

2018 ENGINE**Engine Mechanical - 2.0L (LTG) - 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
Combustion Fuel Injector Seal
Connecting Rod Bearing
Crankshaft Front Oil Seal
Crankshaft Rear Oil Seal
Cylinder Head Core Hole Plug
Cylinder Head Gasket
Engine Coolant Thermostat Gasket
Engine Oil Cooler Gasket
Exhaust Manifold Gasket
Fuel Injector Seal Ring
Fuel Injector Spacer
Fuel Pump Gasket
Fuel Pump Housing Seal
Intake Manifold Gasket
Oil Pump Screen Gasket
Oil Pump Seal
Piston Pin Retainer
Positive Crankcase Ventilation Hose Fitting
Positive Crankcase Ventilation Tube
Positive Crankcase Ventilation Valve
Thermostat Bypass Pipe Gasket
Throttle Body Gasket
Timing Chain Tensioner Gasket
Turbocharger Coolant Feed and Return Pipe Gasket
Turbocharger Coolant Feed and Return Pipe Washer
Turbocharger Gasket
Turbocharger Oil Feed Pipe Gasket
Turbocharger Oil Feed Pipe Washer
Turbocharger Oil Return Pipe Gasket
Vacuum Pump Gasket
Vacuum Pump Seal
Valve Stem Oil Seal
Water Outlet Gasket
Water Pump Gasket

Single Use Threaded Fastener/Component tightening Specifications

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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 [8x]	
• First Pass:	20 N.m (15 lb ft)
• Second Pass:	30 N.m (22 lb ft)
• Final Pass:	40 degrees
Balance Shaft Sprocket Bolt	
• First Pass:	40 N.m (30 lb ft)
• Final Pass:	50 degrees
Camshaft Position Actuator Bolt	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	100 degrees
Connecting Rod Bolt	
• First Pass:	25 N.m (18 lb ft)
• Final Pass:	110 degrees
Crankshaft Balancer Bolt	
• First Pass:	150 N.m (111 lb ft)
• Final Pass:	140 degrees
Cylinder Head Bolt [10x]	
• First Pass:	30 N.m (22 lb ft)
• Final Pass:	190 degrees
Cylinder Head Core Hole Plug	50 N.m (37 lb ft)
Cylinder Head Oil Gallery Plug	40 N.m (30 lb ft)
Engine Front Cover Bolt - M10 [3x]	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	130 degrees
Engine Mount Engine Side Bolt [2x]	

NOTE:

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

Application	Specification
	Metric (English)
• First Pass:	100 N.m (74 lb ft)
• Final Pass:	75 degrees
Exhaust Manifold Bolt [5x]	20 N.m (15 lb ft)
Exhaust Manifold Brace Nut [2x]	25 N.m (18 lb ft)
Fuel Feed Intermediate Pipe	
• First Pass:	15 N.m (11 lb ft)
• Final Pass:	30 N.m (22 lb ft)
Fuel Pump Bolt [2x]	
• First Pass:	8 N.m (71 lb in)
• Final Pass:	50 degrees
Lower Crankcase Bolt [10x]	
• First Pass:	20 N.m (15 lb ft)
• Final Pass:	140 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 [4x]	
• First Pass:	30 N.m (22 lb ft)
• Second Pass:	90 degrees

Reusable Threaded Fastener tightening Specifications

NOTE:

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

Application	Specification
	Metric (English)
Air Conditioning Compressor Bolt	22 N.m (16 lb ft)
Balance Chain Guide Bolt [2x]	10 N.m (89 lb in)
Balancer Chain Tensioner Bolt	10 N.m (89 lb in)
Balancer Shaft with Oil Pump Bolt [8x]	
• First Pass:	58 N.m (43 lb ft)

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

Application	Specification
	Metric (English)
Final Pass:	58 N.m (43 lb ft)
Camshaft Bearing Cap Bolt [18x]	10 N.m (89 lb in)
Camshaft Bearing Cap Bolt- Front [4x]	10 N.m (89 lb in)
Camshaft Cover Bolt [23x]	10 N.m (89 lb in)
Camshaft Cover Heat Shield Bolt [4x]	10 N.m (89 lb in)
Camshaft Cover Plug	35 N.m (26 lb ft)
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m (89 lb in)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Catalytic Converter Brace Bolt [4x]	25 N.m (18 lb ft)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Drive Belt Tensioner Bolt	58 N.m (43 lb ft)
Engine Block Oil Gallery Plug	65 N.m (48 lb ft)
Engine Block Oil Gallery Plug	40 N.m (30 lb ft)
Engine Coolant Air Bleed Pipe Bolt	10 N.m (89 lb in)
Engine Coolant Heater	50 N.m (37 lb ft)
Engine Coolant Heater Hole Plug	60 N.m (44 lb ft)
Engine Coolant Thermostat Housing Bolt [2x]	10 N.m (89 lb in)
Engine Front Cover Bolt - [4x]	10 N.m (89 lb in)
Engine Front Cover Bolt - [13x]	25 N.m (18 lb ft)
Engine Lift Front Bracket Bolt [2x]	25 N.m (18 lb ft)
Engine Lift Rear Bracket Bolt [2x]	25 N.m (18 lb ft)
Engine Mount Bolt [2x]	100 N.m (74 lb ft)
Engine Mount Brace Bolt [2x]	22 N.m (16 lb ft)
Engine Oil Cooler Bolt	10 N.m (89 lb in)
Engine Oil Cooler Connector	50 N.m (37 lb ft)
Engine Oil Level Indicator Switch Bolt	10 N.m (89 lb in)
Engine Oil Pressure Sensor	35 N.m (26 lb ft)
Exhaust Manifold Brace Bolt [2x]	25 N.m (18 lb ft)
Exhaust Manifold Heat Shield Bolt [2x]	14 N.m (124 lb in)
Fuel Feed Pipe Fitting	30 N.m (22 lb ft)
Fuel Feed Pipe Clip Stud	10 N.m (89 lb in)
Fuel Injection Fuel Rail Bolt [4x]	25 N.m (18 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m (24 lb ft)
Fuel Pump Shield Bolt [2x]	10 N.m (89 lb in)
Ignition Coil Bolt [4x]	10 N.m (89 lb in)
Intake Manifold Bolt [5x]	12 N.m (106 lb in)
Intake Manifold Cover Bolt [3x]	9 N.m (80 lb in)
Knock Sensor Bolt [2x]	25 N.m (18 lb ft)
Lower Crankcase Bolt [11x]	25 N.m (18 lb ft)
Lower Oil Pan Bolt [8x]	10 N.m (89 lb in)
Manifold Absolute Pressure Sensor Bolt	5 N.m (44 lb in)
Oil Pan Baffle Bolt [5x]	10 N.m (89 lb in)
Oil Pan Bolt [2x]	10 N.m (89 lb in)
Oil Pan Bolt [11x]	25 N.m (18 lb ft)
Oil Pan Bolt @ Transmission [2x]	25 N.m (18 lb ft)
Oil Pan Cover Bolt	10 N.m (89 lb in)
Oil Pan Drain Plug	25 N.m (18 lb ft)

NOTE:

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

Application	Specification
	Metric (English)
Oil Pump Suction Pipe Bolt [2x]	10 N.m (89 lb in)
Oil Pump Flow Control Valve Bolt	10 N.m (89 lb in)
Oil Pump Flow Control Valve Heat Shield Bolt	58 N.m (43 lb in)
Piston Oil Nozzle Bolt [4x]	10 N.m (89 lb in)
Positive Crankcase Ventilation Hose Fastener	12 N.m (106 lb in)
Positive Crankcase Ventilation Hose Fitting Bolt	8 N.m (71 lb in)
Pump and Component Oil Heat Shield Bolt [2x]	9 N.m (80 lb in)
Thermostat Bypass Pipe Bolt [2x]	10 N.m (89 lb in)
Throttle Body Bolt [4x]	10 N.m (89 lb in)
Timing Chain Guide Bolt [2x]	25 N.m (18 lb ft)
Timing Chain Tensioner Bolt [2x]	25 N.m (18 lb ft)
Timing Chain Tensioner Shoe Bolt	25 N.m (18 lb ft)
Turbocharger Bypass Valve Solenoid Bolt [3x]	8 N.m (71 lb in)
Turbocharger Coolant Feed Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Feed Pipe Bolt [2x]	10 N.m (89 lb in)
Turbocharger Coolant Return Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Heat Shield Bolt [3x]	14 N.m (124 lb in)
Turbocharger Exhaust Pipe Stud [4x]	25 N.m (18 lb ft)
Turbocharger Oil Feed Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Oil Feed Pipe Bolt [2x]	10 N.m (89 lb in)
Turbocharger Oil Return Pipe Bolt [4x]	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Bolt [2x]	8 N.m (71 lb in)
Turbocharger Wastegate Regulator Solenoid Valve Bolt	8 N.m (71 lb in)
Vacuum Pump Bolt [3x]	10 N.m (89 lb in)
Water Outlet Bolt [2x]	10 N.m (89 lb in)
Water Pump Bolt [3x]	25 N.m (18 lb ft)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
LCV, LHP, LTG		
Oil Capacity - 2WD	4.7L	5.0 quarts
Oil Capacity - AWD	5.7L	6.0 quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.0 L	122 CID
• RPO	LTG	
• VIN	-	

Application	Specification	
	Metric	English
• Bore	85.992 - 86.008 mm	3.3855 - 3.3861 in
• Stroke	86 mm	3.386 in
• Compression Ratio	9.50	
• Spark Plug Gap	0.95 - 1.10 mm	0.037 - 0.043 in
Block		
• Crankshaft Main Bearing Bore Diameter	60.862 - 60.876 mm	2.3961 - 2.3967 in
• Cylinder Bore Diameter	85.992 - 86.008 mm	3.3855 - 3.3861 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	0.001 in
• Cylinder Head Deck Surface Flatness - over 150 mm length	0.050 mm	0.002 in
Engine Block to Bedplate Flatness - overall	0.1 mm	0.0039 in
Engine Block to Bedplate Flatness - straightness	0.050 mm within every 100 mm	0.002 in within every 3.937 in
Piston Deck Height - Below Deck	1.155 - 1.725 mm	0.0455 - 0.0679 in
Camshaft		
• Camshaft End Play	0.040 - 0.307 mm	0.0016 - 0.0121 in
• Camshaft Journal Diameter - Journal 1	34.935 - 34.960 mm	1.3754 - 1.3764 in
• Camshaft Journal Diameter - Journal 2 thru 5	26.935 - 26.960 mm	1.0604 - 1.0614 in
• Camshaft Thrust Width - Camshaft with Phaser installed	30.025 - 30.175 mm	1.1821 - 1.1880 in
• Camshaft Thrust Width - Cylinder Head	29.868 - 29.890 mm	1.1759 - 1.1768 in
Connecting Rod		
• Connecting Rod Bearing to Crankpin Clearance	0.030 - 0.073 mm	0.0012 - 0.0029 in
• Connecting Rod Bore Diameter - Bearing End	52.118 - 52.134 mm	2.0519 - 2.05252 in
• Connecting Rod Bore Diameter - Pin End	24.007 - 24.017 mm	0.9452 - 0.9455 in

Application	Specification	
	Metric	English
Connecting Rod Side Clearance	0.070 - 0.370 mm	0.0028 - 0.0146 in
Connecting Rod Straightness - Bend - Maximum	0.017 mm	0.0007 in
Connecting Rod Straightness - Twist - Maximum	0.040 mm	0.0016 in
Crankshaft		
Connecting Rod Pin Diameter	48.999 - 49.015 mm	1.9291 - 1.9297 in
Crankshaft End Play	0.040 - 0.270 mm	0.0016 - 0.0106 in
Crankshaft Main Bearing Clearance	0.020 - 0.048 mm	0.0008 - 0.0019 in
Crankshaft Main Journal Diameter	55.993 - 56.009 mm	2.2044 - 2.2051 in
Crankshaft Thrust Bearing Width	20.30 - 20.45 mm	0.799 - 0.805
Cylinder Head		
Surface Flatness - Block Deck - in 25 mm	0.025 mm	0.0001 in
Surface Flatness - Block Deck - in 150 mm	0.050 mm	0.0019 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	6.000 - 6.020 mm	0.2362 - 0.2370 in
Valve Guide Bore - Intake	6.000 - 6.020 mm	0.2362 - 0.2370 in
Valve Lifter Bore Diameter - Stationary Lash Adjusters	12.008 - 12.030 mm	0.4728 - 0.4736 in
Valve Seat Angle - Relief Surface	30 Degrees	
Valve Seat Angle - Seating Surface	45 Degrees	
Valve Seat Angle - Undercut Surface	60 Degrees	
Valve Seat Runout - Maximum	0.080 mm	0.0031 in
Lubrication System		

Application	Specification	
	Metric	English
Oil Pressure - @ 700 RPM 100Â°C	140 - 200 kPa	20 - 29 psi
Piston Rings		
Piston Ring End Gap - Top	0.20 - 0.35 mm	0.008 - 0.014 in
Piston Ring End Gap - Second	0.35 - 0.55 mm	0.014 - 0.022 in
Piston Ring End Gap - Oil Control	0.25 - 0.75 mm	0.010 - 0.030 in
Piston Ring to Groove Clearance - Top	0.04 - 0.08 mm	0.0015 - 0.0031 in
Piston Ring to Groove Clearance - Second	0.030 - 0.070 mm	0.0012 - 0.0030 in
Piston Ring to Groove Clearance - Oil Control	0.024 - 0.176 mm	0.0009 - 0.0069 in
Piston Ring Thickness - Top	1.170 - 1.190 mm	0.0461 - 0.0469 in
Piston Ring Thickness - Second	1.470 - 1.490 mm	0.0579 - 0.0587 in
Piston Ring Thickness - Oil Control - Rail	0.447 - 0.473 mm	0.0176 - 0.0186 in
Piston Ring Thickness - Oil Control - Spacer	0.960 - 1.040 mm	0.0378 - 0.0409 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	0.005 - 0.013 mm	0.0002 - 0.0005 in
Pin - Piston Pin Diameter	23.997 - 24.000 mm	0.9448 - 0.9449 in
Pin - Piston Pin End Play	0.263 - 1.164 mm	0.0104 - 0.0458 in
Piston - Piston Diameter - @ 14.8 mm up	85.968 - 85.982 mm	3.3846 - 3.3851 in
Piston - Piston Pin Bore Diameter	24.005 - 24.010 mm	0.9451 - 0.9453 in
Piston - Piston Ring Groove Width - Top	1.23 - 1.25 mm	0.0484 - 0.0492 in
Piston - Piston Ring Groove Width - Second	1.52 - 1.54 mm	0.0598 - 0.0606 in
Piston - Piston Ring Groove Width - Oil Control	2.01 - 2.03 mm	0.0791 - 0.0799 in

Application	Specification	
	Metric	English
Piston - Piston to Bore Clearance - w/o polymer	0.010 - 0.041 mm	0.0004 - 0.0016 in
Valve System		
Valves - Valve Face Angle	45 Degrees	
Valves - Valve Face Runout - Maximum	0.040 mm	0.0016 in
Valves - Valve Seat Runout - Maximum	0.080 mm	0.0031 in
Valves - Valve Seat Gauge Ball Height - Exhaust	12.746 - 12.976 mm	0.4912 - 0.5038 in
Valves - Valve Seat Gauge Ball Height - Intake	12.425 - 12.653 mm	0.4892 - 0.4981 in
Valves - Valve Stem Diameter - Exhaust	5.945-5.965 mm	0.2341 - 0.2348 in
Valves - Valve Stem Diameter - Intake	5.955 - 5.975 mm	0.2344 - 0.2352 in
Valves - Valve Stem Installed Height	Check and Record	
Valves - Valve Stem to Guide Clearance - Exhaust	0.038 - 0.082 mm	0.0015 - 0.0032 in
Valves - Valve Stem to Guide Clearance - Intake	0.030 - 0.057 mm	0.0012 - 0.0022 in
Valve Lash Adjusters - Valve Lash Adjuster Diameter - Stationary Lash Adjuster	11.986 - 12.000 mm	0.0005 - 0.0020 in
Valve Lash Adjusters - Valve Lash-Adjuster-to-Bore Clearance - Stationary Lash Adjuster	0.013 - 0.051 mm	3.2210 - 3.2299 in
Valve Springs - Valve Spring Installed Height	35.0 mm	1.3779 in
Valve Springs - Valve Spring Load - Closed - @ 35 mm	247 - 273 N	56 - 61 lb
Valve Springs - Valve Spring Load - Open - @ 24 mm	598 - 662 N	134 - 149 lb

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Balance Shaft Bearings	5W-30, Dexos1 Gen 2	88865635	88865988
Cam Lobes	5W-30, Dexos1 Gen 2	88865635	88865988
Camshaft Cover ¹	Sealant	12378521	88901148
Crank Sensor O-ring	5W-30, Dexos1 Gen 2	88865635	88865988

Application	Type of Material	GM Part Number	
		United States	Canada
Cylinder Bores	5W-30, Dexos1 Gen 2	88865635	88865988
Cylinder Head Plugs	Threadlocker	12345382	10953489
Engine Block Threaded Plugs	Sealant	12346004	10953480
Engine Block to Bedplate ¹	Sealant	12378521	88901148
Engine Front Cover ¹	Sealant	12378521	88901148
Engine Oil	5W-30, Dexos1 Gen 2	88865635	88865988
Fuel Injection Pump Bolt	Threadlocker	12345382	10953489
Fuel Injector O-rings	5W-30, Dexos1 Gen 2	88865635	88865988
Fuel Injector Tip Insulators, for Multiple Port Injection Only	5W-30, Dexos1 Gen 2	88865635	88865988
Hydraulic Lash Adjusters	5W-30, Dexos1 Gen 2	88865635	88865988
Ignition Coils	Lubricant	19260901	19260902
Intake and Exhaust Valve Stems	5W-30, Dexos1 Gen 2	88865635	88865988
Lower Oil Pan ¹	Sealant	12378521	88901148
Main Bearings	5W-30, Dexos1 Gen 2	88865635	88865988
Oil Filter - Threads and O-ring Lead-in Chamfers	5W-30, Dexos1 Gen 2	88865635	88865988
Oil Level Indicator Tube O-ring	Lubricant	88862586	88862827
Oil Pan to Bedplate Joint ¹	Sealant	12378521	88901148
Oil Pump - Pump Elements	5W-30, Dexos1 Gen 2	88865635	88865988
Oxygen Sensor Threads	Anti-seize	88862477	88862478
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	5W-30, Dexos1 Gen 2	88865635	88865988
Rod Bearings - Rod Pins of Crankshaft	5W-30, Dexos1 Gen 2	88865635	88865988
Thread Repair Cutting Oil	Lubricant	1052864	992881
Thread Repair	Cleaner	88862650	88901247
Timing Chain Tensioner Cover	Sealant	12378521	88901148
Valves	Parts Immersion Solvent	12345368	10953514
Valve Rocker Arm/Valve Tip	5W-30, Dexos1 Gen 2	88865635	88865988
Water Feed Tube O-rings	Lubricant	19260901	19260902
¹ Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant			

THREAD REPAIR SPECIFICATIONS

Engine Block - Front View

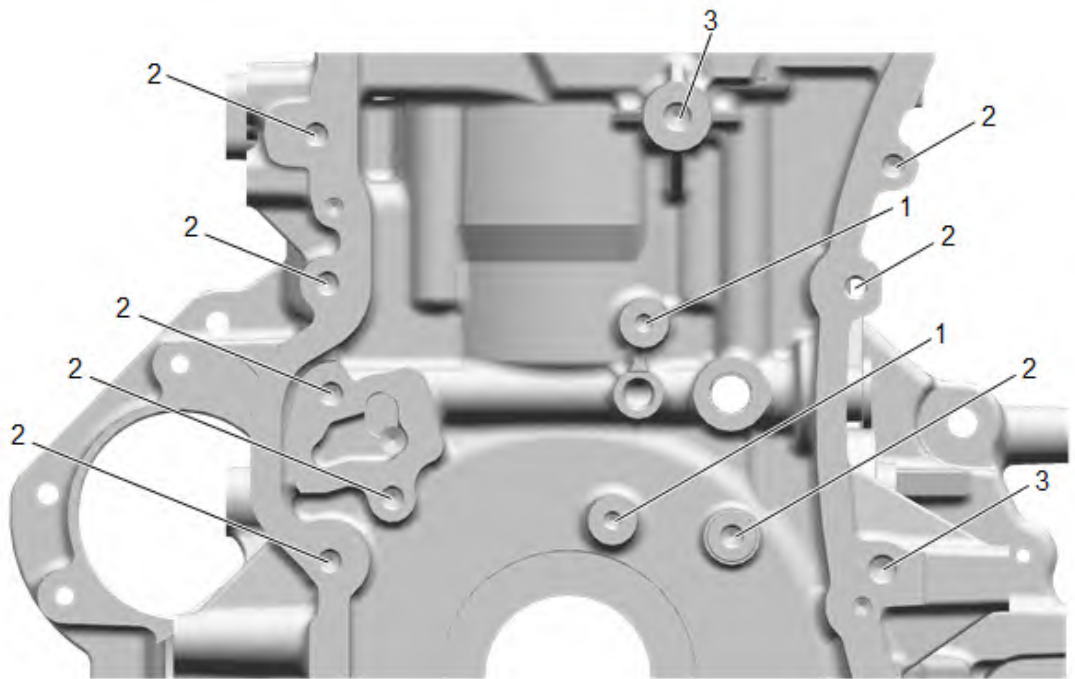


Fig. 1: Engine Block -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

Engine Block - Back View

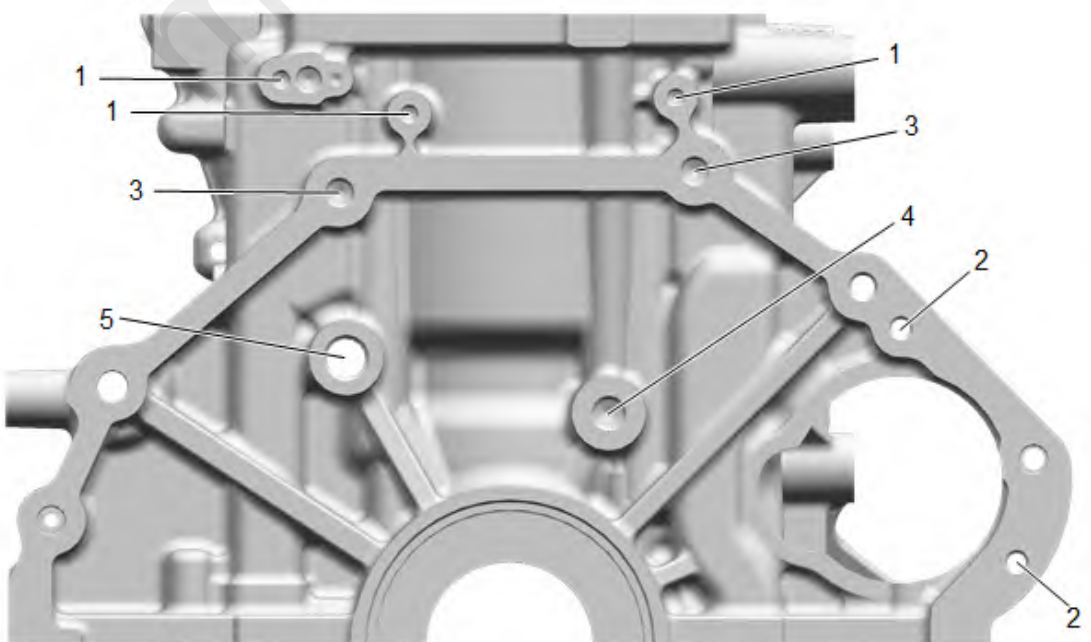


Fig. 2: Engine Block -- Back View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	24.0	1.35
4	M12x1.75	865	856	857	858	859	27.5	1.08	27.5	1.08
5	M16x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

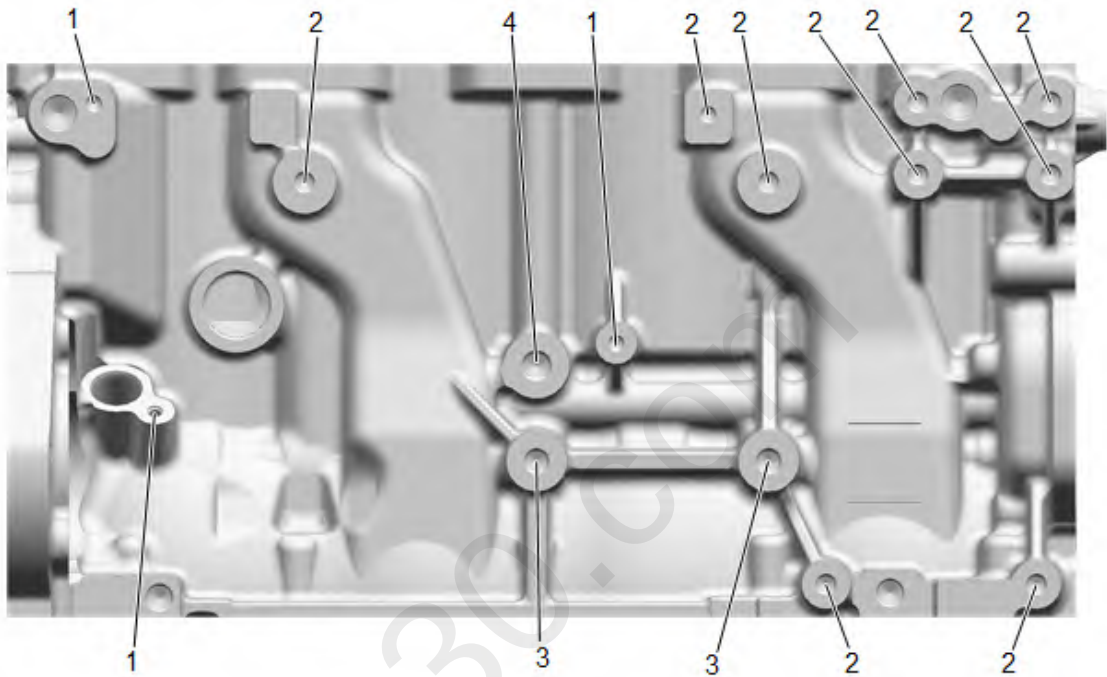
Engine Block - Right Side View

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							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	m10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M12x1.75	865	856	857	858	859	27.5	1.08	27.5	1.08

Engine Block - Bottom View

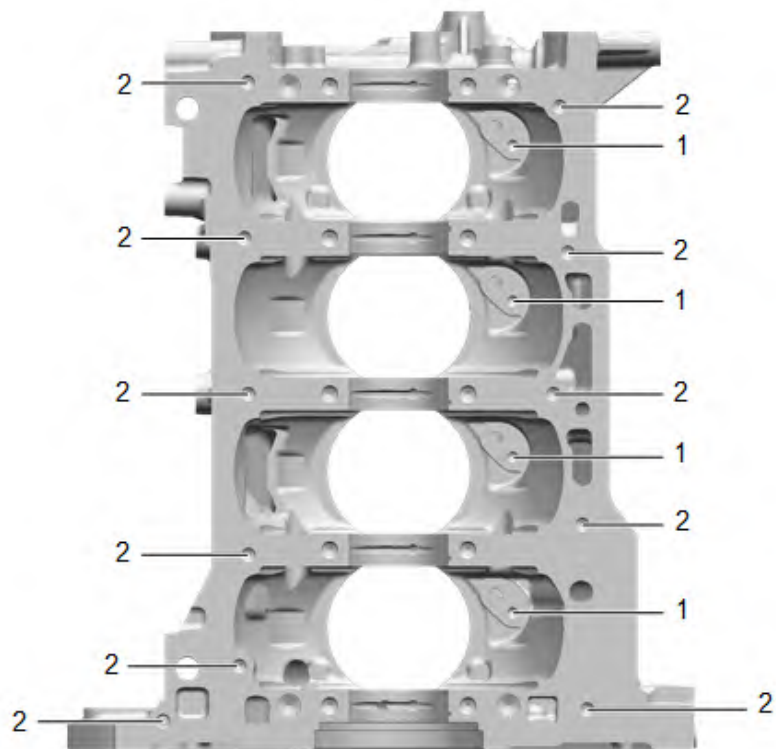


Fig. 4: Engine Block -- Bottom View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
							MM	(IN)	MM	(IN)
EN 42385										
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

Engine Block - Left Side View

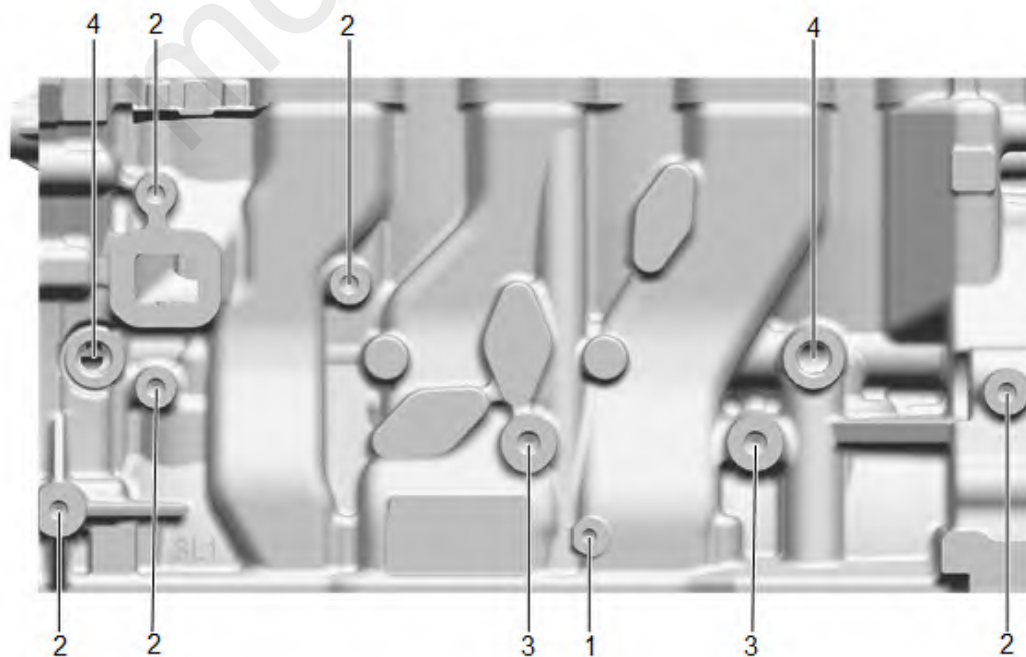


Fig. 5: Engine Block -- Left Side View
 Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M16x1.5	420	211	212	213	214	22.0	0.866	22.0	0.866

Engine Block - Top View

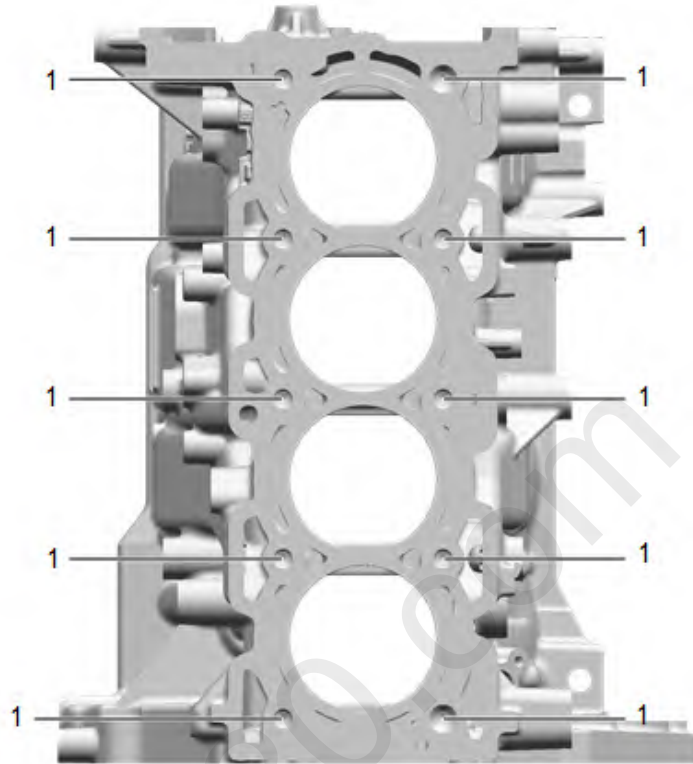


Fig. 6: Engine Block -- Top View

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)	
EN 42385							MM	(IN)	MM	(IN)
1	M11x2.0	108	723	none	724	725	88.0	3.46	80.0	3.15

Lower Crankcase - Bottom View

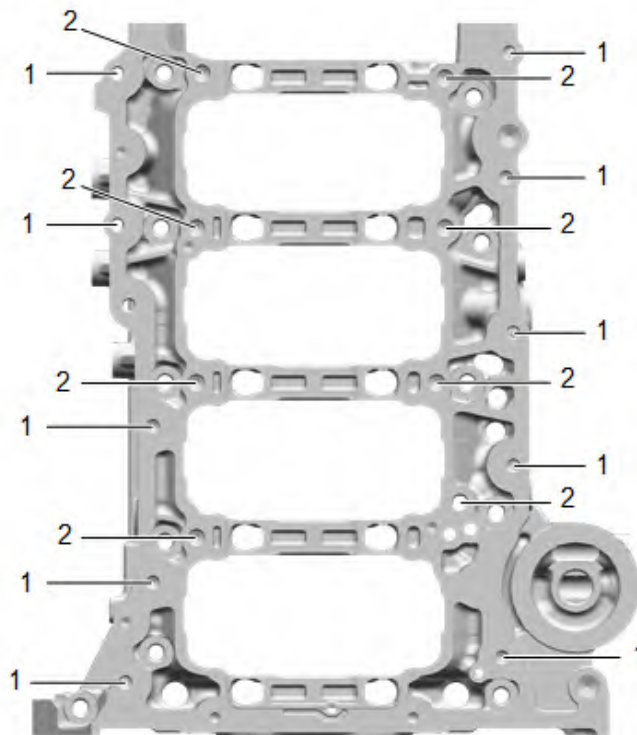


Fig. 7: Lower Crankcase -- Bottom View
Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
2	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

Lower Crankcase - Right Side View

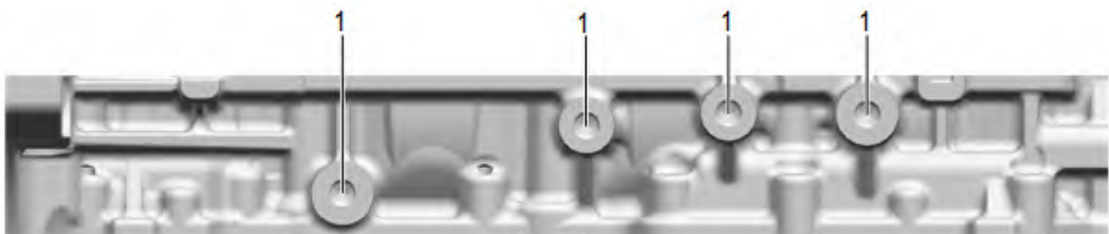


Fig. 8: Lower Crankcase -- Right Side View
Courtesy of GENERAL MOTORS COMPANY

Lower Crankcase - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

Lower Crankcase - Left Side View

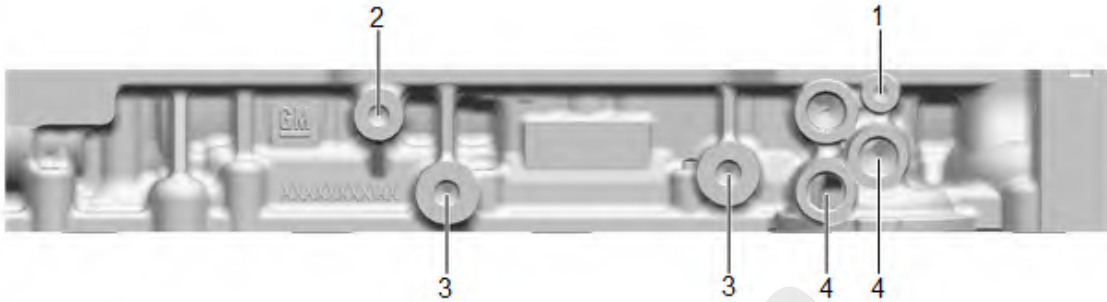


Fig. 9: Lower Crankcase -- Left Side View

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)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35
4	M16x1.5	420	211	212	213	214	22.0	0.866	22.0	0.866

Cylinder Head - Top View

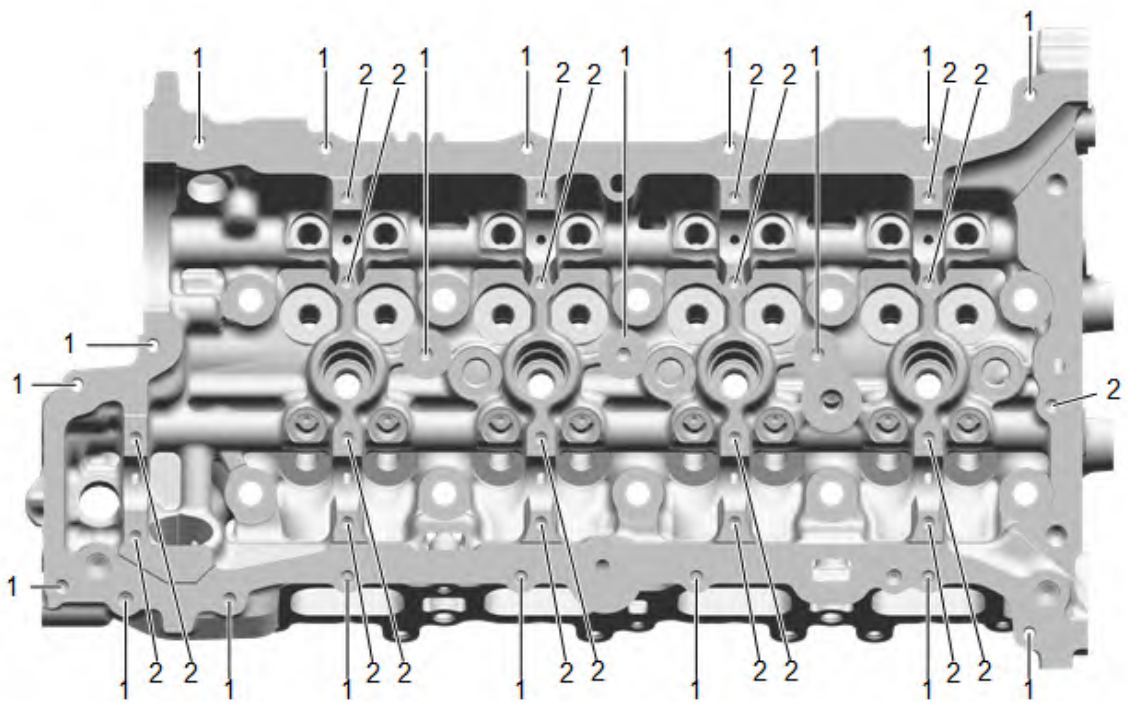


Fig. 10: Cylinder Head -- Top View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
2	M6x1.0	205	701	none	203	204	23.0	0.907	23.0	0.907

Cylinder Head Right Side View - Intake Manifold Deck Face

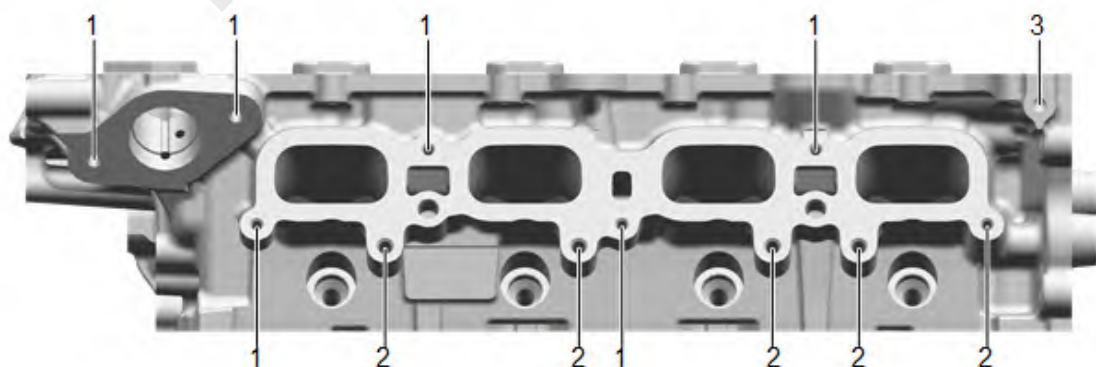


Fig. 11: Cylinder Head Right Side View -- Intake Manifold Deck Face
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head Right Side View - Intake Manifold Deck Face

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
EN 42385							MM	IN	MM	IN
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
3	M6x1.0	205	701	none	203	204	23.0	0.907	23.0	0.907

Cylinder Head Left Side View - Exhaust Manifold Deck Face

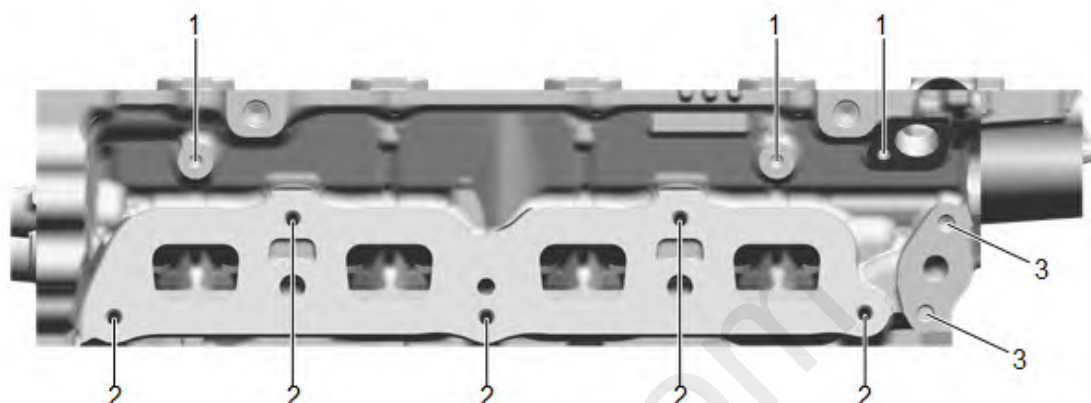


Fig. 12: Cylinder Head Left Side View -- Exhaust Manifold Deck Face

Courtesy of GENERAL MOTORS COMPANY

Cylinder Head Left Side View - Exhaust Manifold Deck Face

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385 - 850							MM	(IN)	MM	(IN)
1	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
3	M8x1.25	210	206	207	208	209	29.0	1.14	29.0	1.14

Cylinder Head - Front View

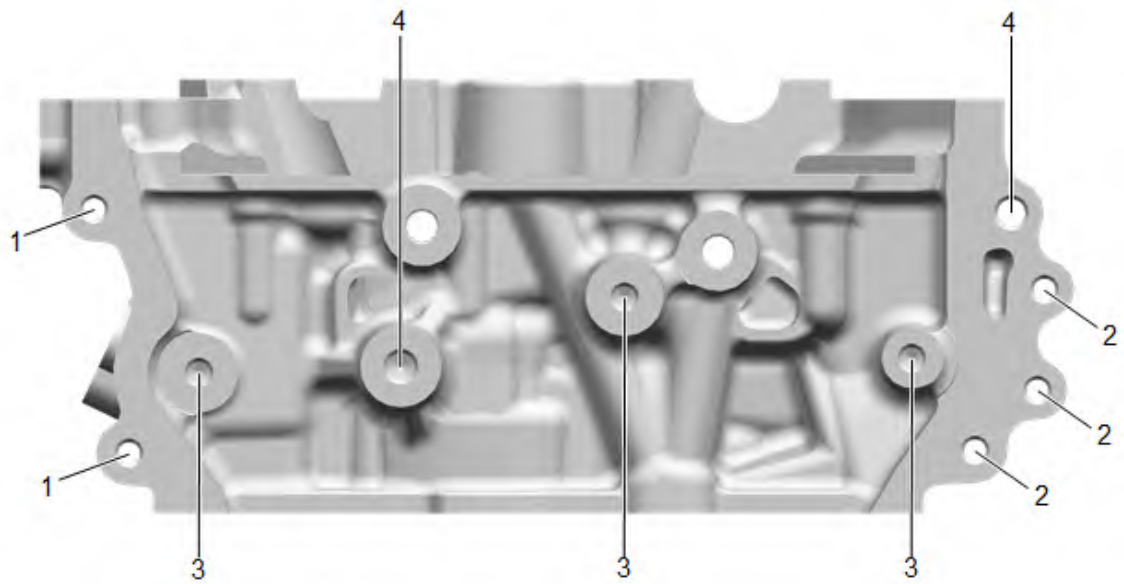


Fig. 13: Cylinder Head -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M8x1.25	18129	206	207	208	209	29.0	1.14	29.0	1.14
2	M8x1.25	18127	206	207	208	209	29.0	1.14	29.0	1.14
3	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
4	M10x1.5	420	211	212	213	214	34.0	1.35	34.0	1.35

Cylinder Head - Back View

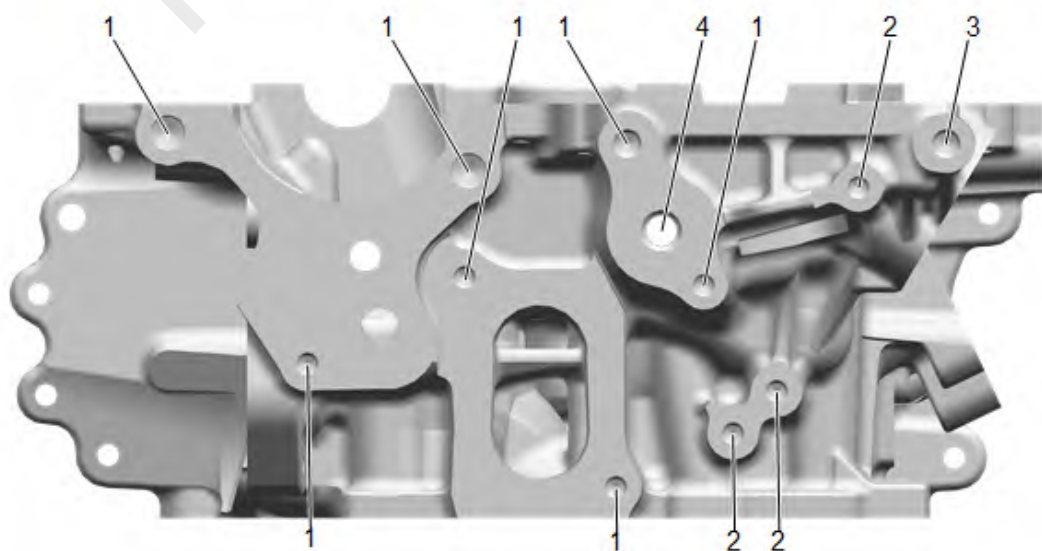


Fig. 14: Cylinder Head -- Back View
 Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth Maximum		Tap Depth Maximum	
EN 42385							MM	IN	MM	IN
1	M6X1	205	201	202	203	204	20	0.787	16	0.63
2	M6X1	205	701	none	203	204	20	0.787	16	0.63
3	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14
4	M12x1.75	865	856	857	858	859	18	0.709	14	0.551

Upper Oil Pan - Top View

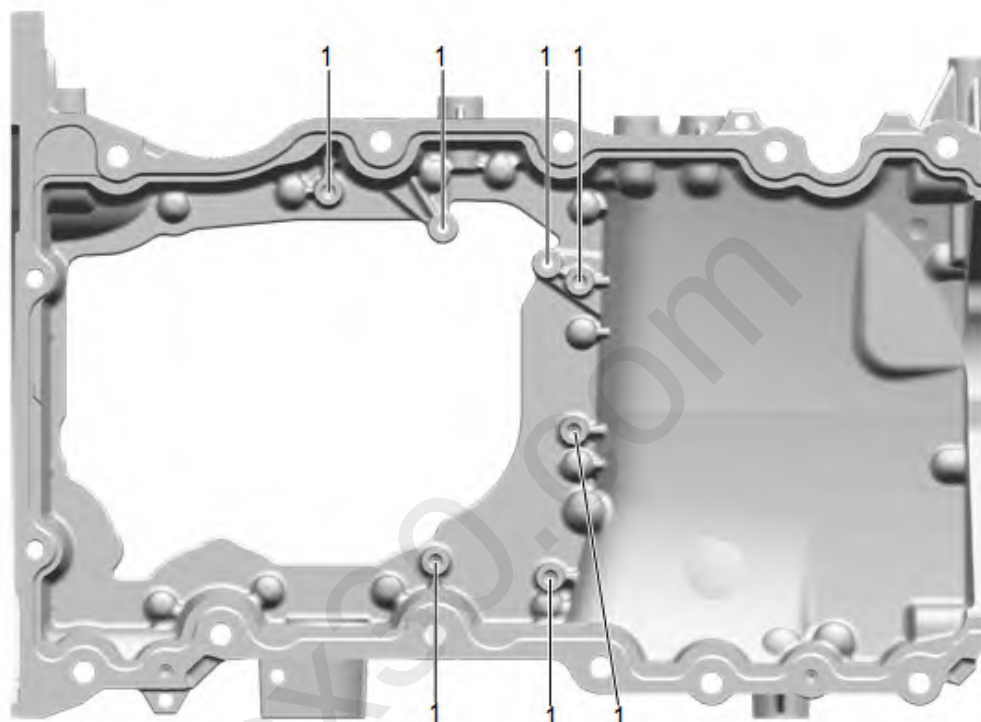


Fig. 15: Upper Oil Pan -- Top View
 Courtesy of GENERAL MOTORS COMPANY

Upper Oil Pan - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907

Upper Oil Pan - Bottom View

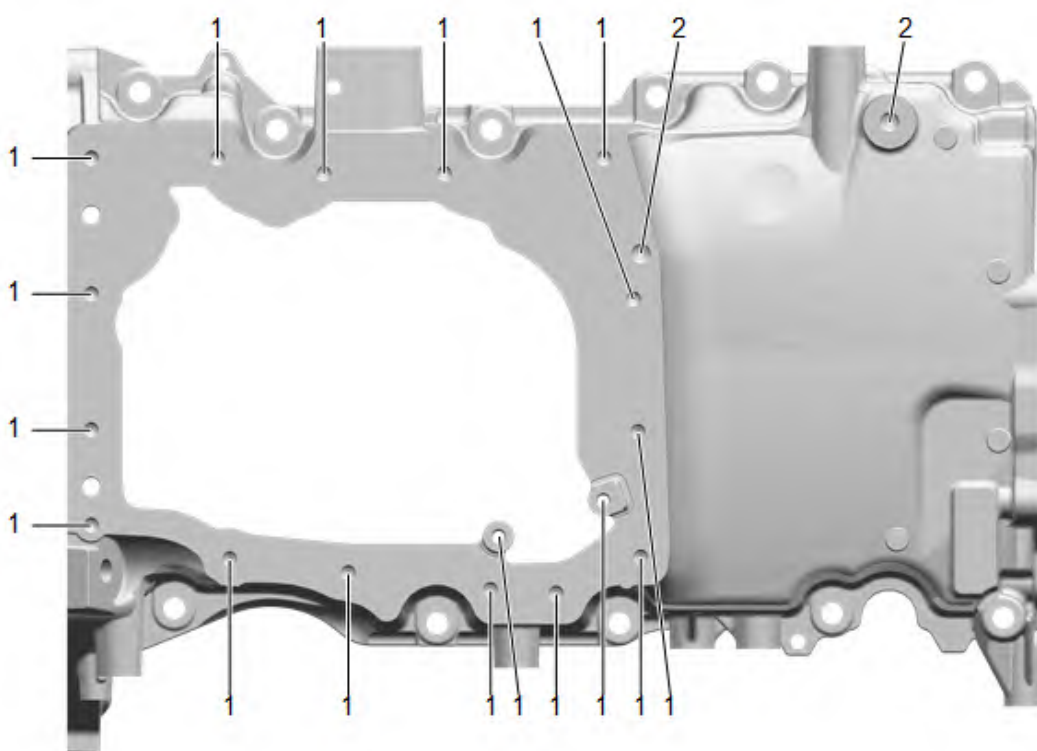


Fig. 16: Upper Oil Pan -- Bottom View
 Courtesy of GENERAL MOTORS COMPANY

Upper Oil Pan - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

Upper Oil Pan - Front View

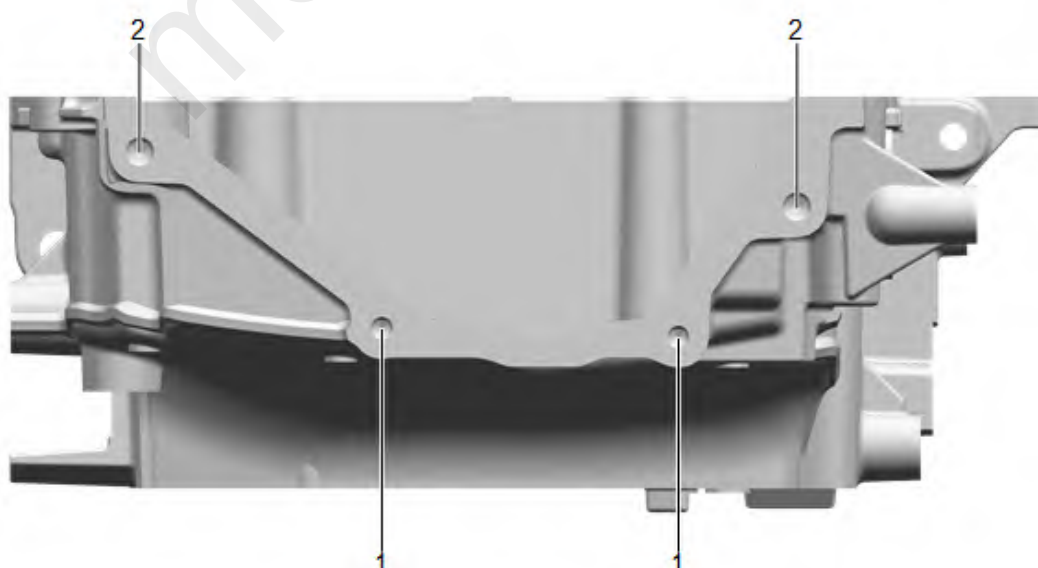


Fig. 17: Upper Oil Pan -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Upper Oil Pan - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M10x1.5	216	211	212	213	214	34.0	1.35	34.0	1.35
2	M8x1.25	181213	206	207	208	209	29.0	1.14	29.0	1.14

Upper Oil Pan - Back View

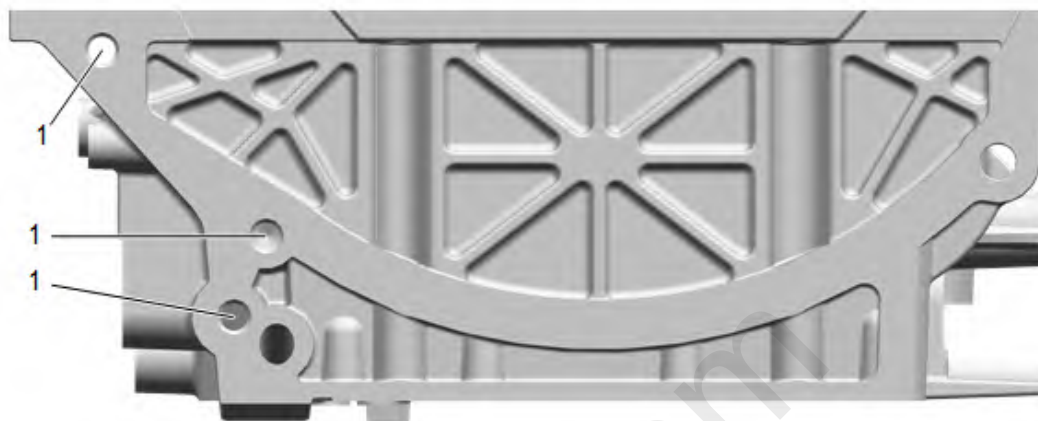


Fig. 18: Upper Oil Pan -- Back View

Courtesy of GENERAL MOTORS COMPANY

Upper Oil Pan - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385							MM	(IN)	MM	(IN)
1	M6x1.0	161031	201	202	203	204	23.0	0.907	23.0	0.907

Engine Front Cover - Top View

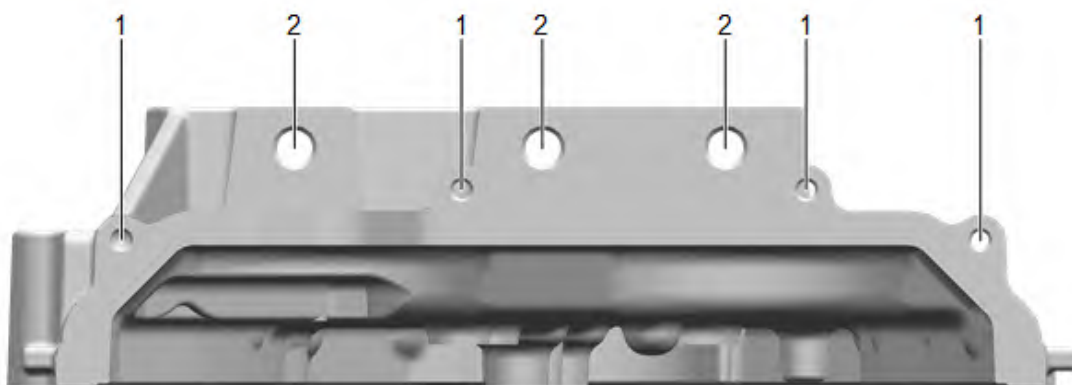


Fig. 19: Engine Front Cover -- Top View
 Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover - 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										
1	M5x0.8	3005	3001	3002	3003	3004	23.0	0.907	23.0	0.907
2	M6x1.0	205	201	202	203	204	23.0	0.907	23.0	0.907

Engine Front Cover - Front View

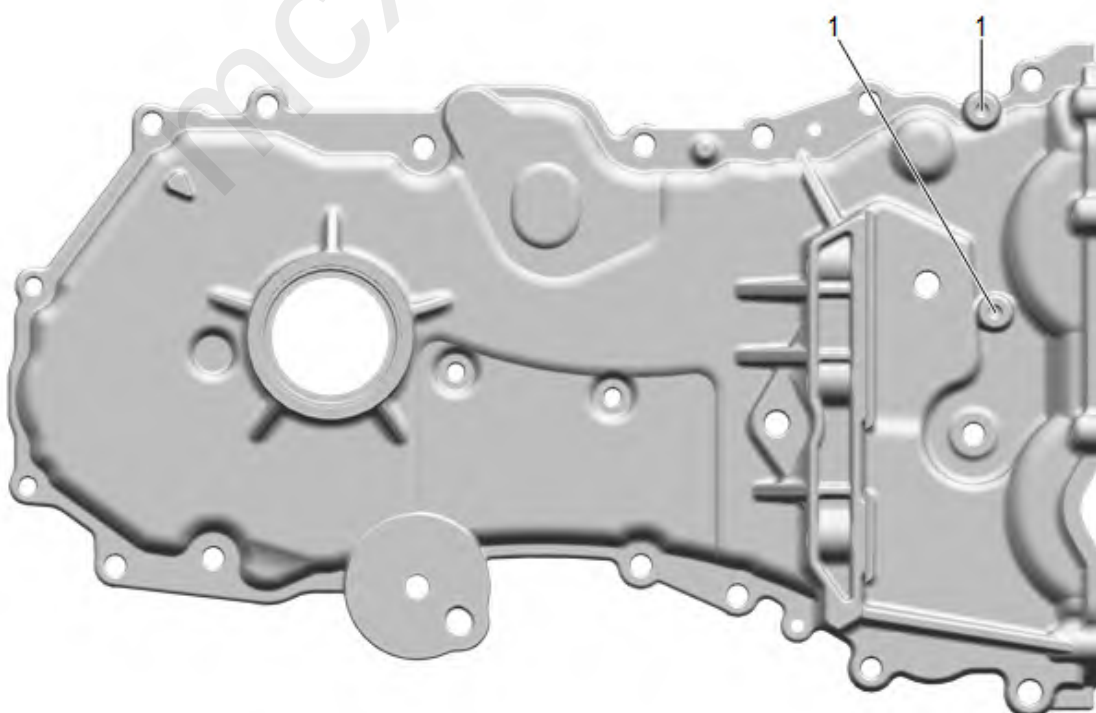


Fig. 20: Engine Front Cover -- Front View
 Courtesy of GENERAL MOTORS COMPANY

Engine Front Cover - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
EN 42385 - 850							MM	(IN)	MM	(IN)
1	M6x1.0	16105	201	202	203	204	23.0	0.907	23.0	0.907
2	M6x1.0	420	201	202	203	204	23.0	0.907	23.0	0.907

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS (2.0L (LTG))

Oil Pressure Control (LTG)

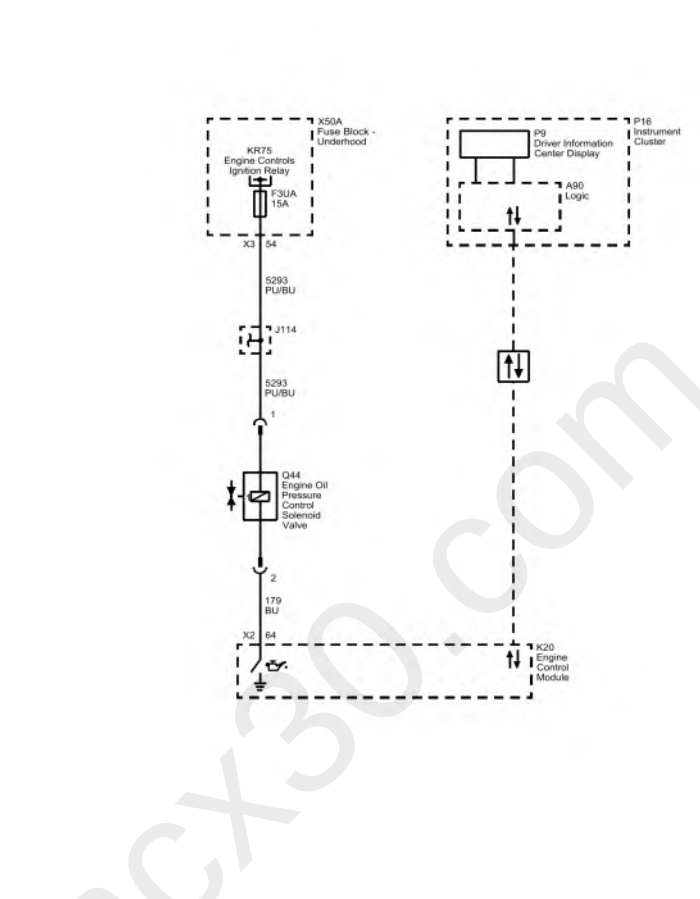


Fig. 21: Oil Pressure Control (LTG)
Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Camshaft Cover and Components

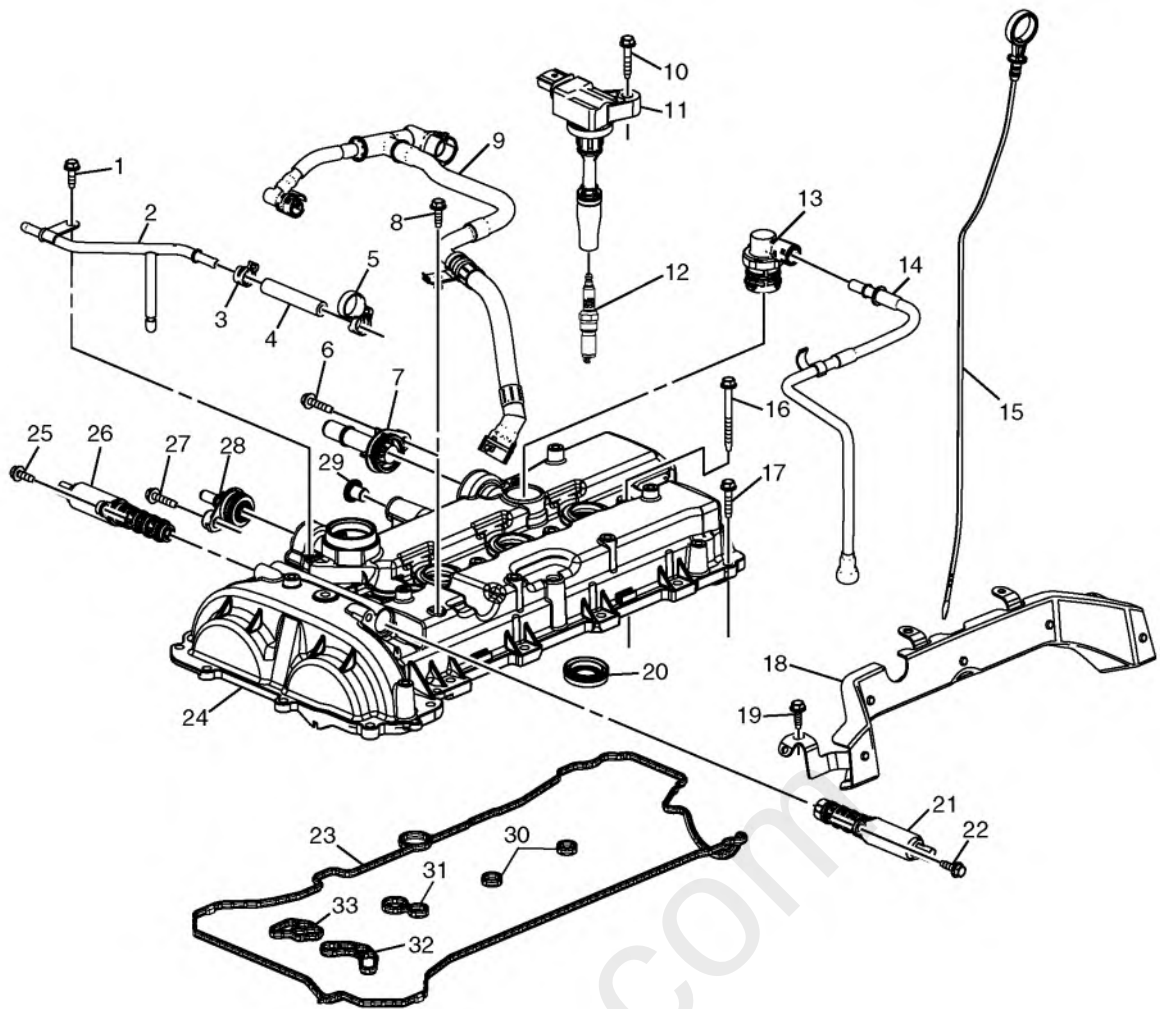


Fig. 22: Camshaft Cover and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Air Bleed Pipe Bolt
2	Engine Coolant Air Bleed Pipe
3	Engine Coolant Air Bleed Hose Clamp
4	Engine Coolant Air Bleed Hose
5	Engine Coolant Air Bleed Hose Clamp
6	PCV Valve Bolt
7	PCV Valve
8	PCV Tube Assembly Bolt
9	PCV Tube Assembly
10	Ignition Coil Bolt
11	Ignition Coil
12	Spark Plug
13	PCV Valve Assembly
14	PCV Tube Assembly
15	Oil Level Indicator
16	Camshaft Cover Bolt
17	Camshaft Cover Bolt
18	Camshaft Housing Cover Heat Shield
19	Camshaft Housing Cover Heat Shield Bolt
20	Spark Plug Shield Seal
21	Camshaft Position Actuator Control Solenoid Valve - Exhaust
22	Camshaft Position Actuator Control Solenoid Valve Bolt - Exhaust
23	Camshaft Cover Gasket
24	Camshaft Cover

Callout	Component Name
25	Camshaft Position Actuator Control Solenoid Valve Bolt - Intake
26	Camshaft Position Actuator Control Solenoid Valve - Intake
27	PCV Valve Bolt
28	PCV Valve
29	Camshaft Cover Plug
30	Camshaft Cover Inner Gasket
31	Camshaft Cover Inner Gasket
32	Exhaust Camshaft Cover Gasket
33	Intake Camshaft Cover Gasket

Cylinder Head and Components

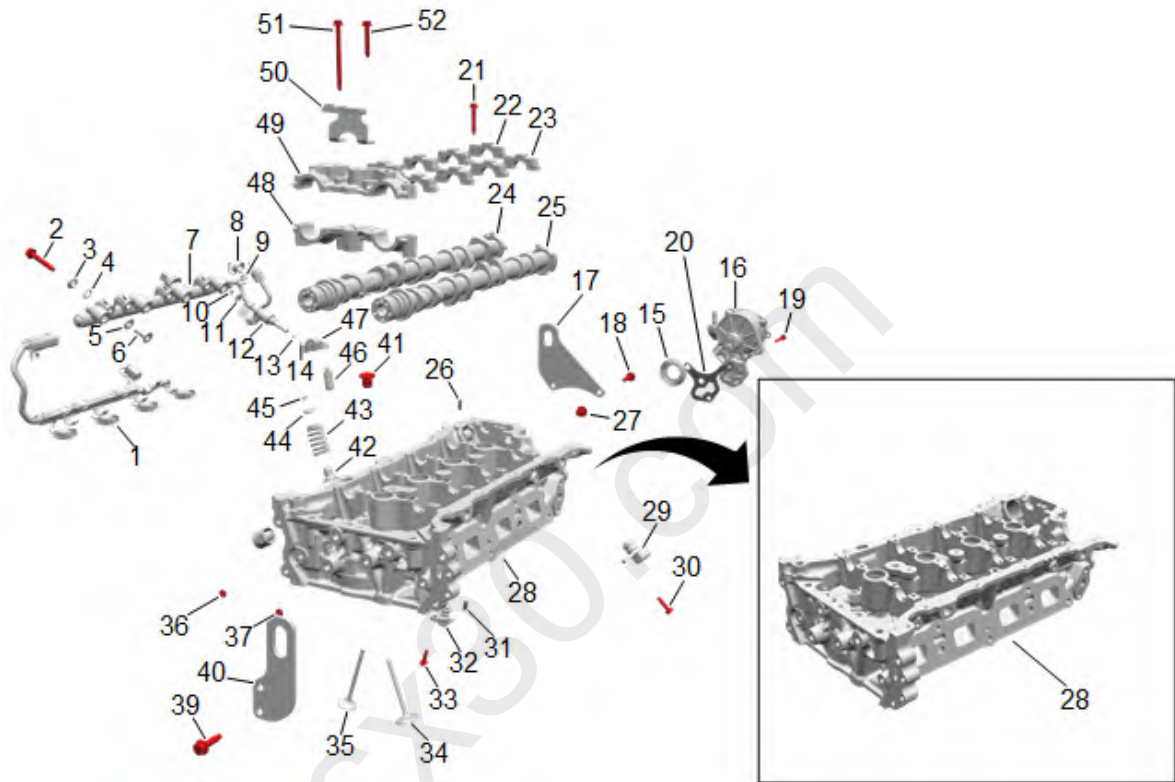


Fig. 23: Cylinder Head and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injector Wiring Harness
2	Fuel Injection Fuel Rail Bolt
3	Fuel Rail Insulator Bushing
4	Fuel Rail Insulator Washer
5	Fuel Rail Insulator Washer
6	Fuel Rail Insulator Sleeve
7	Fuel Injection Fuel Rail
8	Fuel Injector Holding Clamp
9	Fuel Injector Retainer
10	Fuel Injection Fuel Rail O-Ring Seal
11	Fuel Injector Seal Spacer
12	Direct Fuel Injector Assembly
13	Fuel Injector Nozzle Housing Seal
14	Fuel Injector Nozzle Housing Seal
15	Vacuum Pump Seal
16	Vacuum Pump Assembly
17	Engine Rear Lift Bracket
18	Engine Rear Lift Bracket Bolt

Callout	Component Name
19	Vacuum Pump Bolt
20	Vacuum Pump Gasket
21	Camshaft Bearing Cap Bolt
22	Camshaft Bearing Cap
23	Camshaft Bearing Cap
24	Intake Camshaft
25	Exhaust Camshaft
26	Cylinder Head Locating Pin
27	Cylinder Head Oil Gallery Plug
28	Cylinder Head
29	Camshaft Position Sensor
30	Camshaft Position Sensor Bolt
31	Cylinder Head Oil Gallery Restrictor
32	Camshaft Position Sensor
33	Camshaft Position Sensor Bolt
34	Intake Valve
35	Exhaust Valve
36	Cylinder Head Oil Gallery Plug
37	Cylinder Head Oil Gallery Plug
38	Engine Front Lift Bracket Bolt
39	Engine Front Lift Bracket
40	Valve Lifter Follower
41	Cylinder Head Core Hole Plug
42	Valve Stem Oil Seal
43	Valve Spring
44	Valve Spring Retainer
45	Valve Stem Key
46	Hydraulic Valve Lash Adjuster
47	Valve Rocker Arm
48	Camshaft Bearing Front Lower Cap
49	Camshaft Bearing Front Cap
50	Timing Chain Cam to Cam Guide
51	Camshaft Bearing Cap Bolt
52	Timing Chain Guide Bolt

Intake Manifold and Components

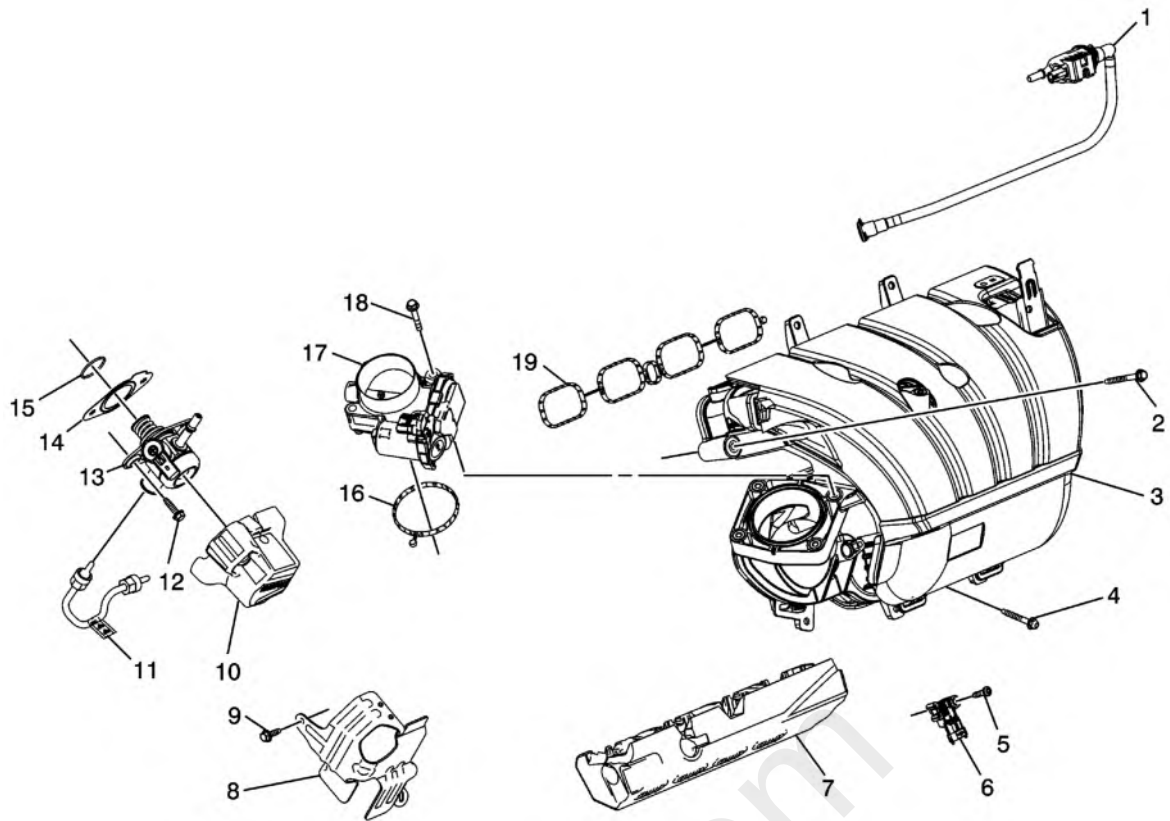


Fig. 24: Intake Manifold and Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Evaporative Emission Canister Purge Valve Assembly
2	Intake Manifold Bolt
3	Intake Manifold
4	Intake Manifold Bolt
5	Manifold Absolute Pressure (MAP) Sensor Bolt
6	Manifold Absolute Pressure (MAP) Sensor
7	Fuel Rail Noise Shield
8	Fuel Pump Cover
9	Fuel Pump Cover Bolt
10	Fuel Pump Insulator
11	Fuel Feed Intermediate Pipe Assembly
12	Fuel Pump Bolt
13	Fuel Pump
14	Fuel Pump Housing Gasket
15	Fuel Pump Housing O-Ring Seal
16	Throttle Body Assembly Gasket
17	Throttle Body Assembly
18	Throttle Body Assembly Bolt
19	Intake Manifold Gasket

Turbocharger and Components

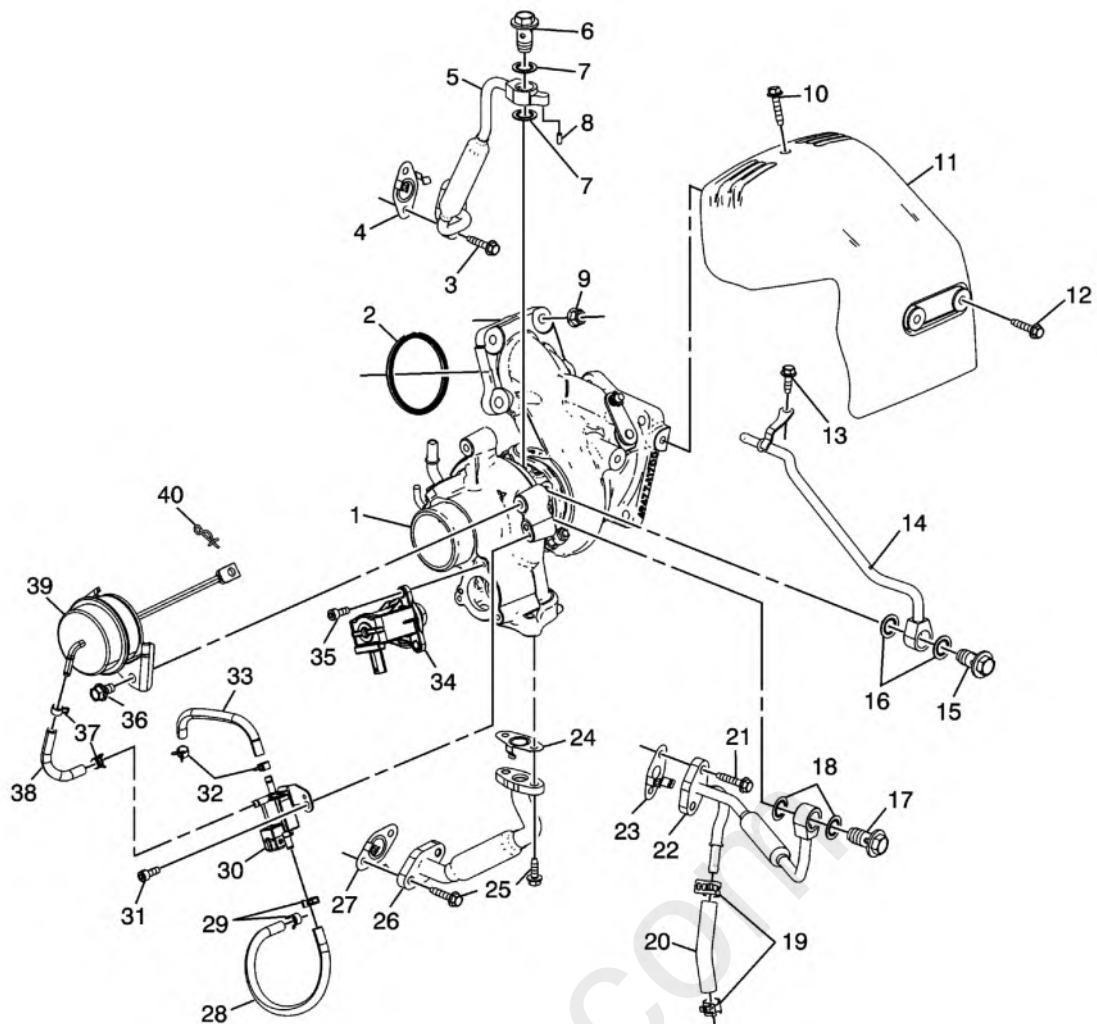


Fig. 25: Turbocharger and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger
2	Turbocharger Gasket
3	Turbocharger Oil Feed Pipe Bolt
4	Turbocharger Oil Feed Pipe Gasket
5	Turbocharger Oil Feed Pipe Assembly
6	Turbocharger Oil Feed Pipe Bolt
7	Turbocharger Oil Feed Pipe Washer
8	Turbocharger Oil Feed Pipe Anti-Rotate Roll Pin
9	Turbocharger Nut
10	Turbocharger Heat Shield Bolt
11	Turbocharger Heat Shield
12	Turbocharger Heat Shield Bolt
13	Turbocharger Coolant Return Pipe Bolt
14	Turbocharger Coolant Return Pipe Assembly
15	Turbocharger Coolant Return Pipe Bolt
16	Turbocharger Coolant Return Pipe Washer
17	Turbocharger Coolant Feed Pipe Bolt
18	Turbocharger Coolant Feed Pipe Washer
19	Turbocharger Coolant Feed Hose Clamp
20	Turbocharger Coolant Feed Hose
21	Turbocharger Coolant Feed Pipe Bolt
22	Turbocharger Coolant Feed Pipe Assembly
23	Turbocharger Coolant Feed Pipe Gasket
24	Turbocharger Oil Return Pipe Gasket

Callout	Component Name
25	Turbocharger Oil Return Pipe Bolt
26	Turbocharger Oil Return Pipe Assembly
27	Turbocharger Oil Return Pipe Gasket
28	Turbocharger Wastegate Regulator Solenoid Valve Hose
29	Turbocharger Wastegate Regulator Solenoid Valve Hose Clamp
30	Turbocharger Wastegate Regulator Solenoid Valve
31	Turbocharger Wastegate Regulator Solenoid Valve Bolt
32	Turbocharger Wastegate Regulator Solenoid Valve Hose Clamp
33	Turbocharger Wastegate Regulator Solenoid Valve Hose
34	Turbocharger Air Bypass Valve Solenoid
35	Turbocharger Air Bypass Valve Solenoid Bolt
36	Turbocharger Wastegate Actuator Bolt
37	Turbocharger Wastegate Actuator Hose Clamp
38	Turbocharger Wastegate Actuator Hose
39	Turbocharger Wastegate Actuator
40	Turbocharger Wastegate Actuator Arm Retaining Clip

Exhaust Manifold and Components

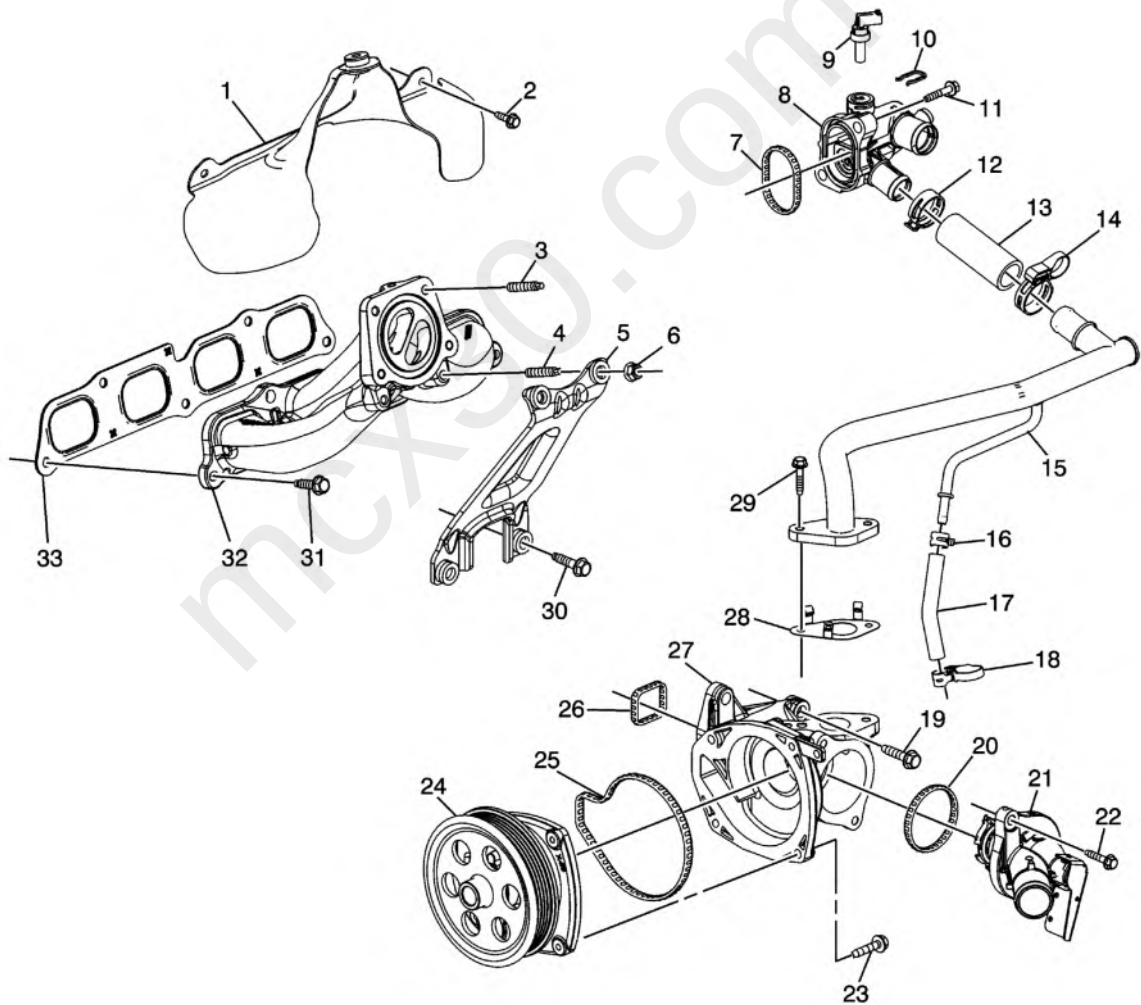


Fig. 26: Exhaust Manifold and Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Heat Shield
2	Exhaust Manifold Heat Shield Bolt
3	Exhaust Manifold Stud
4	Exhaust Manifold Stud
5	Exhaust Manifold Brace

Callout	Component Name
6	Exhaust Manifold Brace Nut
7	Water Outlet Gasket
8	Water Outlet
9	Engine Coolant Temperature Sensor
10	Engine Coolant Temperature Sensor Retainer
11	Water Outlet Bolt
12	Thermal Bypass Hose Clamp
13	Thermal Bypass Hose
14	Thermal Bypass Hose Clamp
15	Thermal Bypass Pipe
16	Engine Oil Cooler Coolant Outlet Hose Clamp
17	Engine Oil Cooler Coolant Outlet Hose
18	Engine Oil Cooler Coolant Outlet Hose Clamp
19	Water Pump Bolt
20	Engine Coolant Thermostat Housing Gasket
21	Engine Coolant Thermostat Housing
22	Engine Coolant Thermostat Housing Bolt
23	Water Pump Housing Bolt
24	Water Pump Front Housing
25	Water Pump Inlet Gasket
26	Water Pump Gasket
27	Water Pump Rear Housing
28	Thermal Bypass Pipe Gasket
29	Thermal Bypass Pipe Bolt
30	Exhaust Manifold Brace Bolt
31	Exhaust Manifold Bolt
32	Exhaust Manifold
33	Exhaust Manifold Gasket

Engine Block and Components

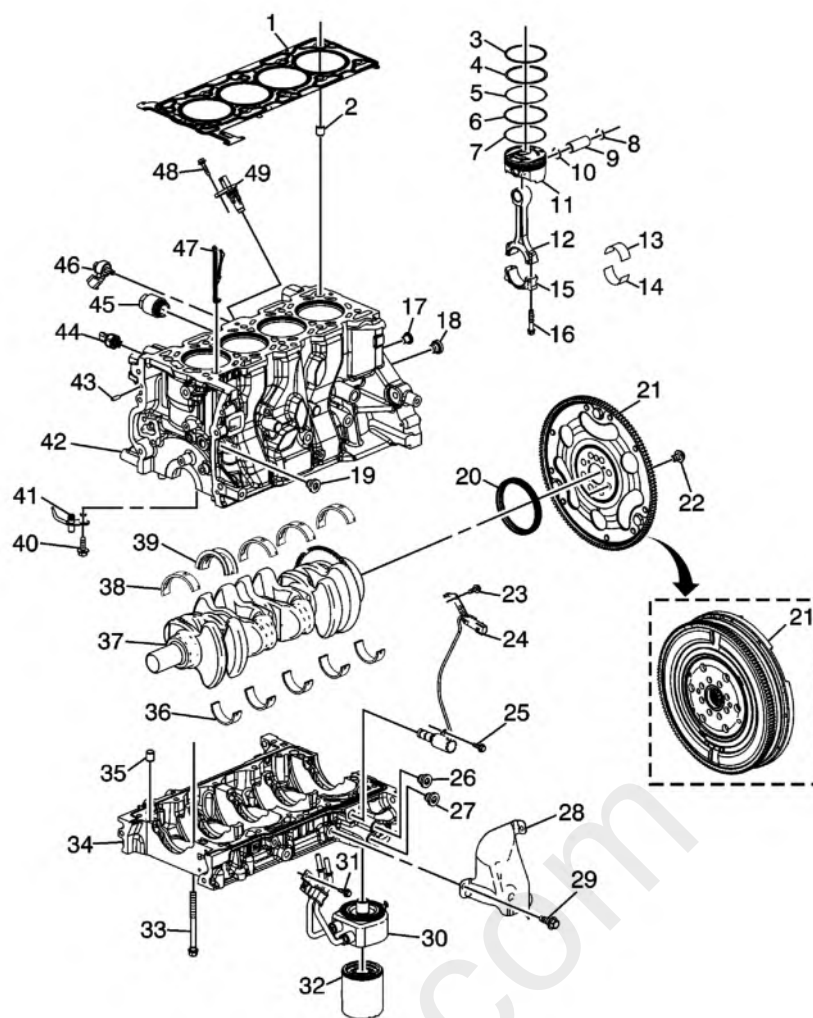


Fig. 27: Engine Block and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Cylinder Head Gasket
2	Cylinder Head Locating Pin
3	Piston Upper Compression Ring
4	Piston Lower Compression Ring
5	Piston Oil Ring Rail
6	Piston Oil Ring Rail Spacer
7	Piston Oil Ring Rail
8	Piston Pin Retainer
9	Piston Pin
10	Piston Pin Retainer
11	Piston
12	Connecting Rod
13	Connecting Rod Bearing
14	Connecting Rod Bearing
15	Connecting Rod Cap
16	Connecting Rod Bolt
17	Engine Block Oil Gallery Plug
18	Engine Block Oil Gallery Plug
19	Engine Block Oil Gallery Plug
20	Crankshaft Rear Oil Seal
21	Automatic Transmission Flex Plate
22	Automatic Transmission Flex Plate Bolt
23	Oil Pump Flow Control Valve Assembly Bolt
24	Oil Pump Flow Control Valve Assembly

Callout	Component Name
25	Oil Pump Flow Control Valve Assembly Bolt
26	Engine Block Oil Gallery Plug
27	Engine Block Oil Gallery Plug
28	Oil Pump and Compressor Heat Shield
29	Oil Pump and Compressor Heat Shield Bolt
30	Engine Oil Cooler Assembly
31	Engine Oil Cooler Assembly Bolt
32	Oil Filter
33	Lower Crankcase Bolt
34	Lower Crankcase
35	Lower Crankcase Locating Pin
36	Crankshaft Lower Bearing
37	Crankshaft
38	Crankshaft Upper Bearing
39	Crankshaft Upper Thrust Bearing
40	Piston Oil Nozzle Bolt
41	Piston Oil Nozzle
42	Engine Block
43	Engine Front Cover Locating Pin
44	Engine Oil Pressure Sensor
45	Engine Coolant Heater
46	Knock Sensor
47	Engine Block Coolant Baffle
48	Crankshaft Position Sensor Bolt
49	Crankshaft Position Sensor

Upper and Lower Oil Pan and Components - FWD

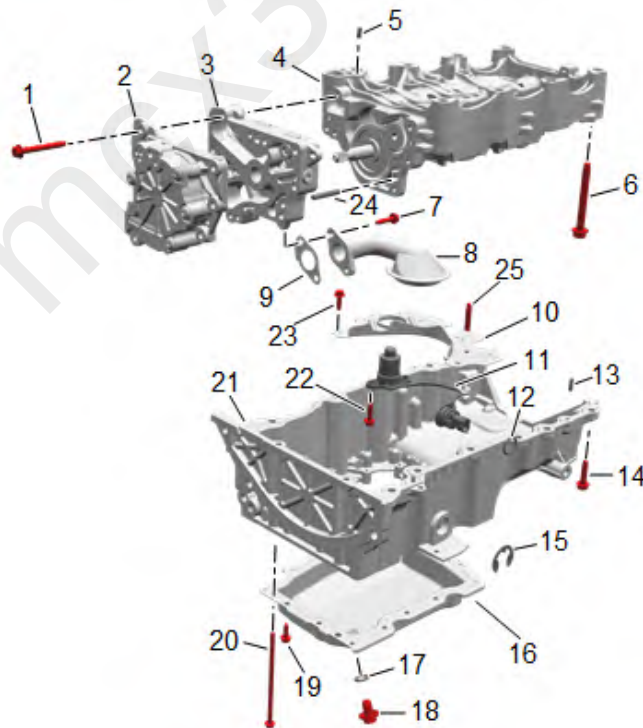


Fig. 28: Upper and Lower Oil Pan & Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Assembly Bolt
2	Oil Pump Assembly

Callout	Component Name
3	Oil Pump Cover
4	Balancer Shaft Module
5	Balancer Shaft Housing Locating Pin
6	Balancer Shaft Housing Bolt
7	Oil Pump Suction Pipe Bolt
8	Oil Pump Screen Assembly with Suction Pipe
9	Oil Pump Screen Gasket
10	Oil Pan Baffle
11	Engine Oil Level Indicator Switch
12	Engine Oil Level Indicator Seal
13	Oil Pan Locating Pin
14	Oil Pan Bolt
15	Engine Oil Level Sensor Lead Clip
16	Lower Oil Pan
17	Oil Pan Drain Plug Seal
18	Oil Pan Drain Plug
19	Oil Pan Bolt
20	Oil Pan Bolt
21	Upper Oil Pan
22	Engine Oil Level Indicator Switch Bolt
23	Oil Pan Baffle Bolt
24	Oil Pump Locating Pin

Upper and Lower Oil Pan and Components - AWD

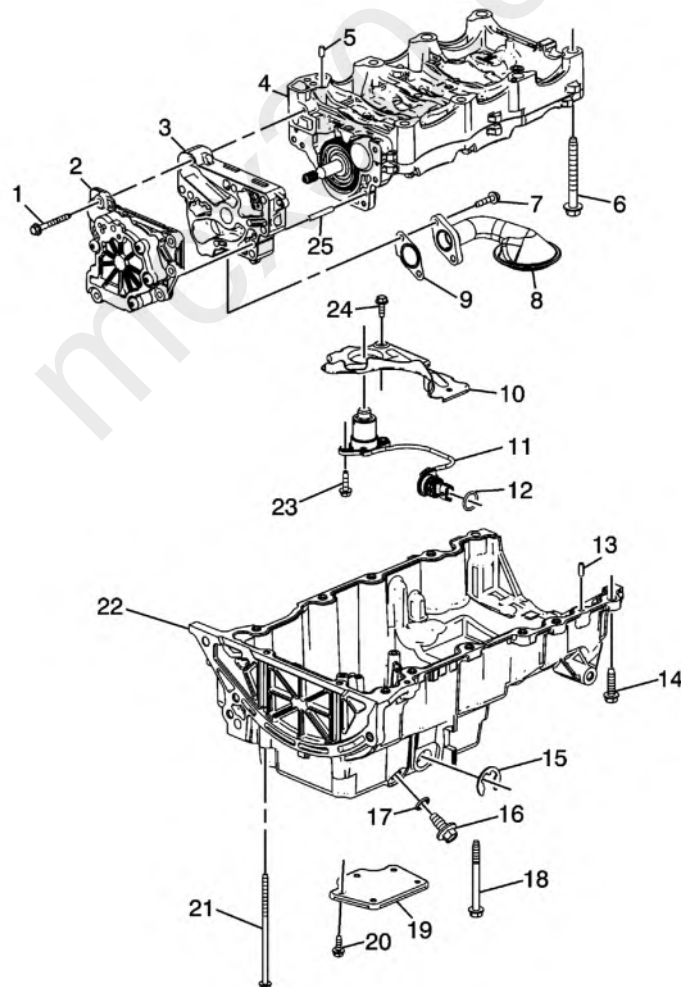


Fig. 29: Upper and Lower Oil Pan and Components - AWD
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Assembly Bolt
2	Oil Pump Assembly
3	Oil Pump Cover
4	Balancer Shaft Module
5	Balancer Shaft Housing Locating Pin
6	Balancer Shaft Housing Bolt
7	Oil Pump Suction Pipe Bolt
8	Oil Pump Screen Assembly with Suction Pipe
9	Oil Pump Screen Gasket
10	Oil Pan Baffle
11	Engine Oil Level Indicator Switch
12	Engine Oil Level Indicator Seal
13	Oil Pan Locating Pin
14	Oil Pan Bolt
15	Engine Oil Level Sensor Lead Clip
16	Oil Pan Drain Plug
17	Oil Pan Drain Plug Seal
18	Oil Pan Bolt
19	Oil Pan Cover
20	Oil Pan Cover Bolt
21	Oil Pan Bolt
22	Upper Oil Pan
23	Engine Oil Level Indicator Switch Bolt
24	Oil Pan Baffle Bolt
25	Oil Pump Locating Pin

Timing Chain and Components

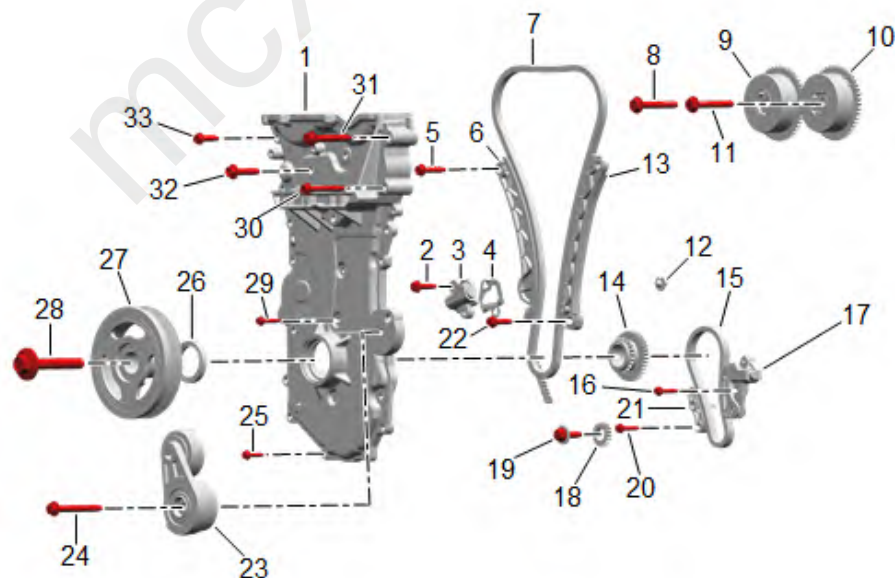


Fig. 30: Timing Chain and Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Front Cover
2	Timing Chain Tensioner Bolt

Callout	Component Name
3	Timing Chain Tensioner
4	Timing Chain Tensioner Gasket
5	Timing Chain Tensioner Pivot Arm Bolt
6	Timing Chain Tensioner Pivot Arm
7	Timing Chain
8	Camshaft Position Actuator Bolt
9	Intake Camshaft Position Actuator
10	Exhaust Camshaft Position Actuator
11	Camshaft Position Actuator Bolt
12	Timing Chain Oil Nozzle
13	Timing Chain Guide
14	Crankshaft Sprocket
15	Balancer Chain
16	Balancer Chain Tensioner Bolt
17	Balancer Chain Tensioner
18	Balancer Shaft Driven Sprocket
19	Balancer Shaft Sprocket Bolt
20	Balancer Chain Guide Bolt
21	Balancer Chain Guide
22	Timing Chain Guide Bolt
23	Drive Belt Tensioner
24	Drive Belt Tensioner Bolt
25	Engine Front Cover Bolt
26	Crankshaft Front Oil Seal
27	Crankshaft Balancer
28	Crankshaft Balancer Bolt
29	Engine Front Cover Bolt
30	Engine Front Cover Bolt
31	Timing Chain Tensioner Cover
32	Timing Chain Tensioner Cover Bolt
33	Engine Front Cover Bolt
34	Engine Front Cover Bolt
35	Engine Front Cover Bolt

ENGINE IDENTIFICATION

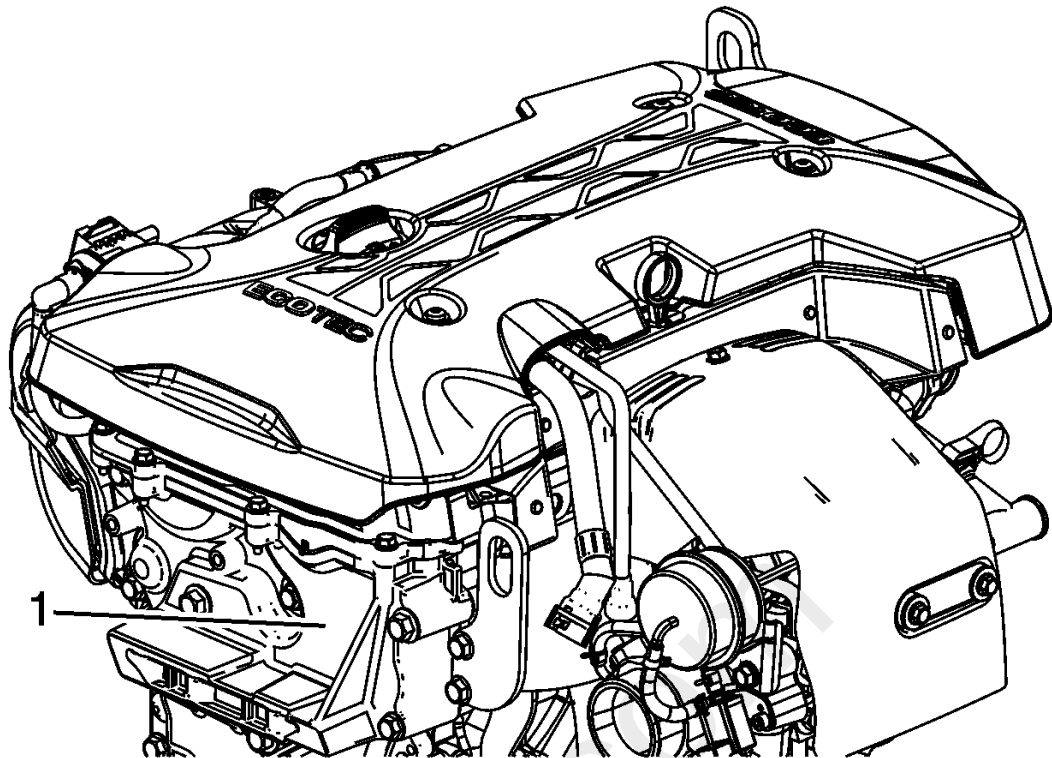


Fig. 31: Engine Identification (LTG)
 Courtesy of GENERAL MOTORS COMPANY

Identification can be made through the use of the Engine Traceability label (1) on the engine.

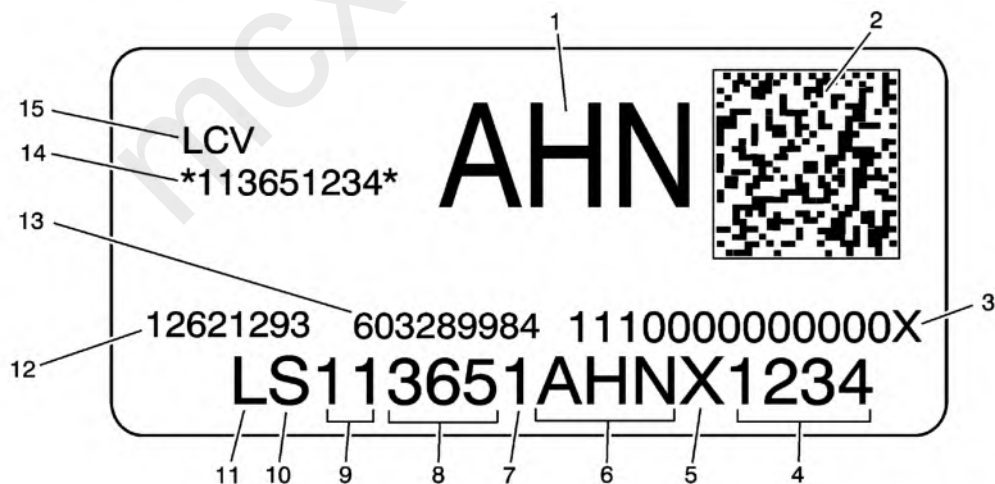


Fig. 32: Engine Traceability Label
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Broadcast Code
2	Machine Readable 2D Matrix
3	VPPS Code
4	Part Sequence Number
5	Reserved Use
6	Broadcast Code
7	Model Year

Callout	Component Name
8	Julian Date
9	Build Year
10	Shift ID
11	Plant ID
12	GM Part Number
13	Plant DUNS Number
14	Sequence Number
15	RPO/Engine Family Code

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE CONTROL

Diagnostic Instructions

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

DTC Descriptors

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open / High Resistance	Short to Voltage	Signal Performance
Ignition	P0130, P0135, P0443, P0458, P06DA, P06DB, P16CF, P16D2, P2645, P2648	P06DA, P06DB	-	-
Control	P06DB	P06DA	P06DC	P06DD, P06DE

Circuit/System Description

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

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

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

Conditions for Running the DTC

- The system voltage is greater than 11 V.
- Engine is running

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

- DTC P06DB is a Type A DTC.
- DTC P06DA and P06DC are Type B DTCs.
- ECM commands the engine oil pressure control solenoid valve Off.
- ECM commands Reduced Engine Power.

Conditions for Clearing the MIL/DTC

- DTC P06DB is a Type A DTC.
- DTC P06DA and P06DC are Type B DTCs.

Reference Information

Schematic Reference

Engine Mechanical Wiring Schematics (2.0L (LTG))

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

Refer to Circuit/System Testing.

- **Go to next step: If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

4. Verify the DTC does not set.

- **If the DTC sets**

Refer to Circuit/System Testing.

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

5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q44 Engine Oil Pressure Control Solenoid Valve, ignition ON.

2. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.

- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp.

2. Test for less than 2 Ω in the ignition circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω verify the fuse is not open and there is voltage at the fuse.

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

1. Ignition OFF, remove the test lamp.

NOTE: An short to ground in any circuit or shorted component supplied voltage by the fuse may cause the fuse to open and set a DTC.

2. Test for infinite resistance between the ignition circuit and ground

- If less than infinite resistance, repair the short to ground in the circuit.
- If infinite resistance, test all the components connected to fuse and replace as necessary.

- **Go to next step: If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the ignition circuit terminal 1 and the control circuit terminal 2.

- **If the test lamp illuminates**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2. Test for infinite resistance between the control circuit and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, replace the K20 Engine Control Module.

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

4. Remove the test lamp, command the Q44 Engine Oil Pressure Control Solenoid Valve On with a scan tool.

5. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status parameter displays OK.

- **If OK is not displayed**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

2. Test for less than 1 V between the control circuit and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V, replace the K20 Engine Control Module.

- **Go to next step: If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.

7. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Circuit High Voltage Test Status parameter displays Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve On.

- **If Malfunction is not displayed**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2. Test for less than 2 Ω in the control circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω replace the K20 Engine Control Module.

- **Go to next step: If Malfunction is displayed**

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

Component Testing

Static Test

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

Replace the Q44 Engine Oil Pressure Control Solenoid Valve.
 - **Go to next step: If between 10.0-30.0 Ω**
3. Test for infinite resistance between each terminal and the Q44 Engine Oil Pressure Control Solenoid Valve housing.
 - **If not infinite**

Replace the Q44 Engine Oil Pressure Control Solenoid Valve.
 - **Go to next step: If infinite**
4. All OK.

Repair Instructions

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

- [Oil Pump Flow Control Valve Replacement](#) for engine oil pressure control solenoid valve replacement.
- [Control Module References](#) for engine control module replacement, programming, and setup.

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

Diagnostic Instructions

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

DTC Descriptors

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

DTC P06DE

Engine Oil Pressure Control Solenoid Valve Stuck On

Circuit/System Description

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

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

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

Conditions for Running the DTC

P06DD

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

P06DE

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

Conditions for Setting the DTC

P06DD or P06DE

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

Action Taken When the DTC Sets

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type A DTC.

- Reduced Engine Power = Active
- P16 Instrument Cluster = Reduced Engine Power
- Q44 Engine Oil Pressure Control Solenoid Valve = Inactive
- Engine Oil Pressure = High

Conditions for Clearing the DTC

P06DD

DTC P06DD is a Type B DTC.

P06DE

DTC P06DE is a Type A DTC.

Reference Information

Schematic Reference

Engine Mechanical Schematics (2.0L (LTG))

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: The engine oil level and condition has a major impact on the engine oil pressure control system. Debris in the oil can interfere with the engine oil pressure control solenoid valve operation. Inspect for dirty or degraded crankcase oil. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.

1. Verify correct engine oil level and condition.
2. Engine Running, increase and maintain the engine speed at 1, 800 RPM.

NOTE: Selecting the scan tool line graph function may make it easier to identify Engine Oil Pressure changes.

3. Verify the scan tool Engine Oil Pressure parameter changes greater than 30 kPa (4 PSI) when commanding the Engine Oil Pressure Control Solenoid On and Off.
 - **If the parameter does not change**
Replace the Q44 Engine Oil Pressure Control Solenoid.
 - **Go to next step: If the parameter changes**
4. 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.
5. Verify the DTC does not set.
 - **If the DTC sets**
Refer to Oil Pressure Diagnosis and Testing.
 - **Go to next step: If the DTC is not set**
6. All OK.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Oil Pump Flow Control Valve Replacement for engine oil pressure control solenoid replacement.

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

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

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

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

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

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.

Cause	Correction
A loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Damage to the MAP sensor housing	Replace the intake manifold.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	• Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. • Repair or replace the oil pump as required. • Replace the oil control valve solenoid 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 P0300 DTC may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine, and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to 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

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Stuck valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft, valve lash adjusters, and roller finger followers.
Sticking valve lash adjusters	Replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to Oil Pressure Diagnosis and Testing. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to Camshaft Position Actuator and Camshaft Replacement - Intake, or Camshaft Position Actuator and Camshaft Replacement - Exhaust.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

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

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

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

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

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

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

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 lash adjusters	Replace the valve lash adjusters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn, damaged, or faulty timing chain tensioners	Replace tensioners
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lash adjusters as required.

Cause	Correction
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to 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	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to Symptoms - Engine Controls .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen - an oil pan that has been damaged, may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace as required.

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

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to 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
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

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

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Inspect for cracked cylinder wall.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	1. Inspect timing chain and gears. 2. Repair as required.
Seized balance shaft	1. Inspect balance shaft. 2. Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	1. Inspect cylinder for damaged components and/or foreign materials. 2. Inspect for fallen cylinder wall. 3. Repair or replace as required.

Cause	Correction
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Inspect for fallen cylinder wall. 3. Repair as required.
Bent or broken connecting rod	1. Inspect connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect crankshaft. 2. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 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 Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cylinder head or block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Cause	Correction

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 Cleaning and Inspection , and Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head and gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cylinder head or block porosity	Replace the components as required.

ENGINE COMPRESSION TEST

Special Tools

EN-51749 Compression Gauge Tester Kit

Equivalent regional tools: [Special Tools](#)

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

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 ignition coils and spark plugs from all cylinders. Refer to [Spark Plug Replacement](#).
4. 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.
5. Measure the engine compression, using the following procedure:
 1. Install the **EN-51749** adapter into the spark plug hole.
 2. Install the **EN-51749** gauge into the **EN-51749** adapter.

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

3. Enable cranking via the GDS2 or remote start switch. When using a remote start switch, crank the engine for four compression strokes. Record the reading after the cranking cycle completes.
4. Repeat the compression test for each cylinder.
6. Compare the compression readings from all of the cylinders.
 - The lowest reading should not be less than 70 percent of the highest reading.
 - No cylinder should read less than 690 kPa (100 psi).
 - For example, if the highest pressure in any 1 cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). ($1035 \times 70\% = 725$) ($150 \times 70\% = 105$).
7. 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.

8. Disconnect GDS2 diagnostic tool or remote start switch.

9. Install the spark plugs for all cylinders. Refer to [Spark Plug Replacement](#) .

10. Install the ignition coils for all cylinders. Refer to [Ignition Coil Replacement](#) .

TURBOCHARGER LEAKING FLUIDS EXTERNALLY

Condition	Action
Leaking Coolant from Coolant interfaces; Feed and/or Return Pipe	• Inspect Seal Surfaces on Bearing Housing, Pipes, and Banjo Bolt • If Turbo Seal Surface is damaged replace turbo • If Pipe Seal Surface is damaged replace Pipe • If Banjo Bolt Seal Surface is damaged replace Banjo Bolt • Reassemble with new seals in all cases
Leaking Coolant from area other than Coolant interfaces; NOT Feed and/or Return Pipe	Replace component that is leaking
Leaking Oil from Oil interfaces; Feed and/or Return Pipe	• Inspect Seal Surfaces on Bearing Housing, Pipes, and Bolts • If Turbo Seal Surface is damaged replace turbo • If Pipe Seal Surface is damaged replace Pipe • If Bolt Seal Surface is damaged replace Bolt • Reassemble with new seals in all cases
Oil on Compressor Cover	• Check for correct PCV System functionality, refer to Crankcase Ventilation System Inspection/Diagnosis • Check Turbocharger Oil Drain Pipe for restriction • Check PCV connection in Compressor Housing, inspect O-ring • Check Fresh Air Duct connection at Compressor inlet, look for damage and replace if necessary • Check Compressor Outlet connection, look for damage and replace if necessary
All Other External Turbocharger Leaks	Replace Turbocharger

TURBOCHARGER HISSING NOISE

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

Condition	Action
Leaking or restricted intake system	- Using less than 34 kPa (5 PSI) to pressurize the intake system, inspect for leaks in the following components: - Charge Air Cooler - Charge Air Cooler Outlet and Inlet Ducts - Intake Manifold - Purge Lines - Inspect for obstructions in the intake system.

TURBOCHARGER NOISE

Some noise is normal. Compare to a known good vehicle.

Condition	Action
Compressor Inlet leaks or Obstructions	Inspect for leaks or obstructions in the Turbocharger inlet.
Compressor Outlet Leaks or Obstruction	Inspect for leaks or obstructions in the Turbocharger outlet.
Charge Air Cooler and Engine Intake system Leaks or Obstructions	- Inspect for leaks - Inspect for obstructions
Damaged Electric Recirculation Valve	- Check Seal to Compressor Cover - Check DTCs for Bypass/Recirculation codes, replace if necessary
Compressor/Turbine Wheel Damage - Bent or Broken Blades	Replace the Turbocharger.
Compressor/Turbine Wheel to Housing contact	Replace the Turbocharger.

TURBOCHARGER SMOKE OR SMELL

Condition	Action
Oil or Coolant Leak	Correct the leak.
Exhaust Leak	- Inspect Gaskets and Sealing Surfaces - Correct Leak - Look for external cracks in Turbocharger components NOTE: Cracks in the Turbine Inlet Partition Wall are acceptable. - Replace turbocharger assembly if external cracks found
Nearby Component Out of Position/Touching Turbocharger	Check for Turbine housing for contact with nearby components.

TURBOCHARGER LOSS OF BOOST PRESSURE

Condition	Action

Condition	Action
Perceived Loss of Boost	• Check DTC codes • No Codes Present - Do not replace Turbocharger

CYLINDER LEAKAGE TEST

Special Tools

EN 35667-A Cylinder Head Leakdown Tester

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

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

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

WARNING: Unless directed otherwise, the ignition must be OFF with the key removed, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.

For Vehicles equipped with OnStar® (UE1) with Back Up Battery:

The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar® module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power should be allowed to time out or be disabled (simply opening the driver door should disable retained accessory power) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with retained accessory power activated may cause activation of the OnStar® Back-Up Battery system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The back-up battery is not rechargeable and once activated the back-up battery must be replaced.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to [Spark Plug Replacement](#) in Engine Controls.
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 35667-A tester or equivalent.

NOTE: It may be necessary to hold the crankshaft balancer bolt to prevent the engine from rotating.

5. Apply shop air pressure to the **EN 35667-A** tester and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
 - Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
 - Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
 - Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
 - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

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

- External oil leaks
tighten bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator
With the vehicle on a level surface, allow adequate drain down time and inspect for the correct oil level.
- Improper oil viscosity
Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, or the seal omitted
Ream guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly
Allow adequate time for rings to seat. Replace broken or worn rings, as necessary.
- Piston improperly installed or mis-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-21867-850** Oil Pressure Gauge Adapter
- **GE-21867-A** Oil Pressure Gauge Kit

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

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

Add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
2. Run the engine, and verify low, or no oil pressure on the vehicle gauge or light.

Listen for a noisy valve train or a knocking noise.
3. Inspect for the following:

- Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
- Oil diluted by moisture or unburned fuel mixtures
- Improper oil viscosity for the expected temperature
- Incorrect or malfunctioning oil pressure sender
- Incorrect or malfunctioning oil pressure gauge
- Plugged oil filter
- Malfunctioning oil bypass valve

4. Remove the oil pressure sender or another engine block oil gallery plug.

5. Install **EN-21867-850** adapter and **GE-21867** gauge and measure the engine oil pressure.

6. Compare the readings to specifications. Refer to [Engine Mechanical Specifications](#).

7. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:

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

Refer to [Balancer Shaft with Oil Pump Cleaning and Inspection](#).

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

Refer to [Crankshaft and Bearing Cleaning and Inspection](#).

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

Refer to [Engine Block Assemble](#).

- Broken lash adjusters

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
DEFINITION: You can repair most fluid leaks by first, visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. Refer to 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. Check for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3

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. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, for example, baby powder or foot powder, to the suspected area. 3. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 8

Step	Action	Yes	No
8	Use EN 28428-E Dye and Light Kit, in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK
11	Repair or replace all damaged or modified components. Did you complete the repair?	Go to Step 1	-

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Special Tools

EN 23951 Valve Manometer

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

1. Verify clean air cleaner.
2. Verify oil fill cap is in place.
3. Verify oil level indicator is installed.
4. Remove the oil level indicator. Install a **EN 23951** valve manometer or equivalent, into the oil level indicator hole.
5. Start the engine.
6. Check for slight vacuum. The vacuum level should be less than 3.377 kPa (13.571 in H² O).
7. If vacuum is higher, inspect and verify that the clean air hose from cam cover to air intake is not blocked or kinked.
8. If vacuum is in the normal range, remove the PCV line from the fresh air valve near oil fill cap. Block fresh air valve and also plug the fresh air hose. Vacuum should increase on the manometer. If held too long, vacuum

will be drawn through the crankshaft seals creating a sucking sound.

9. If vacuum does not increase, the orifice in the camshaft cover assembly could be plugged. The valve is between the camshaft cover assembly and the cylinder head assembly.
10. If there is zero vacuum or pressure, verify compression of the engine.
11. If compression is normal, check for a blocked orifice at the camshaft cover assembly. Clean the orifice.
12. The hose from valve cover to the turbo is also for the positive crankcase ventilation (PCV) and is used for PCV flow under normal operation and only PCV flow during turbo boost conditions. If the hose is plugged, replace the PCV hose assembly and PCV fitting assembly at the turbocharger.

Concern	Action
External Oil Leak	Inspect for any of the following conditions: • Plugged air intake system • Plugged positive crankcase ventilation (PCV) orifice/check valve in the camshaft cover assembly • Plugged or kinked PCV hoses • Damaged or incorrectly installed PCV hoses • Excessive crankcase pressure • Plugged PCV hose from camshaft cover to turbocharger
Rough Idle	Inspect for any of the following conditions: • Plugged or incorrectly installed air intake system • Plugged PCV orifice/check valve in the camshaft cover assembly • Plugged or kinked PCV hoses • Leaking or damaged PCV hoses • Leaking PCV hose from camshaft cover to turbocharger
Stalling or Slow Idle Speed	Inspect for any of the following conditions: • Plugged air intake system • Plugged PCV orifice in the camshaft cover assembly • Plugged or kinked PCV hoses • Leaking or damaged PCV hoses • Leaking PCV hose from camshaft cover to turbocharger
High Idle Speed	Inspect for any of the following conditions: • Air intake system incorrectly installed • Leaking or damaged PCV hoses
Sludge in the Engine	Inspect for any of the following conditions: • Plugged or incorrectly installed air intake system • Plugged PCV orifice in the camshaft cover assembly • Plugged or kinked PCV hoses • Plugged PCV hose from camshaft cover to turbocharger

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.

- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, worn, misaligned drive belt pulleys 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.

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

19

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

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

Step	Action	Yes	No
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
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.

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.

12

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

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

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 rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical or Vibration Analysis - Engine	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
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 (LTG) . 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

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

2

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

4

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5

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

6

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

7

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

13

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

14

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

15

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

Step	Action	Yes	No
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.			

Step	Action	Yes	No
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	CAUTION: Refer to Fastener Caution . 1. tighten any loose fasteners. Refer to Fastener 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 Replacement . 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 repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to 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 repair 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

Step	Action	Yes	No

Step	Action	Yes	No
1	1. Remove the drive belt. Refer to Drive Belt Replacement. 2. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 6	Go to Step 2
2	Rotate the drive belt tensioner pulleys. Do the pulleys rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 6
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	Go to Step 4	Go to Step 6
4	Inspect tensioner for indication of oil leaks. Does it show signs of oil leaking?	Go to Step 6	Go to Step 5
5	Remove top tensioner bolt, above hydraulic tensioner and verify tensioner assembly moves about center pivot by applying light force. Does the tensioner Asm move without binding?	System OK	Go to Step 6
6	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

INTAKE MANIFOLD COVER REPLACEMENT

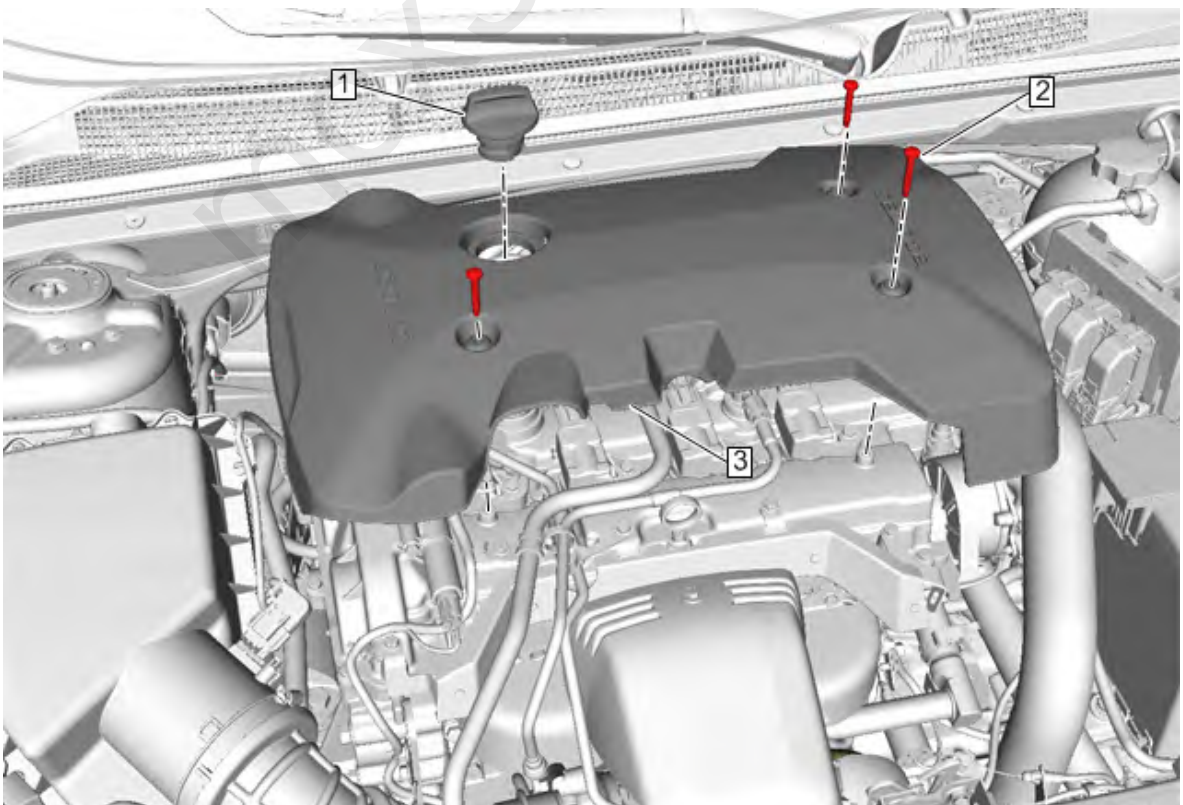


Fig. 33: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Filler Cap

Callout	Component Name
2	Intake Manifold Cover Bolt [3x] CAUTION: Refer to Fastener Caution . tighten 9 N.m (80 lb in)
3	Intake Manifold Cover

DRIVE BELT REPLACEMENT

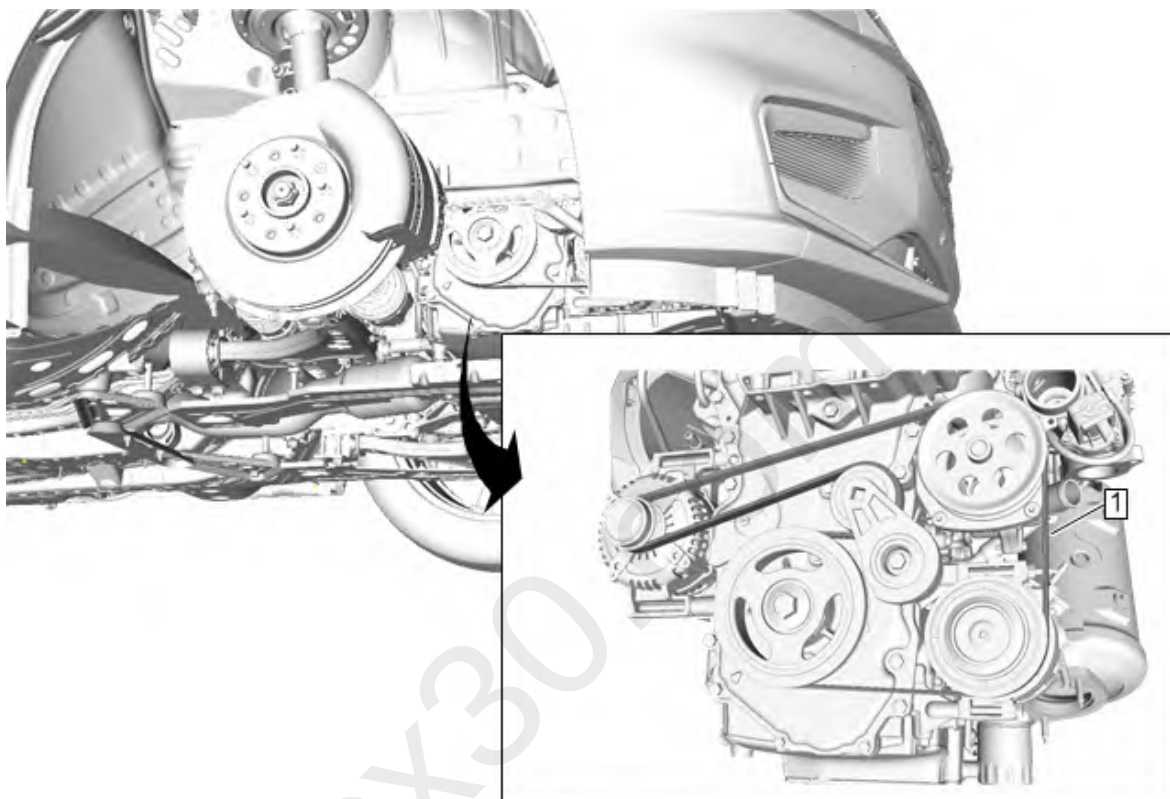


Fig. 34: Drive Belt Routing

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Front Wheelhouse Liner Replacement - Right Side (Equinox) Front Wheelhouse Liner Replacement - Right Side (Terrain)	
1	Drive Belt Procedure 1. Slowly release the tension on the drive belt tensioner. 2. Remove the drive belt.

DRIVE BELT TENSIONER REPLACEMENT

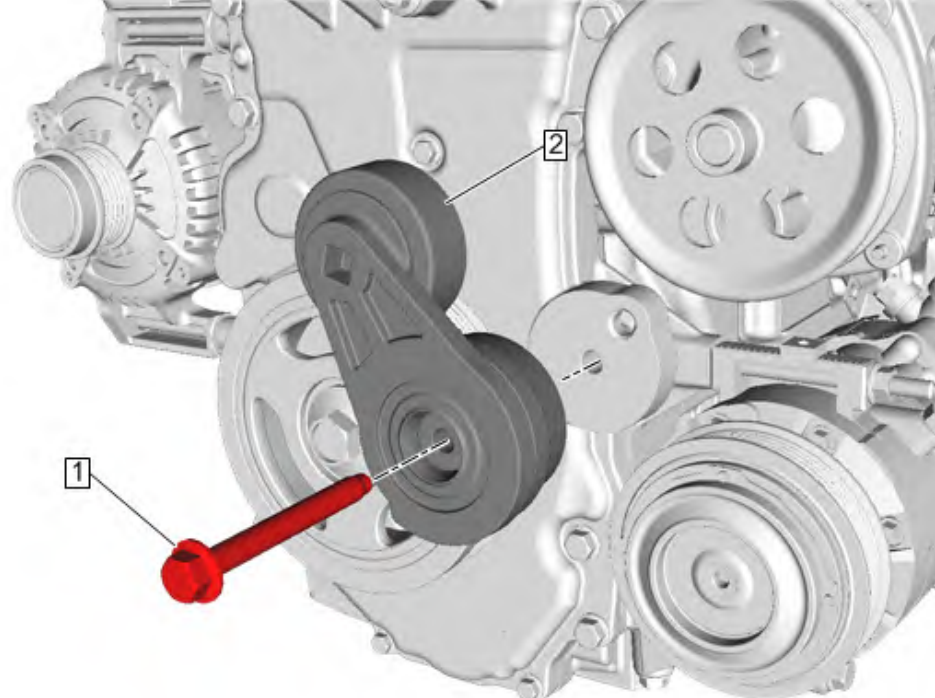


Fig. 35: Drive Belt Tensioner

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
Drive Belt Replacement	
1	Drive Belt Tensioner Fastener CAUTION: Refer to Fastener Caution . tighten 58 N.m (43 lb ft)
2	Drive Belt Tensioner

ENGINE MOUNT INSPECTION

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

1. Install the engine support fixture. Refer to **Engine Support Fixture**. Raising the engine removes the weight from the engine mount and creates slight tension in the rubber.
2. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
 - The hard rubber surface is covered with heat check cracks.
 - The rubber is split through the center of the engine mount.
 - The GLYCOL™ fluid is leaking from the engine mount.
3. Inspect the system for loose vacuum hose connections or vacuum leaks. Refer to Vacuum Operated Engine Mounts Description and Operation.
4. Inspect the engine mount valve assemblies for loose electrical connections. Inspect the electrical system connected to the engine mount valve assemblies. Refer to **Diagnostic System Check - Vehicle** .
5. Inspect for the presence of glycol fluid in the vacuum system. Remove the hose assembly connections at the engine mounts. If fluid is present in the engine mount vacuum system, the entire vacuum system should be replaced.

POWERTRAIN MOUNT BALANCING

Removal Procedure

1. Raise the vehicle. [Lifting and Jacking the Vehicle](#)
2. Loosen the transmission front strut bolt at the transmission mount strut bracket. [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](#)

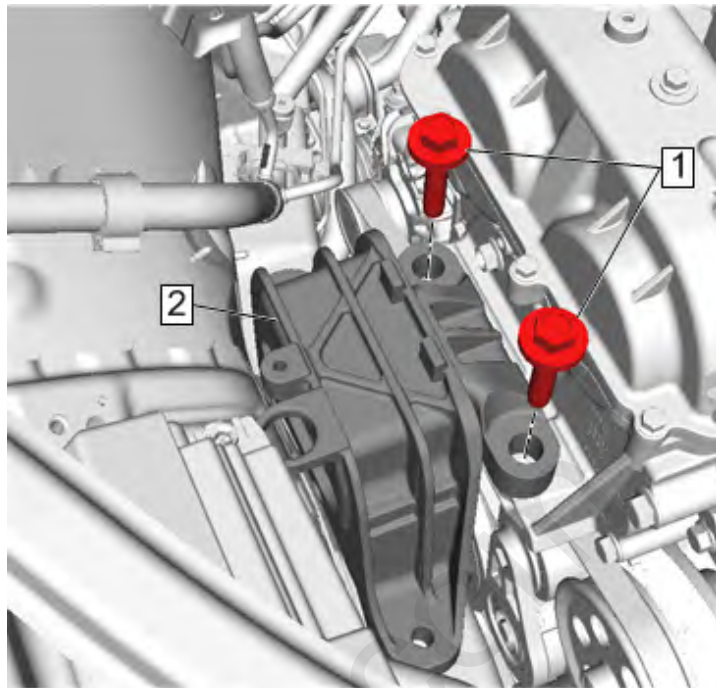


Fig. 36: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

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

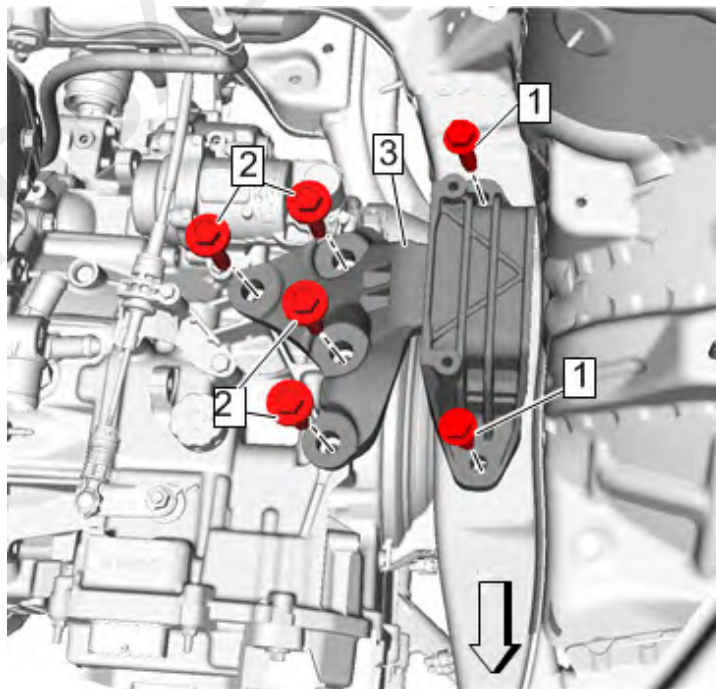


Fig. 37: Bolts At Left Transmission Mount

Courtesy of GENERAL MOTORS COMPANY

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

6. Loosen bolts (2) at the left transmission mount (3). [Transmission Mount Replacement \(Left Side M3U\)](#) [Transmission Mount Replacement \(Left Side M3D/M3H\)](#)

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.

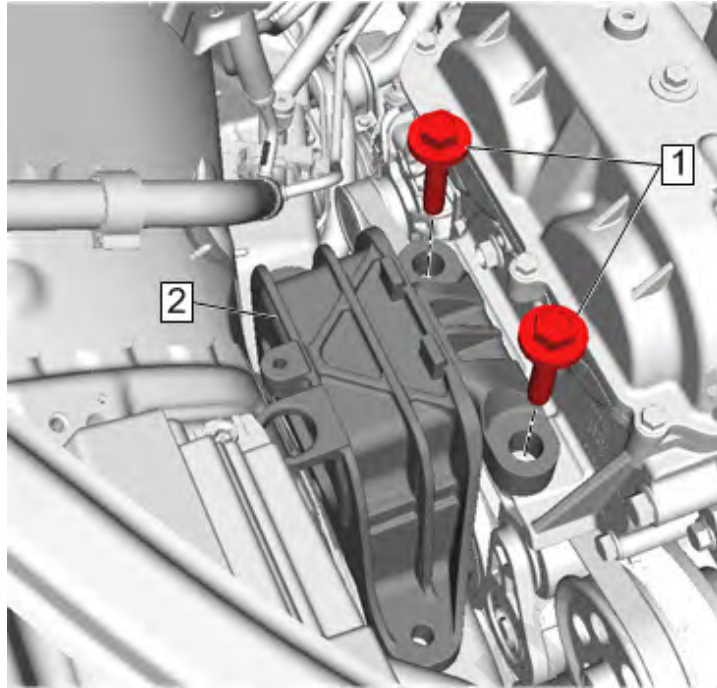


Fig. 38: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

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

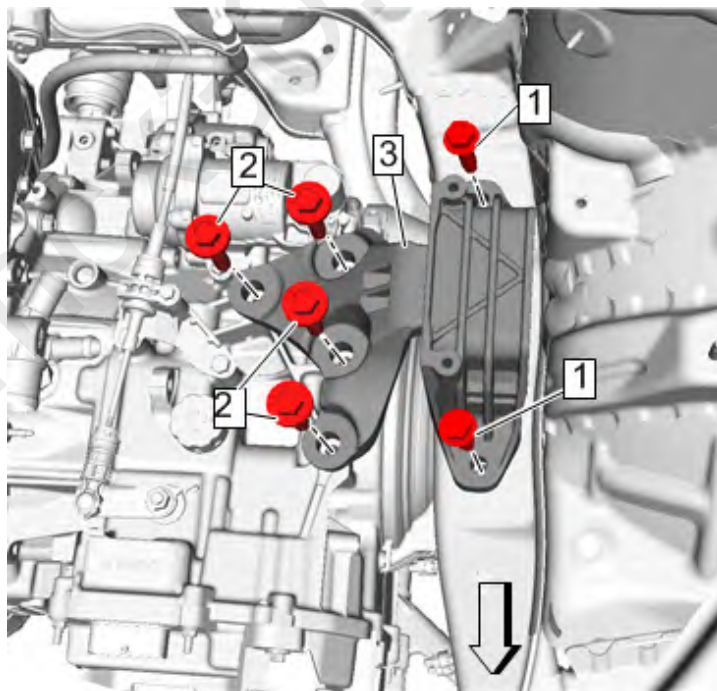


Fig. 39: Bolts At Left Transmission Mount

Courtesy of GENERAL MOTORS COMPANY

4. tighten bolts (2) at the left transmission mount (3). [Transmission Mount Replacement \(Left Side M3U\)](#)
[Transmission Mount Replacement \(Left Side M3D/M3H\)](#)
5. Raise the vehicle. [Lifting and Jacking the Vehicle](#)
6. tighten the transmission front strut bolt at the transmission mount strut bracket. [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 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](#)

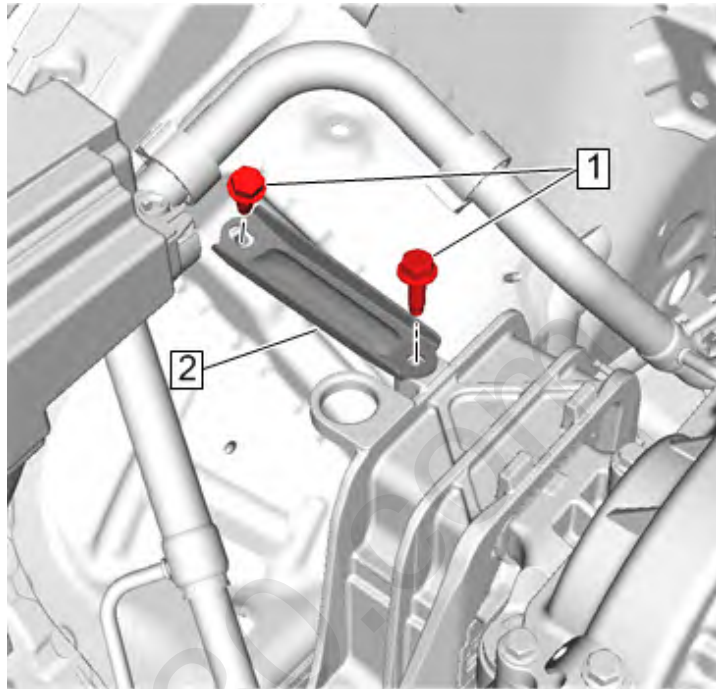


Fig. 40: Engine Mount Brace And Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove Engine Mount Brace Bolt (1) - [2x]
5. Remove Engine Mount Brace (2) -

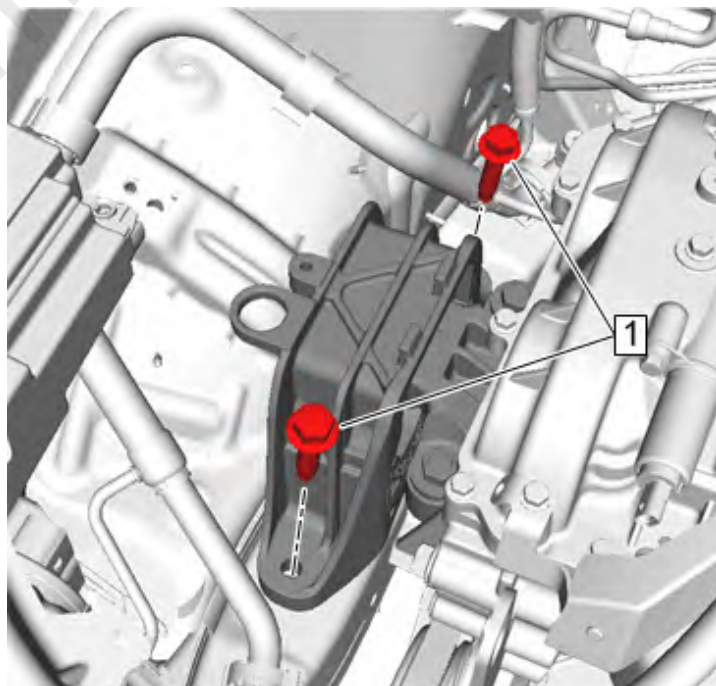


Fig. 41: Engine Mount Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove Engine Mount Bolt (1) - [2x]

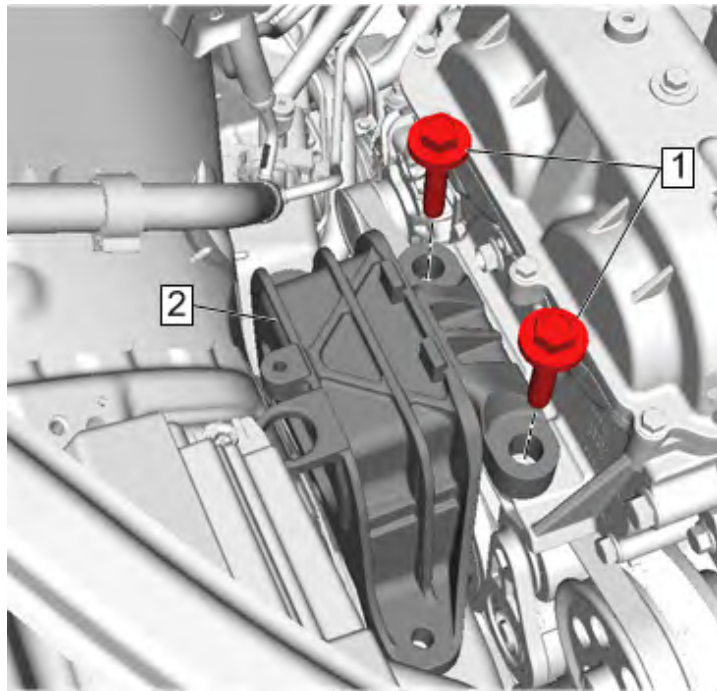


Fig. 42: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Remove Engine Mount Engine Side Bolt (1) and DISCARD [2x]
8. Remove Engine Mount (2)

Installation Procedure

NOTE: For ease of installation, all engine mount bolts should be hand started prior to performing final tightening steps.

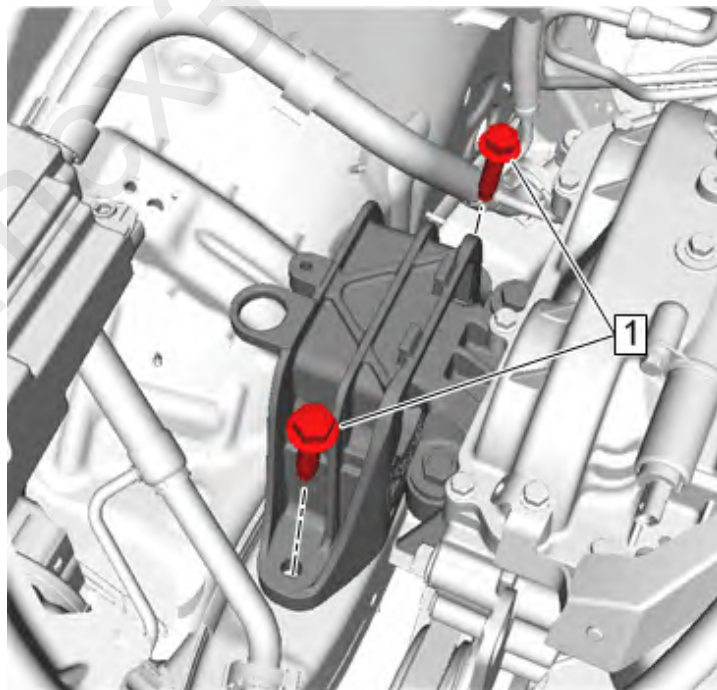


Fig. 43: Engine Mount Bolt

Courtesy of GENERAL MOTORS COMPANY

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

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

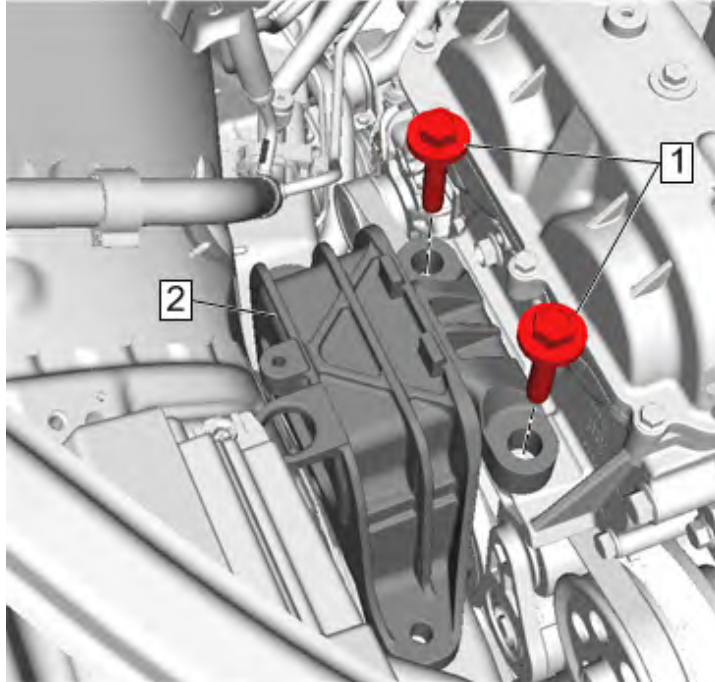


Fig. 44: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install NEW bolts.

2. Hand start NEW engine mount engine side bolts (1).
3. With the mount fasteners hand tighten ed, release the tension from the engine support fixture.
 1. Shake the powertrain vigorously by hand to allow the powertrain to settle.

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

4. tighten the NEW engine mount engine side bolts (1).

tighten

1. First Pass:100 N.m (74 lb ft)
2. Final Pass:60 - 75 degrees - EN-45059 meter

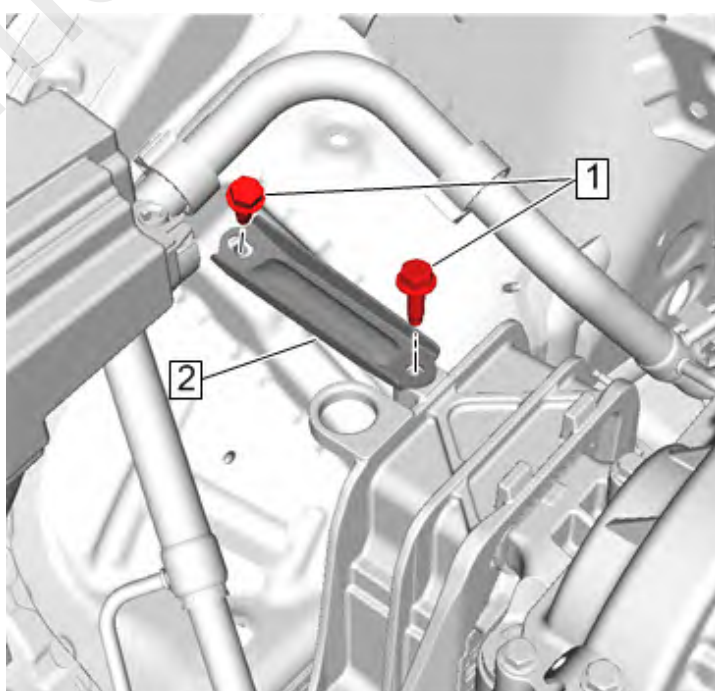


Fig. 45: Engine Mount Brace And Bolt

Courtesy of GENERAL MOTORS COMPANY

5. Install Engine Mount Brace (2)

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

ENGINE SUPPORT FIXTURE

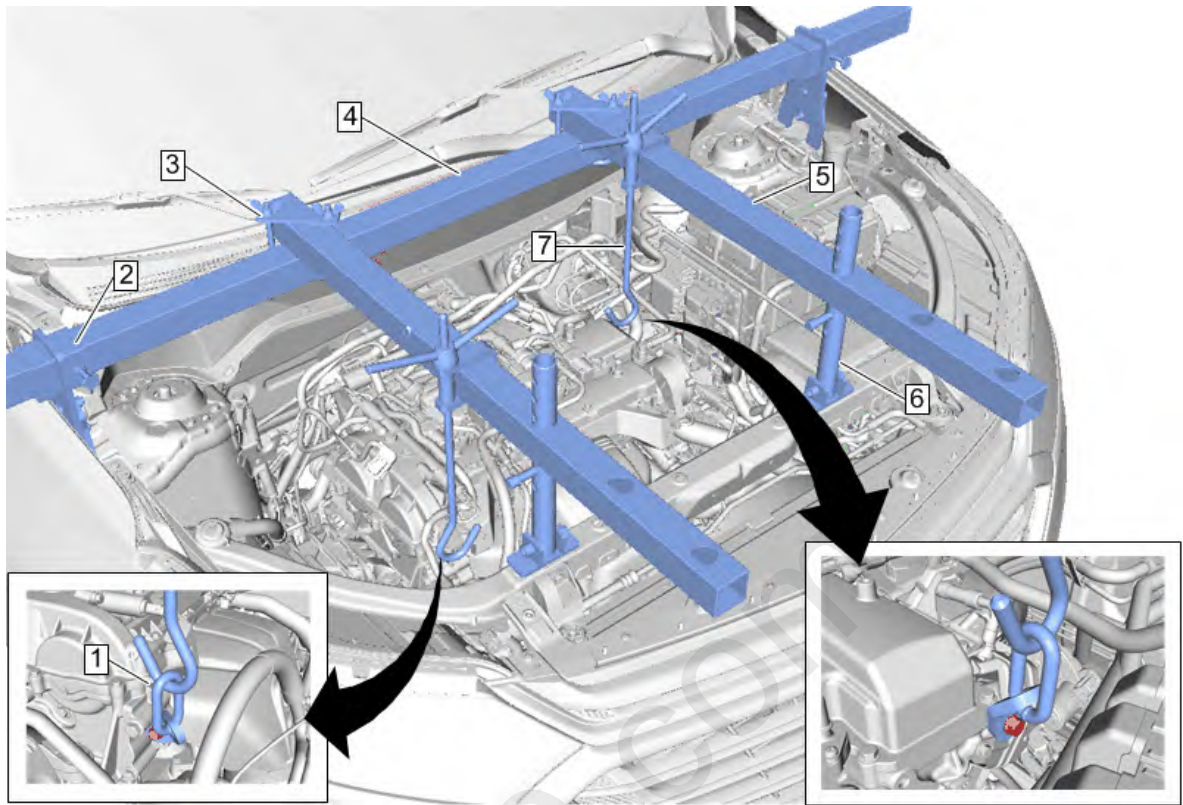


Fig. 46: Engine Support Fixture
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Intake Manifold Cover Replacement Charge Air Cooler Outlet Air Tube Replacement	
Special Tools - EN-36857 Engine Lift Bracket - 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	
Equivalent regional tools: Special 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: 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

TURBOCHARGER HEAT SHIELD REPLACEMENT

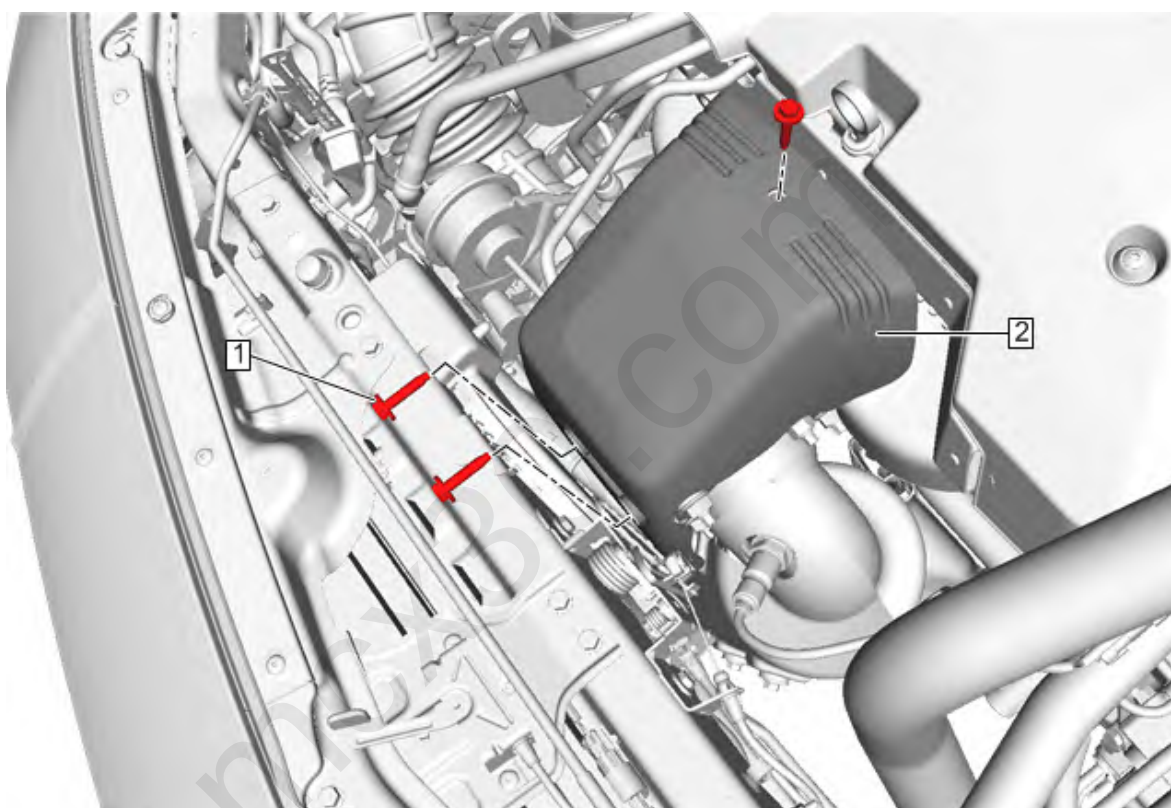


Fig. 47: Turbocharger Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Heat Shield Bolt [3x] CAUTION: Refer to Fastener Caution . NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt. tighten 14 N.m (10 lb ft)
2	Turbocharger Heat Shield

TURBOCHARGER REPLACEMENT (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

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. Remove [Intake Manifold Cover Replacement](#).
2. Remove [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#) [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#) .

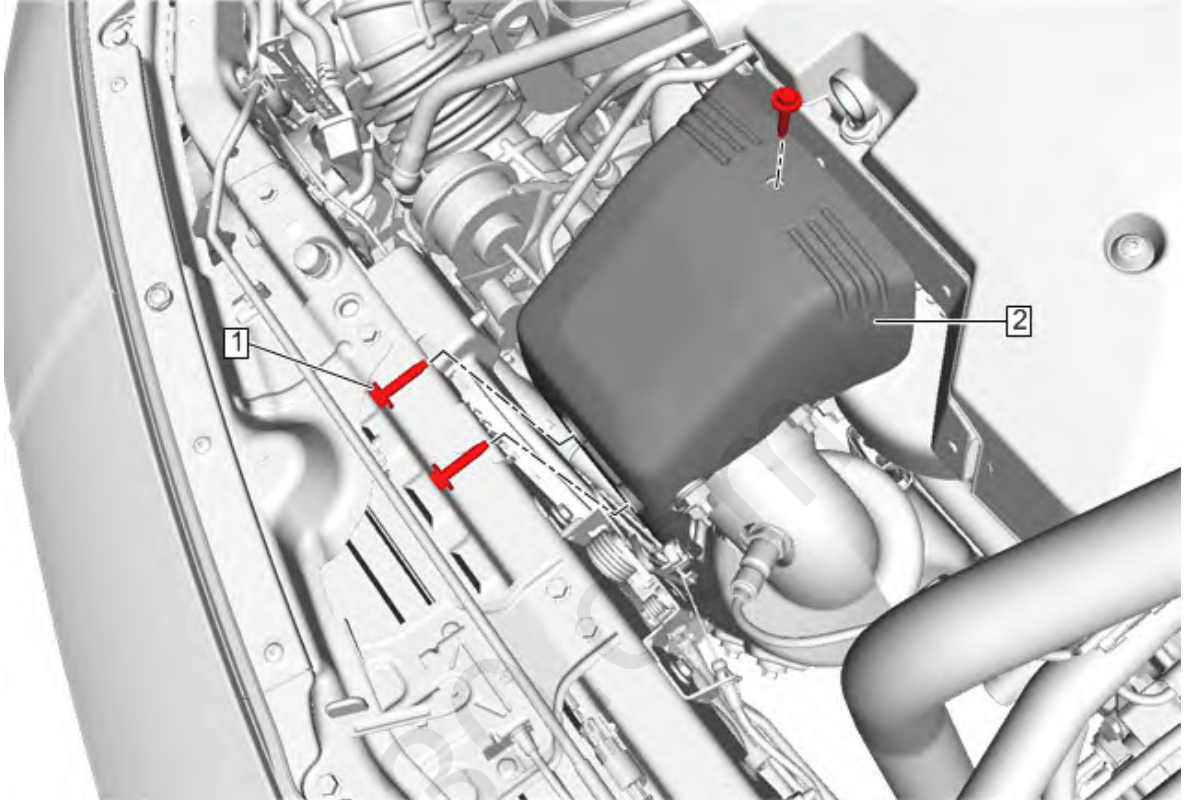


Fig. 48: Turbocharger Heat Shield
Courtesy of GENERAL MOTORS COMPANY

3. Remove Turbocharger Heat Shield (2) - [Turbocharger Heat Shield Replacement](#)
4. Remove [Turbocharger Coolant Return Pipe Replacement \(LTG\)](#) .
5. Remove [Warm Up Three-Way Catalytic Converter Replacement \(LTG\)](#) .
6. Remove [Turbocharger Oil Return Pipe Replacement](#).
7. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

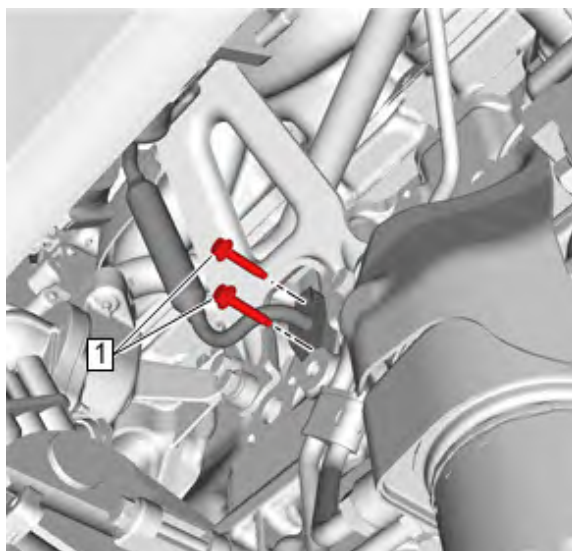


Fig. 49: Turbocharger Oil Feed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove Turbocharger Oil Feed Pipe Bolt (1) [2x]
9. Remove [Turbocharger Coolant Feed Pipe Replacement \(LTG\)](#).
10. Remove [Charge Air Cooler Inlet Air Tube Replacement](#)
11. Lower the vehicle. [Lifting and Jacking the Vehicle](#)

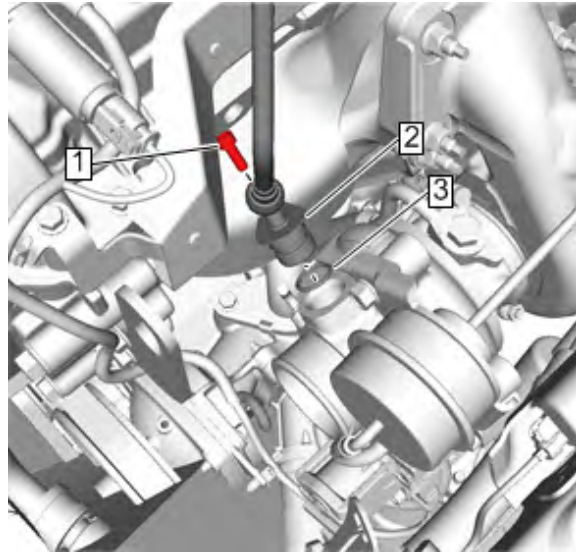


Fig. 50: PCV Valve

Courtesy of GENERAL MOTORS COMPANY

- NOTE:** The PCV hose and fitting assembly connection is permanent. Reinstall these components as an assembly unless new components are being used.
- NOTE:** Always ensure the PCV hose fitting O-Ring (3) seal is free of cuts or abrasions each time the fitting is attached to the turbocharger.

12. Remove Positive Crankcase Ventilation Hose Fitting Bolt (1).
13. Disconnect Positive Crankcase Ventilation Hose Fitting (2).
14. Disconnect the electrical connectors from the turbocharger.

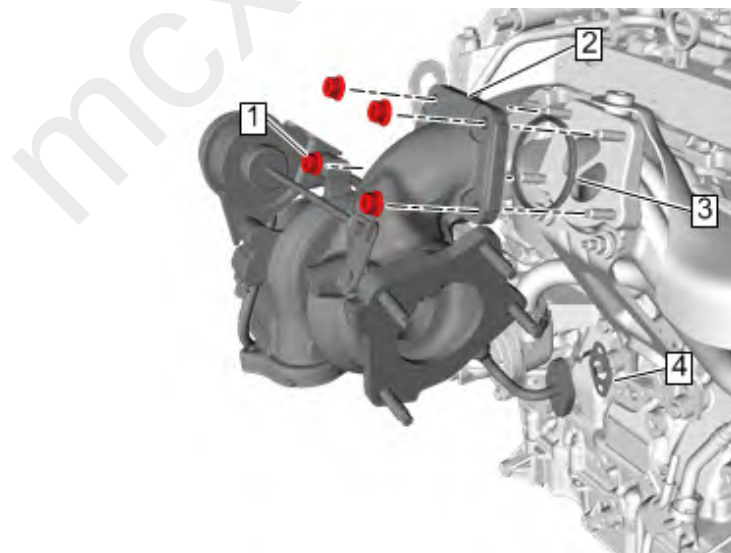


Fig. 51: Turbocharger Nut

Courtesy of GENERAL MOTORS COMPANY

- NOTE:** The exhaust pipe studs do not come installed on new turbochargers. If the turbocharger is being replaced, new studs will need to be installed.

15. Remove Turbocharger Nut (1) and DISCARD [4x]
16. Remove Turbocharger (2)
17. Remove Turbocharger Gasket (3) and DISCARD
18. Remove Turbocharger Oil Feed Pipe Gasket (4) and DISCARD

19. Clean and inspect Turbocharger (2) - [Camshaft Cover and Compressor Air Intake Turbocharger Cleaning and Inspection](#)

20. Transfer components as necessary.

Installation Procedure

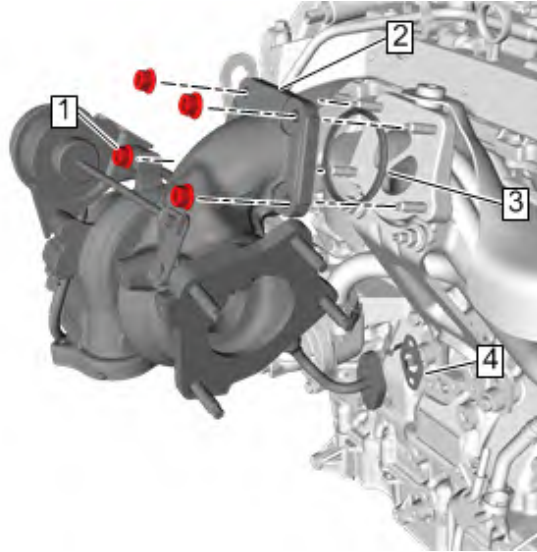


Fig. 52: Turbocharger Nut

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a NEW gasket.

1. Install Turbocharger Oil Feed Pipe Gasket (4)

NOTE: Install a NEW gasket.

2. Install Turbocharger Gasket (3)

3. Install Turbocharger (2)

NOTE: Install NEW nuts.

NOTE: The exhaust pipe studs do not come installed on new turbochargers. If the turbocharger is being replaced, new studs will need to be installed.

4. Loosely Install Turbocharger Nut (1) - [4x]

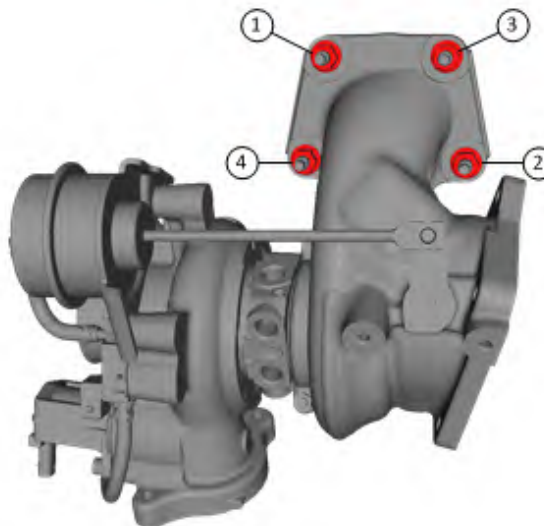


Fig. 53: Turbocharger Nut tighten in sequence

Courtesy of GENERAL MOTORS COMPANY

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

CAUTION: This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.

5. Turbocharger Nut - tighten in sequence

tighten

1. First Pass:30 N.m (22 lb ft)
2. Final Pass:an additional 90 degrees

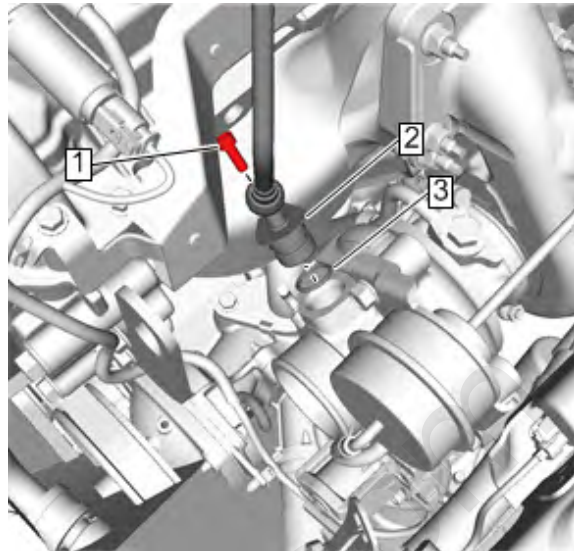


Fig. 54: PCV Valve

Courtesy of GENERAL MOTORS COMPANY

NOTE: Always ensure the PCV hose fitting O-Ring (3) seal is free of cuts or abrasions each time the fitting is attached to the turbocharger.

6. Inspect the O-ring and replace if necessary. (3)
7. Connect Positive Crankcase Ventilation Hose Fitting (2)
8. Install Positive Crankcase Ventilation Hose Fitting Bolt (1) and tighten 8 N.m (71 lb in)
9. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

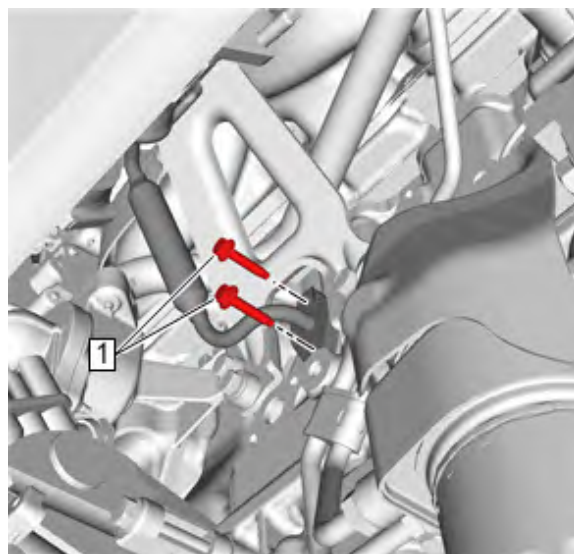


Fig. 55: Turbocharger Oil Feed Pipe Bolt

Courtesy of GENERAL MOTORS COMPANY

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

10. Install Turbocharger Oil Feed Pipe Bolt (1) and tighten [2x] 10 N.m (89 lb in)

11. Lower the vehicle. [Lifting and Jacking the Vehicle](#)
12. Install [Turbocharger Coolant Feed Pipe Replacement \(LTG\)](#) .
13. Install [Turbocharger Coolant Return Pipe Replacement \(LTG\)](#) .
14. Install [Warm Up Three-Way Catalytic Converter Replacement \(LTG\)](#) .
15. Install [Turbocharger Oil Return Pipe Replacement](#).
16. Install [Charge Air Cooler Inlet Air Tube Replacement](#) .
17. Connect the turbocharger electrical connectors.

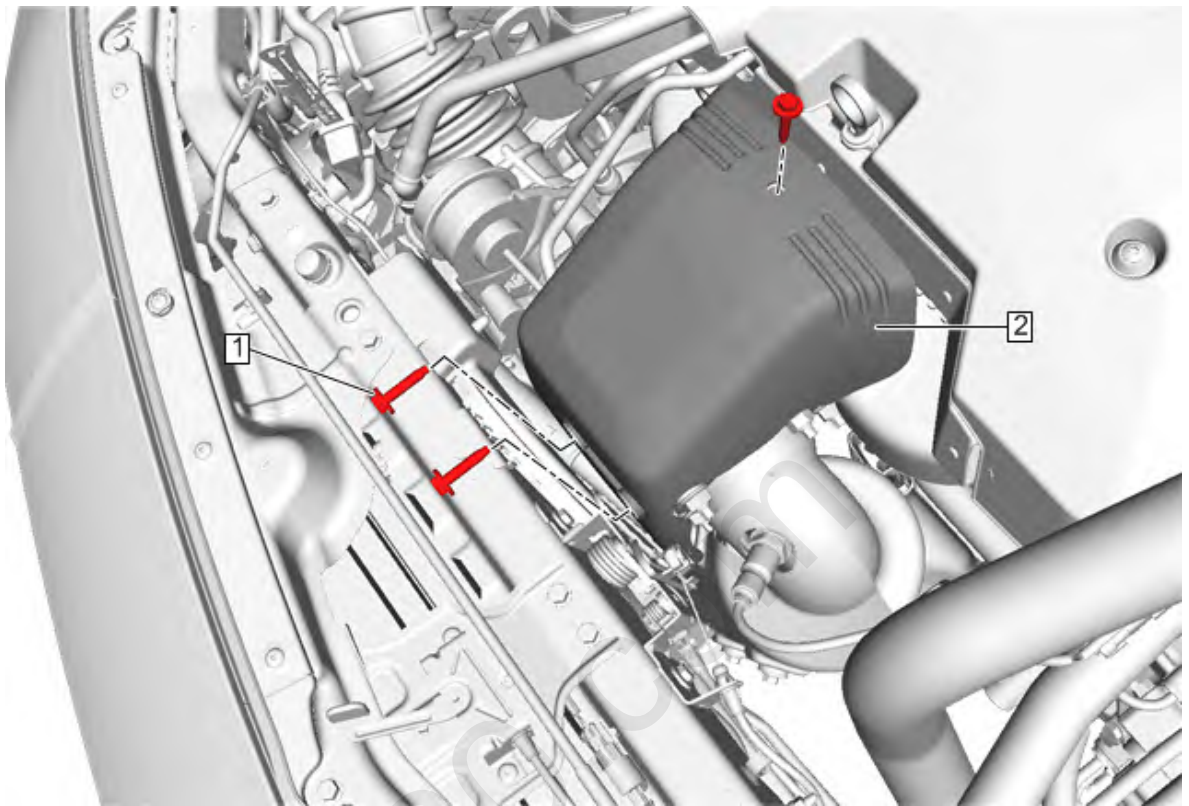


Fig. 56: Turbocharger Heat Shield

Courtesy of GENERAL MOTORS COMPANY

18. Install Turbocharger Heat Shield (2) - [Turbocharger Heat Shield Replacement](#)
19. Install [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#) [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#) .
20. Install [Intake Manifold Cover Replacement](#).

TURBOCHARGER OIL RETURN PIPE REPLACEMENT

Removal Procedure

1. Remove [Warm Up Three-Way Catalytic Converter Replacement \(LTG\)](#).
2. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

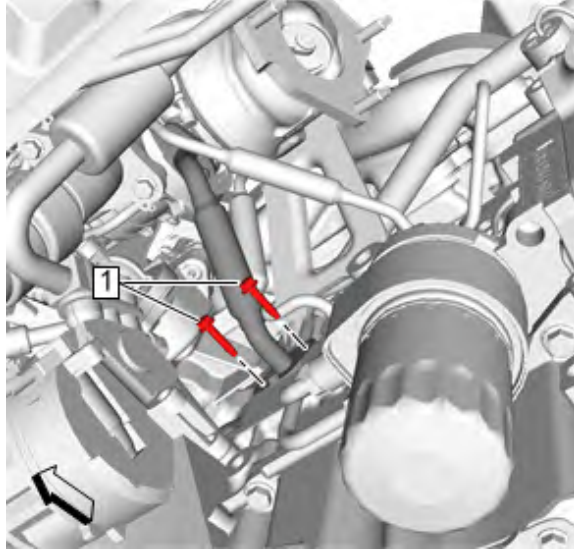


Fig. 57: Turbocharger Oil Return Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove Turbocharger Oil Return Pipe Bolt (1) - [2x]

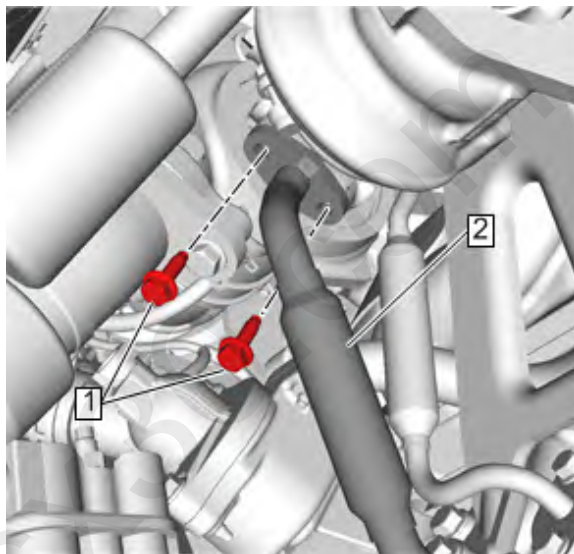


Fig. 58: Turbocharger Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Remove Turbocharger Oil Return Pipe Bolt (1) - [2x]
5. Remove Turbocharger Oil Return Pipe (2)



Fig. 59: Turbocharger Oil Return Pipe Gaskets
Courtesy of GENERAL MOTORS COMPANY

6. Remove Turbocharger Oil Return Pipe Gasket (1) and DISCARD [2x]

Installation Procedure



Fig. 60: Turbocharger Oil Return Pipe Gaskets
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a **NEW** gasket.

1. Install Turbocharger Oil Return Pipe Gasket (1) [2x]

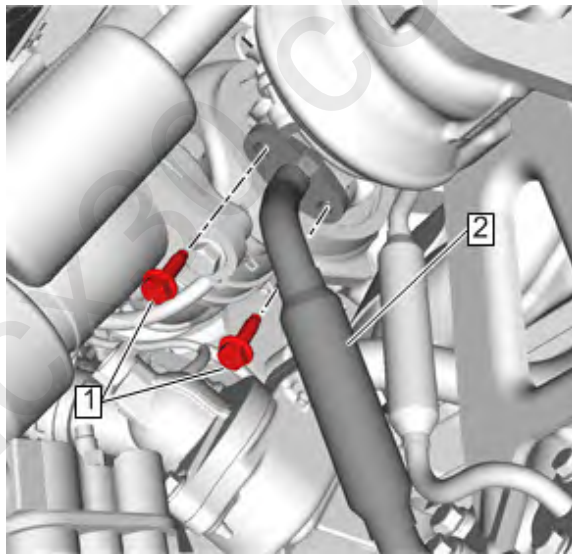


Fig. 61: Turbocharger Oil Return Pipe
Courtesy of GENERAL MOTORS COMPANY

2. Install Turbocharger Oil Return Pipe (2)

CAUTION: Refer to **Fastener Caution** .

