore sleeve installer EN-45680-853 (1) from **EN 45680-850** over the cylinder bore sleeve (117) and onto the cylinder block. See **Special Tools**. Do not

apply downward pressure to the cylinder bore sleeve (117).

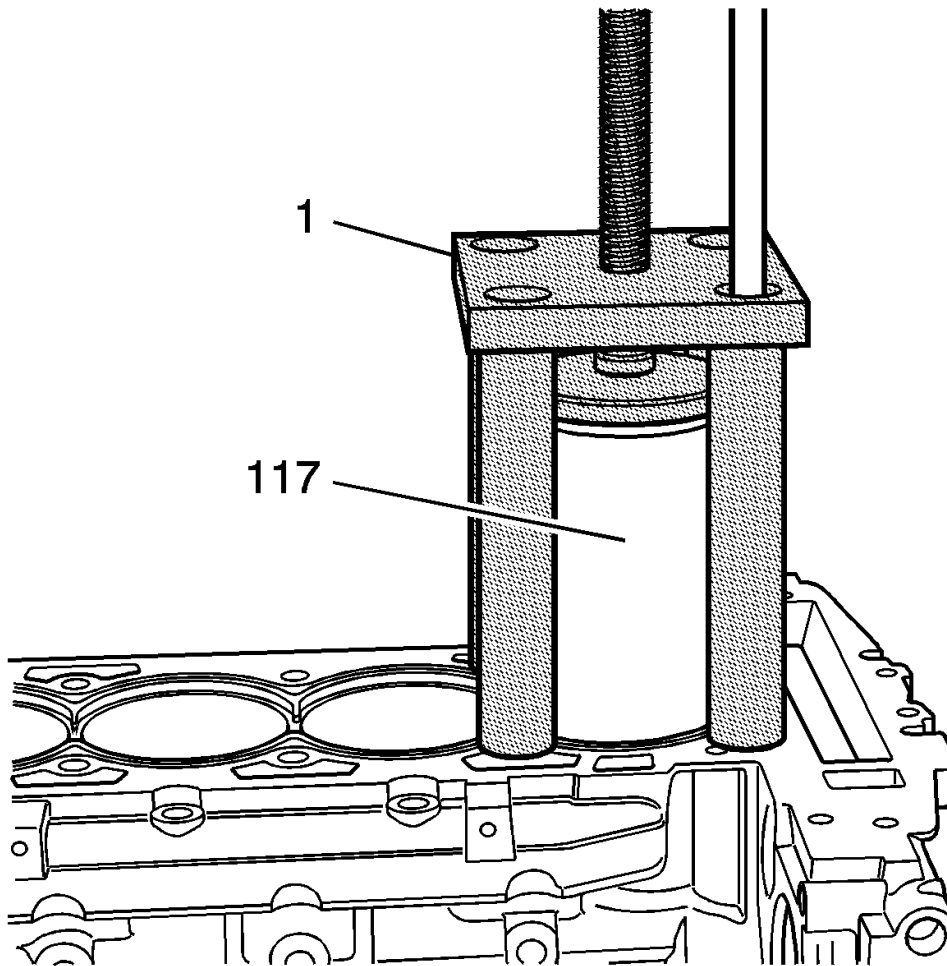


Fig. 407: Installing Cylinder Bore Sleeve Puller Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

3. Insert the 4 attachment bolts into the legs of the fixture EN-45680-851 (1).

NOTE: Refer to Fastener Notice .

4. Tighten the 4 attachment bolts. Do not apply downward pressure to the cylinder bore sleeve (117).

Tighten: Tighten the 4 attachment bolts to 15 N.m (11 lb ft).

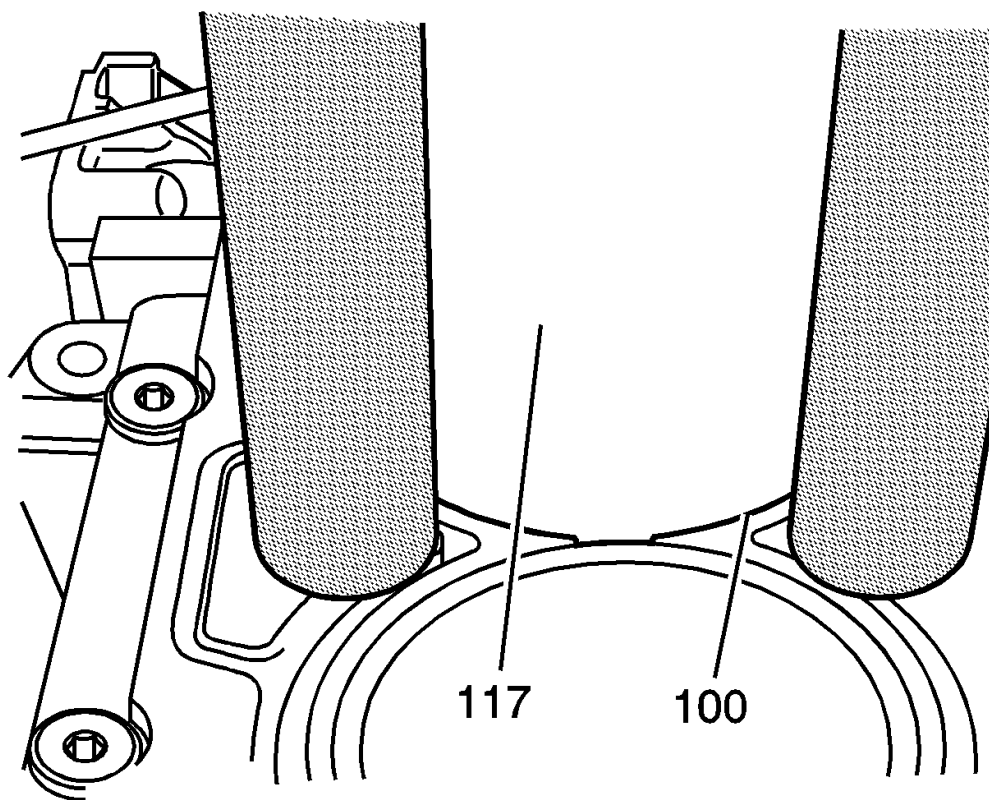


Fig. 408: View Of Proper Liner Alignment
Courtesy of GENERAL MOTORS CORP.

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).

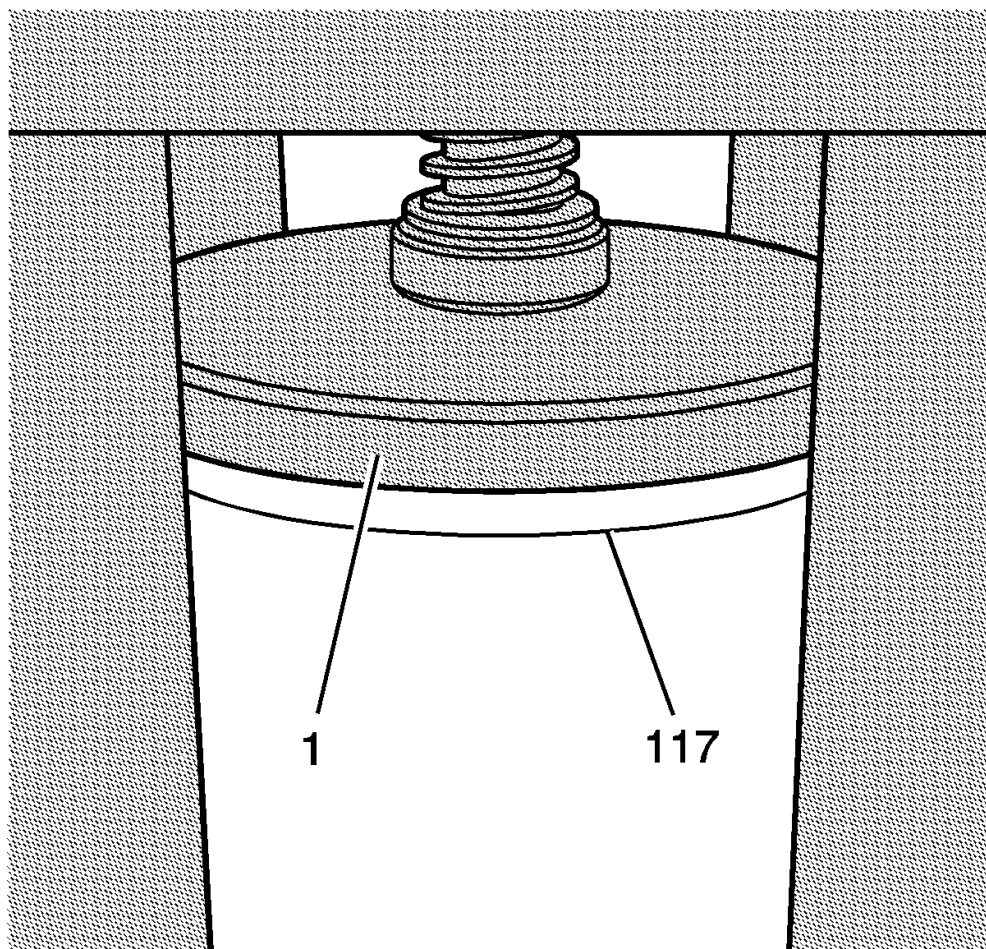


Fig. 409: View Of Installation Arbor
Courtesy of GENERAL MOTORS CORP.

6. Align the installation arbor (1) of the cylinder bore sleeve installer EN-45680-853 onto the top of the cylinder bore sleeve (117).

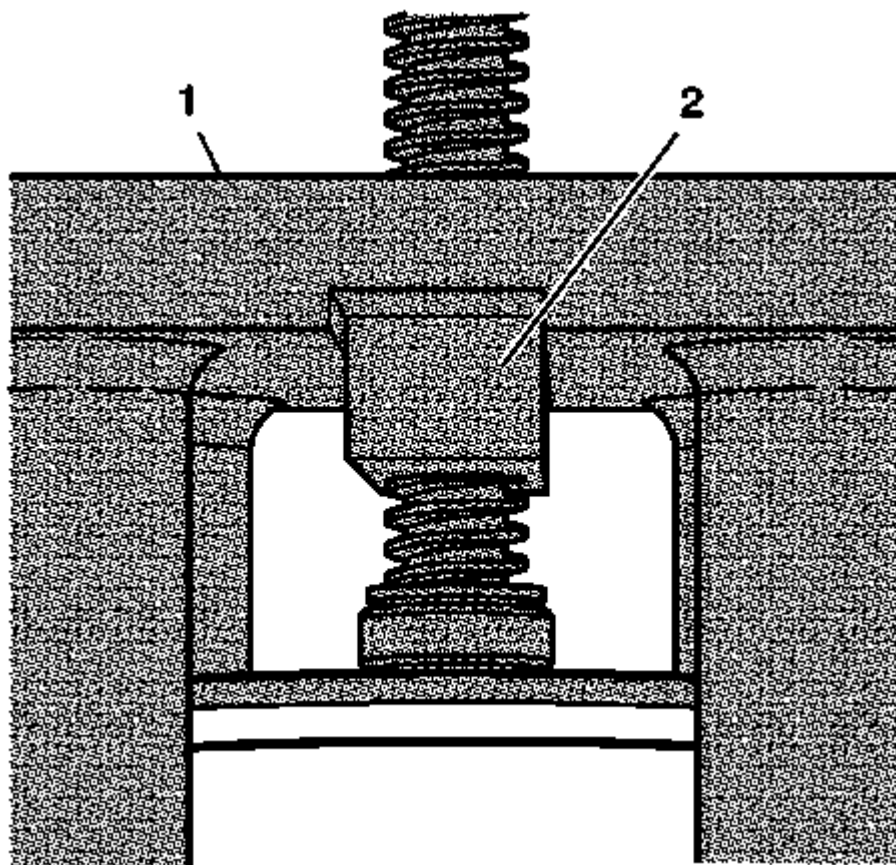


Fig. 410: View Of Pusher Block

Courtesy of GENERAL MOTORS CORP.

7. Align the pusher block (2) of the cylinder bore sleeve installer EN 45680-853 into the groove of fixture EN 45680-851 (1).

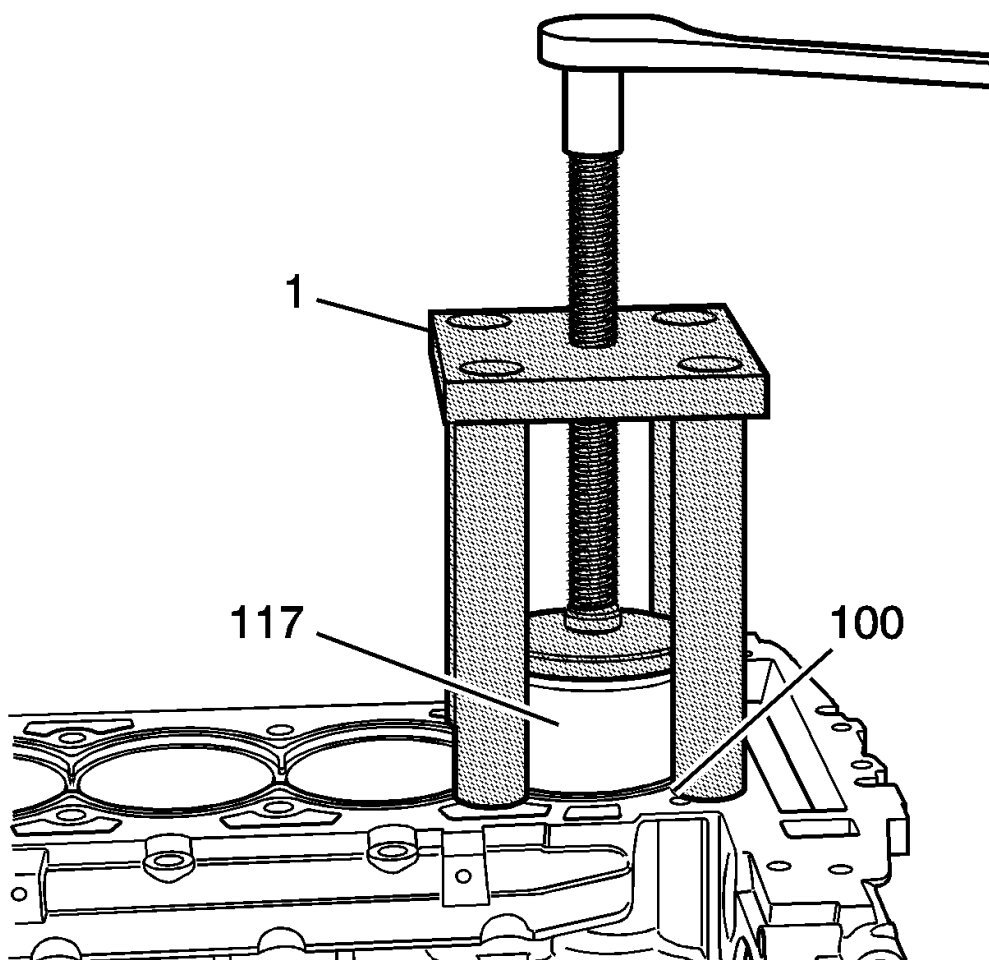


Fig. 411: Installing Cylinder Bore Sleeve Into Engine Block Using Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any air powered or electric tools to rotate the threaded shaft of the cylinder bore sleeve installer in the fixture assembly or damage to the cylinder bore sleeve will occur.

8. Using a ratchet, rotate the threaded shaft of the cylinder bore sleeve installer EN 45680-853 (1) in order to install the cylinder bore sleeve (117) into the engine block (100).
9. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

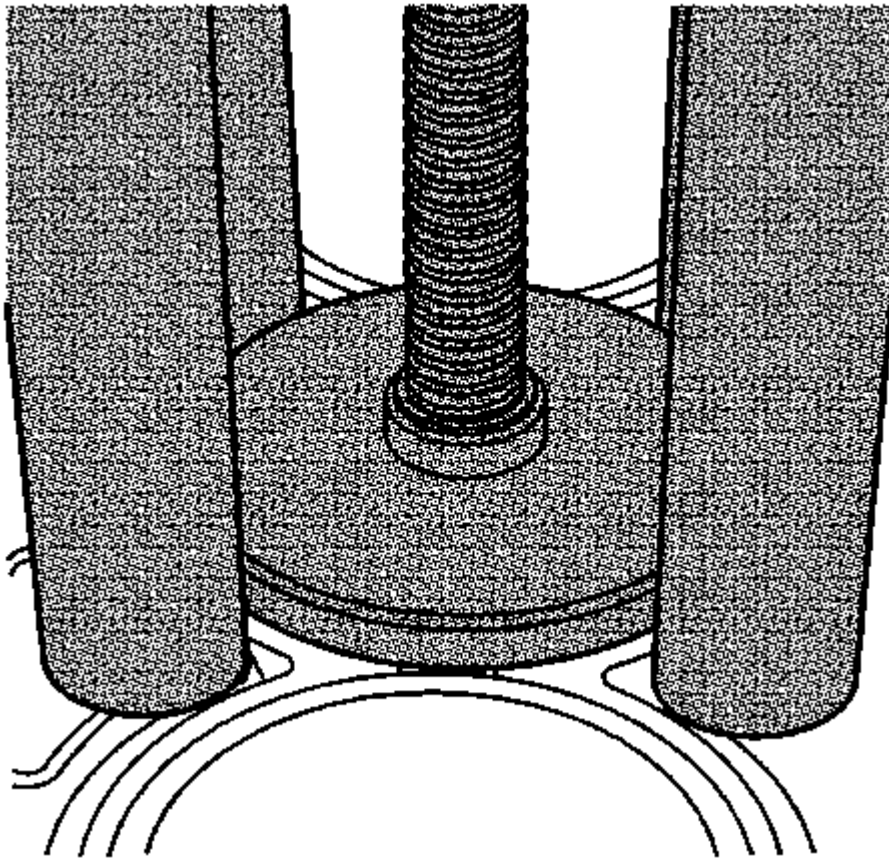


Fig. 412: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

10. Using a torque wrench, torque the threaded shaft to 102 N.m (75 lb ft) to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore sleeve flange will protrude above the block deck surface.

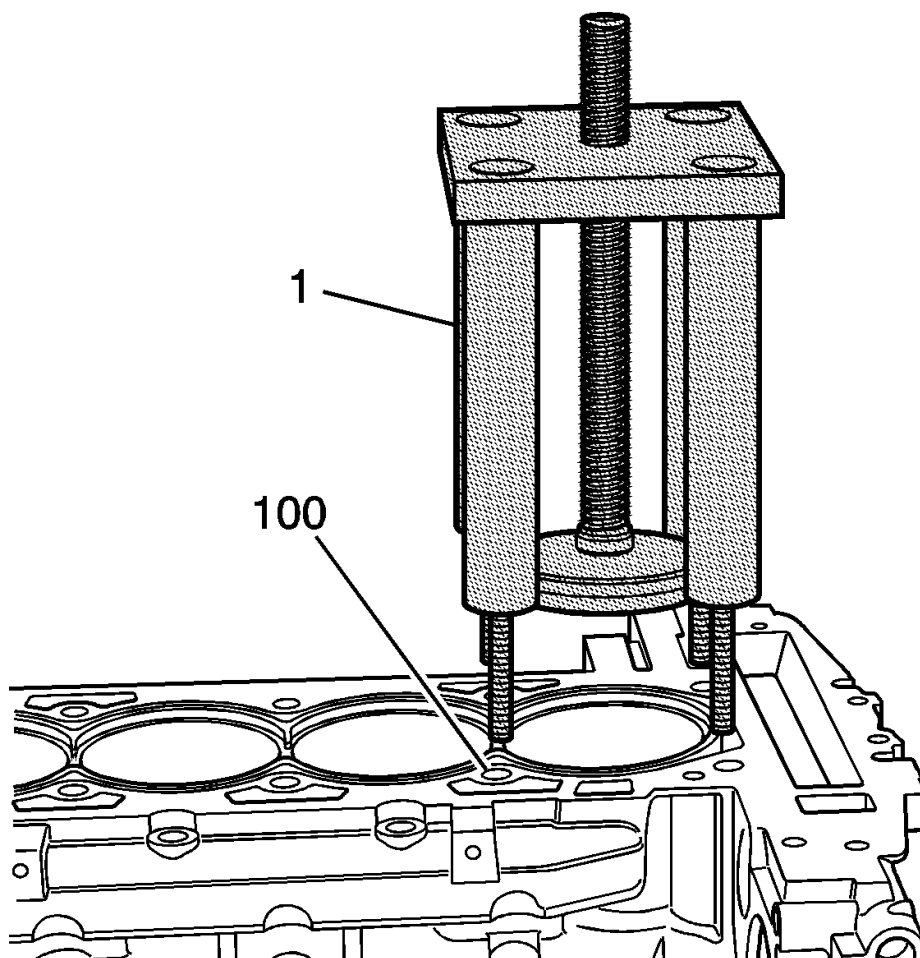


Fig. 413: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixture assembly EN 45680-851 with the cylinder bore sleeve installer EN 45680-853 (1) from the cylinder block (100).

Cylinder Sleeve Trimming

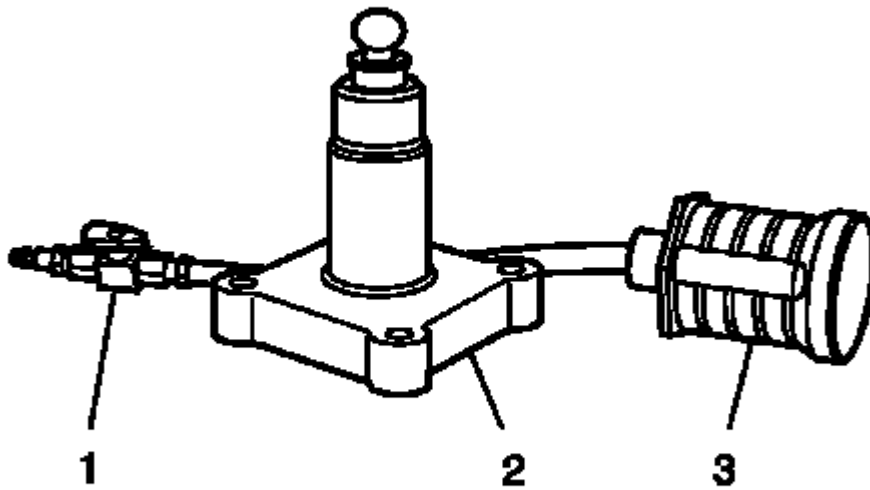


Fig. 414: Cylinder Liner Trimming Tools View (1 Of 2)
 Courtesy of GENERAL MOTORS CORP.

The EN 45680-861 trim tool assembly (2) from EN 45680-850 contains or requires the following components to complete 86 mm cylinder sleeve trimming:

- Debris collector (3) with filter EN-45680-865 from EN 45680-850 . See **Special Tools**.
- Air control valve (1)
- Drill motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction
- EN 45680-869 bore cutter bit and screw from EN 45680-850 . See **Special Tools**.
- EN 45680-899 Bore trimmer pilot from EN 45680-850 , white in color. See **Special Tools**.

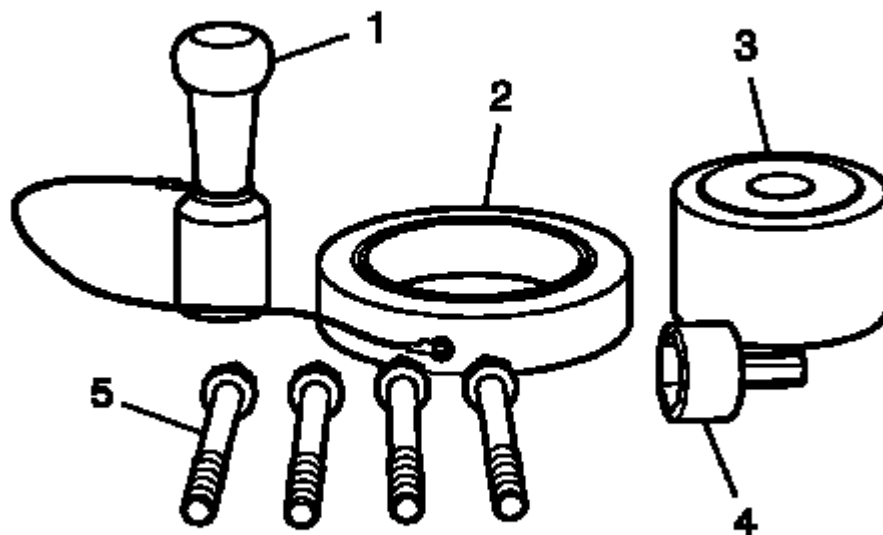


Fig. 415: Cylinder Liner Trimming Tools View (2 Of 2)

Courtesy of GENERAL MOTORS CORP.

- Gage ring assembly EN-45680-862 from **EN 45680-850** . See Special Tools.
 - Trim tool preloader (1)
 - Set gage ring (2)
- EN 45680-412 Set Gage Ring (2)
- EN 45680-863 metal shavings catch plug (3) from **EN 45680-850** . See Special Tools.
- EN 45680-866 drive adapter (4) from **EN 45680-850** . See Special Tools.
- EN 45680-864 bolts (5) from **EN 45680-850** . See Special Tools.

NOTE:

Do not bore or hone the cylinder bore sleeve. The cylinder bore sleeve inside diameter (I.D) is fully machined and honed to size and is optimally finished as shipped. Any attempt to modify this factory-produced sizing and finish with additional boring and honing will lead to engine damage, excessive noise or abnormal oil consumption.

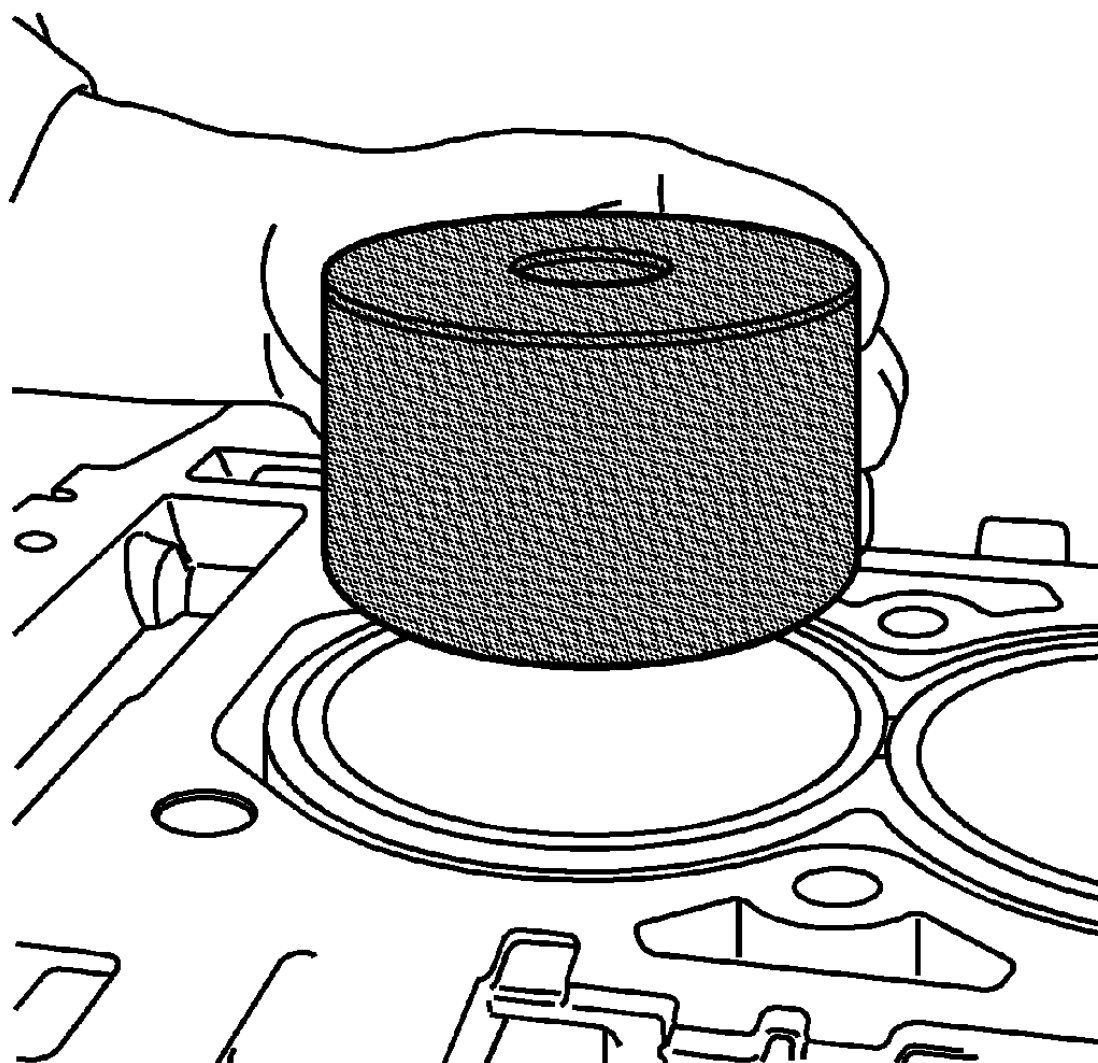


Fig. 416: Placing Metal Shaving Catch Plug Into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

1. After installing the NEW cylinder bore sleeve(s) into the engine block, trim the excess material from the cylinder bore sleeve flange.

NOTE: **Ensure that all the metal particles are collected in order to prevent internal damage to the engine or bearings.**

2. Place the metal shaving catch plug EN 45680-863 into the cylinder bore sleeve to be trimmed. Position the top approximately 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.
3. Place an additional metal shaving catch plug EN 45680-863 into all remaining cylinder bore sleeves.

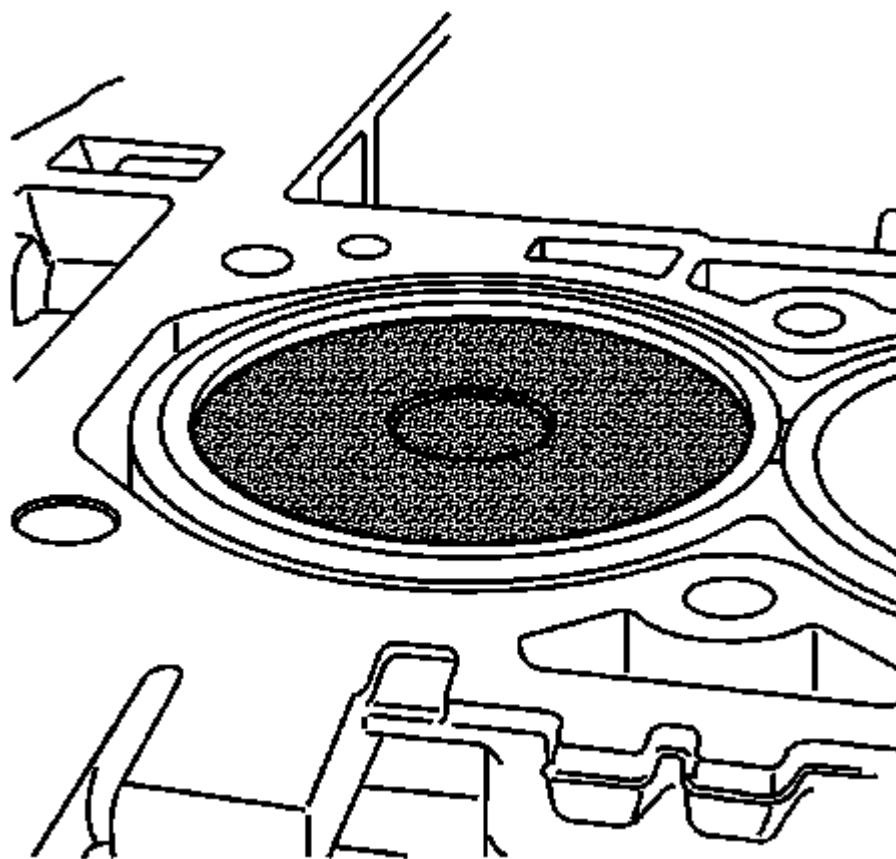


Fig. 417: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Installing the metal shaving catch plug deeper than the recommended depth will create a decrease in vacuum system performance. A decrease in vacuum system performance will cause metal shavings to enter the engine and cause engine failure.

NOTE: Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.

4. Ensure that the metal shaving catch plug EN 45680-863 is 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.
5. Ensure that the correct bore trimmer pilot and cutter bit are installed on the trimmer base assembly EN 45680-861:
 - EN 45680-869 cutter bit and screw
 - EN 45680-899 trimmer pilot, 86 mm sleeve

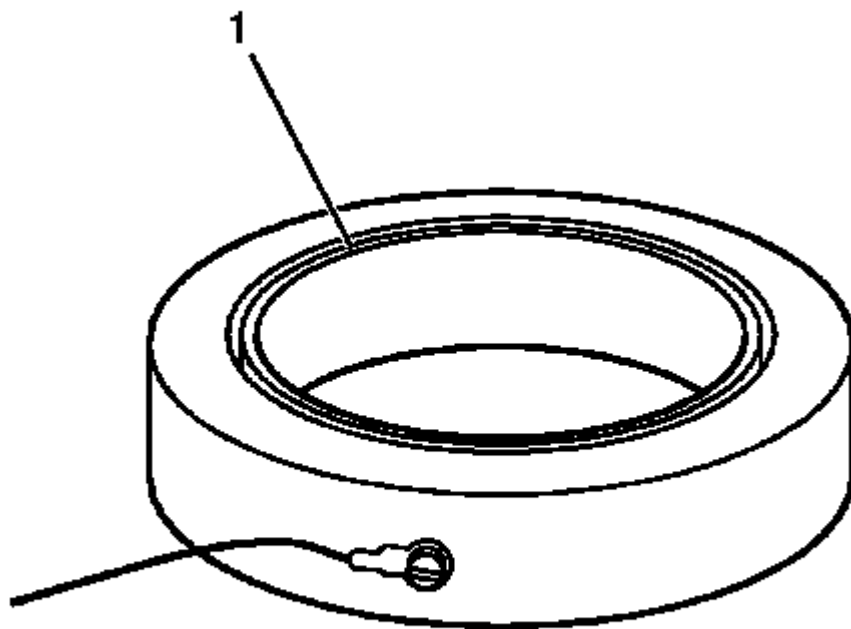


Fig. 418: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Before using the trim tool assembly, the height of the cutting blades must be set to the proper specification. The proper specification is that the cylinder bore sleeve flange must be flush to $+0.02$ mm (0.0008 in) above the block deck surface.

6. The groove side of the set gage ring (1) on the gage ring assembly EN 45680-862 should be positioned upward on a flat surface.

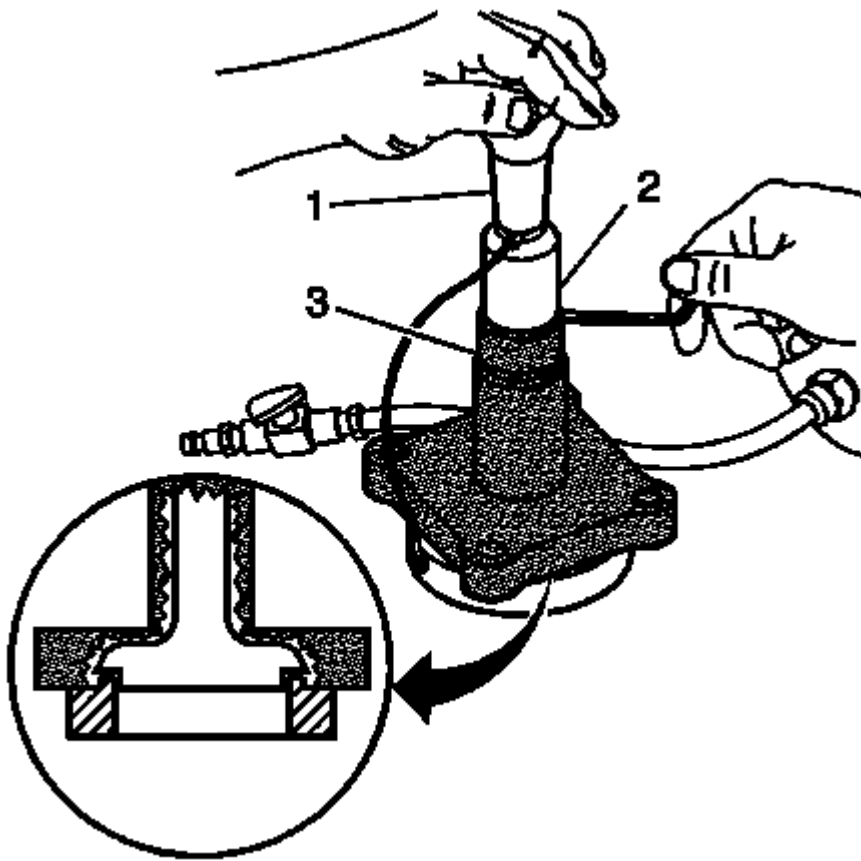


Fig. 419: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the set gage ring surfaces are clean.

7. Carefully position the trim tool assembly EN 45680-861 onto the set gage ring.
8. Loosen the shaft collar screw (2).
9. Push the shaft collar (2) downward using the trim tool preloader (1) on the gage ring assembly EN 45680-862 until the shaft collar is positioned against the top of the flange bearing (3).

IMPORTANT: Once this procedure is done, it is not necessary to reset the trim tool assembly height until the blades are worn, damaged, or replaced.

10. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw.

Tighten: Tighten the shaft collar screw to 19 N.m (14 lb ft).

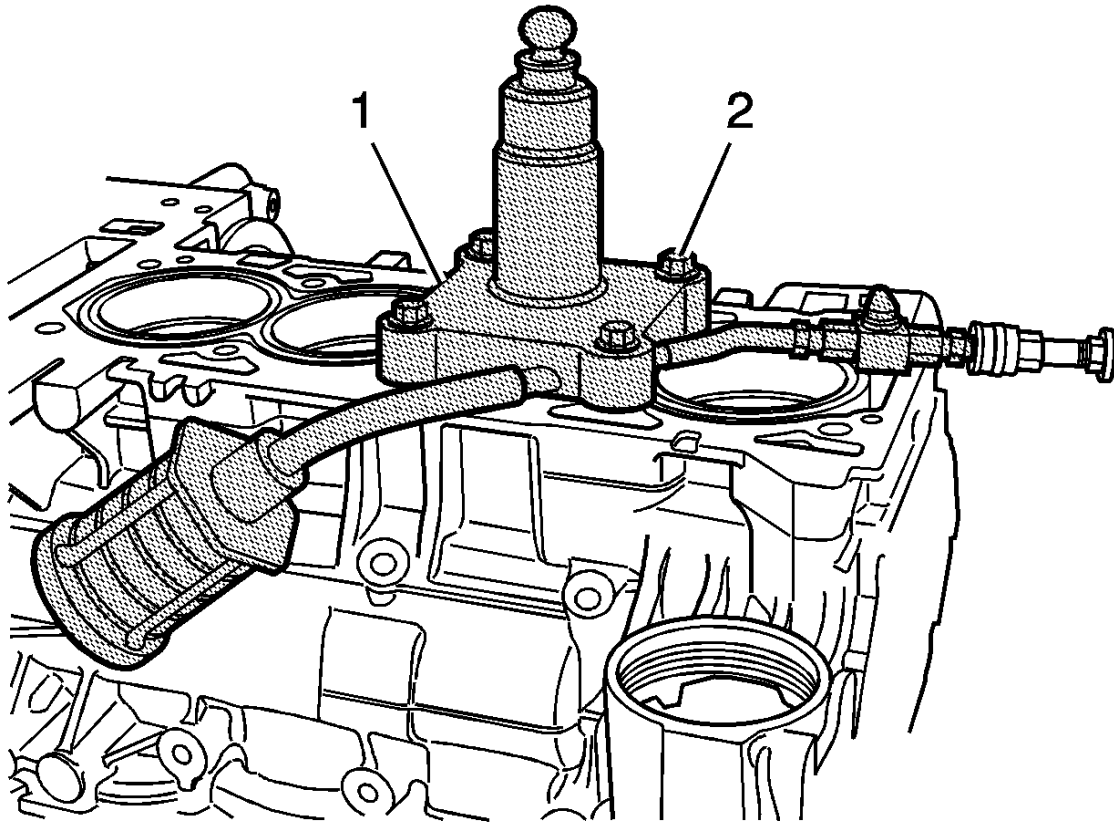


Fig. 420: Aligning Trim Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Place the trim tool assembly EN 45680-861 onto the cylinder to be trimmed with the directional arrow (1) pointing in line with the crankshaft centerline and the front of the block.
12. Install the 4 bolts EN 45680-864 (2) into the cylinder head bolt holes in the block.

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

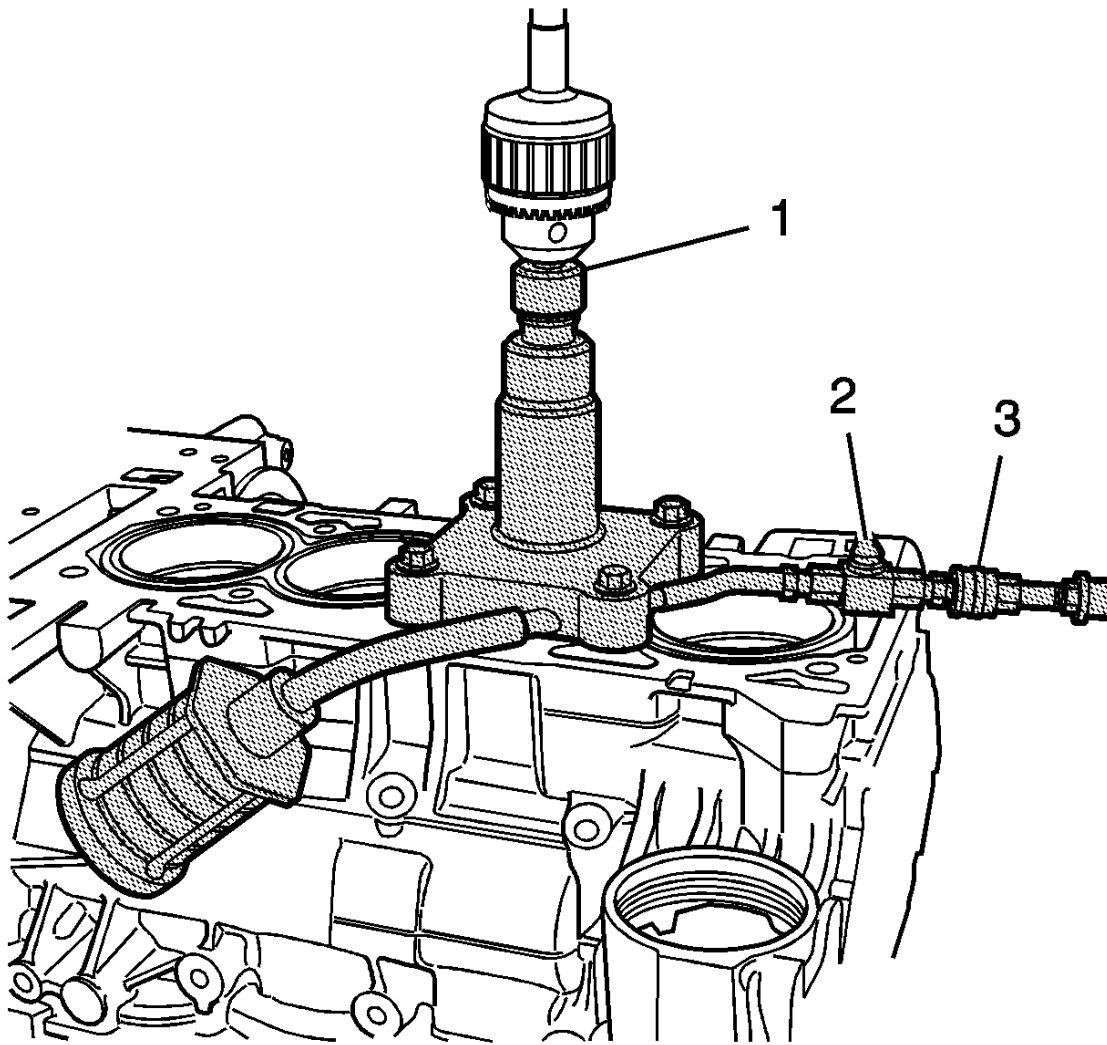


Fig. 421: View Of Drive Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: For proper tool operation, a drill motor with a 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction must be used. If the proper drill motor is not used, damage to the cylinder bore sleeve will occur.

13. Fasten the drive adapter EN 45680-866 (1) into the drill chuck.

NOTE: Ensure that there are no crimps in the air feed hose or the vacuum hose. Crimps in the hose may cause metal shavings to exit the cutting tool in any direction, causing engine damage.

14. Connect a compressed air supply 517.10-861.84 kPa (75-125 psi) to the male quick connect (3) located on trim tool assembly EN 45680-861. Turn the compressed air valve (2) to the open position. This starts the venturi vacuum system that will catch the metal shavings.

IMPORTANT: It should not take longer than 15 seconds to complete the trimming procedure. If it does, the trimming bits must be repositioned to a new cutting surface.

15. Place the drive adapter EN 45680-866 and drill assembly (1) vertically onto the drive adapter end of trim tool assembly EN 45680-861. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, apply firm downward force until the cutting action is complete.
16. Remove the drive adapter EN 45680-866 (1) and drill assembly from the trim tool assembly EN 45680-861.
17. Turn off the compressed air valve (2).
18. Remove the trim tool assembly EN 45680-861 from the engine block.
19. Remove any material shavings that may be found on the metal shaving catch plug EN 45680-863.
20. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug EN 45680-863.

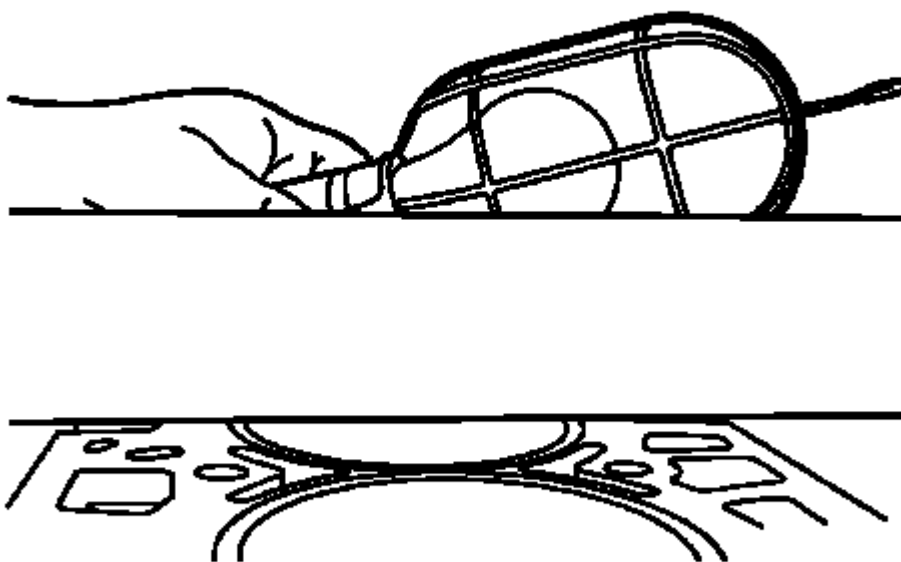


Fig. 422: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

21. Install a straight edge on the cylinder block perpendicular to the crankshaft center line.

22. Using a light, illuminate the backside of the straight edge.

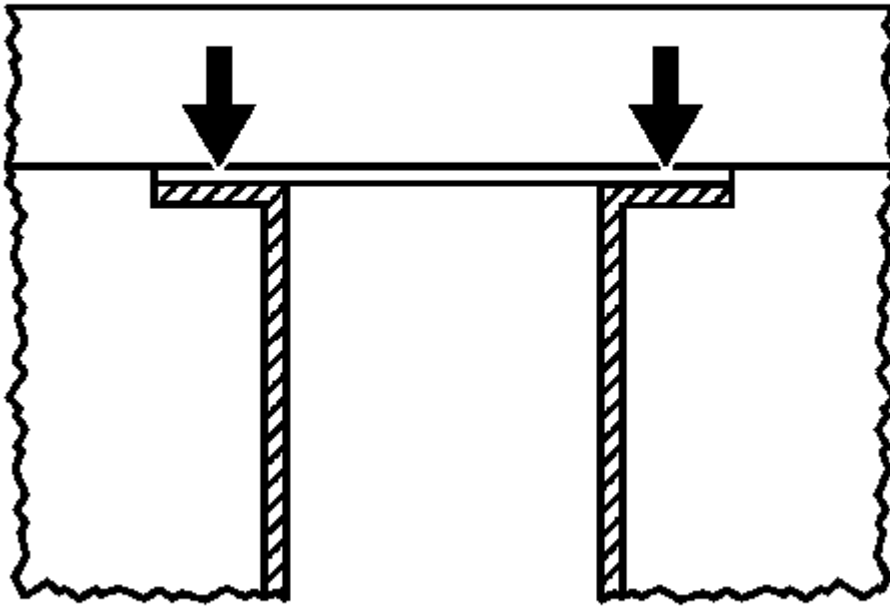


Fig. 423: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

23. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder bore sleeve flange. If light is present on either side or both sides of the cylinder bore sleeve, the cylinder bore sleeve is cut incorrectly and a new cylinder bore sleeve needs to be installed.

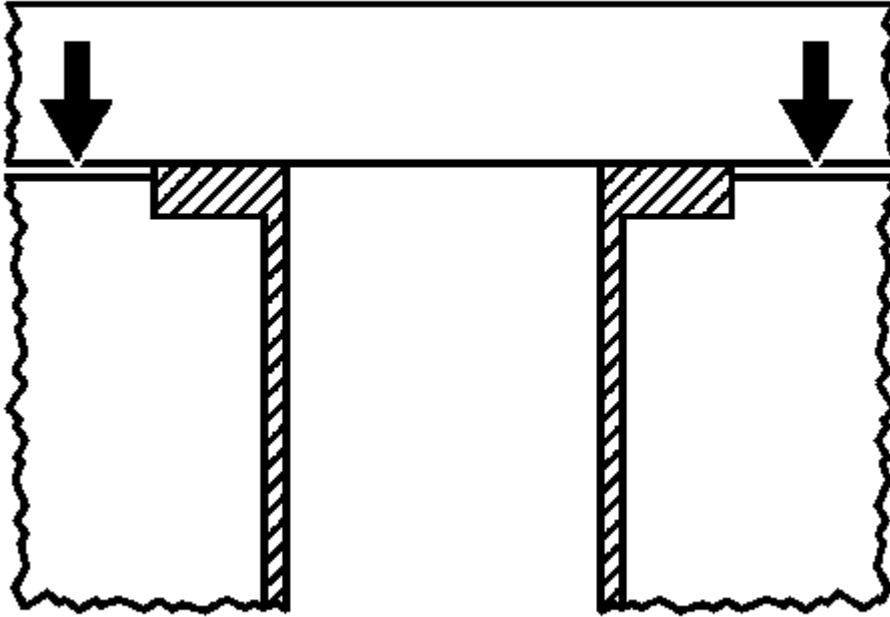


Fig. 424: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

24. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.
25. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

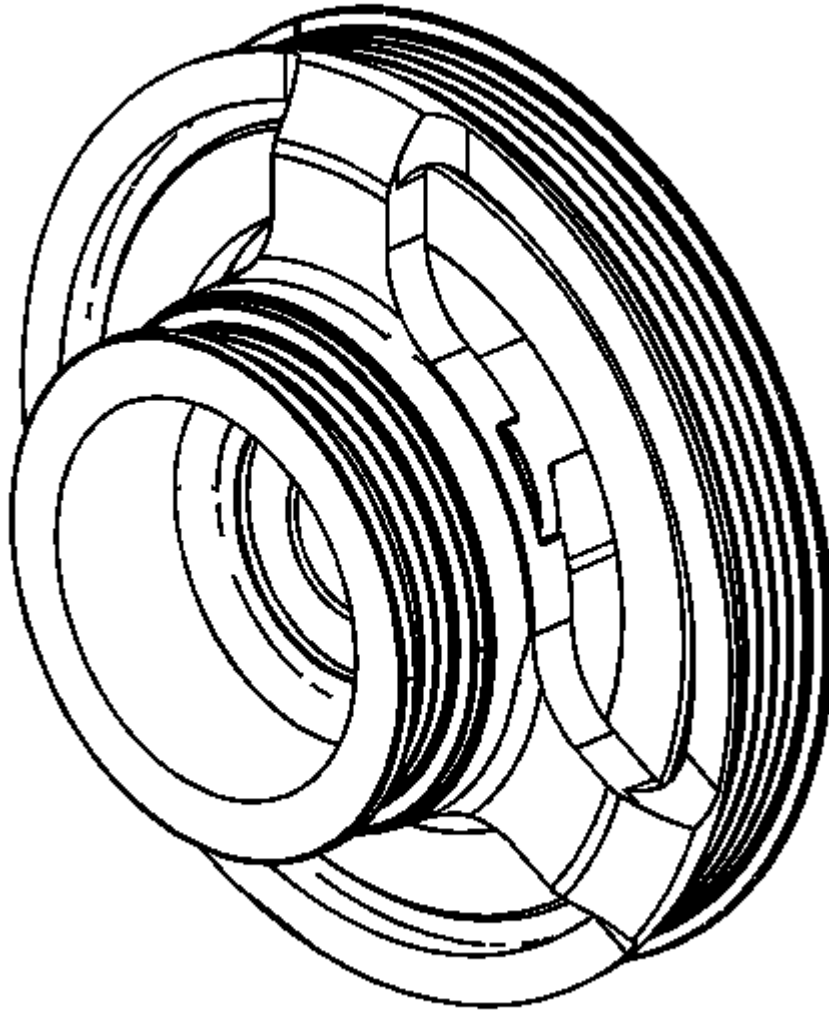


Fig. 425: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer.
2. Clean the belt grooves of all dirt or debris with a wire brush.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the crankshaft balancer with compressed air.

4. Inspect the crankshaft balancer for the following conditions:

- Worn, grooved, or damaged hub seal surface

A crankshaft balancer hub seal surface with excessive scoring, grooves, rust, or other damage must be replaced.

- Axial cracks in and around the keyway

IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves

The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly. Minor imperfections may be removed with a fine file.

- Worn, chunking, or deteriorated rubber between the hub and pulley

ENGINE FLYWHEEL CLEANING AND INSPECTION

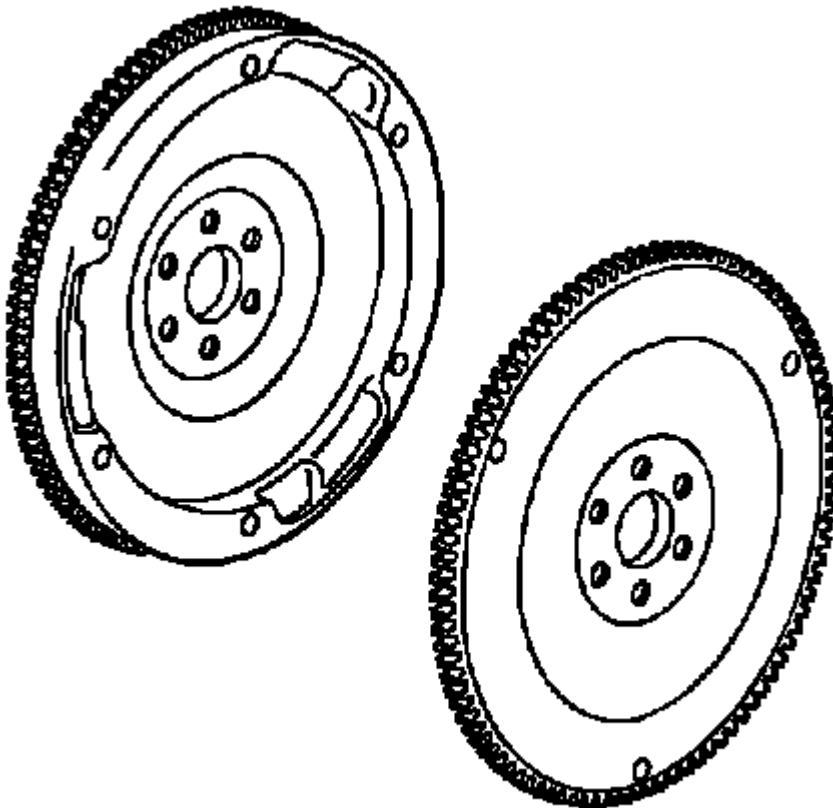


Fig. 426: Identifying Engine Flywheel

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to maintain the proper component balance, contact surface taper, and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the flywheel in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the flywheel with compressed air.

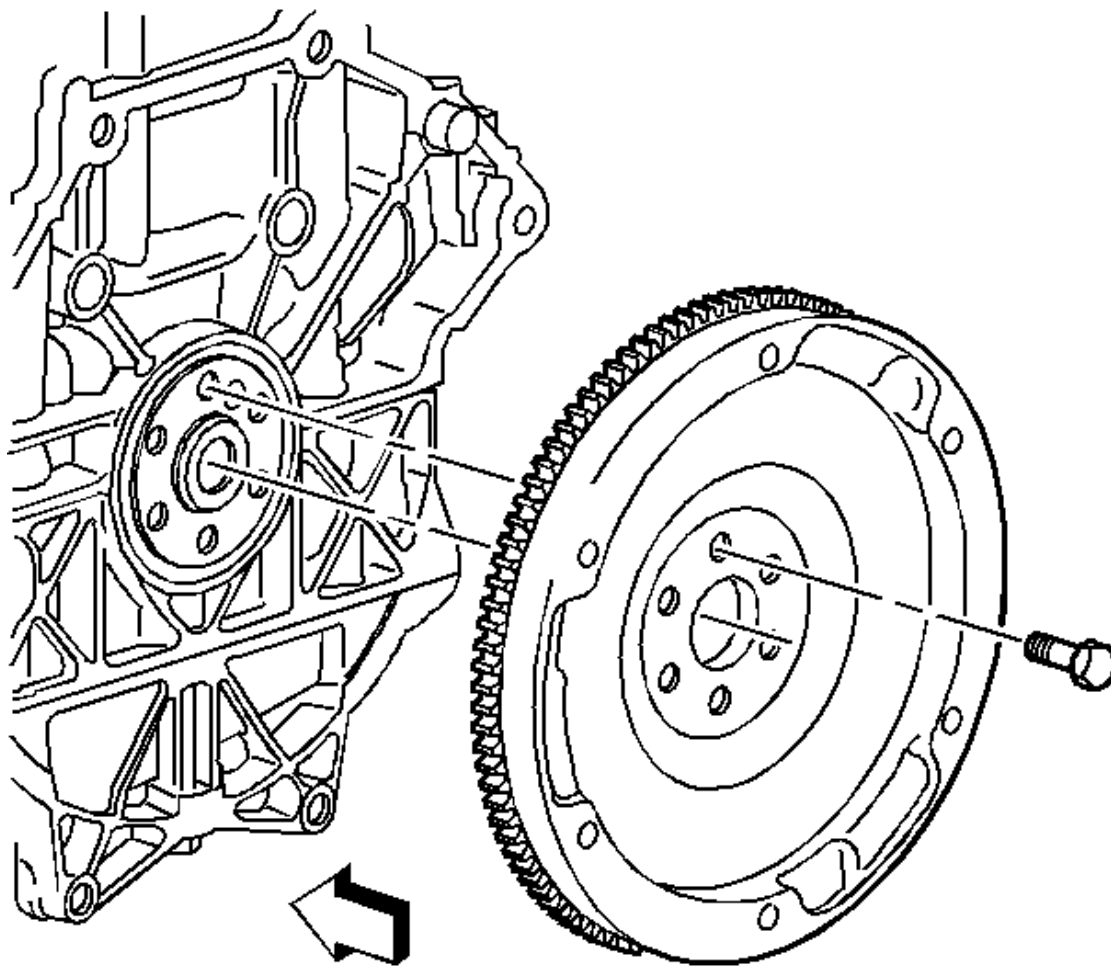


Fig. 427: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Inspect the manual transmission flywheel for the following conditions:

- Damaged ring gear teeth
- Loose or improperly positioned ring gear

The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.

- A scored, grooved or damaged friction surface

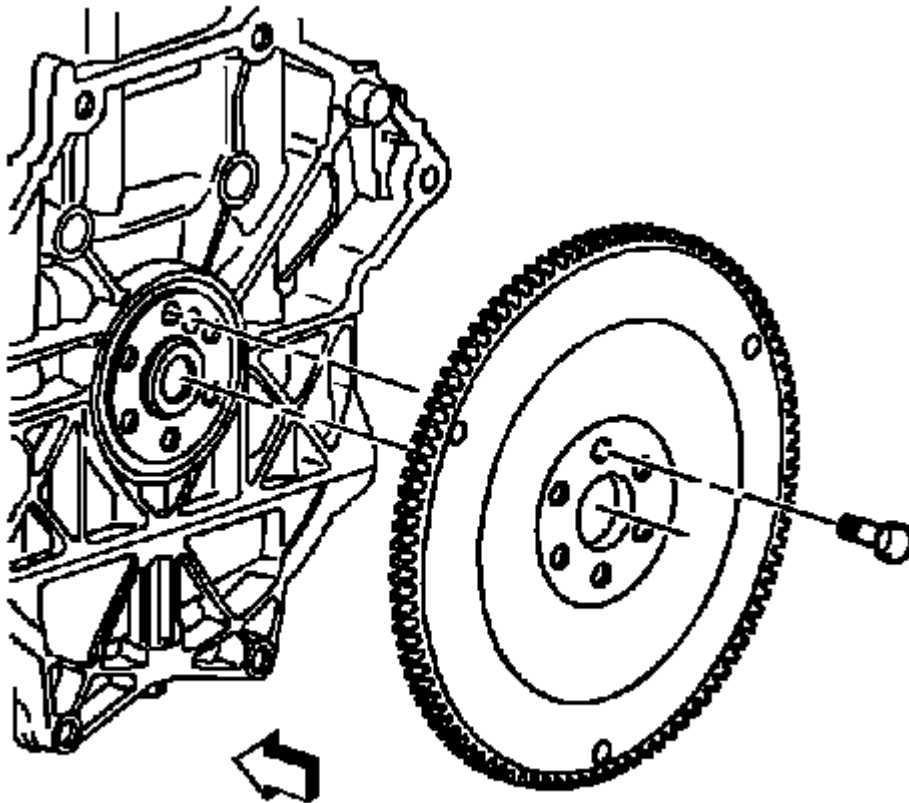


Fig. 428: View Of Flywheel

Courtesy of GENERAL MOTORS CORP.

4. Inspect the automatic transmission flywheel for the following conditions:

- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations
- Weight saving holes

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator Set. See Special Tools.

Cleaning and Inspection Procedure

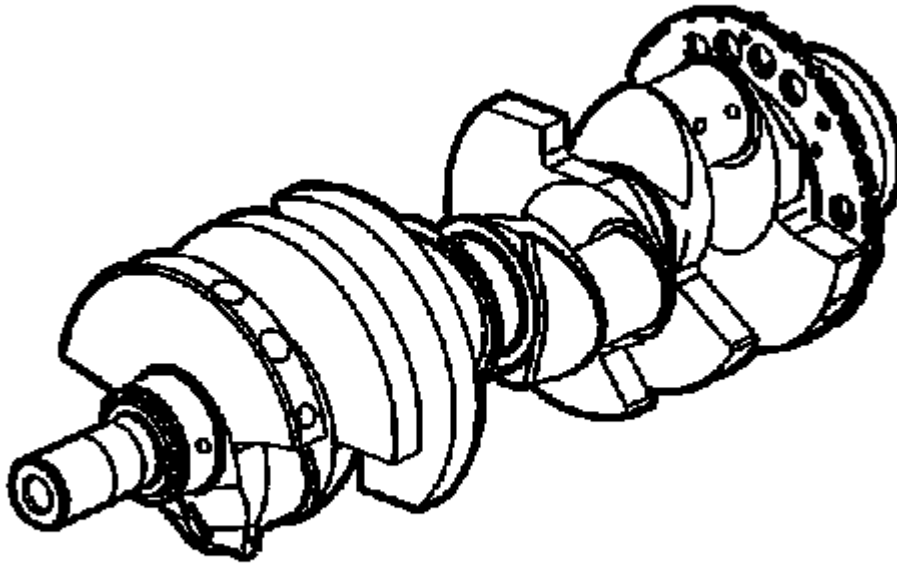


Fig. 429: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the crankshaft with compressed air.

IMPORTANT: 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.

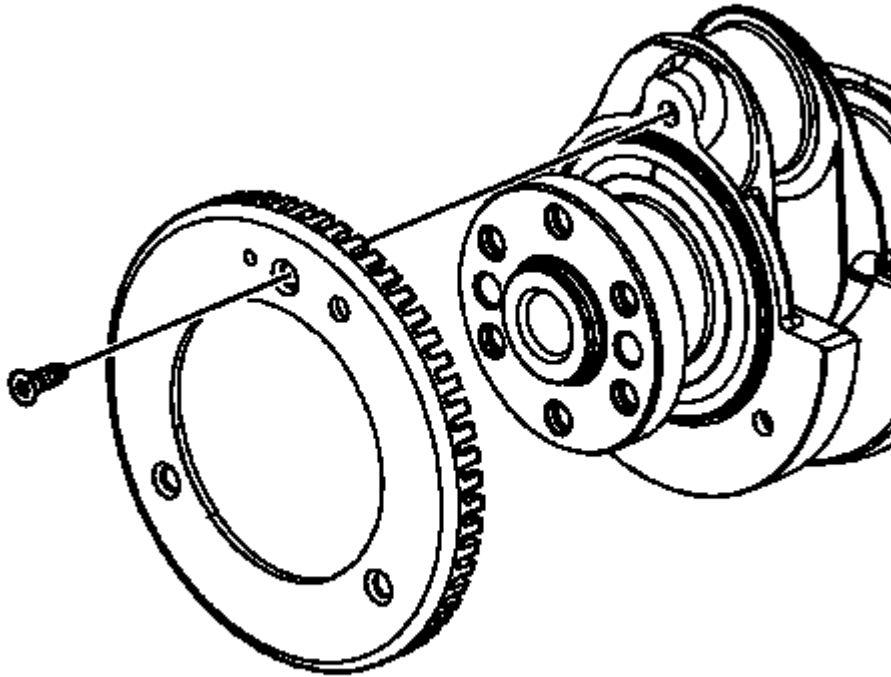


Fig. 430: View Of Crankshaft Position Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft position reluctor ring may be replaced if damaged.

Tighten: Tighten the crankshaft position reluctor ring bolts to 15 N.m (11 lb ft).

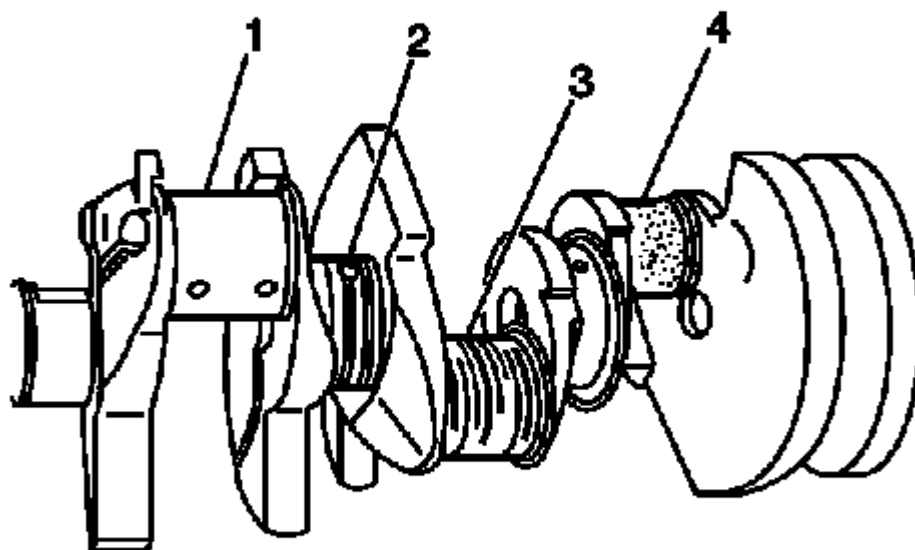


Fig. 431: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

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).

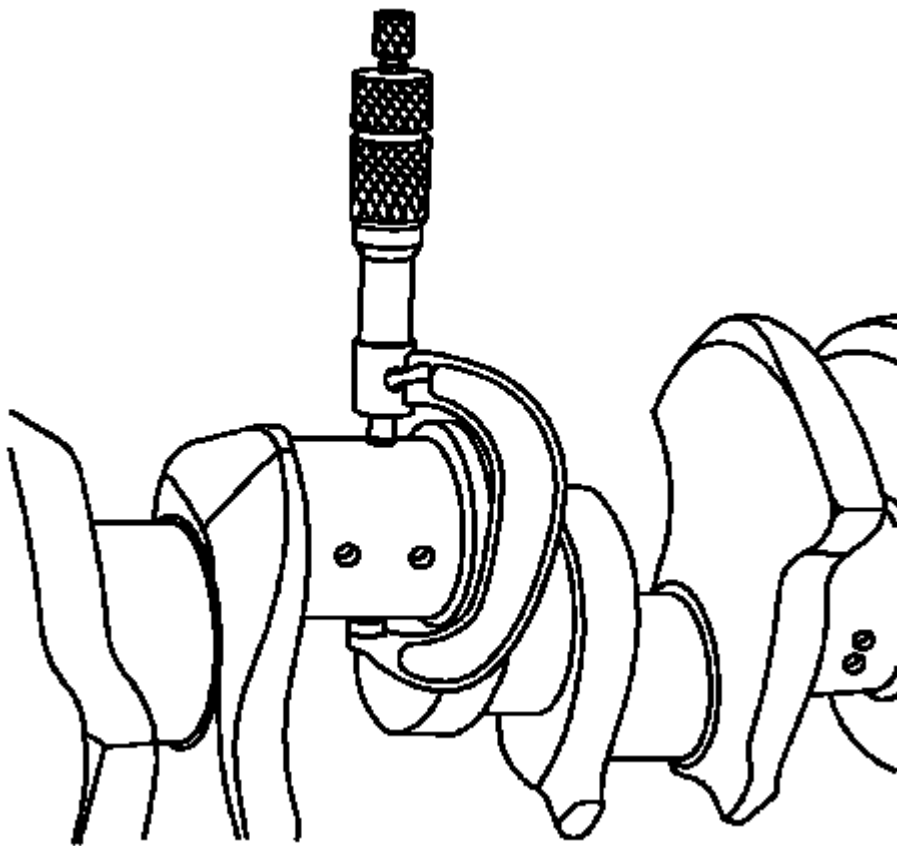


Fig. 432: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft journals for out-of-round.
11. Measure the crankshaft journals for taper.

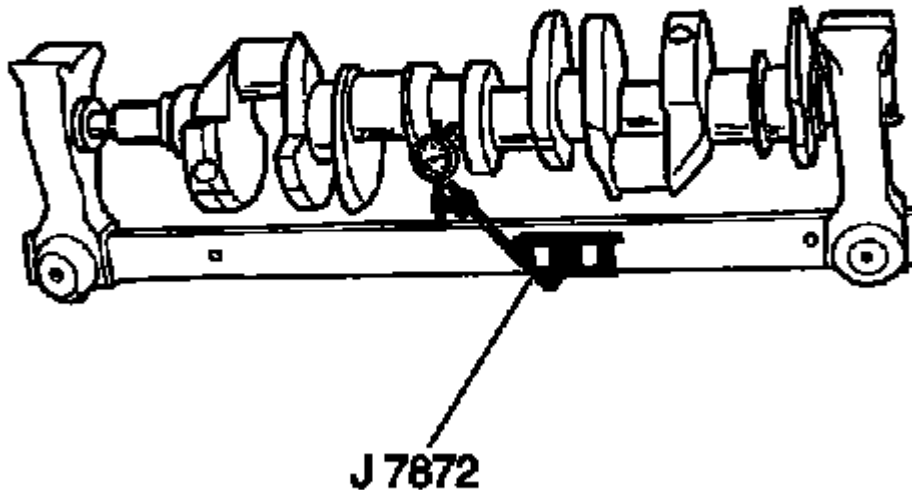


Fig. 433: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals. See **Special Tools**.
14. Use the **J 7872** in order to measure the runout of the crankshaft rear flange. See **Special Tools**.
15. Replace the crankshaft if the measurements are not within specifications.

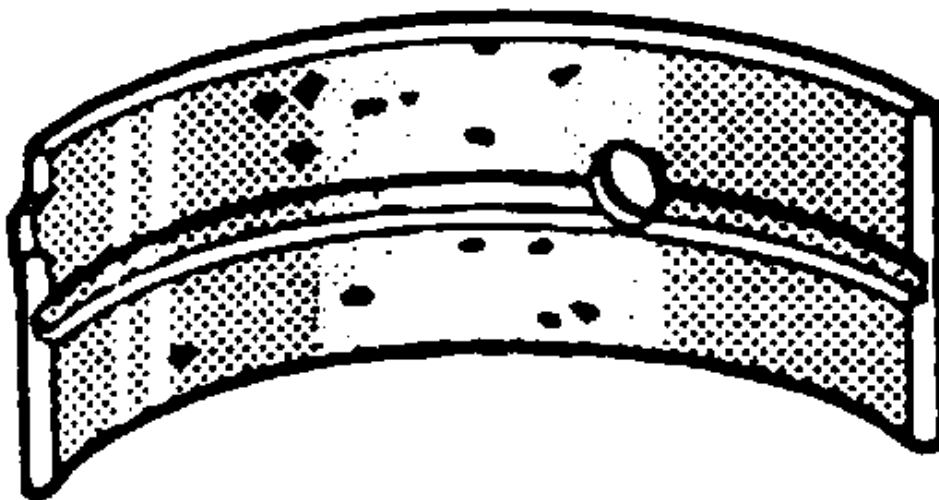


Fig. 434: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

16. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

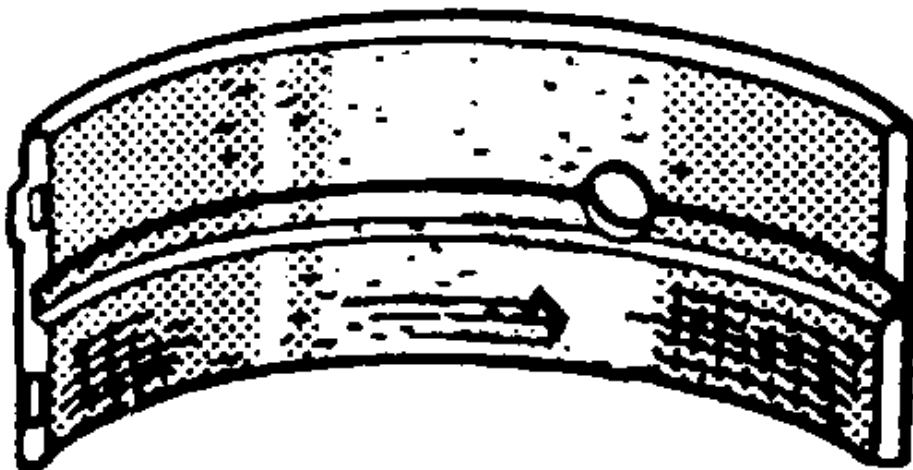


Fig. 435: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

17. Inspect the crankshaft bearings for excessive scoring or discoloration.
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

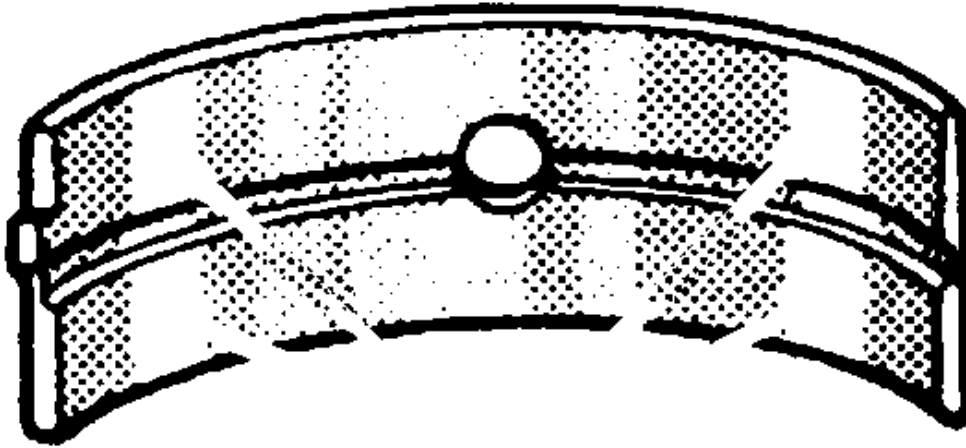


Fig. 436: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

- EN-46745 Piston Clip Retainer Remover/Installer. See **Special Tools**.
- EN-46745-4 Piston Clip Retainer Remover/Installer Adapter. See **Special Tools**.

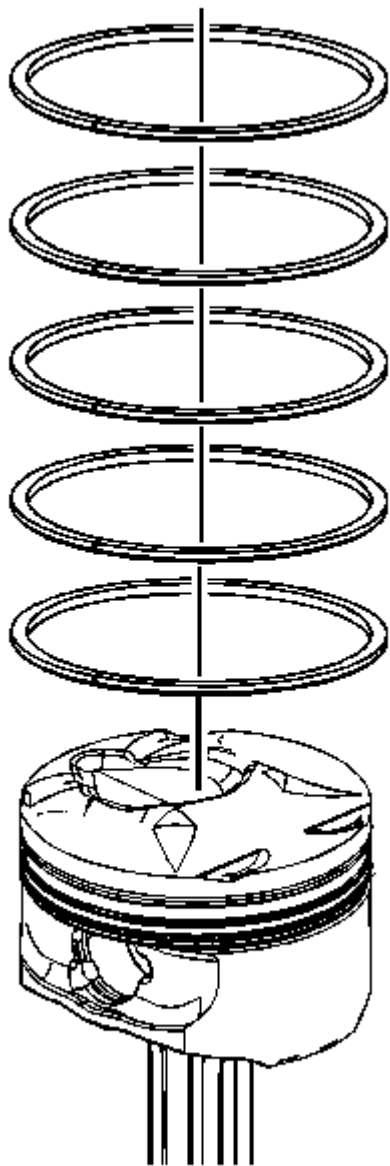


Fig. 437: Identifying Piston Rings

Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings. Use a suitable tool to expand the rings. The piston rings must not be reused.

