

2018 ENGINE**Engine Mechanical - 1.5L (LYX) - Equinox & Terrain****SPECIFICATIONS****FASTENER SPECIFICATIONS****Single Use Non-Threaded Fasteners/Components**

Application
NOTE: <i>All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.</i>
Camshaft Cover Gasket
Camshaft Housing Gasket
Combustion Fuel Injector Seal
Connecting Rod Bearing
Crankshaft Front Oil Seal
Cylinder Head Core Hole Plug
Cylinder Head Gasket
Engine Oil Cooler Gasket
Engine Oil Manifold Check Valve
Fuel Injector
Fuel Pump Housing Seal
Intake Manifold Gasket
Lower Oil Pan
Oil Pan Drain Plug Seal
Oil Pump Seal
Positive Crankcase Ventilation Tube
Positive Crankcase Ventilation Valve
Throttle Body Gasket
Timing Chain Oil Nozzle
Turbocharger Coolant Feed Pipe Seal
Turbocharger Coolant Return Pipe Fitting
Turbocharger Coolant Return Pipe Seal
Turbocharger Gasket
Turbocharger Oil Feed Pipe Washer
Turbocharger Oil Return Pipe Gasket
Turbocharger Pipe Fitting
Vacuum Pump Gasket
Vacuum Pump Seal
Valve Stem Oil Seal
Water Outlet Gasket
Water Pump Housing Gasket

Single Use Threaded Fastener/Component Tightening Specifications

NOTE: <i>All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.</i>

NOTE:	
All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.	
Application	Specification
	Metric (English)
Automatic Transmission Flex Plate Bolt	
• First Pass:	20 N.m (15 lb ft)
• Second Pass:	30 N.m (22 lb ft)
• Final Pass:	70 degrees
Camshaft Position Actuator Bolt	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	90 degrees
Connecting Rod Bolt	
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	75 degrees
Crankshaft Balancer Bolt	
• First Pass:	100 N.m (74 lb ft)
• Final Pass:	180 degrees
Cylinder Head Bolt	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	240 degrees
Cylinder Head Core Hole Plug	75 N.m (55 lb ft)
Cylinder Head Core Hole Plug	25 N.m (18 lb ft)
Engine Mount Bracket Engine Side Bolt	
• First Pass:	58 N.m (43 lb ft)
• Final Pass:	60-75 degrees
Engine Mount Engine Side Bolt Refer to procedure for tightening sequence and torque values.	<u>Engine Mount Replacement</u>
Fuel Feed Intermediate Pipe	30 N.m (22 lb ft)
Fuel Injector Bolt	5 N.m (44 lb in)
Fuel Pump Bolt	25 N.m (18 lb ft)

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Lower Crankcase Bolt	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	180 degrees
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange
Positive Crankcase Ventilation Valve Bolt	10 N.m (89 lb in)
Turbocharger Nut	
• First Pass:	15 N.m (11 lb ft)
• Second Pass:	20 N.m (15 lb ft)
• Final Pass:	60 degrees
Turbocharger Coolant Return Pipe Fitting	35 N.m (26 lb ft)
Turbocharger Oil Feed Pipe Fitting	35 N.m (26 lb ft)
Turbocharger Stud	10 N.m (89 lb in)

Reusable Threaded Fastener Tightening Specifications

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Camshaft Bearing Cap Bolt	12 N.m (106 lb in)
Camshaft Cover Bolt	15 N.m (11 lb ft)
Camshaft Cover Opening Plug	12 N.m (106 lb in)
Camshaft Cover Stud [2x]	15 N.m (11 lb ft)
Camshaft Cover Stud	10 N.m (89 lb in)
Camshaft Housing 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)
Charge Air Bypass Valve Bolt	8 N.m (71 lb in)
Crankshaft Oil Deflector Bolt	10 N.m (89 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Engine Block Oil Gallery Plug	65 N.m (48 lb ft)
Engine Coolant Heater Hole Plug	60 N.m (44 lb ft)
Engine Front Cover Bolt [11x]	15 N.m (133 lb in)
Engine Front Cover Bolt [1x]	15 N.m (133 lb in)
Engine Front Cover Bolt [1x]	58 N.m (43 lb ft)
Engine Front Cover Hole Plug	50 N.m (37 lb ft)
Engine Front Cover Stud	15 N.m (133 lb in)

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Engine Lift Front Bracket Bolt - Model Dependent	25 N.m (18 lb ft)
Engine Lift Rear Bracket Bolt	25 N.m (18 lb ft)
Engine Mount Bolt	100 N.m (74 lb ft)
Engine Mount Brace Bolt	22 N.m (16 lb ft)
Engine Oil Cooler Bolt [2x]	10 N.m (89 lb in)
Engine Oil Cooler Bolt [2x]	25 N.m (18 lb ft)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Fuel Feed Front Pipe Bracket Bolt	10 N.m (89 lb in)
Fuel Feed Intermediate Pipe Bolt	10 N.m (89 lb in)
Fuel Injection Fuel Rail Bolt	10 N.m (89 lb in)
Ignition Coil Bolt	10 N.m (89 lb in)
Intake Air Pressure and Temperature Sensor Bolt	5 N.m (44 lb in)
Intake Manifold Bolt	12 N.m (106 lb in)
Intake Manifold Cover Fastener	9 N.m (80 lb in)
Knock Sensor Bolt	25 N.m (18 lb ft)
Lower Crankcase Bolt	
• First Pass:	5 N.m (44 lb in)
• Final Pass:	10 N.m (89 lb in)
Lower Oil Pan Bolt	10 N.m (89 lb in)
Oil Filter Fitting	55 N.m (41 lb ft)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pump Bolt	10 N.m (89 lb in)
Oil Pump Drive Chain Tensioner Bolt	10 N.m (89 lb in)
Piston Oil Nozzle Bolt	10 N.m (89 lb in)
Positive Crankcase Ventilation Hose Fitting Bolt	10 N.m (89 lb in)
Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt	10 N.m (89 lb in)
Spark Plug	17 N.m (13 lb ft)
Thermostat Bypass Pipe Bolt	10 N.m (89 lb in)
Throttle Body Bolt	10 N.m (89 lb in)
Timing Chain Guide Bolt	10 N.m (89 lb in)
Timing Chain Guide Bolt	10 N.m (89 lb in)
Timing Chain Oil Nozzle	15 N.m (11 lb ft)
Timing Chain Tensioner Bolt	25 N.m (18 lb ft)
Timing Chain Tensioner Shoe Bolt	25 N.m (18 lb ft)
Turbocharger Bypass Valve Solenoid Bolt	10 N.m (89 lb in)
Turbocharger Coolant Feed Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Return Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Return Pipe Bracket Bolt	10 N.m (89 lb in)
Turbocharger Heat Shield Bolt	10 N.m (89 lb in)
Turbocharger Oil Feed Pipe Bolt	32 N.m (24 lb ft)
Turbocharger Oil Return Pipe Bolt	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Nut	10 N.m (89 lb in)
Upper Oil Pan Bolt	10 N.m (89 lb in)
Vacuum Pump Bolt	

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	25 N.m (18 lb ft)
Water Outlet Bolt	10 N.m (89 lb in)
Water Pump Bolt	25 N.m (18 lb ft)
Wiring Harness Bracket Bolt	10 N.m (89 lb in)
Wiring Harness Connector Bolt	10 N.m (89 lb in)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
LFV, LYX		
Oil Capacity - AWD	5.0L	5.3 quarts
Oil Capacity - FWD	4.0L	4.2 quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• Engine Type	4-Cylinder Inline	
• Displacement	1.5L	92 CID
• RPO	LYX	
• Valves	16	
• Bore	74 mm	2.91 in
• Stroke	86.6 mm	3.409 in
• Compression Ratio	10.0:1	
• Spark Plug Gap	0.60 - 0.70 mm	0.024 - 0.028 in
• Firing Order	1 - 3 - 4 - 2	
Block		

Application	Specification	
	Metric	English
• Crankshaft Main Bearing Bore Diameter	51.868 - 51.882	2.0420 - 2.0426 in
• Cylinder Bore Diameter	73.992 - 74.008 mm	2.913 - 2.914 in
• Cylinder Bore Out-of-Round - Maximum	0.013 mm	0.0005 in
• Cylinder Head Deck Surface Flatness - over 25 mm length	0.025 mm	0.0010 in
• Cylinder Head Deck Surface Flatness - over 150 mm length	0.050 mm	0.0020 in
Engine Block to Bedplate Flatness - overall	0.1 mm	0.004 in
Engine Block to Bedplate Flatness - straightness	0.050 - 0.100 mm	0.0020 - 0.0040 in
Piston Deck Height - Below Deck	0.74 - 0.94 mm	0.029 - 0.037 in
Camshaft		
• Camshaft End Play	0.040 - 0.660 mm	0.0016 - 0.0260 in
• Camshaft Journal Clearance	0.040 - 0.085 mm	0.0016 - 0.0033 in
• Camshaft Journal Diameter - Journal 1	30.935 - 30.960 mm	1.2179 - 1.2189 in
• Camshaft Journal Diameter - Journal 2 - 6	23.935 - 23.960 mm	0.9423 - 0.9433 in
• Camshaft Thrust Width - Camshaft with Phaser installed	33.175 - 33.525 mm	1.3061 - 1.3199 in
• Camshaft Thrust Width - Cylinder Head	32.865 - 33.135 mm	1.2939 - 1.3045 in
Connecting Rod		
• Connecting Rod Bearing to Crankpin Clearance	0.013 - 0.068 mm	0.0005 - 0.0027 in
• Connecting Rod Bore Diameter - Bearing End	47.186 - 47.202 mm	1.8577 - 1.8583 in
• Connecting Rod Bore Diameter - Pin End w/Bushing	18.007 - 18.017 mm	0.7089 - 0.7093 in
• Connecting Rod Side Clearance	0.090 - 0.350 mm	0.0035 - 0.0138 in
• Connecting Rod Straightness - Bend - Maximum	0.017 mm	0.0007 in
• Connecting Rod Straightness - Twist - Maximum	0.040 mm	0.0016 in

Application	Specification	
	Metric	English
Crankshaft		
• Connecting Rod Journal Diameter	43.992 - 44.008 mm	1.7320 - 1.7326 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft End Play	0.15 - 0.38	0.0059 - 0.0150 in
• Crankshaft Main Bearing Clearance #1 Bearing	0.011 - 0.070	0.0004 - 0.0028
• Crankshaft Main Bearing Clearance # 2, 3, 4 and 5 Bearings	0.012 - 0.067	0.0005 - 0.0026
• Crankshaft Main Journal Diameter	46.992 - 47.008	1.8501 - 1.8507 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
Cylinder Head		
• Surface Flatness - Block Deck - in 25 mm	0.025 mm	0.0010 in
• Surface Flatness - Block Deck - in 150 mm	0.050 mm	0.0020 in
• Surface Flatness - Block Deck - between bolts	0.030 mm	0.0012 in
• Surface Flatness - Block Deck - Overall	0.100 mm	0.0039 in
• Valve Guide Bore - Exhaust	5.000 - 5.020 mm	0.1968 - 0.1976 in
• Valve Guide Bore - Intake	5.000 - 5.020 mm	0.1968 - 0.1976 in
• Valve Lifter Bore Diameter - Stationary Lash Adjusters	12.008 - 12.030 mm	0.4728 - 0.4736 in
• Valve Seat Angle - Relief Surface	50 Degrees	
• Valve Seat Angle - Seating Surface	90 Degrees	
• Valve Seat Angle - Undercut Surface	120 Degrees	
• Valve Seat Runout - Maximum	0.080 mm	0.0031 in
Lubrication System		

Application	Specification	
	Metric	English
Oil Pressure - @1500 RPM 100Â°C	200 - 250 kPa	29 - 36 psi
Piston Rings		
Piston Ring End Gap - Top	0.25 - 0.40 mm	0.010 - 0.016 in
Piston Ring End Gap - Second	0.40 - 0.60 mm	0.016 - 0.024 in
Piston Ring End Gap - Oil Control	0.25 - 0.75 mm	0.010 - 0.030 in
Piston Ring to Groove Clearance - Top	0.03 - 0.08 mm	0.001 - 0.003 in
Piston Ring to Groove Clearance - Second	0.03 - 0.07 mm	0.001 - 0.003 in
Piston Ring to Groove Clearance - Oil Control	0.050 - 0.190 mm	0.0020 - 0.0075 in
Piston Ring Thickness - Top	1.17 - 1.19 mm	0.046 - 0.047 in
Piston Ring Thickness - Second	1.17 - 1.19 mm	0.046 - 0.047 in
Piston Ring Thickness - Oil Control - Rail	0.045 - 0.47 mm	0.0018 - 0.0019 in
Piston Ring Thickness - Oil Control - Spacer	1.67 - 1.79 mm	0.066 - 0.071 in
Pistons and Pins		
Pin - Piston Pin Clearance to Connecting Rod Bore	0.007 - 0.020 mm	0.0003 - 0.0008 in
Pin - Piston Pin Clearance to Piston Pin Bore	0.002 - 0.010 mm	0.0001 - 0.0004 in
Pin - Piston Pin Diameter	17.997 - 18.000 mm	0.7085 - 0.7087 in
Pin - Piston Pin End Play	0.18 - 0.79 mm	0.0071 - 0.0311 in
Piston - Piston Diameter - @38 mm up from crown	73.957 - 73.971 mm	2.9117 - 2.9122 in
Piston - Piston Pin Bore Diameter	18.002 - 18.010 mm	0.7087 - 0.7091 in
Piston - Piston Ring Groove Width - Top	1.23 - 1.25 mm	0.0484 - 0.0492 in

Application	Specification	
	Metric	English
• Piston - Piston Ring Groove Width - Second	1.23 - 1.25 mm	0.0484 - 0.0492 in
• Piston - Piston Ring Groove Width - Oil Control	2.03 - 2.05 mm	0.0799 - 0.0807 in
• Piston - Piston to Bore Clearance - w/Polymer	-0.017 mm to +0.029 mm	-0.0007 in to +0.0011 in
Valve System		
• Valves - Valve Face Angle	90 Degrees	
• Valves - Valve Face Runout - Maximum	0.050 mm	0.0020 in
• Valves - Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valves - Valve Seat Gauge Ball Height - Exhaust	8.85 - 9.09 mm	0.3484 - 0.3579 in
• Valves - Valve Seat Gauge Ball Height - Intake	9.47 - 9.71 mm	0.3728 - 0.3823 in
• Valves - Valve Stem Diameter - Exhaust	4.945 - 4.965 mm	0.1947 - 0.1955 in
• Valves - Valve Stem Diameter - Intake	4.955 - 4.975 mm	0.1951 - 0.1959 in
• Valves - Valve Stem Installed Height	Check and Record	
• Valves - Valve Stem to Guide Clearance - Exhaust	0.035 - 0.075 mm	0.0014 - 0.0030 in
• Valves - Valve Stem to Guide Clearance - Intake	0.025 - 0.065 mm	0.0010 - 0.0026 in
• Valve Lash Adjusters - Valve Lash Adjuster Diameter - Stationary Lash Adjuster	11.986 - 12.000 mm	0.4719 - 0.4724 in
• Valve Lash Adjusters - Valve Lash-Adjuster-to-Bore Clearance - Stationary Lash Adjuster	0.008 - 0.044 mm	0.0003 - 0.0017 in
• Valve Springs - Valve Spring Installed Height	34.50 - 35.50 mm	1.358 - 1.398 in
• Valve Springs - Valve Spring Load - Closed - @35 mm	225 - 245 N	51 - 55 lb
• Valve Springs - Valve Spring Load - Open - @26.5 mm	405 - 445 N	91 - 100 lb

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Cover ¹	Sealant	12378521	88901148
Camshaft Cover Opening Plug	Threadlocker	19333511	10953489
Camshaft Lobes	0W-20	19352900	-
Crankshaft Sensor O-Ring	0W-20	19352900	-
Cylinder Bores	0W-20	19352900	-
Cylinder Head Plugs	Threadlocker	19333511	10953489
Engine Block Plugs	Sealant	12346004	10953480
Engine Front Cover ¹	Sealant	12378521	88901148
Engine Oil	0W-20	19352900	-
Fuel Injector O-Rings	0W-20	19352900	-
Hydraulic Valve Lash Adjuster Arm	0W-20	19352900	-
Hydraulic Valve Lash Adjuster	0W-20	19352900	-
Ignition Coil	Lubricant	19260901	19260902
Intake and Exhaust Valve Stems	0W-20	19352900	-
Lower Crankcase ¹	Sealant	12378521	88901148
Lower Crankcase Bolt	Threadlocker	19333511	10953489
Main Bearings	0W-20	19352900	-
Oil Filter	0W-20	19352900	-
Oil Level Indicator Tube O-Ring	Lubricant	88862586	88862827
Oil Pan ¹	Sealant	12378521	88901148
Oil Pan Bolt	Threadlocker	19333511	10953489
Oil Pump - Pump Elements	0W-20	19352900	-
Oxygen Sensor	Anti-seize	88862477	88862478
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	0W-20	19352900	-
Rod Bearings - Rod Pins of Crankshaft	0W-20	19352900	-
Thread Repair Cutting Oil	Lubricant	1052864	992881
Thread Repair	Cleaner	88862650	88901247
Timing Chain Guide Bolt Access Hole Plug	Threadlocker	19333511	10953489
Valves	Parts Immersion Solvent	12345368	10953514
Water Feed Tube O-Rings	Lubricant	19260901	19260902
Water Pump Drain Plug	Sealant	12346004	10953480
¹ Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u>			

THREAD REPAIR SPECIFICATIONS**Engine Block - Front View**

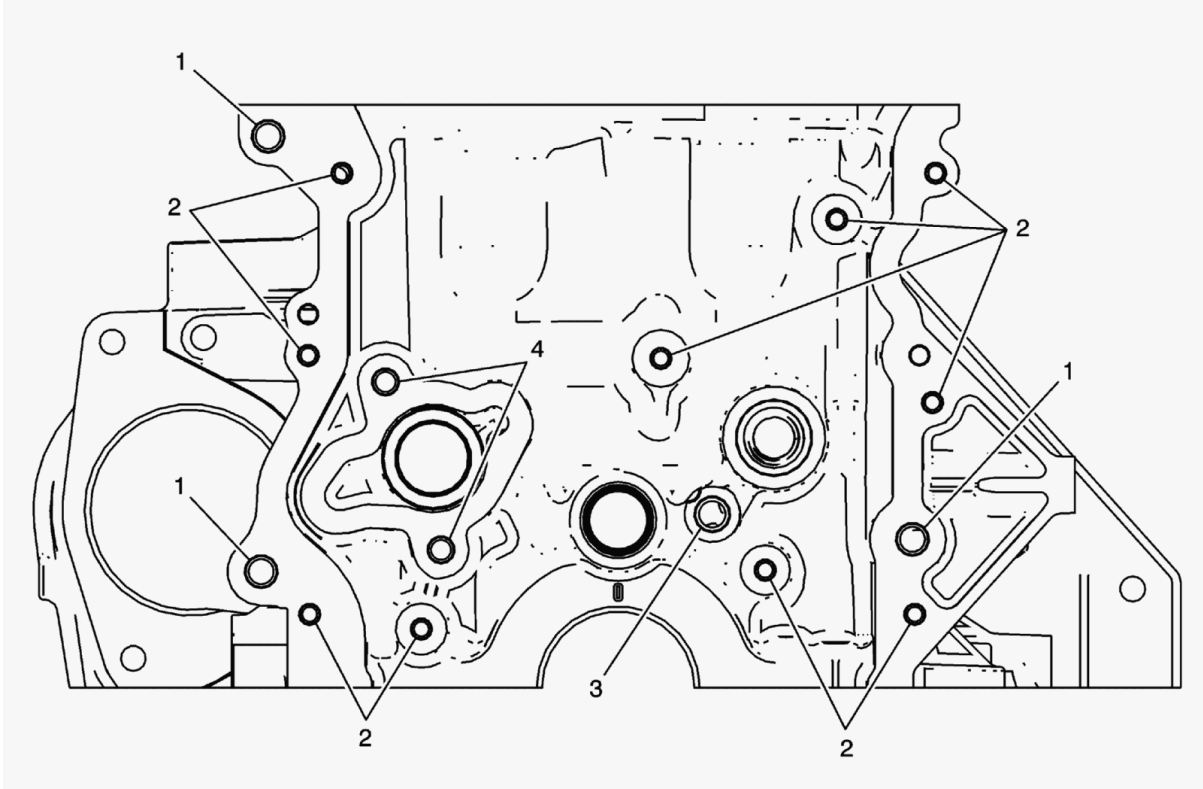


Fig. 1: Engine Block -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M10x1.5	420	211	212	213	214	27.0	1.063	27.0	1.063
2	M6x1.0	205	201	202	203	204	20.0	0.787	20.0	0.787
3	Not Serviced									
4	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142

Engine Block - Rear View

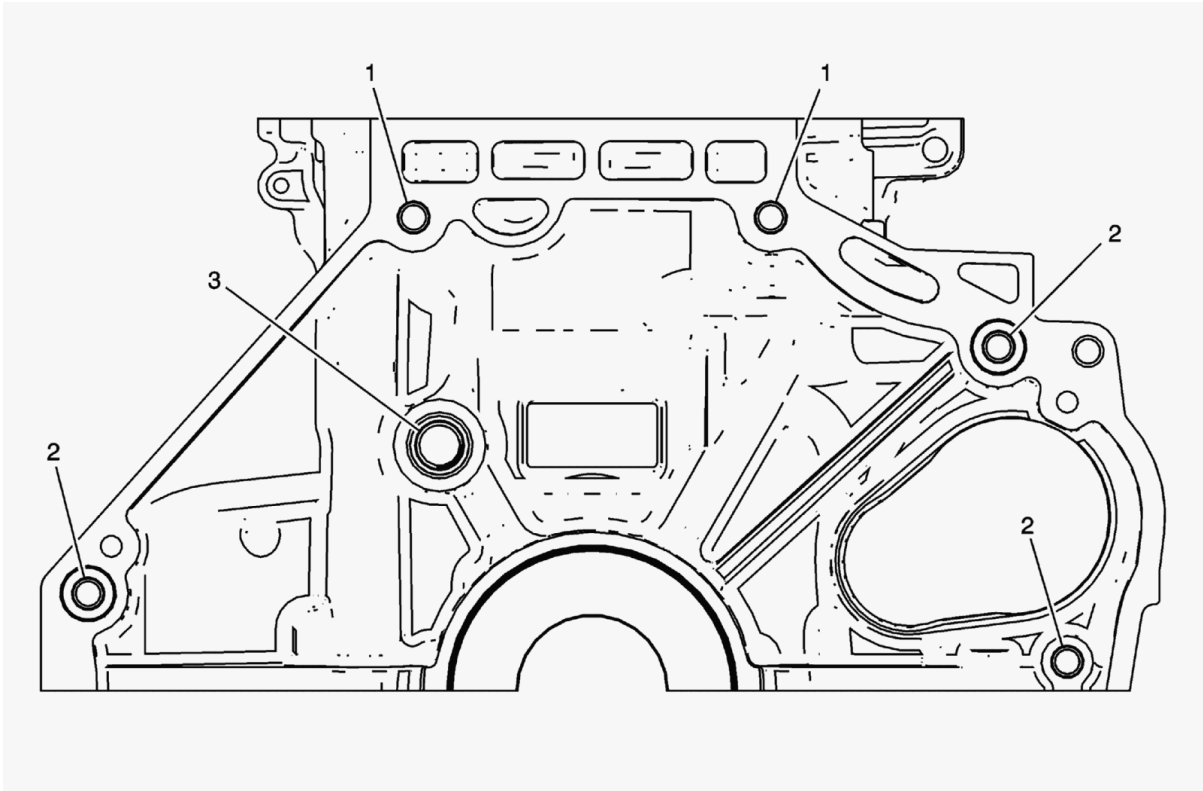


Fig. 2: Engine Block -- Rear View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Rear View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M10x1.5	904	211	212	213	903	36.0	1.417	36.0	1.417
2	M10x1.5	215	211	212	213	214	25.0	0.984	25.0	0.984
3	Not Serviced									

Engine Block - Right Side View

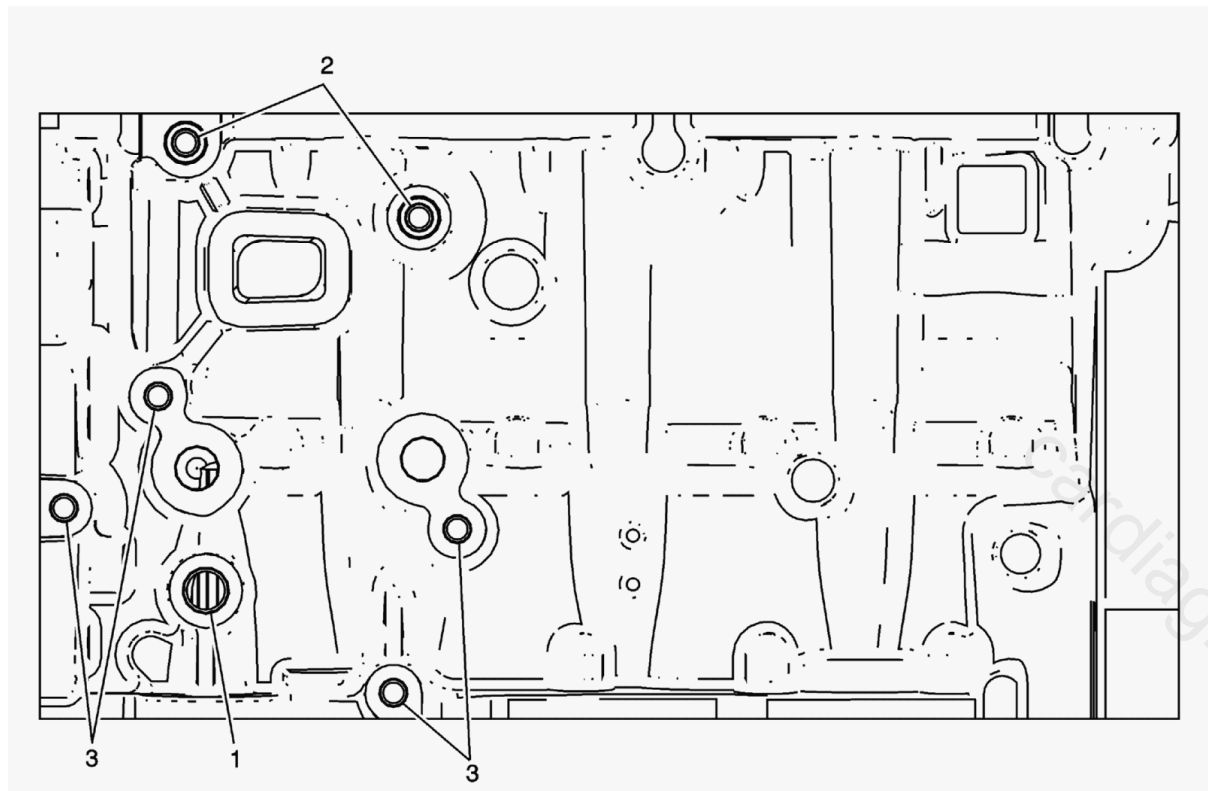


Fig. 3: Engine Block -- Right Side View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M14x1.5	735	409	410	411	412	20.0	0.787	20.0	0.787
2	M8x1.25	210	206	207	208	209	37.0	1.457	37.0	1.457
3	M8x1.25	61	206	207	208	209	29.0	1.141	29.0	1.141

Engine Block - Left Side View

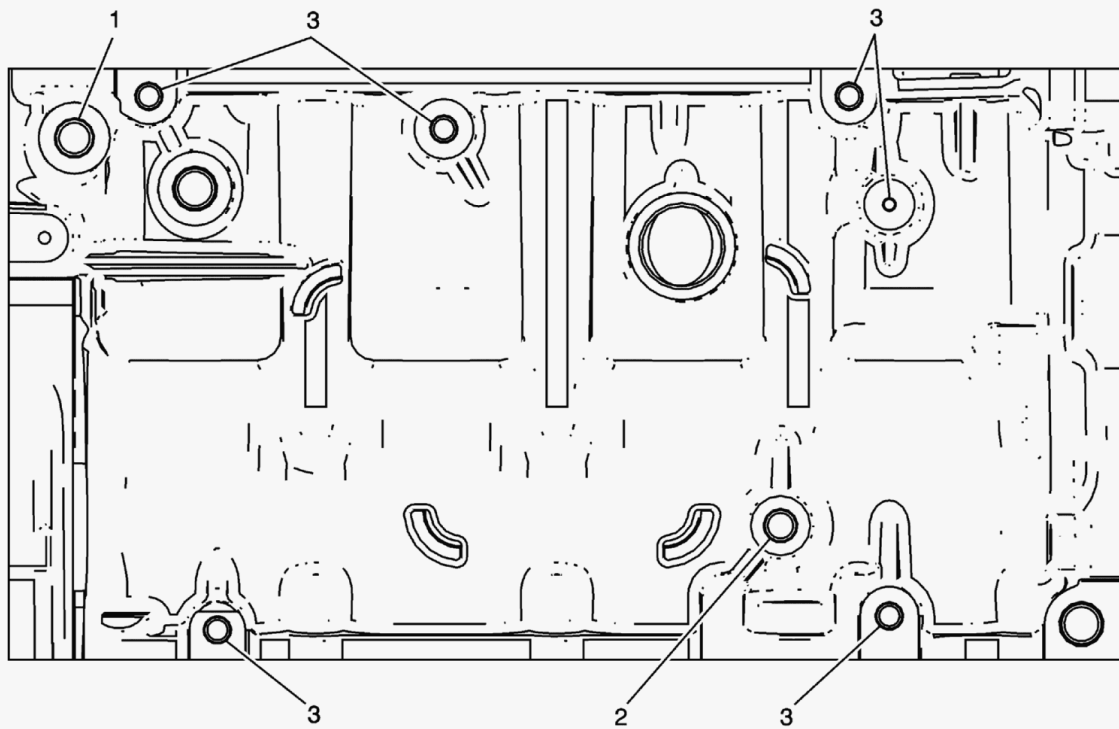


Fig. 4: Engine Block -- Left Side View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
EN 42385-400										
1	M12x1.75	865	856	857	858	859	24.0	0.944	24.0	0.944
2	M10x1.5	420	211	212	213	214	34.0	1.338	34.0	1.338
3	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142

Engine Block - Bottom View

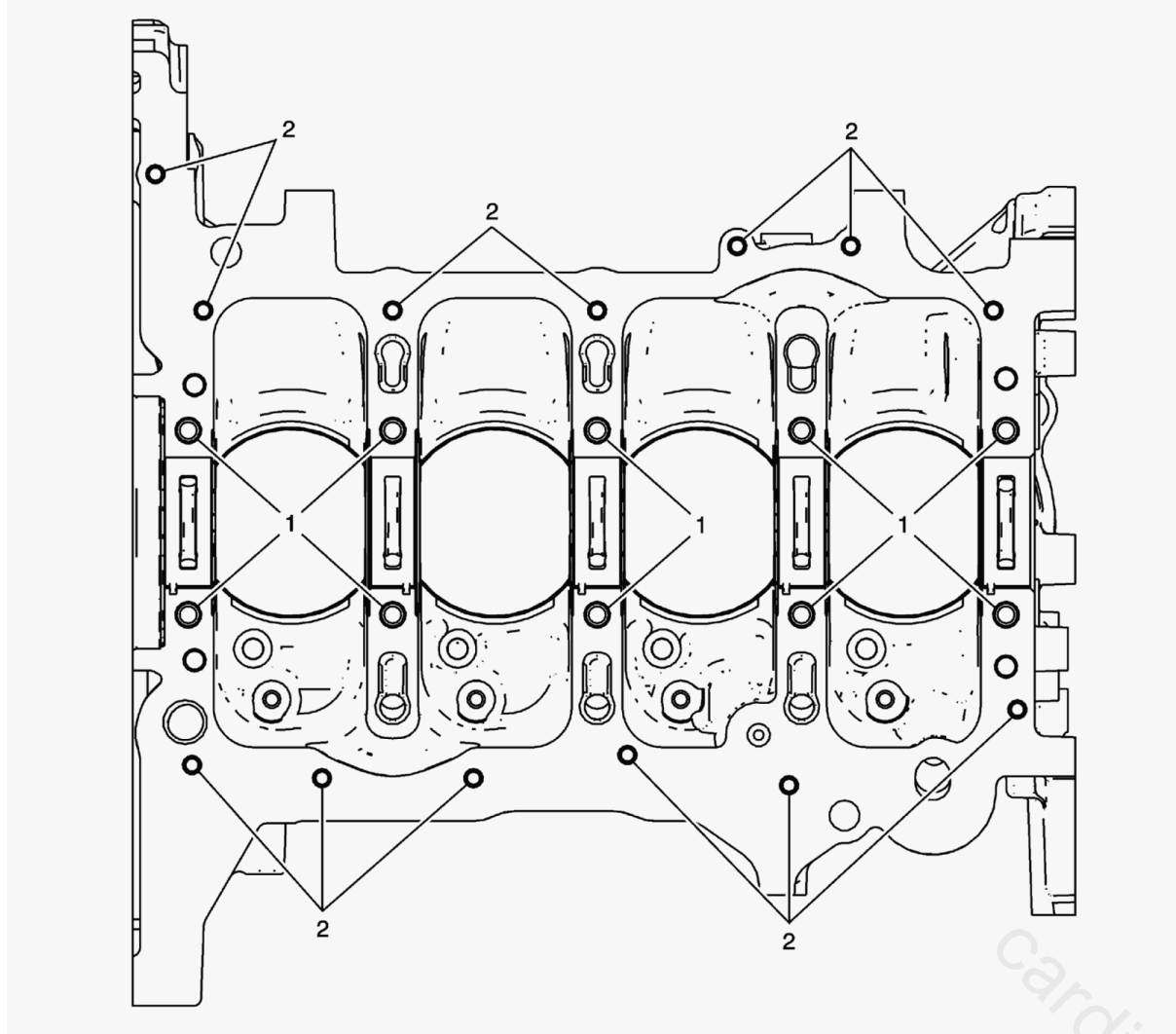


Fig. 5: Engine Block -- Bottom View
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	Not Serviceable									
2	M6x1.0	205	201	202	203	204	22.0	0.866	22.0	0.866

Engine Block - Top View

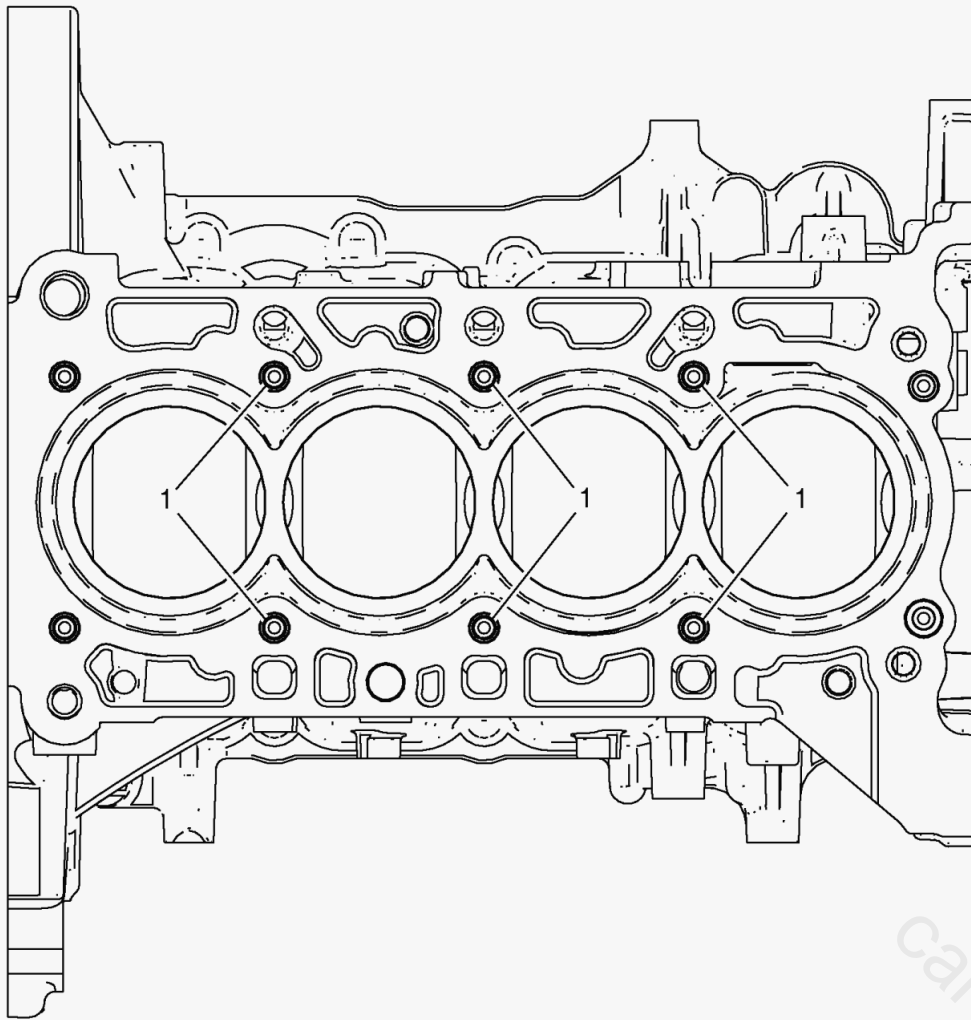


Fig. 6: Engine Block -- Top View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
							EN 42385-900			
1	M10x1.5	904	901	901	903	904	86.38	3.40	86.38	3.40

Lower Crankcase - Front View

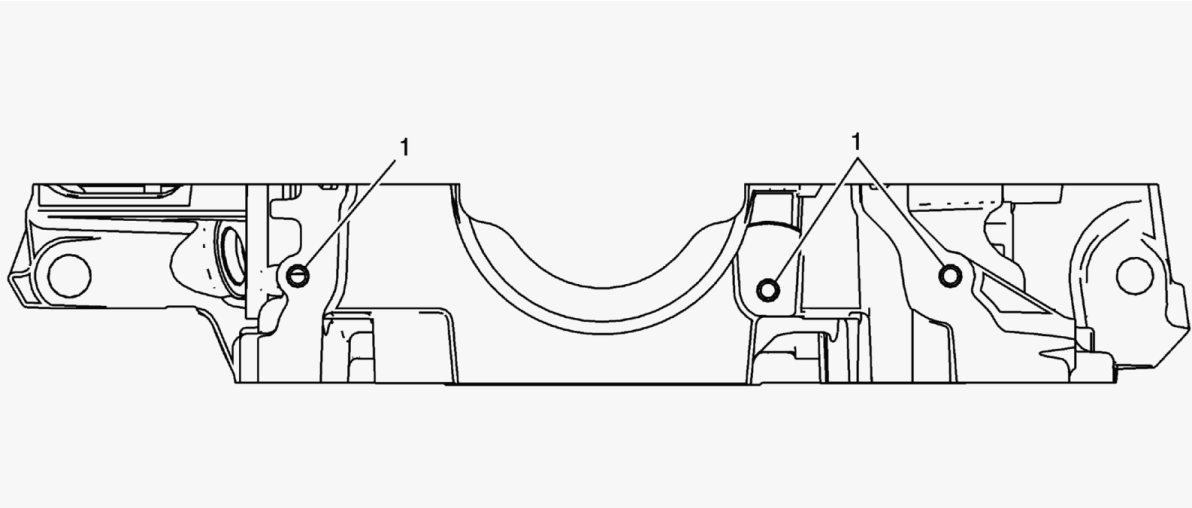
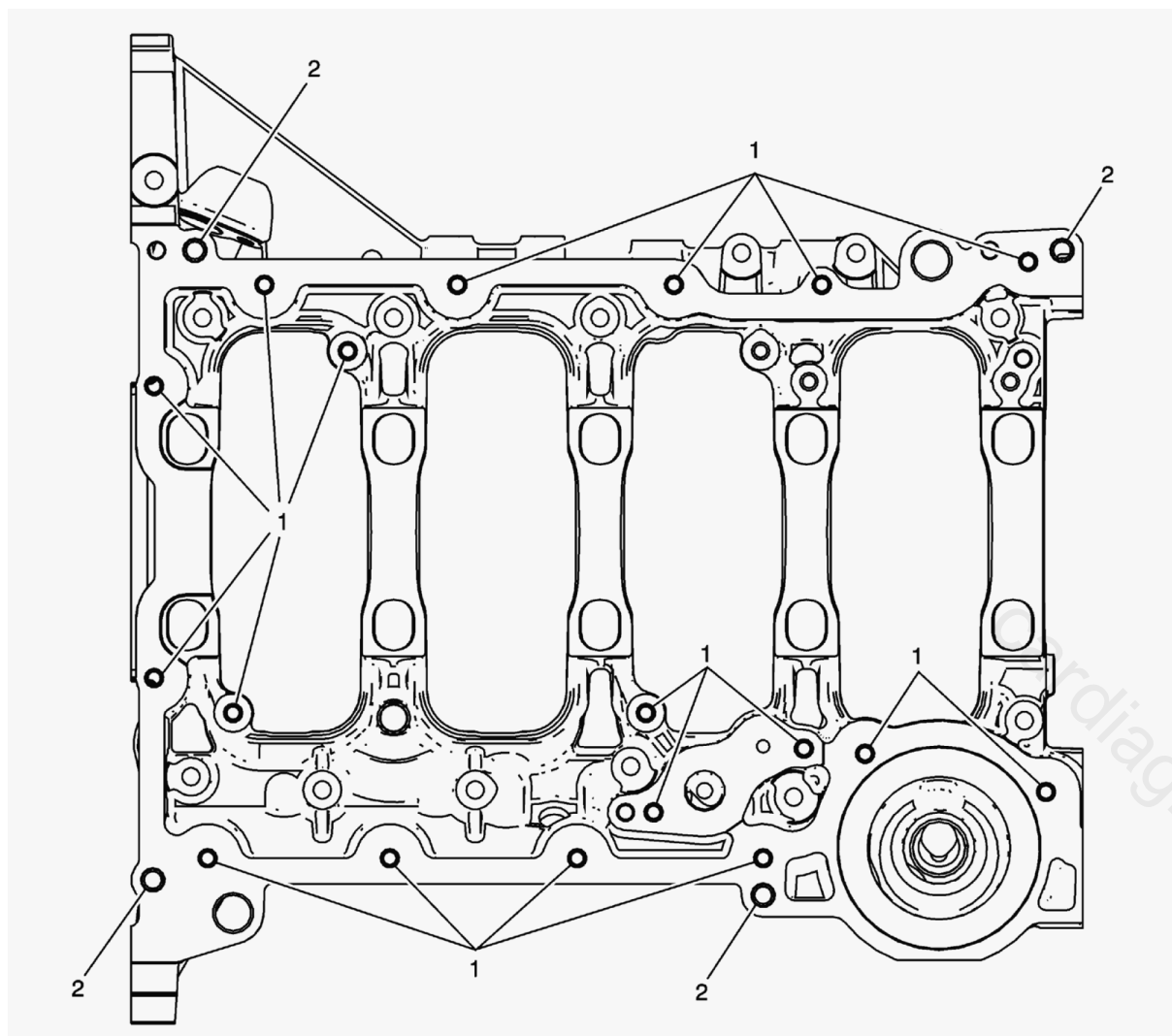


Fig. 7: Lower Crankcase -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	63	201	202	203	204	20.0	0.787	20.0	0.787

Lower Crankcase - Bottom View**Fig. 8: Lower Crankcase -- Bottom View****Courtesy of GENERAL MOTORS COMPANY****Lower Crankcase - Bottom View**

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	63	201	202	203	204	23.0	0.905	23.0	0.905
2	M8x1.25	210	206	207	208	209	24.0	0.945	24.0	0.945

Lower Crankcase - Right Side View

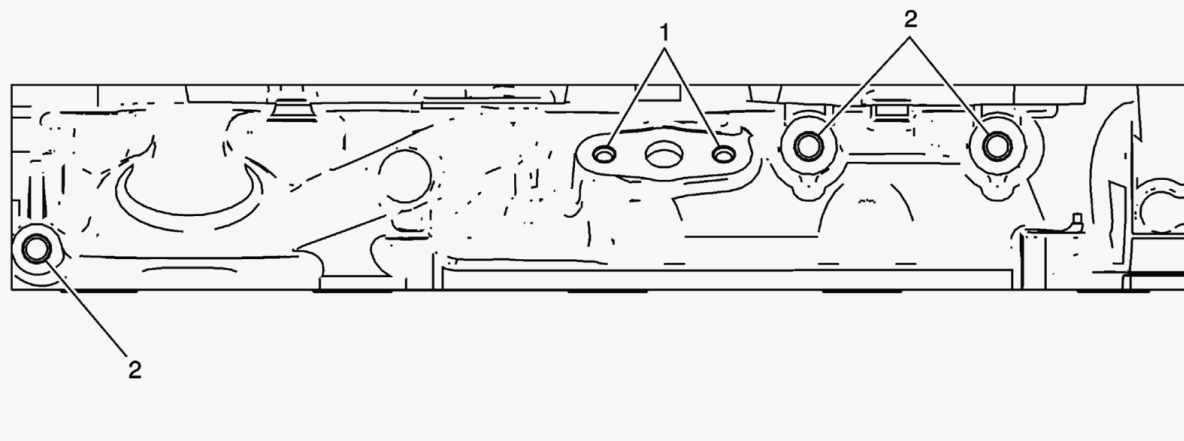


Fig. 9: Lower Crankcase -- Right Side View
Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
EN 42385-400										
1	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
2	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142

Lower Crankcase - Left Side View

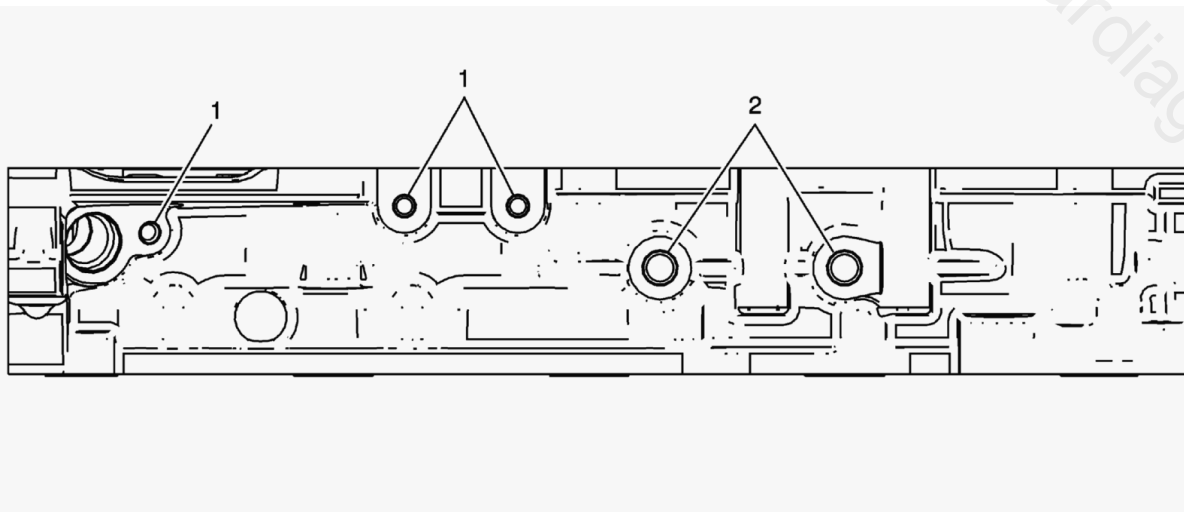


Fig. 10: Lower Crankcase -- Left Side View
Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
2	M10x1.5	420	211	212	213	214	34.0	1.338	34.0	1.338

Cylinder Head - Top View

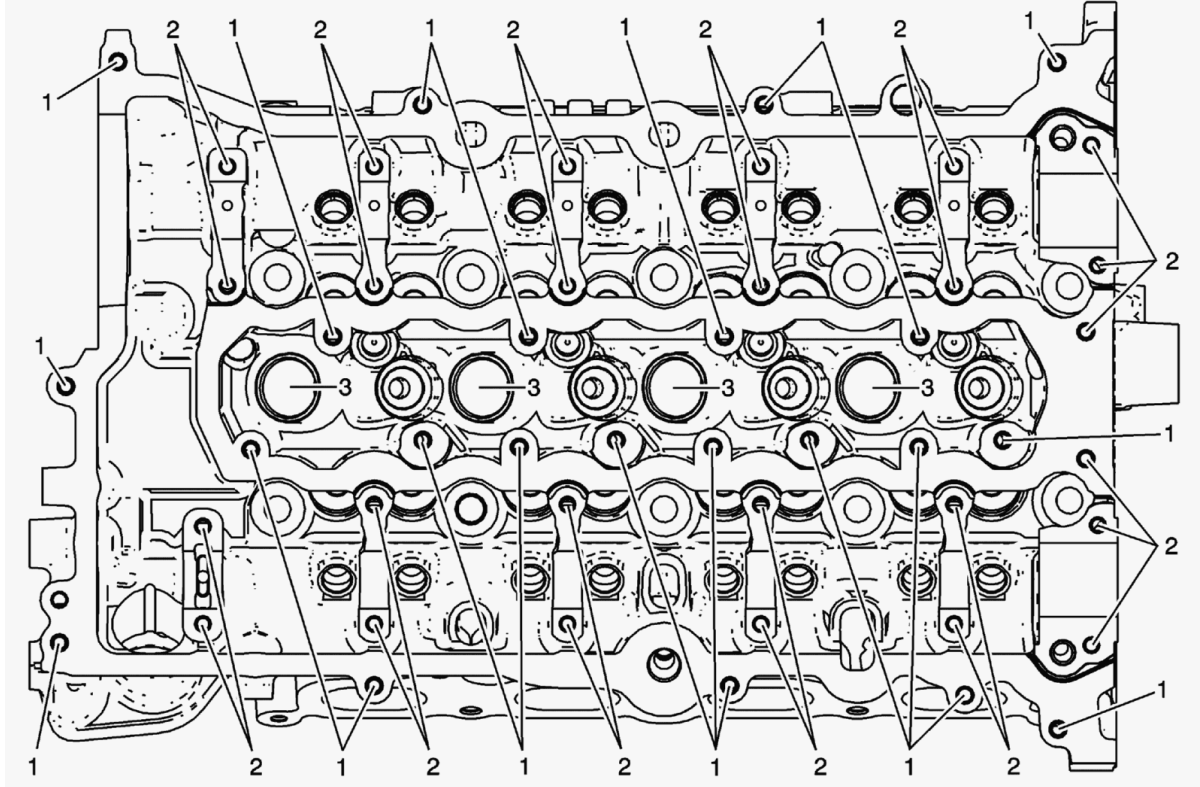


Fig. 11: Cylinder Head -- Top View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	22.0	0.865	22.0	0.865
2	M6x1.0	63	201	852 core drill as c bore	203	204	22.0	0.865	22.0	0.865
3	Not Serviceable									

Cylinder Head - Intake Manifold Deck View

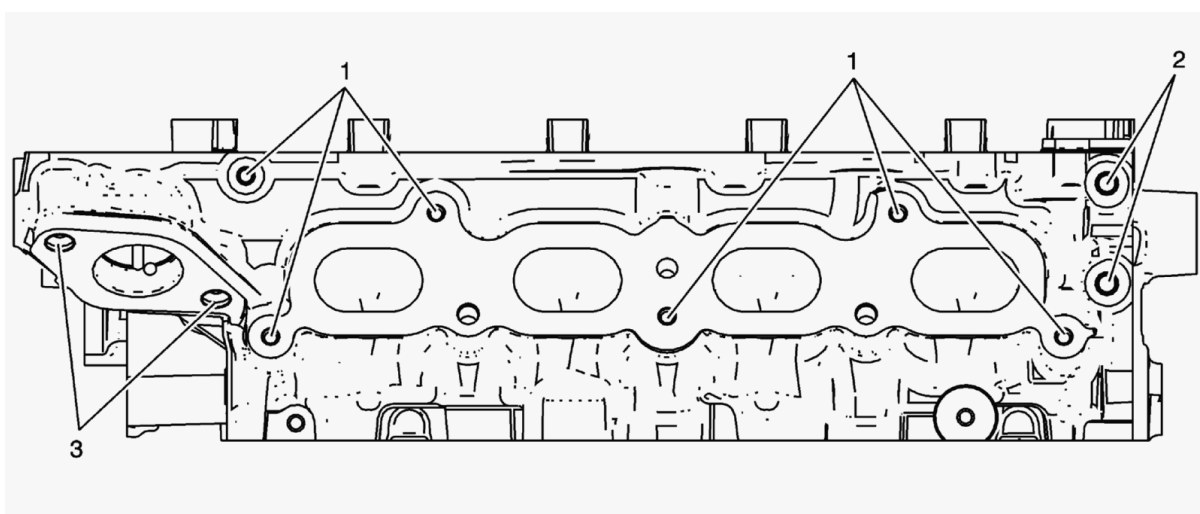


Fig. 12: Cylinder Head -- Intake Manifold Deck View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Intake Manifold Deck View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
1	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
2	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142
3	M8x1.25	210	206	207	208	209	29.0	1.142	29.0	1.142

Cylinder Head - Exhaust Side View

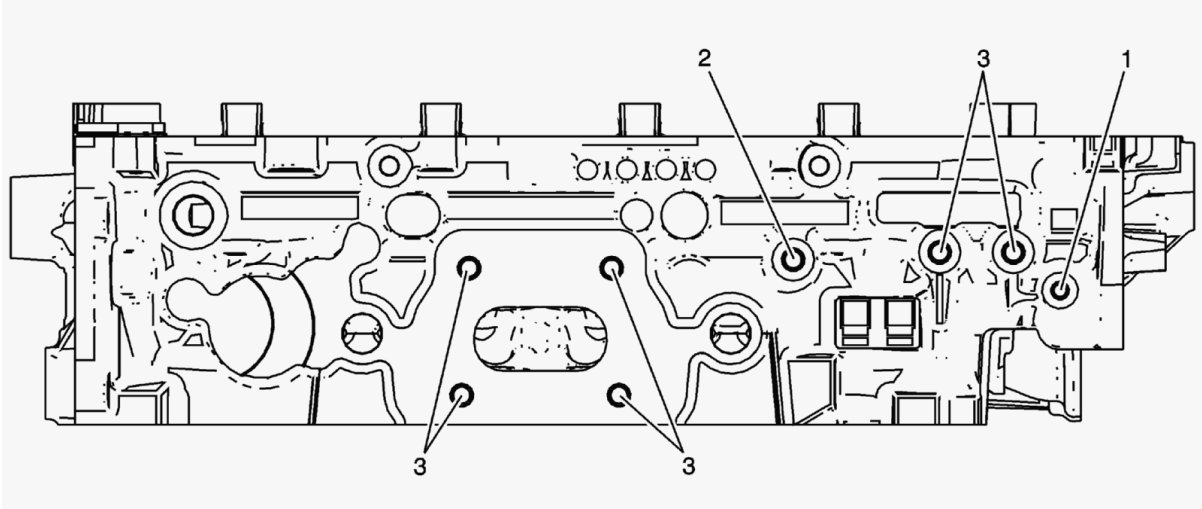


Fig. 13: Cylinder Head -- Exhaust Side View
Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Exhaust Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
2	M8x1.25	906	206	207	208	209	29.0	1.142	29.0	1.142
3	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142

Cylinder Head - Front View

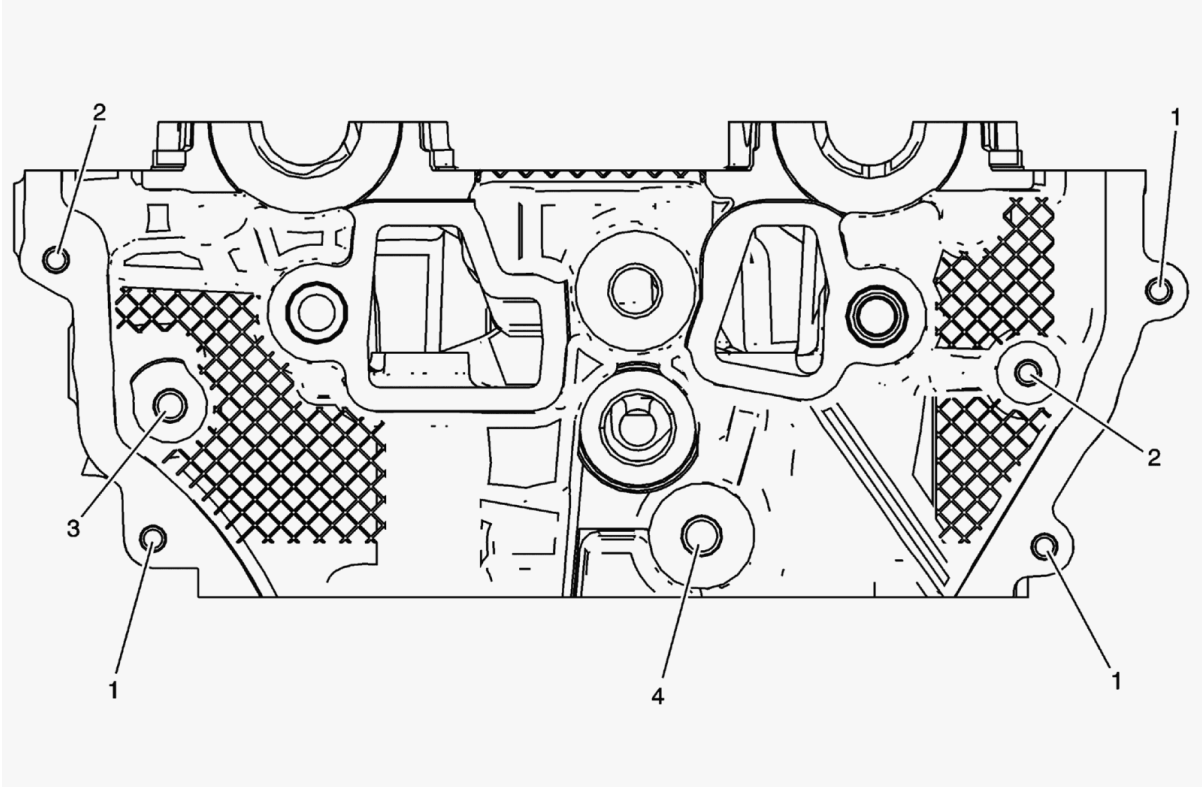


Fig. 14: Cylinder Head -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	19.0	0.747	19.0	0.747
2	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
3	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142
4	M10x1.5	420	211	212	213	214	32.0	1.260	32.0	1.260

Cylinder Head - Back View

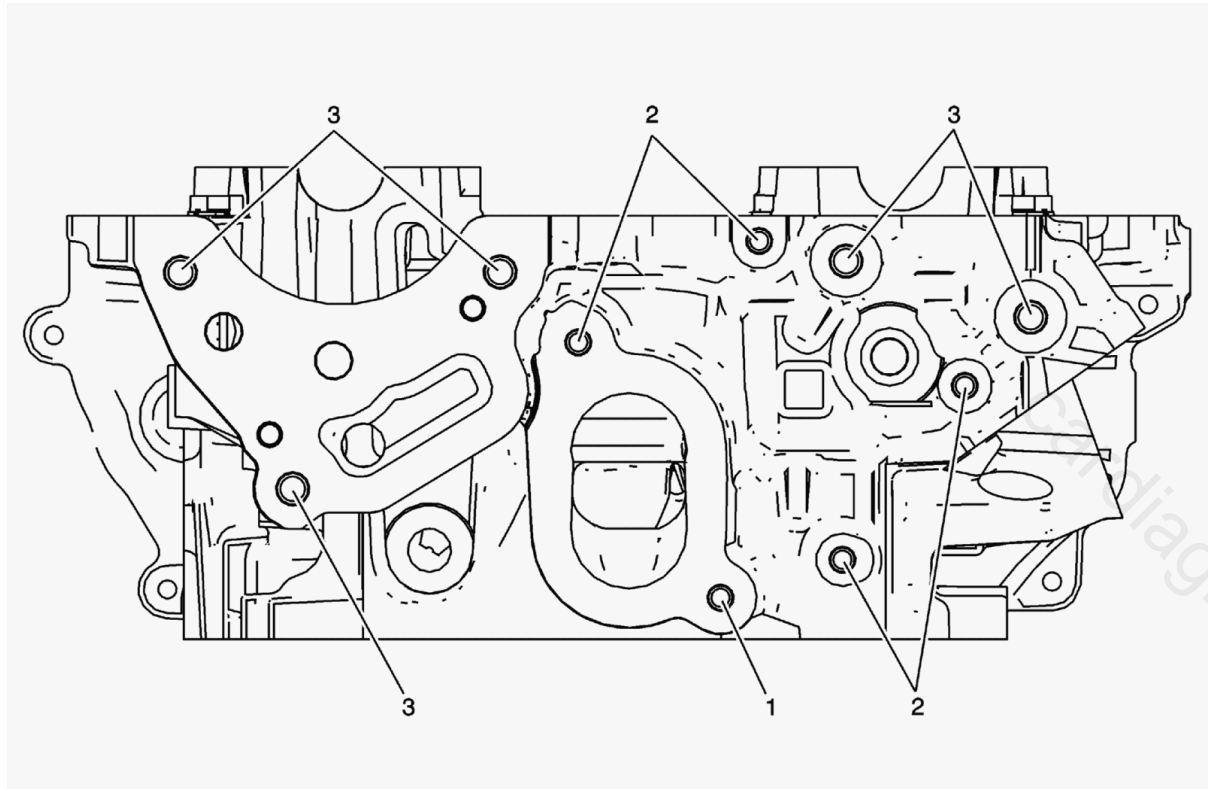


Fig. 15: Cylinder Head -- Back View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385-400							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	19.0	0.747	19.0	0.747
2	M6x1.0	63	201	202	203	204	22.0	0.865	22.0	0.865
3	M8x1.25	61	206	207	208	209	29.0	1.142	29.0	1.142

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS (1.5L (LYX))

Oil Pressure Control (LYX)

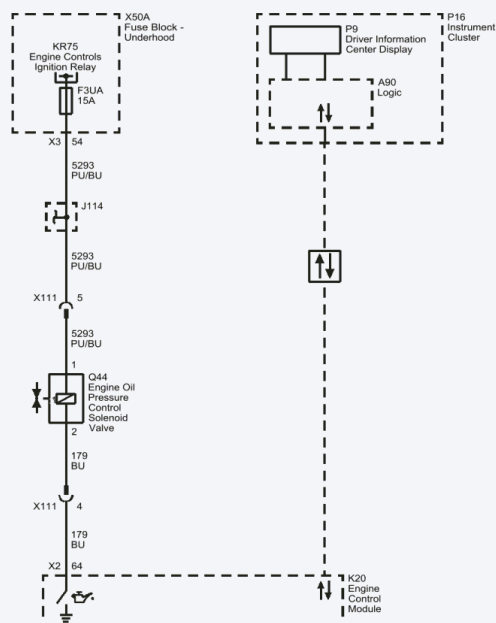


Fig. 16: Oil Pressure Control (LYX)
Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Camshaft Cover and Components

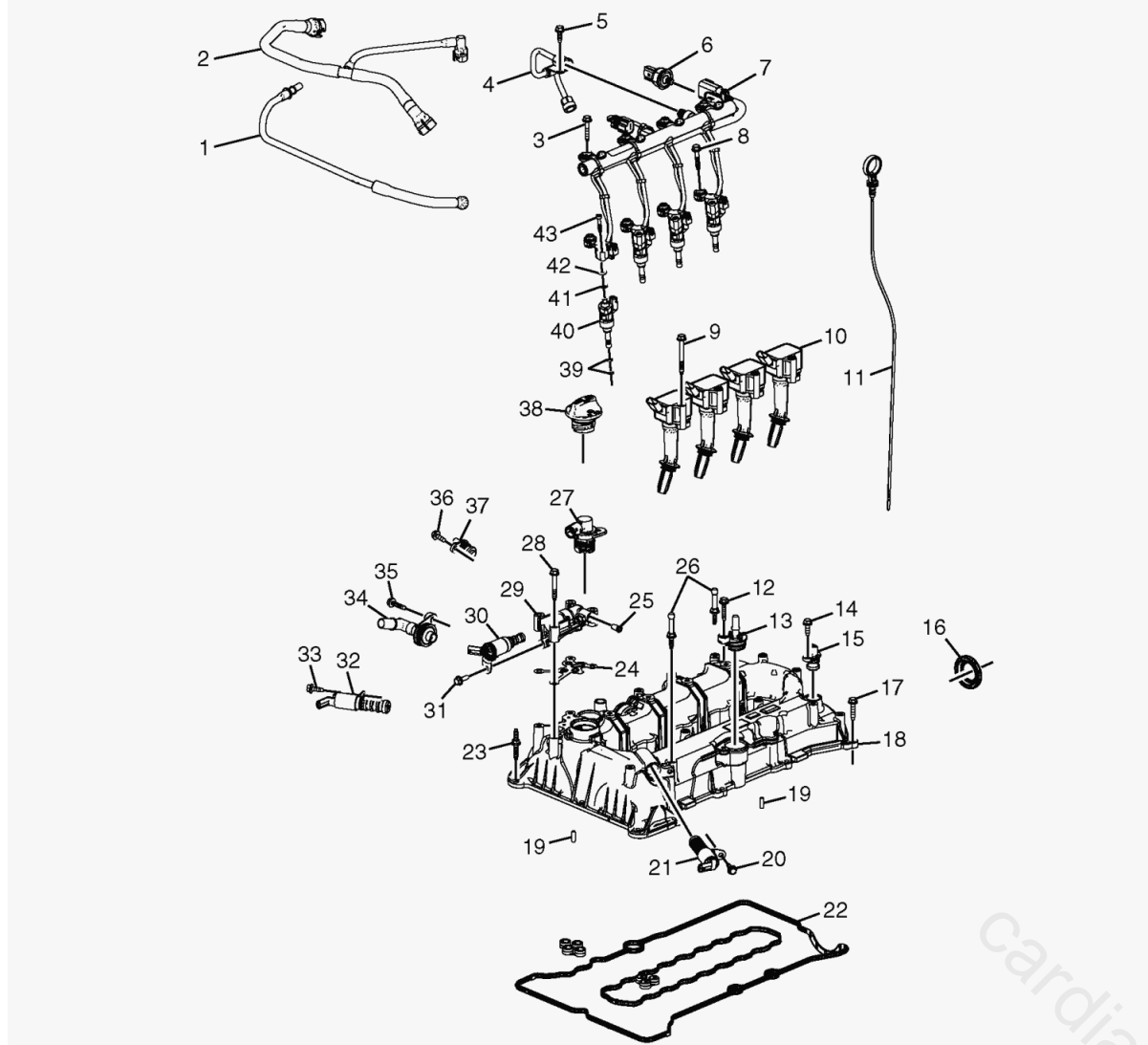


Fig. 17: View Of Camshaft Cover and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube
2	Positive Crankcase Ventilation Tube
3	Fuel Injection Fuel Rail Bolt- Upper[4x]
4	Fuel Feed Intermediate Pipe
5	Fuel Feed Intermediate Pipe Bolt
6	Fuel Injection Fuel Rail Fuel Pressure Sensor
7	Fuel Injection Fuel Rail
8	Fuel Injection Fuel Rail Bolt- Lower[4x]
9	Ignition Coil Bolt[4x]
10	Ignition Coil[4x]
11	Oil Level Indicator
12	Positive Crankcase Ventilation Valve Bolt
13	Positive Crankcase Ventilation Valve
14	Camshaft Position Sensor Bolt
15	Camshaft Position Sensor
16	Vacuum Pump Seal
17	Camshaft Cover Bolt[18x]
18	Camshaft Cover
19	Camshaft Cover Locating Pin[2x]
20	Camshaft Position Actuator Solenoid Valve Bolt
21	Camshaft Position Actuator Solenoid Valve
22	Camshaft Cover Gasket

Callout	Component Name
23	Camshaft Cover Stud[2x]
24	Camshaft Housing Gasket
25	Camshaft Cover Opening Plug
26	Camshaft Housing Cover Stud[2x]
27	Positive Crankcase Ventilation Valve
28	Camshaft Housing Bolt[4x]
29	Camshaft Housing
30	Camshaft Position Actuator Locating Pin Control Valve
31	Camshaft Position Actuator Solenoid Valve Bolt
32	Camshaft Position Actuator Solenoid Valve
33	Camshaft Position Actuator Solenoid Valve Bolt
34	Positive Crankcase Ventilation Valve
35	Positive Crankcase Ventilation Valve Bolt
36	Camshaft Position Sensor Bolt
37	Camshaft Position Sensor
38	Oil Filler Cap
39	Combustion Fuel Injector Seal[8x]
40	Direct Fuel Injector[4x]
41	Fuel Injector Seal Retainer
42	Fuel Injector Seal Ring
43	Fuel Injector Bolt[8x]

Cylinder Head and Components

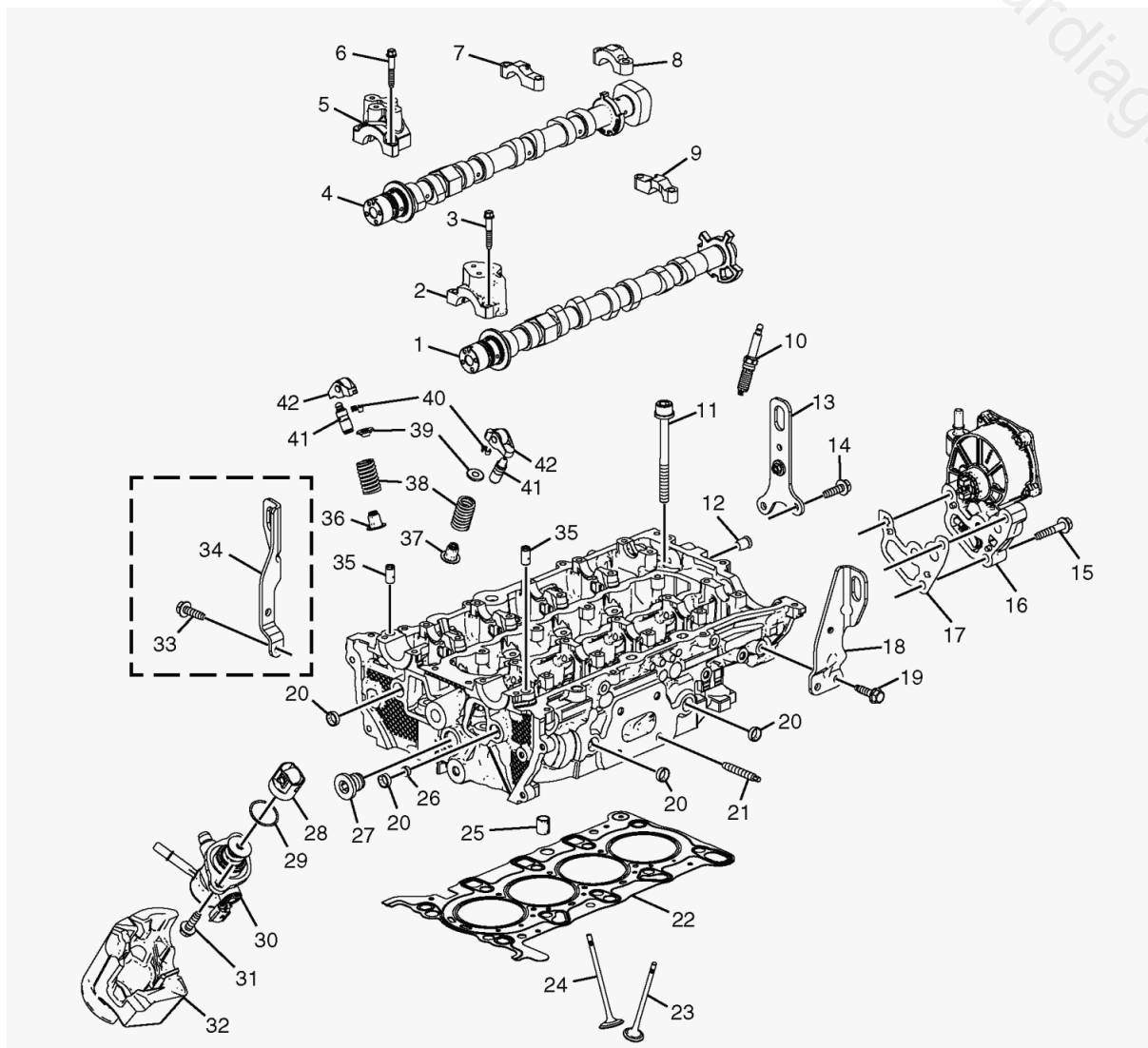


Fig. 18: View Of Cylinder Head and Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Camshaft
2	Camshaft Bearing Front Exhaust Cap
3	Camshaft Bearing Cap Bolt[12x]
4	Intake Camshaft
5	Camshaft Bearing Front Intake Cap
6	Camshaft Bearing Cap Bolt[12x]
7	Camshaft Bearing Cap[4x]
8	Camshaft Bearing Rear Cap
9	Camshaft Bearing Cap[5x]
10	Spark Plug[4x]
11	Cylinder Head Bolt[10x]
12	Cylinder Head Core Hole Plug[5x]
13	Engine Lift Rear Bracket
14	Engine Lift Rear Bracket Bolt[2x]
15	Vacuum Pump Bolt[3x]
16	Vacuum Pump
17	Vacuum Pump Gasket
18	Engine Lift Rear Bracket
19	Engine Lift Rear Bracket Bolt[2x]
20	Cylinder Head Core Hole Plug[4x]
21	Turbocharger Stud[4x]
22	Cylinder Head Gasket
23	Exhaust Valve[8x]
24	Intake Valve[8x]
25	Cylinder Head Locating Pin[2x]
26	Cylinder Head Oil Gallery Restrictor
27	Cylinder Head Core Hole Plug
28	Valve Lifter Follower
29	Fuel Pump Housing Seal
30	Fuel Pump
31	Fuel Pump Bolt[2x]
32	Fuel Pump Insulator
33	Engine Lift Front Bracket Bolt[2x]-Model Dependent
34	Engine Lift Front Bracket - Model Dependent
35	Engine Oil Manifold Check Valve[2x]
36	Valve Stem Oil Seal[8x]
37	Valve Stem Oil Seal[8x]
38	Valve Spring[16x]
39	Valve Spring Retainer[16x]
40	Valve Stem Key[32x]
41	Hydraulic Valve Lash Adjuster[16x]
42	Hydraulic Valve Lash Adjuster Arm[16x]

Drive Belt Accessory Components

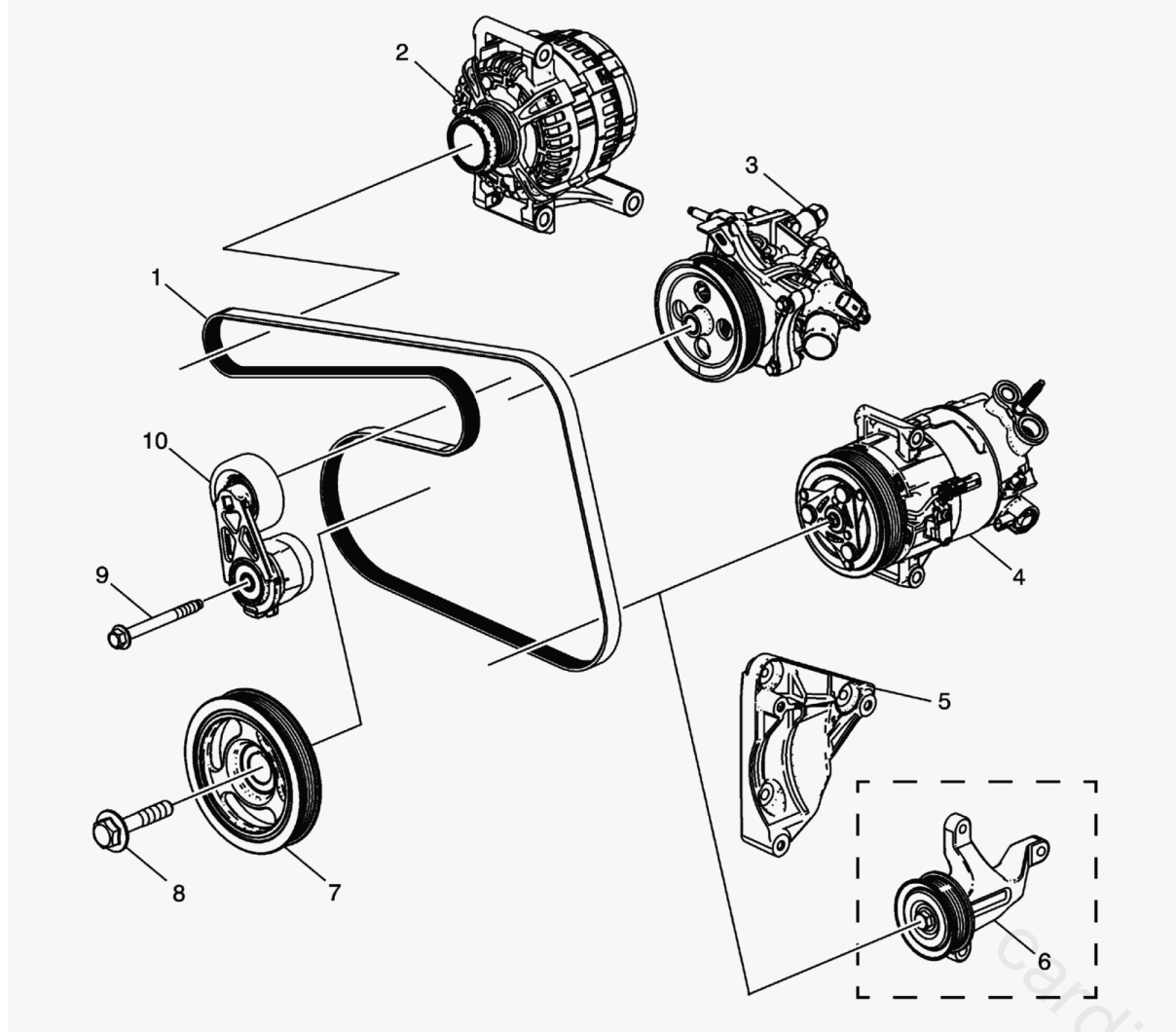


Fig. 19: View Of Drive Belt Accessory Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt
2	Generator
3	Water Pump
4	A/C Compressor
5	A/C Compressor Bracket
6	Belt Idler Bracket Assembly, Some Models
7	Crankshaft Balancer
8	Crankshaft Balancer Bolt
9	Drive Belt Tensioner Bolt
10	Drive Belt Tensioner

Engine Block and Components

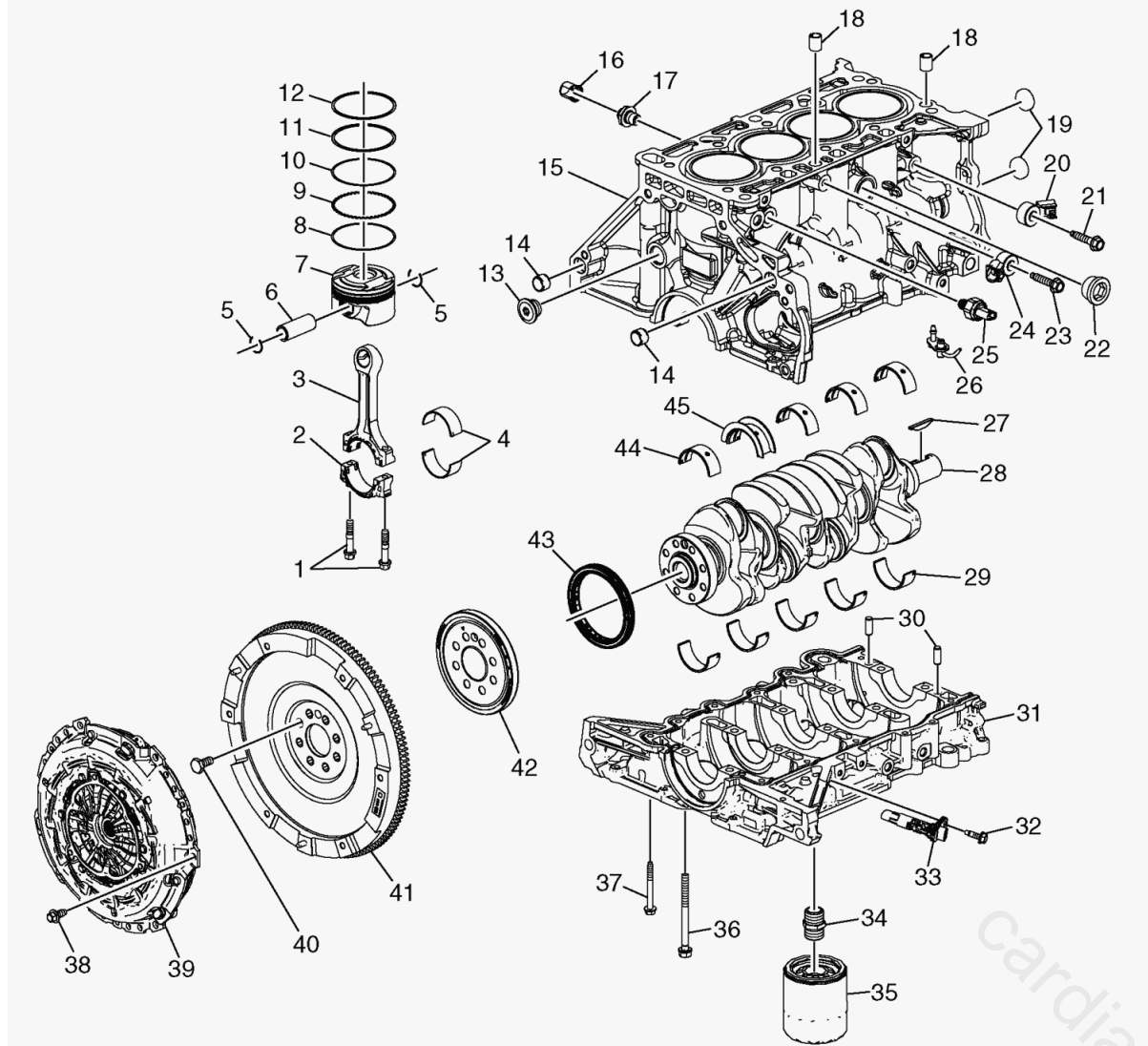


Fig. 20: Engine Block and Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Connecting Rod Bolt[8x]
2	Connecting Rod Cap[4x]
3	Connecting Rod[4x]
4	Connecting Rod Bearing[4x]
5	Piston Pin Retainer [8x]
6	Piston Pin[4x]
7	Piston[4x]
8	Piston Oil Ring Rail[4x]
9	Piston Oil Ring Rail Spacer[4x]
10	Piston Oil Ring Rail[4x]
11	Piston Compression Lower Ring[4x]
12	Piston Compression Upper Ring [4x]
13	Engine Block Oil Gallery Plug
14	Transmission Locating Pin[2x]
15	Engine Block
16	Turbocharger Oil Feed Pipe Clip
17	Turbocharger Pipe Fitting
18	Cylinder Head Locating Pin[2x]
19	Engine Block Core Hole Plug[2x]
20	Knock Sensor
21	Knock Sensor Bolt
22	Engine Coolant Heater Hole Plug

Callout	Component Name
23	Knock Sensor Bolt
24	Knock Sensor
25	Engine Oil Pressure Sensor
26	Piston Oil Nozzle[4x]
27	Crankshaft Balancer Key
28	Crankshaft
29	Crankshaft Lower Bearing[5x]
30	Lower Crankcase Locating Pin[4x]
31	Lower Crankcase
32	Crankshaft Position Sensor Bolt
33	Crankshaft Position Sensor
34	Oil Filter Fitting
35	Oil Filter
36	Lower Crankcase Bolt[10x]
37	Lower Crankcase Bolt[13x]
38	Clutch Pressure Plate Bolt[6x]
39	Clutch Pressure Plate
40	Engine Flywheel Bolt[8x]
41	Engine Flywheel
42	Crankshaft Position Sensor Reluctor Ring
43	Crankshaft Rear Oil Seal
44	Crankshaft Upper Bearing[4x]
45	Crankshaft Thrust Upper Bearing

Engine Front Cover and Components

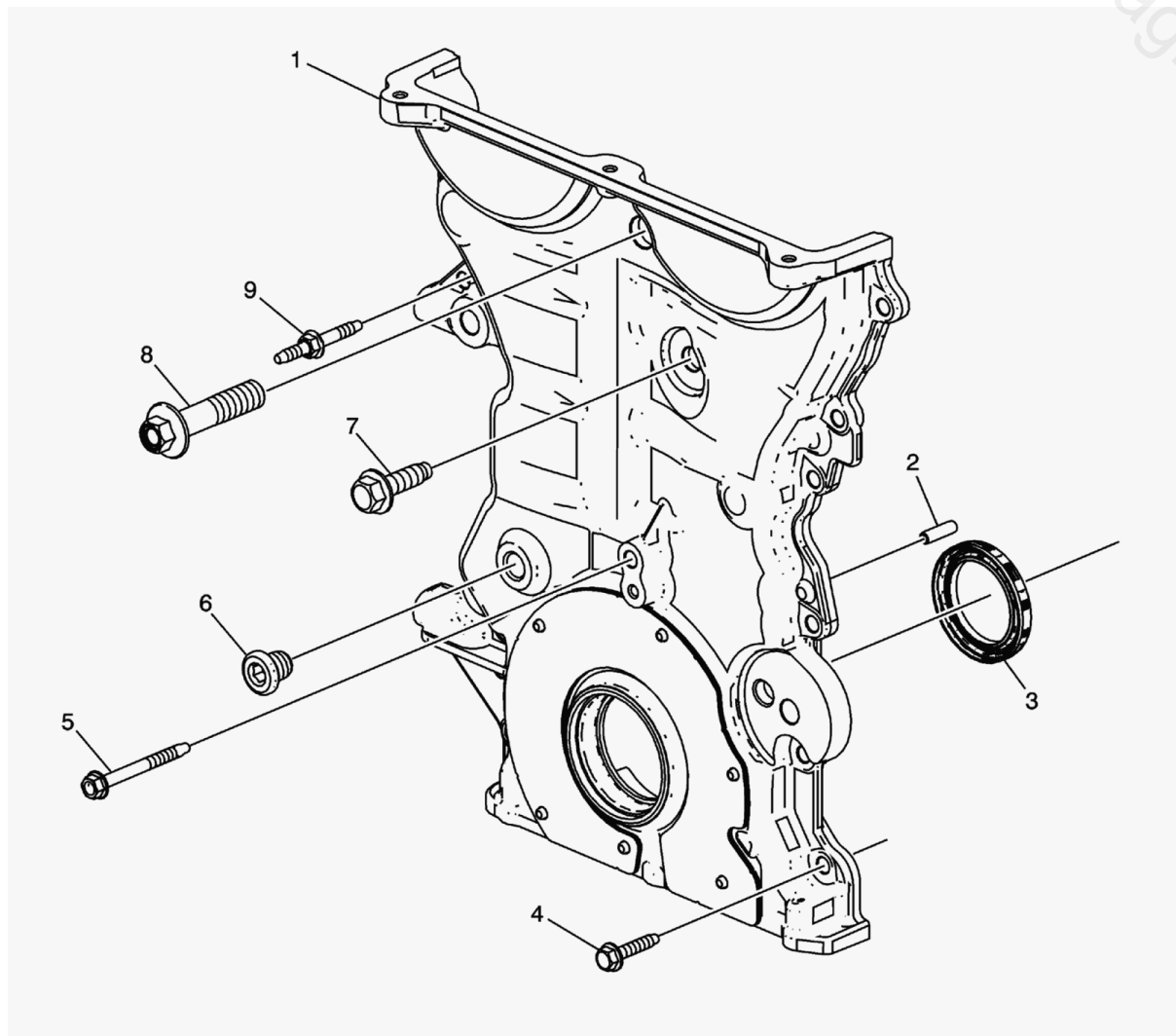


Fig. 21: Engine Front Cover and Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Front Cover
2	Engine Front Cover Locating Pin
3	Crankshaft Front Oil Seal
4	Engine Front Cover Bolt - M6 (Qty: 11)
5	Engine Front Cover Bolt - M6 (Qty: 1)
6	Engine Front Cover Hole Plug
7	Engine Front Cover Bolt - M14 (Qty: 1)
8	Engine Front Cover Bolt - M14 (Qty: 1)
9	Engine Front Cover Stud (Qty: 1)

Turbocharger and Components

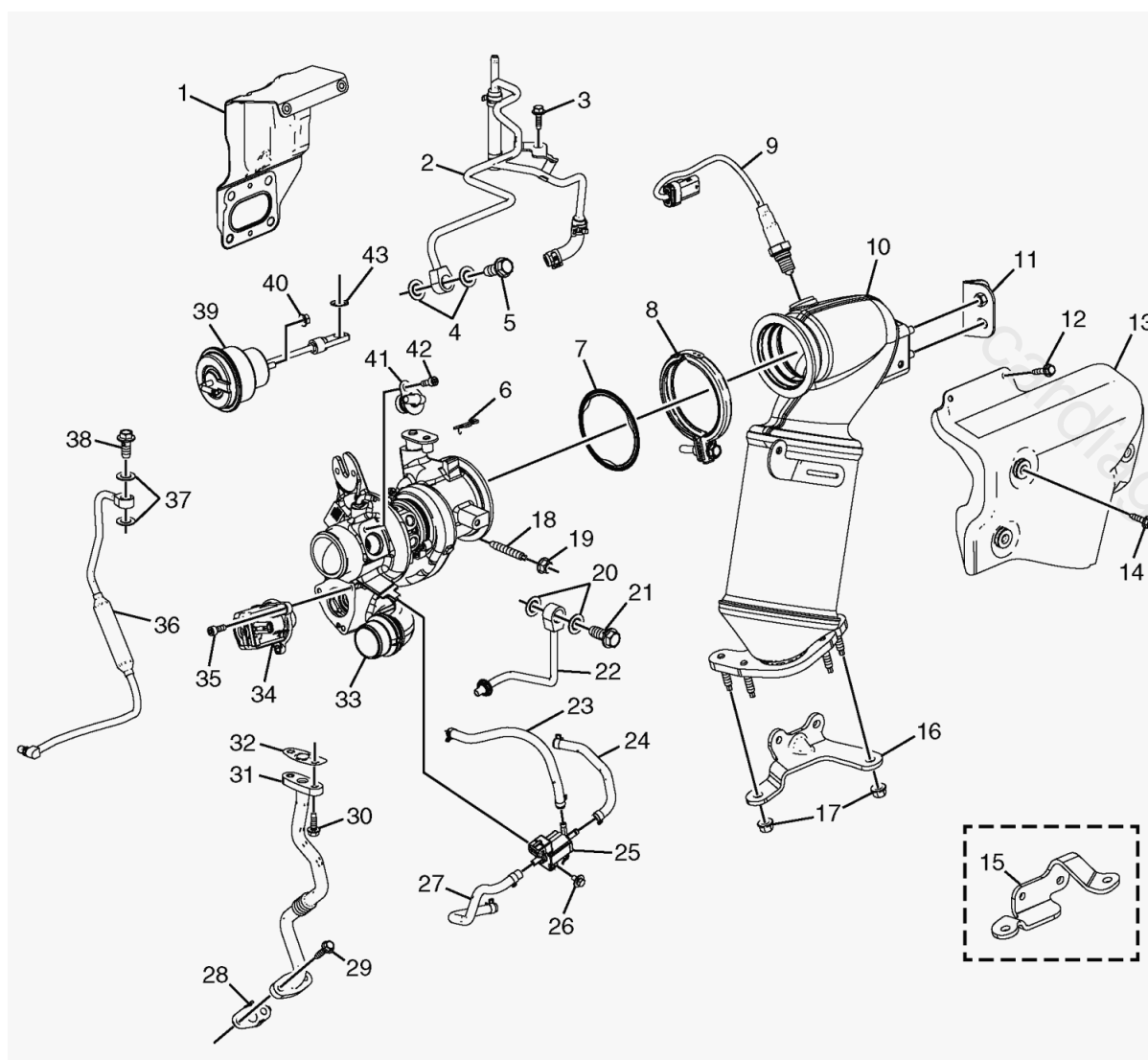


Fig. 22: Turbocharger and Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Heat Shield
2	Turbocharger Coolant Return Pipe
3	Turbocharger Coolant Return Pipe Bracket Bolt
4	Turbocharger Coolant Return Pipe Seal[2x]
5	Turbocharger Coolant Return Pipe Bolt
6	Turbocharger Wastegate Actuator Arm Retainer
7	Catalytic Converter Gasket

Callout	Component Name
8	Exhaust Pipe Clamp
9	Oxygen Sensor
10	Catalytic Converter
11	Catalytic Converter Bracket
12	Catalytic Converter Heat Shield Bolt
13	Catalytic Converter Heat Shield
14	Catalytic Converter Heat Shield Bolt
15	Catalytic Converter Bracket - Model Dependent
16	Catalytic Converter Bracket
17	Catalytic Converter Bracket Nut[2x]
18	Turbocharger Stud[4x]
19	Turbocharger Nut[4x]
20	Turbocharger Coolant Feed Pipe Seal [2x]
21	Turbocharger Coolant Feed Pipe Bolt
22	Turbocharger Coolant Feed Pipe
23	Turbocharger Wastegate Regulator Solenoid Valve Hose
24	Turbocharger Wastegate Regulator Solenoid Valve Hose
25	Turbocharger Wastegate Regulator Solenoid Valve
26	Turbocharger Wastegate Regulator Solenoid Valve Bolt
27	Turbocharger Wastegate Regulator Solenoid Valve Hose
28	Turbocharger Oil Return Pipe Gasket
29	Turbocharger Oil Return Pipe Bolt[2x]
30	Turbocharger Oil Return Pipe Bolt[2x]
31	Turbocharger Oil Return Pipe
32	Turbocharger Oil Return Pipe Gasket
33	Turbocharger
34	Turbocharger Bypass Valve Solenoid
35	Charge Air Bypass Valve Bolt[3x]
36	Turbocharger Oil Feed Pipe
37	Turbocharger Oil Feed Pipe Washer[2x]
38	Turbocharger Oil Feed Pipe Bolt
39	Turbocharger Wastegate Actuator
40	Turbocharger Wastegate Actuator Nut[2x]
41	Positive Crankcase Ventilation Hose Fitting
42	Positive Crankcase Ventilation Hose Fitting Bolt
43	Turbocharger Wastegate Actuator Rod Spring

Water Pump and Components

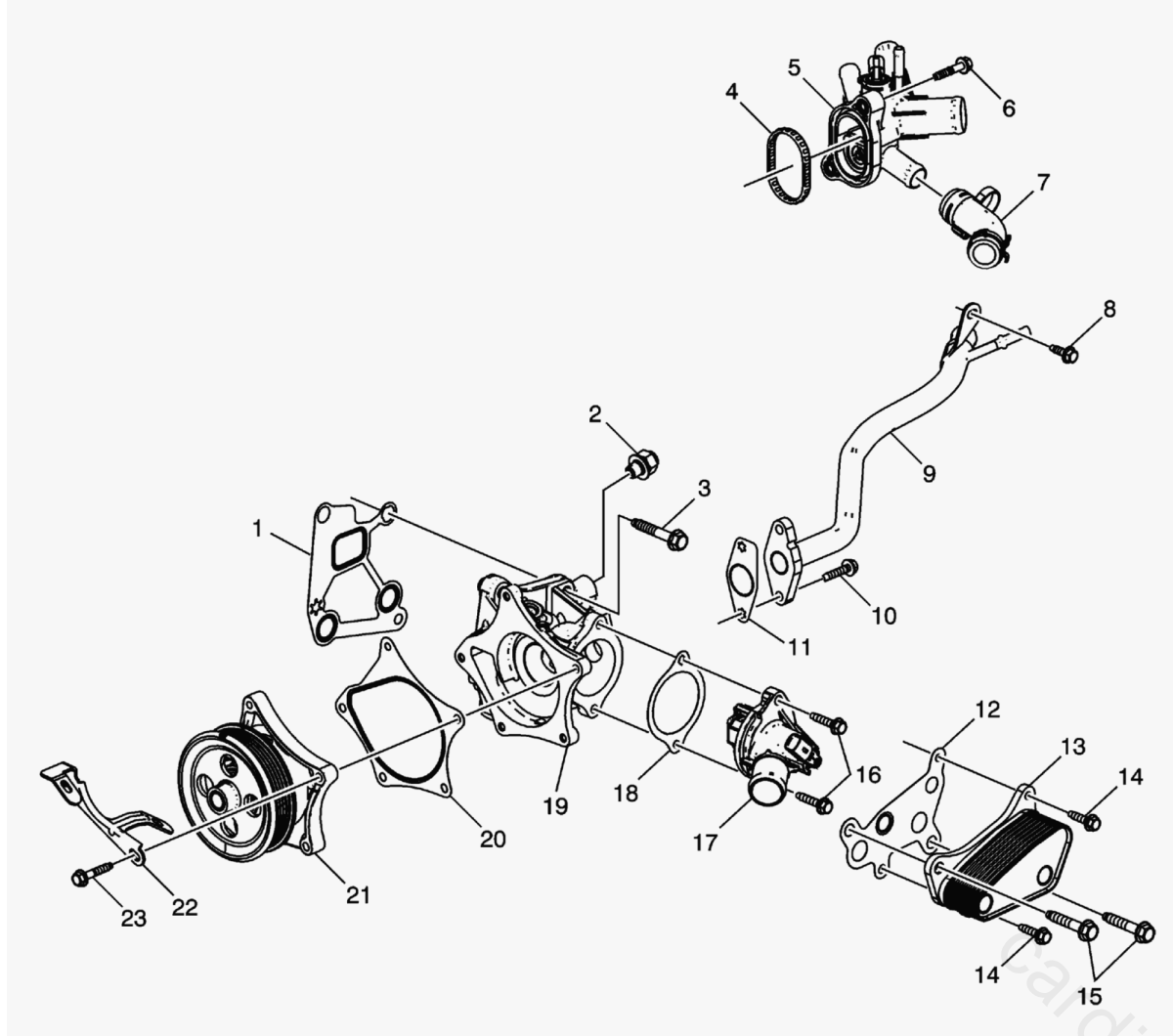


Fig. 23: Water Pump and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Housing Gasket
2	Turbocharger Oil Feed Pipe Fitting
3	Water Pump Rear Housing Bolt (Qty: 2)
4	Water Outlet Gasket
5	Water Outlet Assembly
6	Water Outlet Assembly Bolt (Qty: 2)
7	Thermal Bypass Hose
8	Thermal Bypass Pipe Assembly Bolt (Qty: 1)
9	Thermal Bypass Pipe Assembly
10	Thermal Bypass Pipe Assembly Bolt (Qty: 2)
11	Thermal Bypass Pipe Gasket
12	Engine Oil Cooler Gasket
13	Engine Oil Cooler Assembly
14	Engine Oil Cooler Assembly Bolt (Qty: 2)
15	Engine Oil Cooler Assembly Bolt (Qty: 2)
16	Engine Coolant Thermostat Housing Bolt
17	Engine Coolant Thermostat Housing Assembly
18	Engine Coolant Thermostat Housing Gasket
19	Water Pump Rear Housing
20	Water Pump Gasket
21	Water Pump Housing Assembly
22	ECM Engine Wiring Harness Bracket
23	Water Pump Housing Assembly Bolt (Qty: 5)

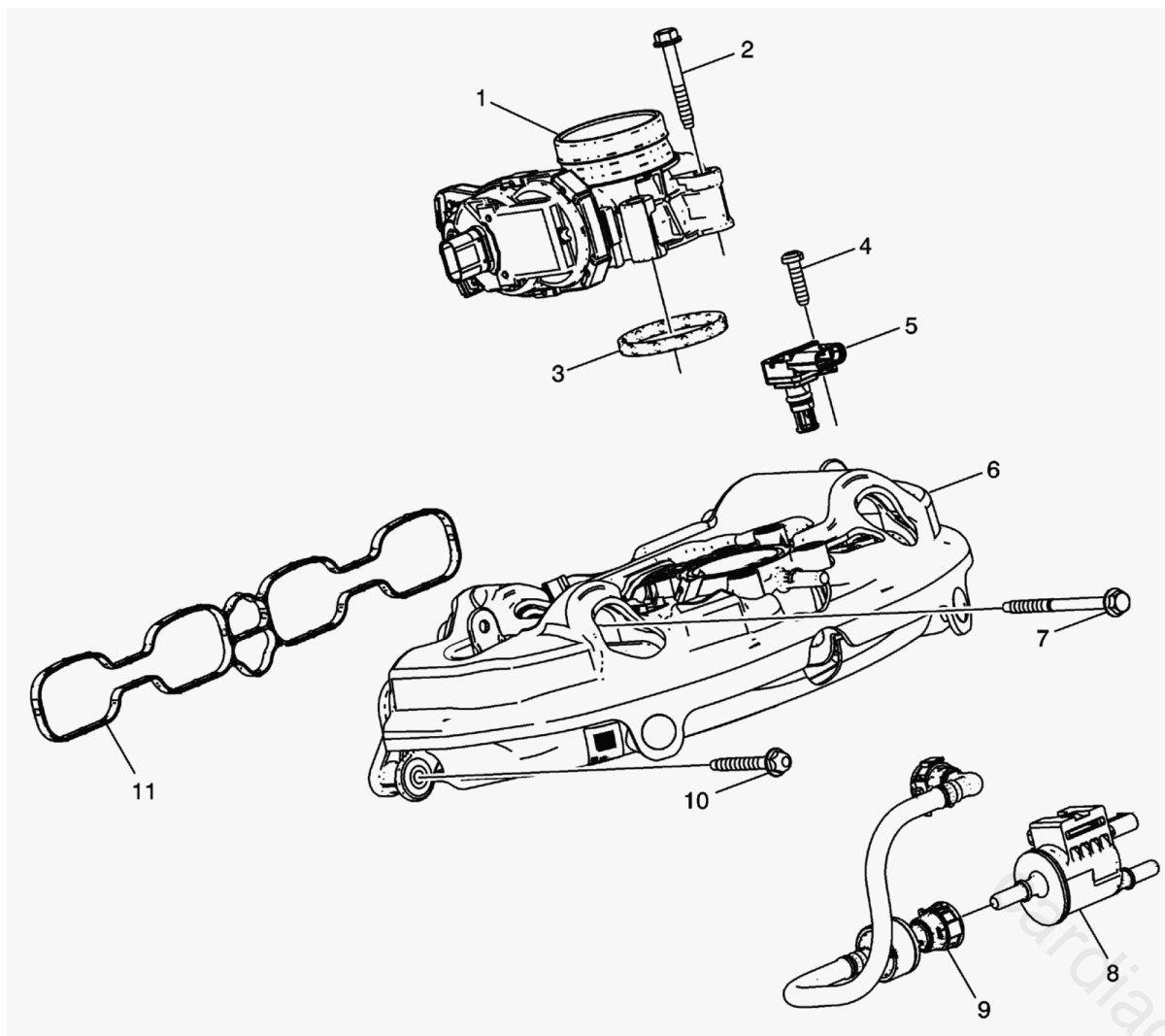


Fig. 24: Intake Manifold and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Assembly
2	Throttle Body Assembly Bolt (Qty: 4)
3	Throttle Body Gasket
4	Intake Air Pressure and Temperature Sensor Bolt
5	Intake Air Pressure and Temperature Sensor
6	Intake Manifold Assembly
7	Intake Manifold Assembly Bolt (Qty: 3)
8	Evaporative Emission Canister Purge Valve
9	Evaporative Emission Canister Purge Tube Assembly
10	Intake Manifold Assembly Bolt (Qty: 2)
11	Intake Manifold Gasket

Oil Pan and Components - FWD

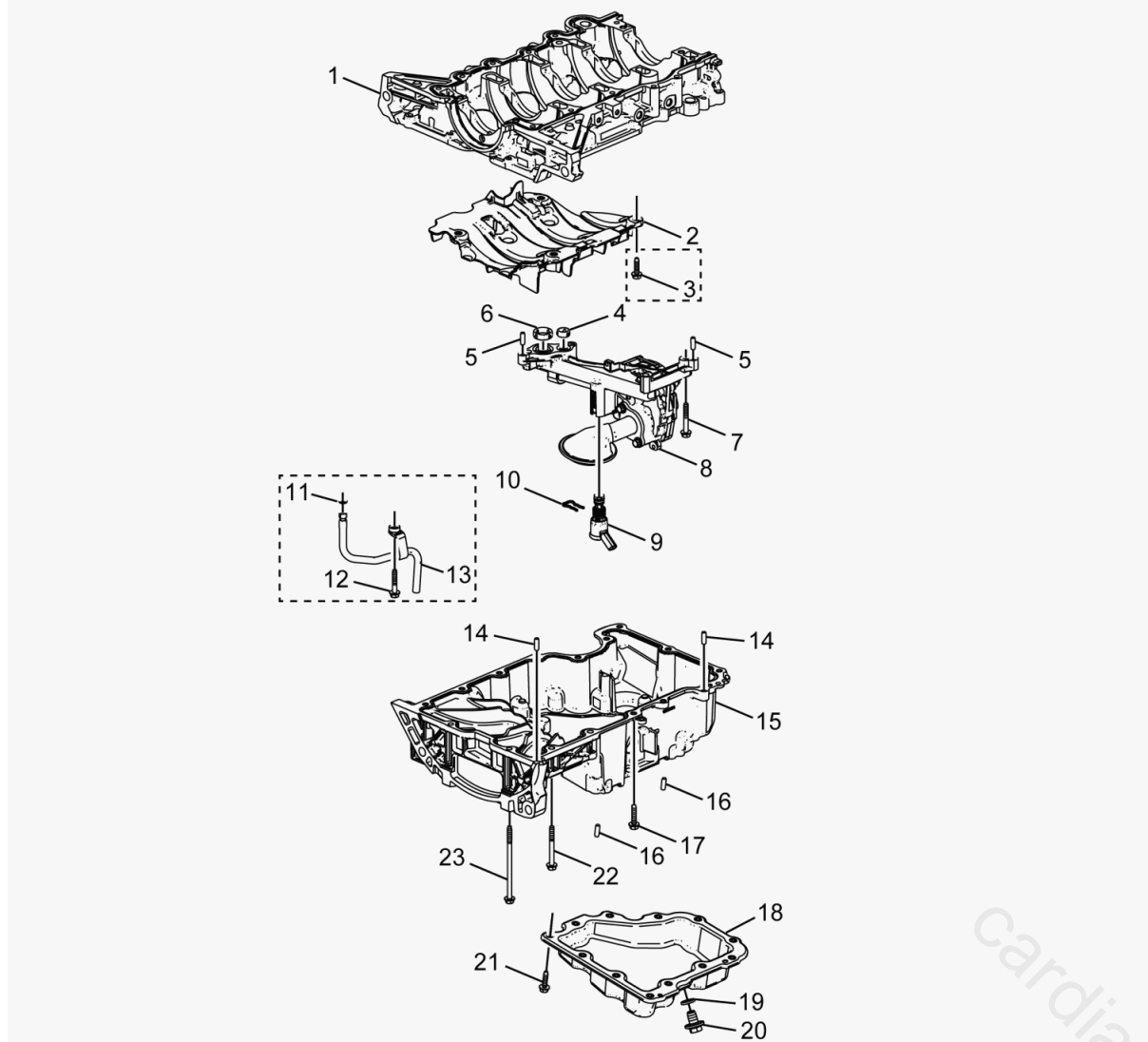


Fig. 25: Oil Pan and Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Lower Crankcase
2	Crankshaft Oil Deflector
3	Crankshaft Oil Deflector Bolt [3x]
4	Oil Pump Gasket
5	Oil Pump Locating Pin
6	Oil Pump Gasket
7	Oil Pump Bolt [4x]
8	Oil Pump
9	Oil Pump Flow Control Solenoid Valve
10	Oil Pump Flow Control Solenoid Valve Retainer
11	Positive Crankcase Ventilation Oil Separator Seal
12	Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt
13	Positive Crankcase Ventilation Oil Separator Drain Pipe
14	Oil Pan Locating Pin [2x]
15	Upper Oil Pan
16	Oil Pan Locating Pin [2x]
17	Oil Pan Bolt [12x]
18	Lower Oil Pan
19	Oil Pan Drain Plug Seal
20	Oil Pan Drain Plug
21	Lower Oil Pan Bolt [12x]
22	Oil Pan Bolt [2x]

Callout	Component Name
23	Oil Pan Bolt [2x]

Timing Chain and Components

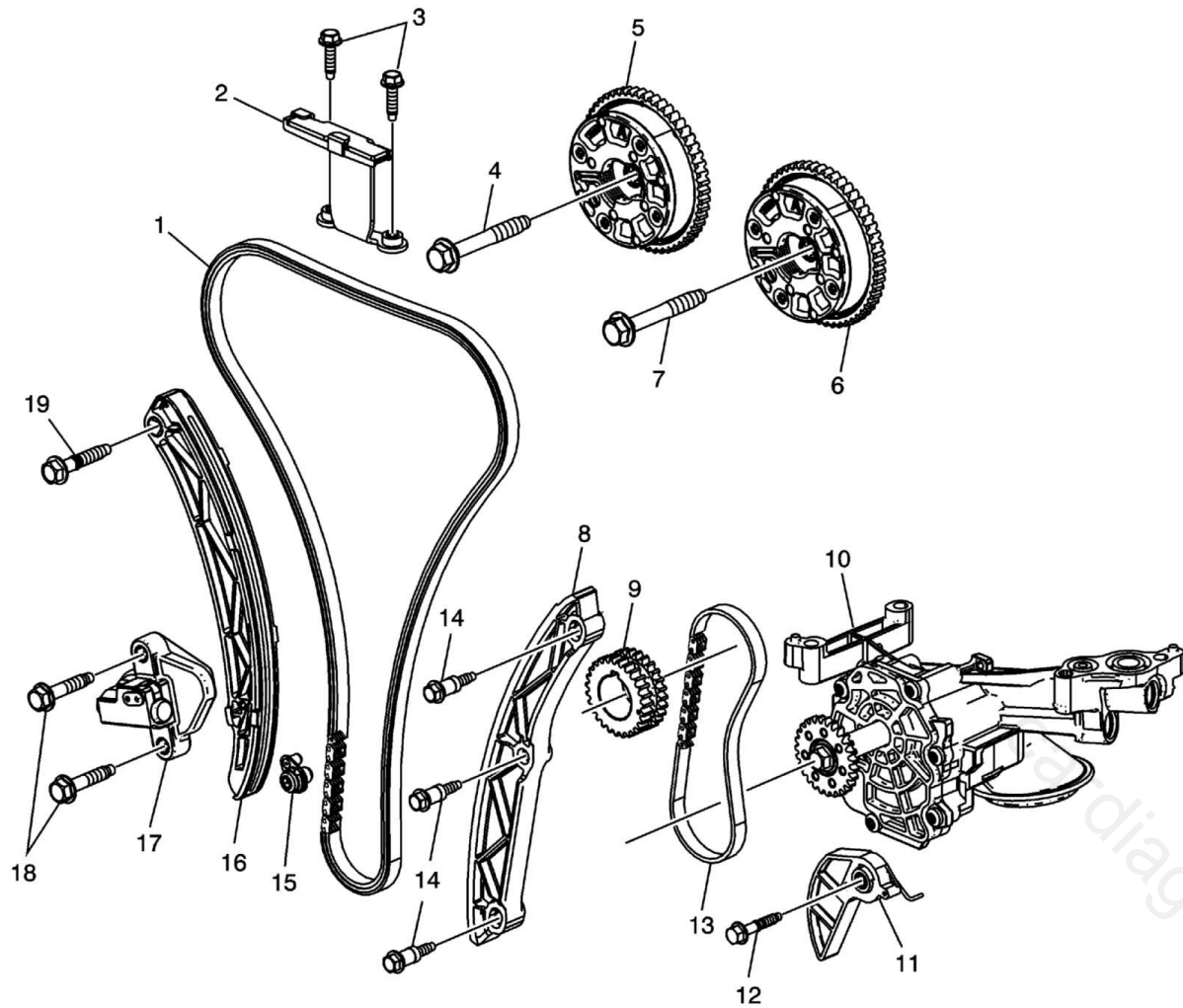


Fig. 26: Timing Chain and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain
2	Timing Chain Guide - to Cylinder Head
3	Timing Chain Guide Bolt
4	Camshaft Position Actuator Bolt
5	Camshaft Position Actuator Assembly - Intake
6	Camshaft Position Actuator Assembly - Exhaust
7	Camshaft Position Actuator Bolt
8	Timing Chain Guide - Exhaust Side
9	Crankshaft Sprocket
10	Oil Pump Assembly
11	Oil Pump Drive Chain Tensioner Assembly
12	Oil Pump Drive Chain Tensioner Bolt
13	Oil Pump Drive Chain
14	Timing Chain Guide Bolt (Qty: 3)
15	Timing Chain Oil Nozzle
16	Timing Chain Tensioner Shoe Assembly
17	Timing Chain Tensioner Assembly
18	Timing Chain Tensioner Bolt
19	Timing Chain Tensioner Shoe Bolt

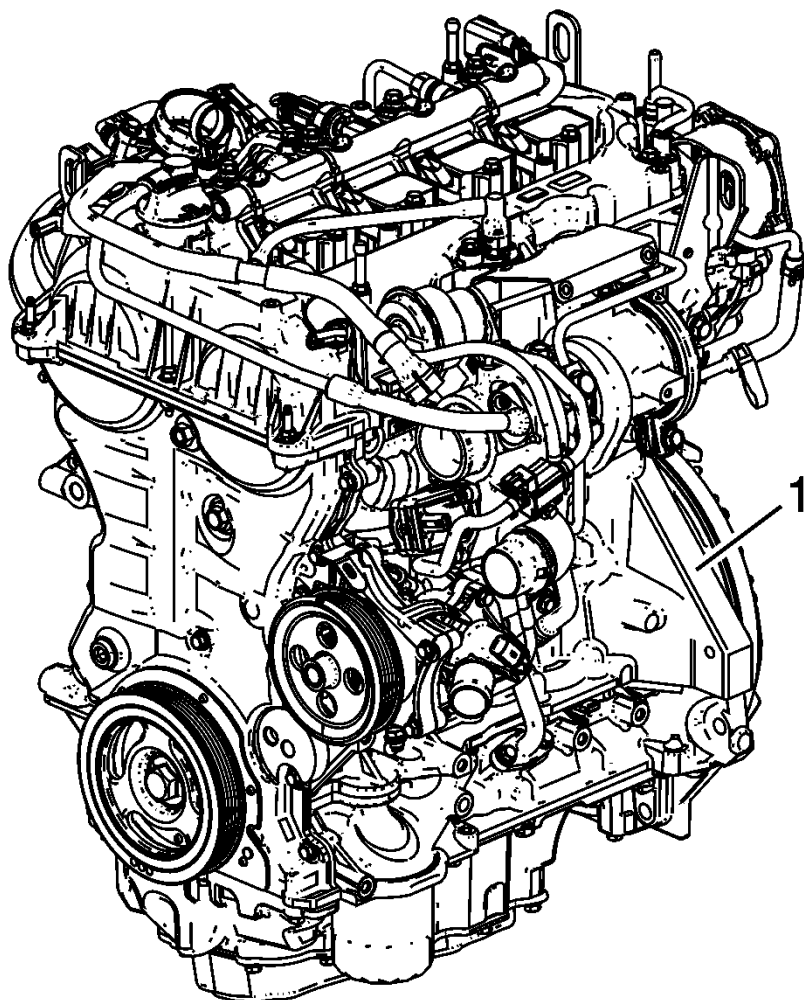


Fig. 27: Engine Identification Code

Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine identification number must be stamped to the cylinder block in case of engine replacement.

The engine identification code (1) is stamped on the flattened area of the cylinder block, at the transmission side.

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DE: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE

Diagnostic Instructions

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

DTC Descriptor

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P06DA, P06DB*	P06DA, P06DB	-	-
Control	P06DB	P06DA	P06DC	P06DD, P06DE
* Additional DTCs may set.				

Circuit/System Description

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

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

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

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

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

Conditions for Running the DTC

DTC P06DA, P06DB, P06DC

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

DTCs run continuously when the above conditions are met.

DTC P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229, P2230 = Not set
- Engine Speed = 1, 500 to 2, 500 RPM

DTCs run continuously when the above conditions are met.

DTC P06DE

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P06DD, P06DE, P111E, P2227, P2228, P2229, P2230 = Not set
- Engine = Running - For greater than 1.5s
- Engine Speed = 1, 500 to 2, 500 RPM
- Engine Oil Pressure Control Solenoid Valve = On - For greater than 1.5s

DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

DTC P06DA, P06DB, P06DC

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

DTC P06DD

Engine Oil Pressure = Less than a predefined threshold

DTC P06DE

Engine Oil Pressure = Greater than a predefined threshold

Actions Taken When the DTC Sets

- DTCs P06DB, P06DE are Type A DTCs.
- DTCs P06DA, P06DC, P06DD are Type B DTCs.
- Engine Oil Pressure Control Solenoid Valve = Off
- Reduced Engine Power = Active

Conditions for Clearing the DTC

- DTCs P06DA, P06DC, P06DD are Type B DTCs.
- DTCs P06DB, P06DE are Type A DTCs.

Reference Information

Schematic Reference

Engine Mechanical Schematics (1.5L (LYX))

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

- [Testing for Intermittent Conditions and Poor Connections](#)
- [Wiring Repairs](#)

DTC Type Reference

[Powertrain Diagnostic Trouble Code \(DTC\) Type Definitions](#)

Scan Tool Reference

[Control Module References](#)

[Circuit/System Verification](#)

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

1. Ignition - On / Vehicle - In Service Mode
2. Verify there are no DTCs set related to the following system/component:
 - B35B Engine Oil Level Sensor
 - B37B Engine Oil Pressure Sensor
 - B37 Engine Oil Pressure Switch
 - **If other DTCs are set**

Refer to: [Diagnostic Trouble Code \(DTC\) List - Vehicle](#)

- **Go to next step: If no other DTCs are set**
3. Verify the condition does not exist:
 - Low Engine Oil Level
 - Dirty or contaminated oil
 - **If a condition exists**

Repair as necessary

 - **Go to next step: If no condition exists**
 4. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure - High Pressure

Verify the scan tool parameter:

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

Refer to: Circuit/System Testing

- **Go to next step: If the specified state**
5. Engine running.
 6. Perform the following steps:
 1. Increase the engine speed slowly to 1, 800 RPM.

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

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

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

- If the change is 30 kPa (4 PSI) or less Â» Replace the component: Q44 Engine Oil Pressure Control Solenoid Valve
- If the change is greater than 30 kPa (4 PSI)

7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Verify the DTC does not set.

- **If the DTC sets**

Refer to: Circuit/System Testing

- **Go to next step: If the DTC is not set**

8. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems - Off
2. Disconnect the appropriate electrical connector: Inline Harness Connector
3. Ignition - On / Vehicle - In Service Mode

NOTE: Testing for steps 4 to 9 is performed on the control module K20 side of the inline harness connector.

4. Verify a test lamp turns On between the test points: Ignition circuit terminal 5 & Ground

- **If the test lamp does not turn On and the circuit fuse is OK**

1. Ignition/Vehicle - Off & Remove - Test lamp
2. Test for less than 2 Ω between the test points: Ignition circuit terminal 5 & Fuse
 - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
 - If less than 2 Ω Â» Verify the fuse is OK and there is voltage at the fuse.

- **If the test lamp does not turn On and the circuit fuse is open**

1. Ignition/Vehicle - Off & Remove - Test lamp

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

2. Test for infinite resistance between the test points: Ignition circuit terminal 5 & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance Refer to: Step 10

- **Go to next step: If the test lamp turns On**

5. Verify a test lamp does not turn On between the test points: Control circuit terminal 4 & B+

- **If the test lamp turns On**

1. Ignition/Vehicle - Off & Remove - Test lamp
2. Disconnect the electrical connector: K20 Engine Control Module
3. Test for infinite resistance between the test points: Inline Harness Connector Control circuit terminal 4 & Ground
 - If less than infinite resistance - Repair the short to ground on the circuit.
 - If infinite resistance - Replace the component: K20 Engine Control Module

- **Go to next step: If the test lamp does not turn On**

6. Remove - Test Lamp

7. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure

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

- **If not the specified state**

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector: K20 Engine Control Module
3. Test for less than $2\ \Omega$ between the test points: Inline Harness Connector Control circuit terminal 4 & The other end of the circuit
 - If $2\ \Omega$ or greater $\hat{A}$ » Repair the open/high resistance in the circuit.
 - If less than $2\ \Omega$ $\hat{A}$ » Replace the component: K20 Engine Control Module

- **Go to next step: If the specified state**

8. Connect a 3 A fused jumper wire between the test points: Control circuit terminal 4 & Ignition circuit terminal 5
9. Perform the scan tool control function: Engine Oil Pressure Control Solenoid Valve - Low Pressure.

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

- **If not the specified state**

1. Ignition/Vehicle - Off & Remove - Jumper wire(s)
2. Disconnect the electrical connector: K20 Engine Control Module
3. Test for less than $2\ \Omega$ between the test points: Inline Harness Connector Control circuit terminal 4 & The other end of the circuit
 - If $2\ \Omega$ or greater $\hat{A}$ » Repair the open/high resistance in the circuit.
 - If less than $2\ \Omega$ $\hat{A}$ » Replace the component: K20 Engine Control Module

- **Go to next step: If the specified state**

NOTE: Testing for steps 10 to 12 is performed on the component side of the inline harness connector: Q44 Engine Oil Pressure Control Solenoid Valve

10. Test for 10 to $30\ \Omega$ between the test points: Control circuit terminal 4 & Ignition circuit terminal 5

- **If not between 10 and $30\ \Omega$**

1. Disconnect the electrical connector: Q44 Engine Oil Pressure Control Solenoid Valve
2. Test for less than $2\ \Omega$ between the test points:
 - Ignition circuit terminal 5 & The other end of the circuit
 - Control circuit terminal 4 & The other end of the circuit
 - If $2\ \Omega$ or greater $\hat{A}$ » Repair the open/high resistance in the circuit.
 - If less than $2\ \Omega$ $\hat{A}$ » Test or replace the component: Q44 Ω Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If between 10 and $30\ \Omega$**

11. Test for infinite resistance between the test points:

- Ignition circuit terminal 5 & Ground
- Control circuit terminal 4 & Ground
- **If less than infinite resistance**

Repair the short to ground on the circuit.

- **Go to next step: If infinite resistance**

12. Test for less than 1 V between the test points:

- Ignition circuit terminal 5 & Ground

- Control circuit terminal 4 & Ground
- **If 1 V or greater**

Repair the short to voltage on the circuit.

- **Go to next step: If less than 1 V**

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

Component Testing

Static Test

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

Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If between 10 and 30ohm**

4. Test for infinite resistance between the test points:Each terminal of the component & The component's housing

- **If less than infinite resistance**

Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If infinite resistance**

5. All OK.

Dynamic Test

1. Ignition/Vehicle - Off
2. Disconnect the electrical connector:Q44 Engine Oil Pressure Control Solenoid Valve
3. Connect a 10 A fused jumper wire between the test points: Ignition terminal 1/A & 12 V

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

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

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

- **If the component does not turn On and Off**

Replace the component:Q44 Engine Oil Pressure Control Solenoid Valve

- **Go to next step: If the component turns On and Off**

5. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair: [Diagnostic Repair Verification](#)

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

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

Perform the [Diagnostic System Check - Vehicle](#) .

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 make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- [Engine Noise Under Load](#)
- [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 Will Not Crank - Crankshaft Will Not Rotate](#)
- [Coolant in Engine Oil](#)
- [Engine Compression Test](#)
- [Oil Consumption Diagnosis](#)
- [Oil Pressure Diagnosis and Testing](#)
- [Oil Leak Diagnosis](#)
- [Drive Belt Chirping, Squeal, and Whine Diagnosis](#)
- [Drive Belt Rumbling and Vibration Diagnosis](#)
- [Drive Belt Falls Off and Excessive Wear Diagnosis](#)
- [Drive Belt Tensioner Diagnosis](#)

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- CH-48027 Digital Pressure Gauge
- EN-21867-850 Oil Pressure Gauge Adapter

For equivalent regional tools, refer to [Special Tools](#).

Procedure

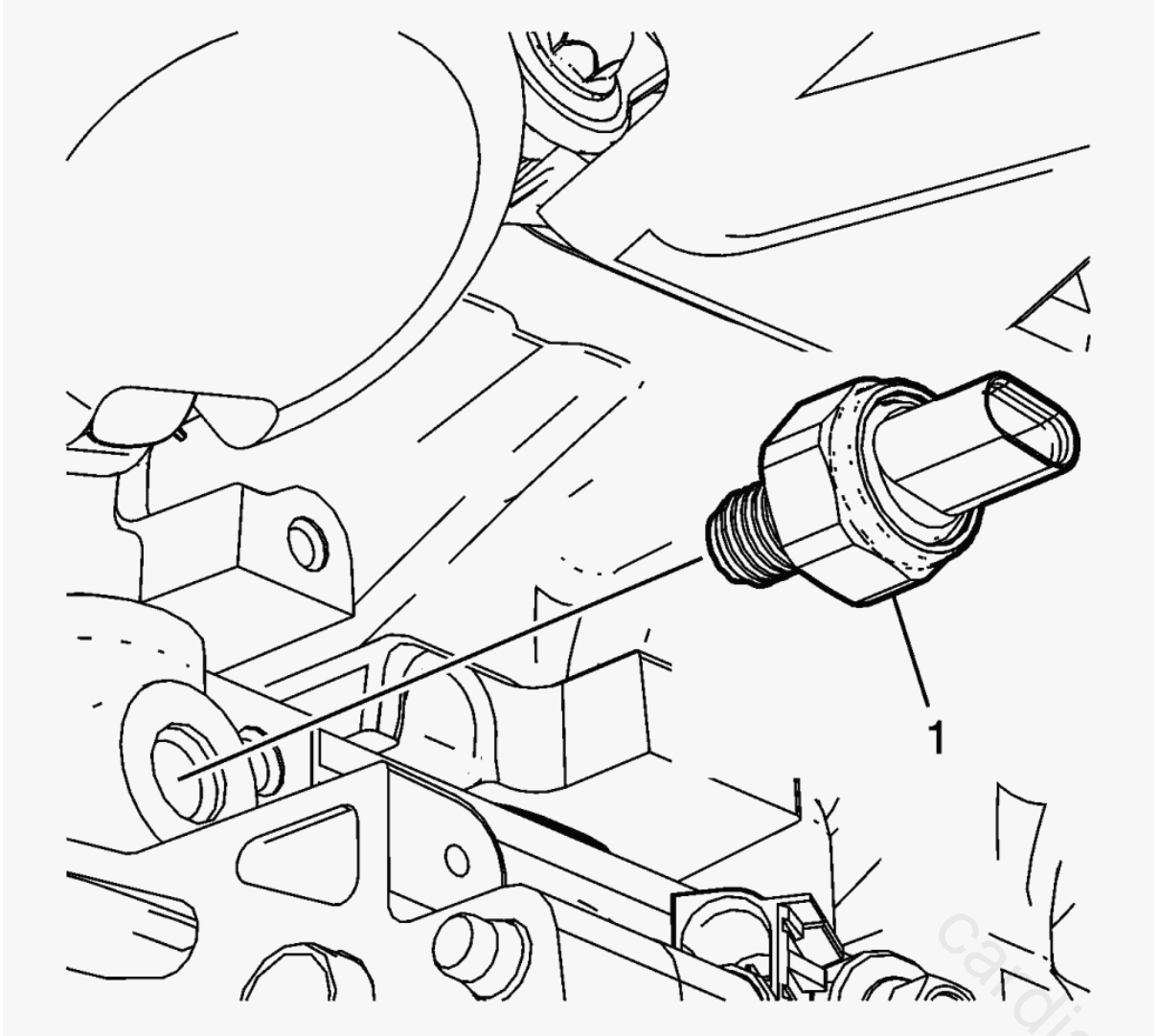


Fig. 28: Engine Oil Pressure Sensor

Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine oil pressure sensor (1).

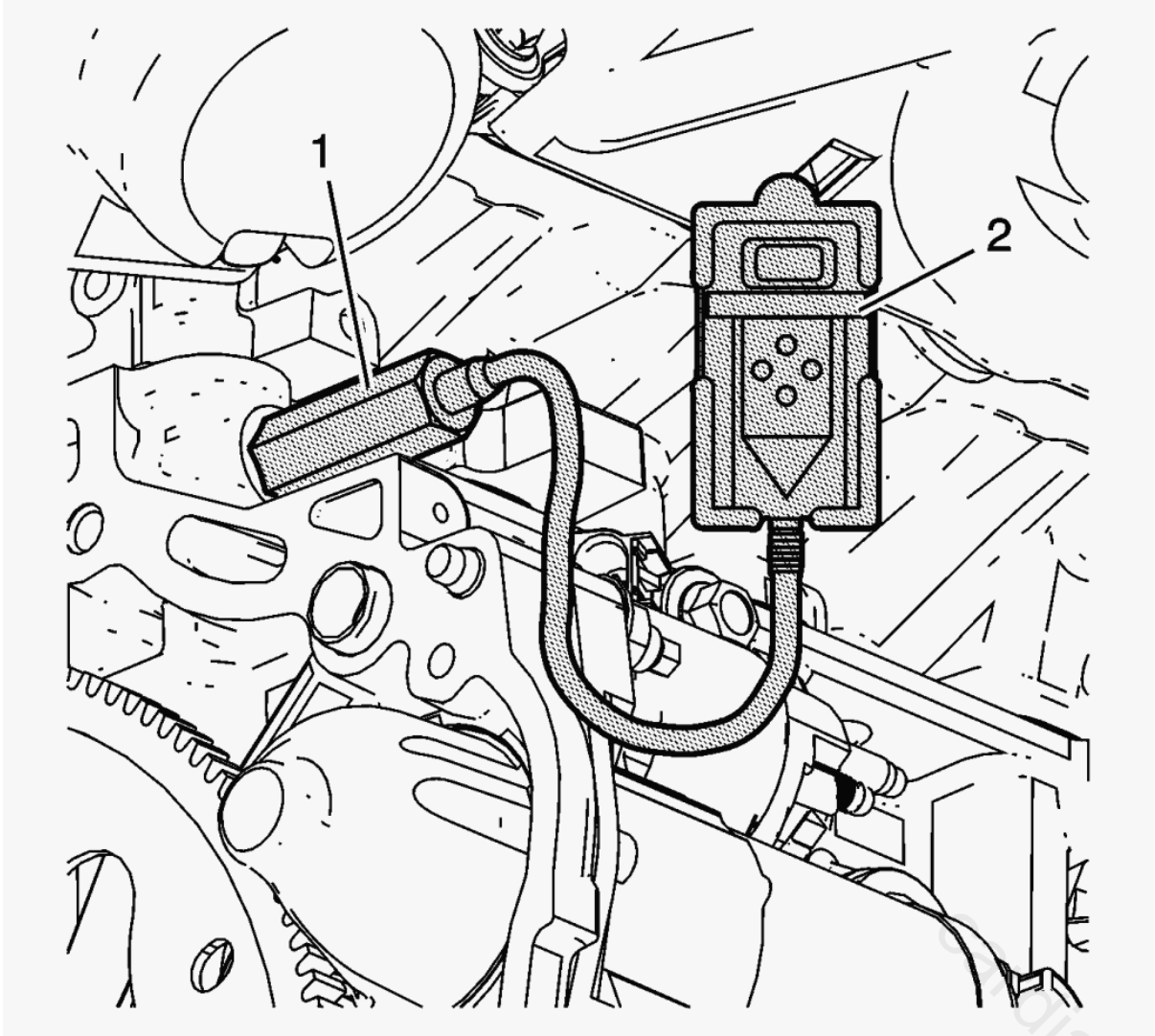


Fig. 29: Adapter And Gauge

Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-21867-850** adapter (1).
3. Install the **CH-48027** gauge (2).
4. Start the engine.
5. Check oil pressure.
6. At idling speed, the oil pressure must be greater than 180 kPa (26.11 psi) and the oil temperature must be 85°C (185°F) or more.
7. Remove the **CH-48027** gauge (2).
8. Remove the **EN-21867-850** adapter (1).
9. Turn off the engine.

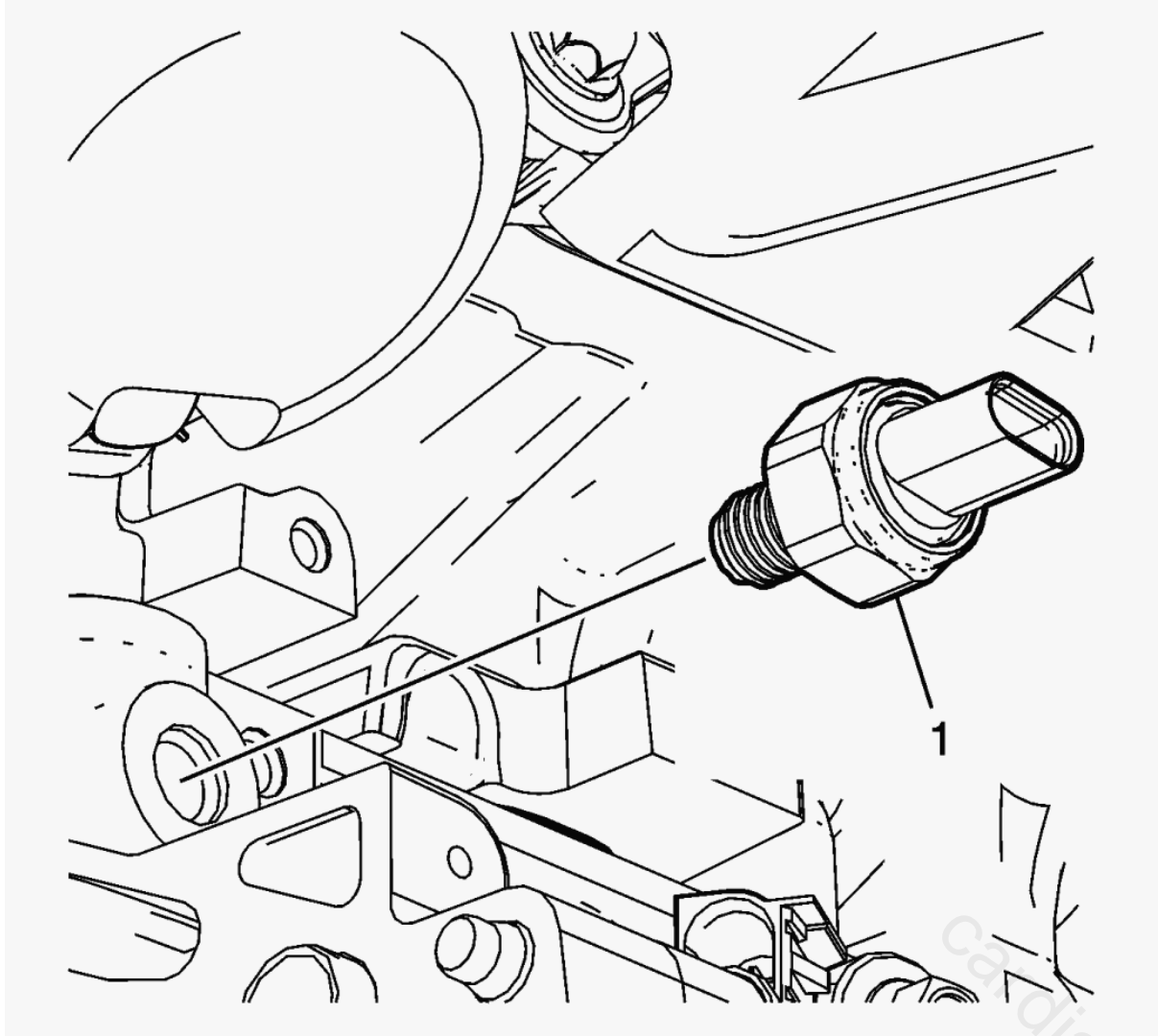


Fig. 30: Engine Oil Pressure Sensor

Courtesy of GENERAL MOTORS COMPANY

10. Install the engine oil pressure sensor (1).
11. Tighten the sensor to 35 N.m (26 lb ft).
12. Check the engine oil level.

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 leak and the cause of the leak.			
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to Engine Mechanical Specifications. 2. Park the vehicle on a level surface over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings.		
	Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3

Step	Action	Yes	No
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. 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

Step	Action	Yes	No
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	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 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 required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage or customer modifications to the engine?	Go to Step 11	System OK
11	Repair or replace all damaged or modified components. Did you complete the repair?	Go to Step 1	-

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 0.9 L (1 quart) 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.

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 overheating condition which may cause engine component damage. NOTE: While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in cooling system. It is important to follow the kit instructions. This is not a substitute for service information. Combustion leak tests are available from a wide variety of aftermarket suppliers. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders side-by-side on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection , and Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Replacement .
Cracked cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Replacement .

Cause	Correction
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 Lower Engine Noise, Regardless of Engine Speed. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders side-by-side on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Replacement .
Cracked cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Replacement .
Cracked cylinder liner	Replace the components as required.
Cylinder head or block porosity	Replace the components as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. Refer to Symptoms - Engine Controls .
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

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lash adjuster leak down rate	Replace the lash adjusters as required.
Worn crankshaft thrust bearing	1. Inspect the thrust bearing and crankshaft. 2. Repair or replace as required.
Damaged or faulty oil filter by-pass valve	1. Inspect the oil filter by-pass valve for proper operation. 2. Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination. 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.

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.

Cause	Correction
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Damage to the MAP sensor housing	Replace the intake manifold.
Worn rocker arms	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.	• Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to Engine Compression Test. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.

Cause	Correction
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a DTC P0300 or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

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

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

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

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides, and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. • Repair or replace as required.

Cause	Correction
Worn piston rings Oil consumption may or may not cause the engine to misfire.	- Inspect the spark plugs for oil deposits. - Inspect the cylinders for a loss of compression. Refer to Engine Compression Test. - Perform cylinder leak down and compression testing to determine the cause. - Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	- Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. - 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 timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn, damaged, or faulty timing chain tensioner	Replace the tensioner.
Worn engine camshaft lobes	- Inspect the engine camshaft lobes. - Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: - The valves - The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components and repair as required: - The valves - The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction

Cause	Correction
Low oil pressure	- Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. - Repair or replace damaged components as required.
Worn accessory drive components - abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components	- Inspect the accessory drive system. - Repair or replace as required.
Loose or damaged crankshaft balancer	- Inspect the crankshaft balancer. - Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to Symptoms - Engine Controls .
Loose torque converter bolts	- Inspect the torque converter bolts and flywheel. - Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
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.	- Inspect the oil pan. - Inspect the oil pump screen. - Repair or replace as required.
Oil pump screen loose, damaged or restricted	- Inspect the oil pump screen. - Repair or replace as required.
Excessive piston-to-cylinder bore clearance	- Inspect the piston and cylinder bore. - Repair as required.
Excessive piston pin-to-bore clearance	- Inspect the piston, piston pin, and the connecting rod. - 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

Cause	Correction
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 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.

Cause	Correction
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

ENGINE COMPRESSION TEST

Special Tools

EN-51749 Compression Gauge Tester Kit

For equivalent regional tools, refer to [Special Tools](#).

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

Removal Procedure

NOTE: The battery must be at or near full charge.

1. Connect a battery charger to the battery for the duration of the test to maintain an adequate battery level.
2. Engine OFF.
3. Remove the spark plugs. Refer to [Spark Plug Replacement](#).
4. Interrupt the fuel supply.

Measurement Procedure

1. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.

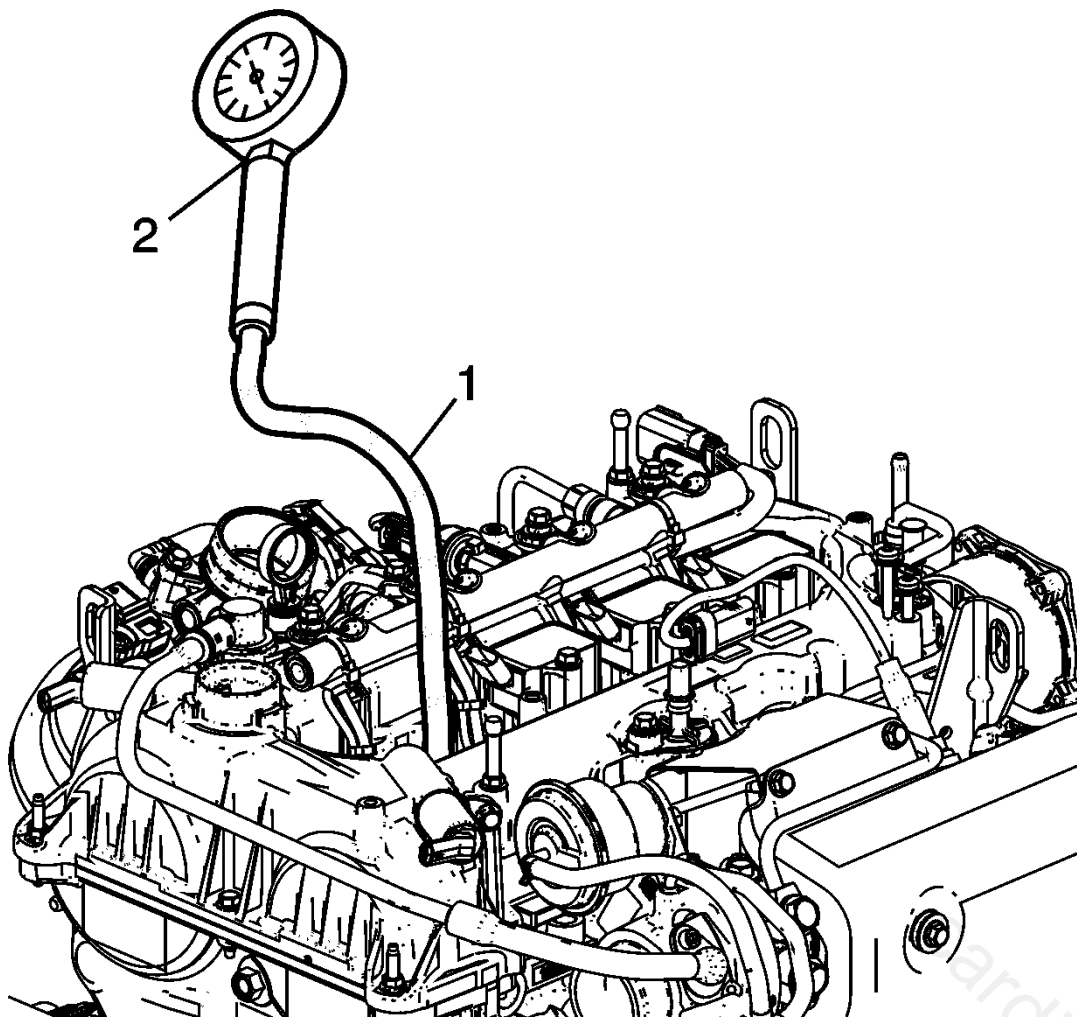


Fig. 31: Compression Gauge

Courtesy of GENERAL MOTORS COMPANY

2. Install the EN-51749 gauge (1, 2) into the spark plug hole for the cylinder that is being checked.

NOTE: Engine should be operated at least 300 revolutions per minute (RPM).

NOTE: When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.

3. Use a remote start switch to crank the engine. If cranking function exists via GDS2, this can be used as an alternative method. Record the reading after the cranking cycle completes.
4. Repeat the compression test for each cylinder.
5. Compare the compression readings from all of the cylinders. Maximum pressure differential 100 kPa (14.5 psi).
6. The following are indicators of potential problems:
 - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
 - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
 - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
7. Disconnect GDS2 diagnostic tool or remote start switch.

1. Restore the fuel supply.
2. Install the spark plugs. Refer to [Spark Plug Replacement](#).

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

Test Description

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

2

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

3

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

4

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

6

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

10

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

12

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

14

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

15

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

16

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

17

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

19

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

Step	Action	Yes	No
CAUTION: Refer to Belt Dressing Caution .			
DEFINITION: The following items are indications of chirping: - A high pitched noise that is heard once per revolution of the drive belt or a pulley. - Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: - A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. - The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: - A high pitched continuous noise. - The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids

Step	Action	Yes	No
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis. Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19

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

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

2

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

3

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

4

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

5

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

9

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.

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

Step	Action	Yes	No
CAUTION: Refer to Belt Dressing Caution .			
DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: • Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove • The separation of the drive belt • A damaged drive belt • A worn drive belt idler pulley DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to Drive Belt Replacement . Did you correct the condition?	Go to Step 8	Go to Step 7

Step	Action	Yes	No
7	Install a new drive belt. Refer to Drive Belt Replacement . Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	Go to Step 11
11	Inspect for a bent water pump shaft. Refer to Water Pump Replacement (LYX) . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

CYLINDER LEAKAGE TEST

Special Tools

EN-51749 Compression Gauge Tester Kit

For equivalent regional tools, refer to [Special Tools](#).

NOTE:

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

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

WARNING: Refer to [Battery Disconnect Warning](#) .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to [Spark Plug Replacement](#) .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **EN-51749** gauge according to the manufacturers instructions.

NOTE:

It may be necessary to hold the crankshaft balancer bolt to prevent

the crankshaft from rotating.

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

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

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

DRIVE BELT 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.

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

2

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

4

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

5

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

6

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

7

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

13

The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by false 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
CAUTION: Refer to Belt Dressing Caution . DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical

Step	Action	Yes	No
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement . 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 correct the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and correct the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . 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 correct the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to Drive Belt Replacement . 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 correct the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the drive belt. Refer to Drive Belt Replacement . Did you complete the replacement?	Go to Step 17	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Diagnosis consists of a function check on the automatic belt tensioner and a visual check on the belt and the components linked to the belt.

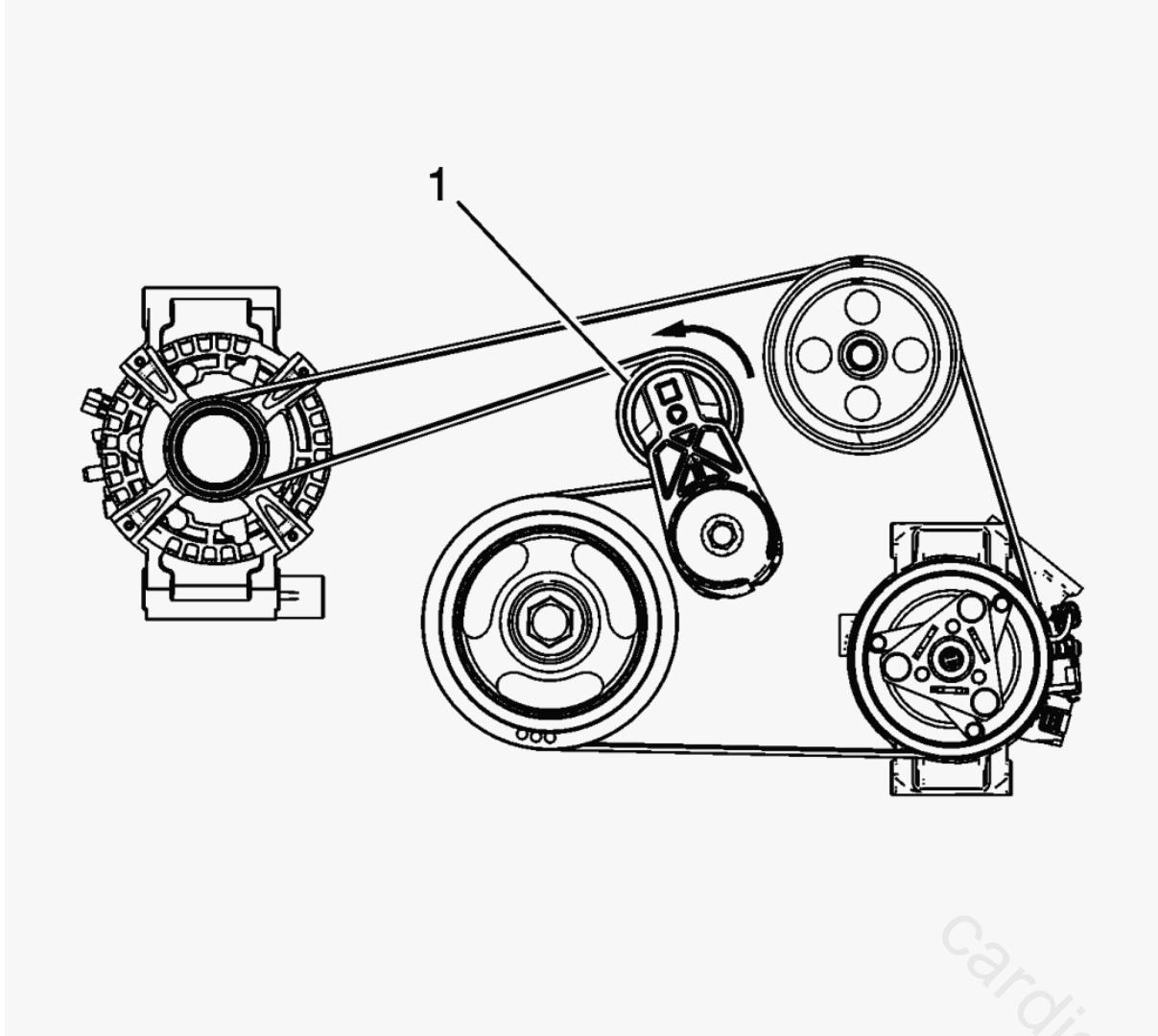


Fig. 32: Applying Tension To Belt Tensioner

Courtesy of GENERAL MOTORS COMPANY

1. Apply the tension to the belt tensioner via the cast projection (1) in the direction of the arrow, counterclockwise, and allow to slide back slowly.
2. The tensioner must slide back to the initial position.

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT

Removal Procedure

1. Remove Front Wheelhouse Liner-Right Side - **Front Wheelhouse Liner Replacement - Right Side (Equinox)** **Front Wheelhouse Liner Replacement - Right Side (Terrain)**.

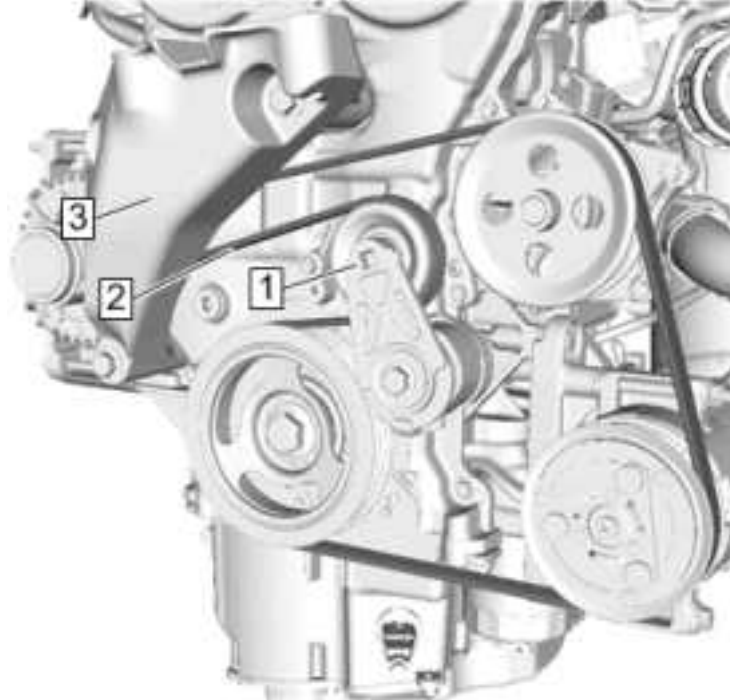


Fig. 33: Drive Belt Diagram

Courtesy of GENERAL MOTORS COMPANY

2. Rotate the drive belt tensioner (1) counterclockwise and hold tension.

NOTE: It is NOT necessary to remove the engine mount bracket (3) to remove the belt. Once the drive belt has been removed from the pulleys, navigate the belt past the engine mount bracket to remove.

3. Remove Drive Belt (2).
4. Slowly release the tension on the drive belt tensioner.(1)

Installation Procedure

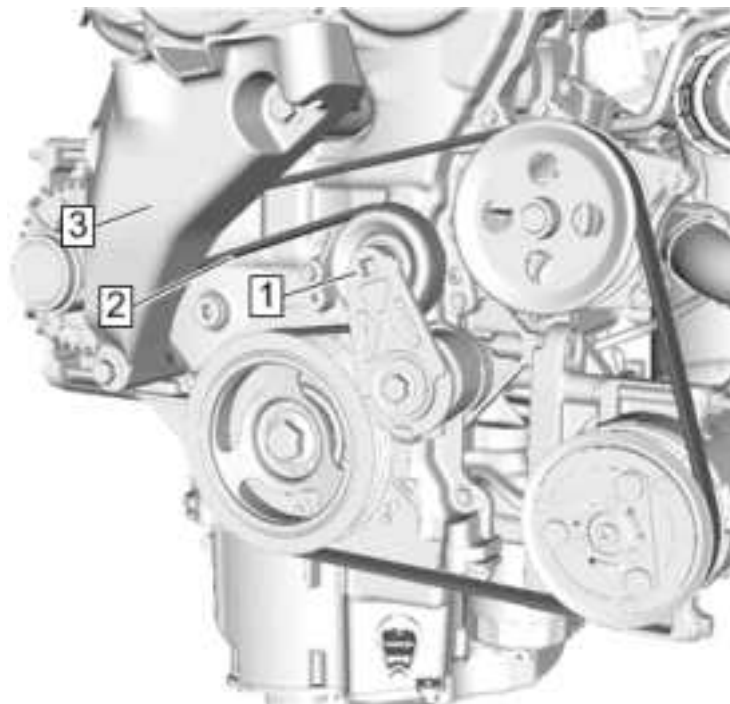


Fig. 34: Drive Belt Routing

Courtesy of GENERAL MOTORS COMPANY

1. Apply tension to the drive belt tensioner (1) by rotating counterclockwise and hold tension.

NOTE: Navigate the belt (2) past the engine mount bracket (3) and properly install.

2. Install Drive Belt (2).
3. Slowly release the tension on the drive belt tensioner.(1)
4. Inspect the drive belt for proper installation and alignment.
5. Install Front Wheelhouse Liner-Right Side - [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#) [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)
6. Lower the vehicle.

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

1. Remove Drive Belt - [Drive Belt Replacement](#)

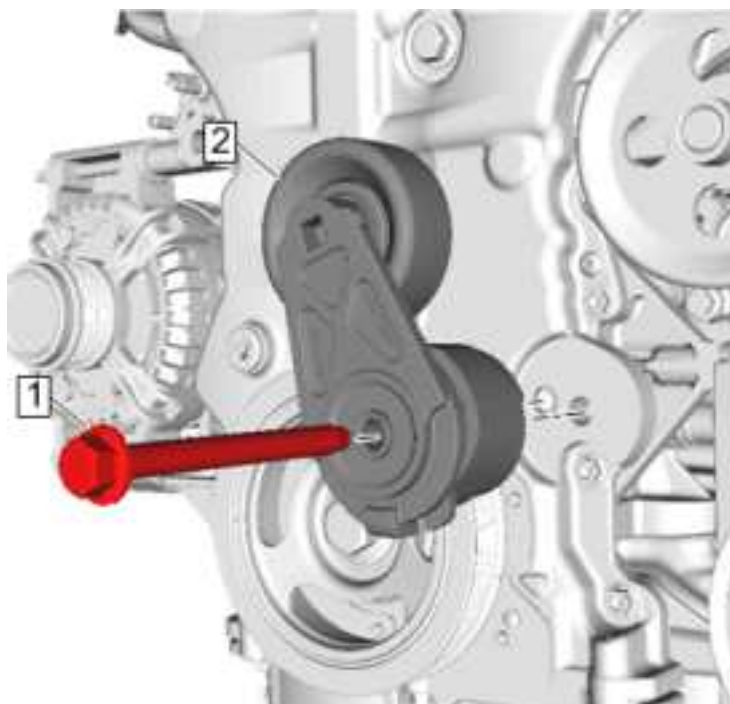
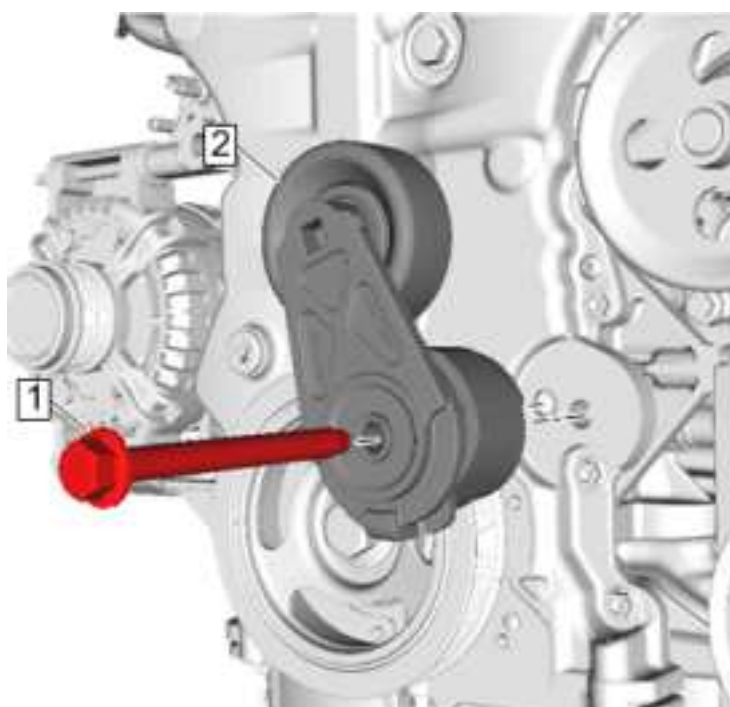


Fig. 35: Drive Belt Tensioner

Courtesy of GENERAL MOTORS COMPANY

2. Remove Drive Belt Tensioner Fastener (1).
3. Remove Drive Belt Tensioner (2).

Installation Procedure



NOTE: Ensure that the drive belt tensioner pin engages the engine front cover hole.

1. Install Drive Belt Tensioner(2)

CAUTION: Refer to Fastener Caution .

2. Install Drive Belt Tensioner Fastener(1) and tighten 58 N.m (43 lb ft)
3. Install Drive Belt - Drive Belt Replacement

CAMSHAFT COVER REPLACEMENT

Removal Procedure

1. Remove Air Cleaner Assembly -Air Cleaner Assembly Replacement
2. Remove Fuel Injection Fuel Rail Assembly -Fuel Injection Fuel Rail Assembly Replacement
3. Remove Vacuum Pump Assembly - Vacuum Pump Assembly Replacement

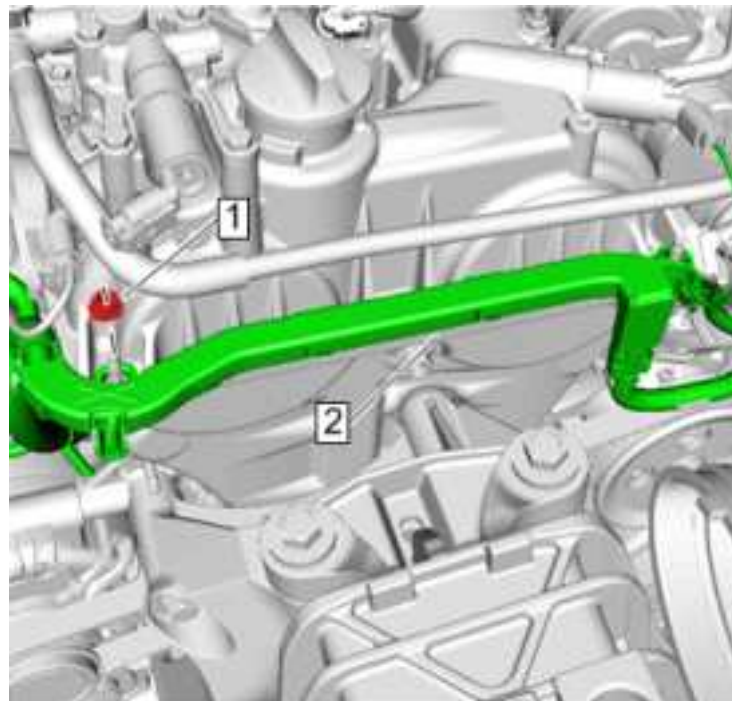


Fig. 37: Wiring Harness And Fastener
Courtesy of GENERAL MOTORS COMPANY

4. Remove the wiring harness fastener (1) then reposition the wiring harness (2) as needed.

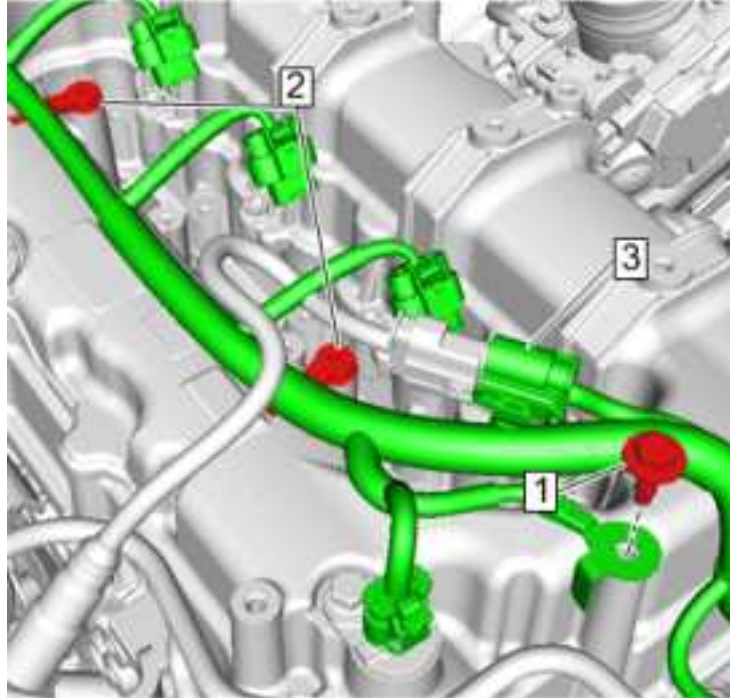


Fig. 38: Engine Wiring Harness Bolt And Retainer
 Courtesy of GENERAL MOTORS COMPANY

5. Remove Engine Wiring Harness Bolt.
6. Remove Engine Wiring Harness Retainer (2) - [2x]
7. Disconnect Electrical Connector (3).
8. Remove Air Cleaner Outlet Duct@Turbocharger - [Air Cleaner Outlet Duct Replacement](#)

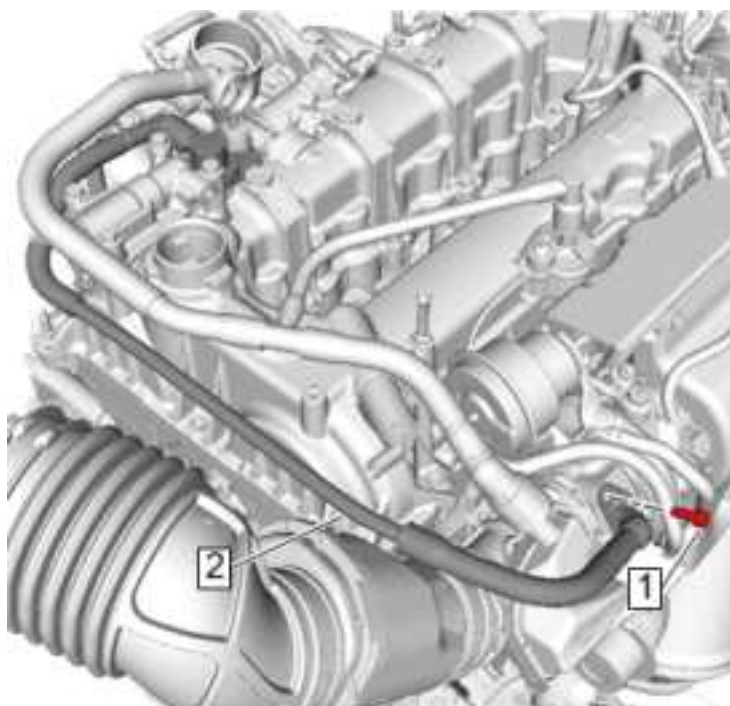


Fig. 39: PCV Valve Tube And Fastener
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The positive crankcase ventilation valve and tube assembly (2) are not reusable. If reinstalling the camshaft cover, do not remove the PCV valve and tube assembly (2) from the camshaft cover.

9. Remove the PCV valve tube fastener (1).
10. Remove Turbocharger Coolant Return Pipe - [Turbocharger Coolant Return Pipe Replacement \(LYX\)](#)
11. Remove Engine Lift Rear Bracket - [Engine Lift Rear Bracket Replacement](#)
12. Remove the oil level indicator.

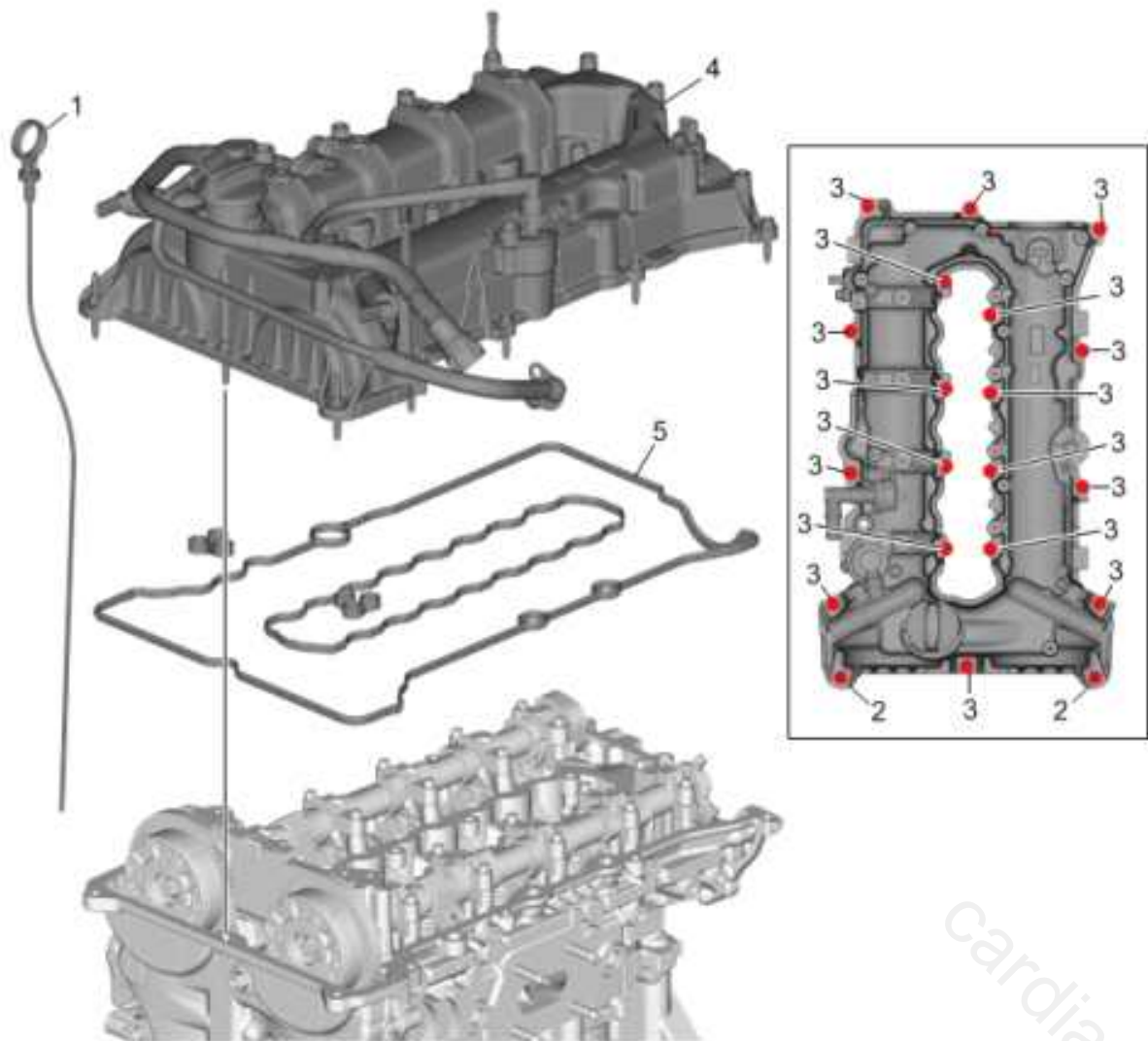


Fig. 40: Camshaft Cover and Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Remove the camshaft cover with the PCV tubes attached.

13. Remove Camshaft Cover (4) - [Camshaft Cover Removal](#)
14. If reinstalling the camshaft cover, clean and inspect the cover, replace seals, gaskets and transfer components as needed.
15. If replacing the camshaft cover, remove the following:
 1. Remove Camshaft Position Actuator Solenoid Valve - Intake - [Camshaft Position Actuator Solenoid Valve Replacement - Intake](#)
 2. Remove Camshaft Position Actuator Solenoid Valve - Exhaust - [Camshaft Position Actuator Solenoid Valve Replacement - Exhaust](#)
 3. Remove Camshaft Position Sensor - [Camshaft Position Sensor Replacement - Intake](#)
 4. Remove Camshaft Position Sensor - [Camshaft Position Sensor Replacement - Exhaust](#)
 5. Remove Camshaft Position Actuator Locating Pin Control Valve - [Camshaft Position Actuator Locating Pin Control Valve Replacement](#)

Installation Procedure

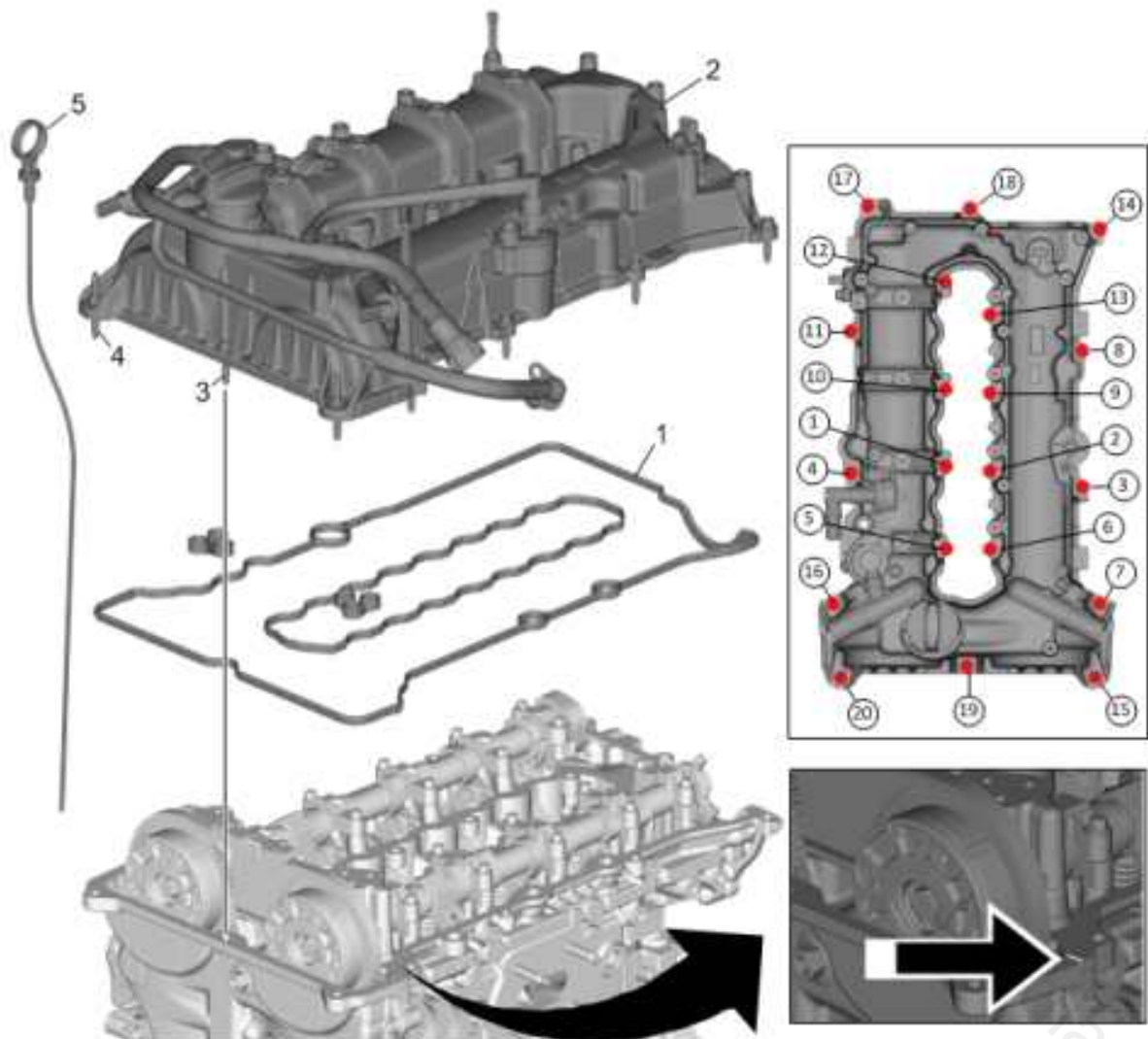


Fig. 41: Camshaft Cover With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

1. Install Camshaft Cover (2) [Camshaft Cover Installation](#)
2. If replacing the camshaft cover, install the following:
 1. Remove Camshaft Position Actuator Solenoid Valve - Intake - [Camshaft Position Actuator Solenoid Valve Replacement - Intake](#)
 2. Remove Camshaft Position Actuator Solenoid Valve - Exhaust - [Camshaft Position Actuator Solenoid Valve Replacement - Exhaust](#)
 3. Remove Camshaft Position Sensor - [Camshaft Position Sensor Replacement - Intake](#)
 4. Remove Camshaft Position Sensor - [Camshaft Position Sensor Replacement - Exhaust](#)
 5. Remove Camshaft Position Actuator Locating Pin Control Valve - [Camshaft Position Actuator Locating Pin Control Valve Replacement](#)
3. Install the oil level indicator.
4. Install Engine Lift Rear Bracket - [Engine Lift Rear Bracket Replacement](#)
5. Install Turbocharger Coolant Return Pipe - [Turbocharger Coolant Return Pipe Replacement \(LYX\)](#)

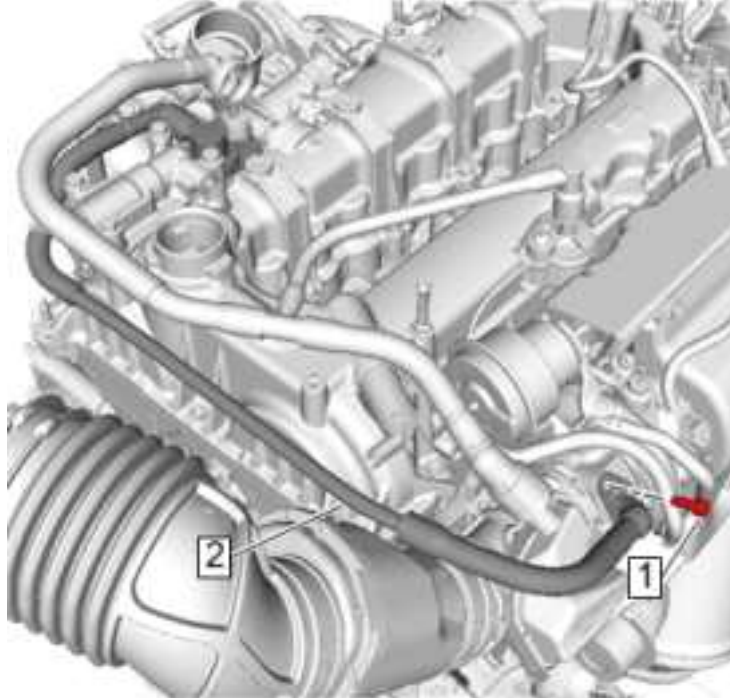


Fig. 42: PCV Valve Tube And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the PCV valve has been removed from the valve cover, replace the valve and tube assembly (2).

6. Install the PCV valve tube fastener (1). Tighten to 10 N.m (89 lb in)

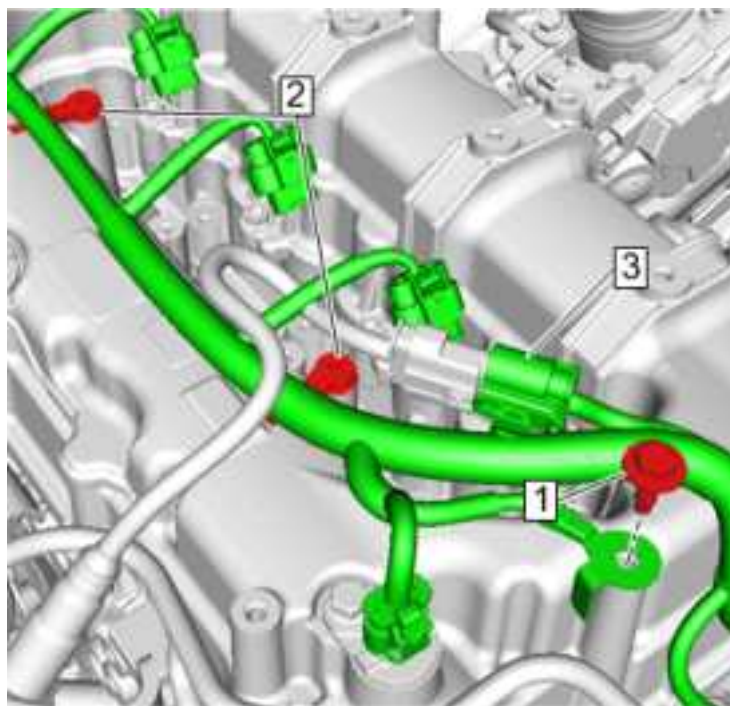


Fig. 43: Engine Wiring Harness Bolt And Retainer

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Wiring Harness Retainer (2)
8. Connect Electrical Connector (3)
9. Install Engine Wiring Harness Bolt (1) and tighten 9 N.m (80 lb in)
10. Install Air Cleaner Outlet Duct@Turbocharger - [Air Cleaner Outlet Duct Replacement](#)

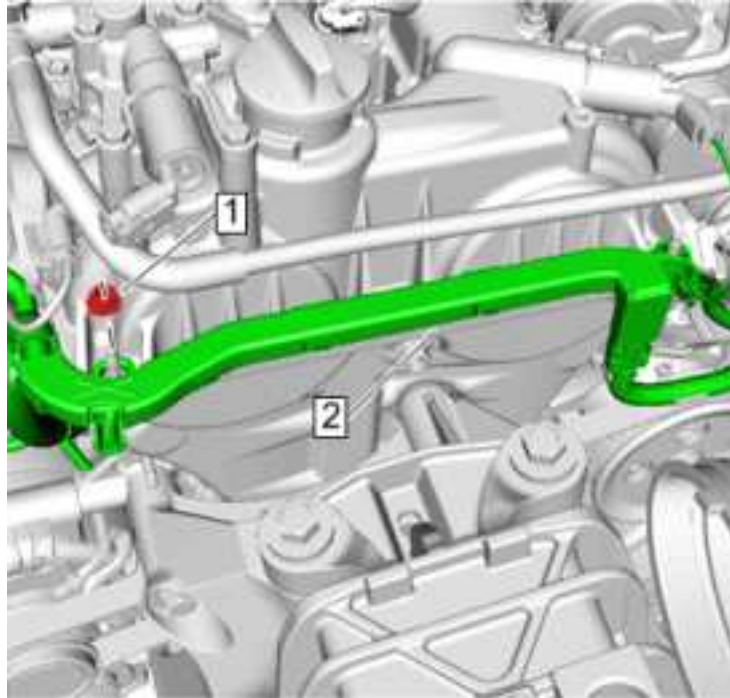


Fig. 44: Wiring Harness And Fastener

Courtesy of GENERAL MOTORS COMPANY

11. Reposition the wiring harness (2) then install and tighten the engine wiring harness bolt (1). 10 N.m (89 lb in)
12. Install Fuel Injection Fuel Rail Assembly - [Fuel Injection Fuel Rail Assembly Replacement](#)
13. Install Vacuum Pump Assembly - [Vacuum Pump Assembly Replacement](#)
14. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

CAMSHAFT POSITION ACTUATOR REPLACEMENT

Special Tools

- EN-45059 Torque Angle Sensor Kit
- EN-51367 Camshaft Locking Tool
- EN-51397 Timing Chain Retainer

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)
2. Remove Camshaft Cover - [Camshaft Cover Replacement](#)

NOTE: Perform step 3 if the Intake camshaft position actuator is being removed.

3. Remove Fuel Pump - [Fuel Pump Replacement](#)



Fig. 45: Crankshaft Balancer Markings

Courtesy of GENERAL MOTORS COMPANY

4. Adjust the engine to cylinder 1 top dead center (TDC) of the combustion stroke. Using the crankshaft balancer bolt (3), rotate the crankshaft in direction of engine rotation until the markings (1, 2) line up.

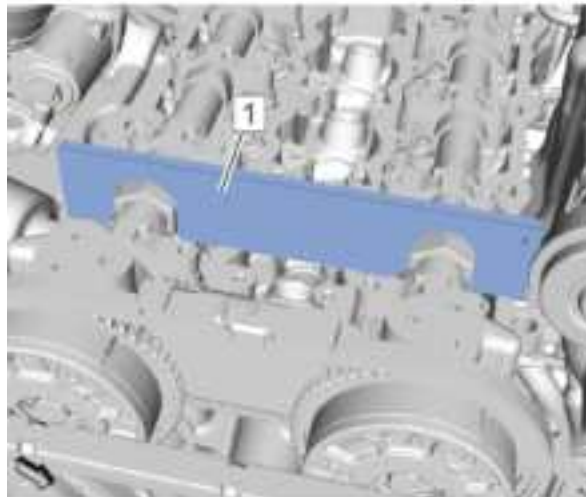


Fig. 46: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-51367** Camshaft Locking Tool (1).
6. Remove Timing Chain Upper Guide - [Timing Chain Upper Guide Replacement](#)



NOTE: The actuator marks (2) should be at the 12 O'clock position when cylinder 1 is at top dead center.