3. Install Turbocharger Oil Return Pipe Bolt (1) and tighten [2x] 10 N.m (89 lb in)

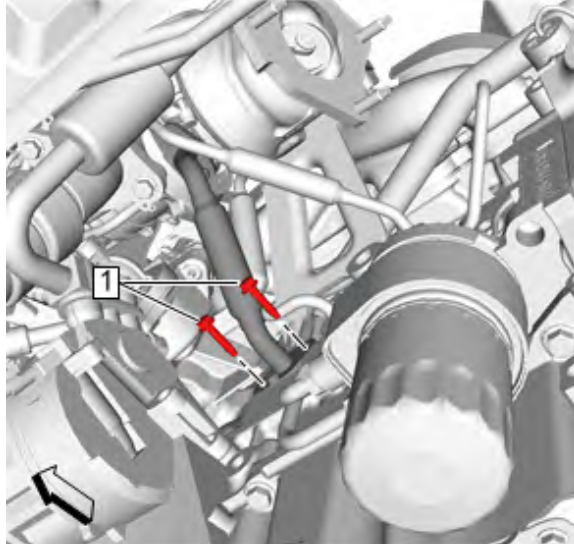


Fig. 62: Turbocharger Oil Return Pipe Bolt
 Courtesy of GENERAL MOTORS COMPANY

4. Install Turbocharger Oil Return Pipe Bolt (1) and tighten [2x] 10 N.m (89 lb in)
5. Install [Warm Up Three-Way Catalytic Converter Replacement \(LTG\)](#).
6. Lower the vehicle. [Lifting and Jacking the Vehicle](#)

TURBOCHARGER OIL FEED PIPE REPLACEMENT

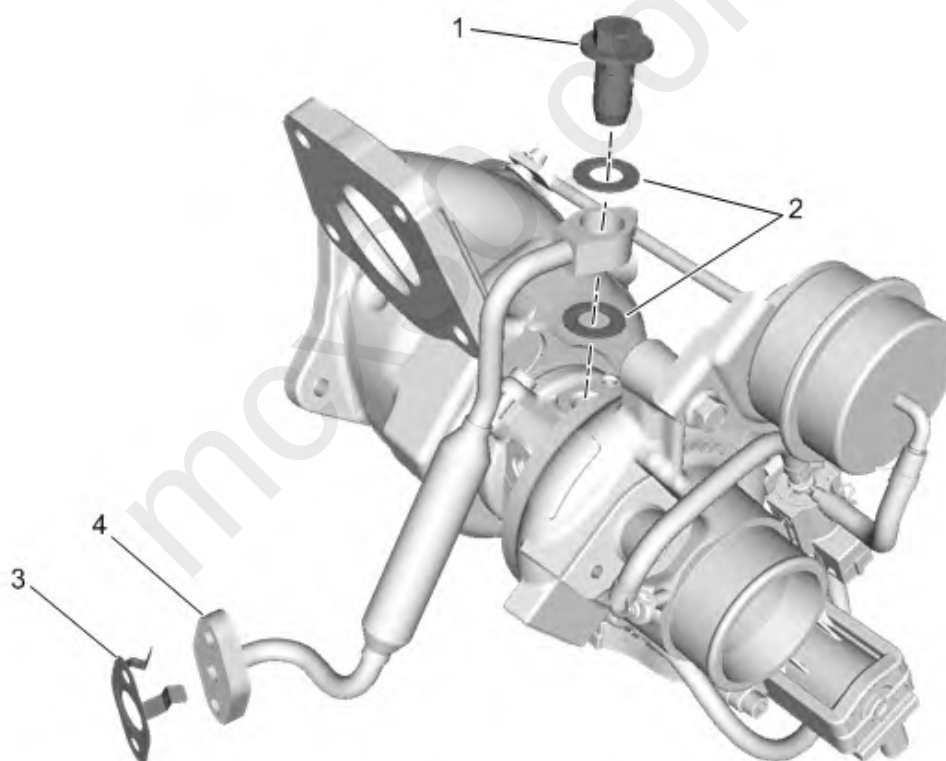


Fig. 63: Turbocharger Oil Feed Pipe Bolt And Sealing Washers
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
<u>Turbocharger Replacement (1st Design Tamper-Proof PCV System)</u>	

Callout	Component Name
1	Turbocharger Oil Feed Pipe Bolt CAUTION: Refer to Fastener Caution . tighten 35 N.m (26 lb ft)
2	Turbocharger Oil Feed Pipe Washer [2x] Procedure Install NEW sealing washers.
3	Turbocharger Oil Feed Pipe Gasket Procedure Install a NEW gasket.
4	Turbocharger Oil Feed Pipe

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT

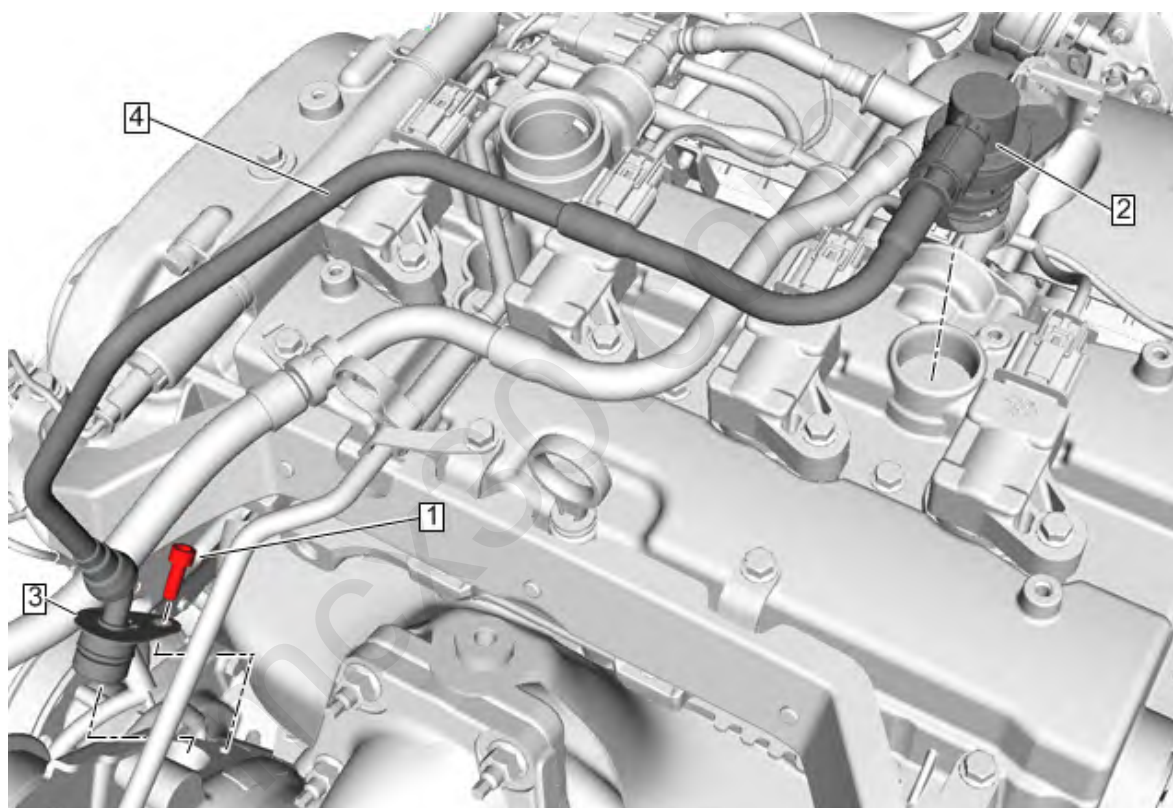


Fig. 64: Positive Crankcase Ventilation Valve (LTG)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures <u>Intake Manifold Cover Replacement</u> 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.	

Callout	Component Name
1	Positive Crankcase Ventilation Hose Fitting Fastener CAUTION: Refer to Fastener Caution . tighten 8 N.m (71 lb in)
2	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.
3	Positive Crankcase Ventilation Hose Fitting
4	Positive Crankcase Ventilation Hose/Tube Procedure If necessary, un-clip the hose from the retainer.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (CAMSHAFT COVER TO AIR INLET)

Special Tools

- EN-50956 Tamper Proof Drive Bit

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

Removal Procedure

1. Remove [Intake Manifold Cover Replacement](#).
2. Disconnect Positive Crankcase Ventilation Tube @ Air Cleaner Outlet Duct - [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#) [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#).

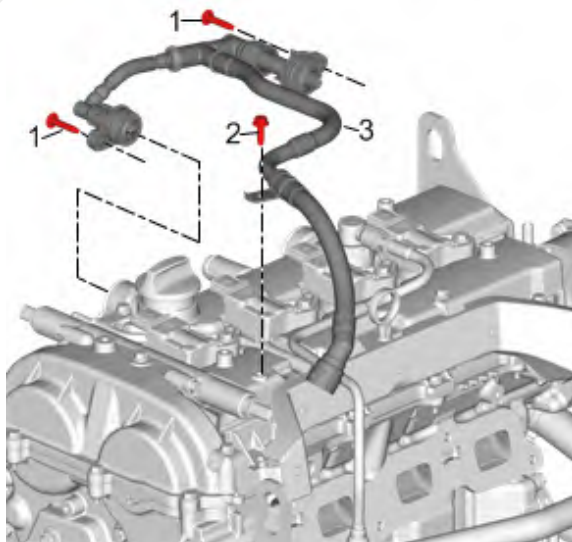


Fig. 65: PCV Valve/Tube Assembly And Fasteners

Courtesy of GENERAL MOTORS COMPANY

NOTE: PCV Valve fasteners are tamper proof and must have a slot cut in the fastener to be removed.

3. Using a suitable cutting tool, cut a slot in the fasteners. Remove the PCV valve fasteners with a flat blade screw driver and DISCARD (1).
4. Remove the PCV hose fastener (2) from the camshaft cover.

NOTE: PCV valves and PCV tube assembly have tamper-proof connections and cannot be disassembled.

5. Remove the PCV valves and PCV tube assembly.

Installation Procedure

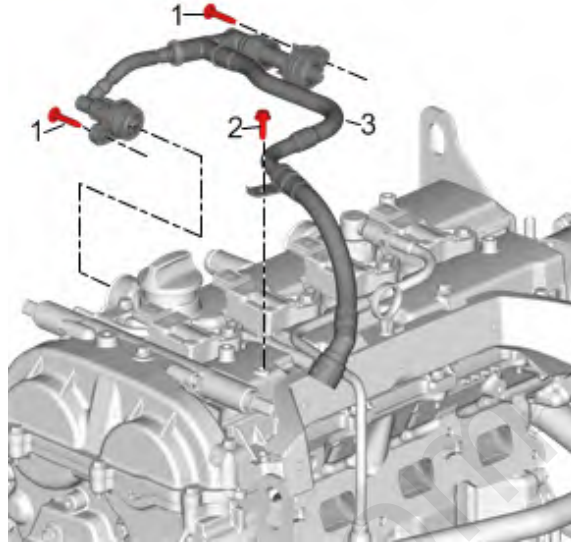


Fig. 66: PCV Valve/Tube Assembly And Fasteners
Courtesy of GENERAL MOTORS COMPANY

1. Install the PCV hose assembly and PCV valves (3).

CAUTION: Refer to Fastener Caution .

2. Install the NEW PCV valve fasteners (1) using **EN-50956** tamper proof drive bit and tighten to 10 N.m (89 lb in).
3. Install the PCV hose fastener (2) and tighten to 12 N.m (106 lb in).
4. Connect Positive Crankcase Ventilation Tube @ Air Cleaner Outlet Duct - Air Cleaner Outlet Duct Replacement (Non-Tamperproof) Air Cleaner Outlet Duct Replacement (Tamperproof)
5. Install Intake Manifold Cover Replacement

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Remove Intake Manifold Cover - Intake Manifold Cover Replacement

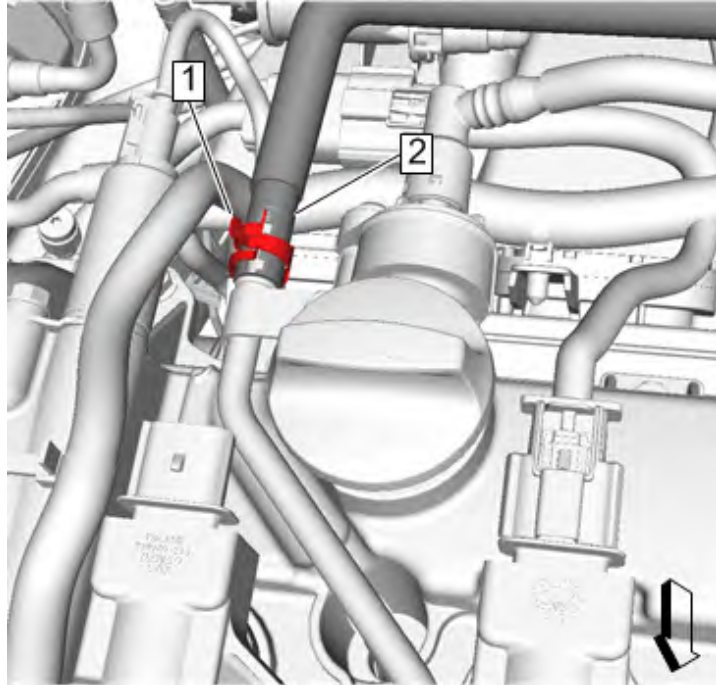


Fig. 67: Engine Coolant Air Bleed Hose Clamp
 Courtesy of GENERAL MOTORS COMPANY

2. Disconnect and reposition the engine coolant air bleed hose (2) as necessary. [Engine Coolant Air Bleed Hose Replacement \(Radiator Surge Tank to Radiator to Engine Coolant Air Bleed Pipe LTG\)](#)
3. Remove Fuel Feed Front Pipe - [Fuel Feed Front Pipe Replacement](#)
4. Remove Air Cleaner Outlet Duct - [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#) [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#)
5. Remove Evaporative Emission Canister Purge Solenoid Valve - [Evaporative Emission Canister Purge Solenoid Valve Replacement](#)
6. Remove Throttle Body Assembly - [Throttle Body Assembly Replacement](#)
7. Disconnect Engine Coolant Air Bleed Hose @ Engine Coolant Air Bleed Pipe - [Engine Coolant Air Bleed Pipe Replacement \(LTG\)](#)

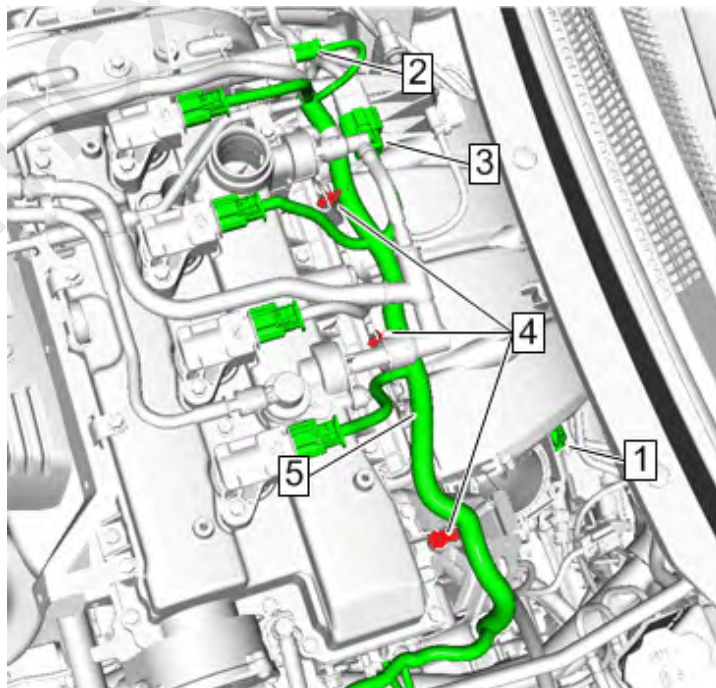


Fig. 68: Electrical Connector And Engine Wiring Harness
 Courtesy of GENERAL MOTORS COMPANY

8. Disconnect Electrical Connector (1)
9. Disconnect Electrical Connector (2)
10. Disconnect Electrical Connector (3)
11. Disconnect Wiring Harness Retainer (4) [3x]

12. Reposition away Engine Wiring Harness (5)
13. Raise the vehicle. [Lifting and Jacking the Vehicle](#)

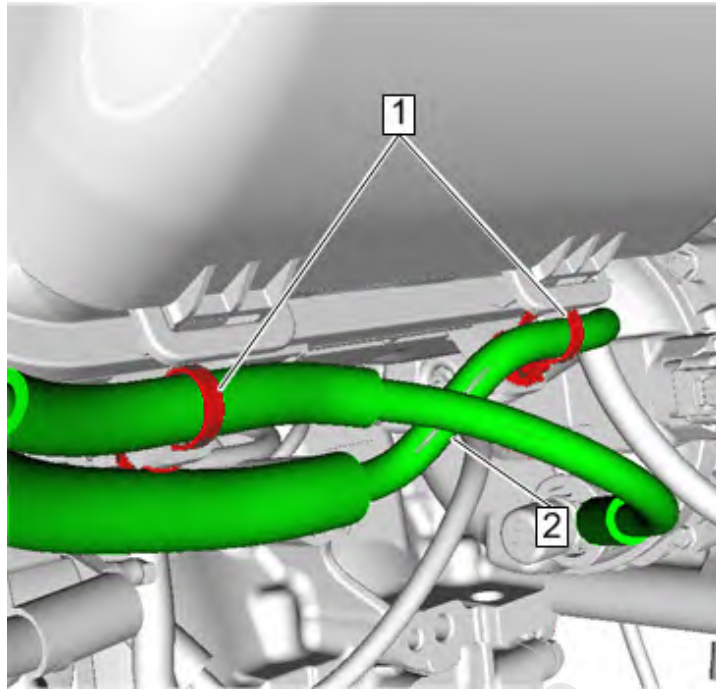


Fig. 69: Wiring Harness And Retainers
Courtesy of GENERAL MOTORS COMPANY

14. Remove the wiring harness retainers (1), then reposition the harness (2) as needed.

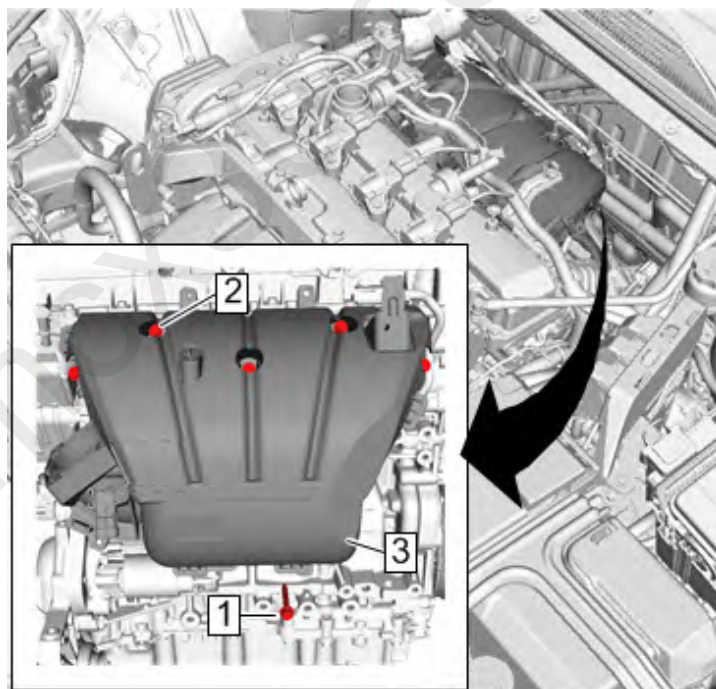


Fig. 70: Intake Manifold And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: The intake manifold bolts are retained in the intake manifold. Fully loosen the bolts until the threads are disengaged from the cylinder head.

15. Loosen Intake Manifold Bolt (1).
16. Lower the vehicle. [Lifting and Jacking the Vehicle](#)
17. Loosen Intake Manifold Bolt (2) - [5x]

NOTE: The fuel injection fuel rail fuel pressure sensor must be removed to obtain enough clearance to remove the intake manifold from the vehicle.

18. Separate the intake manifold from the engine to gain access to the fuel pressure sensor.

19. Remove the fuel injection fuel rail fuel pressure sensor. [Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement](#)

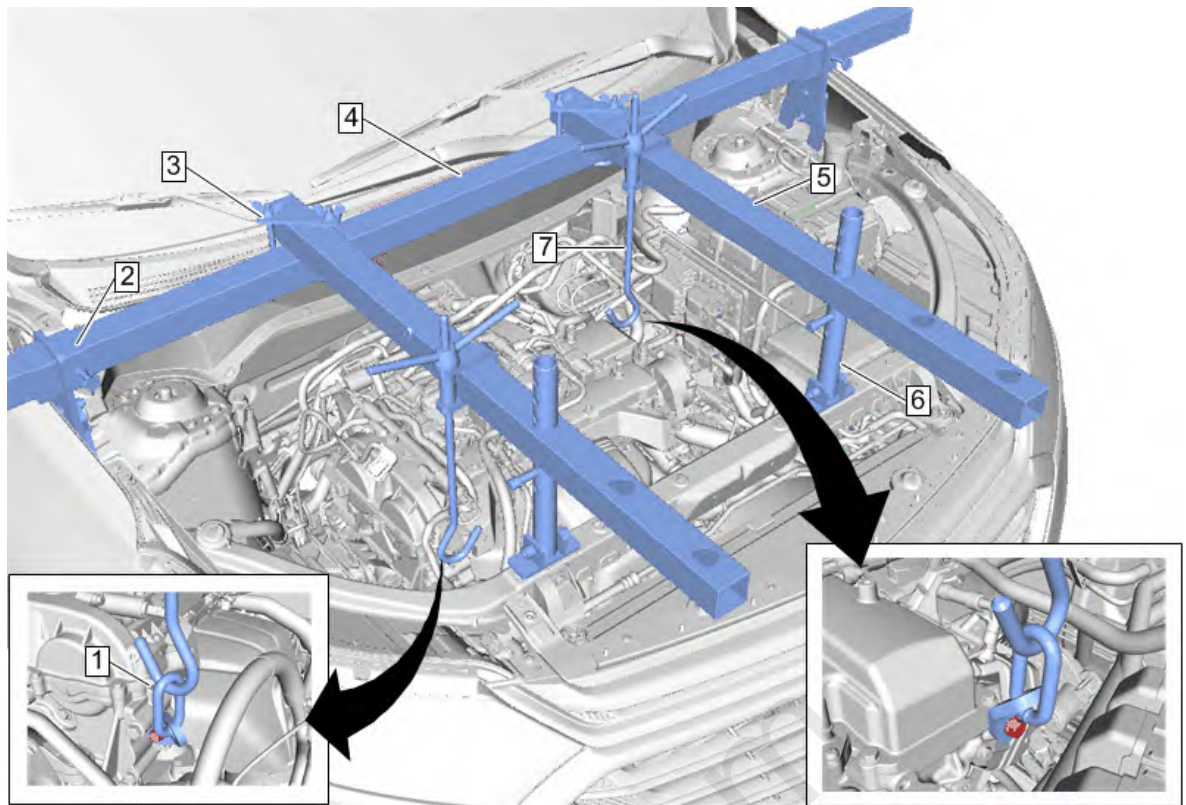


Fig. 71: Engine Support Fixture

Courtesy of GENERAL MOTORS COMPANY

20. Install Engine Support Fixture (1, 2, 3, 4, 6, and 7) - [Engine Support Fixture](#)

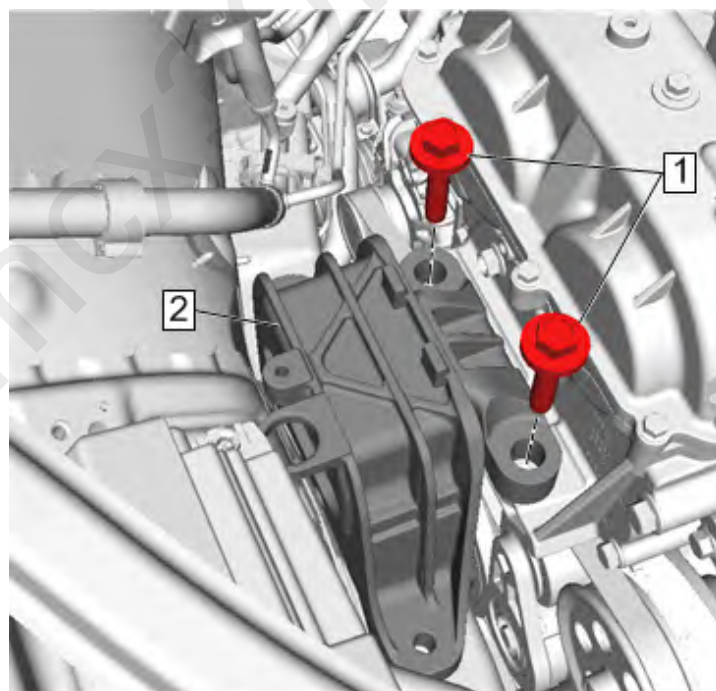


Fig. 72: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

21. Remove Engine Mount Bolt (1) - [2x] - [Engine Mount Replacement](#)
22. Lower the front of the engine enough to gain clearance to remove the intake manifold.
23. Remove Intake Manifold.

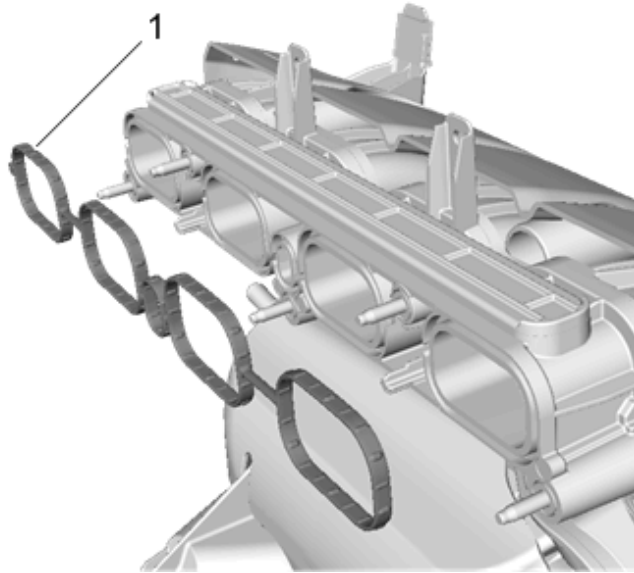


Fig. 73: Intake Manifold Gasket
Courtesy of GENERAL MOTORS COMPANY

24. Remove Intake Manifold Gasket (1) and DISCARD
25. Clean and inspect the intake manifold. [Intake Manifold Cleaning and Inspection](#)

Installation Procedure

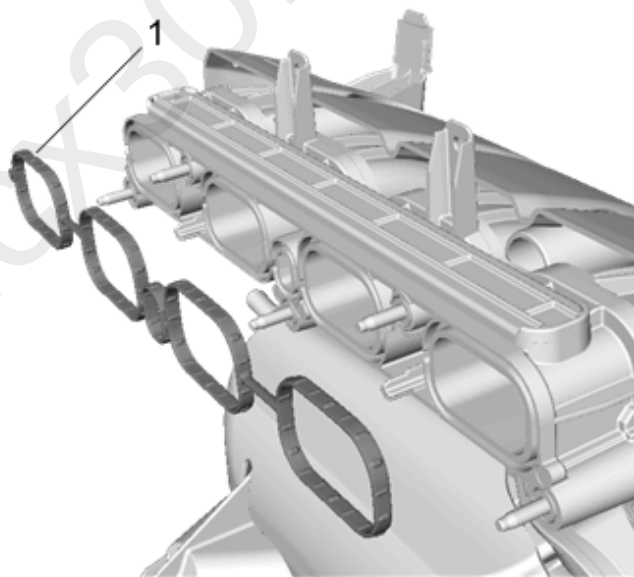


Fig. 74: Intake Manifold Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW Intake Manifold Gasket (1)
2. Install Intake Manifold.
3. Raise the front of the engine back into position.

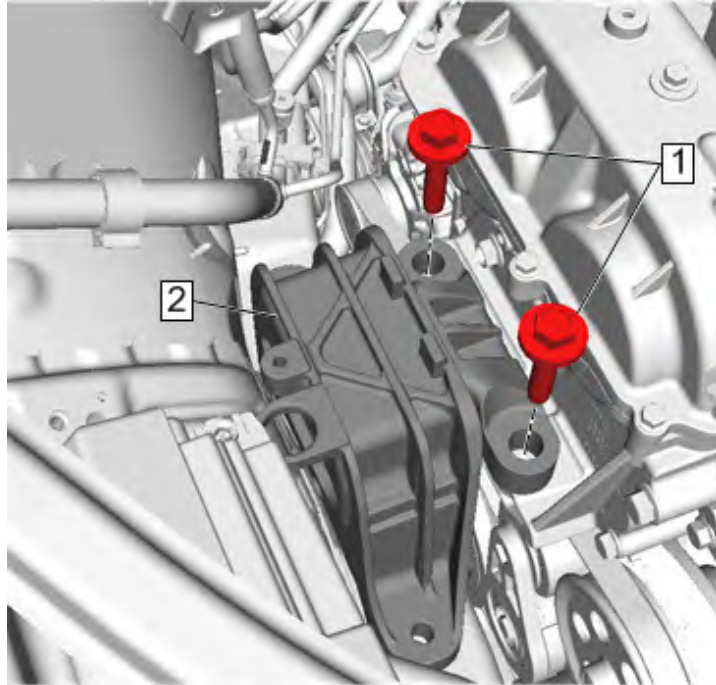


Fig. 75: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Install Engine Mount Bolt (1) - [2x] - [Engine Mount Replacement](#)

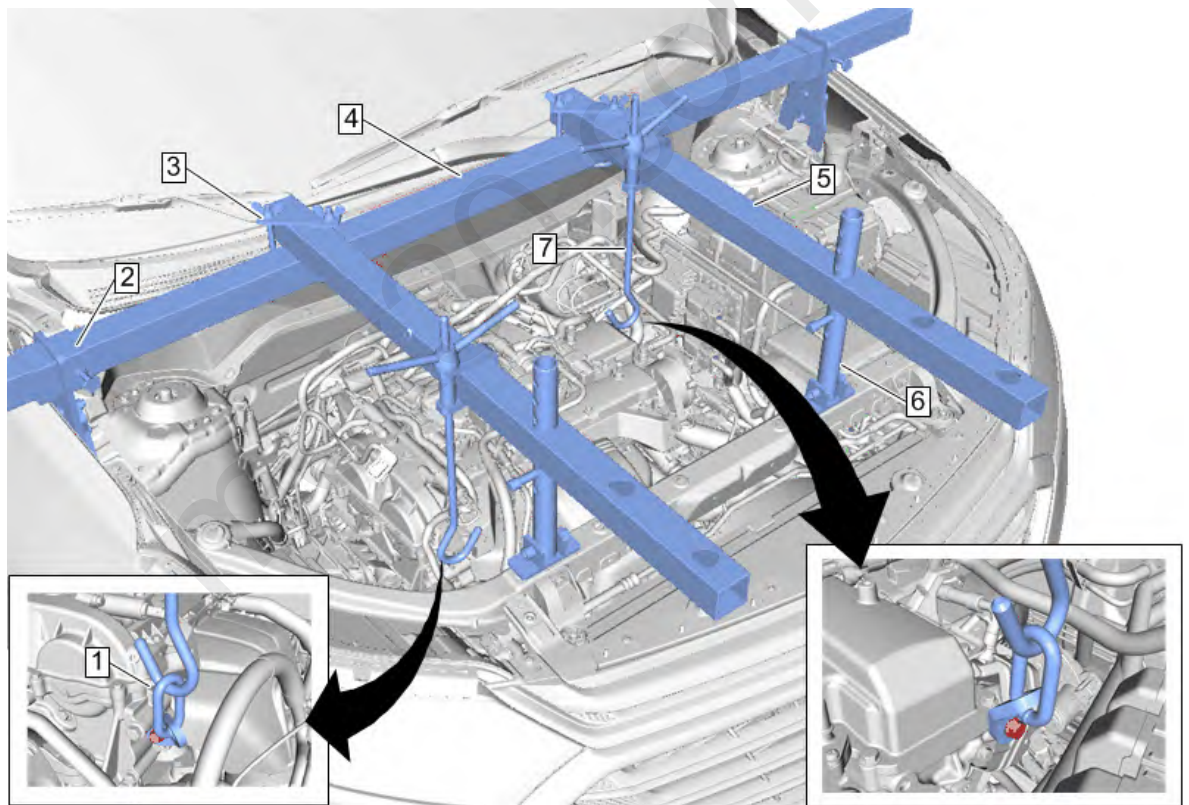


Fig. 76: Engine Support Fixture
Courtesy of GENERAL MOTORS COMPANY

5. Remove Engine Support Fixture (1, 2, 3, 4, 6, and 7) - [Engine Support Fixture](#)
6. Install the fuel injection fuel rail fuel pressure sensor. [Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement](#)

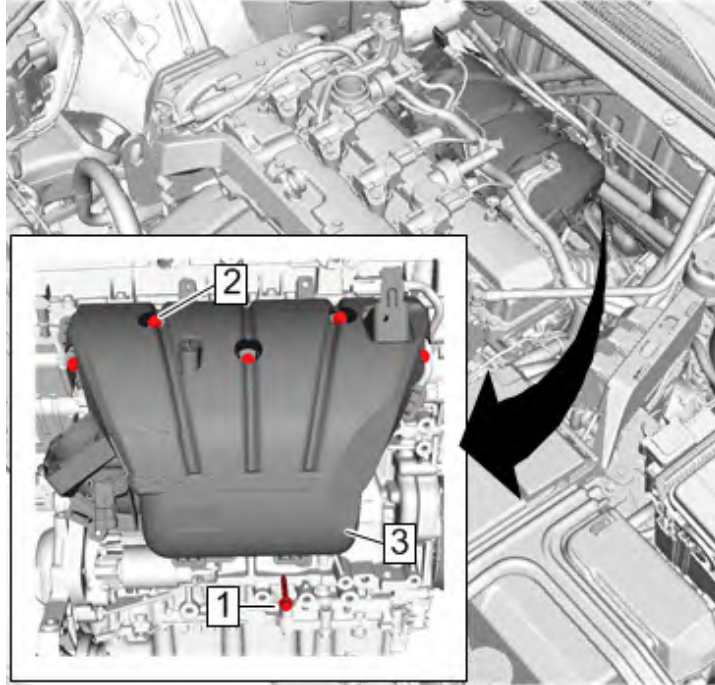


Fig. 77: Intake Manifold And Bolts

Courtesy of GENERAL MOTORS COMPANY

- 7.
8. Loosely install Upper Intake Manifold Bolt (3)
9. Raise the vehicle. [Lifting and Jacking the Vehicle](#)
10. Loosely install Lower Intake Manifold Bolt.

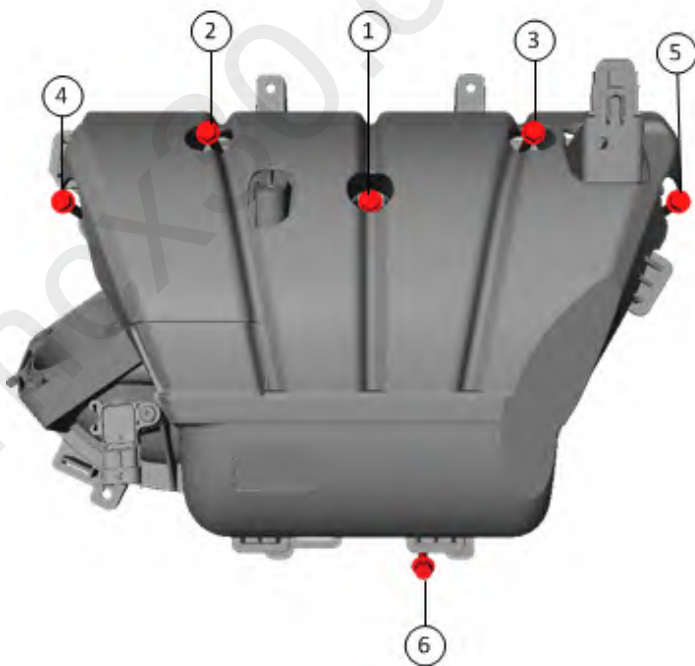


Fig. 78: Intake Manifold Bolts tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

11. tighten in sequence

tighten

1. First Pass:12 N.m (106 lb in)
2. Final Pass:12 N.m (106 lb in)

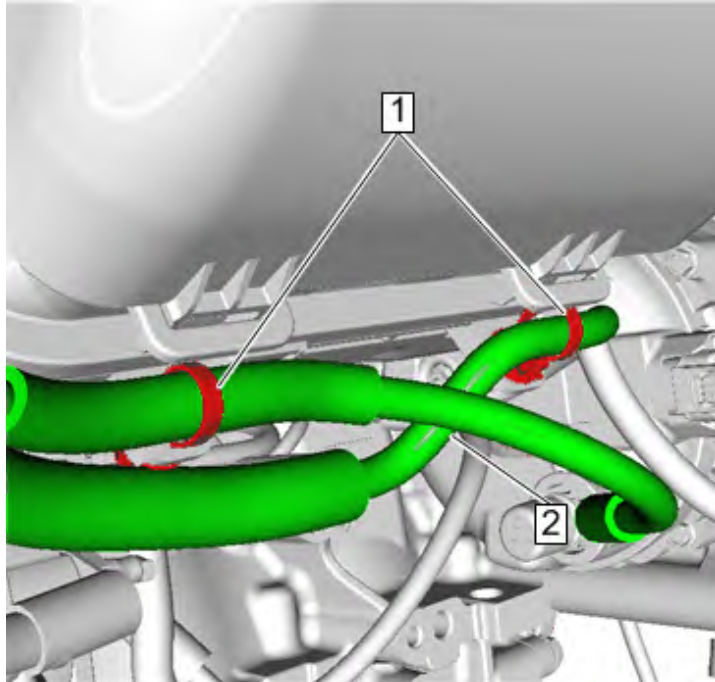


Fig. 79: Wiring Harness And Retainers

Courtesy of GENERAL MOTORS COMPANY

12. Reposition the harness (2) as needed, then install the wiring harness retainers (1).

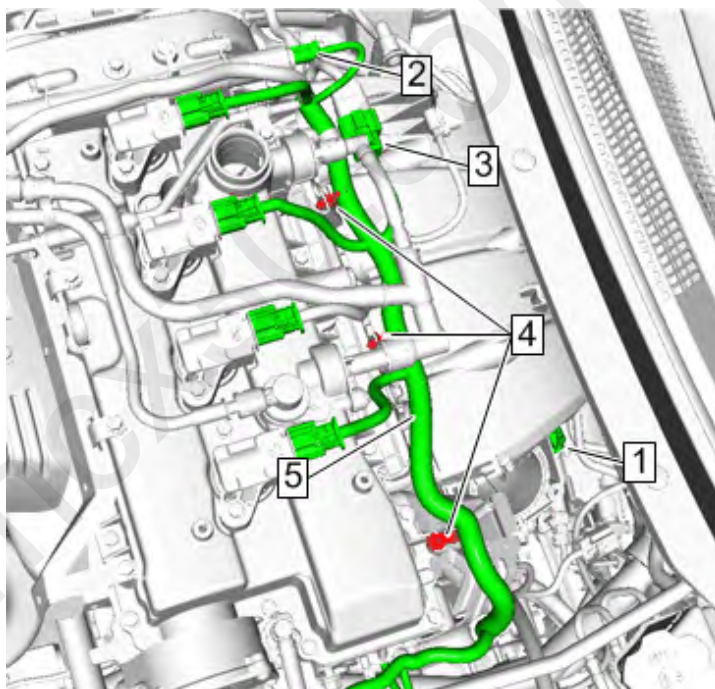


Fig. 80: Electrical Connector And Engine Wiring Harness

Courtesy of GENERAL MOTORS COMPANY

13. Reposition Engine Wiring Harness (5)
14. Connect Electrical Connector (2)
15. Connect Electrical Connector (3)
16. Connect Wiring Harness Retainer (4) [3x]
17. Connect Electrical Connector (1)

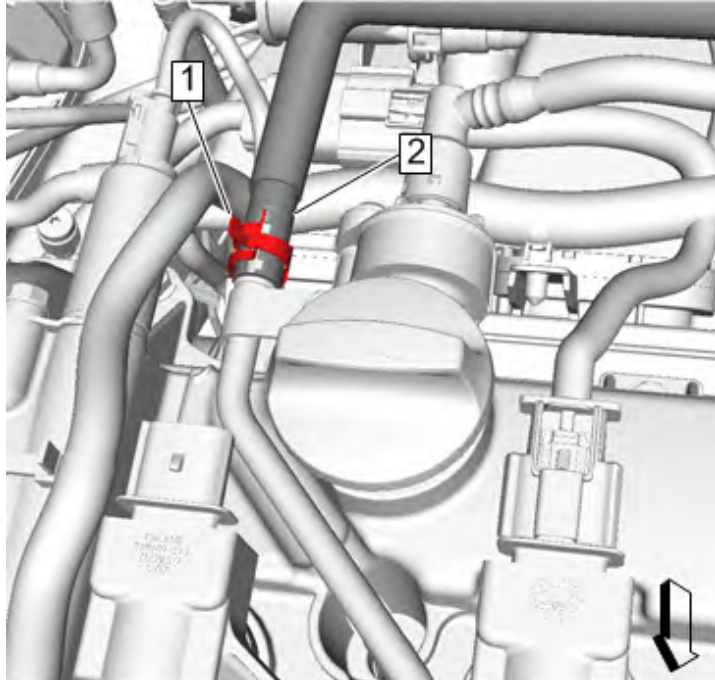


Fig. 81: Engine Coolant Air Bleed Hose Clamp
Courtesy of GENERAL MOTORS COMPANY

18. Reposition and connect the engine coolant air bleed hose (2) as necessary. [Engine Coolant Air Bleed Hose Replacement \(Radiator Surge Tank to Radiator to Engine Coolant Air Bleed Pipe LTG\)](#)
19. Install Throttle Body Assembly - [Throttle Body Assembly Replacement](#)
20. Install Fuel Feed Front Pipe - [Fuel Feed Front Pipe Replacement](#)
21. Install Evaporative Emission Canister Purge Solenoid Valve - [Evaporative Emission Canister Purge Solenoid Valve Replacement](#)
22. Install Air Cleaner Outlet Duct - [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#) [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#)
23. Remove Intake Manifold Cover - [Intake Manifold Cover Replacement](#)

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- EN-45059 Angle Meter
- EN-51577 Crankshaft Balancer Holder/Remover
- J-41816-2 or EN-38416-2 Crankshaft End Protector

Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Remove the drive belt. [Drive Belt Replacement](#)

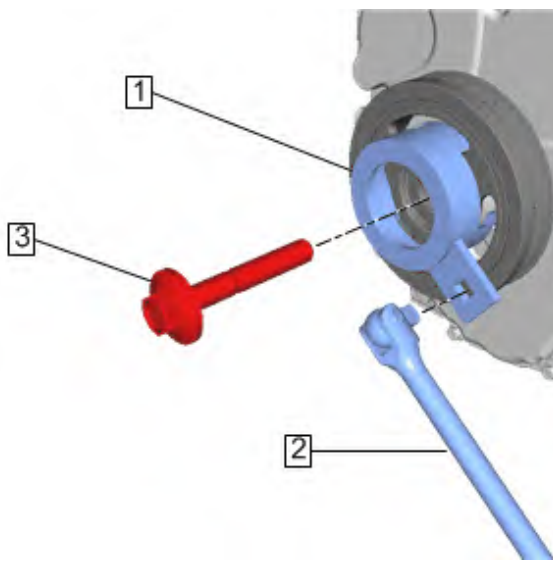


Fig. 82: Crankshaft Balancer Remover, Breaker Bar And Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Use **EN-51577-1** Crankshaft Balancer Remover (1) and breaker bar (2) prevent the crankshaft from rotating while loosening the crankshaft balancer fastener (3).
3. Remove and DISCARD the crankshaft balancer fastener (3).

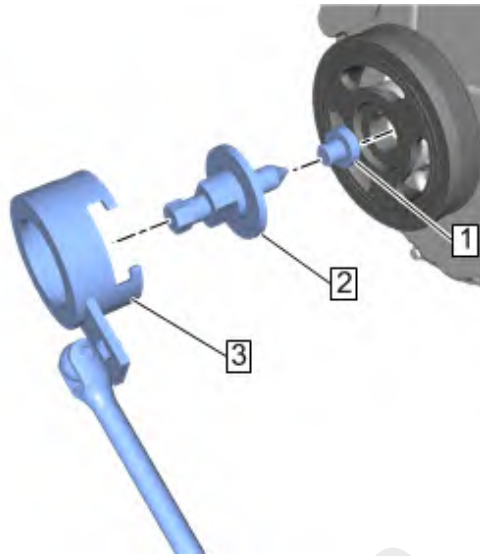


Fig. 83: Crankshaft End Protector And Balancer Remover
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft balancer holder then install the **J-41816-2 or EN-38416-2** Crankshaft End Protector (1) and all components of **EN-51577** Crankshaft Balancer Remover (2, 3) as shown.

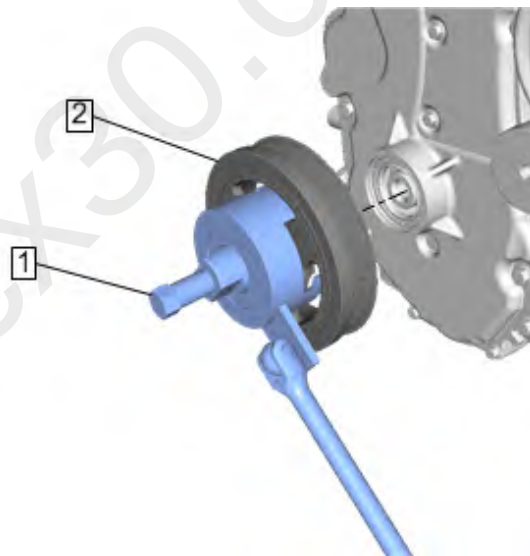


Fig. 84: Crankshaft Balancer Remover And Balancer
Courtesy of GENERAL MOTORS COMPANY

5. tighten the crankshaft balancer remover (1) in order to remove the crankshaft balancer (2).

Installation Procedure

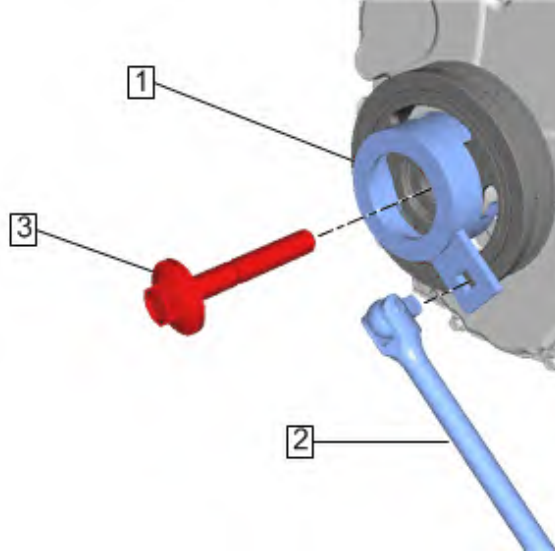


Fig. 85: Crankshaft Balancer Remover, Breaker Bar And Fastener
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft balancer with NEW fastener. Use **EN-51577-1** Crankshaft Balancer Remover (1) and breaker bar (2) prevent the crankshaft from rotating while tightening the NEW crankshaft balancer fastener (3).

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

2. tighten the crankshaft balancer bolt to 150 N.m (111 lb ft) plus an additional 140 degrees using the **EN-45059** meter.
3. Install the drive belt. [Drive Belt Replacement](#)
4. Perform the crankshaft position variation learn procedure. [Crankshaft Position Variation Learn](#)

TIMING CHAIN CRANKSHAFT SPROCKET REPLACEMENT

Special Tools

- **EN-51577-1** Crankshaft Balancer Remover
- **EN-50837** Timing Chain Tensioner Retraction Tool

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

Removal Procedure

1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).
2. Remove the timing chain. Refer to [Camshaft Timing Chain and Tensioner Replacement](#).

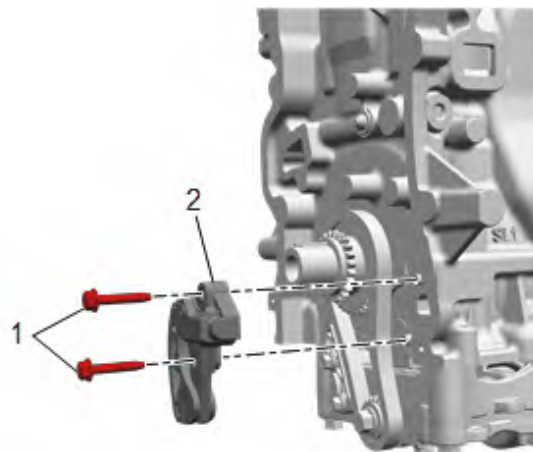


Fig. 86: Balancer Chain Tensioner Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the balancer chain tensioner bolt (1).
4. Remove the balancer chain tensioner (2).
5. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.

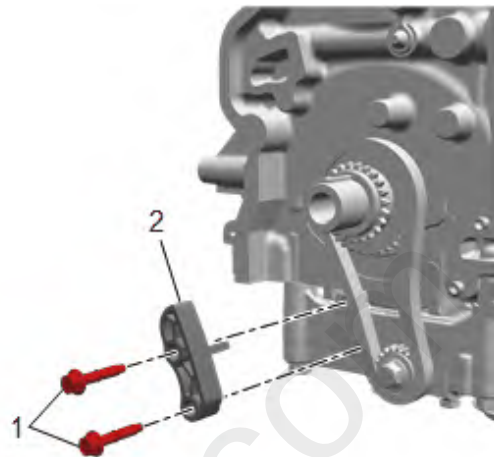


Fig. 87: Balancer Chain Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove the balancer chain guide bolt (1).
7. Remove the balancer chain guide (2).

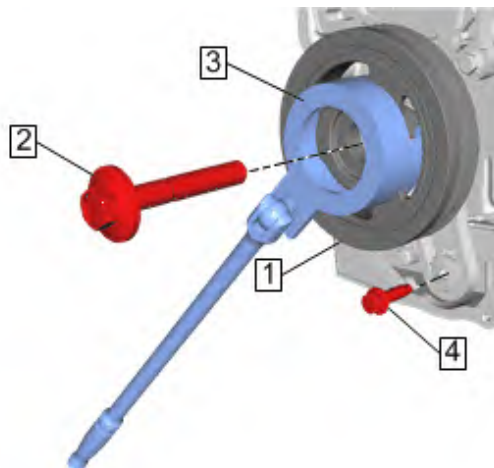


Fig. 88: Holding Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft balancer and the ORIGINAL balancer bolt will be temporarily installed in order to counter hold the crankshaft while removing the balancer shaft driven sprocket bolt.

8. TEMPORARILY install the crankshaft balancer (1).

1. TEMPORARILY install the ORIGINAL crankshaft balancer bolt (2).
2. Counter hold the crankshaft balancer pulley (1) using the **EN-51577-1** Crankshaft Balancer Remover (3).
3. While counter holding, remove and DISCARD the balancer shaft driven sprocket bolt (4).
4. Remove the crankshaft balancer bolt (2), balancer (1) and tool (3).

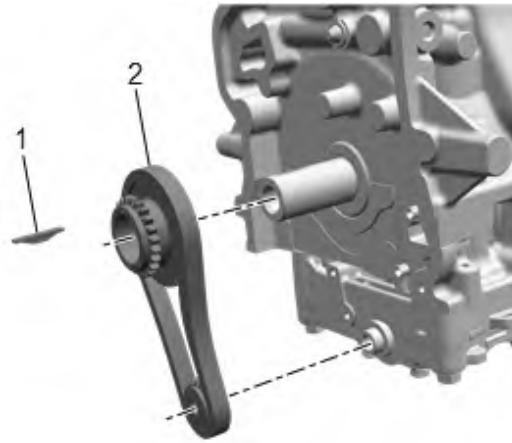


Fig. 89: Balancer Shaft Driven Sprocket And Balancer Chain
 Courtesy of GENERAL MOTORS COMPANY

9. Remove the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain (1) simultaneously.

Installation Procedure

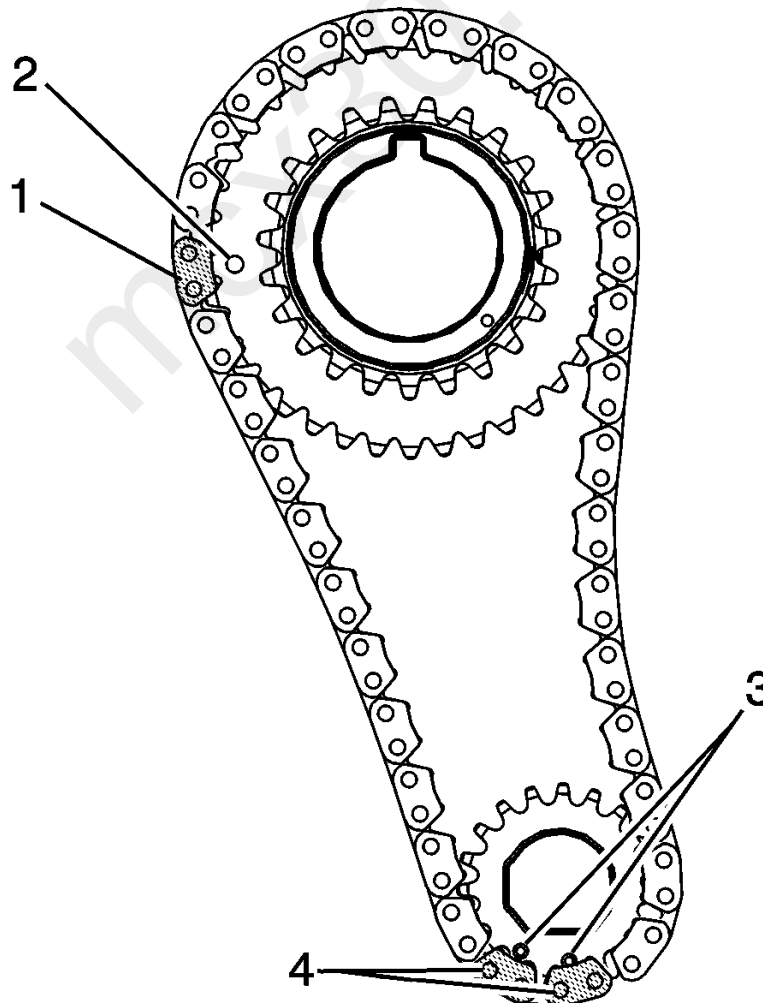


Fig. 90: Timing Link Lines & Timing Mark
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

Proper setup is critical to ensure correct timing when installing the sprockets and chain simultaneously onto the shafts. The timing links are heat treated blued steel.

1. Assemble the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain. Ensure the timing link (1) lines up with the timing mark (2) on the crankshaft sprocket. Ensure that both timing teeth (3) on the balancer shaft driven sprocket line up with the timing links (4).

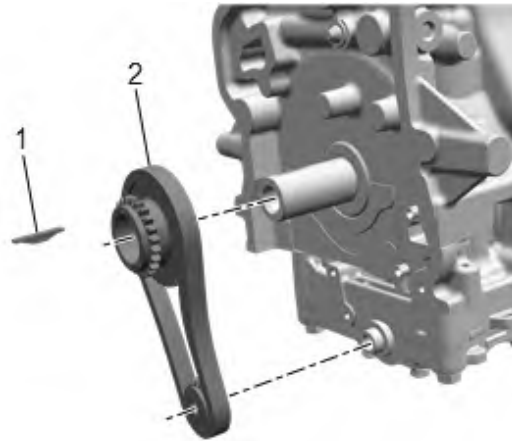
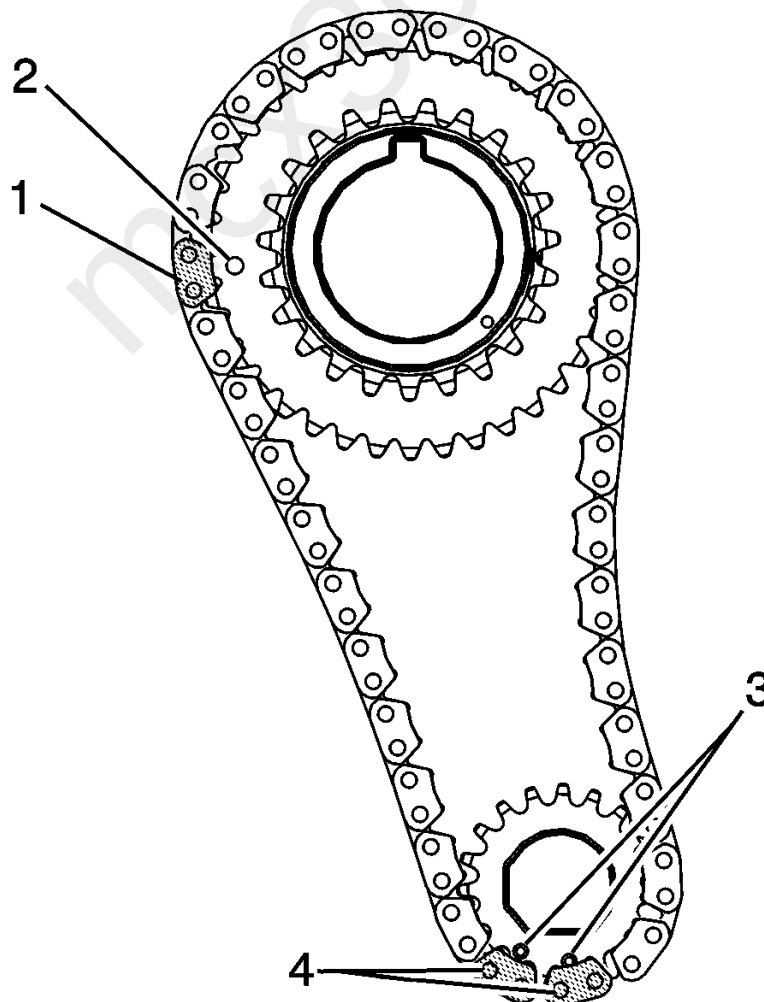


Fig. 91: Balancer Shaft Driven Sprocket And Balancer Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE:

The crankshaft keyway should be in the 12 O'clock position.

2. Install the sprockets and chain (1) as an assembly to the crankshaft and balancer shaft assembly.



3. Ensure the timing link (1) is aligned with the crankshaft sprocket timing mark (2).
4. Ensure the adjacent timing links (4) are aligned with both of the timing marks (3) on the balancer shaft driven sprocket.

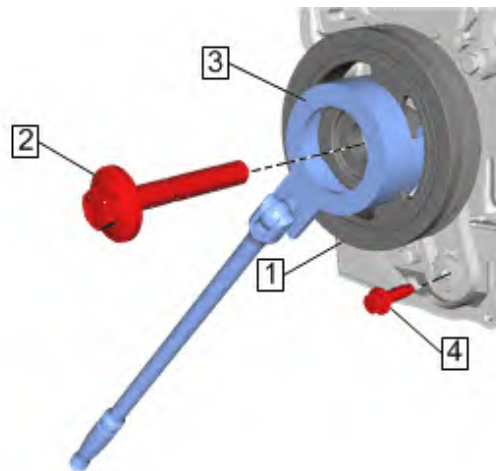


Fig. 93: Holding Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft balancer and the ORIGINAL balancer bolt will be temporarily installed again in order to counter hold the crankshaft while tightening the balancer shaft driven sprocket bolt.

5. Hand start the NEW balancer shaft driven sprocket bolt (4).
 1. TEMPORARILY install the crankshaft balancer (1).
 2. TEMPORARILY install the ORIGINAL crankshaft balancer bolt (2).
 3. Counter hold the crankshaft balancer pulley (1) using the EN-51577-1 Crankshaft Balancer Remover (3).

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

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

4. Counter hold the crankshaft balancer using the EN-51577-1 Crankshaft Balancer Remover (3).
5. While counter holding, tighten the balancer shaft driven sprocket bolt (4) to 40 N.m (30 lb ft) plus 50 degrees

NOTE: A NEW crankshaft balancer bolt will be installed during final installation of the crankshaft balancer.

6. Remove and DISCARD the crankshaft balancer bolt (2).
7. Remove the crankshaft balancer (1) and EN-51577-1 Crankshaft Balancer Remover (3).

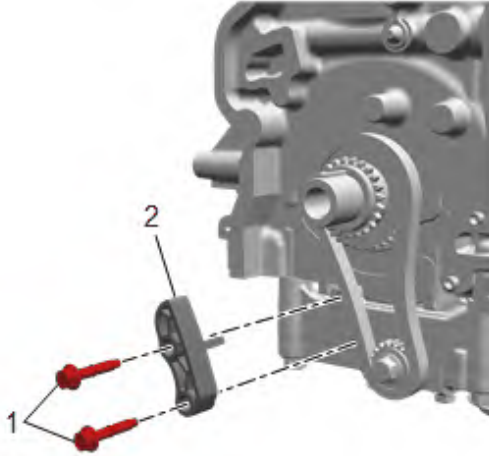


Fig. 94: Balancer Chain Guide Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the guide is installed in the correct orientation. The long end must point toward the crankshaft and the flat edge must be adjacent to the balance chain.

6. Install the balancer chain guide (2).
7. Install the balancer chain guide bolts (1). tighten the bolts to 10 N.m (89 lb in).

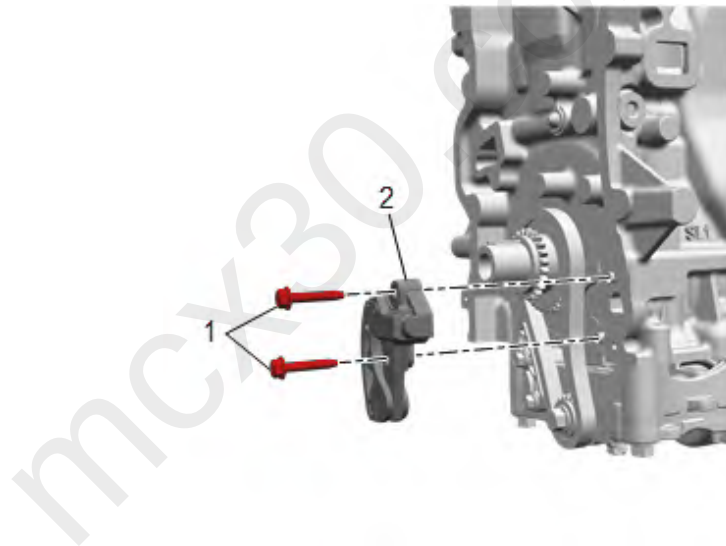


Fig. 95: Balancer Chain Tensioner Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Install the balancer chain tensioner (2).
9. Install the balancer chain tensioner bolts (1). tighten the bolts to 10 N.m (89 lb in).
10. Remove **EN-50837** retention tool to restore the tension to the balancer chain.
11. Install the timing chain. Refer to [Camshaft Timing Chain and Tensioner Replacement](#).
12. Install the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

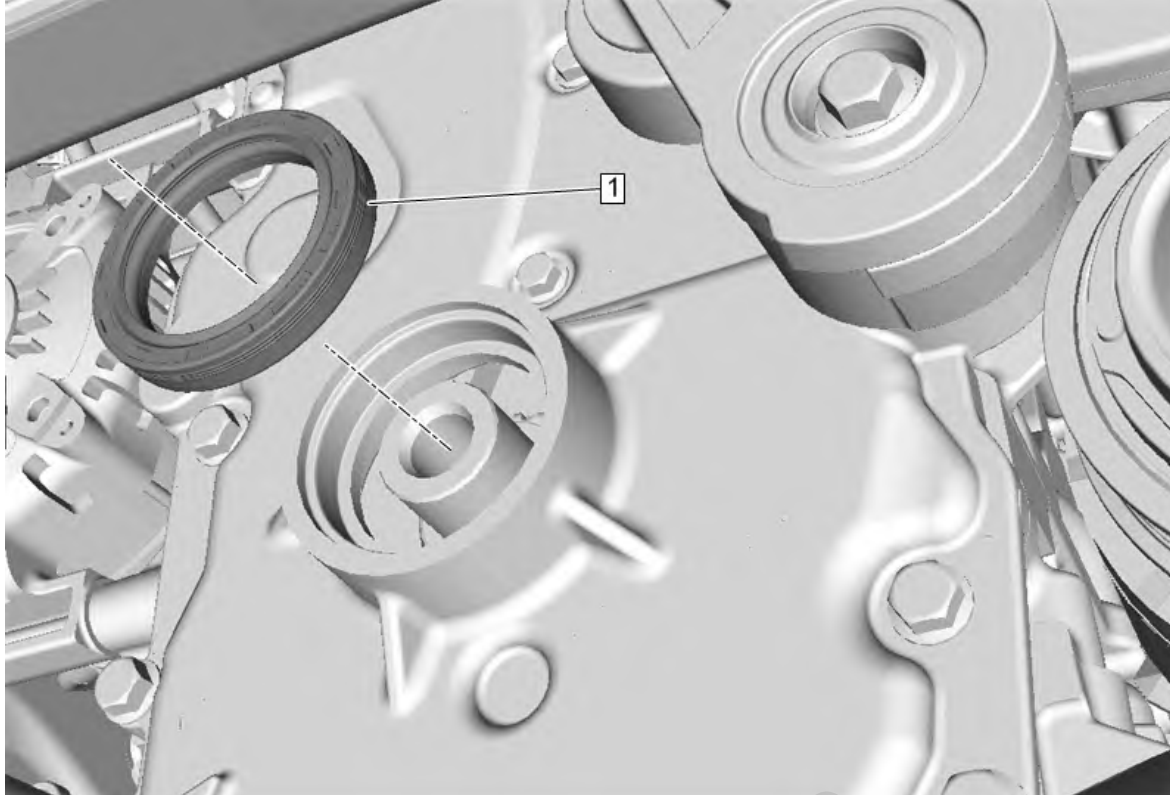


Fig. 96: Crankshaft Front Oil Seal

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Crankshaft Balancer Replacement	
1	Crankshaft Front Oil Seal Procedure 1. Use a suitable tool to remove the seal. 2. Use the EN 50820 Front Crankshaft Seal Installer to install the seal. Special Tools EN 50820 Front Crankshaft Seal Installer Equivalent regional tools: Special Tools

ENGINE FRONT COVER REPLACEMENT

Special Tools

- **EN-45059** Angular Meter
- **EN-50820** Front Crankshaft Seal Installer
- **KM-470 - B** Angular Torque Gauge

Equivalent regional tools: **Special Tools**

Removal Procedure

1. Remove Air Cleaner Assembly - **Air Cleaner Assembly Replacement**
2. Remove Camshaft Cover - **Camshaft Cover Replacement (1st Design Tamper-Proof PCV System)**
3. Remove Engine Mount - **Engine Mount Replacement**
4. Remove Crankshaft Balancer - **Crankshaft Balancer Replacement**
5. Remove Drive Belt Tensioner - **Drive Belt Tensioner Replacement**

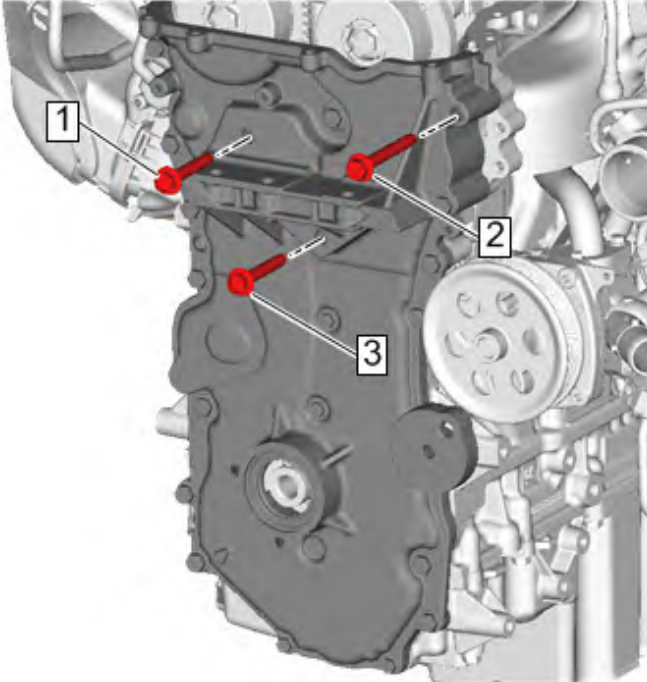


Fig. 97: Identifying Engine Front Cover Bolts
 Courtesy of GENERAL MOTORS COMPANY

6. Remove Engine Front Cover Bolt (1, 2, 3) and DISCARD

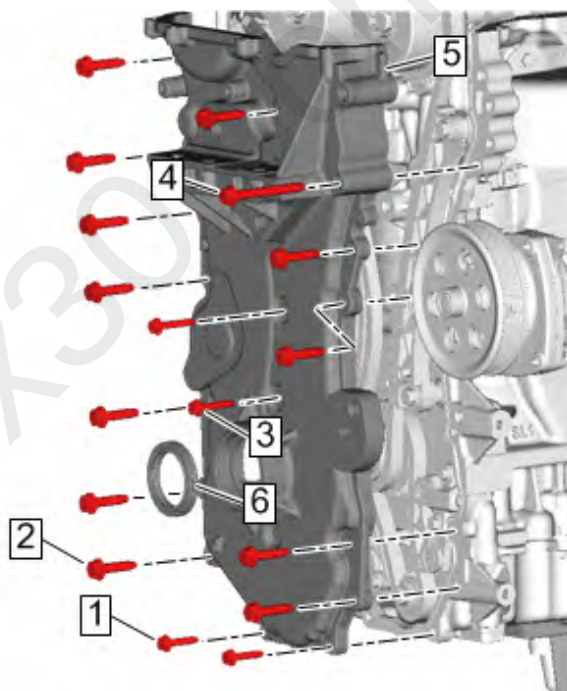


Fig. 98: Identifying Front Cover Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The engine front cover bolts vary in lengths. Mark the bolts to ensure they are installed in the correct locations.

7. Remove Engine Front Cover Bolt (1) [2x]
8. Remove Engine Front Cover Bolt (2) [12x]
9. Remove Engine Front Cover Bolt (3) [2x]
10. Remove Engine Front Cover Bolt (4)
11. Remove Engine Front Cover (5).
12. If replacing the engine front cover, remove and DISCARD the crankshaft front oil seal (6) using an appropriate tool.

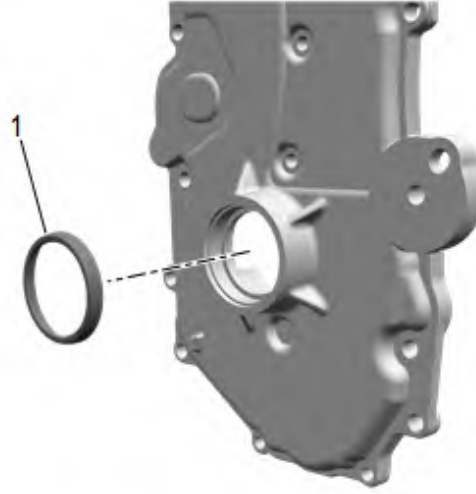


Fig. 99: Front Crankshaft Seal

Courtesy of GENERAL MOTORS COMPANY

1. If removed, Use **EN-50820** installer, to install the front crankshaft seal (1) into the engine front cover.

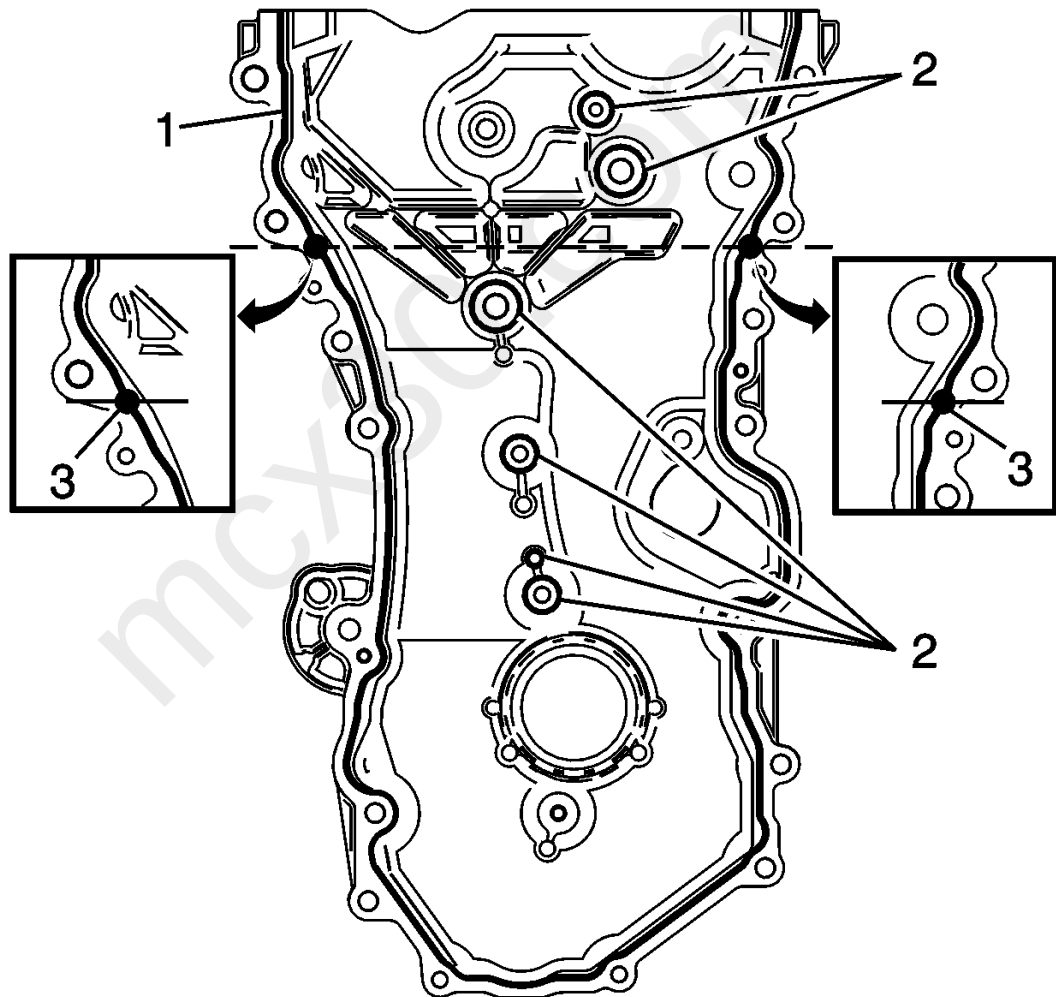


Fig. 100: Applying Bead Of Sealer Directly In Flange

Courtesy of GENERAL MOTORS COMPANY

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 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 5 mm bead of sealer directly in the flange (1) of the engine front cover perimeter mating surface. Also apply a 5 mm bead of sealer directly to the locations indicated (2). Finally, apply a 14 mm dab of sealant at the locations indicated (3). [Adhesives, Fluids, Lubricants, and Sealers](#).

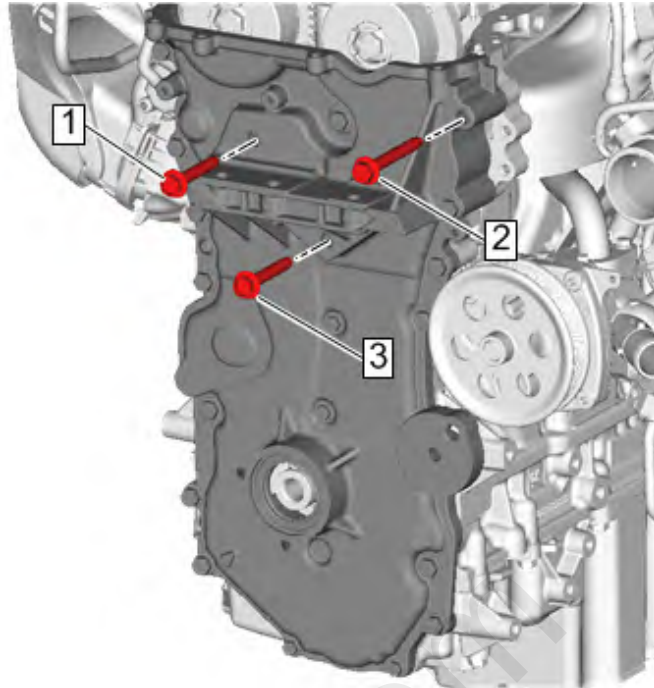


Fig. 101: Identifying Engine Front Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

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

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

3. Install by hand 3 NEW bolts (1, 2 and 3).

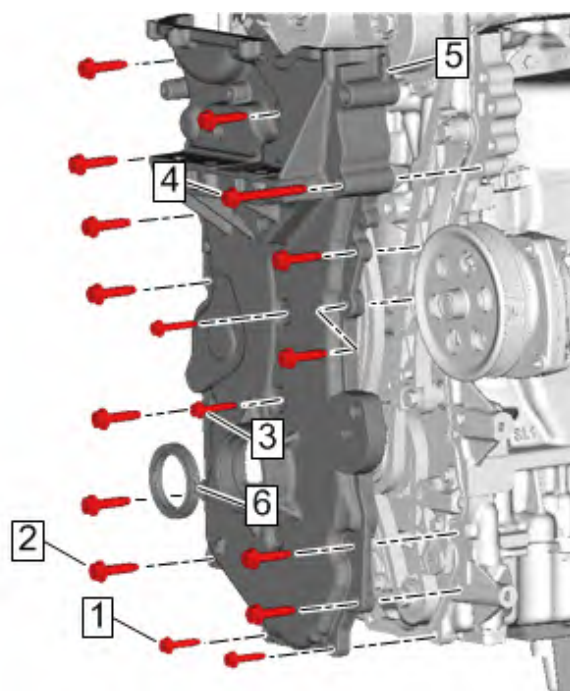


Fig. 102: Identifying Front Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the bolts are installed in the previously marked positions.

4. Install Engine Front Cover (5)
5. Loosely Install Engine Front Cover Bolt (1) [2x]
6. Loosely Install Engine Front Cover Bolt (2) [12x]
7. Loosely Install Engine Front Cover Bolt (3) [2x]
8. Loosely Install Engine Front Cover Bolt (4).

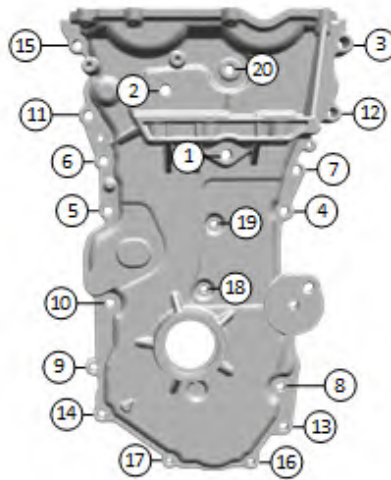


Fig. 103: Engine Front Cover Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

9. tighten the engine front cover bolts in sequence to final torque twice:

tighten

1. tighten sequence 1 - 3 bolts a first pass to 15 N.m (11 lb ft).
2. tighten sequence 1 - 3 bolts a final pass 130 degrees using **EN-45059** meter.
3. tighten sequence 4 - 15 bolts to 25 N.m (18 lb ft).
4. tighten sequence 16 - 17 bolts to 10 N.m (7 lb ft)
5. tighten sequence 18 - 19 bolts to 10 N.m (7 lb ft).
6. tighten sequence 20 bolt to 25 N.m (18 lb ft).
10. Install Drive Belt Tensioner - [Drive Belt Tensioner Replacement](#)
11. Install Crankshaft Balancer - [Crankshaft Balancer Replacement](#)
12. Install Engine Mount - [Engine Mount Replacement](#)
13. Install Camshaft Cover - [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#)
14. Install Air Cleaner Assembly - [Air Cleaner Assembly Replacement](#)

INTAKE VALVE ROCKER ARM REPLACEMENT

Removal Procedure

1. Remove the camshaft position actuator and camshaft - intake. Refer to [Camshaft Position Actuator and Camshaft Replacement - Intake](#).

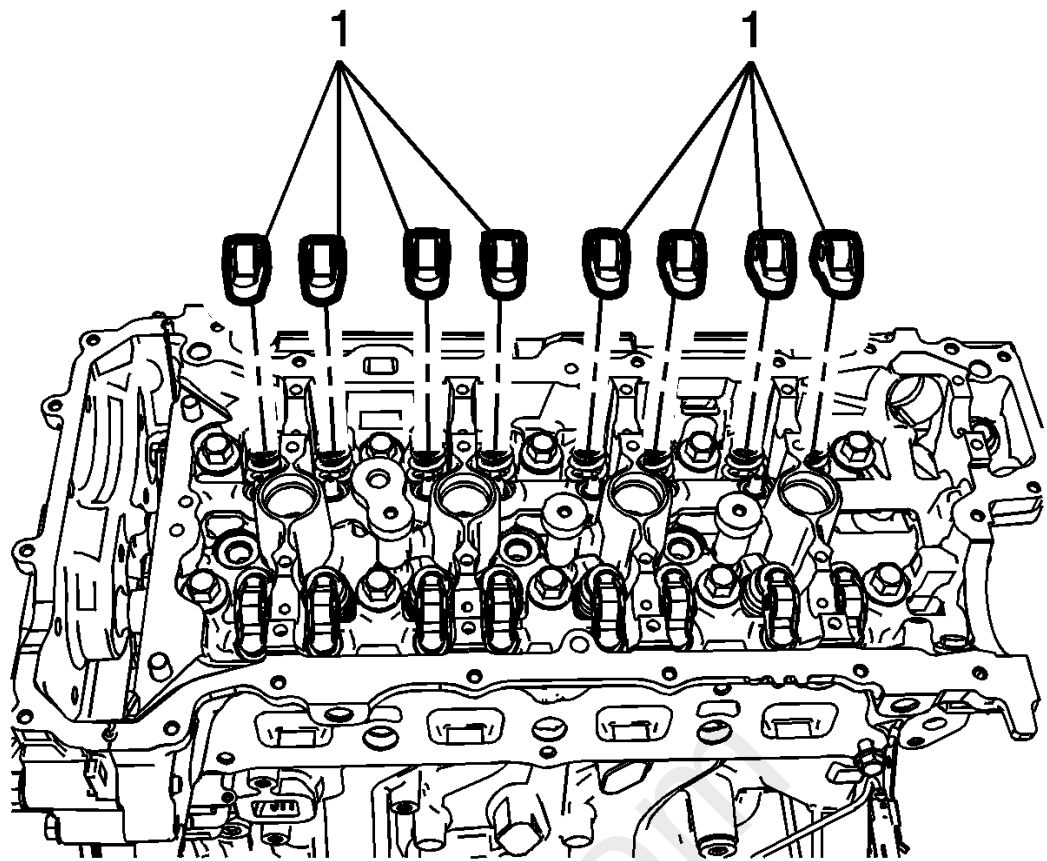


Fig. 104: Intake Rocker Arm

Courtesy of GENERAL MOTORS COMPANY

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

2. Remove the intake rocker arm (1).

Installation Procedure

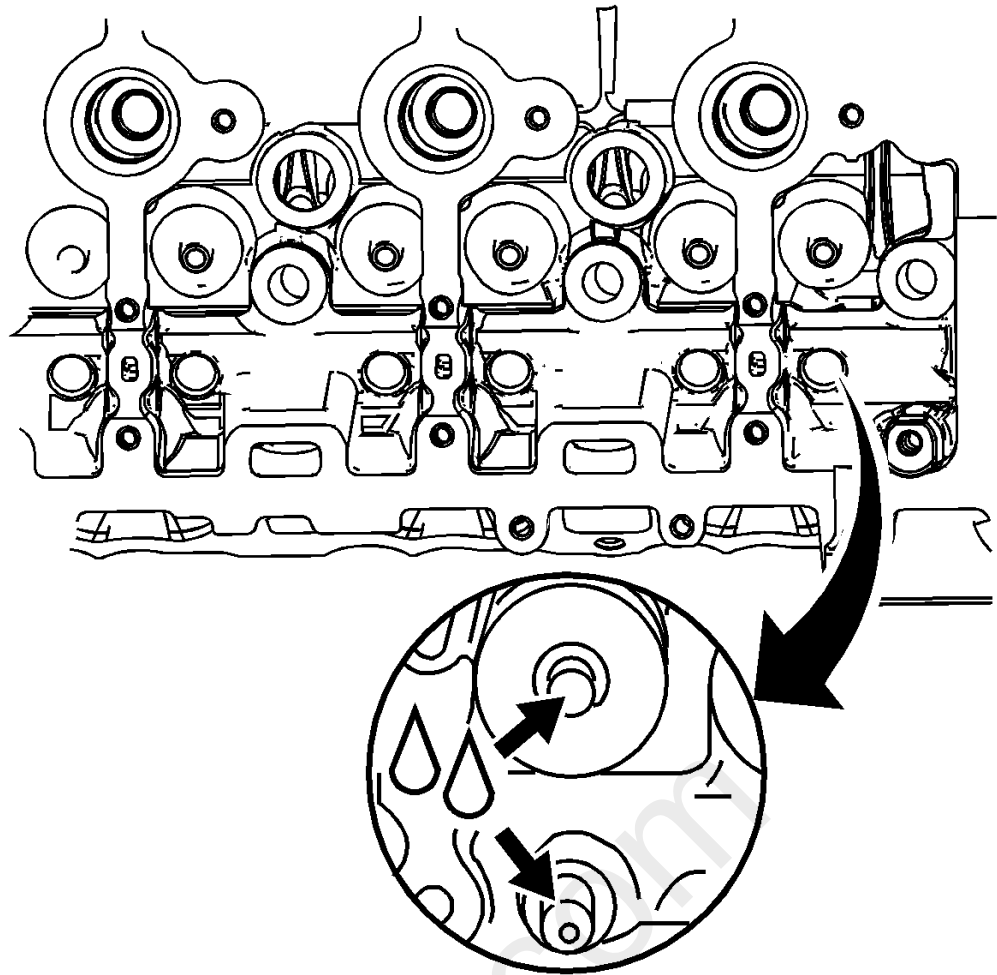


Fig. 105: Valve Tips

Courtesy of GENERAL MOTORS COMPANY

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

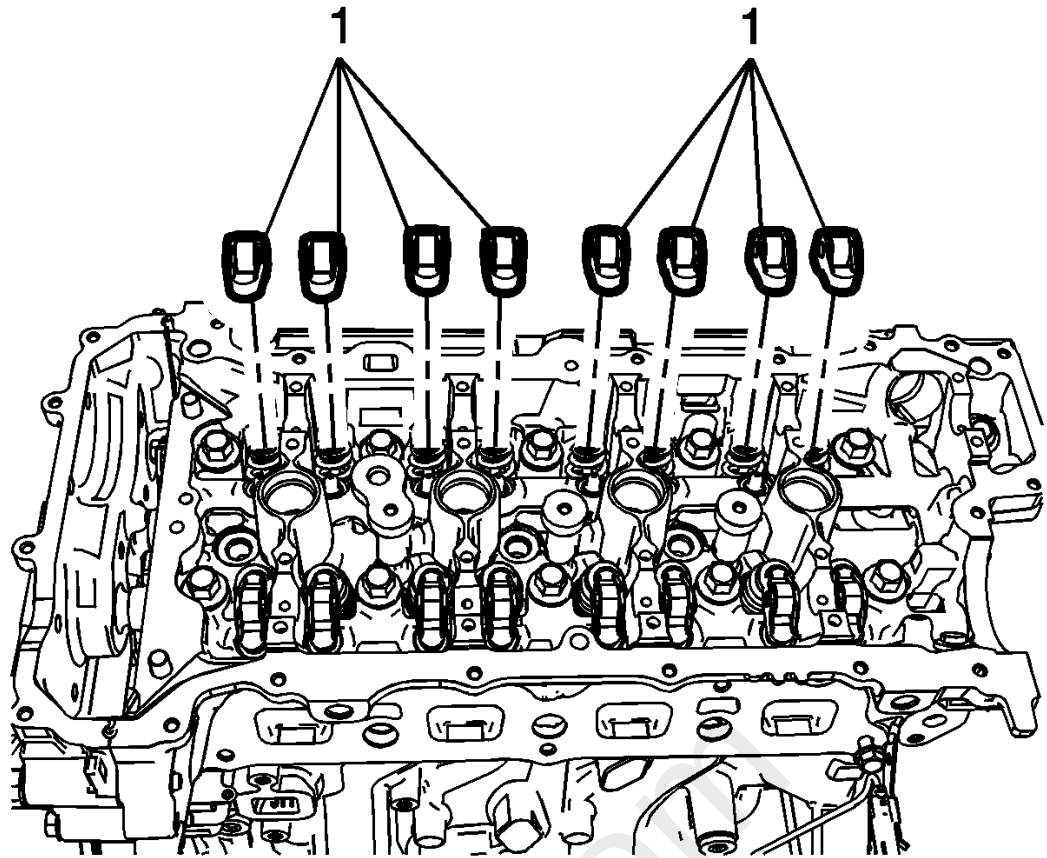


Fig. 106: Intake Rocker Arm

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.
 - Pre-oil roller bearings before installation.
2. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
 3. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
 4. Install the camshaft position actuator and camshaft - intake. Refer to [Camshaft Position Actuator and Camshaft Replacement - Intake](#).

EXHAUST VALVE ROCKER ARM REPLACEMENT

Removal Procedure

1. Remove the camshaft position actuator and camshaft - exhaust. Refer to [Camshaft Position Actuator and Camshaft Replacement - Exhaust](#).

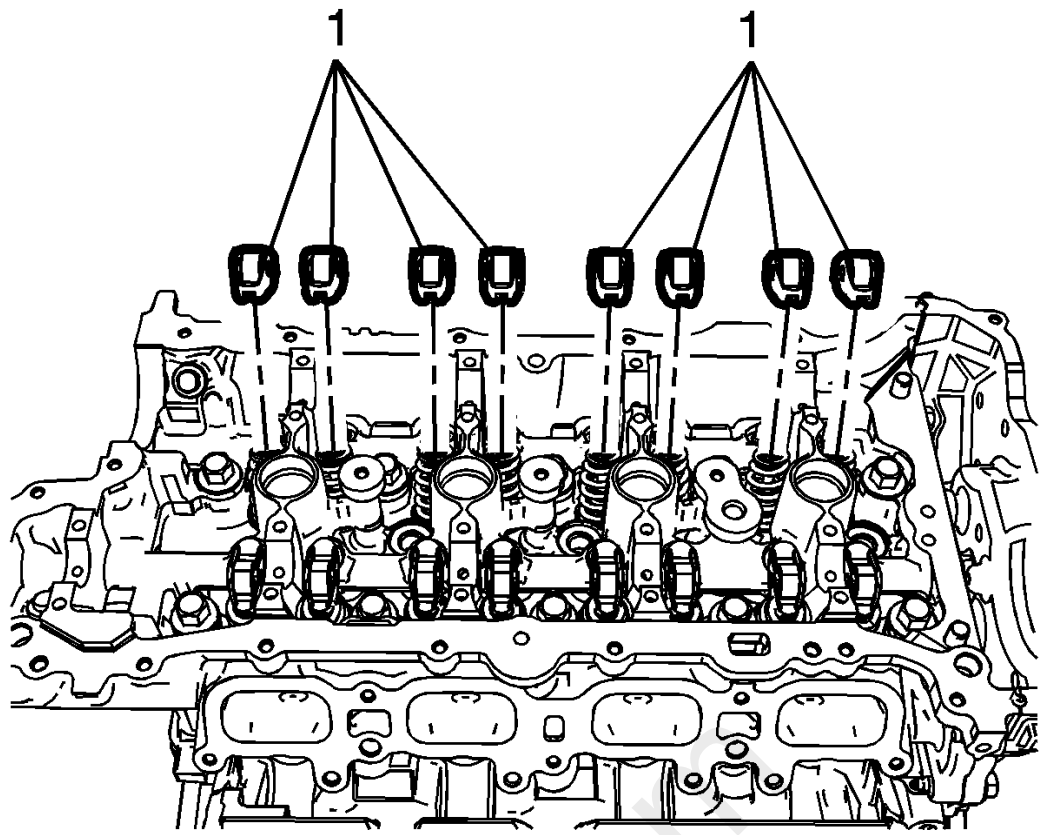


Fig. 107: Exhaust Rocker Arm

Courtesy of GENERAL MOTORS COMPANY

NOTE: Keep all of the Valve Rocker Arms and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

2. Remove the exhaust rocker arm (1).

Installation Procedure

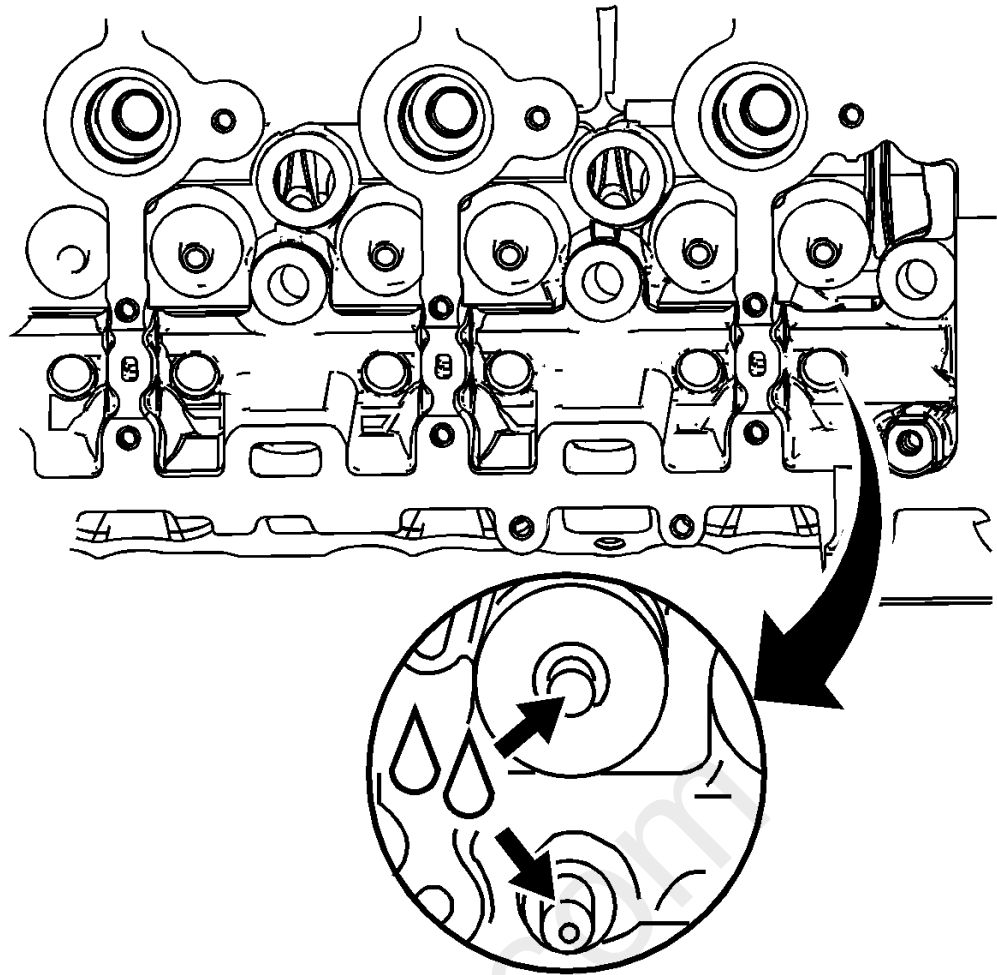


Fig. 108: Valve Tips

Courtesy of GENERAL MOTORS COMPANY

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

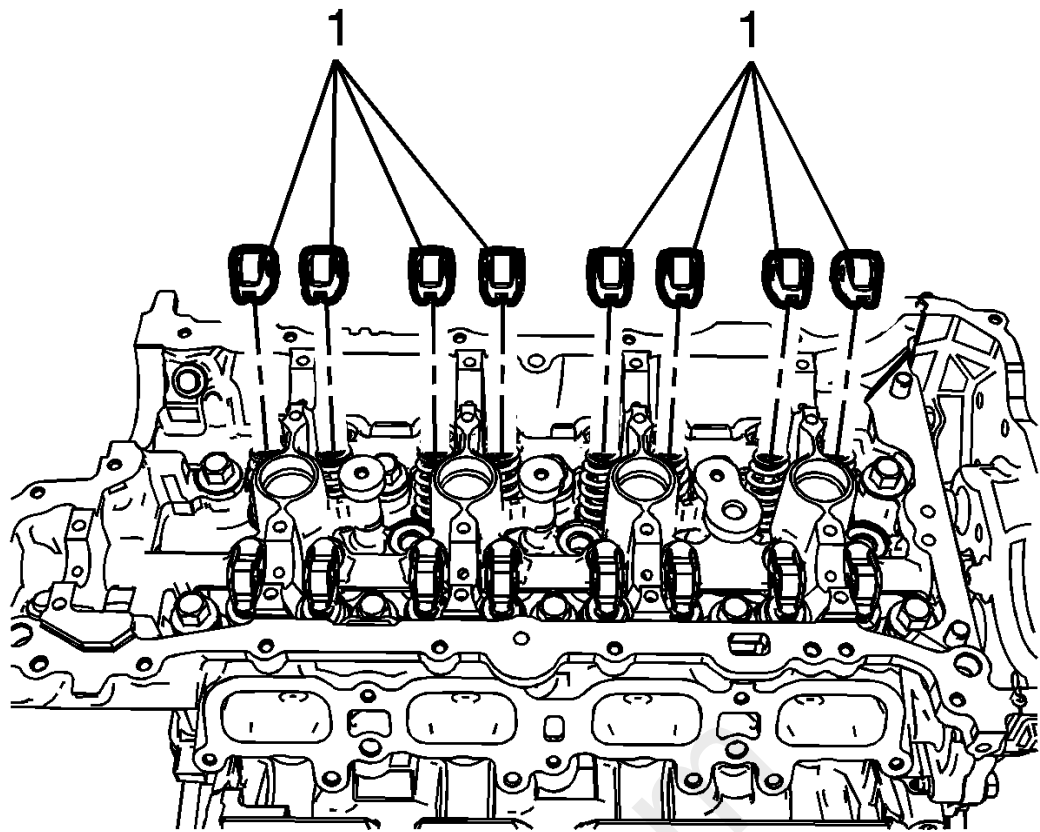


Fig. 109: Exhaust Rocker Arm

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Used rocker arms must be returned to the original position on the camshaft. If the camshaft is being replaced, the rocker arms actuated by the camshaft must also be replaced.
 - Pre-oil roller bearings before installation.
2. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
 3. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
 4. Install the camshaft position actuator and camshaft - exhaust. Refer to [Camshaft Position Actuator and Camshaft Replacement - Exhaust](#).

CAMSHAFT TIMING CHAIN AND TENSIONER REPLACEMENT

Removal Procedure

1. Remove the engine front cover. Refer to [Engine Front Cover Replacement](#).

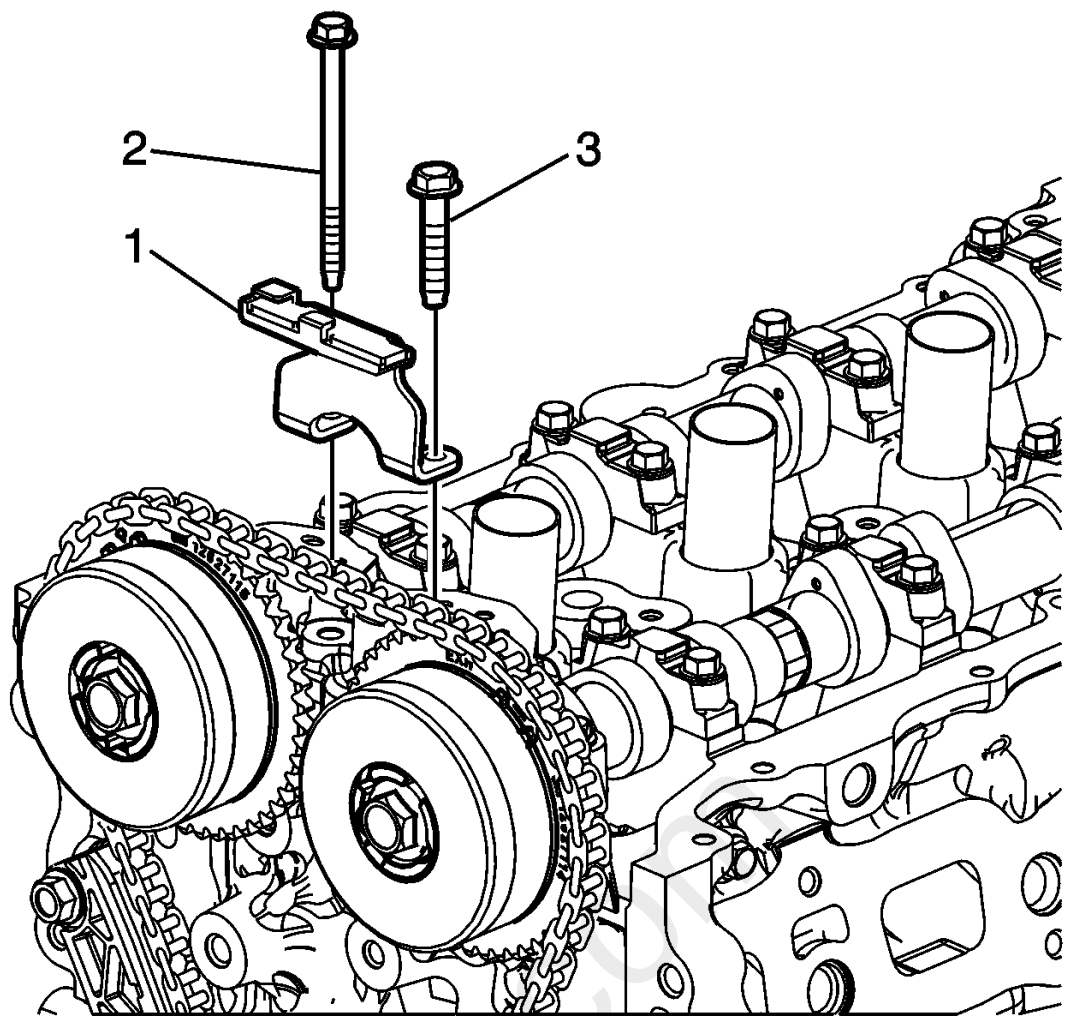


Fig. 110: Upper Timing Chain Guide Bolts
 Courtesy of GENERAL MOTORS COMPANY

2. Remove the upper timing chain guide bolts (2, 3).
3. Remove the upper timing chain guide (1).

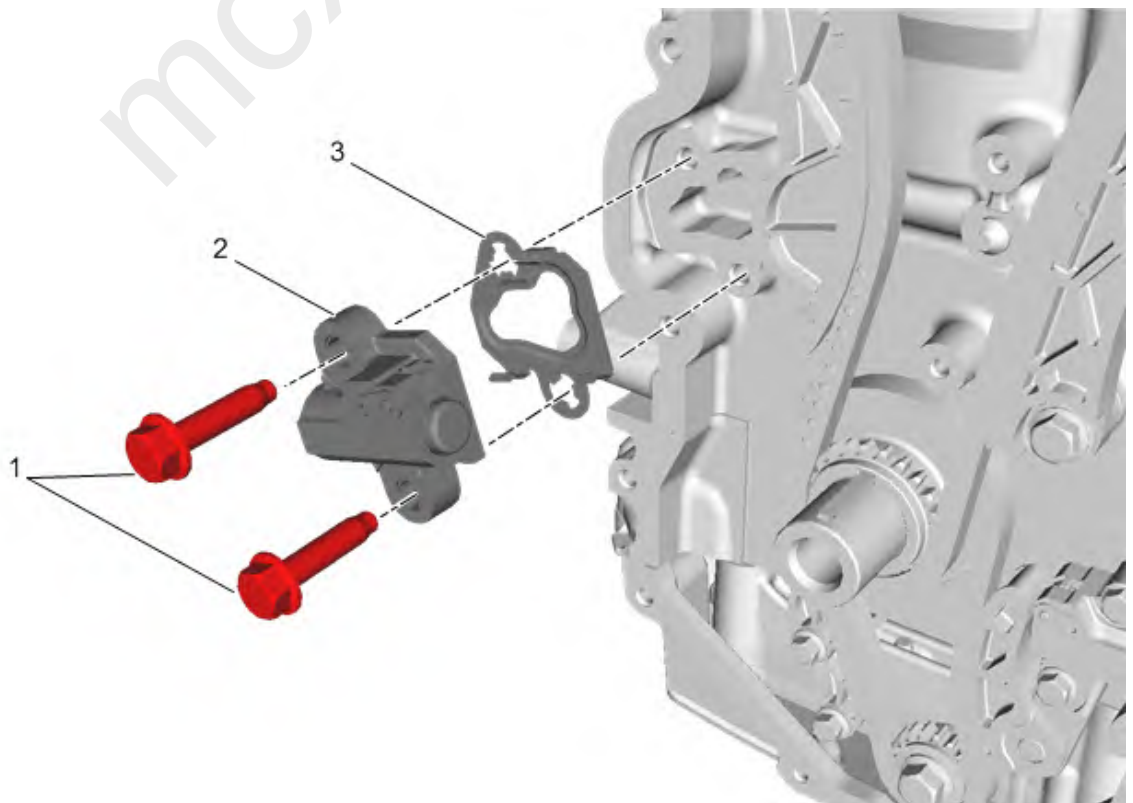


Fig. 111: Timing Chain Tensioner Bolts And Timing Chain Tensioner
 Courtesy of GENERAL MOTORS COMPANY

4. Remove Timing Chain Tensioner Bolt (1) [2x]
5. Remove Timing Chain Tensioner (2).
6. Remove Timing Chain Tensioner Gasket (3) and DISCARD

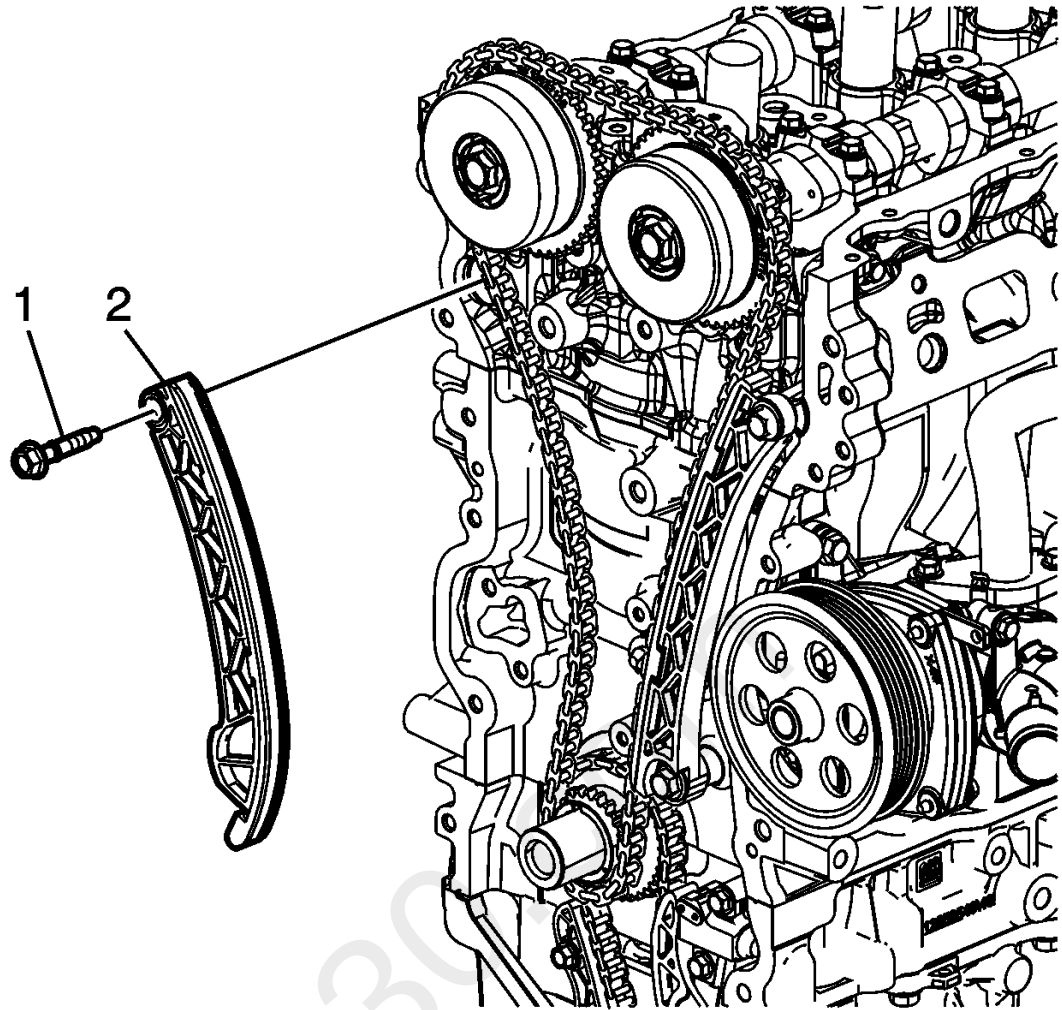


Fig. 112: Timing Chain Tensioner Pivot Arm Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Remove the timing chain tensioner pivot arm bolt (1).
8. Remove the timing chain tensioner pivot arm (2).

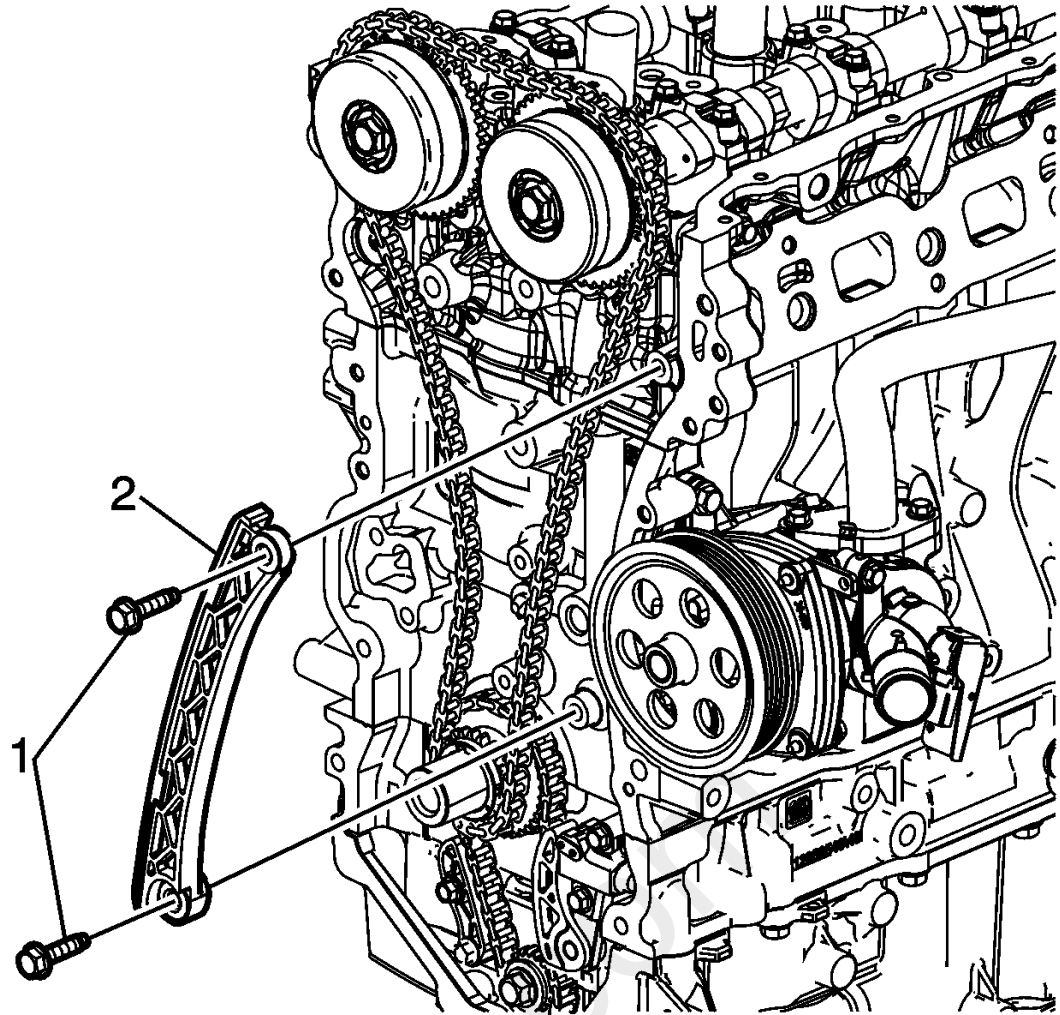


Fig. 113: Timing Chain Guide Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Remove the timing chain guide bolts (1).
10. Remove the timing chain guide (2).

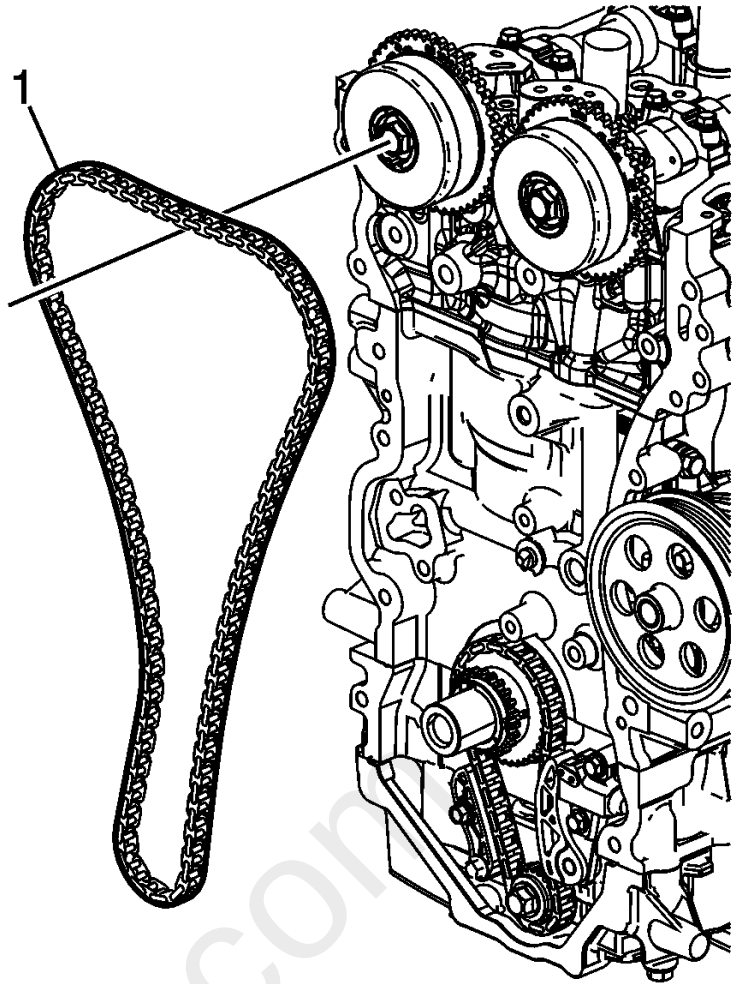


Fig. 114: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

11. Remove the timing chain (1).

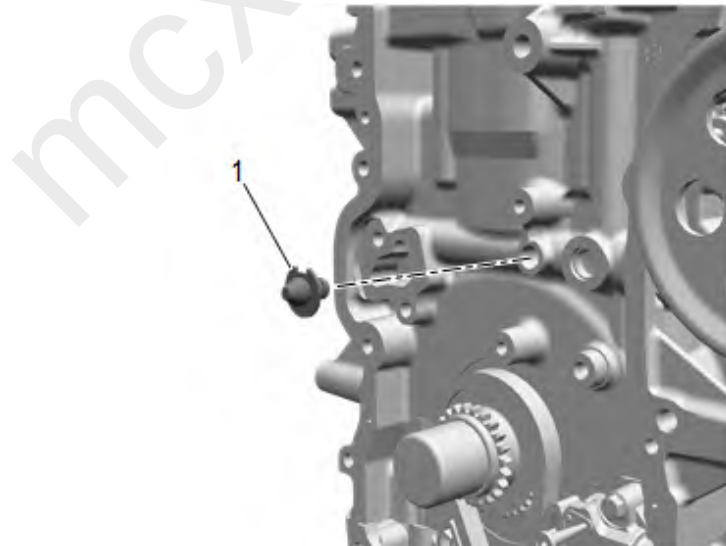


Fig. 115: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

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

Installation Procedure

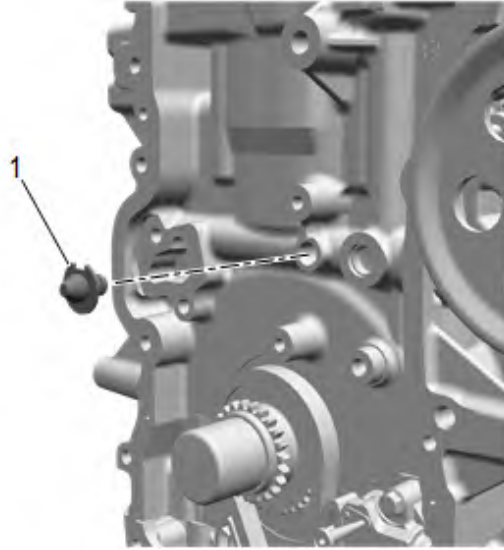


Fig. 116: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the timing chain oil nozzle is rotated with the notch facing upward, and aligned with the tab on the engine block.

1. Install the timing chain oil nozzle (1).

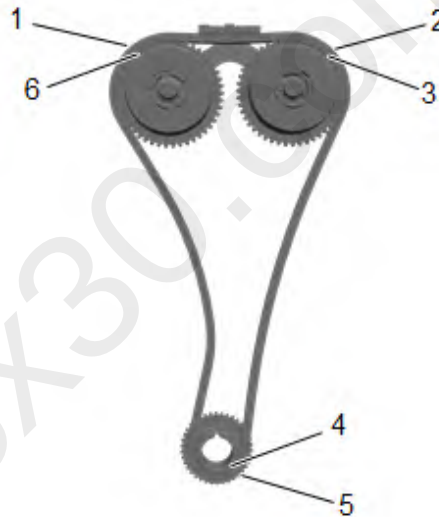


Fig. 117: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

NOTE: There are three colored links on the timing chain. The two links that align to the timing marks on the actuators are the same color. The timing link that aligns with the timing mark on the crankshaft sprocket is a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

2. Loop the timing chain over the intake and exhaust camshaft actuators, aligning one of the same colored links (2) with the timing mark on the exhaust camshaft actuator (3).

NOTE: The same colored link corresponding to the intake actuator will not initially align with the intake actuator timing mark, nor the unique colored timing chain link align with the crankshaft sprocket timing mark.

3. Ensure the crankshaft key in the 12 O'clock position. Loop the timing chain onto the crankshaft sprocket.

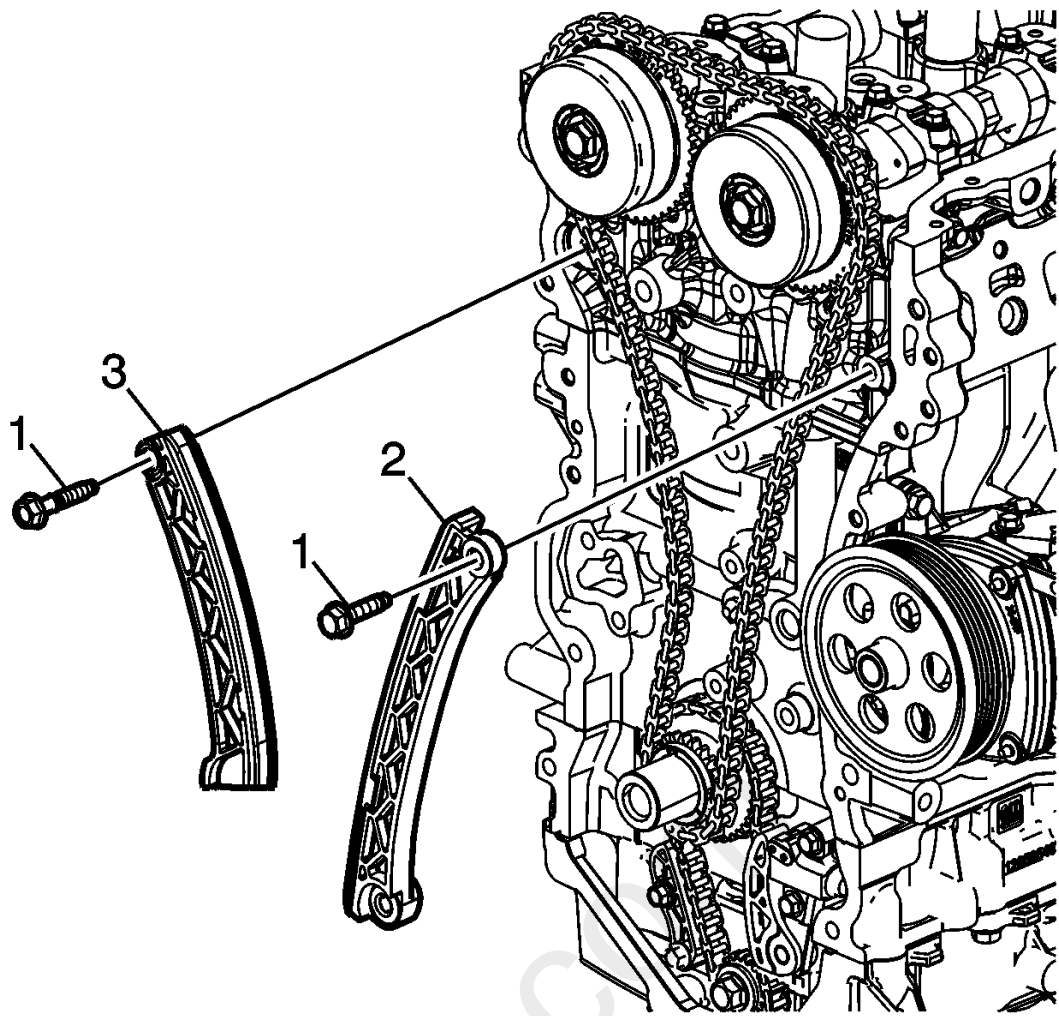


Fig. 118: Timing Chain Guides And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Timing will be established before the final install and torque of the guide bolts.

4. Install the timing chain guide (2) and upper bolt (1) only, finger tight.
5. Install the timing chain tensioner pivot arm (3).
6. Install the pivot arm bolt (1) finger tight.

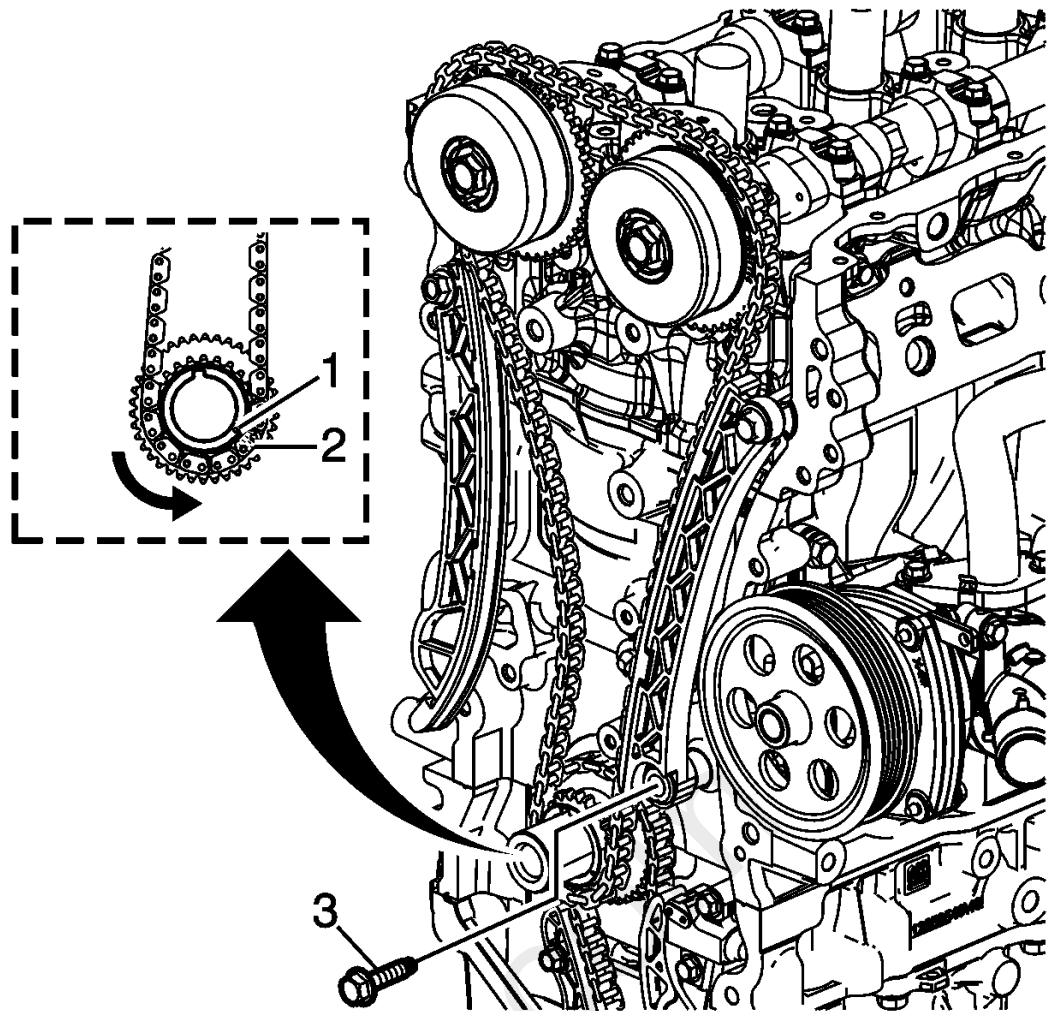


Fig. 119: Crankshaft Sprocket

Courtesy of GENERAL MOTORS COMPANY

7. With a suitable tool, rotate the crankshaft counterclockwise to align the timing mark on the crankshaft sprocket (1) with the timing link (2).

NOTE:

- Continue to rotate the crankshaft counterclockwise as necessary to maintain timing alignment.
- Ensure that the alignment mark on the exhaust camshaft actuator remains aligned with the timing link.

8. Rotate the lower end of the fixed timing chain guide into installation position and install the lower bolt (3).

CAUTION: Refer to **Fastener Caution** .

9. tighten the timing chain guide upper and lower bolts to 25 N.m (18 lb ft).

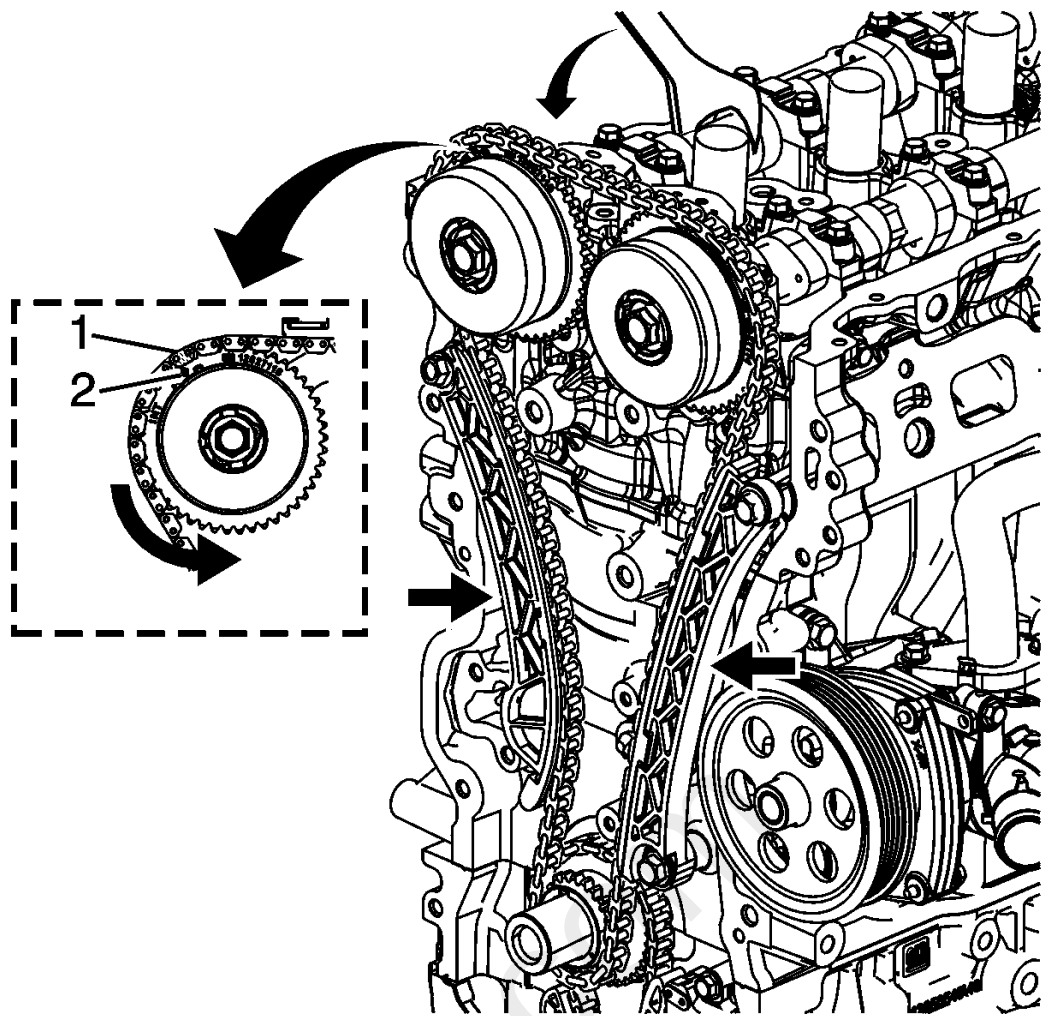


Fig. 120: Timing Mark On Intake Actuator
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The timing for the exhaust camshaft actuator and the crankshaft sprocket has been established.
- Applying or loosening pressure by hand between the timing chain guides will allow the chain to slip or bind during counterclockwise rotation of the camshaft.

10. Using a suitable tool, rotate the intake camshaft counterclockwise until the timing mark on the intake actuator (2) is aligned with the timing link (1). Maintain tension on intake camshaft until the timing chain tensioner can be installed and activated.

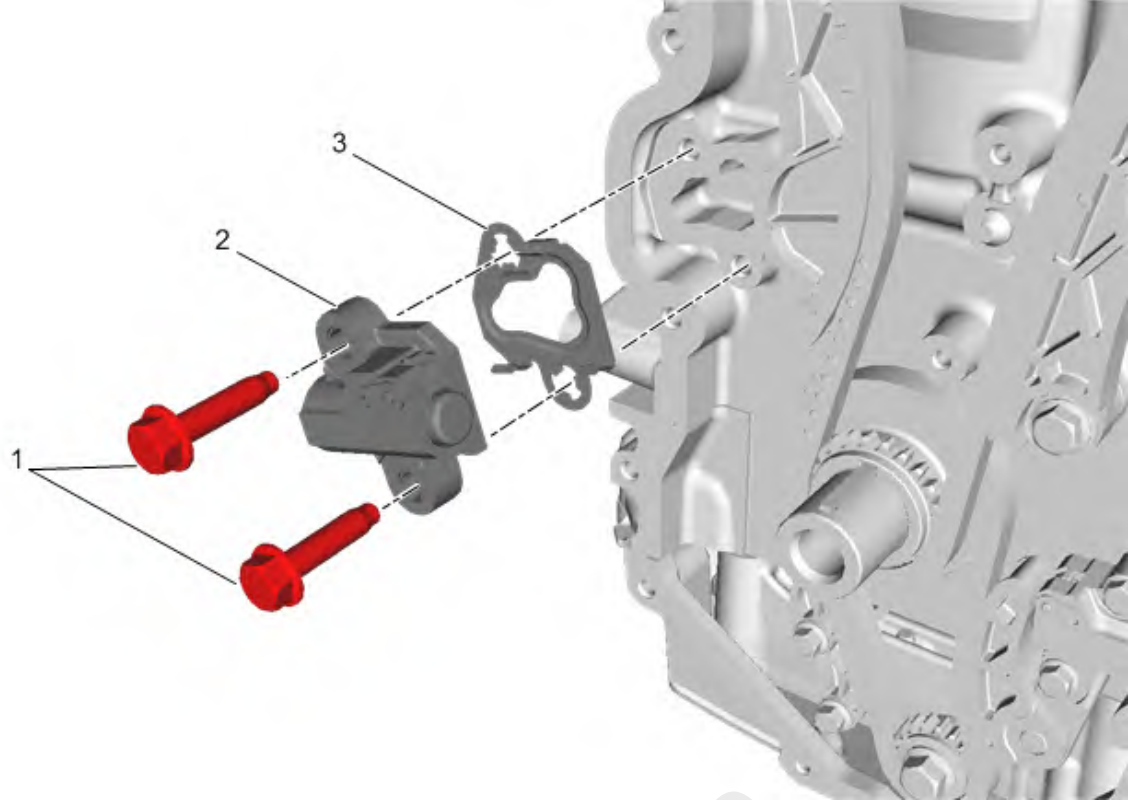


Fig. 121: Timing Chain Tensioner Bolts And Timing Chain Tensioner
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Use a NEW gasket.

11. Install Timing Chain Tensioner Gasket (3).
12. Install Timing Chain Tensioner (2).
13. Install Timing Chain Tensioner Bolt (1) and tighten [2x] 25 N.m (18 lb ft)

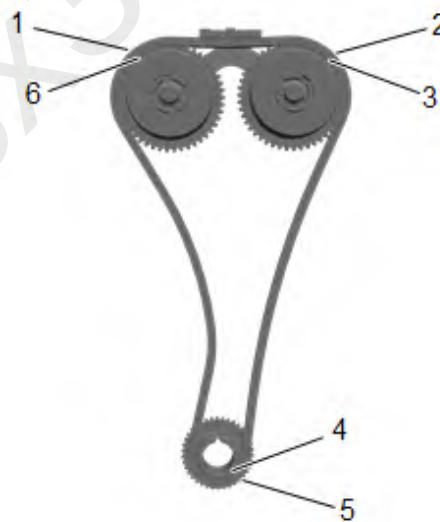


Fig. 122: Timing Chain Oil Nozzle
 Courtesy of GENERAL MOTORS COMPANY

14. Verify the timing links on the timing chain are properly aligned to the timing marks:
 1. The timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
 2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
15. If they are not, repeat the portion of the procedure necessary to align the timing marks.

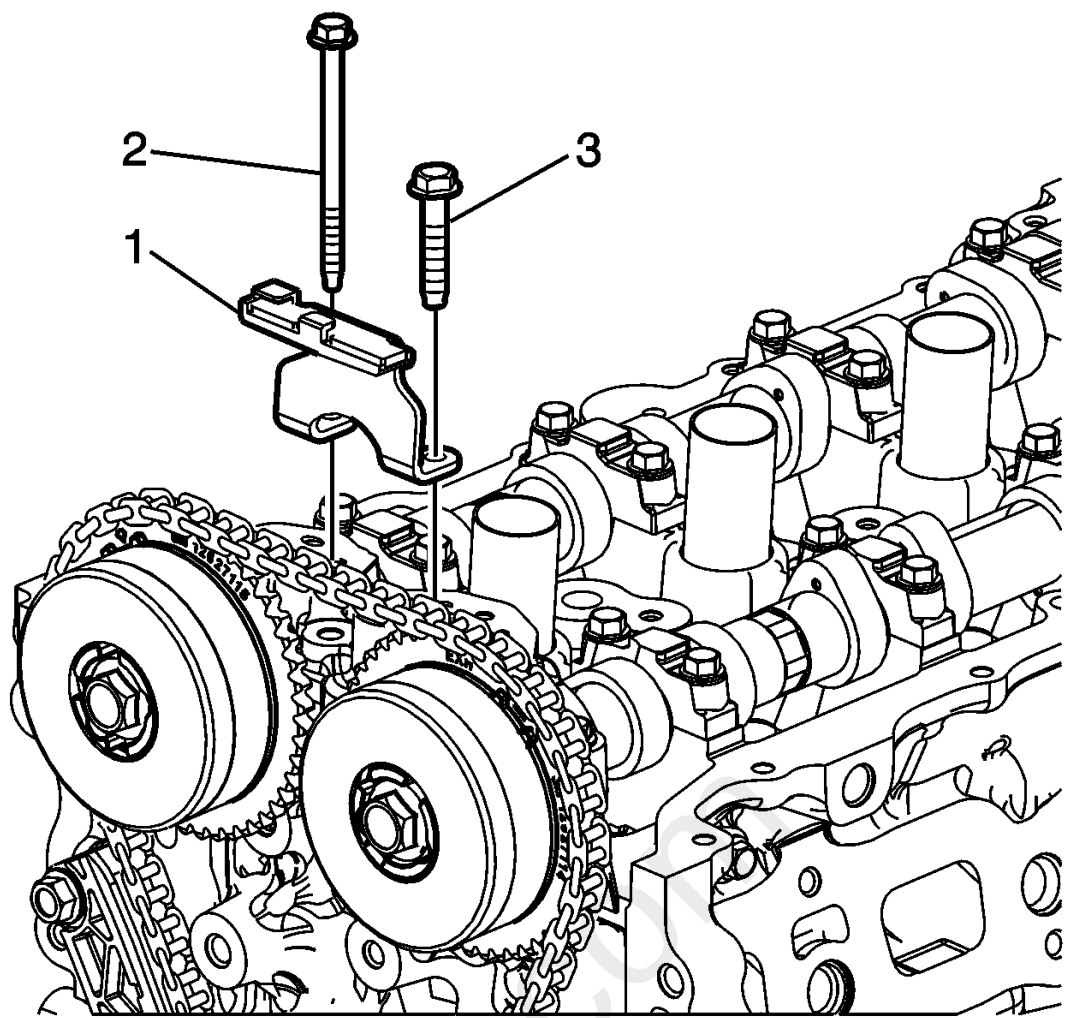


Fig. 123: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Install the timing chain guide (1) and bolts (2, 3) finger tight.

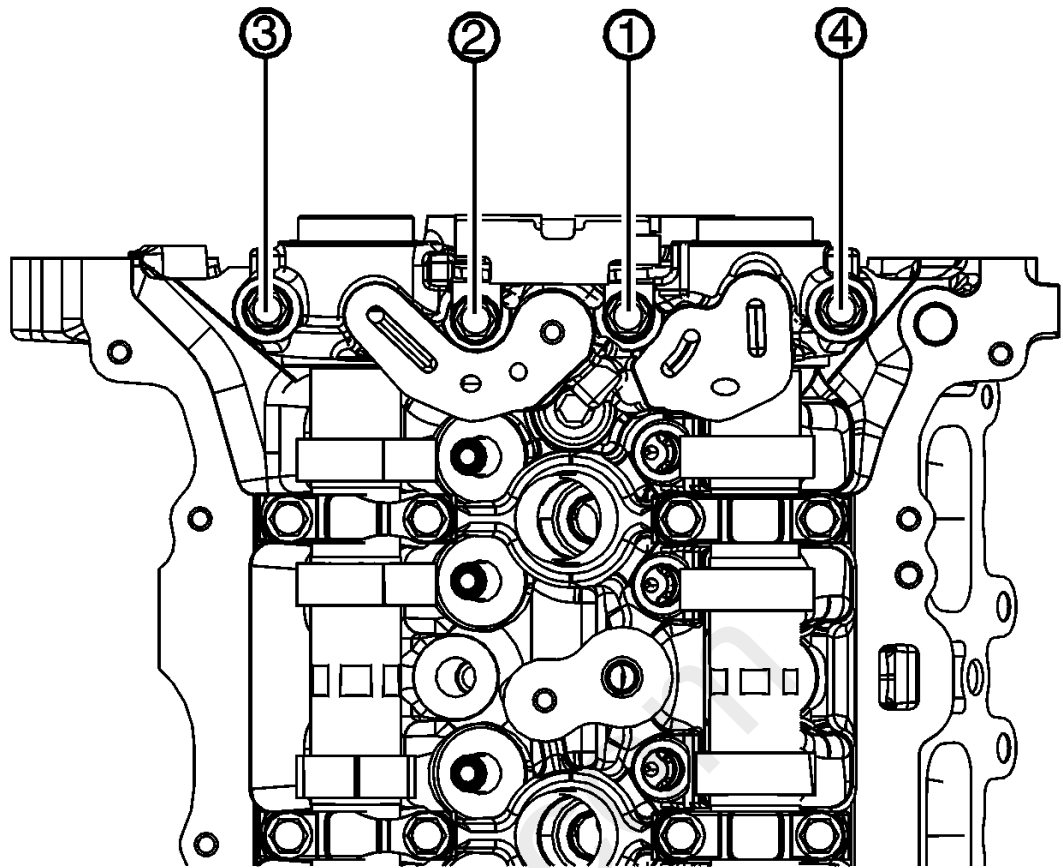


Fig. 124: Front Camshaft Cap Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

17. tighten the front camshaft cap bolts in sequence to 10 N.m (7 lb ft) twice.
18. Rotate the crankshaft clockwise to see if either of the actuators or the crankshaft sprocket jump timing chain teeth. If this occurs, repeat procedure to align the timing marks.

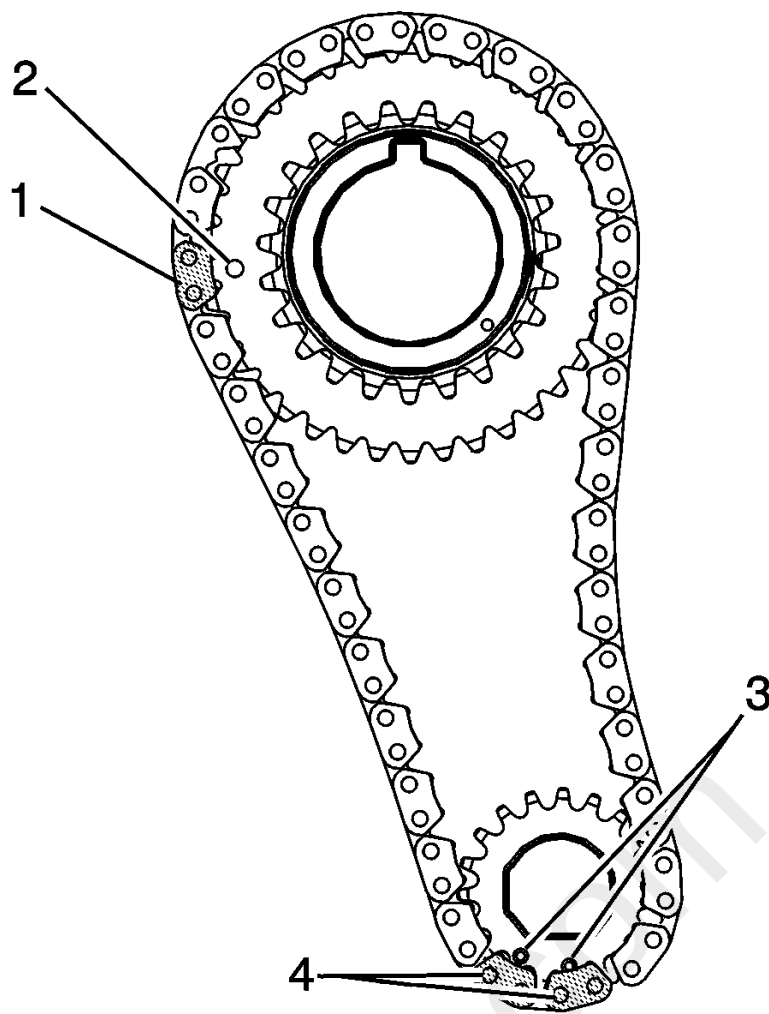
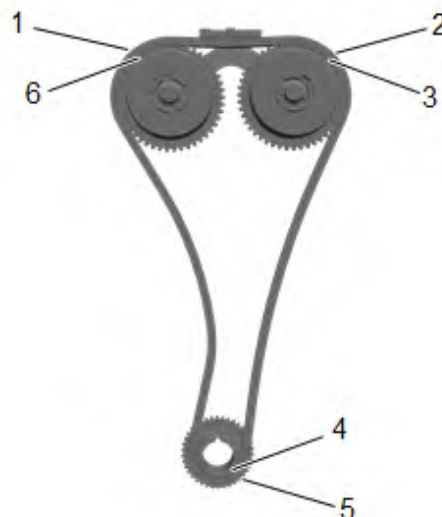


Fig. 125: Timing Link Lines & Timing Mark
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Due to the difference of crankshaft sprocket and balance shaft sprocket, timing marks on the chain will not match during every crankshaft revolution. Ensure that the marks on the sprockets are aligned appropriately before installing the timing chain.

19. Rotate the crankshaft slightly in clockwise direction to allow chain to settle on actuator and sprocket teeth. If the timing chain jumps actuator teeth, repeat procedure to align the timing marks.
20. Verify the timing links on both the timing chain & balance chain are properly aligned to the timing marks:
 1. The timing link (1) is aligned to the timing mark on the crankshaft sprocket (2).
 2. The adjacent timing links (4) are aligned with both timing marks (3) on the balancer shaft driven sprocket.



NOTE: Because of slight clockwise rotation all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still align.

21. The timing chain links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
22. Install the engine front cover. Refer to [Engine Front Cover Replacement](#).

BALANCER SHAFT WITH OIL PUMP REPLACEMENT

Removal Procedure

1. Remove [Oil Pan Replacement \(AWD\)](#)[Oil Pan Replacement \(FWD\)](#).
2. Remove [Timing Chain Crankshaft Sprocket Replacement](#)

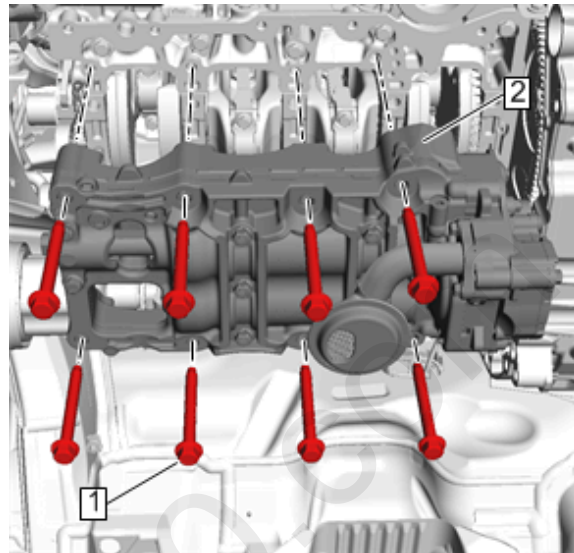


Fig. 127: Balancer Shaft with Oil Pump And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove Balancer Shaft with Oil Pump Bolt (1) [8x]
4. Remove Balancer Shaft with Oil Pump (2)

NOTE: If replacing the oil pump, remove it from the balancer shaft.

5. Remove the oil pump. [Balancer Shaft with Oil Pump Disassemble](#)

Installation Procedure

1. Install the oil pump. [Balancer Shaft with Oil Pump Assemble](#)

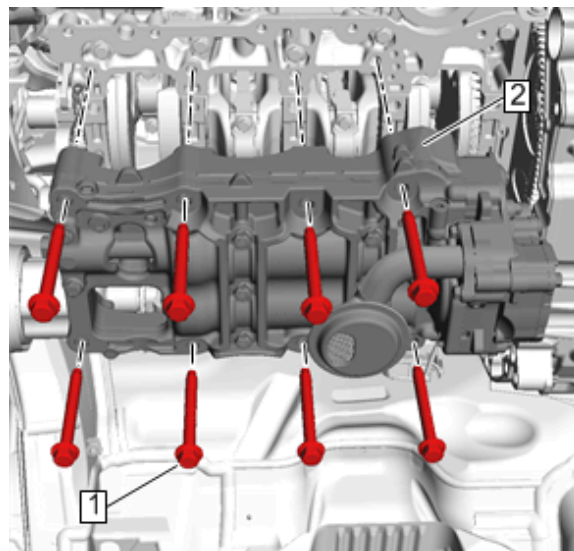


Fig. 128: Balancer Shaft with Oil Pump And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install Balancer Shaft with Oil Pump (2)
3. Loosely Install Balancer Shaft with Oil Pump Bolt (1) - [8x]

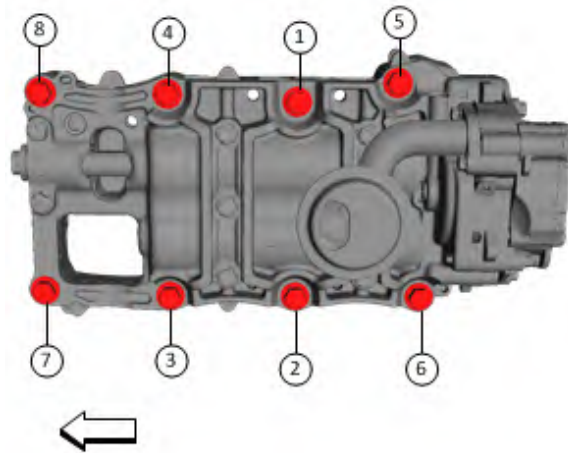


Fig. 129: Balancer Shaft With Oil Pump Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

4. Balancer Shaft with Oil Pump Bolt - tighten in sequence [8x]

tighten

1. **First pass** 58 N.m (43 lb ft)
2. **Final pass** 58 N.m (43 lb ft)
5. Install **Timing Chain Crankshaft Sprocket Replacement**
6. Install **Oil Pan Replacement (AWD)****Oil Pan Replacement (FWD)**

CAMSHAFT COVER REPLACEMENT (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

Removal Procedure

1. Remove Ignition Coil - **Ignition Coil Replacement**
2. Remove Vacuum Pump - **Vacuum Pump Replacement**
3. Remove Turbocharger Heat Shield - **Turbocharger Heat Shield Replacement**

NOTE: The air cleaner outlet duct is equipped with a tamper proof connection that should NOT be removed unless the PCV tube or air cleaner outlet duct is being replaced. Loosening the air cleaner outlet duct clamps will allow the duct to be disconnected from the air cleaner assembly and turbocharger for repositioning without removing the tamper proof connection.

4. Loosen Air Cleaner Outlet Duct Clamp - **Air Cleaner Outlet Duct Replacement (Non-Tamperproof)** **Air Cleaner Outlet Duct Replacement (Tamperproof)**

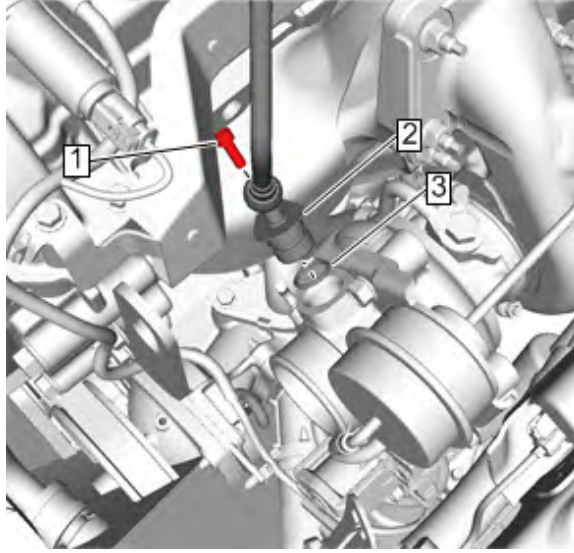


Fig. 130: PCV Valve

Courtesy of GENERAL MOTORS COMPANY

NOTE: The PCV hose and fitting assembly (2) is a permanent connection. Reinstall these components as an assembly unless new components are being used.

NOTE: Always ensure the PCV hose fitting O-Ring (3) seal is free of cuts or abrasions each time the fitting is attached to the turbocharger.

5. Remove Positive Crankcase Ventilation Hose Fitting Bolt (1).
6. Disconnect Positive Crankcase Ventilation Hose Fitting (2).
7. Remove Turbocharger Coolant Return Pipe. [Turbocharger Coolant Return Pipe Replacement \(LTG\)](#)
8. Remove Oil Level Indicator.
9. Remove Engine Coolant Air Bleed Pipe. [Engine Coolant Air Bleed Pipe Replacement \(LTG\)](#)
10. Remove Camshaft Position Actuator Solenoid Valve - Intake - [Camshaft Position Actuator Intake Solenoid Valve Replacement](#)
11. Remove Camshaft Position Actuator Solenoid Valve - Exhaust - [Camshaft Position Actuator Exhaust Solenoid Valve Replacement](#)
12. Remove Camshaft Cover Heat Shield - [Camshaft Cover Heat Shield Replacement](#)
13. Disconnect and reposition engine electrical harness.

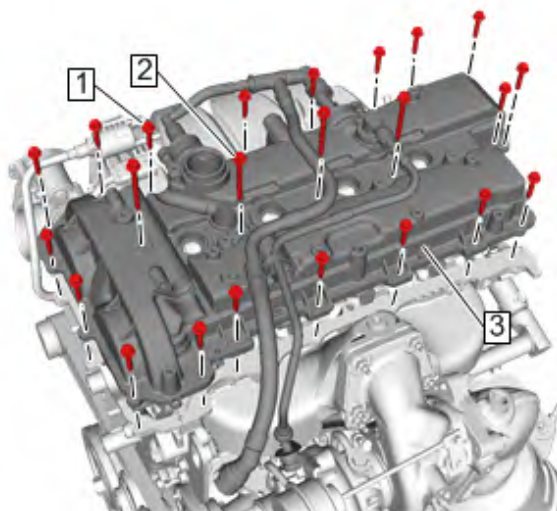


Fig. 131: Identifying Four Long Camshaft Cover Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Note the location of the four long camshaft cover bolts (2) for proper installation.

14. Remove Camshaft Cover Bolt (1, 2).

NOTE: If reinstalling the camshaft cover, remove the camshaft cover with the PCV tubes and the air cleaner outlet duct.

15. Remove Camshaft Cover (3).

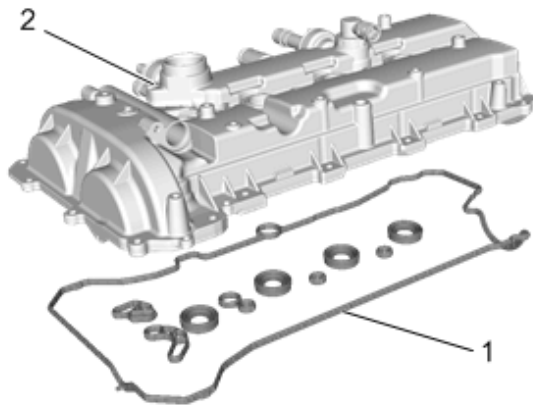


Fig. 132: Camshaft Cover Gasket

Courtesy of GENERAL MOTORS COMPANY

16. Remove Camshaft Cover Gasket (1) and DISCARD

17. If reinstalling the camshaft cover (2), clean and inspect as needed. [Camshaft Cover and Compressor Air Intake Turbocharger Cleaning and Inspection](#)

Installation Procedure

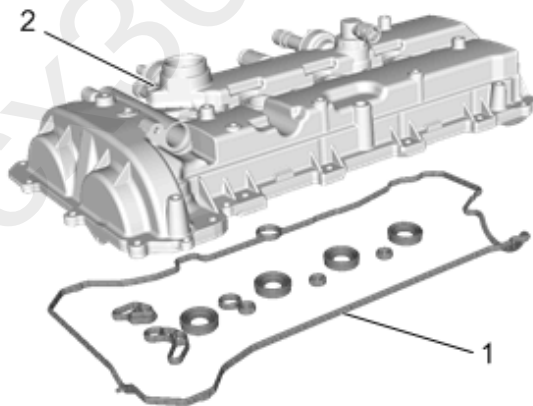


Fig. 133: Camshaft Cover Gasket

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a NEW gasket.

NOTE: Add 14mm bead of sealant at right and left T-Joint where front cover meets head and at rear of camshaft cover right and left T-Joint where vacuum pump bolts on.

1. Install Camshaft Cover Gasket (1)

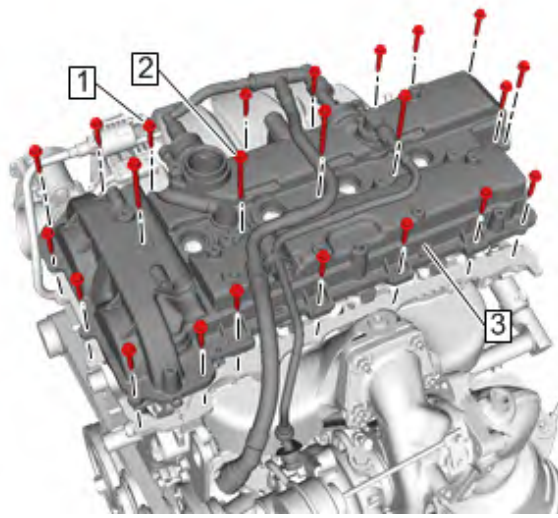


Fig. 134: Identifying Four Long Camshaft Cover Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Install Camshaft Cover (3).

NOTE: Ensure the long camshaft cover bolts (2) are installed in the correct positions.

3. Loosely install Camshaft Cover Bolt (1, 2).

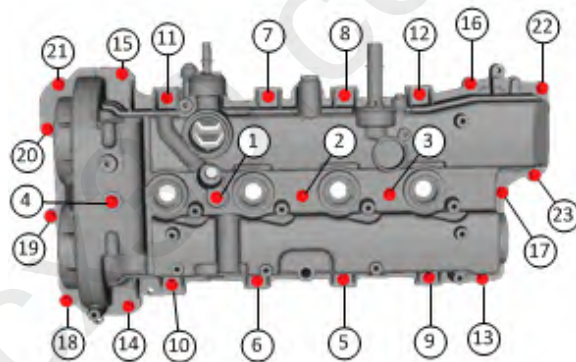


Fig. 135: Camshaft Cover Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

4. tighten the camshaft cover bolts in sequence to 10 N.m (89 lb in).
5. Reposition and reconnect engine wiring harness.
6. Install Camshaft Cover Heat Shield - [Camshaft Cover Heat Shield Replacement](#)

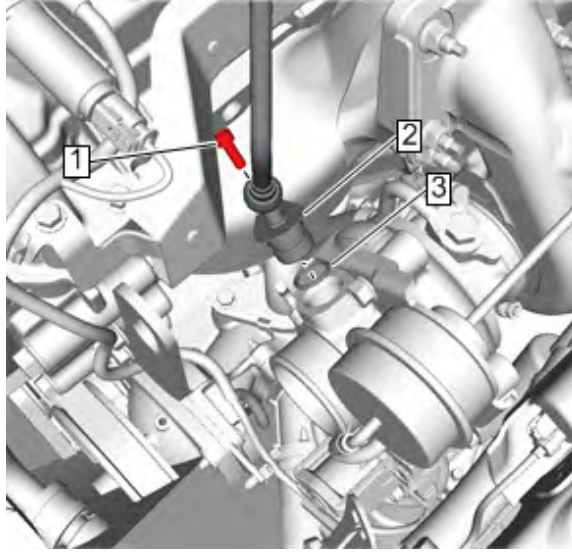


Fig. 136: PCV Valve

Courtesy of GENERAL MOTORS COMPANY

NOTE: Always ensure the PCV hose fitting O-Ring (3) seal is free of cuts or abrasions each time the fitting is attached to the turbocharger.

7. Inspect the O-ring and replace if necessary. (3)
8. Connect Positive Crankcase Ventilation Hose Fitting (2).
9. Install Positive Crankcase Ventilation Hose Fitting Bolt (1) and tighten 8 N.m (71 lb in)
10. Install Camshaft Position Actuator Solenoid Valve - Exhaust - [Camshaft Position Actuator Exhaust Solenoid Valve Replacement](#)
11. Install Camshaft Position Actuator Solenoid Valve - Intake - [Camshaft Position Actuator Intake Solenoid Valve Replacement](#)
12. Install the engine oil level indicator.
13. Install Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement](#)
14. Air Cleaner Outlet Duct Clamp - tighten - [Air Cleaner Outlet Duct Replacement \(Non-Tamperproof\)](#), [Air Cleaner Outlet Duct Replacement \(Tamperproof\)](#)
15. Install Turbocharger Coolant Return Pipe - [Turbocharger Coolant Return Pipe Replacement \(LTG\)](#)
16. Install Engine Coolant Air Bleed Pipe - [Engine Coolant Air Bleed Pipe Replacement \(LTG\)](#)
17. Install Vacuum Pump - [Vacuum Pump Replacement](#)
18. Install Ignition Coil - [Ignition Coil Replacement](#)

TIMING CHAIN TENSIONER REPLACEMENT

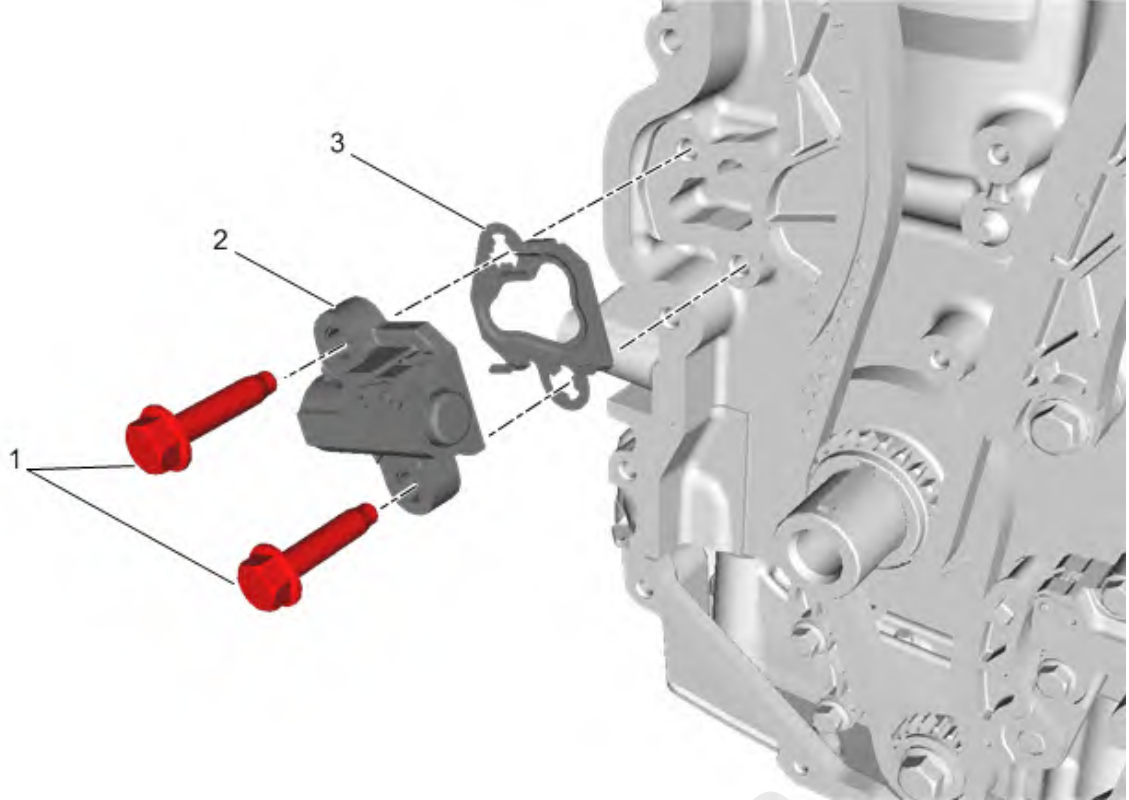


Fig. 137: Timing Chain Tensioner Bolts And Timing Chain Tensioner
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Engine Front Cover Replacement</u>	
1	Timing Chain Tensioner Bolt (2) CAUTION: Refer to <u>Fastener Caution</u> . tighten 25 N.m (18 lb ft)
2	Timing Chain Tensioner
3	Timing Chain Tensioner Gasket Procedure Install a NEW gasket.

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT - EXHAUST

Removal Procedure

1. Remove the exhaust valve rocker arm. Refer to **Exhaust Valve Rocker Arm Replacement**.

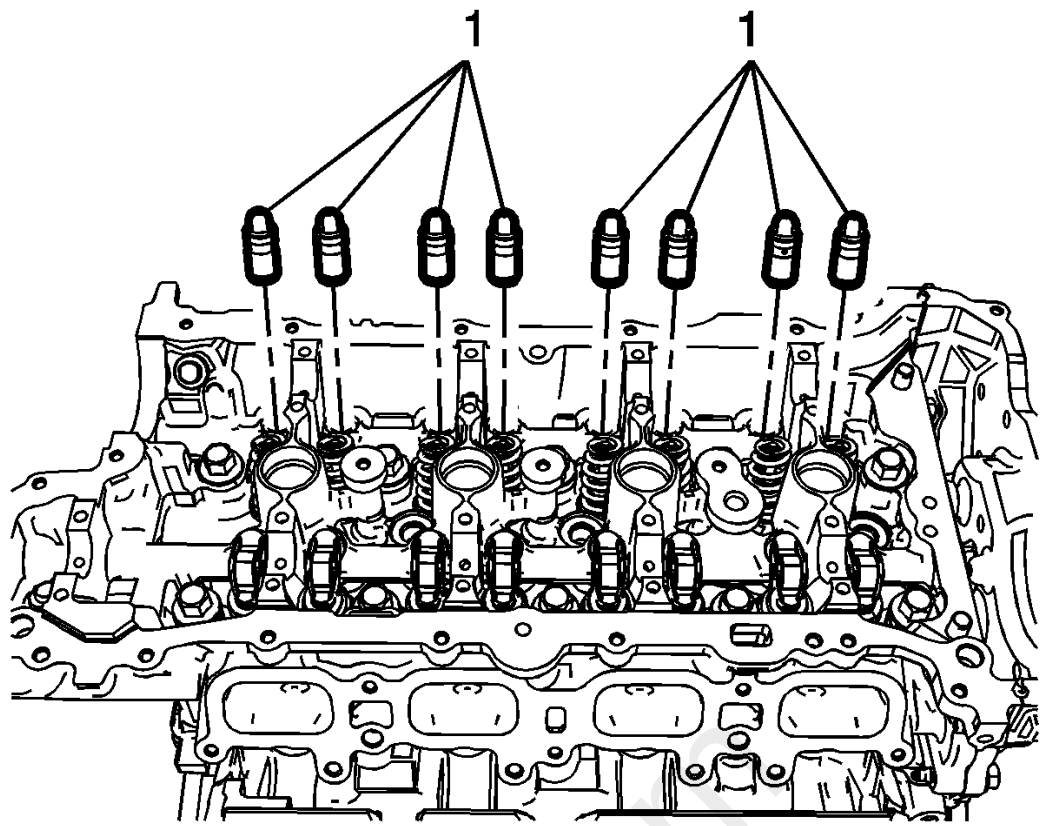


Fig. 138: Hydraulic Lash Adjusters - Exhaust
Courtesy of GENERAL MOTORS COMPANY

2. Remove the hydraulic lash adjusters (1).

Installation Procedure

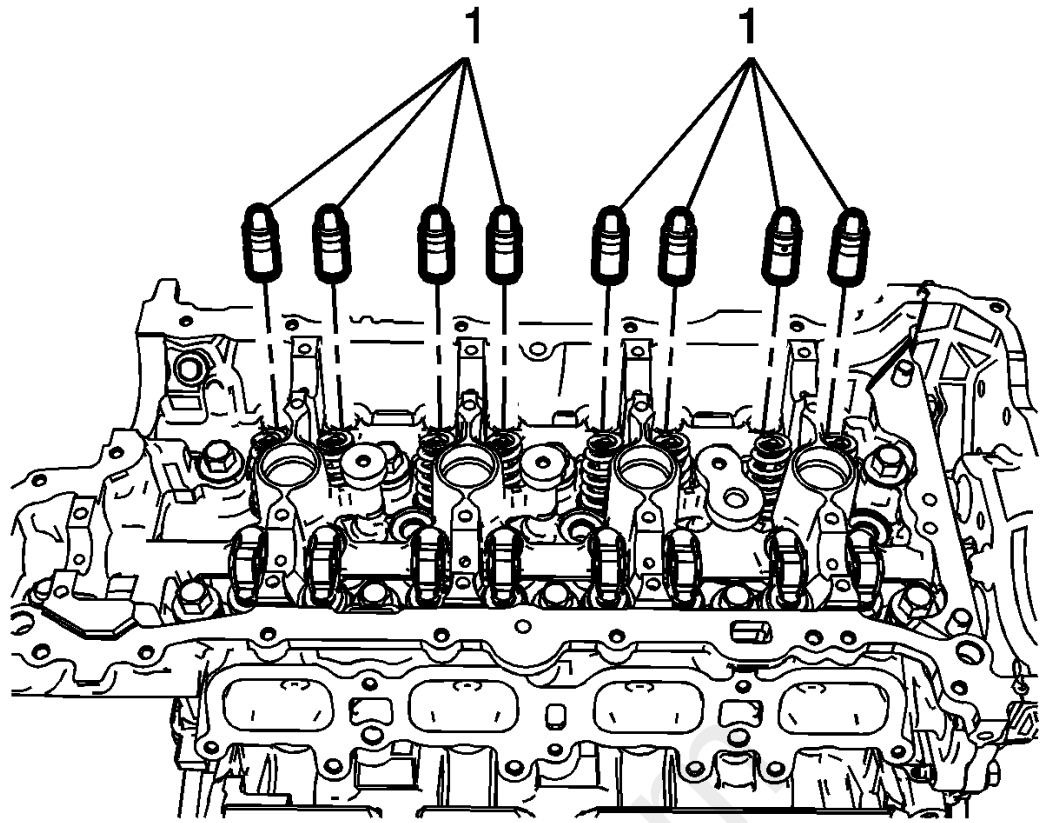


Fig. 139: Hydraulic Lash Adjusters - Exhaust
Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
2. Install the exhaust valve rocker arm. Refer to [Exhaust Valve Rocker Arm Replacement](#).

HYDRAULIC VALVE LASH ADJUSTER REPLACEMENT - INTAKE

Removal Procedure

1. Remove the intake valve rocker arm. Refer to [Intake Valve Rocker Arm Replacement](#).

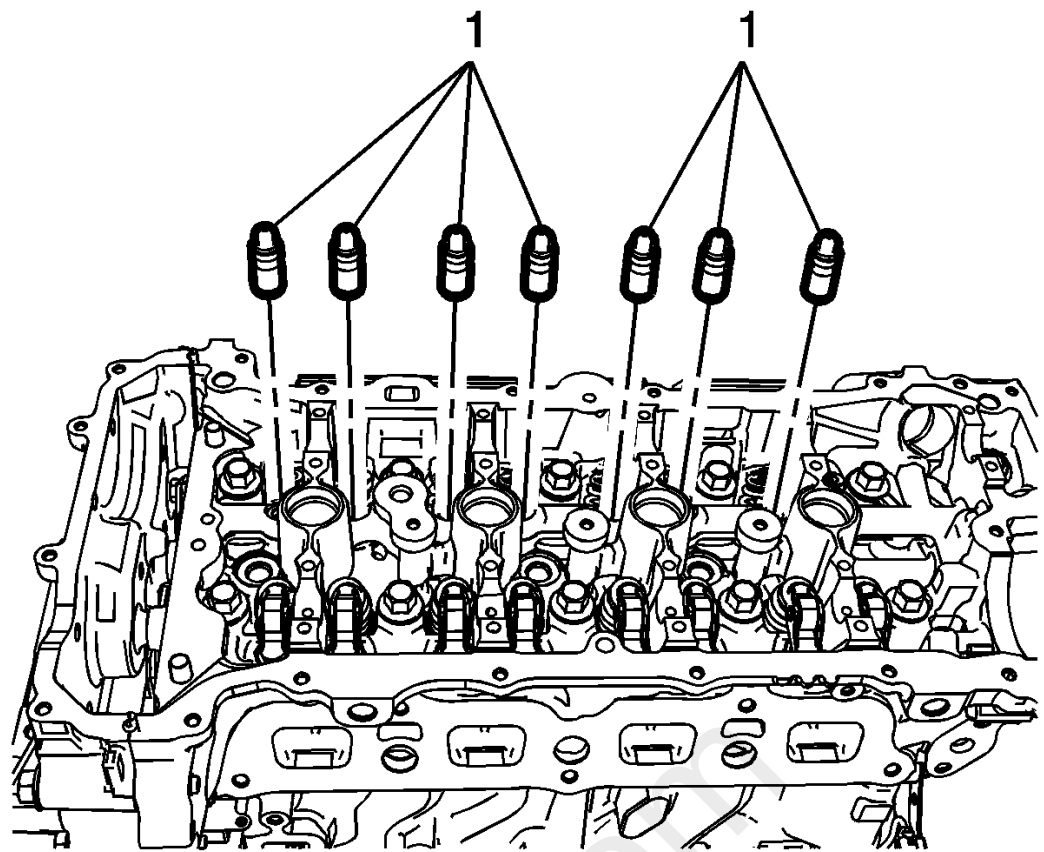


Fig. 140: Hydraulic Lash Adjusters - Intake
Courtesy of GENERAL MOTORS COMPANY

2. Remove the hydraulic lash adjusters (1).

Installation Procedure

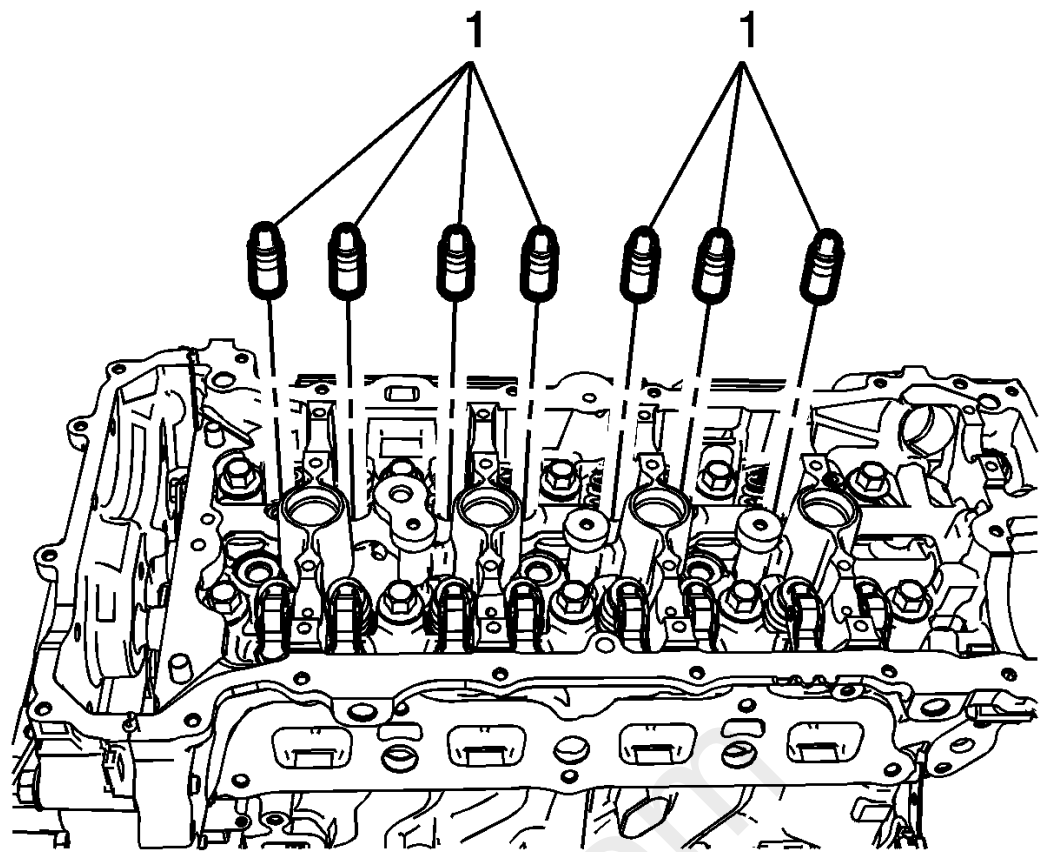


Fig. 141: Hydraulic Lash Adjusters - Intake
Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
2. Install the intake valve rocker arm. Refer to [Intake Valve Rocker Arm Replacement](#).

CAMSHAFT POSITION ACTUATOR AND CAMSHAFT REPLACEMENT - INTAKE

Special Tools

- EN-50656 Holding Tool
- EN 50793 Locking Tool

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

Removal Procedure

NOTE: Ensure the engine is properly timed to Top Dead Center (TDC), prior to performing repairs.

1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).
2. Remove the high pressure fuel pump. Refer to [Fuel Pump Replacement](#).

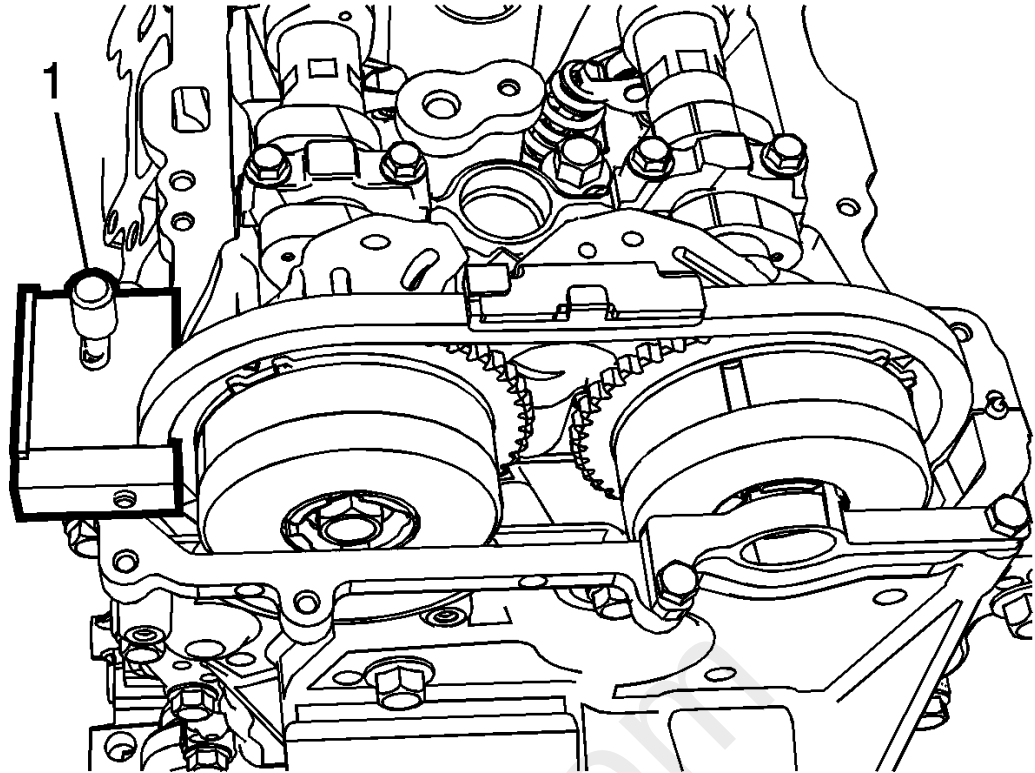


Fig. 142: Identifying Timing Chain Holding Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the EN-50656 holding tool is installed and securely tightened to prevent the camshaft chain from dropping into the front engine cover during camshaft actuator replacement.