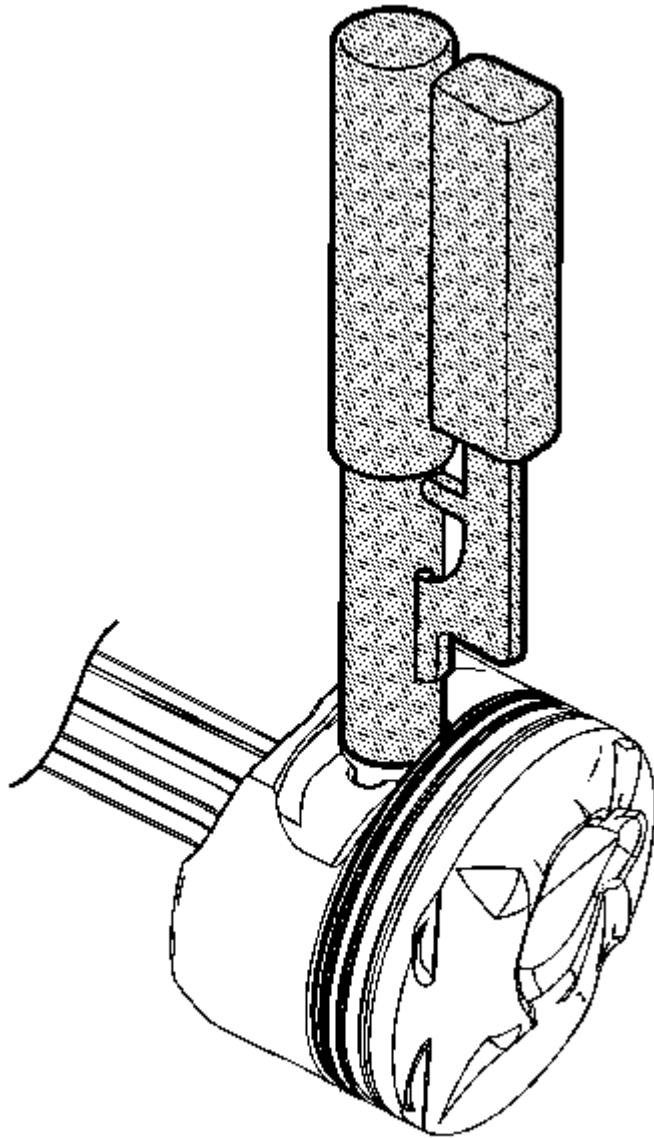


Fig. 438: Identifying Piston Pin Retainer Remover & Installer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 2 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** and the **EN-46745-4** . See **Special Tools**.

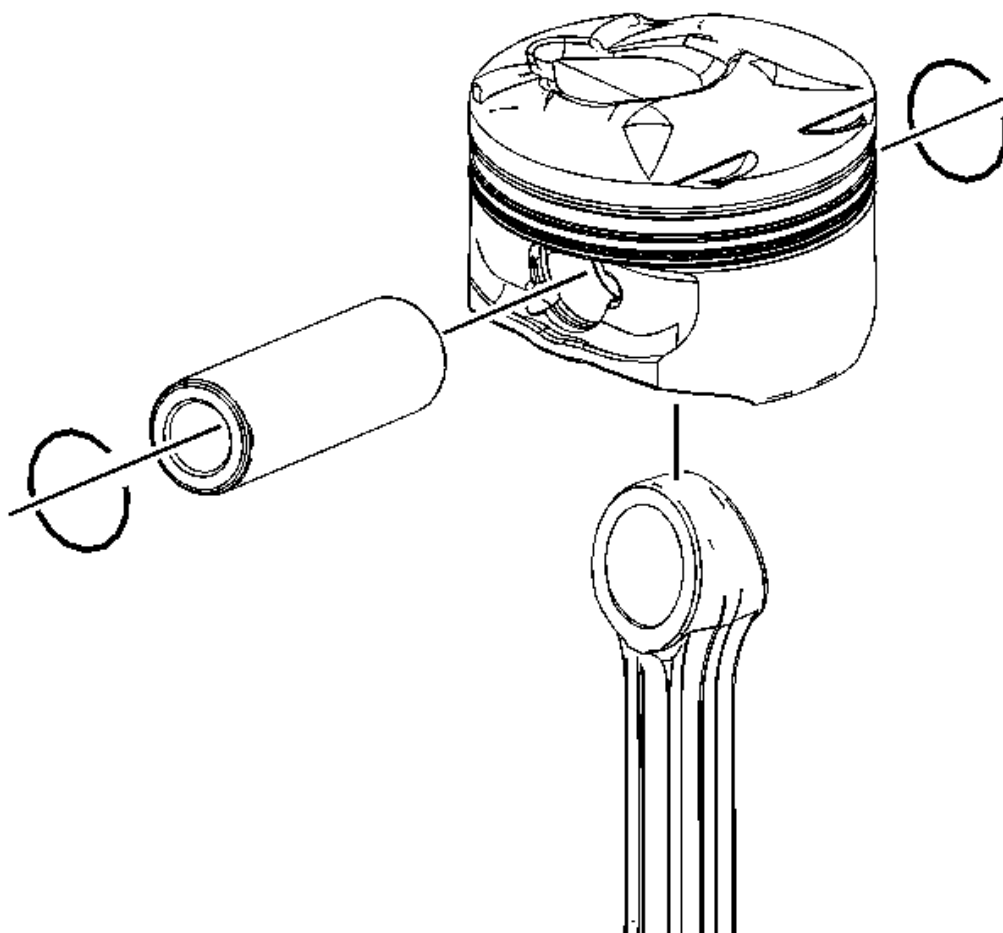


Fig. 439: Identifying Piston Pin
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

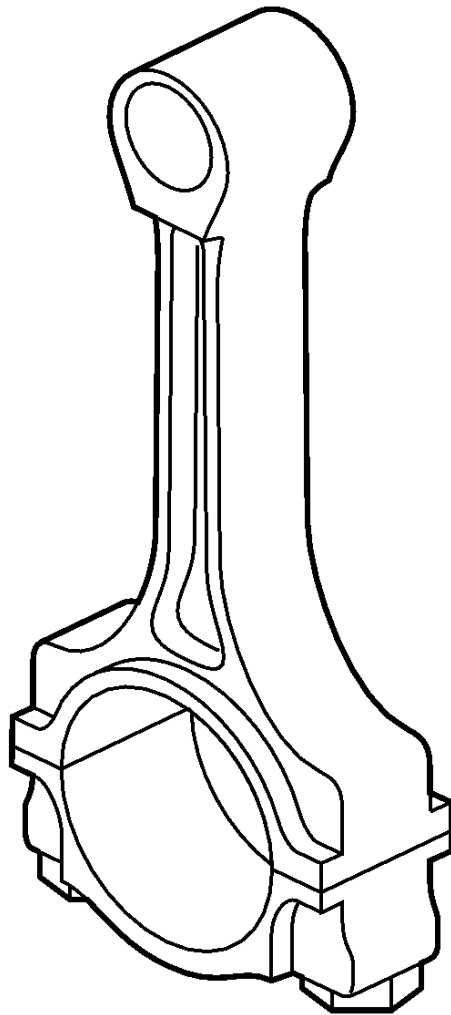


Fig. 440: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean the connecting rods in solvent and dry with compressed air.
2. Inspect the connecting rods for the following conditions:
 - 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

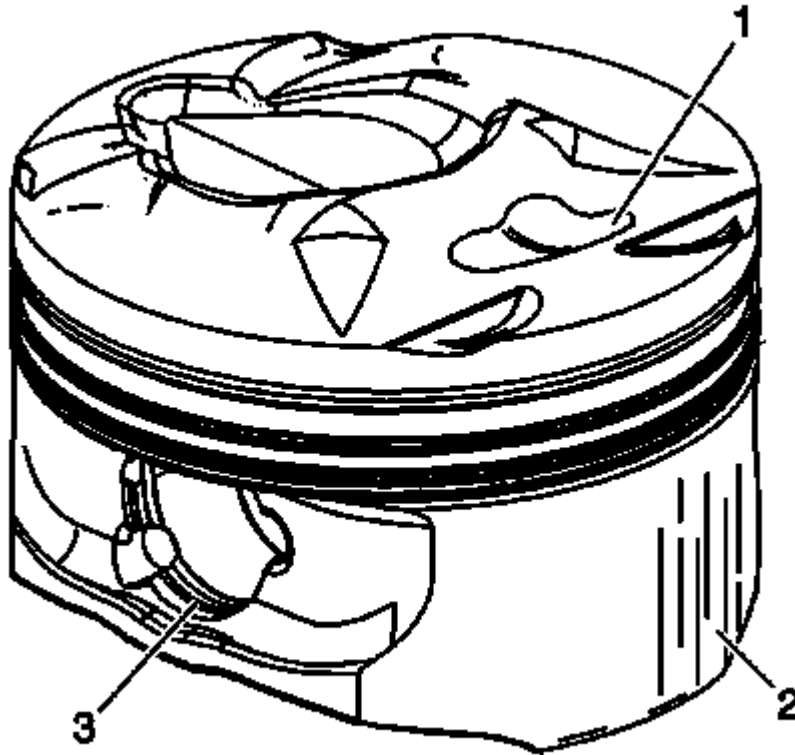


Fig. 441: Inspecting For Piston Wear
Courtesy of GENERAL MOTORS CORP.

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. Ensure the 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.

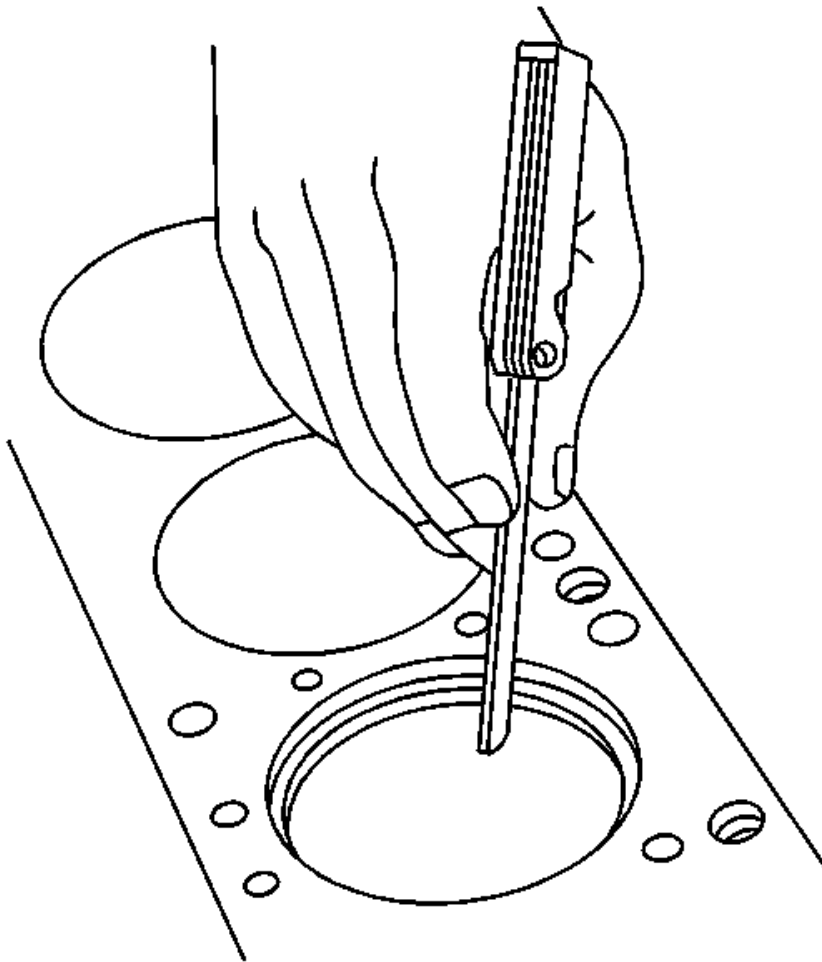


Fig. 442: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

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. Ensure 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 gages. Compare the measurements with those

provided below:

Specification:

- The top compression ring end gap should be 0.20-0.35 mm (0.0078-0.0138 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.

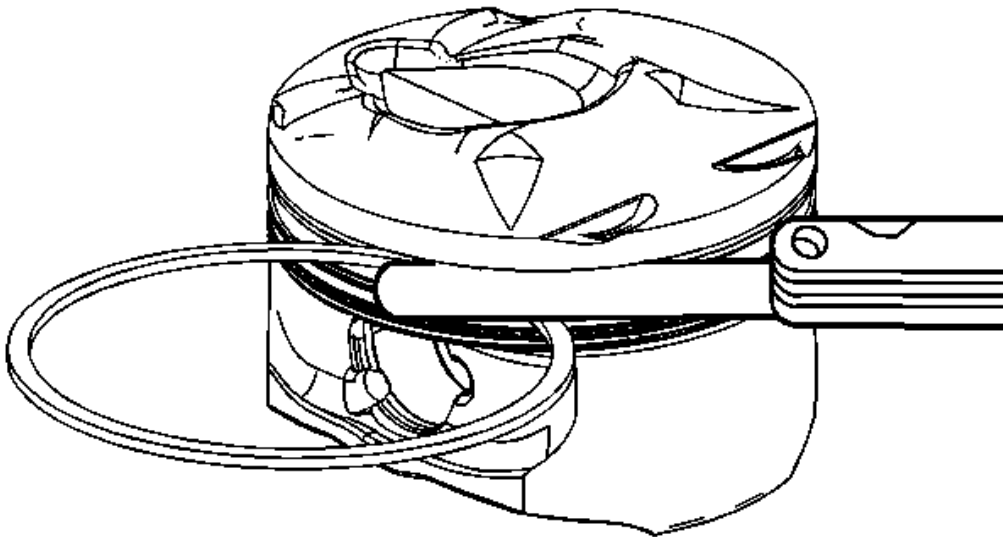


Fig. 443: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

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 gages to measure clearance at multiple locations.
 3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.055 mm (0.0022 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 0.055 mm (0.0022 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 second

compression ring near the end for identification of the top side. Install the second 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 0.032 mm (0.0012 in).
10. If the new ring does not reduce the clearance to 0.032 mm (0.0012 in) or less, install a new piston.

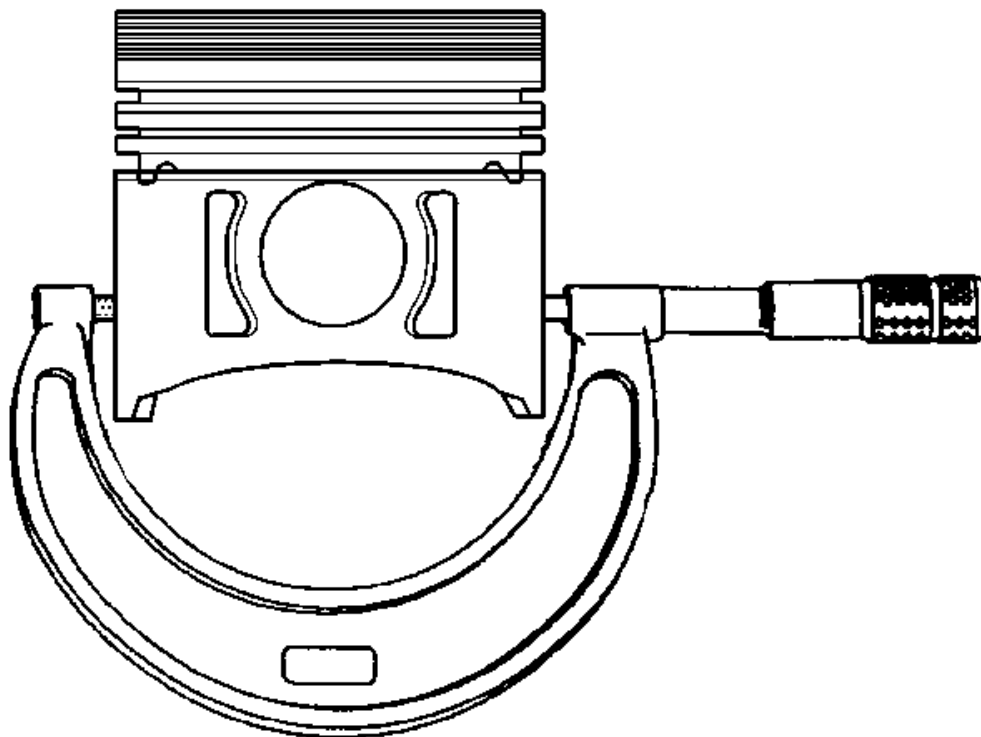


Fig. 444: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

11. Measure piston width using the following procedure:
 1. Using an outside micrometer, measure the width of the piston 12.5 mm (0.4925 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.

Piston Selection

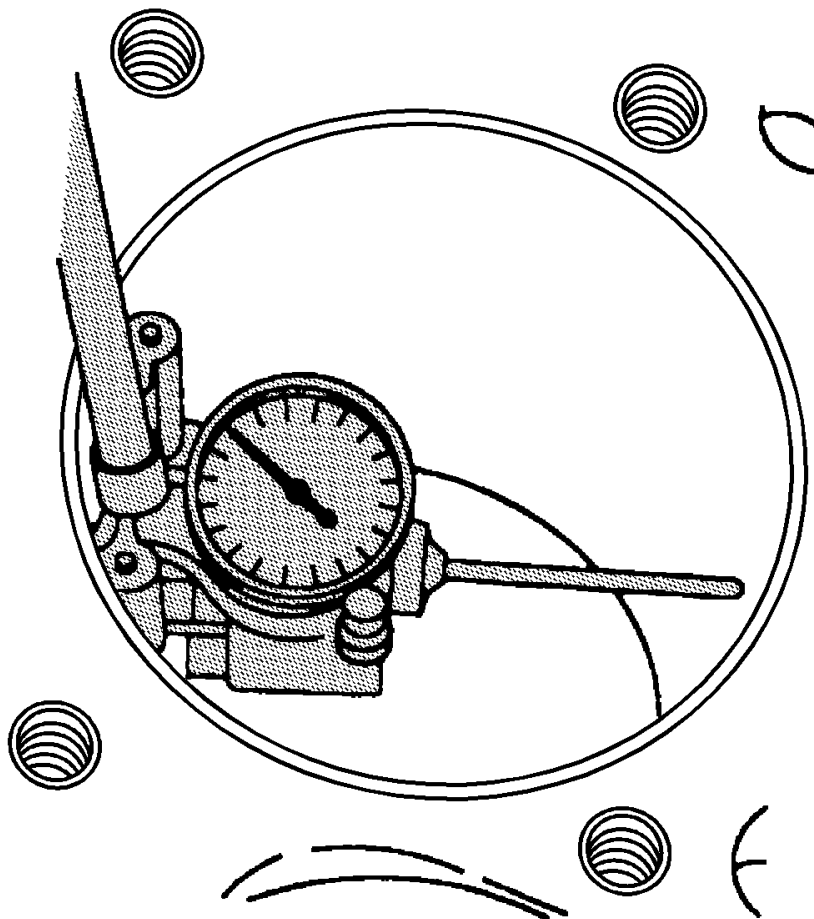


Fig. 445: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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. Using a bore gage, measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

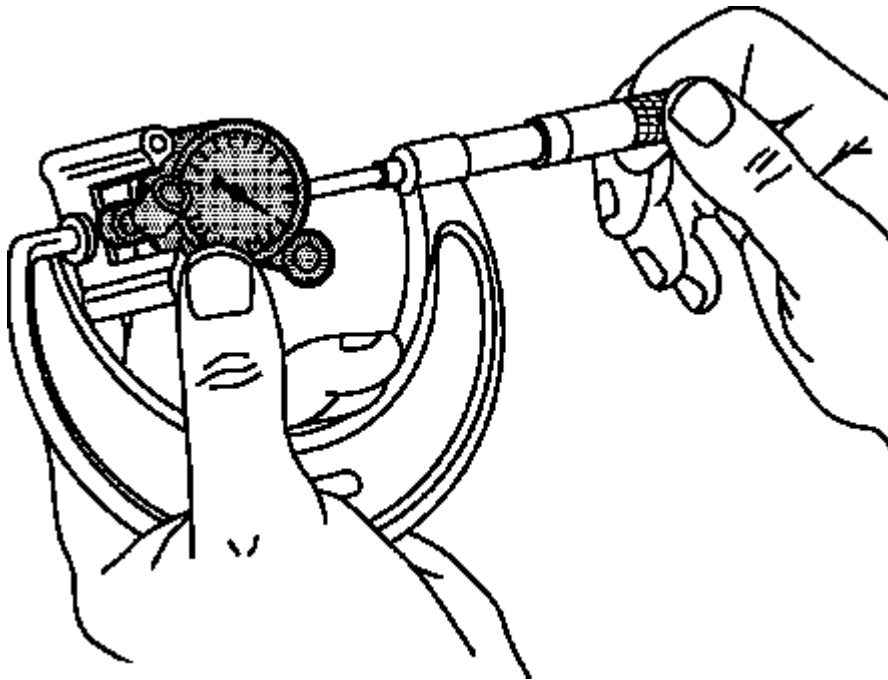


Fig. 446: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gage with a micrometer and record the reading.

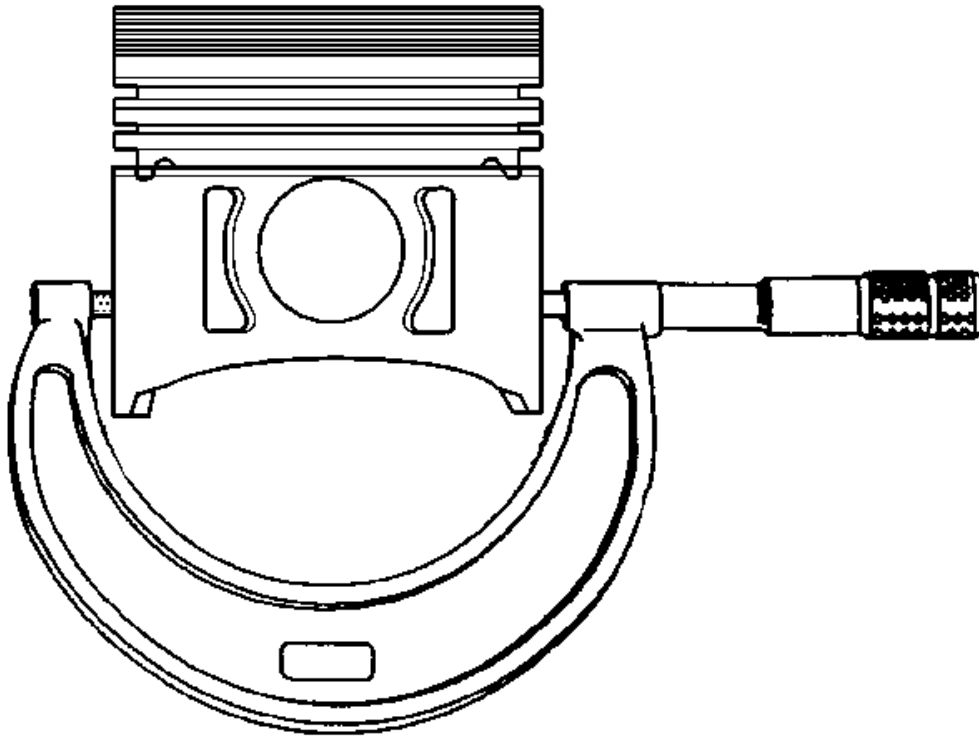


Fig. 447: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

- **EN-46745** Piston Pin Clip Remover/Installer. See **Special Tools**.
- **EN-46745-4** Piston Pin Clip Remover/Installer Adapter. See **Special Tools**.

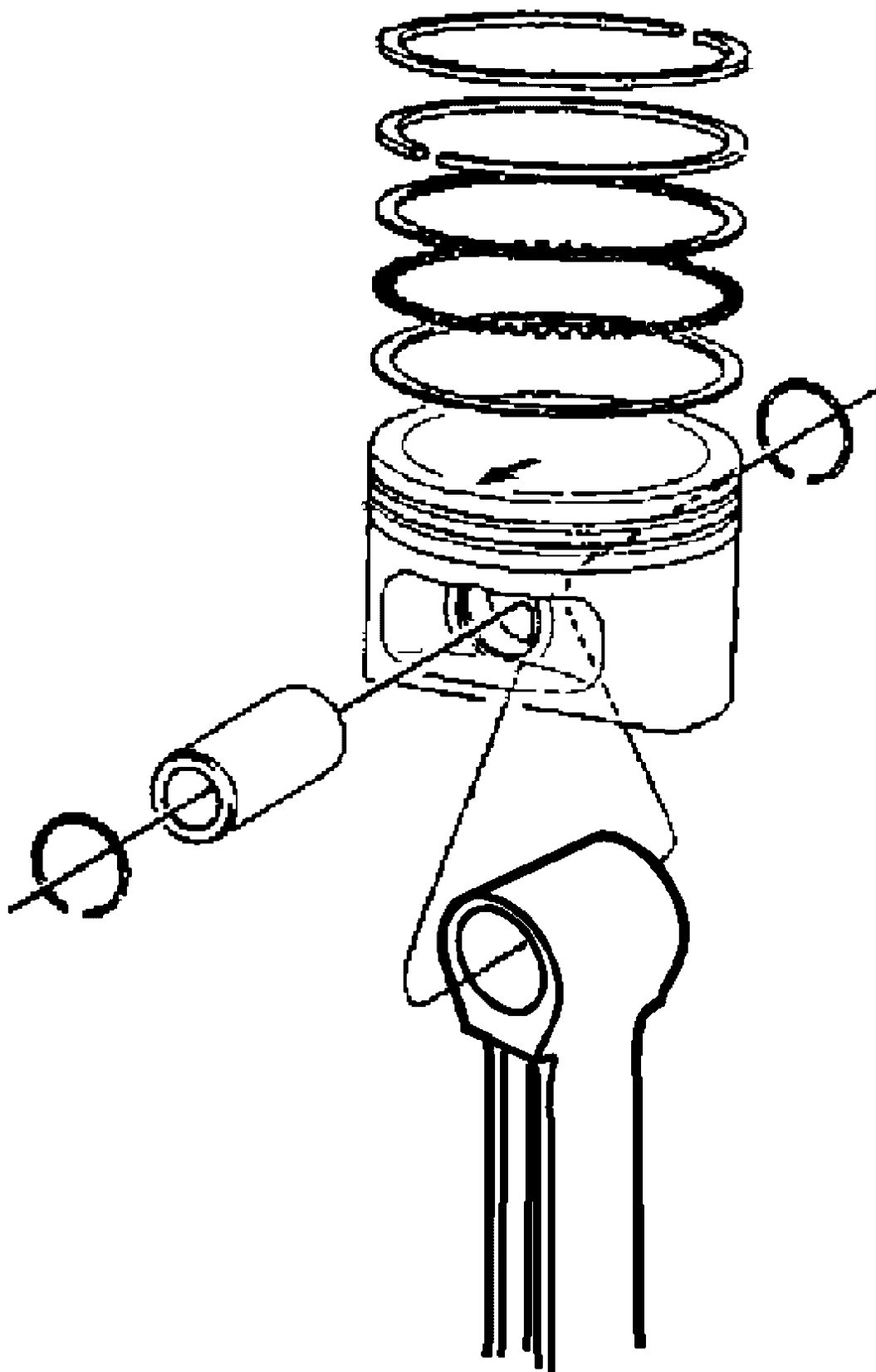


Fig. 448: Assembling Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the piston onto the connecting rod with the arrow oriented toward the front of the engine.

1. Assemble the connecting rod and the piston.

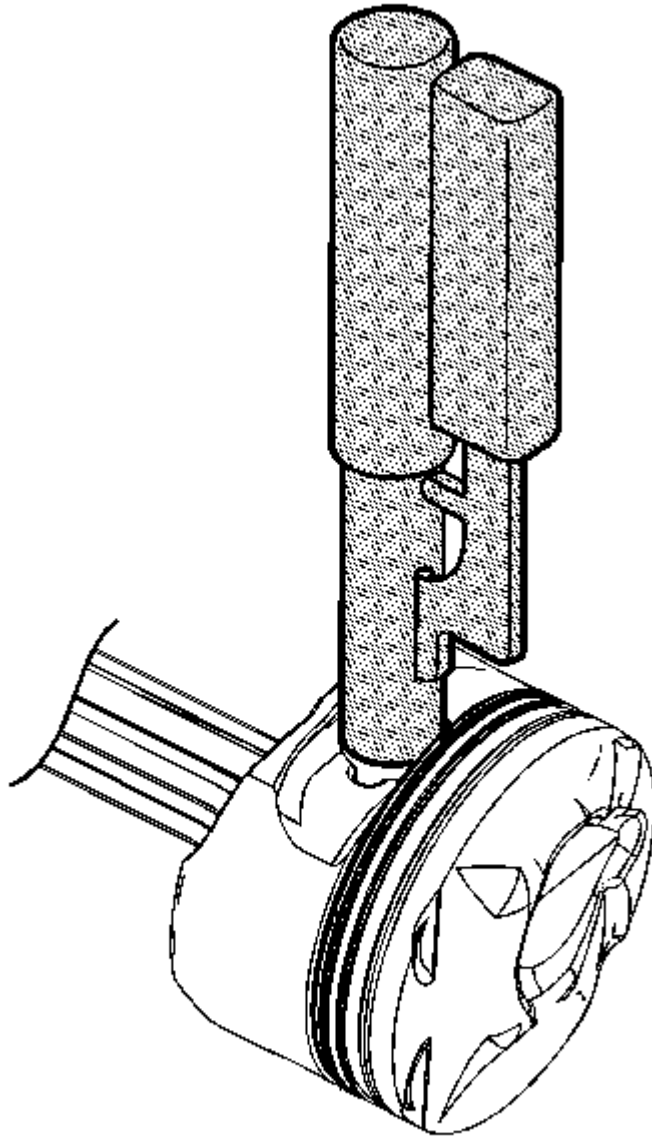


Fig. 449: Piston Pin Retainer Remover And Installer
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

2. Use the following procedure to assemble the piston pin and the retainer:

1. Coat the piston pin with oil.
2. Using the **EN-46745** and the **EN-46745-4** , install one side of one piston pin retainer into the retaining groove. See **Special Tools**. 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. Using the **EN-46745** and the **EN-46745-4** , install the second piston pin retainer. See **Special Tools**.
5. Ensure that the piston moves freely.

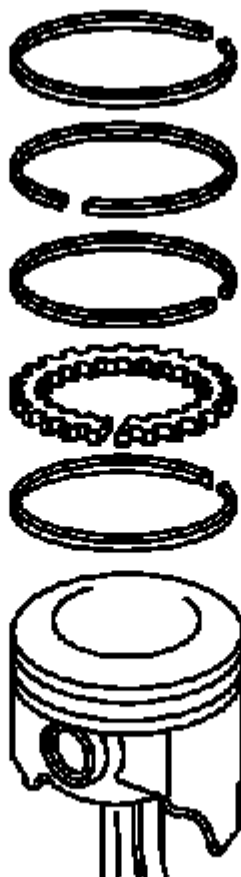


Fig. 450: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

3. Install the following components of the oil control ring assembly - bottom ring:
 1. The expander
 2. The lower oil control ring

3. The upper control ring
4. Install the lower compression ring - second ring. Place the manufacturer's mark facing up.
5. Install the upper compression ring - top ring.

CAMSHAFT CLEANING AND INSPECTION

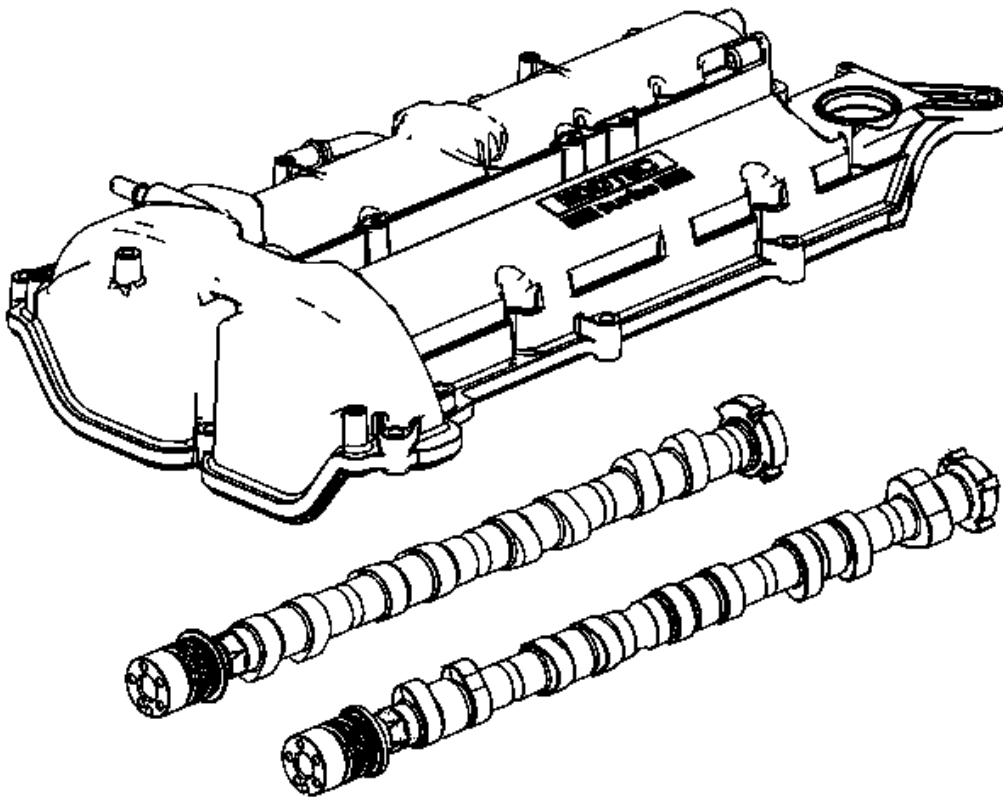


Fig. 451: View Of Camshafts & Cover
Courtesy of GENERAL MOTORS CORP.

- Inspect the camshaft journals and lobes for wear or scoring.
- Inspect the camshaft sprocket alignment notch for damage.
- Inspect the camshaft cover for damage or loose oil control baffles.
- Clean the camshaft cover.
- Wash the camshaft in solvent.
- Oil the camshaft.
- Inspect the camshaft cover for cracks or other signs of damage.

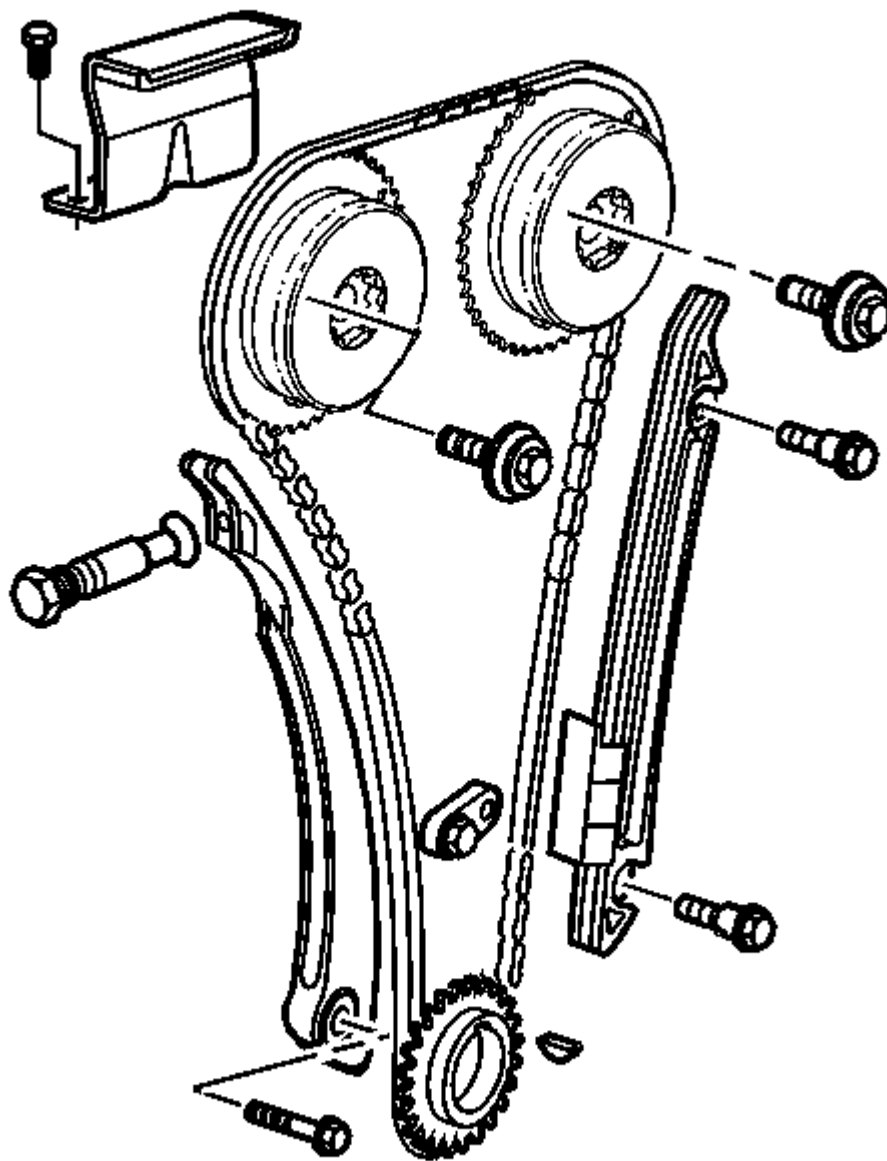
CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

Fig. 452: View Of Timing Chain & Guides
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. Inspect the timing chain tensioner for the scoring or free movement.
10. Inspect the timing chain seal for damage. If damaged, replace the seal.

BALANCE SHAFT CLEANING AND INSPECTION

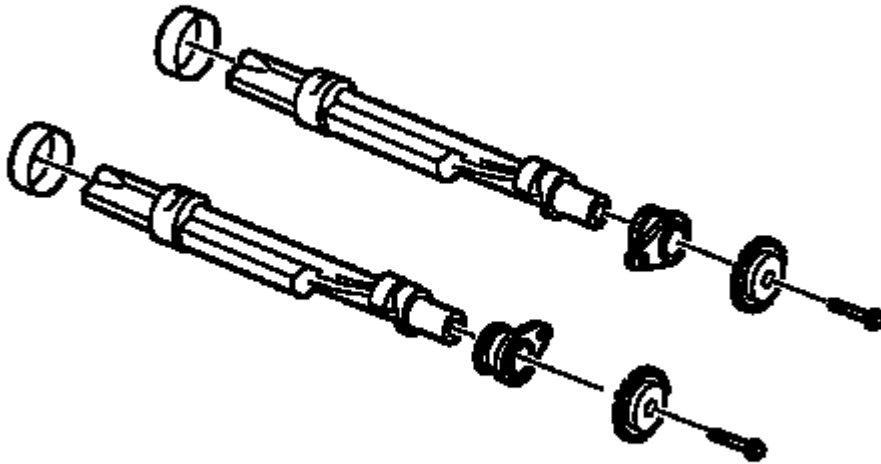


Fig. 453: Identifying Balance Shafts
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shafts in solvent.
2. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.
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

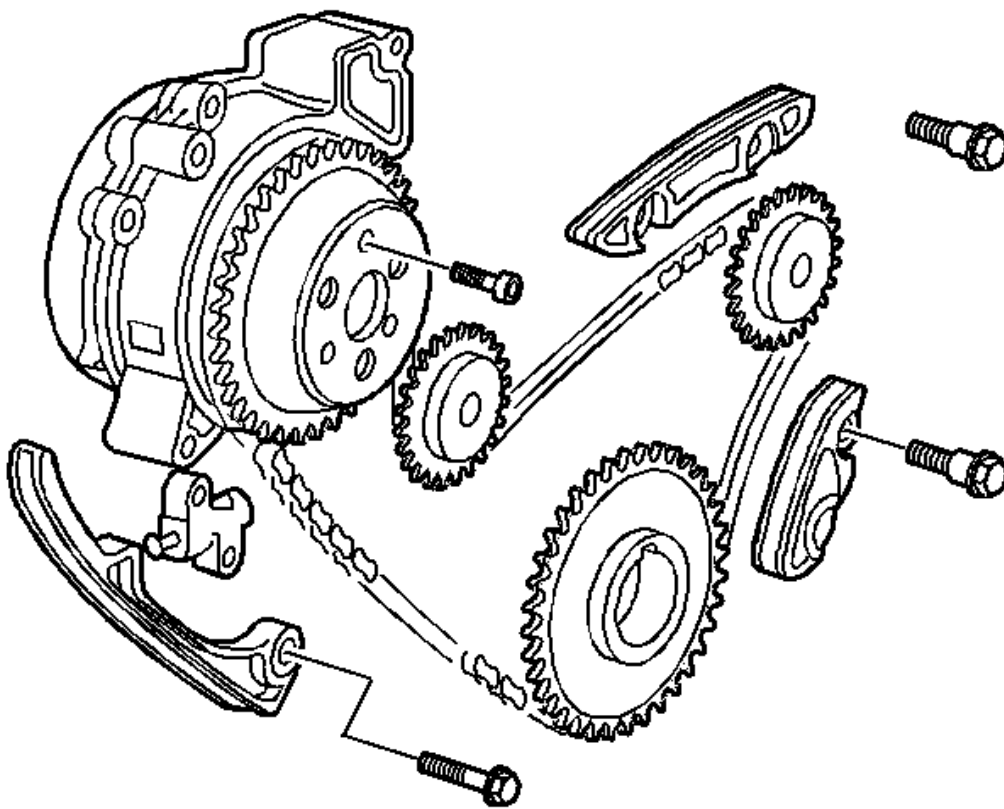


Fig. 454: Inspecting Balance Shaft Drive Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

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.

IMPORTANT: The crankshaft sprocket is not serviceable.

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

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 36017** Valve Seal Remover. See **Special Tools**.
- **J 43963** Valve Spring Compressor (off car). See **Special Tools**.

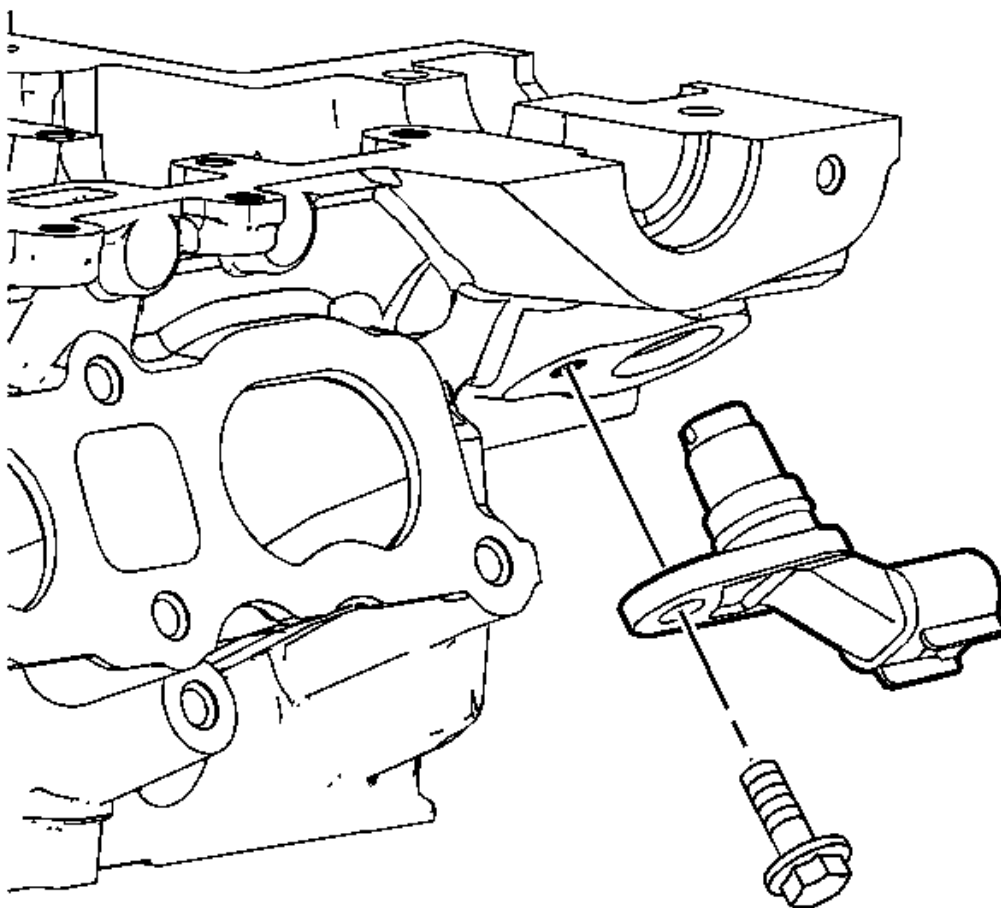


Fig. 455: View Of Intake Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position sensor and bolt.

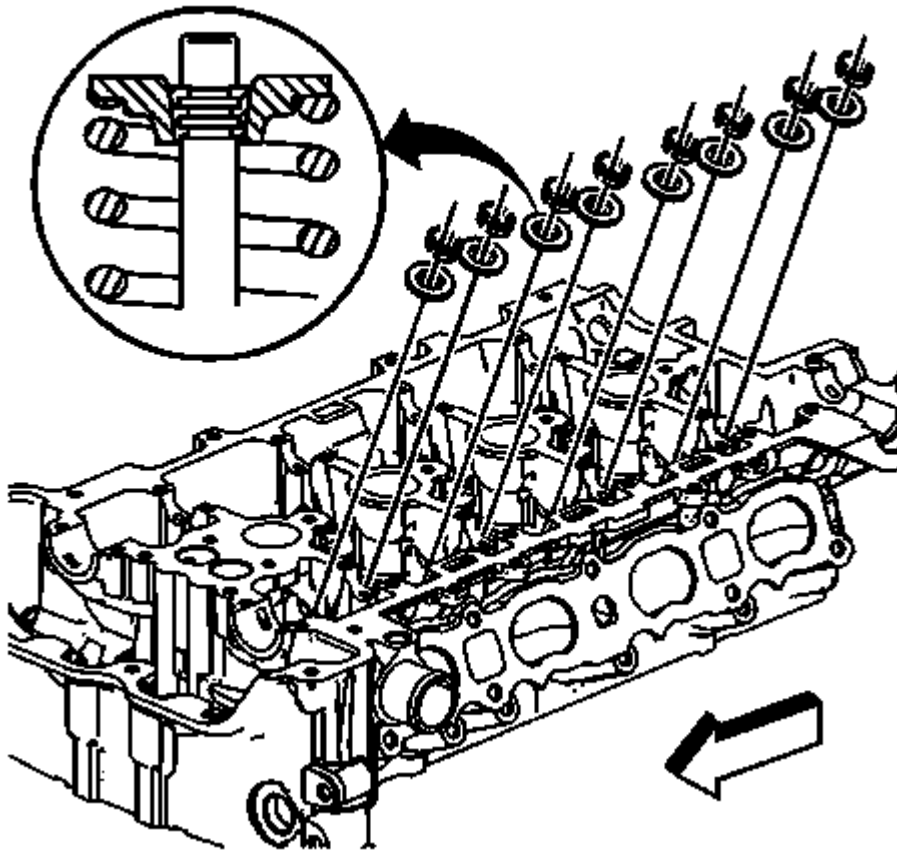


Fig. 456: View Of Valve Train Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

2. Using the **J 8062** and the **J 43963** , compress the valve spring. See **Special Tools**.
3. Remove the valve keys.
4. Slowly release the **J 8062** and the **J 43963** from the valve spring assembly. See **Special Tools**.
5. Remove the retainer.

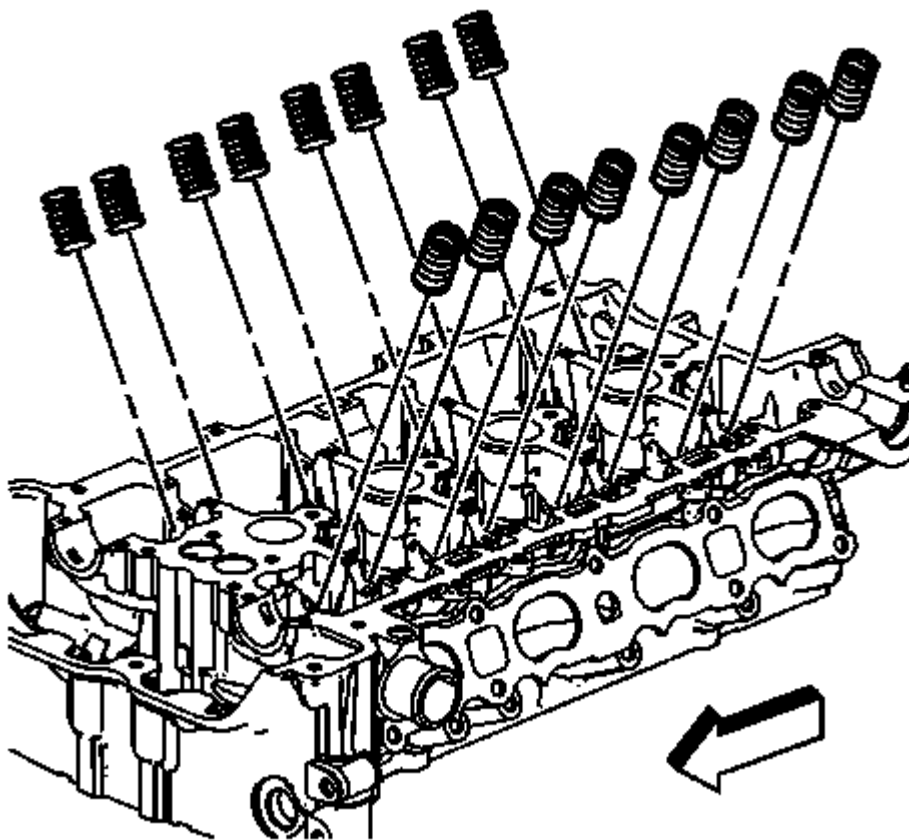


Fig. 457: View Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Remove the spring.

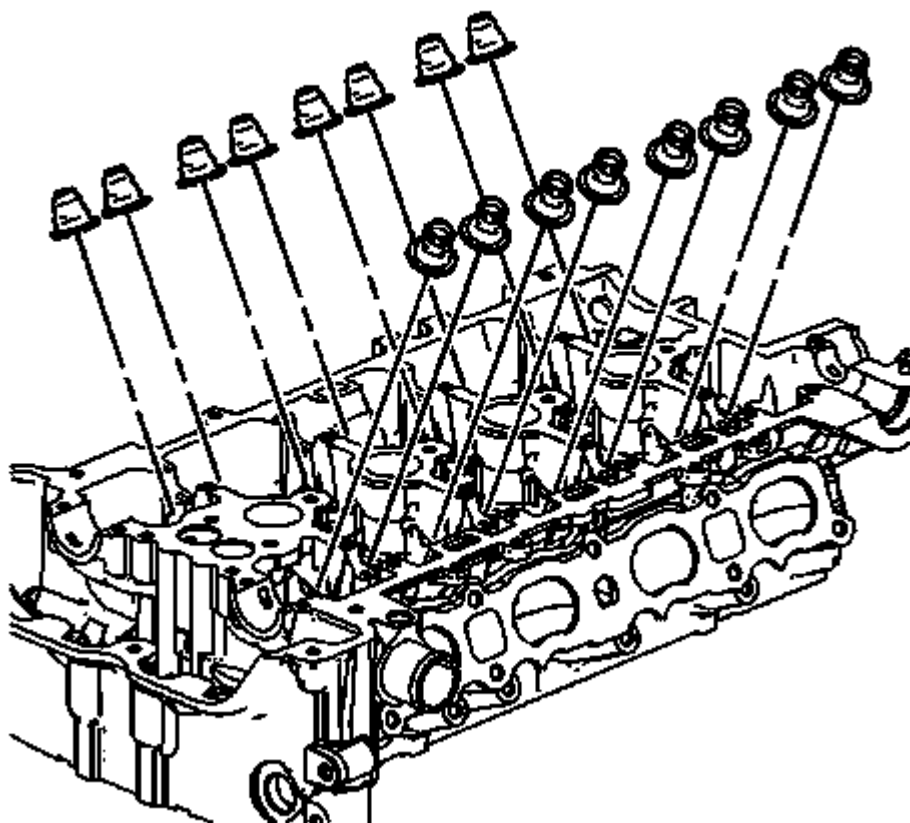


Fig. 458: View Of Valve Guides

Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

7. Using the **J 36017** , remove the valve seal. See **Special Tools**. Do not reuse the valve seal.

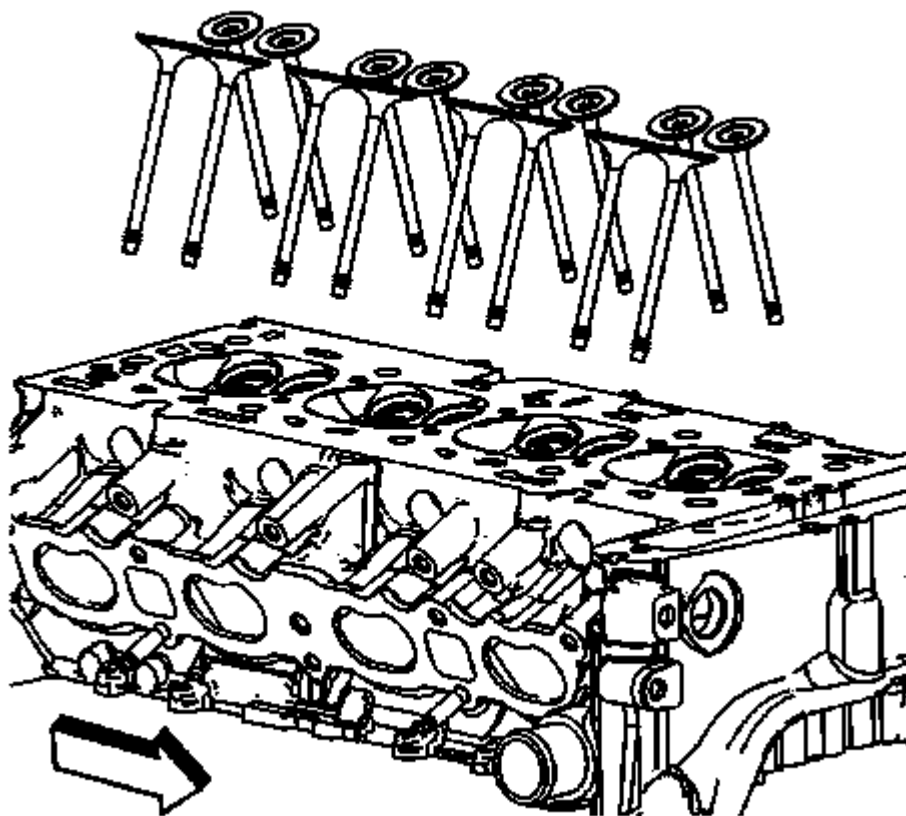


Fig. 459: View Of Valves

Courtesy of GENERAL MOTORS CORP.

8. Remove the valve.
9. Remove the remaining valves.

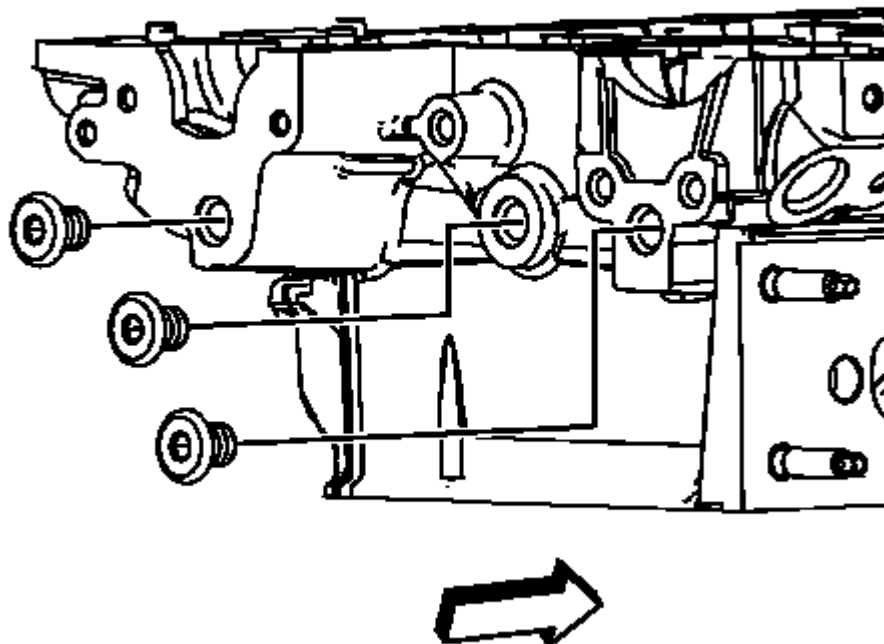


Fig. 460: Locating Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plugs.

CYLINDER HEAD CLEANING AND INSPECTION

Valve Cleaning and Inspection

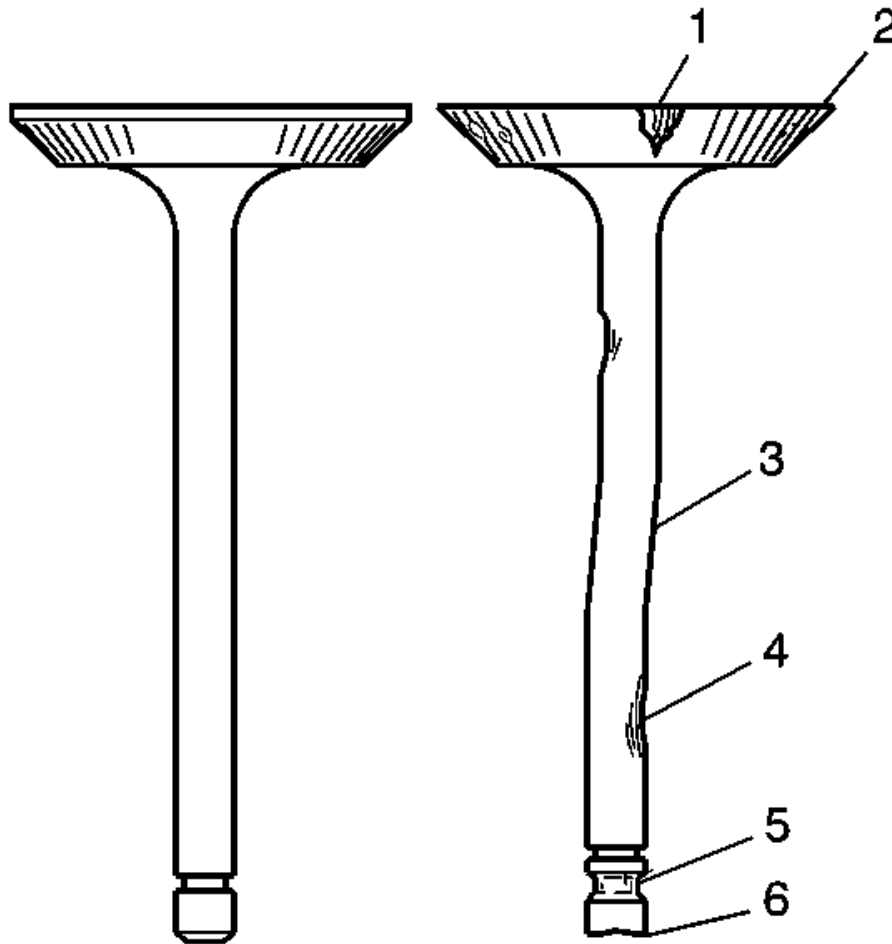


Fig. 461: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not scratch the valve stem with the wire brush.

1. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush. Varnish can be removed by soaking in Parts Immersion Solvent GM P/N 12345368 (Canadian P/N 10953514) or equivalent.
2. Clean the valve guides.
3. Inspect the valve stem for wear (4).
4. Inspect the valve keeper 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 and the valve head for bending or distortion (3) 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. The valves may be lightly lapped to the valve seats.

Cylinder Head and Gasket Surface Cleaning and Inspection

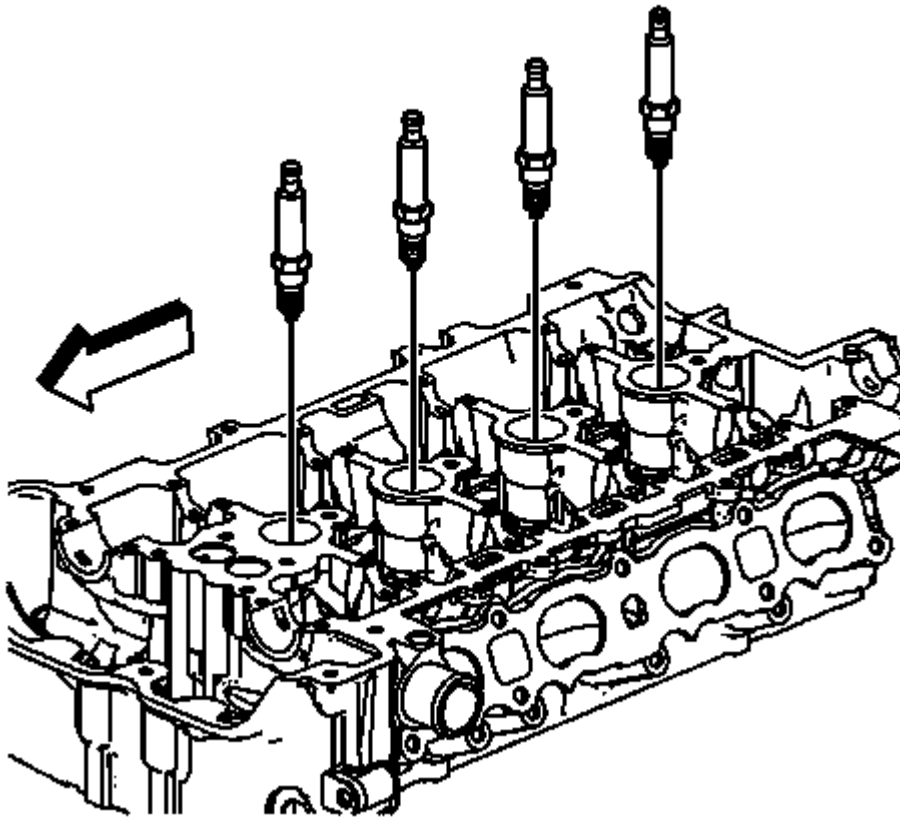


Fig. 462: Identifying Spark Plugs
Courtesy of GENERAL MOTORS CORP.

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

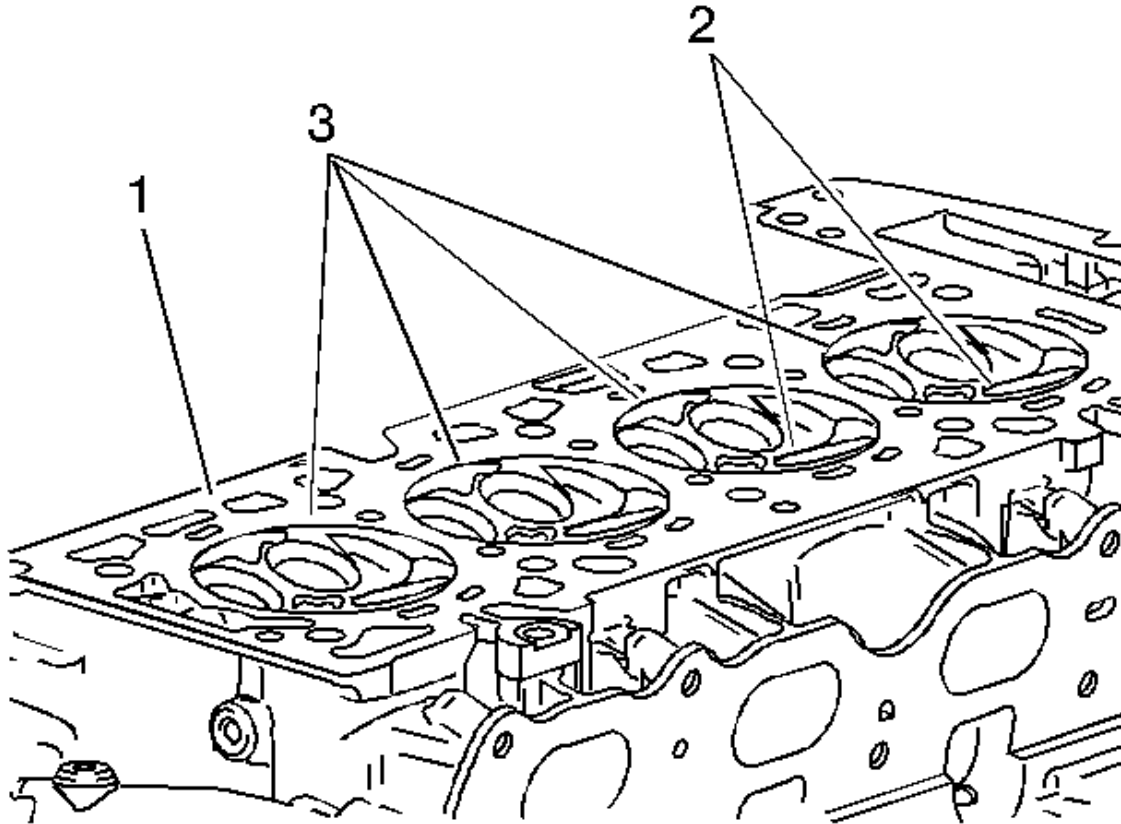


Fig. 463: Locating Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head gasket surface.
 - The 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.

IMPORTANT: Do not use a wire brush on any gasket sealing surface.

5. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
6. Clean the valve guides.
7. Clean the threaded holes. Use a nylon bristle brush.
8. Clean the remains of the sealer from the plug holes.
9. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
10. Replace all suspect bolts.
11. Inspect the cylinder head for cracks. Inspect between the valve seats and in the exhaust ports.

IMPORTANT: Do not attempt to weld the cylinder head; replace it.

12. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

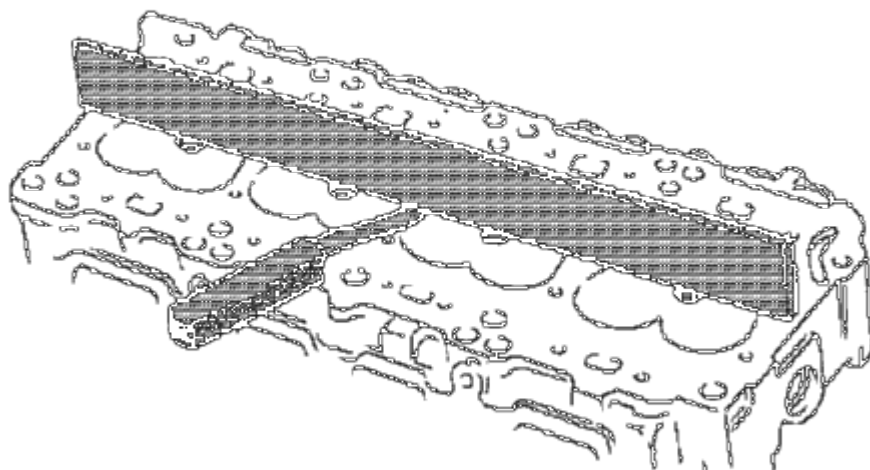


Fig. 464: Inspecting Cylinder Head Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

13. 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.
14. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.

15. Inspect the sealing surfaces.

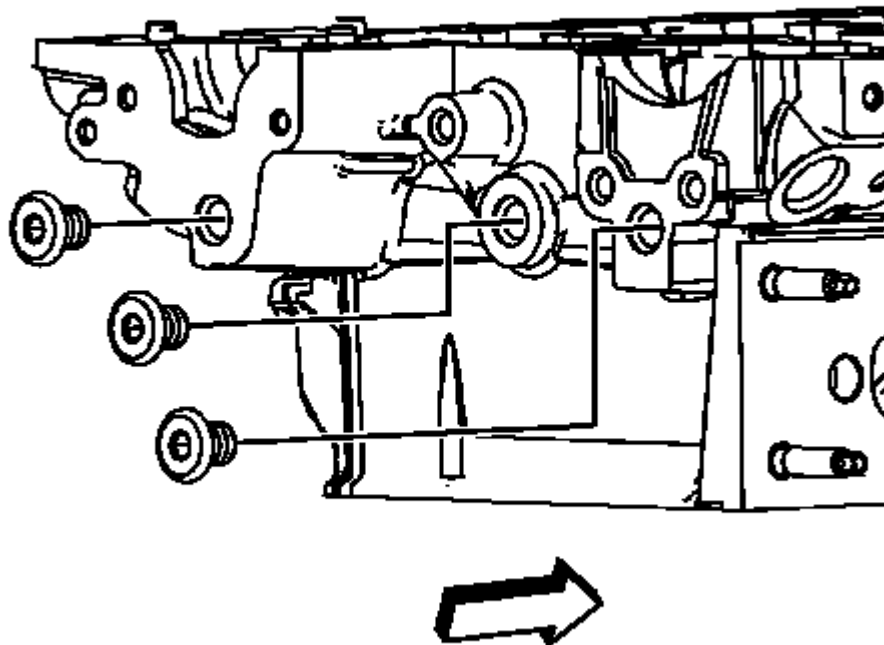


Fig. 465: Locating Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder head plugs.

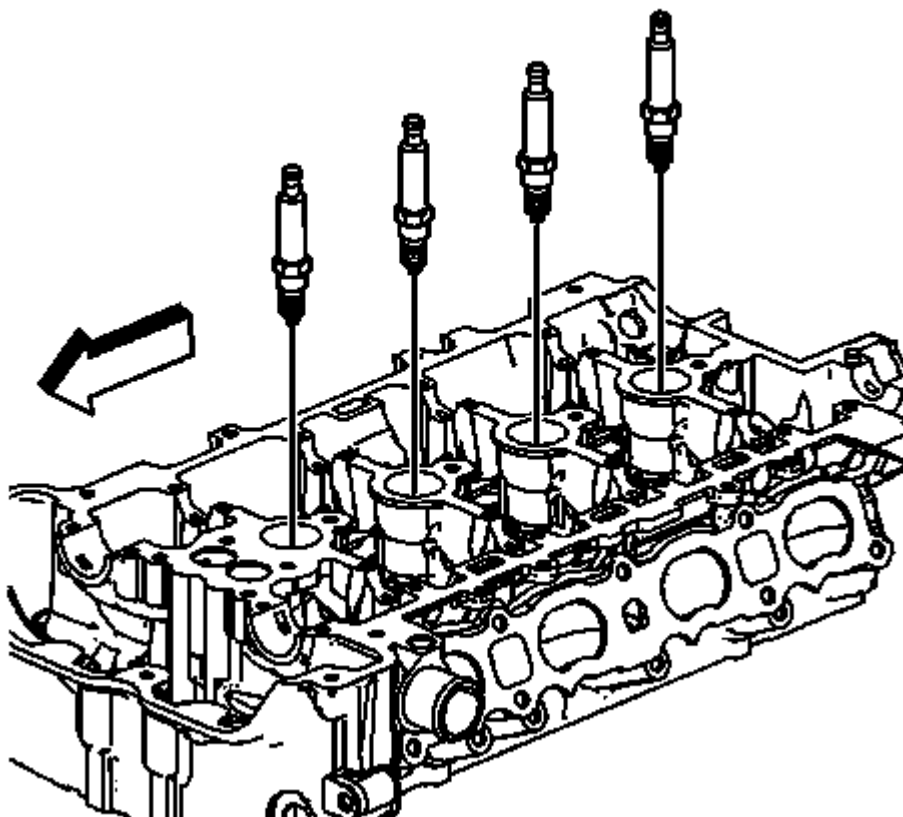


Fig. 466: Identifying Spark Plugs
Courtesy of GENERAL MOTORS CORP.

17. Install the spark plugs.

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

CYLINDER HEAD ASSEMBLE

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools**.
- **J 9666** Valve Spring Tester. See **Special Tools**.
- **J 43963** Valve Spring Compressor (off car). See **Special Tools**.

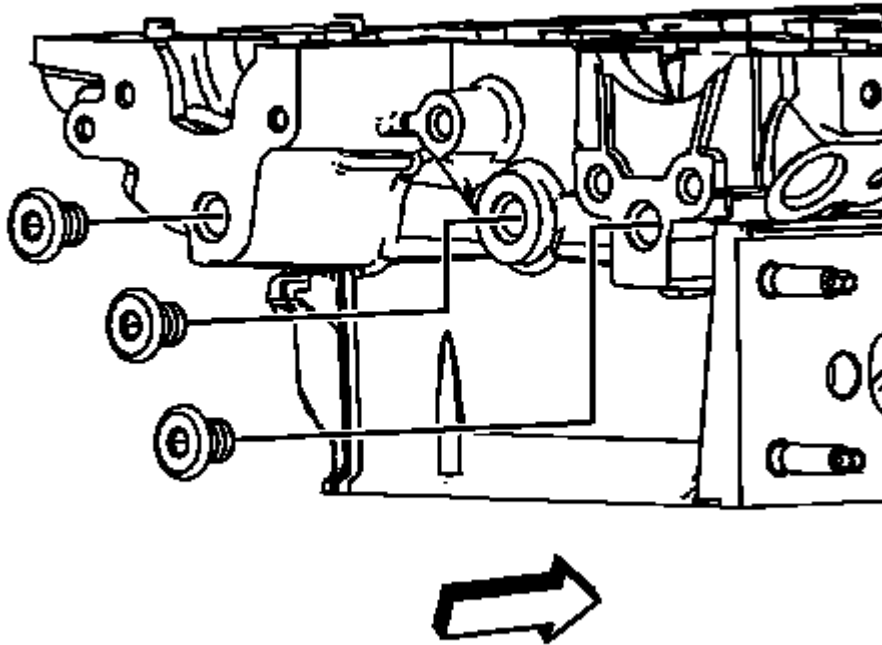


Fig. 467: Locating Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

1. Install NEW cylinder head plugs. Coat the plugs with sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent.
2. Inspect the valve springs.
3. Look for the following conditions when inspecting the valve springs:
 - Expanded height
 - Unparallel spring ends
 - Spring tension using **J 9666** . See **Special Tools**.
 - Any distorted springs should be replaced

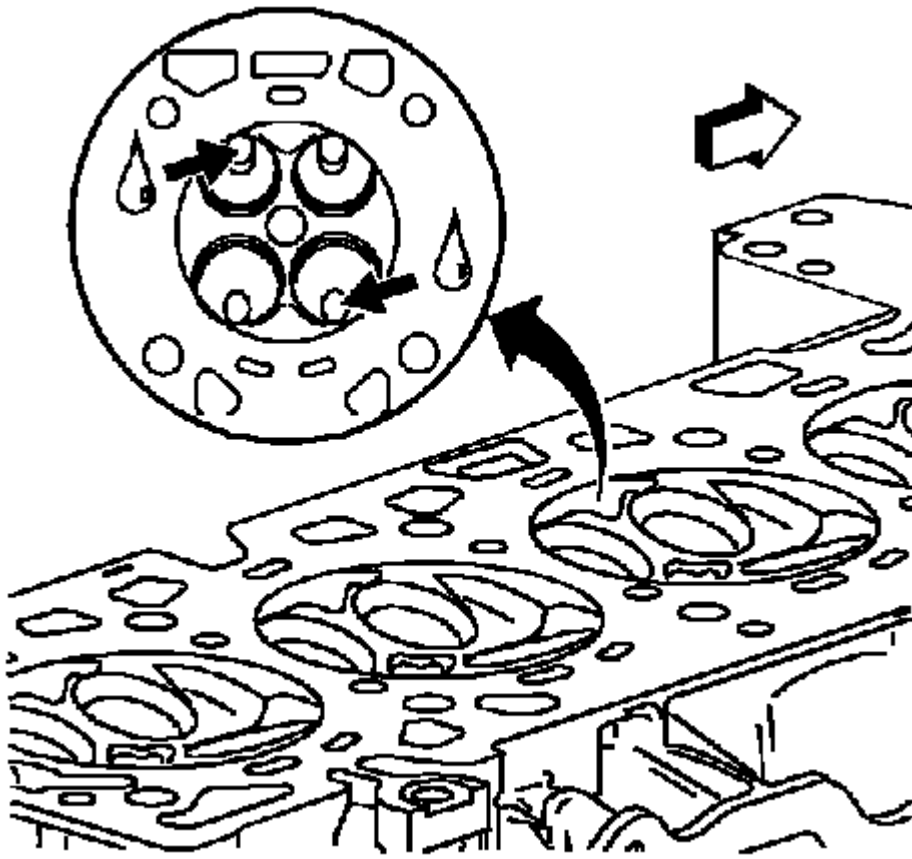


Fig. 468: Applying Prussian Blue
Courtesy of GENERAL MOTORS CORP.

4. Assemble the valves.
5. Use the following steps to measure valve runout:
 1. Apply a dab of Prussian blue on the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.
 2. Clean all traces of Prussian blue.
 3. Apply a dab of Prussian blue on the valve seat and repeat the inspection. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.

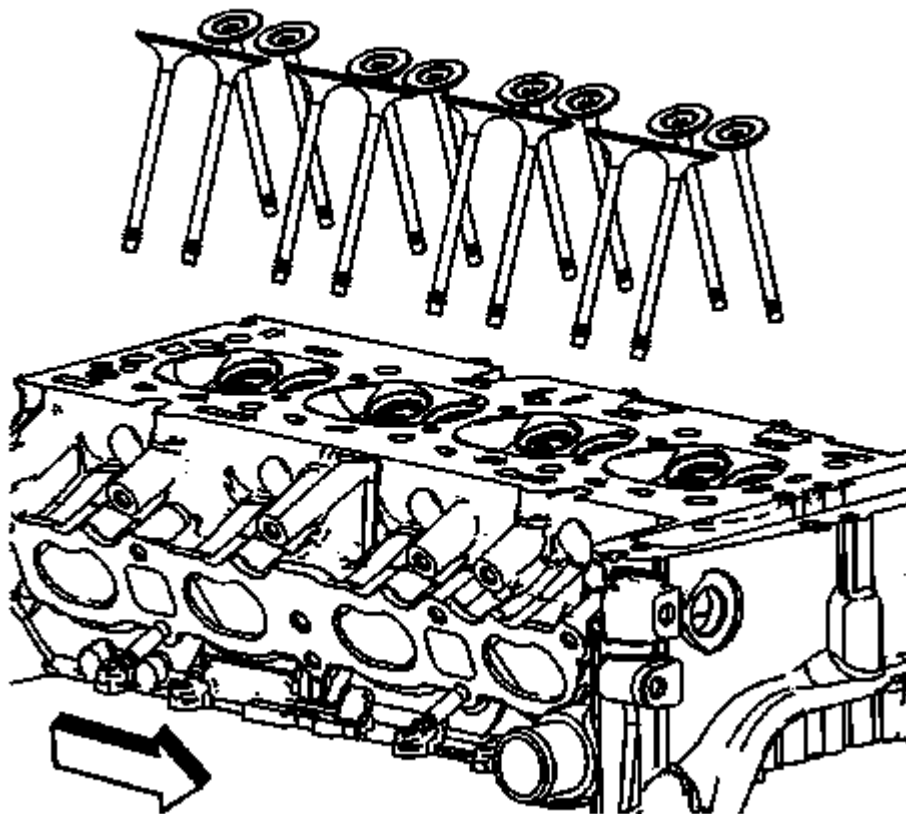


Fig. 469: View Of Valves

Courtesy of GENERAL MOTORS CORP.