7. Mark the camshaft timing chain (1) at the corresponding actuator marks (2).

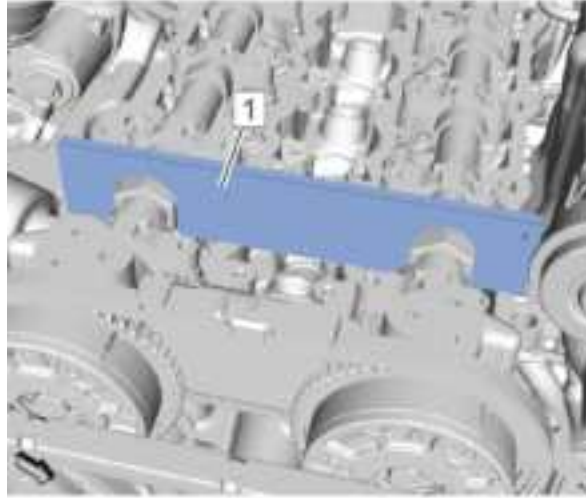


Fig. 48: Camshaft Holder
Courtesy of GENERAL MOTORS COMPANY

8. Remove EN-51367 Camshaft Locking Tool
9. Using a wrench rotate the intake camshaft clockwise, then release. Repeat this three times to relieve oil pressure from the tensioner.



Fig. 49: Camshaft Position Actuator Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do NOT remove or back out the camshaft position actuator bolt(s). Break them loose from their fully-torqued position. The position actuators must stay firmly attached until the retaining tools are in place, they should be broken loose while the chain is still tight and in position.

10. Loosen Camshaft Position Actuator Bolt (1)@Camshaft Position Actuator - [2x]

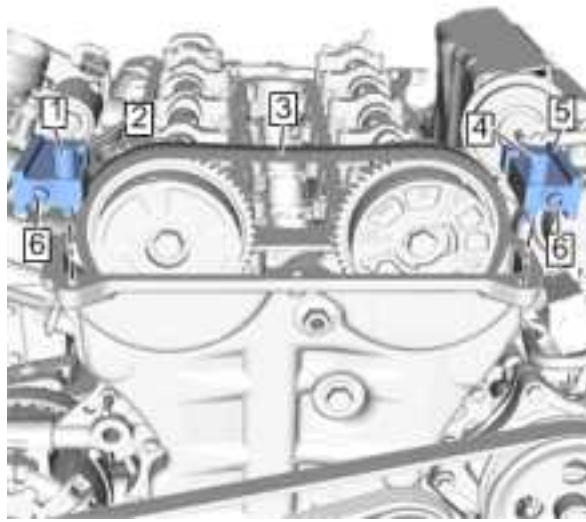


Fig. 50: Timing Chain Retainer And Camshaft Timing Chain
Courtesy of GENERAL MOTORS COMPANY

11. Pre-Install the **EN-51397-2** Timing Chain Retainer (2) to the intake side of the camshaft timing chain (3).
12. Pre-Install the **EN-51397-1** Timing Chain Retainer (5) to the exhaust side of the camshaft timing chain.
13. Hand tighten the thumb wheels (1, 4) securely.

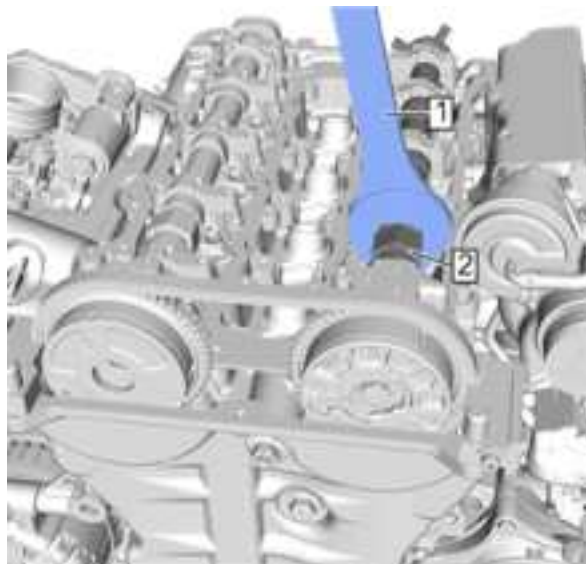


Fig. 51: Exhaust Camshaft And Wrench
Courtesy of GENERAL MOTORS COMPANY

CAUTION: The tightening force must be applied gently to the wrench. Using too much force will lead to an overlap of the timing chain that will cause severe engine damages.

14. Install a suitable wrench (1) at the exhaust camshaft (2).
15. Apply tension to the chain tensioner by rotating the exhaust camshaft counter-clockwise.

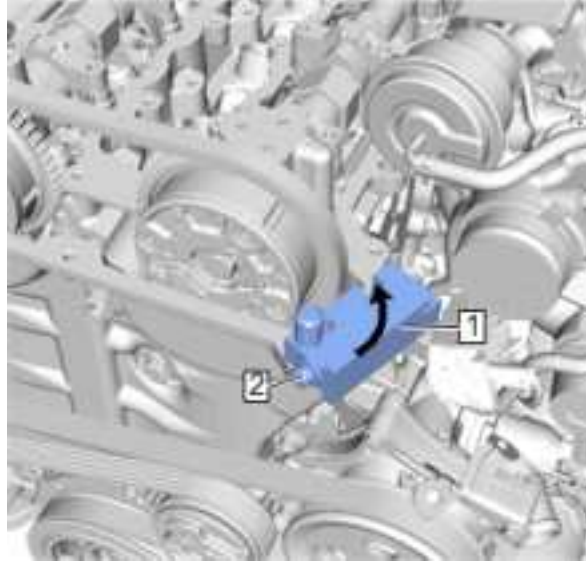


Fig. 52: Timing Chain Retainer And Bolt
Courtesy of GENERAL MOTORS COMPANY

16. While maintaining tension against the exhaust camshaft, install the **EN-51397-1** Timing Chain Retainer(1) to the exhaust side of the camshaft timing chain.

CAUTION: Refer to **Fastener Caution** .

17. Tighten bolt (2) of the **EN-51397-1** Timing Chain Retainer (1) to 5 N.m (44 lb in).
18. Remove the wrench from the exhaust camshaft, and apply to the intake camshaft.
19. Apply tension to the chain tensioner by slightly rotating the intake camshaft clockwise.

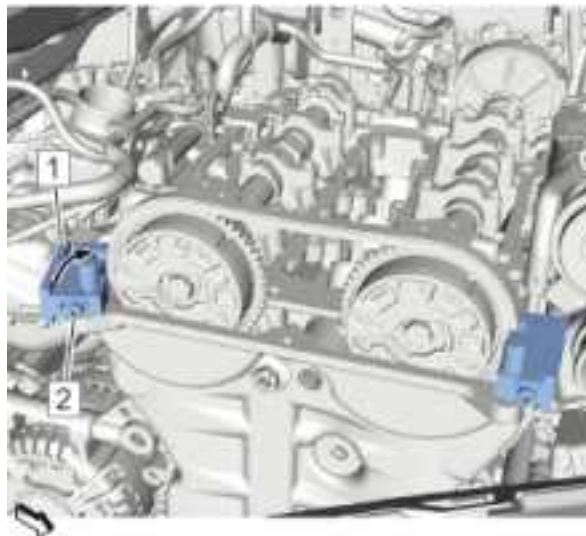


Fig. 53: Bolt And Retainer
Courtesy of GENERAL MOTORS COMPANY

20. While maintaining tension against the intake camshaft, install the **EN-51397-2** Timing Chain Retainer (1) to the intake side of the camshaft timing chain.
21. Tighten the bolt (2) of the **EN-51397-2** Timing Chain Retainer to N.m (lb in).
22. If removing the exhaust camshaft position actuator, proceed to step 28.



Fig. 54: Intake Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

23. Remove and DISCARD the intake camshaft position actuator bolt (1).

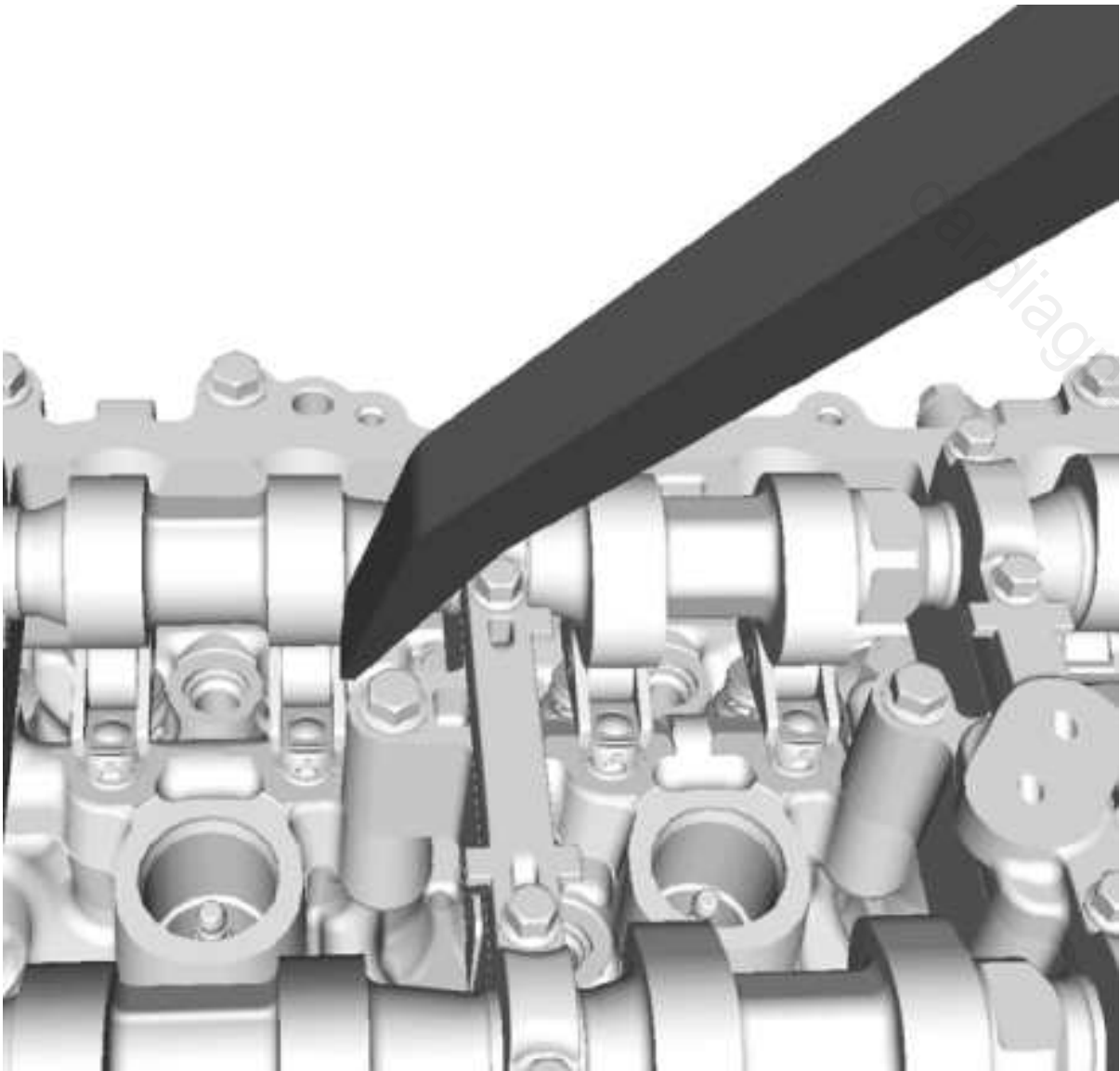


Fig. 55: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not pry against the face of the camshaft position actuators or the position actuator retaining bolts as the position actuators will be damaged.

24. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully pry the camshaft to move as far as possible toward the rear/flywheel end of the engine to help gain clearance for actuator removal.

NOTE: The camshaft timing chain will be held by the EN-51397 Timing Chain Retainers.

25. Pull the camshaft actuator straight back and off the nose of the camshaft, leaving it in place temporarily with the timing chain.

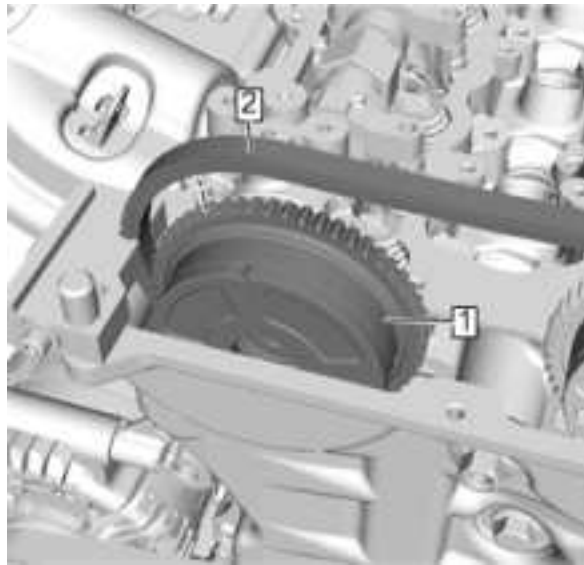


Fig. 56: Intake Camshaft Position Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

26. Disengage and lower the intake camshaft position actuator (1) from the timing chain (2).



Fig. 57: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

27. Remove Camshaft Position Actuator (1)

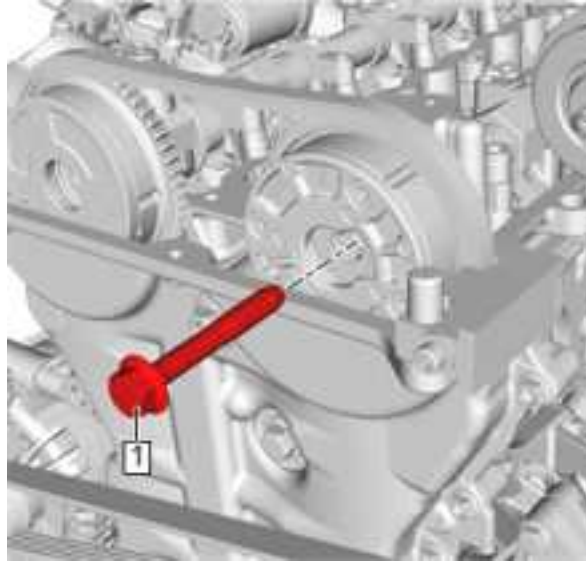


Fig. 58: Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

28. Remove and DISCARD the exhaust camshaft position actuator bolt (1).

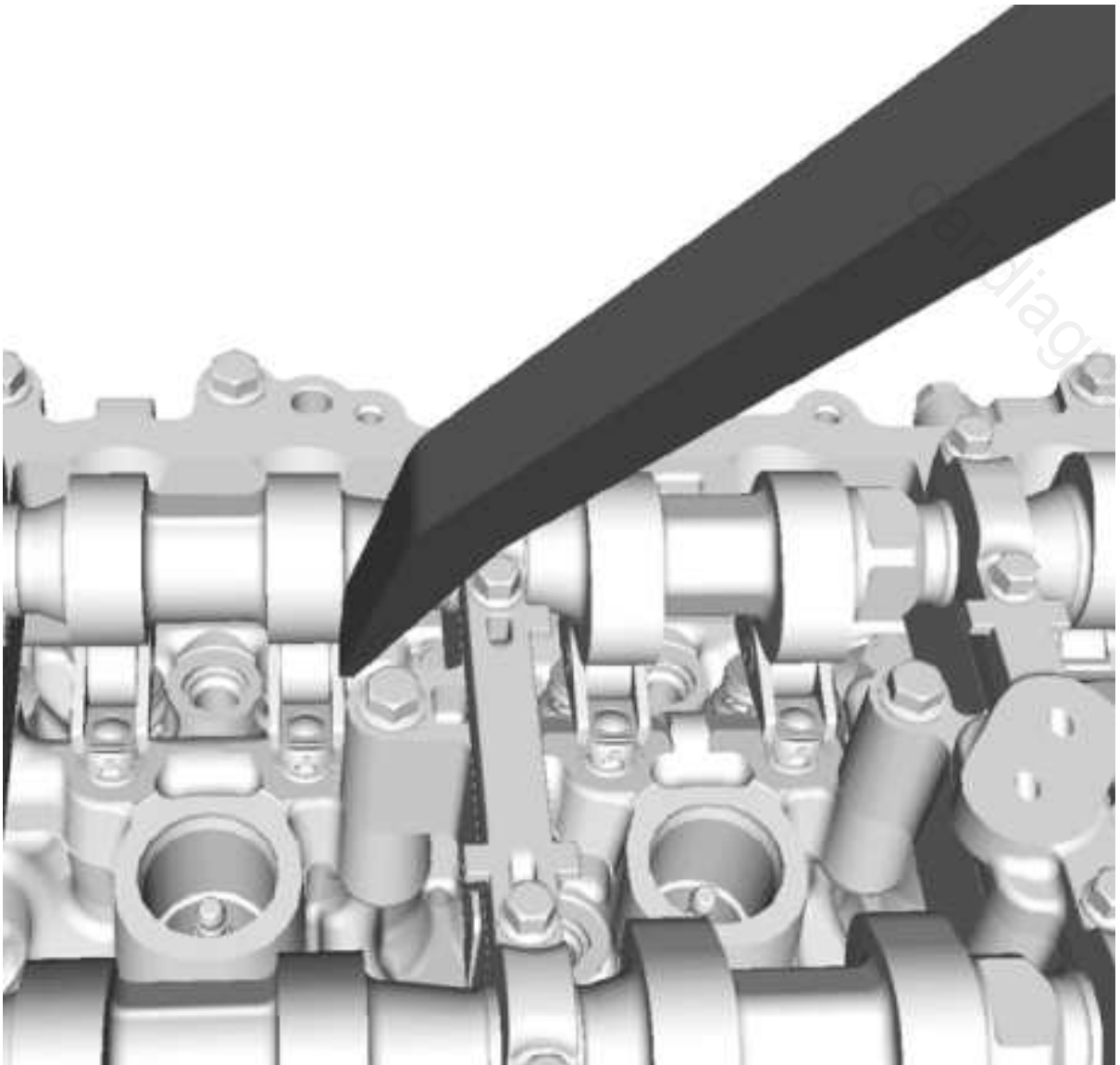


Fig. 59: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not pry against the face of the camshaft position actuators or the position actuator retaining bolts as the position actuators will be damaged.

29. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully pry the camshafts to move as far as possible toward the rear/flywheel end of the engine to help gain clearance for actuator removal.

NOTE: The camshaft timing chain will be held by the EN-51397 Timing Chain Retainers.

30. Pull the camshaft actuator straight back and off the nose of the camshaft, leaving it in place temporarily with the timing chain.

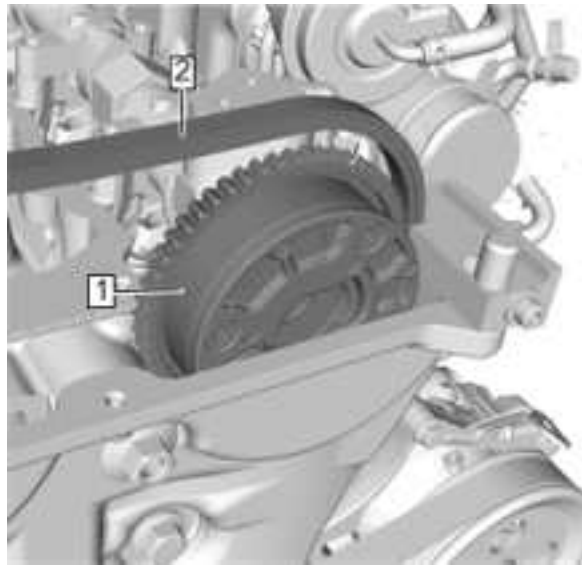


Fig. 60: Exhaust Camshaft Position Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

31. Disengage and lower the exhaust camshaft position actuator (1) from the timing chain (2)

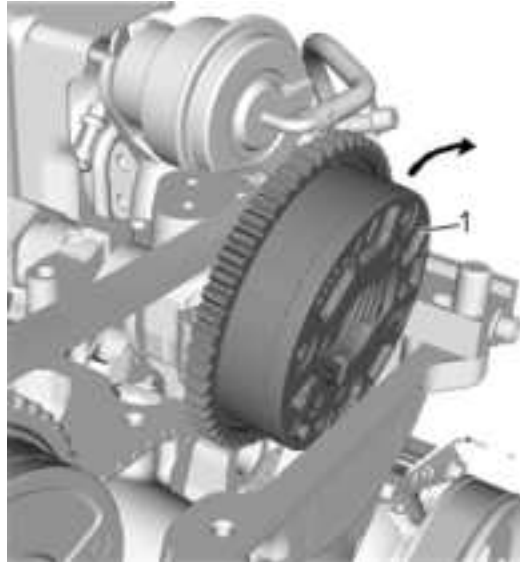


Fig. 61: Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

32. Remove Camshaft Position Actuator (1)

Installation Procedure

1. Apply lubricant to the back of the camshaft position actuators and front of the camshaft bearing cap. **Adhesives, Fluids, Lubricants, and Sealers**
2. If installing the intake camshaft position actuator, proceed to step 9.

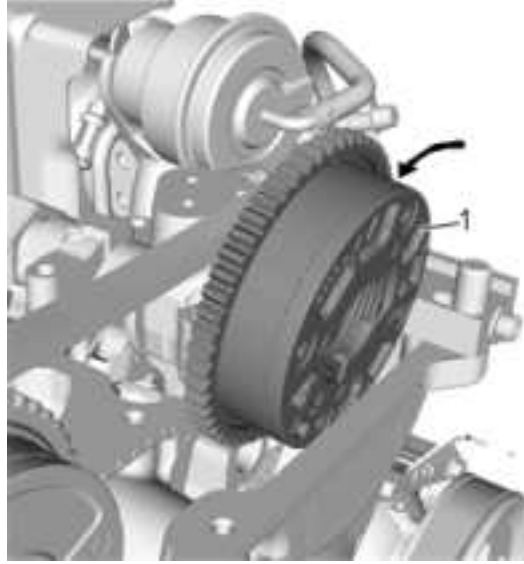


Fig. 62: Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

3. Lower the exhaust camshaft position actuator (1) into place below the timing chain (2)

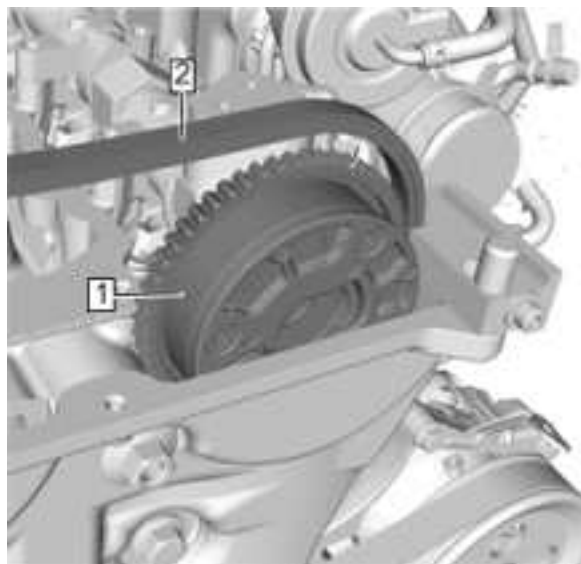


Fig. 63: Exhaust Camshaft Position Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: The timing mark on the camshaft position actuator needs to be aligned to the corresponding timing mark that was applied to the timing chain prior to removal of the camshaft position actuator.

4. Raise the exhaust camshaft position actuator (1) to engage the timing chain (2).

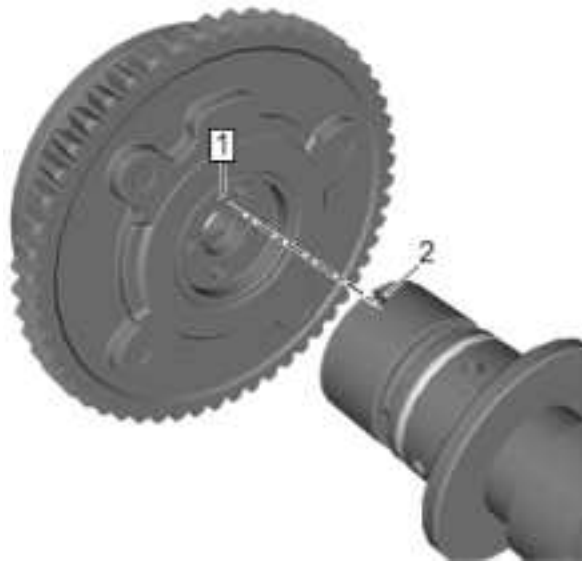


Fig. 64: Dowel Pin And Camshaft Slot
Courtesy of GENERAL MOTORS COMPANY

5. Adjust the camshaft until the dowel pin (1) aligns with the camshaft slot (2).

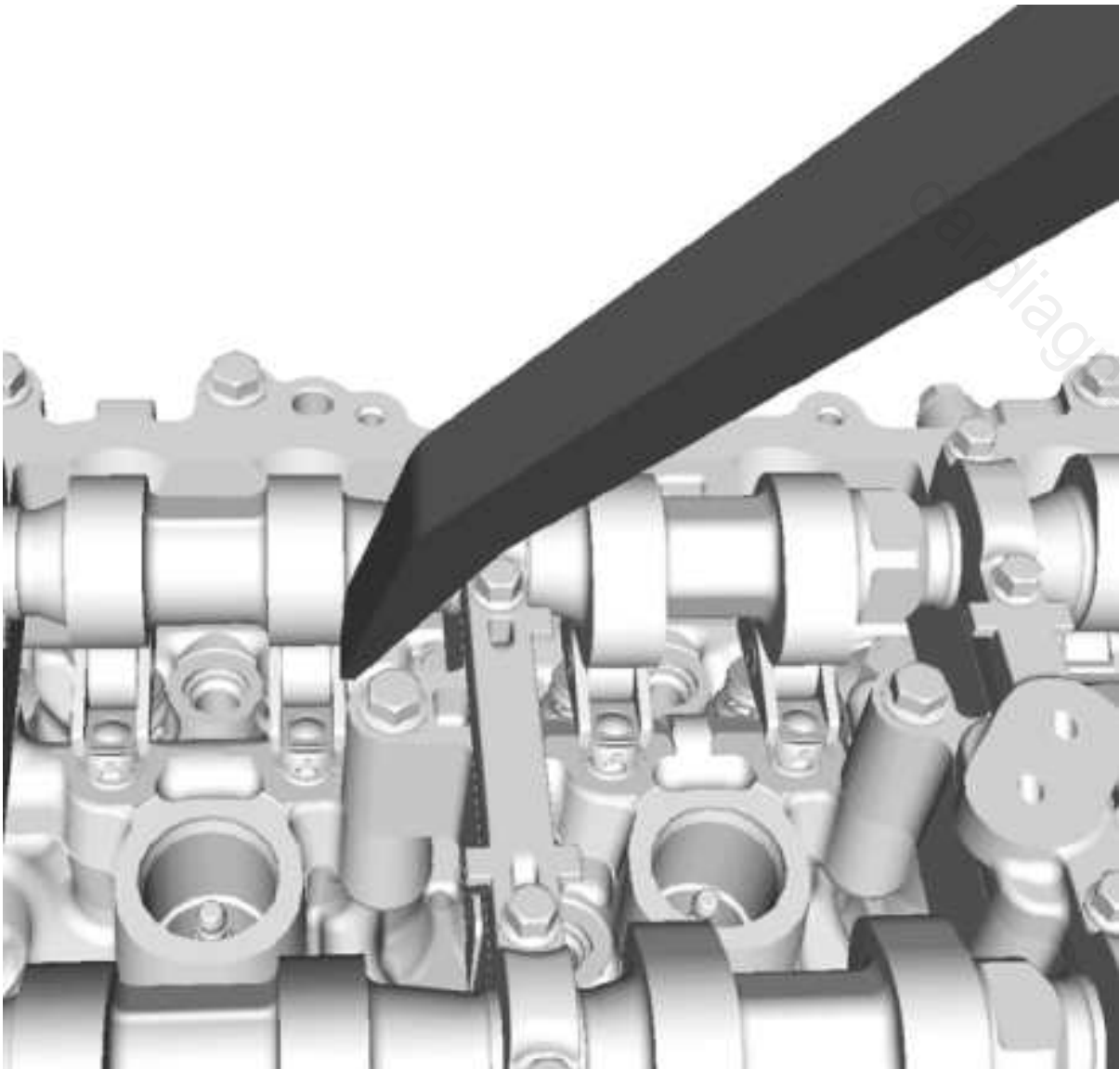


Fig. 65: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not pry against the face of the camshaft position actuators or the position actuator retaining bolts as the position actuators will be damaged.

6. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully pry the camshaft forward.
7. Ensure the exhaust camshaft position actuator is seated properly on the end of the camshaft.

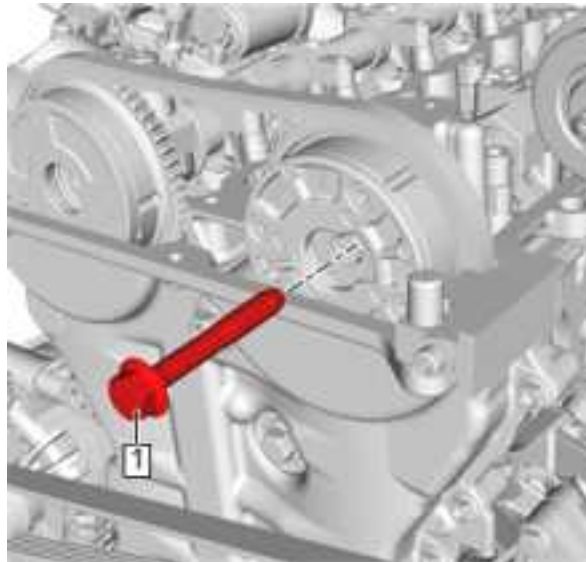


Fig. 66: Exhaust Camshaft Position Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the camshaft position actuator bolt snugly but do not torque at this step.

8. Install the NEW exhaust camshaft position actuator bolt (1).

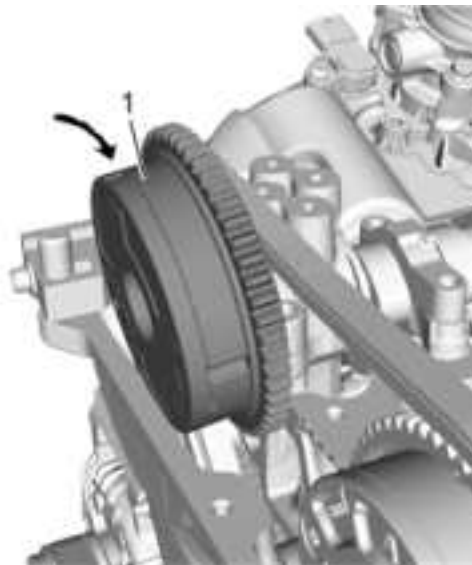


Fig. 67: Intake Camshaft Position Actuator
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

9. Lower the intake camshaft position actuator (1) into place below the timing chain.

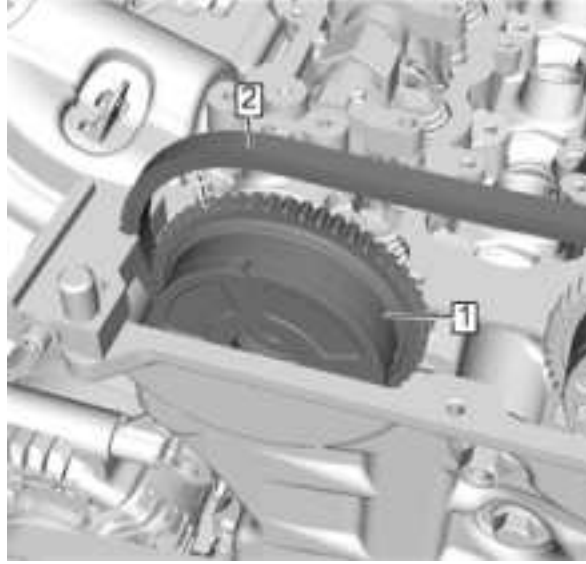


Fig. 68: Intake Camshaft Position Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: The timing mark on the camshaft position actuator needs to be aligned to the corresponding timing mark that was applied to the timing chain prior to removal of the camshaft position actuator.

10. Raise the intake camshaft position actuator (1) to engage the timing chain (2).



Fig. 69: Dowel Pin And Camshaft Slot
Courtesy of GENERAL MOTORS COMPANY

11. Adjust the camshaft until the dowel pin (1) aligns with the camshaft slot (2).

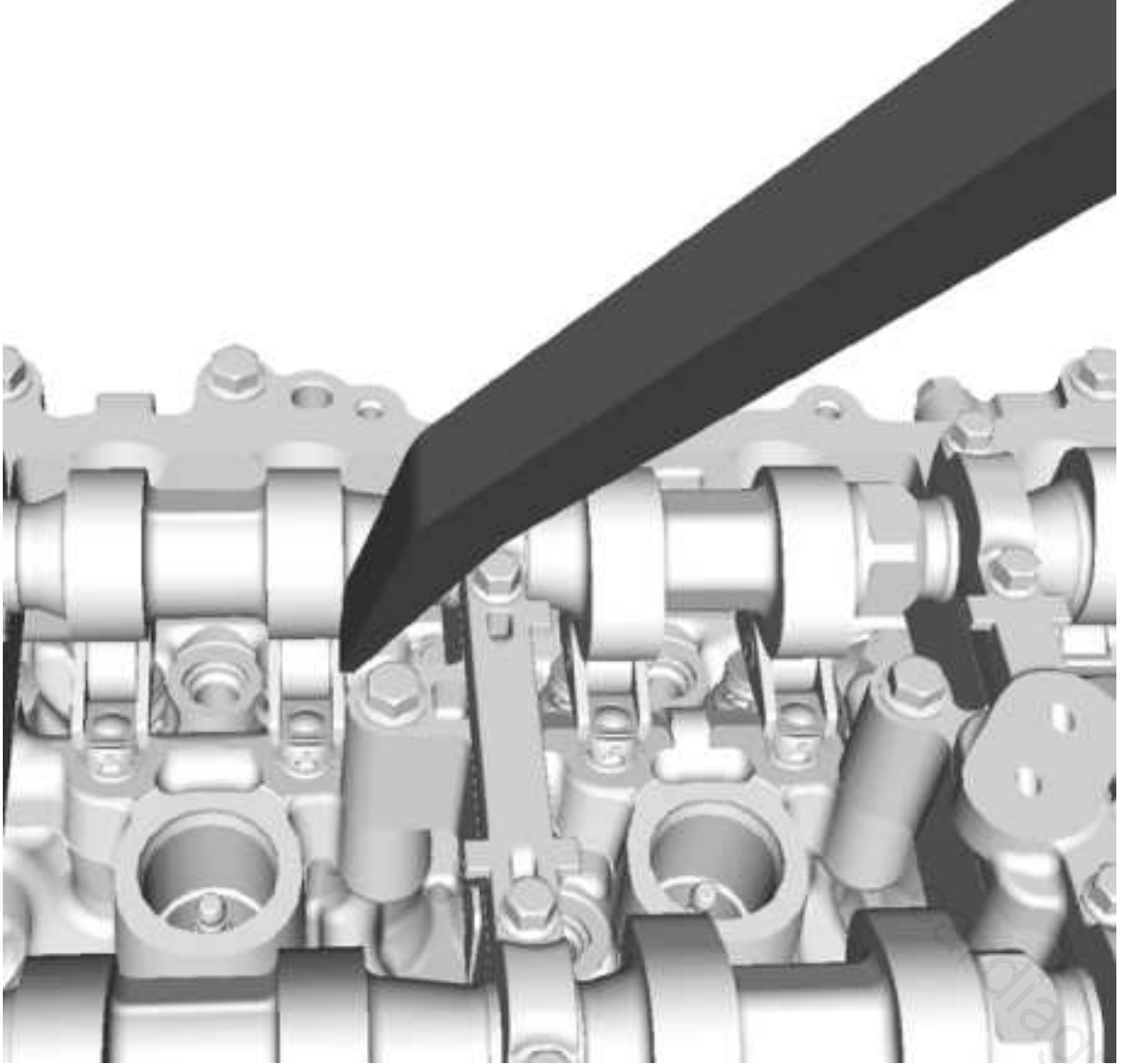


Fig. 70: Prying Camshaft Toward Rear/Flywheel End Of Engine
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not pry against the face of the camshaft position actuators or the position actuator retaining bolts as the position actuators will be damaged.

12. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully pry the camshaft forward.
13. Ensure the intake camshaft position actuator is seated properly on the end of the camshaft.



NOTE: Install the camshaft position actuator bolt snugly but to not torque at this step.

14. Install the NEW intake camshaft position actuator bolt (1).



Fig. 72: Camshaft Position Actuator Marks And Timing Chain Marks
Courtesy of GENERAL MOTORS COMPANY

15. Ensure the marks of the camshaft position actuators (2) are matched to the marks of the camshaft timing chain (1).

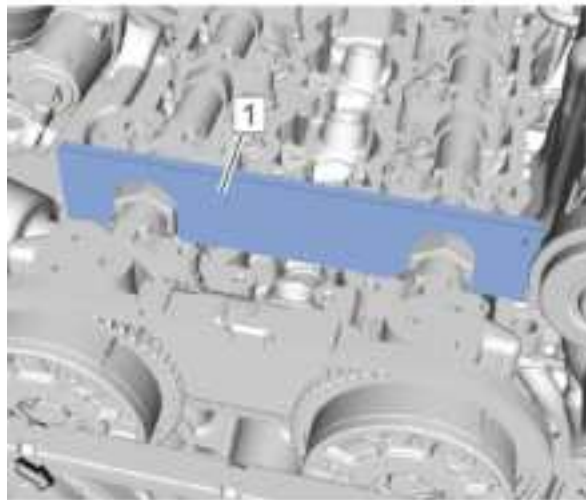


Fig. 73: Camshaft Holder
Courtesy of GENERAL MOTORS COMPANY

16. Install the **EN-51367** Camshaft Locking Tool (1).

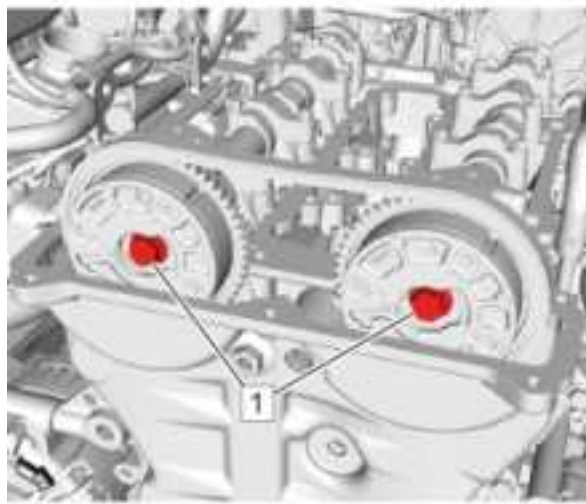


Fig. 74: Camshaft Position Actuator Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

NOTE: Counterhold the camshaft with a suitable tool.

17. Camshaft Position Actuator Bolt (1) - Tighten

Tighten

1. First pass to 20 N.m (15 lb ft)
2. Final pass to an additional 90 degrees using the **EN-45059** Torque Angle Sensor Kit

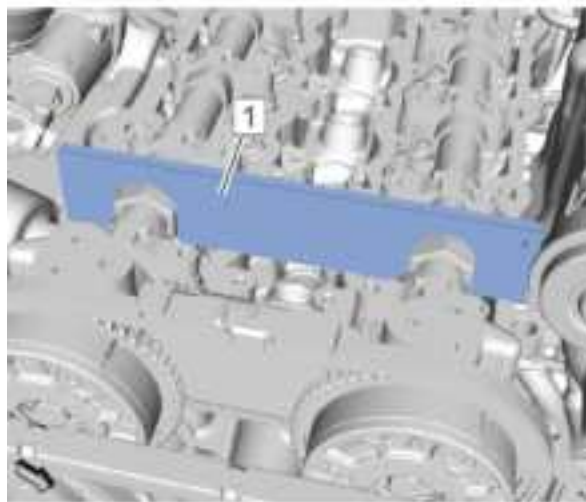


Fig. 75: Camshaft Holder
Courtesy of GENERAL MOTORS COMPANY

18. Remove the **EN-51367** Camshaft Locking Tool (1).

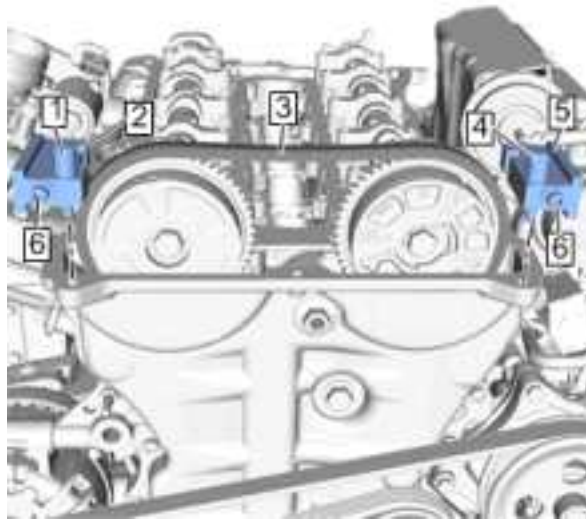


Fig. 76: Timing Chain Retainer And Camshaft Timing Chain
Courtesy of GENERAL MOTORS COMPANY

19. Loosen the bolt.(6)[2x]
20. Loosen the bolt.(1, 4)[2x]
21. Remove **EN-51397-2** Timing Chain Retainer (2).
22. Remove **EN-51397-1** Timing Chain Retainer (5).
23. Install Timing Chain Upper Guide - **Timing Chain Upper Guide Replacement**
24. Check the position of the crankshaft, camshaft and camshaft position actuator.

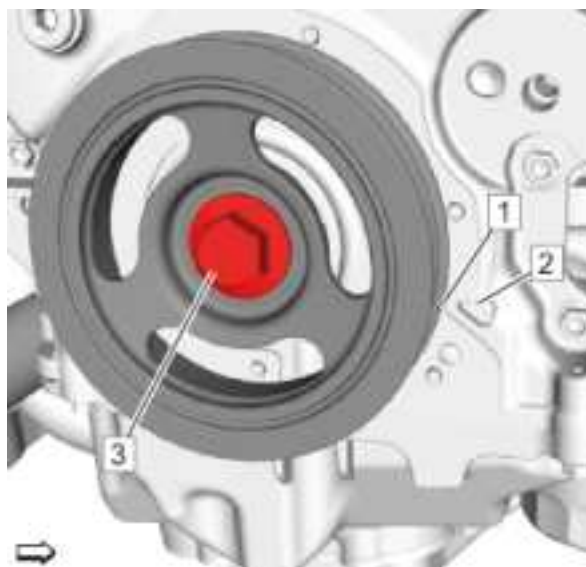


Fig. 77: Crankshaft Balancer Markings
Courtesy of GENERAL MOTORS COMPANY

25. Turn crankshaft 720 degrees in the direction of engine rotation using the crankshaft balancer bolt (3).
26. Adjust the engine to cylinder 1 TDC of combustion stroke. Using the crankshaft balancer bolt (3), rotate the crankshaft in direction of engine rotation until the markings (1, 2) line up.

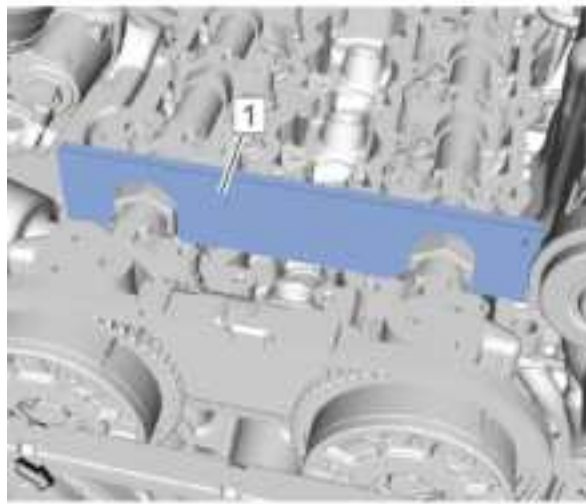


Fig. 78: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

27. Install the **EN-51367** Camshaft Locking Tool.
28. If the **EN-51367** Camshaft Locking Tool can be installed, the engine timing is properly adjusted.
29. Remove the **EN-51367** Camshaft Locking Tool

NOTE: Perform step 19 if the Intake camshaft position actuator was removed.

30. Install Fuel Pump - [Fuel Pump Replacement](#)
31. Install Camshaft Cover - [Camshaft Cover Replacement](#)
32. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

EXHAUST CAMSHAFT REPLACEMENT

Removal Procedure

1. Remove Camshaft Position Actuator - [Camshaft Position Actuator Replacement](#)

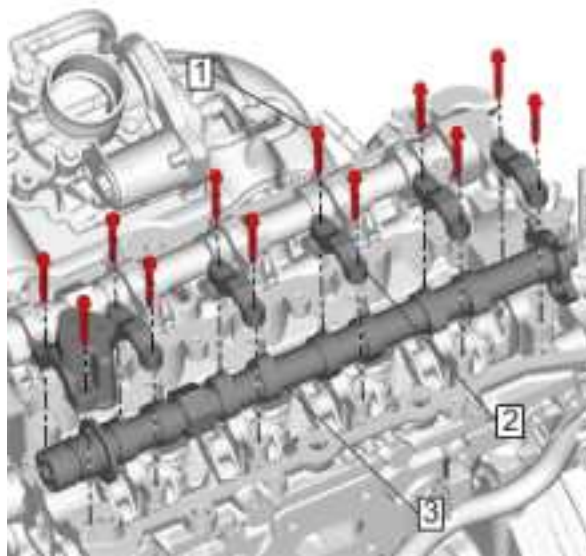


Fig. 79: Camshaft Bearing Caps And Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. Components **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts.

2. Tag or mark each part immediately after removal. Indicate location, direction, and orientation when necessary.
3. Loosen the 12 camshaft bearing cap bolts (1) 1/2 turn working from outside to inside in a spiral in direction.

NOTE: **Observe the markings on the bearing caps. Ensure that each bearing cap is marked in order to identify its location and direction.**

4. Remove the camshaft bearing cap bolts.(1)[12x]
5. Remove the camshaft bearing caps.(2)[6x]
6. Remove the exhaust camshaft.(3)

Installation Procedure

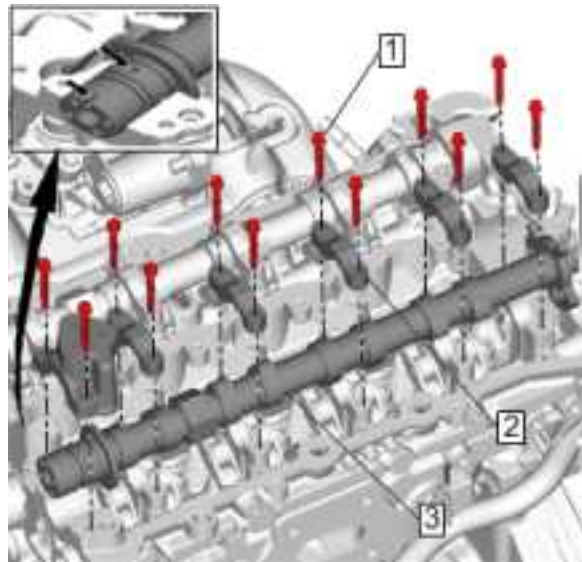


Fig. 80: Exhaust Camshaft

Courtesy of GENERAL MOTORS COMPANY

1. Coat the exhaust camshaft with engine oil. [Adhesives, Fluids, Lubricants, and Sealers](#)

NOTE: **Ensure that the camshaft notch at the front of the camshaft indicated by arrow is in the 12 O ' clock position before installing the camshaft caps.**

2. Install the exhaust camshaft (3) in the cylinder head.
3. Prior to installing the camshaft bearing caps, rotate the oil seal in the groove of the number one camshaft journal so that the split line is approximately at the 12 O ' clock position as indicated by the arrow.

NOTE: **Ensure the caps are installed in the original location and position.**

4. Lubricate the camshaft bearing caps (2) and the bolts (1) with clean engine oil. [Adhesives, Fluids, Lubricants, and Sealers](#)
5. Install the camshaft bearing caps.(2)[6x]
6. Hand start the 12 camshaft bearing cap bolts (1).

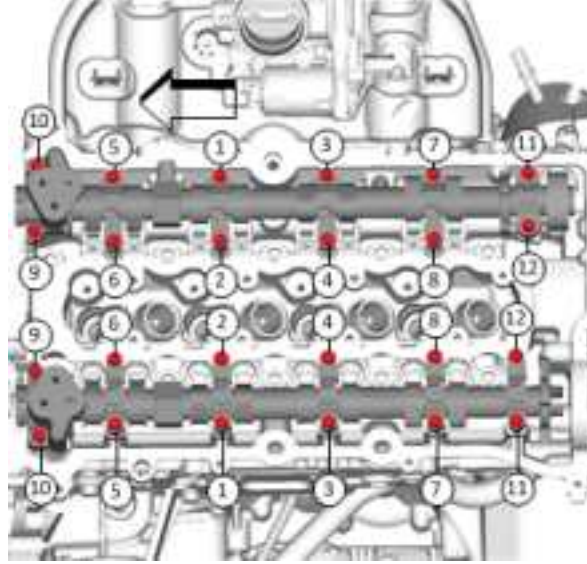


Fig. 81: Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

7. Tighten the bearing cap bolts (1) in sequence three turns each until the caps are seated.
8. Tighten the bearing cap bolts (1) in sequence as shown to 12 N.m (106 lb in).
9. Install Camshaft Position Actuator - [Camshaft Position Actuator Replacement](#)

INTAKE CAMSHAFT REPLACEMENT

Removal Procedure

1. Remove [Camshaft Position Actuator Replacement](#).

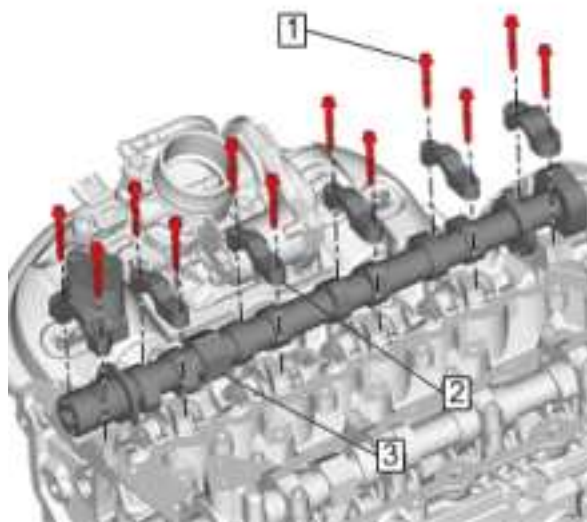


Fig. 82: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. Components **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts.

2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.
3. Loosen the 12 camshaft bearing cap bolts (1) 1/2 turn working from outside to inside in spiral steps.

NOTE: Observe the markings on the bearing caps. Ensure that each bearing cap is marked in order to identify its location and direction.

4. Remove the camshaft bearing cap bolts.(1)[12x]
5. Remove the camshaft bearing caps.(2)[6x]
6. Remove the intake camshaft.(3)

Installation Procedure

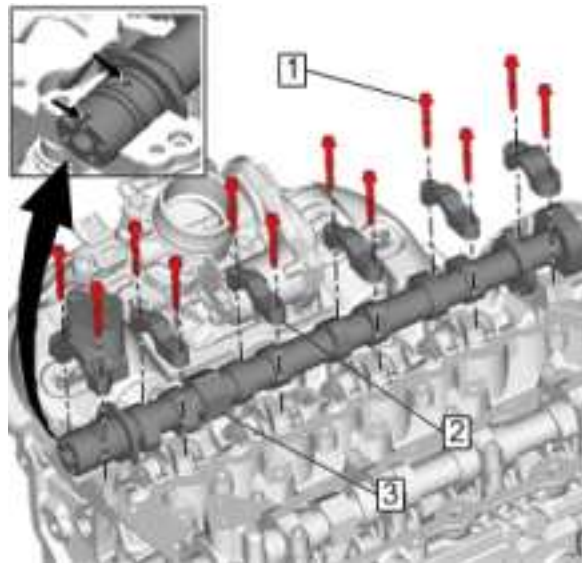


Fig. 83: Intake Camshaft

Courtesy of GENERAL MOTORS COMPANY

1. Coat the intake camshaft with engine oil. Refer to: [Adhesives, Fluids, Lubricants, and Sealers](#)

NOTE: Ensure that the camshaft notch at the front of the camshaft indicated by arrow is in the 12 O ' clock position before installing the camshaft caps.

2. Install the intake camshaft (3) in the cylinder head.
3. Prior to installing the camshaft bearing caps, rotate the oil seal in the groove of the number one camshaft journal so that the split line is approximately at the 12 O ' clock position as indicated by the arrow

NOTE: Ensure the caps are installed in the original location and position.

4. Lubricate the camshaft bearing caps (2) and the bolts (1) with clean engine oil. Refer to: [Adhesives, Fluids, Lubricants, and Sealers](#)
5. Install the camshaft bearing caps.(2)[6x]
6. Hand start the 12 camshaft bearing cap bolts (1).

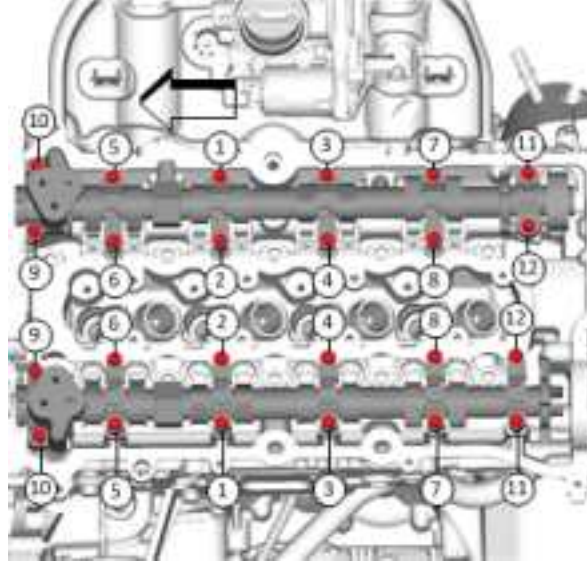


Fig. 84: Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution.

7. Tighten the bearing cap bolts (1) in sequence three turns each until the caps are seated.
8. Tighten the bearing cap bolts in sequence as shown to 12 N.m (106 lb in).
9. Install **Camshaft Position Actuator Replacement**.

CAMSHAFT TIMING CHAIN REPLACEMENT

Special Tools

EN-51367 Camshaft Holder

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Remove Camshaft Cover Replacement.



Fig. 85: Crankshaft Balancer Markings
Courtesy of GENERAL MOTORS COMPANY

NOTE: Adjust the engine to cylinder 1 top dead center (TDC) of combustion stroke. Set crankshaft in direction of engine rotation until the markings (1, 2) line up.

2. Rotate at the crankshaft balancer bolt (3).

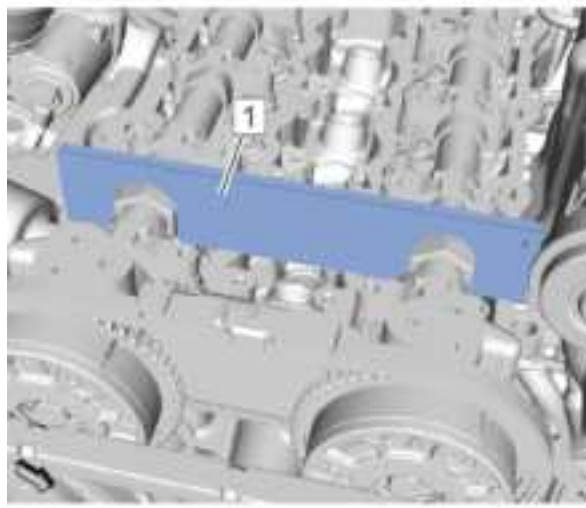


Fig. 86: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

3. Install the **EN-51367** holder (1).
4. Remove [Engine Front Cover Replacement](#)
5. Remove [Timing Chain Upper Guide Replacement](#)

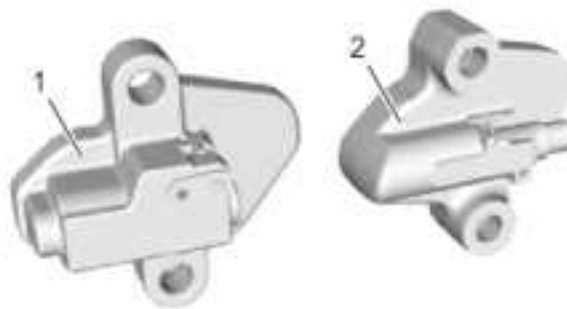


Fig. 87: Tensioner Designs

Courtesy of GENERAL MOTORS COMPANY

6. The engine has one of the two tensioner designs (1, 2). Each design has a different release mechanism and position.

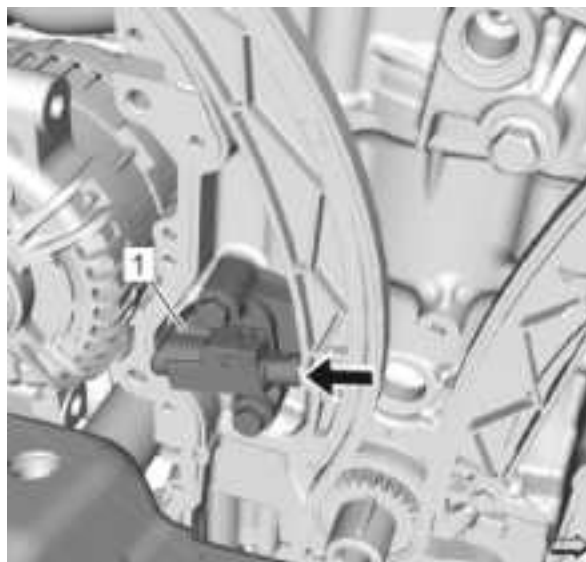


Fig. 88: Timing Chain Tensioner In Service Position
Courtesy of GENERAL MOTORS COMPANY

7. Fix the timing chain tensioner with design 1 (1) in service position:

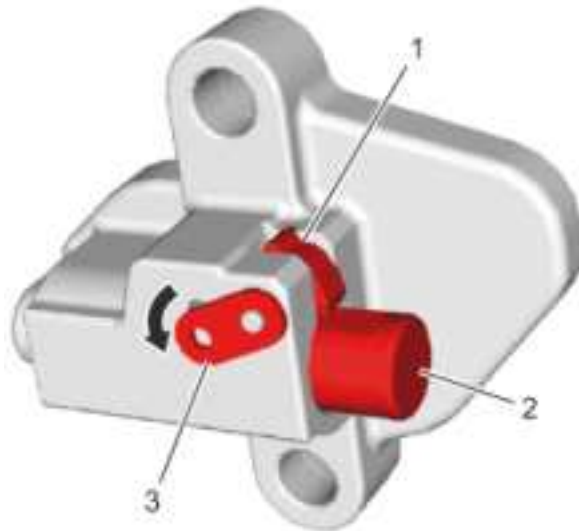


Fig. 89: Releasing Tension From Piston
Courtesy of GENERAL MOTORS COMPANY

1. Slightly release tension from the piston (2) until bar (1) can be unlocked by rotating the lever (3) in direction of arrow.

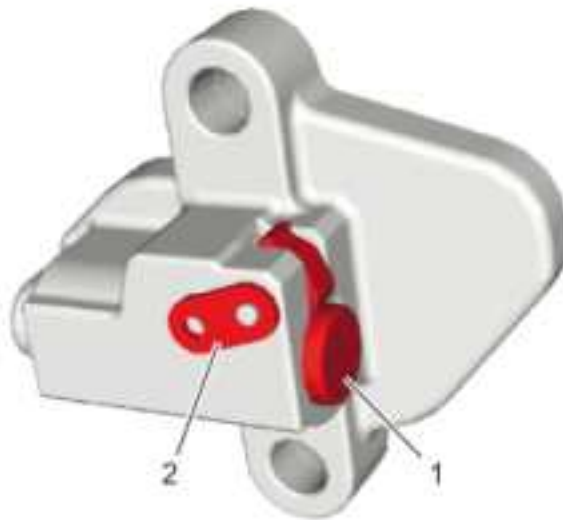


Fig. 90: Pushing Back Piston
Courtesy of GENERAL MOTORS COMPANY

2. Entirely push back the piston (1) until the tensioner lever (2) cannot be locked in this position.

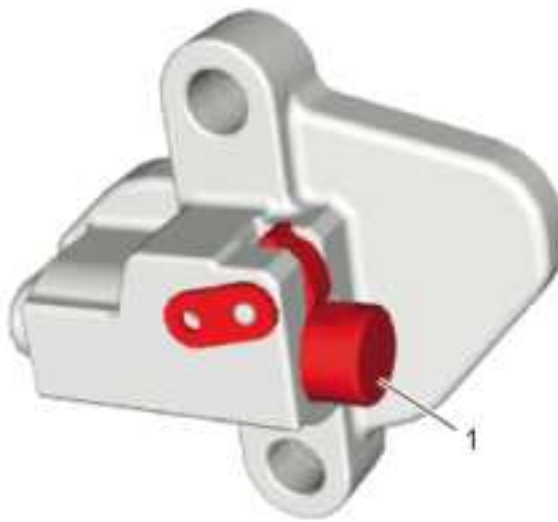


Fig. 91: Piston

Courtesy of GENERAL MOTORS COMPANY

3. Release tension from the piston (1) until it releases for three ratchets. The three ratchets can be noticed by the click noises.

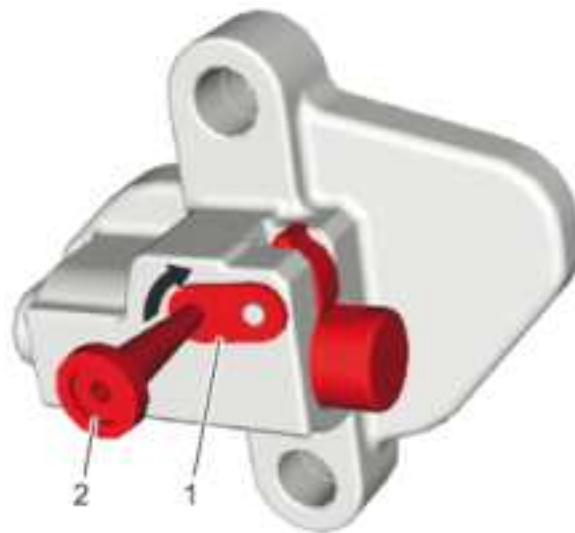


Fig. 92: Lever And Fixing Pin

Courtesy of GENERAL MOTORS COMPANY

4. Apply tension to the piston until the lever (1) is rotated back into the locking position where the bore in the lever aligns with the bore in the tensioner housing.
5. Fix the lever in this position with a suitable fixing pin (2).

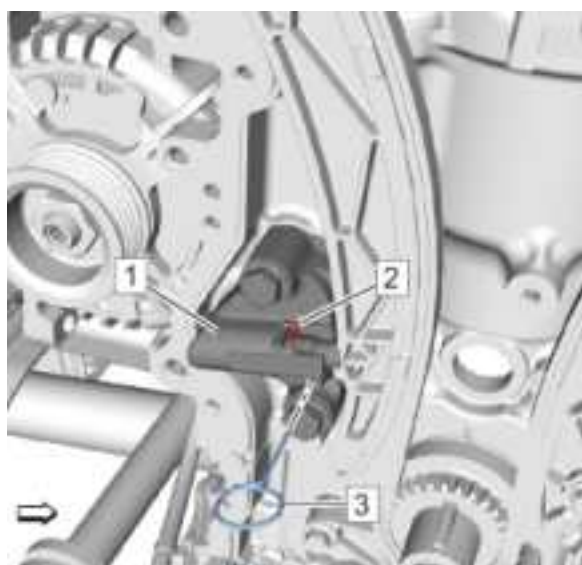


Fig. 93: Tensioner Design 2

Courtesy of GENERAL MOTORS COMPANY

6. The style of tensioner design 2 (1) can be released by using a punch and pressing on the release clip (2).
7. Secure the timing chain tensioner with suitable sized drill bit (3).

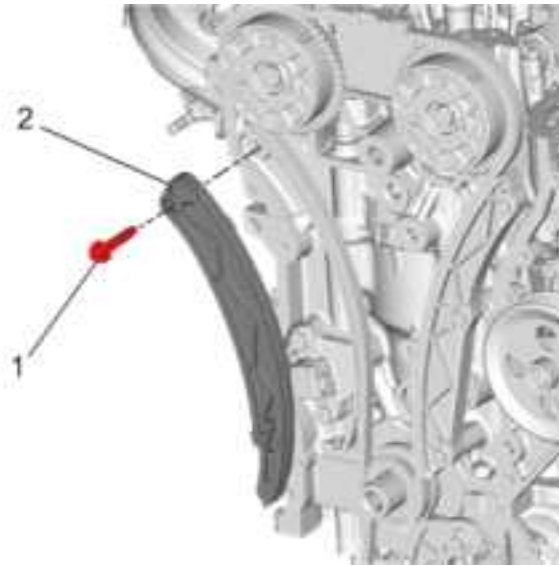


Fig. 94: Timing Chain Tensioner Shoe Fastener

Courtesy of GENERAL MOTORS COMPANY

8. Remove Timing Chain Tensioner Shoe Bolt(1)
9. Remove Timing Chain Tensioner Shoe(2)

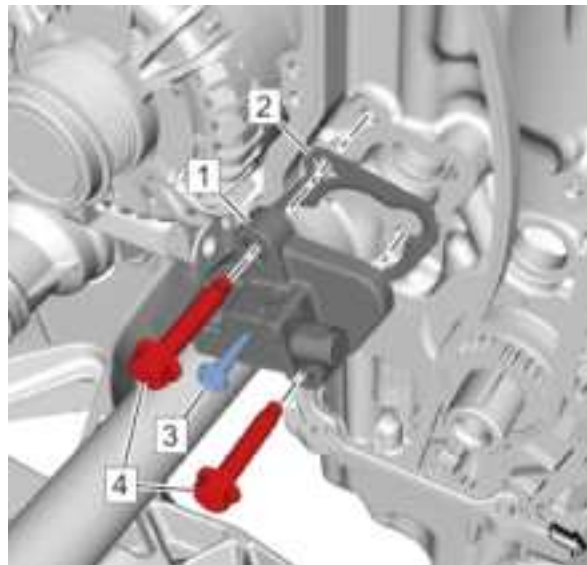


Fig. 95: Timing Chain Tensioner Tool, Timing Chain Tensioner, Bolts And Gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: Both tensioner designs have the same removal procedure. Each tensioner design uses a different fixing procedure and fixing tool see steps 7.1 - 7.7.

10. Ensure the correct fixation of the tool (3) is used.
11. Remove Timing Chain Tensioner Bolt (4)
12. Remove Timing Chain Tensioner (1)
13. Remove and DISCARD the gasket. (2)

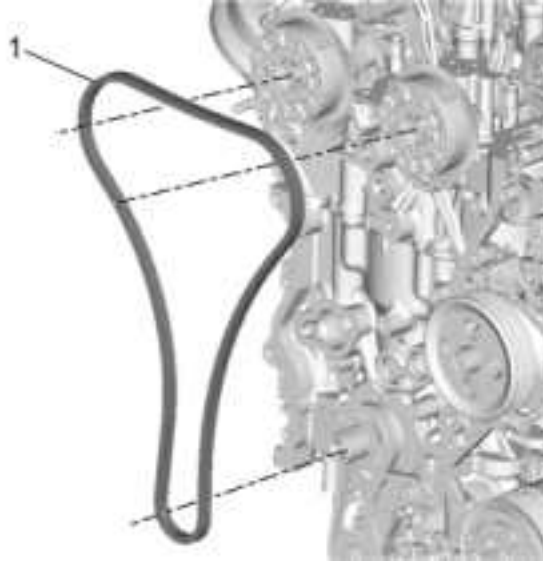


Fig. 96: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

14. Remove Timing Chain (1)
15. If reinstalling timing components, clean and inspect as needed prior to reinstalling. [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#)

Installation Procedure

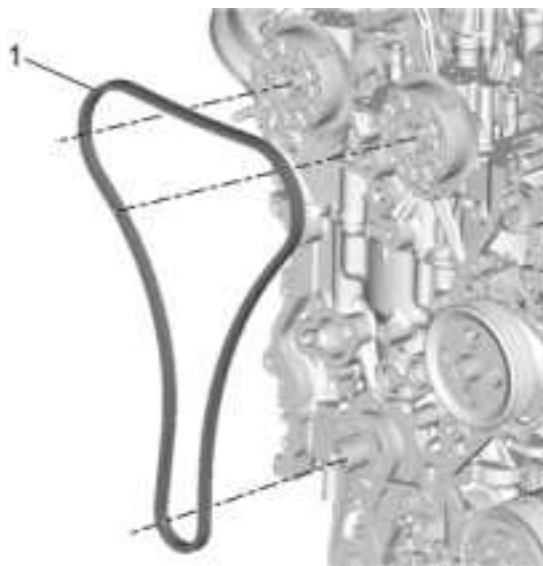


Fig. 97: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the actuator timing marks are approximately the 12 O'clock position.

1. Install Timing Chain (1).

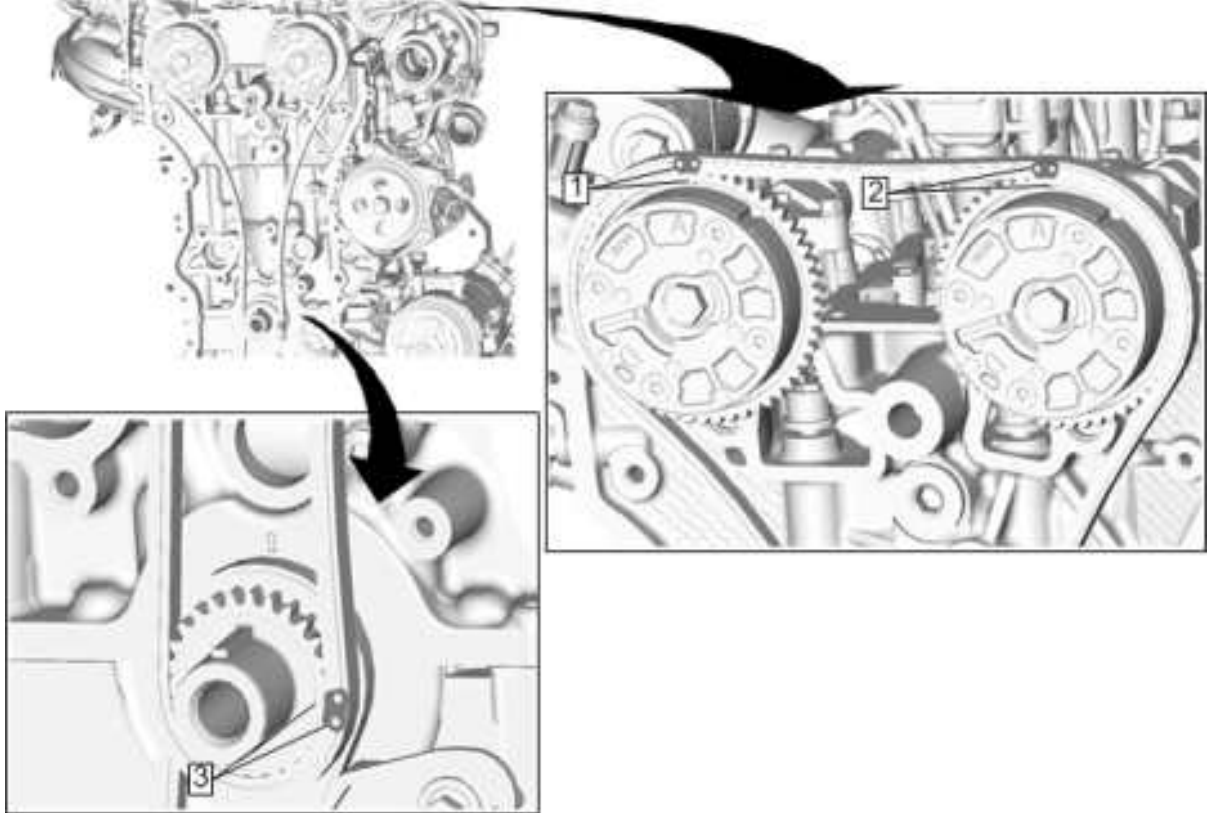


Fig. 98: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

2. Ensure that the colored link (3) matches to the arrow on the crankshaft sprocket.
3. Ensure that the colored links (1, 2) match to the marks on the camshaft position adjuster actuators.

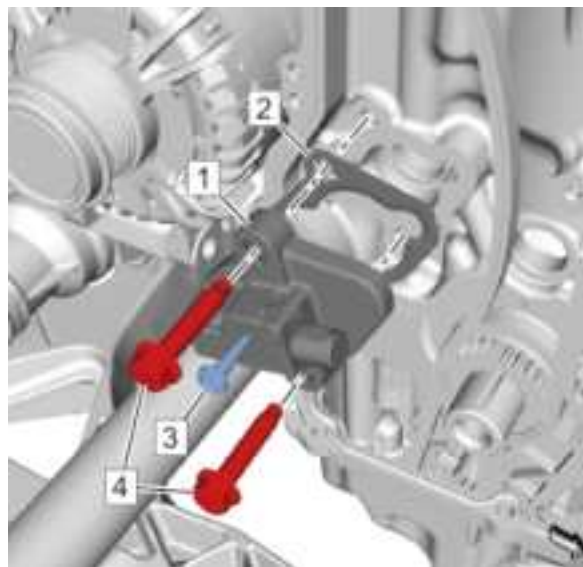


Fig. 99: Timing Chain Tensioner Tool, Timing Chain Tensioner, Bolts And Gasket

Courtesy of GENERAL MOTORS COMPANY

4. Install a NEW gasket.(2)
5. Install Timing Chain Tensioner(1).

CAUTION: Refer to **Fastener Caution** .

6. Install Timing Chain Tensioner Bolt (4) and tighten 25 N.m (18 lb ft)[2x].

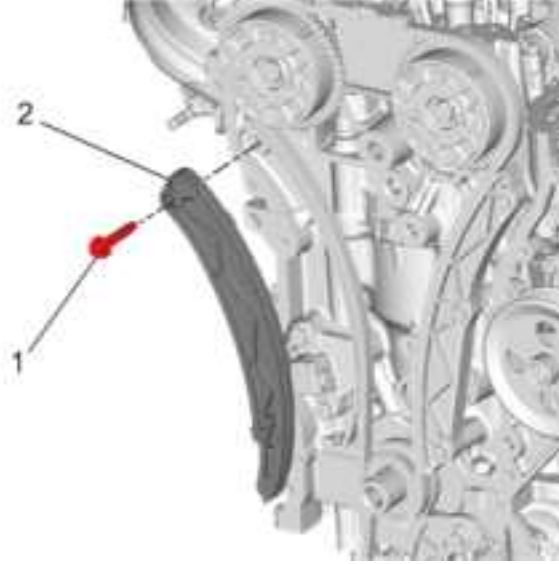


Fig. 100: Timing Chain Tensioner Shoe Fastener
Courtesy of GENERAL MOTORS COMPANY

7. Install Timing Chain Tensioner Shoe (2)
8. Install Timing Chain Tensioner Shoe Bolt (1) and tighten 25 N.m (18 lb ft)
9. Remove the suitable tool from the timing chain tensioner.

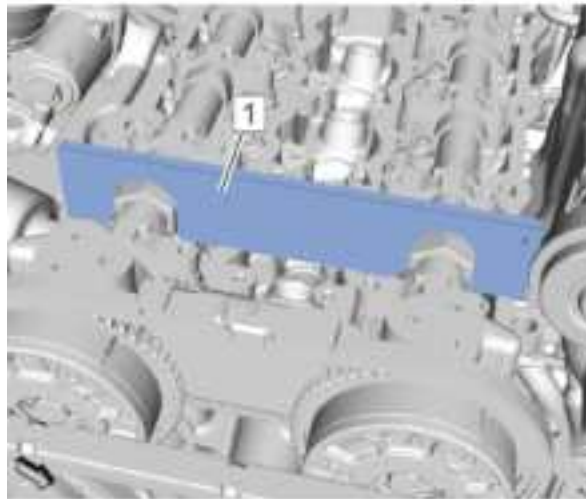


Fig. 101: Camshaft Holder
Courtesy of GENERAL MOTORS COMPANY

10. Remove the **EN-51367** holder (1).
11. Install **Timing Chain Upper Guide Replacement**.
12. Check the position of the crankshaft, camshaft and camshaft position actuator adjuster.
 1. Install the engine front cover with 4 bolts and the crankshaft balancer.



Fig. 102: Crankshaft Balancer Markings
Courtesy of GENERAL MOTORS COMPANY

2. Turn crankshaft 720 degrees in the direction of engine rotation by the crankshaft balancer bolt (2).

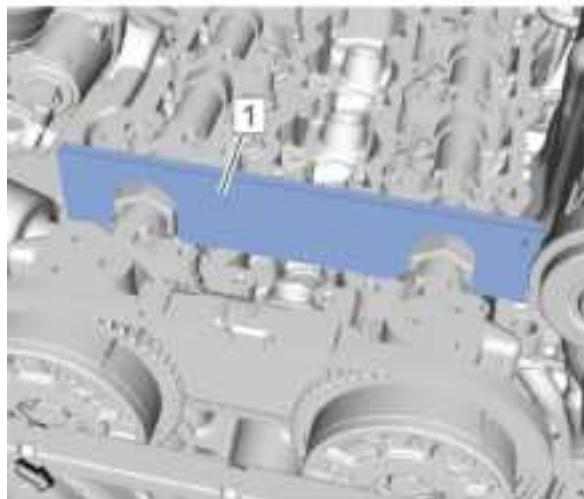


Fig. 103: Camshaft Holder
Courtesy of GENERAL MOTORS COMPANY

13. Install the **EN-51367** holder (1).
14. If the **EN-51367** holder (1) can be installed, the engine timing is properly adjusted.
15. Remove the **EN-51367** holder.
16. Remove the engine front cover and crankshaft balancer.
17. Install [Engine Front Cover Replacement](#)
18. Install [Camshaft Cover Replacement](#)

CAMSHAFT TIMING CHAIN INSPECTION

Special Tools

EN-51367 Camshaft Holder

Equivalent regional tools: [Special Tools](#)

1. Remove Camshaft Cover - [Camshaft Cover Replacement](#)
2. Remove Front Wheelhouse Liner-Right Side - [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#) [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)



Fig. 104: Crankshaft Balancer Markings

Courtesy of GENERAL MOTORS COMPANY

3. Adjust the engine to cylinder 1 top dead center (TDC) of combustion stroke. Using the balancer bolt (3) rotate the crankshaft in direction of engine rotation until the markings (1, 2) line up.

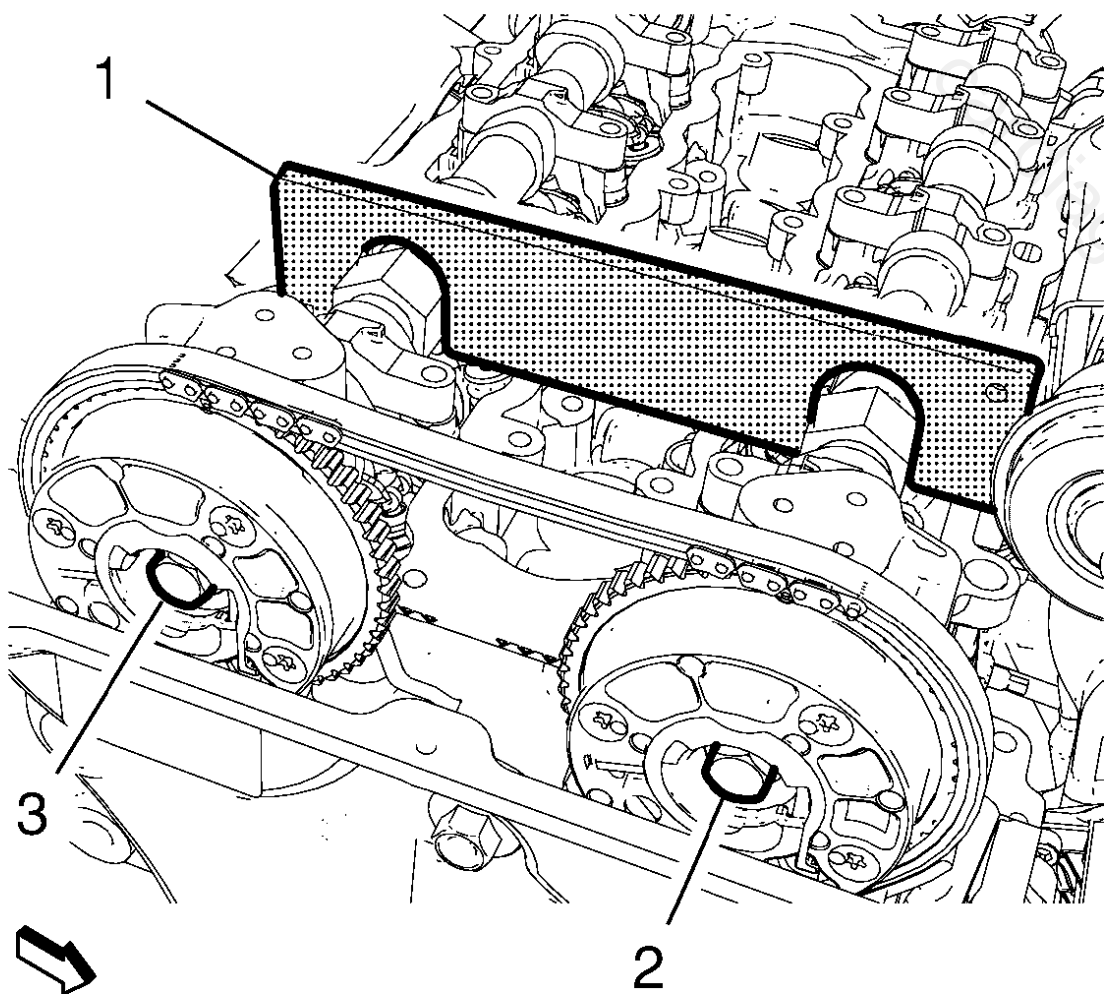


Fig. 105: Holder

Courtesy of GENERAL MOTORS COMPANY

4. Install the EN-51367 holder (1).

NOTE: The marks of the camshaft position actuators must be at the 12 O'clock position.

5. If the **EN-51367** holder (1) can be installed, the engine timing is properly adjusted.
6. If the **EN-51367** holder (1) can't be installed, inspect for wear, damage and proper installation of the timing chain components and replace as necessary. [Camshaft Timing Chain Replacement](#)
7. Remove the **EN-51367** holder (1).
8. Install Camshaft Cover - [Camshaft Cover Replacement](#)
9. Install Front Wheelhouse Liner-Right Side - [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#) [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)

TIMING CHAIN OIL NOZZLE REPLACEMENT

Removal Procedure

1. Remove the engine front cover. [Engine Front Cover Replacement](#)
2. Reset the tensioner plunger and inspect for proper operation. [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#)

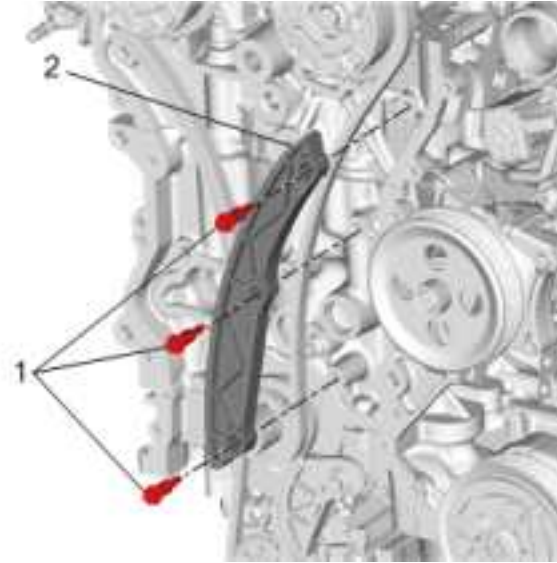


Fig. 106: Timing Chain Guide And Fasteners
Courtesy of GENERAL MOTORS COMPANY

3. Remove the timing chain guide fasteners (1) then remove the timing chain guide (2). [Timing Chain Upper Guide Replacement](#)

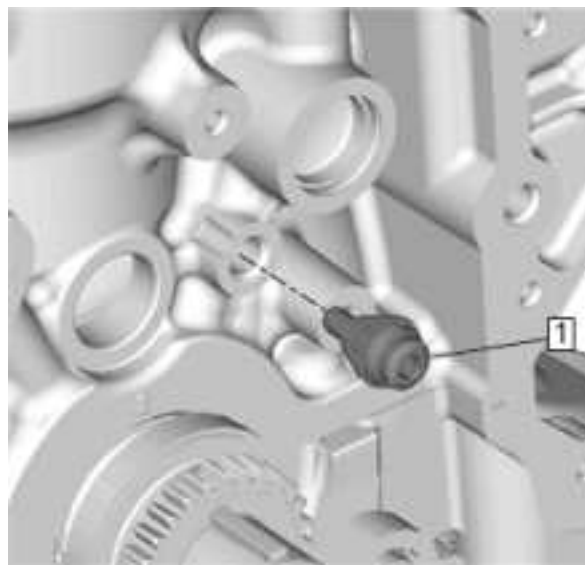


Fig. 107: Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS COMPANY

4. Remove the timing chain oil nozzle (1).
5. For camshaft timing chain, oil nozzle, sprocket and tensioner cleaning and inspection, refer to [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#).

1. Ensure that the timing chain oil nozzle is clean and free of debris. [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#)

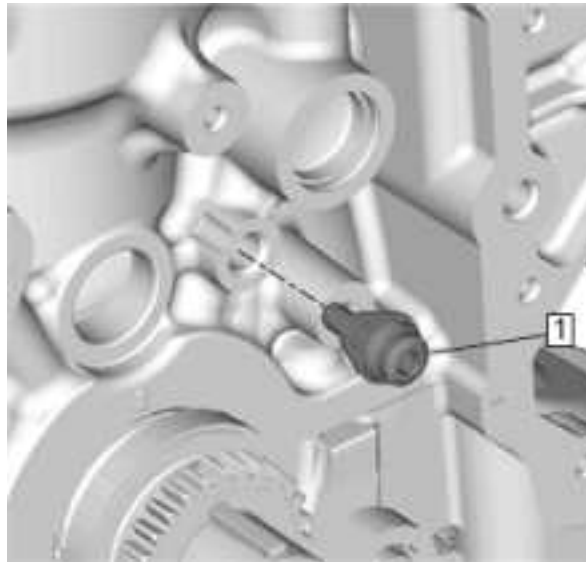


Fig. 108: Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Component Fastener Tightening Caution](#) .

2. Install the timing chain oil nozzle (1). Tighten to 15 N.m (11 lb ft).

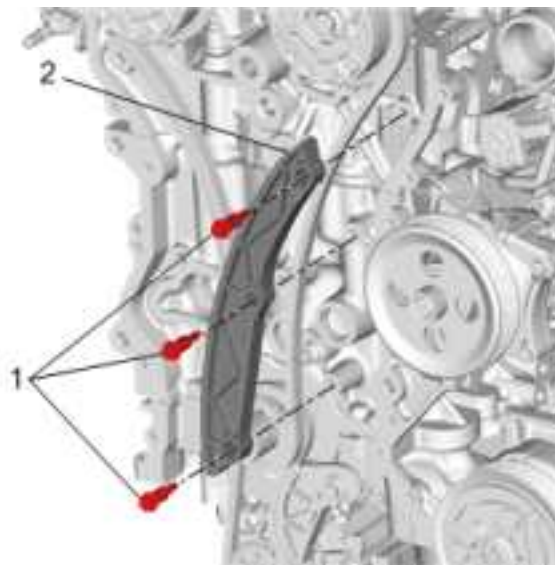


Fig. 109: Timing Chain Guide And Fasteners
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

3. Install the timing chain guide (2) and bolts (1). [Timing Chain Upper Guide Replacement](#)

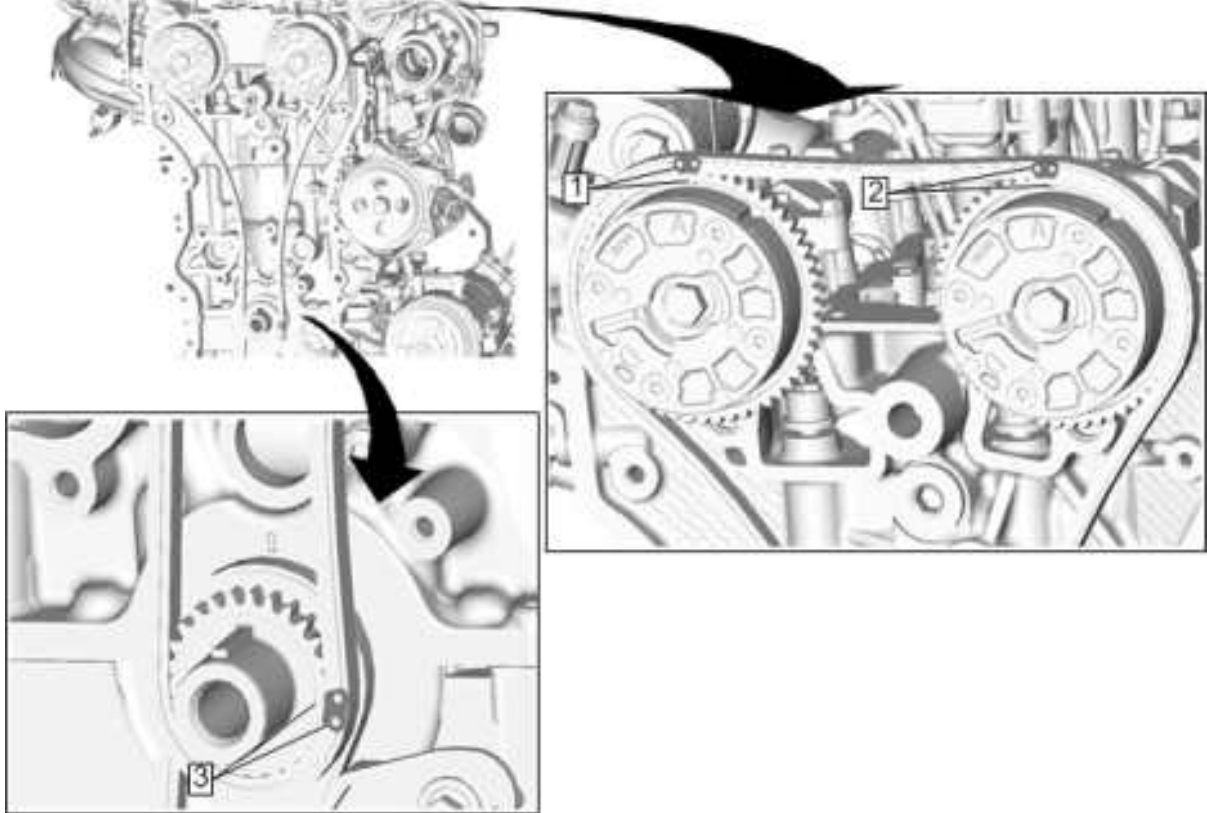


Fig. 110: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

4. Inspect the timing chain marks to confirm they remained aligned after engaging the timing chain tensioner.
5. Using a suitable tool, rotate the crankshaft one complete engine cycle then verify the timing chain marks (1, 2 and 3) are aligned properly.
6. Install the engine front cover. [Engine Front Cover Replacement](#)

HYDRAULIC VALVE LASH ADJUSTER ARM REPLACEMENT

Removal Procedure

1. Remove [Intake Camshaft Replacement](#)
2. Remove [Exhaust Camshaft Replacement](#)

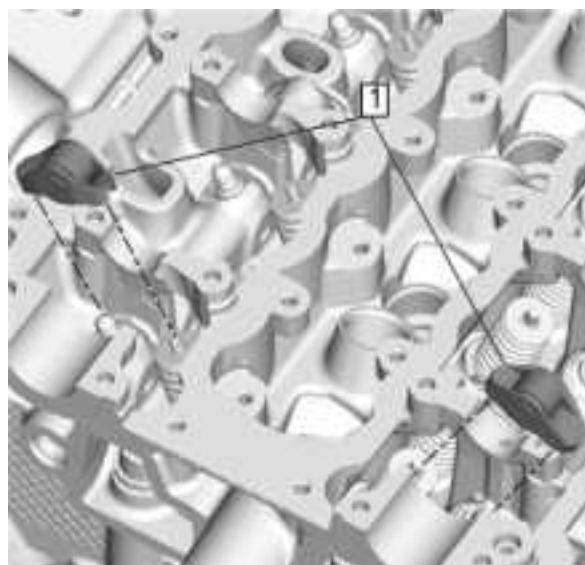


Fig. 111: Hydraulic Valve Lash Adjuster Arm

Courtesy of GENERAL MOTORS COMPANY

NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces.

NOTE:

Components **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.

3. Remove Hydraulic Valve Lash Adjuster Arm (1)[16x]

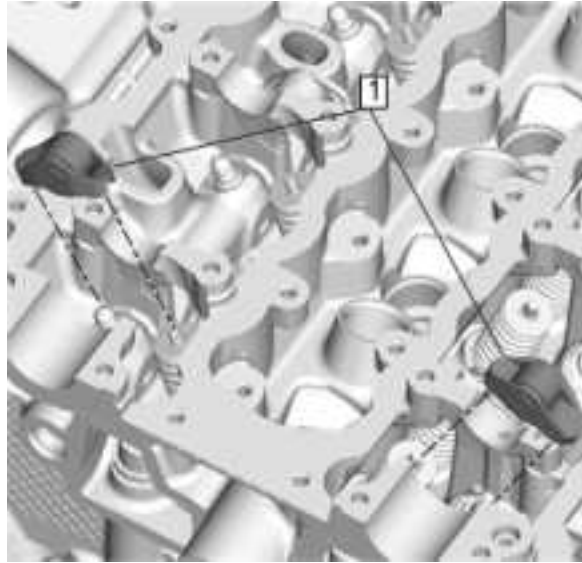
Installation Procedure

Fig. 112: Hydraulic Valve Lash Adjuster Arm

Courtesy of GENERAL MOTORS COMPANY

NOTE:

Used lash adjuster arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the lash adjuster arms actuated by the camshaft must also be replaced.

1. Apply lubricant to the valve tips. [Adhesives, Fluids, Lubricants, and Sealers](#)
2. Position the 16 hydraulic lash adjuster arms (1) on the tip of the valve stems and on the lash adjusters.
3. Apply lubricant to the 16 hydraulic lash adjuster arms (1). [Adhesives, Fluids, Lubricants, and Sealers](#)
4. Install [Exhaust Camshaft Replacement](#).
5. Install [Intake Camshaft Replacement](#).

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT**Removal Procedure**

1. Remove [Hydraulic Valve Lash Adjuster Arm Replacement](#)

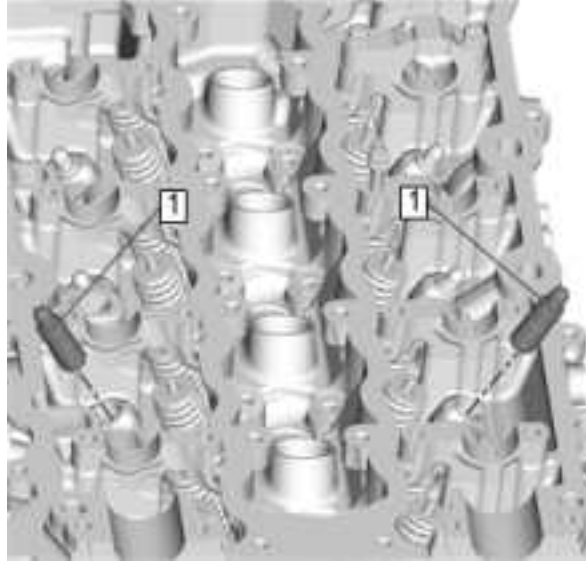


Fig. 113: Hydraulic Valve Lash Adjuster
Courtesy of GENERAL MOTORS COMPANY

NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. Components **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts.

2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.
3. Remove Hydraulic Valve Lash Adjuster (1)[16x]

Installation Procedure

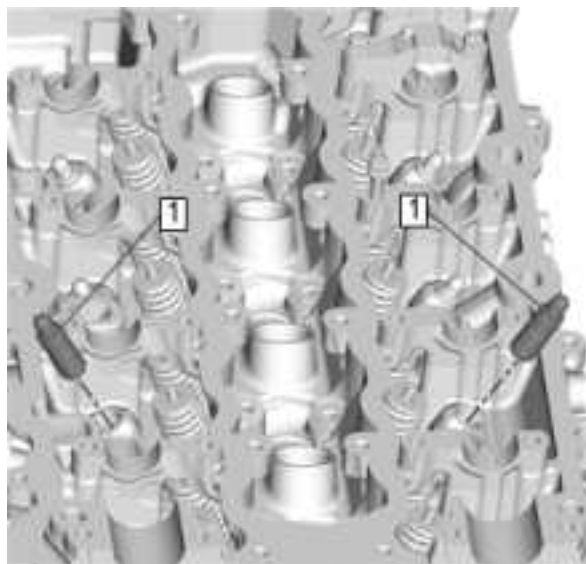


Fig. 114: Hydraulic Valve Lash Adjuster
Courtesy of GENERAL MOTORS COMPANY

1. Install the 16 hydraulic valve lash adjusters (1) in the bores in the cylinder head.
2. Apply lubricant to the 16 hydraulic valve lash adjusters (1). **Adhesives, Fluids, Lubricants, and Sealers.**
3. Install **Hydraulic Valve Lash Adjuster Arm Replacement**

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- EN-46116 Valve Stem Seal Remover
- EN-50717 Universal Valve Spring Compressor Kit

- EN-51511 Injector Port Service Plug

Equivalent regional tools: [Special Tools](#).

Removal Procedure

1. Remove [Spark Plug Replacement](#)
2. Remove [Hydraulic Valve Lash Adjuster Arm Replacement](#)

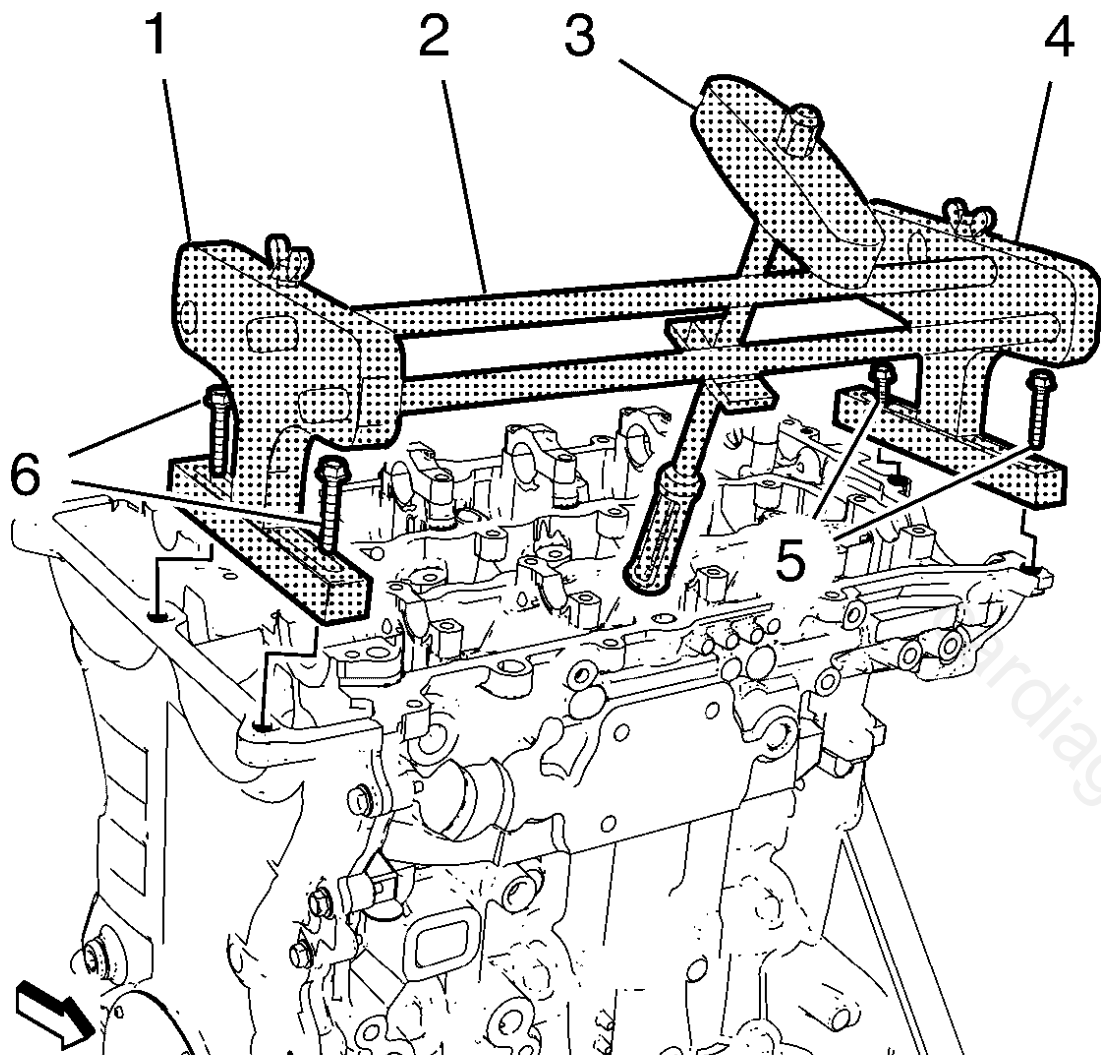


Fig. 115: Valve Stem Oil Seal and Valve Spring Tools

Courtesy of GENERAL MOTORS COMPANY

3. Install the 2 EN-50717-1 stands (1, 4) to the cylinder head and fix them with the screws (5, 6).
4. Install the 2 EN-50717-3 rods (2) to the EN-50717-1 stands (1, 4).
5. Install the EN-50717-2 compressor (3) to the EN-50717-3 rods (2).
6. Plug the injector bores, using the EN-51511 plug.
7. Install a suitable air pressure adapter to the spark plug hole.

NOTE: To keep the valve seated in the valve seat, ensure that air pressure is always applied to the combustion chamber of the treated cylinder.

8. Apply air pressure to the corresponding cylinder.
9. Position the EN-50717-2 compressor (3) so that its adapter properly contacts the valve spring retainer then pretension the compressor.

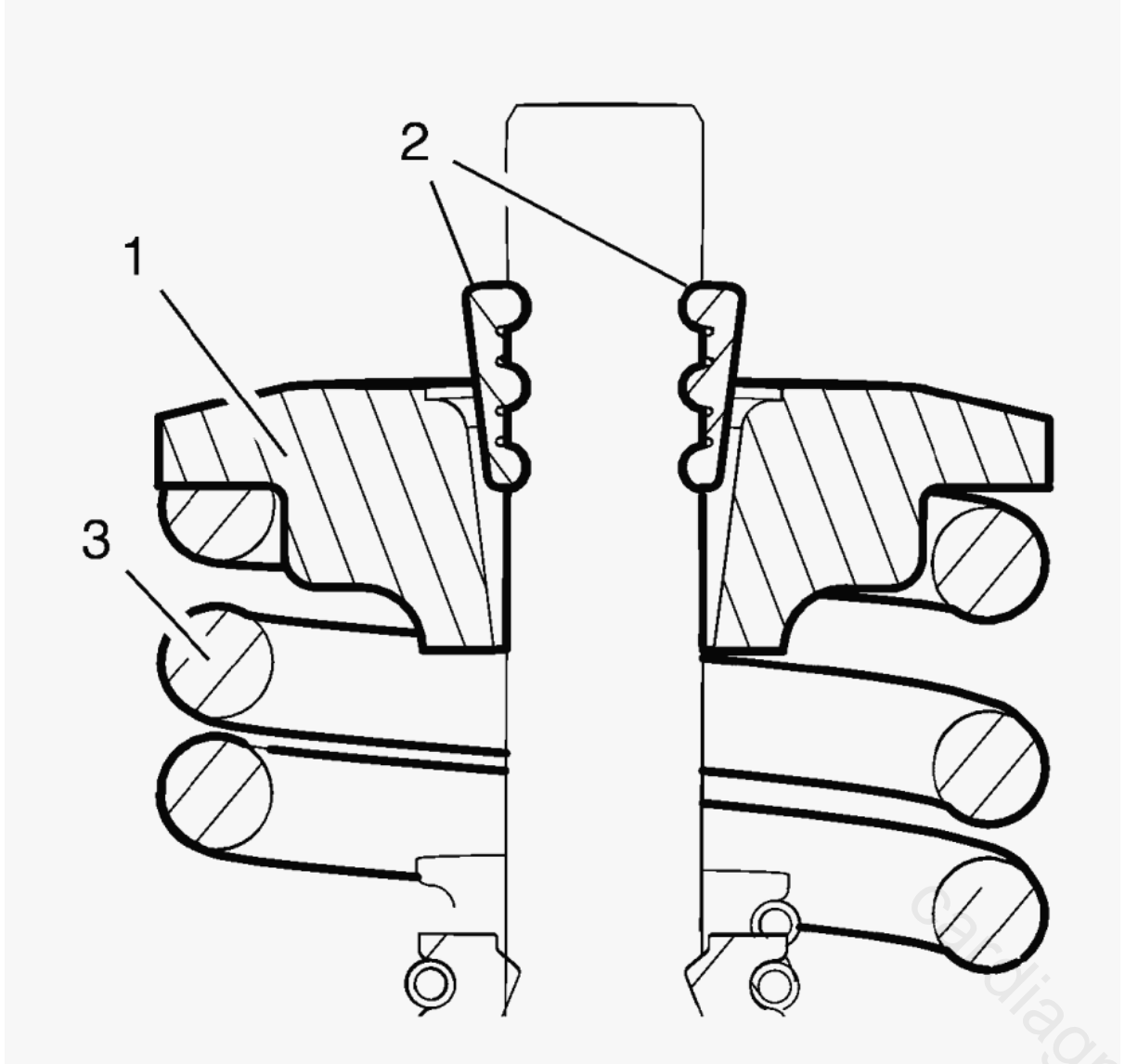


Fig. 116: Valve Spring Retainer And Valve Spring
Courtesy of GENERAL MOTORS COMPANY

WARNING: Valve springs can be tightly compressed. Use care when removing the retainers and plugs. Personal injury could result.

NOTE: Mark all components to ensure they are returned to their original location upon installation.

10. Apply pressure to the **EN-50717-2** compressor to push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) are free from tension.
11. Carefully remove the valve keys (2).
12. Release the tension from the **EN-50717-2** compressor.

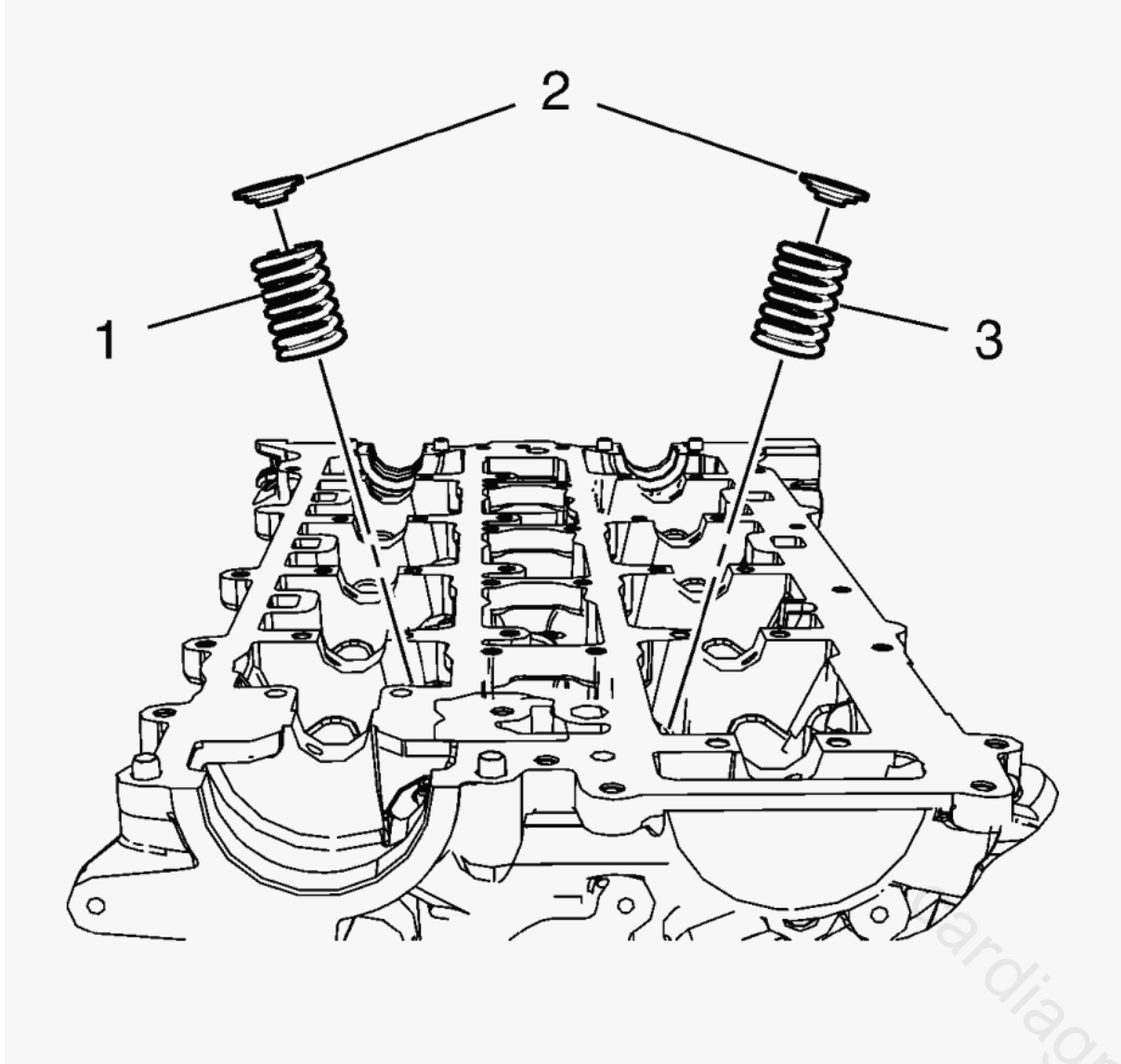


Fig. 117: Valve Springs And Retainers

Courtesy of GENERAL MOTORS COMPANY

13. Remove the valve spring retainer (2) and the exhaust valve spring (1) or intake valve spring (3).

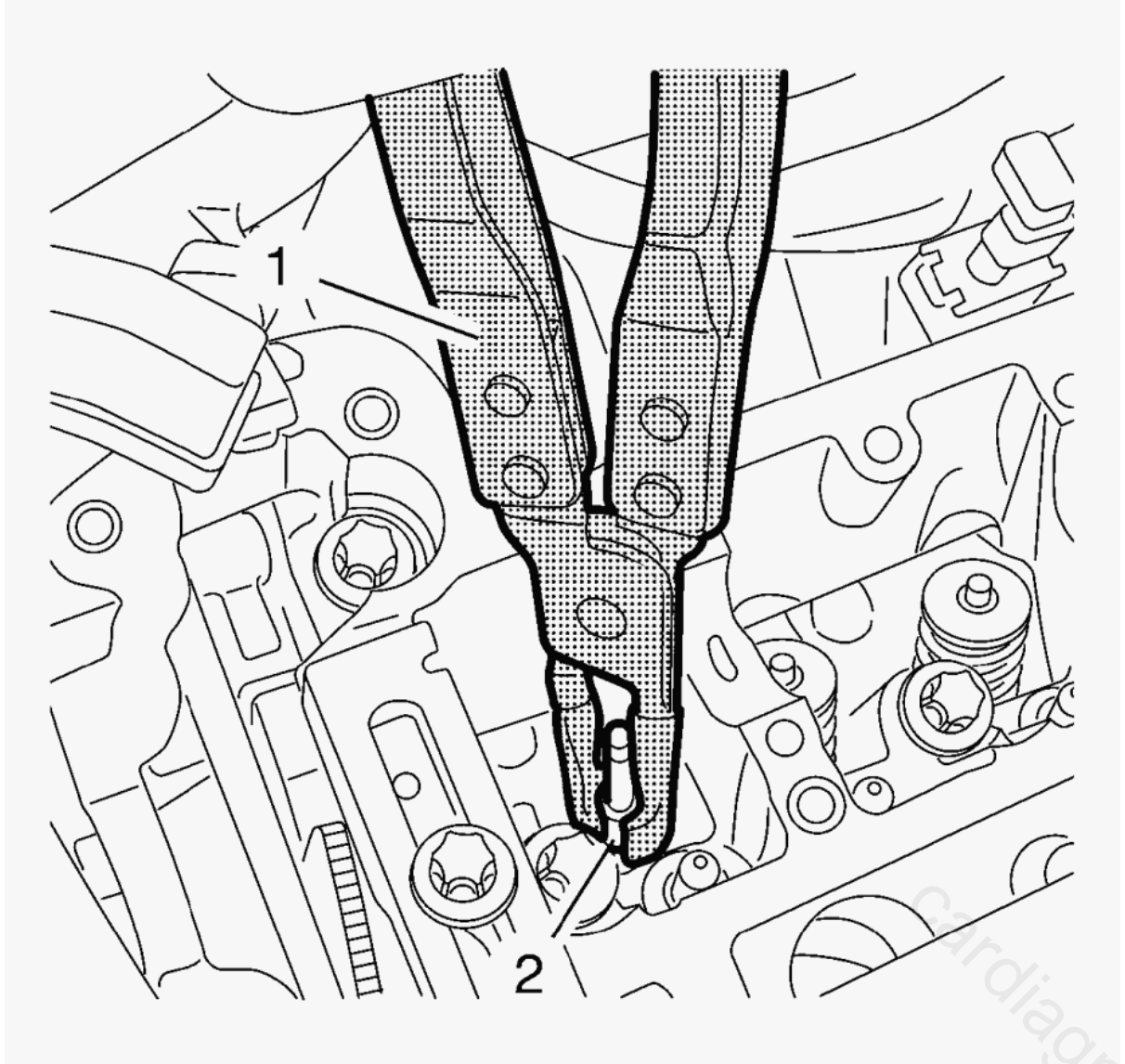


Fig. 118: Pliers And Intake Valve Stem Oil Seals
Courtesy of GENERAL MOTORS COMPANY

14. Using **EN-46116** remover (1), remove and DISCARD the valve stem oil seal (2).

Installation Procedure

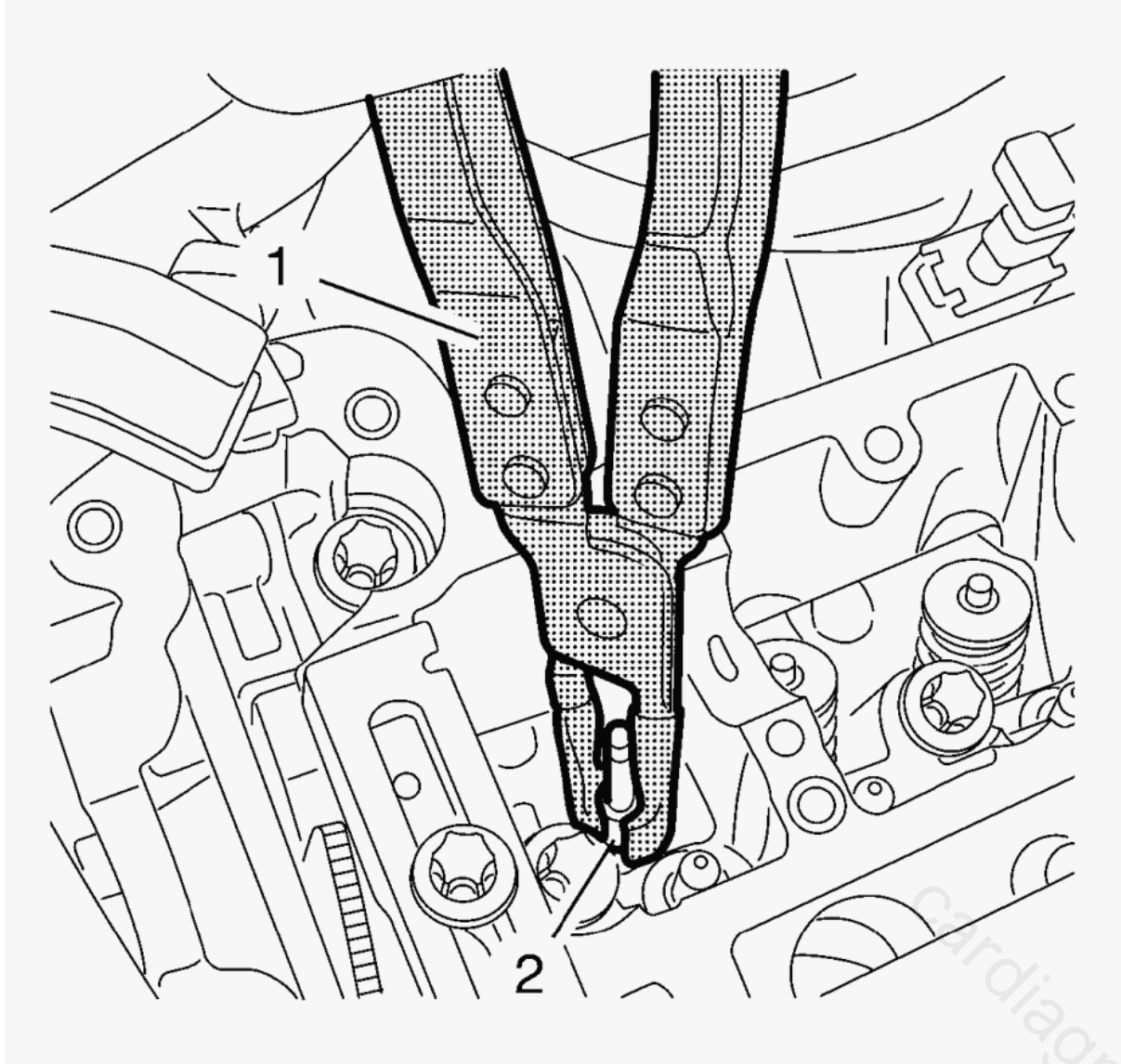


Fig. 119: Pliers And Intake Valve Stem Oil Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: Valve stem oil seal sets will contain 2 different colored seals, black and green. The set of 8 seals that are green should be installed onto the exhaust valves.

1. Using the **EN-46116** installer (1), install NEW valve stem oil seal (2).

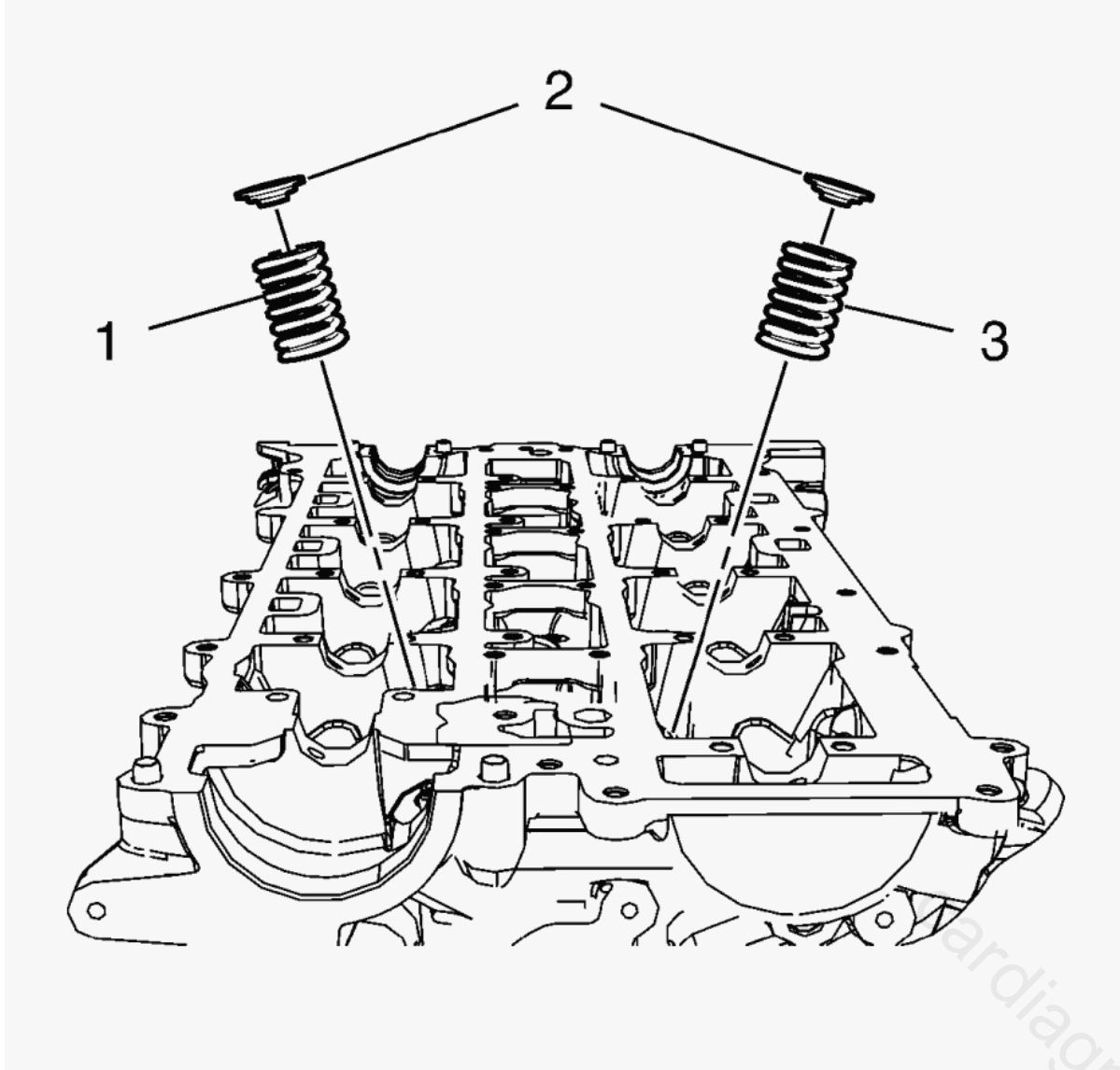


Fig. 120: Valve Springs And Retainers

Courtesy of GENERAL MOTORS COMPANY

NOTE: Make sure that the valve springs and the valve spring retainers are installed in their original position.

2. Install the exhaust valve spring (1), or the intake valve spring (3) and the upper valve spring retainer (2).

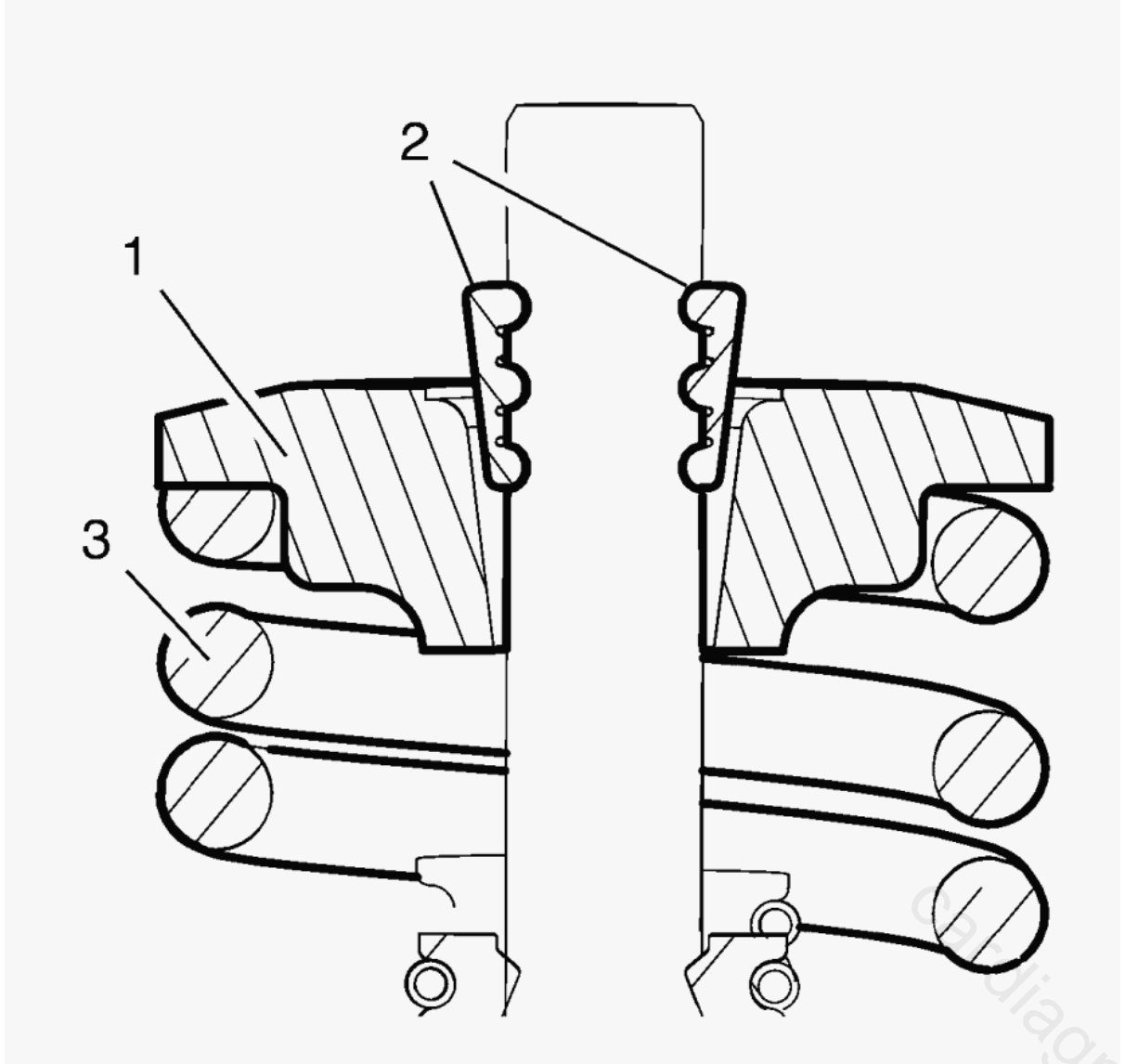


Fig. 121: Valve Spring Retainer And Valve Spring
Courtesy of GENERAL MOTORS COMPANY

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

3. Using the **EN-50717-2** compressor, push down the valve spring retainer (1) and compress the valve spring (3) until the valve keys (2) can be inserted.
4. Carefully insert the valve keys (2), so that they are properly installed into the valve stem grooves.
5. Carefully release the tension from the **EN-50717-2** compressor.
6. Inspect the valve keys (2) and valve spring retainer (1) for proper seat.

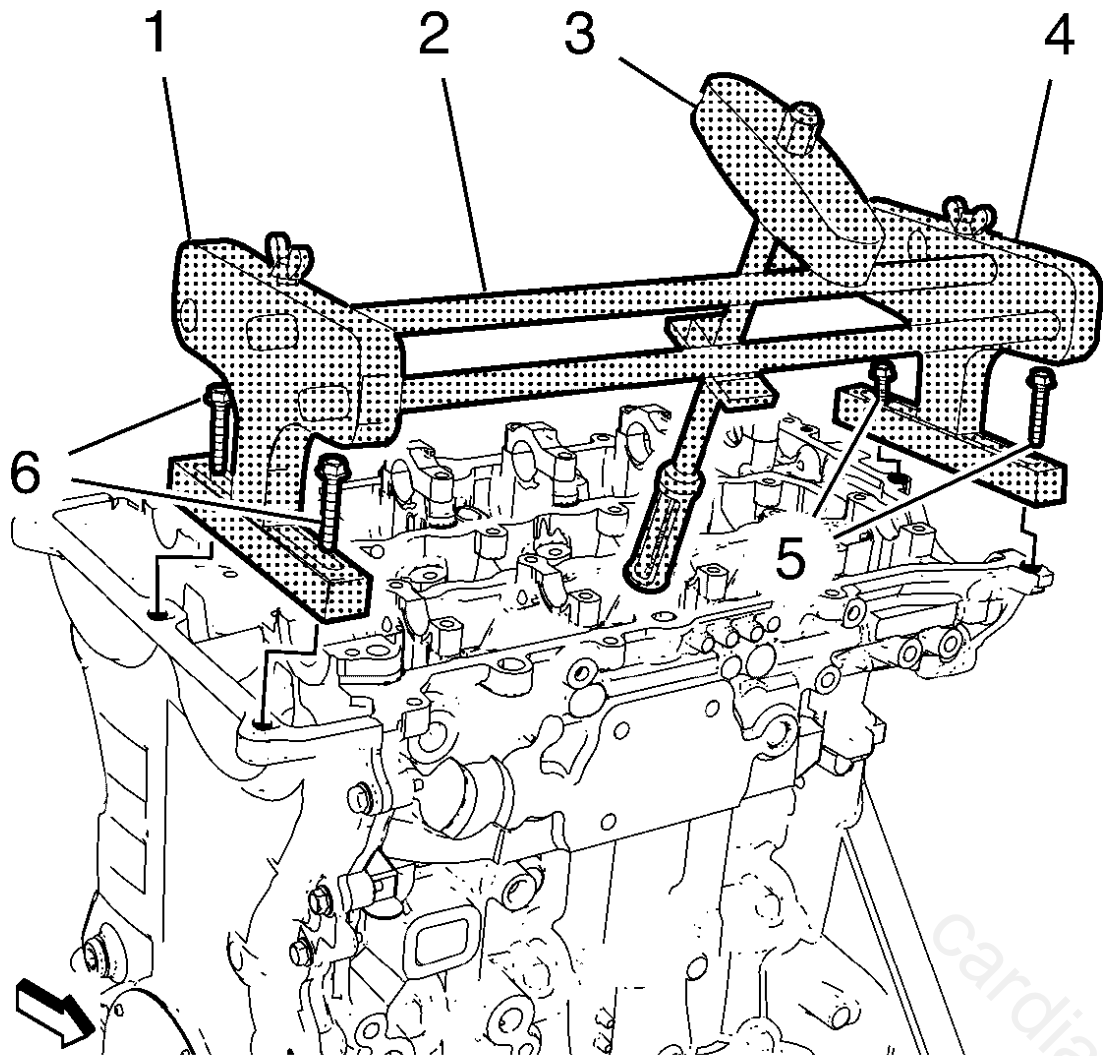


Fig. 122: Valve Stem Oil Seal and Valve Spring Tools
 Courtesy of GENERAL MOTORS COMPANY

NOTE: To keep the valve seated in the valve seat, ensure that air pressure is always applied to the combustion chamber of the treated cylinder.

7. Repeat the procedure with the remaining valves and cylinders.
8. Transfer the EN-50717-1 stands, EN-51511 plug and the EN-50717-2 compressor (1 - 6) as needed.
9. Remove the EN-51511 plug from the injector bores.
10. Remove EN-50717-1 stands and the EN-50717-2 compressor from the cylinder head.
11. Install [Hydraulic Valve Lash Adjuster Arm Replacement](#)
12. Install [Spark Plug Replacement](#)

VALVE LIFTER FOLLOWER REPLACEMENT

Special Tools

EN-51365 High Pressure Fuel Pump Installation Alignment Gauge

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove Fuel Pump - [Fuel Pump Replacement](#)

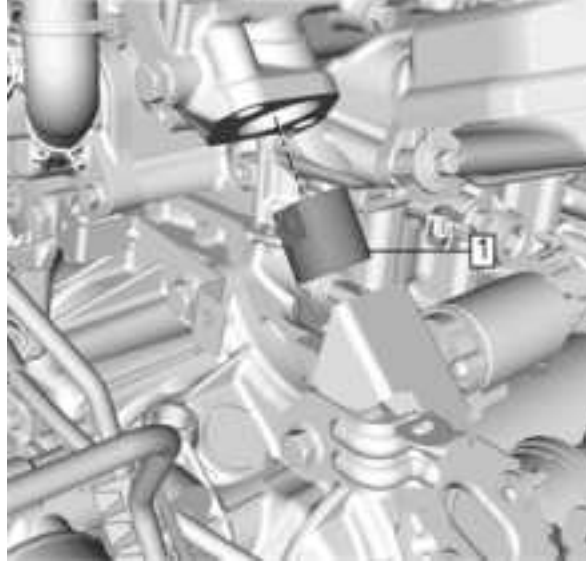


Fig. 123: Valve Lifter Follower

Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve lifter follower (1) from the cylinder head bore.

Installation Procedure

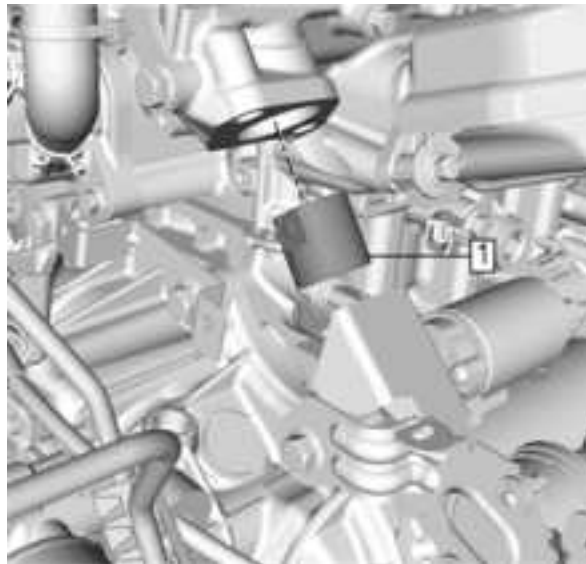
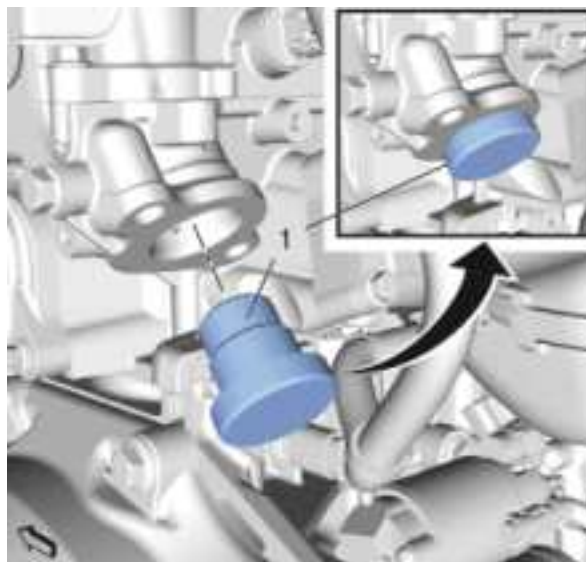


Fig. 124: Valve Lifter Follower

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the valve lifter follower (1) with engine oil. [Adhesives, Fluids, Lubricants, and Sealers](#)
2. Install the valve lifter follower into the cylinder head bore.



NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed.

3. Install the **EN-51365** gauge (1).
4. Rotate the crankshaft until the **EN-51365** gauge (1) is flush with the cylinder head. This indicates the camshaft lobe is at base circle position.
5. Remove the **EN-51365** gauge (1).
6. Install Fuel Pump - [Fuel Pump Replacement](#)

POSITIVE CRANKCASE VENTILATION TUBE REPLACEMENT (FRESH AIR)

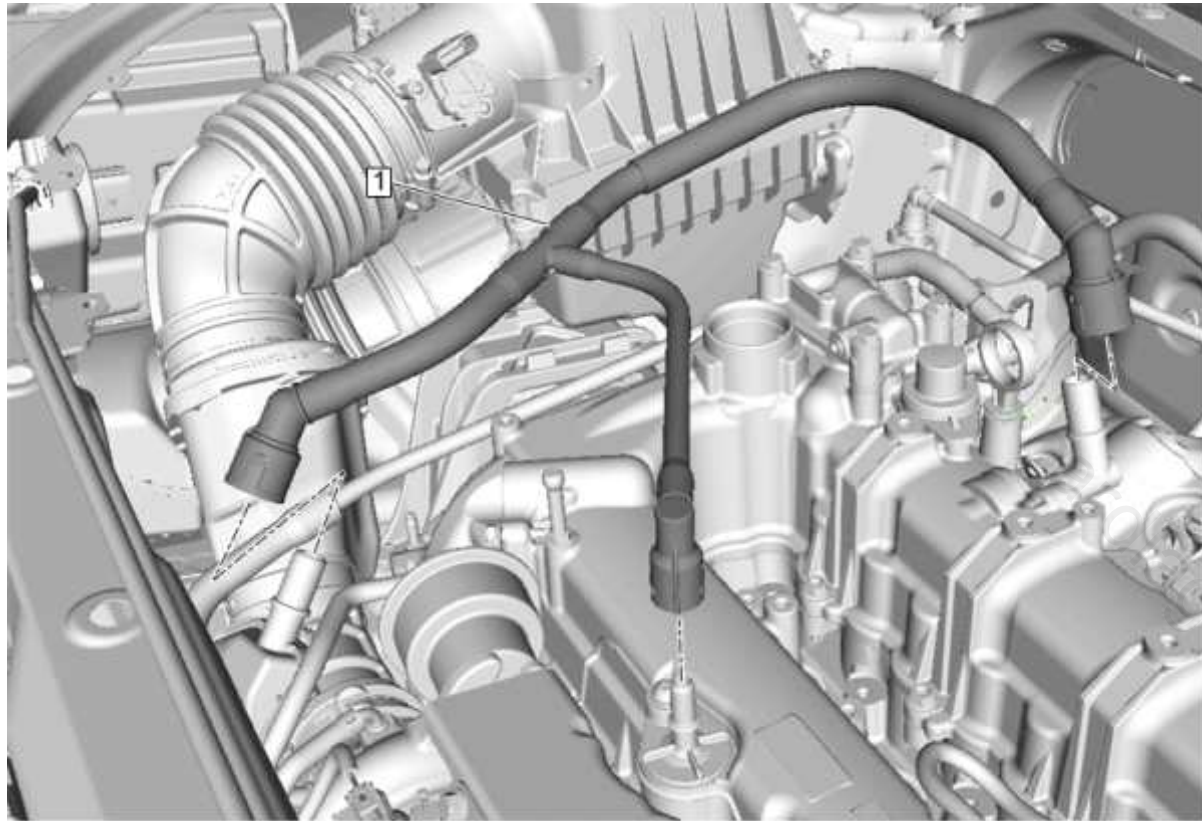


Fig. 126: Positive Crankcase Ventilation Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Intake Manifold Cover Replacement	
1	Positive Crankcase Ventilation Tube CAUTION: The Positive Crankcase Ventilation (PCV) line is tamper resistant and must always be replaced once it is removed. The fittings connected to the PCV line must also be replaced if they are damaged when the PCV line is removed. To reduce the risk of damage to the fittings, use a suitable cutting tool and carefully cut the connections away. Procedure Using a suitable cutting tool, carefully cut the PCV tube away from the fittings at the air cleaner outlet rear duct and the camshaft cover. If any damage occurs to either the air intake tube or camshaft cover fitting, they must be replaced. Air Cleaner Outlet Duct Replacement

POSITIVE CRANKCASE VENTILATION TUBE REPLACEMENT (FOUL AIR)

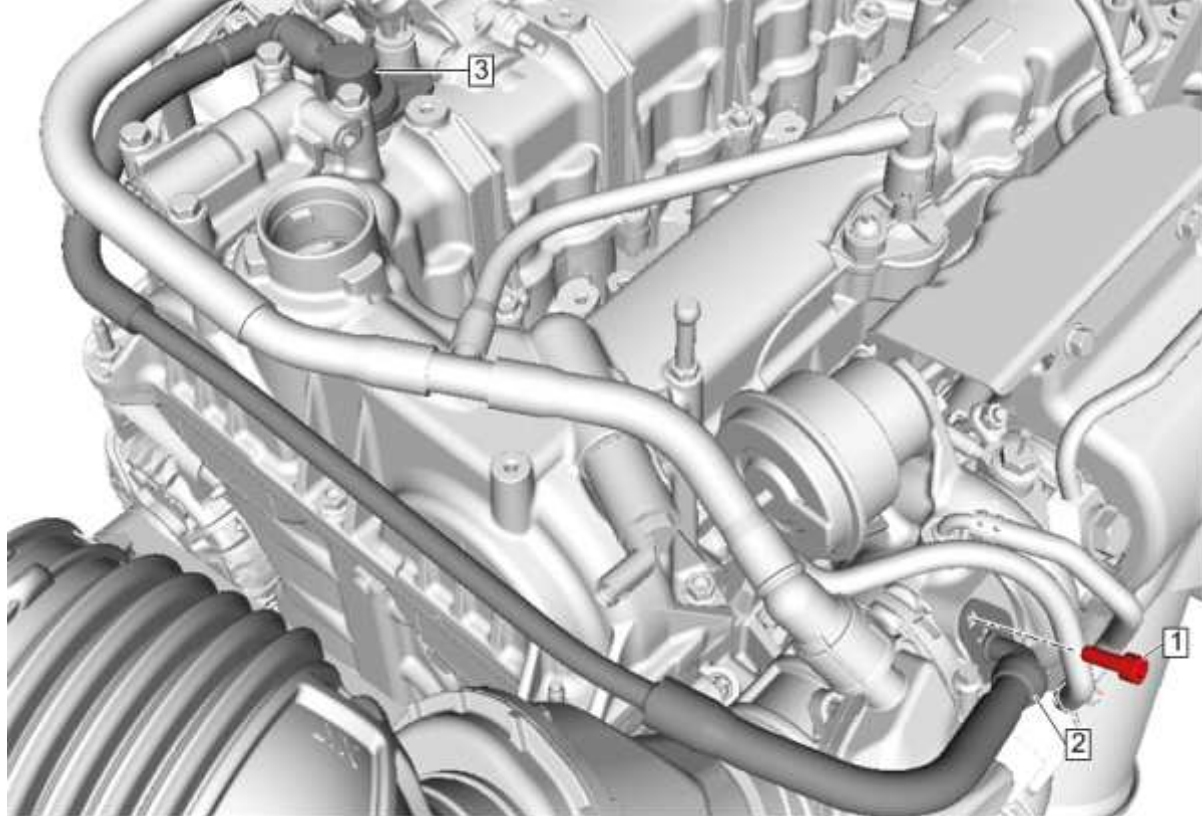


Fig. 127: Positive Crankcase Ventilation Tube
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement NOTE: Inspect each component while attached to the camshaft cover. Do not remove the PCV components unless inspection indicates a suspect component. Replace the PCV valve, PCV tube assembly, and PCV hose fitting as an assembly. The connections between these components are permanent.	
1	Positive Crankcase Ventilation Valve Bolt CAUTION: Refer to Fastener Caution . Tighten 8 N.m (71 lb in)
2	Positive Crankcase Ventilation Valve Fitting
3	Positive Crankcase Ventilation Valve Procedure Inspect the PCV valve. If the PCV valve is suspect, use a suitable tool to pry the valve off of the cover. Retrieve any particles that fall onto the baffle in the cover. DISCARD the valve and particles. NOTE: When the PCV valve is removed, small particles of the valve will break and fall into the cover.

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT - FRESH AIR

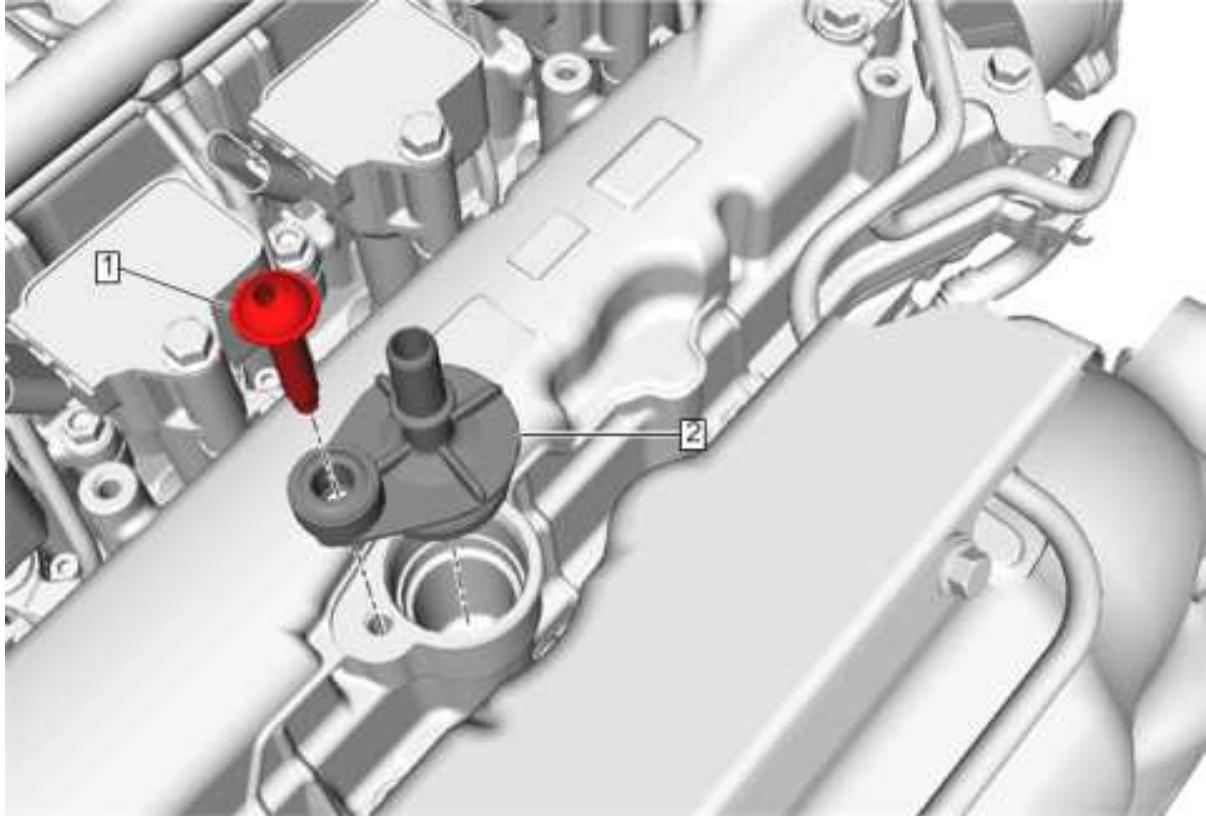


Fig. 128: Positive Crankcase Ventilation Valve (Fresh Air)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Positive Crankcase Ventilation Tube Replacement (Fresh Air)	
1	Positive Crankcase Ventilation Valve Bolt CAUTION: Refer to Fastener Caution . CAUTION: The Positive Crankcase Ventilation (PCV) line is tamper resistant and must always be replaced once it is removed. The fittings connected to the PCV line must also be replaced if they are damaged when the PCV line is removed. To reduce the risk of damage to the fittings, use a suitable cutting tool and carefully cut the connections away. Procedure Using a suitable tool, cut a slot in the tamper-resistant positive crankcase ventilation (PCV) bolt heads and remove with a flat-bladed tool. Discard bolts. NOTE: Bolt is a one-time use ONLY, will need to be slotted then removed and replaced Tighten 10 N.m (89 lb in) Special Tools EN-50956 Tamper Proof Drive Bit Equivalent regional tools:Special Tools
2	Positive Crankcase Ventilation Valve

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT - SECONDARY

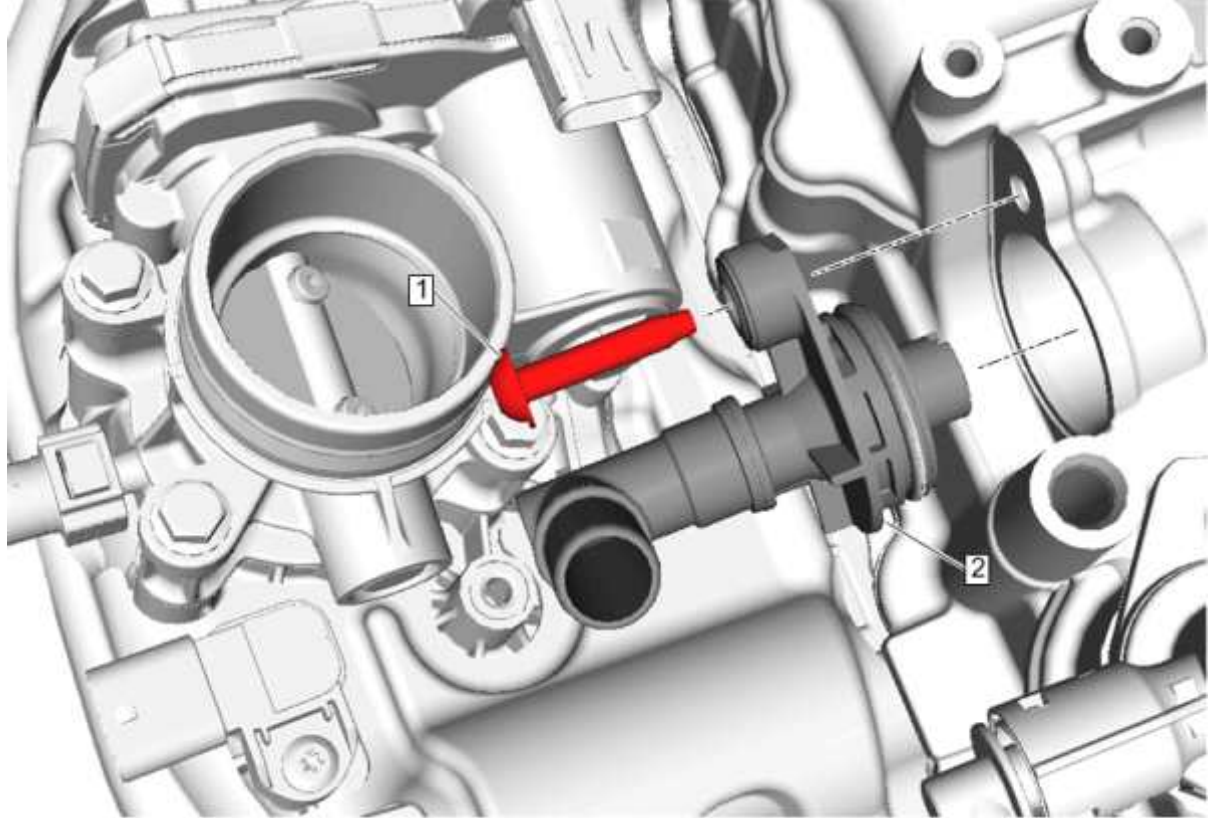


Fig. 129: Positive Crankcase Ventilation Valve
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Positive Crankcase Ventilation Tube Replacement (Fresh Air)Positive Crankcase Ventilation Tube Replacement (Foul Air)	
1	Positive Crankcase Ventilation Valve Bolt CAUTION: Refer to Fastener Caution . CAUTION: The Positive Crankcase Ventilation (PCV) line is tamper resistant and must always be replaced once it is removed. The fittings connected to the PCV line must also be replaced if they are damaged when the PCV line is removed. To reduce the risk of damage to the fittings, use a suitable cutting tool and carefully cut the connections away. Procedure Using a suitable tool, cut a slot in the tamper-resistant positive crankcase ventilation (PCV) bolt heads and remove with a flat-bladed tool. DISCARD bolt. NOTE: Bolt is a one-time use ONLY, will need to be slotted then removed and replaced Tighten 10 N.m (89 lb in) Special Tools EN-50956 Tamper Proof Drive Bit Equivalent regional tools:Special Tools
2	Positive Crankcase Ventilation Valve

Removal Procedure

1. Remove Camshaft Cover - [Camshaft Cover Replacement](#)

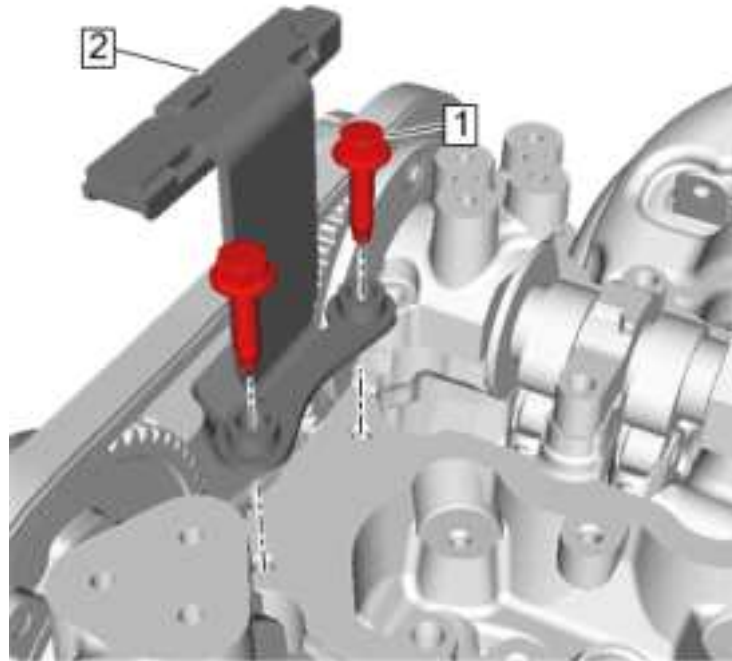


Fig. 130: Timing Chain Upper Guide And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove Timing Chain Upper Guide Bolt (1)
3. Remove Timing Chain Upper Guide (2)
4. Inspect the timing chain components for damage or excessive wear. [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#)

Installation Procedure

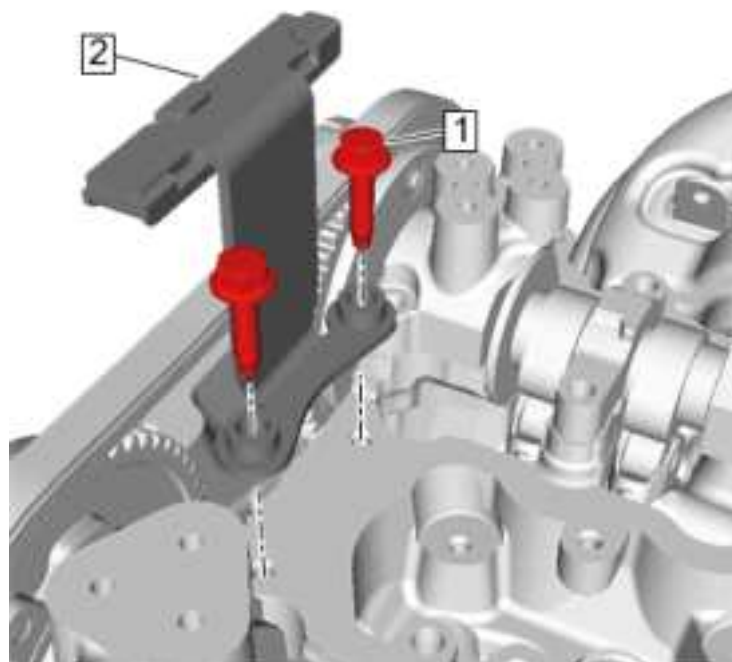


Fig. 131: Timing Chain Upper Guide And Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

1. Install Timing Chain Upper Guide (2)
2. Install Timing Chain Upper Guide Bolt (1) and tighten 10 N.m (89 lb in)

3. Install Camshaft Cover - [Camshaft Cover Replacement](#)

TIMING CHAIN GUIDE REPLACEMENT - LEFT SIDE (EXHAUST)

Special Tools

EN-51367 Camshaft Holder

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove [Engine Front Cover Replacement](#)
2. Set the engine to top dead center (TDC).

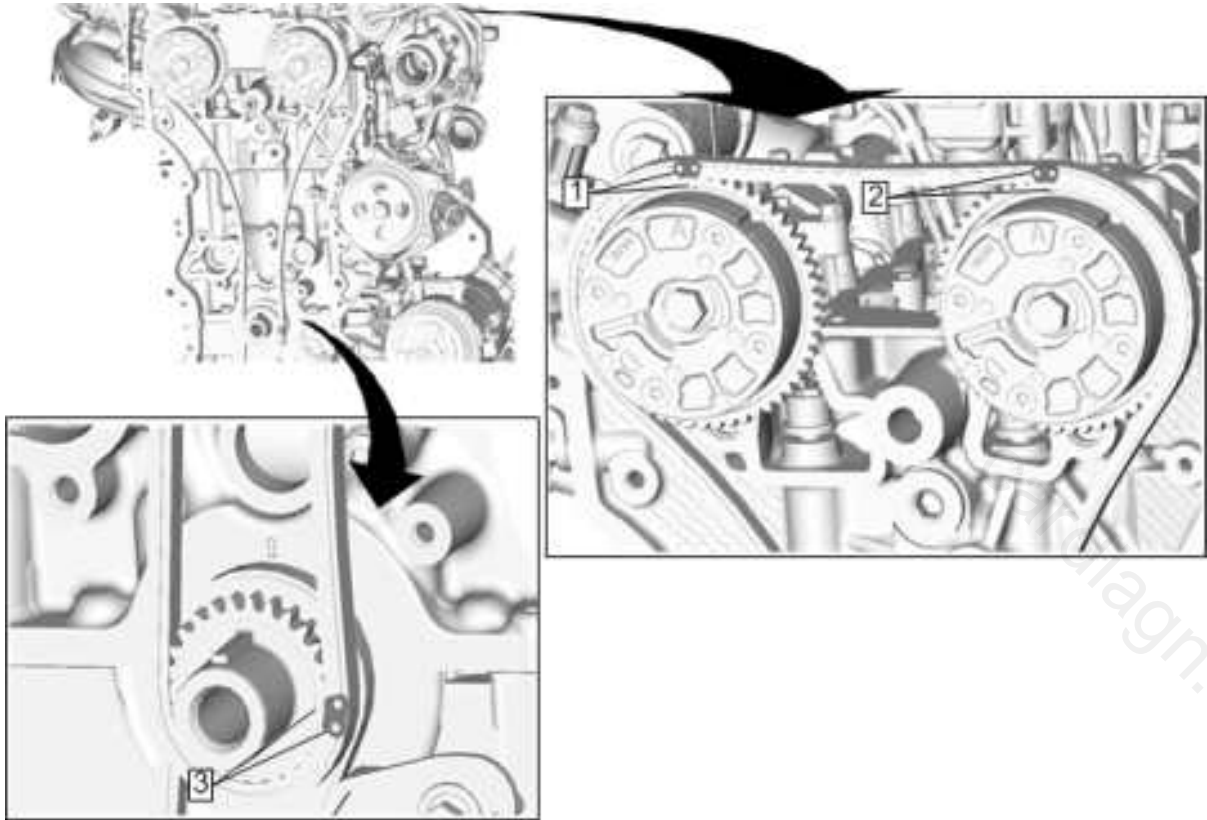


Fig. 132: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

3. Inspect the timing chain marks (1, 2, and 3) to confirm they are properly aligned.

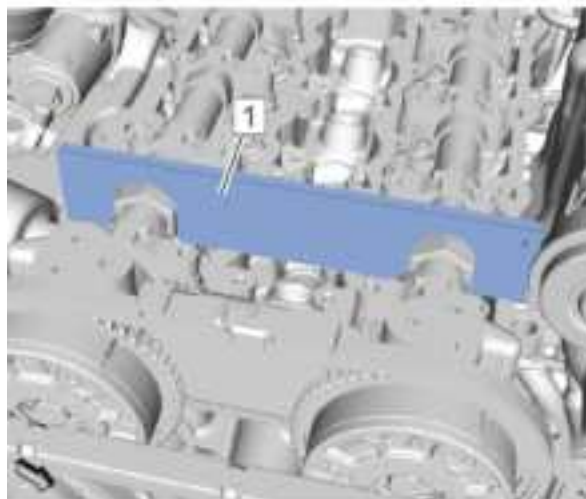


Fig. 133: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

4. Install camshaft holding tool **EN-51367** (1).

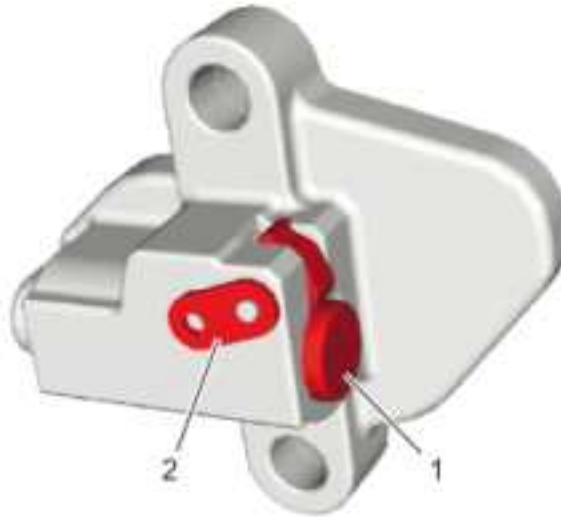


Fig. 134: Pushing Back Piston

Courtesy of GENERAL MOTORS COMPANY

5. Reset the tensioner plunger (1). **Timing Chain Tensioner Replacement**

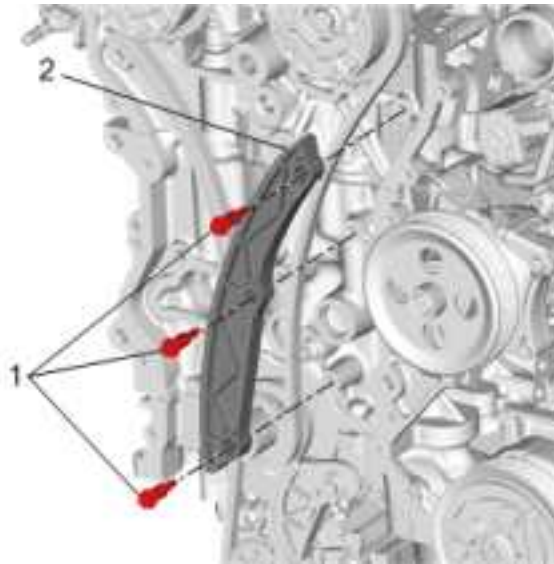


Fig. 135: Timing Chain Guide And Fasteners

Courtesy of GENERAL MOTORS COMPANY

6. Remove Timing Chain Guide Fastener (1)

7. Remove Timing Chain Guide (2)

NOTE: It is not necessary to remove the timing chain from the sprockets.

8. Inspect, timing components as necessary. For camshaft timing chain, oil nozzle, sprocket and tensioner cleaning and inspection. **Camshaft Timing Chain and Sprocket Cleaning and Inspection.**

Installation Procedure

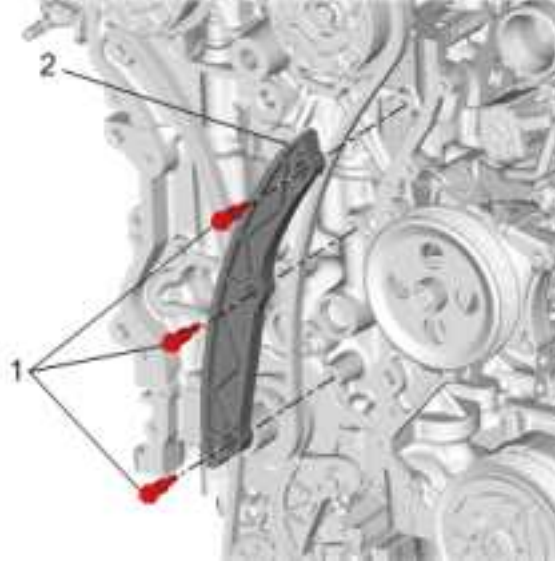


Fig. 136: Timing Chain Guide And Fasteners
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

1. Install Timing Chain Guide (2)
2. Install Timing Chain Guide Fastener (1) and tighten 10 N.m (89 lb in)

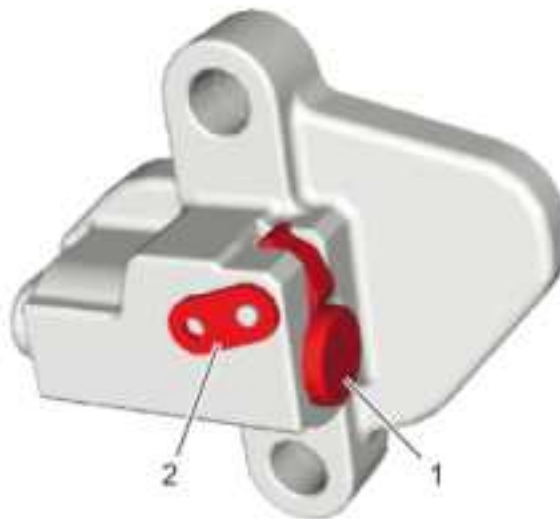


Fig. 137: Pushing Back Piston
 Courtesy of GENERAL MOTORS COMPANY

3. Release the tensioner plunger (1). [Timing Chain Tensioner Replacement](#)

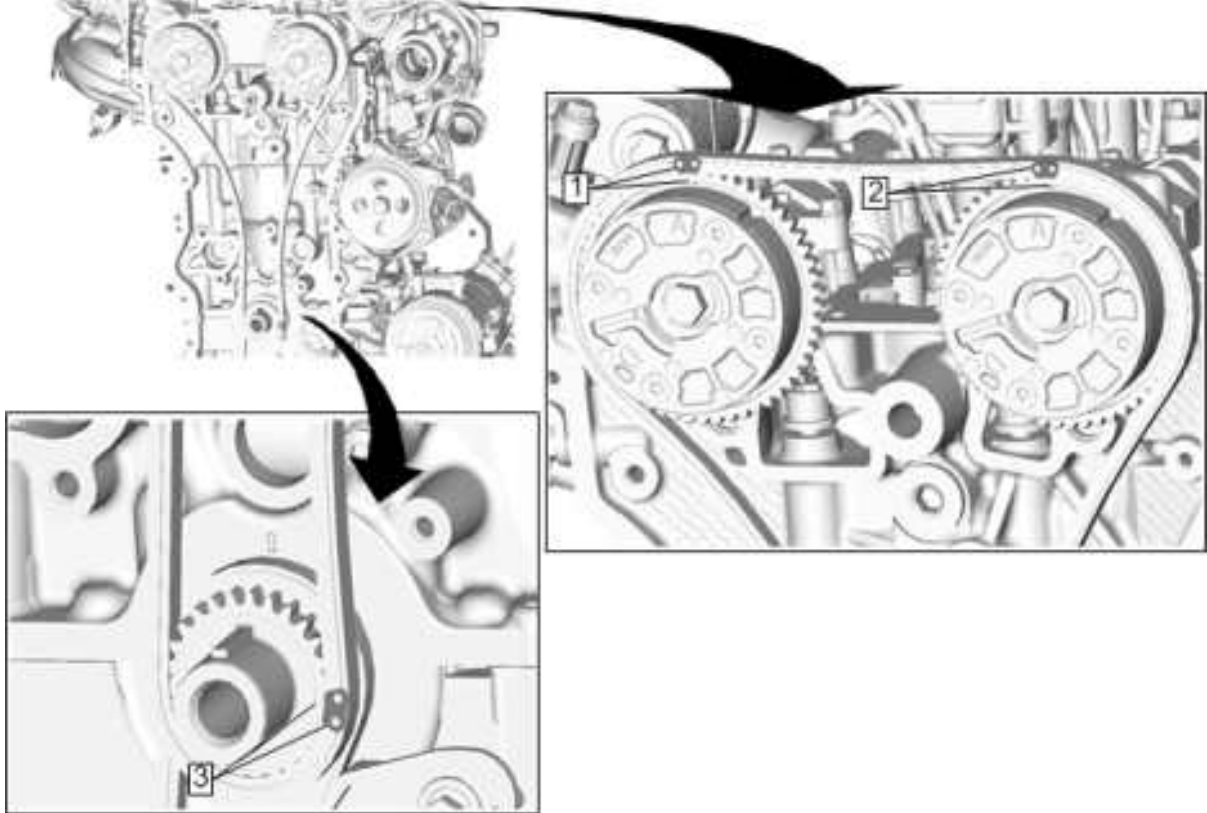


Fig. 138: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

4. Inspect the timing chain marks (1, 2, and 3) to confirm they remained aligned after engaging the timing chain tensioner.

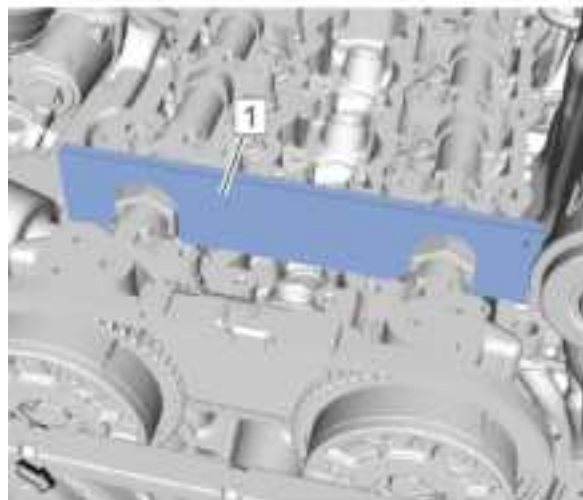


Fig. 139: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

5. Remove camshaft holding tool **EN-51367** (1).
6. Using a suitable tool, rotate the crankshaft one complete engine cycle then verify the timing chain marks are aligned properly.
7. Install **Engine Front Cover Replacement**

TIMING CHAIN TENSIONER REPLACEMENT

Special Tools

EN-51367 Camshaft Holder

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Remove Camshaft Cover [Camshaft Cover Replacement](#)
2. Remove Front Wheelhouse Liner-Right Side [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#) [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)



Fig. 140: Crankshaft Balancer Markings

Courtesy of GENERAL MOTORS COMPANY

NOTE: Adjust the engine to cylinder 1 top dead center (TDC) of combustion stroke. Turn the crankshaft in direction of engine rotation until the markings (1, 2) line up.

3. Rotate at the crankshaft balancer bolt (3).

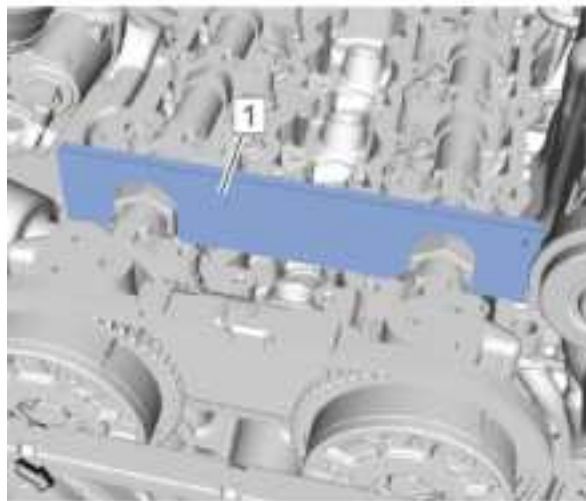


Fig. 141: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

4. Install the **EN-51367** holder (1).
5. Remove Engine Front Cover - [Engine Front Cover Replacement](#)
6. Remove Timing Chain Upper Guide - [Timing Chain Upper Guide Replacement](#)

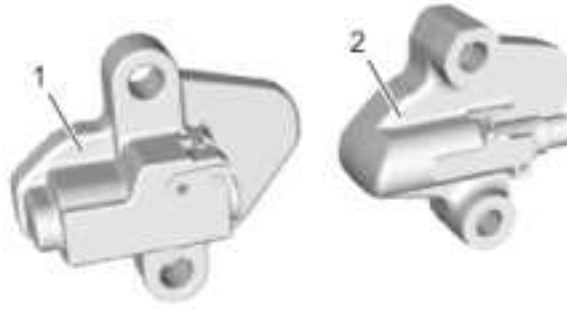


Fig. 142: Tensioner Designs

Courtesy of GENERAL MOTORS COMPANY

7. The engine has one of the two tensioner designs (1, 2). Each design has a different release mechanism and position.

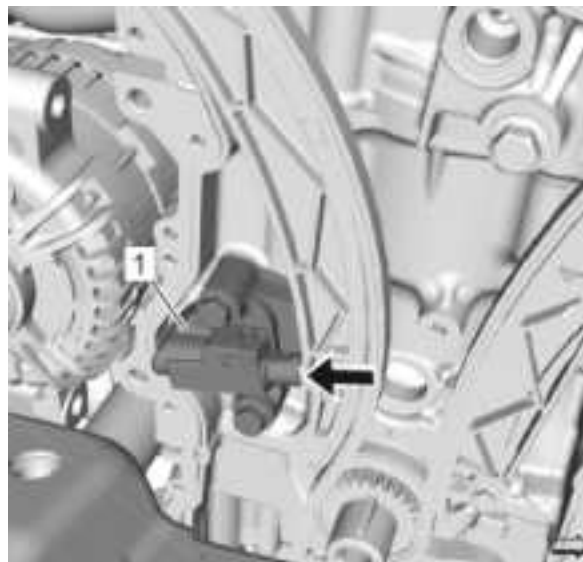


Fig. 143: Timing Chain Tensioner In Service Position

Courtesy of GENERAL MOTORS COMPANY

8. Fix the timing chain tensioner with design 1 (1) in service position:

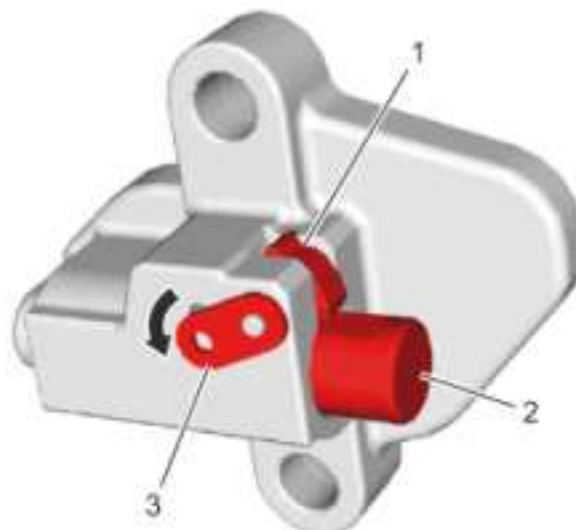


Fig. 144: Releasing Tension From Piston

Courtesy of GENERAL MOTORS COMPANY

1. Slightly release tension from the piston (2) until bar (1) can be unlocked by rotating the lever (3) in direction of arrow.

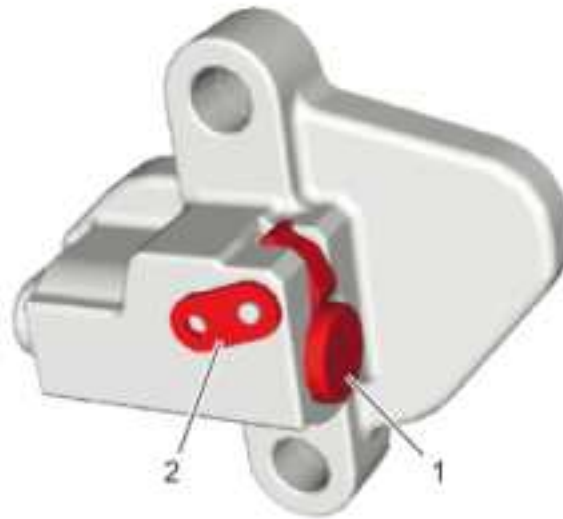


Fig. 145: Pushing Back Piston

Courtesy of GENERAL MOTORS COMPANY

2. Entirely push back the piston (1) until the tensioner lever (2) cannot be locked in this position.

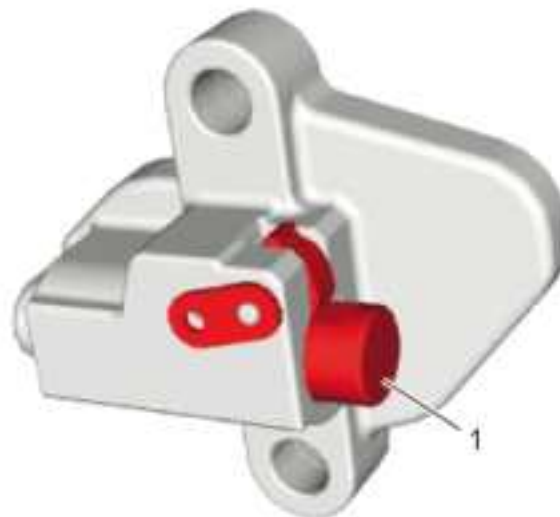


Fig. 146: Piston

Courtesy of GENERAL MOTORS COMPANY

3. Release tension from the piston (1) until it releases for three ratchets. The three ratchets can be noticed by the click noises.

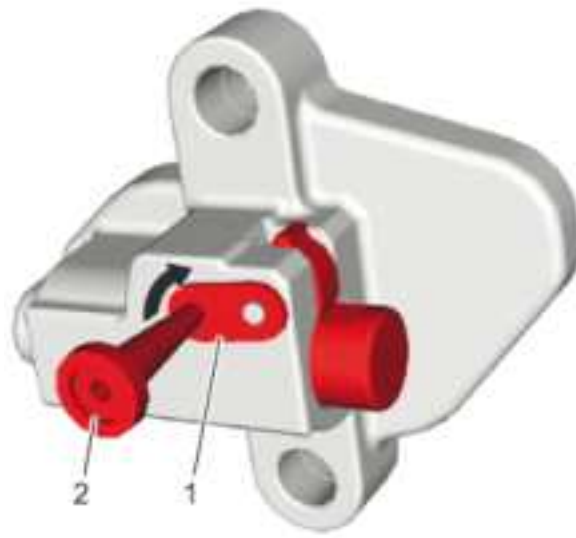


Fig. 147: Lever And Fixing Pin

Courtesy of GENERAL MOTORS COMPANY

4. Apply tension to the piston until the lever (1) is rotated back into the locking position where the bore in the lever aligns with the bore in the tensiometer housing.
5. Fix the lever in this position with a suitable fixing pin (2).

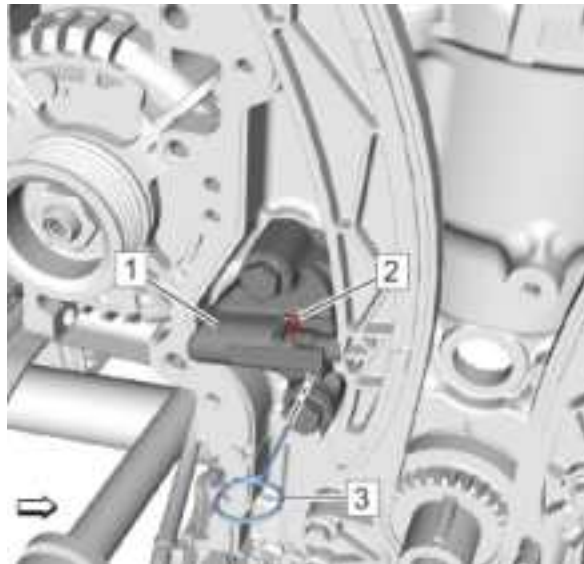


Fig. 148: Tensioner Design 2

Courtesy of GENERAL MOTORS COMPANY

6. The style of tensioner design 2 (1) can be released by using a punch and pressing on the release clip (2).
7. Secure the timing chain tensioner with suitable sized drill bit (3).

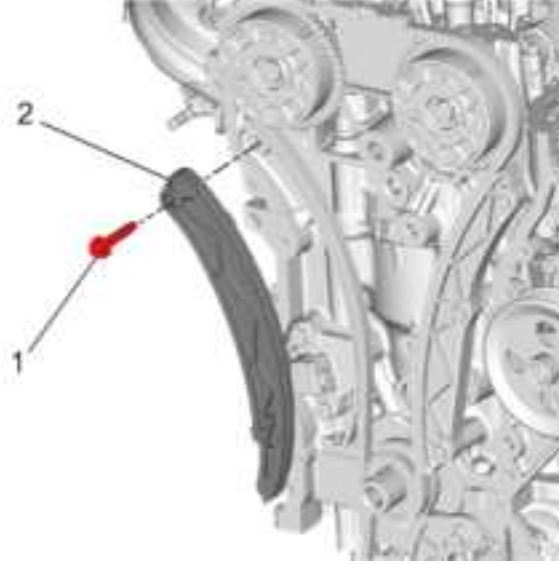


Fig. 149: Timing Chain Tensioner Shoe Fastener
 Courtesy of GENERAL MOTORS COMPANY

9. Remove Timing Chain Tensioner Shoe Bolt (1)
10. Remove Timing Chain Tensioner Shoe (2)

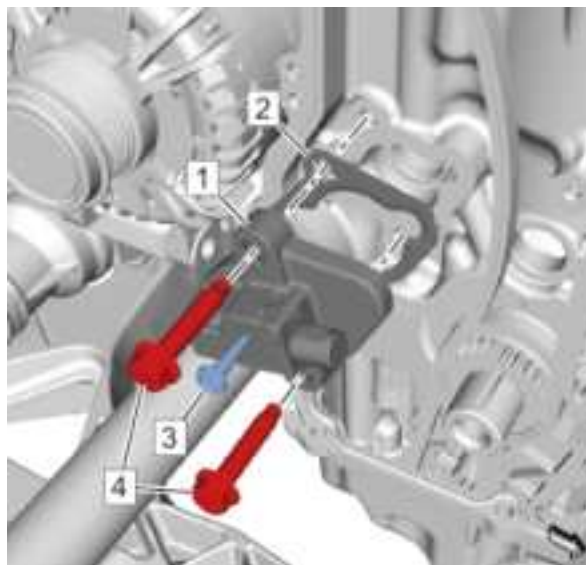


Fig. 150: Timing Chain Tensioner Tool, Timing Chain Tensioner, Bolts And Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Both tensioner designs have the same removal procedure. Each tensioner design uses a different fixing procedure and fixing tool see steps 7 - 8.7.

11. Ensure the correct fixation of the tool (3) is used.
12. Remove Timing Chain Tensioner Bolt (4) - [2x]
13. Remove Timing Chain Tensioner (1)
14. Remove and DISCARD the gasket.(2)

Installation Procedure

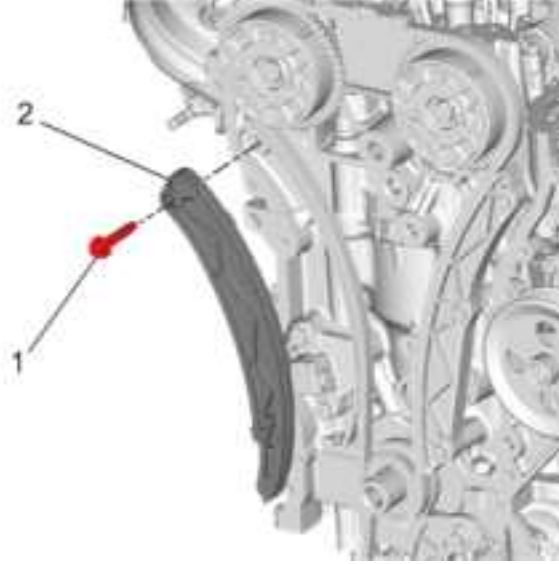


Fig. 151: Timing Chain Tensioner Shoe Fastener
 Courtesy of GENERAL MOTORS COMPANY

1. Install Timing Chain Tensioner Shoe (2).

CAUTION: Refer to [Fastener Caution](#) .