3. Install EN-50656 timing chain holding tool (1) and tighten to 8 N.m (71 lb in).

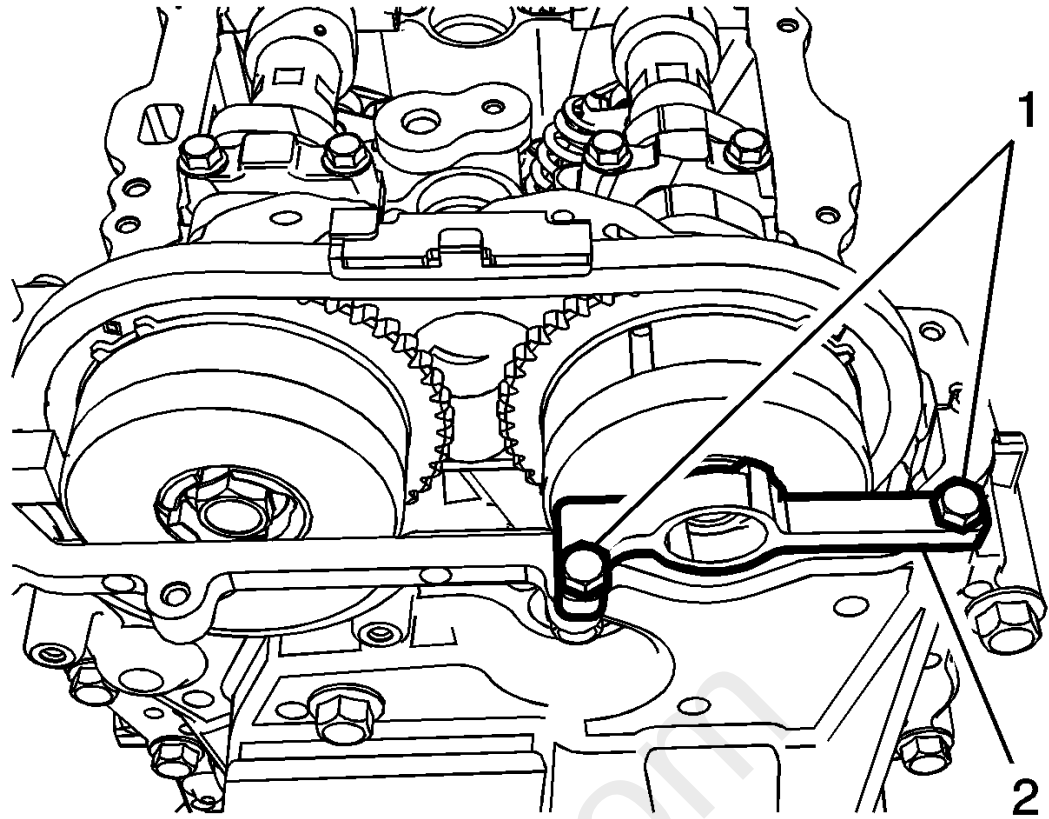


Fig. 143: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

NOTE: Ensure to mark actuator sprocket and chain before removal.

4. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the exhaust camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

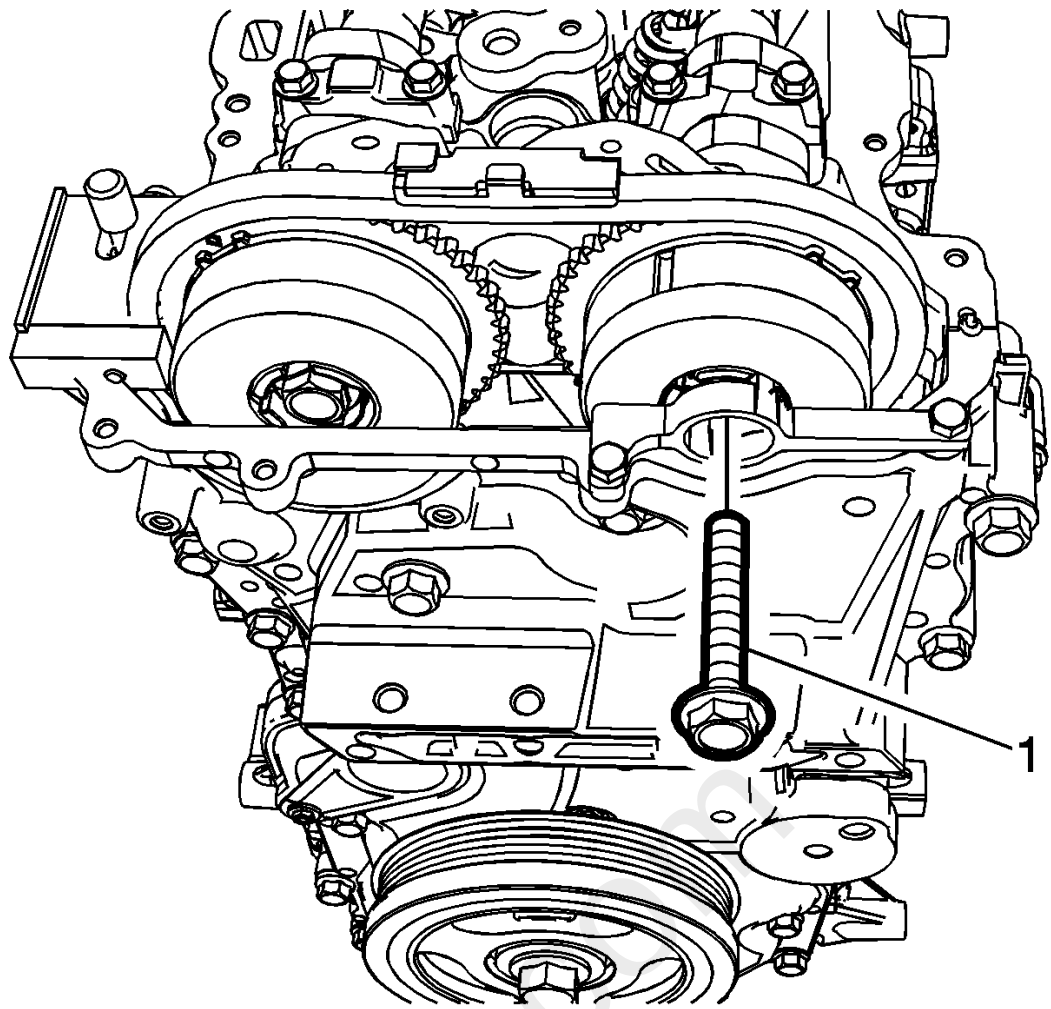


Fig. 144: Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Remove and DISCARD the camshaft actuator bolt (1).

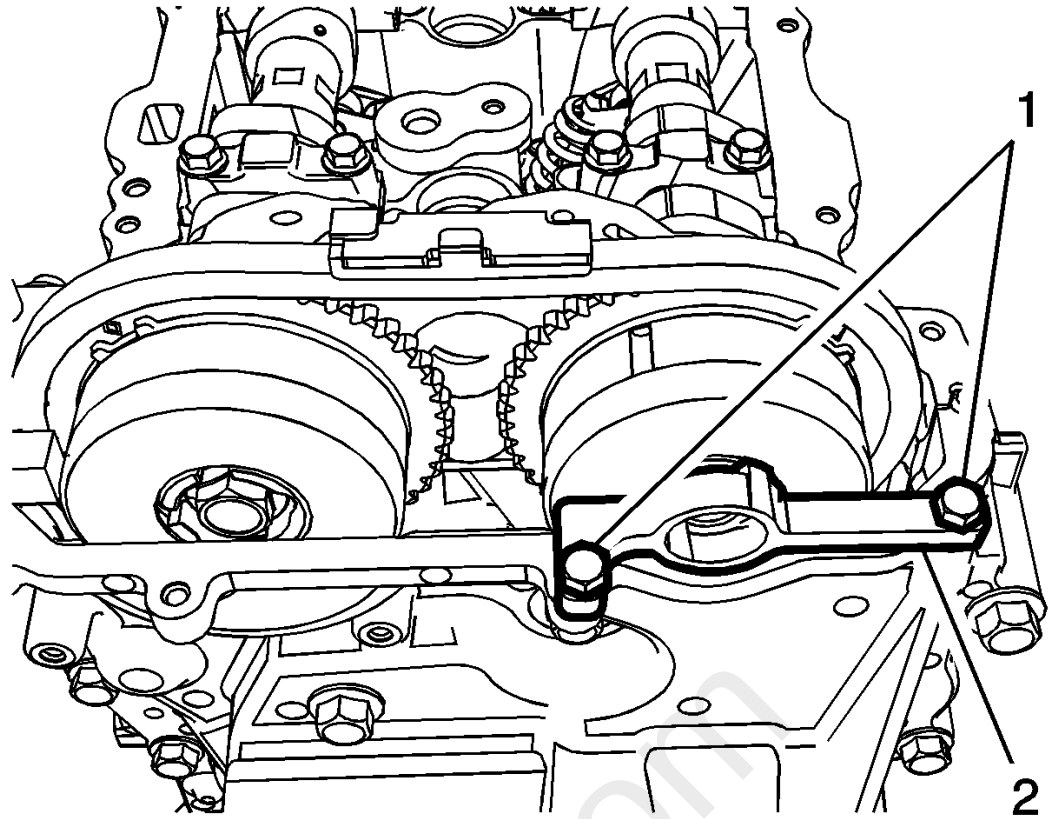


Fig. 145: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

6. Remove the EN-50793 holding tool (2).

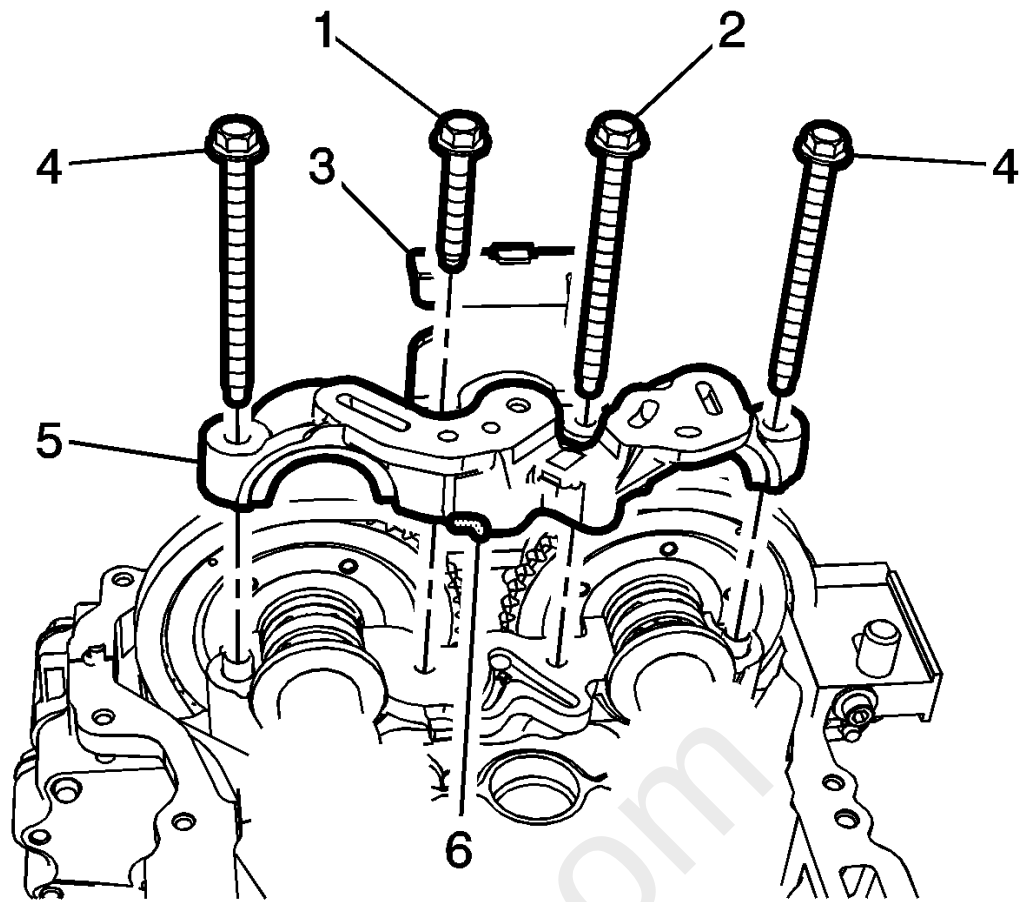


Fig. 146: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the upper timing chain guide bolts (1, 2).
8. Remove the upper timing chain guide (3).
9. Remove the camshaft front bearing cap bolts (4).

NOTE: Locate the pry points (6) in the camshaft front bearing cap. When using the 3 pry points to remove the front bearing cap evenly, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.

10. Remove the camshaft front bearing cap (5).

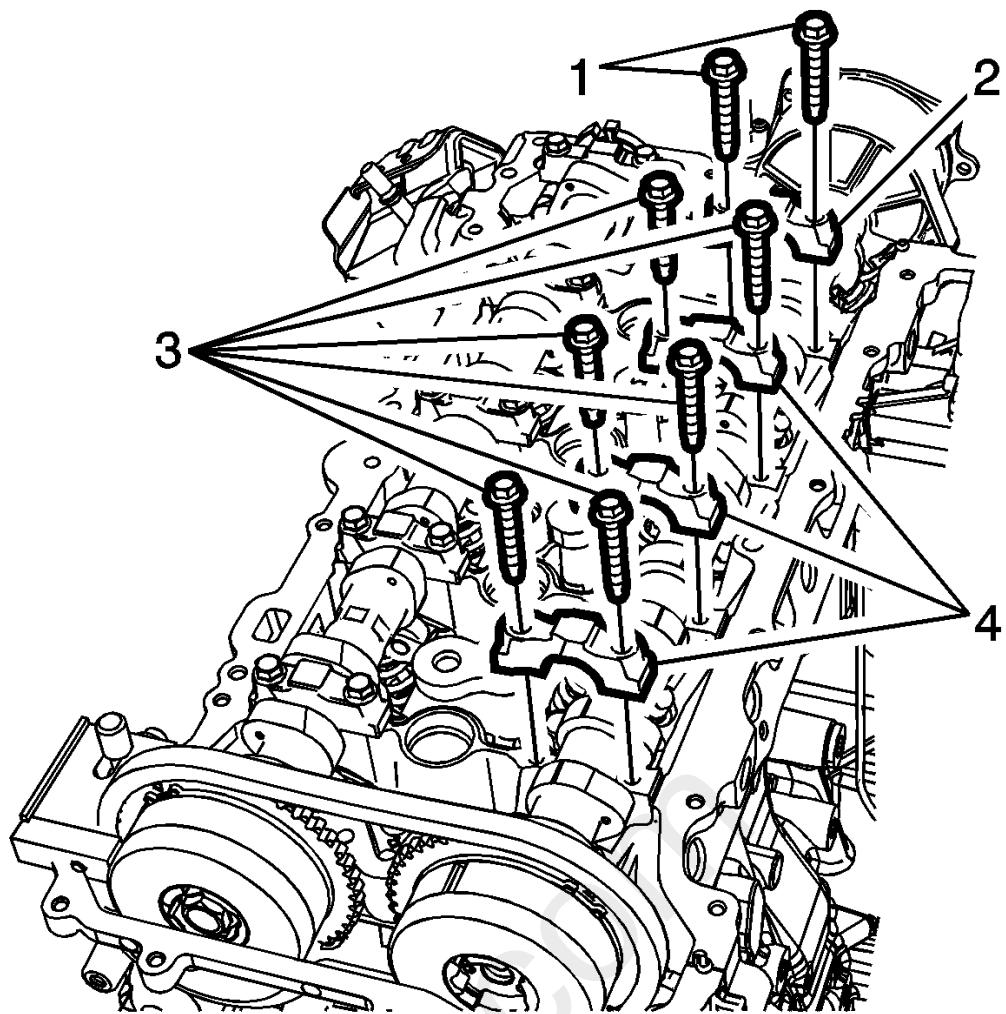


Fig. 147: Exhaust Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

11. Mark the exhaust camshaft rear cap to ensure it is installed in the same position. Remove the exhaust camshaft bearing rear cap bolts (1) and cap (2).

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

12. Mark the camshaft caps (4) to ensure they are installed in the same position.
13. Remove the exhaust camshaft cap bolts (3).
14. Remove the camshaft caps (4).

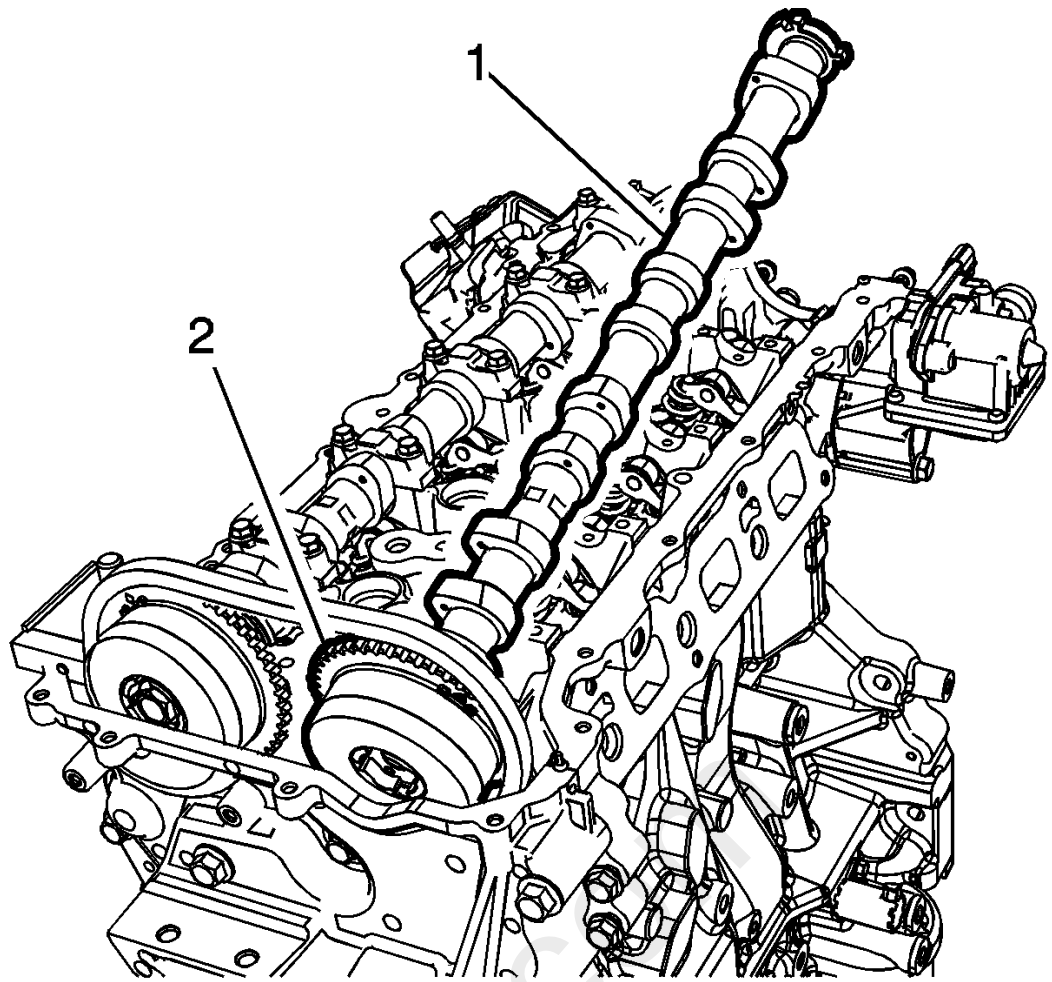


Fig. 148: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

15. Pull exhaust camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of exhaust camshaft assembly to a tilt and pull free from exhaust camshaft actuator assembly (2).

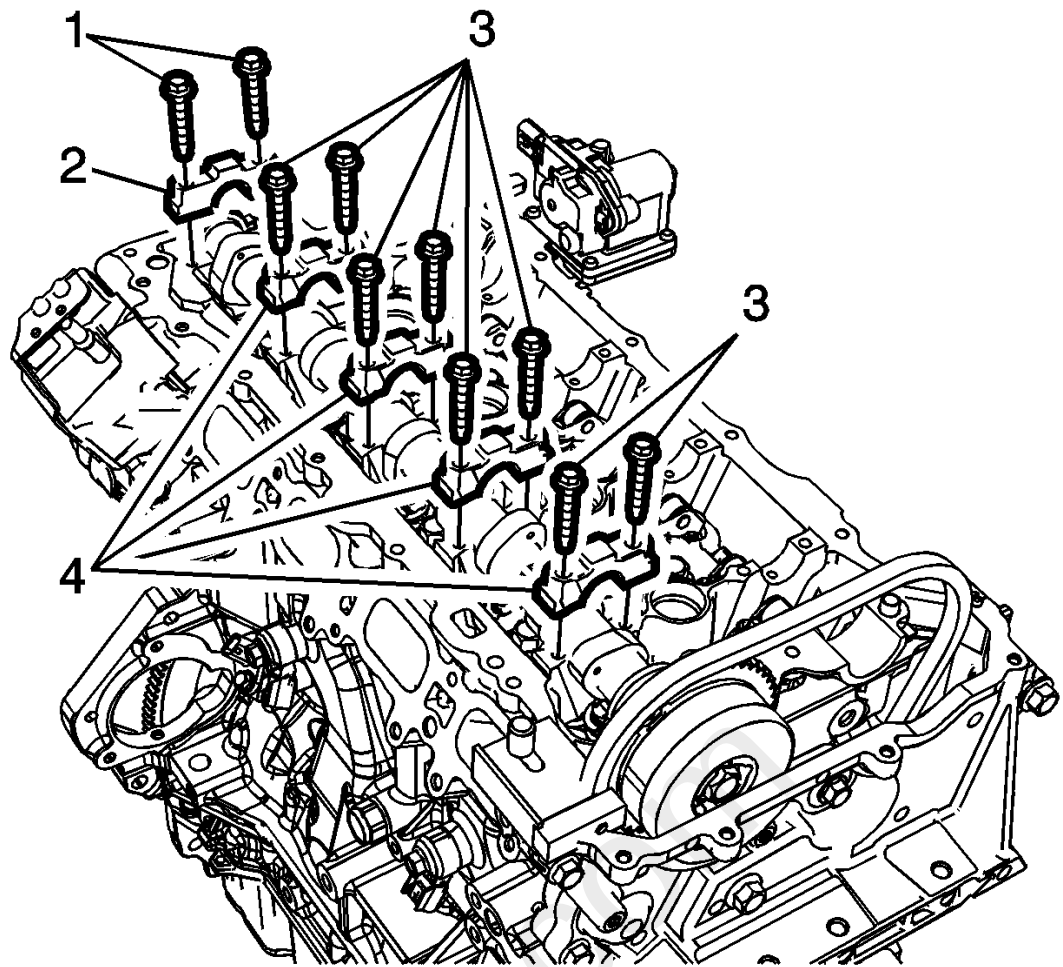


Fig. 149: Intake Camshaft Bearing Rear Cap Bolts And Cap

Courtesy of GENERAL MOTORS COMPANY

16. Mark the intake camshaft rear cap to ensure it is installed in the same position. Remove the intake camshaft bearing rear cap bolts (1) and cap (2).

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

17. Mark the camshaft caps (4) to ensure they are installed in the same position.
18. Remove the intake camshaft cap bolts (3).
19. Remove the camshaft caps (4).
20. Lift and roll intake camshaft assembly from original position over into exhaust camshaft position within engine head assembly.

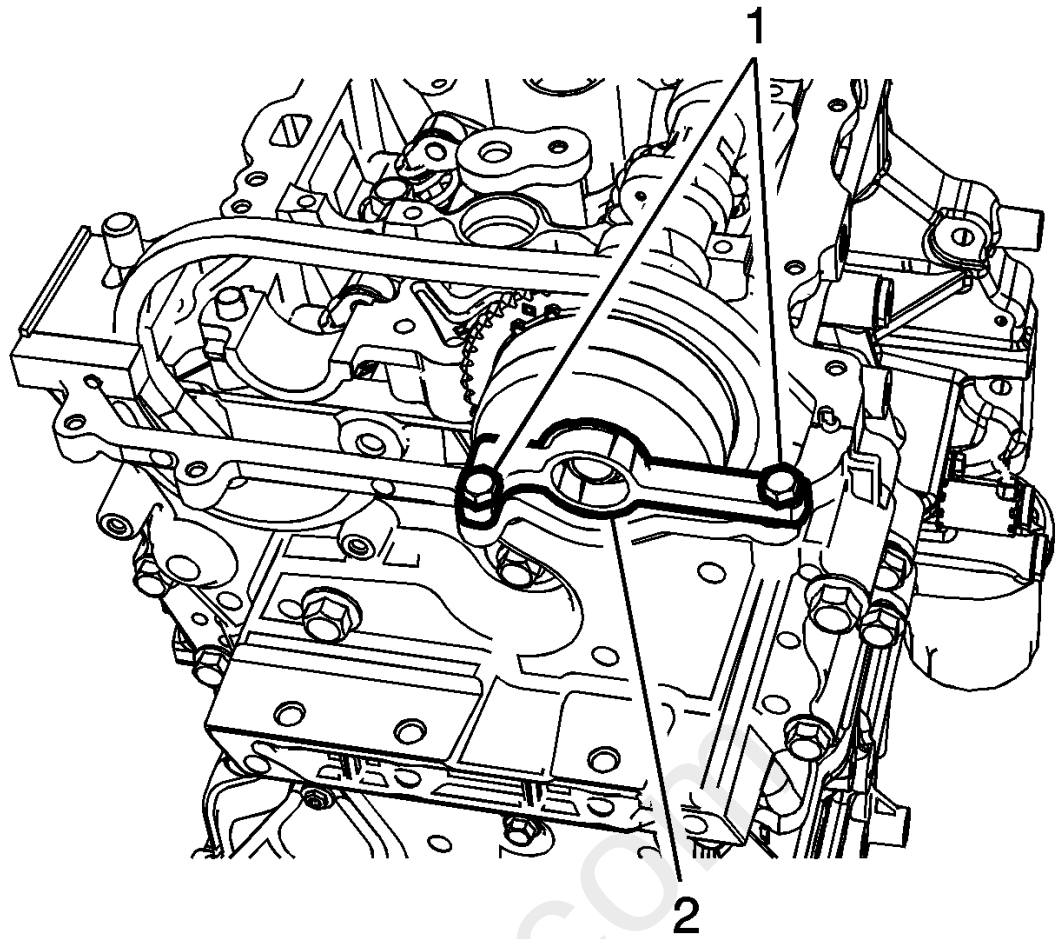


Fig. 150: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

21. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

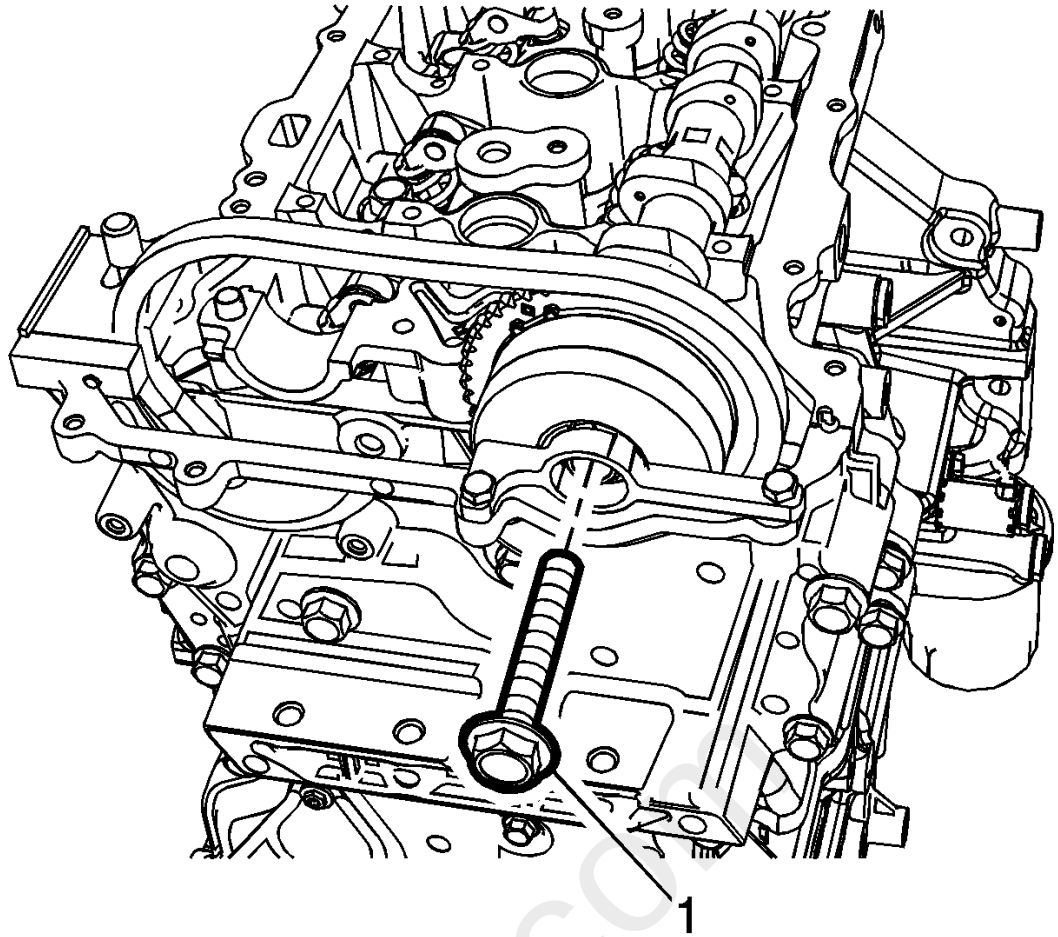


Fig. 151: Camshaft Actuator Bolt

Courtesy of GENERAL MOTORS COMPANY

22. Remove the camshaft actuator bolt (1).

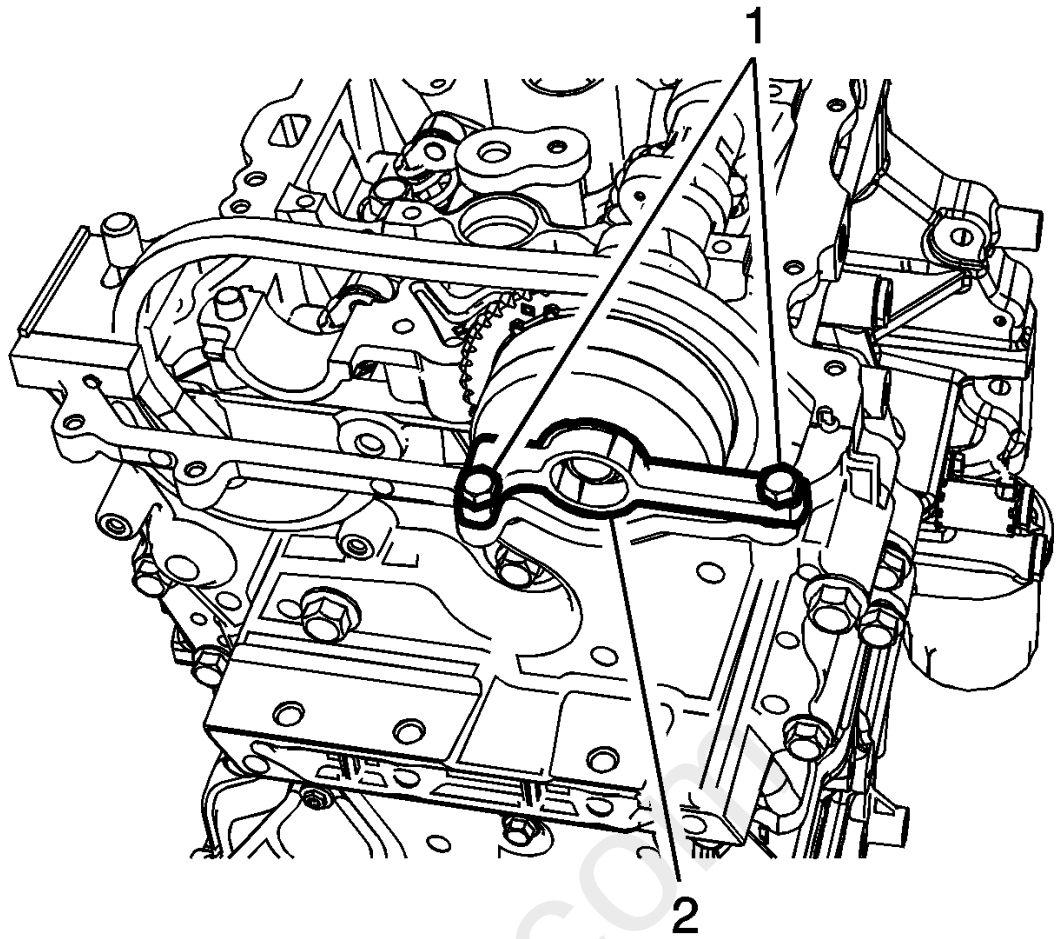


Fig. 152: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

23. Remove the EN-50793 holding tool (2).

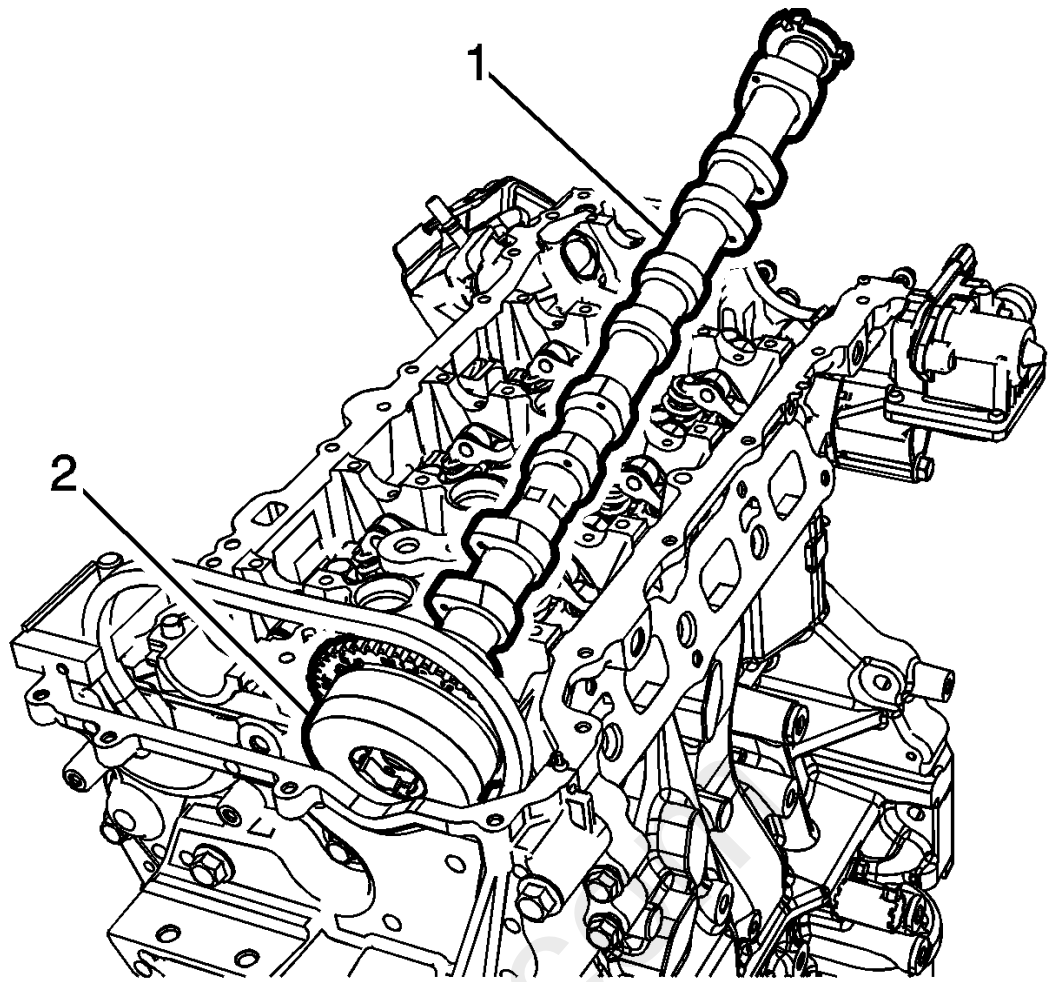


Fig. 153: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

24. Pull intake camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of intake camshaft assembly to a tilt and pull free from intake camshaft actuator assembly (2).

NOTE: If replacing the camshaft, ensure to transfer any marking from the old camshaft to the new one.

25. Replace the camshaft if necessary.

Installation Procedure

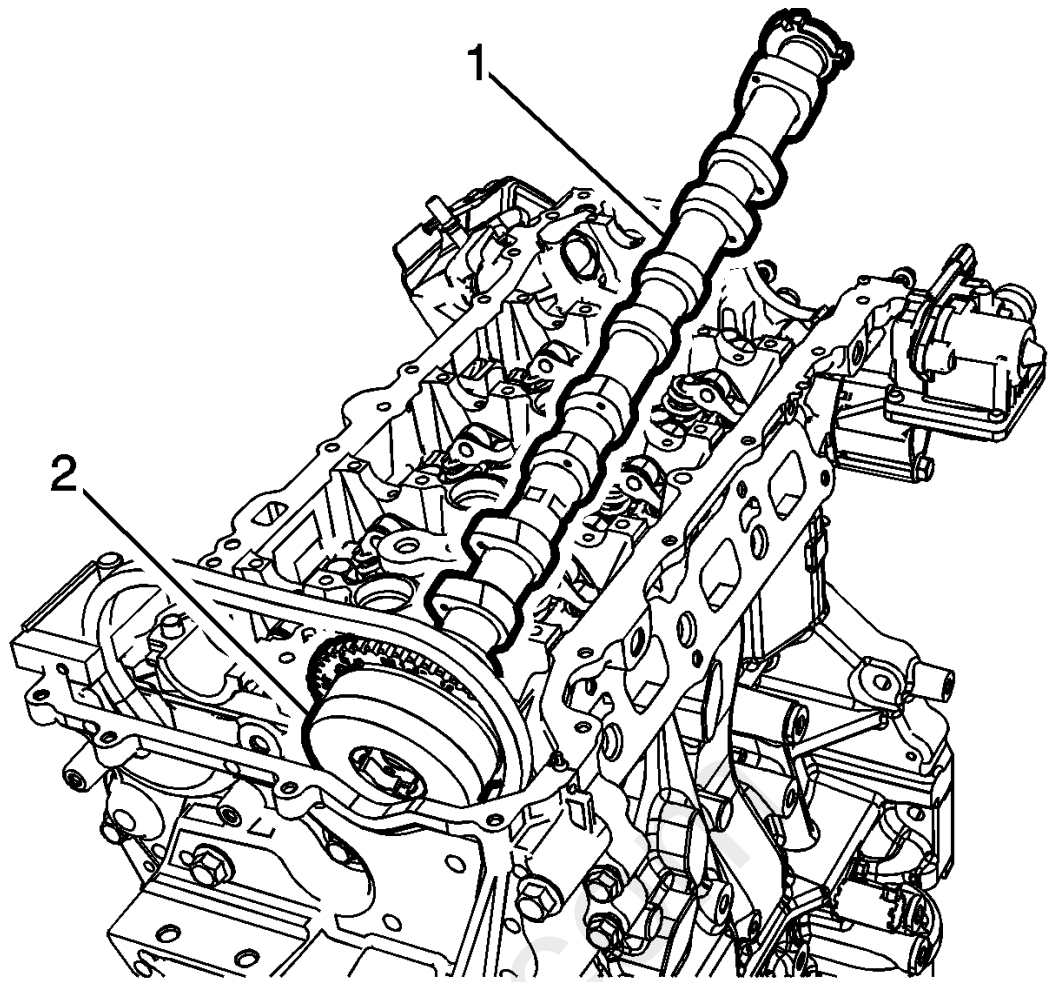


Fig. 154: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

1. Install the intake camshaft (1) and camshaft actuator (2).

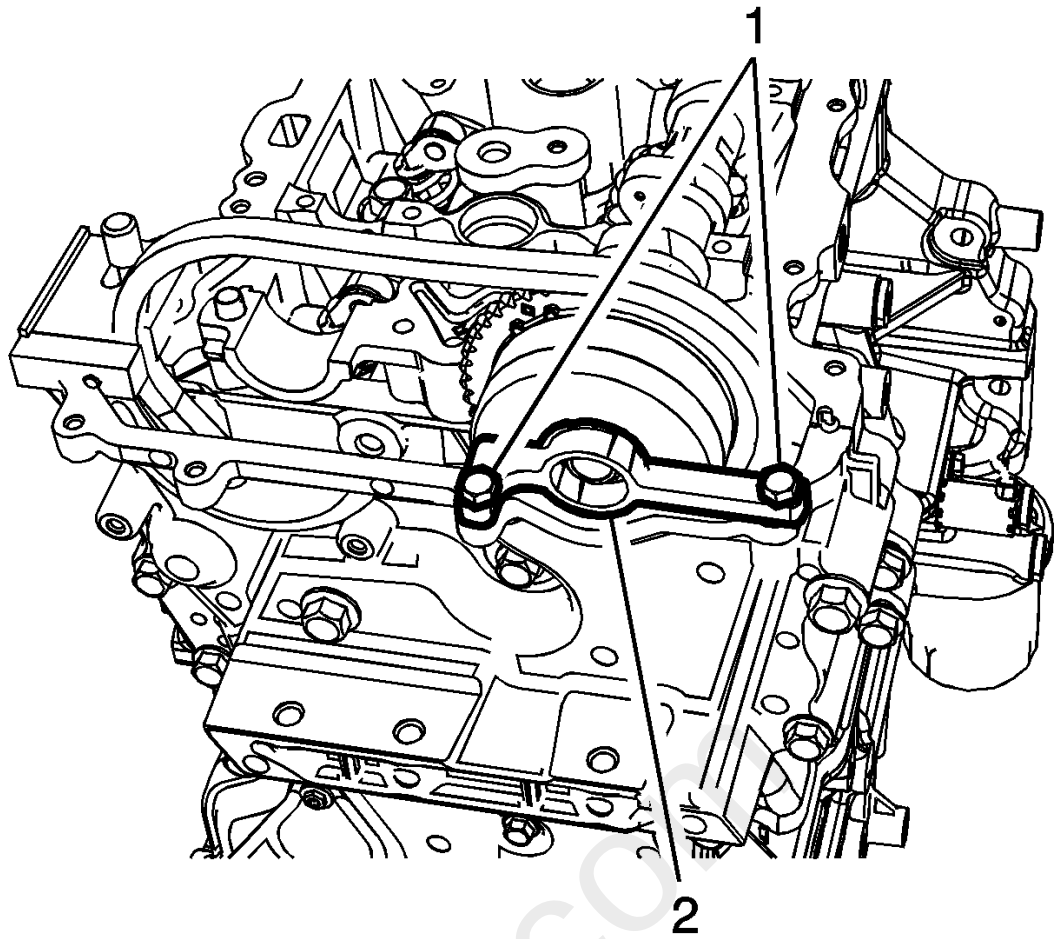


Fig. 155: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

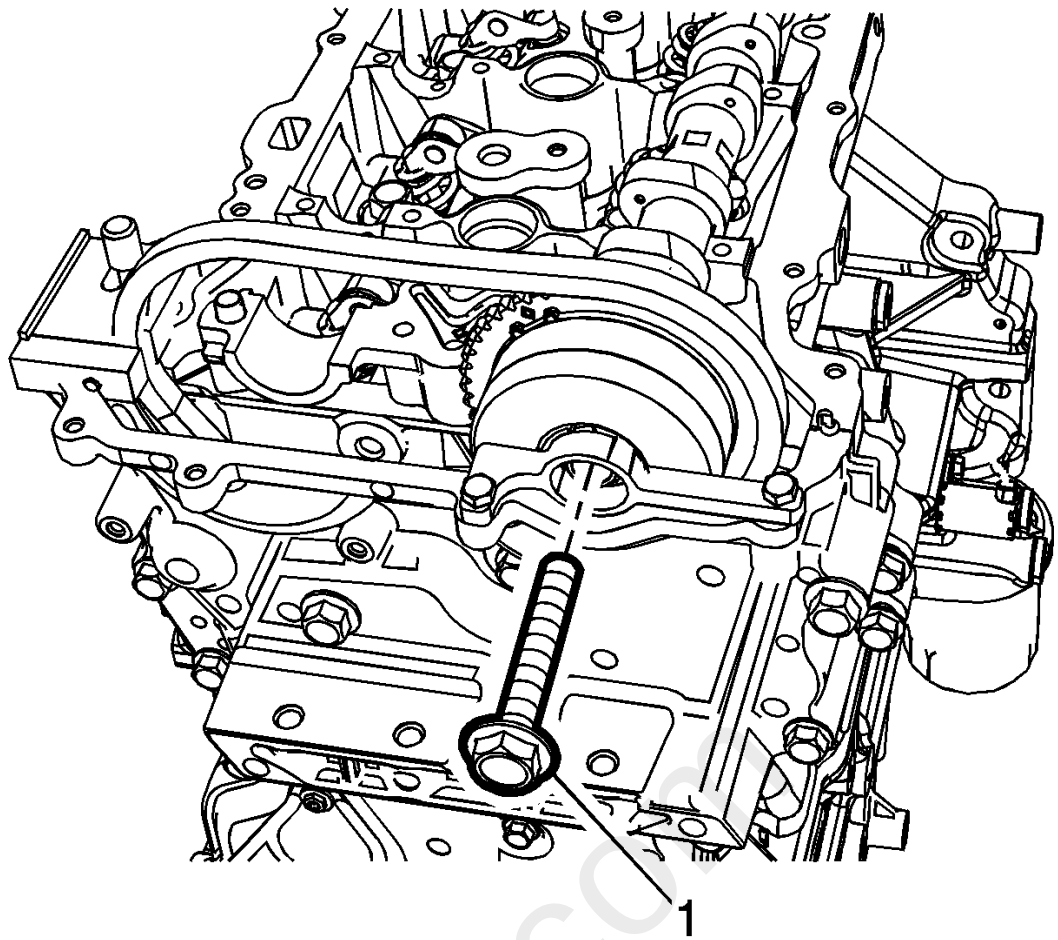


Fig. 156: Camshaft Actuator Bolt

Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.
4. Lift and roll intake camshaft assembly from exhaust camshaft position over into original position.

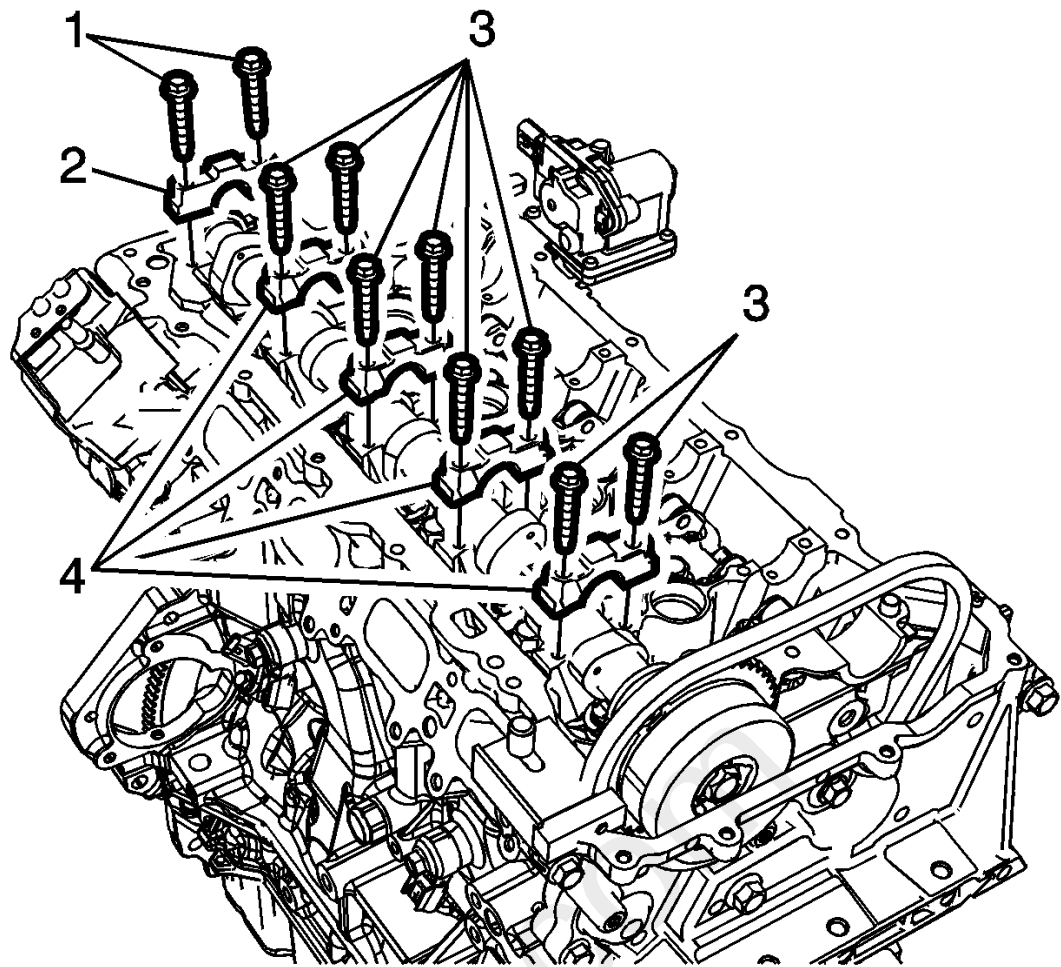


Fig. 157: Intake Camshaft Bearing Rear Cap Bolts And Cap

Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals with the intake actuator timing mark at approximately the 11 O'clock position.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

6. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
7. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).

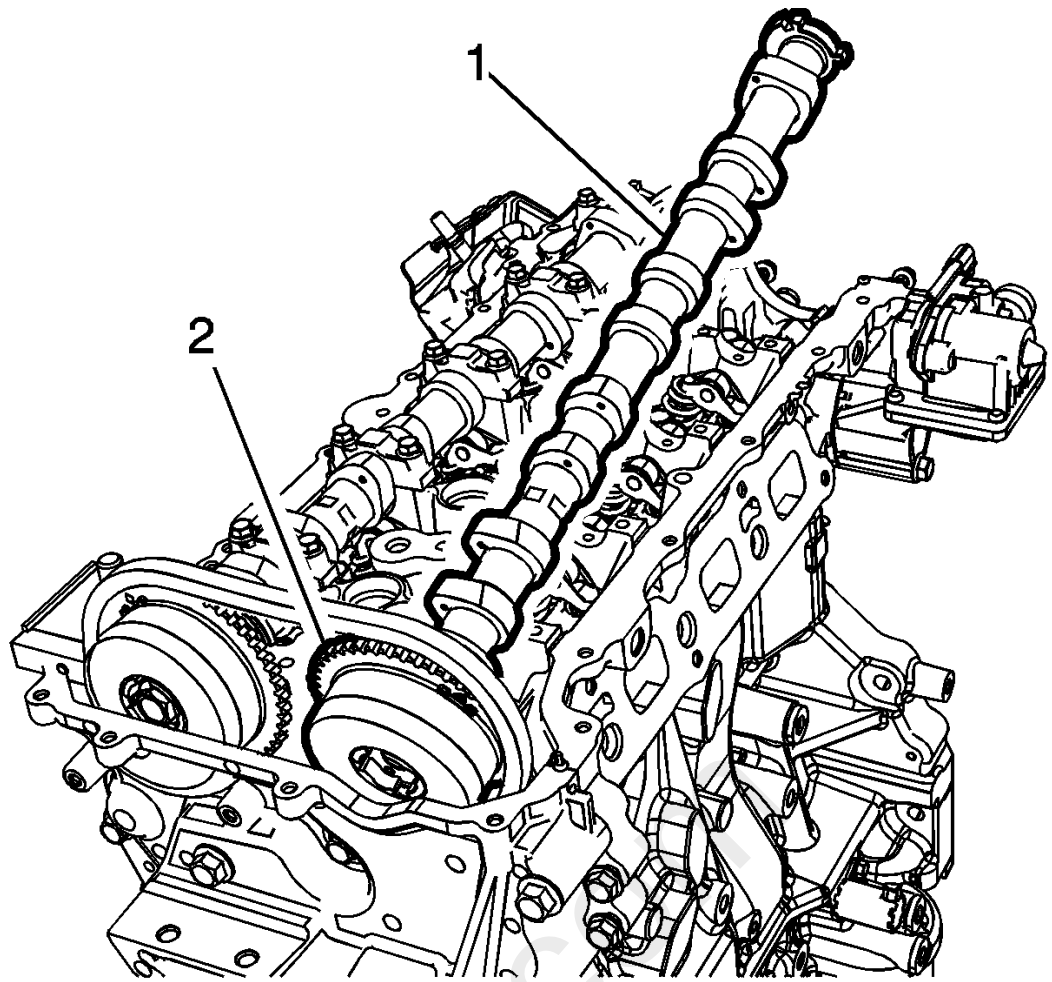


Fig. 158: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust camshaft (1) and camshaft actuator (2).

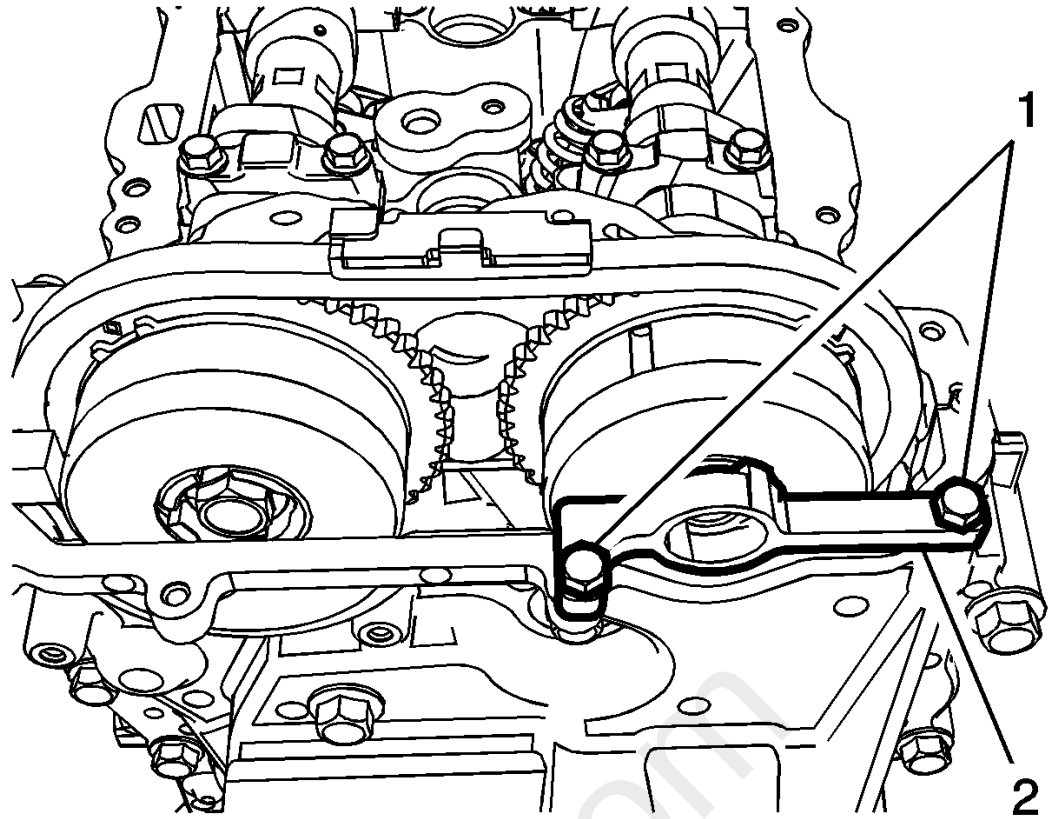


Fig. 159: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

9. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

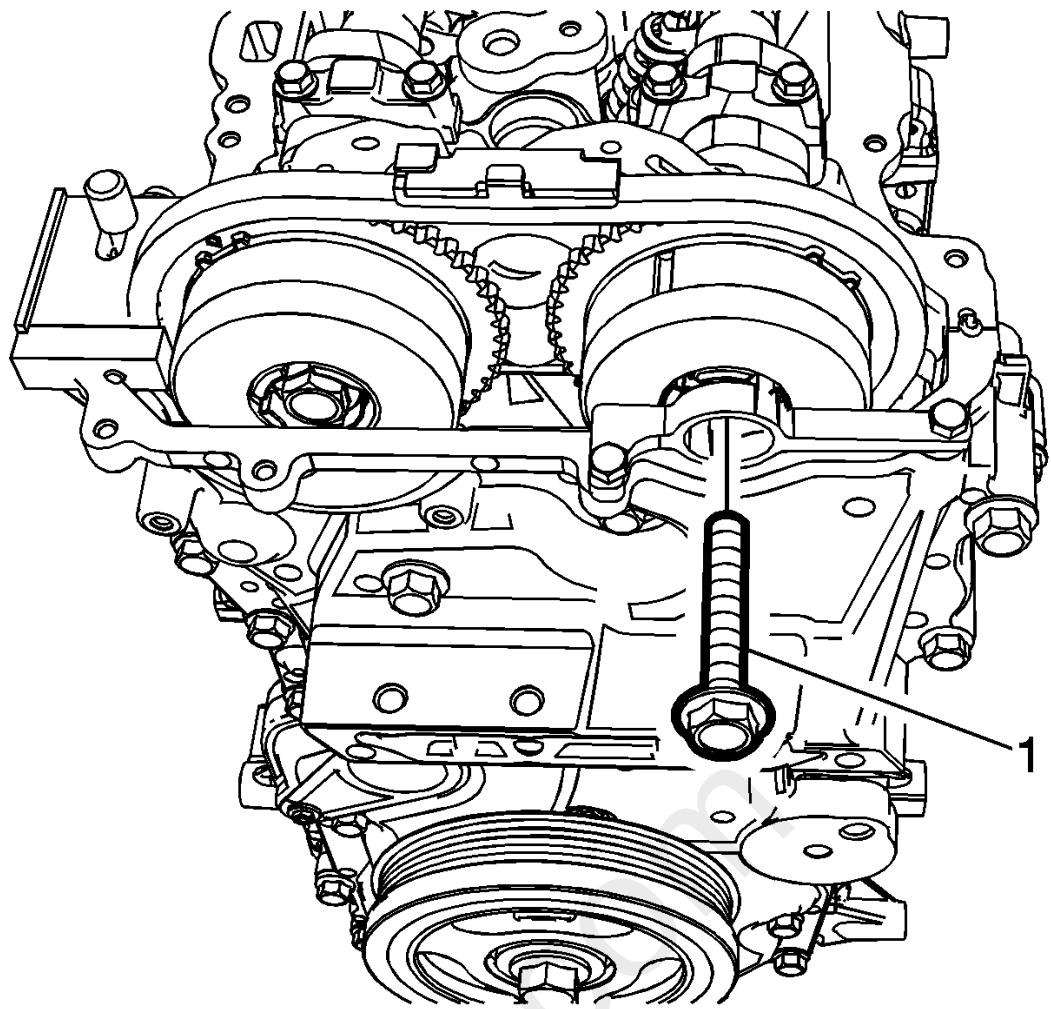


Fig. 160: Camshaft Actuator Bolt

Courtesy of GENERAL MOTORS COMPANY

10. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.

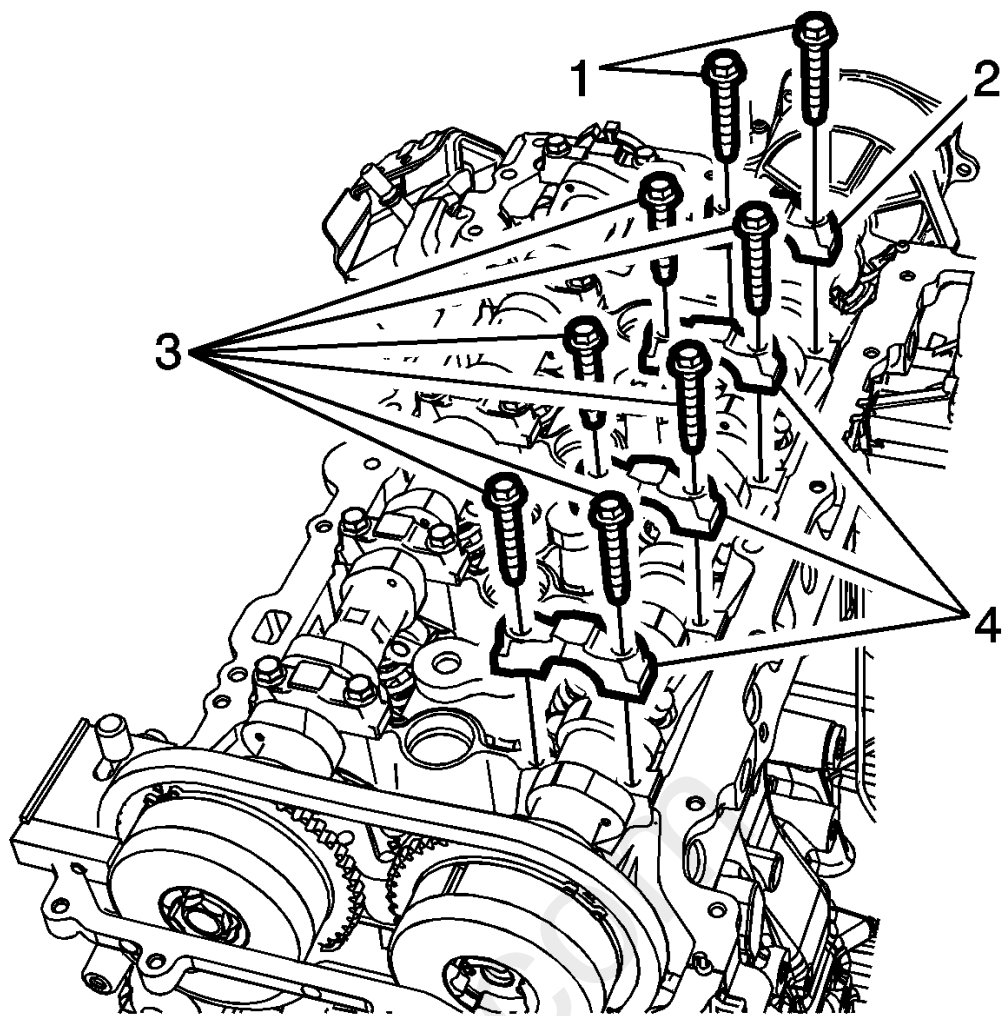


Fig. 161: Exhaust Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

11. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals with the exhaust actuator timing mark at approximately the one O'clock position.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

12. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
13. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).

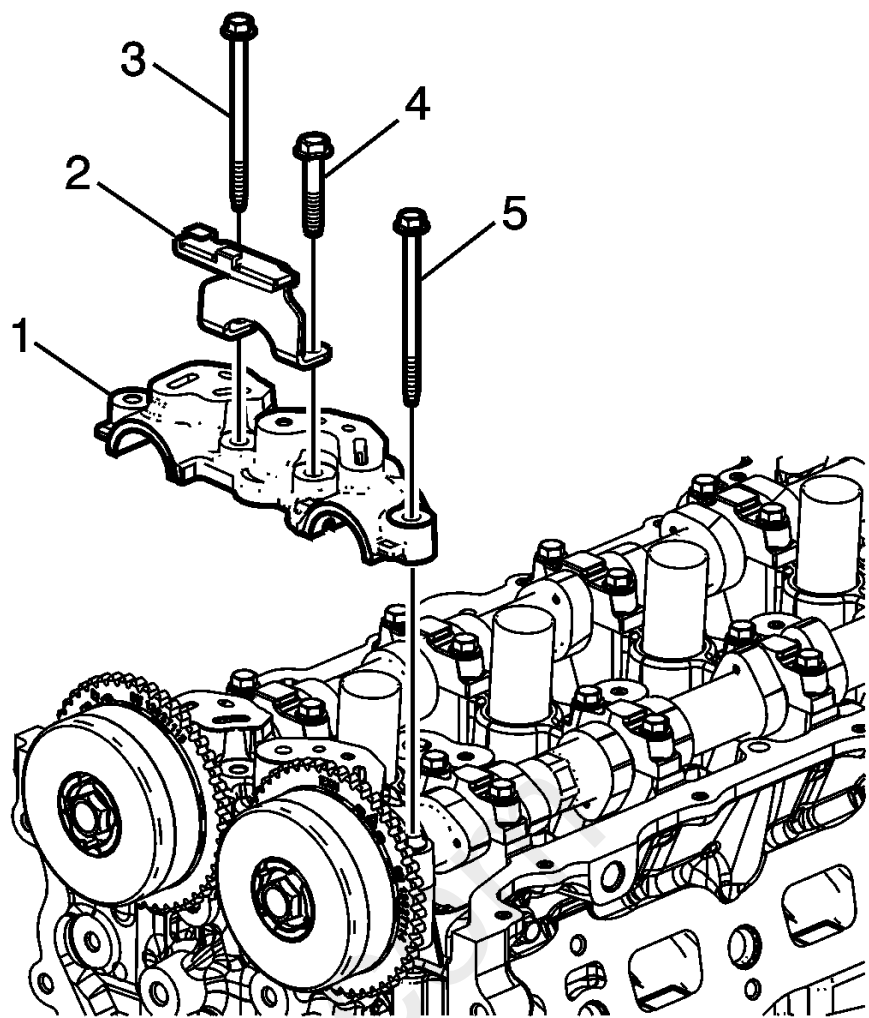


Fig. 162: Front Camshaft Bearing Cap
 Courtesy of GENERAL MOTORS COMPANY

14. Install the front camshaft bearing cap (1). Install the timing chain guide (2) onto the front camshaft bearing cap, then hand start the camshaft cap bolts (3 - 5).

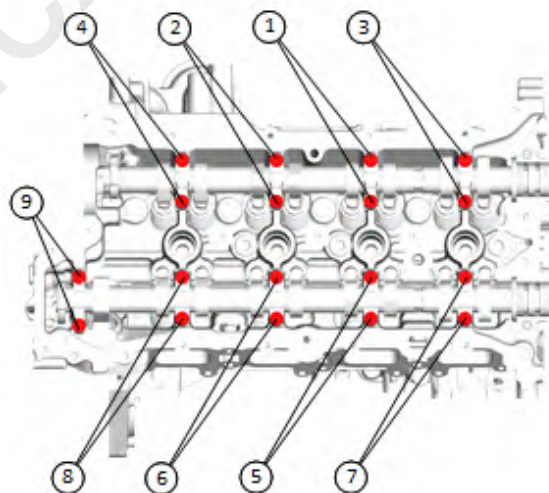


Fig. 163: Camshaft Cap Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

15. tighten the camshaft cap bolts in sequence using the following procedure:
 1. tighten the camshaft cap bolts in sequence to 8 N.m (71 lb in).

2. Loosen both bolts in each cap in sequence to 180 degrees.
3. tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

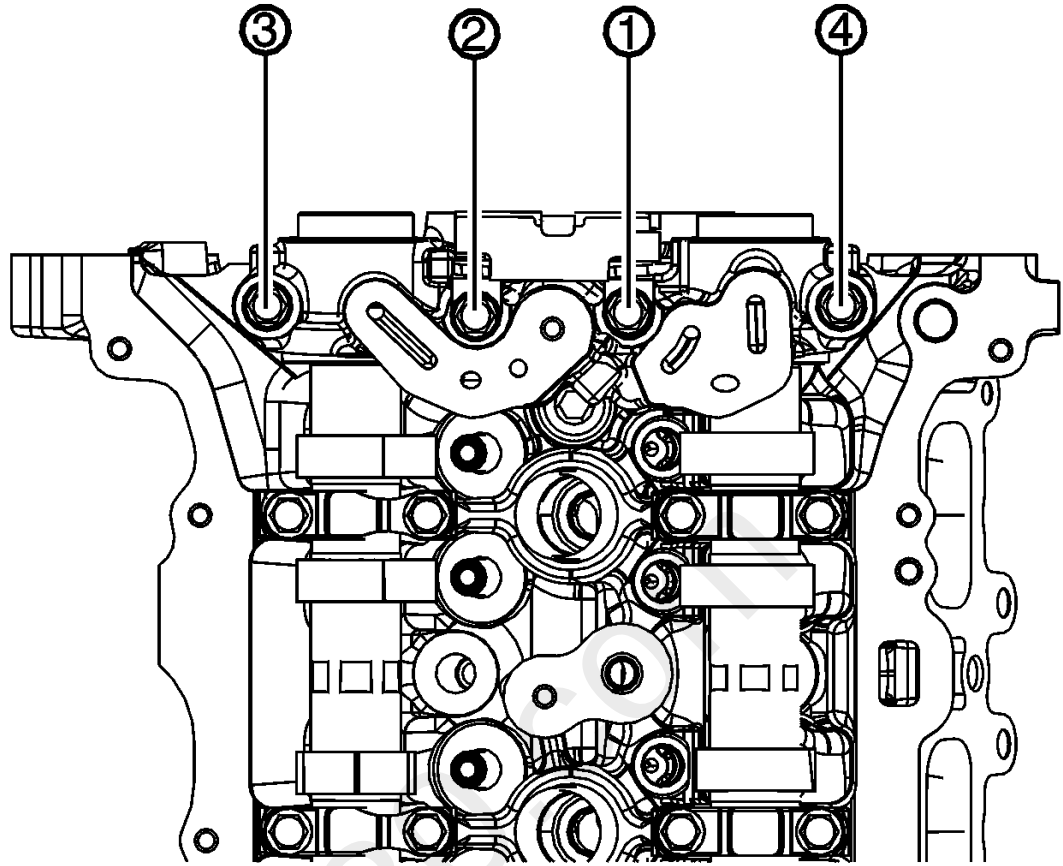


Fig. 164: Front Camshaft Cap Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

16. tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

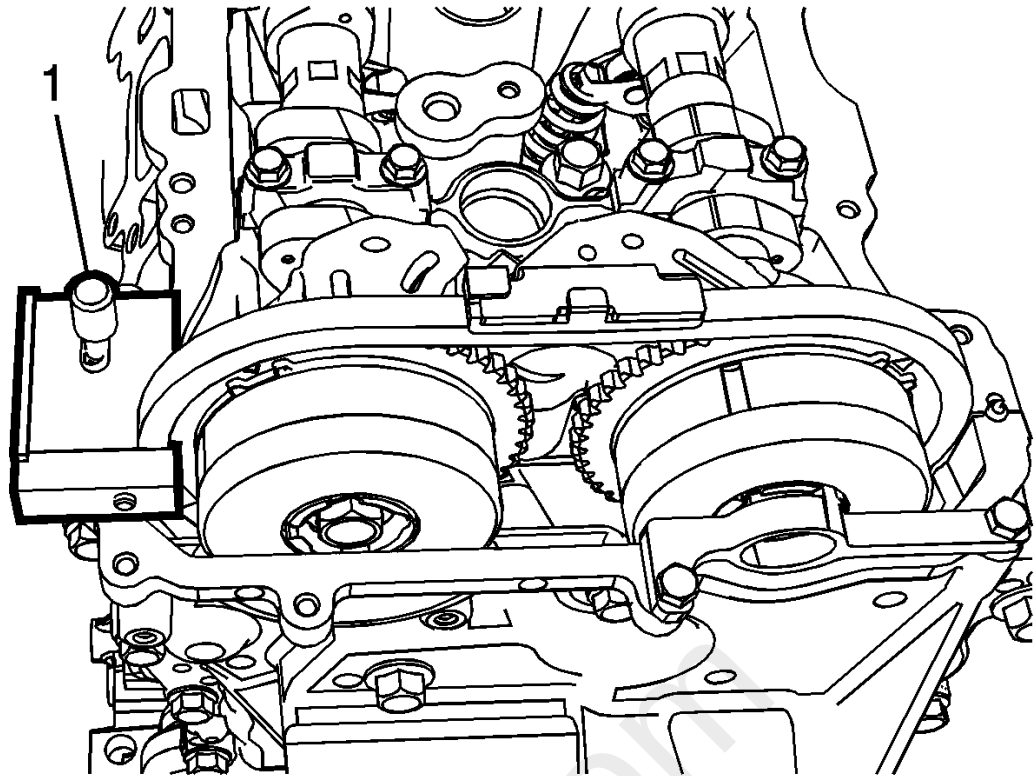


Fig. 165: Identifying Timing Chain Holding Tool
Courtesy of GENERAL MOTORS COMPANY

17. Remove **EN-50656** timing chain holding tool (1).
18. Install the high pressure fuel pump. Refer to [Fuel Pump Replacement](#) .
19. Install the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).

CAMSHAFT POSITION ACTUATOR AND CAMSHAFT REPLACEMENT - EXHAUST

Special Tools

- **EN-50656** Holding Tool
- **EN 50793** Locking Tool

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

Removal Procedure

NOTE: Ensure the engine is properly timed to Top Dead Center (TDC), prior to performing repairs.

1. Remove the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).

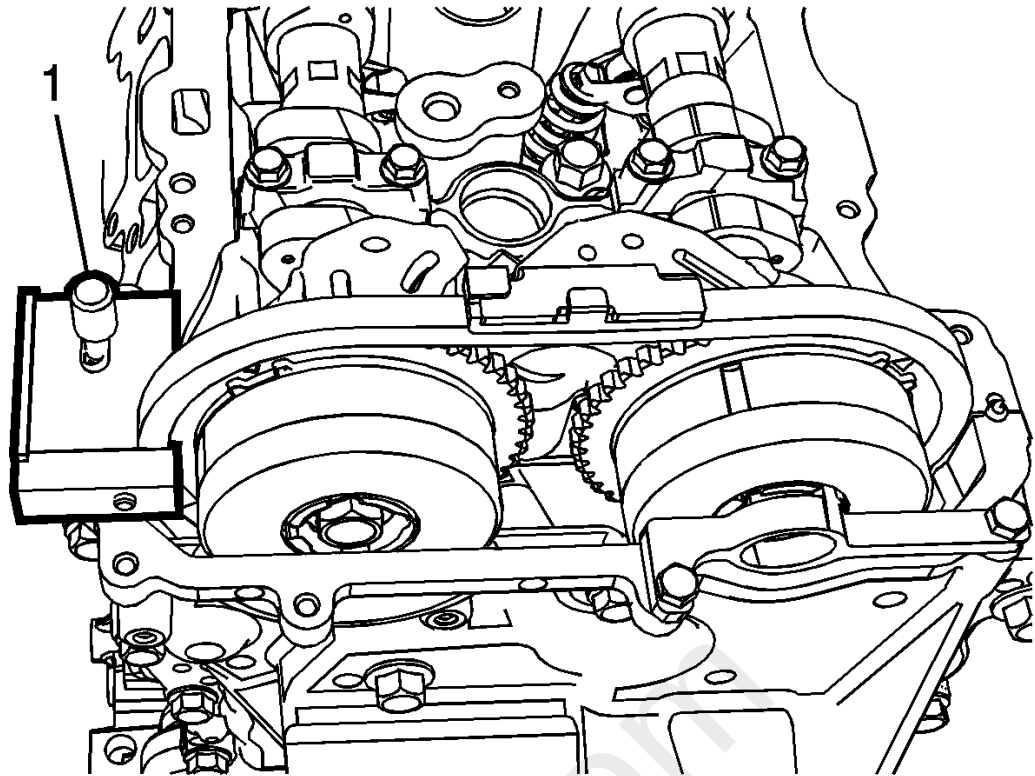


Fig. 166: Identifying Timing Chain Holding Tool

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the EN-50656 Holding tool is installed and securely tightened to prevent the camshaft chain from dropping into the front engine cover during camshaft actuator replacement.

2. Install EN-50656 timing chain holding tool (1) and tighten to 8 N.m (71 lb in).

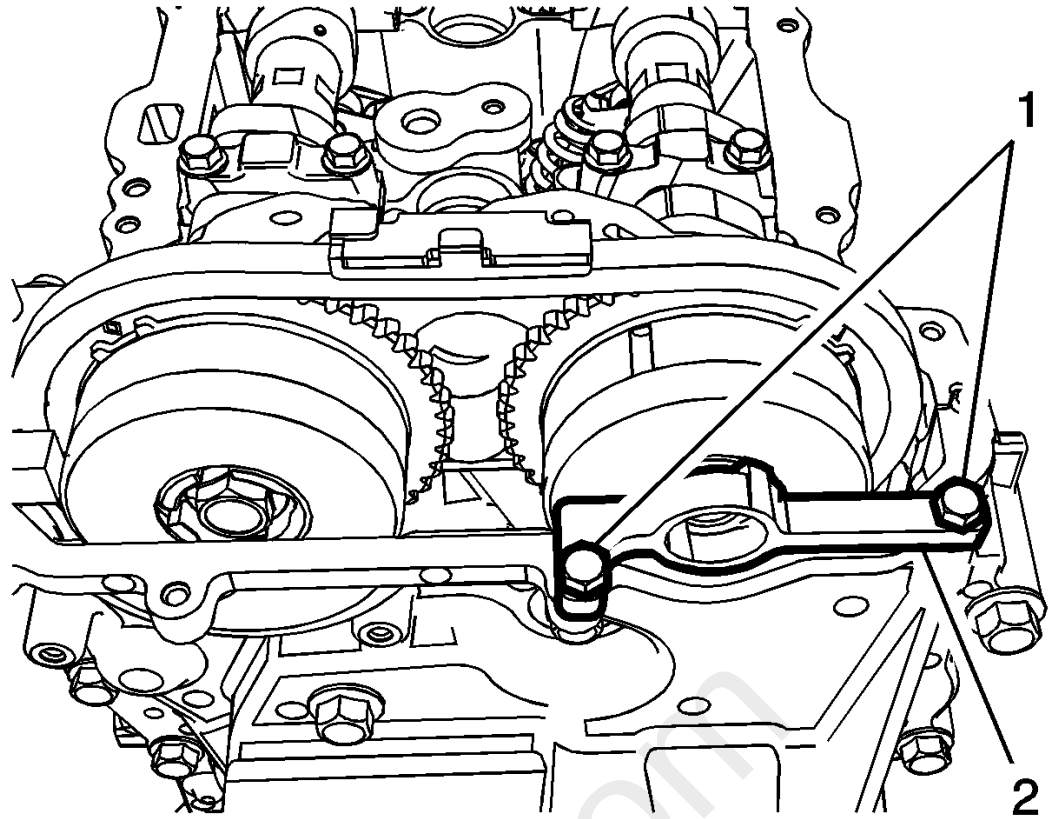


Fig. 167: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

NOTE: Ensure to mark actuator sprocket and chain before removal.

3. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the exhaust camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

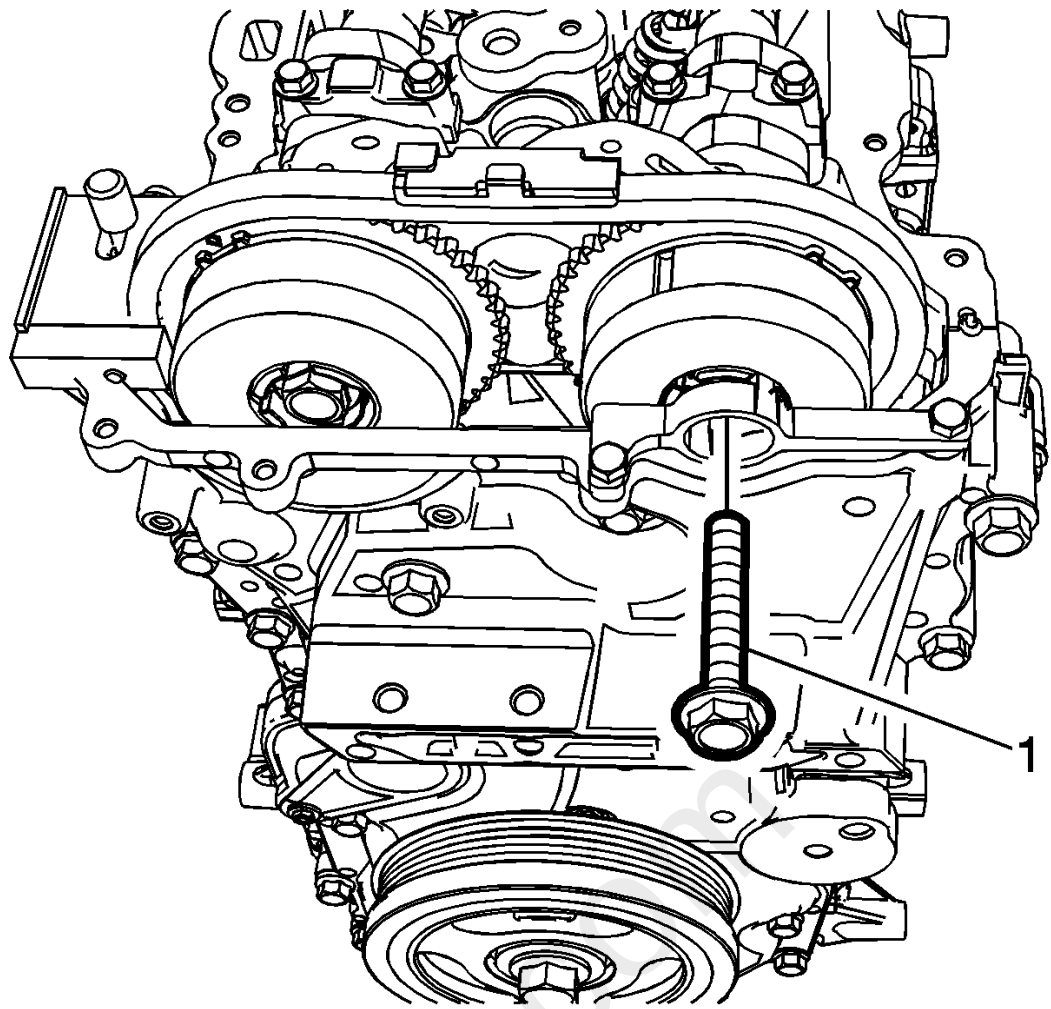


Fig. 168: Camshaft Actuator Bolt

Courtesy of GENERAL MOTORS COMPANY

4. Remove and DISCARD the camshaft actuator bolt (1).

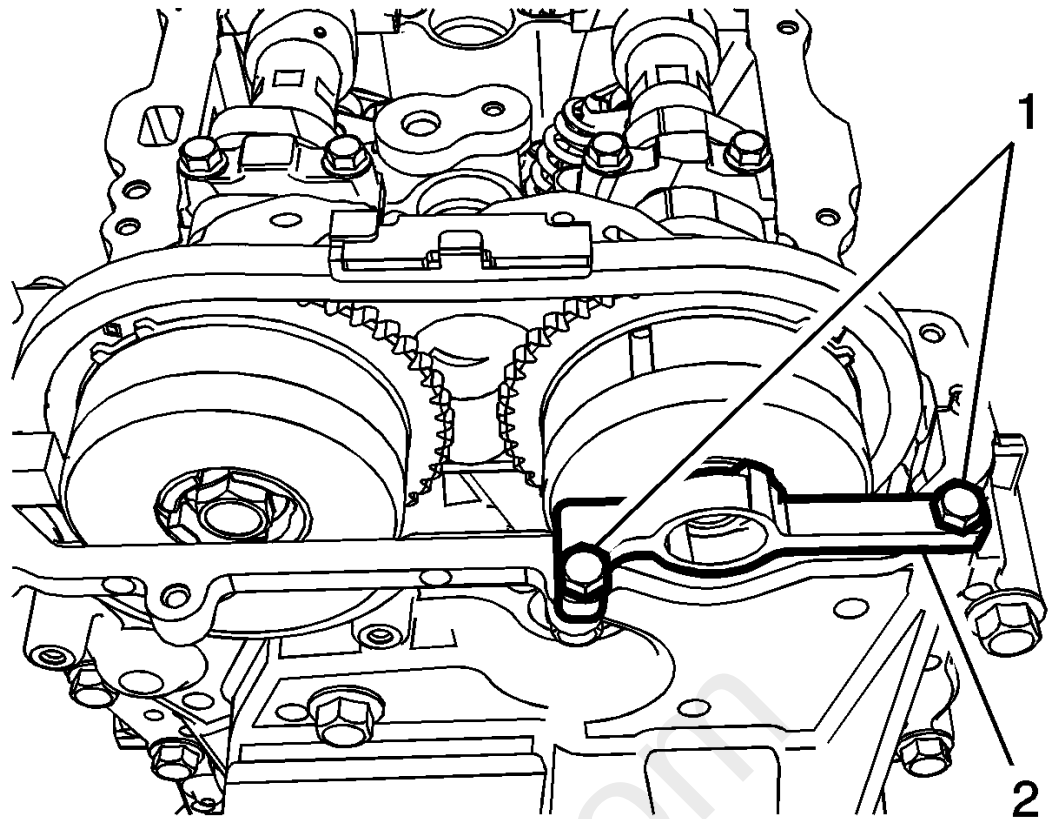


Fig. 169: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

5. Remove the EN-50793 holding tool (2).

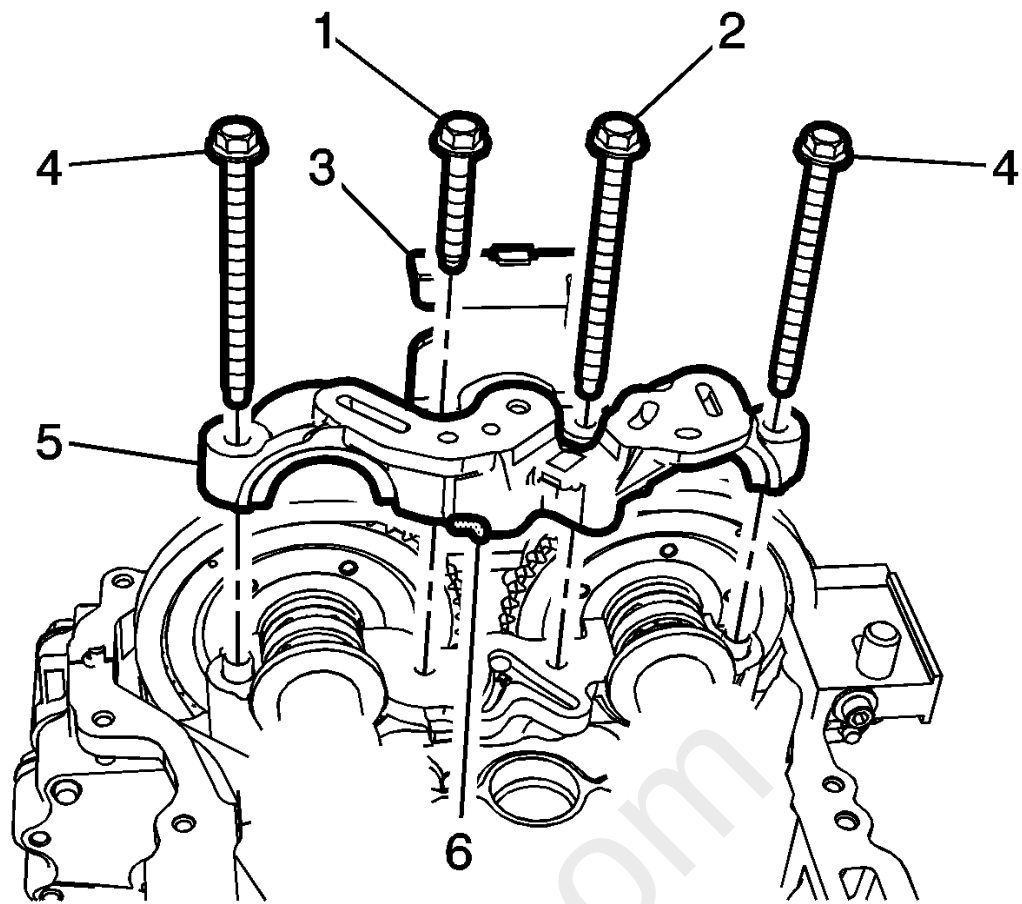


Fig. 170: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the upper timing chain guide bolts (1, 2).
7. Remove the upper timing chain guide (3).
8. Remove the camshaft front bearing cap bolts (4).

NOTE: Locate the pry points (6) in the camshaft front bearing cap. When using the 3 pry points to remove the front bearing cap evenly, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.

9. Remove the camshaft front bearing cap (5).

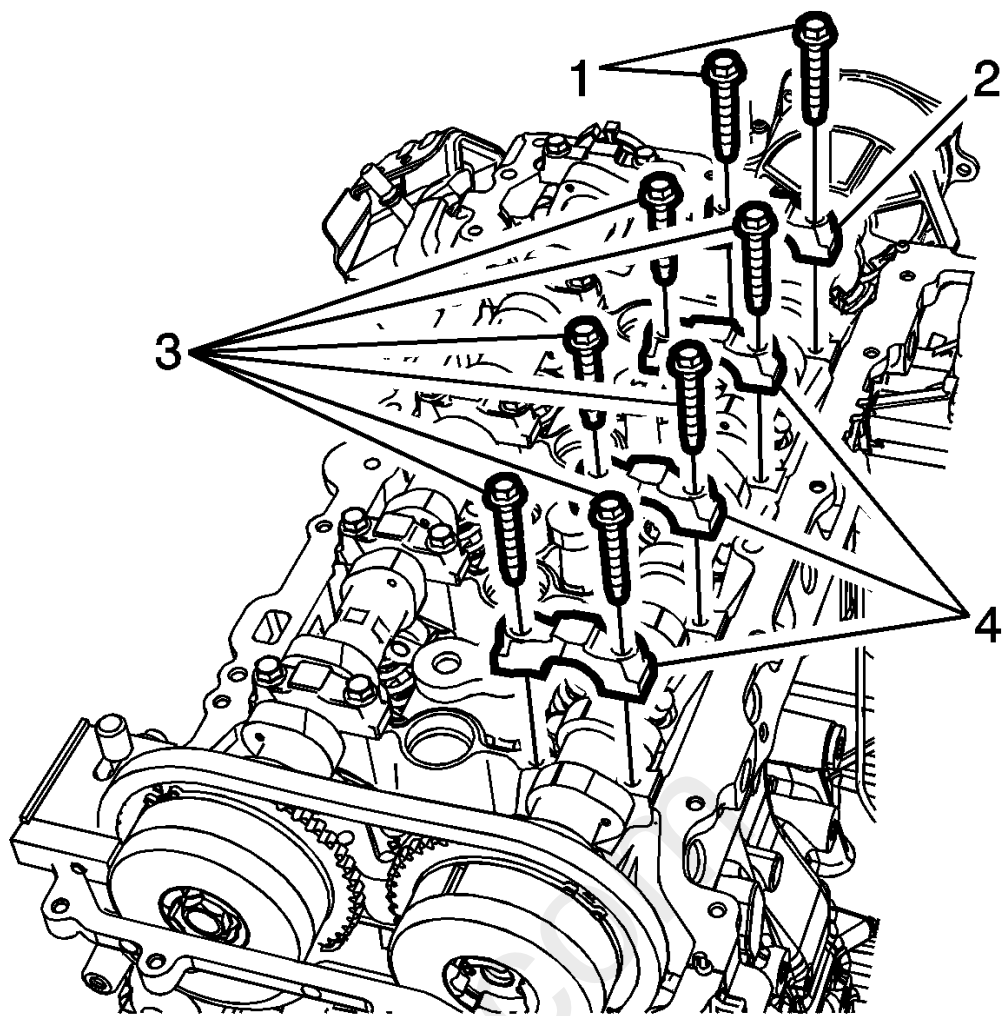


Fig. 171: Exhaust Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

10. Mark the exhaust camshaft rear cap to ensure it is installed in the same position. Remove the exhaust camshaft bearing rear cap bolts (1) and cap (2).

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

11. Mark the camshaft caps (4) to ensure they are installed in the same position.
12. Remove the exhaust camshaft cap bolts (3).
13. Remove the camshaft caps (4).

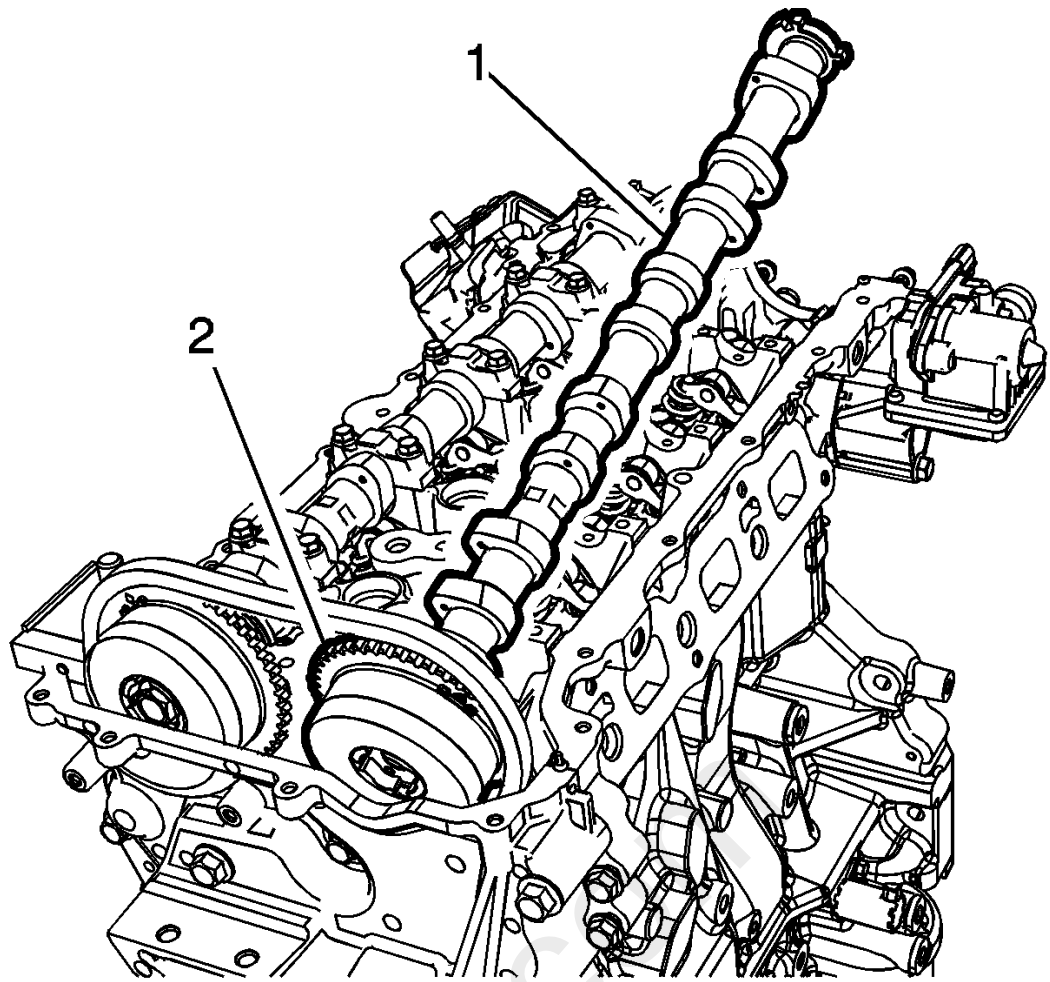


Fig. 172: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

14. Pull exhaust camshaft actuator assembly forward away from camshaft assembly (1), then lift rear of exhaust camshaft assembly to a tilt and pull free from exhaust camshaft actuator assembly (2).

NOTE: If replacing the camshaft, ensure to transfer any marking from the old camshaft to the new one.

15. Replace the camshaft if necessary.

Installation Procedure

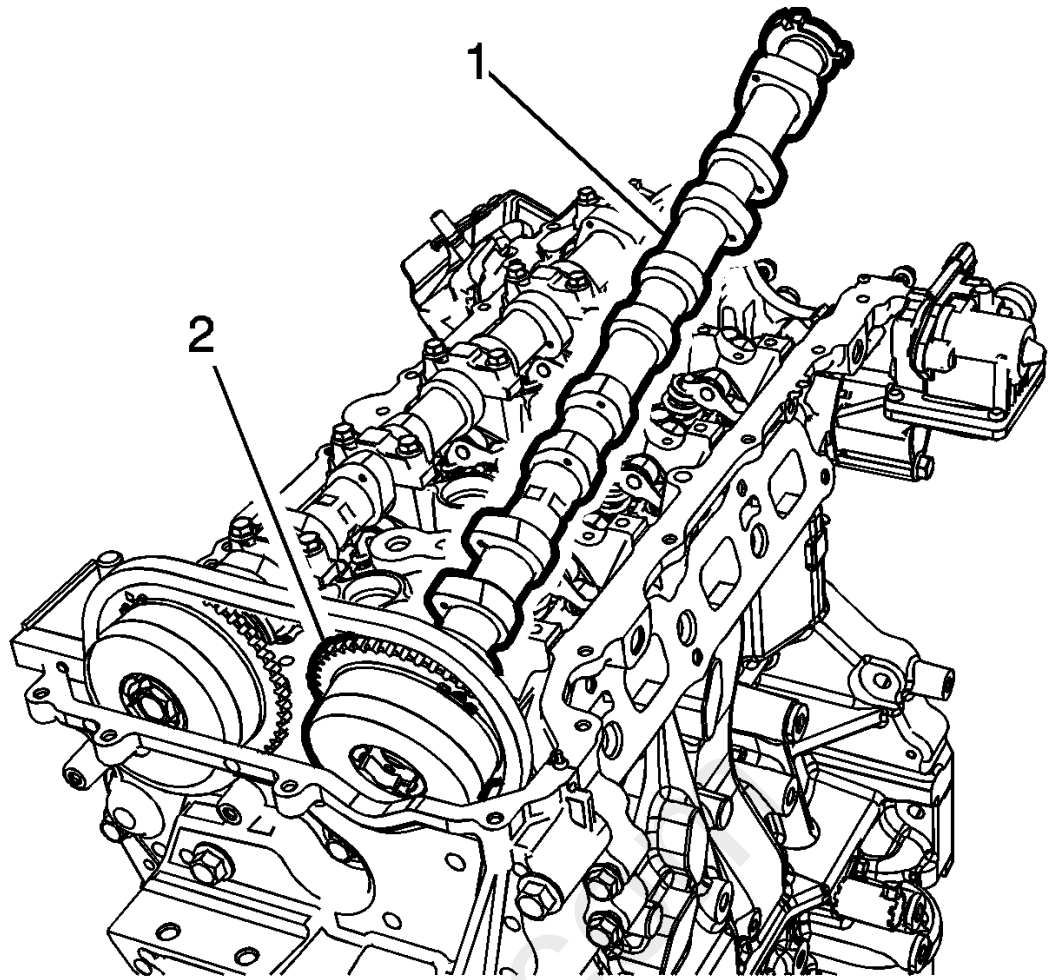


Fig. 173: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust camshaft (1) and camshaft actuator (2).

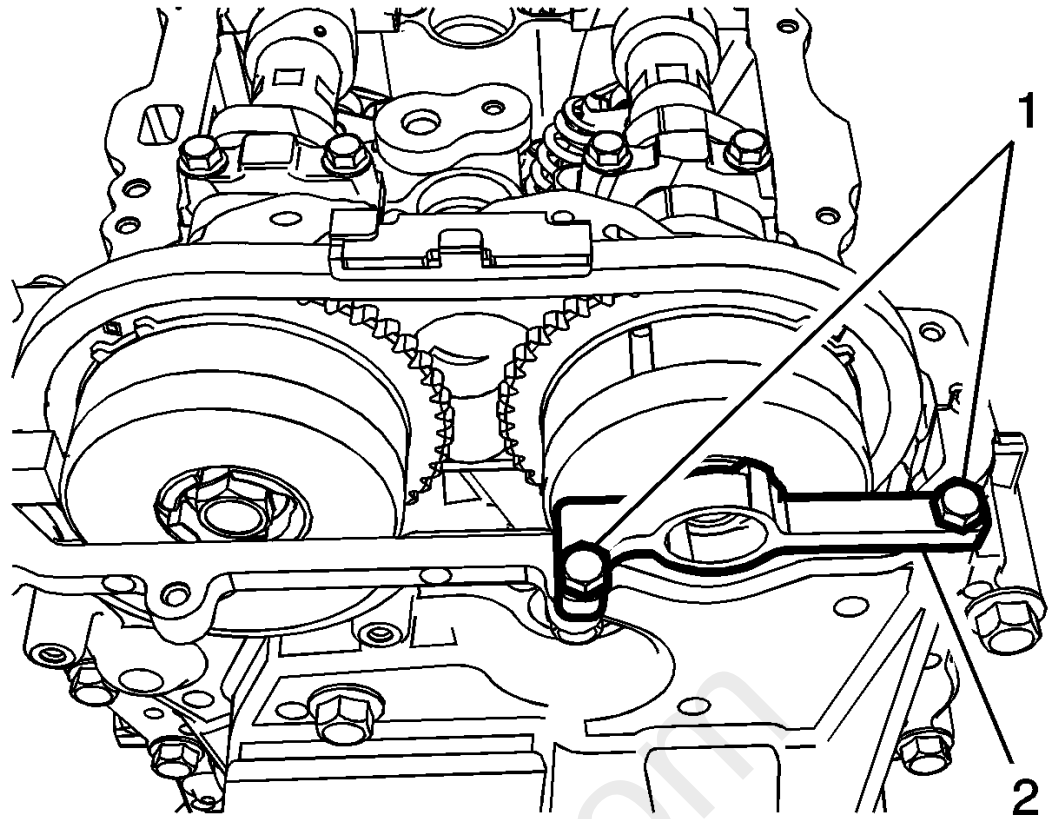


Fig. 174: Camshaft Actuator Locking Tool
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. Align and install camshaft actuator locking tool (2) **EN 50793** into the slots of the intake camshaft actuator and mount tool to engine front cover assembly and tighten the bolts (1) to 10 N.m (89 lb in).

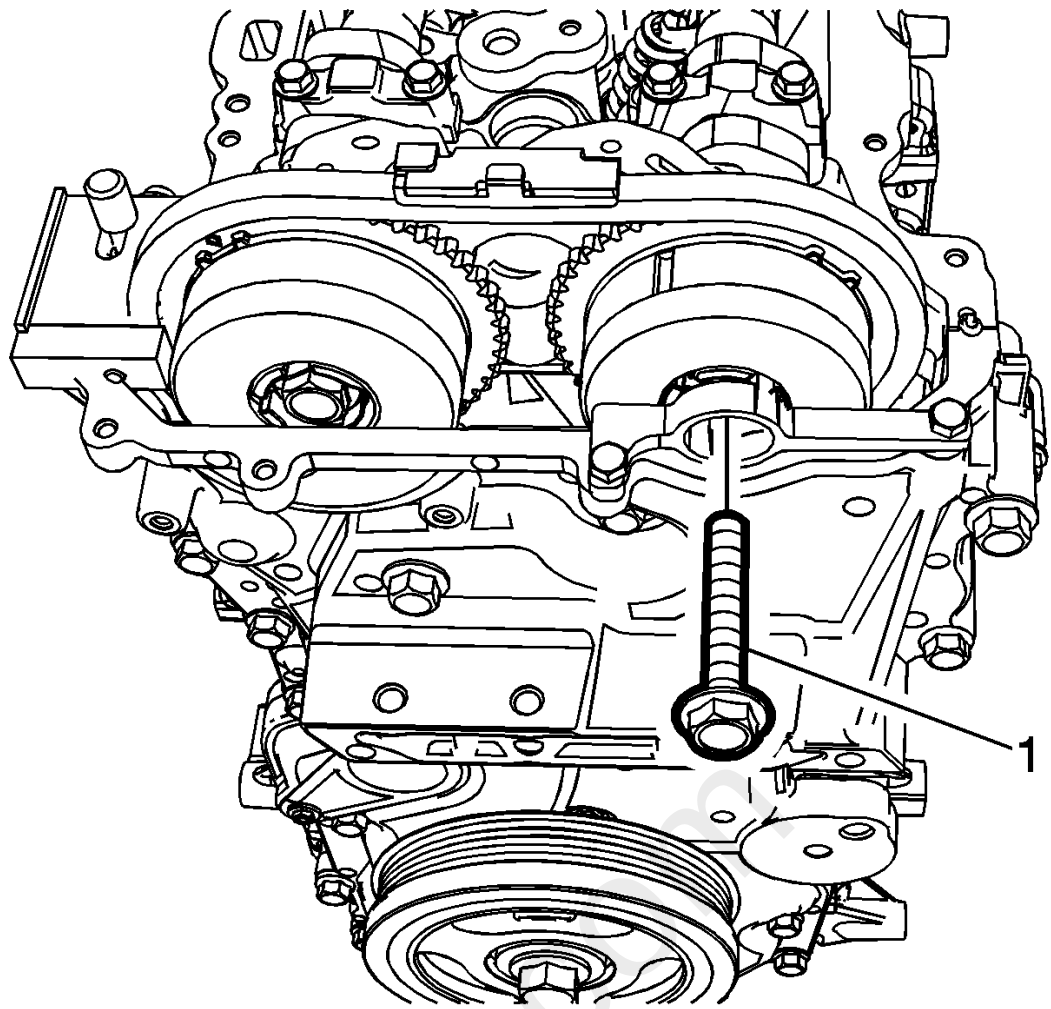


Fig. 175: Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW camshaft actuator bolt (1) and tighten to 30 N.m (22 lb ft) plus 100 degrees.

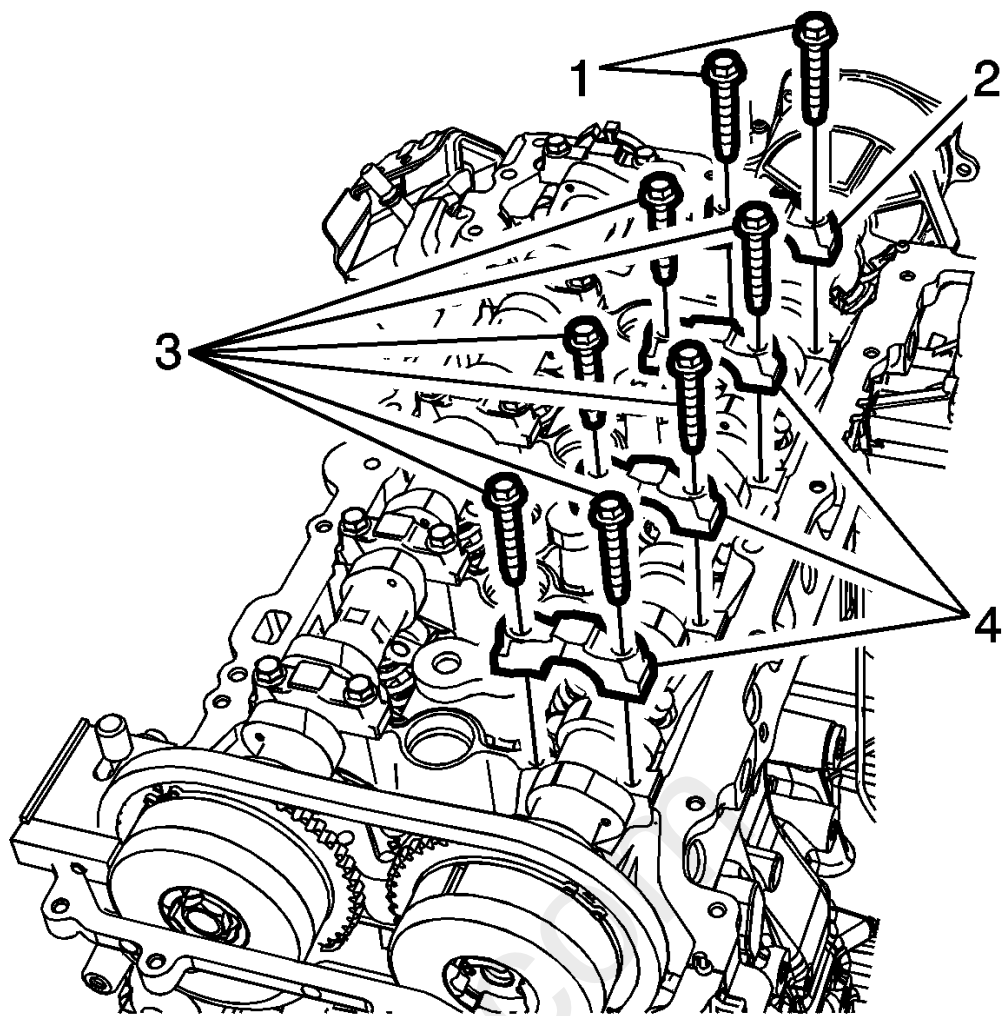


Fig. 176: Exhaust Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

4. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals with the exhaust actuator timing mark at approximately the one O'clock position.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

5. Install the camshaft cap bolts (1, 3) into the camshaft caps (2, 4).
6. Install the camshaft caps (2, 4) and hand start the camshaft cap bolts (1, 3).

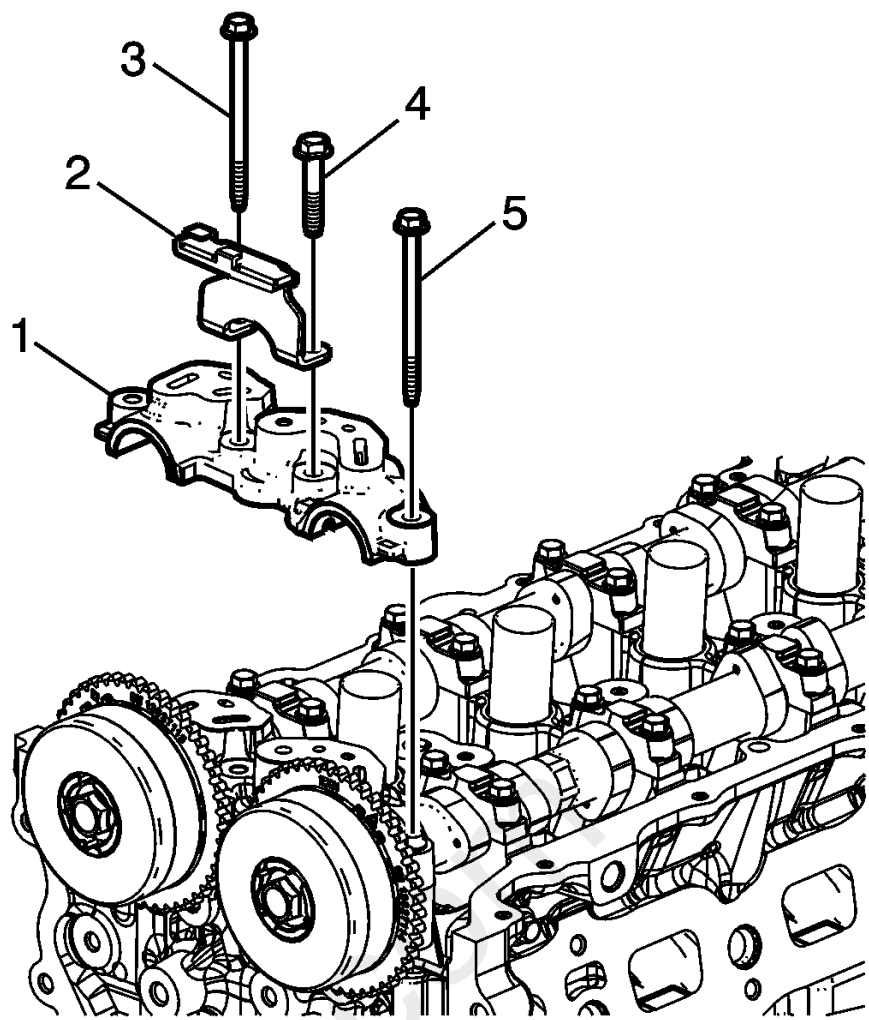


Fig. 177: Front Camshaft Bearing Cap
Courtesy of GENERAL MOTORS COMPANY

7. Install the front camshaft bearing cap (1). Install the timing chain guide (2) onto the front camshaft bearing cap, then hand start the camshaft cap bolts (3 - 5).

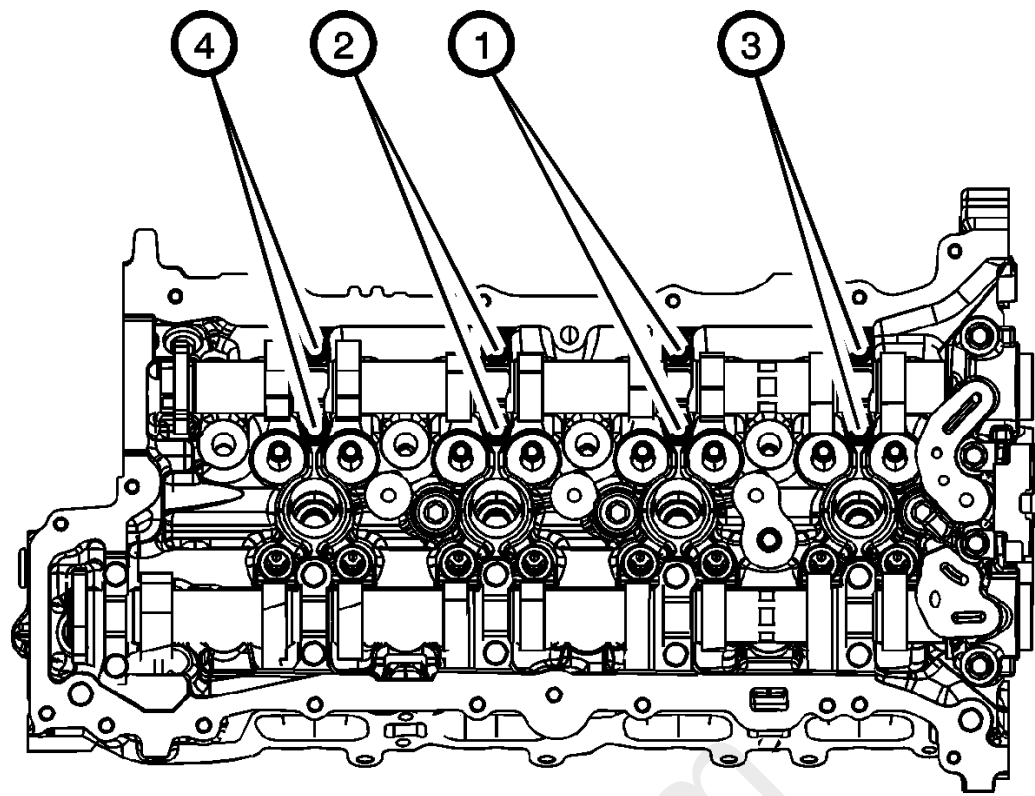


Fig. 178: Camshaft Cap Bolts tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

8. Install the camshaft cap bolts in sequence using the following procedure:
 1. tighten the camshaft cap bolts in sequence to 8 N.m (71 lb in).
 2. Loosen both bolts in each cap in sequence to 180 degrees.
 3. tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

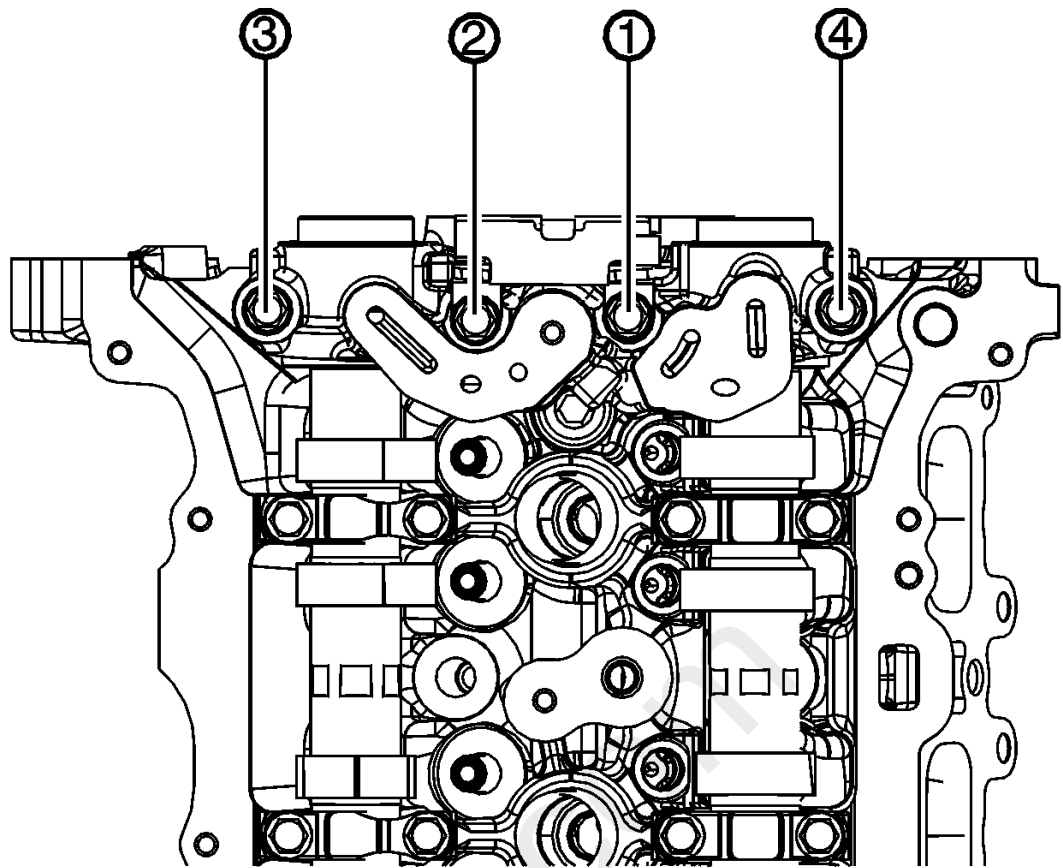


Fig. 179: Front Camshaft Cap Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

9. tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

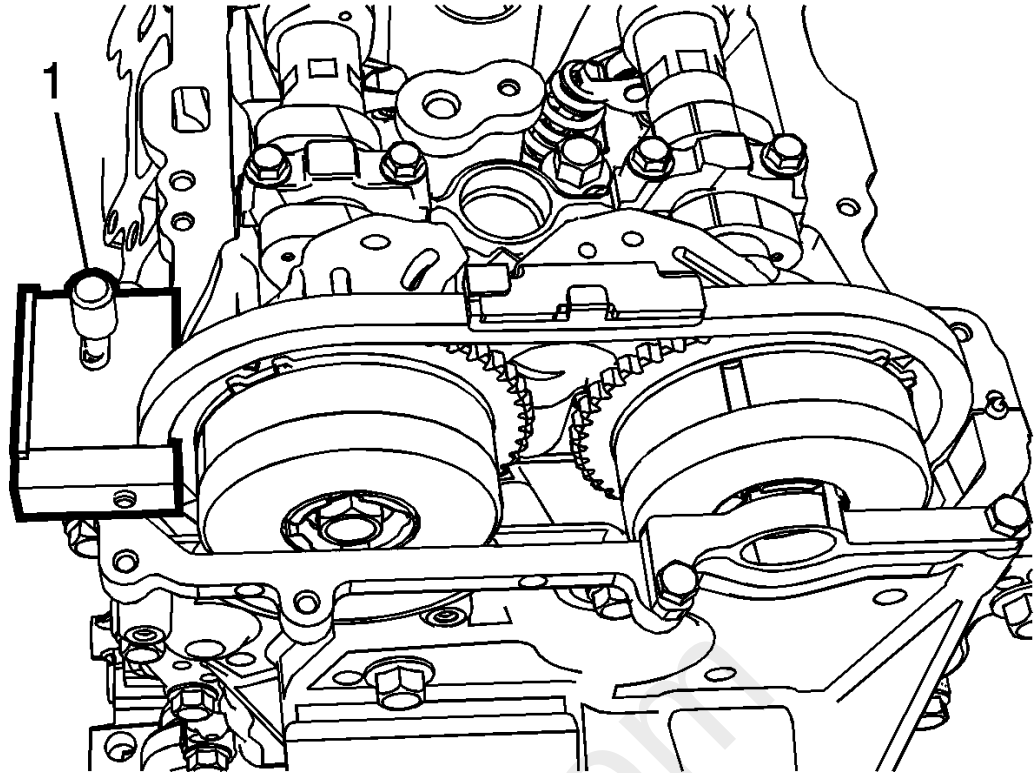


Fig. 180: Identifying Timing Chain Holding Tool
 Courtesy of GENERAL MOTORS COMPANY

10. Remove EN-50656 timing chain holding tool (1).
11. Install the camshaft cover. Refer to [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#).

CAMSHAFT COVER HEAT SHIELD REPLACEMENT

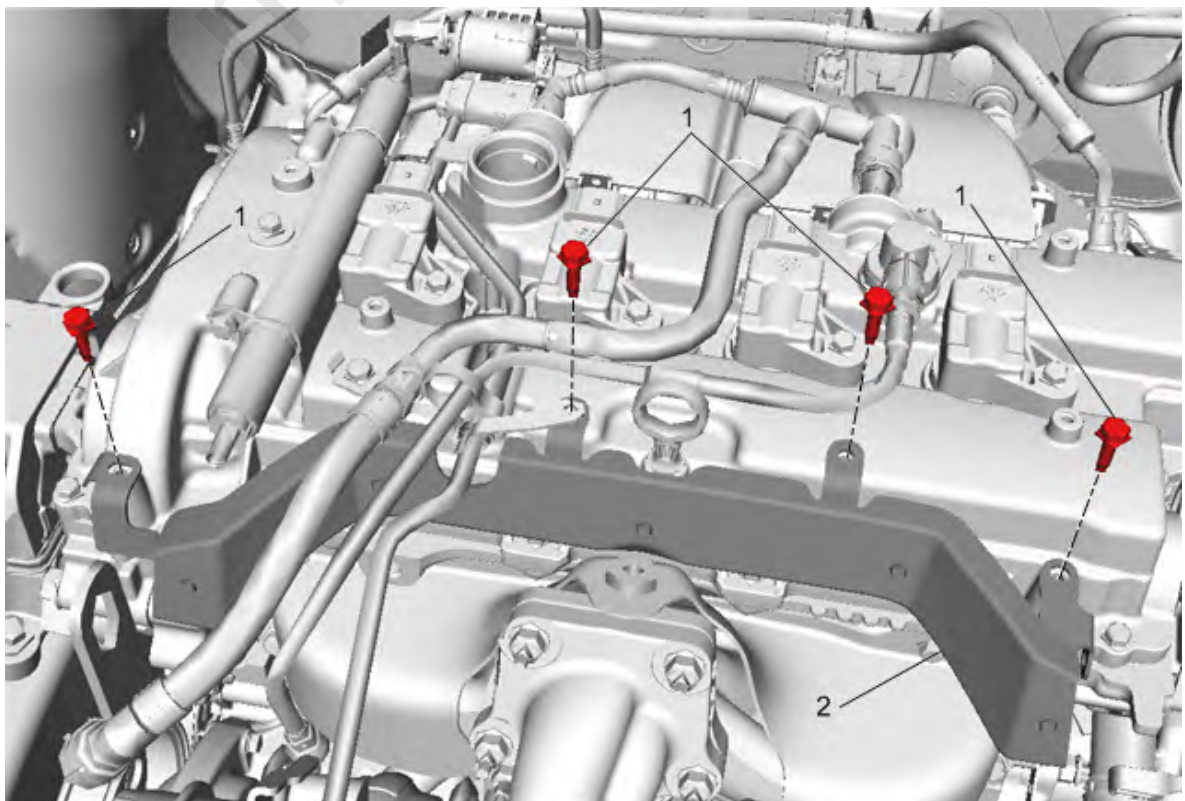


Fig. 181: Camshaft Cover Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement 2. Turbocharger Heat Shield Replacement 3. Disconnect and reposition the engine wiring harness.	
1	Camshaft Cover Heat Shield Bolt [4x] CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)
2	Camshaft Cover Heat Shield Procedure Disconnect the camshaft position actuator solenoid valve. NOTE: When removing the camshaft cover heat shield, carefully guide the shield past the turbocharger coolant return and PCV pipes.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- EN-37281-A Valve Guide Seal Remover
- EN-50717 Valve Spring Compressor
- EN-50792 Flywheel Holding Tool

Equivalent regional tools: [Special Tools](#)

Removal Procedure

NOTE: Prevent the crankshaft from rotating clockwise or counterclockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-50792 Flywheel Holding Tool.

1. If equipped with a manual transmission, leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped with an automatic transmission, remove the starter. [Starter Replacement \(LTG - All Wheel Drive\)](#), [Starter Replacement \(LTG - Front Wheel Drive\)](#)
3. Install EN-50792 Flywheel Holding Tool.
4. Remove Valve Rocker Arm - [Intake Valve Rocker Arm Replacement](#), [Exhaust Valve Rocker Arm Replacement](#)

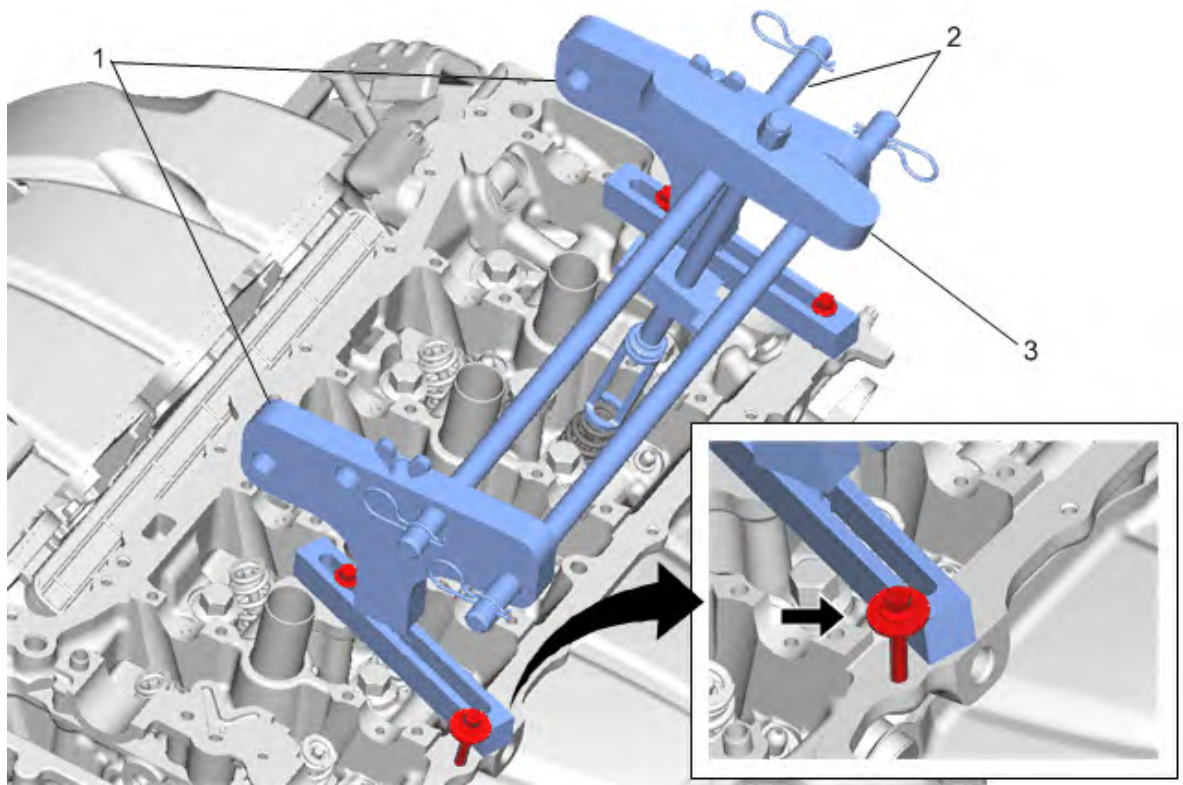


Fig. 182: Valve Spring Compressor

Courtesy of GENERAL MOTORS COMPANY

NOTE: When mounting the valve spring compressor to the cylinder head, a suitable large washer should be used as indicated by the arrow.

5. Install the **EN-50717** Valve Spring Compressor (1) to the front and rear of the cylinder head as shown.
6. Install the cross bars and locks (2) of the **EN-50717** Valve Spring Compressor to the valve spring compressor adaptors.
7. Remove the spark plugs. [Spark Plug Replacement](#)
8. Install an air hose adapter into the spark plug hole.
9. Attach an air hose to the adapter and pressurize the cylinder to 690 kPa (100 psi).
10. Compress the valve spring using the valve spring compressor (3).

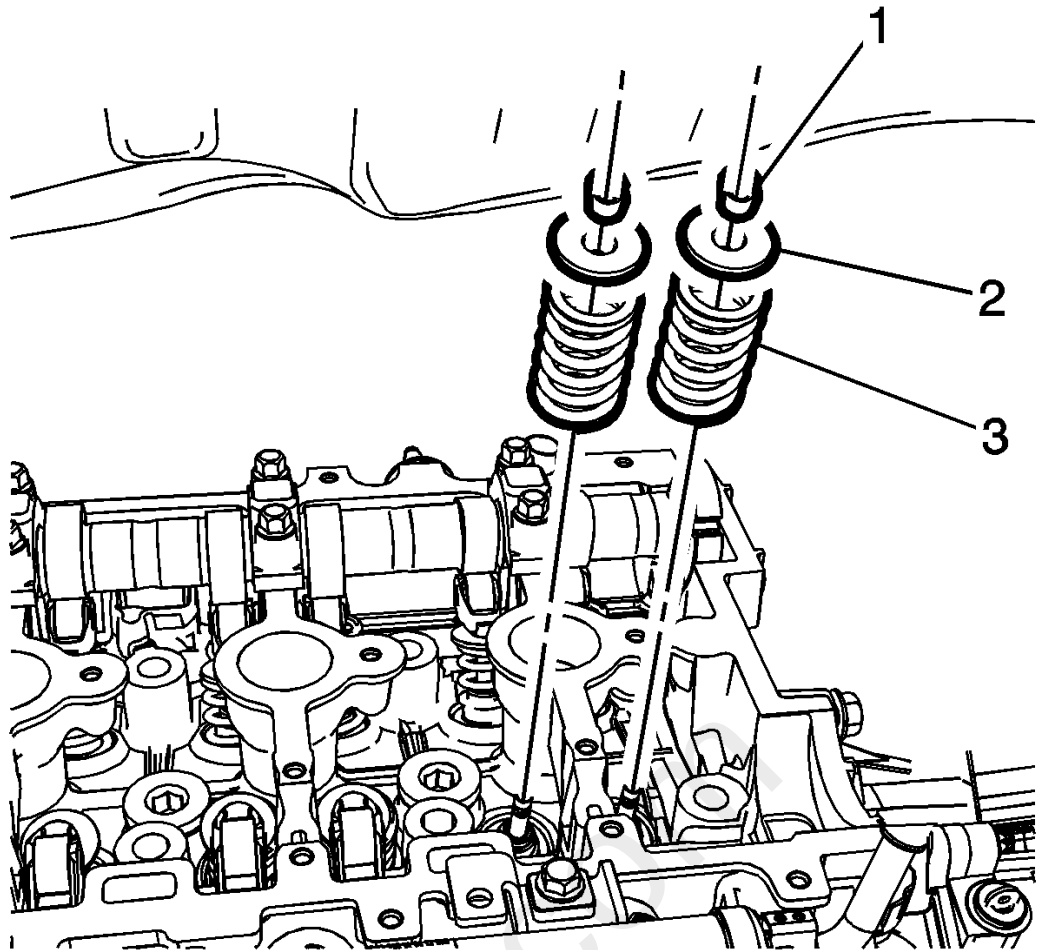


Fig. 183: Valve Spring, Keepers And Retainer
Courtesy of GENERAL MOTORS COMPANY

11. Remove the valve spring keepers (1).
12. Remove the valve spring (3) and retainer (2).
13. Use the **EN-37281-A** Valve Guide Seal Remover to remove the valve seal.

Installation Procedure

1. Using the **EN-37281-A** Valve Guide Seal Remover, install the NEW valve seal. Fully seat the seal onto the valve guide.

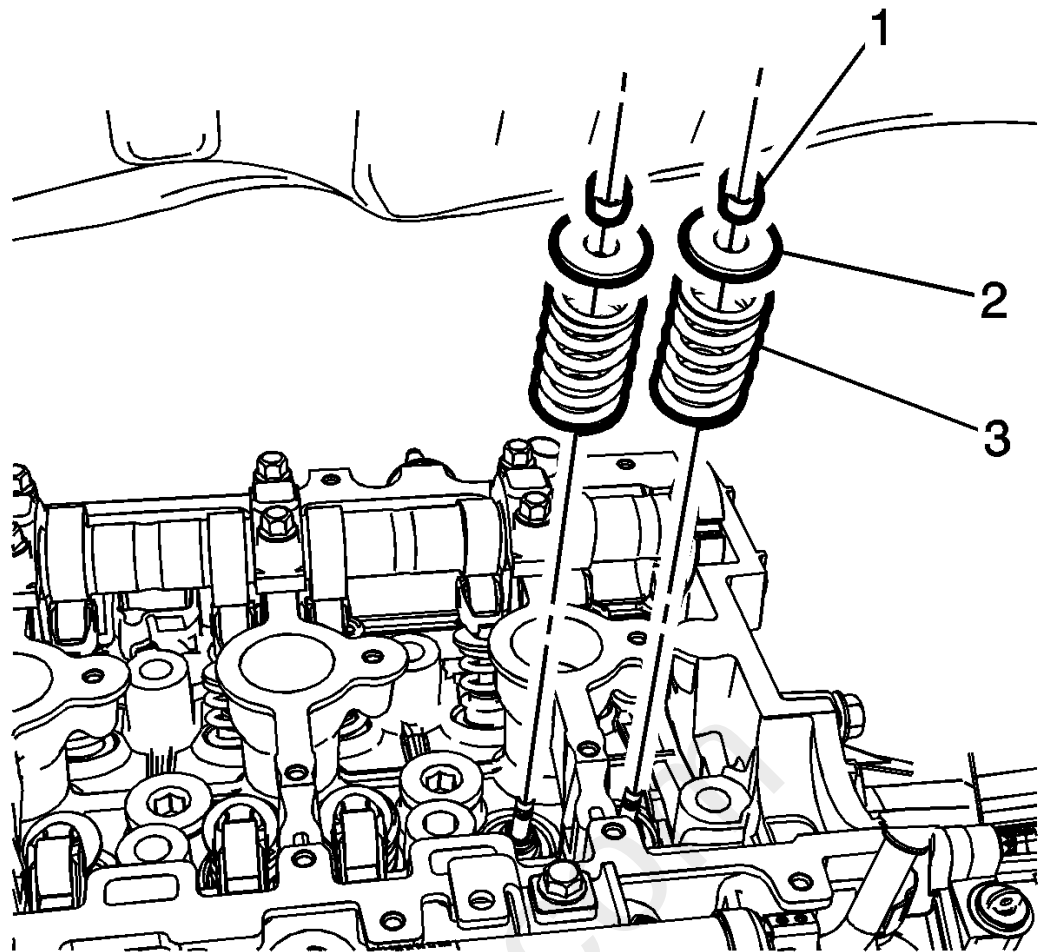
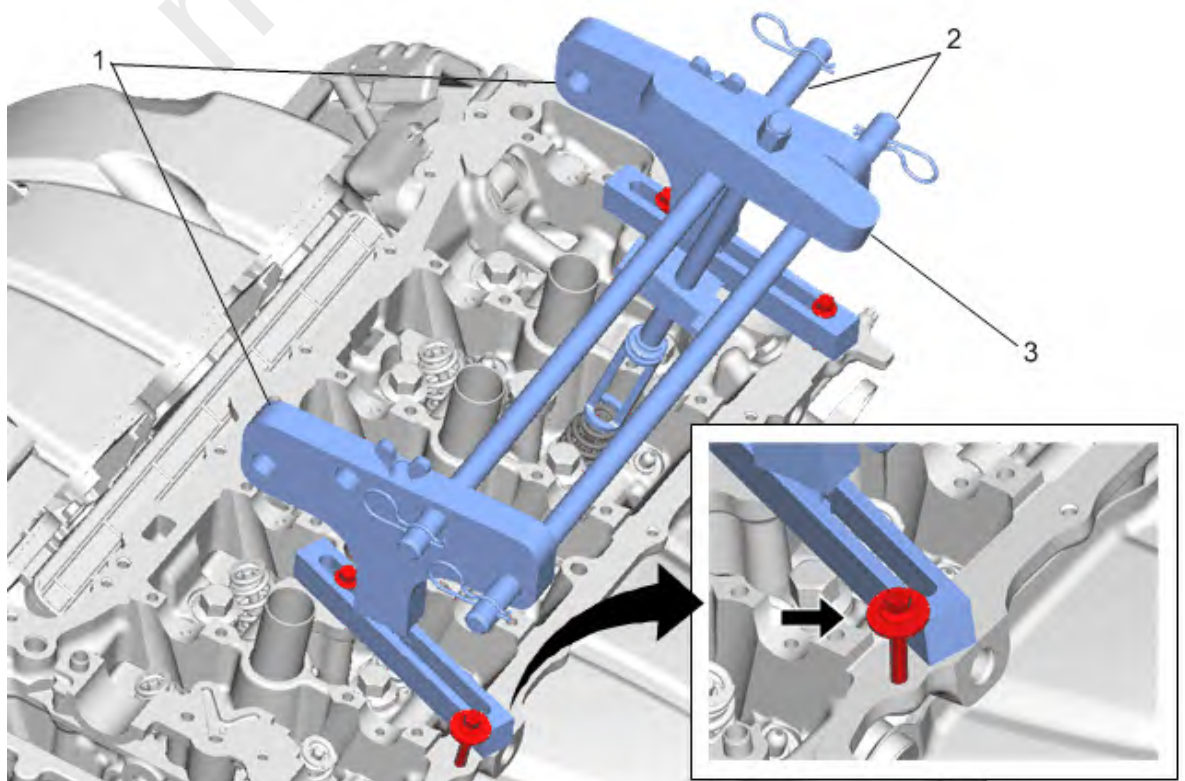


Fig. 184: Valve Spring, Keepers And Retainer
 Courtesy of GENERAL MOTORS COMPANY

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



6. Remove the **EN-50717** Valve Spring Compressor and **EN-50717** Valve Spring Compressor adapter set from the cylinder head.
7. Install the spark plugs. [Spark Plug Replacement](#)
8. Install Valve Rocker Arm - [Intake Valve Rocker Arm Replacement](#), [Exhaust Valve Rocker Arm Replacement](#)
9. Remove the **EN-50792** Flywheel Holding Tool.
10. If equipped with an automatic transmission, install the starter. [Starter Replacement \(LTG - All Wheel Drive\)](#), [Starter Replacement \(LTG - Front Wheel Drive\)](#)

CYLINDER HEAD REPLACEMENT

Special Tools

- **EN-38188** Cylinder Head Broken Bolt Extractor Kit - or equivalent aftermarket tool
- **EN-45059** Angle Meter
- **J-36857** Engine Lift Bracket

Removal Procedure

Equivalent regional tools: [Special Tools](#)

1. Drain the coolant system. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)
2. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
3. Remove the camshaft cover. [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#)

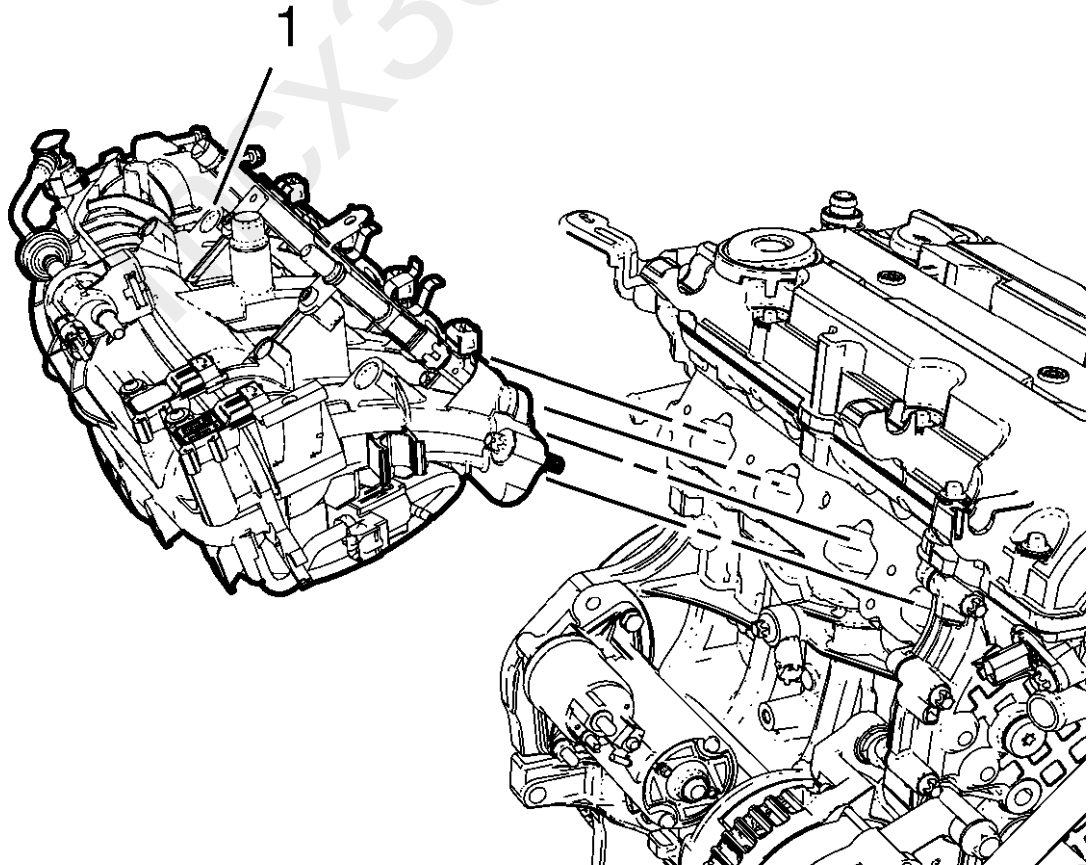


Fig. 186: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

4. Remove the intake manifold (1). [Intake Manifold Replacement](#)
5. Remove the exhaust manifold. [Exhaust Manifold Replacement \(LTG\)](#)
6. Remove the engine front cover. [Engine Front Cover Replacement](#)

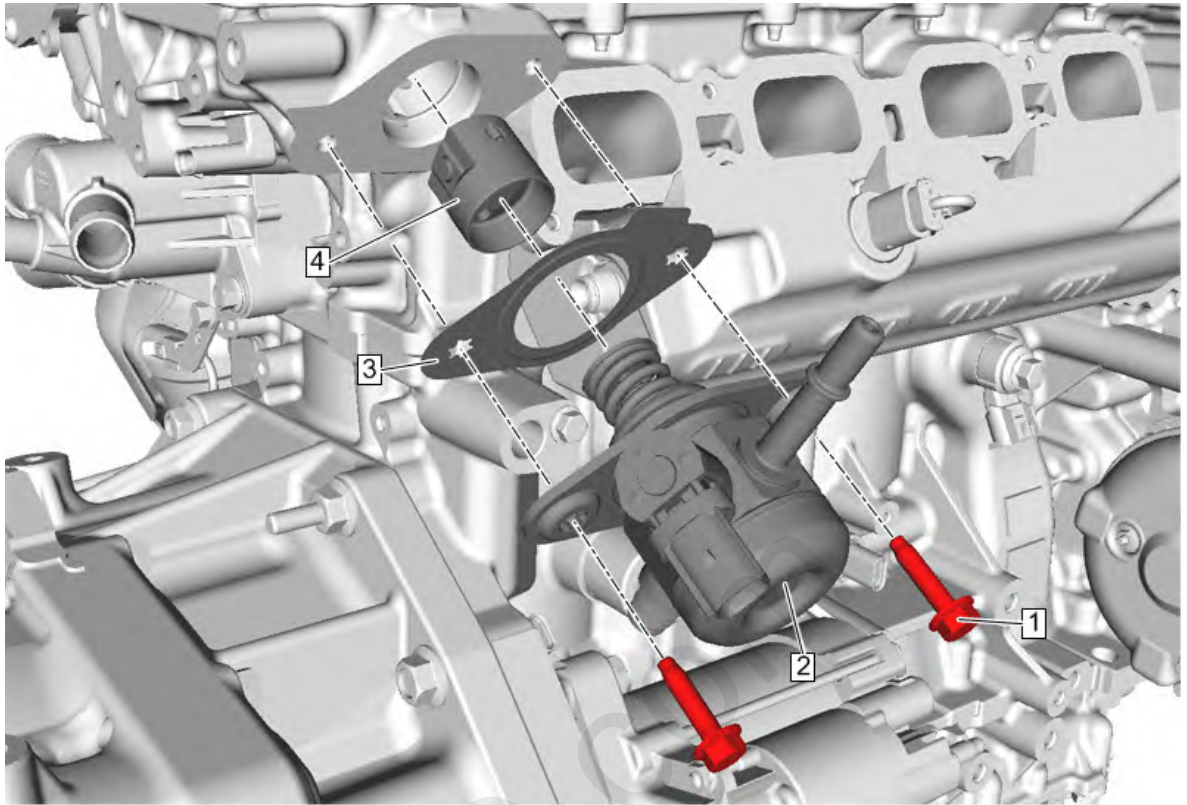


Fig. 187: Fuel Pump

Courtesy of GENERAL MOTORS COMPANY

7. Remove the fuel pump (2). [Fuel Pump Replacement](#)
8. Remove the timing chain and tensioner. [Camshaft Timing Chain and Tensioner Replacement](#)
9. Remove the intake and exhaust camshaft, bearing cap and lash adjuster. [Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Removal](#)
10. Disconnect the intake camshaft position sensor. [Camshaft Position Sensor Replacement - Intake](#)
11. Disconnect the exhaust camshaft position sensor. [Camshaft Position Sensor Replacement - Exhaust](#)

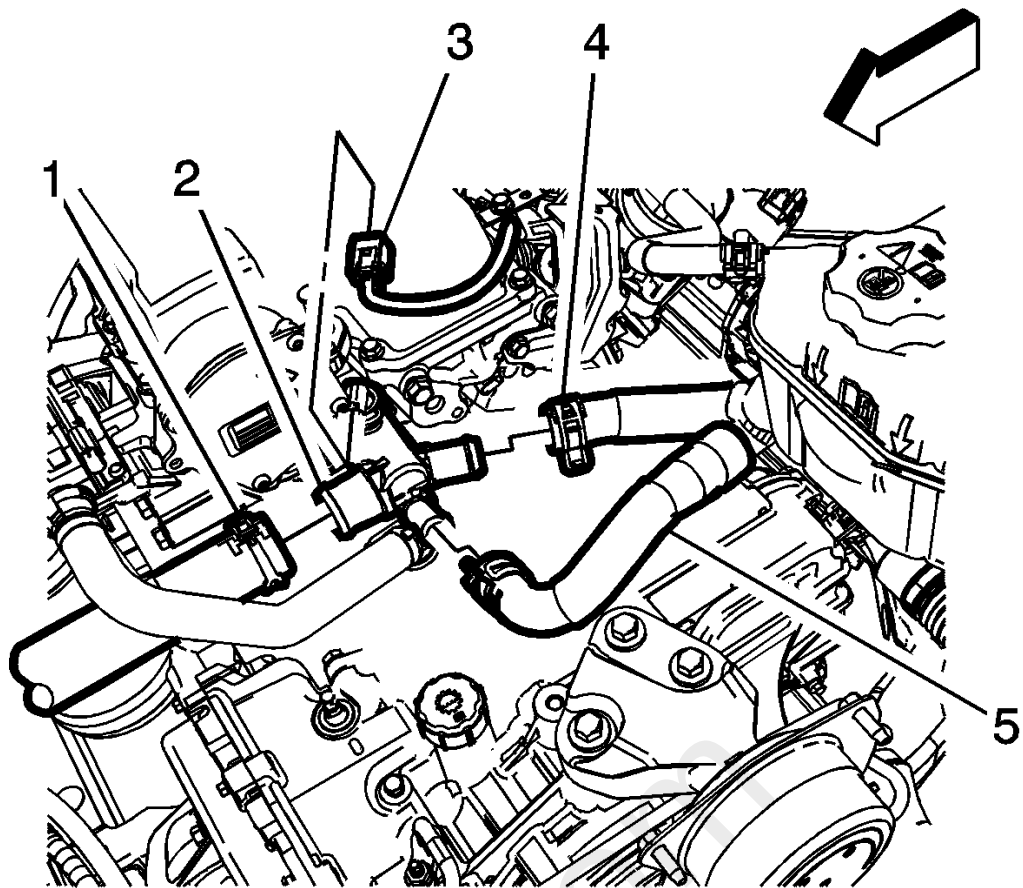


Fig. 188: Engine Coolant Temperature (ECT) Sensor Connector
 Courtesy of GENERAL MOTORS COMPANY

12. Disconnect the hoses from the water outlet (2). [Water Outlet Replacement \(LTG\)](#)
13. Remove Thermostat Bypass Pipe - [Thermostat Bypass Pipe Replacement \(LTG\)](#)

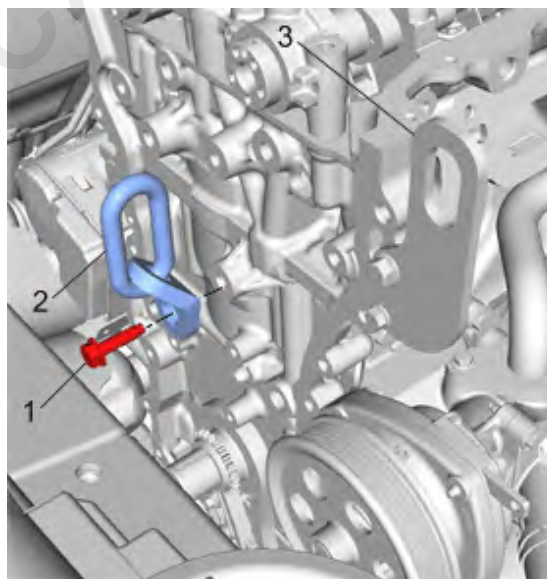


Fig. 189: Engine Lift Brackets And Fastener
 Courtesy of GENERAL MOTORS COMPANY

14. Install the J-36857 Engine Lift Bracket (2) and fastener (1) into the engine block.

NOTE: Support the engine as necessary from underneath while repositioning the engine support fixture.

15. Reposition the engine support fixture lift hook from the engine lift bracket (3) to the **J-36857** Engine Lift Bracket (2)

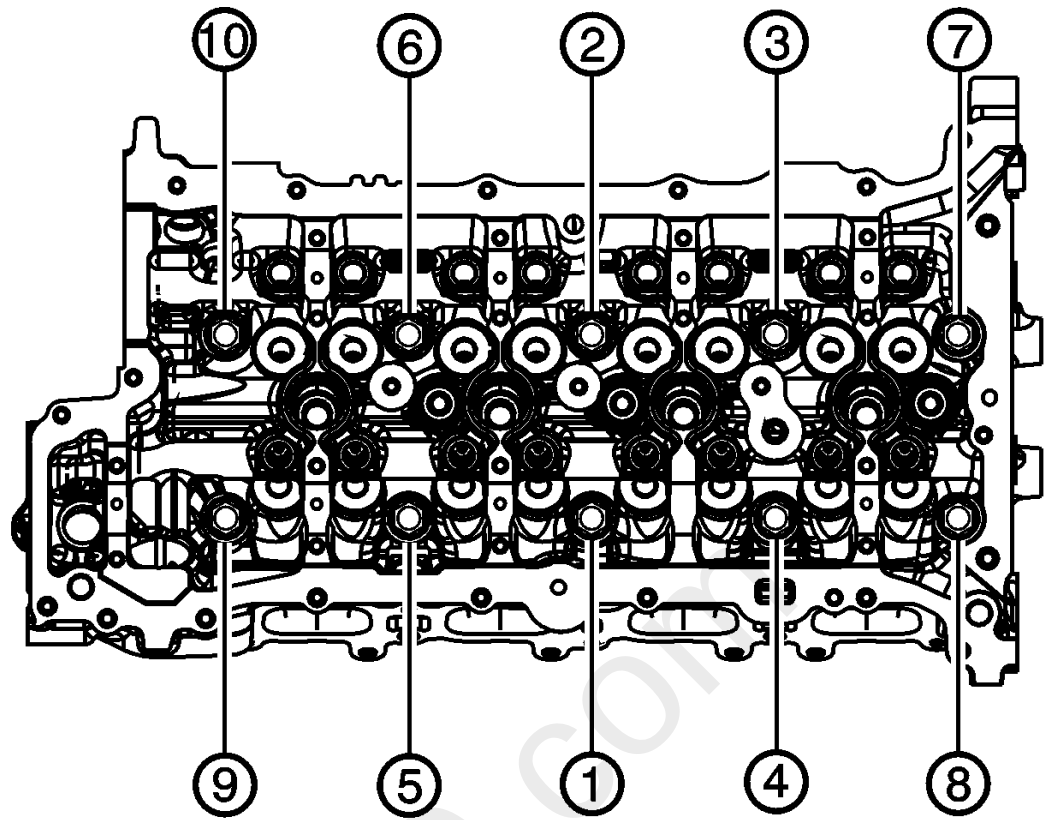


Fig. 190: Cylinder Head Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

16. Remove the cylinder head to the block bolts in sequence.
Discard the bolts.

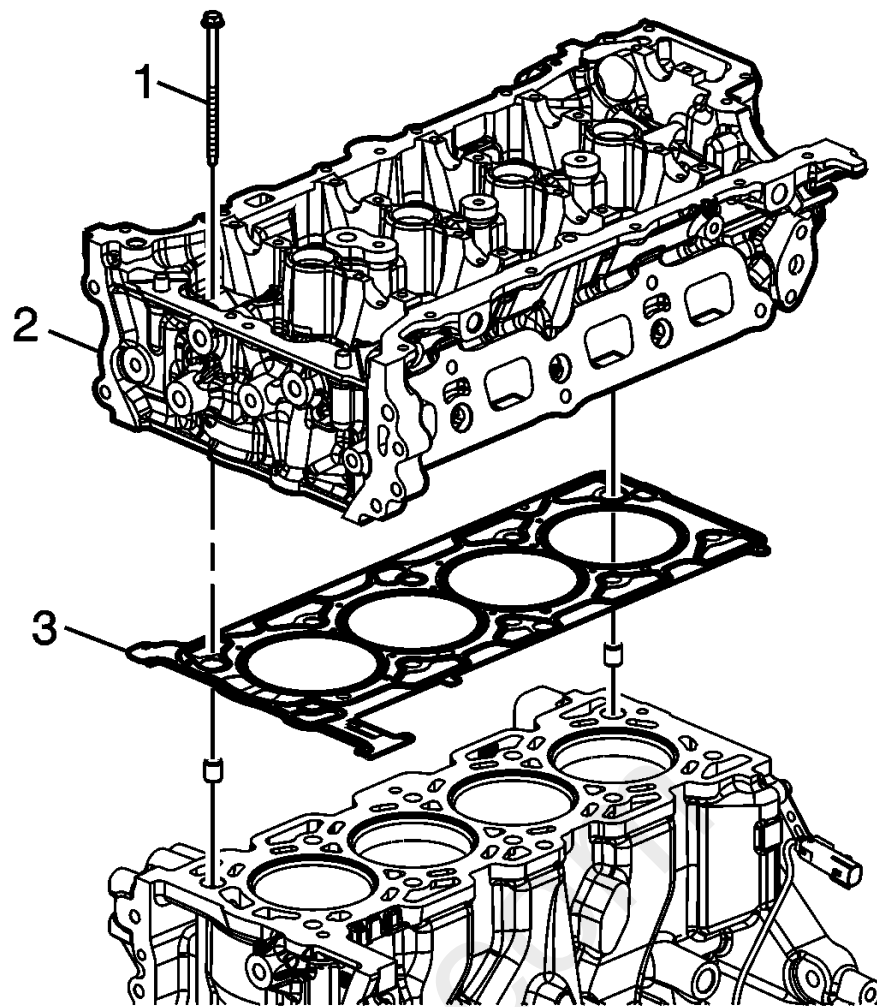


Fig. 191: Cylinder Head Bolts

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.

17. Disconnect ground wire.
18. Remove the cylinder head (2).
19. Remove the cylinder head gasket (3).
20. Clean all of the gasket surfaces.
21. Use the following procedures when cleaning the cylinder head and cylinder 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.
 - Use a gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.
 - Do not use any other method or technique to clean these gasket surfaces.

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

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

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

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

25. Remove any broken long cylinder head bolts using the EN 38188 kit.
26. If replacing the cylinder head, remove the fuel injection fuel rail and transfer as necessary. [Fuel Injection Fuel Rail Assembly Replacement](#)
27. For cylinder head disassemble. [Cylinder Head Disassemble](#)
28. For cylinder head cleaning and inspection. [Cylinder Head Cleaning and Inspection](#)

Installation Procedure

1. For cylinder head assemble. [Cylinder Head Assemble](#)

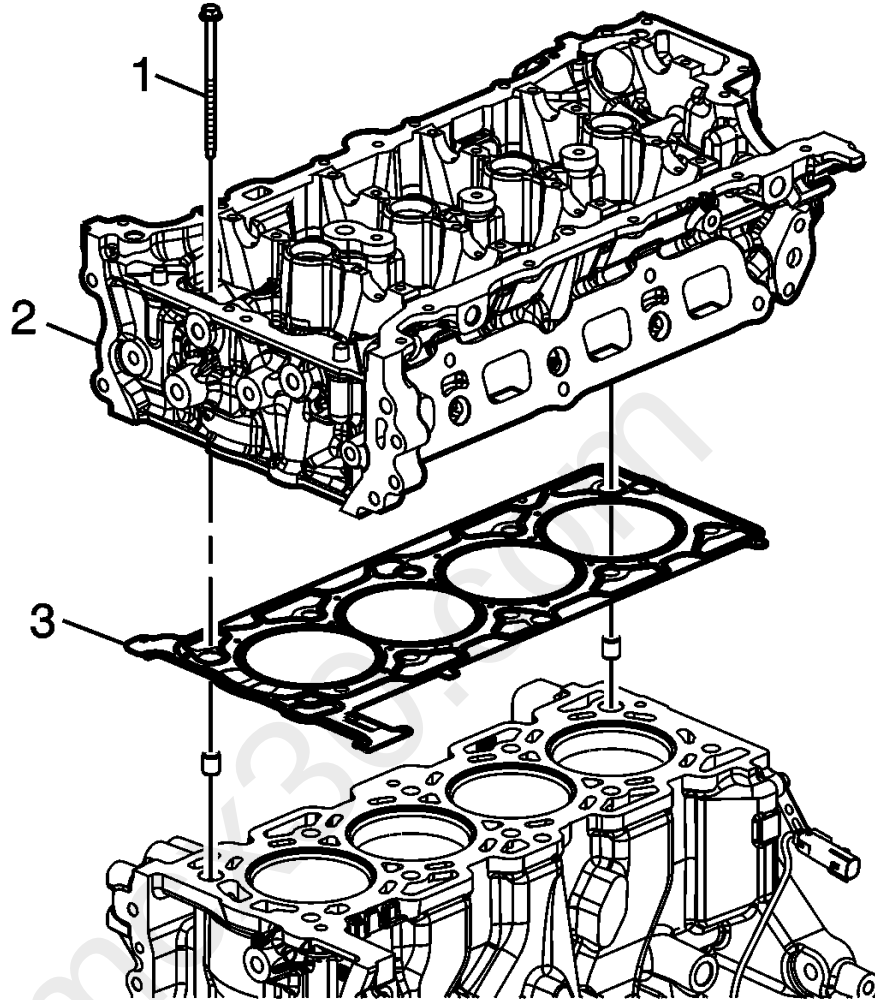


Fig. 192: Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not use any sealing material.

2. Install the cylinder head gasket (3) to the block.
3. Install the cylinder head (2). Ensure the number 1 cylinder is at top dead center (TDC). The key on the crankshaft should be on top in the 12 o'clock position.

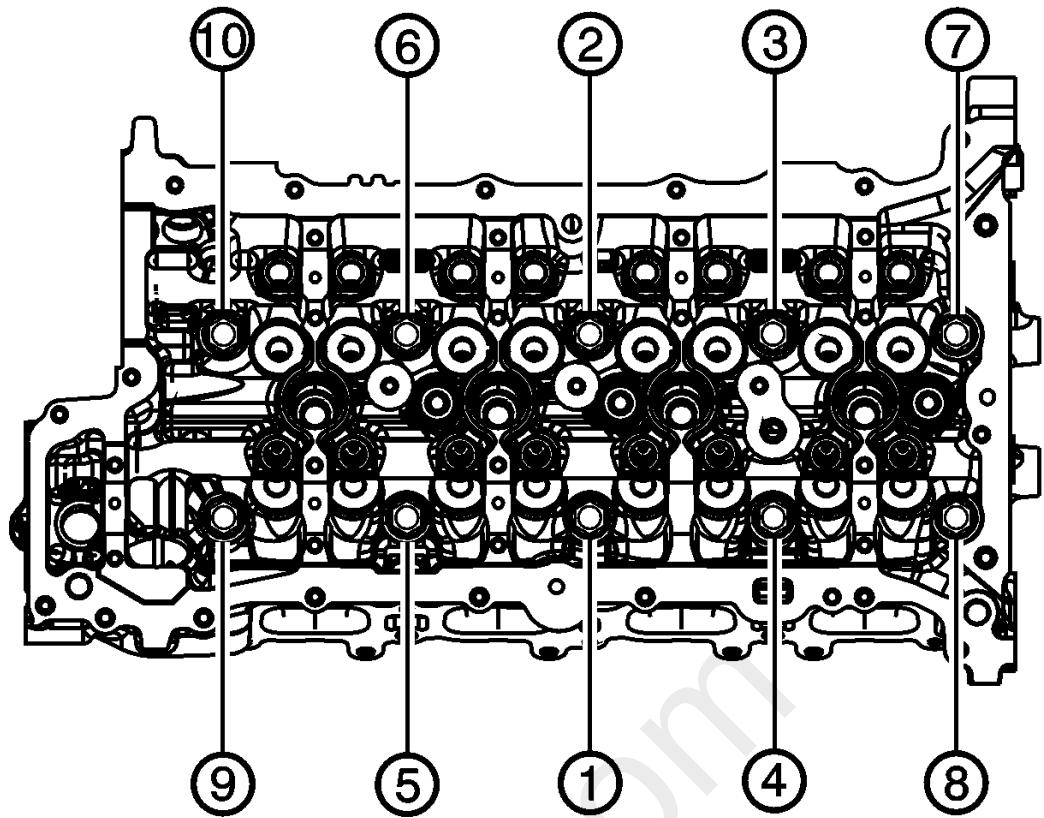


Fig. 193: Cylinder Head Bolt tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

NOTE: Always use NEW cylinder head bolts.

4. Install the cylinder head bolts.
 1. **First Pass:** tighten the bolts in sequence to 30 N.m (22 lb ft).
 2. **Final Pass:** tighten the bolts an additional 190 degrees in sequence using the **EN 45059** meter.

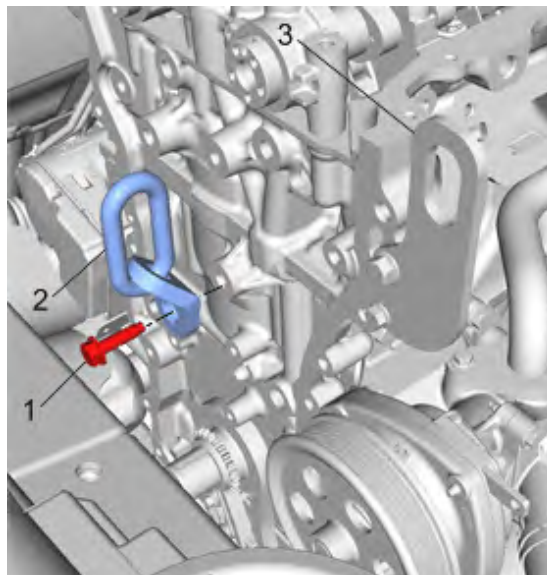


Fig. 194: Engine Lift Brackets And Fastener
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

Support engine as necessary from underneath while repositioning the engine support fixture. [Engine Support Fixture](#)

5. Reposition the engine support fixture lift hook from the **J-36857** Engine Lift Bracket (2) to the engine lift bracket (3).
6. Remove the **J-36857** Engine Lift Bracket (2) and fastener (1) from the engine block.
7. Install Thermostat Bypass Pipe - [Thermostat Bypass Pipe Replacement \(LTG\)](#)

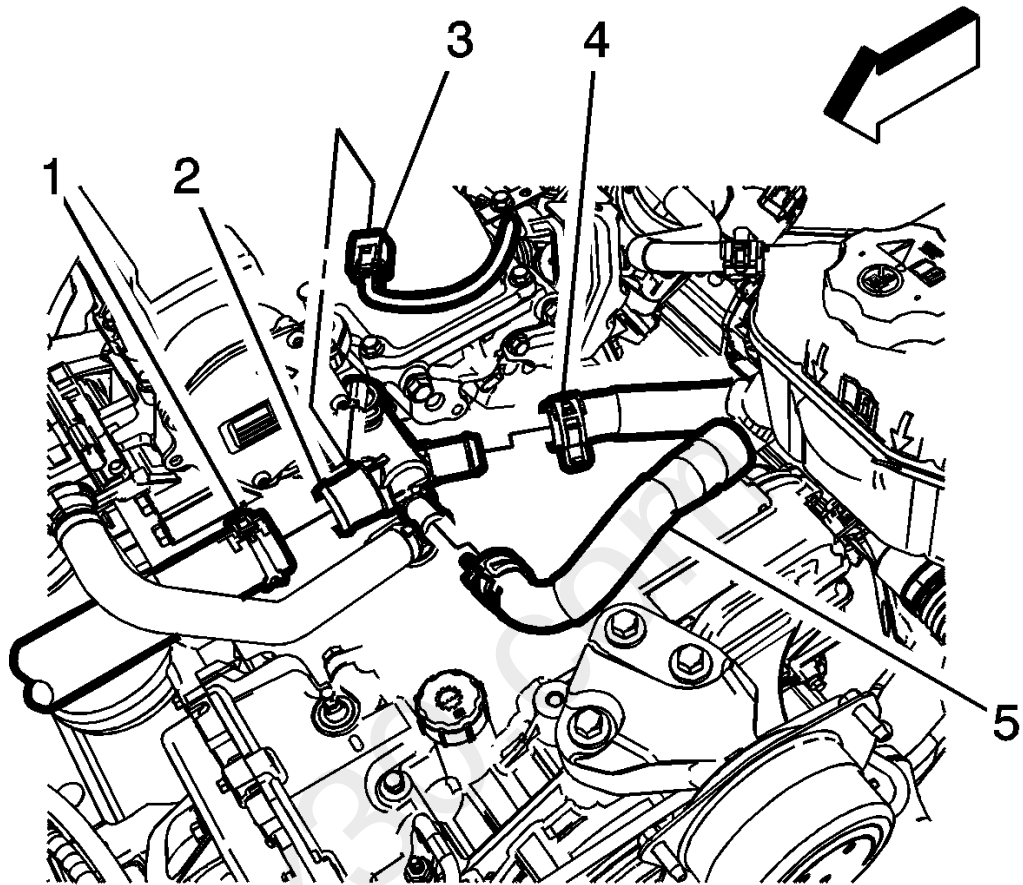


Fig. 195: Engine Coolant Temperature (ECT) Sensor Connector
Courtesy of GENERAL MOTORS COMPANY

8. Reconnect ground wire.
9. Connect the hoses at the water outlet. [Water Outlet Replacement \(LTG\)](#)
10. Install ground wire.
11. Connect the exhaust camshaft position sensor. [Camshaft Position Sensor Replacement - Exhaust](#)
12. Connect the intake camshaft position sensor. [Camshaft Position Sensor Replacement - Intake](#)
13. Install the intake and exhaust camshaft, bearing cap and lash adjuster. [Intake and Exhaust Camshaft, Bearing Cap, and Lash Adjuster Removal](#)
14. Install the timing chain and tensioner. [Camshaft Timing Chain and Tensioner Replacement](#)

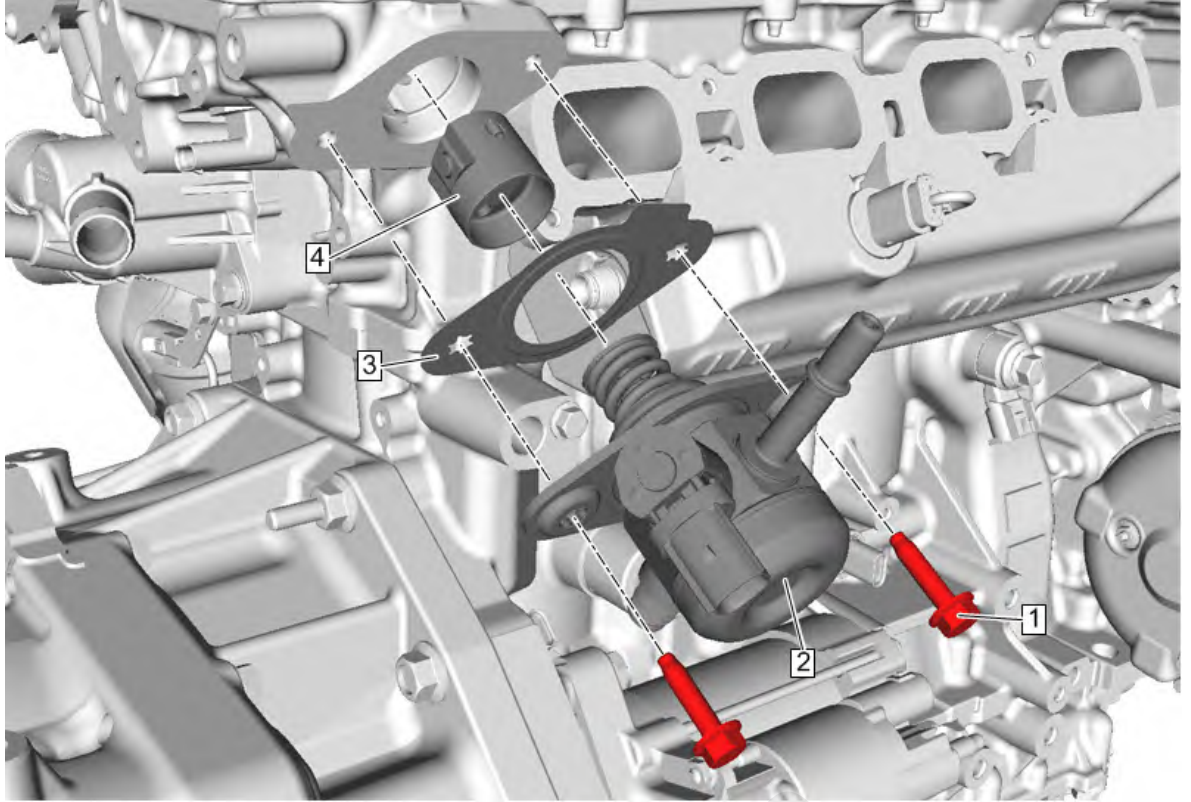
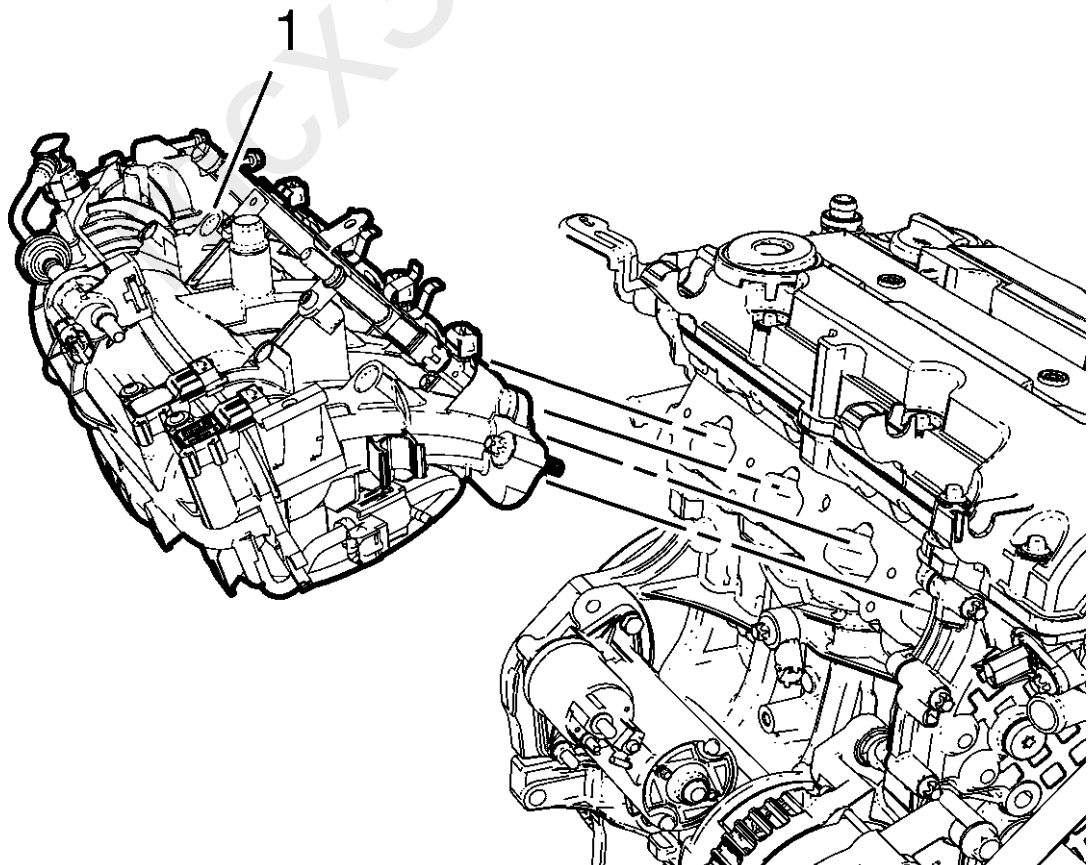


Fig. 196: Fuel Pump

Courtesy of GENERAL MOTORS COMPANY

15. Install the fuel pump. (2) [Fuel Pump Replacement](#)
16. Install the engine front cover. [Engine Front Cover Replacement](#)
17. Install the exhaust manifold. [Exhaust Manifold Replacement \(LTG\)](#)



18. Install the intake manifold. [Intake Manifold Replacement](#)
19. Install the camshaft cover. [Camshaft Cover Replacement \(1st Design Tamper-Proof PCV System\)](#)
20. Refill the engine with NEW oil. [Engine Oil and Oil Filter Replacement](#)
21. Refill the coolant system. [Cooling System Draining and Filling \(GE 47716\)](#) [Cooling System Draining and Filling \(Static\)](#)

OIL PAN COVER REPLACEMENT

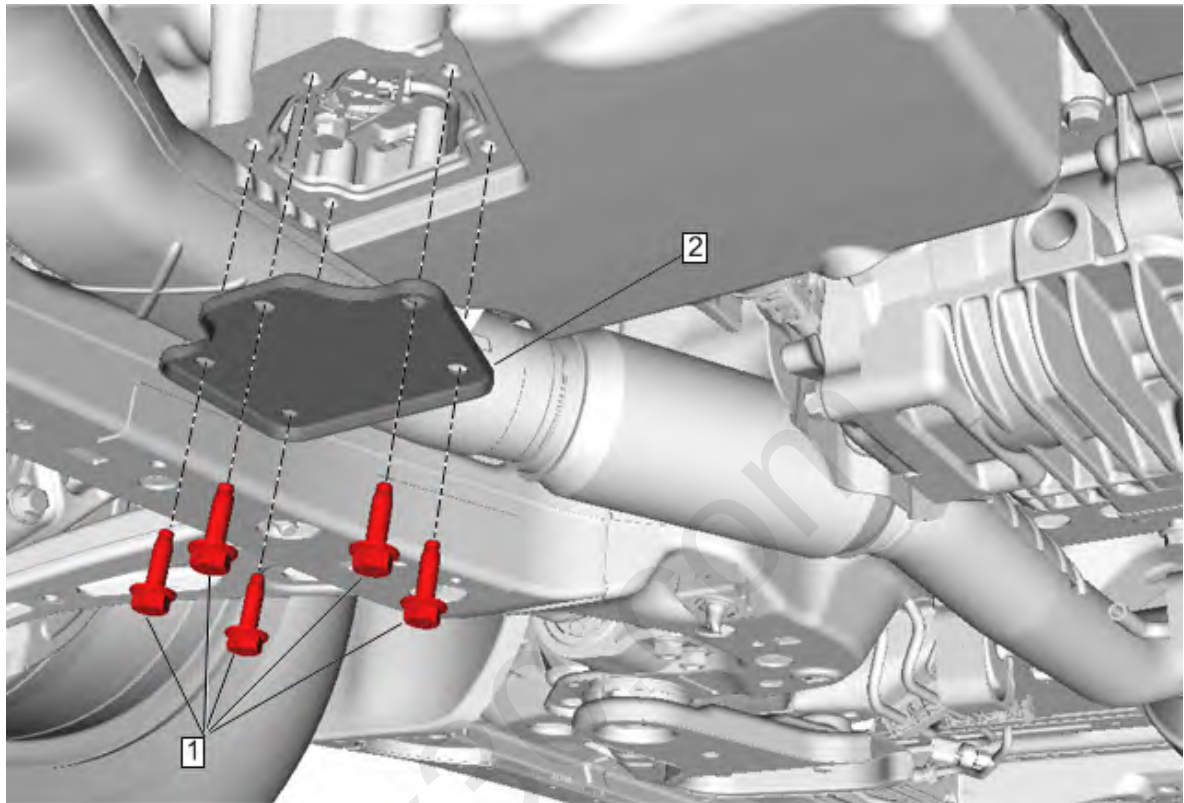


Fig. 198: Lower Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Procedure Engine Oil and Oil Filter Replacement	
1	Oil Pan Fastener [5x] CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)
2	Lower Oil Pan Procedure Apply a 2.25 mm bead of sealer on the level part of the flange around the perimeter of the lower oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. NOTE: • The lower crankcase surface must be free of contamination prior to applying the sealer. • The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

OIL PAN REPLACEMENT (AWD)

Removal Procedure

1. Drain the engine oil and remove the oil filter. Refer to [Engine Oil and Oil Filter Replacement](#).
2. Support the engine. Refer to [Engine Support Fixture](#).
3. Remove [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#).
4. Remove [Oil Pump Flow Control Valve Heat Shield Replacement](#)
5. Remove the front engine cover (1). Refer to [Engine Front Cover Replacement](#).
6. Remove the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LTG\)](#).