6. Replace the valves, if required.

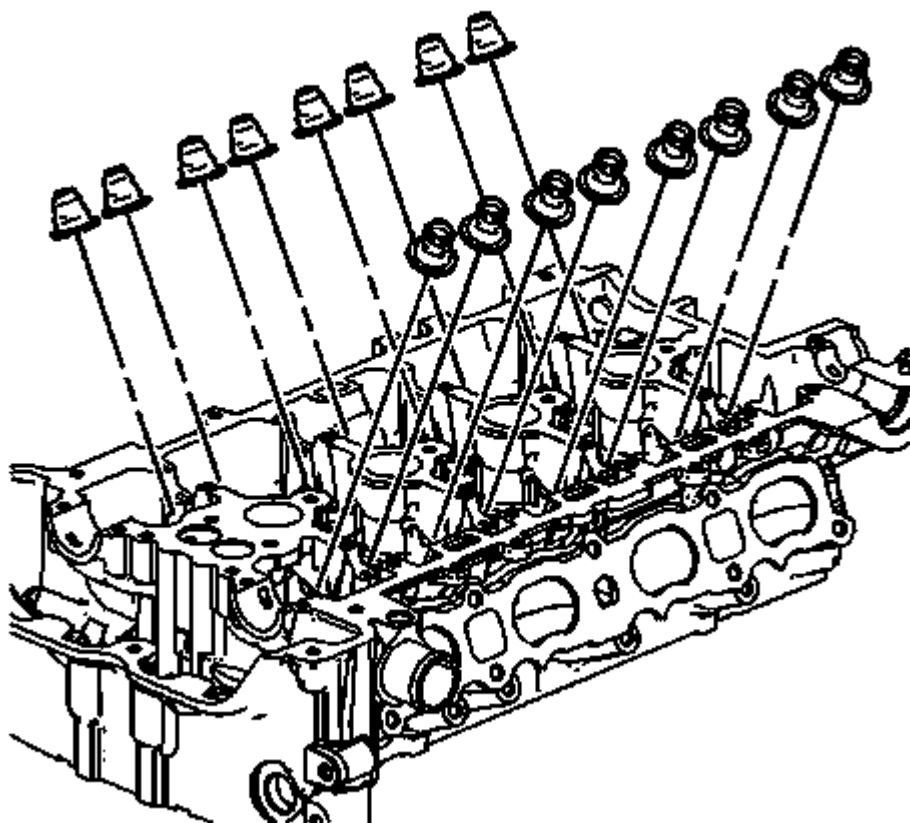


Fig. 470: View Of Valve Guides

Courtesy of GENERAL MOTORS CORP.

7. Install the new valve seals. Fully seat the seals on the valve guides.

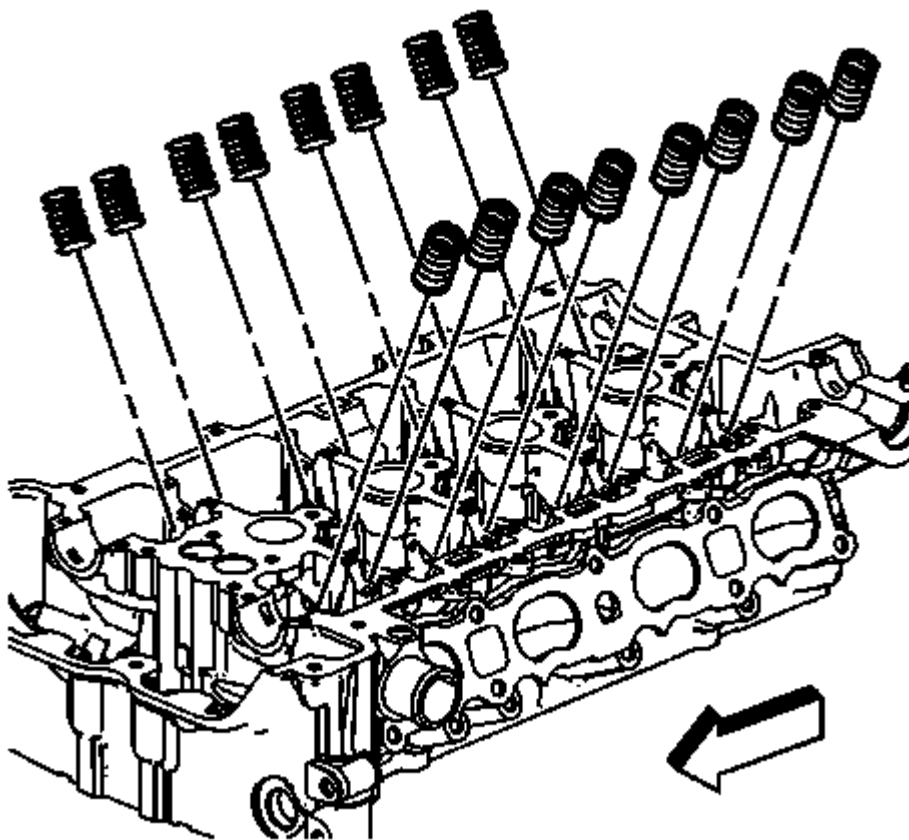


Fig. 471: View Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

8. Install the springs.

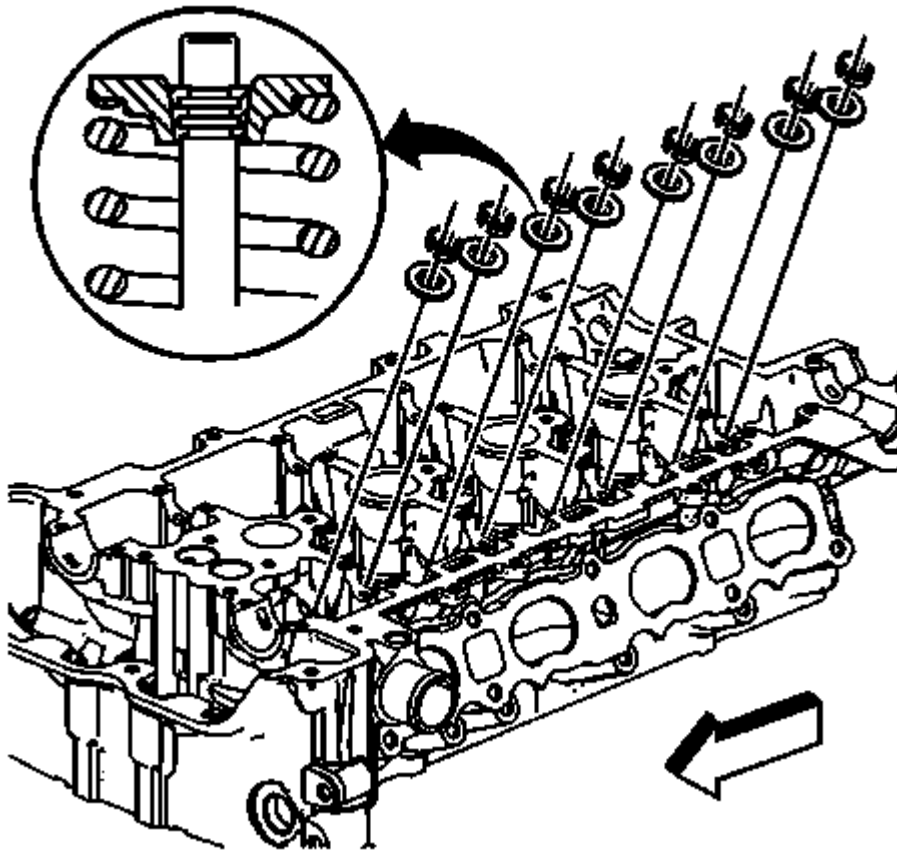


Fig. 472: View Of Valve Train Components
Courtesy of GENERAL MOTORS CORP.

9. Install the retainer.
10. Using the **J 8062** and the **J 43963** , compress the valve spring. See **Special Tools**.
11. Install the valve keys.
12. Slowly release the **J 8062** and the **J 43963** from the valve/spring assembly. See **Special Tools**.
13. Inspect for proper valve key seating.
14. Install the remaining valves, springs, and other components.

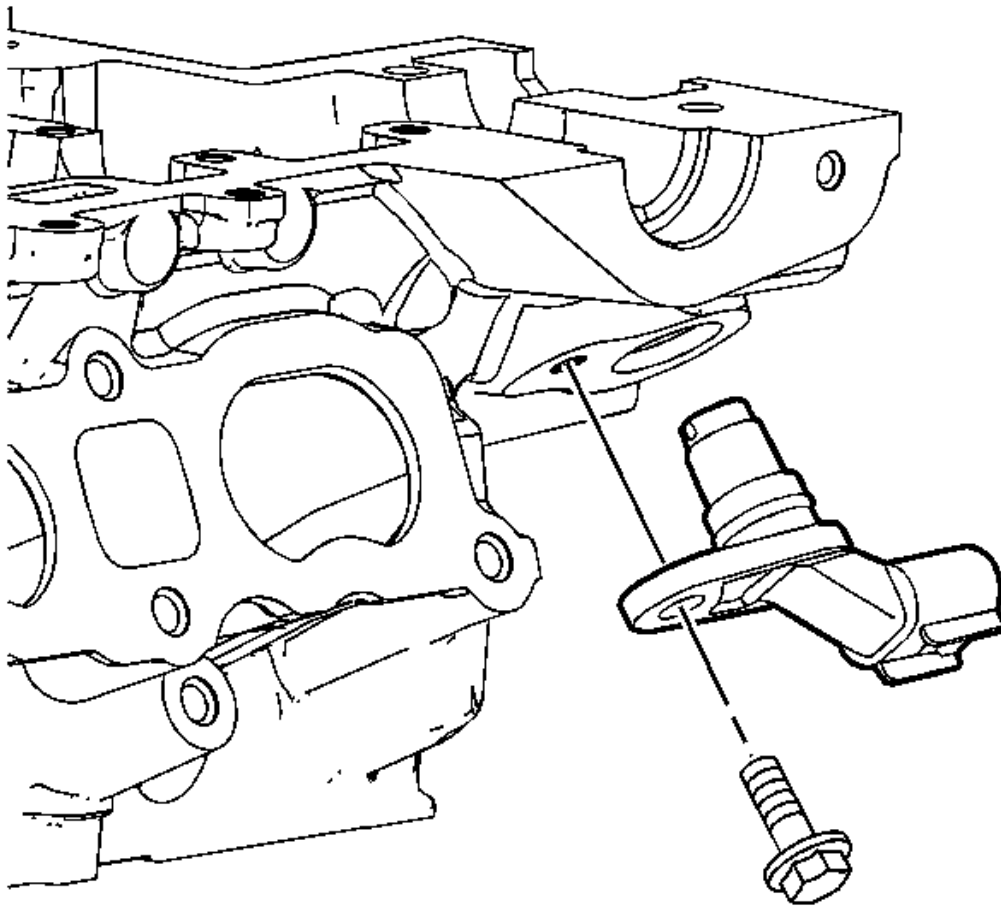


Fig. 473: View Of Intake Camshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

15. Lubricate the camshaft position sensor O-ring with clean engine oil.
16. Install the intake camshaft position sensor and bolt.

Tighten: Tighten the intake camshaft position sensor bolt to 10 N.m (89 lb in).

OIL PUMP DISASSEMBLE

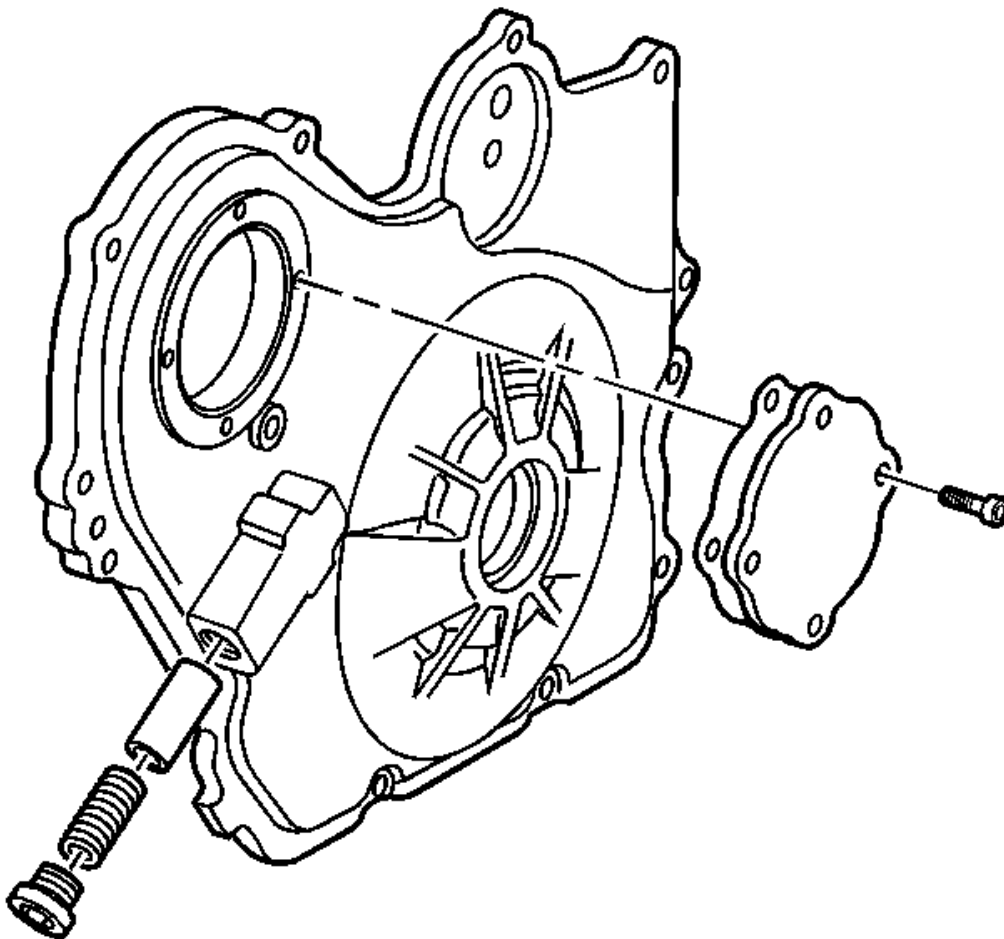


Fig. 474: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

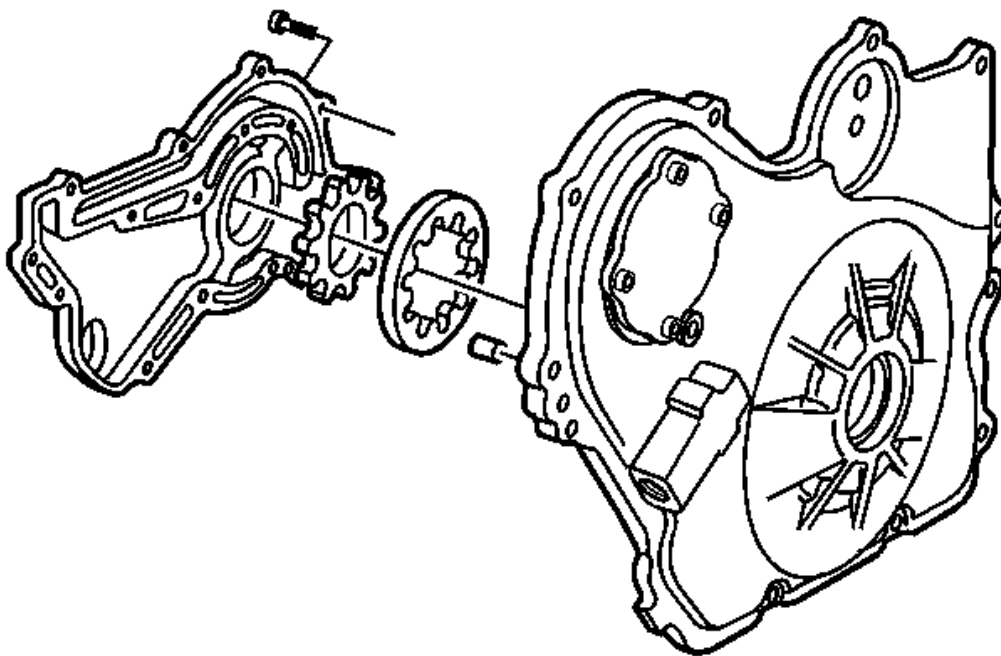


Fig. 475: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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. Ensure that all components are within specifications. Refer to **Engine Mechanical Specifications**.
5. Replace the front cover and oil pump assembly if it is out of specification or damaged.

OIL PUMP ASSEMBLE

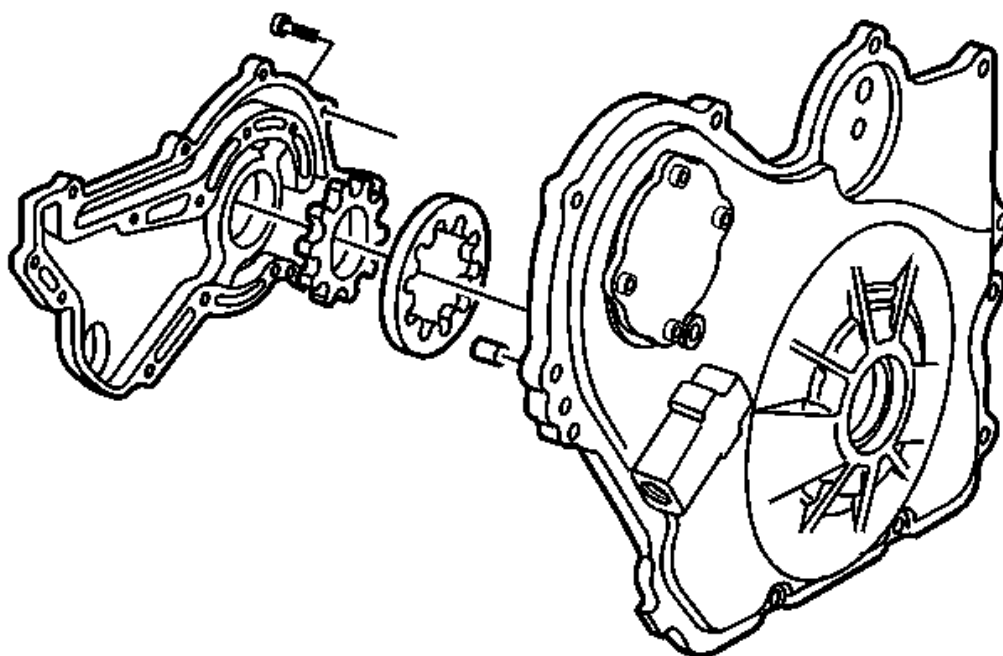


Fig. 476: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

IMPORTANT: 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.

NOTE: Refer to Fastener Notice .

4. Install the oil pump gerotor cover and bolts.

Tighten: Tighten the oil pump gerotor bolts to 6 N.m (53 lb in).

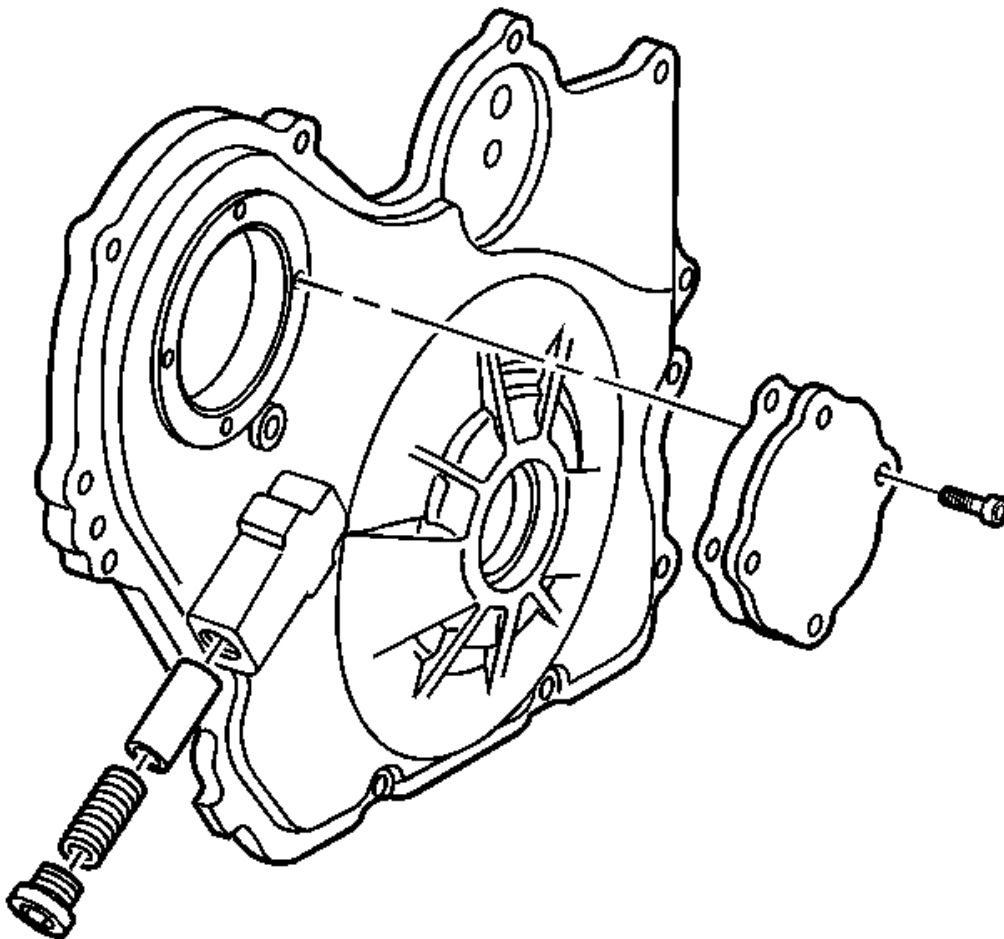


Fig. 477: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure relief valve piston.
6. Install the pressure relief valve spring.

Tighten: Tighten the pressure relief valve plug to 40 N.m (30 lb ft).

TURBOCHARGER CLEANING AND INSPECTION

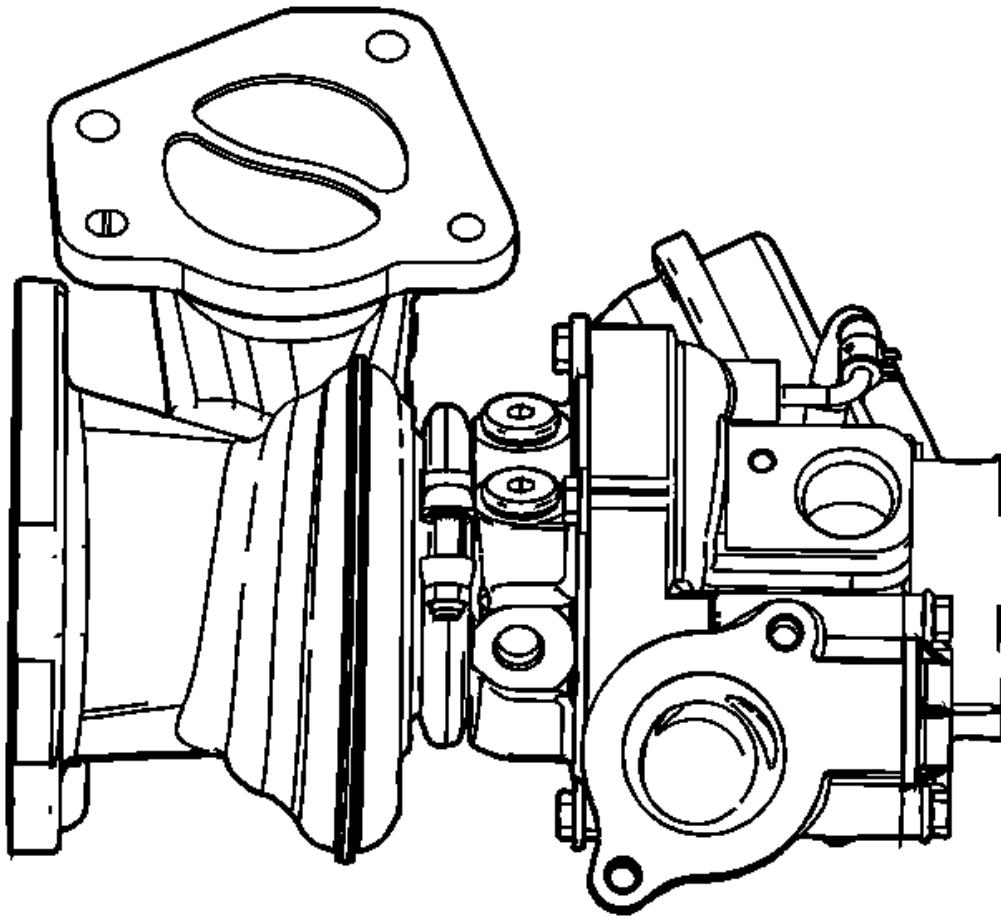


Fig. 478: View Of Turbocharger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Refer to Symptoms - Engine Mechanical.

1. Clean all mating surfaces.
2. Inspect all threaded holes for damage.
3. Inspect the wastegate actuator rod for damage.
4. Inspect the compressor and turbine blades for damage or foreign material.
5. Clean the turbocharger inlet mating surfaces.
6. Inspect the turbocharger inlet mating surfaces for damage. Replace the turbocharger if damage is found.

7. Inspect the turbocharger wastegate regulator solenoid hoses for damage. Replace the hoses if necessary.

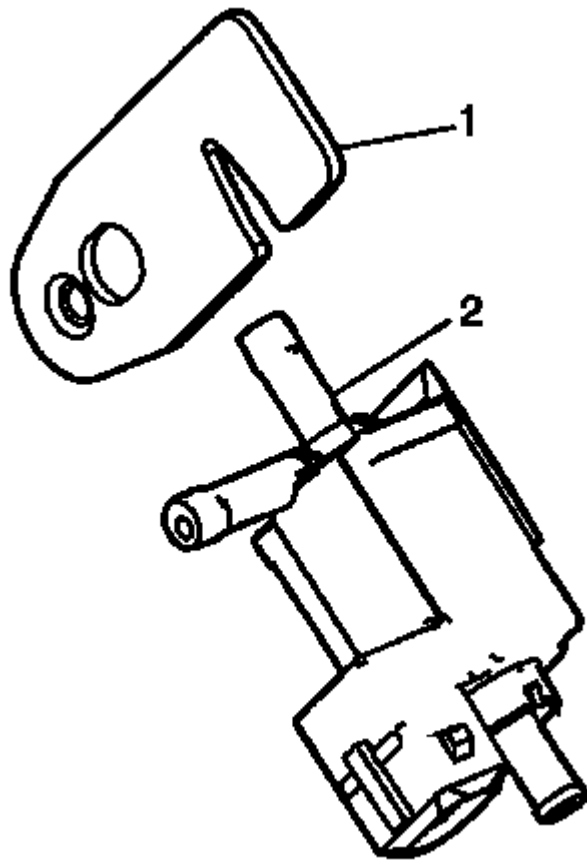


Fig. 479: View Of Turbocharger Wastegate Regulator Solenoid Valve Assembly & Bracket
Courtesy of GENERAL MOTORS CORP.

8. Inspect the turbocharger wastegate regulator solenoid valve assembly and bracket. Replace if necessary.

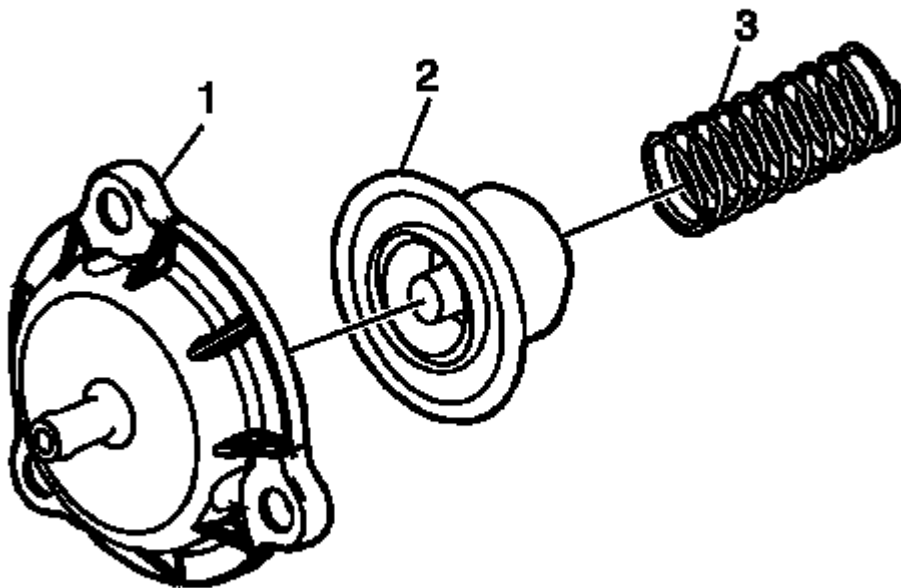


Fig. 480: View Of Turbocharger Air Bypass Diaphragm Assembly
Courtesy of GENERAL MOTORS CORP.

9. Inspect the turbocharger air bypass diaphragm assembly, valve cover, and valve spring. Replace if necessary.

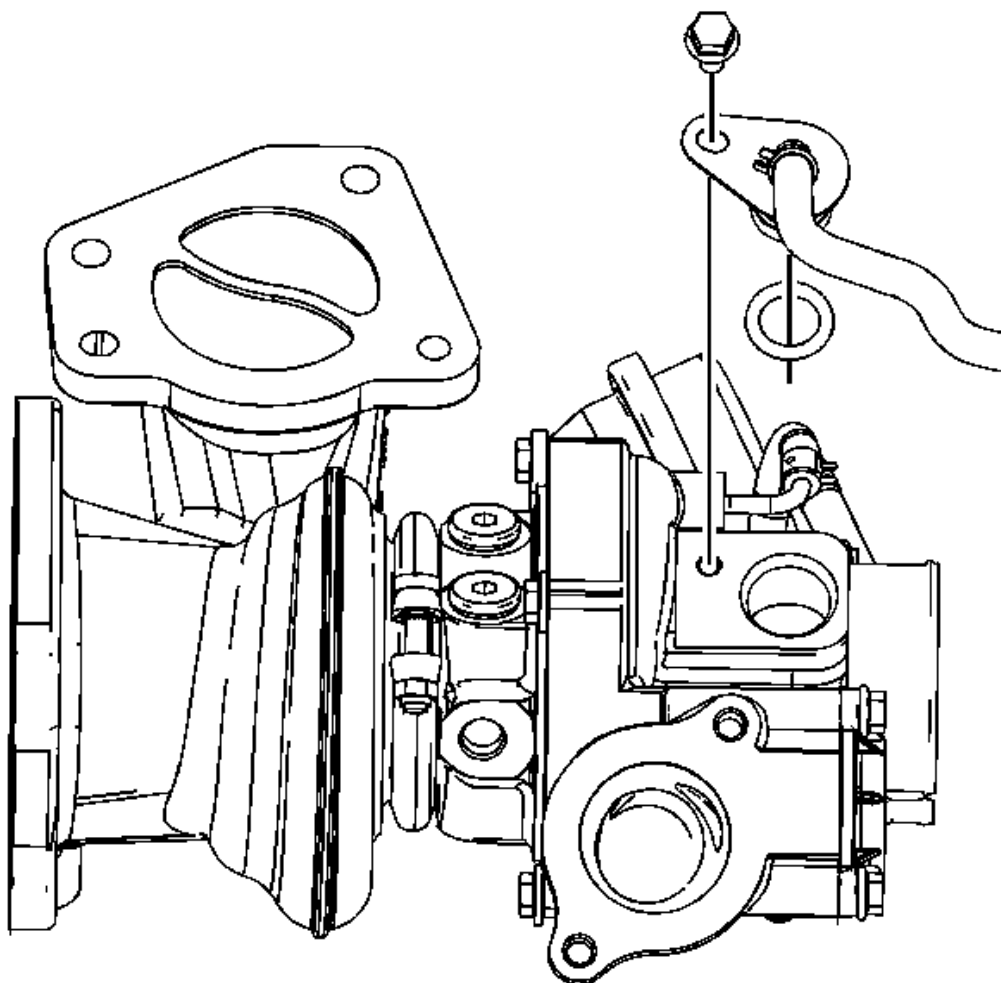


Fig. 481: PCV Fitting Bolt

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the PCV hose from the fitting as damage to the hose will occur.

10. Inspect the positive crankcase ventilation (PCV) O-ring for damage. Replace the O-ring if damaged or leaking.
11. Inspect the PCV hose and PCV fitting for damage. Replace the camshaft cover if damage to the PCV hose or fitting is present.

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Tools Required

- **EN-47909** Injector Bore and Sleeve Cleaning Kit
- **EN-48266** Injector Seal Installer and Sizer

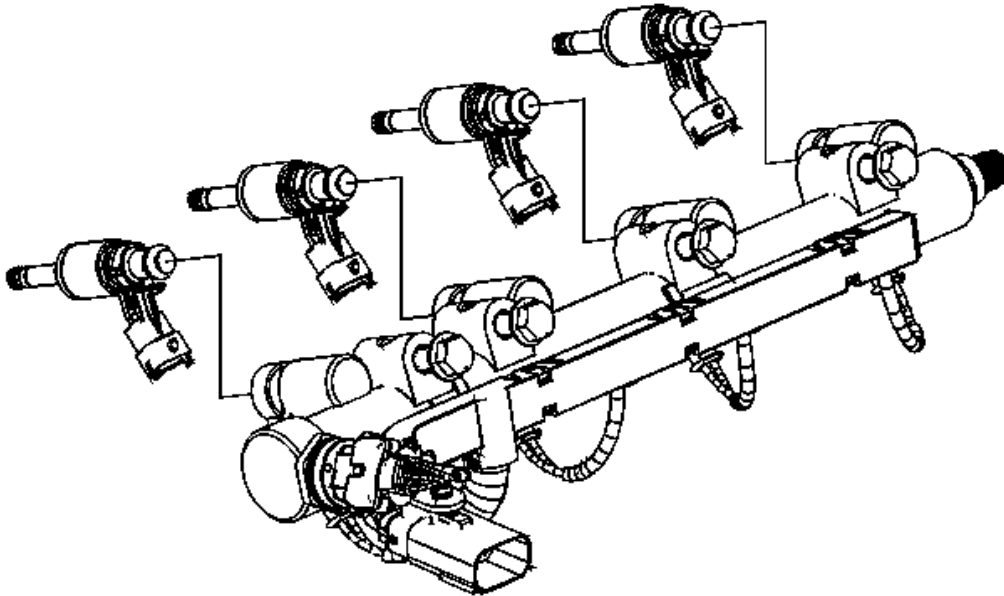


Fig. 482: View Of Injectors & Fuel Rail
Courtesy of GENERAL MOTORS CORP.

1. Unplug the electrical connections from the fuel injectors.
2. Remove the injectors from the fuel rail.

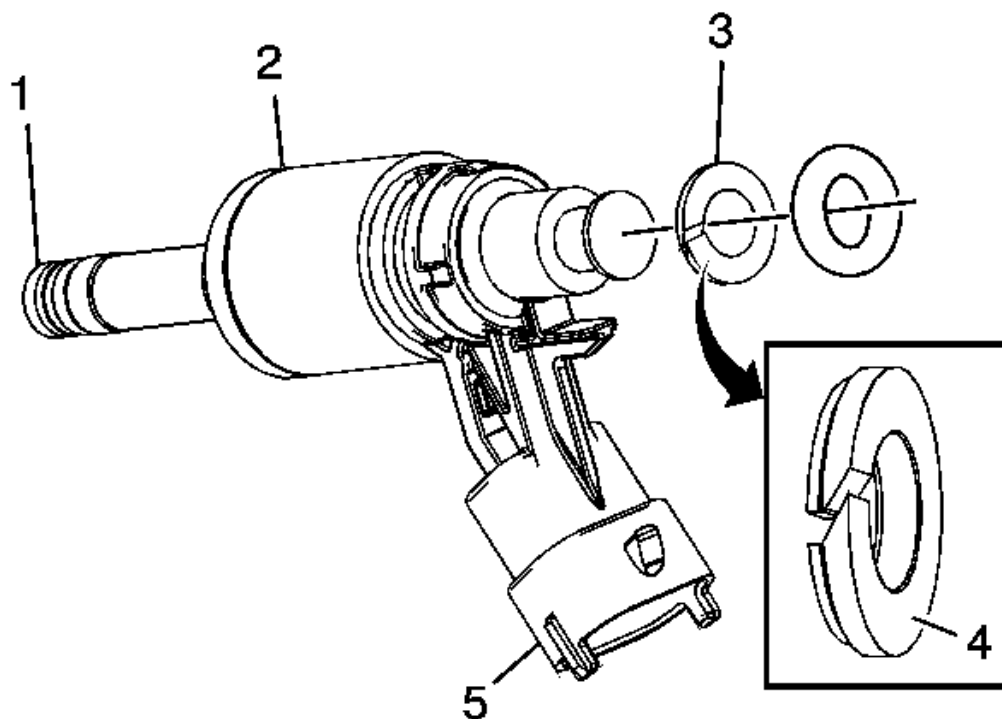


Fig. 483: View Of Fuel Injector Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the fuel injector hold-down clamp.
4. Remove and discard the fuel injector O-ring and plastic spacer.

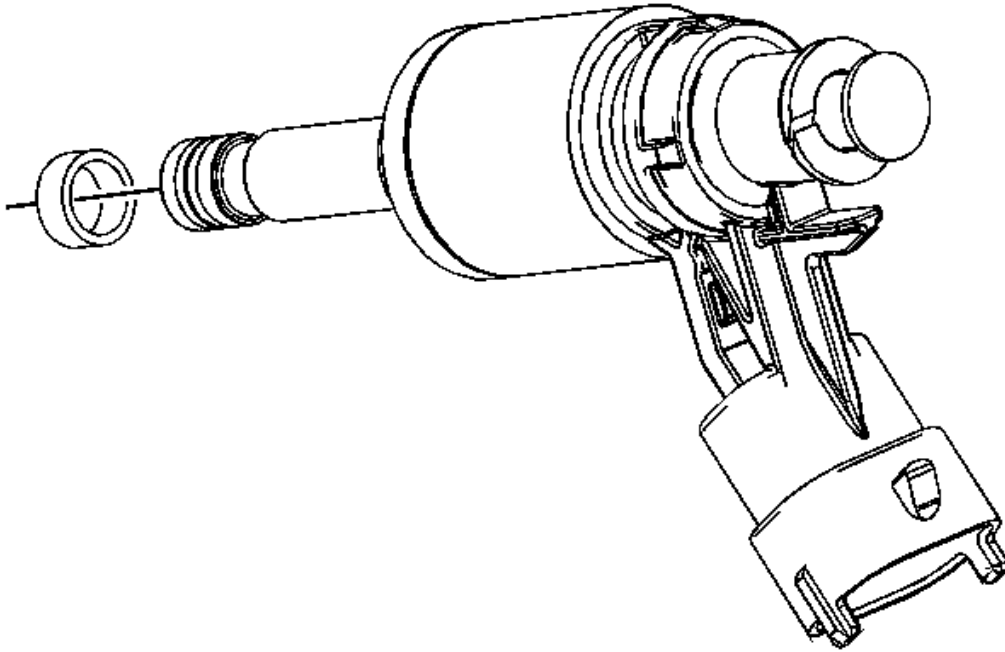


Fig. 484: View Of Fuel Injector Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the fuel injector seal.

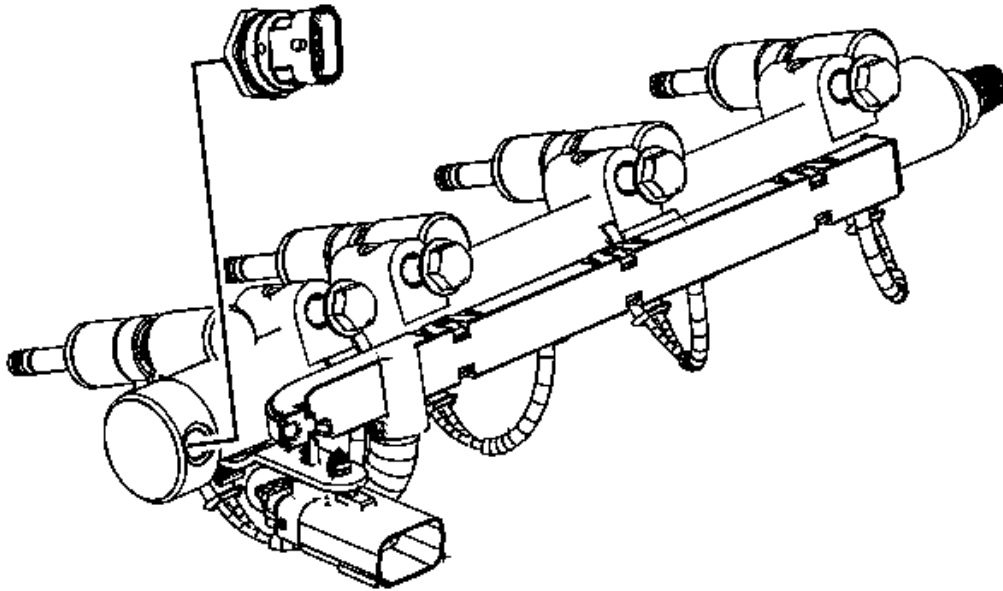


Fig. 485: View Of High Pressure Fuel Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not soak or submerge the fuel rail or injectors in solvent.

6. Clean the exterior of the fuel rail and injectors in solvent.

NOTE: Refer to **Fastener Notice** .

7. Inspect the high pressure fuel sensor for damage.
 1. If replacing, dry the fuel pressure sensor bore in the fuel rail with a lint free cloth.
 2. The bore should be free of fuel, debris, and burrs.
 3. Lubricate the fuel pressure sensor bore, in the fuel rail, with clean engine oil.
 4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
 5. Install the new fuel pressure sensor hand tight.
 6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
 7. Re-install the fuel pressure sensor.

Tighten: Tighten the high pressure fuel sensor to 33 N.m (25 lb ft).

8. Clean the injector bore using the **EN-47909** .

9. Inspect the fuel rail and components for the following conditions:

- Damage, debris, or restrictions to the fuel rail
- Damage, debris, or restrictions to the fuel ports in the fuel rail
- Damage to the mounting area for the fuel rail
- Damage to the fuel rail mounting bolts
- Damage to the threads on the fuel rail fuel feed fitting

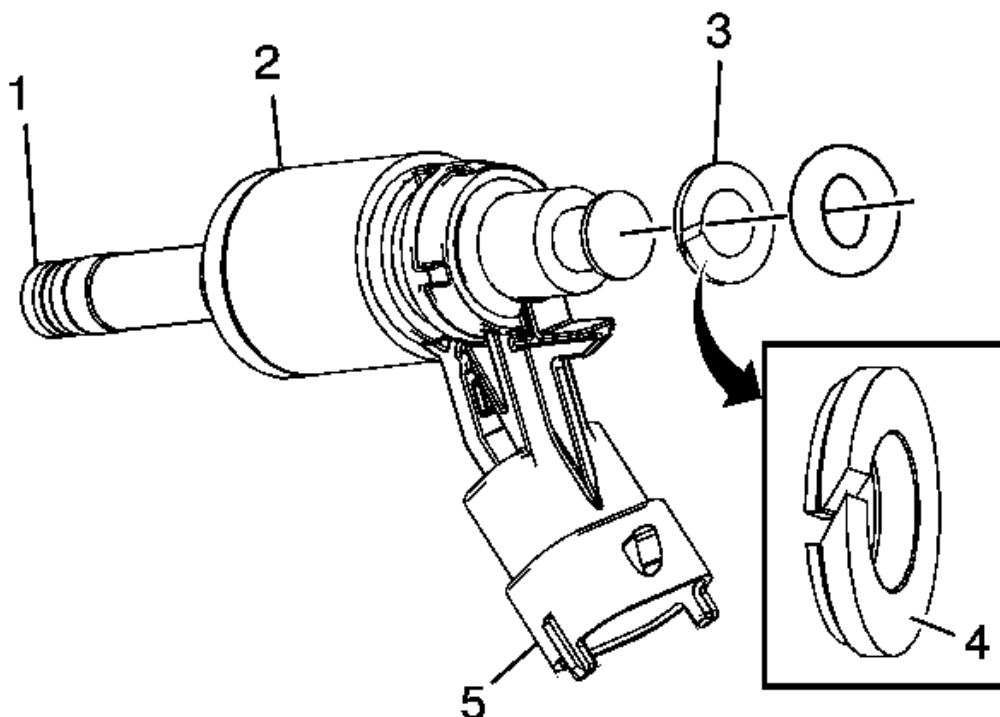


Fig. 486: Fuel Injector Assembly
 Courtesy of GENERAL MOTORS CORP.

10. Inspect the fuel injectors for the following conditions:

- Damage to the fuel injector connector (5)
- Damage to the fuel injector harness connector
- Damage to the plastic fuel injector spacer (3)
- Damage to the fuel injector tip (1)
- Damage to the tolerance ring (2)

11. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.

12. Lubricate the NEW O-ring with 5W30 engine oil.
13. Install a NEW O-ring and plastic spacer on the injector. The plastic spacer has a top (4) and a bottom. The top, O-ring sealing area, is wider.

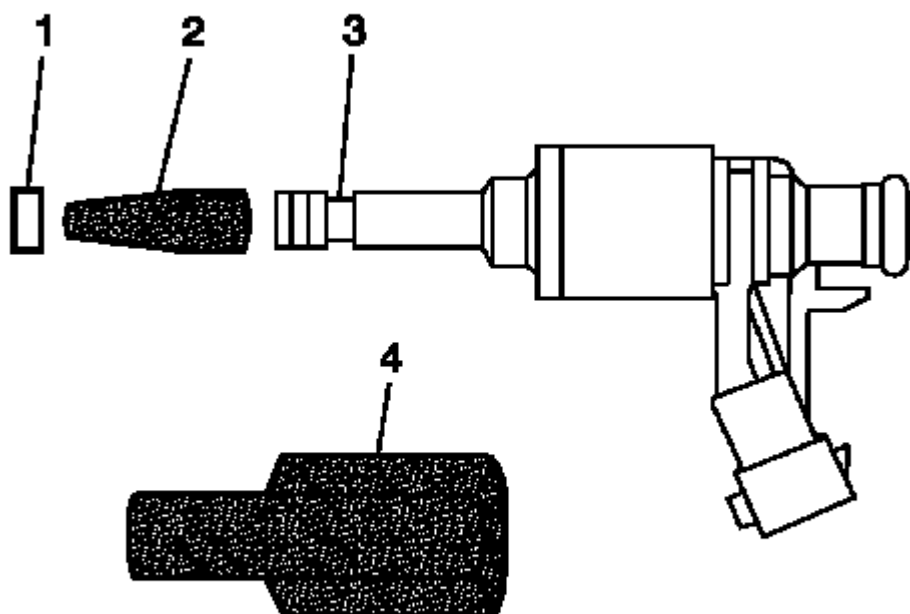


Fig. 487: Using The EN-48266-1
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type of lubricant when installing the NEW seal.

14. Install a NEW seal on the injector using the EN-48266-1. The seal must be installed/slid into the recessed area of the fuel injector. Compress the seal with your fingers before resizing the seal using the EN-48266-2.
15. Using the EN-48266-2, resize the seal.

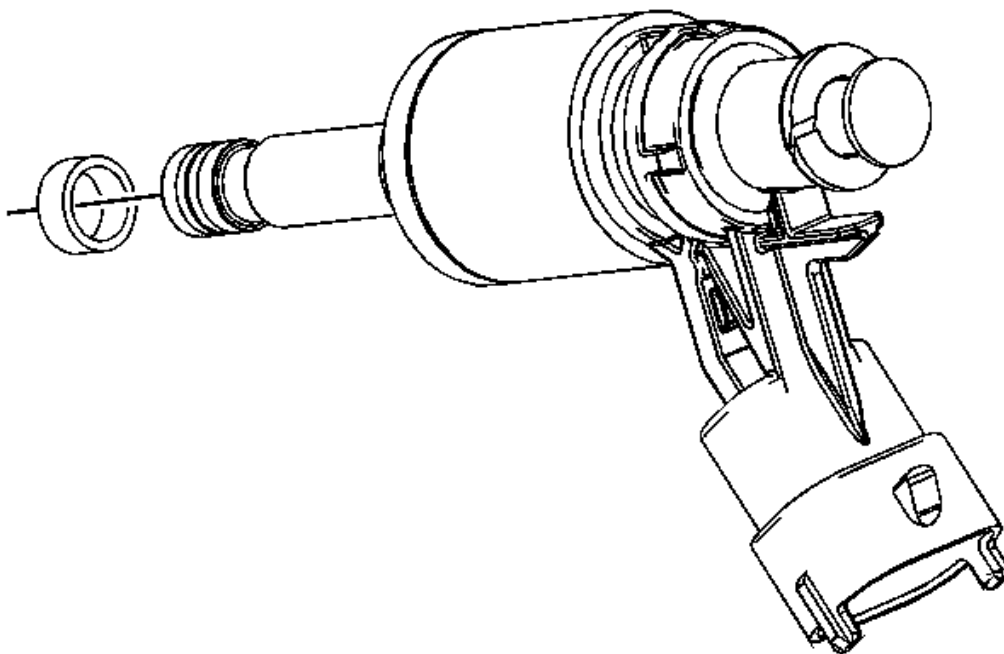


Fig. 488: View Of Fuel Injector Seal
Courtesy of GENERAL MOTORS CORP.

16. Install a NEW fuel injector hold-down clamp.
17. Install the injector into the fuel rail.
18. Connect the electrical connection to the fuel rail.

INTAKE MANIFOLD CLEANING AND INSPECTION

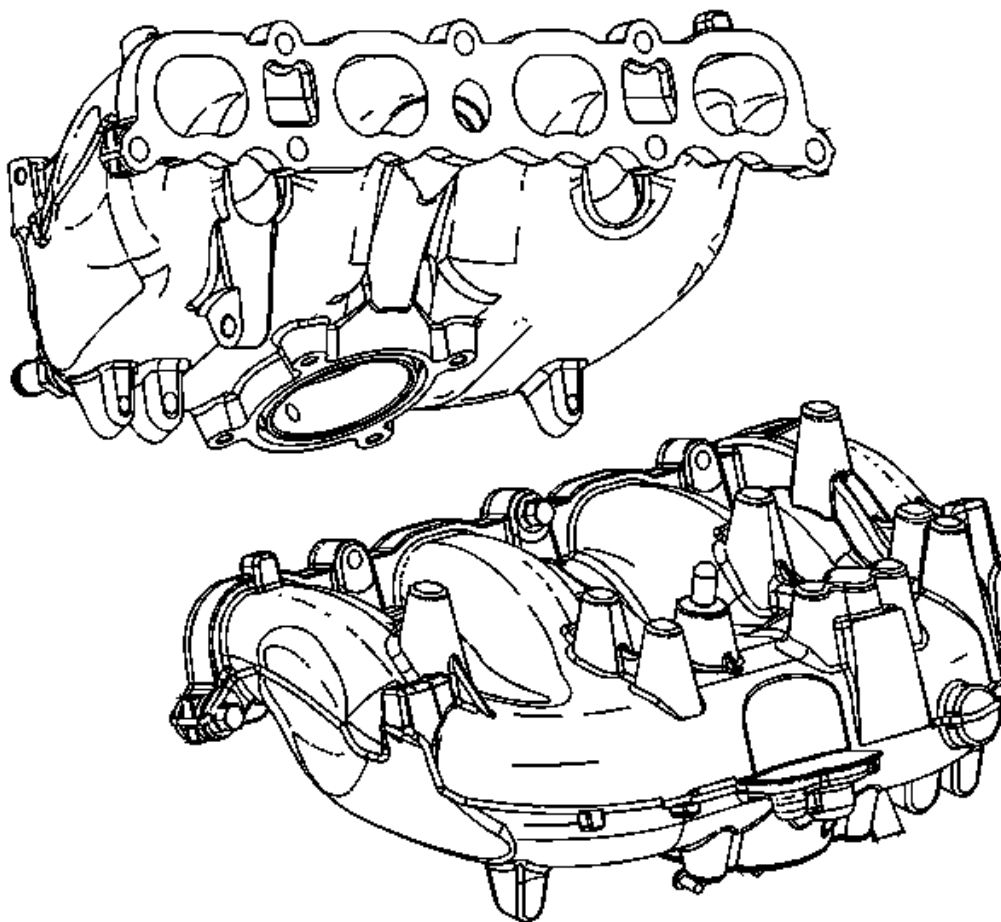


Fig. 489: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the intake manifold mating surfaces.
2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.
4. Inspect the crankcase ventilation passages in the intake manifold face for blockage.

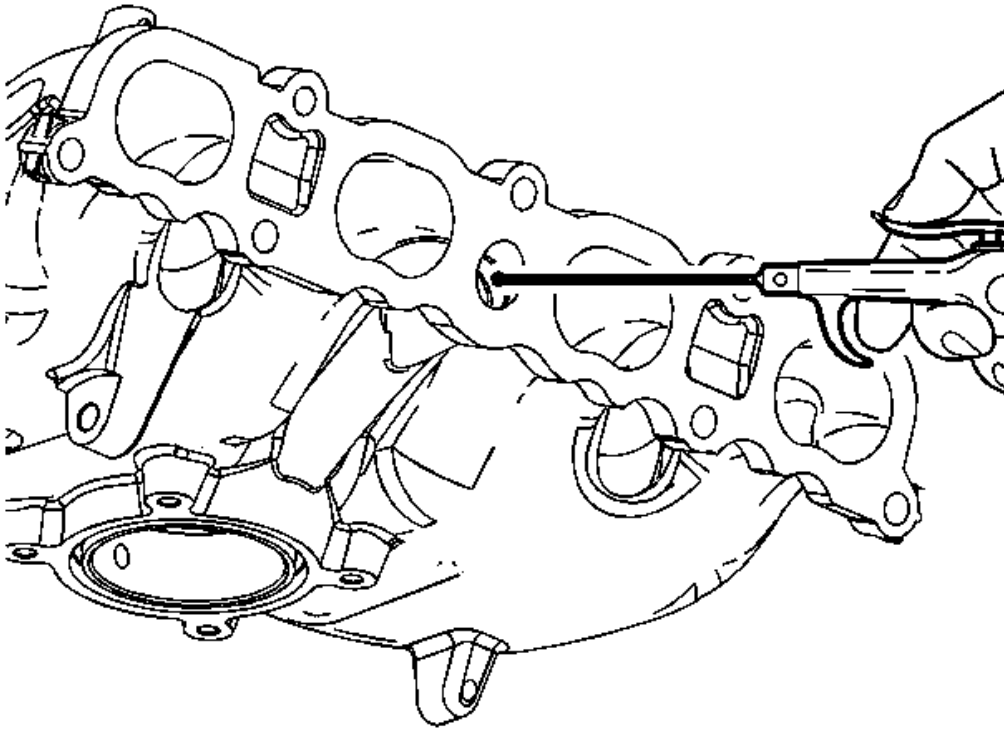


Fig. 490: Cleaning Crankcase Ventilation Passages
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

5. Clean the crankcase ventilation passages with compressed air, if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold, as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

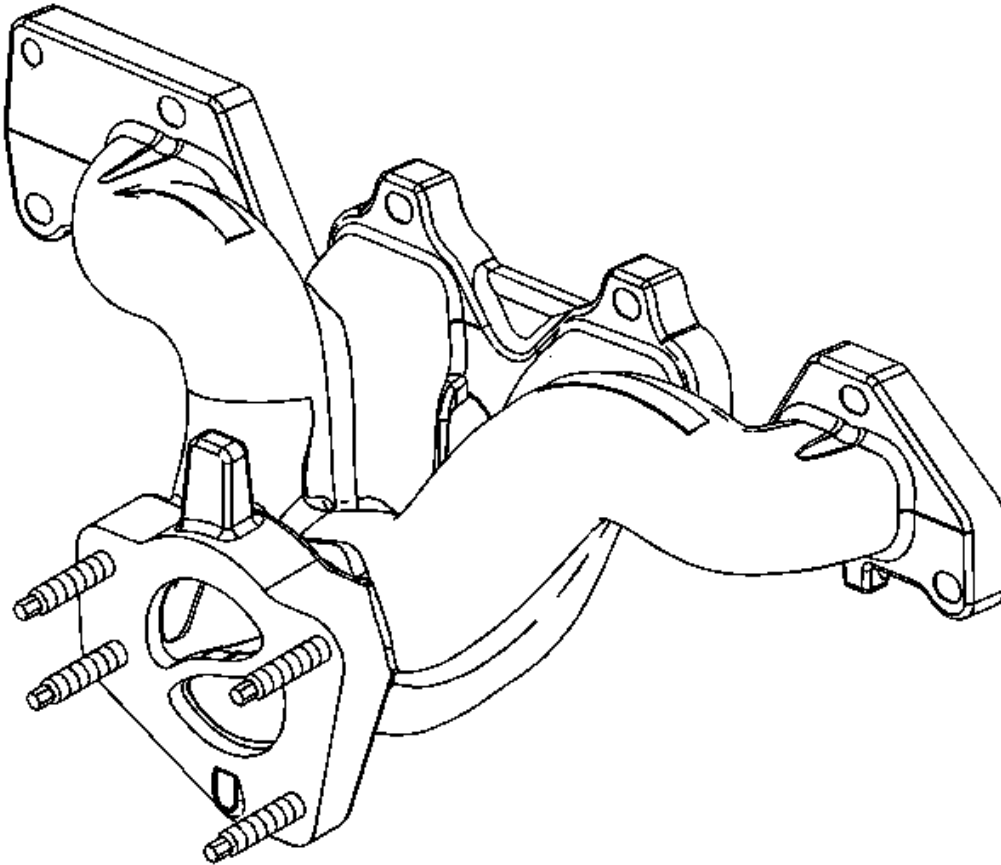


Fig. 491: View Of Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 affect on-board diagnostics (OBD) II system performance.

1. Clean the exhaust manifold in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the exhaust manifold with compressed air.
3. Internal heat cracks are allowed. Do not replace the exhaust manifold for this condition.

4. Inspect the heat shield for damage.

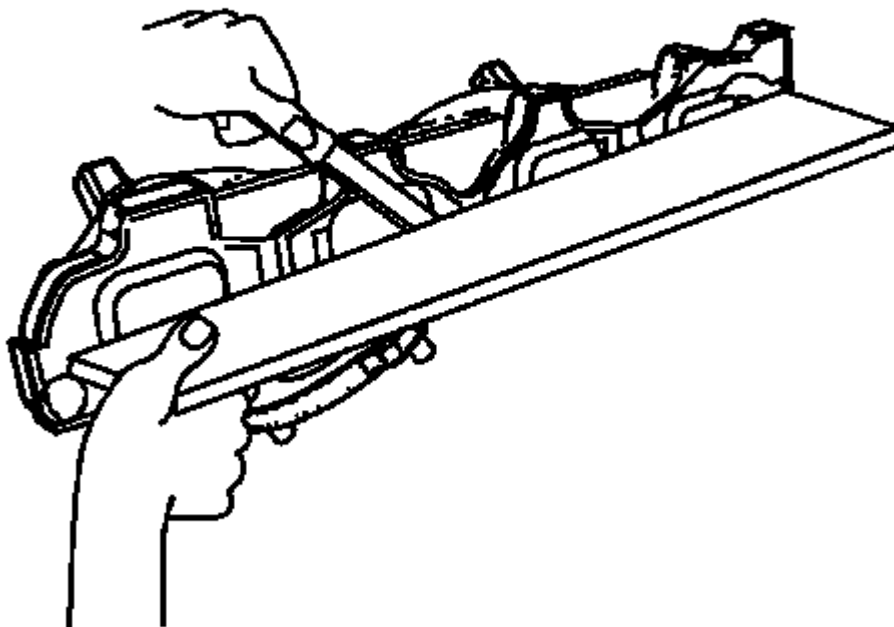


Fig. 492: Checking Exhaust Manifold Mounting Face For Warpage
Courtesy of GENERAL MOTORS CORP.

5. Use a straight edge and a feeler gage and measure the exhaust manifold mounting face for warpage.

An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

OIL PAN CLEANING AND INSPECTION

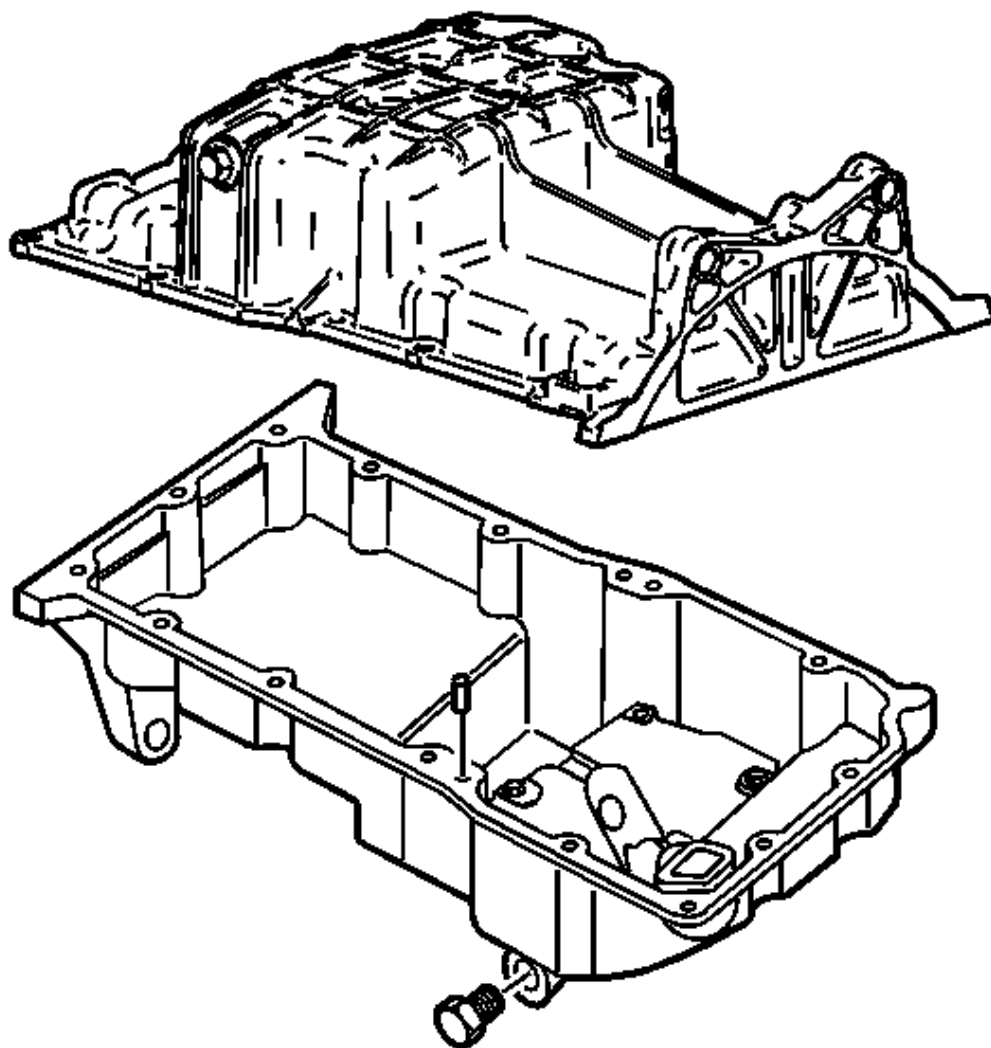


Fig. 493: Inspecting Oil Pan

Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pan mating surface.

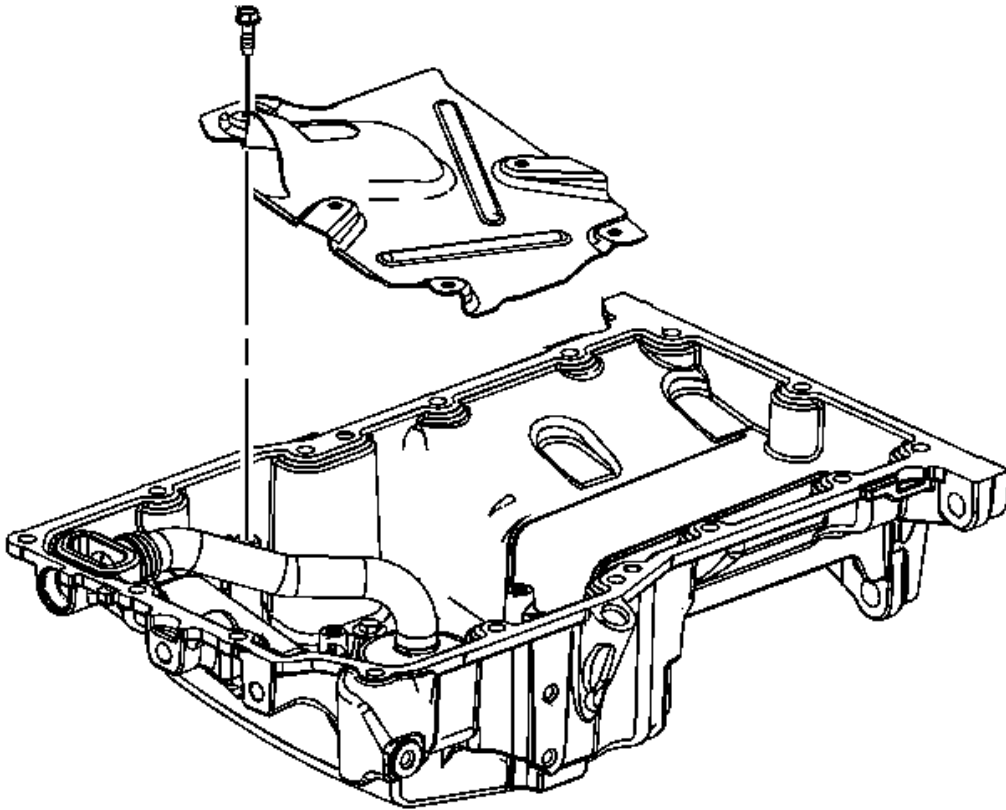


Fig. 494: View Of Oil Pan Baffle
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan baffle bolts.

IMPORTANT: Do not remove the pickup screen. It is press-fit into the oil pan.

3. Remove the oil pan baffle.
4. Clean the oil pan. Remove all the sludge and the oil deposits.
5. Inspect the engine oil drain plug threads.
6. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
7. Inspect the oil pan for cracking resulting from impact or flying road debris.
8. Inspect the oil pan baffle and pickup screen.
9. Install the oil pan baffle.

NOTE: Refer to Fastener Notice .

10. Install the oil pan baffle bolts.

Tighten: Tighten the oil pan baffle bolts to 14 N.m 10 lb ft.

THREAD REPAIR

Tools Required

J 42385-850 Thread Repair Kit. See Special Tools.

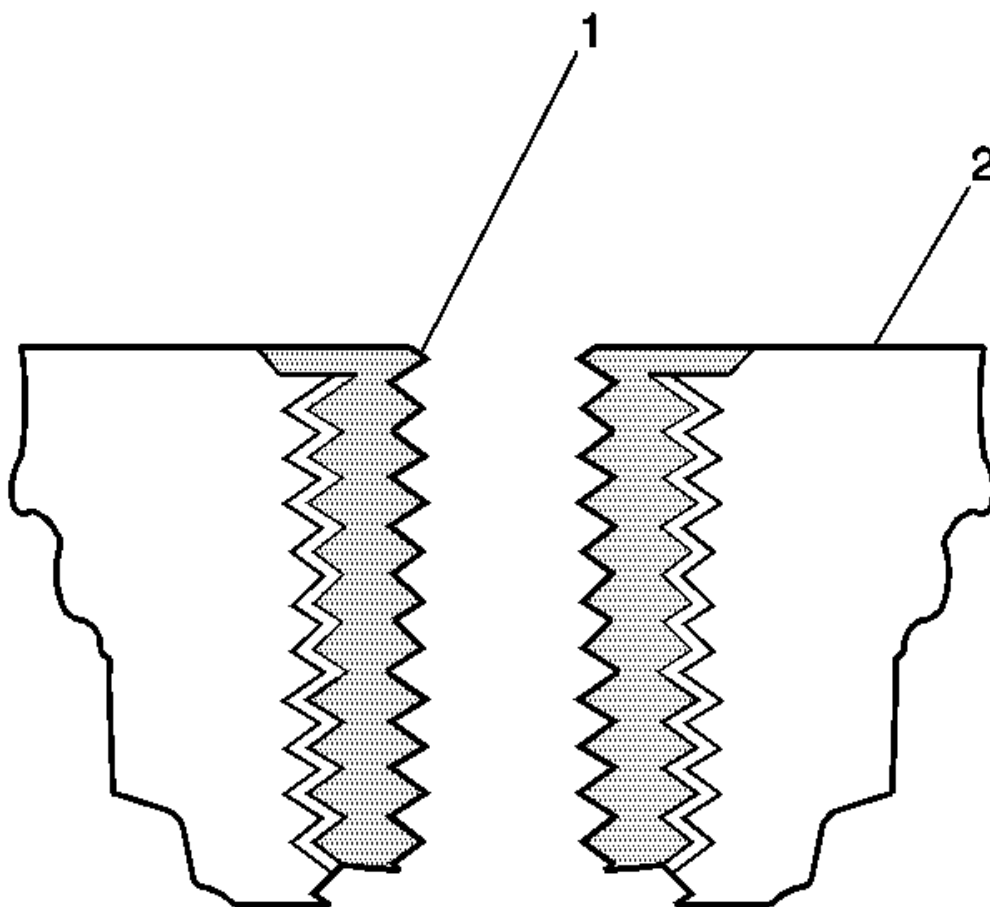


Fig. 495: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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.

General Thread Repair

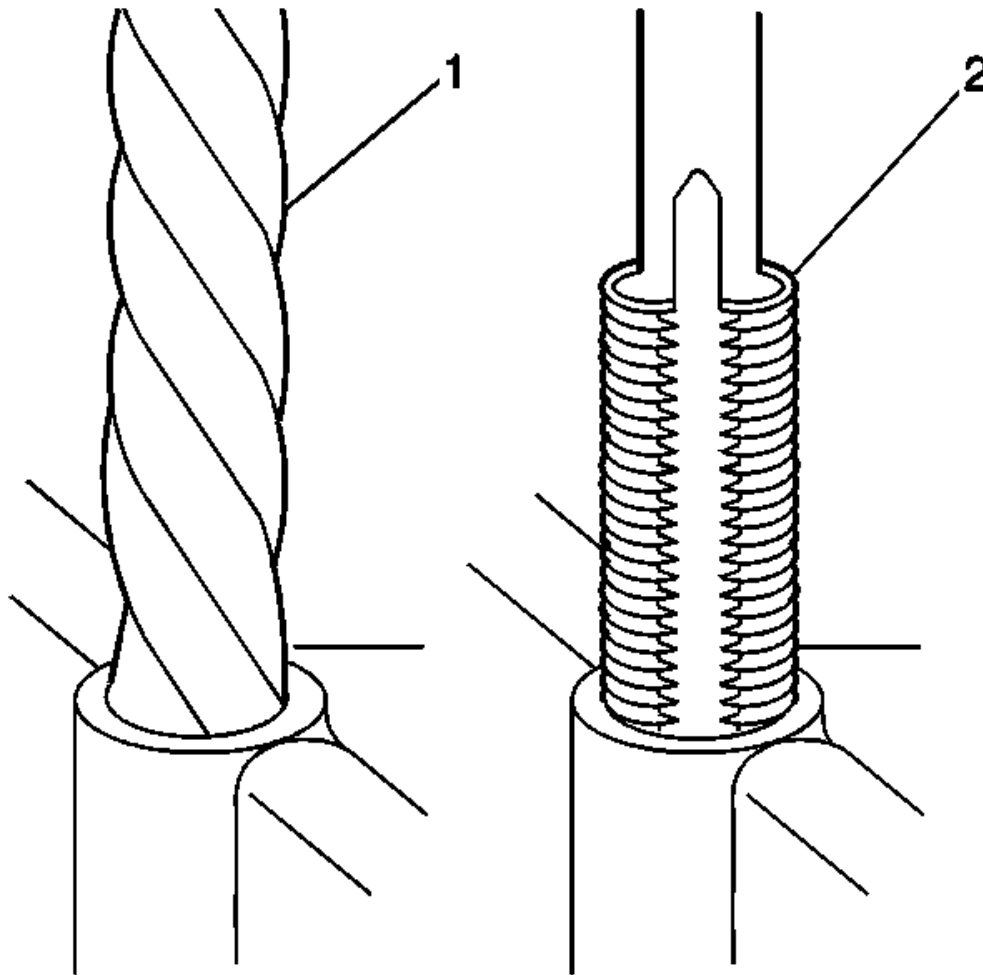


Fig. 496: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.
Driver oil **MUST** be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

1. Drill out the threads of the damaged hole (1).
 - M6 inserts require a minimum drill depth of 15 mm (0.59 in).

- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
 - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

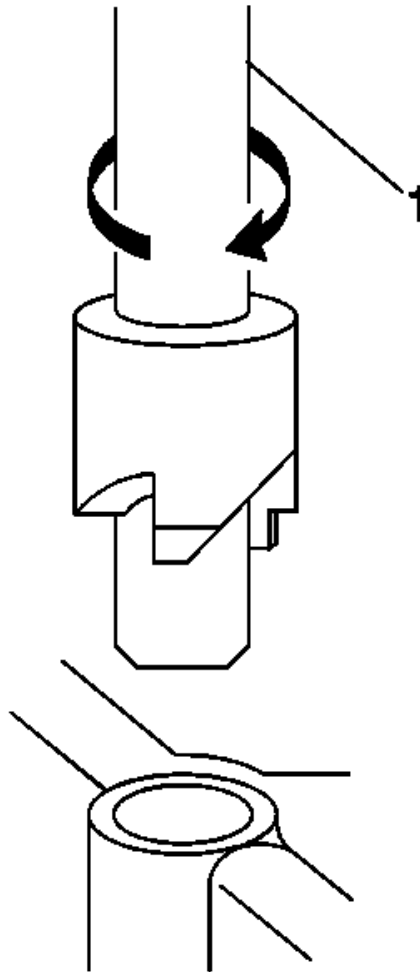


Fig. 497: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

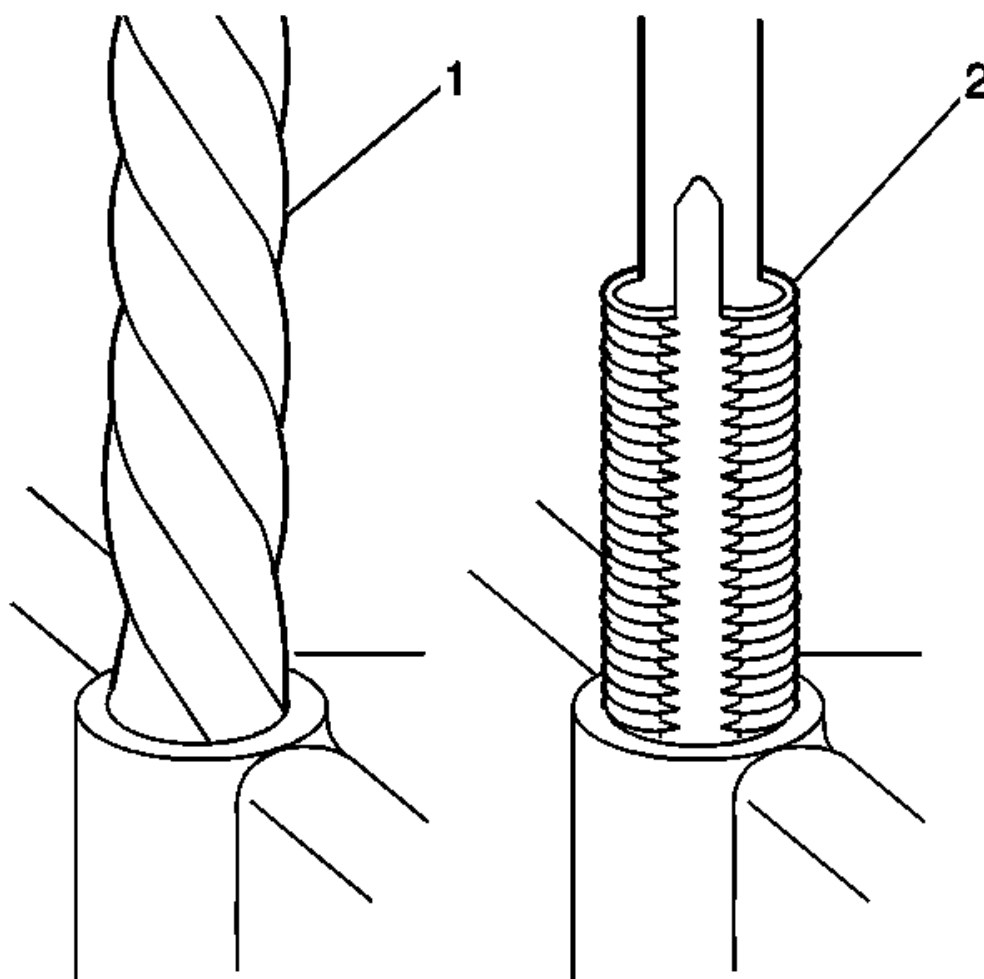


Fig. 498: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

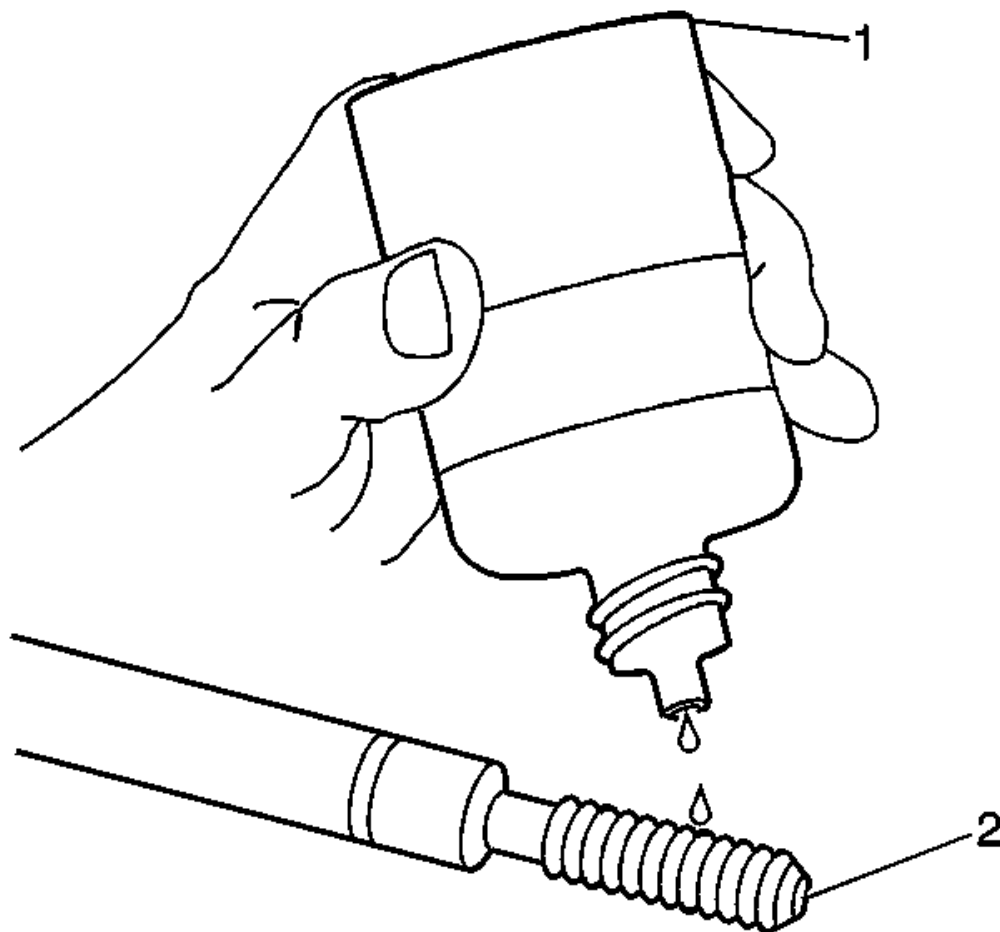


Fig. 499: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

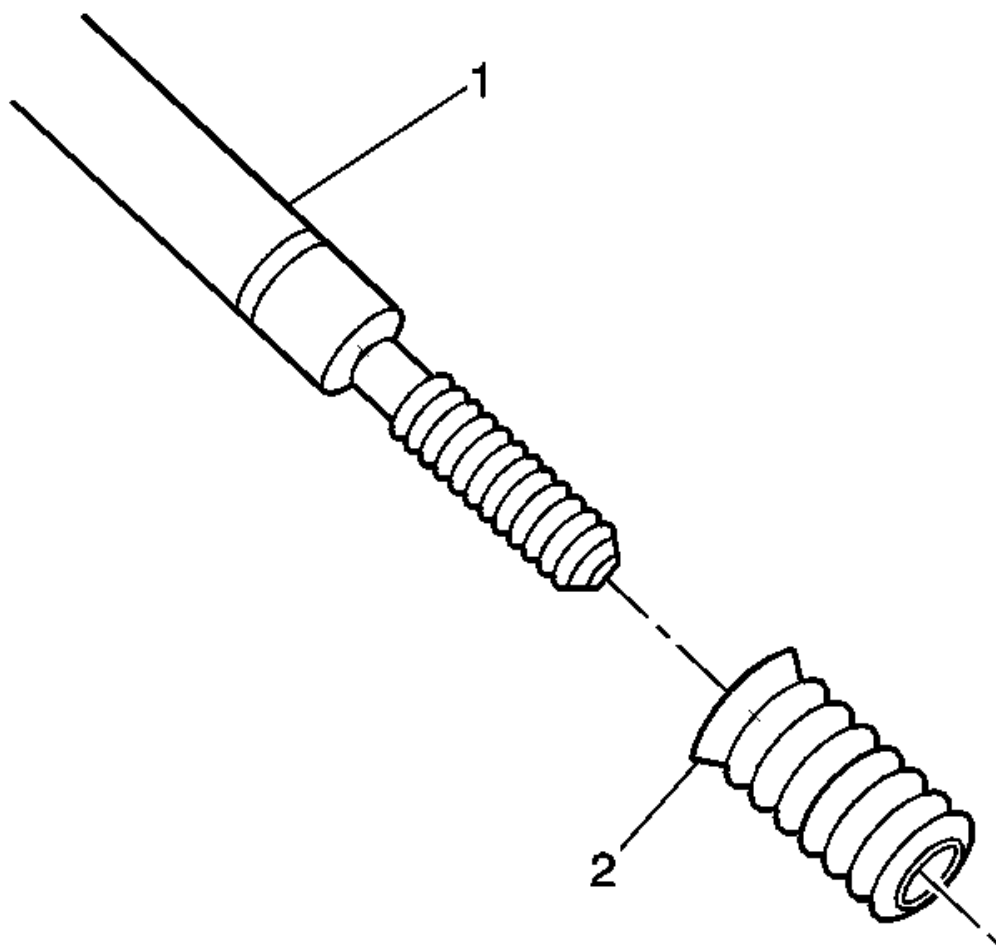


Fig. 500: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

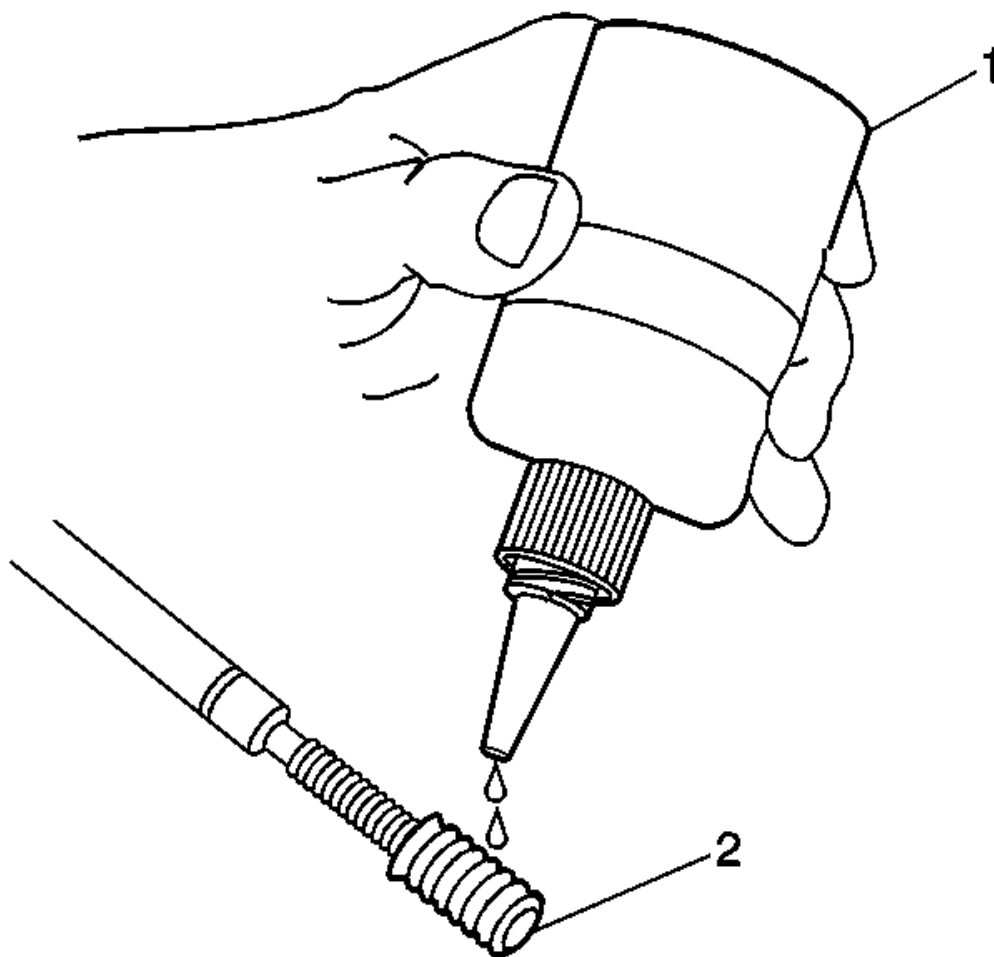


Fig. 501: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

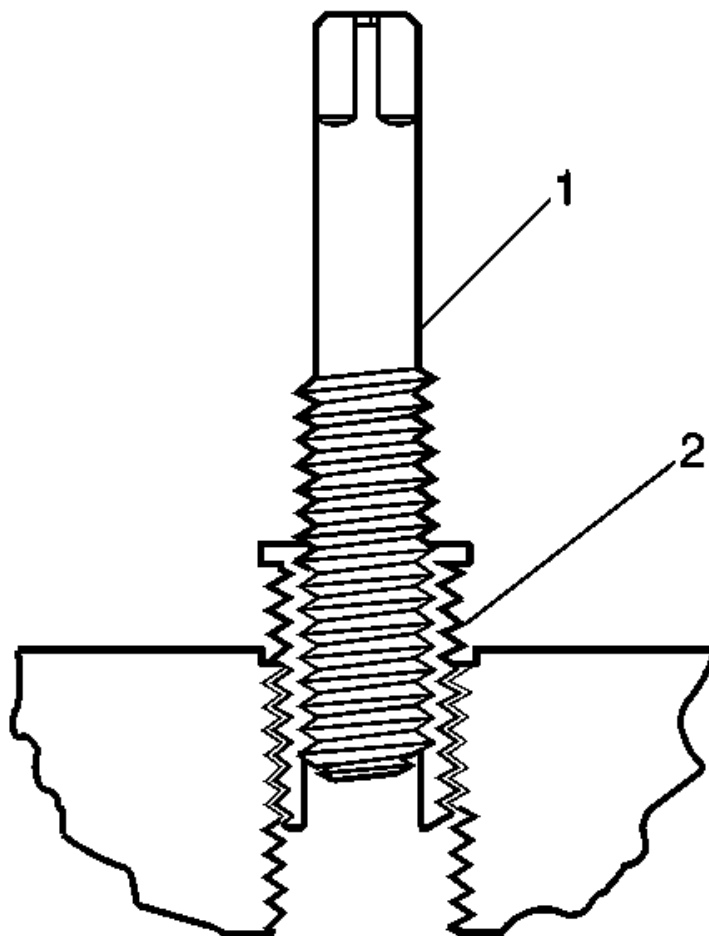


Fig. 502: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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.