2. Install Timing Chain Tensioner Shoe Bolt (1) and tighten 25 N.m (18 lb ft)

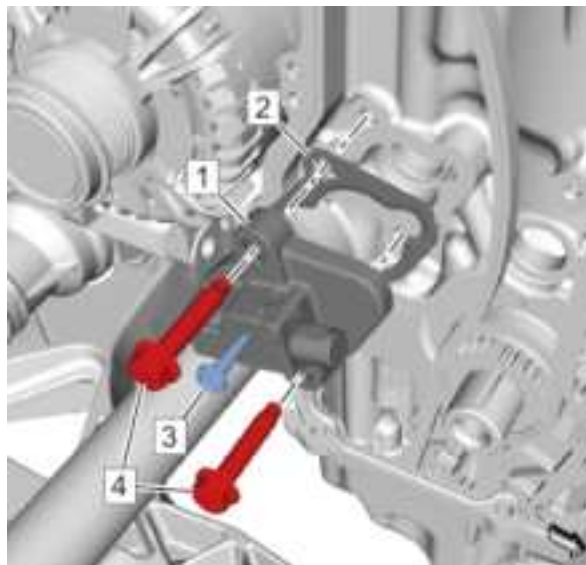


Fig. 152: Timing Chain Tensioner Tool, Timing Chain Tensioner, Bolts And Gasket
 Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW gasket.(2)
4. Install Timing Chain Tensioner(1)
5. Install Timing Chain Tensioner Bolt (4) - and tighten 25 N.m (18 lb ft).
6. Remove the suitable tool (3) from the timing chain tensioner.

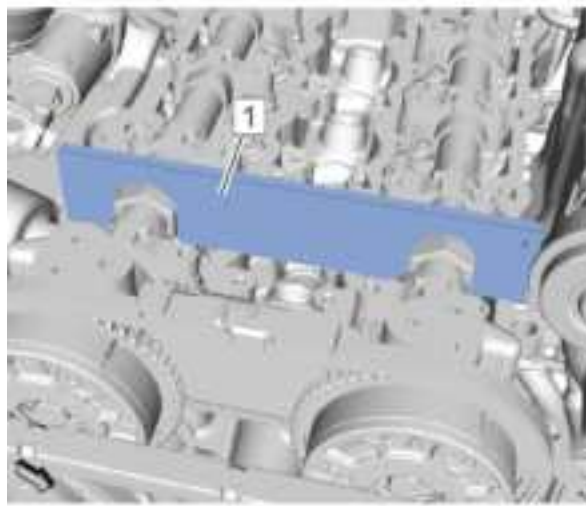


Fig. 153: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

7. Remove the EN-51367 holder (1).
8. Install Timing Chain Upper Guide - [Timing Chain Upper Guide Replacement](#)
9. Check the position of the crankshaft, camshaft and camshaft position actuator adjuster.
 1. TEMPORARILY install the engine front cover with 4 bolts and the crankshaft balancer.



Fig. 154: Crankshaft Balancer Markings

Courtesy of GENERAL MOTORS COMPANY

2. Turn crankshaft 720 degrees in the direction of engine rotation by the crankshaft balancer bolt (3).

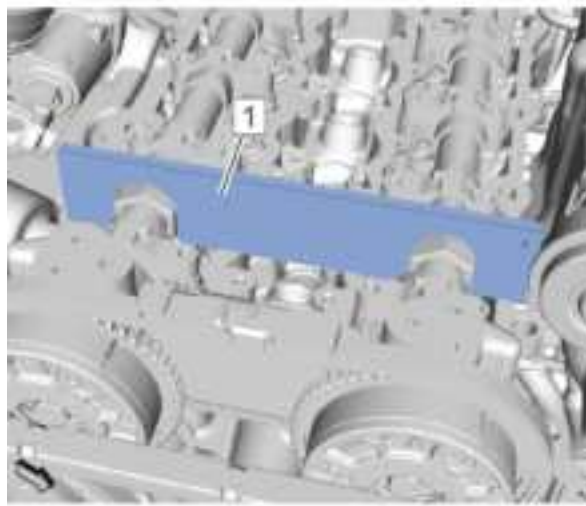


Fig. 155: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

NOTE: If the EN-51367 holder (1) can be installed, the engine timing is properly adjusted. If the EN-51367 holder (1) can not be installed, confirm the engine is set to cylinder 1 top dead center (TDC) of combustion stroke.

10. Install the **EN-51367** holder (1).
11. Remove the **EN-51367** holder.
12. Remove the TEMPORARILY installed engine front cover and crankshaft balancer.
13. Install Engine Front Cover - [Engine Front Cover Replacement](#)

NOTE: Right Side

- 14.
15. Install Front Wheelhouse Liner-Right Side - [Front Wheelhouse Liner Replacement - Right Side \(Equinox\)](#) [Front Wheelhouse Liner Replacement - Right Side \(Terrain\)](#)
16. Install Camshaft Cover - [Camshaft Cover Replacement](#)

TIMING CHAIN TENSIONER SHOE REPLACEMENT

Special Tools

EN-51367 Camshaft Holder

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove [Engine Front Cover Replacement](#)
2. Set the engine to top dead center (TDC).

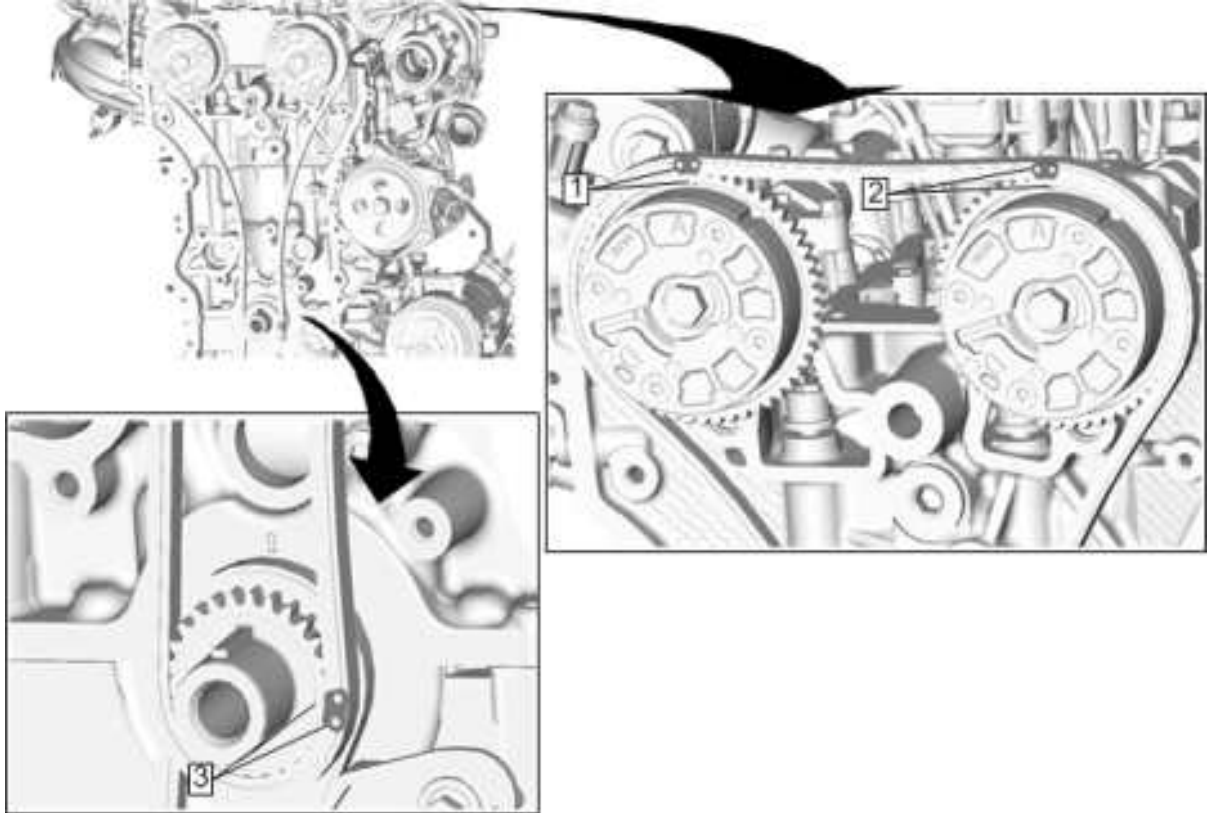


Fig. 156: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

3. Inspect the timing chain marks (1, 2, and 3) to confirm they are properly aligned.

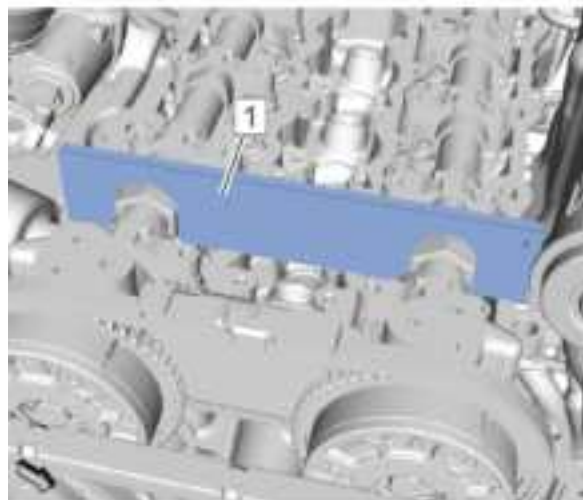


Fig. 157: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

4. Install camshaft holding tool EN-51367 (1).

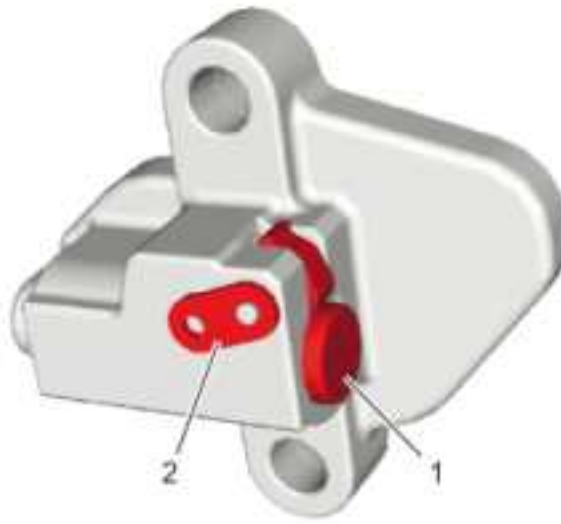


Fig. 158: Pushing Back Piston

Courtesy of GENERAL MOTORS COMPANY

5. Reset the tensioner plunger (1). [Timing Chain Tensioner Replacement](#)

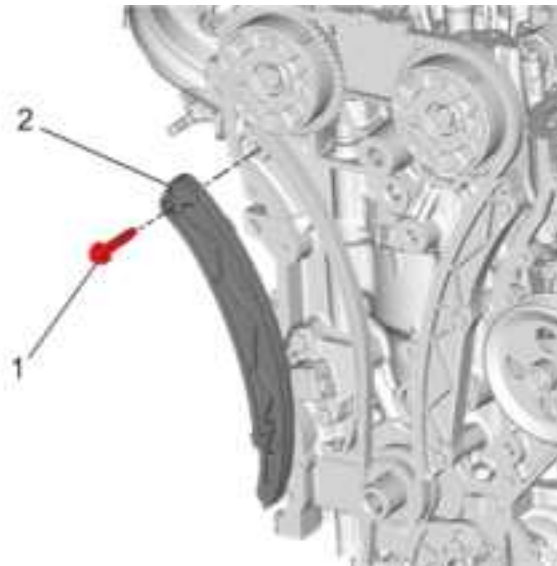


Fig. 159: Timing Chain Tensioner Shoe Fastener

Courtesy of GENERAL MOTORS COMPANY

6. Remove Timing Chain Tensioner Shoe Bolt (1)
7. Remove Timing Chain Tensioner Shoe (2)

NOTE: It is not necessary to remove the timing chain from the sprockets.

8. Inspect, timing components as necessary. For camshaft timing chain, oil nozzle, sprocket and tensioner cleaning and inspection. [Camshaft Timing Chain and Sprocket Cleaning and Inspection](#)

Installation Procedure

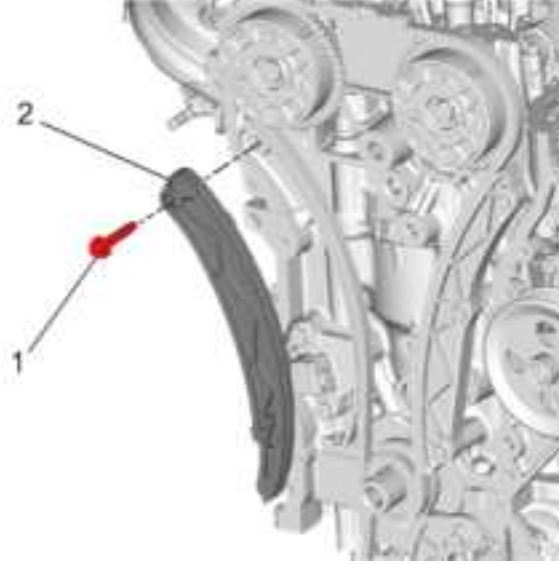


Fig. 160: Timing Chain Tensioner Shoe Fastener
 Courtesy of GENERAL MOTORS COMPANY

1. Install Timing Chain Tensioner Shoe (2)

CAUTION: Refer to [Fastener Caution](#) .

2. Install Timing Chain Tensioner Shoe Bolt (1) and tighten 25 N.m (18 lb ft)

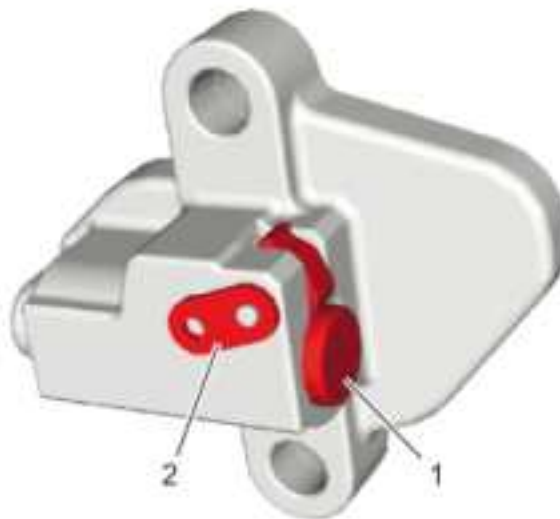


Fig. 161: Pushing Back Piston
 Courtesy of GENERAL MOTORS COMPANY

3. Release the tensioner plunger (1). [Timing Chain Tensioner Replacement](#)

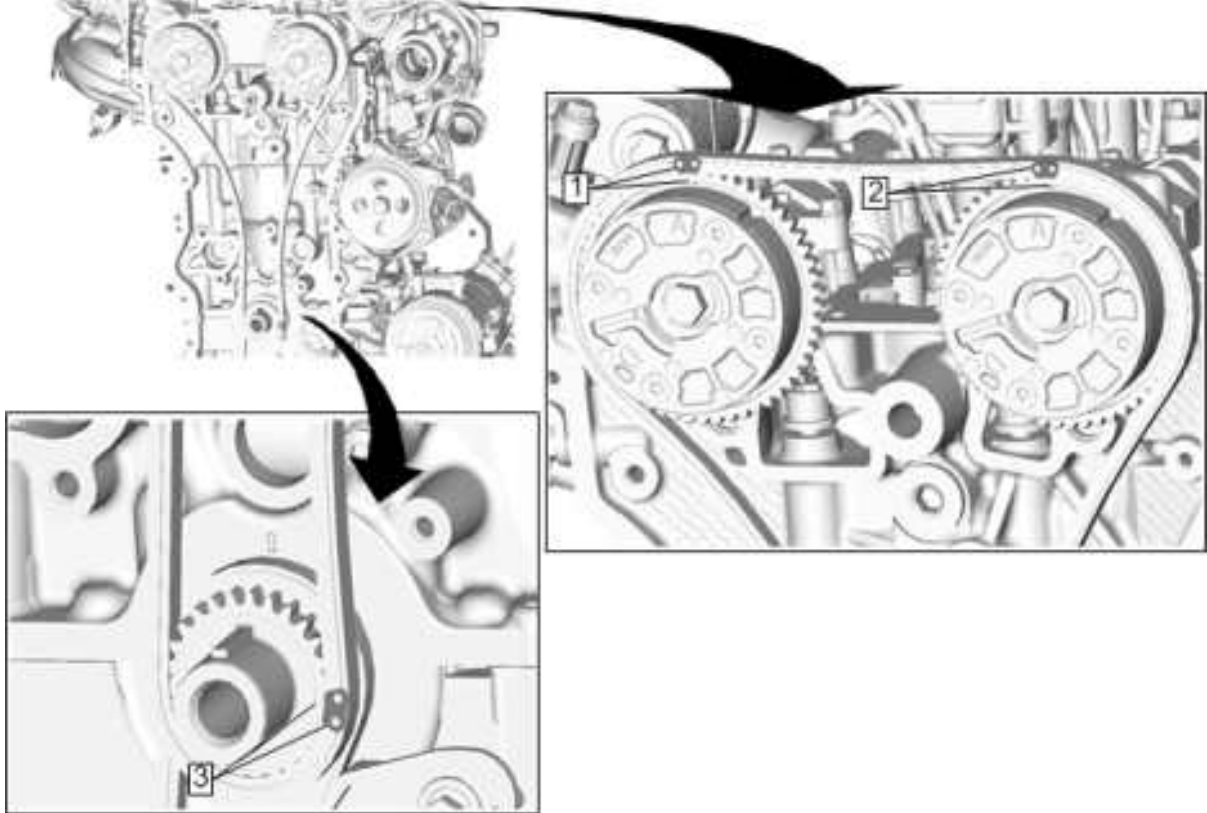


Fig. 162: Timing Chain Marks

Courtesy of GENERAL MOTORS COMPANY

4. Inspect the timing chain marks to confirm they remained aligned after engaging the timing chain tensioner.

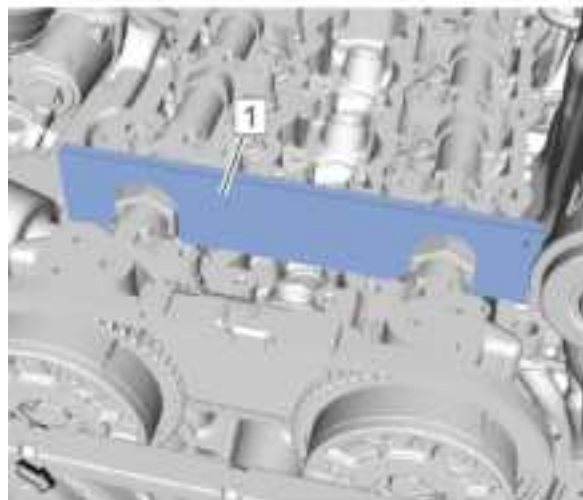


Fig. 163: Camshaft Holder

Courtesy of GENERAL MOTORS COMPANY

5. Remove camshaft holding tool **EN-51367** (1).
6. Using a suitable tool, rotate the crankshaft one complete engine cycle then verify the timing chain marks (1, 2 and 3) are aligned properly.
7. Install [Engine Front Cover Replacement](#)

TURBOCHARGER HEAT SHIELD REPLACEMENT

Removal Procedure

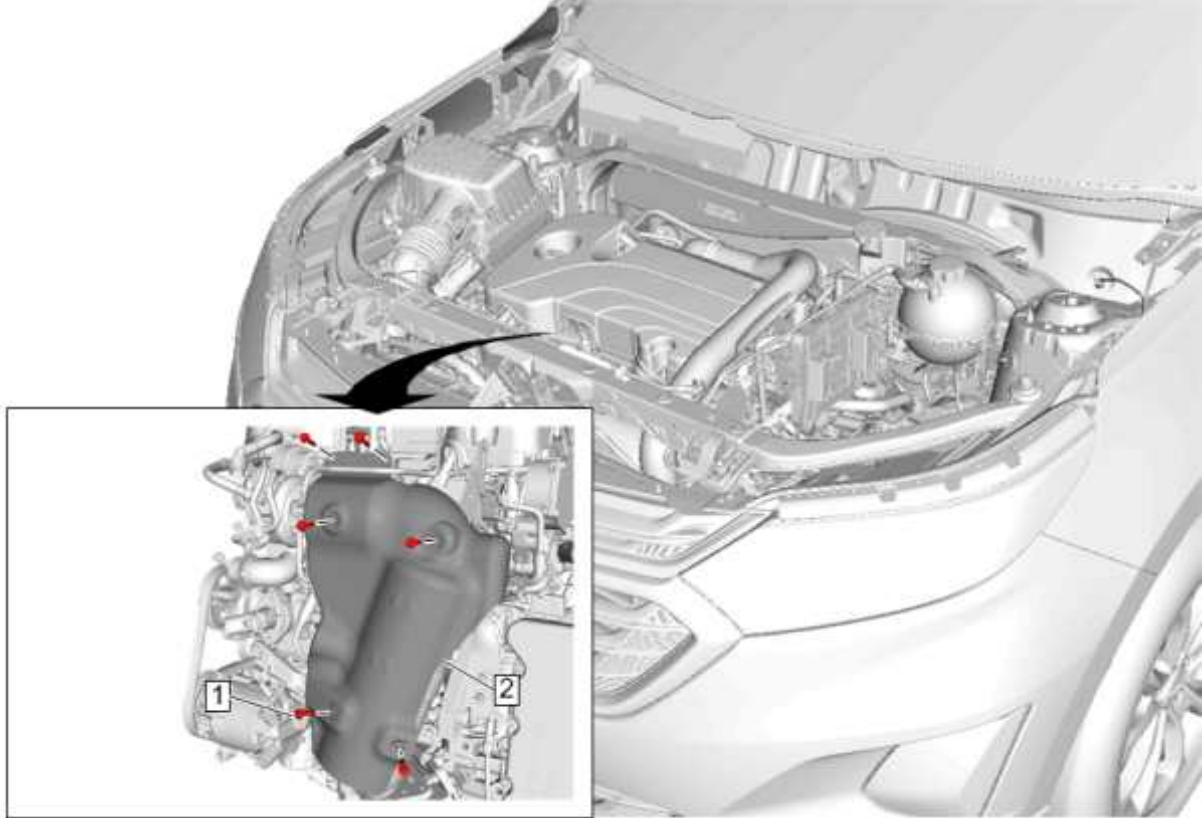


Fig. 164: Turbocharger Heat Shield And Fastener
Courtesy of GENERAL MOTORS COMPANY

1. Remove Turbocharger Heat Shield Fastener (1)
2. Remove Turbocharger Heat Shield (2)

Installation Procedure

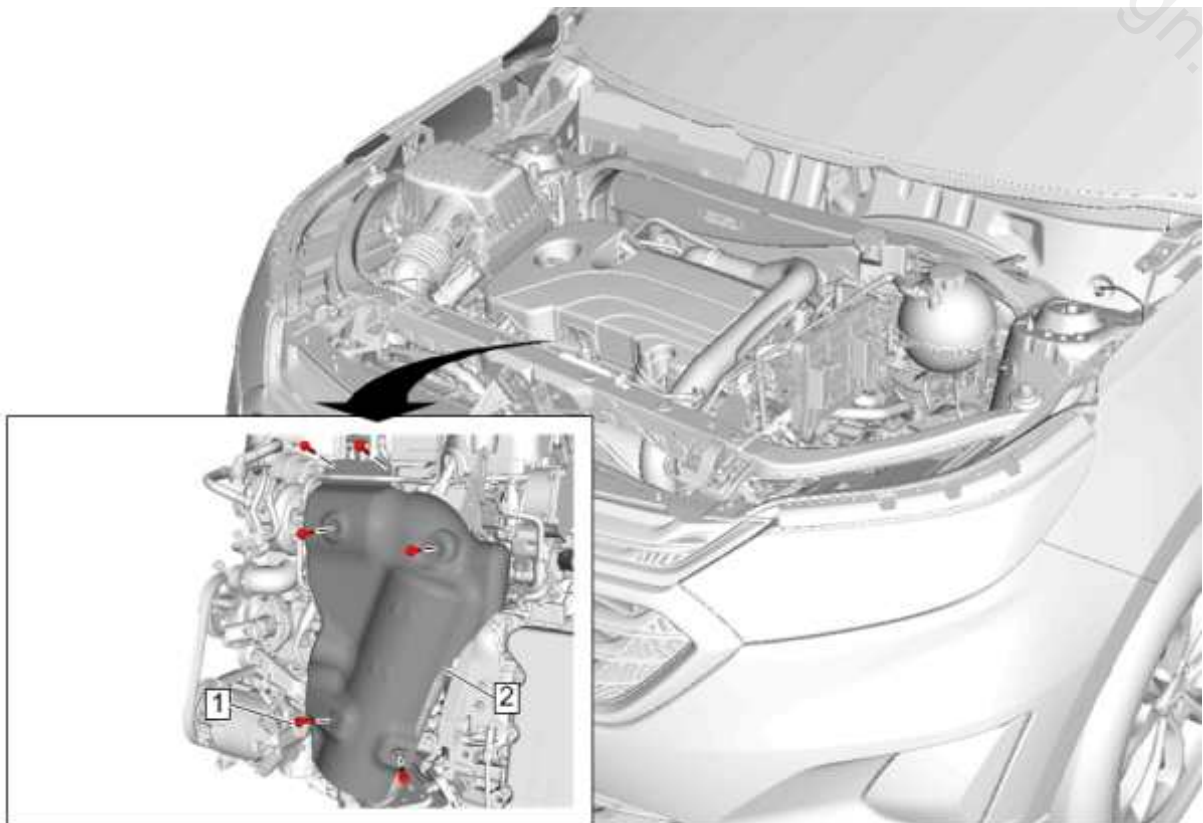


Fig. 165: Turbocharger Heat Shield And Fastener
Courtesy of GENERAL MOTORS COMPANY

1. Install Turbocharger Heat Shield (2)

CAUTION: Refer to [Fastener Caution](#) .

2. Install Turbocharger Heat Shield Fastener (1) and tighten 10 N.m (89 lb in)

TURBOCHARGER OIL FEED PIPE REPLACEMENT

Removal Procedure

1. Remove [Air Conditioning Compressor Bracket Replacement \(LYX\)](#)

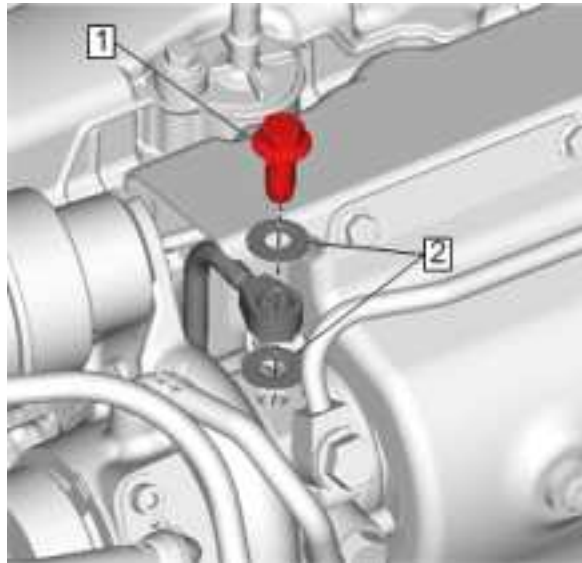


Fig. 166: Turbocharger Oil Feed Pipe Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

2. Remove the turbocharger oil feed pipe bolt (1).
3. Remove and DISCARD the 2 turbocharger oil feed pipe gaskets (2).
4. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

NOTE: It is necessary to remove the catalytic converter to gain more space for the turbocharger oil feed pipe removal.

- 5.

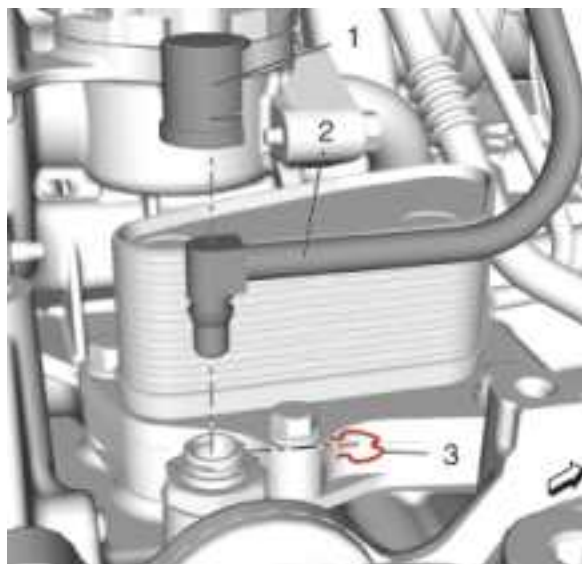


Fig. 167: Turbocharger Oil Feed Pipe, Clip And Retainer
Courtesy of GENERAL MOTORS COMPANY

6. Remove the turbocharger oil feed pipe clip (1).
7. Remove and DISCARD the turbocharger oil feed pipe retainer (3).
8. Remove the turbocharger oil feed pipe (2).

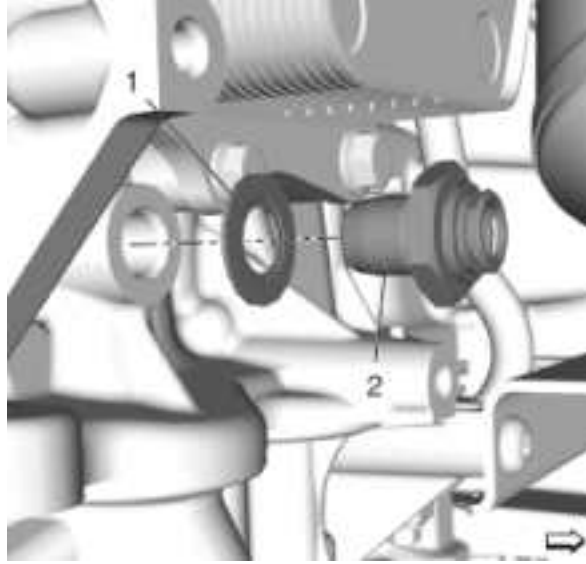


Fig. 168: Turbocharger Oil Feed Pipe Fitting Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The turbocharger oil feed pipe fitting is not reusable.

9. Remove and DISCARD the turbocharger oil feed pipe fitting (2).
10. Remove and DISCARD the turbocharger oil feed pipe fitting gasket (1).

Installation Procedure

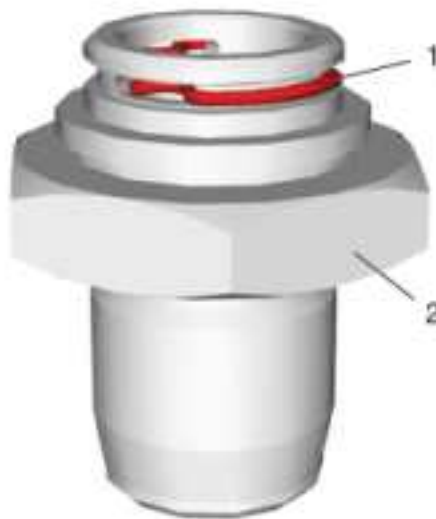


Fig. 169: Turbocharger Oil Feed Pipe Fitting
 Courtesy of GENERAL MOTORS COMPANY

1. The retainer (1) of the turbocharger oil feed pipe fitting (2) is pre-installed.

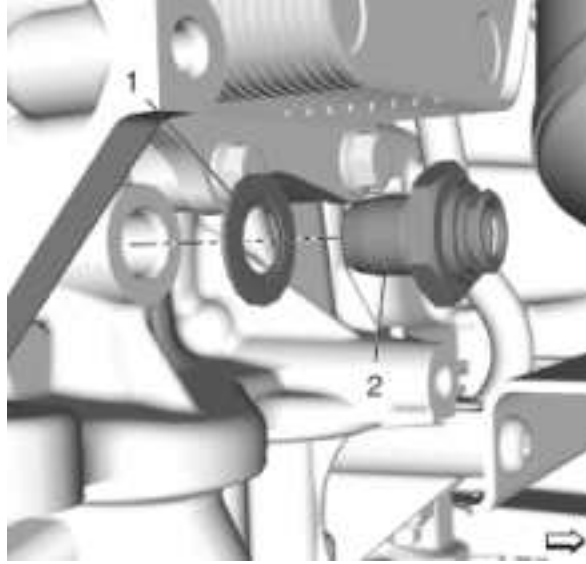


Fig. 170: Turbocharger Oil Feed Pipe Fitting Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW turbocharger oil feed pipe fitting gasket (1).

CAUTION: Refer to [Component Fastener Tightening Caution](#) .

3. Install a NEW turbocharger oil feed pipe fitting (2) and tighten to 35 N.m (26 lb ft).

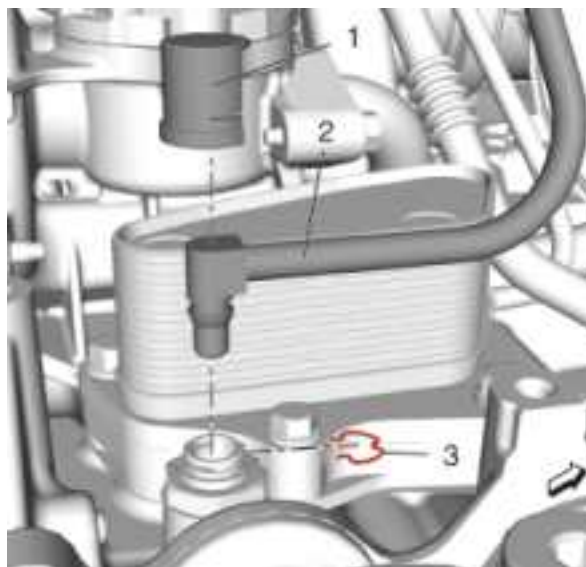


Fig. 171: Turbocharger Oil Feed Pipe, Clip And Retainer
Courtesy of GENERAL MOTORS COMPANY

CAUTION: When installing a quick-connect turbocharger oil feed pipe, ensure that the oil feed pipe is fully secured into the oil feed pipe fitting. An audible click will be heard when the oil feed pipe is seated. If the oil feed pipe is not fully seated, an oil leak can occur in certain RPM ranges and will cause significant component and/or vehicle damage. Due to the possibility of significant component and/or vehicle damage from an oil feed pipe leak, it is necessary to start the engine and inspect for signs of leakage around the connections after performing the repair.

NOTE: The retainer (3) is pre-installed in the fitting. Therefore the pipe can be snapped into the fitting but cannot be removed once installed.

4. Install the turbocharger oil feed pipe (2).
5. Install the turbocharger oil feed pipe clip (1).

6. Pull back on turbocharger oil feed pipe (2) to be sure the retainer (3) properly retains the pipe in the fitting.
7. Lower the vehicle.

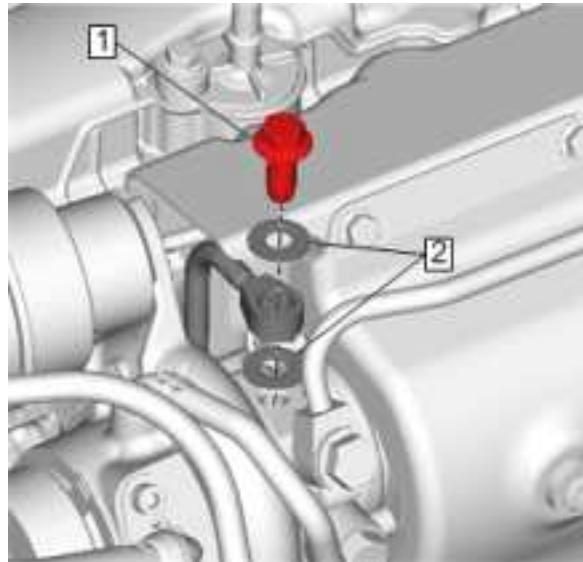


Fig. 172: Turbocharger Oil Feed Pipe Bolt And Gaskets
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Ensure that the turbocharger oil feed pipe does not rotate while torquing it. There should be a minimum 10 mm gap between the oil feed pipe and the v-band clamp. Failure to perform this could result in damage to the oil feed pipe and create an oil leak.

8. Install 2 NEW turbocharger oil feed pipe gaskets (2).
9. Install the turbocharger oil feed pipe bolt (1) and tighten to 32 N.m (24 lb ft)
10. Install [Air Conditioning Compressor Bracket Replacement \(LYX\)](#) .

TURBOCHARGER OIL RETURN PIPE REPLACEMENT

Removal Procedure

1. Remove Warm Up Three-Way Catalytic Converter - [Warm Up Three-Way Catalytic Converter Replacement \(LYX\)](#)

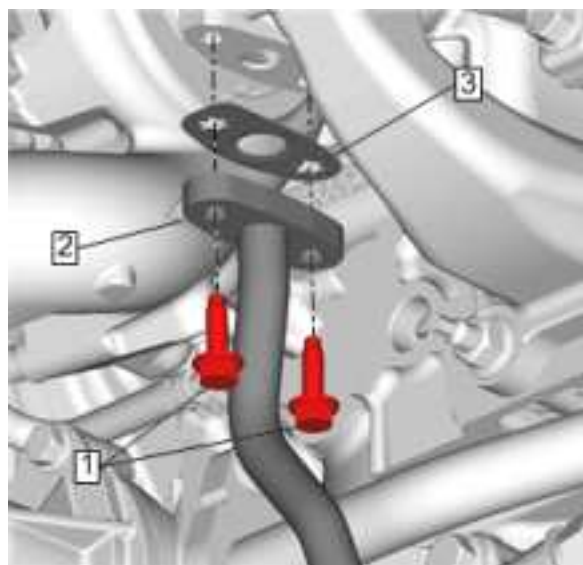


Fig. 173: Turbocharger Oil Return Pipe, Fasteners And Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Remove the short turbocharger oil return pipe fasteners (1).
3. Remove and DISCARD the gasket (3) from the turbocharger oil return pipe (2).

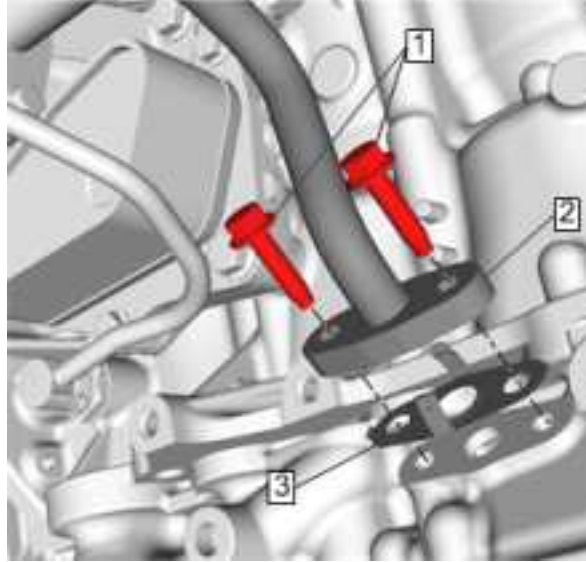


Fig. 174: Turbocharger Oil Return Pipe, Fasteners And Gasket
 Courtesy of GENERAL MOTORS COMPANY

4. Remove the long turbocharger oil return pipe fasteners (1) then remove the pipe (2).
5. Remove and DISCARD the turbocharger oil return pipe gasket (3).

Installation Procedure

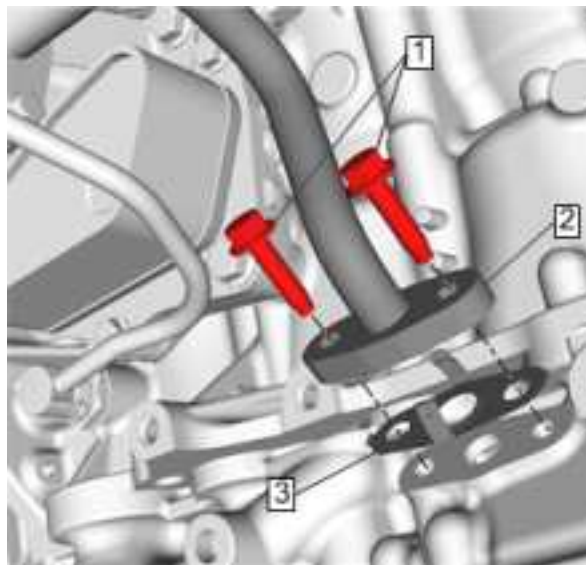


Fig. 175: Turbocharger Oil Return Pipe, Fasteners And Gasket
 Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW turbocharger return pipe gasket (3).

CAUTION: Refer to **Fastener Caution** .

2. Position the turbocharger oil return pipe (2) then hand start the long turbocharger oil return pipe to engine block fasteners (1). Tighten to 10 N.m (89 lb in).

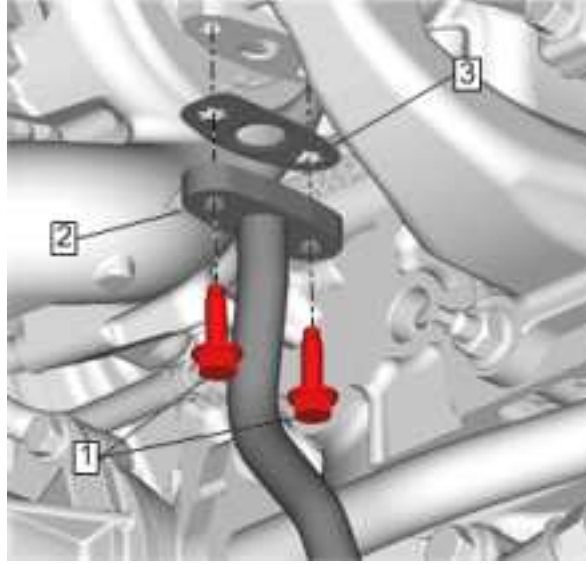


Fig. 176: Turbocharger Oil Return Pipe, Fasteners And Gasket
 Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW turbocharger oil return pipe gasket (3).
4. Hand start the short turbocharger oil return pipe to turbocharger fasteners (1). Tighten to 10 N.m (89 lb in).
5. Install Warm Up Three-Way Catalytic Converter - [Warm Up Three-Way Catalytic Converter Replacement \(LYX\)](#)

TURBOCHARGER REPLACEMENT

Special Tools

- EN-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

Removal Procedure

CAUTION: If a turbocharger has failed, clean any turbocharger debris or excessive oil from the charge air cooler system before installing the new turbocharger. Failure to clean debris from the charge air cooler system will cause severe turbocharger and engine damage upon startup.

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement](#)
3. Disconnect Air Cleaner Outlet Duct@Turbocharger - [Air Cleaner Outlet Duct Replacement](#)
4. Disconnect Air Cleaner Outlet Duct@Air Cleaner Assembly - [Air Cleaner Outlet Duct Replacement](#)

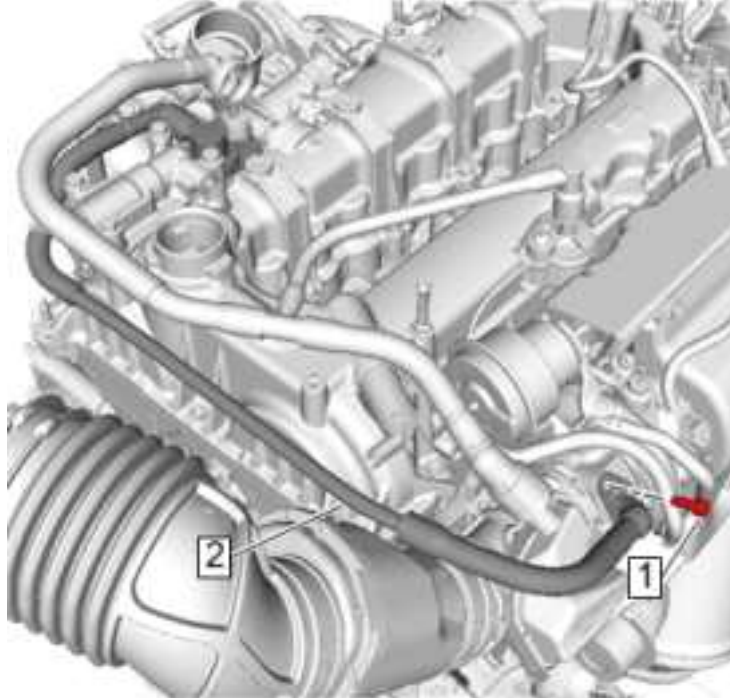


Fig. 177: PCV Valve Tube And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: The positive crankcase ventilation valve and tube assembly (2) are not reusable. If reinstalling the camshaft cover, do not remove the PCV valve and tube assembly (2) from the camshaft cover.

5. Disconnect Positive Crankcase Ventilation Tube with Positive Crankcase Ventilation Valve - Foul Air@Turbocharger - [Positive Crankcase Ventilation Tube Replacement \(Fresh Air\)](#)[Positive Crankcase Ventilation Tube Replacement \(Foul Air\)](#)
6. Remove Charge Air Cooler Inlet Hose - [Charge Air Cooler Inlet Air Tube Replacement](#)
7. Remove Warm Up Three-Way Catalytic Converter - [Warm Up Three-Way Catalytic Converter Replacement \(LYX\)](#)

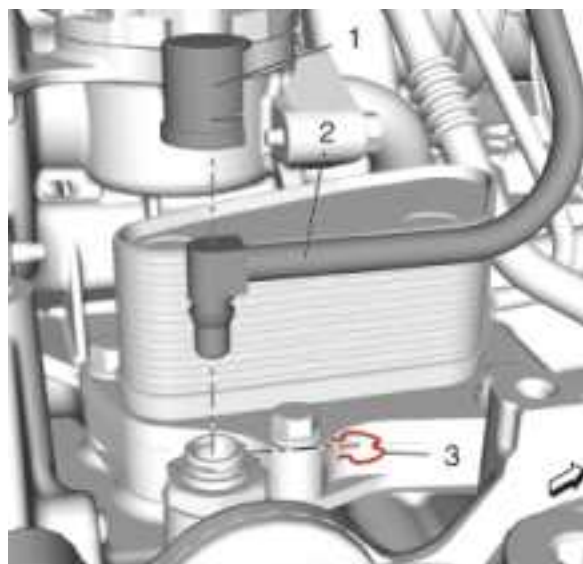


Fig. 178: Turbocharger Oil Feed Pipe, Clip And Retainer

Courtesy of GENERAL MOTORS COMPANY

8. Remove Turbocharger Oil Feed Pipe - [Turbocharger Oil Feed Pipe Replacement](#)
9. Remove Turbocharger Coolant Return Pipe - [Turbocharger Coolant Return Pipe Replacement \(LYX\)](#)
10. Remove Turbocharger Coolant Feed Pipe - [Turbocharger Coolant Feed Pipe Replacement \(LYX\)](#)

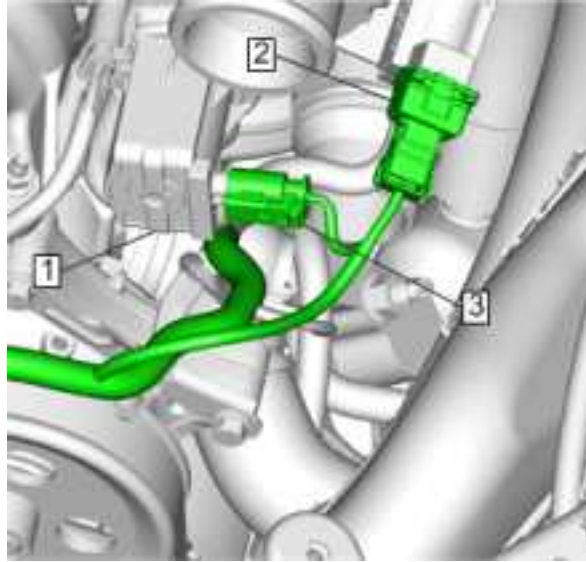


Fig. 179: Turbocharger Bypass Valve Solenoid And Electrical Connectors
 Courtesy of GENERAL MOTORS COMPANY

11. Disconnect Electrical Connector (3)@Turbocharger Bypass Valve Solenoid (1)
12. Disconnect the turbocharger wastegate regulator solenoid valve electrical connector (2).
13. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

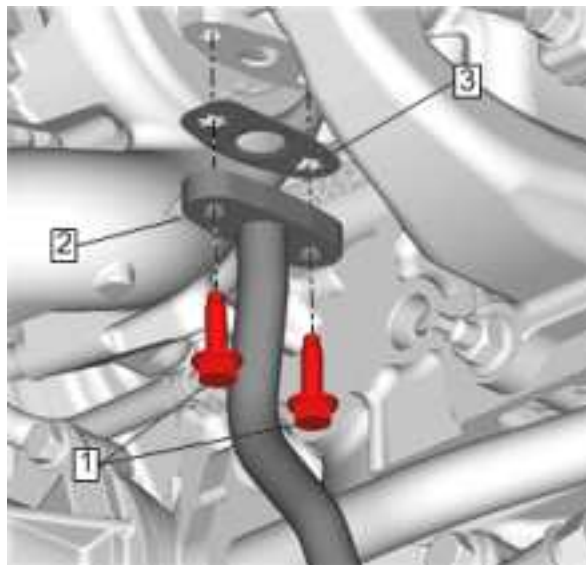


Fig. 180: Turbocharger Oil Return Pipe, Fasteners And Gasket
 Courtesy of GENERAL MOTORS COMPANY

14. Remove the turbocharger oil return pipe bolts (1) and carefully separate the pipe (2).
15. Remove Remove Turbocharger Oil Return Pipe Gasket (3) and DISCARD
16. Lower the vehicle. [Lifting and Jacking the Vehicle](#)

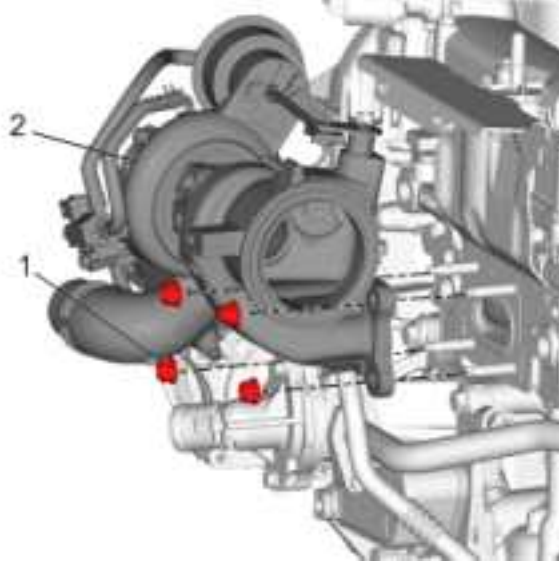


Fig. 181: Turbocharger And Nuts

Courtesy of GENERAL MOTORS COMPANY

17. Remove Turbocharger Nut (1) and DISCARD[4x]
18. Remove Turbocharger (2).

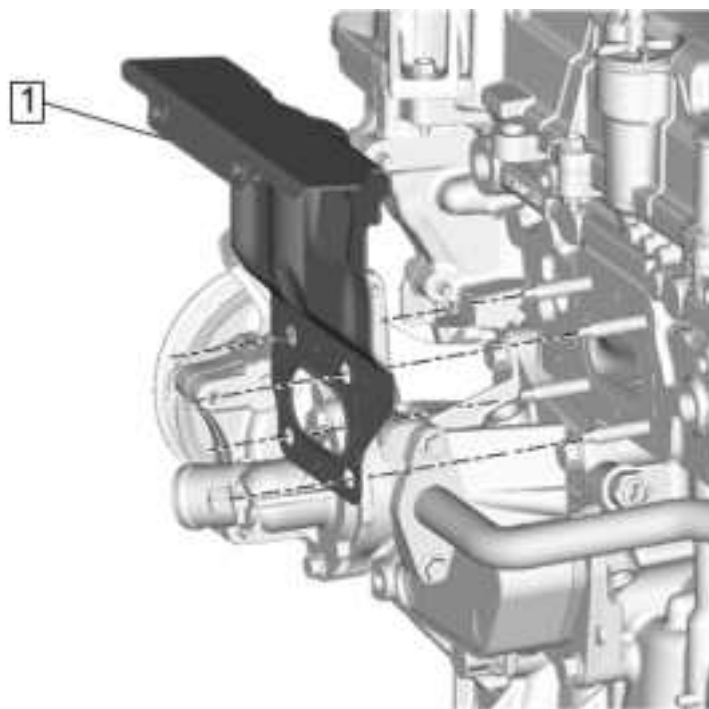


Fig. 182: Turbocharger Heat Shield

Courtesy of GENERAL MOTORS COMPANY

19. Remove and DISCARD the turbocharger heat shield with gasket (1).
 20. Clean the exhaust manifold sealing surface at the cylinder head.
 21. Clean the 4 turbocharger studs at the cylinder head.
 22. Clean and inspect the turbocharger and transfer remaining components as needed. **Turbocharger**
- Cleaning and Inspection**

Installation Procedure

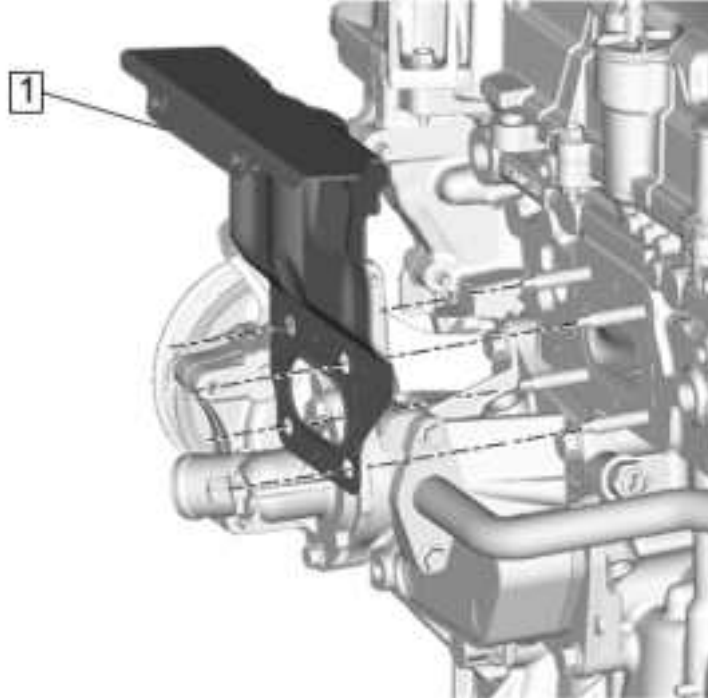


Fig. 183: Turbocharger Heat Shield

Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW turbocharger heat shield with gasket (1).

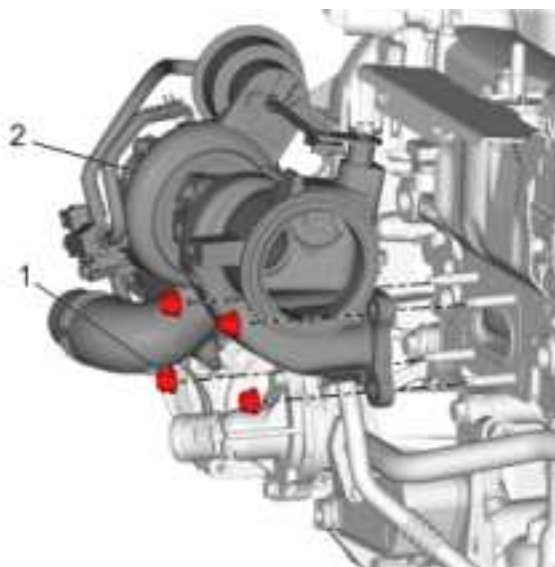


Fig. 184: Turbocharger And Nuts

Courtesy of GENERAL MOTORS COMPANY

2. Install Turbocharger (2)
3. Raise the vehicle.
4. Install and hand tighten the 4 NEW turbocharger nuts (1).

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

5. Turbocharger Nut (1) - Tighten in sequence [4x] - [Turbocharger Installation](#)

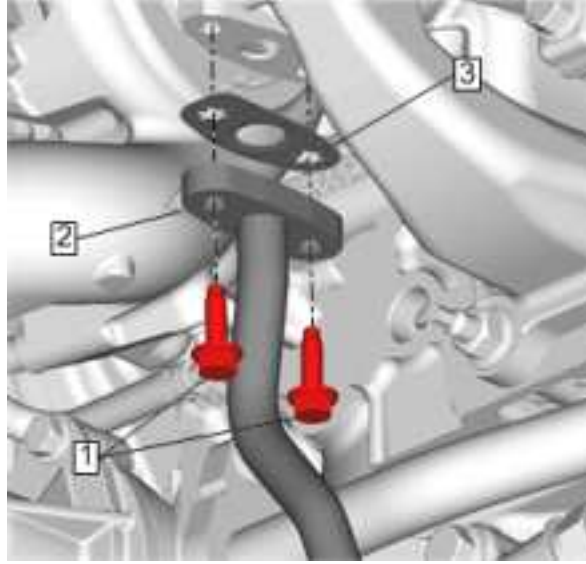


Fig. 185: Turbocharger Oil Return Pipe, Fasteners And Gasket
Courtesy of GENERAL MOTORS COMPANY

6. Install a NEW Turbocharger Oil Return Pipe Gasket (3).
7. Position the pipe (2) then install the turbocharger oil return pipe bolts (1). [Turbocharger Oil Return Pipe Replacement](#)
8. Lower the vehicle.

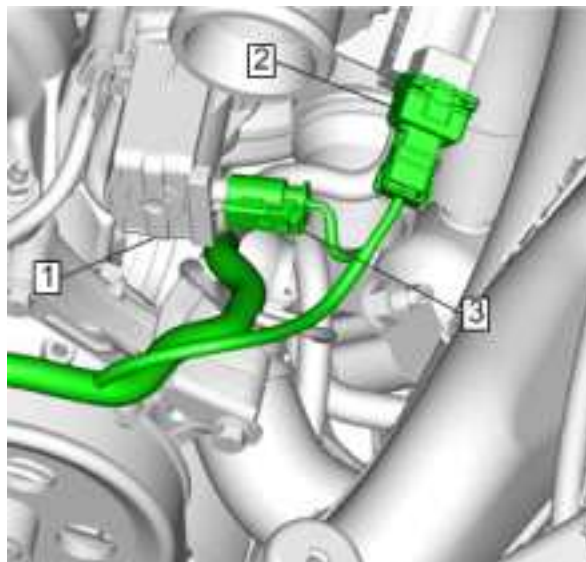


Fig. 186: Turbocharger Bypass Valve Solenoid And Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

9. Connect the turbocharger wastegate regulator solenoid valve electrical connector (2).
10. Connect Electrical Connector (3) @Turbocharger Bypass Valve Solenoid (1)
11. Install Turbocharger Coolant Feed Pipe - [Turbocharger Coolant Feed Pipe Replacement \(LYX\)](#)
12. Install Turbocharger Coolant Return Pipe - [Turbocharger Coolant Return Pipe Replacement \(LYX\)](#)

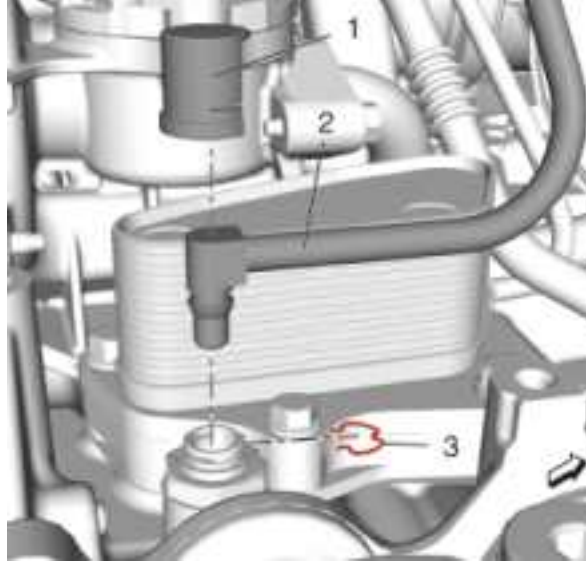


Fig. 187: Turbocharger Oil Feed Pipe, Clip And Retainer
 Courtesy of GENERAL MOTORS COMPANY

13. Install Turbocharger Oil Feed Pipe (2) - [Turbocharger Oil Feed Pipe Replacement](#)
14. Install Warm Up Three-Way Catalytic Converter - [Warm Up Three-Way Catalytic Converter Replacement \(LYX\)](#)

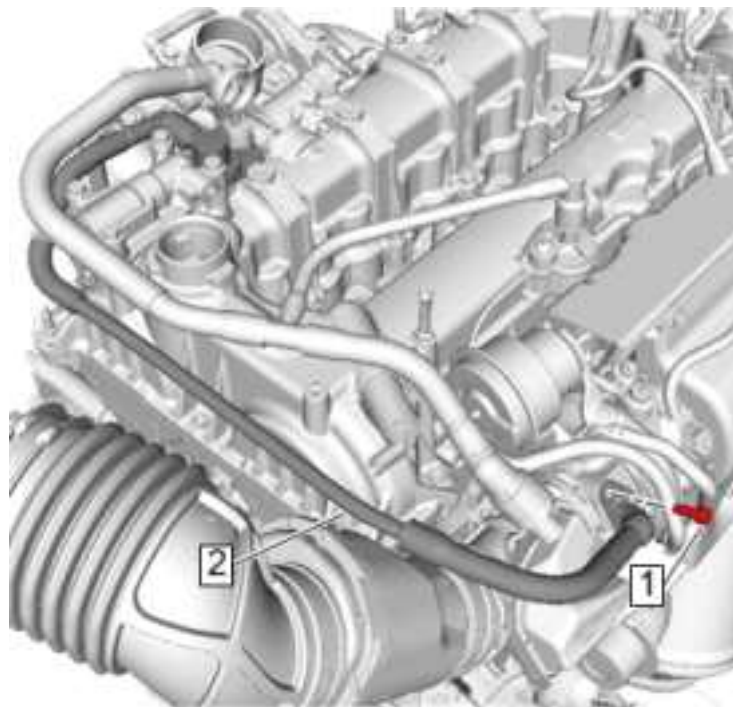


Fig. 188: PCV Valve Tube And Fastener
 Courtesy of GENERAL MOTORS COMPANY

15. Connect Positive Crankcase Ventilation Tube with Positive Crankcase Ventilation Valve - Foul Air (2) @Turbocharger - [Positive Crankcase Ventilation Tube Replacement \(Fresh Air\)Positive Crankcase Ventilation Tube Replacement \(Foul Air\)](#)
16. Install Charge Air Cooler Inlet Hose - [Charge Air Cooler Inlet Air Tube Replacement](#)
17. Install Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement](#)
18. Connect Air Cleaner Outlet Duct@Turbocharger - [Air Cleaner Outlet Duct Replacement](#)
19. Connect Air Cleaner Outlet Duct@Air Cleaner Assembly - [Air Cleaner Outlet Duct Replacement](#)
20. Connect the battery negative cable. [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
21. Perform the Intake System Learned Values Reset. [Intake System Learned Values Reset](#)

INTAKE MANIFOLD COVER REPLACEMENT

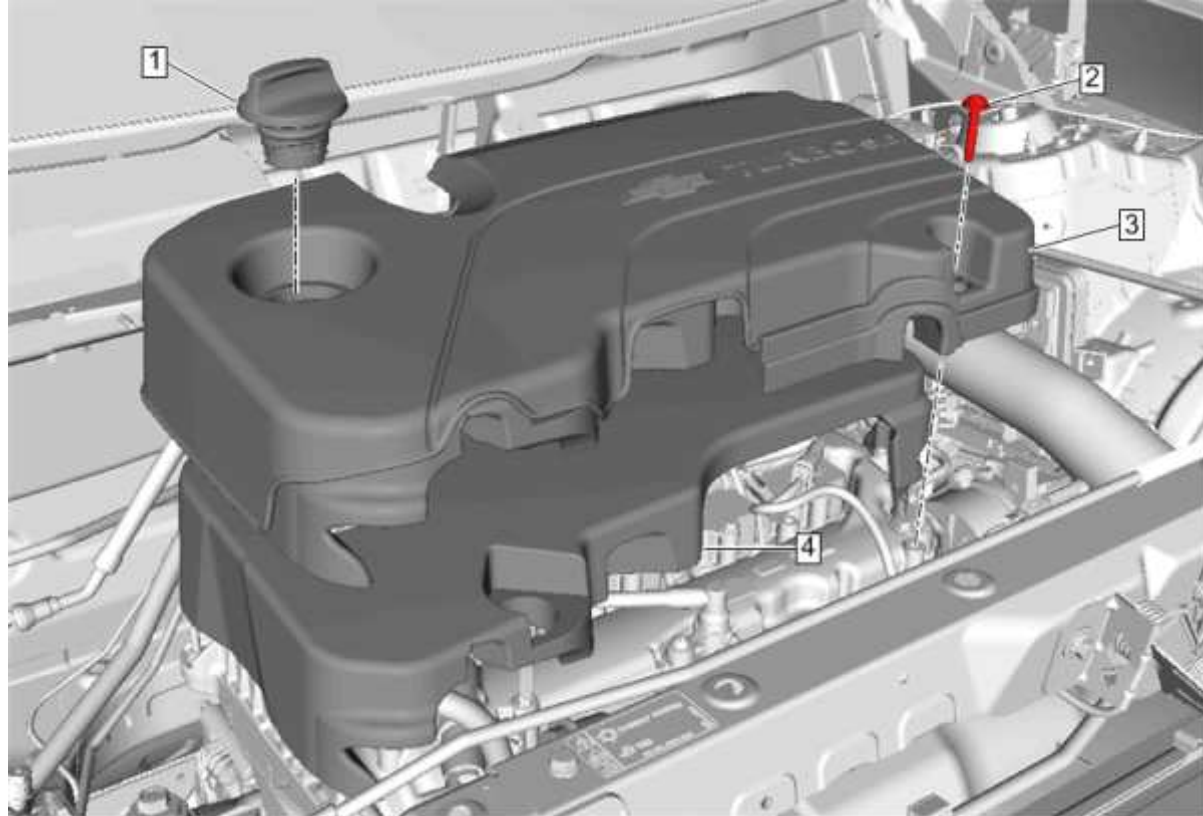


Fig. 189: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Filler Cap
2	Intake Manifold Cover Fastener CAUTION: Refer to Fastener Caution . Tighten 9 N.m (80 lb in)
3	Intake Manifold Cover Procedure Release the intake manifold cover retainers by pulling the intake manifold cover upwards.
4	Intake Manifold Cover Insulator

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove Intake Manifold Cover -[Intake Manifold Cover Replacement](#)
2. Reposition away Fuel Feed Front Pipe -[Fuel Feed Front Pipe Replacement](#)
3. Remove Evaporative Emission Canister Purge Solenoid Valve -[Evaporative Emission Canister Purge Solenoid Valve Replacement](#)

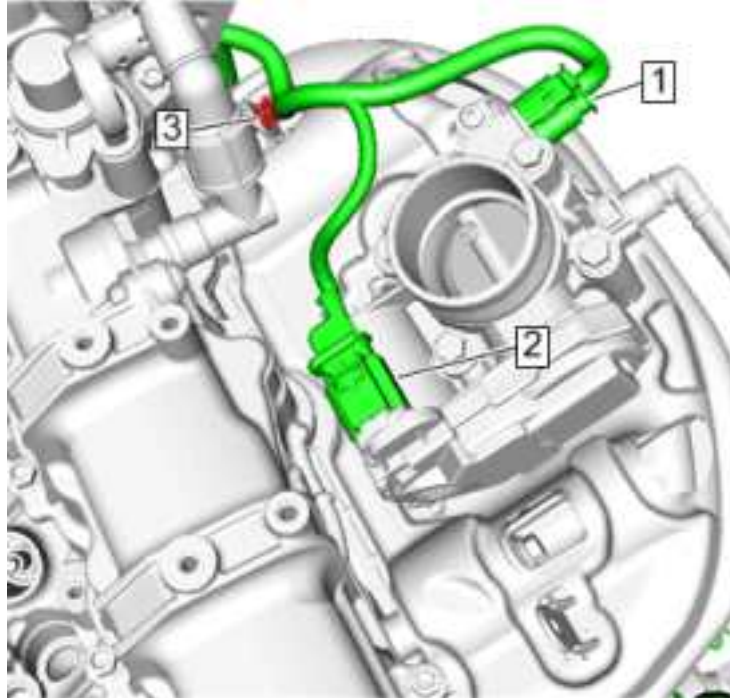


Fig. 190: Electrical Connectors

Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the electrical connectors (1, 2)
5. Remove Wiring Harness Retainer (3)
6. Remove Throttle Body Assembly - [Throttle Body Assembly Replacement](#)

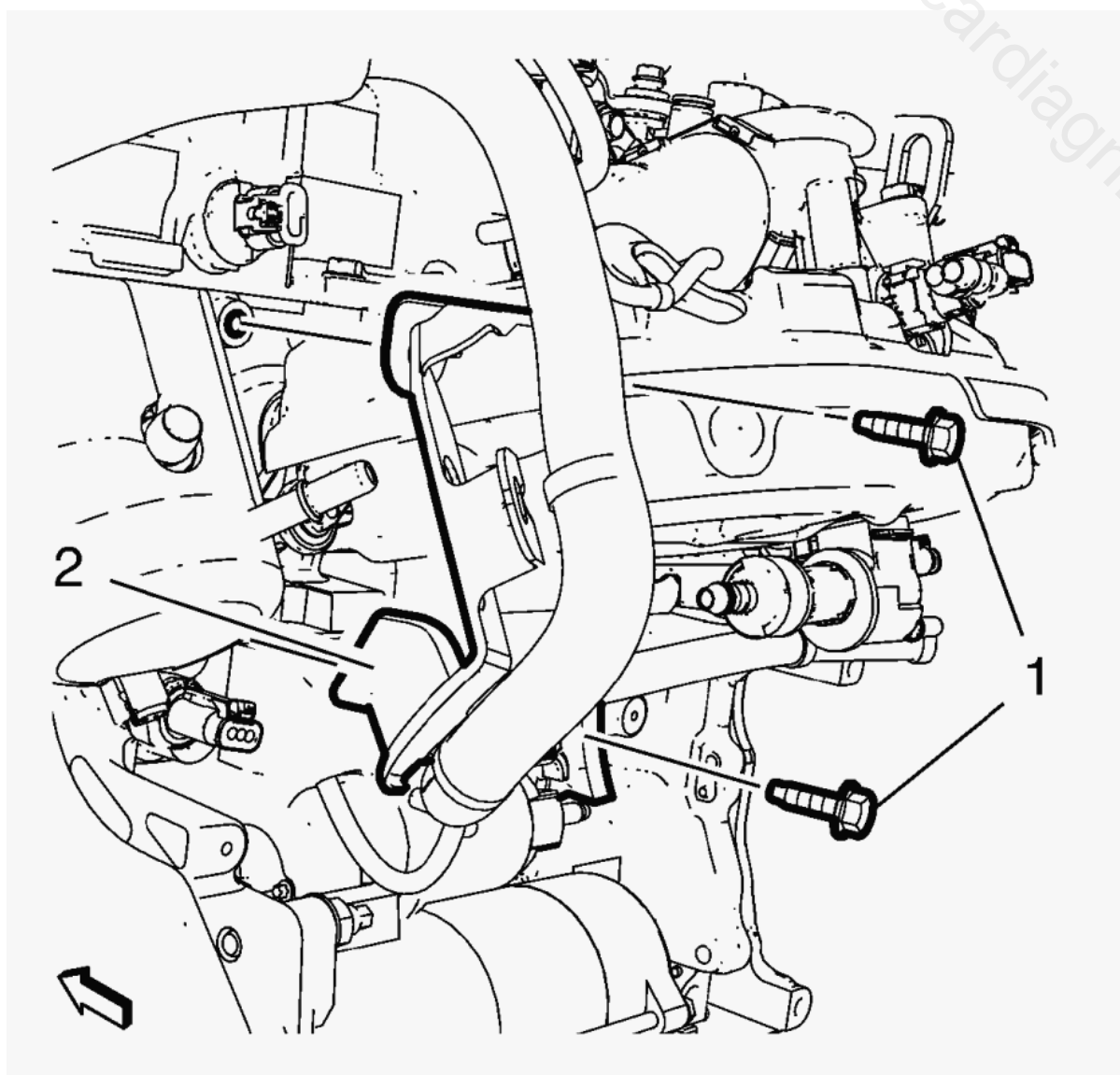


Fig. 191: Engine Wiring Harness Bracket
Courtesy of GENERAL MOTORS COMPANY

7. Remove Engine Wiring Harness Bracket Bolt (1)
8. Reposition away Engine Wiring Harness Bracket (2)

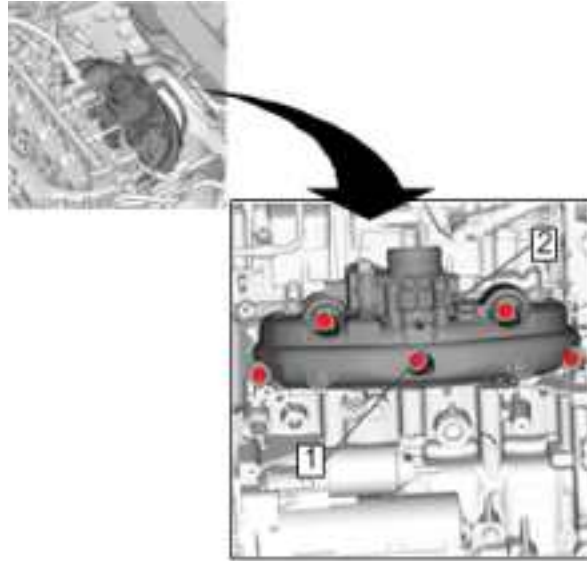


Fig. 192: Intake Manifold And Fasteners
Courtesy of GENERAL MOTORS COMPANY

NOTE: Bolt retainers keep the bolts in position on the assembly. If the bolts are removed from the assembly, the 2 shorter bolts go to the outside lower locations.

9. Fully loosen the intake manifold fasteners (1) then remove the intake manifold (2).

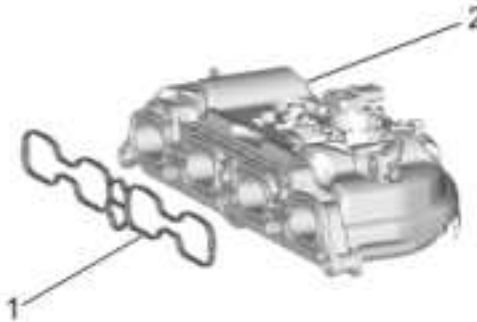


Fig. 193: Intake Manifold Gasket
Courtesy of GENERAL MOTORS COMPANY

10. Remove Intake Manifold Gasket (2) and DISCARD
11. Clean and inspect the intake manifold. [Intake Manifold Cleaning and Inspection](#)
12. If replacing the intake manifold, transfer all necessary parts.

Installation Procedure

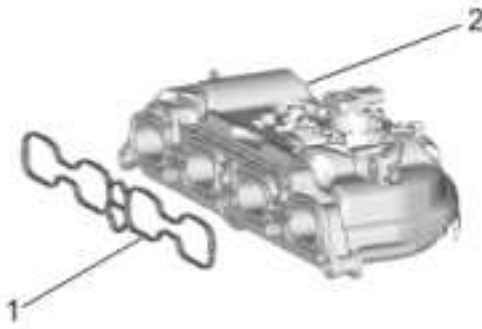


Fig. 194: Intake Manifold Gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: Upon installation of the intake manifold, ensure the gasket remains properly seated into the intake manifold (2).

1. Install a NEW intake manifold gasket.

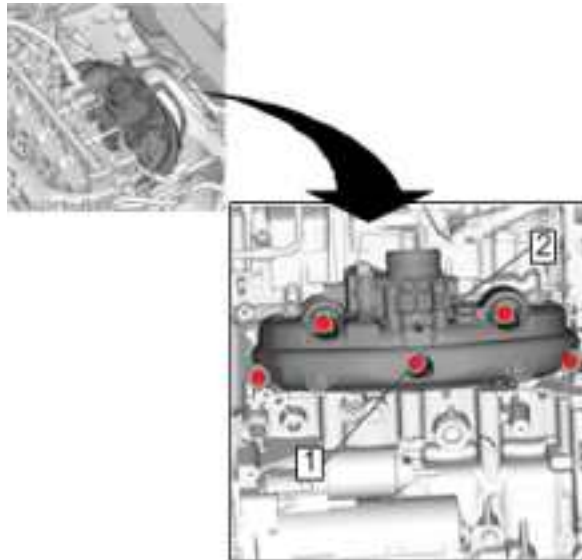


Fig. 195: Intake Manifold And Fasteners

Courtesy of GENERAL MOTORS COMPANY

2. Install the intake manifold (2).
3. Hand tighten the bolts.

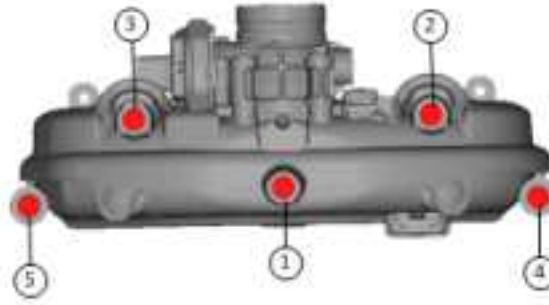


Fig. 196: Intake Manifold Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

4. Tighten the bolts in sequence. 12 N.m (106 lb in)

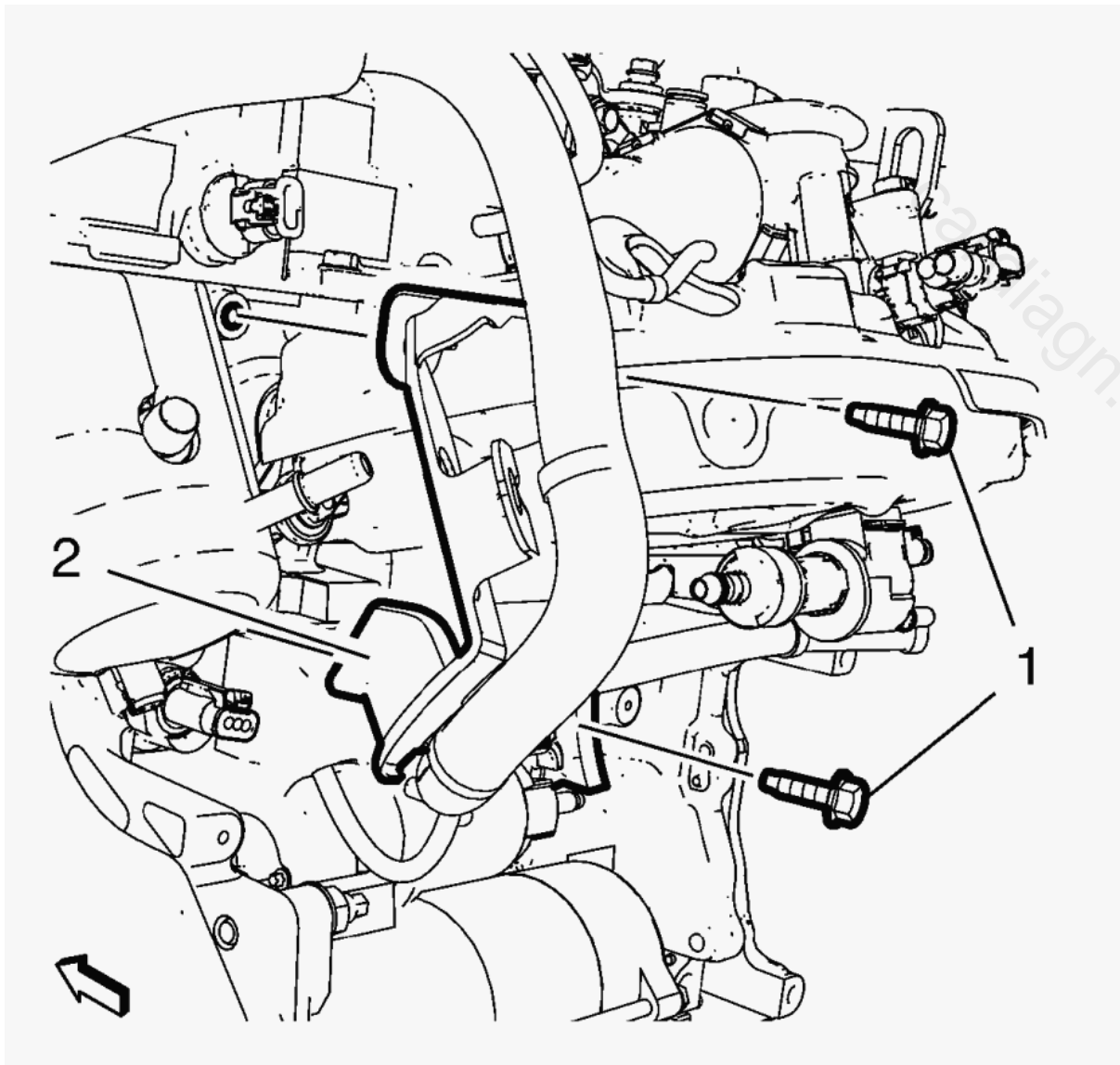


Fig. 197: Engine Wiring Harness Bracket
 Courtesy of GENERAL MOTORS COMPANY

5. Install Engine Wiring Harness Bracket (2).
6. Install Engine Wiring Harness Bracket Bolt (1) - and tighten 9 N.m (80 lb in) [2x]
7. Install Fuel Feed Front Pipe - [Fuel Feed Front Pipe Replacement](#)
8. Install Throttle Body Assembly - [Throttle Body Assembly Replacement](#)

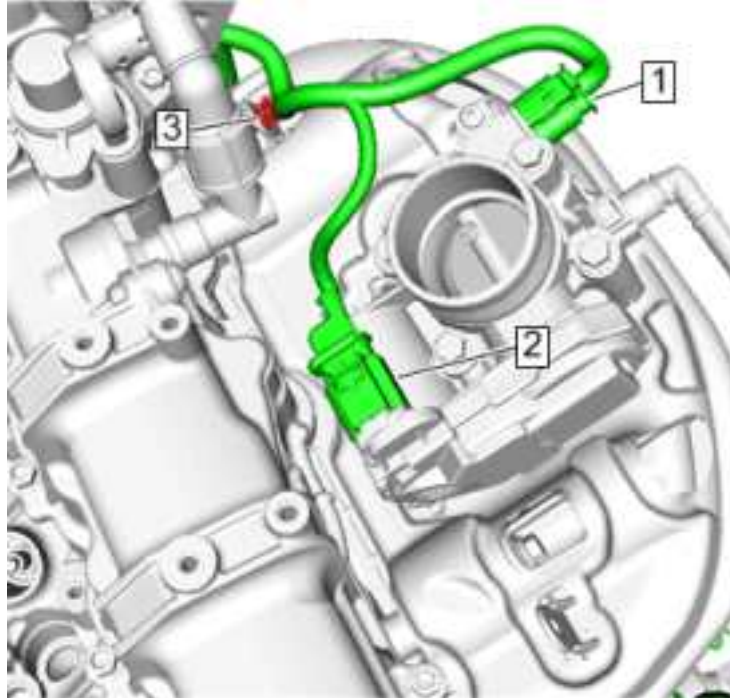


Fig. 198: Electrical Connectors

Courtesy of GENERAL MOTORS COMPANY

9. Connect the electrical connectors.(1, 2)
10. Install Wiring Harness Retainer (3)
11. Install Evaporative Emission Canister Purge Solenoid Valve - [Evaporative Emission Canister Purge Solenoid Valve Replacement](#)
12. Install Intake Manifold Cover - [Intake Manifold Cover Replacement](#)

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- EN-44226 Crankshaft Balancer Remover
- EN-44226-5 Crankshaft Protector
- EN-45059 Angle Meter
- EN-51368 Front Crankshaft Seal Installer

Equivalent regional tools:[Special Tools](#)

Removal Procedure

1. Remove [Drive Belt Replacement](#)

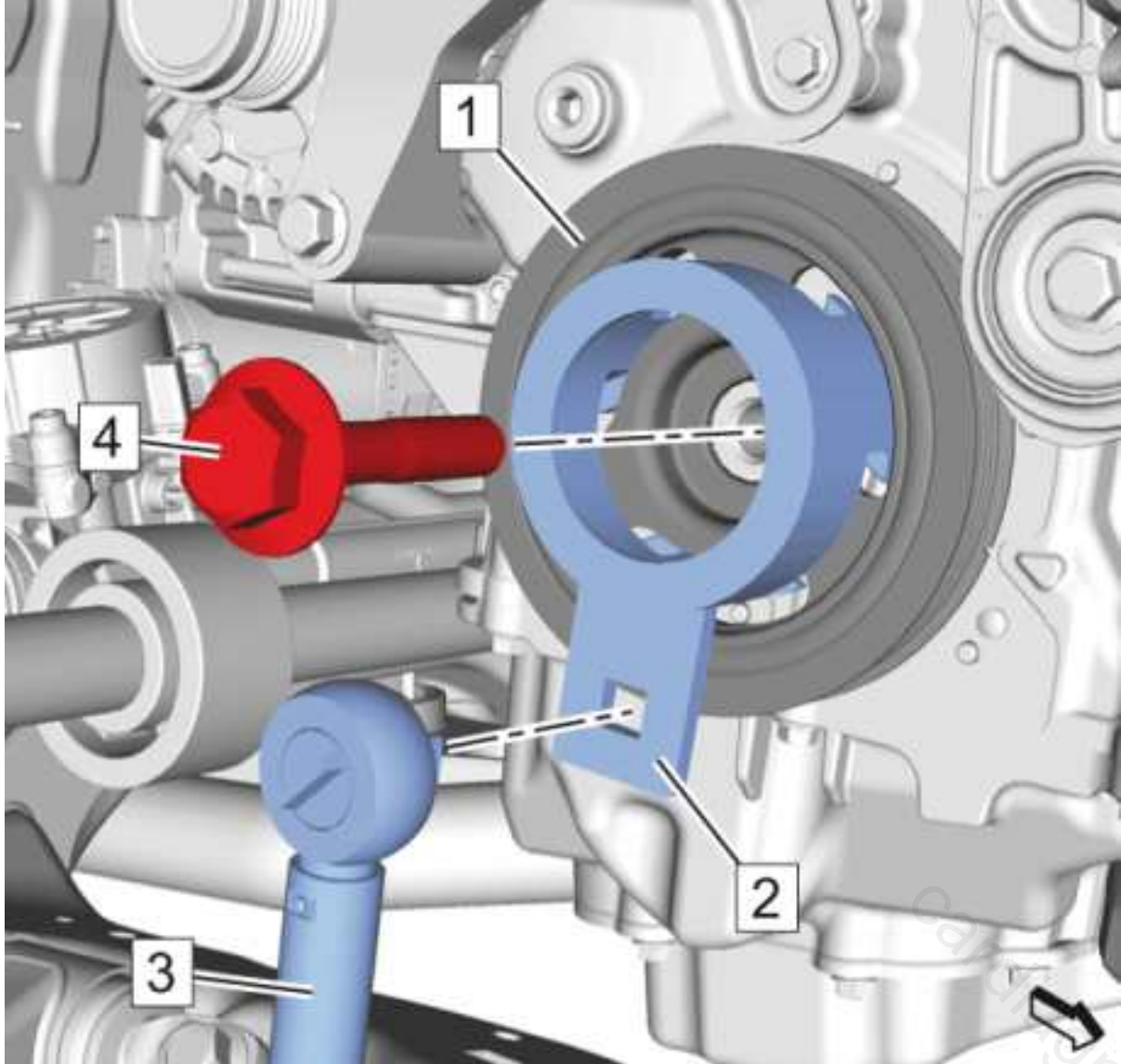


Fig. 199: Crankshaft Balancer, Special Tools And Bolt
 Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-44226-1** remover (2) to the crankshaft balancer (1).
3. Loosen the crankshaft balancer bolt (3) by counter holding the crankshaft balancer (1) with the **EN-44226-1** remover (3) and suitable tool.
4. Remove the **EN-44226-1** remover.
5. Remove the crankshaft balancer bolt.



Fig. 200: Protector And Crankshaft
 Courtesy of GENERAL MOTORS COMPANY

6. Install the **EN-44226-5** protector (1) to the crankshaft (2).



Fig. 201: Remover Plate Assembly And Balancer
Courtesy of GENERAL MOTORS COMPANY

7. Install **EN-44226-1** remover (2) and **EN-44226-2** remover plate (3) onto the balancer (4).
8. Install the **EN-44226-3** remover screw (1) through the **EN-44226-2** remover plate and against the **EN-44226-5** protector.
9. Counter hold the **EN-44226-2** remover plate and turn the **EN-51368** installer screw to remove the balancer.
10. Remove the **EN-44226** remover.
11. Remove the crankshaft balancer (4).
12. Remove the **EN-44226-5** protector.

Installation Procedure

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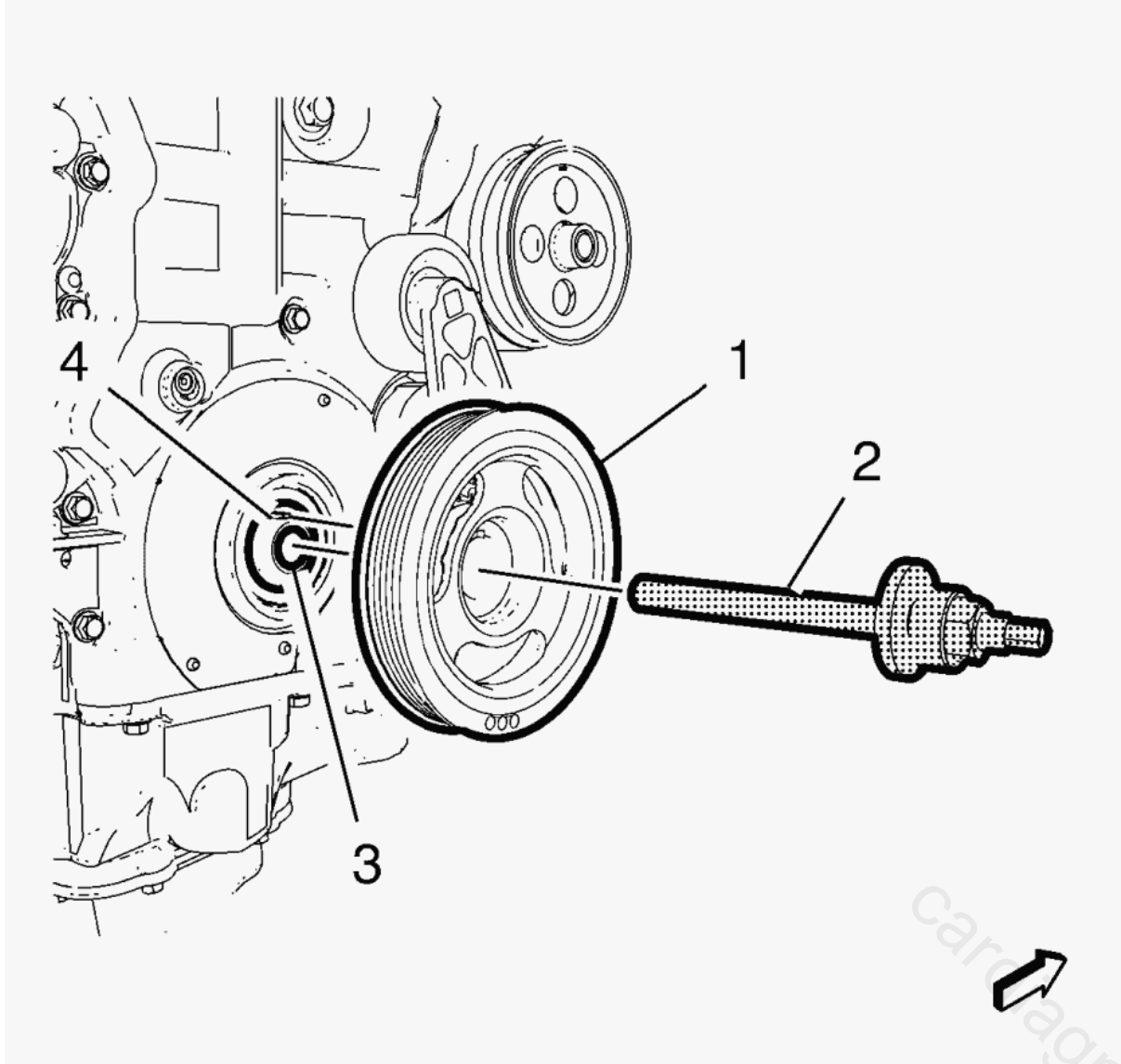


Fig. 202: Crankshaft Balancer, Key And Special Tool
Courtesy of GENERAL MOTORS COMPANY

1. Install Crankshaft Balancer (1) @Crankshaft (3).
2. Make sure that the key is properly seated (4) on crankshaft balancer notch.
3. Install the **EN-51368** installer (2)
4. Install the crankshaft balancer by screwing the flange from **EN-51368** installer.
5. Remove the **EN-51368** installer (2)

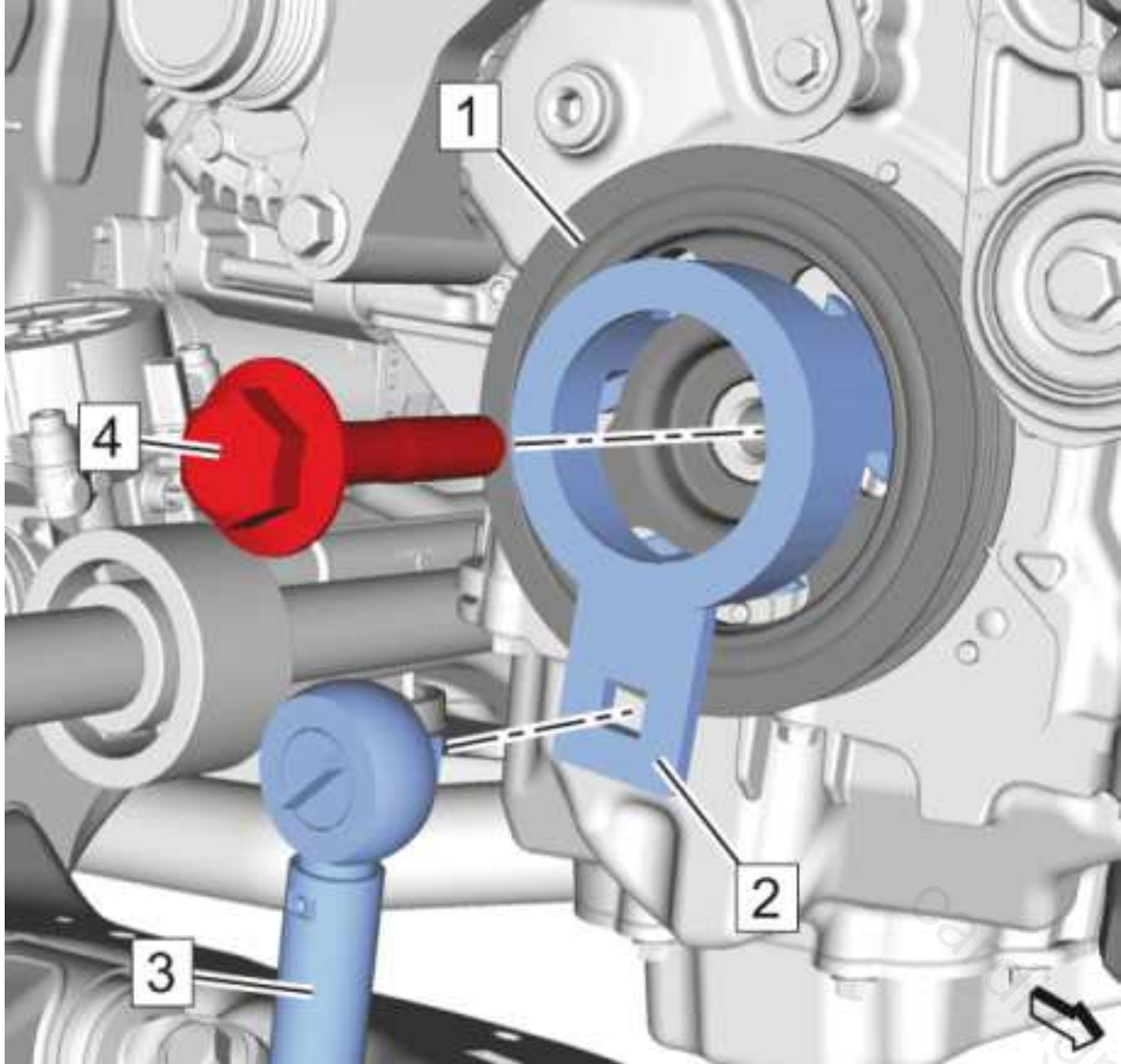


Fig. 203: Crankshaft Balancer, Special Tools And Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Install and handtighten the crankshaft balancer bolt (3).
7. Install the **EN-44226-1** remover (2) to the crankshaft balancer (1).

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

8. Tighten the crankshaft balancer bolt (3) by counter holding the crankshaft balancer (1) with the **EN-44226-1** (3) and torque wrench.
 1. First pass to 100 N.m (74 lb ft)
 2. Loosen the bolt to 360 degrees
 3. Final pass to an additional 180 degree, using the **EN-45059** meter
9. Remove **EN-44226-1** remover (2) from the crankshaft balancer (1).
10. Install Drive Belt Replacement.

CRANKSHAFT POSITION SENSOR RELUCTOR RING REPLACEMENT

Removal Procedure

1. Remove Automatic Transmission Flex Plate Replacement

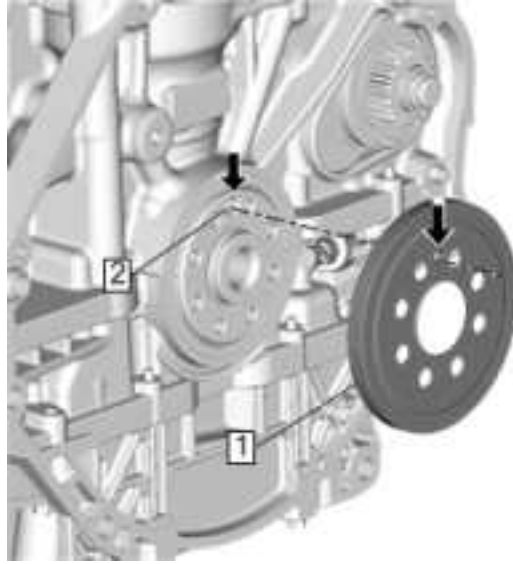


Fig. 204: Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft position sensor reluctor ring.(1)

Installation Procedure

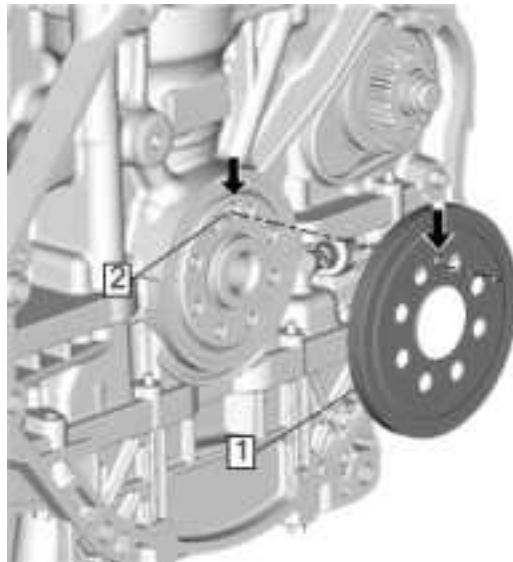


Fig. 205: Crankshaft Position Sensor Reluctor Ring
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not allow the crankshaft position sensor reluctor ring to come into contact with external magnetic fields or sharp metal objects. Do not drop the crankshaft position sensor reluctor ring. Do not damage the rubberized encoder track. Failure to follow these precautions may cause damage to the component.

NOTE: Ensure that the crankshaft reluctor ring alignment hole indicated by arrows properly aligns with the hole in the crankshaft (2).

1. Install the crankshaft position sensor reluctor ring.(1)
2. Install [Automatic Transmission Flex Plate Replacement](#)

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

- EN-51368 Front Crankshaft Seal Installer
- DT-6125-1B Slide Hammer
- DT-23129 Seal Remover

Removal Procedure

1. Remove [Crankshaft Balancer Replacement](#)

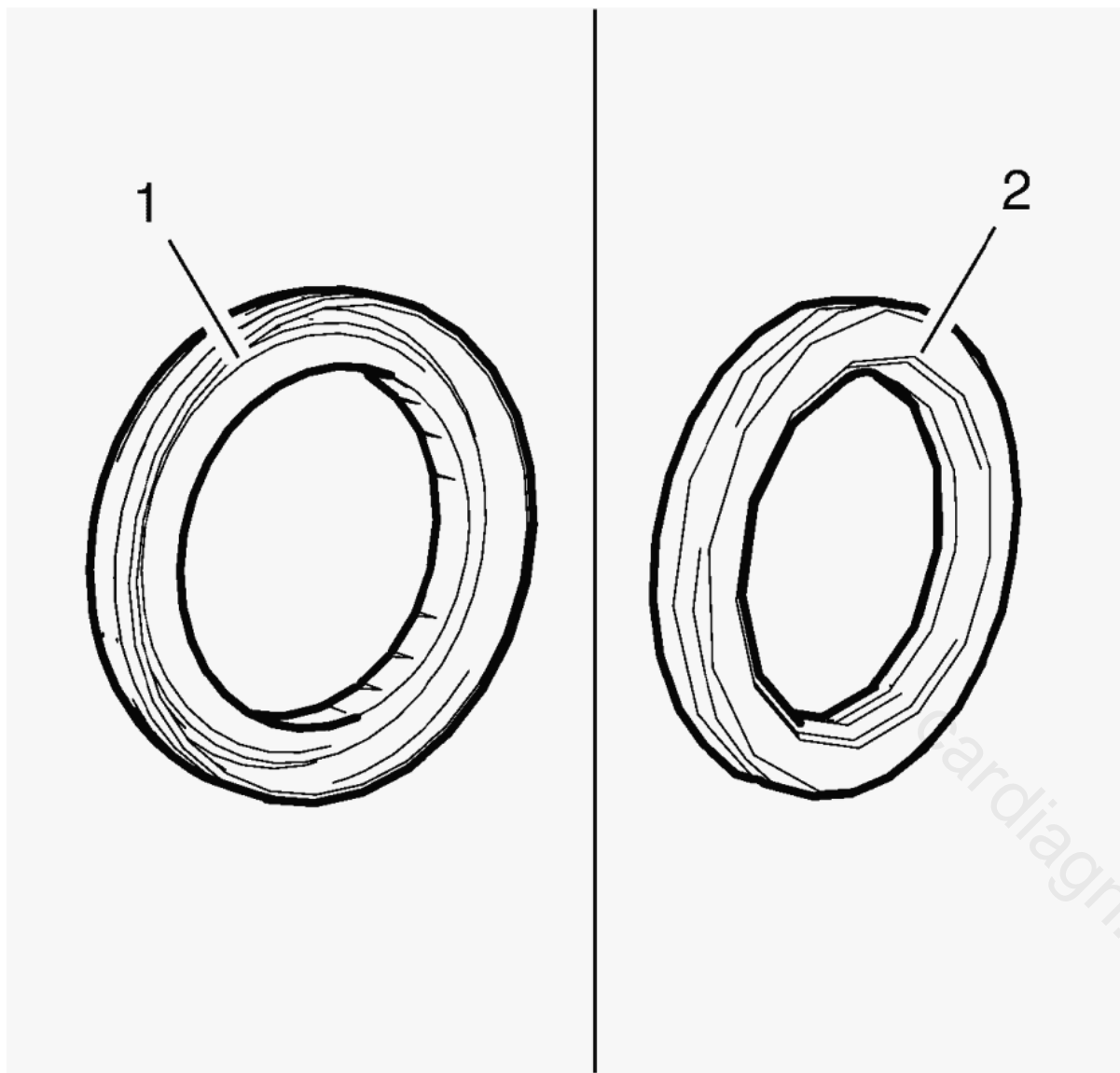


Fig. 206: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine can be equipped with two different front oil seal designs.

2. Check the seal to confirm which crankshaft front oil seal (1, 2) is installed.

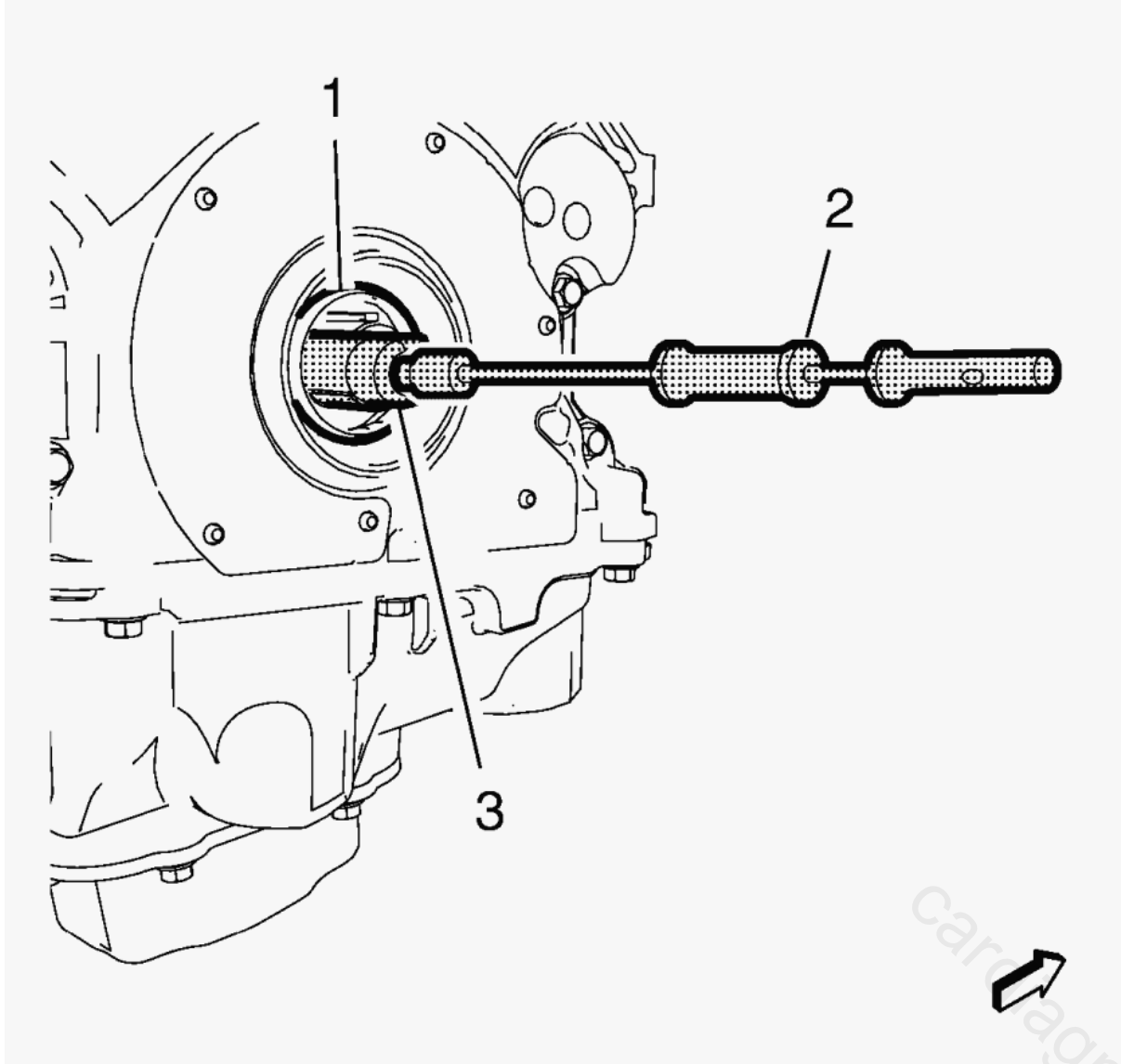


Fig. 207: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

3. Install the **DT-6125-B** hammer (2) to **DT-23129** seal remover (3).
4. Install the **DT-2165-B** hammer with the **DT-23129** seal remover behind the crankshaft front oil seal (1).
5. Remove the crankshaft front oil seal (1), with the **DT-6125-B** hammer (2).

Installation Procedure

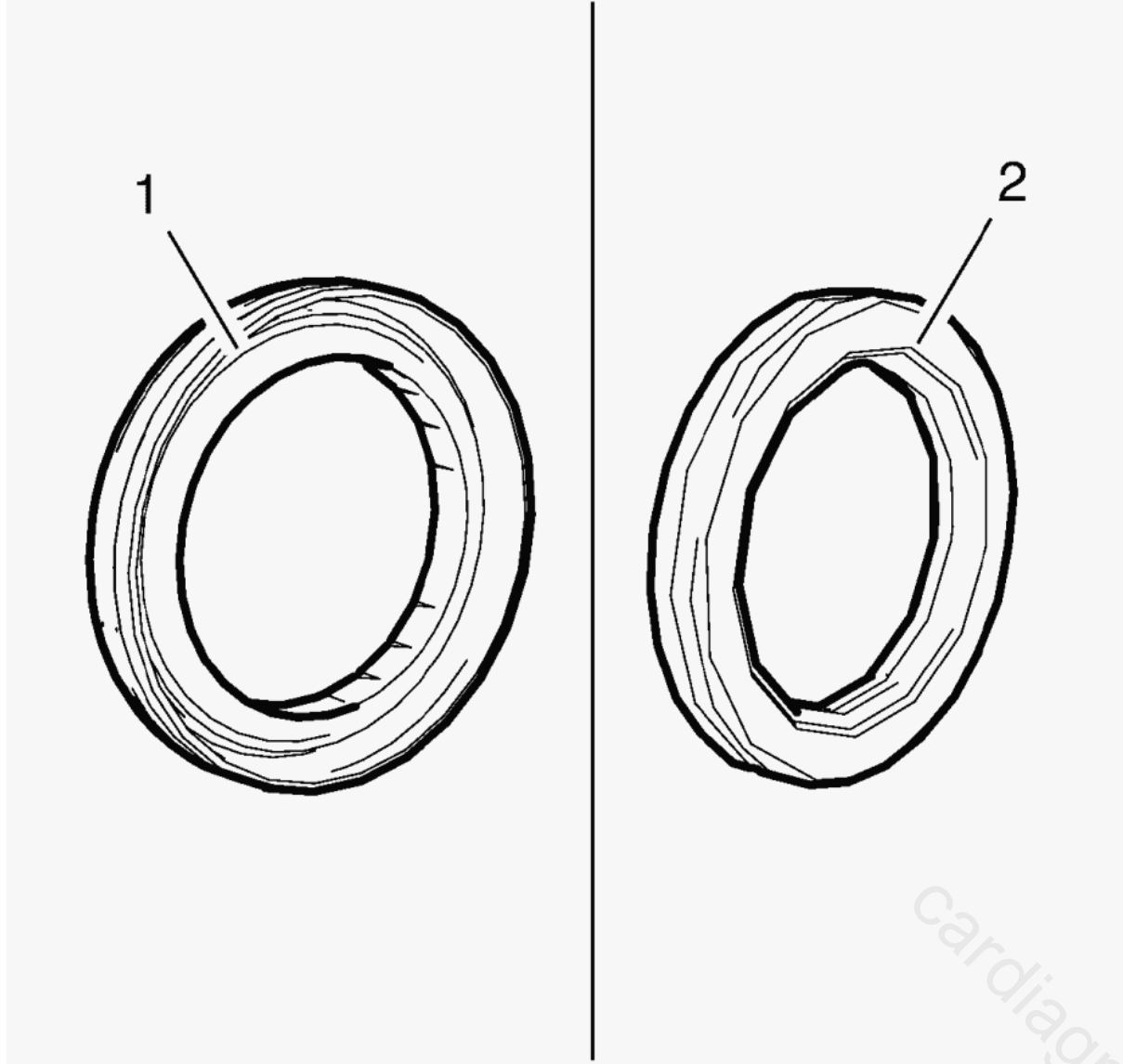


Fig. 208: Identifying Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine can be equipped with two different front oil seal designs.

1. Check the seal to confirm which crankshaft front oil seal (1, 2) is installed.

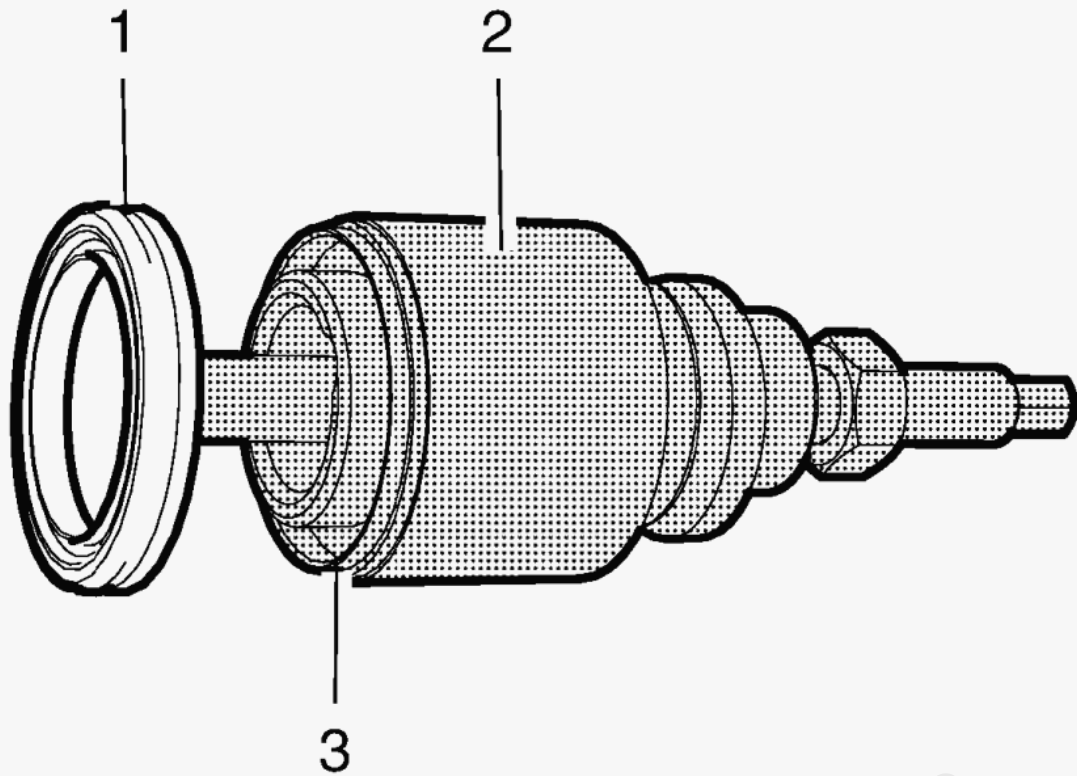


Fig. 209: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. For front oil seal first design, use the following procedure:

NOTE: The special tool EN-51368 seal installer can be used in two positions, depending which crankshaft front oil seal type is used.

3. Install the crankshaft front oil seal (1) to the EN-51368 seal installer (2) with the notch on the surface. (3).

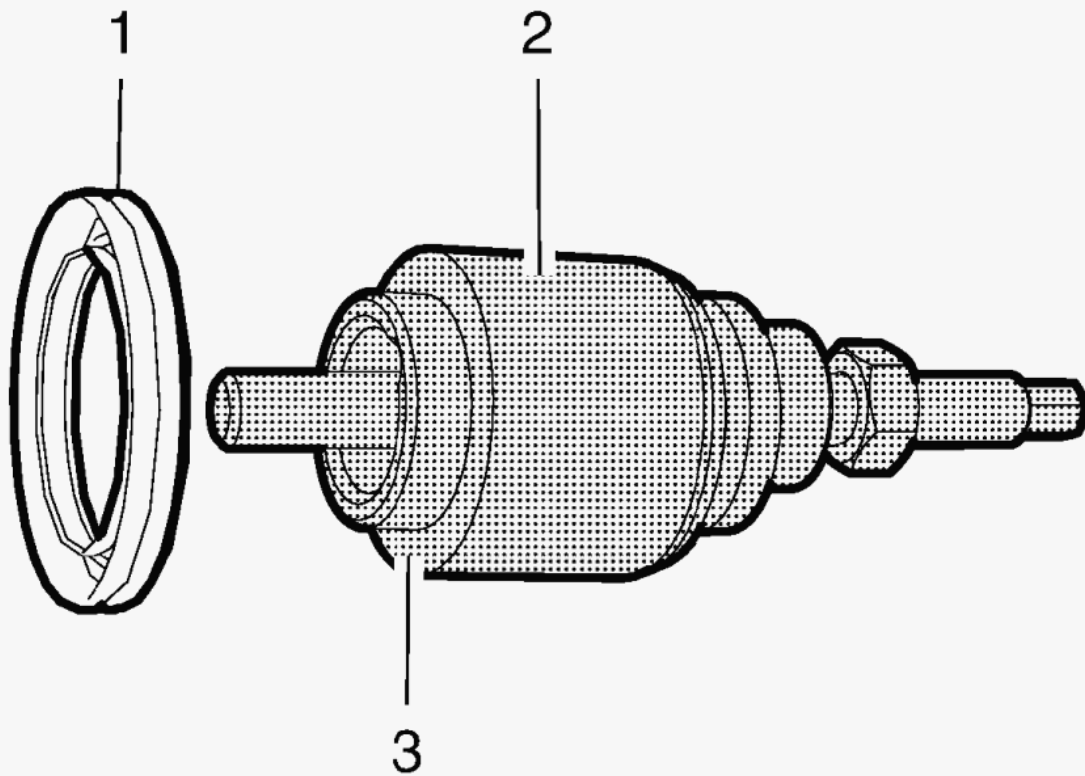


Fig. 210: Front Oil Seal Second Design Procedure
 Courtesy of GENERAL MOTORS COMPANY

4. For front oil seal second design, use the following procedure:

NOTE: The special tool EN-51368 seal installer can be used in two positions, depending which crankshaft front oil seal type is used.

5. Install the crankshaft front oil seal (1) to the EN-51368 seal installer (2) with the plain surface (3).

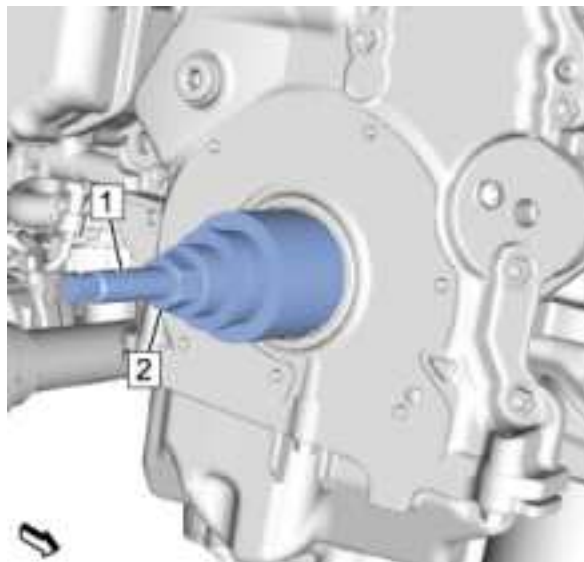


Fig. 211: Installing Crankshaft Front Oil Seal
 Courtesy of GENERAL MOTORS COMPANY

CAUTION:

Be careful that the crankshaft front oil seal does not deform while installing. Failing to do so may reduce the leak-tightness and could cause damage to the crankshaft.

6. Press the crankshaft front oil seal into the correct seat, by tightening the nut (2) from the **EN-51368** seal installer (1).
7. Remove the **EN-51368** seal installer
8. Check to ensure that the crankshaft front oil seal is properly seated.
9. Install [Crankshaft Balancer Replacement](#)

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tool

EN-51369 Rear Crankshaft Seal Installer

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove [Crankshaft Position Sensor Reluctor Ring Replacement](#)

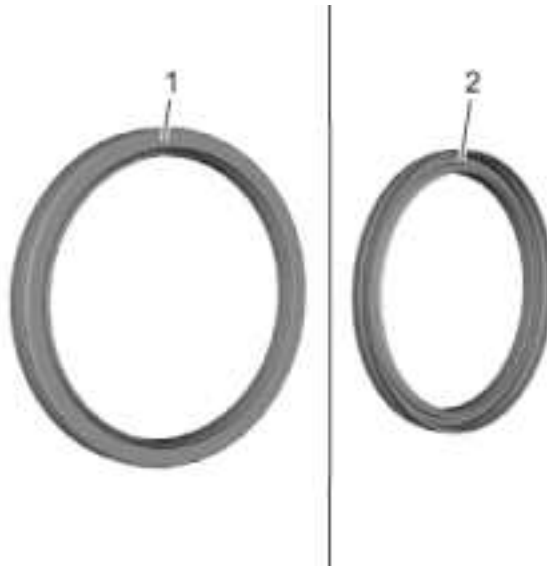
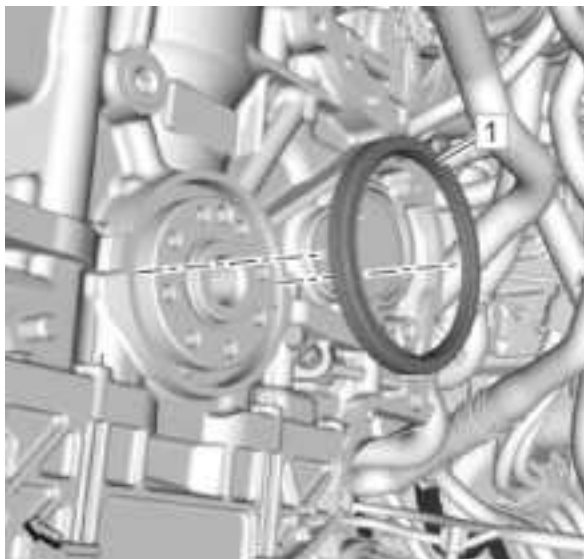


Fig. 212: Identifying Crankshaft Rear Oil Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine could be equipped with two different rear oil seal designs.

2. Check which of the crankshaft rear oil seals (1, 2) is installed.



CAUTION: Be careful that the crankshaft will not be damaged while the crankshaft rear oil seal is pulled out. Failing to do so may reduce the leak-tightness and could cause damage to the crankshaft.

NOTE: Use a suitable tool to remove the seal.

3. Remove Crankshaft Rear Oil Seal (2) @Crankshaft (1)

Installation Procedure

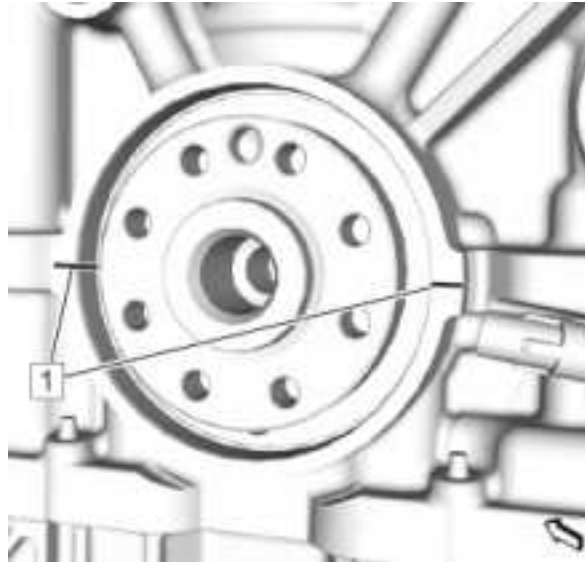


Fig. 214: RTV Sealant Application Points
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the seal recess (1) for excess sealer material at the lower crankcase to engine block mating location.
2. Remove excess sealer, if present.
3. Add RTV sealer at the 2 locations (1) where the bedplate and block join prior to installing the oil seal. Adhesives, Fluids, Lubricants, and Sealers

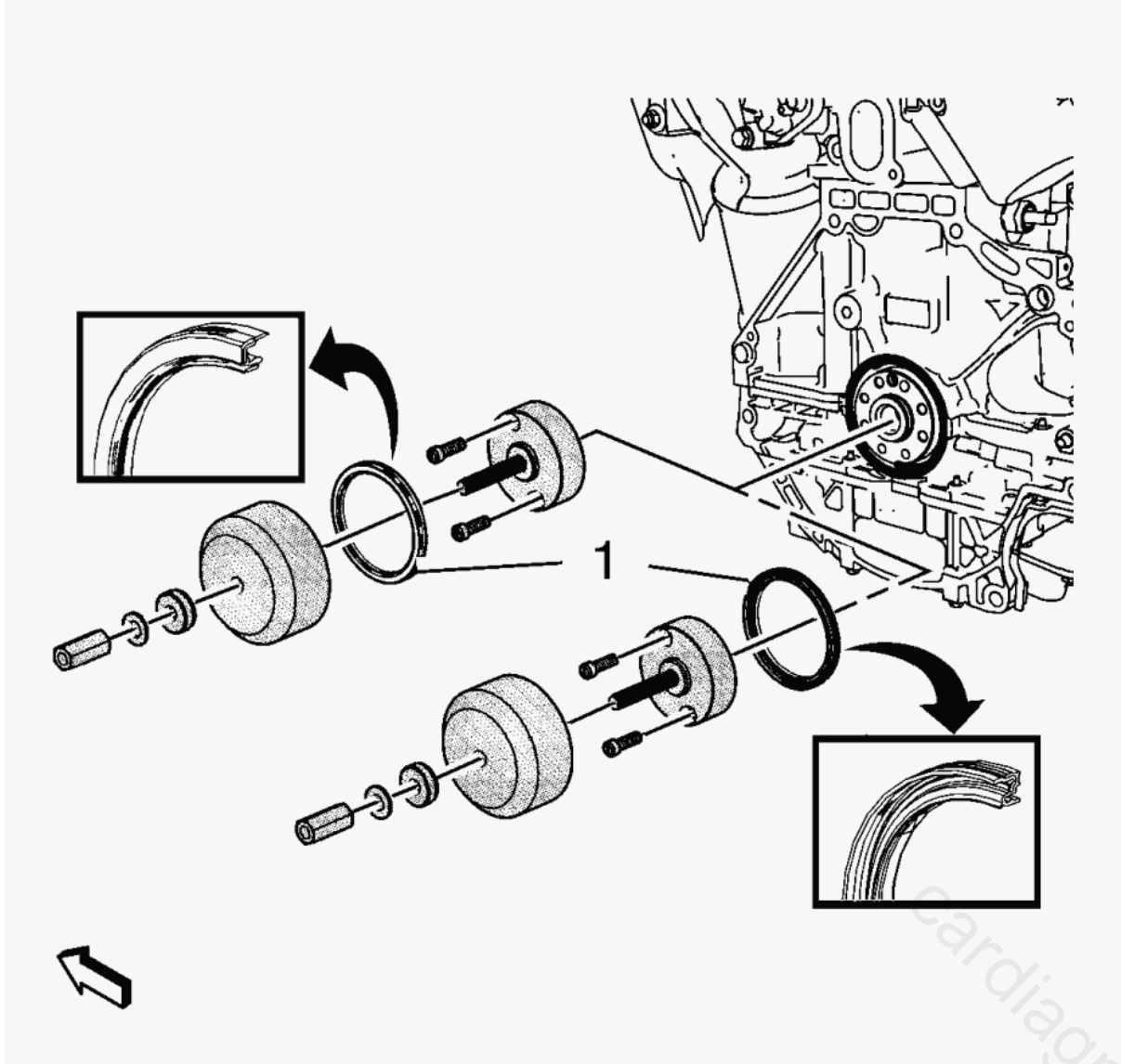


Fig. 215: Installing Oil Seal

Courtesy of GENERAL MOTORS COMPANY

NOTE: The oil seal must be installed in the correct direction. The side that faces out will have "this side out" printed on it. Depending on seal design, the way the seal is installed on the EN-51369 installer is opposite. Either the seal is installed over the back of the installer, or the seal is installed over the front of the installer. Match the seal design as shown above and install the seal onto the installer in the correct direction.

4. Install the oil seal (1) in the correct direction on the EN-51369 installer.

NOTE: If the seal is improperly installed on the special tool, it will not install correctly.

5. Inspect the seal on EN-51369 installer, and ensure that the seal lip is not deformed. If necessary, remove the seal and reinstall on the special tool.

NOTE: The special tool installs and establishes the proper depth of the seal in the crankshaft seal bore.

6. Use EN-51369 installer to press the new crankshaft seal into the housing.

7. Ensure that the seal is installed in the crankshaft seal bore flush to 0.5 mm (0.2 in) depth.

8. Install [Crankshaft Position Sensor Reluctor Ring Replacement](#)

CRANKSHAFT SPROCKET REPLACEMENT

Removal Procedure

1. Remove [Camshaft Timing Chain Replacement](#)
2. Remove [Oil Pump Drive Chain Replacement](#)

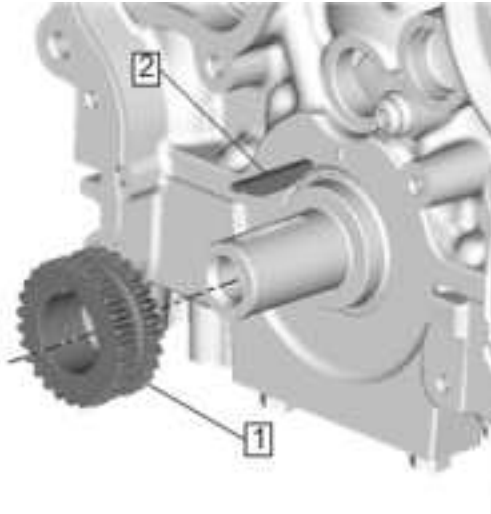


Fig. 216: Crankshaft Sprocket And Balancer Key
Courtesy of GENERAL MOTORS COMPANY

3. Remove Crankshaft Sprocket (1)
4. Remove the crankshaft balancer key.(2)

Installation Procedure

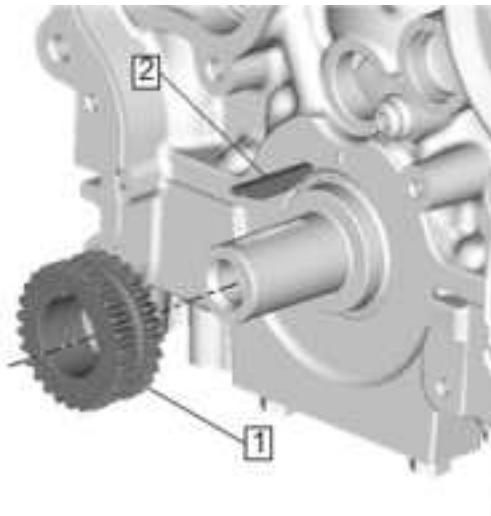


Fig. 217: Crankshaft Sprocket And Balancer Key
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft balancer key (2).
2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.
3. Install Crankshaft Sprocket (1)
4. Install [Oil Pump Drive Chain Replacement](#)
5. Install [Camshaft Timing Chain Replacement](#)

CRANKSHAFT OIL DEFLECTOR REPLACEMENT

Removal Procedure

1. Remove the upper oil pan. Refer to [Upper Oil Pan Replacement](#).

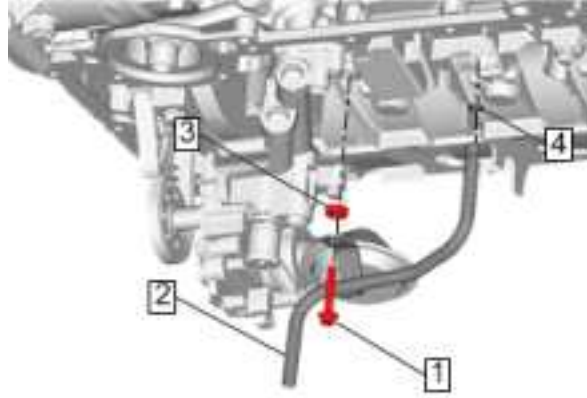


Fig. 218: Crankcase Ventilation Oil Separator Drain Pipe, Fastener, Retainer And Seal
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the position of the retainer (3) for proper installation.

2. Remove the positive crankcase ventilation oil separator drain pipe fastener (1) then remove the pipe (2).

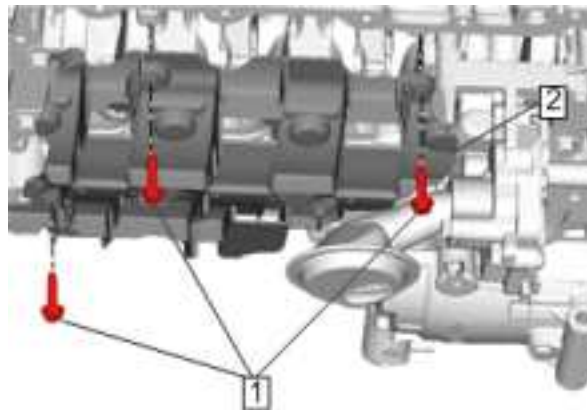


Fig. 219: Oil Deflector And Fasteners
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil deflector fasteners (1) then remove the oil deflector (2).

Installation Procedure

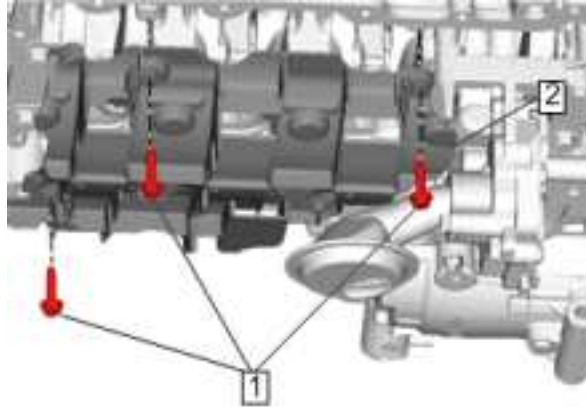


Fig. 220: Oil Deflector And Fasteners

Courtesy of GENERAL MOTORS COMPANY

1. Position the oil deflector (2) then hand start the oil deflector fasteners (1).

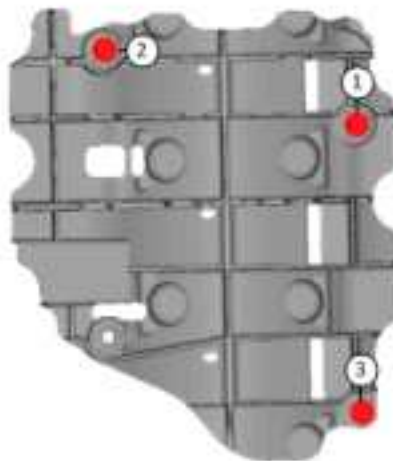
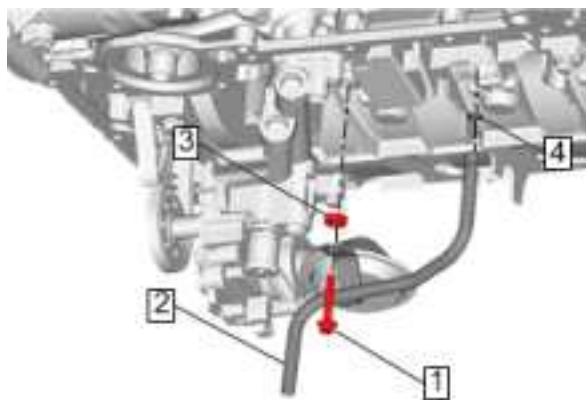


Fig. 221: Oil Deflector Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. Tighten the fasteners in sequence as shown to 10 N.m (89 lb in).



NOTE: Ensure that the retainer (3) is properly installed.

NOTE: Inspect the seal (4) and install NEW if necessary.

3. Position the positive crankcase ventilation oil separator drain pipe (2) then hand start the fastener (1). Tighten to 10 N.m (89 lb in).
4. Install the upper oil pan. Refer to [Upper Oil Pan Replacement](#).

ENGINE LIFT FRONT BRACKET REPLACEMENT

Removal Procedure

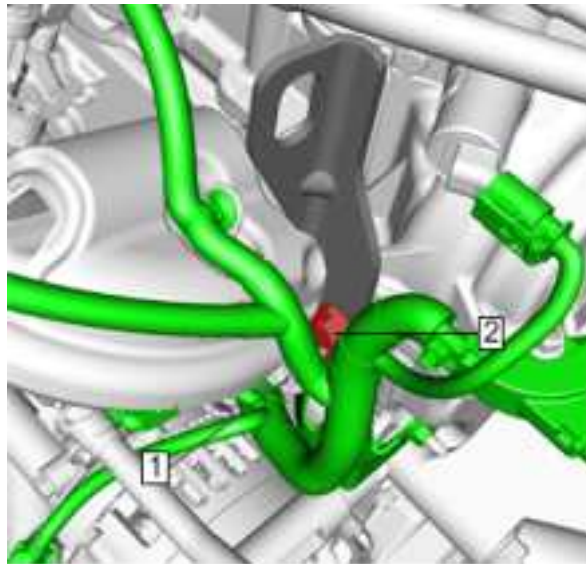


Fig. 223: Wiring Harness And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Slight repositioning of the wiring harness will gain enough clearance to access the bolts (2)

1. Reposition the wiring harness (1)

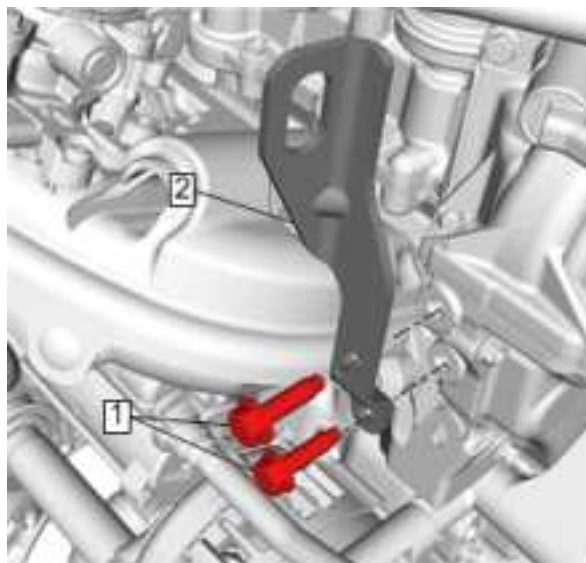


Fig. 224: Engine Lift Bracket And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove Engine Lift Bracket Bolt (1)
3. Remove Engine Lift Bracket (2)

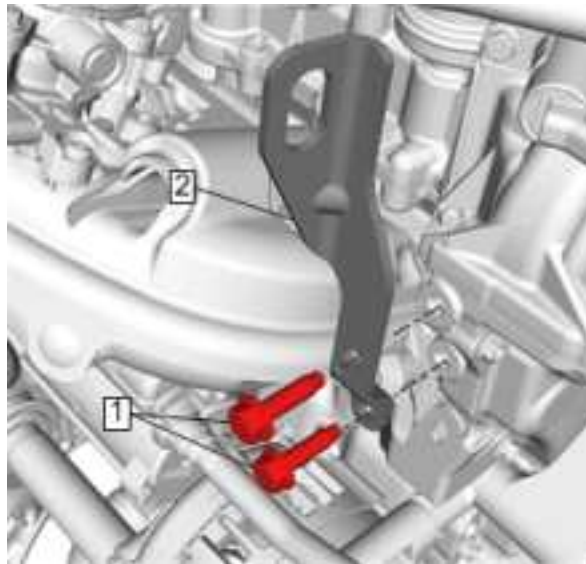


Fig. 225: Engine Lift Bracket And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Lift Bracket (2)

CAUTION: Refer to [Fastener Caution](#) .

2. Install Engine Lift Bracket Bolt (1) and tighten 25 N.m (18 lb ft)

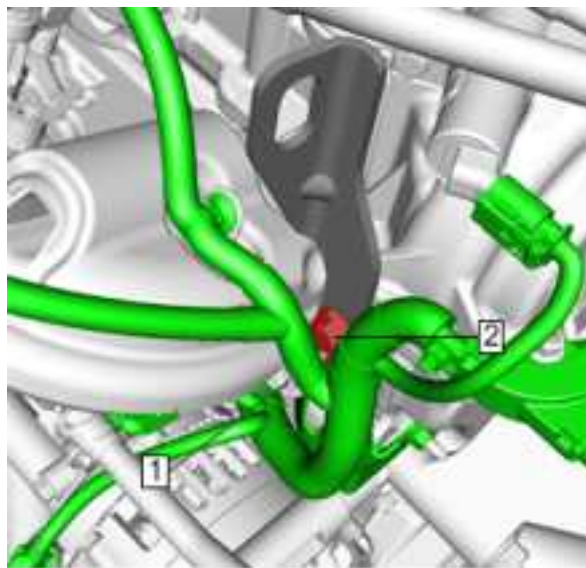


Fig. 226: Wiring Harness And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Properly position wiring harness (1) after tightening bolts (2)

ENGINE LIFT REAR BRACKET REPLACEMENT

Removal Procedure

1. Remove Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)

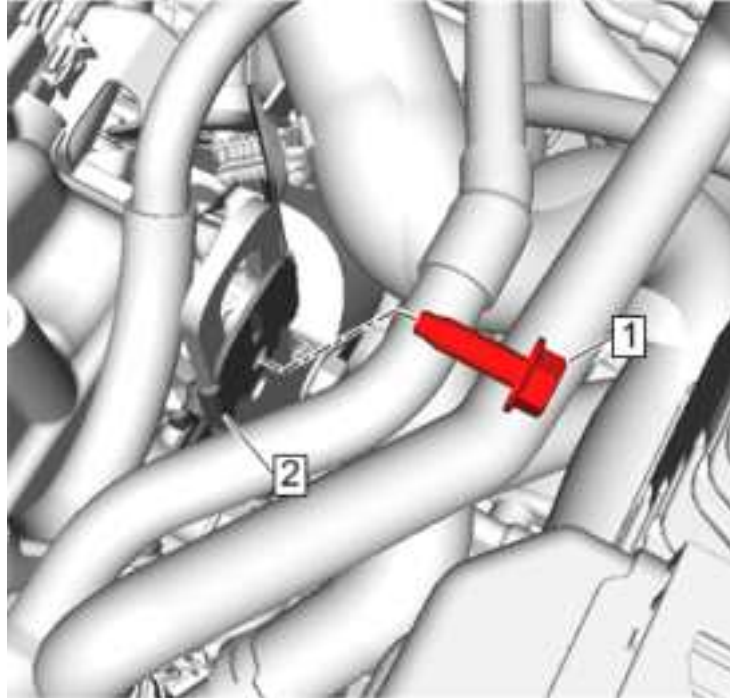


Fig. 227: Engine Wiring Harness Bracket Bolt And Charge Air Cooler Outlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

2. Remove Engine Wiring Harness Bracket Bolt (1).

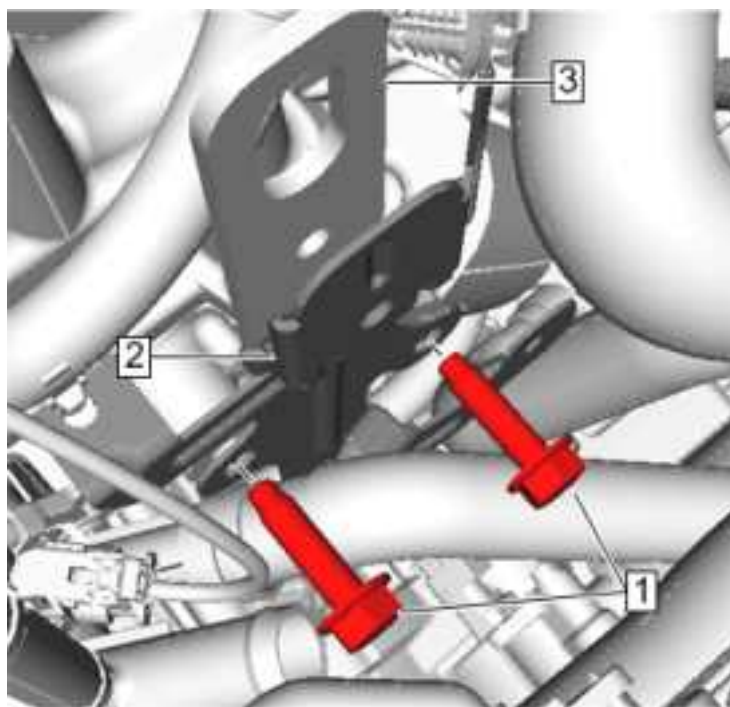


Fig. 228: Engine Wiring Harness Bracket And Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

3. Remove Engine Lift Bracket Bolt (1)
4. Separate the engine wiring harness bracket (2) from the engine lift bracket then remove the engine lift bracket (3).

Installation Procedure

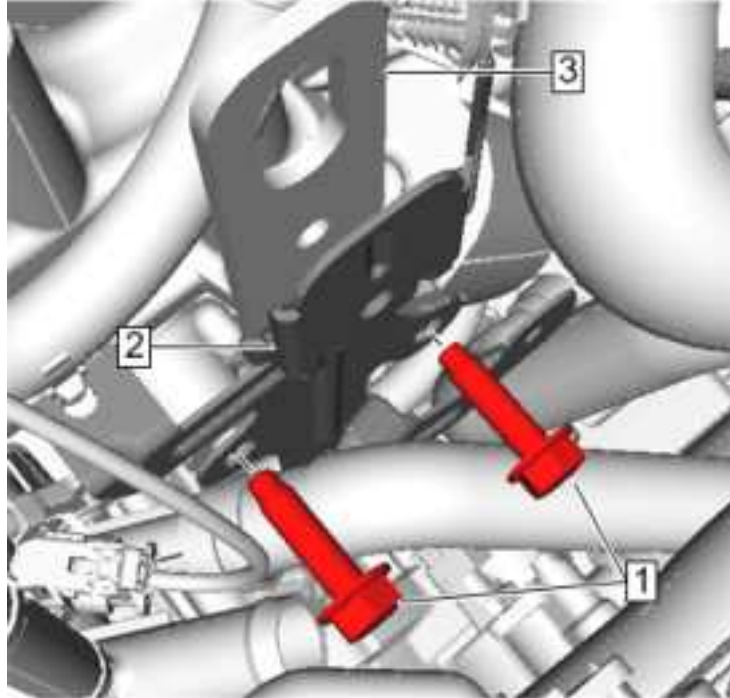


Fig. 229: Engine Wiring Harness Bracket And Engine Lift Bracket
 Courtesy of GENERAL MOTORS COMPANY

1. Install the engine lift bracket (3) then install the engine wiring harness bracket (2).

CAUTION: Refer to [Fastener Caution](#) .

2. Install Engine Lift Bracket Bolt (1) and tighten 25 N.m (18 lb ft)

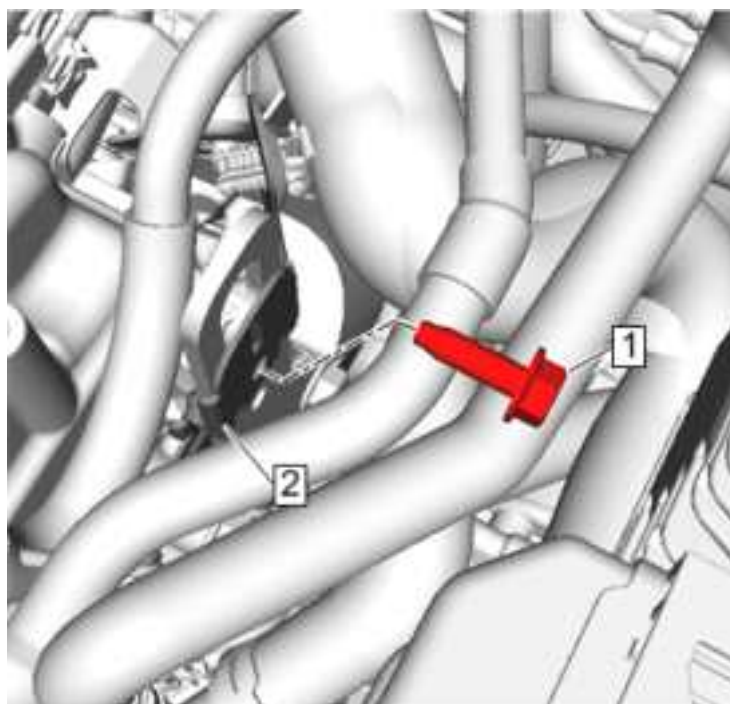


Fig. 230: Engine Wiring Harness Bracket Bolt And Charge Air Cooler Outlet Air Tube
 Courtesy of GENERAL MOTORS COMPANY

3. Install Engine Wiring Harness Bracket Bolt and tighten 10 N.m (89 lb in)
4. Install Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)

CYLINDER HEAD REPLACEMENT

Special Tools

- EN 38188 Cylinder Head Broken Bolt Extractor Kit - or equivalent aftermarket tool
- EN 45059 Angle Meter

- EN-36857 Engine Lift Bracket

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)
2. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
3. Drain the coolant. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)

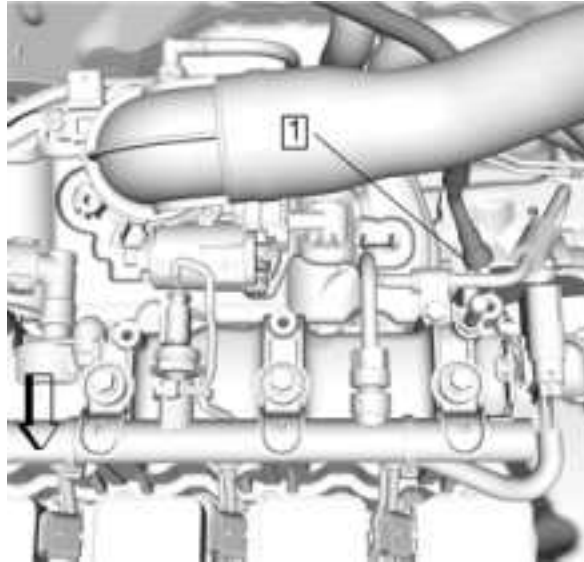


Fig. 231: Fuel Feed Hose

Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Fuel Feed Hose (1) [Metal Collar Quick Connect Fitting Service](#)
5. Remove Camshaft Timing Chain - [Camshaft Timing Chain Replacement](#)
6. Remove Intake Manifold - [Intake Manifold Replacement](#)

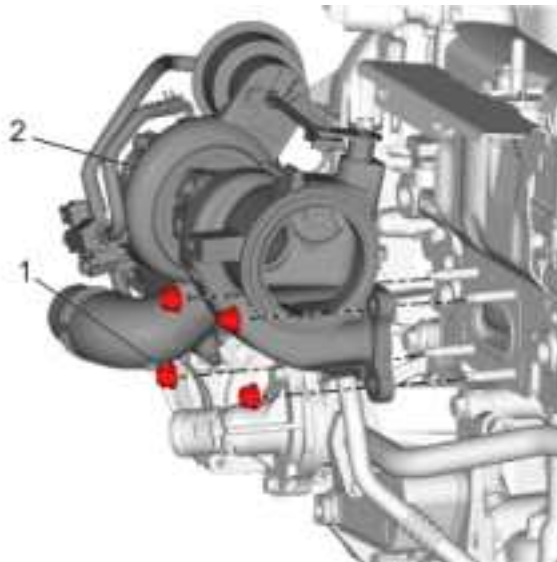


Fig. 232: Turbocharger And Nuts

Courtesy of GENERAL MOTORS COMPANY

7. Remove Turbocharger (2) - [Turbocharger Replacement](#)
8. Remove Fuel Pump - [Fuel Pump Replacement](#)
9. Remove Water Outlet - [Water Outlet Replacement \(LYX\)](#)
10. Remove Vacuum Pump Assembly - [Vacuum Pump Assembly Replacement](#)

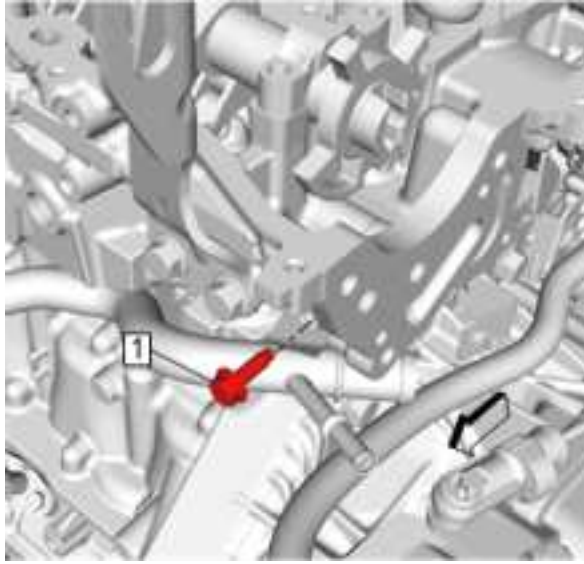


Fig. 233: Thermostat Bypass Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Remove Thermostat Bypass Pipe Bolt (1)

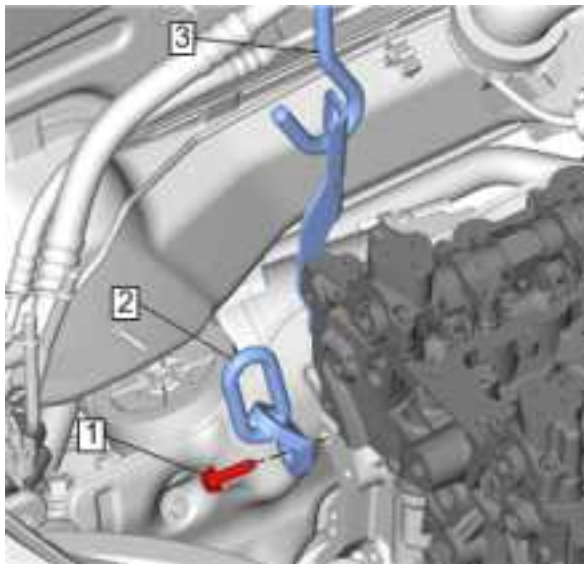


Fig. 234: Engine Lift Bracket, Fixture Hook And Bolt
Courtesy of GENERAL MOTORS COMPANY

12. Install the EN-36857 Engine Lift Bracket (2) then install the bolt (1).

NOTE: Use a suitable device to support the engine while repositioning the lift hook.

13. Reposition the engine support fixture hook (3) to the newly installed EN-36857 engine lift bracket (2).

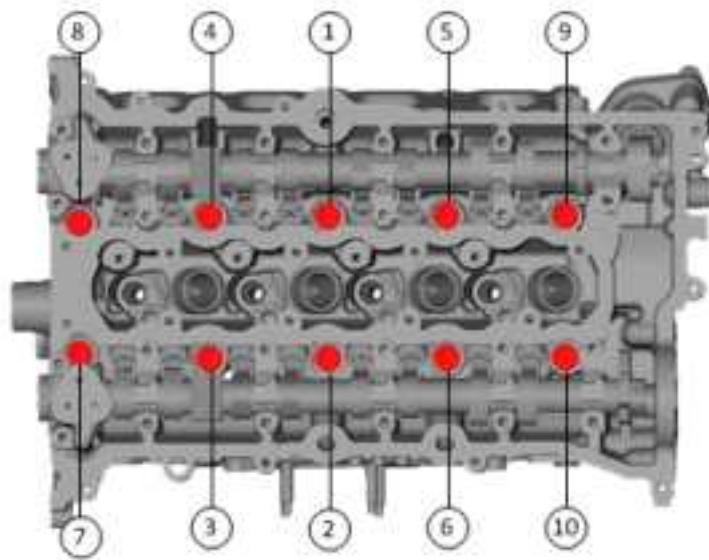


Fig. 235: Cylinder Head Bolt Loosening/Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

14. Loosen the cylinder head bolts in sequence shown.

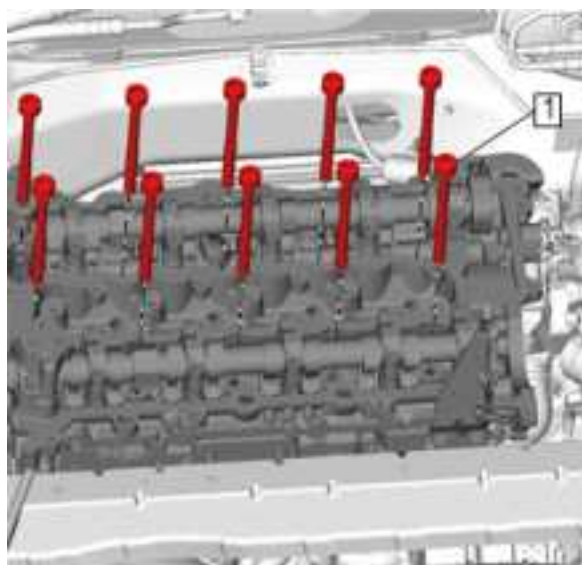


Fig. 236: Cylinder Head Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Remove any broken bolts using the EN 38188 Cylinder Head Broken Bolt Extractor Kit or equivalent.

15. Remove and DISCARD the cylinder head bolts (1)

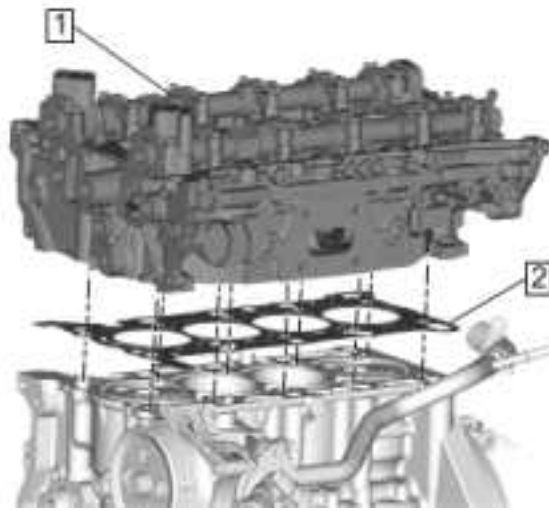


Fig. 237: Cylinder Head And Gasket

Courtesy of GENERAL MOTORS COMPANY

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

16. Remove the cylinder head (1)
17. Remove and DISCARD the cylinder head gasket (2)

NOTE: A nylon bristle brush should be used to clean the bolt holes. Do not use a tap to clean the cylinder head bolt holes.

18. Clean the old sealer/lube and dirt from the bolt holes.
19. Remove any broken cylinder head bolts using the EN 38188 kit or equivalent.

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

NOTE:

- When cleaning the engine block 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.
- Use a gasket scraper to clean the cylinder head and block surfaces.
- 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.
- Do not use a tap to clean the cylinder head bolt holes.

20. Clean the mating surfaces at the engine block.
21. If not replacing the cylinder head, clean and inspect the cylinder head. [Cylinder Head Cleaning and Inspection](#)
22. If replacing cylinder head, swap components as needed. [Cylinder Head Disassemble](#)
 1. Remove timing components as needed. [Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Removal](#)

1. If replacing cylinder head, swap components as needed. **Cylinder Head Assemble**
 1. Install timing components as needed. **Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Installation**

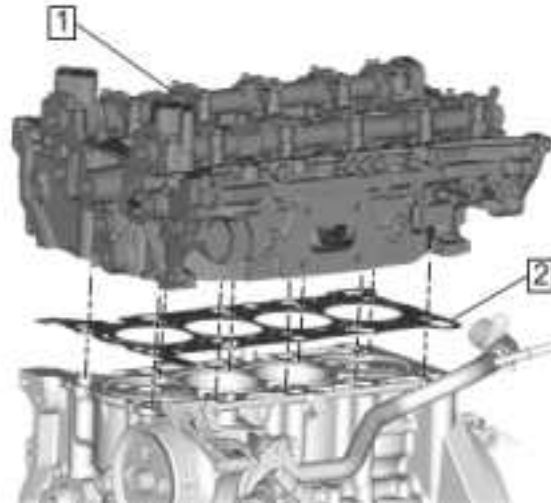


Fig. 238: Cylinder Head And Gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the cylinder head and the cylinder block sealing surfaces are clear of oil, grease and old gasket material.

2. Install the NEW cylinder head gasket (2)
3. Install the cylinder head (1)

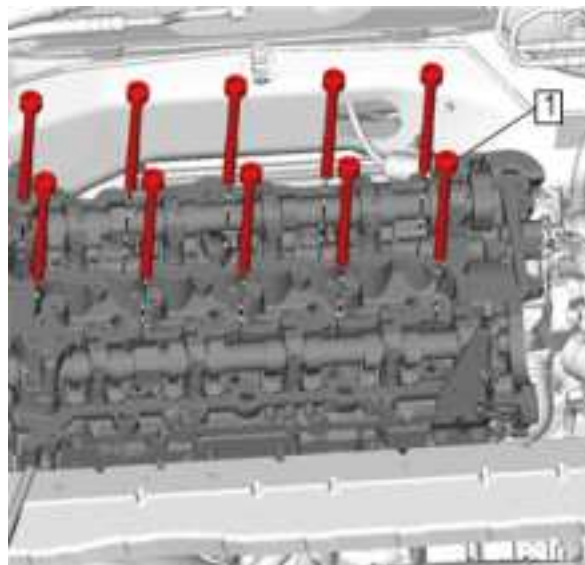


Fig. 239: Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

4. Loosely install Cylinder Head Bolt (1)

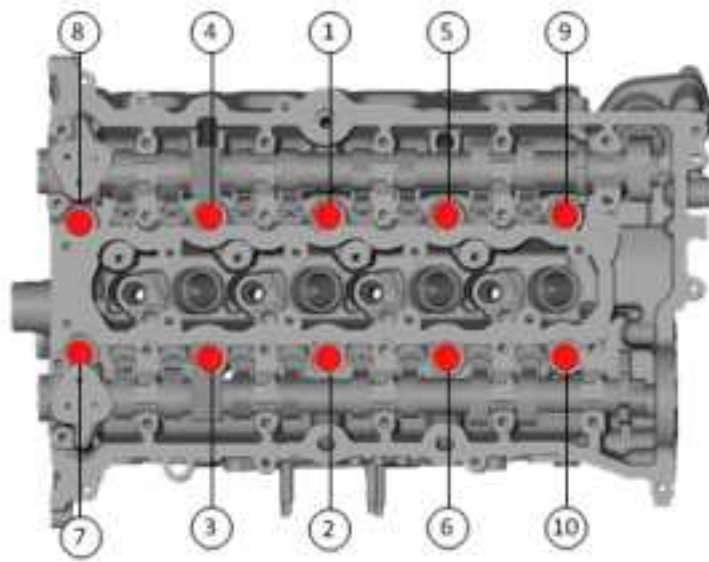


Fig. 240: Cylinder Head Bolt Loosening/Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

CAUTION: Refer to [Fastener Caution](#) .

5. Tighten the NEW bolts in sequence shown.

Tighten

1. Tighten the bolts a first pass to 30 N.m (22 lb ft).
2. Using the **EN-45059** angle meter, tighten the bolts a final pass to 240 degrees.

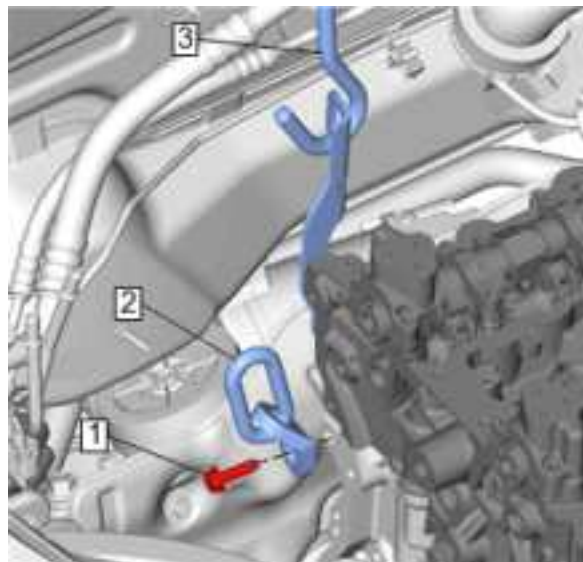


Fig. 241: Engine Lift Bracket, Fixture Hook And Bolt
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Use a suitable device to support the engine while repositioning the lift hook.

6. Reposition the lift hook from the **EN-36857** Engine Lift Bracket to the cylinder head lift bracket.
7. Remove the **EN-36857** Engine Lift Bracket (2).
8. Remove the suitable device holding the engine during lift hook repositioning.
9. Install Water Outlet - [Water Outlet Replacement \(LYX\)](#)

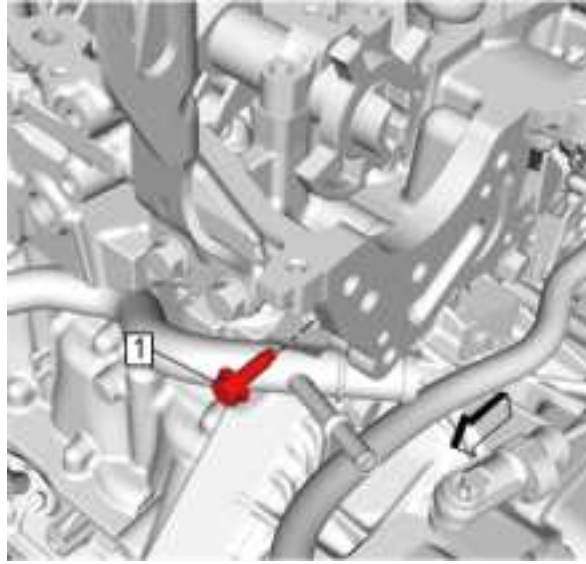


Fig. 242: Thermostat Bypass Pipe Bolt

Courtesy of GENERAL MOTORS COMPANY

10. Install Thermostat Bypass Pipe Bolt and tighten - [Thermostat Bypass Pipe Replacement \(LYX\)](#)
11. Install Camshaft Timing Chain - [Camshaft Timing Chain Replacement](#)
12. Install Fuel Pump - [Fuel Pump Replacement](#)
13. Install Intake Manifold - [Intake Manifold Replacement](#)
14. Install Vacuum Pump Assembly - [Vacuum Pump Assembly Replacement](#)

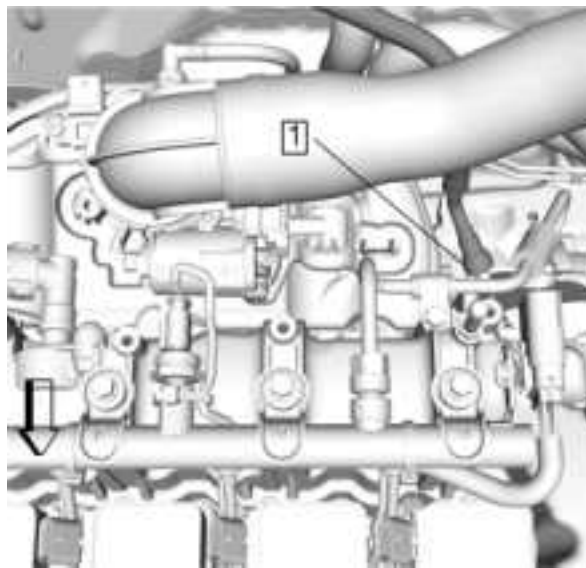


Fig. 243: Fuel Feed Hose

Courtesy of GENERAL MOTORS COMPANY

15. Connect Fuel Feed Hose - [Metal Collar Quick Connect Fitting Service](#)

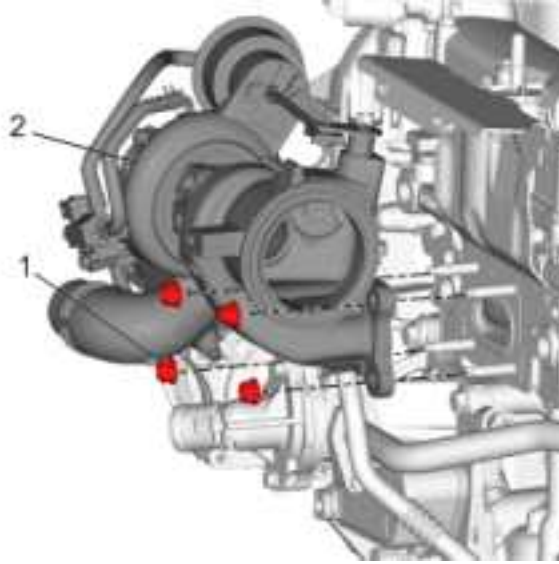


Fig. 244: Turbocharger And Nuts

Courtesy of GENERAL MOTORS COMPANY

16. Install Turbocharger - [Turbocharger Replacement](#)
17. Change the engine oil and filter. [Engine Oil and Oil Filter Replacement](#)
18. Fill the cooling system to the proper level. [Cooling System Draining and Filling \(GE 47716\)](#)
[Cooling System Draining and Filling \(Static\)](#)

ENGINE FRONT COVER REPLACEMENT

Removal Procedure

1. Remove [Camshaft Cover Replacement](#)
2. Remove [Engine Mount Bracket Replacement](#)
3. Remove [Crankshaft Balancer Replacement](#)
4. Remove [Drive Belt Tensioner Replacement](#)
5. Remove [Generator Replacement \(LYX\)](#)
6. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
7. Remove [Upper Oil Pan Replacement](#)

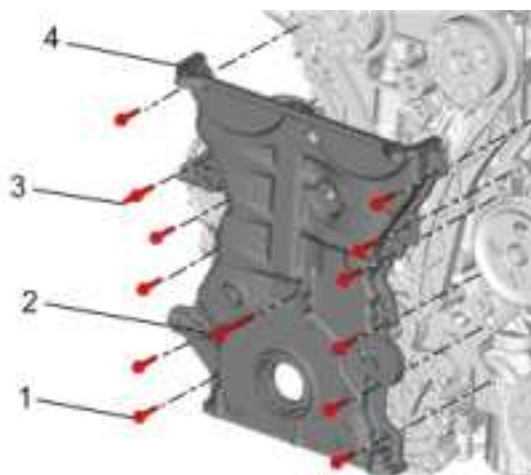


Fig. 245: Identifying Fasteners

Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the location of the long fastener (2), short fasteners (1) and stud fastener (3) for correct installation.

8. Remove Engine Front Cover (4) [Engine Front Cover Removal](#)

9. Transfer parts as needed.
10. Install a NEW seal. [Crankshaft Front Oil Seal Replacement](#)

Installation Procedure

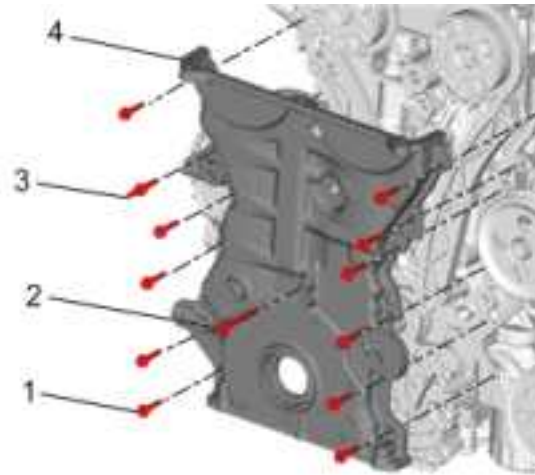


Fig. 246: Identifying Fasteners

Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Front Cover (4) [Engine Front Cover Installation](#)
2. Install [Upper Oil Pan Replacement](#)
3. Install [Crankshaft Balancer Replacement](#)
4. Install [Camshaft Cover Replacement](#)
5. Install [Engine Mount Bracket Replacement](#)
6. Install [Generator Replacement \(LYX\)](#)
7. Install [Drive Belt Tensioner Replacement](#)
8. Fill the engine oil to the proper level with NEW engine oil. [Engine Oil and Oil Filter Replacement](#)

POWERTRAIN MOUNT BALANCING (ALL WHEEL DRIVE)

Removal Procedure

1. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

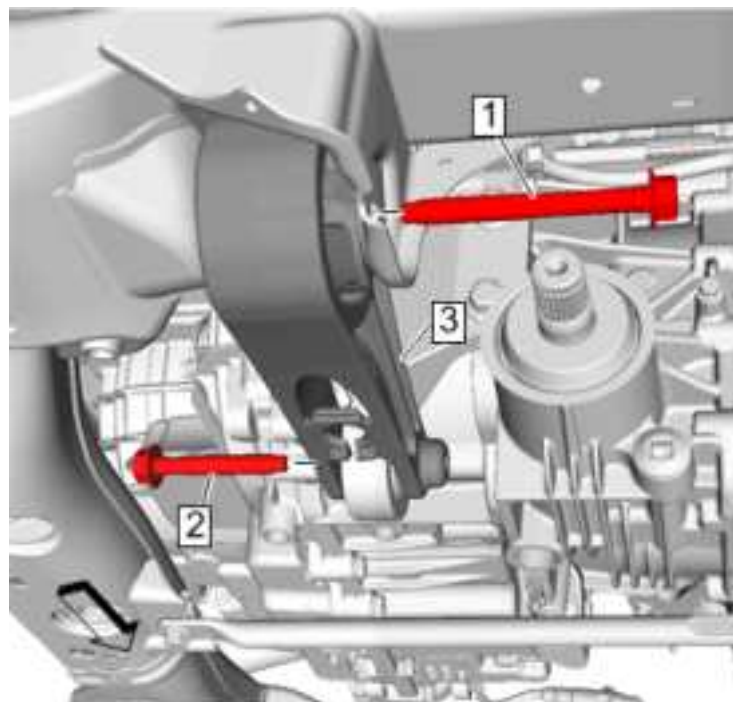


Fig. 247: Transmission Mount Strut Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Loosen the transmission mount strut bolt (2) at the transmission mount strut (3). **Transmission Mount Strut Replacement (All Wheel Drive)** **Transmission Mount Strut Replacement (Front Wheel Drive)**
3. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.
4. Lower the vehicle. **Lifting and Jacking the Vehicle**

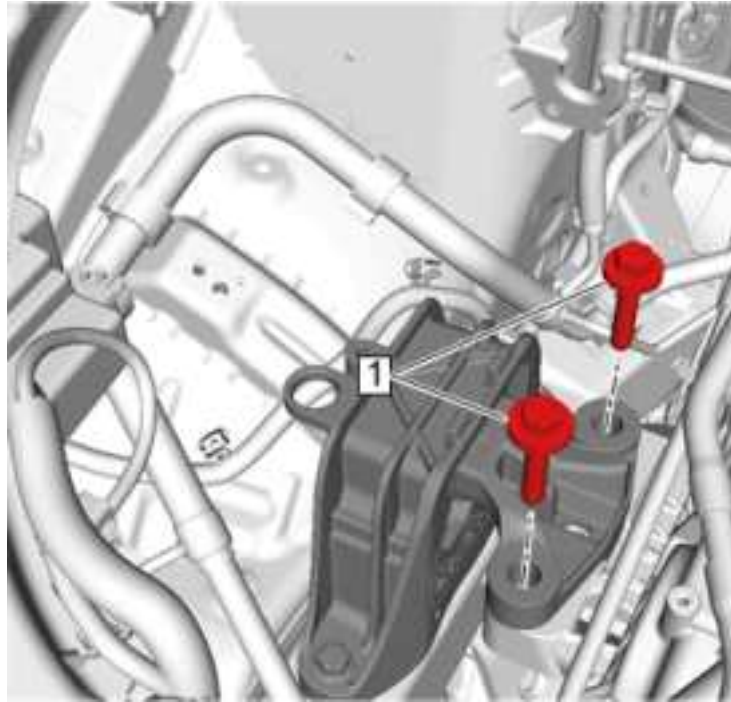


Fig. 248: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Loosen ONLY the engine mount to engine mount bracket bolts (1). **Engine Mount Replacement**

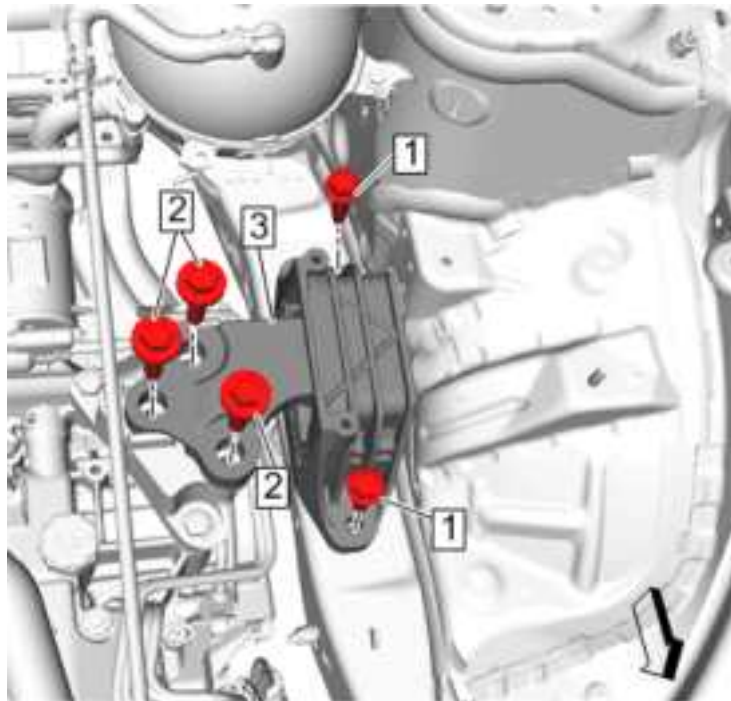


Fig. 249: Transmission Mount Bolts And Fastener
Courtesy of GENERAL MOTORS COMPANY

NOTE: Only the transmission mount to transmission bolts should be loosened. Bolts (1) should remain tightened during the balancing procedure.

6. Loosen ONLY bolts (2) at the left transmission mount (3). [Transmission Mount Replacement - Left Side](#)

Installation Procedure

1. Reposition both floor jacks and blocks of wood in order to allow a 1/8 inch gap between the mount and bracket.
2. Shake the powertrain vigorously by hand from front to rear and allow the powertrain to settle.

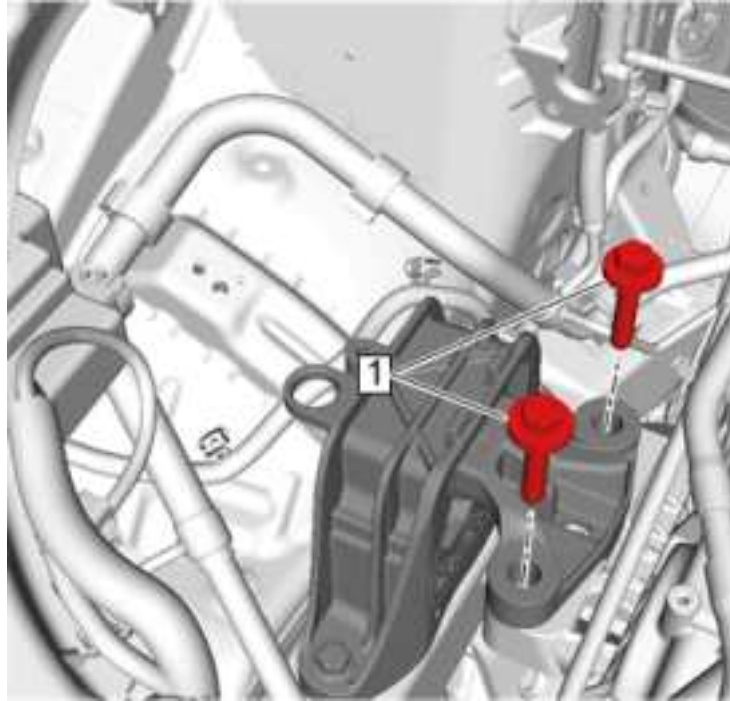


Fig. 250: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Tighten the engine mount to engine mount bracket bolts (1). [Engine Mount Replacement](#)

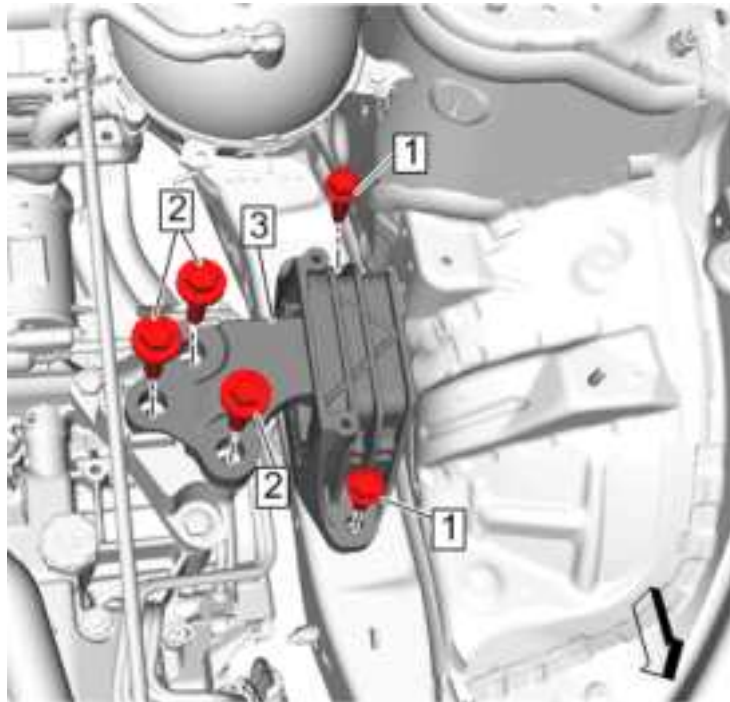


Fig. 251: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: Bolts (1) should remain tightened during the balancing procedure.