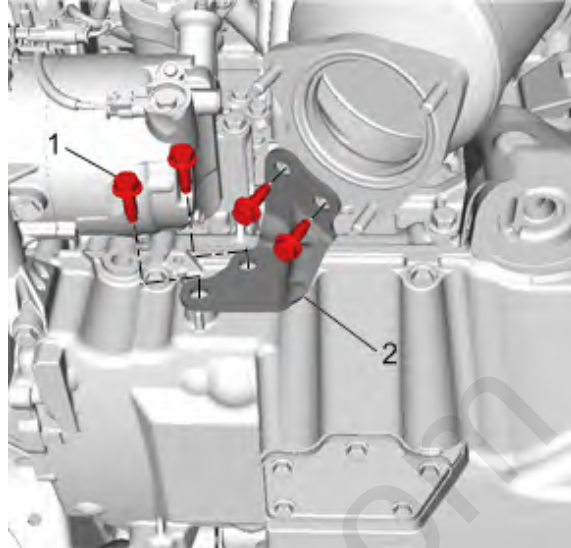


Fig. 199: Catalytic Lower Brace And Fasteners
Courtesy of GENERAL MOTORS COMPANY

7. Remove the catalytic converter to oil pan brace fasteners (1).
8. Remove the catalytic lower brace (2).

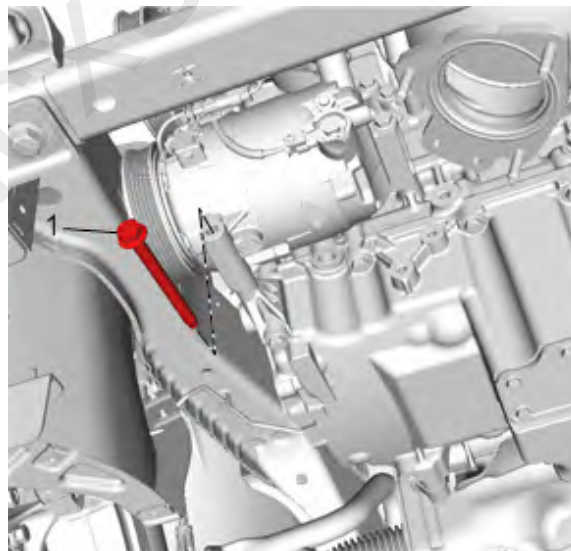


Fig. 200: Compressor Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Remove the bolt (1)

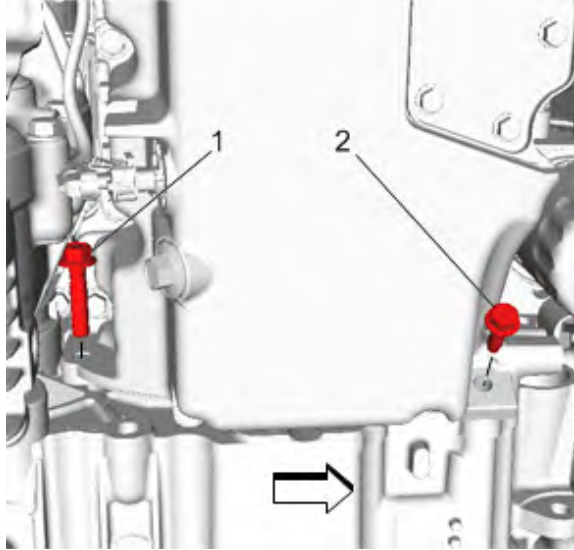


Fig. 201: Oil Pan To Transmission Fasteners
Courtesy of GENERAL MOTORS COMPANY

10. Remove the oil pan to transmission bolts (1, 2)

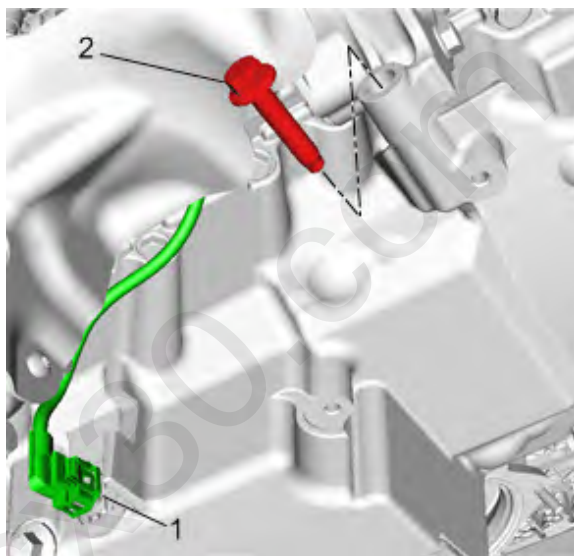


Fig. 202: Electrical Connector And Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Disconnect the electrical connector (1)
12. Remove the bolt (2)

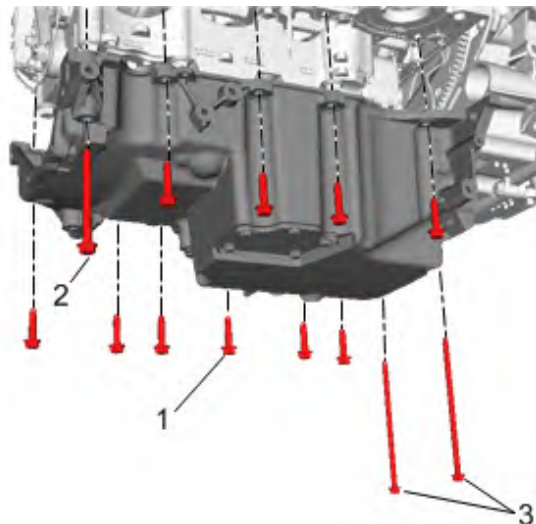


Fig. 203: Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

13. Remove the long oil pan bolts (3), medium bolt (2) and short bolts (1), then remove the oil pan.
14. For part transfer, cleaning and inspection, refer to [Oil Pan Cleaning and Inspection](#).

Installation Procedure

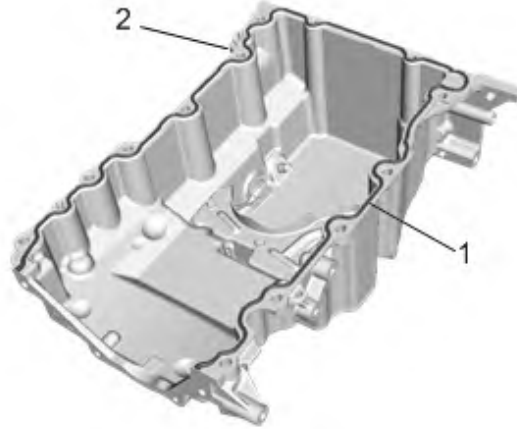


Fig. 204: Applying Sealer

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 10 minutes of applying the sealer.
- The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.

1. Apply a 4.25 mm bead of sealer (1) on the level part of the flange around the perimeter of the oil pan (2) as shown. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

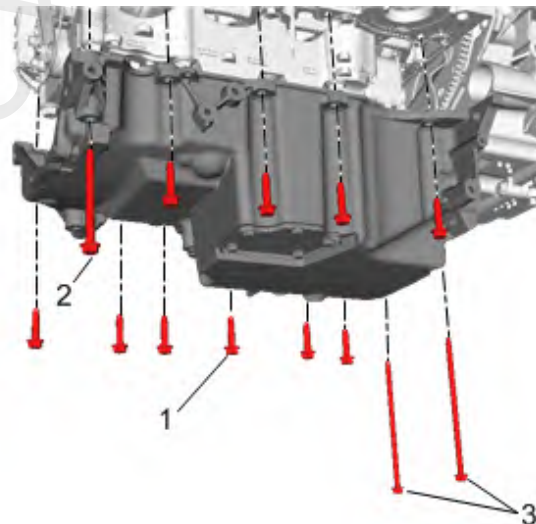


Fig. 205: Oil Pan Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE:

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

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

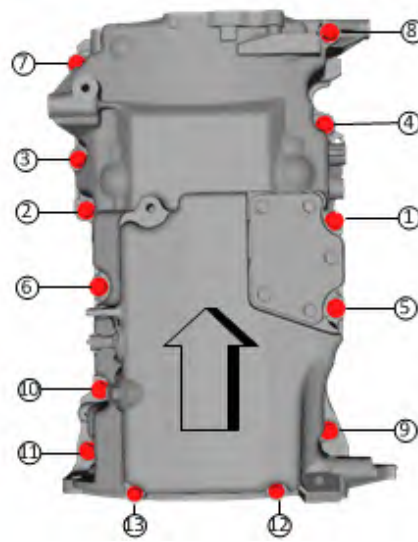


Fig. 206: Oil Pan Bolt tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

3. tighten the oil pan bolts in sequence to final torque twice using the following procedure:
 1. tighten bolts in sequence 1 - 11 to 25 N.m (18 lb ft).
 2. tighten bolts in sequence 12 - 13 to 10 N.m (89 lb in).

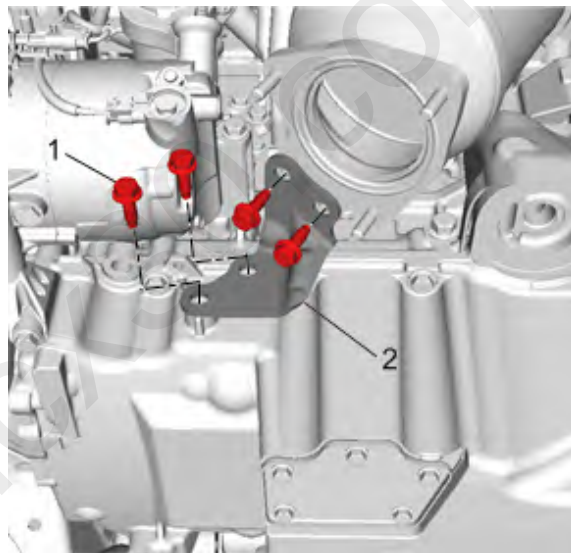


Fig. 207: Catalytic Lower Brace And Fasteners
 Courtesy of GENERAL MOTORS COMPANY

4. Install the catalytic converter lower brace (2).
5. Install the catalytic converter to oil pan brace fasteners (1). tighten 25 N.m (18 lb ft)

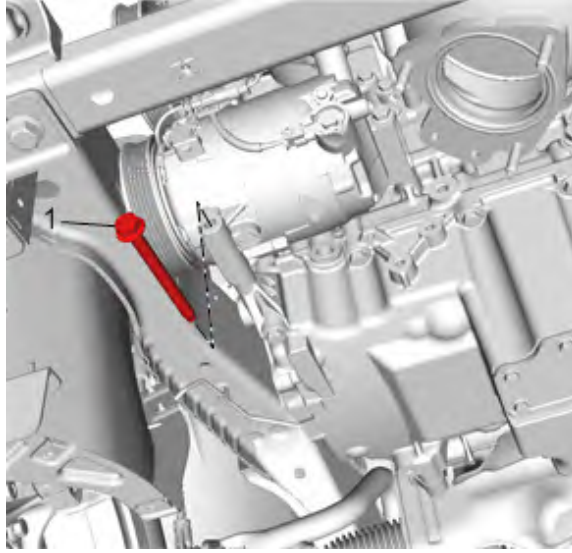


Fig. 208: Compressor Bolt

Courtesy of GENERAL MOTORS COMPANY

6. Install the compressor bolt (1). tighten 22 N.m (16 lb ft)

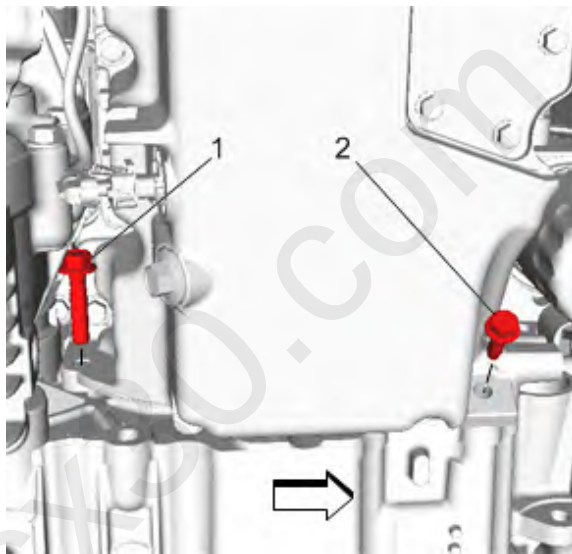


Fig. 209: Oil Pan To Transmission Fasteners

Courtesy of GENERAL MOTORS COMPANY

7. Install the oil pan to transmission fasteners. tighten 25 N.m (18 lb ft)

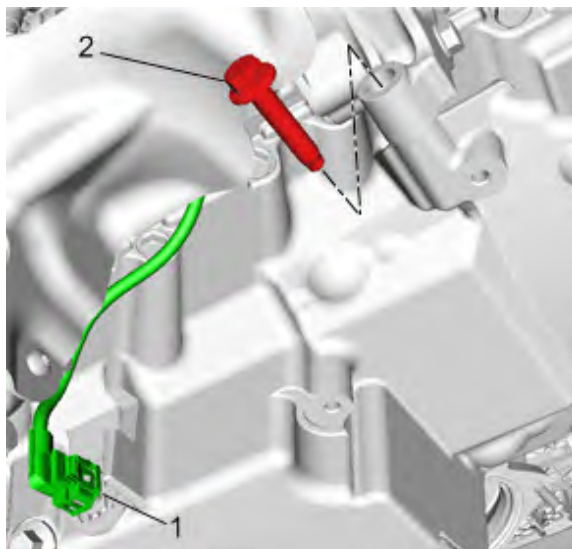


Fig. 210: Electrical Connector And Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Connect the electrical connector (1)

9. Install the bolt (2) tighten 58 N.m (43 lb ft)
10. Install [Oil Pump Flow Control Valve Heat Shield Replacement](#)
11. Install the exhaust front pipe. Refer to [Exhaust Front Pipe Replacement \(LTG\)](#) .
12. Install the front engine cover (1). Refer to [Engine Front Cover Replacement](#).
13. Install [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)
14. Remove the engine support fixture. Refer to [Engine Support Fixture](#).
15. Refill the engine oil and install a NEW oil filter. Refer to [Engine Oil and Oil Filter Replacement](#).

OIL PAN REPLACEMENT (FWD)

Removal Procedure

1. Drain the engine oil and remove the oil filter. [Engine Oil and Oil Filter Replacement](#)
2. Remove Drivetrain and Front Suspension Cradle - [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#)
3. Remove Oil Pump Flow Control Valve Heat Shield - [Oil Pump Flow Control Valve Heat Shield Replacement](#)
4. Remove Engine Front Cover - [Engine Front Cover Replacement](#)

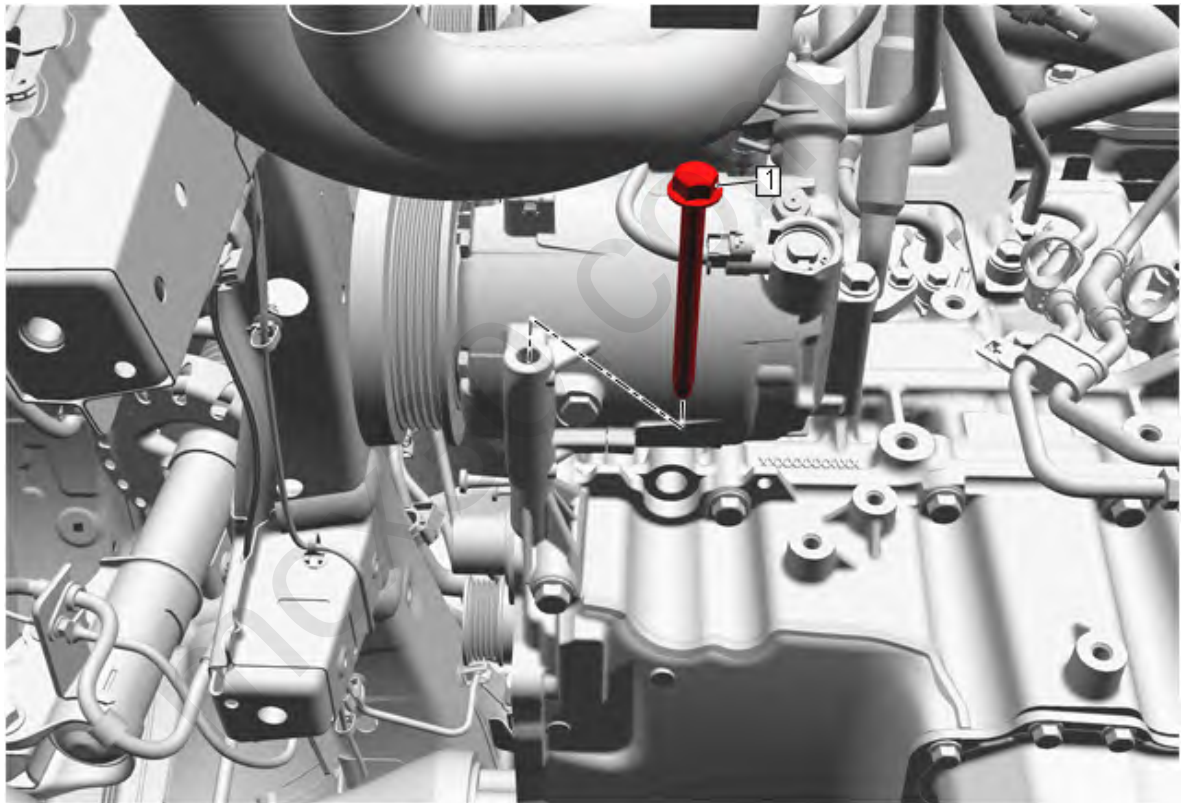


Fig. 211: Air Conditioning Compressor Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Remove Air Conditioning Compressor Bolt (1)

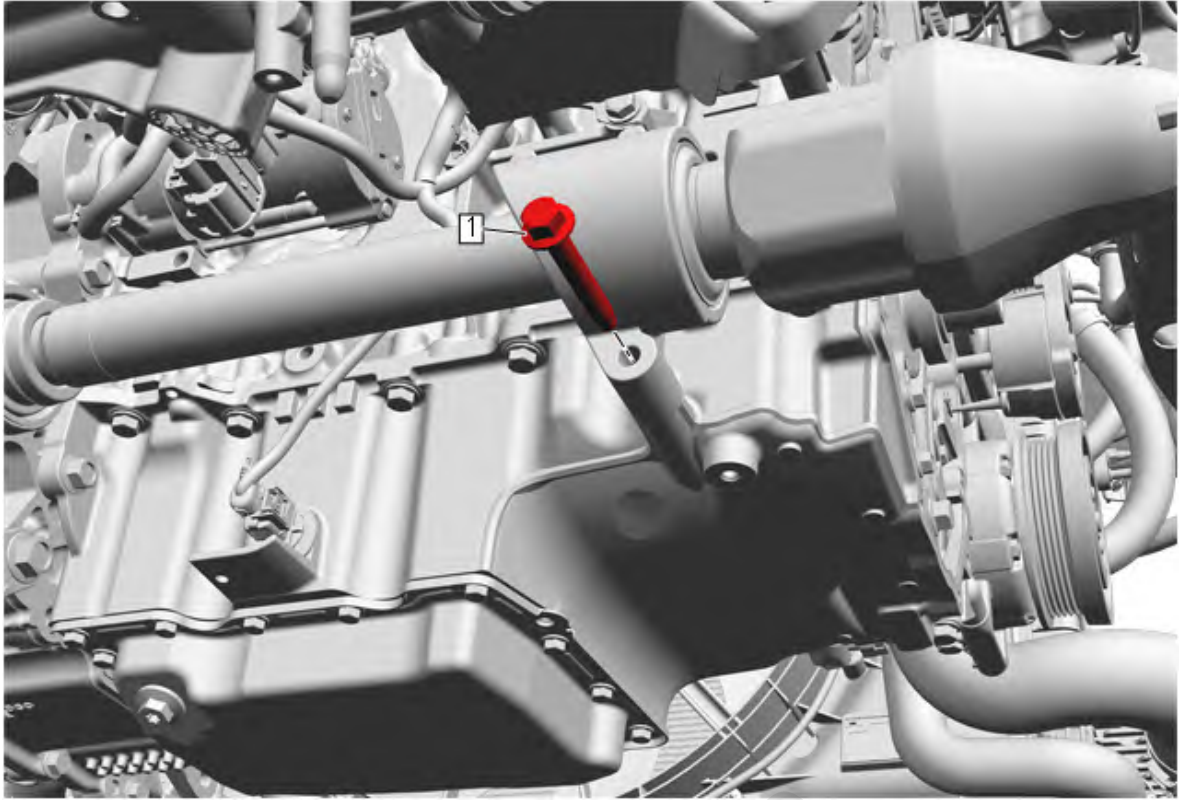


Fig. 212: Front Wheel Drive Intermediate Shaft Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove Front Wheel Drive Intermediate Shaft Bracket Bolt (1)

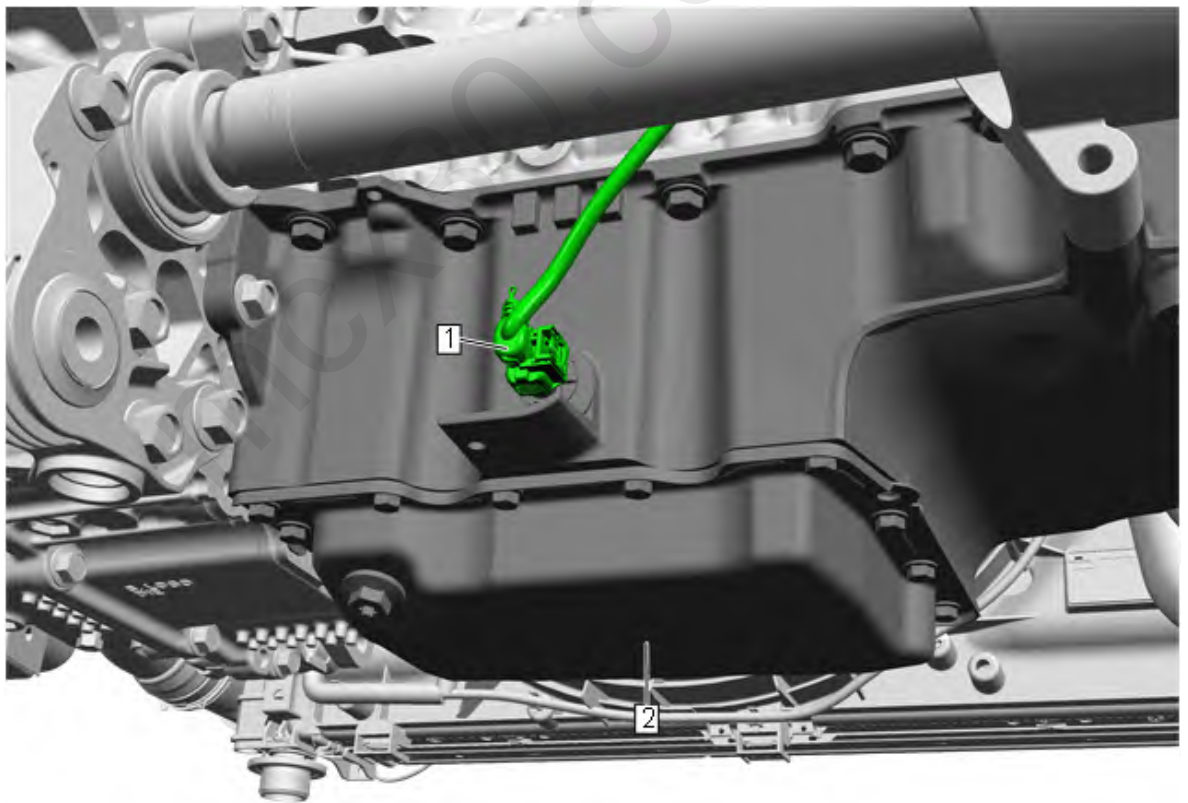


Fig. 213: Electrical Connector And Oil Pan
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect Electrical Connector (1) @ Oil Pan (2)

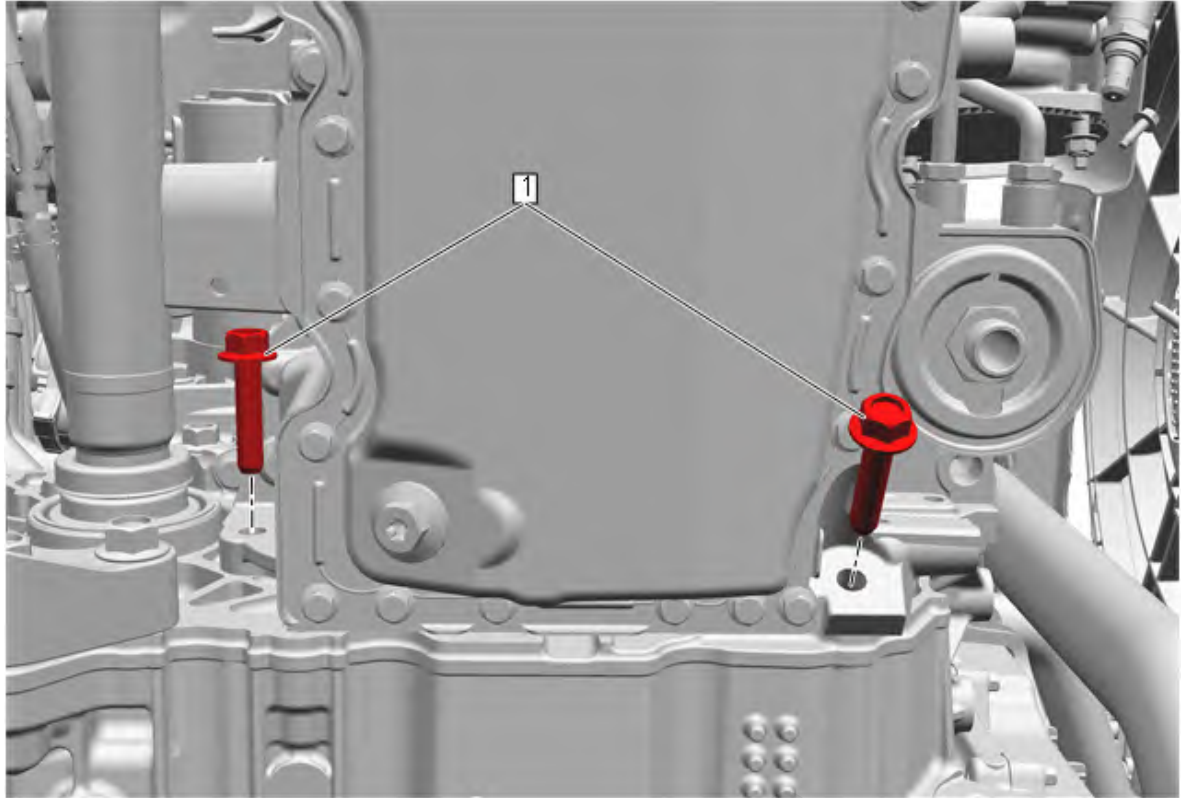


Fig. 214: Transmission Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Remove Transmission Bolt (1)

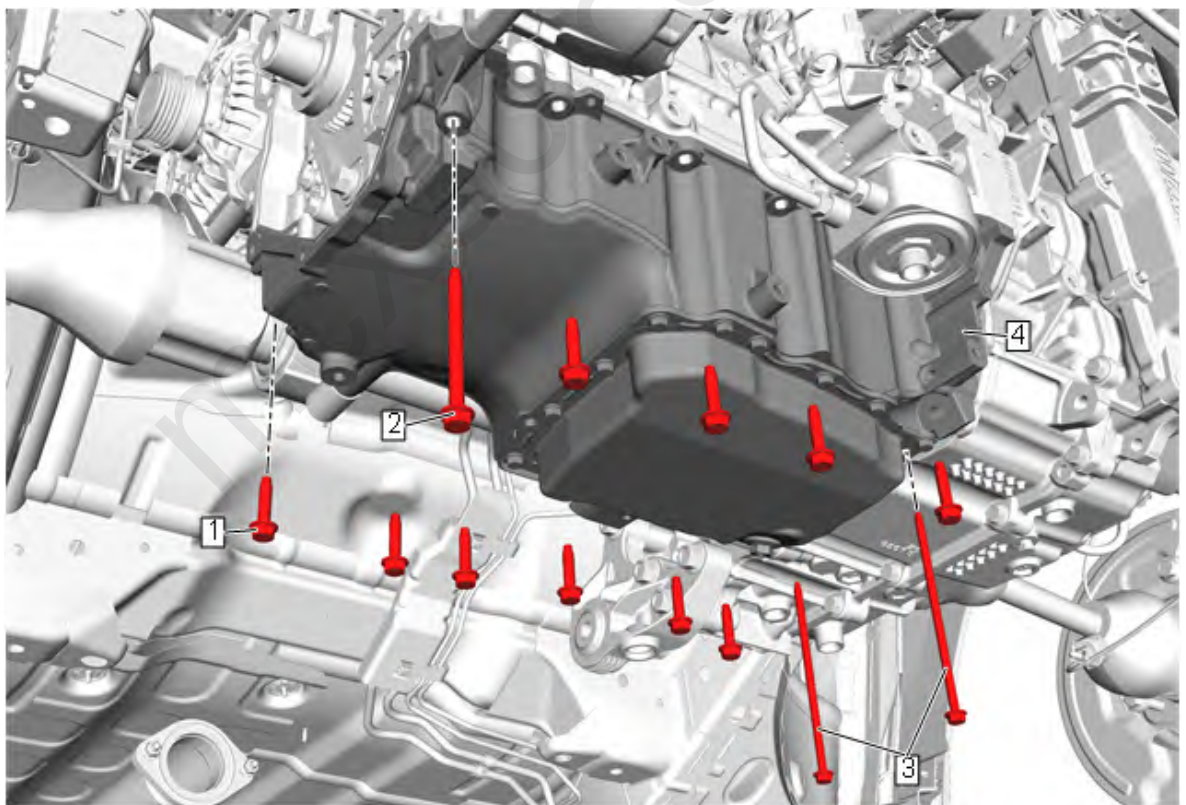


Fig. 215: Oil Pan Bolt And Bolt

Courtesy of GENERAL MOTORS COMPANY

9. Remove Oil Pan Bolt.
10. Remove Oil Pan Bolt.
11. Remove Oil Pan Bolt.
12. Remove Oil Pan.
13. For part transfer, and cleaning and inspection, refer to [Oil Pan Cleaning and Inspection](#).

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)

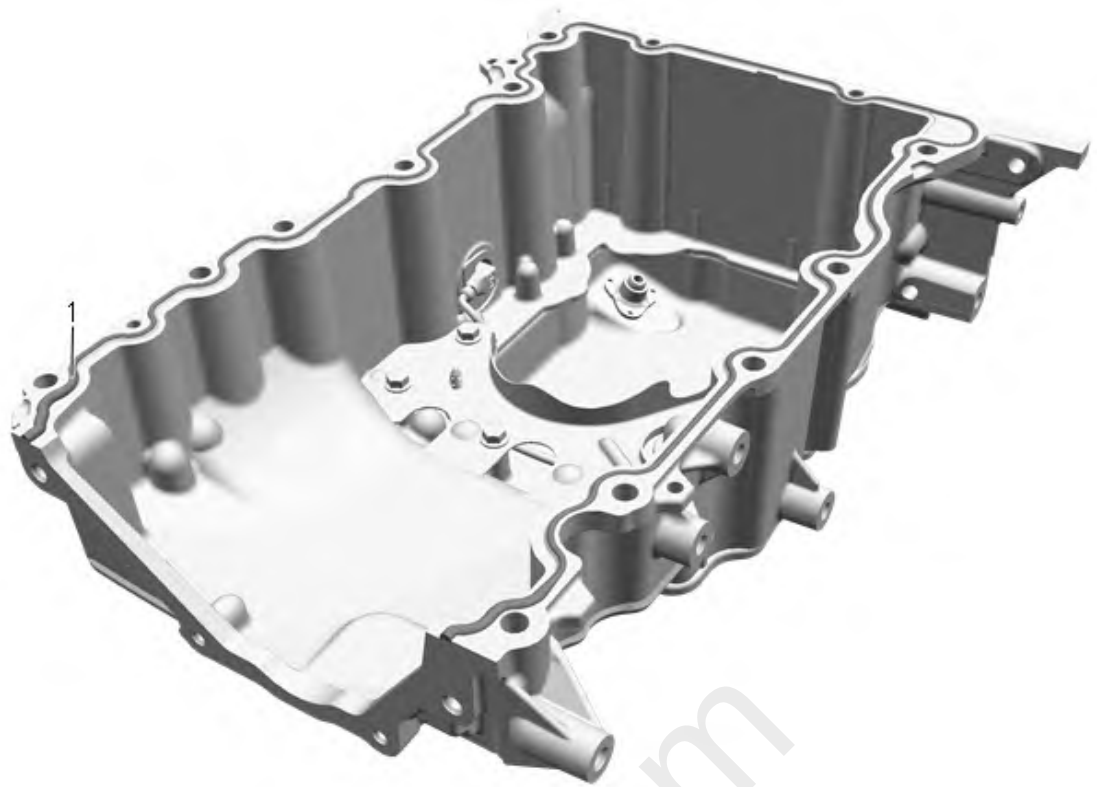
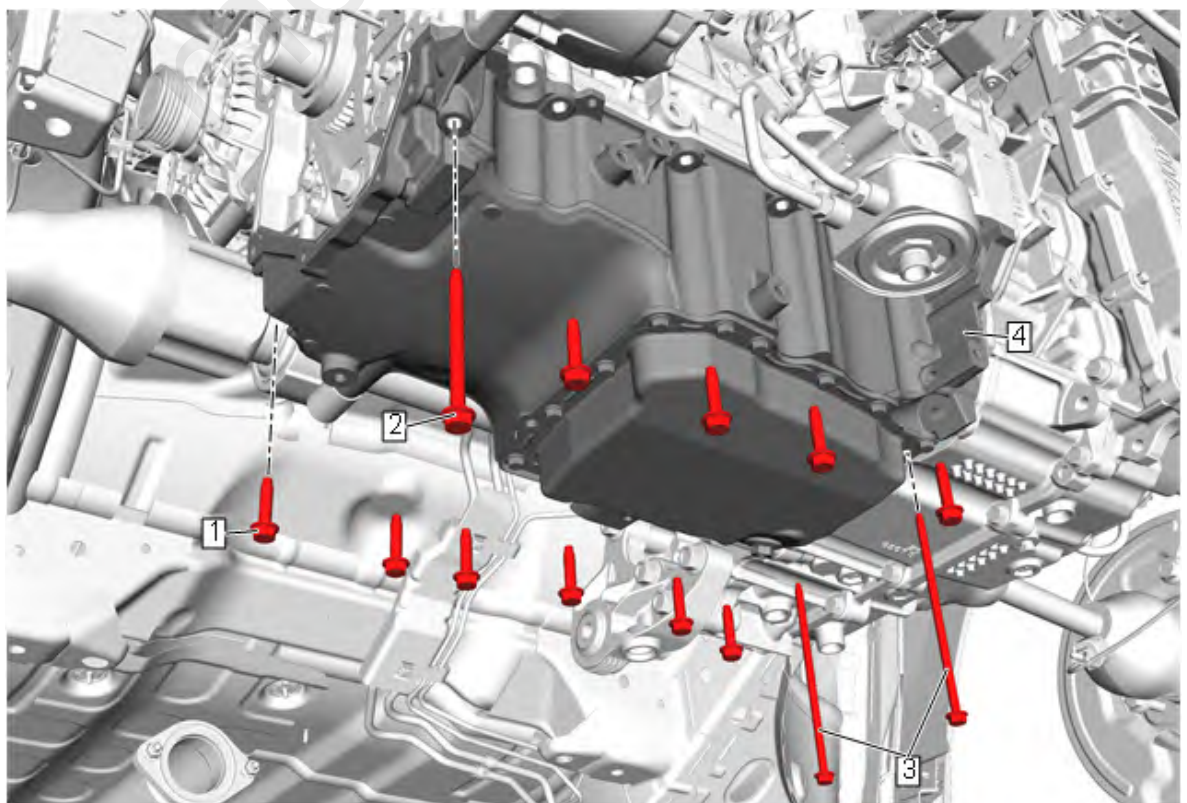


Fig. 216: Apply 4.25 mm Bead Of Sealer Around Perimeter Of Oil Pan
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The lower crankcase surface must be free of contamination prior to applying the sealer.
- Install and align the oil pan to block within 20 minutes of applying the sealer.

2. Apply a 4.25 mm bead of sealer (1) on the level part of the flange around the perimeter of the oil pan as shown. [Adhesives, Fluids, Lubricants, and Sealers](#)



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

3. Install Oil Pan (4)
4. Install Oil Pan Bolt (3) and hand tighten
5. Install Oil Pan Bolt a (2) nd hand tighten
6. Install Oil Pan Bolt (1) and hand tighten
7. tighten the oil pan bolts in sequence. [Oil Pan Installation \(FWD\)](#)

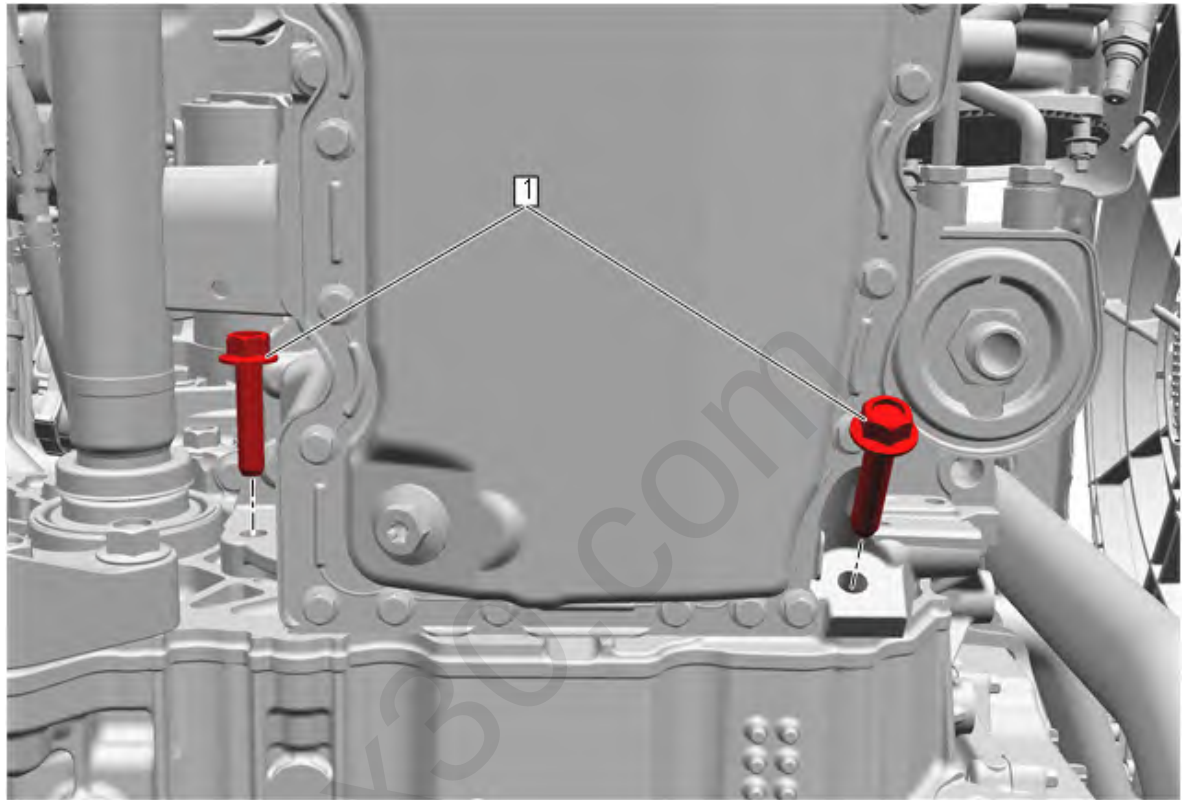


Fig. 218: Transmission Bolt

Courtesy of GENERAL MOTORS COMPANY

8. Install Transmission Bolt (1) - [Transmission Replacement \(Front Wheel Drive\)](#)

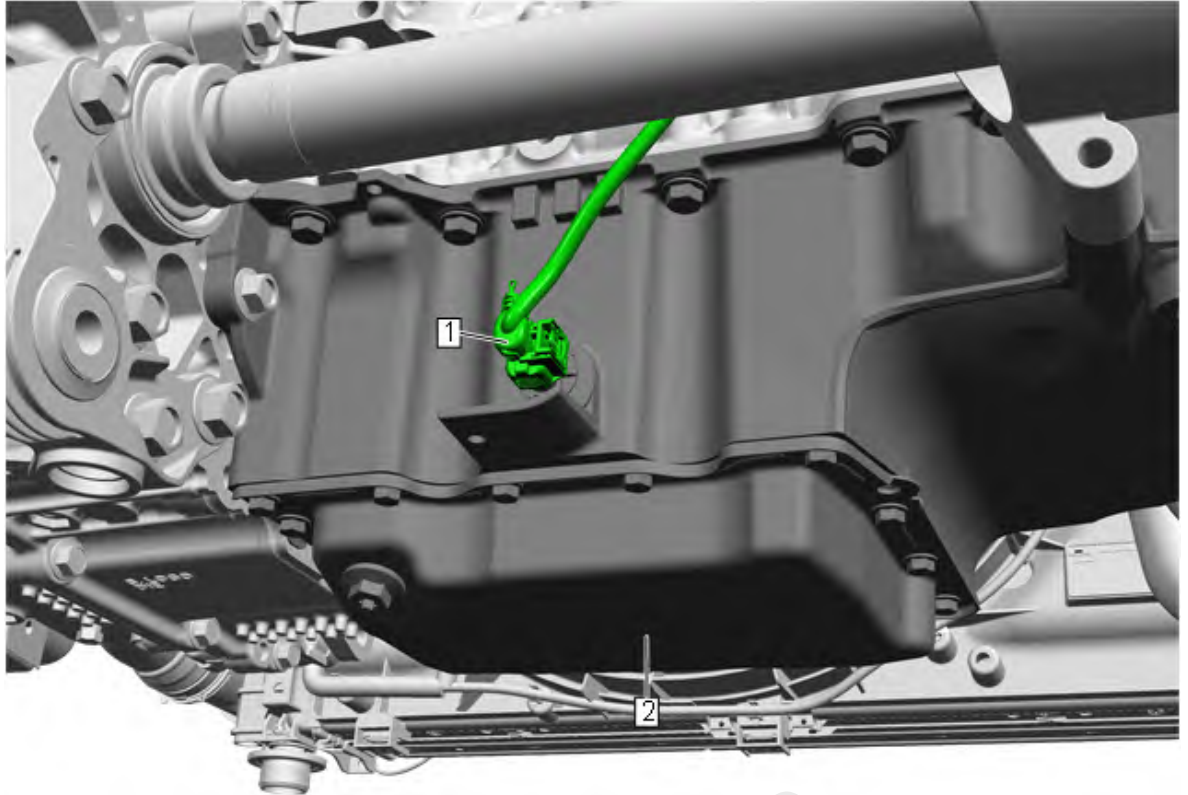


Fig. 219: Electrical Connector And Oil Pan
Courtesy of GENERAL MOTORS COMPANY

9. Connect Electrical Connector (1) @ Oil Pan (2)

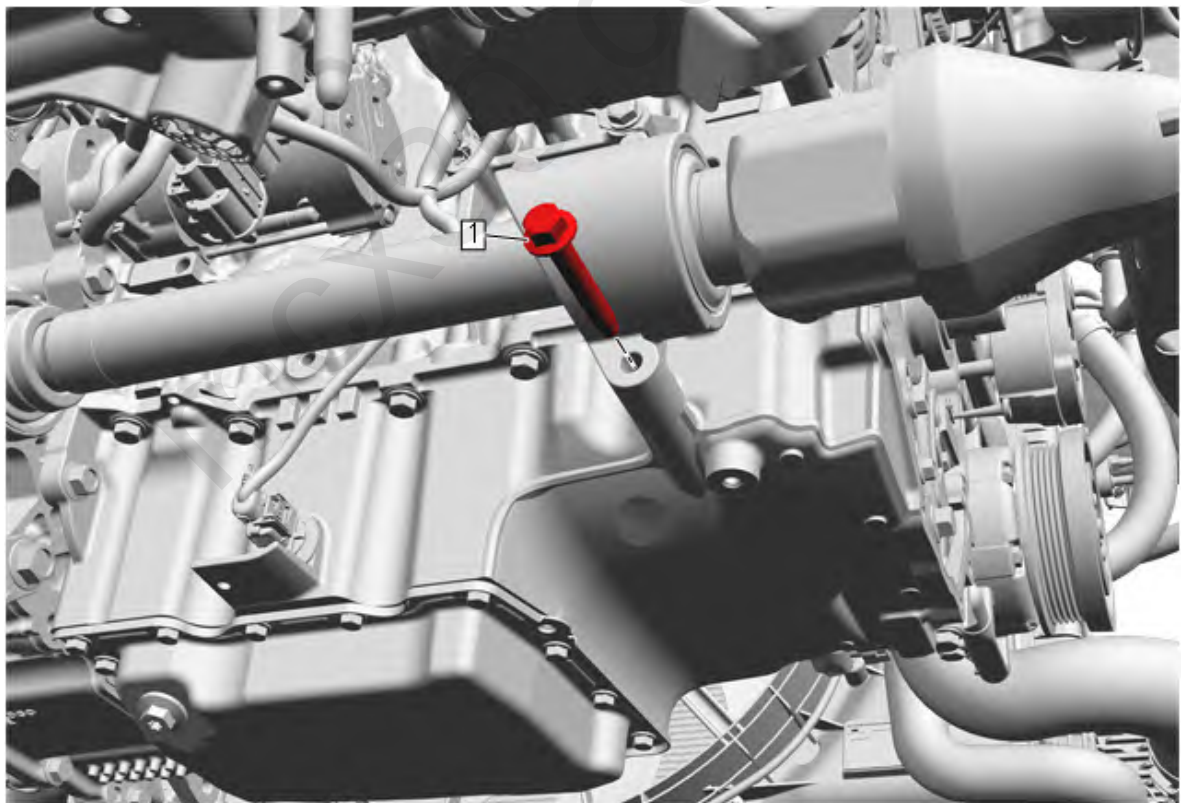


Fig. 220: Front Wheel Drive Intermediate Shaft Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Install Front Wheel Drive Intermediate Shaft Bracket Bolt (1) - **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)**

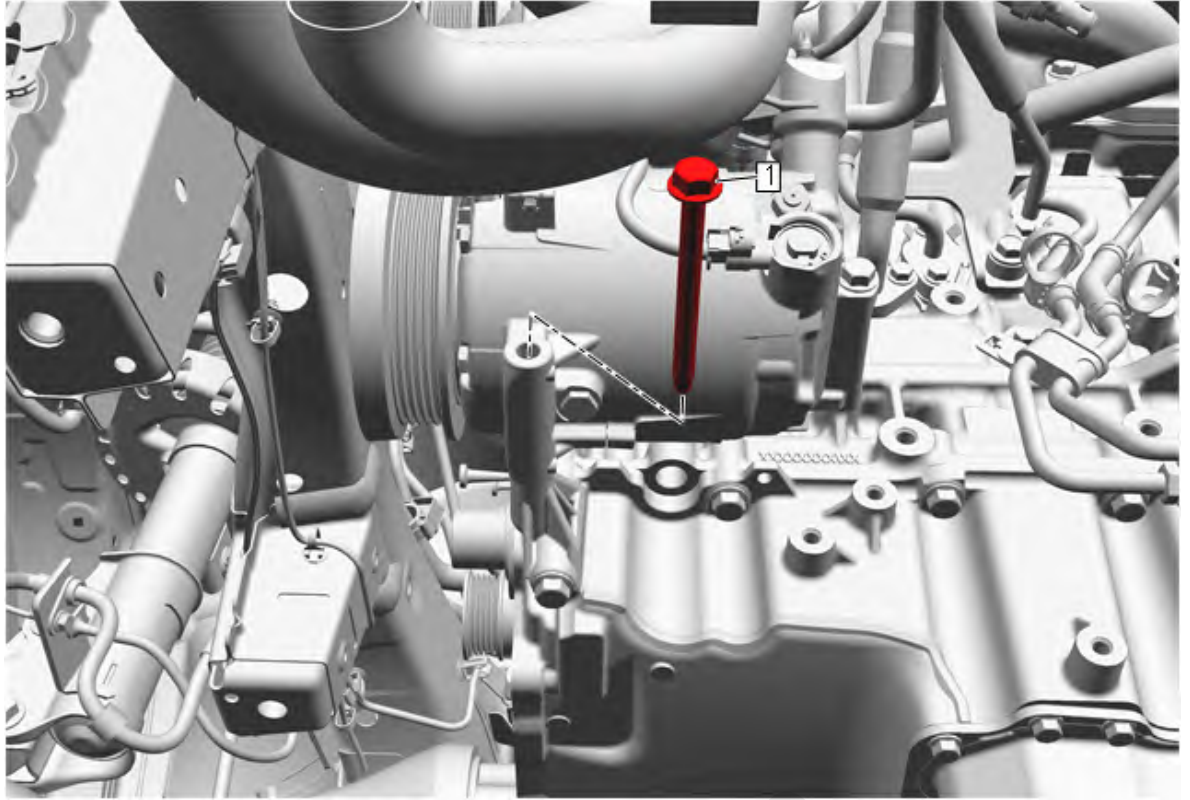


Fig. 221: Air Conditioning Compressor Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Install Air Conditioning Compressor Bolt (1) - [Air Conditioning Compressor Replacement \(LTG\)](#)
12. Install Engine Front Cover - [Engine Front Cover Replacement](#)
13. Install Oil Pump Flow Control Valve Heat Shield - [Oil Pump Flow Control Valve Heat Shield Replacement](#)
14. Install Drivetrain and Front Suspension Cradle - [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#)
15. Fill the engine oil to the proper level with NEW engine oil. [Engine Oil and Oil Filter Replacement](#)

LOWER OIL PAN REPLACEMENT

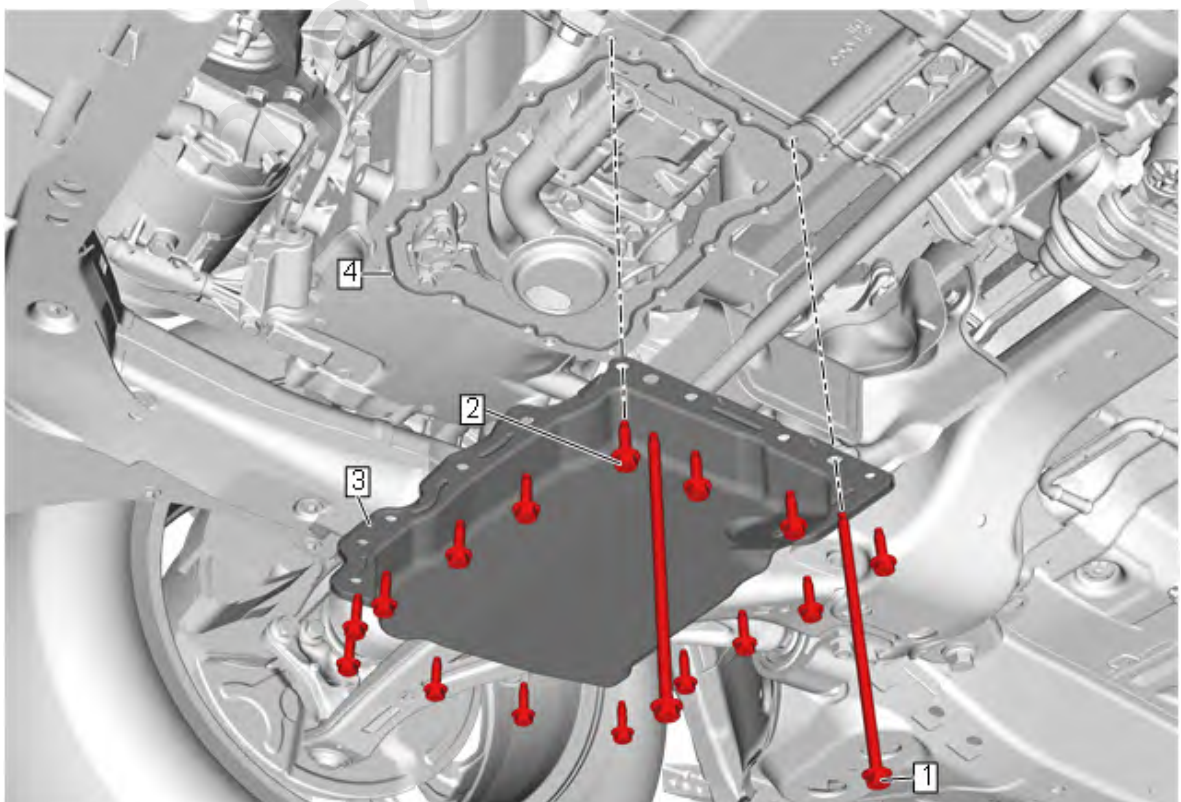


Fig. 222: Lower Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove Exhaust Front Pipe - Exhaust Front Pipe Replacement (LTG). 2. Drain the engine oil. Engine Oil and Oil Filter Replacement	
1	Oil Pan Bolt CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)
2	Oil Pan Bolt tighten 10 N.m (89 lb in)
3	Lower Oil Pan
4	Lower Oil Pan Sealant NOTE: • The lower crankcase surface must be free of contamination prior to applying the sealer. • Install and align the oil pans within 20 minutes of applying the sealer. • Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant Apply a bead of RTV sealant to the perimeter of the lower oil pan. Adhesives, Fluids, Lubricants, and Sealers

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT (AWD)

Removal Procedure

1. Remove the oil pan cover. [Oil Pan Cover Replacement](#)

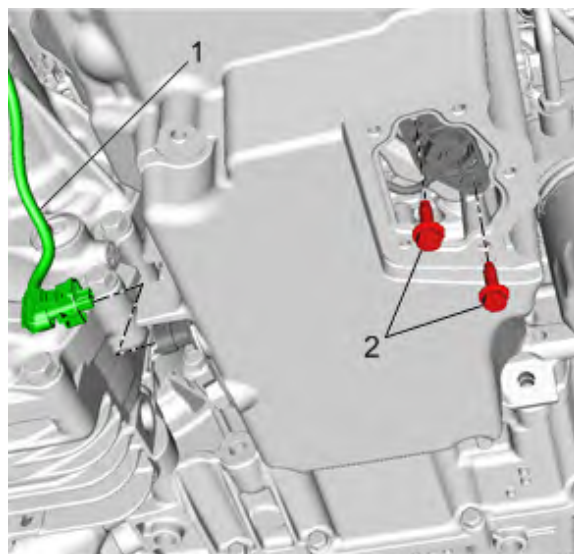


Fig. 223: Oil Level Sensor Connector And Fasteners
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the engine oil level indicator switch electrical connector (1).
3. Remove the 2 engine oil level indicator switch fasteners (2).

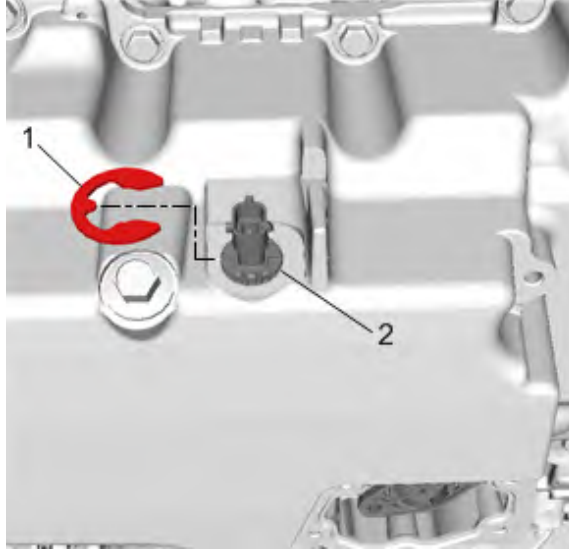


Fig. 224: Engine Oil Level Sensor Connector And C-Clip

Courtesy of GENERAL MOTORS COMPANY

4. Remove the engine oil level indicator switch C-clip (1).

NOTE: Use wire or suitable device to route the indicator switch connector through the oil pan opening.

5. Push the engine oil level indicator switch connector (2) through the oil pan to remove.

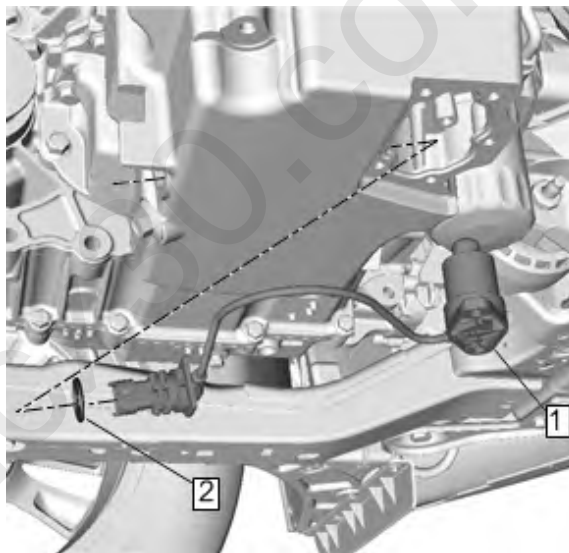


Fig. 225: Engine Oil Level Sensor And O-Ring

Courtesy of GENERAL MOTORS COMPANY

6. Remove the engine oil level indicator switch (1) from the oil pan.

NOTE: This step is necessary only if reusing the old engine oil level indicator switch.

7. Remove Engine Oil Level Indicator Switch O-Ring Seal and DISCARD

Installation Procedure

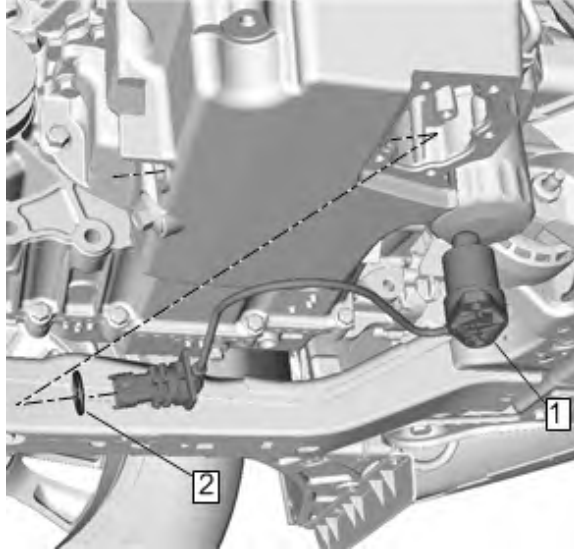


Fig. 226: Engine Oil Level Sensor And O-Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: This step is necessary only if reusing the old engine oil level indicator switch.

1. Install NEW Engine Oil Level Indicator Switch O-Ring Seal.

NOTE:

- Lubricate the O-ring seal with clean engine oil prior to installing the indicator switch. [Adhesives, Fluids, Lubricants, and Sealers](#)
- Use wire or suitable device to route the indicator switch connector through the oil pan opening.
- If reinstalling the indicator switch, replace the O-ring (2).

2. Install the engine oil level indicator switch (1).

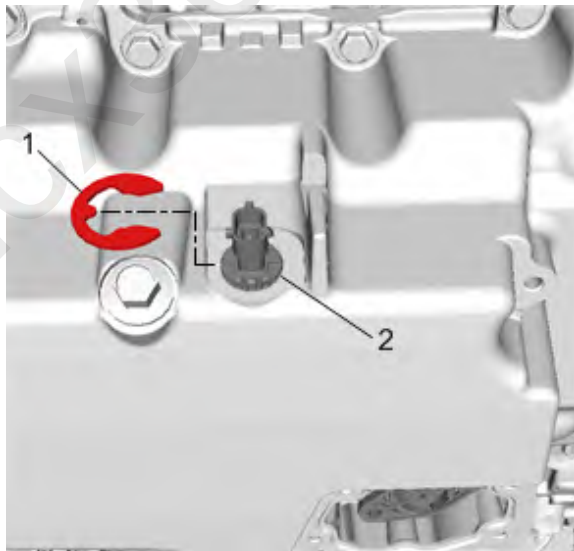


Fig. 227: Engine Oil Level Sensor Connector And C-Clip
Courtesy of GENERAL MOTORS COMPANY

NOTE: Pull the indicator switch connector (2) through the connector opening and ensure that it is properly seated.

3. Install the engine oil level indicator switch C-clip (1).

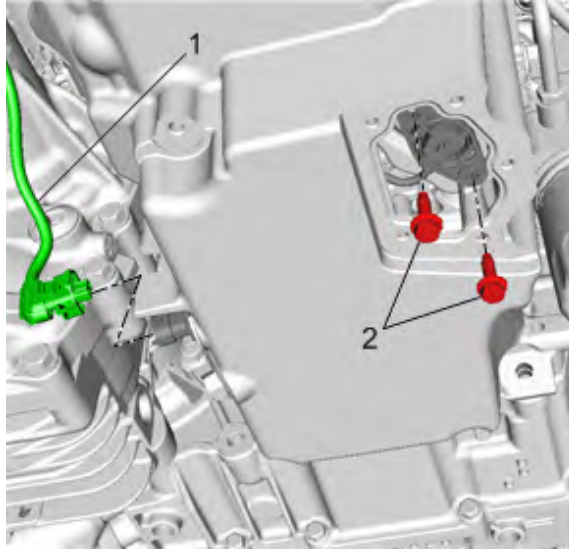


Fig. 228: Oil Level Sensor Connector And Fasteners

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

4. Install the 2 engine oil level indicator switch fasteners (2) and tighten to 10 N.m (89 lb in).
5. Connect the oil level indicator switch electrical connector (1).
6. Install the oil pan cover. **Oil Pan Cover Replacement**

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT (FWD)

Removal Procedure

1. Remove Lower Oil Pan - **Lower Oil Pan Replacement**

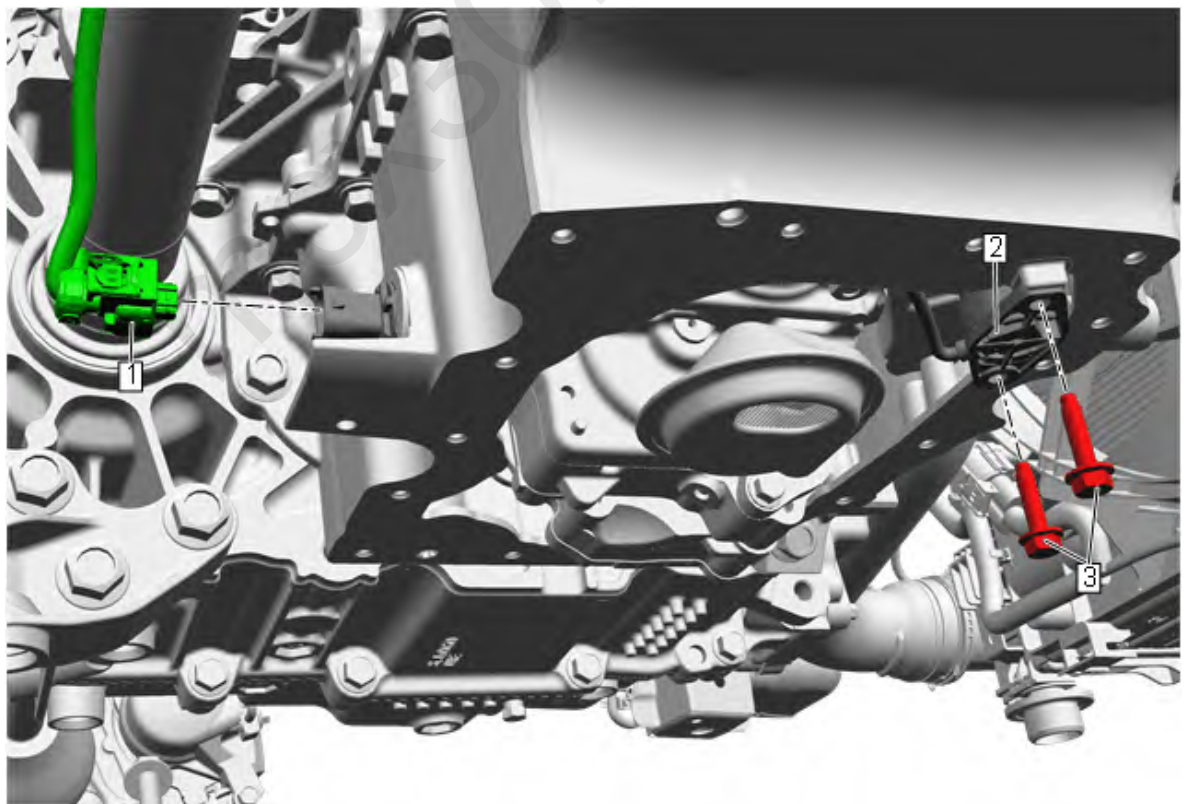


Fig. 229: Electrical Connector And Engine Oil Level Indicator Switch

Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Electrical Connector (1) @ Engine Oil Level Indicator Switch (2)
3. Remove Engine Oil Level Indicator Switch Bolt (3)

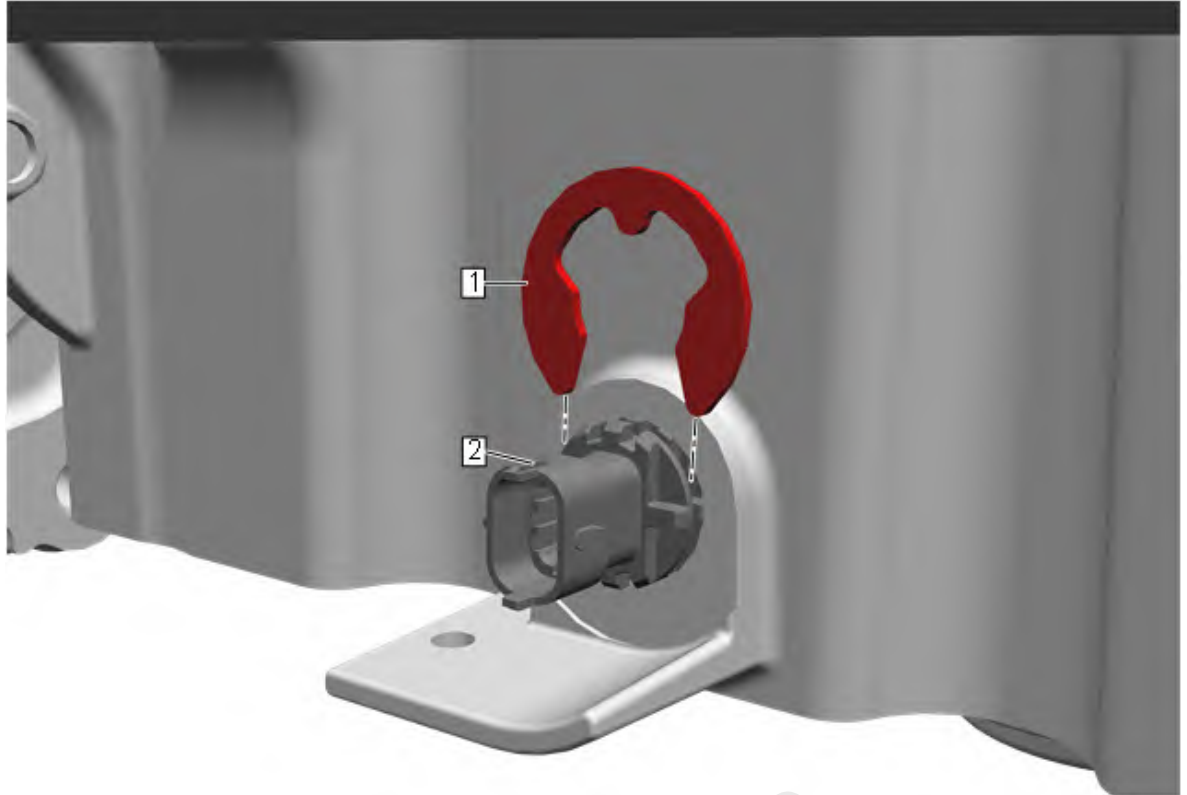


Fig. 230: Engine Oil Level Sensor Lead Clip And Sensor Connector
 Courtesy of GENERAL MOTORS COMPANY

4. Remove Engine Oil Level Sensor Lead Clip (1)
5. Push the sensor connector (2) through the oil pan.

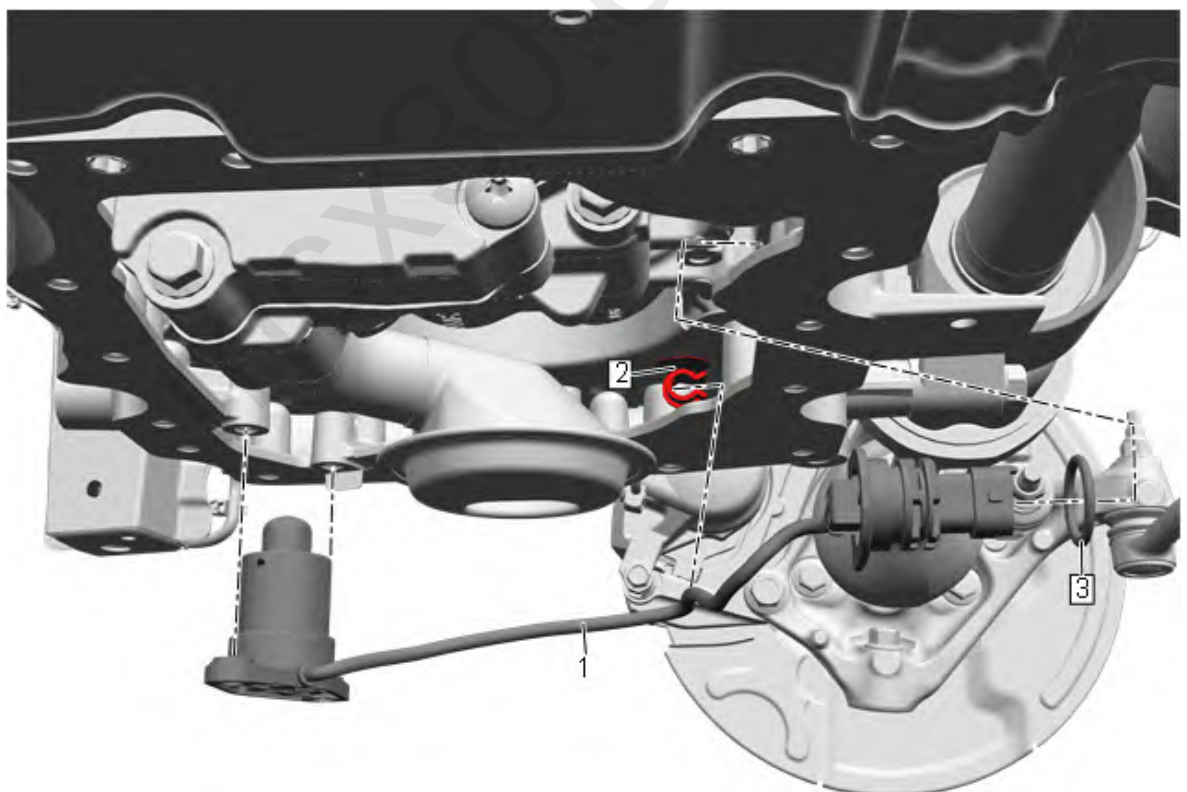


Fig. 231: O-Ring Seal And Engine Oil Level Indicator Switch
 Courtesy of GENERAL MOTORS COMPANY

6. Disconnect Engine Oil Level Indicator Switch (1) @ Oil Pump Flow Control Solenoid Valve Wire Clip (2)
7. Remove Engine Oil Level Indicator Switch (1)

NOTE: This step is necessary only if reusing the old engine oil level indicator switch.

8. Engine Oil Level Indicator Switch O-Ring Seal (3) and DISCARD

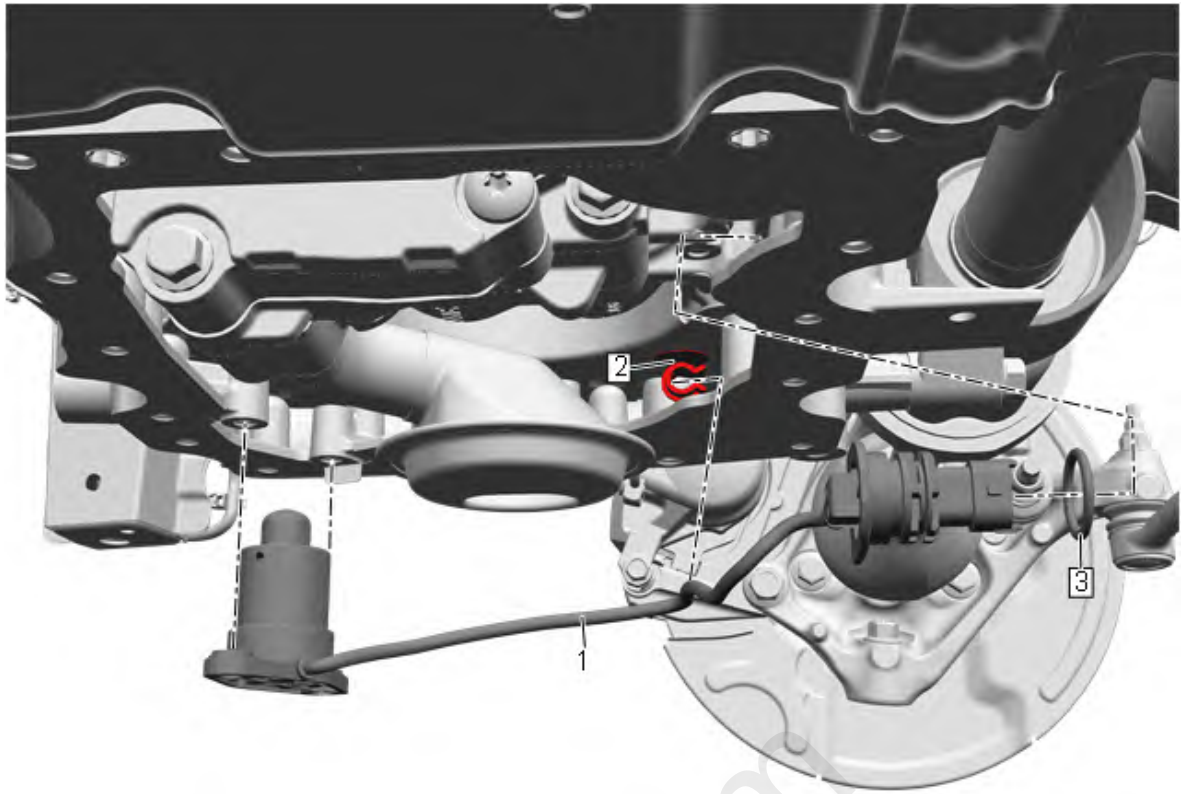


Fig. 232: O-Ring Seal And Engine Oil Level Indicator Switch

Courtesy of GENERAL MOTORS COMPANY

NOTE: This step is necessary only if reusing the old engine oil level indicator switch.

1. Install NEW Engine Oil Level Indicator Switch O-Ring Seal.

NOTE:

- Lubricate the O-ring seal (3) with clean engine oil prior to installing the sensor. **Adhesives, Fluids, Lubricants, and Sealers**
- Use wire or suitable device to route the sensor connector through the oil pan opening.

2. Install Engine Oil Level Indicator Switch (1)

3. Connect Engine Oil Level Indicator Switch (1) @ Oil Pump Flow Control Solenoid Valve Wire Clip (2)

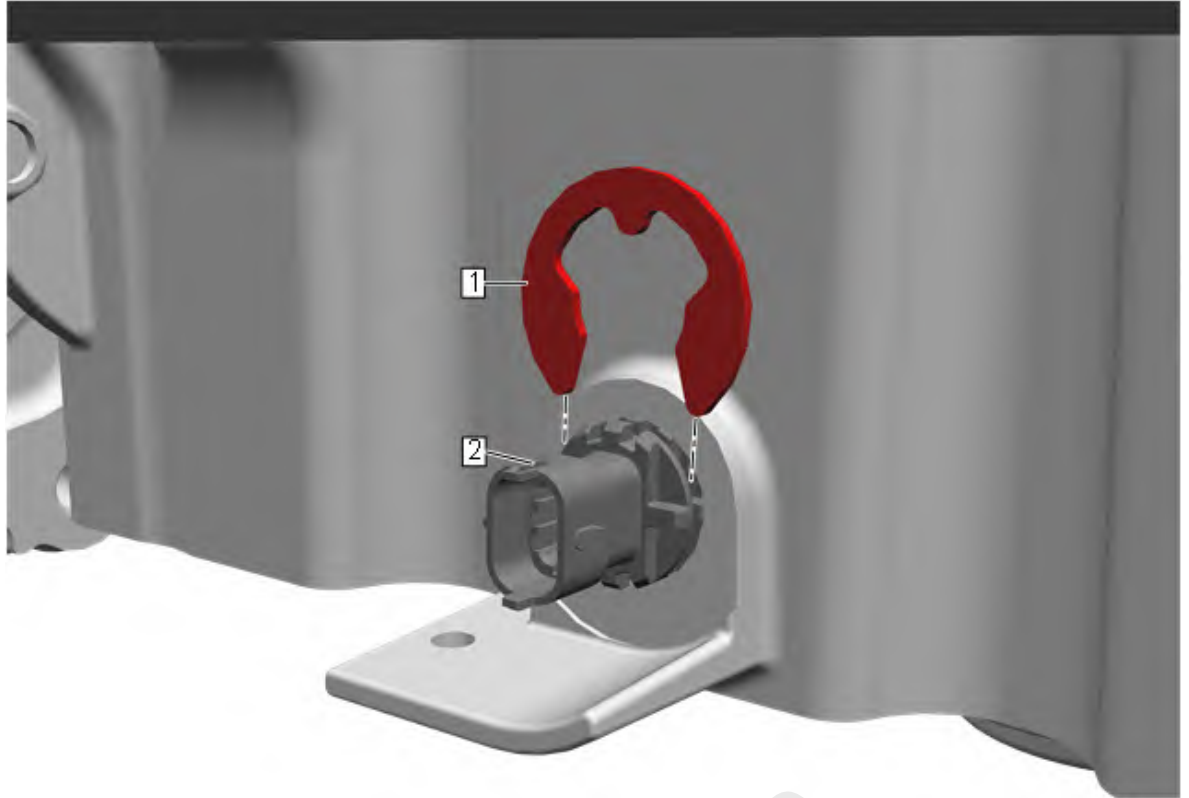


Fig. 233: Engine Oil Level Sensor Lead Clip And Sensor Connector
 Courtesy of GENERAL MOTORS COMPANY

4. Pull the sensor connector (2) through the oil pan and ensure that it is fully seated.
5. Install Engine Oil Level Sensor Lead Clip (1)

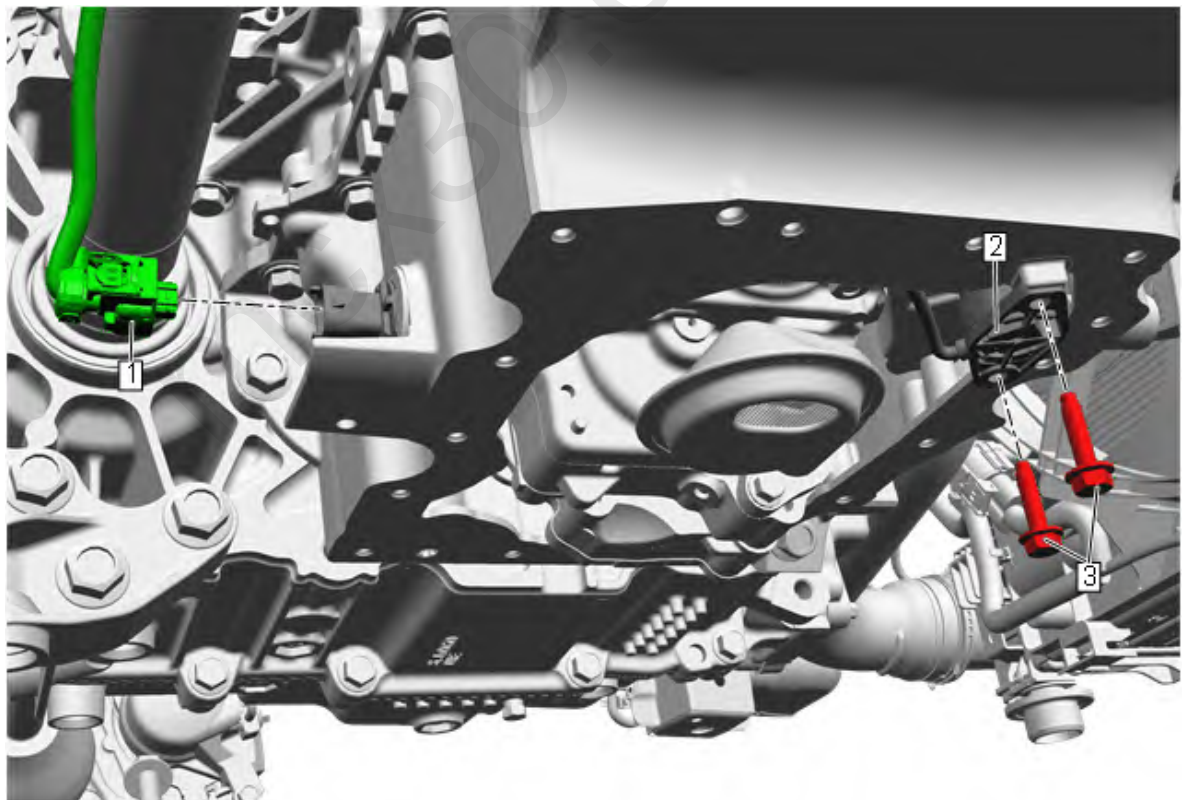


Fig. 234: Electrical Connector And Engine Oil Level Indicator Switch
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

6. Install Engine Oil Level Indicator Switch Bolt (3) and tighten [2x] 10 N.m (89 lb in)
7. Connect Electrical Connector (1) @ Engine Oil Level Indicator Switch (2)
8. Install Lower Oil Pan - **Lower Oil Pan Replacement**

Removal Procedure

Special Tools

- **EN-45059** Angle Meter
- **EN-50792** Holding Tool

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

1. Remove the transmission. Refer to [Transmission Replacement \(Front Wheel Drive except Diesel Engine\)](#), [Transmission Replacement \(All Wheel Drive except Diesel Engine\)](#).

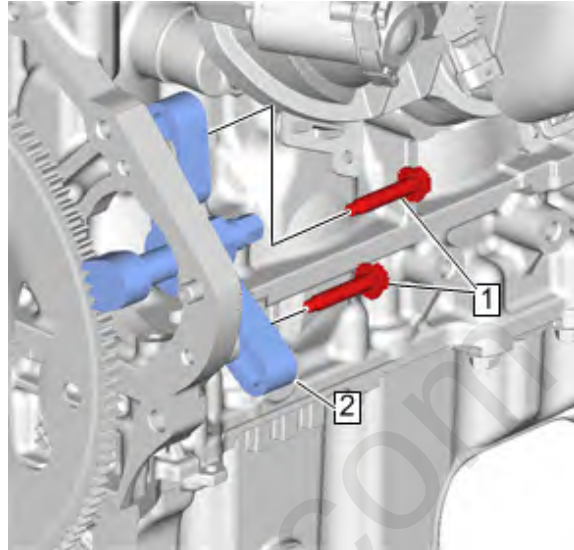


Fig. 235: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

2. To prevent crankshaft rotation, install the **EN-50792** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the automatic flex plate.

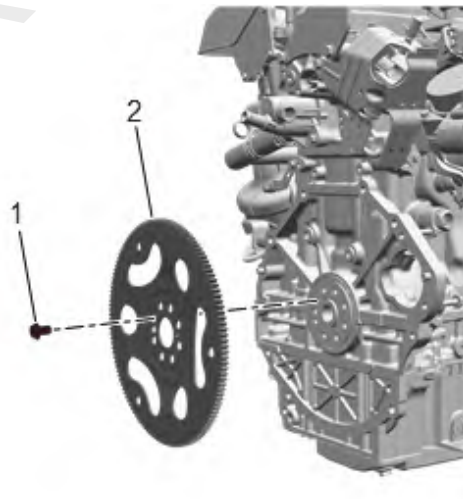


Fig. 236: Automatic Flex Plate Attaching Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Remove the automatic transmission flex plate attaching bolts (1).
4. Remove the automatic transmission flex plate (2).
5. Remove the **EN-50792** holding tool.
6. For automatic transmission flex plate cleaning and inspection, Refer to [Automatic Transmission Flex Plate Cleaning and Inspection](#).

Installation Procedure

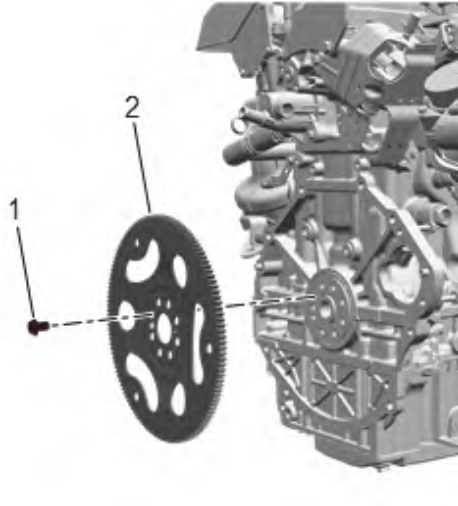


Fig. 237: Automatic Flex Plate Attaching Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

1. Install the automatic transmission flex plate (2) and hand start NEW bolts (1).

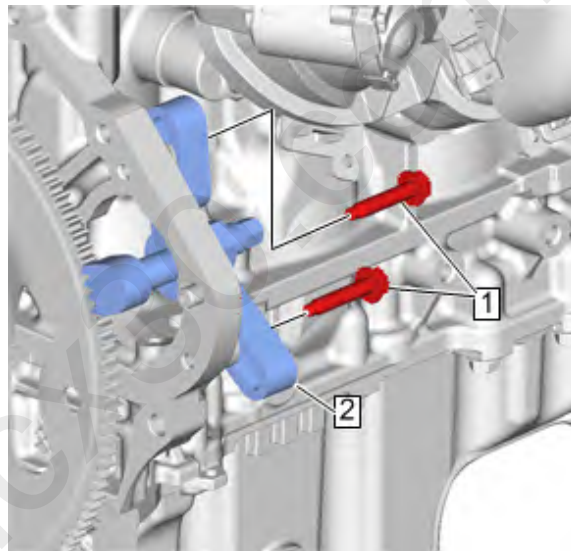
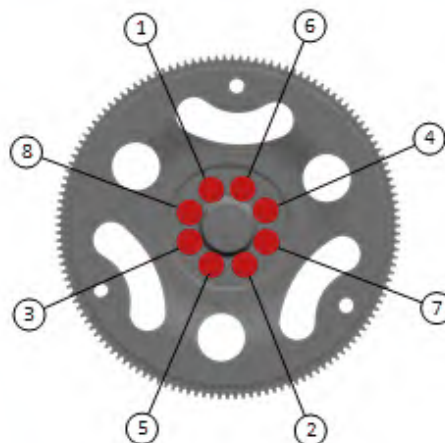


Fig. 238: Starter Motor Bolts
 Courtesy of GENERAL MOTORS COMPANY

2. To prevent crankshaft rotation, install EN-50792 holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flex plate.



CAUTION: Refer to **Fastener Caution** .

3. tighten the bolts evenly using the following procedure:
 1. tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
 2. tighten the bolts a second pass in sequence to 30 N.m (22 lb ft).
 3. tighten the bolts a final pass in sequence 40 degrees using the **EN 45059** meter.
4. Remove the **EN-50792** holding tool.
5. Install the transmission. Refer to **Transmission Replacement (Front Wheel Drive except Diesel Engine)**.
Transmission Replacement (All Wheel Drive except Diesel Engine) .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

EN-51380 Seal Installer

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

Removal Procedure

1. Remove the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement**.

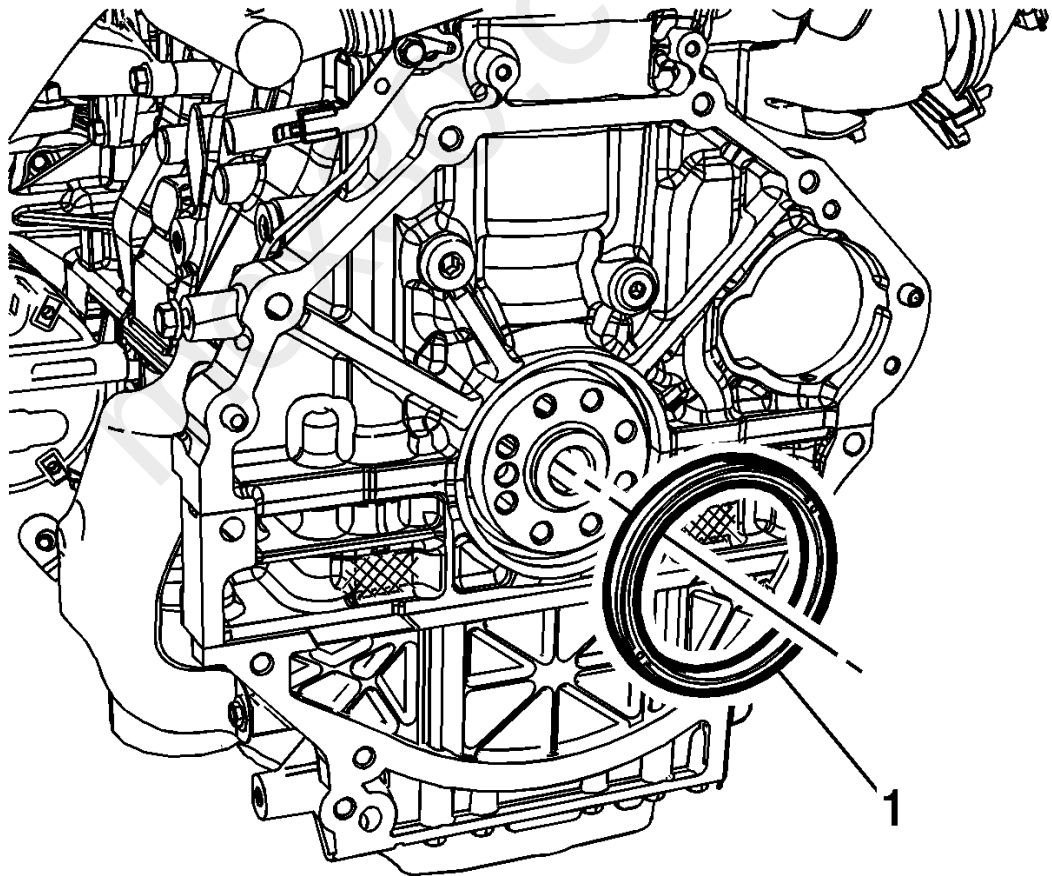


Fig. 240: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

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

2. Use a suitable tool to remove the crankshaft rear oil seal (1).

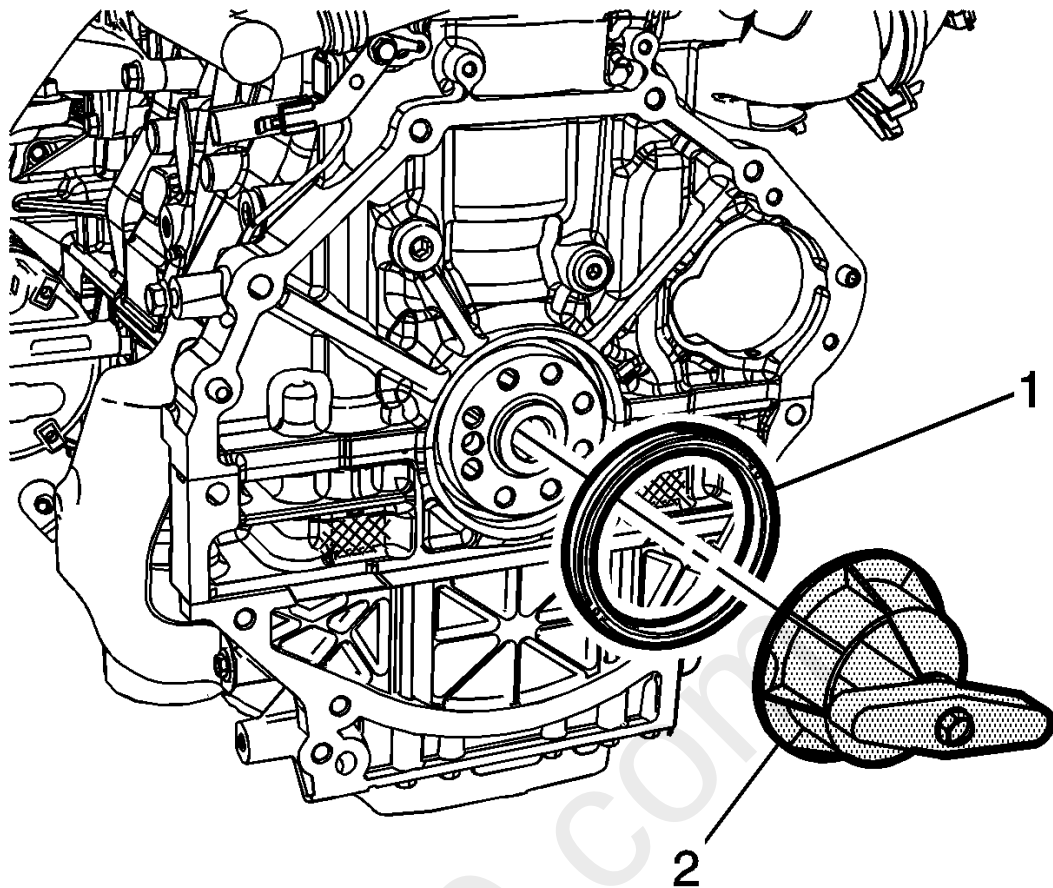


Fig. 241: Crankshaft Rear Oil Seal And Seal Installer

Courtesy of GENERAL MOTORS COMPANY

1. Using the (2) **EN-51380** seal installer, install a NEW crankshaft rear oil seal (1).
2. Install the automatic transmission flex plate. Refer to [Automatic Transmission Flex Plate Replacement](#).

ENGINE REPLACEMENT (2 WHEEL DRIVE)

Removal Procedure

1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)
2. Recover the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\)](#) [Refrigerant Recovery and Recharging \(R-1234yf\)](#)
3. Drain the cooling system. [Cooling System Draining and Filling \(GE 47716\)](#) [Cooling System Draining and Filling \(Static\)](#)
4. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
5. Remove Battery Tray [Battery Tray Replacement](#)

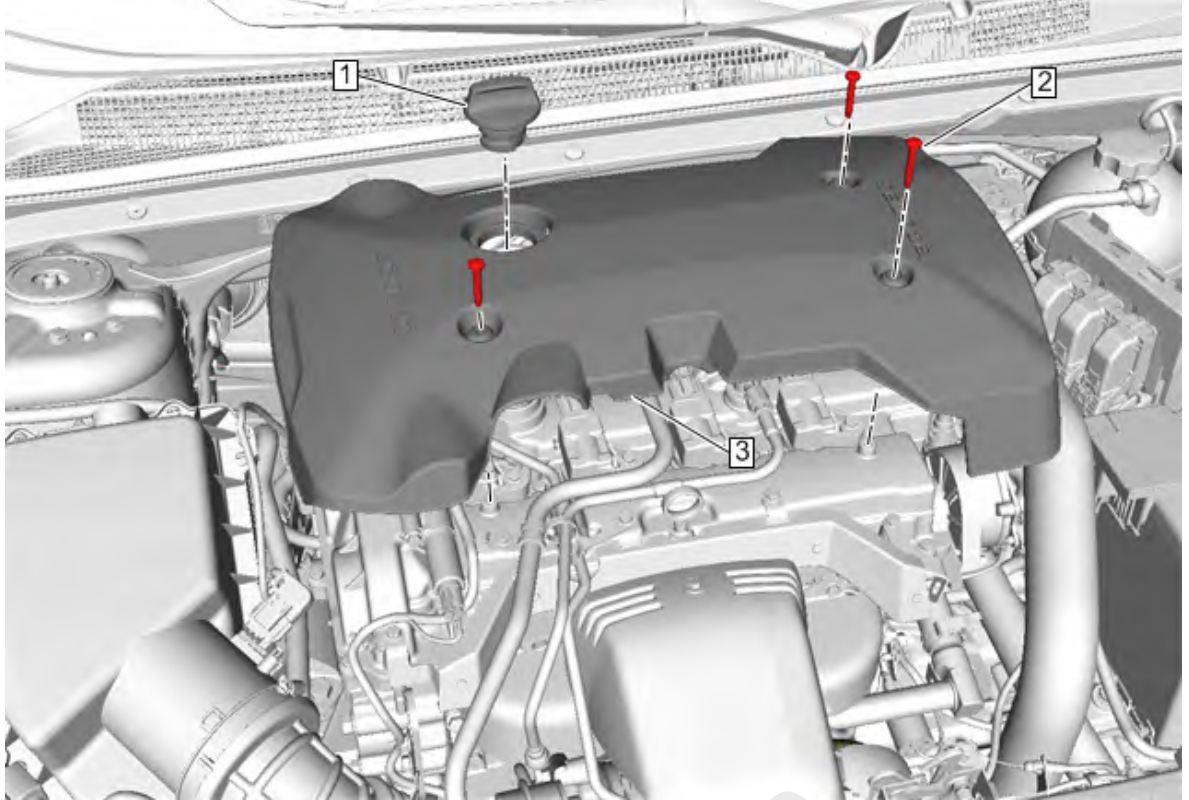


Fig. 242: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

6. Remove Intake Manifold Cover (3) [Intake Manifold Cover Replacement](#)

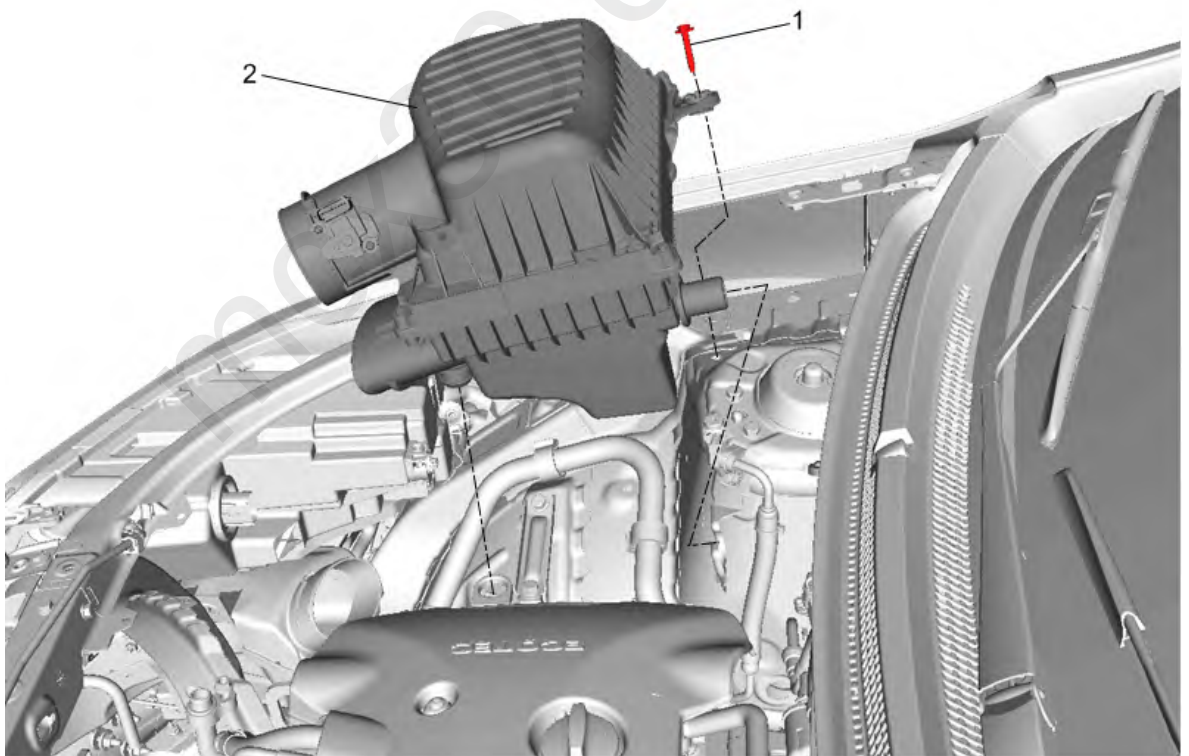


Fig. 243: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

7. Remove Air Cleaner Assembly (2) [Air Cleaner Assembly Replacement](#) .

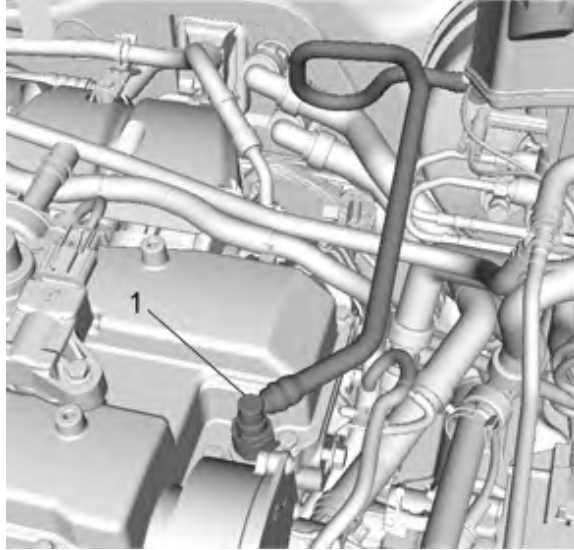


Fig. 244: Vacuum Hose

Courtesy of GENERAL MOTORS COMPANY

8. Disconnect Power Brake Booster Vacuum Pipe (1) [Plastic Collar Quick Connect Fitting Service](#)

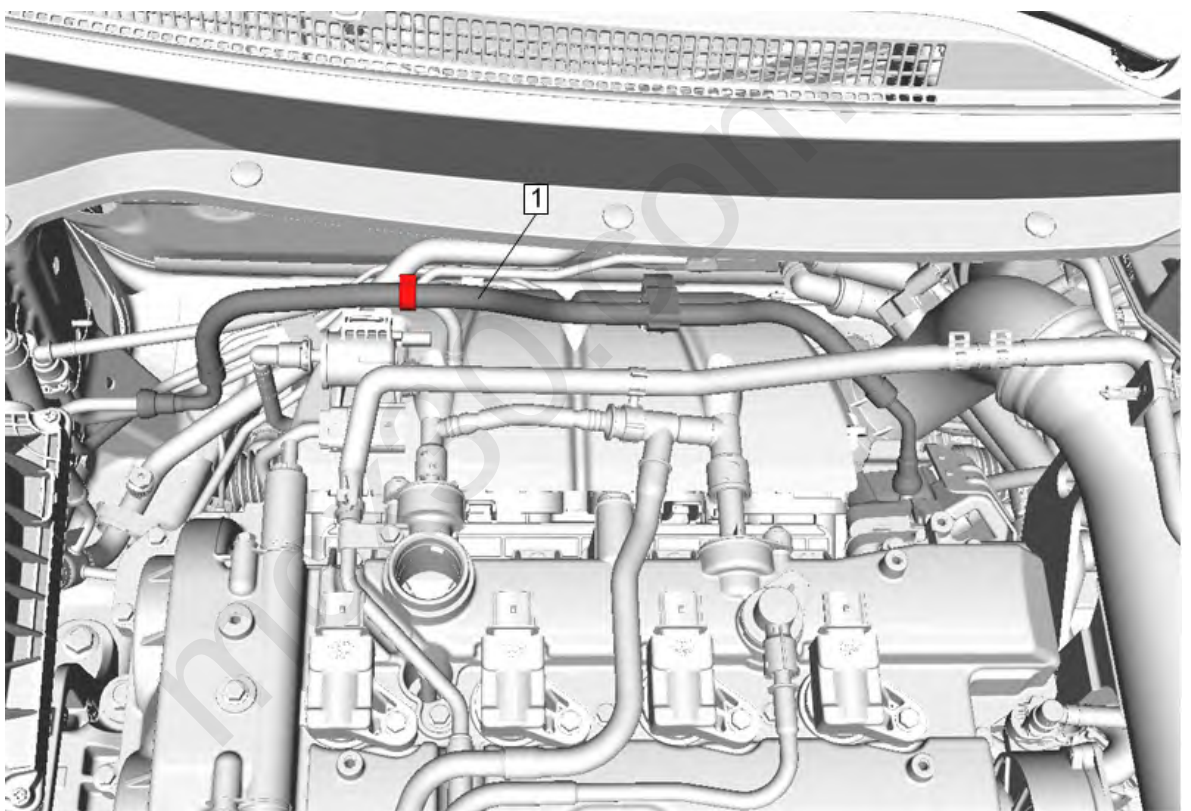


Fig. 245: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

9. Remove Fuel Feed Front Pipe (1) [Fuel Feed Front Pipe Replacement](#)

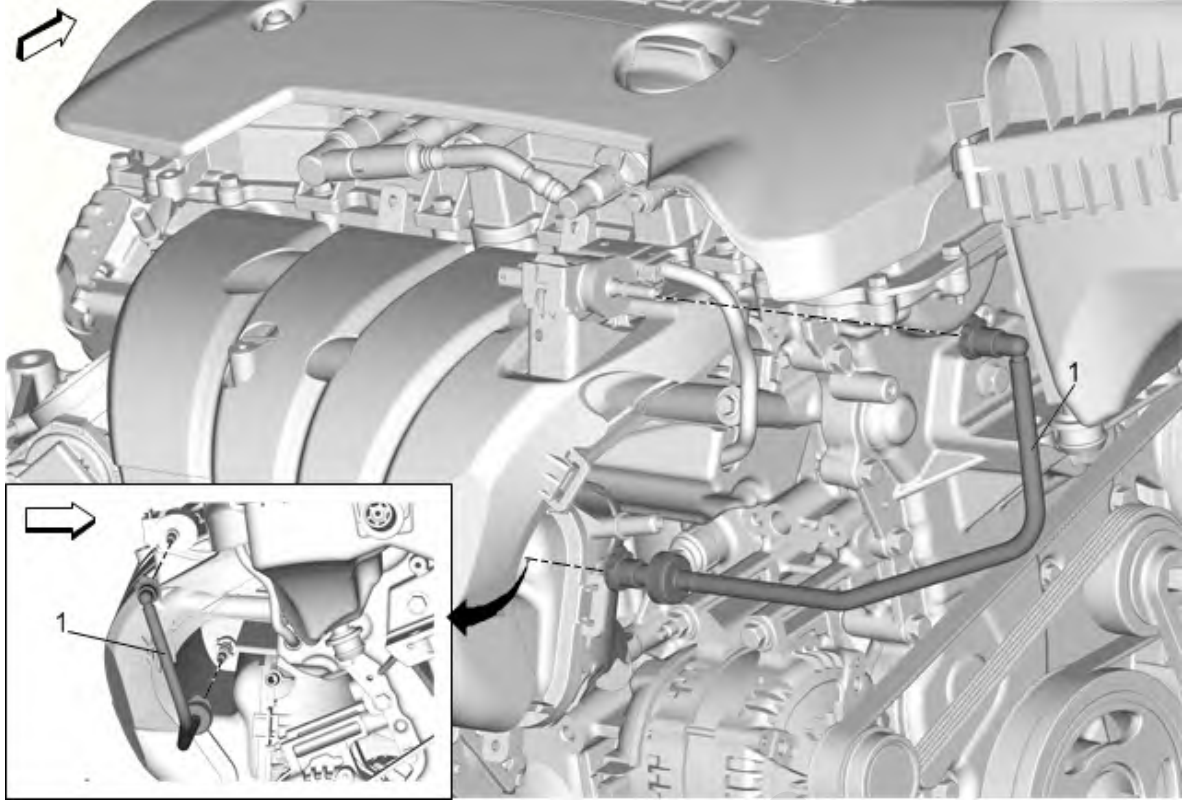


Fig. 246: Evaporative Emission Canister Purge Tube

Courtesy of GENERAL MOTORS COMPANY

10. Remove Evaporative Emission Canister Purge Tube (1) [Evaporative Emission Canister Purge Tube Replacement](#)

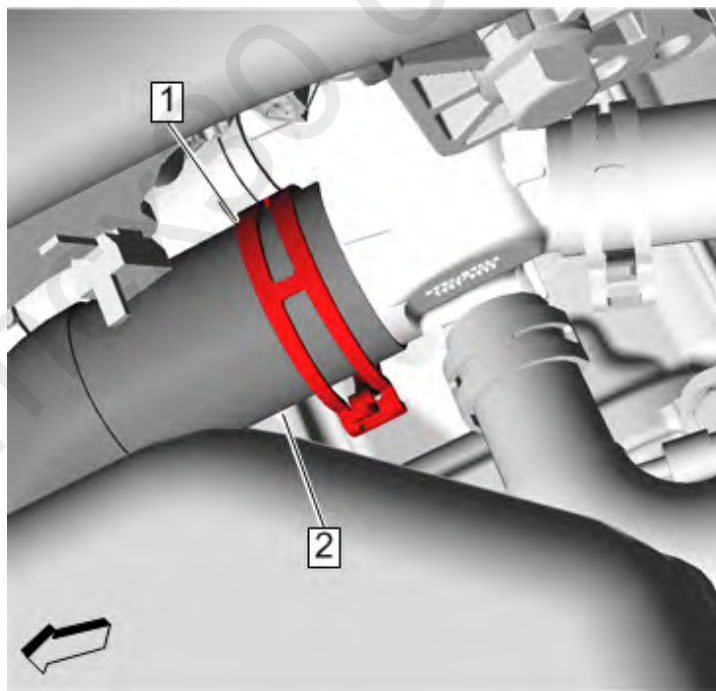


Fig. 247: Heater Inlet Hose

Courtesy of GENERAL MOTORS COMPANY

11. Disconnect Heater Inlet Hose (2) @ Water Outlet - [Heater Inlet Hose Replacement \(LTG with KL9\)](#)

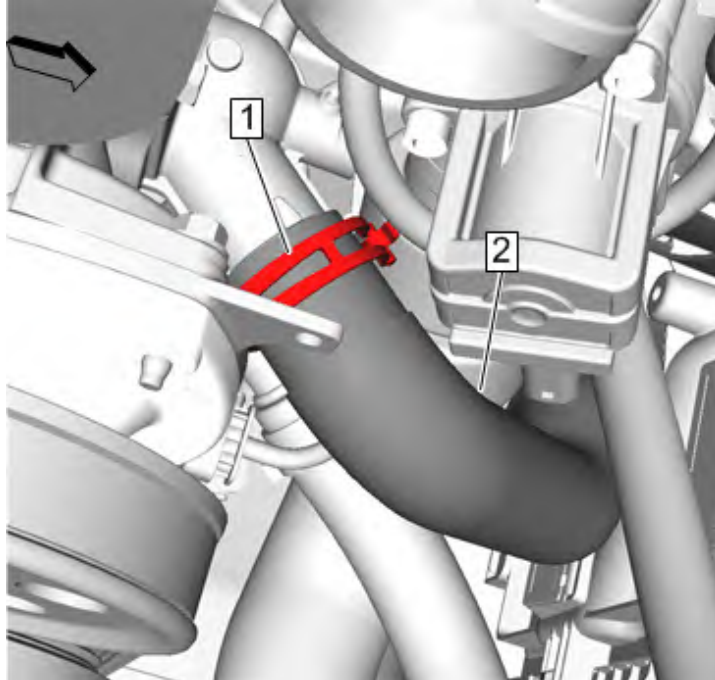


Fig. 248: Radiator Outlet Hose

Courtesy of GENERAL MOTORS COMPANY

12. Disconnect Radiator Outlet Hose (2) @ Engine Coolant Thermostat Housing - [Radiator Outlet Hose Replacement \(LTG with KL9\)](#)

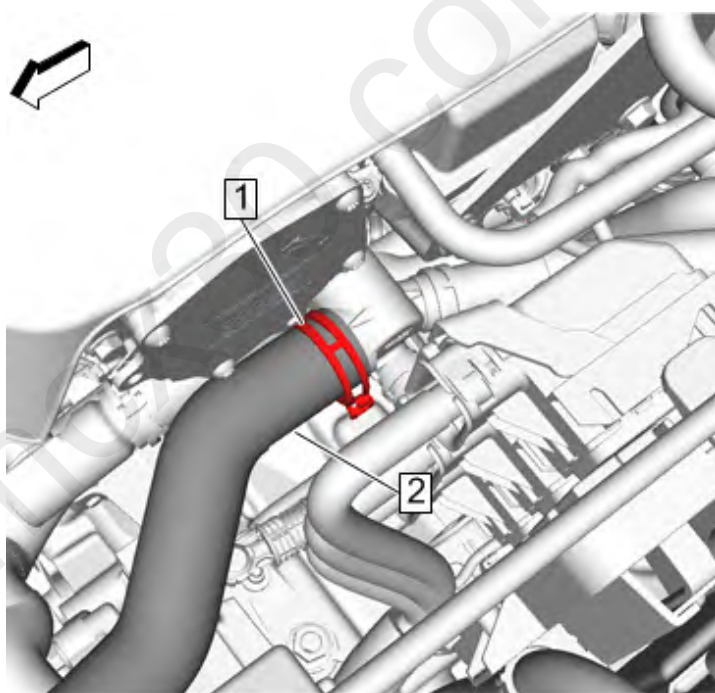


Fig. 249: Radiator Inlet Hose Clamp

Courtesy of GENERAL MOTORS COMPANY

13. Disconnect Radiator Inlet Hose (2) @ Water Outlet - [Radiator Inlet Hose Replacement \(LTG with KL9\)](#)

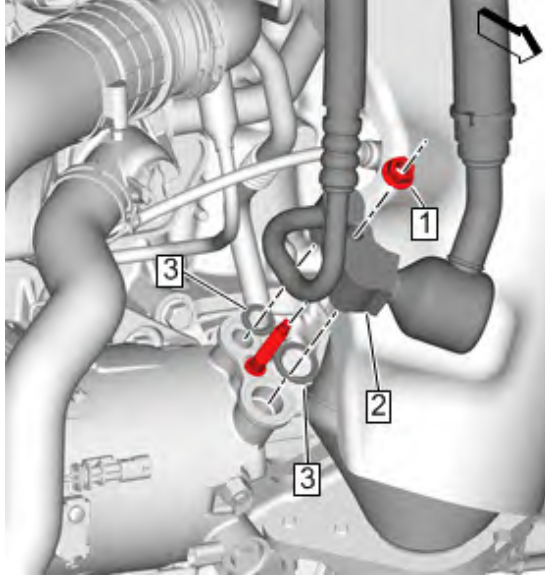


Fig. 250: Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose
 Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor - **Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement (LTG)**

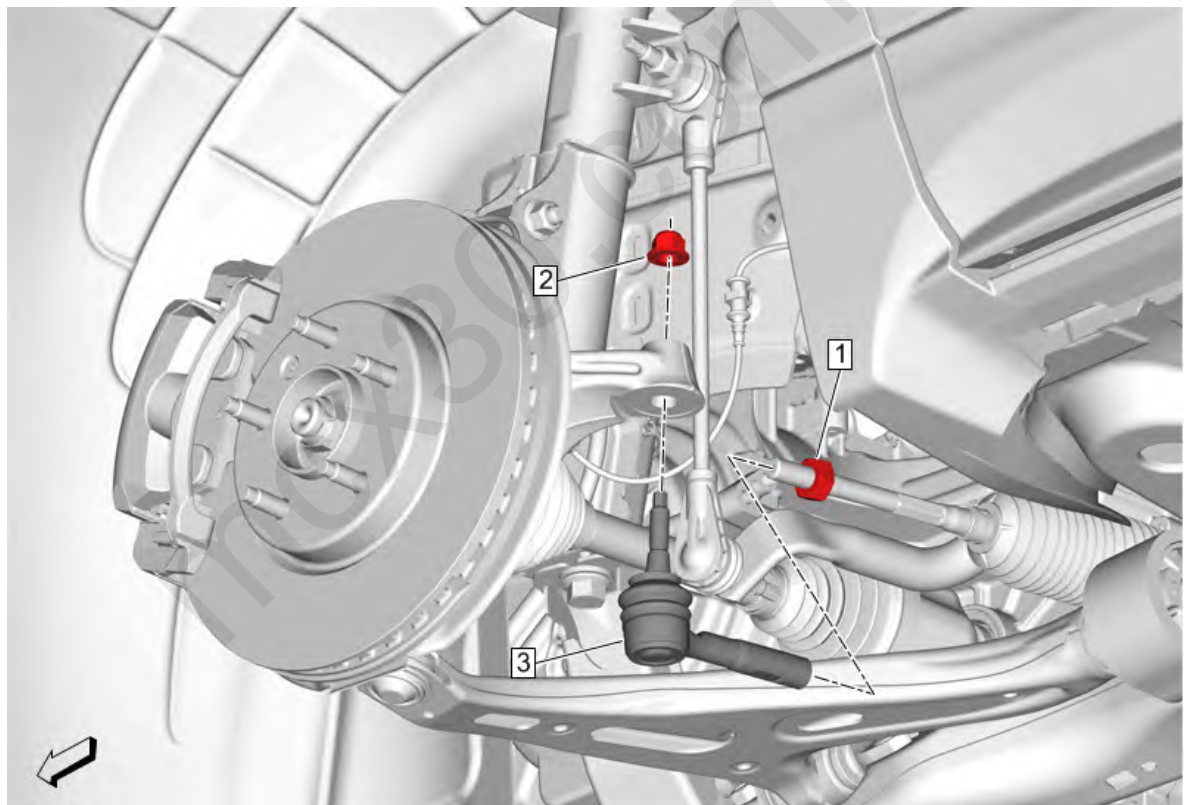


Fig. 251: Steering Linkage Outer Tie Rod
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Left side shown, right side similar.

15. Disconnect Steering Linkage Outer Tie Rod (3) @ Steering Knuckle - **Steering Linkage Outer Tie Rod Replacement**

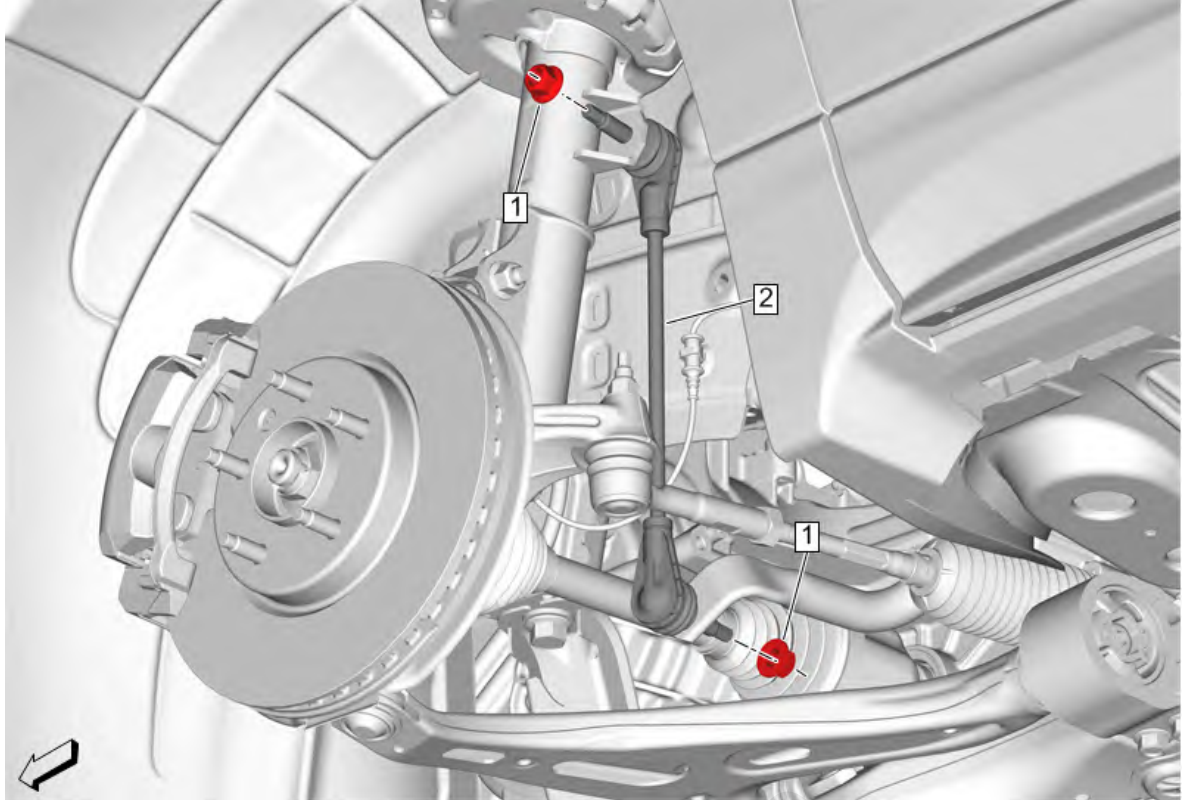


Fig. 252: Upper Stabilizer Shaft Link Nut

Courtesy of GENERAL MOTORS COMPANY

16. Disconnect Stabilizer Shaft Link(2) @ Stabilizer Shaft - [Stabilizer Shaft Link Replacement \(Equinox\)](#)
[Stabilizer Shaft Link Replacement \(Terrain\)](#)

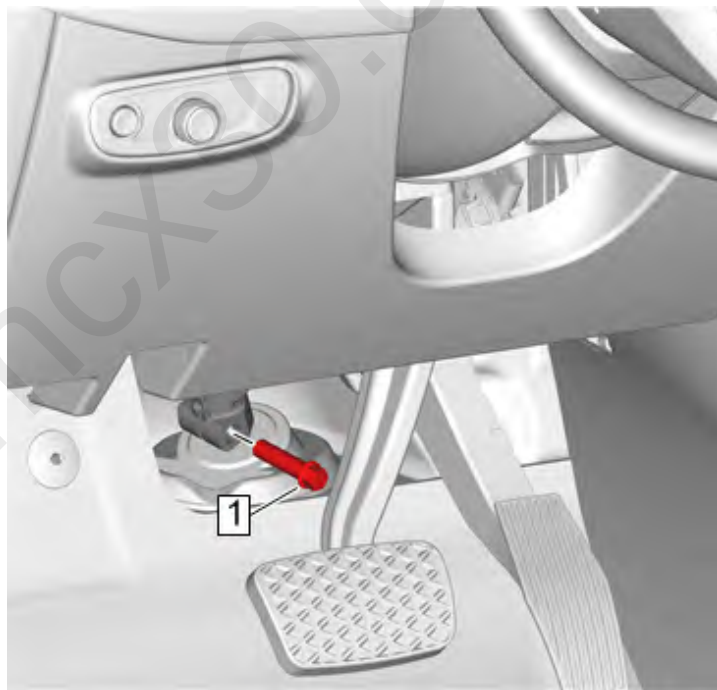


Fig. 253: Intermediate Shaft Pinch Bolt

Courtesy of GENERAL MOTORS COMPANY

17. Remove the intermediate shaft pinch bolt (1), then disconnect the intermediate shaft from the steering gear.
[Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)
18. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LTG\)](#)

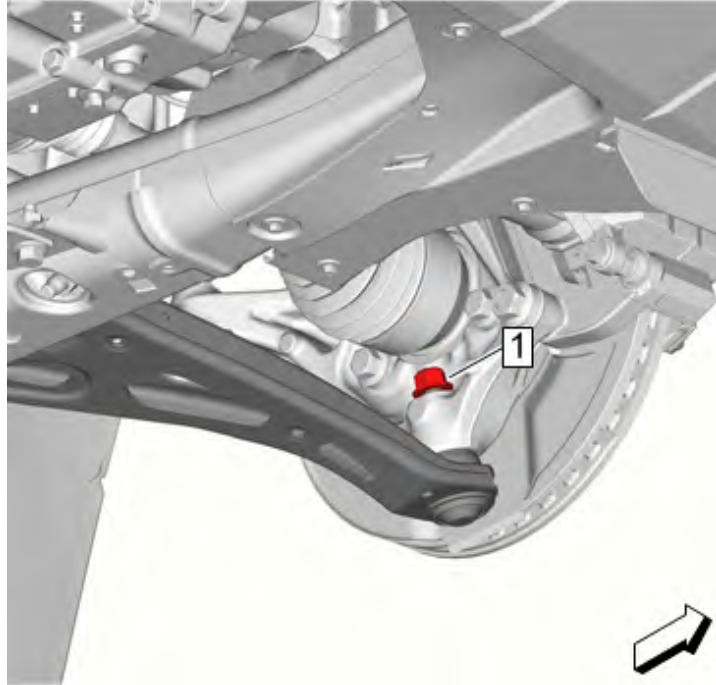


Fig. 254: Lower Control Arm To Steering Knuckle Nut
 Courtesy of GENERAL MOTORS COMPANY

19. Remove the front lower control arm ball stud nuts (1) then disconnect the lower control arms from the steering knuckles. [Lower Control Arm Replacement \(Equinox\)](#) [Lower Control Arm Replacement \(Terrain\)](#) .
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 \(M3U, MHG, MNH, MNK with FWD\)](#) [Front Wheel Drive Half Shaft Replacement - Right Side \(M3D, M3H with FWD\)](#)

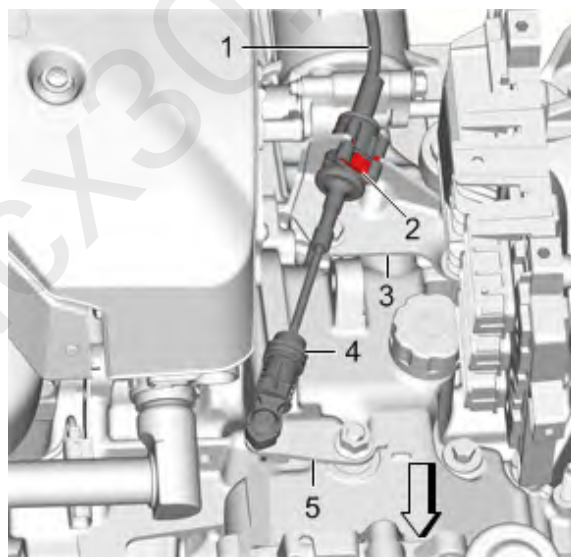


Fig. 255: Transmission Range Selector Lever Cable Components
 Courtesy of GENERAL MOTORS COMPANY

22. Disconnect the range selector lever cable terminal from the transmission manual shift lever.

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

23. Position an engine support table under the powertrain assembly.
24. Blocks of wood can be used between the front of the frame and the oil pan to table in order to level the powertrain during the removal.
25. With the table positioned, fully raise the table to contact with the powertrain assembly.

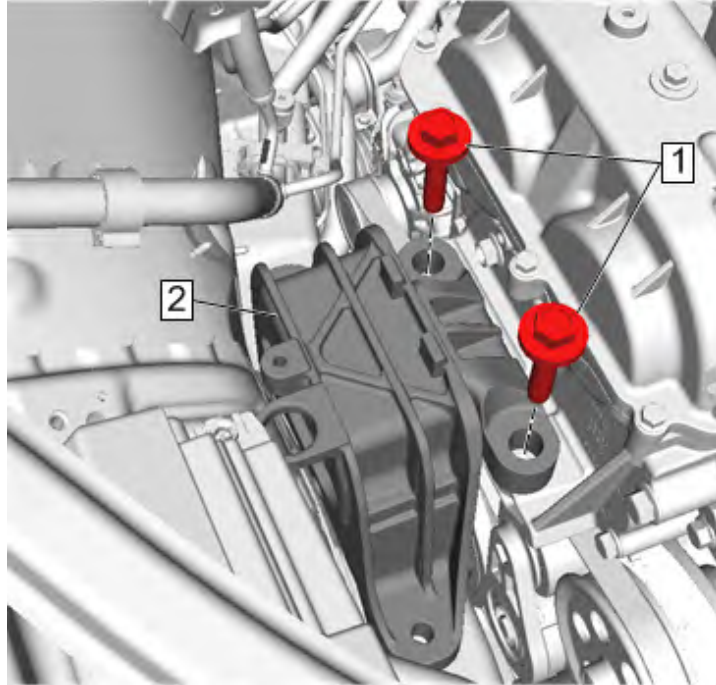


Fig. 256: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

26. Remove Engine Mount Bolt (1) - [Engine Mount Replacement](#)
27. Remove Transmission Mount - [Transmission Mount Replacement \(Left Side M3U\)](#) [Transmission Mount Replacement \(Left Side M3D/M3H\)](#)

NOTE: Remove **ONLY** the body to frame bolts as the powertrain will be removed while still bolted to the frame.

28. Remove the frame to body bolts. [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#).
29. Disconnect electrical connectors as necessary.
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 transaxle. [Transmission Replacement \(Front Wheel Drive\)](#) [Transmission Replacement \(All Wheel Drive\)](#).
32. Install the engine to a suitable engine stand.

Installation Procedure

1. Install the engine to the transaxle. [Transmission Replacement \(Front Wheel Drive\)](#) [Transmission Replacement \(All Wheel Drive\)](#).
2. Position the powertrain 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.
5. Install the frame to body bolts. [Drivetrain and Front Suspension Cradle Replacement \(Front Wheel Drive\)](#) [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#).
6. Lower the vehicle.
7. Install Transmission Mount - [Transmission Mount Replacement \(Left Side M3U\)](#) [Transmission Mount Replacement \(Left Side M3D/M3H\)](#).

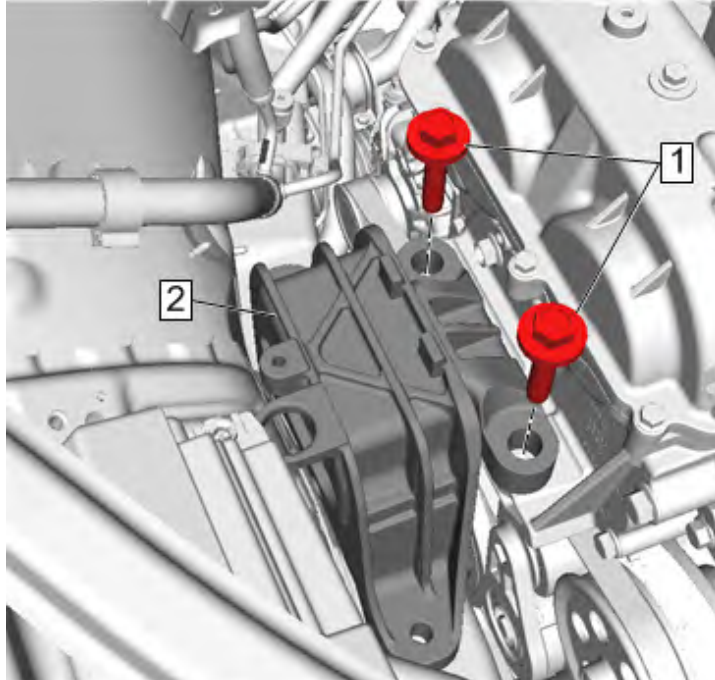


Fig. 257: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Install Engine Mount Bolt (1) - [Engine Mount Replacement](#)

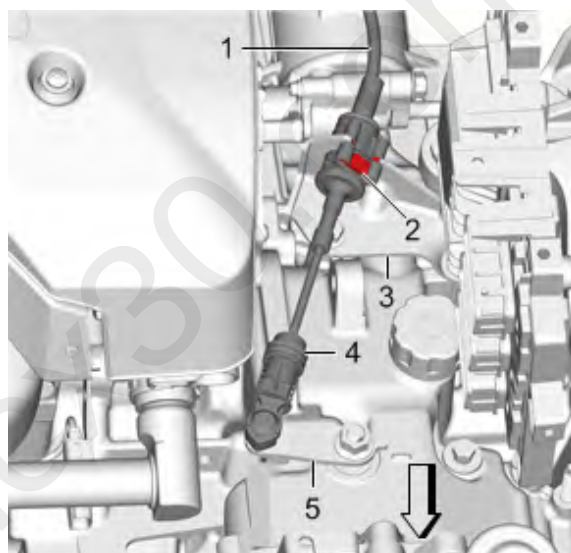


Fig. 258: Transmission Range Selector Lever Cable Components
Courtesy of GENERAL MOTORS COMPANY

9. Connect the range selector lever cable terminal(4) to the transmission manual shift lever (5)
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 \(M3D, M3H with FWD\)](#)

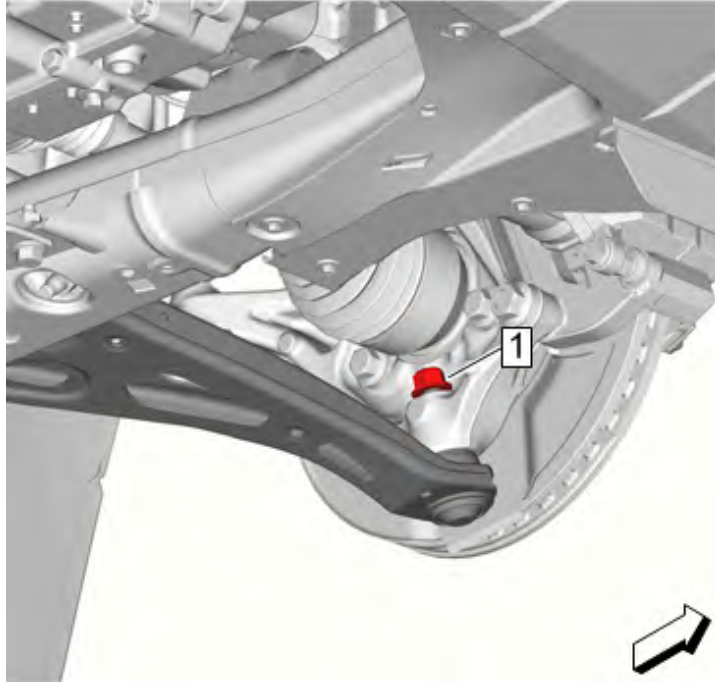


Fig. 259: Lower Control Arm To Steering Knuckle Nut
 Courtesy of GENERAL MOTORS COMPANY

12. Connect the lower control arms to the steering knuckles then install the lower control arm ball stud nuts (1). [Lower Control Arm Replacement \(Equinox\)](#) [Lower Control Arm Replacement \(Terrain\)](#)
13. Install Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LTG\)](#)

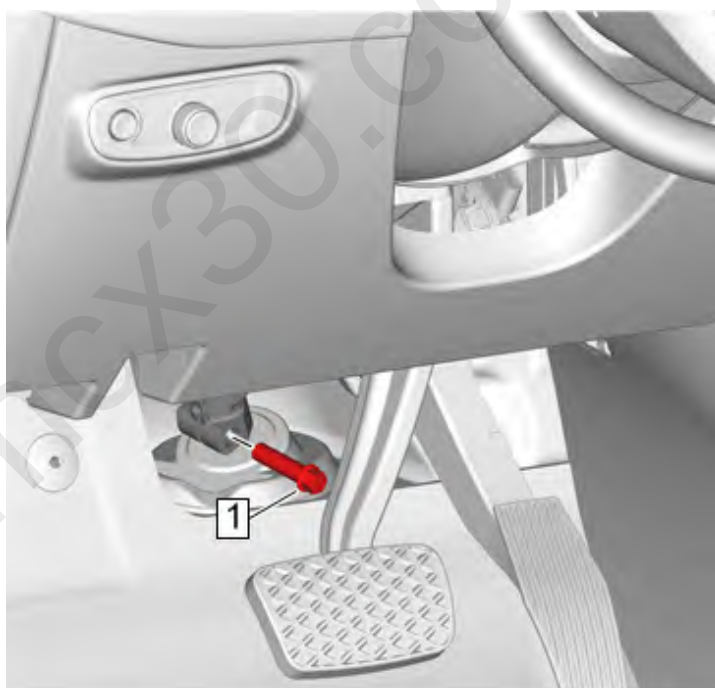


Fig. 260: Intermediate Shaft Pinch Bolt
 Courtesy of GENERAL MOTORS COMPANY

14. Connect the intermediate shaft to the steering gear then install the pinch bolt (1). [Intermediate Steering Shaft Replacement \(Equinox\)](#) [Intermediate Steering Shaft Replacement \(Terrain\)](#)

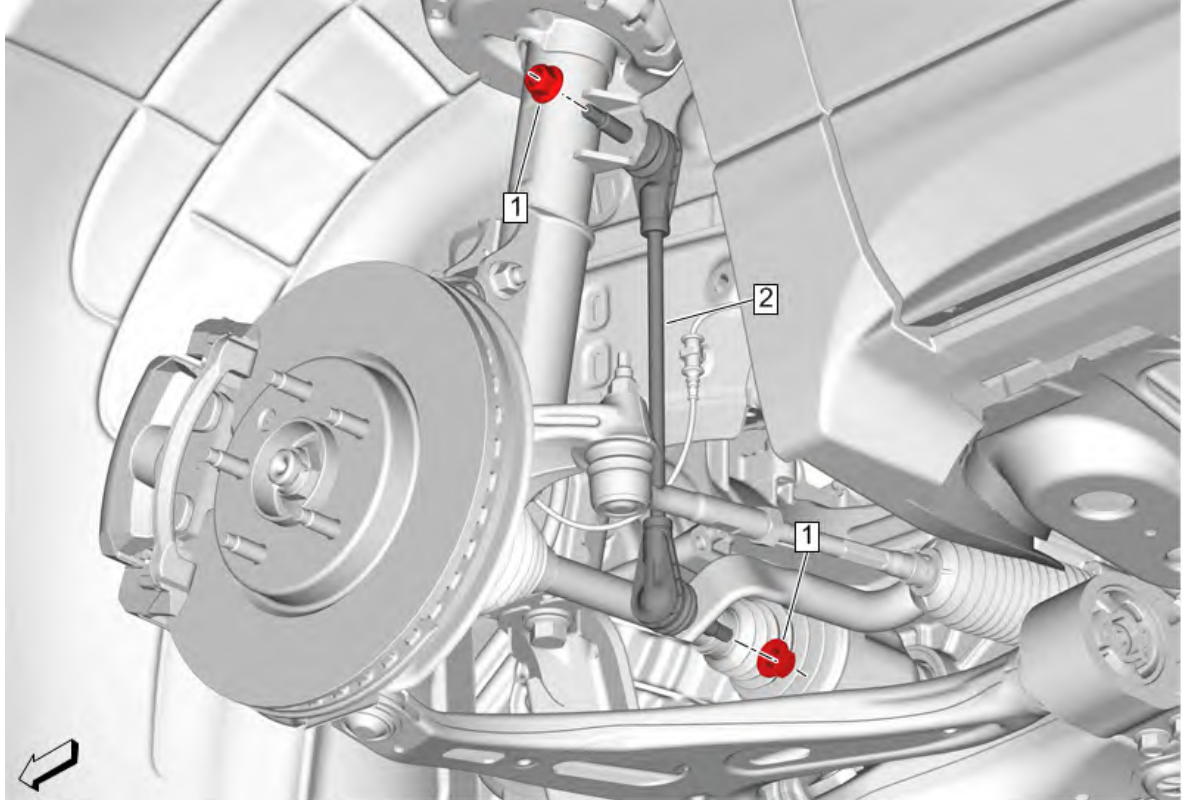


Fig. 261: Upper Stabilizer Shaft Link Nut
 Courtesy of GENERAL MOTORS COMPANY

15. Connect Stabilizer Shaft Link @ Stabilizer Shaft (2) [Stabilizer Shaft Link Replacement \(Equinox\)](#)
[Stabilizer Shaft Link Replacement \(Terrain\)](#)

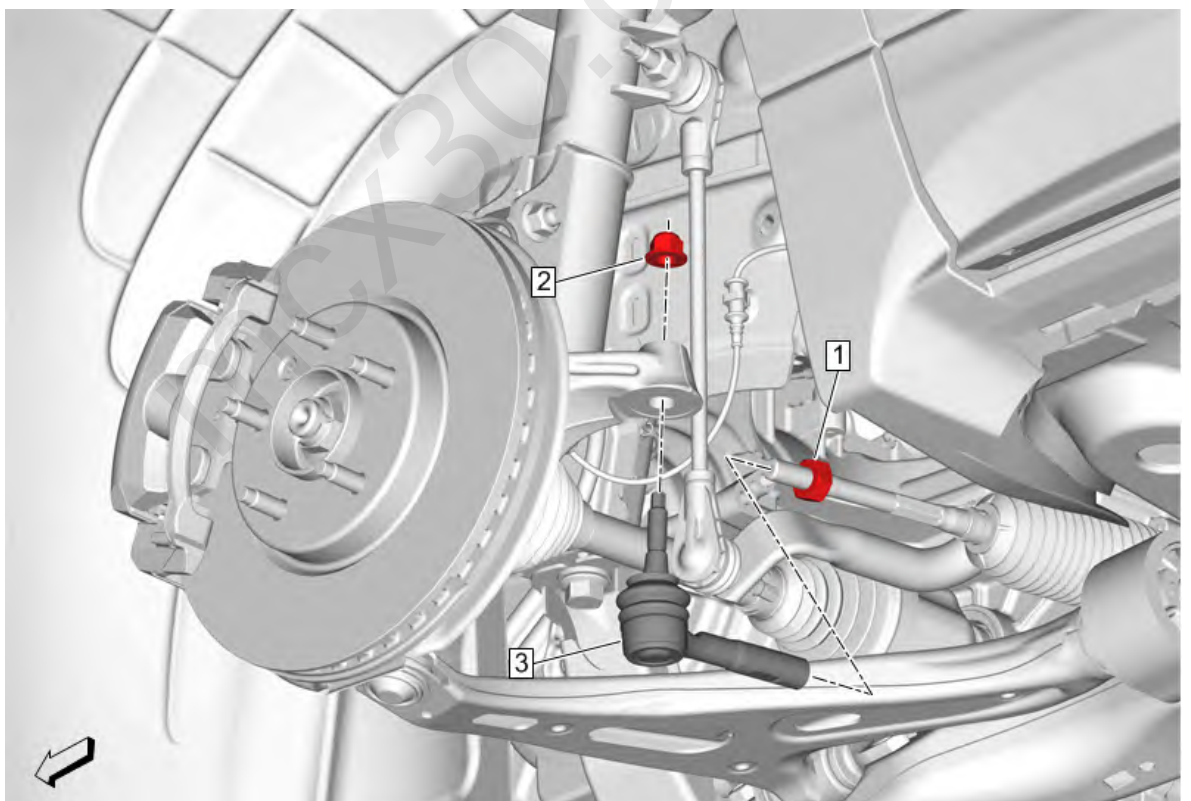


Fig. 262: Steering Linkage Outer Tie Rod
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Left side shown, right side similar.

16. Connect Steering Linkage Outer Tie Rod (3) @ Steering Knuckle - [Steering Linkage Outer Tie Rod Replacement](#)

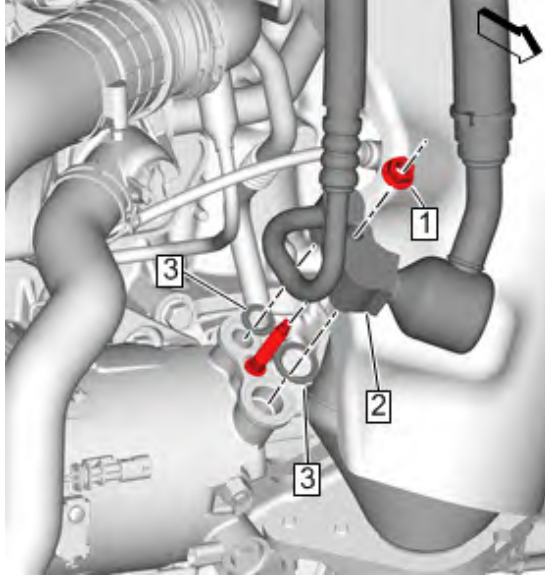


Fig. 263: Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose
 Courtesy of GENERAL MOTORS COMPANY

17. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LTG\)](#)

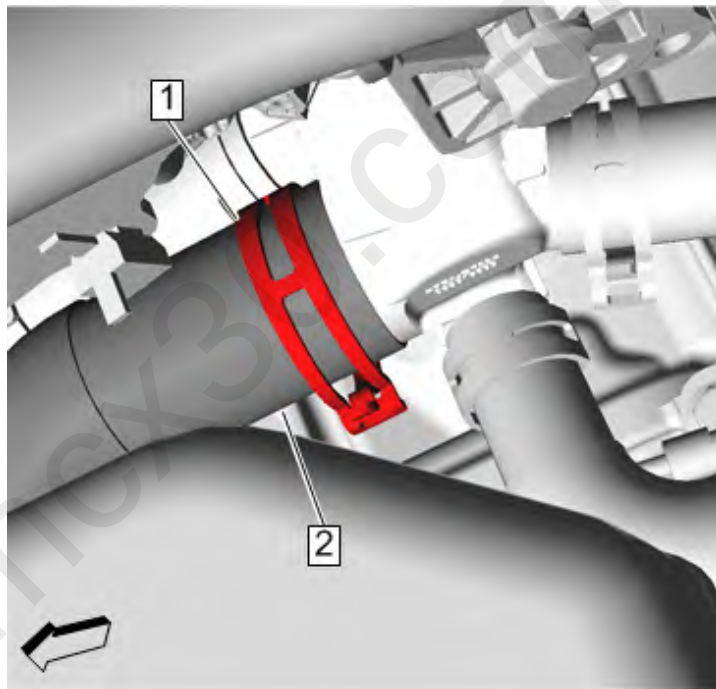


Fig. 264: Heater Inlet Hose
 Courtesy of GENERAL MOTORS COMPANY

18. Connect Heater Inlet Hose (2) @ Water Outlet - [Heater Inlet Hose Replacement \(LTG with KL9\)](#)

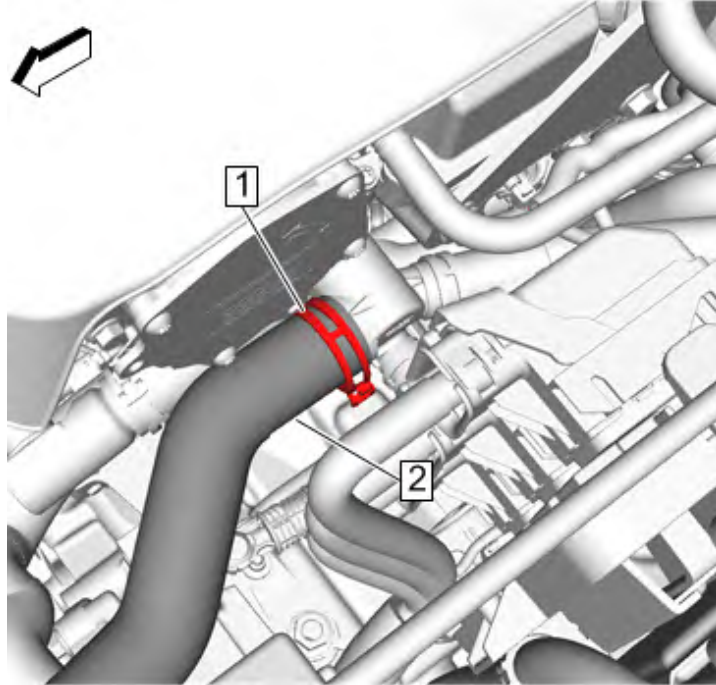


Fig. 265: Radiator Inlet Hose Clamp

Courtesy of GENERAL MOTORS COMPANY

19. Connect Radiator Inlet Hose (2) @ Water Outlet - **Radiator Inlet Hose Replacement (LTG with KL9)**

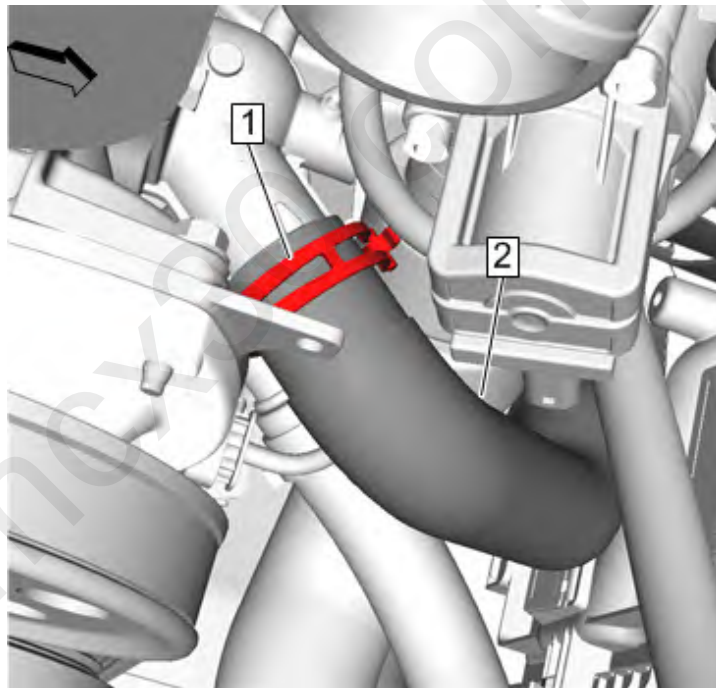


Fig. 266: Radiator Outlet Hose

Courtesy of GENERAL MOTORS COMPANY

20. Connect Radiator Outlet Hose (2) @ Engine Coolant Thermostat Housing - **Radiator Outlet Hose Replacement (LTG with KL9)**
21. Install Heater Core Outlet Hose - **Heater Outlet Hose Replacement (LYX without KL9)** .

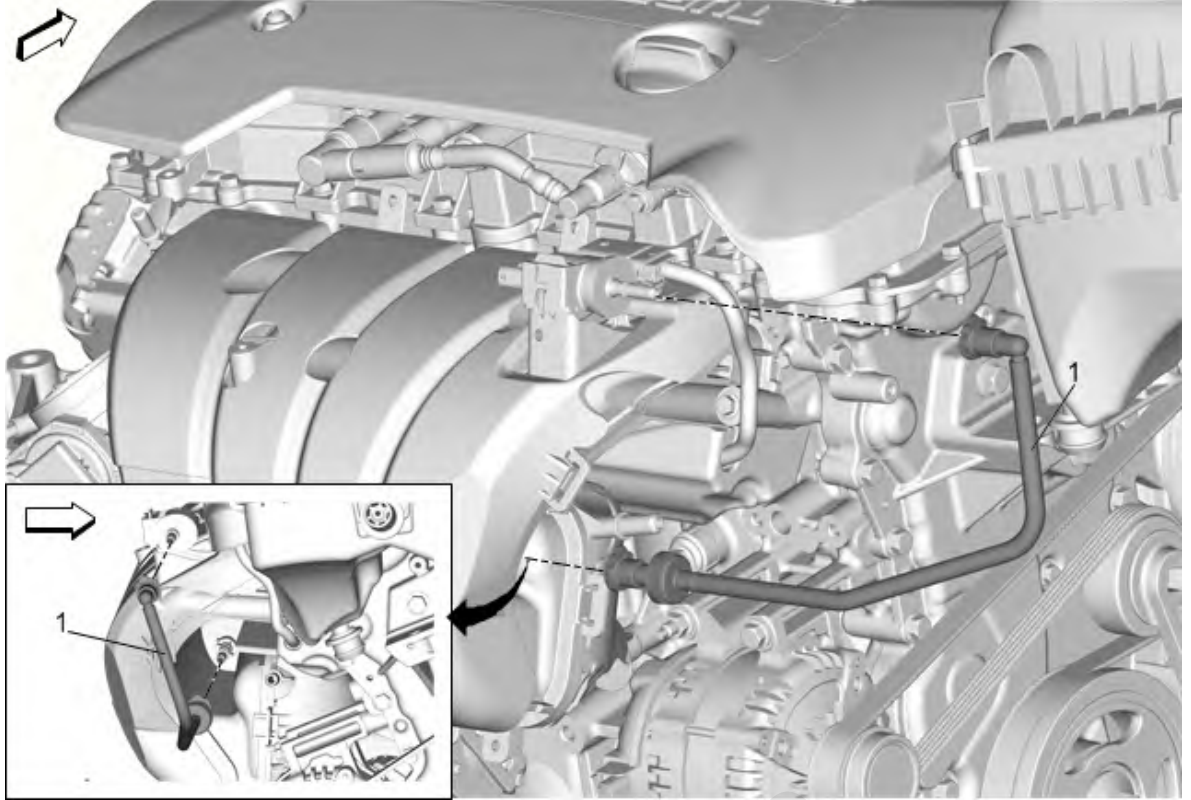


Fig. 267: Evaporative Emission Canister Purge Tube

Courtesy of GENERAL MOTORS COMPANY

22. Install Evaporative Emission Canister Purge Tube (1) - [Evaporative Emission Canister Purge Tube Replacement](#)

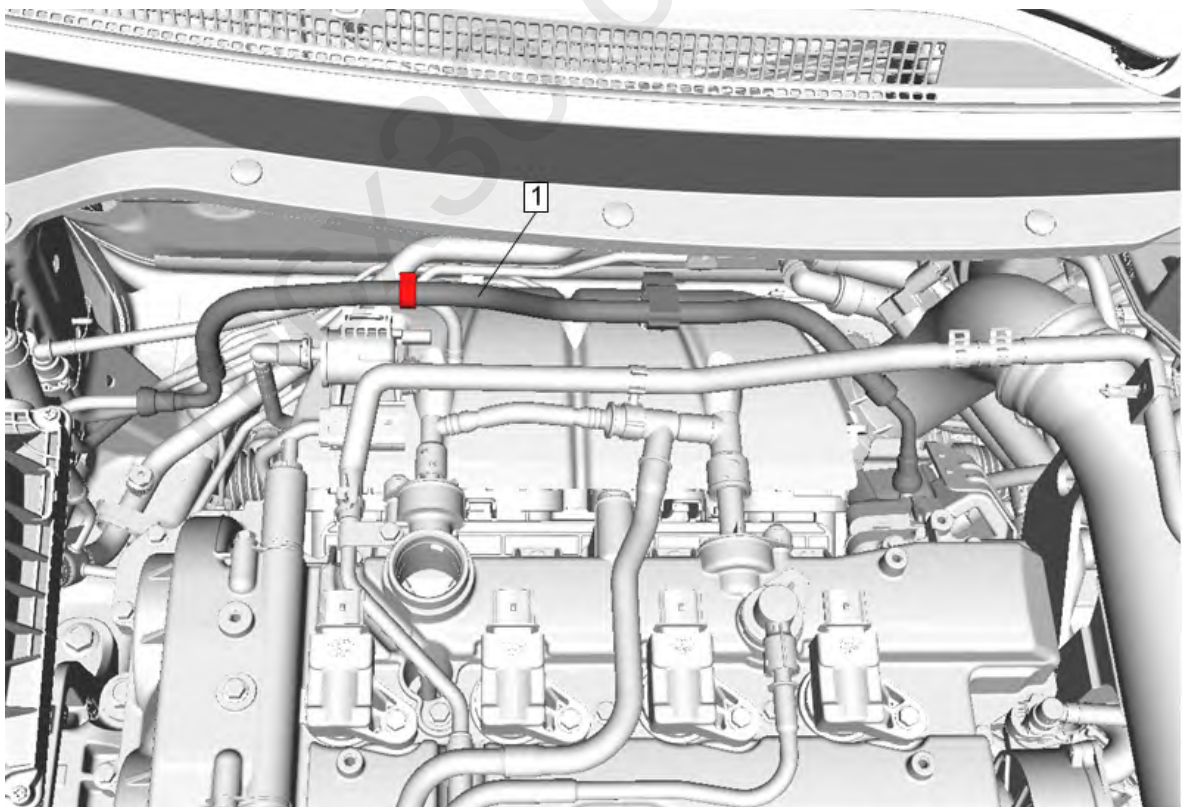


Fig. 268: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

23. Install Fuel Feed Front Pipe (1)- [Fuel Feed Front Pipe Replacement](#)

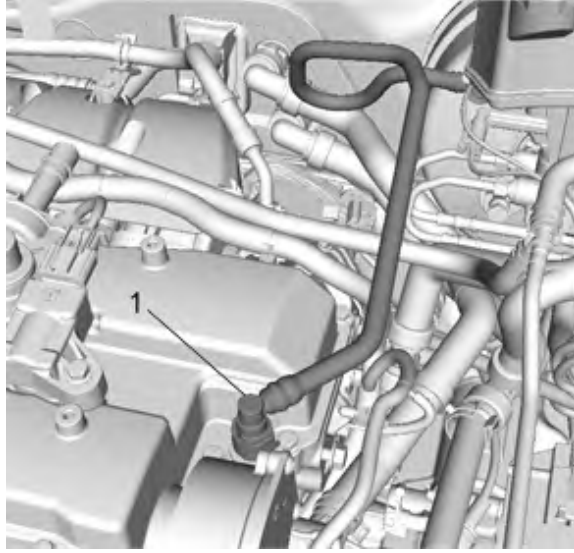


Fig. 269: Vacuum Hose

Courtesy of GENERAL MOTORS COMPANY

24. Connect Power Brake Booster Vacuum Pipe (1) - [Plastic Collar Quick Connect Fitting Service](#)
25. Connect electrical connectors as needed.

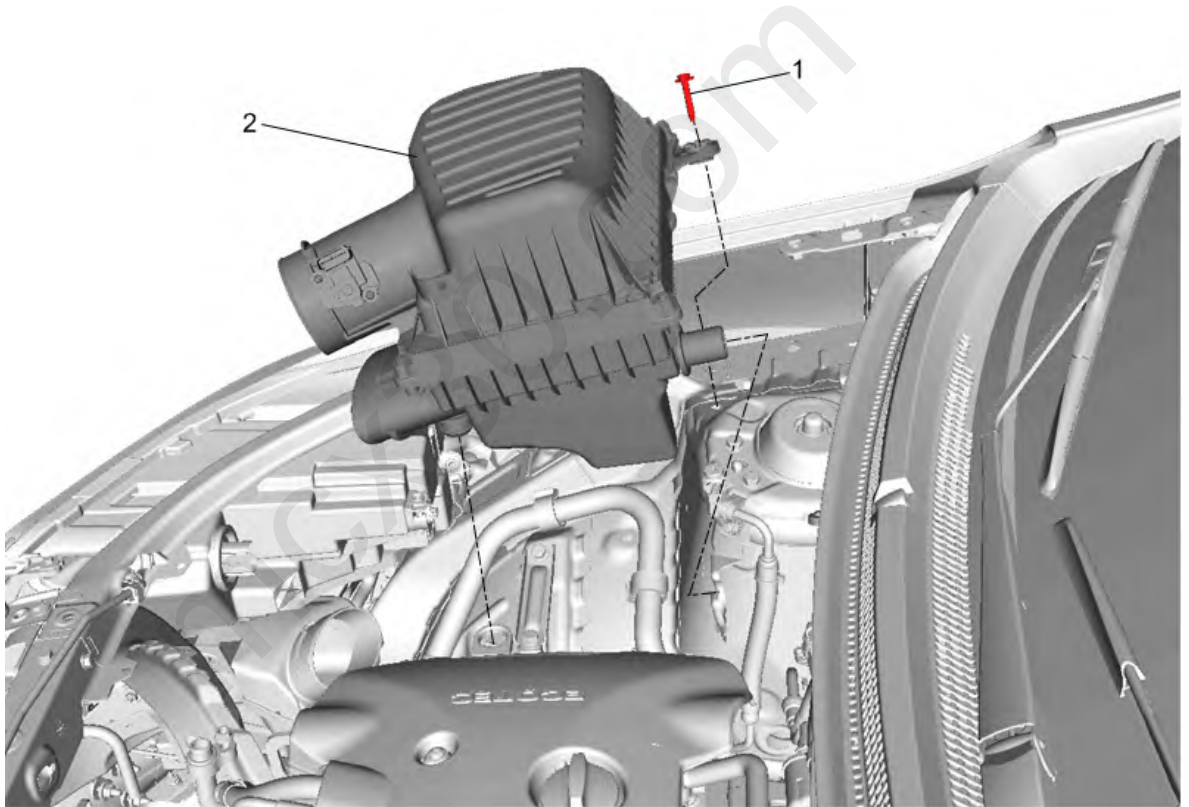


Fig. 270: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

26. Install Air Cleaner Assembly (2) - [Air Cleaner Assembly Replacement](#) .

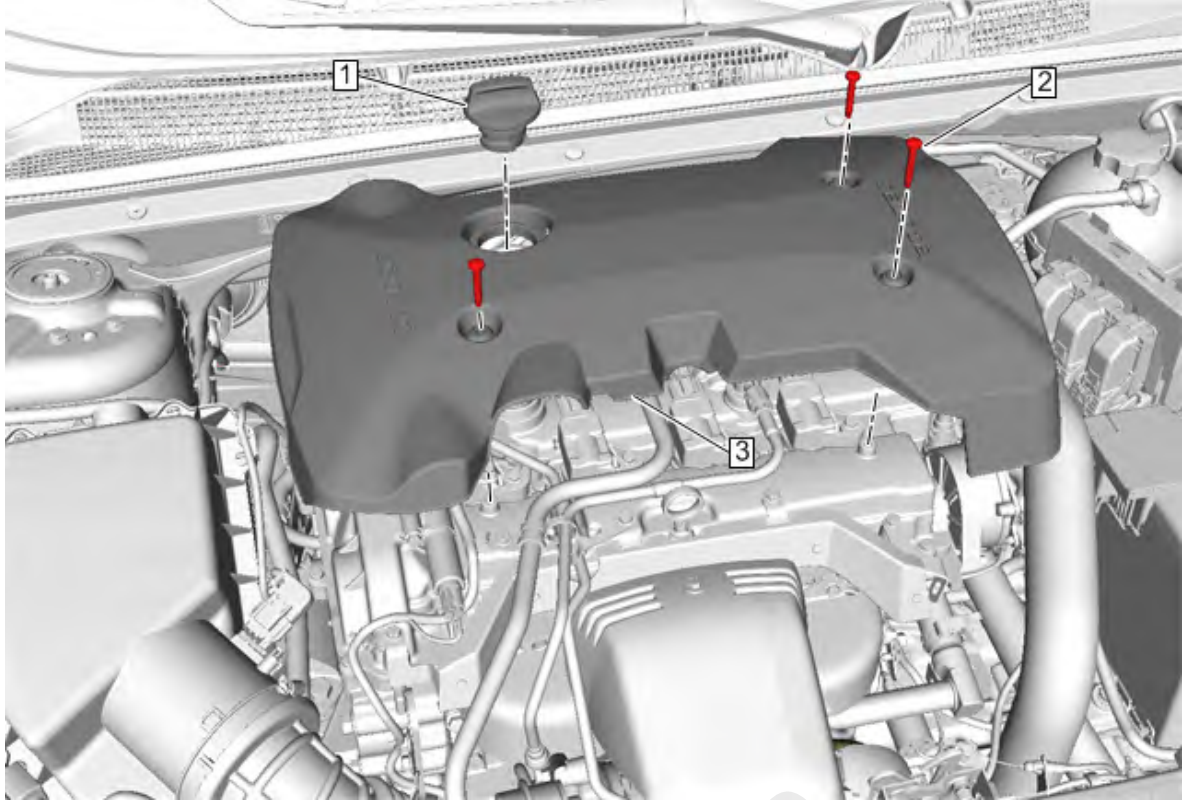


Fig. 271: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

27. Install Intake Manifold Cover (3) - [Intake Manifold Cover Replacement](#)
28. Install the battery tray. [Battery Tray Replacement](#)
29. Recharge the A/C system. [Refrigerant Recovery and Recharging \(R-134a\) Refrigerant Recovery and Recharging \(R-1234yf\)](#) .
30. Fill the cooling system. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#) .

NOTE: **Prelube is necessary if the engine is replaced or overhauled.**

31. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. [Engine Prelubing](#).
32. If prelubing has not been performed, fill the engine oil. [Engine Oil and Oil Filter Replacement](#).
33. Connect the negative battery cable. Refer to [Battery Negative Cable Disconnection and Connection \(KL9\)](#).
34. Perform the Crankshaft Position Variation Learn procedure. [Crankshaft Position Variation Learn](#)

ENGINE REPLACEMENT (ALL WHEEL DRIVE)

Removal Procedure

1. Relieve the fuel system pressure. [Fuel Pressure Relief](#)
2. Recover the refrigerant. [Refrigerant Recovery and Recharging \(R-134a\) Refrigerant Recovery and Recharging \(R-1234yf\)](#)
3. Drain the cooling system. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#)
4. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
5. Remove Battery Tray -[Battery Tray Replacement](#)

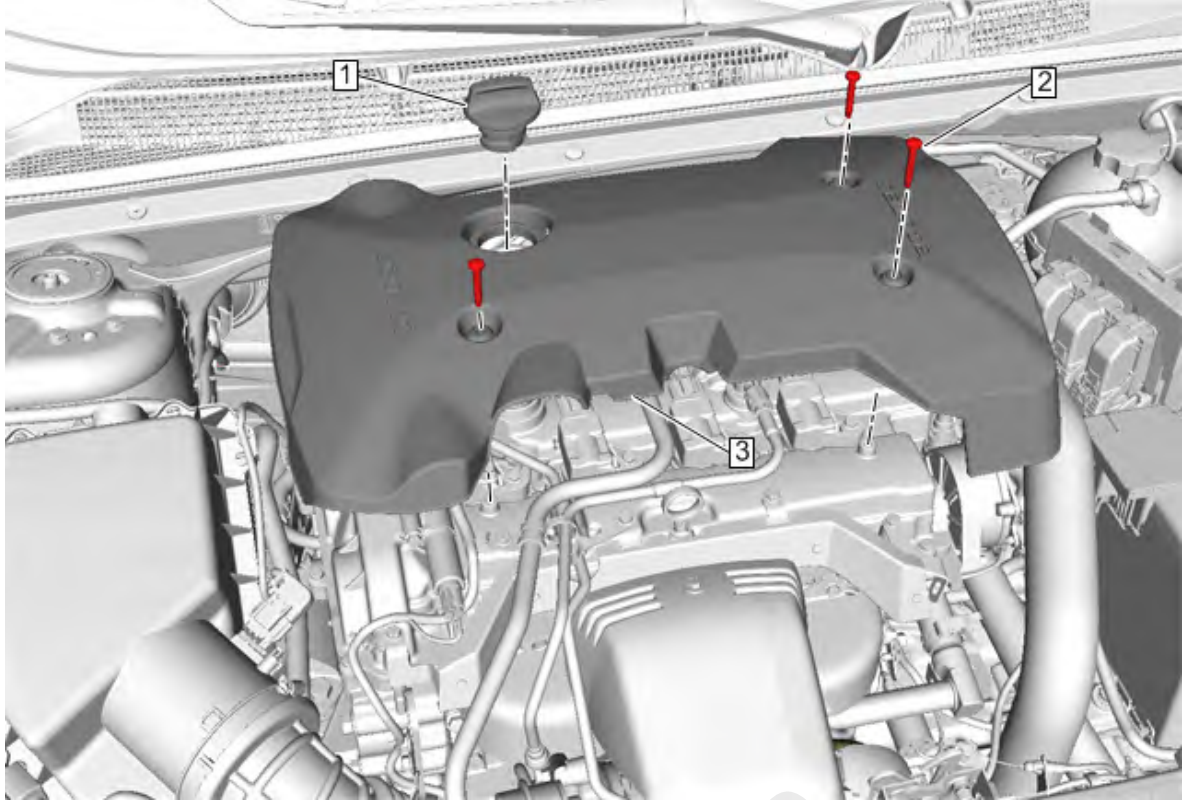


Fig. 272: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

6. Remove Intake Manifold Cover (3) - [Intake Manifold Cover Replacement](#)

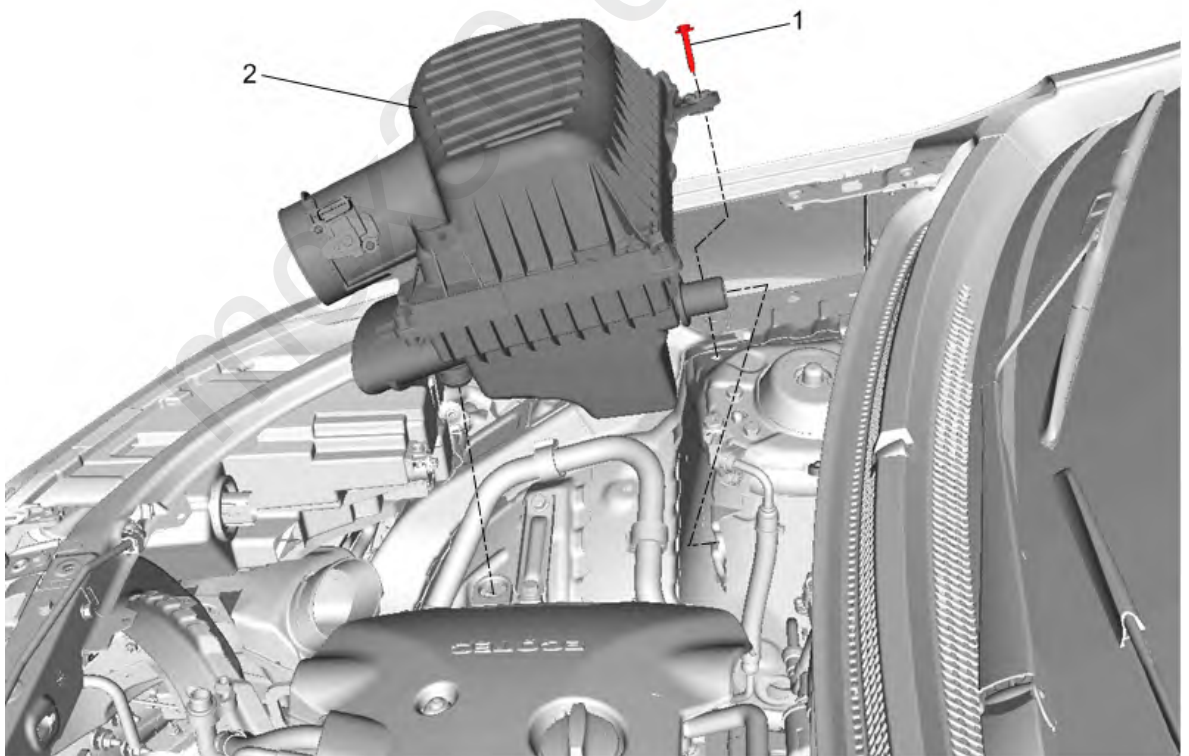


Fig. 273: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

7. Remove Air Cleaner Assembly (2) - [Air Cleaner Assembly Replacement](#) .

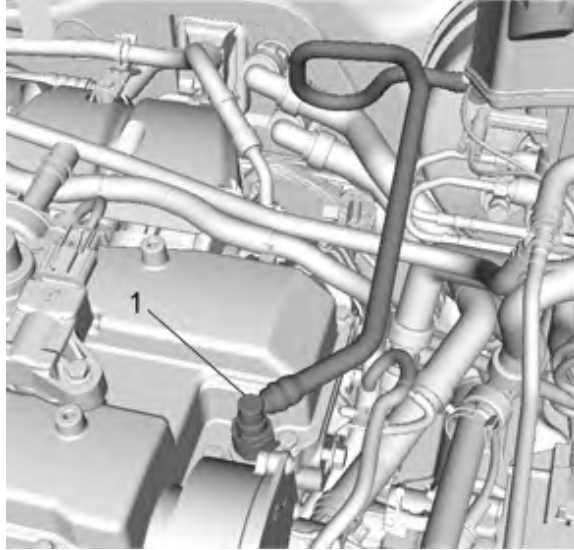


Fig. 274: Vacuum Hose

Courtesy of GENERAL MOTORS COMPANY

8. Disconnect Power Brake Booster Vacuum Pipe (1) - [Plastic Collar Quick Connect Fitting Service](#)

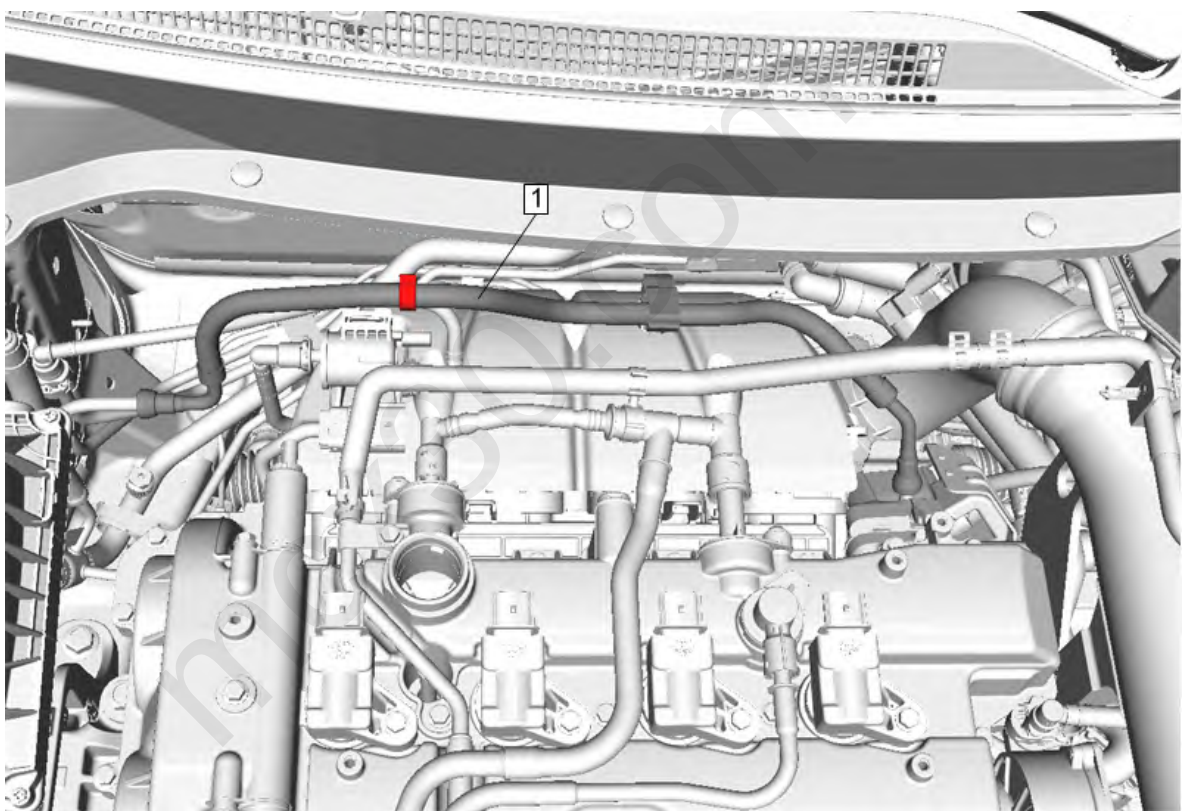


Fig. 275: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

9. Remove Fuel Feed Front Pipe (1) - [Fuel Feed Front Pipe Replacement](#)

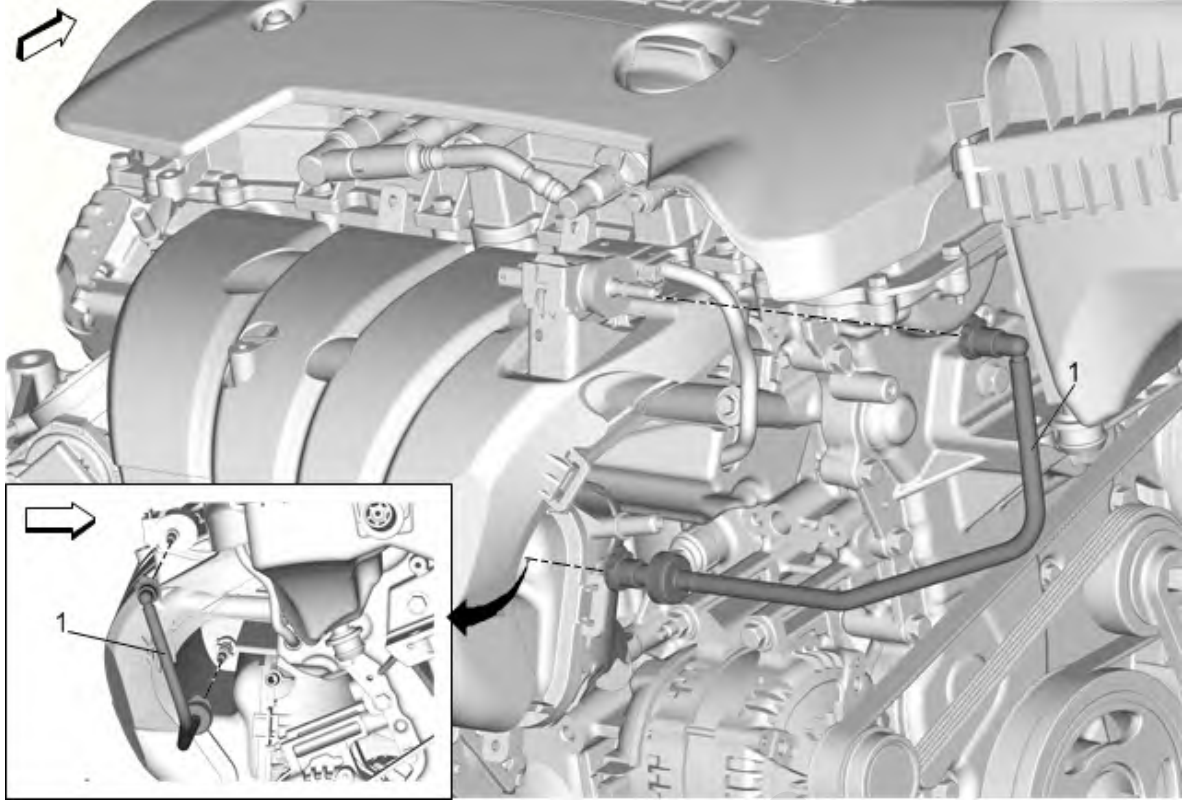


Fig. 276: Evaporative Emission Canister Purge Tube

Courtesy of GENERAL MOTORS COMPANY

10. Remove Evaporative Emission Canister Purge Tube (1) - **Evaporative Emission Canister Purge Tube Replacement**

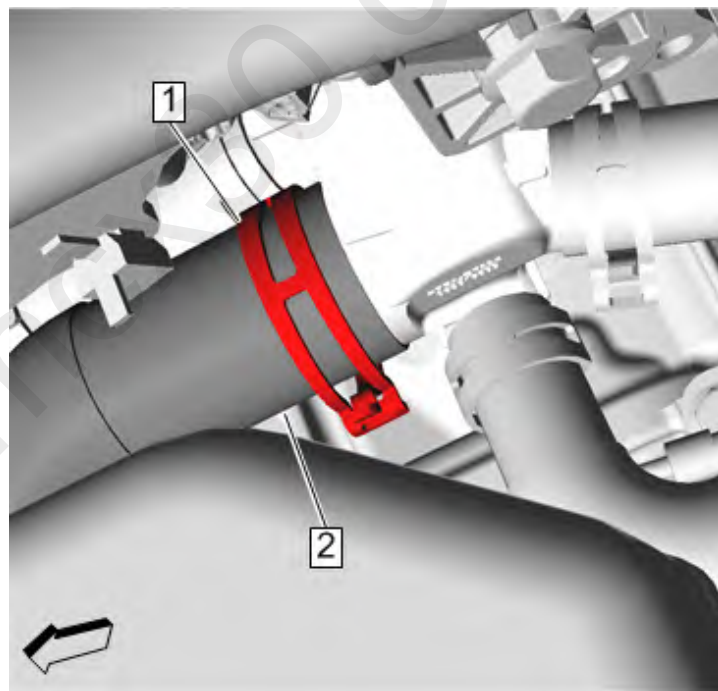


Fig. 277: Heater Inlet Hose

Courtesy of GENERAL MOTORS COMPANY

11. Disconnect Heater Inlet Hose (2) @ Water Outlet - **Heater Inlet Hose Replacement (LTG with KL9)**

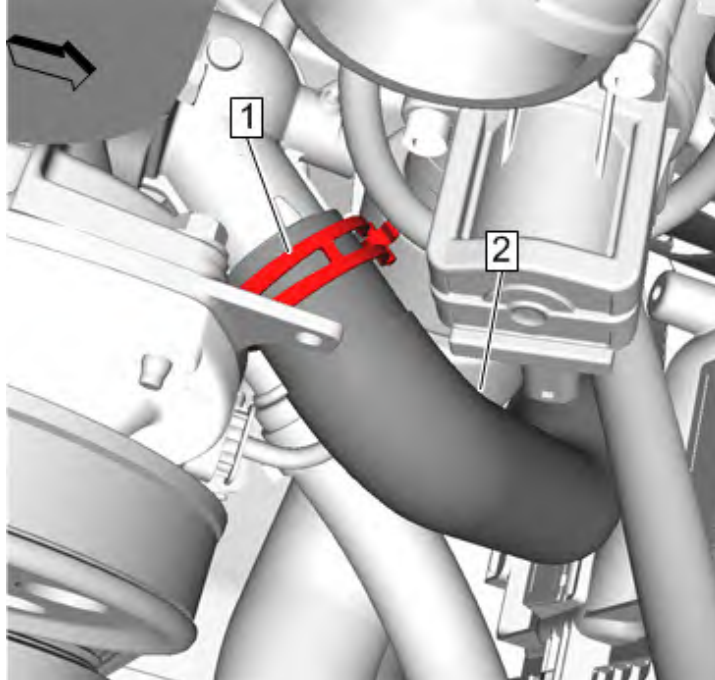


Fig. 278: Radiator Outlet Hose

Courtesy of GENERAL MOTORS COMPANY

12. Disconnect Radiator Outlet Hose (2) @ Engine Coolant Thermostat Housing - [Radiator Outlet Hose Replacement \(LTG with KL9\)](#)

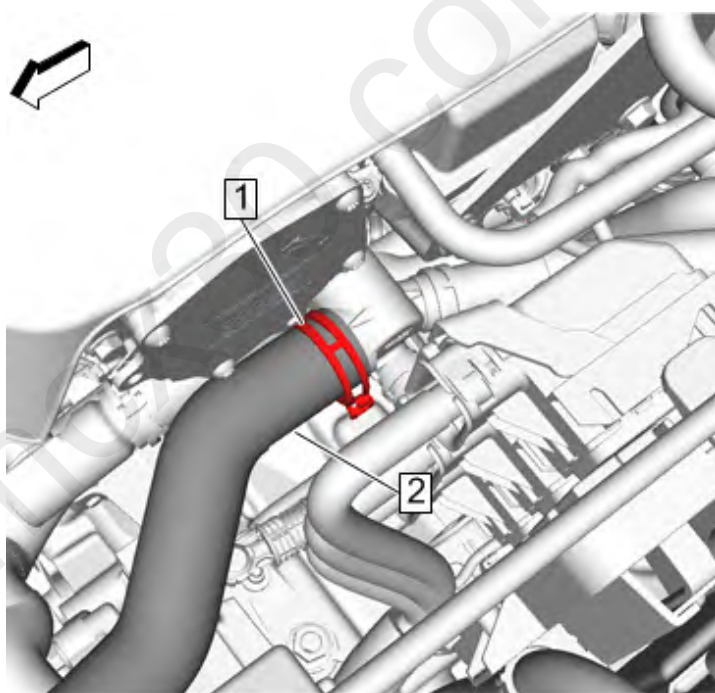


Fig. 279: Radiator Inlet Hose Clamp

Courtesy of GENERAL MOTORS COMPANY

13. Disconnect Radiator Inlet Hose (2) @ Water Outlet - [Radiator Inlet Hose Replacement \(LTG with KL9\)](#)

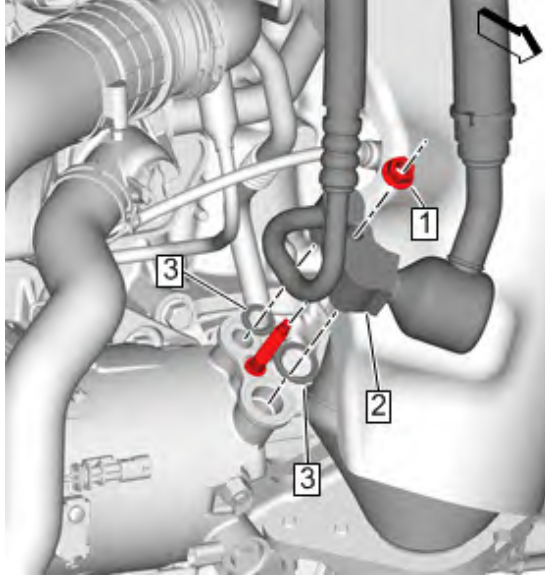


Fig. 280: Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose
 Courtesy of GENERAL MOTORS COMPANY

14. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor - **Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement (LTG)**

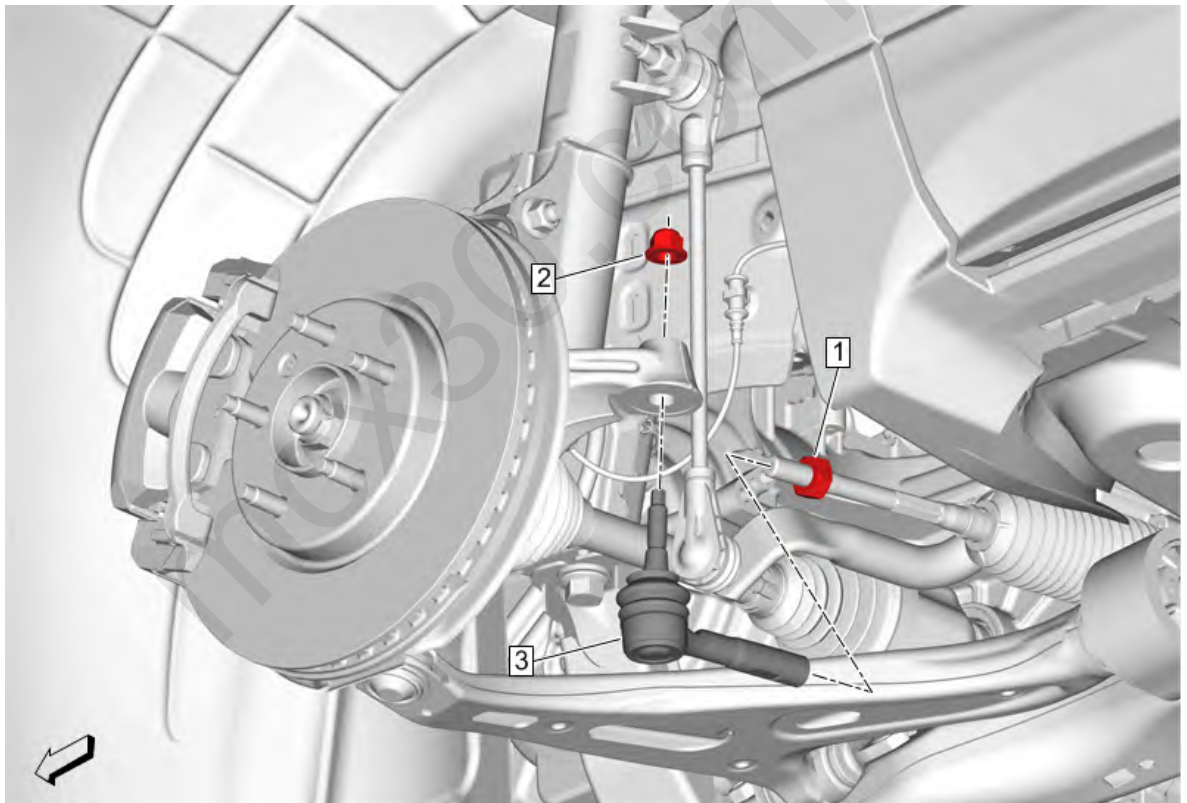


Fig. 281: Steering Linkage Outer Tie Rod
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Left side shown, right side similar.