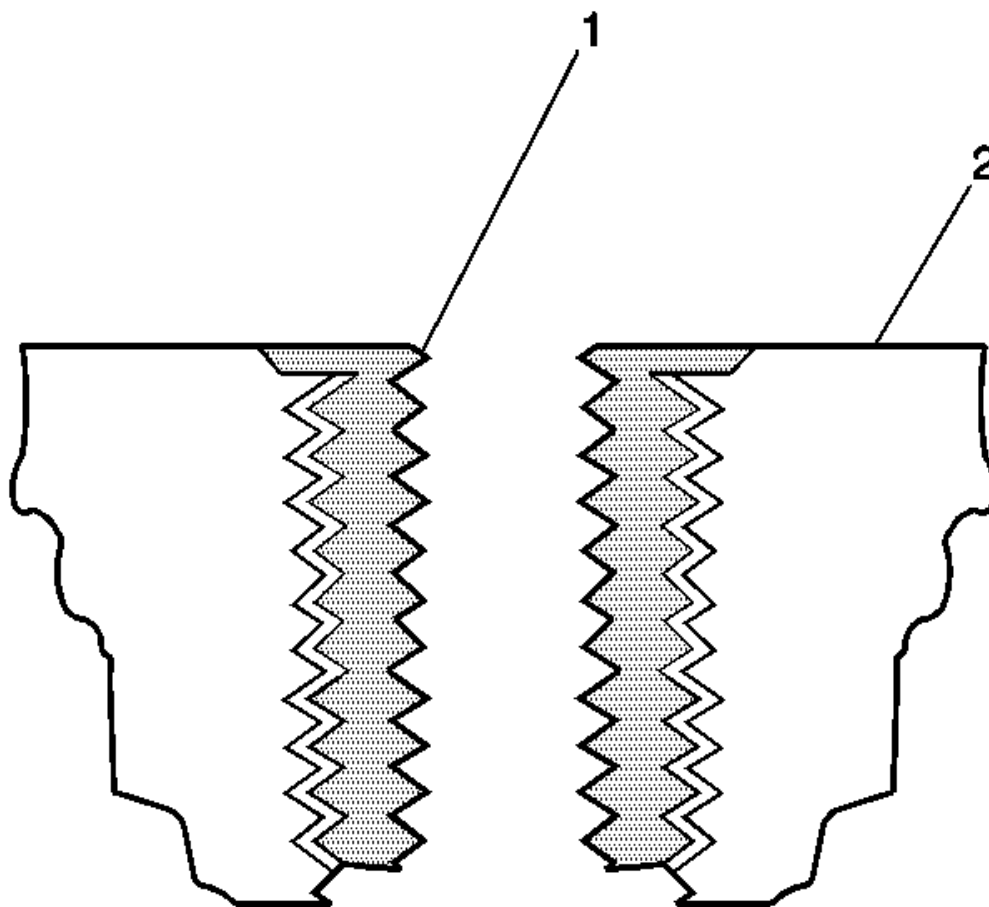


Fig. 503: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

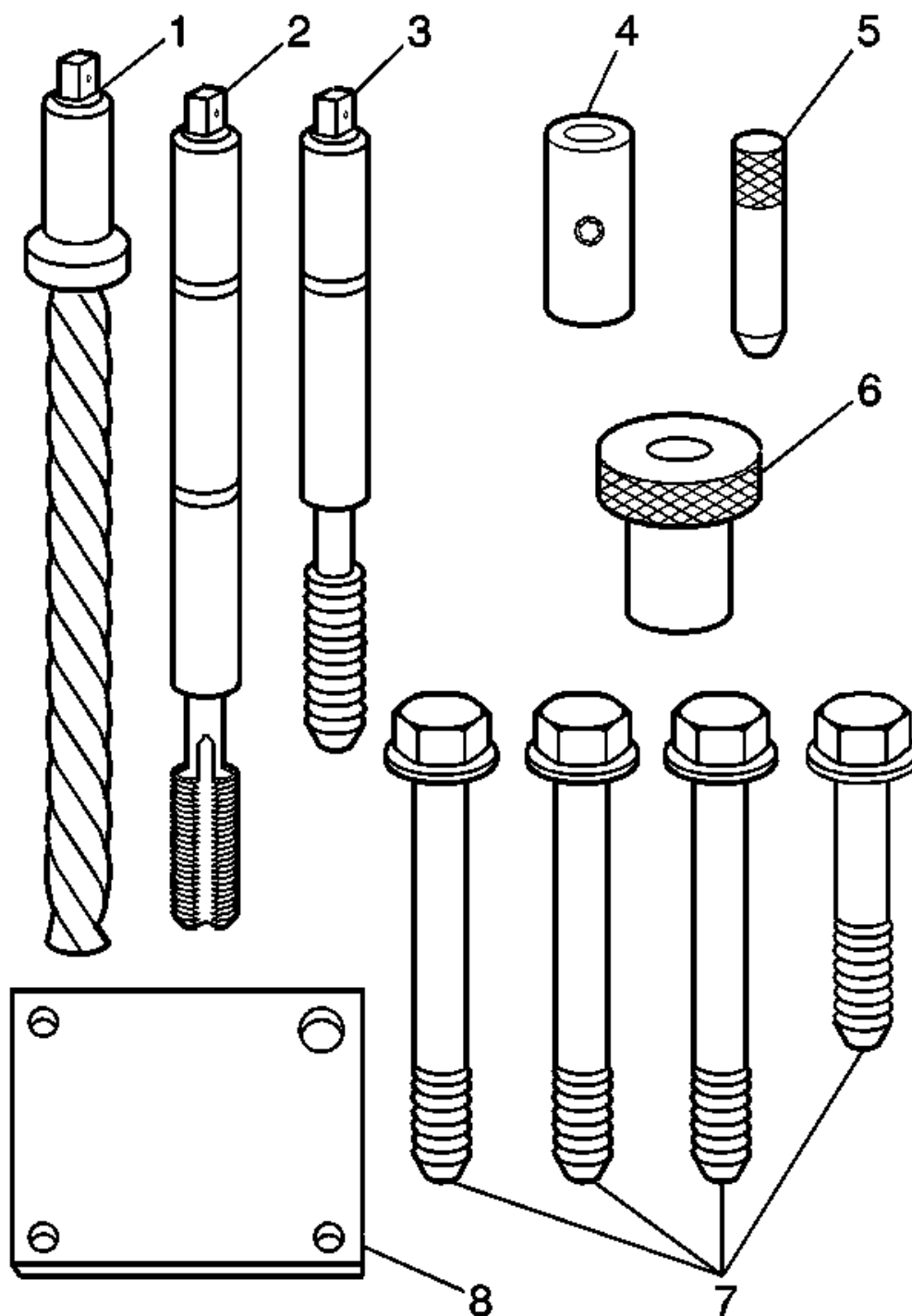


Fig. 504: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

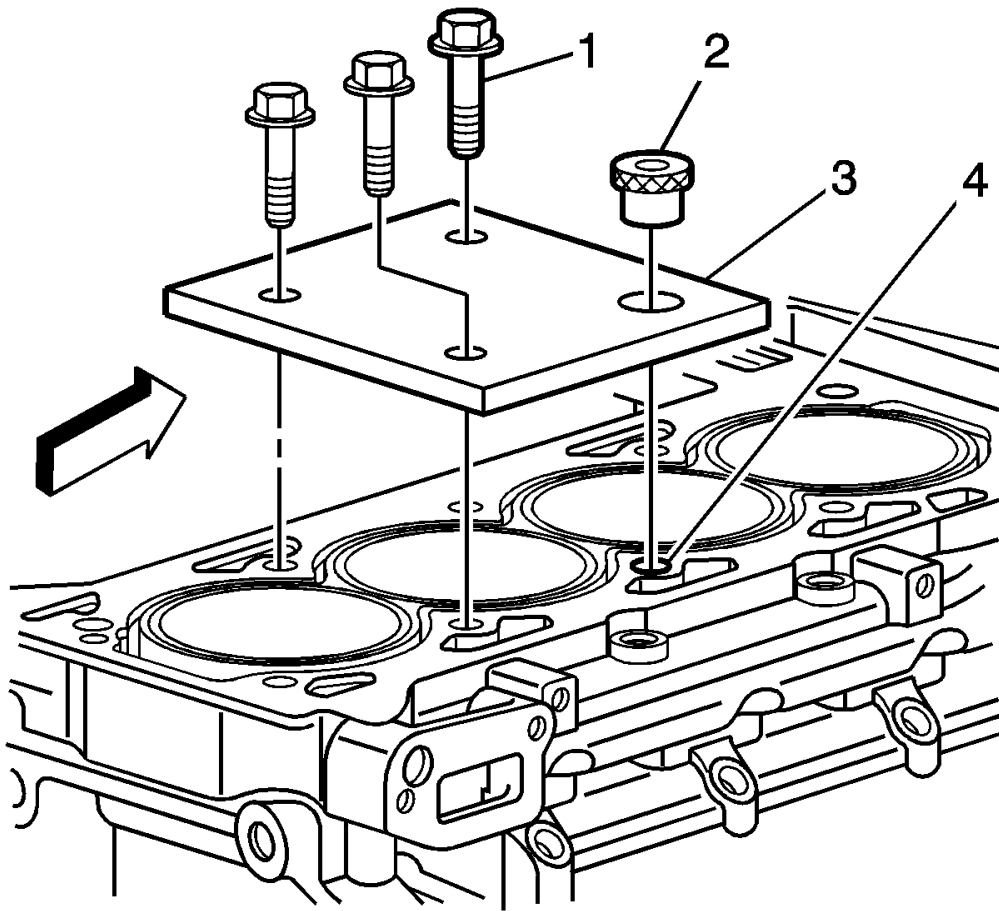


Fig. 505: Installing Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures.

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).

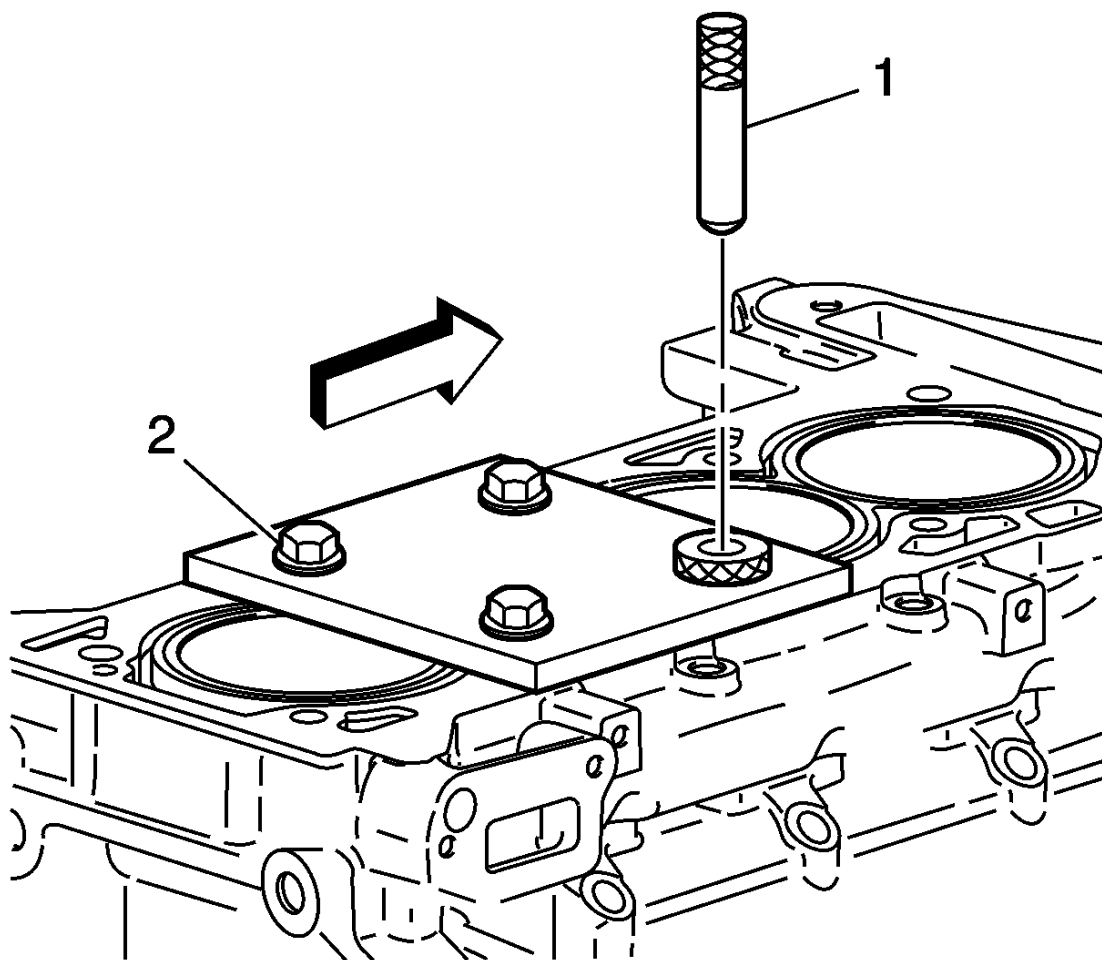


Fig. 506: Identifying Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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.

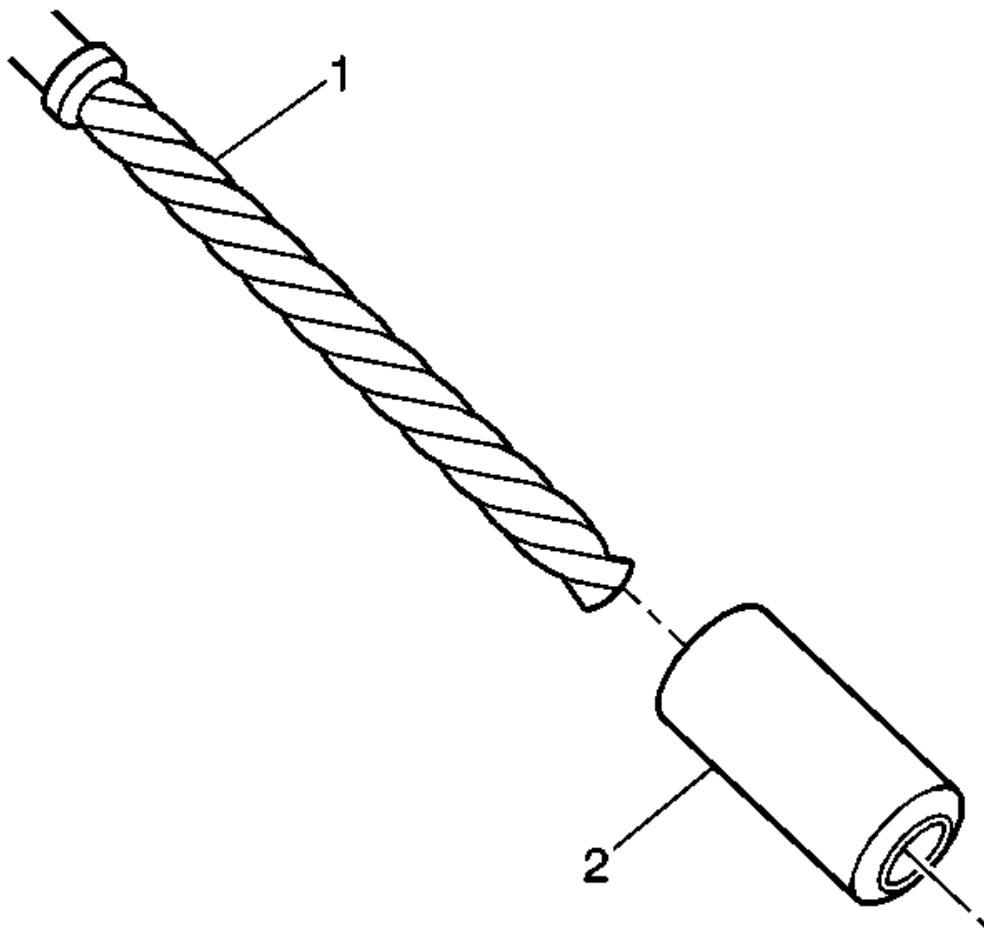


Fig. 507: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

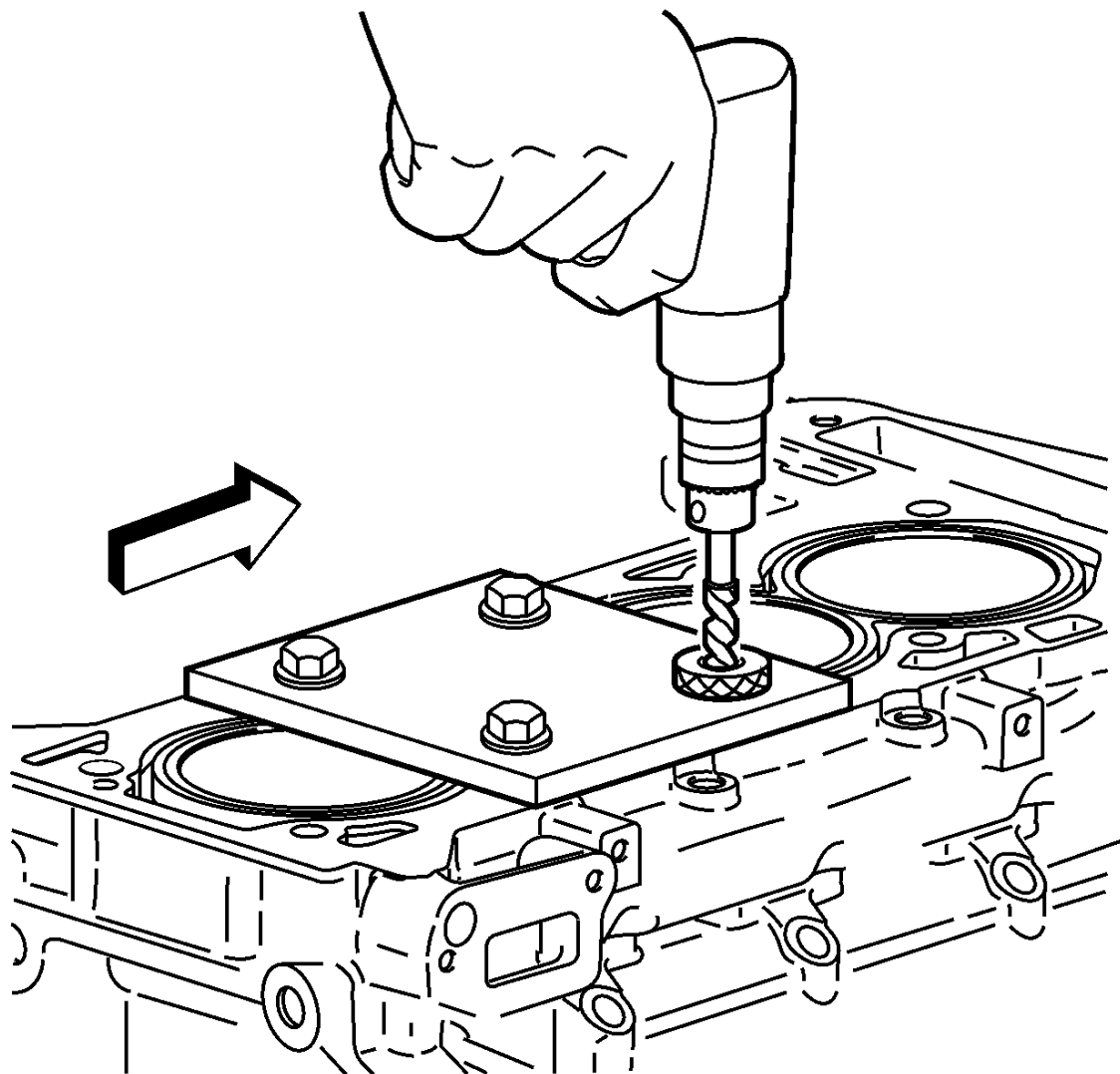


Fig. 508: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

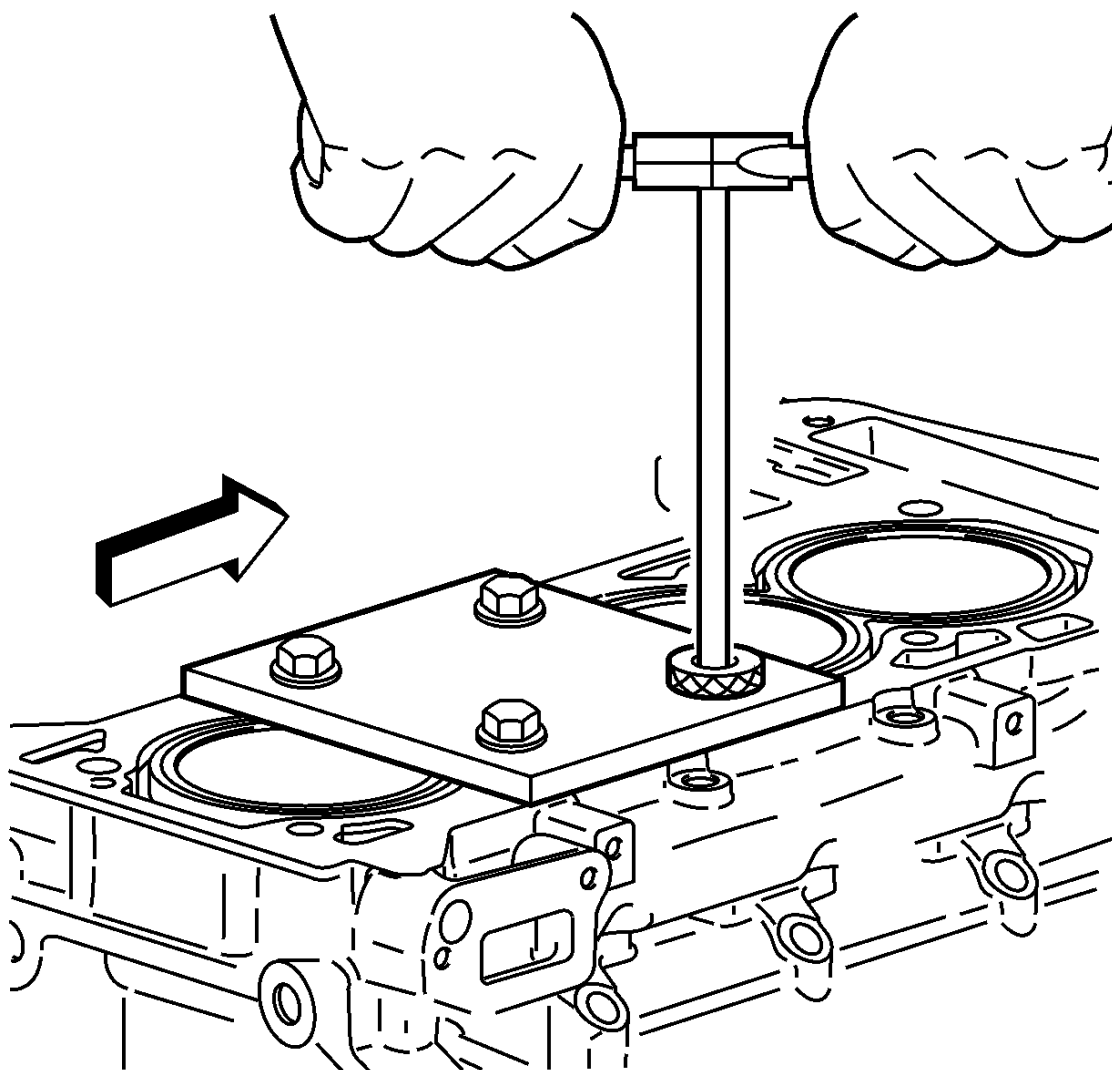


Fig. 509: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

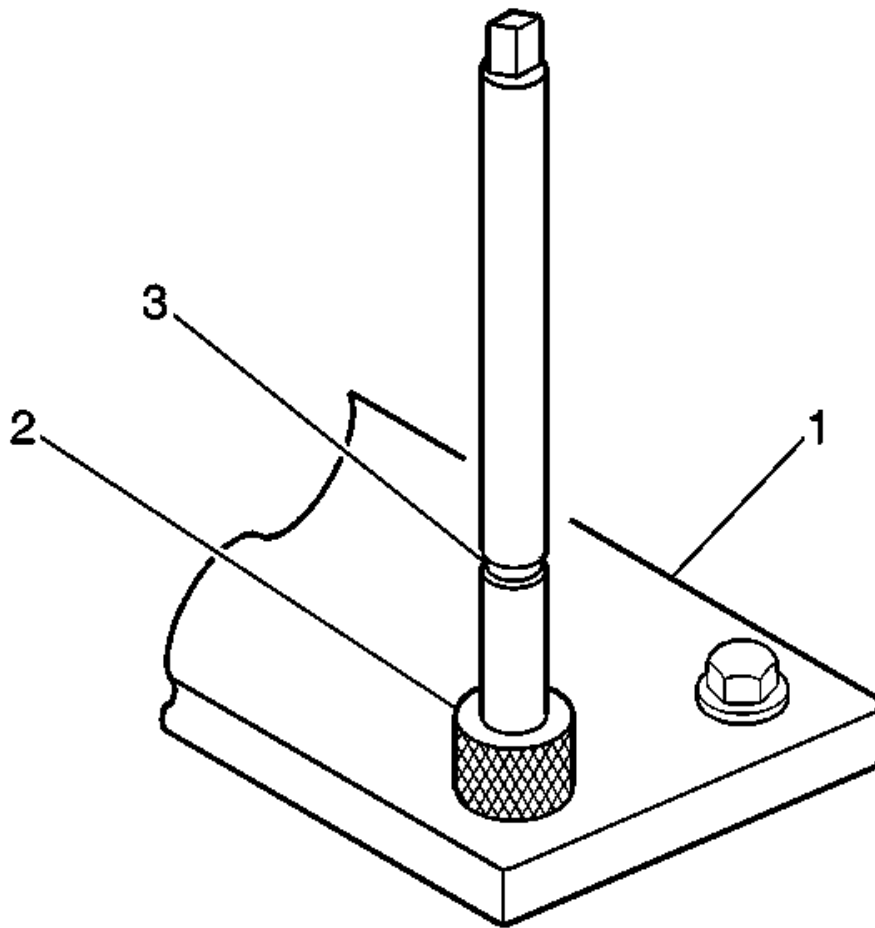


Fig. 510: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139 or GM P/N 1237798 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

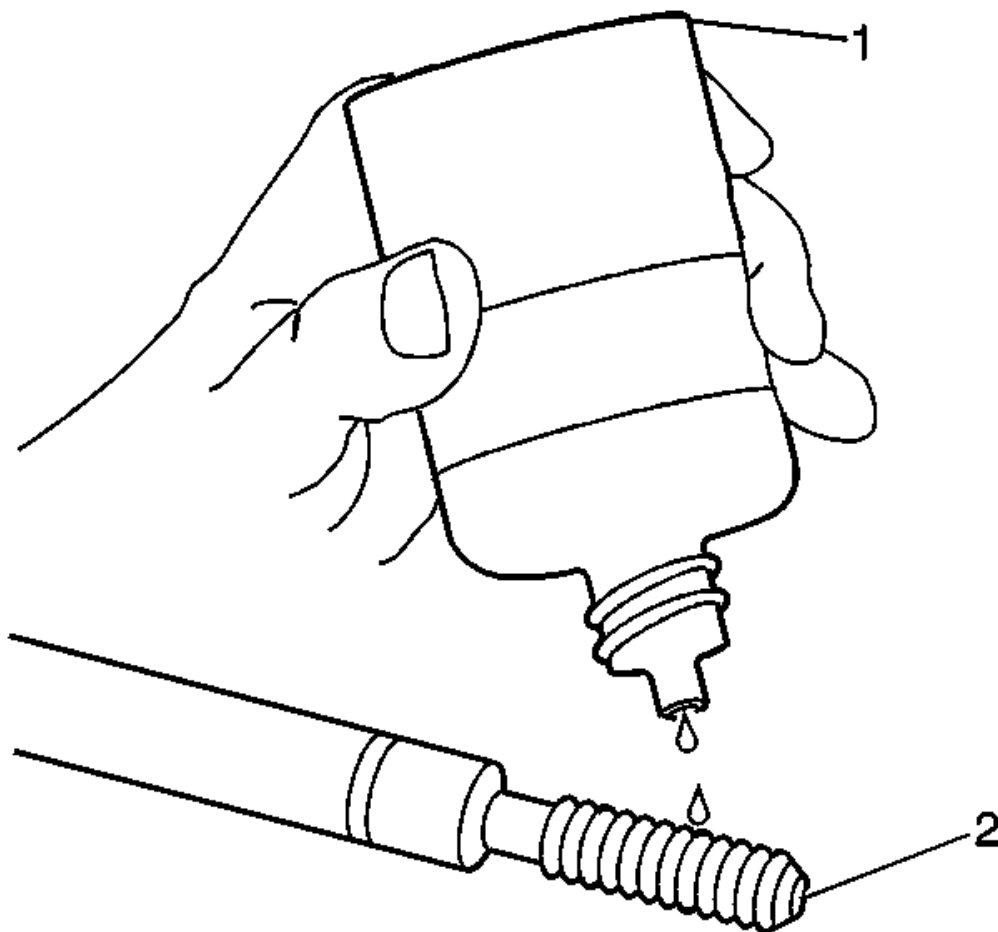


Fig. 511: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

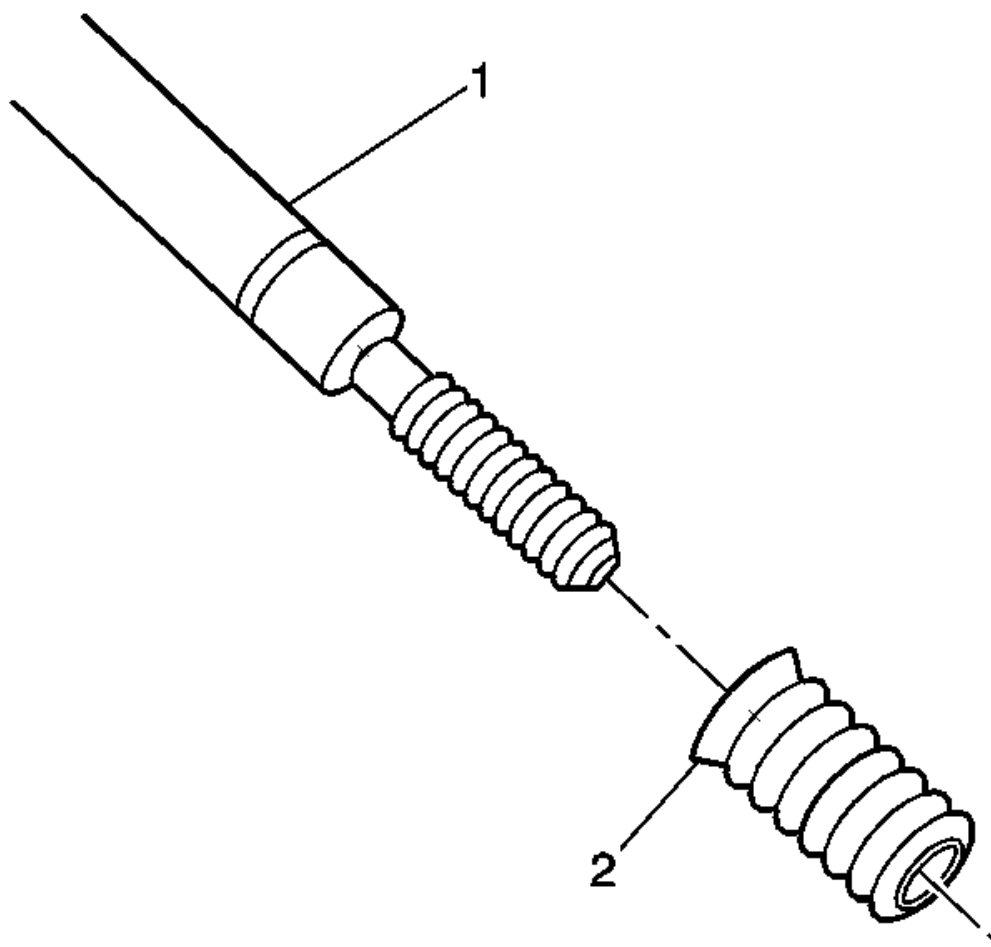


Fig. 512: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

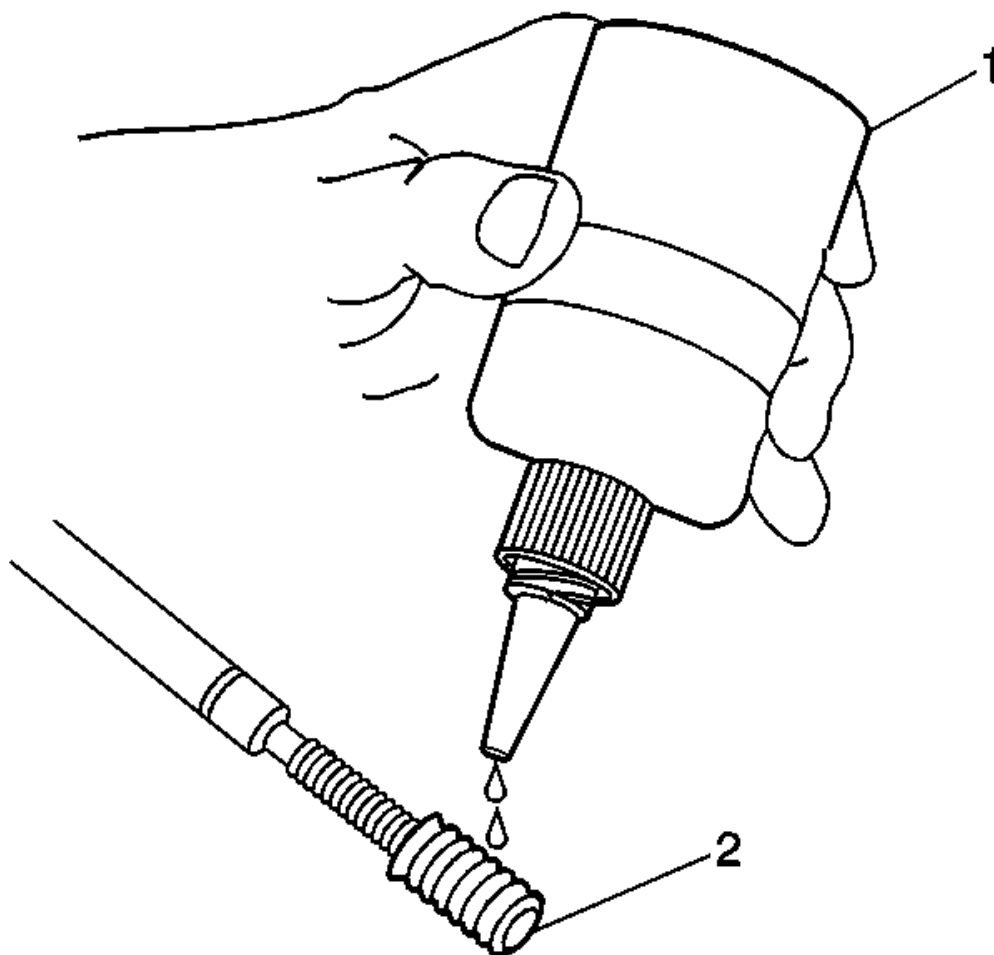


Fig. 513: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

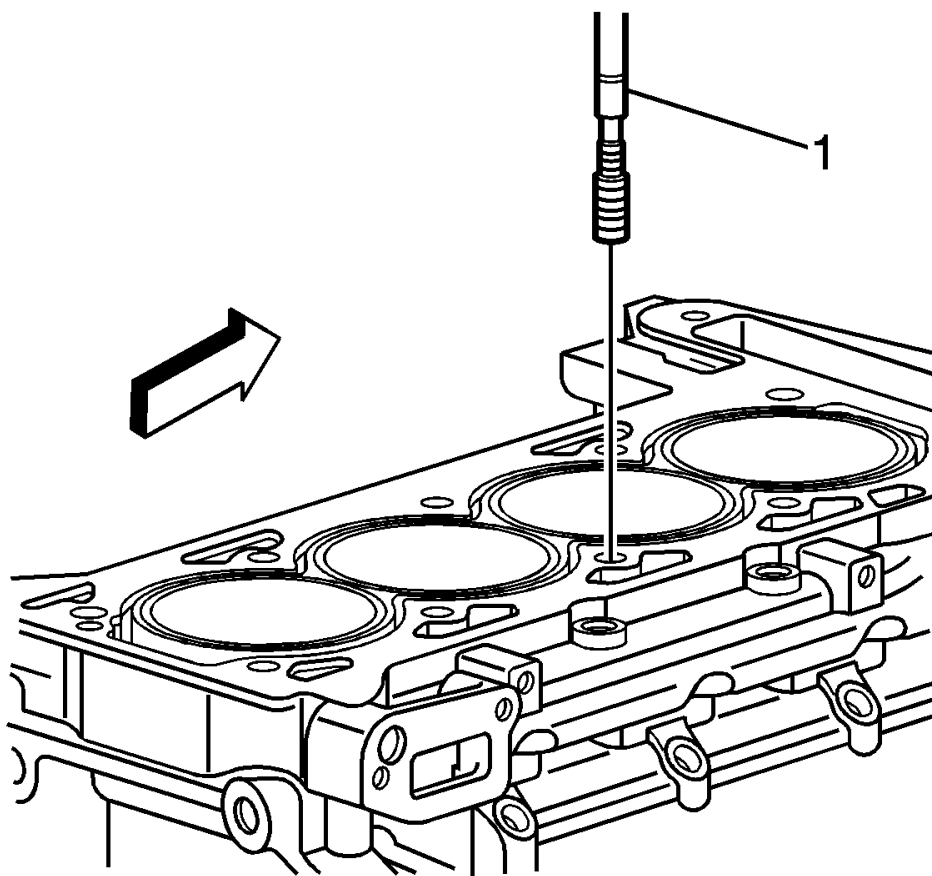


Fig. 514: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS CORP.

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.

Main Cap Bolt Hole Thread Repair

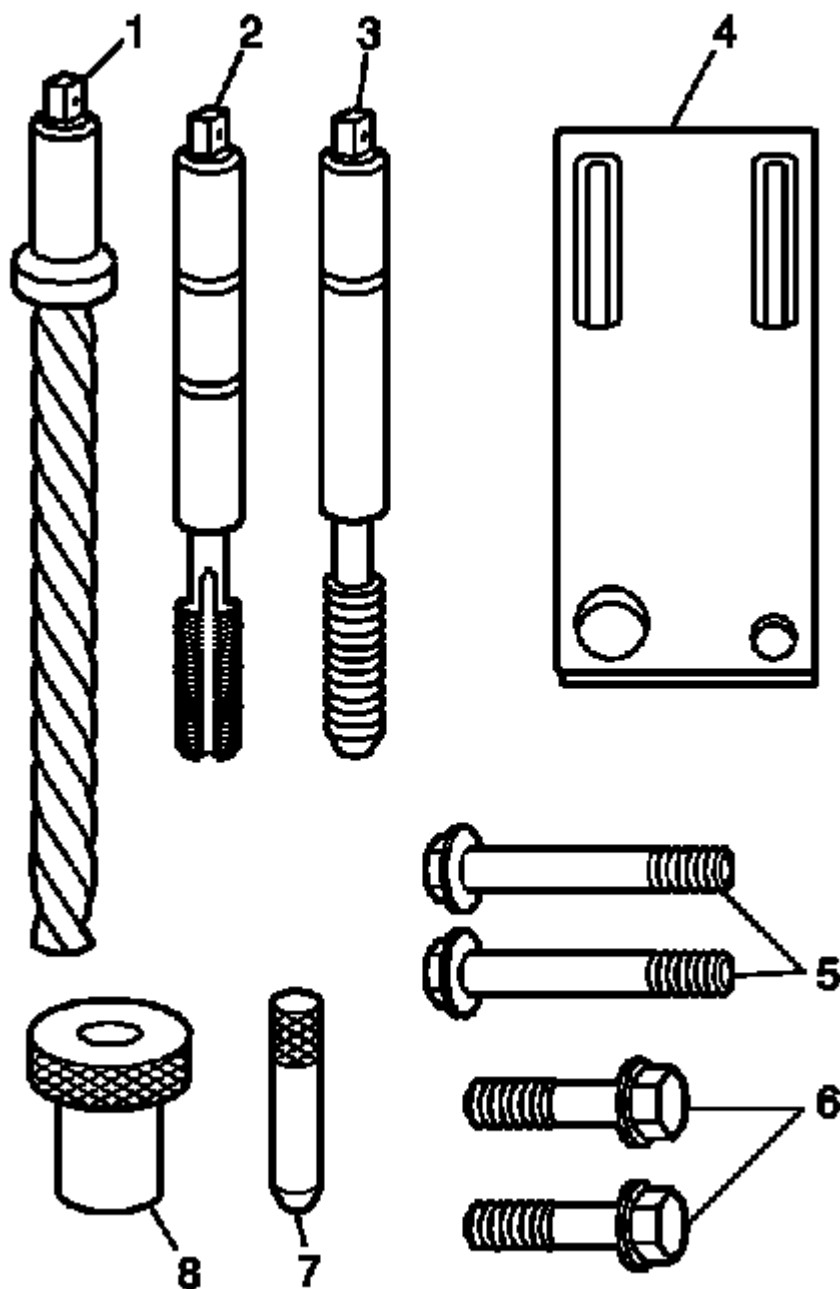


Fig. 515: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

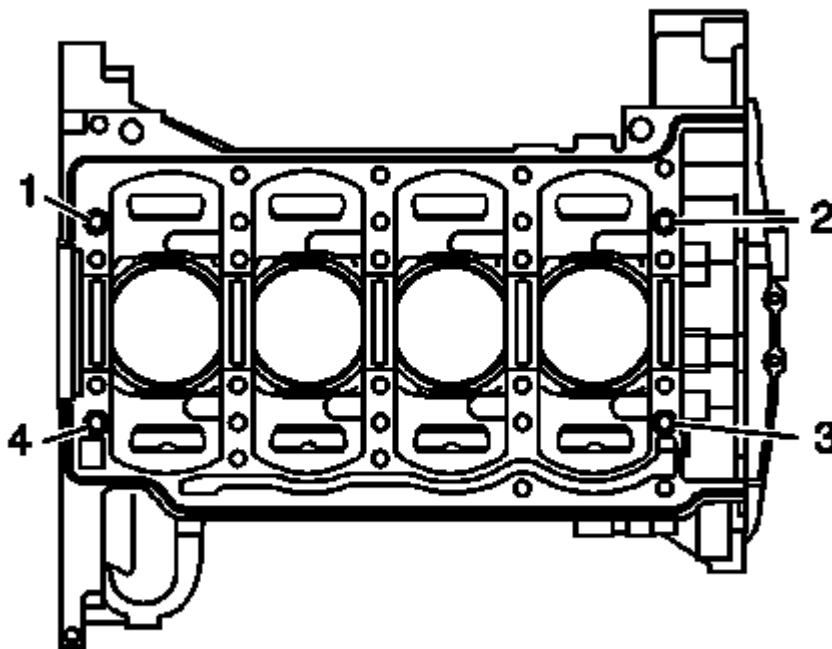


Fig. 516: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment dowel pins from the holes (1-4), if necessary.

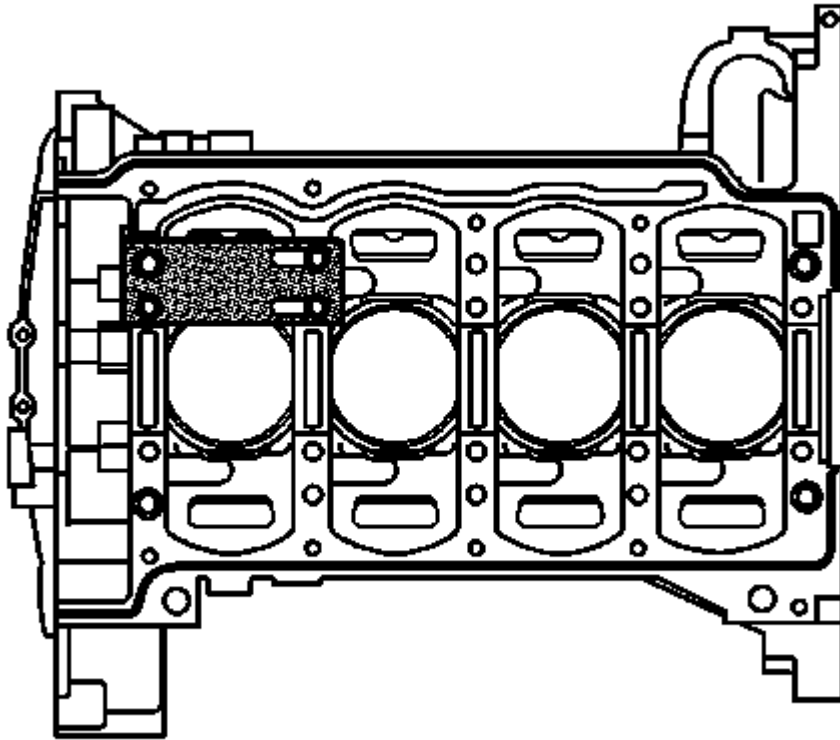


Fig. 517: Installing Fixture Plate, Bolt, & Bushing Onto Engine Block
Courtesy of GENERAL MOTORS CORP.

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.
6. Using compressed air, clean out any chips.

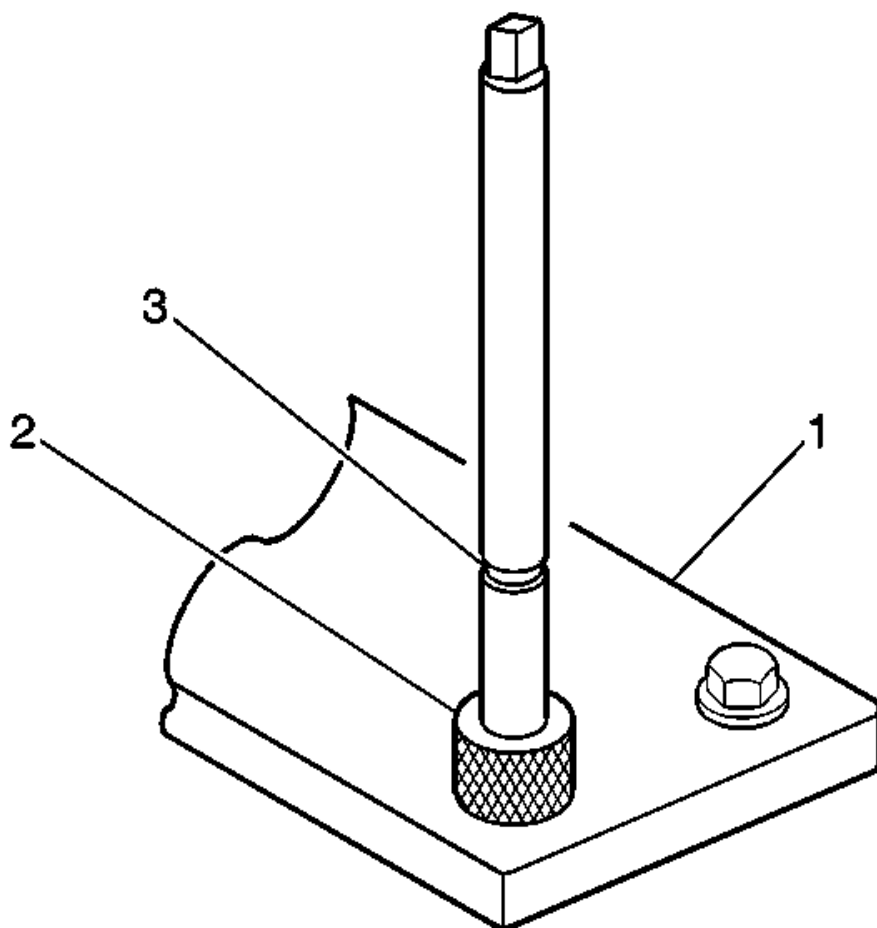


Fig. 518: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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).

8. Using compressed air, clean out any chips.
9. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), or equivalent, into the hole.
10. Using compressed air, clean any cutting oil and chips out of the hole.

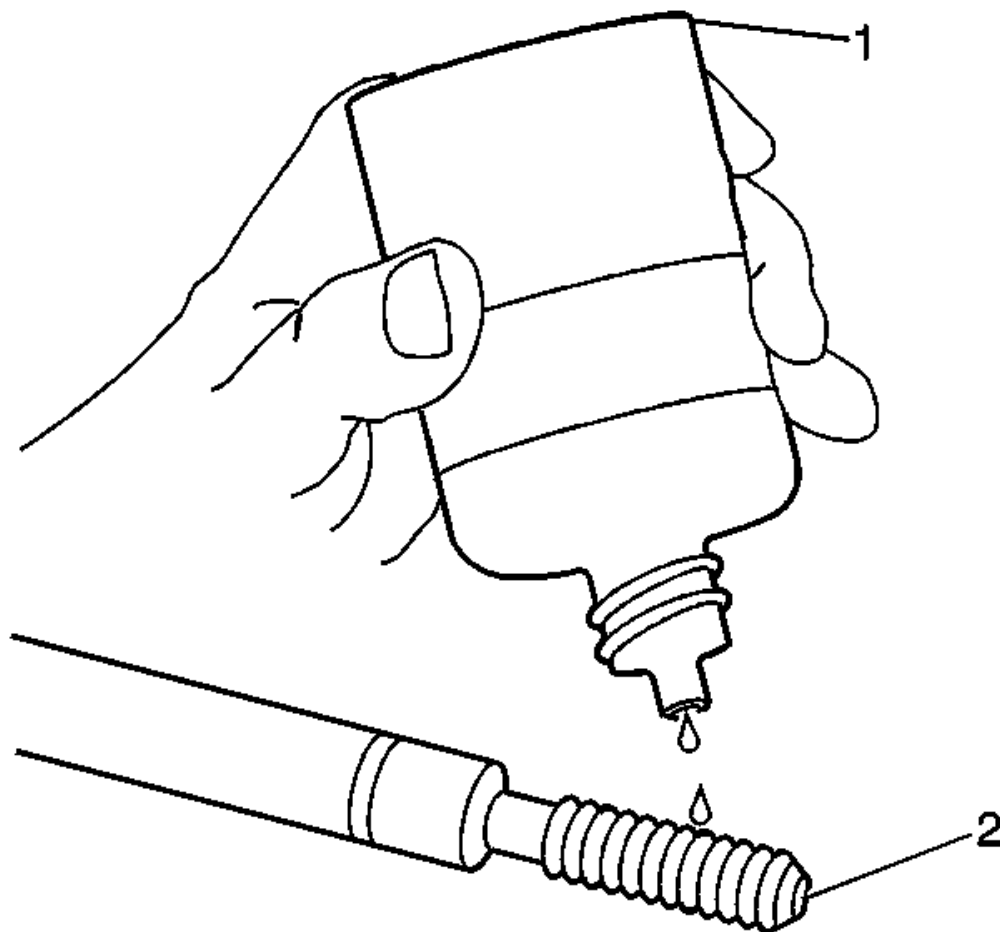


Fig. 519: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

11. Lubricate the threads of the installer tool (2) with the driver oil (1).

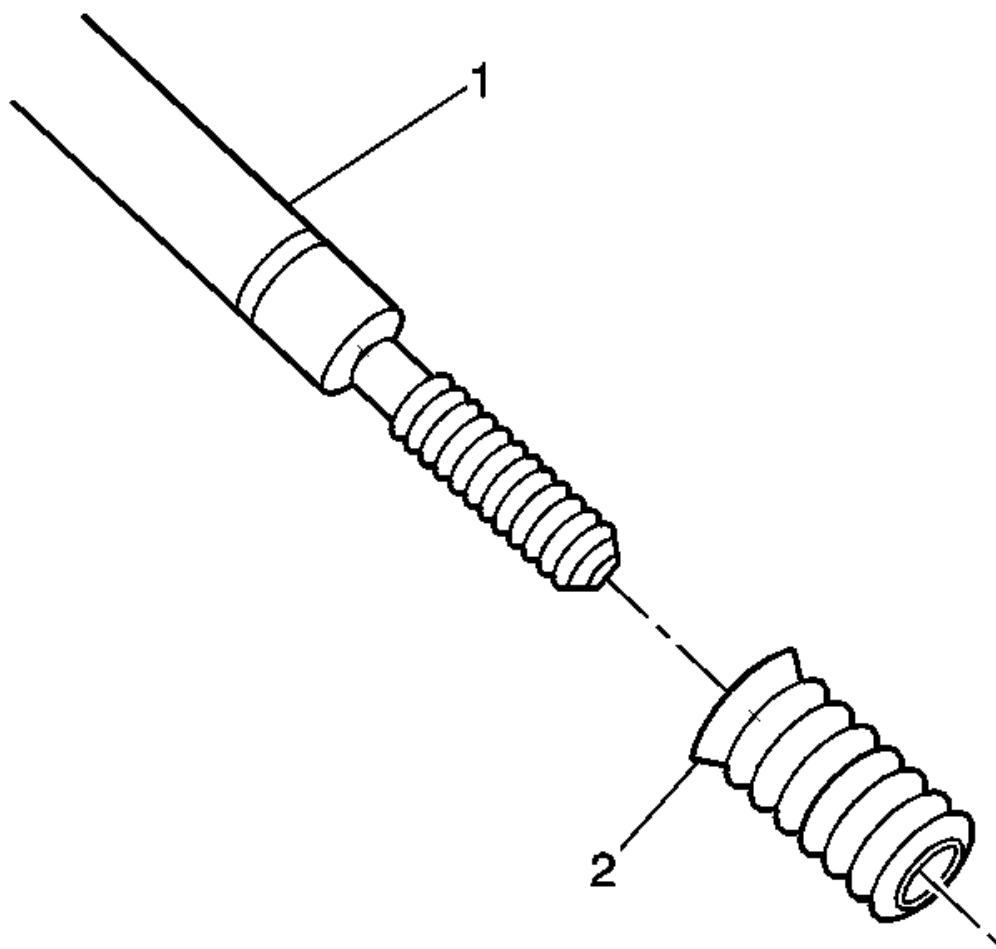


Fig. 520: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

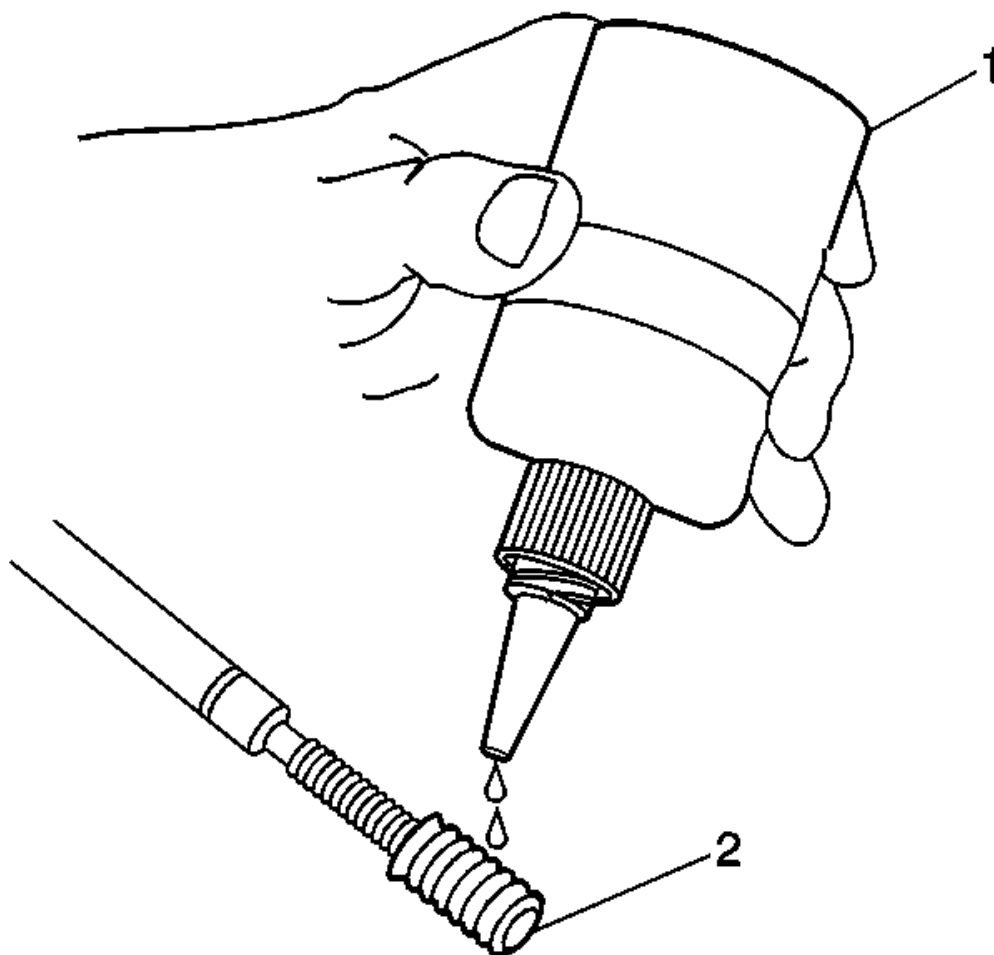


Fig. 521: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

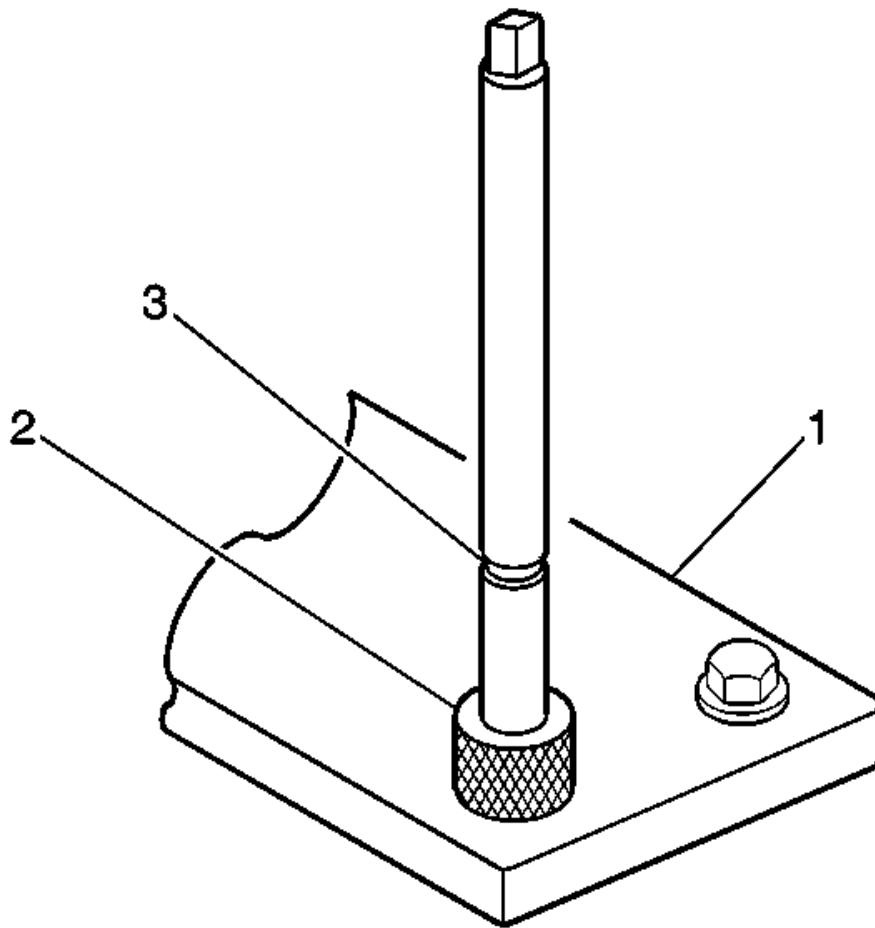


Fig. 522: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

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.

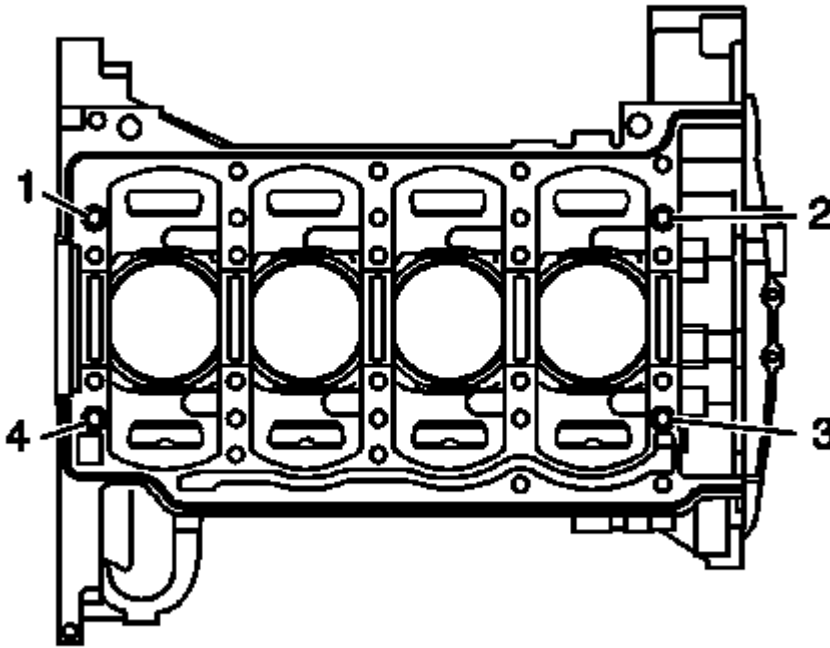


Fig. 523: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

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

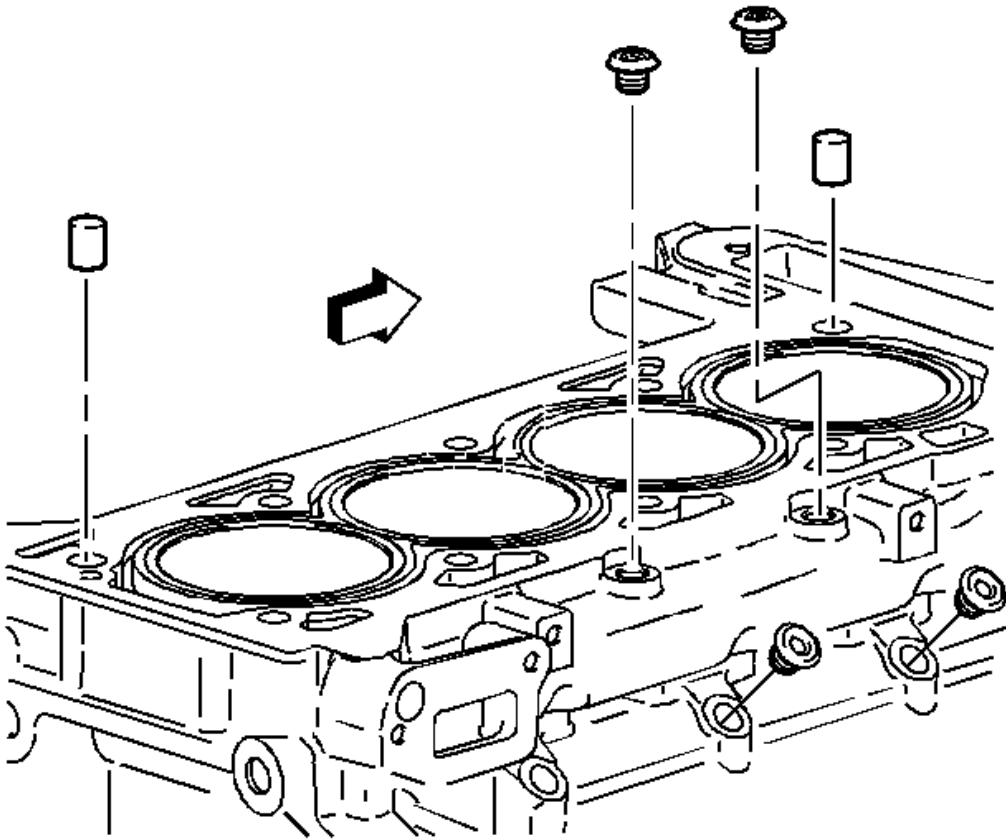


Fig. 524: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the drain plug in the water pump.
2. Apply GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the plug before installation.

NOTE: Refer to Fastener Notice .

3. Install the coolant jacket plugs.

Tighten: Tighten the coolant jacket plug to 35 N.m (26 lb ft).

4. Install the rear oil passage plugs.
5. Apply GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the plugs before installation.

Tighten: Tighten the oil passage plug to 60 N.m (44 lb ft).

6. Install the other oil passage plugs.
7. Apply GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the plug before installation.

Tighten: Tighten the oil passage plugs to 35 N.m (26 lb ft).

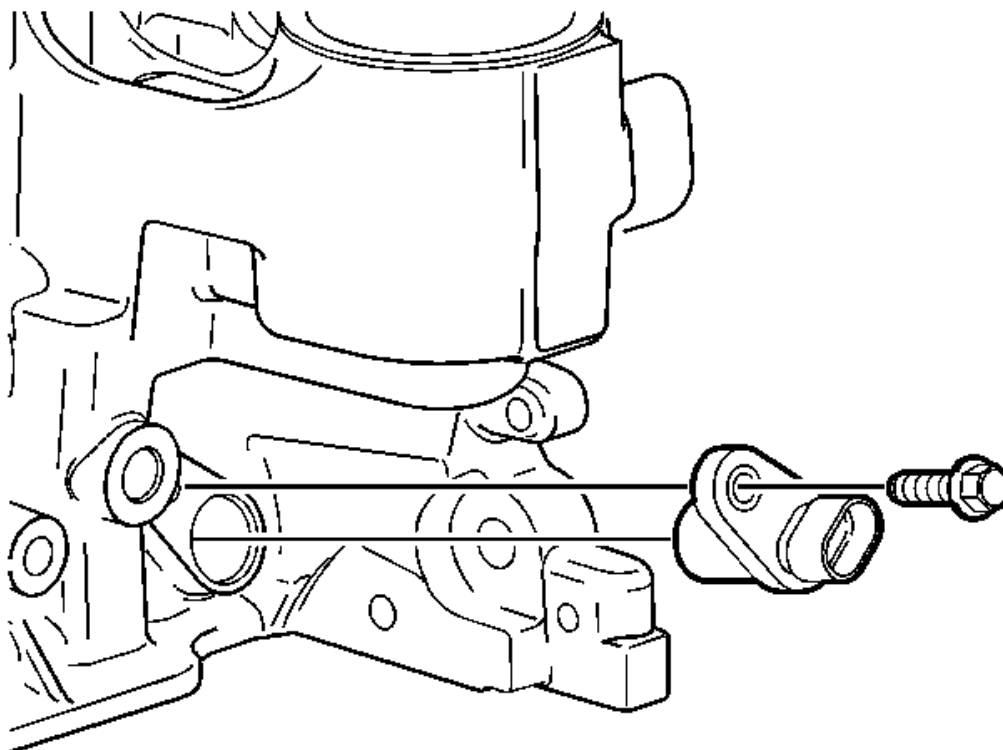


Fig. 525: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the crankshaft position (CKP) sensor O-ring with clean engine oil.
9. Install the CKP sensor and bolt.

Tighten: Tighten the CKP sensor bolt to 10 N.m (89 lb in).

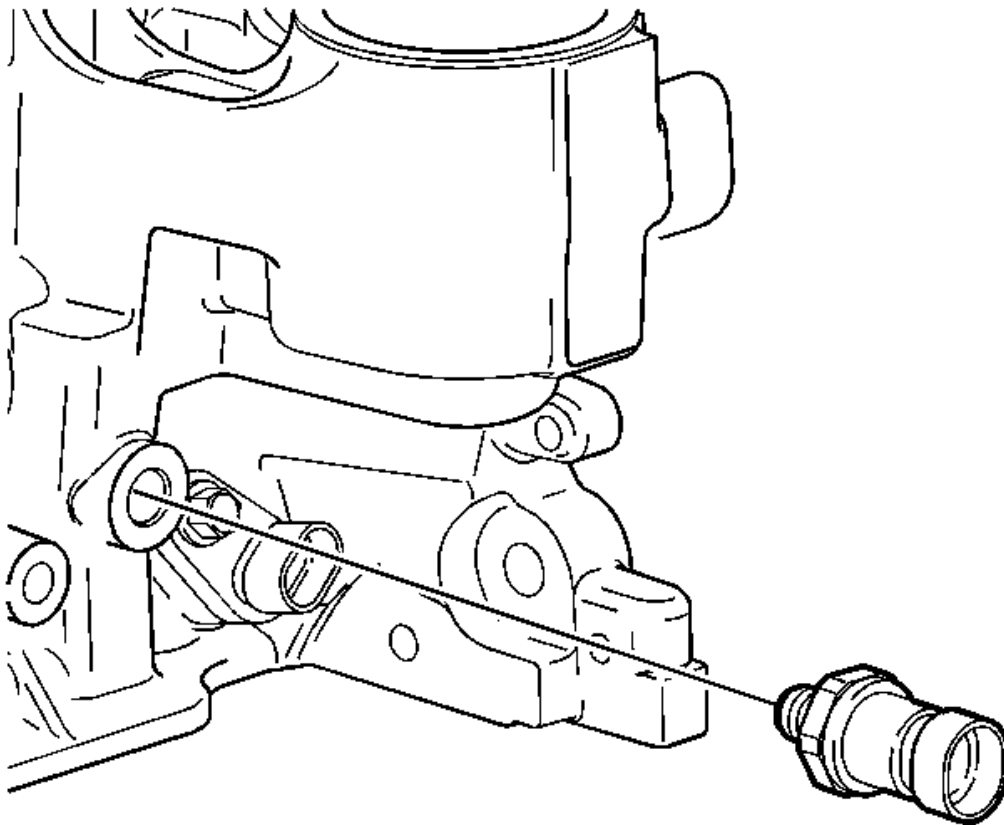


Fig. 526: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pressure switch.

Tighten: Tighten the oil pressure switch to 26 N.m (19 lb ft).