4. Tighten bolts (2) at the left transmission mount (3). [Transmission Mount Replacement - Left Side](#)

5. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

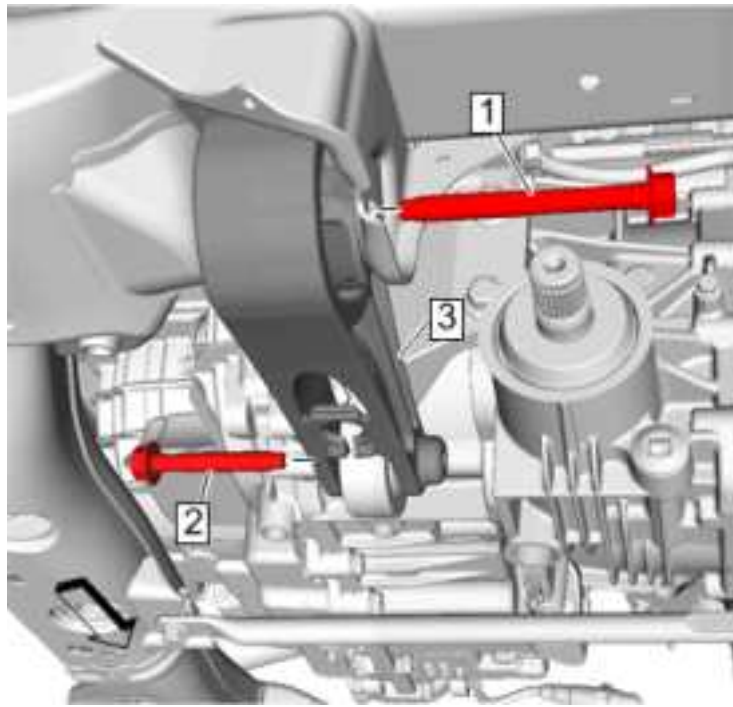


Fig. 252: Transmission Mount Strut Bolt

Courtesy of GENERAL MOTORS COMPANY

6. Tighten the transmission mount strut bolt (2) at the transmission mount strut (3). [Transmission Mount Strut Replacement \(All Wheel Drive\)](#) [Transmission Mount Strut Replacement \(Front Wheel Drive\)](#)
7. Remove the jack stands and wood blocks supporting the engine and transaxle from underneath the powertrain.
8. Lower the vehicle. [Lifting and Jacking the Vehicle](#)

POWERTRAIN MOUNT BALANCING (FRONT WHEEL DRIVE)

Removal Procedure

1. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

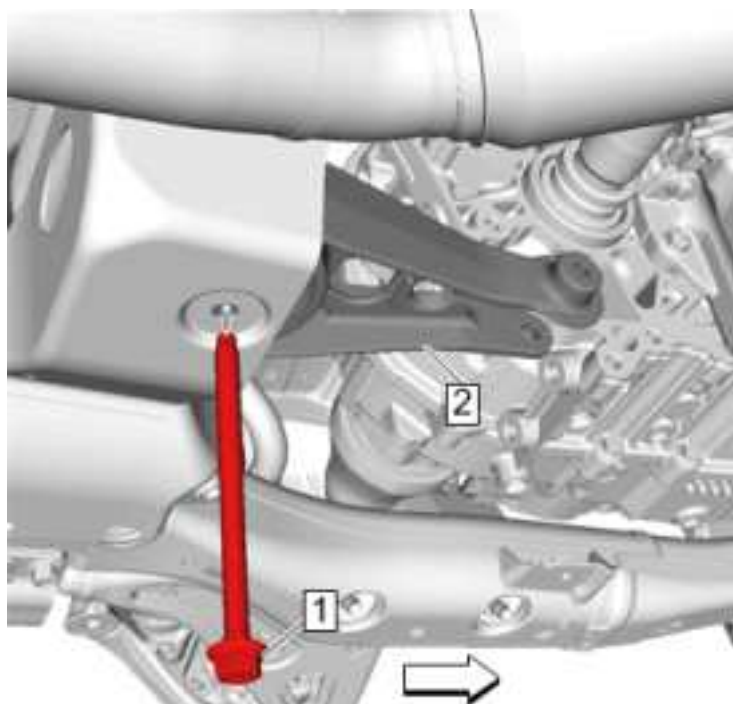


Fig. 253: Transmission Mount Strut Bolt

Courtesy of GENERAL MOTORS COMPANY

2. Loosen the transmission mount strut bolt (1) at the transmission mount strut (2). [Transmission Mount Strut Replacement \(All Wheel Drive\)](#) [Transmission Mount Strut Replacement \(Front Wheel Drive\)](#)
3. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.
4. Lower the vehicle. [Lifting and Jacking the Vehicle](#)

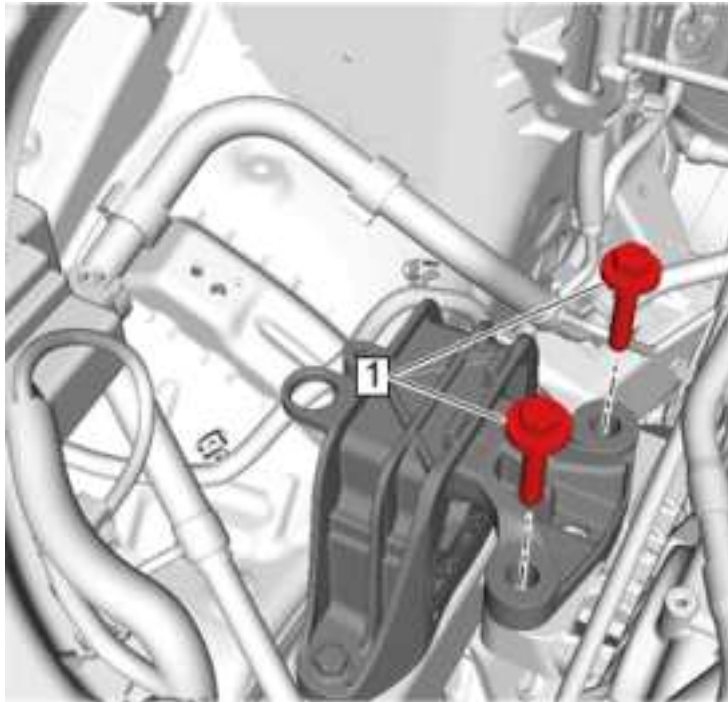


Fig. 254: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Loosen ONLY the engine mount to engine mount bracket bolts (1). [Engine Mount Replacement](#)

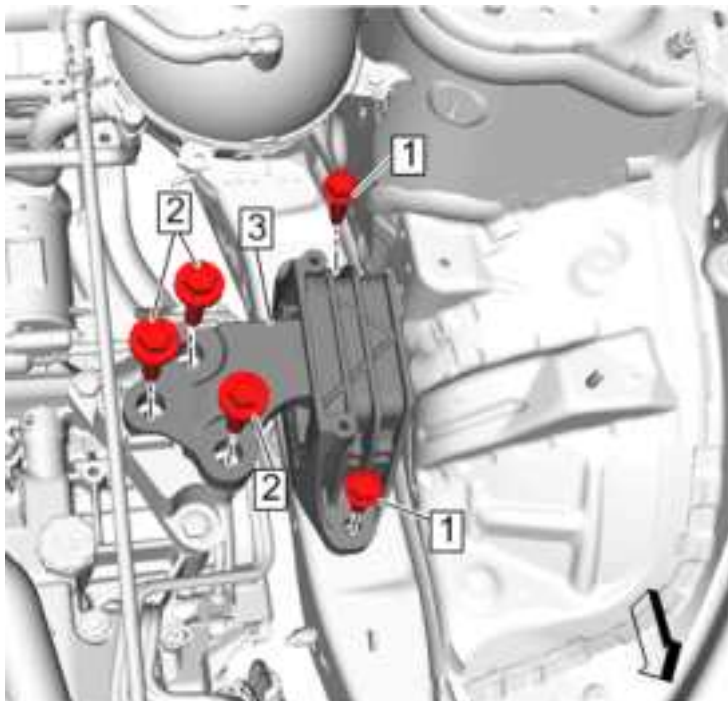


Fig. 255: Transmission Mount Bolts And Fastener
Courtesy of GENERAL MOTORS COMPANY

NOTE: Only the transmission mount to transmission bolts should be loosened. Bolts (1) should remain tightened during the balancing procedure.

6. Loosen ONLY bolts (2) at the left transmission mount (3). [Transmission Mount Replacement - Left Side](#)

Installation Procedure

1. Reposition both floor jacks and blocks of wood in order to allow a 1/8 inch gap between the mount and bracket.
2. Shake the powertrain vigorously by hand from front to rear and allow the powertrain to settle.

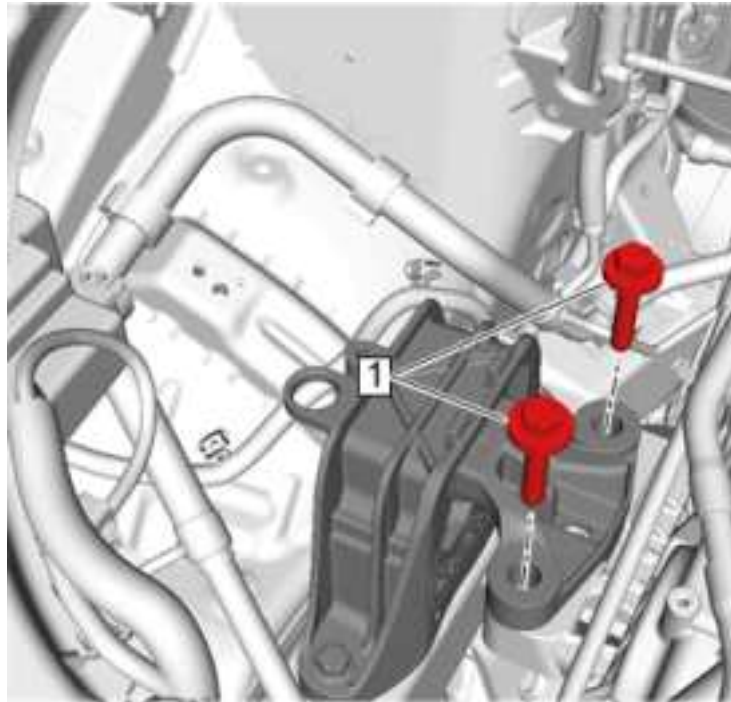


Fig. 256: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Tighten the engine mount to engine mount bracket bolts (1). [Engine Mount Replacement](#)

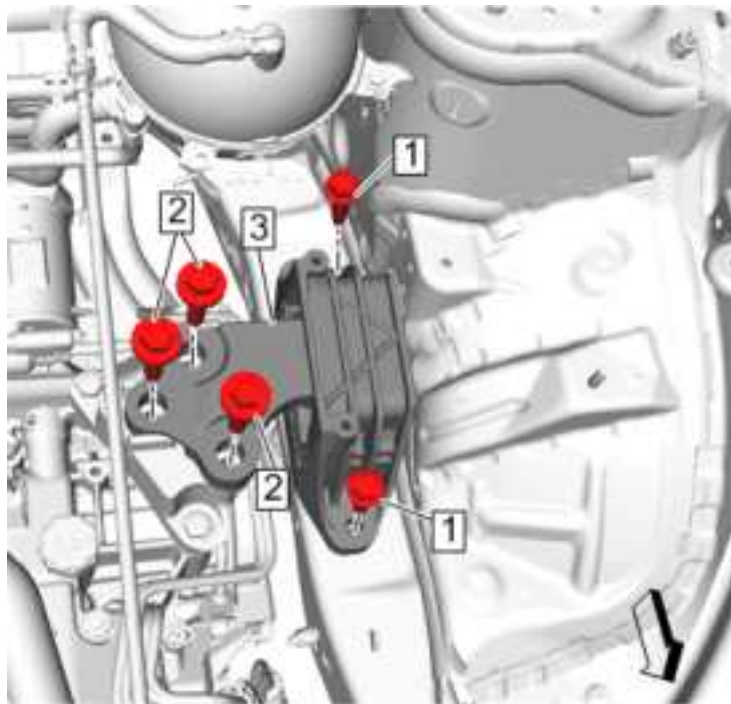


Fig. 257: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: Bolts (1) should remain tightened during the balancing procedure.

4. Tighten bolts (2) at the left transmission mount (3). [Transmission Mount Replacement - Left Side](#)
5. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

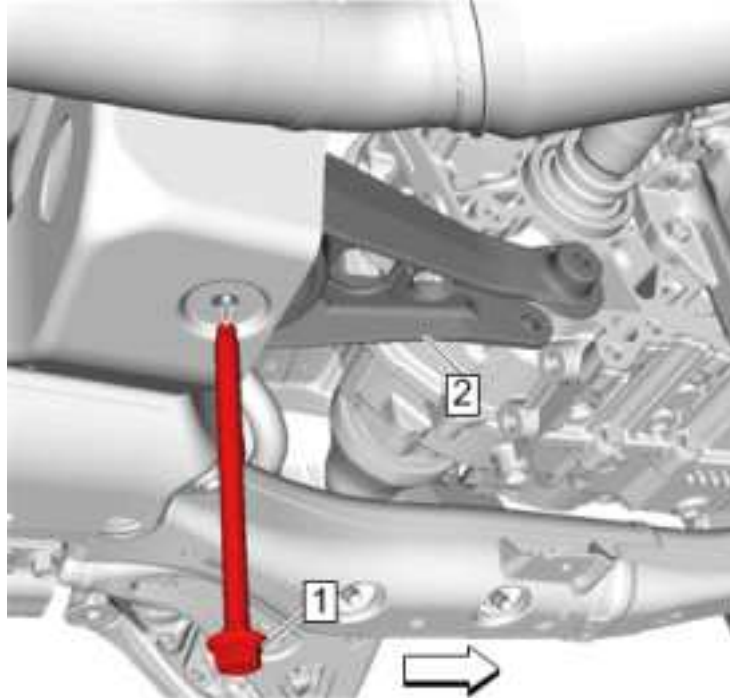


Fig. 258: Transmission Mount Strut Bolt
 Courtesy of GENERAL MOTORS COMPANY

6. Tighten the transmission mount strut bolt (1) at the transmission mount strut (2). **Transmission Mount Strut Replacement (All Wheel Drive)**, **Transmission Mount Strut Replacement (Front Wheel Drive)**.
7. Remove the jack stands and wood blocks supporting the engine and transaxle from underneath the powertrain.
8. Lower the vehicle. **Lifting and Jacking the Vehicle**

ENGINE MOUNT BRACKET REPLACEMENT

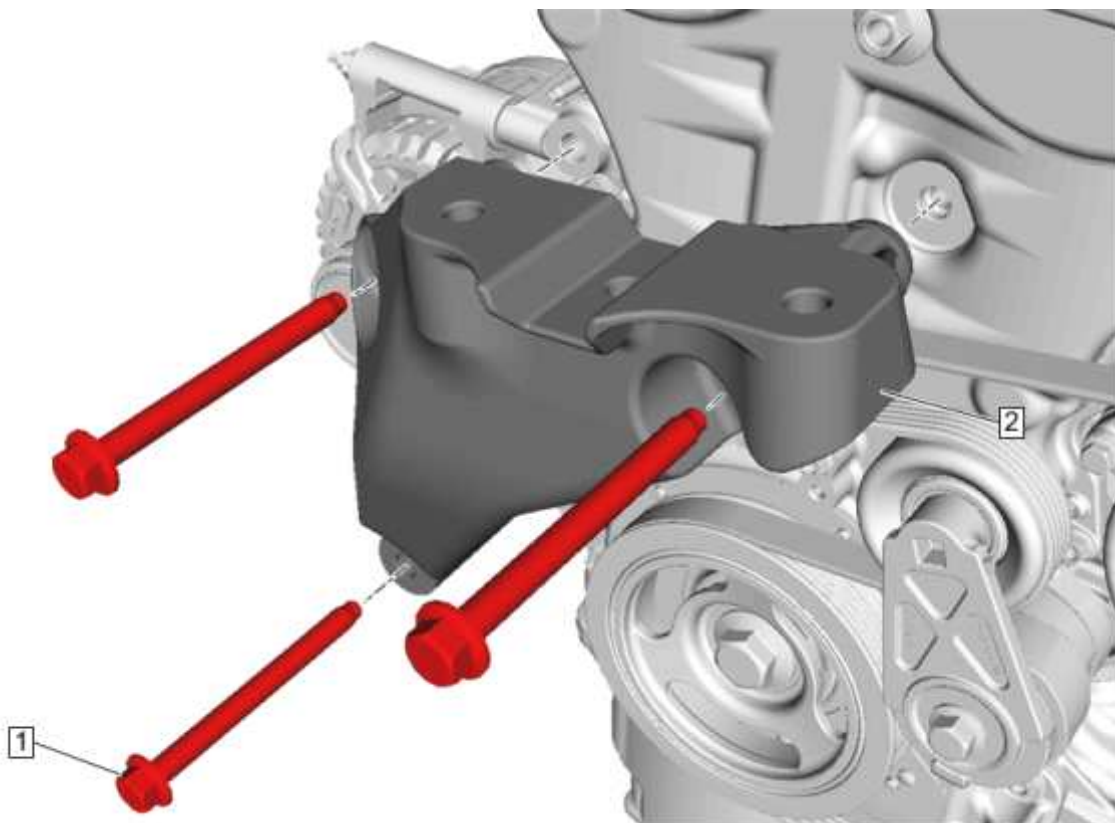


Fig. 259: Engine Mount Bracket
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure <u>Engine Mount Replacement</u>	
1	Engine Mount Bracket Engine Side Bolt [3x] CAUTION: Refer to <u>Fastener Caution</u> . Procedure Remove and DISCARD the fasteners. NOTE: Install NEW engine mount bracket fasteners. Tighten First Pass: 58 N.m (43 lb ft) Final Pass: 60 - 75 degrees
2	Engine Mount Bracket

ENGINE MOUNT REPLACEMENT

Special Tools

EN-45059 Angle Meter

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Remove Intake Manifold Cover - **Intake Manifold Cover Replacement**
2. Remove Air Cleaner Assembly - **Air Cleaner Assembly Replacement**
3. Install Engine Support Fixture - **Engine Support Fixture**

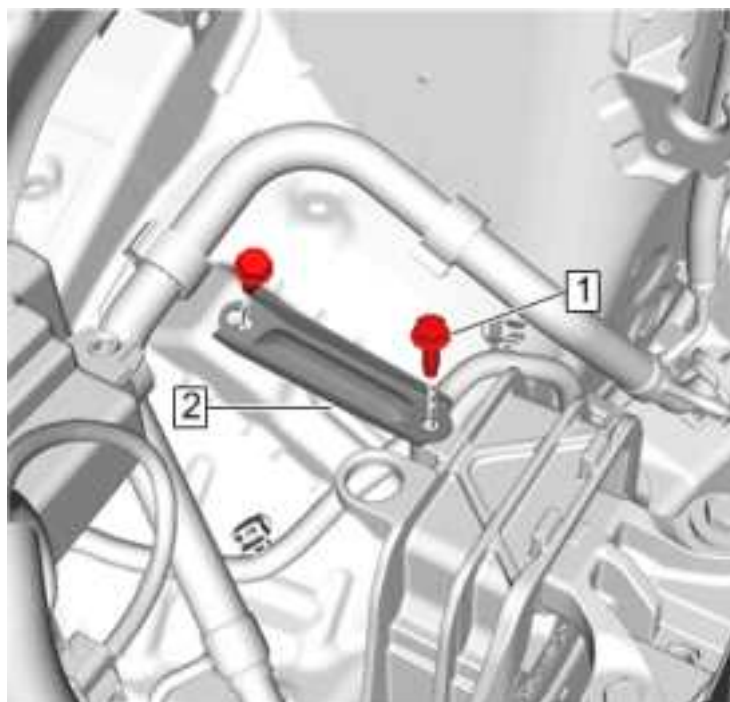


Fig. 260: Engine Mount Brace And Bolt
 Courtesy of GENERAL MOTORS COMPANY

4. Remove Engine Mount Brace Bolt (1)

5. Remove Engine Mount Brace (2)

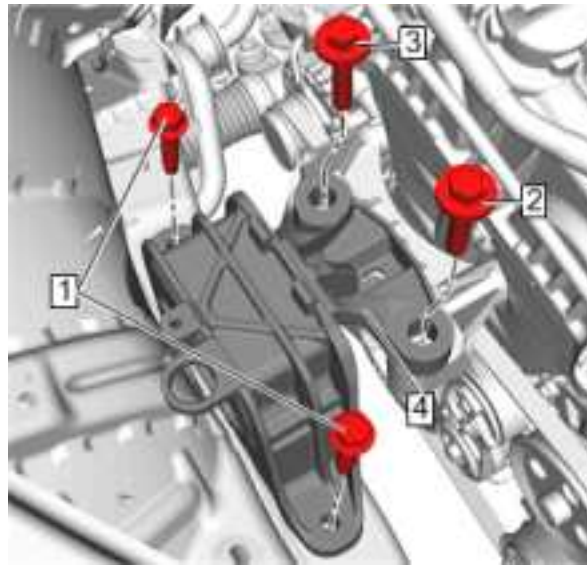


Fig. 261: Engine Mount Bolt

Courtesy of GENERAL MOTORS COMPANY

6. Remove Engine Mount Bolt (1)
7. Remove Engine Mount Engine Side Bolt (2) and DISCARD
8. Remove Engine Mount Engine Side Bolt (3) and DISCARD
9. Remove Engine Mount (4)

Installation Procedure

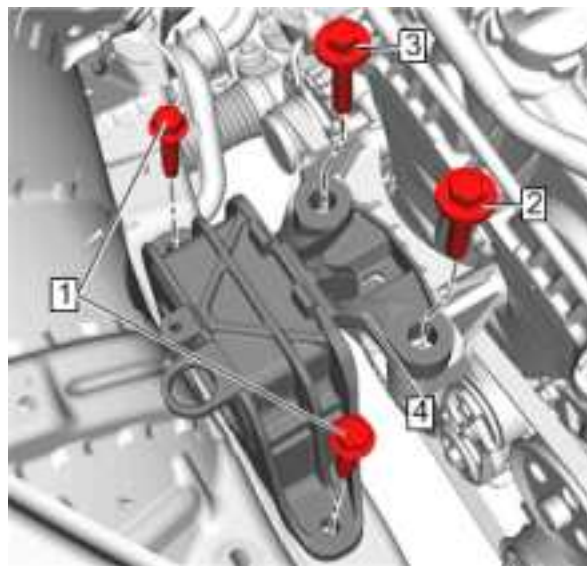


Fig. 262: Engine Mount Bolt

Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Mount (4)

CAUTION: Fastener Caution

2. Install Engine Mount Bolt (1) and tighten 100 N.m (74 lb ft)

CAUTION: Torque-to-Yield Fastener Caution

3. Install NEW Engine Mount Engine Side Bolt (2, 3)
4. Engine Mount Engine Side Bolt (2) - Tighten
 1. First Pass: 35 N.m (26 lb ft)
5. Engine Mount Engine Side Bolt (3) - Tighten

1. First Pass:35 N.m (26 lb ft)
6. Engine Mount Engine Side Bolt (2, 3) - Tighten
 1. Second Pass:100 N.m (74 lb ft)
 2. Final Pass:60 - 75 degrees - **EN-45059** Angle Meter

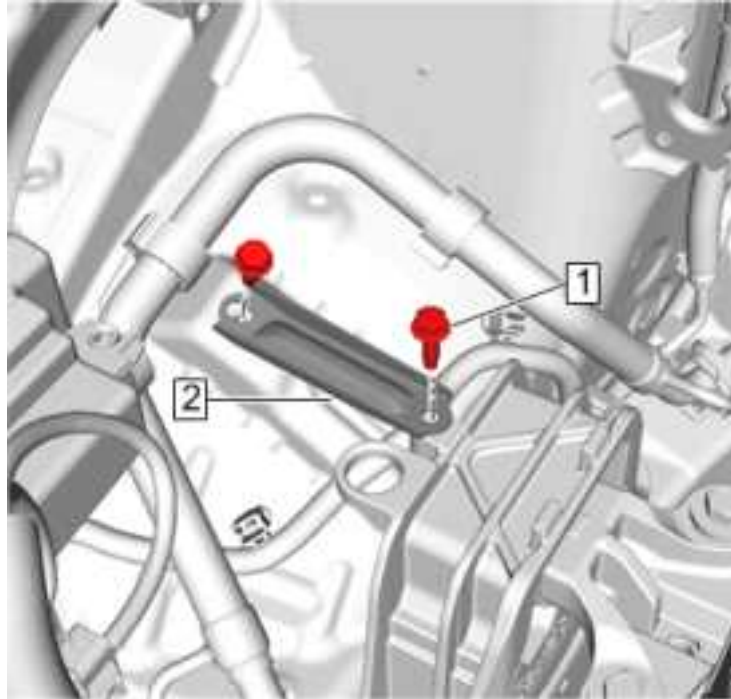


Fig. 263: Engine Mount Brace And Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Mount Brace (2)
8. Install Engine Mount Brace Bolt (1) and tighten 22 N.m (16 lb ft)
9. Install Engine Support Fixture - [Engine Support Fixture](#)
10. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)
11. Install Intake Manifold Cover - [Intake Manifold Cover Replacement](#)

UPPER OIL PAN REPLACEMENT

Removal Procedure

1. Remove Engine Oil Level Indicator Control Module Wiring Harness - [Engine Oil Level Indicator Control Module Wiring Harness Replacement](#)
2. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)

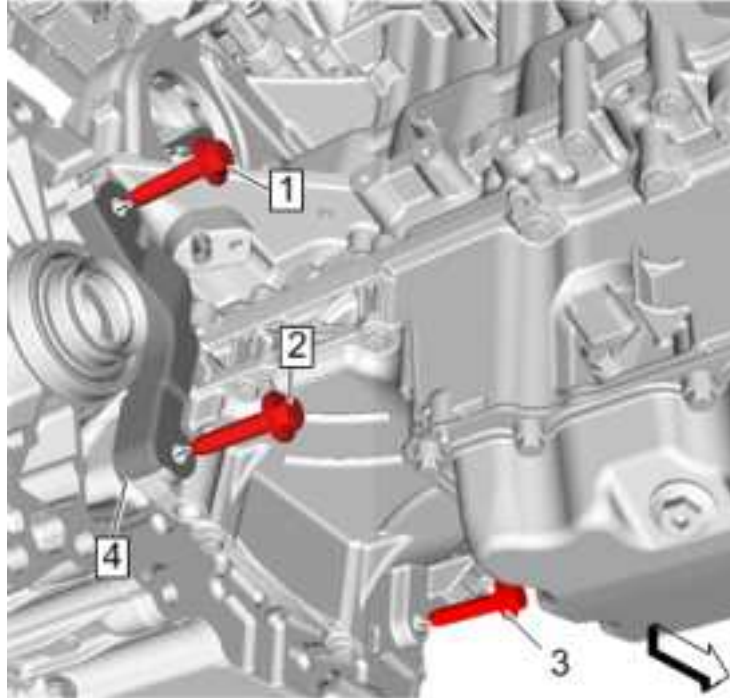


Fig. 264: Transmission Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove the transmission bolts (1, 2, 3) Transmission Replacement (Front Wheel Drive except Diesel Engine) Transmission Replacement (All Wheel Drive except Diesel Engine)
4. Remove Torque Converter Cover (4)

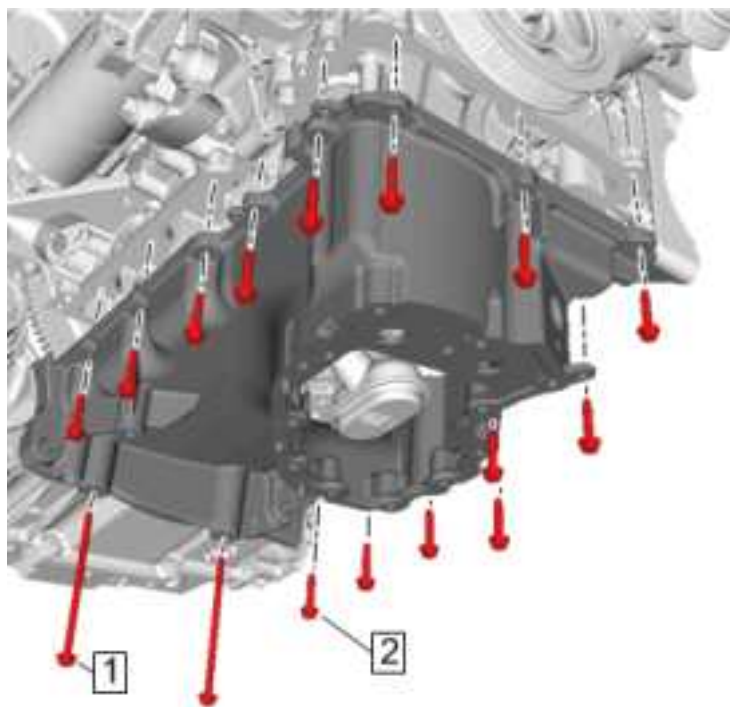


Fig. 265: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Mark the position of the oil pan bolts because of different length.

5. Remove the oil pan bolts (1, 2)
6. Carefully pry the oil pan loose and remove.
7. For part transfer, cleaning and inspection Oil Pan Cleaning and Inspection.

Installation Procedure

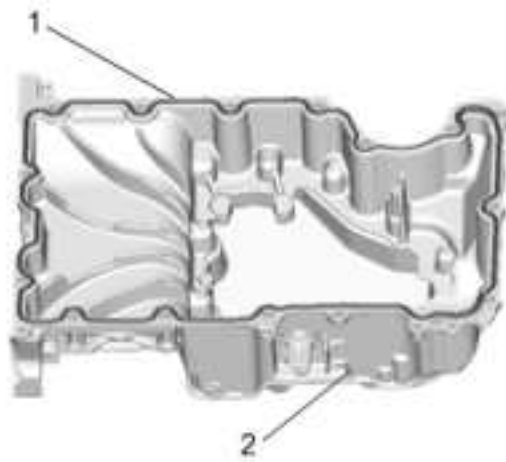


Fig. 266: Sealant Application Points

Courtesy of GENERAL MOTORS COMPANY

1. Apply sealer (1) around the perimeter of the oil pan (2). [Oil Pan Installation](#)

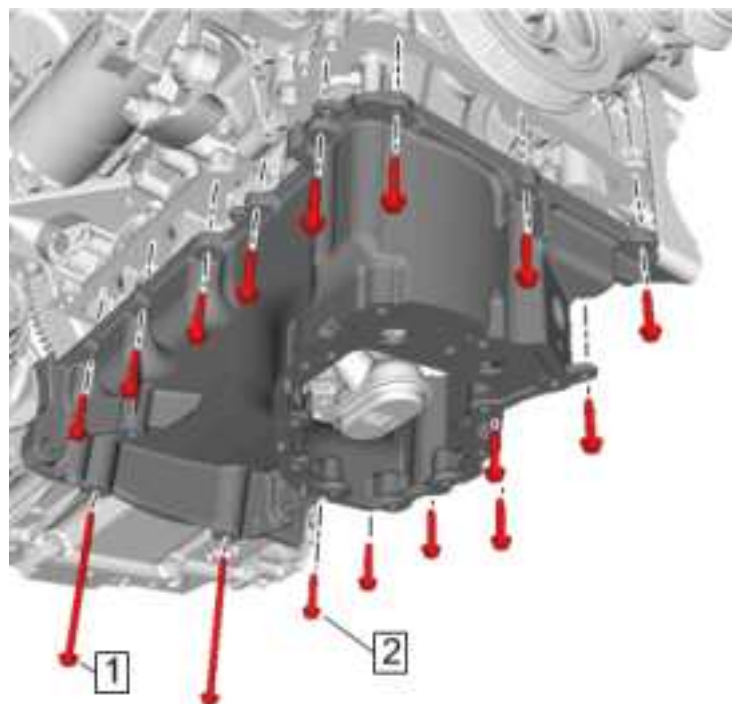


Fig. 267: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the different length bolts are installed in the same positions from which they were removed.

NOTE: When installing the oil pan, carefully align the oil pan to the locating pins and install the pan onto the lower crankcase.

2. Coat the oil pan bolts (1) and (2) with sealant prior to installation. [Adhesives, Fluids, Lubricants, and Sealers](#)
3. Loosely install the oil pan bolts.

NOTE: Inspect for excessive sealer around the oil filter mounting area. If extra sealer is present remove and clean accordingly.

4. Tighten the oil pan bolts in sequence. [Oil Pan Installation](#)

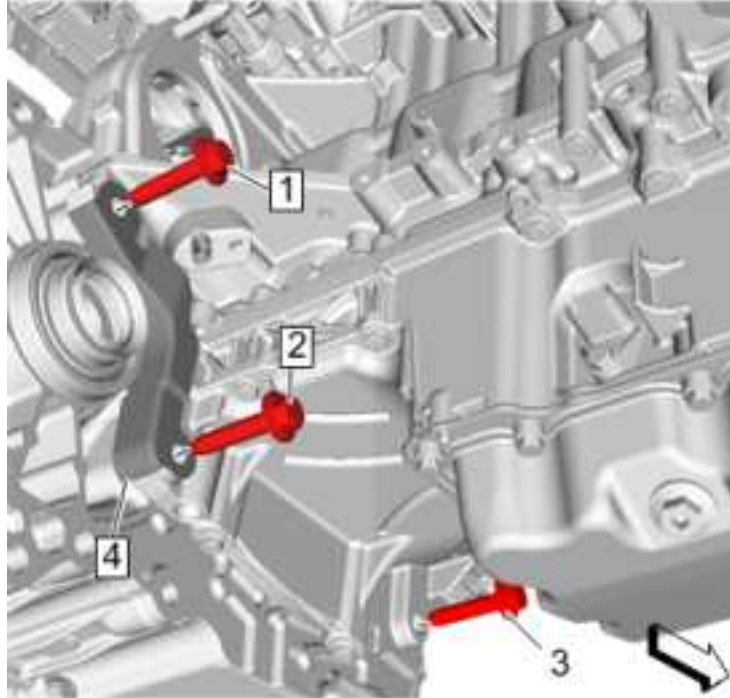


Fig. 268: Transmission Bolts

Courtesy of GENERAL MOTORS COMPANY

5. Install Torque Converter Cover (4)
6. Install the transmission bolts. [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#)
7. Install Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)
8. Install Engine Oil Level Indicator Control Module Wiring Harness - [Engine Oil Level Indicator Control Module Wiring Harness Replacement](#)
9. Change the engine oil and filter. [Engine Oil and Oil Filter Replacement](#)

LOWER OIL PAN REPLACEMENT

Removal Procedure

1. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)

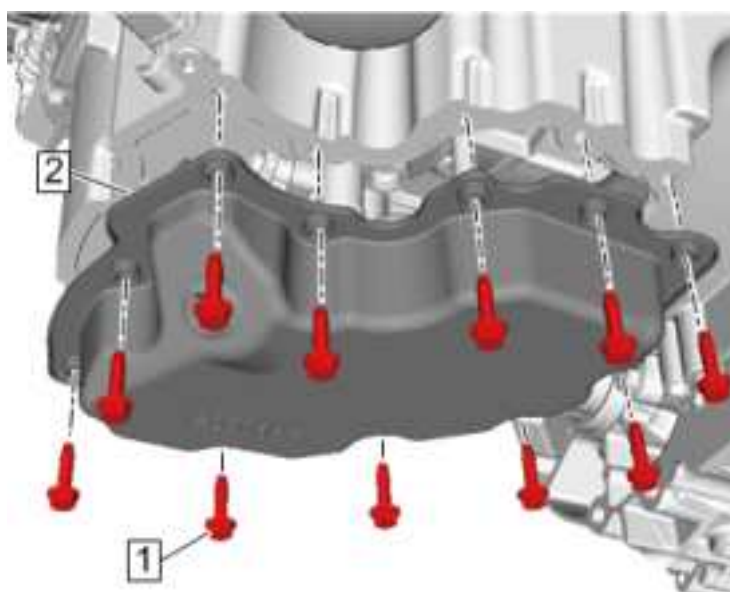


Fig. 269: Lower Oil Pan Bolt

Courtesy of GENERAL MOTORS COMPANY

2. Remove Lower Oil Pan Bolt (1)

CAUTION: Always replace the used oil pan with a new oil pan. The lower oil pan becomes damaged during removal and oil leaks may occur if it is not replaced with a new oil pan.

3. Remove Lower Oil Pan (2) and DISCARD
4. Clean and inspect the lower oil pan locating pins and the lower oil pan to upper oil pan mating surfaces. Oil Pan Cleaning and Inspection

Installation Procedure

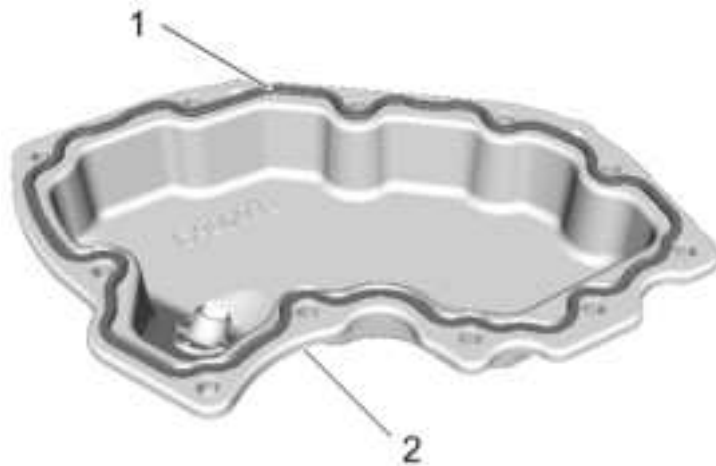


Fig. 270: Sealer

Courtesy of GENERAL MOTORS COMPANY

1. Apply bead of sealer (1) on the level part of the flange around the perimeter of the NEW oil pan
- (2). Oil Pan Installation

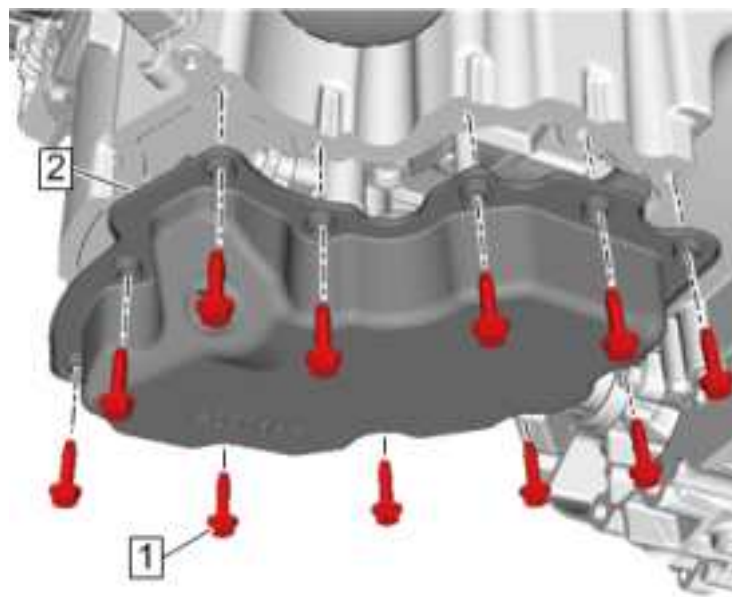


Fig. 271: Lower Oil Pan Bolt

Courtesy of GENERAL MOTORS COMPANY

2. Install NEW Lower Oil Pan (2)
3. Loosely install Lower Oil Pan Bolt (1)

4. Lower Oil Pan Bolt (1) - Tighten in sequence - [Oil Pan Installation](#)
5. Change the engine oil and filter. [Engine Oil and Oil Filter Replacement](#)

ENGINE OIL LEVEL INDICATOR CONTROL MODULE WIRING HARNESS REPLACEMENT

Removal Procedure

1. Disconnect the battery negative cable. [Battery Negative Cable Disconnection and Connection \(KL9\)](#)
2. Remove Lower Oil Pan - [Lower Oil Pan Replacement](#)

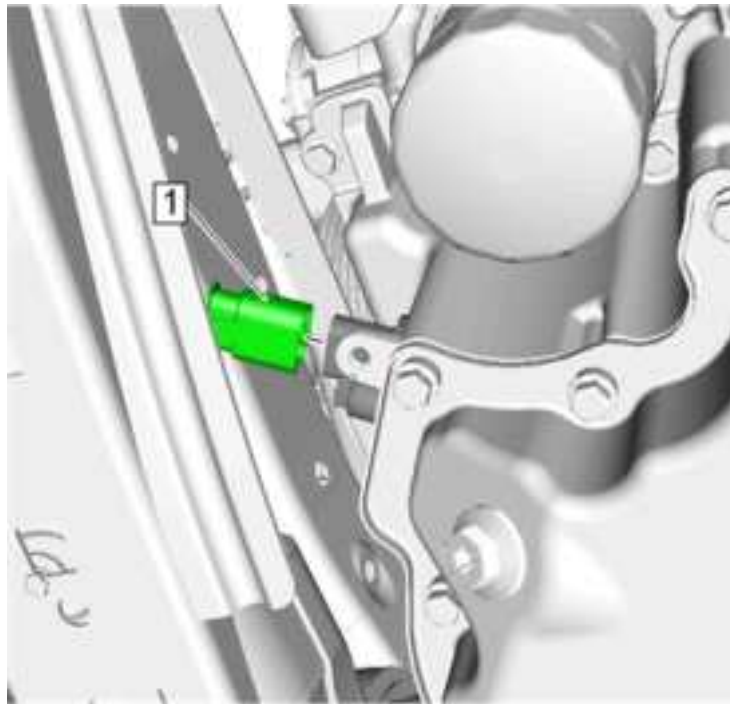


Fig. 272: Electrical Connector

Courtesy of GENERAL MOTORS COMPANY

3. Disconnect Electrical Connector (1) @Engine Oil Level Indicator Control Module Wiring Harness

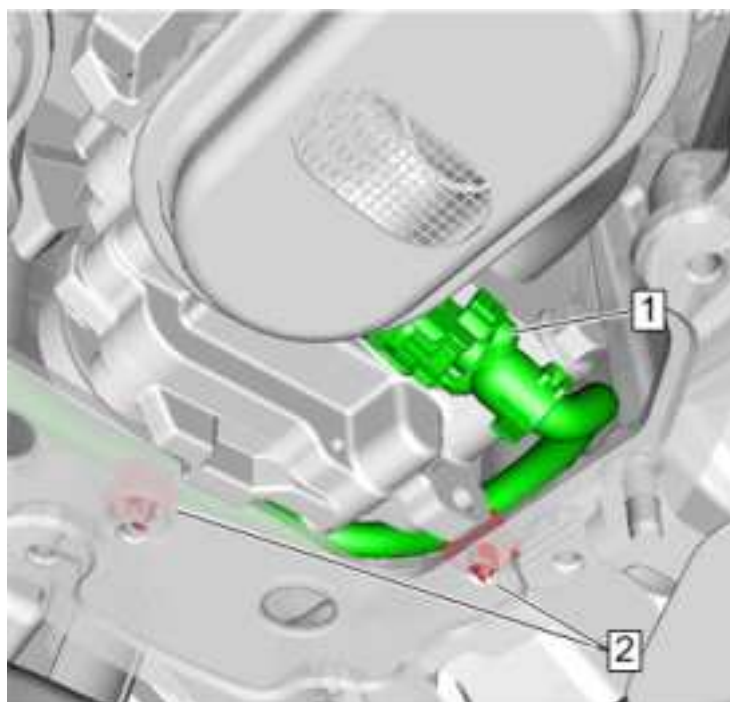


Fig. 273: Electrical Connector And Wiring Harness Retainer

Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Electrical Connector (1) @ Oil Pump Flow Control Solenoid Valve

5. Remove { If equipped } Wiring Harness Retainer (2)

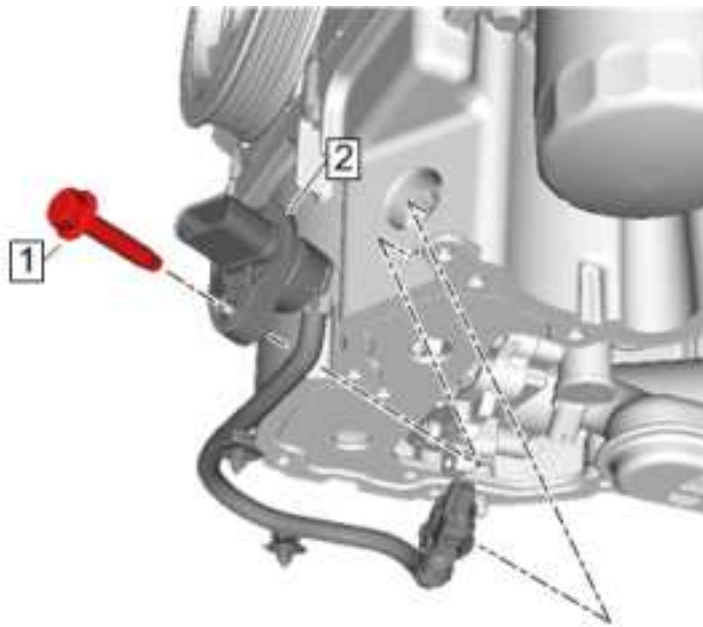


Fig. 274: Wiring Harness Connector Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove Wiring Harness Connector Bolt (1)
7. Remove Engine Oil Level Indicator Control Module Wiring Harness

Installation Procedure

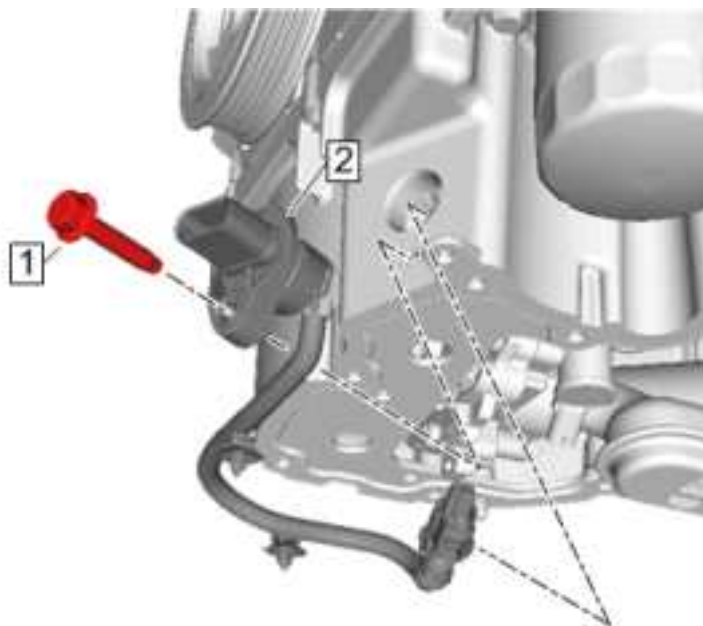


Fig. 275: Wiring Harness Connector Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Oil Level Indicator Control Module Wiring Harness (2)

CAUTION: Fastener Caution

2. Install Wiring Harness Connector Bolt (1) and tighten 10 N.m (89 lb in)

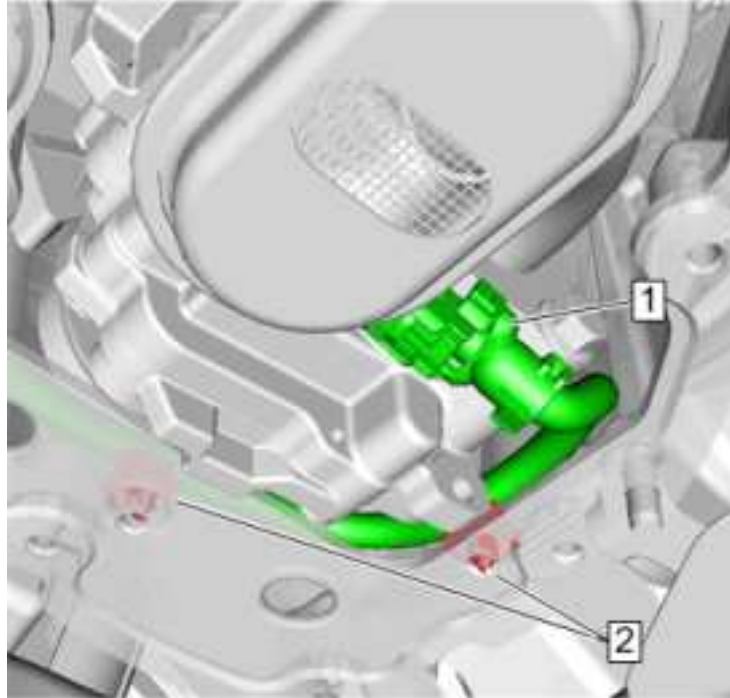


Fig. 276: Electrical Connector And Wiring Harness Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Install { If equipped } Wiring Harness Retainer (2)
4. Connect Electrical Connector (1) @Oil Pump Flow Control Solenoid Valve (1).

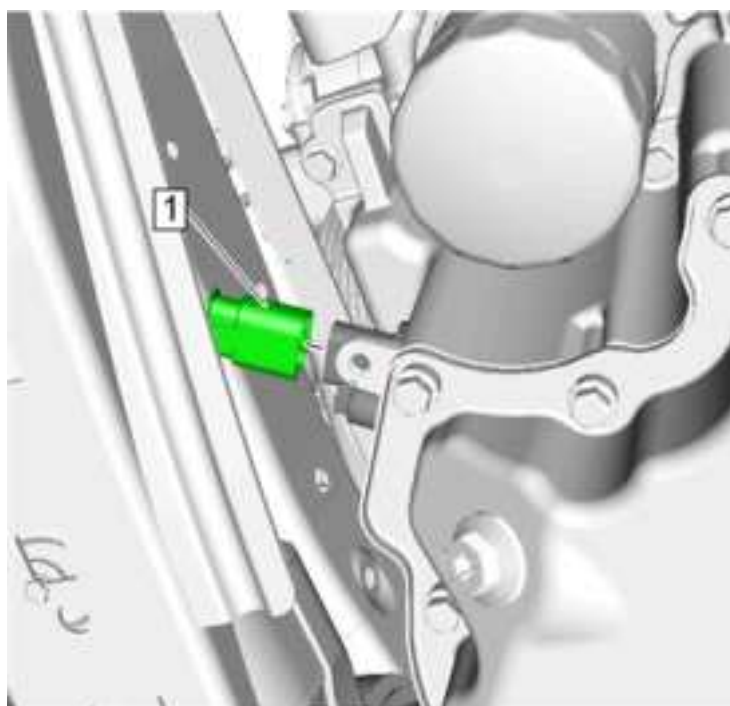


Fig. 277: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

5. Connect Electrical Connector (1) @Engine Oil Level Indicator Control Module Wiring Harness
6. Install Lower Oil Pan - **Lower Oil Pan Replacement**
7. Connect the battery negative cable. **Battery Negative Cable Disconnection and Connection (KL9)**

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil drain plug.

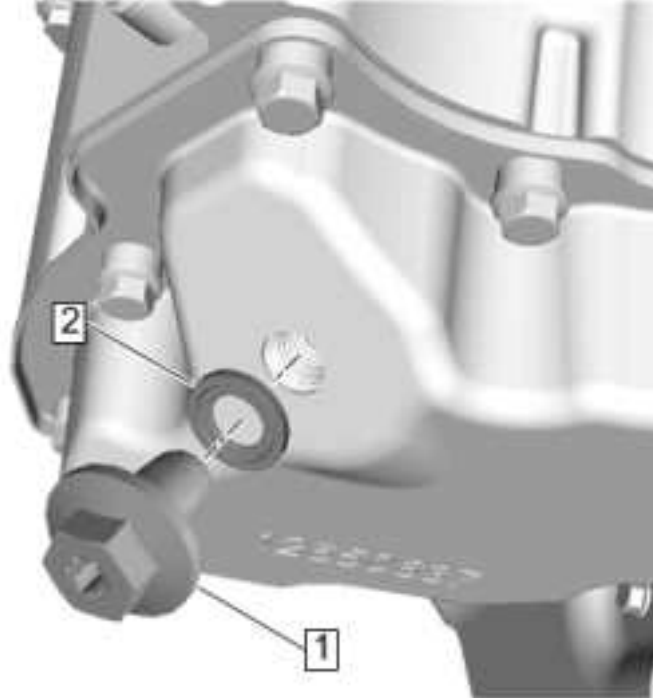


Fig. 278: Oil Pan Drain Plug

Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil pan drain plug (1)
4. Allow the oil to drain completely.

CAUTION: Refer to [Component Fastener Tightening Caution](#) .

NOTE: Inspect the oil drain plug (1) and ring seal (2), replace only if damaged.

5. Install the oil pan drain plug (1) Tighten 25 N.m (18 lb ft).

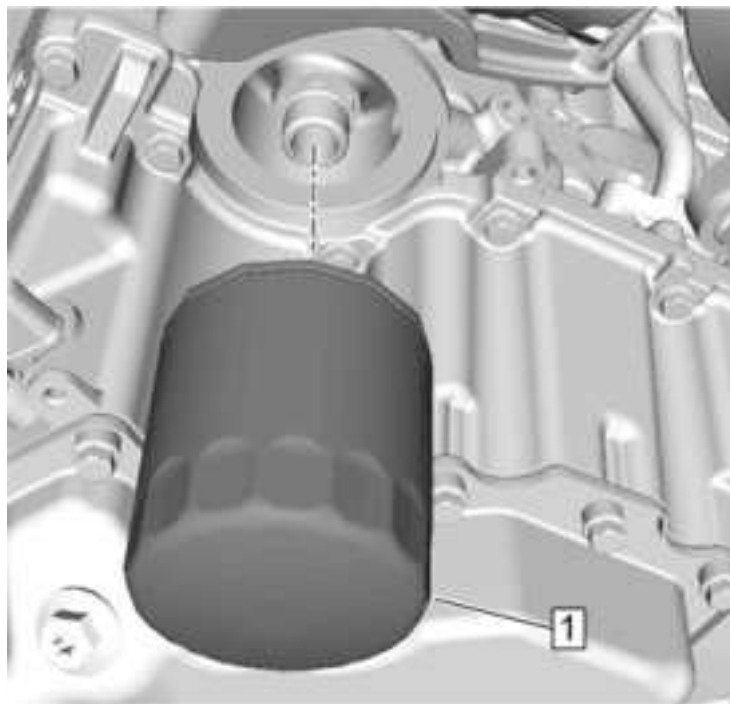


Fig. 279: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

6. Place the drain pan under the oil filter.
7. Remove and DISCARD the oil filter (1)
8. Ensure that the old oil filter seal has been removed.

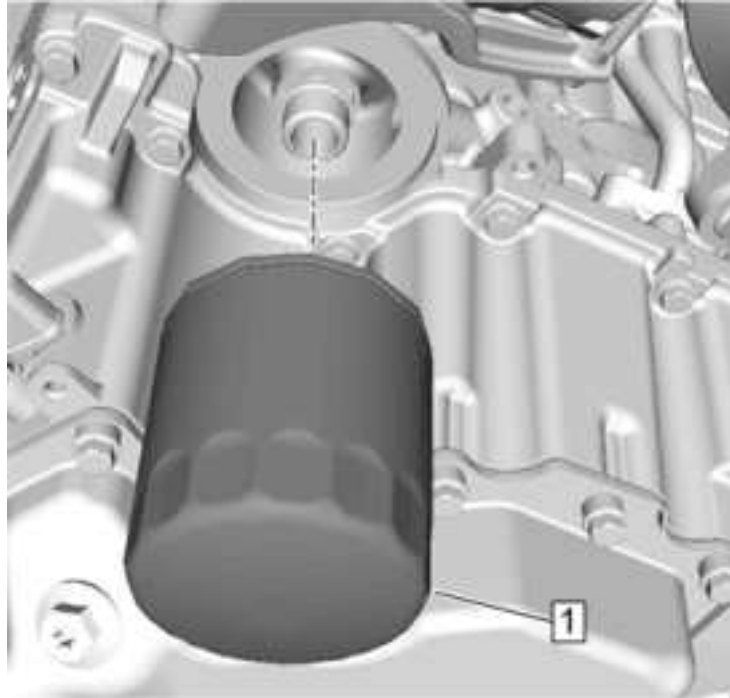


Fig. 280: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the NEW oil filter gasket with clean engine oil.
2. Install a NEW oil filter and tighten 3/4 to 1 full turn after the gasket makes contact with the sealing surface on the filter mounting flange.
3. Remove the drain pan.
4. Lower the vehicle.
5. Fill the engine oil to the proper level using the appropriate oil type. [Approximate Fluid Capacities, Adhesives, Fluids, Lubricants, and Sealers](#)
6. Start the engine and inspect for leaks.

OIL PUMP FLOW CONTROL SOLENOID VALVE REPLACEMENT

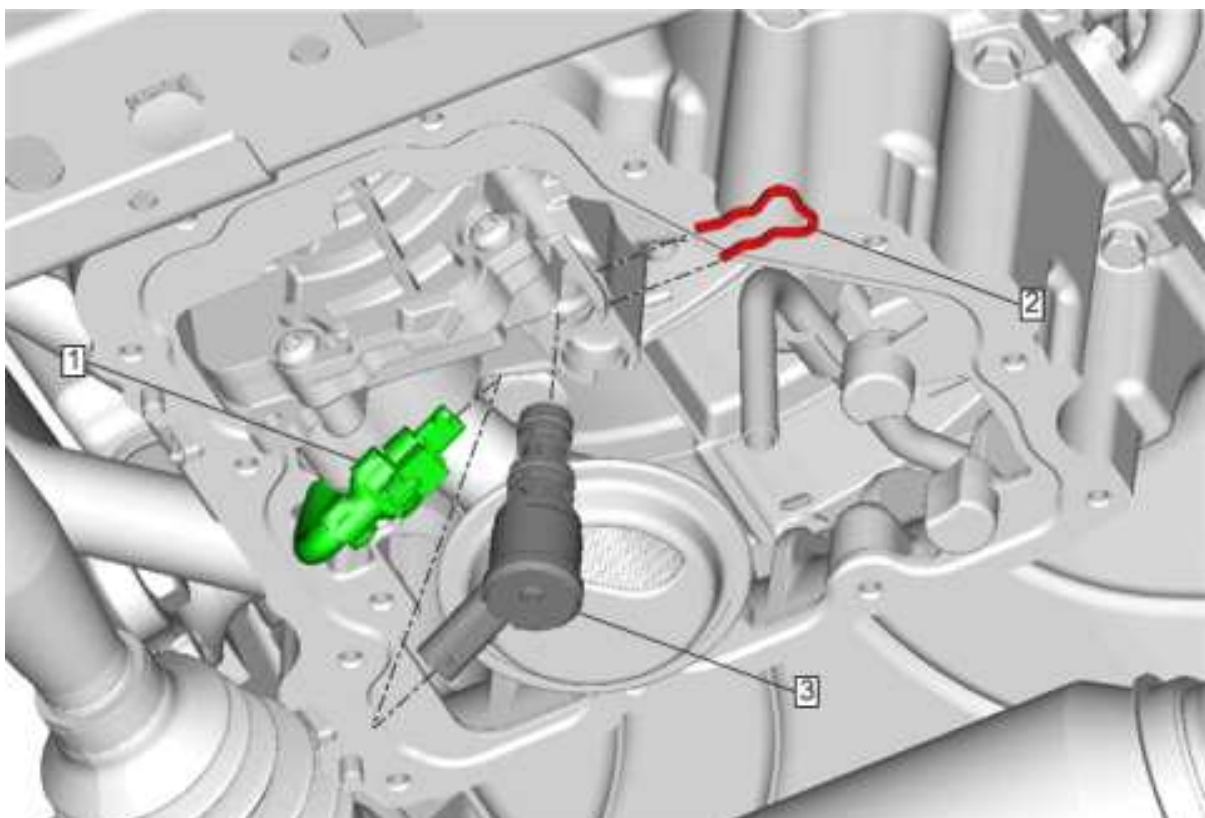


Fig. 281: Oil Pump Flow Control Solenoid Valve

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Lower Oil Pan Replacement	
1	Oil Pump Flow Control Solenoid Valve Electrical Connector
2	Oil Pump Flow Control Solenoid Valve Retainer Procedure Using a suitable tool, remove the retainer.
3	Oil Pump Flow Control Solenoid Valve

OIL PUMP DRIVE CHAIN REPLACEMENT

Removal Procedure

1. Remove **Oil Pump Drive Chain Tensioner Replacement**
2. Remove **Camshaft Timing Chain Replacement**
3. Remove **Oil Pump Replacement**.

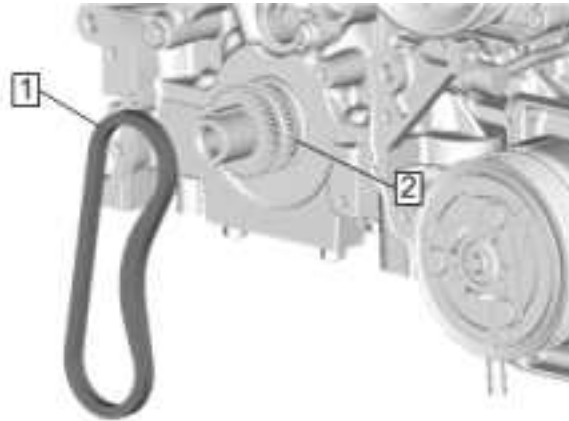


Fig. 282: Oil Pump Drive Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

4. Remove the oil pump drive chain (1) from the crankshaft sprocket (2).

Installation Procedure

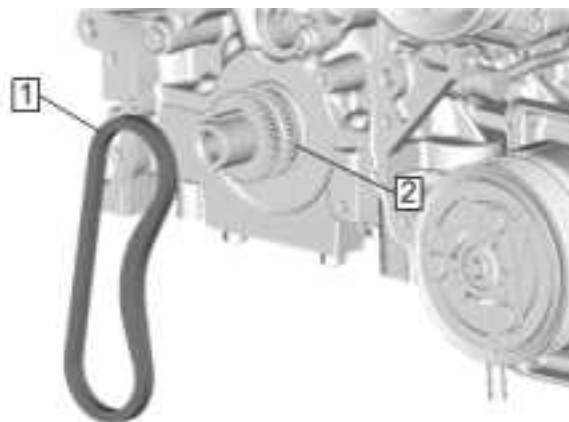


Fig. 283: Oil Pump Drive Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

1. Install the oil pump drive chain (1) onto the crankshaft sprocket (2).

2. Install [Oil Pump Replacement](#).
3. Install [Oil Pump Drive Chain Tensioner Replacement](#).
4. Install [Camshaft Timing Chain Replacement](#).

OIL PUMP DRIVE CHAIN TENSIONER REPLACEMENT

Removal Procedure

1. Remove [Engine Front Cover Replacement](#)

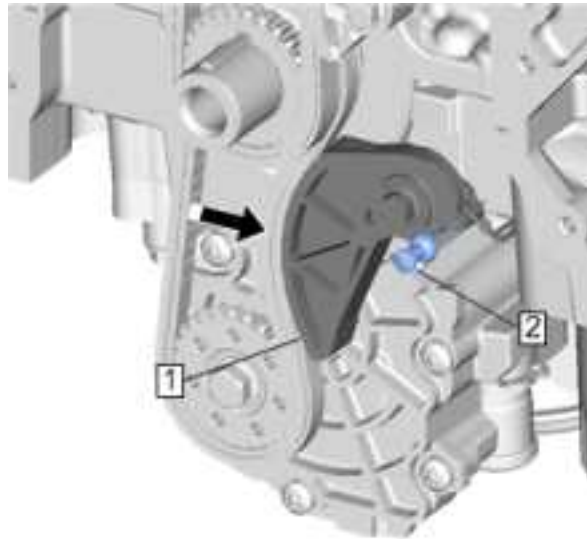


Fig. 284: Pushing Oil Pump Drive Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

2. Push the oil pump drive chain tensioner (1) in direction of arrow.
3. Lock the tensioner using a suitable tool (2).

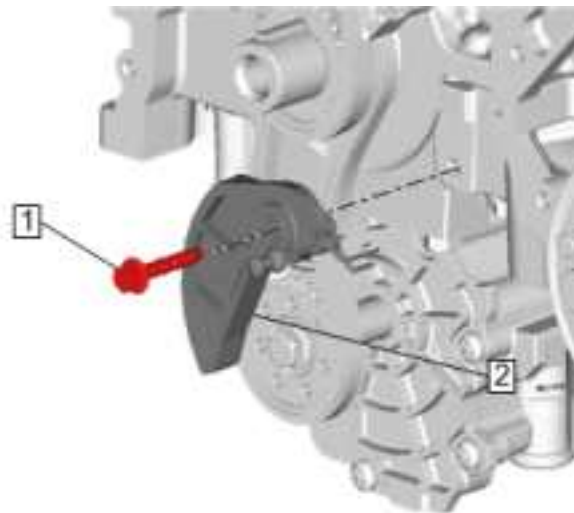


Fig. 285: Oil Pump Drive Chain Tensioner And Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the oil pump drive chain tensioner bolt (1).
5. Remove the oil pump drive chain tensioner (2).

Installation Procedure

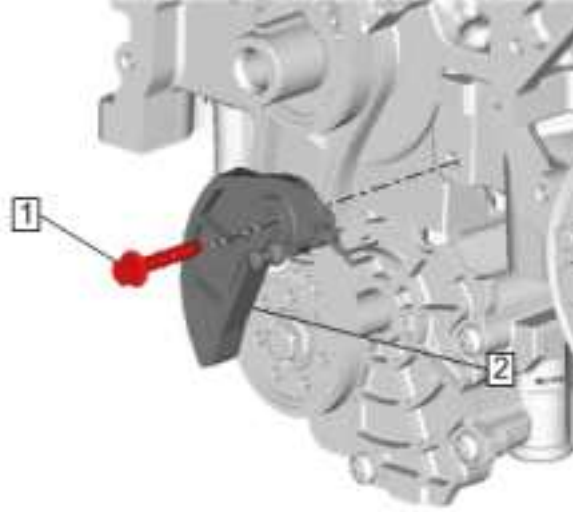


Fig. 286: Oil Pump Drive Chain Tensioner And Bolt
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the tensioner spring is retained in the correct position prior to installation.

1. Install the oil pump drive chain tensioner (2).

CAUTION: Refer to [Fastener Caution](#) .

2. Install the oil pump drive chain tensioner bolt (1) and tighten to 10 N.m (89 lb in).

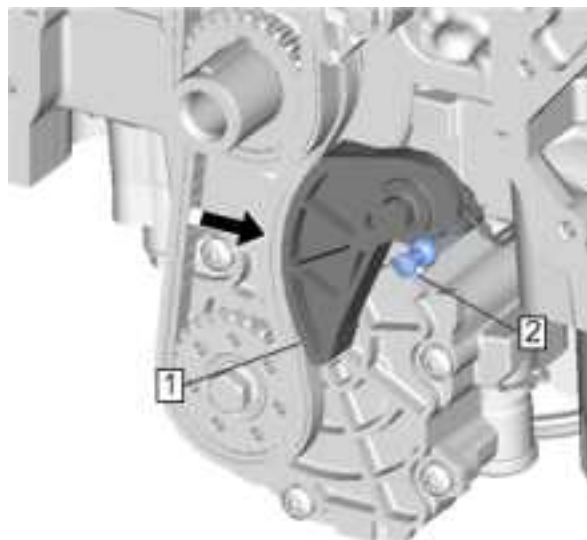


Fig. 287: Pushing Oil Pump Drive Chain Tensioner
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the suitable tool (2) from the oil pump drive chain tensioner (1).
4. Install [Engine Front Cover Replacement](#).

OIL PUMP REPLACEMENT

Removal Procedure

1. Remove [Upper Oil Pan Replacement](#)

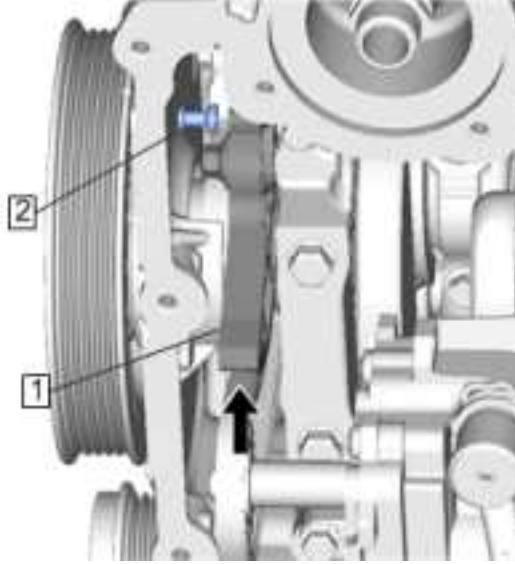


Fig. 288: Unlocking Tensioner

Courtesy of GENERAL MOTORS COMPANY

2. Push the oil pump drive chain tensioner (1) in direction of arrow.
3. Lock the tensioner using a suitable tool (2).
4. If replacing the oil pump, remove the oil pump flow control solenoid valve. [Oil Pump Flow Control Solenoid Valve Replacement](#)

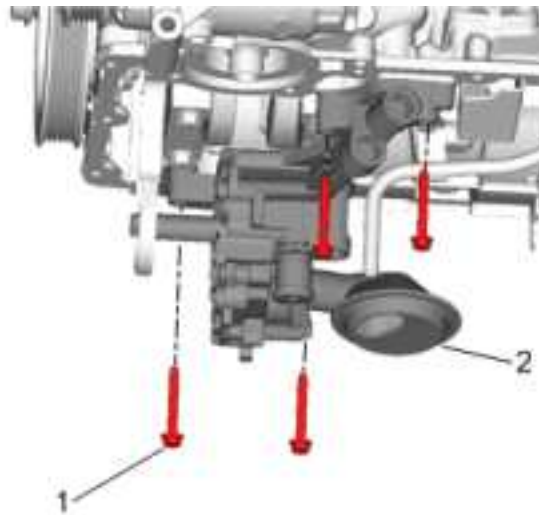


Fig. 289: Oil Pump Fasteners

Courtesy of GENERAL MOTORS COMPANY

NOTE: It may be necessary to leave one fastener in the pump assembly to secure the pump prior to removing it from the engine.

5. Remove all EXCEPT one of the oil pump fasteners (1) securing the oil pump (2).

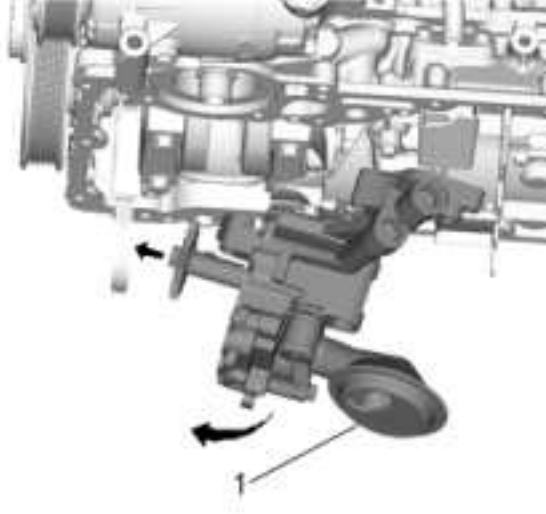


Fig. 290: Oil Pump

Courtesy of GENERAL MOTORS COMPANY

NOTE: The last oil pump fastener should be removed while simultaneously tilting the pump in the direction of the arrow.

6. Remove the remaining oil pump fastener.
7. Remove the oil pump (1).



Fig. 291: Oil Pump Seals

Courtesy of GENERAL MOTORS COMPANY

8. Remove and DISCARD the oil pump seals (1).

Installation Procedure



Fig. 292: Oil Pump Seals

Courtesy of GENERAL MOTORS COMPANY

1. Install NEW oil pump seals (1).

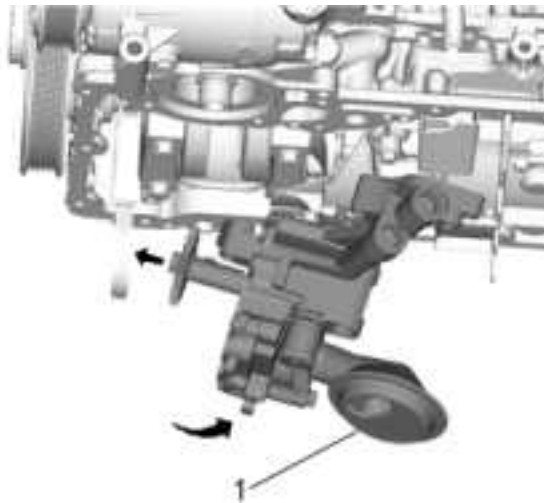


Fig. 293: Oil Pump Assembly

Courtesy of GENERAL MOTORS COMPANY

2. Tilt the oil pump assembly (1) in order to install the drive chain over the oil pump shaft sprocket.

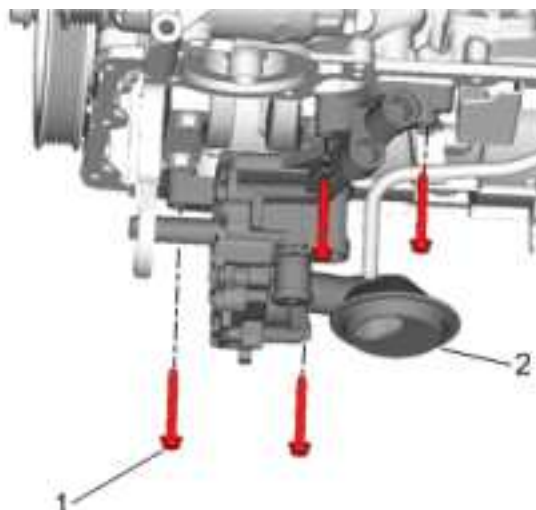


Fig. 294: Oil Pump Fasteners

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

NOTE: Ensure the oil pump assembly (2) is properly positioned. The fasteners should only be installed and tightened after the drive chain is correctly positioned on the sprocket.

3. Install the oil pump fasteners (1). Tighten to 10 N.m (89 lb in)
4. If replacing the oil pump, install the oil pump flow control solenoid valve. [Oil Pump Flow Control Solenoid Valve Replacement](#)

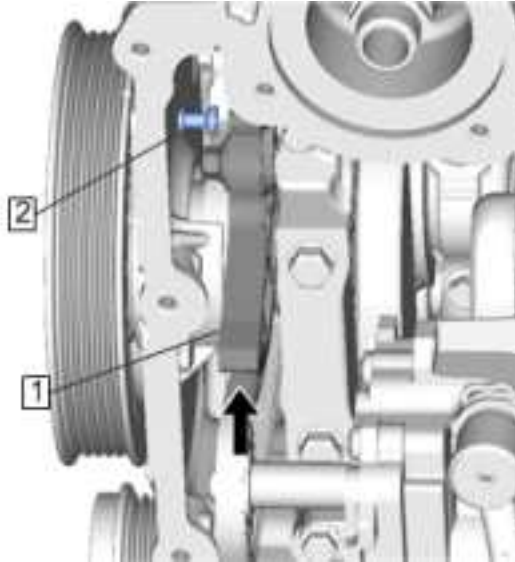


Fig. 295: Unlocking Tensioner

Courtesy of GENERAL MOTORS COMPANY

5. Remove the suitable tool (2) to unlock the tensioner (1).
6. Install [Upper Oil Pan Replacement](#).

ENGINE REPLACEMENT (ALL WHEEL DRIVE)

Special Tools

- **BO-38185** Hose Clamp Pliers

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)

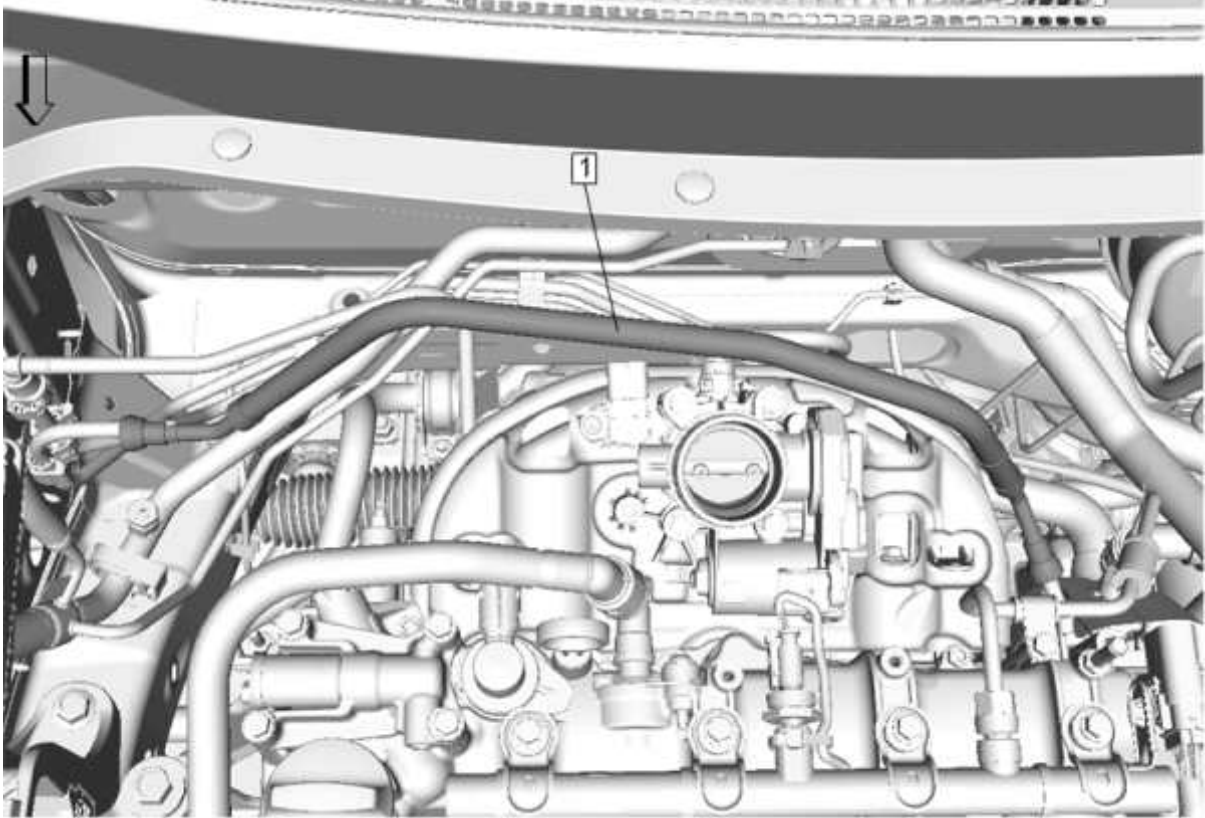


Fig. 296: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Fuel Feed Front Pipe (1) @ Engine [Fuel Feed Front Pipe Replacement](#)
3. Recover the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\)](#) [Refrigerant Recovery and Recharging \(R-1234yf\)](#)

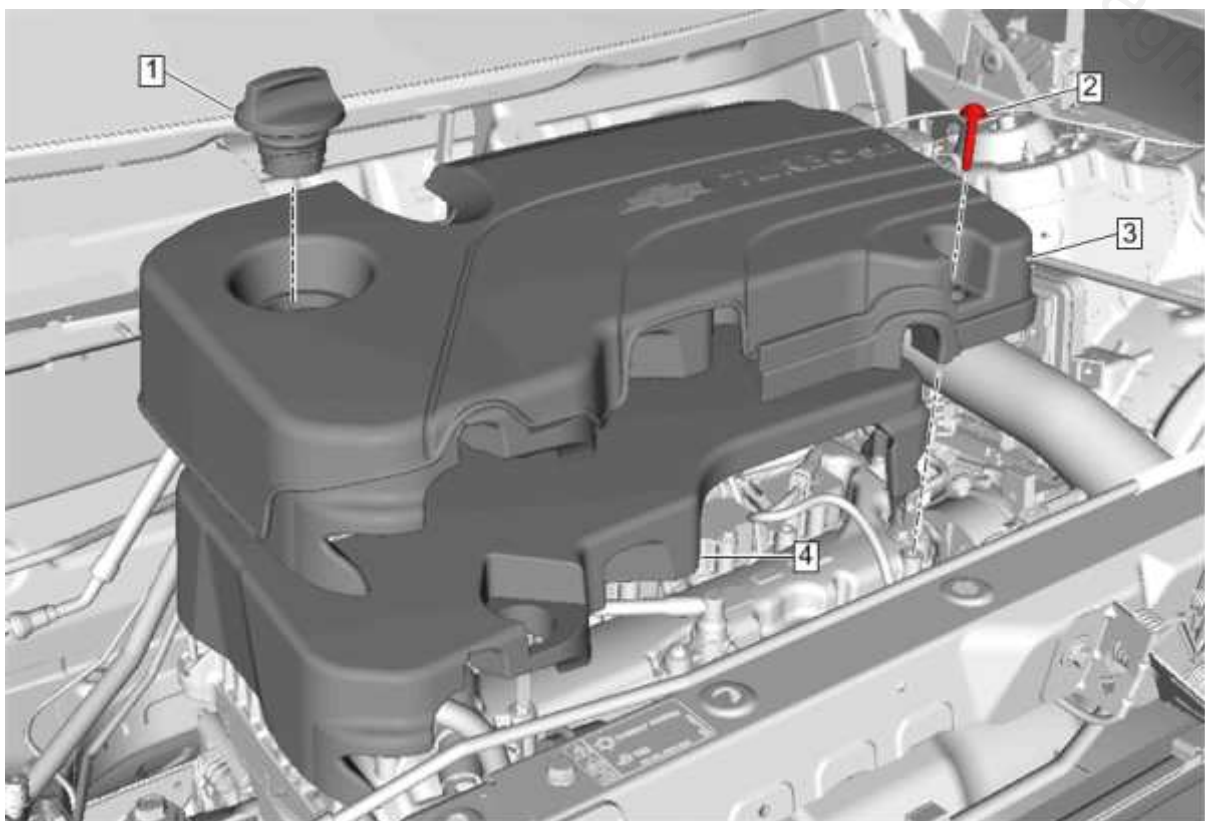


Fig. 297: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

4. Remove Intake Manifold Cover (3) - [Intake Manifold Cover Replacement](#)
5. Remove Charge Air Cooler Inlet Air Tube - [Charge Air Cooler Inlet Air Tube Replacement](#)
6. Remove Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)
7. Remove Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

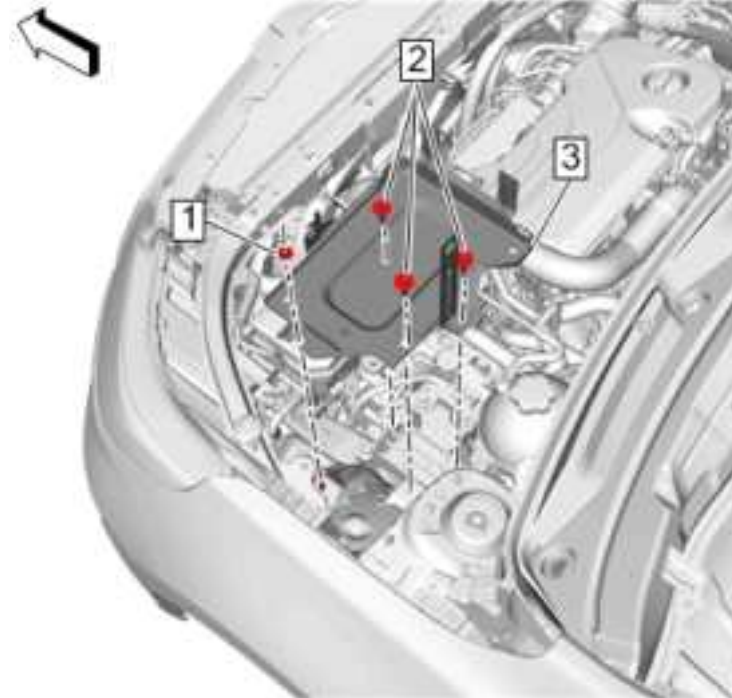


Fig. 298: Battery Tray

Courtesy of GENERAL MOTORS COMPANY

8. Remove Battery Tray (3) [Battery Tray Replacement](#)
9. Remove Radiator Inlet Hose - [Radiator Inlet Hose Replacement \(LYX\)](#)
10. Remove Radiator Outlet Hose - [Radiator Outlet Hose Replacement \(LYX\)](#)

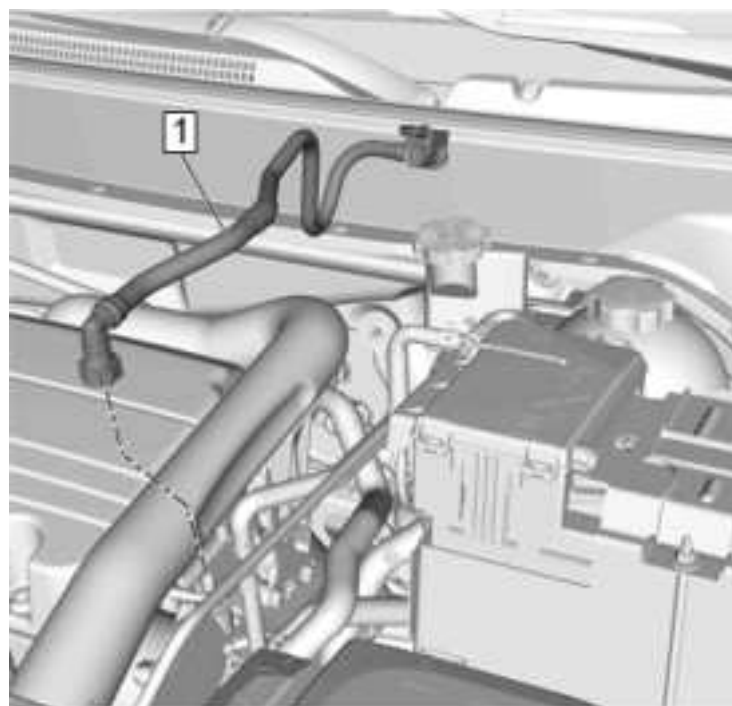


Fig. 299: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

11. Remove Power Brake Booster Vacuum Pipe (1) [Power Brake Booster Vacuum Pipe Replacement \(LYX\)](#)
12. Remove Heater Inlet Hose - [Heater Inlet Hose Replacement \(LYX AWD without KL9\)](#) [Heater Inlet Hose Replacement \(LYX with KL9\)](#)
13. Remove Heater Outlet Hose - [Heater Outlet Hose Replacement \(LYX without KL9\)](#)

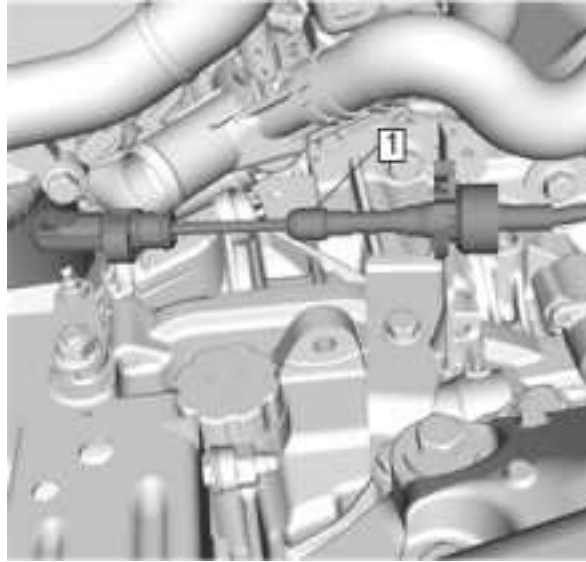


Fig. 300: Range Selector Lever Cable

Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Range Selector Lever Cable (1) @Transmission - [Range Selector Lever Cable Replacement](#)
15. Remove Underbody Front Air Deflector - [Underbody Front Air Deflector Replacement \(Equinox\)](#) [Underbody Front Air Deflector Replacement \(Terrain\)](#)
16. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)
17. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose@Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LYX\)](#)

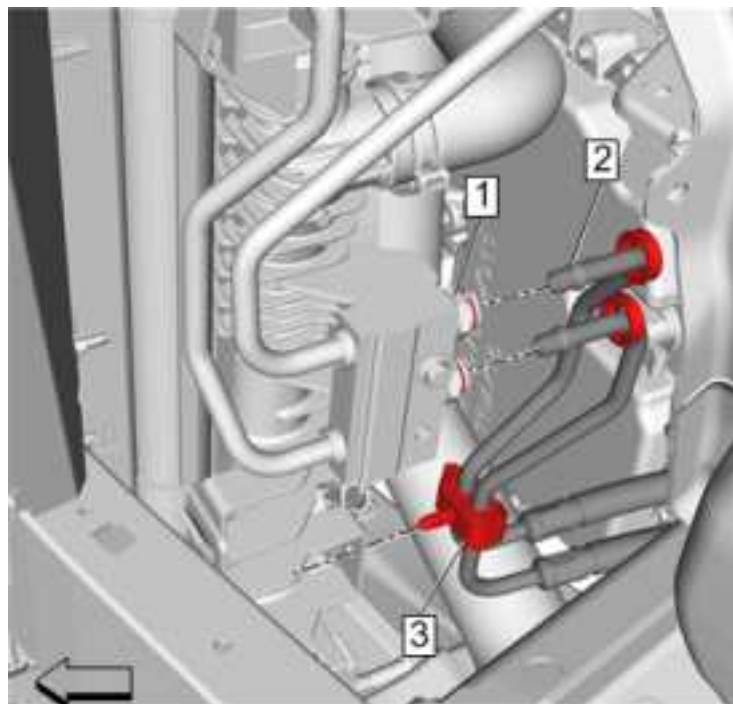


Fig. 301: Transmission Fluid Cooler Inlet and Outlet Pipe

Courtesy of GENERAL MOTORS COMPANY

18. Disconnect Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator Assembly - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#) [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(M3D, M3H, M3U\)](#)
19. Remove Front Wheel Drive Half Shaft-Left Side - [Front Wheel Drive Half Shaft Replacement - Left Side](#)
20. Remove Front Wheel Drive Half Shaft-Right Side - [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG, MNH, MNK with FWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3D, M3H with FWD\)](#)

21. Remove Propeller Shaft - [Two-Piece Propeller Shaft Replacement](#)

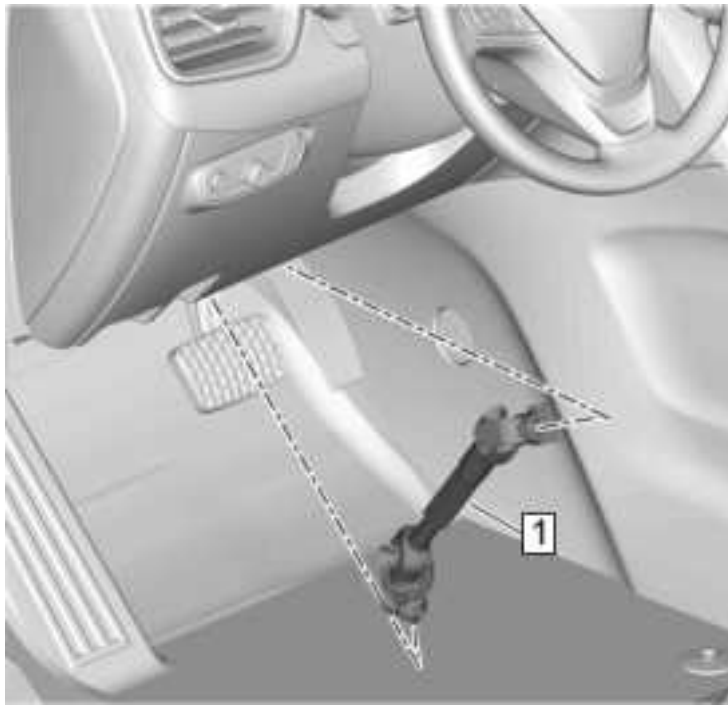


Fig. 302: Intermediate Steering Shaft

Courtesy of GENERAL MOTORS COMPANY

22. Remove Intermediate Steering Shaft - [Intermediate Steering Shaft Replacement \(Equinox\)](#)
[Intermediate Steering Shaft Replacement \(Terrain\)](#)

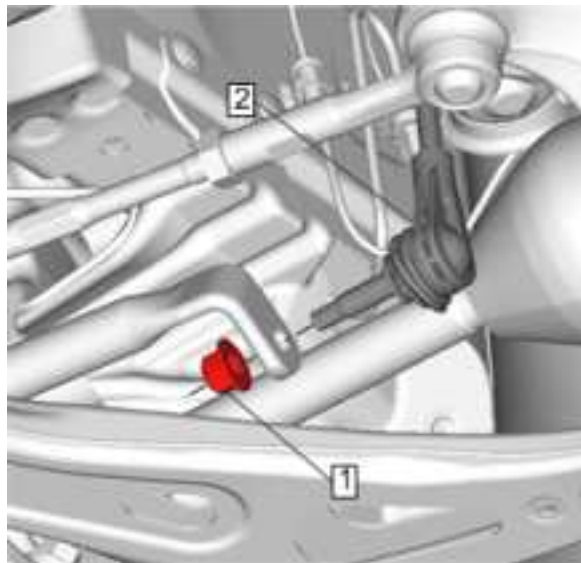


Fig. 303: Stabilizer Link Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

23. Remove left and right side the stabilizer link nuts (1) then disconnect the links at the stabilizer.
[Stabilizer Shaft Link Replacement \(Equinox\)](#) [Stabilizer Shaft Link Replacement \(Terrain\)](#)

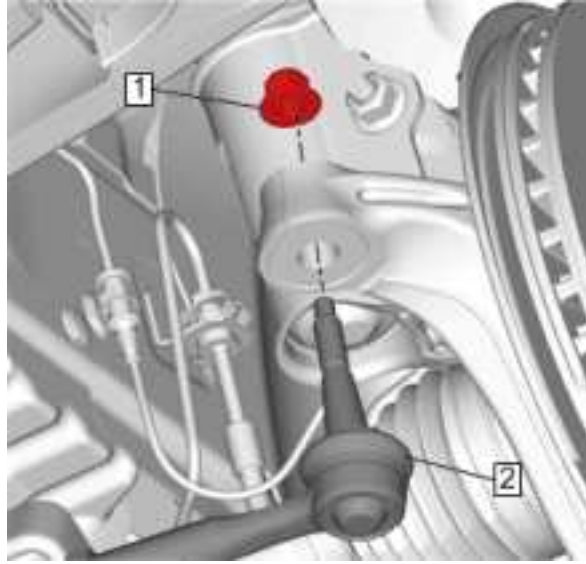


Fig. 304: Tie Rods And Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

24. Remove the left and right side tie rod nuts (1), then disconnect the tie rods (2) from the steering knuckles. [Steering Linkage Outer Tie Rod Replacement](#)

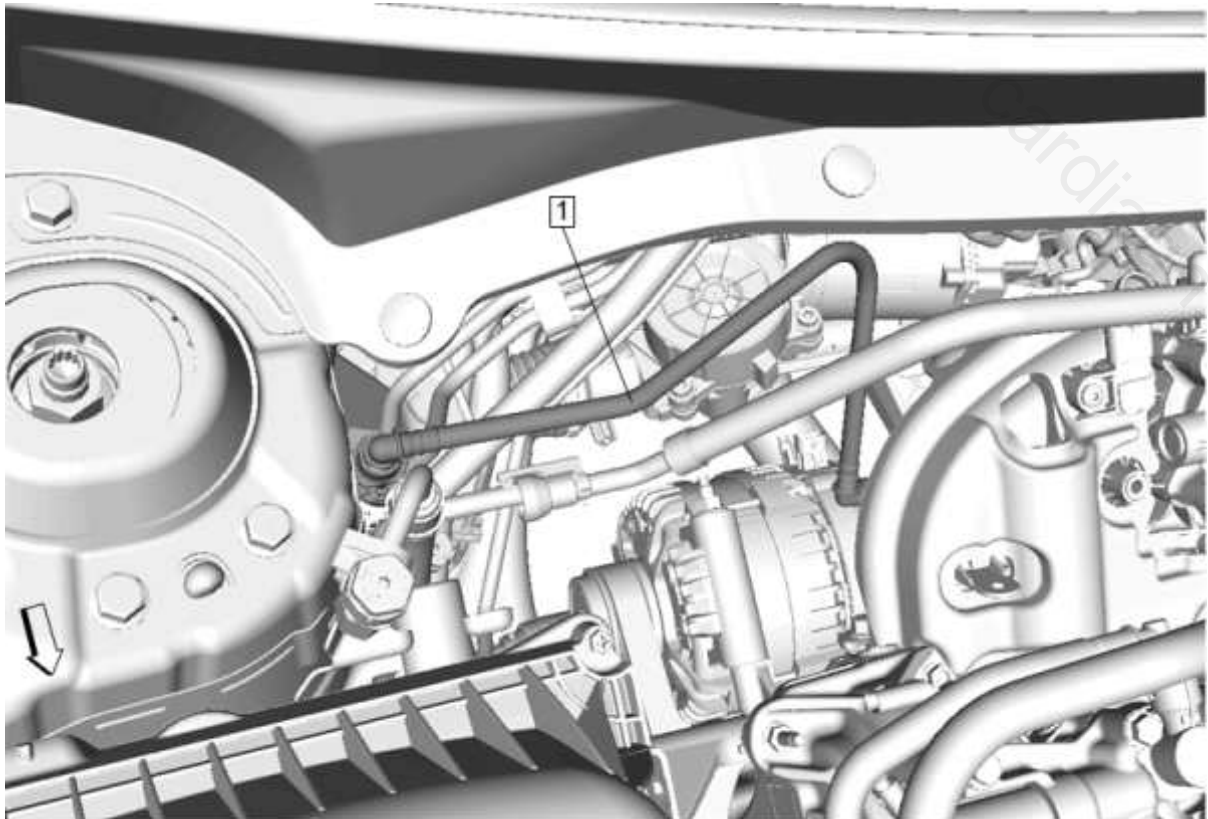


Fig. 305: Evaporative Emission Front Hose

Courtesy of GENERAL MOTORS COMPANY

25. Remove Evaporative Emission Front Hose - [Evaporative Emission Front Hose Replacement](#)
26. Position a suitable engine table or equivalent under the cradle to support the cradle and powertrain.

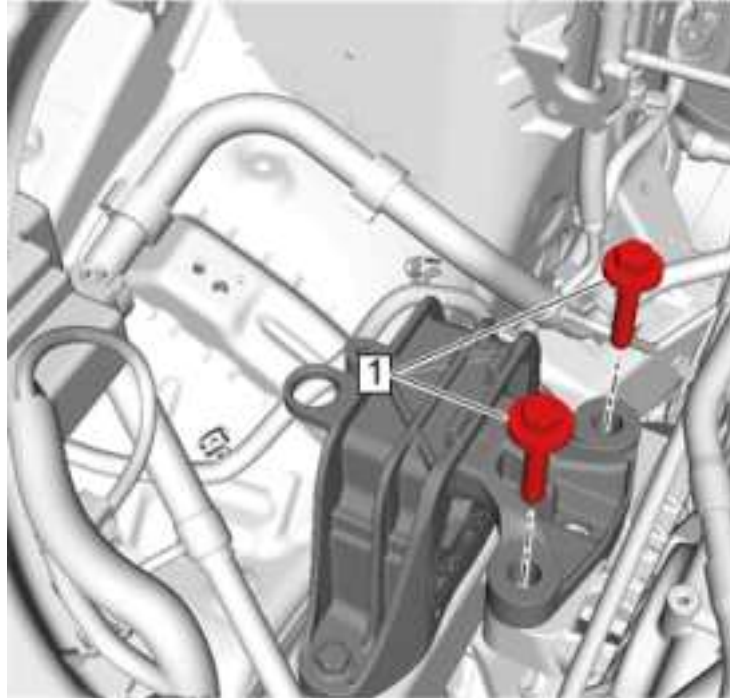


Fig. 306: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

27. Remove Engine Mount Fastener - and DISCARD - [Engine Mount Replacement](#)

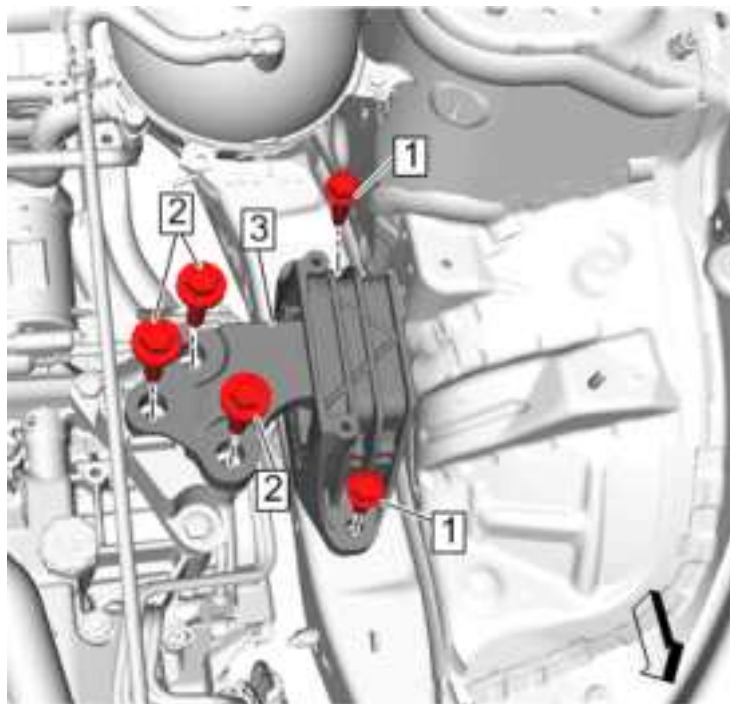


Fig. 307: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: ONLY the fasteners (2) should be removed and DISCARDED

28. Remove Transmission Mount Fastener (2) and DISCARD [3x] - [Transmission Mount Replacement - Left Side](#)

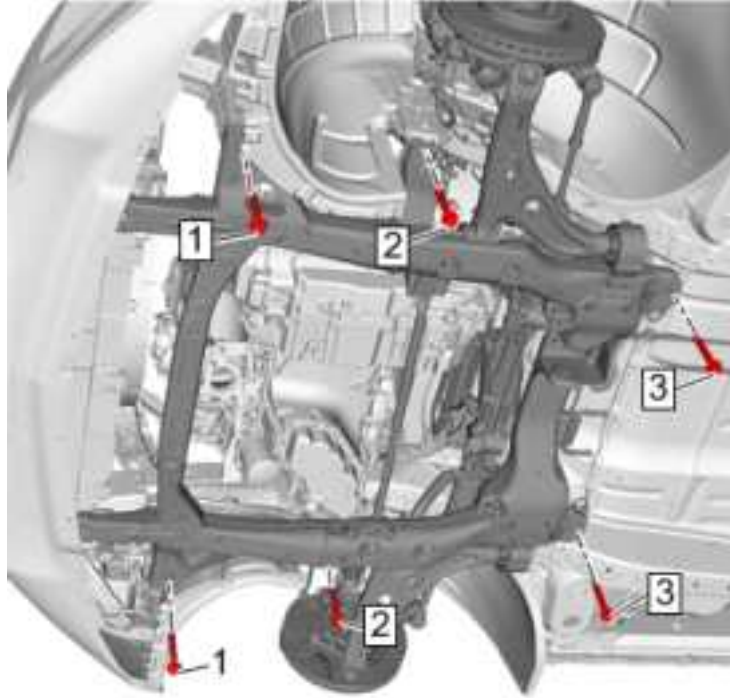


Fig. 308: Front Cradle Mounting Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Use a suitable device to hold the cradle while removing the fasteners.

NOTE: Remove **ONLY** the body to frame bolts as the powertrain will be removed while still bolted to the frame.

29. Remove bolts necessary to remove the cradle (1) (2) and (3). [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)
30. Disconnect electrical connections and reposition harnesses as needed.
31. Carefully lower the engine table and raise the body on the hoist until the engine/transaxle and frame are separated from the vehicle.
32. Separate the engine from the transmission. [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#) [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#)
33. Install the engine to a suitable engine stand.

Installation Procedure

1. Install the transmission to the engine. [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#) [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#)
2. Position the powertrain and support table under the vehicle.
3. Raise the powertrain into position under the vehicle.
4. With the table positioned, if required, lower the vehicle over the powertrain.

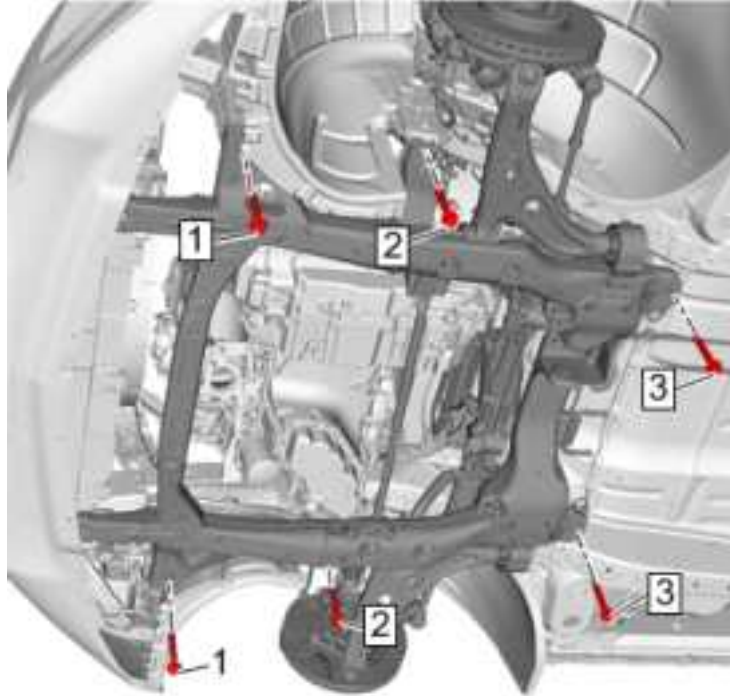


Fig. 309: Front Cradle Mounting Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the previously removed body to frame bolts to secure the frame and powertrain.

5. Install bolts (1) (2) and frame (3). [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)

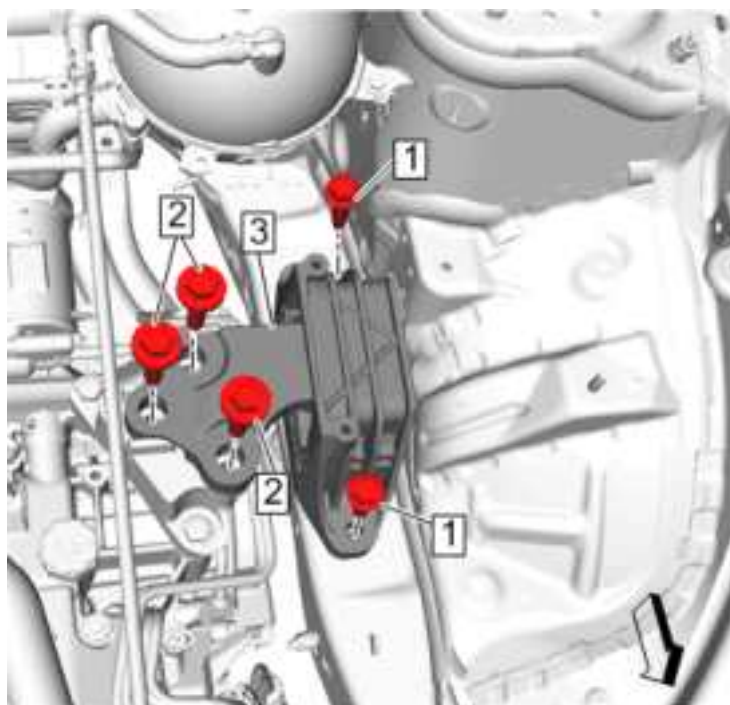


Fig. 310: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

6. Install Transmission Mount Fastener (2) - [3x] - [Transmission Mount Replacement - Left Side](#)

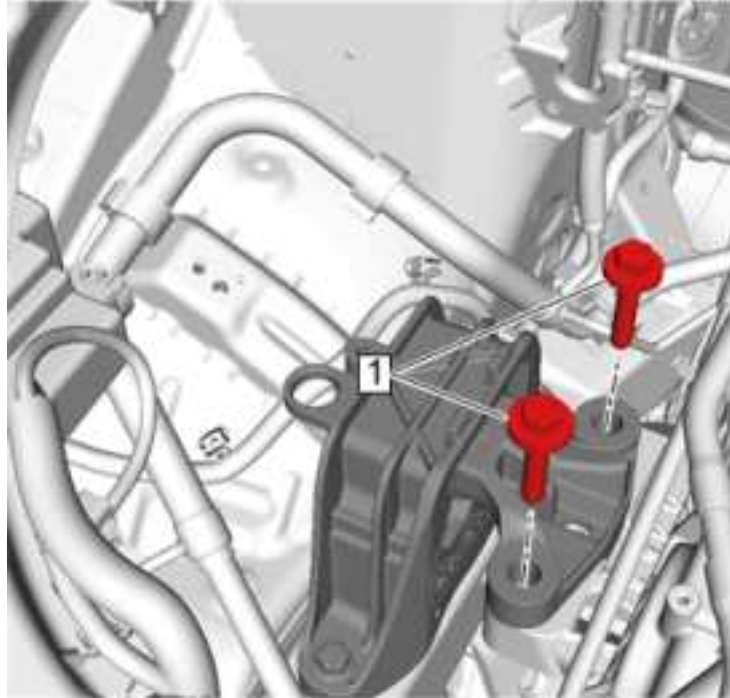


Fig. 311: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: ONLY the fasteners (1) should be removed and DISCARDED

7. Install NEW Engine Mount Fastener - [Engine Mount Replacement](#)
8. Remove the suitable engine table or equivalent from under the powertrain and cradle.
9. Install Front Wheel Drive Half Shaft-Left Side - [Front Wheel Drive Half Shaft Replacement - Left Side](#)
10. Install Front Wheel Drive Half Shaft-Right Side - [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG, MNH, MNK with FWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3D, M3H with FWD\)](#)
11. Install Propeller Shaft - [Two-Piece Propeller Shaft Replacement](#)

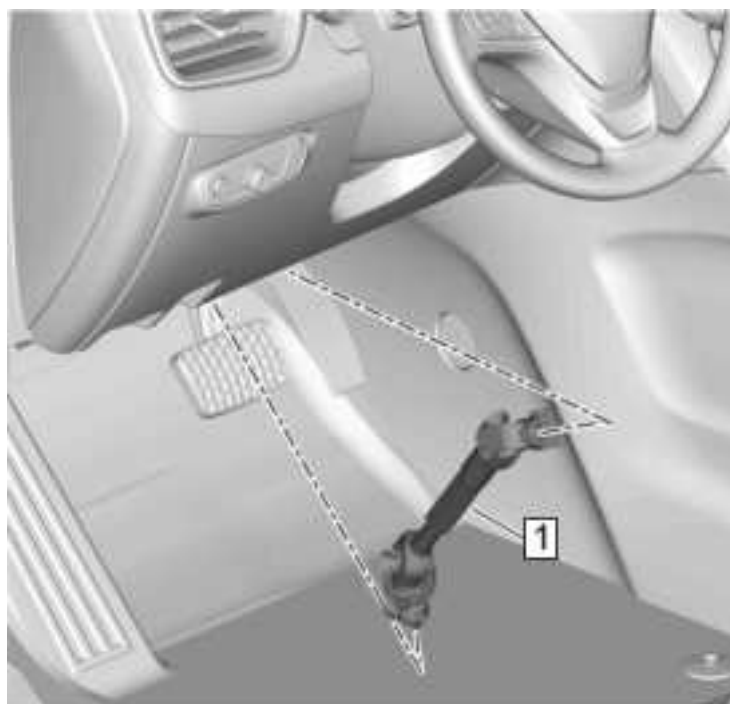


Fig. 312: Intermediate Steering Shaft

Courtesy of GENERAL MOTORS COMPANY

12. Connect Intermediate Steering Shaft@Steering Gear - [Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)

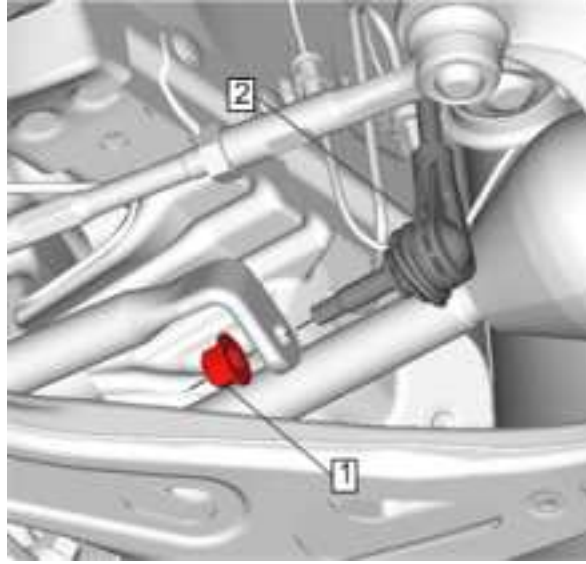


Fig. 313: Stabilizer Link Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

13. Connect the stabilizer links (2) and install nuts (1). [Stabilizer Shaft Link Replacement \(Equinox\)](#) [Stabilizer Shaft Link Replacement \(Terrain\)](#)

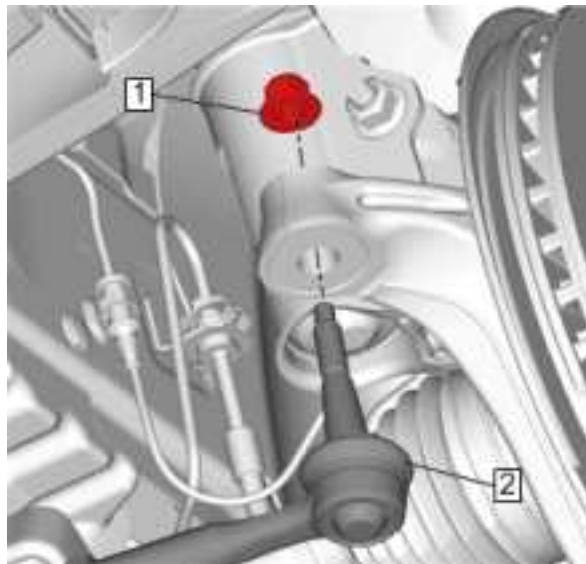


Fig. 314: Tie Rods And Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

14. Install the tie rod ends (2) then install nuts (1). [Steering Linkage Outer Tie Rod Replacement](#)

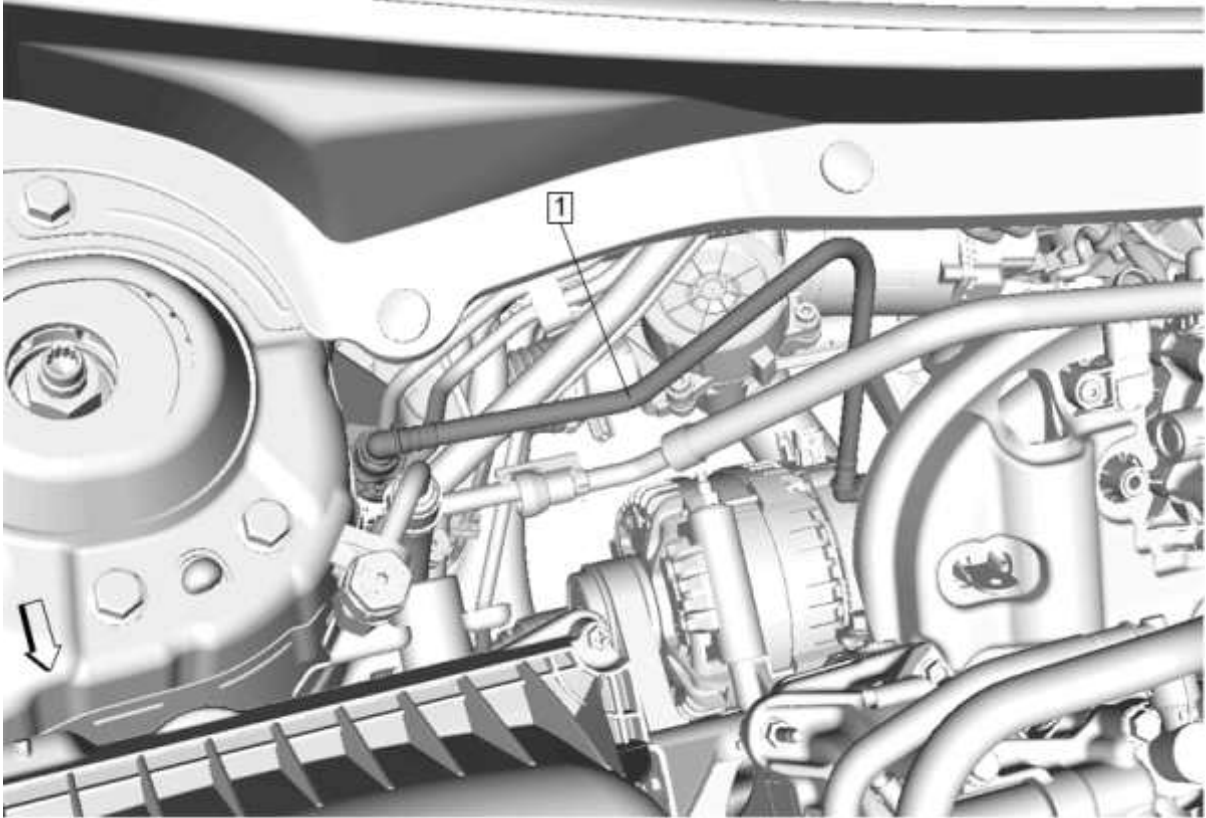


Fig. 315: Evaporative Emission Front Hose
 Courtesy of GENERAL MOTORS COMPANY

15. Install Evaporative Emission Front Hose - [Evaporative Emission Front Hose Replacement](#)

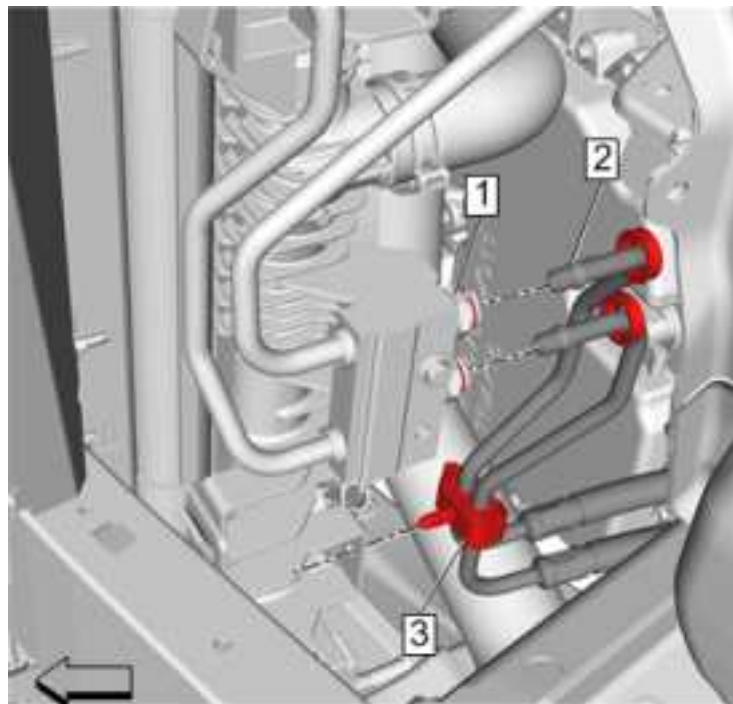


Fig. 316: Transmission Fluid Cooler Inlet and Outlet Pipe
 Courtesy of GENERAL MOTORS COMPANY

16. Connect Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator Assembly - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#) [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(M3D, M3H, M3U\)](#)
17. Connect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose@Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LYX\)](#)

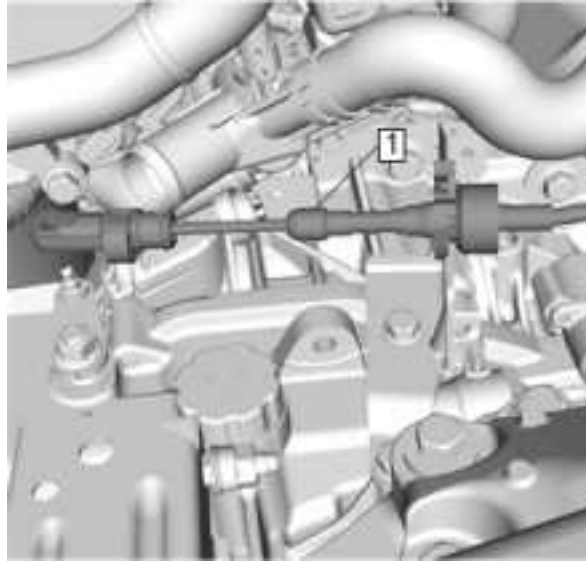


Fig. 317: Range Selector Lever Cable

Courtesy of GENERAL MOTORS COMPANY

18. Connect Range Selector Lever Cable@Transmission - [Range Selector Lever Cable Replacement](#)
19. Install Heater Inlet Hose - [Heater Inlet Hose Replacement \(LYX AWD without KL9\)](#), [Heater Inlet Hose Replacement \(LYX with KL9\)](#)
20. Install Heater Outlet Hose - [Heater Outlet Hose Replacement \(LYX without KL9\)](#)
21. Install Radiator Inlet Hose - [Radiator Inlet Hose Replacement \(LYX\)](#)
22. Install Radiator Outlet Hose - [Radiator Outlet Hose Replacement \(LYX\)](#)

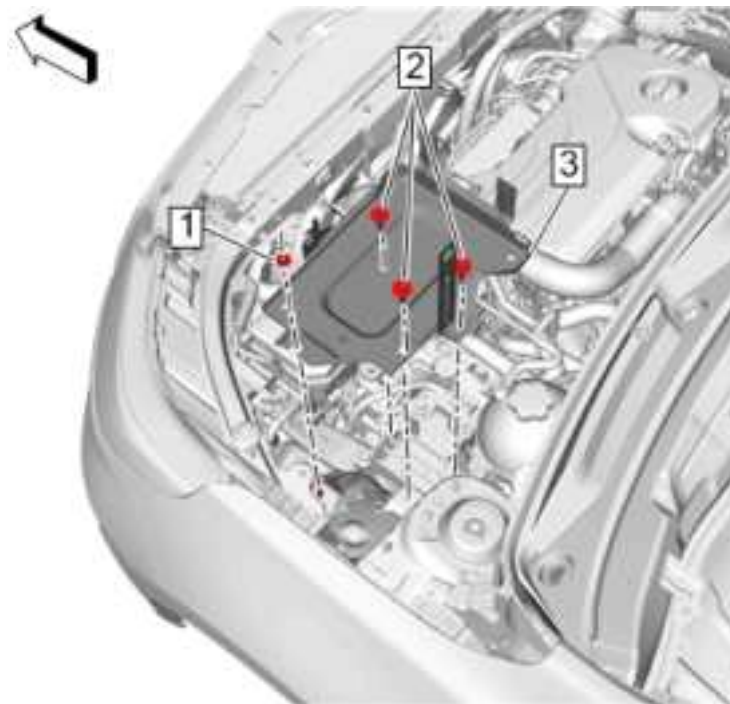


Fig. 318: Battery Tray

Courtesy of GENERAL MOTORS COMPANY

23. Install Battery Tray - [Battery Tray Replacement](#)

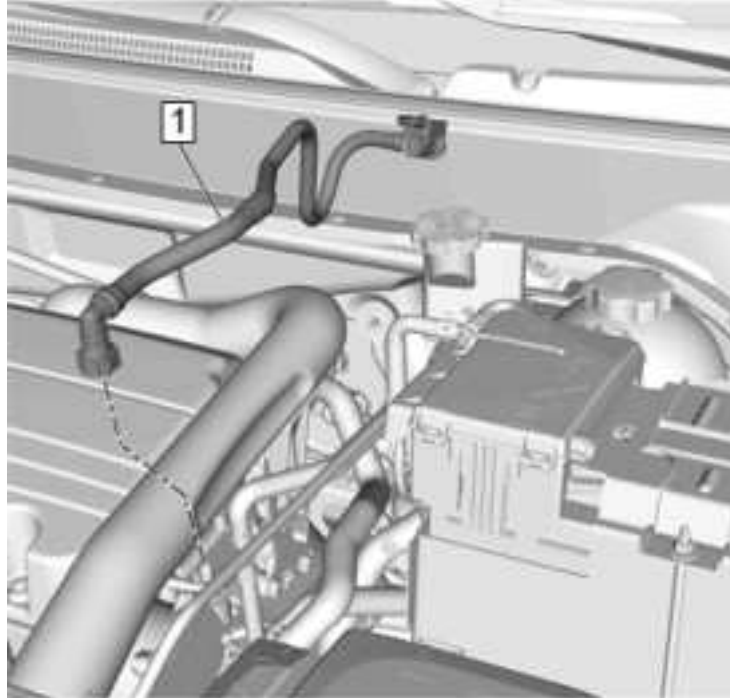


Fig. 319: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

- 24. Install Power Brake Booster Vacuum Pipe - [Power Brake Booster Vacuum Pipe Replacement \(LYX\)](#)
- 25. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

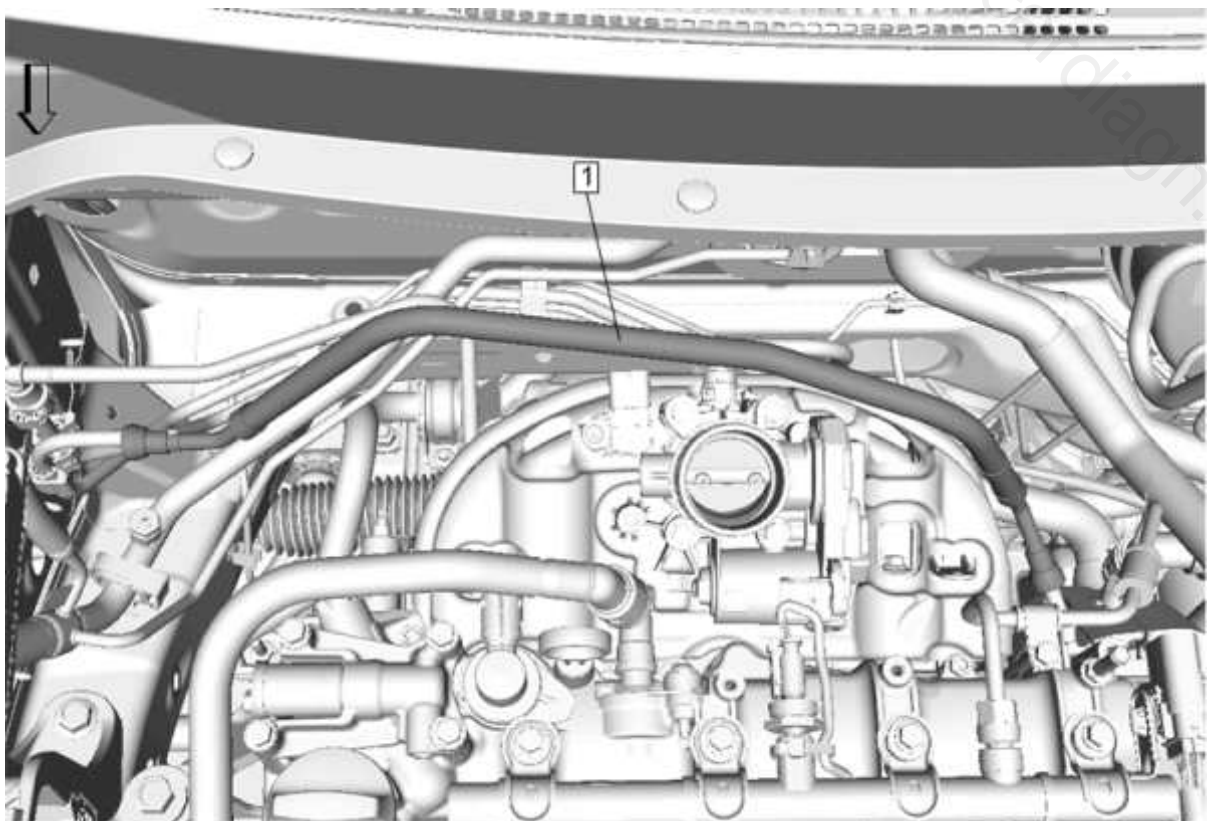


Fig. 320: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

- 26. Connect Fuel Feed Front Pipe @ Engine - [Fuel Feed Front Pipe Replacement](#)
- 27. Install Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)
- 28. Install Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)
- 29. Install Underbody Front Air Deflector - [Underbody Front Air Deflector Replacement \(Equinox\)](#) [Underbody Front Air Deflector Replacement \(Terrain\)](#)
- 30. Install Charge Air Cooler Inlet Air Tube - [Charge Air Cooler Inlet Air Tube Replacement](#)

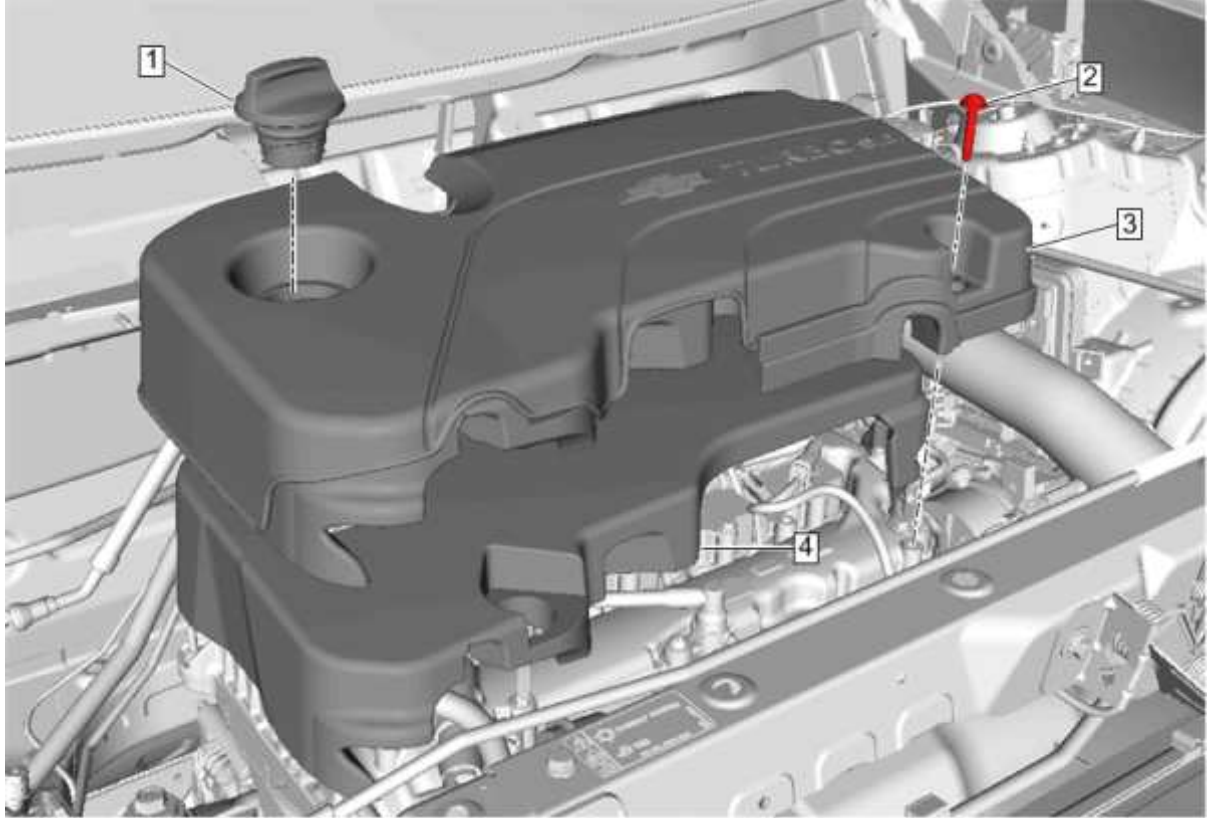


Fig. 321: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

31. Install Intake Manifold Cover - [Intake Manifold Cover Replacement](#)
32. Recharge the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\) Refrigerant Recovery and Recharging \(R-1234yf\)](#)
33. Fill the cooling system to the proper level. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)

NOTE: Prelube is necessary if the engine is replaced or overhauled.

34. If the engine is replaced with a new engine or has been overhauled, perform the engine prelubing procedure. [Engine Prelubing](#)
35. If the engine has not been replaced or overhauled, check and correct engine oil level as needed. [Engine Oil and Oil Filter Replacement](#)
36. Perform the crankshaft position variation learn. [Crankshaft Position Variation Learn](#)

ENGINE REPLACEMENT (FRONT WHEEL DRIVE)

Special Tools

- **BO-38185** Hose Clamp Pliers

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)

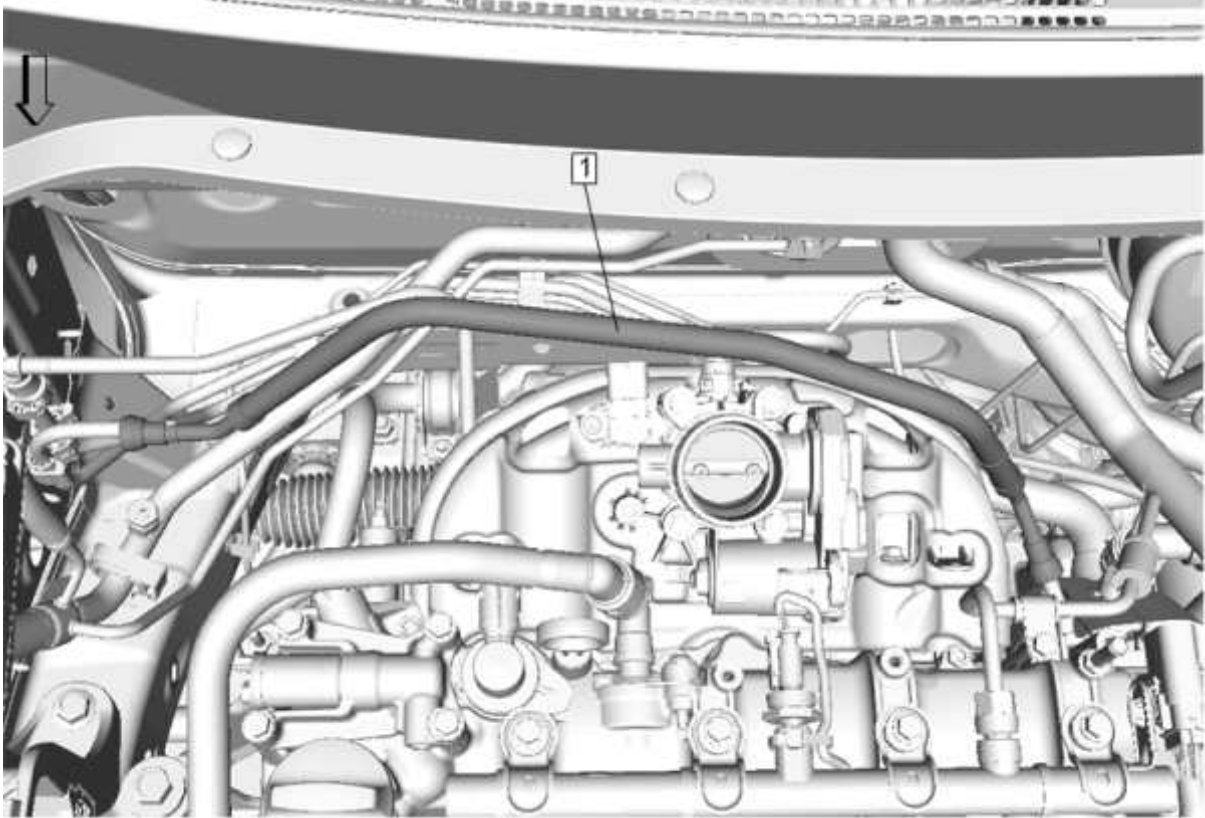


Fig. 322: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Fuel Feed Front Pipe (1) @ Engine - [Fuel Feed Front Pipe Replacement](#)
3. Recover the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\)](#) [Refrigerant Recovery and Recharging \(R-1234yf\)](#)

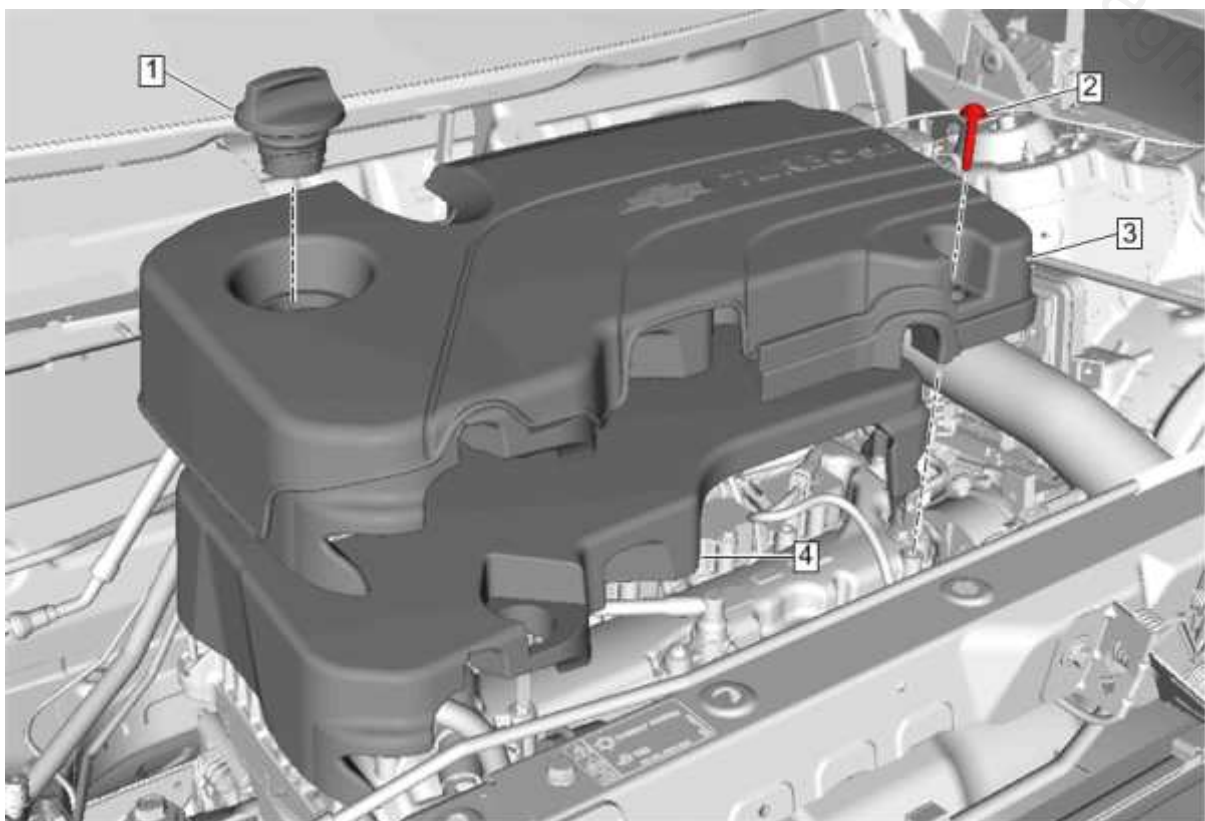


Fig. 323: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

4. Remove Intake Manifold Cover (3) [Intake Manifold Cover Replacement](#)
5. Remove Charge Air Cooler Inlet Air Tube - [Charge Air Cooler Inlet Air Tube Replacement](#)
6. Remove Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)
7. Remove Air Cleaner Assembly [Air Cleaner Assembly Replacement](#)

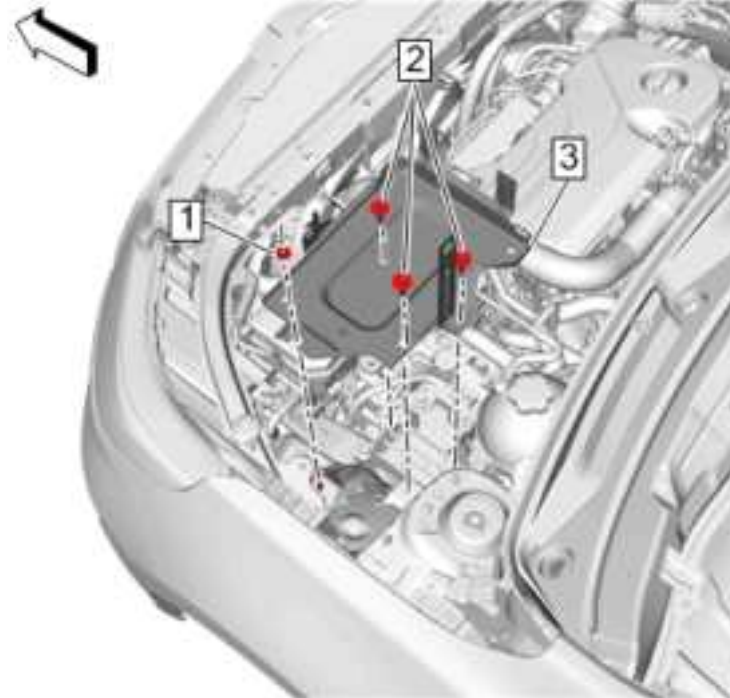


Fig. 324: Battery Tray

Courtesy of GENERAL MOTORS COMPANY

8. Remove Battery Tray (3) [Battery Tray Replacement](#)
9. Remove Radiator Inlet Hose - [Radiator Inlet Hose Replacement \(LYX\)](#)
10. Remove Radiator Outlet Hose - [Radiator Outlet Hose Replacement \(LYX\)](#)

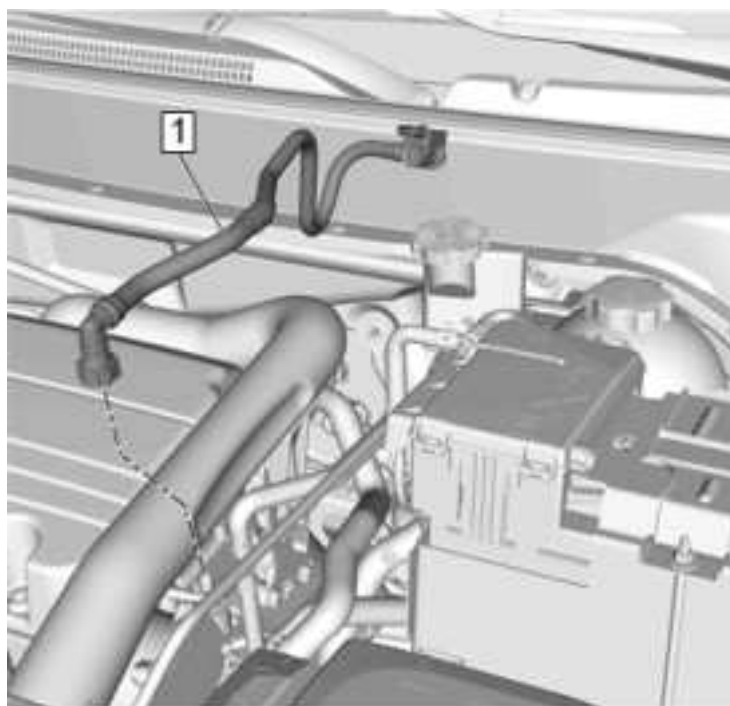


Fig. 325: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

11. Remove Power Brake Booster Vacuum Pipe (1) [Power Brake Booster Vacuum Pipe Replacement \(LYX\)](#)
12. Remove Heater Inlet Hose - [Heater Inlet Hose Replacement \(LYX AWD without KL9\)](#) [Heater Inlet Hose Replacement \(LYX with KL9\)](#) [Heater Inlet Hose Replacement \(LH7 Terrain\)](#) [Heater Inlet Hose Replacement \(LH7 Equinox\)](#) [Heater Inlet Hose Replacement \(LTG with KL9\)](#)
13. Remove Heater Outlet Hose - [Heater Outlet Hose Replacement \(LYX without KL9\)](#) [Heater Outlet Hose Replacement \(LH7\)](#)

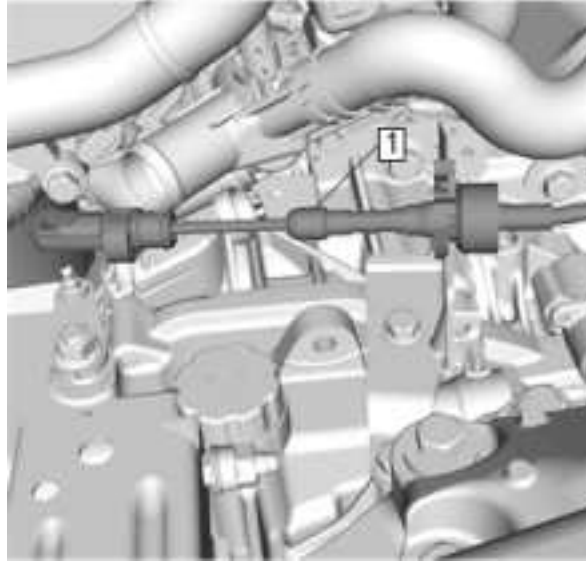


Fig. 326: Range Selector Lever Cable

Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Range Selector Lever Cable (1) @Transmission - [Range Selector Lever Cable Replacement](#)
15. Remove Underbody Front Air Deflector - [Underbody Front Air Deflector Replacement \(Equinox\)](#) [Underbody Front Air Deflector Replacement \(Terrain\)](#)
16. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)
17. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose@Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LYX\)](#)

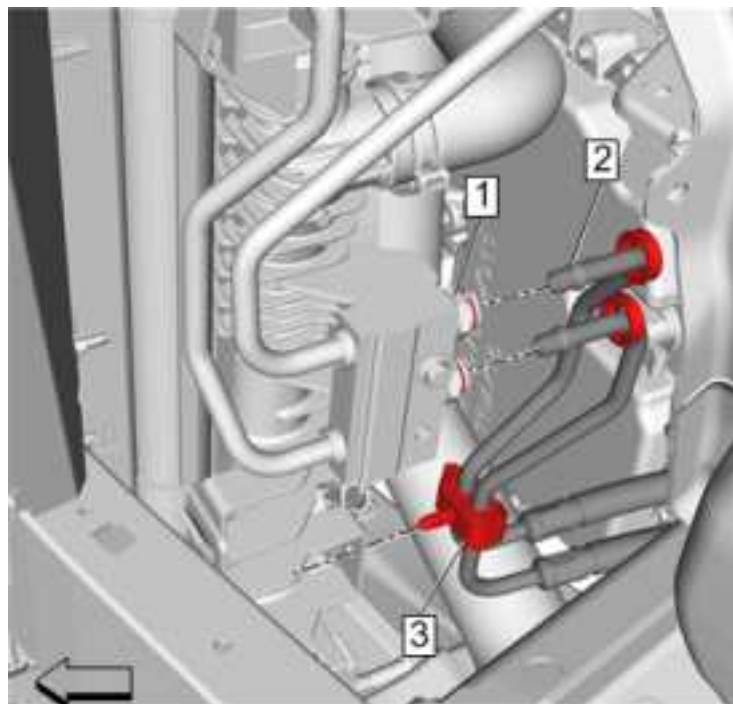


Fig. 327: Transmission Fluid Cooler Inlet and Outlet Pipe

Courtesy of GENERAL MOTORS COMPANY

18. Disconnect Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator Assembly - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#) [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(M3D, M3H, M3U\)](#)
19. Disconnect electrical connections and reposition harnesses as needed.
20. Remove Front Wheel Drive Half Shaft-Left Side - [Front Wheel Drive Half Shaft Replacement - Left Side](#)
21. Remove Front Wheel Drive Half Shaft-Right Side - [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG\)](#)

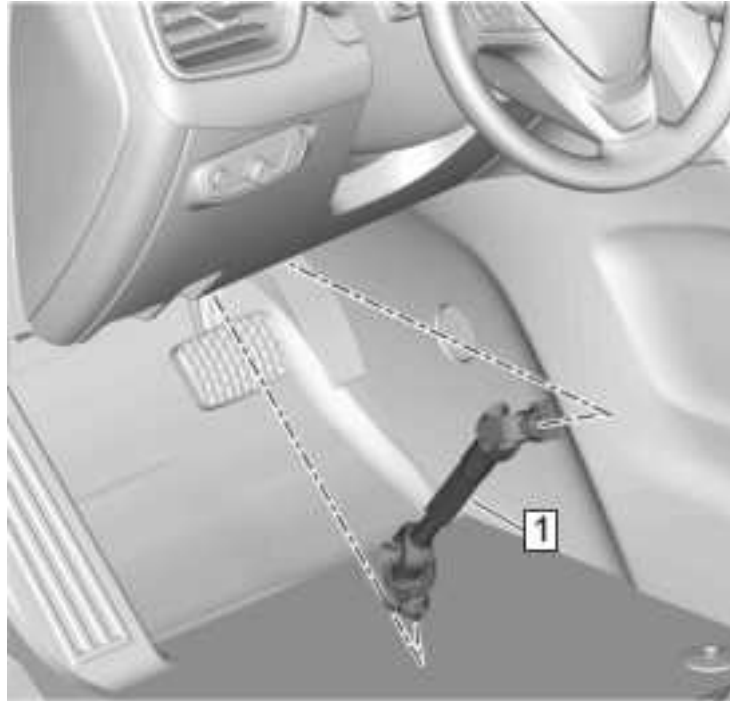


Fig. 328: Intermediate Steering Shaft
Courtesy of GENERAL MOTORS COMPANY

22. Remove Intermediate Steering Shaft (1) [Intermediate Steering Shaft Replacement \(Equinox\)](#), [Intermediate Steering Shaft Replacement \(Terrain\)](#).

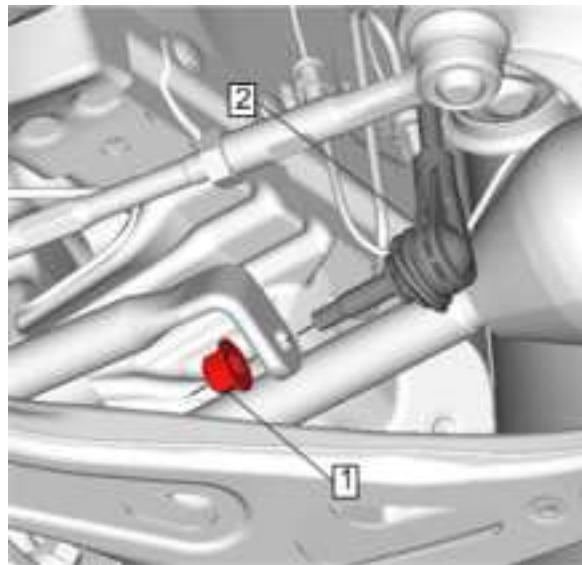


Fig. 329: Stabilizer Link Nuts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

23. Remove left and right side the stabilizer link nuts (1) then disconnect the links at the stabilizer. [Stabilizer Shaft Link Replacement \(Equinox\)](#), [Stabilizer Shaft Link Replacement \(Terrain\)](#).

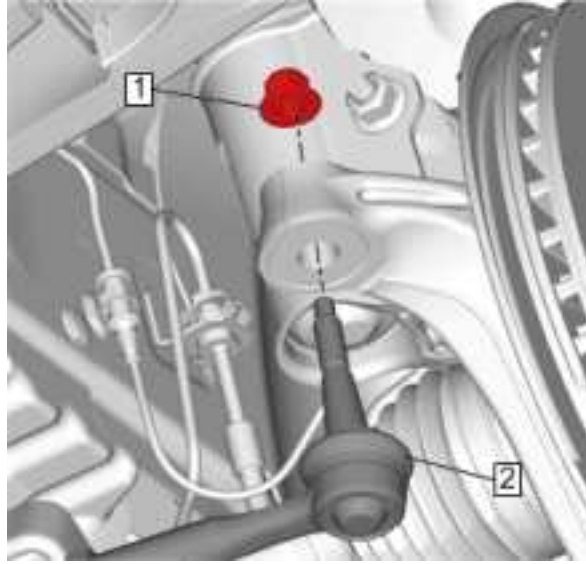


Fig. 330: Tie Rods And Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

24. Remove the left and right side tie rod nuts (1), then disconnect the tie rods (2) from the steering knuckles. [Steering Linkage Outer Tie Rod Replacement](#)

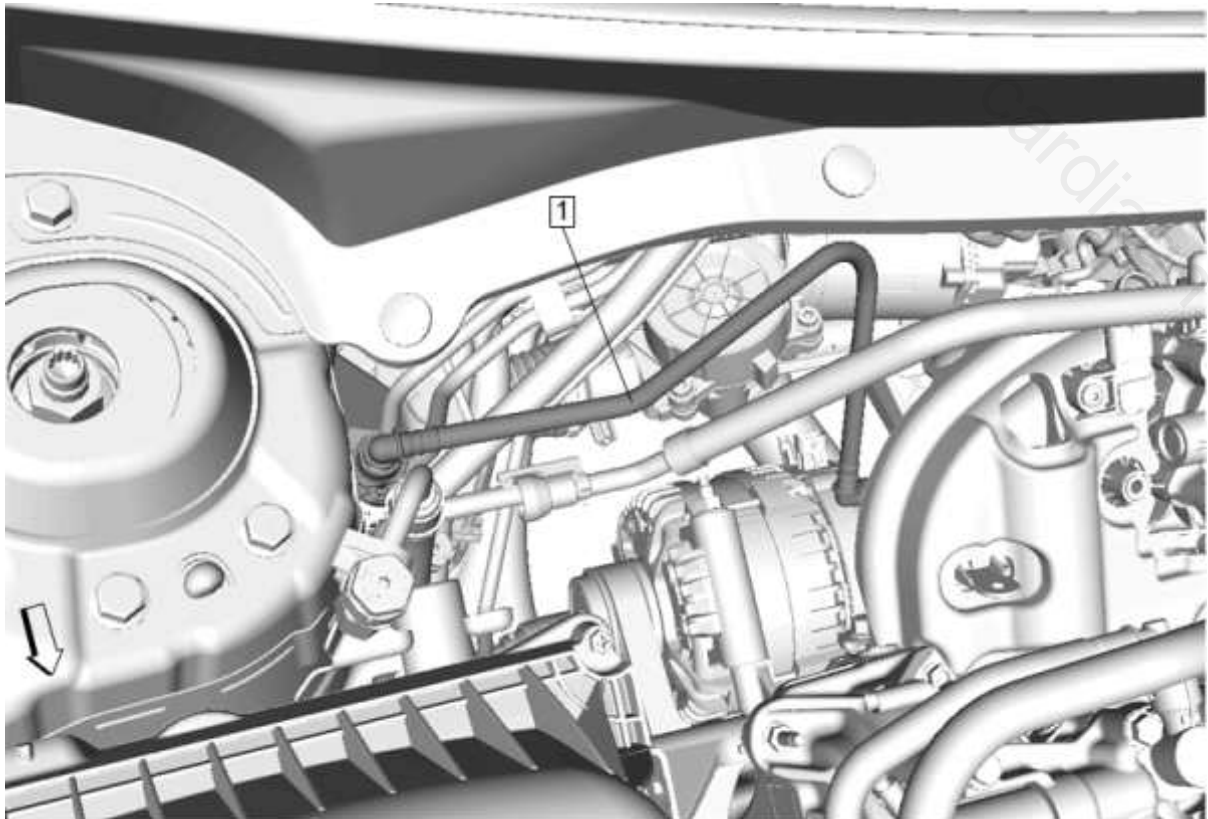


Fig. 331: Evaporative Emission Front Hose

Courtesy of GENERAL MOTORS COMPANY

25. Remove Evaporative Emission Front Hose (1) [Evaporative Emission Front Hose Replacement](#)
26. Position a suitable engine table or equivalent under the cradle to support the cradle and powertrain.

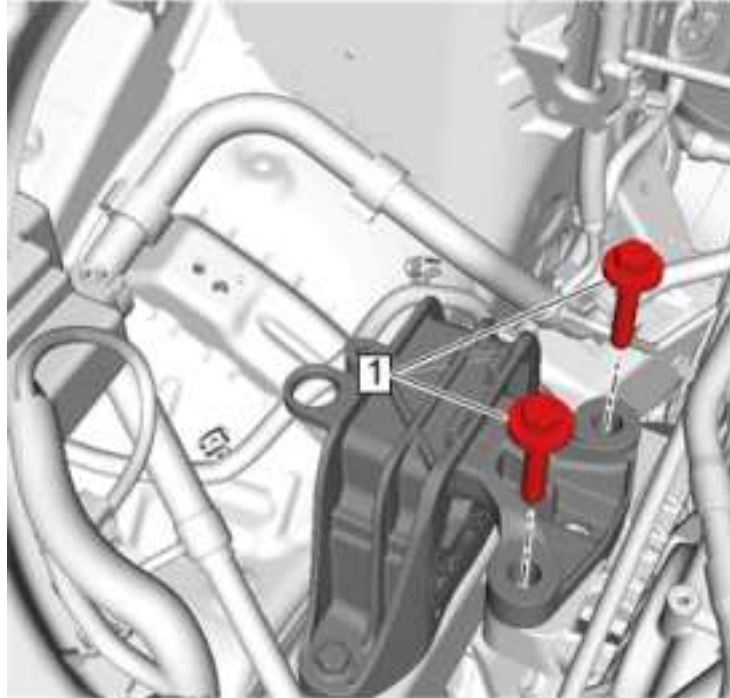


Fig. 332: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

27. Remove Engine Mount Fastener (1) and DISCARD - [Engine Mount Replacement](#)

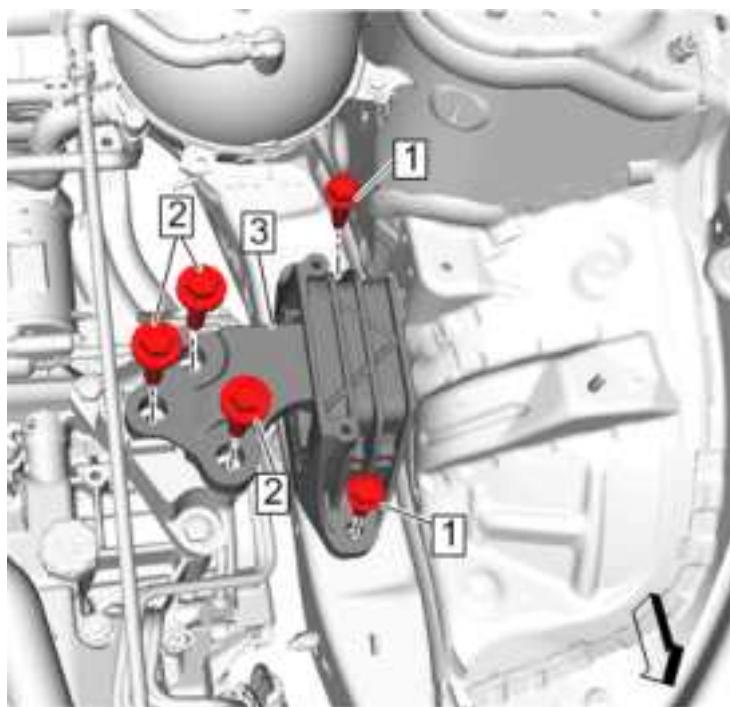


Fig. 333: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

NOTE: ONLY the fasteners (2) should be removed and DISCARDED

28. Remove Transmission Mount Fastener (2) and DISCARD - [Transmission Mount Replacement - Left Side](#)

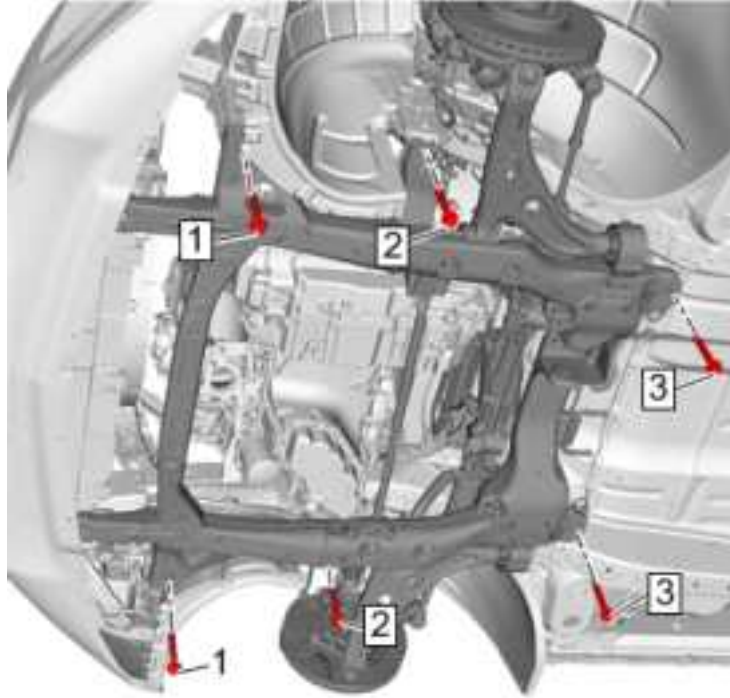


Fig. 334: Front Cradle Mounting Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Use a suitable device to hold the cradle while removing the fasteners.

NOTE: Remove **ONLY** the body to frame bolts as the powertrain will be removed while still bolted to the frame.

29. Remove bolts necessary to remove the cradle (1) (2) and (3). [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)
30. Carefully lower the engine table and raise the body on the hoist until the engine/transaxle and frame are separated from the vehicle.
31. Separate the engine from the transmission. [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#) [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#)
32. Install the engine to a suitable engine stand.
33. Transfer components as necessary.

Installation Procedure

1. Install the transmission to the engine. [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#) [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#)
2. Position the powertrain and support table under the vehicle.
3. Raise the powertrain into position under the vehicle.
4. With the table positioned, if required, lower the vehicle over the powertrain.

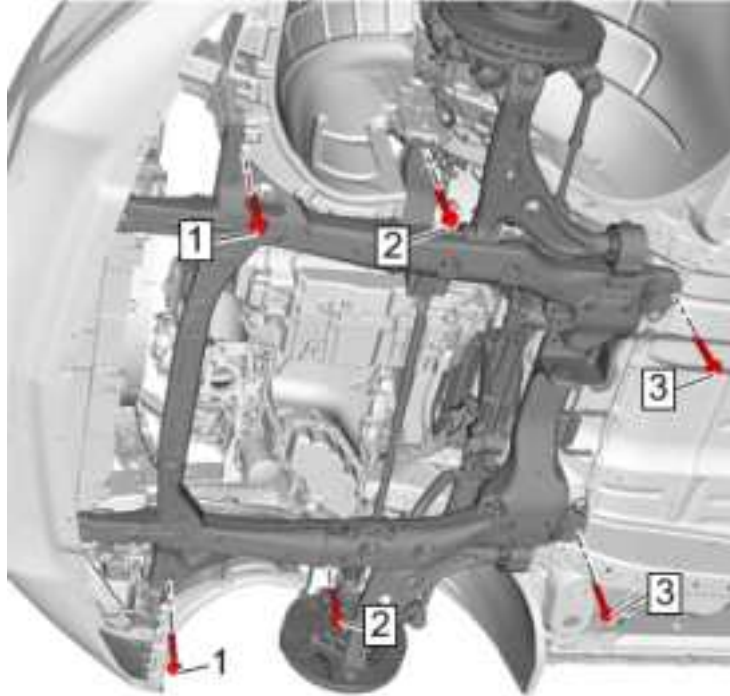


Fig. 335: Front Cradle Mounting Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the previously removed body to frame bolts to secure the frame and powertrain.

5. Install bolts (1) (2) and frame (3). [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)

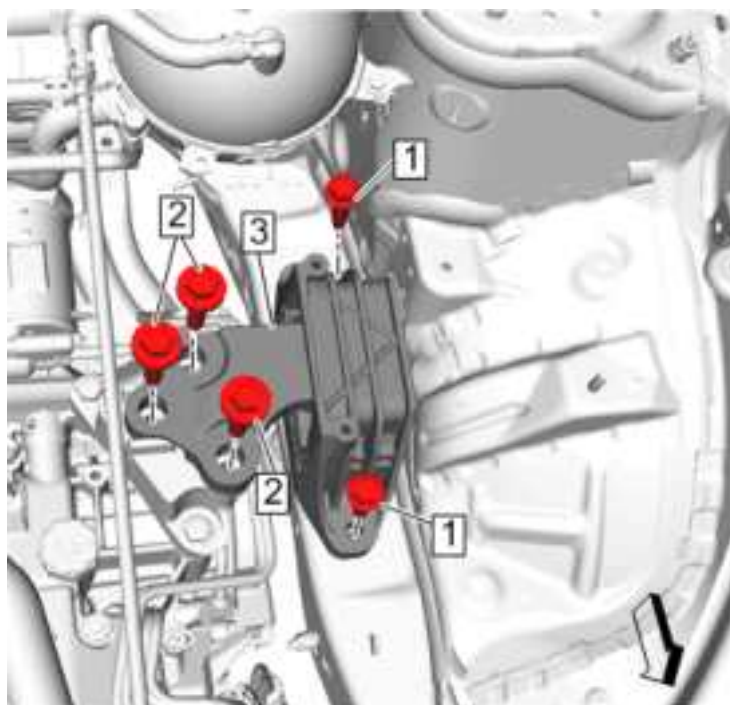


Fig. 336: Transmission Mount Bolts And Fastener

Courtesy of GENERAL MOTORS COMPANY

6. Install Transmission Mount Fastener [Transmission Mount Replacement - Left Side](#)

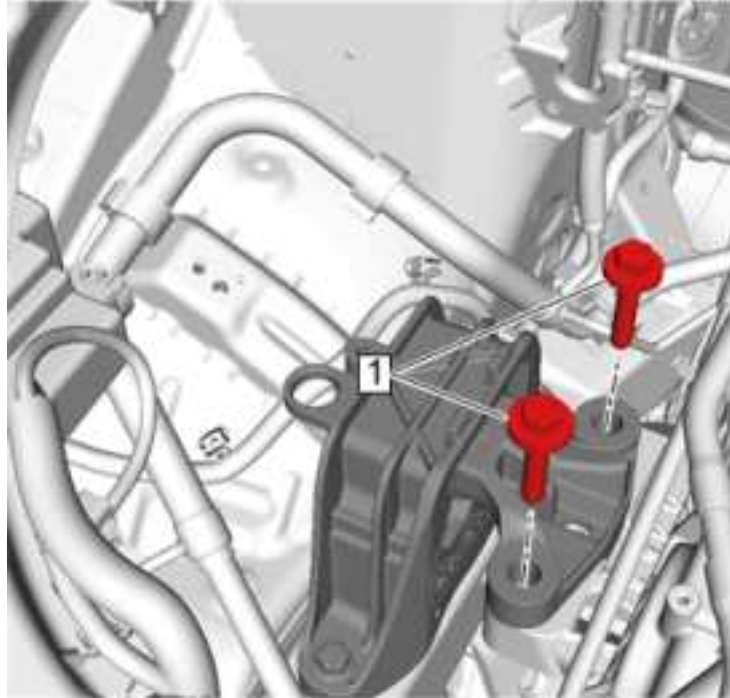


Fig. 337: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Install Engine Mount Fastener - [Engine Mount Replacement](#)
8. Remove the suitable engine table or equivalent from under the powertrain and cradle.
9. Reconnect electrical connections and reposition harnesses as needed.
10. Install Front Wheel Drive Half Shaft-Left Side - [Front Wheel Drive Half Shaft Replacement - Left Side](#)
11. Install Front Wheel Drive Half Shaft-Right Side - [Front Wheel Drive Half Shaft Replacement - Right Side \(AWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3U, MHG, MNH, MNK with FWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3D, M3H with FWD\)](#)

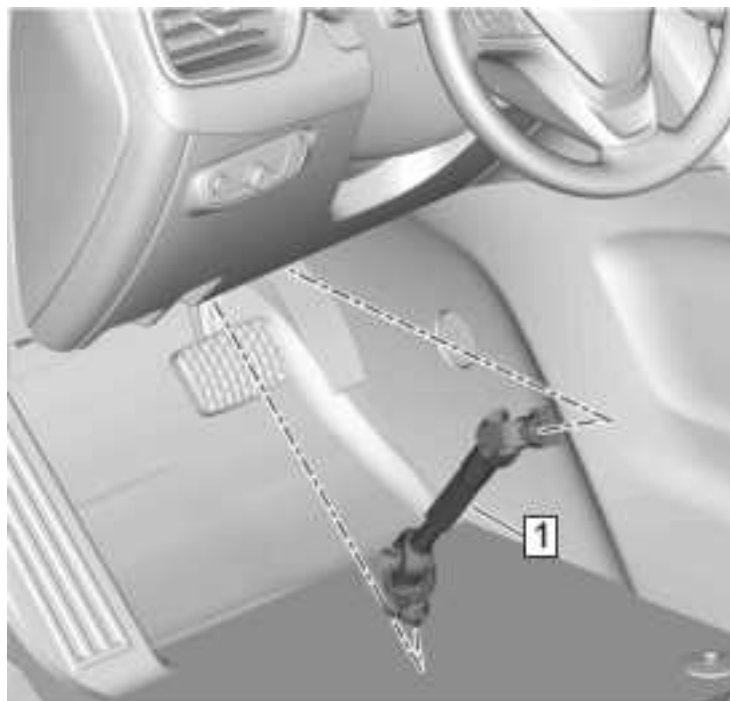


Fig. 338: Intermediate Steering Shaft

Courtesy of GENERAL MOTORS COMPANY

12. Install Intermediate Steering Shaft - [Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)

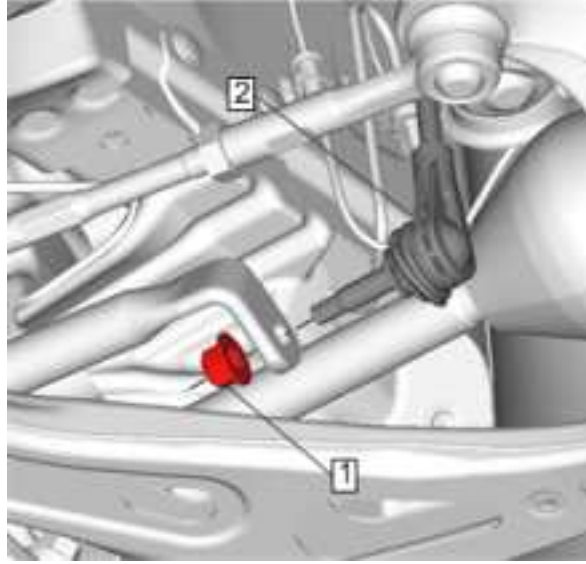


Fig. 339: Stabilizer Link Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

13. Connect the stabilizer links (2) and install nuts (1). [Stabilizer Shaft Link Replacement \(Equinox\)](#) [Stabilizer Shaft Link Replacement \(Terrain\)](#)

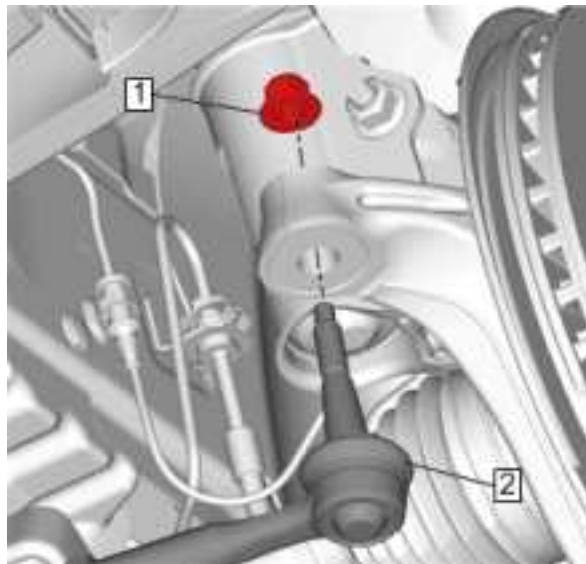


Fig. 340: Tie Rods And Nuts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Right side shown, left side is similar.

14. Install the tie rod ends (2) then install nuts (1). [Steering Linkage Outer Tie Rod Replacement](#)

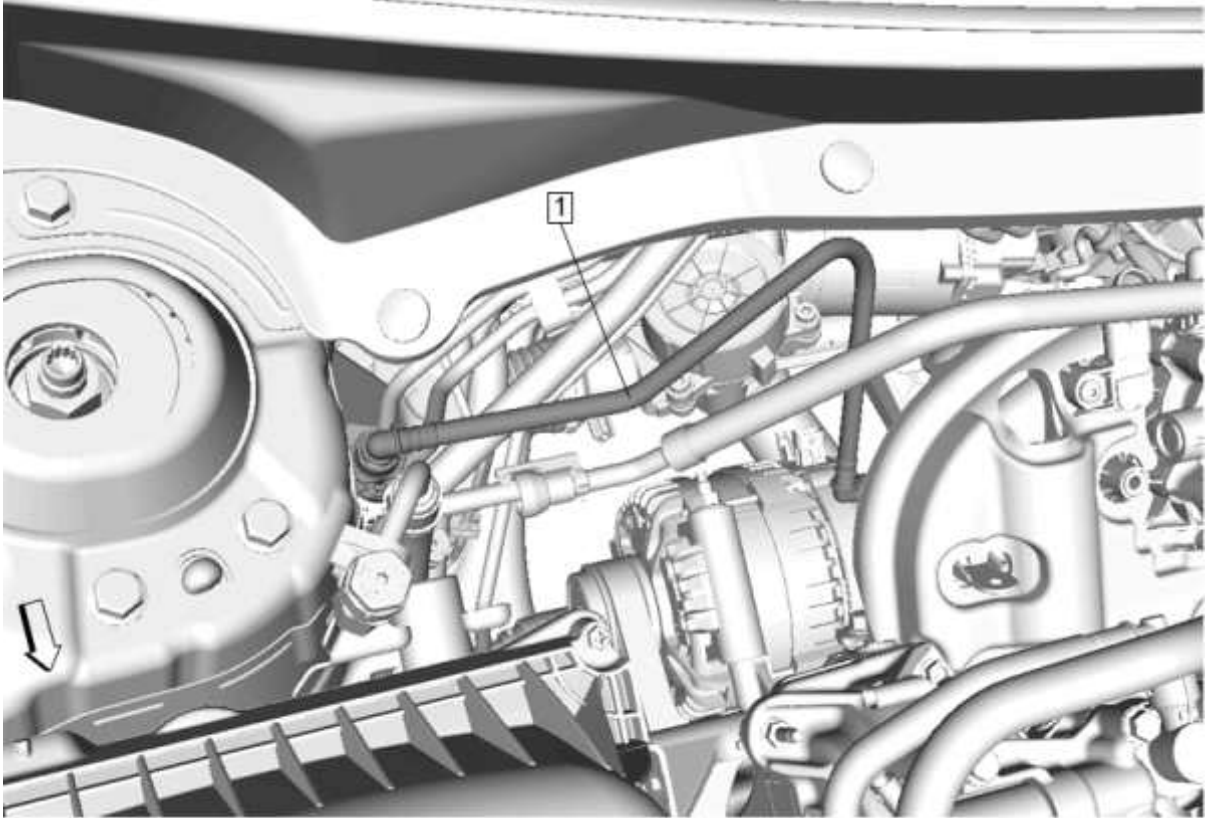


Fig. 341: Evaporative Emission Front Hose
 Courtesy of GENERAL MOTORS COMPANY

15. Install Evaporative Emission Front Hose - [Evaporative Emission Front Hose Replacement](#)

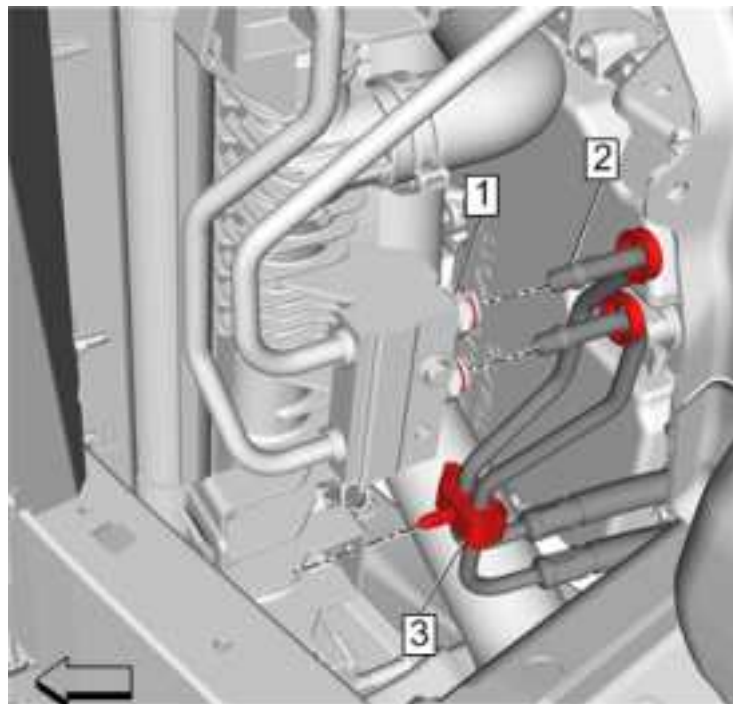


Fig. 342: Transmission Fluid Cooler Inlet and Outlet Pipe
 Courtesy of GENERAL MOTORS COMPANY

16. Connect Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator Assembly - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(MNH, MHG\)](#) [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(M3D, M3H, M3U\)](#)
17. Connect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose@Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LYX\)](#)

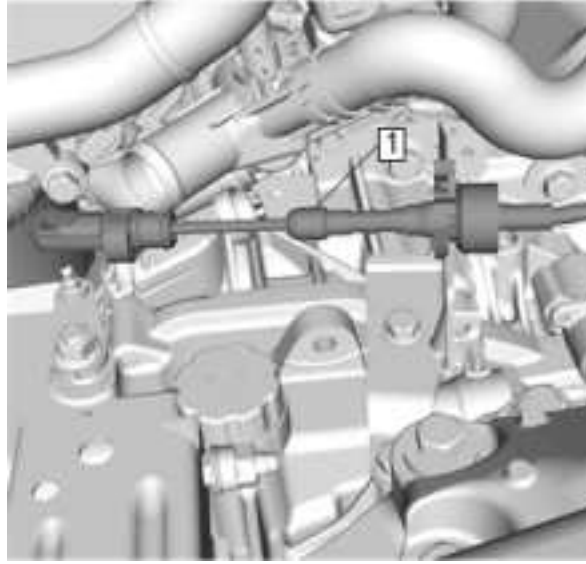


Fig. 343: Range Selector Lever Cable

Courtesy of GENERAL MOTORS COMPANY

18. Connect Range Selector Lever Cable@Transmission - [Range Selector Lever Cable Replacement](#)
19. Install Heater Inlet Hose - [Heater Inlet Hose Replacement \(LYX AWD without KL9\)](#), [Heater Inlet Hose Replacement \(LYX with KL9\)](#)
20. Install Heater Outlet Hose - [Heater Outlet Hose Replacement \(LYX without KL9\)](#)
21. Install Radiator Inlet Hose - [Radiator Inlet Hose Replacement \(LYX\)](#)
22. Install Radiator Outlet Hose - [Radiator Outlet Hose Replacement \(LYX\)](#)

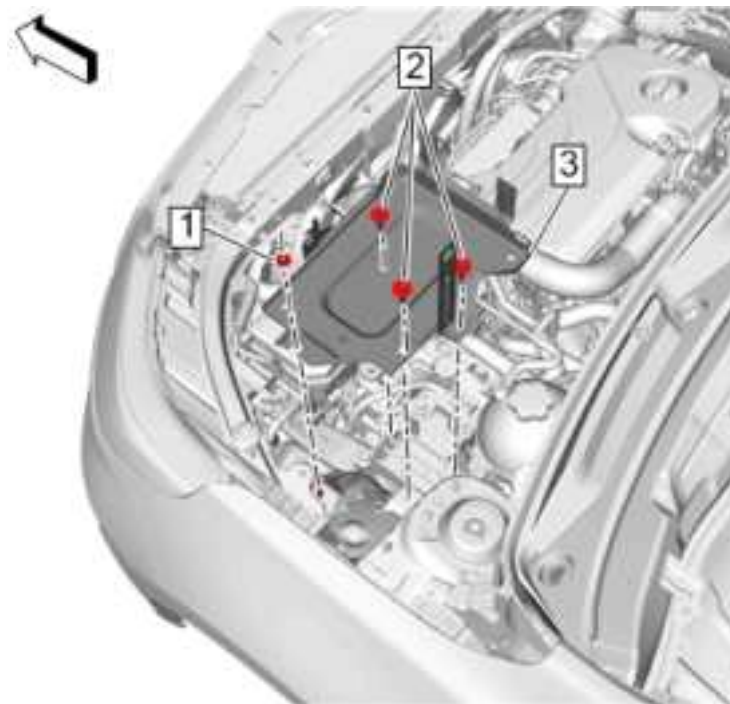


Fig. 344: Battery Tray

Courtesy of GENERAL MOTORS COMPANY

23. Install Battery Tray - [Battery Tray Replacement](#)

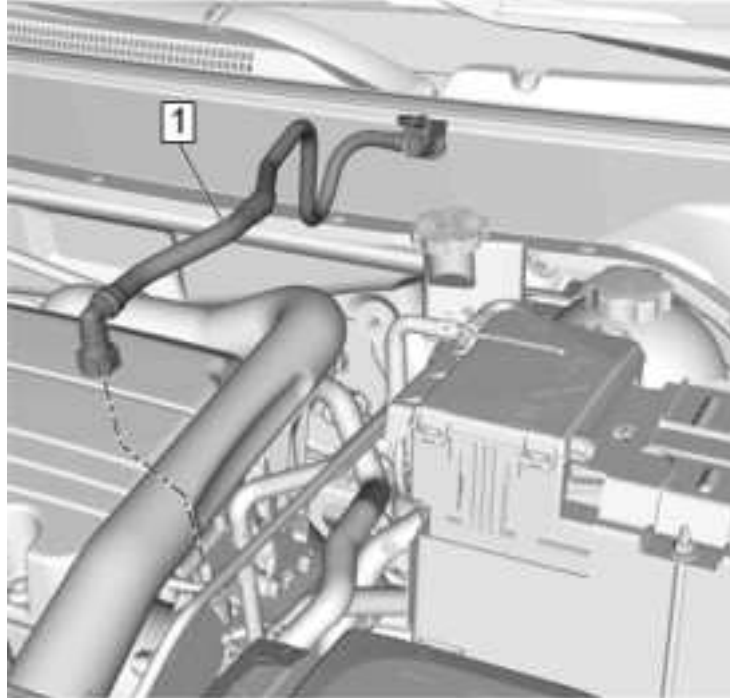


Fig. 345: Power Brake Booster Vacuum Pipe

Courtesy of GENERAL MOTORS COMPANY

- 24. Install Power Brake Booster Vacuum Pipe - [Power Brake Booster Vacuum Pipe Replacement \(LYX\)](#)
- 25. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

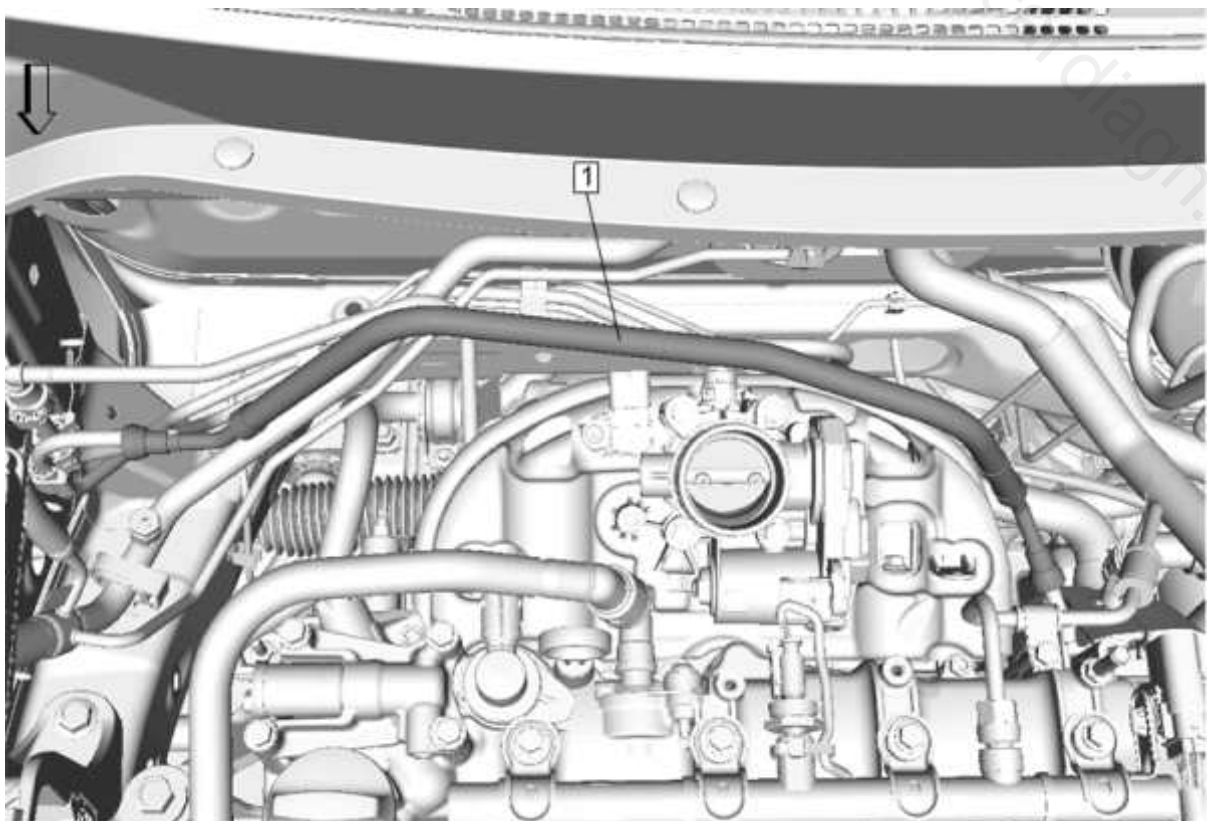


Fig. 346: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

- 26. Connect Fuel Feed Front Pipe @ Engine - [Fuel Feed Front Pipe Replacement](#)
- 27. Install Charge Air Cooler Outlet Air Tube - [Charge Air Cooler Outlet Air Tube Replacement](#)
- 28. Install Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LYX\)](#)
- 29. Install Underbody Front Air Deflector - [Underbody Front Air Deflector Replacement \(Equinox\)](#) [Underbody Front Air Deflector Replacement \(Terrain\)](#)
- 30. Install Charge Air Cooler Inlet Air Tube - [Charge Air Cooler Inlet Air Tube Replacement](#)

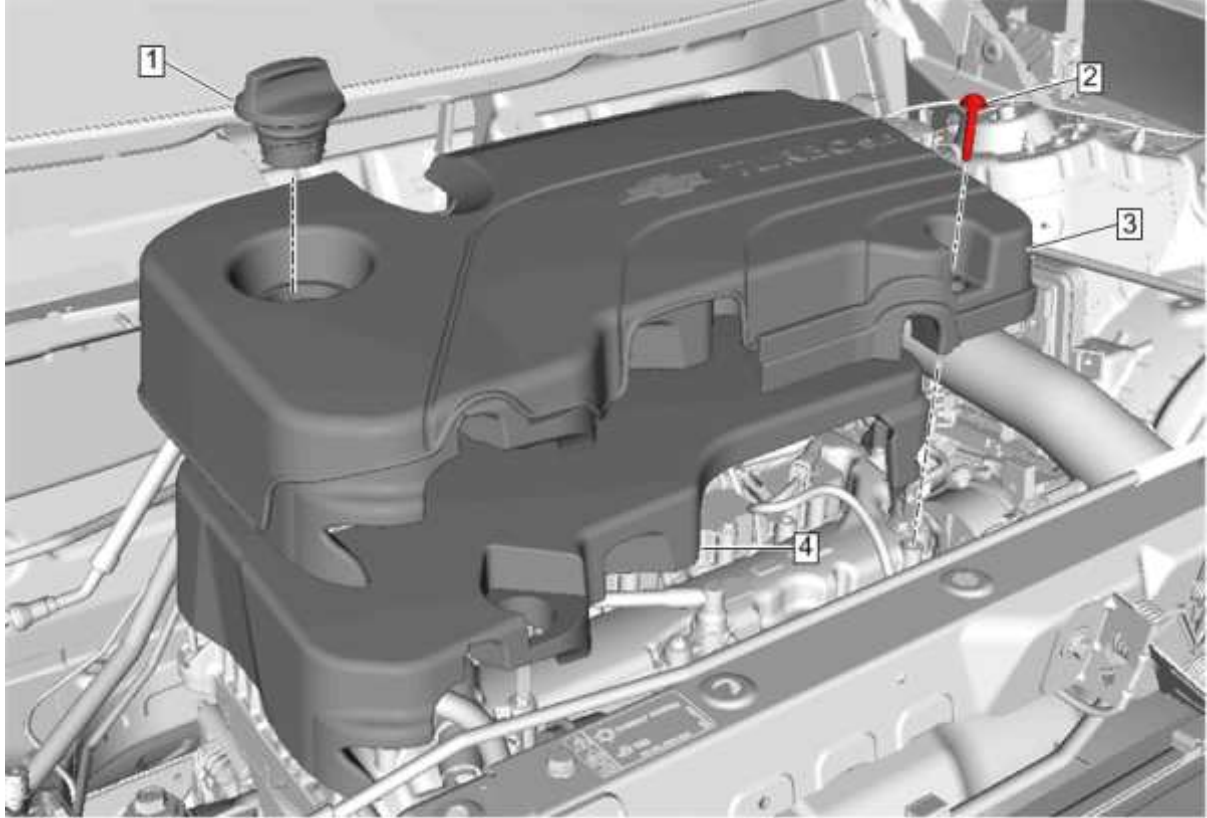


Fig. 347: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

31. Install Intake Manifold Cover - [Intake Manifold Cover Replacement](#)
32. Recharge the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\)](#) [Refrigerant Recovery and Recharging \(R-1234yf\)](#)
33. Fill the cooling system to the proper level. [Cooling System Draining and Filling \(GE 47716\)](#) [Cooling System Draining and Filling \(Static\)](#)

NOTE: Prelube is necessary if the engine is replaced or overhauled.