15. Disconnect Steering Linkage Outer Tie Rod (3) @ Steering Knuckle - **Steering Linkage Outer Tie Rod Replacement**

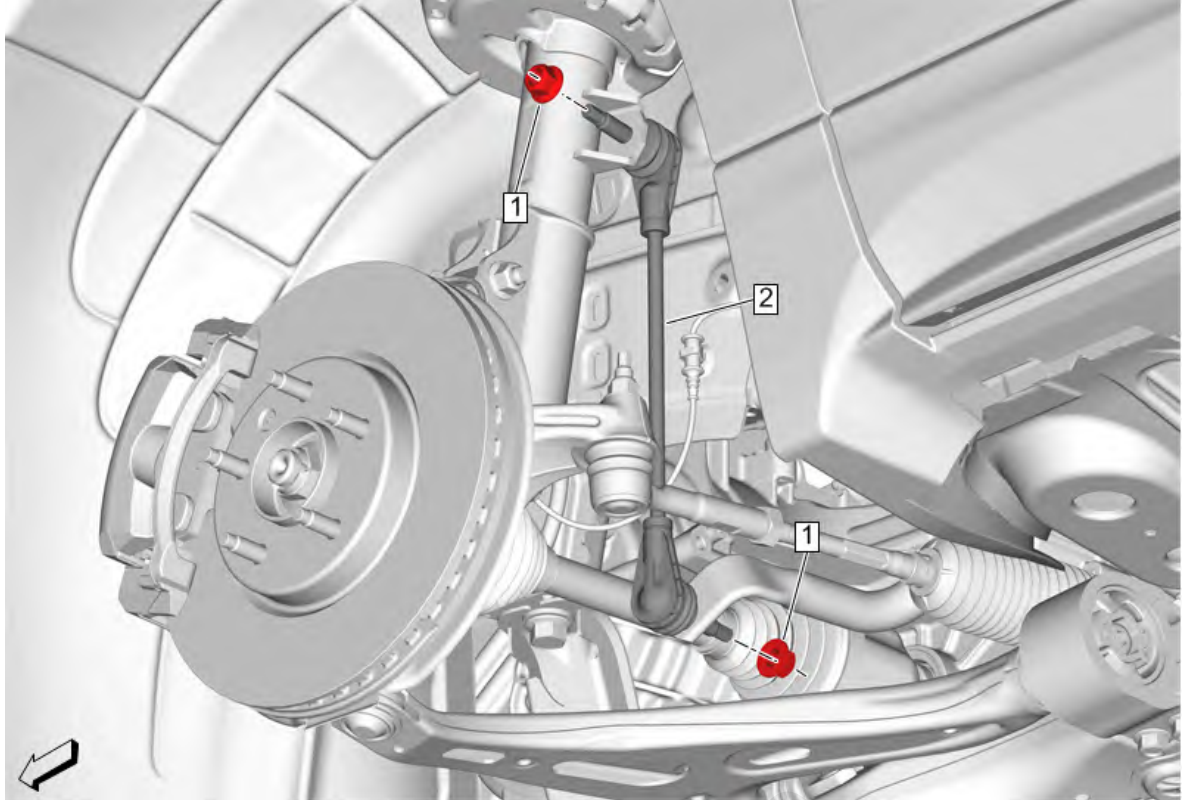


Fig. 282: Upper Stabilizer Shaft Link Nut

Courtesy of GENERAL MOTORS COMPANY

16. Disconnect Stabilizer Shaft Link (2) @ Stabilizer Shaft - [Stabilizer Shaft Link Replacement \(Equinox\)](#).
[Stabilizer Shaft Link Replacement \(Terrain\)](#).

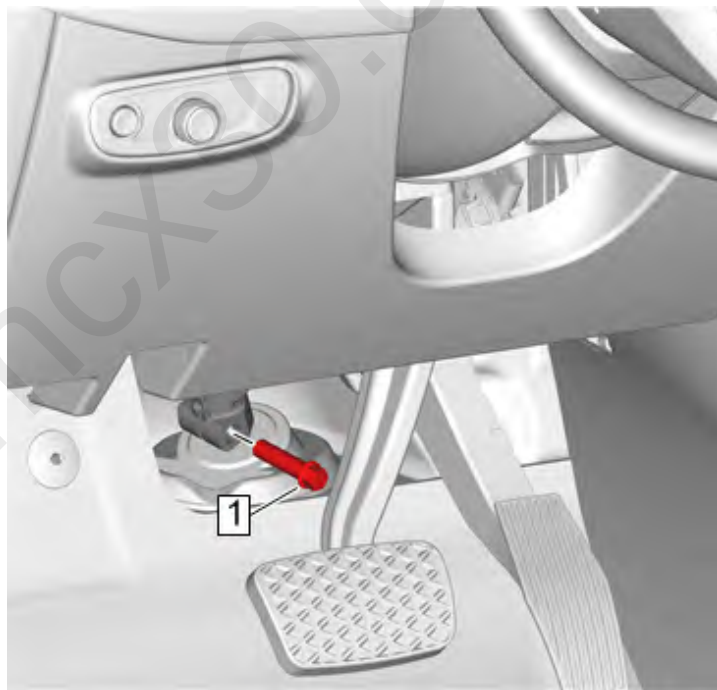


Fig. 283: Intermediate Shaft Pinch Bolt

Courtesy of GENERAL MOTORS COMPANY

17. Remove the intermediate shaft pinch bolt (1), then disconnect the intermediate shaft from the steering gear.
[Intermediate Steering Shaft Replacement \(Equinox\)](#). [Intermediate Steering Shaft Replacement \(Terrain\)](#).
18. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LTG\)](#)

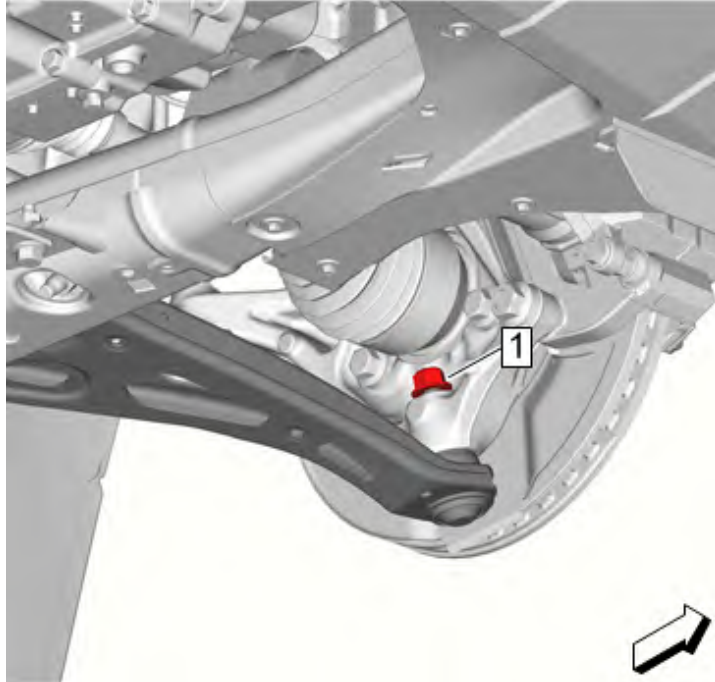


Fig. 284: Lower Control Arm To Steering Knuckle Nut
 Courtesy of GENERAL MOTORS COMPANY

19. Remove the front lower control arm ball stud nuts (1) then disconnect the lower control arms from the steering knuckles. [Lower Control Arm Replacement \(Equinox\)](#). [Lower Control Arm Replacement \(Terrain\)](#).
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 \(AWD\)](#).
22. Remove Propeller Shaft - [Two-Piece Propeller Shaft Replacement](#)

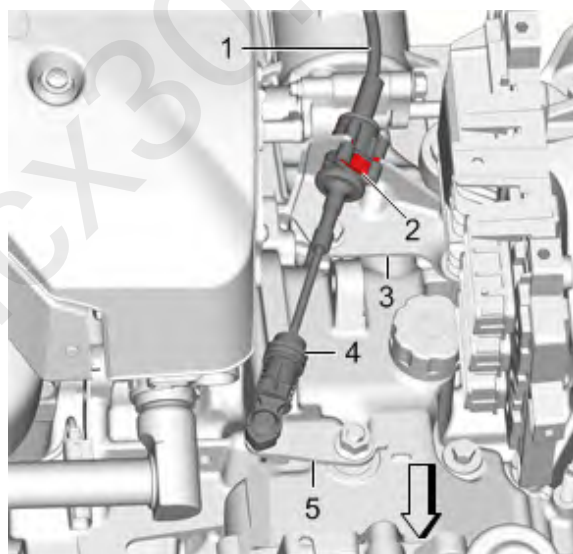


Fig. 285: Transmission Range Selector Lever Cable Components
 Courtesy of GENERAL MOTORS COMPANY

23. Disconnect the range selector lever cable terminal from the transmission manual shift lever.

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

24. Position an engine support table under the powertrain assembly.
25. Blocks of wood can be used between the front of the frame and the oil pan to table in order to level the powertrain during the removal.
26. With the table positioned, fully raise the table to contact with the powertrain assembly.

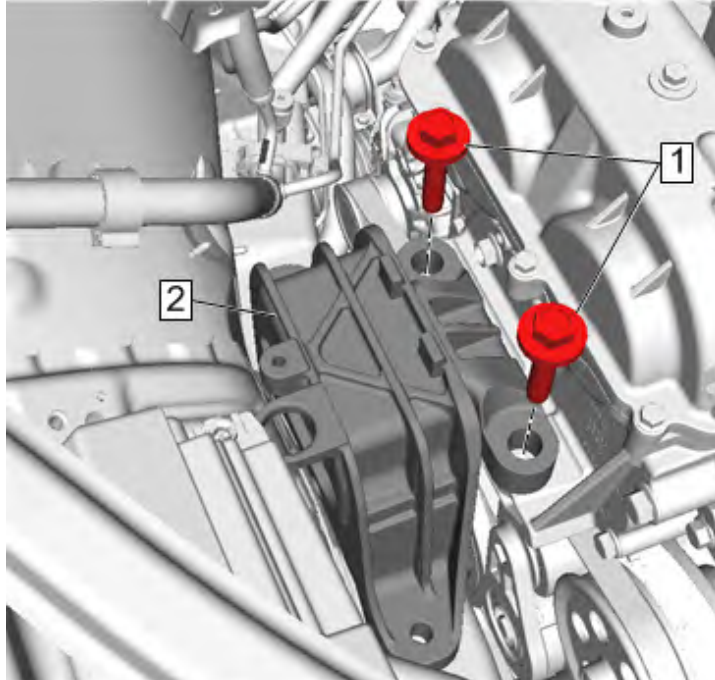


Fig. 286: Engine Mount Bracket Bolts

Courtesy of GENERAL MOTORS COMPANY

27. Remove Engine Mount Bolt (1) - [Engine Mount Replacement](#)
28. Remove Transmission Mount - [Transmission Mount Replacement \(Left Side M3U\)](#) [Transmission Mount Replacement \(Left Side M3D/M3H\)](#)

NOTE: Remove **ONLY** the body to frame bolts as the powertrain will be removed while still bolted to the frame.

29. Remove the frame to body bolts. [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)
30. Disconnect electrical connectors as necessary.
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 transaxle. [Transmission Replacement \(All Wheel Drive\)](#)
33. Install the engine to a suitable engine stand.

Installation Procedure

1. Install the engine to the transaxle. [Transmission Replacement \(All Wheel Drive\)](#)
2. Position the powertrain 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.
5. Install the frame to body bolts. [Drivetrain and Front Suspension Cradle Replacement \(All Wheel Drive\)](#)
6. Lower the vehicle.
7. Install Transmission Mount - [Transmission Mount Replacement \(Left Side M3U\)](#) [Transmission Mount Replacement \(Left Side M3D/M3H\)](#)

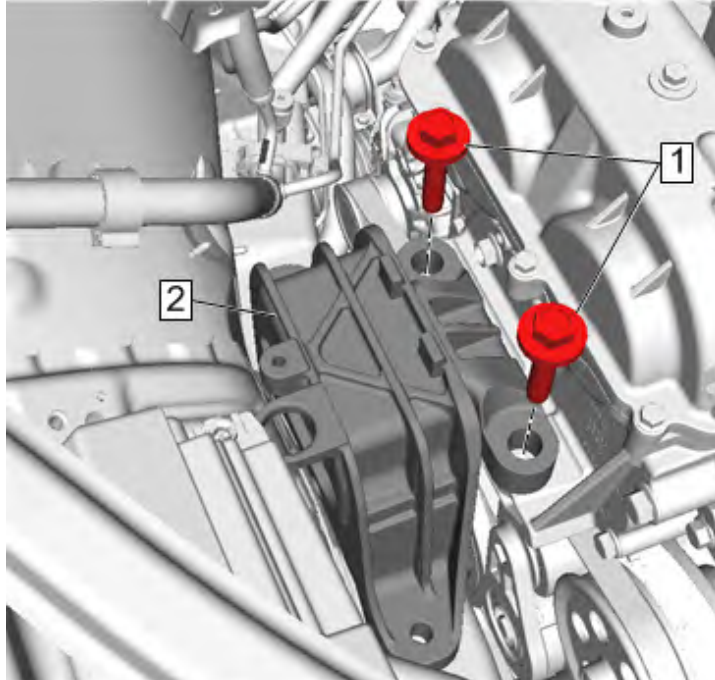


Fig. 287: Engine Mount Bracket Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Install Engine Mount Bolt (1) - [Engine Mount Replacement](#)

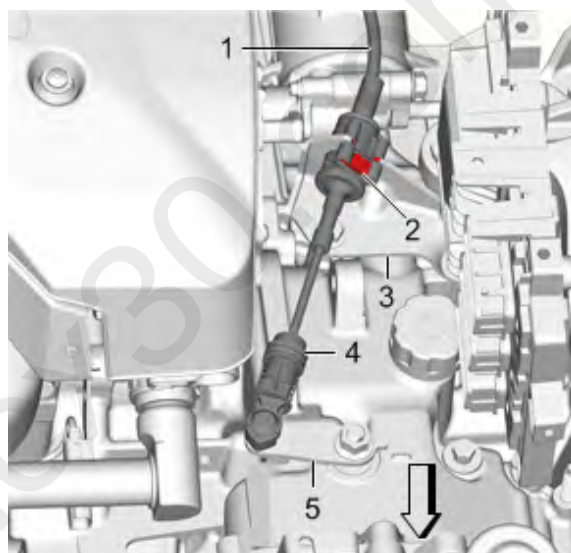


Fig. 288: Transmission Range Selector Lever Cable Components
Courtesy of GENERAL MOTORS COMPANY

9. Connect the range selector lever cable terminal (4) to the transmission manual shift lever (5)
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 \(AWD\)](#)
12. Install Propeller Shaft - [Two-Piece Propeller Shaft Replacement](#)

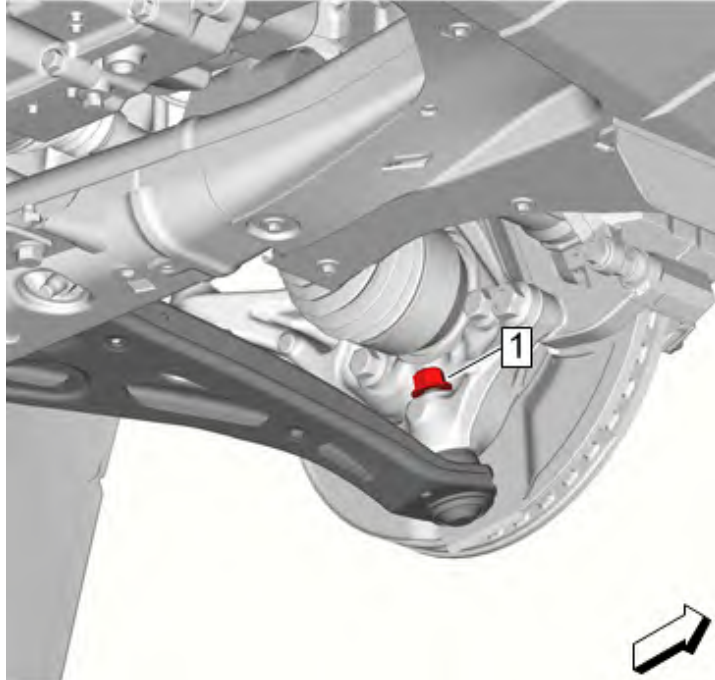


Fig. 289: Lower Control Arm To Steering Knuckle Nut
 Courtesy of GENERAL MOTORS COMPANY

13. Connect the lower control arms to the steering knuckles then install the lower control arm ball stud nuts (1).
Lower Control Arm Replacement (Equinox) Lower Control Arm Replacement (Terrain)
14. Install Exhaust Front Pipe - Exhaust Front Pipe Replacement (LTG)

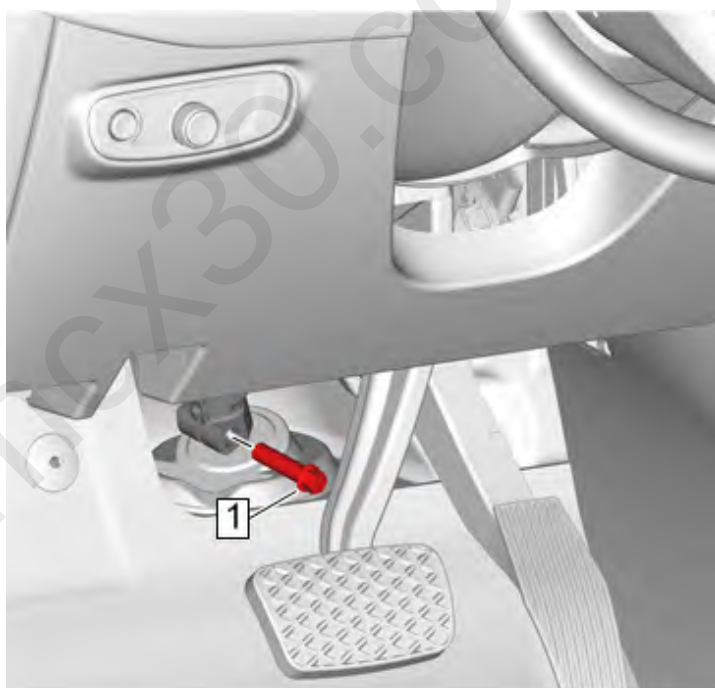


Fig. 290: Intermediate Shaft Pinch Bolt
 Courtesy of GENERAL MOTORS COMPANY

15. Connect the intermediate shaft to the steering gear then install the pinch bolt (1). Intermediate Steering Shaft Replacement (Equinox) Intermediate Steering Shaft Replacement (Terrain)

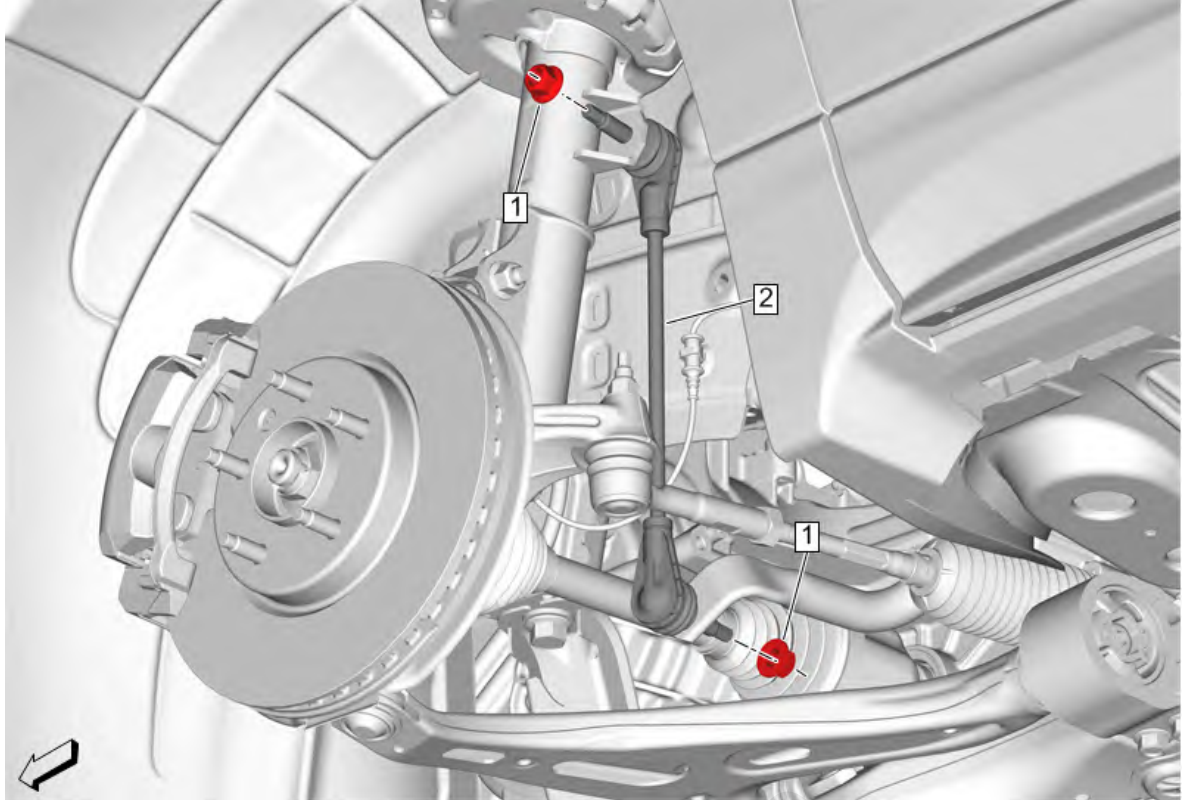


Fig. 291: Upper Stabilizer Shaft Link Nut

Courtesy of GENERAL MOTORS COMPANY

16. Connect Stabilizer Shaft Link (2) @ Stabilizer Shaft - [Stabilizer Shaft Link Replacement \(Equinox\)](#)
[Stabilizer Shaft Link Replacement \(Terrain\)](#)

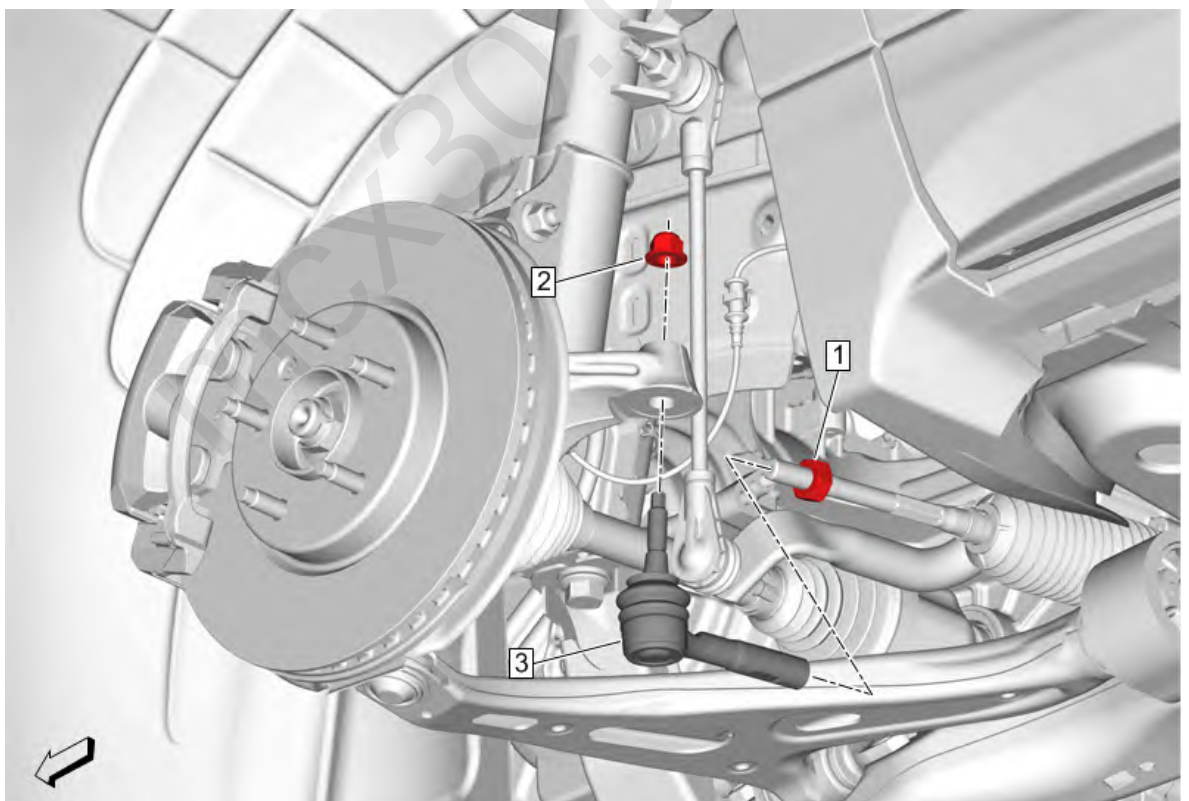


Fig. 292: Steering Linkage Outer Tie Rod

Courtesy of GENERAL MOTORS COMPANY

NOTE: Left side shown, right side similar.

17. Connect Steering Linkage Outer Tie Rod (3) @ Steering Knuckle - [Steering Linkage Outer Tie Rod Replacement](#)

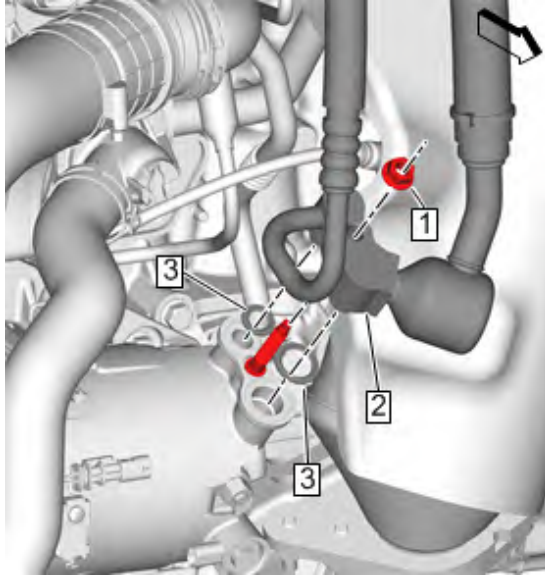


Fig. 293: Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose
 Courtesy of GENERAL MOTORS COMPANY

18. Disconnect Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose (2) @ Air Conditioning Compressor - [Air Conditioning Evaporator Connector Hose/Tube and Compressor Hose Replacement \(LTG\)](#)

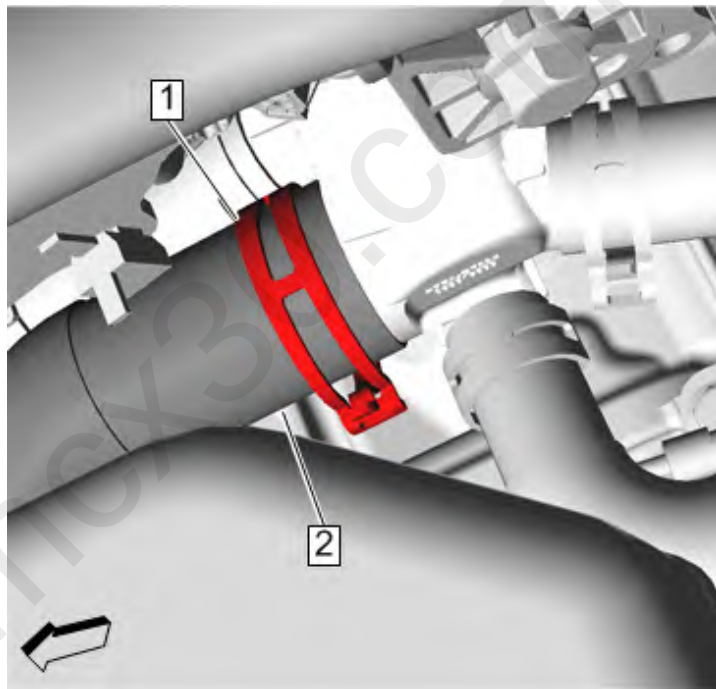


Fig. 294: Heater Inlet Hose
 Courtesy of GENERAL MOTORS COMPANY

19. Connect Heater Inlet Hose (2) @ Water Outlet - [Heater Inlet Hose Replacement \(LTG with KL9\)](#)

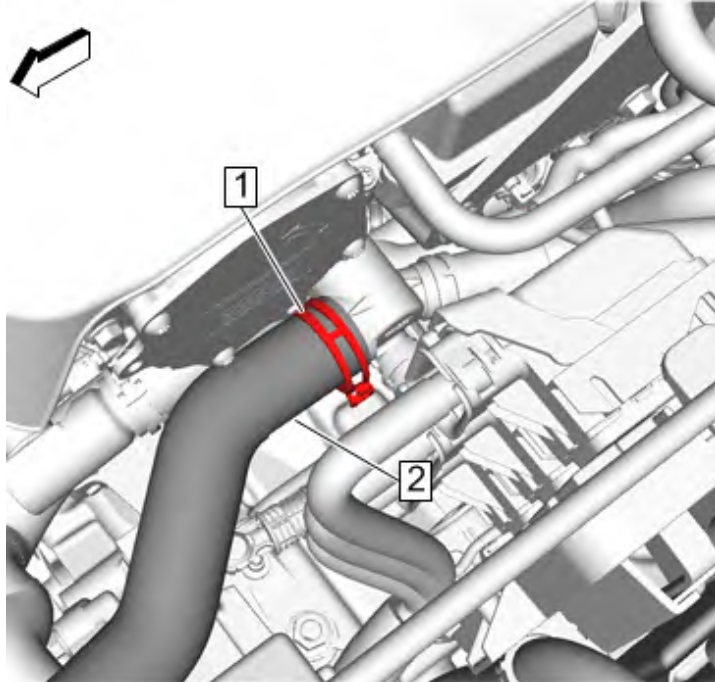


Fig. 295: Radiator Inlet Hose Clamp

Courtesy of GENERAL MOTORS COMPANY

20. Connect Radiator Inlet Hose (2) @ Water Outlet - **Radiator Inlet Hose Replacement (LTG with KL9)**

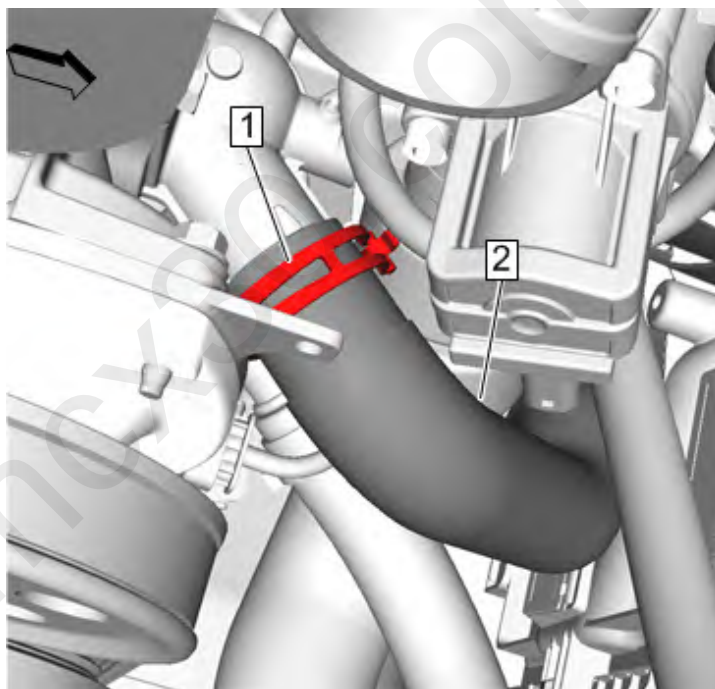


Fig. 296: Radiator Outlet Hose

Courtesy of GENERAL MOTORS COMPANY

21. Connect Radiator Outlet Hose (2) @ Engine Coolant Thermostat Housing - **Radiator Outlet Hose Replacement (LTG with KL9)**
22. Install Heater Core Outlet Hose - **Heater Outlet Hose Replacement (LYX without KL9)** **Heater Outlet Hose Replacement (LH7)** .

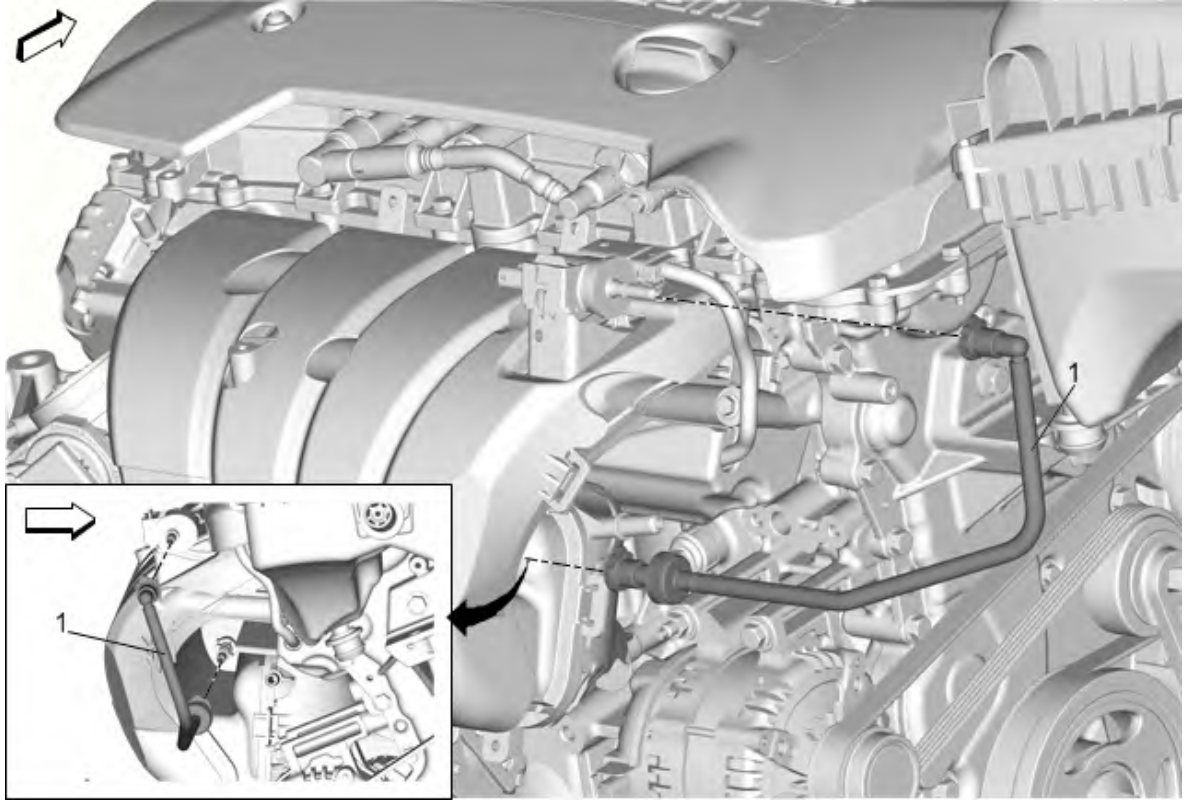


Fig. 297: Evaporative Emission Canister Purge Tube

Courtesy of GENERAL MOTORS COMPANY

23. Install Evaporative Emission Canister Purge Tube (1) - **Evaporative Emission Canister Purge Tube Replacement**

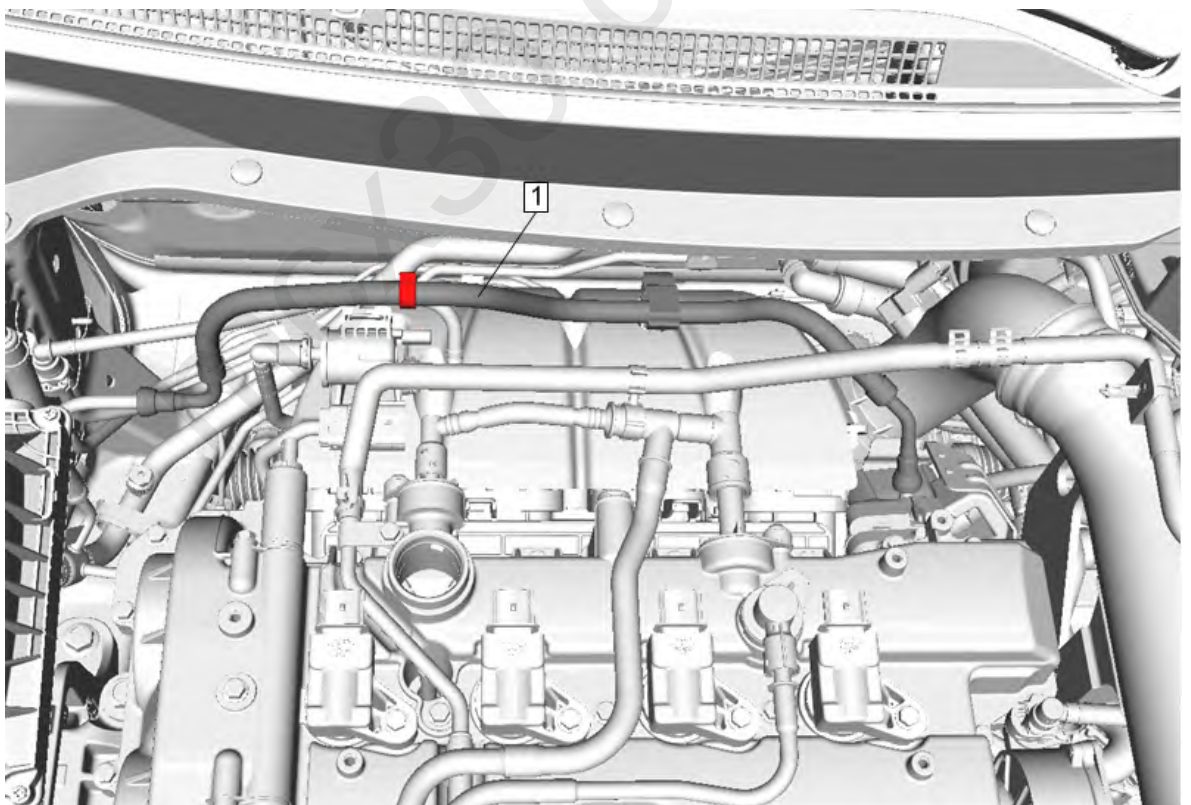


Fig. 298: Fuel Feed Front Pipe

Courtesy of GENERAL MOTORS COMPANY

24. Install Fuel Feed Front Pipe (1) - **Fuel Feed Front Pipe Replacement**

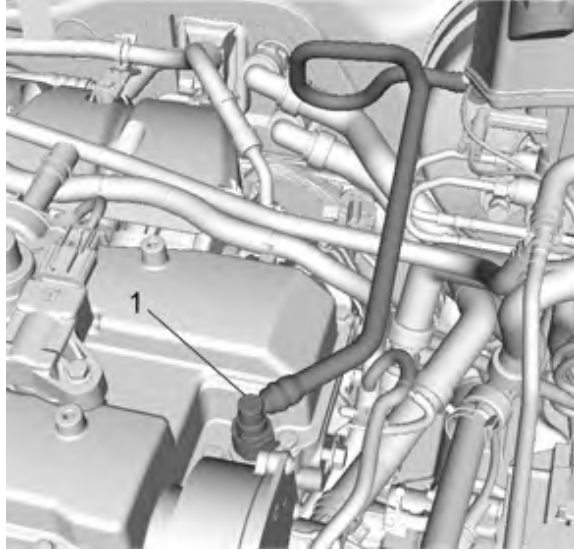


Fig. 299: Vacuum Hose

Courtesy of GENERAL MOTORS COMPANY

25. Connect Power Brake Booster Vacuum Pipe (1) - [Plastic Collar Quick Connect Fitting Service](#)
26. Connect electrical connectors as needed.

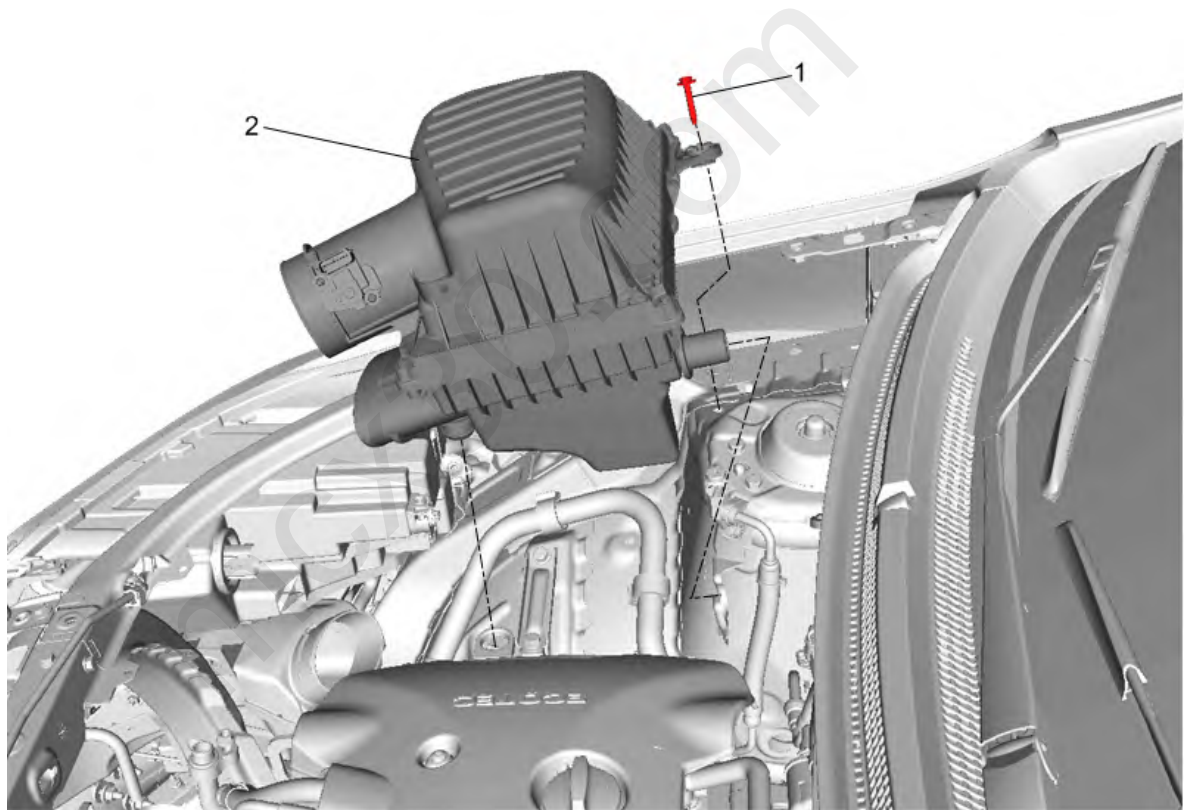


Fig. 300: Air Cleaner Assembly

Courtesy of GENERAL MOTORS COMPANY

27. Install Air Cleaner Assembly (2) - [Air Cleaner Assembly Replacement](#) .

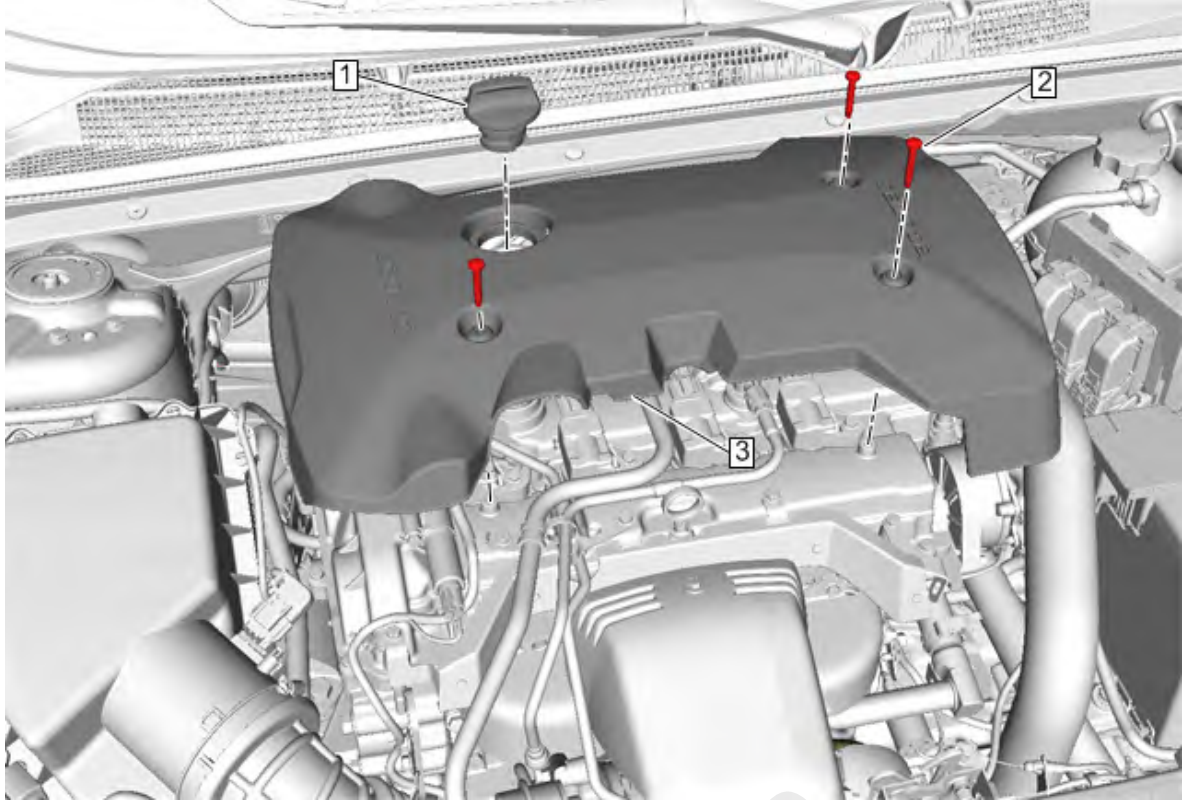


Fig. 301: Intake Manifold Cover

Courtesy of GENERAL MOTORS COMPANY

28. Install Intake Manifold Cover (3) - [Intake Manifold Cover Replacement](#)
29. Install the battery tray. [Battery Tray Replacement](#)
30. Recharge the A/C system. [Refrigerant Recovery and Recharging \(R-134a\) Refrigerant Recovery and Recharging \(R-1234yf\)](#) .
31. Fill the cooling system. [Cooling System Draining and Filling \(GE 47716\) Cooling System Draining and Filling \(Static\)](#) .

NOTE: **Prelube is necessary if the engine is replaced or overhauled.**

32. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. [Engine Prelubing](#).
33. If prelubing has not been performed, fill the engine oil. [Engine Oil and Oil Filter Replacement](#).
34. Connect the negative battery cable. [Battery Negative Cable Disconnection and Connection \(KL9\)](#) .
35. Perform the Crankshaft Position Variation Learn procedure. [Crankshaft Position Variation Learn](#)

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.

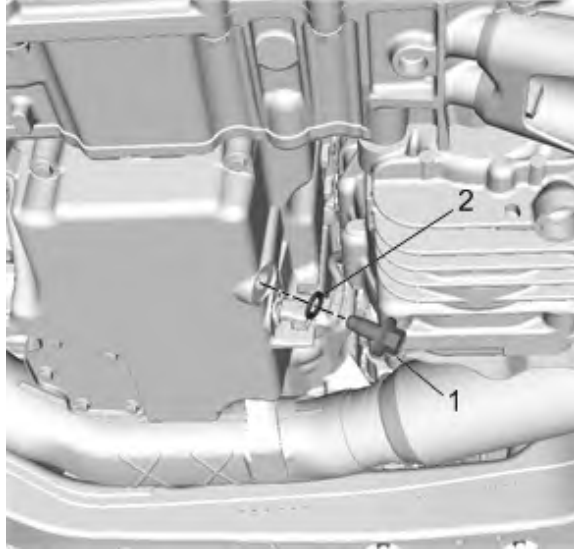


Fig. 302: Oil Pan Drain Plug And Seal

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).

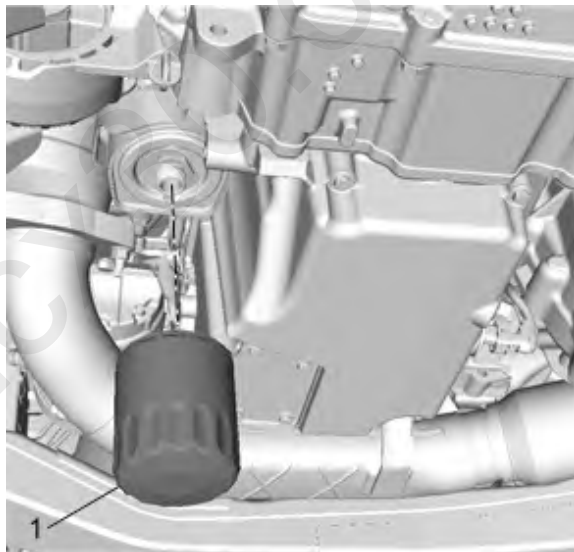


Fig. 303: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

6. Place a drain pan under the vehicle.
7. Remove and DISCARD the oil filter (1)
8. Ensure that the old oil filter seal has been removed.

Installation Procedure

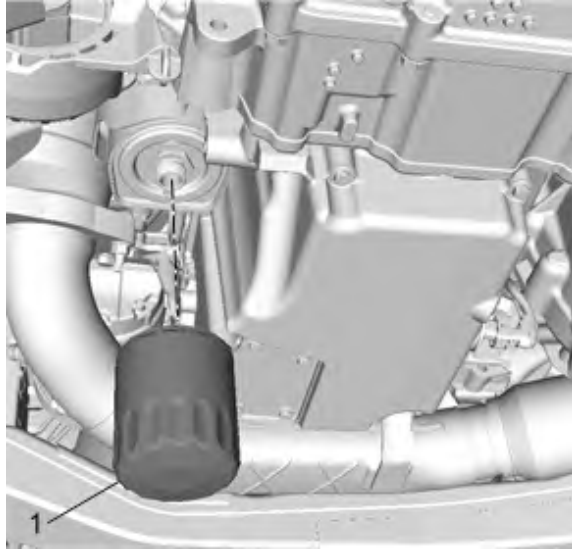


Fig. 304: Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the NEW oil filter gasket with clean engine oil.
2. Install a NEW oil filter and tighten $\frac{3}{4}$ 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 with NEW engine oil.
6. Start the engine and inspect for leaks.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

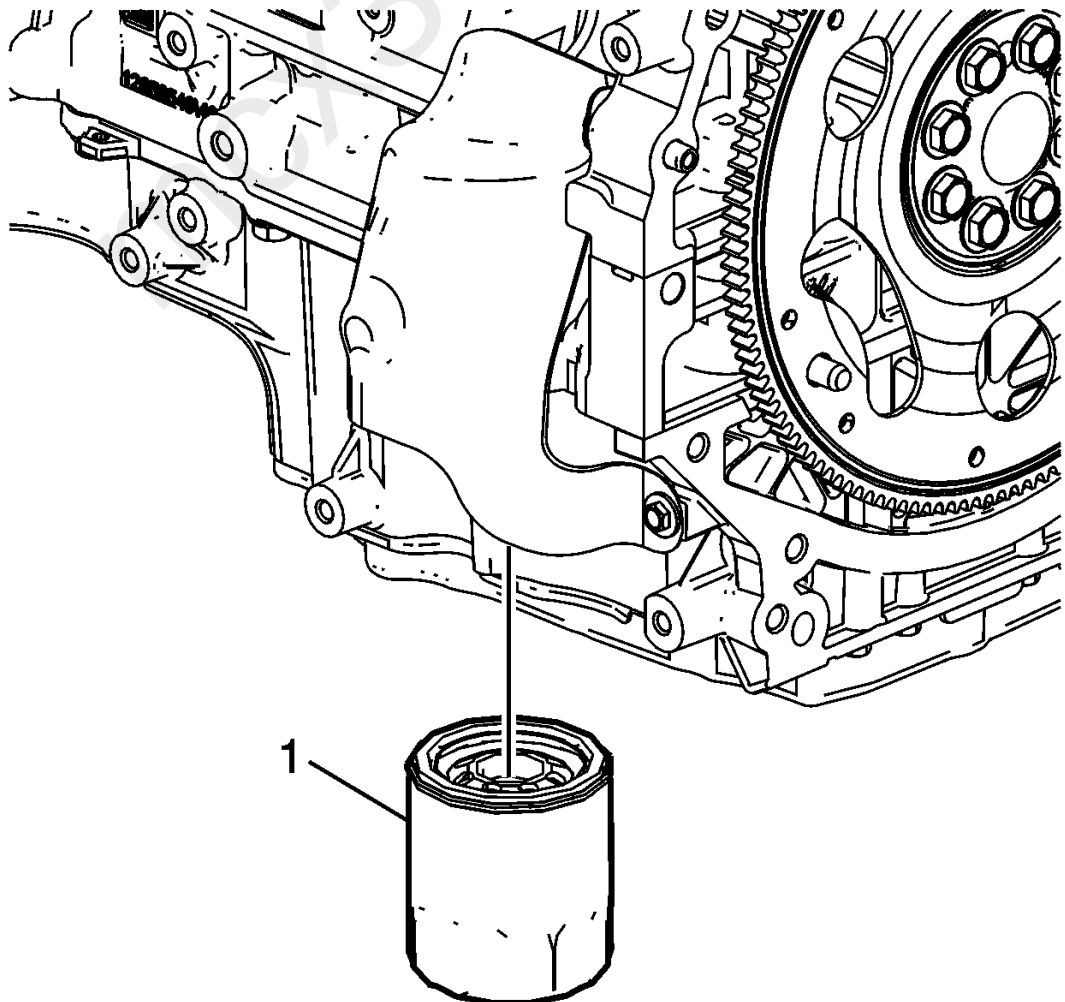


Fig. 305: Engine Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil filter (1). Remove the oil pan drain plug and allow the oil to drain out.
2. Clean the oil filter housing in the engine block.

CAUTION: Refer to **Fastener Caution** .

3. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
4. If cleaning or repairing the engine block, it is not necessary to reinstall the plug.

CRANKSHAFT BALANCER REMOVAL

Special Tools

- EN-38416-2 Crankshaft Button
- EN-41816 Crankshaft Balancer Remover
- EN-41816-2 Crankshaft End Protector
- EN - 51760 Flywheel Holding Tool

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

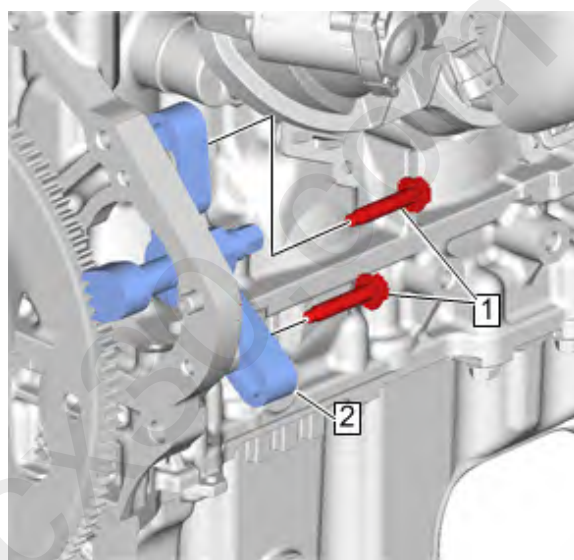


Fig. 306: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install **EN-51760** holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

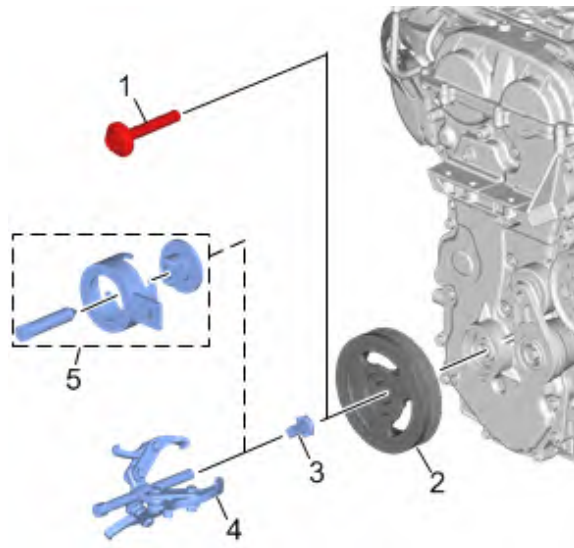


Fig. 307: Crankshaft Balancer

Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the crankshaft balancer bolt (1) and washer.

NOTE: When necessary, EN-38416-2 button can be used instead of EN-41816-2 protector.

3. Install EN-41816-2 protector (3) to protect the crankshaft end during balancer removal.

NOTE: EN-51577-1 remover (5) can be used alternatively for EN-41816 remover (4).

4. Using EN-41816 remover (4), remove the balancer (2).
5. Remove the special tools.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

EN-51760 Flywheel Holding Tool

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

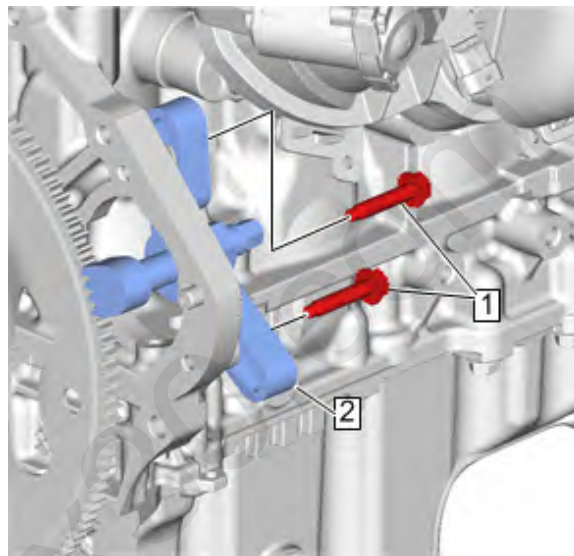


Fig. 308: Starter Motor Bolts
Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install EN-51760 holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

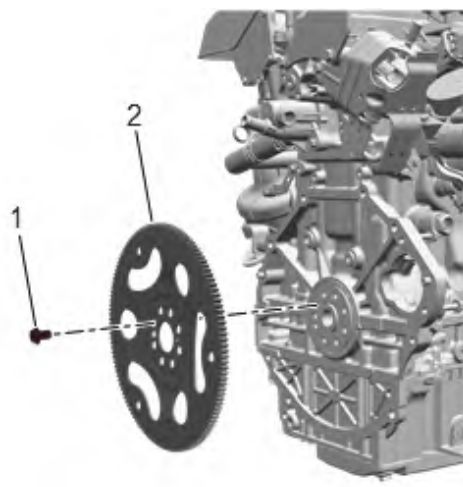


Fig. 309: Automatic Flex Plate Attaching Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the flywheel attaching bolts (1).

3. Remove the flywheel (2).
4. Remove **EN 51760** holding tool.

INTAKE MANIFOLD REMOVAL

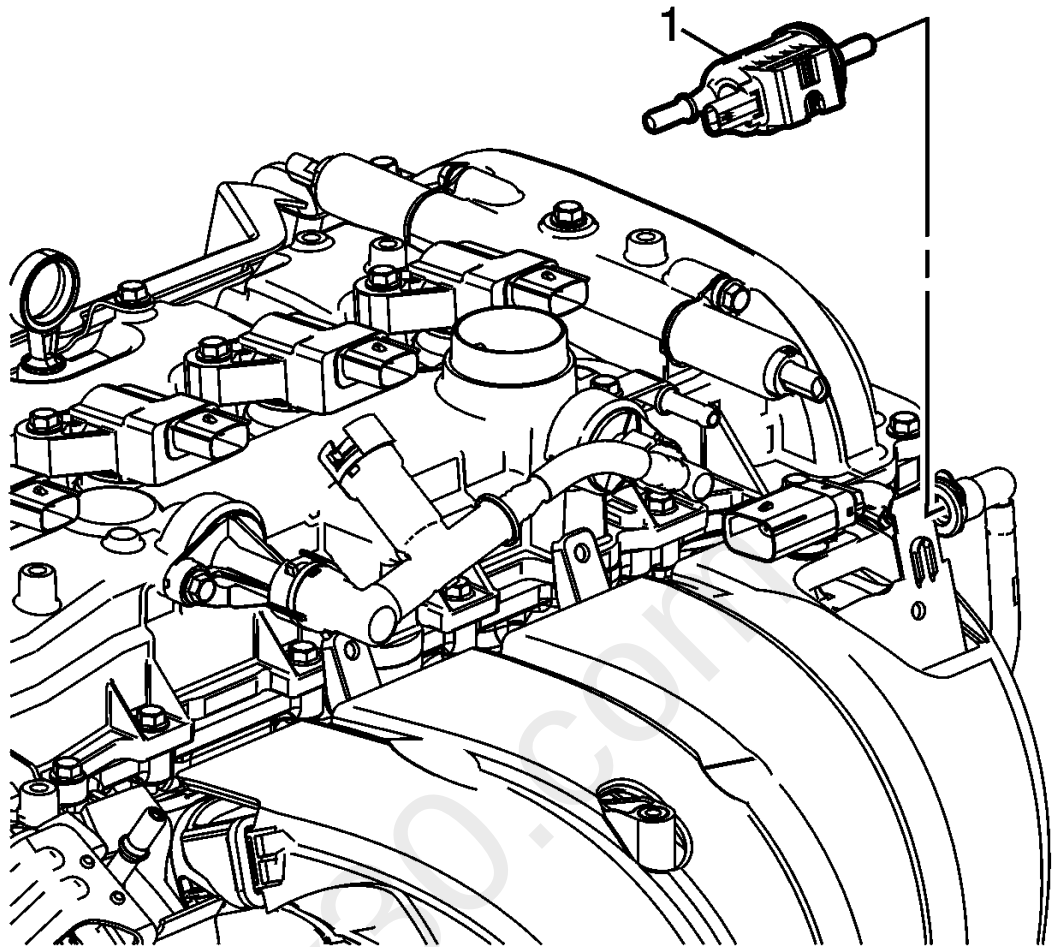


Fig. 310: EVAP Canister Valve

Courtesy of GENERAL MOTORS COMPANY

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

1. Remove the EVAP canister valve (1).

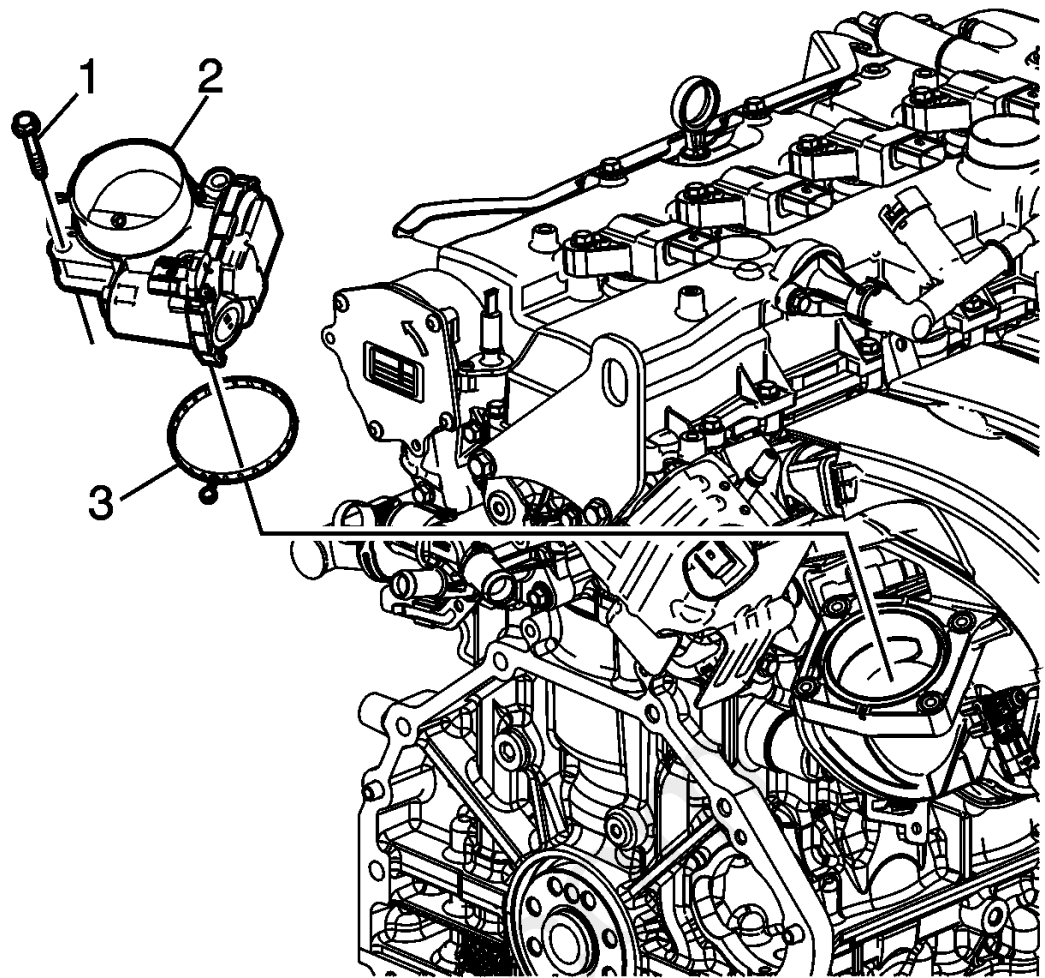


Fig. 311: Throttle Body Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Remove the throttle body bolts (1).
3. Remove the throttle body (2) and seal (3).

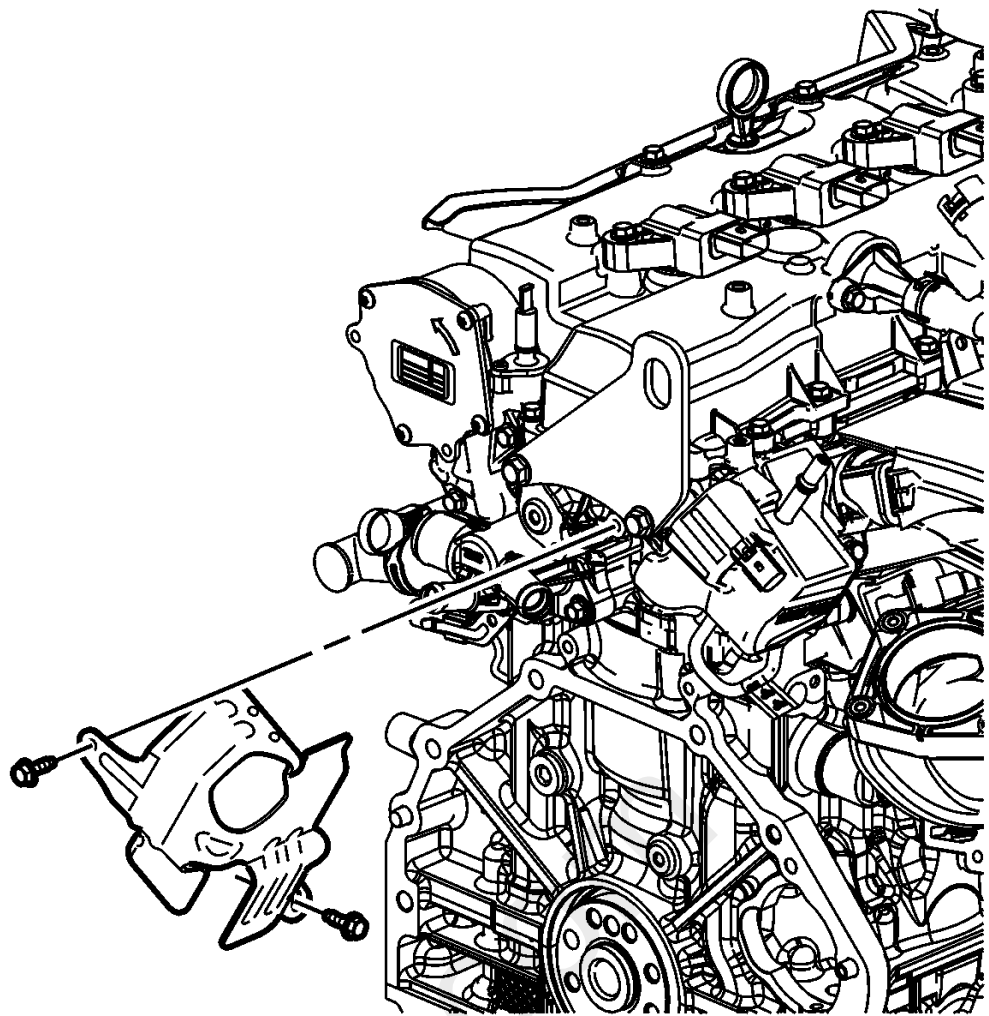


Fig. 312: Fuel Pump Cover Bolts And Cover
Courtesy of GENERAL MOTORS COMPANY

4. Remove the fuel pump cover bolts and cover.

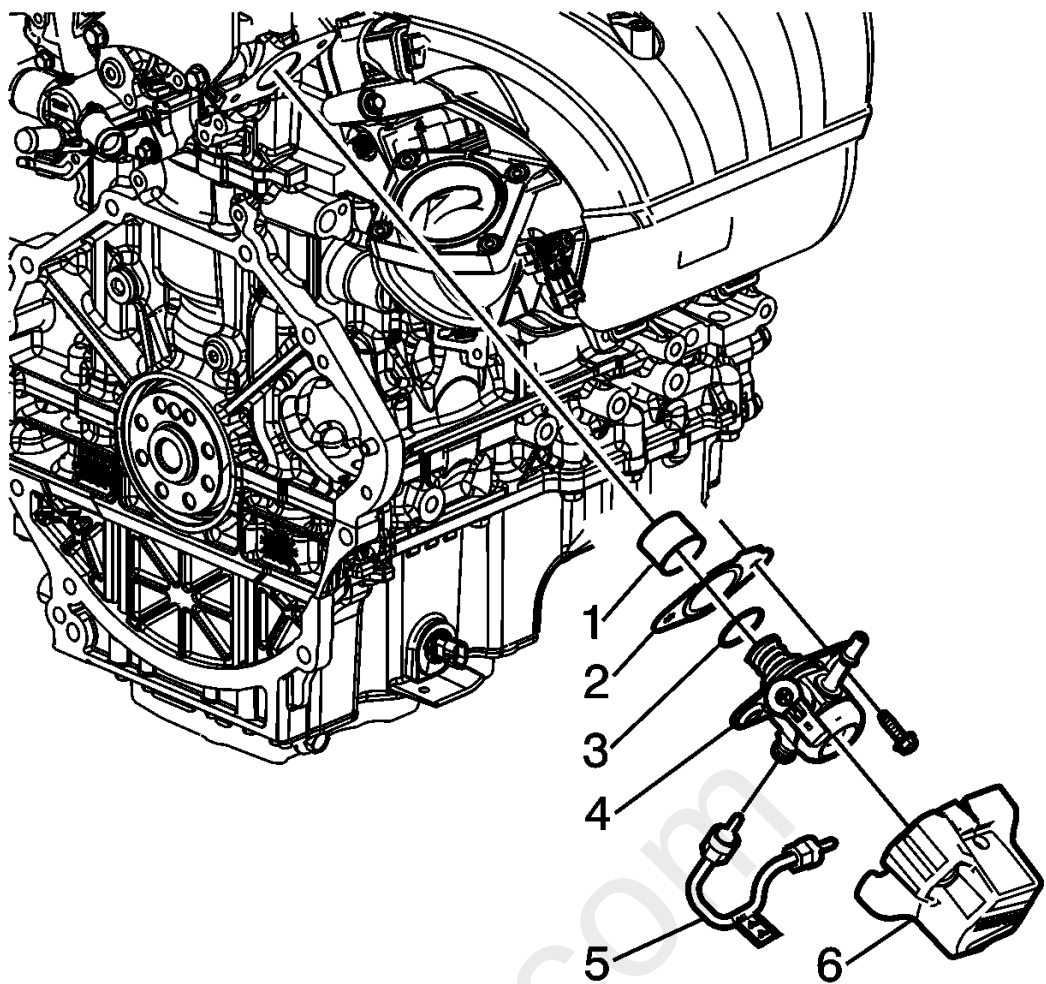


Fig. 313: High Pressure Fuel Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

WARNING: The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

5. Remove the fuel pump insulator (6).

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.

6. Remove and discard the fuel feed intermediate pipe (5).

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

7. Remove and discard the fuel pump bolts.

8. Remove the fuel pump (4), O-ring (3), and gasket (2). Discard the O-ring and gasket.

9. Remove the valve lifter follower (1).

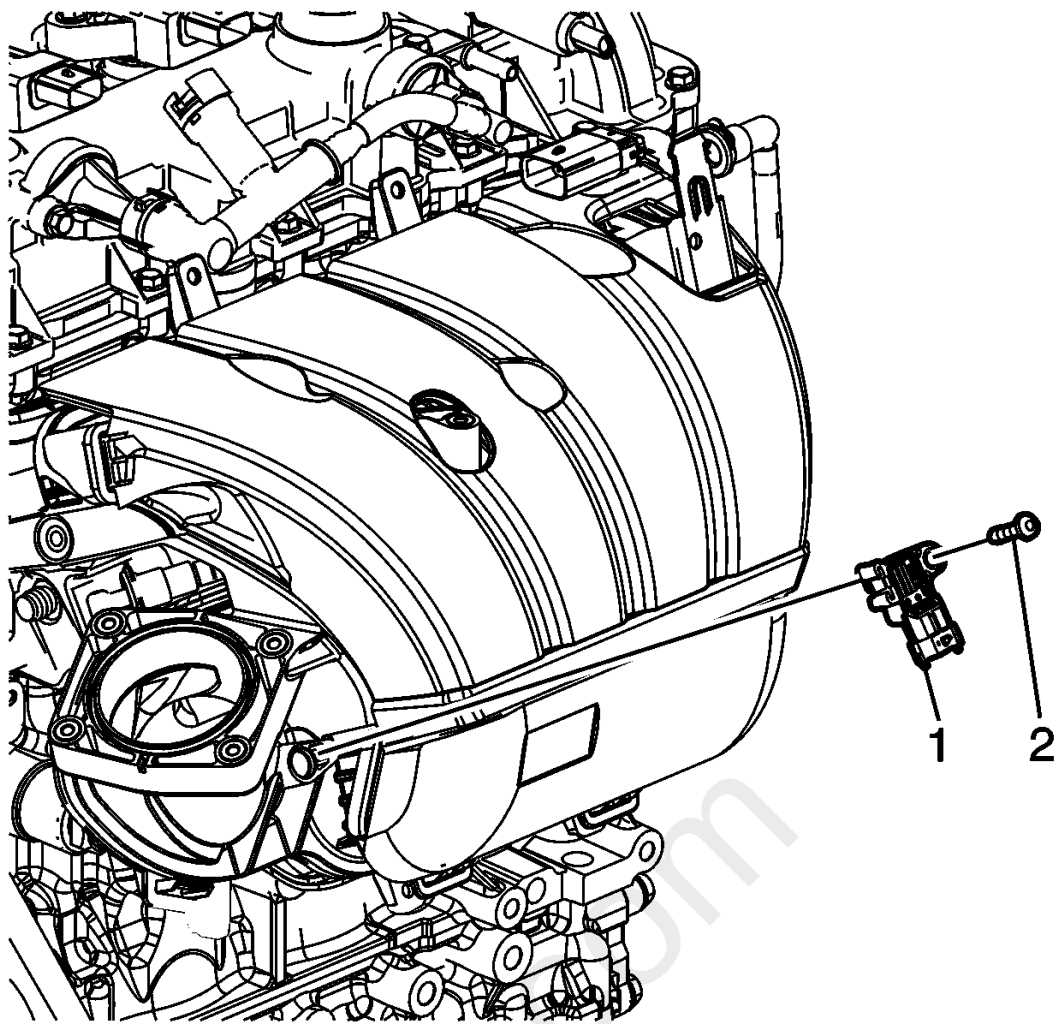


Fig. 314: MAP Sensor And Bolt

Courtesy of GENERAL MOTORS COMPANY

10. Remove the MAP sensor (1) and bolt (2).

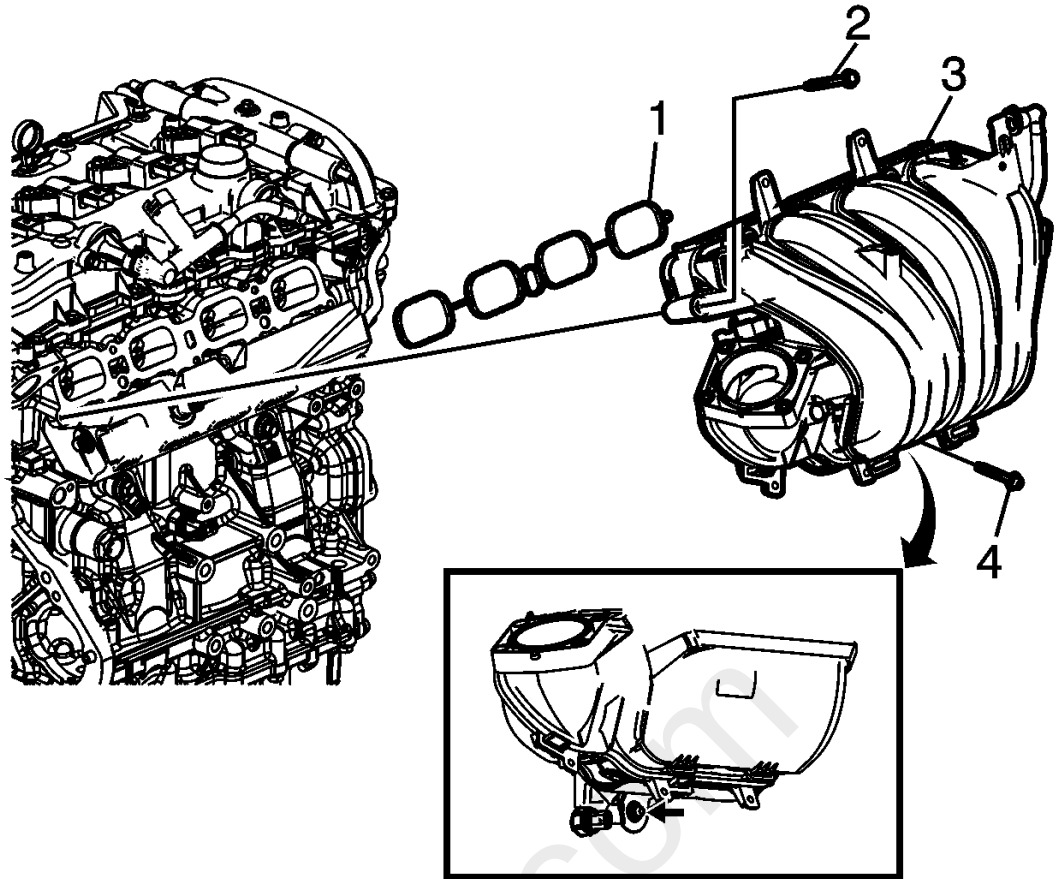


Fig. 315: Intake Manifold And Gasket

Courtesy of GENERAL MOTORS COMPANY

11. Remove the intake manifold retaining bolts (2, 4).
12. Remove the intake manifold (3) and gasket (1).
13. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

CAMSHAFT COVER AND COMPRESSOR AIR INTAKE TURBOCHARGER REMOVAL (2ND DESIGN TAMPER-PROOF PCV SYSTEM)

Turbocharger Component Removal

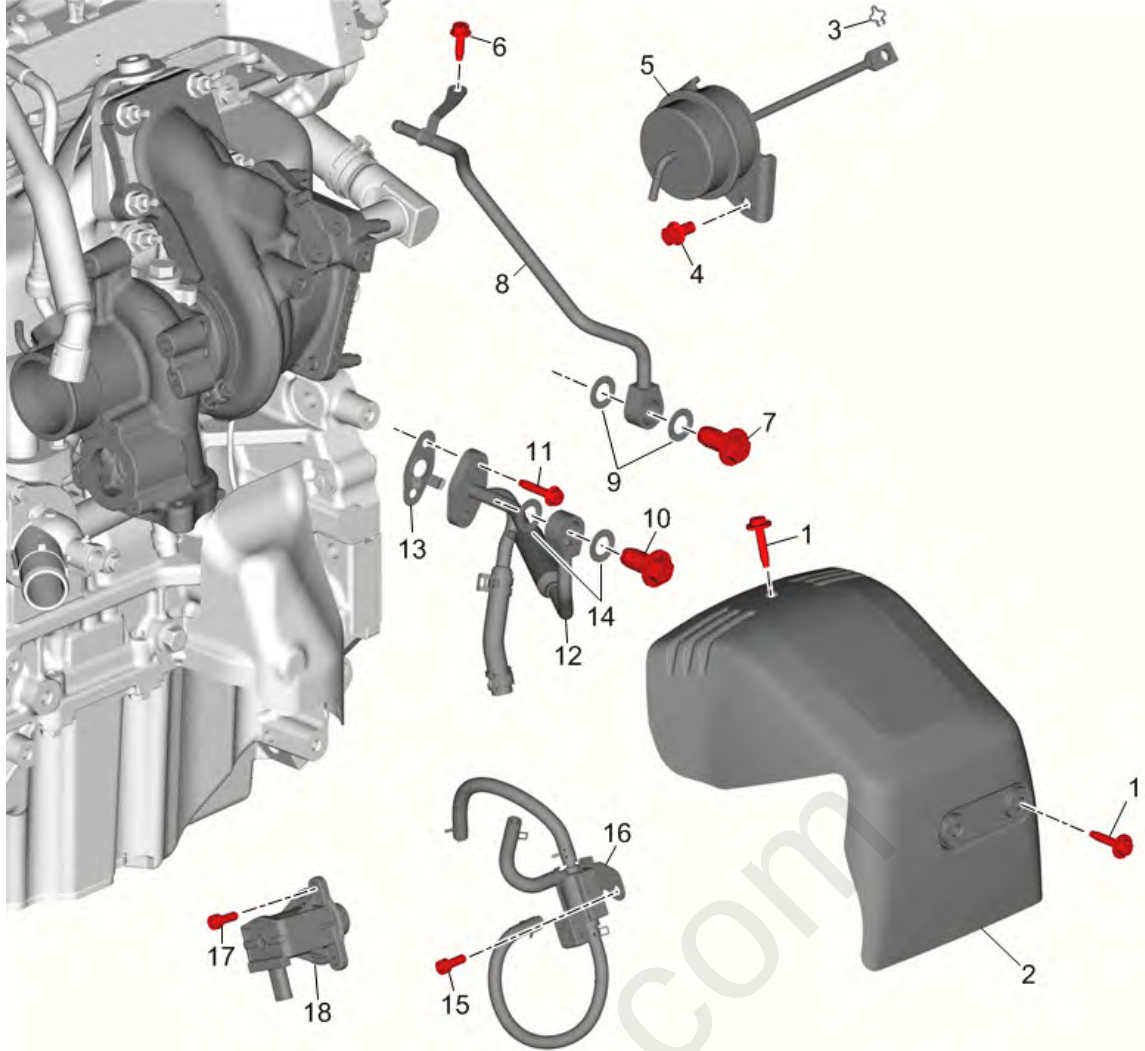


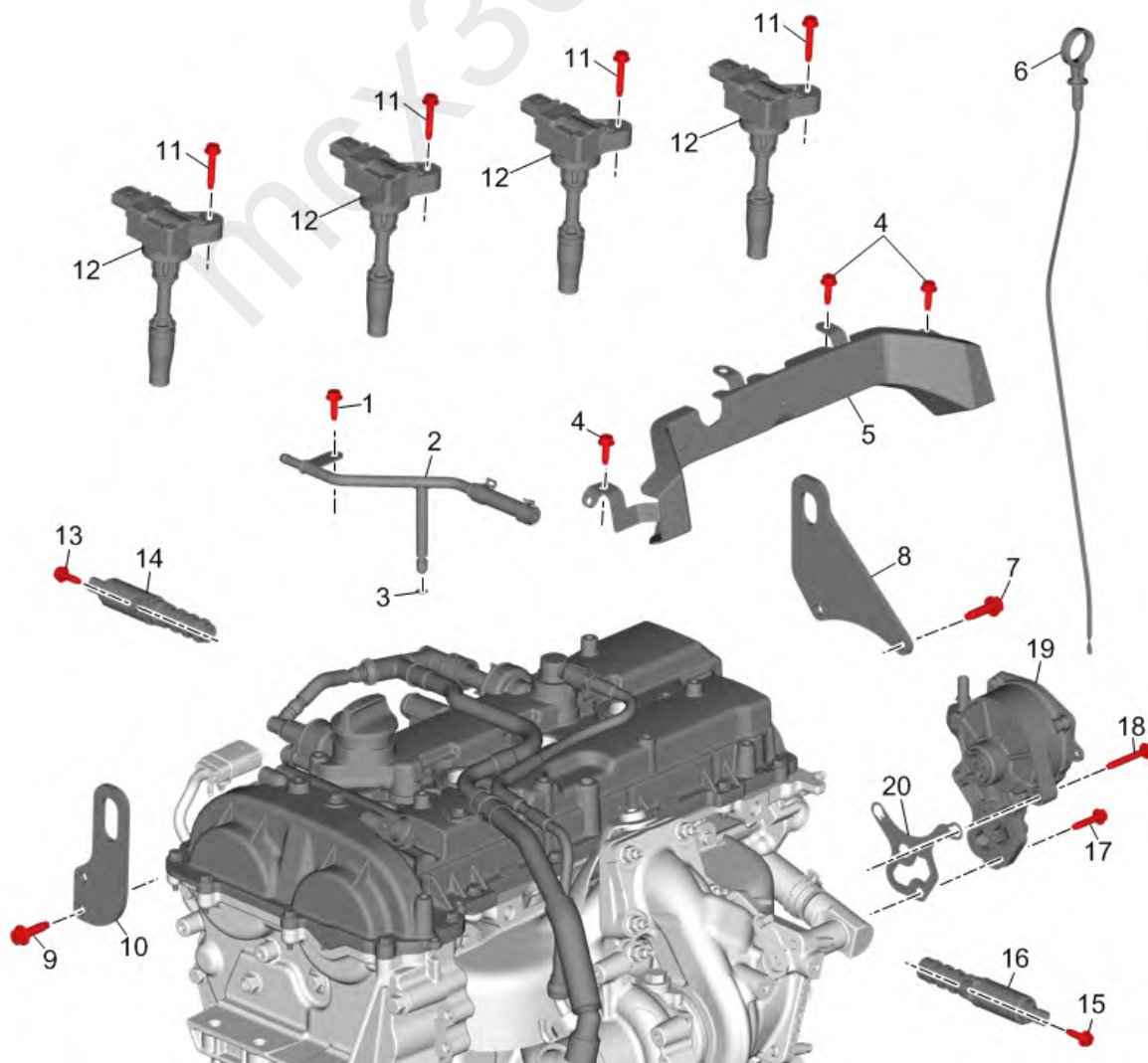
Fig. 316: Turbocharger Component
 Courtesy of GENERAL MOTORS COMPANY

Turbocharger Component Removal

Callout	Component Name
1	Turbocharger Heat Shield Bolt NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt.
2	Turbocharger Heat Shield
3	Turbocharger Wastegate Actuator Arm Retainer
4	Turbocharger Wastegate Actuator Bolt
5	Turbocharger Wastegate Actuator
6	Turbocharger Coolant Return Pipe Bolt NOTE: One bolt retains the turbocharger coolant return pipe and the camshaft cover heat shield at the same location.
7	Turbocharger Coolant Return Pipe Bolt
8	Turbocharger Coolant Return Pipe Procedure Disconnect the turbocharger coolant return pipe from the air bleed hose.

Callout	Component Name
9	Turbocharger Coolant Return Pipe Washer NOTE: Discard the washers.
10	Turbocharger Coolant Feed Pipe Bolt
11	Turbocharger Coolant Feed Pipe Bolt
12	Turbocharger Coolant Feed Pipe Procedure Disconnect the turbocharger coolant feed pipe hose from the engine oil cooler.
13	Turbocharger Coolant Feed Pipe Gasket NOTE: Discard the gasket.
14	Turbocharger Coolant Feed Pipe Washer NOTE: Discard the washers.
15	Turbocharger Wastegate Regulator Solenoid Valve Bolt
16	Turbocharger Wastegate Regulator Solenoid Valve Procedure Disconnect the turbocharger wastegate regulator solenoid valve hoses from the turbocharger.
17	Turbocharger Air Bypass Valve Solenoid Bolt
18	Turbocharger Air Bypass Valve Solenoid

Camshaft Cover Component Removal



Camshaft Cover Component Removal

Callout	Component Name
1	Engine Coolant Air Bleed Pipe Bolt
2	Engine Coolant Air Bleed Pipe
3	Engine Coolant Air Bleed Pipe O-Ring NOTE: Inspect O-ring and discard if necessary.
4	Camshaft Cover Heat Shield Bolt NOTE: An additional bolt retains the camshaft cover heat shield and the turbocharger coolant return pipe.
5	Camshaft Cover Heat Shield
6	Oil Level Indicator NOTE: Inspect and replace the oil indicator O-ring seals, if necessary.
7	Engine Lift Rear Bracket Bolt
8	Engine Lift Rear Bracket
9	Engine Lift Front Bracket Bolt
10	Engine Lift Front Bracket
11	Ignition Coil Bolt
12	Ignition Coil
13	Camshaft Position Actuator Solenoid Valve Bolt
14	Camshaft Position Actuator Solenoid Valve - Intake
15	Camshaft Position Actuator Solenoid Valve Bolt
16	Camshaft Position Actuator Solenoid Valve - Exhaust
17	Vacuum Pump Bolt
18	Vacuum Pump Bolt
19	Vacuum Pump
20	Vacuum Pump Gasket NOTE: Discard the gasket.

Camshaft Cover and Turbocharger Removal

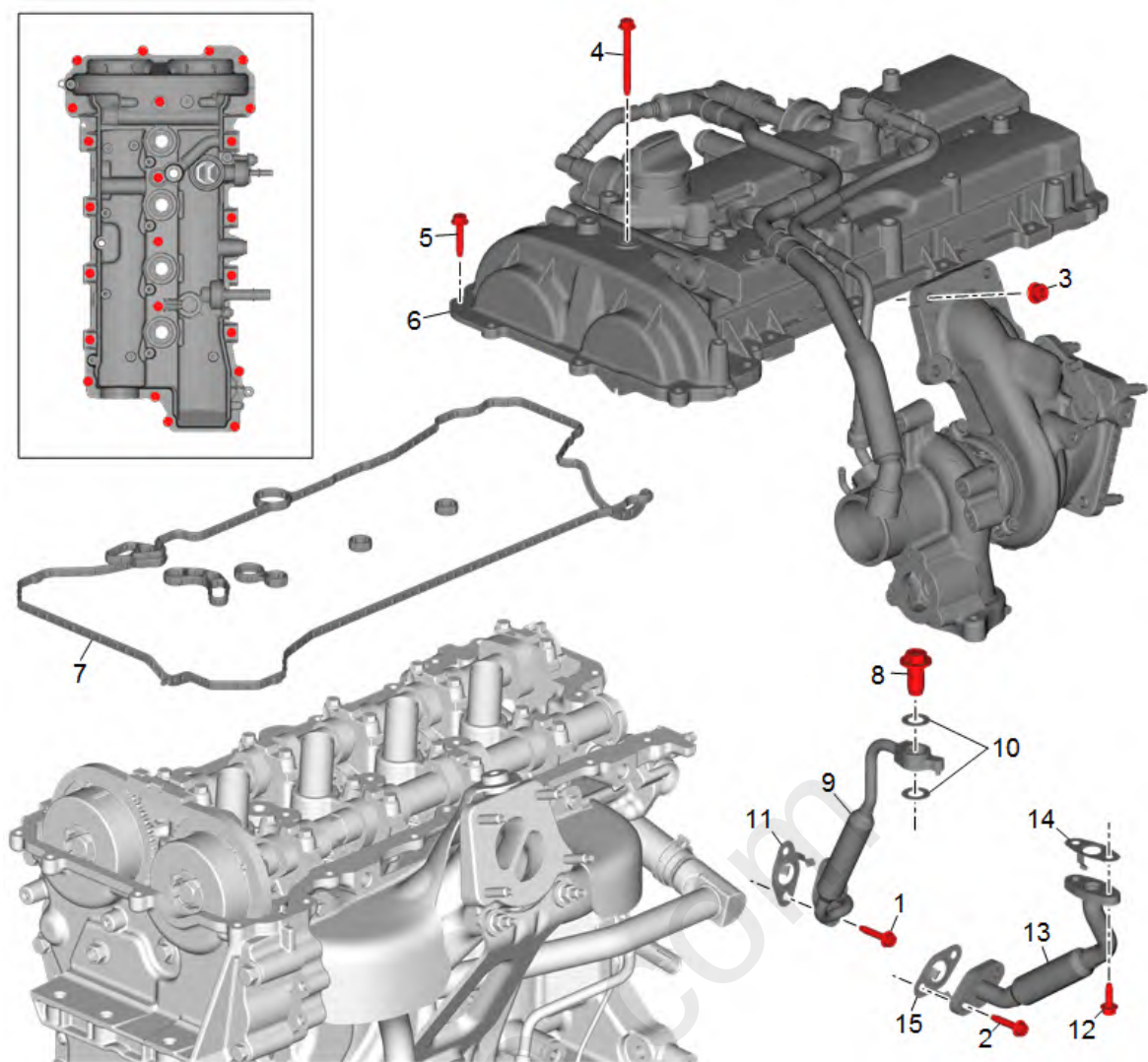


Fig. 318: Camshaft Cover and Turbocharger
 Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover and Turbocharger Removal

Callout	Component Name
1	Turbocharger Oil Feed Pipe Bolt
2	Turbocharger Oil Return Pipe Bolt
3	Turbocharger Nut NOTE: Discard the nuts.
4	Camshaft Cover Bolt
5	Camshaft Cover Bolt

Callout	Component Name
6	Camshaft Cover Positive Crankcase Ventilation Tube Turbocharger NOTE: The tamper-proof positive crankcase ventilation system includes components that may be replaced if necessary. The system may include an outlet duct connected to the end of the Positive Crankcase Ventilation Tube. If any component is suspect, refer to the inspection procedures and individual replacement procedures before attempting to disassemble the PCV system. Be careful when moving the assembled components with tamper-proof fittings to avoid stress on the connections. NOTE: The assembly is removed with the oil return pipe and oil feed pipe attached at the turbocharger. Procedure 1. The assistance of a second technician may be necessary to support and move the assembly during removal. 2. Ensure a large enough clean area is prepared before removing the assembly. 3. Refer to Camshaft Cover and Compressor Air Intake Turbocharger Cleaning and Inspection.
7	Camshaft Cover Gasket NOTE: Ensure all camshaft cover gaskets, including the inner gaskets, are removed and discarded.
8	Turbocharger Oil Feed Pipe Bolt
9	Turbocharger Oil Feed Pipe
10	Turbocharger Oil Feed Pipe Washer NOTE: Discard the washers.
11	Turbocharger Oil Feed Pipe Gasket NOTE: Discard the gasket.
12	Turbocharger Oil Return Pipe Bolt
13	Turbocharger Oil Return Pipe
14	Turbocharger Oil Return Pipe Gasket NOTE: Discard the gasket.
15	Turbocharger Oil Return Pipe Gasket NOTE: Discard the gasket.

TURBOCHARGER REMOVAL (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

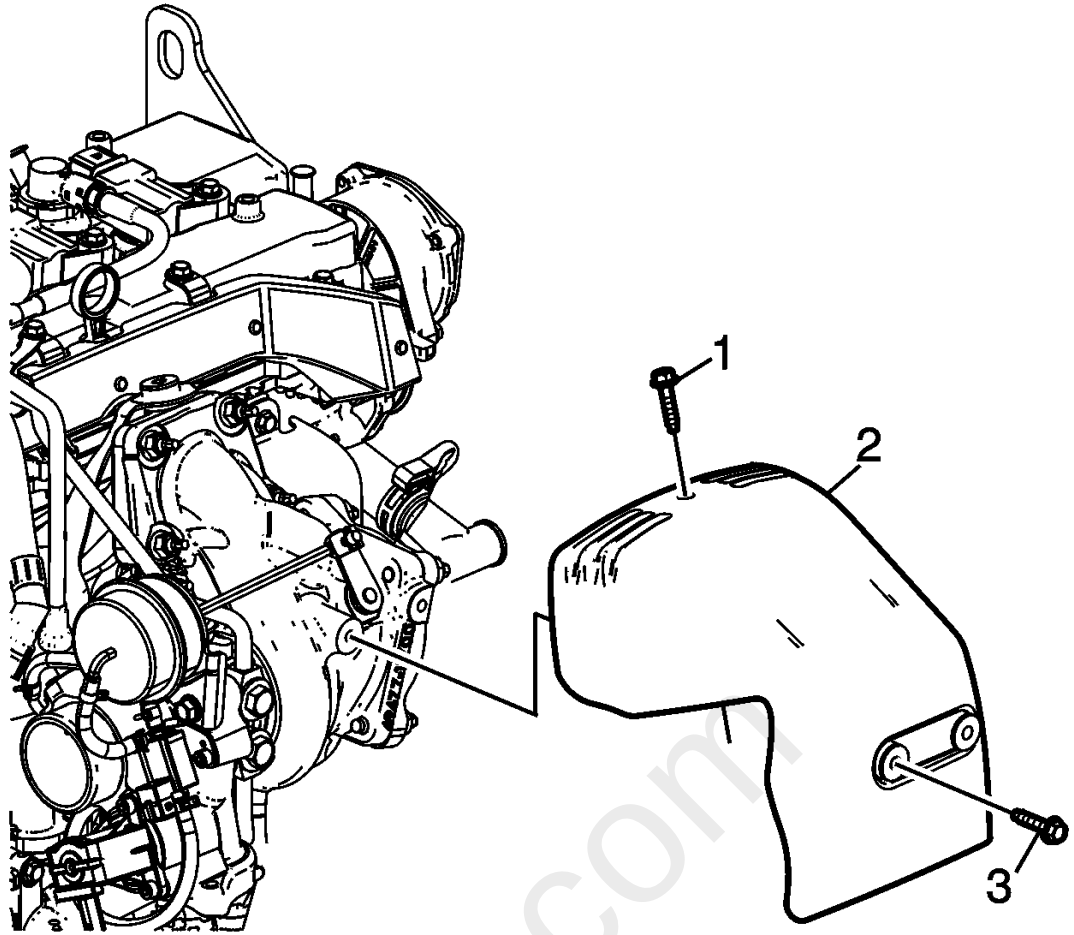


Fig. 319: Turbocharger Heat Shield Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt.

1. Remove the turbocharger heat shield bolts (1, 3).
2. Remove the turbocharger heat shield (2).

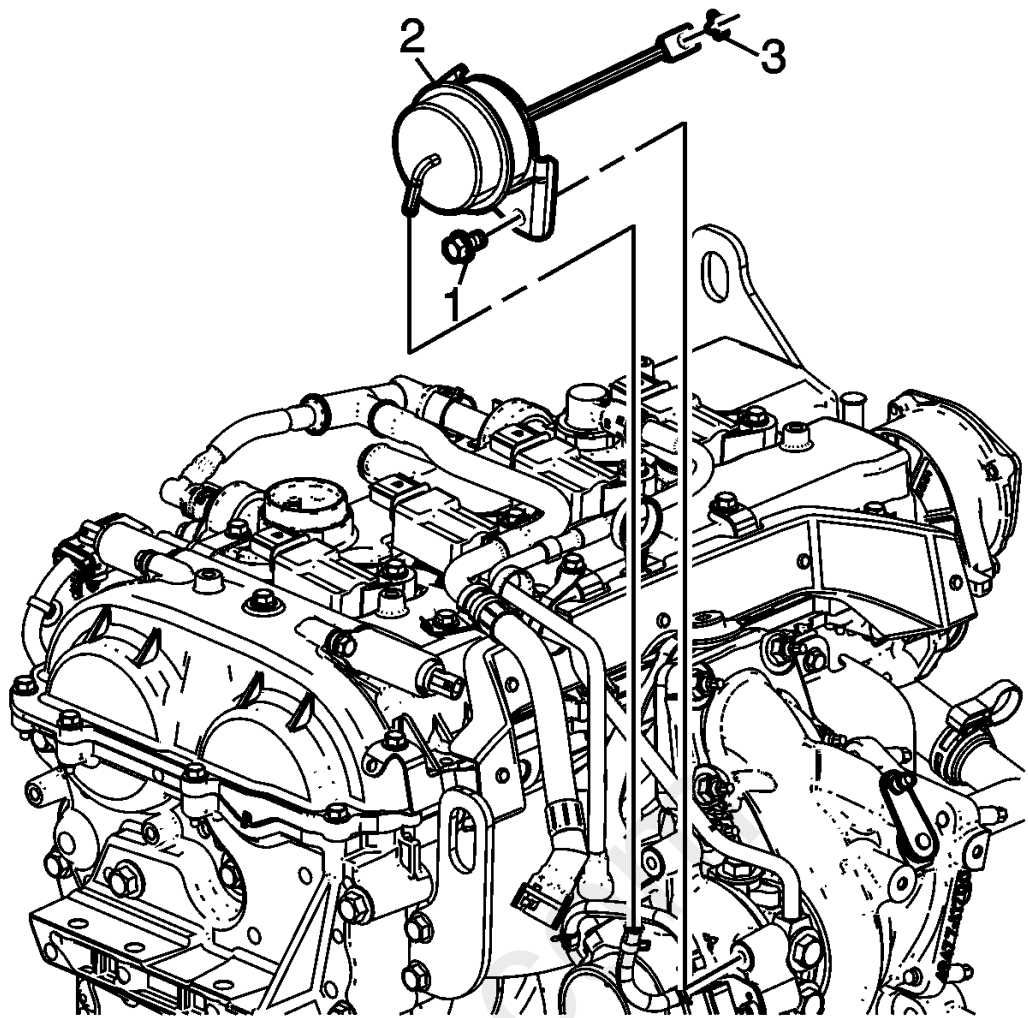


Fig. 320: Turbocharger Wastegate Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Remove the turbocharger wastegate actuator arm retainer (3).
4. Remove the turbocharger wastegate actuator bolts (1) and actuator (2).

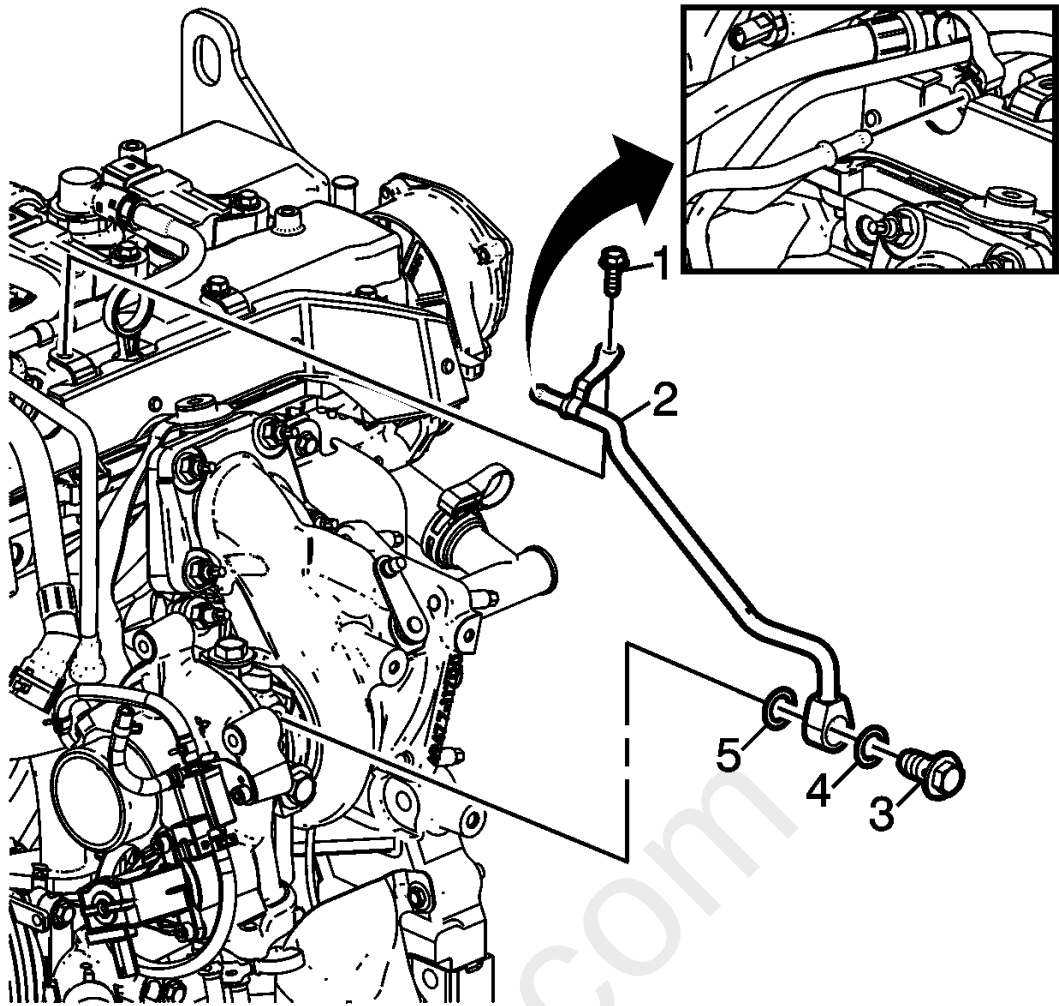


Fig. 321: Camshaft Cover Heat Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Remove the camshaft cover heat shield bolt (1) that retains the turbocharger coolant return pipe (2) at the camshaft cover.
6. Disconnect the turbocharger coolant return pipe from the air bleed hose.
7. Remove the turbocharger coolant return pipe bolt (3).
8. Remove the turbocharger coolant return pipe (2) and washers (4, 5). Discard the washers.

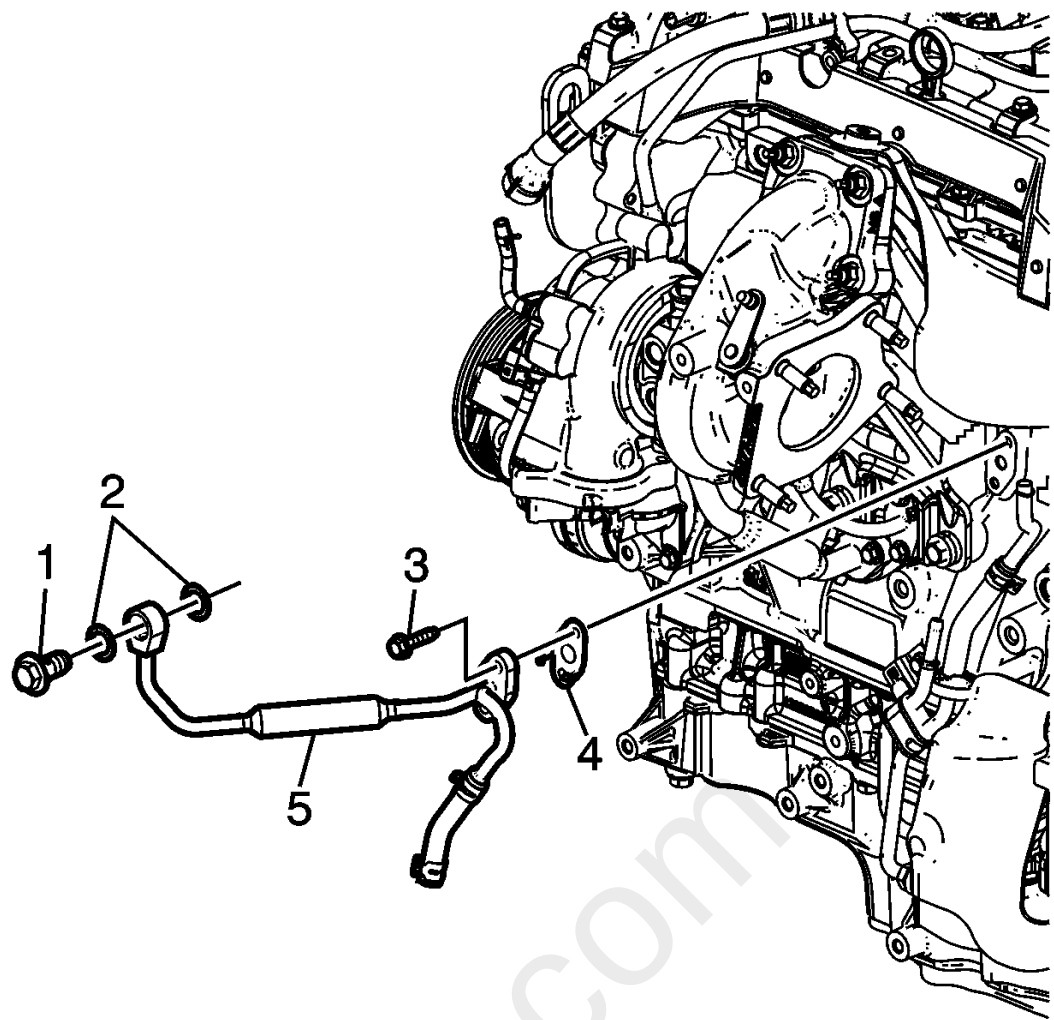


Fig. 322: Turbocharger Coolant Feed Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Remove the turbocharger coolant feed pipe bolts (1, 3).
10. Disconnect the turbocharger coolant feed pipe hose from the engine oil cooler.
11. Remove the turbocharger coolant feed pipe gasket (4) and discard.
12. Remove the turbocharger coolant feed pipe (5) and washers (2). Discard the washers.

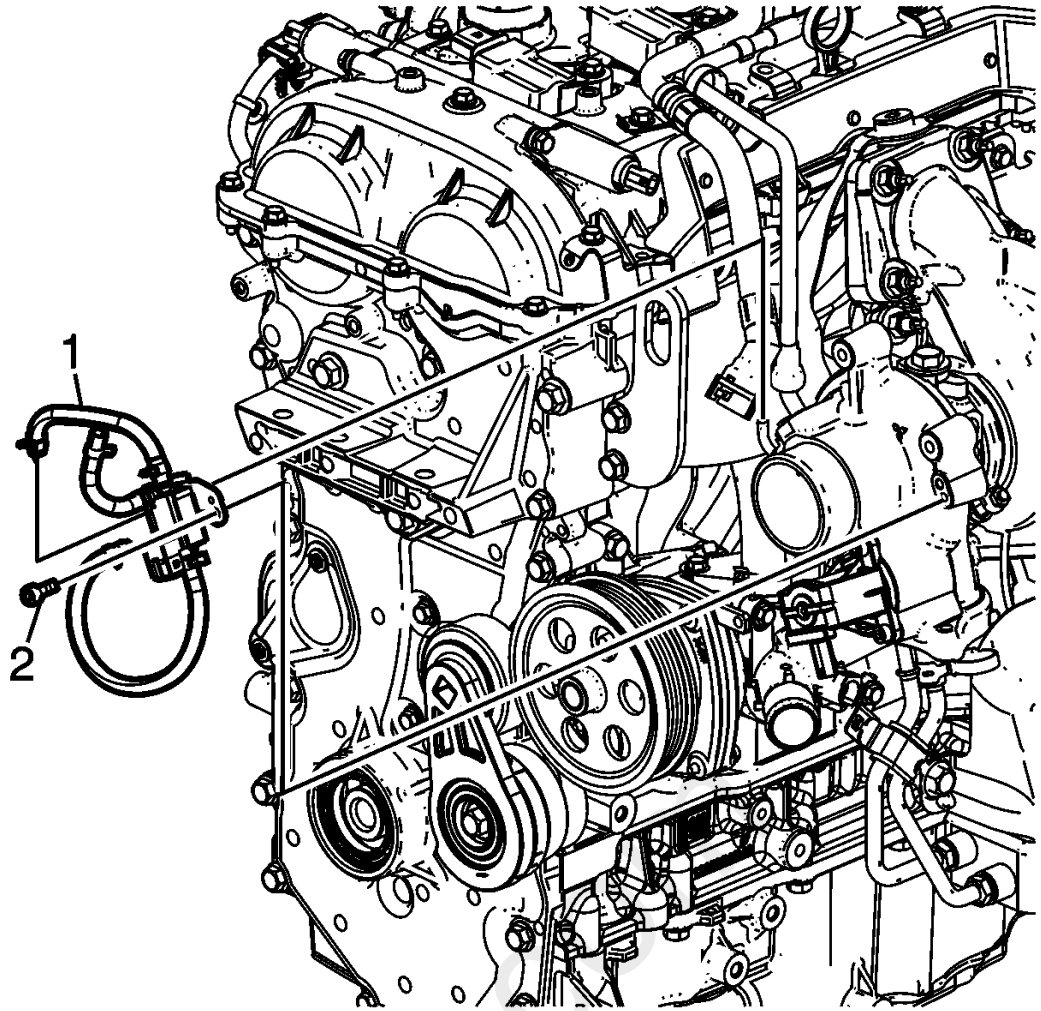


Fig. 323: Turbocharger Wastegate Regulator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the turbocharger wastegate regulator solenoid valve hoses from the turbocharger.
14. Remove the turbocharger wastegate regulator solenoid valve bracket bolt (2).
15. Remove the turbocharger wastegate regulator solenoid valve (1).

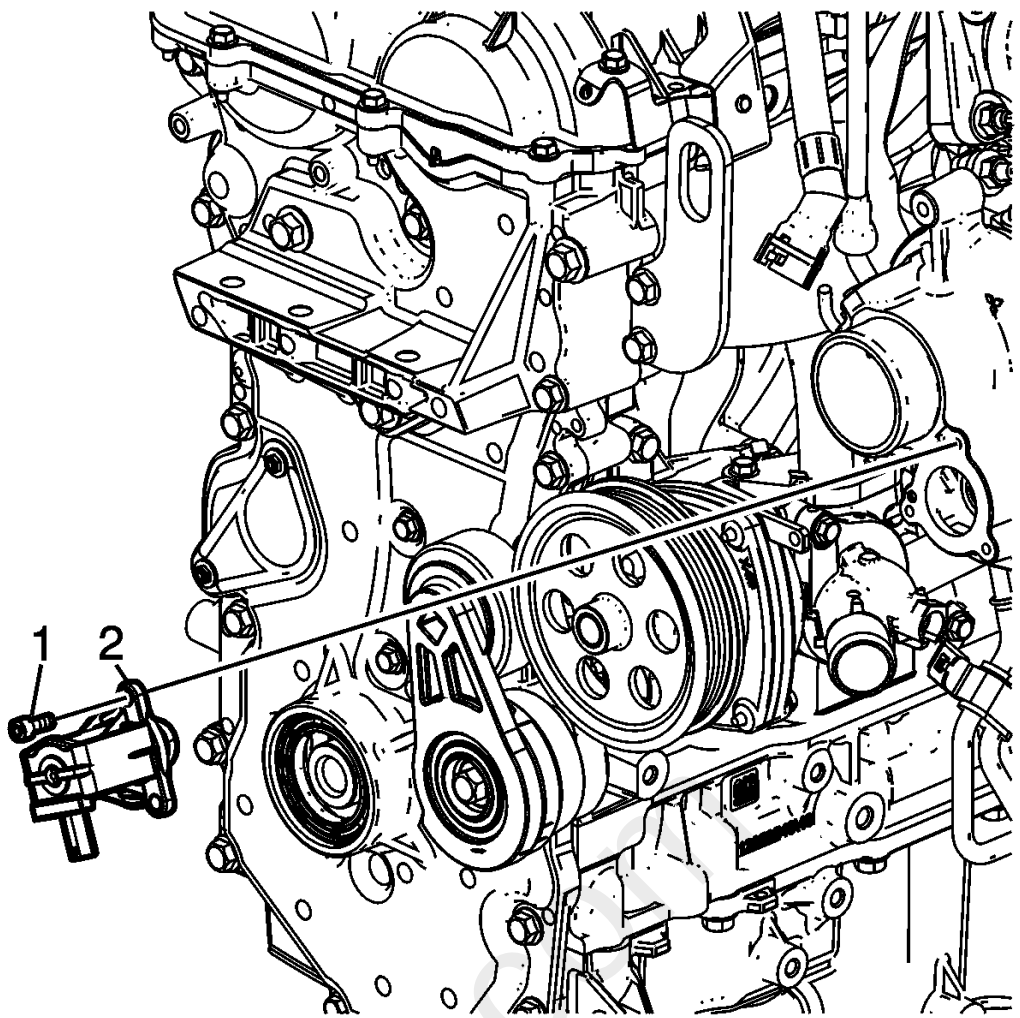


Fig. 324: Turbocharger Bypass Valve Solenoid Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the turbocharger bypass valve solenoid bolts (1).
17. Remove the turbocharger bypass valve solenoid (2).

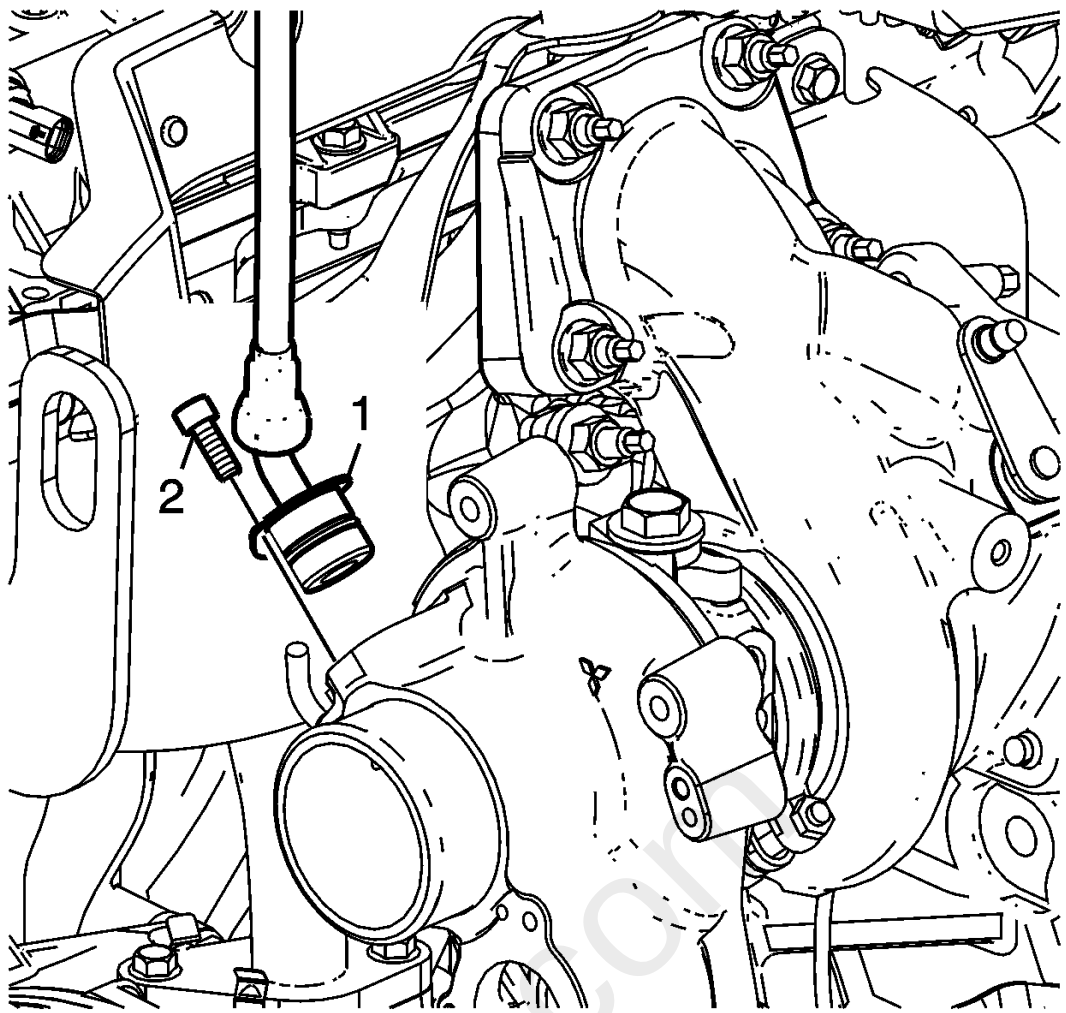


Fig. 325: PCV Hose Fitting Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not disturb the joint between the PCV hose and PCV hose fitting at the turbocharger. This is a permanent connection.

18. Remove the PCV hose fitting bolt (2). Disconnect the PCV hose fitting (1) with the PCV hose attached from the turbocharger.

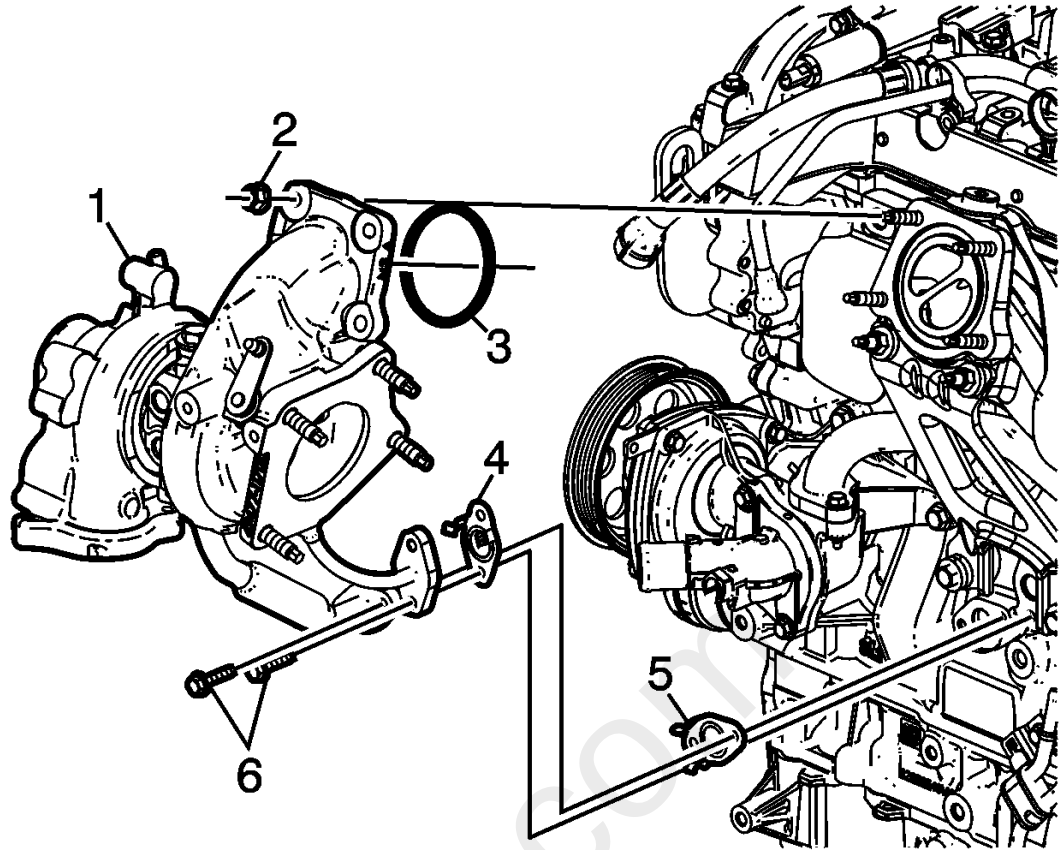


Fig. 326: Exploded View Of Turbocharger
Courtesy of GENERAL MOTORS COMPANY

19. Remove the turbocharger nuts (2) and discard.
20. Remove the turbocharger oil feed and return pipe bolts (6) at the engine block.
21. Remove the turbocharger (1) with the oil return pipe and oil feed pipe attached.
22. Remove the turbocharger oil feed and oil return pipe gaskets (4, 5) and discard.
23. Remove the turbocharger gasket (3) and discard.

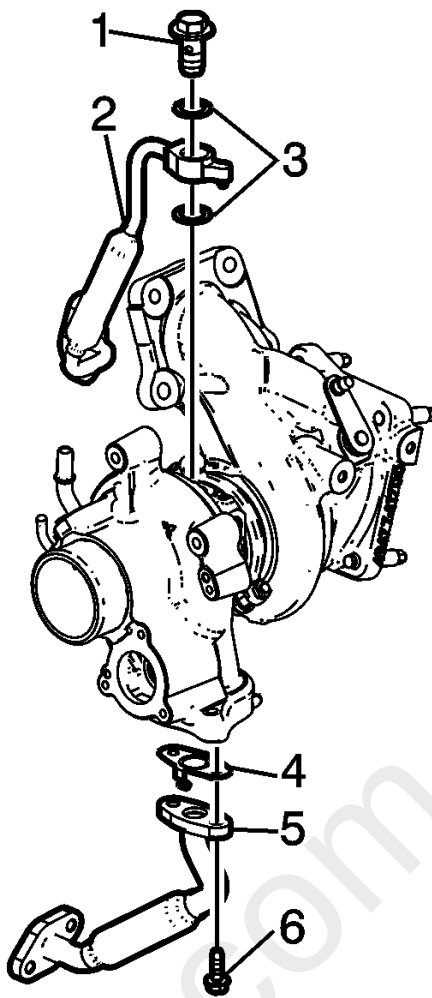


Fig. 327: Turbocharger Oil Feed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

24. Remove the turbocharger oil feed pipe bolt (1) from the turbocharger.
25. Remove the turbocharger oil feed pipe (2) and washers (3). Discard the washers.
26. Remove the turbocharger oil return pipe bolts (6).
27. Remove the turbocharger oil return pipe (5).
28. Remove and discard the turbocharger oil return pipe gasket (4).
29. Clean and inspect the turbocharger and components. Refer to [Camshaft Cover and Compressor Air Intake Turbocharger Cleaning and Inspection](#).

EXHAUST MANIFOLD REMOVAL

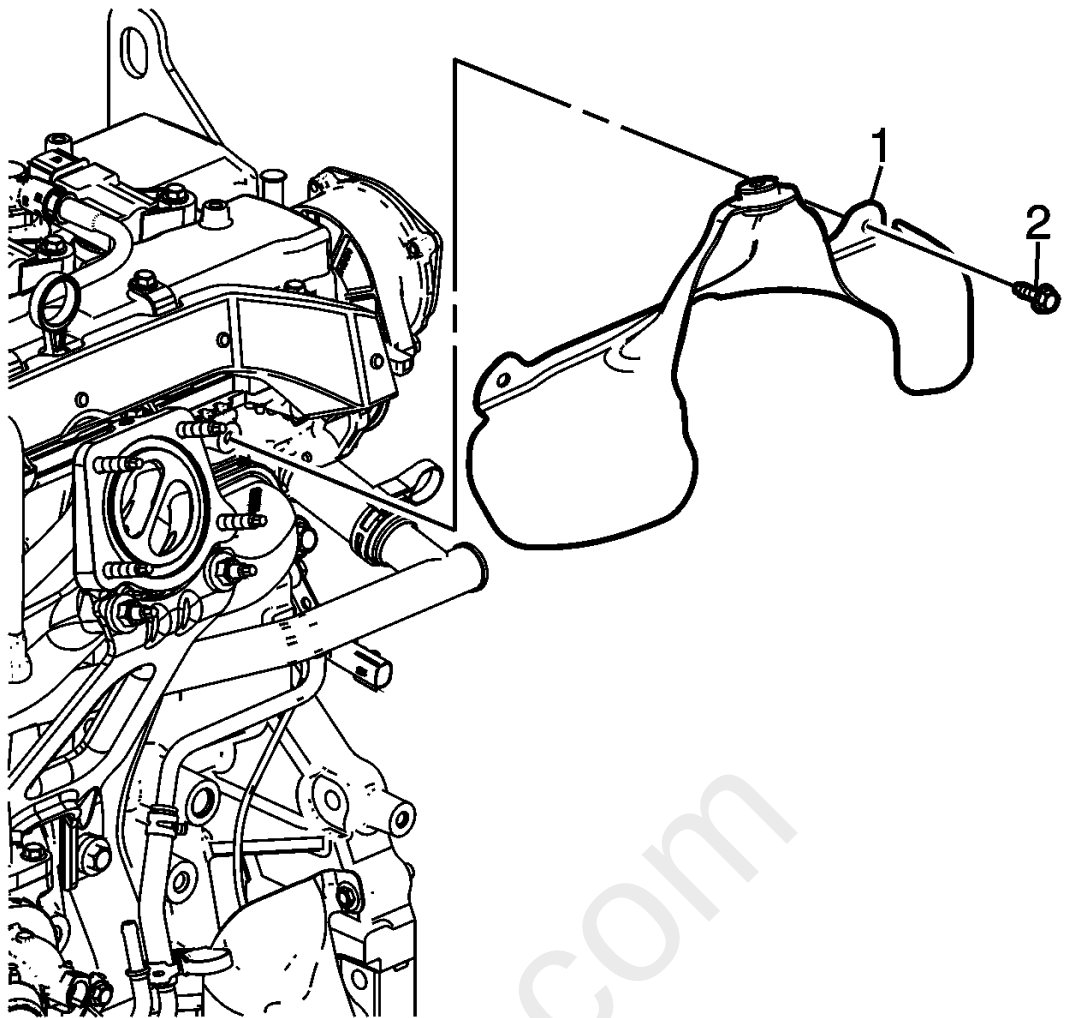


Fig. 328: Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: In the event that a bolt breaks upon removal of components, perform an extraction of the broken bolt.

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

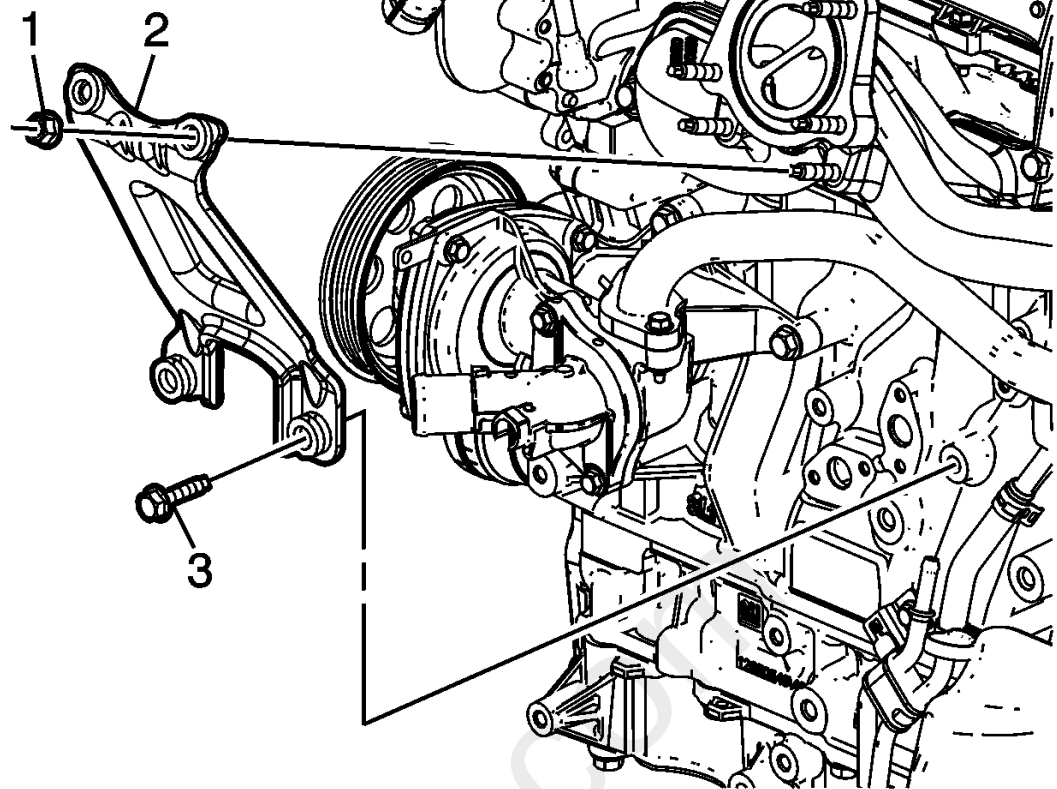


Fig. 329: Exhaust Manifold Brace Nuts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the exhaust manifold brace nuts (1) and discard.
4. Remove the exhaust manifold brace bolts (3).
5. Remove the exhaust manifold brace (2).

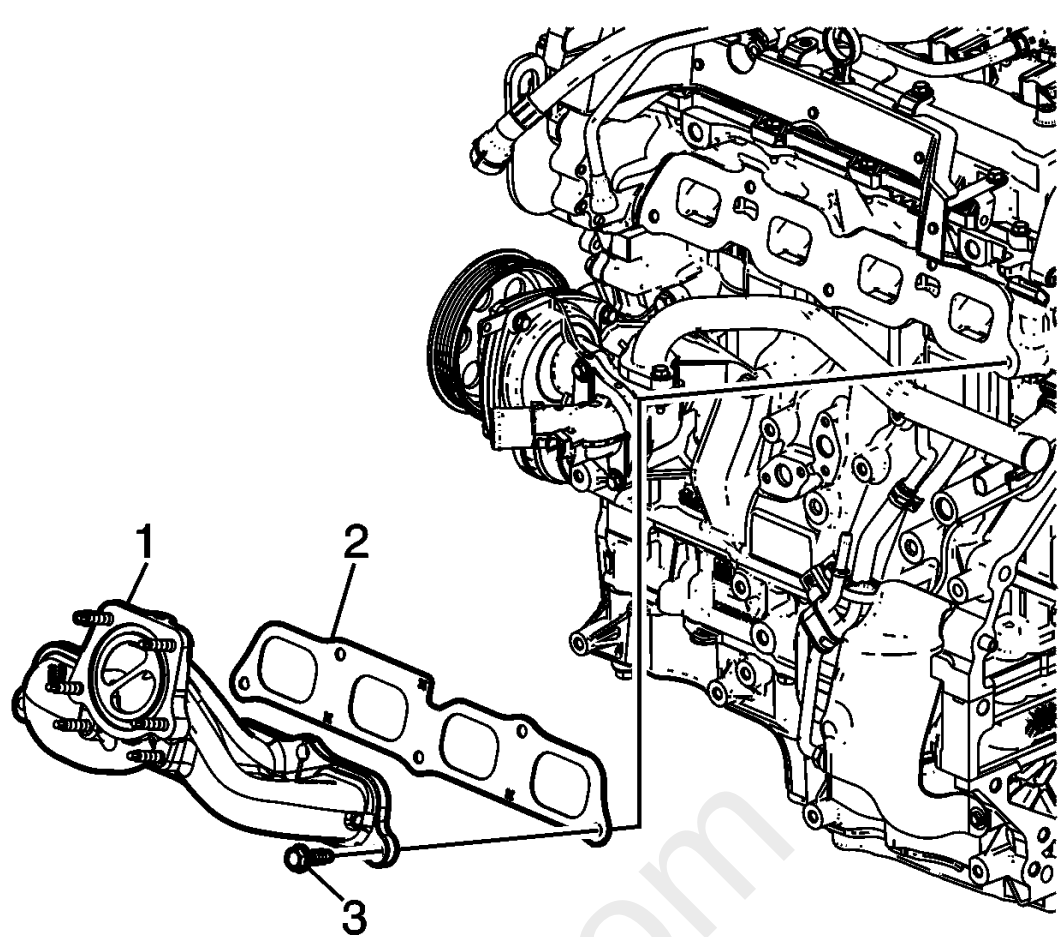


Fig. 330: Exhaust Manifold And Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the exhaust manifold to cylinder head bolts (3).
7. Remove the exhaust manifold (1).
8. Remove and discard the exhaust manifold gasket (2).
9. Clean all of the sealing surfaces.

FUEL RAIL AND INJECTORS REMOVAL

Special Tools

EN-49248 Fuel Rail Assembly Remover

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

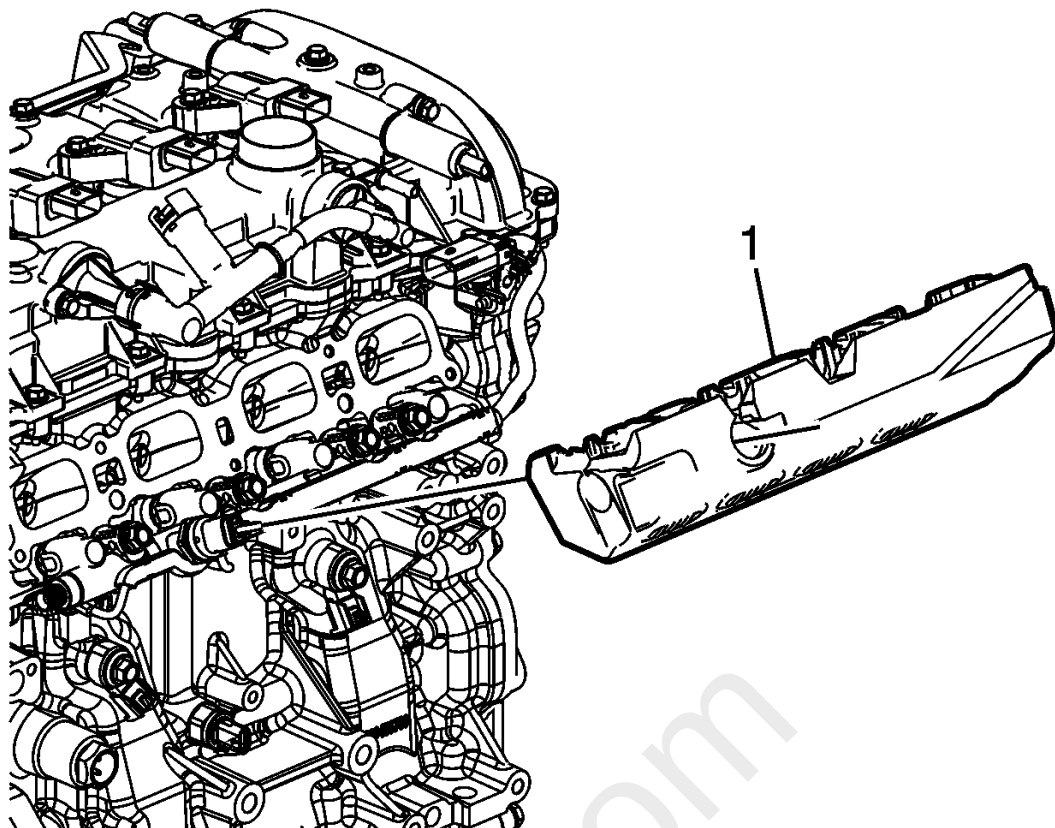


Fig. 331: Fuel Injection Fuel Rail Noise Shield

Courtesy of GENERAL MOTORS COMPANY

WARNING:

The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

1. Remove the fuel injection fuel rail noise shield (1).

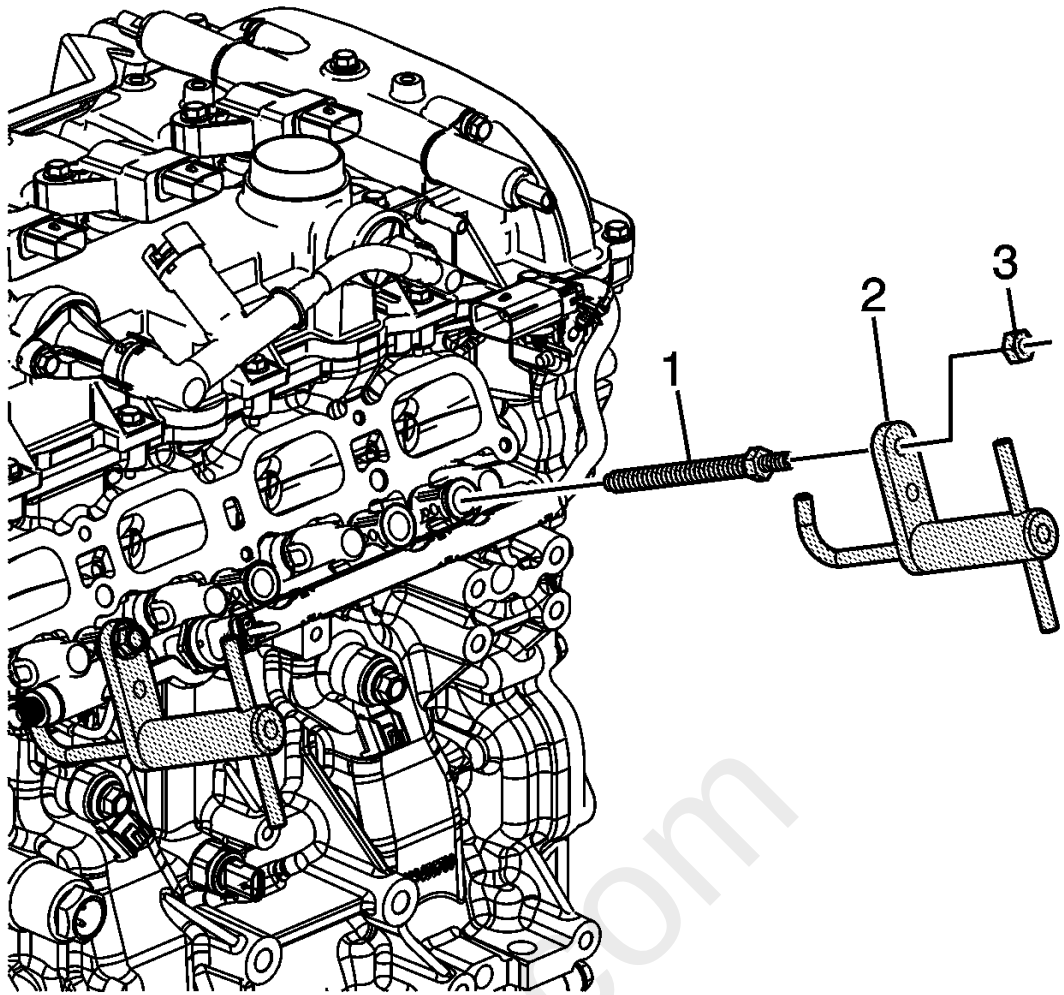


Fig. 332: Identifying Fuel Rail Assembly Remover Studs

Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical harness from the fuel rail harness connection.

NOTE: Fuel rail bolts are captured in the fuel rail assembly

- Ensure the bolt is completely loosened, and the threads are no longer engaged.
- Use a suitable tool to apply enough force to pull the bolt straight out of the fuel rail.

3. Remove the fuel rail assembly retaining bolts.

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

4. Install EN-49248 studs (1) into the 2 outermost fuel rail assembly retaining bolt locations. tighten the studs to 22 N.m (16 lb ft).
5. Install EN-49248 remover (2) onto each stud, and engage the hooks to the fuel rail. Install the nuts (3) retaining the remover onto the studs and tighten until snug.

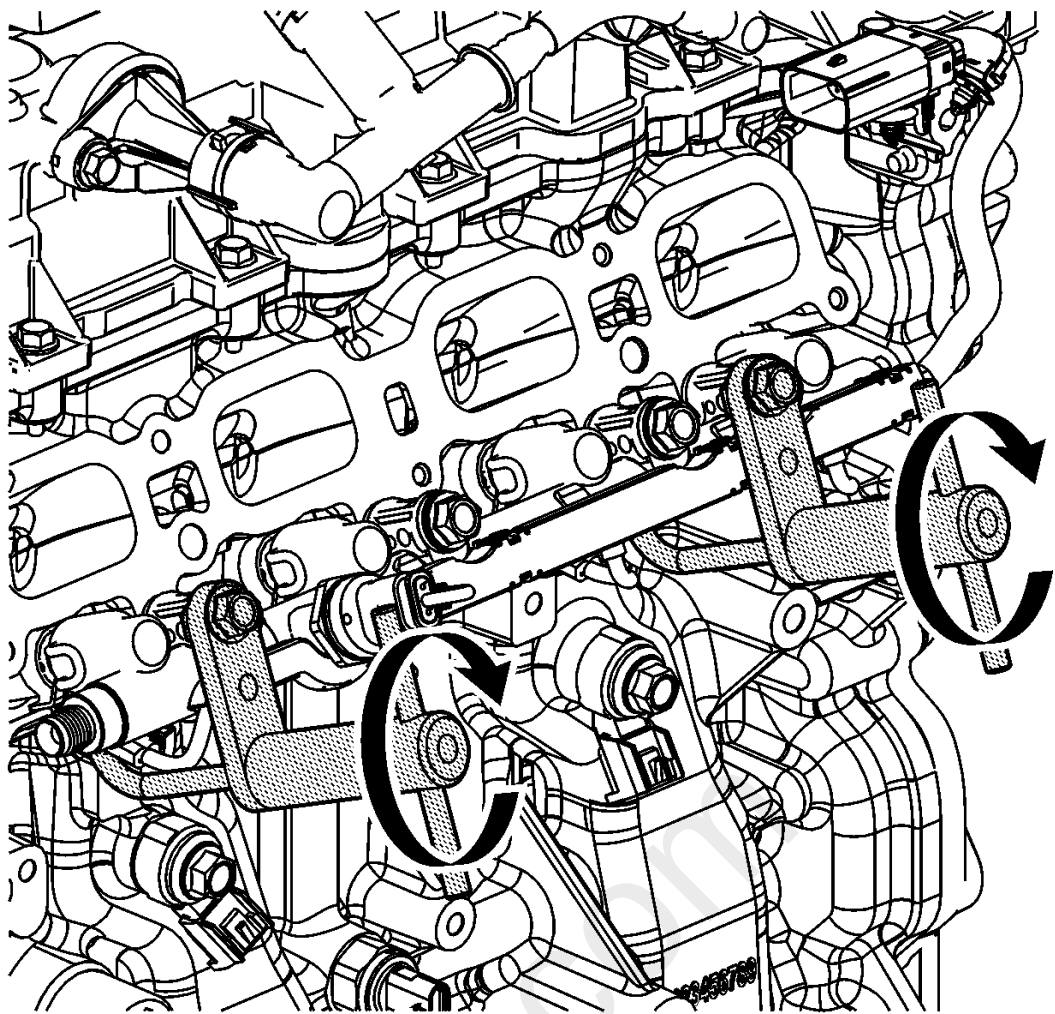


Fig. 333: Fuel Rail Assembly Remover

Courtesy of GENERAL MOTORS COMPANY

CAUTION:

- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.

NOTE:

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

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

6. Using EN-49248 remover, remove the fuel rail assembly.

CAMSHAFT COVER REMOVAL (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

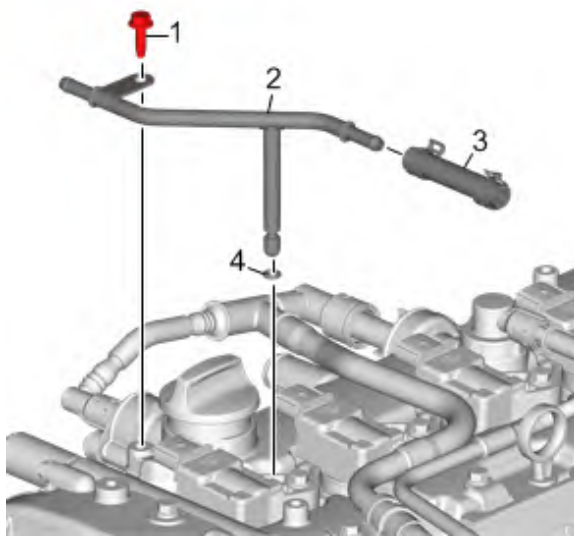


Fig. 334: Engine Coolant Air Bleed Pipe/Hose, Bolt And O-Ring
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine coolant air bleed pipe bolt (1).
2. Remove the engine coolant air bleed pipe (2), hose (3), and O-ring (4). Inspect O-ring and discard if necessary.

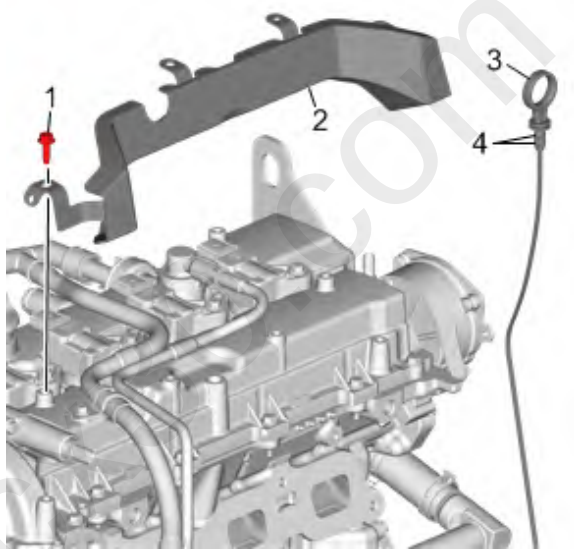


Fig. 335: Oil Level Indicator, O-Rings, Camshaft Cover Heat Shield And Bolts
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil level indicator (3). Inspect and replace the oil indicator O-ring seals (4), if necessary.
4. Remove the camshaft cover heat shield (2) and bolts (1).

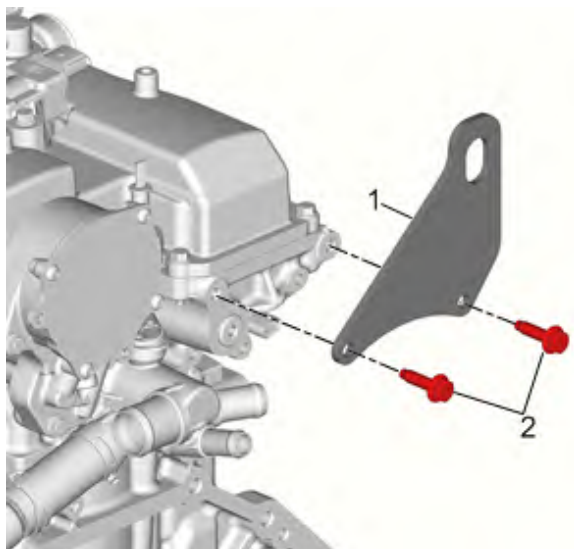


Fig. 336: Rear Lift Bracket And Bolts
 Courtesy of GENERAL MOTORS COMPANY

5. Remove the rear lift bracket (1) and bolts (2).

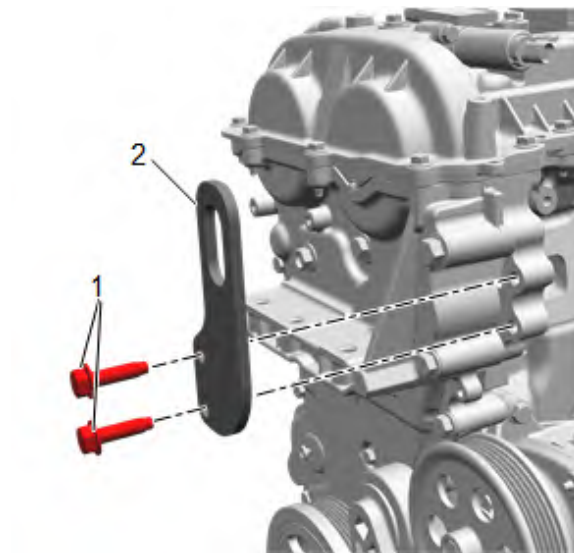


Fig. 337: Front Lift Bracket

Courtesy of GENERAL MOTORS COMPANY

6. Remove the front lift bracket (2) and bolts (1).

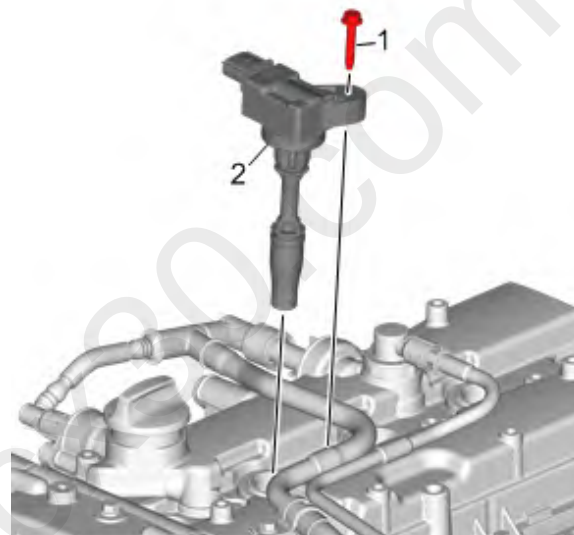


Fig. 338: Ignition Coils And Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Remove the ignition coils (2) and bolts (1).

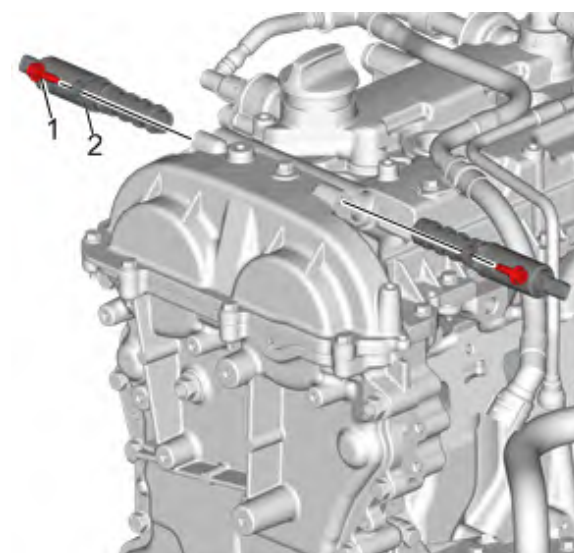


Fig. 339: Camshaft Position Actuator Solenoid Valves And Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Remove the camshaft position actuator solenoid valves (2) and bolts (1).

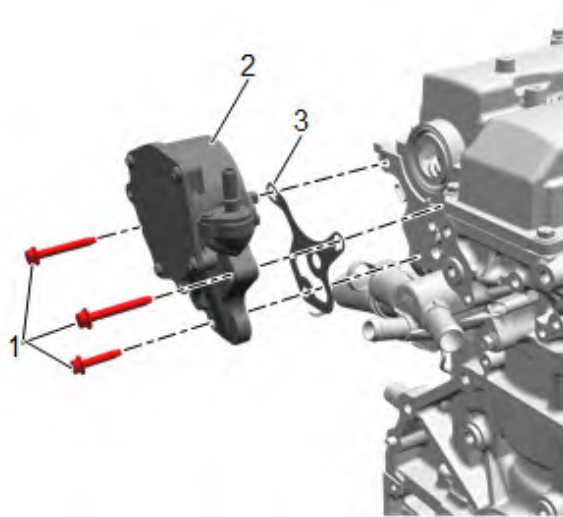


Fig. 340: Vacuum Assembly And Bolts

Courtesy of GENERAL MOTORS COMPANY

9. Remove the vacuum assembly (2) and bolts (1).
10. Remove the vacuum assembly gasket (3) and discard.

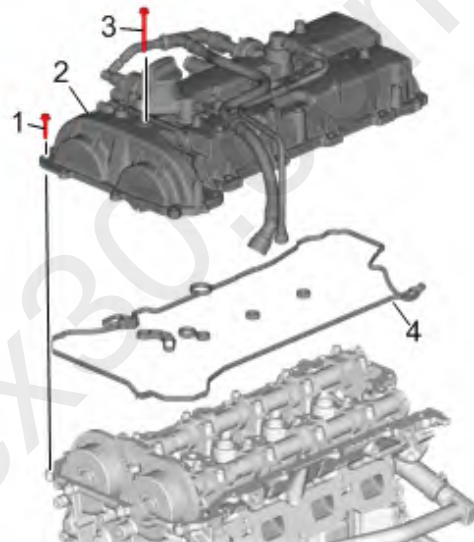


Fig. 341: Camshaft Cover, Bolts And Gasket

Courtesy of GENERAL MOTORS COMPANY

11. Remove the camshaft cover bolts (1, 3) and camshaft cover (2).

NOTE: Ensure all camshaft cover gaskets, including the inner gaskets, are removed and discarded.

12. Remove and discard the camshaft cover gaskets and camshaft cover inner gaskets (4).

ENGINE FRONT COVER REMOVAL

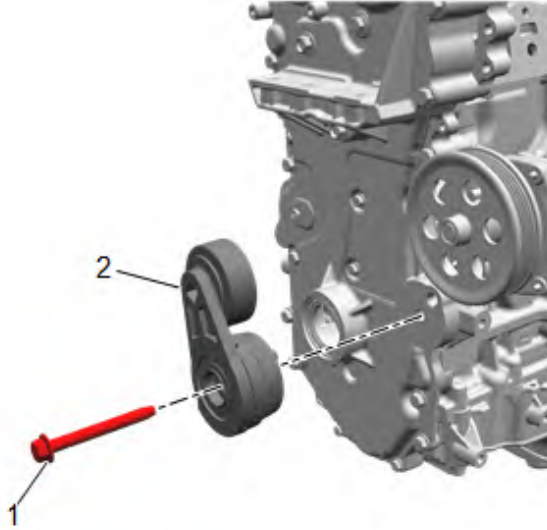


Fig. 342: Accessory Drive Belt Tensioner And Bolt
 Courtesy of GENERAL MOTORS COMPANY

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

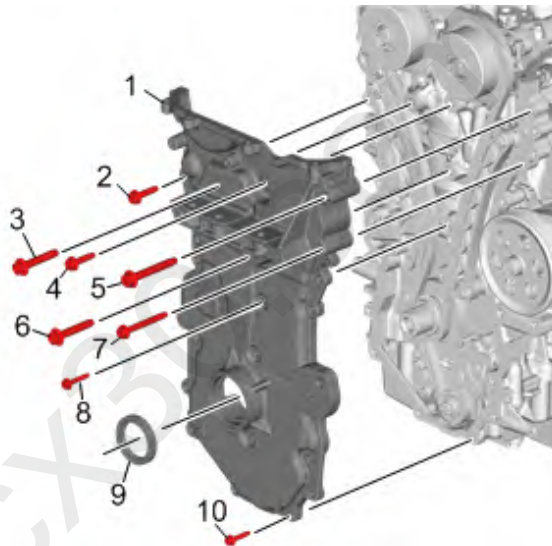


Fig. 343: Engine Front Cover, Bolts And Front Oil Seal
 Courtesy of GENERAL MOTORS COMPANY

3. Remove the engine front cover bolts (2 - 8, 10).
4. Discard bolts 3, 5, and 6.

NOTE: Inspect around the edges of the cover for pry locations. Use a suitable tool at the pry locations to assist with removal of the cover.

5. Remove the engine front cover (1).
6. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
7. Clean and Inspect the engine front cover mating surface.
8. Remove the front oil seal (9) with an appropriate tool, and discard.

CAMSHAFT TIMING CHAIN AND TENSIONER REMOVAL

Special Tools

EN 50837 Timing Chain Tensioner Retraction Tool

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

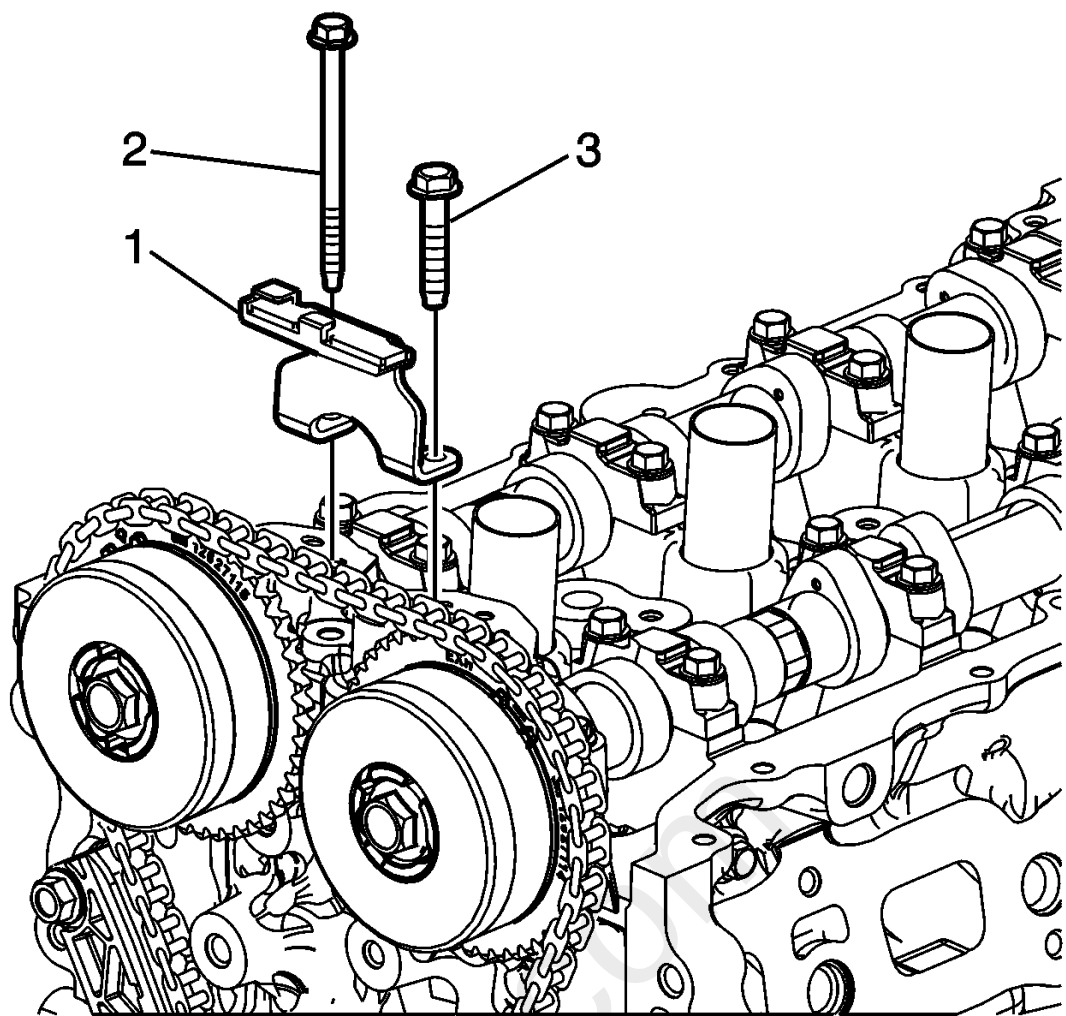


Fig. 344: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Remove the upper timing chain guide bolts (2, 3).
2. Remove the upper timing chain guide (1).



Fig. 345: Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Remove the timing chain tensioner bolts (1) and timing chain tensioner (2).
4. Remove the timing chain tensioner gasket (3) and discard.
5. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a counterclockwise direction.
 2. Compress the tensioner while holding lever arm.

3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
4. Pull lever clockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.

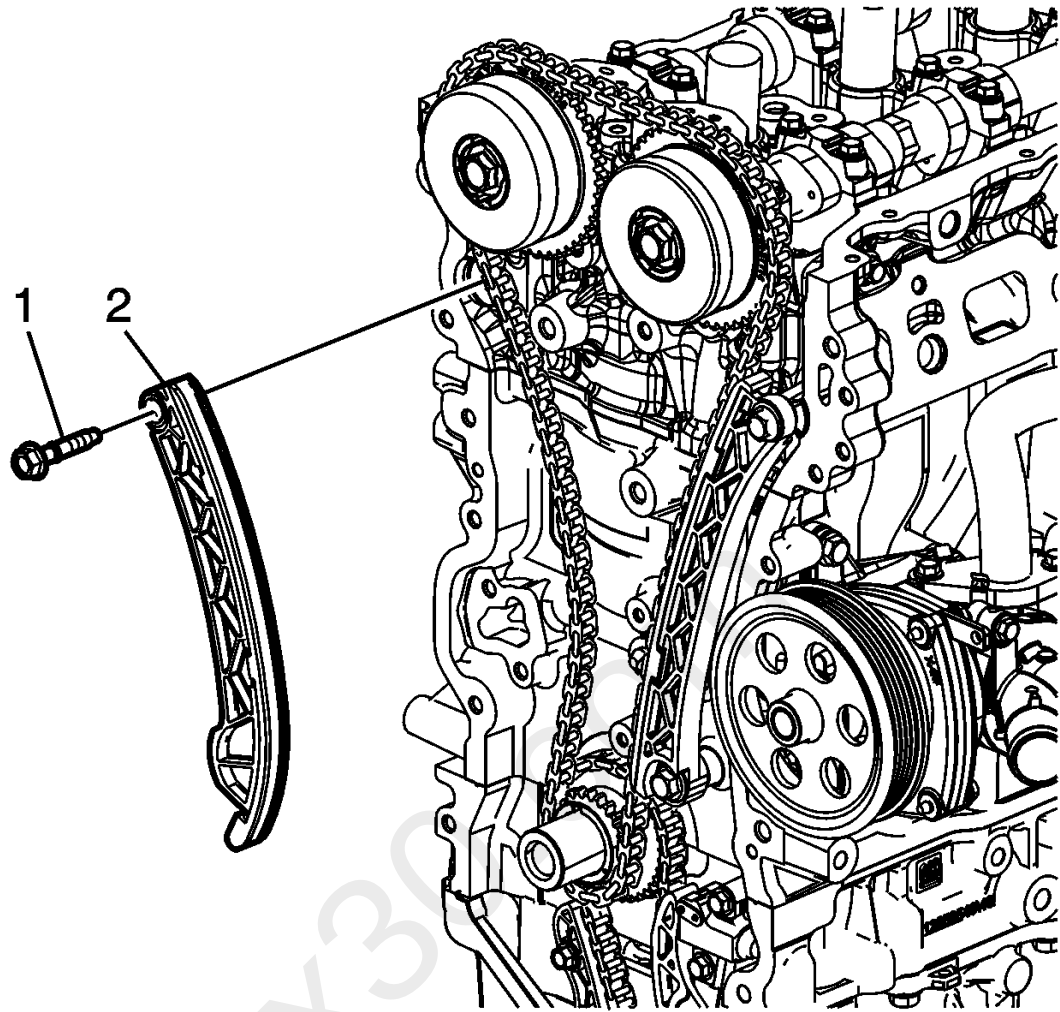


Fig. 346: Timing Chain Tensioner Pivot Arm Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Remove the timing chain tensioner pivot arm bolt (1).
7. Remove the timing chain tensioner pivot arm (2).

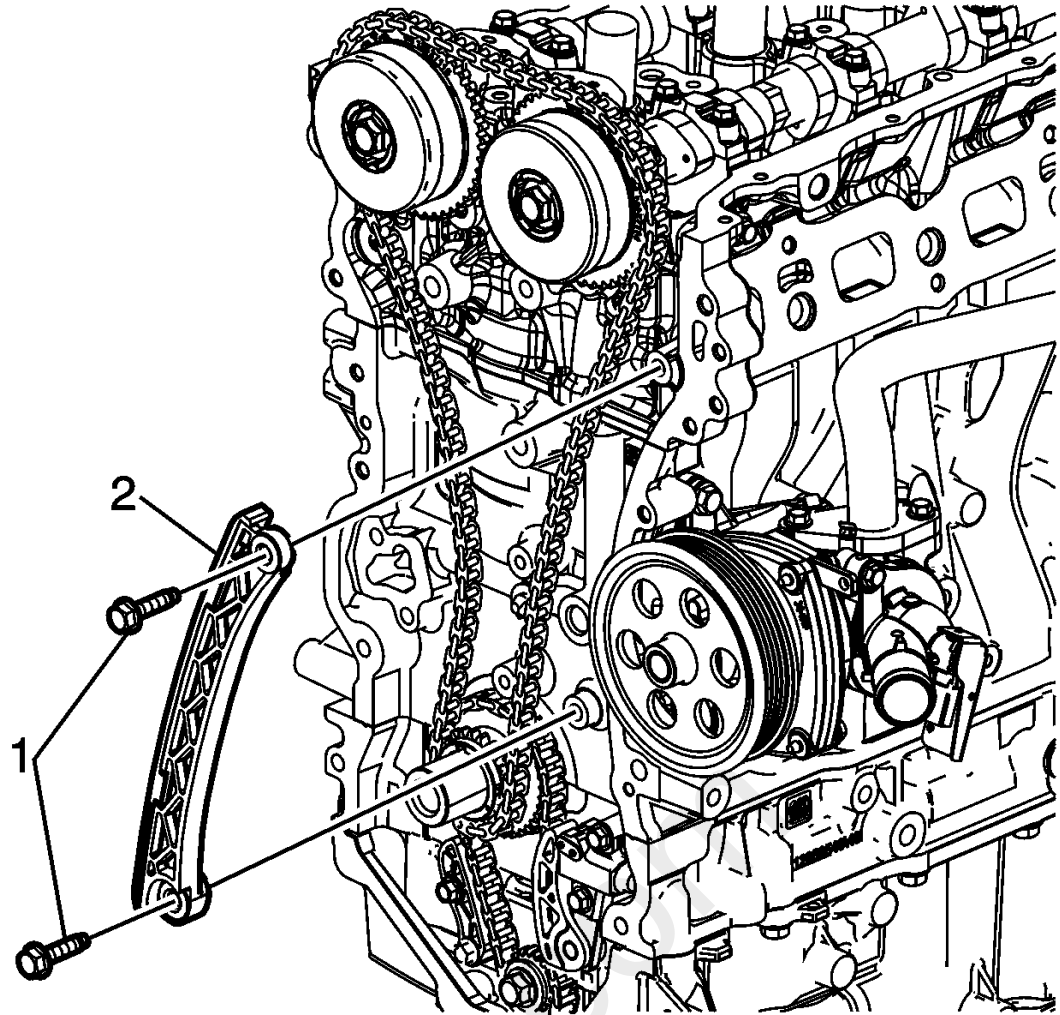


Fig. 347: Timing Chain Guide Bolts

Courtesy of GENERAL MOTORS COMPANY

8. Remove the timing chain guide bolts (1).
9. Remove the timing chain guide (2).

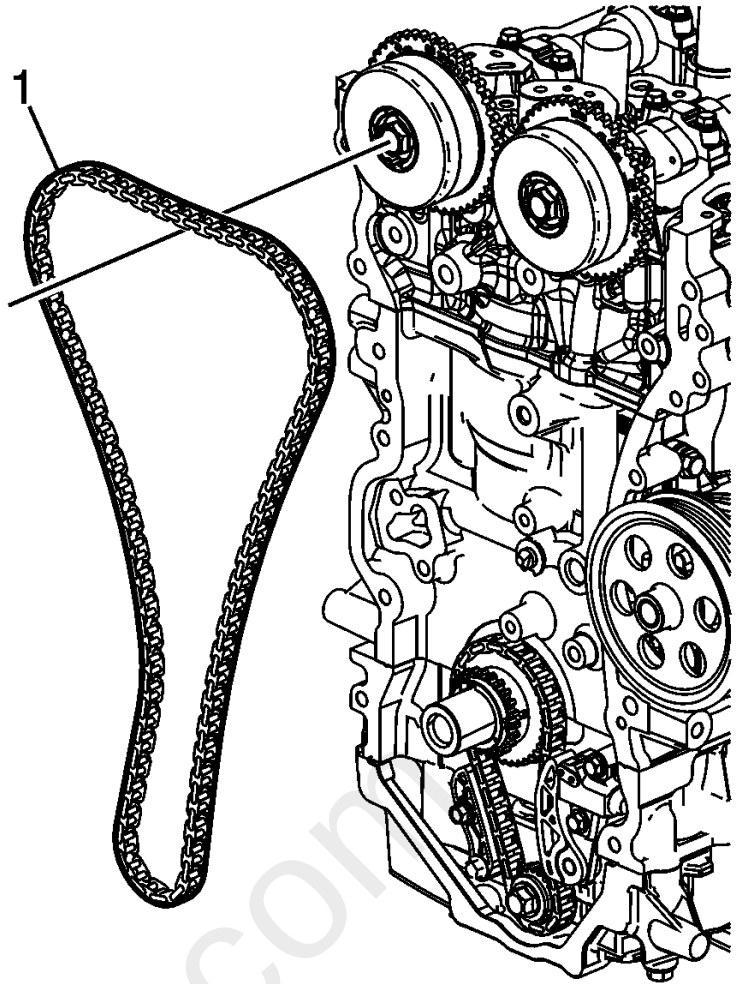


Fig. 348: Timing Chain

Courtesy of GENERAL MOTORS COMPANY

10. Remove the timing chain (1).

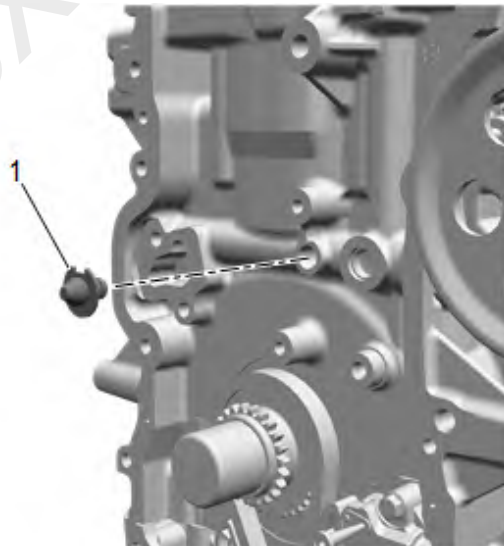


Fig. 349: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

11. Remove the timing chain oil nozzle (1).

OIL PAN REMOVAL (AWD)

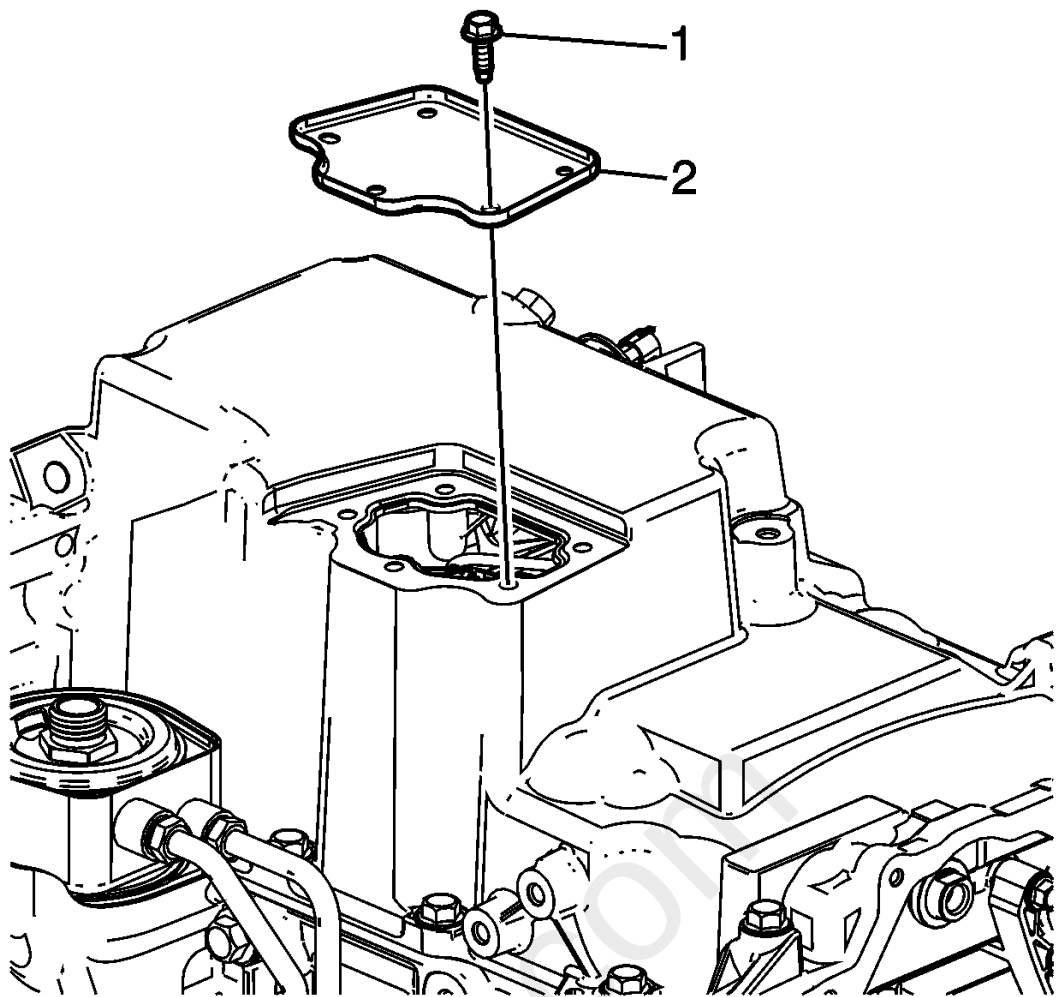


Fig. 350: Oil Pan Cover And Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pan cover bolts (1).
2. Remove the oil pan cover (2).