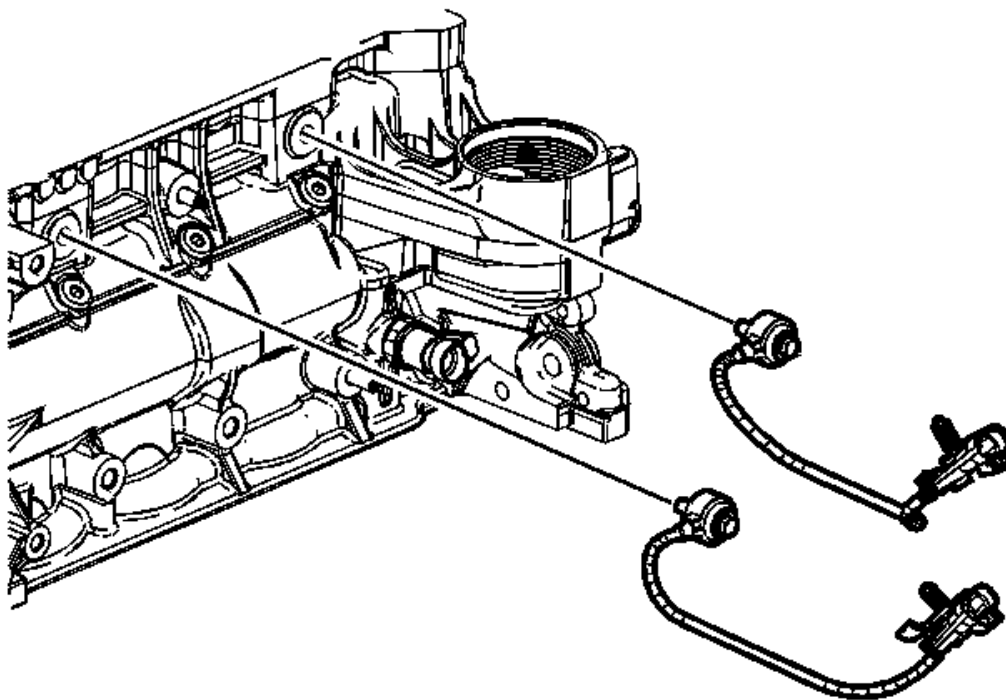


Fig. 527: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

11. Install the knock sensors and bolts.

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

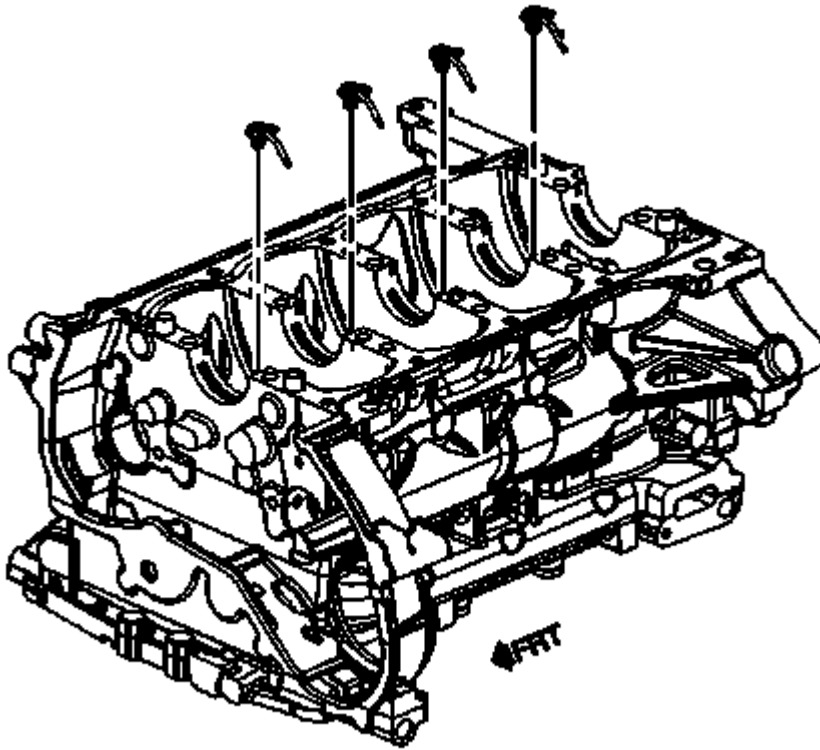


Fig. 528: Identifying Piston Oil Squirters
Courtesy of GENERAL MOTORS CORP.

12. Install the piston oil nozzle assemblies.
13. Install the piston oil nozzle assembly bolts.

Tighten: Tighten the piston oil nozzle assembly bolts to 15 N.m (11 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Tools Required

- **J 8087** Cylinder Bore Checking Gage. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.

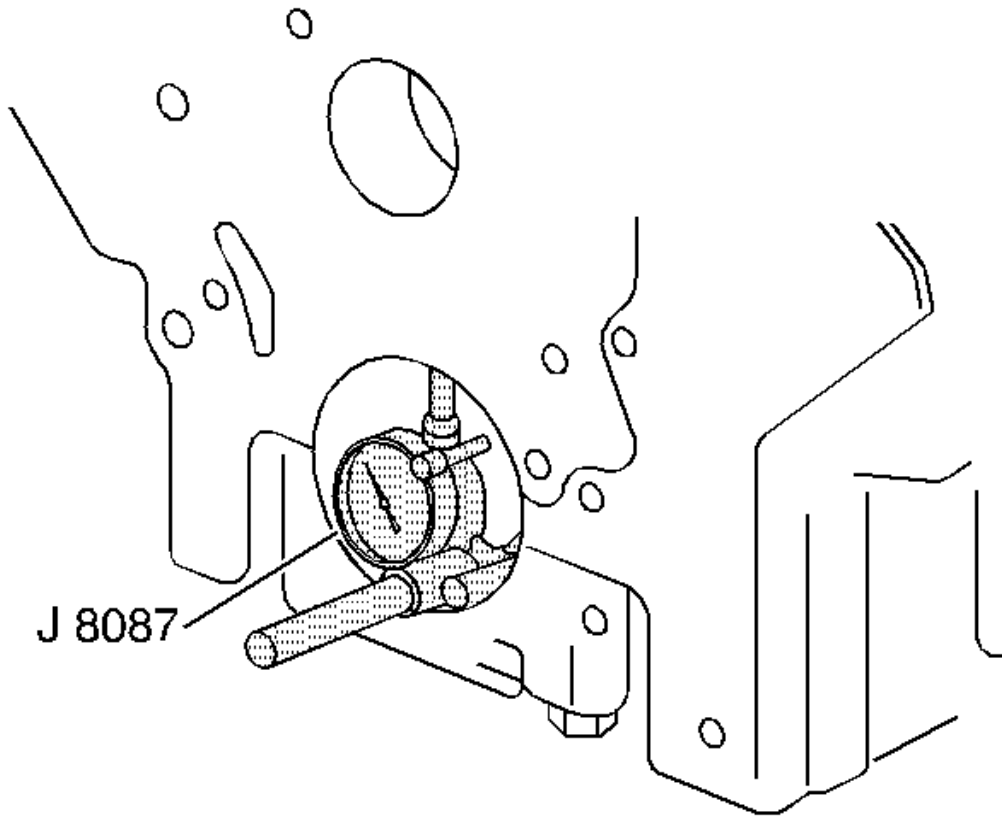


Fig. 529: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 **J 45059** . See **Special Tools**.
- Measure the bearing bore for taper and out-of-round using the **J 8087** . See **Special Tools**.
- 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.

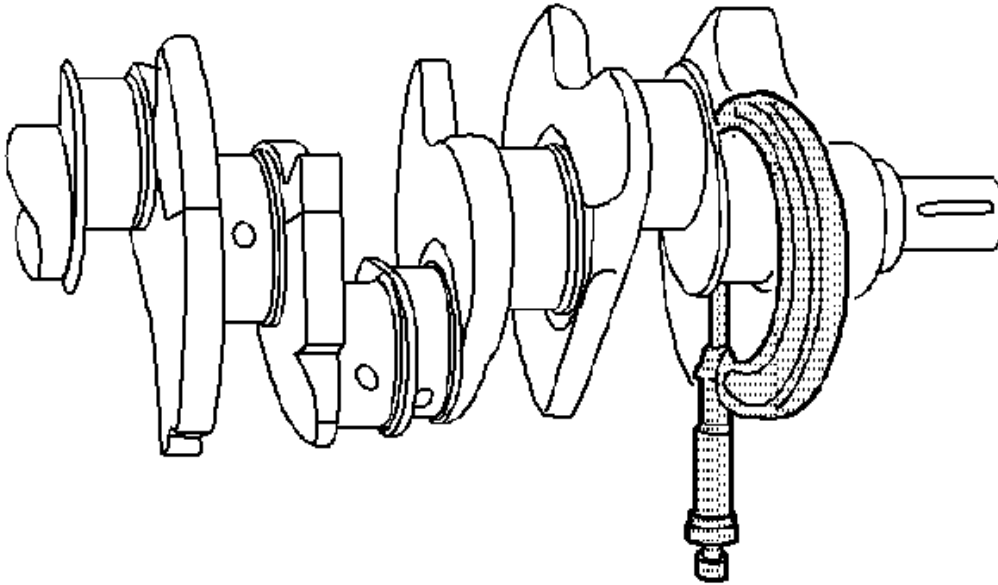


Fig. 530: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 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.

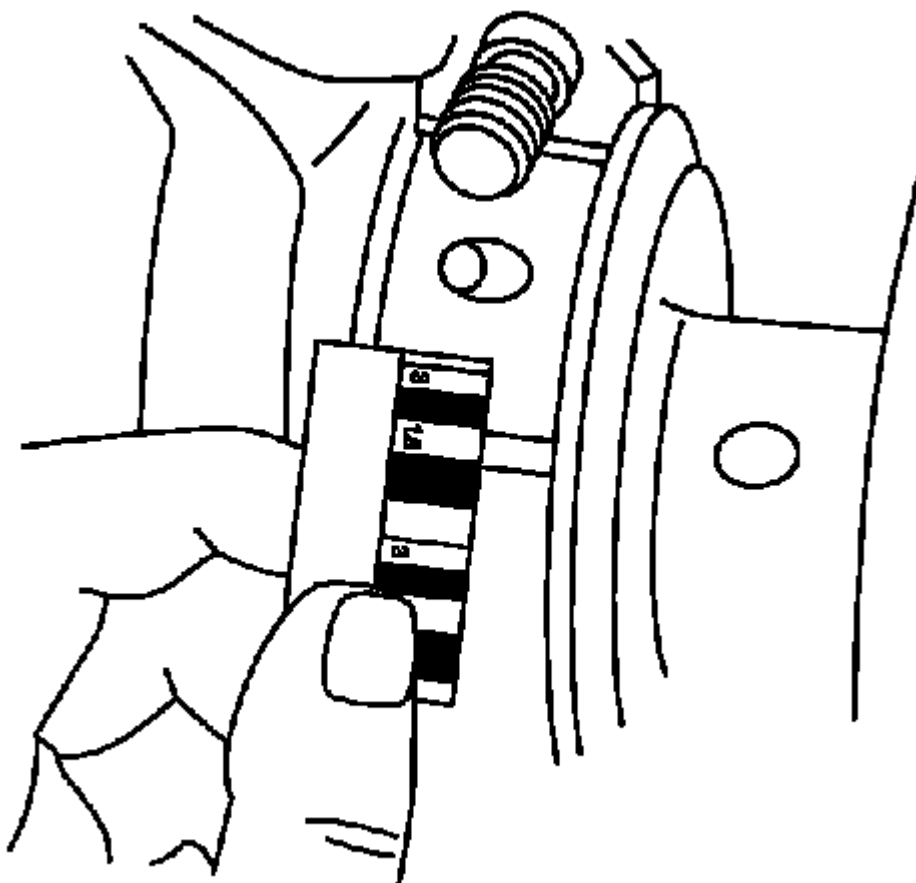


Fig. 531: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: 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.

IMPORTANT: 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 printed on the gaging plastic package.
8. Remove the gaging plastic.

LOWER CRANKCASE INSTALLATION

Tools Required

J 45059 Angle Meter. See Special Tools.

Installation Procedure

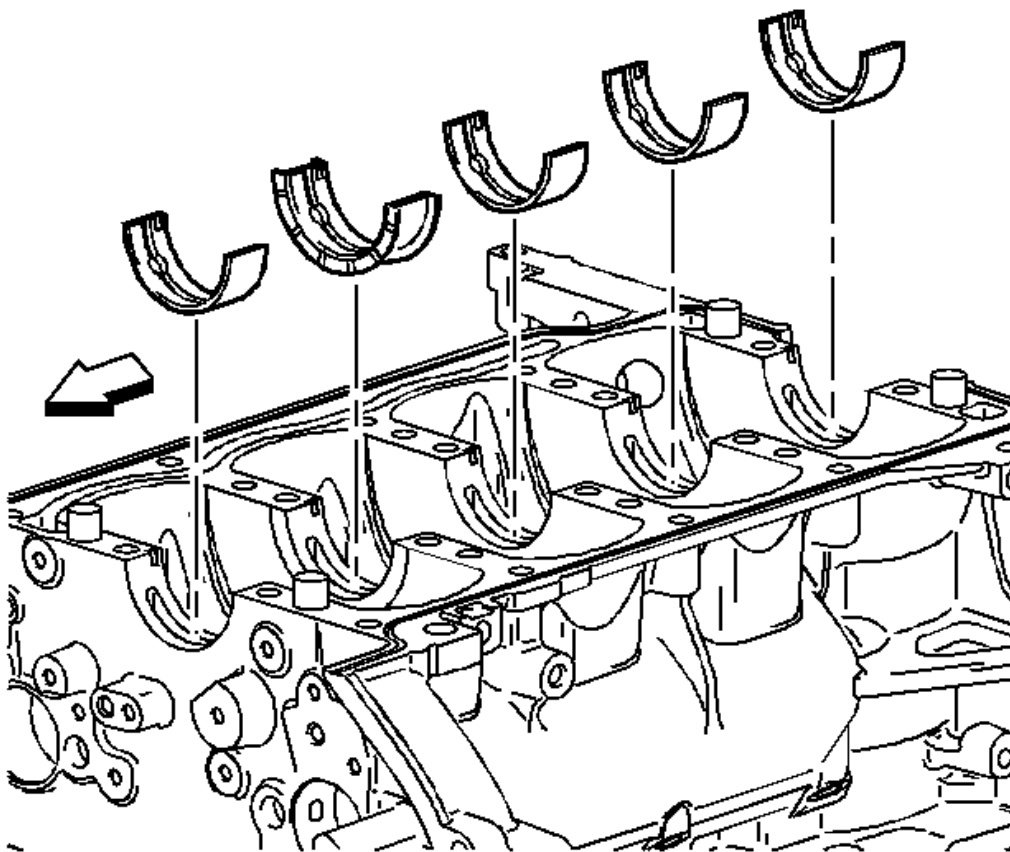


Fig. 532: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft bearings and lubricate bearing surfaces with engine oil.

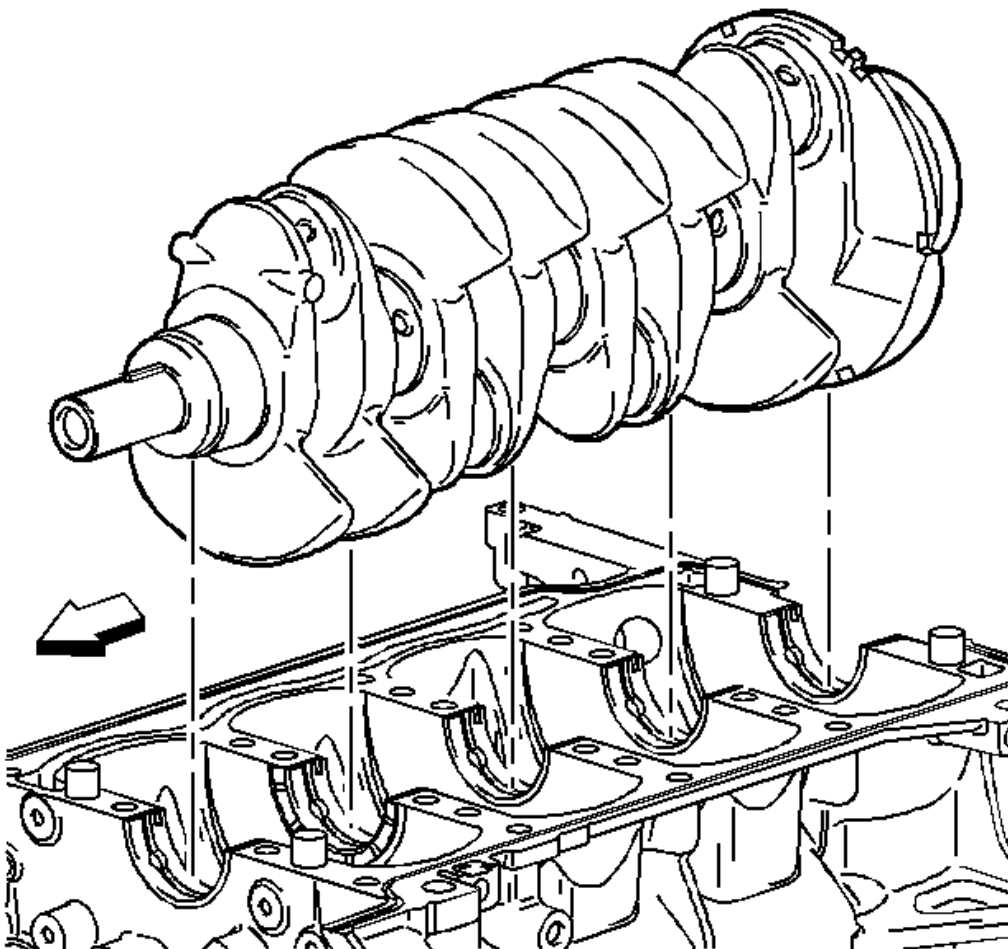


Fig. 533: Installing Crankshaft On Journals
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft on the journals.

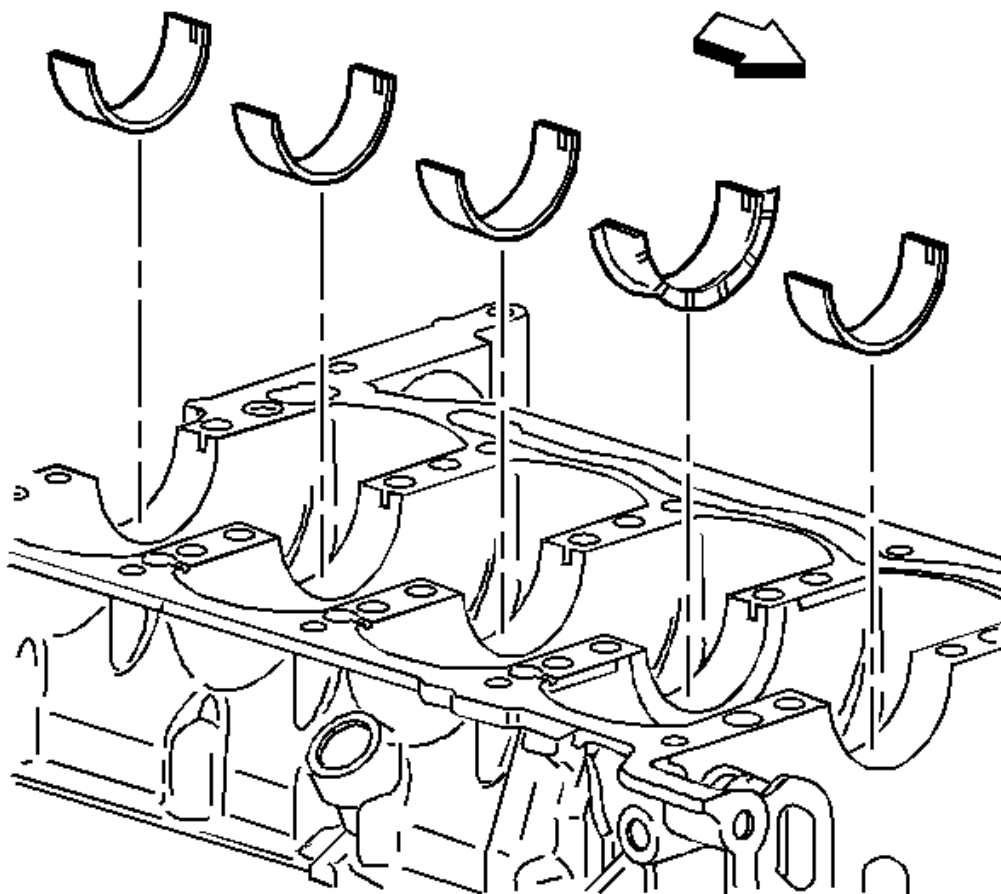


Fig. 534: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Install the lower bearing halves, without grooves, into the lower crankcase. Apply oil to bearing surfaces.

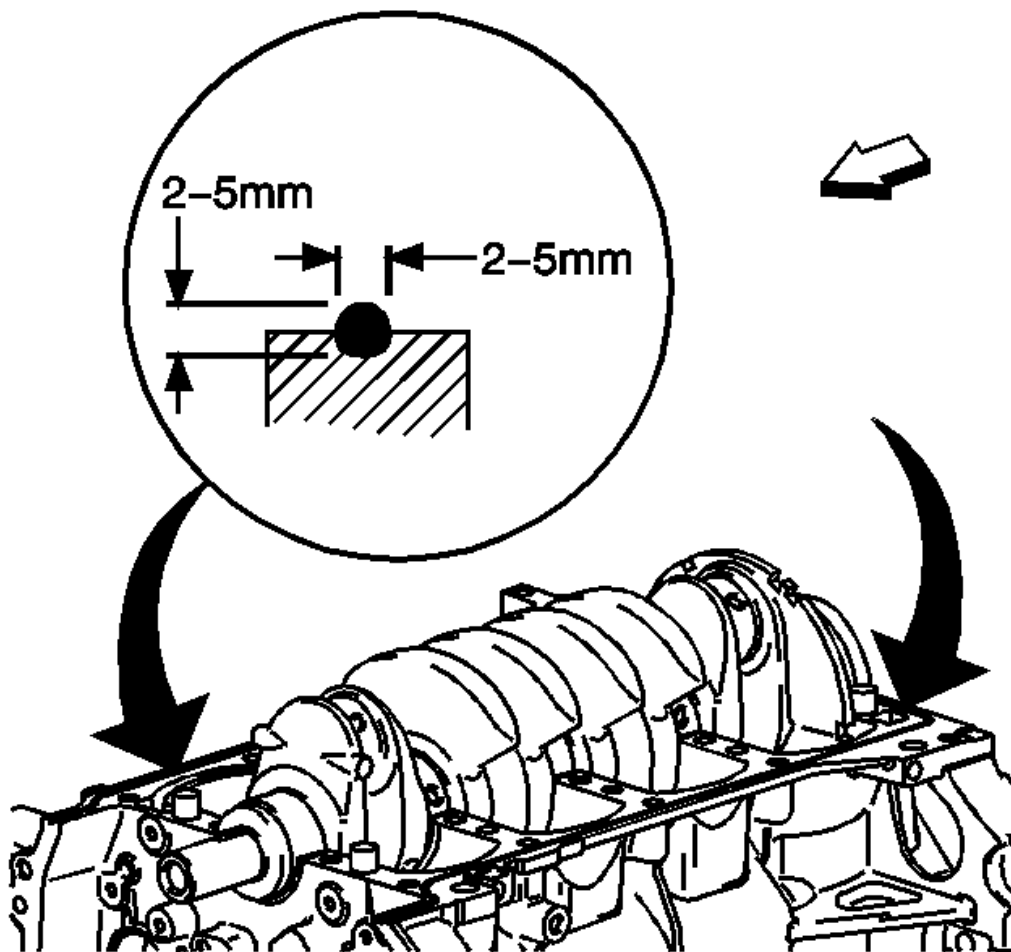


Fig. 535: Applying Sealer To Surfaces Of Engine Block To Bedplate Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) to the surfaces of the engine block to bedplate mating surfaces.

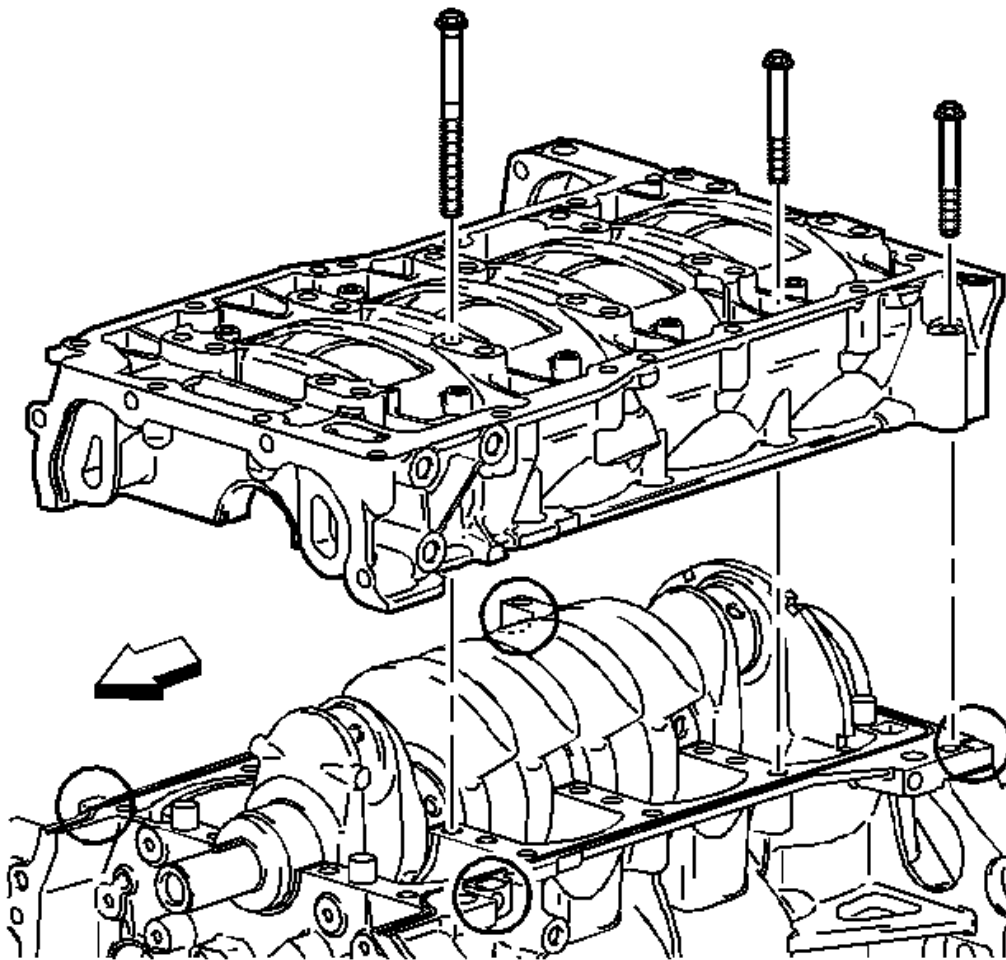


Fig. 536: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase. Tap gently into place with a suitable tool, if necessary. Ensure the lower crankcase is aligned properly on the dowels.

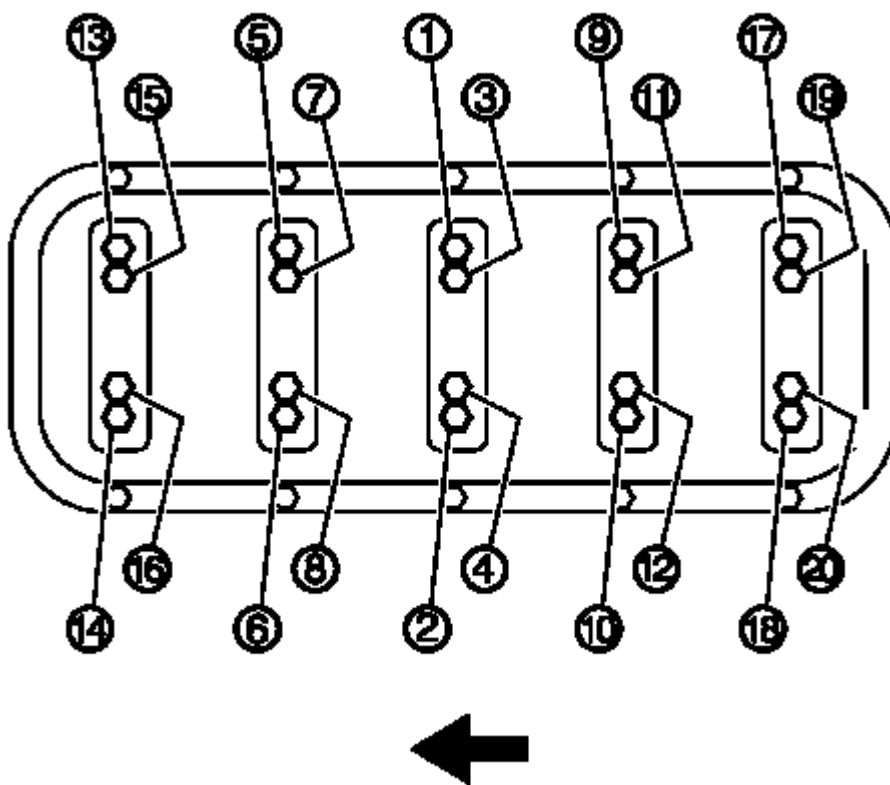


Fig. 537: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the NEW crankshaft bearing bolts in sequence finger tight.

Tighten:

1. Tighten the crankshaft bearing bolts in sequence to 20 N.m (15 lb ft).
2. Using the **J 45059** , tighten the crankshaft bearing bolts in sequence to 77 degrees. See Special Tools.

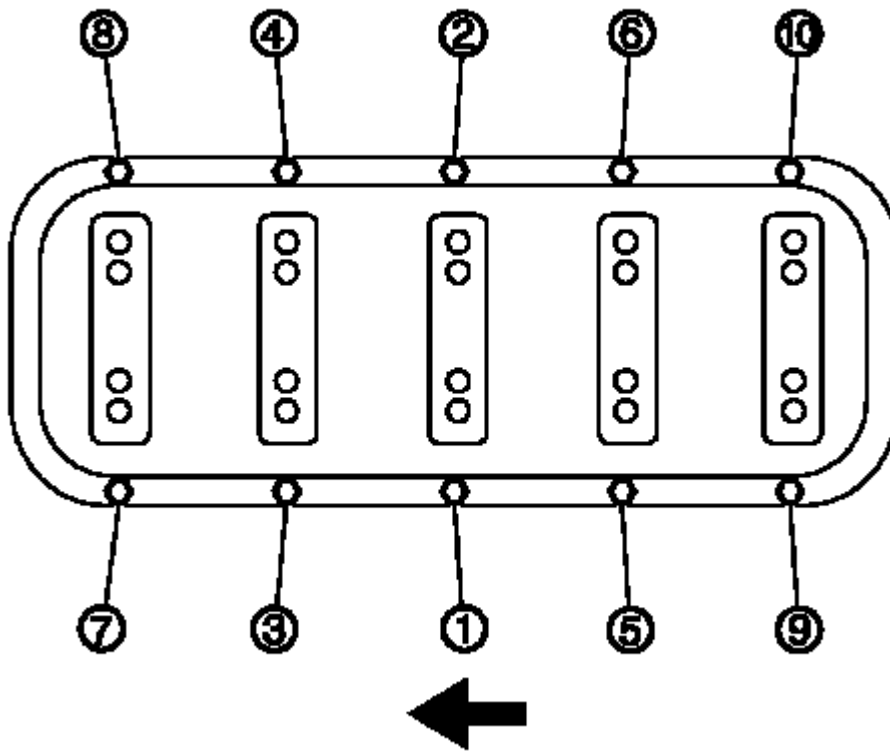


Fig. 538: Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not forget the 2 rear outer bolts.

7. Install the lower crankcase perimeter bolts.

Tighten: Tighten the lower crankcase perimeter bolts in sequence to 25 N.m (18 lb ft).

CRANKSHAFT REAR OIL SEAL INSTALLATION

Tools Required

J 42067 Rear Main Seal Installer. See **Special Tools**.

Installation Procedure

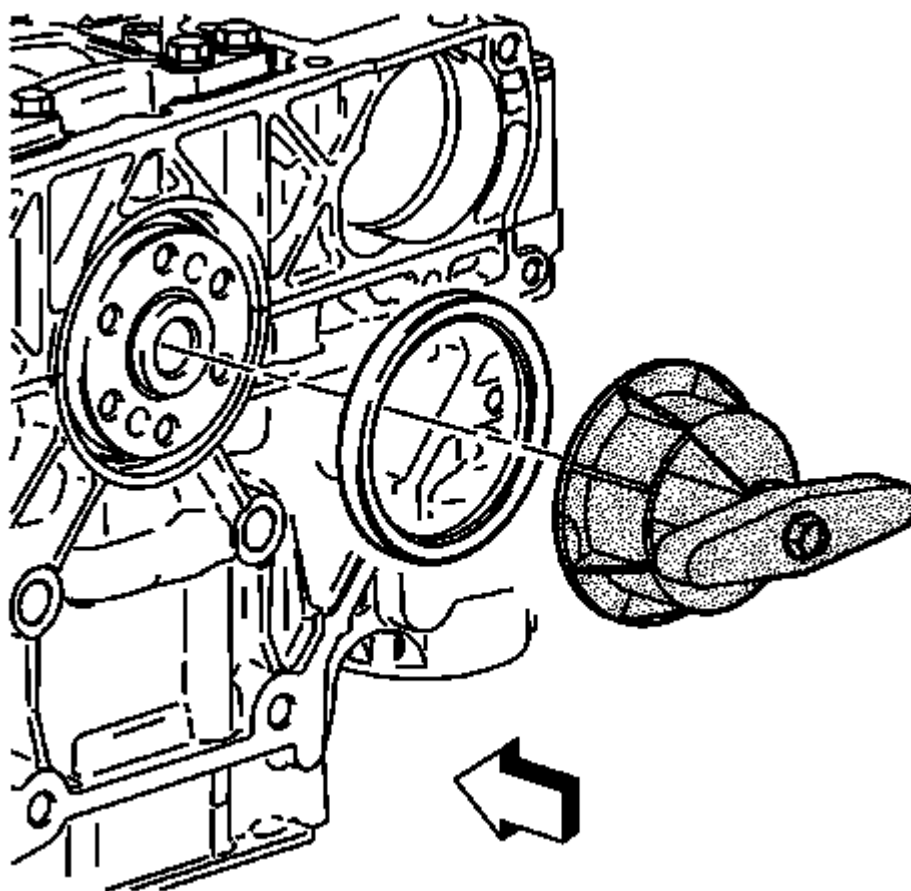


Fig. 539: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove excess sealer from seal recess.
2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **J 42067**, press the new crankshaft seal into the housing. See **Special Tools**. The **J 42067** also establishes the depth of the seal in the crankshaft seal bore. See **Special Tools**. The seal should be flush to 0.5 mm (0.0197 in) deep.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Tools Required

- **J 43953** Piston Ring Compressor
- **J-43966-1** Connecting Rod Guides. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

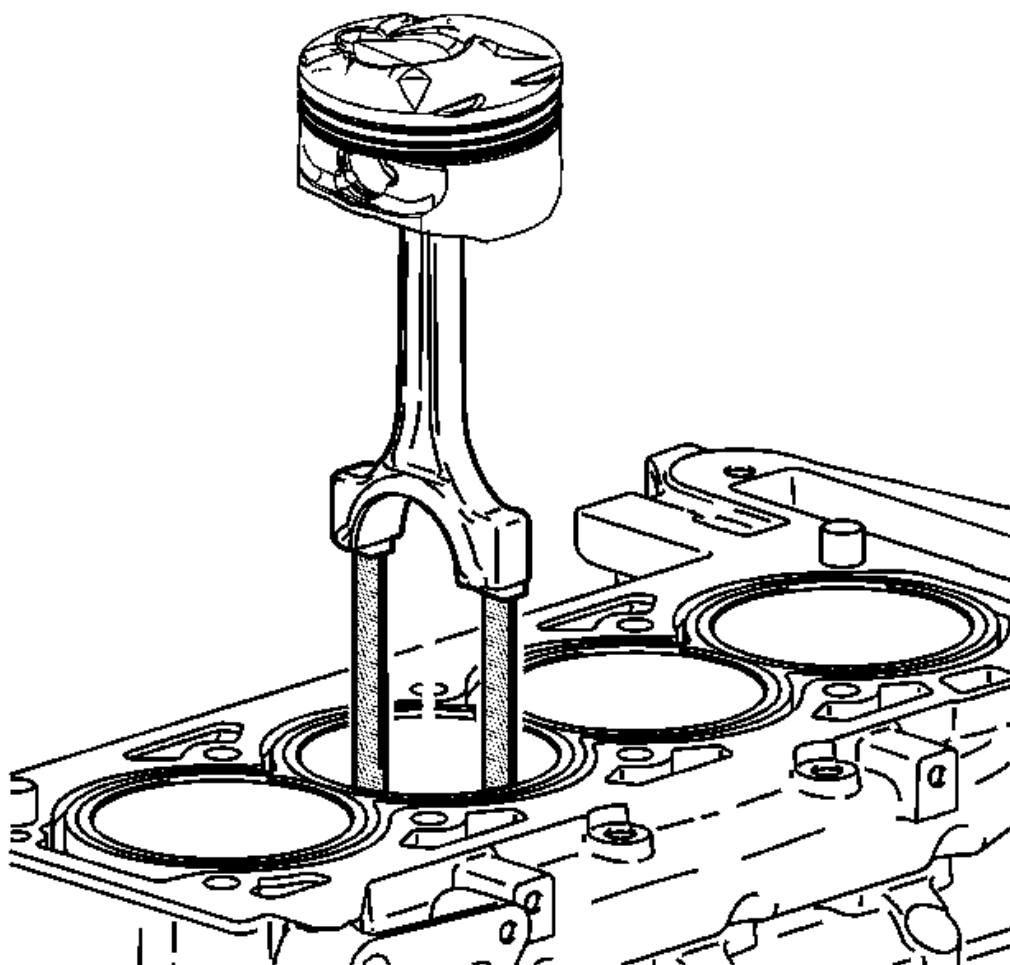


Fig. 540: View Of Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW connecting rod 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 **J-43966-1** into the connecting rod bolt holes. See **Special Tools**. This protects the crankshaft journal during piston and connecting rod installation.
3. Install the **J 43953** , the 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 **J 43953** 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.

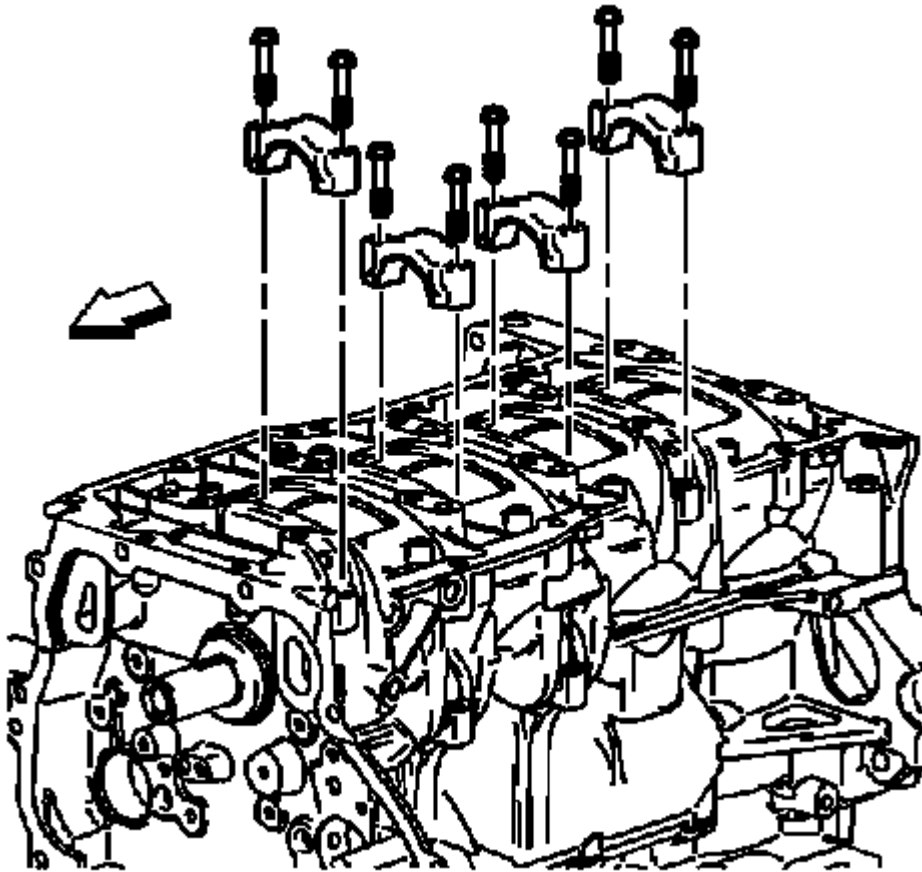


Fig. 541: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap.

NOTE: Refer to Fastener Notice .

5. Install the connecting rod bolts. Always use NEW bolts.

Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft), plus 100 degrees using the **J 45059** . See

Special Tools.

6. Install the remaining connecting rods and piston assemblies.

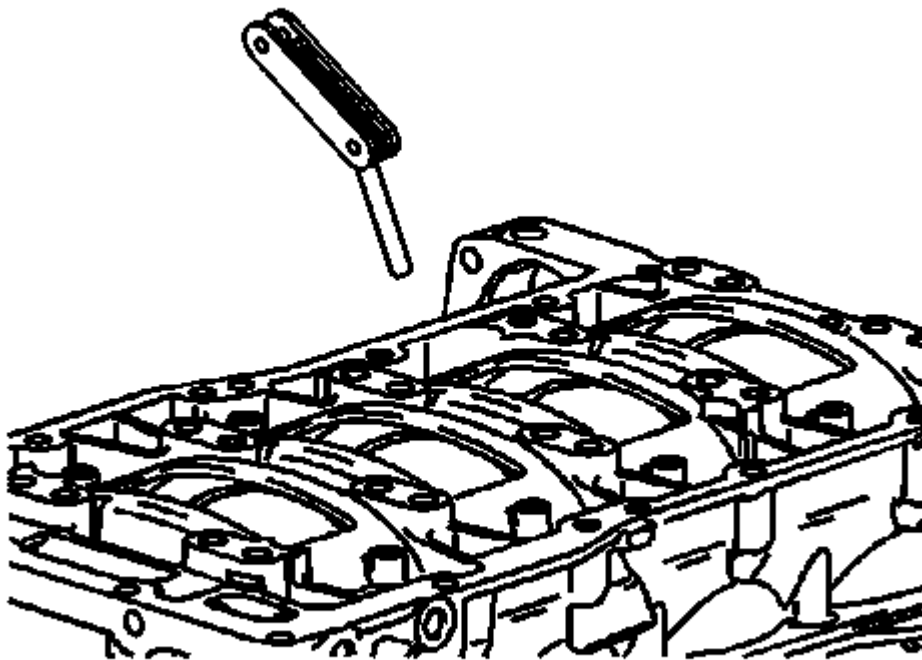


Fig. 542: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the connecting rod side clearance with a feeler gage.

The correct clearance is 0.07-0.37 mm (0.0027-0.0145 in).

CYLINDER HEAD INSTALLATION**Tools Required**

J 45059 Angle Meter. See **Special Tools**.

Installation Procedure

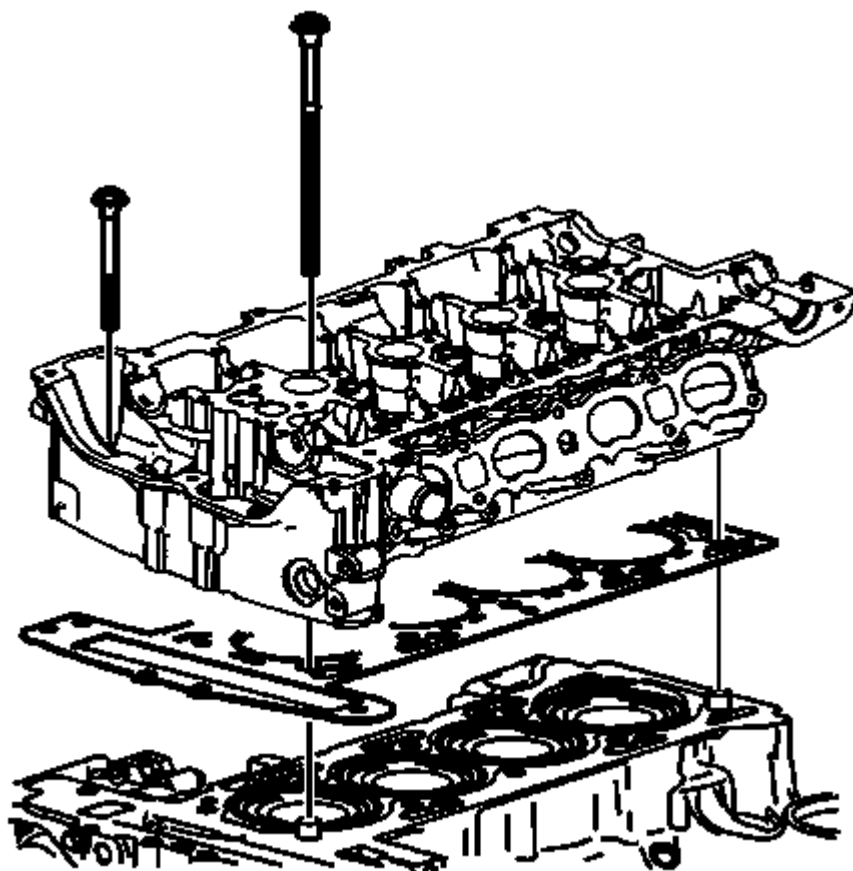


Fig. 543: View Of Cylinder Head, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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.

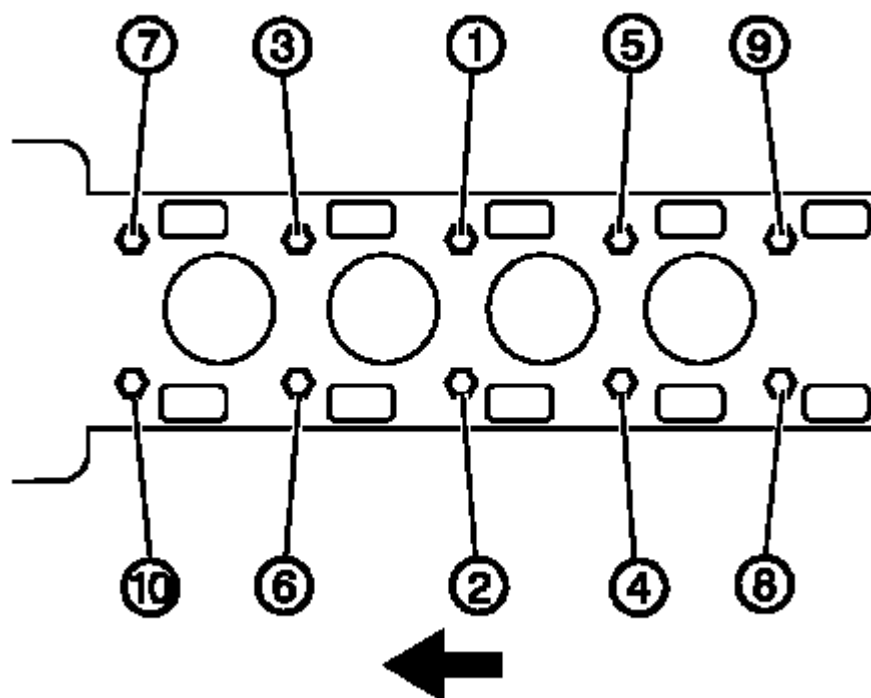


Fig. 544: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Always use **NEW** cylinder head bolts.

3. Install the cylinder head bolts.

Tighten:

- Tighten the bolts in sequence to 30 N.m (22 lb ft).
- Tighten the bolts an additional 155 degrees in sequence using the **J 45059** . See Special Tools.

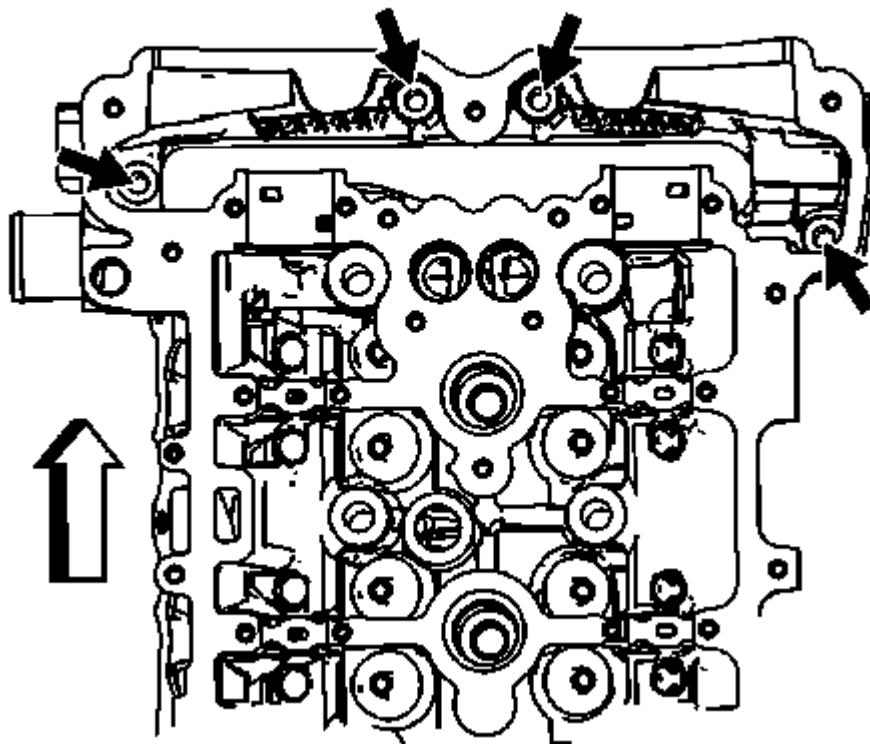


Fig. 545: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the front cylinder head bolts.

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

INTAKE CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

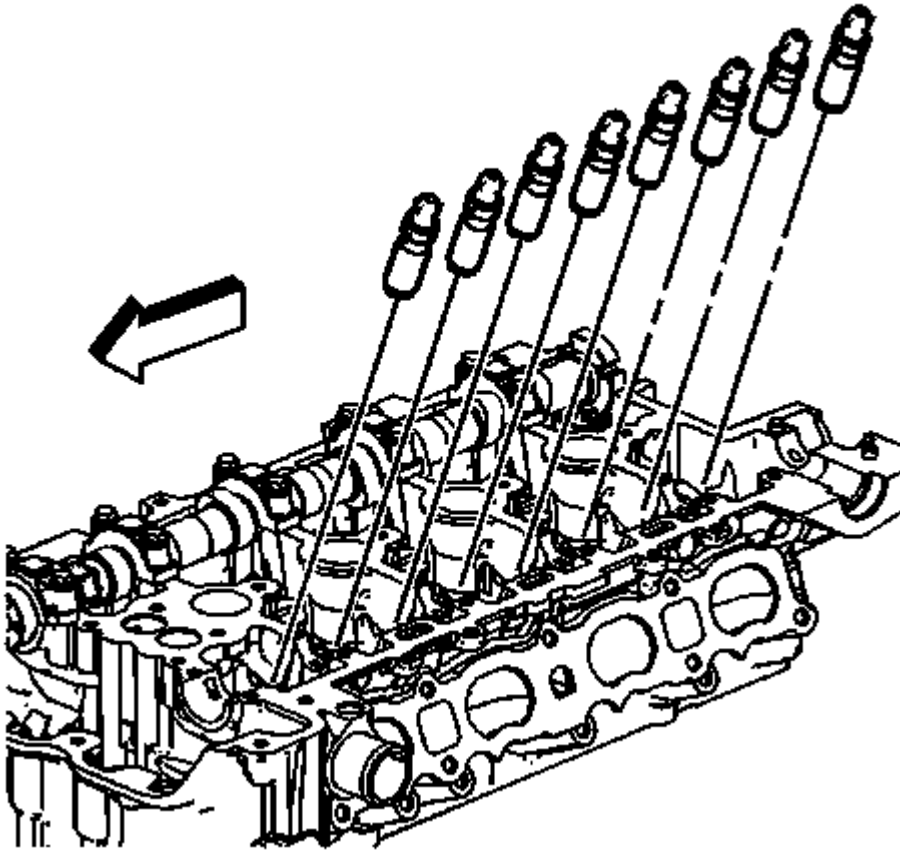


Fig. 546: View Of Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters with GM P/N 1234550 (Canadian P/N 992704), or equivalent.

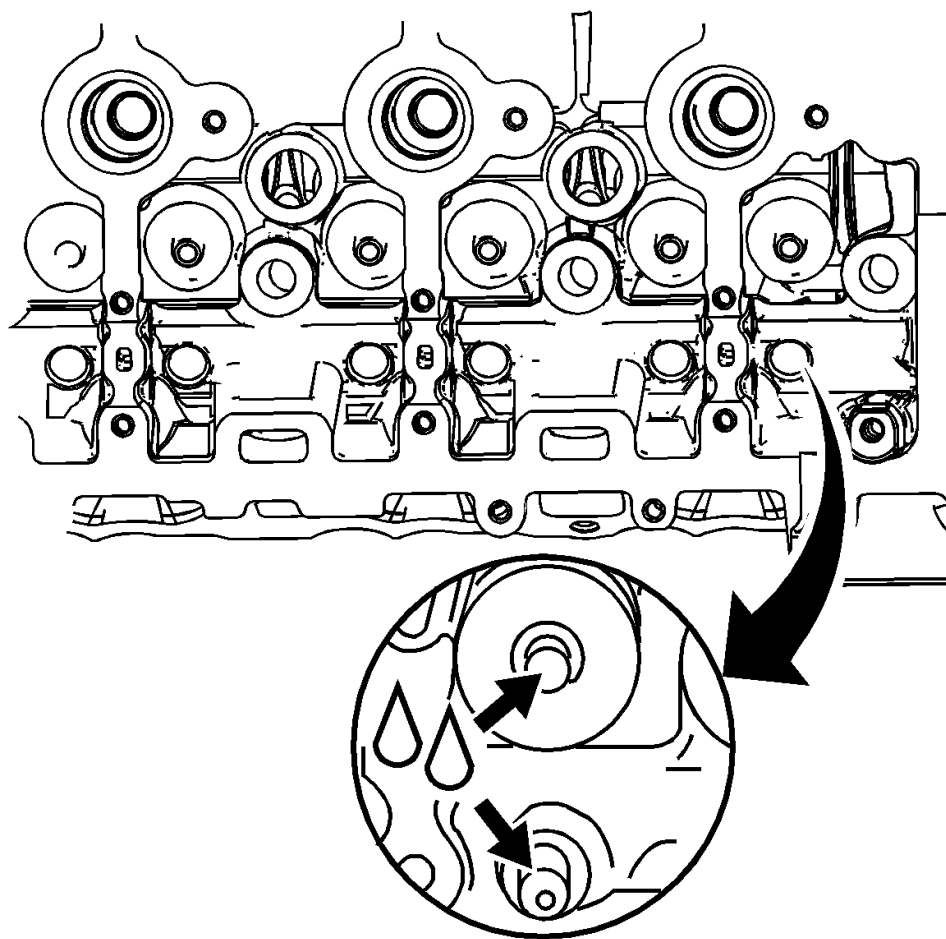


Fig. 547: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips.

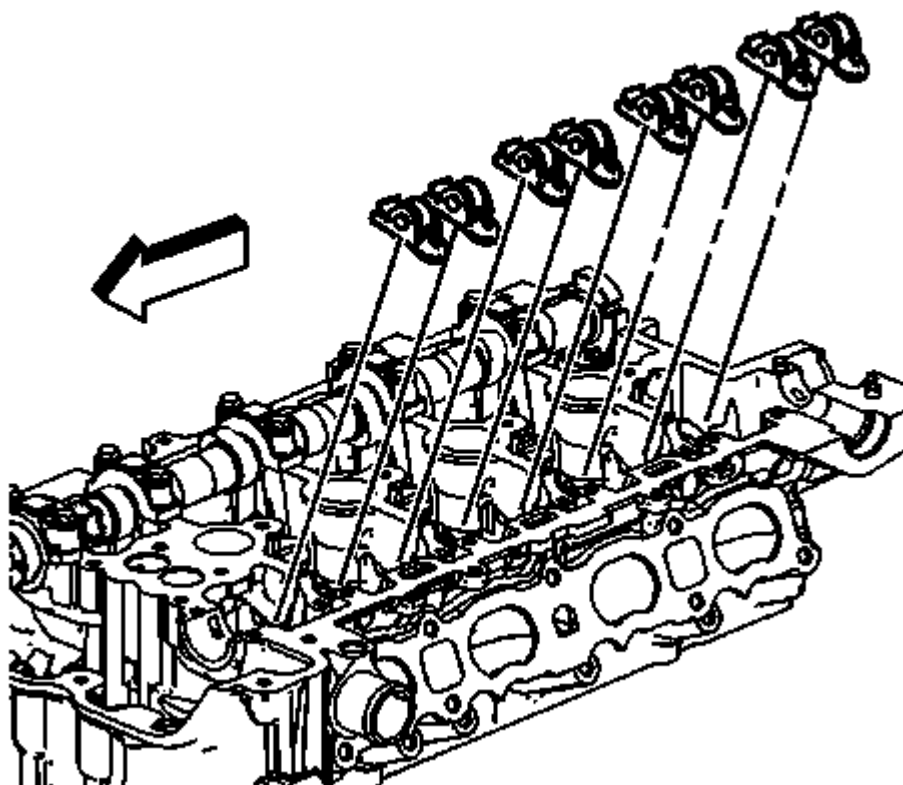


Fig. 548: View Of Intake Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 with GM P/N 12345501 (Canadian P/N 992704), or equivalent.

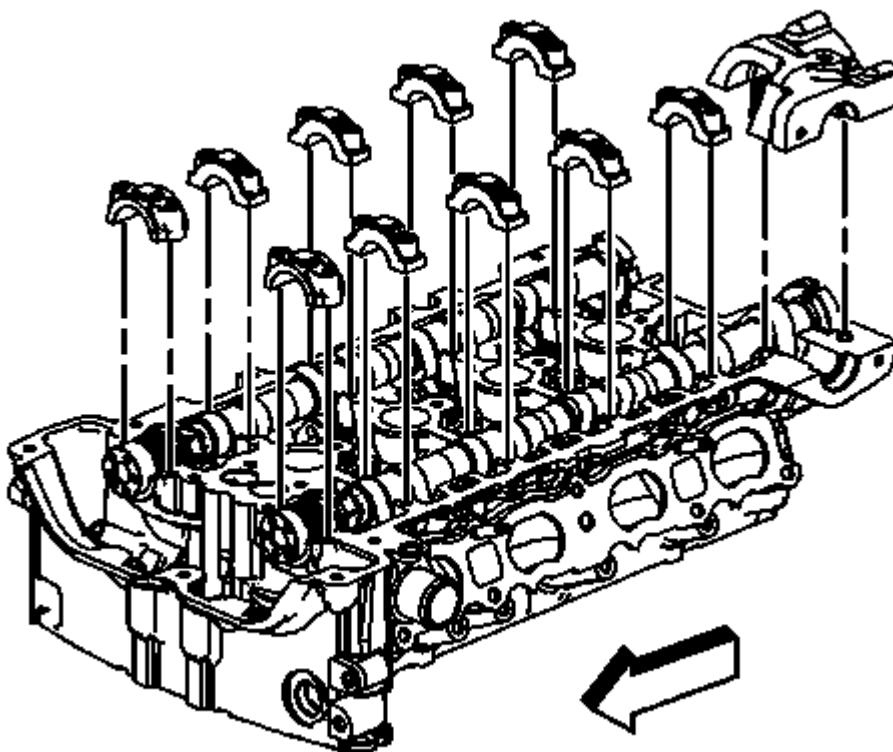
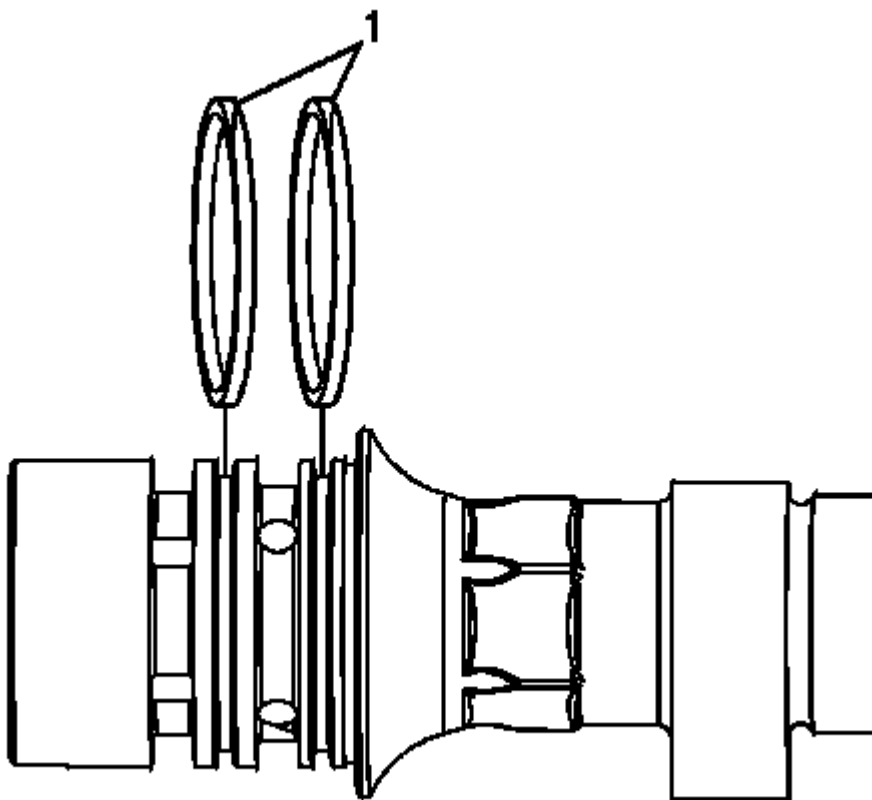


Fig. 549: Intake Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704), or equivalent.

**Fig. 550: View Of 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.

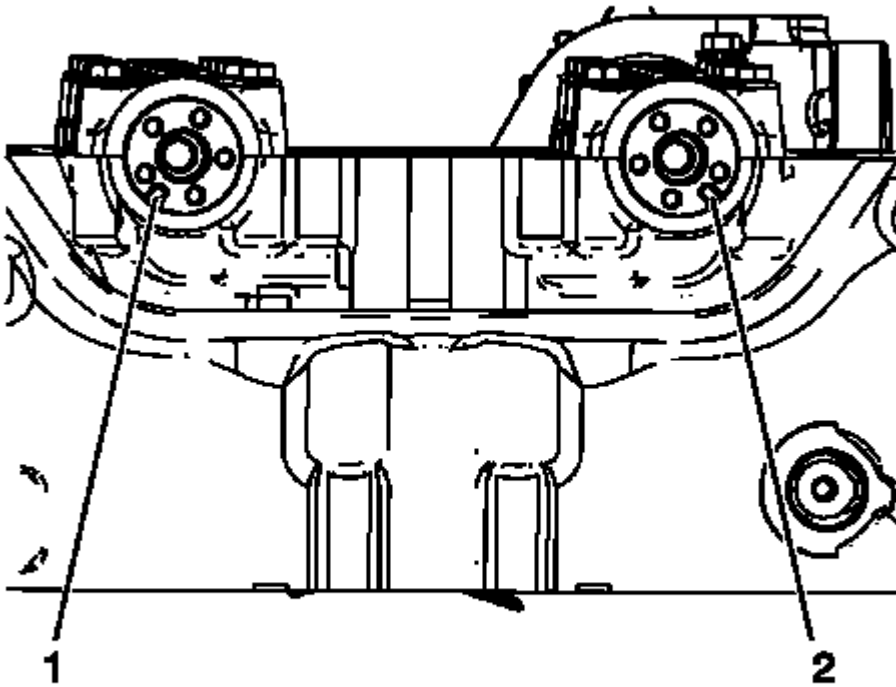


Fig. 551: Identifying Proper Exhaust/Intake Camshaft Alignment positions
 Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The number 1 cylinder must be at top dead center (TDC), crankshaft keyway at the 12 o'clock position.

7. Install the intake camshaft with the notch on the front at approximately the 5 o'clock position (2).
8. Install the camshaft caps and hand start the camshaft cap bolts.

NOTE: Refer to Fastener Notice .

9. Tighten the camshaft cap bolts in increments of 3 turns until they are seated.

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

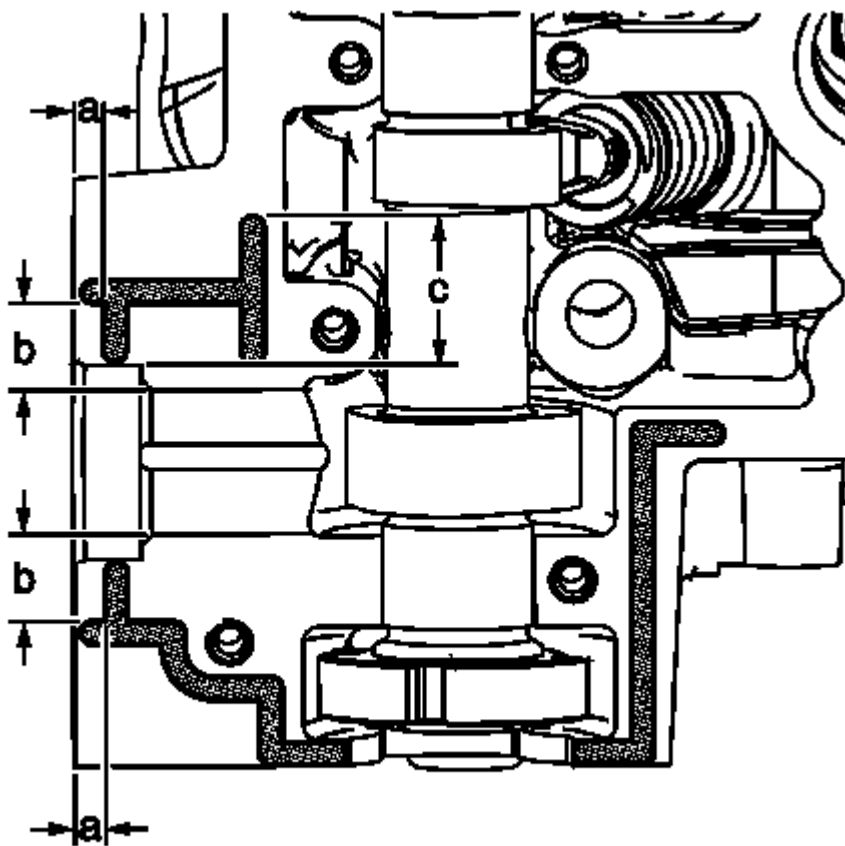


Fig. 552: Locating Sealer Application Areas
Courtesy of GENERAL MOTORS CORP.

10. Apply a 3.5 mm bead of sealer GM P/N 12378521 (Canadian P/N 88901148) to the cylinder head to number 6 camshaft cap mating surface.
11. Install the number 6 rear camshaft cap.

Tighten: Tighten the number 6 rear camshaft cap to 10 N.m (89 lb in).

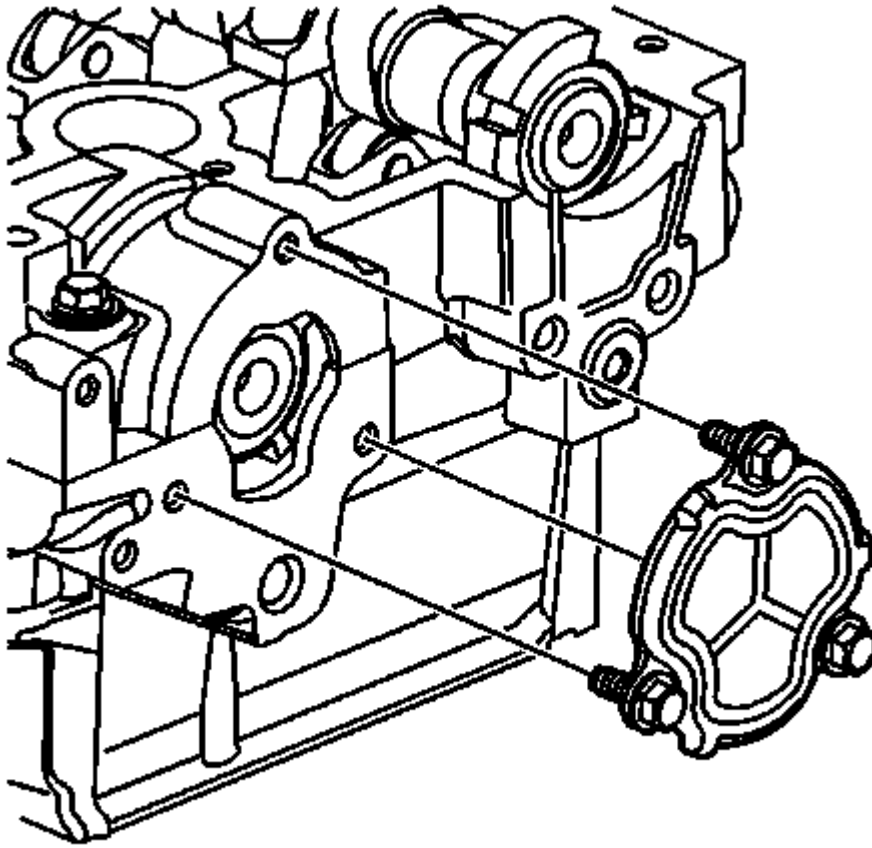


Fig. 553: View Of Cylinder Head Opening Plate
Courtesy of GENERAL MOTORS CORP.

12. Install the rear cylinder head opening plate and bolts.

Tighten: Tighten the rear cylinder head opening plate bolts to 10 N.m (89 lb in).

EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

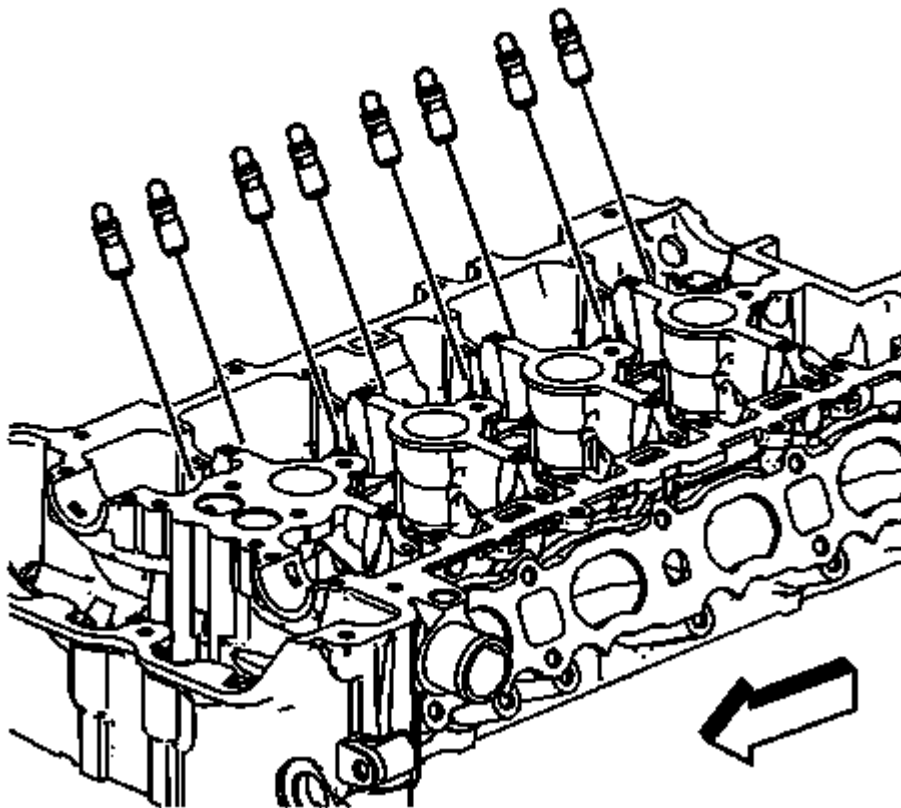


Fig. 554: View Of Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head. Apply lubricant GM P/N 12345501 (Canadian P/N 992704), or equivalent.

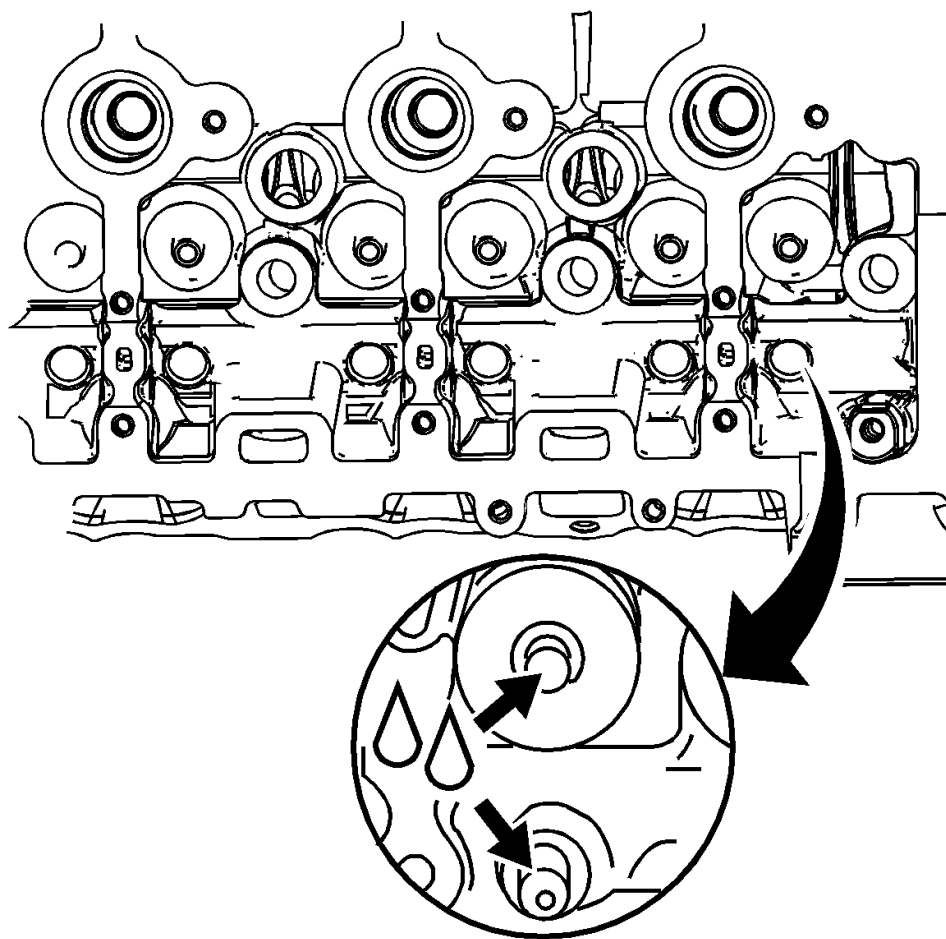


Fig. 555: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the valve tips with GM P/N 12345501 (Canadian P/N 992704), or equivalent.

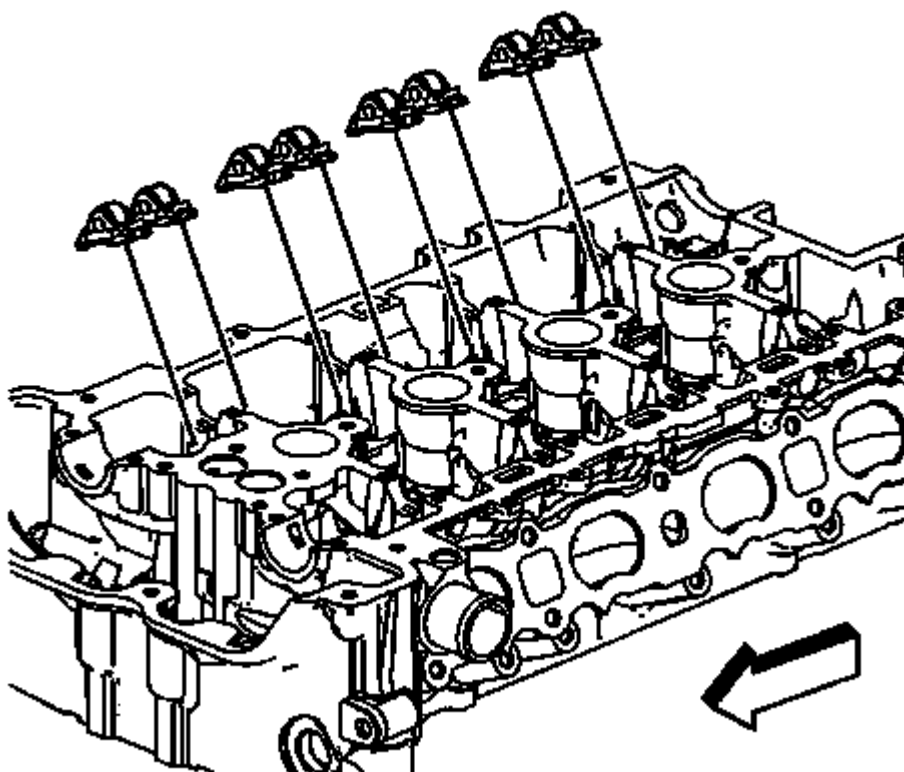


Fig. 556: View Of Exhaust Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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. Apply lubricant GM P/N 12345501 (Canadian P/N 992704), or equivalent.