34. If the engine is replaced with a new engine or has been overhauled, perform the engine prelubing procedure. [Engine Prelubing](#)
35. If the engine has not been replaced or overhauled, check and correct engine oil level as needed. [Engine Oil and Oil Filter Replacement](#)
36. Perform the crankshaft position variation learn. [Crankshaft Position Variation Learn](#)

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Special Tools

- EN-45059 Angle Meter
- EN-51760 Flywheel Holding Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove Transmission - [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#) [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#) [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#)
2. Install the EN-51760 Holding Tool.

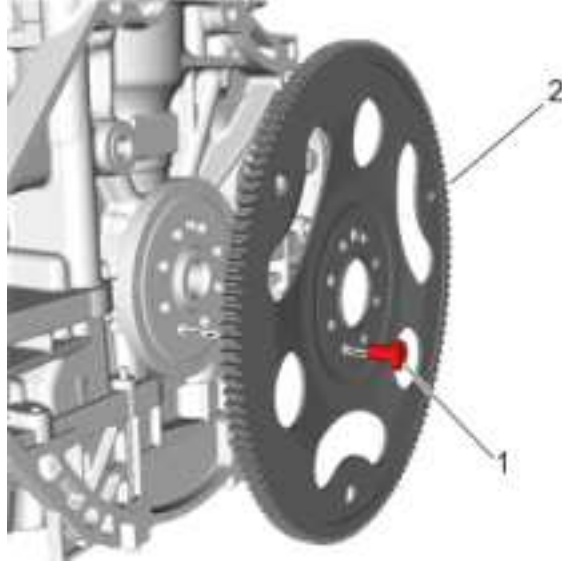


Fig. 348: Automatic Transmission Flex Plate Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove Automatic Transmission Flex Plate Bolt (1) and DISCARD
4. Remove Automatic Transmission Flex Plate (2)

Installation Procedure

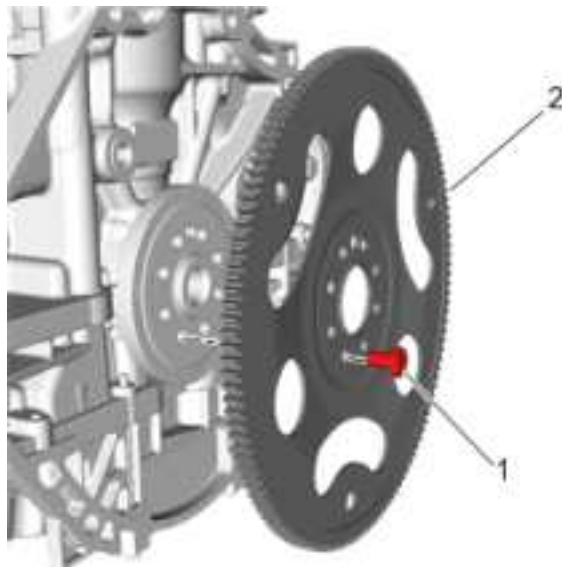


Fig. 349: Automatic Transmission Flex Plate Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Flywheel (2)

NOTE: Install NEW bolts.

NOTE: Bolts have adhesive patch and must be tightened to final torque within 5 minutes.

2. Loosely install Automatic Transmission Flex Plate Bolt (1)

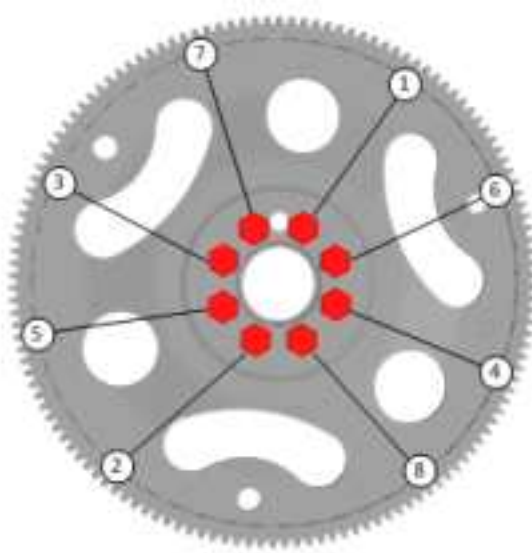


Fig. 350: Flywheel Bolts

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to [Fastener Caution](#) .

CAUTION: Refer to [Torque-to-Yield Fastener Caution](#) .

3. Tighten the flywheel bolts in the sequence shown.

Tighten

1. First Pass:20 N.m (15 lb ft)
2. Second Pass:30 N.m (22 lb ft)
3. Final Pass:70 degrees, using the **EN-45059** angle meter
4. Remove the **EN-51760** Holding tool.
5. Install Transmission - [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#). [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#). [Transmission Replacement \(All Wheel Drive with Diesel Engine, Equinox\)](#). [Transmission Replacement \(Front Wheel Drive with Diesel Engine\)](#). [Transmission Replacement \(All Wheel Drive with Diesel Engine, Terrain\)](#).

ENGINE SUPPORT FIXTURE

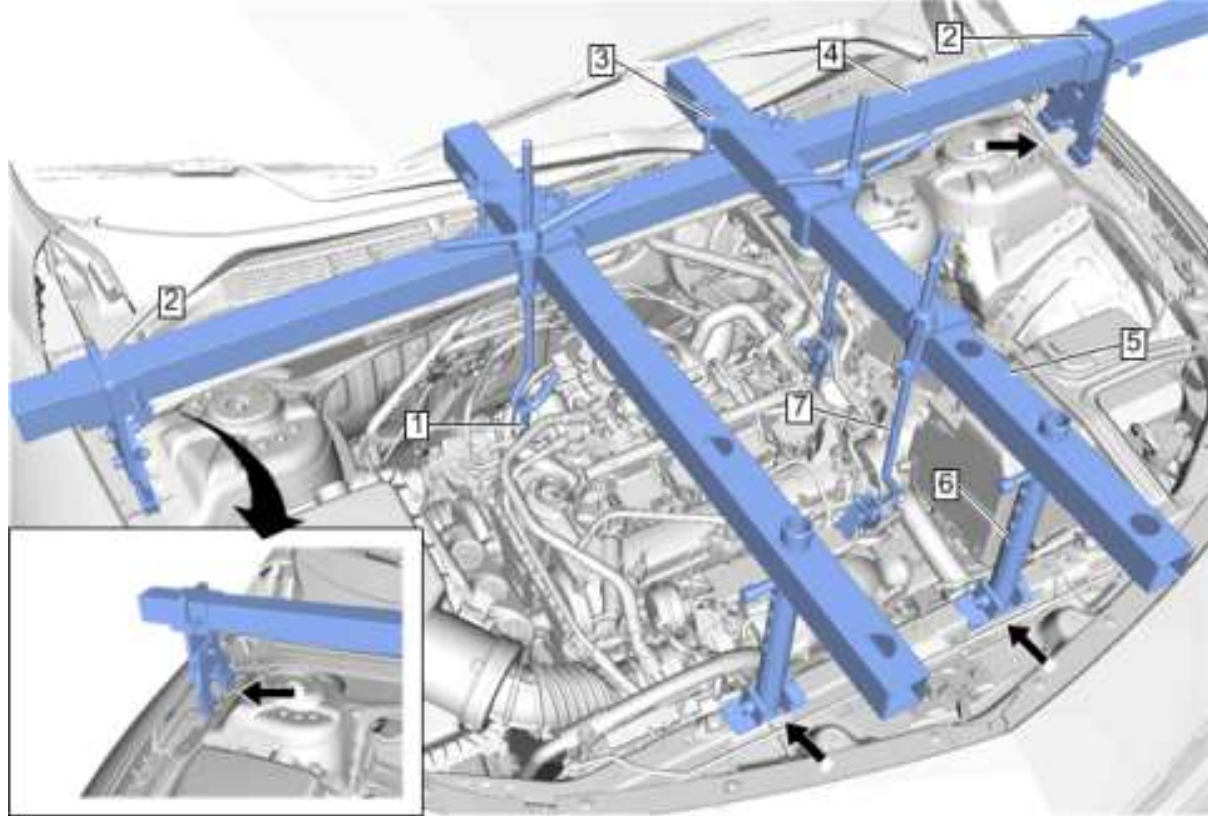


Fig. 351: Engine Support Fixture

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Intake Manifold Cover Replacement Charge Air Cooler Outlet Air Tube Replacement	
Special Tools - EN-51007-1 Main Support Beam - EN-51007-3 Radiator Support Beam - EN-51007-4 Clamp - EN-51007-5 Support Leg, Front - EN-51007-6 Hook - EN-51007-7 Support Leg, Side - EN-36857 Engine Lift Bracket	
Equivalent regional tools: Special Tools (Diagnostic Tools) Special Tools (Mechanical Tools) .	
1	EN-36857 Engine Lift Bracket Procedure NOTE: The engine support fixture and lift brackets can be repositioned to either lift bracket to lift in desired lift points. If engine lift brackets are not present, install EN-36857 engine lift brackets as needed.

Callout	Component Name
2	EN-51007-7 Support Leg, Side Procedure NOTE: Ensure that the engine support fixture only contacts the frame in the area indicated by arrows. Do not install on top of fender lip. Install the EN-51007-7 Support Leg, Side to frame as shown.
3	EN-51007-4 Clamp
4	EN-51007-1 Main Support Beam
5	Z EN-51007-3 Radiator Support Beam
6	EN-51007-5 Support Leg, Front
7	EN-51007-6 Hook

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

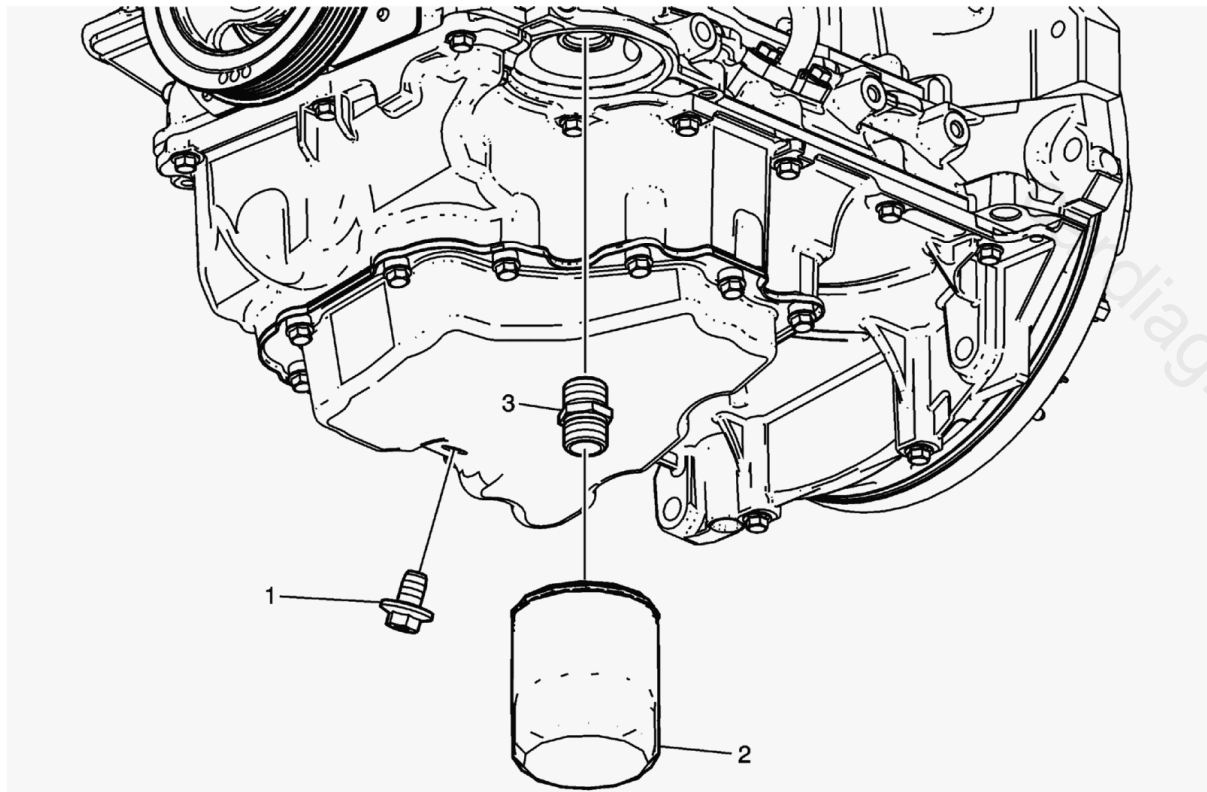


Fig. 352: Draining Fluids and Oil Filter

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Drain Plug CAUTION: Refer to <u>Fastener Caution</u> . NOTE: Place a drip pan underneath. Allow the oil to drain completely.
2	Oil Filter Special Tools EN-726-A Oil Filter Wrench For equivalent regional tools, refer to <u>Special Tools</u> .

Callout	Component Name
3	Oil Filter Fitting

CRANKSHAFT BALANCER REMOVAL

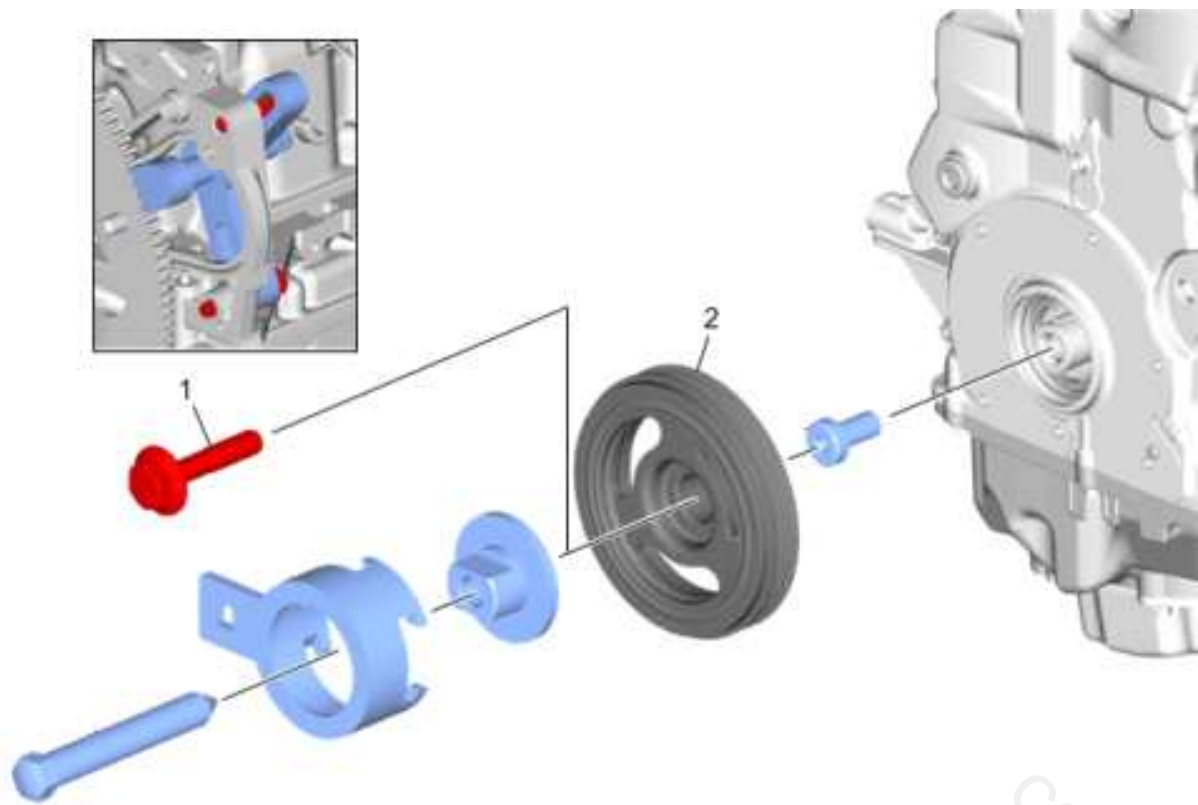


Fig. 353: Crankshaft Balancer
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Install the EN-51760 holder, lock the automatic transmission flex plate via the starter ring gear.	
Special Tools EN-51760 Flywheel HolderFor equivalent regional tools, refer to Special Tools .	
1	Crankshaft Balancer Bolt
2	Crankshaft Balancer Procedure 1. Install the EN-44226-5 protector onto the crankshaft. 2. Install EN-44226-1 holding body and EN-44226-2 remover plate with remover bolt onto the balancer. 3. Counter hold the EN-44226-2 remover plate and turn the remover screw to remove the balancer. Special Tools • EN-44226 Crankshaft Balancer Remover • EN-44226-5 Crankshaft Protector

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

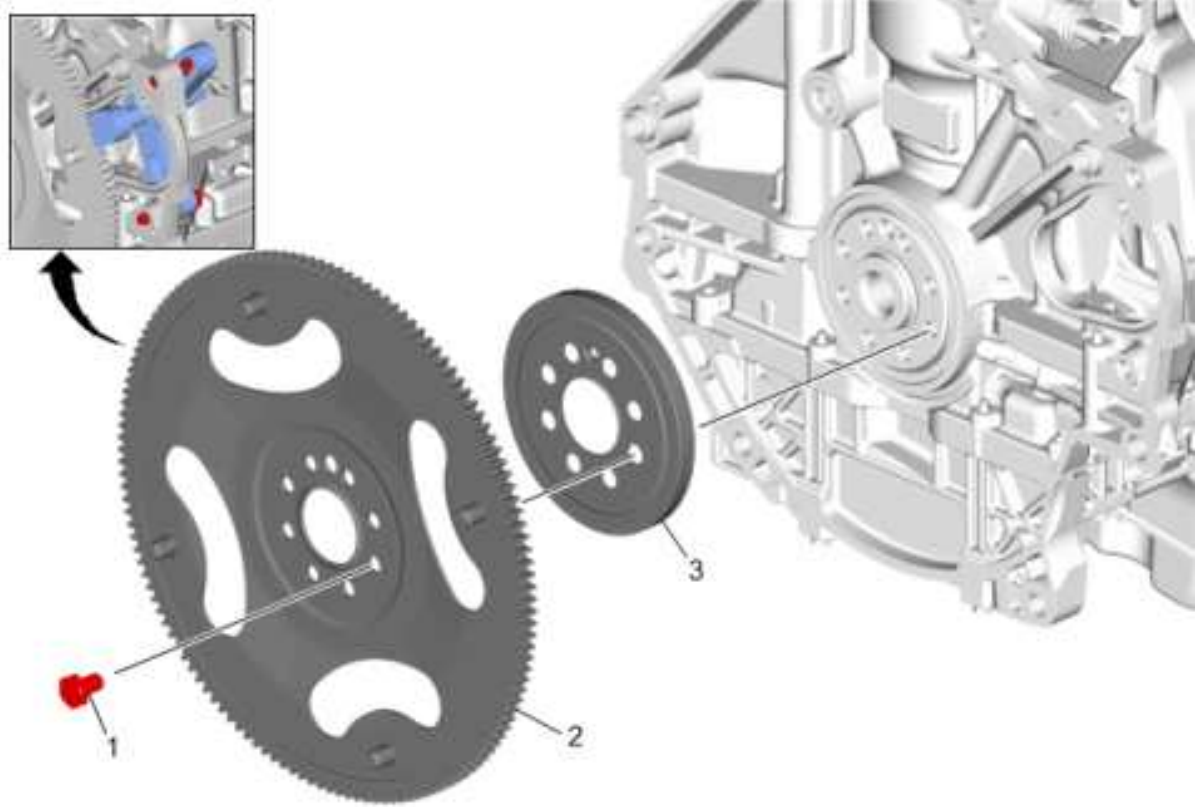


Fig. 354: Automatic Transmission Flex Plate
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Install EN-51760 holder, lock the automatic transmission flex plate via the starter ring gear.	
Special Tools EN-51760 Flywheel Holder For equivalent regional tools, refer to Special Tools .	
1	Automatic Transmission Flex Plate Bolt (Qty: 8) NOTE: Discard the bolts.
2	Automatic Transmission Flex Plate
3	Crankshaft Position Sensor Reluctor Ring CAUTION: Refer to Crankshaft Position Sensor Reluctor Ring Caution .

TURBOCHARGER REMOVAL

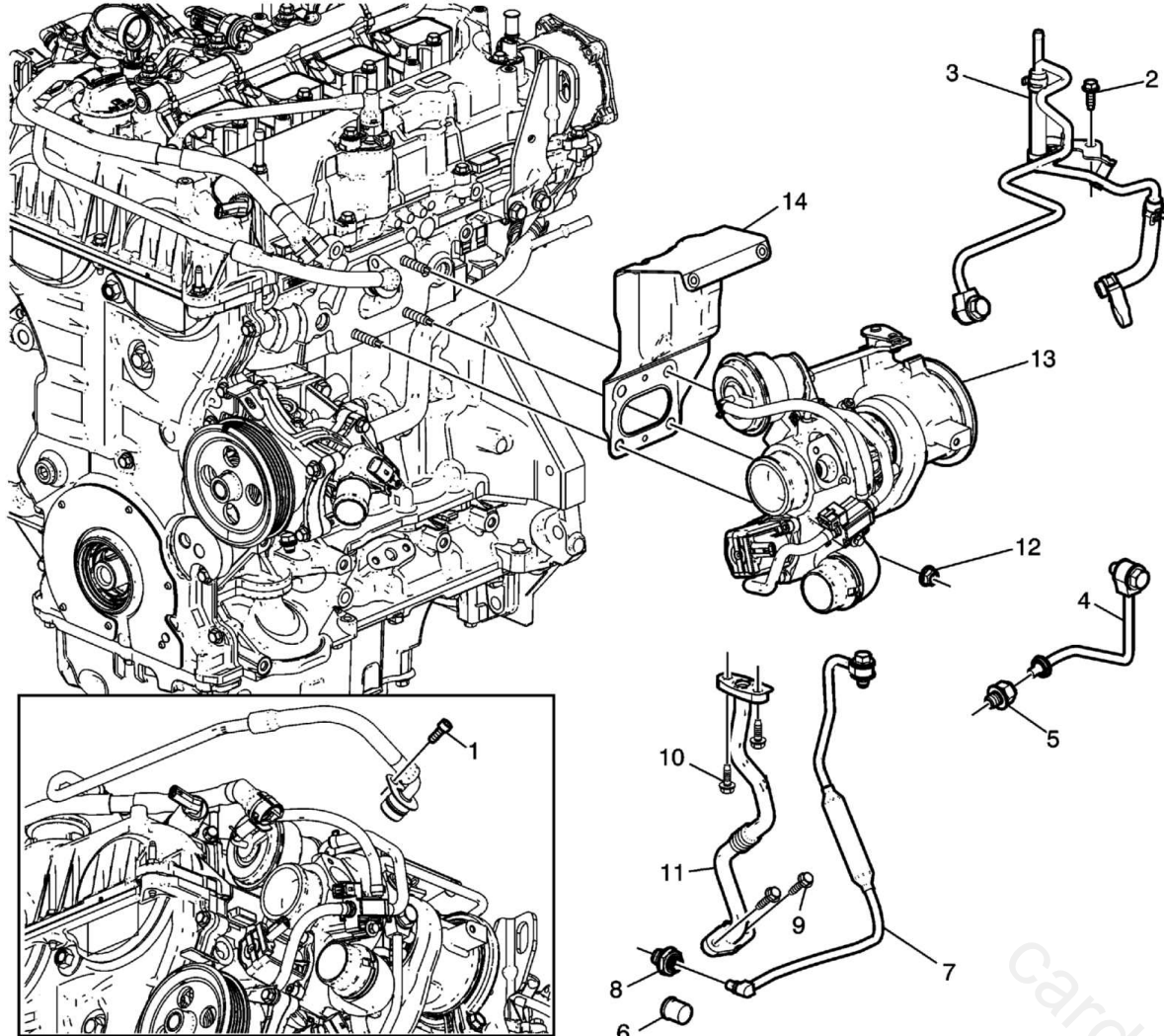


Fig. 355: Turbocharger

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Hose Fitting Bolt NOTE: The connection between the PCV hose and PCV hose fitting at the turbocharger is a permanent connection and cannot be disassembled. Disconnect the PCV fitting, with the PCV hose attached, from the turbocharger.
2	Turbocharger Coolant Return Pipe Bracket Bolt
3	Turbocharger Coolant Return Pipe NOTE: Discard the two gaskets for the bolt at the turbocharger connection.
4	Turbocharger Coolant Feed Pipe Procedure: 1. Loosen the bolt and rotate the pipe downward. Discard the two gaskets for the bolt at the turbocharger connection. 2. Remove and discard the turbocharger coolant feed pipe clamp at the turbocharger pipe fitting. 3. Remove the turbocharger coolant feed pipe.

Callout	Component Name
5	Turbocharger Pipe Fitting NOTE: Discard the turbocharger pipe fitting, including the pipe fitting gasket.
6	Turbocharger Oil Feed Pipe Clip
7	Turbocharger Oil Feed Pipe Assembly Procedure: 1. Remove the turbocharger oil feed pipe bolt. Discard the two gaskets for the bolt at the turbocharger connection. 2. Remove and discard the turbocharger oil feed pipe clamp at the turbocharger pipe fitting. 3. Remove the turbocharger coolant feed pipe.
8	Turbocharger Pipe Fitting NOTE: Discard the turbocharger pipe fitting, including the pipe fitting gasket.
9	Turbocharger Oil Return Pipe Bolt - Flange to Block (Qty: 2)
10	Turbocharger Oil Return Pipe Bolt - Flange to Turbocharger (Qty: 2)
11	Turbocharger Oil Return Pipe Assembly NOTE: Remove and discard the two turbocharger oil return pipe gaskets.
12	Turbocharger Nut (Qty: 4) NOTE: Remove and discard the turbocharger nuts.
13	Turbocharger
14	Turbocharger Heat Shield NOTE: Remove and discard the turbocharger heat shield with gasket.

ENGINE OIL COOLER REMOVAL

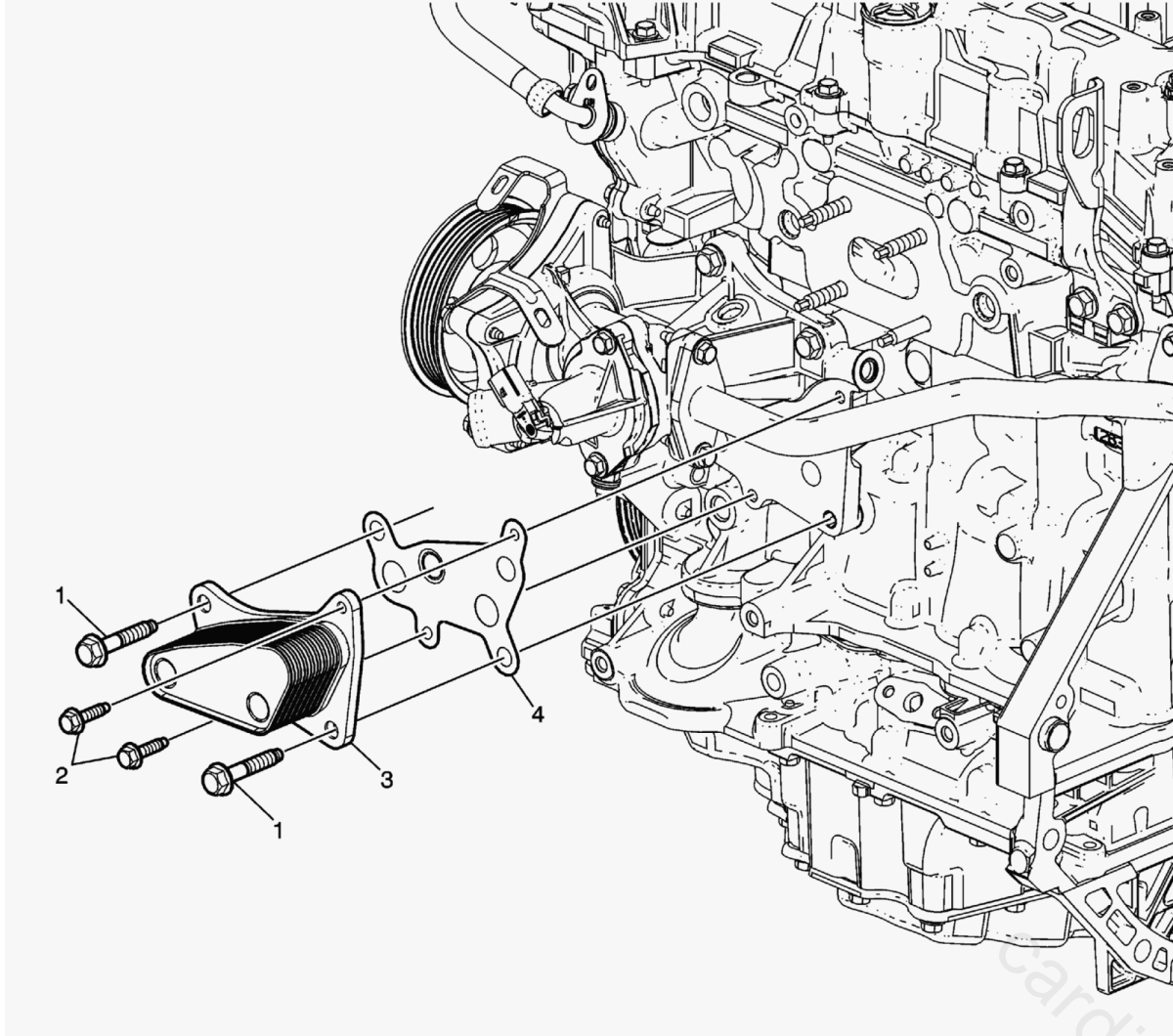


Fig. 356: Engine Oil Cooler

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Assembly Bolt (Qty: 2)
2	Engine Oil Cooler Assembly Bolt (Qty: 2)
3	Engine Oil Cooler Assembly
4	Engine Oil Cooler Gasket

WATER PUMP REMOVAL

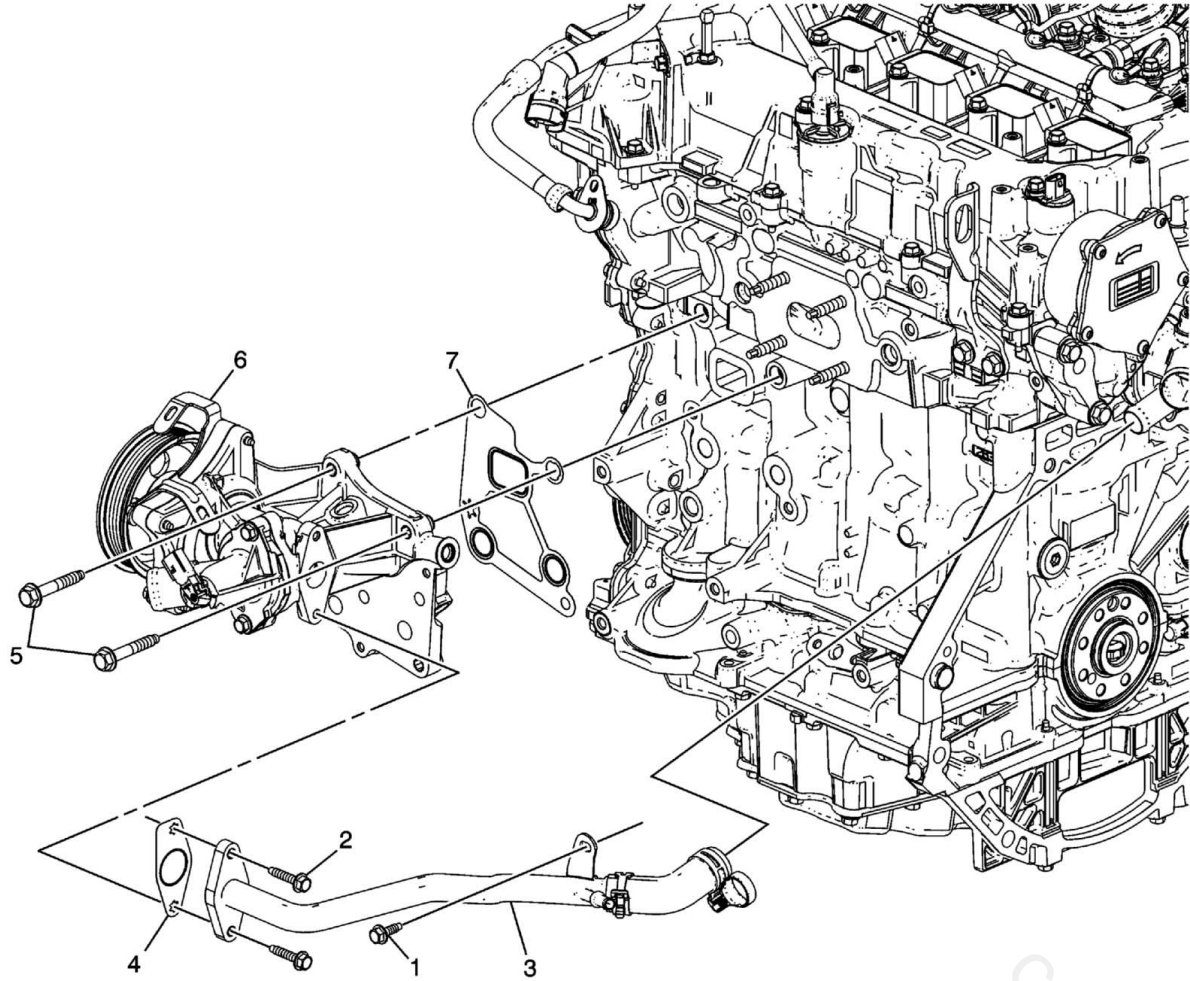


Fig. 357: Water Pump

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Thermostat Bypass Pipe Bolt (Qty: 1)
2	Thermostat Bypass Pipe Bolt (Qty: 2)
3	Thermostat Bypass Pipe Assembly
4	Thermostat Bypass Pipe Gasket
5	Water Pump Bolt (Qty: 2)
6	Water Pump
7	Water Pump Housing Gasket

THROTTLE BODY ASSEMBLY REMOVAL

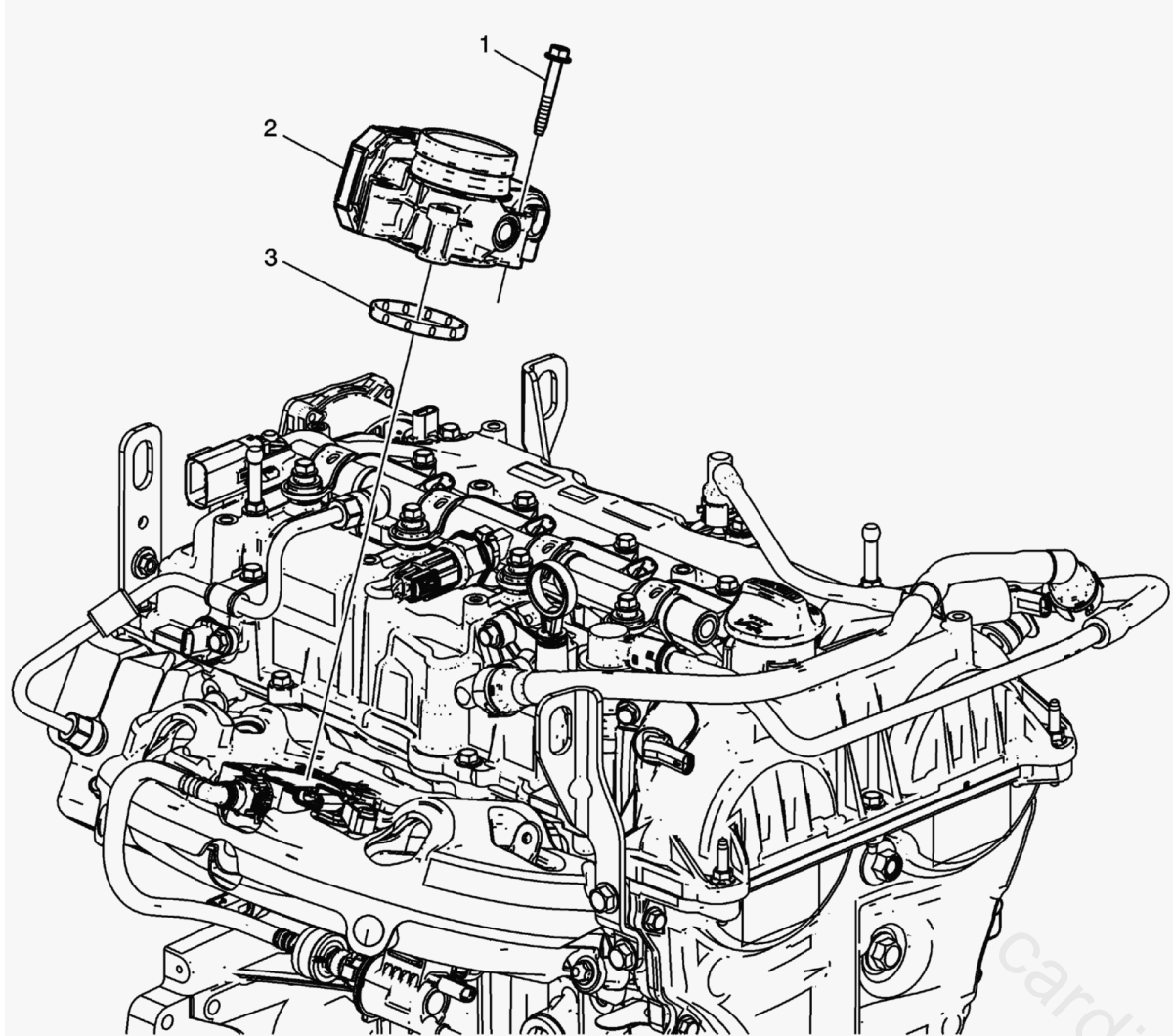


Fig. 358: Throttle Body

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Assembly Bolt (Qty: 4)
2	Throttle Body Assembly
3	Throttle Body Gasket

INTAKE MANIFOLD REMOVAL

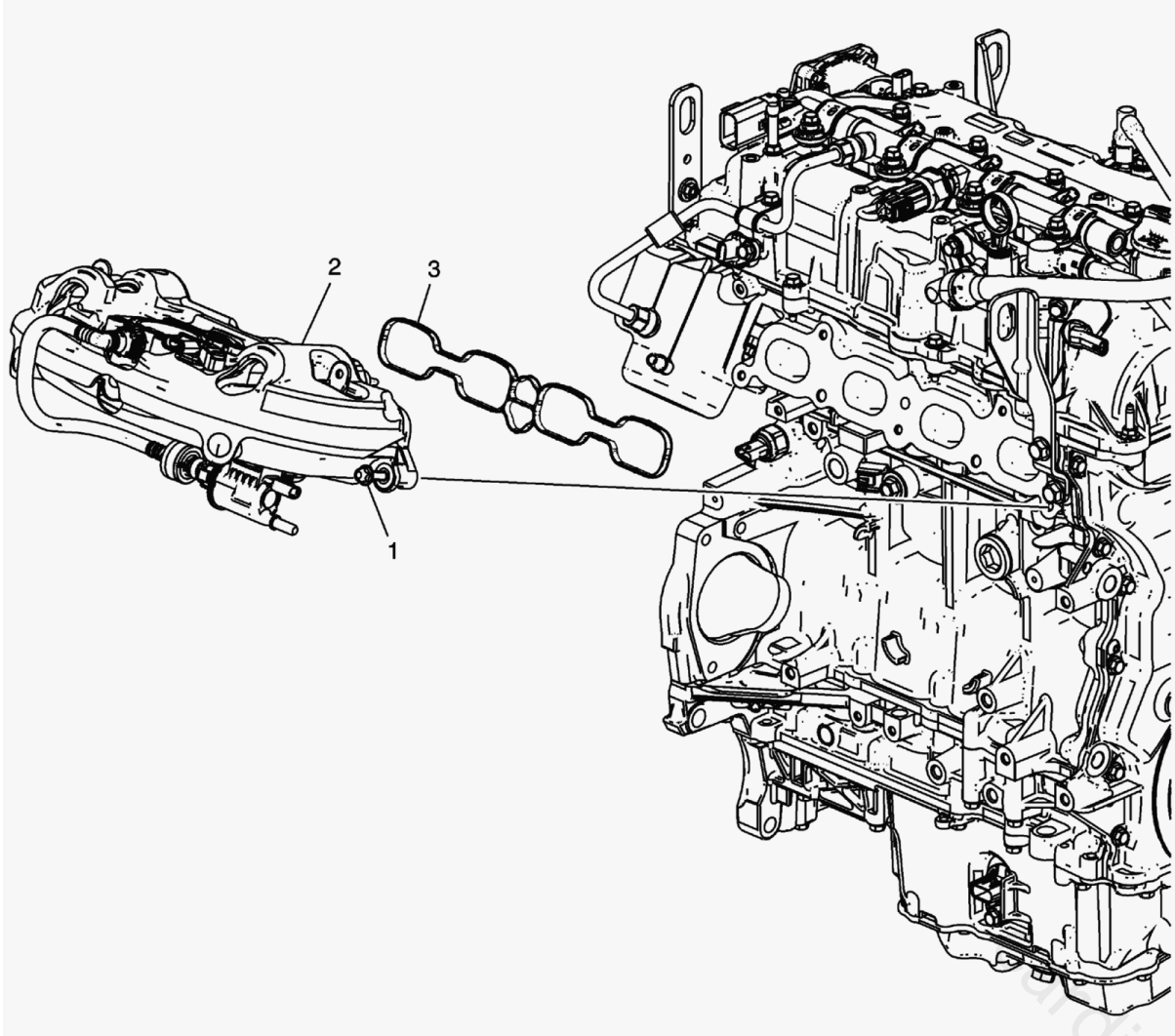


Fig. 359: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Assembly Bolt (Qty: 5) NOTE: Bolt retainers keep the bolts in position on the assembly. If the bolts are removed from the assembly, the 2 shorter bolts go to the outside lower locations. Procedure Loosen bolts until disengaged from mount location.
2	Intake Manifold Assembly
3	Intake Manifold Gasket

FUEL PUMP REMOVAL

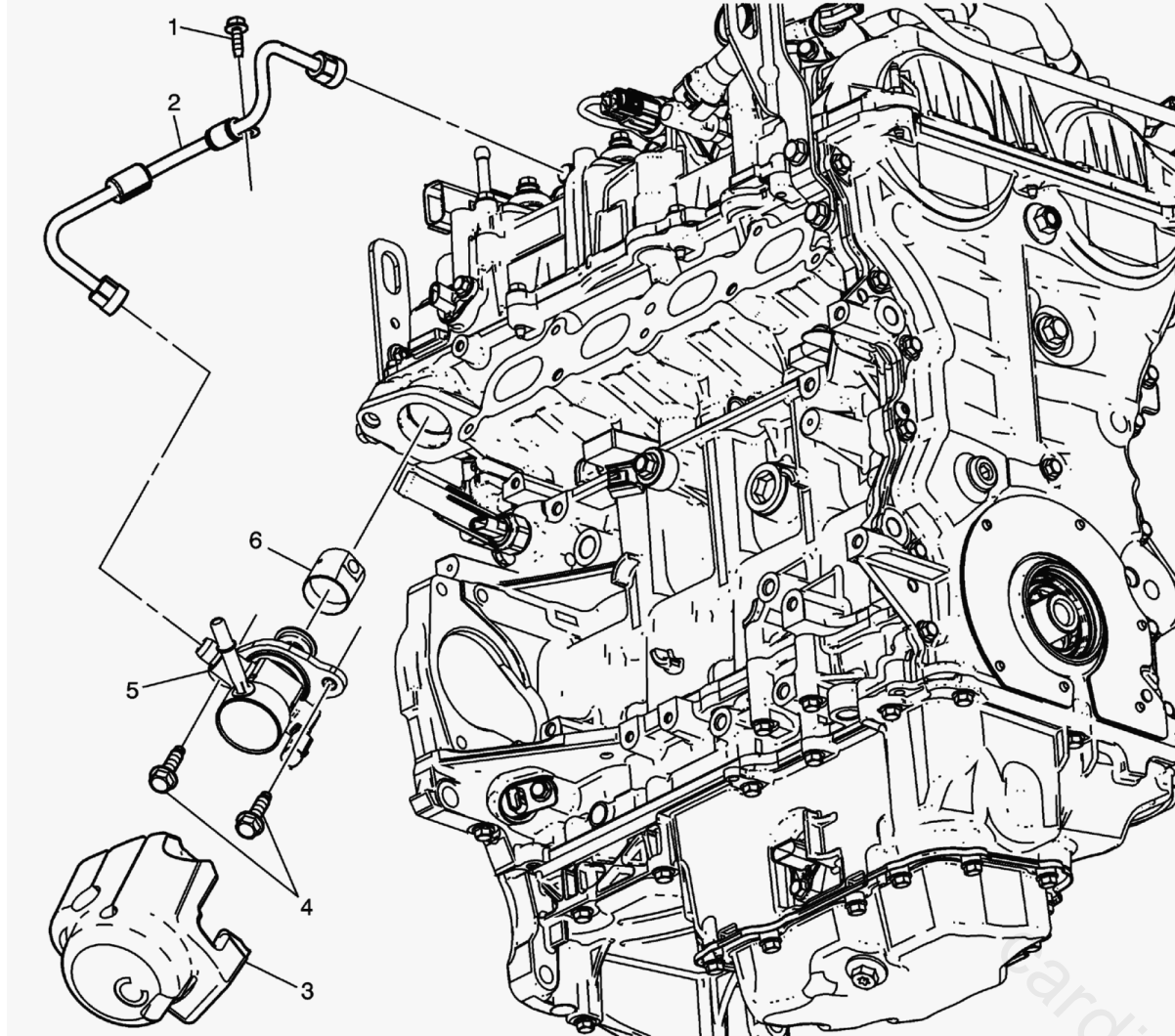


Fig. 360: Fuel Pump

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Feed Intermediate Pipe Bolt (Qty: 1)
2	Fuel Feed Intermediate Pipe WARNING: Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure. NOTE: Discard the pipe.
3	Fuel Pump Insulator WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

Callout	Component Name
4	Fuel Pump Bolt (Qty: 2) CAUTION: Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage Procedure: Remove the fuel injection pump bolts alternating in steps of one turn each. NOTE: Discard the bolts.
5	Fuel Pump
6	Valve Lifter Follower

ENGINE LIFT AND SIGHT SHIELD BRACKET REMOVAL

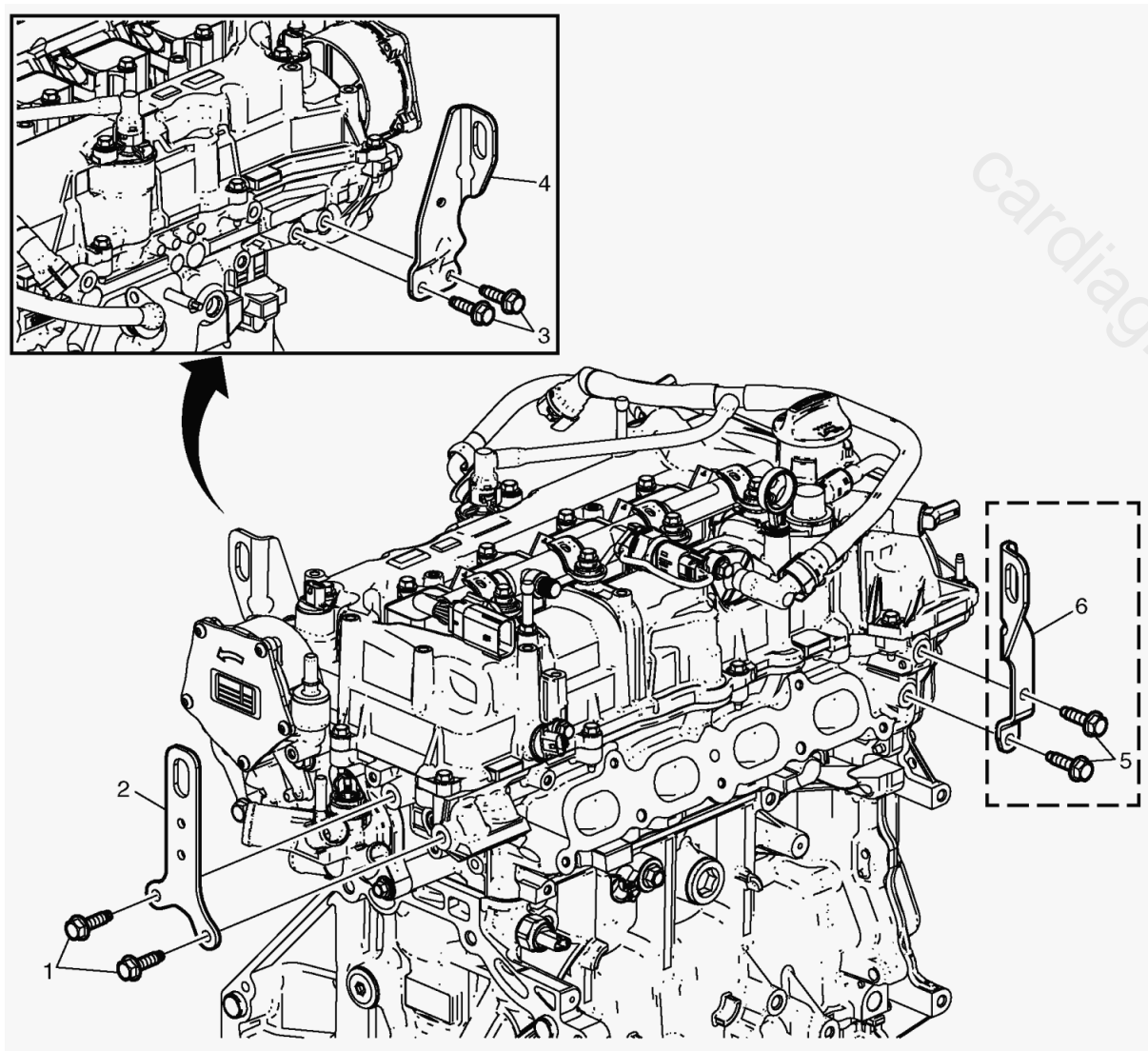


Fig. 361: Engine Lift and Sight Shield Bracket
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Lift Rear Bracket Bolt [2x]
2	Engine Lift Rear Bracket
3	Engine Lift Rear Bracket Bolt [2x]

Callout	Component Name
4	Engine Lift Rear Bracket
5	Engine Lift Front Bracket Bolt [2x] - Model Dependent
6	Engine Lift Front Bracket - Model Dependent

WATER OUTLET REMOVAL

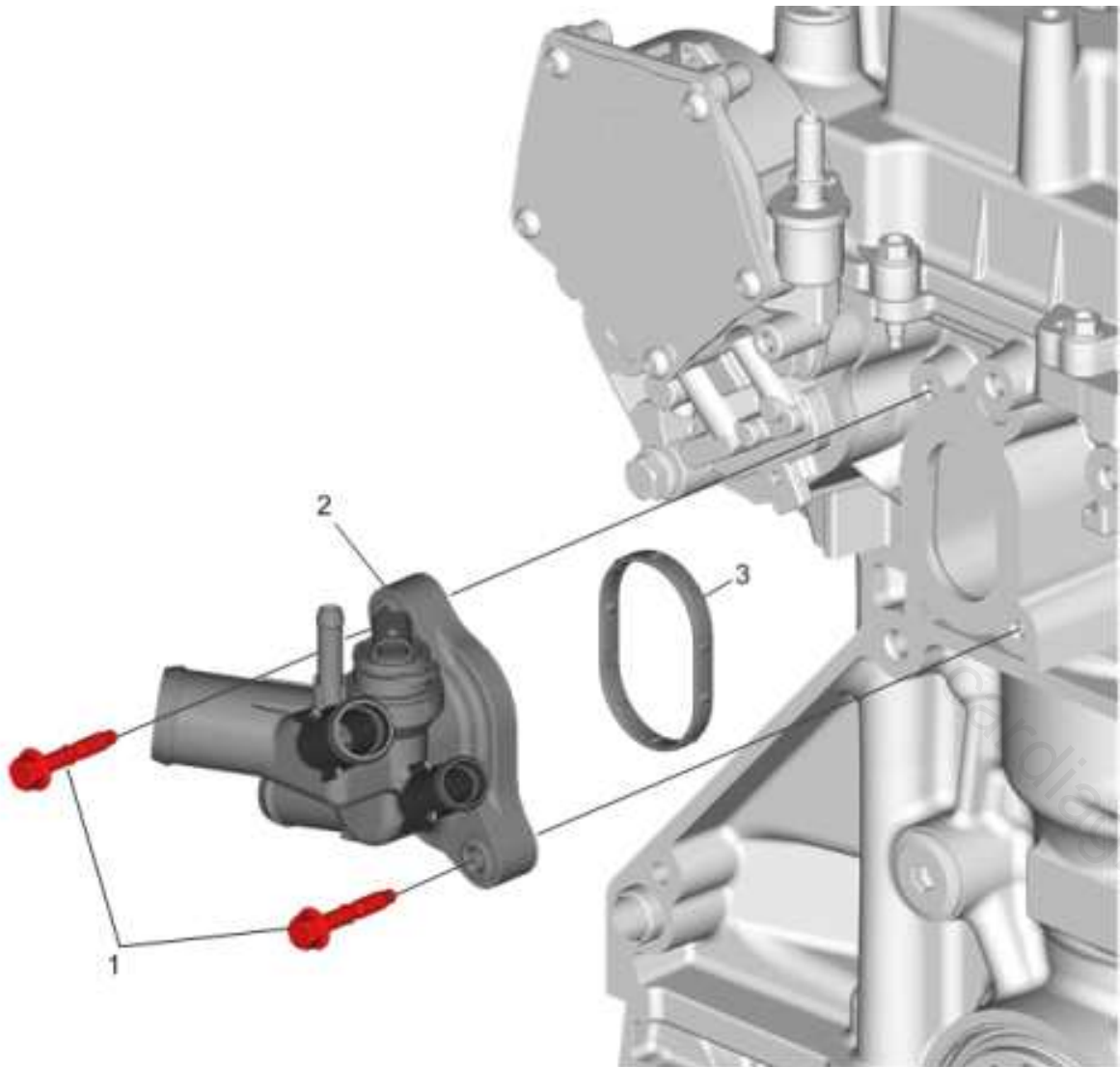


Fig. 362: Water Outlet

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Outlet Assembly Bolt (Qty: 2)
2	Water Outlet Assembly
3	Water Outlet Gasket

VACUUM PUMP REMOVAL

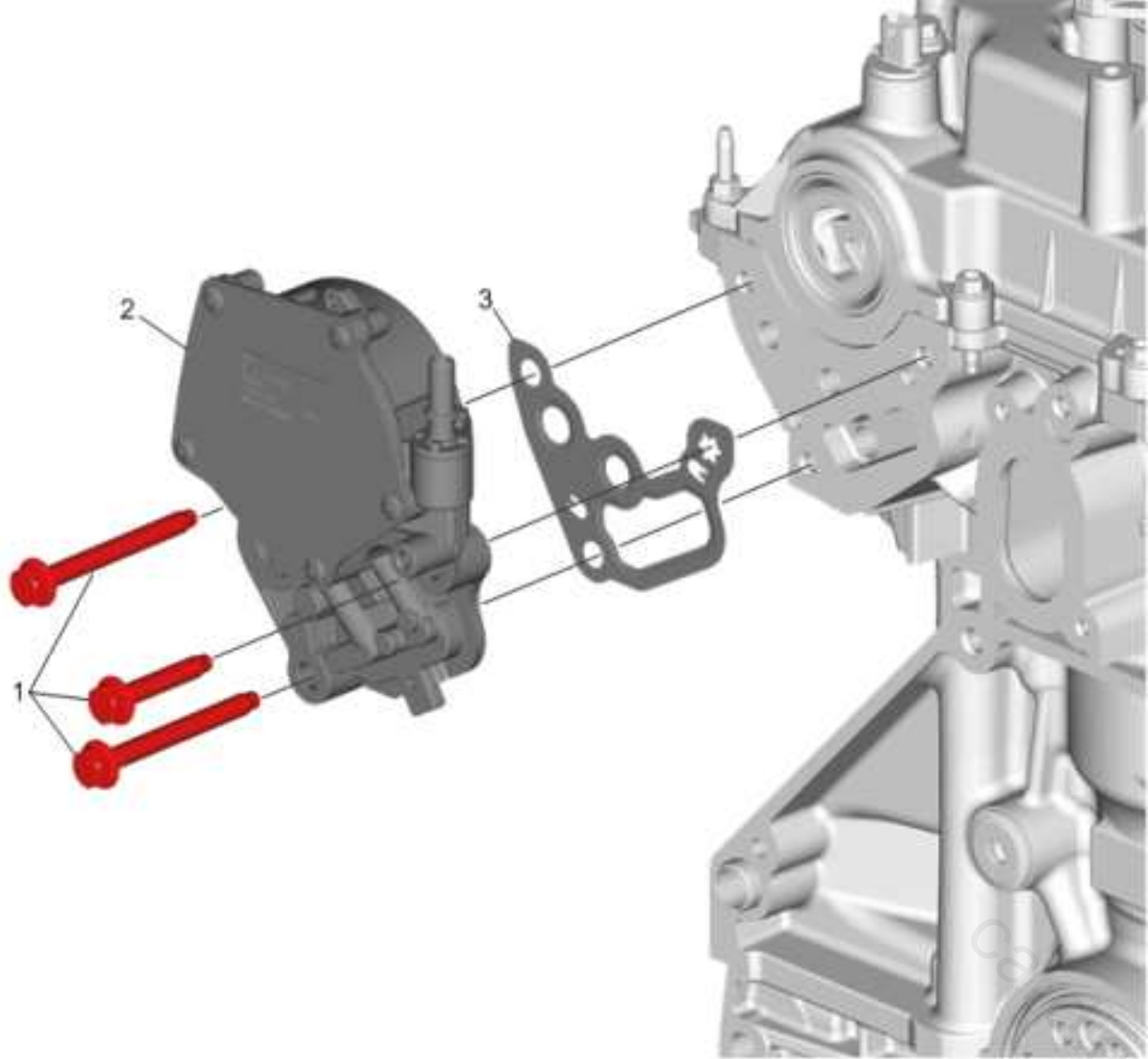


Fig. 363: Vacuum Pump

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Assembly Bolt (Qty: 3)
2	Vacuum Pump Assembly
3	Vacuum Pump Gasket

IGNITION COIL REMOVAL

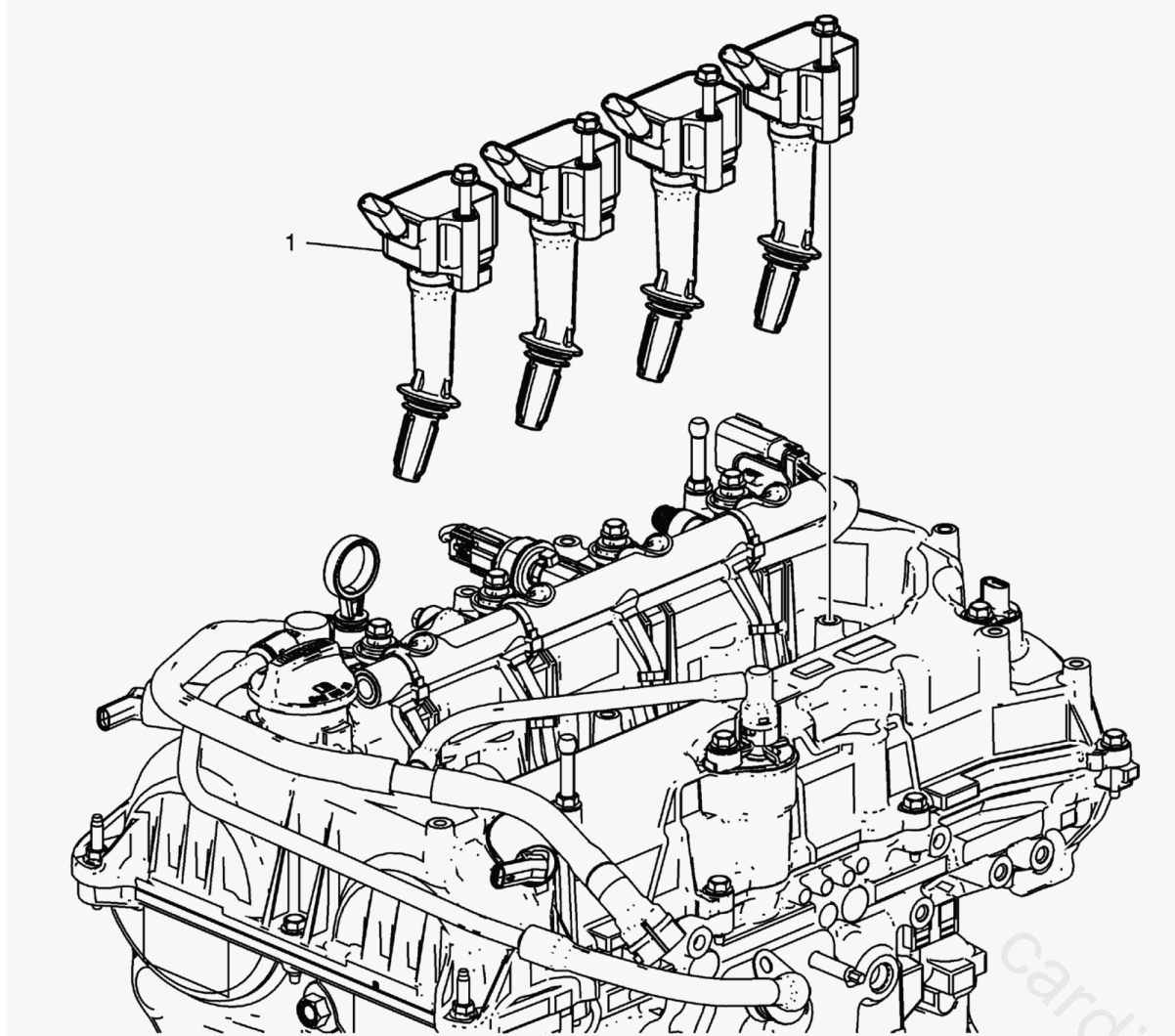


Fig. 364: Ignition Coil

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Ignition Coil Assembly (Qty: 4)

FUEL RAIL AND INJECTORS REMOVAL

Special Tools

- EN-51146 Fuel Injector Removal/Installation Kit
- EN-51146-100 Fuel Injector Removal Plate

For equivalent regional tools, refer to [Special Tools](#).

WARNING: Refer to [Diesel/Gasoline Vapors Warning](#) .

WARNING: Refer to [Safety Goggles and Fuel Warning](#) .

NOTE: Maintain a clean work surface when working with fuel rail and fuel injectors. Use care to avoid contaminants on the injector seals.

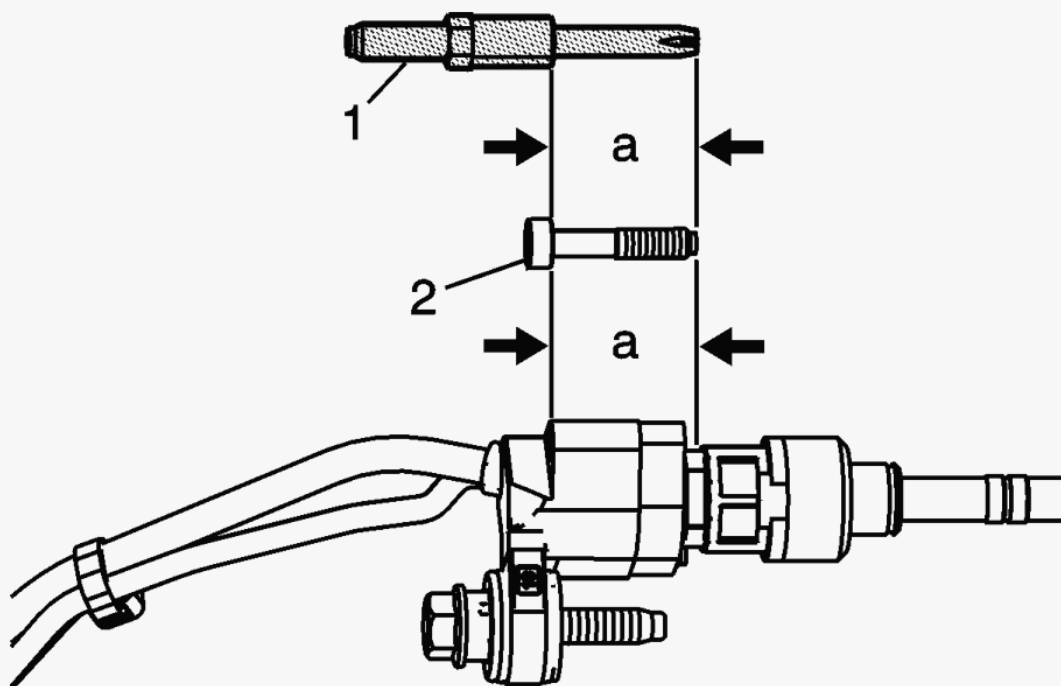


Fig. 365: Fuel Injector Screw

Courtesy of GENERAL MOTORS COMPANY

NOTE: Remove only one fuel injector screw (2) to perform the length check.

1. Ensure the **EN-51146-1-6** demounting screws (1) are used with turbocharger equipped applications. Match the length (a) of the **EN-51146-1-6** demounting screws (1) to the length of the fuel injector screw (2). If the length does not match, refer to the Non-Turbocharger procedure.

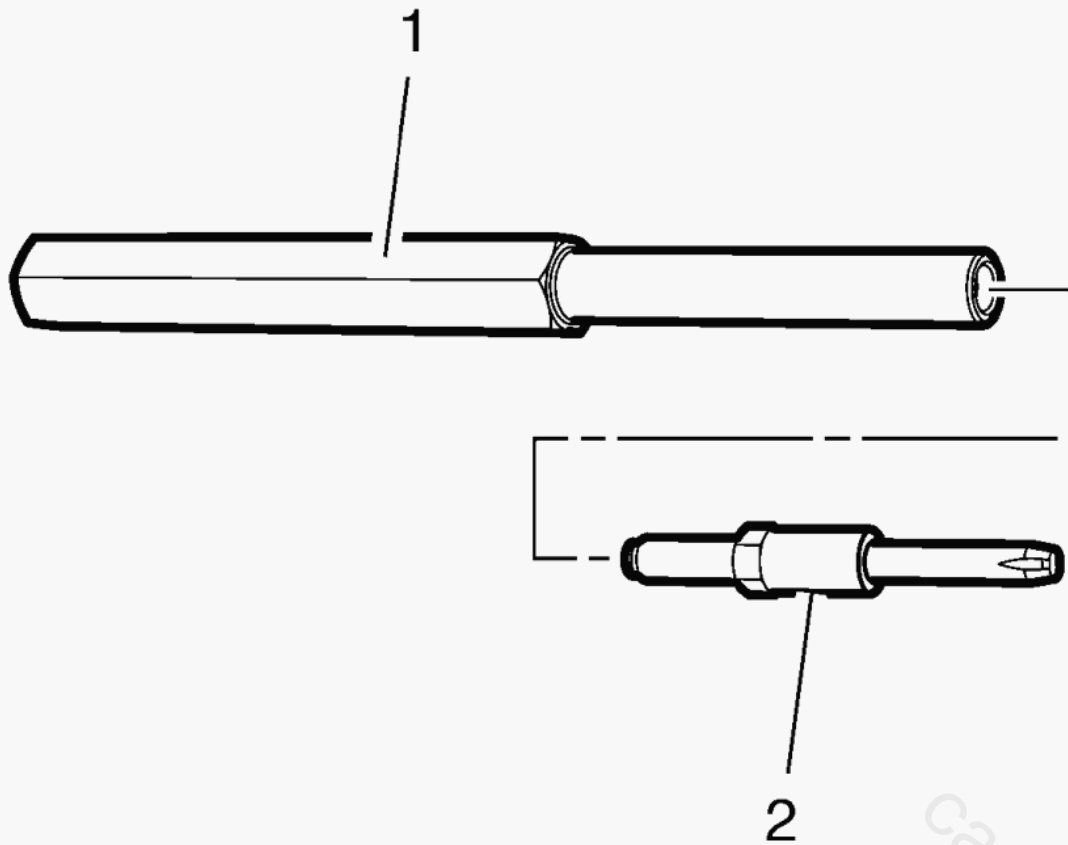


Fig. 366: Continental MGE Demounting Screw
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-51146-1-6** demounting screws (2) to the **EN-51146-1-1** supports (1) and tighten to 7 N.m (62 lb in).

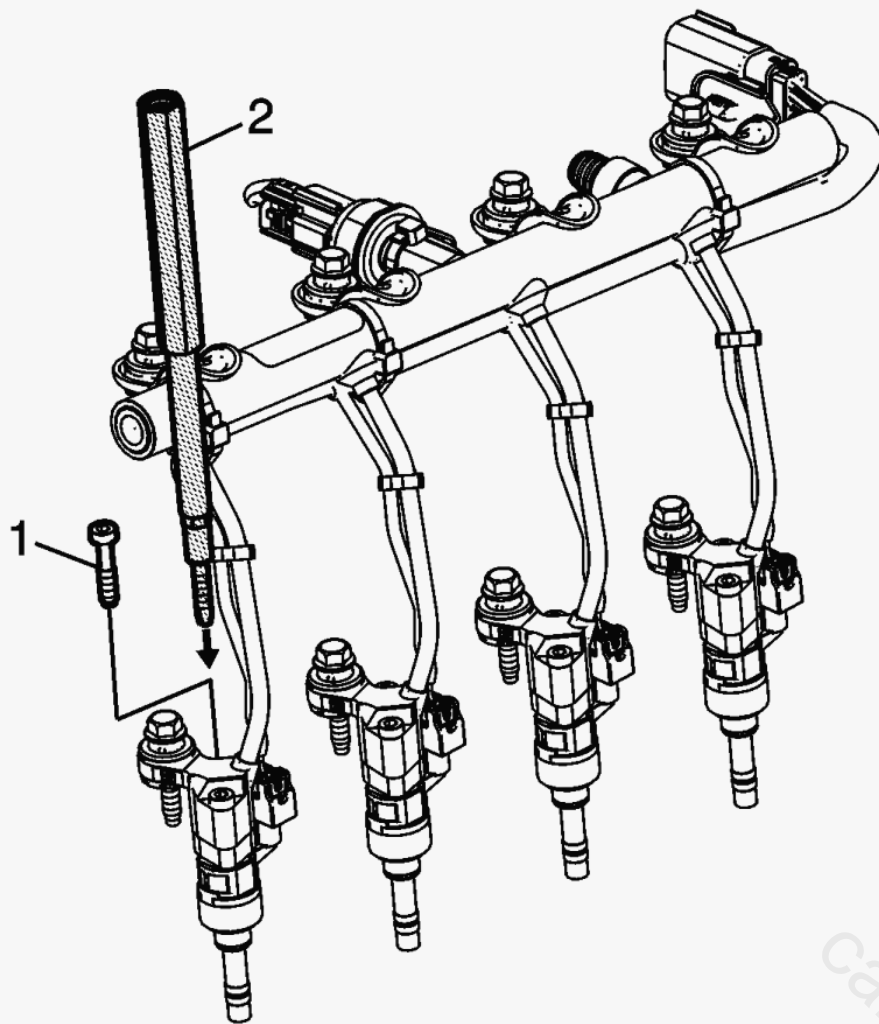


Fig. 367: Inner Fuel Injector Screw

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not loosen or remove both fuel injector screws for an individual fuel injector at the same time. Ensure the EN-51146-1-6 demounting screw and EN-51146-1-1 support is properly installed on the inner fuel injector screw location before removing the remaining outer fuel injector screw. Ensure the screws do not fall into the cylinder head slot.

3. Remove the inner fuel injector screw (1).
4. Install one EN-51146-1-6 demounting screws and EN-51146-1-1 support (2) and tighten to 5 N.m (44 lb in).

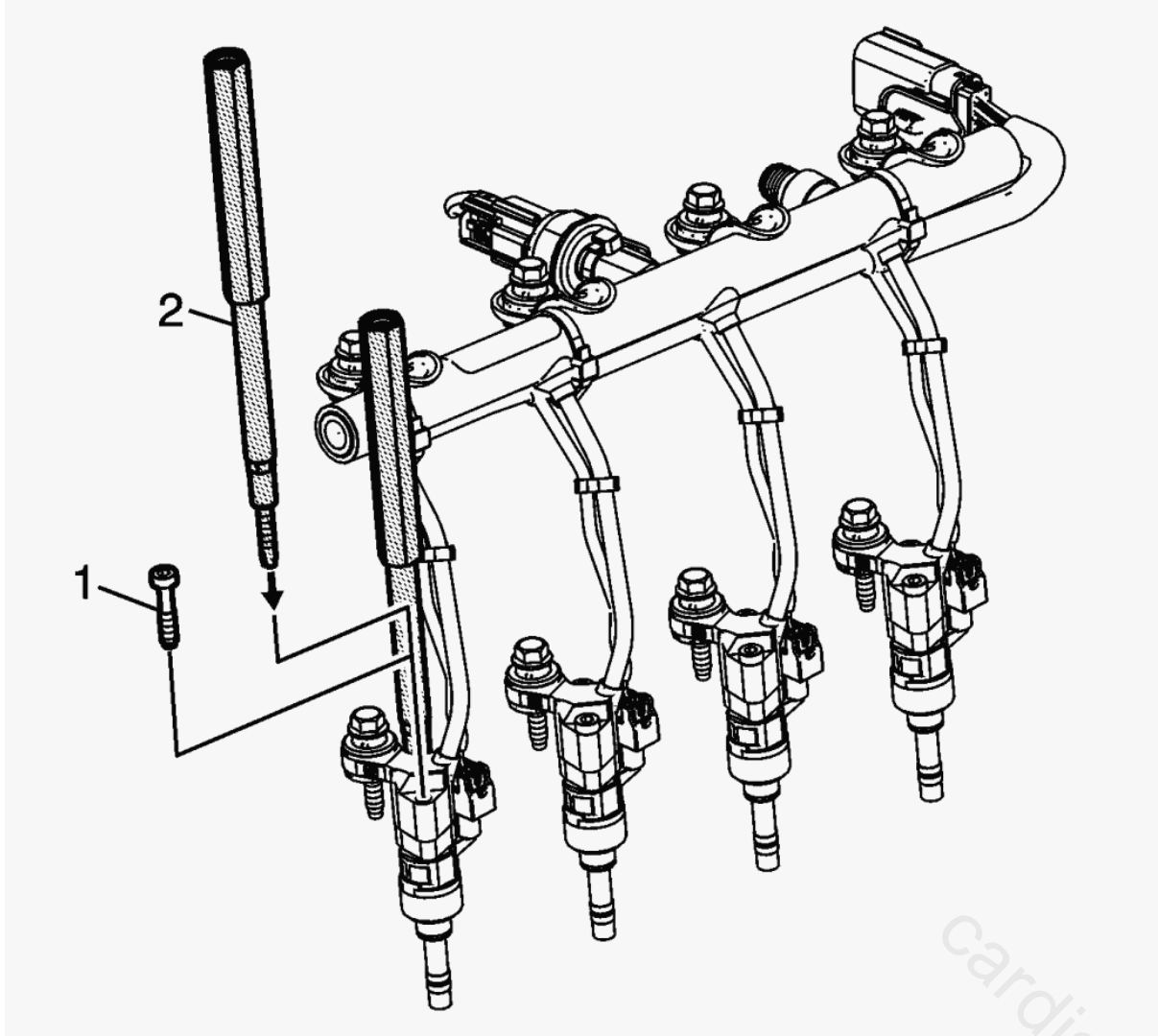


Fig. 368: Outer Fuel Injector Screw

Courtesy of GENERAL MOTORS COMPANY

5. Remove the outer fuel injector screw (1).
6. Install a second **EN-51146-1-6** demounting screws and **EN-51146-1-1** support (2) and tighten to 5 N.m (44 lb in).

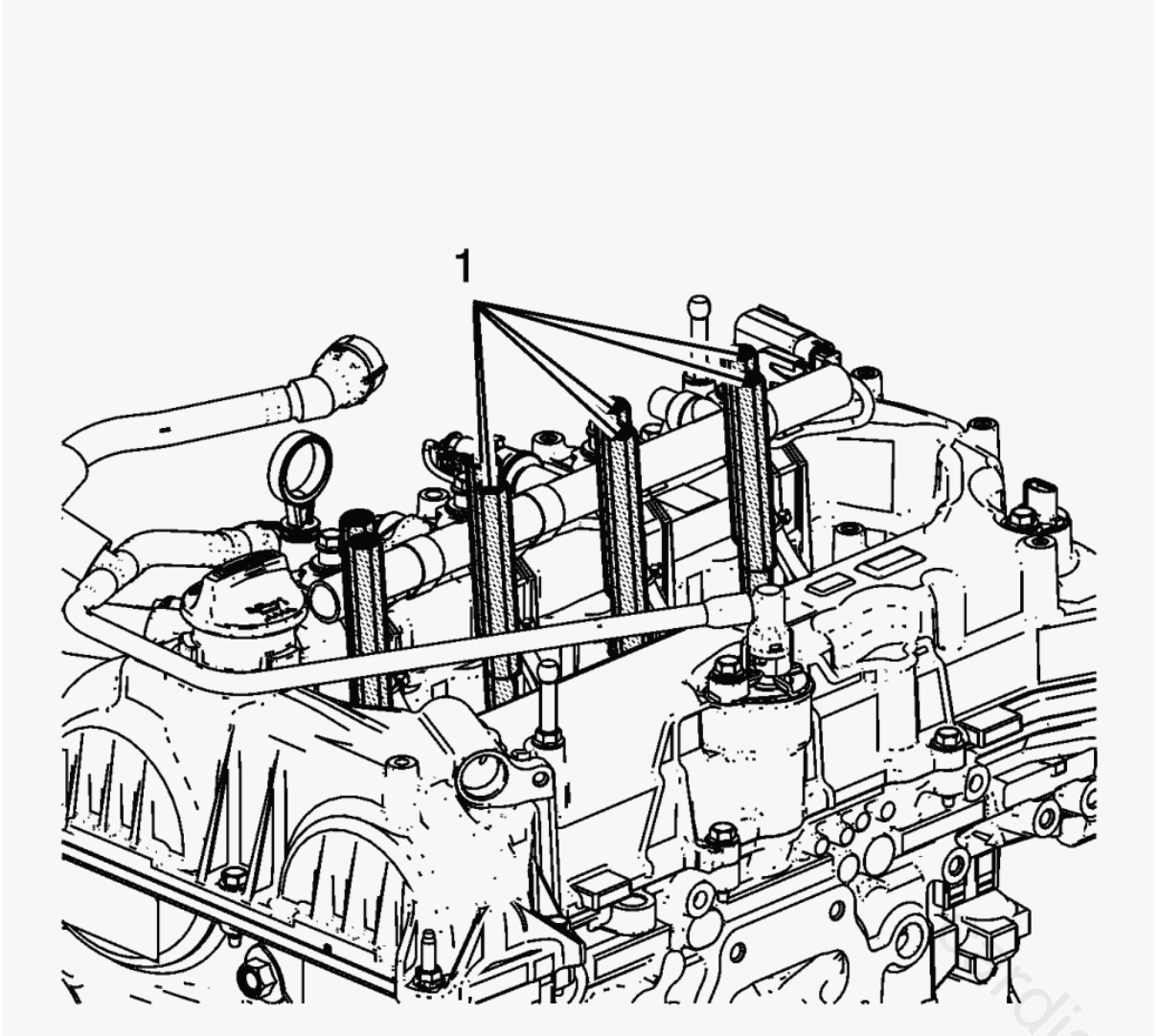


Fig. 369: Supports

Courtesy of GENERAL MOTORS COMPANY

7. Using the same procedure, install the remaining **EN-51146-1-6** demounting screws and **EN-51146-1-1** supports (1) for each fuel injector and tighten to 5 N.m (44 lb in).

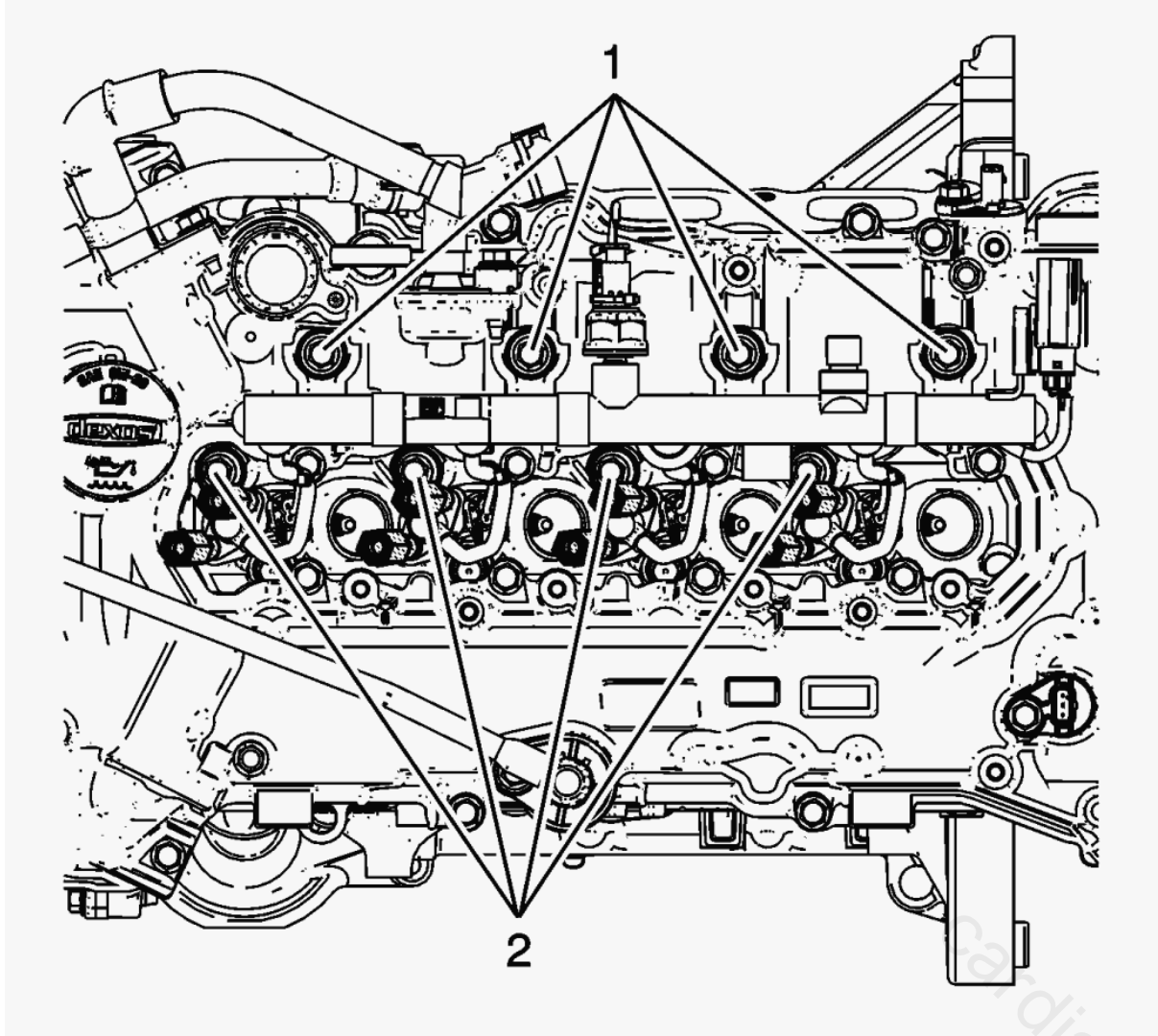


Fig. 370: Upper And Lower Fuel Rail Assembly Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: The fuel rail bolts may remain with the decoupling elements and retainer at the fuel rail assembly.

8. Loosen the 4 upper fuel rail assembly bolts (1) completely from the cylinder head, but do not remove the bolts.
9. Loosen the 4 lower fuel rail assembly bolts (2) completely from the cylinder head, but do not remove the bolts.

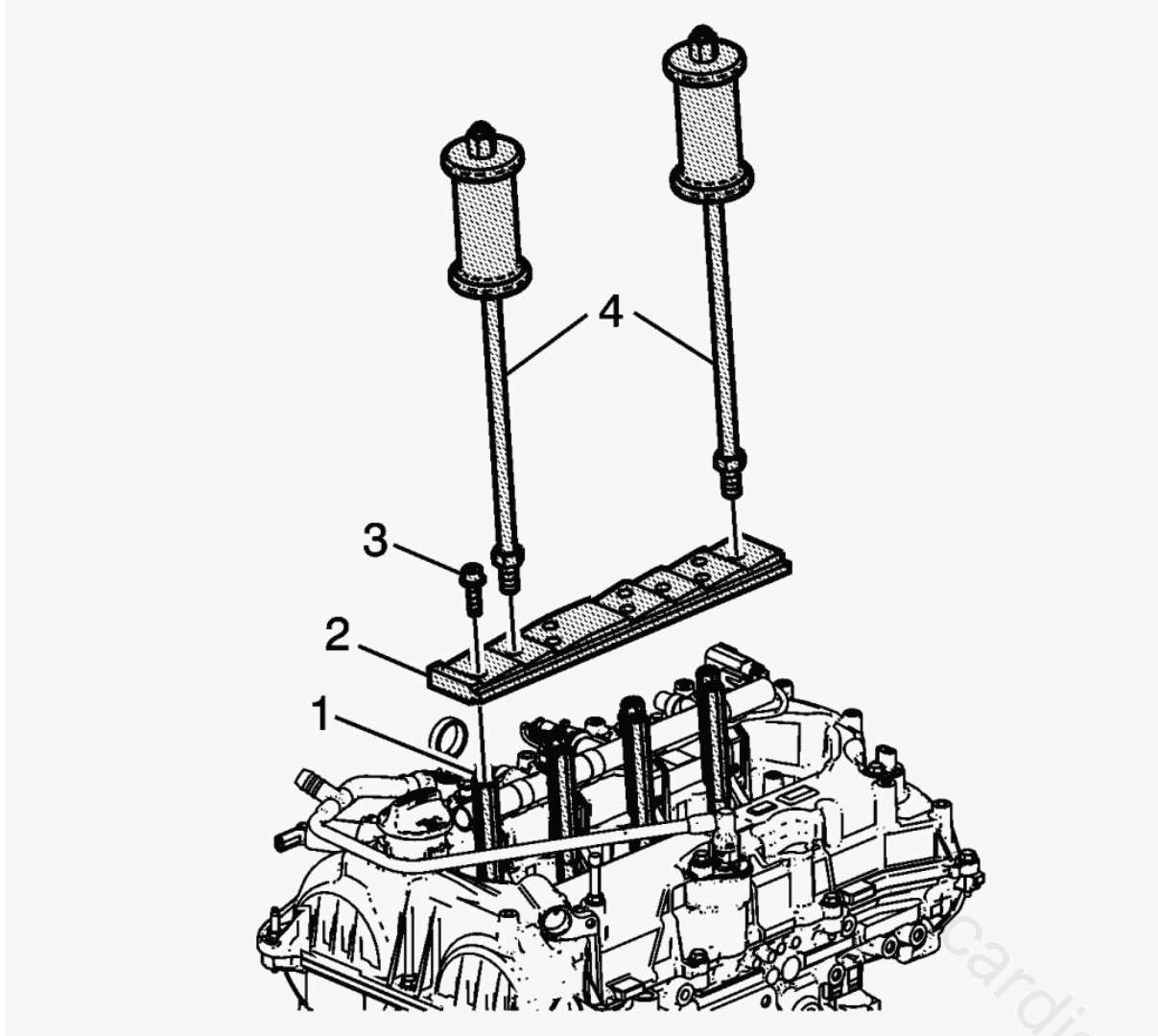


Fig. 371: Plate, Supports, Bolts And Slide Hammers

Courtesy of GENERAL MOTORS COMPANY

10. Install **EN-51146-100** plate (2) to the **EN-51146-1-1** supports (1) using the eight plate bolts (3). Counterhold each support with a wrench while tightening the bolt.
11. Install the **EN-51146-1-3** slide hammers (4) onto the **EN-51146-100** plate (2) using the outer holes.

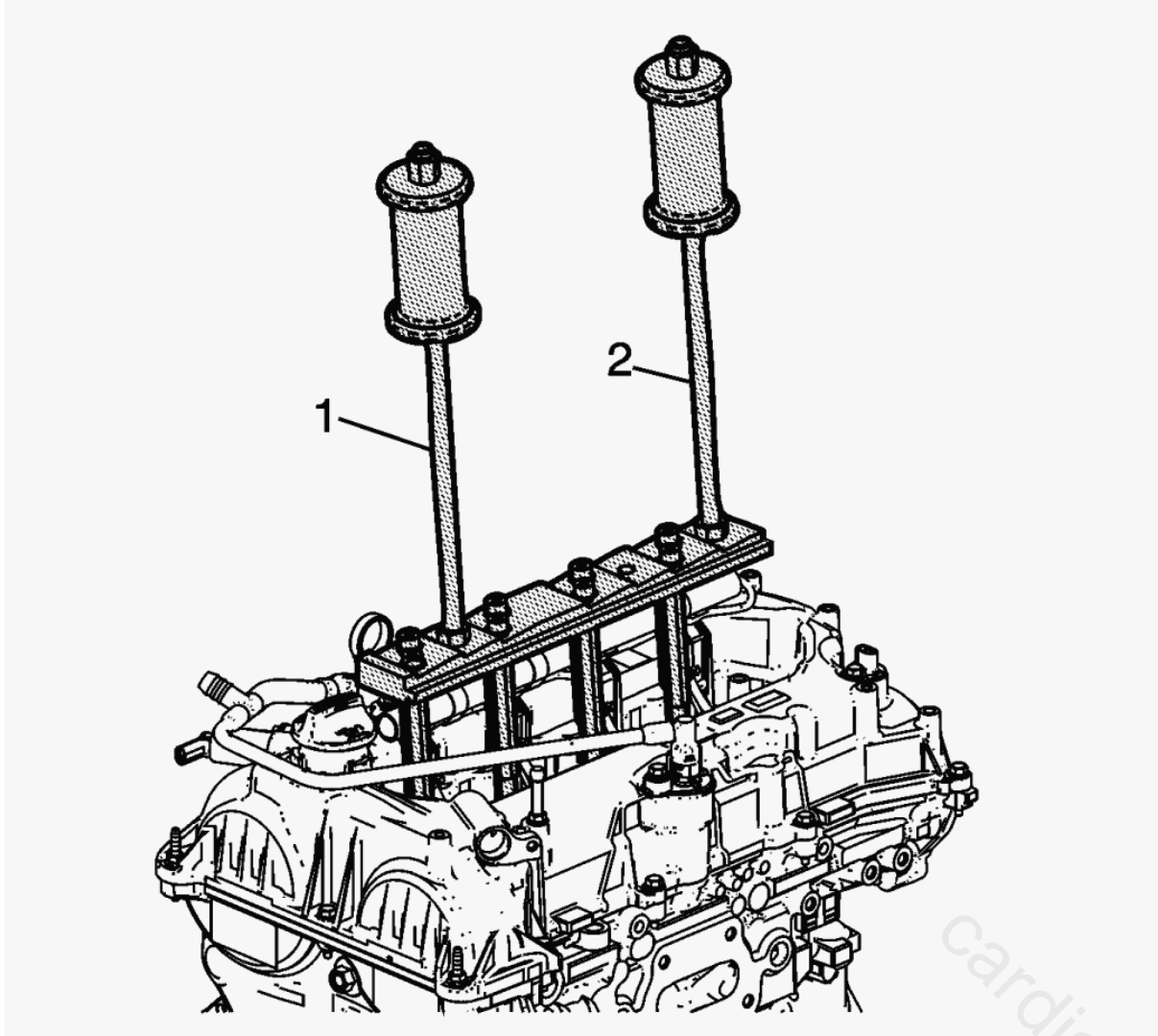


Fig. 372: Removing Fuel Injectors

Courtesy of GENERAL MOTORS COMPANY

NOTE: The alignment of the fuel injectors within the cylinder bores is critical for fuel injection system function. Use equal force on each slide hammer to ensure the fuel injectors are removed without tilting in the injector bore.

12. Using the **EN-51146-1-3** slide hammers (1, 2), begin to remove the fuel injectors by applying slight force equally on both hammers. Observe the alignment of the fuel injectors, and allocate force on the hammers as necessary.

NOTE: After removing the fuel rail and injector assembly, position the assembly on a clean work surface with the fuel injectors on top. Do not allow the weight of the assembly to rest on the fuel injectors.

13. Complete the removal of the fuel rail and injector assembly with the **EN-51146** remover. The slide hammers may then be removed from the plate.
14. Install the **EN-51146-2-5** calibration tools onto the fuel injector tips to protect the injectors.
15. Cover the fuel injector bores at the cylinder head to prevent contamination.

CAMSHAFT COVER REMOVAL

Camshaft Cover and Gasket Removal

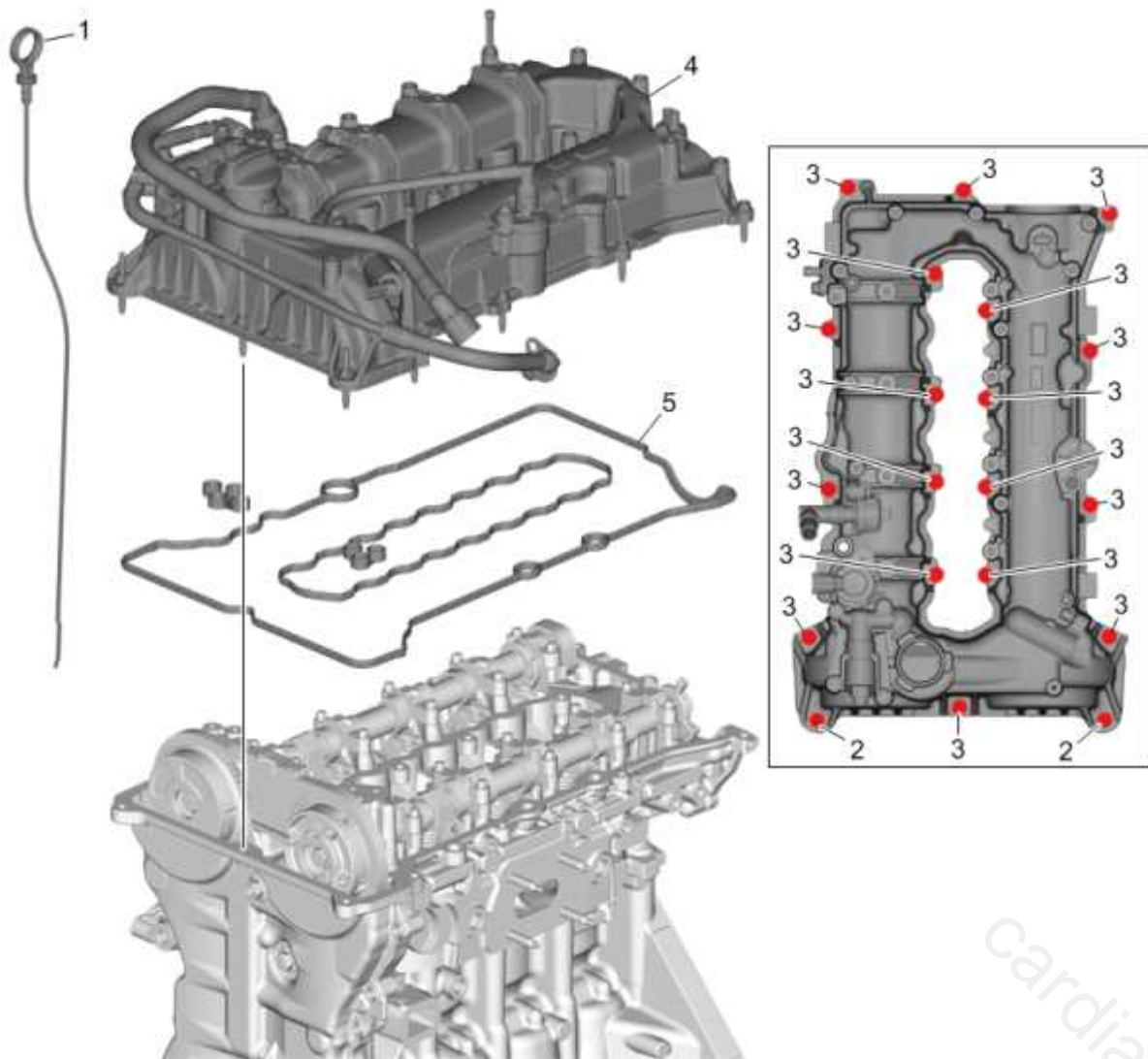


Fig. 373: Camshaft Cover and Gasket

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover and Gasket Removal

Callout	Component Name
1	Oil Level Indicator
2	Camshaft Cover Stud [2x]
3	Camshaft Cover Bolt [18x]
4	Camshaft Cover Procedure Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u>
5	Camshaft Cover Gasket NOTE: Discard the gasket.

Camshaft Cover Positive Crankcase Ventilation Components Removal

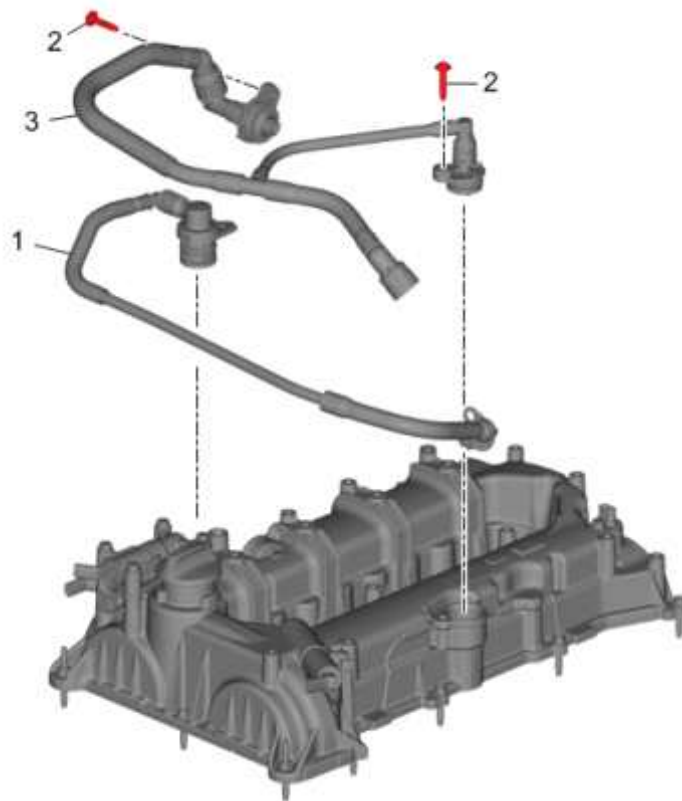


Fig. 374: Camshaft Cover Positive Crankcase Ventilation Components

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Positive Crankcase Ventilation Components Removal

Callout	Component Name
1	Positive Crankcase Ventilation Tube with Positive Crankcase Ventilation Valve - Foul Air NOTE: These components have tamper-proof connections and cannot be disassembled. Remove this component only if inspection indicates replacement is necessary. Procedure 1. Inspect all positive crankcase ventilation (PCV) components prior to removal. Do not remove the PCV components unless a diagnostic or inspection procedure indicates replacement is necessary. 2. Complete all camshaft cover inspections prior to inspecting or removing PCV components. If inspection indicates the camshaft cover requires replacement, all PCV components will be replaced with the cover. 3. Remove the PCV valve from the cover by twisting and breaking the connection. Retrieve any particles that fall onto the baffle in the cover. Discard the valve and particles.
2	Positive Crankcase Ventilation Valve Bolt [2x] NOTE: Bolts are tamper-proof. Remove the bolts only if inspection of the PCV tube or valves indicates replacement is necessary. Procedure 1. Using a suitable tool, cut a slot in the tamper-proof PCV bolt heads and remove with a flat-bladed tool. 2. Discard the bolts.

Callout	Component Name
6	Camshaft Housing Gasket NOTE: Discard the gasket.
7	Camshaft Position Sensor Bolt
8	Camshaft Position Sensor
9	Camshaft Position Sensor Bolt
10	Camshaft Position Sensor
11	Vacuum Pump Seal Special Tools EN-51096 Seal Remover Equivalent regional tools: Special Tools .
12	Camshaft Cover Locating Pin [2x]
13	Camshaft Position Actuator Solenoid Valve Bolt
14	Exhaust Camshaft Position Actuator Solenoid Valve
15	Camshaft Position Actuator Solenoid Valve Bolt
16	Intake Camshaft Position Actuator Solenoid Valve

OIL PAN REMOVAL

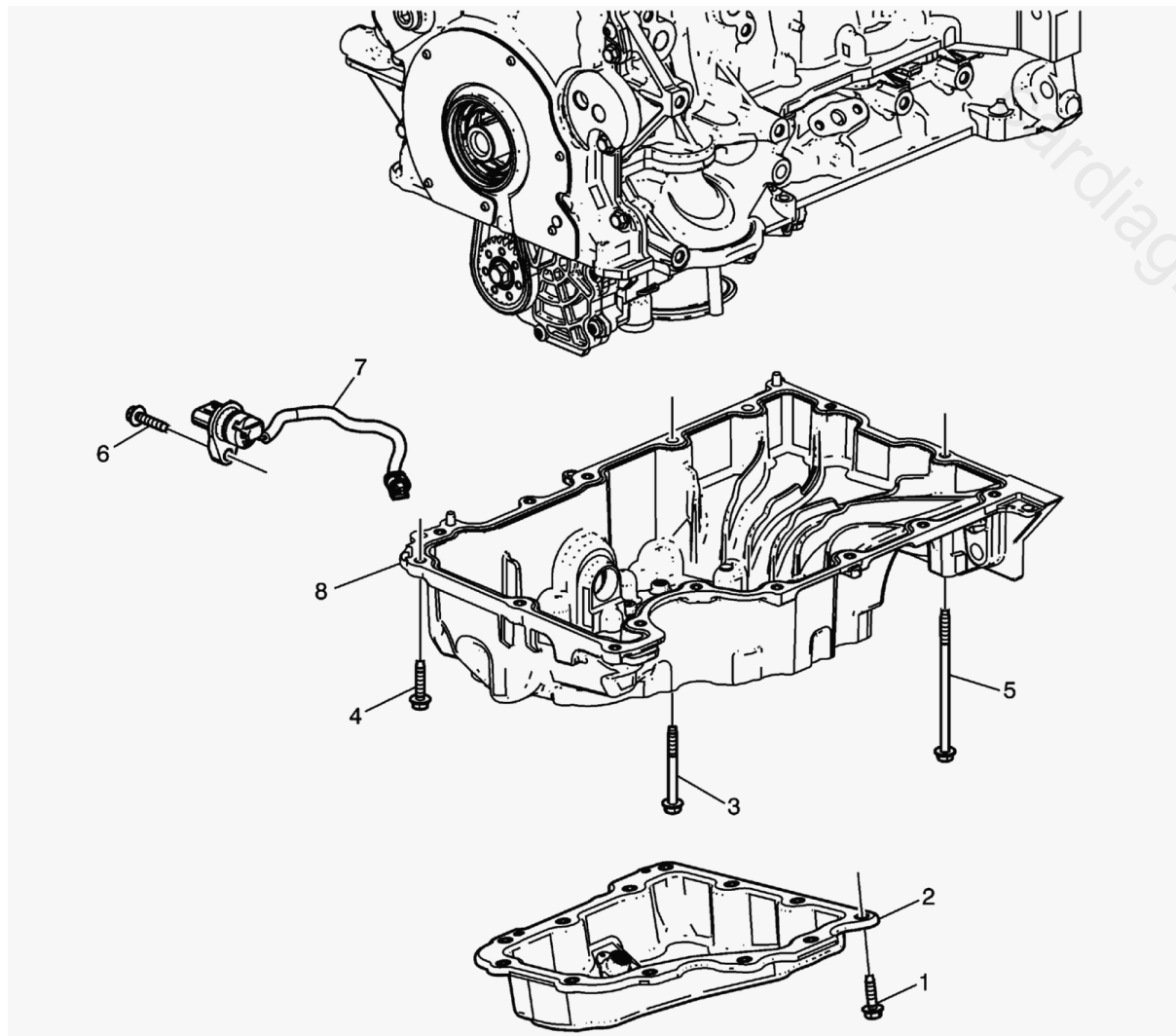


Fig. 376: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Lower Oil Pan Bolt (Qty: 12)

Callout	Component Name
2	Lower Oil Pan Procedure Remove the oil pan drain plug, if applicable. Discard the lower oil pan.
3	Oil Pan Bolt (Qty: 2)
4	Oil Pan Bolt (Qty: 12)
5	Oil Pan Bolt (Qty: 2)
6	Wiring Harness Connector Bolt
7	Wiring Harness Connector Procedure Disconnect the oil pump control valve connector, then remove through the upper oil pan.
8	Upper Oil Pan Assembly

ENGINE FRONT COVER REMOVAL

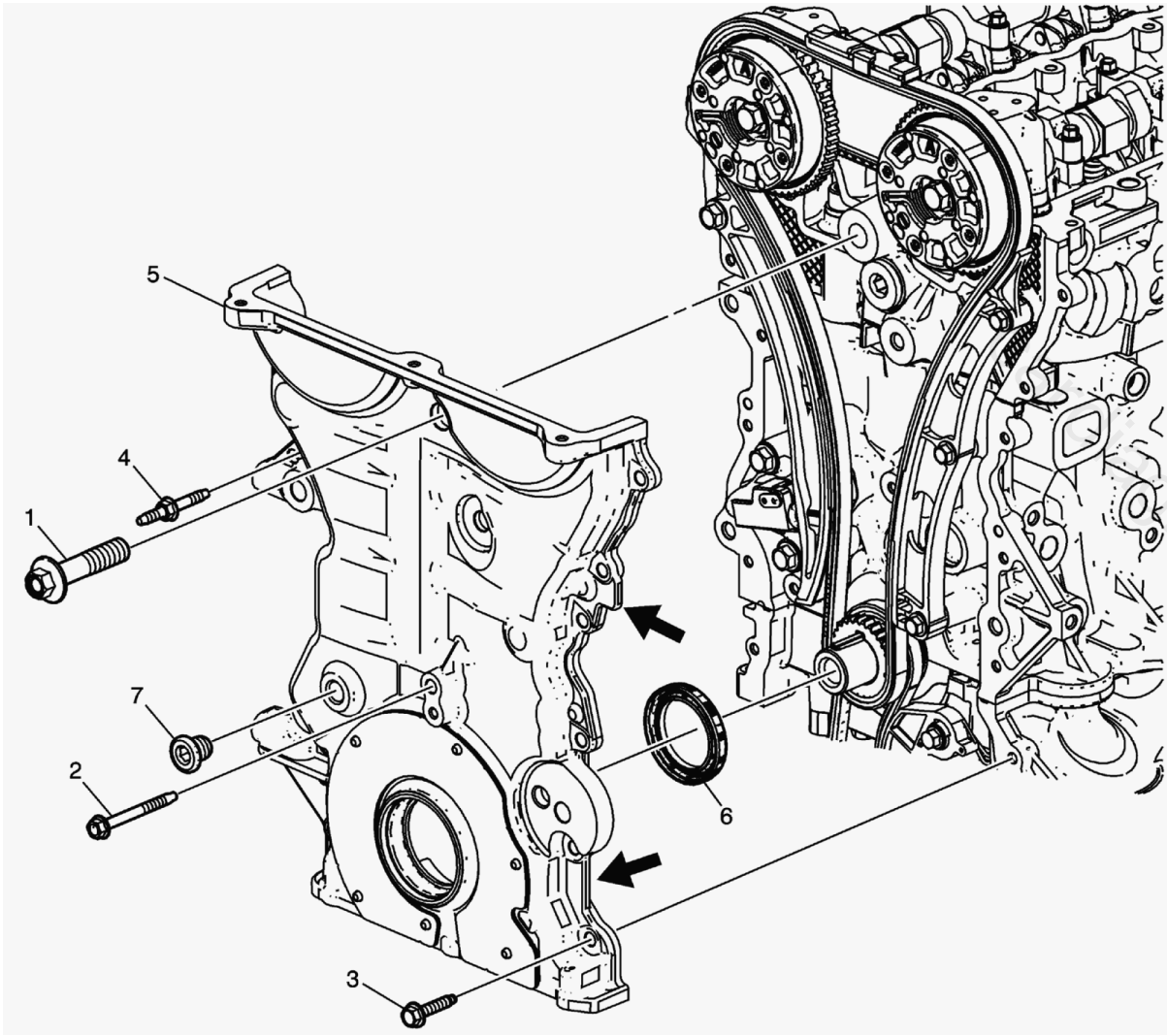


Fig. 377: Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Front Cover Bolt (Qty: 1)
2	Engine Front Cover Bolt (Qty: 1)
3	Engine Front Cover Bolt (Qty: 11)
4	Engine Front Cover Stud (Qty: 1)

Callout	Component Name
5	Engine Front Cover Procedure 1. Locate pry-points on the engine front cover to loosen the cover from the engine block. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 3. Clean and inspect the engine front cover mating surface.
6	Crankshaft Front Oil Seal Procedure Discard the seal. Special Tools EN-51096 Crankshaft Seal Remover For equivalent regional tools, refer to <u>Special Tools</u> .
7	Engine Front Cover Hole Plug

CAMSHAFT TIMING CHAIN REMOVAL

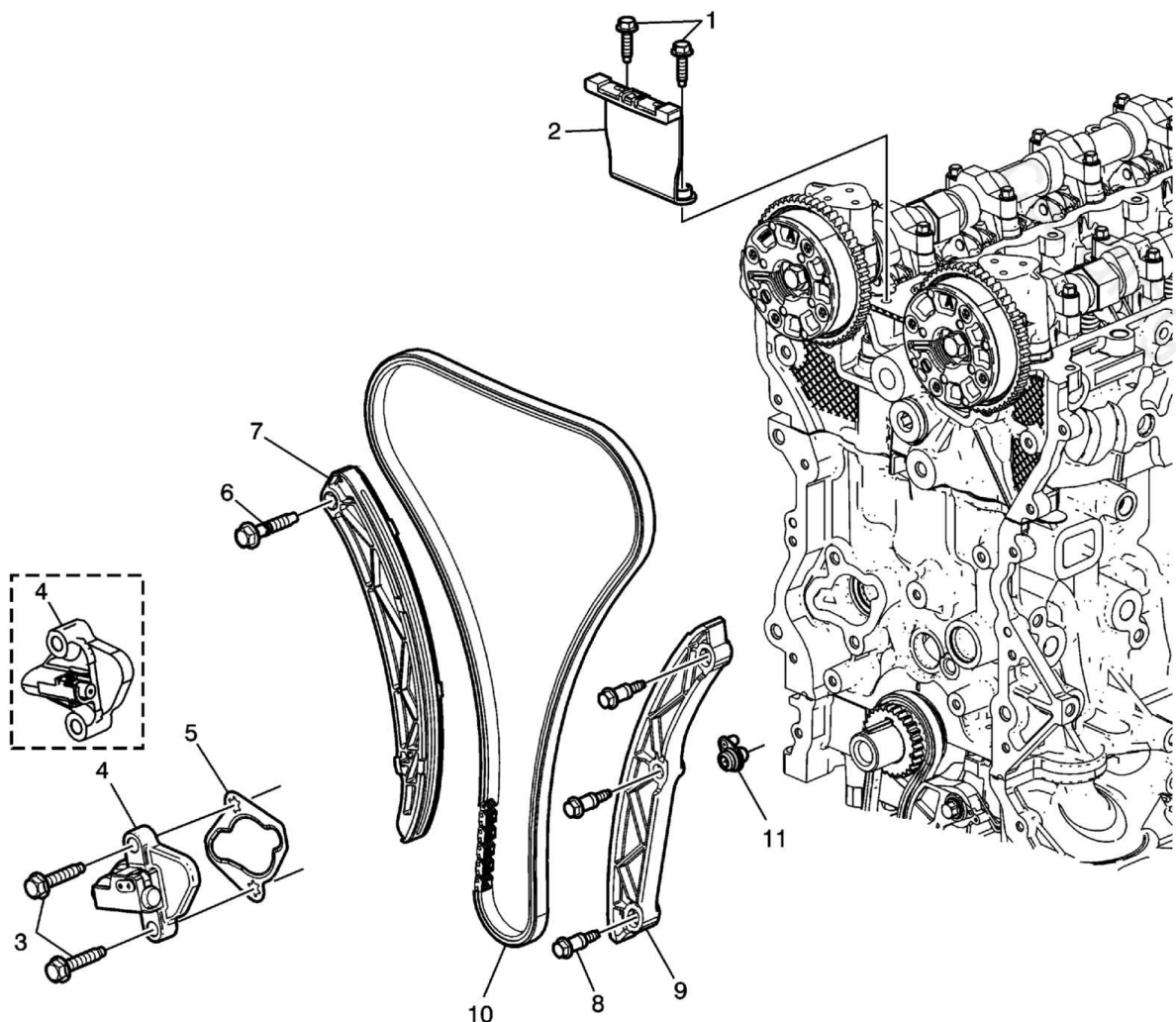


Fig. 378: Camshaft Timing Chain
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Guide Bolt (Qty: 2)
2	Timing Chain Guide - to Cylinder Head
3	Timing Chain Tensioner Bolt (Qty: 2)
4	Timing Chain Tensioner Assembly
5	Timing Chain Tensioner Gasket

Callout	Component Name
6	Timing Chain Tensioner Shoe Bolt (Qty: 1)
7	Timing Chain Tensioner Shoe Assembly
8	Timing Chain Guide Bolt (Qty: 3)
9	Timing Chain Guide - Exhaust Side
10	Timing Chain
11	Timing Chain Oil Nozzle

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

Camshaft Actuator Removal

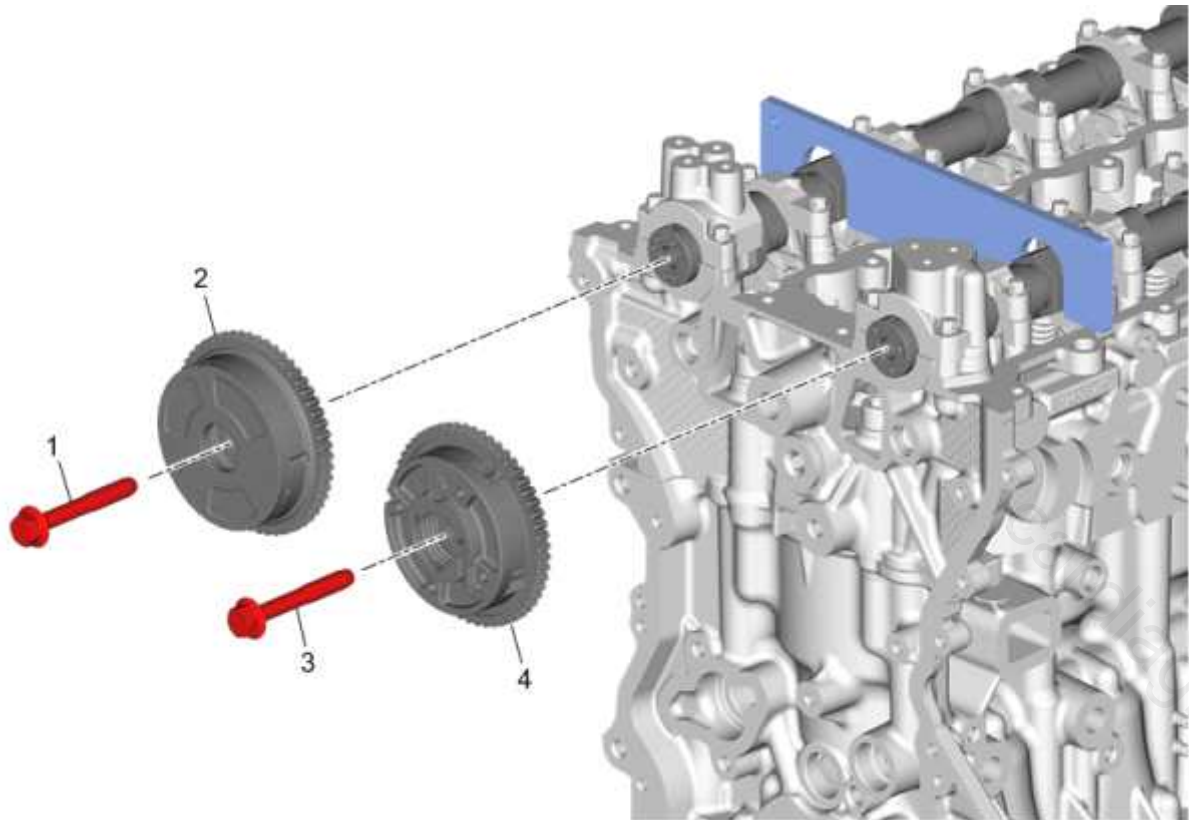


Fig. 379: Camshaft Actuator

Courtesy of GENERAL MOTORS COMPANY

Camshaft Actuator Removal

Callout	Component Name
Preliminary Procedure Install the EN-51367 camshaft locking tool.	
Special Tools EN-51367 Camshaft Locking Tool Equivalent regional tools: Special Tools .	
1	Camshaft Position Actuator Bolt NOTE: Discard the bolt.
2	Camshaft Position Actuator
3	Camshaft Position Actuator Bolt NOTE: Discard the bolt.
4	Camshaft Position Actuator

Camshaft Bearings and Camshaft Removal

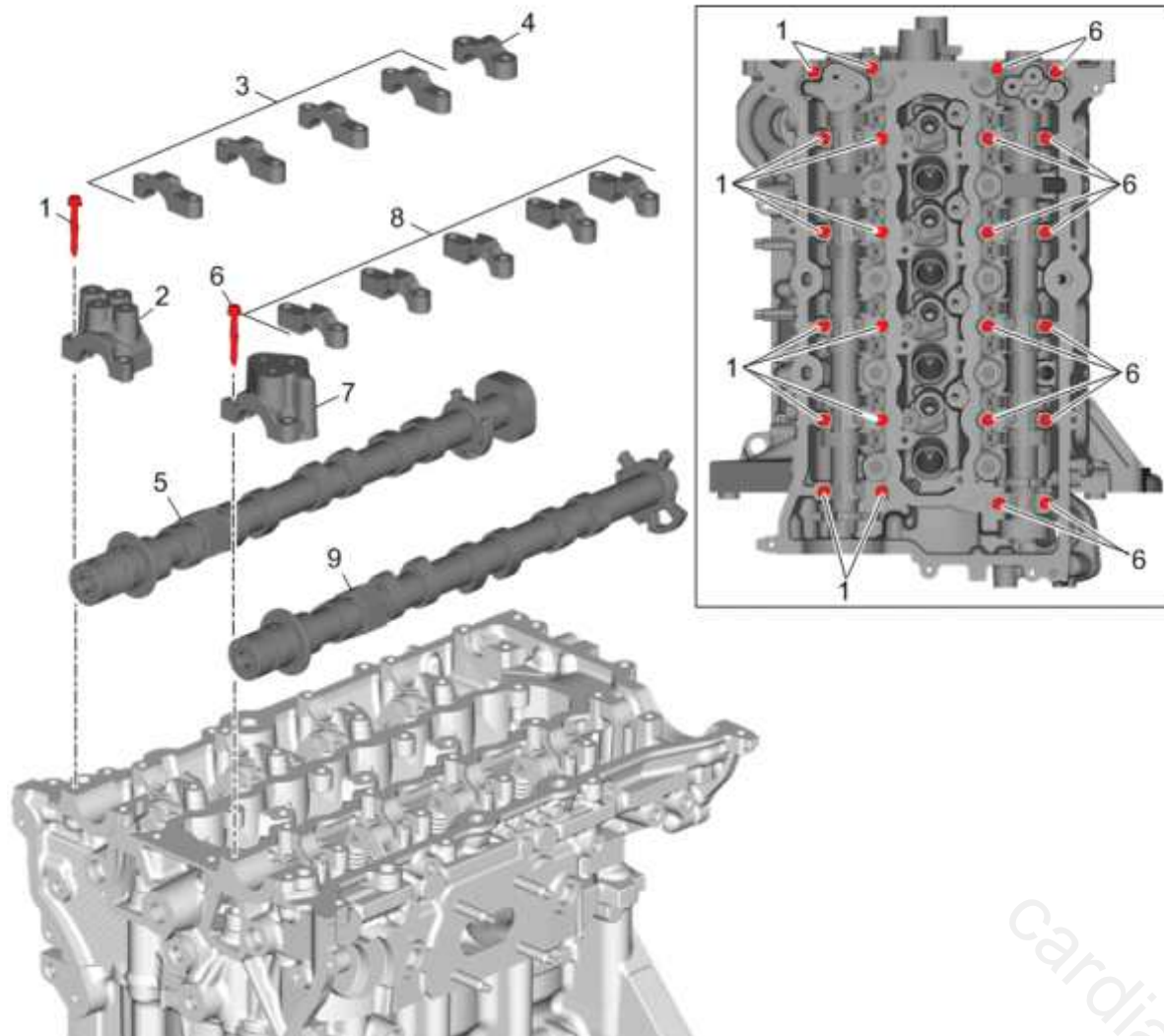


Fig. 380: Camshaft Bearings and Camshaft
Courtesy of GENERAL MOTORS COMPANY

Camshaft Bearings and Camshaft Removal

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.	
1	Camshaft Bearing Cap Bolt [12x] Procedure Loosen each bolt 1/2 turn to reduce spring pressure.
2	Camshaft Bearing Front Intake Cap
3	Camshaft Bearing Cap [4x] NOTE: Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location.
4	Camshaft Bearing Rear Cap

Callout	Component Name
5	Intake Camshaft
6	Camshaft Bearing Cap Bolt [12x] Procedure Loosen each bolt 1/2 turn to reduce spring pressure.
7	Camshaft Bearing Front Exhaust Cap
8	Camshaft Bearing Cap [5x] NOTE: Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location.
9	Exhaust Camshaft

Valve Rocker Arm and Lash Adjuster Removal

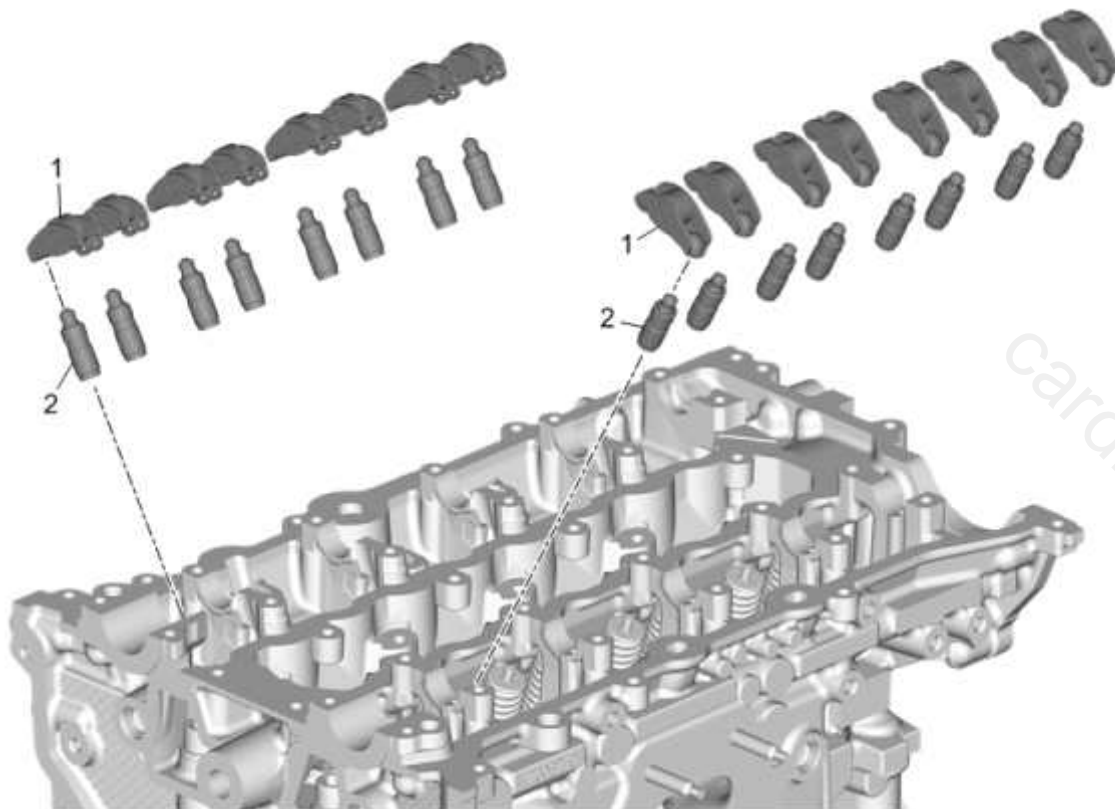


Fig. 381: Valve Rocker Arm and Lash Adjuster

Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm and Lash Adjuster Removal

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.	
1	Hydraulic Valve Lash Adjuster Arm [16x]
2	Hydraulic Valve Lash Adjuster [16x]

CYLINDER HEAD REMOVAL

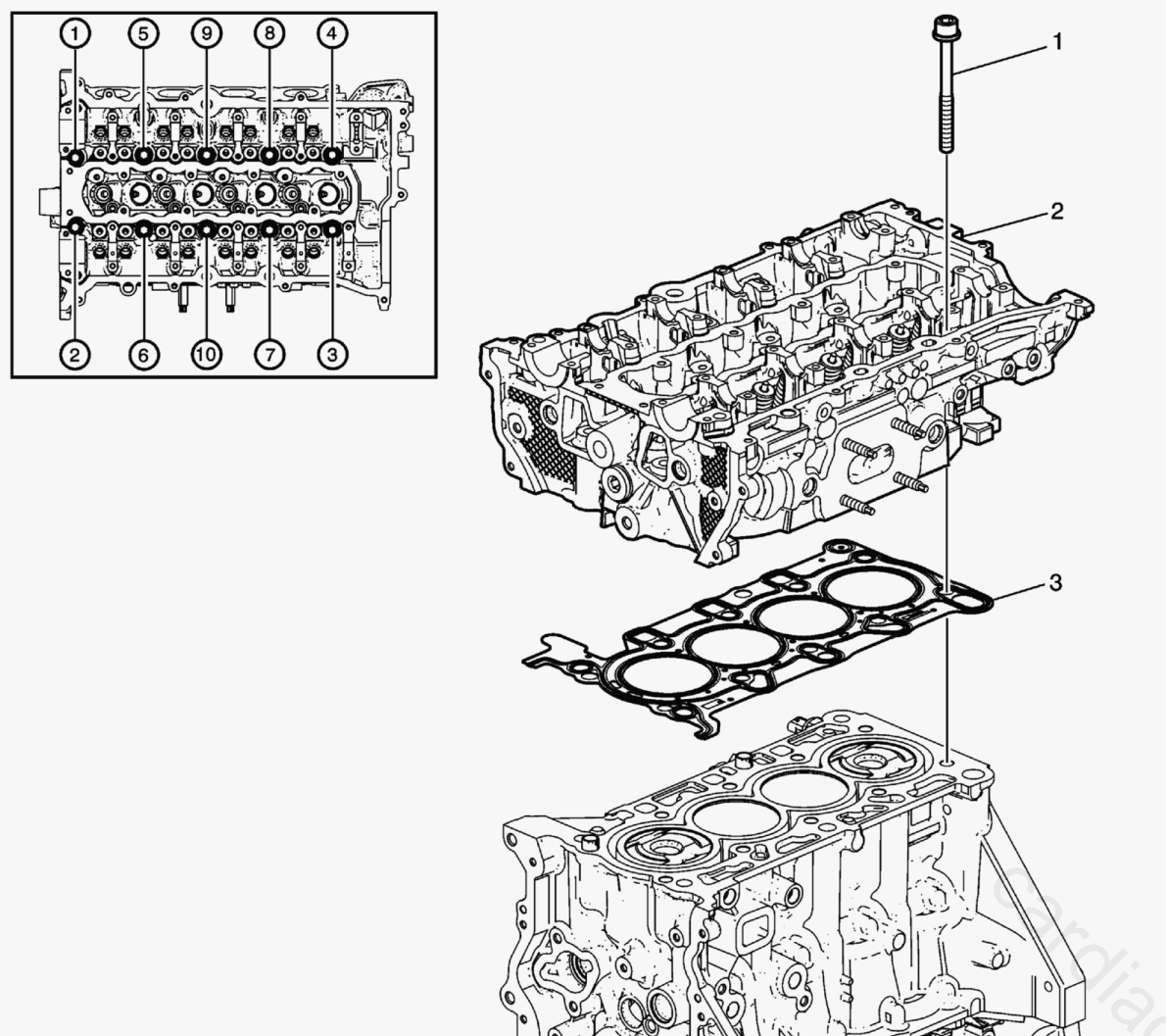


Fig. 382: Cylinder Head (With Loosening/Tightening Sequence)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Bolt (Qty: 10) Procedure Remove the bolts in sequence. Discard the bolts.
2	Cylinder Head Assembly
3	Cylinder Head Gasket

OIL PUMP DRIVE CHAIN AND OIL PUMP REMOVAL

Oil Pump Drive Chain and Crankshaft Sprocket Removal

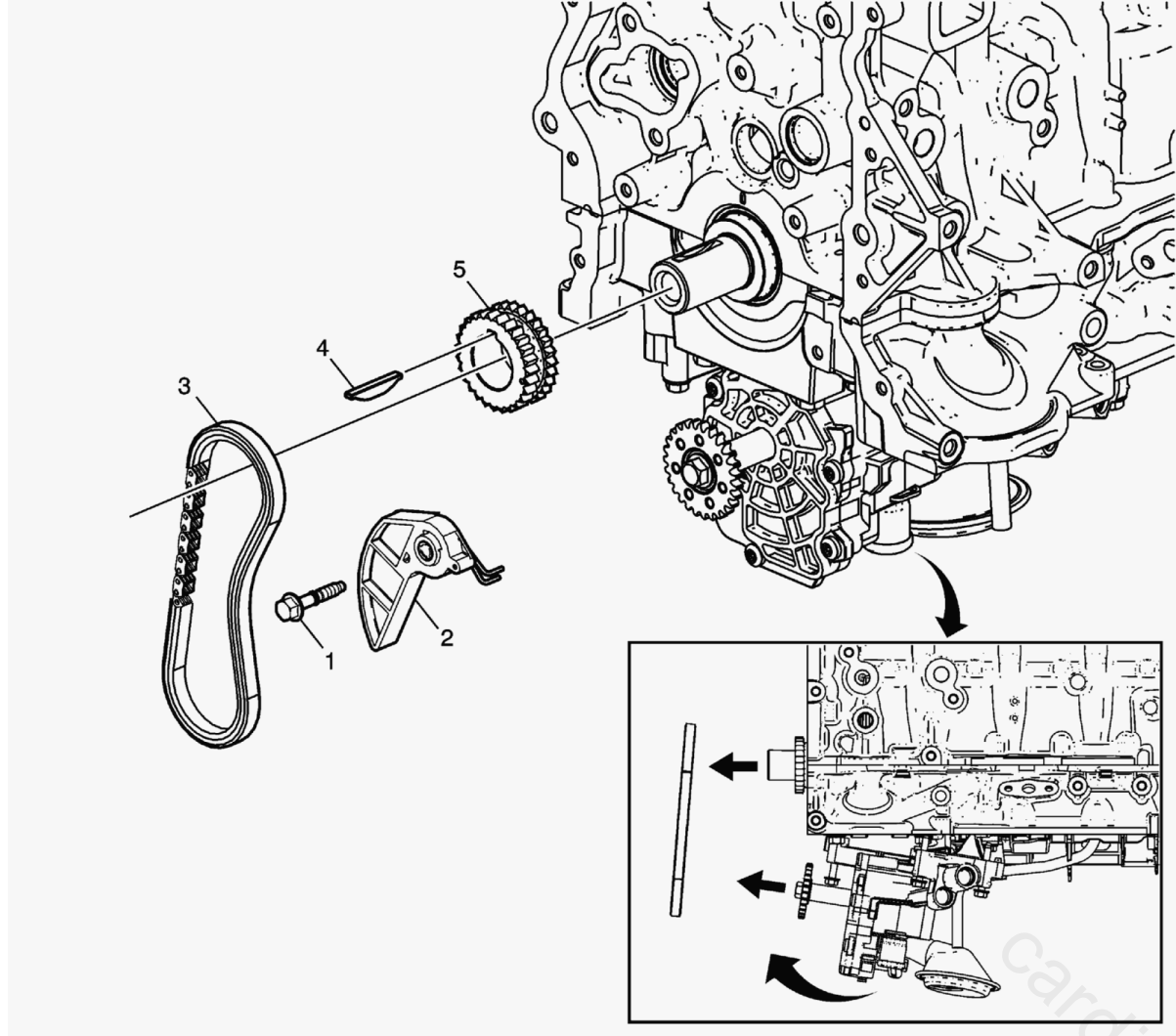


Fig. 383: Oil Pump Drive Chain and Crankshaft Sprocket
 Courtesy of GENERAL MOTORS COMPANY

Oil Pump Drive Chain and Crankshaft Sprocket Removal

Callout	Component Name
1	Oil Pump Drive Chain Tensioner Bolt
2	Oil Pump Drive Chain Tensioner
3	Oil Pump Drive Chain Procedure Loosen the oil pump assembly bolts and tilt the oil pump assembly in order to remove the drive chain.
4	Crankshaft Balancer Key
5	Crankshaft Sprocket

Oil Pump Assembly Removal

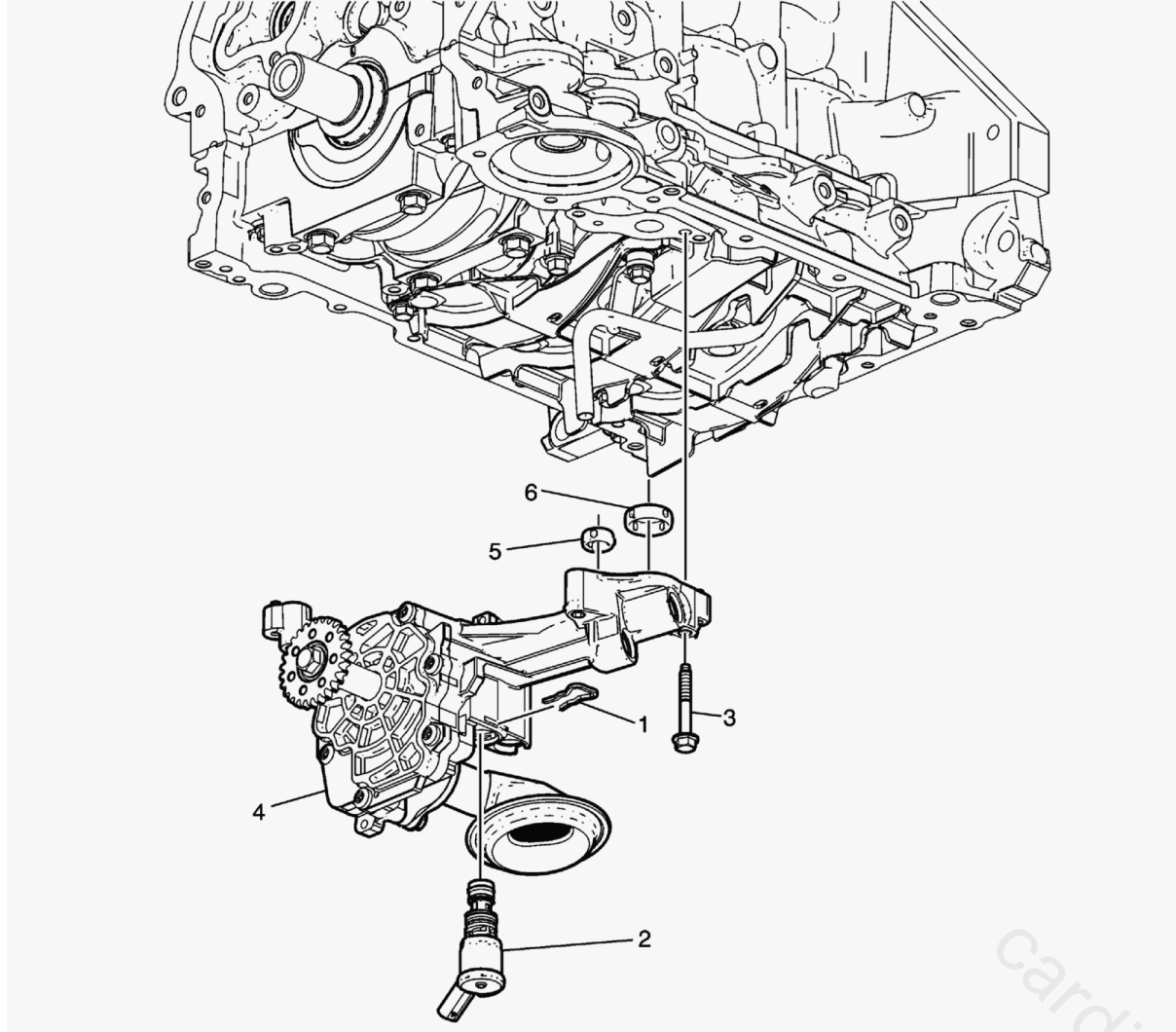


Fig. 384: Oil Pump Assembly

Courtesy of GENERAL MOTORS COMPANY

Oil Pump Assembly Removal

Callout	Component Name
1	Oil Pump Flow Control Solenoid Valve Retainer
2	Oil Pump Flow Control Solenoid Valve
3	Oil Pump Assembly Bolt (Qty: 4)
4	Oil Pump Assembly
5	Oil Pump Gasket
6	Oil Pump Gasket

CRANKSHAFT OIL DEFLECTOR REMOVAL

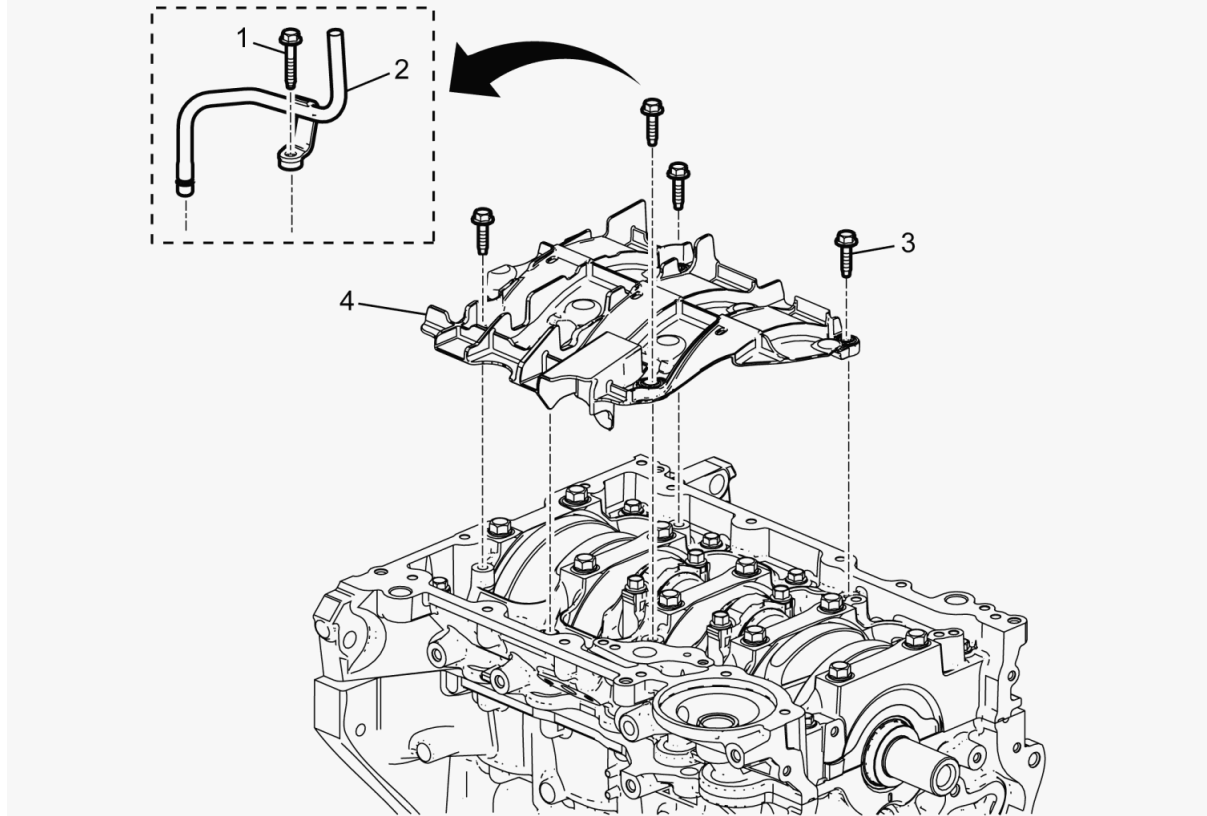


Fig. 385: Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt
2	Positive Crankcase Ventilation Oil Separator Drain Pipe
3	Crankshaft Oil Deflector Bolt (Qty: 3)
4	Crankshaft Oil Deflector

LOWER CRANKCASE REMOVAL

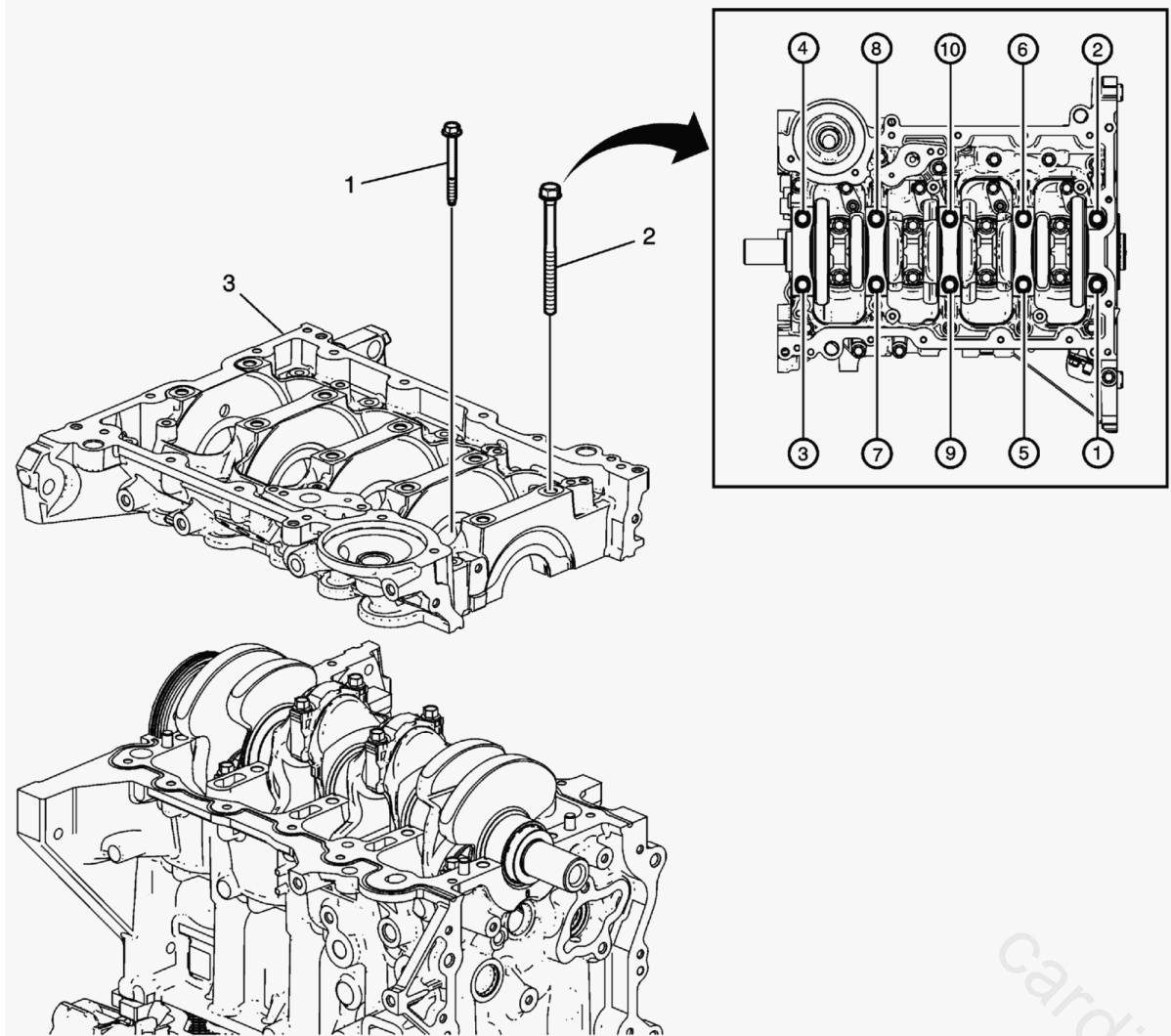


Fig. 386: Lower Crankcase (With Bolt Removal Sequence).

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Lower Crankcase Bolt - Perimeter (Qty: 13)
2	Lower Crankcase Bolt (Qty: 10) Procedure Remove bolts in sequence. Discard the bolts.
3	Lower Crankcase

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary. 3. Before removing the connecting rods, check the connecting rod side clearance using the following procedure: 1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer. 2. Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod. 3. The connecting rod side clearance should not exceed specifications. Refer to Engine Mechanical Specifications 4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to Piston, Connecting Rod, and Bearing Cleaning and Inspection. 5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod. 6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft. NOTE: An arrow/dot showing proper piston orientation is located on the top of the piston. 4. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine. CAUTION: Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed. 5. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.	
1	Connecting Rod Bolt (Qty: 8) CAUTION: Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage. Procedure DO NOT use the bolts for reinstallation. The bolts may be used to keep the parts together and for inspection and specification measurements.

Callout	Component Name
2	Connecting Rod Assembly (Qty: 4) NOTE: The connecting rod caps must remain with the original connecting rod. The caps must be oriented identical to original installation. Procedure Mark the side of the rod with a line that crosses the interface of the rod and cap. Use this line to ensure that the cap and rod are reinstalled in the same orientation.
3	Connecting Rod Bearing (Qty: 4) NOTE: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.
4	Connecting Rod Bearing (Qty: 4) NOTE: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.
5	Connecting Rod Assembly (Qty: 4) NOTE: Piston assembly attached. Procedure Using the EN-51454 guides, push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly. Special Tools EN-51454 Connecting Rod Guides For equivalent regional tools, refer to Special Tools.

CRANKSHAFT AND BEARING REMOVAL

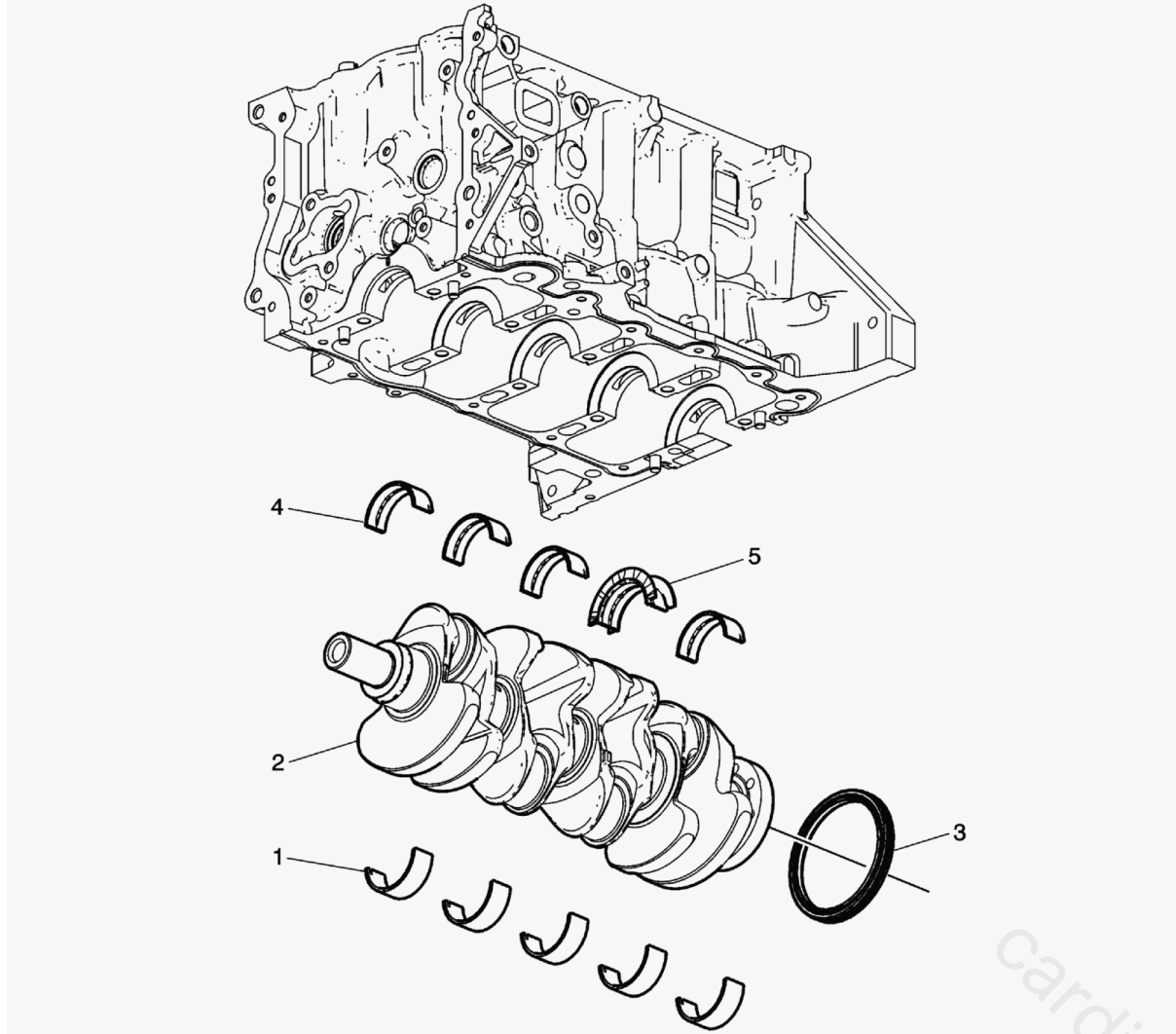


Fig. 388: Crankshaft and Bearing

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Lower Bearing (Qty: 5) NOTE: • Crankshaft bearings MUST be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use. • If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.
2	Crankshaft Assembly
3	Crankshaft Rear Oil Seal
4	Crankshaft Upper Bearing (Qty: 4)
5	Crankshaft Thrust Upper Bearing

CYLINDER HEAD DISASSEMBLE

Intake and Exhaust Valve Removal

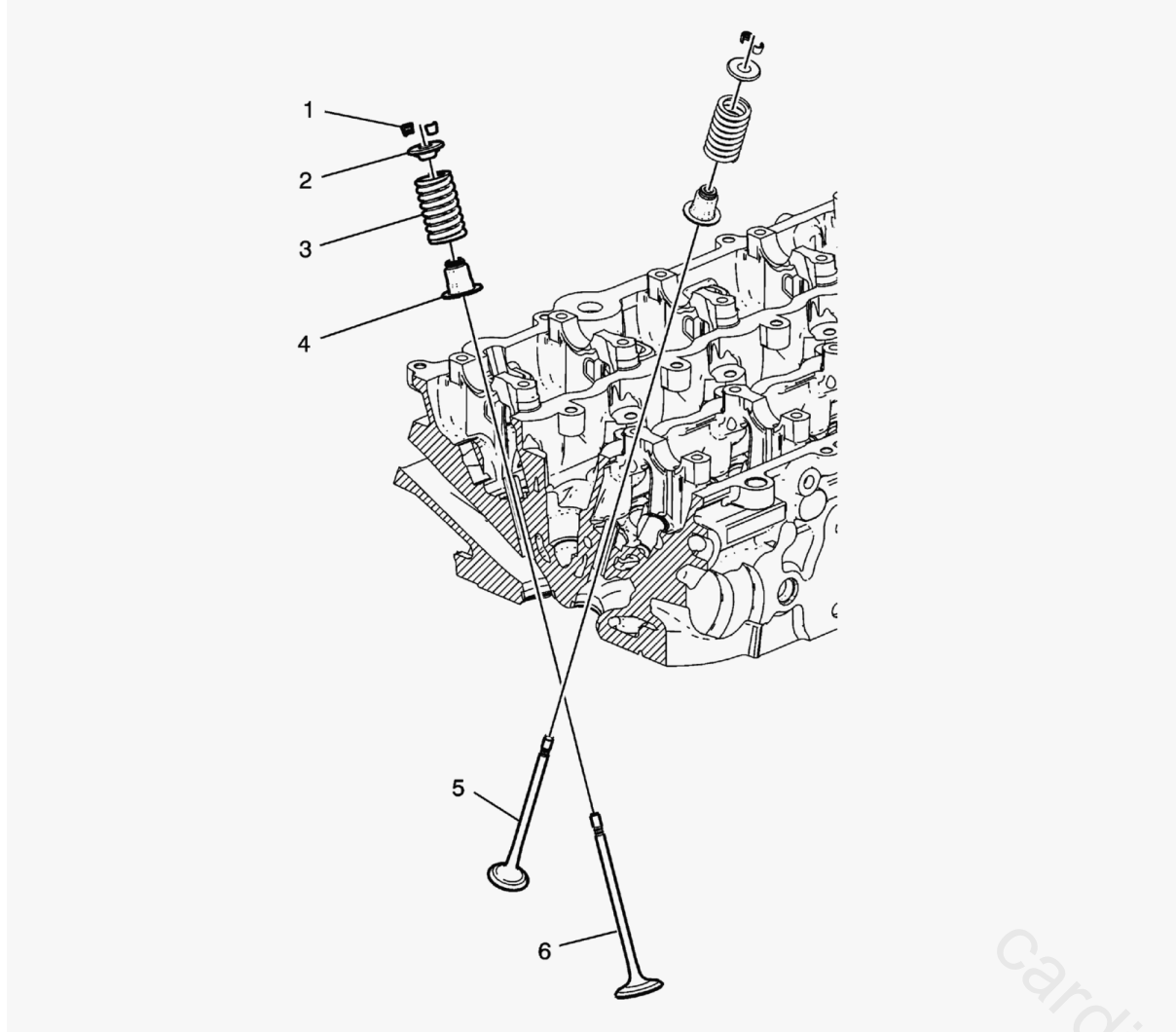


Fig. 389: Intake and Exhaust Valve

Courtesy of GENERAL MOTORS COMPANY

Intake and Exhaust Valve Removal

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.	

Callout	Component Name
1	Valve Stem Key - Intake, Exhaust (Qty: 32) WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury. CAUTION: Do not compress the valve springs less than 25.0 mm (0.984 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage. Procedure 1. Using the EN-8062 compressor and the EN-43963 compressor adapter, compress the valve spring. 2. Remove the valve stem keys. Special Tools • EN-8062 Valve Spring Compressor • EN-43963 Valve Spring Compressor - Off-Car Adapter • EN-50717 Compressor Adapter For equivalent regional tools, refer to Special Tools.
2	Valve Spring Retainer (Qty: 16) Procedure 1. Slowly release the EN-8062 compressor and the EN-43963 compressor adapter from the valve spring assembly. 2. Remove the valve spring retainer.
3	Valve Springs (Qty: 16)
4	Valve Stem Oil Seal (Qty: 16) CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file. Procedure Using EN-46116 remover, remove the seals. Discard all used seals and replace with new. Special Tools EN-46116 Valve Seal Remover For equivalent regional tools, refer to Special Tools.
5	Exhaust Valve (Qty: 8)
6	Intake Valve (Qty: 8)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
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The first two papers by K. A. Brown and J. R. Brown (1990) and by M. L. Anderson et al. (1990) are concerned with the effects of the physical environment on the behavior of the fish. The third paper by S. E. Schmitt and D. W. Schmitt (1990) describes the effects of the social environment on the behavior of the fish. The fourth paper by J. R. Brown and K. A. Brown (1990) describes the effects of the physical environment on the behavior of the fish. The fifth paper by M. L. Anderson et al. (1990) describes the effects of the social environment on the behavior of the fish. The sixth paper by S. E. Schmitt and D. W. Schmitt (1990) describes the effects of the physical environment on the behavior of the fish. The seventh paper by J. R. Brown and K. A. Brown (1990) describes the effects of the social environment on the behavior of the fish. The eighth paper by M. L. Anderson et al. (1990) describes the effects of the physical environment on the behavior of the fish. The ninth paper by S. E. Schmitt and D. W. Schmitt (1990) describes the effects of the social environment on the behavior of the fish. The tenth paper by J. R. Brown and K. A. Brown (1990) describes the effects of the physical environment on the behavior of the fish.

Callout	Component Name
	Engine Oil Manifold Check Valve (Qty: 2)
	Procedure 1. Inspect the oil feed check valves. Damaged, restricted or clogged check valves must be replaced. If check valves are OK, disregard remaining steps which detail replacing the check valves. 2. Insert a punch or drift into the check valve. With moderate pressure, seat the punch into the inner body of the check valve, and remove the upper part of the valve. 3. Remove check ball and check ball spring from inside of check valve. 4. Using EN-46122-3 drill bit, drill the remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve. 5. Lubricate EN-46122-4 tap with lubricant. Tap drilled out portion of check valve remaining in cylinder head. Tap to full depth possible until tap bottoms out in head. 6. Assemble EN-46122-2 bolt, nut, washers, and collar. Position collar with slightly-larger inside diameter DOWN toward the cylinder head. 7. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer. 8. Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve is removed from the cylinder head. 9. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.
1	
	Special Tools EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer For equivalent regional tools, refer to Special Tools .
2	Cylinder Head Core Hole Plug (Qty: 4)
3	Spark Plug (Qty: 4)
4	Cylinder Head Core Hole Plug
5	Cylinder Head Core Hole Plug (Qty: 4)
6	Double End Stud - Cylinder Head to Turbocharger (Qty:4)
7	Cylinder Head Oil Restrictor Plug
8	Cylinder Head Core Hole Plug

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **EN-22738-B** Valve Spring Tester
- **EN-28410** Gasket Remover
- **GE-7872** Magnetic Base Dial Indicator

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

Cylinder Head and Gasket Surface Cleaning and Inspection

1. 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
2. Inspect the fuel injector bores and clean, if required. Refer to [Fuel Injector and Fuel Injector Bore Cleaning and Inspection](#).
3. Inspect the cylinder head gasket surface.
 - Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
 - Replace the cylinder head if the area between the valve seats is cracked (2).
 - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).
4. Ensure proper use of room temperature vulcanizing (RTV) sealant. Properly clean all RTV surfaces, Refer to [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#).

NOTE: 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. Remove any old thread sealant, gasket material or sealant using **EN-28410** remover.
7. Clean all cylinder head surfaces with non-corrosive solvent.
8. Blow out all the oil galleries using compressed air.
9. Clean any debris or build-up from the lifter pockets.
10. Clean the valve guides.
11. Clean the threaded holes. Use a nylon bristle brush.
12. Clean the remains of the sealer from the plug holes.
13. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

NOTE: Do not attempt to weld the cylinder head, replace it.

14. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.
15. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
16. Inspect the sealing surfaces.
17. Inspect the cylinder head plugs and verify the oil orifice is clear and free of debris.

Valve Cleaning and Inspection

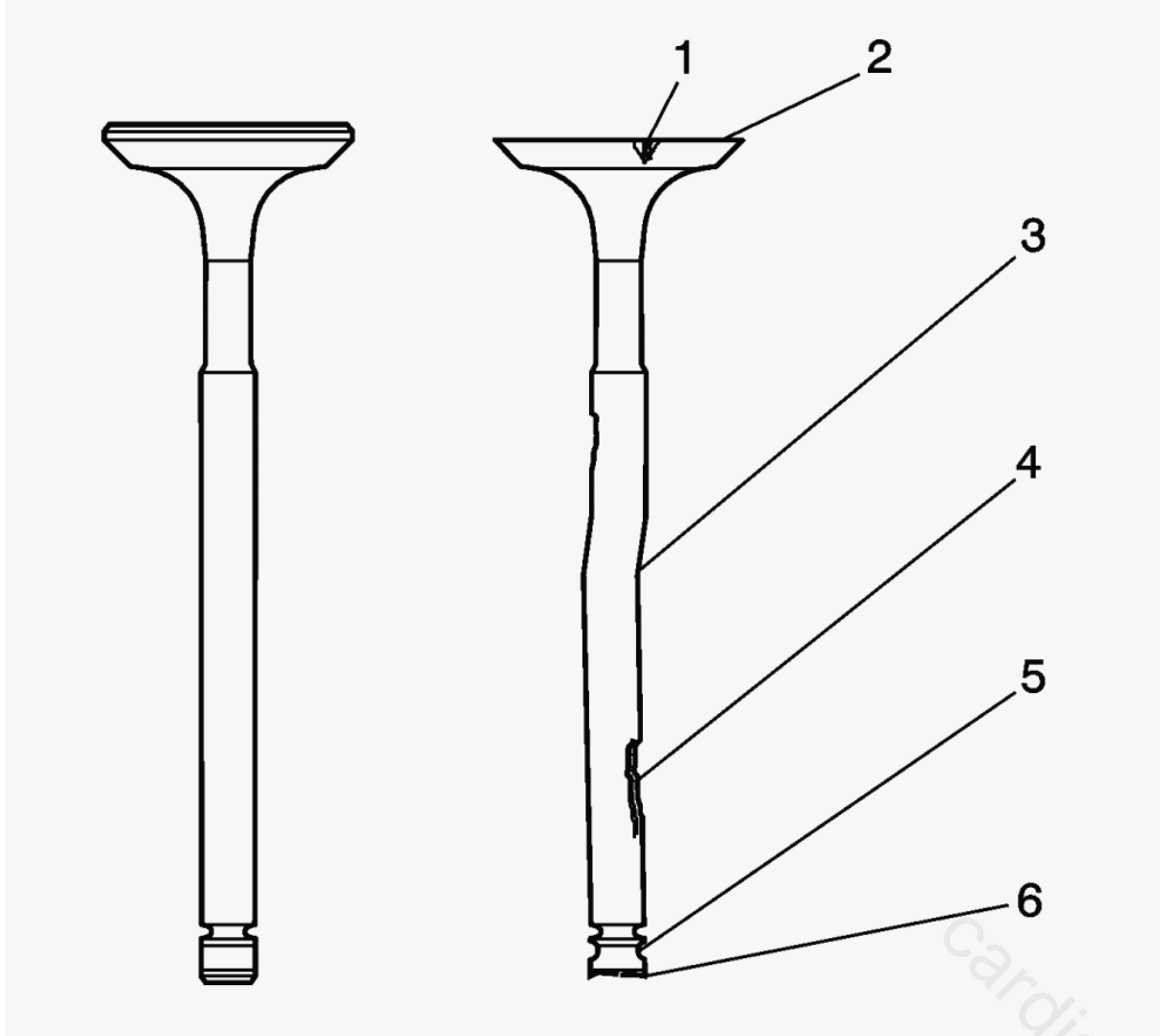


Fig. 391: Valve Inspection Areas

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not use a wire brush on any part of the valve stem.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

1. Clean the valves of carbon, oil and varnish. Use a soft bristle wire brush to clean any carbon build-up from the valve head. Varnish can be removed by soaking in Parts Immersion Solvent or equivalent. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
2. Clean the valve guides.
3. Inspect the valve stem for pitting or wear (4).
4. Inspect the valve key groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness (3) and the valve head for bending or distortion using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. Replace the valve if the valve head O.D. and chamfer (2) is worn or out of specification. Refer to [Valve and Seat Grinding](#).
11. The valves may be lightly lapped to the valve seats.
12. Replace the valve if the valve tip (6) is worn.

13. If no apparent wear, pitting, grooving, or distortion is present, perform the valve measurement and reconditioning procedure to verify valve specification. Refer to [Valve and Seat Grinding](#).

Valve Guide Measurement

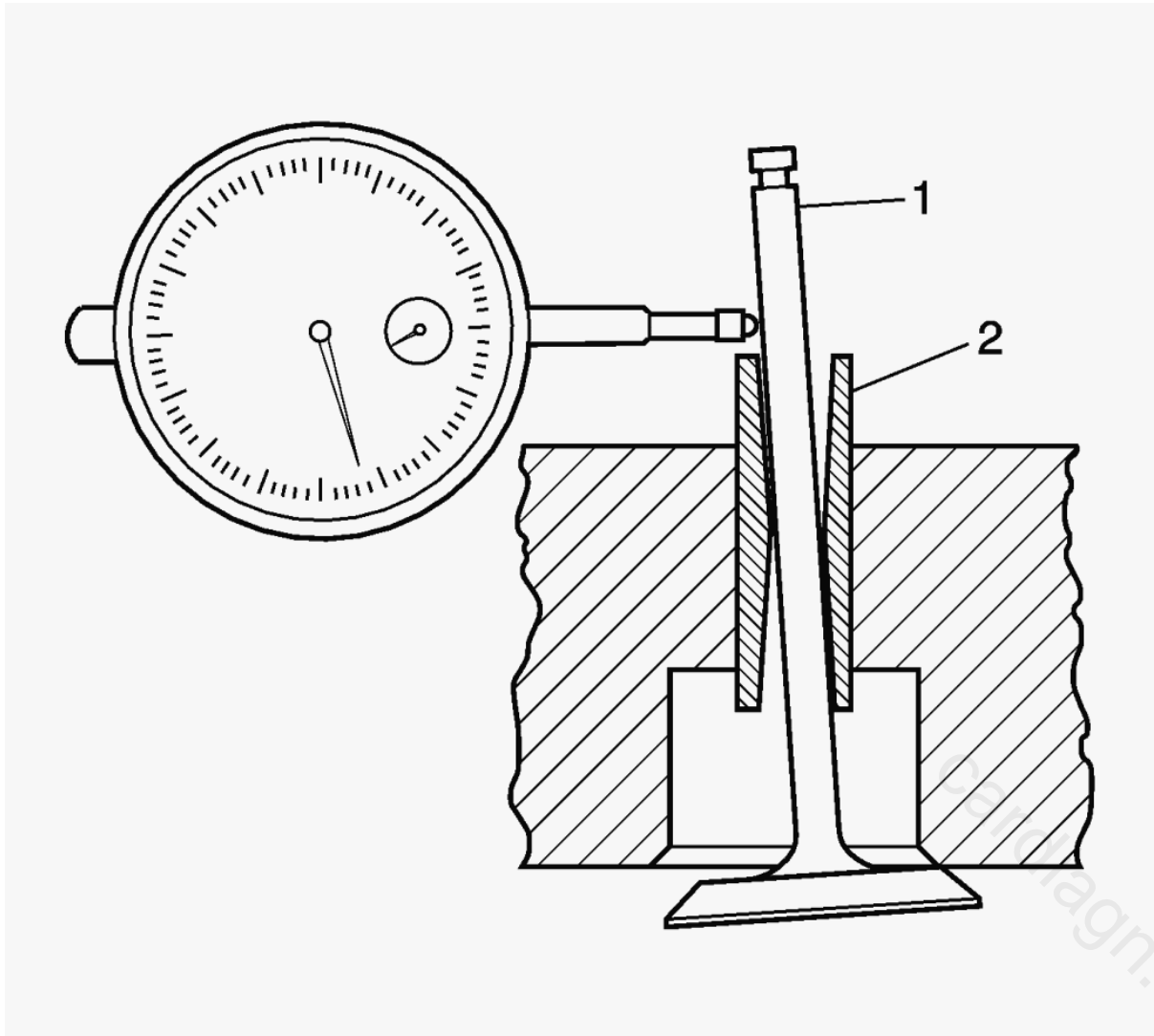


Fig. 392: Inspecting For Excessive Valve Stem To Guide Clearance

Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **GE-7872** indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to [Engine Mechanical Specifications](#) for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

1. Clean the valve springs in solvent.

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

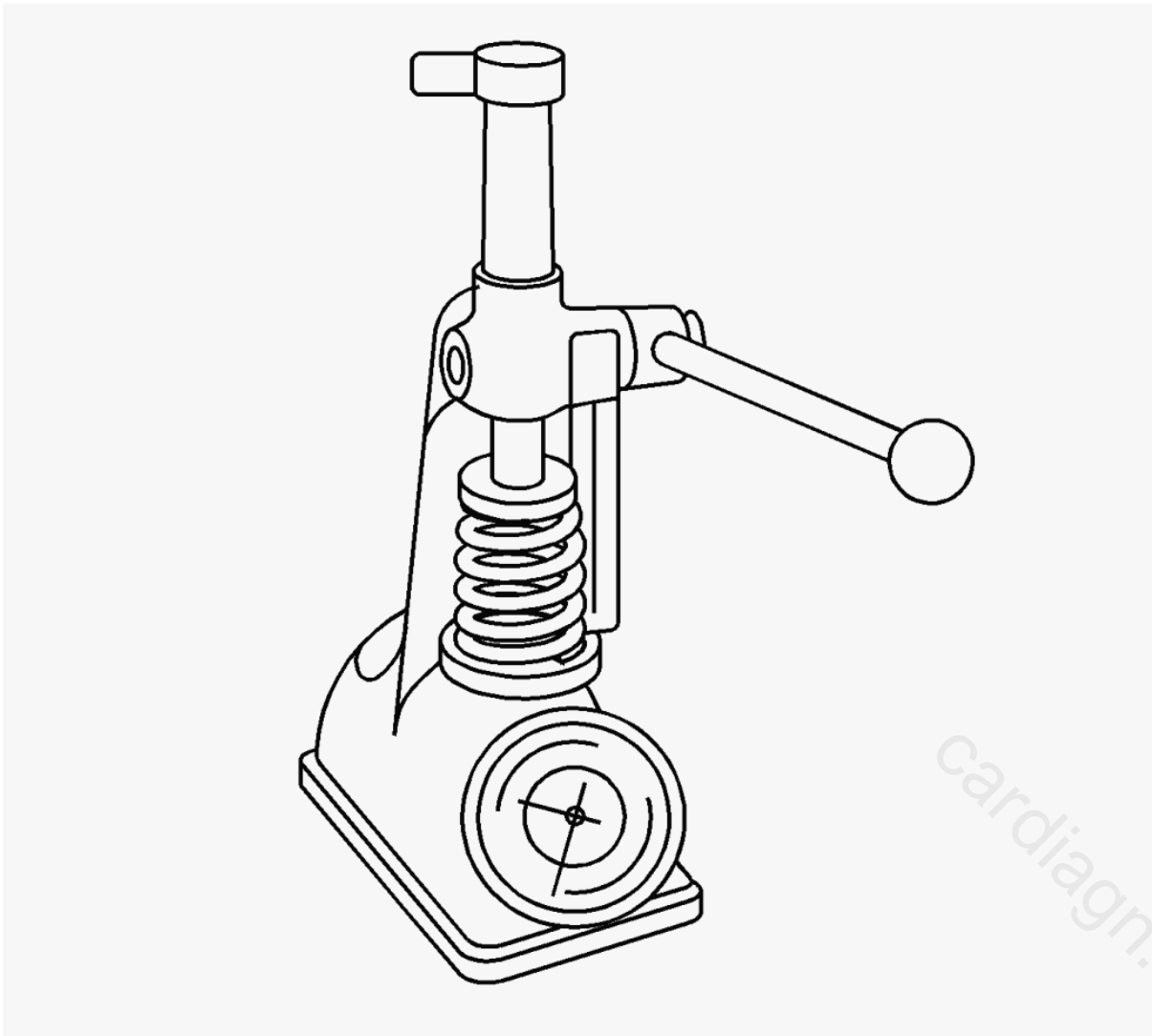


Fig. 393: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS COMPANY

4. Measure the valve spring tension using the **EN-22738-B** tester. Refer to [Engine Mechanical Specifications](#)
5. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

Valve Rocker Arm Cleaning and Inspection

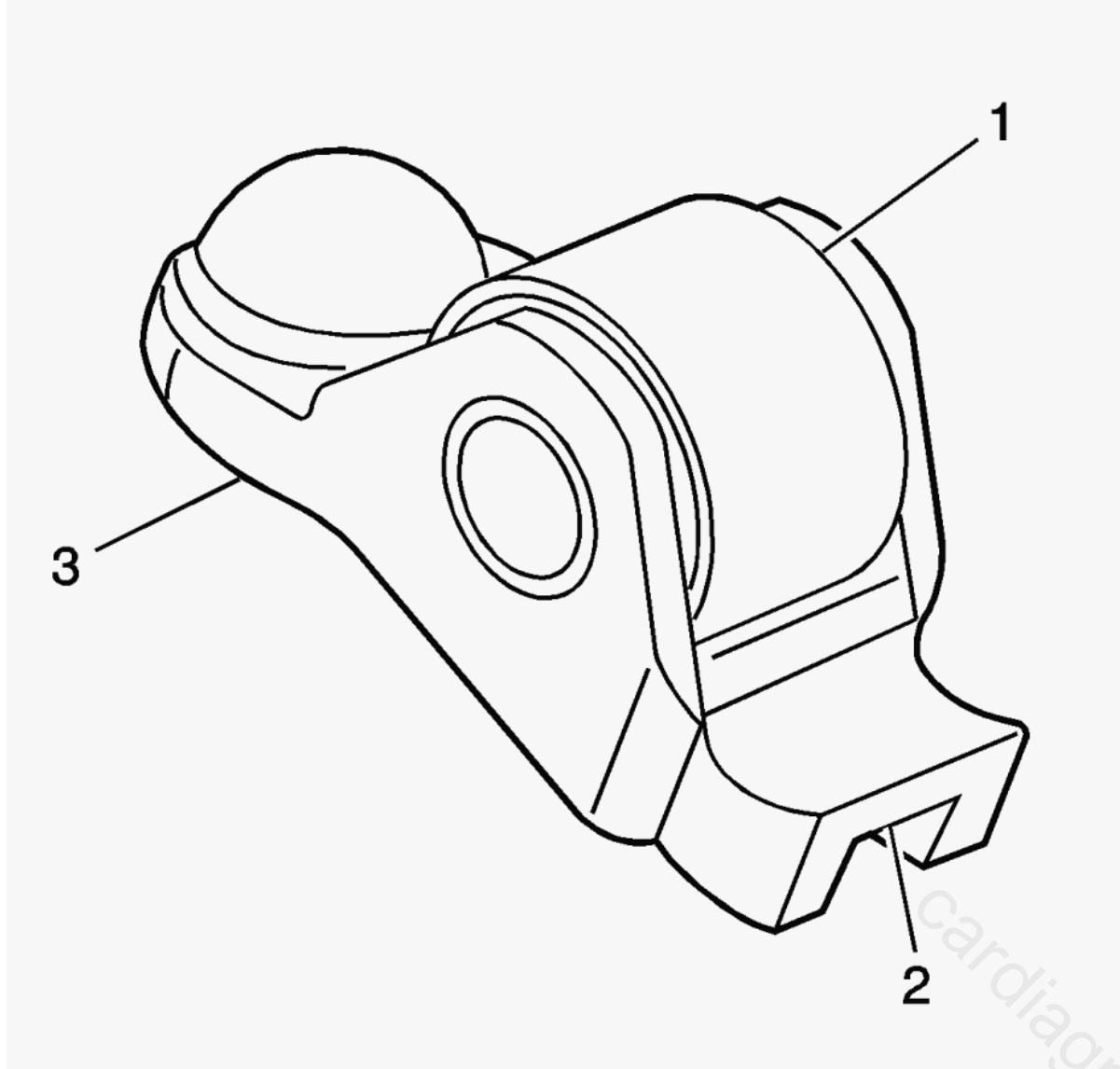


Fig. 394: Inspecting Valve Rocker Arms

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft follower roller (1) for the following:
 - Flat spots
 - Excessive scoring and pitting
 - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

Cylinder Head Deck Flatness Inspection

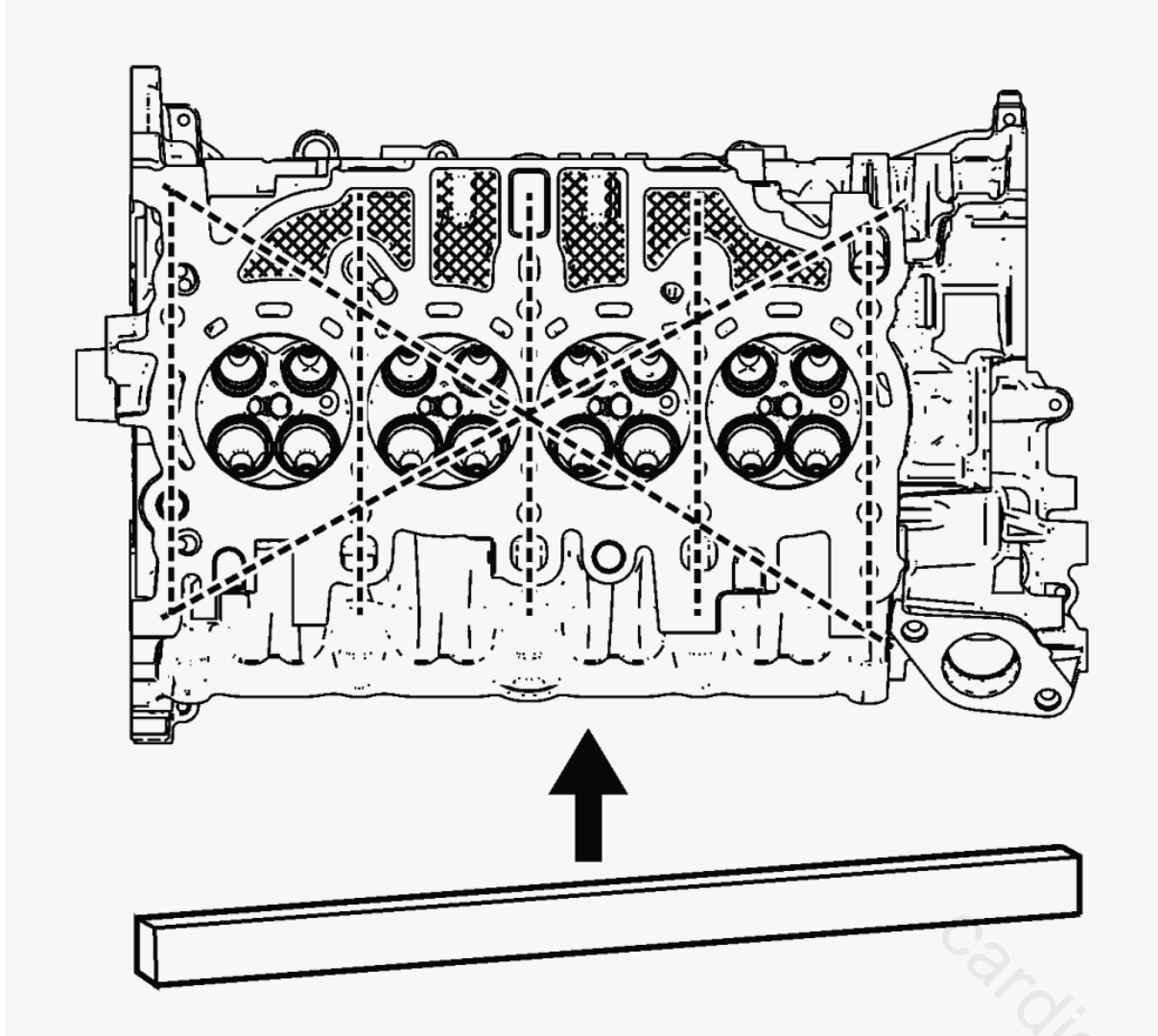


Fig. 395: Inspecting Cylinder Head Deck Surface For Flatness

Courtesy of GENERAL MOTORS COMPANY

1. Ensure the cylinder head decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Using a straight-edge placed diagonally across the deck surface, measure the cylinder head deck surface for flatness using a feeler gauge. Refer to [Engine Mechanical Specifications](#).
4. If the cylinder head deck flatness is more than the specified amount, replace the cylinder head.