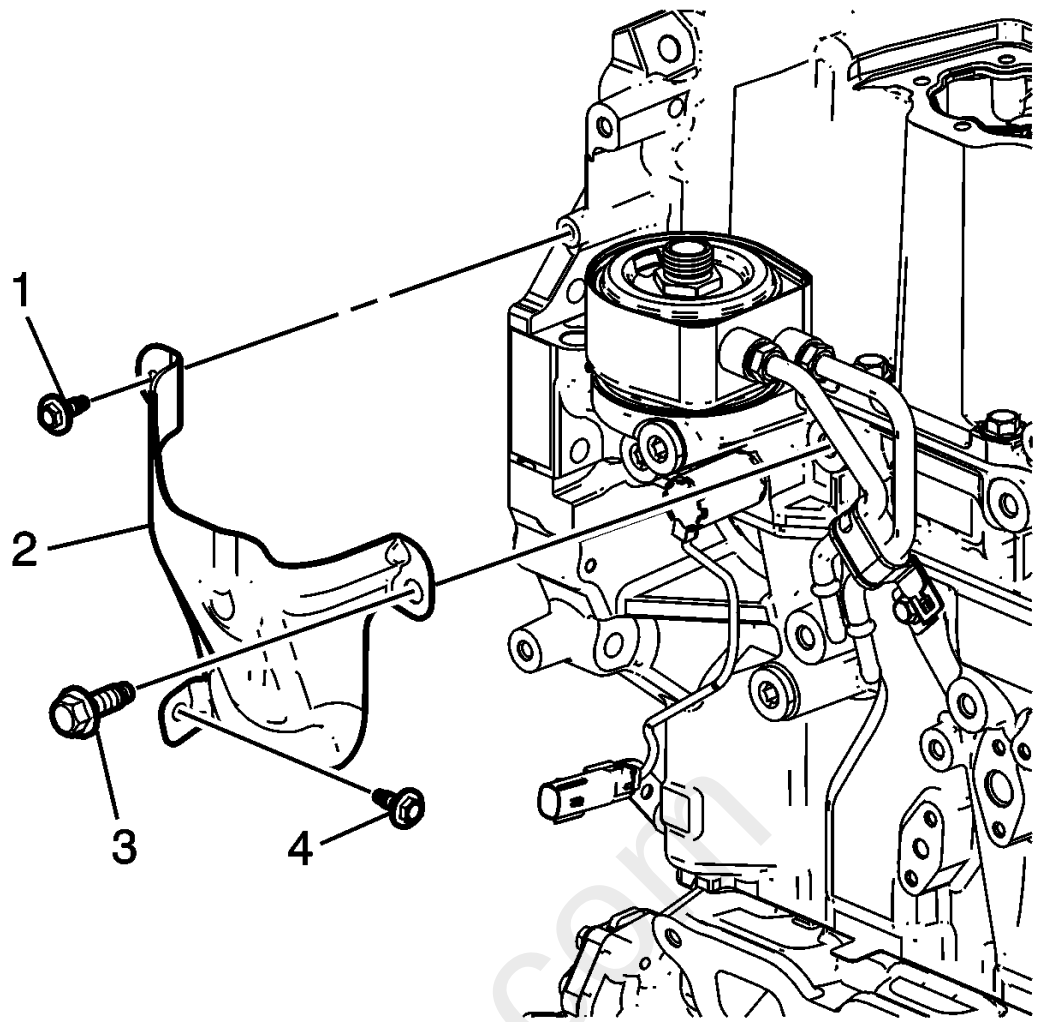


Fig. 351: Oil Pump Flow Control Valve Cover
Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil pump flow control valve cover (2) and bolts (1, 3, 4).

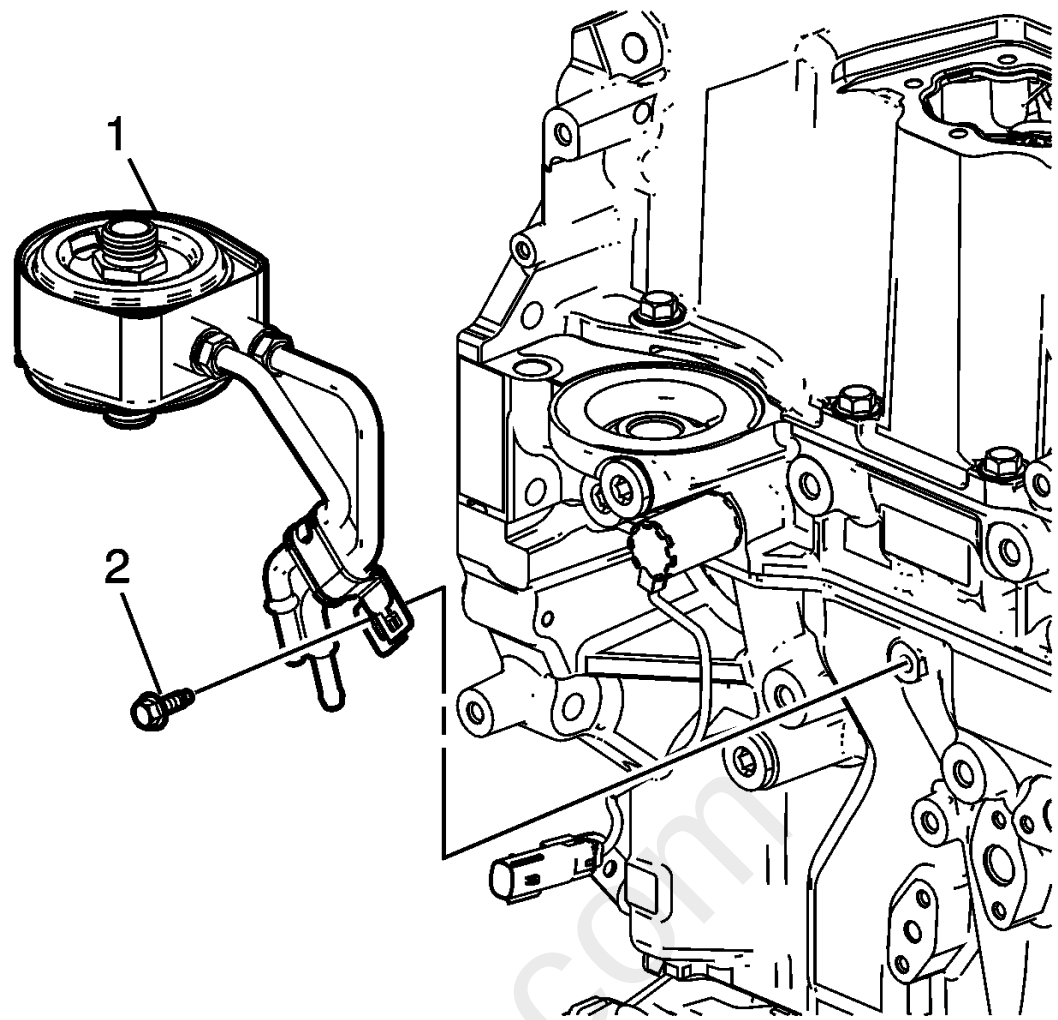


Fig. 352: Engine Oil Cooler

Courtesy of GENERAL MOTORS COMPANY

4. Remove the engine oil cooler (1) and bolts (2).

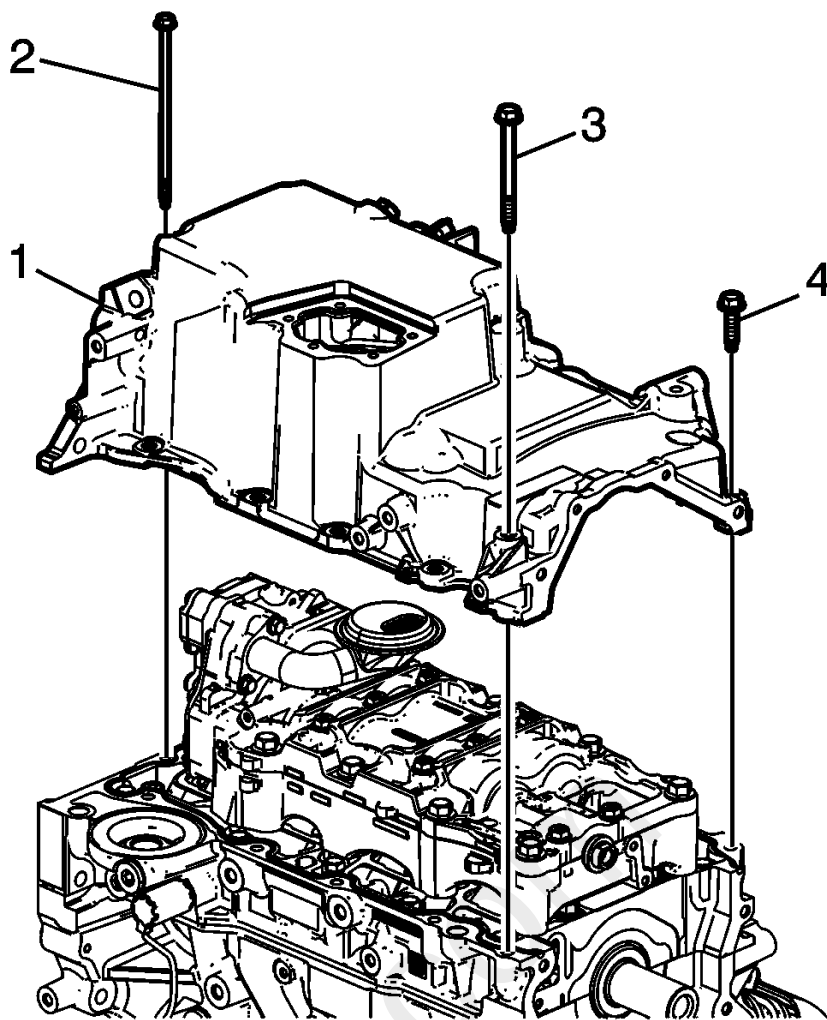


Fig. 353: Upper Oil Pan And Bolts

Courtesy of GENERAL MOTORS COMPANY

5. Remove the upper oil pan bolts (2, 3, 4).
6. Remove the upper oil pan (1).

OIL PAN REMOVAL (FWD)

Oil Pump Flow Control Valve Heat Shield Removal

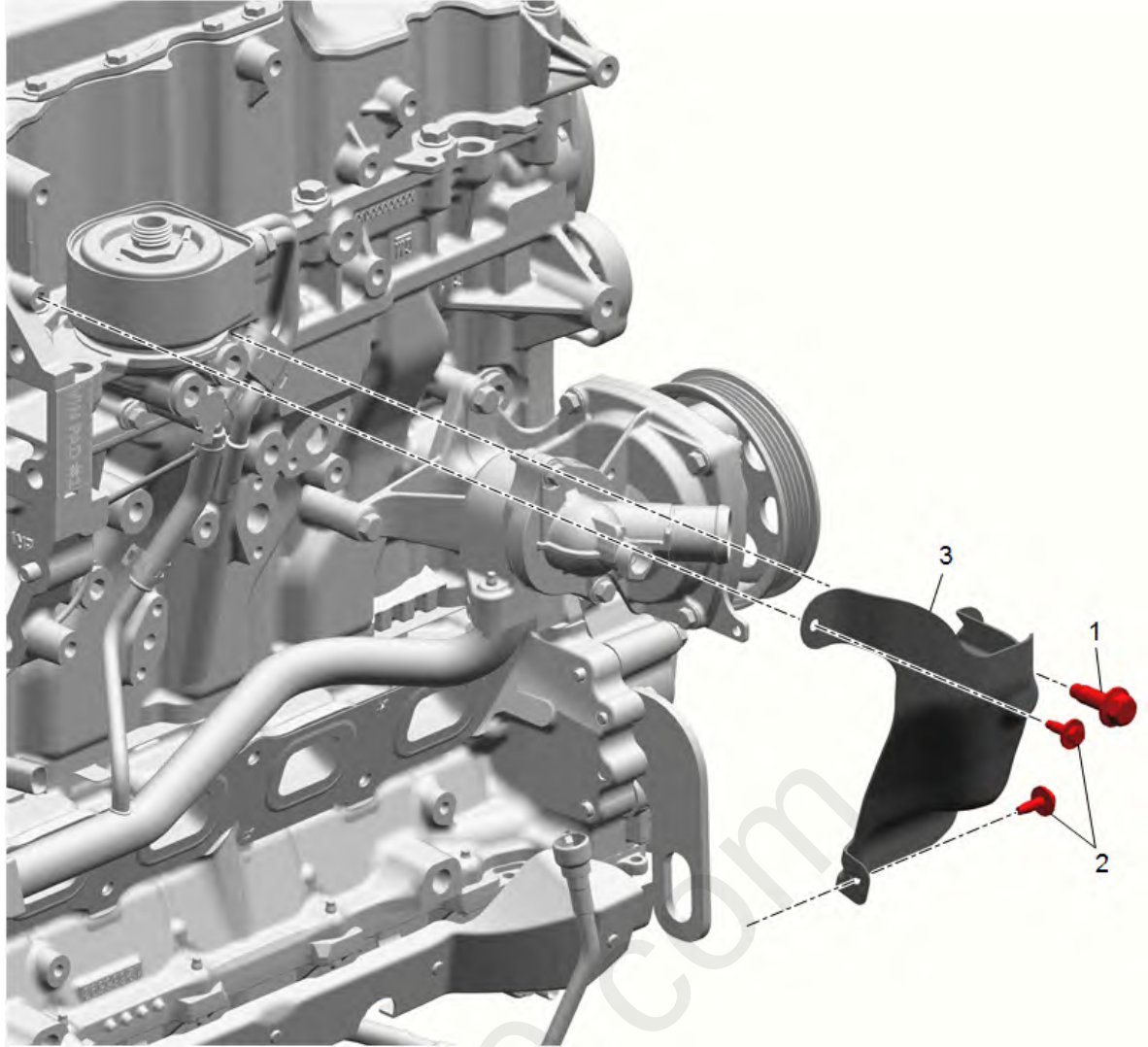


Fig. 354: Oil Pump Flow Control Valve Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Flow Control Valve Heat Shield Bolt
2	Pump and Component Oil Heat Shield Bolt
3	Oil Pump Flow Control Valve Heat Shield

Lower Oil Pan and Engine Oil Cooler Removal

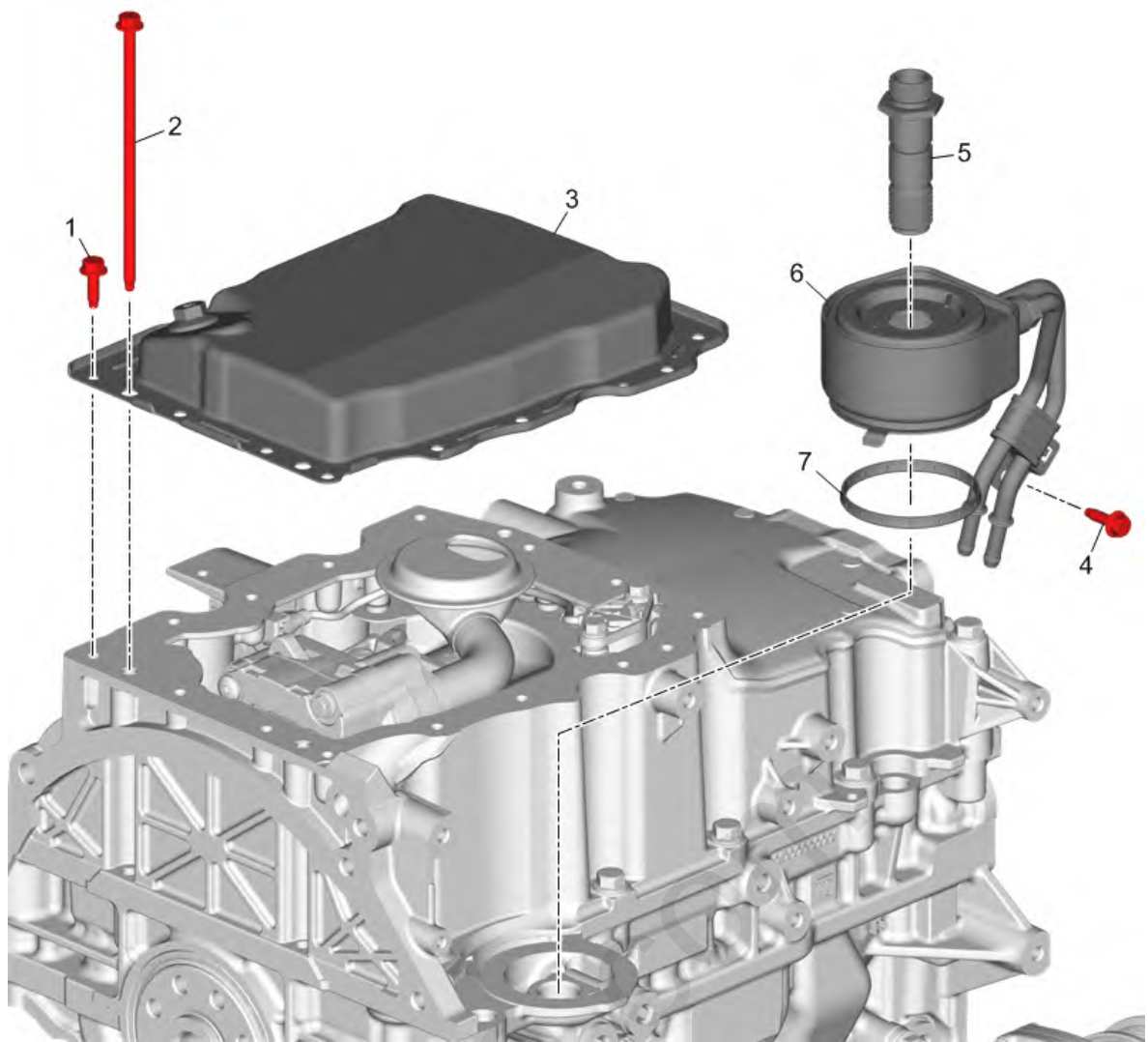


Fig. 355: Lower Oil Pan and Engine Oil Cooler
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt
2	Oil Pan Bolt
3	Lower Oil Pan
4	Engine Oil Cooler Bolt
5	Engine Oil Cooler Connector
6	Engine Oil Cooler
7	Engine Oil Cooler Seal Procedure DISCARD the seal.

Oil Pan Removal

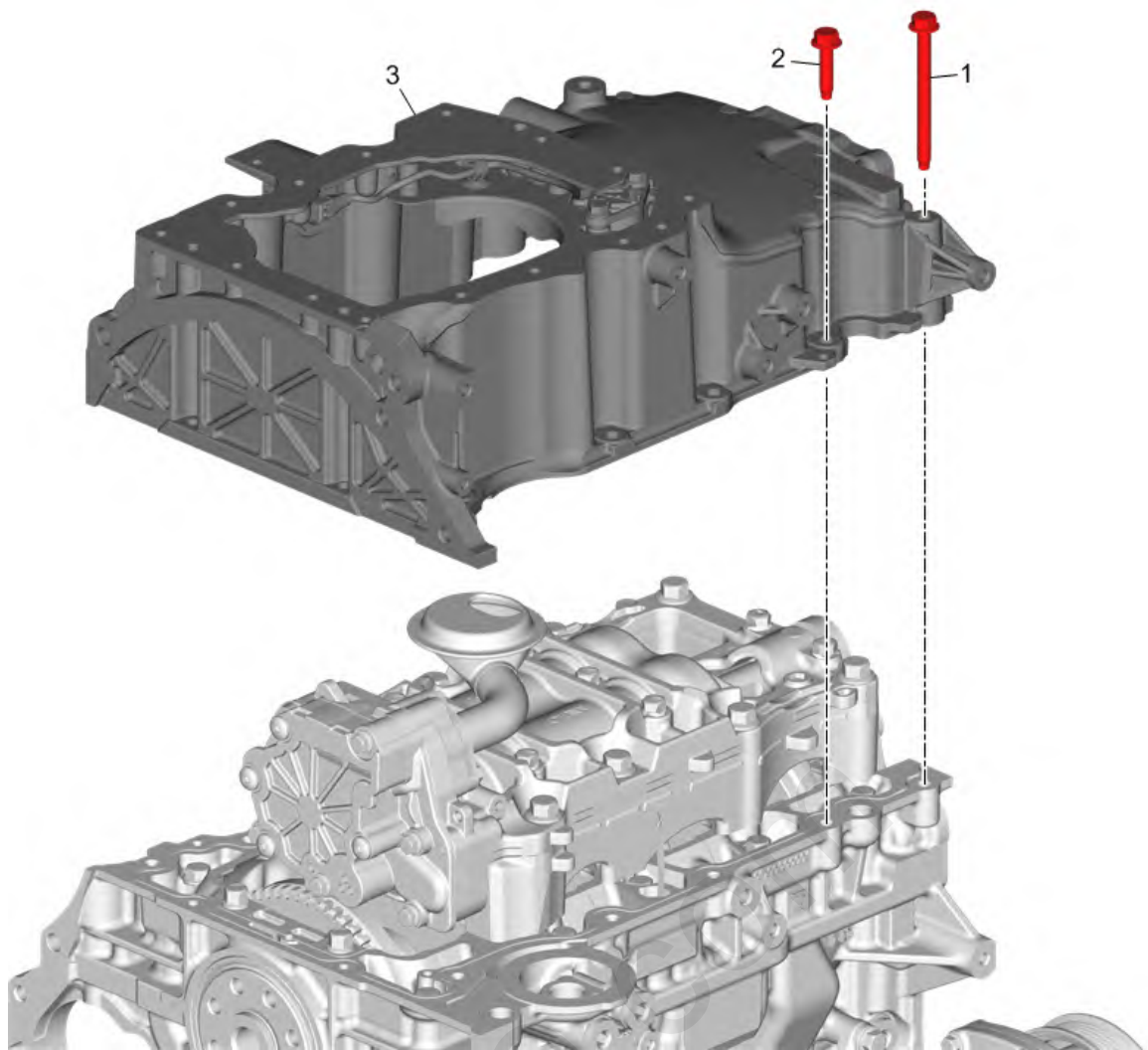


Fig. 356: Oil Pan

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Bolt
2	Oil Pan Bolt
3	Oil Pan

BALANCER CHAIN, SPROCKET, AND TENSIONER REMOVAL

Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

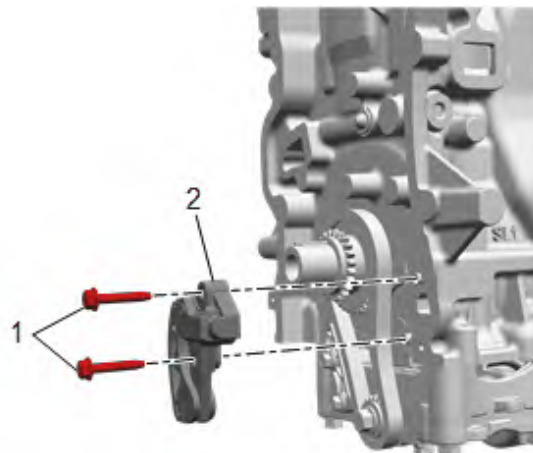


Fig. 357: Balancer Chain Tensioner Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the balancer chain tensioner bolt (1).
2. Remove the balancer chain tensioner (2).
3. Compress and lock the tensioner using **EN-50837** retention tool.
 1. Insert **EN-50837** retention tool into the lever arm and push in a clockwise direction.
 2. Compress the tensioner while holding lever arm.
 3. Relax the force on the lever and tensioner slightly, allowing the tensioner to extend 3 ratchet clicks, and then hold in place.
 4. Pull lever counterclockwise using **EN-50837** retention tool until the hole in the lever aligns with the hole in the tensioner assembly. Push the point of **EN-50837** retention tool through the lever and into the tensioner assembly.

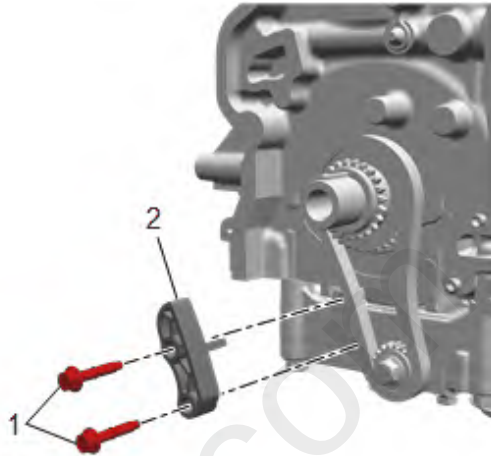


Fig. 358: Balancer Chain Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the balancer chain guide bolt (1).
5. Remove the balancer chain guide (2).

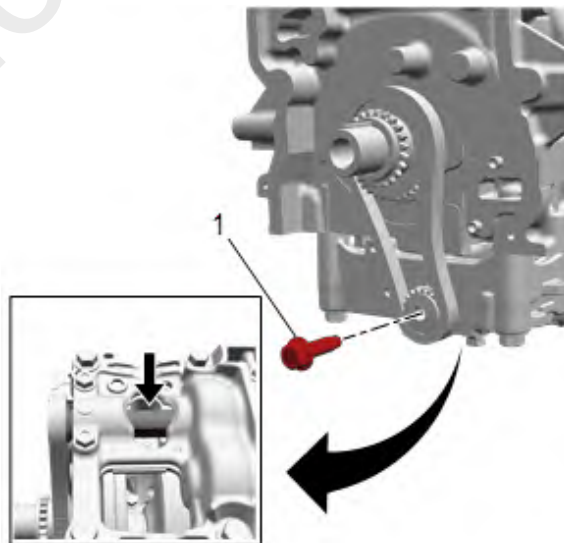


Fig. 359: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Use an open end wrench over flat on balance shaft while loosening balancer shaft sprocket bolt. Remove and discard the balancer shaft driven sprocket bolt (1).

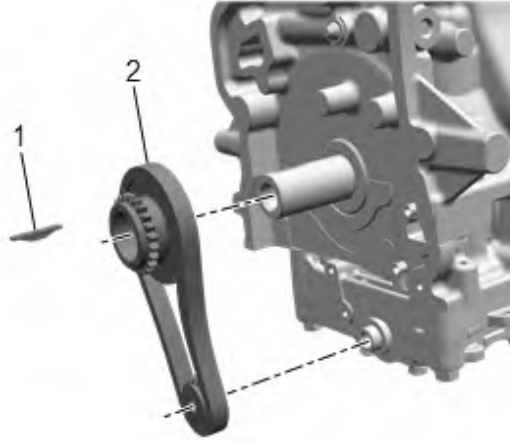


Fig. 360: Balancer Shaft Driven Sprocket And Balancer Chain

Courtesy of GENERAL MOTORS COMPANY

7. Remove the crankshaft key (1).
8. Remove the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain (2) simultaneously.

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

Intake Camshaft and Components Removal

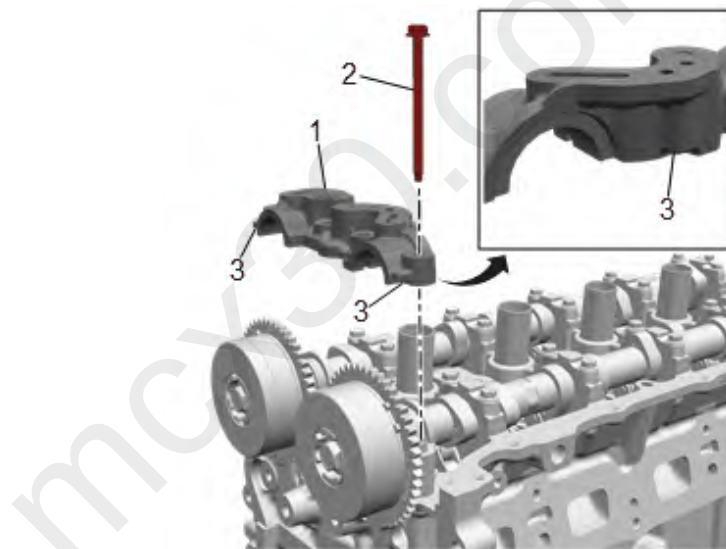


Fig. 361: Camshaft Front Bearing Cap, Bolts And Pry Points

Courtesy of GENERAL MOTORS COMPANY

1. Remove the camshaft front bearing cap bolts (2).

NOTE:

- Locate the pry points (3) on the camshaft front bearing cap.
- When using the pry points to remove the front bearing cap, use a protective material between the camshaft lobes, the cylinder head flange, and pry tool.
- Use 2 pry tools simultaneously to pry the upper front bearing cap away from the lower bearing cap evenly.

2. Using suitable pry tools, remove the camshaft front bearing cap (1)

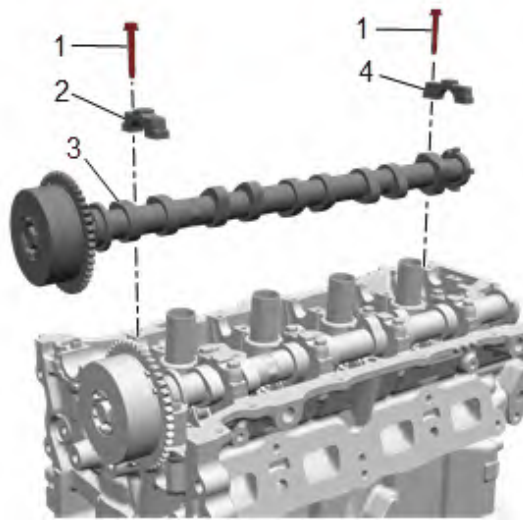


Fig. 362: Intake Camshaft Bearing Rear Cap Bolts And Cap

Courtesy of GENERAL MOTORS COMPANY

3. Mark the intake camshaft rear cap to ensure it is installed in the same position. Remove the intake camshaft bearing rear cap bolts (1) and cap (4).

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

4. Mark the camshaft caps (2) to ensure they are installed in the same position.
5. Remove the intake camshaft cap bolts (1).
6. Remove the camshaft caps (2).
7. Remove the intake camshaft (3).

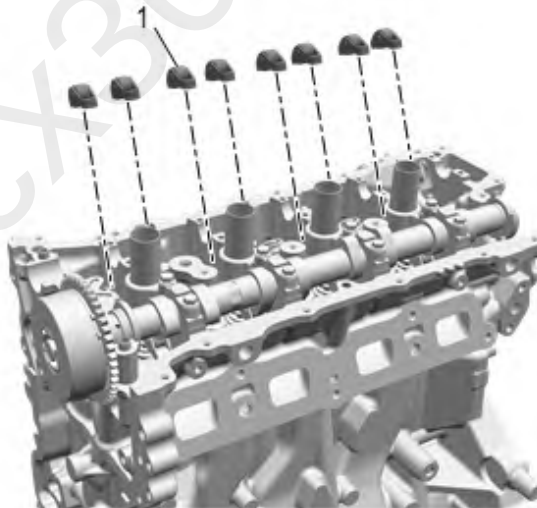


Fig. 363: Intake Camshaft Roller Finger Followers

Courtesy of GENERAL MOTORS COMPANY

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

8. Remove the intake camshaft roller finger followers (1).

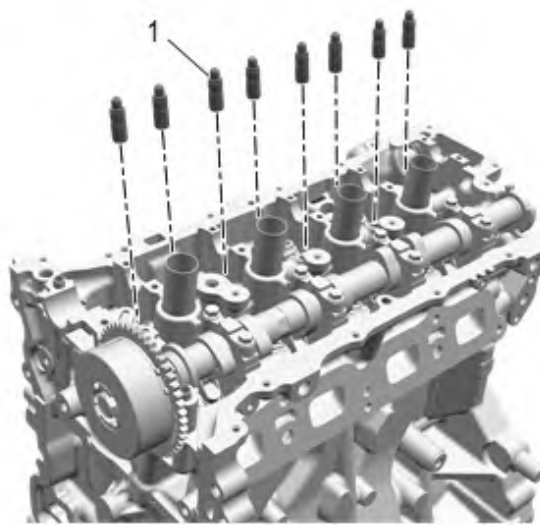


Fig. 364: Hydraulic Lash Adjusters
 Courtesy of GENERAL MOTORS COMPANY

9. Remove the hydraulic lash adjusters (1).

Exhaust Camshaft and Components Removal

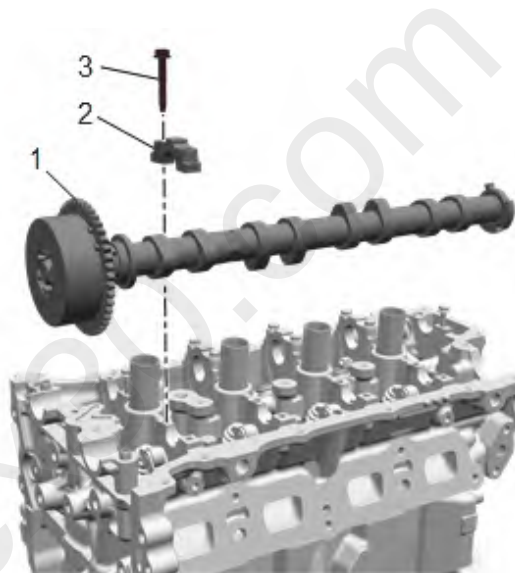


Fig. 365: Camshaft Caps
 Courtesy of GENERAL MOTORS COMPANY

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

1. Mark camshaft caps (2) to ensure they are installed in the same position.
2. Remove the exhaust camshaft cap bolts (3).
3. Remove the camshaft caps (2) ensuring they are marked and refitted in same position on assembly.
4. Remove the exhaust camshaft (1).

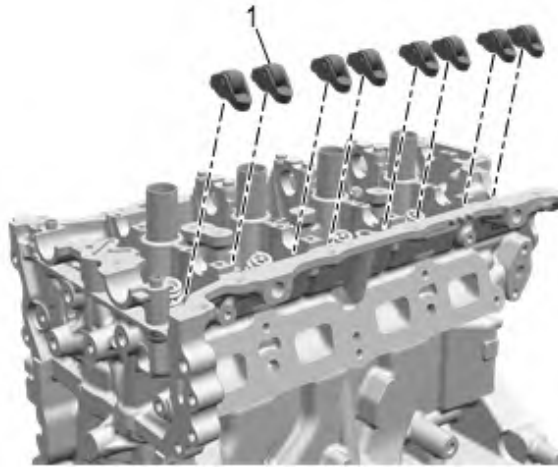


Fig. 366: Exhaust Camshaft Roller Finger Followers

Courtesy of GENERAL MOTORS COMPANY

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

5. Remove the exhaust camshaft roller finger followers (1).

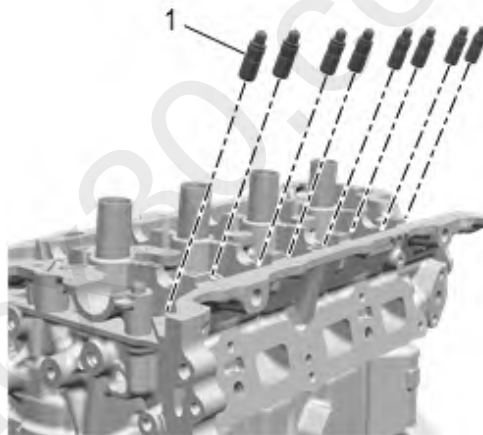
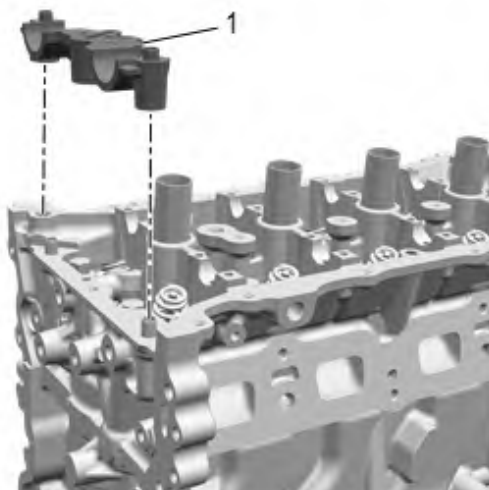


Fig. 367: Hydraulic Lash Adjusters

Courtesy of GENERAL MOTORS COMPANY

6. Remove the hydraulic lash adjusters (1).



7. Remove the camshaft bearing lower front cap (1).

WATER PUMP REMOVAL

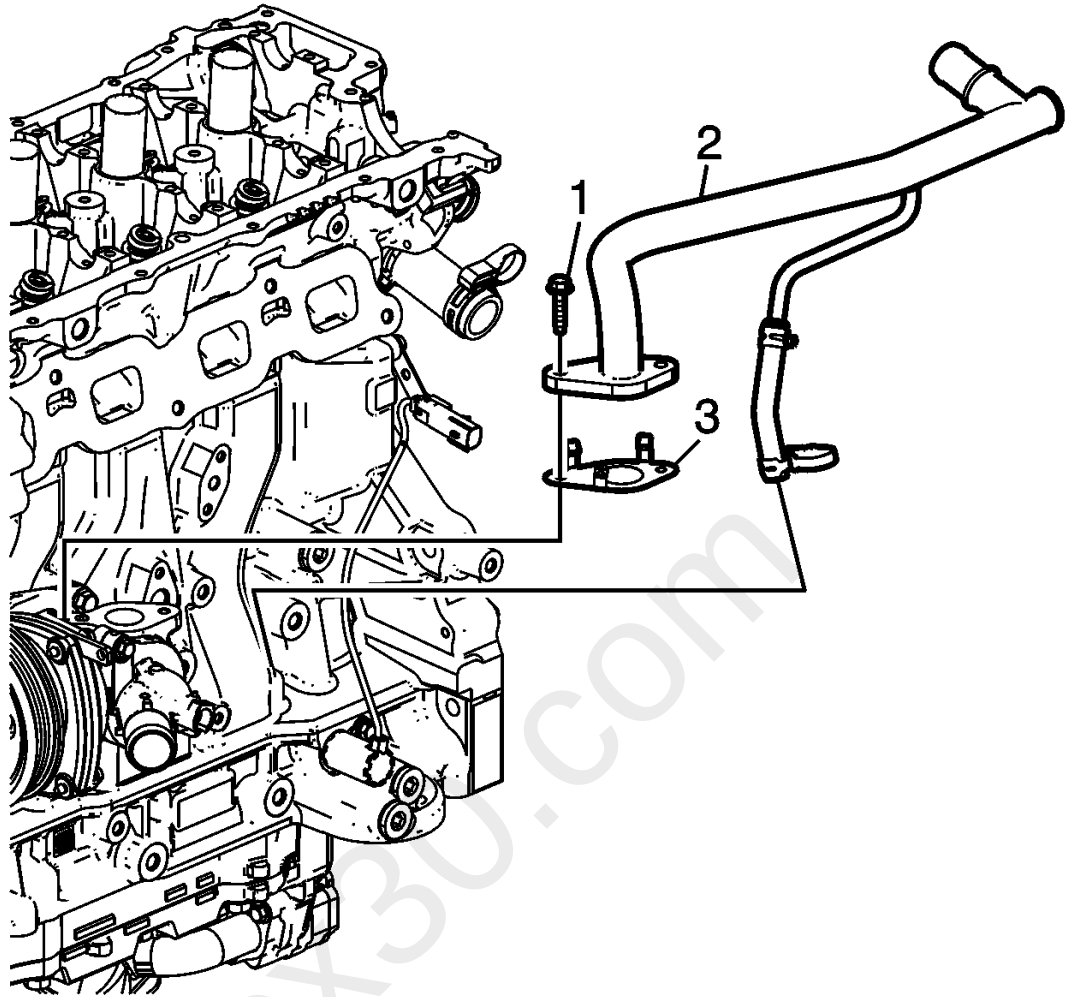


Fig. 369: Thermal Bypass Pipe Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect the thermal bypass hose at the engine oil cooler.
2. Remove the thermal bypass pipe bolts (1) at the water pump assembly.
3. Disconnect the pipe from the water outlet assembly.
4. Remove the thermal bypass pipe (2) and gasket (3) from the water pump assembly. Discard the gasket.

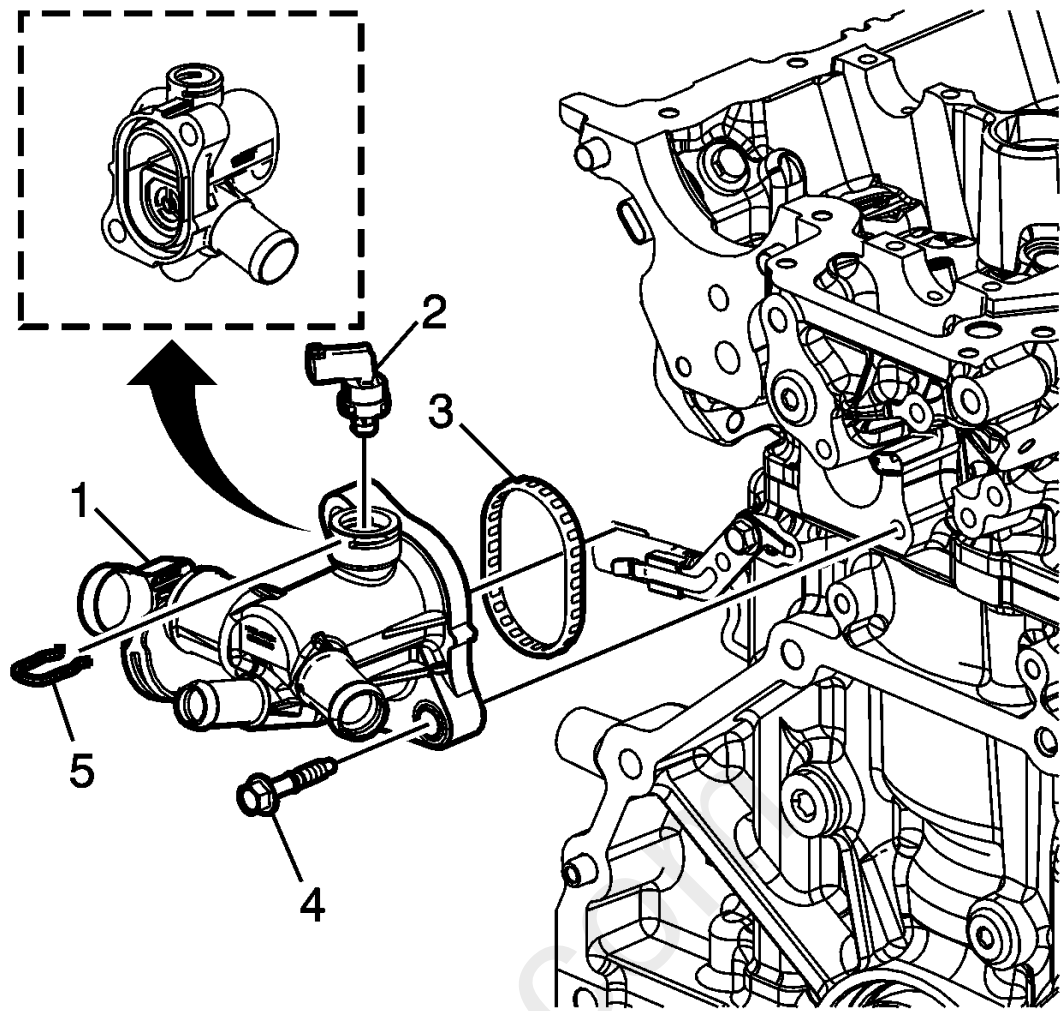


Fig. 370: Retaining Clip And Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

5. Remove the retaining clip (5) and engine coolant temperature sensor (2).
6. Remove the water outlet assembly (1), bolts (4), and gasket seal (3). Discard the gasket.

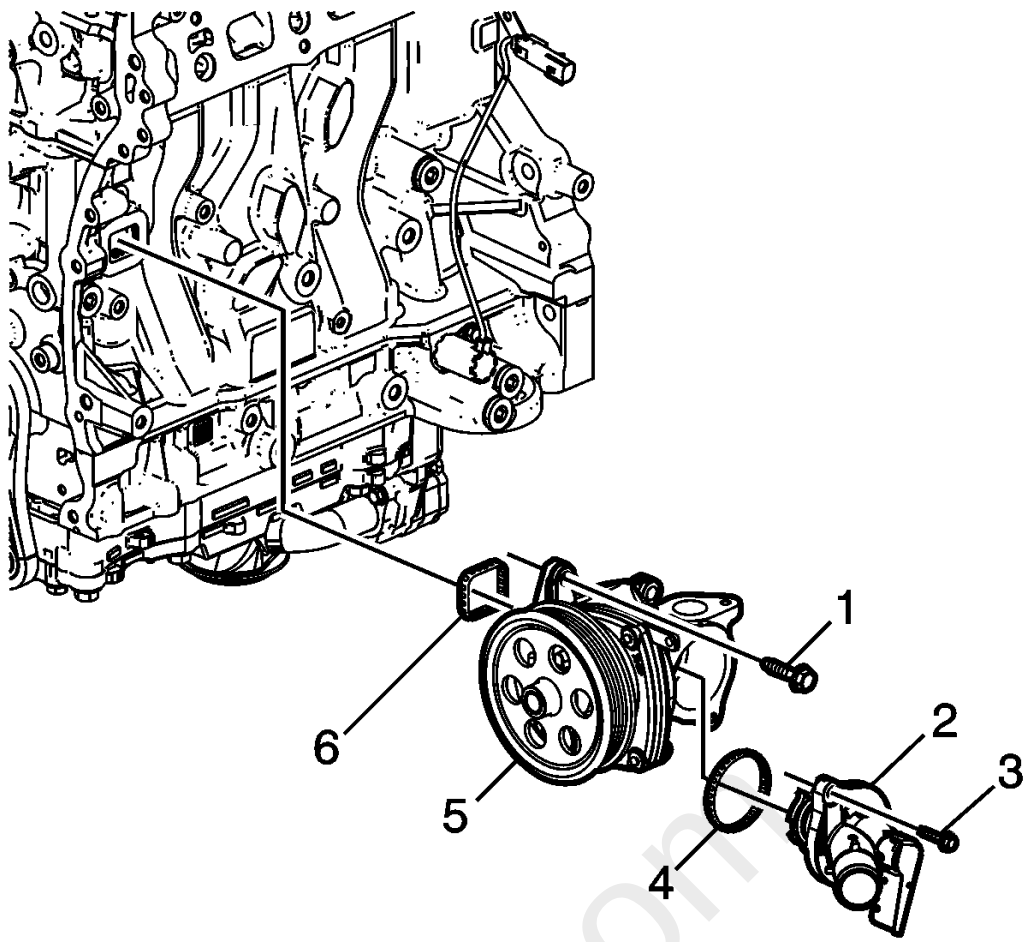


Fig. 371: Thermostat Assembly And Gasket Seal
Courtesy of GENERAL MOTORS COMPANY

7. Remove the thermostat assembly (2), bolts (3), and gasket seal (4). Discard the gasket.
8. Remove the water pump assembly (5), bolts (1), and seal (6). Discard the seal.

CYLINDER HEAD REMOVAL

Special Tools

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

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

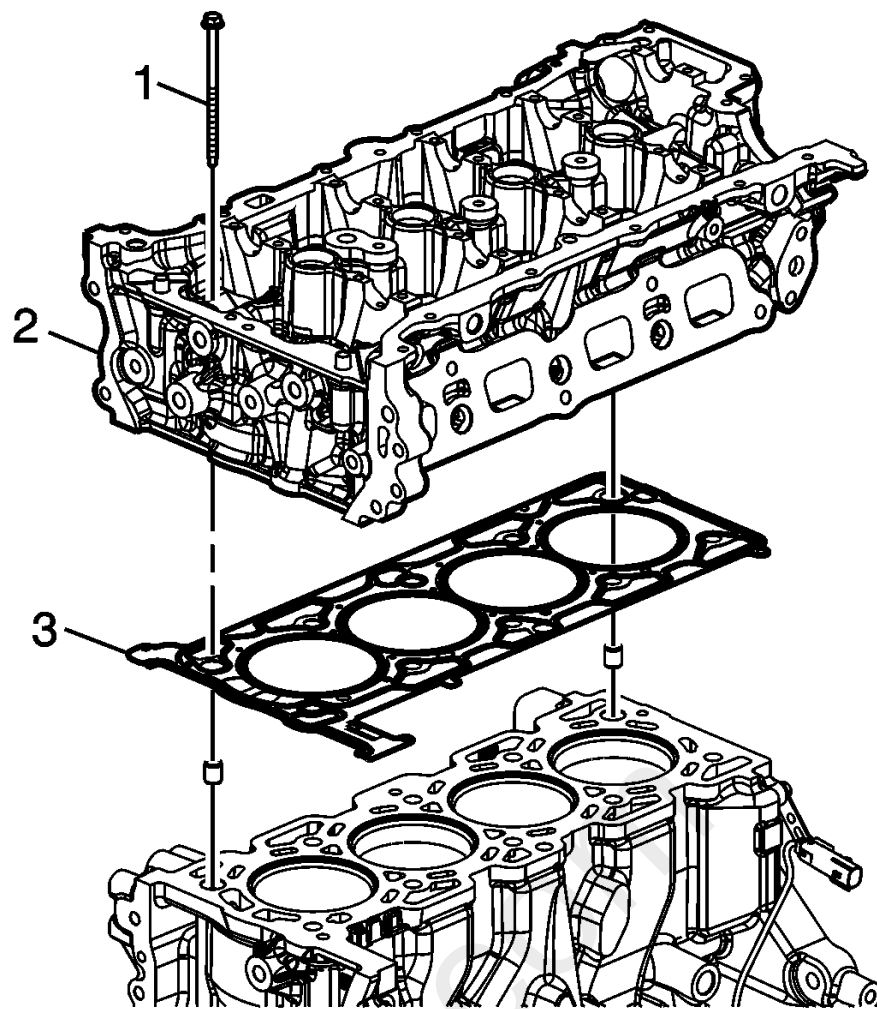


Fig. 372: Cylinder Head Bolts

Courtesy of GENERAL MOTORS COMPANY

1. Remove and discard the cylinder head bolts (1).

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

2. Remove the cylinder head (2).
3. Remove the cylinder head gasket (3).
4. Inspect the cylinder head locating pins. Remove the locating pins and discard, if necessary.
5. Clean all of the gasket surfaces.
6. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:
 - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

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

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

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

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

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

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

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

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

BALANCER SHAFT WITH OIL PUMP REMOVAL

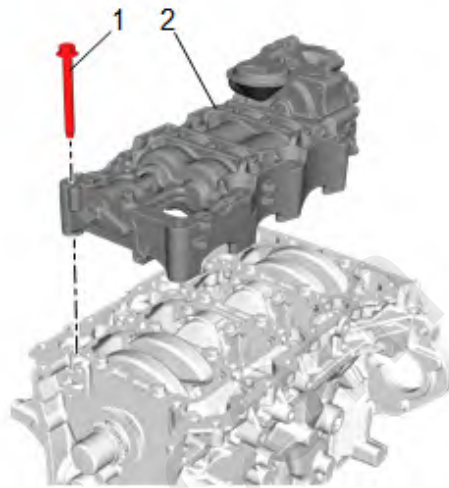


Fig. 373: Balancer And Oil Pump Shaft Assembly Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: DO NOT remove or loosen the balancer assembly bolts that join the two halves of the assembly together. Identify the bolts that retain the balancer assembly to the lower crankcase and ensure only these bolts are removed.

1. Remove the 8 balancer and oil pump shaft assembly bolts (1) along the perimeter of the assembly.
2. Remove the balancer and oil pump shaft assembly (2).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

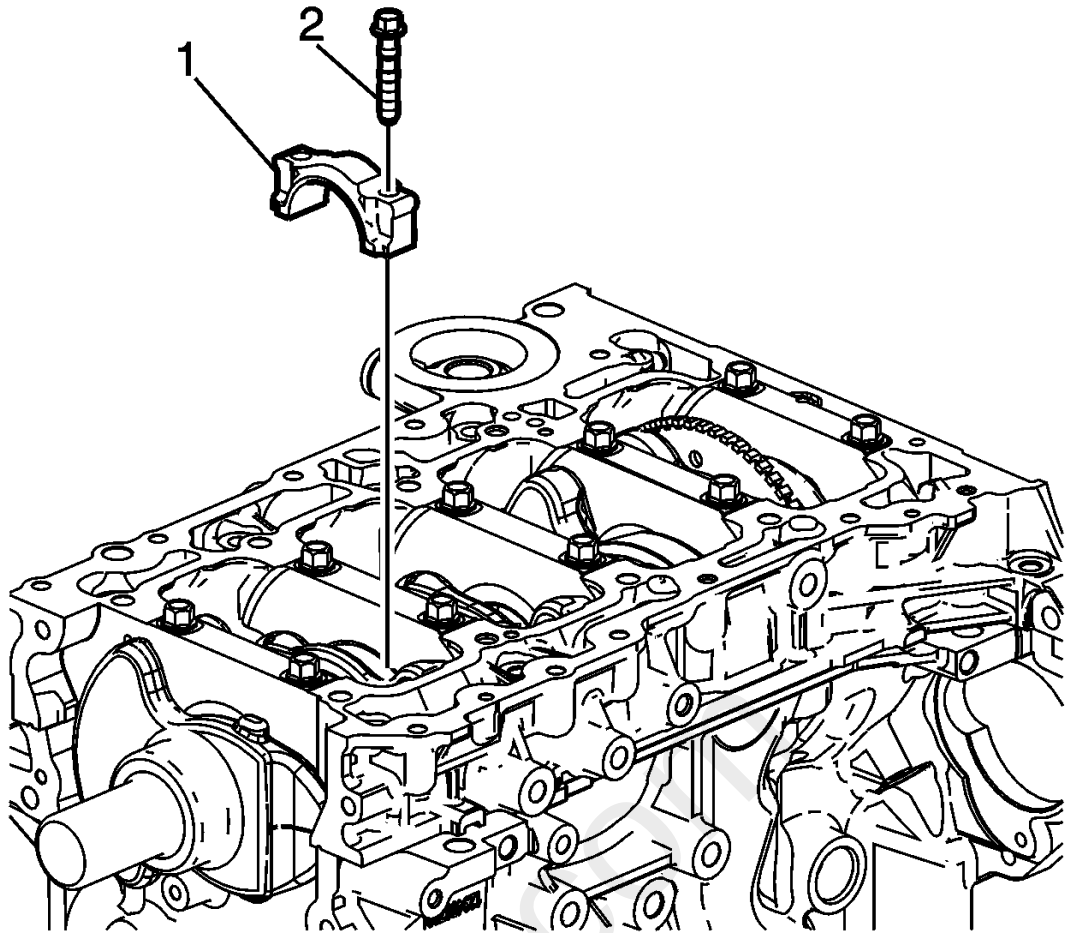


Fig. 374: Connecting Rod Cap

Courtesy of GENERAL MOTORS COMPANY

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

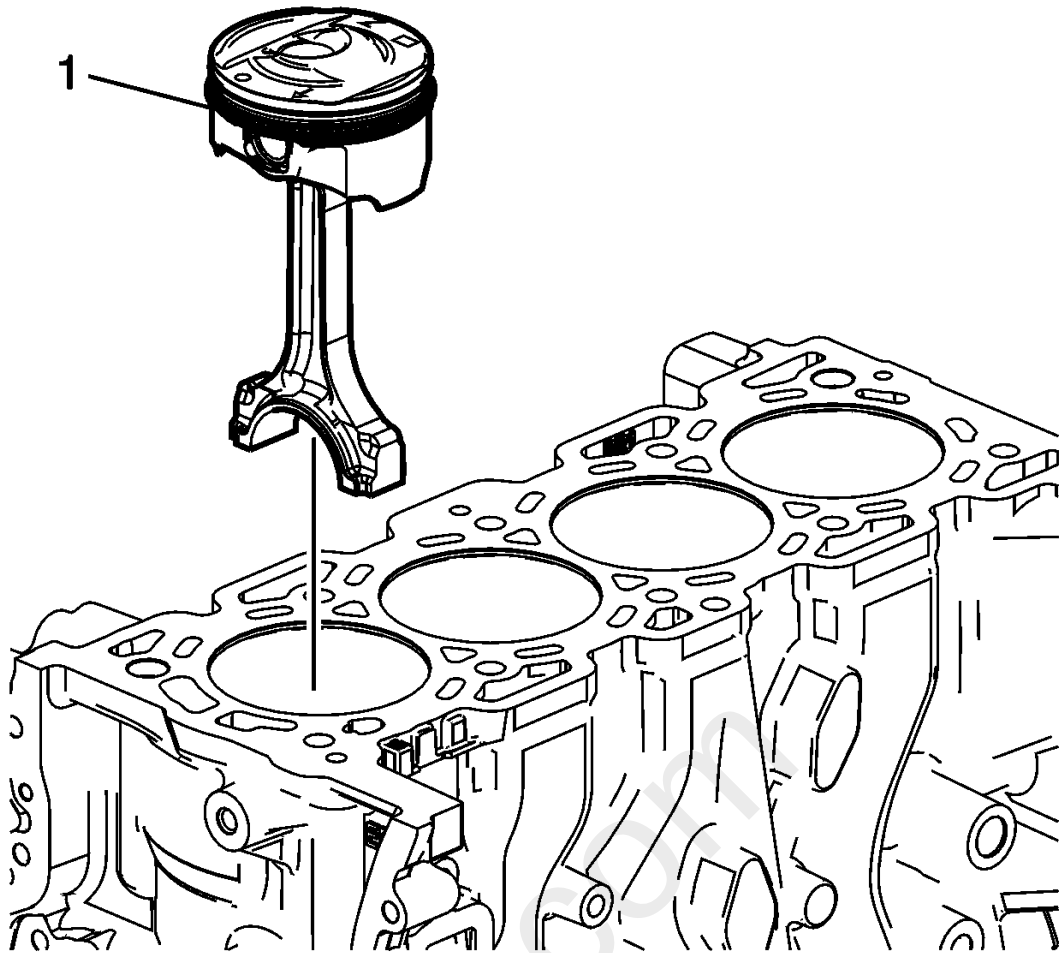


Fig. 375: Piston And Connecting Rod Assembly
 Courtesy of GENERAL MOTORS COMPANY

6. Remove the piston and connecting rod assembly (1).

LOWER CRANKCASE REMOVAL

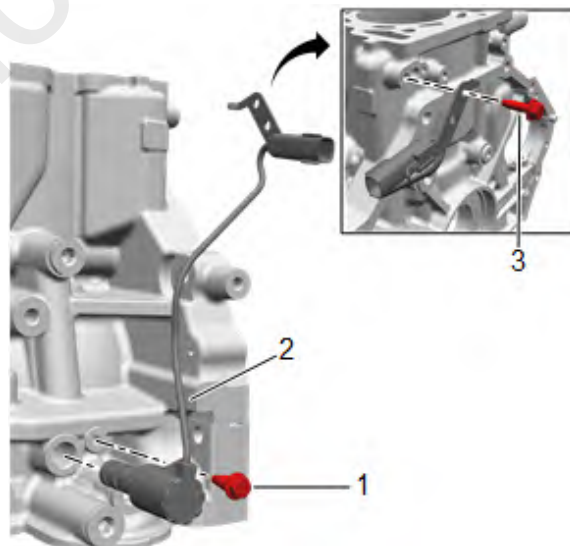


Fig. 376: Oil Pump Flow Control Valve And Bolts
 Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pump flow control valve (2) and bolts (1, 3).

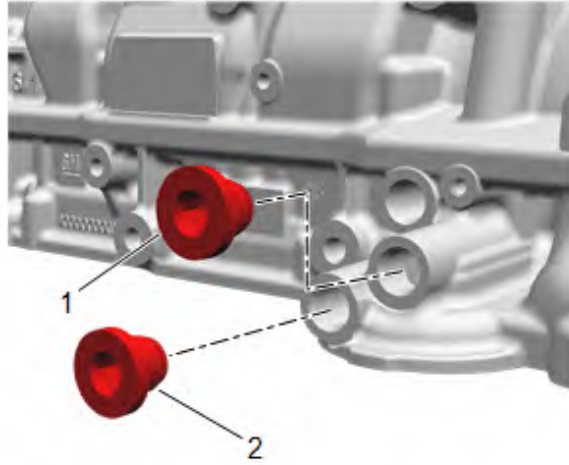


Fig. 377: Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil gallery plugs (1, 2).

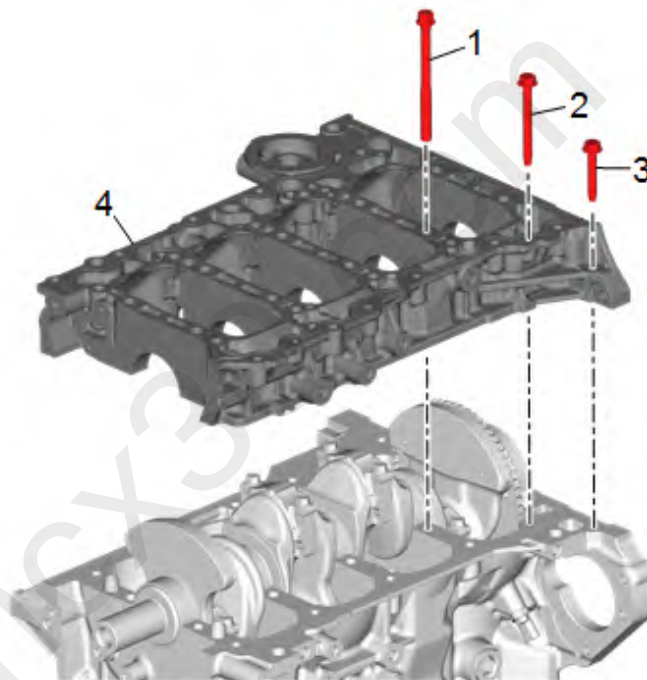


Fig. 378: Lower Crankcase Perimeter Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE: Separate, mark, and organize all reusable lower crankcase bolts to ensure installation in the correct locations.

3. Remove the lower crankcase bolts (2, 3) from the perimeter of the lower crankcase.
4. Remove and discard the inner lower crankcase bolts (1).
5. Gently separate the lower crankcase (4) from the block.

CRANKSHAFT AND BEARING REMOVAL

Crankshaft End Play Measurement

1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to [Engine Mechanical Specifications](#).
4. If the specifications are exceeded inspect the thrust bearing and the crankshaft thrust wall for wear. Refer to [Engine Mechanical Specifications](#).

5. Replace the thrust bearing or crankshaft as necessary.

Crankshaft and Bearing Removal

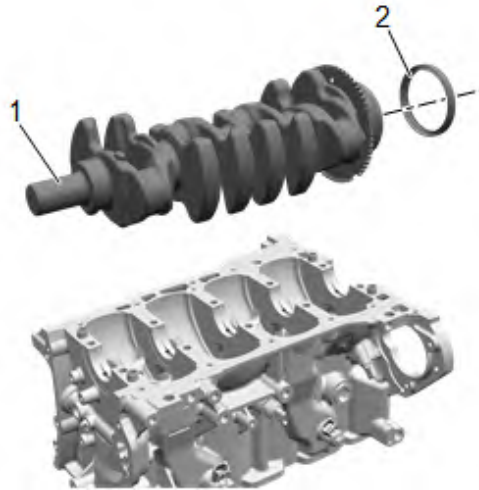


Fig. 379: Crankshaft And Rear Oil Seal

Courtesy of GENERAL MOTORS COMPANY

1. Remove the crankshaft (1) from the block.
2. Remove the crankshaft rear oil seal (2) from the block and discard.

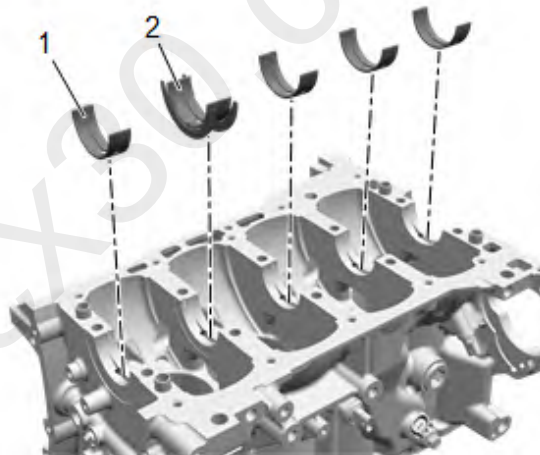


Fig. 380: Crankshaft Upper Bearings

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.

3. Remove the crankshaft upper bearings (1) and the crankshaft upper thrust bearing (2) from the block.

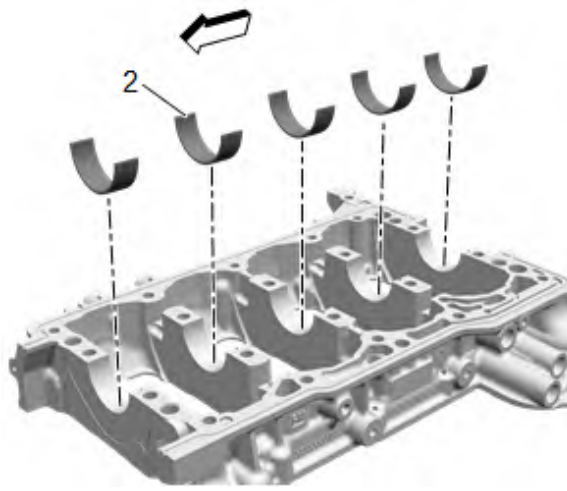


Fig. 381: Crankshaft Lower Bearings

Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft lower bearings (2) from the lower crankcase (1).
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
 - Cracks
 - Chips
 - Gouges
 - Roughness
 - Grooves
 - Overheating (discoloration)
9. Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

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

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

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

ENGINE BLOCK DISASSEMBLE

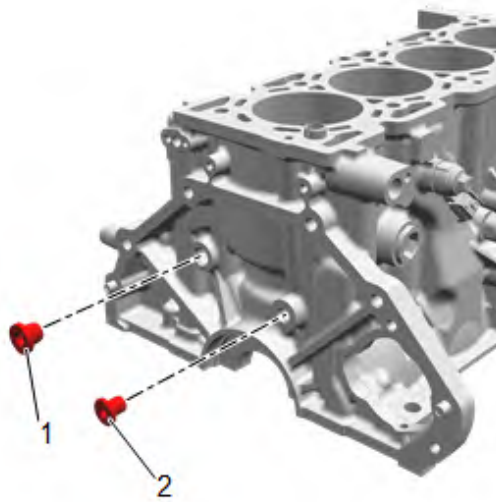


Fig. 382: Engine Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

1. Remove the engine oil gallery plugs (1, 2) from the rear of the block.

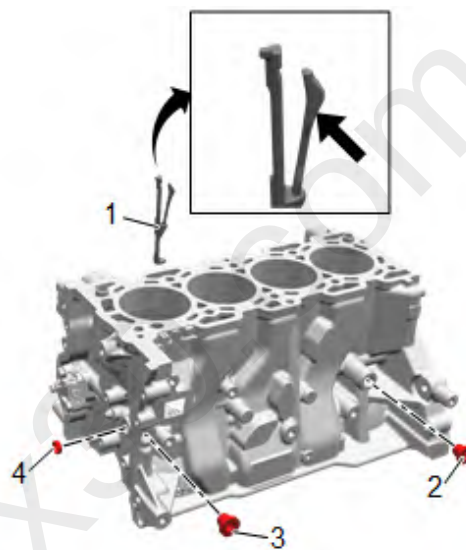


Fig. 383: Engine Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil gallery plugs (2, 3, 4) from the left side and front of the block.
3. Use a suitable hook tool to catch the clip feature and gently remove the engine block coolant baffle (1).

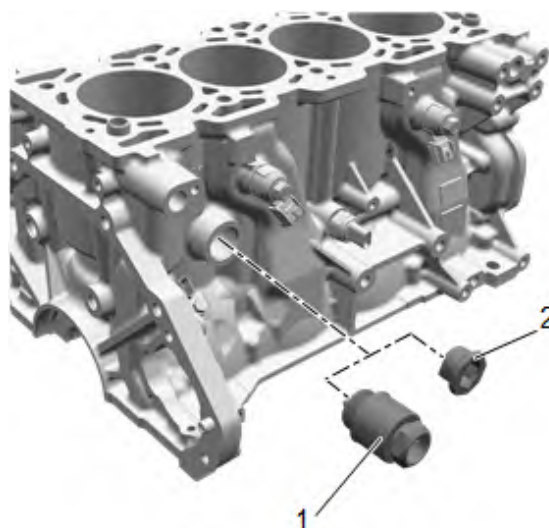


Fig. 384: Engine Coolant Heater

Courtesy of GENERAL MOTORS COMPANY

4. Remove the engine coolant heater (1), if equipped. Remove the engine coolant heater hole plug (2) if the heater is not present.

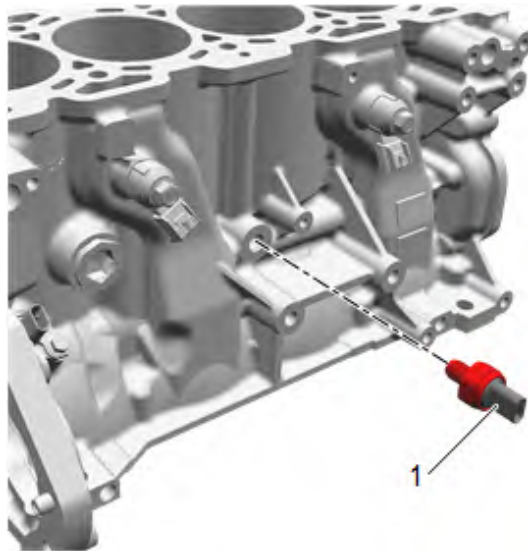


Fig. 385: Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

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

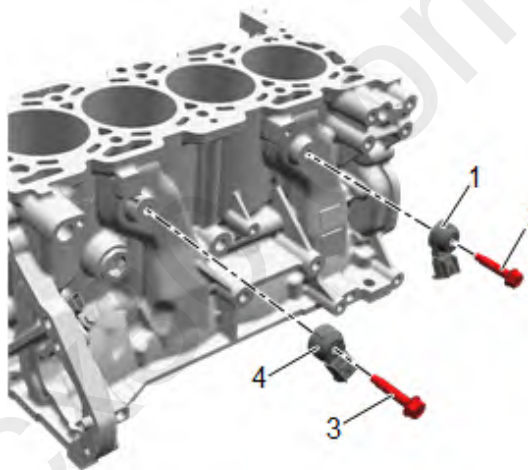
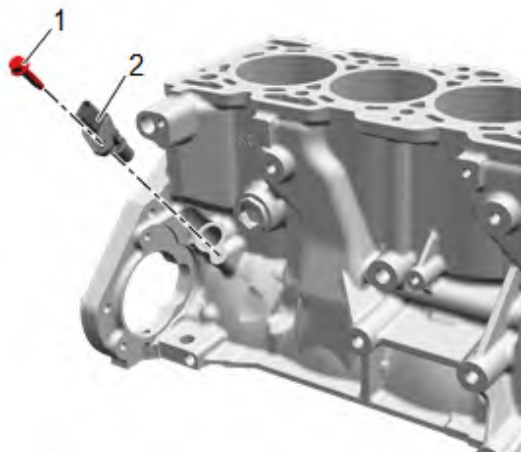


Fig. 386: Knock Sensors And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the knock sensors (1, 4) and bolts (2, 3).



7. Remove the crankshaft position (CKP) sensor (2) and bolt (1).

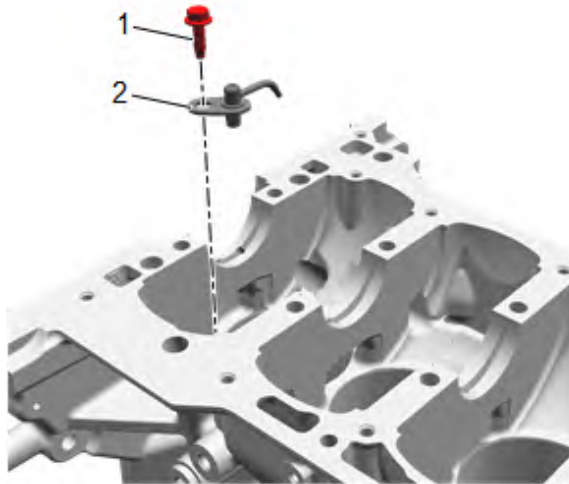


Fig. 388: Piston Oil Nozzle Assembly Bolt
Courtesy of GENERAL MOTORS COMPANY

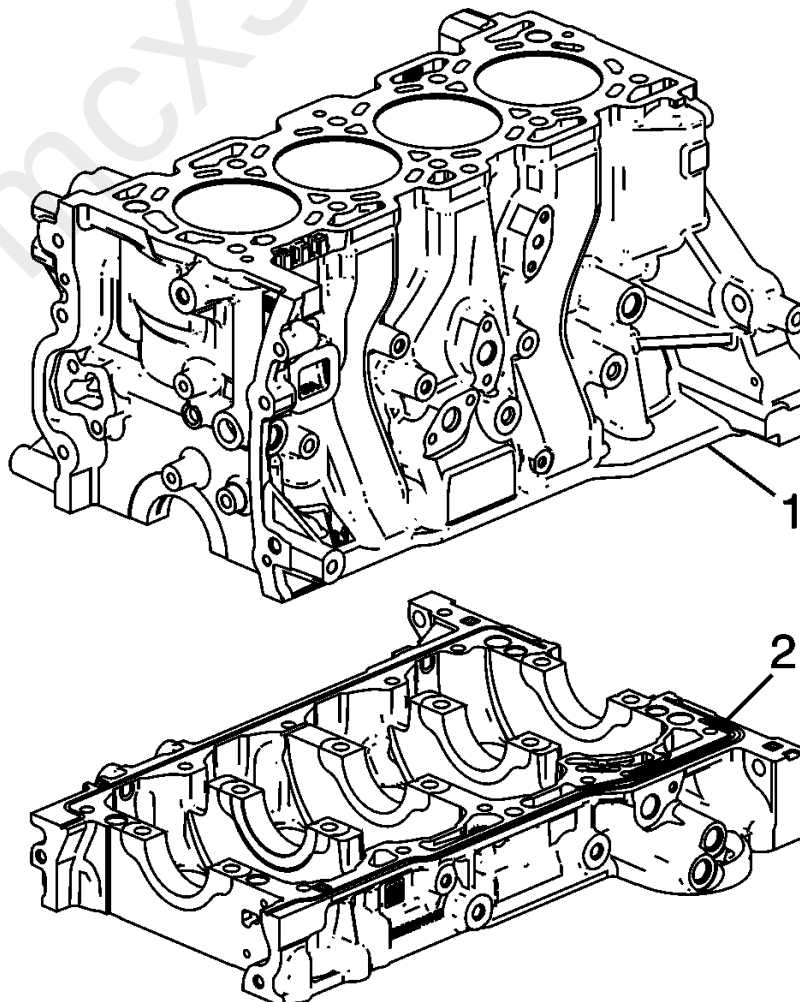
8. Loosen the piston oil nozzle assembly bolt (1) and remove the piston oil nozzle assembly (2).

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator

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



1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
2. Clean the sealing material from the engine block (1) and lower crankcase (2) gasket mating surfaces with a suitable tool.
3. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
4. Flush the engine block with clean water or steam.
5. Clean the oil passages.
6. Clean the blind holes.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to [Thread Repair](#).

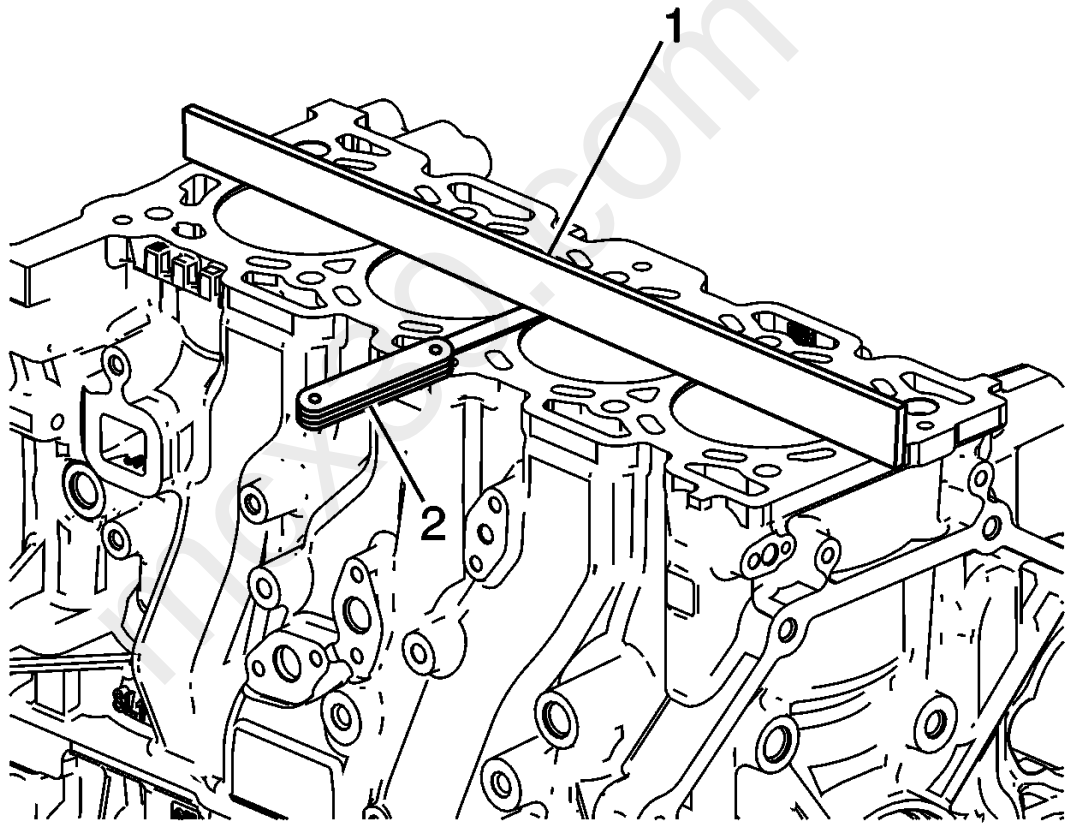


Fig. 390: Using Straight Edge
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

9. Use a straight edge (1) and a feeler gauge (2) to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

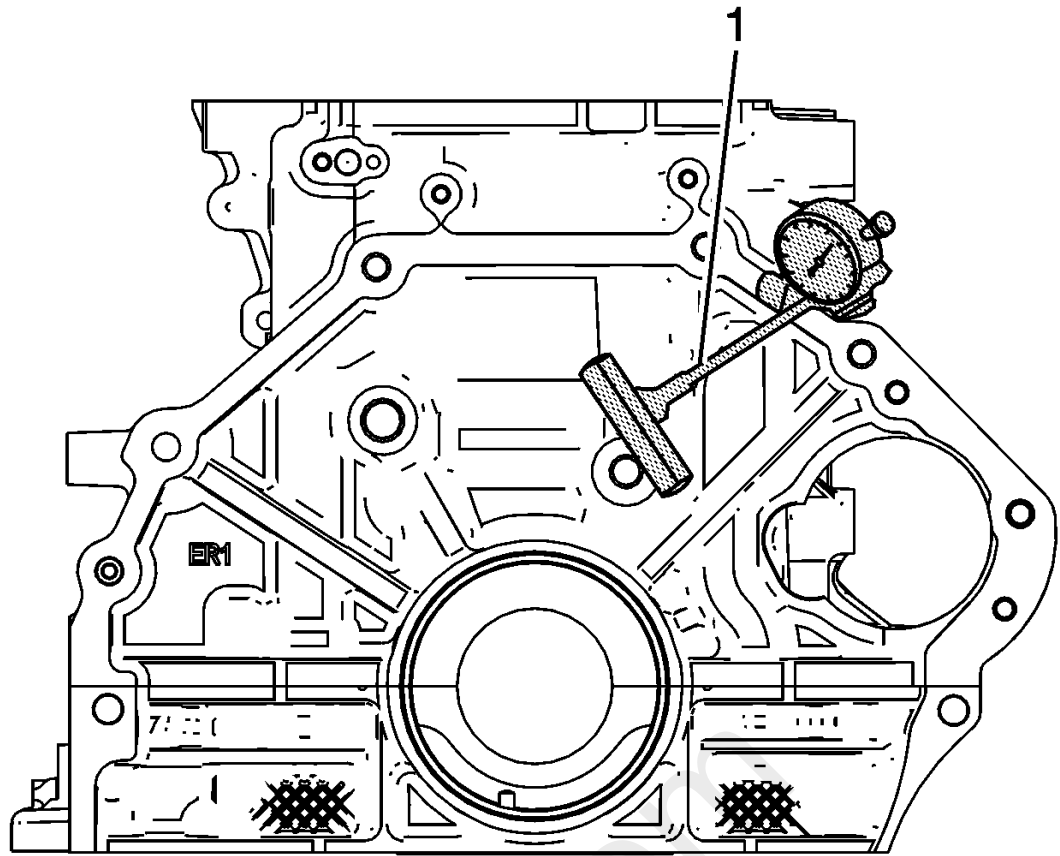


Fig. 391: Measuring Crankshaft Flange Runout Using Dial Indicator
 Courtesy of GENERAL MOTORS COMPANY

11. Inspect the mating surfaces of the transmission face.

CAUTION: A broken flywheel may result if the transmission case mating surface is not flat.

12. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
 1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **GE-7872** dial indicator (1)
 2. Hold the gauge plate flat against the crankshaft flange.
 3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
 4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.203 mm (0.008 in).
 5. Recheck the crankshaft flange runout if the readings vary more than 0.203 mm (0.008 in).
 6. Remove the crankshaft and bearings.

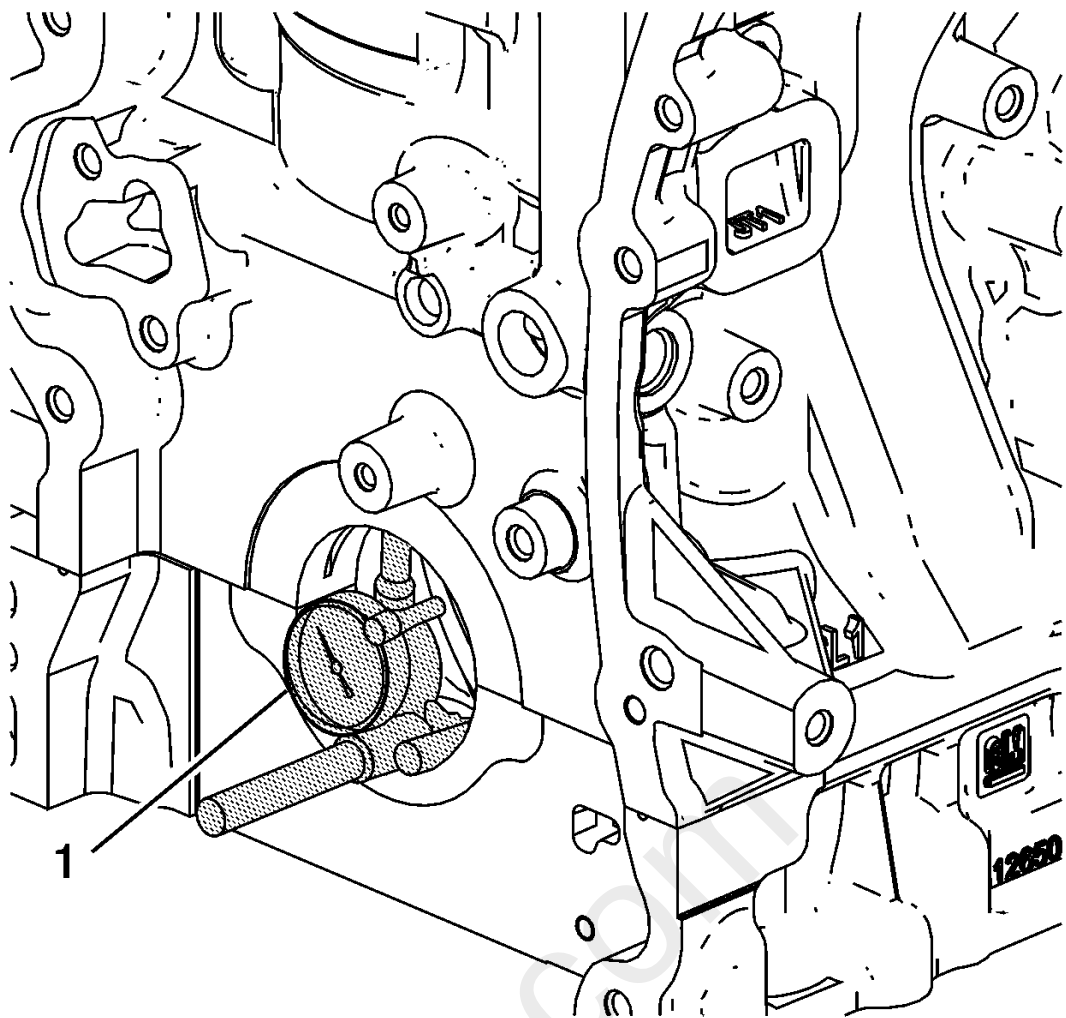


Fig. 392: View Of Cylinder Bore Gauge

Courtesy of GENERAL MOTORS COMPANY

13. Install the bed plate and bolts. tighten the bed plate bolts to specification.

NOTE: A commercially available bore gauge with dial indicator graduations in ten thousandths inch (0.0001") is necessary for measuring engine specification range.

14. Inspect the crankshaft main bearing bores. Use a commercially available bore gauge to measure the bearing bore concentricity and alignment. Refer to [Engine Mechanical Specifications](#).
15. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
16. Remove the bed plate.

Measuring Cylinder Bore Diameter

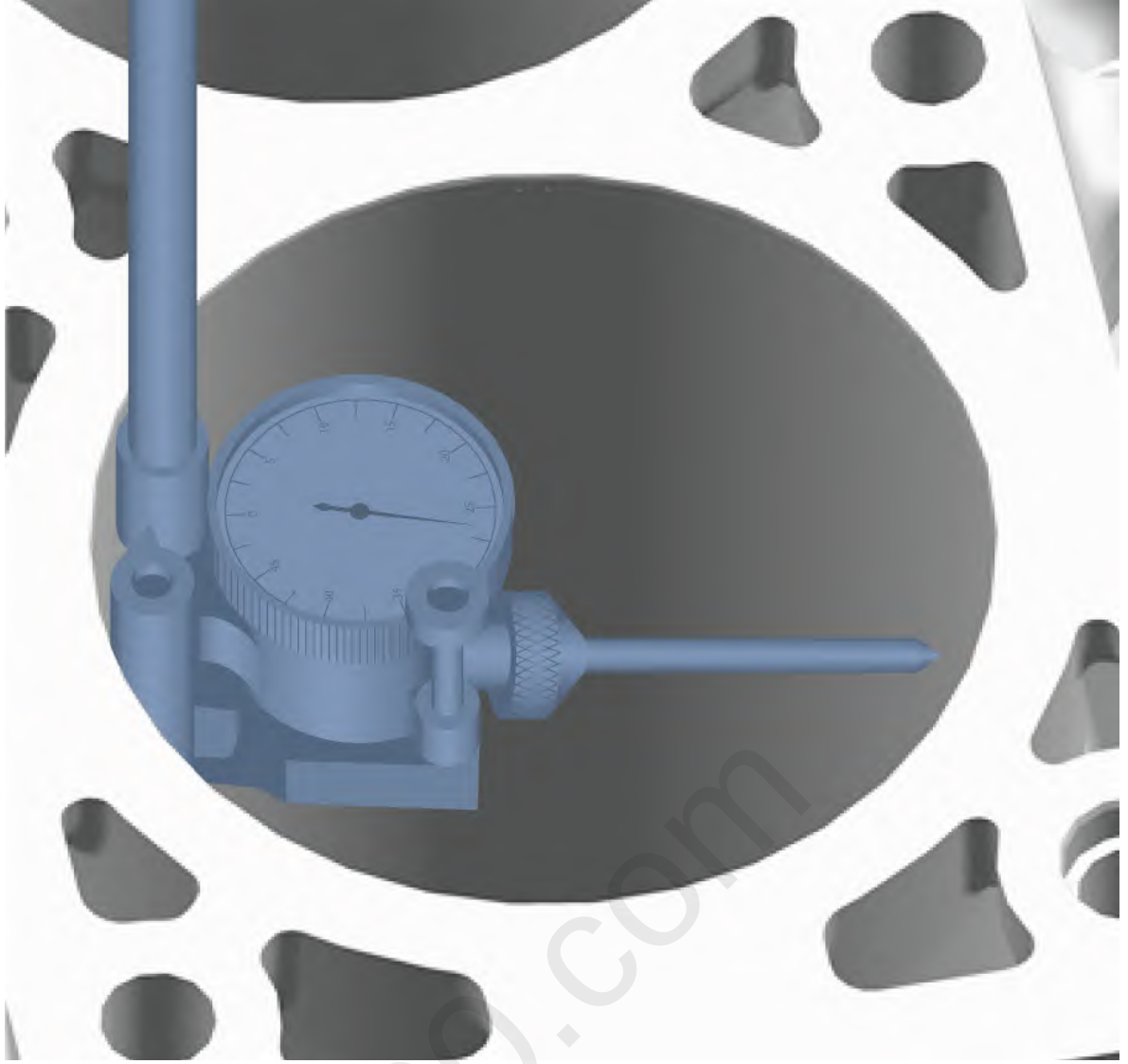


Fig. 393: Measuring Cylinder Bore

Courtesy of GENERAL MOTORS COMPANY

1. 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.

NOTE: A commercially available bore gauge with dial indicator graduations in ten thousandths inch (0.0001") is necessary for measuring engine specification range.

2. Measure the cylinder bore diameter 35 mm (1.378 in) from the deck face using a commercially available bore gauge.
3. Compare your results with the [Engine Mechanical Specifications](#). If the cylinder diameter exceeds the specifications, replace the engine block.

Measuring Cylinder Bore Taper

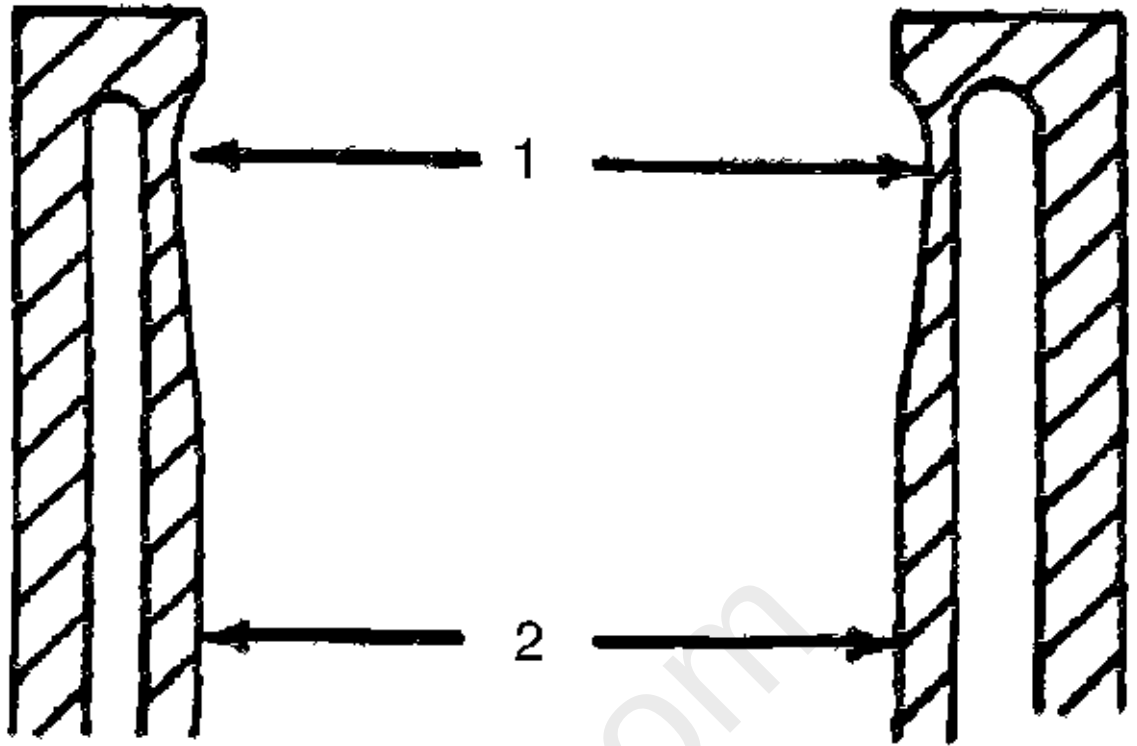


Fig. 394: Measuring Head Gasket Dimensions

Courtesy of GENERAL MOTORS COMPANY

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.394 in) below the deck surface (1) and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 125 mm (4.921 in) below the deck surface (2) and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the [Engine Mechanical Specifications](#). If the cylinders exceed the specifications, replace the engine block.

Measuring Cylinder Bore Out-of-Round

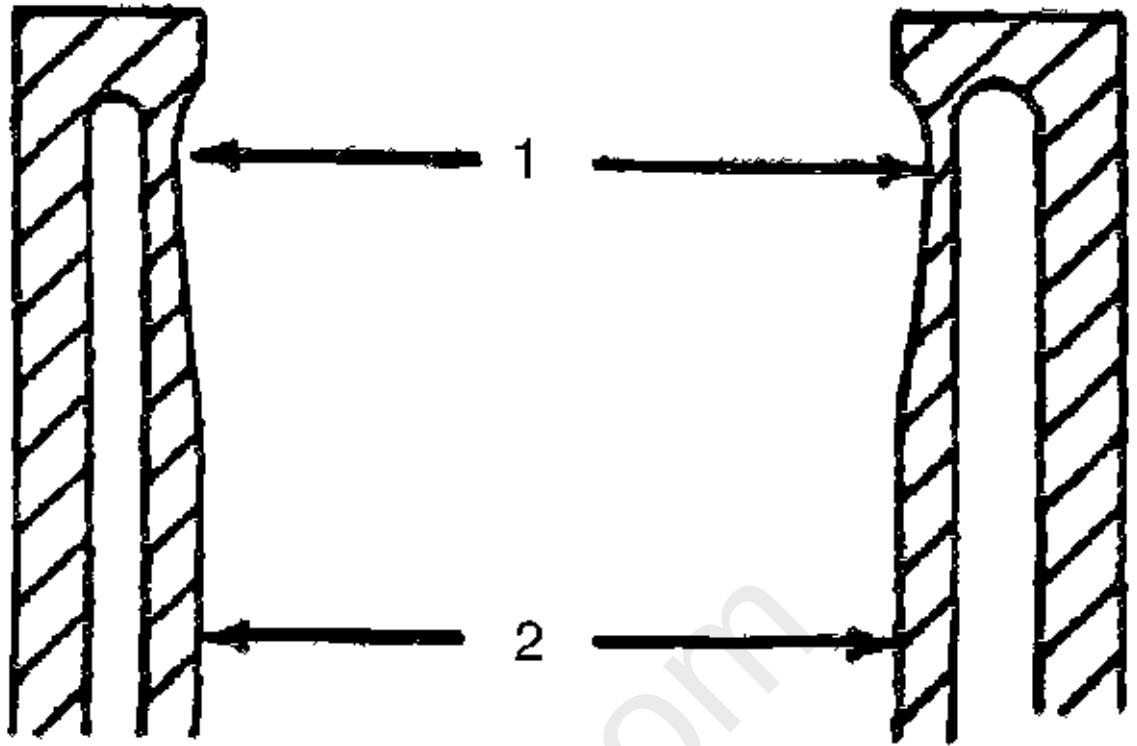


Fig. 395: Measuring Head Gasket Dimensions

Courtesy of GENERAL MOTORS COMPANY

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.394 in) below the deck surface (1). Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 125 mm (4.921 in) below the deck surface (2). Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications**. If the cylinders exceed these specifications, replace the engine block.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

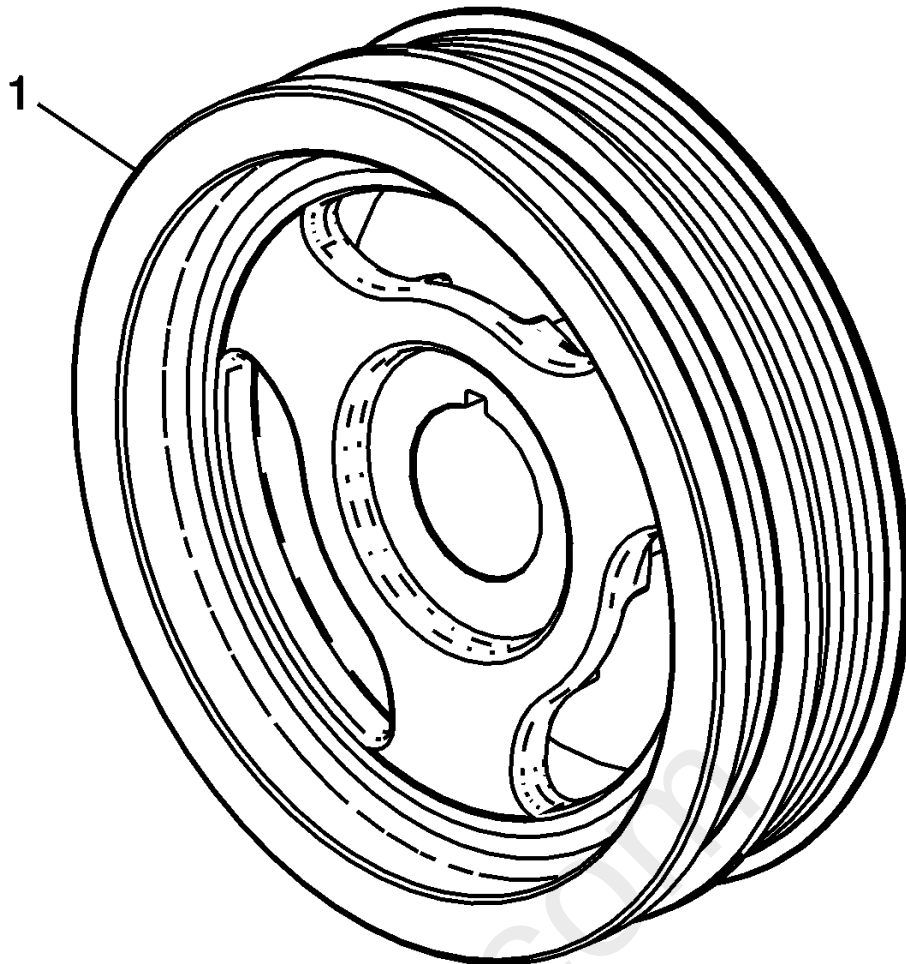


Fig. 396: Crankshaft Balancer

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer WARNING: Refer to Safety Glasses Warning . Procedure 1. Clean the crankshaft balancer. 2. Clean the belt grooves of all dirt or debris with a wire brush. 3. Dry the crankshaft balancer with compressed air. 4. Inspect the crankshaft balancer for the following: • Worn, grooved, or damaged hub seal surface - a crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced. • Dirty or damaged belt grooves - The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly. • Worn, chunking or deteriorated rubber between the hub and pulley. • Minor imperfections may be removed with a fine file.

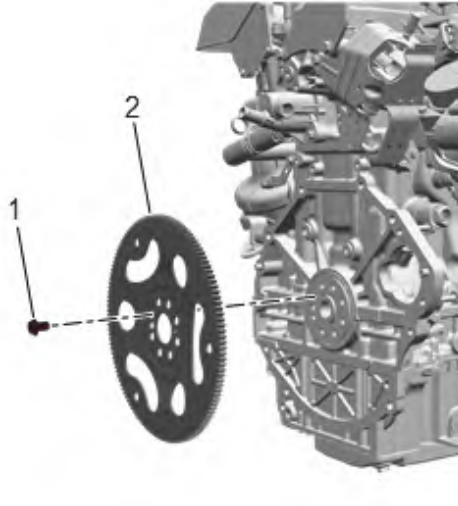


Fig. 397: Automatic Flex Plate Attaching Bolts
 Courtesy of GENERAL MOTORS COMPANY

1. Clean the flywheel (2) in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following:
 - Damaged ring gear teeth.
 - Stress cracks around the flywheel-to-crankshaft bolt hole locations.
 - Weight saving holes.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

GE-7872 Magnetic Base Dial Indicator Set

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

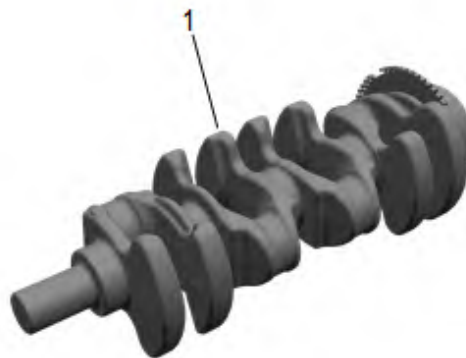


Fig. 398: Measuring Bearing Clearance Using Method A
 Courtesy of GENERAL MOTORS COMPANY

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.
5. Inspect the crankshaft reluctor ring. Replace the crankshaft assembly if damage to the reluctor ring is present.
6. Inspect the crankshaft journals for wear. The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring.
8. Inspect the crankshaft journals for scratches or wear.
9. Inspect the crankshaft journals for pitting or imbedded bearing material.
10. Measure the crankshaft journals for out-of-round.
11. Measure the crankshaft journals for taper.

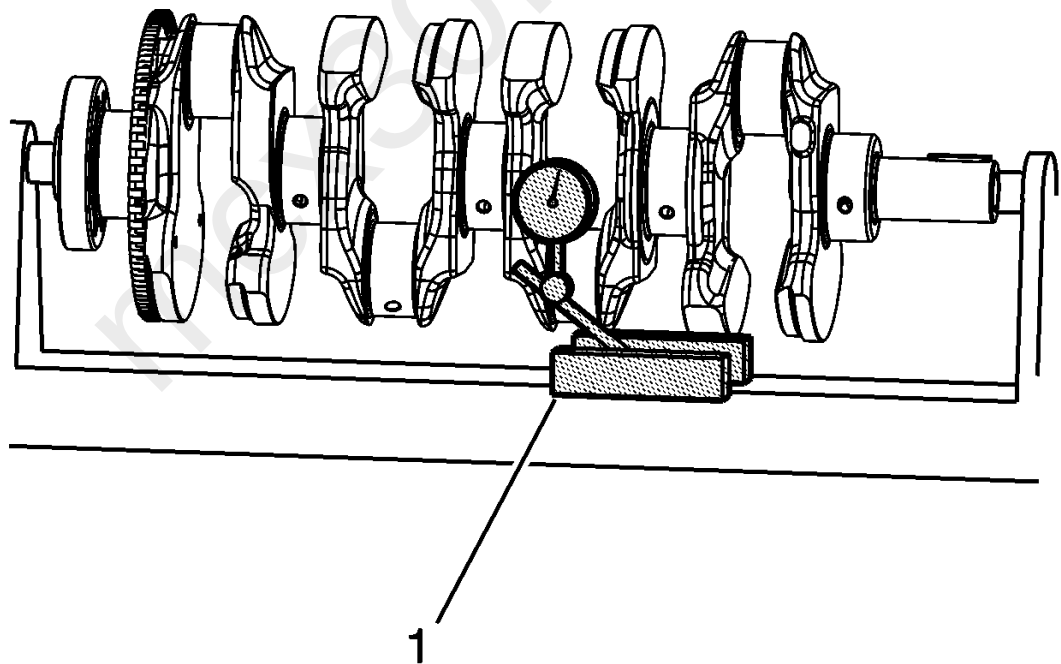


Fig. 399: View Of Magnetic Base Dial Indicator
Courtesy of GENERAL MOTORS COMPANY

12. Measure the crankshaft runout.

Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **GE-7872** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.

14. Use the **GE-7872** indicator in order to measure the runout of the crankshaft rear flange.
15. Replace the crankshaft if the measurements are not within specifications.

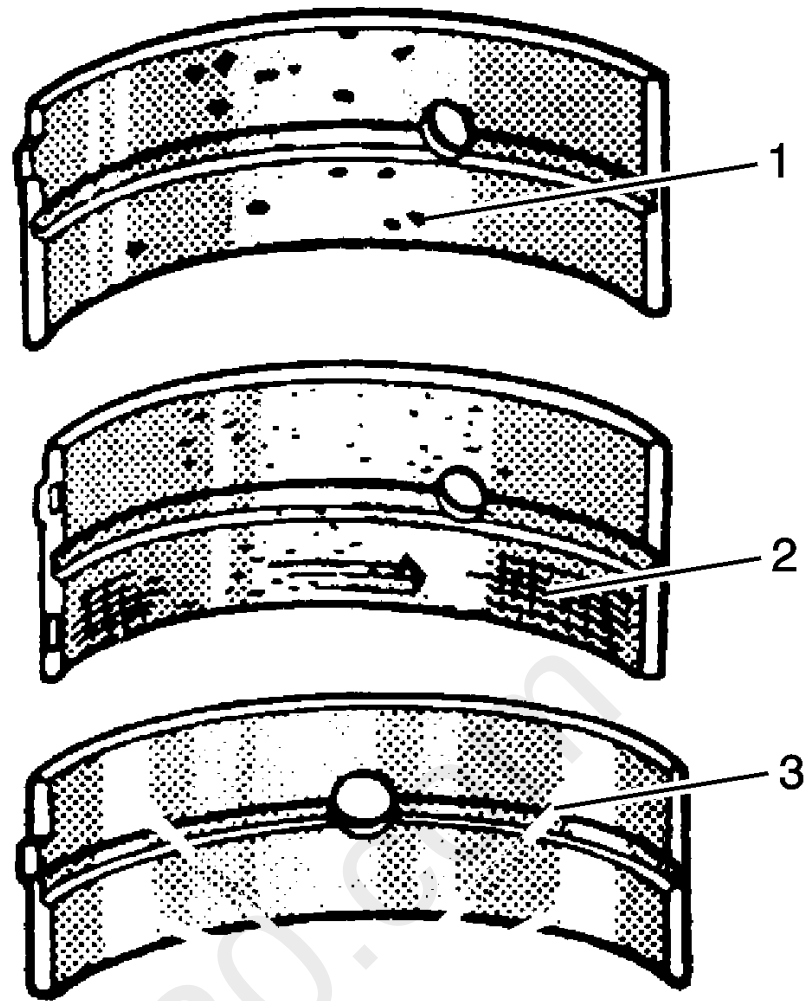


Fig. 400: Identifying Crankshaft Bearings For Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

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.

16. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.
17. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

- **EN-46745** Piston Pin Clip Remover/Installer
- **EN-46745-4** Piston Pin Clip Remover/Installer Adapter

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



Fig. 401: Piston Rings

Courtesy of GENERAL MOTORS COMPANY

WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.

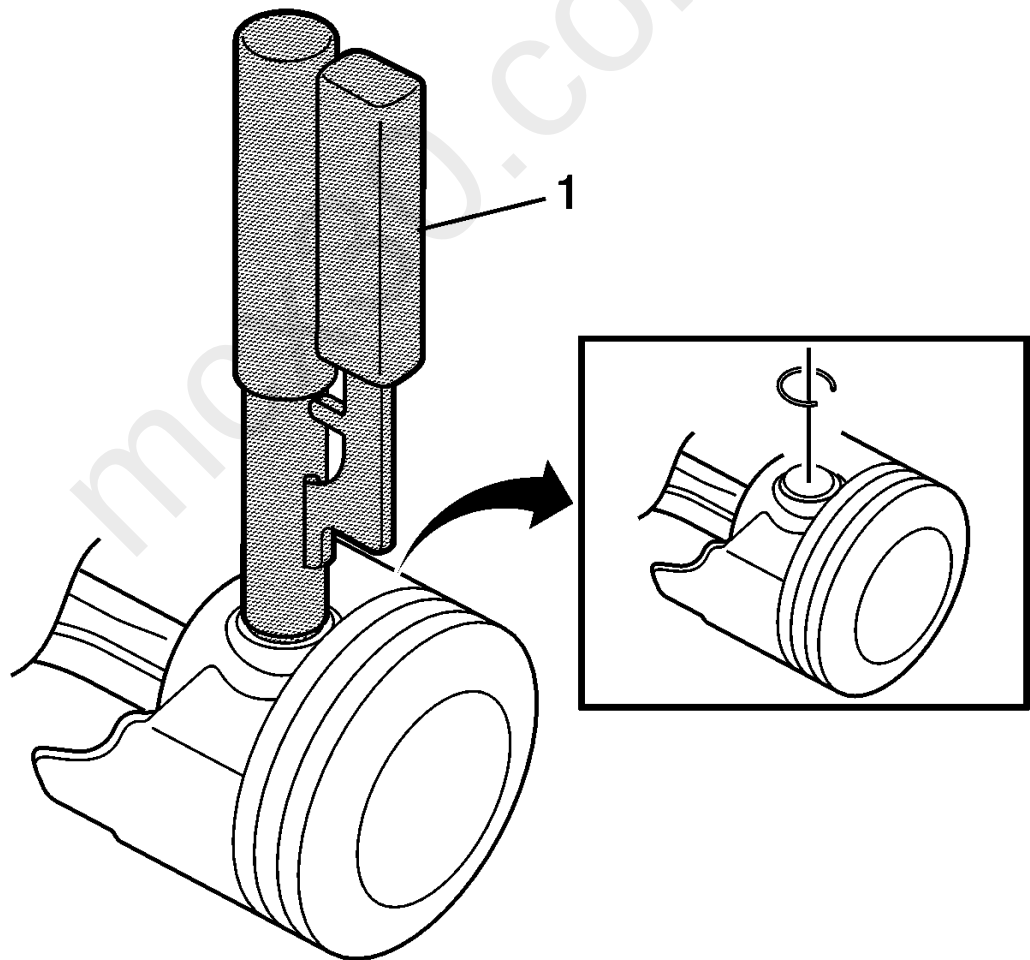


Fig. 402: View of Piston Pin Retainers

Courtesy of GENERAL MOTORS COMPANY

NOTE: Two retainers hold each piston pin in place. Ensure that the piston pin is not damaged. Do not reuse the retainers.

NOTE: Use the appropriate adapter for EN-46745 remover to remove the retainers.

The appropriate adapter will fit the piston pin ID and allow the ring to be removed or installed.

- For LCV/LKW/LD4 piston pin, use EN-46745-2 adapter.
- For LTG piston pin, use EN-46745-4 adapter.

2. Remove the piston pin retainers using the EN-46745 remover (1) and the appropriate adapter. Discard the retainer.

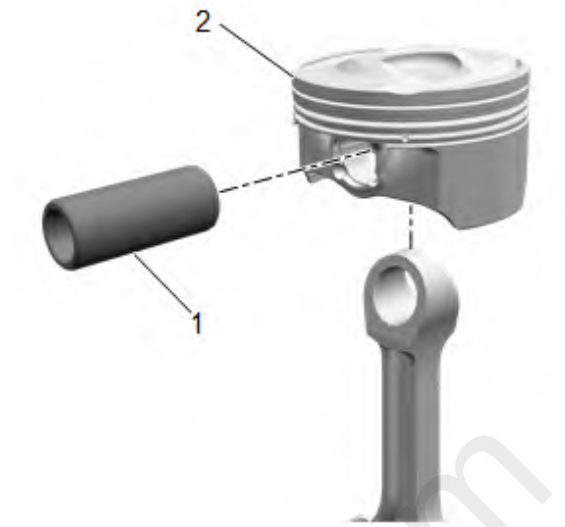


Fig. 403: Piston Pin, Connecting Rod And Piston
Courtesy of GENERAL MOTORS COMPANY

3. Remove the piston pin (1) and the connecting rod (3) from the piston (2).

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

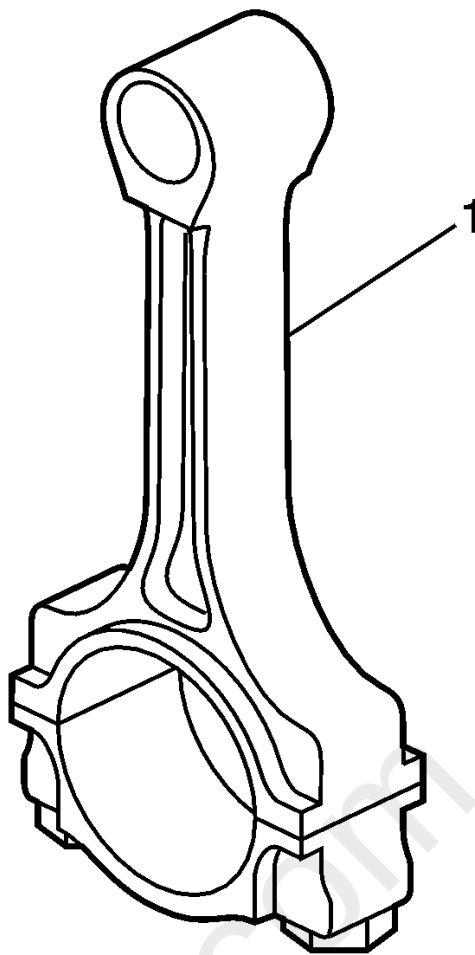


Fig. 404: Connecting Rod

Courtesy of GENERAL MOTORS COMPANY

1. Clean the connecting rods (1) in solvent and dry with compressed air.
2. Inspect the connecting rods for the following:
 - Signs of being twisted, bent, nicked, or cracked
 - Scratches or abrasion on the rod bearing seating surface
3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT scrape the rod or rod cap.
4. If the beam of the rod is scratched or has other damage replace the connecting rod.
5. Measure the piston pin to connecting rod bore using the following procedure:
 1. Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
 2. Using an inside micrometer, measure the connecting rod piston pin bore.
 3. Subtract the piston pin diameter from the piston pin bore diameter.
 4. The clearance should not be more than 0.021 mm (0.0008 in).
6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

Piston Measurement

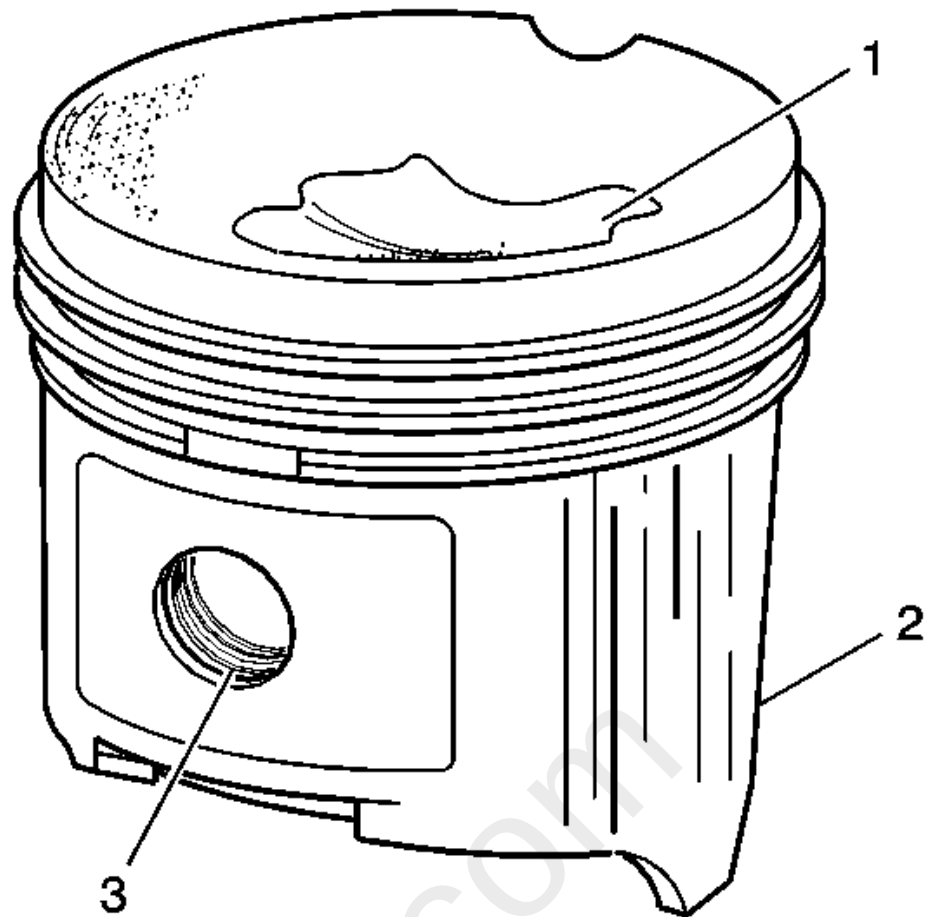


Fig. 405: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts, or pin bosses
 - Ring grooves for nicks, burrs that may cause binding
 - Warped or worn ring lands
 - Eroded areas at the top of the piston (1)
 - Scuffed or damaged skirts (2)
 - Worn piston pin bores (3)
4. Replace pistons that show any signs or damage or excessive wear.
5. Measure the piston pin bore to piston pin clearances using the following procedure:
 1. Piston pin bores and pins must be free of varnish or scuffing.
 2. Use an outside micrometer to measure the piston pin in the piston contact areas.
 3. Using an inside micrometer, measure the piston pin bore.
 4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002 - 0.012 mm (0.00007 - 0.00047 in).
 5. If the clearance is excessive, determine which component is out of specification.

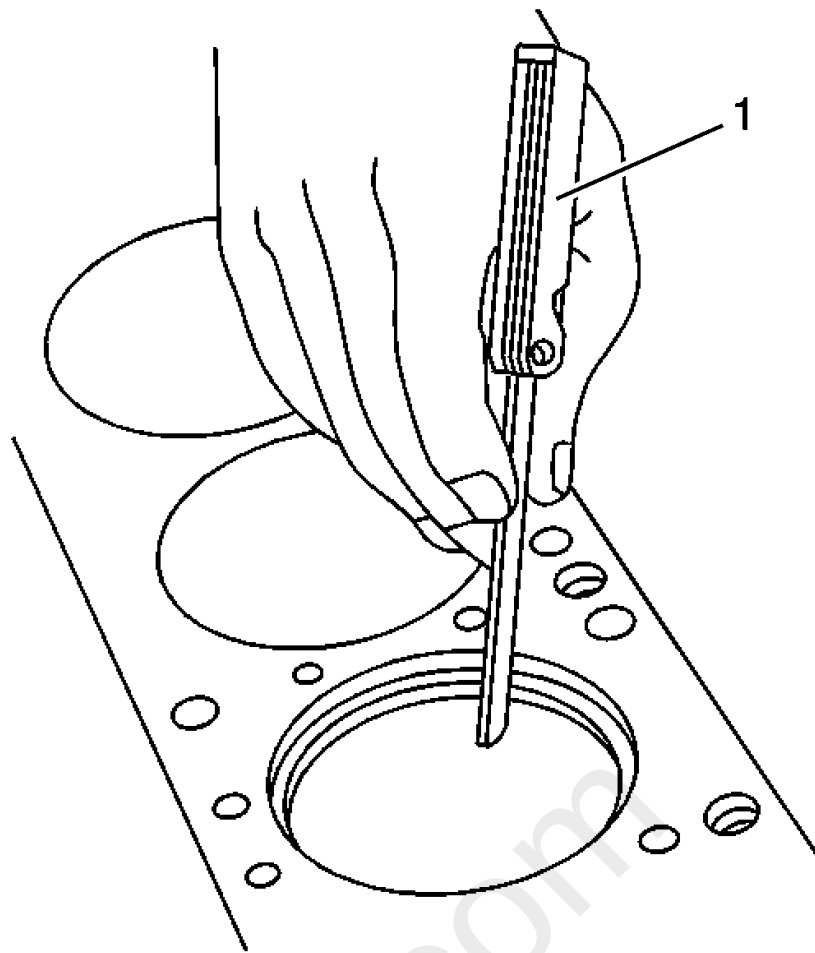


Fig. 406: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS COMPANY

6. Measure the piston ring end gap using the following procedure:
 1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
 2. Measure the end gap of the piston ring with feeler gauges (1). Compare the measurements with those provided below:
 - The top compression ring end gap should be 0.20 - 0.40 mm (0.0060 - 0.015 in).
 - The second compression ring end gap should be 0.35 - 0.55 mm (0.0137 - 0.0216 in).
 - The oil ring end gap should be 0.25 - 0.76 mm (0.0098 - 0.029 in).
 3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
 4. Repeat the procedure for all the piston rings.

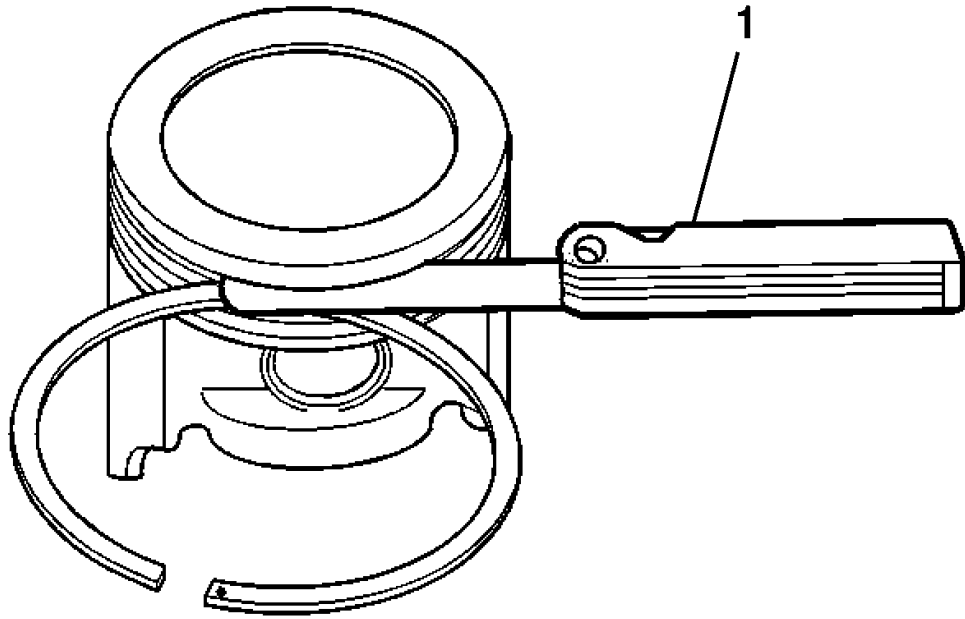


Fig. 407: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

7. Measure the piston ring side clearance using the following procedure:
 1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
 2. With the piston ring on the piston, use feeler gauges (1) to check clearance at multiple locations.
 3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
 4. If the clearance is greater than specifications, replace the piston ring.
 5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.
8. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.
9. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
10. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.

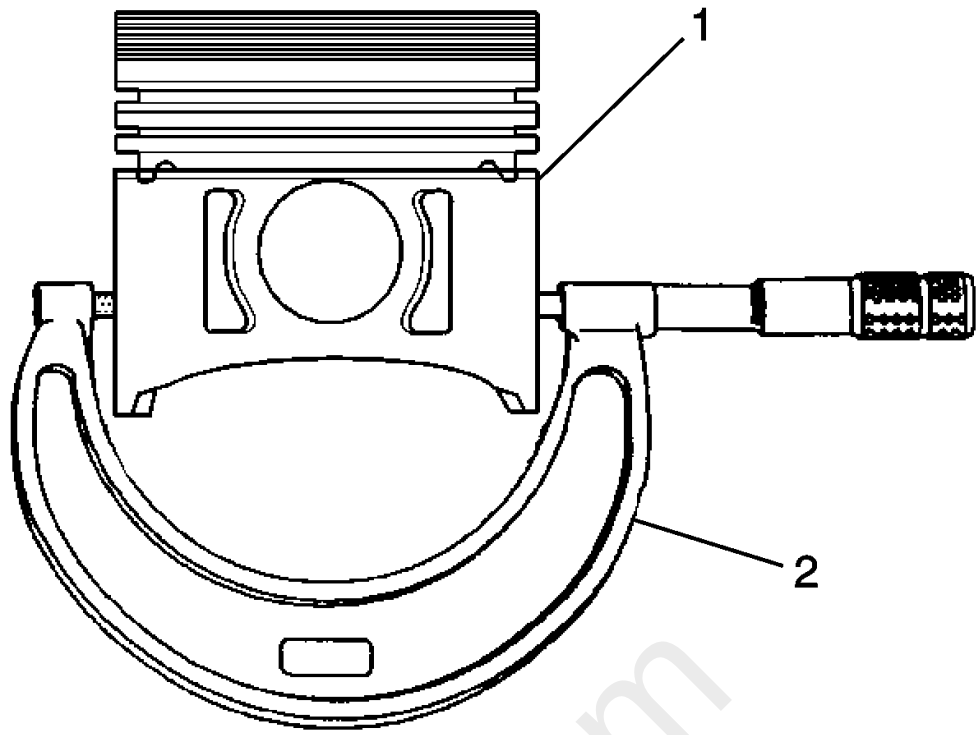


Fig. 408: Measuring Piston Width

Courtesy of GENERAL MOTORS COMPANY

11. Measure piston width using the following procedure:
 1. Using an outside micrometer (2), measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
 2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
 3. The proper clearance specification for the piston is 0.010 - 0.041 mm (0.0004 - 0.0016 in).
12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston (1).

Piston Selection

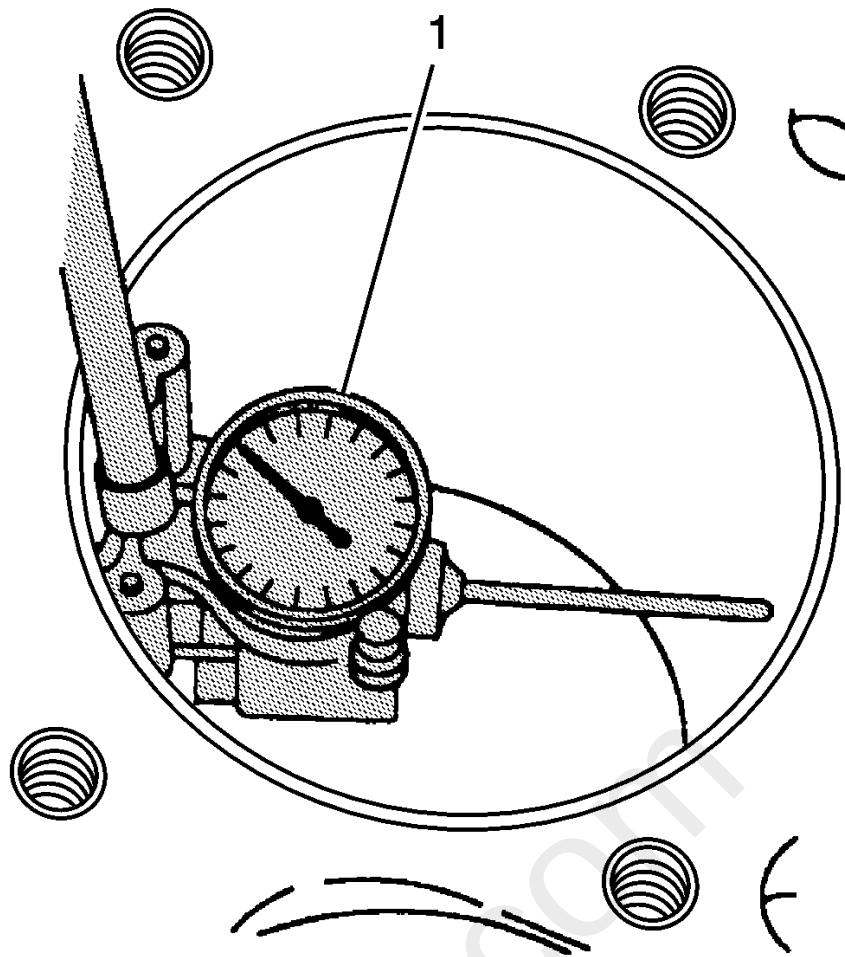


Fig. 409: Measuring Cylinder Bore

Courtesy of GENERAL MOTORS COMPANY

NOTE:

Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

1. Inspect the engine block cylinder bore. Refer to [Engine Block Cleaning and Inspection](#).
2. Inspect the piston and the piston pin.
3. Use a bore gauge (1) and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

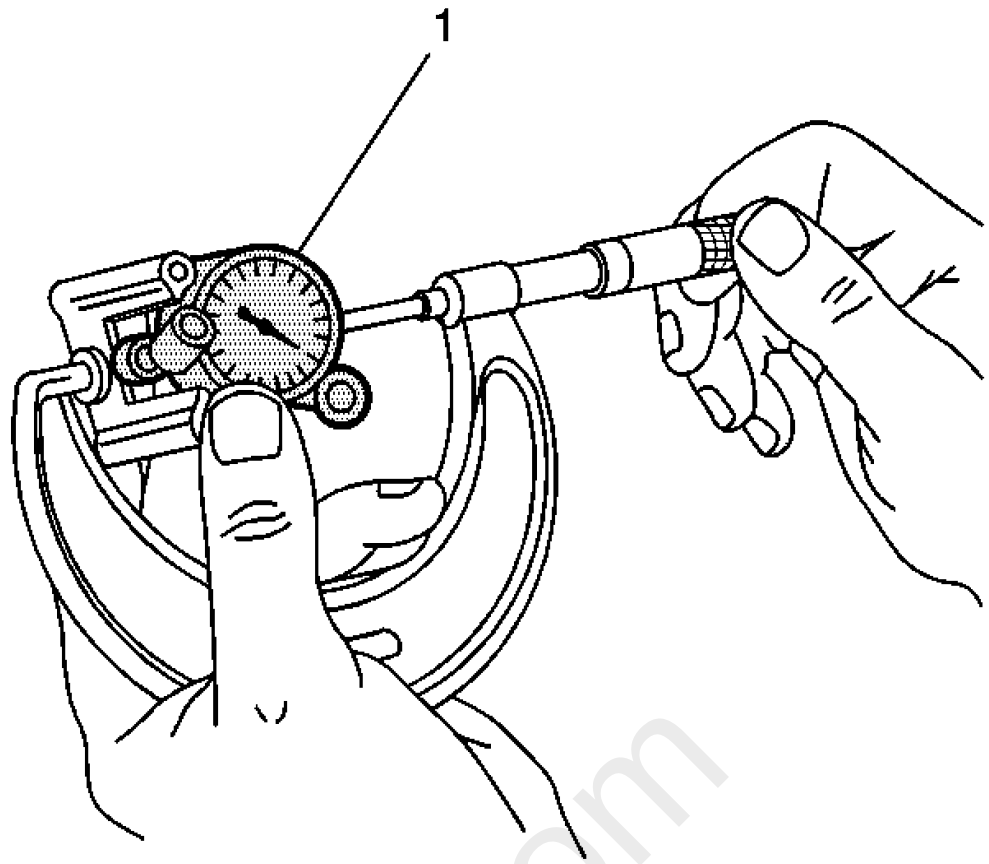


Fig. 410: Measuring Bore Gauge
Courtesy of GENERAL MOTORS COMPANY

4. Measure the bore gauge with a micrometer (1) and record the reading.

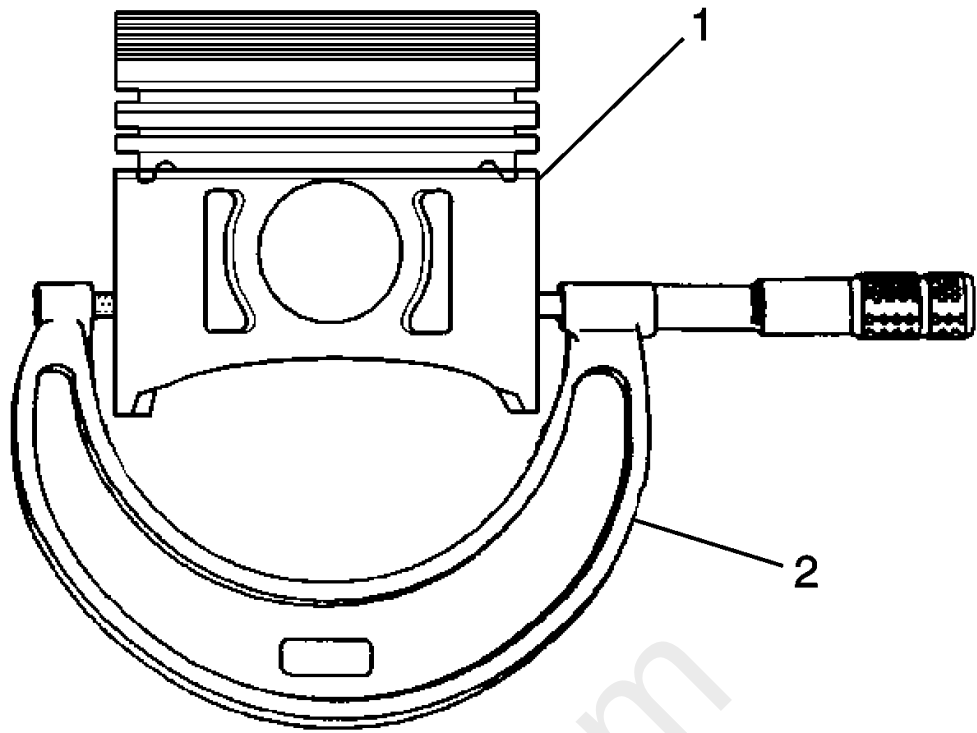


Fig. 411: Measuring Piston Width

Courtesy of GENERAL MOTORS COMPANY

5. With a micrometer (2) or caliper at a right angle to the piston (1), measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to [Engine Mechanical Specifications](#).
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to [Separating Parts](#).

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

- EN-46745 Piston Pin Clip Remover/Installer
- EN-46745-4 Piston Pin Clip Remover/Installer Adapter

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

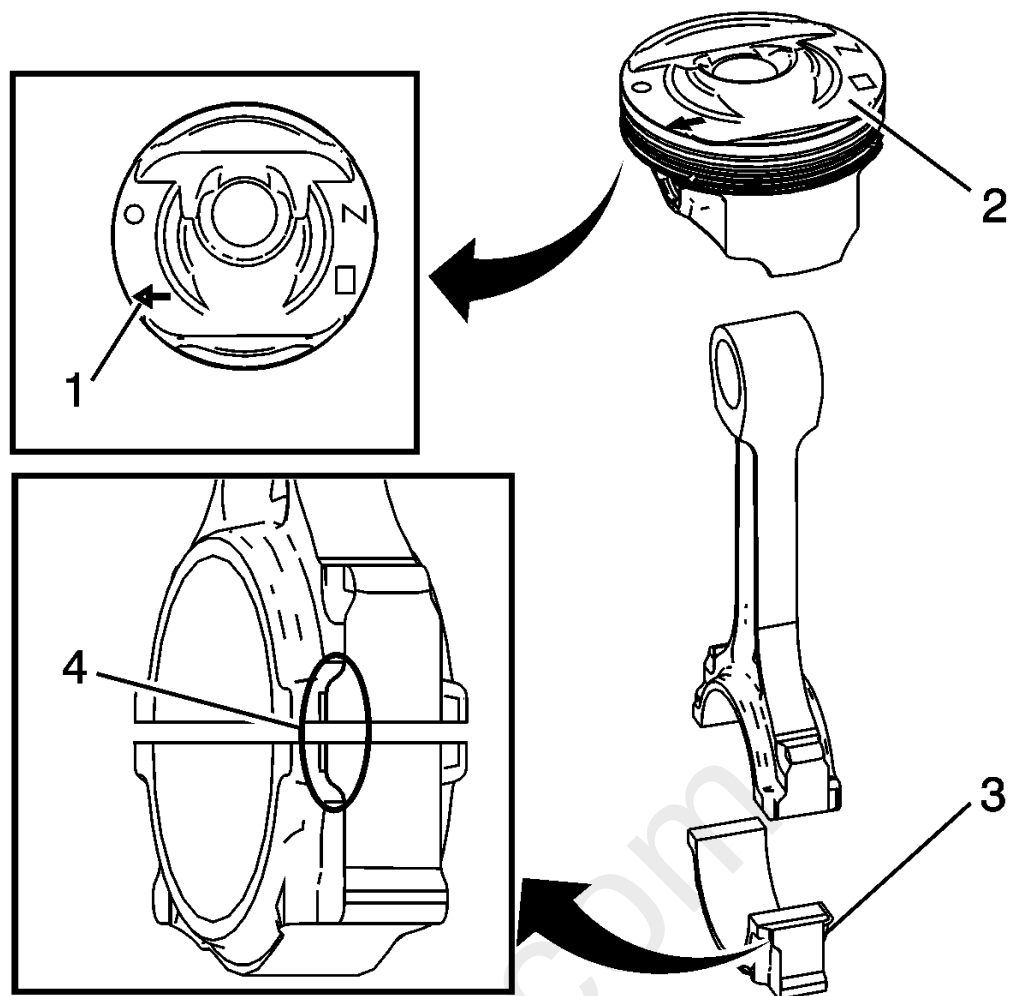


Fig. 412: Connecting Rod And Piston

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install the piston onto the connecting rod with the arrow on top of the piston oriented to the same side as the cast feature at the split line of the connecting rod.

1. The arrow (1), on the top of the piston, must go to the front of the block.
2. The feature at the split line (4), located on one side of the connecting rod, must go to the front of the block.
3. Assemble the connecting rod (3) and the piston (2).

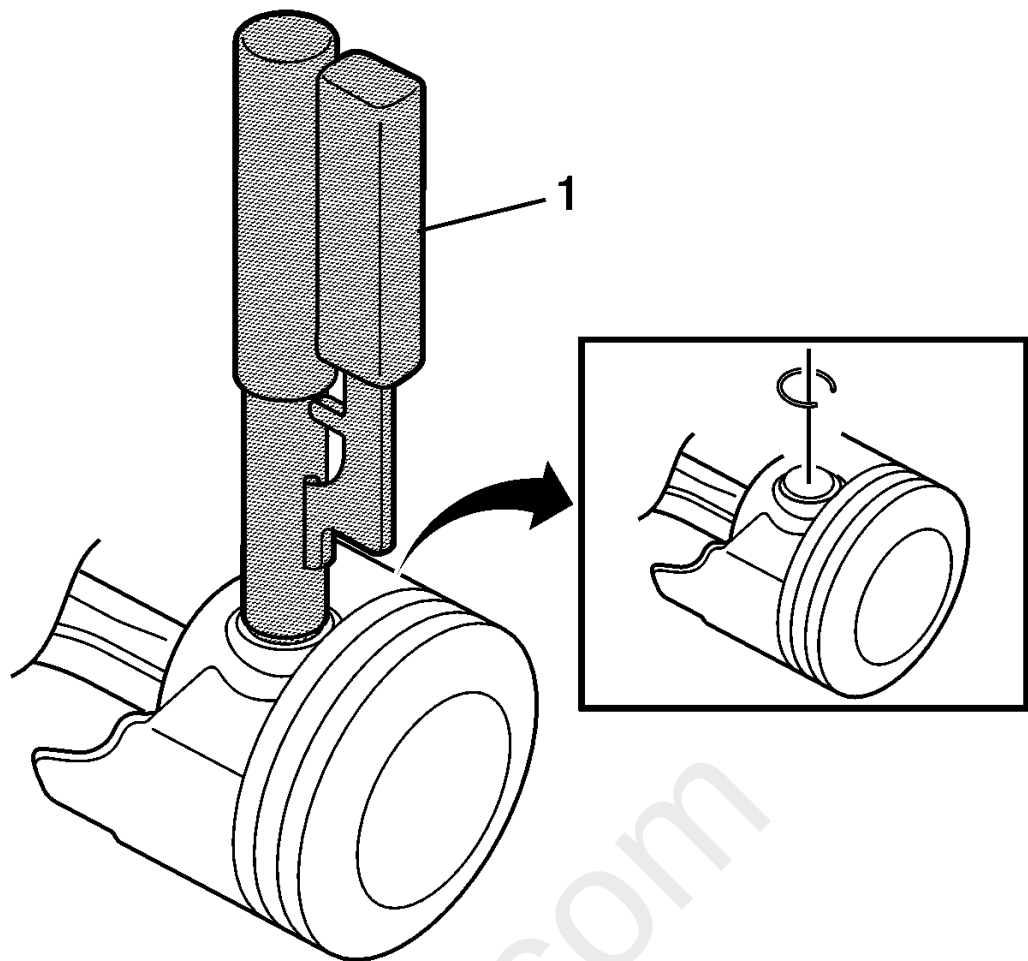


Fig. 413: View of Piston Pin Retainers

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

NOTE: Use NEW retainers. Two retainers hold each piston pin in place.

NOTE: Use the appropriate adapter for EN-46745 installer to install the retainers. The appropriate adapter will fit the piston pin ID and allow the ring to be removed or installed.

- For LCV/LKW/LD4 piston pin, use EN-46745-2 adapter.
- For LTG piston pin, use EN-46745-4 adapter.

4. Use the following procedure to assemble the piston pin and the retainer:

1. Coat the piston pin with oil.
2. Install one NEW piston pin retainer into the retaining groove using EN-46745 installer and the appropriate adapter. Rotate the retainer until it is fully seated in the groove.
3. Install the connecting rod and the piston pin.

Push the piston pin until it bottoms in the previously installed retainer.

4. Install the second NEW piston pin retainer, using EN-46745 installer (1) and the appropriate adapter.
5. Ensure that the piston moves freely.

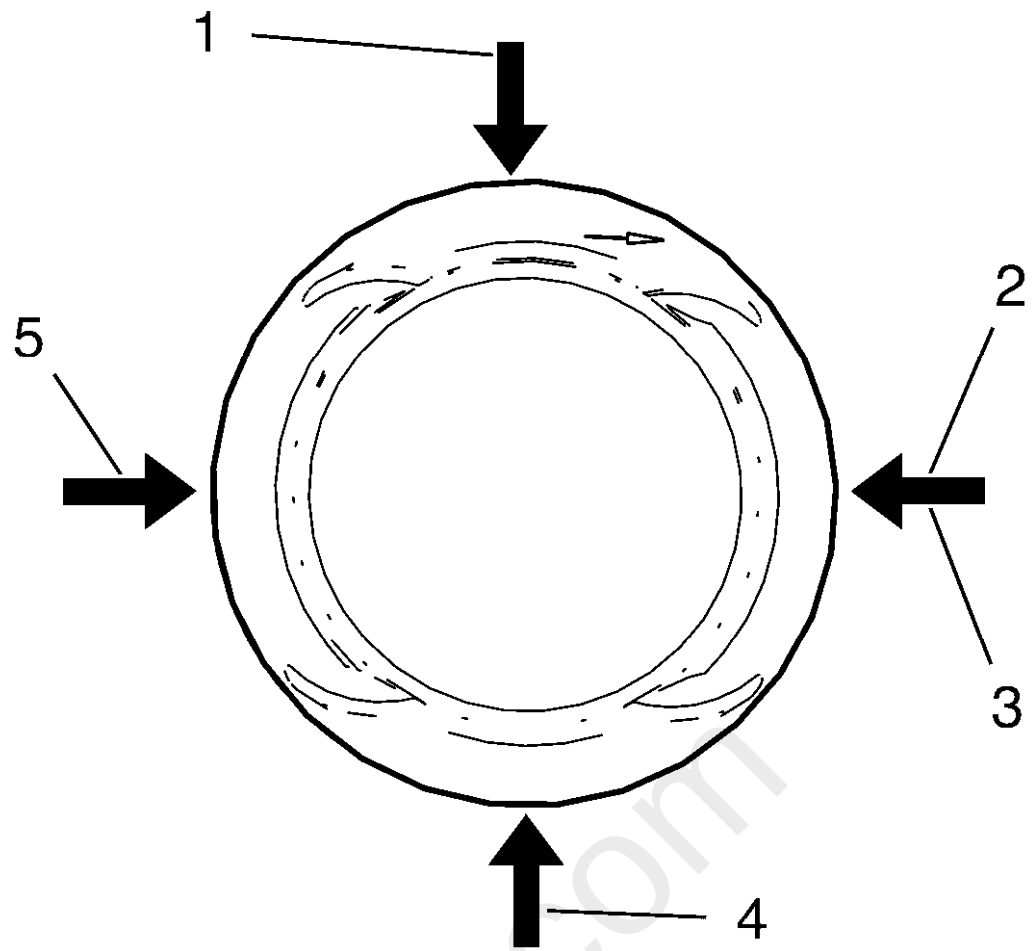


Fig. 414: Oil Ring Joints, Lower Compression Ring Joint, Upper Compression Ring Joint And Oil Ring Spacer Joint

Courtesy of GENERAL MOTORS COMPANY

5. The piston ring end gaps must be positioned 90 degrees to each other.

- Upper compression ring joint (1)
- Lower compression ring joint (2)
- Upper oil ring rail joint (5)
- Oil ring rail spacer joint (4)
- Lower oil ring rail joint (3)



Fig. 415: Piston Rings

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

6. Install the following components of the oil control ring assembly:
 1. The piston oil ring rail (5)
 2. The piston oil ring rail spacer (4)
 3. The second piston oil ring rail (3)
7. Install the piston lower compression ring (2). Place the manufacturer's mark facing up.
8. Install the piston upper compression ring (1).

CAMSHAFT ASSEMBLY DISASSEMBLE

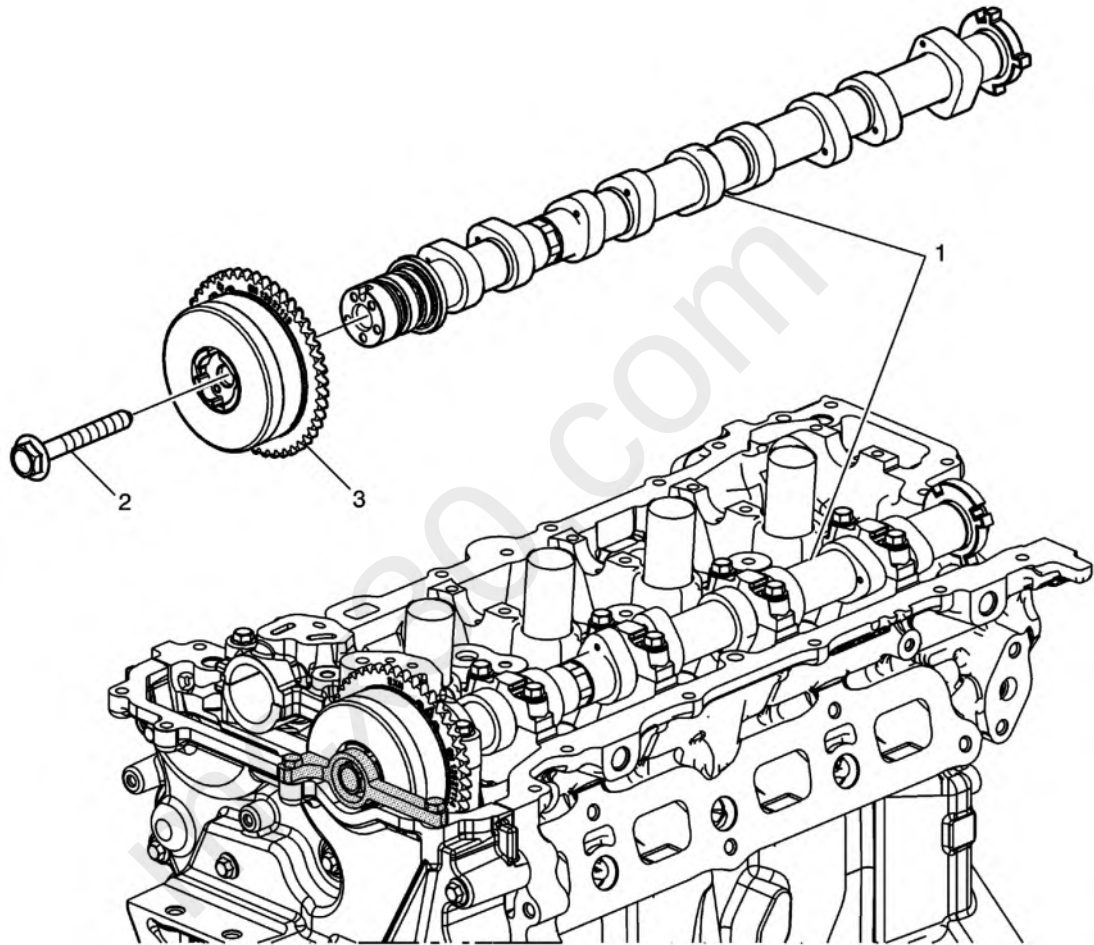


Fig. 416: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
1. Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device. 2. Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position. 3. Install one of the camshafts in the exhaust camshaft position on the cylinder head. 4. Install the camshaft bearing front upper cap and bolts. 5. Install the camshaft bearing caps and bolts. 6. Install EN-50793 locking tool onto the camshaft actuator and engine front cover. 7. The camshaft actuator bolt can now be loosened and the actuator removed from the camshaft. Repeat preliminary procedure for the remaining camshaft assembly.	

Callout	Component Name
1	Camshaft, Intake and Exhaust
2	Camshaft Position Actuator Bolt NOTE: Discard the bolt. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to Special Tools .
3	Camshaft Position Actuator, Intake and Exhaust

CAMSHAFT CLEANING AND INSPECTION

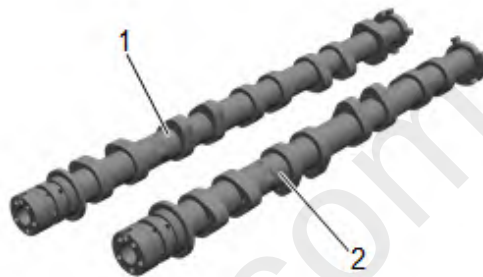


Fig. 417: Camshaft Journals And Lobes

Courtesy of GENERAL MOTORS COMPANY

1. Inspect the camshaft journals and lobes for wear or scoring.
2. Inspect the camshaft sprocket alignment notch for damage.
3. Wash the camshafts (1, 2) in solvent.
4. Oil the camshafts.

CAMSHAFT ASSEMBLY ASSEMBLE

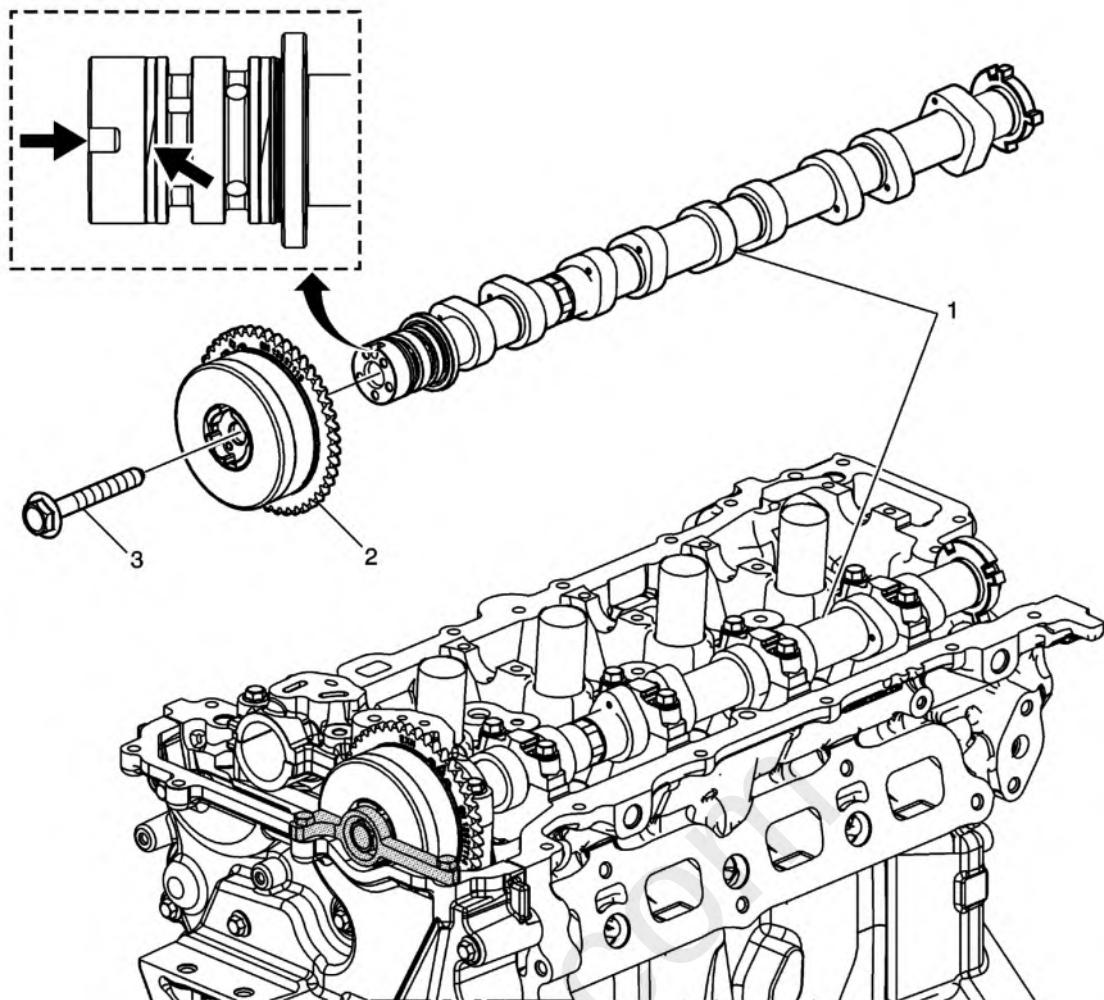


Fig. 418: Camshaft Assembly

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Temporarily install the cylinder head to the engine block, with the engine block securely attached to a mounting device. 2. Temporarily install the engine front cover to the cylinder head, using the upper bolts to hold the cover in position. 3. Install one of the camshafts in the exhaust camshaft position on the cylinder head. 4. Install the camshaft bearing front upper cap and bolts. 5. Install the camshaft bearing caps and bolts. 6. Install the appropriate actuator for the camshaft currently installed on the cylinder head. 7. Install EN-50793 locking tool onto the camshaft actuator and engine front cover. 8. The camshaft actuator bolt can now be installed and tightened to final specification. Repeat preliminary procedure for the remaining camshaft assembly.	
1	Camshaft, Intake and Exhaust NOTE: Ensure that the oil seal near the front of the camshaft is rotated so that the split line on the oil seal is aligned with the notch, and both the notch and split line are at 12 O'clock when installed on the cylinder head.

Callout	Component Name
2	Camshaft Position Actuator, Intake and Exhaust NOTE: Upon camshaft assembly, ensure the camshaft actuator pin aligns with the camshaft notch. The actuator, camshaft, and bolt can be assembled by hand and then placed on the cylinder head for final torque. NOTE: Lubricate the actuator prior to installation.
3	Camshaft Position Actuator Bolt CAUTION: Refer to Fastener Caution . CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. tighten 30 N.m (22 lb ft) plus 100 Degrees. Special Tools EN-50793 Camshaft Actuator Locking Tool For equivalent regional tools, refer to Special Tools.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER CLEANING AND INSPECTION

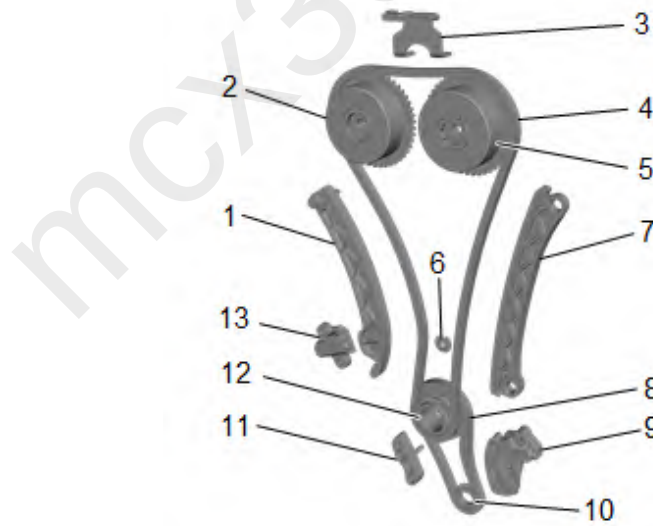


Fig. 419: Camshaft Timing Chain, Sprocket, And Tensioner
Courtesy of GENERAL MOTORS COMPANY

1. Inspect the timing chain guides (3, 7) and timing chain tensioner pivot arm (1) for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner (13) shoe for wear.
4. Replace the timing chain tensioner if shoe wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain (4) and actuators (2, 5) for wear.
6. Inspect the camshaft actuator faces for signs of movement.
7. Inspect the camshaft actuator teeth and chain for signs of excessive wear, chipping, or seizure of the timing chain links.

8. Inspect the timing chain oil nozzle (6) for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged.
9. Verify oil nozzle oil flow with compressed air.
10. Inspect the timing chain tensioner (13) for scoring or free movement.
11. Inspect the timing chain tensioner washer. If damaged, replace the timing chain tensioner.
12. Inspect the crankshaft sprocket (12) for excessive wear or chipping.
13. Inspect the balancer chain (8) for wear.
14. Inspect the balancer chain guide (11) for wear.
15. Inspect the balancer chain tensioner (9) for wear.
16. Inspect the balancer shaft driven sprocket (10) for wear or chipping.

CYLINDER HEAD DISASSEMBLE

Special Tools

- **EN-43963** Valve Spring Compressor (off car)
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-50717** Valve Spring Compressor

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

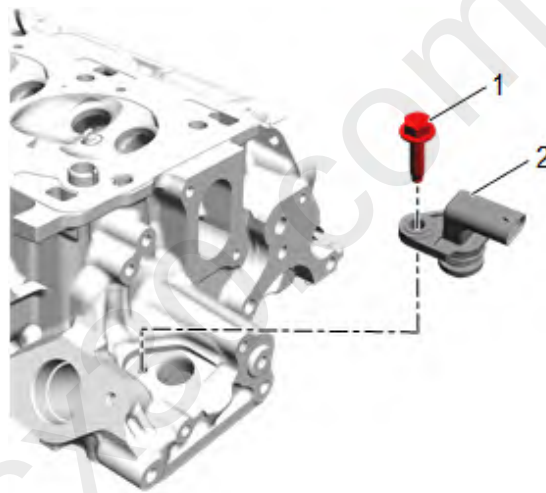


Fig. 420: Intake Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Remove the intake camshaft position sensor (2) and bolt (1).

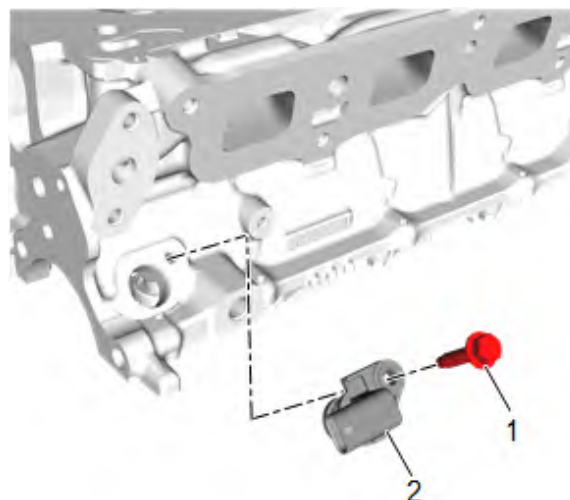


Fig. 421: Exhaust Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the exhaust camshaft position sensor (2) and bolt (1).

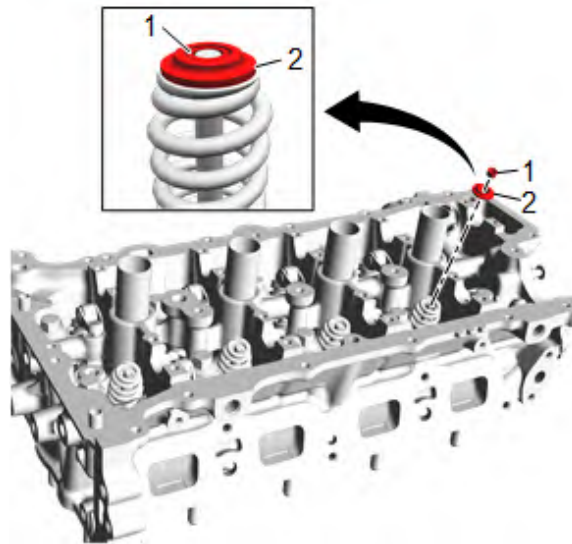


Fig. 422: Valve Keys, Springs, And Retainers

Courtesy of GENERAL MOTORS COMPANY

WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

NOTE: Ensure that the valve train components are kept together and identified in order for proper installation in their original position.

3. Perform the following procedure to remove the valve keys, springs, and retainers:
 1. Using the **EN-50717** fixture and the **EN-43963** compressor adapter, compress the valve spring.
 2. Remove the valve keys (1).
 3. Slowly release the compression from the valve spring assembly.
 4. Remove the retainer (2).

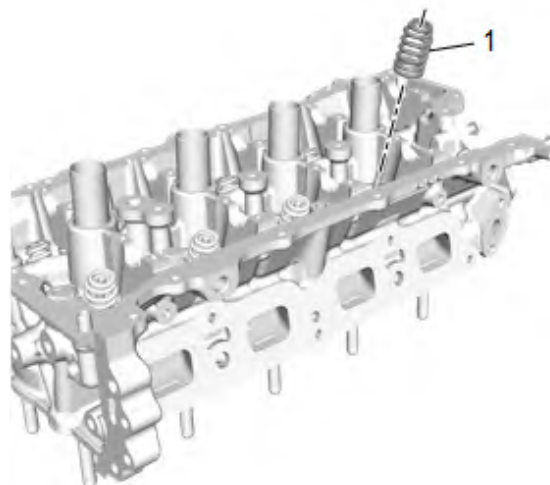


Fig. 423: Valve Springs

Courtesy of GENERAL MOTORS COMPANY

4. Remove the springs (1).

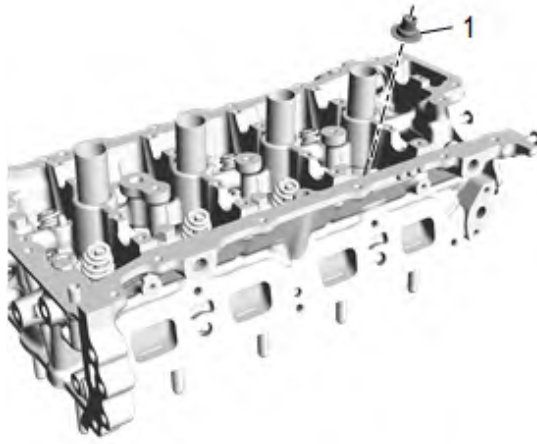


Fig. 424: Valve Seals

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

5. Using EN-46116 remover, remove the valve seals (1). Discard the seals, do not reuse.

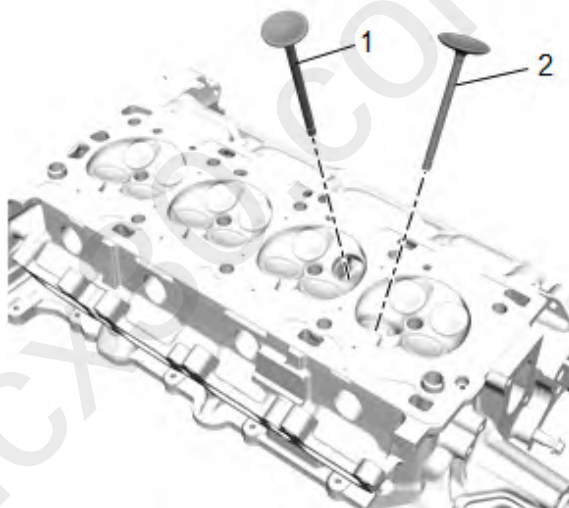
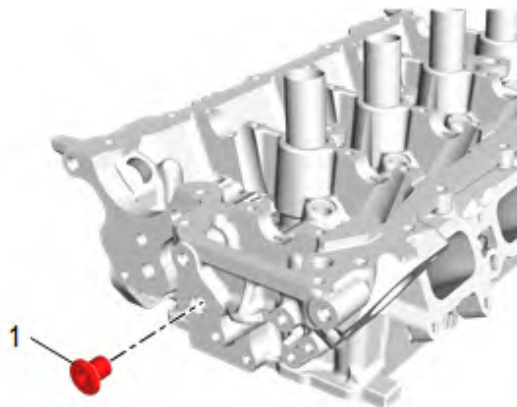


Fig. 425: Valves

Courtesy of GENERAL MOTORS COMPANY

6. Remove the valves (1, 2).



7. Remove the cylinder head plug (1).

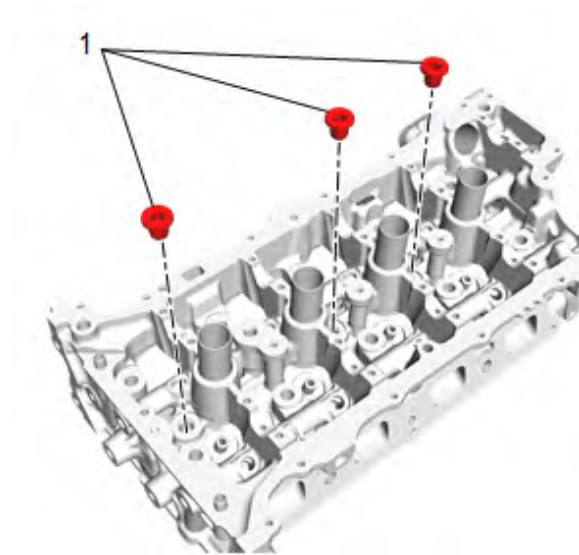


Fig. 427: Cylinder Head Plugs
Courtesy of GENERAL MOTORS COMPANY

8. Remove the cylinder head plugs (1).

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- EN 22738-B Valve Spring Tester
- EN-28410 Gasket Remover
- EN-39358 Spark Plug Socket
- GE 7872 Magnetic Base Dial Indicator

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

Valve Cleaning and Inspection

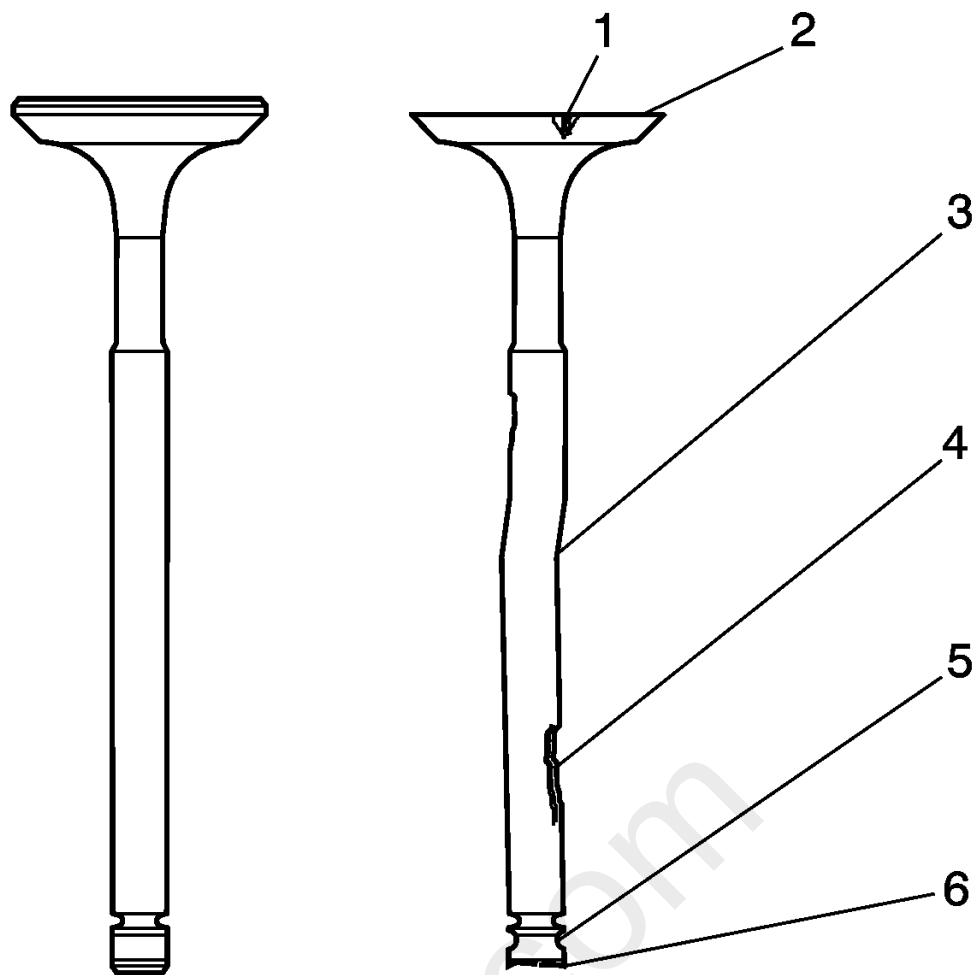


Fig. 428: Valve Inspection Areas

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. 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](#).