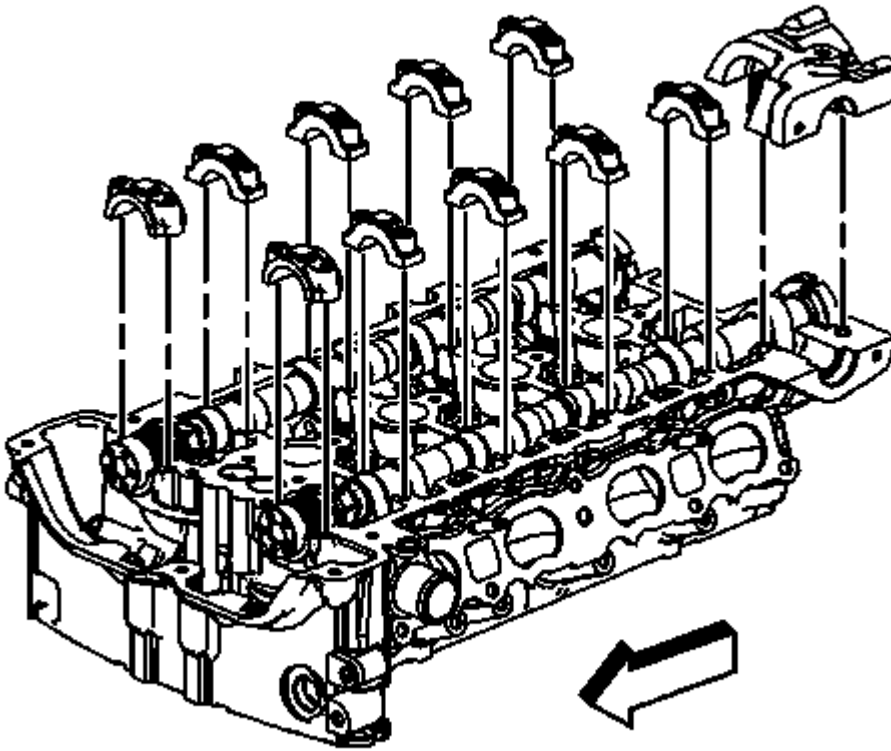
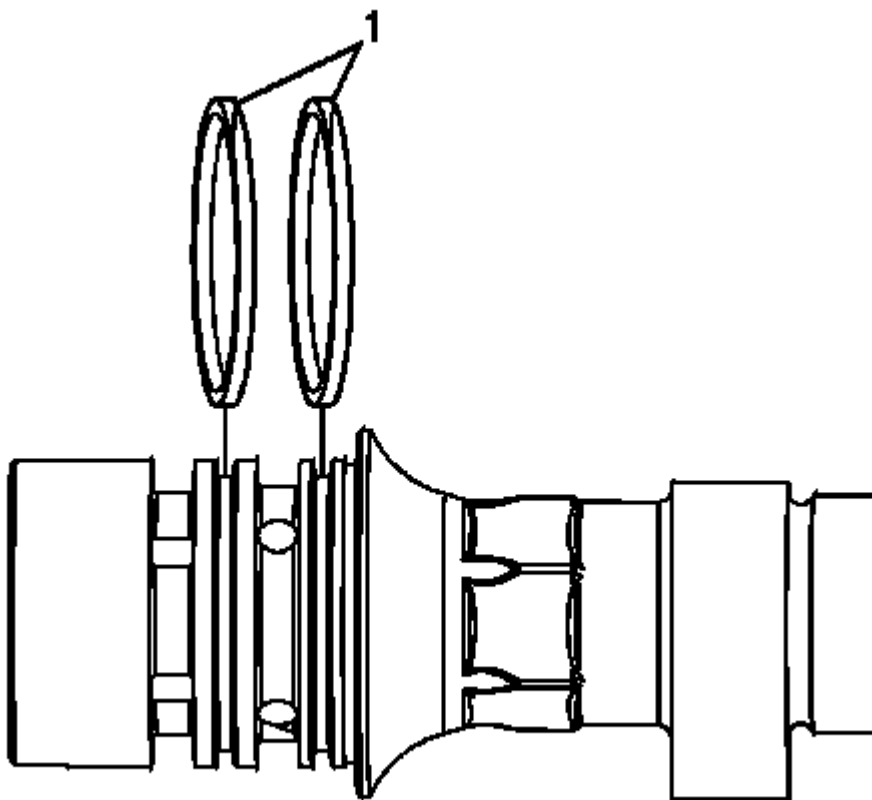


Fig. 557: View Of Intake Camshaft & Caps
Courtesy of GENERAL MOTORS CORP.

4. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704), or equivalent.

**Fig. 558: View Of Oil Seals****Courtesy of GENERAL MOTORS CORP.**

5. 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.

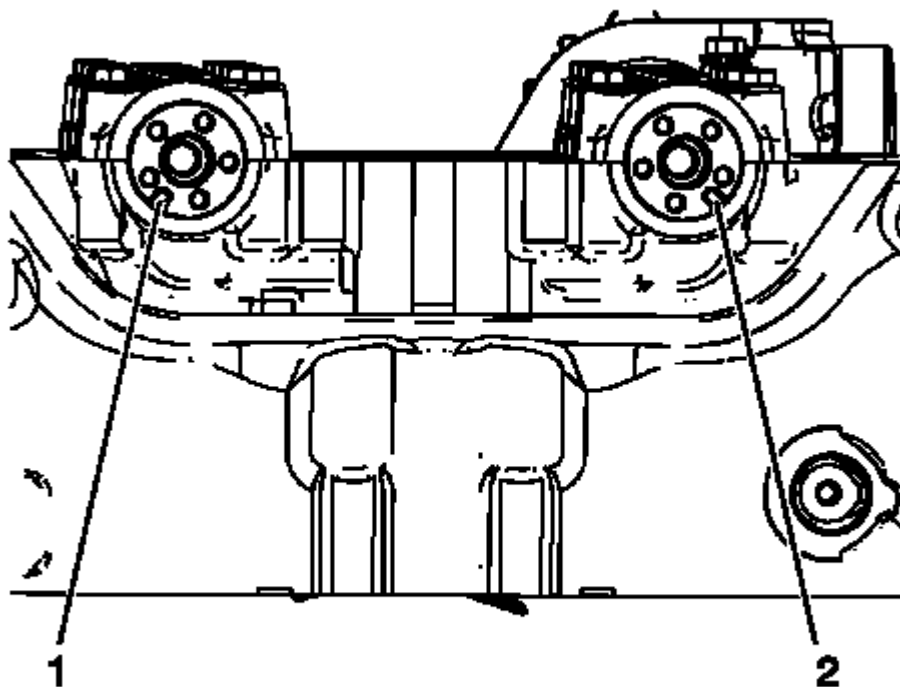


Fig. 559: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

6. Install the exhaust camshaft with the notch on the front (1) at approximately the 7 o'clock position.
7. Install the camshaft caps and hand start the camshaft cap bolts.

NOTE: Refer to Fastener Notice .

8. Lubricate and tighten the camshaft cap bolts in increments of 3 turns until they are seated.

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

BALANCE SHAFT INSTALLATION

Tools Required

J 43650 Balance Shaft Bushing Remover/Installer. See Special Tools.

Installation Procedure

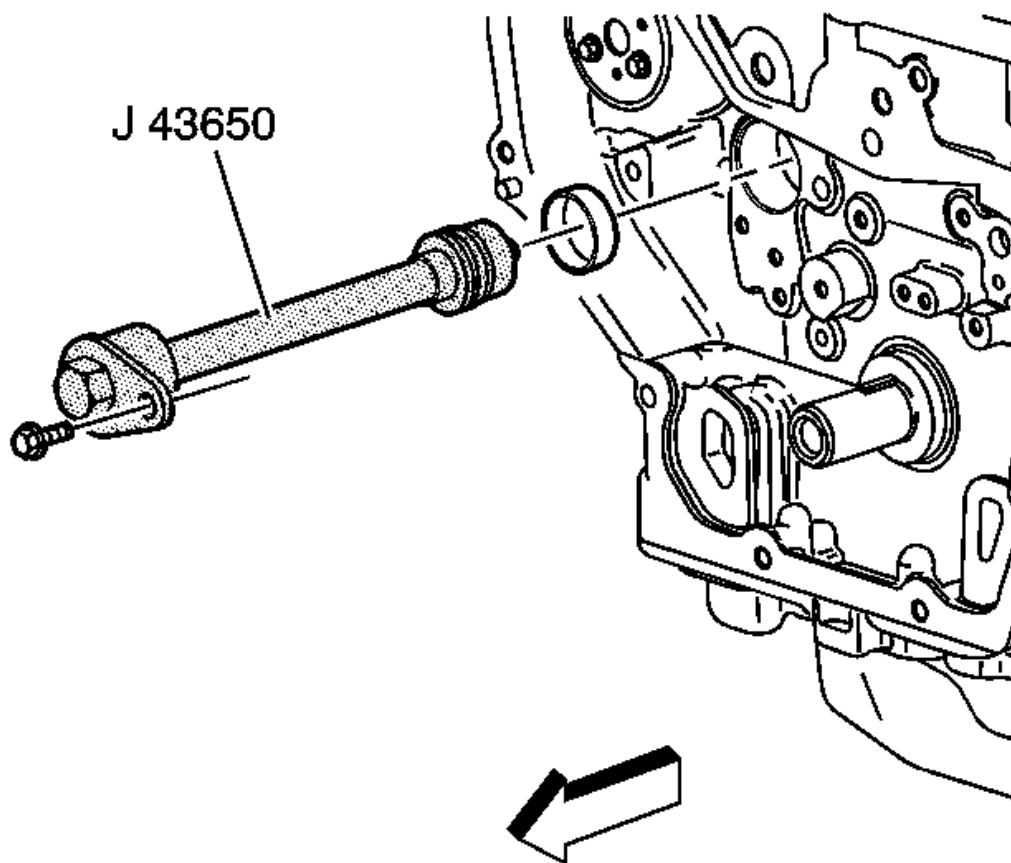


Fig. 560: Installing Balance Shaft Using J 43650
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Service the balance shafts as an assembly. Do not disassemble or assemble the balance shafts.

1. Install the balance shaft bushing using the **J 43650** . See Special Tools.

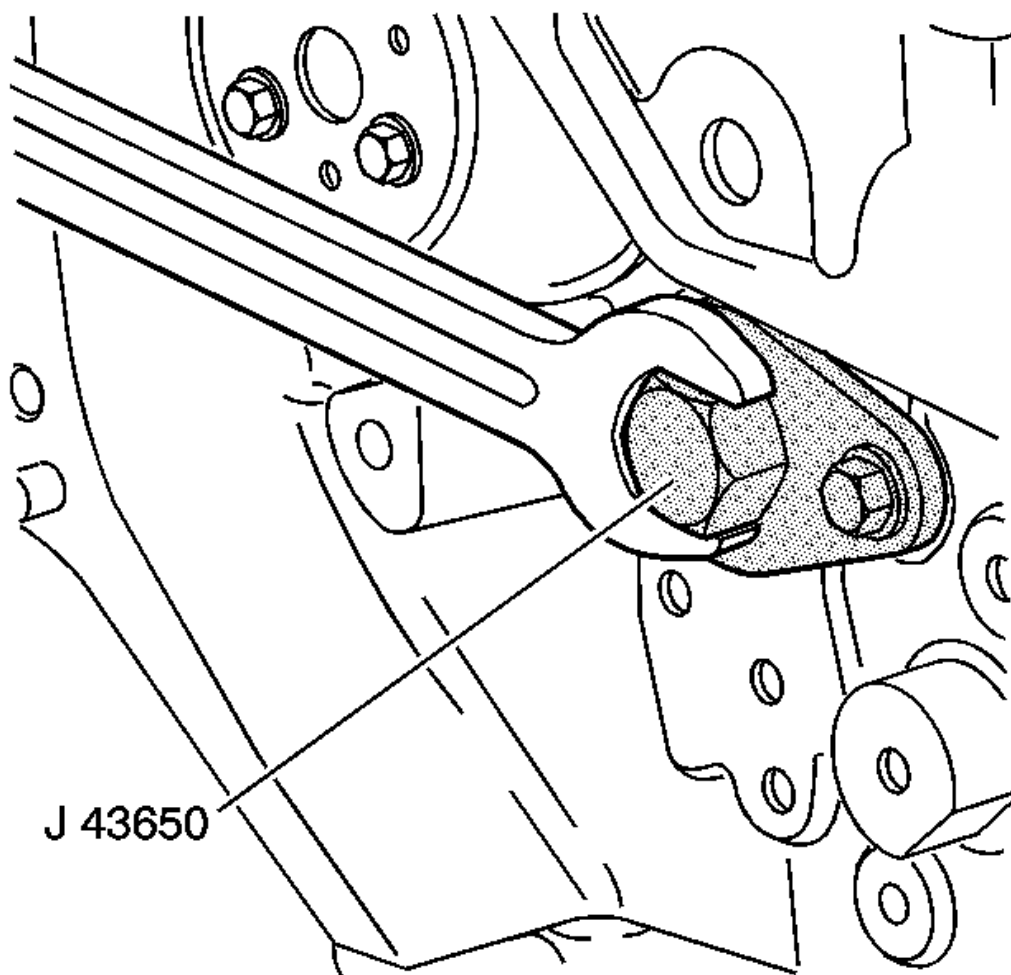


Fig. 561: Seating Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

2. Seat the balance shaft bushing into the bore using the **J 43650** and a wrench. See **Special Tools**.
3. When the **J 43650** is fully seated in the engine block, remove it with a wrench. See **Special Tools**.

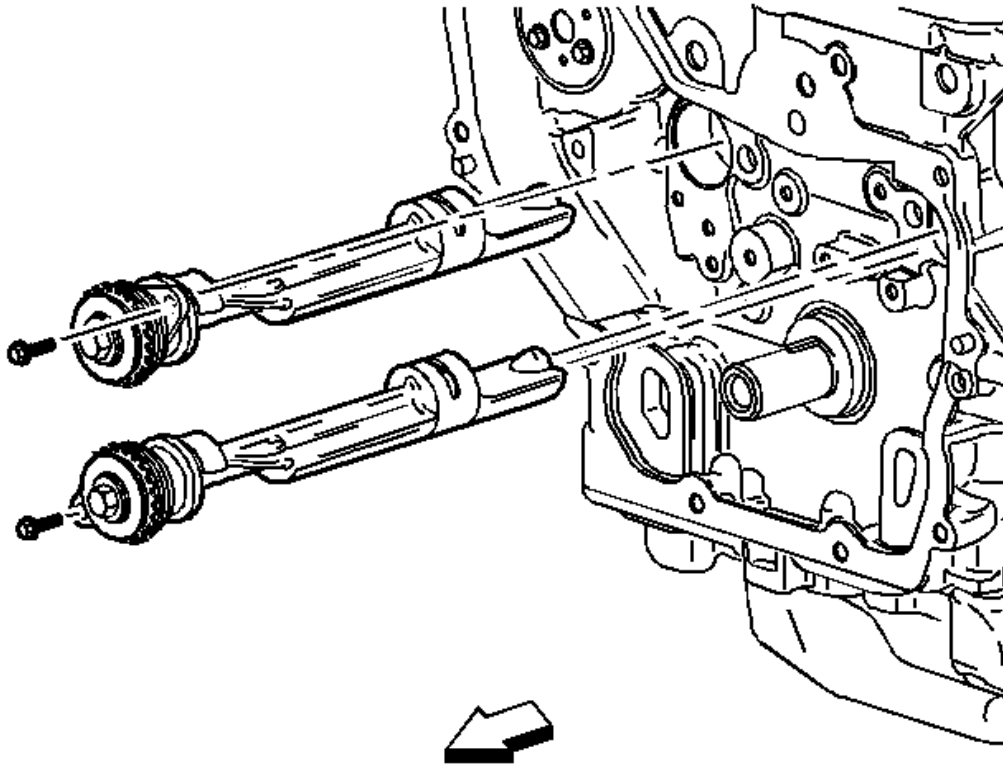


Fig. 562: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.
- Install the balance shaft assemblies to the engine using the following steps:

4. Place the number 1 piston at top dead center (TDC).
5. Lubricate the balance shaft lobes with engine oil.
6. Install the balance shafts into their bores.

NOTE: Refer to Fastener Notice .

7. Install the balance shaft retaining bolts.

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

WATER PUMP INSTALLATION

IMPORTANT: Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to ensure proper sealing.

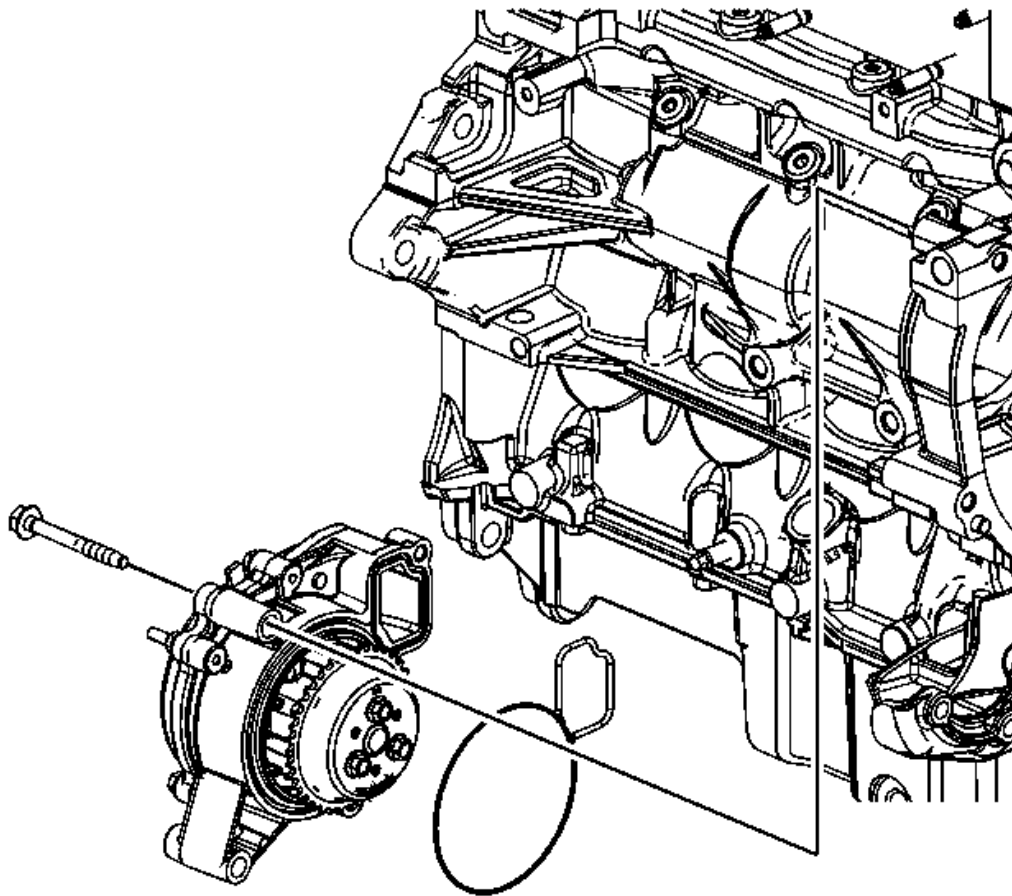


Fig. 563: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump assembly.

IMPORTANT: Do not install the front water pump bolt until after the engine front cover is on.

2. Install the water pump bolts. Finger tighten the bolts.

NOTE: Refer to Fastener Notice .

3. Tighten the water pump bolts.

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

4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the water pump drain plug.
5. Install the water pump drain plug, if necessary.

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

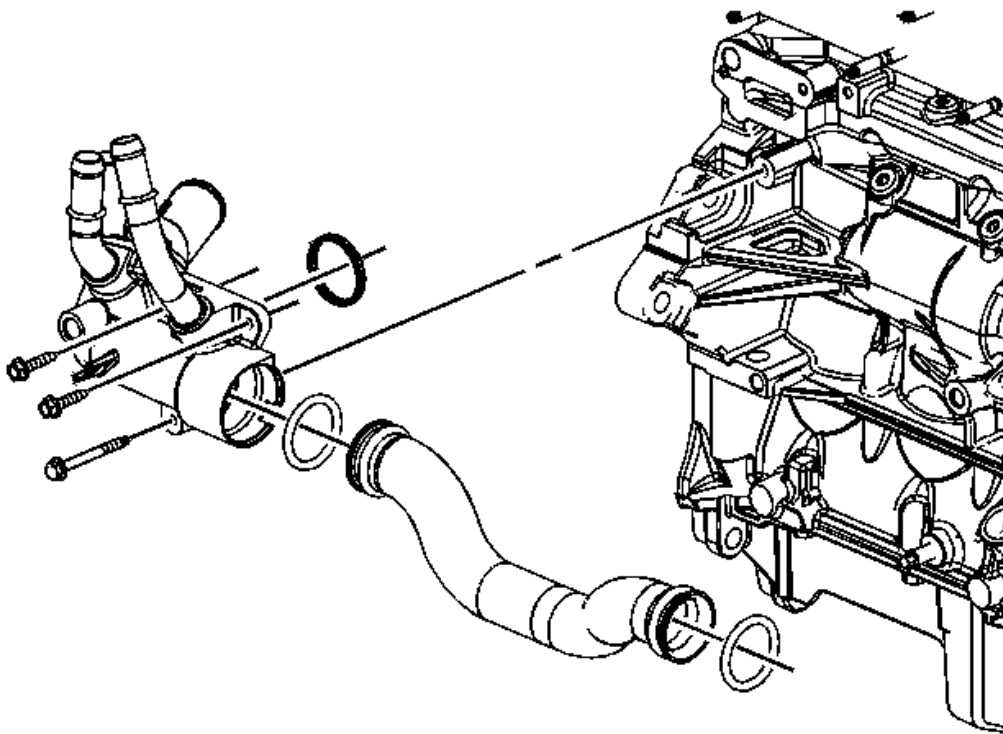


Fig. 564: Identifying Radiator Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

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.

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

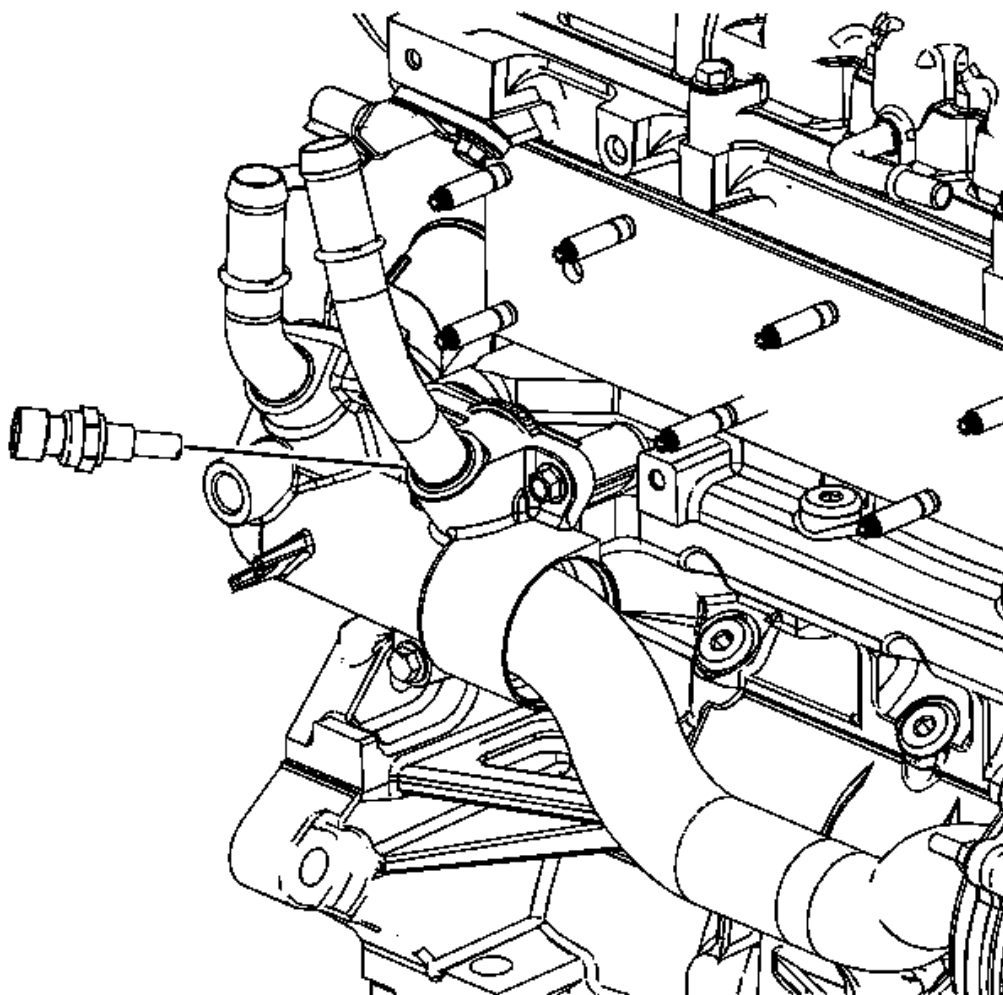


Fig. 565: Locating Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the engine coolant temperature sensor by hand.
11. Tighten the engine coolant temperature sensor.

Tighten: Tighten the engine coolant temperature sensor to 20 N.m (15 lb ft).

BALANCE SHAFT TO ENGINE TIMING

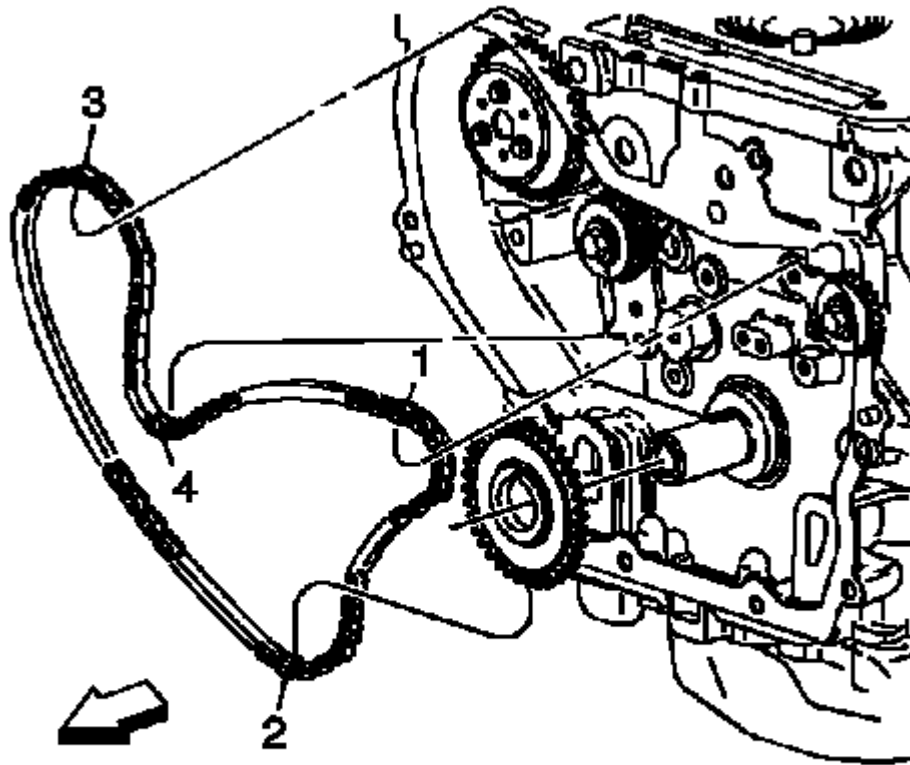


Fig. 566: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft drive sprocket and key.

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 3 colored links on the chain. 2 links are of matching colors, and 1 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 at the 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

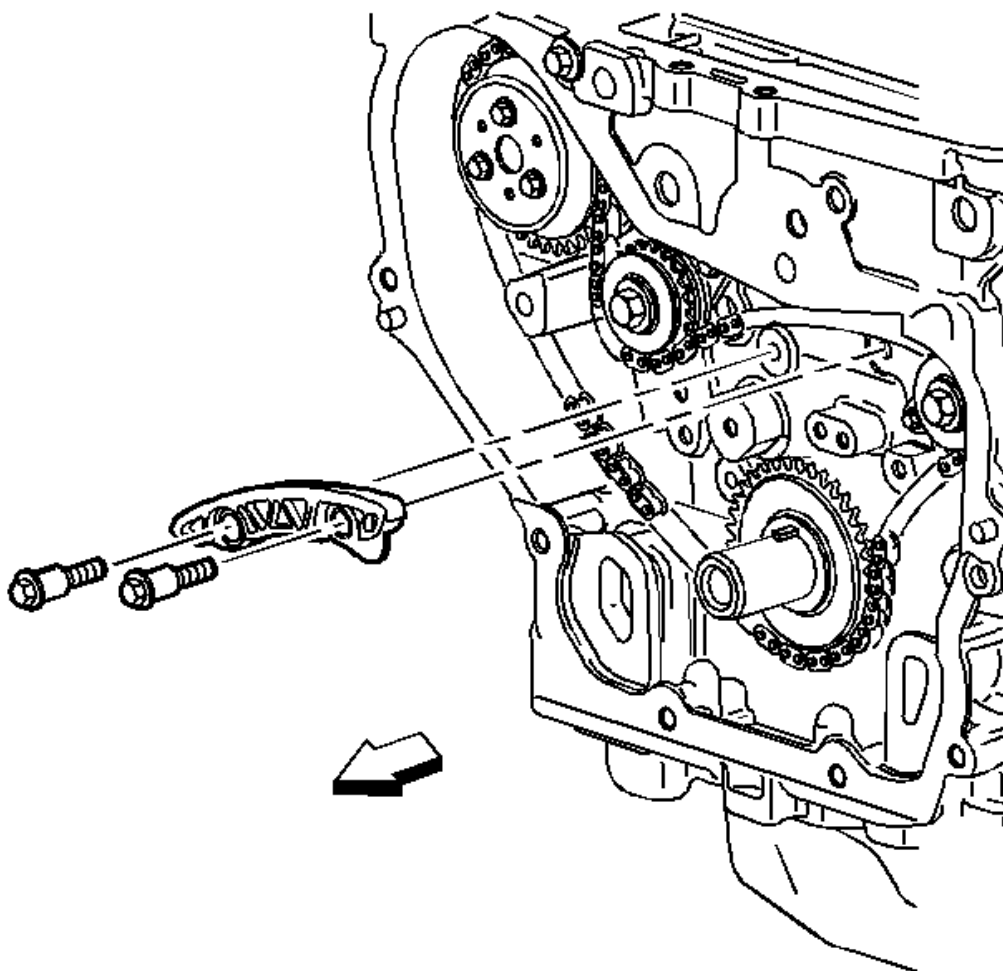


Fig. 567: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to **FASTENER NOTICE** .

IMPORTANT: 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.

Tighten: Tighten the upper balance shaft chain guide bolts to 12 N.m (106 lb in).

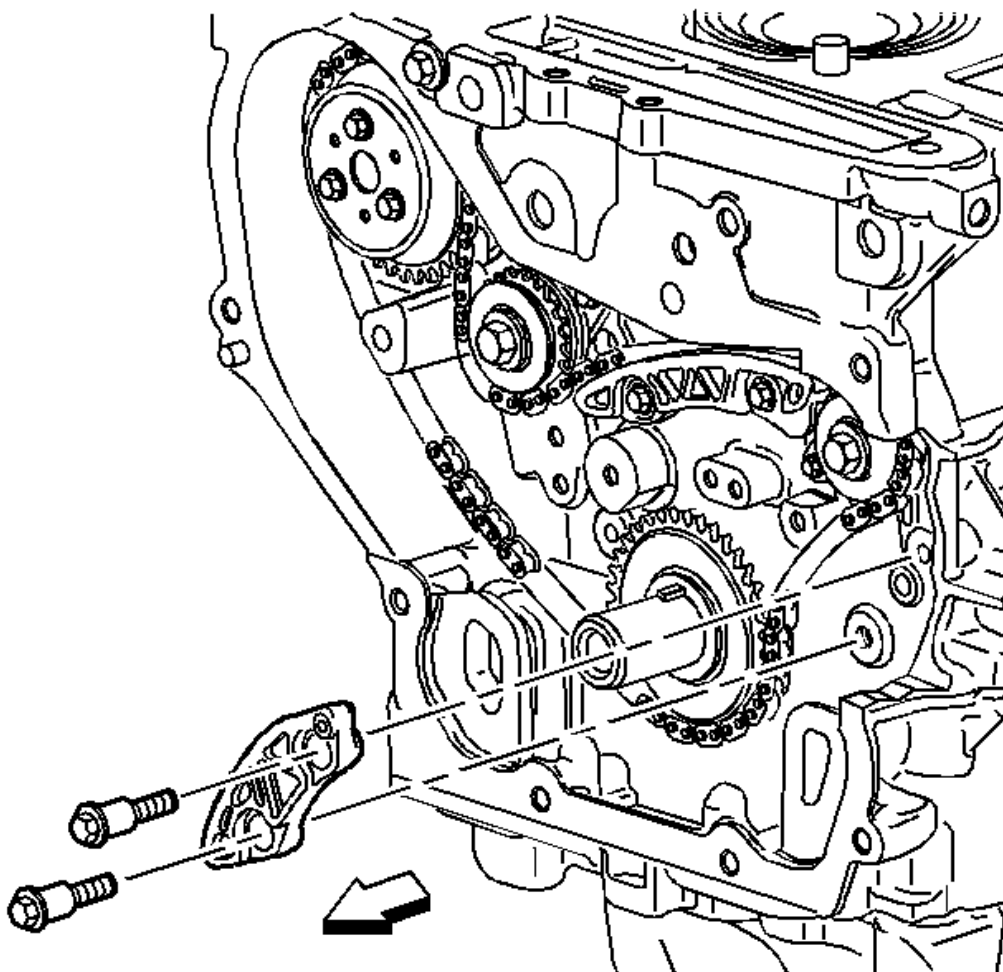


Fig. 568: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts.

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

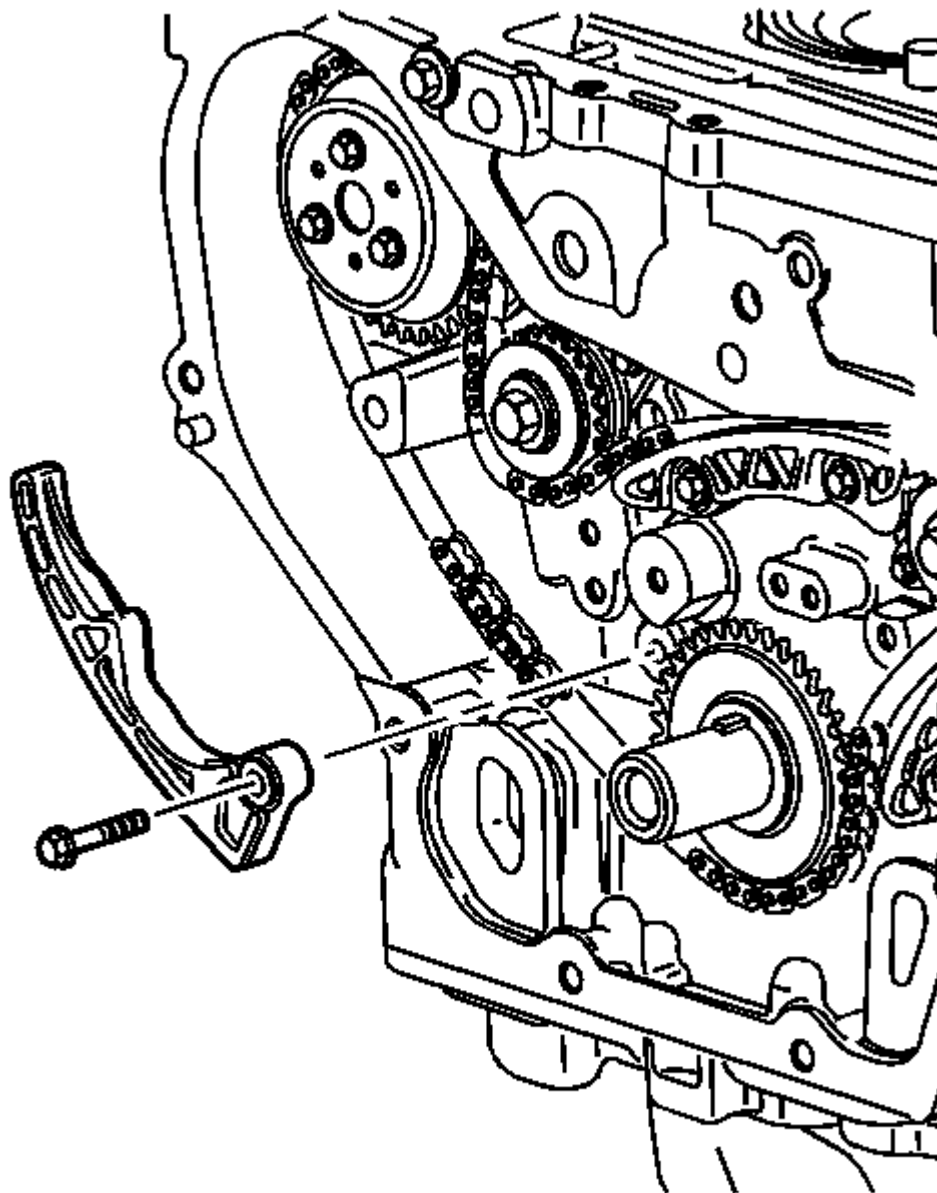


Fig. 569: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the adjustable balance shaft drive chain guide.
5. Install the adjustable balance shaft drive chain guide bolts.

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

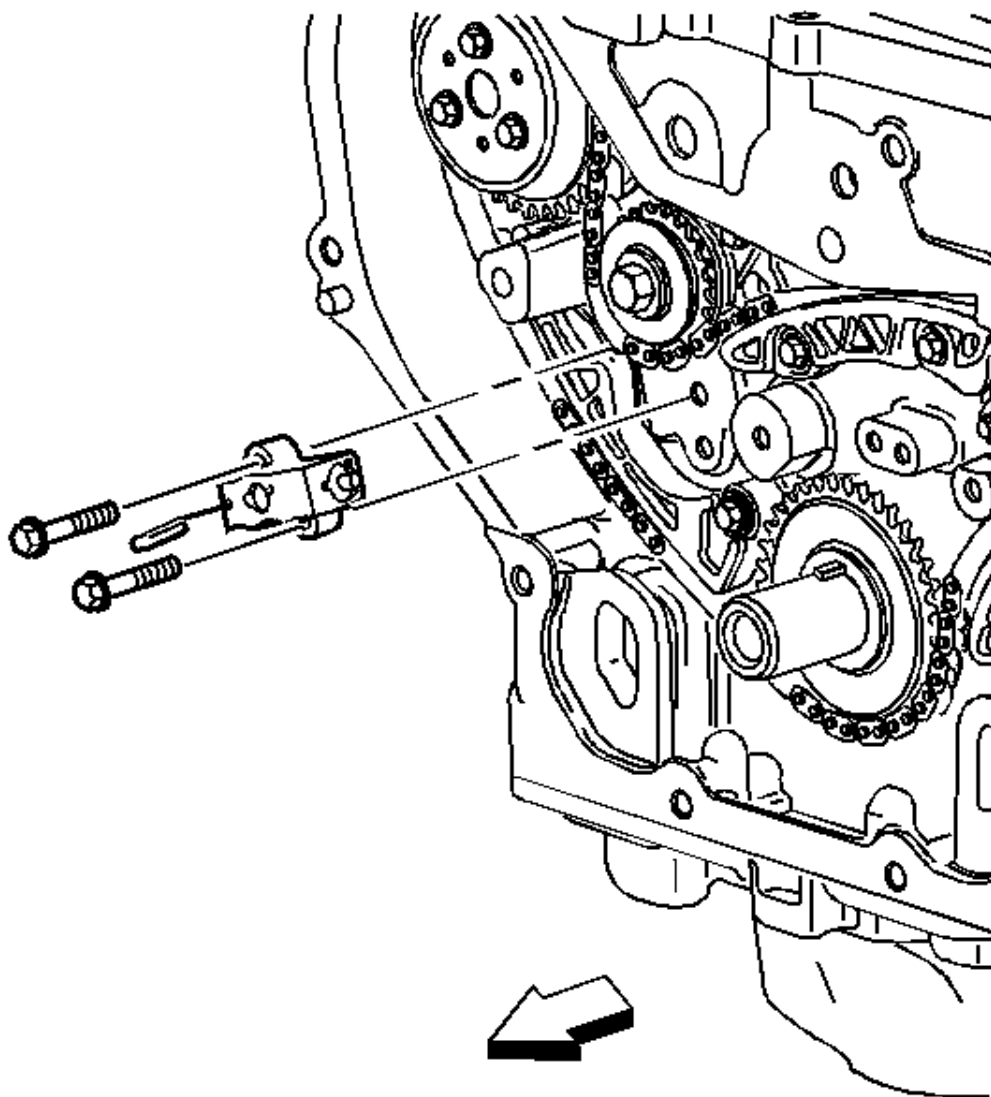


Fig. 570: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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.

Tighten: Tighten the chain tensioner bolts 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

Tools Required

- **J 45027** Tensioner Tool. See Special Tools.
- **J 45059** Angle Meter. See Special Tools.

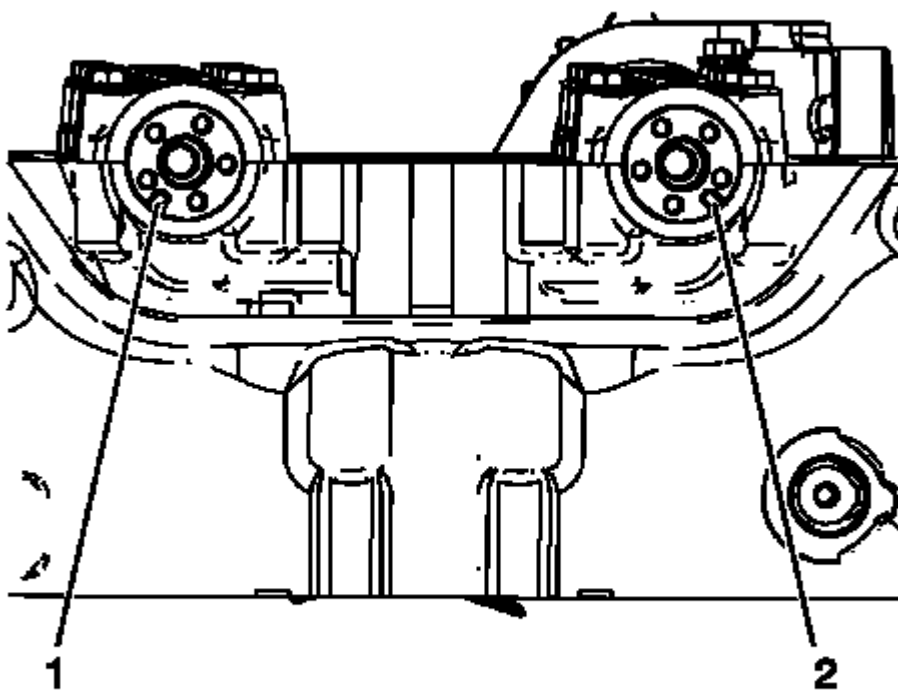


Fig. 571: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

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.

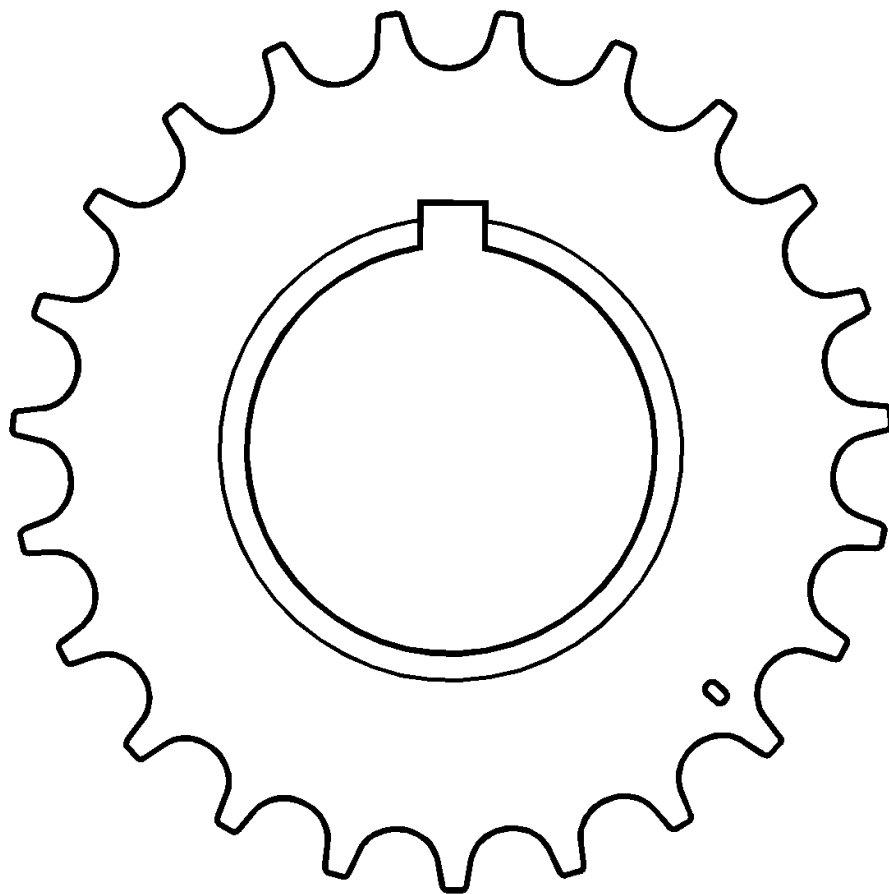


Fig. 572: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

2. 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 out.

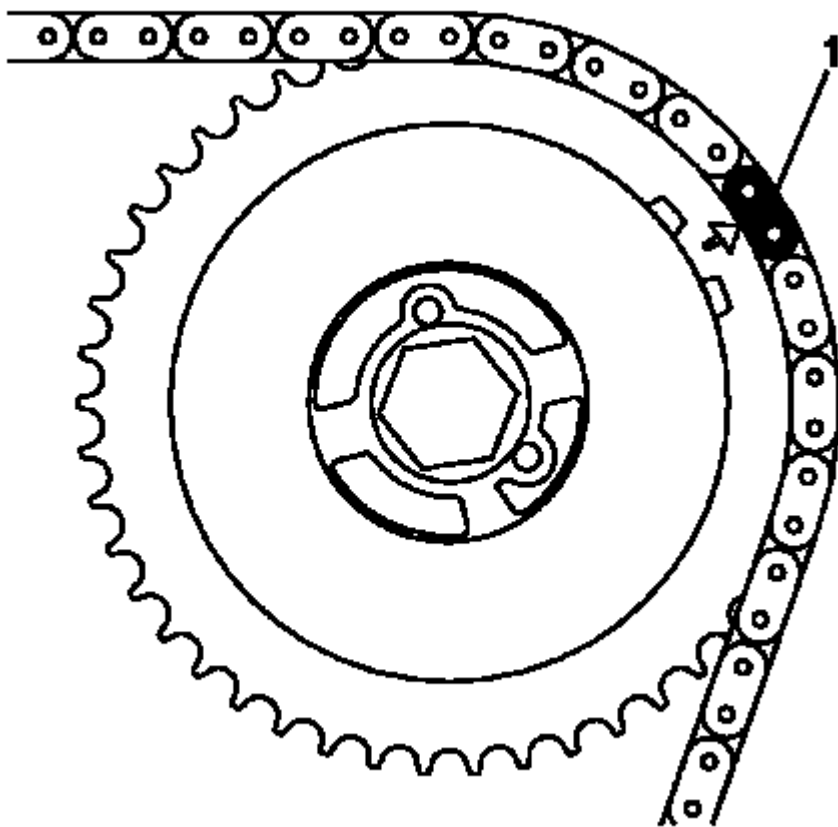


Fig. 573: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- There are 3 colored links on the timing chain. 2 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.
3. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).

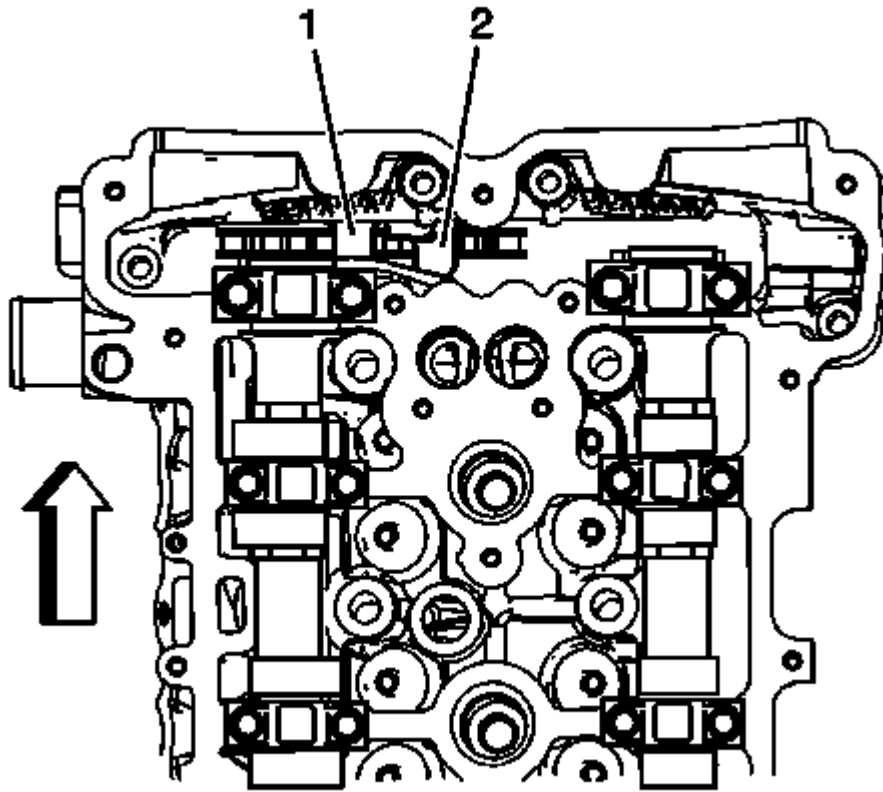


Fig. 574: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

4. 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).
5. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
6. Hand tighten the new intake camshaft actuator bolt.

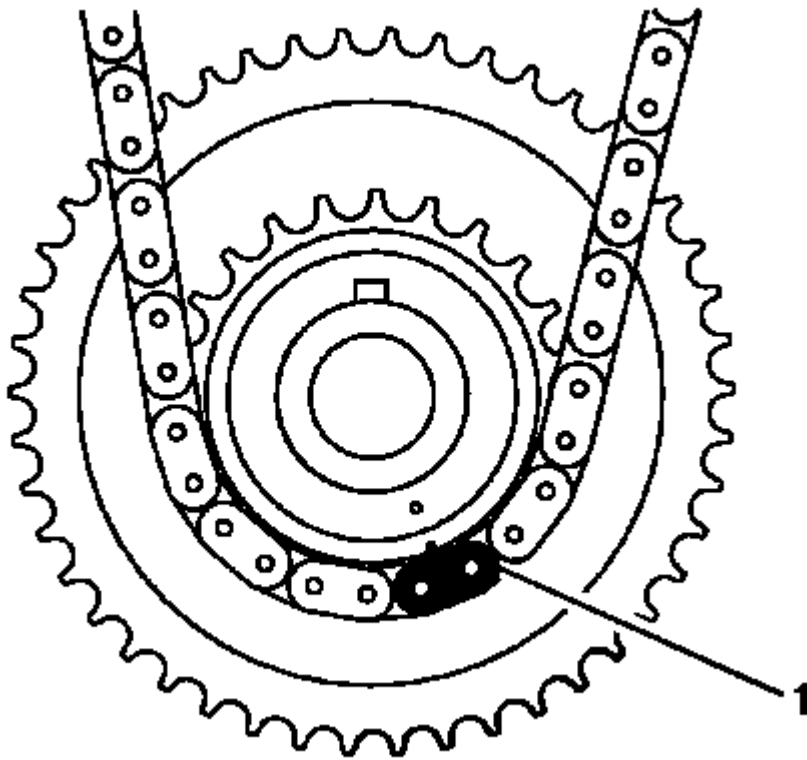


Fig. 575: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

7. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (2) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

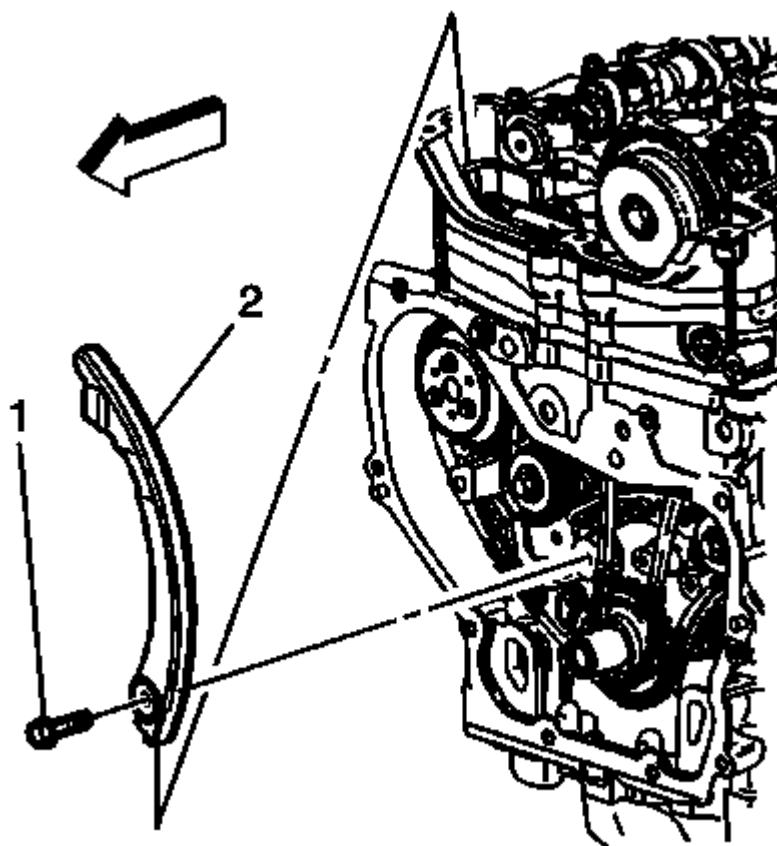


Fig. 576: Identifying Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

8. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.

NOTE: Refer to Fastener Notice .

9. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt.

Tighten: Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

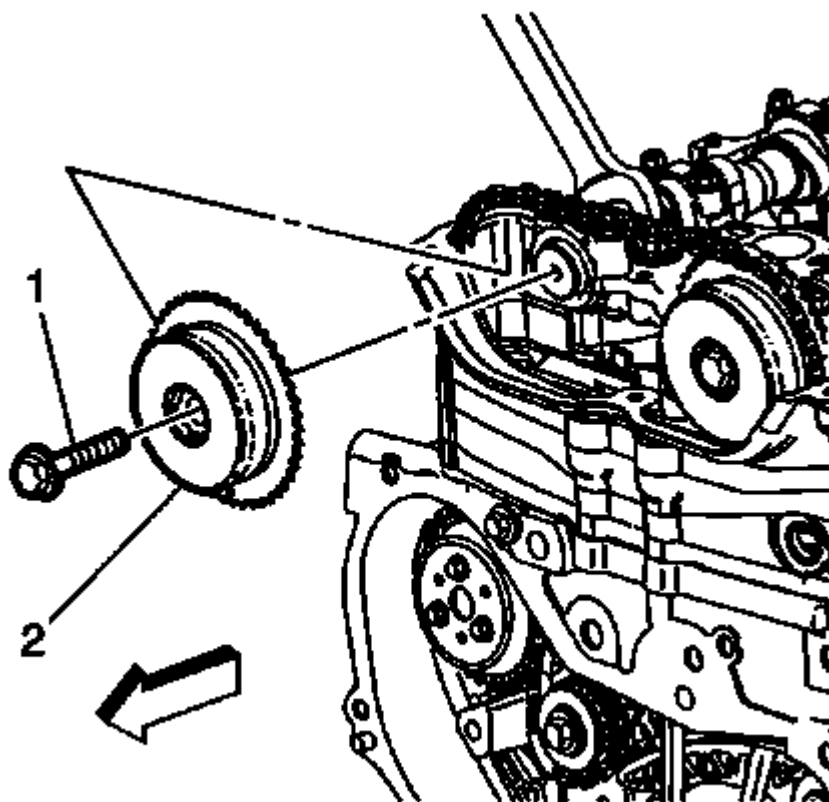


Fig. 577: Locating Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

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

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

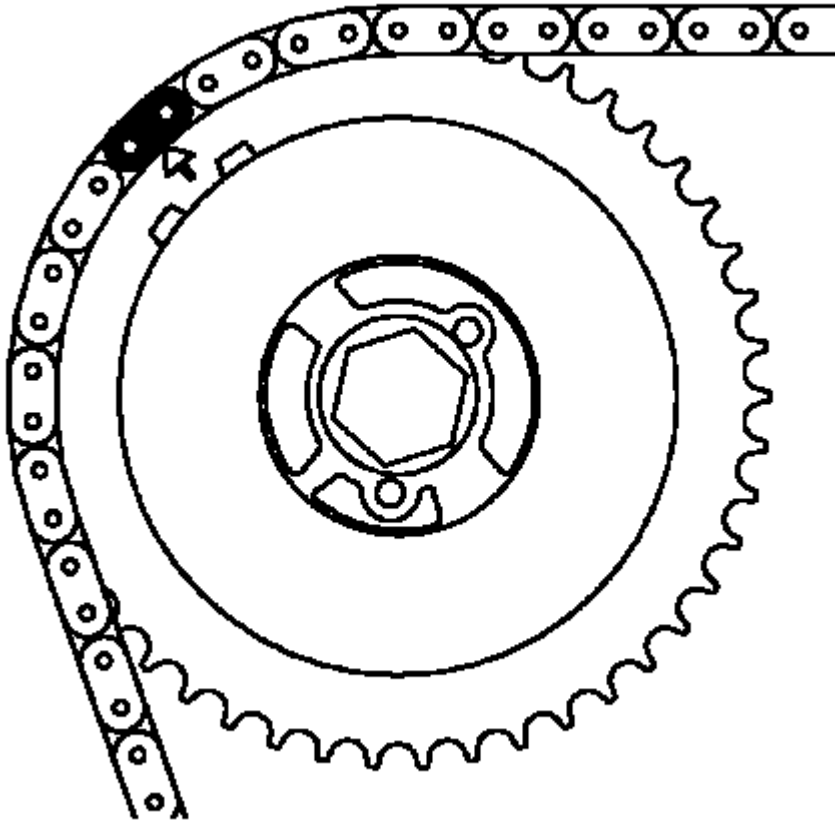


Fig. 578: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

11. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
12. Using a 23 mm open end wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

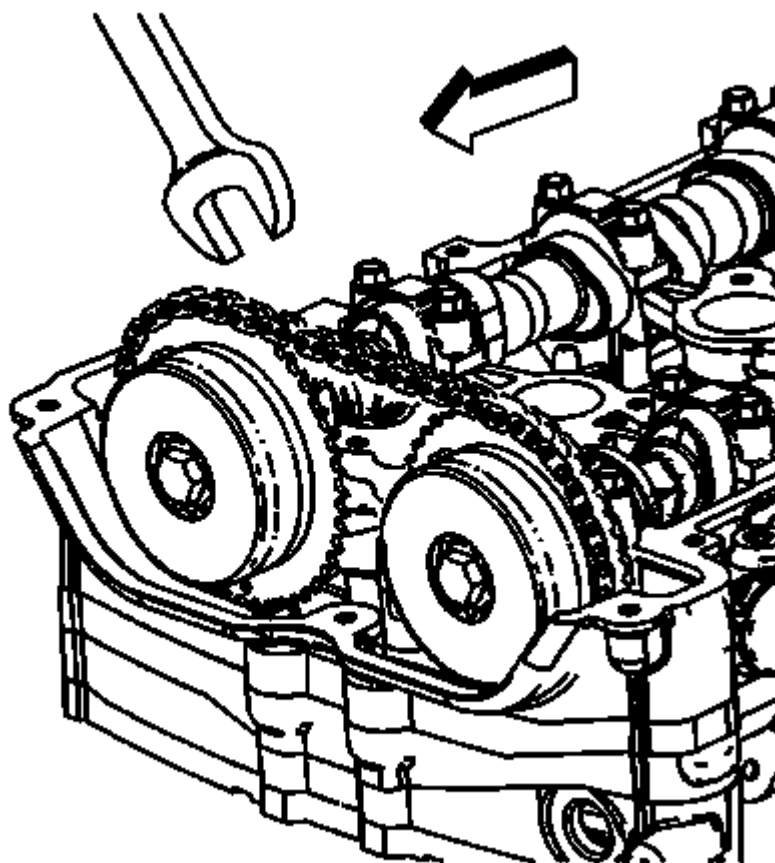


Fig. 579: Using 24mm Wrench To Align Camshaft
Courtesy of GENERAL MOTORS CORP.

13. When the actuator seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.
14. 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.

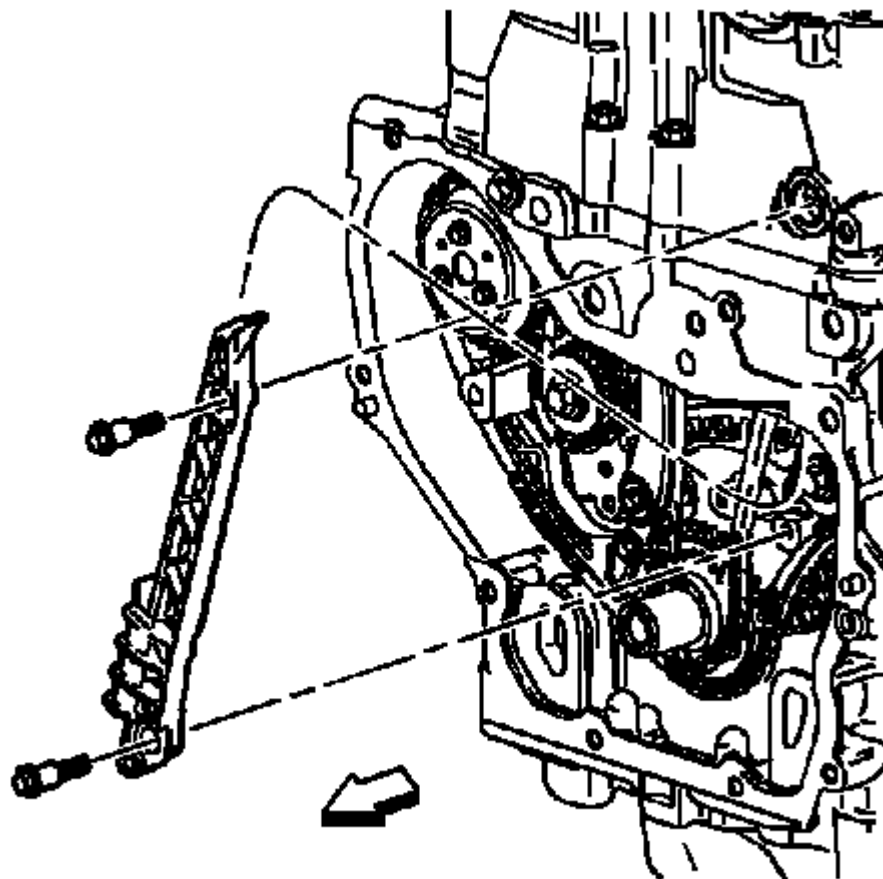


Fig. 580: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

15. Install the fixed timing chain guide and bolts.

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

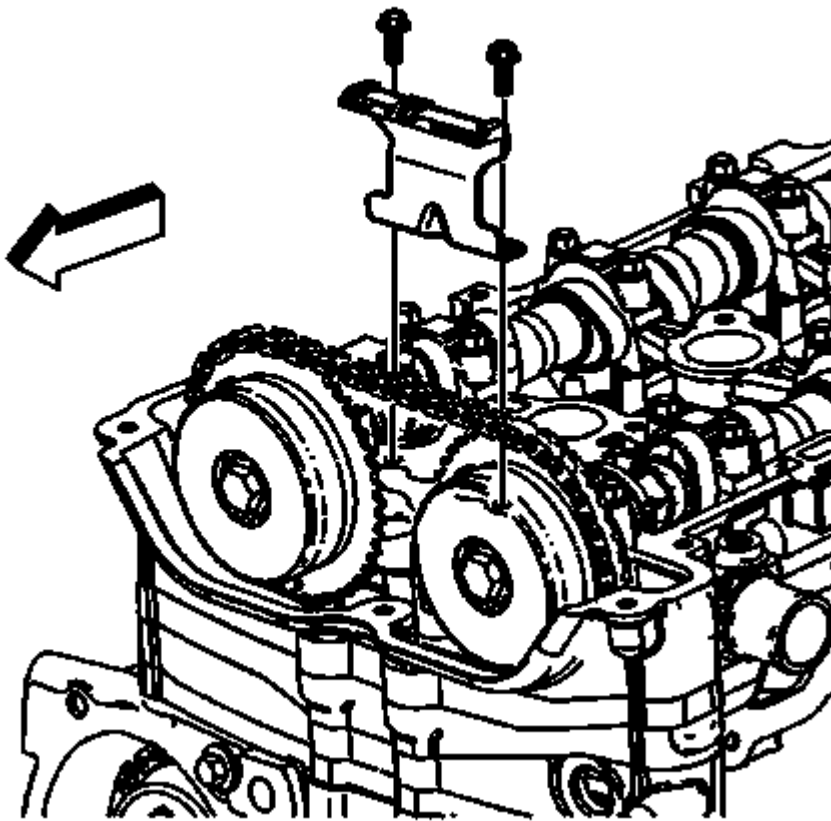


Fig. 581: Locating Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the upper timing chain guide and bolts.

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

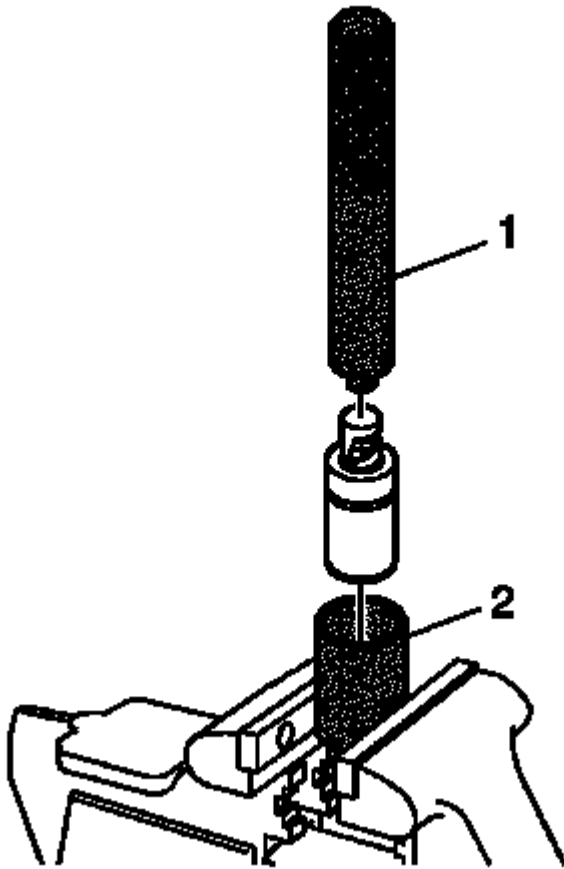


Fig. 582: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

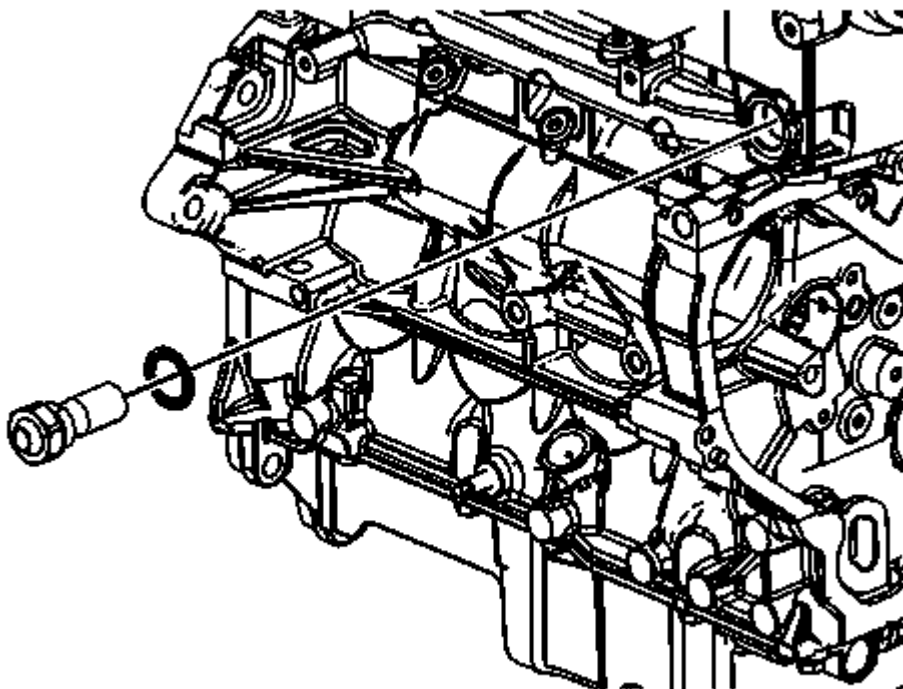


Fig. 583: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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

20. Install the timing chain tensioner assembly.

Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

21. 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.

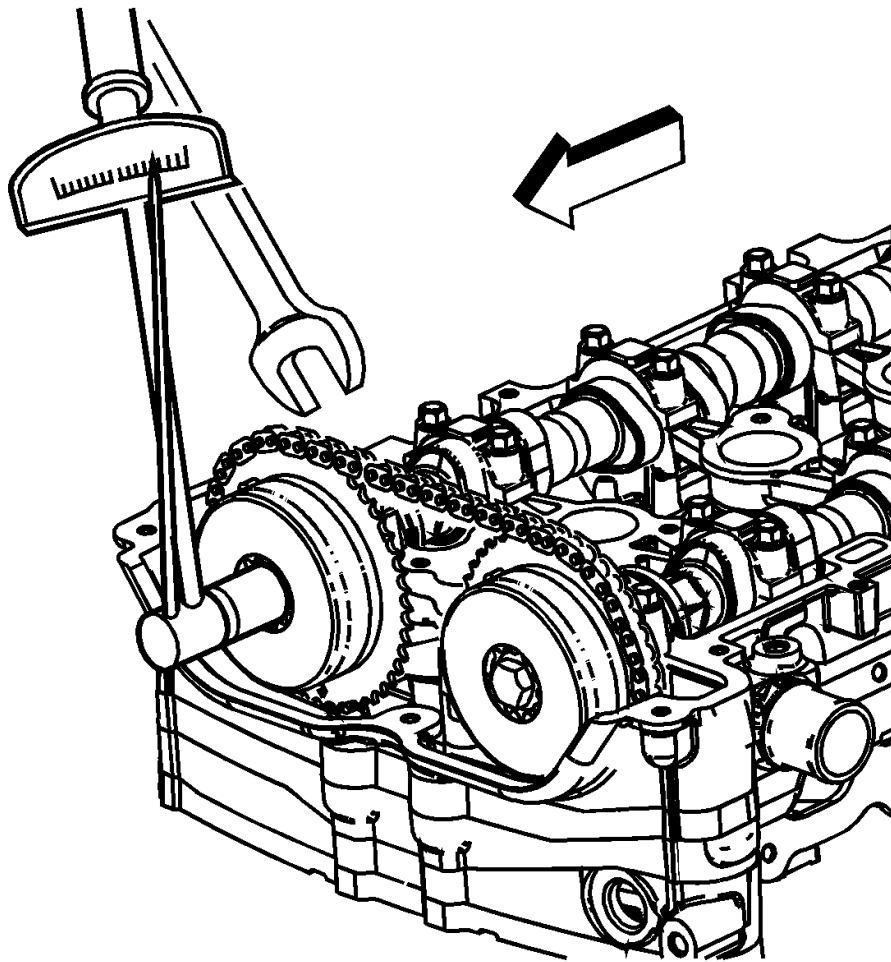


Fig. 584: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

22. Using a 23 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt.

Tighten: Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** . See **Special Tools**.

23. Using a 23 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt.

Tighten: Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** . See **Special Tools**.

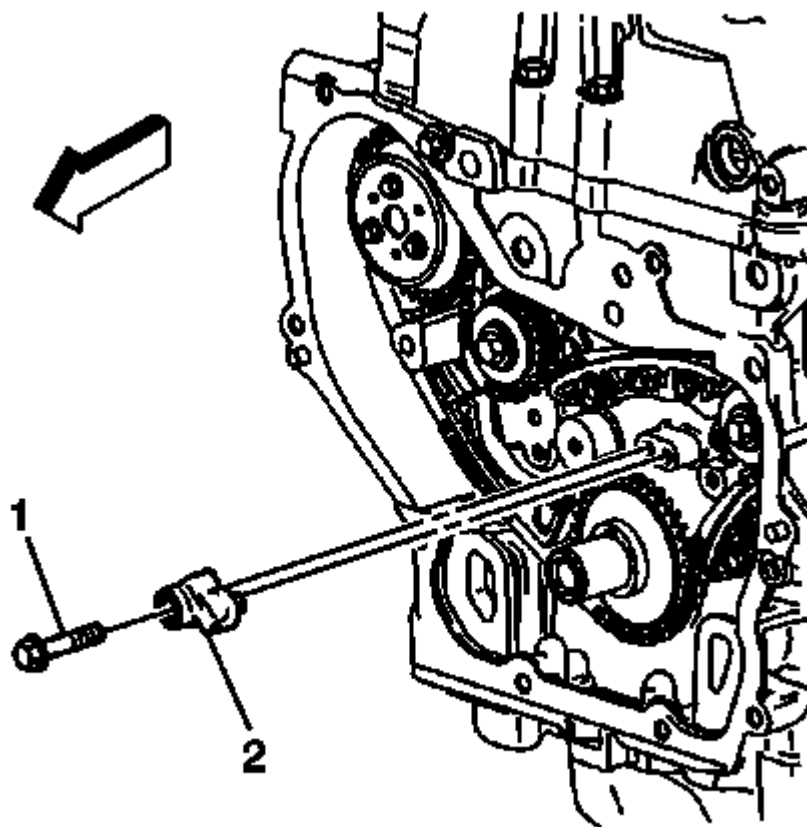


Fig. 585: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

24. Install the timing chain oiling nozzle.

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

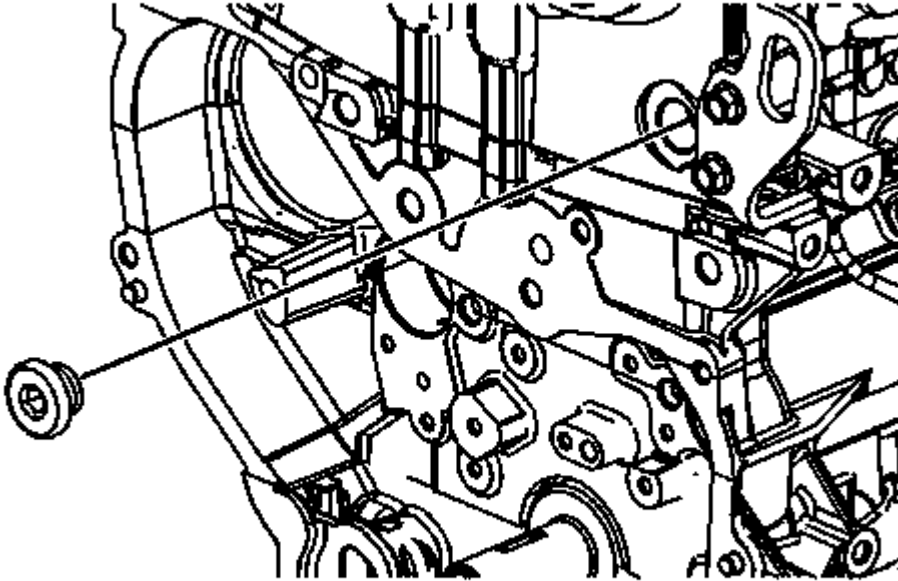


Fig. 586: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

25. Apply sealant compound GM P/N 12345382 (Canadian P/N 10953489) to the thread of the timing chain guide bolt access hole plug.
26. Install the timing chain guide bolt access hole plug.

Tighten: Tighten the access hole plug to 90 N.m (66 lb ft).

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Tools Required

J 34115 Sprocket Bearing Installer. See **Special Tools**.

Installation Procedure

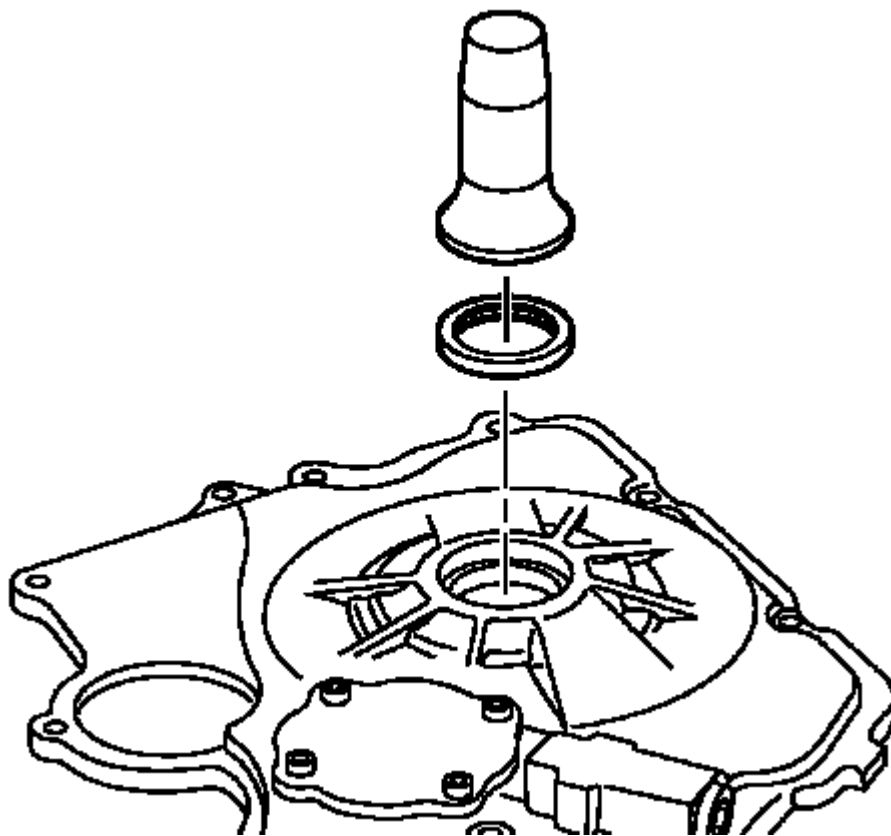


Fig. 587: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the seal into the front cover using the **J 34115** . See **Special Tools**.
2. Ensure that the engine front cover is properly supported when installing the seal.

ENGINE FRONT COVER AND OIL PUMP INSTALLATION

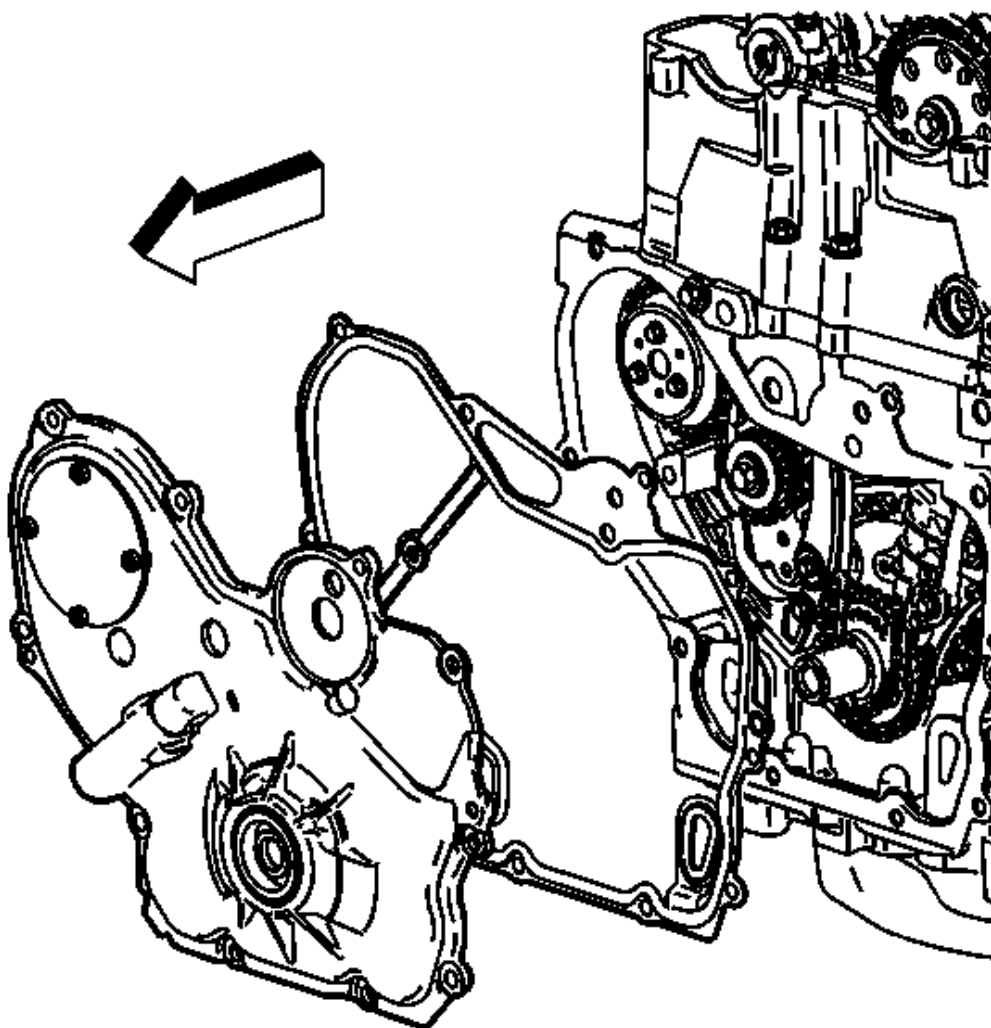


Fig. 588: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Install two new friction washers.
2. Install the engine front cover with a new gasket.