Cylinder Head Deck Height Measurement

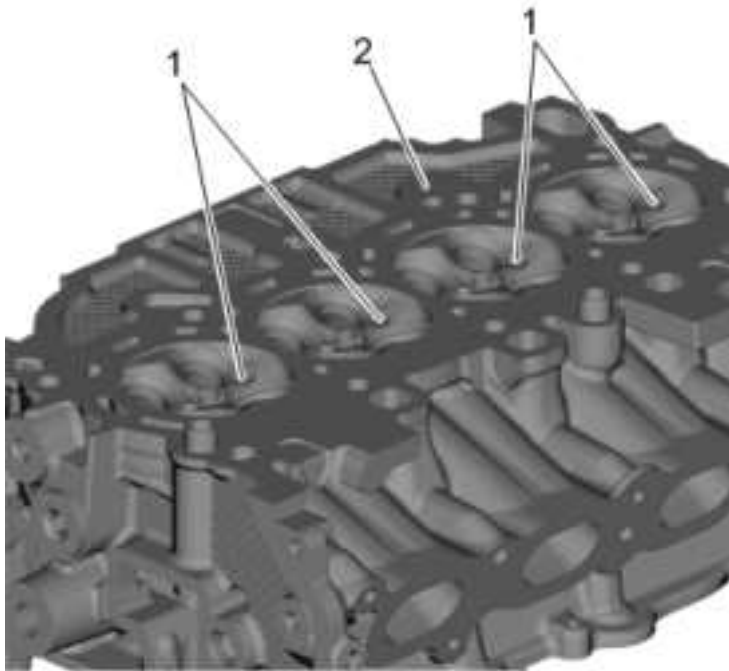


Fig. 396: Cylinder Head Deck Height
Courtesy of GENERAL MOTORS COMPANY

Overall deck height is measured by calculating the average deck height measurement from the 4 pad locations (1) to the deck surface (2), refer to [Engine Mechanical Specifications](#) for deck height specification.

Camshaft Cap Bore Measurement

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

CAUTION: Refer to [Fastener Caution](#) .

2. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
3. Measure the camshaft cap bores using an inside micrometer, refer to [Engine Mechanical Specifications](#) for camshaft cap bore diameter.
4. If camshaft cap bores do not meet specification the cylinder head must be replaced.

Camshaft Cap Bore Alignment

1. Ensure the camshafts are serviceable. Refer to [Camshaft Cleaning and Inspection](#).
2. Inspect the cylinder head camshaft bore surfaces for any imperfections or scratches that could inhibit proper camshaft clearances.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to 10 N.m (89 lb in).
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not turn freely, the cylinder head must be replaced.

VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure

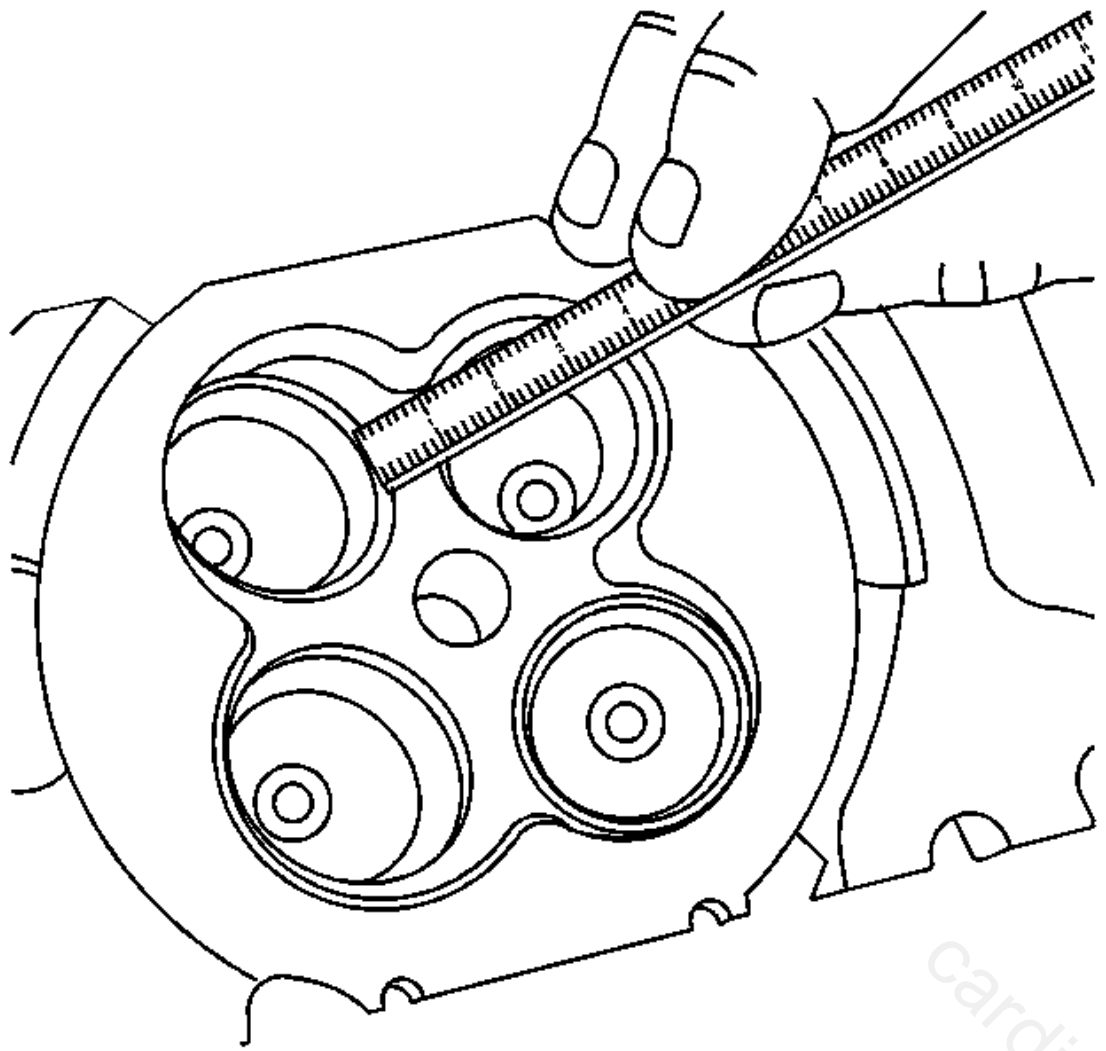


Fig. 397: Checking Valve Seat Width

Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve seat width in the cylinder head using a proper scale.

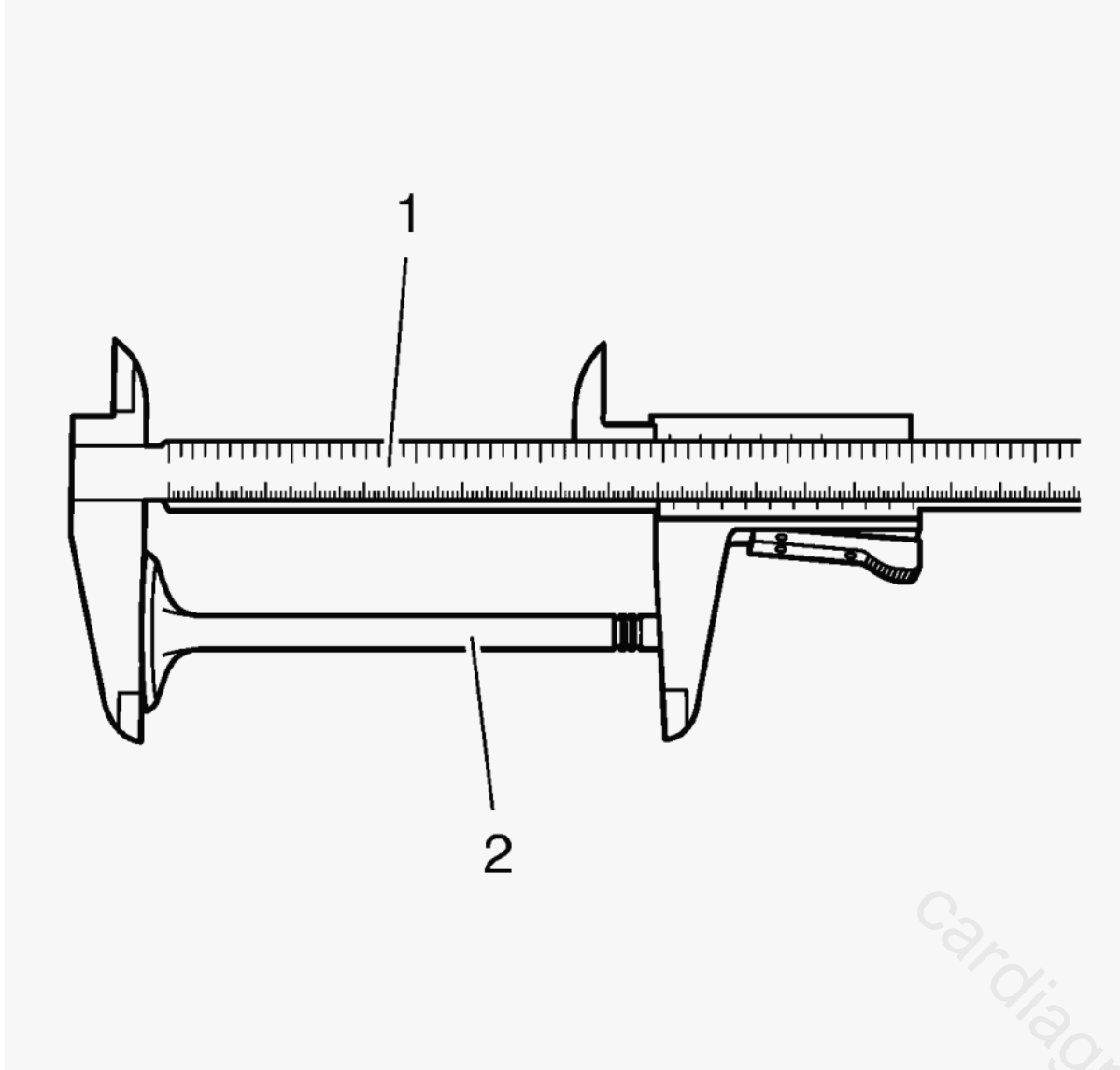


Fig. 398: Measuring Valve Length Using Slide Gauge
Courtesy of GENERAL MOTORS COMPANY

2. Measure the valve length (2). Use a slide gauge (1). Refer to [Engine Mechanical Specifications](#).

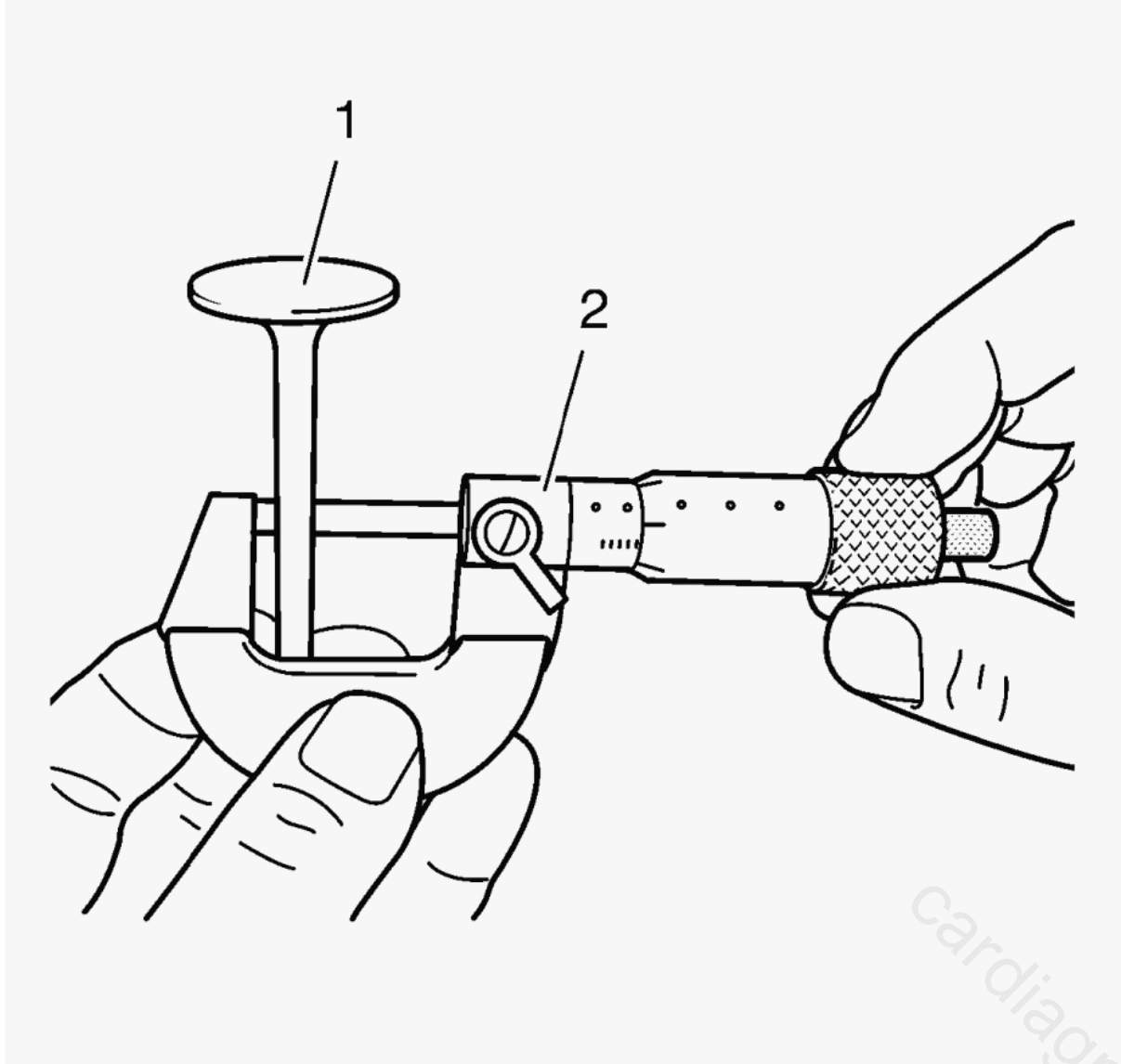


Fig. 399: Measuring Valve Stem Diameter Using Micrometer Gauge
Courtesy of GENERAL MOTORS COMPANY

3. Measure the valve stem diameter (1). Use a micrometer gauge (2). Refer to [Engine Mechanical Specifications](#).

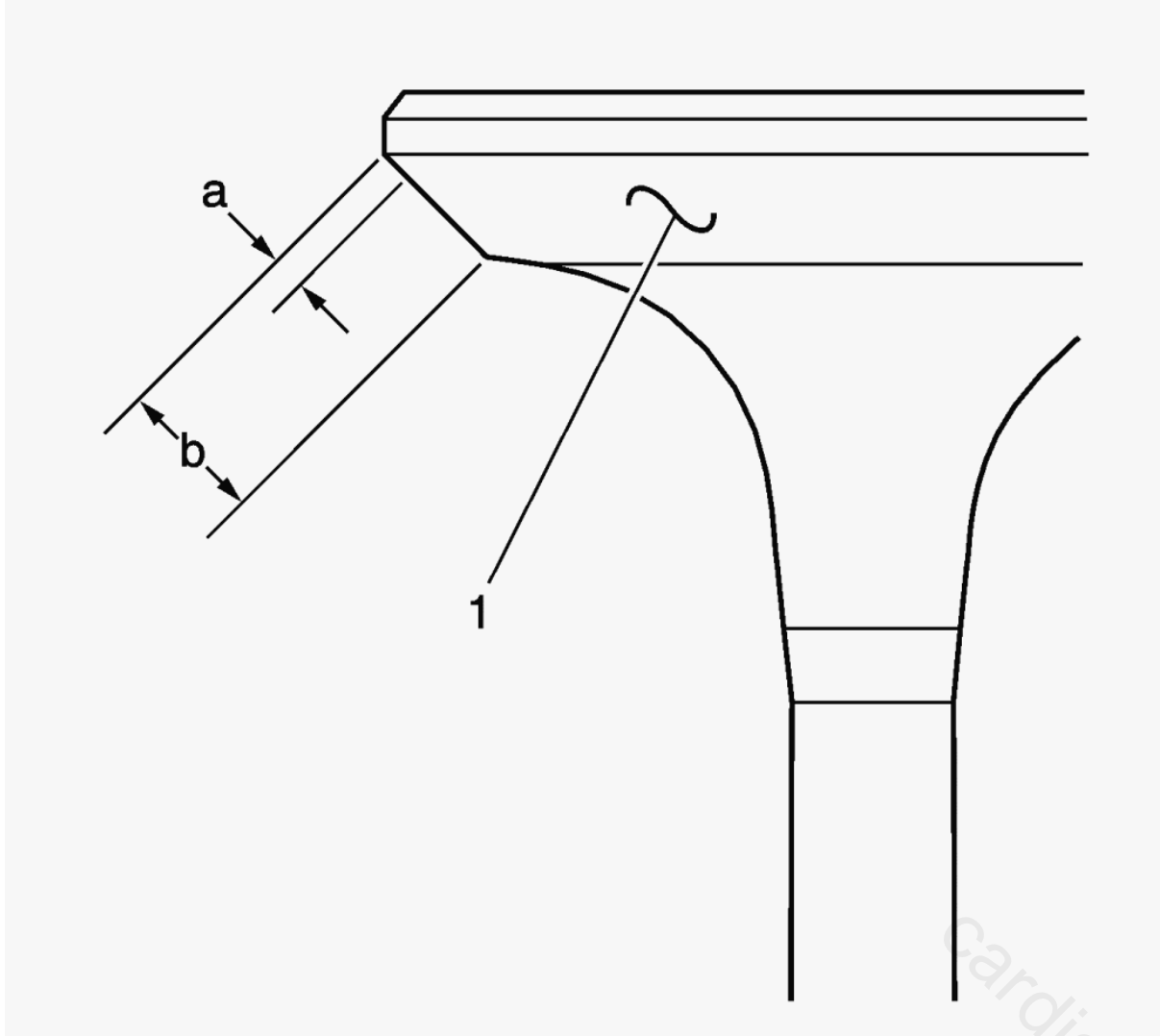


Fig. 400: Valve Face Seat Width

Courtesy of GENERAL MOTORS COMPANY

4. Measure the seat width (b) on the valve face (1) using a proper scale.

NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

5. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
6. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
7. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

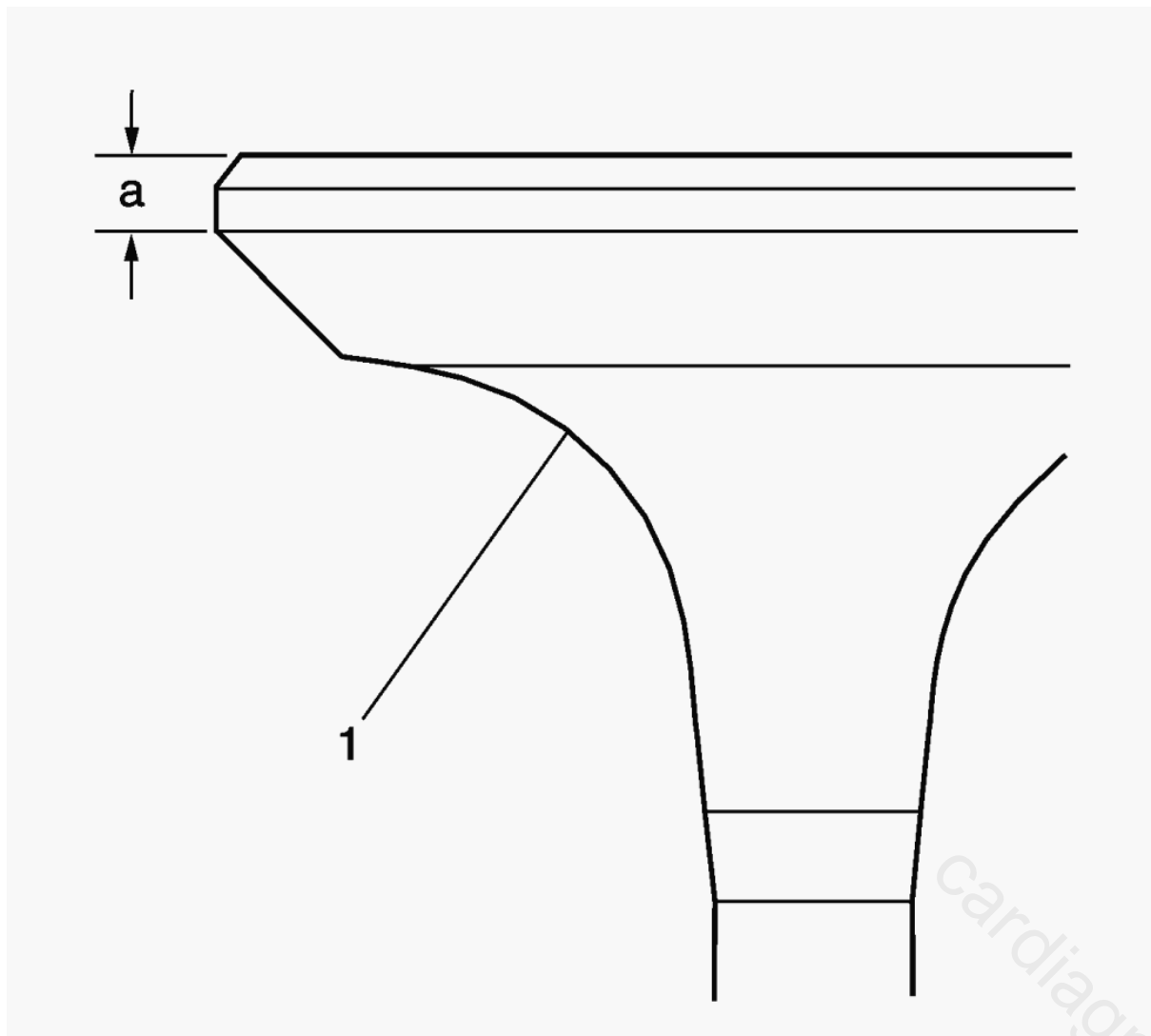


Fig. 401: View Of Valve Head O.D. & Chamfer
Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to [Engine Mechanical Specifications](#).
2. If the valve head O.D. and chamfer is within specification, test the valve (1) for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure. Reinspect the valve head O.D. and chamfer after completing the concentricity measurement if valve seat reconditioning is performed.

Valve-to-Seat Concentricity Measurement Procedure

NOTE:

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.

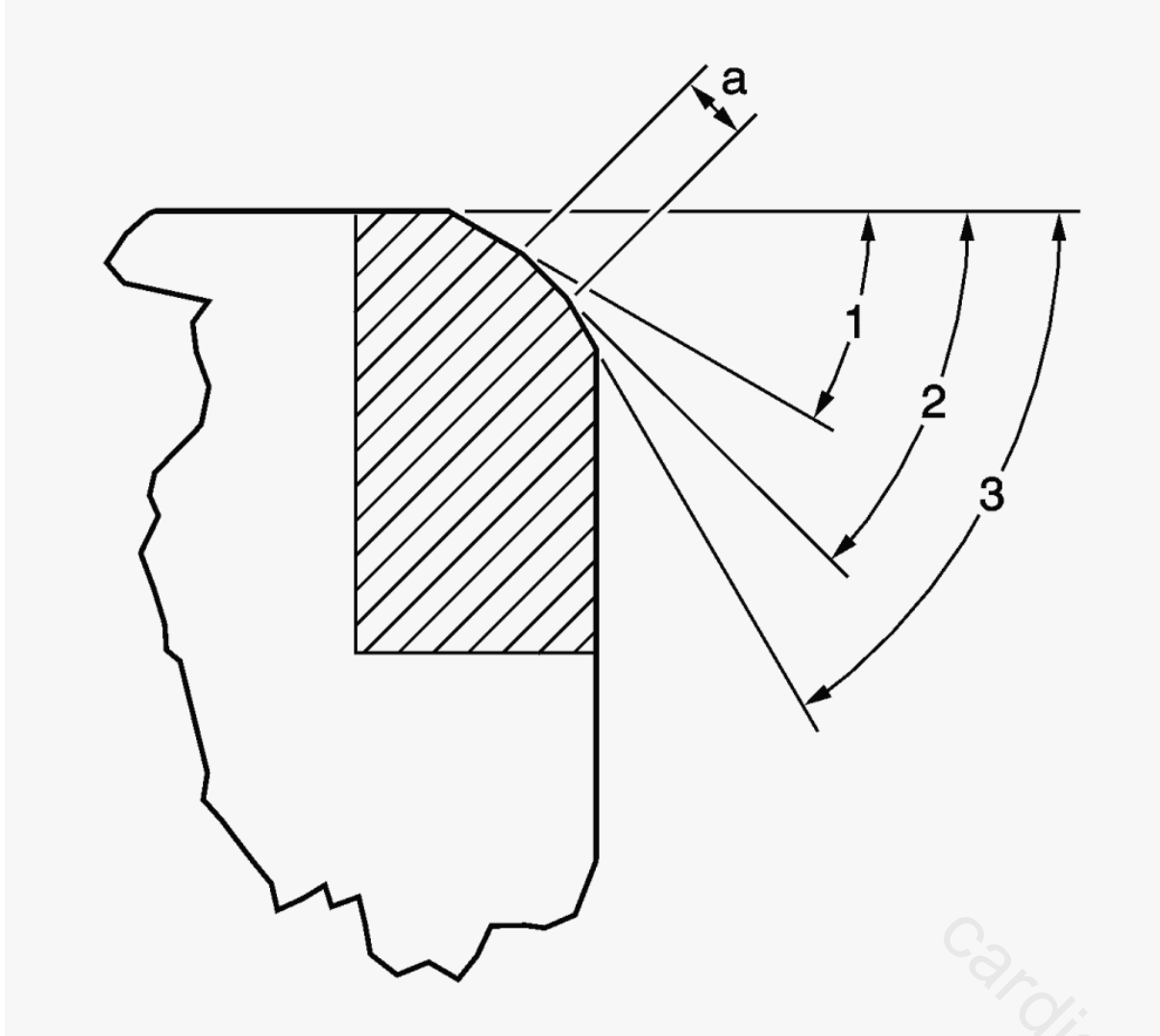


Fig. 403: Valve Seating Surface Angle
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seating surface (a) to the proper angle specification (2). Refer to [Engine Mechanical Specifications](#).
2. Grind the valve relief surface to the proper angle specification (1) to correctly position the valve seating surface (a) to the valve. Refer to [Engine Mechanical Specifications](#).
3. Grind the valve undercut surface to the proper angle specification (3) to narrow the valve seating surface width (a). Refer to [Engine Mechanical Specifications](#).

NOTE:

Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.

4. Replace the intake valve if it is out of specification. Refer to [Engine Mechanical Specifications](#).
5. If the original exhaust valve is being used, grind the valve to the specifications listed in [Engine Mechanical Specifications](#). Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.

- If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.
 - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
 9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

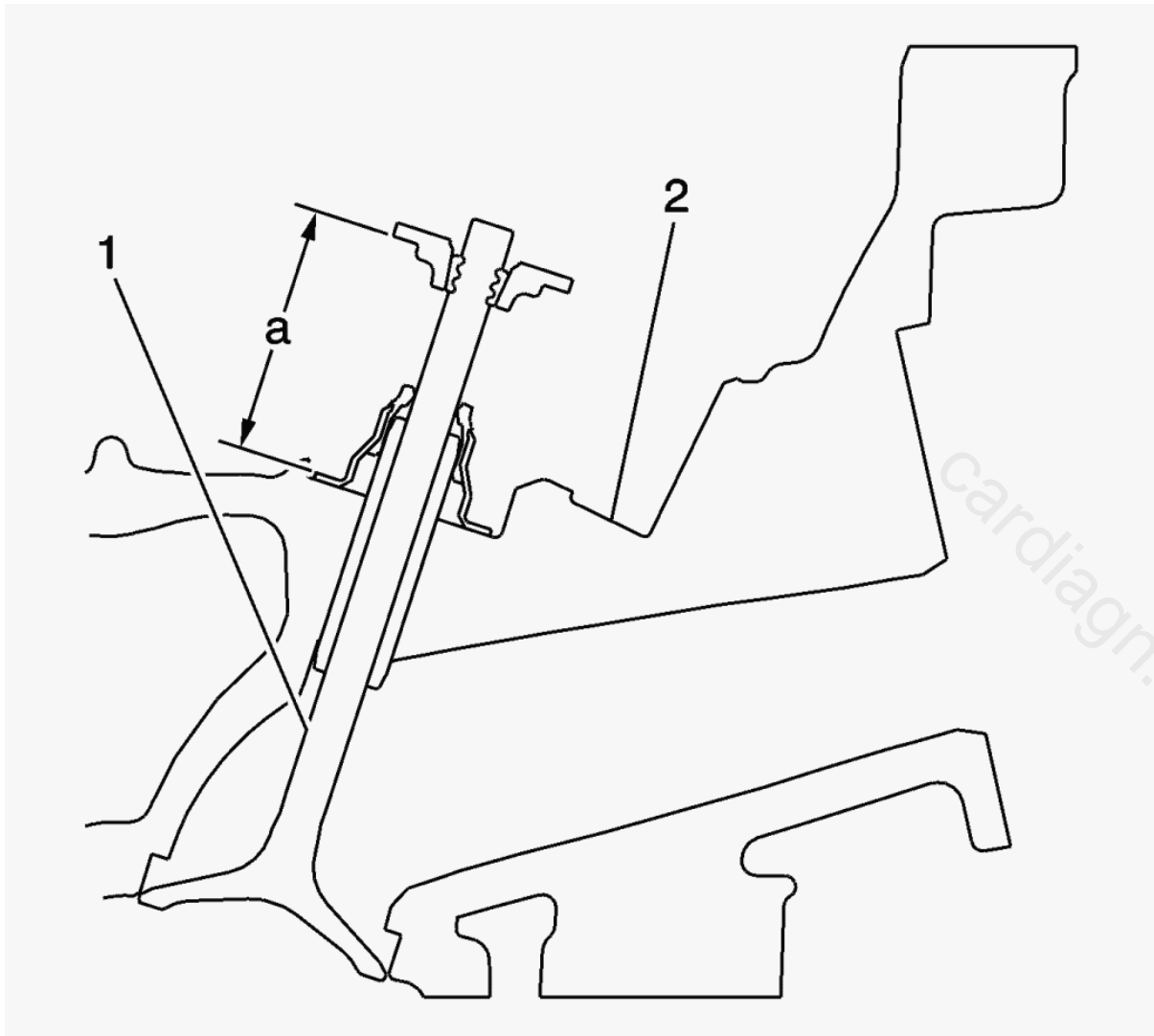


Fig. 404: Valve Stem Height Measurement
 Courtesy of GENERAL MOTORS COMPANY

NOTE: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve (1) into the valve guide in the cylinder head (2).
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (a) between the valve seal lip to the bottom of the valve spring retainer. Refer to [Engine Mechanical Specifications](#).
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

CAUTION: DO NOT grind the valve stem tip. The tip of the valve is hardened

and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

CAUTION: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

Cylinder Head Oil Gallery Plugs, Turbocharger Studs, Spark Plugs, and Engine Oil Manifold Check Valve Installation

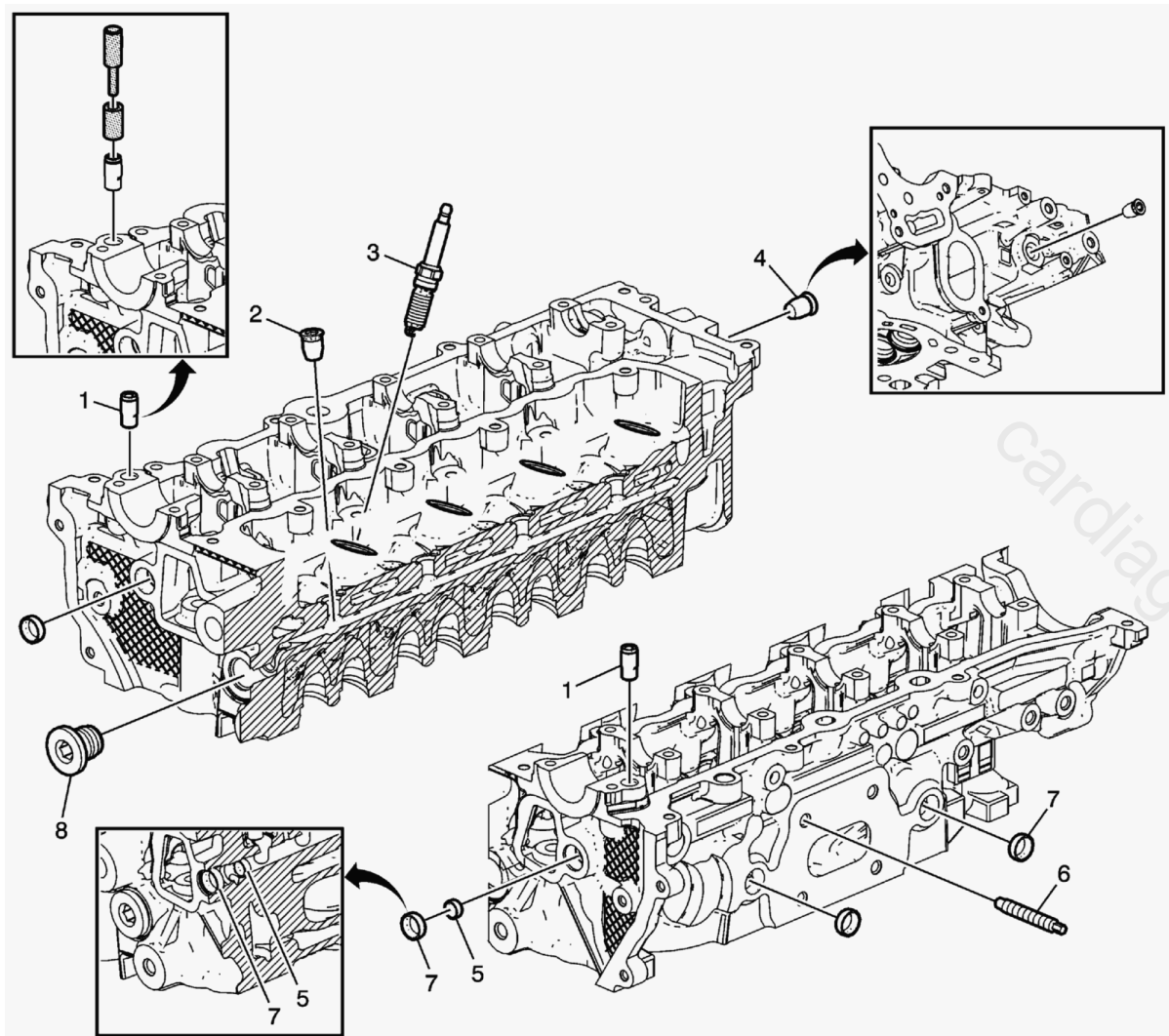


Fig. 405: Cylinder Head Oil Gallery Plugs, Turbocharger Studs, Spark Plugs, and Engine Oil Manifold Check Valve

Courtesy of GENERAL MOTORS COMPANY

Cylinder Head Oil Gallery Plugs, Turbocharger Studs, Spark Plugs, and Engine Oil Manifold Check Valve Installation

Callout	Component Name
Preliminary Procedure	
Apply sealant to all plugs prior to installation. Refer to Adhesives, Fluids, Lubricants, and Sealers .	

Callout	Component Name
1	Engine Oil Manifold Check Valve (Qty: 2) 1. Use lubricant included with EN-46122 remover/installer to lubricate the outside of the new check valve. 2. With the check ball end of the check valve facing DOWN, towards the head, insert the NEW check valve into the check valve bore in the cylinder head. 3. Place EN-46122-2 collar over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head. 4. Using the EN-46122-1 driver, lightly tap the new check valve into place until the driver stops against the top of the collar. Special Tools EN-46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer For equivalent regional tools, refer to Special Tools.
2	Cylinder Head Core Hole Plug (Qty: 4) CAUTION: Refer to Component Fastener Tightening Caution . Procedure Install NEW cylinder head plugs. Tighten 25 N.m (18 lb ft)
3	Spark Plug (Qty: 4) CAUTION: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine. Tighten 17 N.m (13 lb ft)
4	Cylinder Head Core Hole Plug Procedure Install NEW cylinder head plug. Tighten 25 N.m (18 lb ft)
5	Cylinder Head Oil Restrictor Plug (Qty: 1) Procedure Install a NEW cylinder head plug.
6	Double End Stud - Cylinder Head to Turbocharger (Qty:4) CAUTION: Refer to Torque-to-Yield Fastener Caution . Tighten 10 N.m (89 lb in)
7	Cylinder Head Core Hole Plug (Qty: 4) Procedure Install NEW cylinder head plugs.
8	Cylinder Head Core Hole Plug Procedure Install NEW cylinder head plug. Tighten 75 N.m (55 lb ft)

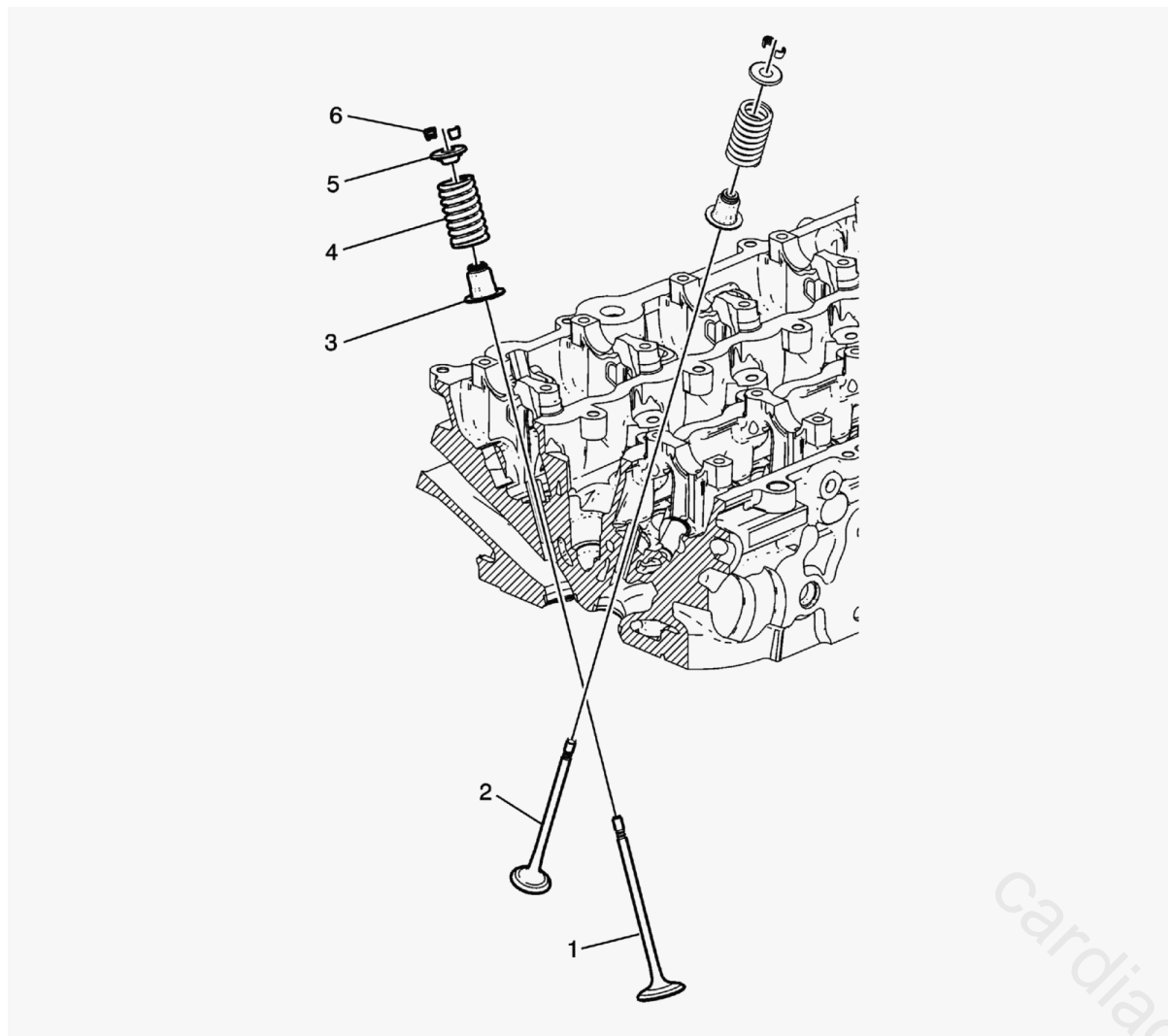


Fig. 406: Intake and Exhaust Valve
Courtesy of GENERAL MOTORS COMPANY

Intake and Exhaust Valve Installation

Callout	Component Name
Preliminary Procedure Ensure that the valve train components will be installed in their original position.	
1	Intake Valve (Qty: 8) NOTE: Lubricate the valve guides and the valve stems with engine oil.
2	Exhaust Valve (Qty: 8) NOTE: Lubricate the valve guides and the valve stems with engine oil.

Callout	Component Name
3	Valve Stem Oil Seal (Qty: 16) NOTE: Valve stem oil seal sets will contain 2 different colored seals, black and green. The set of 8 seals that are green go on the exhaust valves. Procedure 1. Place the valve stem oil seals onto the guides. NOTE: Always use NEW seals when assembling the cylinder head. 2. Mount a new valve stem oil seal using the EN-46116 remover/installer. NOTE: Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation. 3. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the EN-46116 remover/installer. 4. Lubricate the valve stem and valve guide ID with clean engine oil. Refer to <u>Adhesives, Fluids, Lubricants, and Sealers</u>. Special Tools EN-46116 Valve Stem Seal Remover/Installer For equivalent regional tools, refer to <u>Special Tools</u>.
4	Valve Springs (Qty: 16)
5	Valve Spring Retainer (Qty: 16)

Callout	Component Name
6	Valve Stem Key - Intake, Exhaust (Qty: 32) WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury. CAUTION: Do not compress the valve springs less than 25.0 mm (0.984 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage. Procedure 1. Using the EN-8062 compressor and the EN-43963 compressor adapter, compress the valve spring. 2. Install the valve stem keys. 3. Slowly release the tension. 4. Inspect for proper valve key seating. Special Tools • EN-8062 Valve Spring Compressor • EN-43963 Valve Spring Compressor - Off-Car Adapter For equivalent regional tools, refer to Special Tools.

ENGINE BLOCK DISASSEMBLE

Upper Engine Block Disassemble

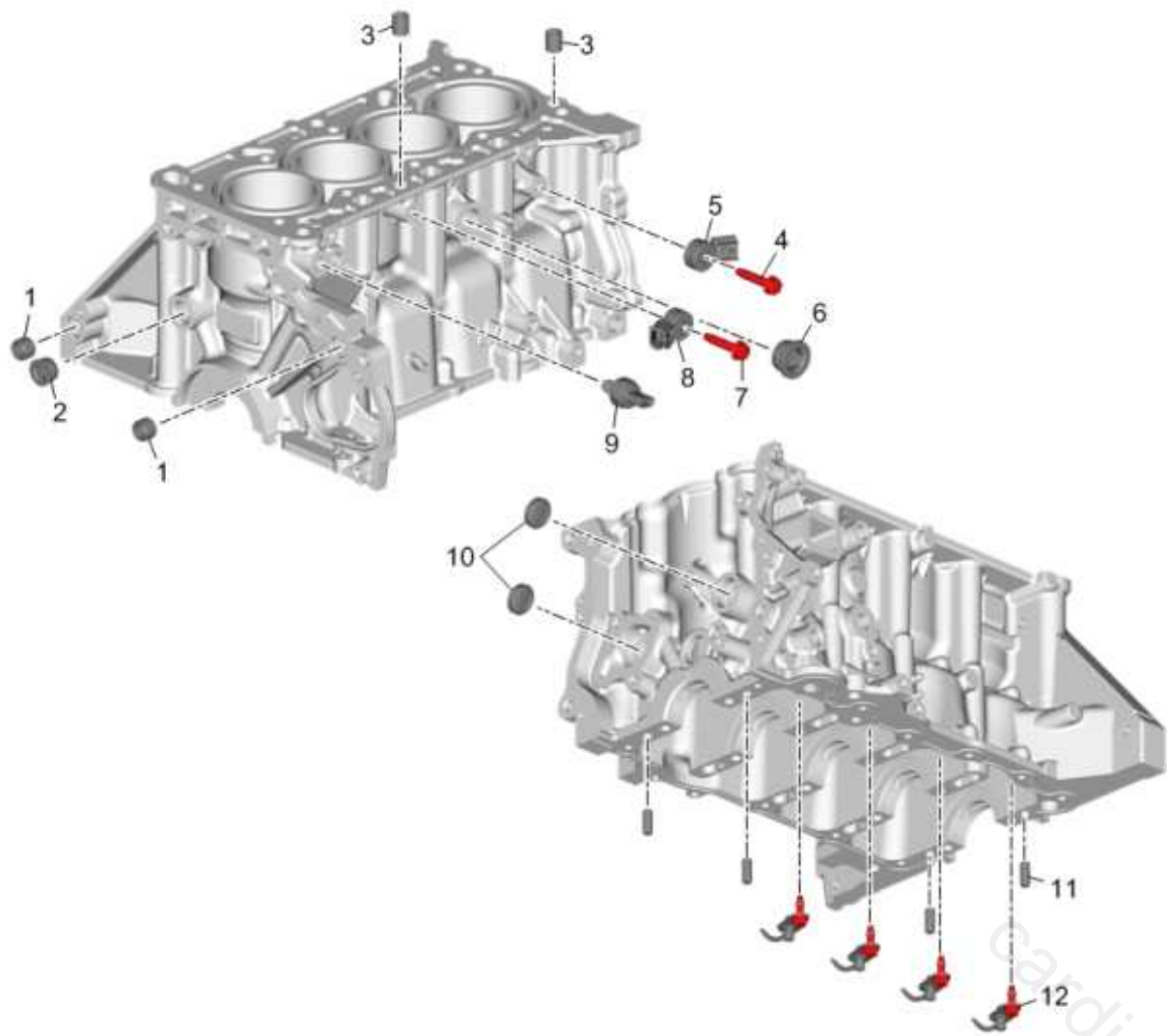


Fig. 407: Upper Engine Block

Courtesy of GENERAL MOTORS COMPANY

Upper Engine Block Disassemble

Callout	Component Name
1	Transmission Locating Pin [2x]
2	Engine Block Oil Gallery Plug
3	Cylinder Head Locating Pin [2x]
4	Knock Sensor Bolt
5	Knock Sensor
6	Engine Coolant Heater Hole Plug
7	Knock Sensor Bolt
8	Knock Sensor
9	Engine Oil Pressure Sensor
10	Engine Block Core Hole Plug [2x]
11	Lower Crankcase Locating Pin [4x]
12	Piston Oil Nozzle [4x]

Lower Crankcase Disassemble

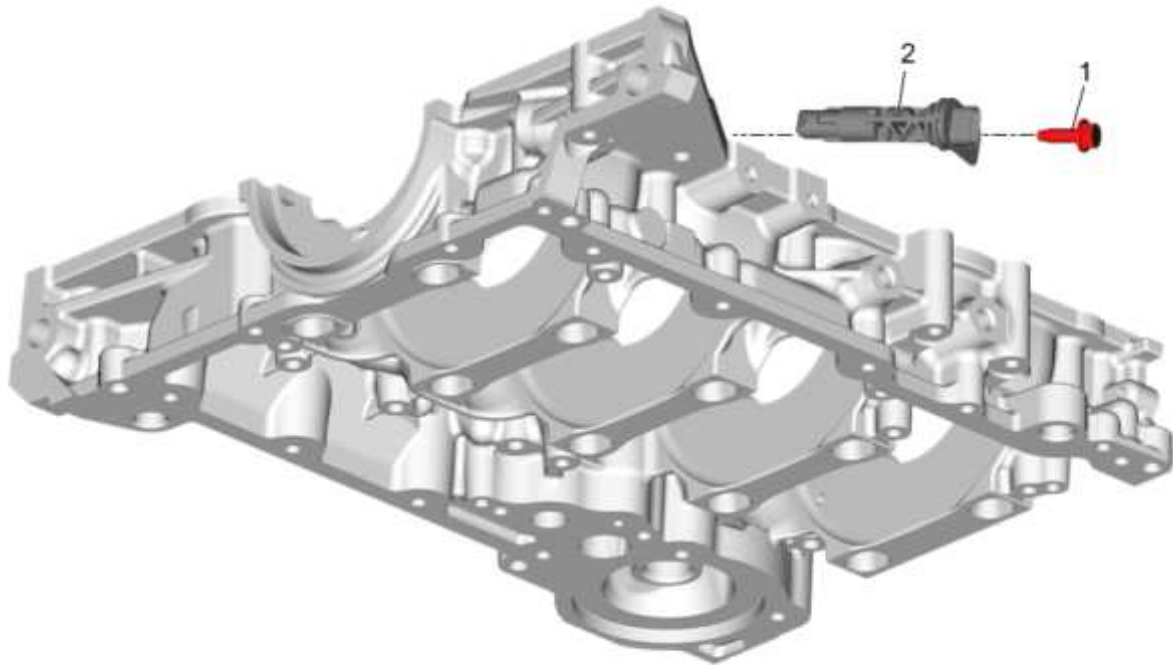


Fig. 408: Lower Crankcase

Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase Disassemble

Callout	Component Name
1	Crankshaft Position Sensor Bolt
2	Crankshaft Position Sensor

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- EN-8087 Cylinder Bore Gauge
- EN-28410 Gasket Remover

For equivalent regional tools, refer to [Special Tools](#).

Cleaning Procedure

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Properly clean all RTV surfaces, Refer to [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#).
2. Remove any old thread sealant, gasket material or sealant using EN-28410 remover.
3. Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages
 - Bearing journals
4. Clean all threaded and through holes with solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

5. Dry the engine block with compressed air.

Visual Inspection

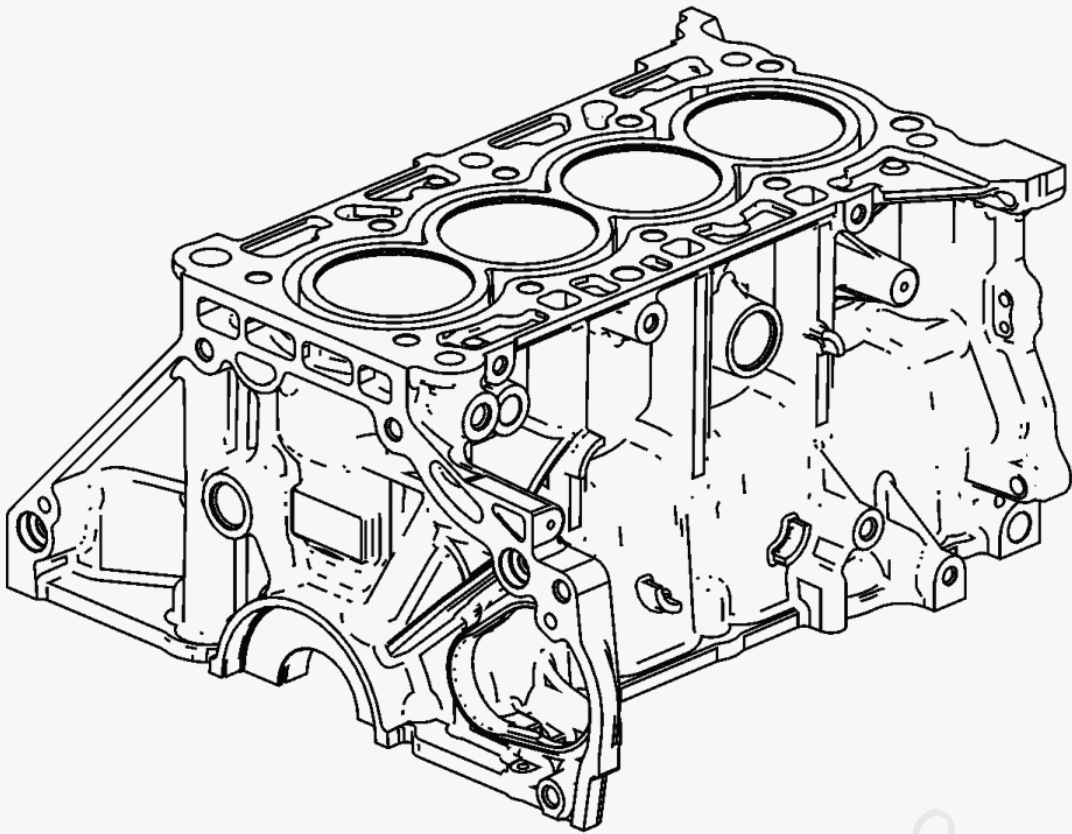


Fig. 409: Block

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.
7. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
8. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
9. Repair any damaged threaded holes. Refer to [**Thread Repair Specifications**](#), and [**Thread Repair**](#).

Measuring Cylinder Bore Diameter

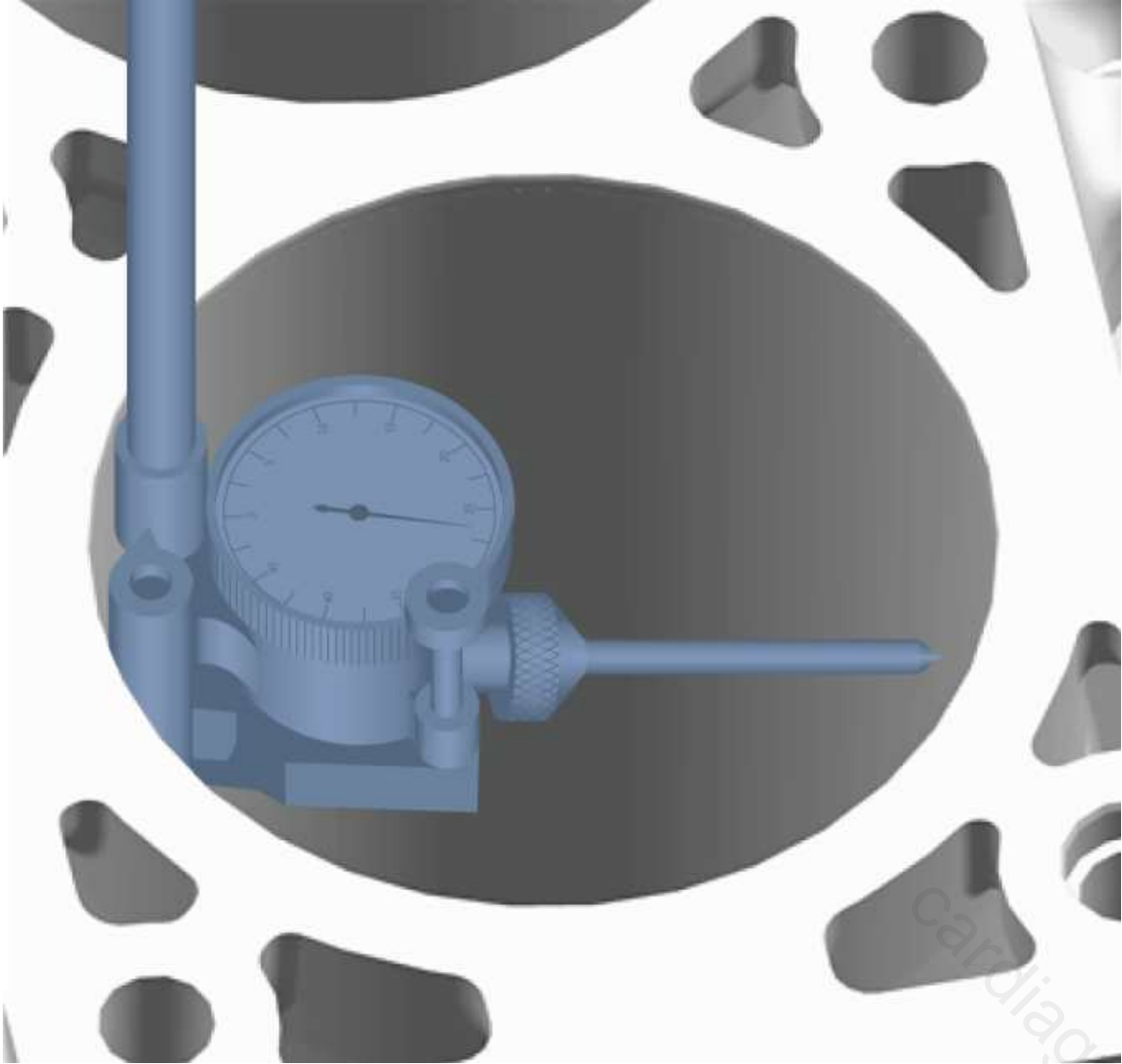


Fig. 410: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

1. Using **EN-8087** gauge, measure the cylinder bore diameter 35 mm (1.378 in) down from deck face perpendicular to the crankshaft centerline. Refer to **Engine Mechanical Specifications**.
2. In the cylinder bore diameter is outside the specification the engine block must be replaced.

Measuring Cylinder Bore Taper

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications**. If the cylinder bores exceed the specifications, the engine block must be replaced.

Measuring Cylinder Bore Out-of-Round

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.

5. Compare your results with the [Engine Mechanical Specifications](#). If the cylinder bores exceed these specifications, the engine block must be replaced.

Engine Block Deck Flatness Inspection

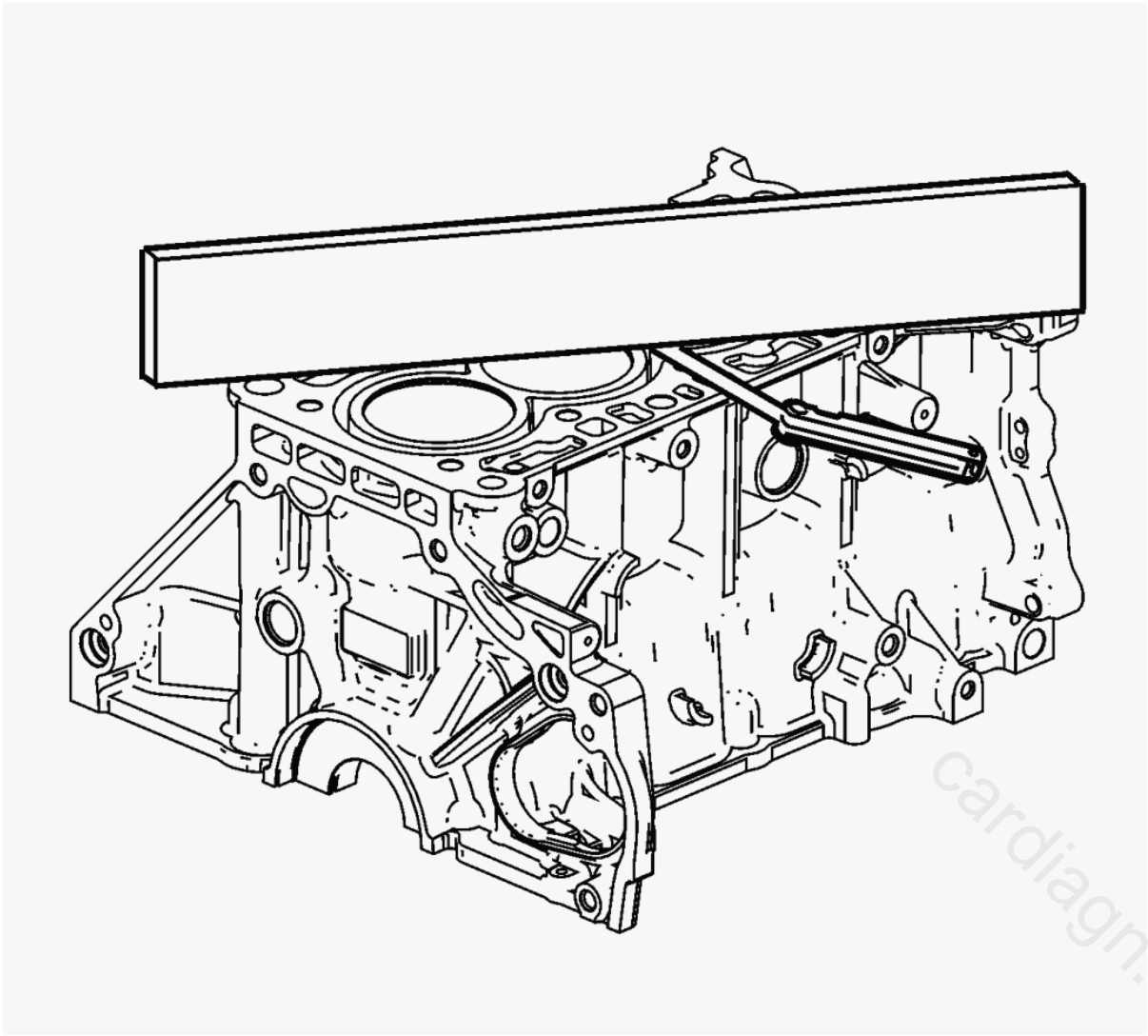


Fig. 411: Checking Deck Flatness

Courtesy of GENERAL MOTORS COMPANY

1. Ensure the engine block deck surface is clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Using a straight-edge placed diagonally across the deck surface, measure the engine block - cylinder head deck surface for flatness using a feeler gauge. Refer to [Engine Mechanical Specifications](#).
4. If the cylinder head deck surface flatness is more than the specified amount, replace the engine.

Engine Block Deck Height Measurement

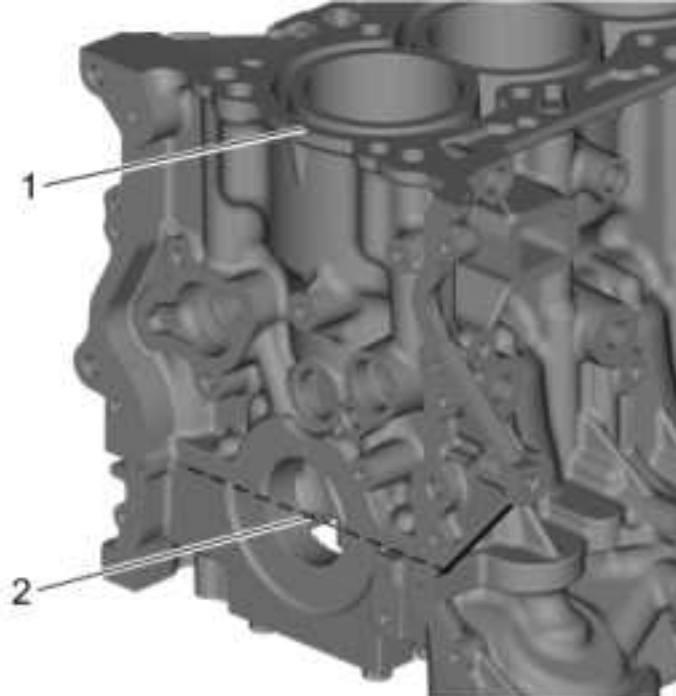


Fig. 412: Engine Block Deck Height
 Courtesy of GENERAL MOTORS COMPANY

Engine block deck height is measured from deck face surface (1) to crankshaft center bore (2). Measure at front and rear of the engine block. Refer to [Engine Mechanical Specifications](#) for engine block deck height specification.

ENGINE BLOCK ASSEMBLE

Lower Crankcase Assemble

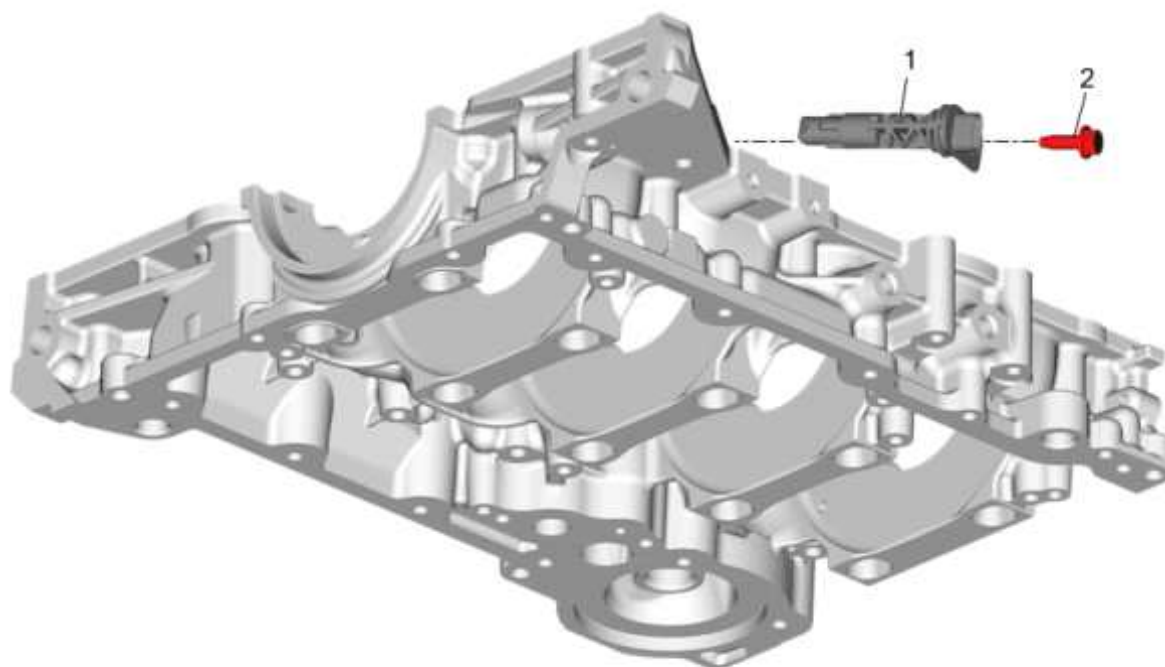


Fig. 413: Lower Crankcase
 Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase Assemble

Callout	Component Name
1	Crankshaft Position Sensor

Callout	Component Name
2	Crankshaft Position Sensor Bolt CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

Upper Engine Block Assemble

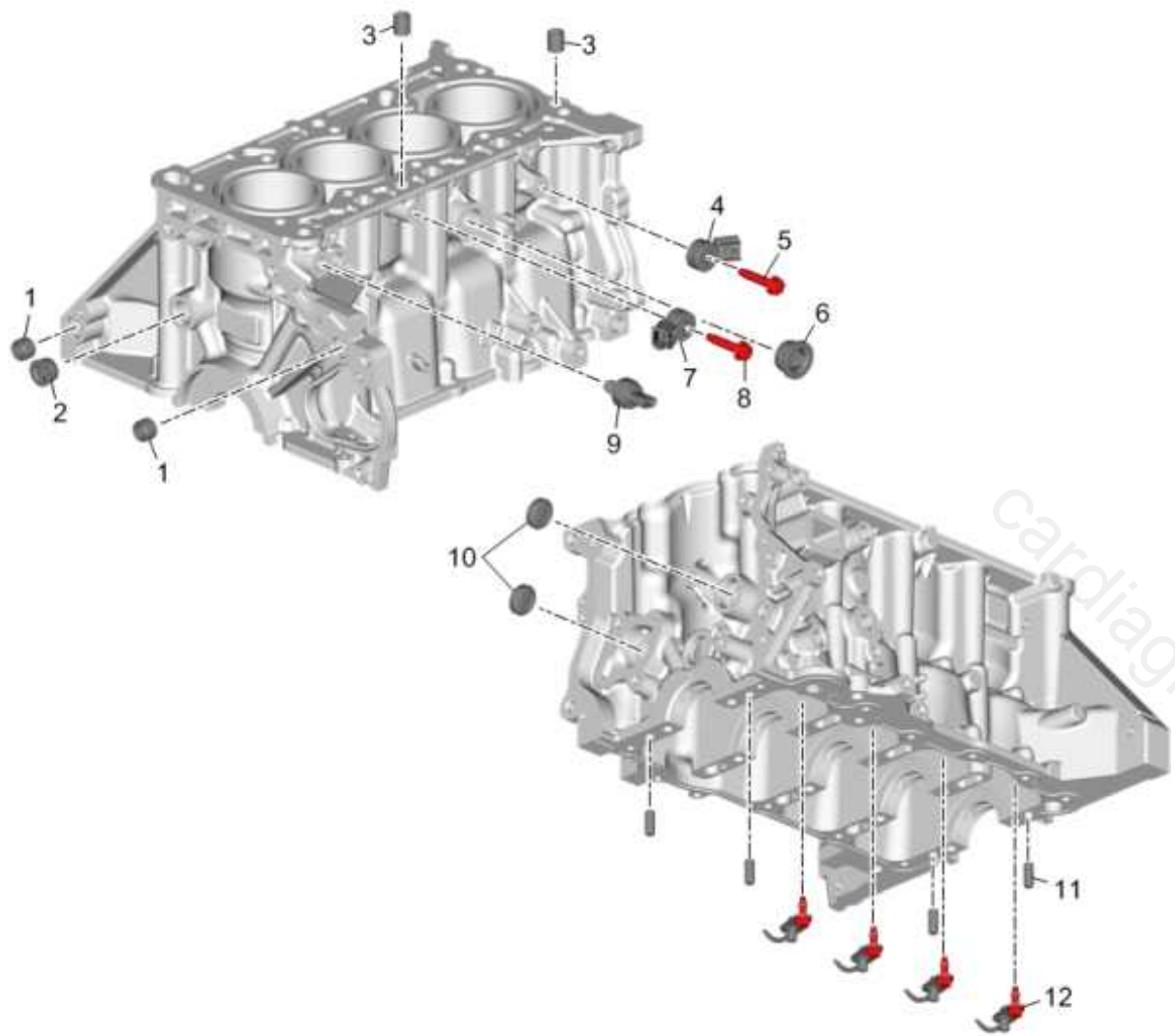


Fig. 414: Upper Engine Block
Courtesy of GENERAL MOTORS COMPANY

Upper Engine Block Assemble

Callout	Component Name
Preliminary Procedure Apply sealant to all plugs prior to installation. Refer to Adhesives, Fluids, Lubricants, and Sealers .	
1	Transmission Locating Pin [2x] Procedure Ensure Transmission locating pins are properly seated and not damaged.

Callout	Component Name
2	Engine Block Oil Gallery Plug CAUTION: Refer to Component Fastener Tightening Caution . Tighten 65 N.m (48 lb ft)
3	Cylinder Head Locating Pin [2x]
4	Knock Sensor
5	Knock Sensor Bolt CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
6	Engine Coolant Heater Hole Plug Tighten 60 N.m (44 lb ft)
7	Knock Sensor
8	Knock Sensor Bolt Tighten 25 N.m (18 lb ft)
9	Engine Oil Pressure Sensor Tighten 35 N.m (26 lb ft)
10	Engine Block Core Hole Plug [2x]
11	Lower Crankcase Locating Pin [4x]
12	Piston Oil Nozzle [4x] Tighten 10 N.m (89 lb in)

FUEL INJECTOR AND FUEL INJECTOR BORE CLEANING AND INSPECTION

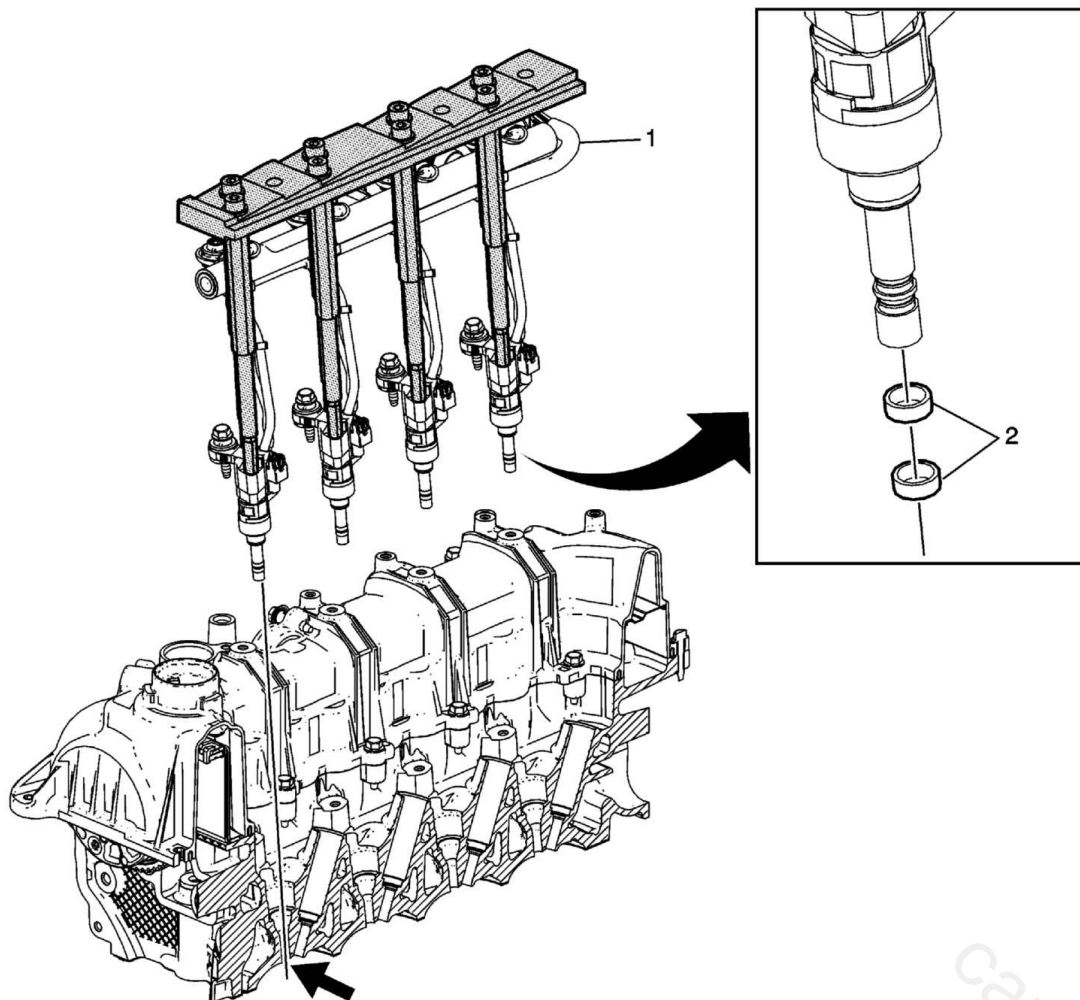


Fig. 415: Fuel Injector and Fuel Injector Bore
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
1. Use EN-47909 cleaning kit to clean the fuel injector bores.	
NOTE: Do not soak or immerse the fuel rail or injectors in solvent.	
2. Clean the exterior of the fuel rail and injectors with solvent.	
Special Tools EN-47909 Injector Bore and Sleeve Cleaning KitFor equivalent regional tools, refer to Special Tools .	

Callout	Component Name
1	Fuel Rail Assembly NOTE: Do not remove the EN-51146 remover unless fuel injector replacement is necessary. Procedure 1. Inspect for damage, debris, or restrictions to the fuel rail and fuel ports. 2. Inspect for damage to the mounting area for the fuel rail. 3. Inspect for damage to the fuel rail mounting bolts. 4. Inspect for damage to the threads on the fuel rail fuel feed fitting. 5. Inspect the fuel rail pressure sensor for damage. 6. Inspect the fuel injector for damage to the harness connector. 7. Inspect the fuel injector tip, tolerance ring, and seal locations.
2	Fuel Injector Combustion Seal NOTE: Discard the seals and use NEW seals upon installation. Procedure 1. If present, remove the calibration tool on the fuel injector tip. 2. Remove and discard the fuel injector combustion seals. 3. Reinspect each fuel injector tip once the seals are removed.

PISTON AND CONNECTING ROD DISASSEMBLE

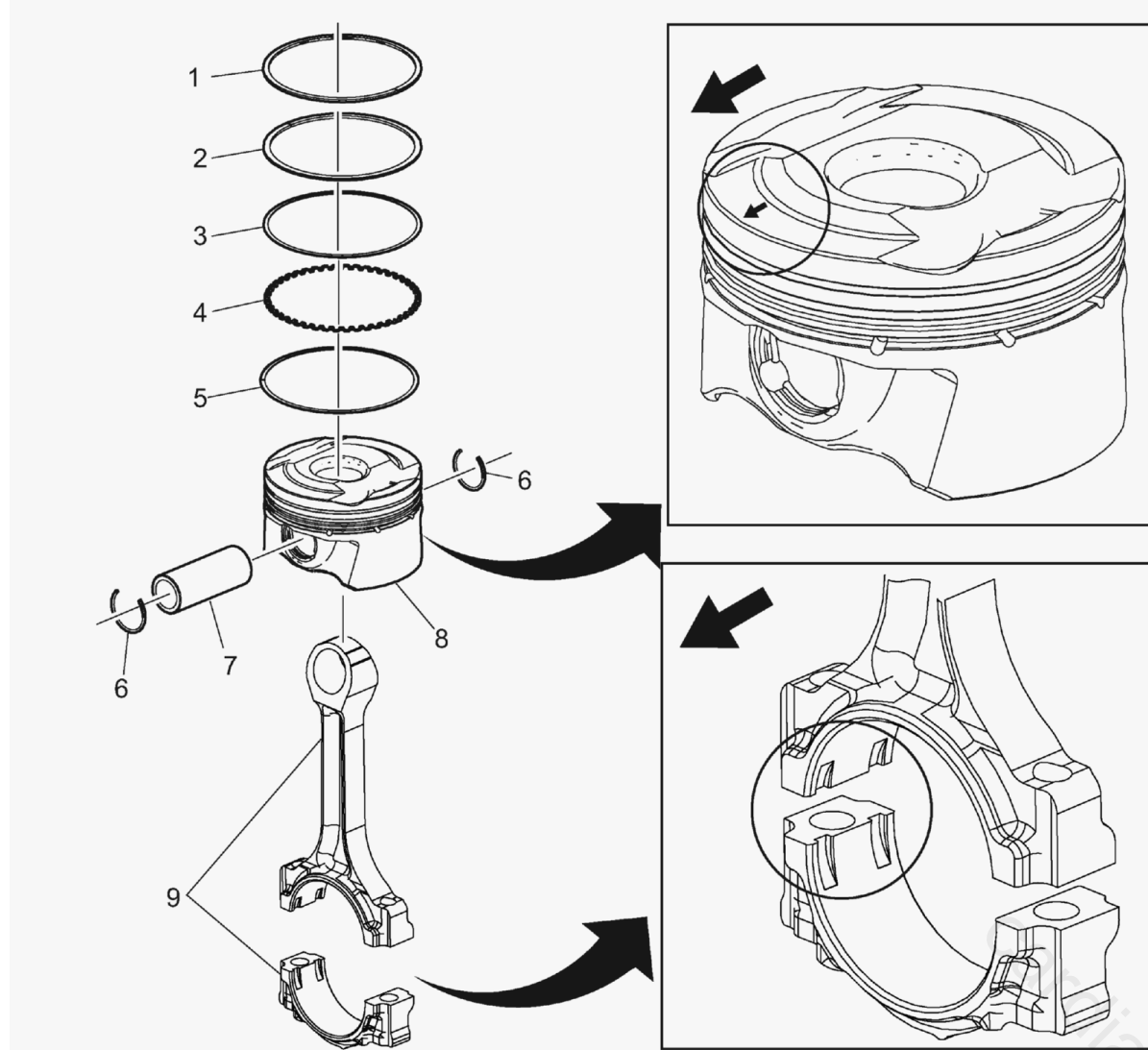


Fig. 416: Piston and Connecting Rod
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Tag or mark each part immediately when removed. Indicate location, direction, or orientation when necessary.	
1	Piston Compression Upper Ring WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury. NOTE: Use a suitable tool to expand the rings. The piston rings must not be reused.
2	Piston Compression Lower Ring
3	Piston Oil Ring Rail

Callout	Component Name
4	Piston Oil Ring Spacer
5	Piston Oil Ring Rail
6	Piston Pin Retainer WARNING: Use extreme care when removing snap rings. Always wear adequate eye protection in order to avoid personal injury. NOTE: Two retainers hold the piston pins in place. Ensure that the piston pin is not damaged. Do not reuse the retainers. Procedure Remove the piston pin retainers using the EN-49941 remover. Special Tools EN-49941 Piston Pin Retainer Remover and Installer For equivalent regional tools, refer to Special Tools.
7	Piston Pin
8	Piston NOTE: An arrow/dot showing proper piston orientation is located on the top of the piston.
9	Connecting Rod NOTE: Features such as a raised section on the connecting rod may help identify the correct orientation relative to the front of the engine. Ensure that each connecting rod has been clearly marked upon removal to identify the cylinder, orientation, and direction of both the rod and cap.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Piston Cleaning Procedure

NOTE: DO NOT wire brush any part of the piston.

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the piston with compressed air.

Piston Inspection Procedure

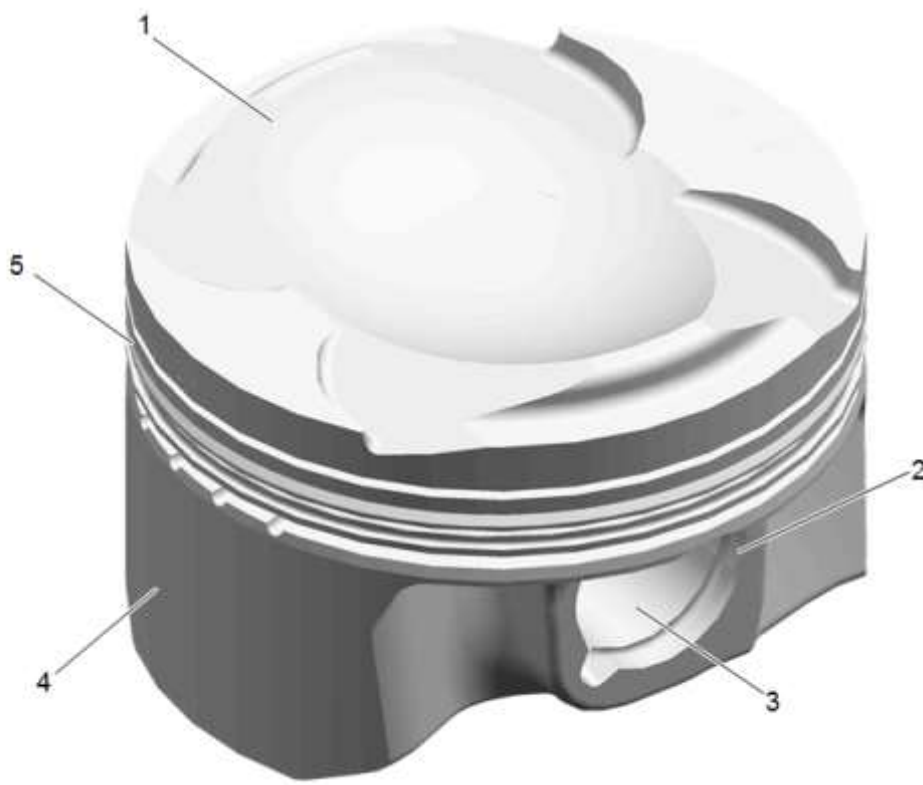


Fig. 417: Identifying Piston Inspection Locations
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts or pin bosses
 - Ring grooves for nicks, burrs that may cause binding (5)
 - Warped or worn ring lands (5)
 - Piston pin retainer grooves for burrs (2)
 - Eroded areas at the top of the piston (1)
 - Scuffed or damaged skirt coating (4)
 - Worn piston pin bores or worn piston pins (3)
2. Replace pistons that show any signs of damage or excessive wear.

Piston Measurement Procedure

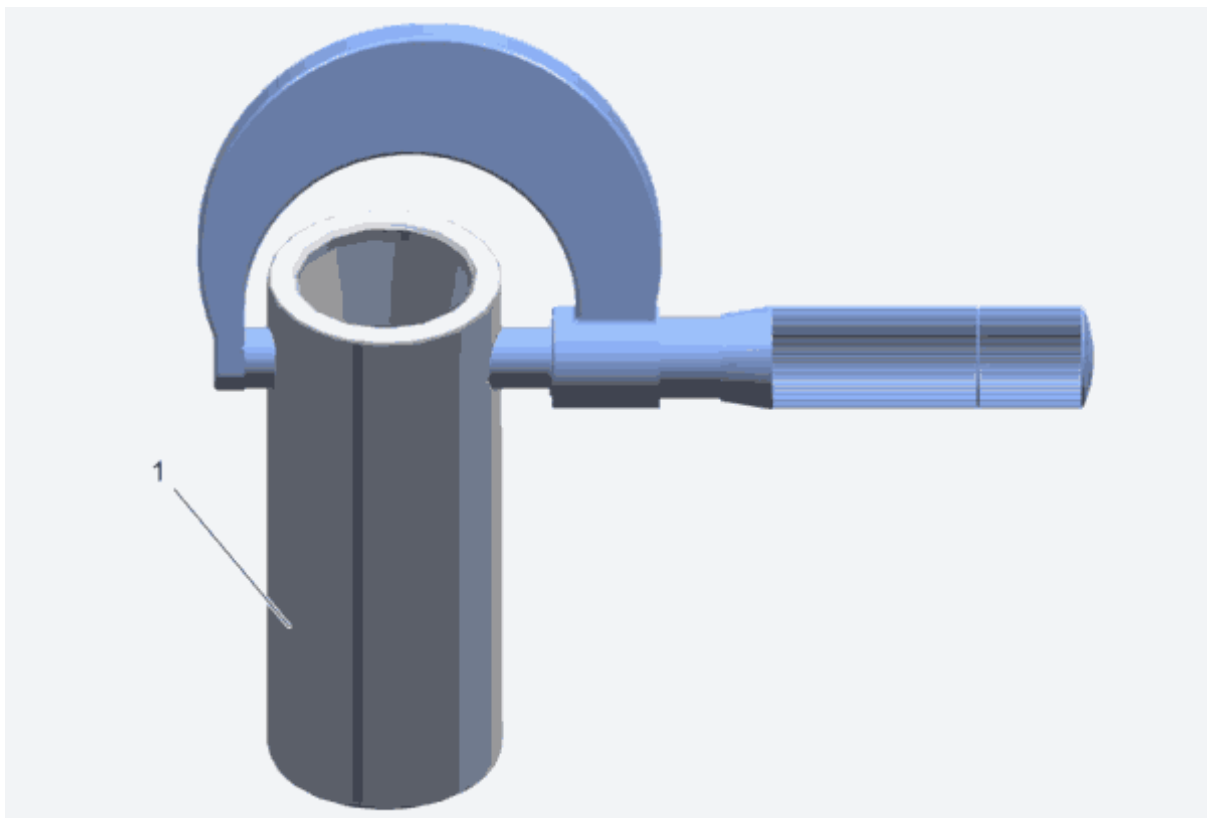


Fig. 418: Measuring Piston Width

Courtesy of GENERAL MOTORS COMPANY

1. Measure piston width using the following procedure:

1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top, (1) at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
3. Check your measurements. Refer to [Engine Mechanical Specifications](#).
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.



2. 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.



Fig. 420: Measuring Piston Pin Bore
Courtesy of GENERAL MOTORS COMPANY

3. Using an inside micrometer, measure the piston pin bore. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance specification. Refer to [Engine Mechanical Specifications](#).
4. If the clearance is excessive, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Piston Ring Measurement Procedure

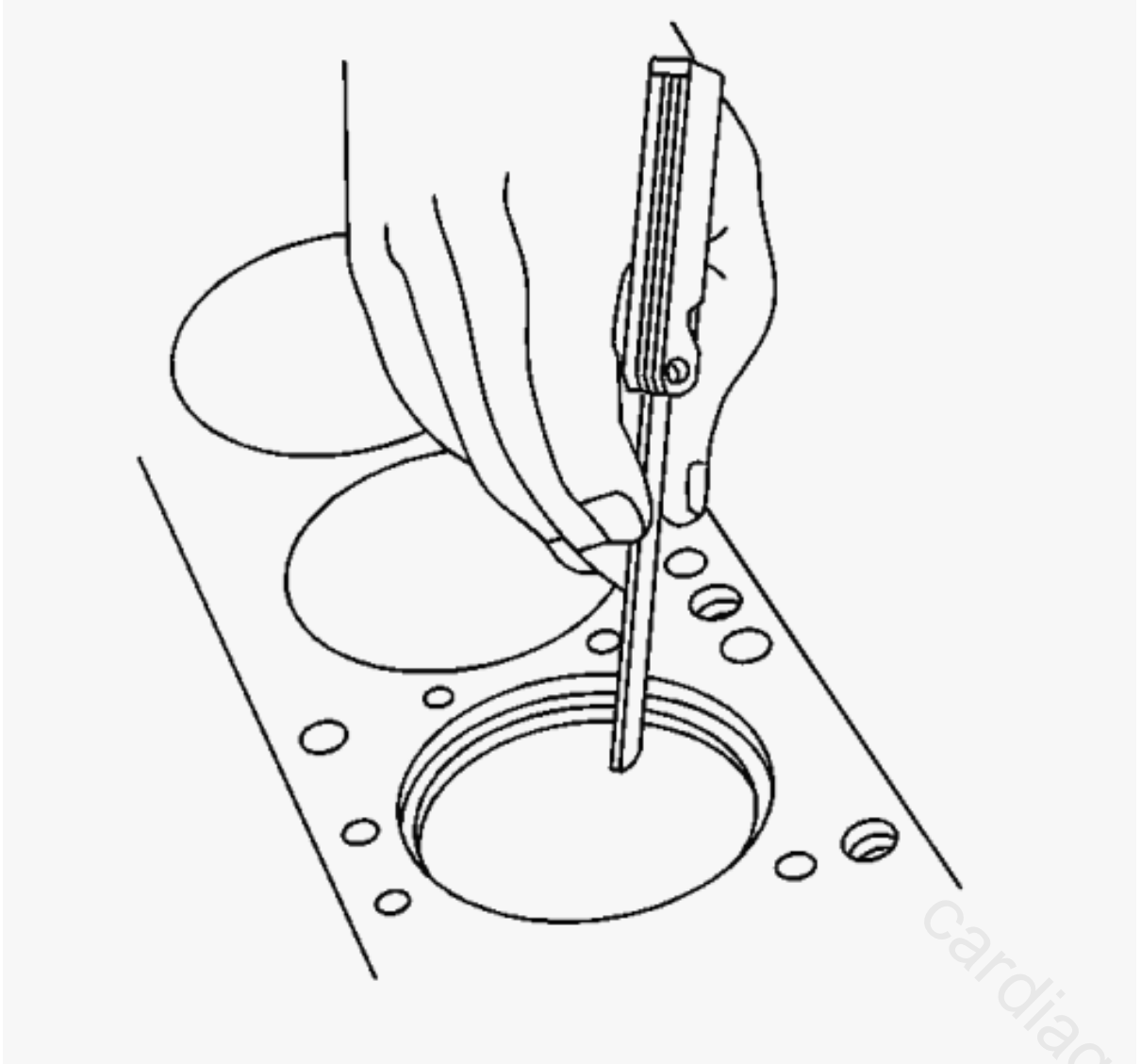


Fig. 421: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS COMPANY

1. 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 (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
 2. Measure the end gap of the piston ring with feeler gauges. Refer to [Engine Mechanical Specifications](#).
 3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
 4. Repeat the procedure for all the piston rings.

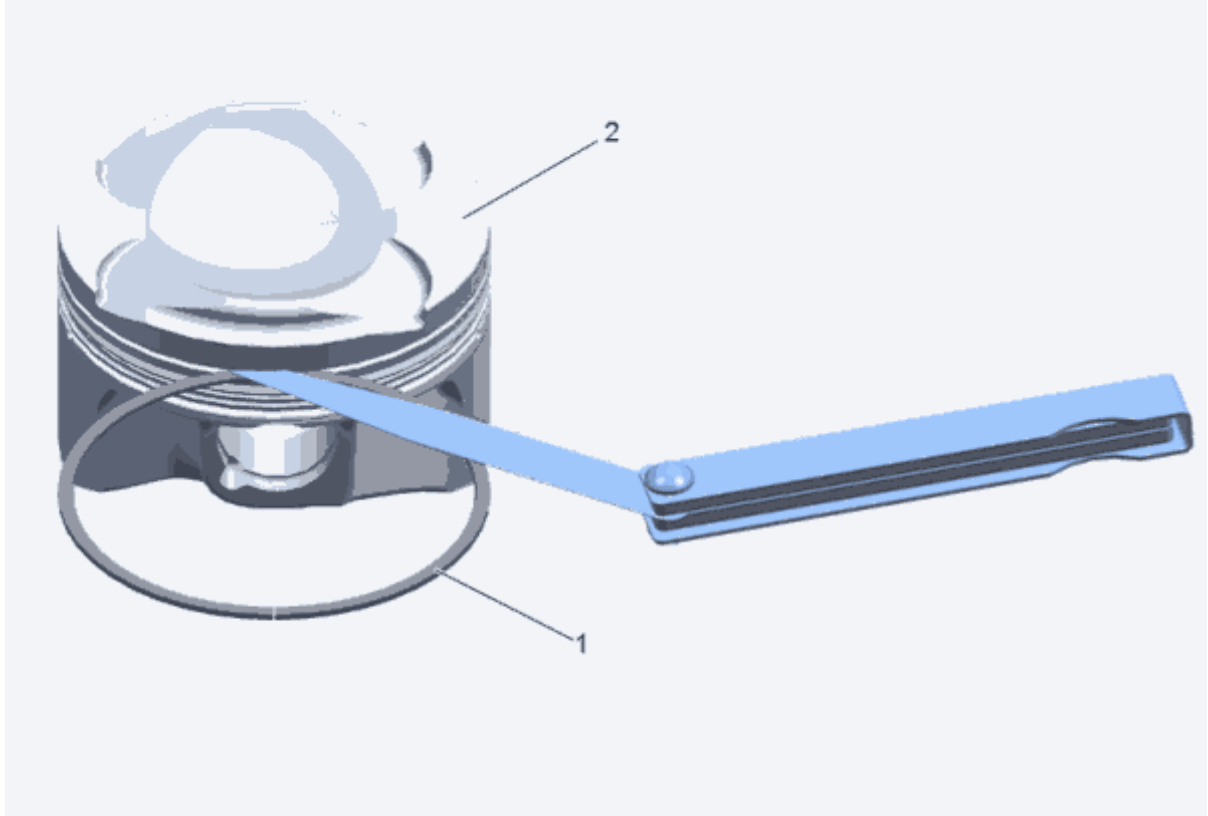


Fig. 422: Measuring Piston Ring Side Clearance

Courtesy of GENERAL MOTORS COMPANY

2. 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 the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.
 2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
 3. Compare the measurements with piston ring side clearance specification. Refer to **Engine Mechanical Specifications**.
 4. If the clearance is greater than specifications, replace the piston rings.

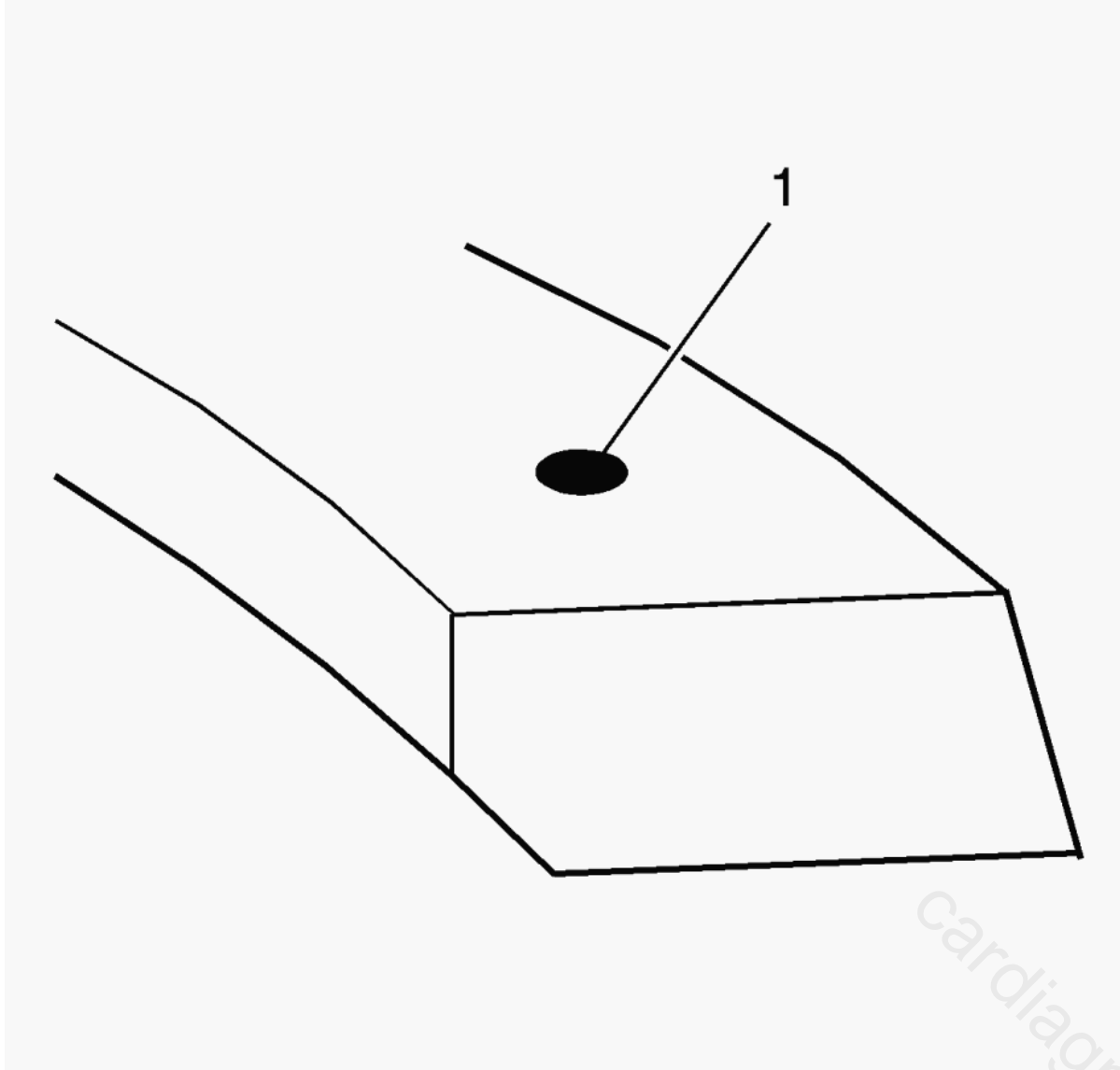


Fig. 423: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS COMPANY

3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the proper specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only 1 size of oversized pistons and rings available for service.

Connecting Rod Cleaning Procedure

1. Clean the connecting rods in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure

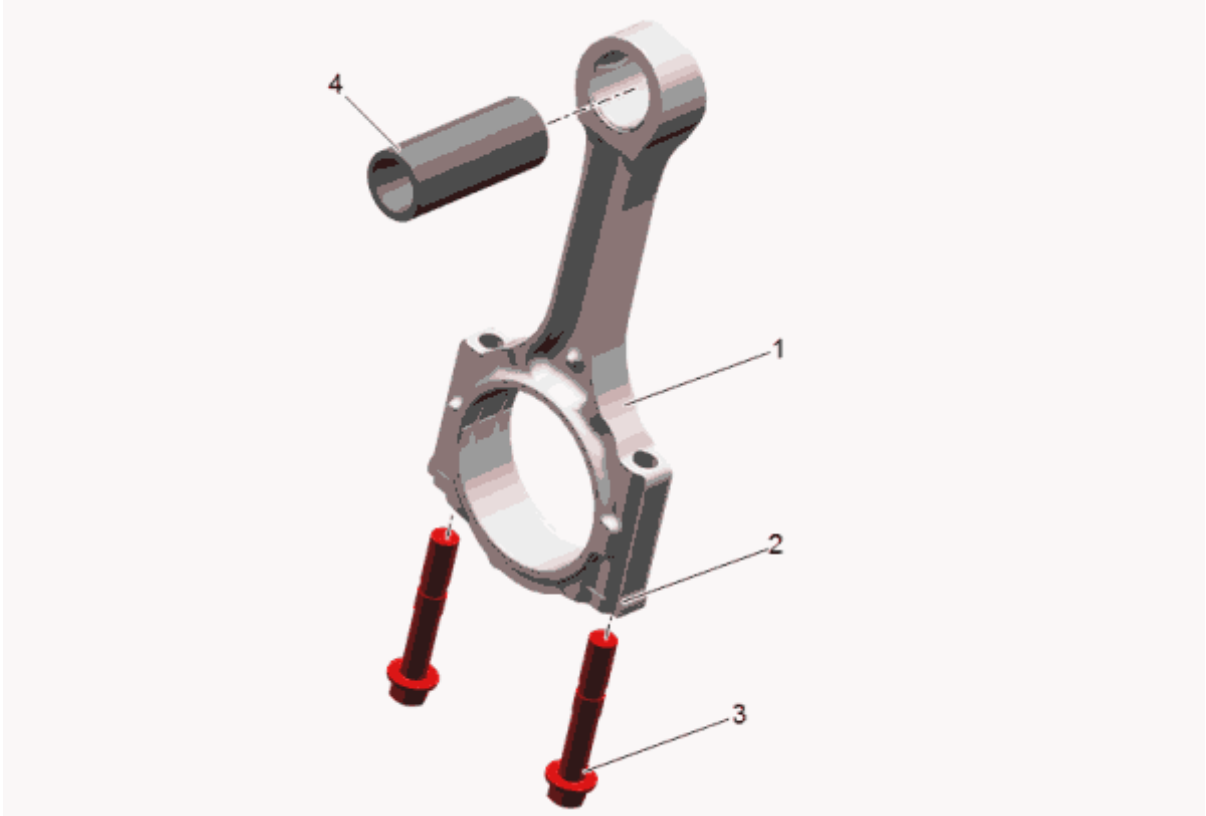


Fig. 424: Inspecting Connecting Rod Components

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

NOTE: **DO NOT scrape the rod or rod cap.**

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. Thoroughly clean the parts and perform a high-pressure wash if an abrasive is used on the bores.

Connecting Rod Measurement Procedure

Piston Pin End

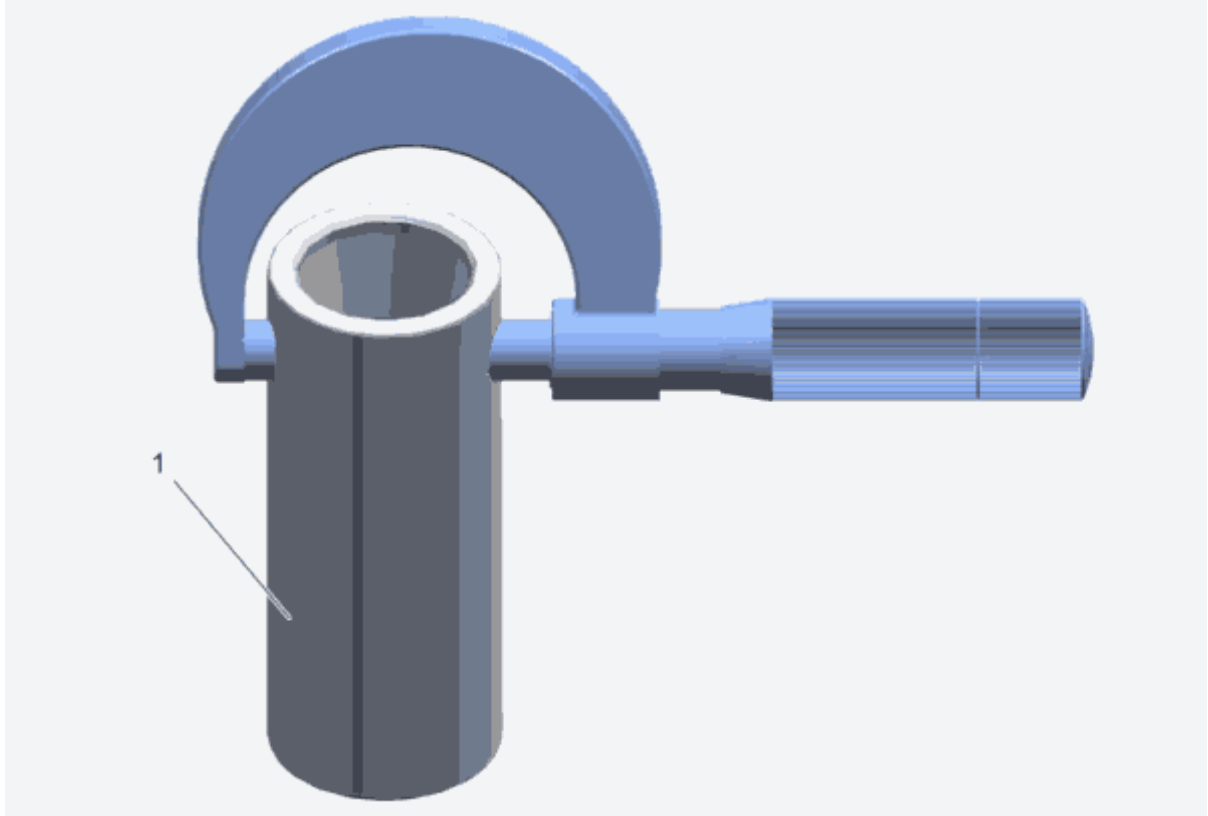


Fig. 425: Measuring Piston Pin Diameter
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Measurements of all components should be taken with the components at normal room temperature.

1. Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

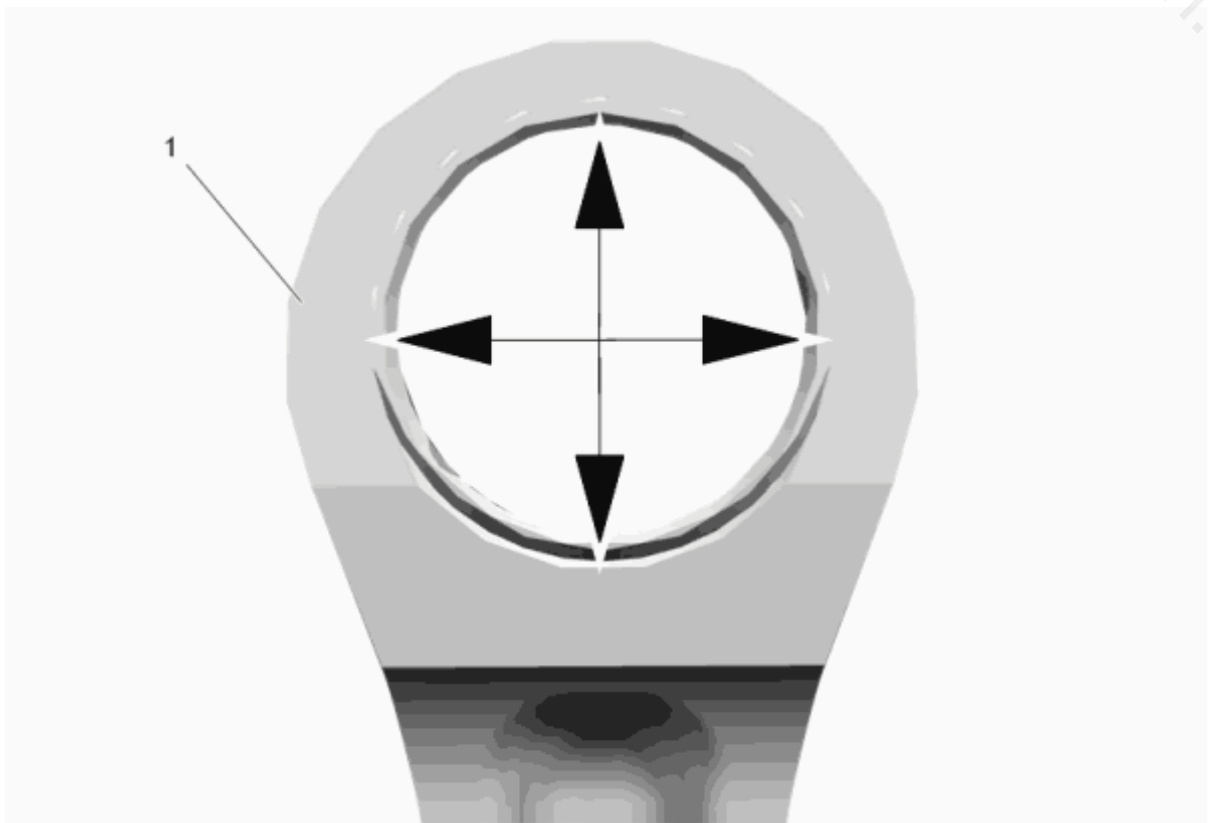


Fig. 426: Checking Connecting Rod Piston Pin Bore Dimensions
 Courtesy of GENERAL MOTORS COMPANY

2. Using an inside micrometer, measure the connecting rod piston pin bore.
3. Subtract the piston pin diameter from the piston pin bore.

4. Compare the clearance measurements to the proper specifications. Refer to [Engine Mechanical Specifications](#).

5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

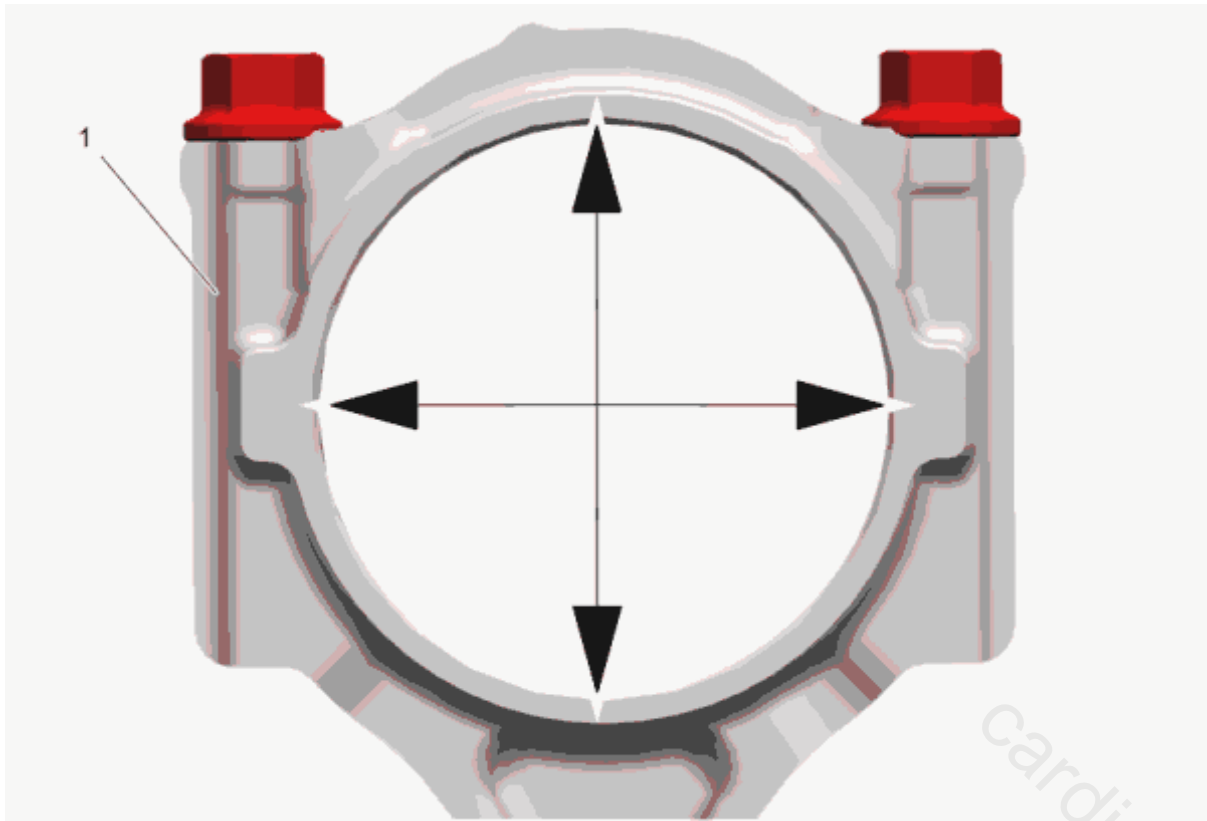


Fig. 427: Measuring Connecting Rod Crankshaft Bearing Bore

Courtesy of GENERAL MOTORS COMPANY

NOTE: Measurements of all components should be taken with the components at normal room temperature.

NOTE: The bore specifications are based on connecting rod bolts at full torque specification.

1. Using the old bolts, tighten the connecting rod cap bolts to 25 N.m (18 lb ft) plus 75 degrees.
2. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
3. Compare the bore measurements to the proper specifications. Refer to [Engine Mechanical Specifications](#).
4. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

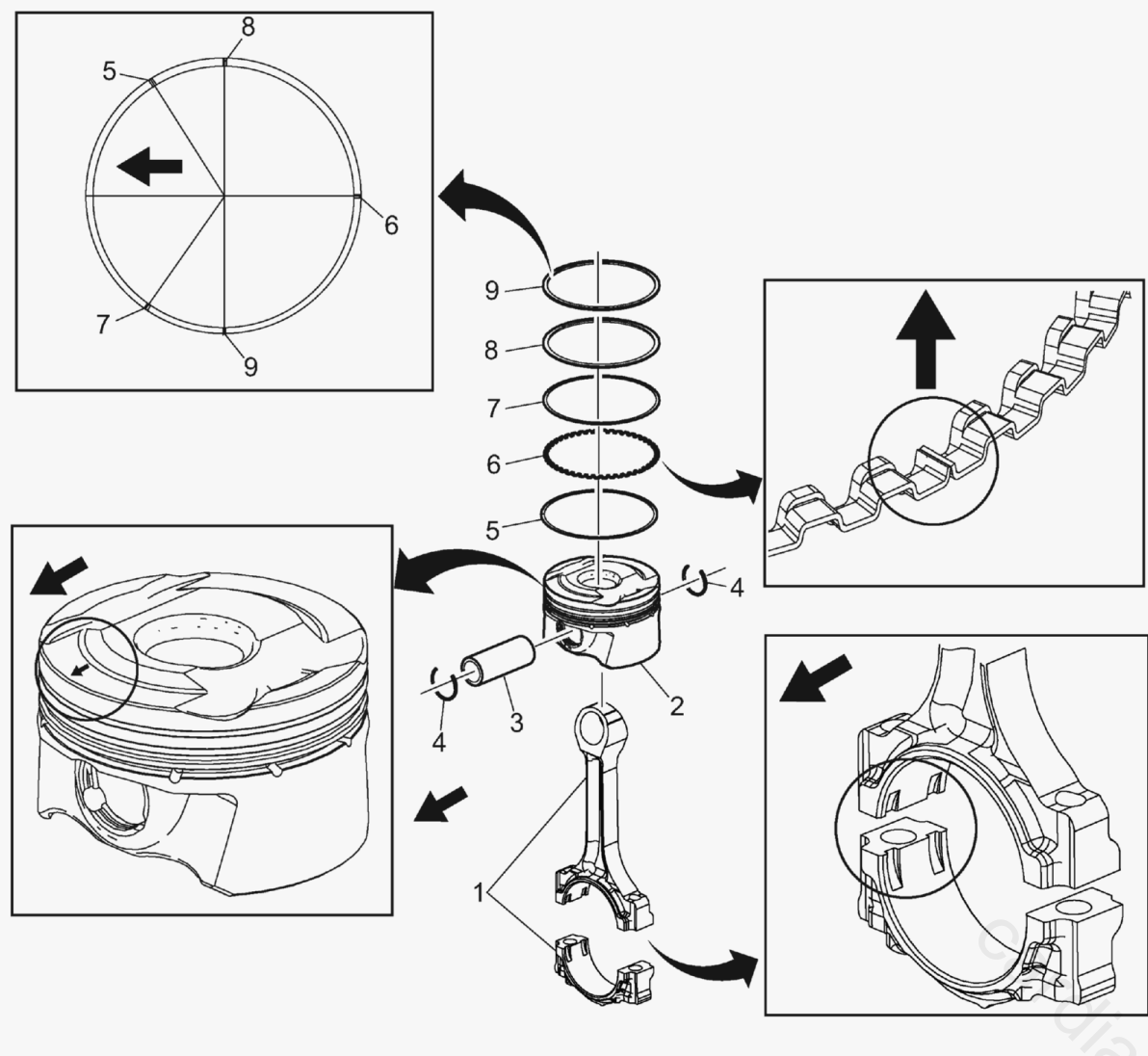


Fig. 428: Piston and Connecting Rod
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Connecting Rod NOTE: Align the connecting rod and piston with the features used to identify the orientation of the component relative to the front of the engine.
2	Piston Procedure 1. Locate the alignment feature or marks on the connecting rod. 2. Locate the alignment feature or marks on the piston. 3. Ensure that the alignment features are in the correct location when assembling the components.
3	Piston Pin

Callout	Component Name
4	Piston Pin Retainer CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage. Procedure 1. Coat the piston pin with oil. 2. Install one side of one piston pin retainer into the retaining groove using EN-49941 installer. Rotate the retainer until it is fully seated in the groove. 3. Install the piston pin. Push the piston pin until it bottoms in the previously installed retainer. 4. Install the second piston pin retainer, using EN-49941 installer. 5. Ensure that the piston moves freely. Special Tools EN-49941 Piston Pin Retainer Remover and Installer For equivalent regional tools, refer to Special Tools.
5	Piston Oil Ring Rail CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.
6	Piston Oil Ring Spacer NOTE: Properly orient the oil ring spacer as shown before installation. The ends of the spacer must be facing toward the top of the piston.
7	Piston Oil Ring Rail
8	Piston Compression Lower Ring
9	Piston Compression Upper Ring Procedure Once the rings are installed, set the ring gaps as shown. Use the piston location arrow for reference.

CAMSHAFT CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator

For equivalent regional tools, refer to [Special Tools](#).

Cleaning Procedure

1. Clean the camshaft in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the camshaft with compressed air.

Visual Inspection

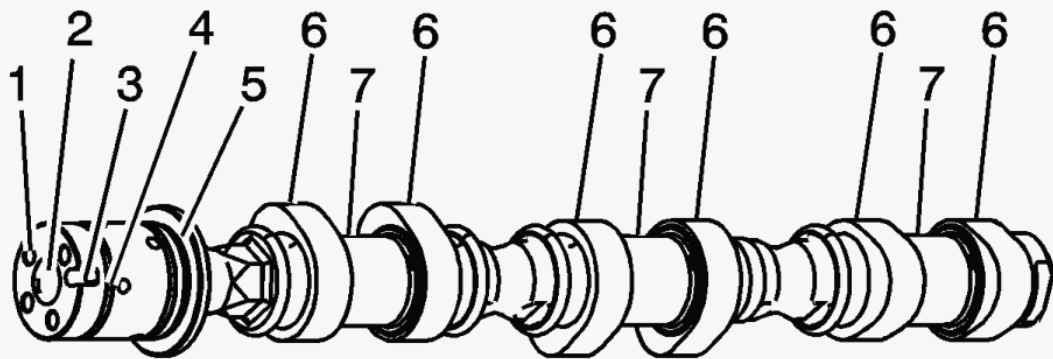


Fig. 429: Identifying Camshaft Inspection Areas

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
 - Excessive scoring or pitting
 - Discoloration from overheating
 - Deformation from excessive wear, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement

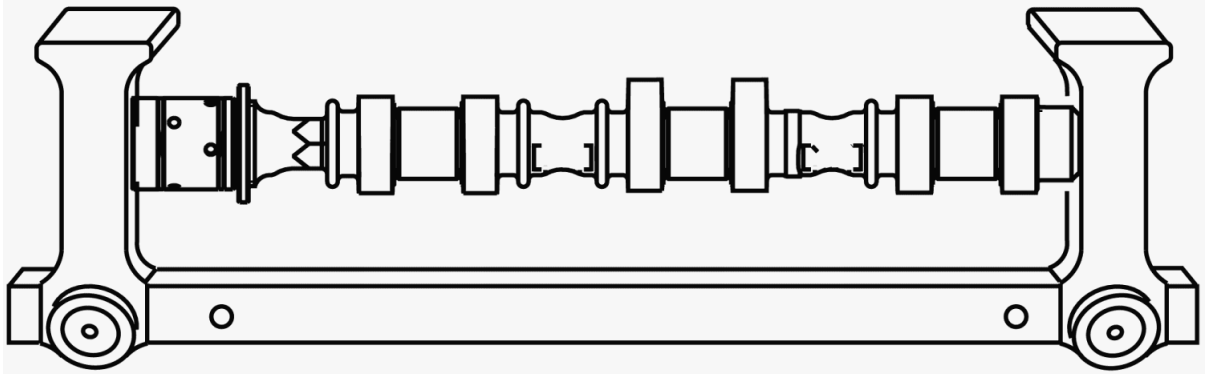


Fig. 430: Supporting Camshaft In Fixture
Courtesy of GENERAL MOTORS COMPANY

1. With the camshaft in a suitable fixture, measure the camshaft for wear.

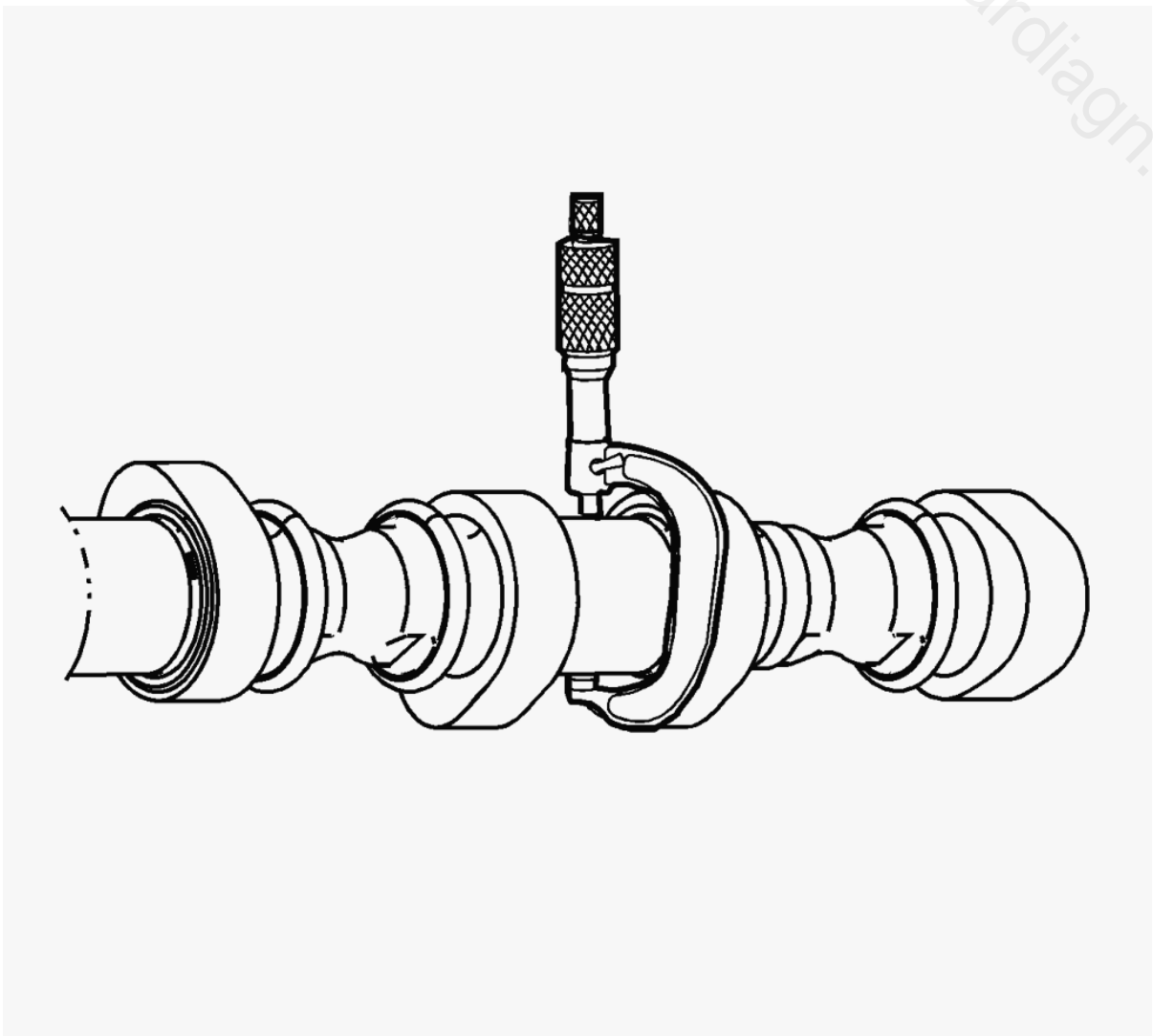


Fig. 431: Measuring Camshaft Journals
Courtesy of GENERAL MOTORS COMPANY

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Refer to [Engine Mechanical Specifications](#).

- If the diameter is smaller than specifications, replace the camshaft.
- If the out-of-round exceeds specifications, replace the camshaft.

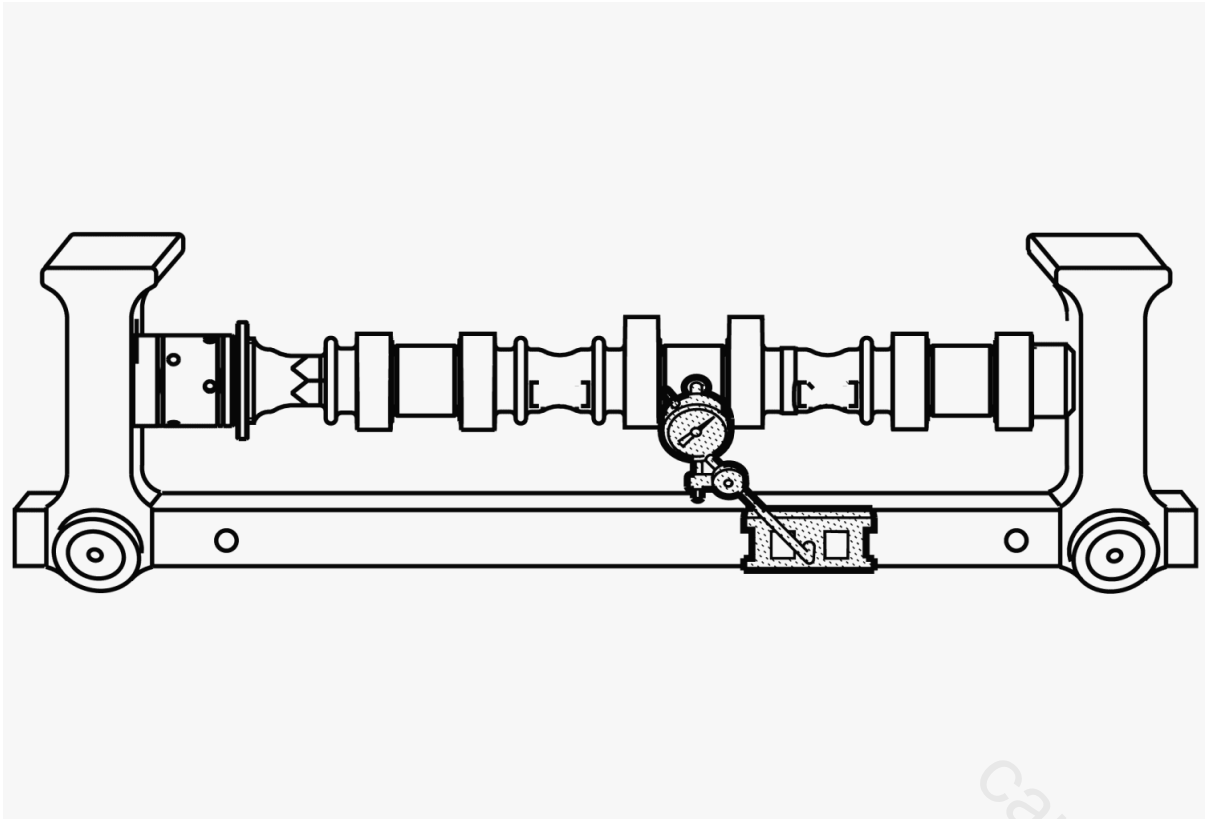


Fig. 432: Checking Camshaft Runout

Courtesy of GENERAL MOTORS COMPANY

3. Measure the camshaft runout using the **GE-7872** indicator. Refer to [Engine Mechanical Specifications](#).

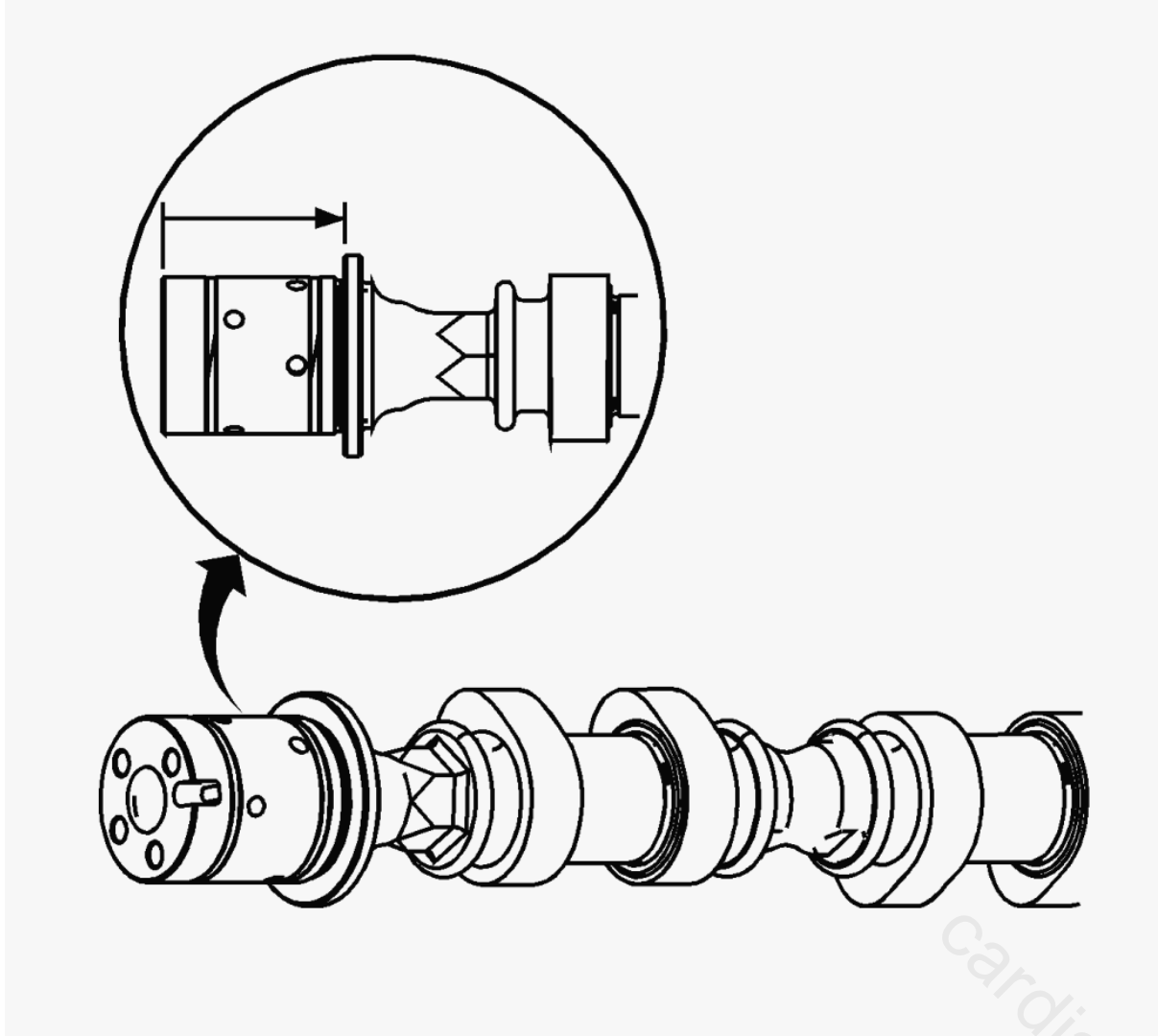


Fig. 433: Measuring Camshaft Thrust Width
 Courtesy of GENERAL MOTORS COMPANY

4. Measure the camshaft thrust width for wear using a depth micrometer. Refer to [Engine Mechanical Specifications](#).

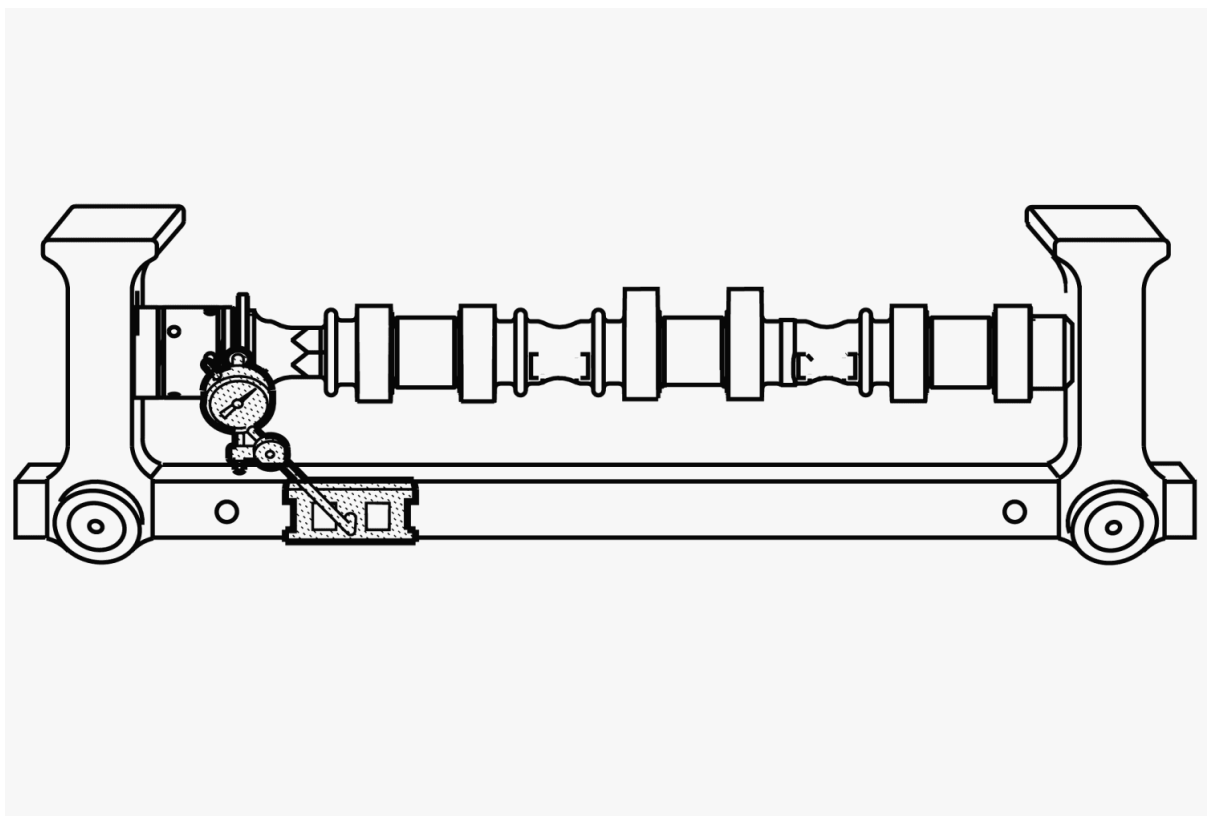


Fig. 434: Measuring Camshaft
 Courtesy of GENERAL MOTORS COMPANY

5. Measure the camshaft thrust wall surface for runout using **GE-7872** indicator. Refer to [Engine Mechanical Specifications](#).
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

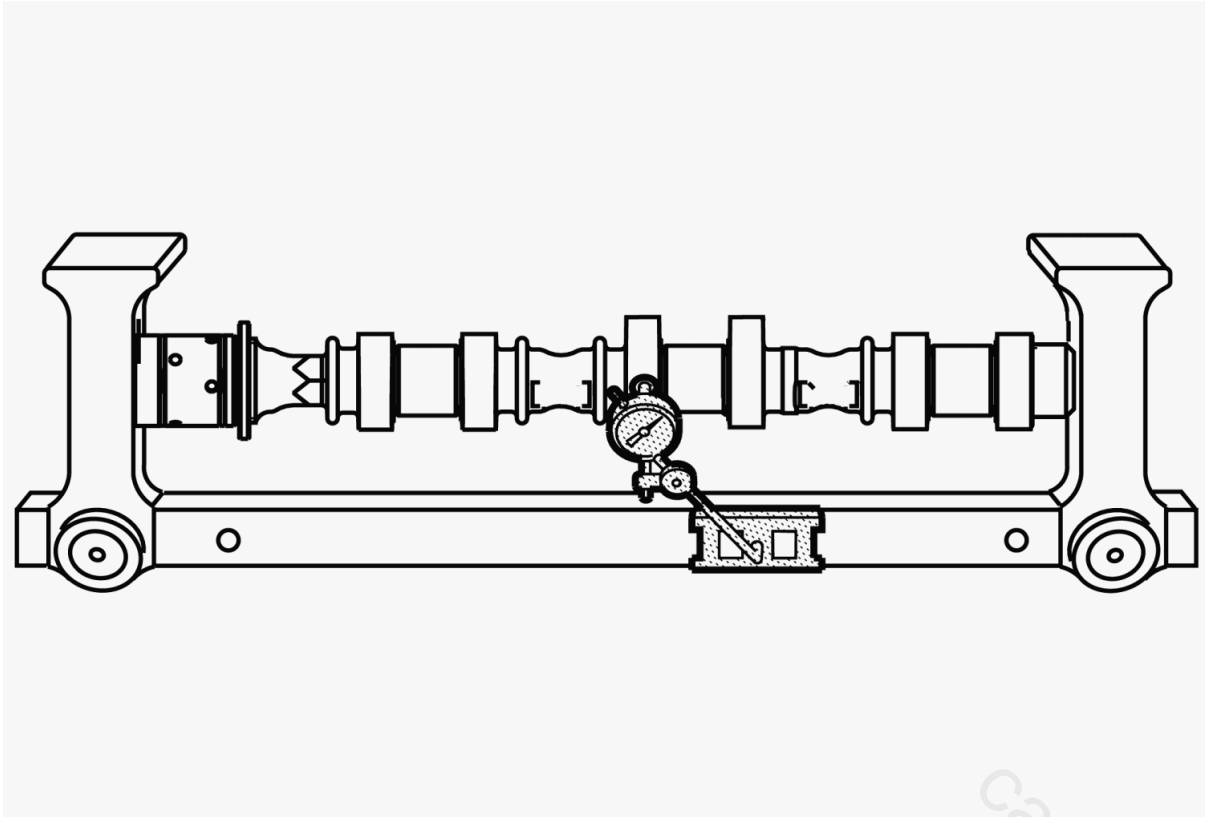


Fig. 435: Measuring Camshaft Lobes For Wear
Courtesy of GENERAL MOTORS COMPANY

7. Measure the camshaft lobes for wear using the **GE-7872** indicator.

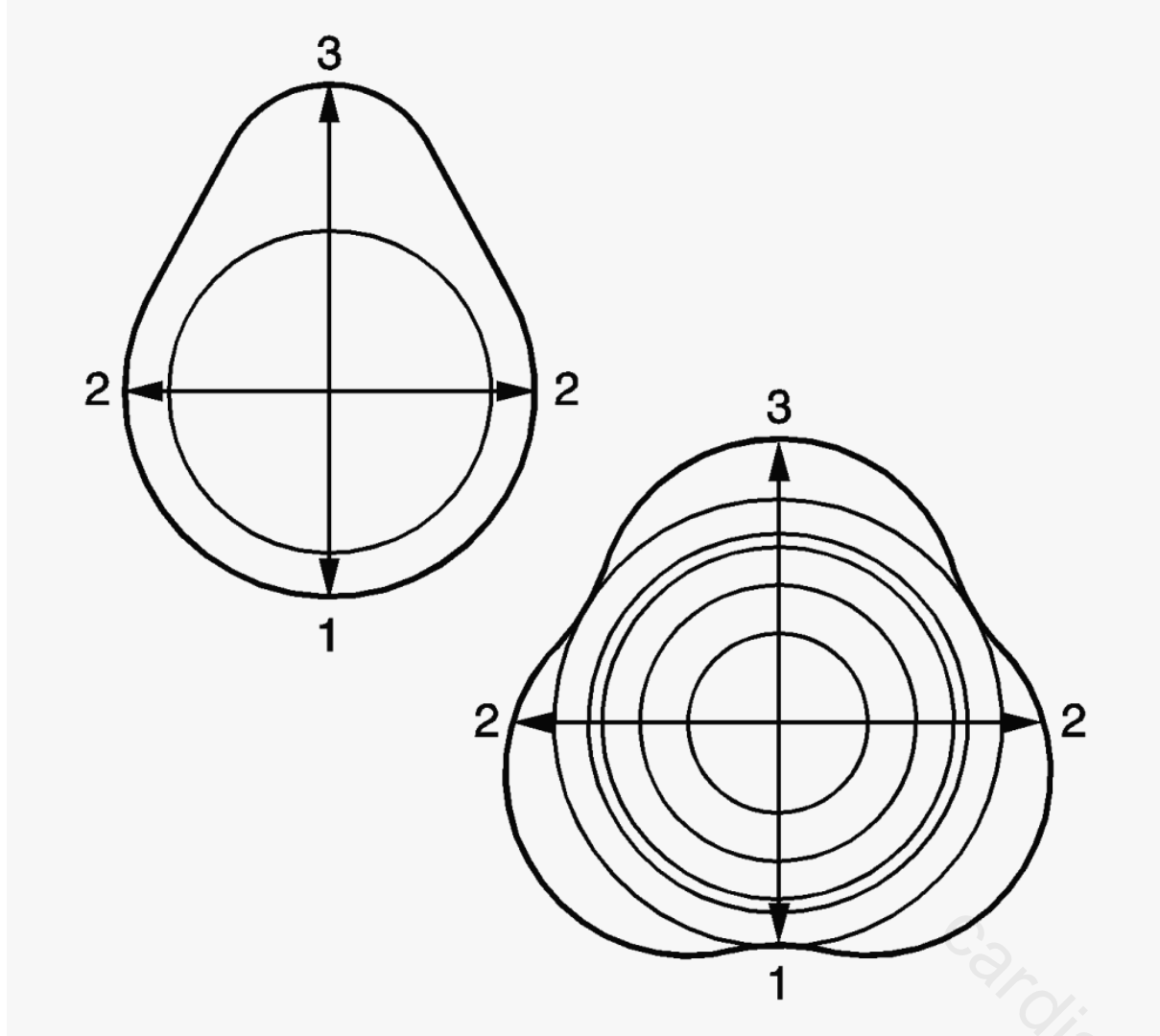


Fig. 436: View of Lobe Diagram

Courtesy of GENERAL MOTORS COMPANY

8. Place the **GE-7872** indicator with the indicator tip on the base circle (1) of the camshaft lobe.
 1. Place the **GE-7872** indicator at zero.
 2. Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. Refer to **Engine Mechanical Specifications**.
 3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

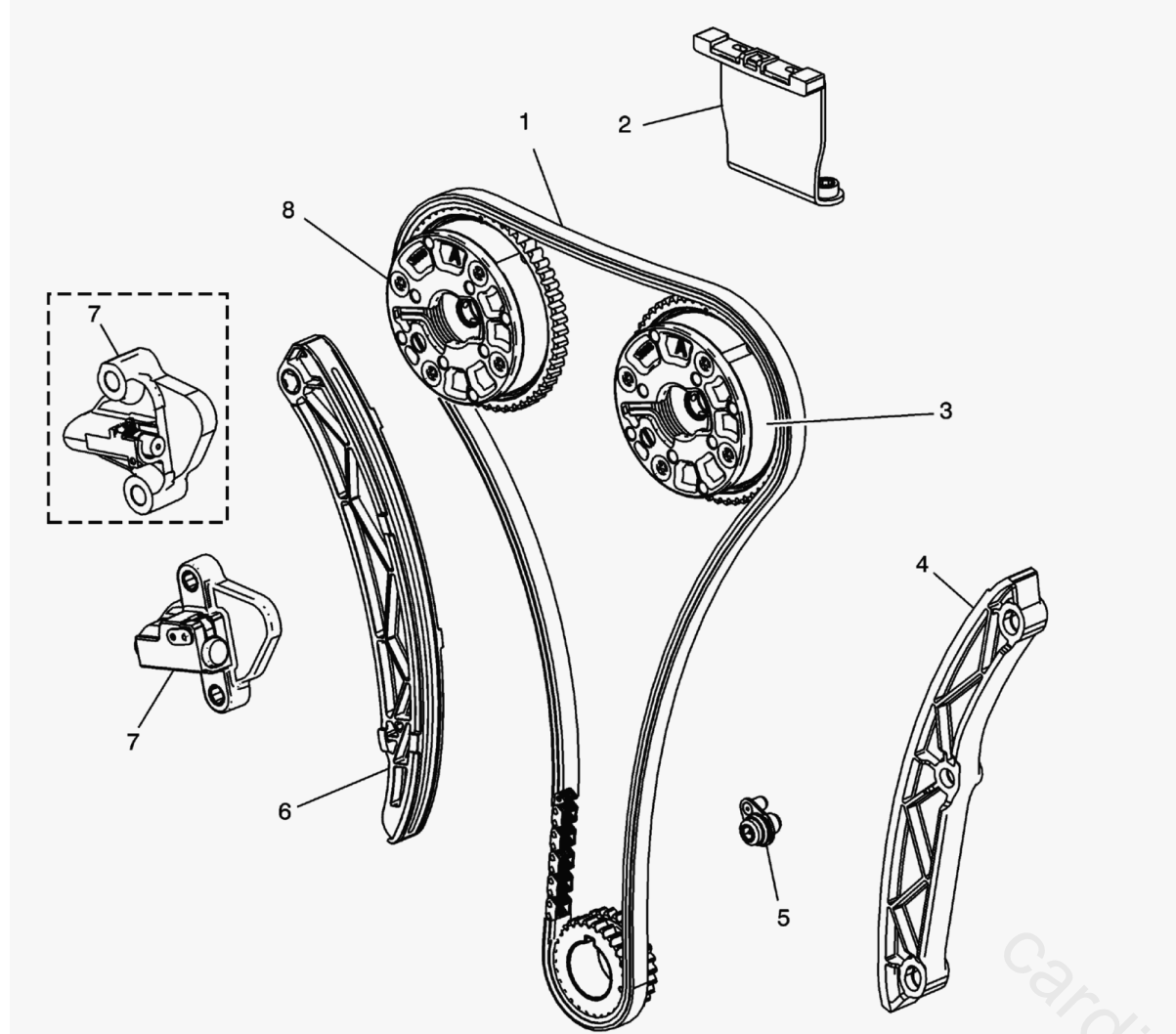


Fig. 437: Camshaft Timing Chain and Sprocket
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Procedure 1. Inspect the timing chain for binding or worn links. 2. Inspect the timing chain for loose links. 3. Inspect the timing chain for loose pins. 4. Replace the timing chain if binding, excessive wear, or a loose condition is present.
2	Timing Chain Guide Procedure 1. Inspect the guide for worn guide surface. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface. 2. Inspect the guide for a cracked or broken guide surface. 3. Inspect the guide for a cracked or damaged guide base. 4. Replace the guide if damage is present.

Callout	Component Name
3	Camshaft Position Actuator Assembly - Exhaust Procedure 1. Inspect the camshaft actuator faces for signs of movement. 2. Inspect the camshaft actuator for sprocket damage. 3. Inspect the actuator bolt seating and sealing inner hub flange for damage. 4. Inspect the back of the actuator for locating pin damage. 5. Ensure the actuator housing bolts are not loose or missing. 6. Inspect the back of the actuator for blockage to the oil passages. 7. Replace the actuator if any of these conditions are present.
4	Timing Chain Guide Procedure 1. Inspect the guide for wear to the guide surface. 2. Inspect the guide for cracked or broken guide surface or base. 3. Replace the guide if these conditions are present.
5	Timing Chain Oil Nozzle Procedure 1. Inspect the oil nozzle body for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged. 2. Verify oil nozzle oil flow with compressed air. 3. Replace the nozzle if damage or oil flow restriction is present.
6	Timing Chain Tensioner Shoe Procedure 1. Inspect for worn, cracked, or broken shoe surface. 2. Inspect the shoe for wear at the tensioner contact pad. 3. Replace the shoe if any of these conditions are present.
7	Timing Chain Tensioner Procedure 1. Inspect the tensioner for damage to the plunger-to-shoe contact surface. 2. Inspect the tensioner for a locked or binding condition. Reset the plunger and ensure the plunger moves freely in and out of the tensioner body. • If the tensioner has a lever on the front, press down on the lever and depress the plunger. Insert a suitable tool into the hole in the tensioner body to hold the plunger in the retracted position. • If the tensioner has a retaining clip, press the clip and depress the plunger. Insert a suitable tool into the hole in the tensioner body to hold the plunger in the retracted position. 3. Inspect the timing chain tensioner gasket for damage. 4. Replace the tensioner if any of these conditions are present.

Callout	Component Name
8	Camshaft Position Actuator Assembly - Intake Procedure 1. Inspect the camshaft actuator faces for signs of movement. 2. Inspect the camshaft actuator for sprocket damage. 3. Inspect the actuator bolt seating and sealing inner hub flange for damage. 4. Inspect the back of the actuator for locating pin damage. 5. Ensure the actuator housing bolts are not loose or missing. 6. Inspect the back of the actuator for blockage to the oil passages. 7. Replace the actuator if any of these conditions are present.

INTAKE MANIFOLD CLEANING AND INSPECTION

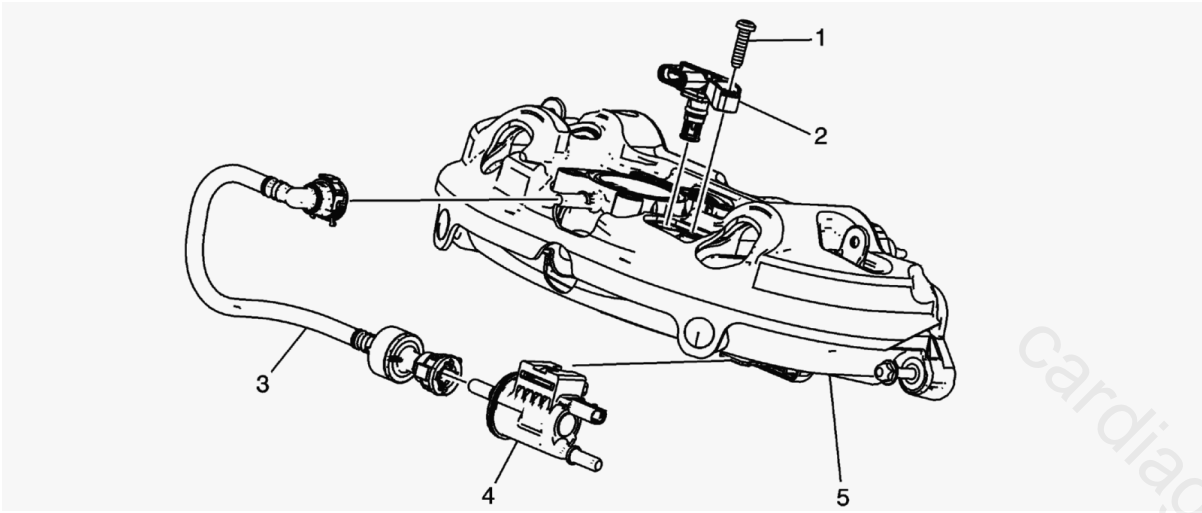


Fig. 438: Intake Manifold Cleaning and Inspection
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove all components prior to cleaning and inspection. 2. Inspect each component.	
1	Intake Air Pressure and Temperature Sensor Bolt CAUTION: Refer to Fastener Caution . Tighten 5 N.m (44 lb in)
2	Intake Air Pressure and Temperature Sensor
3	Evaporative Emission Canister Purge Tube Assembly
4	Evaporative Emission Canister Purge Valve
5	Intake Manifold

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

- EN-8087 Cylinder Bore Checking Gauge
- EN-45059 Angle Meter

- GE-7872 Magnetic Base Dial Indicator Set

For equivalent regional tools, refer to [Special Tools](#).

Crankshaft Cleaning and Inspection

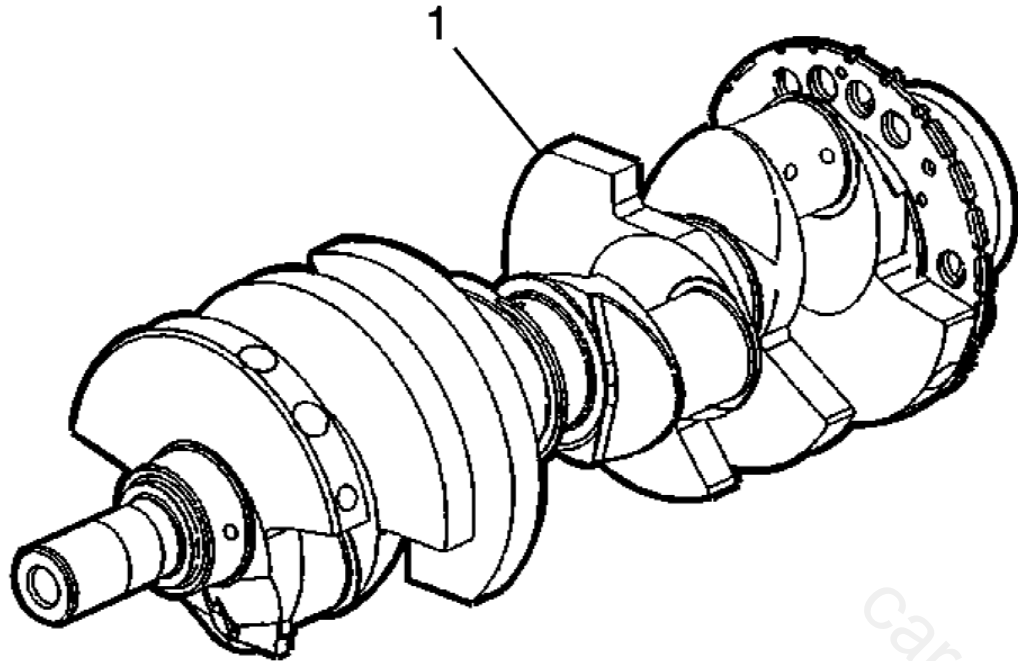


Fig. 439: Clean Crankshaft With Solvent
Courtesy of GENERAL MOTORS COMPANY

NOTE: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may affect on-board diagnostic (OBD) II system performance.

1. Clean the crankshaft (1) with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the crankshaft with compressed air.

NOTE: Reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.

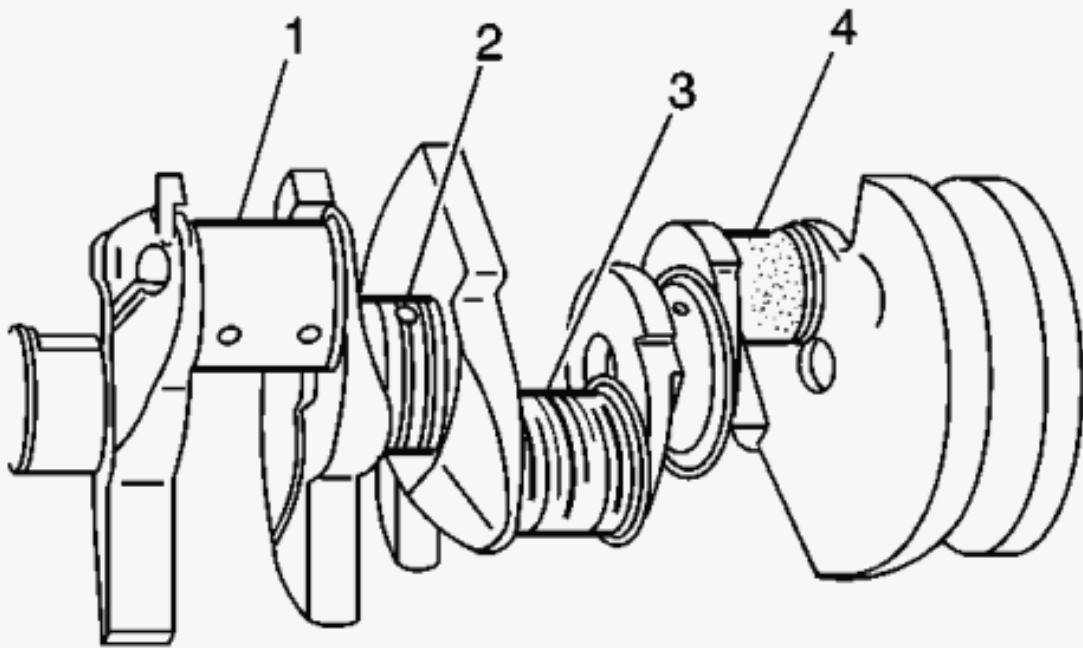


Fig. 440: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS COMPANY

5. Inspect the crankshaft journals for wear (1). The journals should be smooth, with no signs of scoring, wear, or damage.
6. Inspect the crankshaft journals for grooves or scoring (2).
7. Inspect the crankshaft journals for scratches or wear (3).
8. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

Crankshaft Measurements

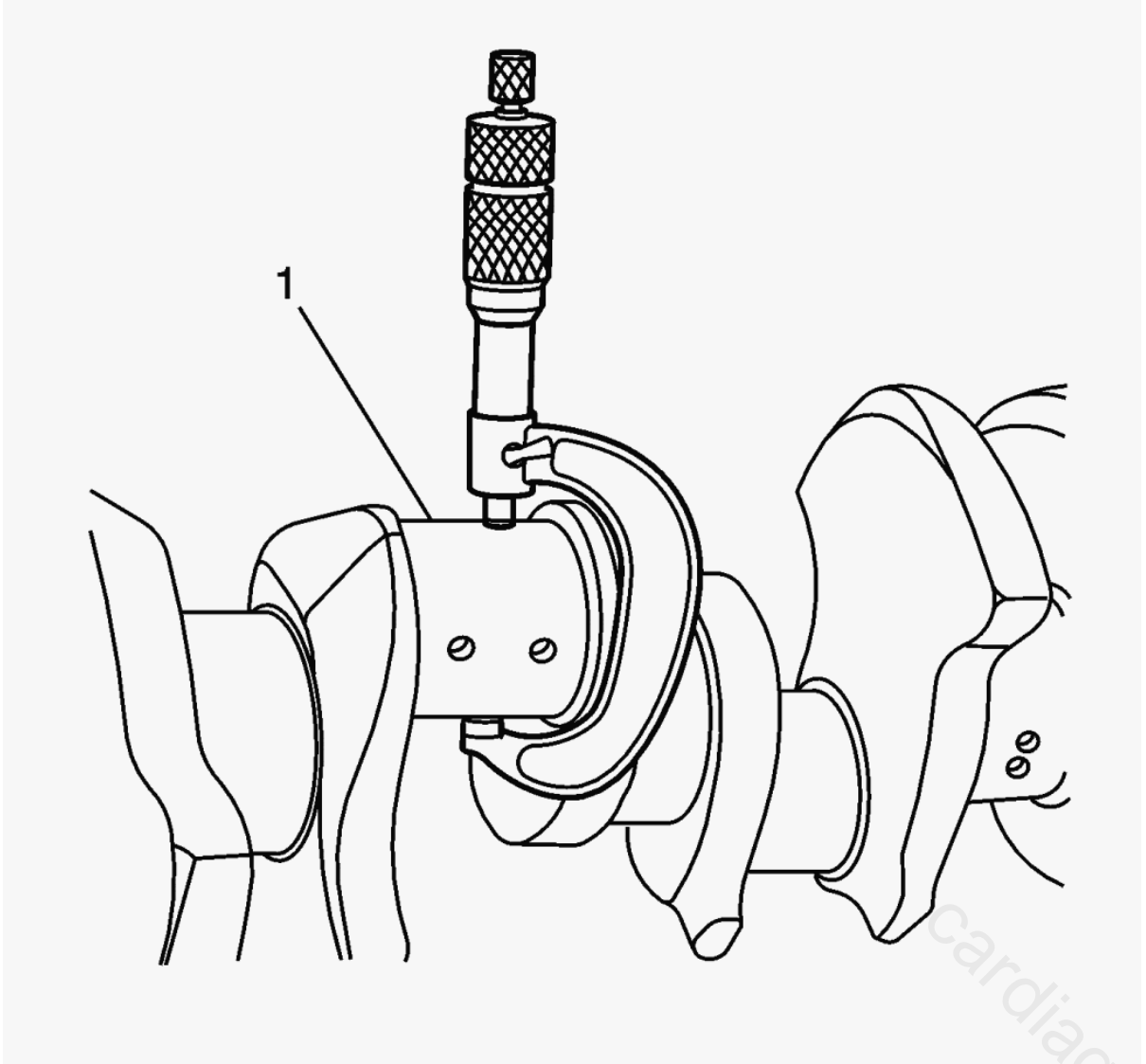


Fig. 441: Measure Crankshaft Journals For Out-Of-Round
Courtesy of GENERAL MOTORS COMPANY

1. Measure the crankshaft journals (1) for out-of-round.
2. Measure the crankshaft journals for taper.

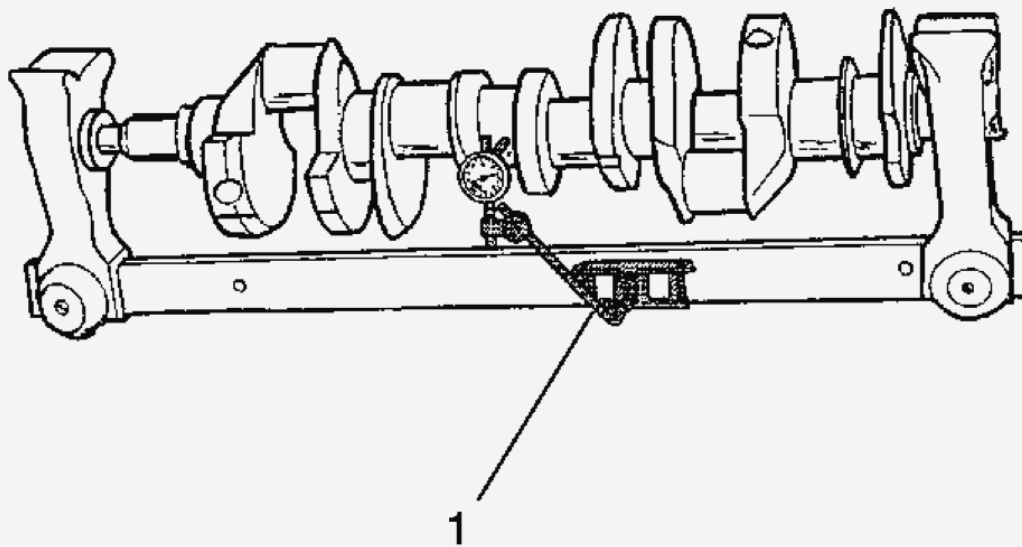


Fig. 442: Measuring The Crankshaft Runout
Courtesy of GENERAL MOTORS COMPANY

3. Measure the crankshaft runout.

Using wooden V-blocks, support the crankshaft on the front and rear journals.

4. Use the **GE-7872** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.
5. Use the **GE-7872** indicator in order to measure the runout of the crankshaft rear flange.
6. Replace the crankshaft if the measurements are not within specifications. Refer to **Engine Mechanical Specifications**.

Crankshaft Bearings Cleaning and Inspection

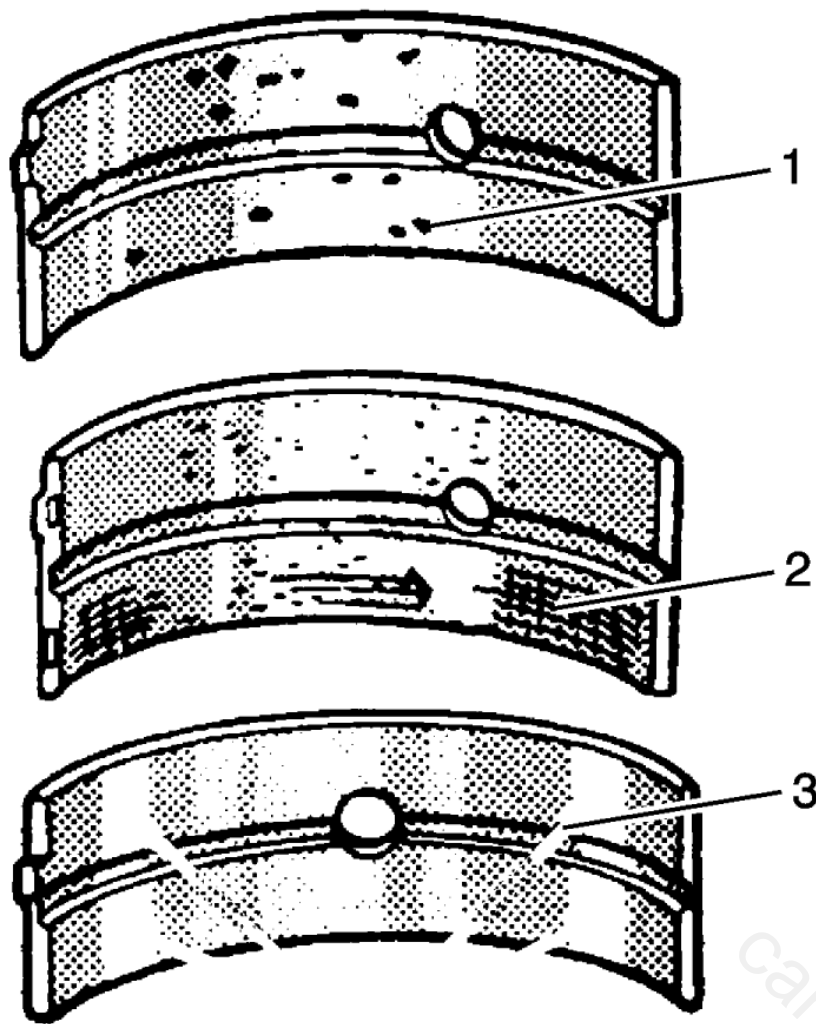


Fig. 443: Identifying Crankshaft Bearings For Craters Or Pockets
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Crankshaft bearings **MUST** be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use.
- If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

1. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.
2. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
3. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
4. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

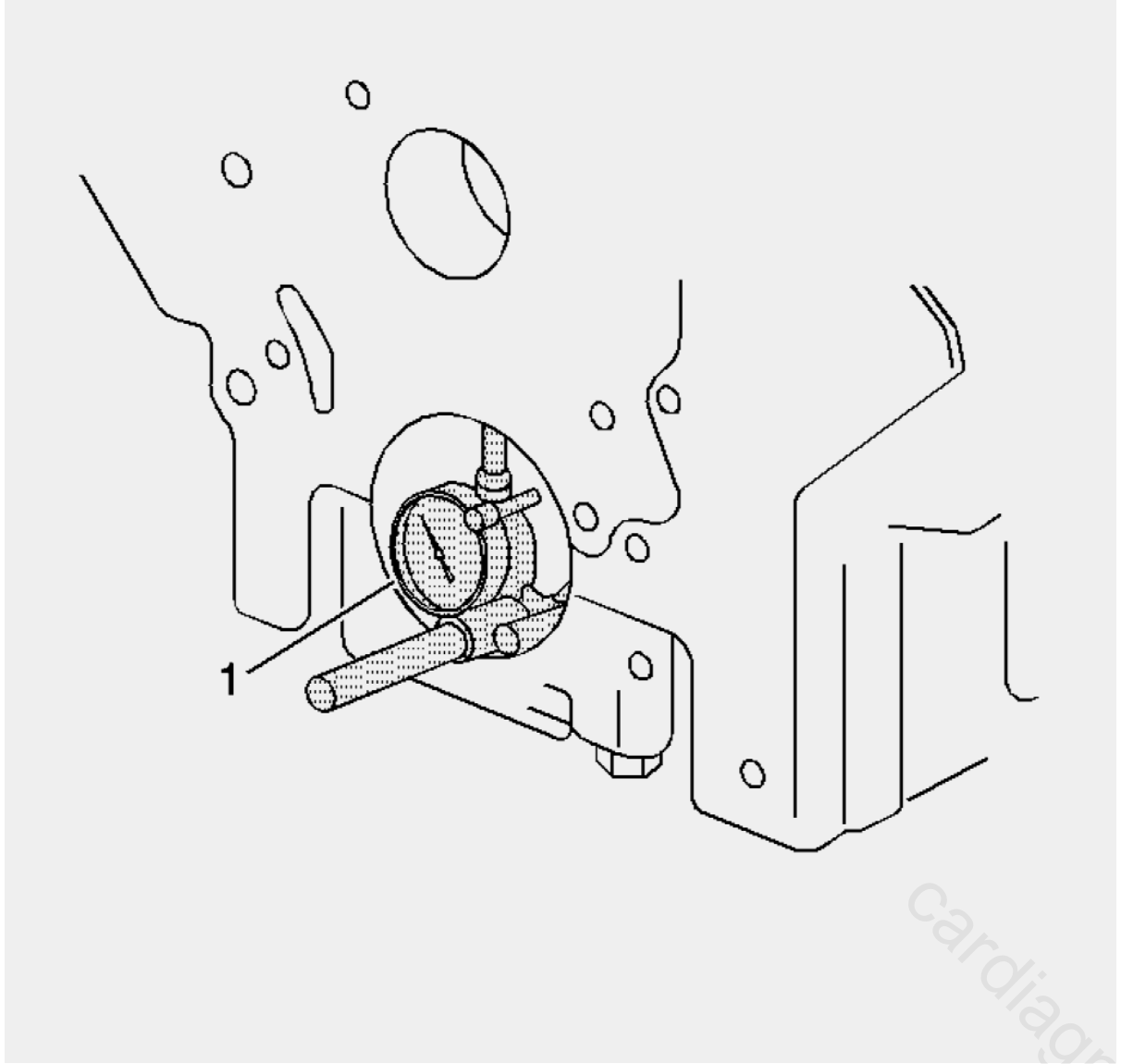


Fig. 444: Measuring Bearing Bore

Courtesy of GENERAL MOTORS COMPANY

5. Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:
 1. Tighten the bedplate to specification using the **EN-45059** meter.
 2. Measure the bearing bore for taper and out-of-round using the **EN-8087** gauge (1).
 3. 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.

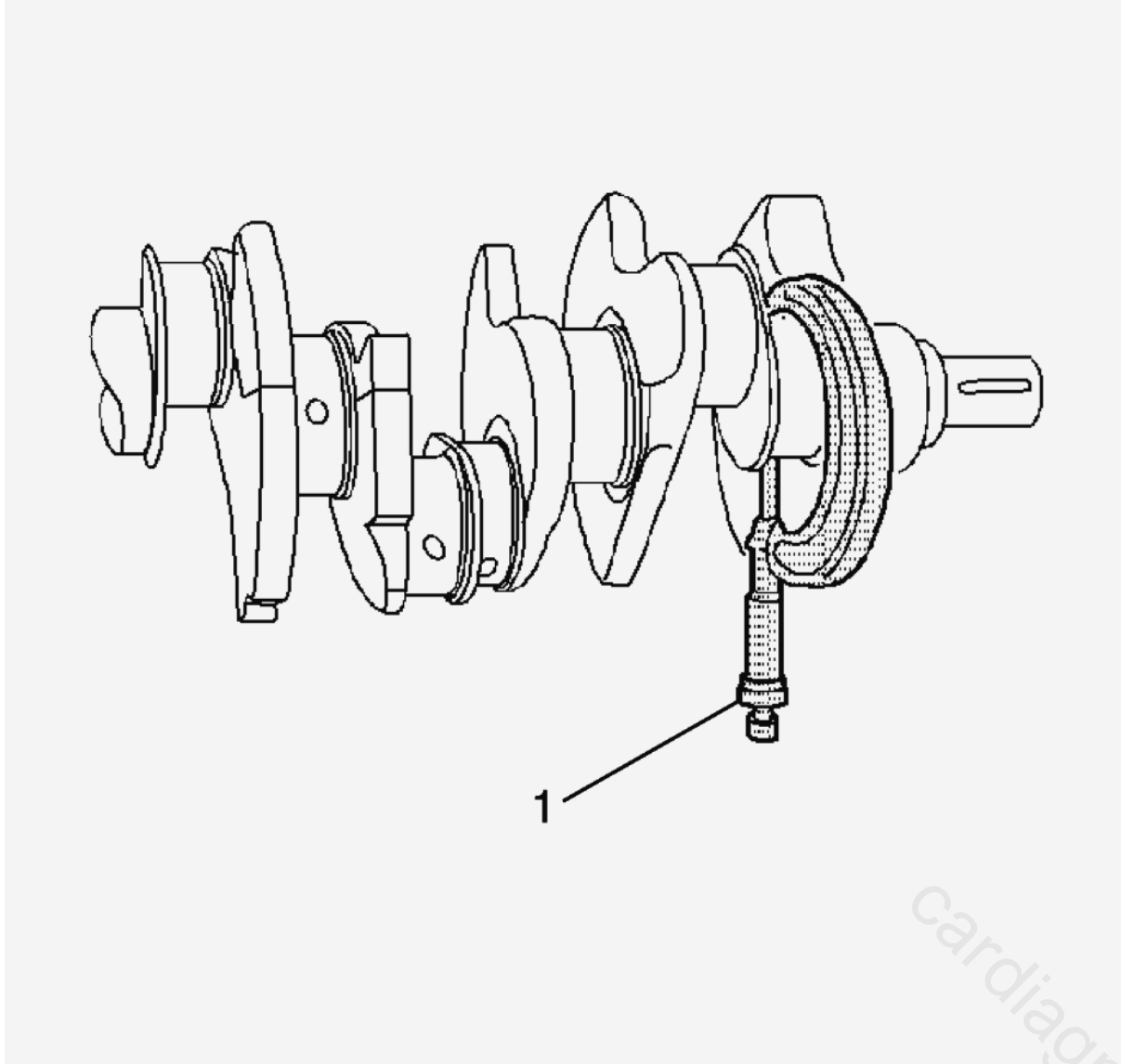


Fig. 445: View of Measuring Crankshaft Bearing Journal Using Method A
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
 1. Measure the crankshaft bearing journal diameter with a micrometer (1) in several places, 90 degrees apart. Average the measurements.
 2. Measure the crankshaft bearing journal taper and runout.
 3. Install the lower crankcase and tighten the bearing cap bolts to specification.
 4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
 5. Subtract journal measurement from bearing ID measurement to determine clearance.
 6. Determine whether clearance is within specification.
 7. If out of specification, choose different inserts.
 8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
 9. Measure the crankshaft main bearing inside diameter with an inside micrometer.

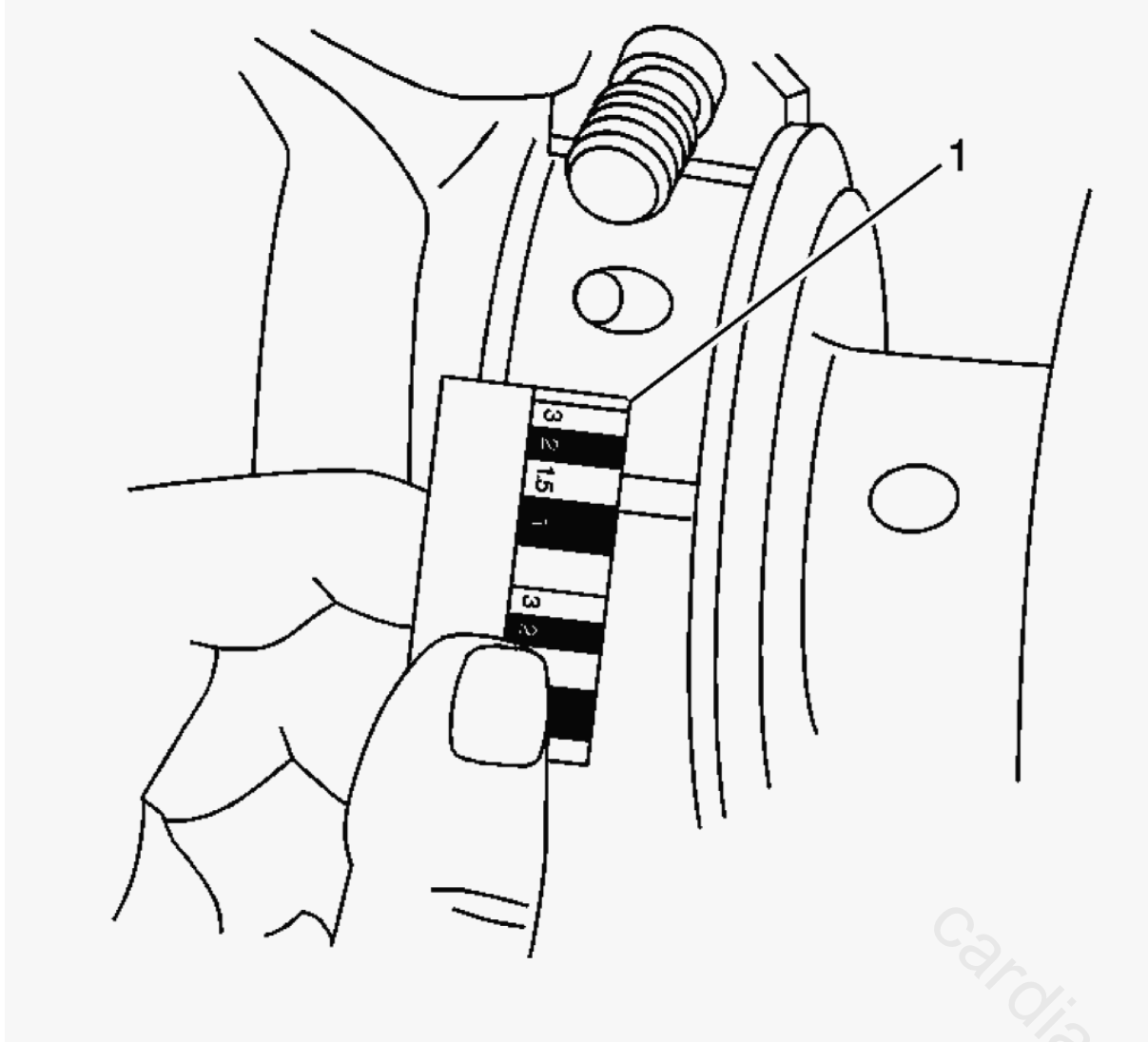


Fig. 446: Measuring Bearing Clearance Using Method B
Courtesy of GENERAL MOTORS COMPANY

3. To measure bearing clearance using Method B, use the following procedure:

1. Clean the used bearing inserts.
2. Install the used bearing inserts.
3. Place a piece of gaging plastic across the entire bearing width.
4. Install the bearing caps.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

5. Install the bearing cap bolts to specification.

NOTE: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or to the bearing cap.
7. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
8. Remove the gauging plastic.