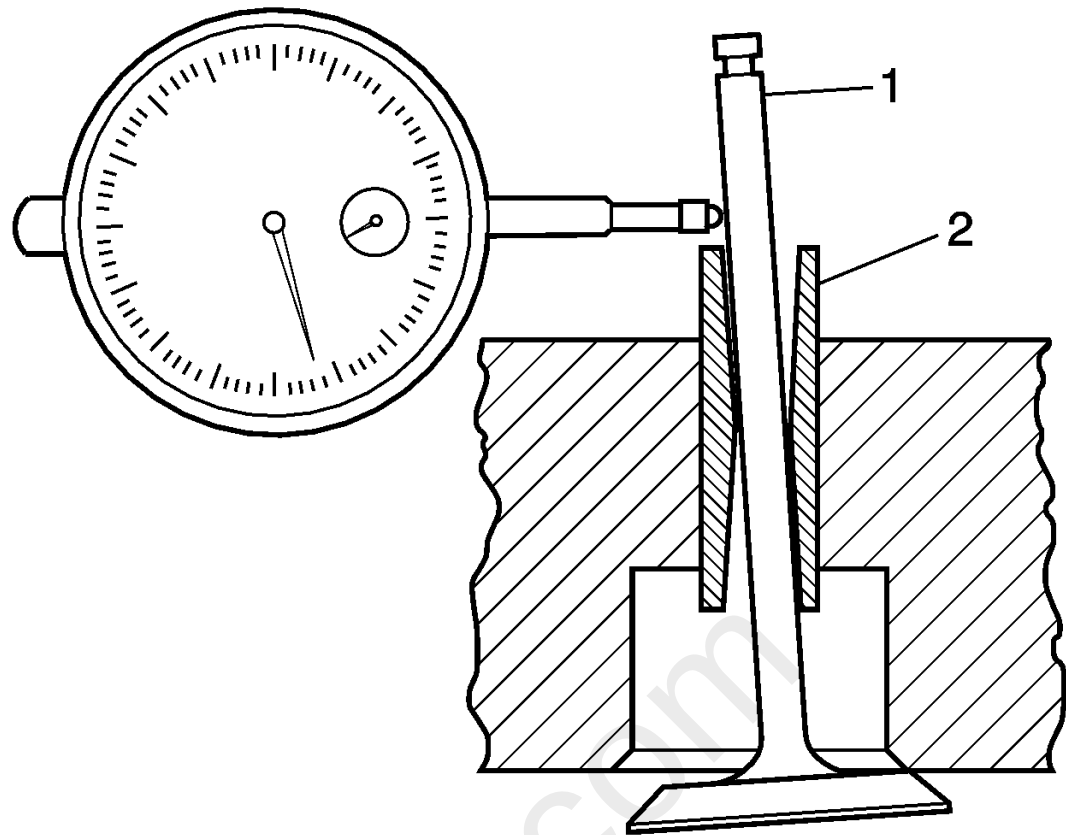


Fig. 429: Inspecting For Excessive Valve Stem To Guide Clearance
 Courtesy of GENERAL MOTORS COMPANY

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** dial indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to [Engine Mechanical Specifications](#) for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

1. Clean the valve springs in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

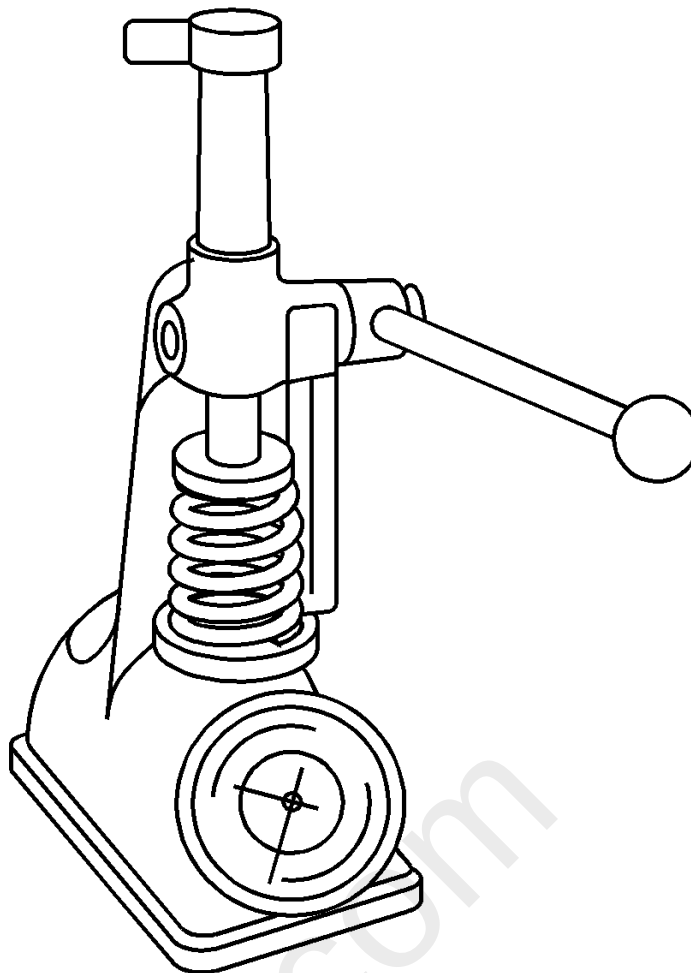


Fig. 430: Measuring Valve Spring Tension

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

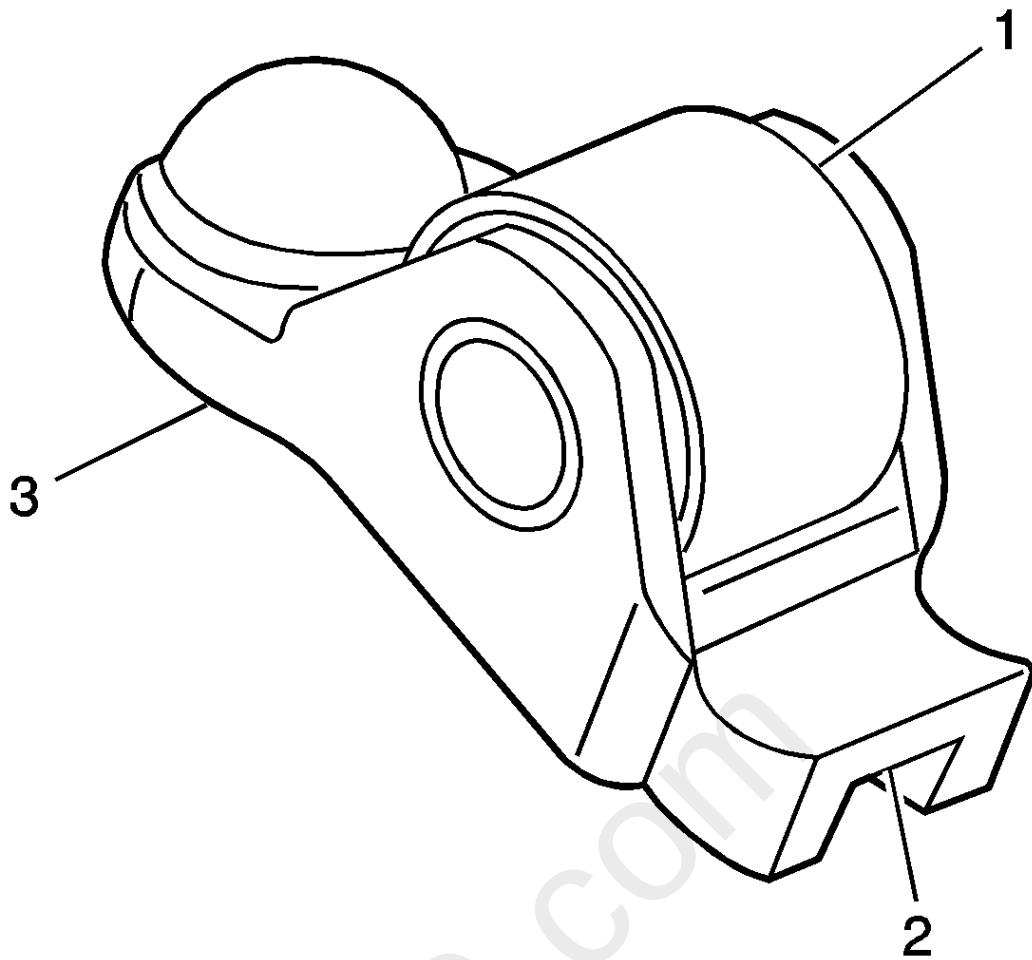


Fig. 431: Inspecting Valve Rocker Arms

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 and Gasket Surface Cleaning and Inspection



1. Remove the spark plugs (1) using **EN-39358** socket.
2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:
 1. Improper installation
 2. Loose or warped cylinder head
 3. Missing, off location or not fully seated dowel pins
 4. Corrosion in the seal area around the coolant passages
 5. Chips or debris in the cylinder head bolt holes
 6. Bolt holes in the cylinder block not drilled or tapped deep enough

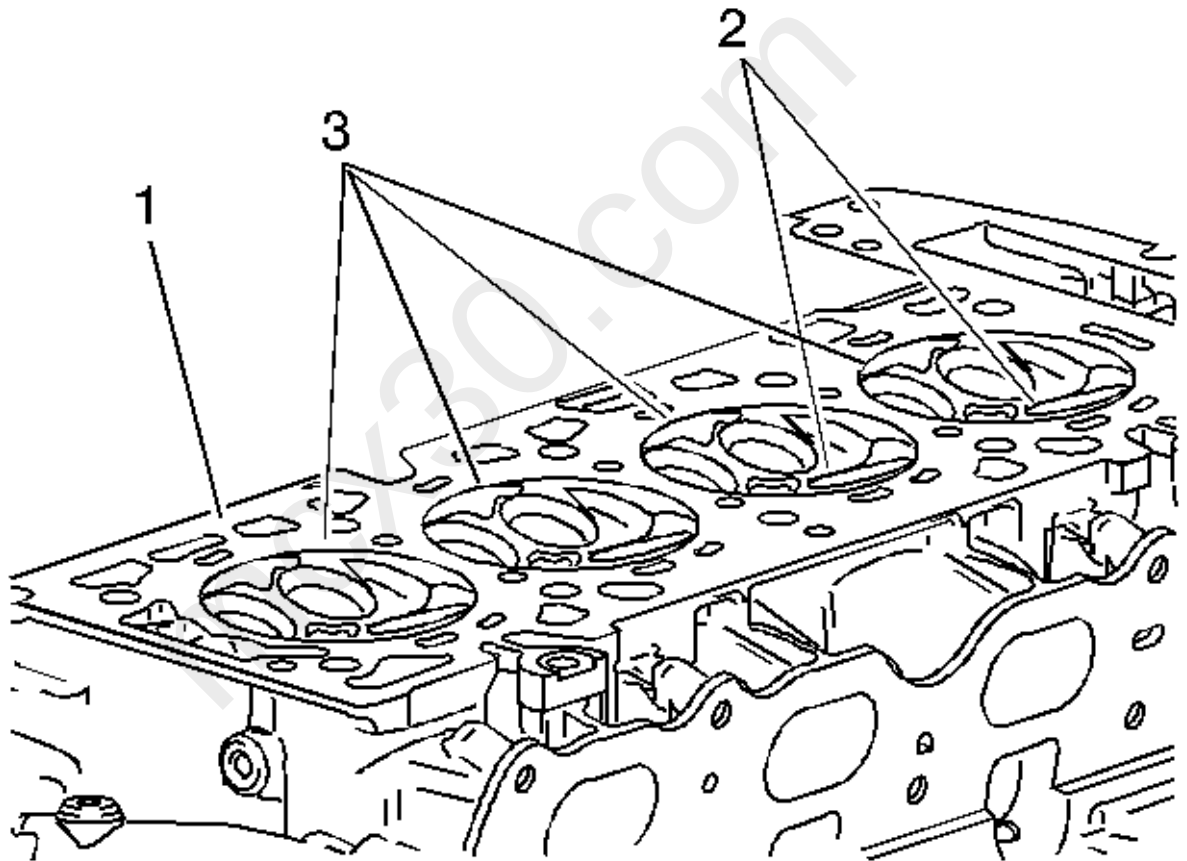


Fig. 433: Locating Combustion Chambers

Courtesy of GENERAL MOTORS COMPANY

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. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**

NOTE: Do not use a wire brush on any gasket sealing surface.

5. Remove the sealant from the rear cap mating surface with **EN-28410** remover. Care must be used to avoid gouging or scraping the sealing surfaces.
6. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
7. Clean the valve guides.
8. Clean the threaded holes. Use a nylon bristle brush.
9. Clean the remains of the sealer from the plug holes.
10. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

NOTE: Do not attempt to weld the cylinder head, replace it.

11. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

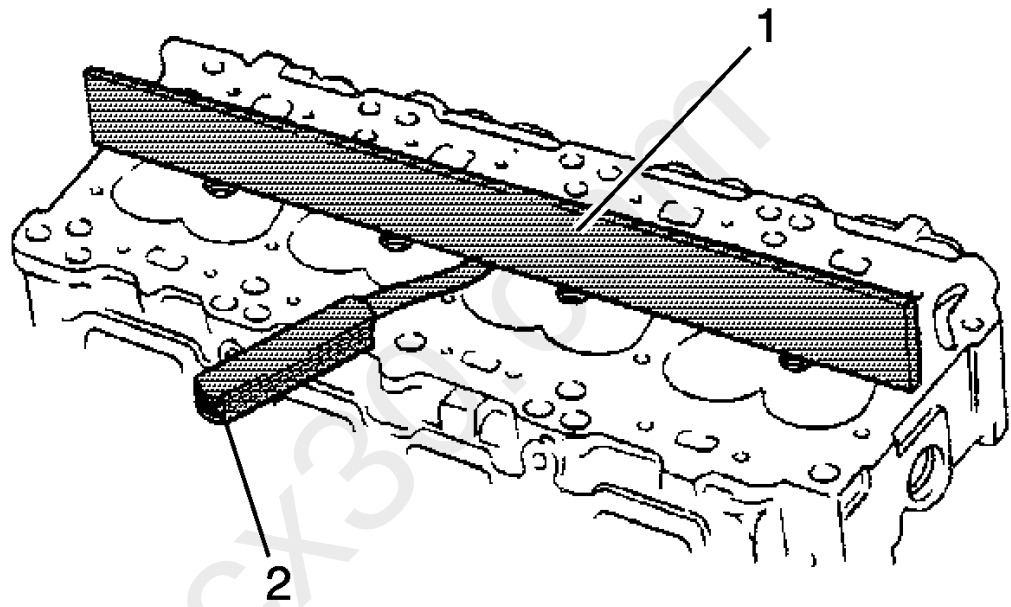


Fig. 434: Checking Cylinder Head Deck Surface For Flatness
Courtesy of GENERAL MOTORS COMPANY

12. Using a straight edge (1) and feeler gauge (2), inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications**. If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
13. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
14. Inspect the sealing surfaces.

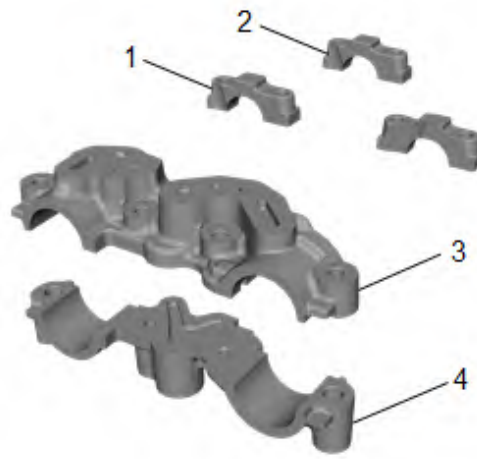


Fig. 435: Intake Camshaft Bearing Rear Cap
 Courtesy of GENERAL MOTORS COMPANY

15. Inspect the intake camshaft bearing rear cap (2) for damage.
16. Inspect the camshaft bearing caps (1) for damage.
17. Inspect the camshaft front upper and lower bearing caps (3, 4) for damage.

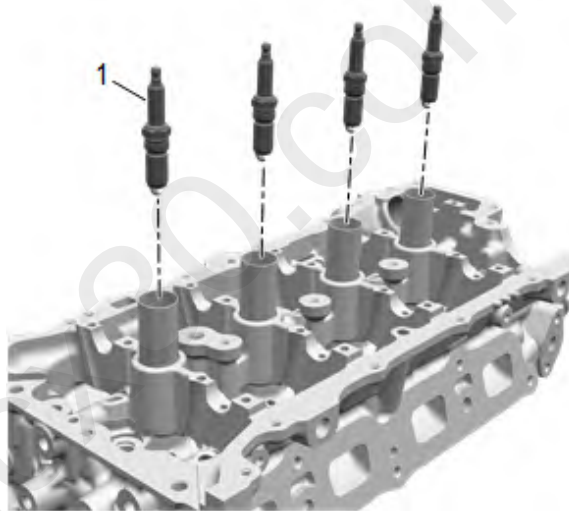


Fig. 436: Spark Plugs
 Courtesy of GENERAL MOTORS COMPANY

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

18. Install the spark plugs (1) using **EN-39358** socket. tighten the plugs to 20 N.m (15 lb ft).

VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure

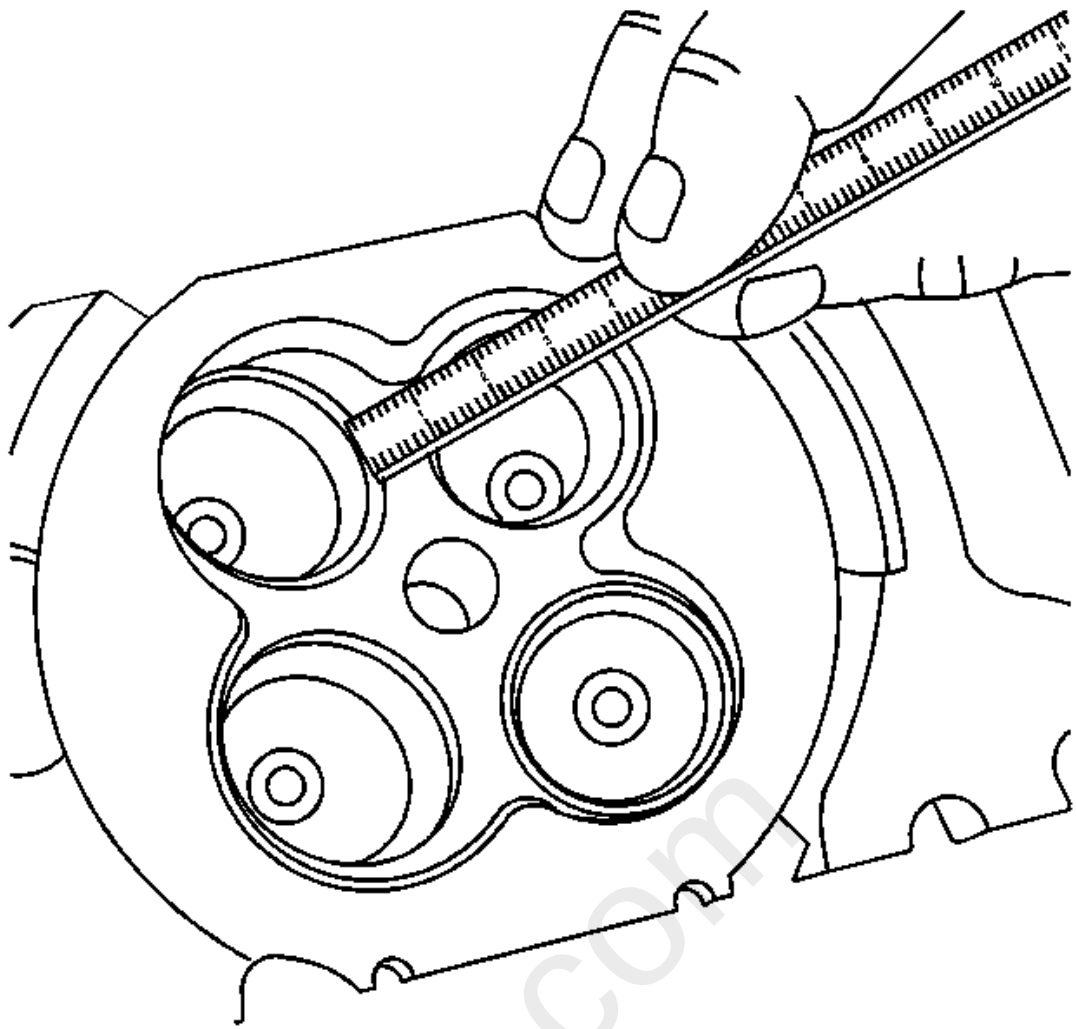


Fig. 437: Checking Valve Seat Width

Courtesy of GENERAL MOTORS COMPANY

1. Measure the valve seat width in the cylinder head using a proper scale.

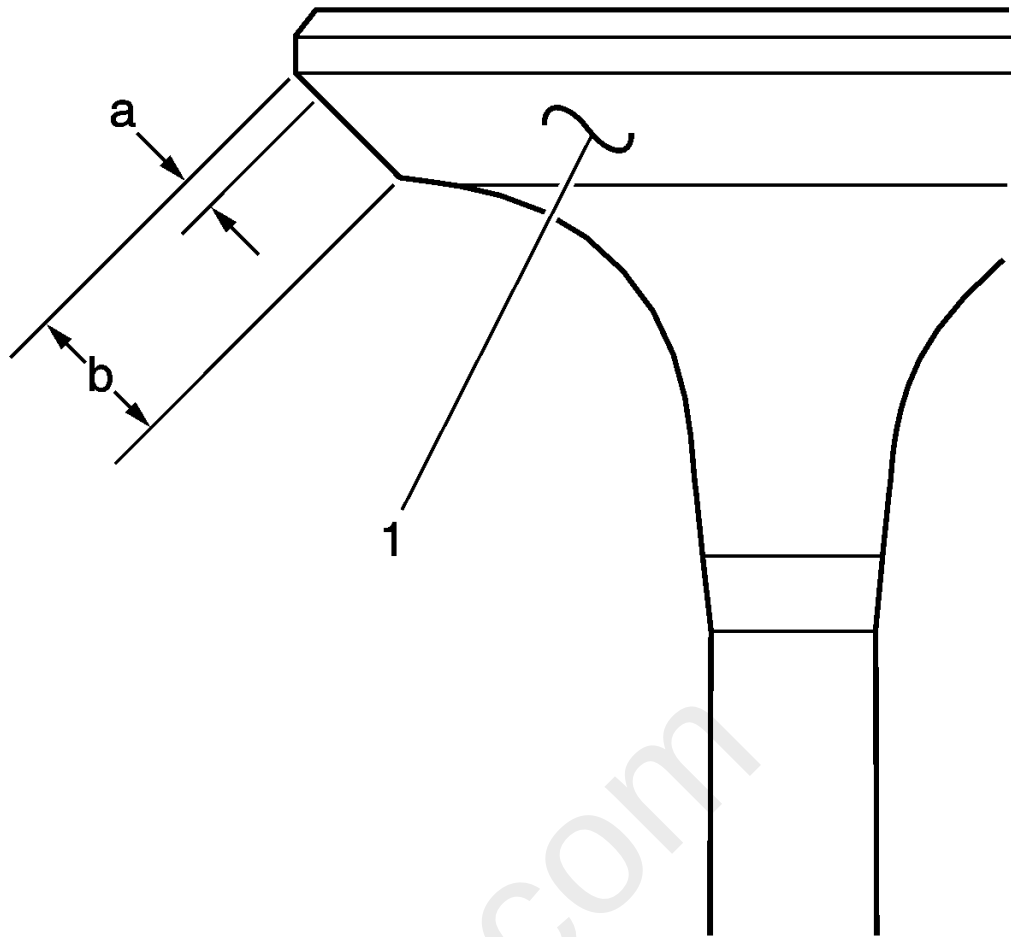


Fig. 438: Valve Face Seat Width

Courtesy of GENERAL MOTORS COMPANY

2. Measure the seat width (b) on the valve face (1) using a proper scale.

NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in [Engine Mechanical Specifications](#).
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Head O.D. and Chamfer Measurement Procedure

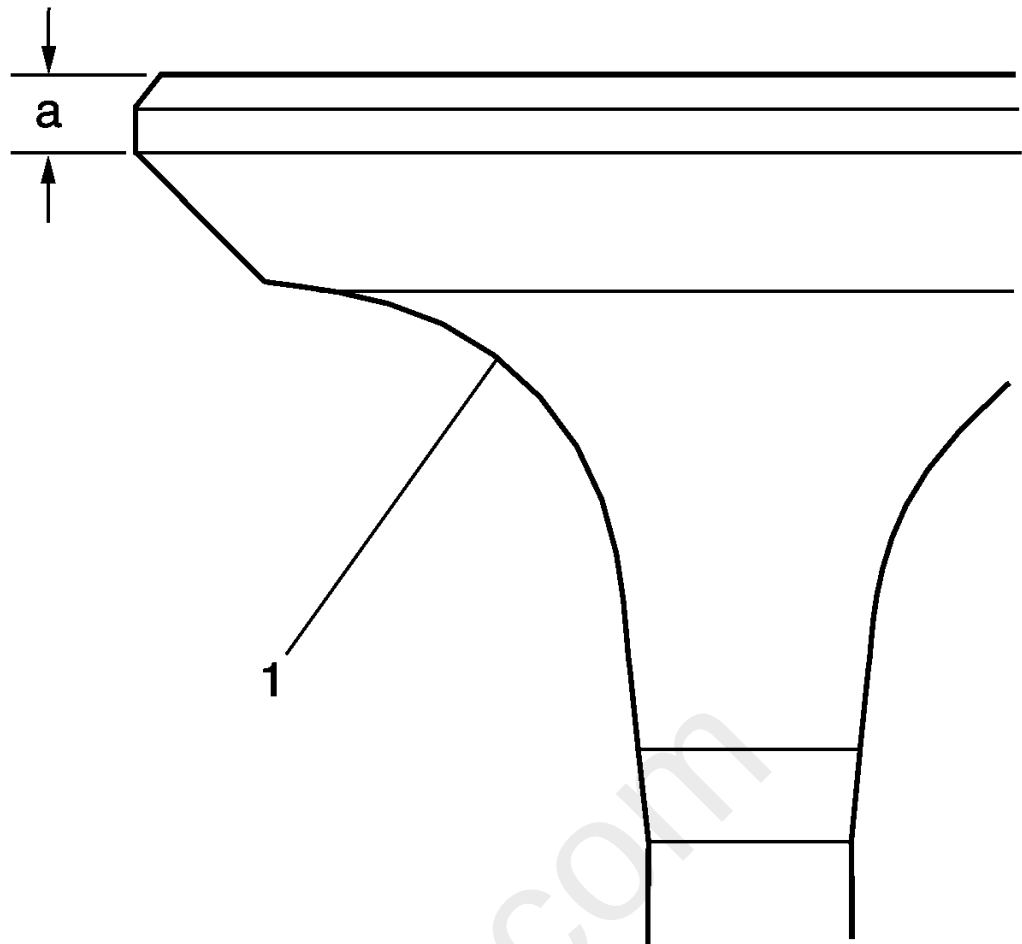


Fig. 439: View Of Valve Head O.D. & Chamfer
Courtesy of GENERAL MOTORS COMPANY

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.**

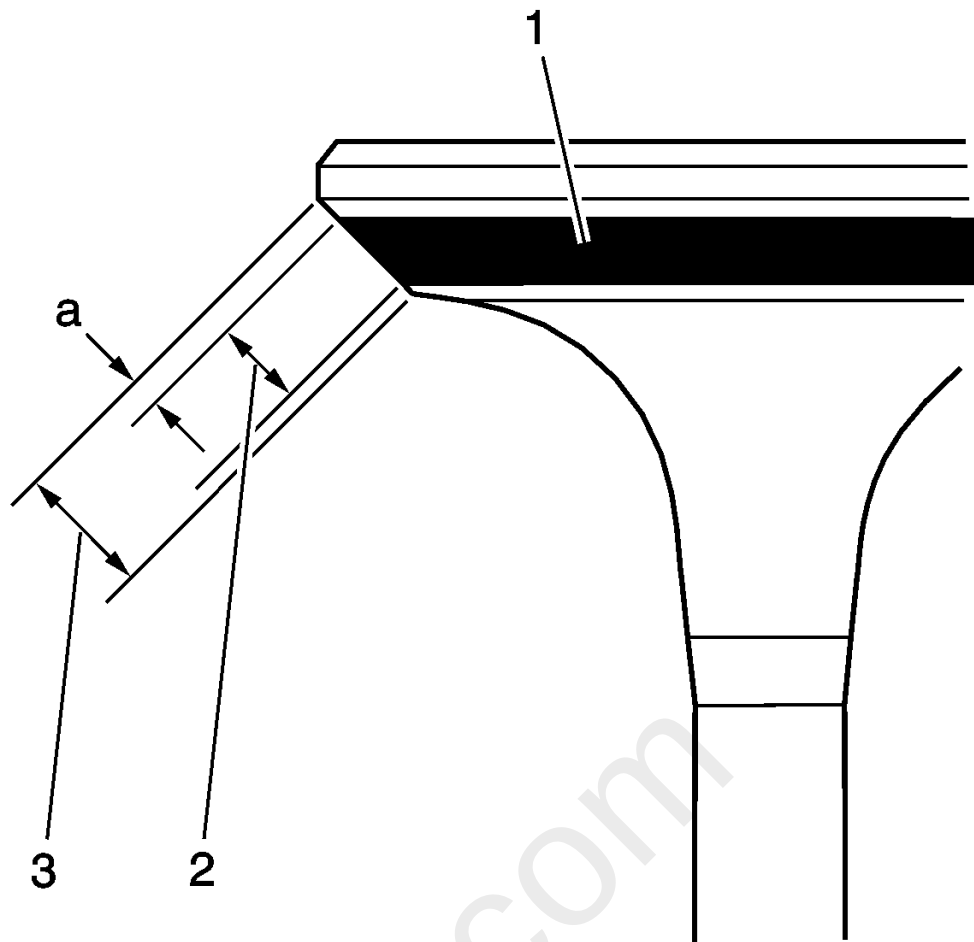


Fig. 440: Inspecting Valve Face

Courtesy of GENERAL MOTORS COMPANY

1. Coat the valve face (3) lightly with blue dye (1).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
 - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

NOTE: The wear mark **MUST** be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

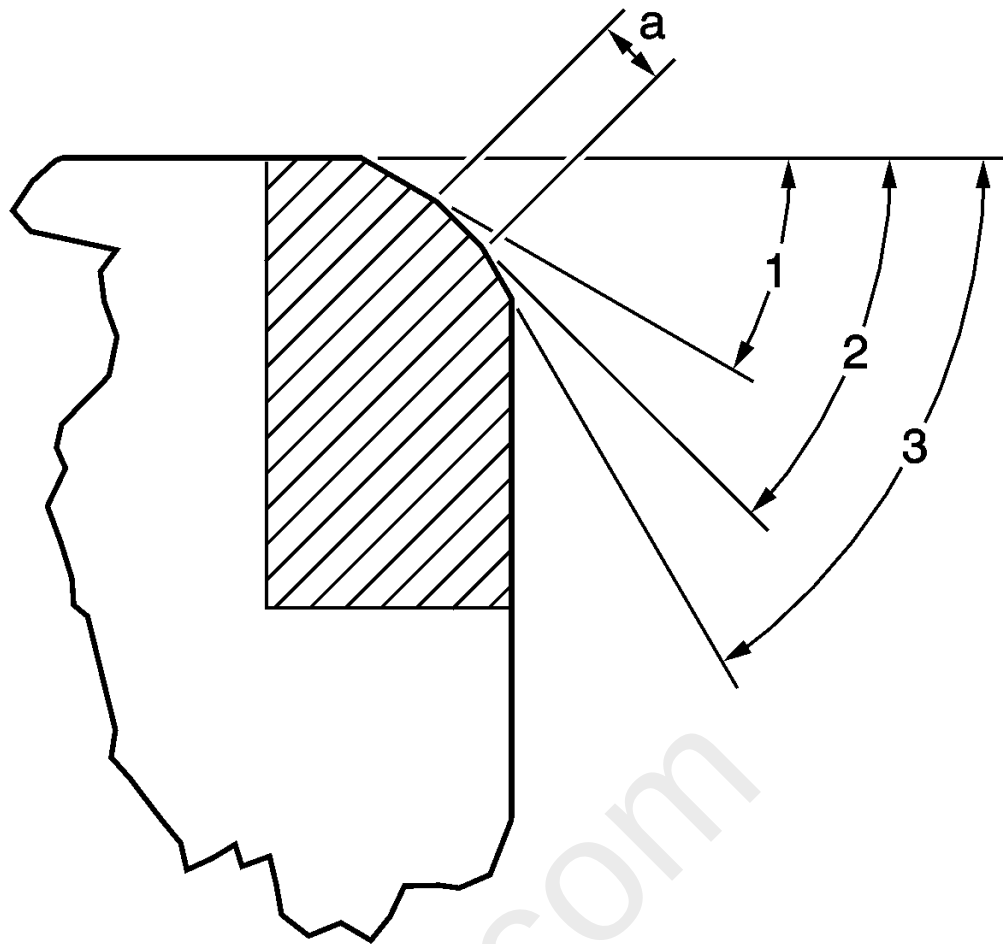


Fig. 441: Valve Seating Surface Angle

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) listed in [Engine Mechanical Specifications](#).
2. Grind the valve relief surface to the proper angle specification (1) listed in [Engine Mechanical Specifications](#), to correctly position the valve seating surface (a) to the valve.
3. Grind the valve undercut surface to the proper angle specification (3) listed in [Engine Mechanical Specifications](#), to narrow the valve seating surface width (a) to the specifications listed in [Engine Mechanical Specifications](#).

NOTE:

Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.

4. Replace the intake valve if it is out of specification. Refer to [Engine Mechanical Specifications](#).
5. If the original exhaust valve is being used, grind the valve to the specifications listed in [Engine Mechanical Specifications](#). Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
 - If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal

lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

- Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.

8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

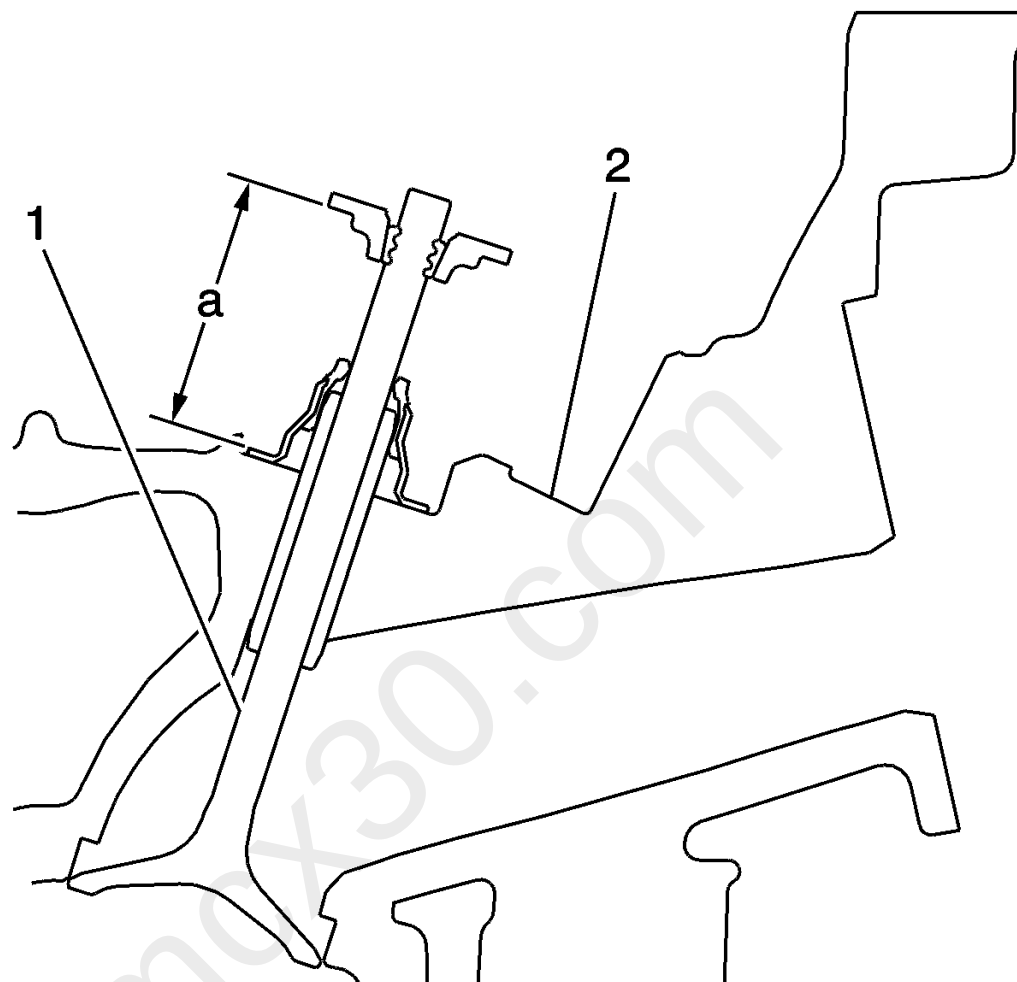


Fig. 442: Valve Stem Height Measurement

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

Special Tools

- EN-50717 Valve Spring Compressor
- EN-9666 Valve Spring Tester
- EN-43963 Valve Spring Compressor (off car)

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

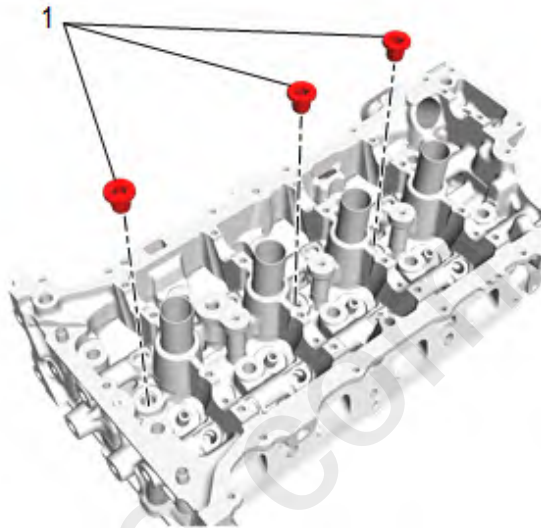


Fig. 443: Cylinder Head Plugs

Courtesy of GENERAL MOTORS COMPANY

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

CAUTION: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

1. Install NEW cylinder head plugs. Coat the plugs with sealer. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
2. Install the water jacket hole plugs (1) in the top of the cylinder head. tighten the plugs to 50 N.m (37 lb ft).

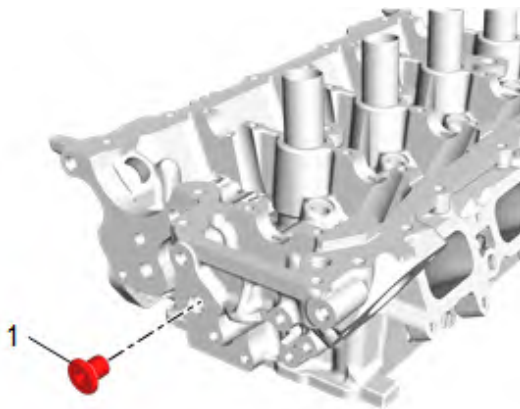


Fig. 444: Cylinder Head Plug

Courtesy of GENERAL MOTORS COMPANY

3. Install the oil gallery plug (1) in the rear of the cylinder head. tighten the plug to 40 N.m (30 lb ft).
4. Inspect the valve springs for the following conditions:
 - Expanded height
 - Unparallel spring ends
 - Spring tension using **EN-9666** tester
 - Any distorted springs should be replaced

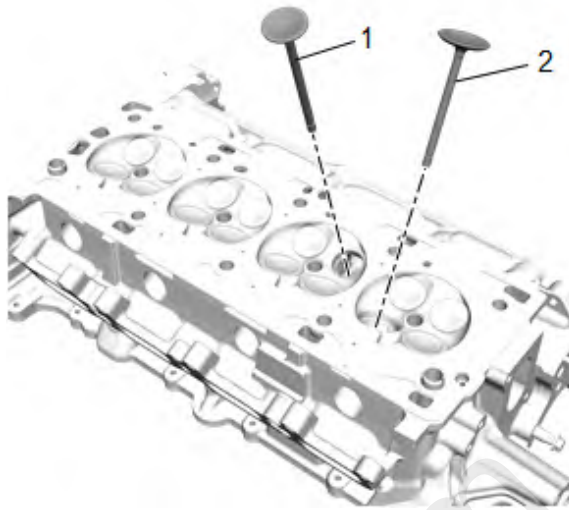


Fig. 445: Valves

Courtesy of GENERAL MOTORS COMPANY

5. Inspect the valves and the valve seats. Refer to [Valve and Seat Grinding](#).
6. Lubricate the valves. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
7. Install the valves (1, 2). Replace the valves, if required.

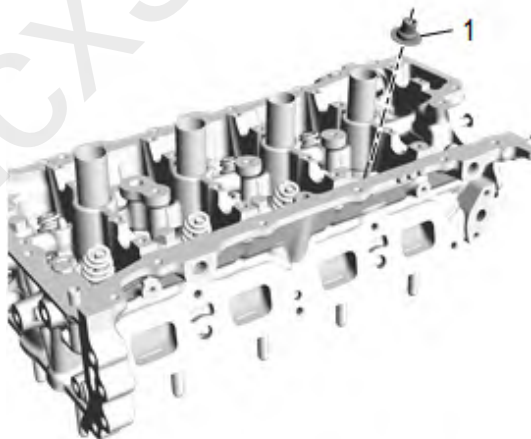


Fig. 446: Valve Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: Always use **NEW** valve stem oil seals when assembling the cylinder head.

8. Install the NEW valve seals (1). Fully seat the seals on the valve guides.

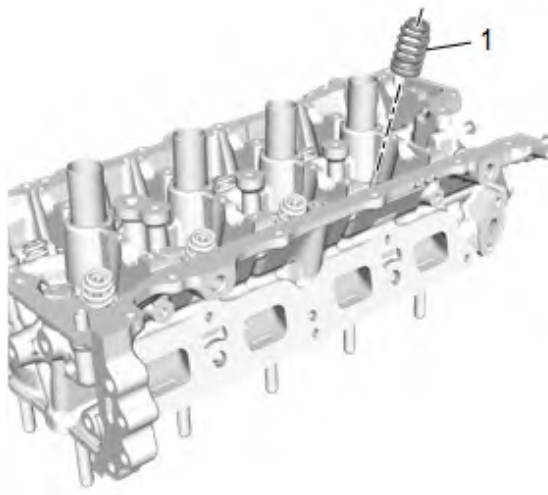


Fig. 447: Valve Springs

Courtesy of GENERAL MOTORS COMPANY

9. Install the springs (1).

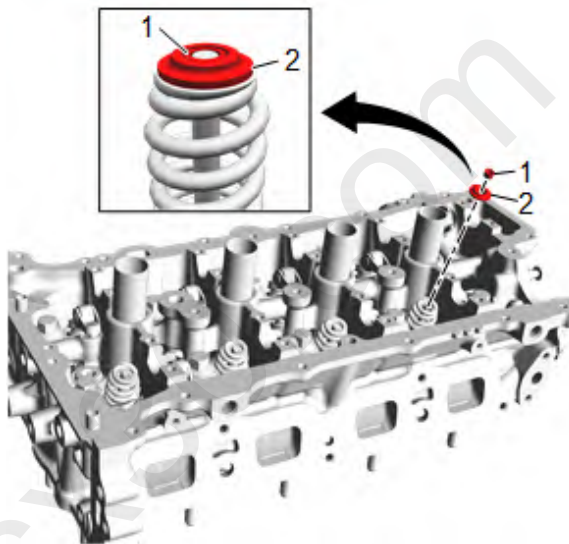


Fig. 448: Valve Keys, Springs, And Retainers

Courtesy of GENERAL MOTORS COMPANY

WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

10. Install the retainers and keys using the following procedure:
 1. Install the retainer (2).
 2. Using the **EN-50717** compressor and the **EN-43963** adapter, compress the valve spring.
 3. Install the valve keys (1).
 4. Slowly release the compression from the valve/spring assembly.
 5. Inspect for proper valve key seating.

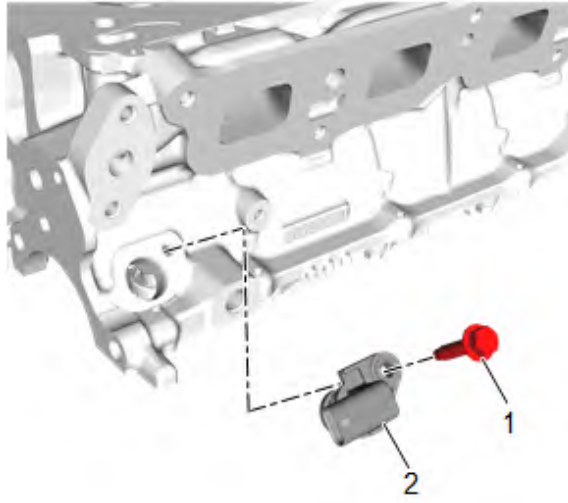


Fig. 449: Exhaust Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Lubricate the camshaft position sensor O-ring with clean engine oil.

CAUTION: Refer to **Fastener Caution** .

12. Install the exhaust camshaft position sensor (2) and bolt (1). tighten the bolt to 10 N.m (89 lb in).

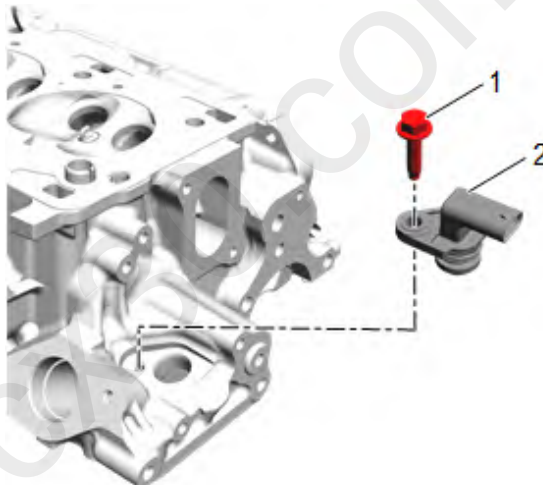


Fig. 450: Intake Camshaft Position Sensor And Bolt
Courtesy of GENERAL MOTORS COMPANY

13. Lubricate the camshaft position sensor O-ring with clean engine oil.
14. Install the intake camshaft position sensor (2) and bolt (1). tighten the bolt to 10 N.m (89 lb in).

BALANCER SHAFT WITH OIL PUMP DISASSEMBLE

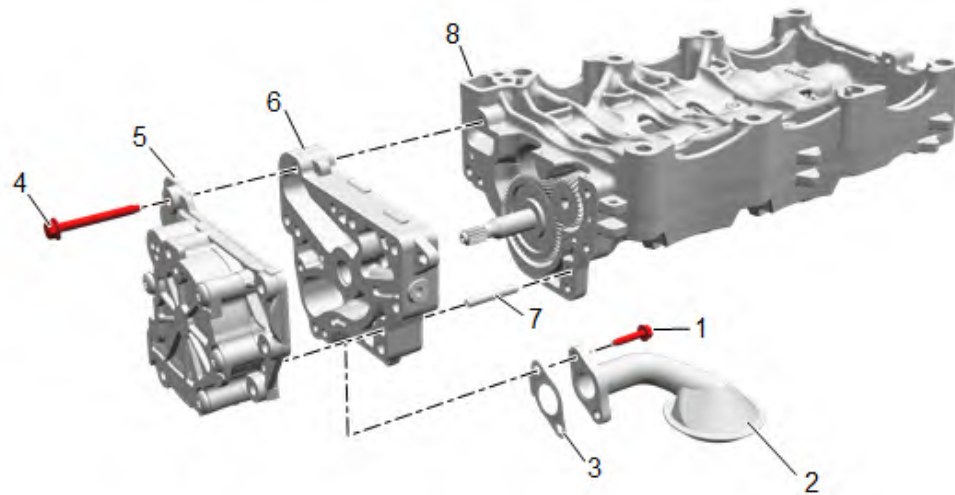


Fig. 451: Oil Pump Assembly

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Suction Pipe Bolt
2	Oil Pump Screen Assembly with Suction Pipe
3	Oil Pump Screen Gasket NOTE: Discard the gasket.
4	Oil Pump Assembly Bolt
5	Oil Pump Assembly
6	Oil Pump Cover
7	Oil Pump Locating Pin
8	Balancer Shaft Module

BALANCER SHAFT WITH OIL PUMP CLEANING AND INSPECTION

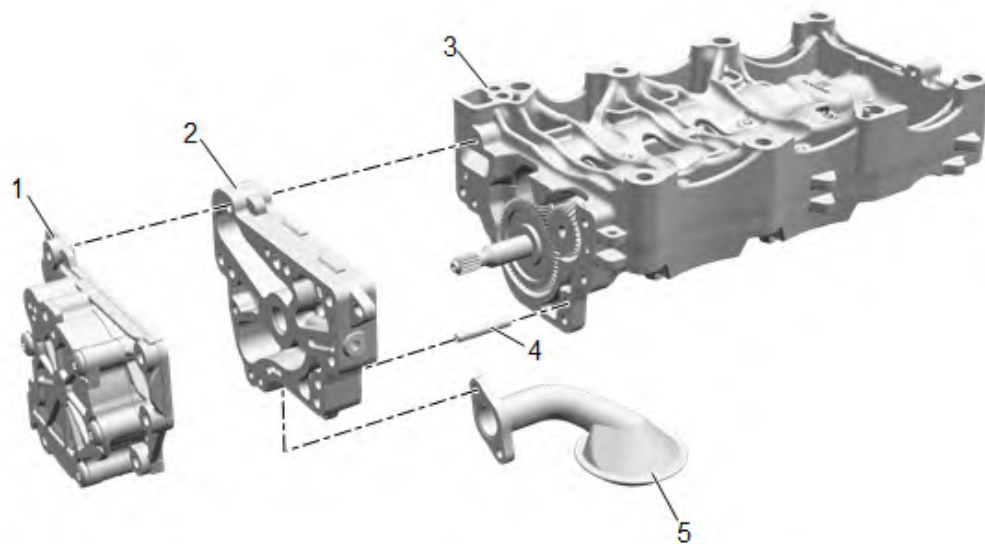


Fig. 452: Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Completely inspect the balancer with oil pump shaft assembly and components. 2. Clean all mating surfaces. 3. Inspect all threaded holes for damage. 4. Inspect the oil pump screen assembly.	
1	Oil Pump Assembly
2	Oil Pump Cover
3	Balancer Shaft Module
4	Oil Pump Locating Pin
5	Oil Pump Screen Assembly with Suction Pipe

BALANCER SHAFT WITH OIL PUMP ASSEMBLE

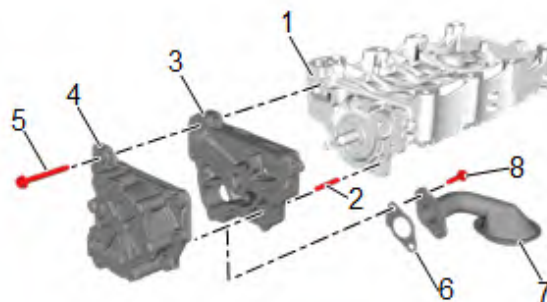


Fig. 453: Balancer Shaft with Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Balancer Shaft Module
2	Oil Pump Locating Pin
3	Oil Pump Cover
4	Oil Pump Assembly
5	Oil Pump Assembly Bolt CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)
6	Oil Pump Screen Gasket NOTE: Use NEW gasket.
7	Oil Pump Screen Assembly with Suction Pipe
8	Oil Pump Suction Pipe Bolt tighten 10 N.m (89 lb in)

CAMSHAFT COVER AND COMPRESSOR AIR INTAKE TURBOCHARGER CLEANING AND INSPECTION

Positive Crankcase Ventilation System Overview

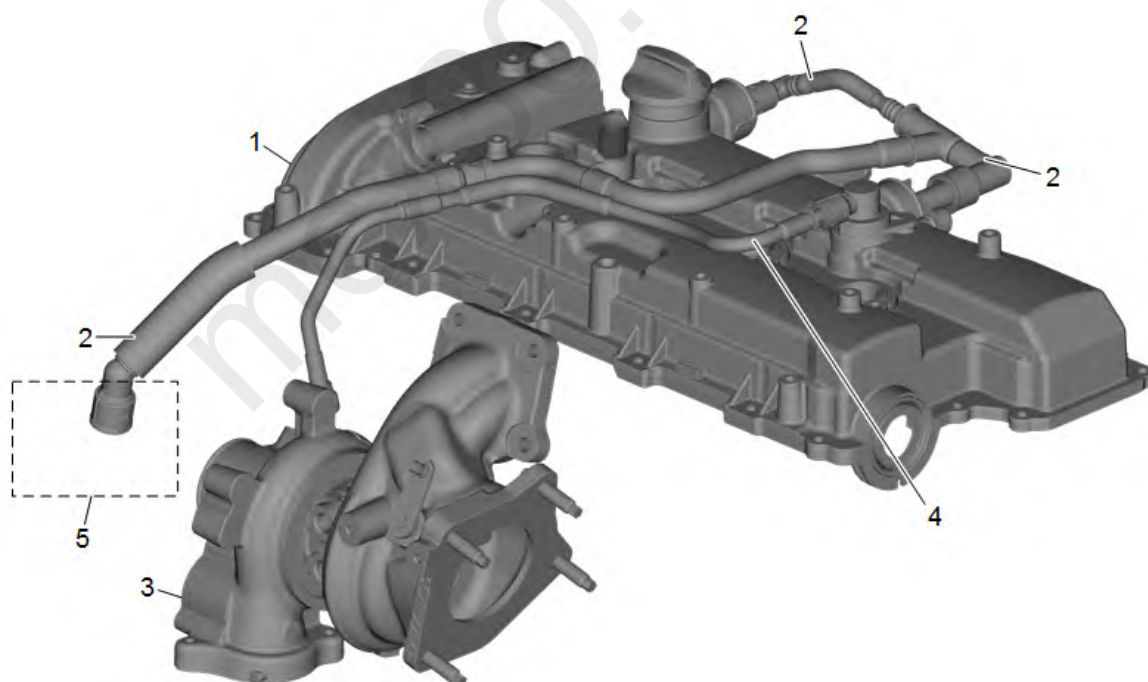


Fig. 454: Positive Crankcase Ventilation System
Courtesy of GENERAL MOTORS COMPANY

Positive Crankcase Ventilation System Overview

Callout	Component Name

Callout	Component Name
Preliminary Procedure The tamper-proof positive crankcase ventilation system includes components that may be replaced if necessary. The system may include an outlet duct connected to the end of the Positive Crankcase Ventilation Tube. If any component is suspect, refer to the inspection procedures and individual replacement procedures before attempting to disassemble the PCV system. Be careful when moving the assembled components with tamper-proof fittings to avoid stress on the connections.	
1	Camshaft Cover NOTE: In the event that the camshaft cover requires replacing, the PCV hose at the air outlet duct and turbocharger will be removed by cutting and/or prying at the connection. The air outlet duct and turbocharger must remain intact in order to reinstall these components. Procedure 1. Thoroughly clean the camshaft cover and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant 3. Refer to Camshaft Cover Replacement (1st Design Tamper-Proof PCV System) if the camshaft cover does not pass inspection.
2	Positive Crankcase Ventilation Tube NOTE: All PCV valves are tamper-proof and cannot be serviced. Procedure Inspect the PCV connection fittings and tubes. Replace the Positive Crankcase Ventilation Tube if suspect. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Camshaft Cover to Air Inlet) .
3	Turbocharger NOTE: The PCV fitting is tamper-proof and cannot be serviced. A new PCV tube and valve are included with a new turbocharger assembly. NOTE: On earlier designs of this system the fastener at the PCV fitting on the turbocharger was not tamper-proof. To aid in disassembly or removal, this fastener can be removed if it is not tamper-proof. Procedure Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Refer to Symptoms - Engine Mechanical .
4	Positive Crankcase Ventilation Tube NOTE: All PCV valves and fittings are tamper-proof and cannot be serviced. Procedure Inspect the PCV connection fittings and tubes. Replace the Positive Crankcase Ventilation Tube if suspect. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Camshaft Cover to Air Inlet) .

Callout	Component Name
5	Air Cleaner Outlet Duct - Model Dependent NOTE: The air cleaner outlet duct is equipped with a tamper proof connection that should NOT be removed unless the PCV tube or air cleaner outlet duct is being replaced. Loosening the air cleaner outlet duct clamps will allow the duct to be disconnected from the air cleaner assembly and turbocharger for repositioning without removing the tamper proof connection. Procedure Inspect the duct and hose, or the connection if the duct is not attached to the hose. Replace any components that are suspect. Refer to Air Cleaner Outlet Duct Replacement (Non-Tamperproof) Air Cleaner Outlet Duct Replacement (Tamperproof) .

Camshaft Cover - Top

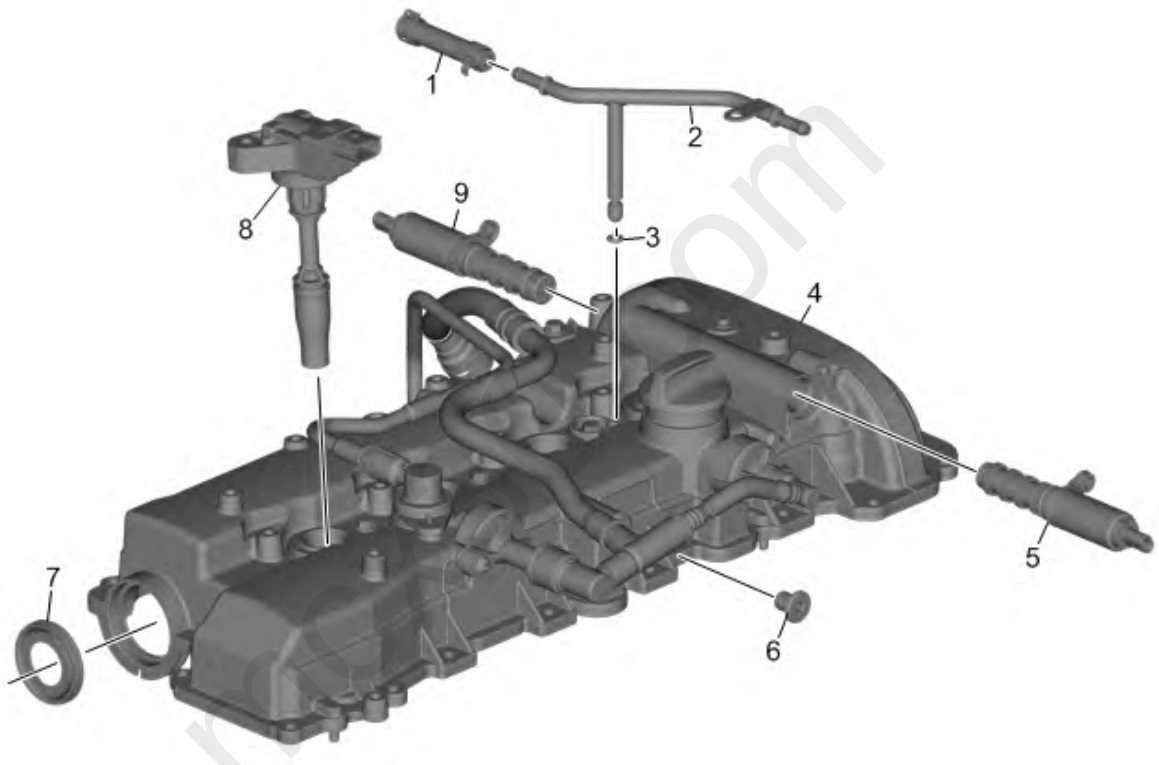


Fig. 455: Camshaft Cover -- Top

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - Top

Callout	Component Name
Preliminary Procedure 1. Thoroughly clean the camshaft cover and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant	
1	Engine Coolant Air Bleed Hose
2	Engine Coolant Air Bleed Pipe
3	Engine Coolant Air Bleed Pipe O-Ring
4	Camshaft Cover
5	Camshaft Position Actuator Solenoid Valve - Intake

Callout	Component Name
6	Camshaft Cover Plug CAUTION: Refer to Fastener Caution . tighten 35 N.m (26 lb ft)
7	Vacuum Pump Seal Special Tools DT 45866 Input Shaft Seal Installer Equivalent regional tools: Special Tools .
8	Ignition Coil
9	Camshaft Position Actuator Solenoid Valve - Exhaust

Camshaft Cover - Bottom

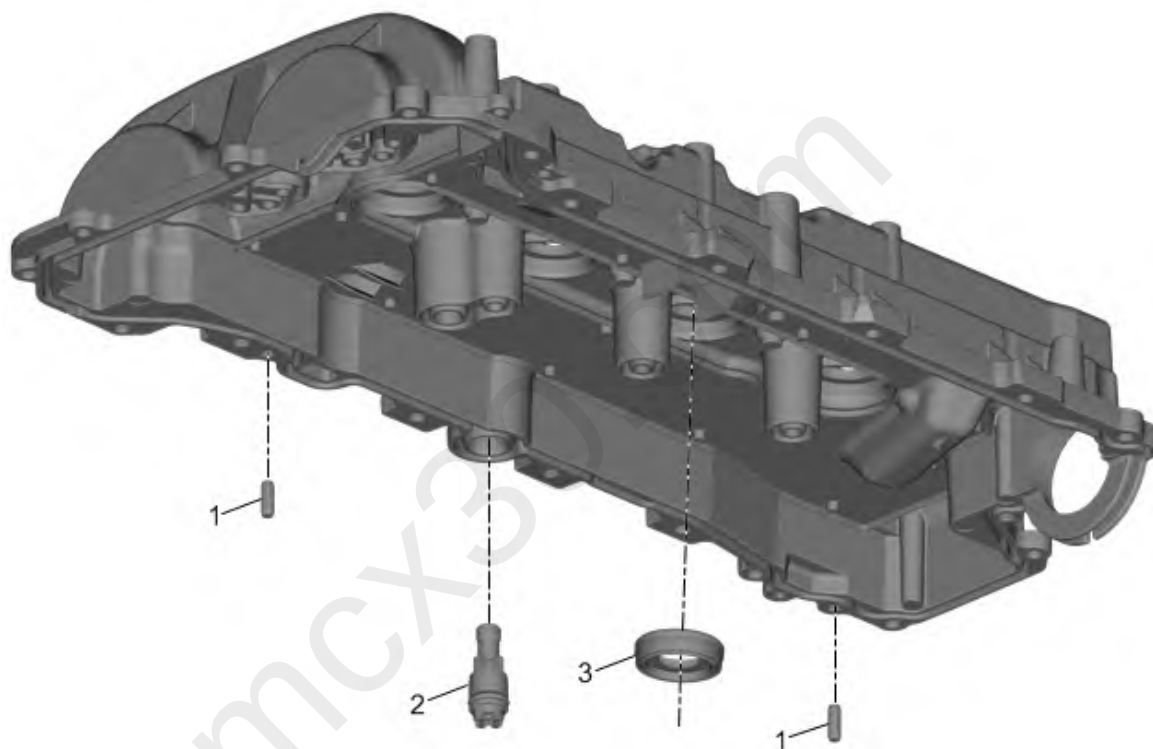


Fig. 456: Camshaft Cover -- Bottom

Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover - Bottom

Callout	Component Name
Preliminary Procedure Inspect each component, O-rings, and fasteners, and replace as necessary.	
1	Camshaft Cover Locating Pin
2	Positive Crankcase Ventilation Valve
3	Spark Plug Shield Seal Special Tools EN 34115 Sprocket Bearing Installer Equivalent regional tools: Special Tools .

Turbocharger and Components Cleaning and Inspection

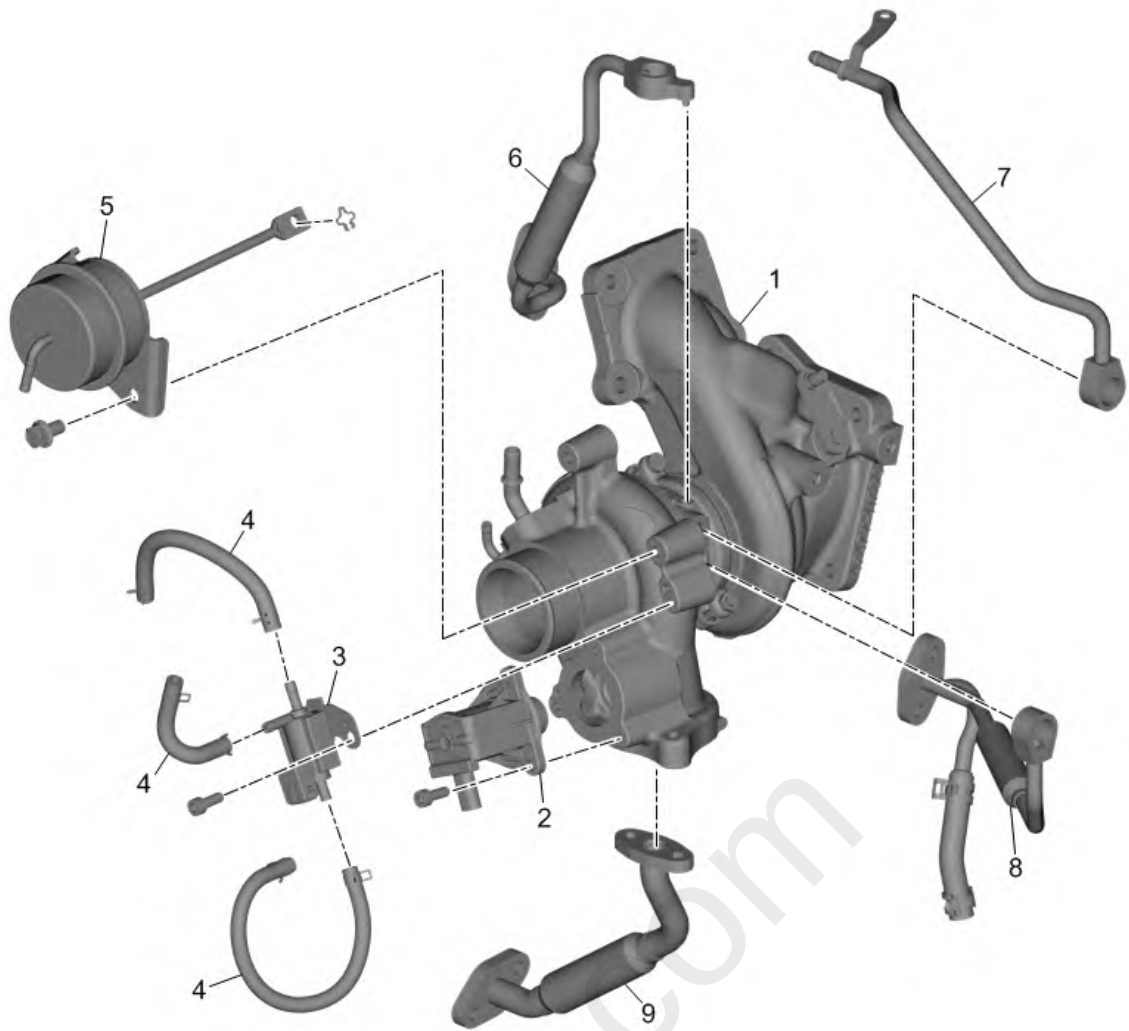


Fig. 457: Turbocharger and Components
 Courtesy of GENERAL MOTORS COMPANY

Turbocharger and Components Cleaning and Inspection

Callout	Component Name

Callout	Component Name
1	Turbocharger Procedure 1. Clean all mating surfaces. 2. Inspect all threaded holes for damage. NOTE: PCV fluids and combustion product buildup are common and not a sign of failure. 3. Inspect the compressor and turbine blades for bent or broken conditions, and foreign material. NOTE: Do not replace the turbocharger if cracks are found on the turbocharger inlet flange partition wall. Replacement should only be performed if external leaks are present or a section is loose or missing. 4. Inspect the turbocharger compressor inlet, compressor outlet, turbine inlet, and turbine outlet surfaces for damage. Replace the turbocharger if damage is found. NOTE: A new PCV tube and fitting are included with a new turbocharger assembly. 5. Replace the turbocharger if damage is found. Refer to Turbocharger Replacement (1st Design Tamper-Proof PCV System).
2	Turbocharger Bypass Valve Solenoid Procedure Inspect the bypass valve solenoid for damage. Replace if necessary.
3	Turbocharger Wastegate Regulator Solenoid Valve NOTE: Do not disassemble solenoid valve from bracket. Procedure Inspect the solenoid valve and bracket for damage. Replace if necessary.
4	Turbocharger Wastegate Regulator Solenoid Valve Hose Procedure Inspect the turbocharger wastegate regulator solenoid hoses for damage. Replace the hoses if necessary.
5	Turbocharger Wastegate Actuator Procedure 1. Inspect the turbocharger wastegate actuator. 2. Inspect the wastegate actuator rod for damage or tampering. 3. Replace the wastegate actuator if damage is found.
6	Turbocharger Oil Feed Pipe Procedure Inspect the pipe. Replace if necessary.
7	Turbocharger Coolant Return Pipe Procedure Inspect the pipe. Replace if necessary.

Callout	Component Name
8	Turbocharger Coolant Feed Pipe Procedure Inspect the pipe. Replace if necessary.
9	Turbocharger Oil Return Pipe Procedure Inspect the pipe. Replace if necessary.

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- EN-47909 Injector Bore and Sleeve Cleaning Kit
- EN-49245 Fuel Injector Seal Install/Sizer
- EN-50791 Fuel Injector Nozzle Installer
- EN-51105 Fuel Injector Seal Installer

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

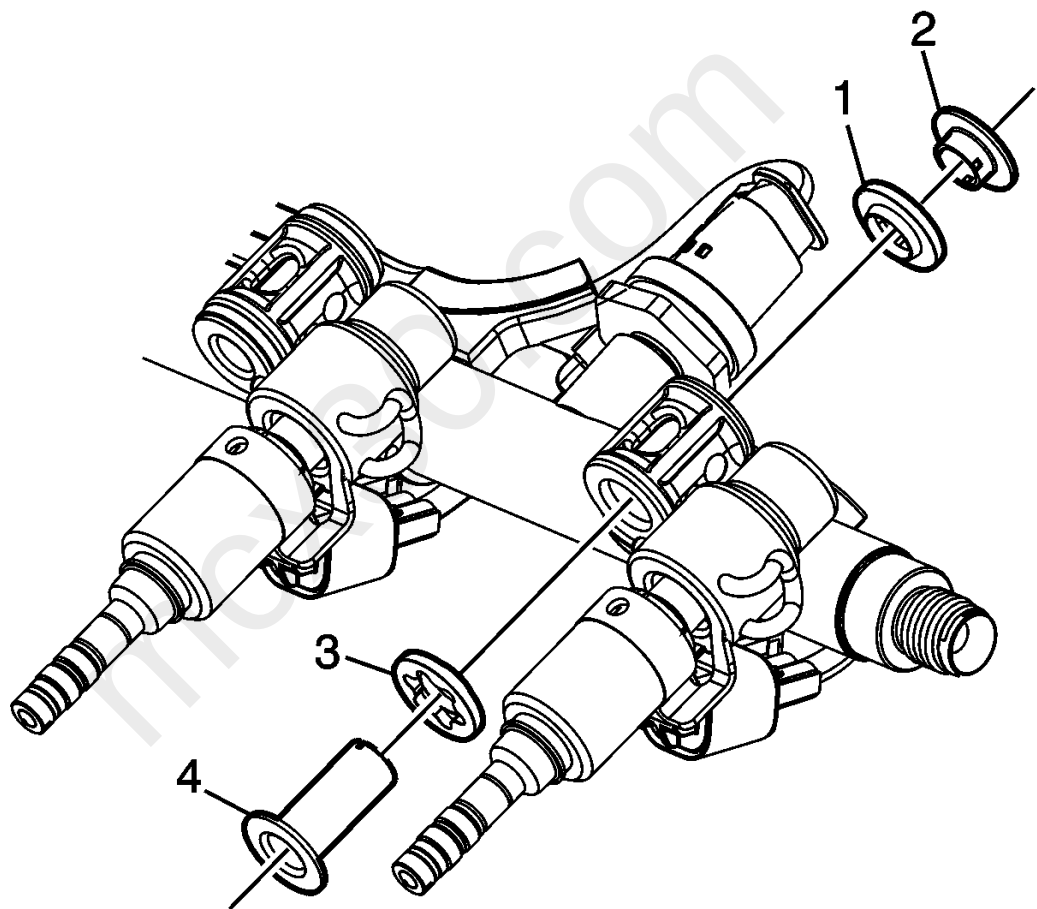


Fig. 458: Fuel Rail Insulator Assemblies

Courtesy of GENERAL MOTORS COMPANY

1. Remove and inspect the fuel rail insulator assemblies (1 - 4). Replace the entire assembly if any components show signs of wear or the insulators (4) show the following conditions:
 - Dry or cracked appearance
 - Flattened or misshapen appearance

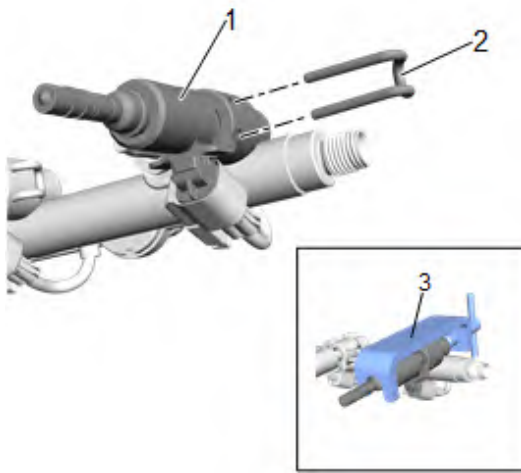


Fig. 459: Fuel Injector And Retaining Pin
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the electrical connections from the fuel injectors.
3. Use **EN-50791** installer (3) to compress the fuel injector (1), and relieve pressure on the retaining pin (2). Remove the fuel injector retaining pin (2). Remove **EN-50791** installer once the retaining pin is removed.

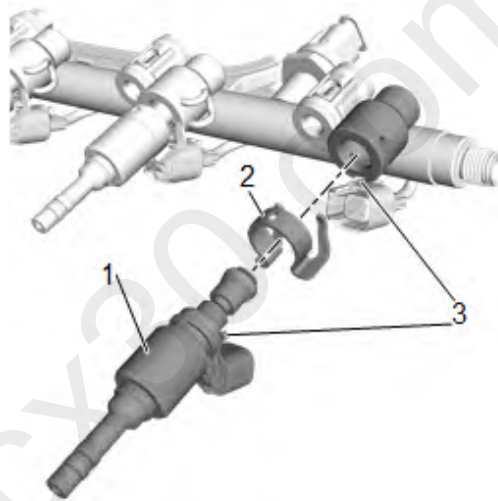


Fig. 460: Injectors And Fuel Rail Slot
Courtesy of GENERAL MOTORS COMPANY

NOTE: Support the fuel injector at the widest point. Support the fuel rail along the bottom.

- **DO NOT** support or hold the fuel injector by the tip or connector
- **DO NOT** tilt or excessively twist the injector during removal

4. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable as long as excessive force is not applied to the fuel injector tab while engaged in the fuel rail slot (3).
5. Remove the fuel injector holding clamp (2) from the rear of the fuel injector.

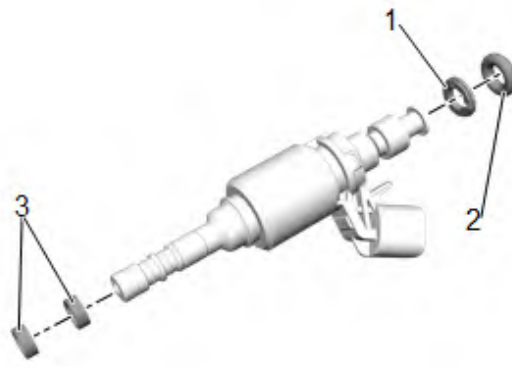


Fig. 461: Fuel Injector O-ring And Plastic Spacer

Courtesy of GENERAL MOTORS COMPANY

6. Remove and discard the fuel injector O-ring (2) and plastic spacer (1).
7. Remove and discard the fuel injector seals (3).

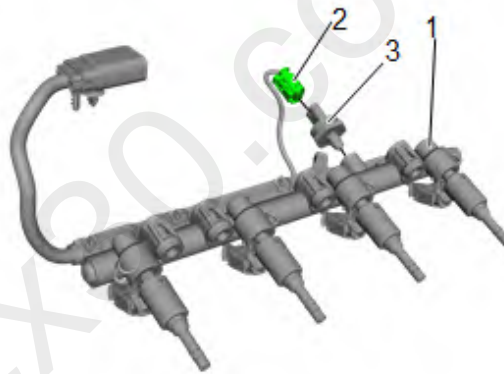


Fig. 462: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not soak or submerge the fuel rail or injectors in solvent. Do not use solvent on the fuel rail label.

8. Clean the exterior of the fuel rail (1) and injectors in solvent.
9. Using **EN-47909** cleaning kit, clean the fuel injector bores and sleeves.
10. Inspect the fuel rail and components for the following conditions:
 - Damage, debris, or restrictions to the fuel rail
 - Damage, debris, or restrictions to the fuel ports in the fuel rail
 - Damage to the mounting area for the fuel rail
 - Damage to the fuel rail mounting bolts
 - Damage to the threads on the fuel rail fuel feed fitting
11. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

CAUTION: Refer to **Fastener Caution** .

NOTE: Remove and inspect the fuel pressure sensor only if the sensor is suspect.

12. Inspect the fuel pressure sensor (3) for damage.

1. Disconnect the harness connector (2) from the fuel pressure sensor.
2. Remove the fuel pressure sensor. Dry the fuel pressure sensor bore in the fuel rail with a lint free cloth. The bore should be free of fuel, debris, and burrs.
3. Lubricate the fuel rail fuel pressure sensor bore with clean engine oil.
4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
5. Install the fuel pressure sensor hand tight.
6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
7. Install the fuel pressure sensor and tighten to 33 N.m (25 lb ft).
8. Connect the harness connector to the fuel pressure sensor.

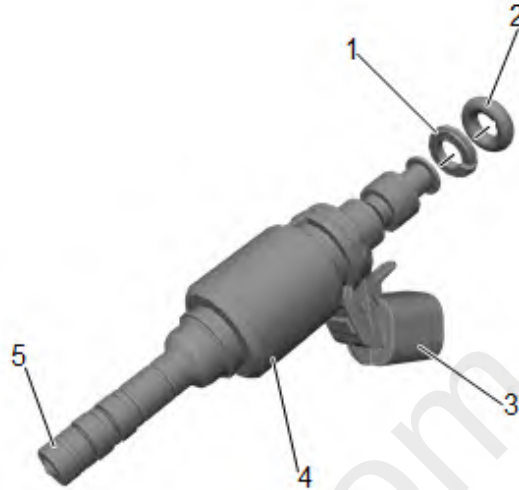


Fig. 463: Fuel Injector Connector

Courtesy of GENERAL MOTORS COMPANY

13. Inspect the fuel injectors for the following conditions:
 - Damage to the fuel injector connector (3)
 - Damage to the fuel injector harness connector
 - Damage to the fuel injector tip (5)
 - Damage to the fuel injector (4)
14. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.
15. Install the a new fuel injector spacer (1).
16. Lubricate the NEW O-ring (2) with one drop of clean engine oil.
17. Install the O-ring on the injector.

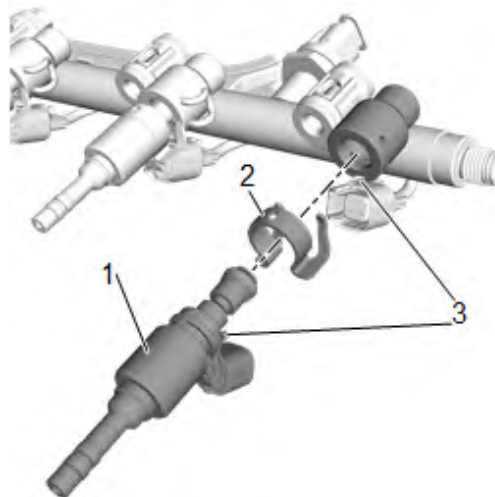


Fig. 464: Injectors And Fuel Rail Slot

Courtesy of GENERAL MOTORS COMPANY

18. Install the fuel injector holding clamp (2) onto the rear of the fuel injector.

19. Hand install fuel injectors (1) to the fuel rail, carefully aligning the fuel injector tab to the slot in the fuel rail (3).

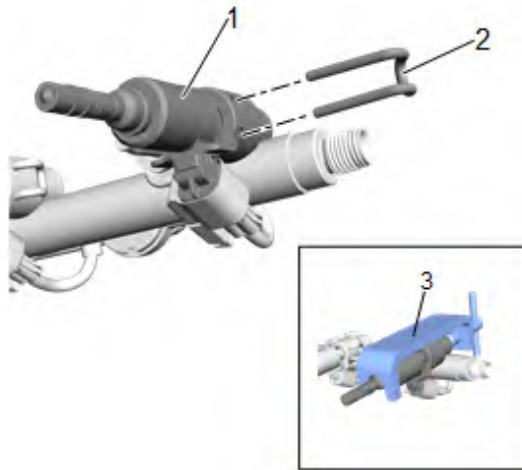


Fig. 465: Fuel Injector And Retaining Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE: The injector must be fully installed and properly aligned with the fuel rail before installing the retaining pin.

20. Using **EN-50791** installer (3), compress the fuel injector (1) into the fuel rail.
21. Ensure the fuel injector is fully seated in the fuel rail, and install the fuel injector retaining pin (4).
22. Ensure the fuel injector retaining pin is fully seated in the fuel rail. Remove **EN-50791** installer. Repeat process until all fuel injectors are properly installed to the fuel rail.

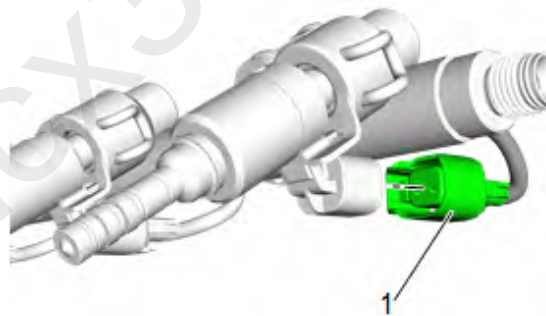


Fig. 466: Fuel Rail Harness Connectors
Courtesy of GENERAL MOTORS COMPANY

23. Connect the electrical connection to the fuel rail.
24. Connect the fuel rail harness connectors (1) to the fuel injectors.

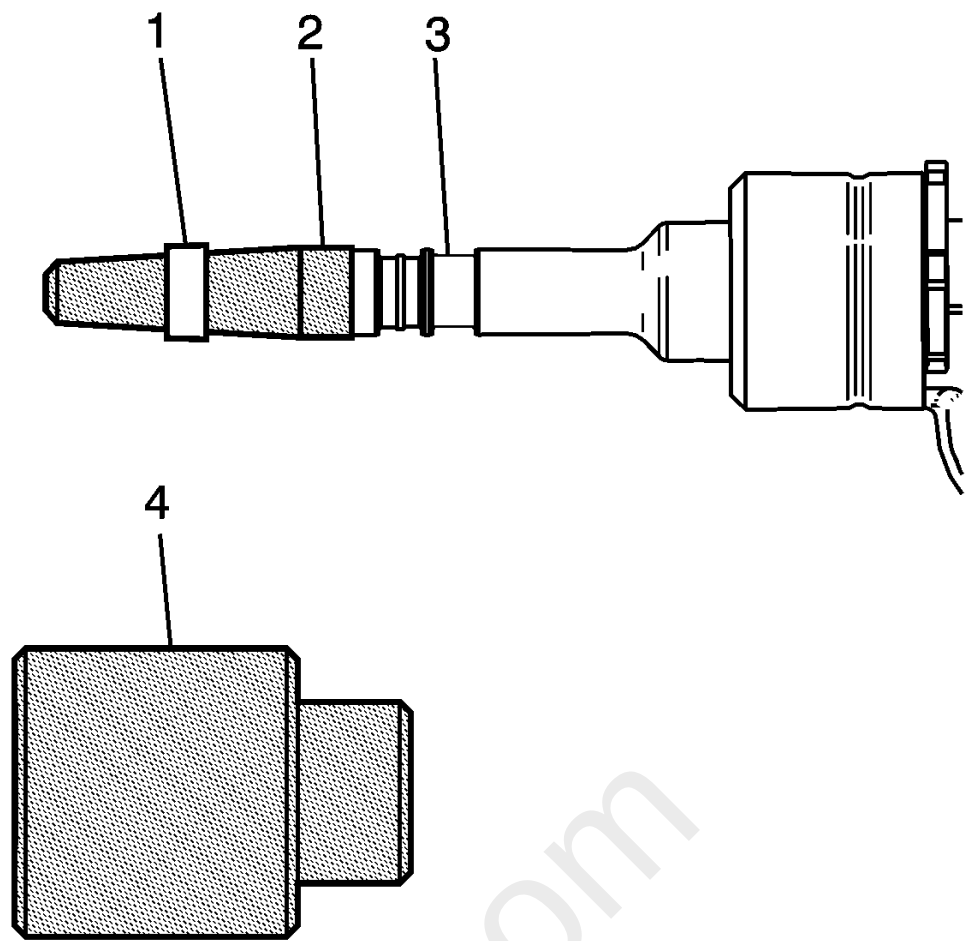


Fig. 467: Second Recessed Area And NEW Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: Do not use any type of lubricant when installing the NEW seals on the fuel injector tip.

25. Install **EN-51105-1** long protector (2) onto the fuel injector tip. Place a NEW seal (1) on **EN-51105-1** long protector.
26. Using **EN-49245** pusher, install the seal into the second recessed area (3) of the fuel injector, then remove the **EN-51105-1** long protector.
27. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).
28. Install **EN-51105-2** short protector (2) onto the fuel injector tip. Place a second NEW seal (1) on **EN-51105-2** short protector.
29. Using **EN-49245** pusher, install the seal into the remaining recessed area of the fuel injector, then remove **EN-51105-2** short protector.
30. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).

INTAKE MANIFOLD CLEANING AND INSPECTION



Fig. 468: Intake Manifold

Courtesy of GENERAL MOTORS COMPANY

1. Clean the intake manifold (1) mating surfaces.
2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.

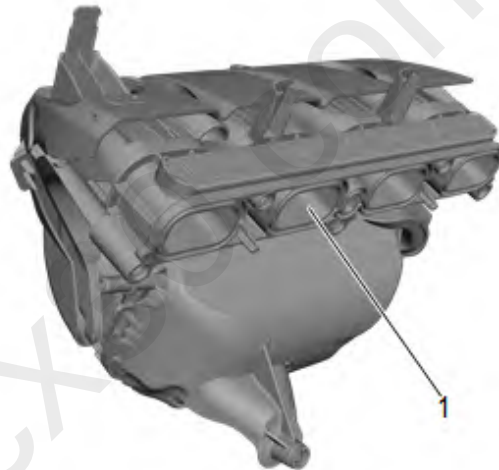


Fig. 469: Crankcase Ventilation Passages

Courtesy of GENERAL MOTORS COMPANY

4. Inspect the crankcase ventilation passages (1) in the intake manifold face for blockage.

WARNING: Refer to [Safety Glasses Warning](#) .

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

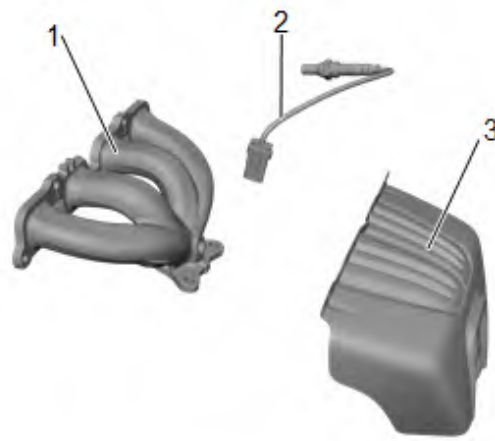


Fig. 470: Exhaust Manifold, Oxygen Sensor And Heat Shield

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.
- Remove the oxygen sensor prior to cleaning the manifold. Do not submerge the oxygen sensor in cleaning solvent.

1. Remove the oxygen sensor (2) from the manifold.
2. Clean the exhaust manifold (1) in solvent.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the exhaust manifold with compressed air.
4. Inspect the exhaust manifold (1) for damage.
5. Inspect the heat shield (3) for damage.

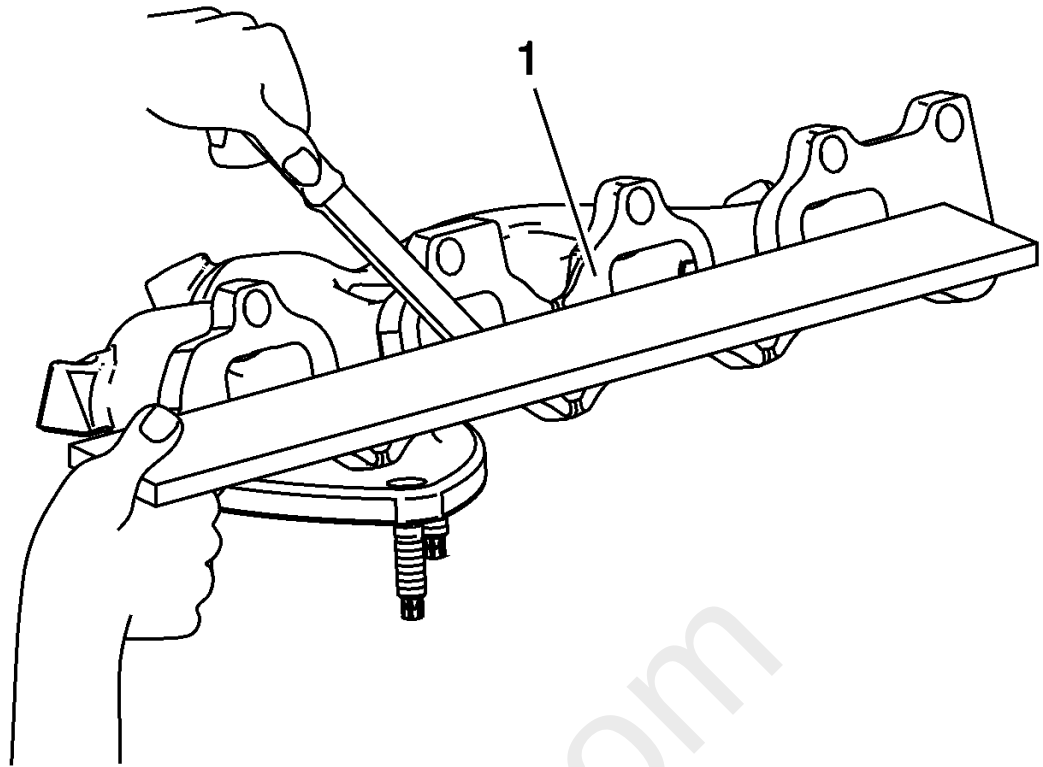


Fig. 471: Measuring Exhaust Manifold Mounting Face
 Courtesy of GENERAL MOTORS COMPANY

6. Use a straight edge and a feeler gauge and measure the exhaust manifold mounting face (1) for warpage.

An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

OIL PAN CLEANING AND INSPECTION

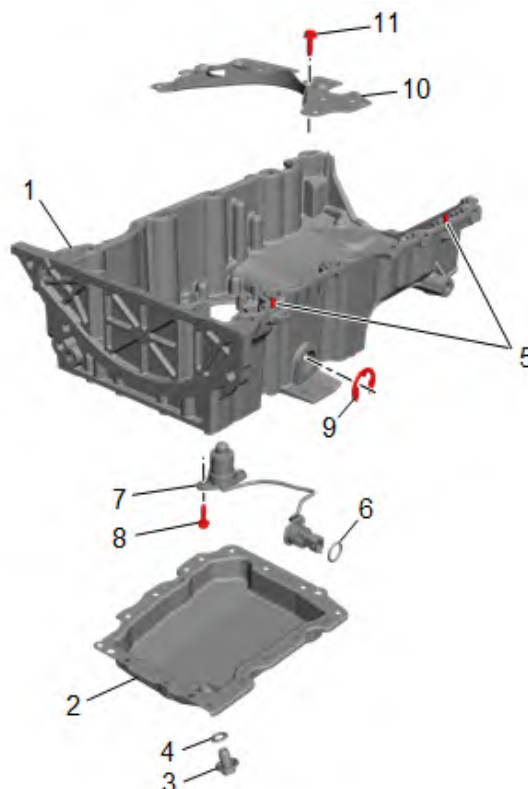


Fig. 472: Oil Pan Cleaning And Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 2. Thoroughly clean the oil pans and mating surfaces. Inspect each component, O-rings, and fasteners, and replace as necessary. 3. Remove all sludge and oil deposits. 4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points. 5. Inspect the oil pan for cracking resulting from impact or flying road debris.	
1	Upper Oil Pan NOTE: Component may vary depending on model.
2	Lower Oil Pan NOTE: Component may vary depending on model.
3	Engine Oil Drain Plug
4	Engine Oil Drain Plug Washer NOTE: It is only necessary to replace the washer if inspection indicates damage is present.
5	Oil Pan Locating Pins NOTE: It is not necessary to remove the locating pins unless the inspection indicates replacement.
6	Engine Oil Level Indicator Switch O-ring Seal
7	Engine Oil Level Indicator Switch
8	Engine Oil Level Indicator Switch Bolt CAUTION: Refer to <u>Fastener Caution</u> . tighten 10 N.m (89 lb in)
9	Engine Oil Level Indicator Switch Connector Retainer
10	Oil Pan Baffle
11	Oil Pan Baffle Bolt tighten 10 N.m (89 lb in)

THREAD REPAIR

Special Tools

- EN 42385 - 700 High Feature Thread Repair Kit
- EN 42385 - 850 Thread Repair Kit

- EN 42385 - 880 Head Bolt Thread Repair Adapter Kit

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

General Thread Repair

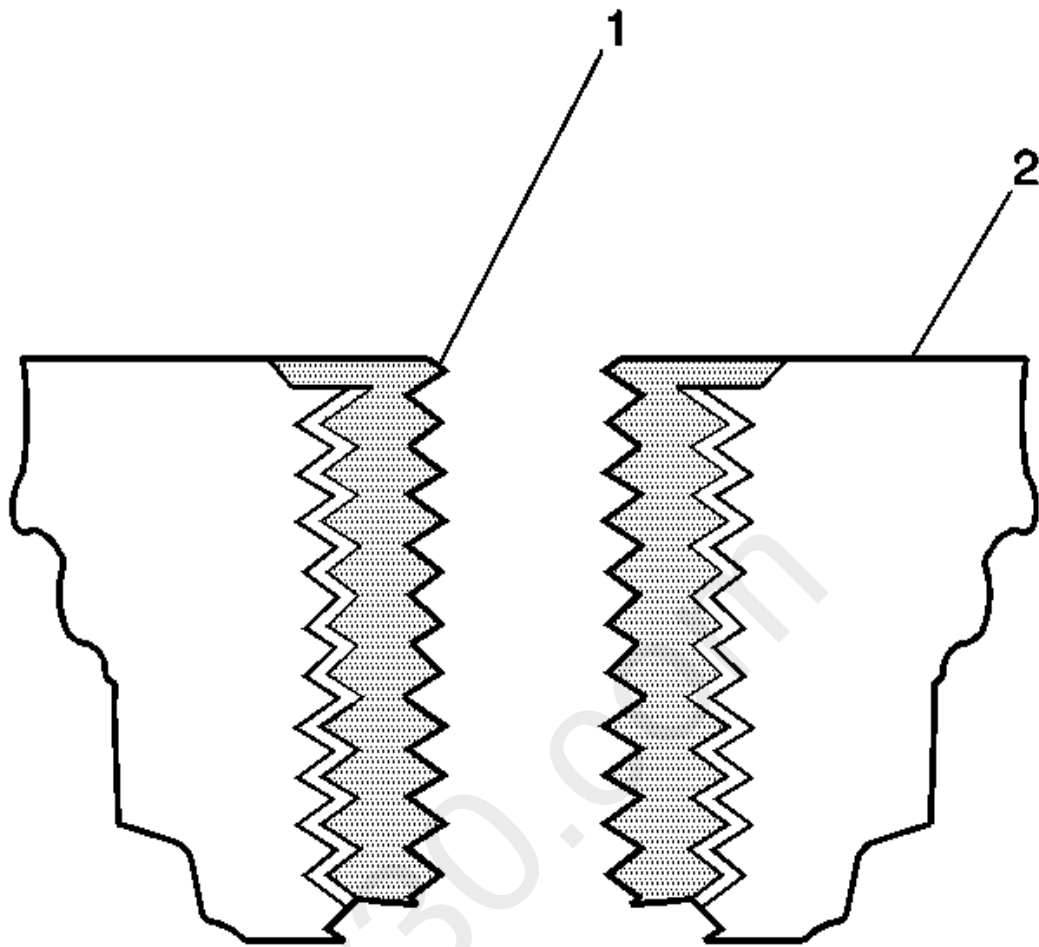


Fig. 473: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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.

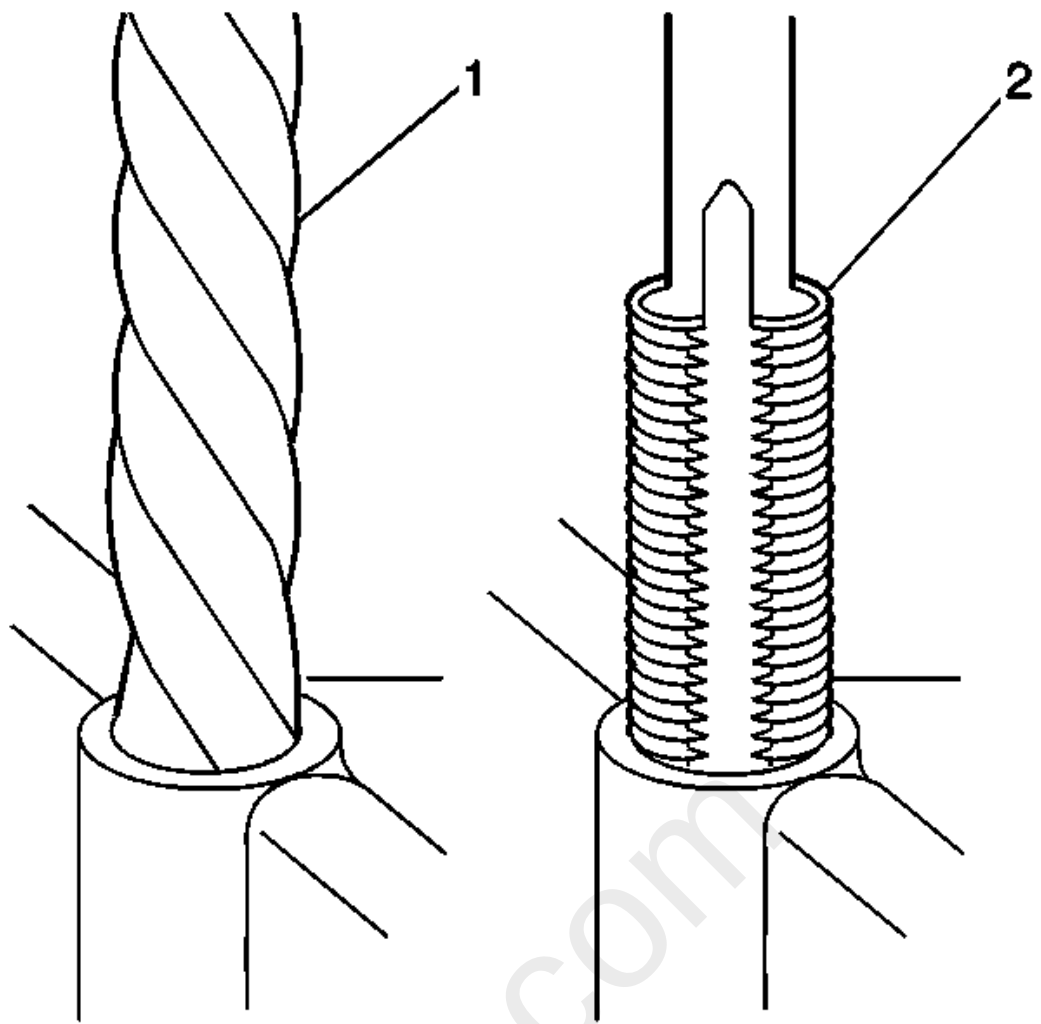


Fig. 474: Drilling & Tapping Threads

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.

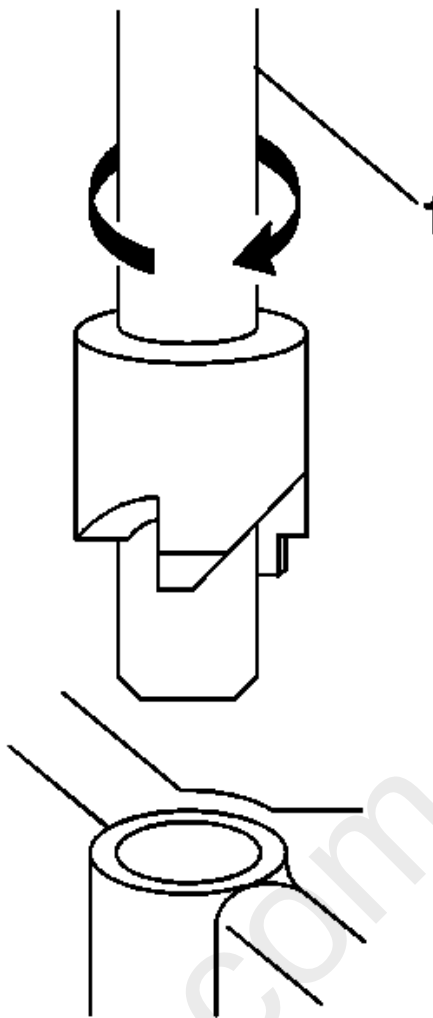


Fig. 475: Identifying Tool Used To Counterbore Hole
Courtesy of GENERAL MOTORS COMPANY

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

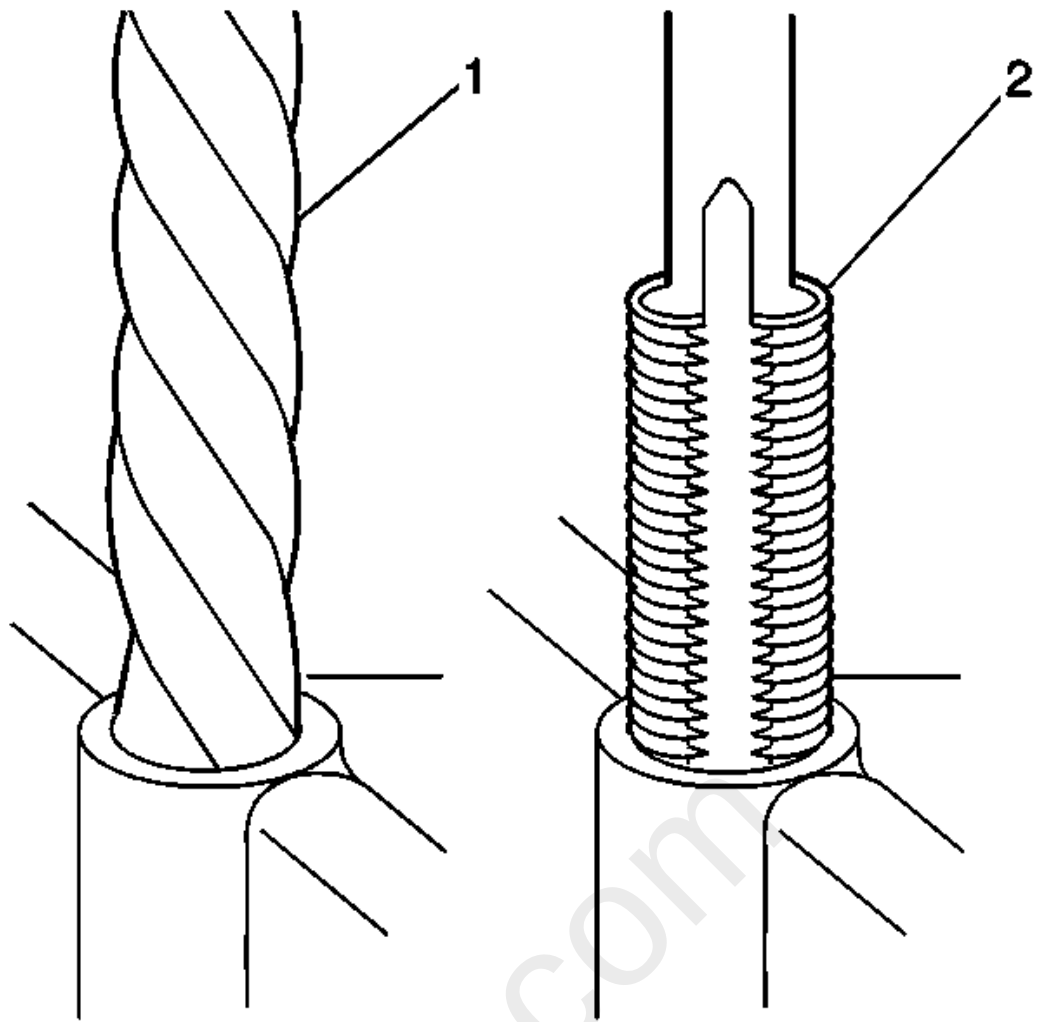


Fig. 476: Drilling & Tapping Threads

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.

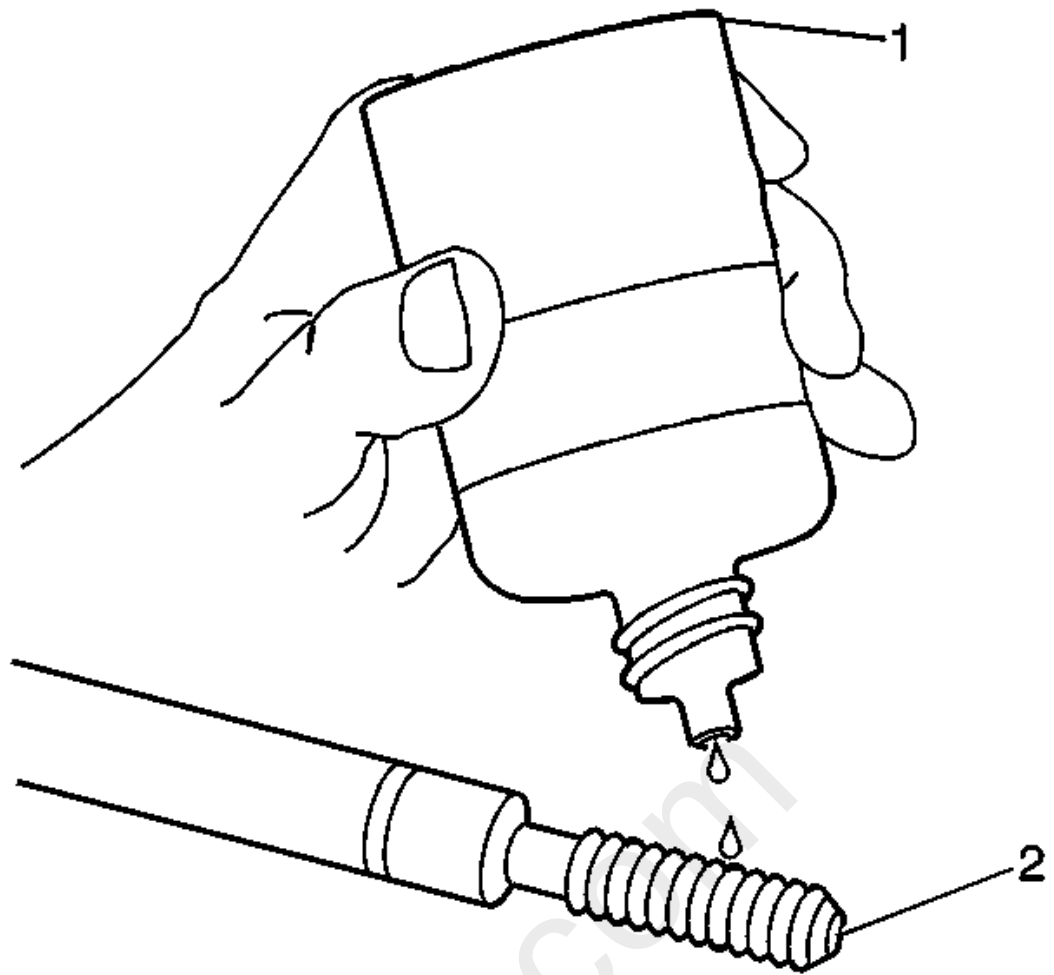


Fig. 477: Lubricating Installer Tool Using Driver Oil

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).

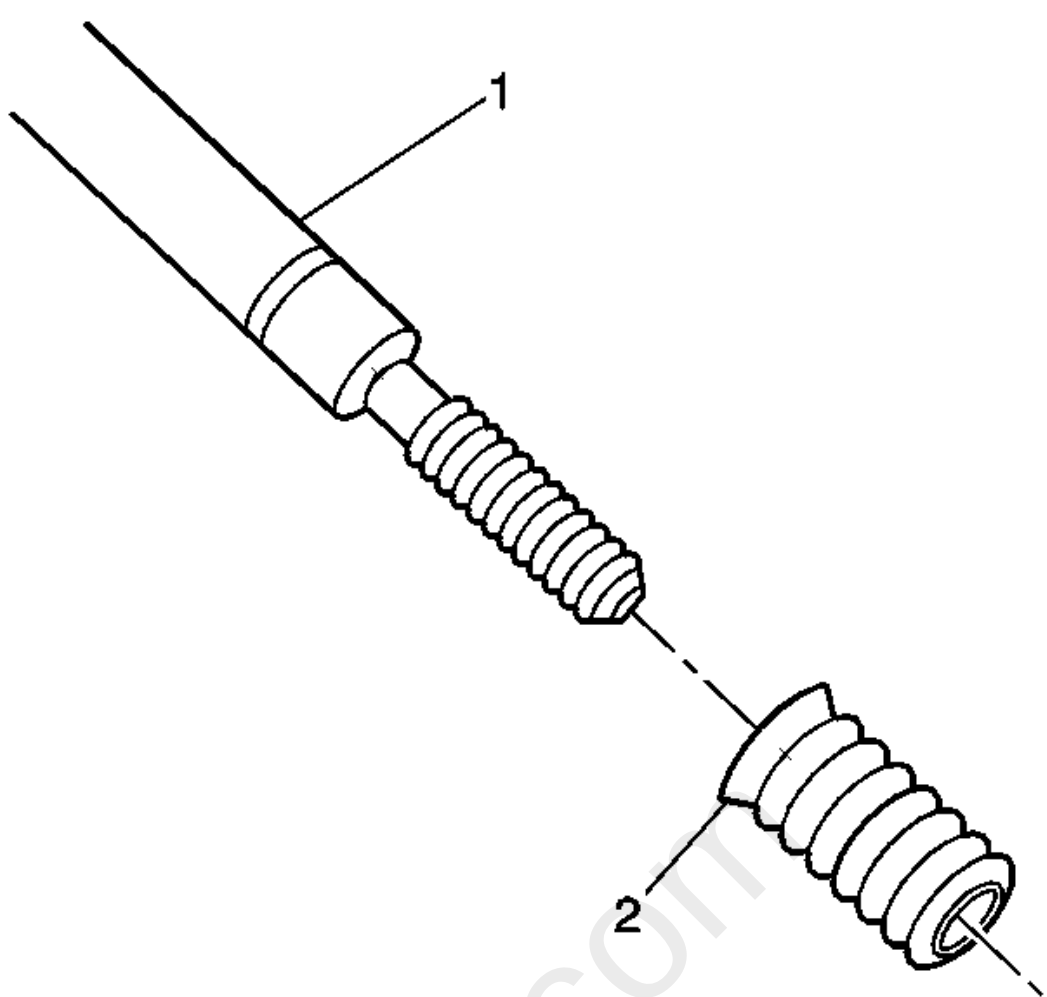


Fig. 478: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

10. Install the insert (2) onto the driver tool (1).

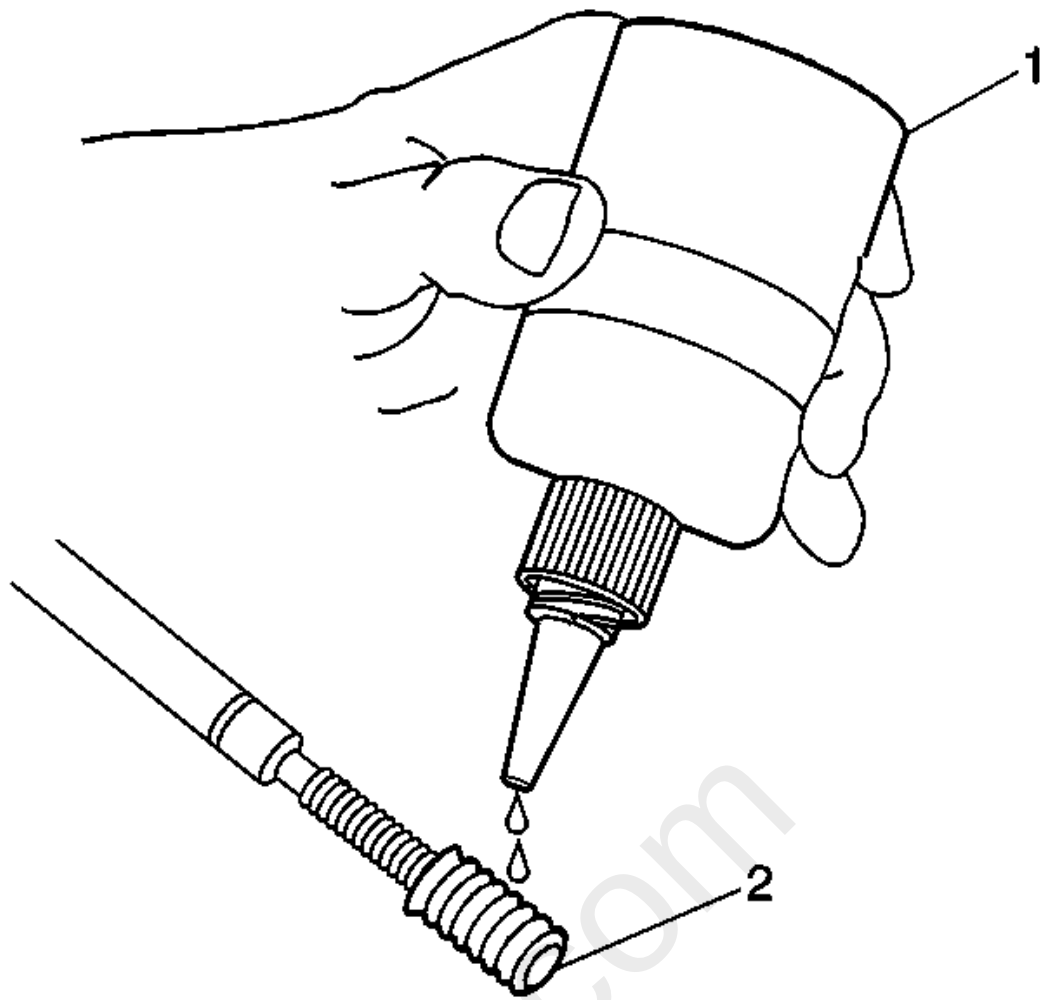


Fig. 479: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock LOCTITE™ 277, EN 42385 - 109 (1) loctite, or equivalent to the insert OD threads (2).

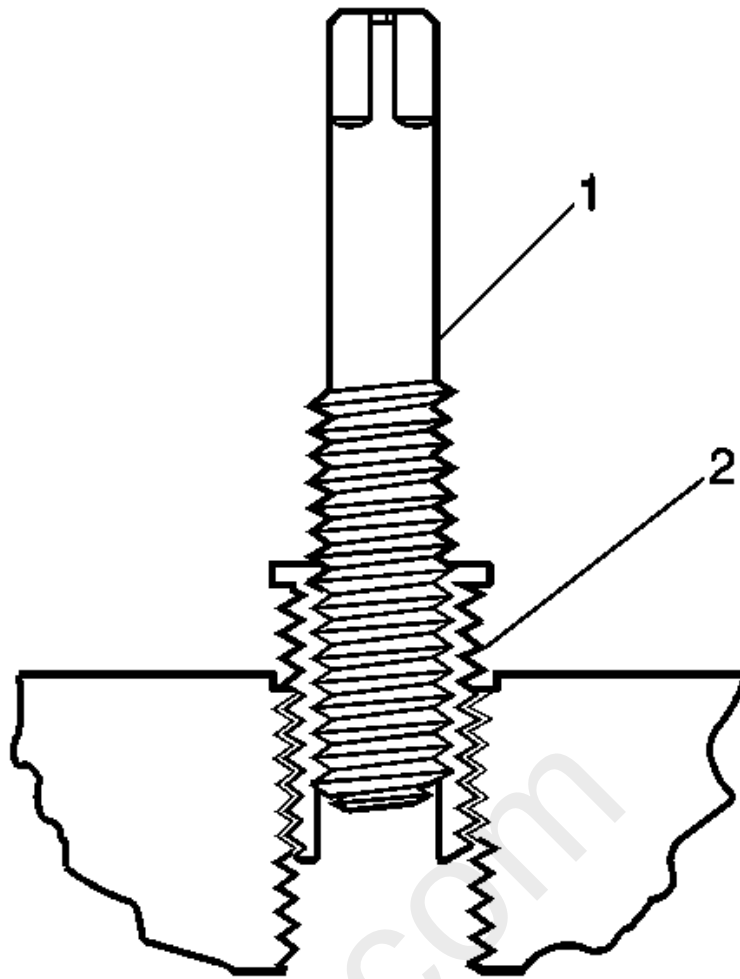


Fig. 480: View Of Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

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.

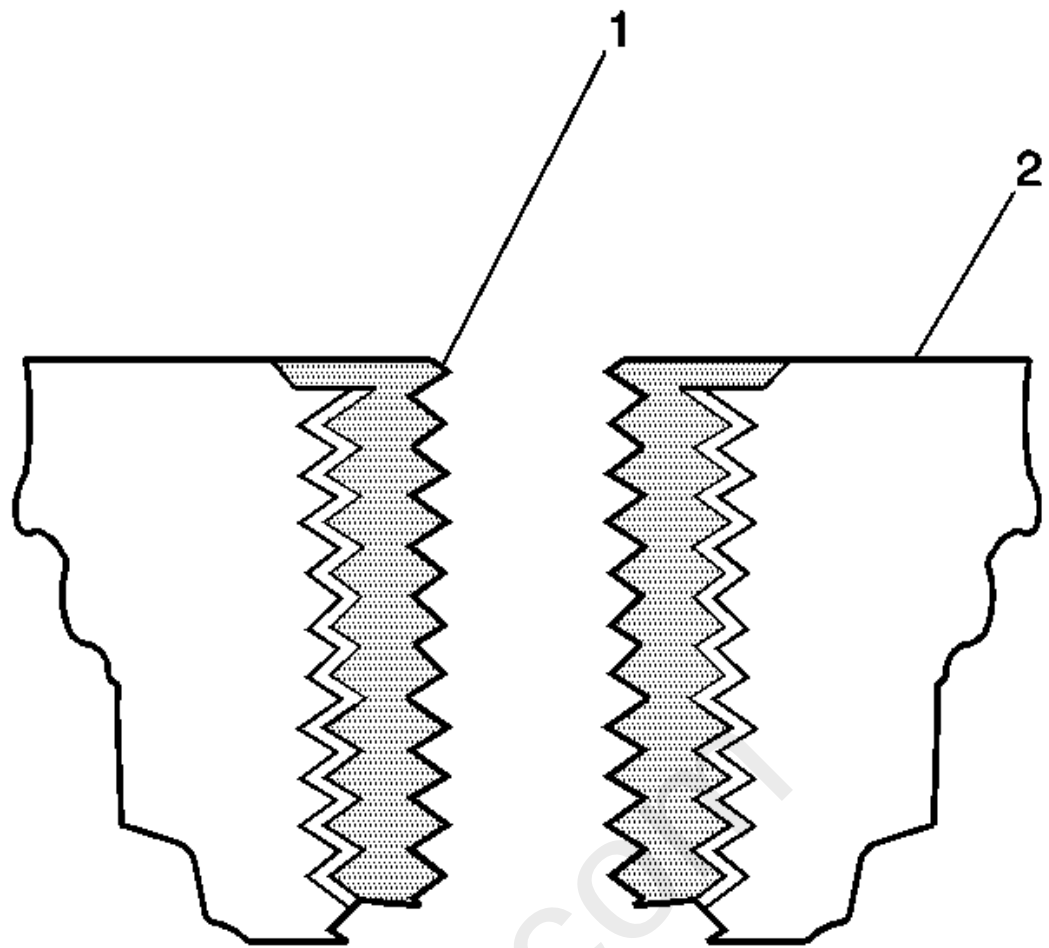


Fig. 481: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS COMPANY

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

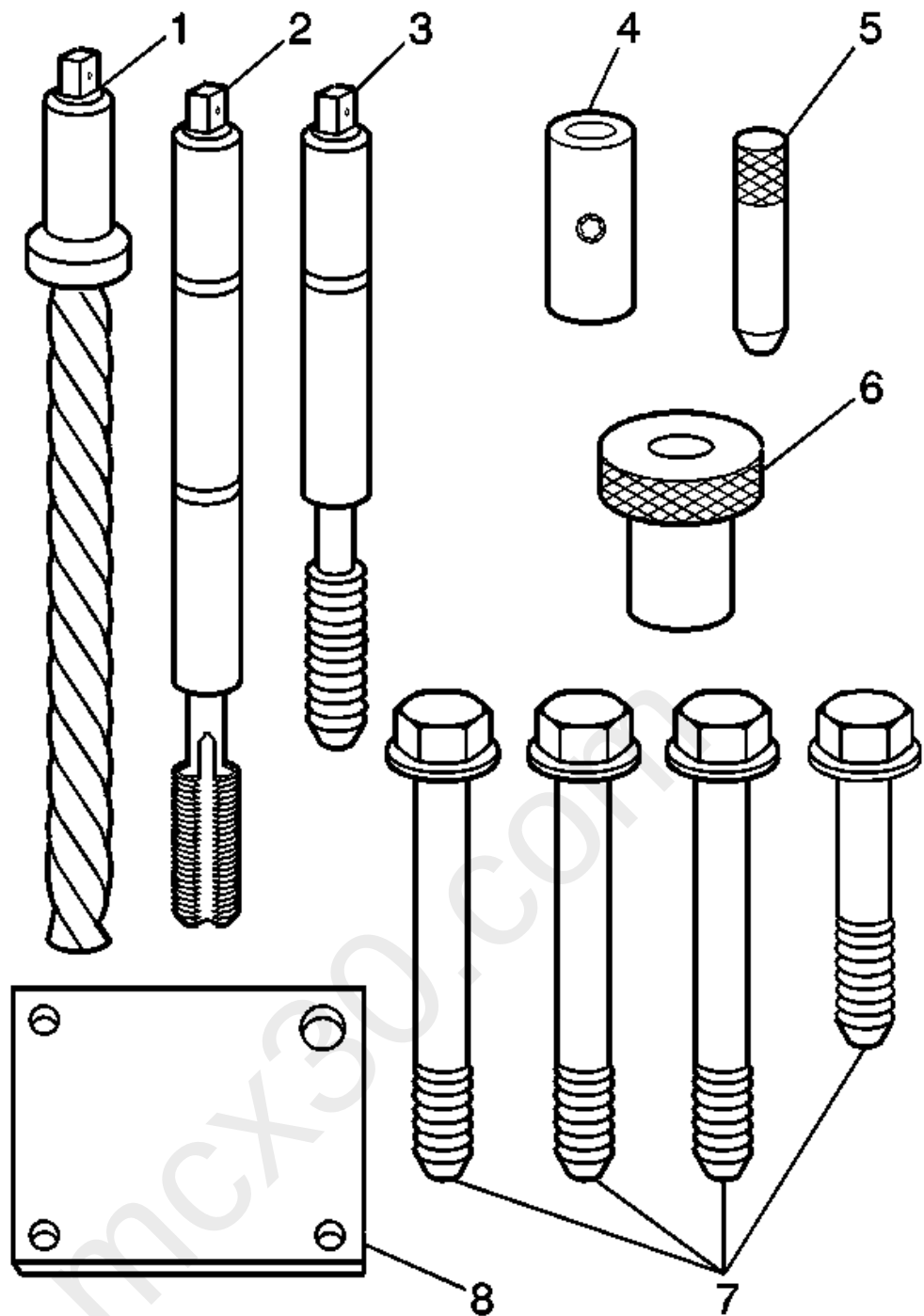


Fig. 482: Identifying Thread Repair Kit Components

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)

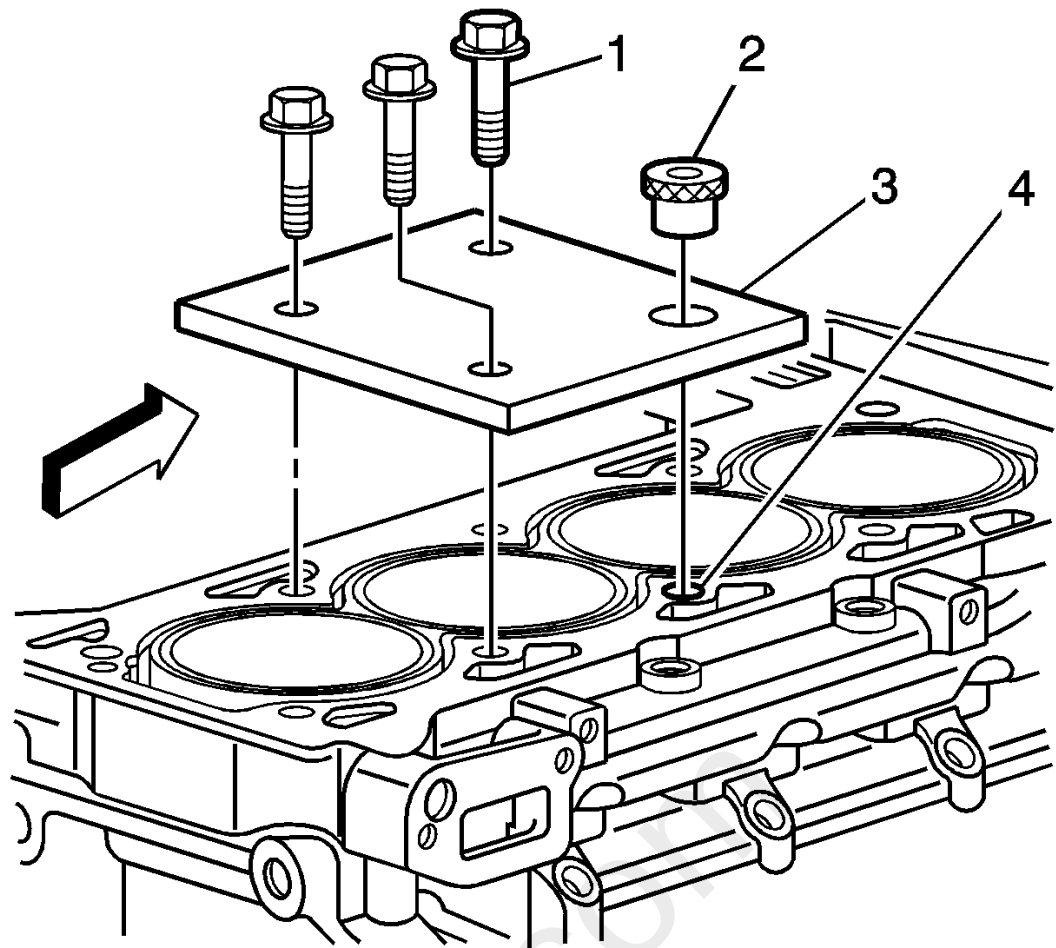


Fig. 483: Identifying Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS COMPANY

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).

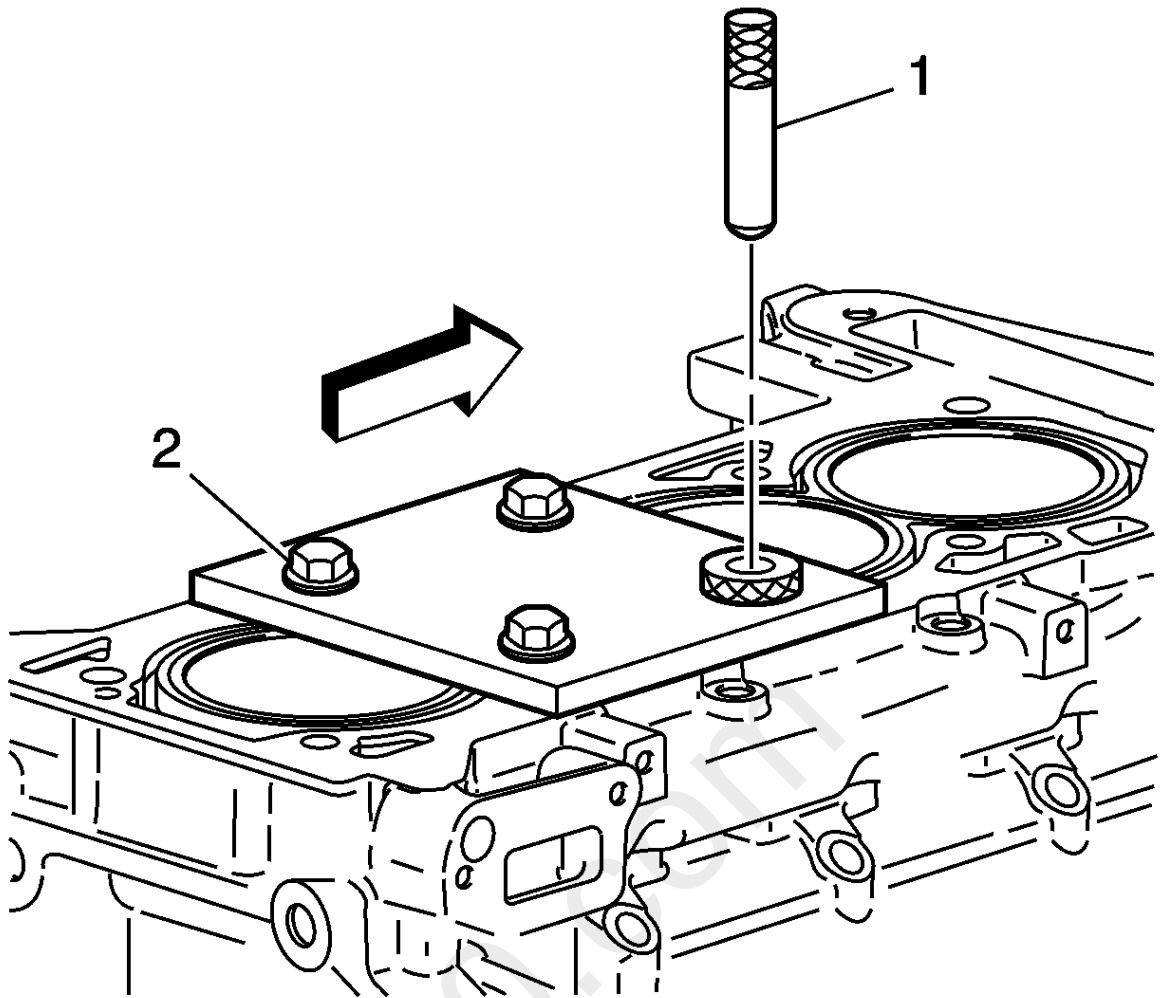


Fig. 484: Identifying Alignment Pin

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.

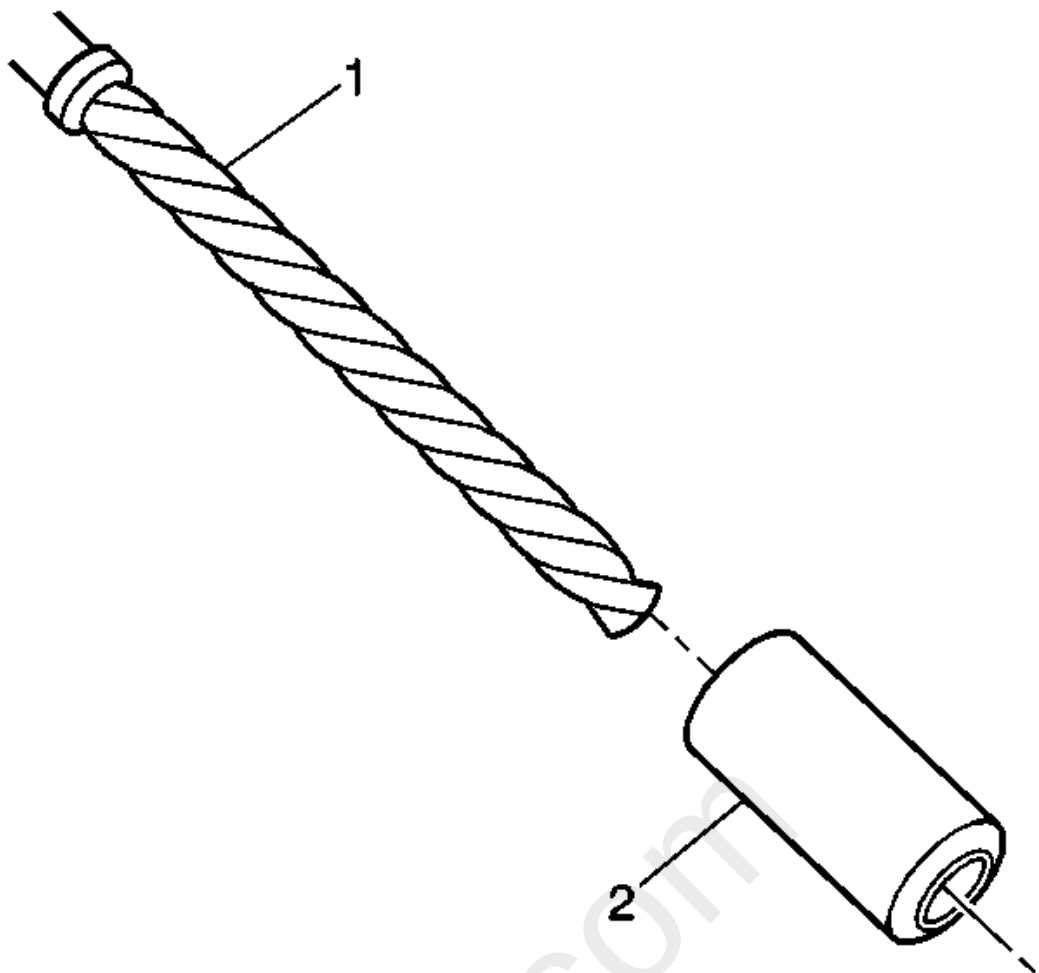


Fig. 485: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

6. Install the sleeve (2) onto the drill (1), if required.

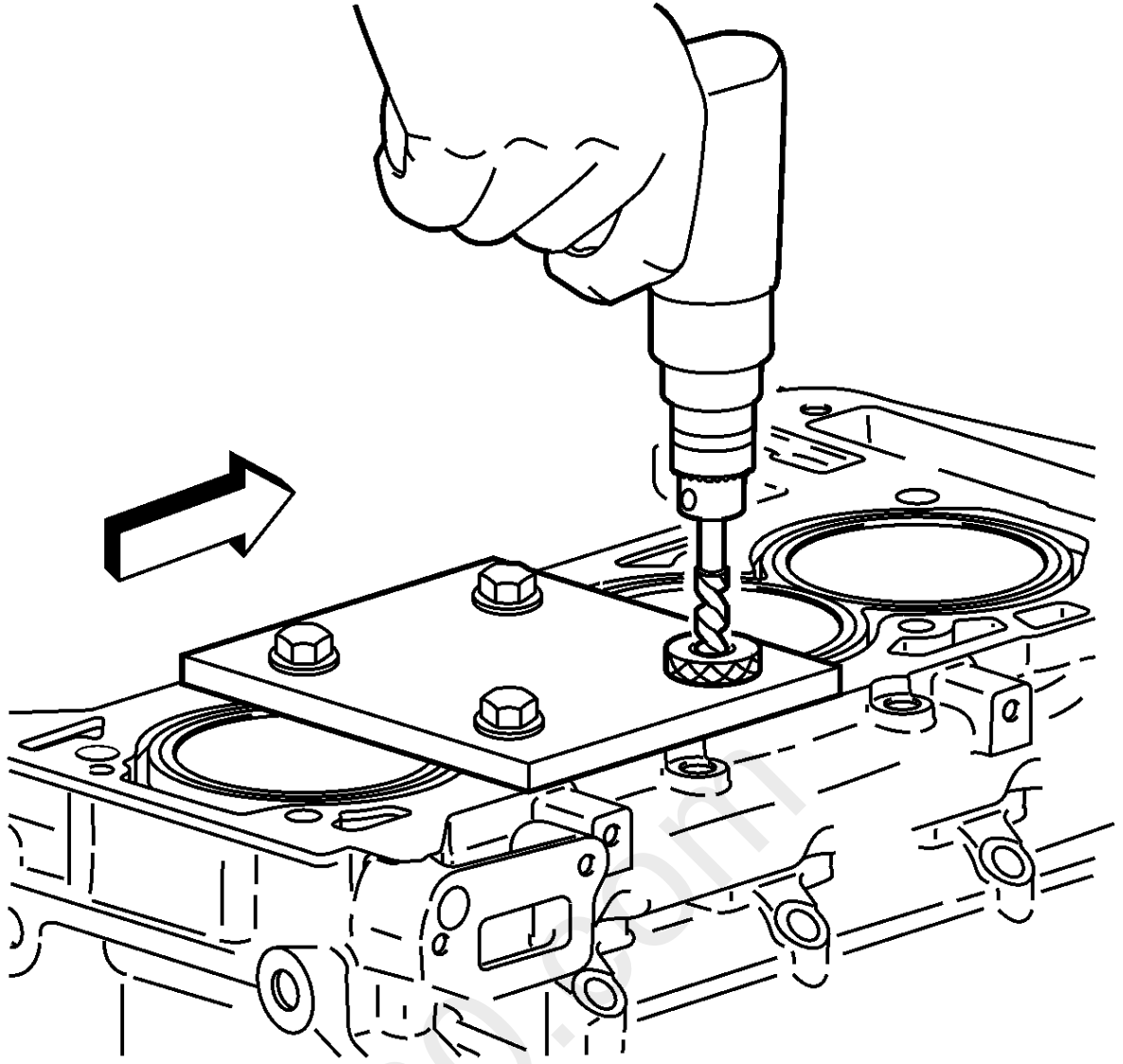


Fig. 486: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS COMPANY

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.

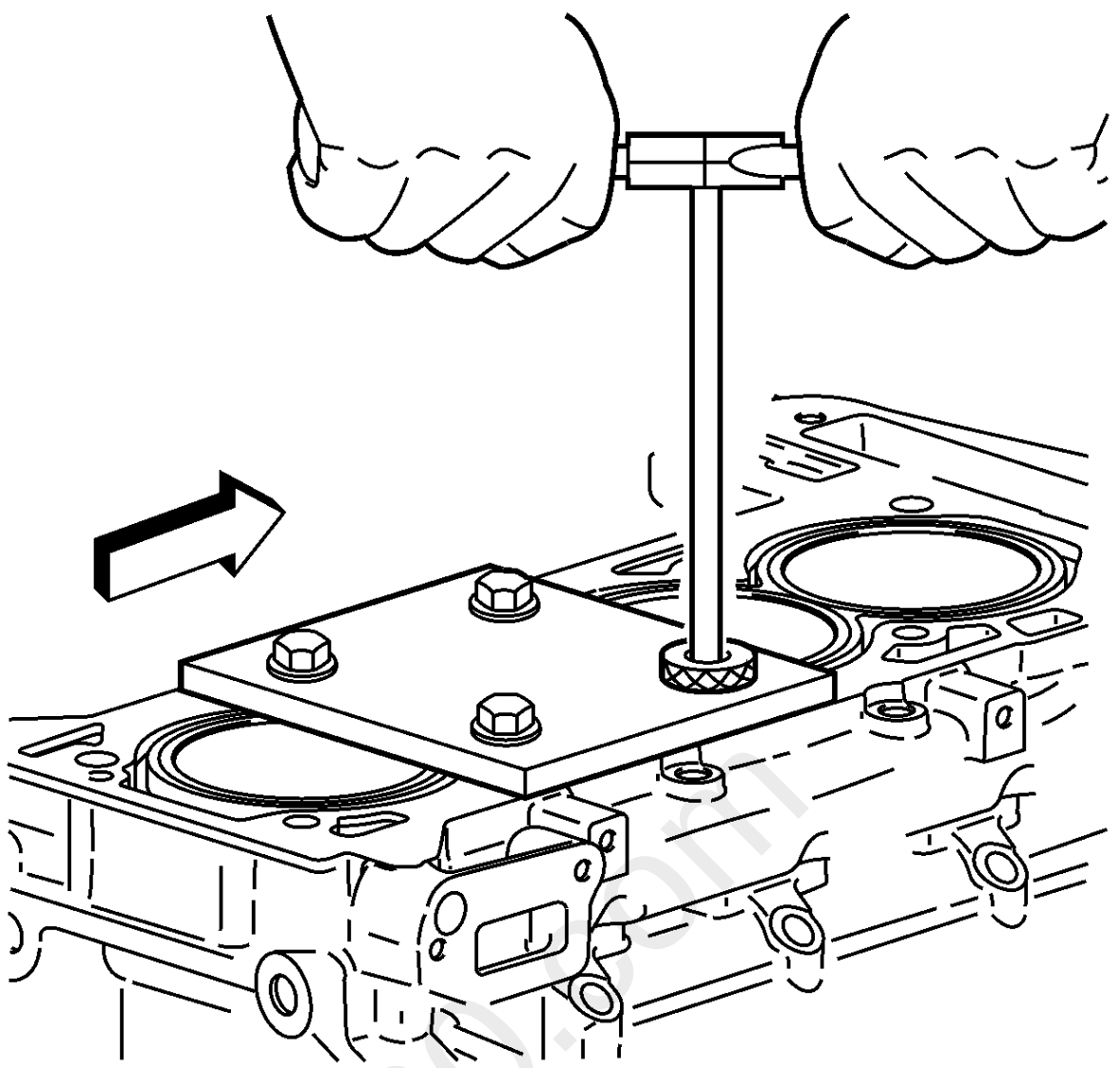


Fig. 487: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS COMPANY

9. Using a tap wrench, tap the threads of the drilled hole.

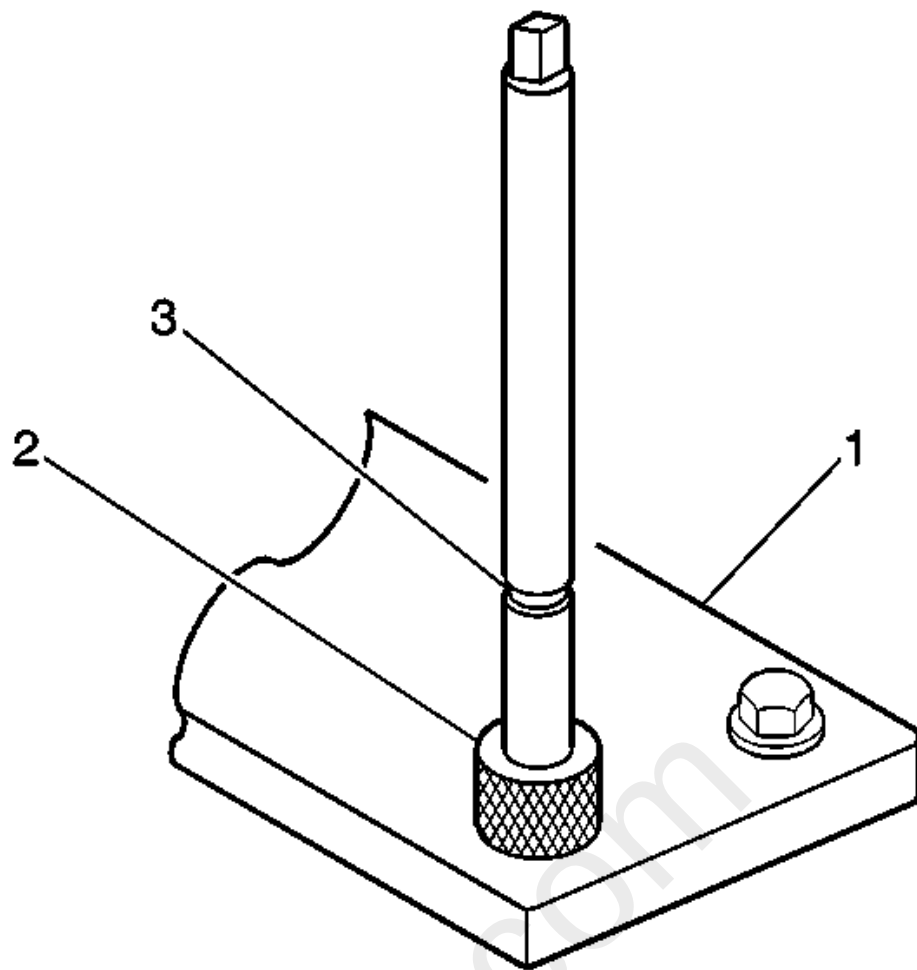


Fig. 488: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS COMPANY

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.

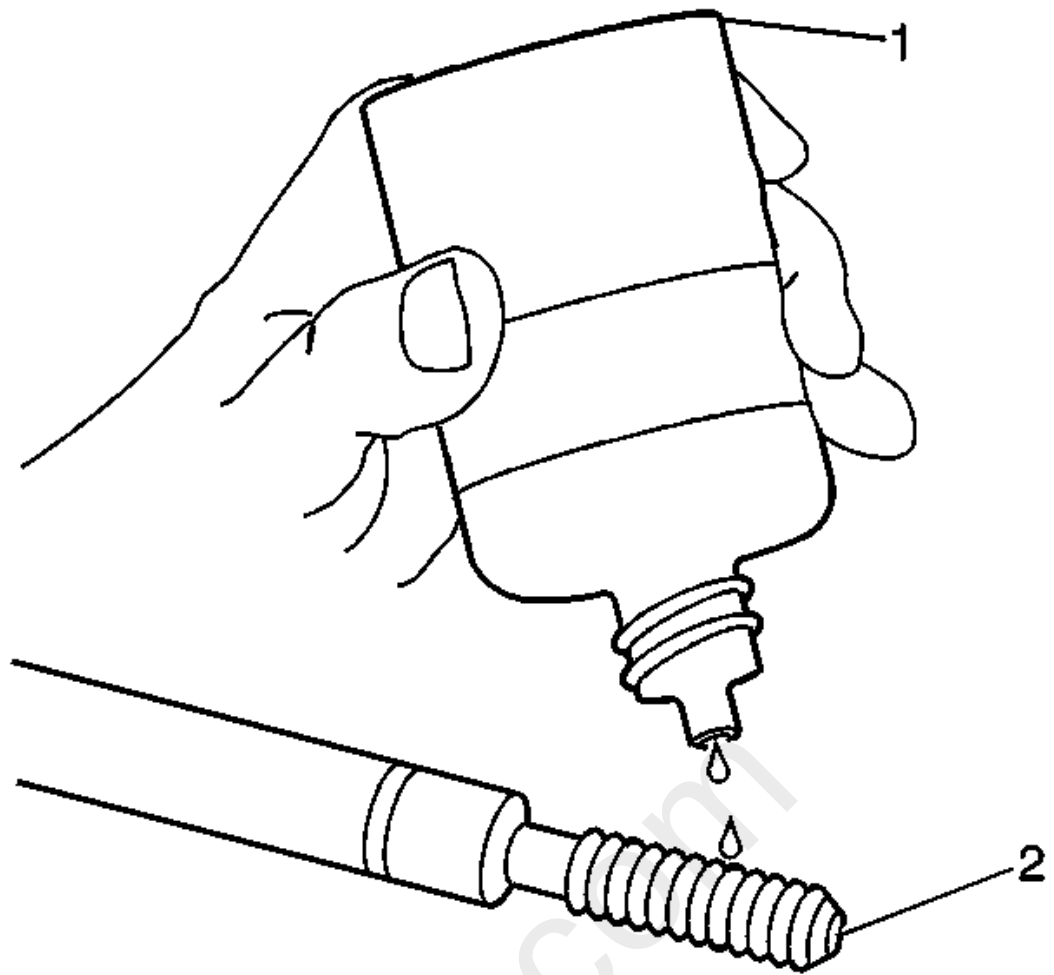


Fig. 489: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

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).

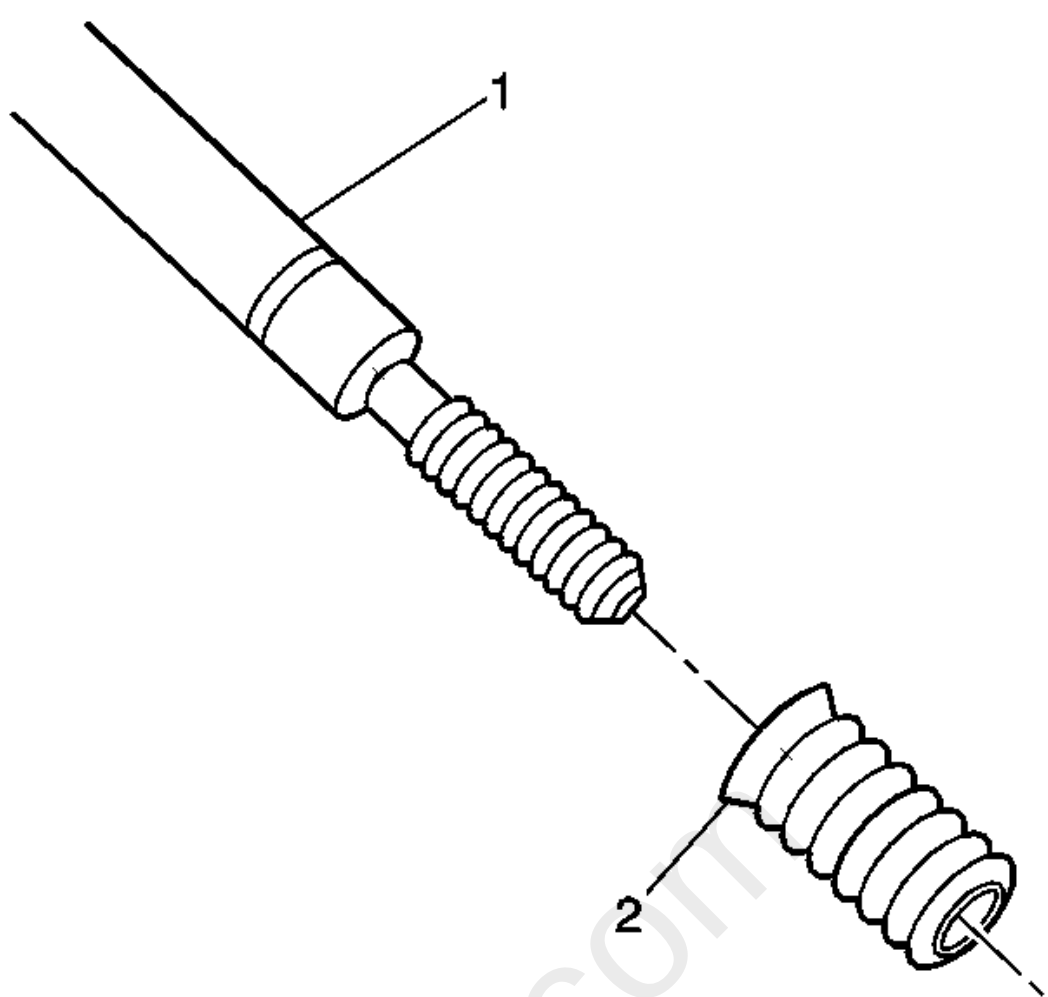


Fig. 490: View of Bushing Type Insert
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert (2) onto the driver tool (1).

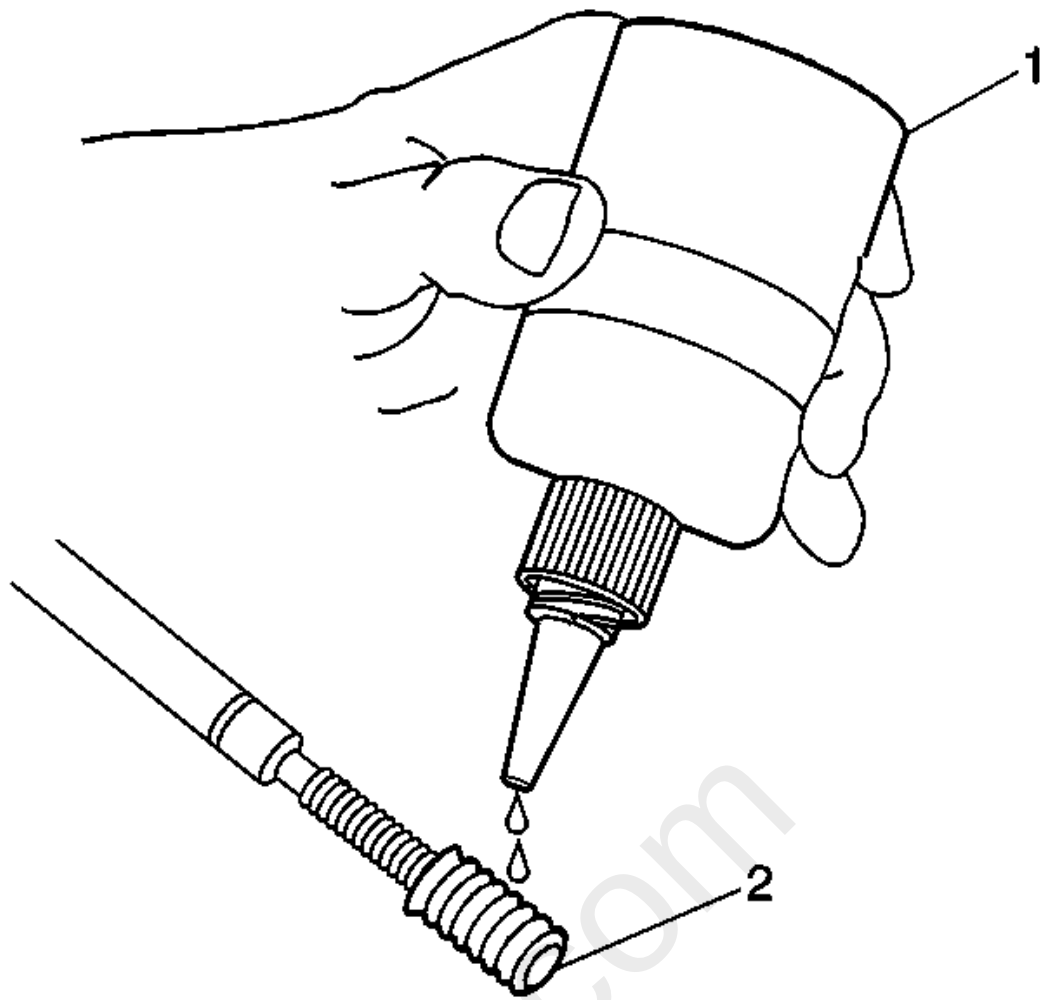


Fig. 491: Applying Threadlock To Insert

Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock LOCTITE™ 277, EN 42385 - 109 loctite (1), or equivalent to the insert OD threads (2).

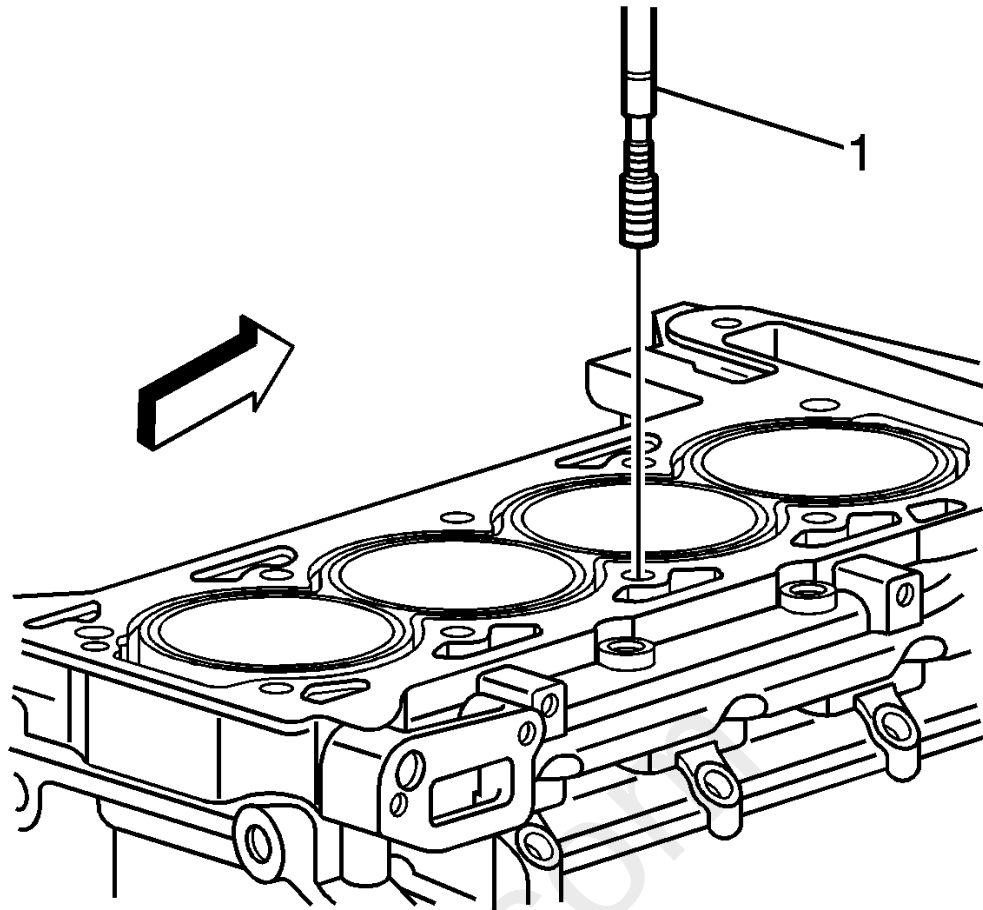


Fig. 492: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS COMPANY

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.

ENGINE BLOCK ASSEMBLE

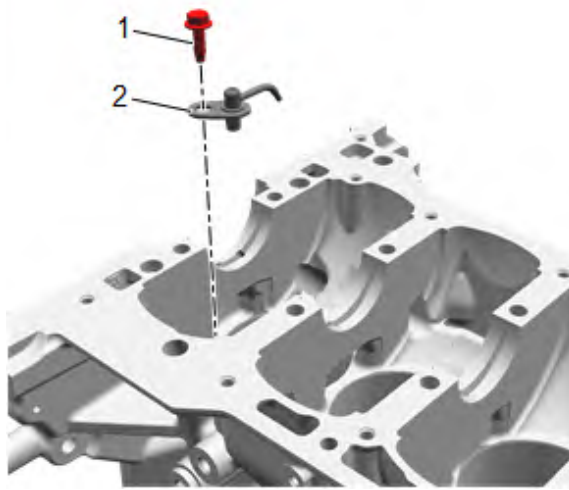


Fig. 493: Piston Oil Nozzle Assembly Bolt
Courtesy of GENERAL MOTORS COMPANY

1. Install the piston oil nozzle assemblies (2), if equipped.

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

2. Install the piston oil nozzle bolts (1) and tighten to 10 N.m (89 lb in).

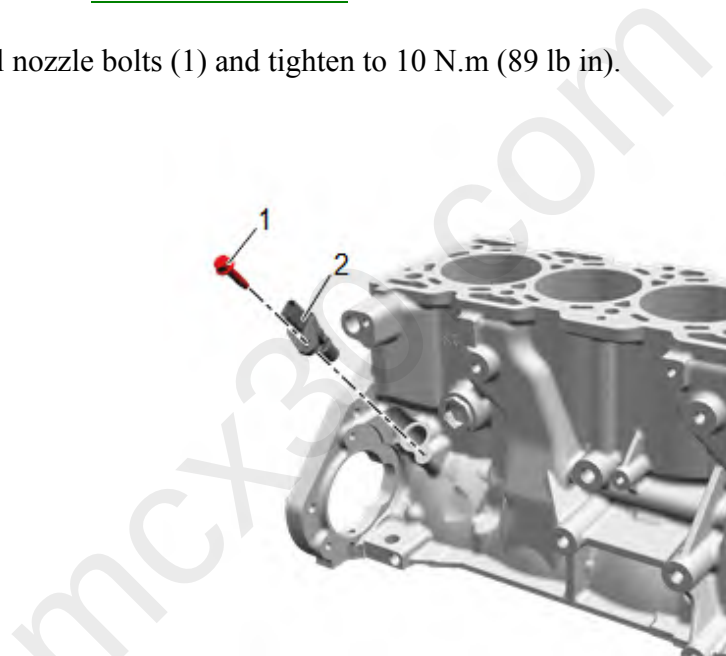


Fig. 494: Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS COMPANY

3. Lubricate the crankshaft position sensor O-ring with engine oil. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

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

4. Install the crankshaft position sensor (2) and bolt (1) and tighten to 10 N.m (89 lb in).

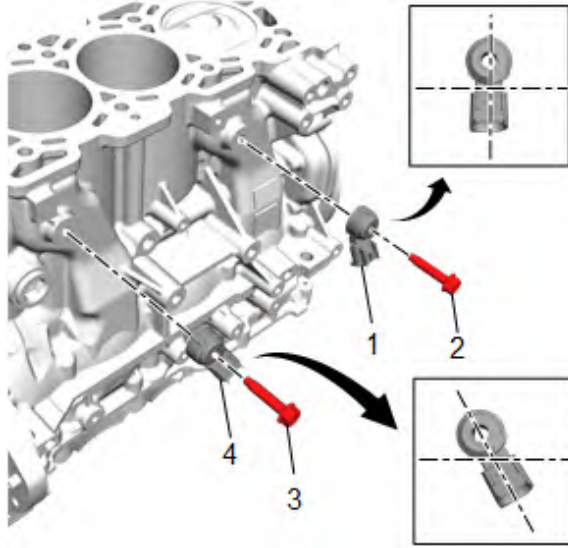


Fig. 495: Knock Sensors And Bolts

Courtesy of GENERAL MOTORS COMPANY

5. Install the knock sensor (1) at 6 O' clock. Install the bolt (2) and tighten to 25 N.m (18 lb ft).
6. Install the knock sensor (4) at 5 O' clock. Install the bolt (3) and tighten to 25 N.m (18 lb ft).

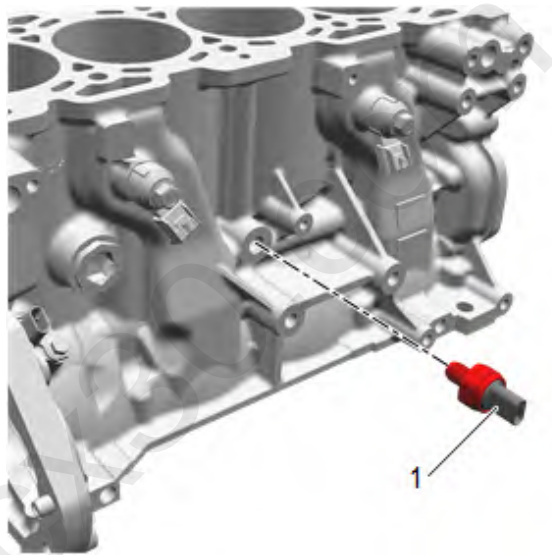


Fig. 496: Engine Oil Pressure Sensor

Courtesy of GENERAL MOTORS COMPANY

7. Install the engine oil pressure sensor (1) and tighten to 35 N.m (26 lb ft).

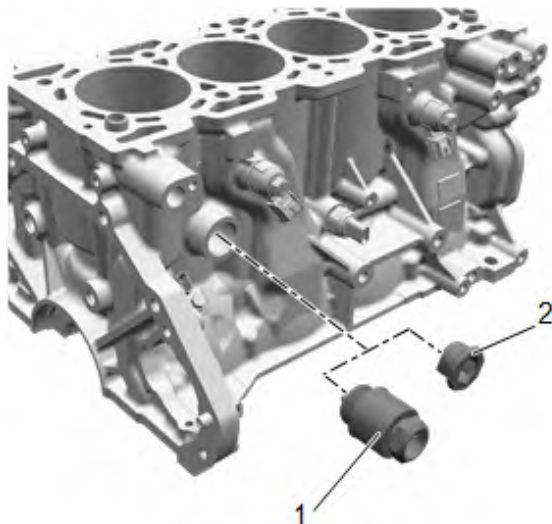


Fig. 497: Engine Coolant Heater

Courtesy of GENERAL MOTORS COMPANY

8. Install the engine coolant heater assembly (1), if equipped. tighten the assembly to 50 N.m (37 lb ft).
9. If the engine coolant heater assembly is not equipped, install the engine coolant heater hole plug (2). tighten the plug to 60 N.m (44 lb ft).

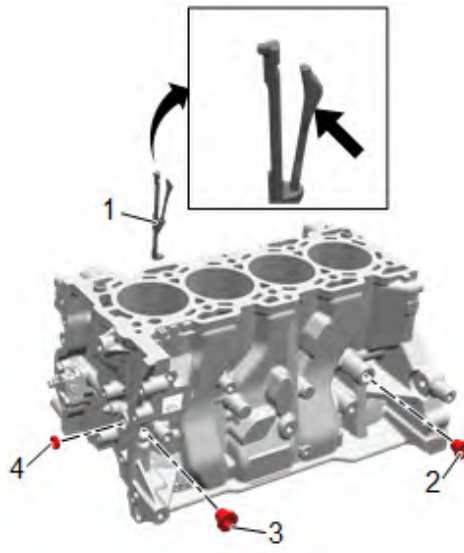


Fig. 498: Engine Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

10. Apply sealant to all plugs prior to installation. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
11. Install the engine oil gallery cup plug (4).
12. Install the engine oil gallery plugs (2, 3), with sealant, and tighten to 65 N.m (48 lb ft).

NOTE: Always install the baffle with the forked end pointed up. Do not force the baffle into place. Aligning the shape of the orifice and the baffle, and gently depressing the clip will allow the baffle to easily drop into place.

13. Carefully align and install the engine block coolant baffle (1).

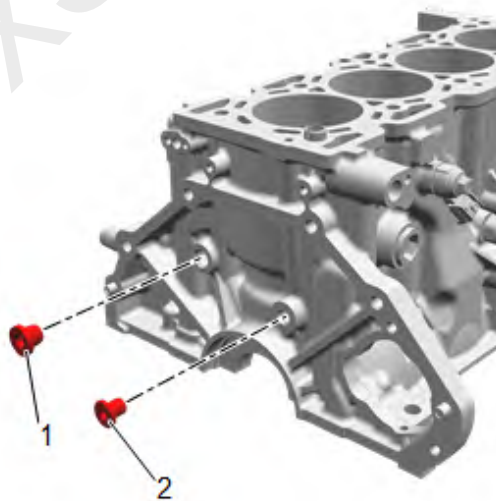


Fig. 499: Engine Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

14. Install the engine oil gallery plug (1), with sealant, and tighten to 65 N.m (48 lb ft).
15. Install the engine oil gallery plug (2), with sealant, and tighten to 40 N.m (30 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- EN-8087 Cylinder Bore Checking Gauge
- EN 45059 Angle Meter

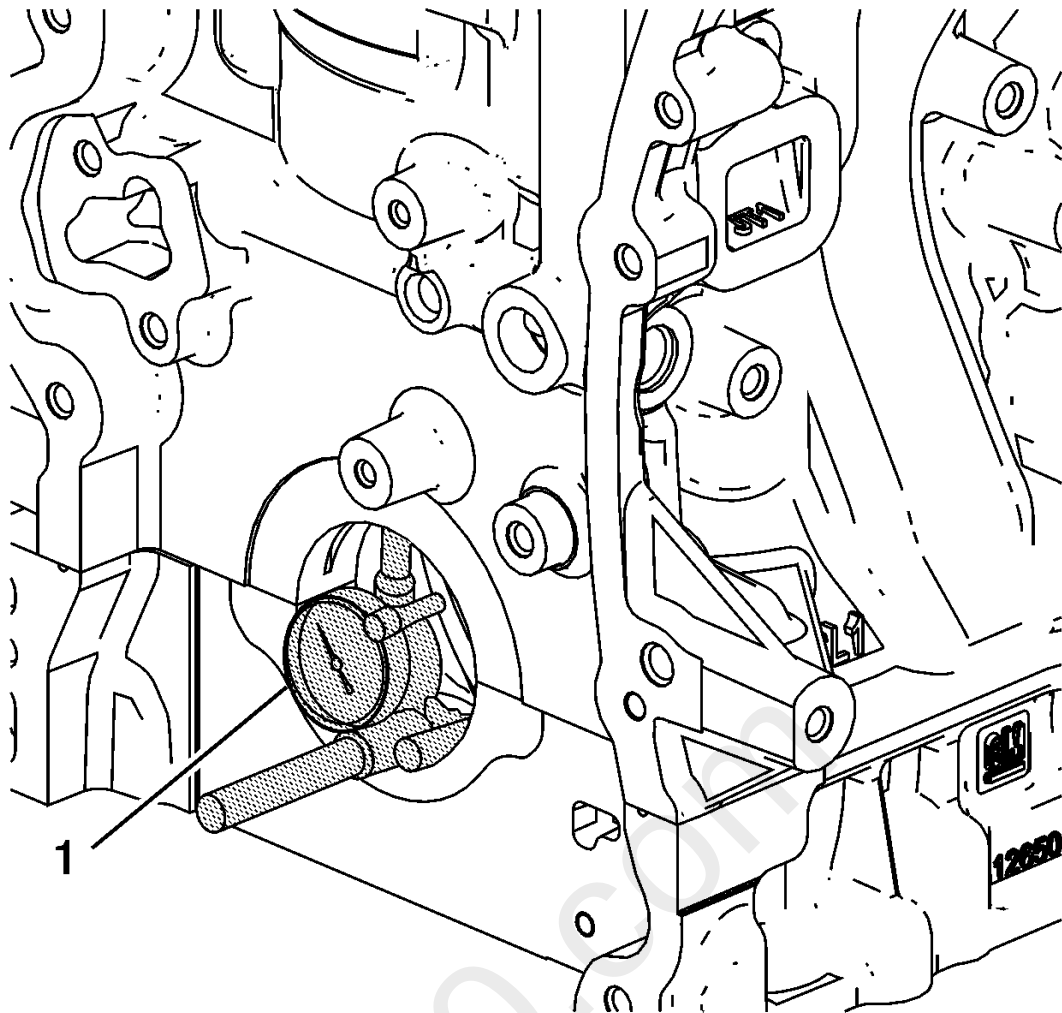


Fig. 500: View Of Cylinder Bore Gauge

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.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- tighten the bedplate to specification using the **EN 45059** meter.
- Measure the bearing bore for taper and out-of-round using the **EN-8087** gauge (1).
- No taper or out-of-round should exist.

Bearing Selection

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are two 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.

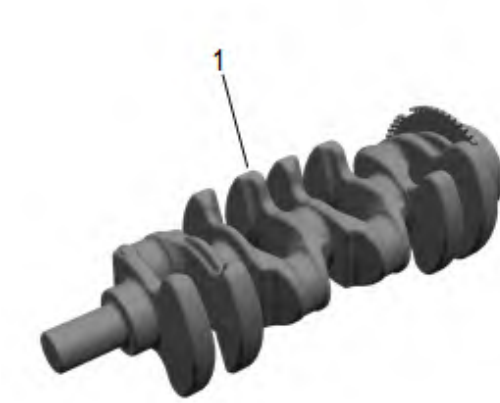


Fig. 501: Measuring Bearing Clearance Using Method A

Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not mix inserts of different nominal size in the same bearing bore.**

2. To measure bearing clearance for the crankshaft (1) using Method A, use the following procedure:
 1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
 2. Measure the crankshaft bearing journal taper and runout.
 3. Install the lower crankcase and tighten the bearing cap bolts to specification.
 4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
 5. Subtract journal measurement from bearing ID measurement to determine clearance.
 6. Determine whether clearance is within specification.
 7. If out of specification, choose different inserts.
 8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
 9. Measure the crankshaft main bearing inside diameter with an inside micrometer.

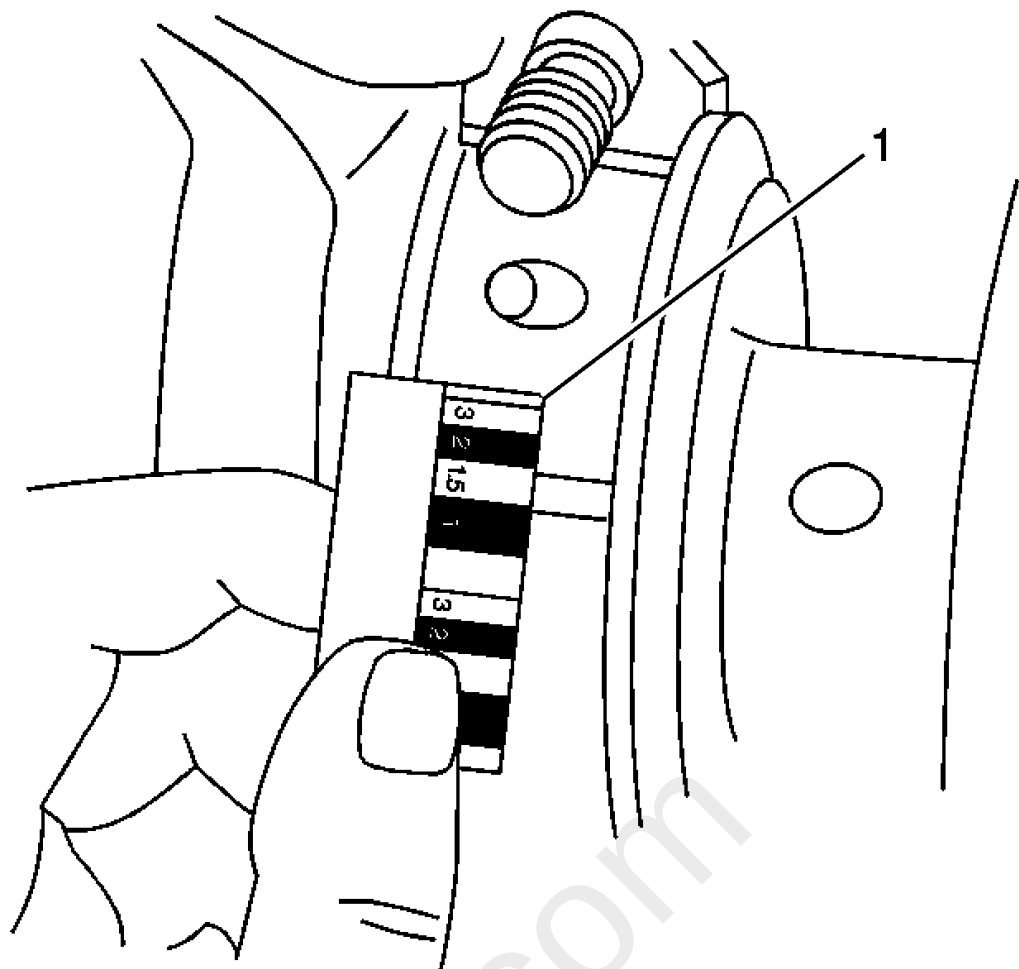


Fig. 502: Measuring Bearing Clearance Using Method B
Courtesy of GENERAL MOTORS COMPANY

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 gauging plastic across the entire bearing width at 90 degrees to block/lower crankcase split line.
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.

Crankshaft Installation

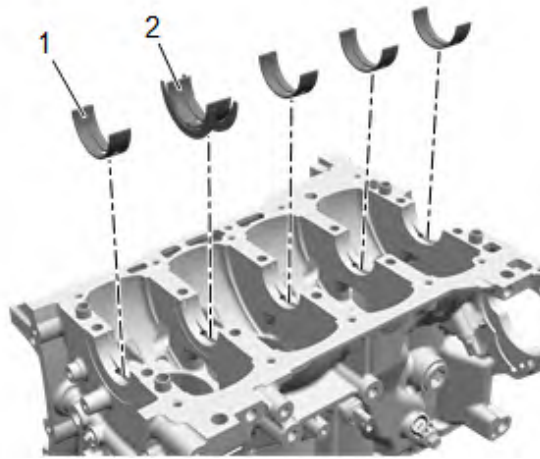


Fig. 503: Crankshaft Upper Bearings

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.

NOTE: If crankshaft bearing kit has a red bearing in it, install this in the front crankshaft bearing position, closest to the crankshaft balancer.

1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.
2. Install the crankshaft upper thrust bearing (2) and lubricate bearing surfaces with engine oil.



Fig. 504: Crankshaft

Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft (1) on the journals.

LOWER CRANKCASE INSTALLATION

Special Tools

- **EN 45059** Angle Meter
- **EN-51380** Seal Installer

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

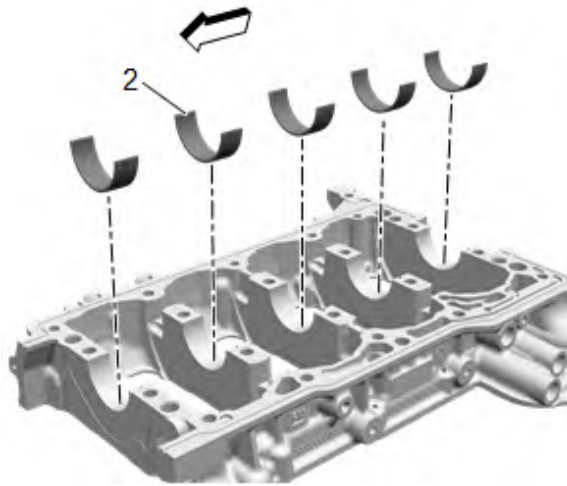


Fig. 505: Crankshaft Lower Bearings

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.

1. Install the lower bearing halves (2), without grooves, into the lower crankcase (1). Apply oil to bearing surfaces.

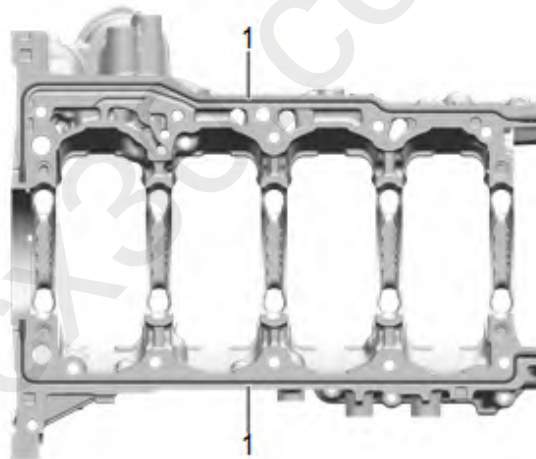


Fig. 506: Applying Bead Of Sealer Directly In Groove

Courtesy of GENERAL MOTORS COMPANY

2. 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.

3. Apply a 4.25 mm bead of sealer directly in the groove (1) of the block to bedplate mating surfaces. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

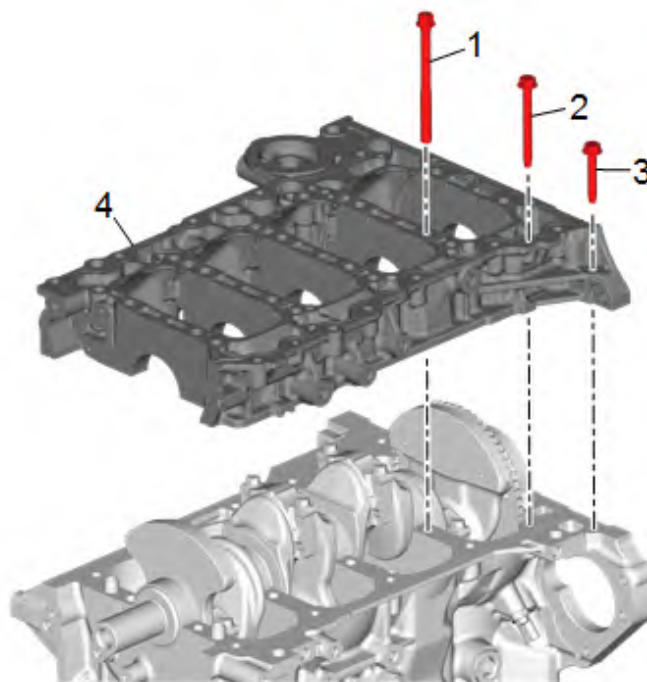


Fig. 507: Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Install the lower crankcase (4). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

5. Install the NEW M10 x 2.00 x 116 lower crankcase bolts (1) at the inner bolt locations finger tight.
6. Install the single M8 x 1.25 x 50 lower crankcase bolt (3) finger tight.
7. Install the M8 x 1.25 x 80 lower crankcase bolts (2) at the crankcase perimeter finger tight.

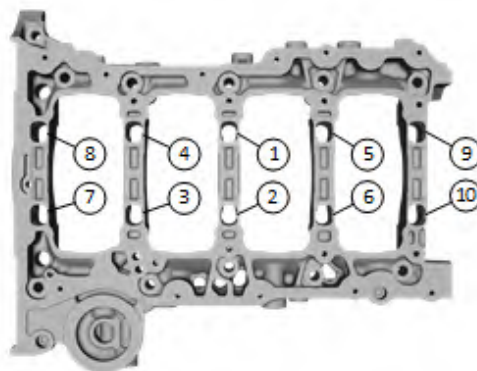


Fig. 508: Crankshaft Bearing Bolts tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

8. tighten the NEW M10 x 2.00 x 116 lower crankcase bolts in sequence using the following procedure:
 1. tighten the lower crankcase bolts a first pass in sequence to 20 N.m (15 lb ft).
 2. tighten the lower crankcase bolts a final pass in sequence using the **EN 45059** meter an additional 140 degrees.

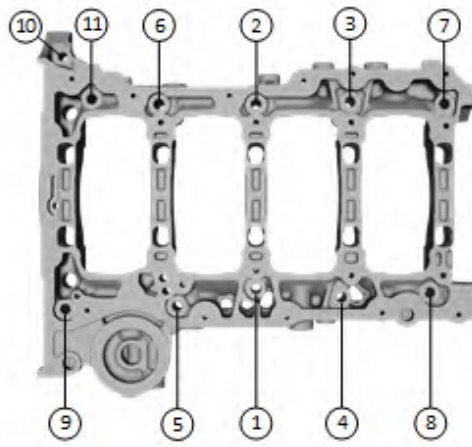


Fig. 509: Lower Crankcase Perimeter Bolts tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

9. tighten the lower crankcase bolts at the crankcase perimeter in sequence to 25 N.m (18 lb ft).

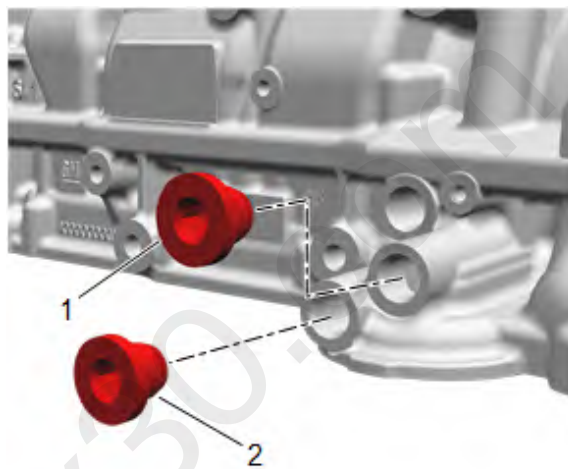


Fig. 510: Oil Gallery Plugs

Courtesy of GENERAL MOTORS COMPANY

10. Install the engine oil gallery plugs (1, 2). tighten the plugs to 65 N.m (48 lb ft).

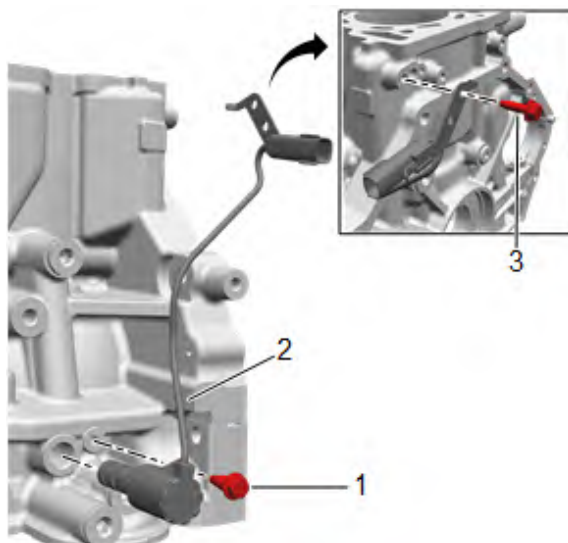


Fig. 511: Oil Pump Flow Control Valve And Bolts

Courtesy of GENERAL MOTORS COMPANY

11. Install the oil pump flow control valve (2) and bolts (1, 3). tighten the bolts to 10 N.m (89 lb in).

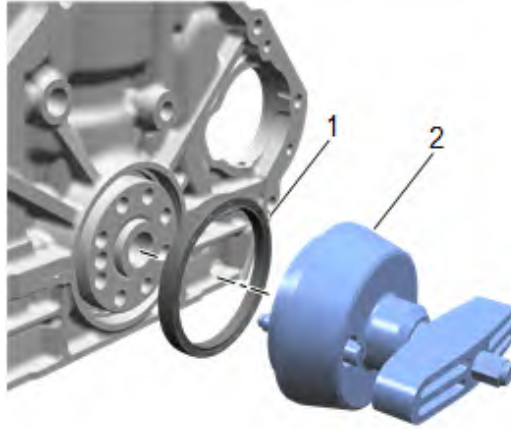


Fig. 512: Crankshaft Rear Oil Seal And Installer

Courtesy of GENERAL MOTORS COMPANY

12. Using **EN-51380** installer (2), install the crankshaft rear oil seal (1) flush or recessed up to 0.5 mm to block.
13. Rotate the crankshaft to ensure that it moves freely and does not bind.
14. Measure and record the crankshaft endplay. Refer to [Engine Mechanical Specifications](#).