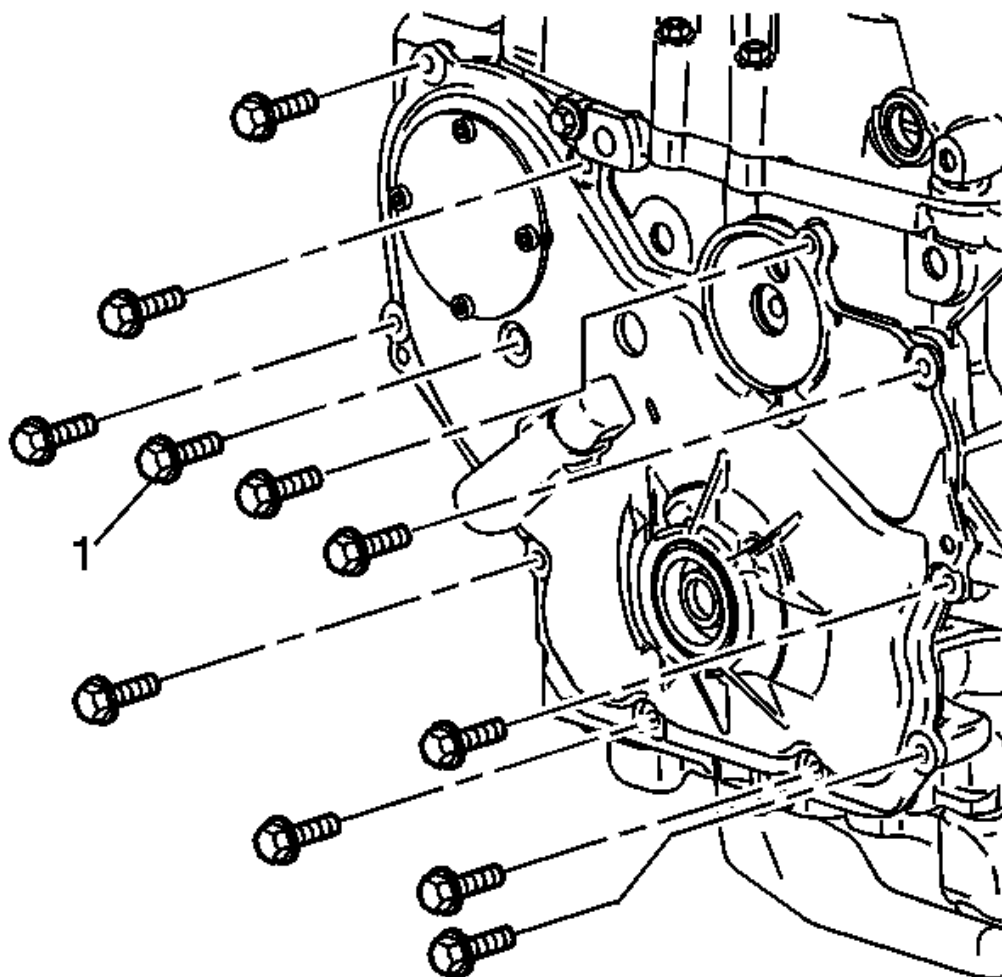


Fig. 589: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: The center bolt (1) should be tightened last.

3. Install the engine front cover bolts.

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

4. Install the long water pump bolt.

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

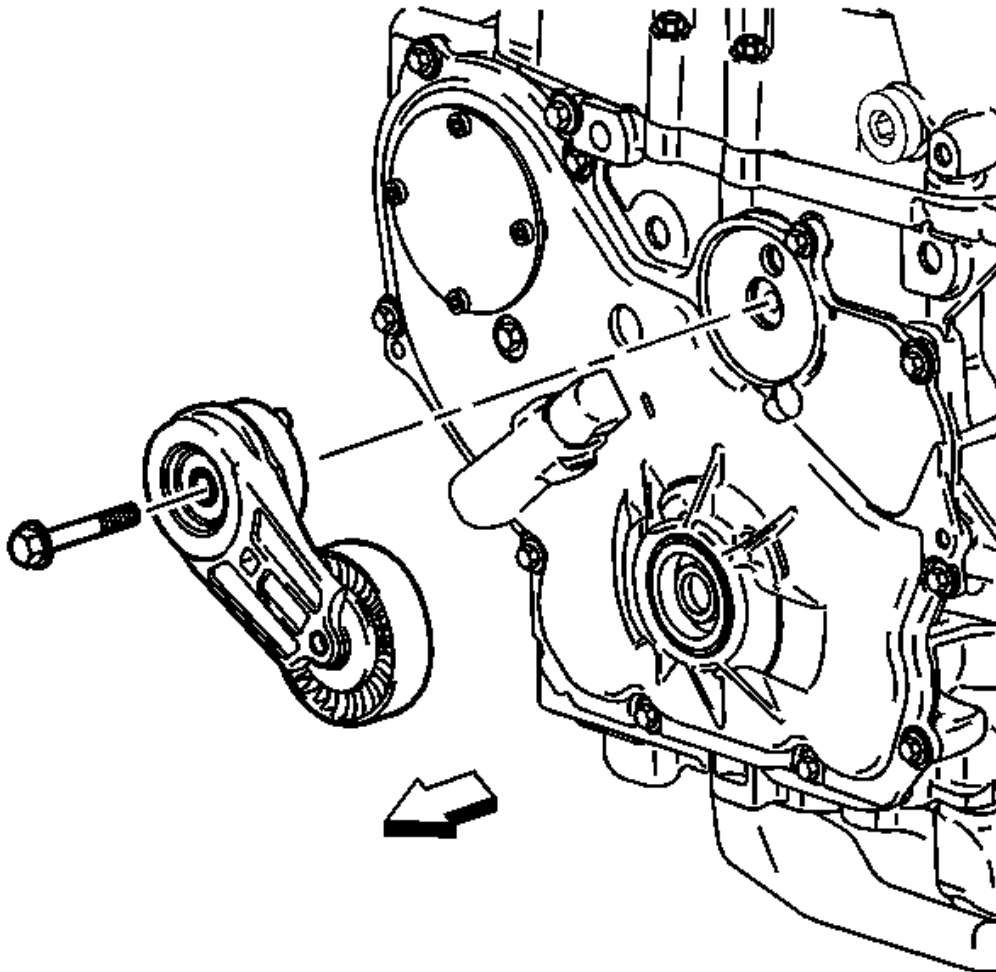


Fig. 590: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

5. Install the accessory drive belt tensioner.
6. Install the accessory drive belt tensioner bolt.

Tighten: Tighten the bolt to 45 N.m (33 lb ft).

CAMSHAFT COVER INSTALLATION

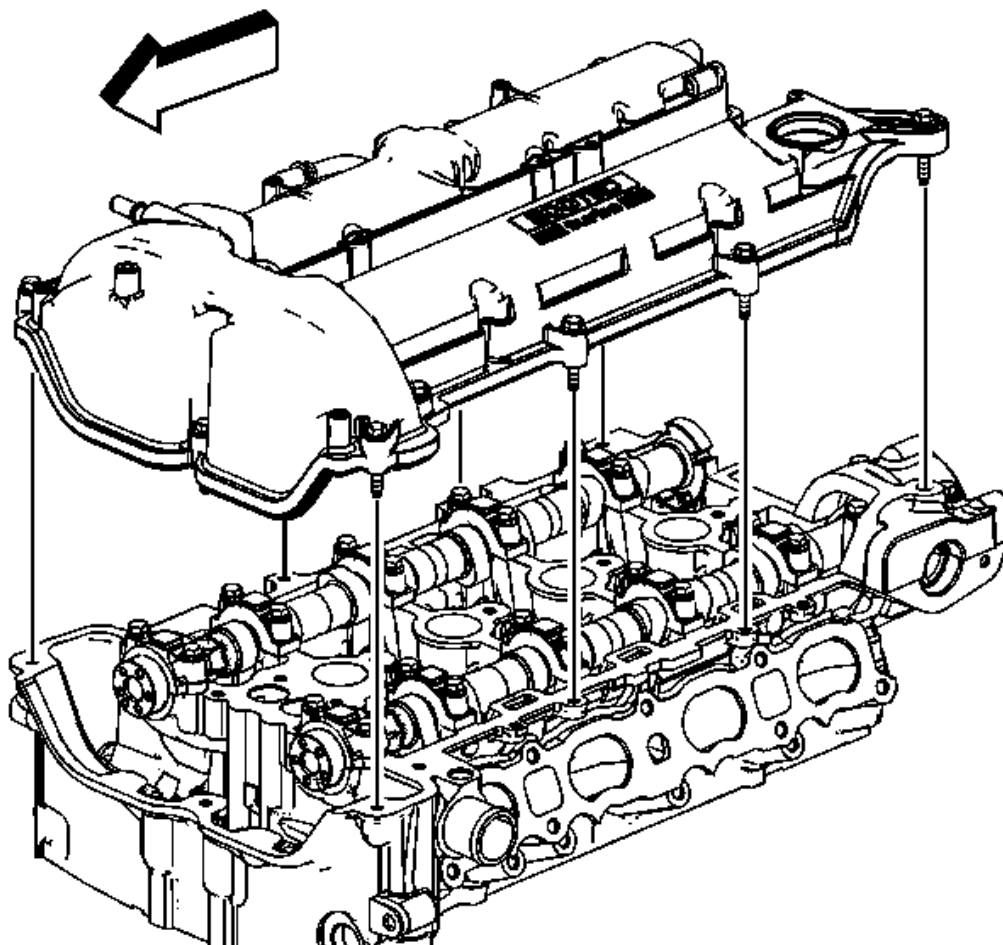


Fig. 591: View Of Camshaft Cover Assembly
Courtesy of GENERAL MOTORS CORP.

1. Assemble the camshaft cover and gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

NOTE: Refer to Fastener Notice

2. Install the cover on the cylinder head and hand start the bolts.

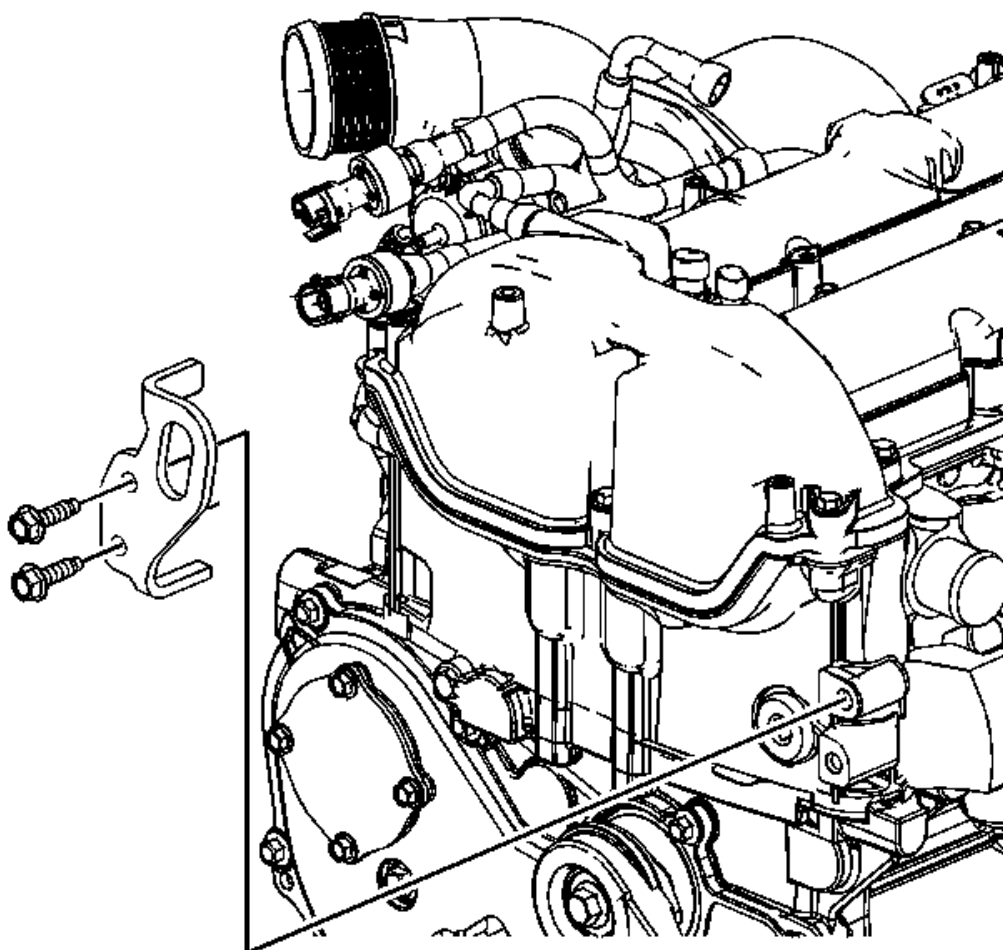


Fig. 592: Identifying Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Install the front lift bracket.
4. Install the front lift bracket bolts.

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

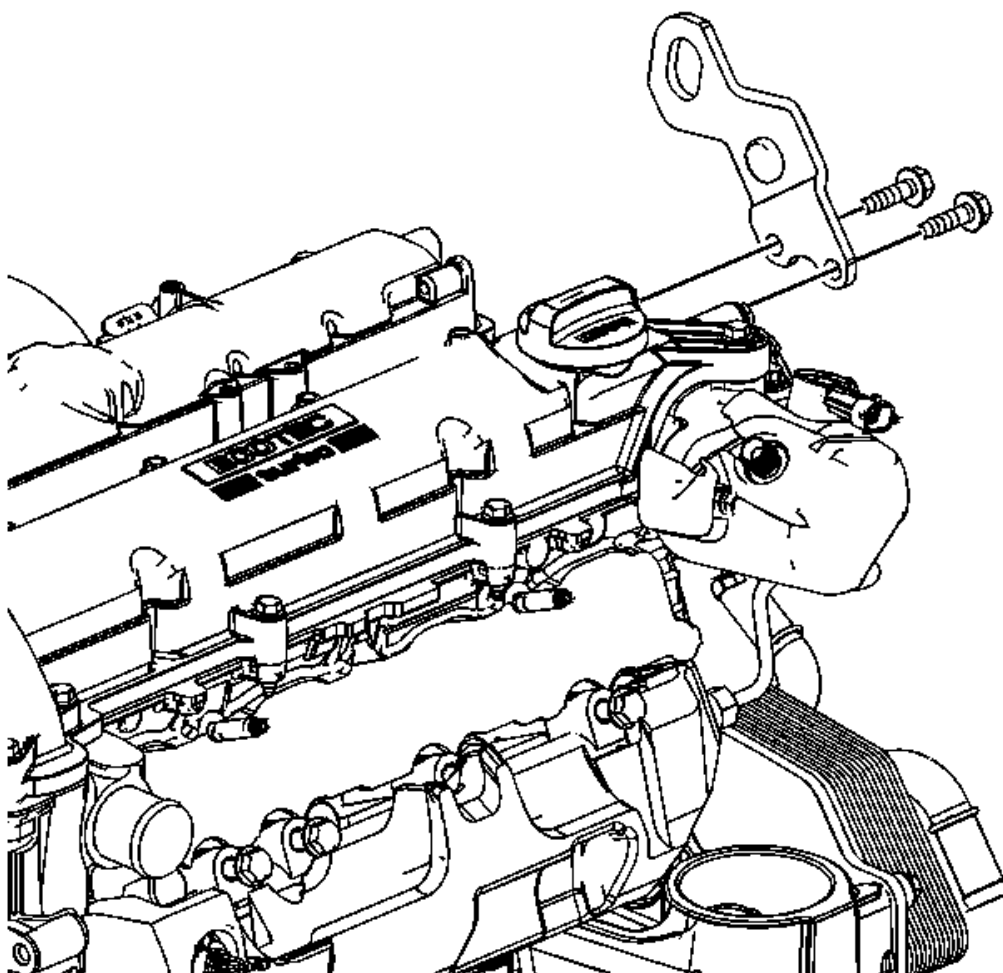


Fig. 593: Identifying Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the rear lift bracket.
6. Install the rear lift bracket bolts.

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

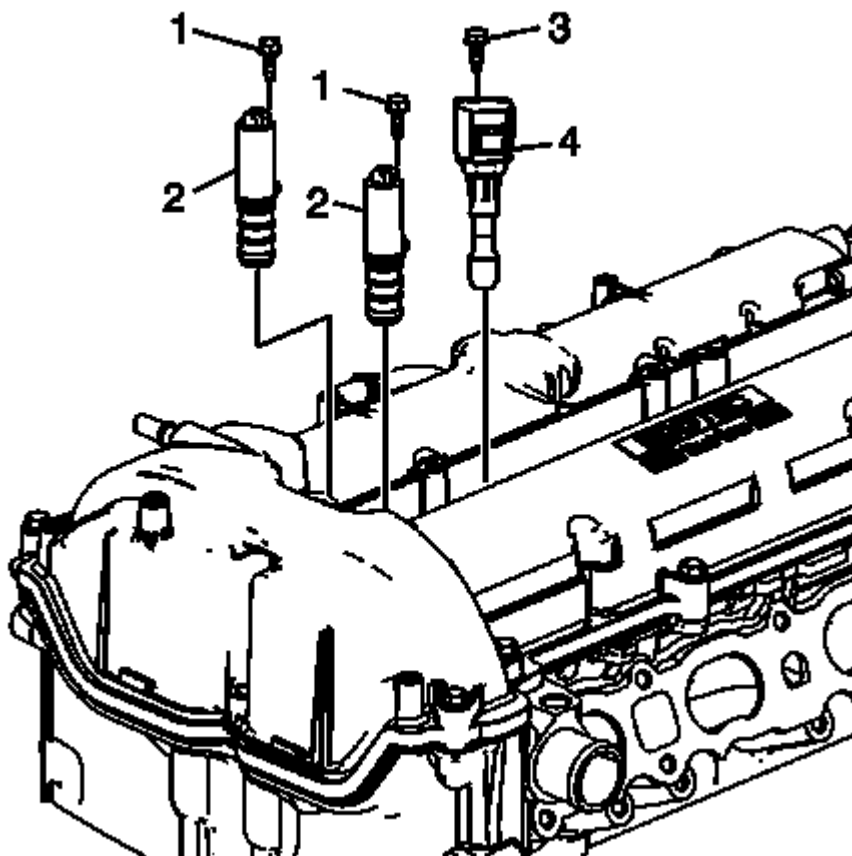


Fig. 594: Identifying Ignition Coils
Courtesy of GENERAL MOTORS CORP.

7. Install the ignition coils.

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

8. Tighten the camshaft cover bolts.

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

IMPORTANT: The solenoid valves are marked intake and exhaust.

9. Install the camshaft position actuator solenoid valves.
10. Install the camshaft position actuator solenoid valve bolts.

Tighten: Tighten the camshaft position actuator solenoid valve bolts to 10 N.m 89 lb in.

OIL PAN INSTALLATION

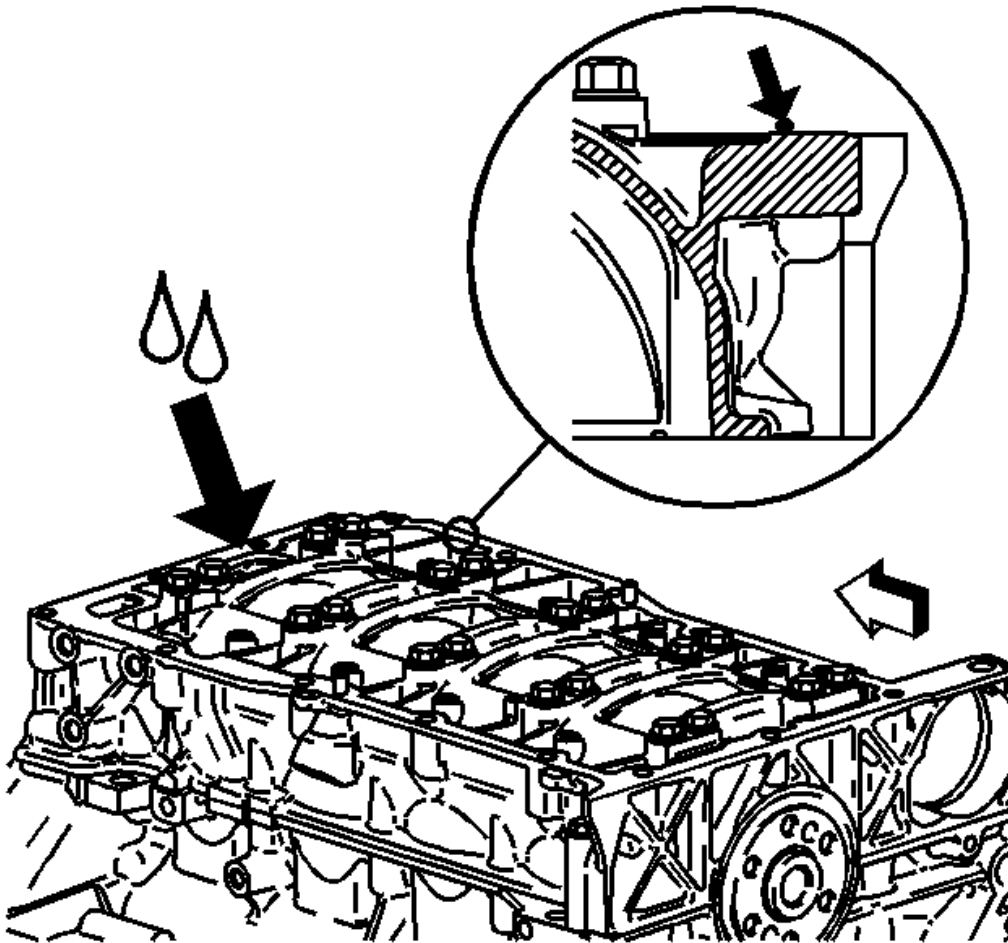


Fig. 595: Applying RTV Around Perimeter Of Oil Pan & Oil Suction Port Opening
Courtesy of GENERAL MOTORS CORP.

1. Ensure the oil pan and mounting surface on the lower crankcase are free of all oil and debris.
2. Apply a 3.5 mm bead of GM P/N 12378521 (Canadian P/N 88901148), or equivalent, around the perimeter of the oil pan and the oil suction port opening.

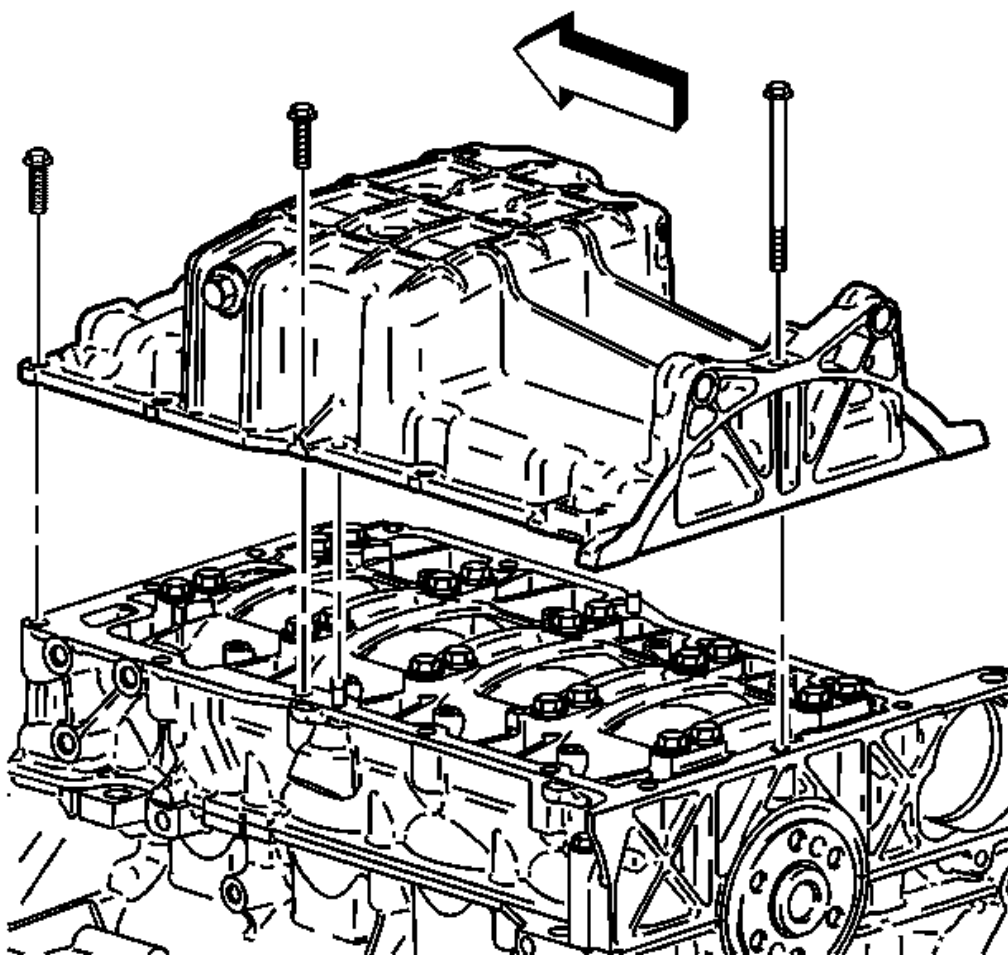


Fig. 596: Installing Oil Pan

Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

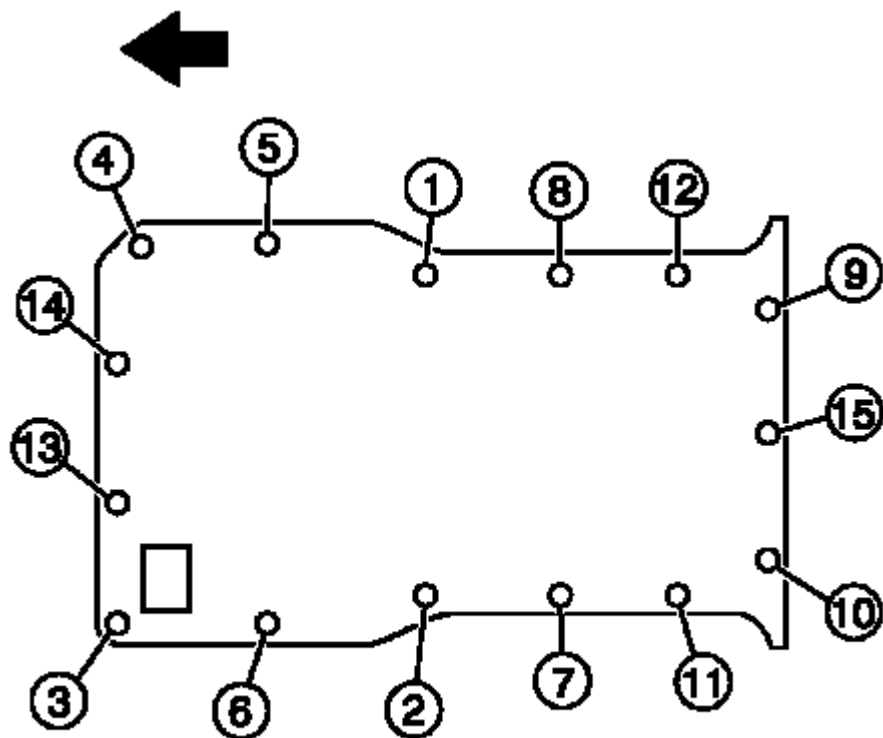


Fig. 597: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the oil pan bolts.

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

CRANKSHAFT BALANCER INSTALLATION

Tools Required

- J 45059 Angle Meter. See Special Tools.
- EN-48585 Crankshaft Balancer Guide. See Special Tools.

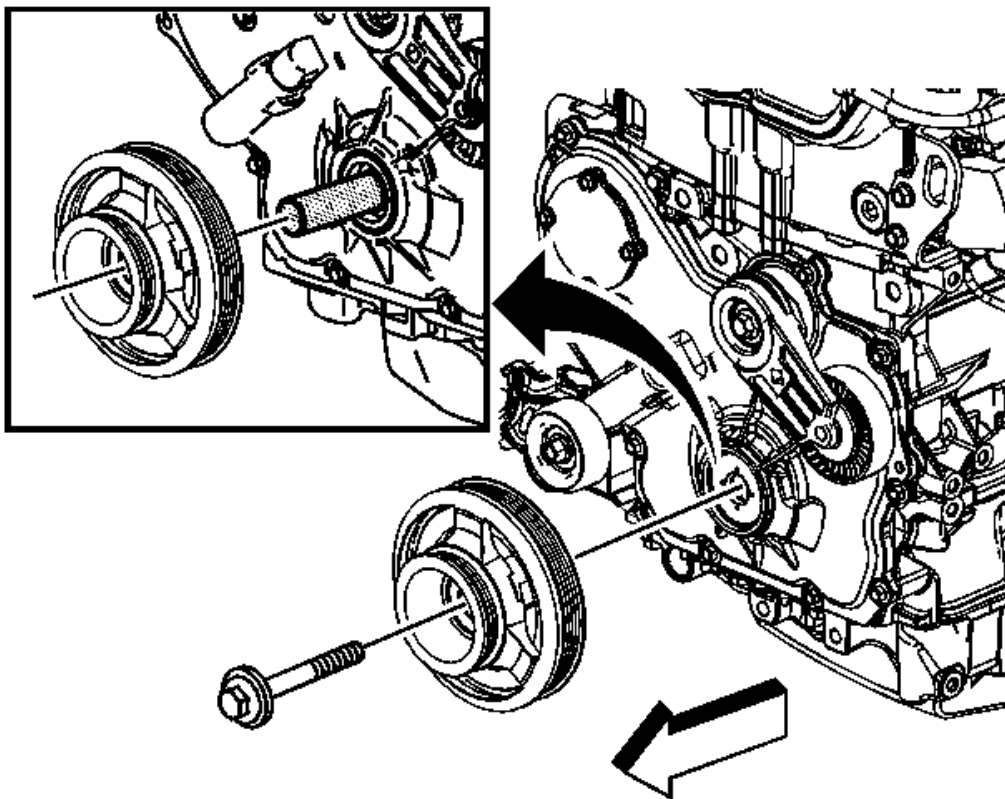


Fig. 598: View Of Crankshaft Balancer & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the balancer onto the EN-48585 . See **Special Tools**. Use care to properly align the keyway and flats on the balancer with the oil pump drive.
2. Install the crankshaft balancer into the end of the crankshaft.

NOTE: Refer to **FASTENER NOTICE** .

IMPORTANT: Always install a NEW crankshaft balancer retaining bolt.

3. Install a NEW retaining bolt. Prevent the crankshaft from rotating when tightening the bolt.

Tighten: Tighten the bolt to 100 N.m (74 lb ft) plus 125 degrees using the J 45059 . See **Special Tools**.

OIL FILTER ADAPTER INSTALLATION**Tools Required**

J 44887 Oil Filter Wrench. See **Special Tools**.

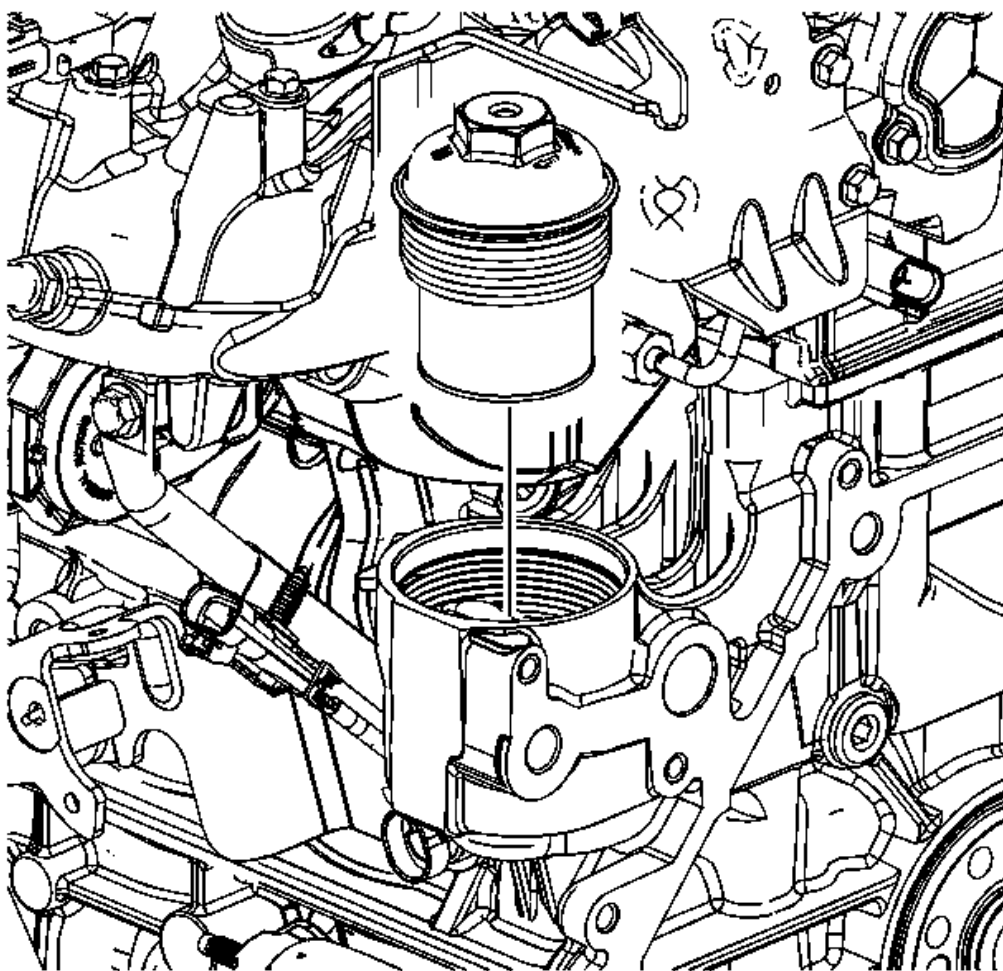
Installation Procedure

Fig. 599: View Of Oil Filter & Cap
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter on the oil filter cap.
2. Lubricate the oil filter cap O-ring with 5W30 engine oil.

NOTE: Refer to Fastener Notice .

3. Use the **J 44887** to install the oil filter adapter. See Special Tools.

Tighten: Tighten the oil filter adapter to 22 N.m (16 lb ft).

FUEL RAIL AND INJECTORS INSTALLATION

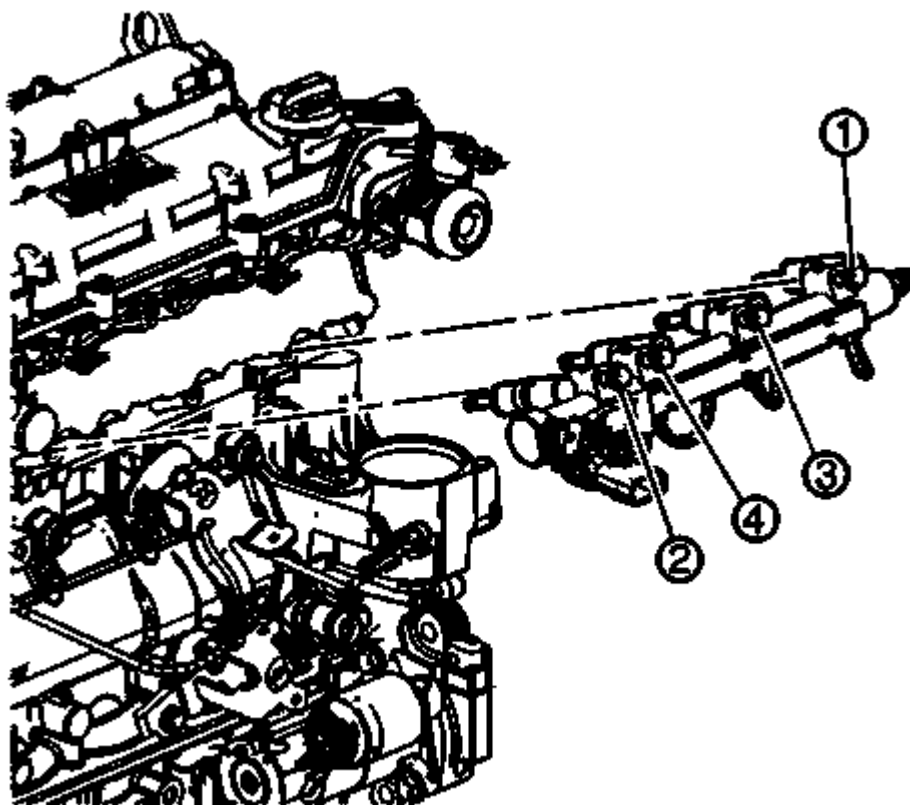


Fig. 600: Identifying Fuel Rail Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel rail with injectors into the cylinder head evenly.
2. Hand tighten the 2 outer fuel rail bolts to seat the injector into the injector bores.

NOTE: Refer to Fastener Notice .

3. Start and hand tighten the remaining fuel rail bolts.

Tighten:

- Tighten the fuel rail bolts in sequence to 22 N.m (16 lb ft).

- Tighten the fuel rail bolts in sequence a second time to 22 N.m (16 lb ft).

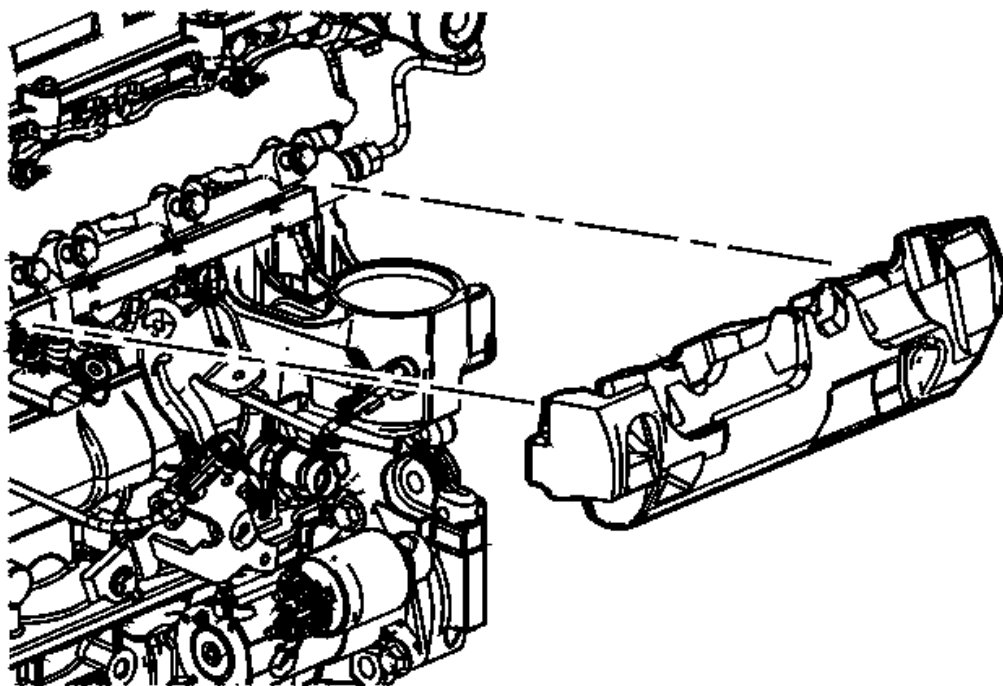


Fig. 601: View Of Fuel Injector Insulator
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel injector noise insulator.
5. Connect the electrical harness to the fuel rail harness connection.

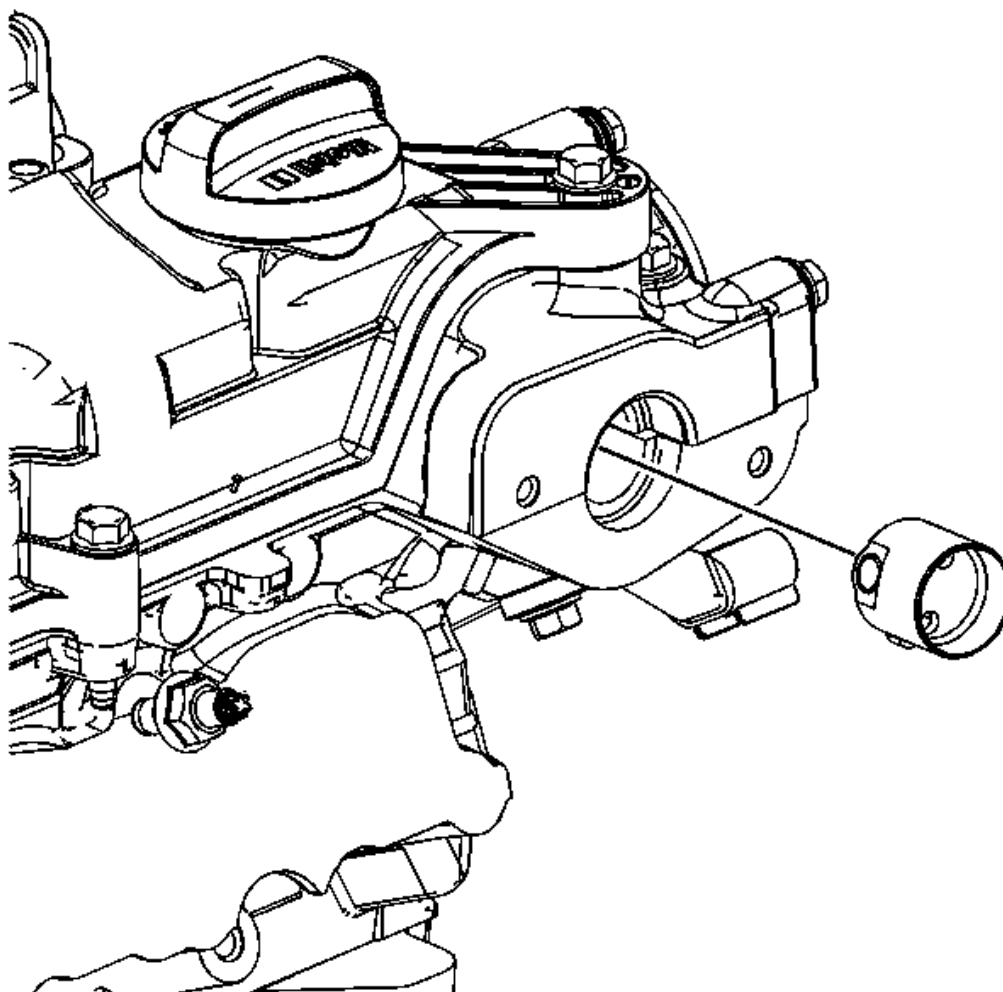


Fig. 602: View Of High Pressure Fuel Pump Roller Lifter
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the high pressure fuel pump cylinder head bore with 5W30 engine oil.

IMPORTANT: 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).

7. Lubricate the high pressure fuel pump roller lifter with 5W30 engine oil and install into the cylinder head bore.

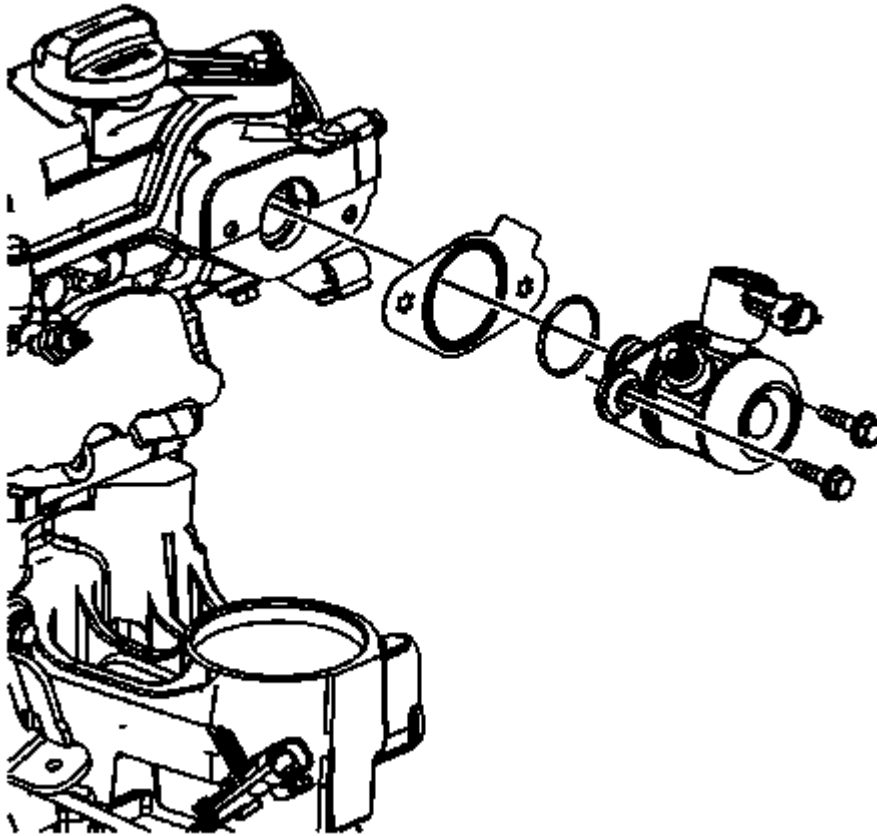


Fig. 603: Identifying High Pressure Fuel Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install a NEW high pressure fuel pump gasket.
9. Install a NEW high pressure fuel pump O-ring.

IMPORTANT: Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.

10. Install the high pressure fuel pump.
11. Start and hand-tighten the high pressure fuel pump bolts evenly.

Tighten: Tighten the high pressure fuel pump bolts evenly to 15 N.m (11 lb ft).

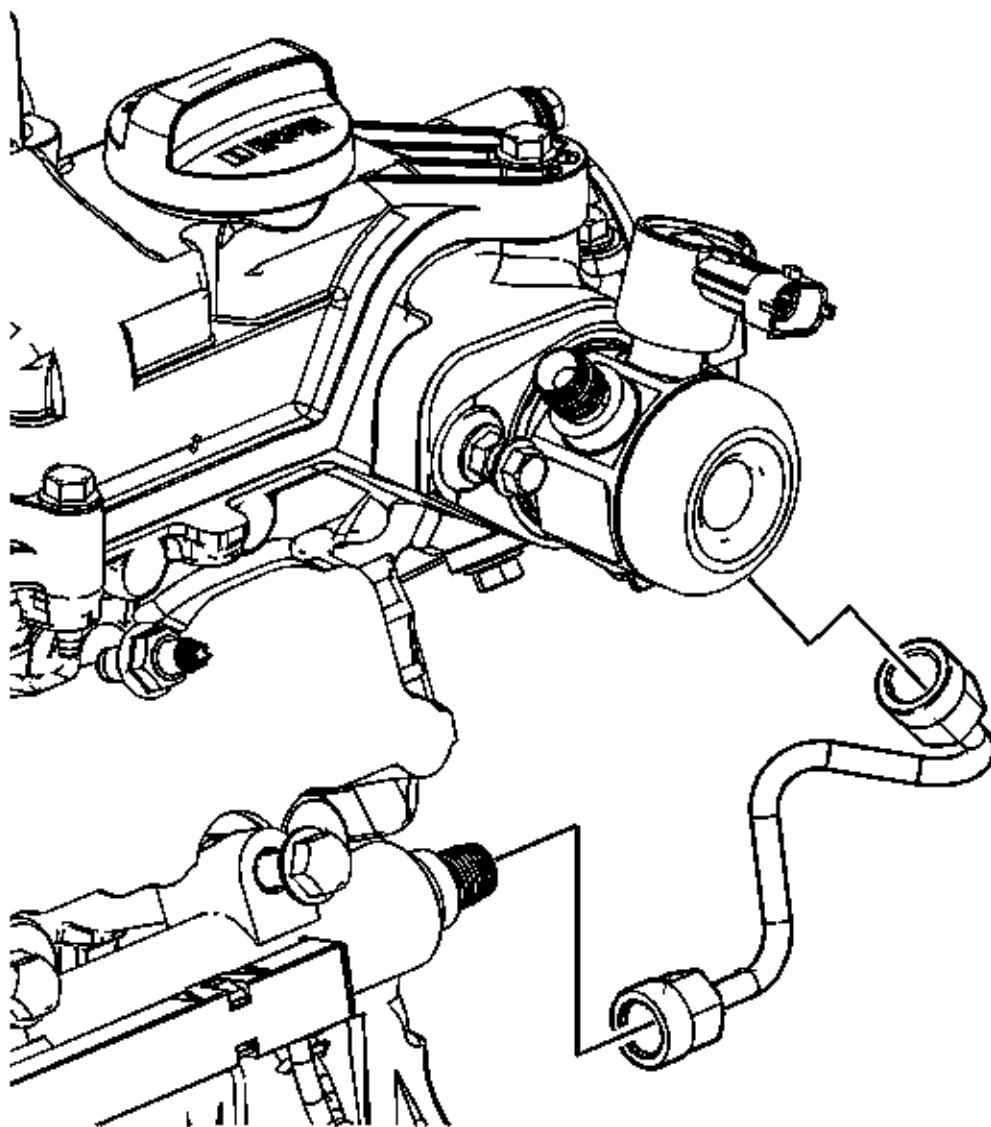


Fig. 604: Identifying High Pressure Fuel Line
Courtesy of GENERAL MOTORS CORP.

12. Install and hand-tighten both ends of the NEW high pressure fuel line.

Tighten: Tighten the high pressure fuel line fitting nuts to 30 N.m (22 lb ft).

TURBOCHARGER INSTALLATION

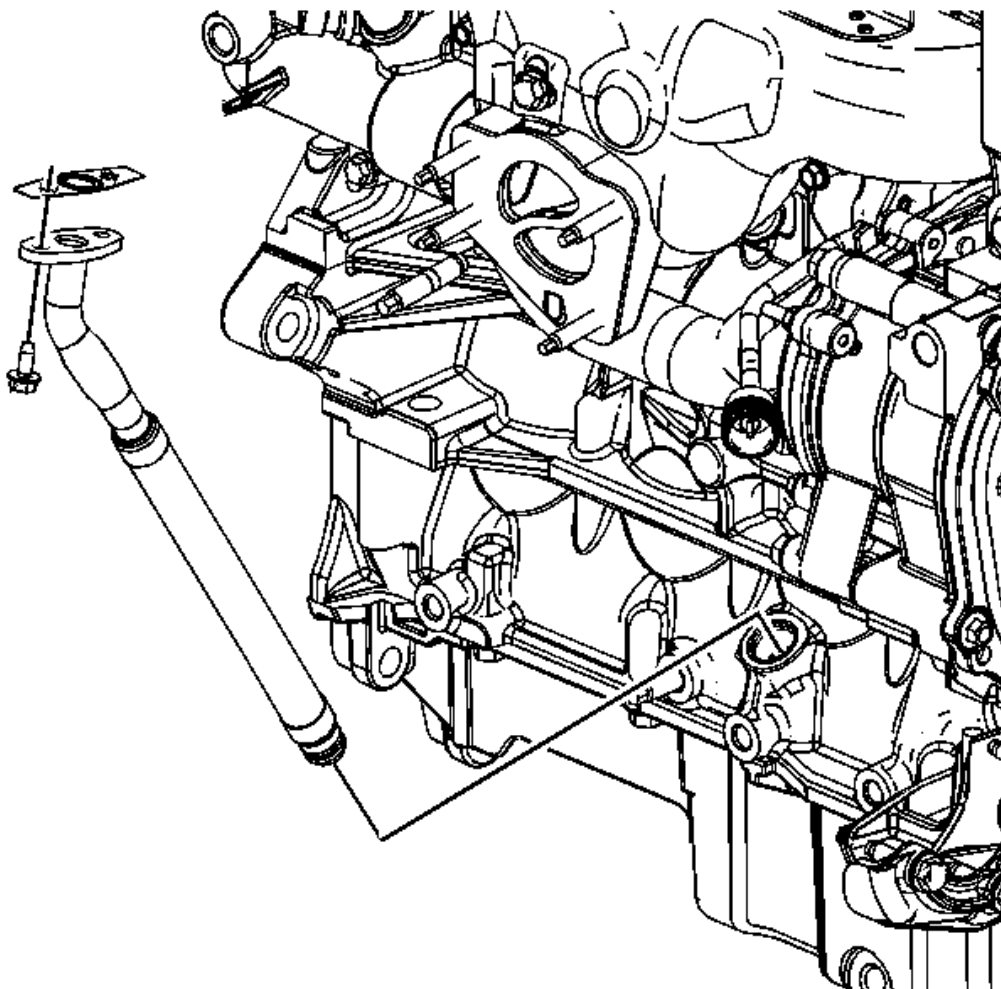


Fig. 605: View Of Turbocharger Oil Return Pipe & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a new turbocharger oil return pipe gasket.
2. Install the turbocharger oil return pipe into the engine block.

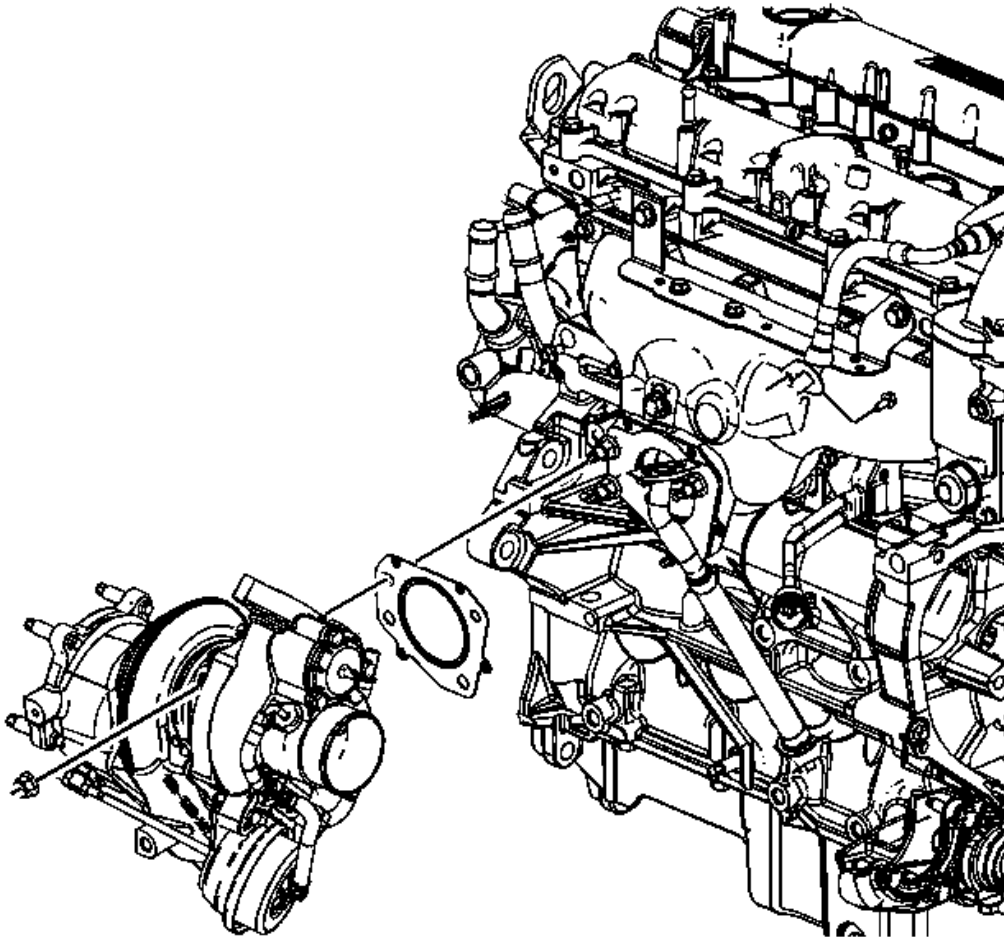


Fig. 606: View Of Turbocharger & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Attach the positive crankcase ventilation (PCV) hose and fitting with O-ring from the camshaft cover to the turbocharger.

NOTE: Refer to Fastener Notice .

4. Install the PCV hose fitting bolt.

Tighten: Tighten the PCV hose fitting bolt to 10 N.m (89 lb in).

5. Lubricate the O-ring on the turbocharger oil return pipe with clean engine oil.
6. Install the turbocharger oil return pipe bolts.

Tighten: Tighten the turbocharger oil return pipe bolts to 10 N.m (89 lb in).

7. Install a new turbocharger gasket.
8. Install the turbocharger.
9. Install the turbocharger nuts.

Tighten

- Tighten the turbocharger nuts to 30 N.m (22 lb ft).
- Tighten the turbocharger nuts a second time to 35 N.m (26 lb ft).

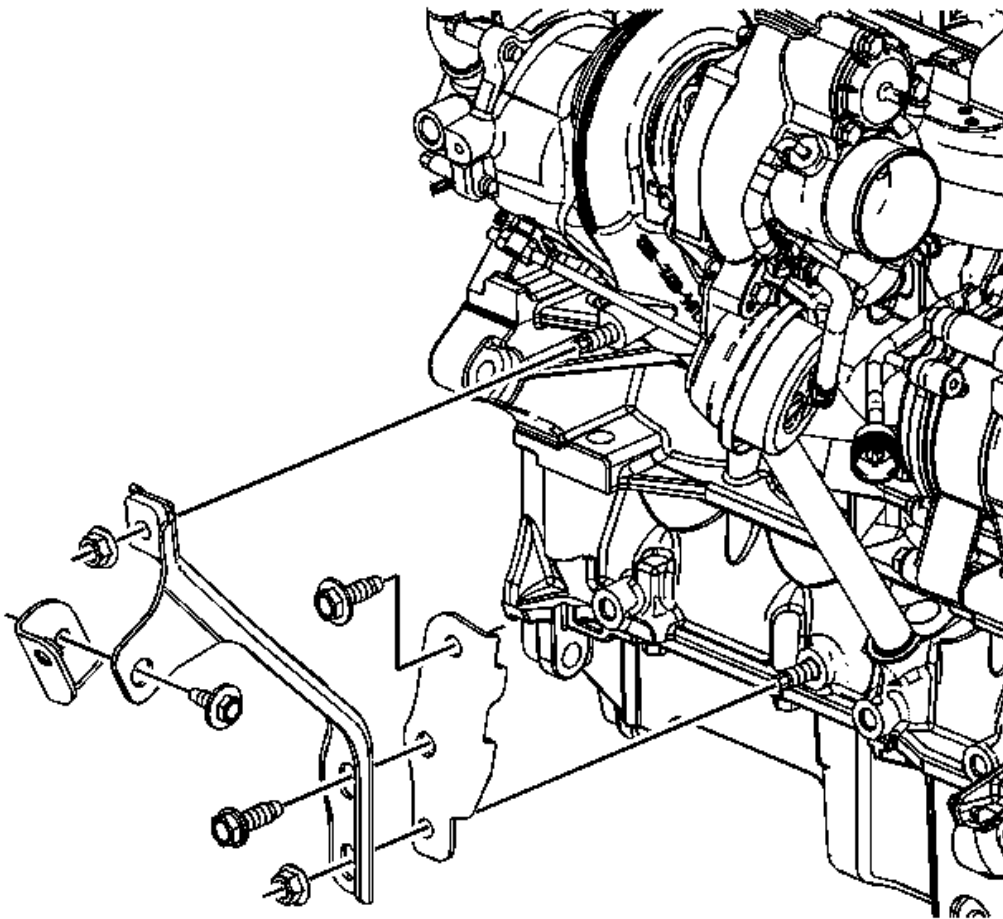


Fig. 607: View Of Turbocharger Brace Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

10. Install the turbocharger brace bracket.
11. Install the turbocharger brace bracket bolt.

Tighten: Tighten the turbocharger brace bolt to 58 N.m (43 lb ft).

12. Install the turbocharger brace.
13. Install the turbocharger brace nuts.

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

14. Install the turbocharger brace bolt.

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

15. Install the turbocharger brace bracket and bolt to the turbocharger brace if necessary.

Tighten: Tighten the turbocharger brace bracket bolt to 22 N.m (16 lb ft).

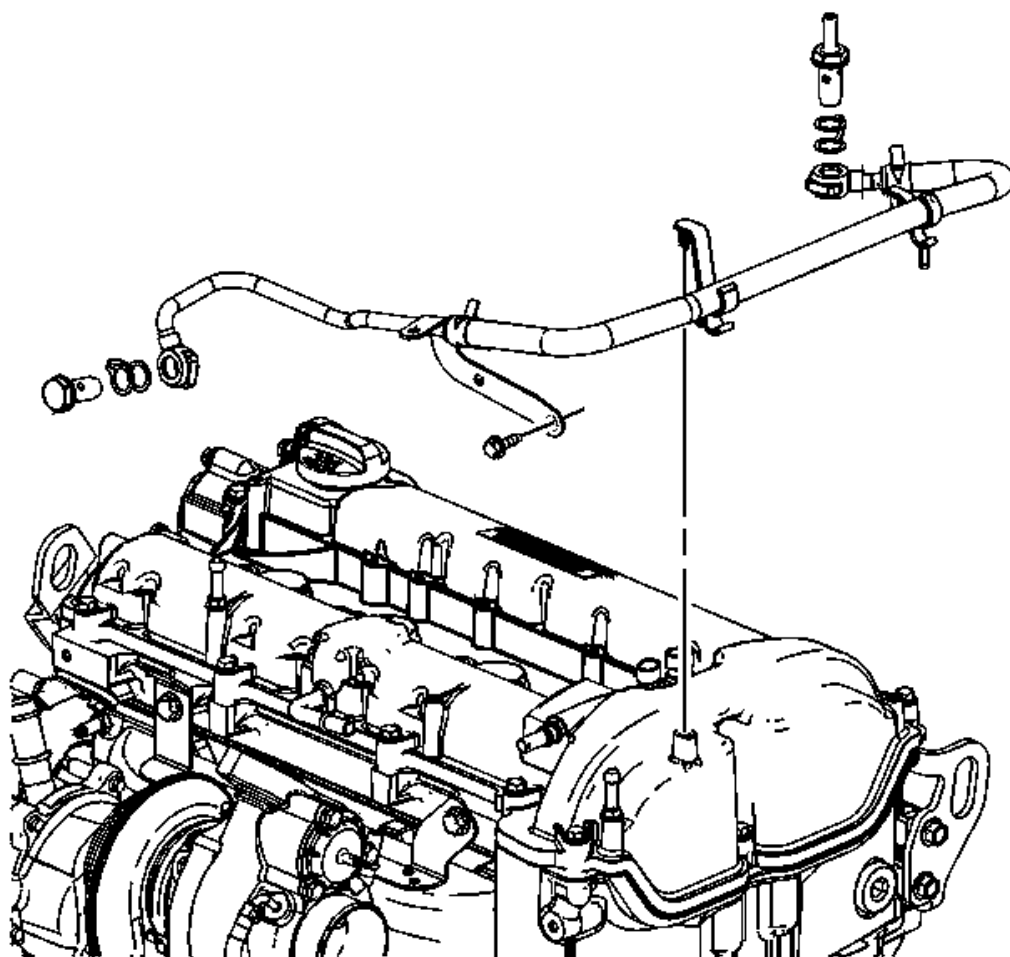


Fig. 608: Identifying Turbocharger Coolant Feed Pipe
Courtesy of GENERAL MOTORS CORP.

16. Install the turbocharger coolant feed pipe.
17. Install the turbocharger coolant feed pipe gaskets.
18. Install the turbocharger coolant feed pipe bolts.

Tighten:

- Tighten the turbocharger coolant feed pipe bolts to 20 N.m (15 lb ft).
 - Tighten the turbocharger coolant feed pipe mounting bolt to 10 N.m (89 lb in).
19. Connect the positive crankcase ventilation (PCV) and hose assembly.

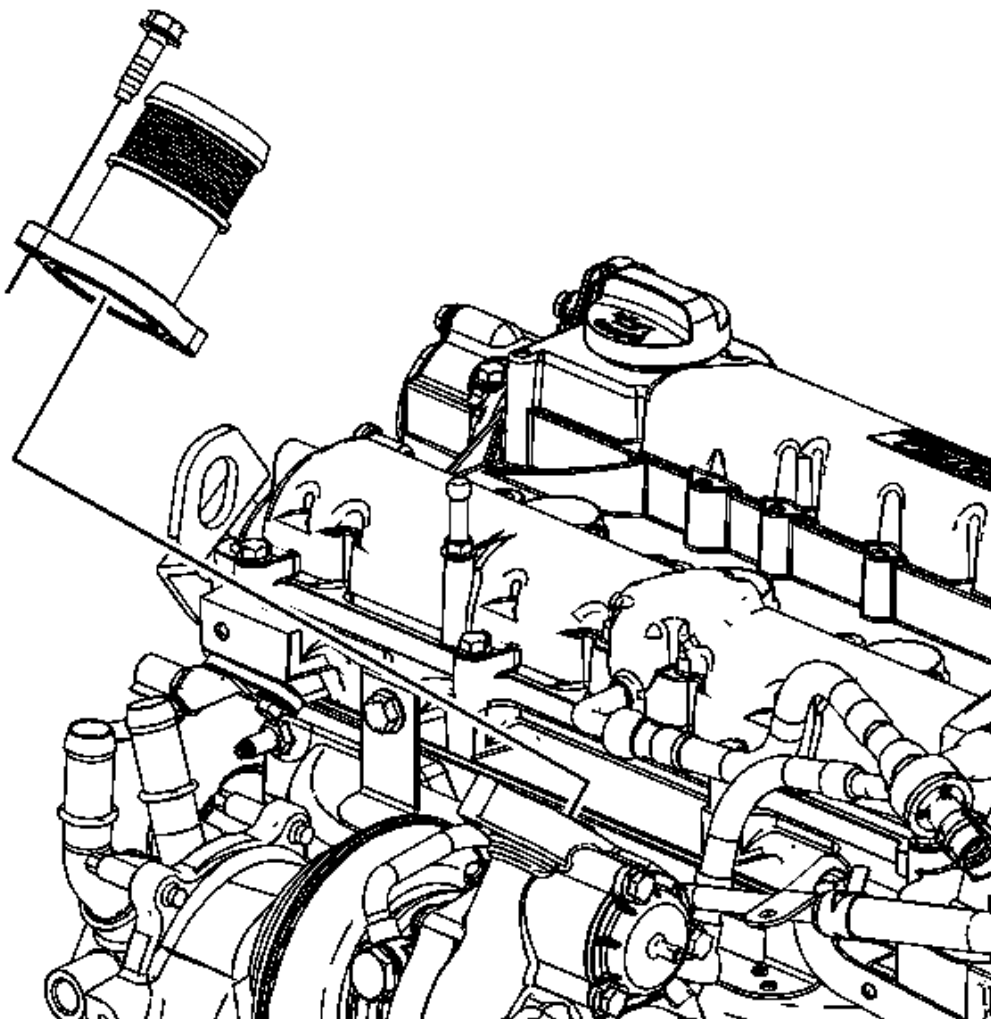


Fig. 609: View Of Turbocharger Coolant Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

20. Install the turbocharger air cooler outlet pipe.
21. Install the turbocharger air cooler outlet pipe bolts.

Tighten: Tighten the turbocharger air cooler outlet pipe bolts to 25 N.m (18 lb ft).

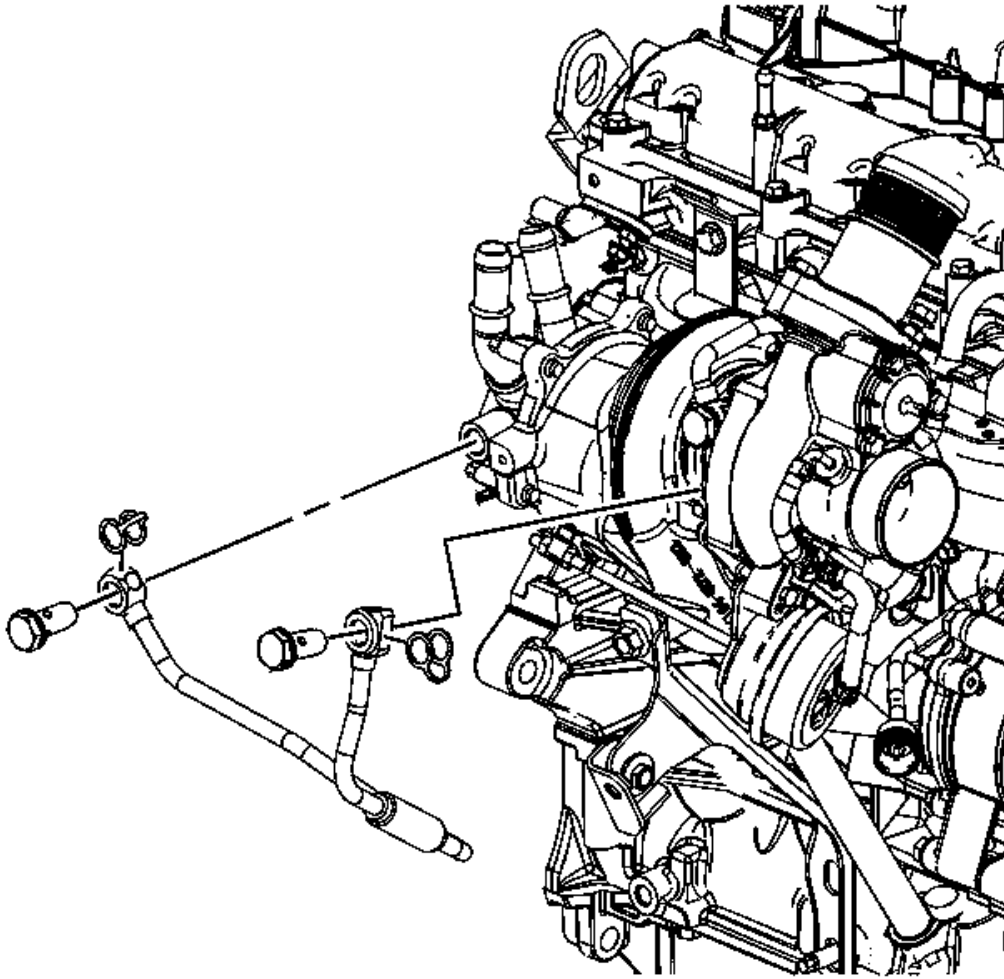


Fig. 610: View Of Turbocharger Coolant Return Pipe
Courtesy of GENERAL MOTORS CORP.

22. Install the turbocharger coolant return pipe.
23. Install the turbocharger coolant return pipe gaskets.
24. Install the turbocharger coolant return pipe bolts.

Tighten: Tighten the turbocharger coolant return pipe bolts to 20 N.m (15 lb ft).

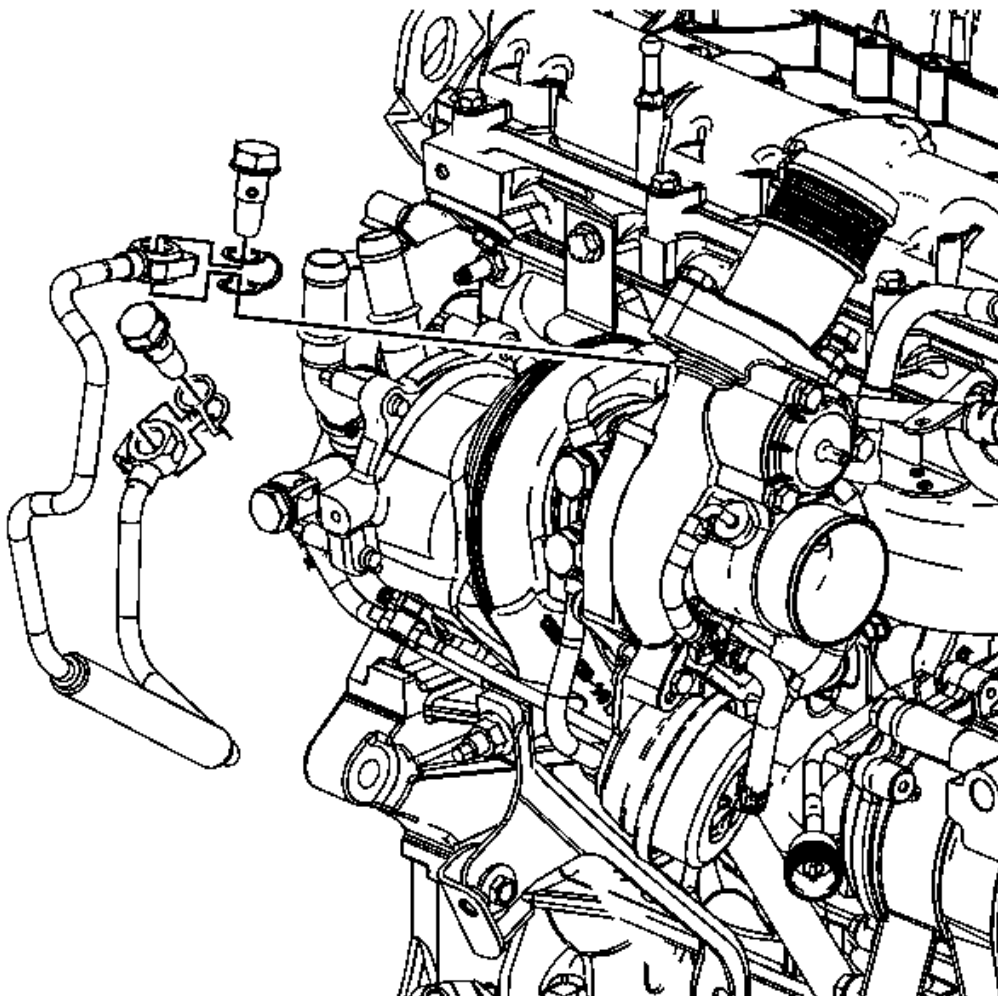


Fig. 611: Identifying Turbocharger Oil Feed Pipe
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not twist the turbocharger oil feed pipe. Twisting of the feed pipe will result in the collapse and deformation of the plastic pipe, restricting oil flow and causing turbocharger damage. During turbocharger replacement, gently push the oil feed pipe towards the front of the engine to clear the turbocharger. Assistance may be required to keep the pipes clear of the turbocharger during removal or installation.

25. Install the turbocharger oil feed pipe.
26. Install the turbocharger oil feed pipe gaskets.

27. Install the turbocharger oil feed pipe bolts.

Tighten: Tighten the turbocharger oil feed pipe bolts to 20 N.m (15 lb ft).

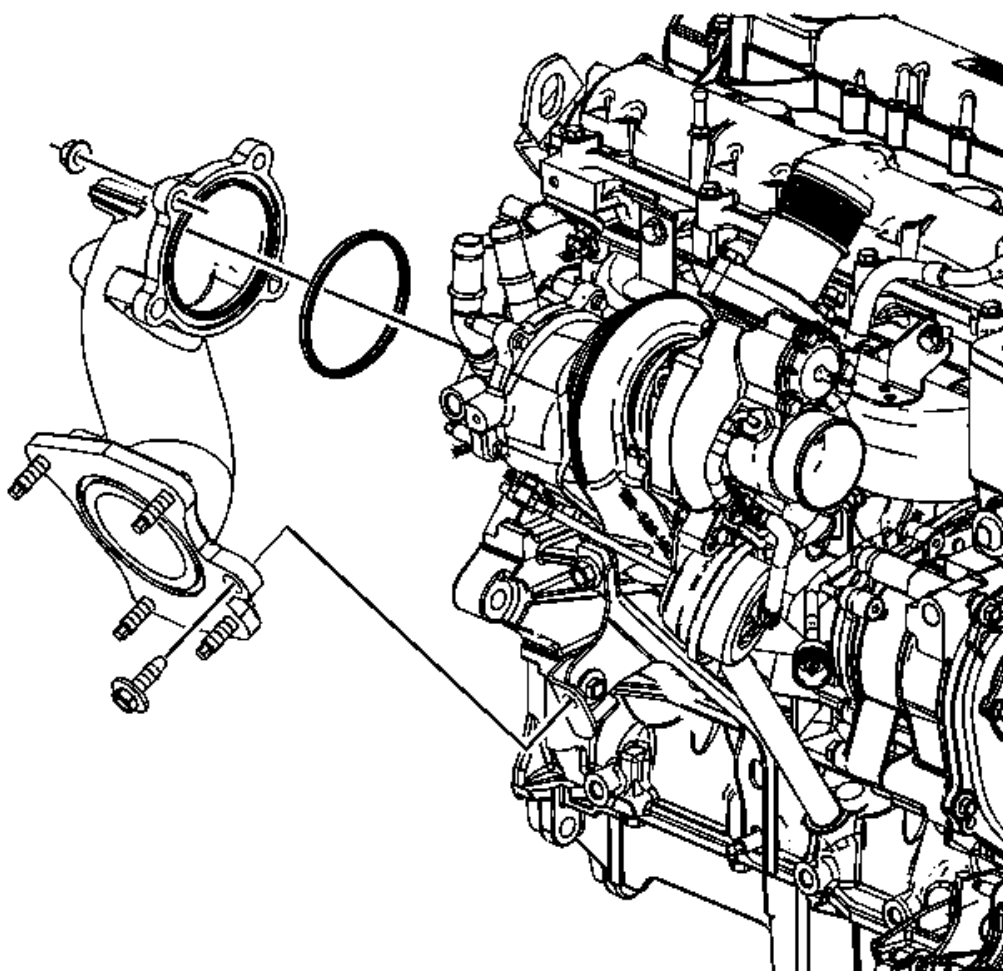


Fig. 612: Identifying Turbocharger Exhaust Pipe & Seal
Courtesy of GENERAL MOTORS CORP.

28. Install the turbocharger exhaust pipe seal.

29. Install the turbocharger exhaust pipe.

30. Install the turbocharger exhaust pipe bolt.

Tighten: Tighten the turbocharger exhaust pipe bolt to 22 N.m (16 lb ft).