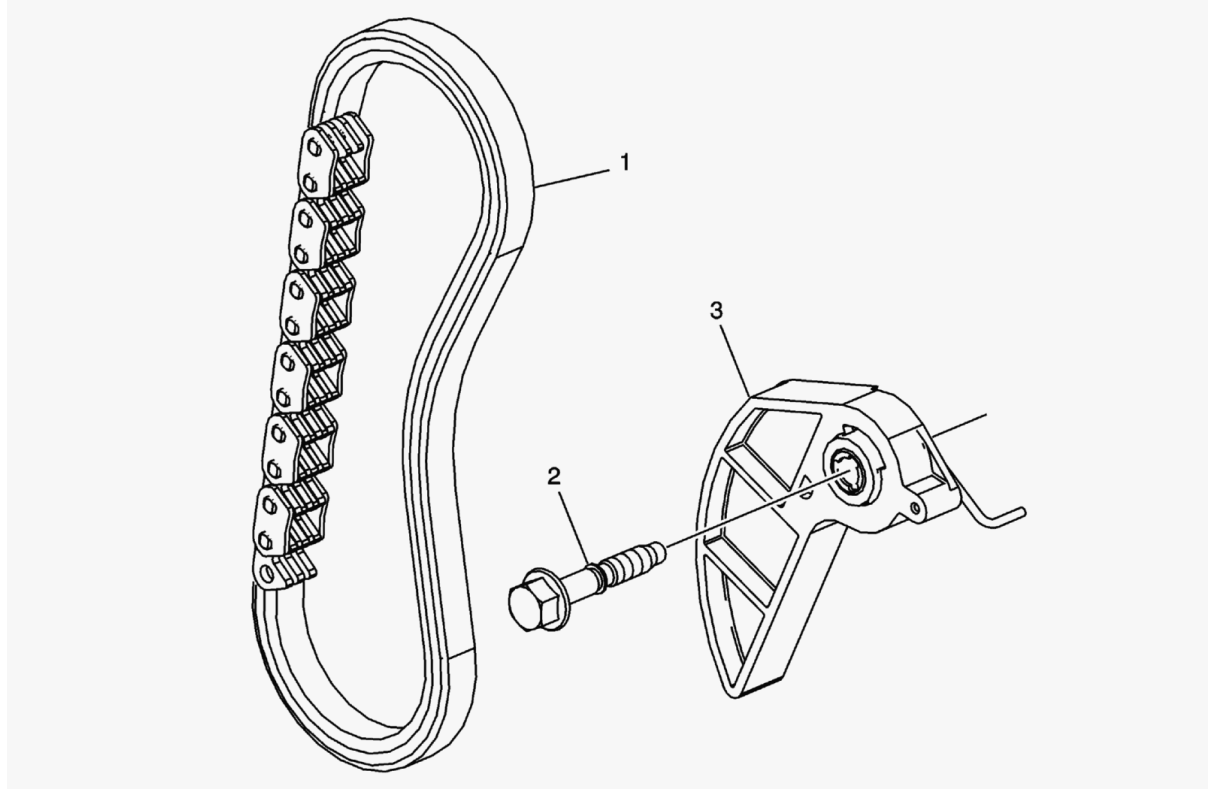


Fig. 447: Oil Pump Drive Chain Tensioner And Oil Pump Drive Chain
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
1. Clean all components.	
2. Inspect each component.	
1	Oil Pump Drive Chain
2	Oil Pump Drive Chain Tensioner Bolt
3	Oil Pump Drive Chain Tensioner

OIL PUMP CLEANING AND INSPECTION

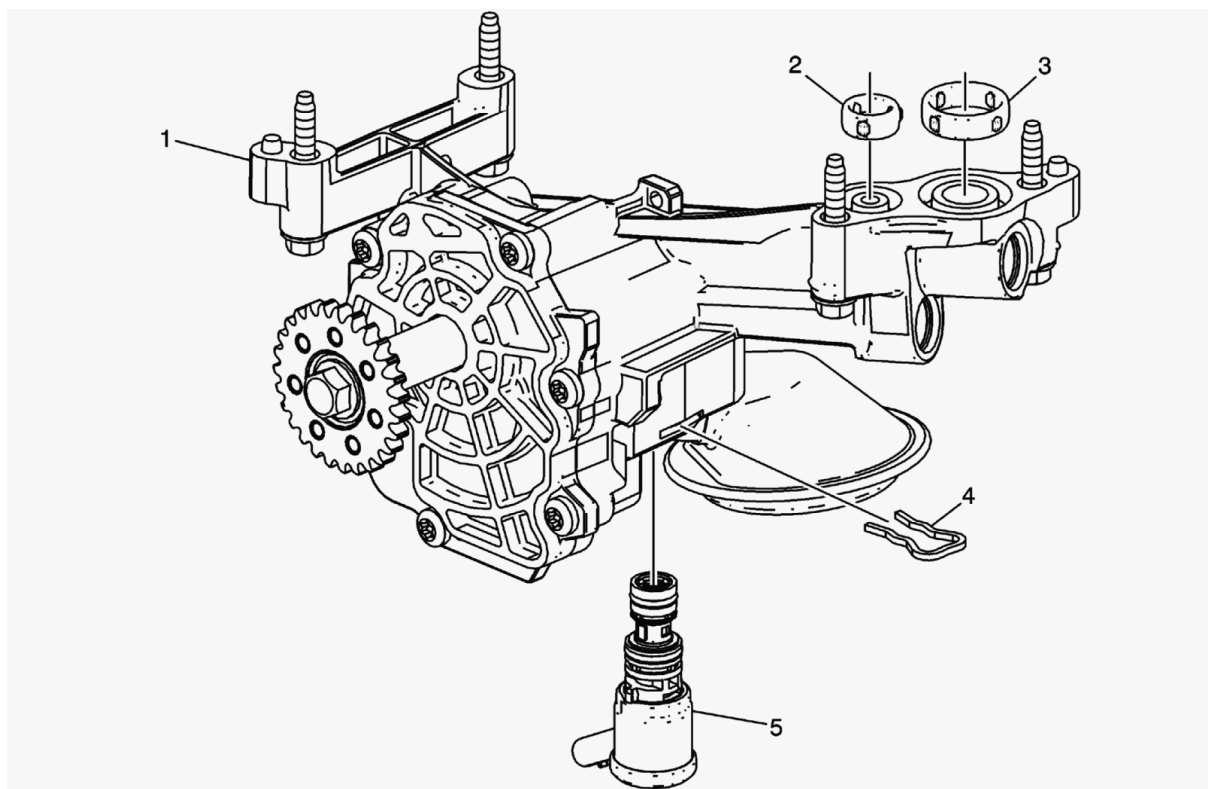


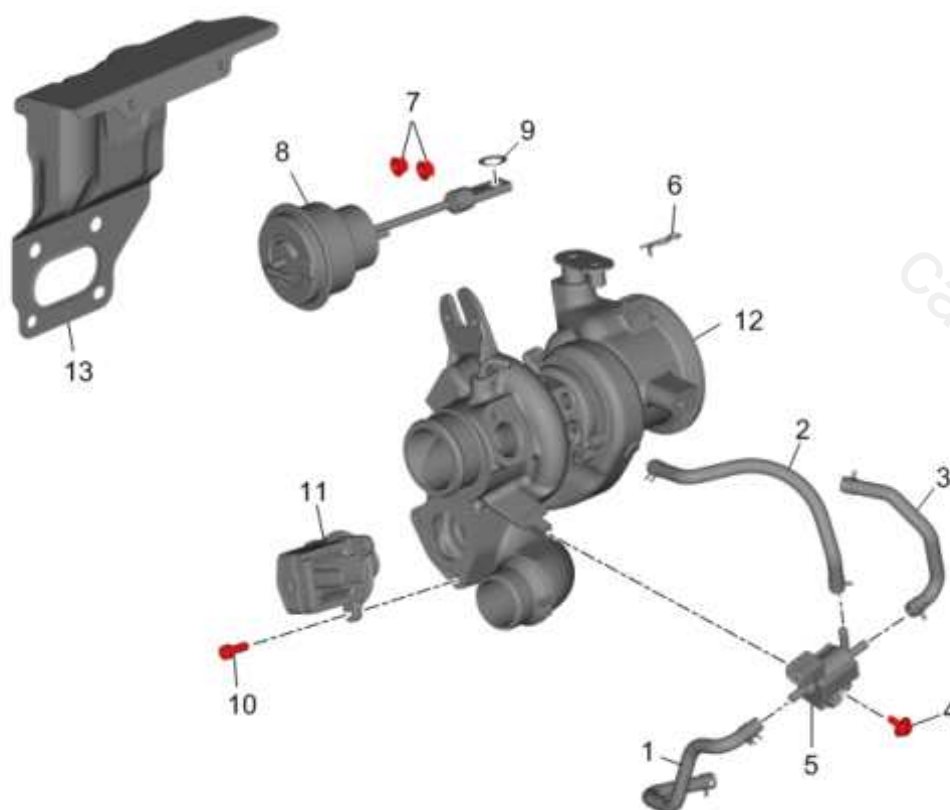
Fig. 448: Oil Pump

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
1. Clean all components. 2. Inspect each component.	
1	Oil Pump
2	Oil Pump Gasket
3	Oil Pump Gasket
4	Oil Pump Flow Control Solenoid Valve Retainer
5	Oil Pump Flow Control Solenoid Valve

TURBOCHARGER CLEANING AND INSPECTION

Turbocharger and Components Cleaning and Inspection

**Fig. 449: Turbocharger and Components**

Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Components Cleaning and Inspection

Callout	Component Name
Preliminary Procedure	
1. Remove all components. 2. Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Refer to Symptoms - Engine Mechanical . 3. Clean all mating surfaces. 4. Inspect all threaded holes for damage.	
1	Turbocharger Wastegate Regulator Solenoid Valve Hose
2	Turbocharger Wastegate Regulator Solenoid Valve Hose
3	Turbocharger Wastegate Regulator Solenoid Valve Hose

Callout	Component Name
4	Turbocharger Wastegate Regulator Solenoid Valve Bolt CAUTION: Refer to Fastener Caution . Tighten 8 N.m (71 lb in)
5	Turbocharger Wastegate Regulator Solenoid Valve
6	Turbocharger Wastegate Actuator Arm Retainer NOTE: Slight force may be needed to compress the turbocharger wastegate actuator rod spring at the wastegate actuator arm enough to install the actuator arm retainer. Be sure to provide only enough force, as needed, to slide the retainer into the slot. Too much force can result in crushing or deforming the washer.
7	Turbocharger Wastegate Actuator Nut [2x] Tighten 10 N.m (89 lb in)
8	Turbocharger Wastegate Actuator Procedure Inspect the wastegate regulator mechanism for functionality.
9	Turbocharger Wastegate Actuator Rod Spring NOTE: Ensure the spring washer is installed in the correct orientation, with the widest side facing up. Do not over-compress the wastegate actuator arm against the spring washer when installing the actuator arm retainer.
10	Charge Air Bypass Valve Bolt [3x] Tighten 10 N.m (89 lb in)
11	Turbocharger Bypass Valve Solenoid
12	Turbocharger Procedure 1. Inspect the compressor and turbine for bent or broken blades and foreign material. PCV fluids and combustion product buildup are common and not a sign of failure. 2. Inspect the mating surfaces for flatness. 3. Replace the turbocharger if damage is found.
13	Turbocharger Heat Shield

Turbocharger Coolant Feed/Return Pipe Assemblies Cleaning and Inspection

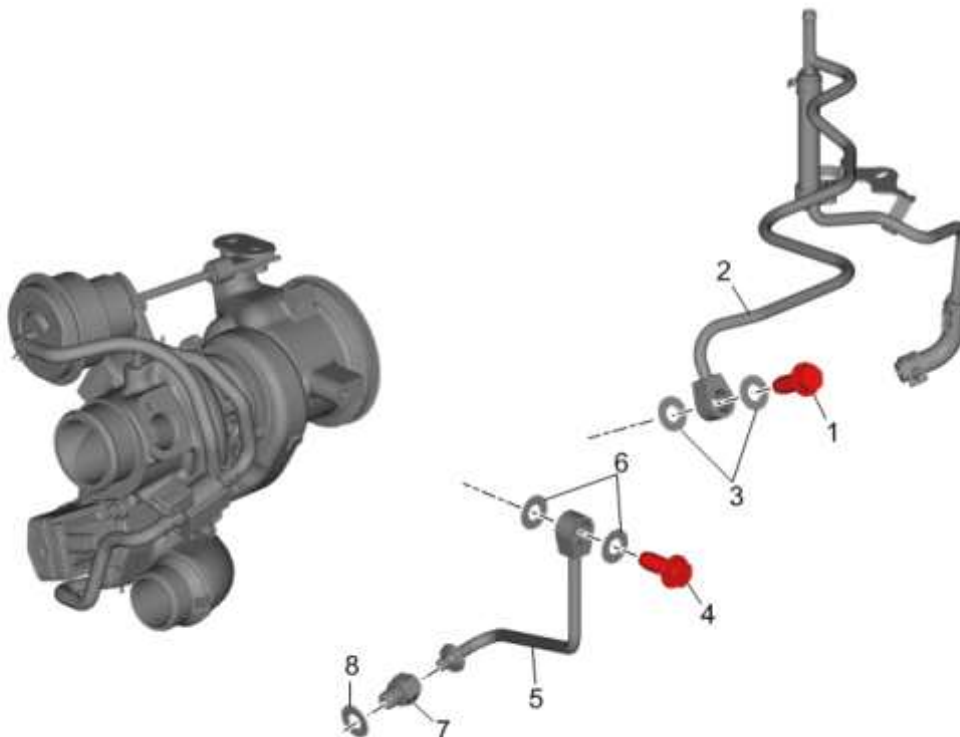


Fig. 450: Turbocharger Coolant Feed/Return Pipe Assemblies

Courtesy of GENERAL MOTORS COMPANY

Turbocharger Coolant Feed/Return Pipe Assemblies Cleaning and Inspection

Callout	Component Name
Preliminary Procedure 1. Clean all components. 2. Inspect each component.	
1	Turbocharger Coolant Return Pipe Bolt
2	Turbocharger Coolant Return Pipe
3	Turbocharger Coolant Return Pipe Seal [2x] NOTE: Discard the seals. Use NEW seals upon installation.
4	Turbocharger Coolant Feed Pipe Bolt
5	Turbocharger Coolant Feed Pipe
6	Turbocharger Coolant Feed Pipe Seal NOTE: Discard the seals. Use NEW seals upon installation.
7	Turbocharger Coolant Return Pipe Fitting NOTE: Discard the pipe fitting. Use a NEW fitting upon installation.
8	Turbocharger Oil Feed Pipe Washer NOTE: Discard the washer. Use a NEW washer upon installation.

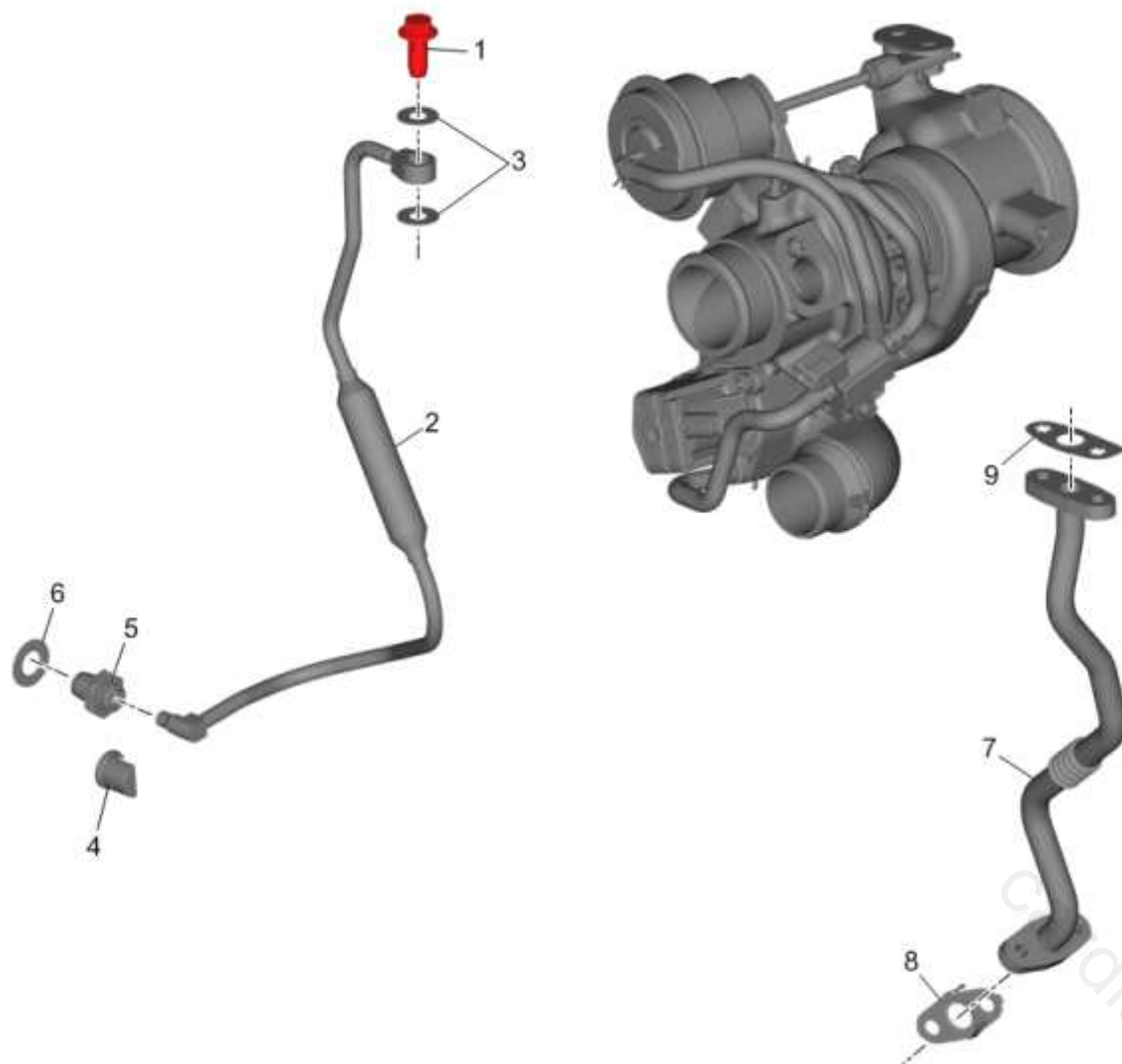


Fig. 451: Turbocharger Oil Feed/Return Pipe Assemblies

Courtesy of GENERAL MOTORS COMPANY

Turbocharger Oil Feed/Return Pipe Assemblies Cleaning and Inspection

Callout	Component Name
Preliminary Procedure 1. Clean all components. 2. Inspect each component.	
1	Turbocharger Oil Feed Pipe Bolt
2	Turbocharger Oil Feed Pipe
3	Turbocharger Oil Feed Pipe Washer [2x] NOTE: Discard the washers. Use NEW washers upon installation.
4	Turbocharger Oil Feed Pipe Clip
5	Turbocharger Pipe Fitting NOTE: Discard the pipe fitting. Use a NEW fitting upon installation.

Callout	Component Name
6	Turbocharger Oil Feed Pipe Washer NOTE: Discard the washer. Use a NEW washer upon installation.
7	Turbocharger Oil Return Pipe
8	Turbocharger Oil Return Pipe Gasket NOTE: Discard the used gasket. Use a NEW gasket upon installation.
9	Turbocharger Oil Return Pipe Gasket NOTE: Discard the used gasket. Use a NEW gasket upon installation.

OIL PAN CLEANING AND INSPECTION

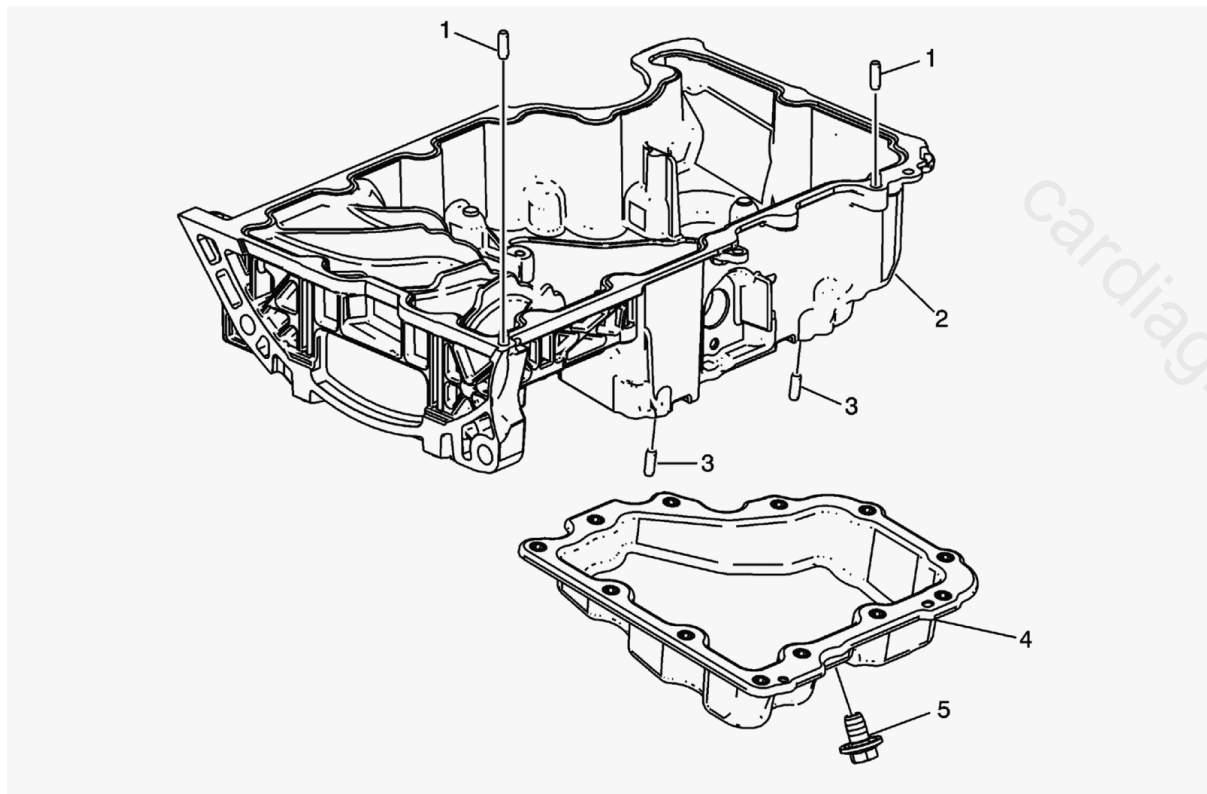


Fig. 452: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
1. Remove all components prior to cleaning. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 3. Clean all components. 4. Inspect each component.	
1	Upper Oil Pan Locating Pin (Qty: 2)
2	Upper Oil Pan
3	Lower Oil Pan Locating Pin (Qty: 2)

Callout	Component Name
4	Lower Oil Pan NOTE: Use a NEW lower oil pan.
5	Oil Pan Drain Plug

THREAD REPAIR

Special Tools

- EN 42385 - 307 Drill Busing
- EN 42385 - 308 Alignment PIn
- EN 42385 - 510 Main Attachment Bolt
- EN 42385 - 900 Head Bolt Thread Repair Kit
- EN 42385 - 904 Thread Insert

For equivalent regional tools, refer to [Special Tools](#).

General Thread Repair

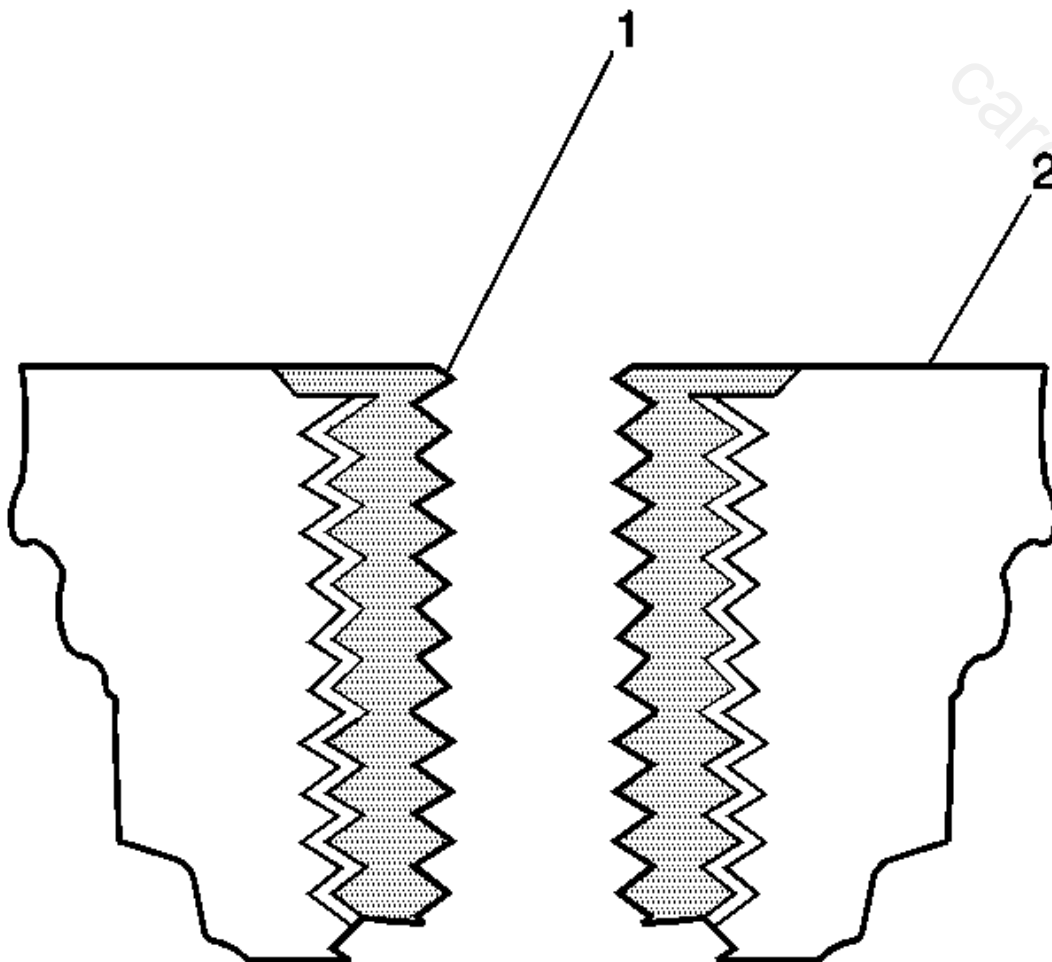


Fig. 453: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

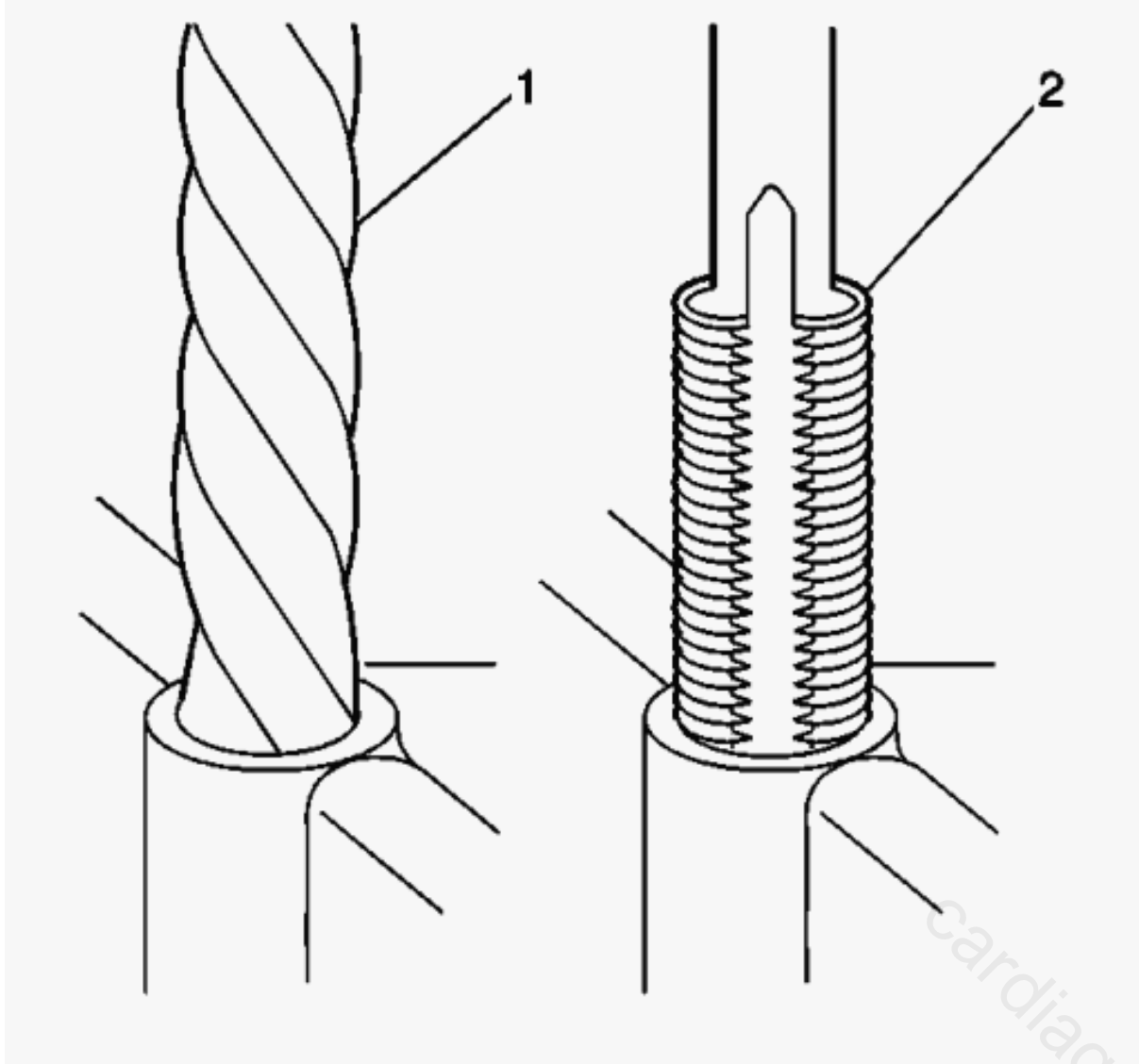


Fig. 454: Drilling & Tapping Threads

Courtesy of GENERAL MOTORS COMPANY

NOTE: The use of a cutting fluid, WD 40®[®], or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Driver oil **MUST** be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

1. Drill out the threads of the damaged hole (1).

- M6 inserts require a minimum drill depth of 15 mm (0.59 in).
- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
- M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

2. Using compressed air, clean out any chips.

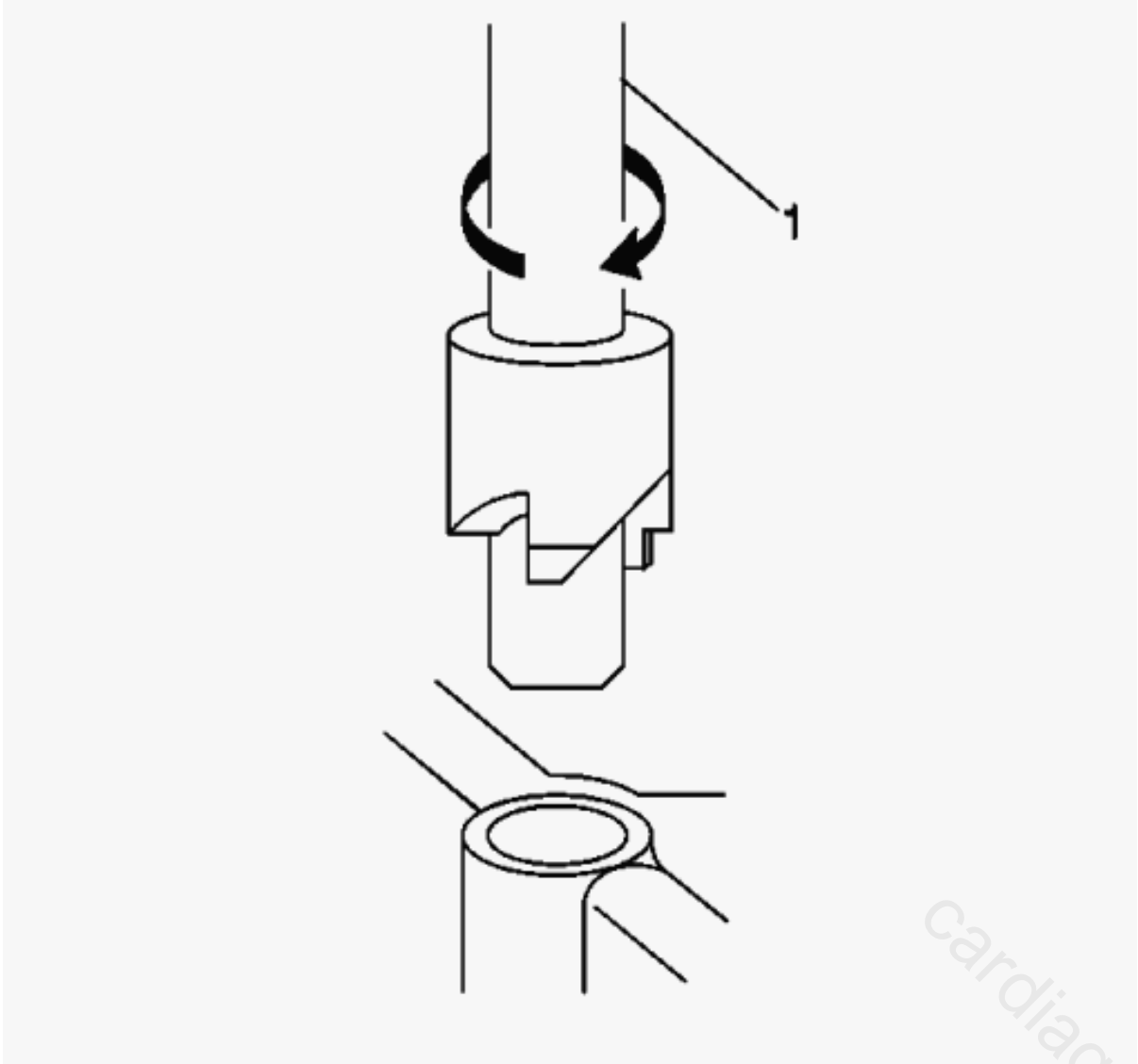


Fig. 455: Identifying Tool Used To Counterbore The Hole
Courtesy of GENERAL MOTORS COMPANY

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

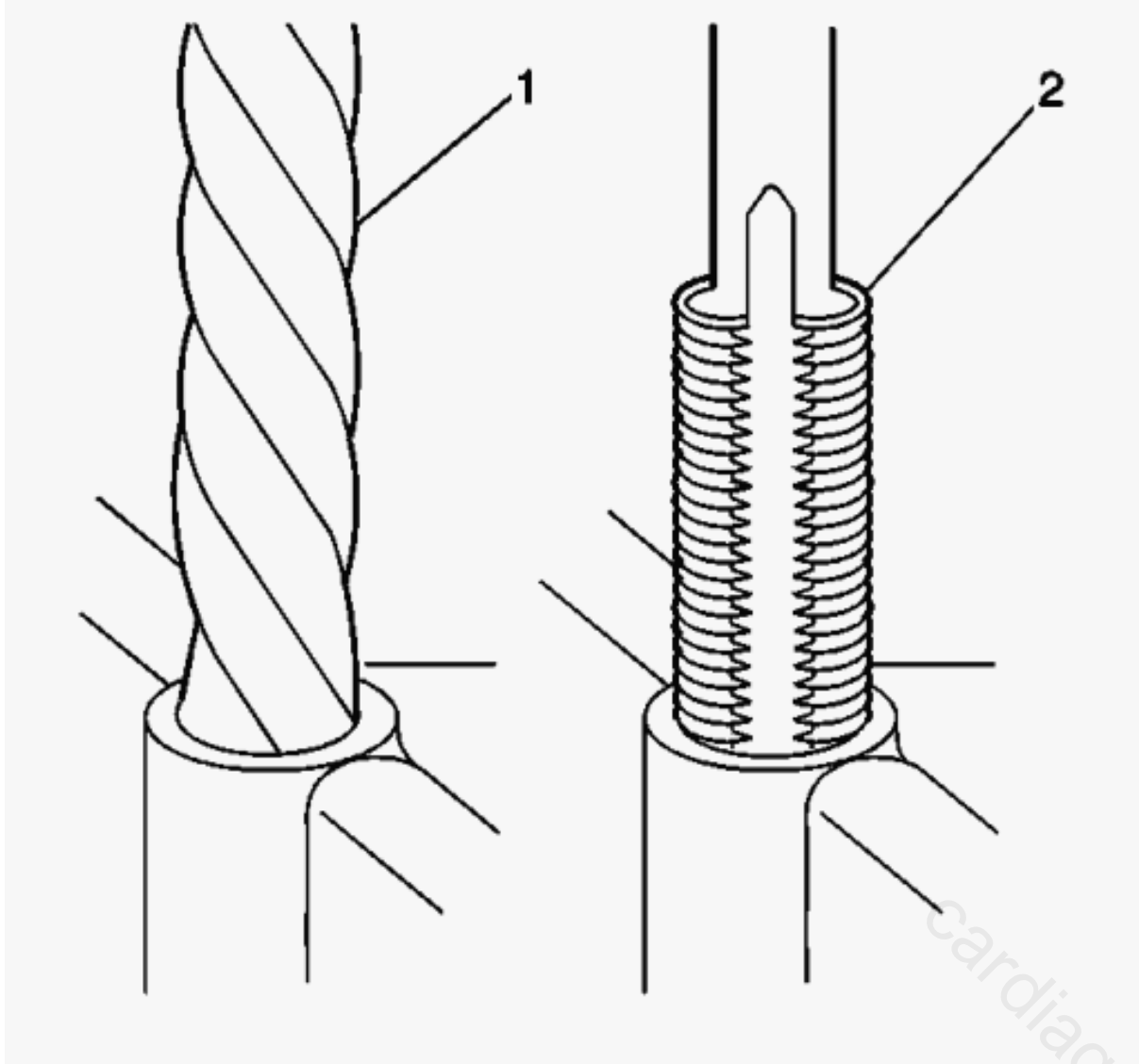


Fig. 456: Drilling & Tapping Threads

Courtesy of GENERAL MOTORS COMPANY

5. Using a tap wrench (2), tap the threads of the drilled hole.
- M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

WARNING: Refer to [Cleaning Solvent Warning](#) .

6. Using compressed air, clean out any chips.
7. Spray cleaner into the hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
8. Using compressed air, clean any cutting oil and chips out of the hole.

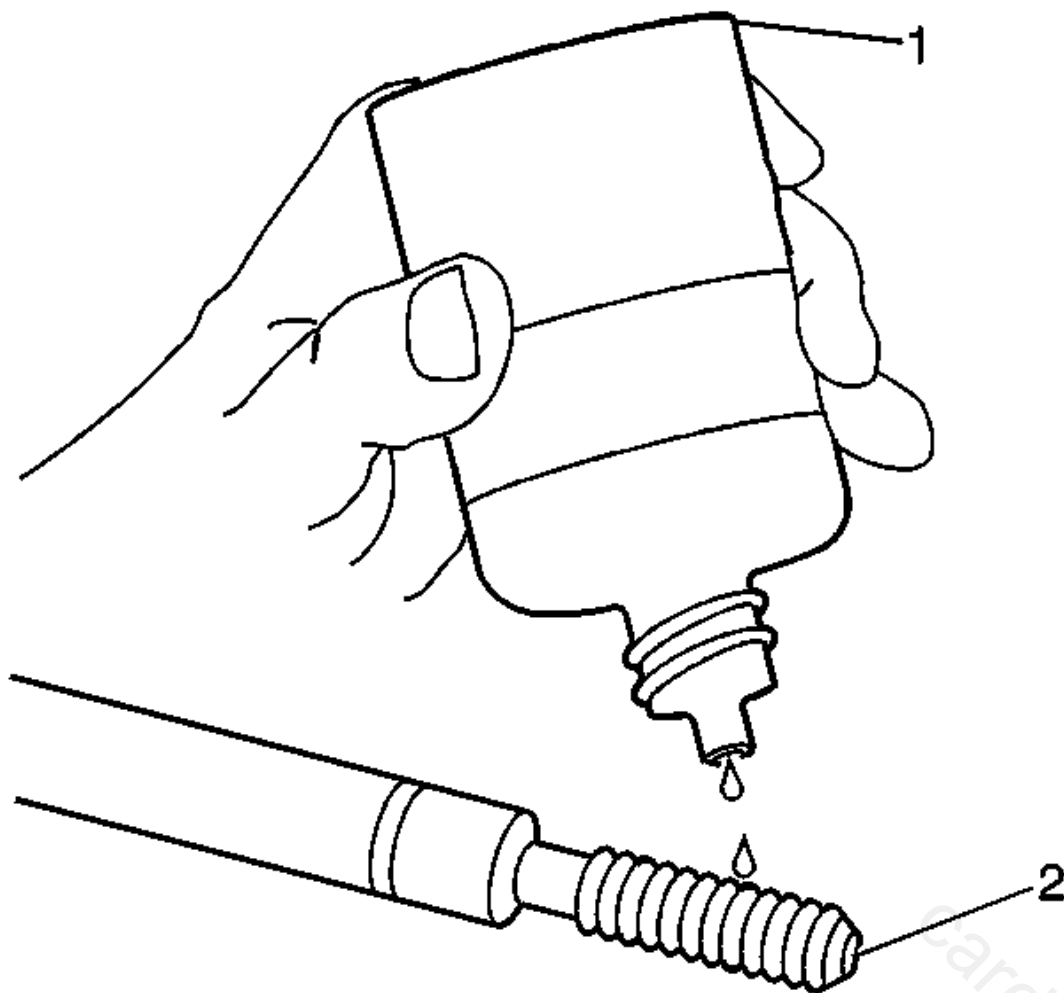


Fig. 457: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

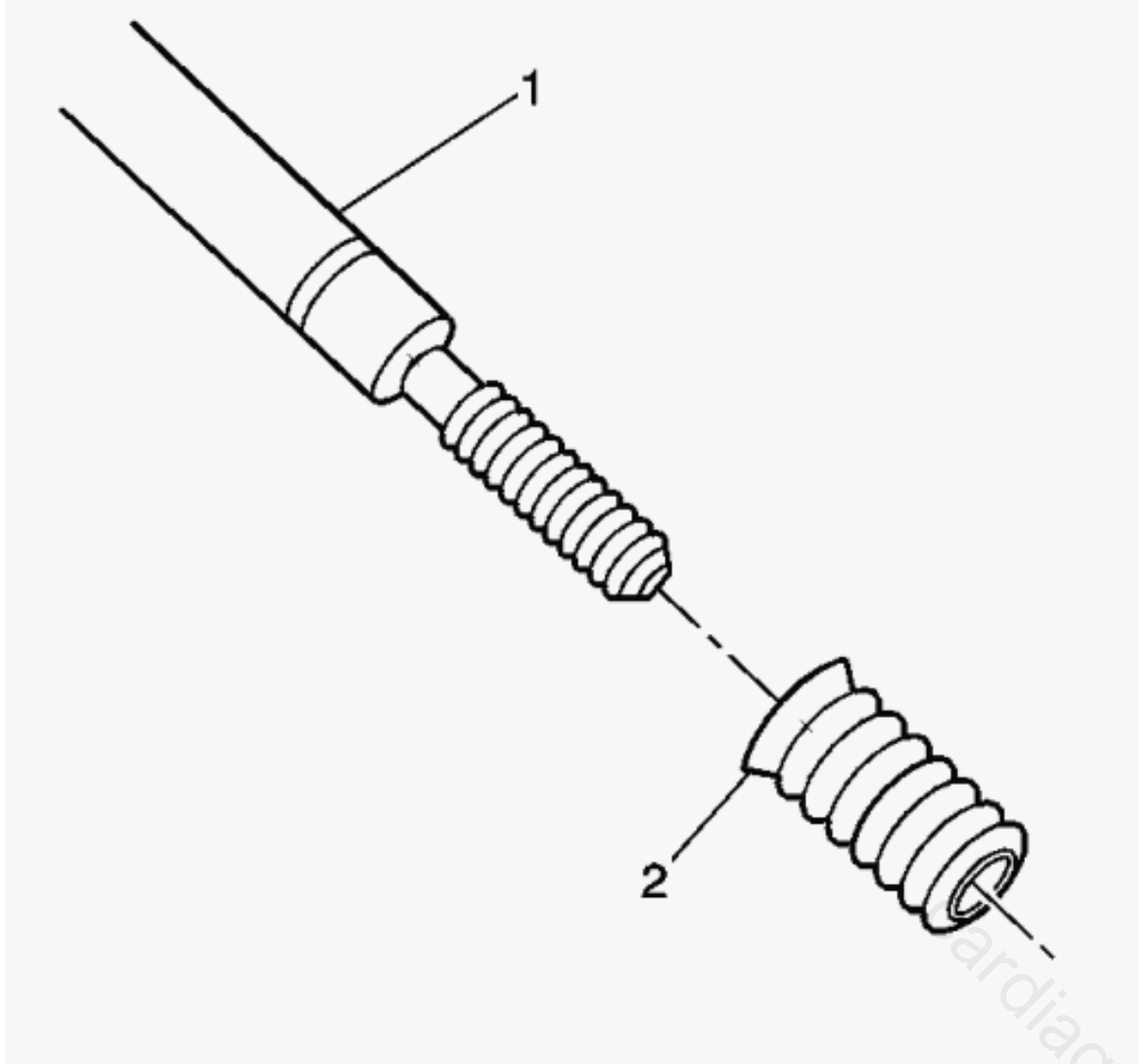


Fig. 458: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

10. Install the insert (2) onto the driver tool (1).

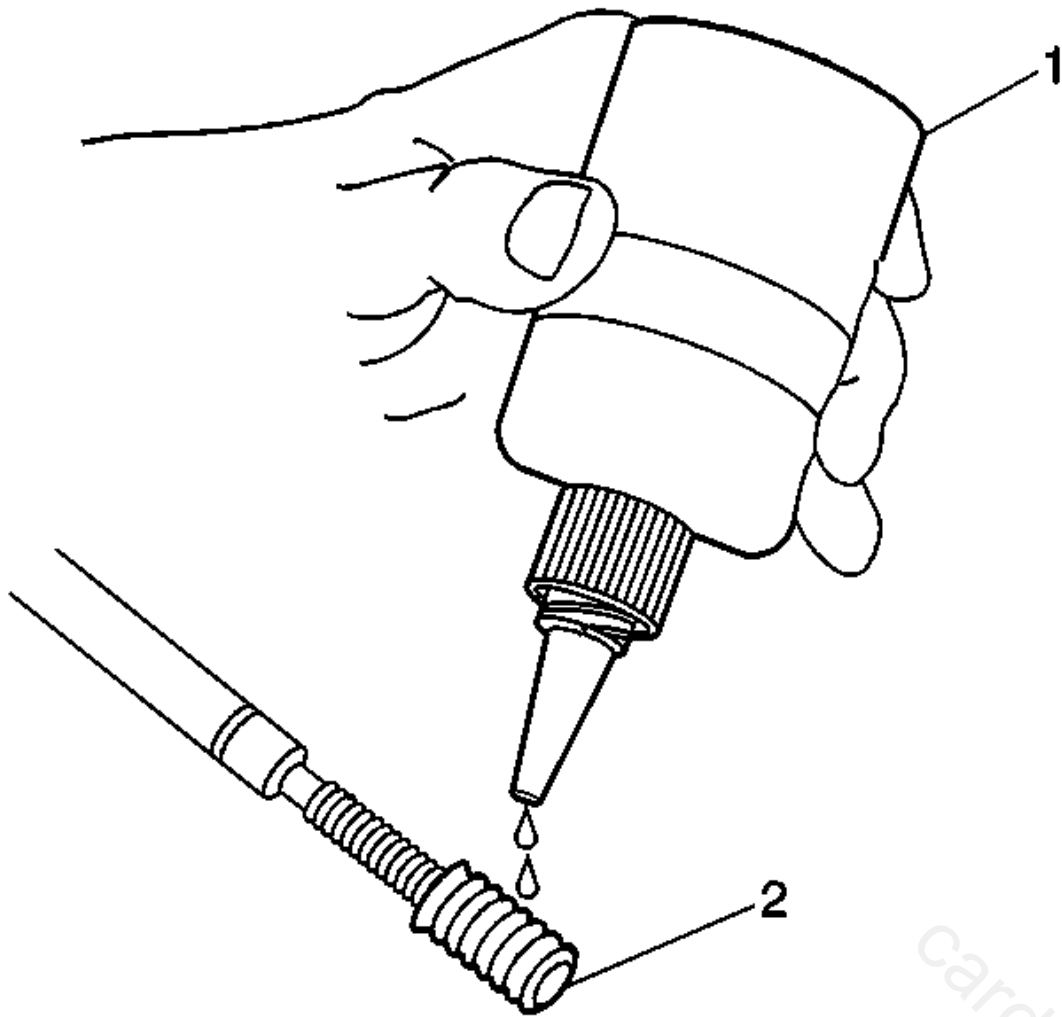


Fig. 459: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock LOCTITE™ 277, EN 42385 - 109 (1) loctite, or equivalent to the insert OD threads (2).

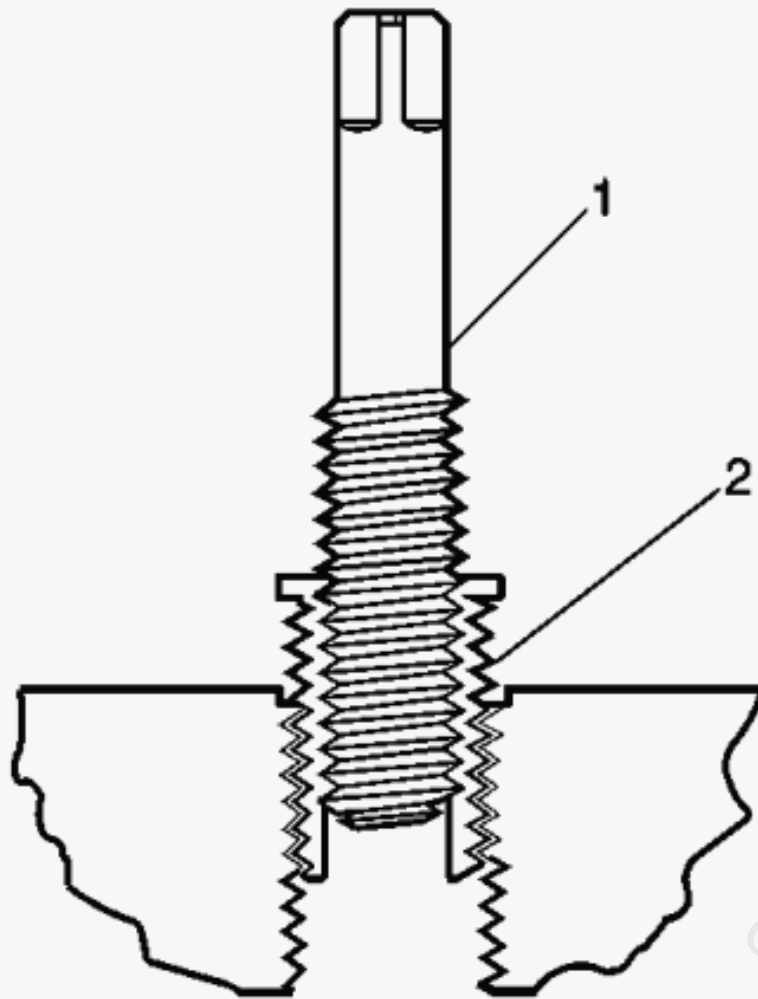


Fig. 460: View Of Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

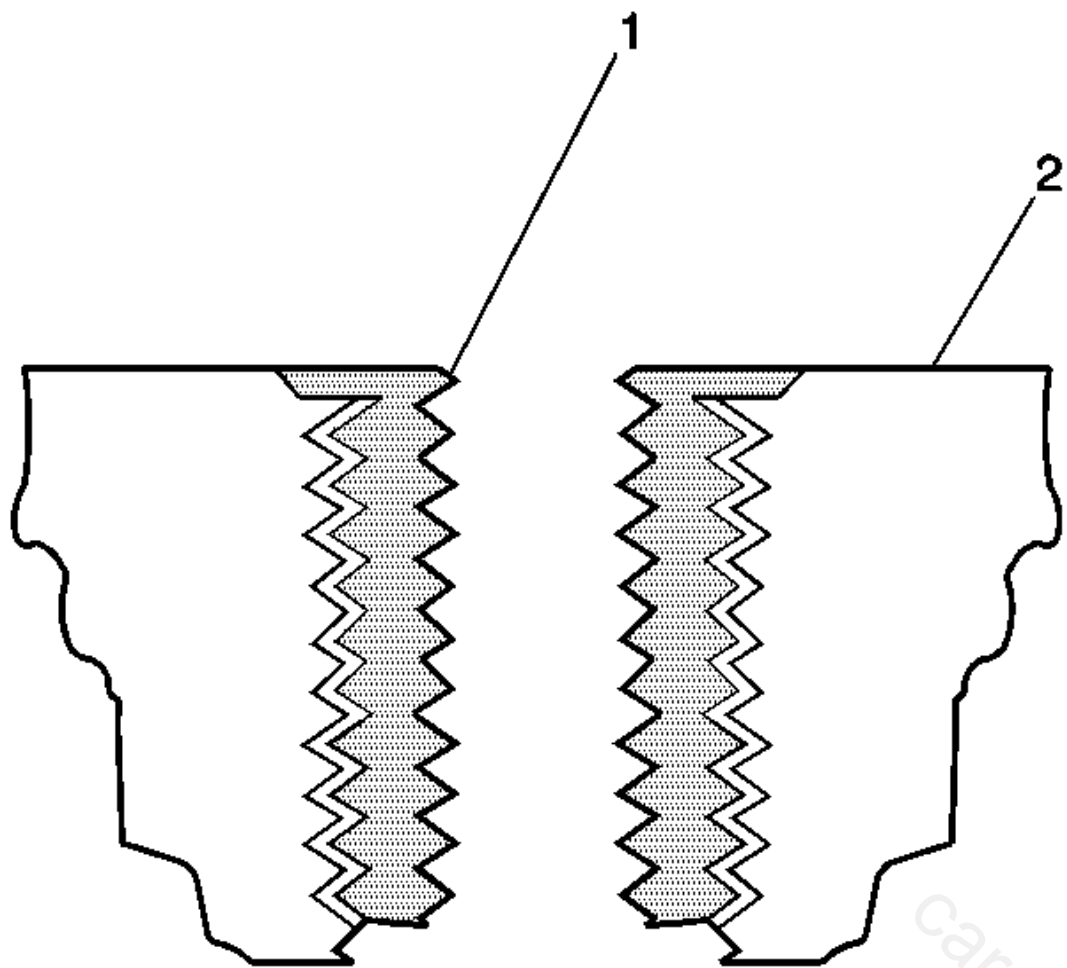


Fig. 461: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

13. Inspect the insert for proper installation into the hole.

A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

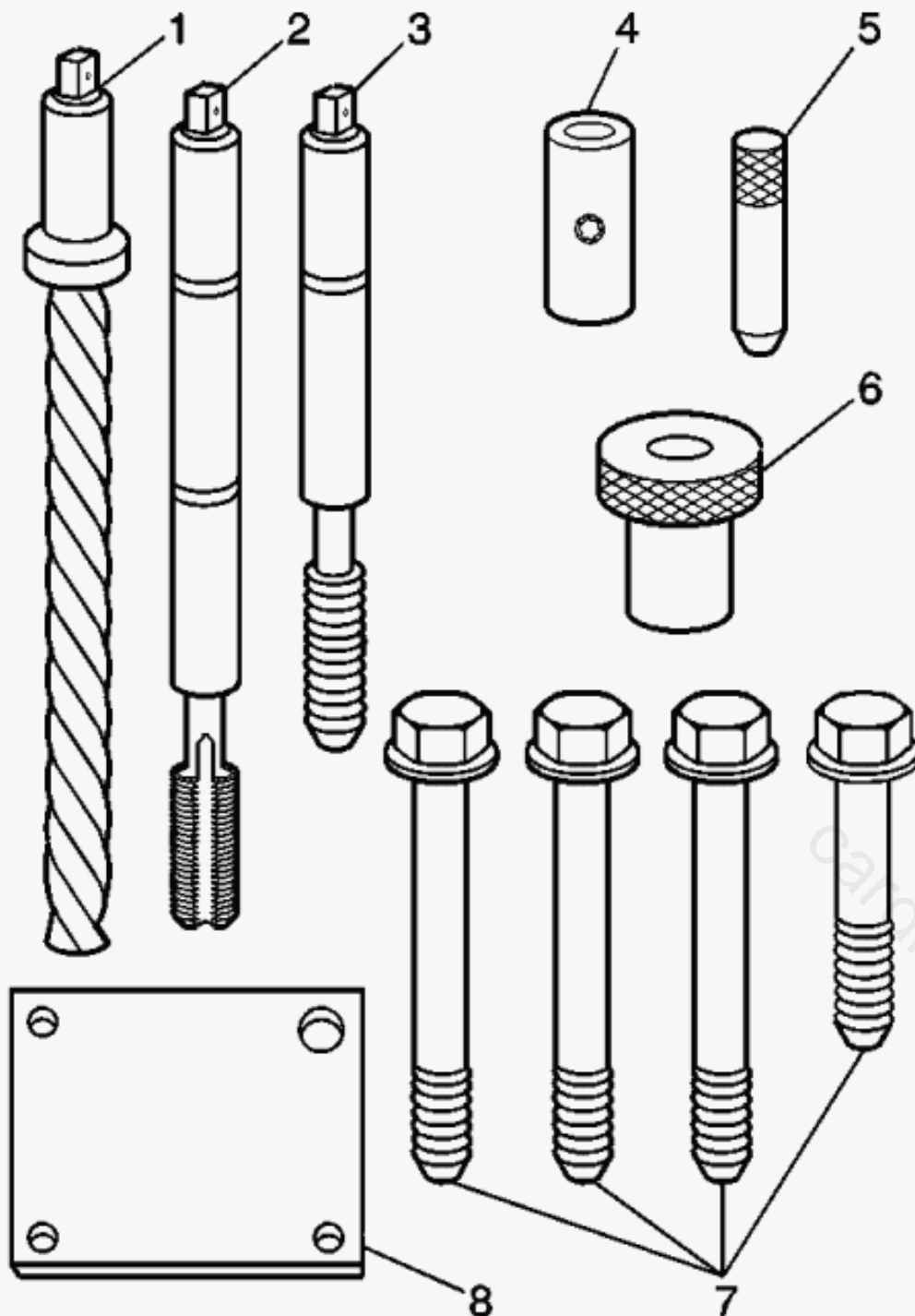


Fig. 462: Identifying Thread Repair Kit Components

Courtesy of GENERAL MOTORS COMPANY

NOTE: The tools listed may not necessarily represent the exact tools used for the procedure.

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)

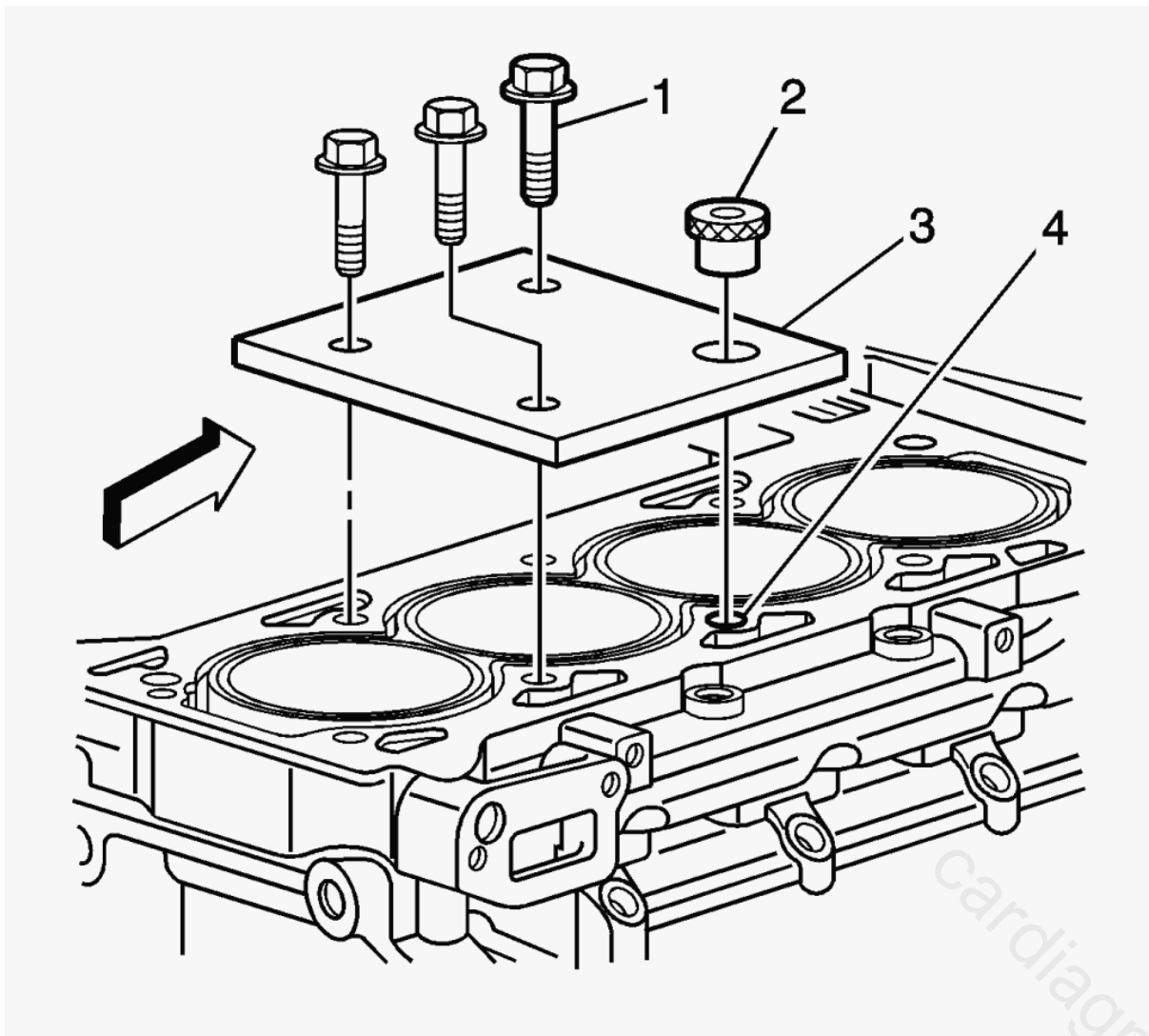


Fig. 463: Identifying Fixture Plate, Bolts, & Bushing

Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

NOTE: The use of a cutting fluid, WD 40®[®], or equivalent, is recommended when performing the drilling and tapping procedures. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Driver oil **MUST** be used on the installer driver tool.

The tool kits are designed for use with either a suitable tap wrench or drill motor.

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

Position the fixture plate and bushing over the hole that is to be repaired (4).

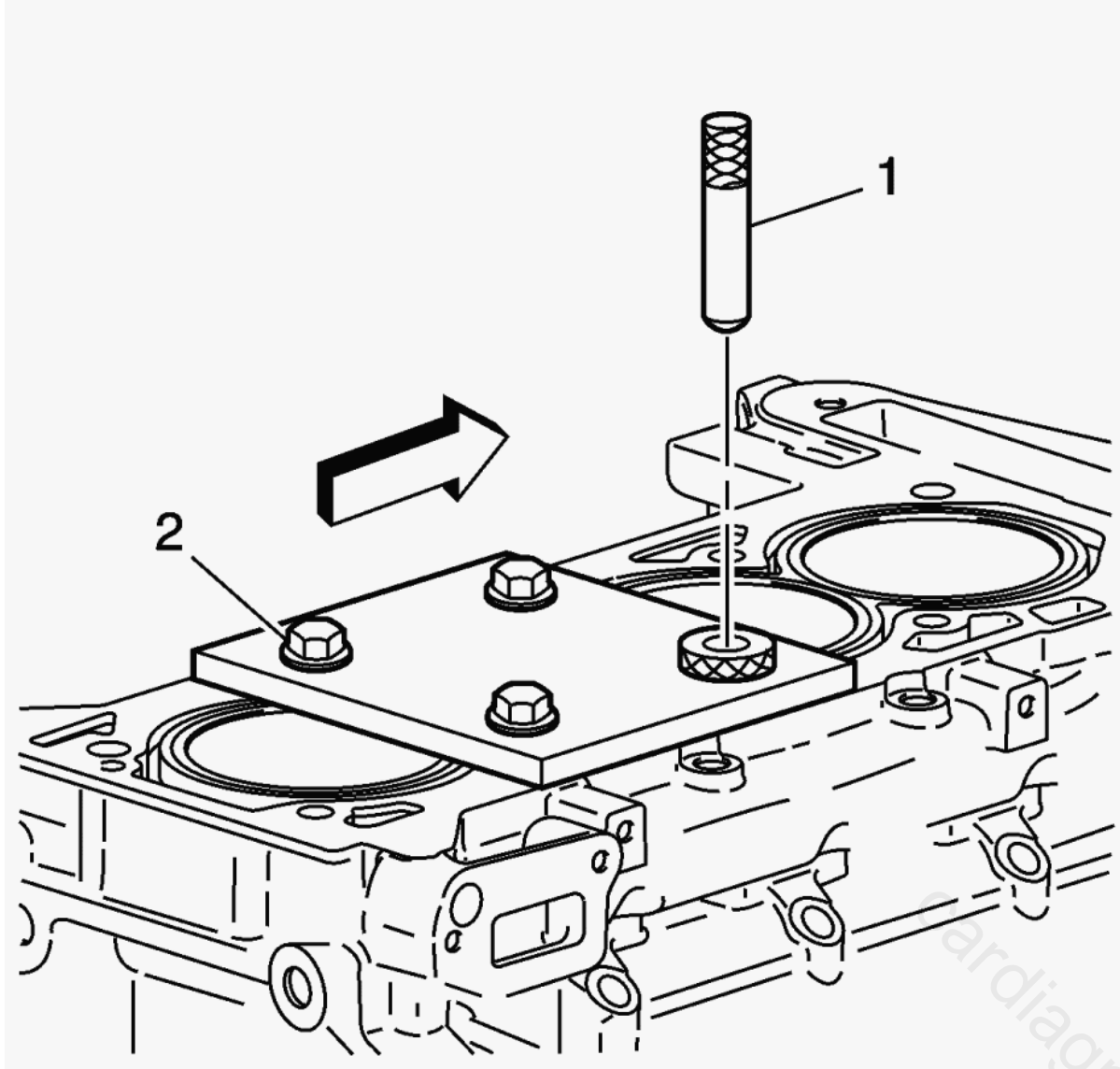


Fig. 464: Identifying Alignment Pin

Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

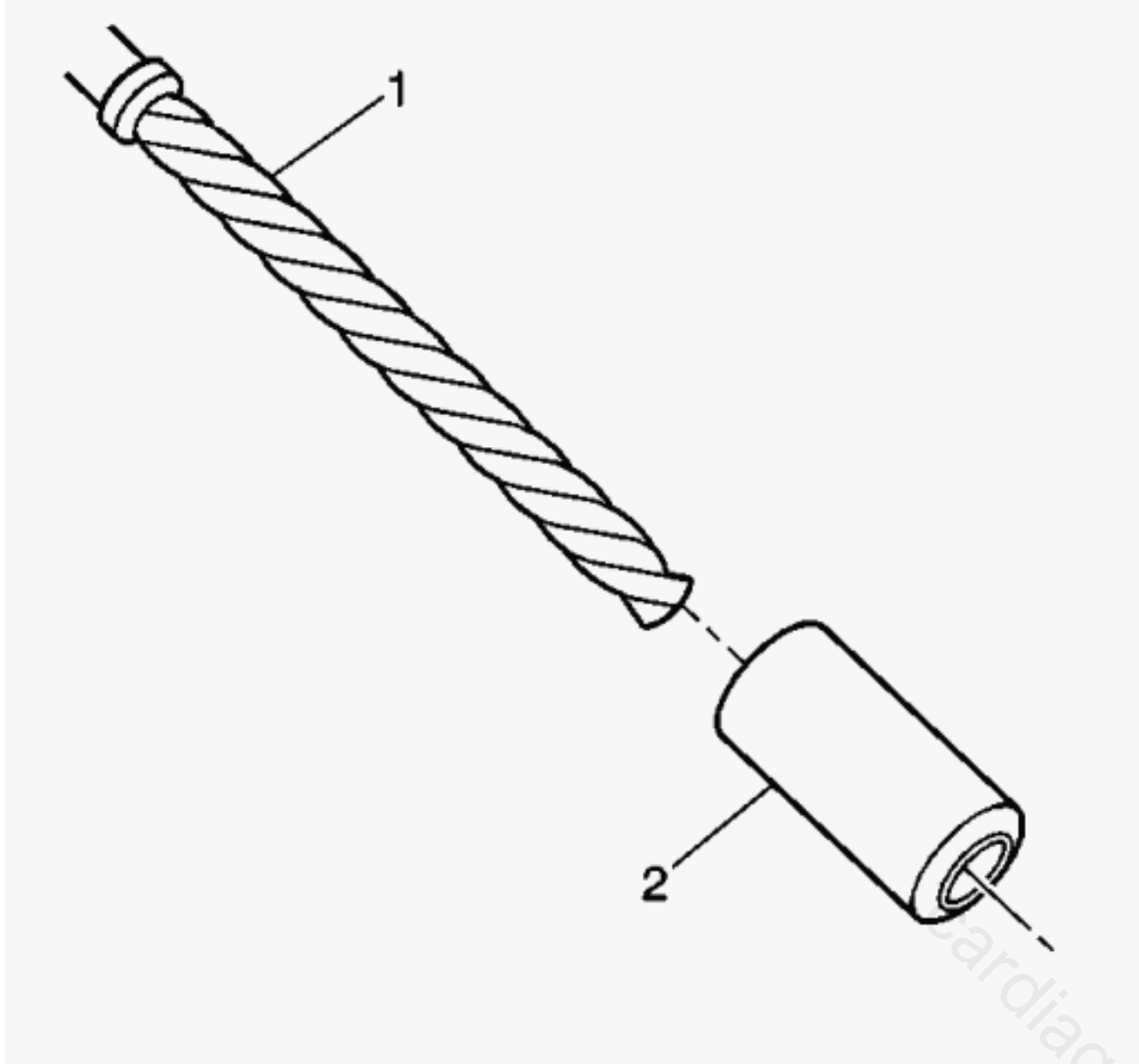


Fig. 465: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

6. Install the sleeve (2) onto the drill (1), if required.

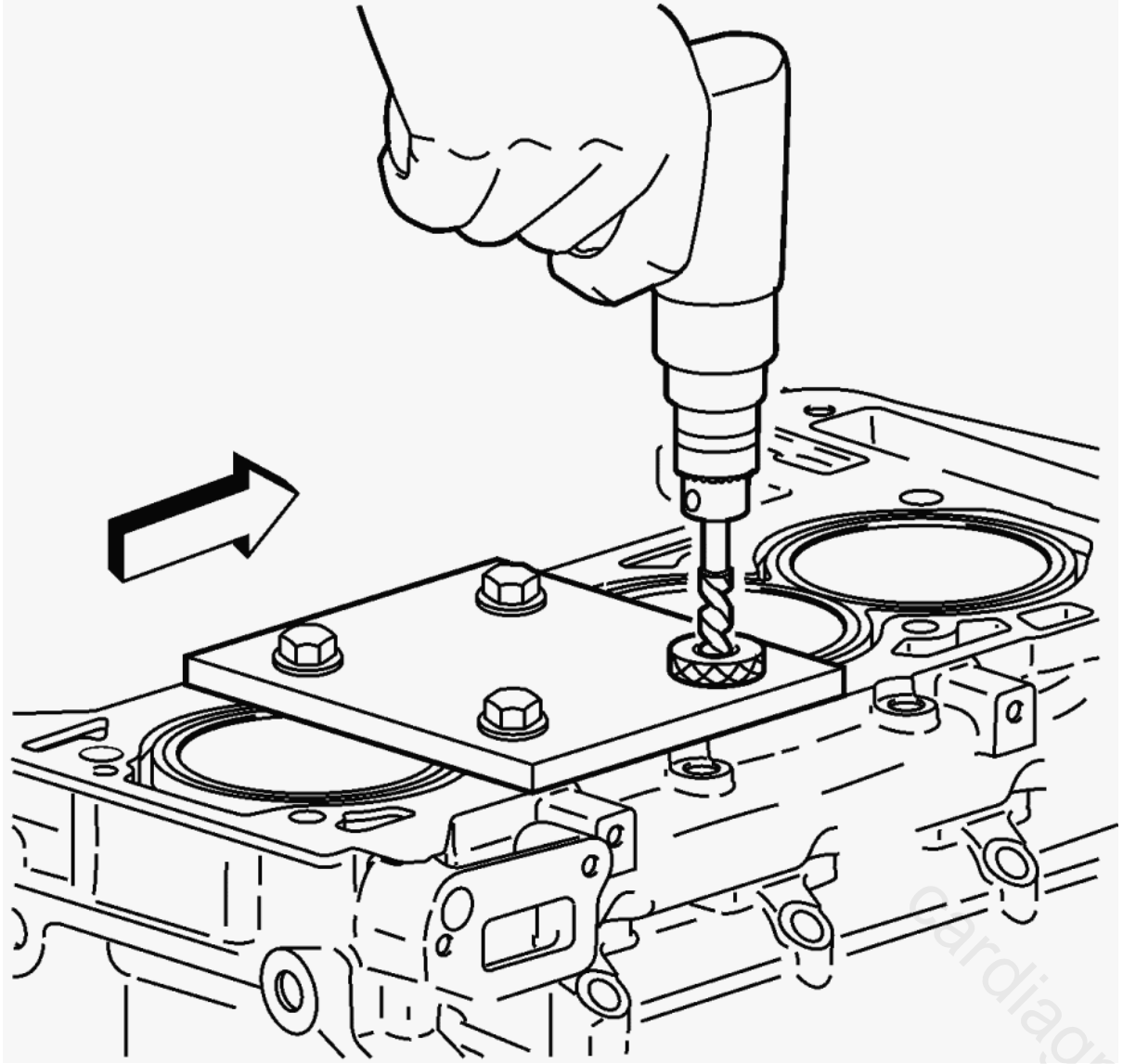


Fig. 466: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

8. Using compressed air, clean out any chips.

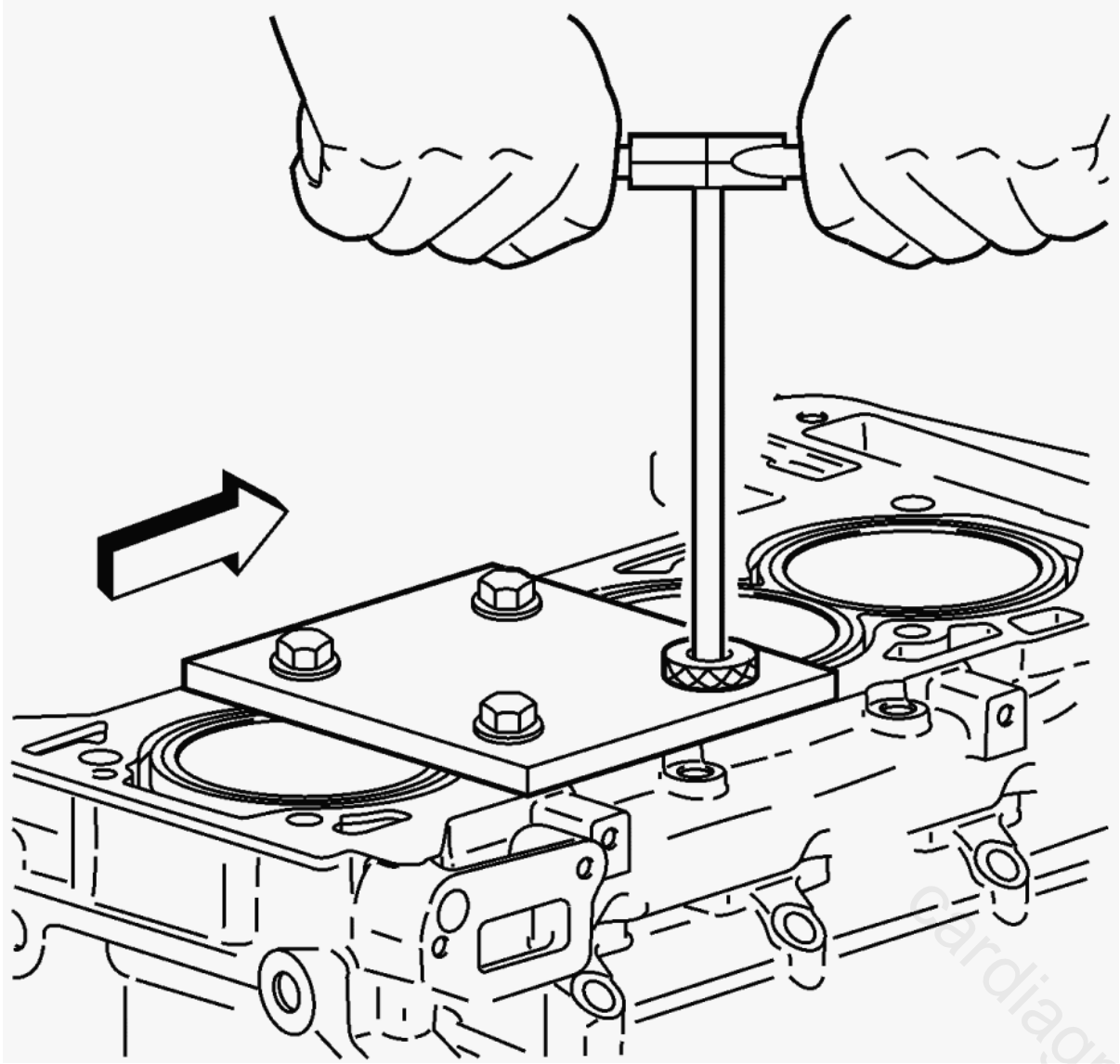


Fig. 467: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS COMPANY

9. Using a tap wrench, tap the threads of the drilled hole.

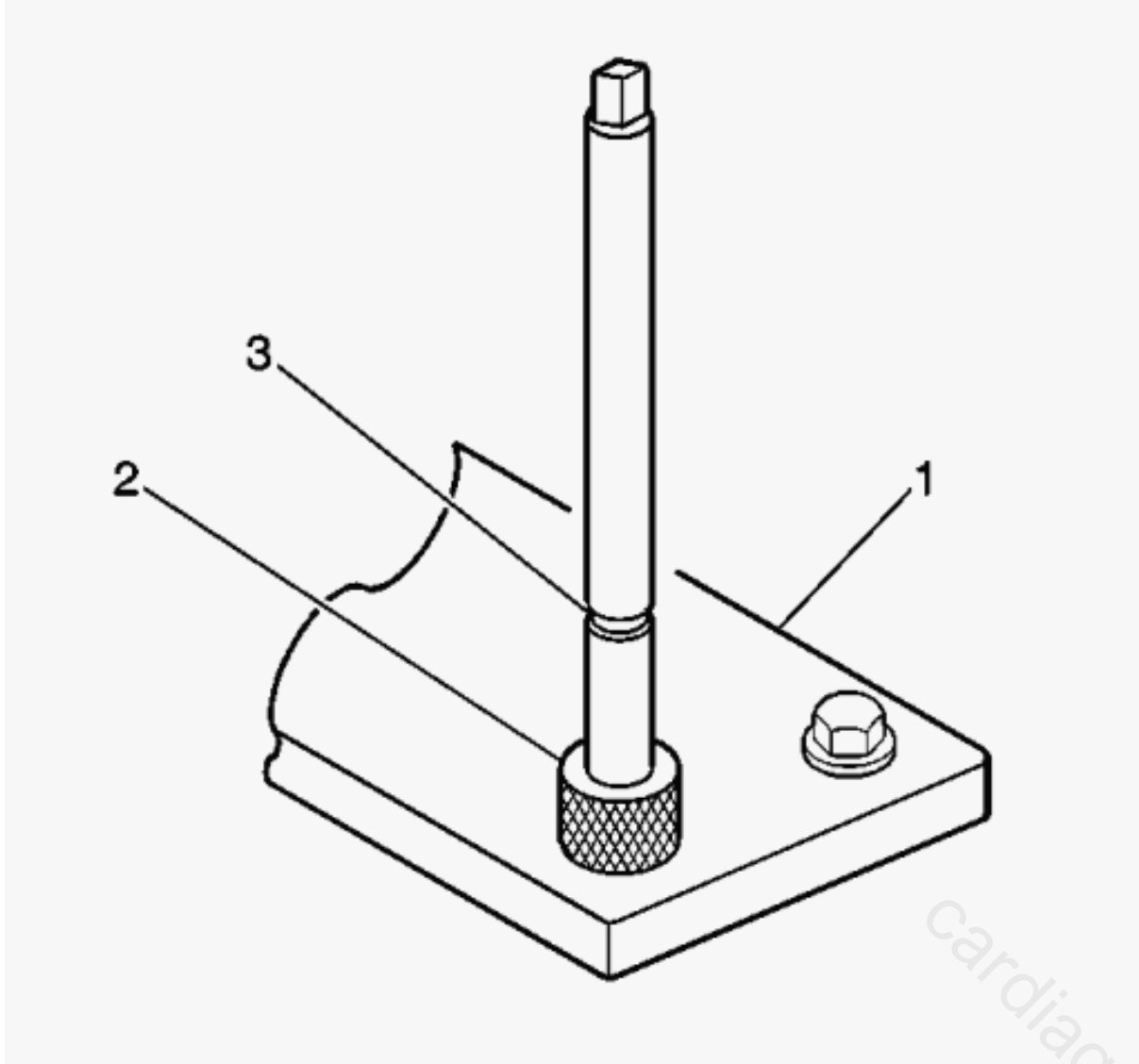


Fig. 468: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

10. Using a TAP wrench, tap the threads of the drilled hole.

In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

WARNING: Refer to [Cleaning Solvent Warning](#) .

12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
14. Using compressed air, clean any cutting oil and chips out of the hole.

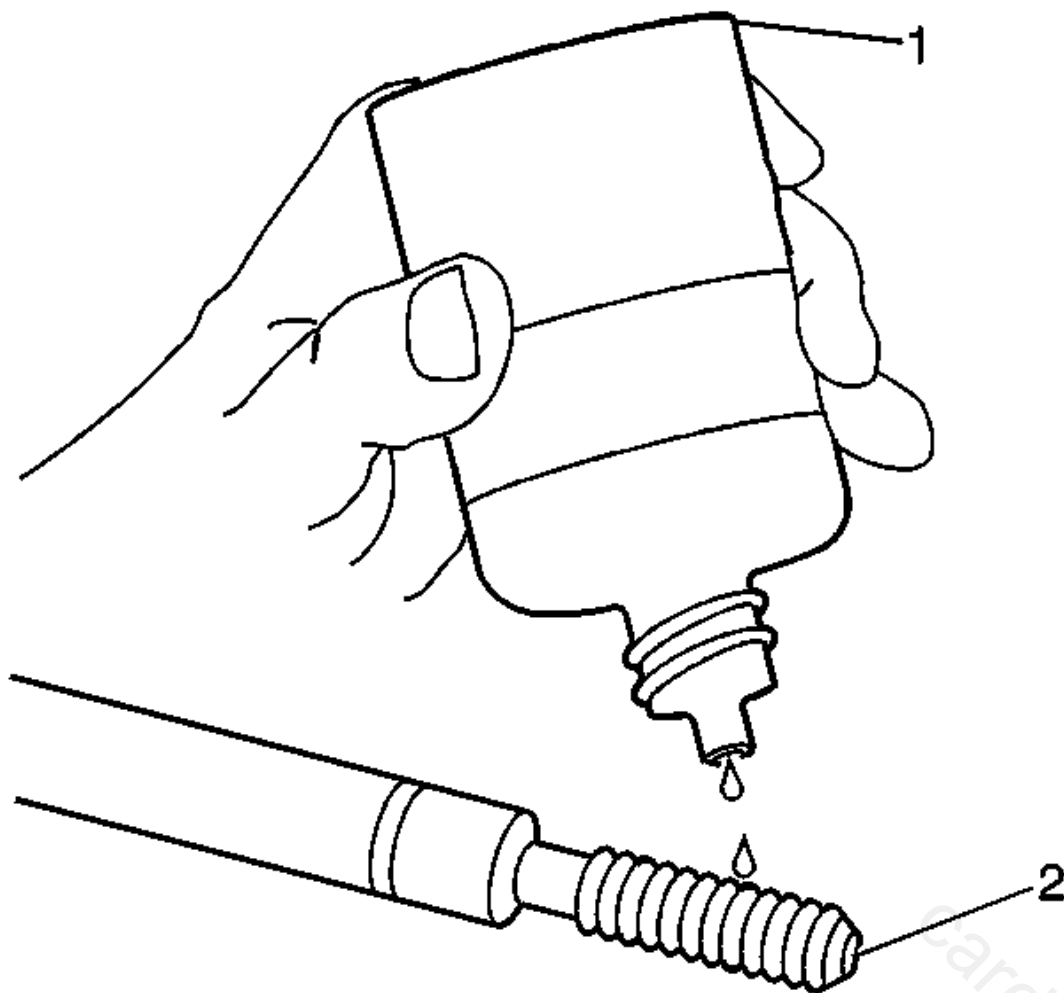


Fig. 469: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

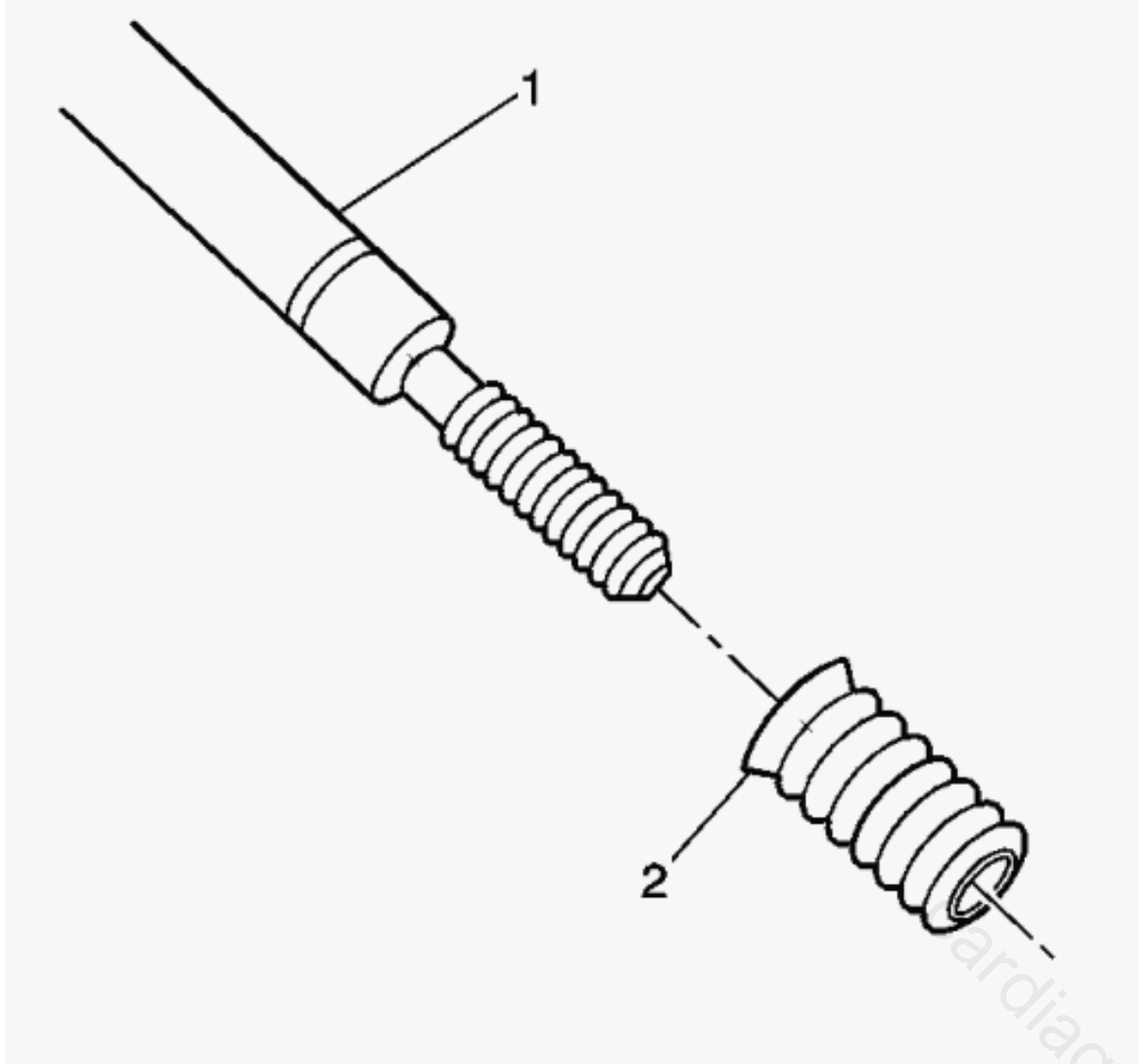


Fig. 470: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert (2) onto the driver tool (1).

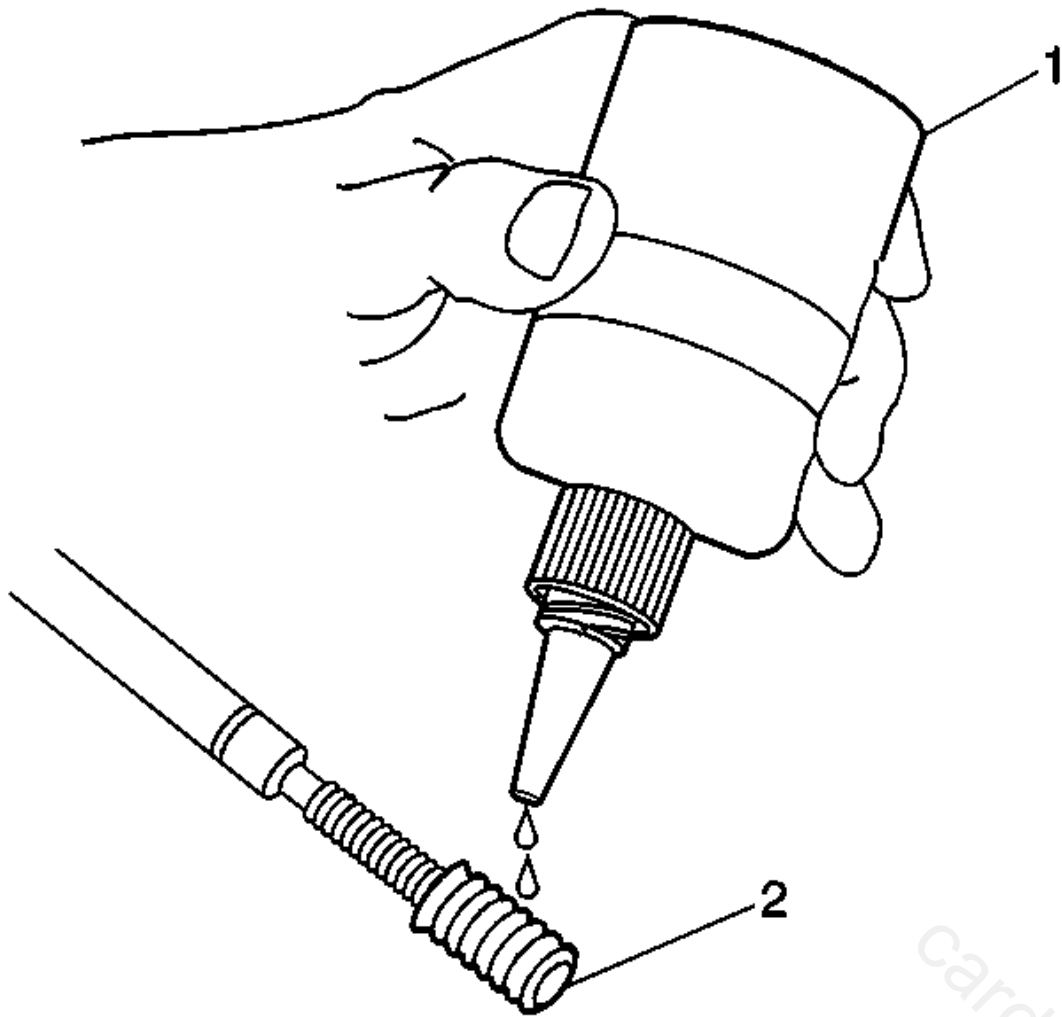


Fig. 471: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock LOCTITE™ 277, EN 42385 - 109 loctite (1), or equivalent to the insert OD threads (2).

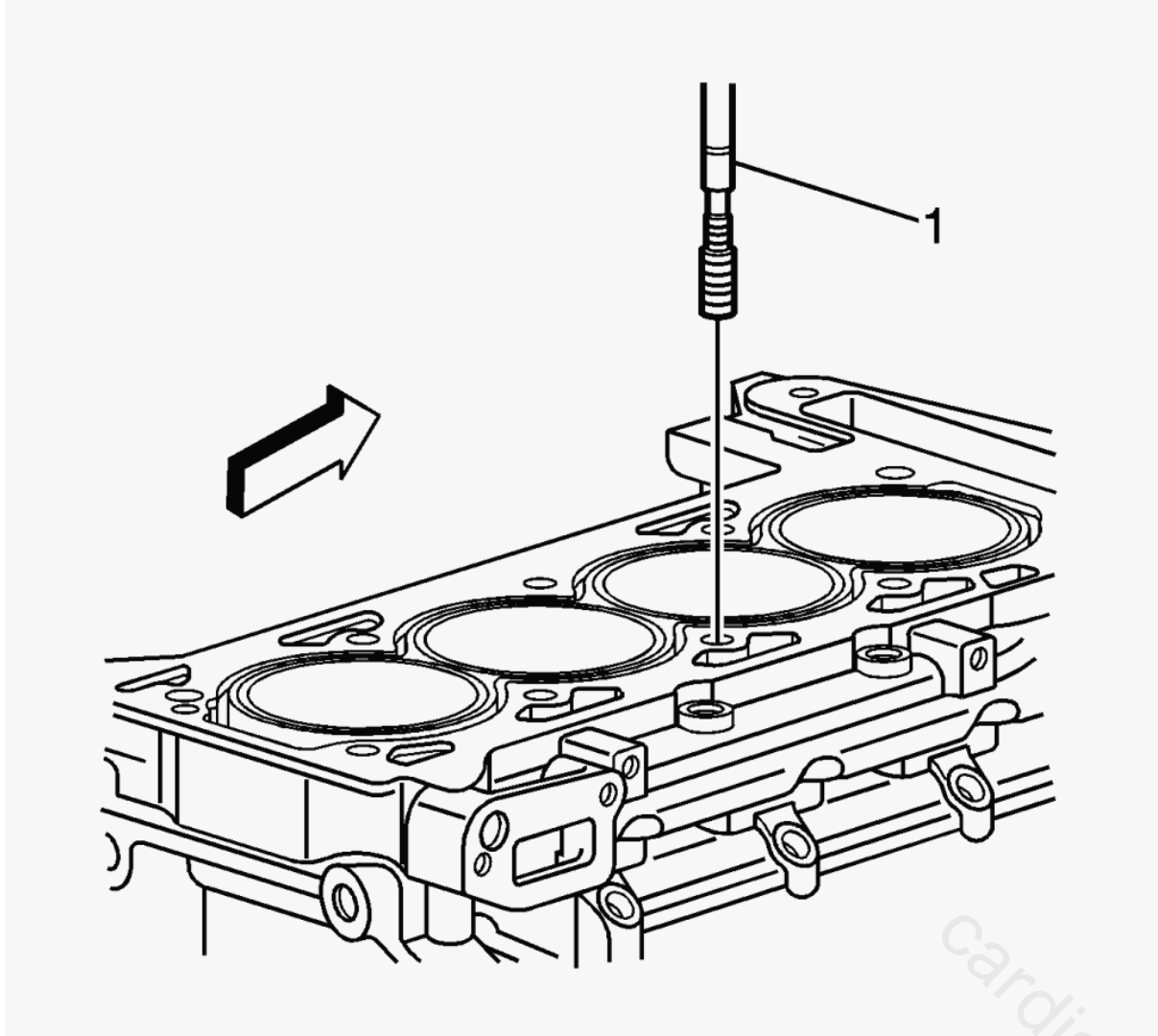


Fig. 472: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS COMPANY

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.

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.

CRANKSHAFT AND BEARING INSTALLATION

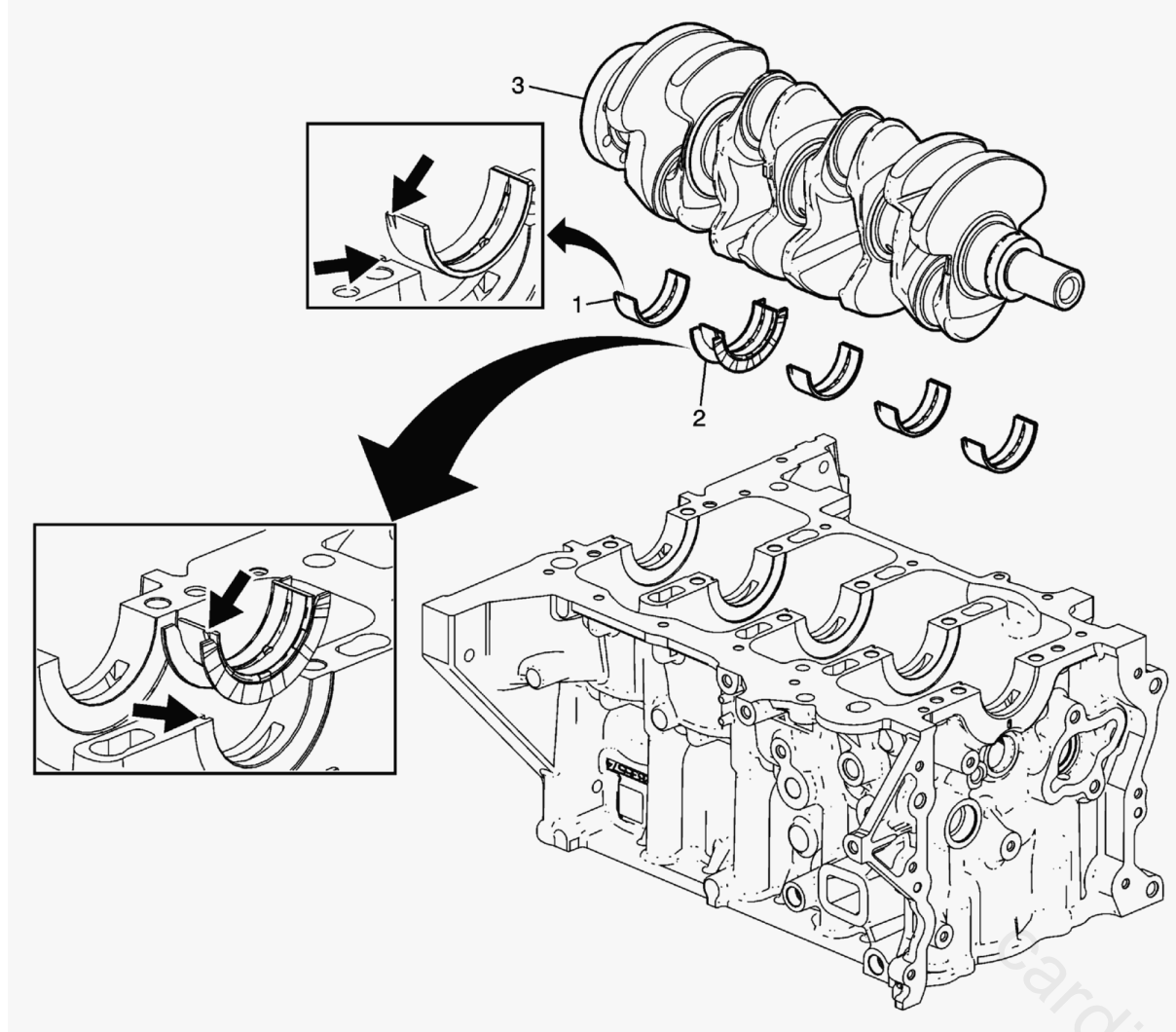


Fig. 473: Crankshaft and Bearing

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Upper Bearing (Qty: 4) NOTE: • Crankshaft bearings MUST be separated, marked, or organized in a way to ensure installation to their original location and position, when suitable for use. • For vehicles equipped with Start/Stop and Hybrid vehicles, the #1 upper bearing is specifically coated for durability and has a blue coloration. Procedure Ensure that the guide lug on the bearing is properly seated to the notch in the engine block for each bearing. Coat the crankshaft bearing shell with engine oil.
2	Crankshaft Thrust Bearing Procedure Ensure that the guide lug on the bearing is properly seated to the notch in the engine block. Coat the crankshaft bearing shell with engine oil.
3	Crankshaft

LOWER CRANKCASE INSTALLATION

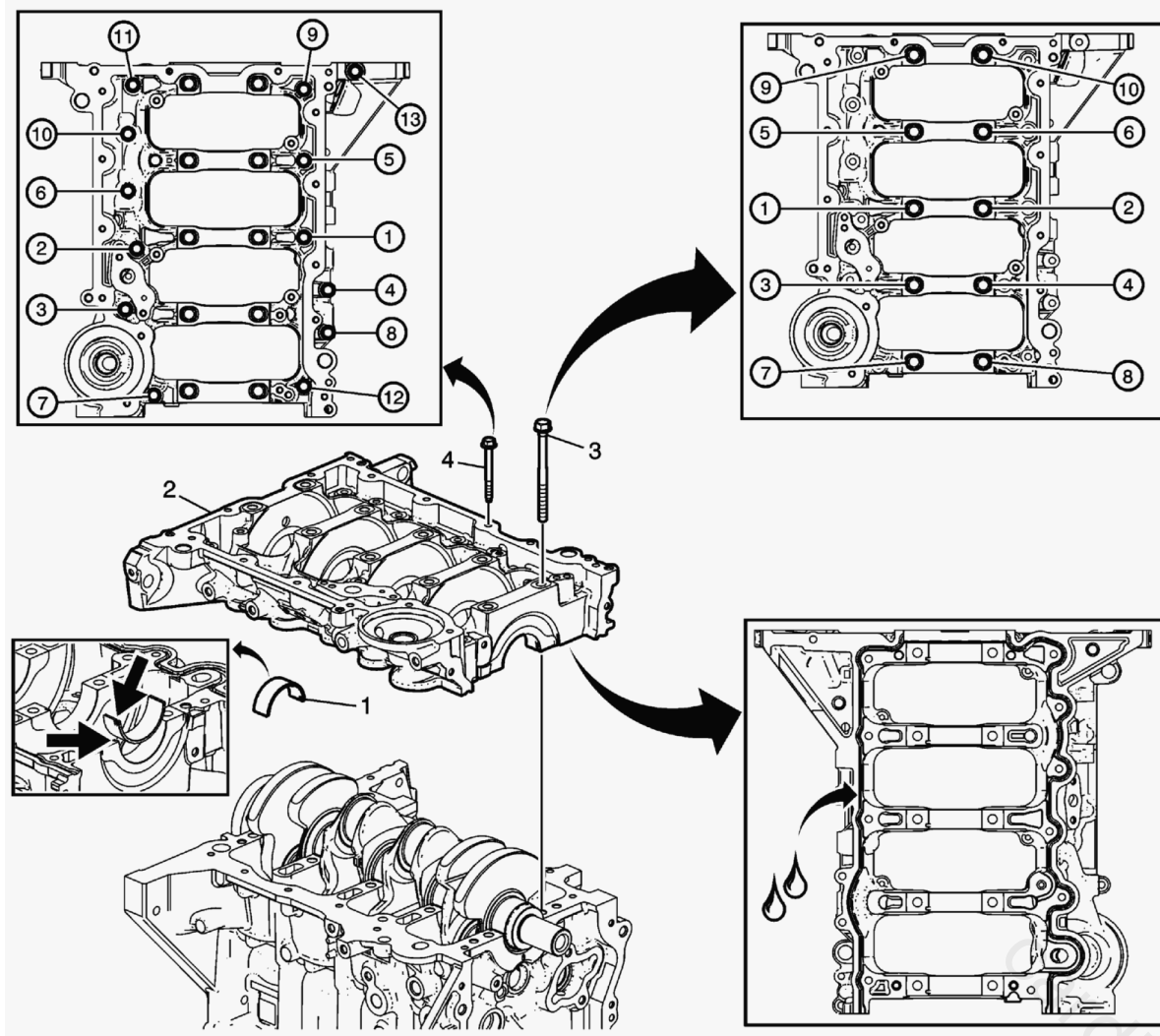


Fig. 474: Lower Crankcase With Bolt Tightening Sequences
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Lower Bearing (Qty: 5) Procedure Install the bearings in the lower crankcase, and ensure that the guide lug on the bearing is properly seated to the notch in the lower crankcase for each bearing. Coat the crankshaft bearing shell with engine oil.
2	Lower Crankcase Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant NOTE: • The block assembly surface must be free of contamination prior to applying the sealer. • Install and align the bedplate to block within 20 minutes of applying the sealer. • The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer. 2. Apply a 3 mm bead of sealer directly in the groove of the block to bedplate mating surfaces. Refer to Adhesives, Fluids, Lubricants, and Sealers. 3. Install the lower crankcase, ensure the lower crankcase is aligned properly on the dowels. Tap gently into place with a suitable tool, if necessary.

Callout	Component Name
3	Lower Crankcase Bolts (Qty: 10) CAUTION: Refer to Fastener Caution . CAUTION: Refer to Torque-to-Yield Fastener Caution . Procedure Tighten the NEW lower crankcase bolts in the sequence shown. 1. Tighten the bolts in sequence a first pass to 15 N.m (11 lb ft). 2. Using the EN 45059 angle meter, tighten the bolts in sequence a final pass to 180 degrees. Special Tools EN-45059 Angle Meter For equivalent regional tools, refer to Special Tools.
4	Lower Crankcase Bolts (Qty: 13) Procedure 1. Apply sealant to the lower crankcase perimeter bolts. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Tighten the lower crankcase bolts in the sequence shown. 3. Tighten the bolts in sequence a first pass to 5 N.m (44 lb in). 4. Tighten the bolts in sequence a final pass to 10 N.m (89 lb in).

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

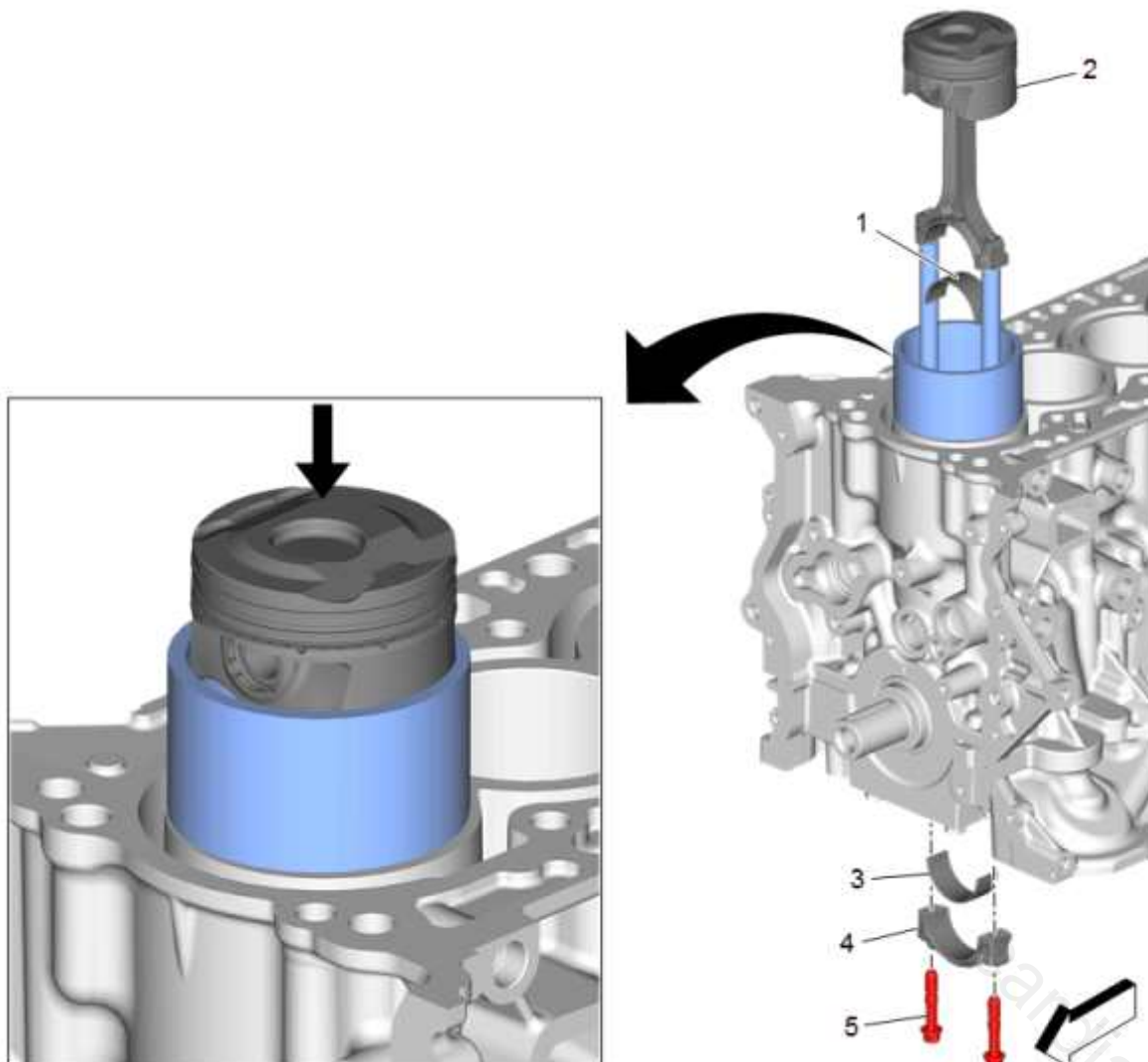


Fig. 475: Piston, Connecting Rod, and Bearing
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure NOTE: Many internal engine components will develop specific wear patterns on their friction surfaces. 1. Components MUST be separated, marked, or organized in a way to ensure installation to their original location and position. Take precautions in order to prevent interchanging of parts. 2. Ensure all components are adequately marked with location, direction, or orientation when necessary.	
1	Connecting Rod Bearing [4x] NOTE: The connecting rod bearing anti-rotation tab grooves are to point toward the right-hand side of the engine. Procedure Install NEW bearings to the connecting rods and lubricate each bearing with engine oil.
2	Piston and Connecting Rod Assembly [4x] NOTE:

Callout	Component Name
	The connecting rods and caps must be installed in the same order and orientation in which they were removed. If new connecting rods are required, the connecting rod is provided as an assembly, and the upper rod will need to be disassembled from the lower cap. Procedure 1. Install the EN-51454 guides into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation. NOTE: Ensure to stagger each piston ring end gap equally around the piston. NOTE: When installing a piston into a cylinder, use a ring compressor sleeve, such as EN-52490-74 or equivalent for best results. The following features should be looked for when selecting a ring compressor sleeve: • Hard anodized and Teflon coated for low friction and prolonged wear resistance. • Smooth radius that tapers down to the specific bore size. • Sleeve should compress the piston rings smoothly and evenly. • Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings. If a ring compressor sleeve is unavailable, a universal ring compressor will work, but is more difficult to use. 2. Install the EN-52490-74 ring compressor or equivalent on the piston. 3. Ensure each piston ring end gap is spaced equally around the piston, refer to Piston and Connecting Rod Assemble. 4. Lubricate the piston and the piston rings with engine oil. Do not disturb the piston ring end gap location. 5. Lubricate the correct engine bore for the piston. NOTE: The piston must be installed oriented correctly to the front of the engine. 6. Position the piston so that the arrow mark on the top of the piston points to the front of the engine. 7. Install the ring compressor, the piston, and the connecting rod to the correct bore. 8. Tap the piston into the bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place. 9. Hold the ring compressor against the engine block until all the rings have entered the cylinder bore. 10. Remove the connecting rod guides from the connecting rod bolt holes. Special Tools • EN-51454 Connecting Rod Guides • EN-52490-74 Piston Ring Compressor

Callout	Component Name
	Equivalent regional tools: Special Tools .
3	Connecting Rod Bearing [4x] Procedure Install NEW bearings to the connecting rod caps and lubricate each bearing with engine oil.
4	Connecting Rod Cap [4x] Procedure Ensure that the connecting rod cap is properly oriented on the connecting rod.
5	Connecting Rod Bolt [8x] CAUTION: Refer to Fastener Caution . CAUTION: Refer to Torque-to-Yield Fastener Caution . Procedure 1. Install NEW connecting rod bolts and tighten using the EN-45059 angle meter. 1. Tighten the bolts a first pass to 25 N.m (18 lb ft). 2. Tighten the bolts a final pass 75 degrees using EN-45059 angle meter. NOTE: Rotate the crankshaft to ensure that it moves freely and does not bind. 2. Measure the connecting rod side clearance with a feeler gauge. Refer to Engine Mechanical Specifications . 3. Measure the piston deck height. Refer to Engine Mechanical Specifications . Special Tools EN-45059 Angle Meter Equivalent regional tools: Special Tools .

CRANKSHAFT OIL DEFLECTOR INSTALLATION

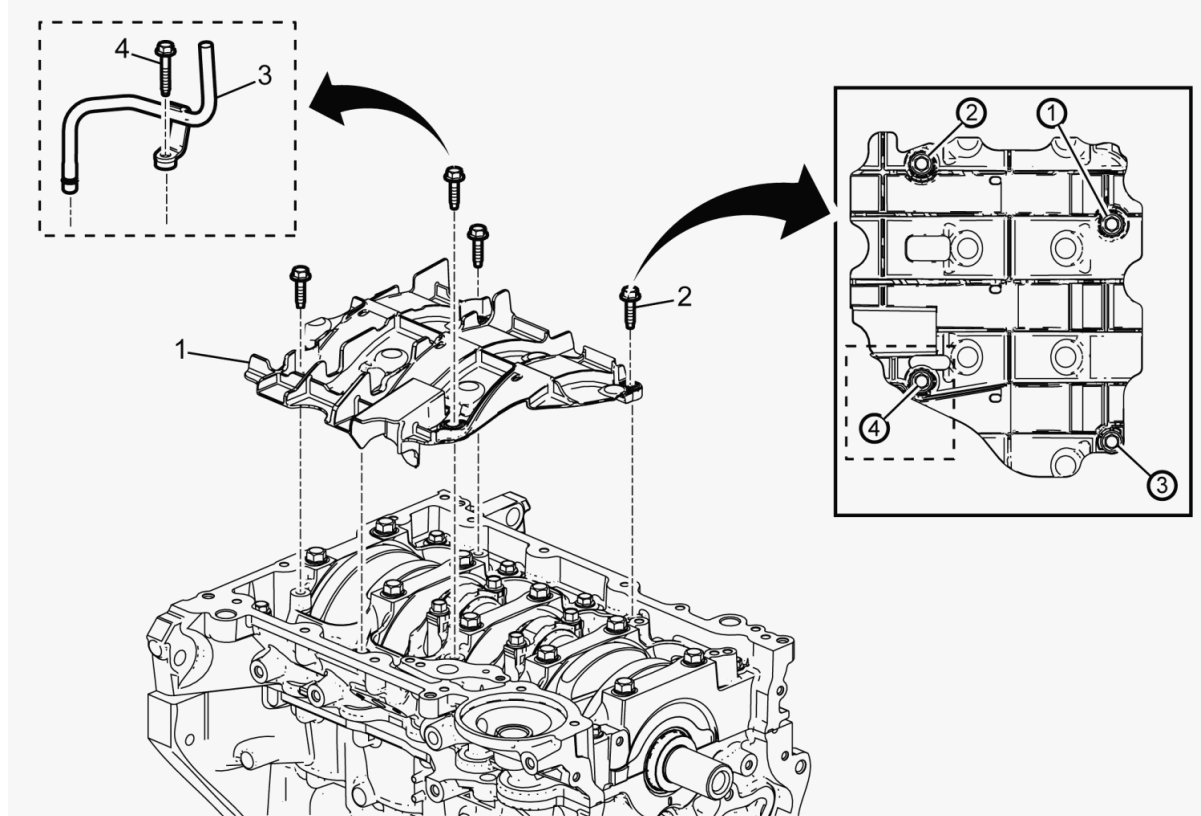


Fig. 476: Crankshaft Oil Deflector (With Bolt Tightening Sequence)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Oil Deflector
2	Crankshaft Oil Deflector Bolt (Qty: 3) CAUTION: Refer to Fastener Caution . Procedure Tighten the bolts in the sequence shown. Tighten 10 N.m (89 lb in)
3	Positive Crankcase Ventilation Oil Separator Drain Pipe
4	Positive Crankcase Ventilation Oil Separator Drain Pipe Bolt Tighten 10 N.m (89 lb in)

CRANKSHAFT REAR OIL SEAL INSTALLATION

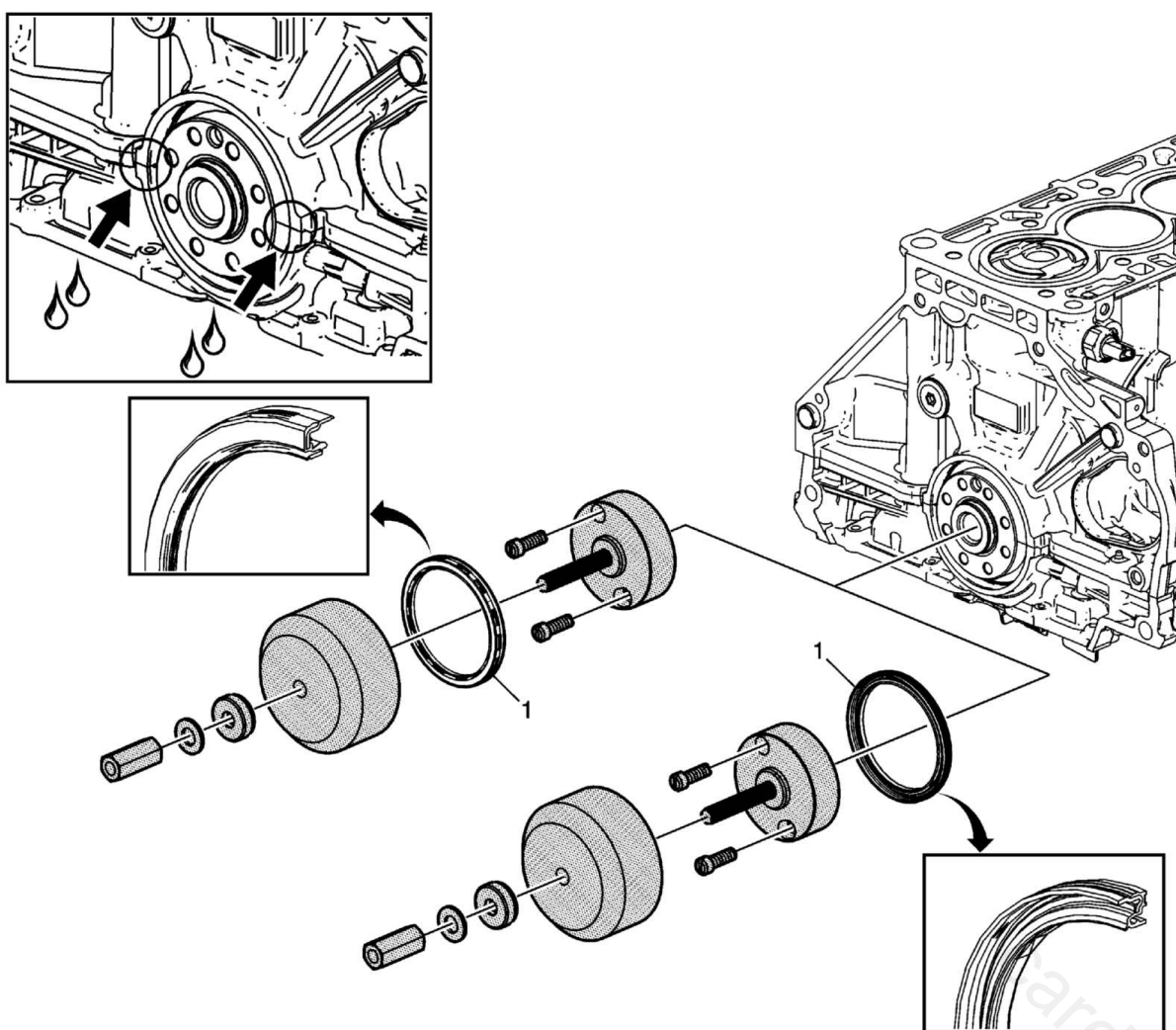


Fig. 477: Crankshaft Rear Oil Seal
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
1	Crankshaft Rear Oil Seal Procedure 1. Inspect the seal recess for excess sealer material at the lower crankcase to engine block mating location. Remove excess sealer, if present. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 3. Add RTV sealer at 2 locations where the bedplate and block join prior to installing the oil seal. Refer to Adhesives, Fluids, Lubricants, and Sealers. NOTE: The oil seal must be installed in the correct direction. The side that faces out will have "this side out" printed on it. Depending on seal design, the way the seal is installed on the EN-51369 installer is opposite. Either the seal is installed over the back of the installer, or the seal is installed over the front of the installer. Match the seal design as shown above and install the seal onto the installer in the correct direction. 4. Install the oil seal in the correct direction on EN-51369 seal installer. NOTE: If the seal is improperly installed on the special tool, it will not install correctly. 5. Inspect the seal on EN-51369 seal installer, and ensure that the seal lip is not deformed. If necessary, remove the seal and reinstall on the special tool. 6. Assemble the EN-51369 seal installer components. NOTE: The special tool installs and establishes the proper depth of the seal in the crankshaft seal bore. 7. Use EN-51369 seal installer to press the new crankshaft seal into the housing. Ensure that the seal is installed in the crankshaft seal bore flush to 0.5 mm depth. Special Tools EN-51369 Seal Installer For equivalent regional tools, refer to Special Tools.

OIL PUMP DRIVE CHAIN AND OIL PUMP INSTALLATION

Oil Pump Assembly Installation

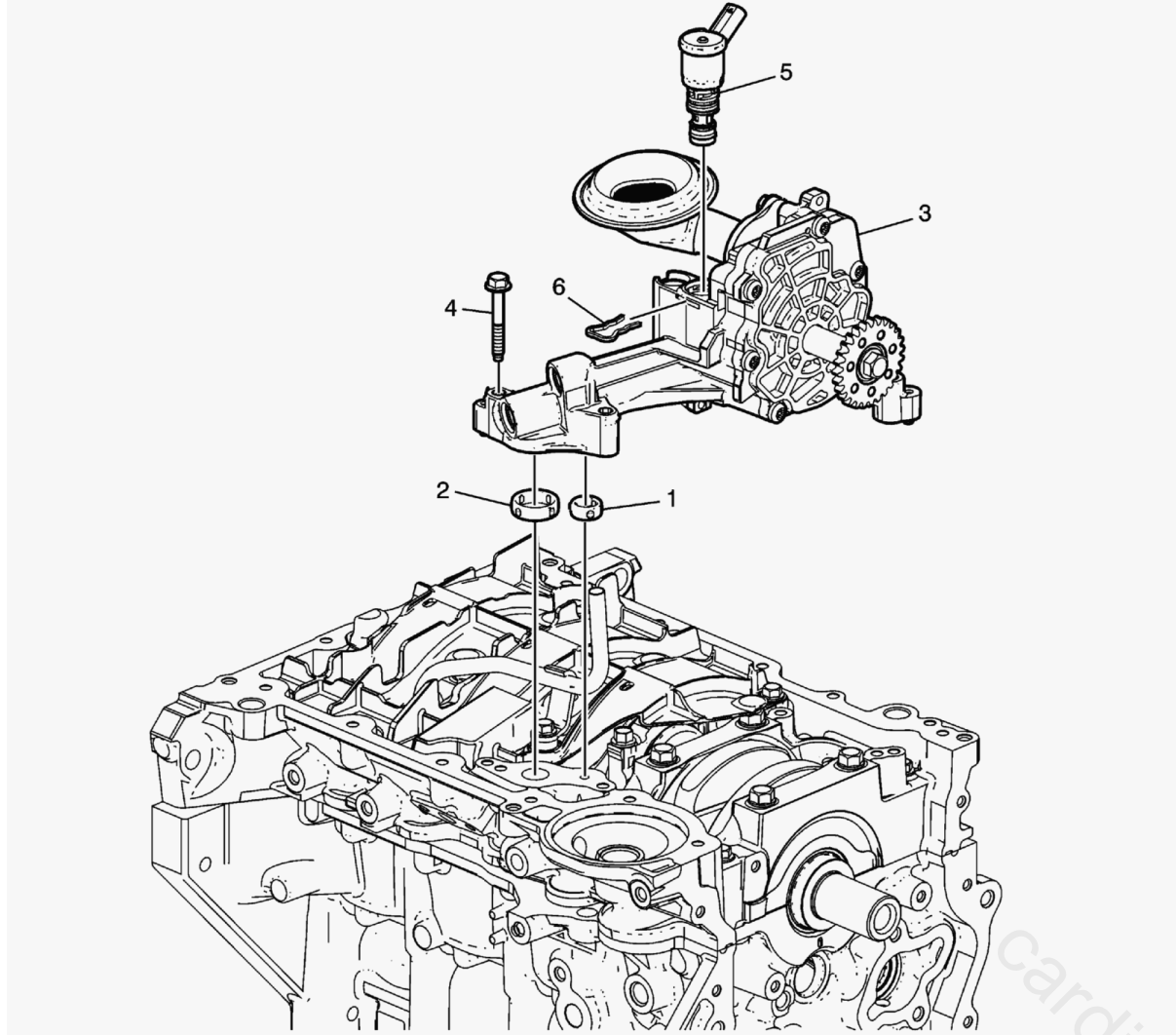


Fig. 478: Oil Pump Assembly

Courtesy of GENERAL MOTORS COMPANY

Oil Pump Assembly Installation

Callout	Component Name
1	Oil Pump Gasket
2	Oil Pump Gasket
3	Oil Pump Assembly
4	Oil Pump Assembly Bolt (Qty: 4) NOTE: Install the oil pump assembly and bolts loosely onto the engine block. Final torque must be performed after the drive chain is installed.
5	Oil Pump Flow Control Solenoid Valve
6	Oil Pump Flow Control Solenoid Valve Retainer

Crankshaft Sprocket and Oil Pump Drive Chain Installation

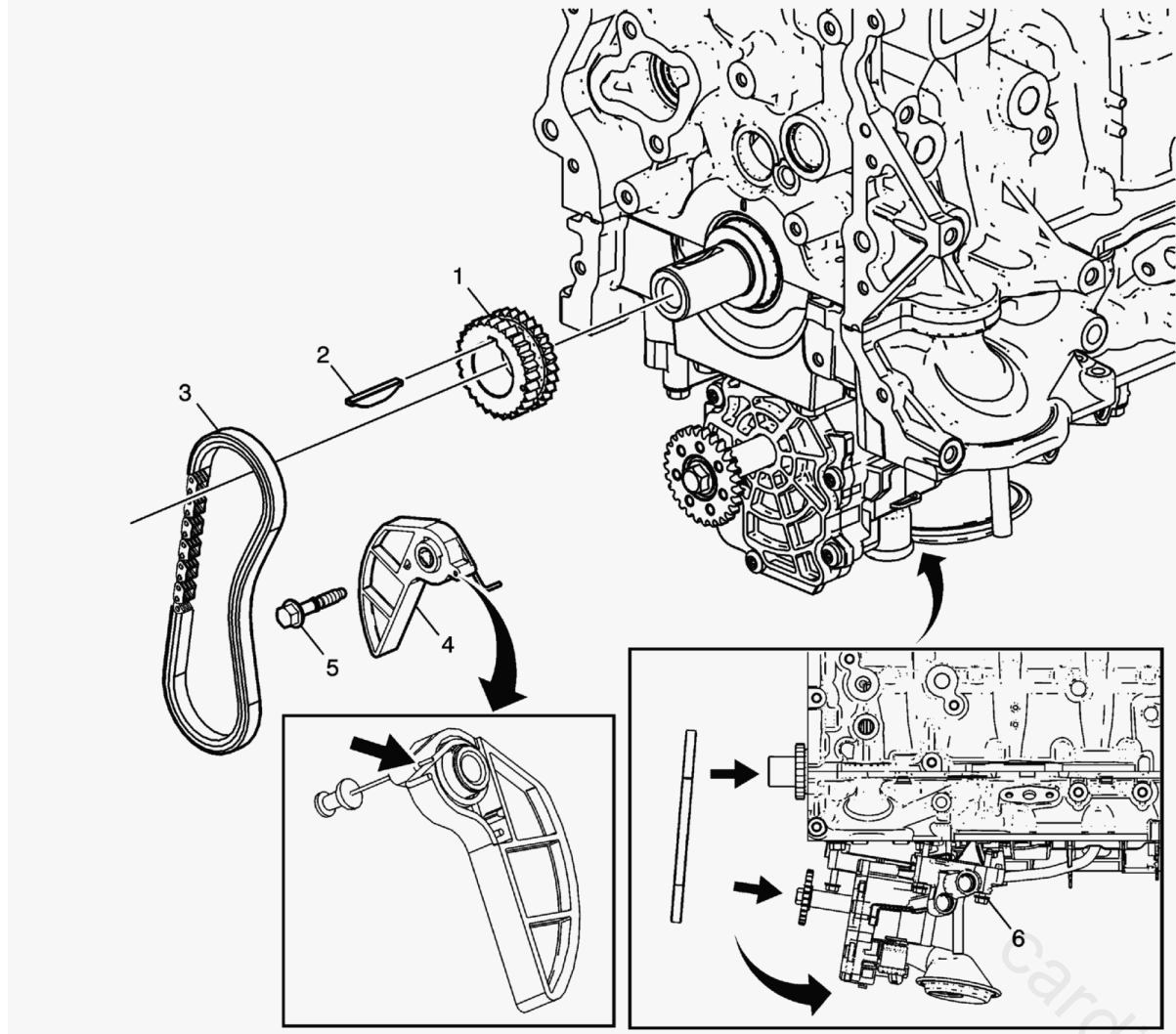


Fig. 479: Crankshaft Sprocket and Oil Pump Drive Chain

Courtesy of GENERAL MOTORS COMPANY

Crankshaft Sprocket and Oil Pump Drive Chain Installation

Callout	Component Name
1	Crankshaft Sprocket
2	Crankshaft Balancer Key
3	Oil Pump Drive Chain CAUTION: Refer to Fastener Caution . Procedure 1. Tilt the oil pump assembly in order to install the drive chain over the oil pump and crankshaft sprockets. 2. Once the drive chain is correctly positioned on the sprockets, tighten the oil pump assembly bolts to 10 N.m (89 lb in).
4	Oil Pump Drive Chain Tensioner Assembly NOTE: Ensure the tensioner spring is retained in the correct position prior to installation.
5	Oil Pump Drive Chain Tensioner Bolt Tighten 10 N.m (89 lb in)

Callout	Component Name
6	Oil Pump Assembly Bolt Tighten 10 N.m (89 lb in)

CYLINDER HEAD INSTALLATION

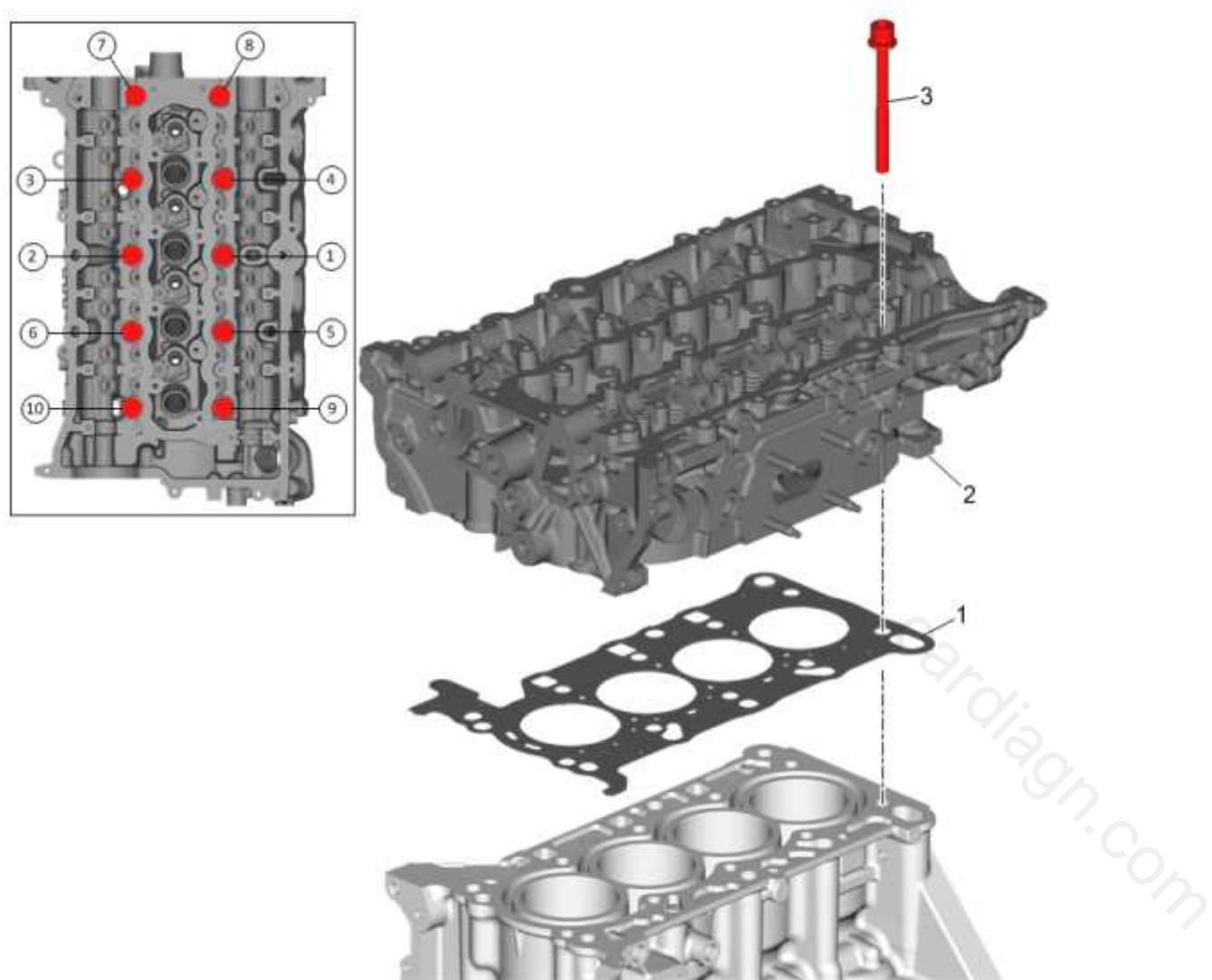


Fig. 480: Cylinder Head With Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Gasket NOTE: Ensure that the cylinder head and the engine block sealing surfaces are clear of oil, grease, and old gasket material.
2	Cylinder Head Assembly

Callout	Component Name
	Cylinder Head Bolt (Qty: 10)
	CAUTION: Refer to Fastener Caution .
	CAUTION: Refer to Torque-to-Yield Fastener Caution .
3	Procedure Tighten the NEW cylinder head bolts in the sequence shown. 1. Tighten the bolts a first pass to 30 N.m (22 lb ft). 2. Using the EN-45059 - A angle meter, tighten the bolts a final pass to 240 degrees. Special Tools EN-45059 - A Angle Meter For equivalent regional tools, refer to Special Tools .

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

Valve Rocker Arm and Lash Adjuster Installation

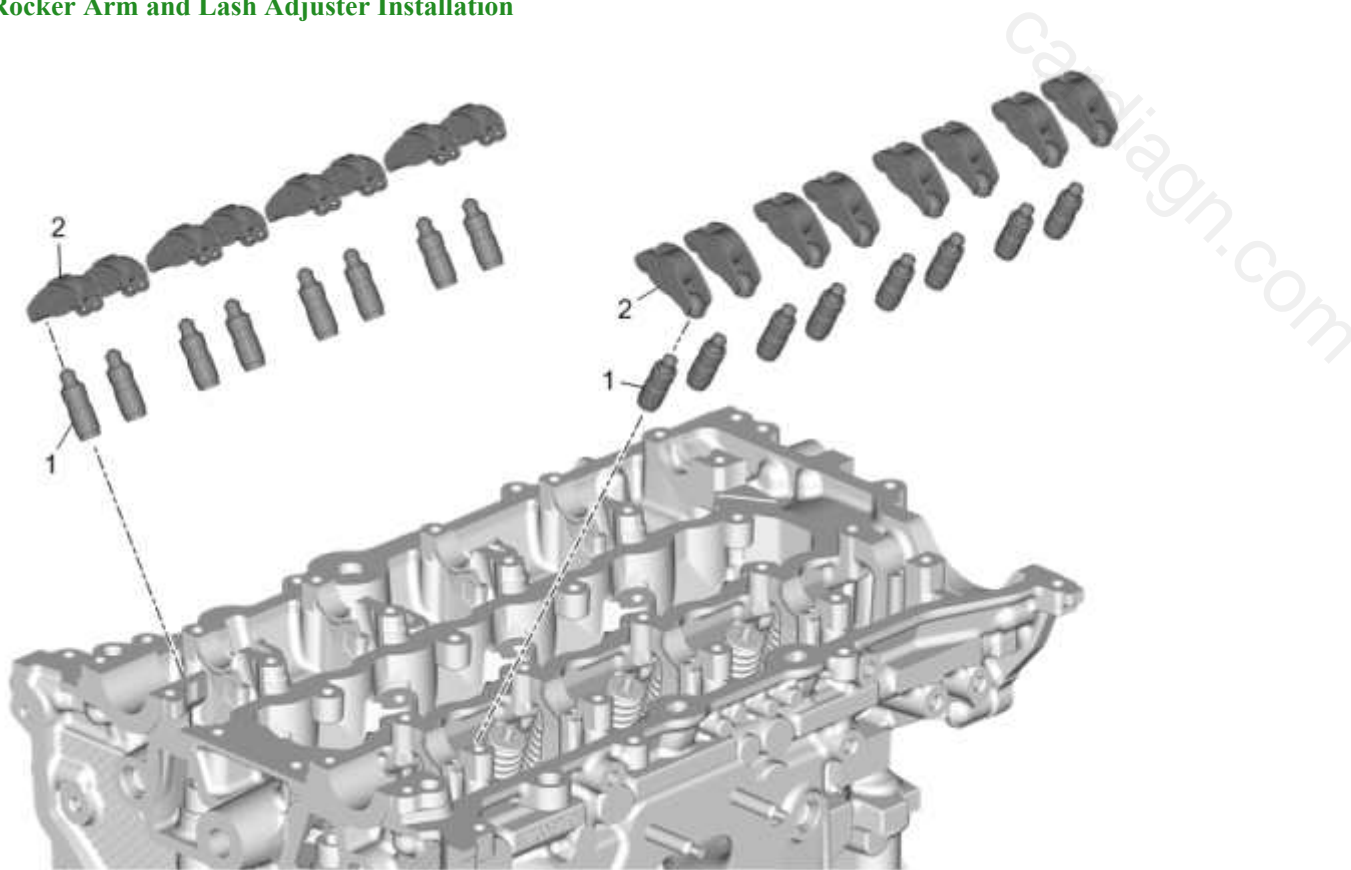


Fig. 481: Valve Rocker Arm and Lash Adjuster
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm and Lash Adjuster Installation

Callout	Component Name
1	Hydraulic Valve Lash Adjuster [16x] Procedure Install the lash adjusters in the bores in the cylinder head. Apply lubricant to the lash adjusters, refer to Adhesives, Fluids, Lubricants, and Sealers .

Callout	Component Name
2	Hydraulic Valve Lash Adjuster Arm [16x] NOTE: Used lash adjuster arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the lash adjuster arms actuated by the camshaft must also be replaced. Procedure 1. Apply lubricant to the valve tips, refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Position the lash adjuster arm on the tip of the valve stem and on the lash adjuster. 3. Apply lubricant to the lash adjuster arms, refer to Adhesives, Fluids, Lubricants, and Sealers.

Camshaft Bearings and Camshaft Installation

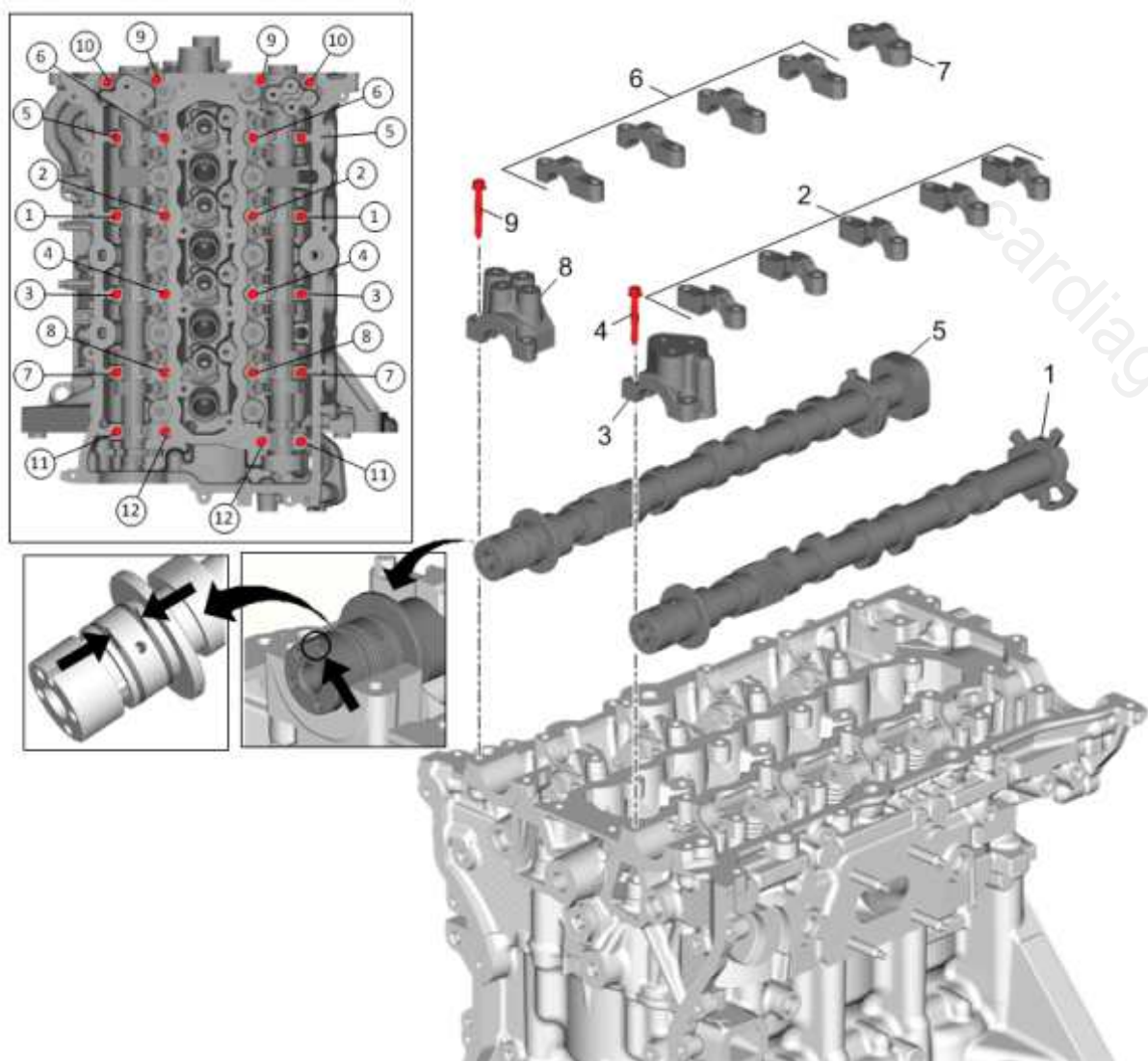


Fig. 482: Camshaft Bearings and Camshaft
Courtesy of GENERAL MOTORS COMPANY

Camshaft Bearings and Camshaft Installation

Callout	Component Name

Callout	Component Name
1	Exhaust Camshaft Procedure 1. Coat the exhaust camshaft with lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Install the exhaust camshaft in the cylinder head. 3. Ensure that the camshaft notch at the front of the camshaft is in the 12 O'clock position. 4. Rotate the oil seals in the groove of the number one camshaft journal so the split line is at approximately the 12 O'clock position before installing the camshaft caps.
2	Camshaft Bearing Cap [5x] NOTE: Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. Ensure the caps are installed in the original location and position. Procedure Install the cap and start the cap bolts by hand.
3	Camshaft Bearing Front Exhaust Cap Procedure Install the cap and start the cap bolts by hand.
4	Camshaft Bearing Cap Bolt [12x] CAUTION: Refer to Fastener Caution . Procedure 1. Lubricate the bearing cap bolts. 2. Tighten the bearing cap bolts in sequence three turns each until the caps are seated. Tighten 12 N.m (106 lb in)
5	Intake Camshaft Procedure 1. Coat the intake camshaft with lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Install the intake camshaft in the cylinder head. 3. Ensure that the camshaft notch at the front of the camshaft is in the 12 O'clock position. 4. Rotate the oil seals in the groove of the number one camshaft journal so the split line is at approximately the 12 O'clock position before installing the camshaft caps.

Callout	Component Name
6	Camshaft Bearing Cap [4x] NOTE: Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. Ensure the caps are installed in the original location and position. Procedure Install the cap and start the cap bolts by hand.
7	Camshaft Bearing Rear Cap Procedure Install the cap and start the cap bolts by hand.
8	Camshaft Bearing Front Intake Cap Procedure Install the cap and start the cap bolts by hand.
9	Camshaft Bearing Cap Bolt [12x] Procedure 1. Lubricate the bearing cap bolts. 2. Tighten the bearing cap bolts in sequence three turns each until the caps are seated. Tighten 12 N.m (106 lb in)

Camshaft Actuator Installation

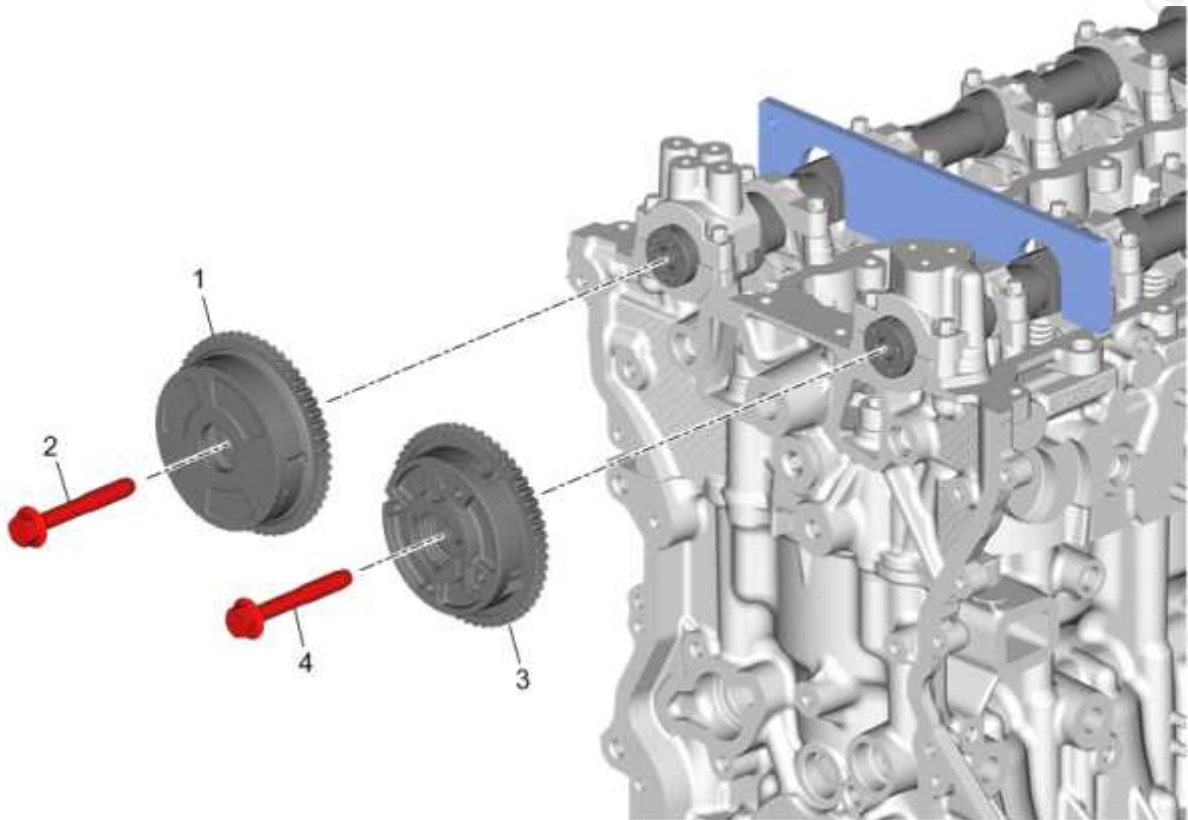


Fig. 483: Camshaft Actuator
 Courtesy of GENERAL MOTORS COMPANY

Camshaft Actuator Installation

Callout	Component Name

Callout	Component Name
Preliminary Procedure Install the EN-51367 camshaft locking tool. Remove when the camshaft actuator bolts are tightened to specification. Special Tools EN-51367 Camshaft Locking Tool Equivalent regional tools: Special Tools .	
1	Camshaft Position Actuator NOTE: Align the actuator with the notch in the camshaft.
2	Camshaft Position Actuator Bolt CAUTION: Refer to <u>Fastener Caution</u> . CAUTION: Refer to <u>Torque-to-Yield Fastener Caution</u> . Procedure Tighten the NEW camshaft position actuator bolt in the sequence shown. 1. Tighten the bolt a first pass to 20 N.m (15 lb ft). 2. Using the EN 45059 angle meter, tighten the bolt a final pass to 90 degrees. Special Tools EN-45059 Angle Meter Equivalent regional tools: Special Tools .
3	Camshaft Position Actuator NOTE: Align the actuator with the notch in the camshaft.
4	Camshaft Position Actuator Bolt Procedure Tighten the NEW camshaft position actuator bolt in the sequence shown. 1. Tighten the bolt a first pass to 20 N.m (15 lb ft). 2. Using the EN-45059 angle meter, tighten the bolt a final pass to 90 degrees. Special Tools EN-45059 Angle Meter Equivalent regional tools: Special Tools .

CAMSHAFT TIMING CHAIN INSTALLATION

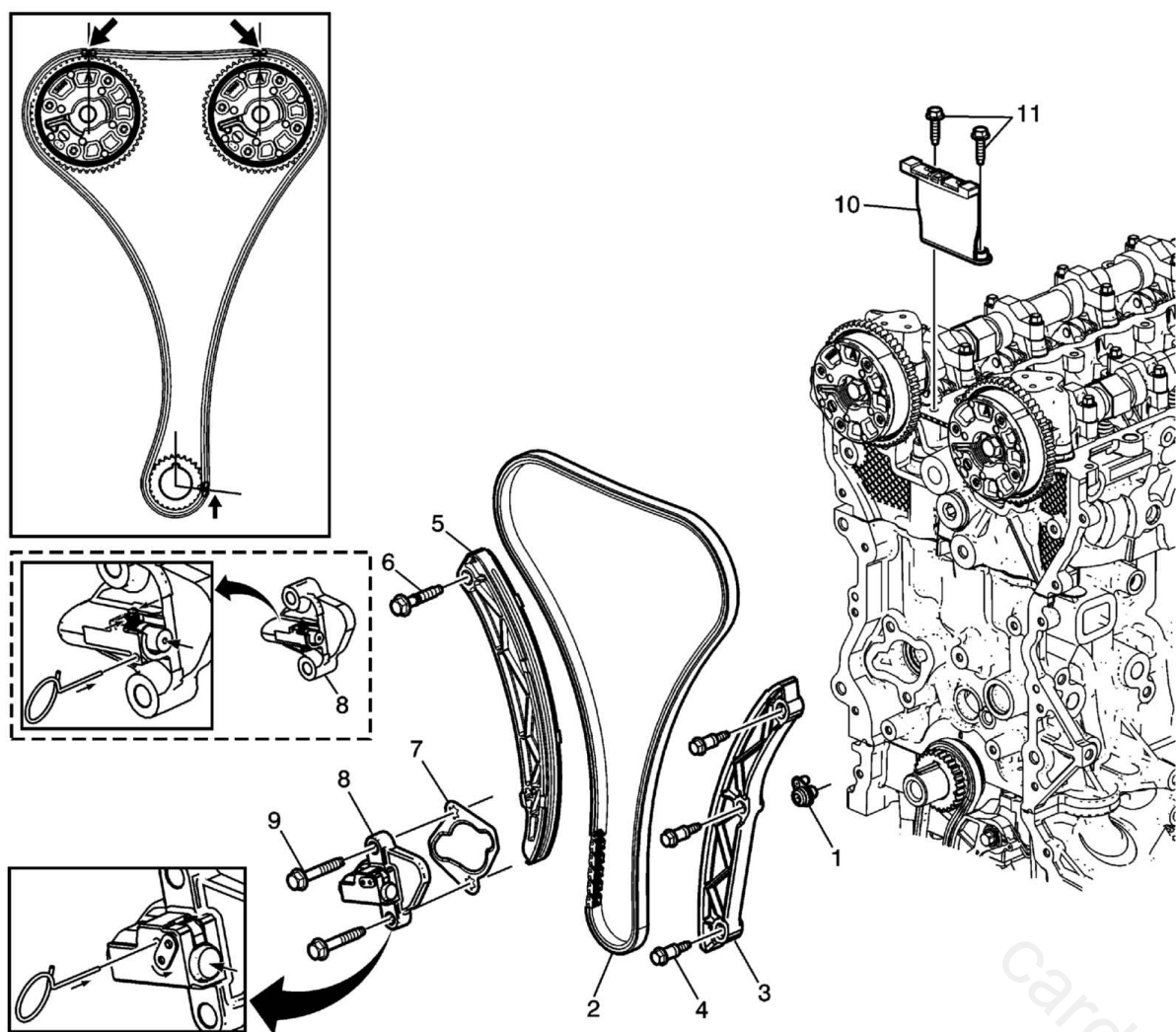


Fig. 484: Camshaft Timing Chain Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Timing Chain Oil Nozzle CAUTION: Refer to Component Fastener Tightening Caution . Tighten 15 N.m (11 lb ft)
2	Timing Chain NOTE: Ensure the actuator timing marks and the crankshaft sprocket keyway are at the 12 O'Clock position. Procedure NOTE: Ensure the correct timing link is aligned with the timing mark. The color of the actuator timing links are the same, and the color of the crankshaft sprocket timing link is unique. 1. Align the first timing chain link with the intake actuator timing mark. 2. Align the second timing chain link with the exhaust actuator timing mark. 3. Align the final timing chain link with the crankshaft sprocket timing mark.

Callout	Component Name
3	Timing Chain Guide - Exhaust Side
4	Timing Chain Guide Bolt (Qty: 3) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
5	Timing Chain Tensioner Shoe Assembly
6	Timing Chain Tensioner Shoe Bolt Tighten 25 N.m (18 lb ft)
7	Timing Chain Tensioner Gasket
8	Timing Chain Tensioner Assembly NOTE: Ensure the tensioner is fully retracted prior to installation. Depending on tensioner model, the procedure to depress and lock the plunger is different. Procedure 1. If the tensioner has a lever on the front, press down on the lever and depress the plunger. Insert a suitable tool into the hole in the tensioner body to hold the plunger in the retracted position. 2. If the tensioner has a retaining clip, press the clip and depress the plunger. Insert a suitable tool into the hole in the tensioner body to hold the plunger in the retracted position.
9	Timing Chain Tensioner Bolt (Qty: 2) Tighten 25 N.m (18 lb ft)
10	Timing Chain Upper Guide - to Cylinder Head
11	Timing Chain Upper Guide Bolt (Qty: 2) Tighten 10 N.m (89 lb in)

ENGINE FRONT COVER INSTALLATION

Engine Front Cover and Components Installation

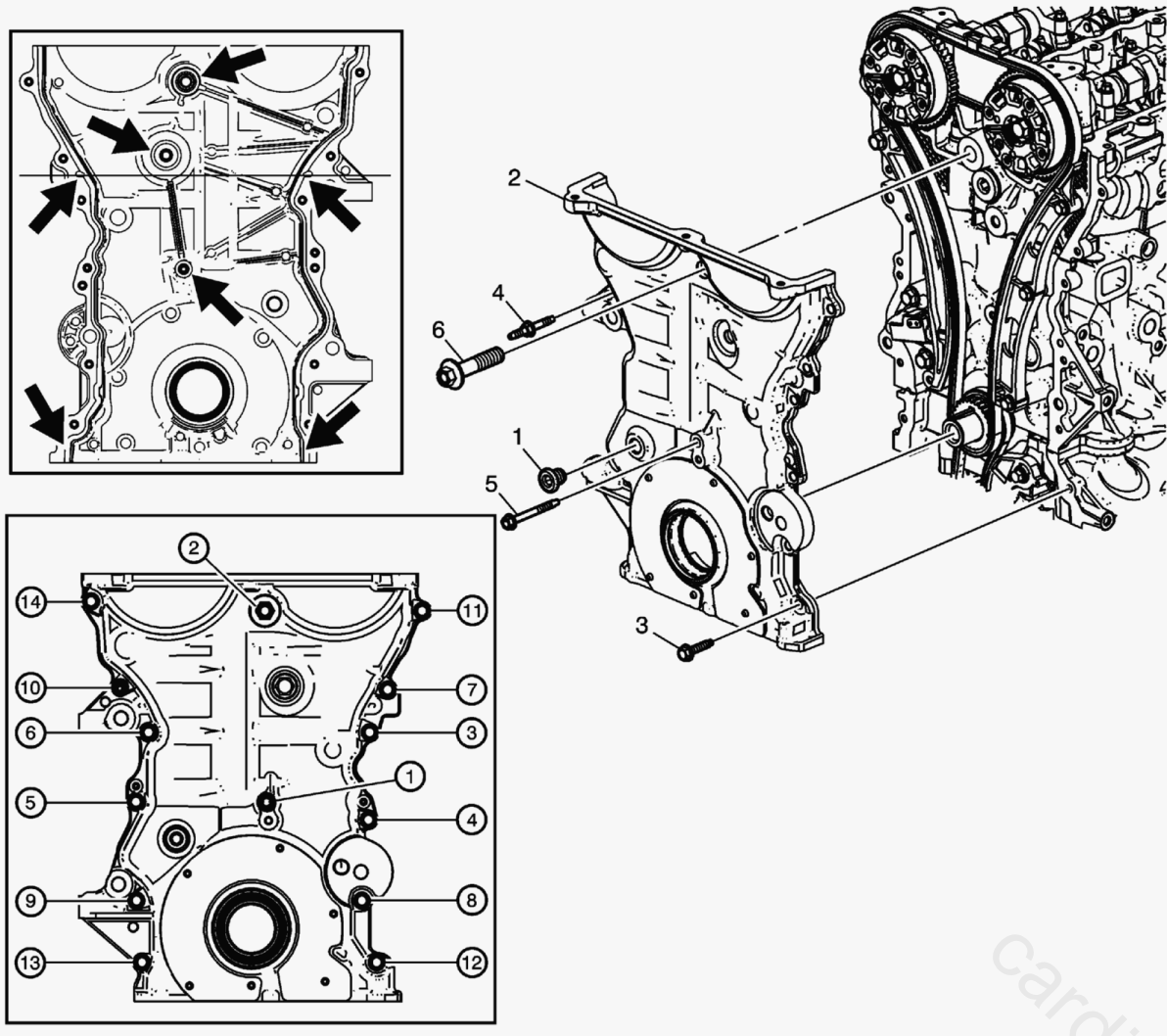


Fig. 485: Engine Front Cover and Components With Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover and Components Installation

Callout	Component Name
1	Engine Front Cover Hole Plug CAUTION: Refer to Fastener Caution . Tighten 50 N.m (37 lb ft)

Callout	Component Name
2	Engine Front Cover Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant NOTE: • The engine front cover surface must be free of contamination prior to applying the sealer. • Install and align the cover within 20 minutes of applying the sealer. • The cover must be fastened to final torque specification within 20 minutes of applying the sealer. • Additional sealant is necessary to reduce the possibility of leakage where the cylinder head to engine block interface along the bead path flange on the front cover. 2. Apply a 4 mm bead of sealer directly in the flange of the engine front cover perimeter mating surface. 3. Apply a 3 mm bead of sealer circling 3 locations on the interior of the engine front cover. 4. Apply a 3 mm bead of sealant at the 2 horizontal groove locations along the flange where the cylinder head and engine block mate. Refer to Adhesives, Fluids, Lubricants, and Sealers.
3	Engine Front Cover Bolt - M6 (Qty: 11) NOTE: Hand start the engine front cover bolts. Torque to specification when all front cover bolts and the stud are installed hand-tight. Tighten 15 N.m (11 lb ft)
4	Engine Front Cover Stud (Qty: 1) Tighten 15 N.m (11 lb ft)
5	Engine Front Cover Bolt - M6 (Qty: 1) NOTE: This interior M6 bolt is longer than the perimeter M6 bolts. Tighten 15 N.m (11 lb ft)
6	Engine Front Cover Bolt - M14 (Qty: 1) Tighten 58 N.m (43 lb ft) Procedure Tighten all the engine front cover bolts in the sequence shown. 1. Tighten the bolts a first pass to 5 N.m (44 lb in). 2. Tighten the bolts a final pass to final torque specification.

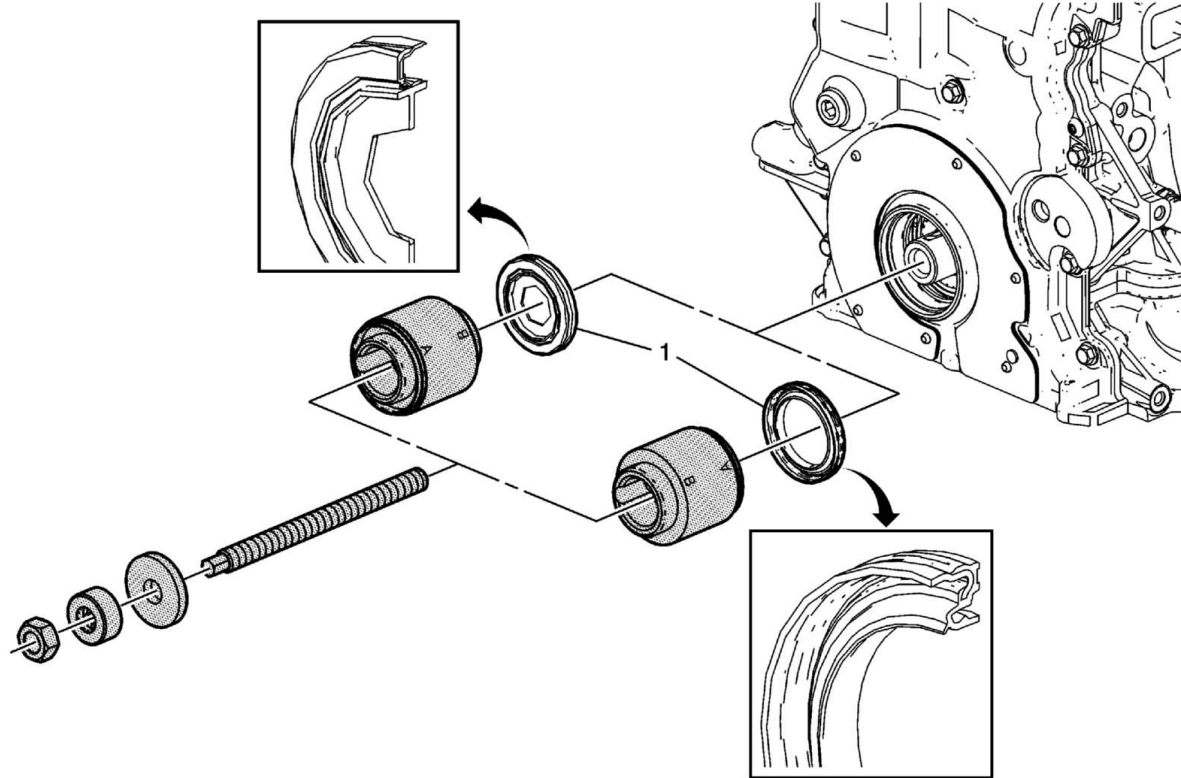


Fig. 486: Crankshaft Front Oil Seal
 Courtesy of GENERAL MOTORS COMPANY

Crankshaft Front Oil Seal Installation

Callout	Component Name
	Crankshaft Front Oil Seal
	Procedure NOTE: The oil seal must be installed in the correct direction. The side that faces out will have "this side out" printed on it. The design of the seal determines which end of the EN 51368 installer is used. Use the end of the installer that matches the design of the seal, as shown.
1	1. Lubricate the outside diameter of the new crankshaft seal with clean engine oil. 2. Determine which end of the EN-51368 installer will be used and install the seal on it. 3. Install the EN-51368 installer over the crankshaft. 4. Install the EN-51368 screw, large washer, bearing, and nut. 5. Counter-hold the screw, and tighten the nut to install the seal.
	Special Tools EN-51368 Front Crankshaft Seal Installer For equivalent regional tools, refer to Special Tools .

OIL PAN INSTALLATION

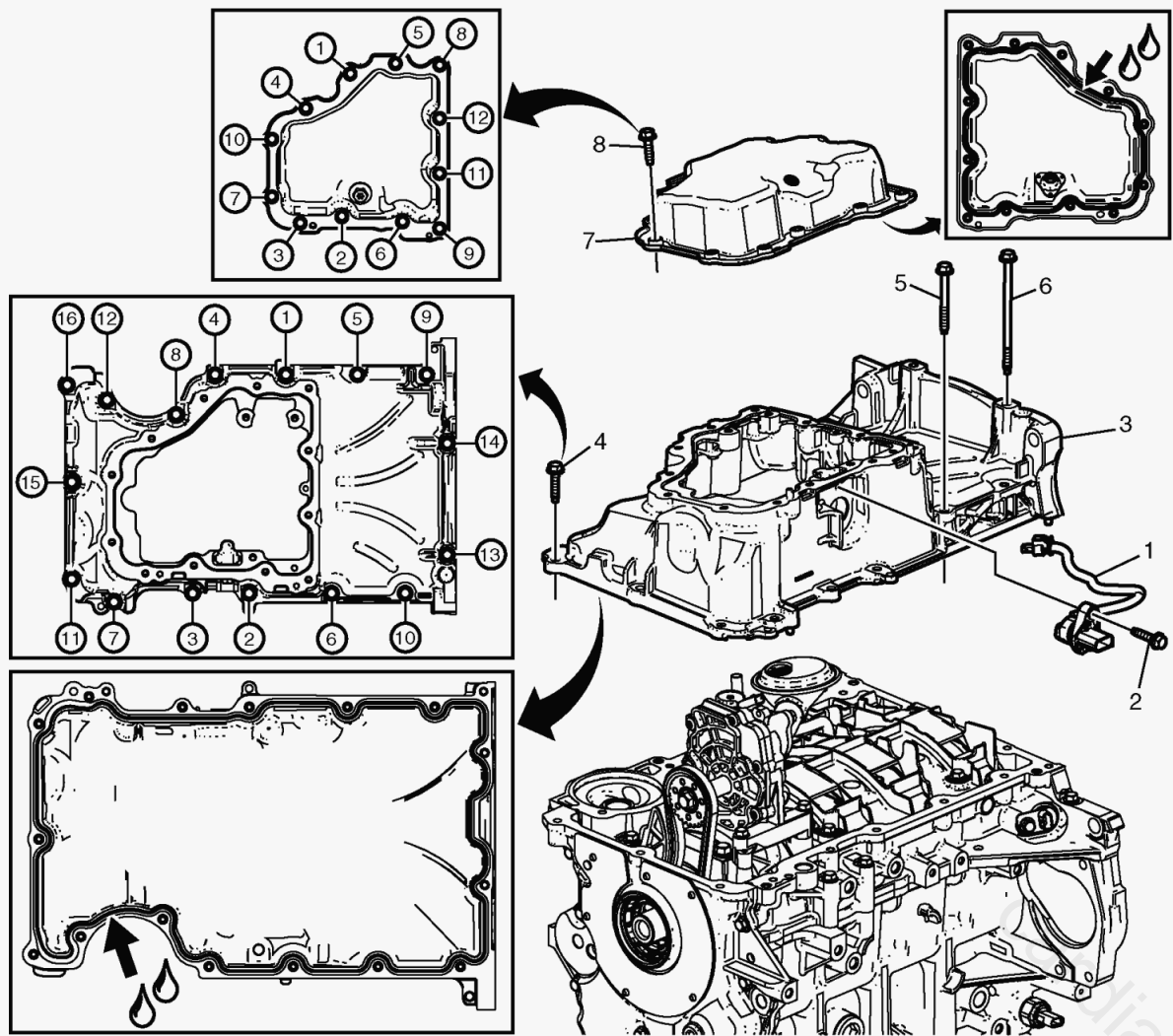


Fig. 487: Oil Pan With Bolt Tightening Sequences
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Level Indicator Control Wiring Harness
2	Wiring Harness Connector Bolt
	CAUTION: Refer to Fastener Caution .
	Tighten 10 N.m (89 lb in)

Callout	Component Name
3	Upper Oil Pan Assembly Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant NOTE: • The lower crankcase and oil pan mating surfaces must be free of contamination prior to applying the sealer. • Install and align the oil pan to block within 20 minutes of applying the sealer. • The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer. • Additional sealant is necessary to reduce the possibility of leakage where the cylinder head to engine block interface along the bead path flange on the front cover. 2. Apply a 3 mm bead of sealer around the perimeter of the oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. 3. Install the oil pan on the lower crankcase, ensure the oil pan locating pins align with the lower crankcase.
4	Oil Pan Bolt (Qty: 12) Procedure 1. Apply sealant to the oil pan bolts. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Hand start the oil pan bolts. Torque to specification when all oil pan bolts are installed hand-tight. Tighten 10 N.m (89 lb in)
5	Oil Pan Bolt (Qty: 2) Procedure 1. Apply sealant to the oil pan bolts. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Hand start the oil pan bolts. Torque to specification when all oil pan bolts are installed hand-tight. Tighten 10 N.m (89 lb in)

Callout	Component Name
6	Oil Pan Bolt (Qty: 2) Procedure 1. Apply sealant to the oil pan bolts. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Tighten all the oil pan bolts in sequence. 3. Inspect for excessive sealer around the oil filter mounting area when final torque is achieved. If extra sealer is present, remove and clean accordingly. Tighten 10 N.m (89 lb in)
7	Lower Oil Pan Procedure 1. Connect the oil pump control valve wiring harness connector. 2. Use a NEW lower oil pan. 3. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 4. Apply a 5 mm bead of sealer around the perimeter of the lower oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. 5. Install the lower oil pan on the upper oil pan, ensure the oil pan locating pins align with the lower oil pan.
8	Lower Oil Pan Bolt (Qty: 12) Procedure Tighten the oil pan bolts in sequence. Tighten 10 N.m (89 lb in)

CAMSHAFT COVER INSTALLATION

Camshaft Cover Components Installation - Bottom

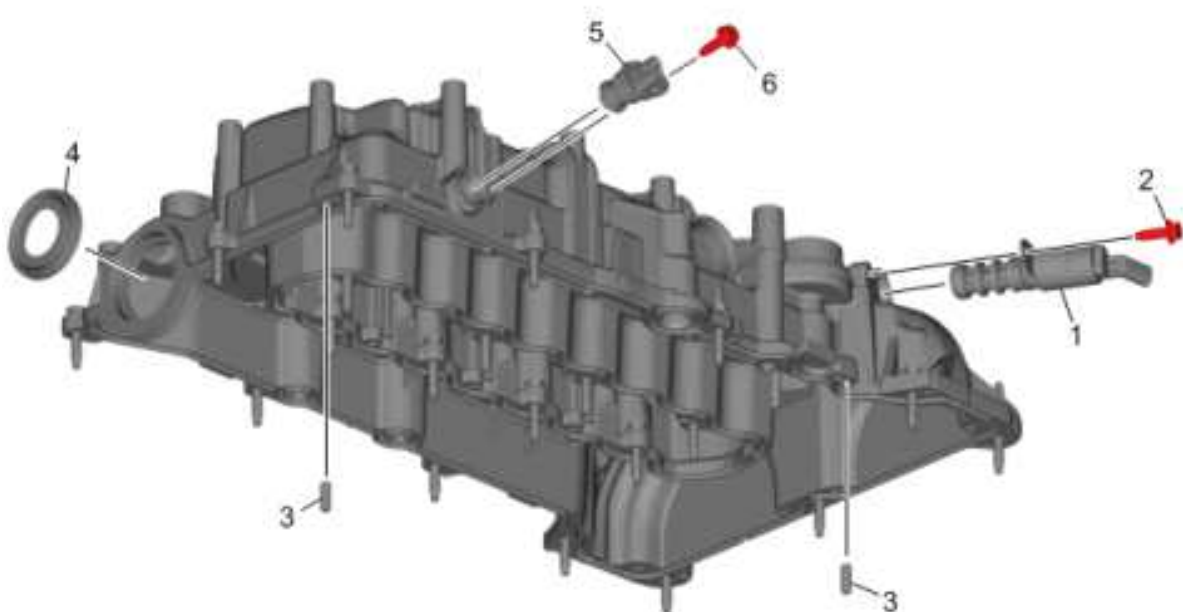


Fig. 488: Camshaft Cover Components -- Bottom
 Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Components Installation - Bottom

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve
2	Camshaft Position Actuator Solenoid Valve Bolt CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
3	Camshaft Cover Locating Pin [2x]
4	Vacuum Pump Seal NOTE: Use NEW seal. Special Tools EN-45866 Seal Installer Equivalent regional tools: Special Tools .
5	Camshaft Position Sensor
6	Camshaft Position Sensor Bolt Tighten 10 N.m (89 lb in)

Camshaft Cover Components Installation - Top

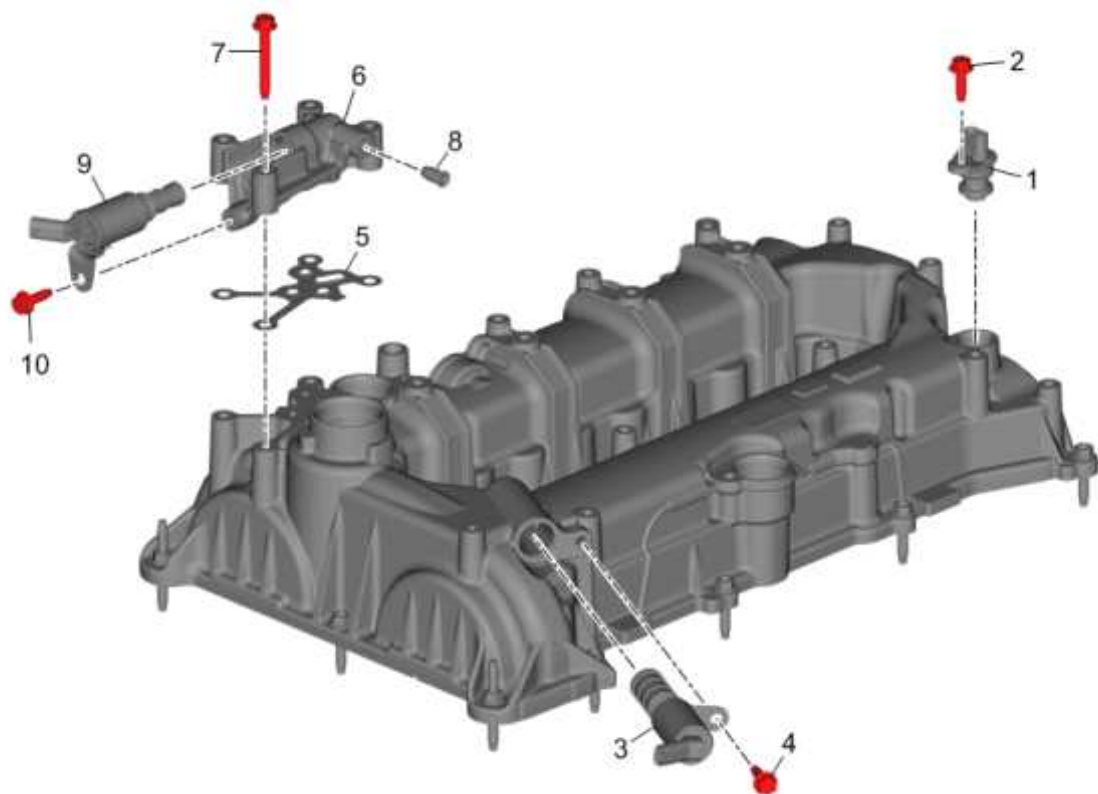


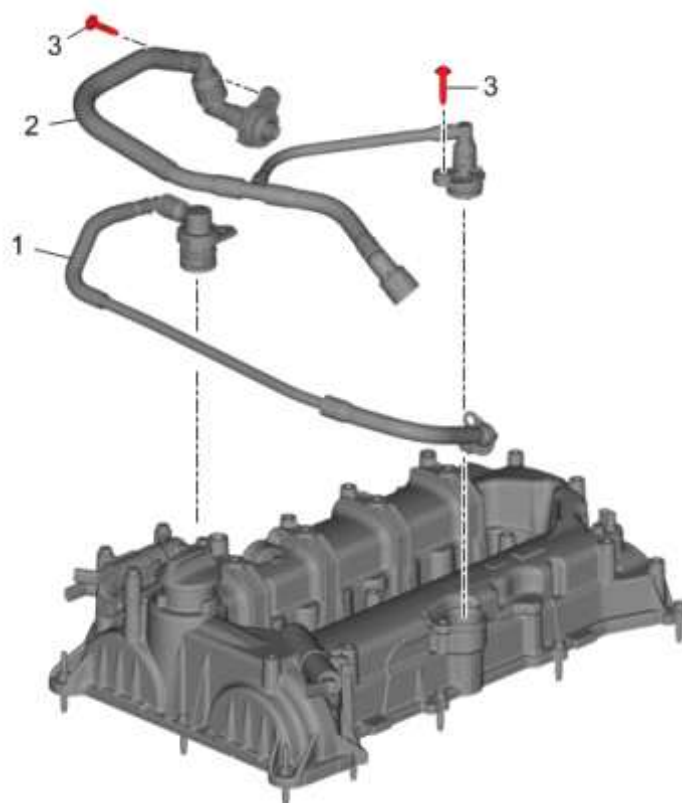
Fig. 489: Camshaft Cover Components - Top
 Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Components Installation - Top

Callout	Component Name

Callout	Component Name
1	Camshaft Position Sensor
2	Camshaft Position Sensor Bolt CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
3	Camshaft Position Actuator Solenoid Valve
4	Camshaft Position Actuator Solenoid Valve Bolt Tighten 10 N.m (89 lb in)
5	Camshaft Housing Gasket NOTE: Use a NEW gasket.
6	Camshaft Housing
7	Camshaft Housing Bolt [4x] Tighten 10 N.m (89 lb in)
8	Camshaft Cover Opening Plug Procedure Apply sealant to the plug prior to installation. Refer to Adhesives, Fluids, Lubricants, and Sealers . Tighten 12 N.m (106 lb in)
9	Camshaft Position Actuator Locating Pin Control Valve
10	Camshaft Position Actuator Solenoid Valve Bolt Tighten 10 N.m (89 lb in)

Camshaft Cover Positive Crankcase Ventilation Components Installation



Camshaft Cover Positive Crankcase Ventilation Components Installation

Callout	Component Name
1	Positive Crankcase Ventilation Tube with Positive Crankcase Ventilation Valve - Foul Air NOTE: These components have tamper-proof connections and cannot be disassembled. Procedure 1. Assemble a NEW PCV Tube, NEW PCV valve, and NEW PCV Hose fitting. 2. Install the PCV valve to the camshaft cover. The valve is retained by snapping into the camshaft cover.
2	Positive Crankcase Ventilation Tube with Positive Crankcase Ventilation Valve - Fresh Air NOTE: These components have tamper-proof connections and cannot be disassembled. The fresh air inlet duct is connected to the PCV Tube with a tamper-proof connection. All components must be replaced once removed. Procedure 1. Assemble a NEW PCV tube with NEW PCV valves and a NEW fresh air inlet duct. 2. Install the PCV valves to the camshaft cover.
3	Positive Crankcase Ventilation Valve Bolt [2x] CAUTION: Refer to Fastener Caution . NOTE: Bolts are tamper-proof. Procedure Using EN-50956 bit, install NEW bolts. Tighten 10 N.m (89 lb in) Special Tools EN-50956 Tamper-Proof Drive Bit Equivalent regional tools: Special Tools.

Camshaft Cover Installation

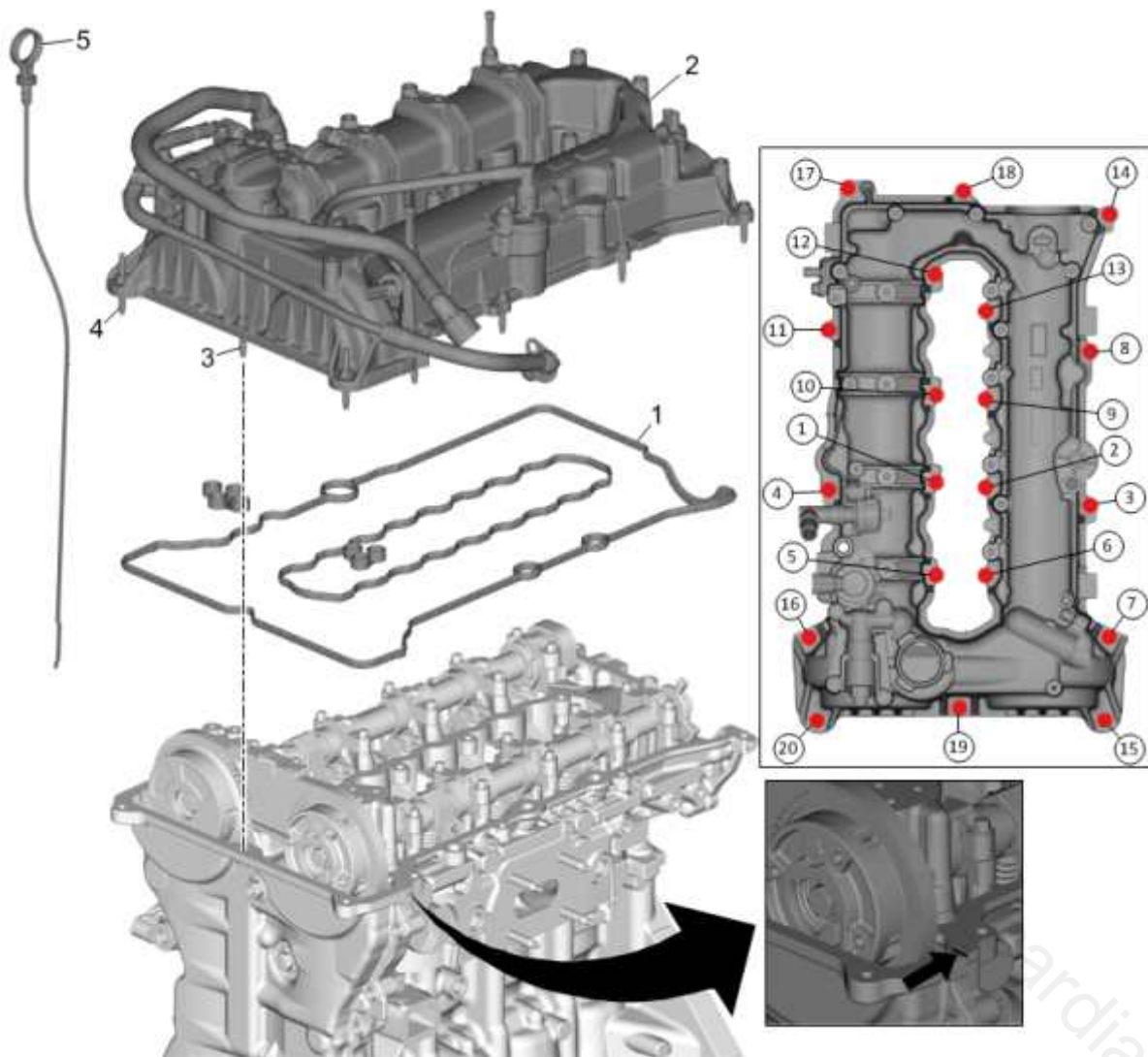


Fig. 491: Camshaft Cover

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Installation

Callout	Component Name
1	Camshaft Cover Gasket NOTE: Use a NEW gasket. Procedure Assemble the camshaft cover and a NEW gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.
2	Camshaft Cover Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 2. Apply approximately a 5 mm (0.2 in) thick bead of camshaft cover sealant on both sides between the cylinder head and the engine front cover. Refer to Adhesives, Fluids, Lubricants, and Sealers.
3	Camshaft Cover Bolt [18x] Procedure Start the bolts by hand. Tighten the engine front cover bolts and studs in sequence.

Callout	Component Name
4	Camshaft Cover Stud [2x] Procedure Tighten the engine front cover bolts and studs in sequence. CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)
5	Oil Level Indicator

FUEL RAIL AND INJECTORS INSTALLATION

Special Tools

- EN-49245 Fuel Injector Seal Installer/Sizer
- EN-51105 Injector Seal Installer Adapters
- EN-51146 Fuel Injector Removal/Installation Kit
- EN-51146-100 Fuel Injector Removal Plate

For equivalent regional tools, refer to [Special Tools](#).

Fuel Injector Installation Procedure

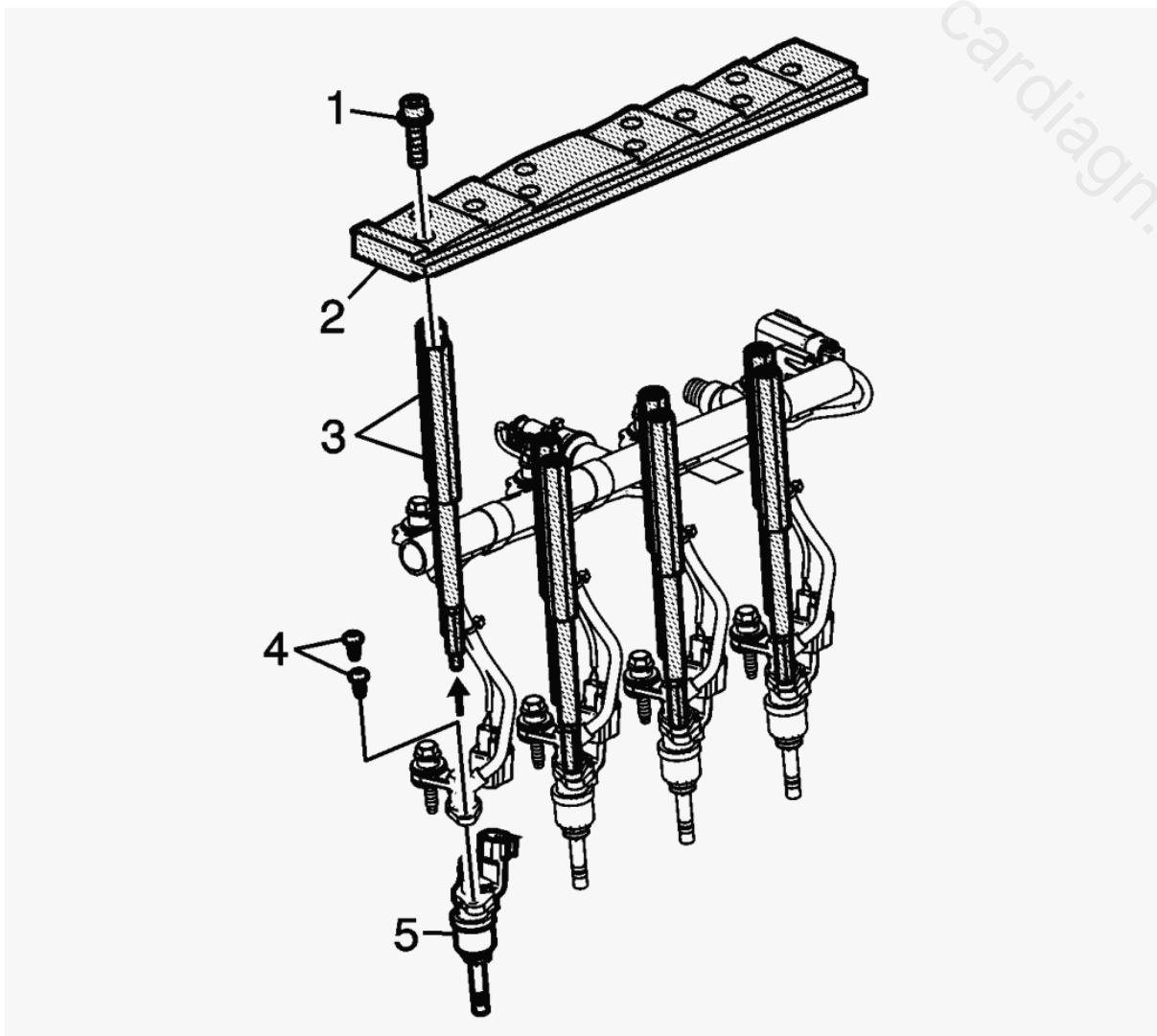


Fig. 492: Installing Fuel Injectors Using Removal/Installation Kit
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not remove the fuel injectors unless inspection indicates

replacement is necessary. Do not remove the EN-51146-1-6 demounting screw and EN-51146-1-1 support unless the fuel injector is being replaced.

1. If one or more fuel injectors are being replaced, remove the bolts (1) and EN-51146-100 plate (2).
2. Remove the EN-51146-1-6 demounting screws and EN-51146-1-1 supports (3) for all fuel injectors that are being replaced.
3. Remove and discard the fuel injectors (5) that are being replaced.
4. Lubricate the O-ring with one drop of clean engine oil. Install a new fuel injector (5).

CAUTION: Refer to [Fastener Caution](#) .

5. Install the NEW fuel injector screws (4) to the NEW fuel injectors (5) and tighten to 5 N.m (44 lb in).
6. Connect the fuel injector wiring harness plugs.

Fuel Injector Combustion Seal Installation Procedure

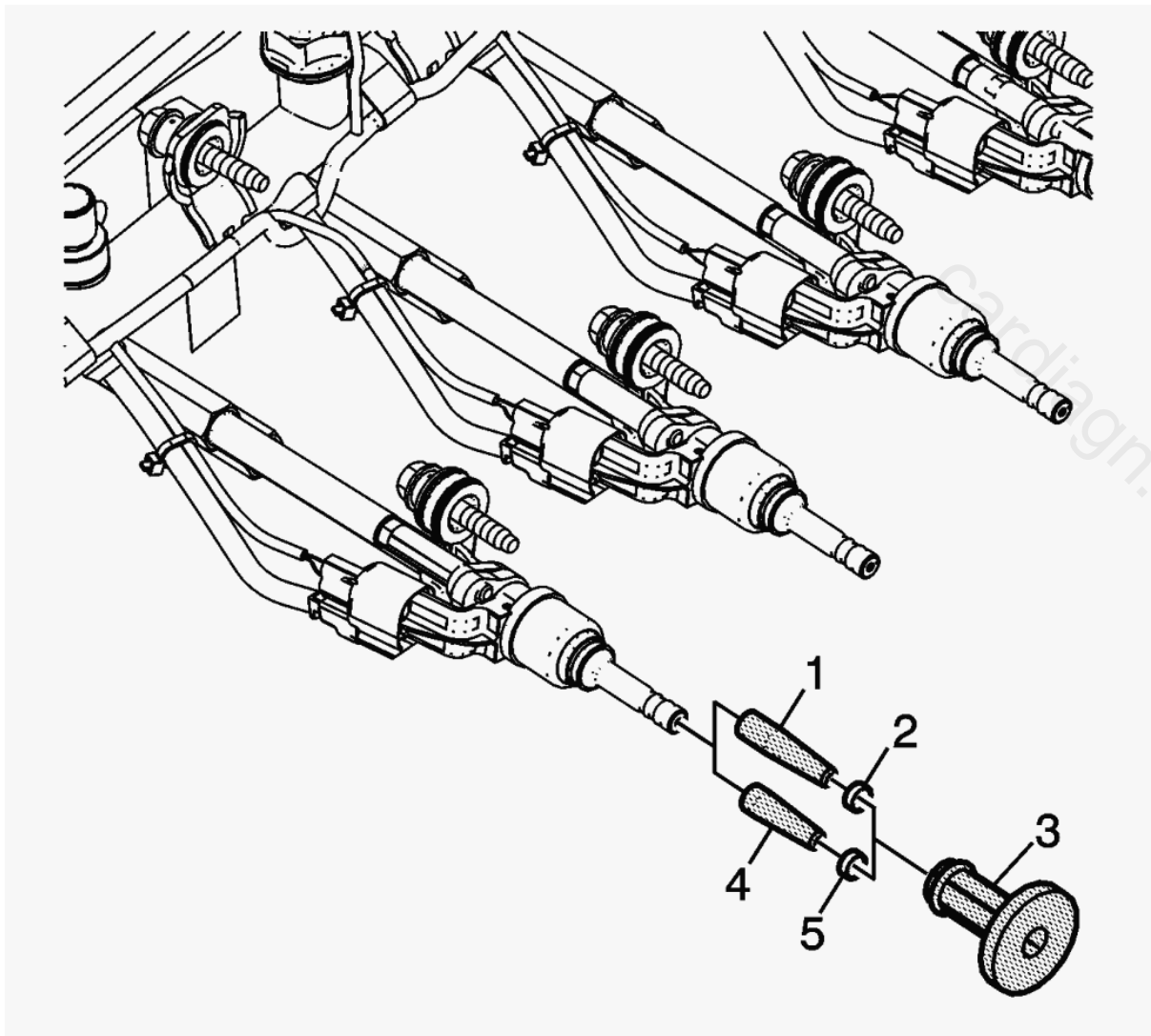


Fig. 493: Installing Combustion Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: DO NOT use any type of lubricant when installing the NEW combustion seals on the fuel injector tip.

NOTE: The injector tip protectors in the EN-49245 set are too small for some injectors. Ensure EN-51105 is used on injector tips during seal installation. The pusher and final sizer work for all injectors.

1. Install EN-51105-1 long protector (1) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a NEW seal (2) on EN-51105-1 long protector (1).

2. Using **EN-49245-3** pusher (3), install the seal (2) into the recessed area of the fuel injector.
3. Compress the seal (2) with your fingers.
4. Install **EN-51105-2** short protector (4) onto the fuel injector tip. Place a NEW seal (5) on **EN-51105-2** short protector (4).
5. Using **EN-49245-3** pusher (3), install the seal (5) into the last recessed area of the fuel injector.
6. Compress the seal (5) with your fingers.

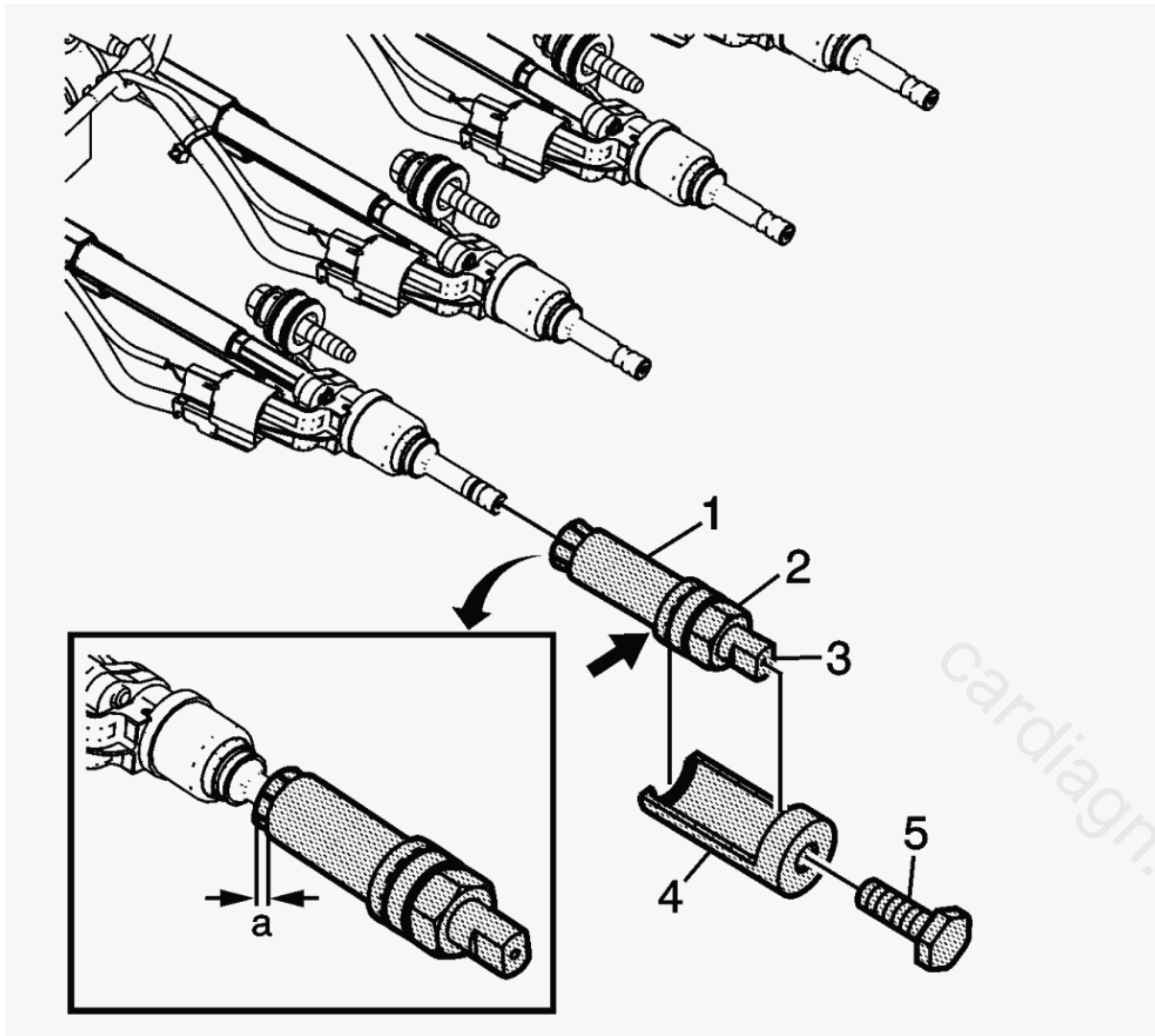


Fig. 494: Pre-Sizing Tool

Courtesy of GENERAL MOTORS COMPANY

7. Push the **EN-51146-2-4** pre-sizing tool (1) over the fuel injector tip.
8. Tighten the nut (2) and counterhold at the spanner flat (3) of the **EN-51146-2-4** pre-sizing tool (1) until the measure (a) of 4.5 mm (0.177 in) is reached.
9. Loosen the nut (2) of the **EN-51146-2-4** pre-sizing tool.
10. Install the **EN-51146-2-4-7** take off chassis (4) to the **EN-51146-2-4** pre-sizing tool (1).
11. Install the **EN-51146-2-4-6** screw M10 (5) to the **EN-51146-2-4-7** take off chassis (4) and tighten until the **EN-51146-2-4** pre-sizing tool (1) is loosened.

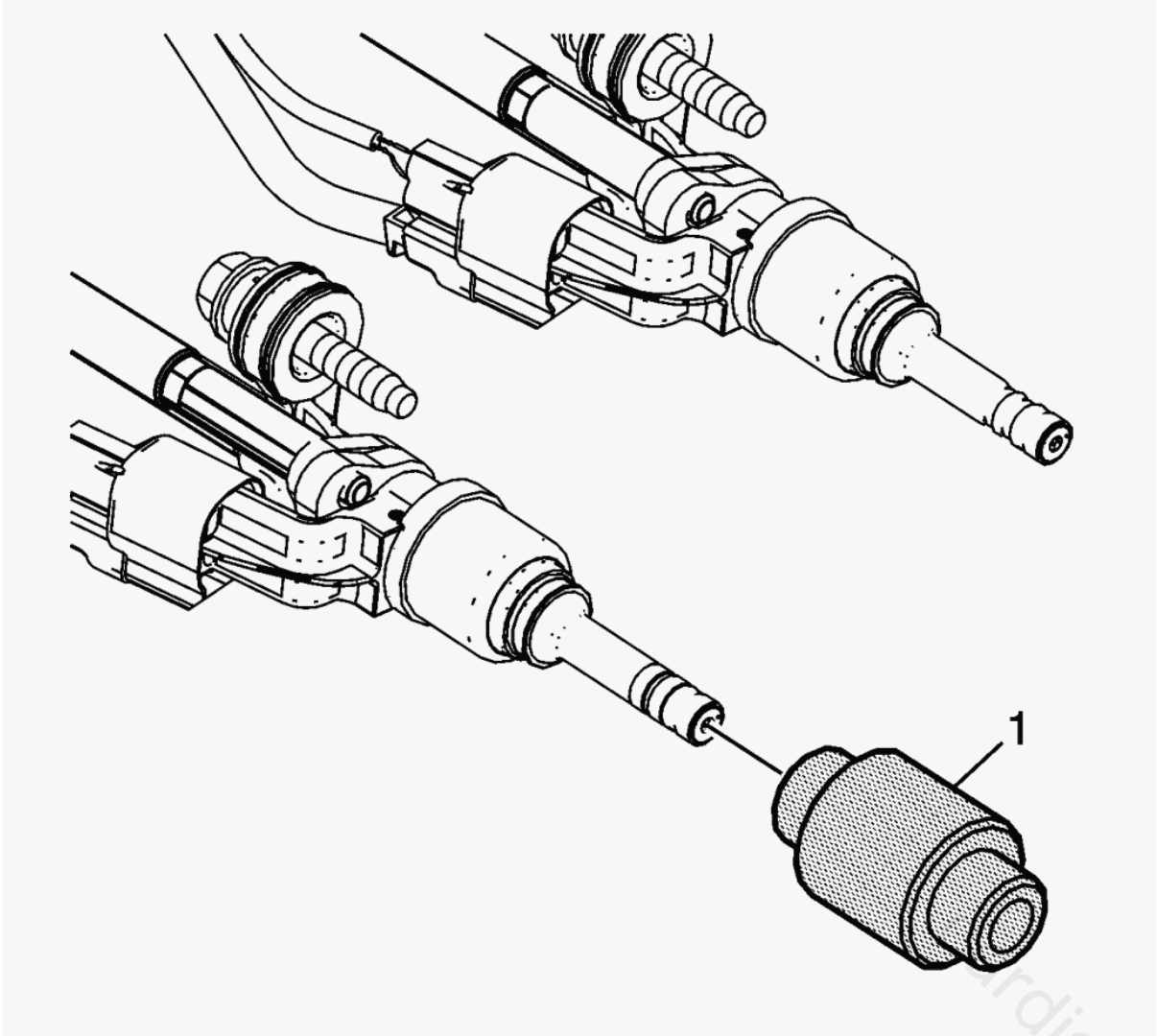


Fig. 495: Sizer

Courtesy of GENERAL MOTORS COMPANY

12. Install the **EN-49245-4** sizer (1) in a rotary motion to the fuel injector tip in order to complete the combustion seal final sizing.

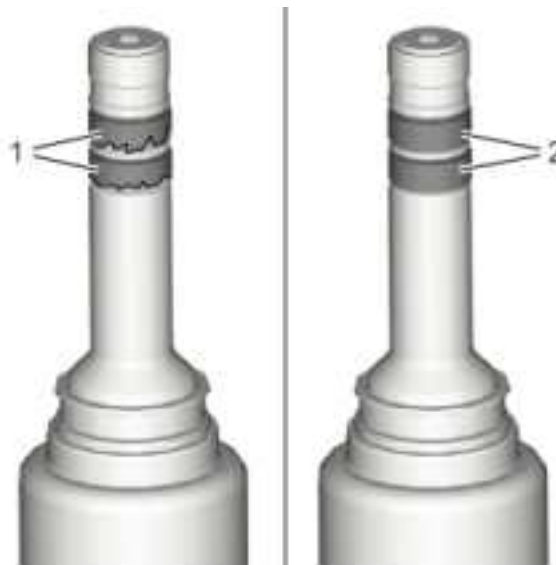


Fig. 496: Installing Seal

Courtesy of GENERAL MOTORS COMPANY

NOTE: The fuel injector seals must fit properly in the relative groove. Overlapping of the fuel injector seals with the external surface of the injector must be avoided.

13. Check both of the fuel injector combustion seals on each fuel injector for correct seat:

- The seal must not be too large, buckled, or corrugated (1)
- The seal must be fixed tight and accurate (2)

14. If the seals are not installed correctly, remove the incorrect seal and replace with a NEW seal.

Fuel Rail Assembly Installation Procedure

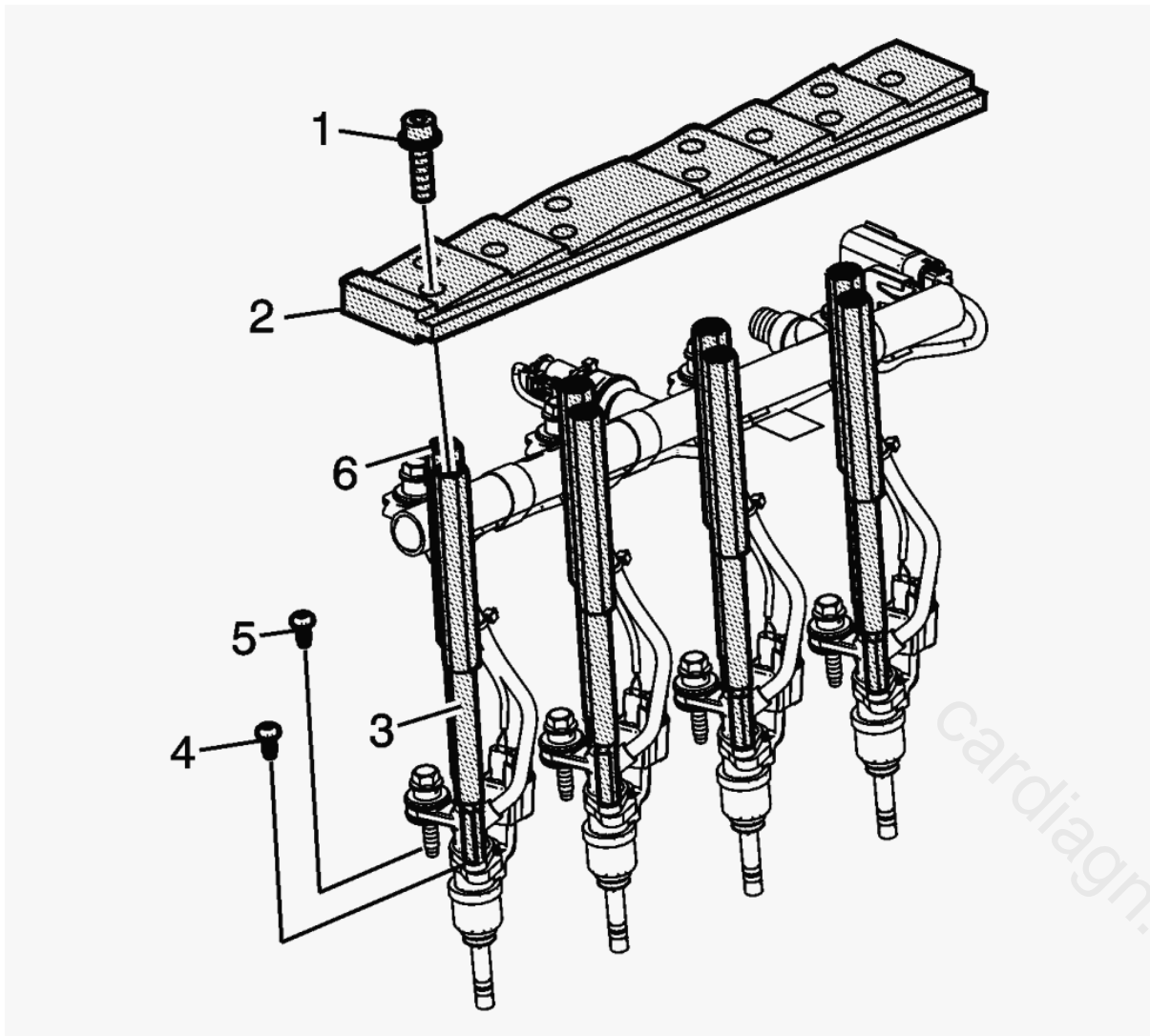


Fig. 497: Plate And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. If any components of EN-51146 remover are installed to the fuel rail, perform the following procedure:

NOTE: If the plate is not installed on the supports, it is likely one or more fuel injectors have been replaced. Disregard the following steps for fuel injectors that have already been replaced.

1. Remove the bolts (1) and EN-51146-100 plate (2).
2. Clean the fuel injector screws of any residual threadlock agent.
3. Remove only the front EN-51146-1-6 demounting screw and EN-51146-1-1 support (3) for the first fuel injector.
4. Apply one drop of threadlock agent onto the screw (4). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

CAUTION: Refer to [Fastener Caution](#) .

5. Install the fuel injector screw (4) and tighten to 5 N.m (44 lb in).
6. Remove the rear EN-51146-1-6 demounting screw and EN-51146-1-1 support (6) for the first fuel injector.

7. Apply one drop of threadlock agent onto the screw (5). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

8. Install the fuel injector screw (5) and tighten to 5 N.m (44 lb in).

9. Repeat the same procedure for the remaining fuel injectors with EN-51146-1-6 demounting screw and EN-51146-1-1 supports still attached.

10. Connect the fuel injector wiring harness plugs, if necessary.

2. Ensure the fuel rail assembly and fuel injector bores have been cleaned prior to installation.

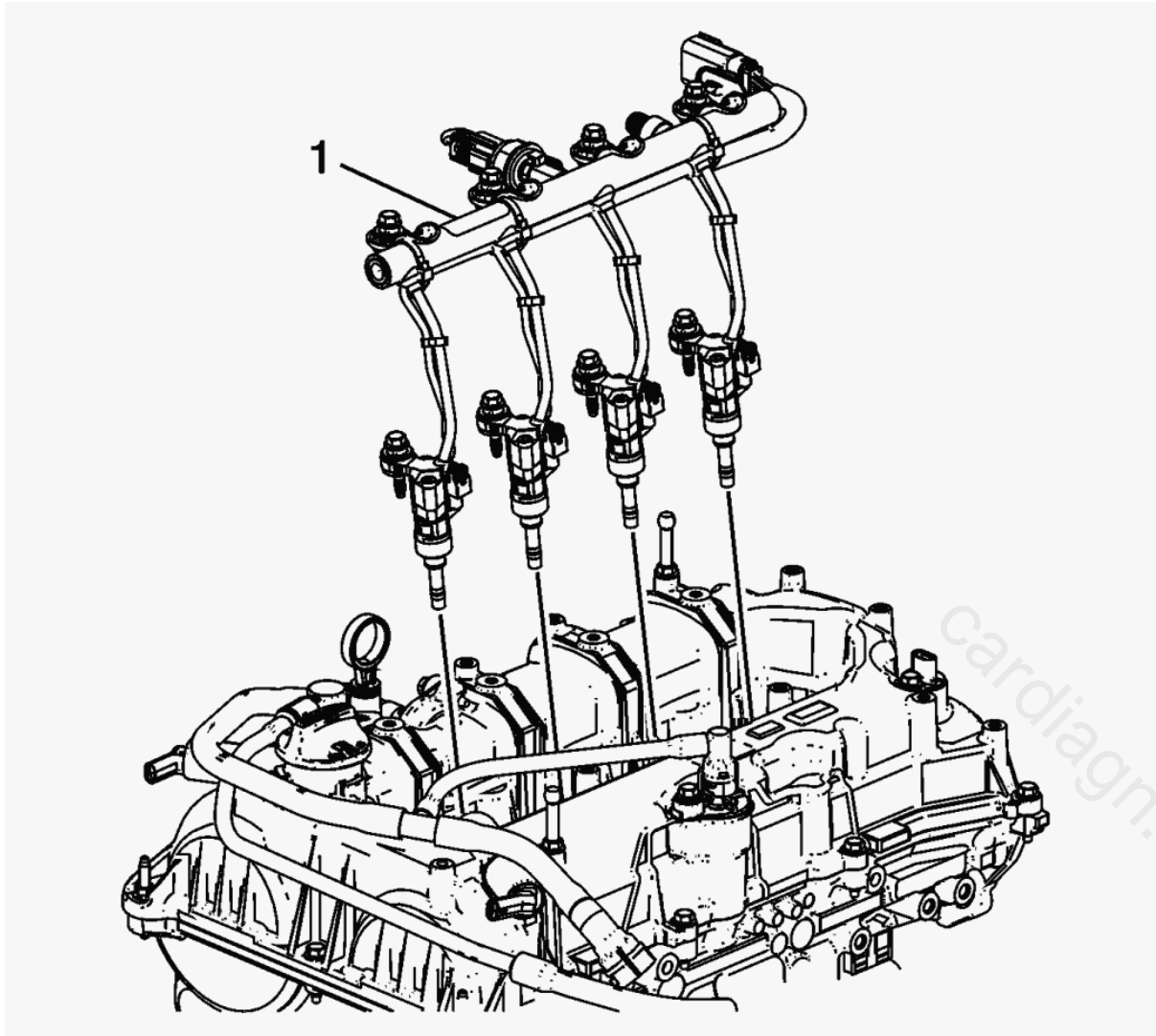


Fig. 498: Fuel Rail Assembly

Courtesy of GENERAL MOTORS COMPANY

NOTE: During the installation of the fuel rail and injector assembly, ensure that the fuel injectors are positioned straight into the injector opening. Failure to follow this caution can tilt or bend the injectors and could cause leaks or malfunction after installation.

3. Carefully install the fuel rail assembly (1).

4. Push the fuel injectors slightly in their seats.

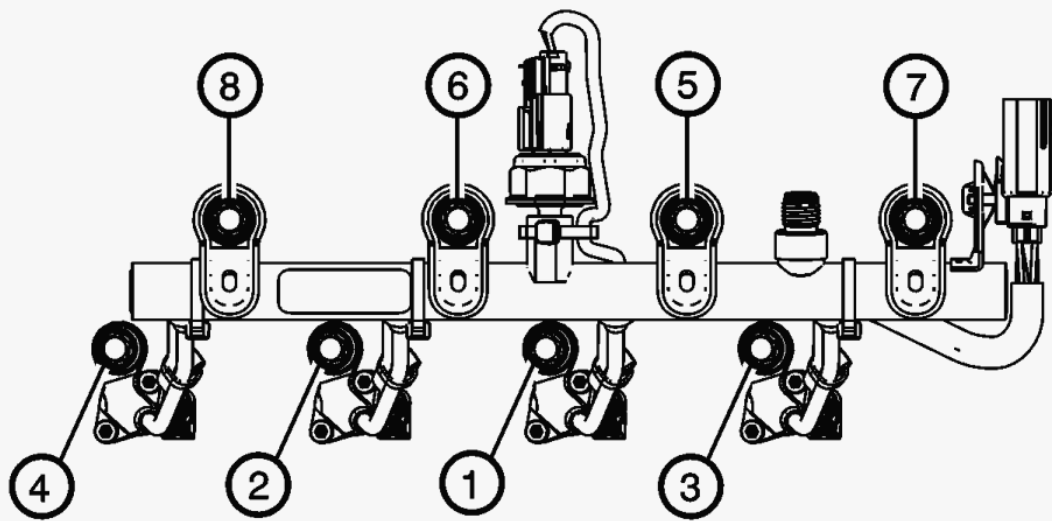


Fig. 499: Fuel Rail Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

5. Tighten the 4 lower fuel rail bolts in increments of 1 turn until they are seated.
6. Tighten the 4 lower fuel rail bolts in sequence to 10 N.m (89 lb in).
7. Tighten the 4 upper fuel rail bolts in sequence to 10 N.m (89 lb in).

IGNITION COIL INSTALLATION

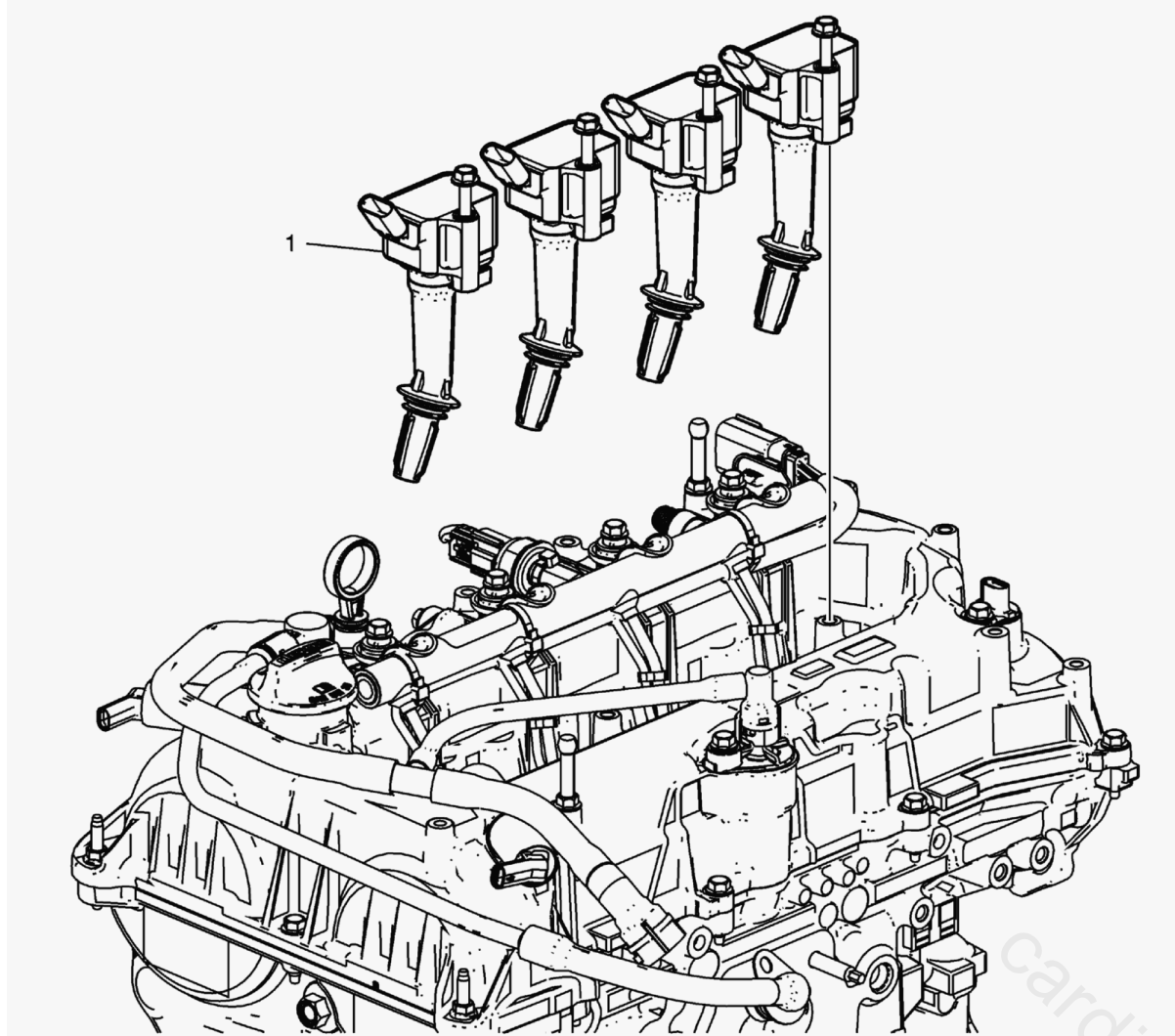


Fig. 500: Ignition Coil

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. 2. If there is no grease present or additional grease is necessary, apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers. 3. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.	
1	Ignition Coil Assembly (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

VACUUM PUMP INSTALLATION

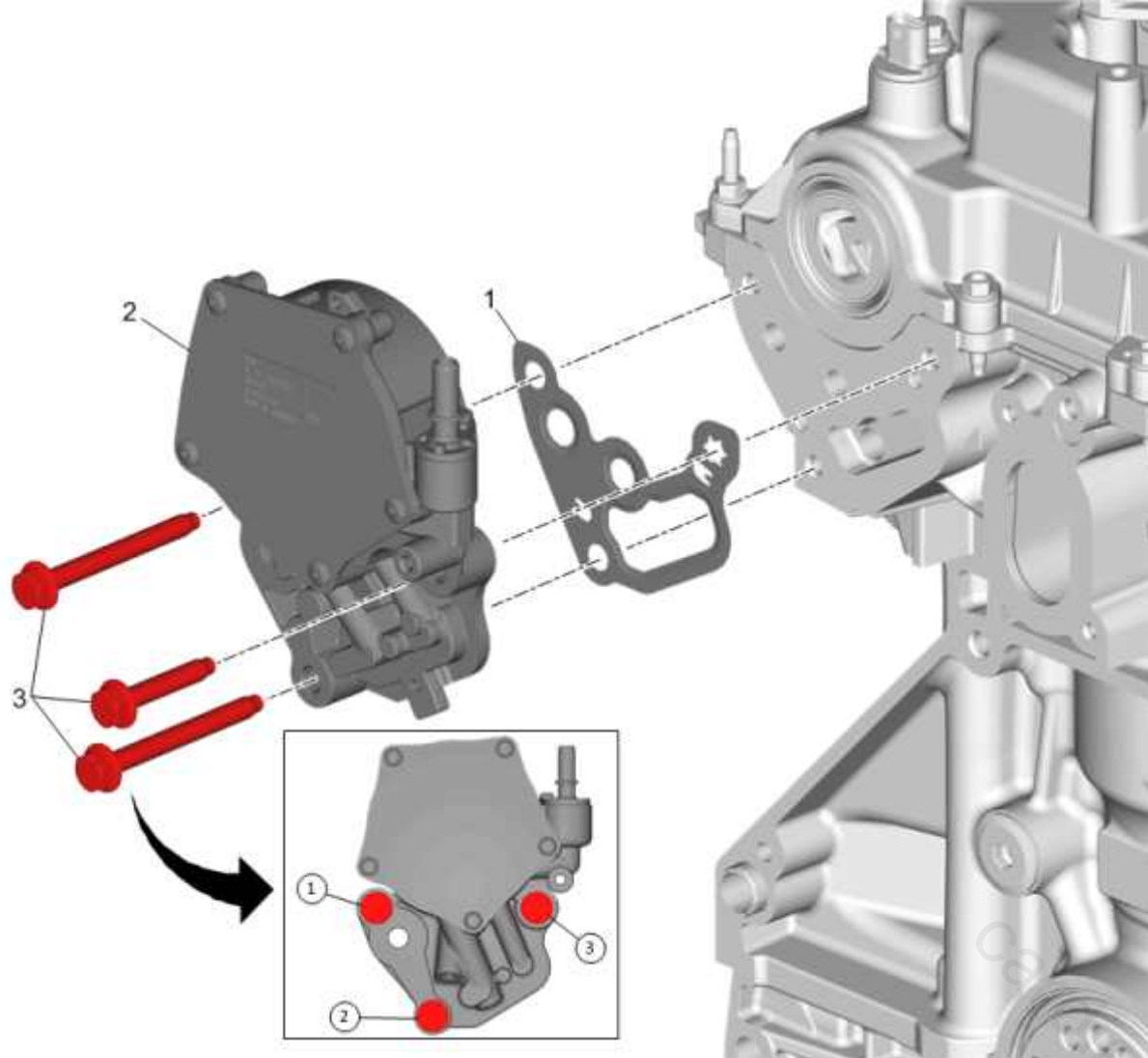


Fig. 501: Vacuum Pump (With Bolt Tightening Sequence)
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Ensure all passages of the vacuum pump are clean and free of debris prior to installation.	
1	Vacuum Pump Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Vacuum Pump Assembly NOTE: • Ensure the 2 locating pins are present and aligned to the cylinder head during installation. • Ensure the vacuum pump drive is aligned with the end of the camshaft. The pump should sit flush to the cylinder head before installing the bolts.

Callout	Component Name
3	Vacuum Pump Assembly Bolt (Qty: 3) CAUTION: Refer to Fastener Caution . Procedure Tighten the vacuum pump bolts in the sequence shown. 1. Tighten the vacuum pump bolts a first pass to 15 N.m (11 lb ft). 2. Tighten the vacuum pump bolts a final pass to 25 N.m (18 lb ft).

WATER OUTLET INSTALLATION

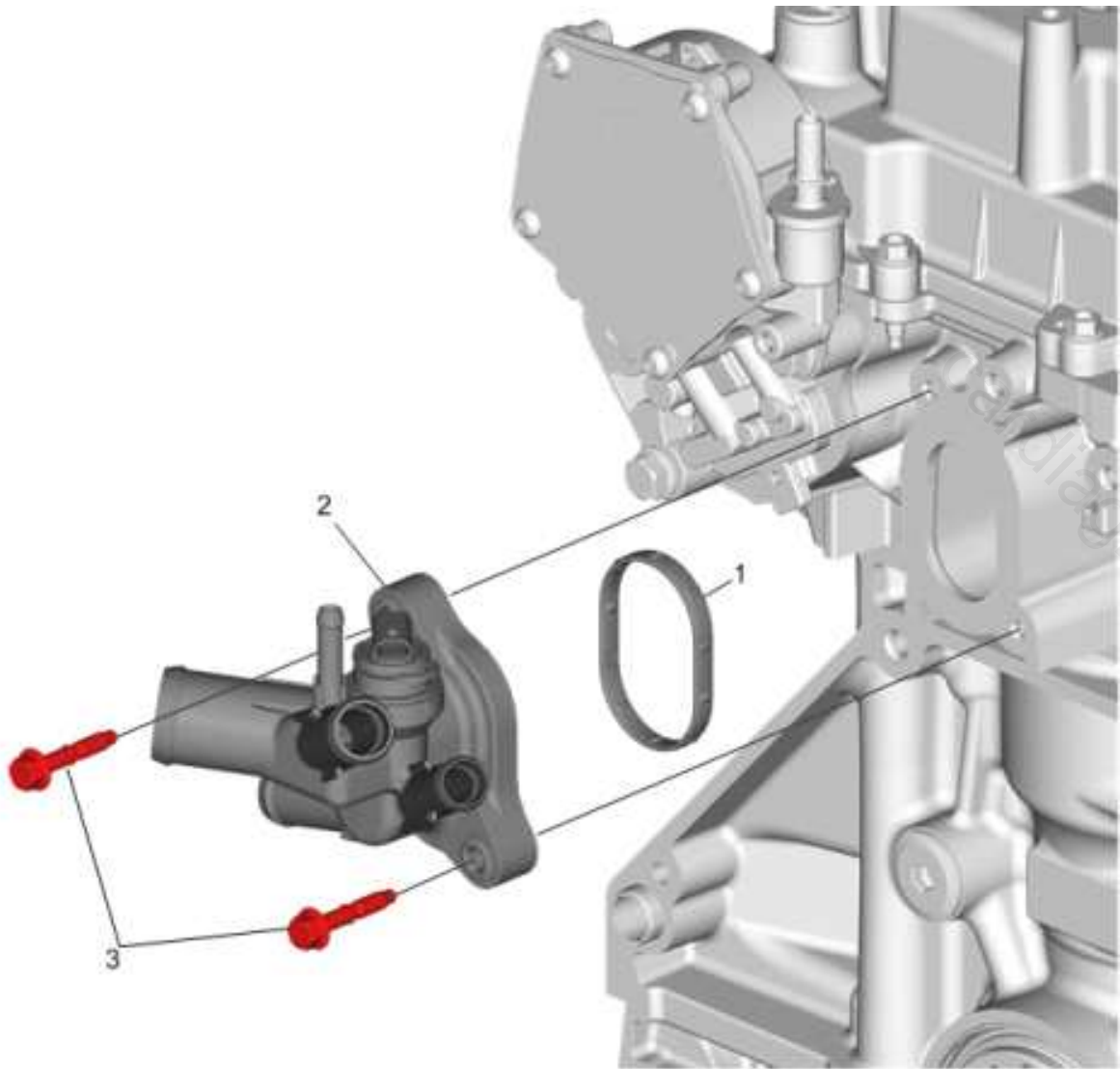


Fig. 502: Water Outlet Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Outlet Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Water Outlet Assembly

Callout	Component Name
3	Water Outlet Assembly Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

ENGINE LIFT AND SIGHT SHIELD BRACKET INSTALLATION

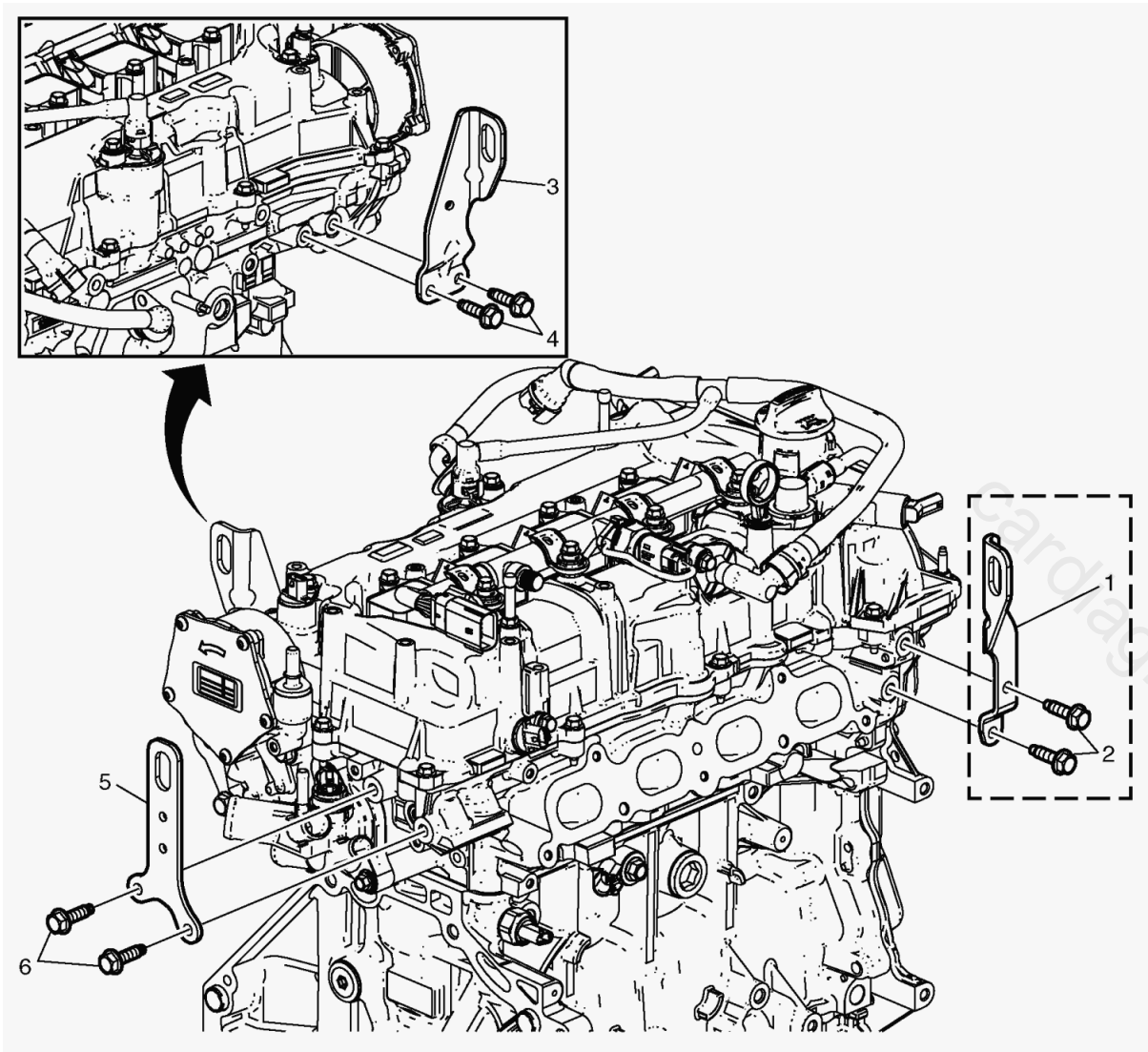


Fig. 503: Engine Lift and Sight Shield Bracket
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Lift Front Bracket - Model Dependent
2	Engine Lift Front Bracket Bolt [2x] - Model Dependent CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
3	Engine Lift Rear Bracket
4	Engine Lift Rear Bracket Bolt [2x] Tighten 25 N.m (18 lb ft)

Callout	Component Name
1	Valve Lifter Follower NOTE: The camshaft must be in the base circle position before the high pressure fuel pump is installed. Procedure 1. Lubricate the valve lifter follower with engine oil, refer to Adhesives, Fluids, Lubricants, and Sealers. NOTE: At the base circle position, the EN-51365 alignment gauge will sit flush with the cylinder head. 2. Install the valve lifter follower. Ensure that the guide pin on the follower is aligned with the groove in the fuel pump bore. Install EN-51365 alignment gauge and rotate the camshaft until the special tool is flush with the cylinder head. This indicates the camshaft lobe is at base circle position. 3. Remove EN-51365 alignment gauge and the valve lifter follower. 4. Lubricate the valve lifter follower again with engine oil. 5. Install the valve lifter follower. Ensure that the guide pin on the follower is aligned with the groove in the fuel pump bore. Special Tools EN-51365 Fuel Pump Installation Gauge For equivalent regional tools, refer to Special Tools.
2	Fuel Pump NOTE: If the fuel pump is not new, replace the fuel pump O-ring seal. Lubricate the O-ring with one drop of clean engine oil.
3	Fuel Pump Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . CAUTION: Refer to Torque-to-Yield Fastener Caution . CAUTION: Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage. Procedure Install NEW fuel injection pump bolts alternating in steps of one turn each until seated to specified torque. Tighten 25 N.m (18 lb ft)

Callout	Component Name
4	Fuel Pump Insulator WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.
5	Fuel Feed Intermediate Pipe NOTE: Use a NEW pipe. Procedure NOTE: Do not remove shipping caps from the fuel rail fitting or fuel pump fitting until installation of pipe. Do not remove the fuel pump inlet shipping cap at any time. 1. Remove any fuel pipe shipping caps, if applicable. 2. Finger start the fuel pipe nuts to pump and fuel rail. 3. Finger start the fuel feed intermediate pipe assembly bolt through the pipe bracket. 4. Snug the fuel pipe nut at the pump by hand, 5 full turns minimum. 5. Snug the fuel pipe nut at the fuel rail by hand, 5 full turns minimum. NOTE: Tightening the bracket bolt prior to final torque for the pipe nuts helps to align the fuel feed pipe. 6. Tighten the fuel feed intermediate pipe assembly bracket bolt to 10 N.m (22 lb ft). 7. Torque the pipe nut to fuel rail to specification. 8. Torque the pipe nut to pump to specification. Tighten 30 N.m (22 lb ft)
6	Fuel Feed Intermediate Pipe Bolt (Qty: 1) Tighten 10 N.m (89 lb in)

INTAKE MANIFOLD INSTALLATION

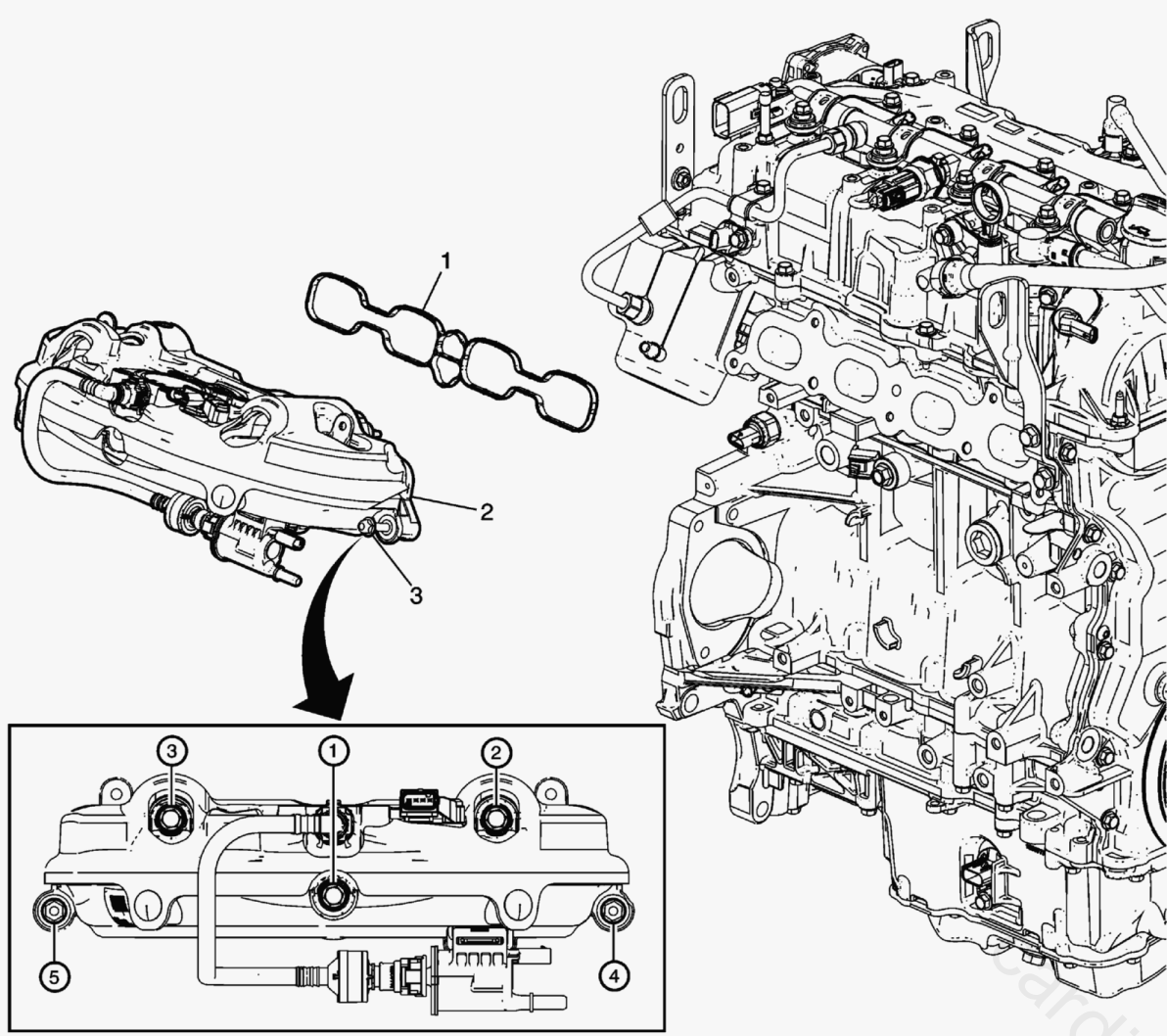


Fig. 505: Intake Manifold With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Intake Manifold Assembly
3	Intake Manifold Assembly Bolt (Qty: 5) CAUTION: Refer to Fastener Caution . NOTE: Bolt retainers keep the bolts in position on the assembly. Procedure Tighten the bolts in sequence. Tighten 12 N.m (106 lb in)

THROTTLE BODY ASSEMBLY INSTALLATION

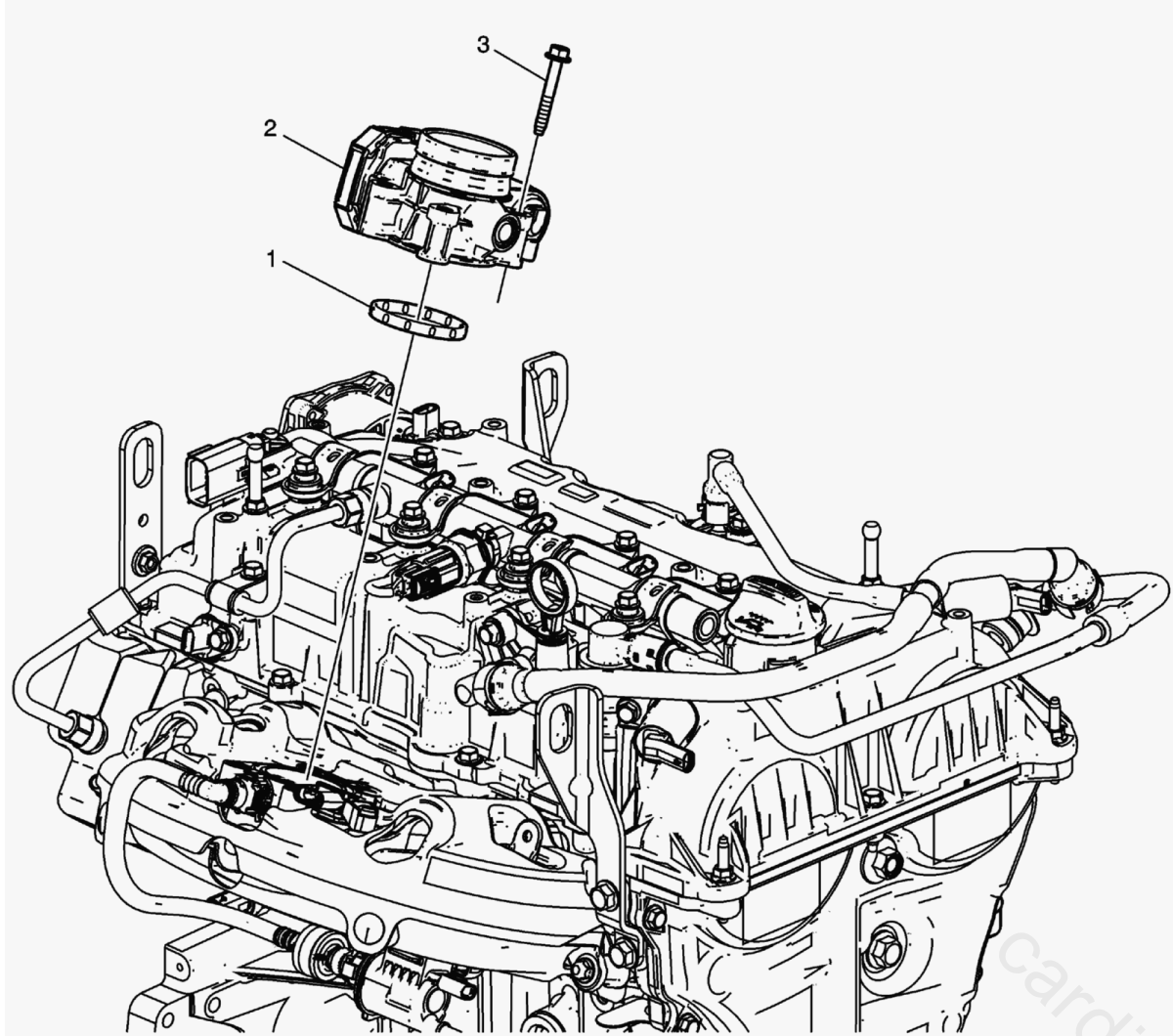


Fig. 506: Throttle Body

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Throttle Body Assembly
3	Throttle Body Assembly Bolt (Qty: 4) NOTE: Tighten the 4 bolts in a criss-cross pattern. CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

WATER PUMP INSTALLATION

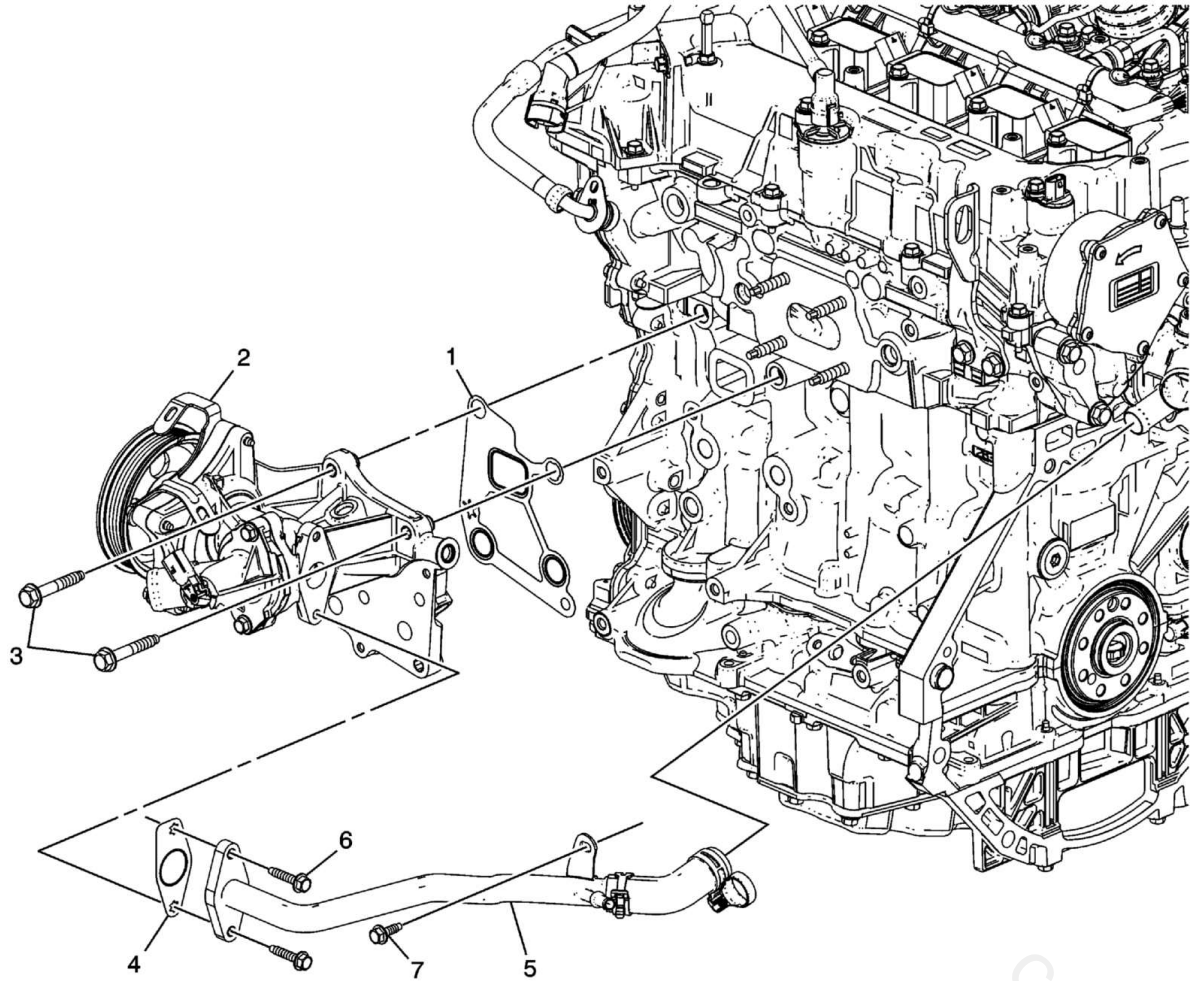


Fig. 507: Water Pump

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Housing Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Water Pump
3	Water Pump Bolt (Qty: 2) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 25 N.m (18 lb ft)
4	Thermostat Bypass Pipe Gasket
5	Thermostat Bypass Pipe Assembly
6	Thermostat Bypass Pipe Bolt (Qty: 2) Tighten 10 N.m (89 lb in)
7	Thermostat Bypass Pipe Bolt (Qty: 1) Tighten 10 N.m (89 lb in)

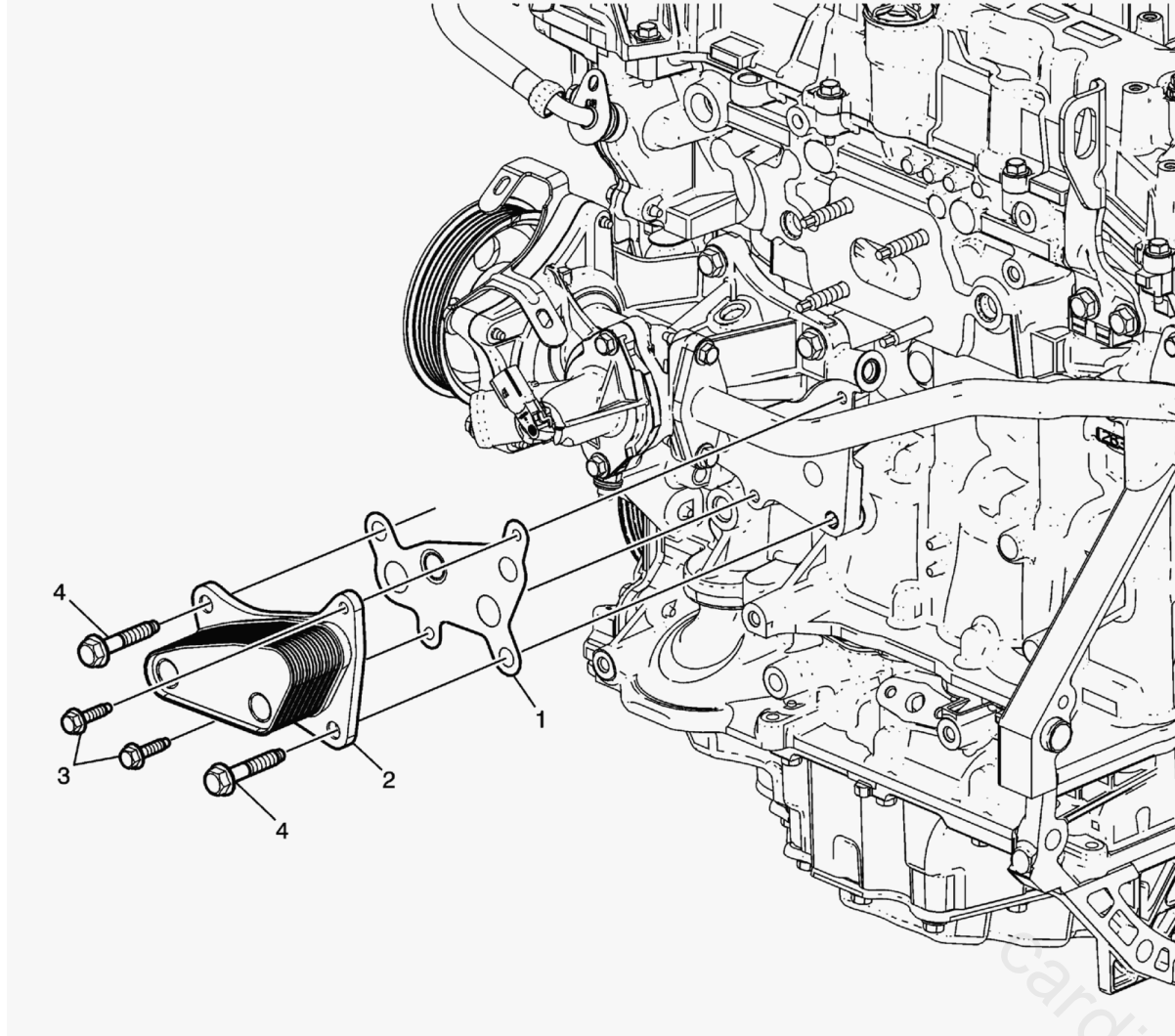


Fig. 508: Engine Oil Cooler

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Gasket NOTE: Use a NEW gasket. Ensure the mating surfaces are clean and free of debris.
2	Engine Oil Cooler Assembly
3	Engine Oil Cooler Assembly Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
4	Engine Oil Cooler Assembly Bolt (Qty: 2) Tighten 25 N.m (18 lb ft)

TURBOCHARGER INSTALLATION

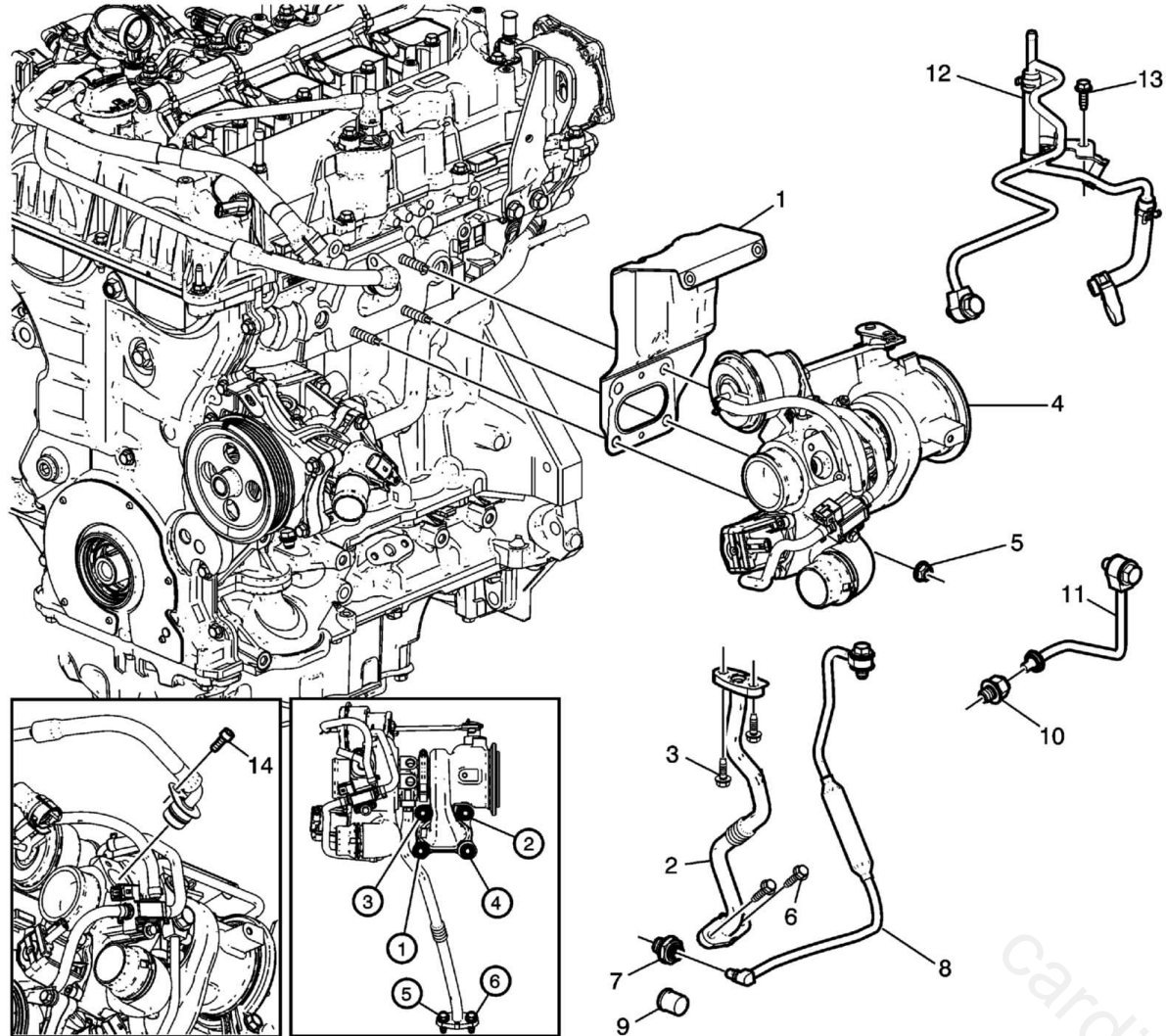


Fig. 509: Turbocharger

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Heat Shield NOTE: Use a NEW heat shield with gasket.
2	Turbocharger Oil Return Pipe NOTE: Use NEW turbocharger oil return pipe gaskets on the oil return pipe.
3	Turbocharger Oil Return Pipe Bolt - Flange to Turbocharger (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
4	Turbocharger

Callout	Component Name
5	Turbocharger Nut (Qty: 4) CAUTION: Refer to Torque-to-Yield Fastener Caution . Procedure Tighten the NEW turbocharger nuts in sequence. 1. Tighten the nuts a first pass to 15 N.m (11 lb ft). 2. Tighten the nuts a second pass to 20 N.m (15 lb ft). 3. Using the EN-45059 angle meter, tighten the bolt a final pass 60 Degrees. Special Tools EN-45059 Angle Meter For equivalent regional tools, refer to Special Tools.
6	Turbocharger Oil Return Pipe Bolt - Flange to Block (Qty: 2) Tighten 10 N.m (89 lb in)
7	Turbocharger Pipe Fitting NOTE: Use a NEW fitting and gasket. Tighten 35 N.m (26 lb ft)

Callout	Component Name
	Turbocharger Oil Feed Pipe CAUTION: When installing a quick-connect turbocharger oil feed pipe, ensure that the oil feed pipe is fully secured into the oil feed pipe fitting. An audible click will be heard when the oil feed pipe is seated. If the oil feed pipe is not fully seated, an oil leak can occur in certain RPM ranges and will cause significant component and/or vehicle damage. Due to the possibility of significant component and/or vehicle damage from an oil feed pipe leak, it is necessary to start the engine and inspect for signs of leakage around the connections after performing the repair. CAUTION: Ensure that the turbocharger oil feed pipe does not rotate while torquing it. There should be a minimum 10 mm gap between the oil feed pipe and the v-band clamp. Failure to perform this could result in damage to the oil feed pipe and create an oil leak.
8	Procedure NOTE: • Use NEW turbocharger oil feed pipe gaskets on the bolt at the turbocharger connection. • A suitable tool can be used to ensure there is a 10 mm gap between the feed pipe and turbine housing while tightening the turbocharger oil feed pipe. 1. Install the pipe with the bolt at the turbocharger. 2. Attached the bottom of the pipe to the turbocharger pipe fitting at the engine block. 3. Ensure that the oil feed pipe is fully secured into the turbocharger pipe fitting. An audible click will be heard when the oil feed pipe is seated. Tighten 32 N.m (24 lb ft)
9	Turbocharger Oil Feed Pipe Clip
10	Turbocharger Pipe Fitting NOTE: Use a NEW fitting and gasket. Tighten 35 N.m (26 lb ft)

Callout	Component Name
11	Turbocharger Coolant Feed Pipe Procedure: 1. Attach the coolant feed pipe at the pipe fitting. 2. Ensure that the coolant feed pipe is fully secured into the turbocharger pipe fitting. An audible click will be heard when the coolant feed pipe is seated. NOTE: Use NEW turbocharger coolant feed pipe gaskets on the bolt at the turbocharger connection. 3. Rotate the coolant feed pipe upwards to attach the bolt at the turbocharger. Tighten 35 N.m (26 lb ft)
12	Turbocharger Coolant Return Pipe Procedure NOTE: Use NEW turbocharger coolant return pipe gaskets on the bolt at the turbocharger connection. 1. Set the coolant return pipe in place and hand tighten the bolt at the turbocharger. 2. Attach the hose to the thermal bypass pipe. 3. Attach the hose at the water outlet assembly. Tighten 35 N.m (26 lb ft)
13	Turbocharger Coolant Return Pipe Bracket Bolt Tighten 10 N.m (89 lb in)
14	Positive Crankcase Ventilation Hose Fitting Bolt NOTE: The PCV hose and fitting assembly connection is permanent. Reinstall these components as an assembly unless new components are being used. Tighten 10 N.m (89 lb in)

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

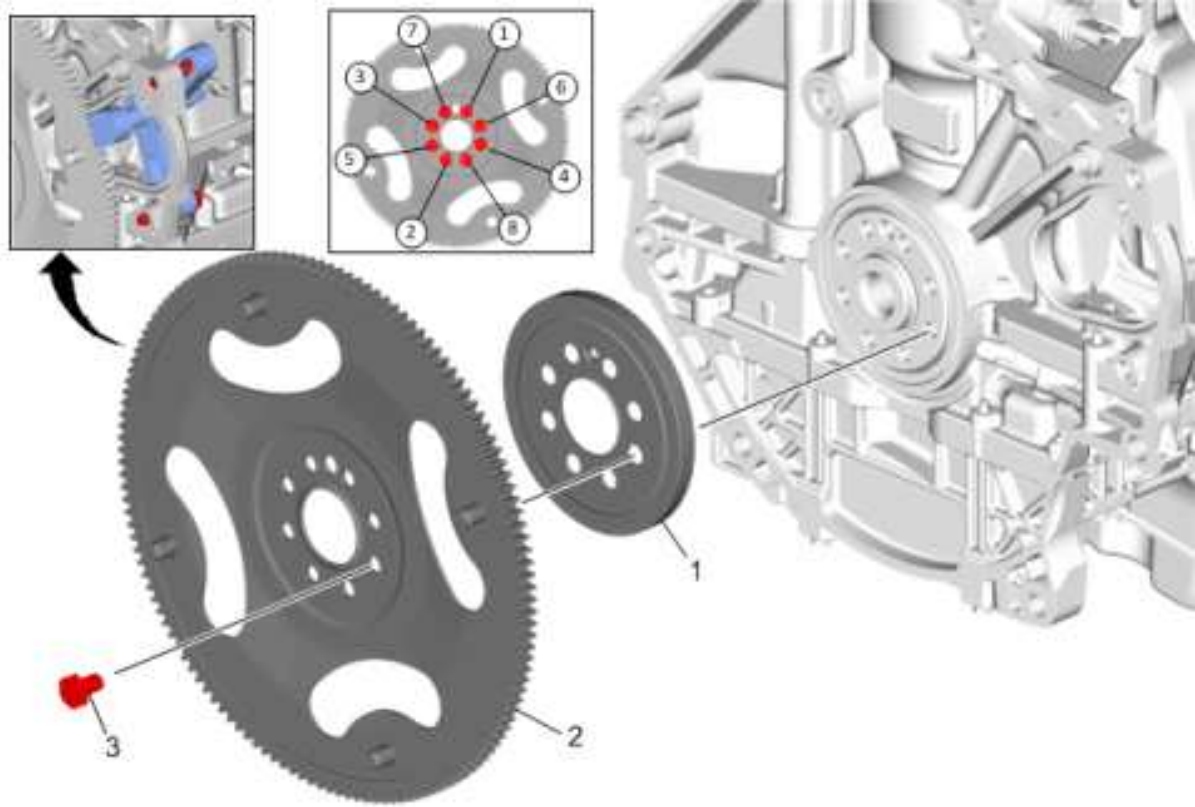


Fig. 510: Automatic Transmission Flex Plate With Bolt Tightening Sequence (North America)
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Position Sensor Reluctor Ring CAUTION: Refer to Crankshaft Position Sensor Reluctor Ring Caution .
2	Automatic Transmission Flex Plate Procedure 1. Install the flex plate, and install the flex plate bolts hand tight to hold in place. 2. Install EN-51760 holder to lock the flywheel via the starter ring gear. Special Tools EN-51760 Flywheel Holder For equivalent regional tools, refer to Special Tools .

Callout	Component Name
3	Automatic Transmission Flex Plate Bolt (Qty: 8) CAUTION: Refer to Fastener Caution . CAUTION: Refer to Torque-to-Yield Fastener Caution . NOTE: Bolts have adhesive patch and must be tightened to final torque within 5 minutes. Procedure Tighten the NEW flex plate bolts in the sequence shown. 1. Tighten the bolts a first pass to 20 N.m (15 lb ft). 2. Tighten the bolts a second pass to 30 N.m (22 lb ft). 3. Using the EN-45059 angle meter, tighten the bolt a final pass 70 degrees. 4. Remove EN-51760 holder once final torque is achieved. Special Tools EN-45059 Angle Meter For equivalent regional tools, refer to Special Tools.

CRANKSHAFT BALANCER INSTALLATION

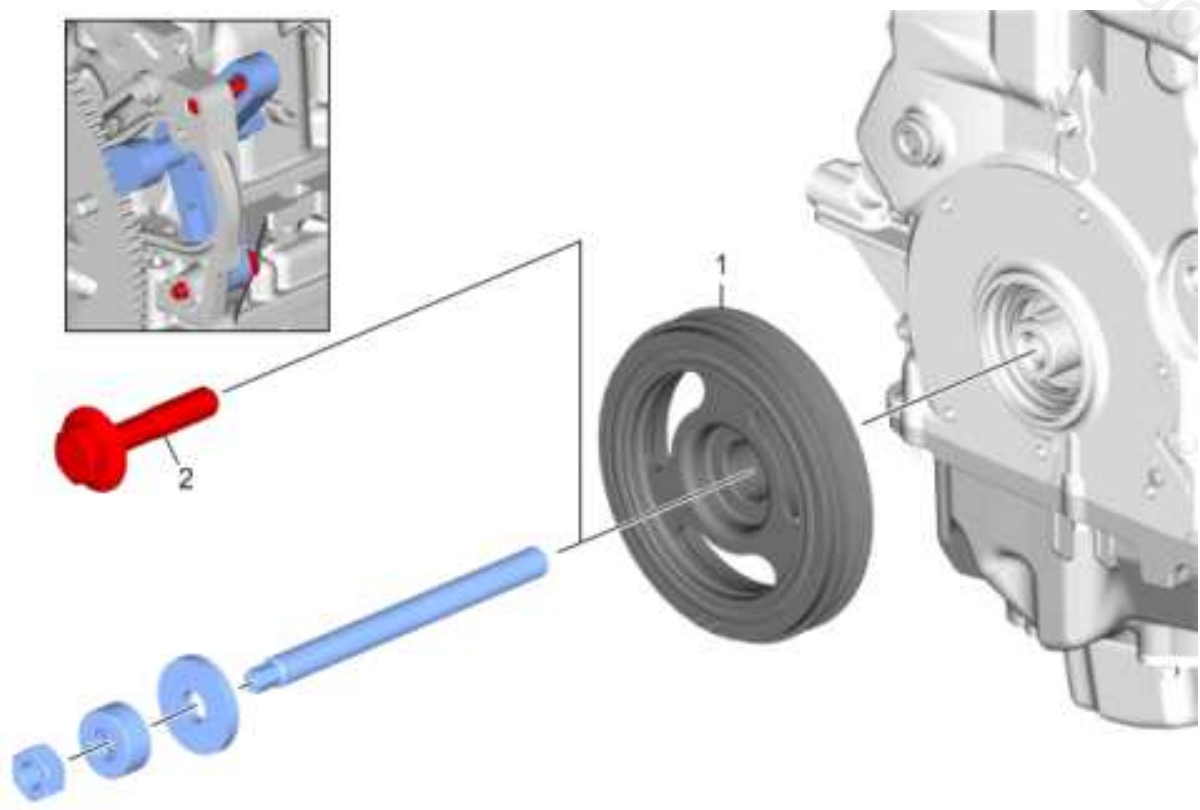


Fig. 511: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Fig. 512: Oil Filter, Fitting Adapter And Drain Plug
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Drain Plug CAUTION: Refer to Component Fastener Tightening Caution . NOTE: Use a NEW gasket. Tighten 25 N.m (18 lb ft)
2	Oil Filter Fitting Tighten 55 N.m (41 lb ft)
3	Oil Filter Tighten 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange. Special Tools EN-726-A Oil Filter Wrench For equivalent regional tools, refer to Special Tools .

ENGINE PRELUBING

Special Tools

EN-45299 Engine Preluber

For equivalent regional tools, refer to [Special Tools](#).

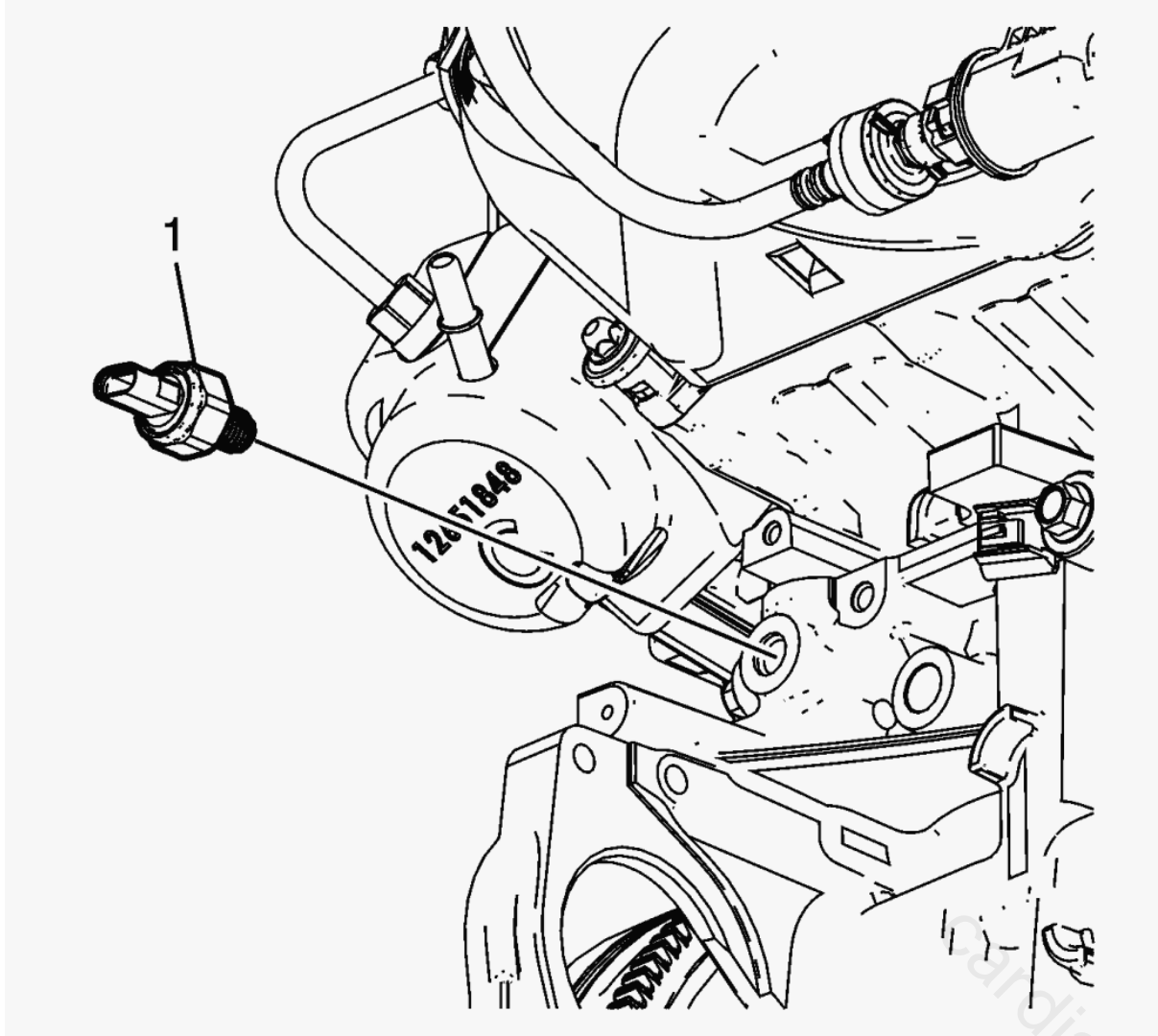


Fig. 513: Oil Pressure Switch

Courtesy of GENERAL MOTORS COMPANY

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

1. Remove the oil pressure switch.
2. Install the M12 x 1.75 adapter (1) P/N 509376.

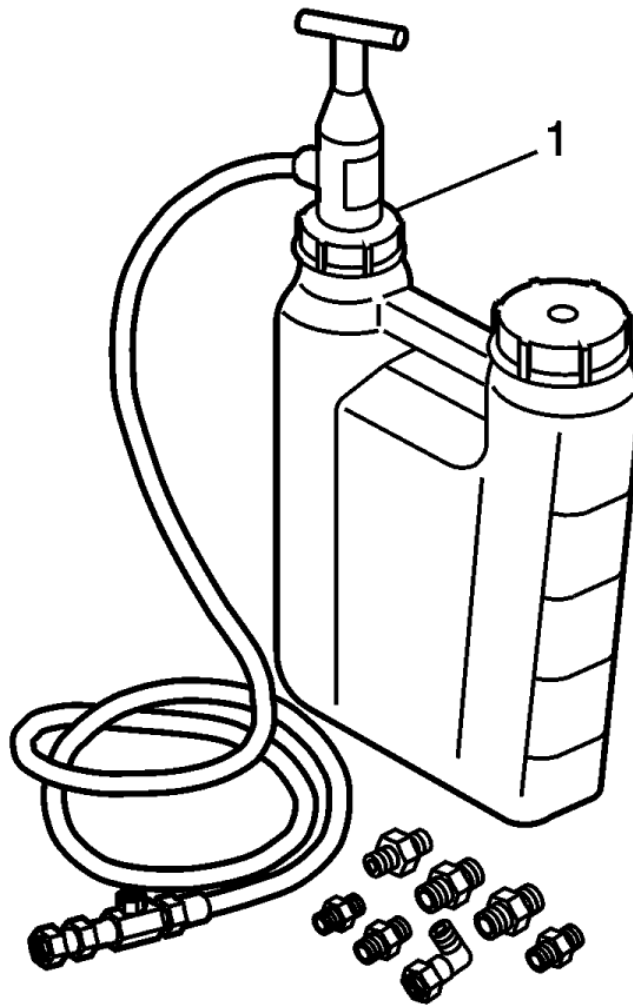


Fig. 514: View of Flexible Hose, Adapter and Preluber
Courtesy of GENERAL MOTORS COMPANY

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **EN-45299** preluber (1) in order to flow a minimum of 1 - 1.9 liters (1 - 2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
5. Close the valve and remove the flexible hose and adapter from the engine.

CAUTION: Refer to **Fastener Caution** .

6. Install the oil pressure switch to the engine and tighten to 26 N.m (19 lb ft).
7. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

Positive Crankcase Ventilation System

The crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting vapors to the atmosphere. Fresh air from the intake system is supplied to the crankcase and mixed with blow-by gases inside the crankcase. Blow-by gases rise to the top of the engine and are picked up into the oil separation chamber in the camshaft cover, where oil is separated from the gases. Blow-by gases are then passed to the intake manifold to be consumed by normal combustion, through a calibrated orifice inside of the camshaft cover.

Operation

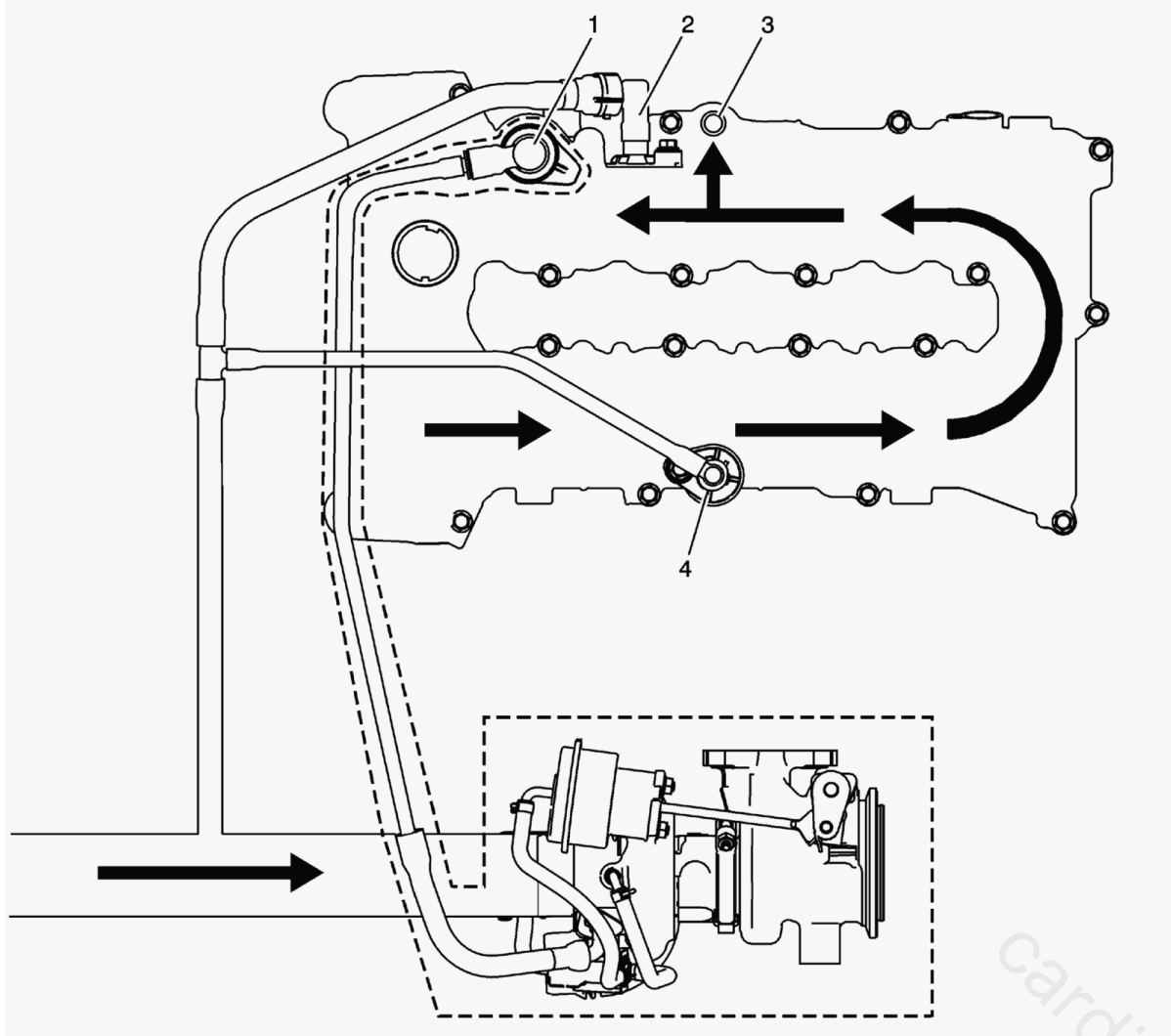


Fig. 515: Crankcase Ventilation System Diagram
 Courtesy of GENERAL MOTORS COMPANY

Fresh air is brought into the engine through the positive crankcase ventilation (PCV) valve (4) as long as the crankcase is under vacuum. The primary control is through the PCV orifice (3) which meters the flow into intake manifold, at a rate depending on manifold vacuum. The PCV orifice is an integral part of the camshaft cover. Under certain operating conditions, the system is designed to allow excessive amounts of blow by gases to flow through the PCV valves (1 or 2) depending on if the engine is in boost mode or excessive crankcase pressure is detected and then routed into the intake system to be consumed by normal combustion.

Turbo Applications:

During normal operating conditions the PCV gases are routed using PCV valve (3) and the internal passage within the camshaft cover. When the Turbo is active, check valve (3) is closed and check valve (1) opens and PCV gases are routed back to the turbocharger to be consumed by normal combustion. If the engine sees excessive positive crankcase pressure check valve (2) opens and the pressure is routed to the air inlet to be reintroduced into the engine.

Non-Turbo Applications:

During normal operating conditions the PCV gases are routed using check valve (3) and the internal passage within the camshaft cover. If the engine sees excessive positive crankcase pressure check valve (2) opens and the pressure is routed to the air inlet. Also for non-turbo applications check valve (1) does not exist.

In any application check valve (2) is only used if the engine sees excessive crankcase pressure.

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

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is constructed of aluminum alloy by high-pressure die casting with 4 cast-in-place iron cylinder liners arranged in-line. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the rear of the engine. The cylinder block incorporates a bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

Crankshaft

The crankshaft is forged micro alloy steel. It is supported in 5 main journals with main bearings which have oil clearance for lubricating. The thrust bearing is located in the 4th position which controls proper crankshaft axial end play. The crankshaft is also comprised of 8 counterweights that have been scalloped for mass reduction and topped for precise engine balance. A harmonic balancer is used to control torsional vibration.

Piston and Connecting Rod

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a recessed top and barrel shaped skirt. The piston pins are chromium steel and are a full-floating design. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance. All applications use a piston with a graphite coated skirt. The piston and pin are to be serviced as an assembly.

Upper Oil Pan

The oil pan is a structural aluminum oil pan with transmission attachment. It includes the oil suction pipe, this pipe is connected with the oil pump. The oil pan is attached at the lower crankcase.

Oil Pump

The oil pump is a crankshaft driven oil pump integrated in pump module. The oil pump draws engine oil from the oil pan and feeds it under pressure to the various parts of the engine. An oil strainer is mounted before the inlet of the oil pump to remove impurities which could clog or damage the oil pump or other engine components. When the crankshaft rotates, the oil pump driven gear rotates. This causes the space between the gears to constantly open and narrow, pulling oil in from the oil pan when the space opens and pumping the oil out to the engine as it narrows. At high engine speeds, the oil pump supplies a much higher amount of oil than required for lubrication of the engine. The oil pressure regulator prevents too much oil from entering the engine lubrication passages.

Cylinder Head

This cylinder head is double over head camshaft (DOHC) type and has 2 camshafts that open 4 valves per cylinder with hydraulic valve lash adjuster. The camshaft sprocket wheels are installed in front of the camshafts. The cylinder head is made of cast aluminum alloy for better strength in hardness with light weight. The combustion chamber of the cylinder head is designed for increasing of squish and swirl efficiency and then this is maximized to gasoline combustion efficiency. The exhaust manifold is integrated into the cylinder head.

Valves

There are 2 intake and 2 exhaust valves per cylinder. Positive valve stem seals are used on all valves.

Valve Lash Adjusters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft/Camshaft Drive

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are assembled with steel lobes.

This engine design uses a chain to drive the dual overhead camshafts. The chain is an inverted tooth or silent design with a 6.35 mm pitch to ensure quiet operation and is hydraulically tensioned to be maintenance-free. The tensioner has a ratchet mechanism to reduce chain movement during engine starts to eliminate noise. The lightweight plastic/composite chain guides have a unique grooved face design to reduce friction for optimum efficiency. Both the crank sprocket and cam sprockets are hardened to prevent wear even with extended oil change intervals.

Intake Manifold

The intake manifold is the air flow passage to the cylinder combustion chamber through the throttle body and has an effect on engine torque, power, noise, drivability, emission, fuel economy and performance. It is made of composite plastic. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases.

Turbocharger, If Equipped

The turbocharger consists of turbine and compressor on a common shaft. The shaft bearing is constructed to higher rotation speed and lubricated by engine oil. The turbocharger is water cooled for improved durability. The turbine wheel is driven by exhaust emissions. The compressor wheel compresses the intake air. A wastegate bypass valve regulates the charging pressure for generating a high pressure at low speed as well. At a defined charging pressure it regulates the way of the exhaust emission on bypassing the turbine wheel. The wastegate valve is controlled pneumatic and electric from the pressure in the intake manifold. The pressure of exhaust emission is reduced by opening the wastegate thereby reducing the intake pressure.

Fuel Injection System

The engine is equipped with a central direct injection system. The fuel system consists of 4 separate direct injection fuel injectors, one high pressure fuel rail, and a high pressure fuel feed pipe that connects the high pressure fuel pump to the fuel rail. The injectors are each seated into their individual bores in the cylinder head with two combustion seals to provide sealing. The high pressure fuel pump mounts to the rear of the cylinder head and is driven by the intake camshaft. Motion is transmitted to the pump from a tri-lobe on the rear of the camshaft through a hydraulic roller lifter. Due to the location of the central direct injection system injector location this provides an increase in fuel economy and performance.

TURBOCHARGER SYSTEM DESCRIPTION

Turbocharger Description and Operation

A turbocharger is a compressor that is used to increase the power output of an engine by increasing the mass of the oxygen and therefore the fuel entering the engine. The single-scroll turbocharger is mounted either to the exhaust manifold or directly to the head. The turbine is driven by the energy generated by the flow of the exhaust gases. The turbine is connected by a shaft to the compressor which is mounted in

the induction system of the engine. The centrifugal compressor blades compress the intake air above atmospheric pressure, thereby increasing the density of the air entering the engine.

The turbocharger incorporates a wastegate that is controlled by the ECM, by means of a pulse width modulated (PWM) solenoid, to control boost pressure. A turbocharger bypass valve (compressor recirculation valve), controlled by the ECM, and is used to prevent compressor surging and damage by opening during abrupt closed throttle conditions. The bypass valve opens during closed throttle deceleration conditions, which allows the air to recirculate to the turbocharger compressor inlet. During a wide open throttle command, the bypass valve closes to optimize turbo response.

The turbocharger is connected to the engine oiling system by a supply and drain pipe. The oil is required for the bearing system function and also serves to carry some heat from the turbocharger. There is a cooling system circuit in the turbocharger that further reduces operating temperatures and passively dissipates bearing housing heat away from the turbocharger on shut down.

Wastegate Solenoid Valve

The wastegate valve opens and closes a bypass passage beside the turbine wheel. A spiral spring works in the closing direction while the pressure in the diaphragm works in the opening direction. The ECM supplies a PWM signal to the solenoid valve, which then allows pressure from the turbo to come through. When the pressure overcomes the spring force the actuator rod begins to move, opening the wastegate valve to a corresponding degree. The ECM changes wastegate valve opening by varying the PWM signal, which regulates the turbine speed.

At low loads, the wastegate valve is closed. All the exhaust gas then passes through the turbine. At high loads, the volume of exhaust gas is greater, which makes the turbine wheel rotate faster. This delivers a greater air displacement mass flow to the engine.

When the air displacement mass flow becomes so large that the current air mass per combustion cannot be controlled with the throttle alone, the turbo must be regulated. This is done by opening the wastegate valve so that some of the exhaust gas passes through the wastegate. Consequently, this gas does not contribute to driving the turbine and the turbine speed will be regulated so that the turbo air displacement mass flow will be correct.

When certain DTCs are set the ECM will limit the amount of available boost pressure. Limiting boost pressure is accomplished by the ECM controlling the wastegate actuator solenoid valve and maintaining the duty cycle at 0%. This means that the ECM will not actively open the wastegate during greater engine loads. The system at this point is limited to mechanical boost. Mechanical boost means that the wastegate will still move, but the amount of motion is limited by the mechanical properties of the return spring within the diaphragm valve, the pneumatic properties of the actuator, and the physics of the exhaust gas flow in the exhaust system.

The following diagrams illustrate the turbocharger wastegate closed and open conditions:

Turbocharger Wastegate Closed

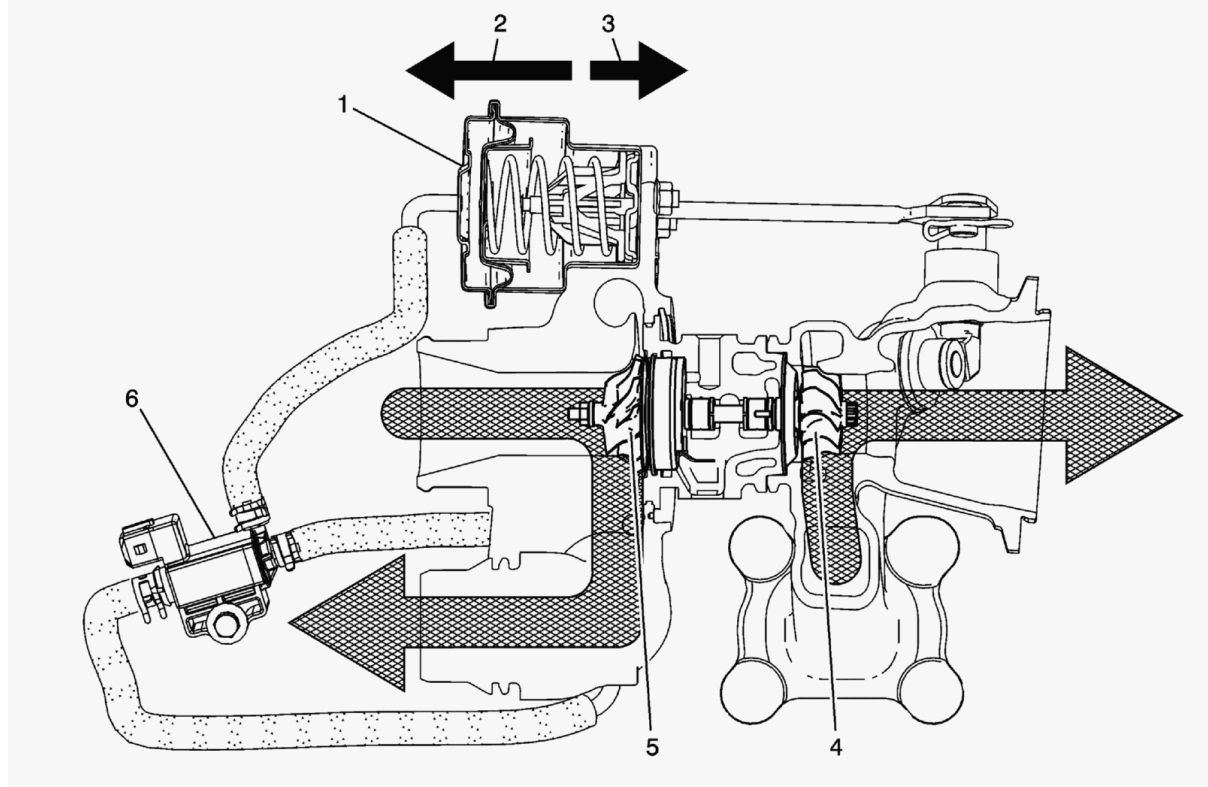


Fig. 516: Turbocharger Wastegate Actuator Solenoid Valve Closed
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Wastegate Diaphragm Valve
2	Spring Force
3	Exhaust Gas Pressure
4	Turbine
5	Compressor
6	Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 100 percent

Turbocharger Wastegate Open

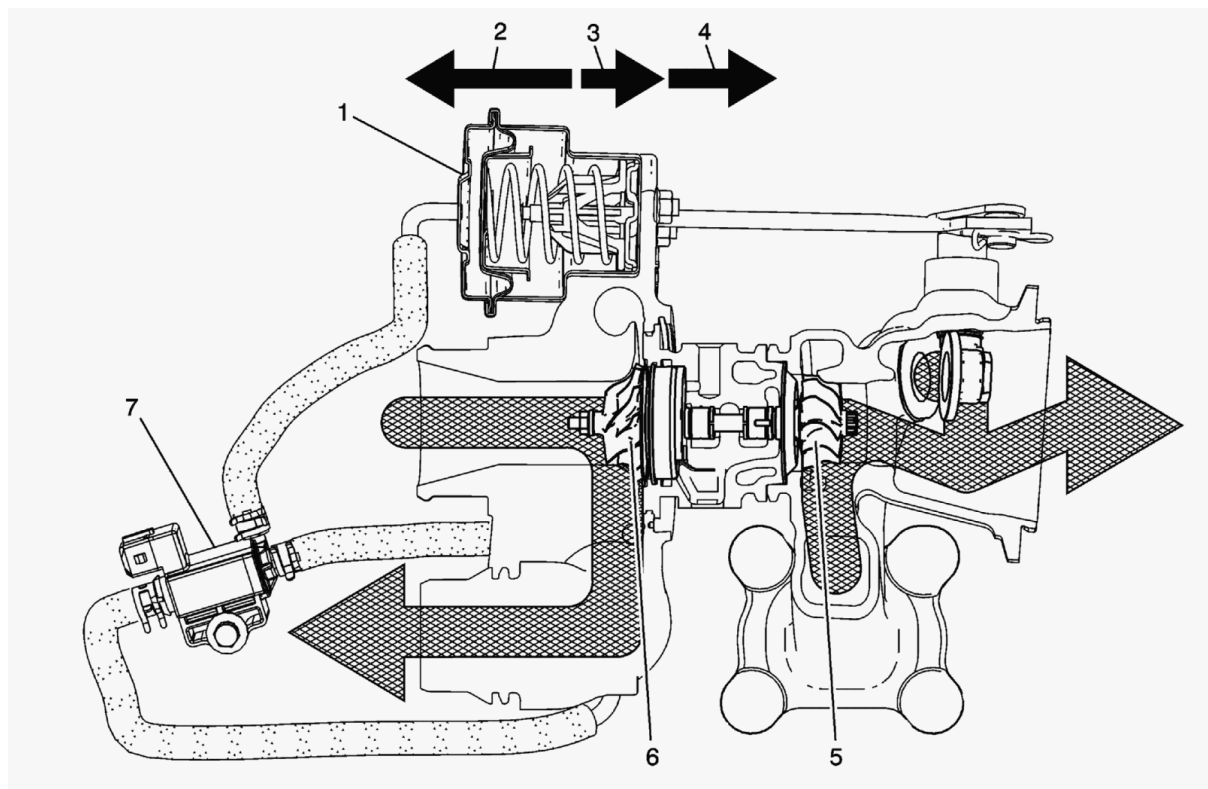


Fig. 517: Turbocharger Wastegate Actuator Solenoid Valve Open
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Wastegate Diaphragm Valve
2	Spring Force
3	Exhaust Gas Pressure
4	Regulating Pressure
5	Turbine
6	Compressor
7	Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 0 percent

The wastegate is completely closed at idle. All of the exhaust energy is passing through the turbine.

During normal operation, when wide open throttle is requested at lower engine speeds, the ECM commands the wastegate solenoid with a duty cycle of 100% to minimize any turbo lag. During engine loads in the middle and upper RPM ranges, the ECM commands the solenoid with a duty cycle of 65 - 80%.

Bypass Solenoid Valve (Compressor Recirculation Valve)

The turbocharger bypass valve prevents the turbo from exceeding the surge limit of the compressor at low flow and high pressure. This occurs when the engine is running with a load and the throttle suddenly closes. In this case, flow is almost null and pressure is very high. This not only is damaging to the turbocharger, but also generates noise and decelerates turbine speed. The ECM supplies a voltage signal to the solenoid valve output driver, which regulates the open or closed valve position.

Accelerator Pedal Depressed

The bypass valve is closed. The force in the return spring integrated in the valve presses the valve cone against its seat in the turbo housing. The valve is turned OFF.

Accelerator Pedal Released

In order to avoid pressure spikes in the intake manifold and unloading or overrunning the turbo, the ECM sends a voltage signal to the bypass valve, which will then open. The compressed air on the pressure side of the turbo is led to the intake via the open valve. When the pressure drops, the turbine speed can be kept relatively high and the turbocharger is prevented from exceeding the surge limit of the compressor.

Charge Air Cooler

The turbocharger intake system is supported by an air-to-air charge air cooler system, which uses fresh air drawn through a heat exchanger to reduce the temperature of the hot compressed air exiting the turbo compressor, prior to delivery to the engine combustion system. Inlet air temperature can be reduced by up to 100°C (180°F), which enhances performance. This is due to the higher density of oxygen in the cooled air, which promotes optimal combustion. The charge air cooler is connected to the turbocharger and to the throttle body by flexible ductwork that requires the use of special high torque fastening clamps. In order to prevent any type of air leak when servicing the ductwork, the tightening specifications, cleanliness and proper positioning of the clamps is critical, and must be strictly adhered to.

SEPARATING PARTS

NOTE:

- 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

LUBRICATION DESCRIPTION

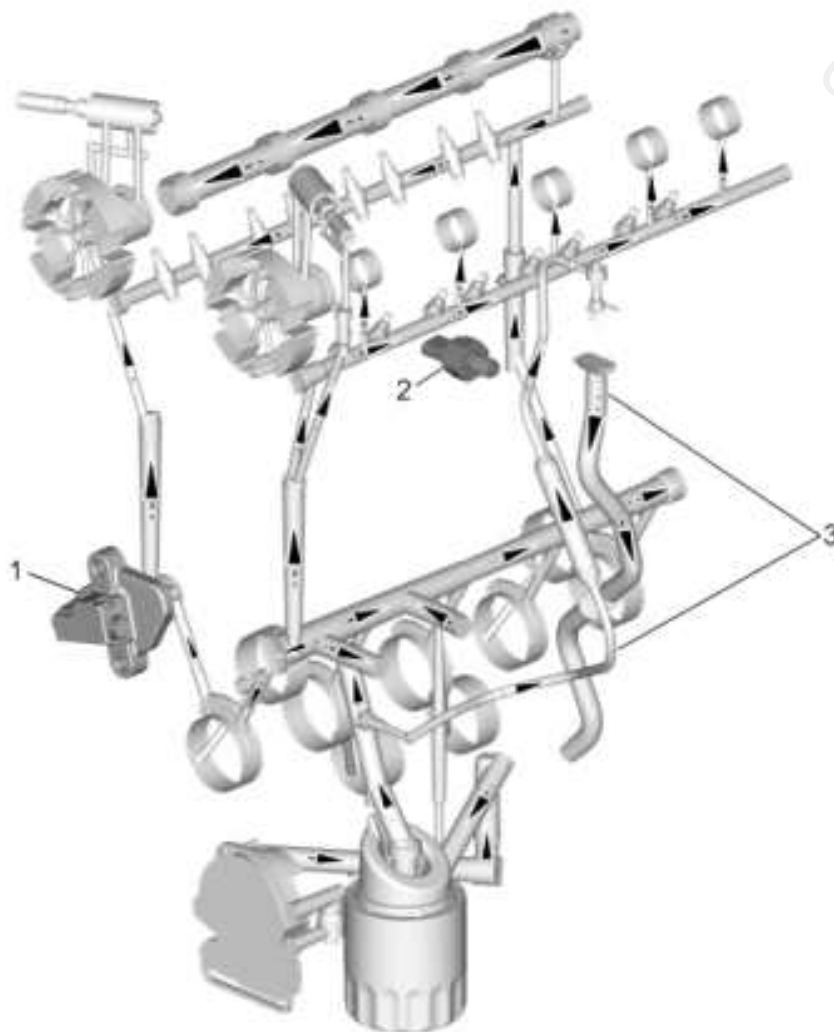


Fig. 518: Cutaway View Of Lubrication System
Courtesy of GENERAL MOTORS COMPANY

Engine lubrication is supplied by a variable displacement two-stage vane-type oil pump assembly. An oil control solenoid valve, controlled by the engine control module (ECM), mounted to the oil pump provides two stage functionality. The oil pump is mounted off-axis on the front of the engine.

All oil passing through the oil pump goes through the oil filter, where contaminants are removed. The oil filter is located on the left front side of the engine block. The oil filter is a spin-on type that mounts directly to the engine block. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted.

Oil then enters the gallery where it is distributed to the crankshaft, piston oil nozzles, and timing chain oil nozzle. For turbo applications, oil is also distributed through the turbocharger oil feed and return pipes (3) and engine oil cooler. The connecting rod bearings are oiled by 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. Passages feed each hydraulic lash adjuster.

The front feed off the main oil gallery also feeds the timing chain tensioner (1) and the intake and exhaust side phasers and oil control valves.

NOTE: **A mechanical vacuum pump is not used on hybrid engine.**

On the exhaust side, drilled passages feed each camshaft journal surface and the exhaust side head gallery feeds the mechanical vacuum pump. On the intake side, the oil is fed through the hollow camshaft to each camshaft journal surface, and a separate connected gallery feeds the intake side hydraulic lash adjusters.

An engine oil pressure sensor (2) is located on the intake rear side of the engine just below the head gasket interface. Oil returns to the oil pan through passages cast into the cylinder head. The phasers and timing chain drive lubrication drains directly into the oil pan behind the front cover.

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.

REPLACING ENGINE GASKETS

Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to [Special Tools](#).

Gasket Use and Applying Sealants

- Do not use any gasket again unless specified.
- Gaskets that can be used again will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** remover or equivalent.

- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
 - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

CAUTION: Refer to Sealant Caution .

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Cleaning Mating Part Surfaces for RTV Joints

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to ensure good adhesion over the life of the product.

CAUTION: When cleaning the sealing surfaces of engine components, **DO NOT** use bristle discs, abrasive pads, wire wheels or surface conditioning discs. These types of devices should not be used because they produce a very fine grit that is abrasive and known to cause internal engine damage. The bristle discs and pads are embedded with abrasive material and wear down as they clean, continually exposing fresh abrasive to the surface of the component.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover, cylinder head, engine block, oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area.

When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1, 600 km (1, 000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

NOTE: After the final cleaning with GM Low VOC Cleaner and before reassembly, **DO NOT touch the cleaned surfaces with your hand. Oils from your skin WILL CONTAMINATE the surface and prevent proper bonding of the new RTV sealant.**

Typical Applications

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.
- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover/rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/cam covers with press in place gaskets using RTV at corners or T-joints.

Materials Needed

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC - Free Cleaner & Degreaser

Procedure:

1. Identify the surfaces to which the RTV will come into contact in the assembled joint.
2. Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.
3. Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some

discoloration of the cloth after wiping however a clean surface should produce the same level of discoloration with successive wiping with a clean cloth and solvent.

4. If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
5. Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
6. Do not touch the cleaned surface with anything prior to RTV application.
7. The surface is now prepared for RTV application.

Sealant Types

NOTE: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following two major types of sealant are commonly used in engines:

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:
 - Gasket Eliminator
 - Pipe Sealant
 - Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Any other surfaces where a different type of sealant is specified in the service procedure
- Do not use RTV sealant unless the ambient air temperature is at least 18°C (65°F) degrees or higher.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

CAUTION: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

- The surfaces to be sealed must be clean and dry.

NOTE: The bead size is critical and is easier to maintain consistency and

application with a RTV dispensing tool. This also helps to eliminate waste.

- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

NOTE: Do not wait for the RTV sealant to skin over.

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
- The surfaces to be sealed must be clean and dry.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.
 - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
 - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
 - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between two close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

NOTE:

- **Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where two parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
 - The exhaust manifold
 - The head gasket
 - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

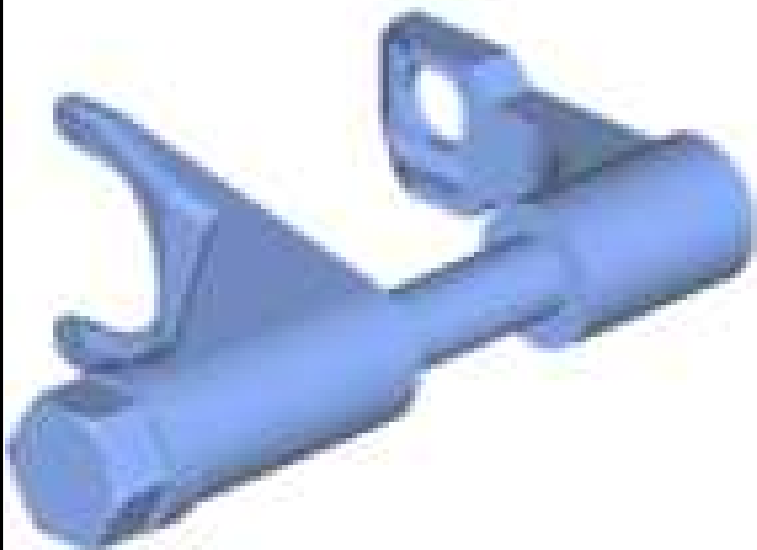
- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

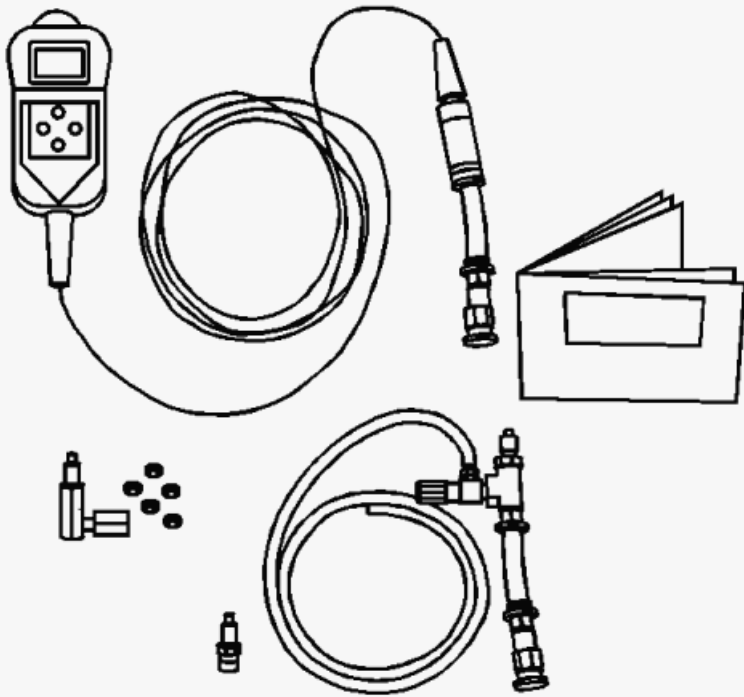
NOTE: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

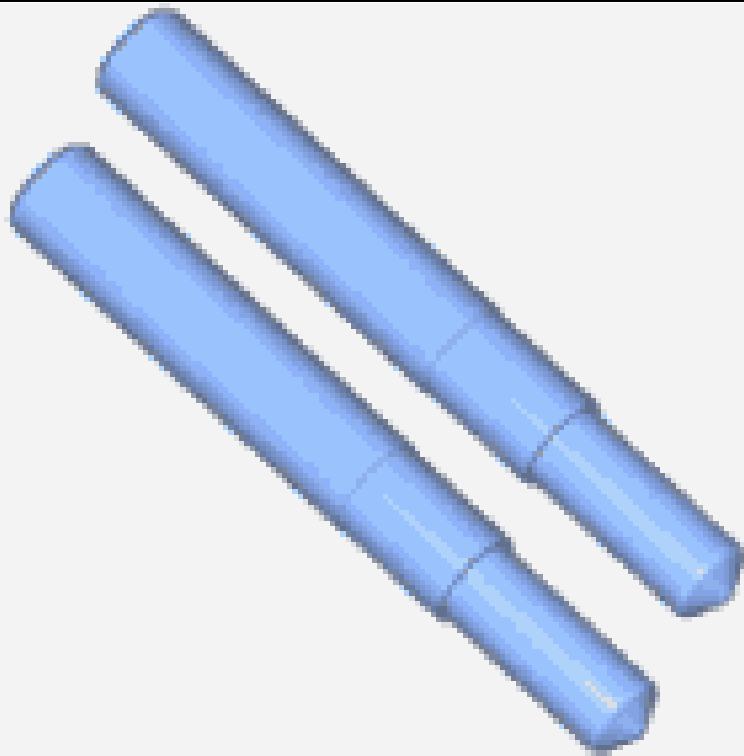
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	CH-42188-B J-42188-B Ball Joint Separator

Illustration**Tool Number/Description**

CH-48027
7-0006833
Digital Pressure Gauge



CH-51034
Cradle Alignment Guide Pins

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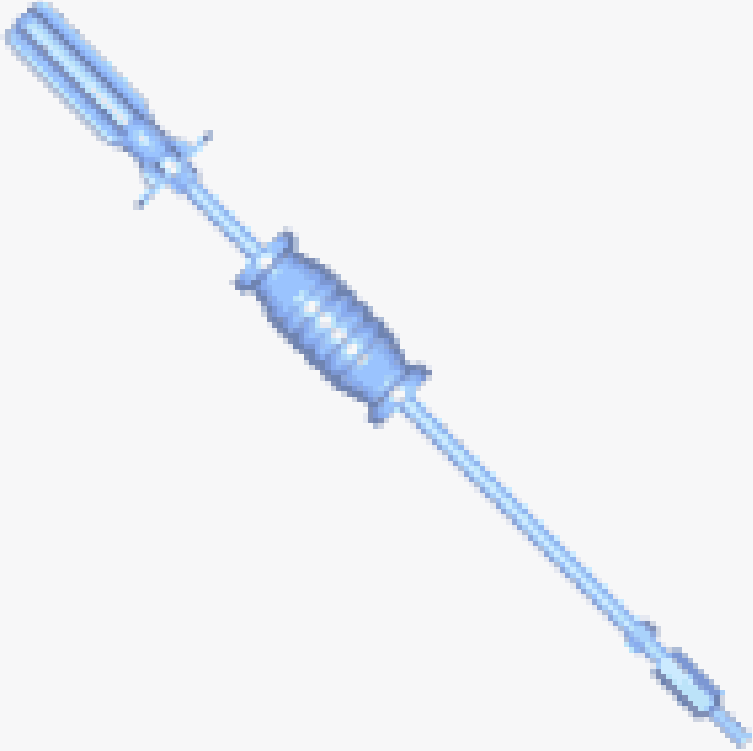
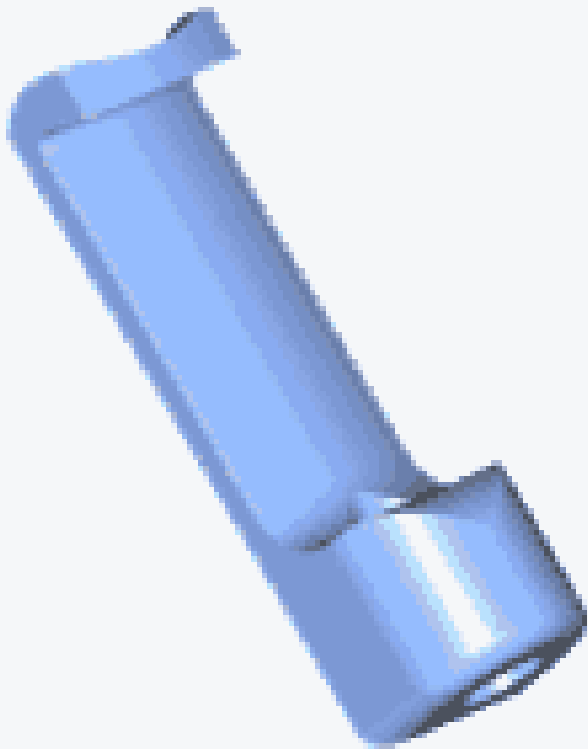
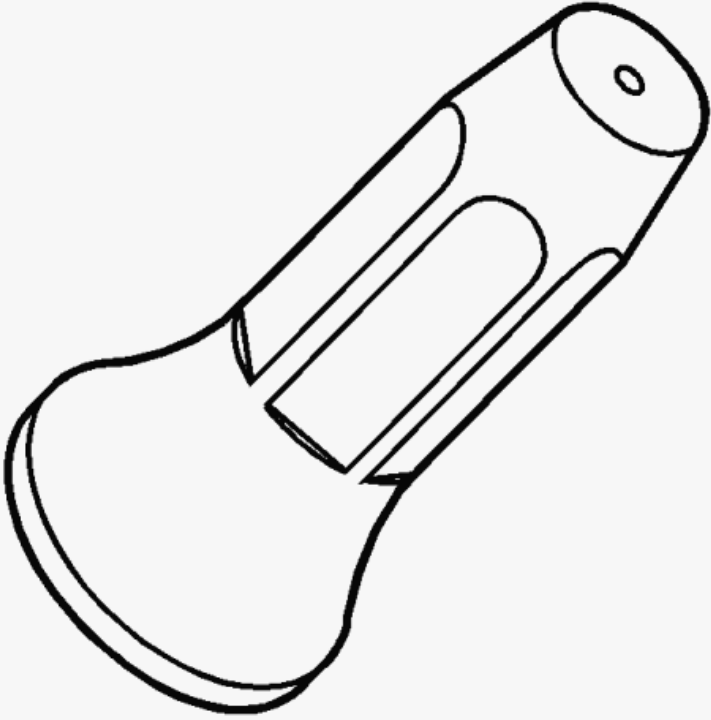
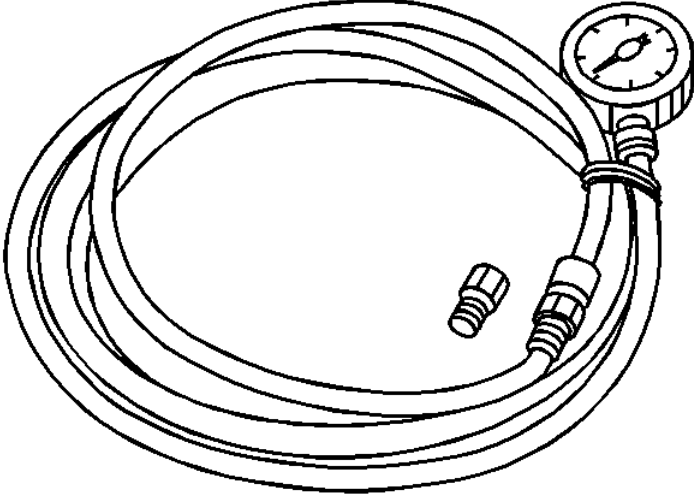
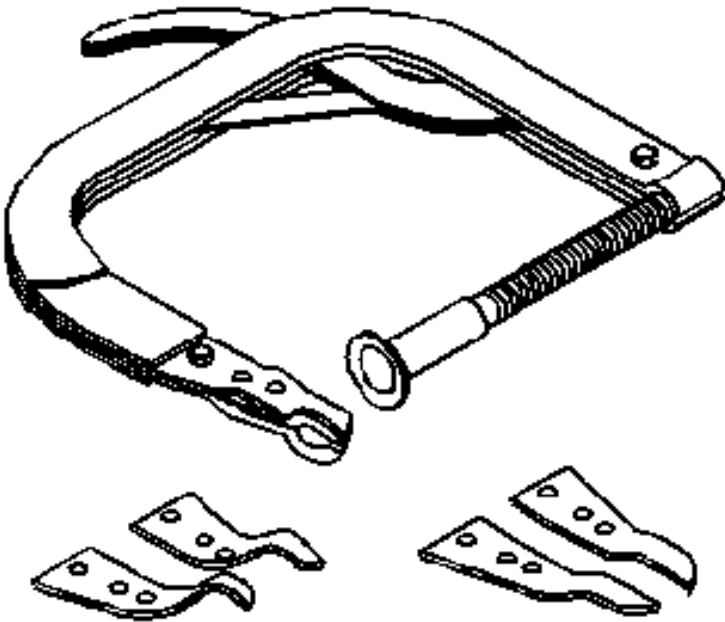
Illustration	Tool Number/Description
	DT-6125-1B J-6125-1B Slide Hammer with Adapter
	DT-23129 J-23129 KM-586 T-0207928 Universal Seal Remover

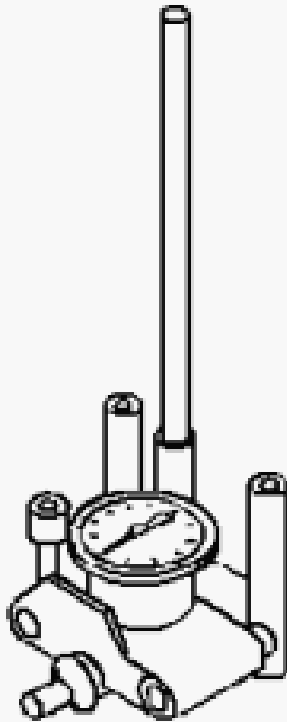
Illustration	Tool Number/Description
	DT-45866 J-45866 7-0007829 Input Shaft Seal Installer
	EN-498-B KM-498-B KM-6106 83 93 852 7-0006833 Oil Pressure Gauge

Illustration

Tool Number/Description

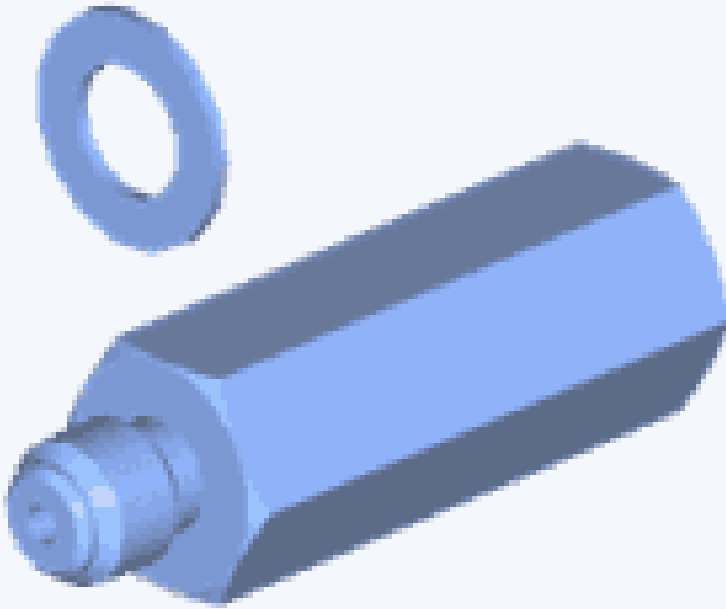


EN-8062
J-8062
KM-348
Valve Spring Compressor - Head Off

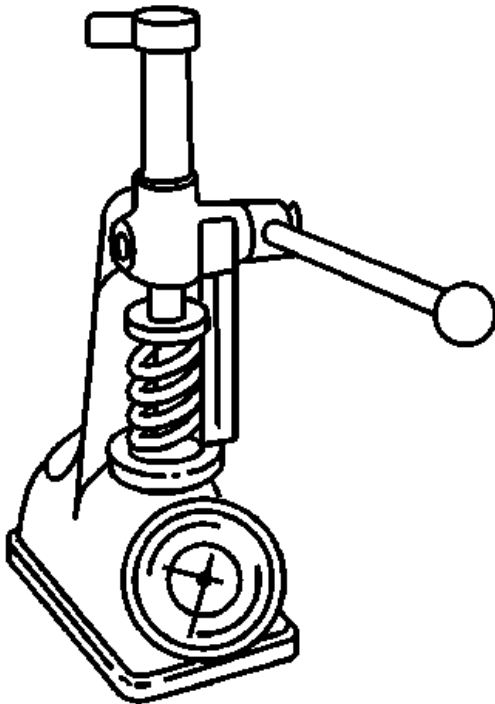


EN-8087
J-8087
Cylinder Bore Gauge

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Illustration**Tool Number/Description**

EN-21867-850
J-21867-850
KM-498-B
KM-6106
83 93 852
Oil Pressure Gauge Adapter



EN-22738-B
GE-22738-B
J-22738-B
J-9666
Valve Spring Tester

cardiagn.com

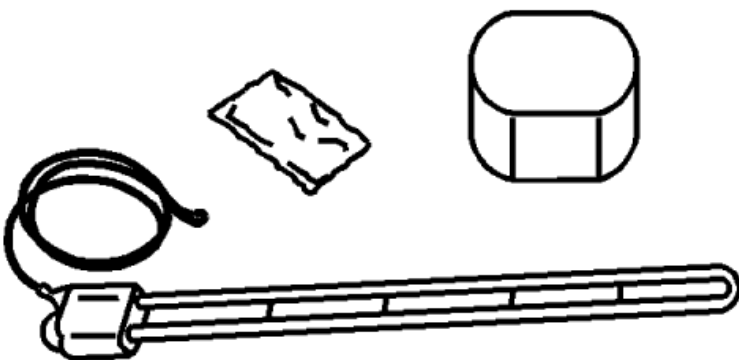
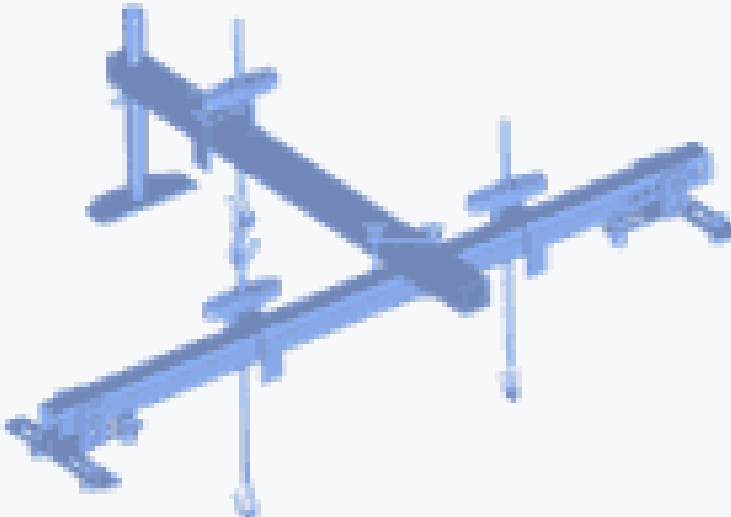
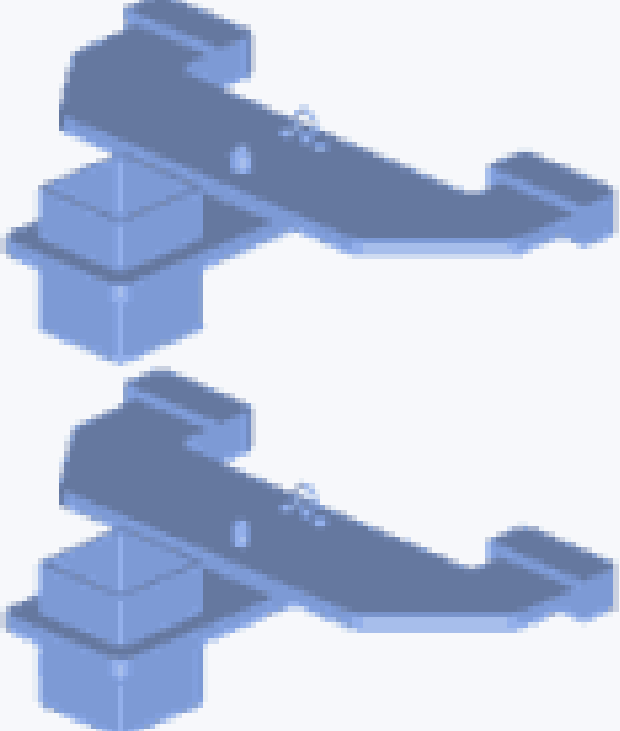
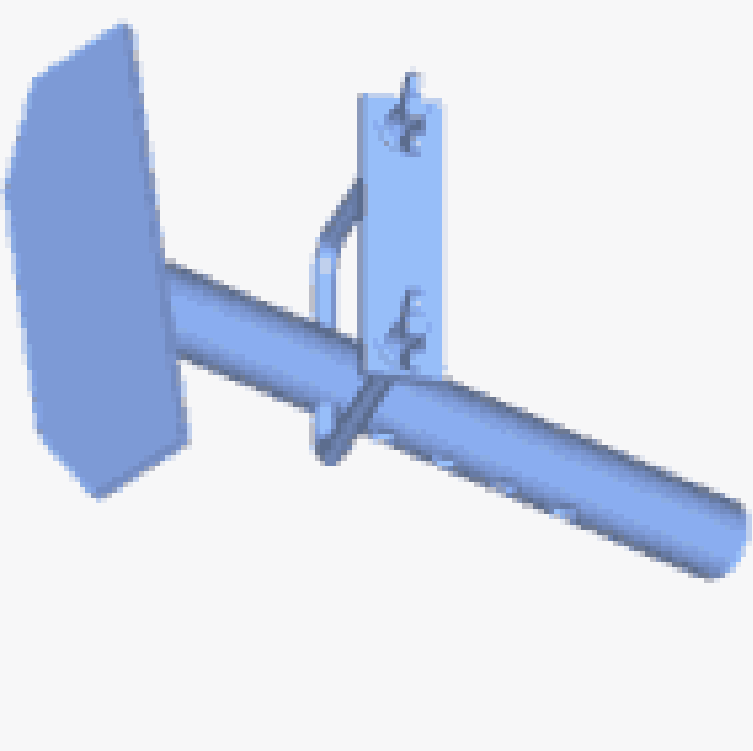
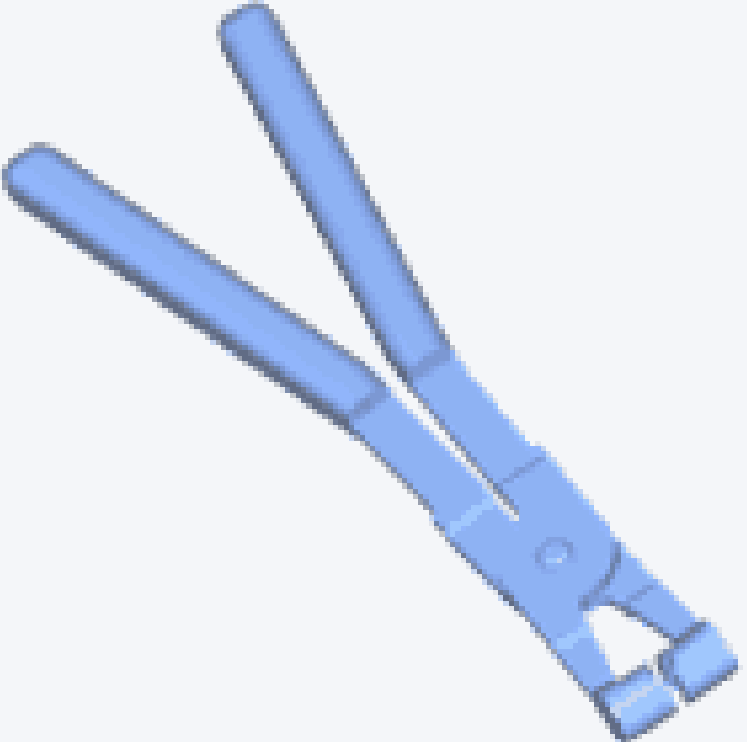
Illustration	Tool Number/Description
	EN-23951 J-23951 Valve Manometer
	EN-28410 J-28410 Gasket Remover cardiagn.com

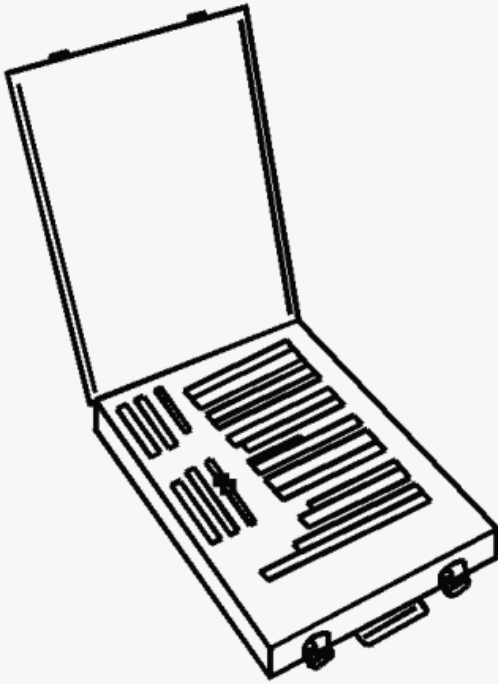
Illustration	Tool Number/Description
	EN-28467-B J-28467-B Universal Engine Support Fixture
	EN-28467-501 J-28467-501 Engine Support Fixture Adapters

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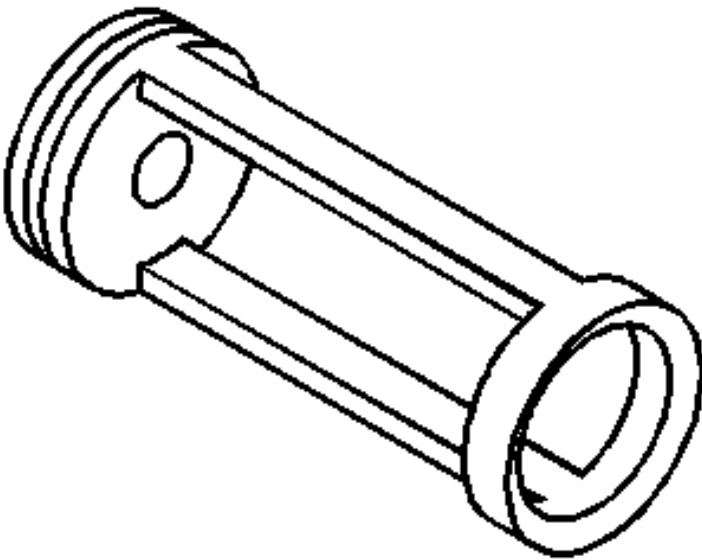
Illustration	Tool Number/Description
	EN-36462-A J-36462-A Engine Support Adapter Leg Set
	EN-36857 J-36857 Engine Lift Bracket

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Illustration	Tool Number/Description
	EN-38185 Hose Clamp Pliers
	EN-41816 J-41816 Crankshaft Balancer Remover

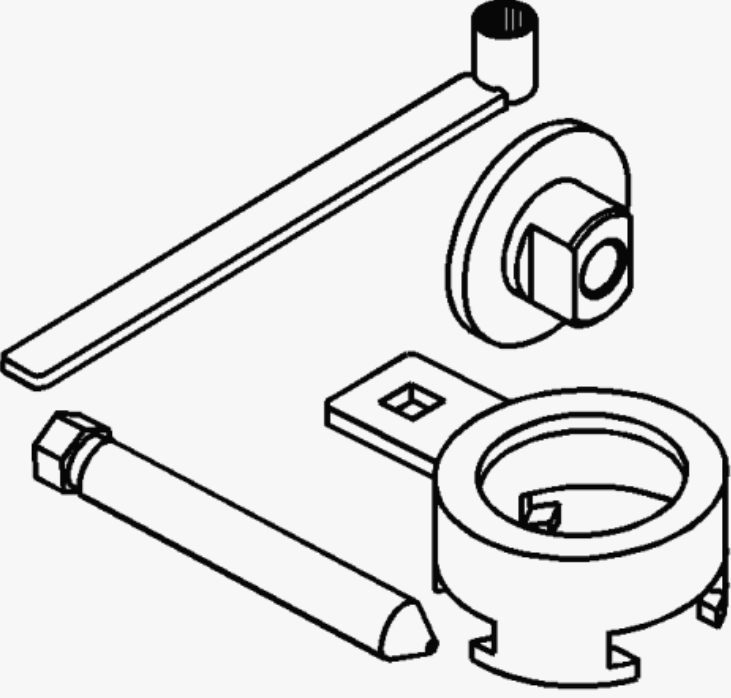
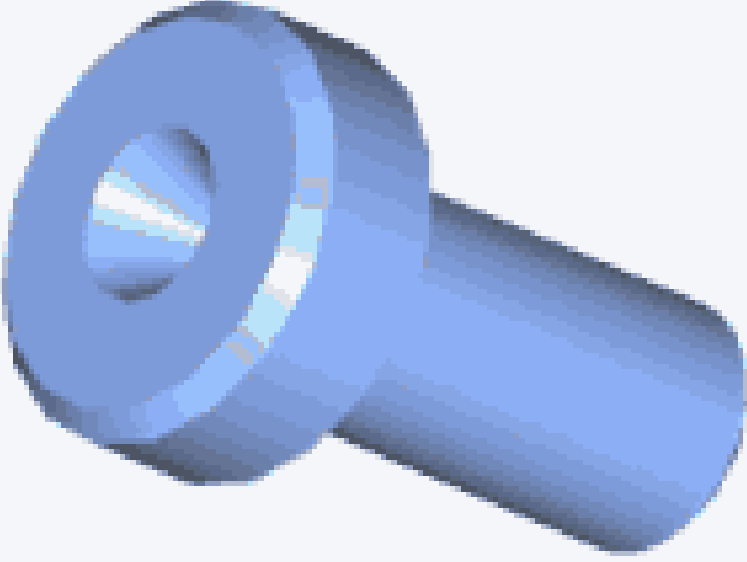
Illustration**Tool Number/Description**

EN-42385-850
J-42385-850
Thread Repair Kit



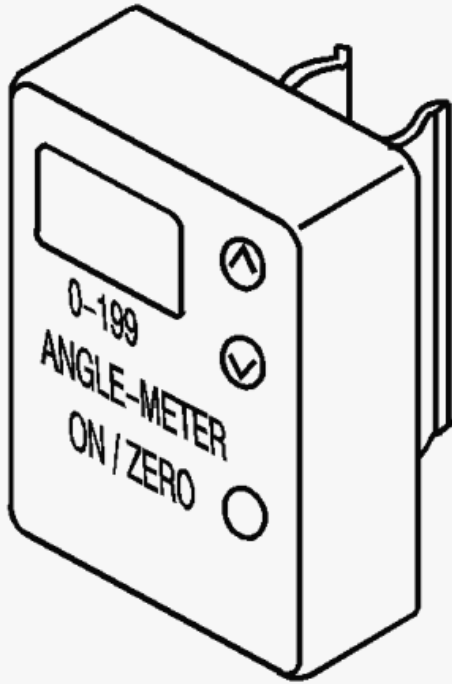
EN-43963
J-43963
KM-6149
Valve Spring Compressor (off car)

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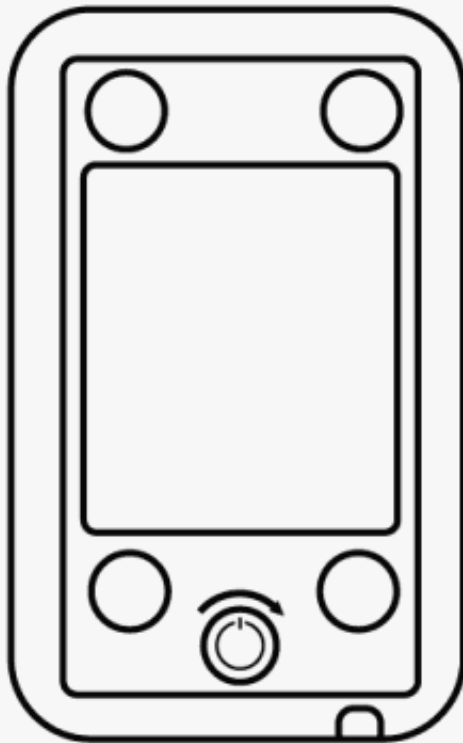
Illustration	Tool Number/Description
	EN-44226 J-44226 J-44226-BR Crankshaft Balancer Remover
	EN-44226-5 J-44226-BR Crankshaft Protector

Illustration

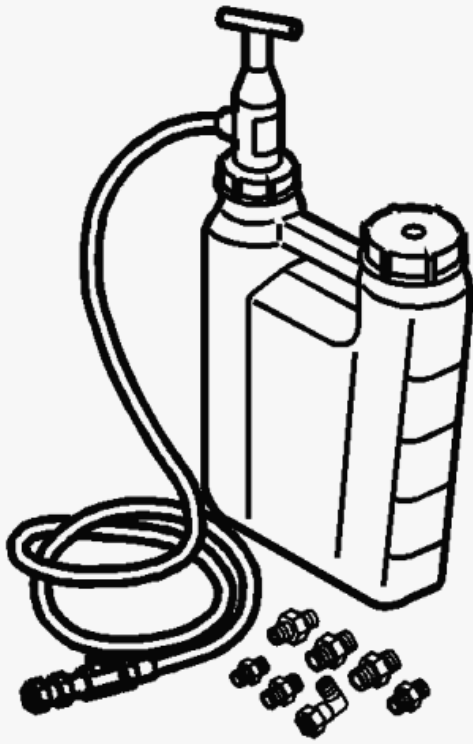
Tool Number/Description



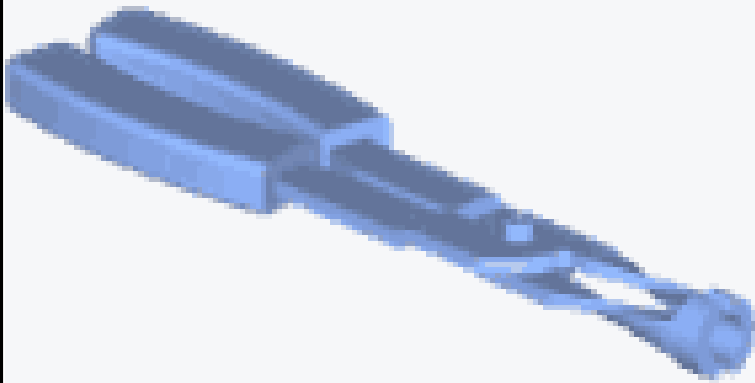
EN-45059
J-45059
KM-470-B
J-840902
Angle Meter



EN-45059 - A
Angle Meter

Illustration**Tool Number/Description**

EN-45299
J-45299
Engine Pre-Luber



EN-46116
X-0606051
Valve Stem Seal Remover

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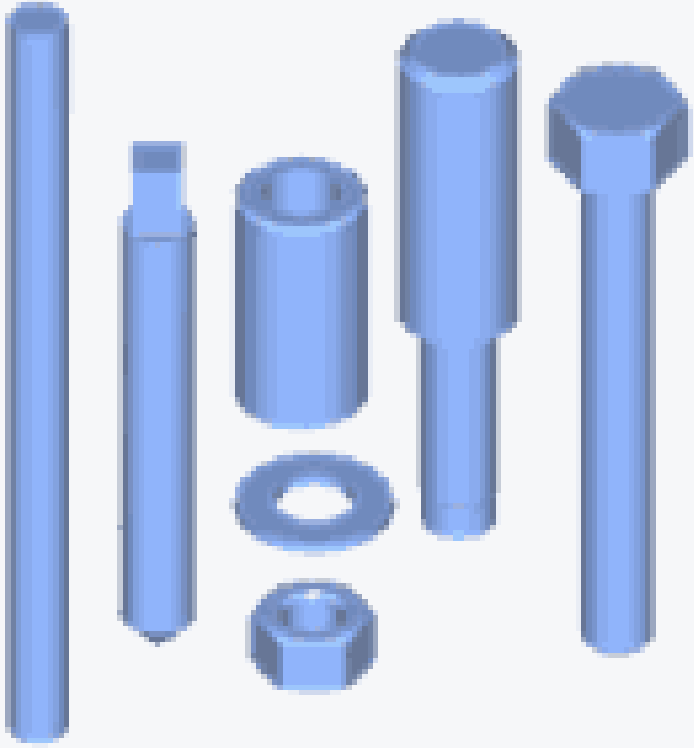
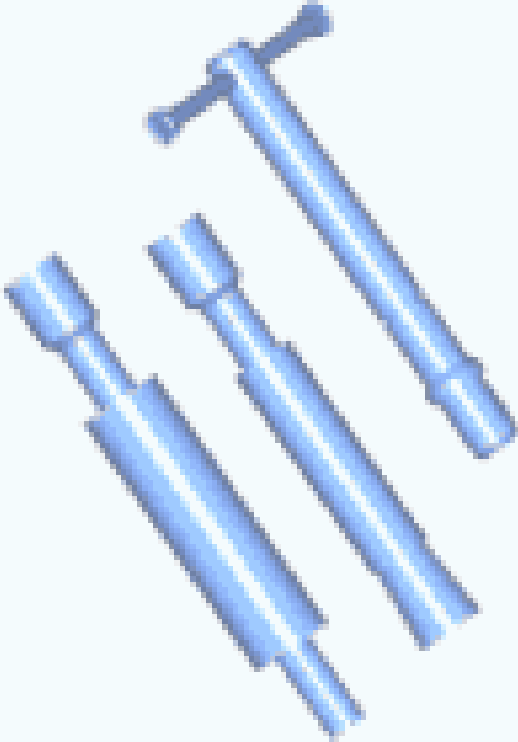
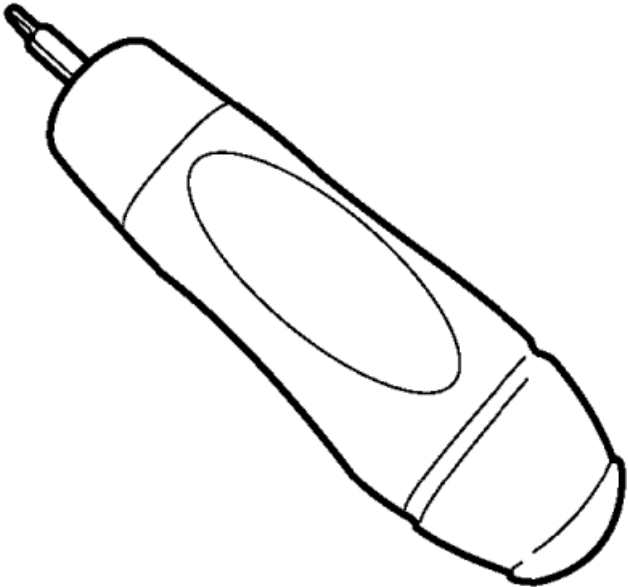
Illustration	Tool Number/Description
	EN-46122 Camshaft Position Actuator Check- Ball Valve Remover/Installer
	EN-47909 Injector Bore and Sleeve Cleaning Kit

Illustration	Tool Number/Description
	EN-49245 Fuel Injector Seal Installer/Sizer
	EN-49941 Piston Pin Clip Remover/Installer

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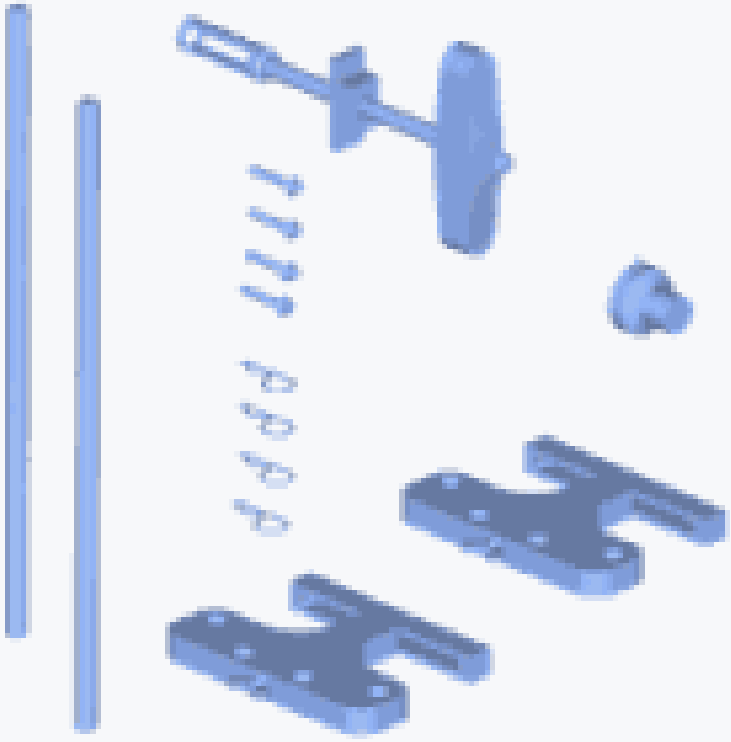
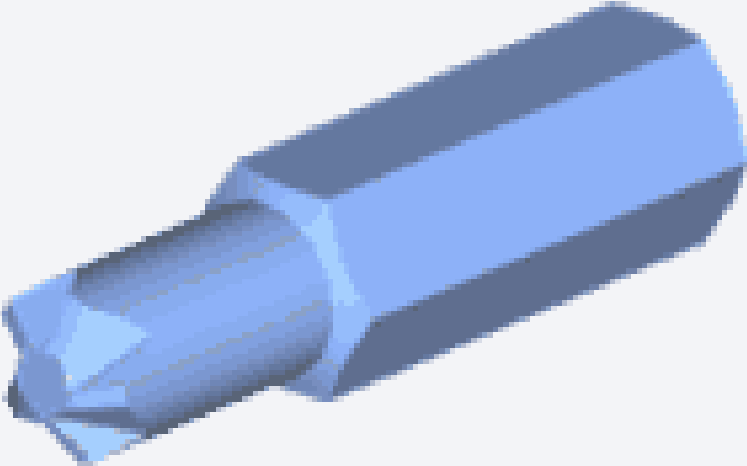
Illustration	Tool Number/Description
	EN-50717 7-0006798 Valve Spring Compressor - Head On
	EN-50956 Tamper Proof Drive Bit

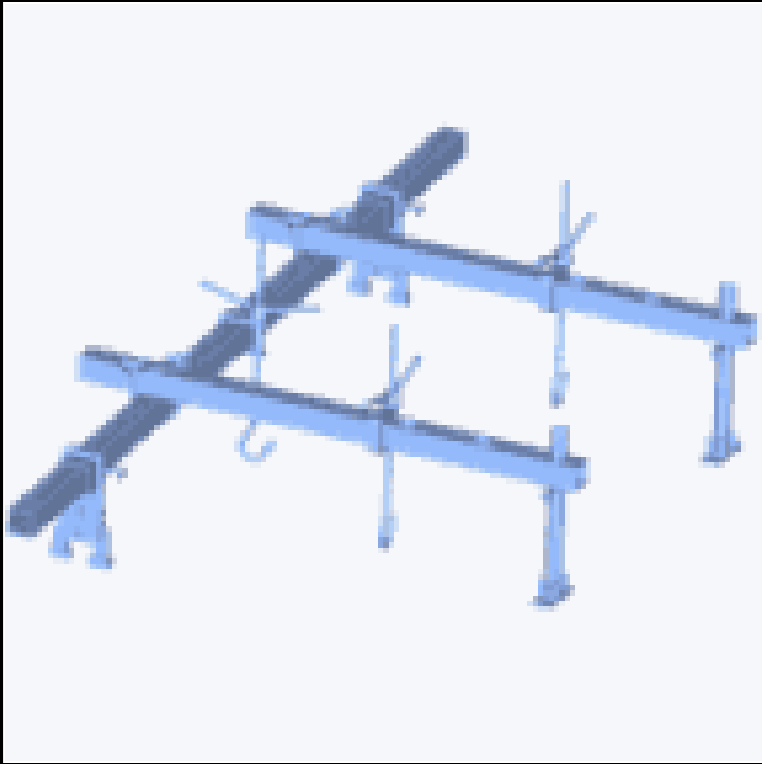
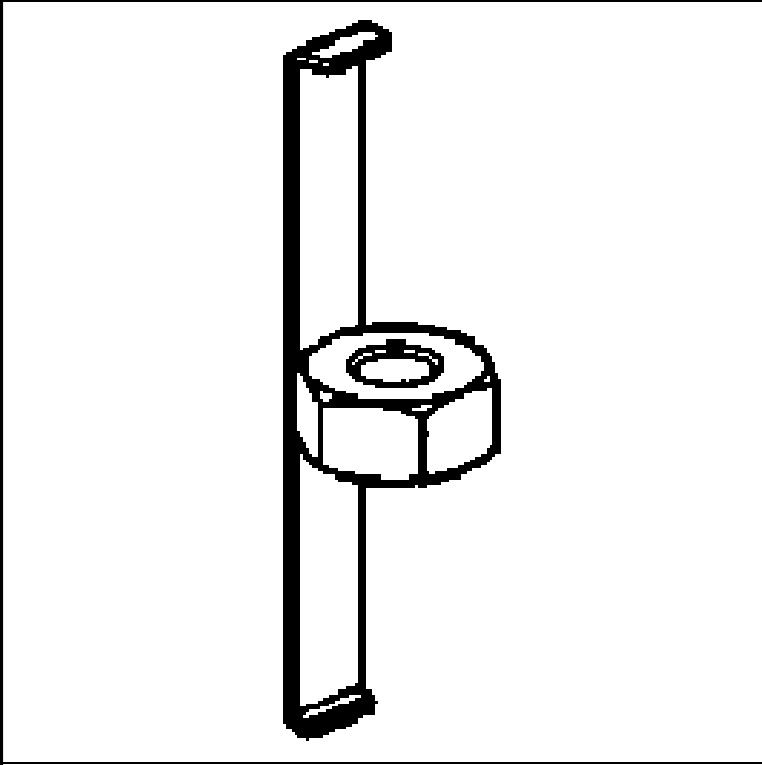
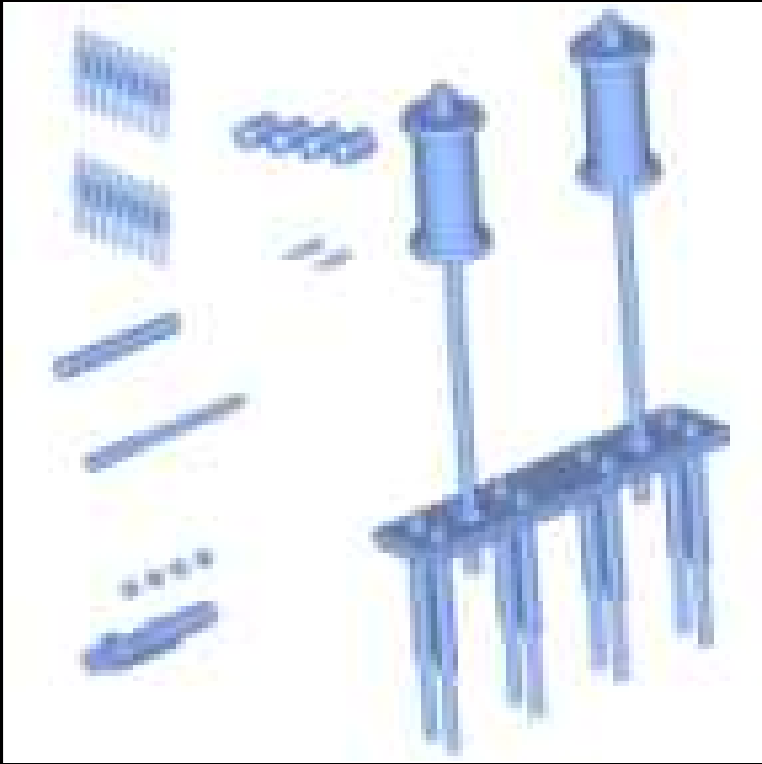
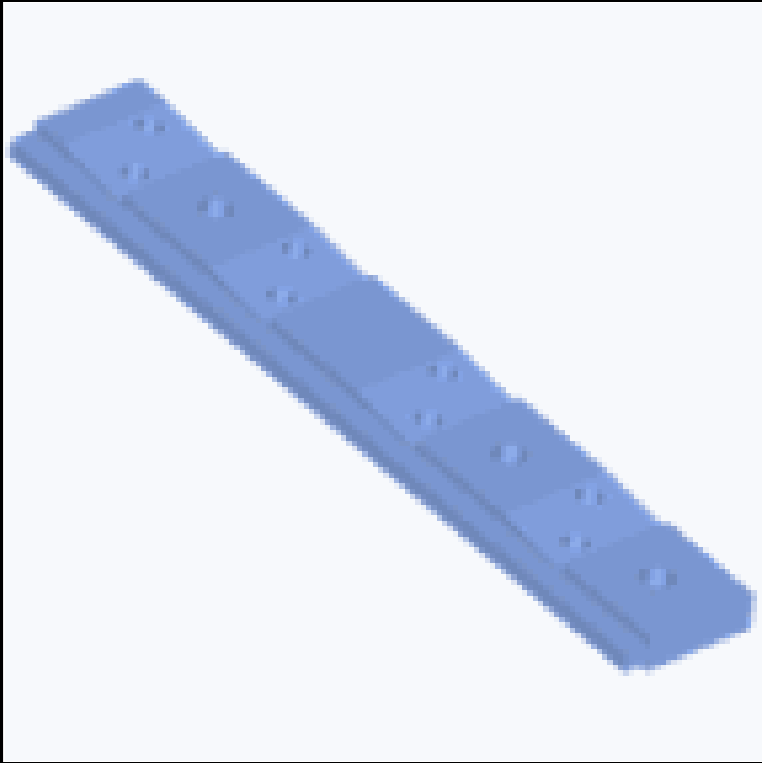
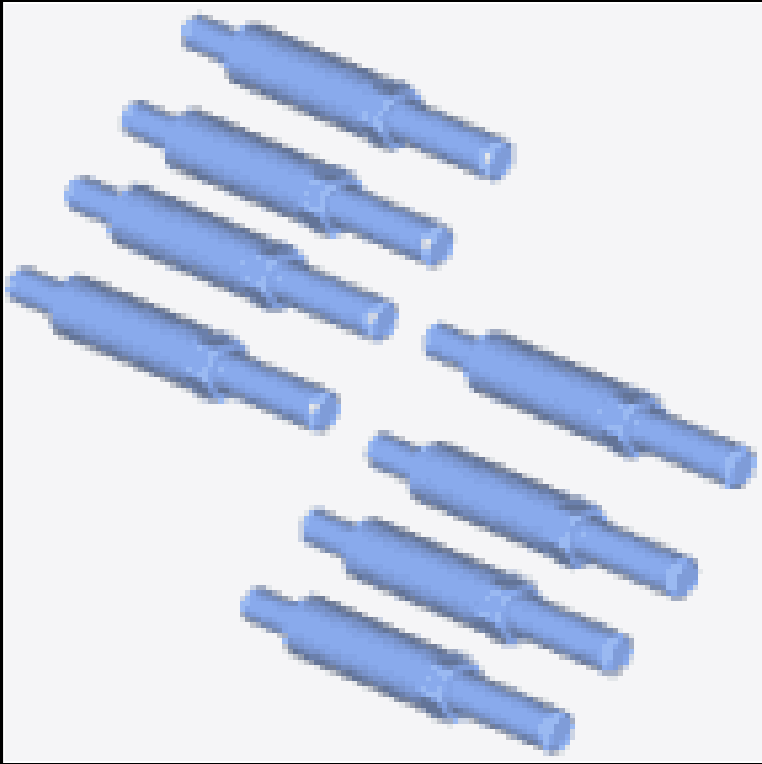
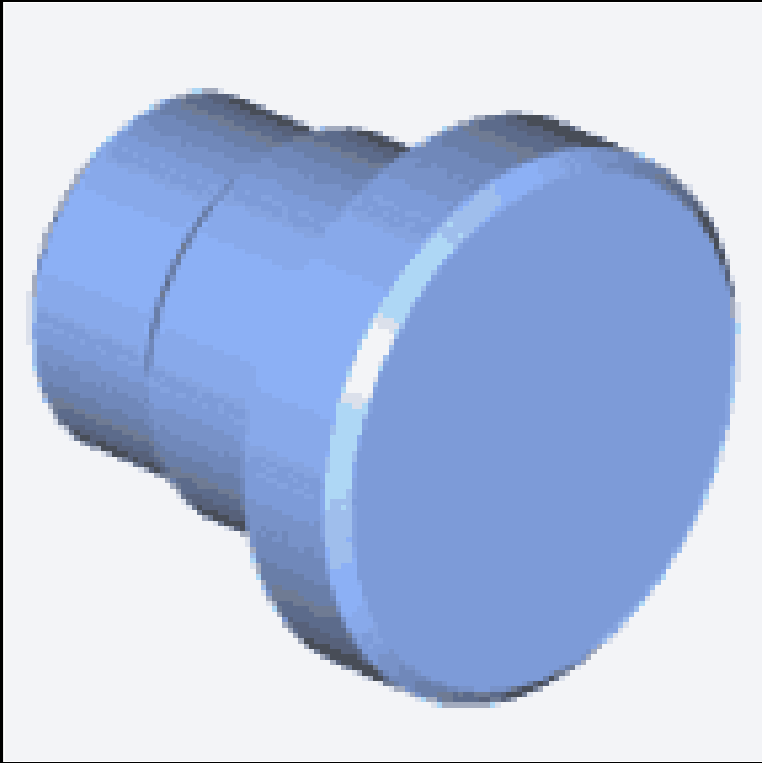
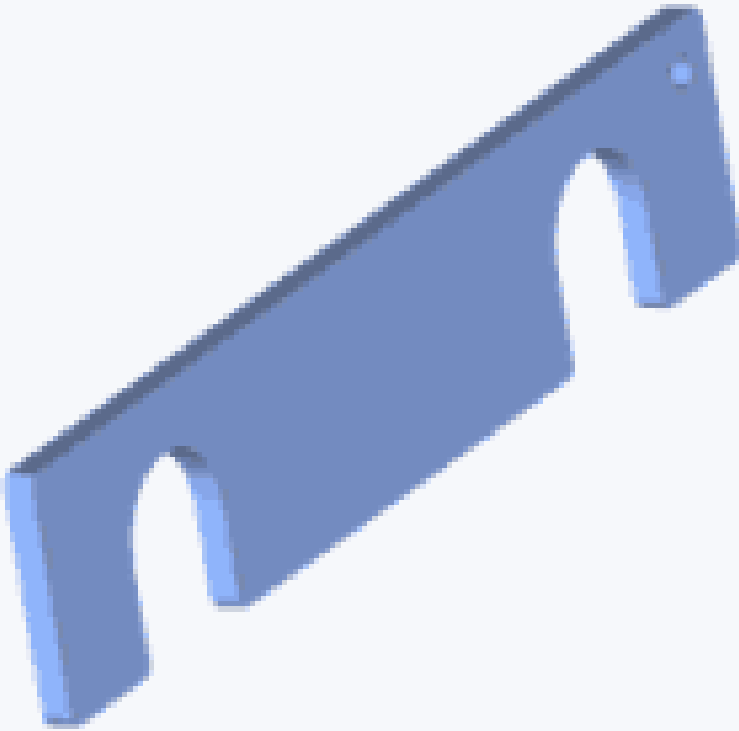
Illustration	Tool Number/Description
	EN-51007 Engine Support Fixture
	EN-51096 Crankshaft Rear Oil Seal Remover

Illustration	Tool Number/Description
	EN-51146 EN-51146-BR Injector Remover/Installer
	EN-51146-100 Fuel Injector Removal Plate

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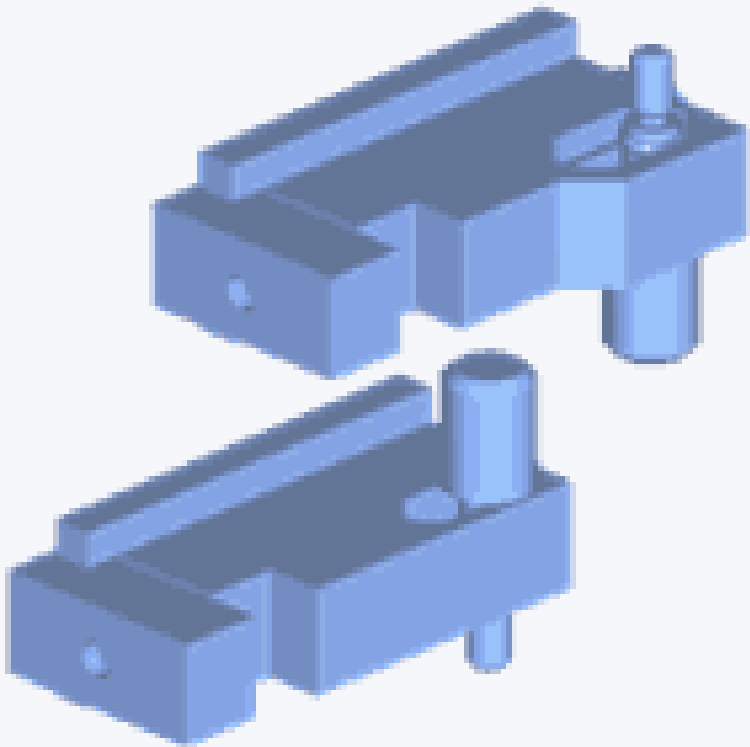
Illustration	Tool Number/Description
	EN-51146-150 Injector Remover/Installer Adapters
	EN-51365 Fuel Pump Installation Gauge

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Illustration	Tool Number/Description
	EN-51367 Camshaft Locking Tool
	EN-51368 Front Crankshaft Seal Installer

Illustration**Tool Number/Description**

EN-51369
Rear Crankshaft Seal Installer



EN-51397
Timing Chain Retainer

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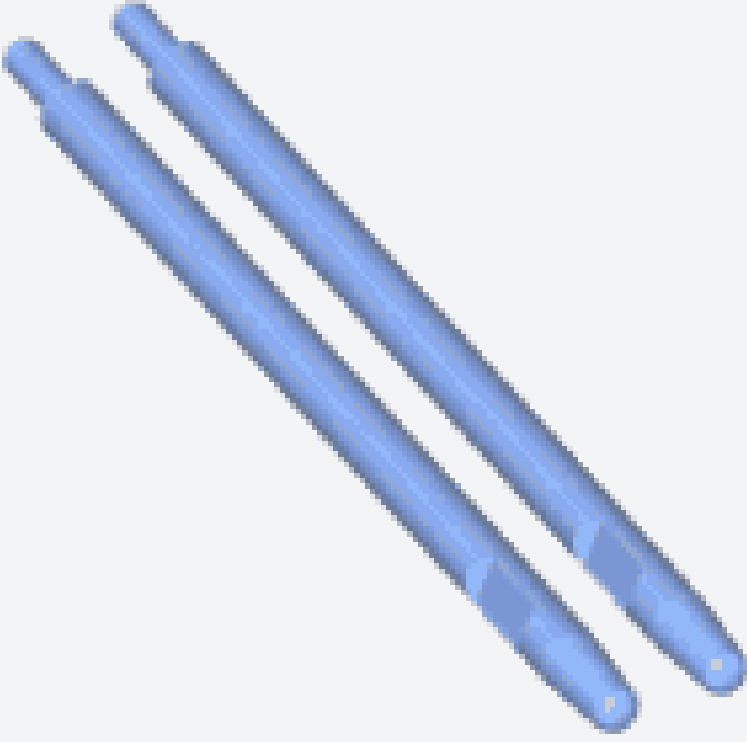
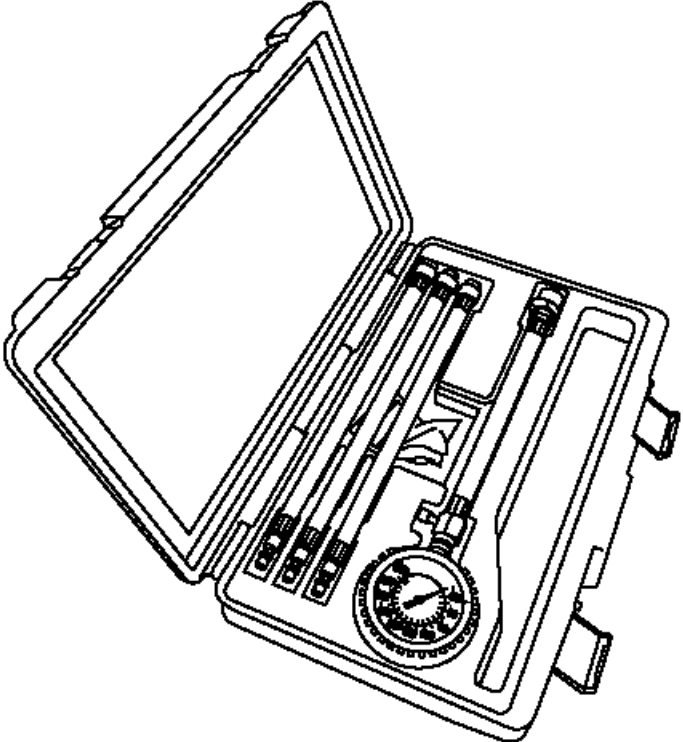
Illustration	Tool Number/Description
	EN-51454 Connecting Rod Guides
	EN-51749 3-0006784 Compression Gauge Tester Kit

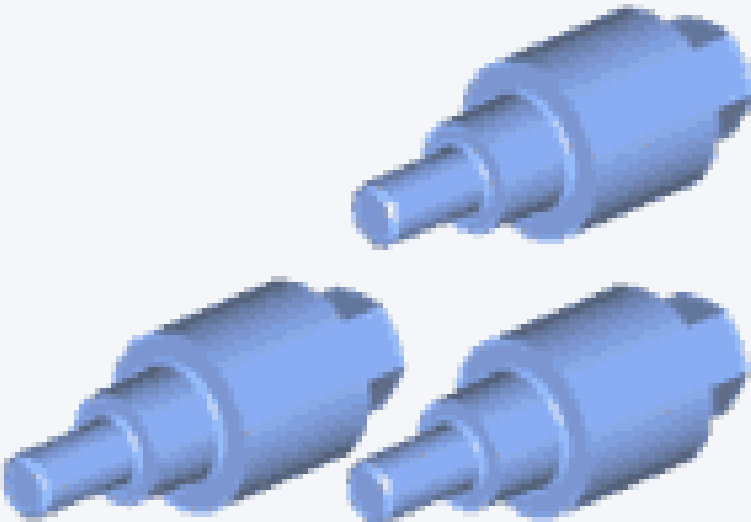
Illustration	Tool Number/Description
	EN-51760 Flywheel Holding Tool
	EN-51768 Engine Support Fixture Adapter Bolts M8

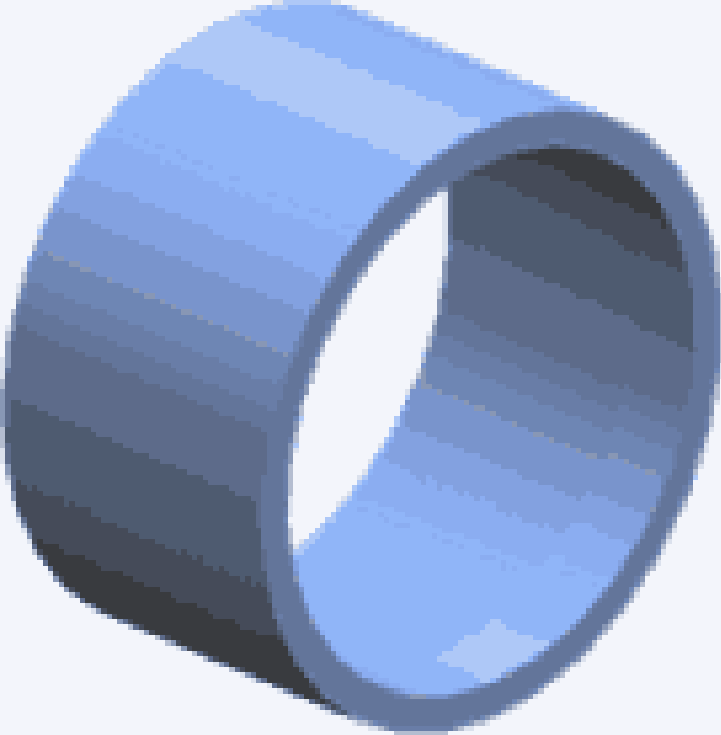
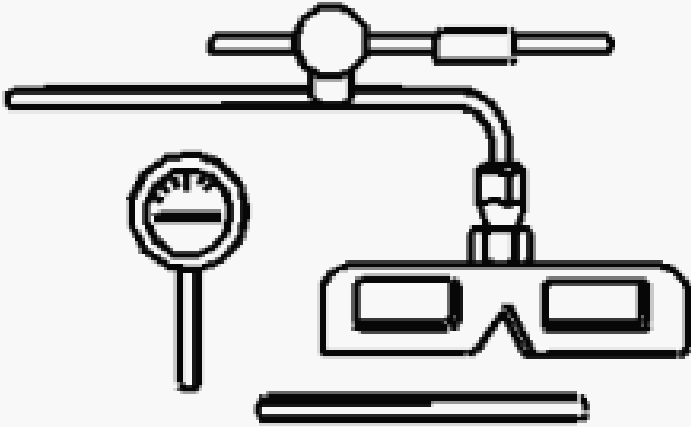
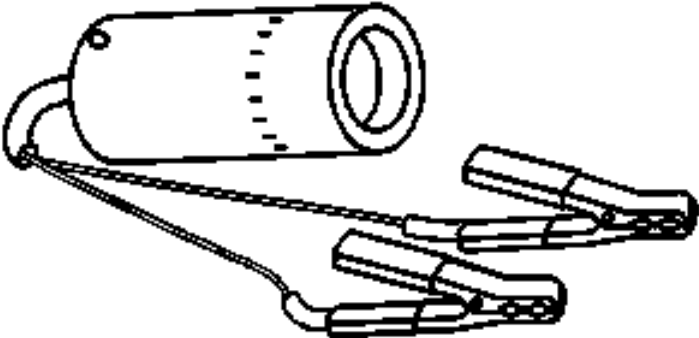
Illustration	Tool Number/Description
	EN-52059 Engine Support Fixture Adapter Bolts M10
	EN-52490-74 Piston Ring Compressor cardiagn.com

Illustration	Tool Number/Description
	GE-7872 J-7872 Magnetic Base Dial Indicator Set
	GE-42220 J-28428-E J-42220 Universal 12V Leak Detection Lamp