31. Install the turbocharger exhaust pipe nuts.

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

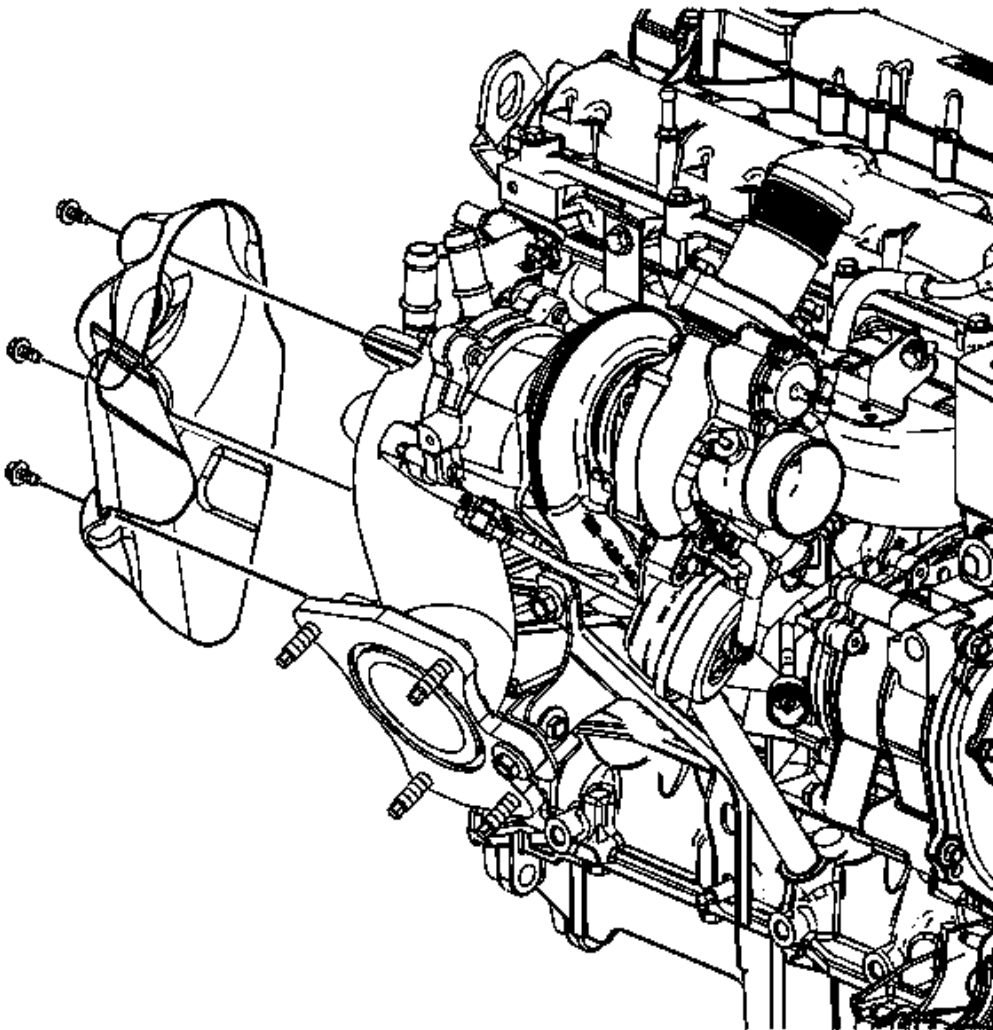


Fig. 613: Identifying Turbocharger Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

32. Install the turbocharger exhaust pipe heat shield.
33. Install the turbocharger exhaust pipe heat shield bolts.

Tighten: Tighten the turbocharger exhaust pipe heat shield bolts to 10 N.m (89 lb in).

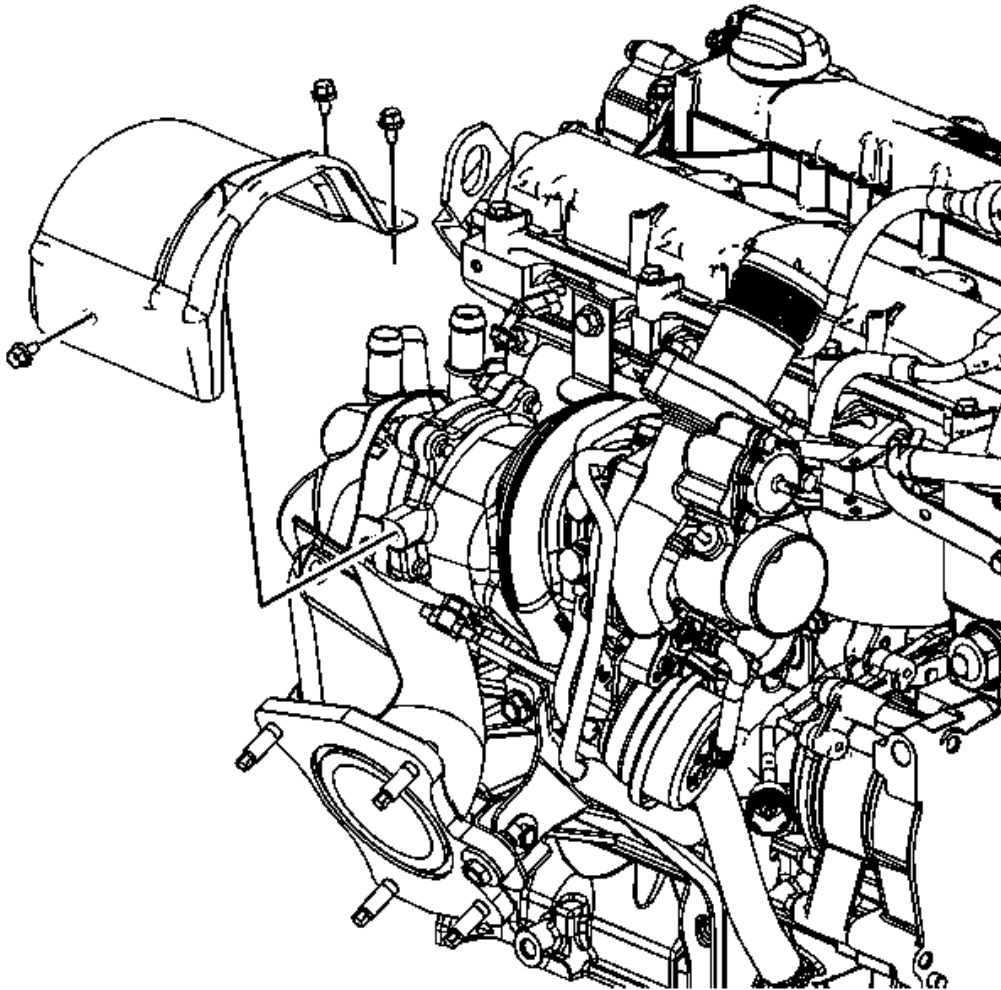


Fig. 614: Identifying Turbocharger Heat Shield
Courtesy of GENERAL MOTORS CORP.

34. Install the turbocharger heat shield.
35. Install the turbocharger heat shield bolts.

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

INTAKE MANIFOLD INSTALLATION

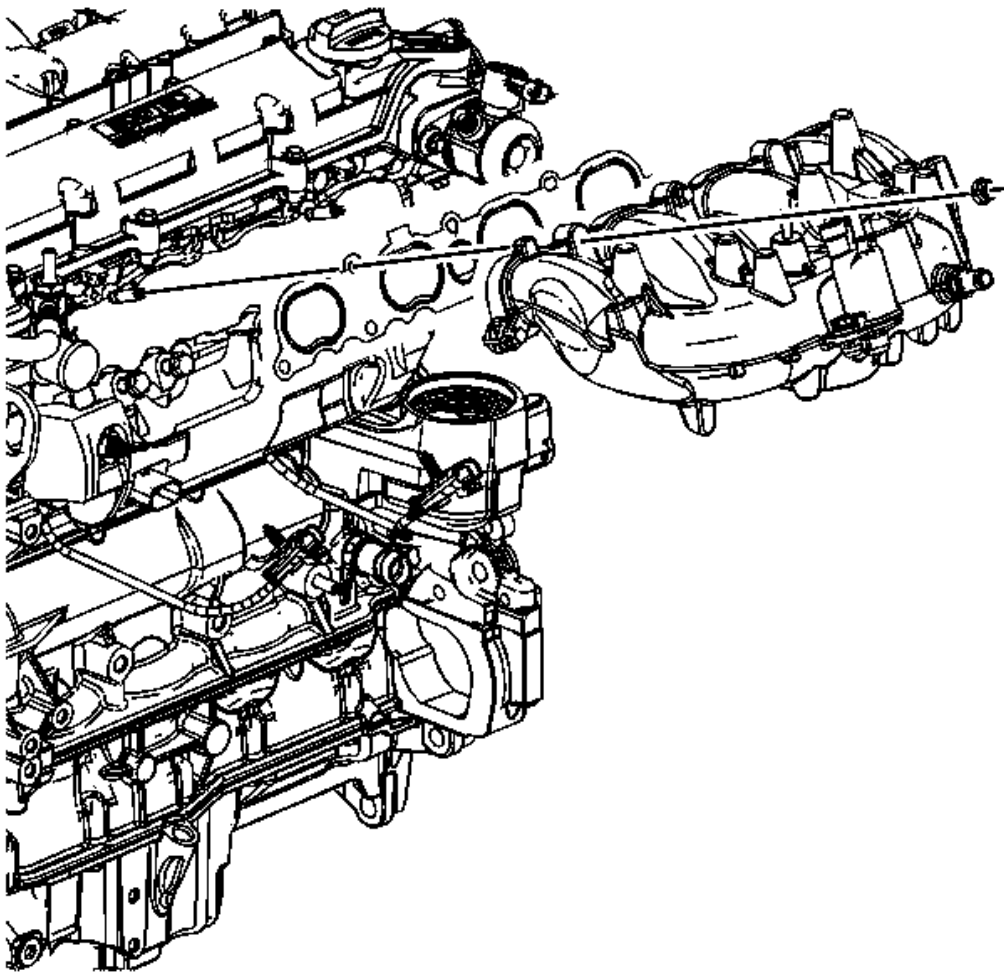


Fig. 615: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW intake manifold gasket.
2. Install the intake manifold.

NOTE: Refer to Fastener Notice .

3. Install the intake manifold bolts and nuts.

Tighten:

1. Tighten the intake manifold bolts to 22 N.m (16 lb ft).

2. Tighten the intake manifold nuts to 22 N.m (16 lb ft).

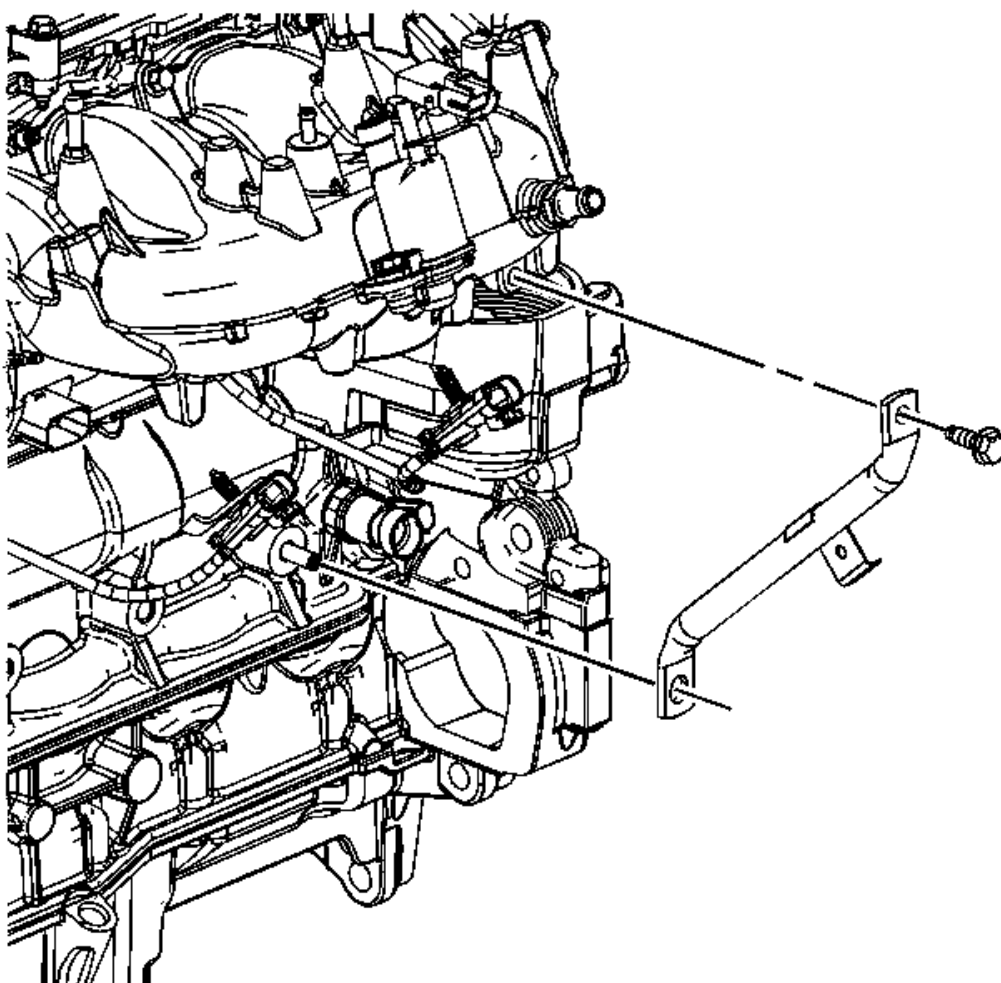


Fig. 616: Identifying Intake Manifold Brace
Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold brace.
5. Install the intake manifold brace bolt.

Tighten: Tighten the intake manifold brace bolt to 22 N.m (16 lb ft).

6. Connect the rear knock sensor to the intake manifold brace.

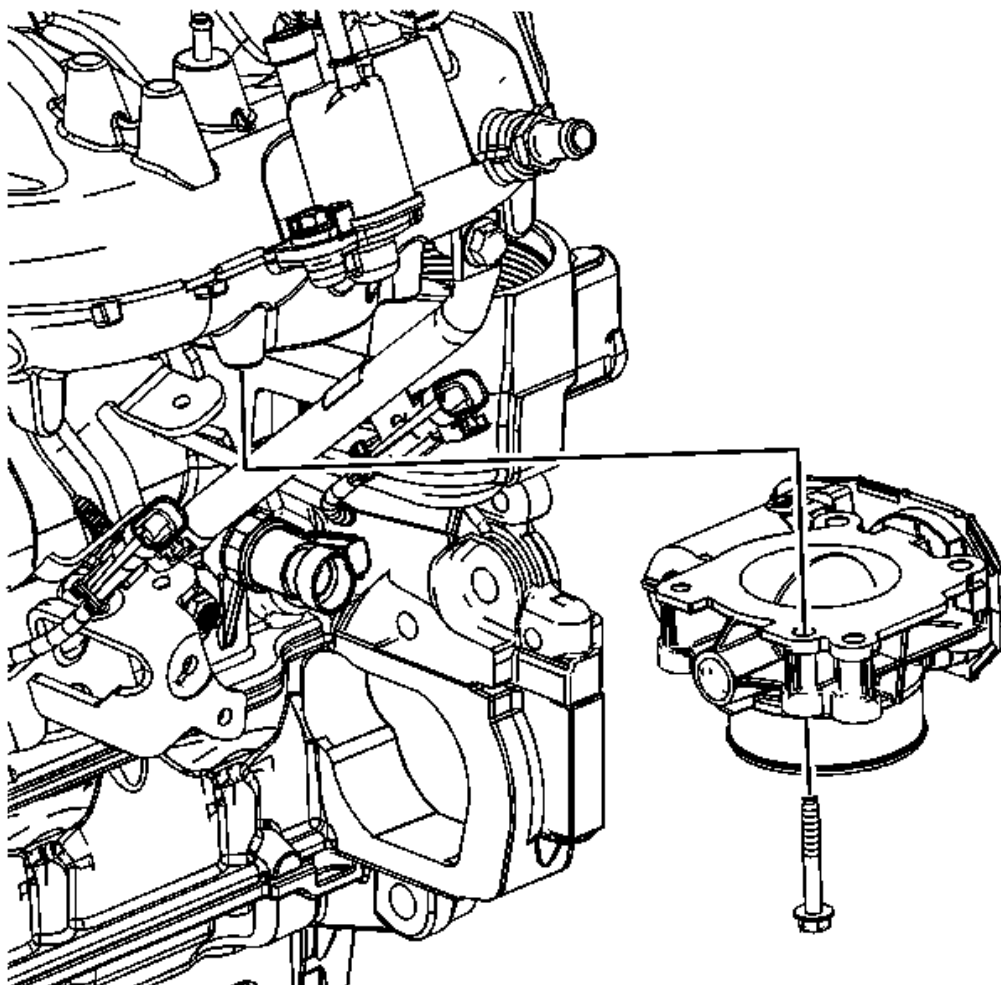


Fig. 617: View Of Throttle Body & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the throttle body.
8. Install the throttle body bolts.

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

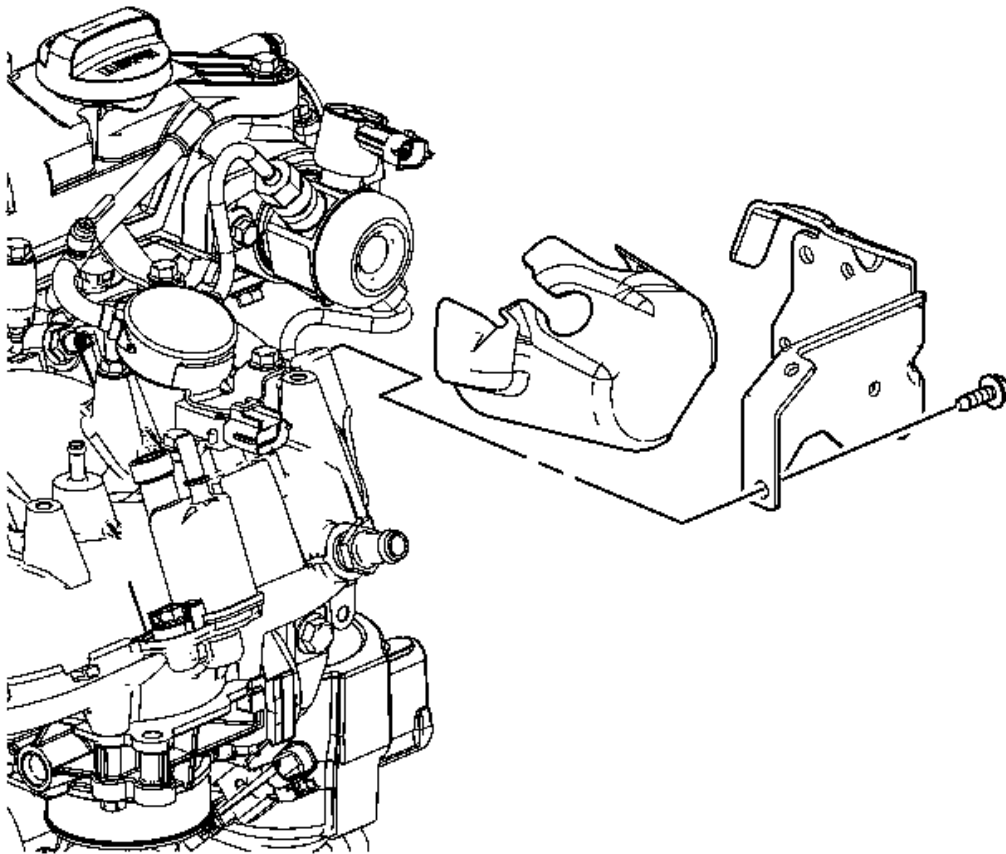


Fig. 618: View Of High Pressure Fuel Pump Cover
Courtesy of GENERAL MOTORS CORP.

9. Install the high pressure fuel pump noise insulator.
10. Install the high pressure fuel pump cover.
11. Install the high pressure fuel pump cover bolts.

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

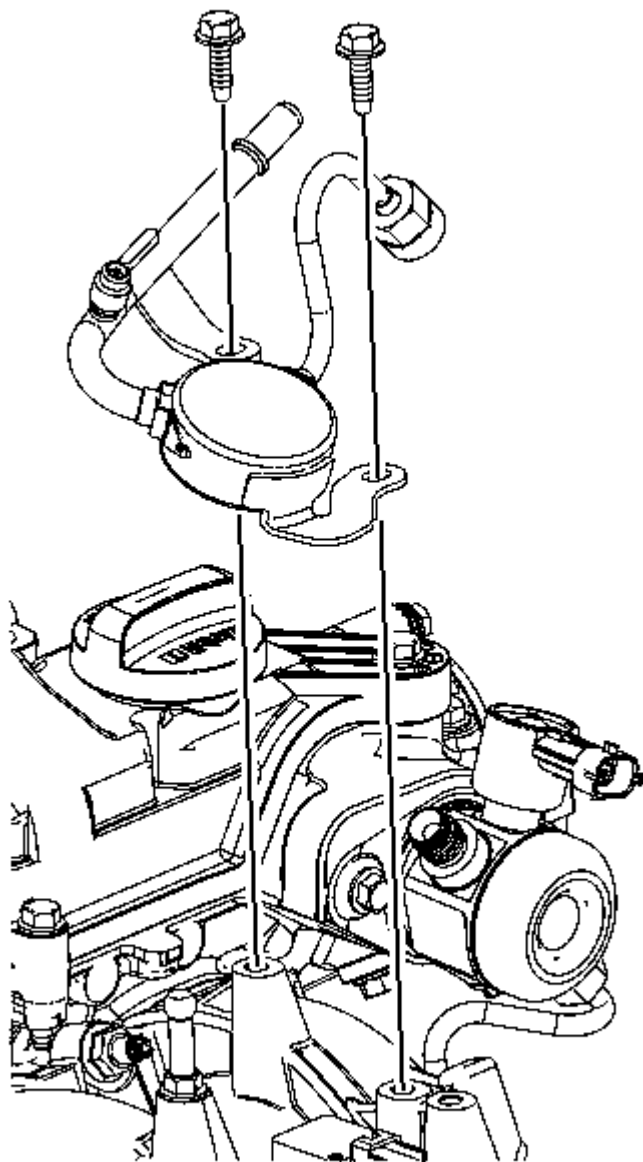


Fig. 619: Identifying Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

12. Lubricate the high pressure fuel pump fuel feed line connection threads with clean 5W30 engine oil.
13. Install the fuel feed line.
14. Install the fuel feed line bolts.

15. Connect the low pressure fuel line nut.

Tighten:

1. Tighten the low pressure fuel line nut to 30 N.m (22 lb ft).
2. Tighten the fuel feed line bolts to 10 N.m (89 lb in).

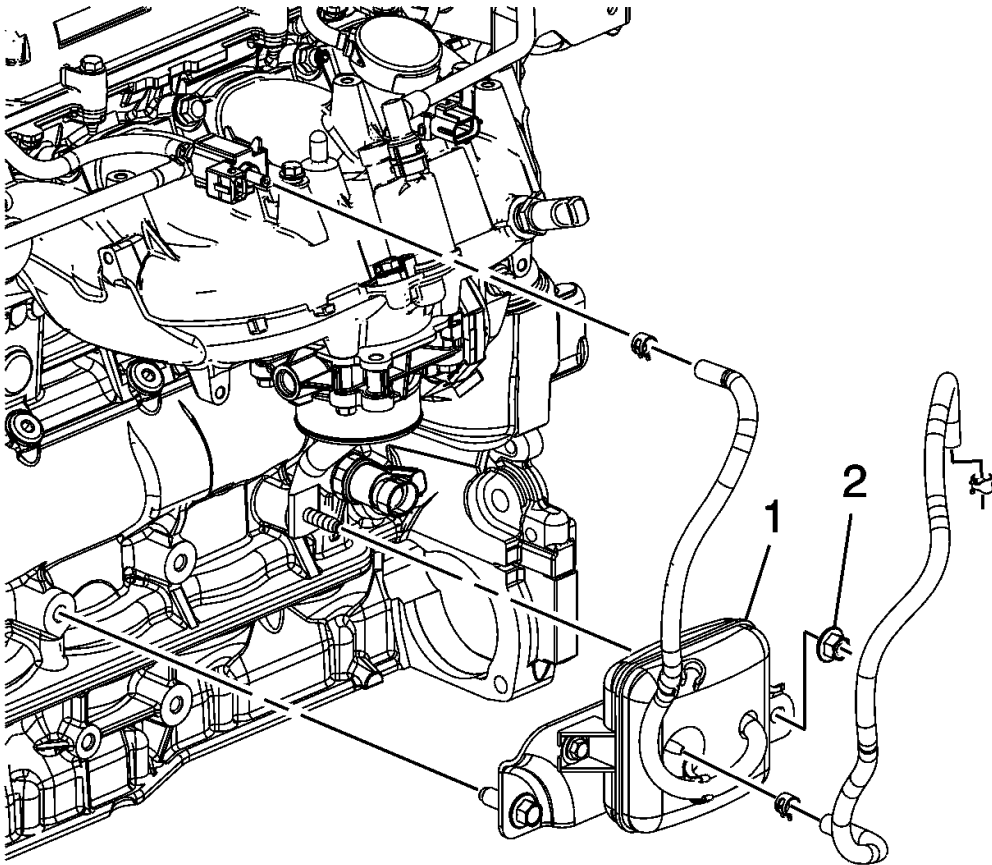


Fig. 620: Identifying AIR Bypass Valve Tank Assembly
Courtesy of GENERAL MOTORS CORP.

16. If the engine is equipped with a charger AIR bypass tank assembly, complete the following procedure:
 1. Install the charger AIR bypass valve tank assembly.
 2. Tighten the charger AIR bypass valve tank assembly bolt.

Tighten: Tighten the charger AIR bypass valve tank assembly bolt to 25 N.m (18 lb ft).

3. Install the charger AIR bypass valve tank assembly nut.

Tighten: Tighten the charger AIR bypass valve tank assembly nut to 25 N.m (18 lb ft).

IMPORTANT: Ensure proper connection of the charger AIR bypass tube assemblies and retaining clips to maintain proper pressure. Connect each tube to the appropriate location. The tube with retaining clamp located on the charger AIR bypass valve tank assembly left side connects to the charger AIR bypass valve solenoid. The right side permanently attached tube connects to the intake manifold.

4. Connect the appropriate charger AIR bypass tube assembly to the intake manifold.

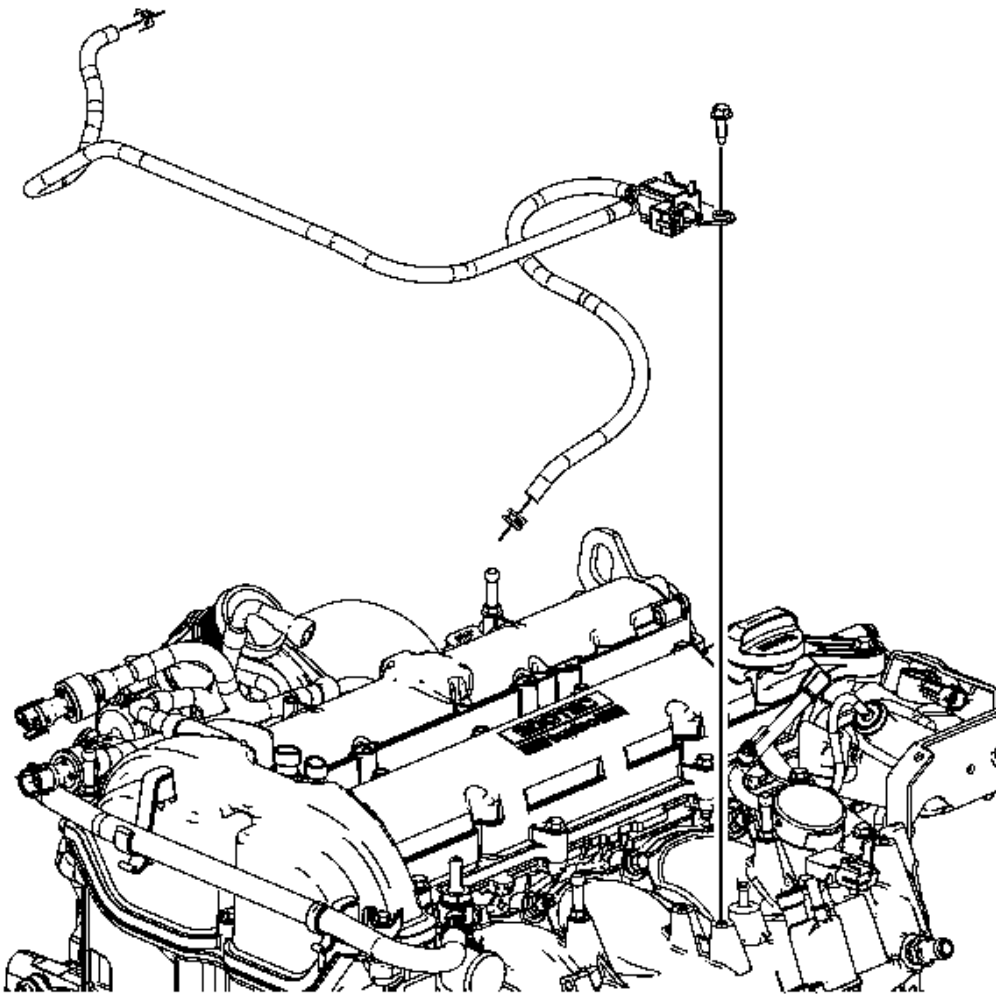


Fig. 621: View Of AIR Bypass Tube Assembly
Courtesy of GENERAL MOTORS CORP.

17. If the engine is equipped with a charger AIR bypass tank assembly, complete the following procedure:
1. Install the charger AIR bypass valve solenoid with charger AIR bypass tube assemblies.
 2. Install the charger AIR bypass valve solenoid bolts.

Tighten: Tighten the charger AIR bypass valve solenoid bolts to 10 N.m (89 lb in).

IMPORTANT: Ensure proper connection of the charger AIR bypass tube assemblies and retaining clips to maintain proper pressure. Connect each tube to the appropriate location.

3. Connect the charger AIR bypass tube assemblies and clamps from the charger AIR bypass valve solenoid to the turbocharger and vehicle.
4. Connect the final charger AIR bypass tube assembly from the charger AIR bypass valve tank assembly to the charger AIR bypass valve solenoid.

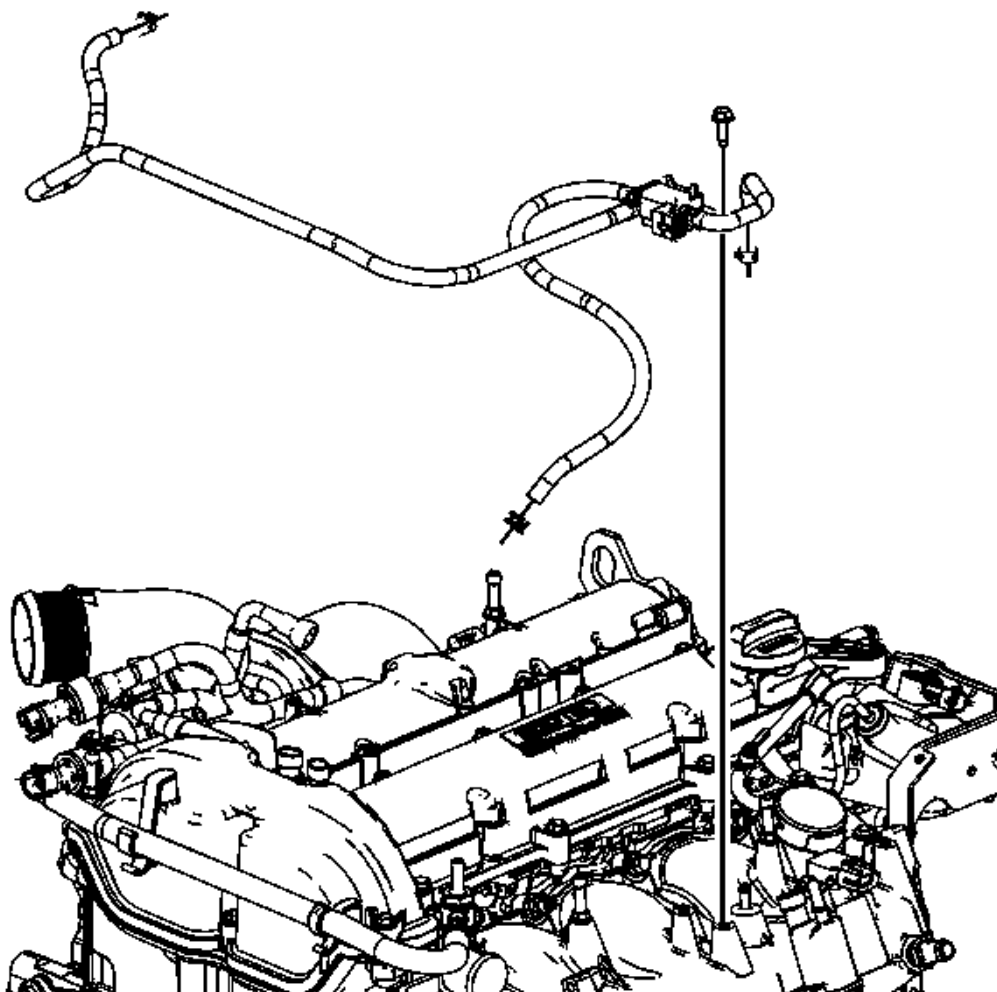


Fig. 622: Bypass Valve Solenoid Hoses
Courtesy of GENERAL MOTORS CORP.

18. If the engine is not equipped with a charger AIR bypass tank assembly, complete the following procedure:
 1. Install the charger AIR bypass valve solenoid with charger AIR bypass tube assemblies.
 2. Install the charger AIR bypass valve solenoid bolts.

Tighten: Tighten the charger AIR bypass valve solenoid bolts to 10 N.m (89 lb in).

IMPORTANT: Ensure proper connection of the charger AIR bypass tube assemblies and retaining clips to maintain proper pressure. Connect

each tube to the appropriate location.

3. Connect the charger AIR bypass tube assemblies and clamps.

EXHAUST MANIFOLD INSTALLATION

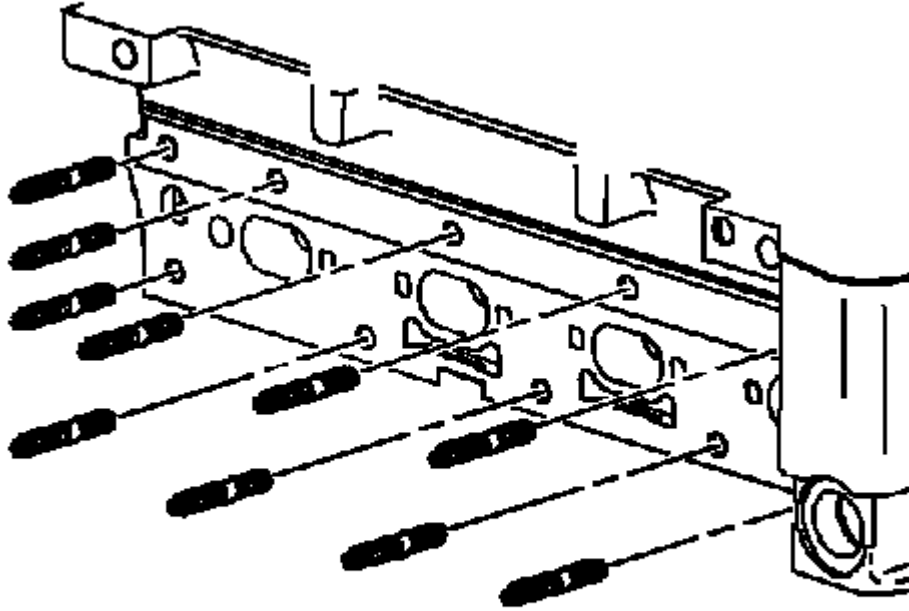


Fig. 623: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install new exhaust manifold studs.

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

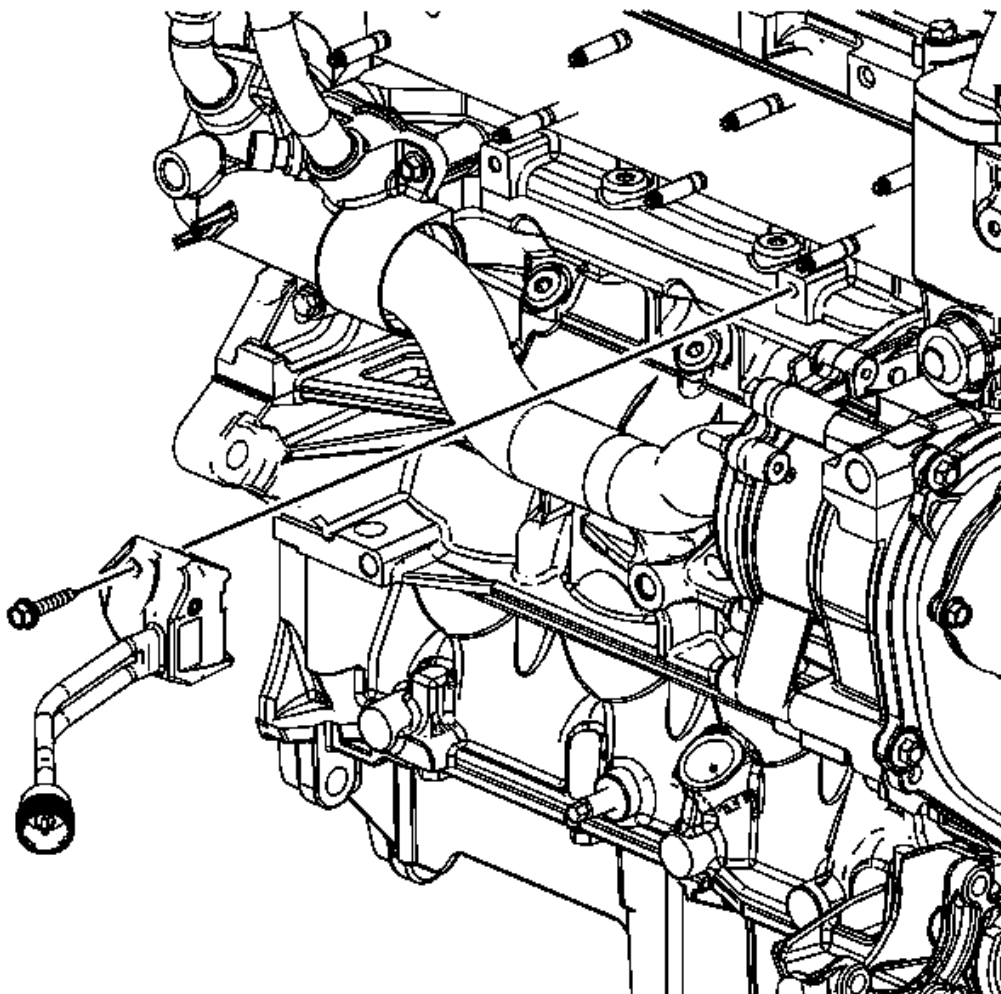


Fig. 624: Identifying Block Heater
Courtesy of GENERAL MOTORS CORP.

2. Install the block heater, if equipped.

Tighten: Tighten the block heater bolt to 10 N.m (89 lb in).

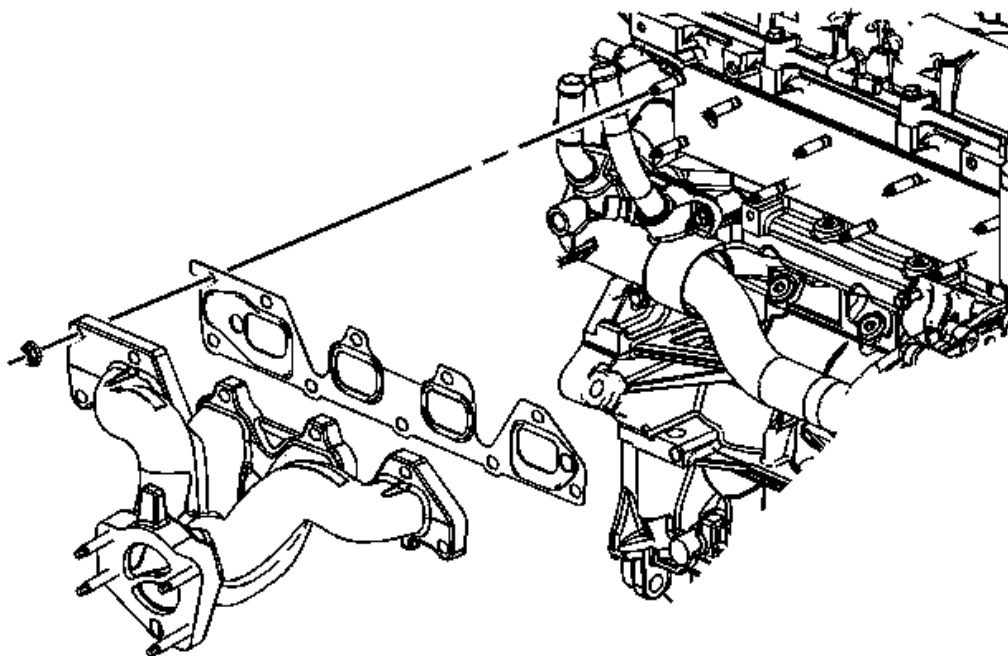


Fig. 625: View Of Exhaust Manifold, Gasket & Nuts
Courtesy of GENERAL MOTORS CORP.

3. Install the exhaust manifold gasket.
4. Install the exhaust manifold to the cylinder head.
5. Install NEW exhaust manifold to cylinder head retaining nuts finger tight.

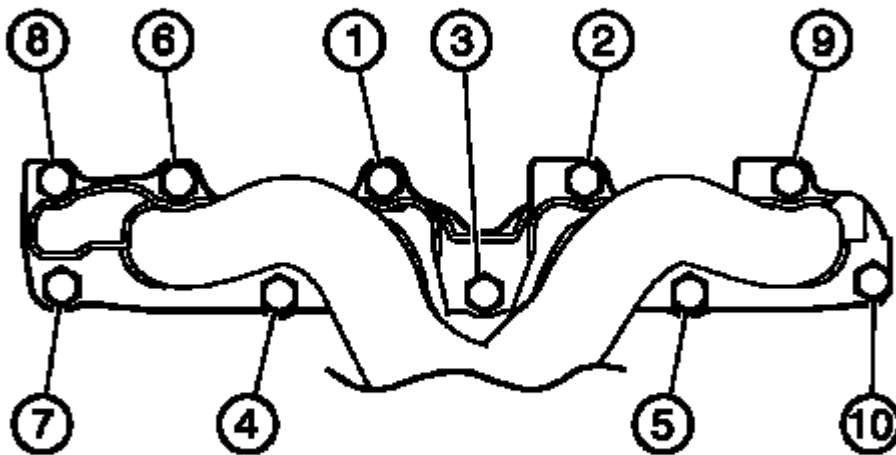


Fig. 626: Exhaust Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

6. Tighten the NEW exhaust manifold to cylinder head retaining nuts in sequence.

Tighten:

1. Tighten the exhaust manifold nuts to 14 N.m (10 lb ft).
2. Tighten the exhaust manifold nuts a second time to 14 N.m (10 lb ft).

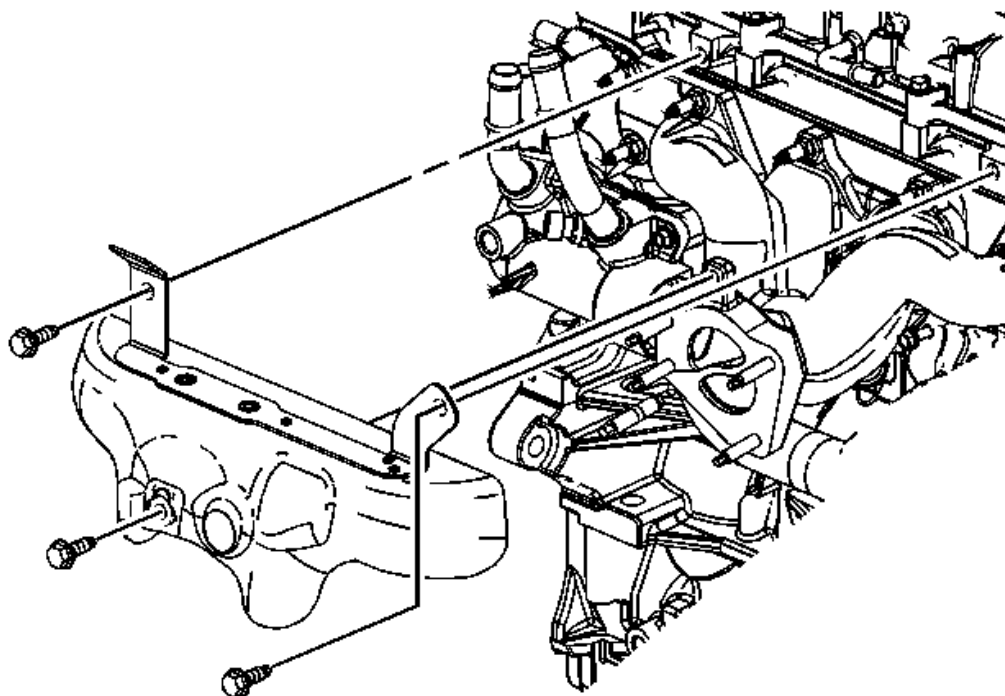


Fig. 627: View Of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust manifold heat shield.
8. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to 25 N.m (18 lb ft).

ENGINE OIL COOLER INSTALLATION

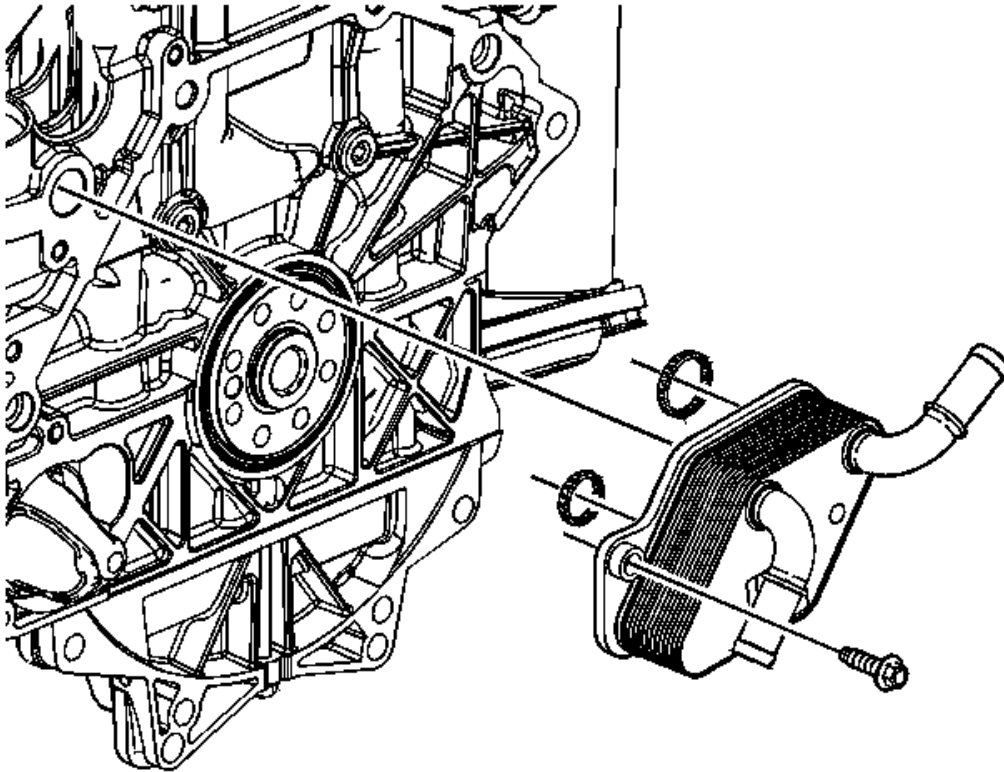


Fig. 628: View Of Engine Oil Cooler
Courtesy of GENERAL MOTORS CORP.

1. Install the oil cooler.

NOTE: Refer to Fastener Notice .

2. Install the oil cooler bolts.

Tighten: Tighten the oil cooler bolts to 22 N.m (16 lb ft).

STARTER INSTALLATION

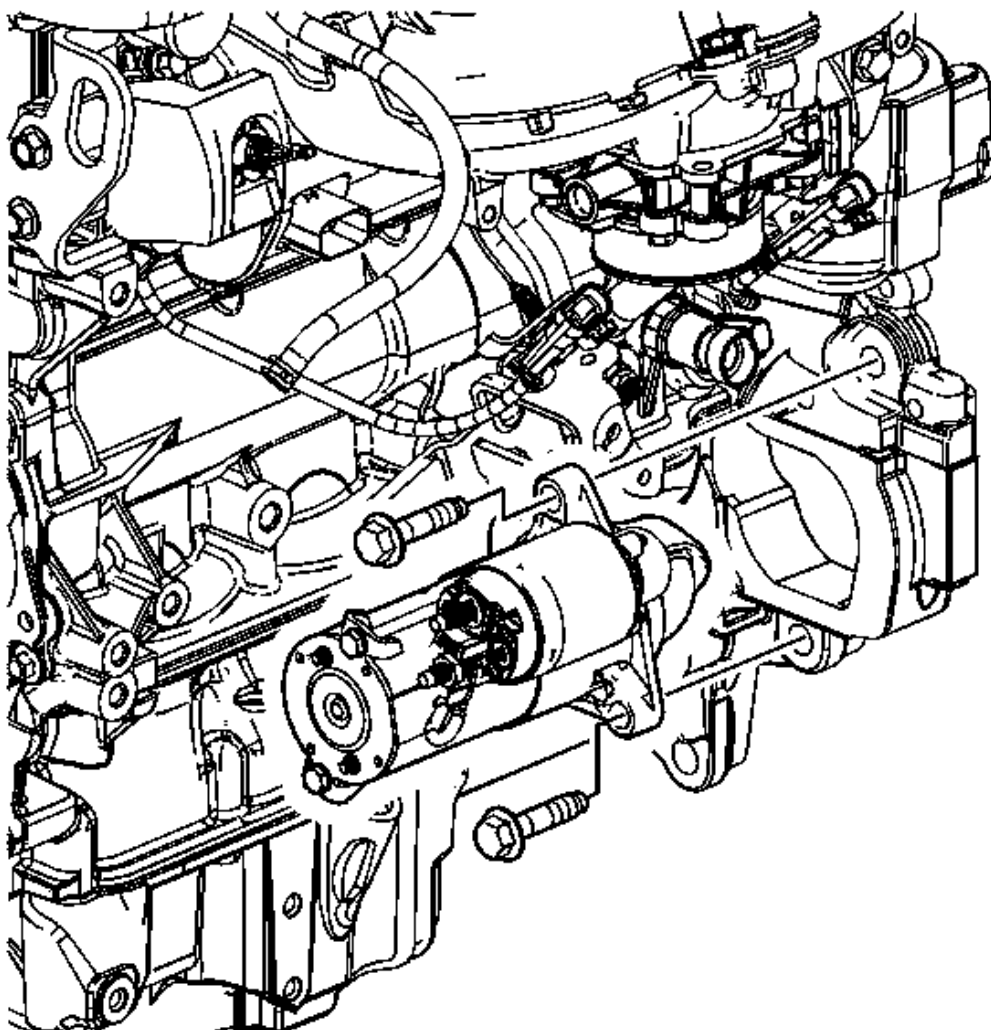


Fig. 629: View Of Starter

Courtesy of GENERAL MOTORS CORP.

1. Install the starter.

NOTE: Refer to Fastener Notice .

2. Install the starter bolts.

Tighten: Tighten the starter bolts to 53 N.m (39 lb ft).

OIL LEVEL INDICATOR AND TUBE INSTALLATION

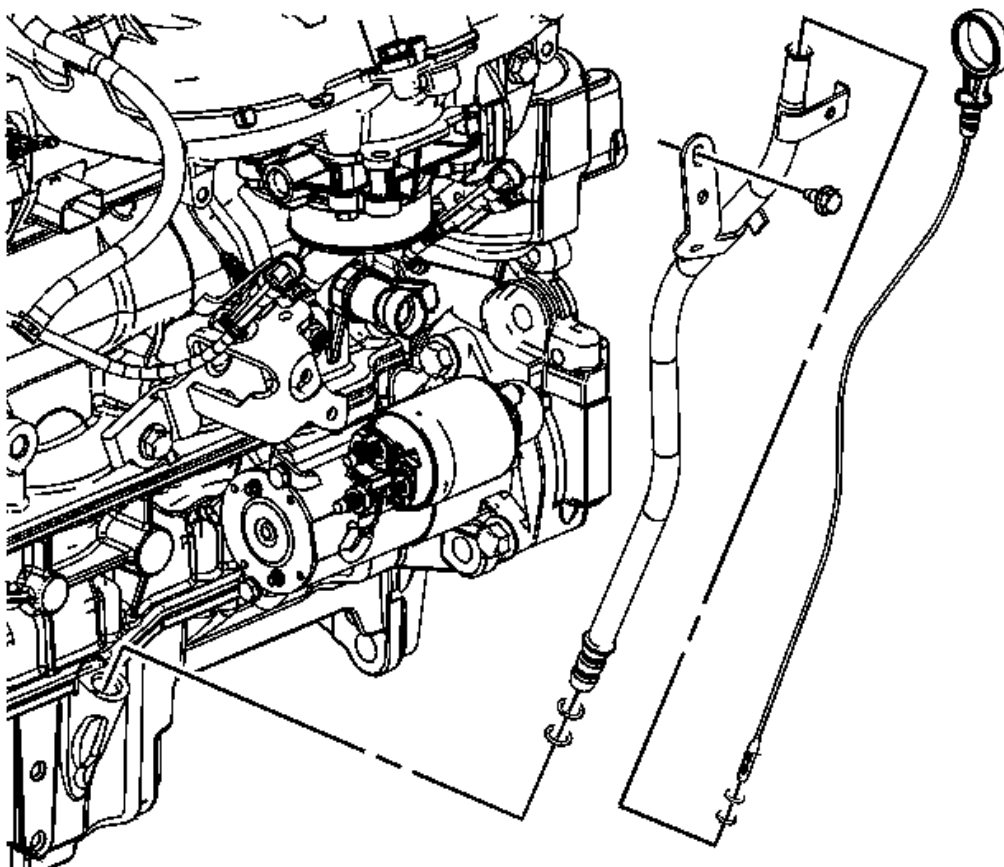


Fig. 630: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring with GM P/N 12345501 (Canadian P/N 992704), or equivalent.
2. Install the oil level indicator and the oil level indicator tube into the oil pan.

NOTE: Refer to Fastener Notice .

3. Install the oil level indicator tube bracket to the intake manifold bolt.

Tighten: Tighten the oil level indicator bolt 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 into the oil level indicator tube.

ENGINE FLYWHEEL INSTALLATION

Tools Required

J 45059 Angle Meter. See Special Tools.

Installation Procedure

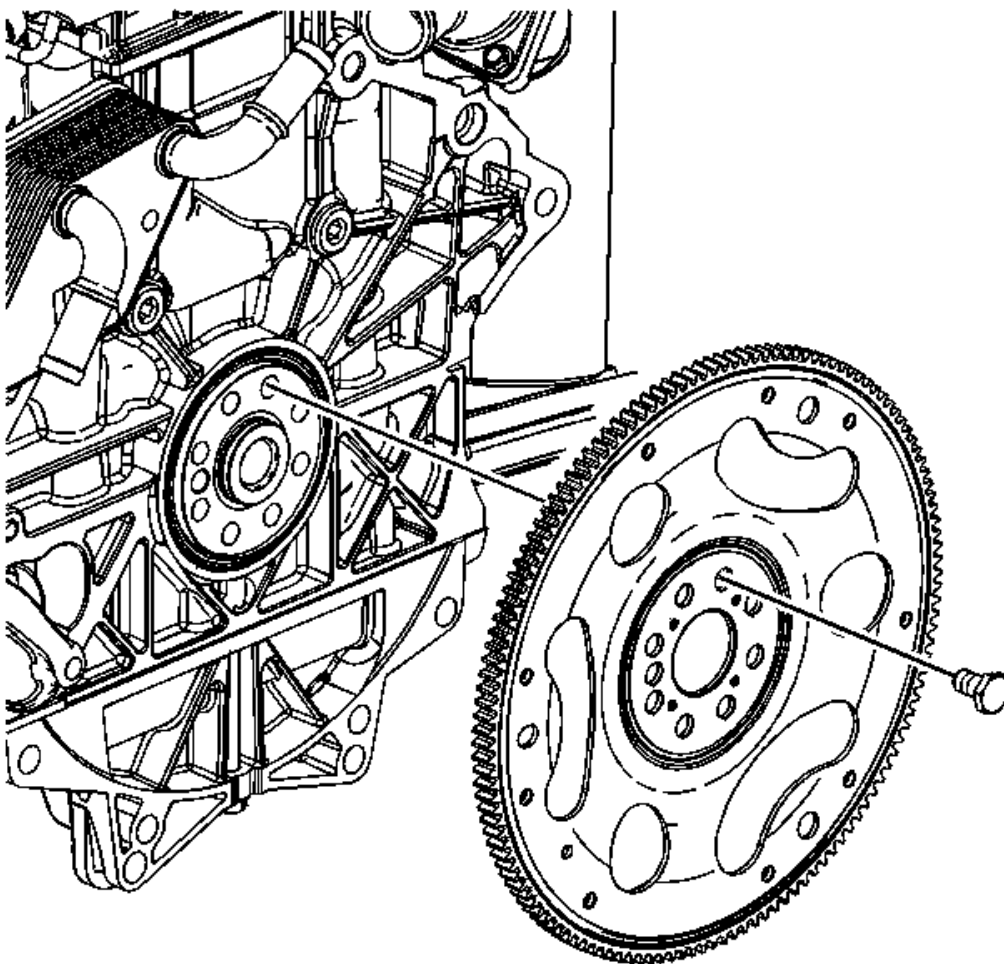


Fig. 631: Flywheel (A/T)

Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel.

2. Install the NEW bolts.

NOTE: Refer to Fastener Notice .

3. Hold the crankshaft.

Tighten: Tighten the flywheel bolts to 53 N.m (39 lb ft), plus 25 degrees, using the **J 45059** . See Special Tools .

ENGINE PRELUBING

Tools Required

J 45299 Engine Preluber. See Special Tools .

Prelubing Procedure

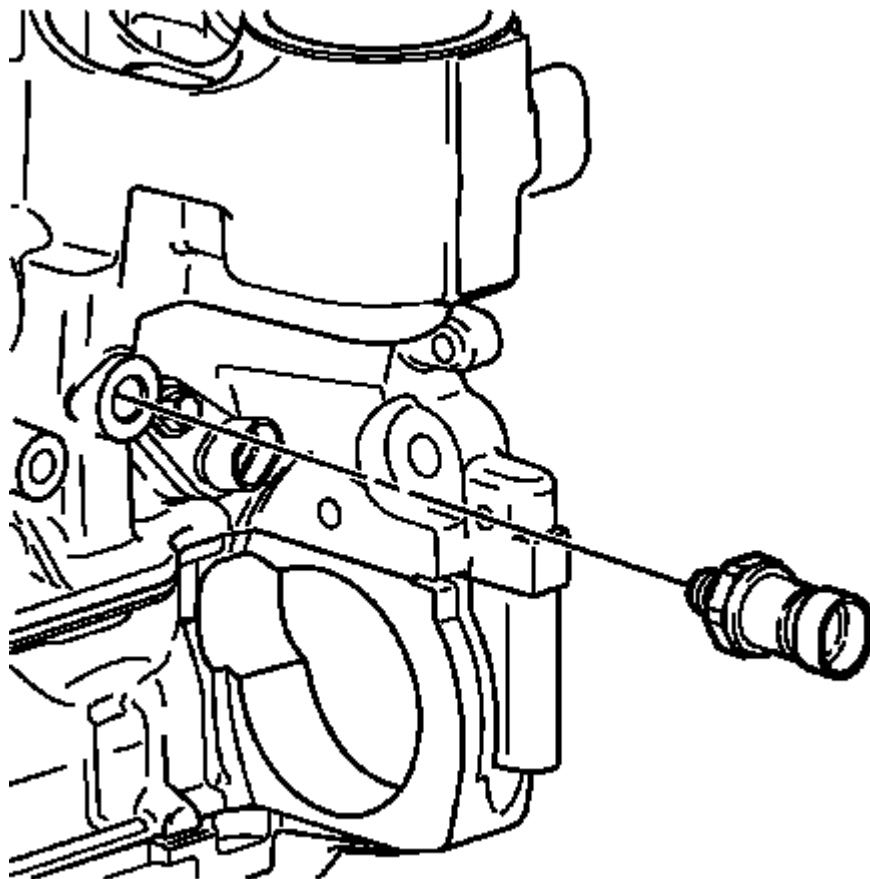


Fig. 632: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 P/N 509376.

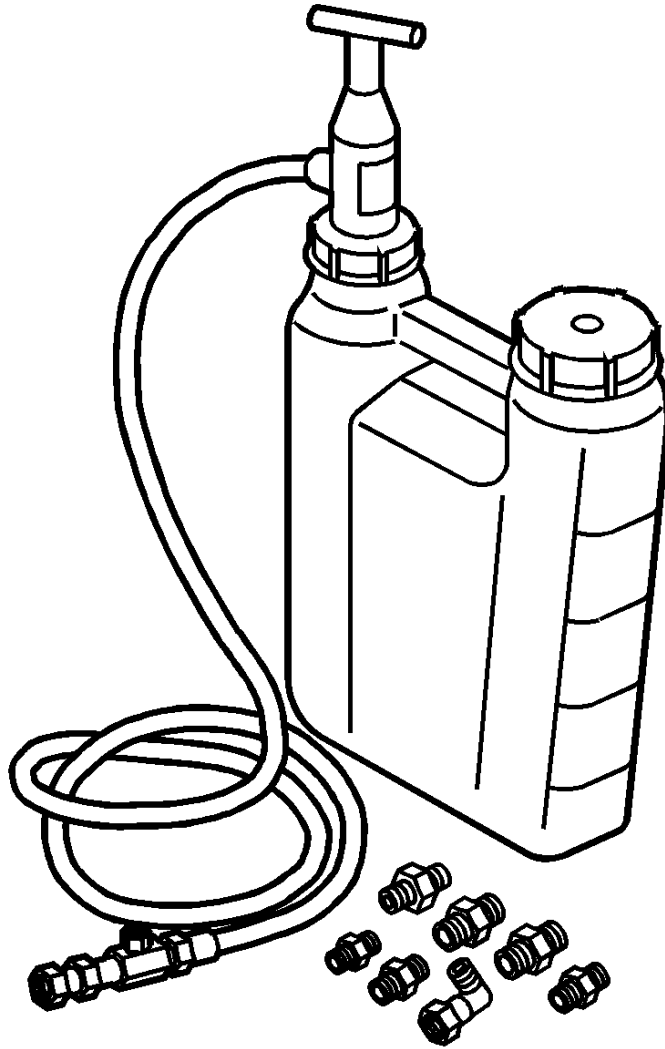


Fig. 633: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **J 45299** in order to flow a minimum of 1-1. See **Special Tools**. 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.

NOTE: Refer to **Fastener Notice** .

6. Install the oil pressure switch to the engine.

Tighten: Tighten the oil pressure switch 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

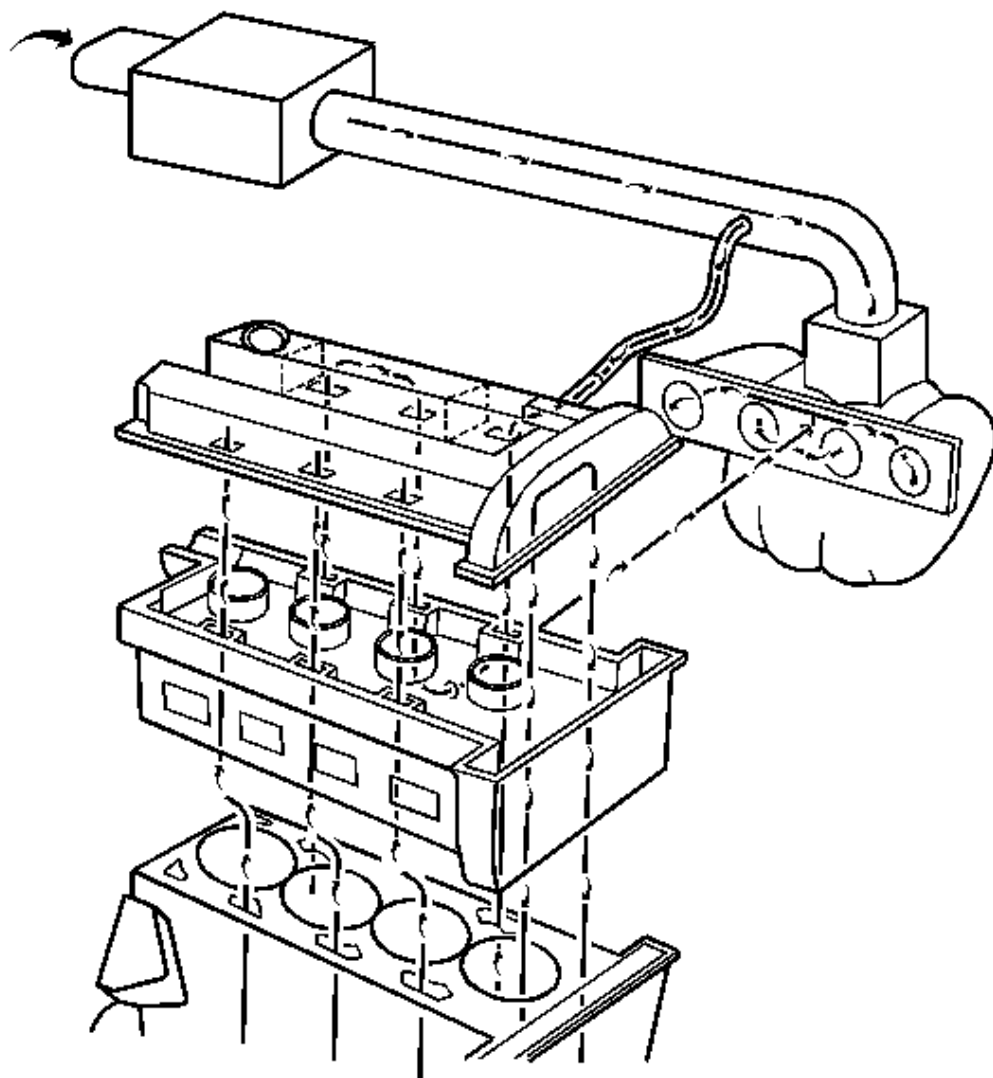


Fig. 634: Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Block

The cylinder block is lost foam cast aluminum with 4 cylinders arranged in-line. The cylinders have pressed in place iron liners. 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 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. A harmonic dampener is used to control torsional vibration.

Connecting Rod and Piston

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 aluminum casting. Pressed-in powdered metal valve guides and valve seat insets are used. The fuel injection nozzle is located below 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

2 camshafts are used, 1 for all intake valves, the other for all exhaust valves. The camshafts are cast iron.

Valve Lifters

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 single row 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 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

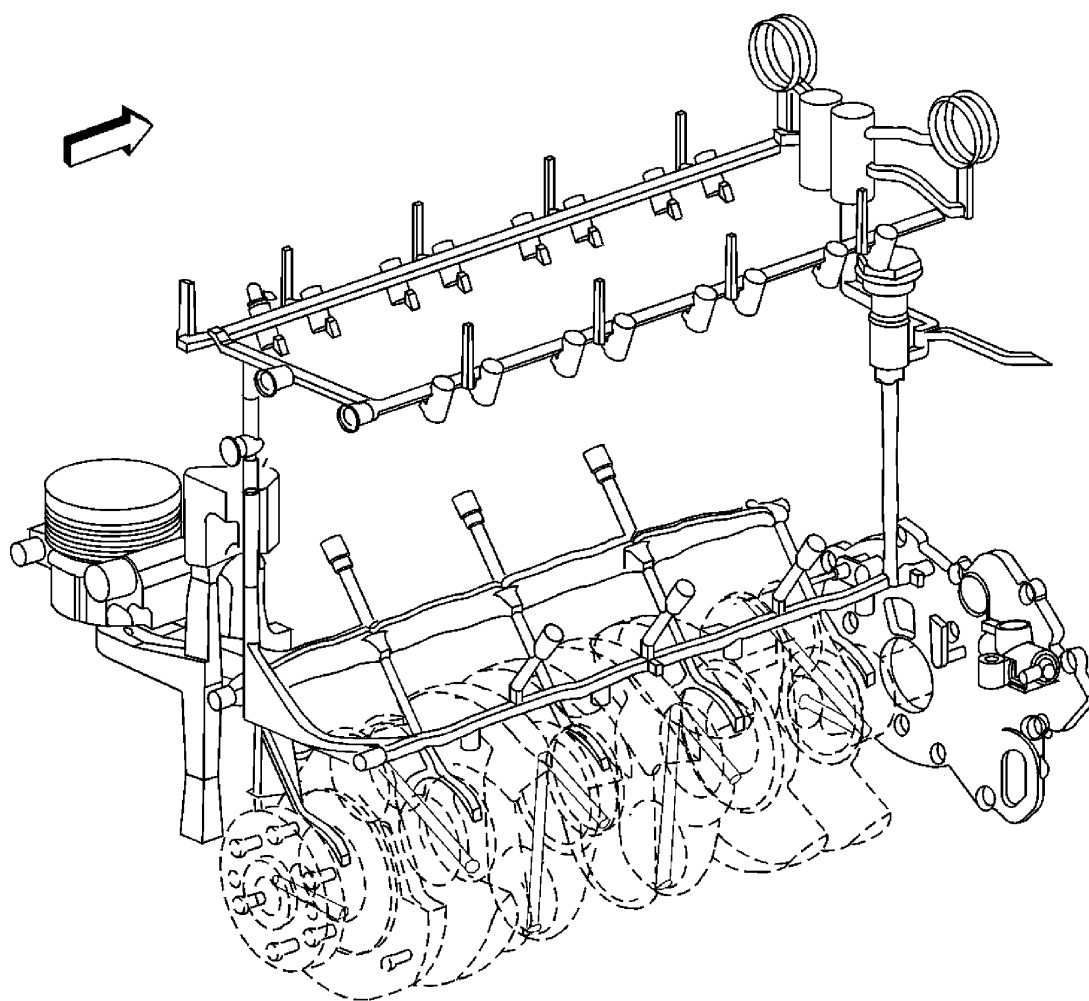


Fig. 635: Cutaway View Of Lubrication System
Courtesy of GENERAL MOTORS CORP.

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

Tools Required**J 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 **J 28410** or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
 - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- 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: 3 types of sealer are commonly used in engines. These are room temperature vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint

compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type 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 the 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

- 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 the 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.

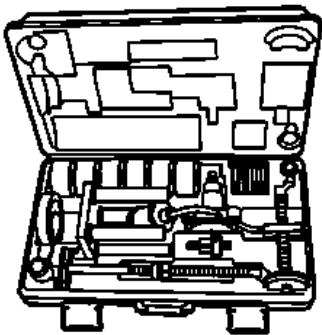
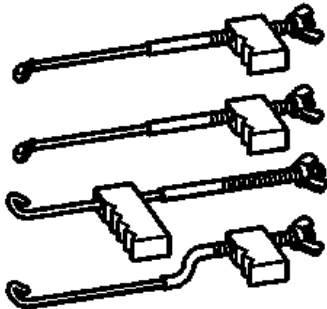
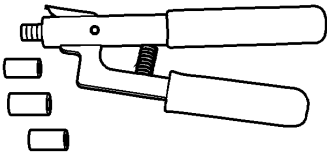
To properly service the engine assembly, the following items should be readily available:

- 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

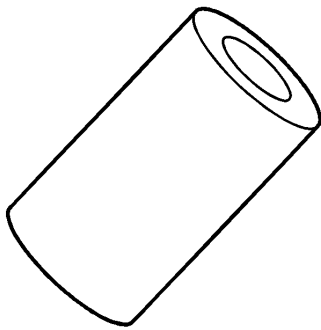
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

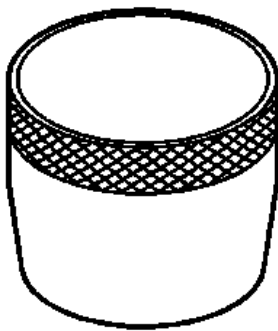
Illustration	Tool Number/Description
	EN 45680-850 Cylinder Liner Removal and Installation Kit
	EN 46327 Timing Chain Retention Tool
	EN-46745 Piston Pin Clip Remover/Installer

2008 Chevrolet Cobalt LT

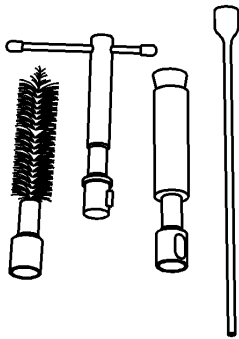
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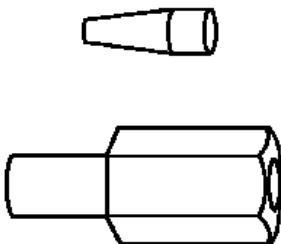
EN-46745-4
Piston Pin Clip Remover/Installer Adapter



EN-47836
Piston Ring Compressor



EN-47909
Injector Bore and Sleeve Cleaning Kit

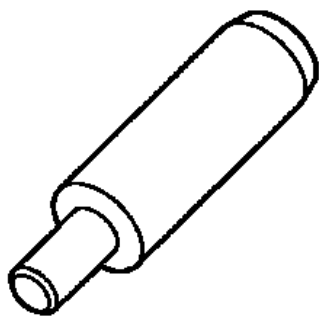


EN-48266
Injector Seal Installer and Sizer

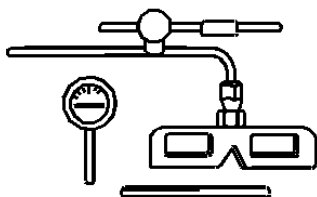
EN-48585
Crankshaft Balancer Guide

2008 Chevrolet Cobalt LT

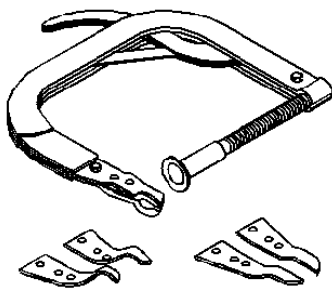
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J 2619-01
Slide Hammer



J 7872
Magnetic Base Dial Indicator Set

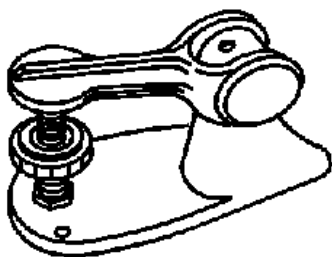
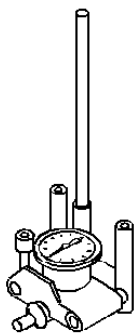


J 8062
Valve Spring Compressor - Head Off

J 8087
Cylinder Bore Gage

2008 Chevrolet Cobalt LT

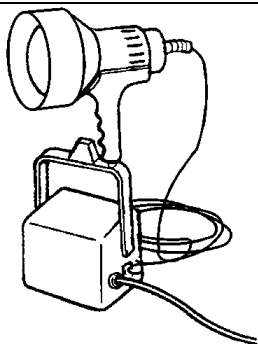
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J 9666
Valve Spring Tester



J 28410
Gasket Remover



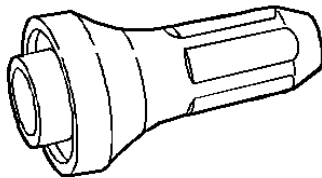
J 28428-E
High-Intensity Black Light Kit

J 34115

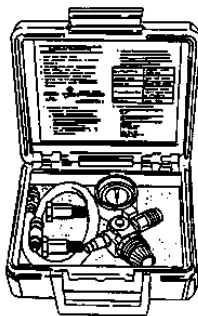
2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt

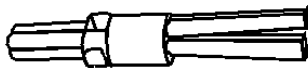
Sprocket Bearing Installer



J 35667-A
Cylinder Head Leakdown Tester



J 36017
Valve Seal Remover



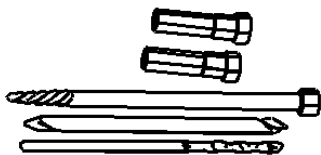
J 37281-A
Injector Remover



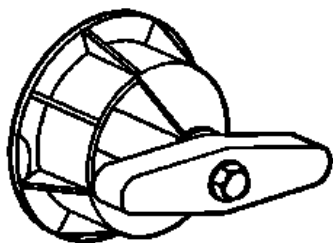
J 38188

2008 Chevrolet Cobalt LT

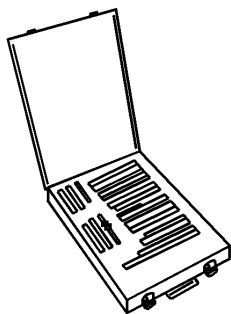
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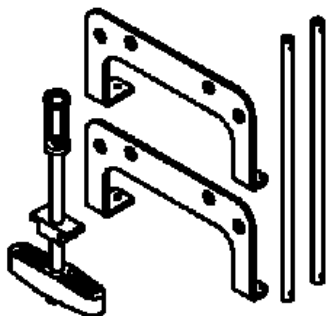
Cylinder Head Broken Bolt Extractor Kit



J 42067
Rear Main Seal Installer



J 42385-850
Thread Repair Kit

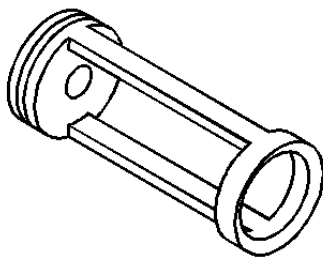
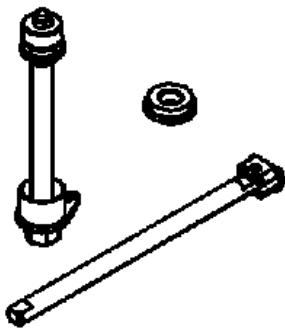


J 43649
Valve Spring Compressor

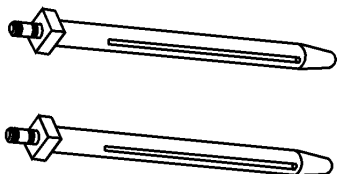
J 43650
Balance Shaft Bearing Remover and Installer

2008 Chevrolet Cobalt LT

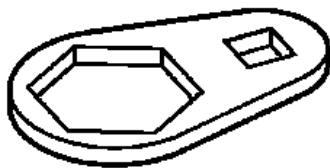
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J 43963
Valve Spring Compressor (off car)



J-43966-1
Connecting Rod Guides

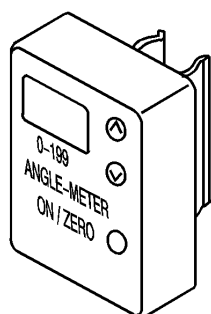
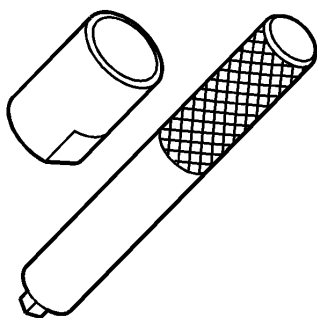


J-44887
Oil Filter Cap Tool

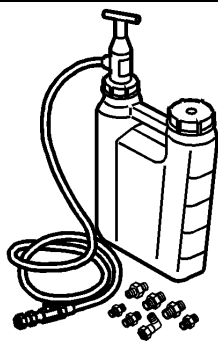
J 45027
Tensioner Tool

2008 Chevrolet Cobalt LT

2008 ENGINE Engine Mechanical - 2.0L - Cobalt



J 45059
Angle Meter



J 45299
Engine Preluber