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

NOTE: This procedure is not used in Europe.

Special Tools

- **EN-43953** Ring Compressor - 86 mm
- **EN-43966** Connecting Rod Guides
- **EN 45059** Angle Meter

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

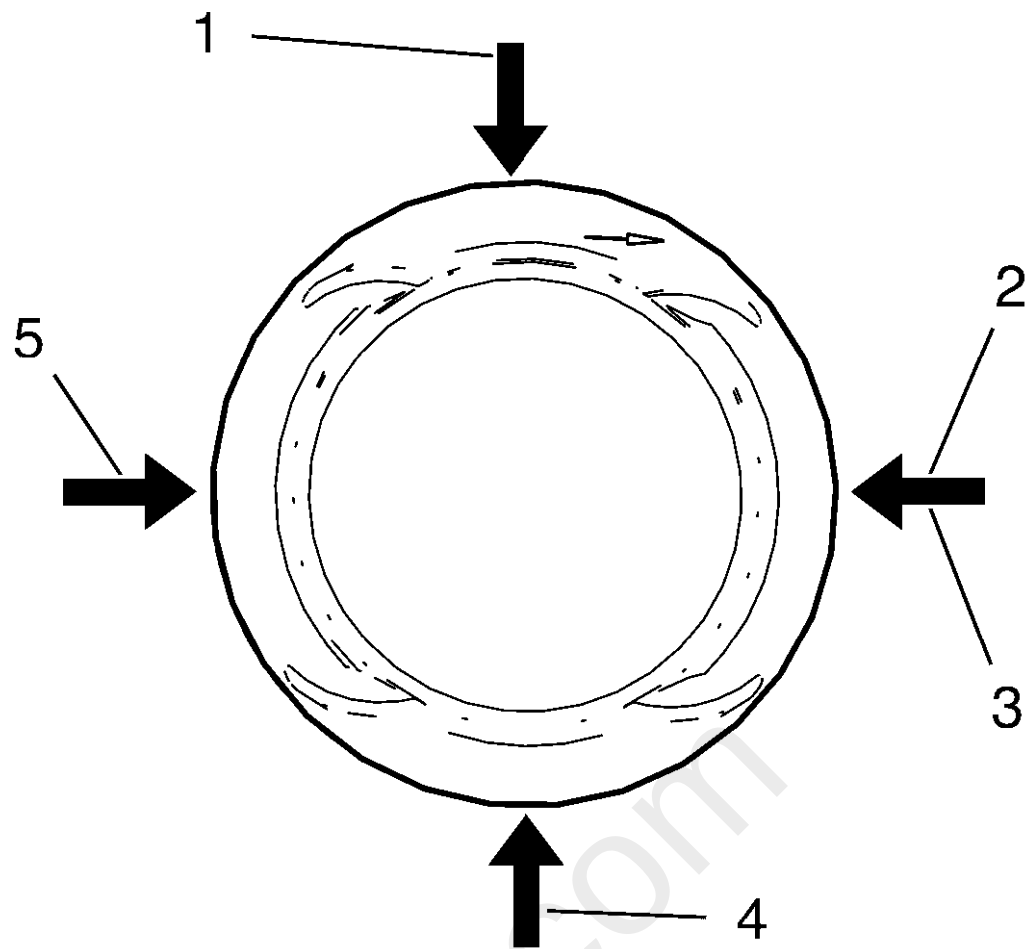


Fig. 513: Oil Ring Joints, Lower Compression Ring Joint, Upper Compression Ring Joint And Oil Ring Spacer Joint

Courtesy of GENERAL MOTORS COMPANY

1. Ensure the piston ring end gaps are positioned 90 degrees to each other.
 - Upper compression ring joint (1)
 - Lower compression ring joint (2)
 - Upper oil ring rail joint (5)
 - Oil ring rail spacer joint (4)
 - Lower oil ring rail joint (3)

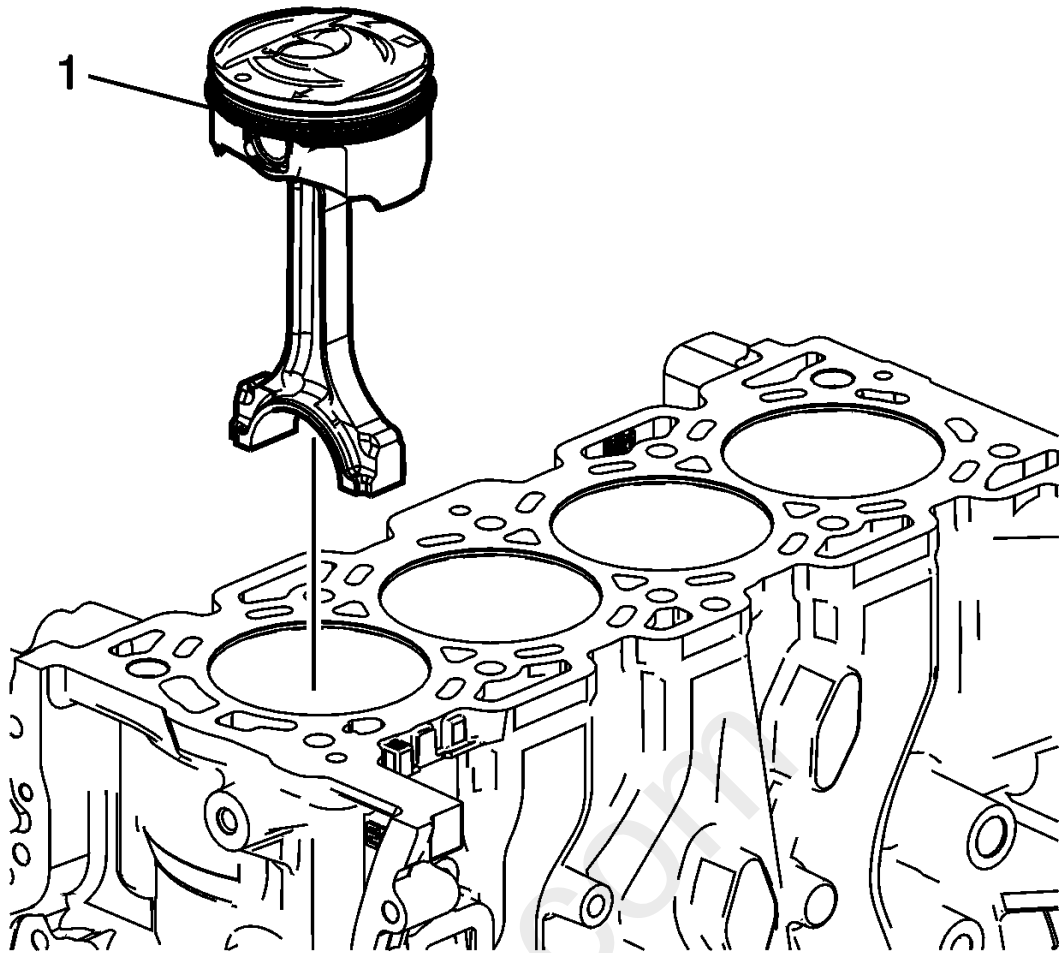


Fig. 514: Piston And Connecting Rod Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: 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.

2. Install the connecting rod bearings. Use NEW bearings.

NOTE: The connecting rod bearing anti-rotation tab grooves are to point toward the right-hand side of the engine.

1. Install the bearing inserts into the connecting rod and the connecting rod cap.
2. Lubricate the connecting rod bearings with engine oil.
3. Install the **EN-43966** guides (2) into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.
4. Install **EN-43953** compressor, piston (1), and the connecting rod to the correct bore.
 1. Lubricate the piston and the piston rings with engine oil.
 2. Do not disturb the piston ring end gap location.
 3. The piston must be installed so that the arrow mark on the top of the piston points to the front of the engine.
 4. Lubricate the engine bore with engine oil, then place the piston in its matching bore.
 5. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
 6. Hold the **EN-43953** compressor against the engine block until all the rings have entered the cylinder bore.
 7. Remove the connecting rod guides from the connecting rod bolt holes.

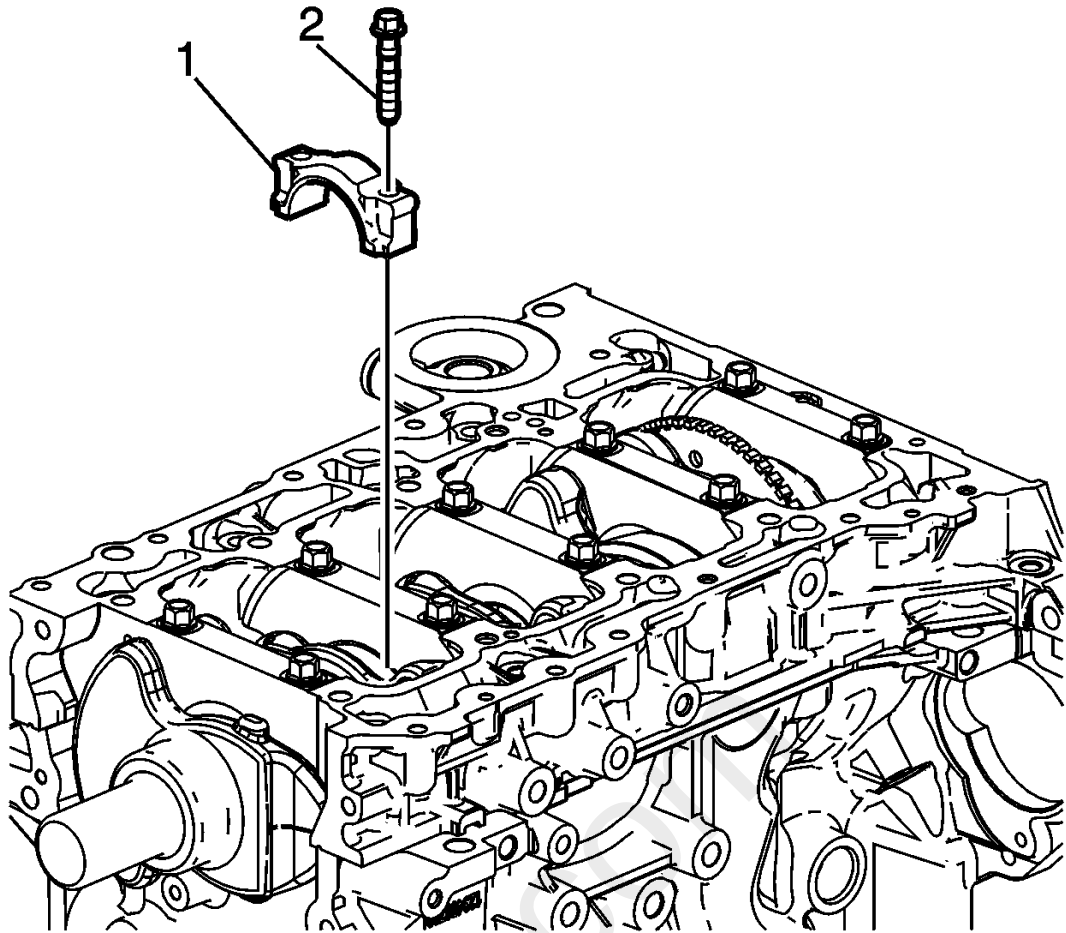


Fig. 515: Connecting Rod Cap

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure that the connecting rod cap is properly oriented on the connecting rod.

5. Install the connecting rod cap (1).

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

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

6. Install the NEW connecting rod bolts (2).

1. tighten all the connecting rod bolts a first pass to 25 N.m (18 lb ft).

2. tighten all the connecting rod bolts a final pass an additional 110 degrees using the **EN 45059** meter.

7. Install the remaining connecting rods and piston assemblies.

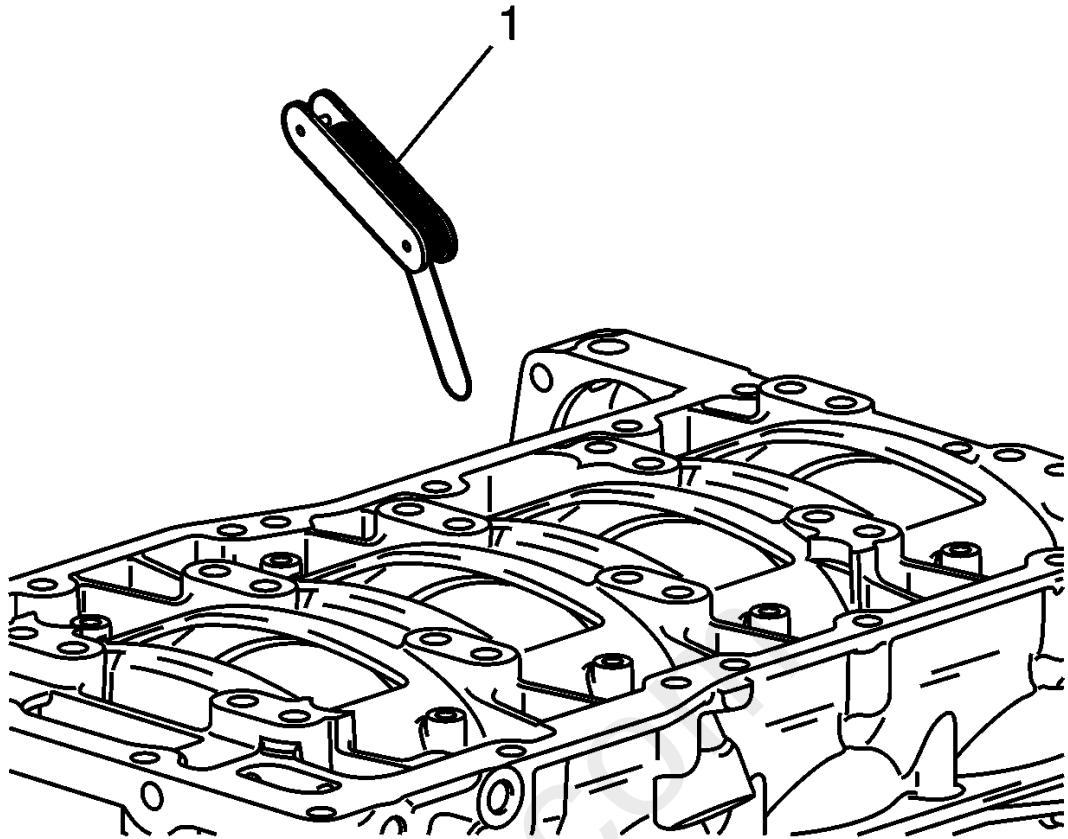


Fig. 516: View of Checking Rod Side Clearance With Feeler Gage
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Rotate the crankshaft to ensure that it moves freely and does not bind.

8. Measure the connecting rod side clearance with a feeler gauge (1). Refer to [Engine Mechanical Specifications](#).
9. Measure the piston deck height. Refer to [Engine Mechanical Specifications](#).

BALANCER SHAFT WITH OIL PUMP INSTALLATION

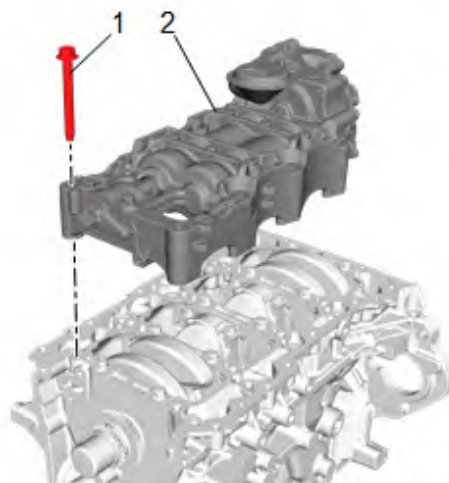


Fig. 517: Balancer And Oil Pump Shaft Assembly Bolts
 Courtesy of GENERAL MOTORS COMPANY

1. Install the balancer and oil pump shaft assembly (2).

2. Install the balancer and oil pump shaft assembly bolts (1) finger tight.

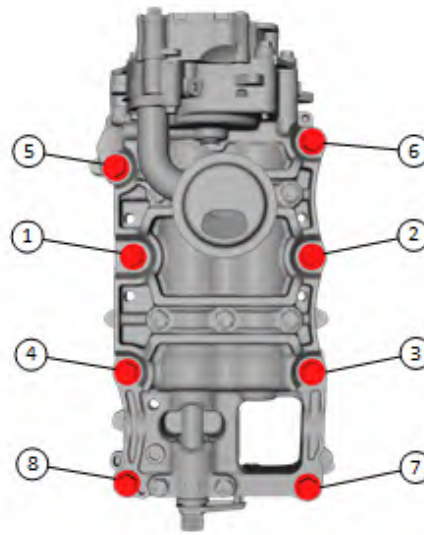


Fig. 518: Bolts Twice In Sequence

Courtesy of GENERAL MOTORS COMPANY

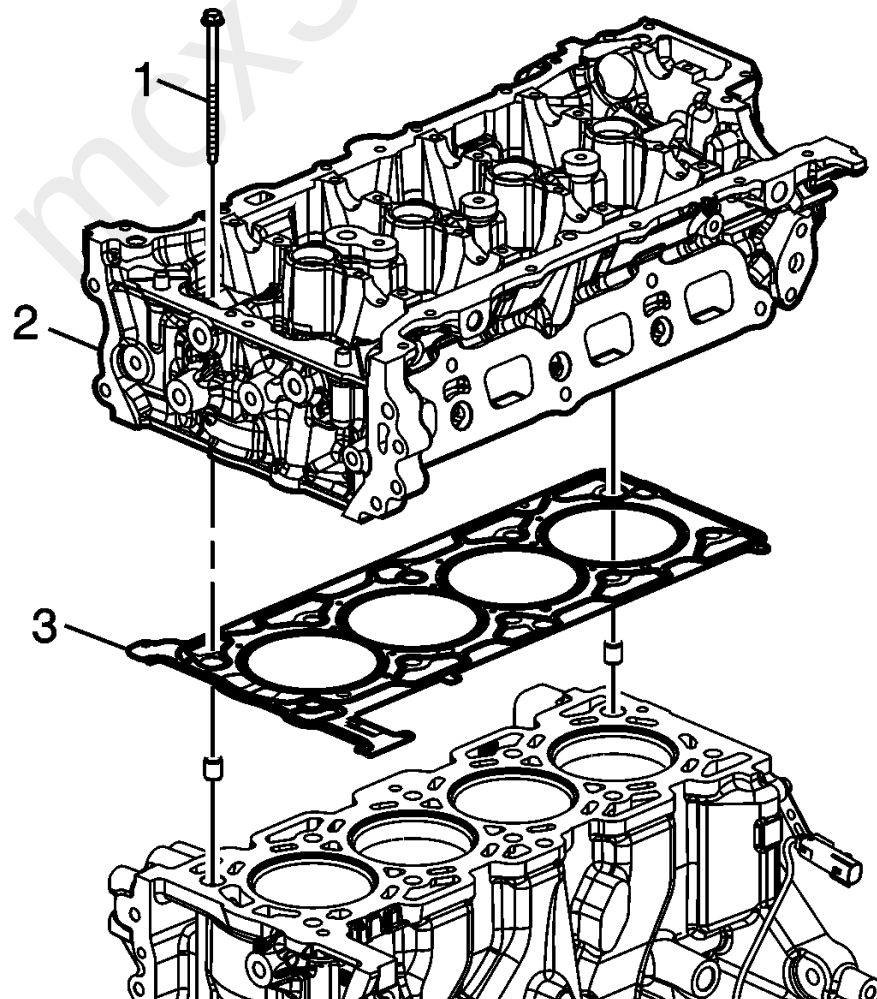
3. tighten the bolts twice in sequence:
 1. tighten the bolts a first pass in sequence to 58 N.m (43 lb ft).
 2. tighten the bolts a final pass in sequence to 58 N.m (43 lb ft).

CYLINDER HEAD INSTALLATION

Special Tools

EN 45059 Angle Meter

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



NOTE: Do not use any sealing material. Ensure that all mating surfaces are clean and free of debris.

1. If necessary, install NEW cylinder head locating pins.
2. Install the cylinder head gasket (3) to the block.
3. Install the cylinder head (2). Ensure the number 1 cylinder is at top dead center (TDC). The key on the crankshaft should be on top in the 12 o'clock position.

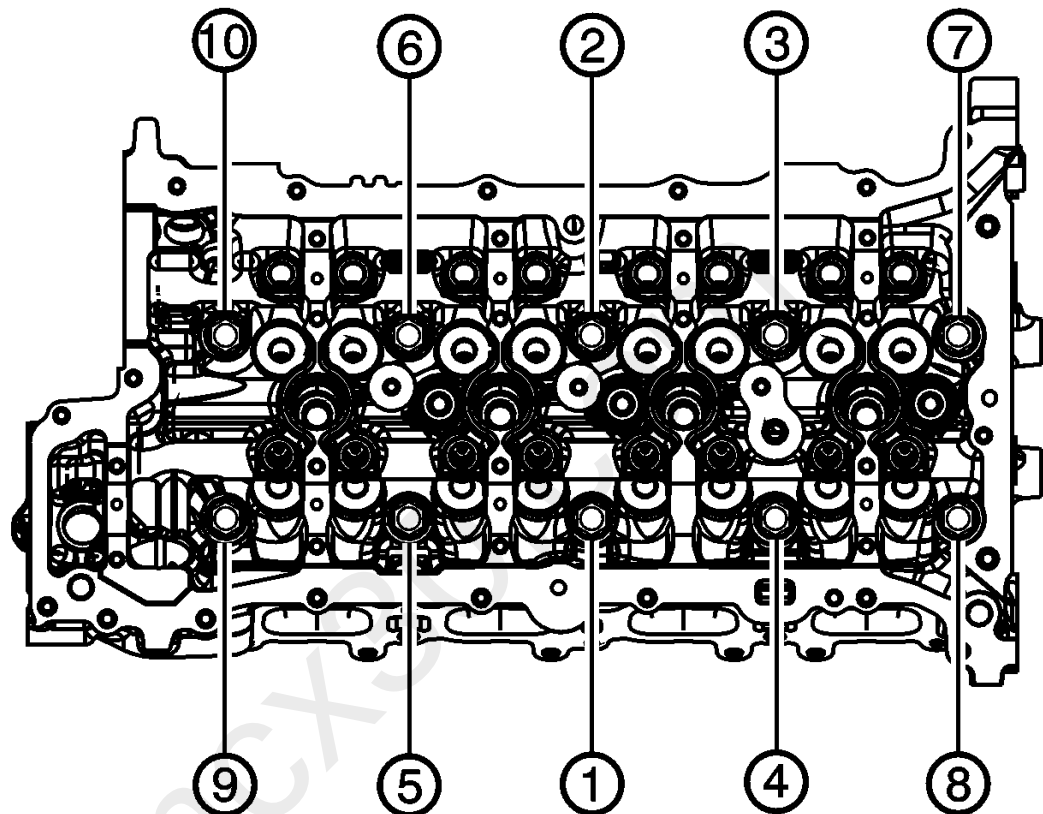


Fig. 520: Cylinder Head Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

4. Install the NEW cylinder head bolts.
 1. tighten the bolts in sequence to 30 N.m (22 lb ft).
 2. tighten the bolts an additional 190 degrees in sequence using the **EN 45059** meter.

WATER PUMP INSTALLATION

Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to ensure proper sealing.

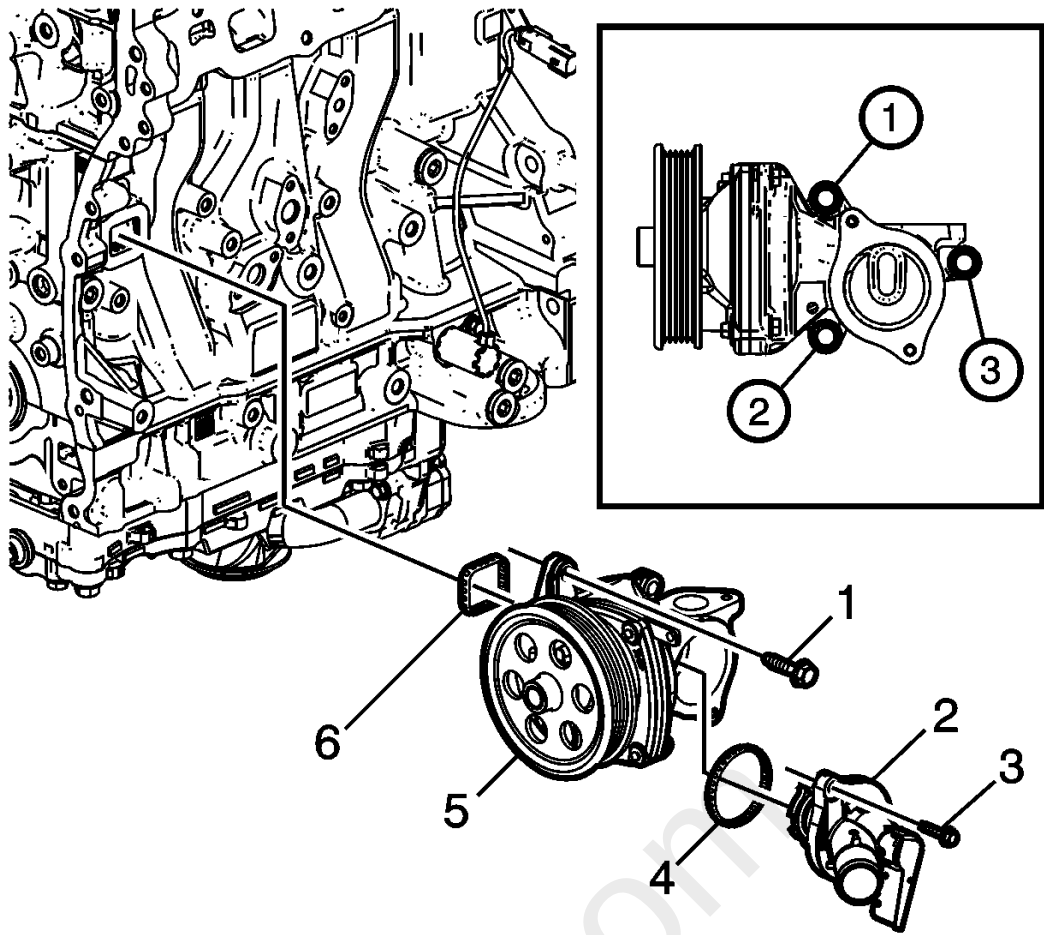


Fig. 521: Water Pump Gasket And Water Pump Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW water pump gasket (6) and the water pump assembly (5).
2. Install the water pump bolts (1). Finger tighten the bolts.

CAUTION: Refer to **Fastener Caution** .

NOTE: The sequence allows the fasteners closest to compress the seal.

3. tighten the water pump bolts in sequence to 25 N.m (18 lb ft).
4. Install a NEW thermostat assembly gasket (4) and the thermostat assembly (2).
5. Install the thermostat assembly bolts (3) and tighten to 10 N.m (89 lb in).

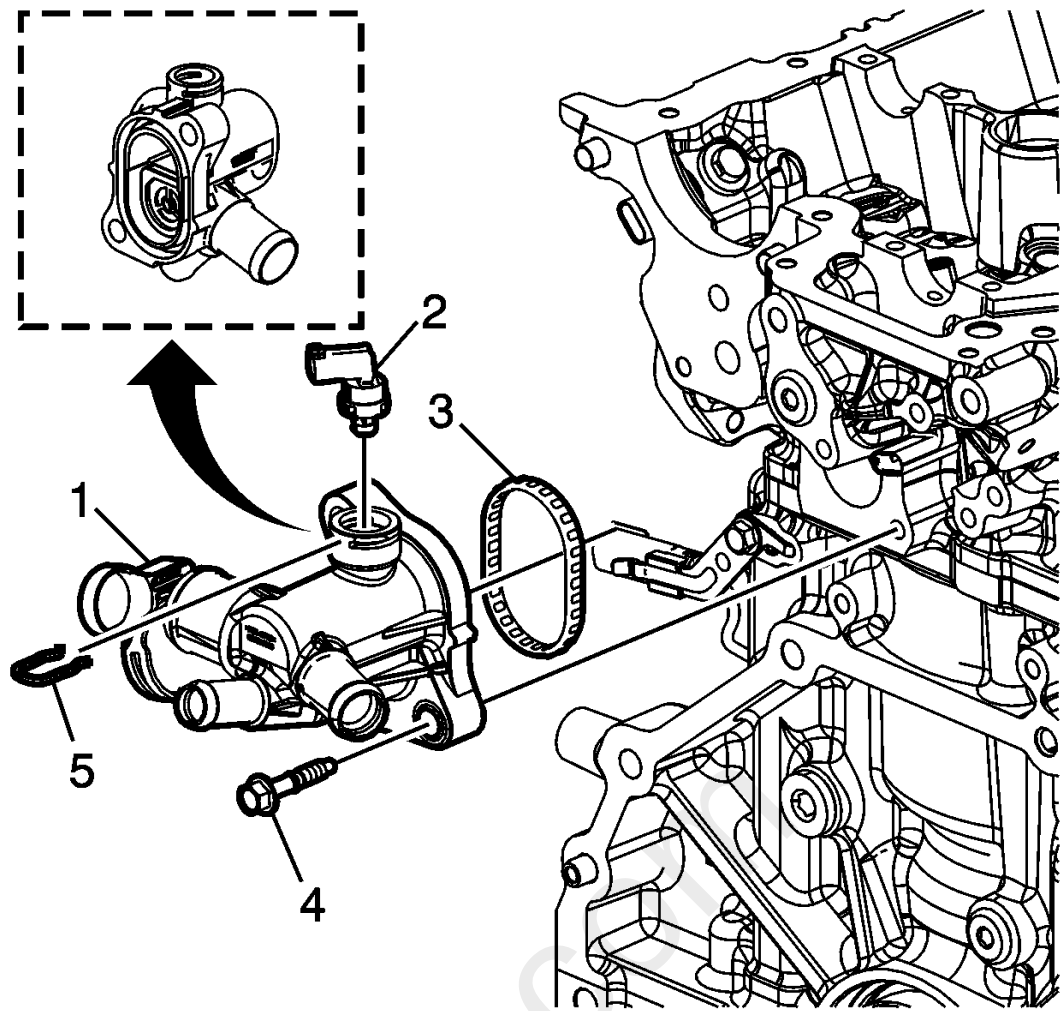


Fig. 522: Retaining Clip And Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

6. Install a NEW water outlet assembly gasket (3), and the water outlet assembly (1).
7. Install the water outlet assembly bolts (4) and tighten to 10 N.m (89 lb in).
8. Install the engine coolant temperature sensor (2).
9. Install the engine coolant temperature sensor retaining clip (5).

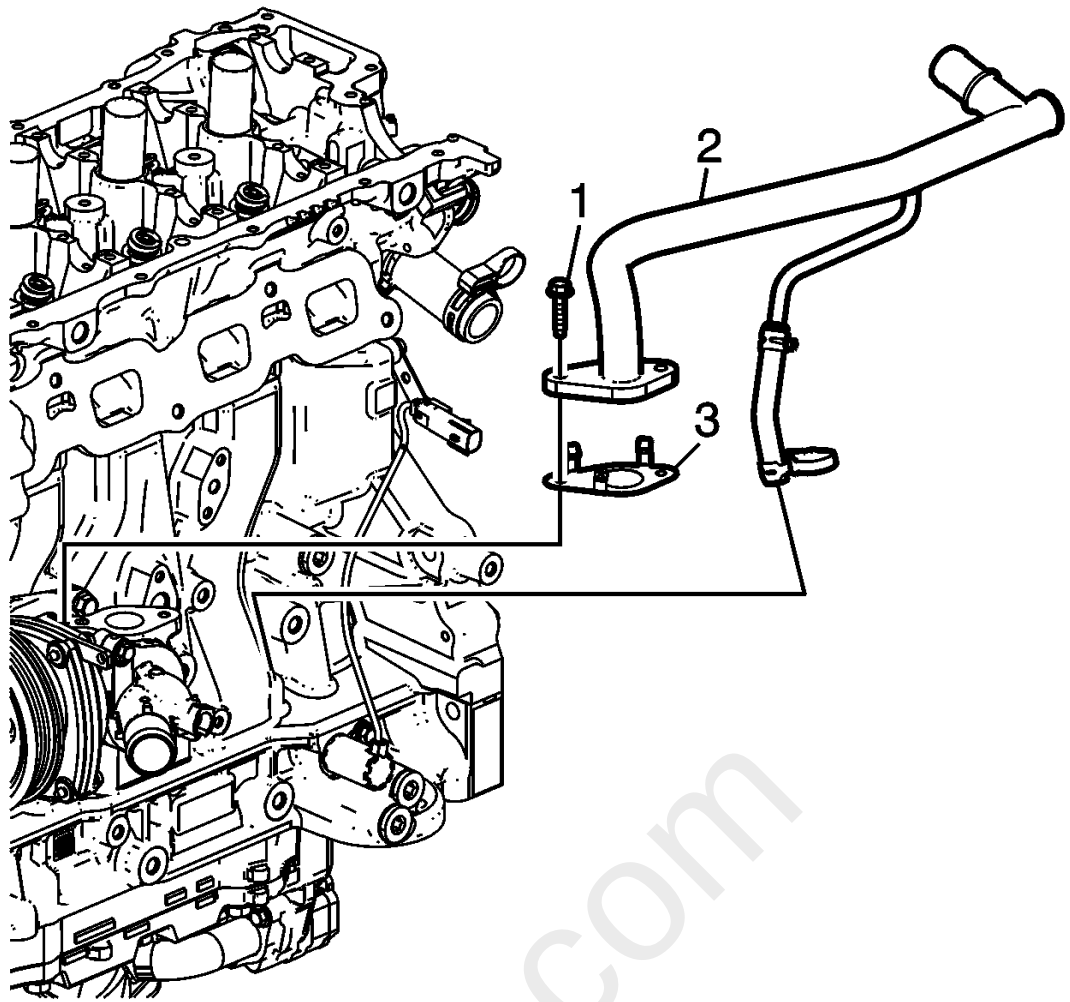


Fig. 523: Thermal Bypass Pipe Bolts And Gasket
Courtesy of GENERAL MOTORS COMPANY

10. Connect the thermal bypass pipe (2) to the water outlet assembly.
11. Connect the thermal bypass hose to the engine oil cooler.
12. Install a NEW thermal bypass pipe gasket (3) on the thermal bypass pipe. Install the thermal bypass pipe to the water pump assembly. Install the bolts (1) and tighten to 10 N.m (89 lb in).

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

Exhaust Camshaft Installation

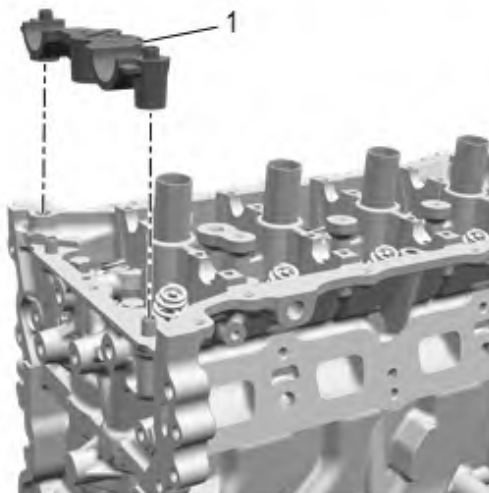


Fig. 524: Camshaft Bearing Lower Front Cap
Courtesy of GENERAL MOTORS COMPANY

1. Install the camshaft bearing lower front cap (1).

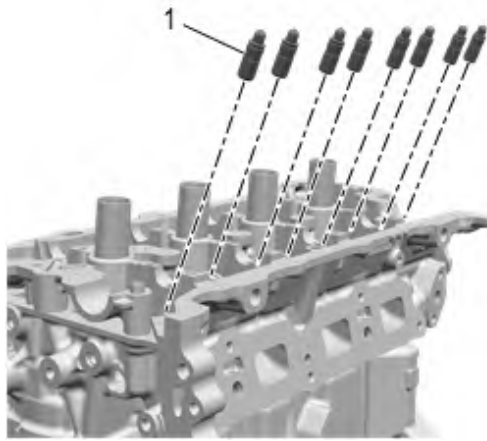


Fig. 525: Hydraulic Lash Adjusters

Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

2. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

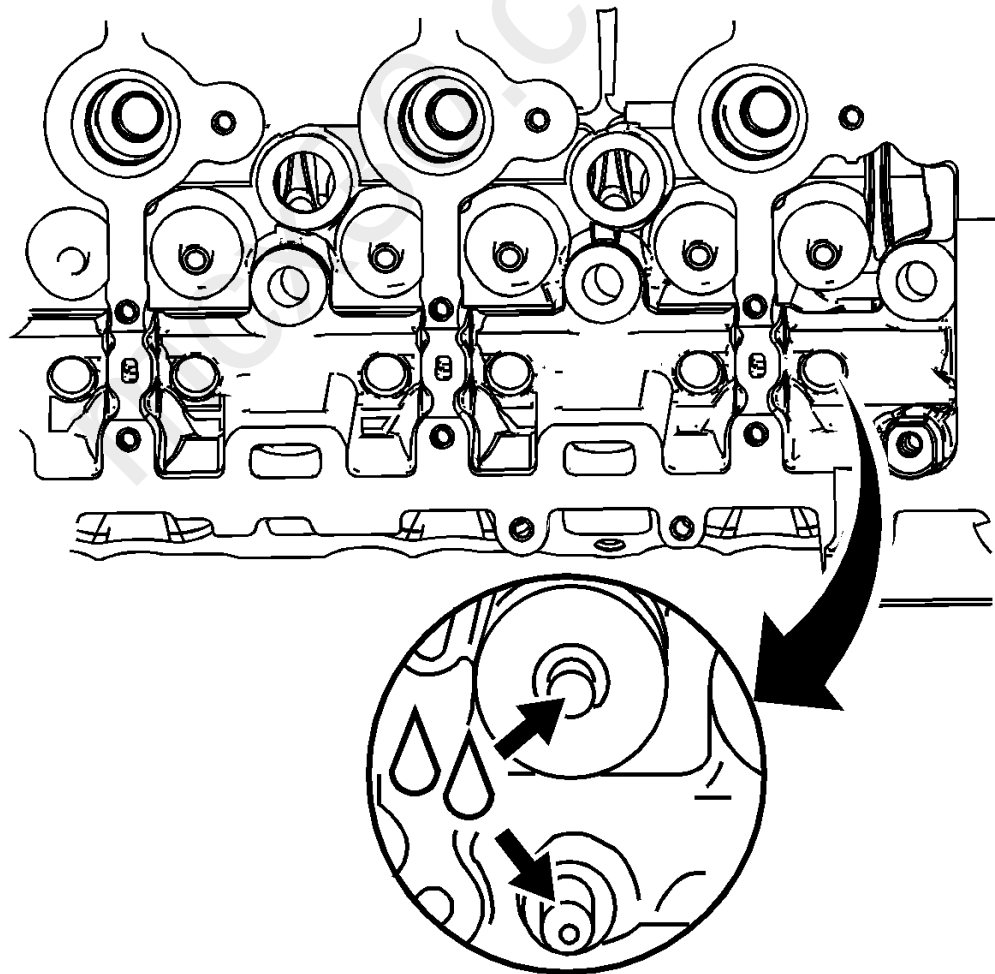


Fig. 526: Valve Tips

Courtesy of GENERAL MOTORS COMPANY

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

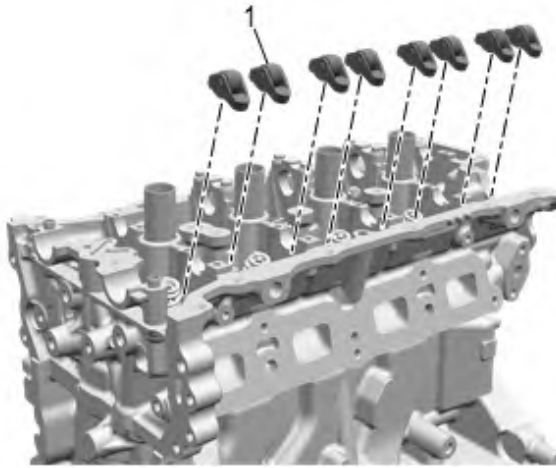


Fig. 527: Exhaust Camshaft Roller Finger Followers

Courtesy of GENERAL MOTORS COMPANY

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

NOTE: Pre-oil roller bearings before installation.

4. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
5. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

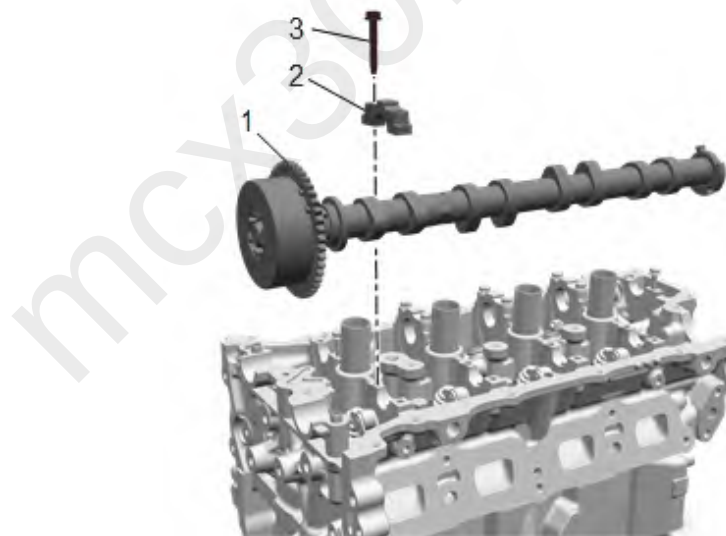


Fig. 528: Camshaft Caps

Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

6. Lubricate the exhaust camshaft lobes and journals with camshaft lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
7. Set the exhaust camshaft (1) on top of the rocker arms in the camshaft bearing journals with the actuator timing mark at approximately the 1 O'clock position.

NOTE:

- Do not apply final torque at this time. Camshaft cap final torque is applied in sequence when all caps are installed on both intake and exhaust camshafts.
- To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the

camshafts.

8. Install the camshaft cap bolts (3) into the camshaft caps (2).
9. Install the camshaft caps (2) and hand start the camshaft cap bolts (3).

Intake Camshaft Installation

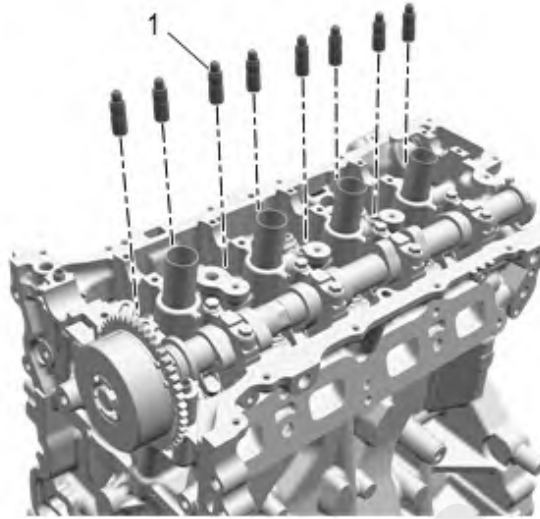


Fig. 529: Hydraulic Lash Adjusters

Courtesy of GENERAL MOTORS COMPANY

NOTE: Pre-fill the low pressure chamber with engine oil. Maintain a vertical orientation of the assembly to retain the oil in the reservoir and high pressure chamber. Do not install the lash adjusters without pre-filling the low pressure chamber. Apply engine oil to the outer diameter surface of all adjusters.

1. Lubricate and install the hydraulic valve lash adjusters (1) into their bores in the cylinder head. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

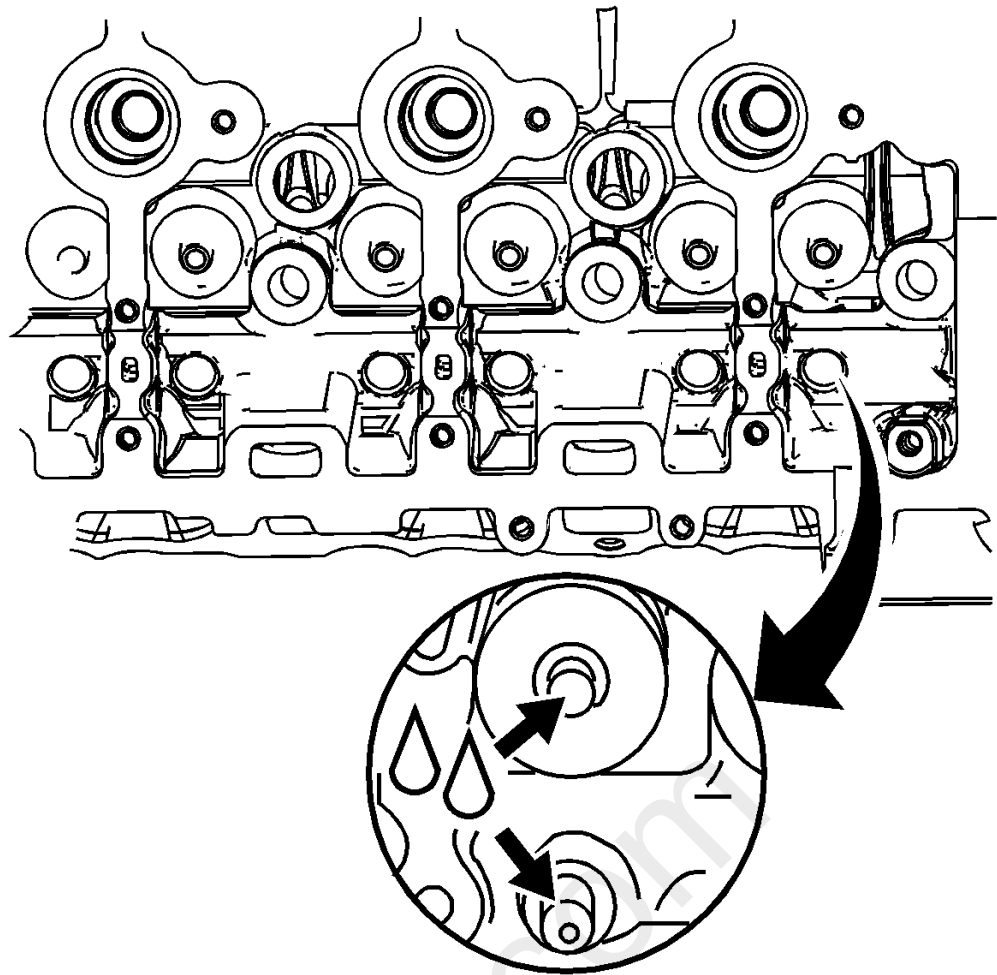


Fig. 530: Valve Tips

Courtesy of GENERAL MOTORS COMPANY

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

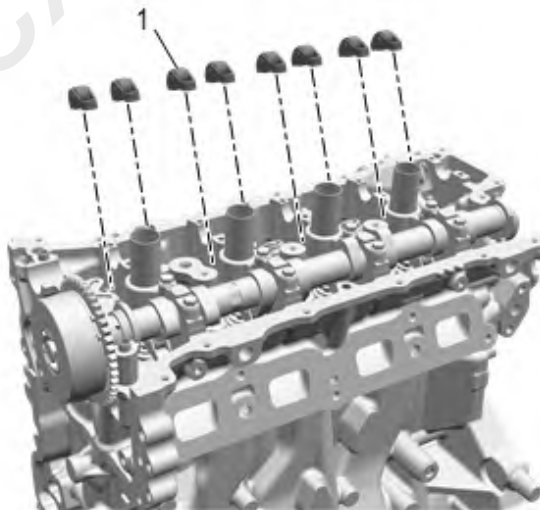


Fig. 531: Intake Camshaft Roller Finger Followers

Courtesy of GENERAL MOTORS COMPANY

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

NOTE: Pre-oil roller bearings before installation.

3. Lubricate the roller bearings with valve rocker arm lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

4. Position the valve rocker arm (1) on the tip of the valve stem and on the lash adjuster and lubricate. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

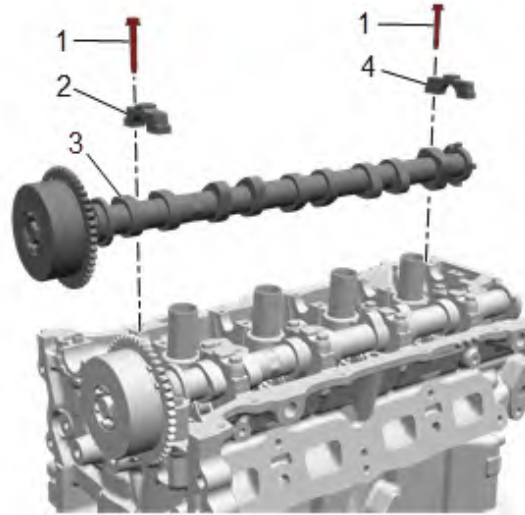


Fig. 532: Intake Camshaft Bearing Rear Cap Bolts And Cap
Courtesy of GENERAL MOTORS COMPANY

NOTE: Apply lubricant to all lobes and journals prior to installing the camshafts.

5. Lubricate the intake camshaft lobes and journals with camshaft lubricant. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Set the intake camshaft (3) on top of the roller followers in the camshaft bearing journals with the intake actuator timing mark at approximately the 11 O'clock position.

NOTE: To properly position the camshaft caps, install the camshaft cap bolts into the camshaft caps prior to installing the camshaft caps on the camshafts.

6. Install the camshaft cap bolts (1) into the camshaft caps (2, 4).
7. Install the camshaft caps (2) and hand start the camshaft cap bolts (1).
8. Install the camshaft rear cap (4) and hand start the camshaft cap bolts (1).

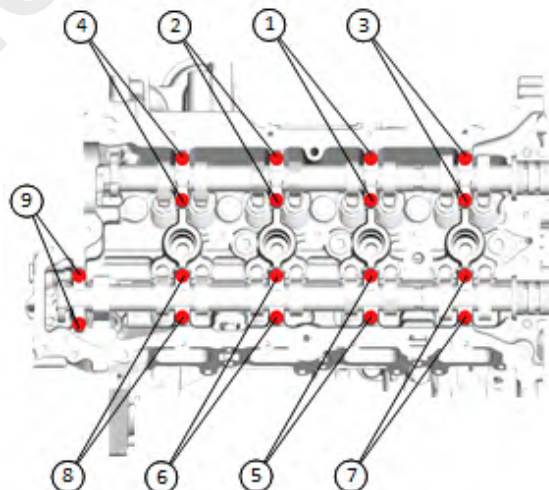


Fig. 533: Camshaft Cap Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

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

NOTE: During the tightening sequence, locate and tighten each camshaft cap bolt installed into the circular hole first. Then, tighten the bolt installed into the slotted hole.

9. tighten the camshaft cap bolts in sequence using the following procedure:
 1. tighten the camshaft cap bolts in sequence to 8 N.m (71 lb in).
 2. Loosen both bolts in each cap in sequence to 180 degrees.
 3. tighten the camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

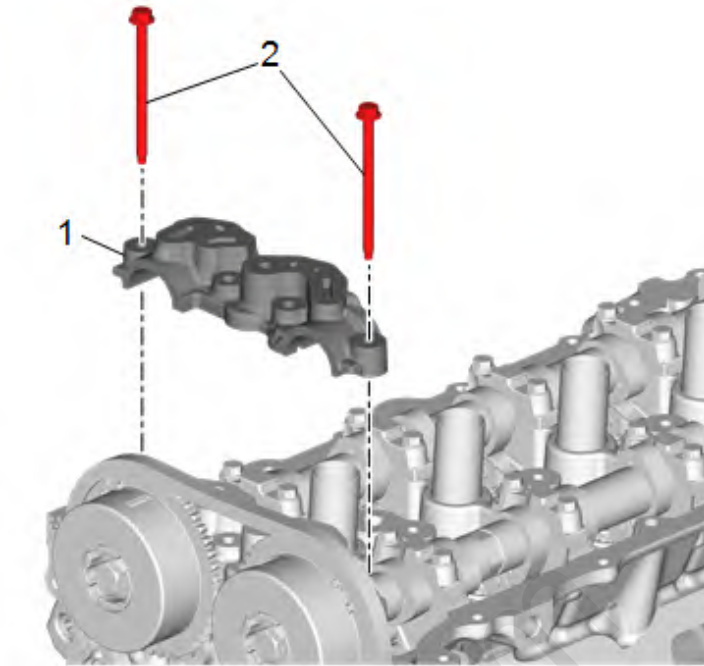


Fig. 534: Front Camshaft Bearing Cap And Outer Bolts

Courtesy of GENERAL MOTORS COMPANY

10. Install the front camshaft bearing cap (1). Install the 2 outer bolts (2) for the front camshaft bearing cap finger tight. Installation of the timing chain guide and bolts, and final torque for the front bearing cap is not performed until after the timing chain is installed.

BALANCER CHAIN, SPROCKET, AND TENSIONER INSTALLATION

Special Tools

EN-50837 Timing Chain Tensioner Retraction Tool

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

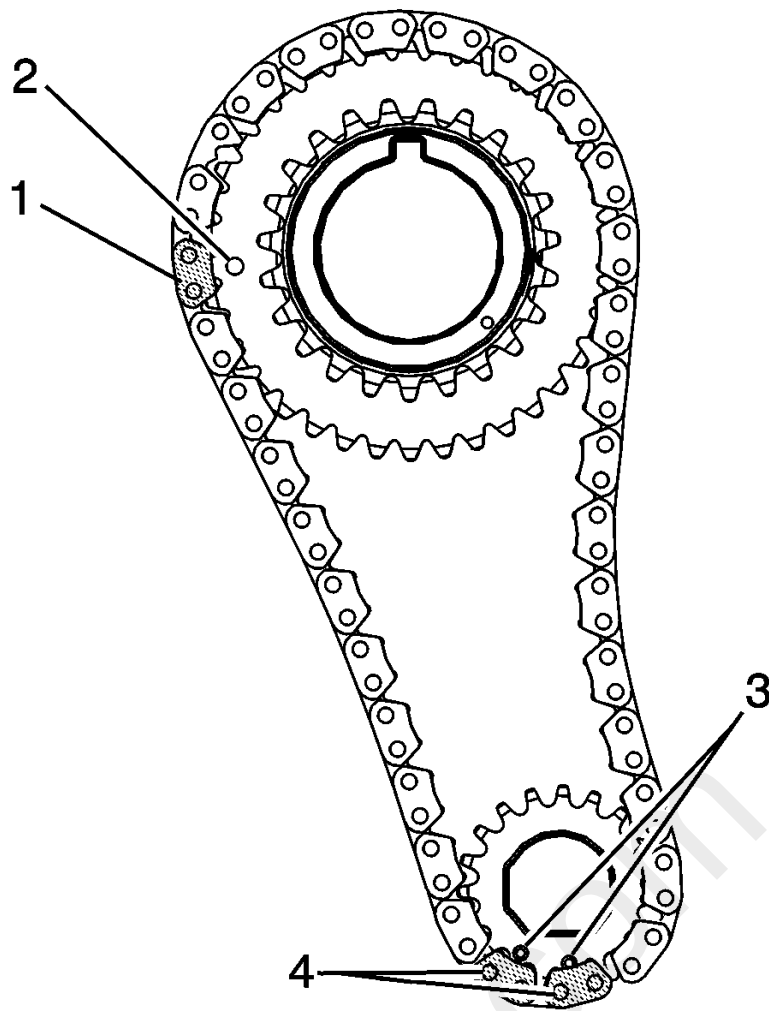


Fig. 535: Timing Link Lines & Timing Mark
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Proper setup is critical to ensure correct timing when installing the sprockets and chain simultaneously onto the shafts. The timing links are heat treated blued steel.

1. Assemble the crankshaft sprocket, balancer shaft driven sprocket, and balancer chain. Ensure the timing link (1) lines up with the timing mark (2) on the crankshaft sprocket. Ensure that both timing teeth (3) on the balancer shaft driven sprocket line up with the timing links (4).

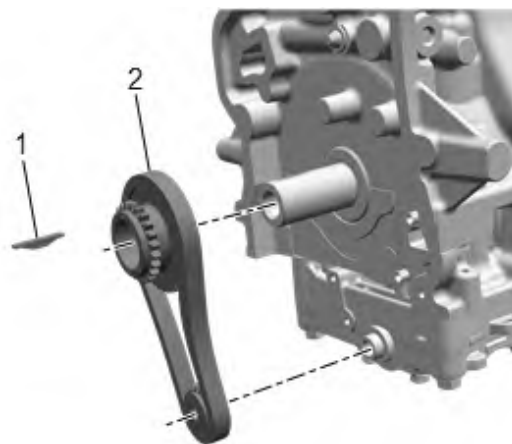


Fig. 536: Balancer Shaft Driven Sprocket And Balancer Chain
 Courtesy of GENERAL MOTORS COMPANY

NOTE: The crankshaft keyway should be in the 12 O'clock position.

2. Install the sprockets and chain (2) as an assembly to the crankshaft and balancer shaft assembly.
3. Install the crankshaft key (1).

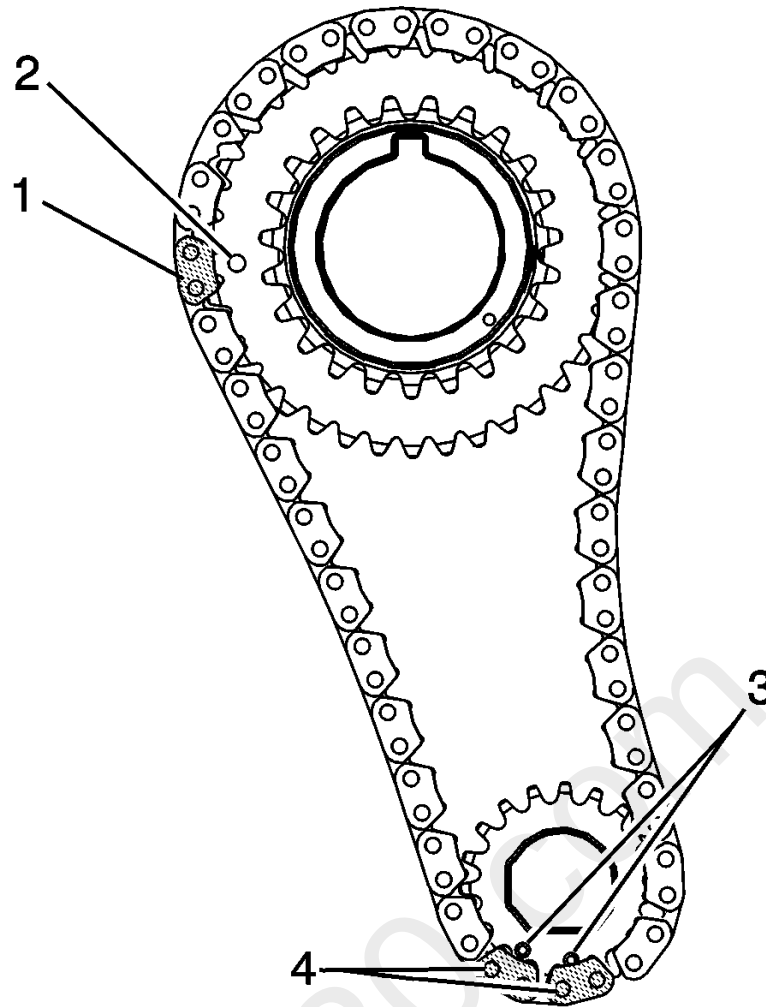


Fig. 537: Timing Link Lines & Timing Mark
Courtesy of GENERAL MOTORS COMPANY

4. Ensure the timing link (1) is aligned with the crankshaft sprocket timing mark (2).
5. Ensure the adjacent timing links (4) are aligned with both of the timing marks (3) on the balancer shaft driven sprocket.

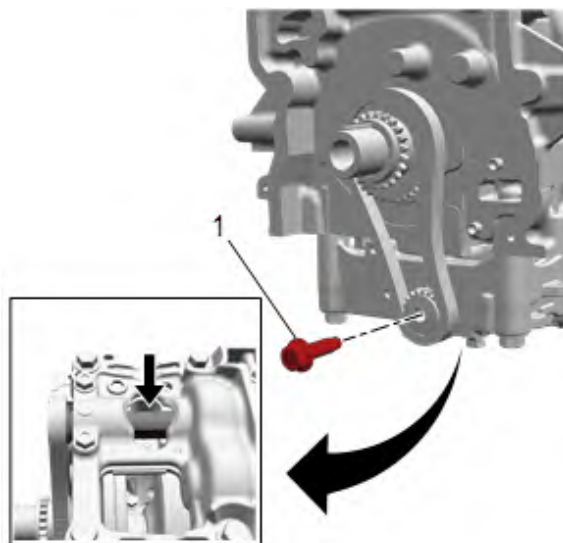


Fig. 538: Balancer Shaft Driven Sprocket Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component.

Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

6. Install the NEW balancer shaft driven sprocket bolt (1).

CAUTION: Refer to **Fastener Caution** .

7. Use an open end wrench over flat on balance shaft while tightening the balancer shaft sprocket bolt to specification. tighten the balancer shaft driven sprocket bolt to 40 N.m (30 lb ft) plus 50 degrees.

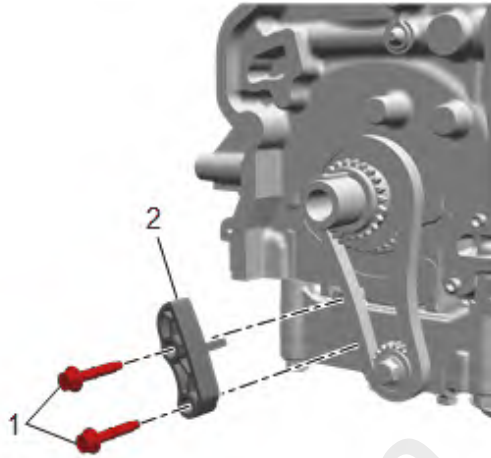


Fig. 539: Balancer Chain Guide Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the guide is installed in the correct orientation. The long end must point toward the crankshaft and the flat edge must be adjacent to the balance chain.

8. Install the balancer chain guide (2).
9. Install the balancer chain guide bolts (1). tighten the bolts to 10 N.m (89 lb in).

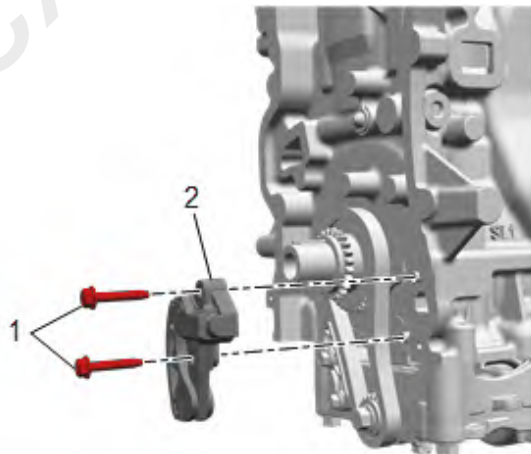


Fig. 540: Balancer Chain Tensioner Bolt

Courtesy of GENERAL MOTORS COMPANY

10. Install the balancer chain tensioner (2).
11. Install the balancer chain tensioner bolts (1). tighten the bolts to 10 N.m (89 lb in).
12. Remove **EN-50837** retention tool to restore the tension to the balancer chain.

OIL PAN INSTALLATION (AWD)

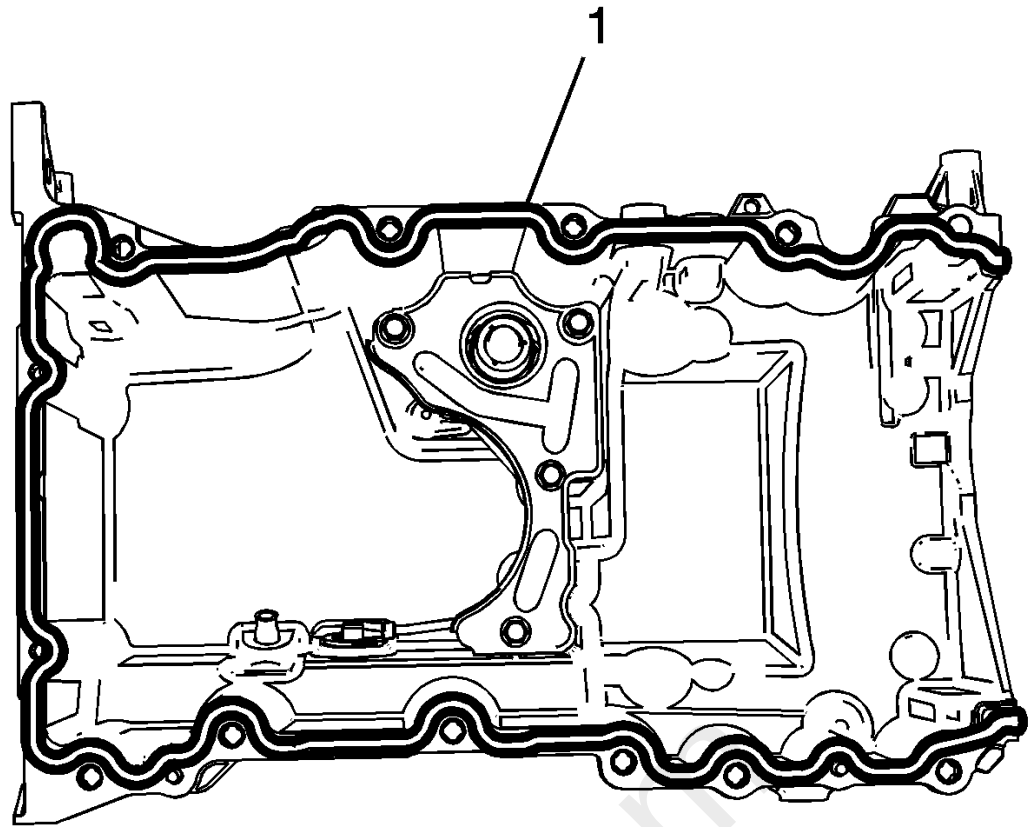


Fig. 541: Engine Oil Pan Sealing Surface

Courtesy of GENERAL MOTORS COMPANY

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
- NOTE:**
- The lower crankcase surface must be free of contamination prior to applying the sealer.
 - Install and align the oil pan to block within 20 minutes of applying the sealer.
 - The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.
2. Apply a 4.25 mm bead of sealer (1) on the level part of the flange around the perimeter of the oil pan. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

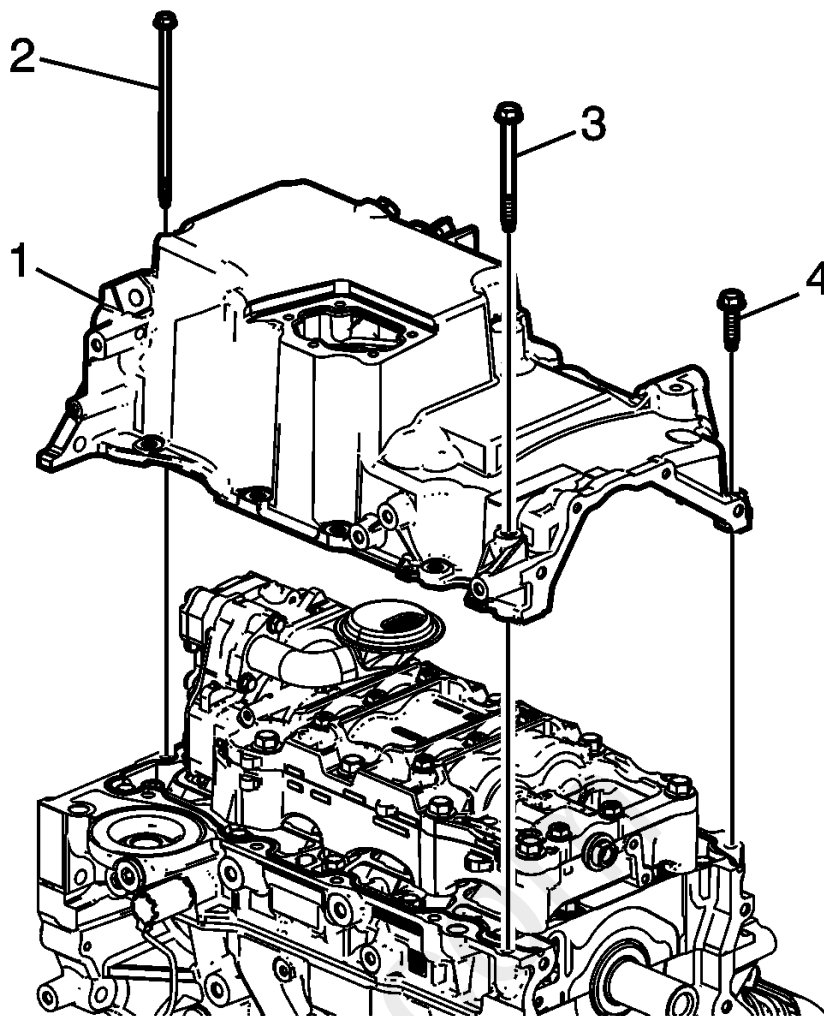


Fig. 542: Upper Oil Pan And Bolts

Courtesy of GENERAL MOTORS COMPANY

3. Install the oil pan (1).
4. Install the oil pan bolts (2, 3, 4) finger tight.

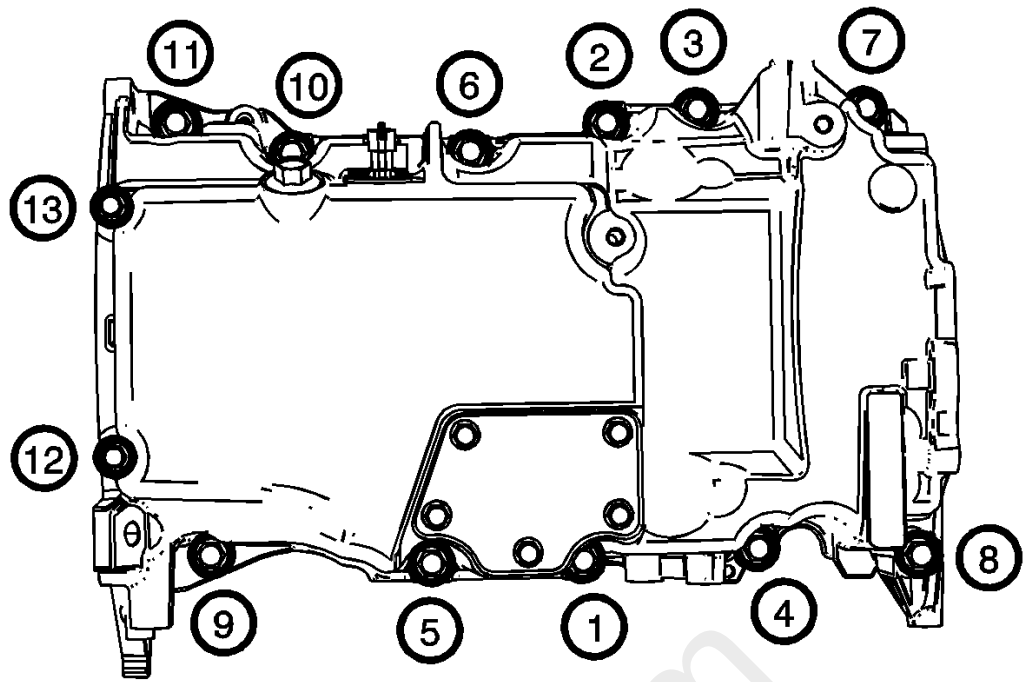


Fig. 543: Oil Pan Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

5. tighten the oil pan bolts in sequence to final torque twice using the following procedure:
 1. tighten bolts in sequence 1 - 11 to 25 N.m (18 lb ft).
 2. tighten bolts in sequence 12 - 13 to 10 N.m (89 lb in).

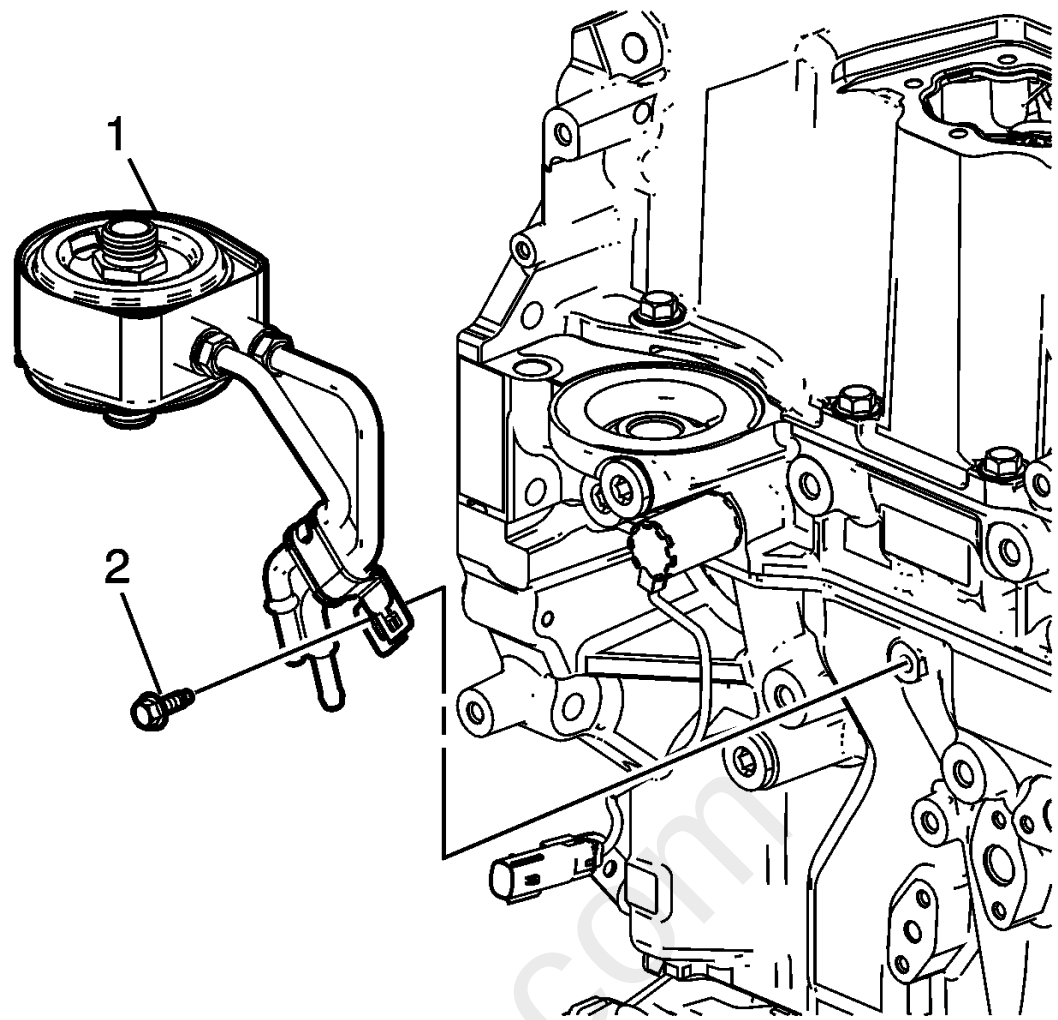


Fig. 544: Engine Oil Cooler

Courtesy of GENERAL MOTORS COMPANY

6. Install the engine oil cooler (1). tighten the engine oil cooler connector to 50 N.m (37 lb ft).
7. Install the engine oil cooler bolt (2) and tighten to 10 N.m (89 lb in).

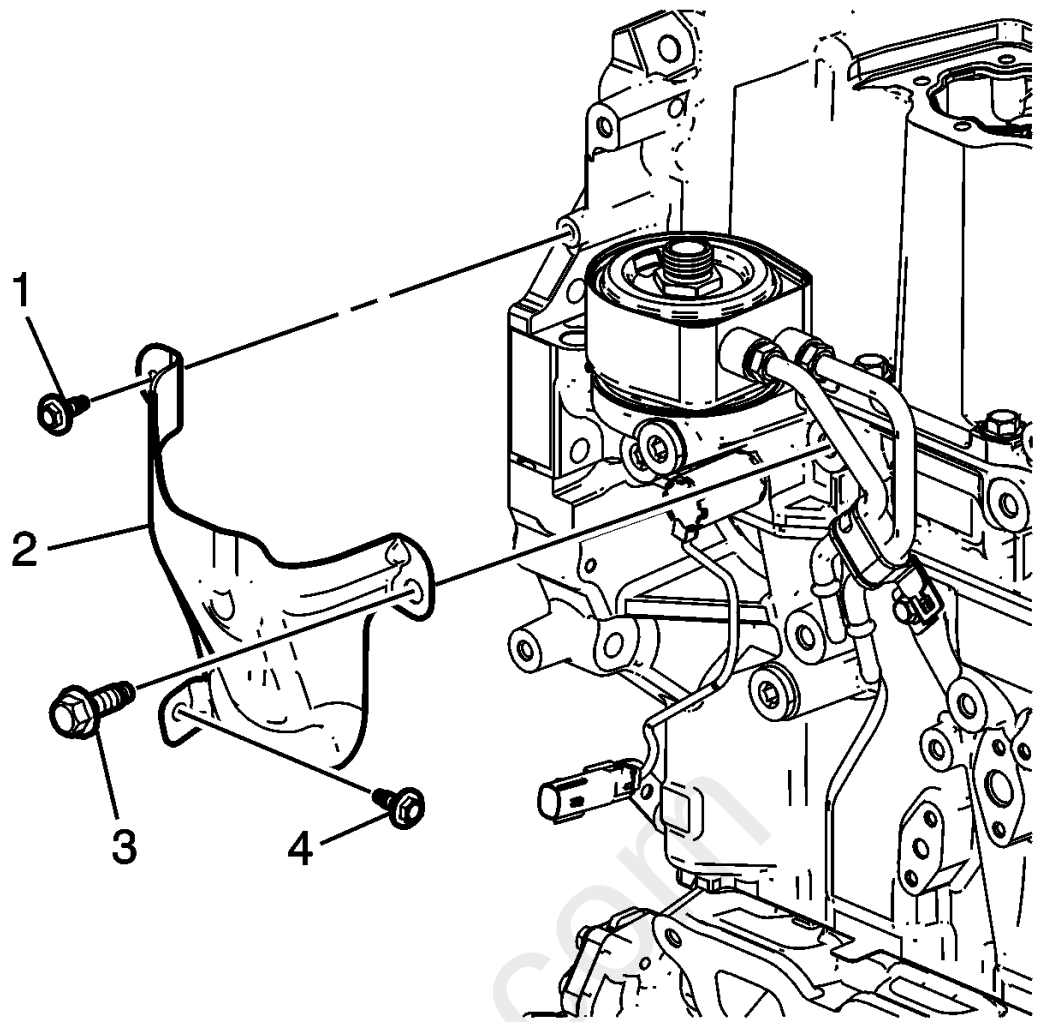


Fig. 545: Oil Pump Flow Control Valve Cover
Courtesy of GENERAL MOTORS COMPANY

8. Install the oil pump flow control valve cover (3).
9. Install the valve cover bolts (1, 4) and tighten to 9 N.m (80 lb in).
10. Install the valve cover bolt (2) and tighten to 58 N.m (43 lb ft).

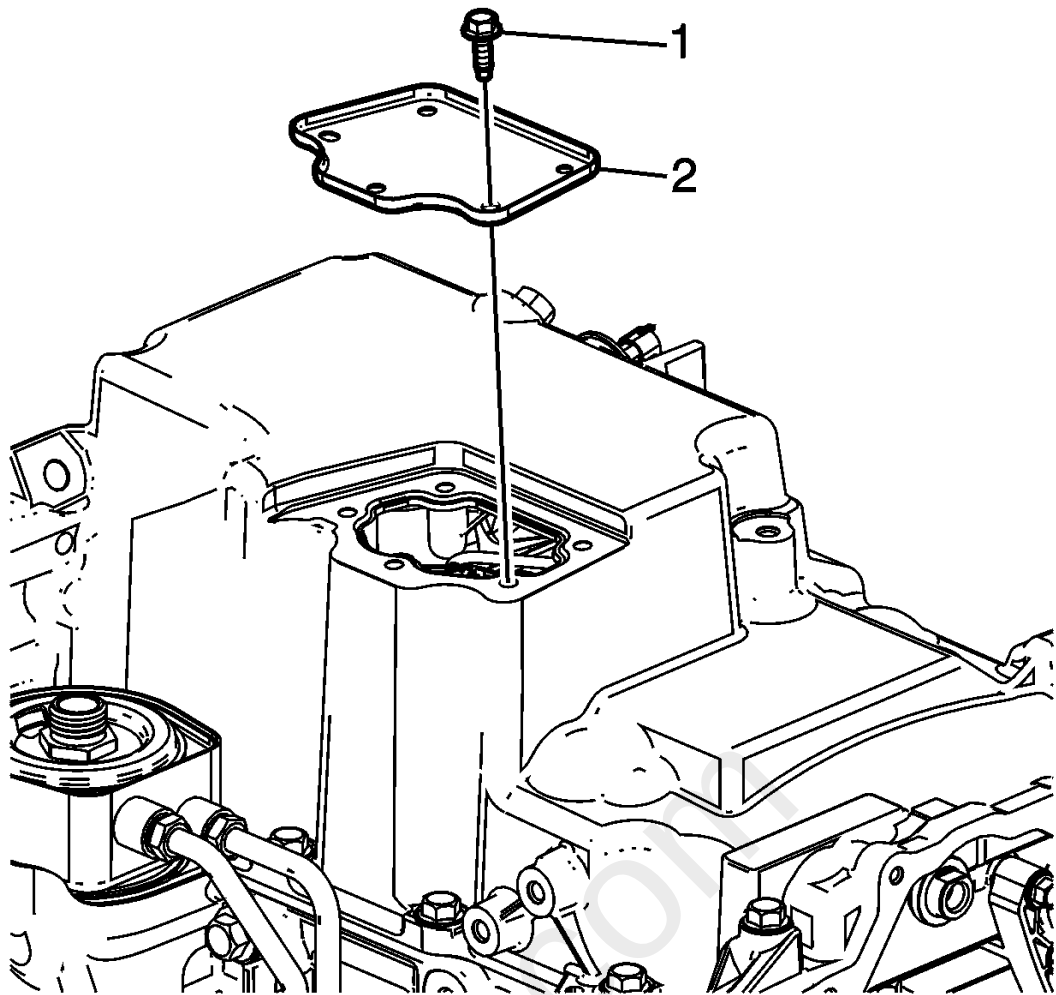


Fig. 546: Oil Pan Cover And Bolts

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The oil pan sealing surfaces must be free of contamination prior to applying the sealer.
- Install and align the oil pans within 20 minutes of applying the sealer.
- The oil pans must be fastened to final torque specification within 60 minutes of applying the sealer.

11. Apply a bead of RTV sealant to the perimeter of the oil pan cover.

12. Install the oil pan cover (2).

13. Install the oil pan cover bolts (1) and tighten to 10 N.m (89 lb in).

OIL PAN INSTALLATION (FWD)

Lower Oil Pan Installation

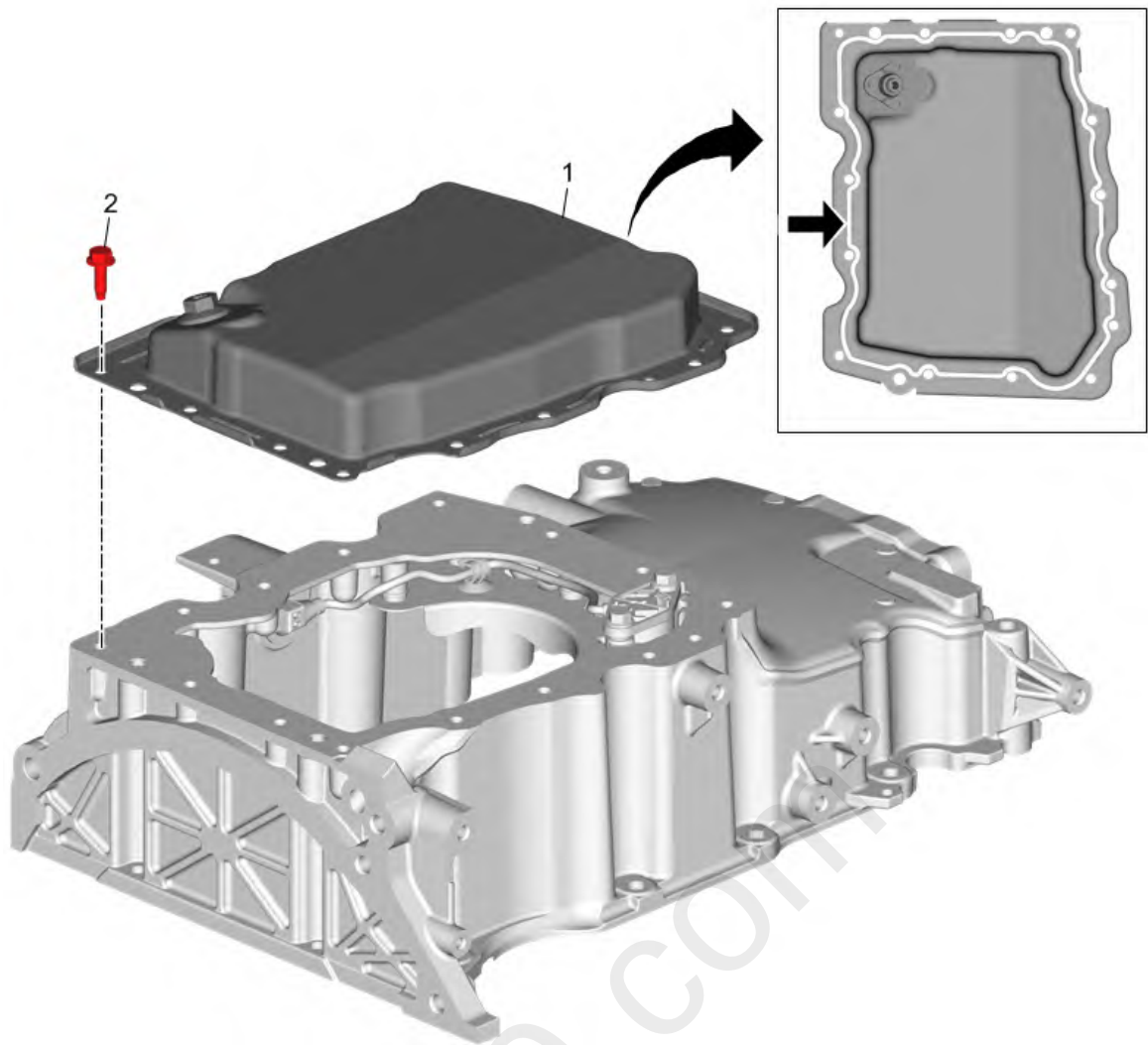


Fig. 547: Lower Oil Pan

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Ensure proper use of room temperature vulcanizing (RTV) sealant: Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant	
1	Lower Oil Pan Procedure NOTE: • The oil pan sealing surfaces must be free of contamination prior to applying the sealer. • Install and align the oil pans within 20 minutes of applying the sealer. 1. Apply a bead of RTV sealant to the perimeter of the lower oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. 2. Install the lower oil pan to the upper oil pan.

Callout	Component Name
2	Oil Pan Bolt NOTE: Two long bolts secure the lower oil pan and upper oil pan together to the lower crankcase. CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)

Oil Pan and Engine Oil Cooler Installation

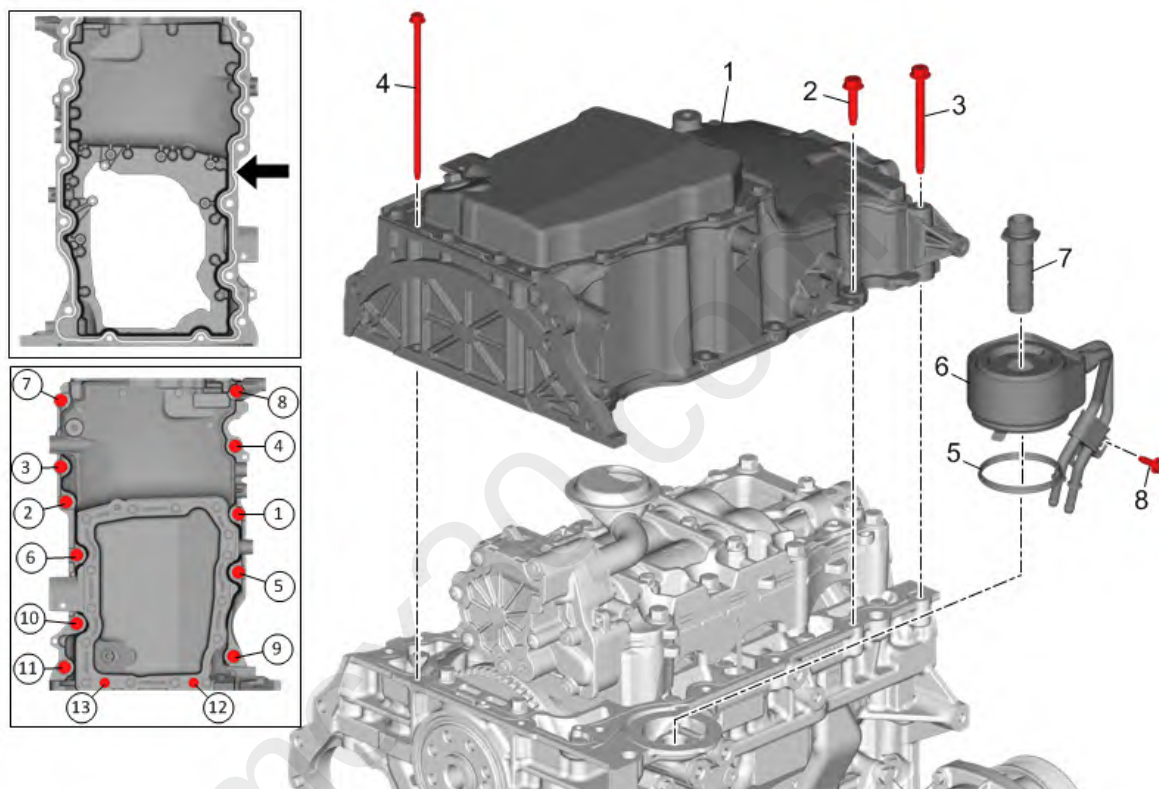


Fig. 548: Oil Pan and Engine Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Ensure proper use of room temperature vulcanizing (RTV) sealant: Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant	
1	Oil Pan Procedure NOTE: - The oil pan sealing surface and lower crankcase surface must be free of contamination prior to applying the sealer. - Install and align the oil pans within 20 minutes of applying the sealer. - Apply a 4.25 mm bead of sealer on the level part of the flange around the perimeter of the oil pan. Refer to Adhesives, Fluids, Lubricants, and Sealers. - Align the locating pins and install the oil pan on the lower crankcase.

Callout	Component Name
2	Oil Pan Bolt NOTE: Install all oil pan bolts finger tight, then tighten in the sequence shown. CAUTION: Refer to Fastener Caution . tighten 25 N.m (18 lb ft)
3	Oil Pan Bolt NOTE: Install all oil pan bolts finger tight, then tighten in the sequence shown. tighten 25 N.m (18 lb ft)
4	Oil Pan Bolt NOTE: tighten the oil pan bolts in the sequence shown. tighten 10 N.m (89 lb in)
5	Engine Oil Cooler Seal Procedure Use a NEW seal.
6	Engine Oil Cooler
7	Engine Oil Cooler Connector tighten 50 N.m (37 lb ft)
8	Engine Oil Cooler Bolt tighten 10 N.m (89 lb in)

Oil Pump Flow Control Valve Heat Shield Installation

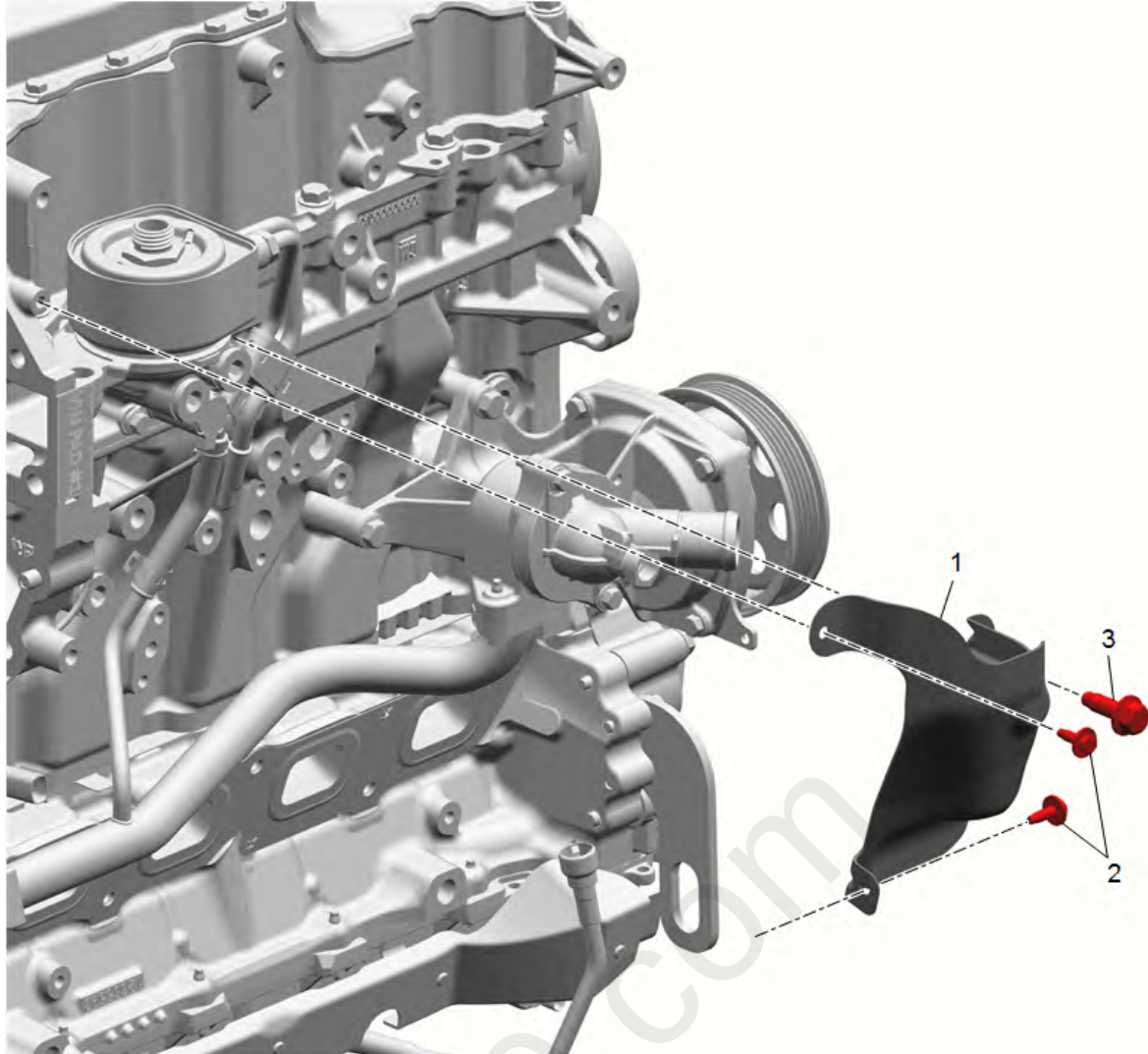


Fig. 549: Oil Pump Flow Control Valve Heat Shield

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Flow Control Valve Heat Shield
2	Pump and Component Oil Heat Shield Bolt CAUTION: Refer to Fastener Caution . tighten 9 N.m (80 lb in)
3	Oil Pump Flow Control Valve Heat Shield Bolt tighten 58 N.m (43 lb ft)

CAMSHAFT TIMING CHAIN AND TENSIONER INSTALLATION

Special Tools

- **EN 45059** Angle Meter
- **EN 50837** Timing Chain Tensioner Retraction Tool

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

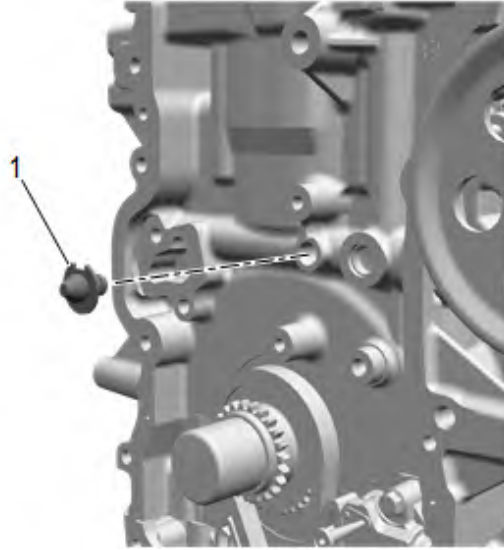


Fig. 550: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the timing chain oil nozzle is rotated with the notch facing upward, and aligned with the tab on the engine block.

1. Install the timing chain oil nozzle (1).

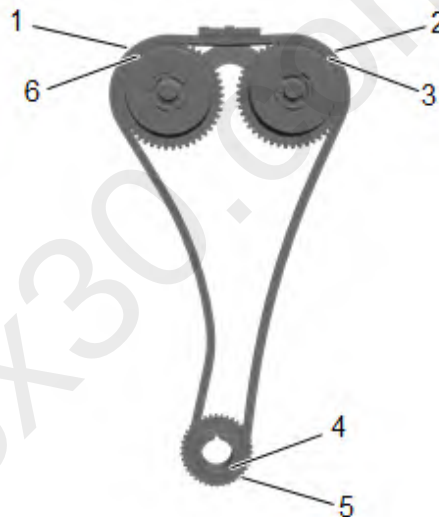


Fig. 551: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

NOTE: There are three colored links on the timing chain. The two links that align to the timing marks on the actuators are the same color. The timing link that aligns with the timing mark on the crankshaft sprocket is a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.

2. Loop the timing chain over the intake and exhaust camshaft actuators, aligning one of the same colored links (2) with the timing mark on the exhaust camshaft actuator (3).

NOTE: The same colored link corresponding to the intake actuator will not initially align with the intake actuator timing mark, nor the unique colored timing chain link align with the crankshaft sprocket timing mark.

3. Ensure the crankshaft key in the 12 O'clock position. Loop the timing chain onto the crankshaft sprocket.

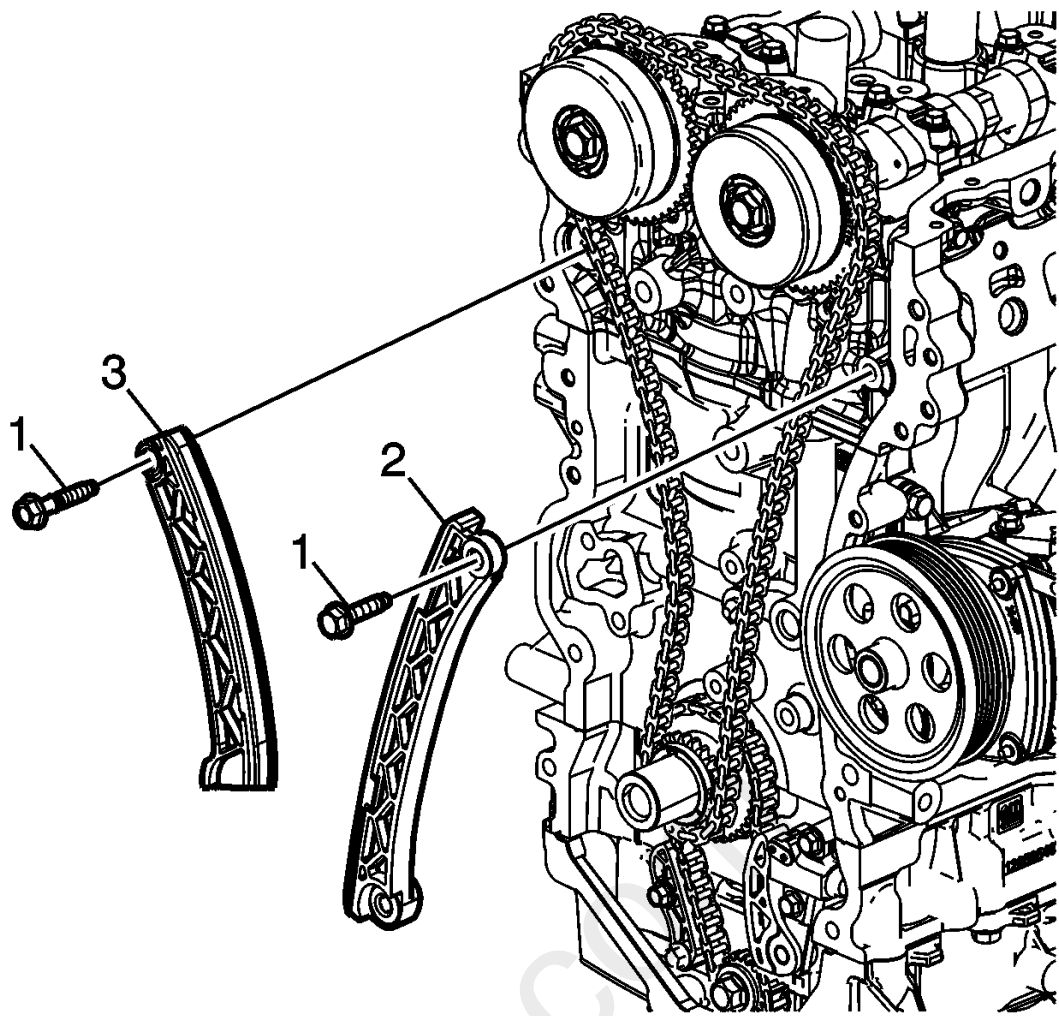


Fig. 552: Timing Chain Guides And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Timing will be established before the final install and torque of the guide bolts.

4. Install the timing chain guide (2) and upper bolt (1) only, finger tight.
5. Install the timing chain tensioner pivot arm (3).
6. Install the pivot arm bolt (1) finger tight.

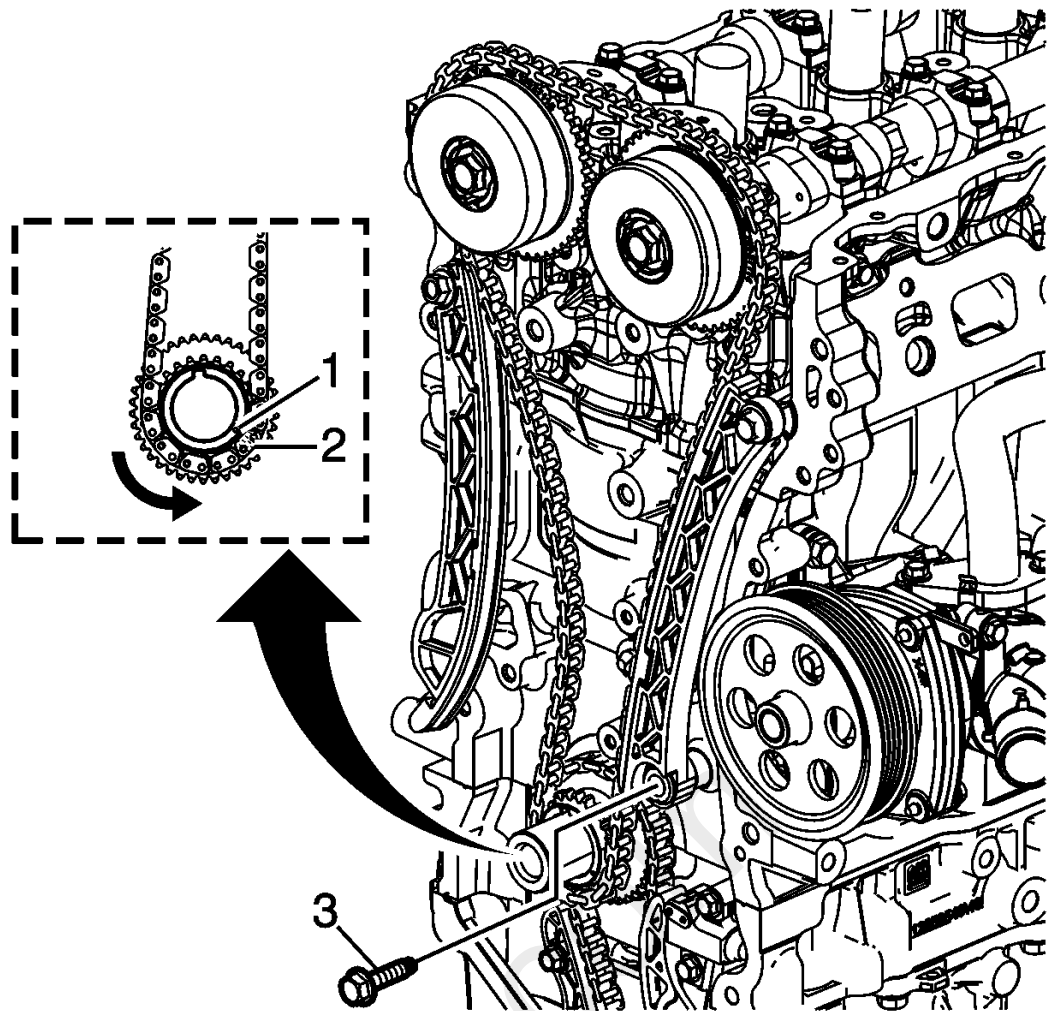


Fig. 553: Crankshaft Sprocket

Courtesy of GENERAL MOTORS COMPANY

7. With a suitable tool, rotate the crankshaft counterclockwise to align the timing mark on the crankshaft sprocket (1) with the unique colored timing link (2).

NOTE:

- Continue to rotate the crankshaft counterclockwise as necessary to maintain timing alignment.
- Ensure that the alignment mark on the exhaust camshaft actuator remains aligned with the corresponding same colored timing link.

8. Rotate the lower end of the fixed timing chain guide into installation position and install the lower bolt (3).

CAUTION: Refer to **Fastener Caution** .

9. tighten the timing chain guide upper and lower bolts to 25 N.m (18 lb ft).

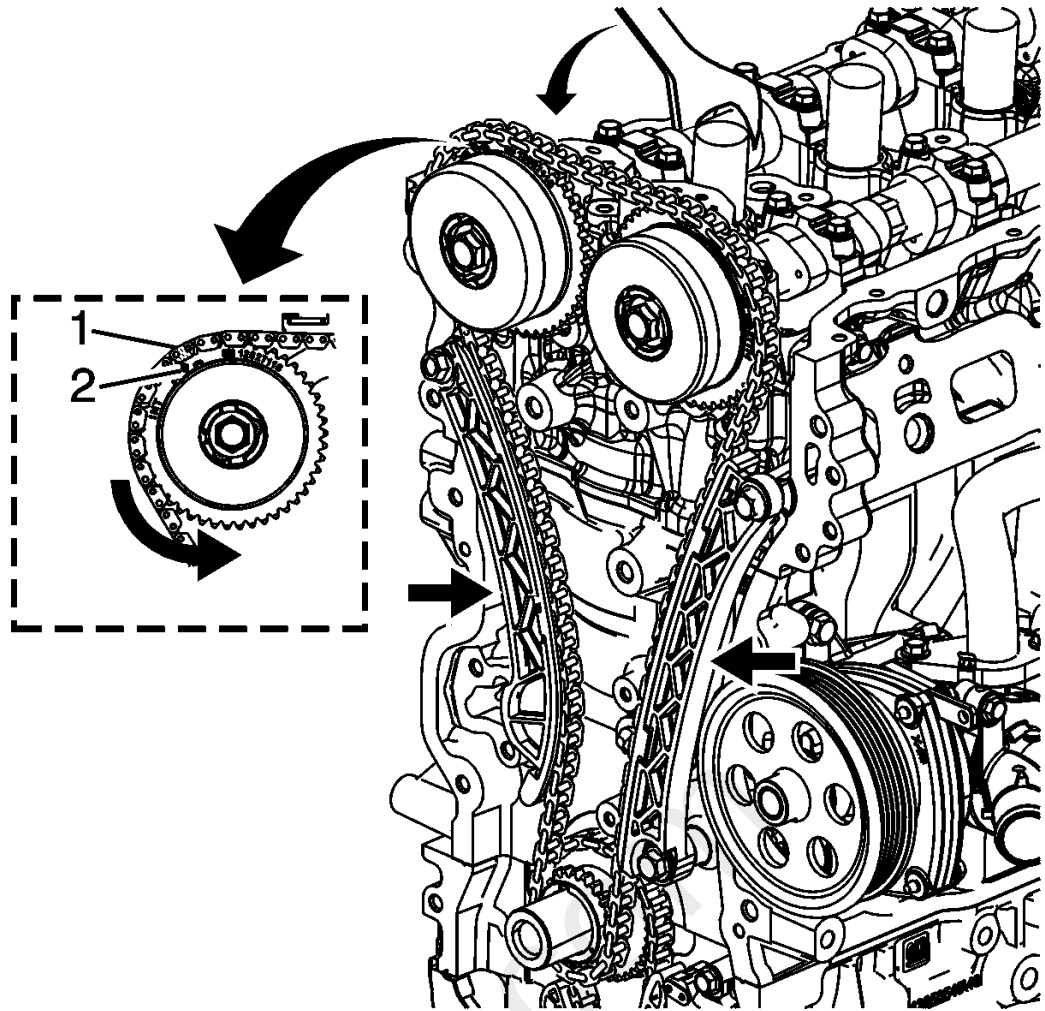


Fig. 554: Timing Mark On Intake Actuator
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

- The timing for the exhaust camshaft actuator and the crankshaft sprocket has been established.
- Applying or loosening pressure by hand between the timing chain guides will allow the chain to slip or bind during counterclockwise rotation of the camshaft.

10. Using a suitable tool, rotate the intake camshaft counterclockwise until the timing mark on the intake actuator (2) is aligned with the corresponding same colored timing link (1). Maintain tension on intake camshaft until the timing chain tensioner can be installed and activated.

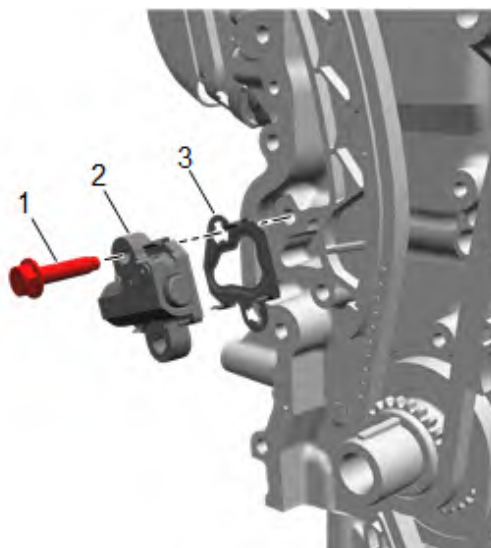


Fig. 555: Timing Chain Tensioner Bolts
 Courtesy of GENERAL MOTORS COMPANY

NOTE:

Ensure EN-50837 retraction tool is installed and the tensioner is locked in a compressed state before installing.

11. Install a NEW timing chain tensioner gasket (3) on the timing chain tensioner (2).
12. While maintaining the intake camshaft actuator timing alignment, install the timing chain tensioner (2) and bolts (1) and tighten to 25 N.m (18 lb ft).
13. tighten the pivot arm bolt to 25 N.m (18 lb ft).
14. Remove **EN-50837** retraction tool.

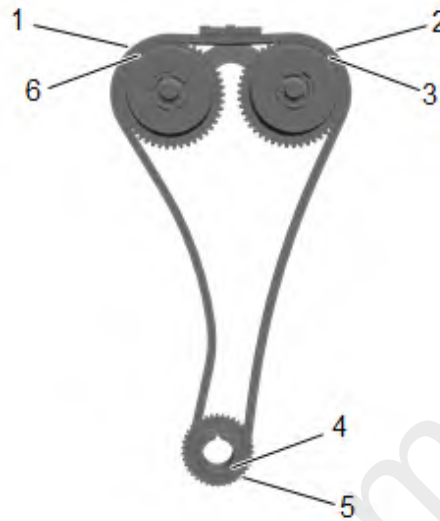


Fig. 556: Timing Chain Oil Nozzle

Courtesy of GENERAL MOTORS COMPANY

15. Verify the timing links on the timing chain are properly aligned to the timing marks:
 1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
 2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
16. If they are not, repeat the portion of the procedure necessary to align the timing marks.

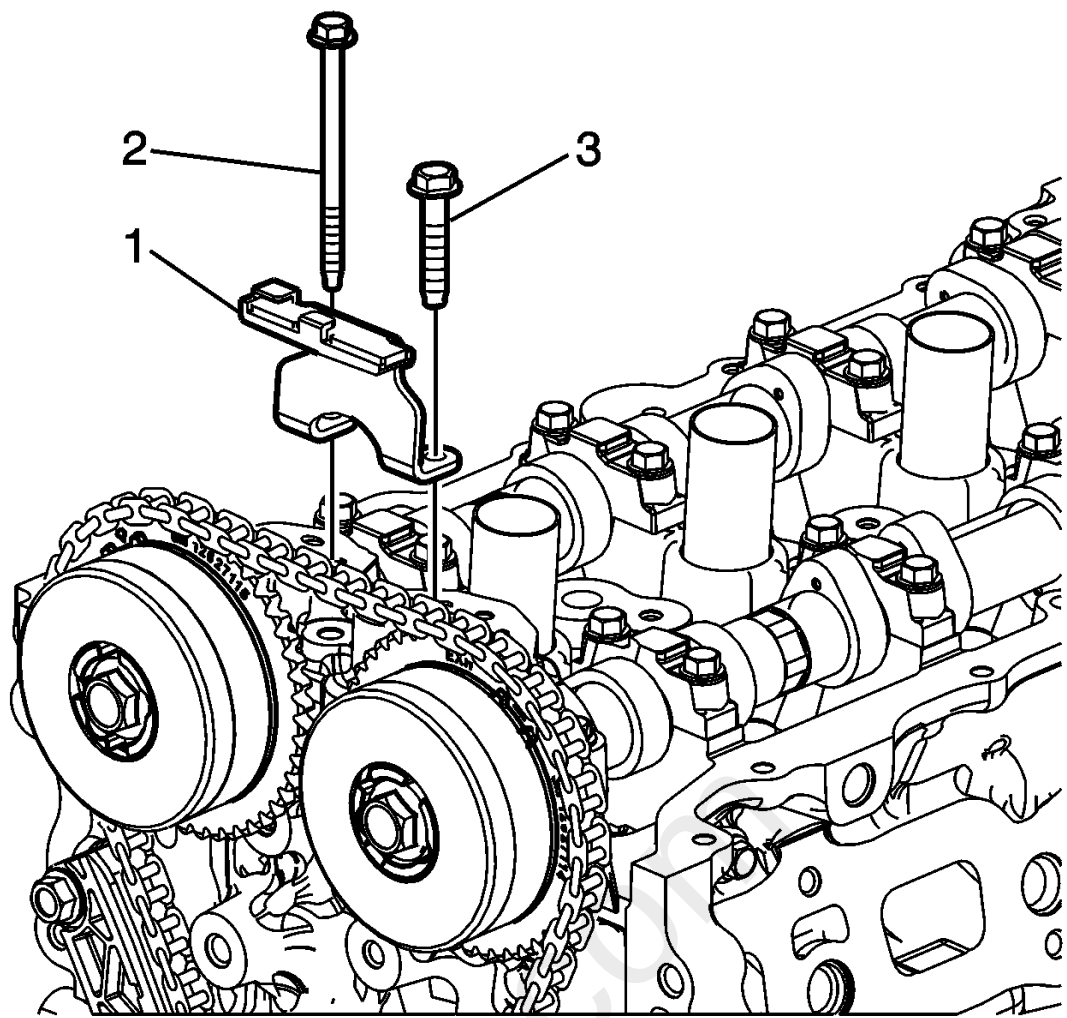


Fig. 557: Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS COMPANY

17. Install the timing chain guide (1) and bolts (2, 3) finger tight.

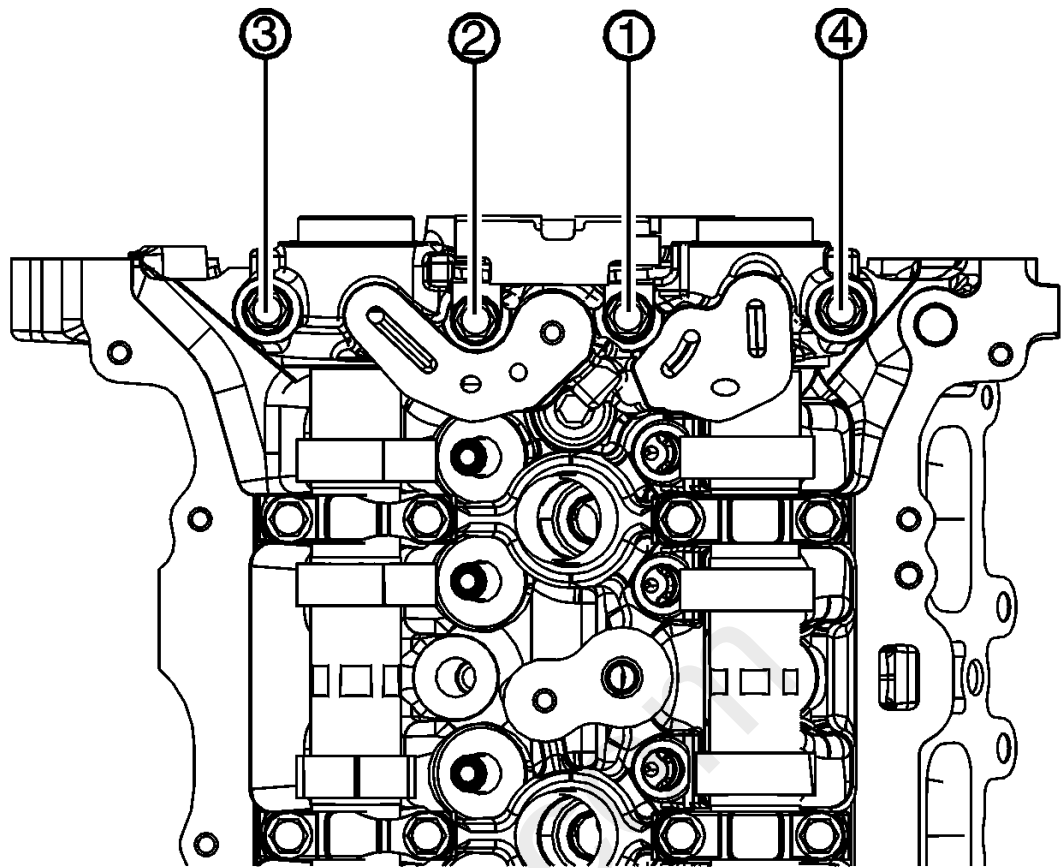


Fig. 558: Front Camshaft Cap Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

18. tighten the front camshaft cap bolts in sequence to 10 N.m (89 lb in) twice.

NOTE: Rotating the crankshaft will engage the tensioner and remove slack from the timing chain.

19. Rotate the crankshaft slightly in a clockwise direction. If the timing chain jumps actuator teeth, repeat procedure to align the timing marks.

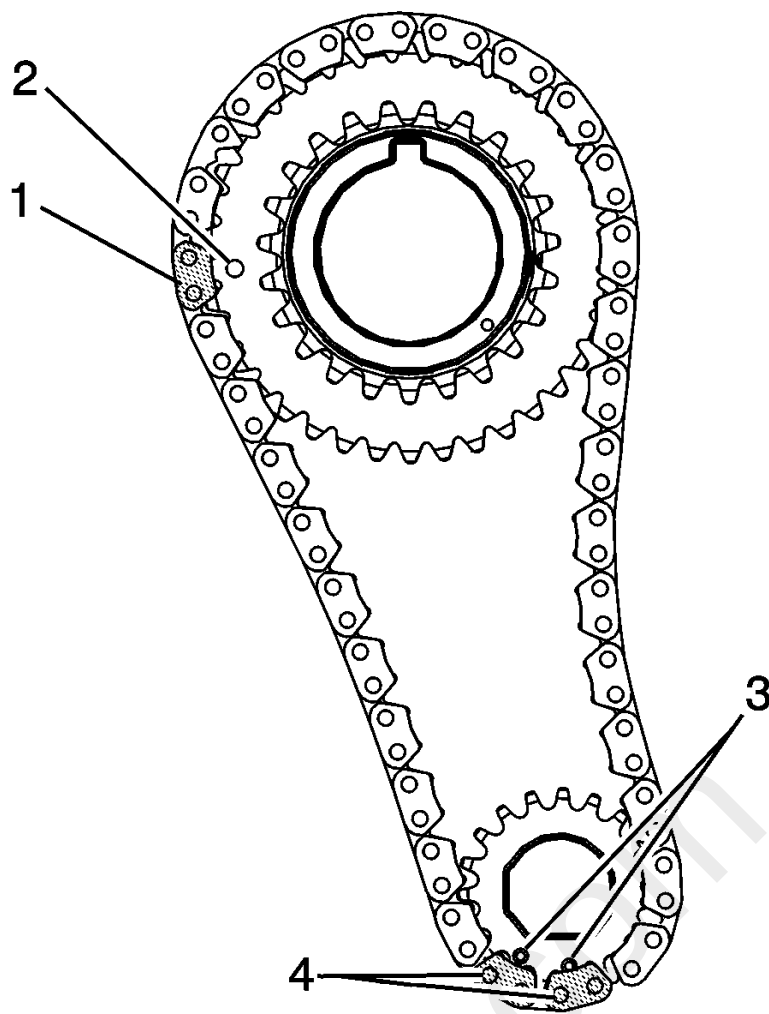
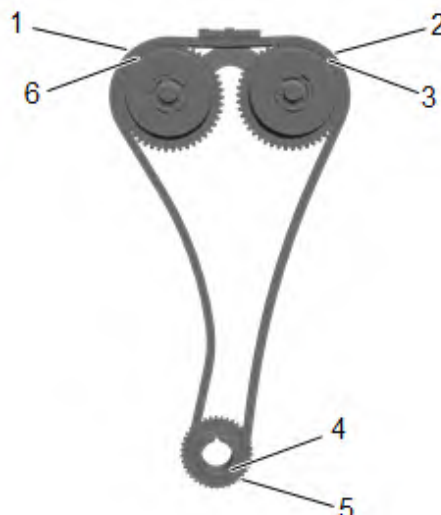


Fig. 559: Timing Link Lines & Timing Mark
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

NOTE: Due to size difference of the crankshaft sprocket and the balance shaft sprocket, timing marks on the chain will not match during every crankshaft revolution. Ensure that the marks on the sprockets are aligned appropriately before installing the timing chain.

20. Verify the timing links on the balance chain are properly aligned to the timing marks:
1. The timing link (1) is aligned to the timing mark on the crankshaft sprocket (2).
 2. The adjacent timing links (4) are aligned with both timing marks (3) on the balancer shaft driven sprocket.



NOTE: Because of slight clockwise rotation, all chain marks may be advanced slightly in relation to the actuator and sprocket marks, yet still aligned.

21. Verify the timing links on the timing chain are properly aligned to the timing marks:
 1. The same colored timing links (1, 2) are aligned to the appropriate timing marks on the camshaft actuators (6, 3).
 2. The unique colored link (5) is aligned to the timing mark on the crankshaft sprocket (4).
22. If they are not, repeat the portion of the procedure necessary to align the timing marks.

ENGINE FRONT COVER INSTALLATION

Special Tools

- **EN-45059** Angle Meter
- **EN-50820** Front Crankshaft Seal Installer

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

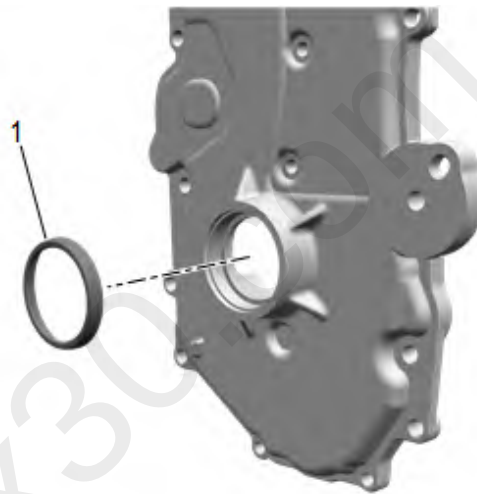


Fig. 561: Front Crankshaft Seal
Courtesy of GENERAL MOTORS COMPANY

1. Using **EN-50820** installer, install the front crankshaft seal (1) into the engine front cover.

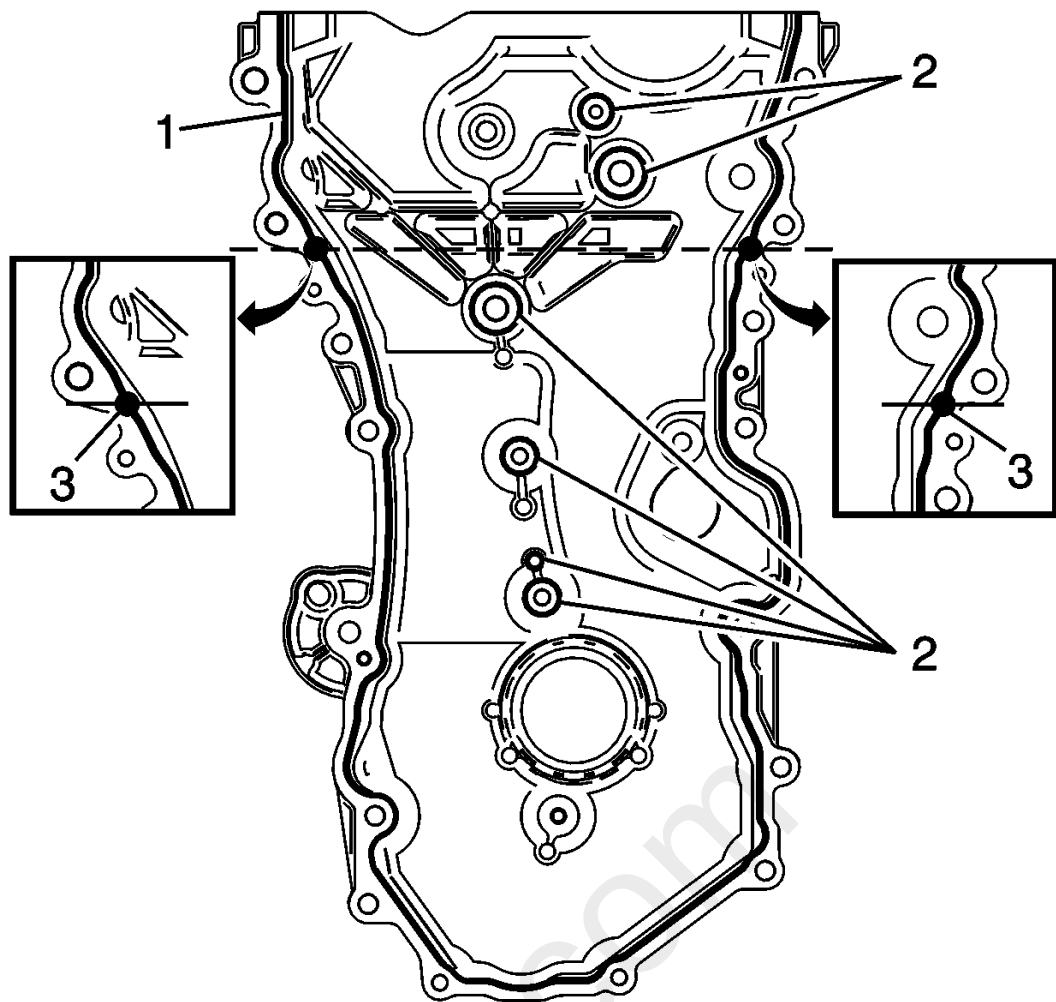


Fig. 562: Applying Bead Of Sealer Directly In Flange

Courtesy of GENERAL MOTORS COMPANY

2. 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 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.
3. Apply a 5 mm bead of sealer directly in the flange (1) of the engine front cover perimeter mating surface. Also apply a 5 mm bead of sealer directly to the locations indicated (2). Finally, apply a 14 mm dab of sealant at the locations indicated (3). Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

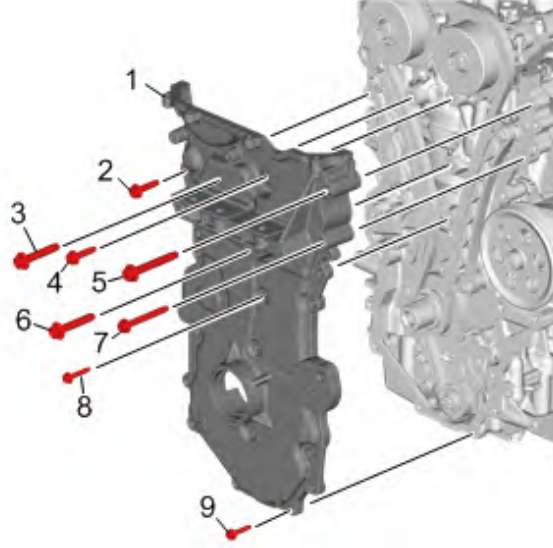


Fig. 563: Engine Front Cover Bolts

Courtesy of GENERAL MOTORS COMPANY

4. Install the engine front cover (1).

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

5. Install by hand 3 NEW M10 bolts (3, 5, 6) in the engine front cover, as shown.
6. Hand start the remaining engine front cover bolts (2, 4, 7, 8, and 9).

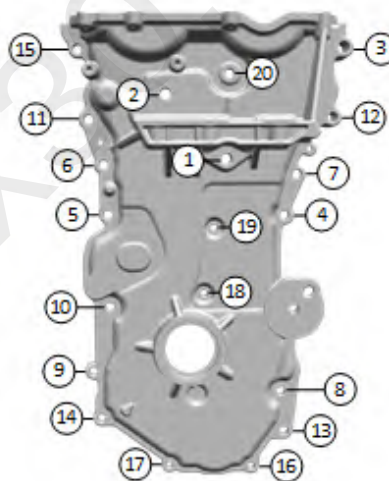


Fig. 564: Engine Front Cover Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

7. tighten the engine front cover bolts in sequence to final torque twice:
 1. tighten the NEW sequence 1 - 3 bolts to 15 N.m (11 lb ft) plus 130 degrees using **EN-45059** meter.
 2. tighten sequence 4 - 11 bolts to 25 N.m (18 lb ft).
 3. tighten sequence 12 bolt to 25 N.m (18 lb ft).
 4. tighten sequence 13 - 15 bolts to 25 N.m (18 lb ft).
 5. tighten sequence 16 - 17 bolts to 10 N.m (89 lb in).
 6. tighten sequence 18 - 19 bolts to 10 N.m (89 lb in).
 7. tighten sequence 20 bolt to 25 N.m (18 lb ft).

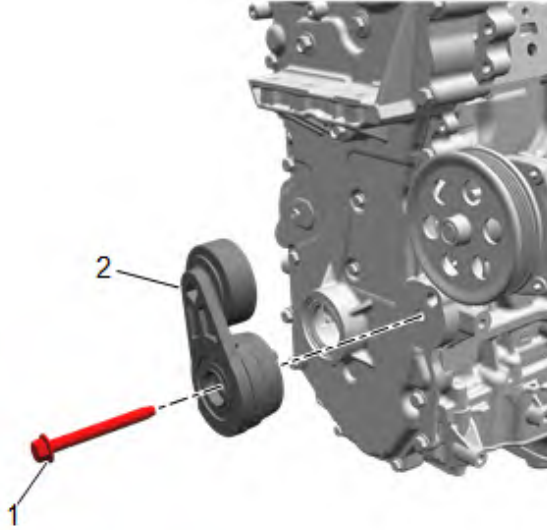


Fig. 565: Accessory Drive Belt Tensioner And Bolt
 Courtesy of GENERAL MOTORS COMPANY

8. Install the accessory drive belt tensioner (2).
9. Install the accessory drive belt tensioner bolt (1) and tighten to 58 N.m (43 lb ft).

CAMSHAFT COVER INSTALLATION (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

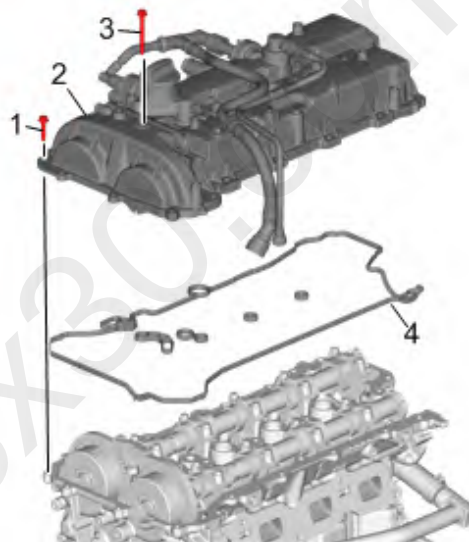


Fig. 566: Camshaft Cover, Bolts And Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure all camshaft cover gaskets are replaced, including the inner gaskets.

1. Assemble the camshaft cover (2) and NEW gaskets (4). Ensure each gasket is located in the correct retaining groove in the camshaft cover.
2. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
3. Add a 14 mm bead of sealant at the right and left T-joint where the front cover meets the cylinder head and at the rear of the camshaft cover at the right and left T-joint where the vacuum pump bolts on. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#).
4. Install the cover on the cylinder head and hand start the bolts (1, 3).

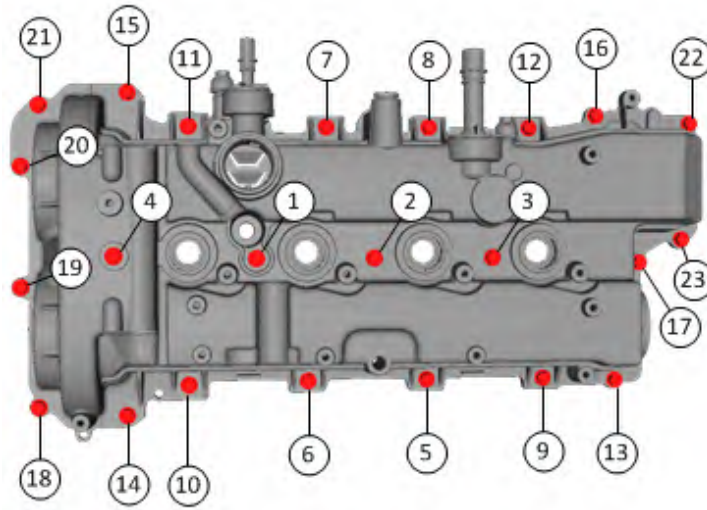


Fig. 567: Camshaft Cover Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

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

5. tighten the camshaft cover bolts in sequence to 10 N.m (89 lb in).

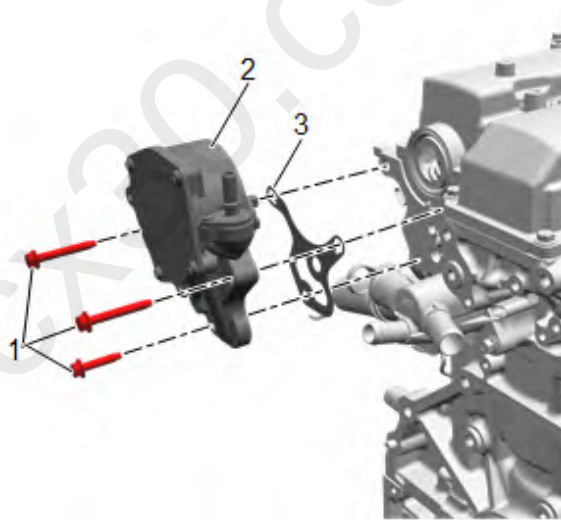


Fig. 568: Vacuum Assembly And Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the vacuum pump seal does not need to be replaced, and the sealing surface is clean prior to installing the gasket and pump.

6. Inspect the vacuum pump seal. Refer to [Camshaft Cover and Compressor Air Intake Turbocharger Cleaning and Inspection](#).
7. Install a NEW vacuum pump assembly gasket (3) on the vacuum pump assembly (2).
8. Install the vacuum pump assembly (2) and bolts (1). tighten the bolts to 10 N.m (89 lb in).

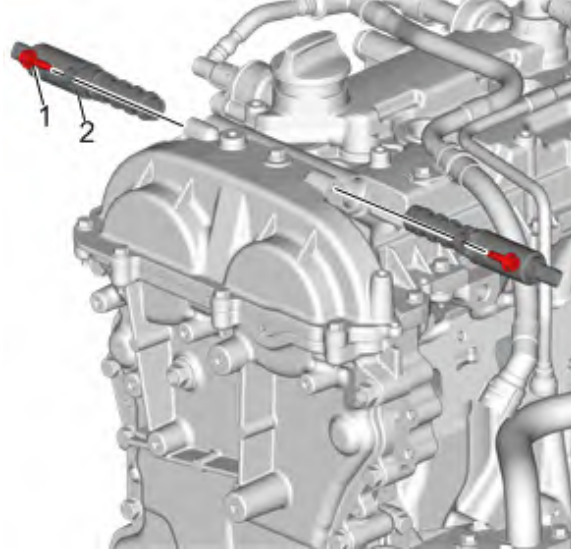


Fig. 569: Camshaft Position Actuator Solenoid Valves And Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Install the camshaft position actuator solenoid valves (2) and bolts (1). tighten the bolts to 10 N.m (89 lb in).

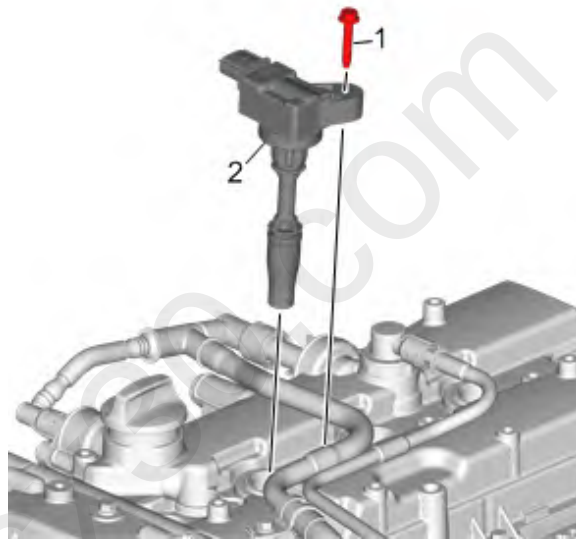


Fig. 570: Ignition Coils And Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:
 1. 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](#).
 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
11. Install the ignition coils (2) and bolts (1). tighten the bolt to 10 N.m (89 lb in).

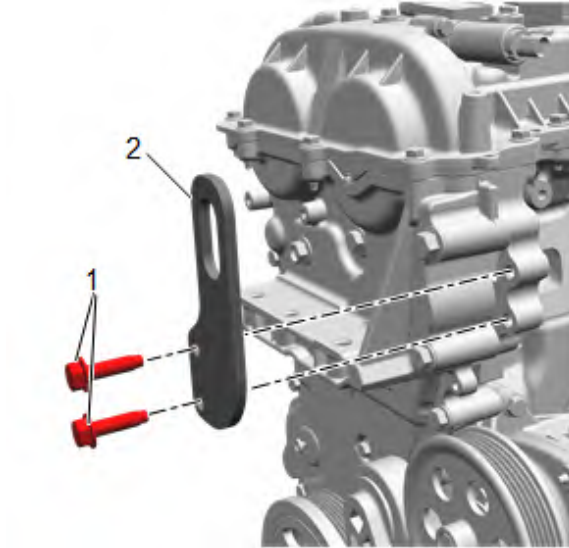


Fig. 571: Front Lift Bracket

Courtesy of GENERAL MOTORS COMPANY

12. Install the front lift bracket (2).
13. Install the front lift bracket bolts (1) and tighten to 25 N.m (18 lb ft).

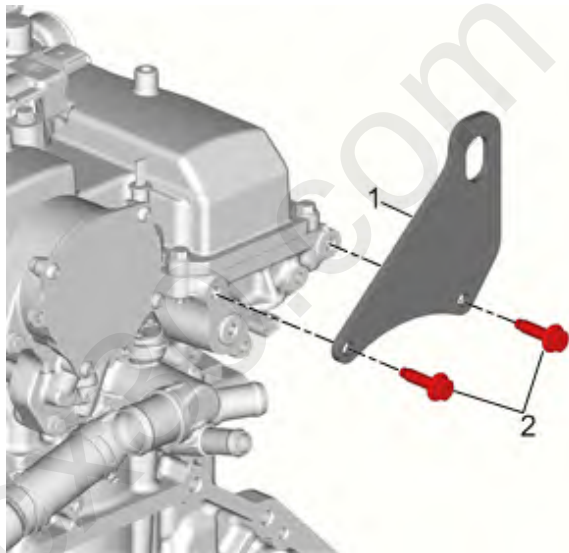


Fig. 572: Rear Lift Bracket And Bolts

Courtesy of GENERAL MOTORS COMPANY

14. Install the rear lift bracket (1).
15. Install the rear lift bracket bolts (2) and tighten to 25 N.m (18 lb ft).

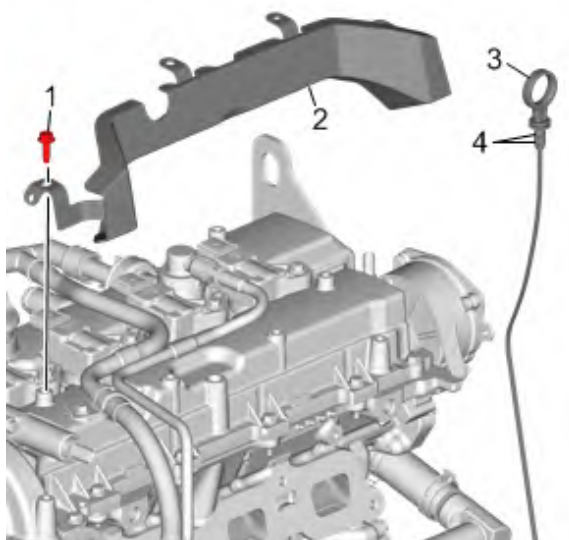


Fig. 573: Oil Level Indicator, O-Rings, Camshaft Cover Heat Shield And Bolts

Courtesy of GENERAL MOTORS COMPANY

16. Install the camshaft cover heat shield (2) and bolts (1). tighten the bolts to 10 N.m (89 lb in).
17. Inspect the oil level indicator O-ring seals (4) and replace if necessary. Install the oil level indicator (3).

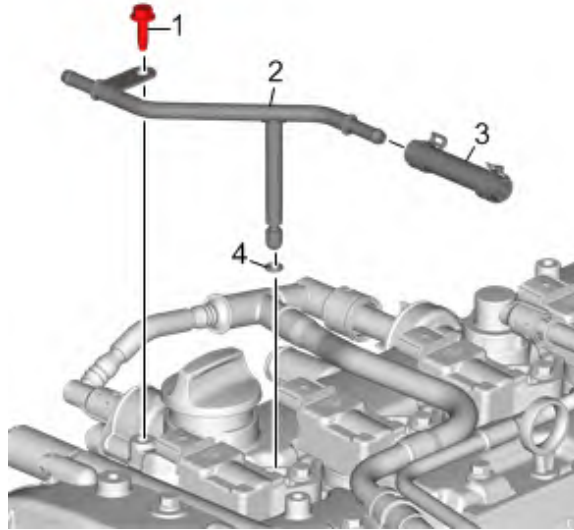


Fig. 574: Engine Coolant Air Bleed Pipe/Hose, Bolt And O-Ring
Courtesy of GENERAL MOTORS COMPANY

18. Inspect the O-ring (4) on the engine coolant air bleed pipe. Replace if necessary.
19. Install the engine coolant air bleed hose (3), if necessary.
20. Install the engine coolant air bleed pipe (2).
21. Install the pipe bolt (1) and tighten to 10 N.m (89 lb in).

FUEL RAIL AND INJECTORS INSTALLATION

Special Tools

EN-47909 Injector Bore and Sleeve Cleaning Kit

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

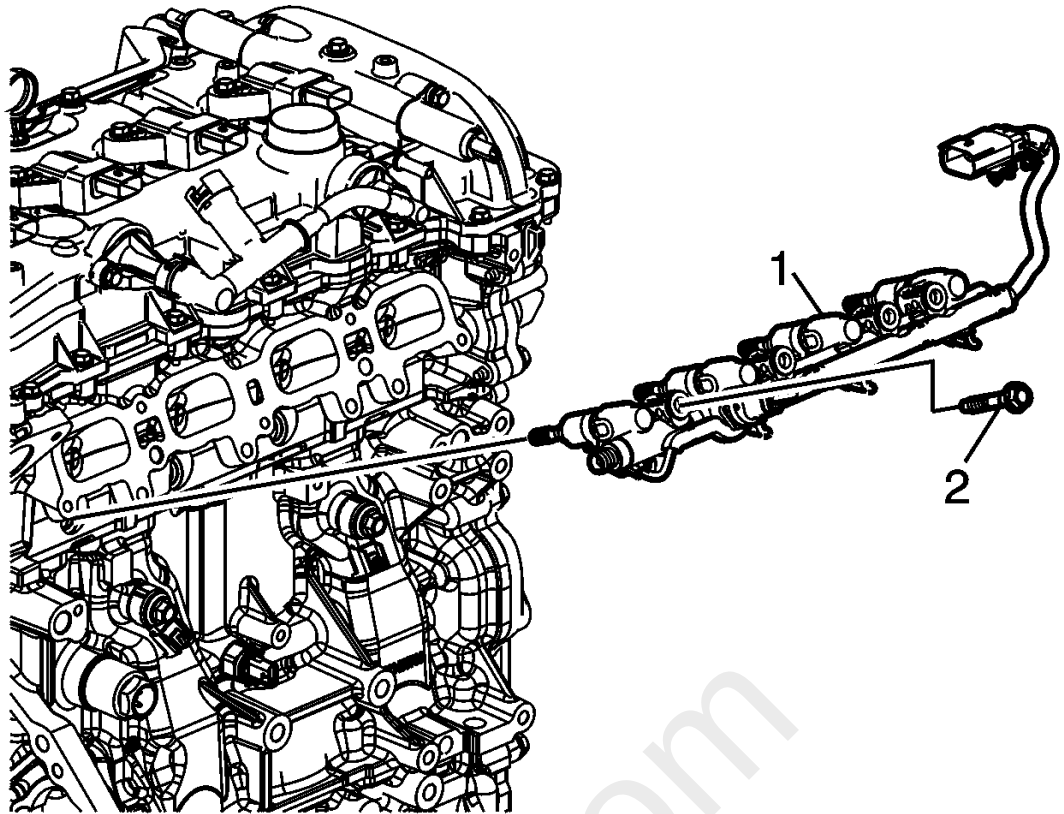


Fig. 575: Fuel Rail

Courtesy of GENERAL MOTORS COMPANY

1. Clean the fuel injector bore in the cylinder head using the EN-47909 kit.
2. Replace the fuel rail insulators, if necessary. Refer to [Fuel Rail and Injectors Cleaning and Inspection](#). Replace the fuel rail bolts, if necessary.
3. Replace fuel injector Teflon seals with NEW when transferring fuel rail and injectors on to service engine assembly. Refer to [Fuel Rail and Injectors Cleaning and Inspection](#).
4. Install the fuel rail (1) with injectors into the cylinder head evenly.

NOTE: Mount the bolts evenly to avoid cocking of the fuel injectors during installation.

NOTE: Avoid contamination and contact damage of fuel injectors nozzle tips.

5. Hand start the 2 outer fuel rail bolts (2) to seat the injectors into the injector bores.
6. Hand start the remaining fuel rail bolts.

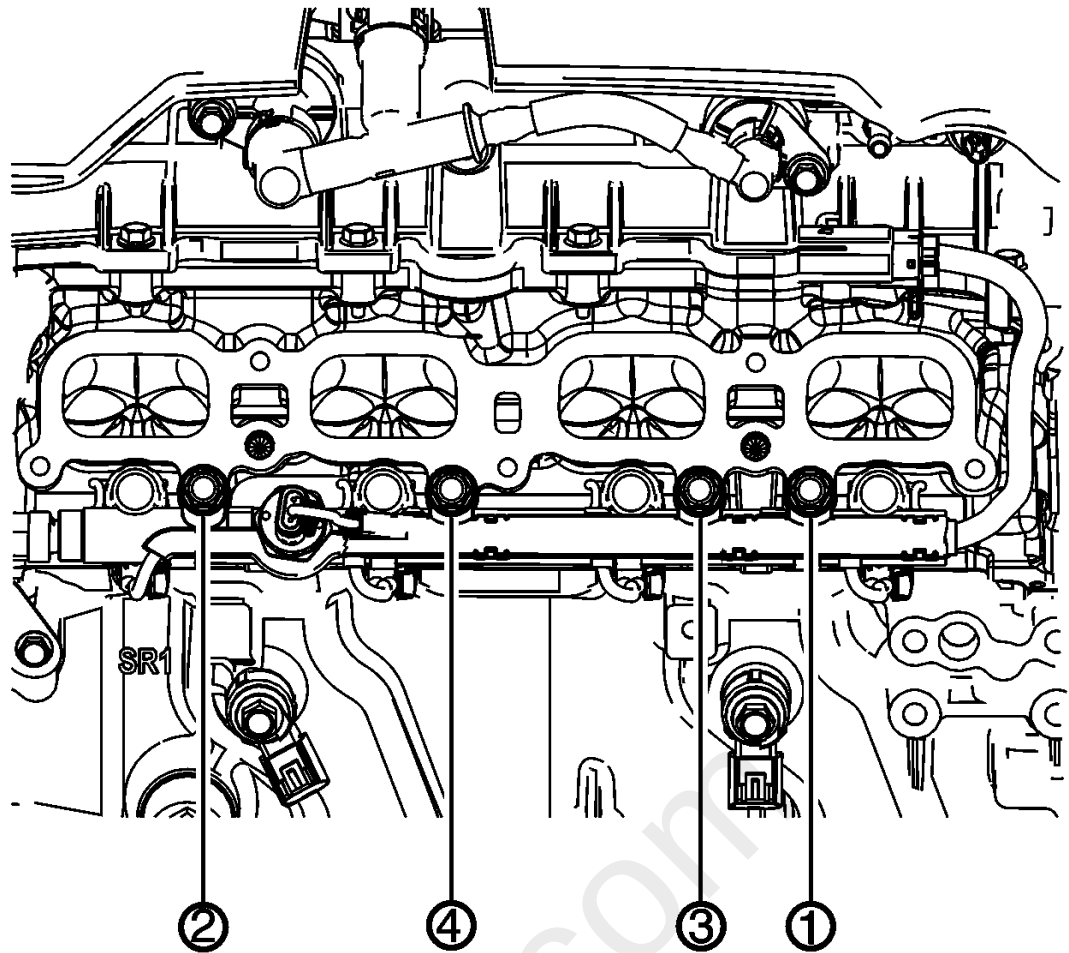


Fig. 576: Fuel Rail Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

7. tighten the fuel rail bolts in sequence to 25 N.m (18 lb ft).
8. Connect the electrical harness to the fuel rail harness connections.

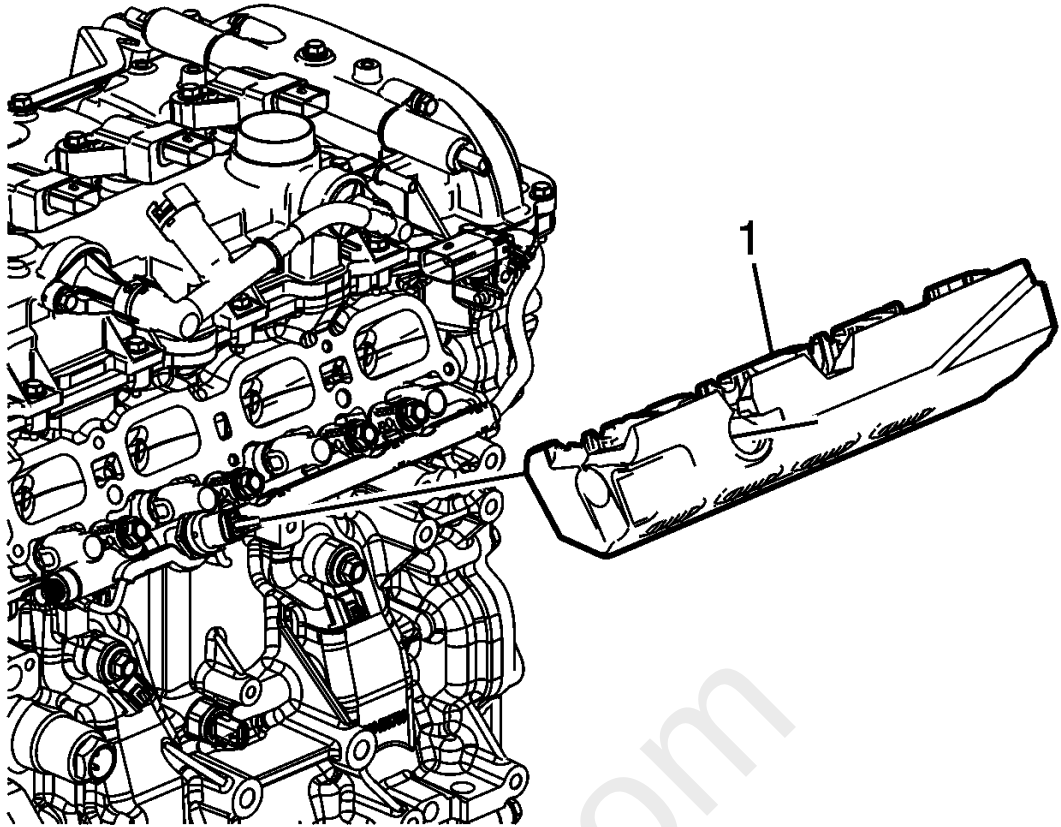


Fig. 577: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

WARNING: The noise cancelling foam component **MUST** be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

9. Install the fuel injection fuel rail noise shield (1).

EXHAUST MANIFOLD INSTALLATION

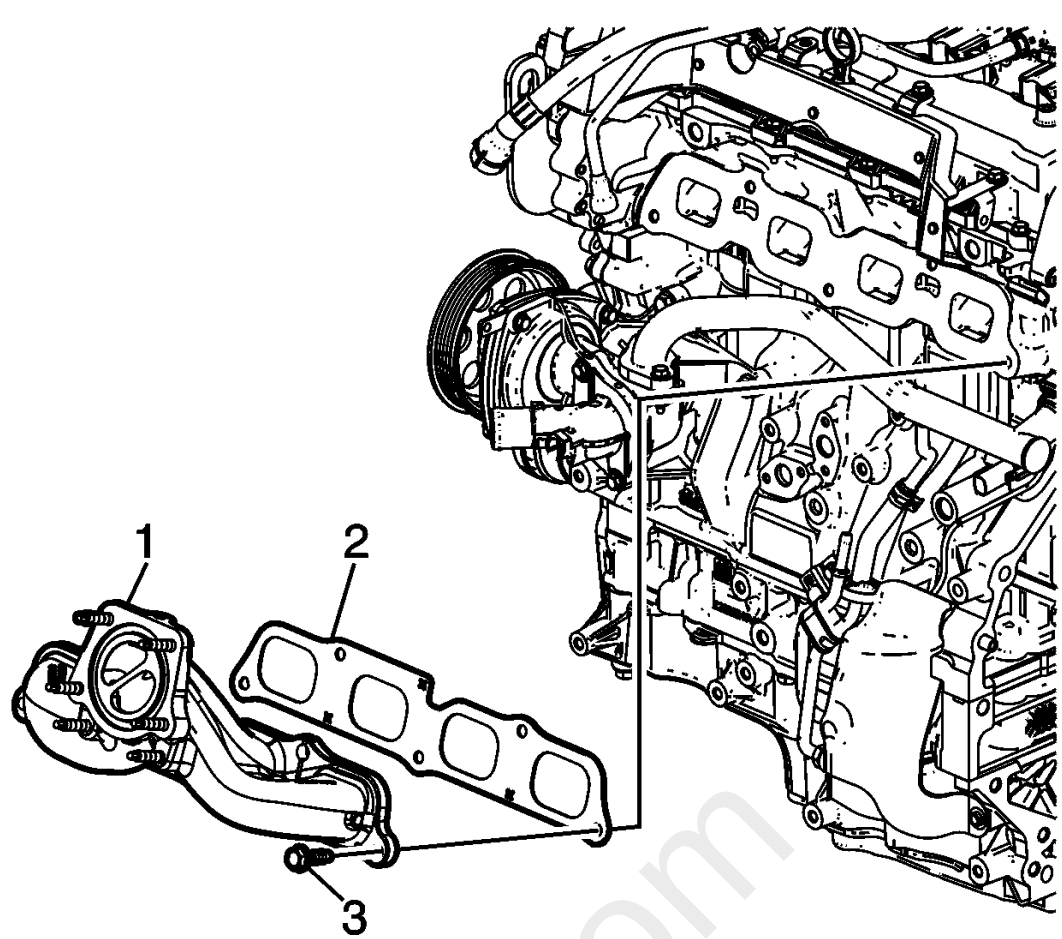


Fig. 578: Exhaust Manifold And Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW exhaust manifold gasket (2).
2. Install the exhaust manifold (1) to the cylinder head.
3. Hand start NEW exhaust manifold to cylinder head retaining bolts (3).

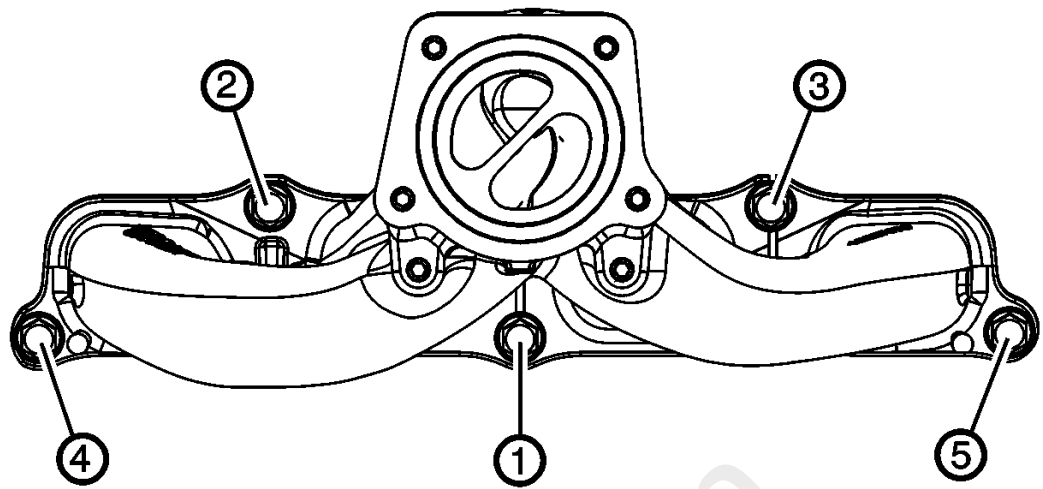


Fig. 579: Exhaust Manifold Bolt tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

4. tighten the NEW exhaust manifold to cylinder head bolts three passes in sequence to 20 N.m (15 lb ft).

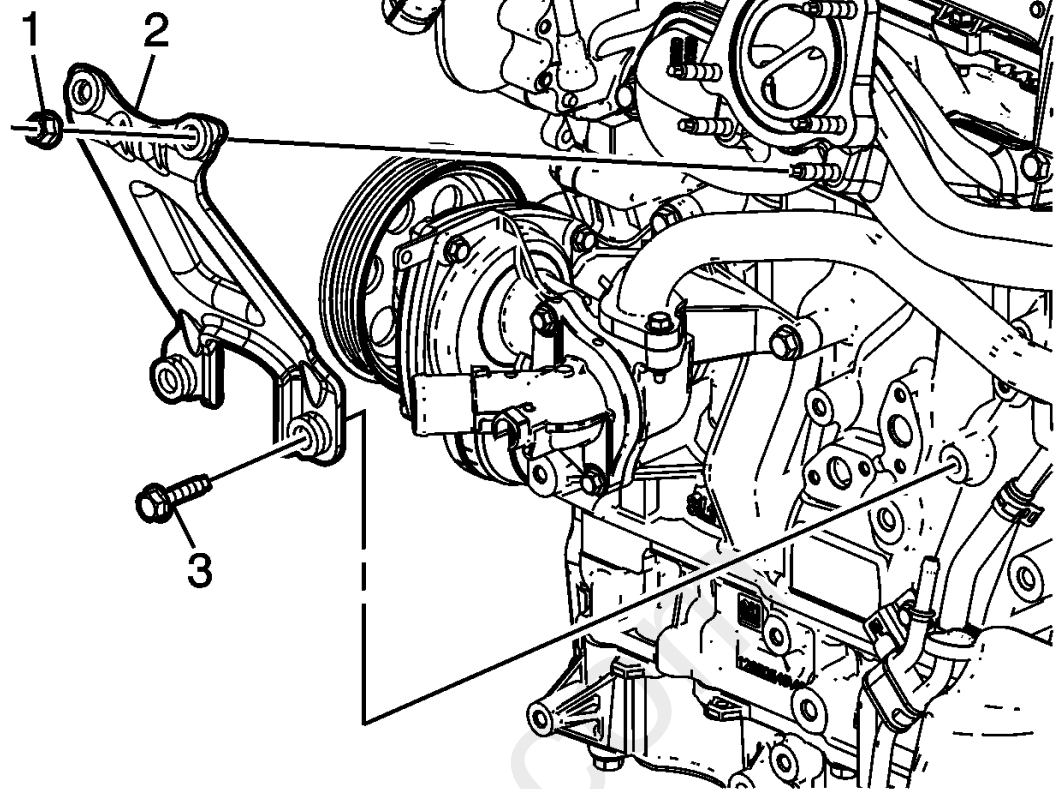


Fig. 580: Exhaust Manifold Brace Nuts
Courtesy of GENERAL MOTORS COMPANY

5. Install the exhaust manifold brace (2).
6. Install the exhaust manifold brace bolts (3) and tighten to 25 N.m (18 lb ft)
7. Install NEW exhaust manifold brace nuts (1) and tighten to 25 N.m (18 lb ft)

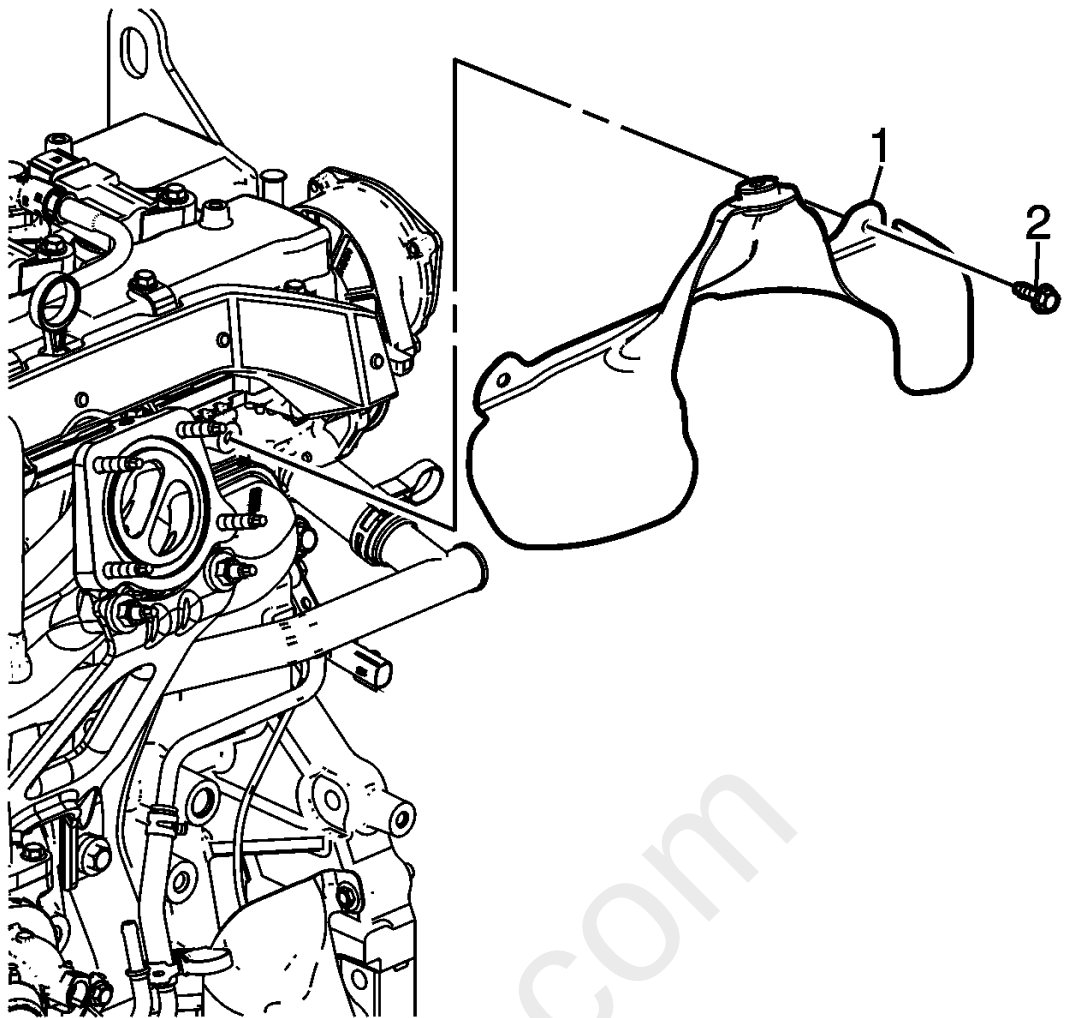


Fig. 581: Exhaust Manifold Heat Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust manifold heat shield (1).
9. Install the exhaust manifold heat shield bolts (2) and tighten to 14 N.m (124 lb in).

CAMSHAFT COVER AND COMPRESSOR AIR INTAKE TURBOCHARGER INSTALLATION (2ND DESIGN TAMPER-PROOF PCV SYSTEM)

Camshaft Cover and Turbocharger Installation

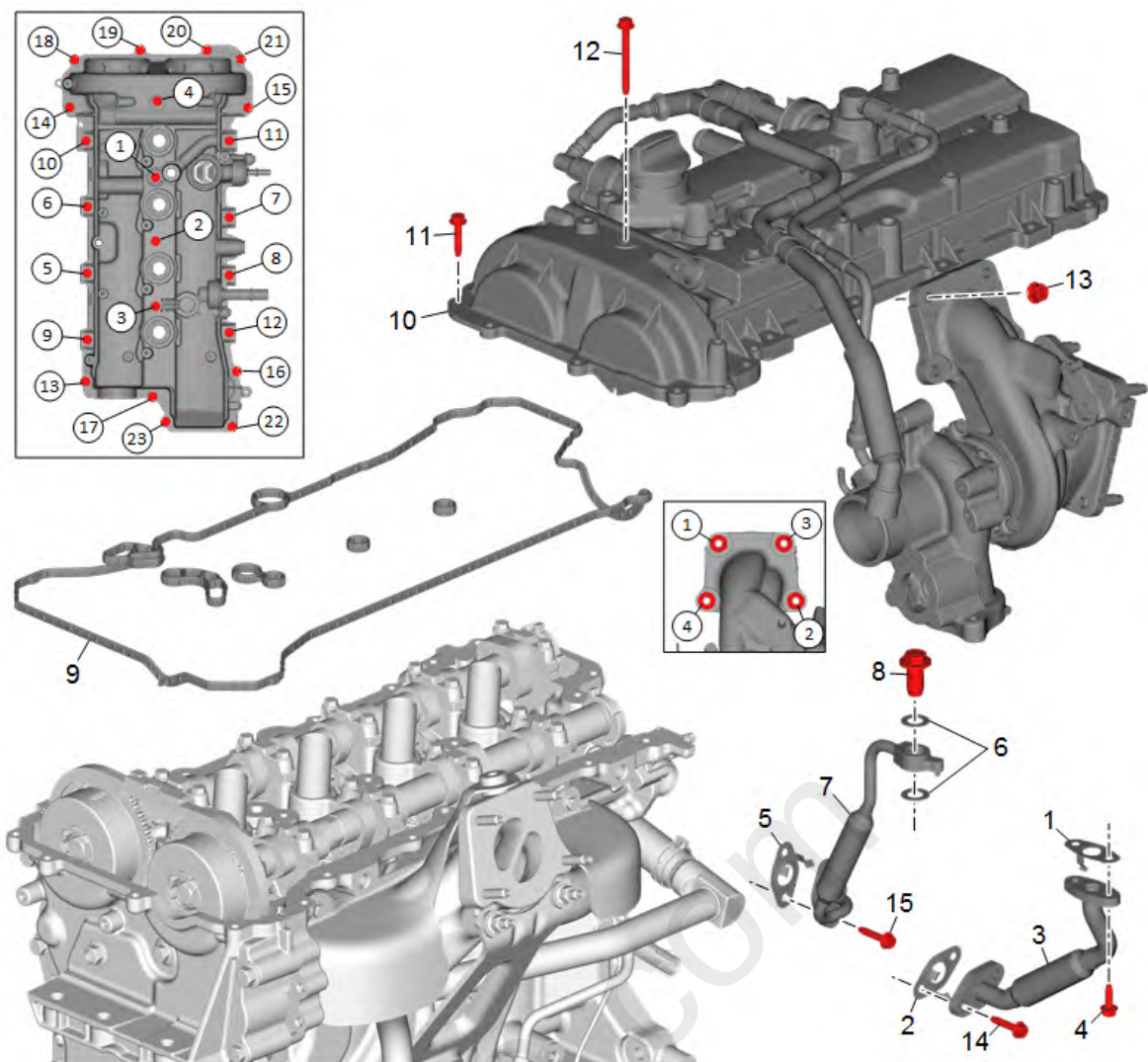


Fig. 582: Camshaft Cover and Turbocharger
Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover and Turbocharger Installation

Callout	Component Name
1	Turbocharger Oil Return Pipe Gasket NOTE: Use a NEW gasket.
2	Turbocharger Oil Return Pipe Gasket NOTE: Use a NEW gasket.
3	Turbocharger Oil Return Pipe
4	Turbocharger Oil Return Pipe Bolt CAUTION: Refer to Fastener Caution . tighten 10 N.m (89 lb in)
5	Turbocharger Oil Feed Pipe Gasket NOTE: Use a NEW gasket.

Callout	Component Name
6	Turbocharger Oil Feed Pipe Washer NOTE: Use NEW washers.
7	Turbocharger Oil Feed Pipe
8	Turbocharger Oil Feed Pipe Bolt tighten 35 N.m (26 lb ft)
9	Camshaft Cover Gasket NOTE: Ensure all camshaft cover gaskets are replaced, including the inner gaskets. Procedure Assemble the camshaft cover and NEW gaskets. Ensure each gasket is located in the correct retaining groove in the camshaft cover.
10	Camshaft Cover Positive Crankcase Ventilation Tube Turbocharger NOTE: The tamper-proof positive crankcase ventilation system includes components that may be replaced if necessary. The system may include an outlet duct connected to the end of the Positive Crankcase Ventilation Tube. Procedure 1. The assistance of a second technician may be necessary to support and move the assembly during installation. 2. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 3. Add a 14 mm bead of sealant at the right and left T-joint where the front cover meets the cylinder head and at the rear of the camshaft cover at the right and left T-joint where the vacuum pump bolts on. Refer to <u>Adhesives, Fluids, Lubricants, and Sealers.</u> NOTE: Be careful when moving the assembled components with tamper-proof fittings to avoid stress on the connections. 4. Install the camshaft cover and turbocharger in position.
11	Camshaft Cover Bolt Procedure Hand start the bolts. tighten all camshaft cover bolts in sequence.
12	Camshaft Cover Bolt Procedure tighten the camshaft cover bolts in sequence to 10 N.m (89 lb in).

Callout	Component Name
13	Turbocharger Nut CAUTION: Refer to Torque-to-Yield Fastener Caution . Procedure 1. tighten the NEW turbocharger nuts a first pass in sequence to 30 N.m (22 lb ft). 2. tighten the NEW turbocharger nuts a final pass in sequence to 90 degrees. Special Tools EN-45059 Angle Meter Equivalent regional tools: Special Tools.
14	Turbocharger Oil Return Pipe Bolt tighten 10 N.m (89 lb in)
15	Turbocharger Oil Feed Pipe Bolt tighten 10 N.m (89 lb in)

Camshaft Cover Component Installation

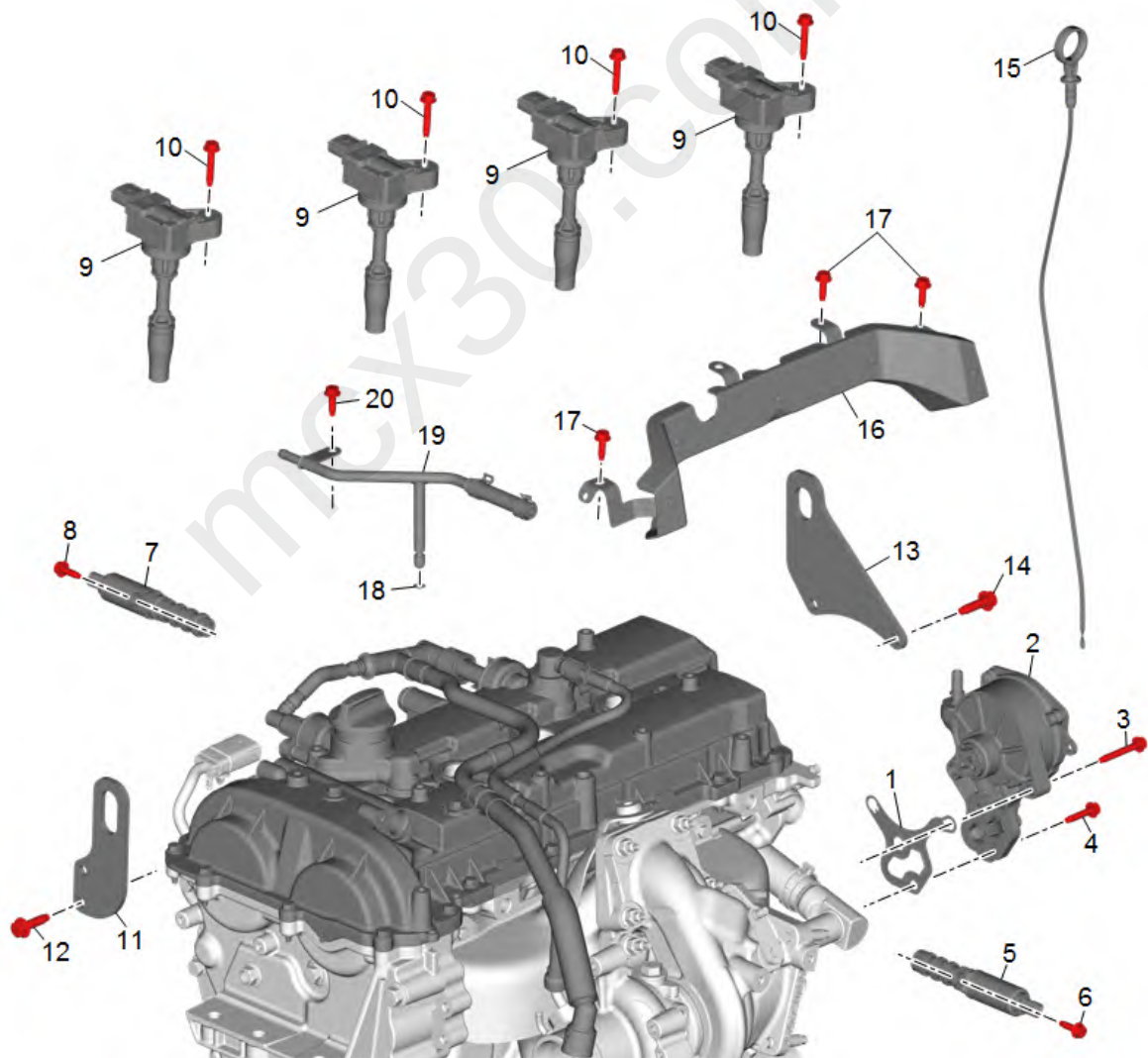


Fig. 583: Camshaft Cover Component
 Courtesy of GENERAL MOTORS COMPANY

Camshaft Cover Component Installation

Callout	Component Name

Callout	Component Name
1	Vacuum Pump Gasket NOTE: Use a NEW gasket.
2	Vacuum Pump
3	Vacuum Pump Bolt tighten 10 N.m (89 lb in)
4	Vacuum Pump Bolt tighten 10 N.m (89 lb in)
5	Camshaft Position Actuator Solenoid Valve - Exhaust
6	Camshaft Position Actuator Solenoid Valve Bolt tighten 10 N.m (89 lb in)
7	Camshaft Position Actuator Solenoid Valve - Intake
8	Camshaft Position Actuator Solenoid Valve Bolt tighten 10 N.m (89 lb in)
9	Ignition Coil 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.
10	Ignition Coil Bolt tighten 10 N.m (89 lb in)
11	Engine Lift Front Bracket
12	Engine Lift Front Bracket Bolt tighten 25 N.m (18 lb ft)
13	Engine Lift Rear Bracket
14	Engine Lift Rear Bracket Bolt tighten 25 N.m (18 lb ft)
15	Oil Level Indicator
16	Camshaft Cover Heat Shield
17	Camshaft Cover Heat Shield Bolt NOTE: An additional bolt retains the camshaft cover heat shield and the turbocharger coolant return pipe. tighten 10 N.m (89 lb in)
18	Engine Coolant Air Bleed Pipe O-Ring
19	Engine Coolant Air Bleed Pipe
20	Engine Coolant Air Bleed Pipe Bolt tighten 10 N.m (89 lb in)

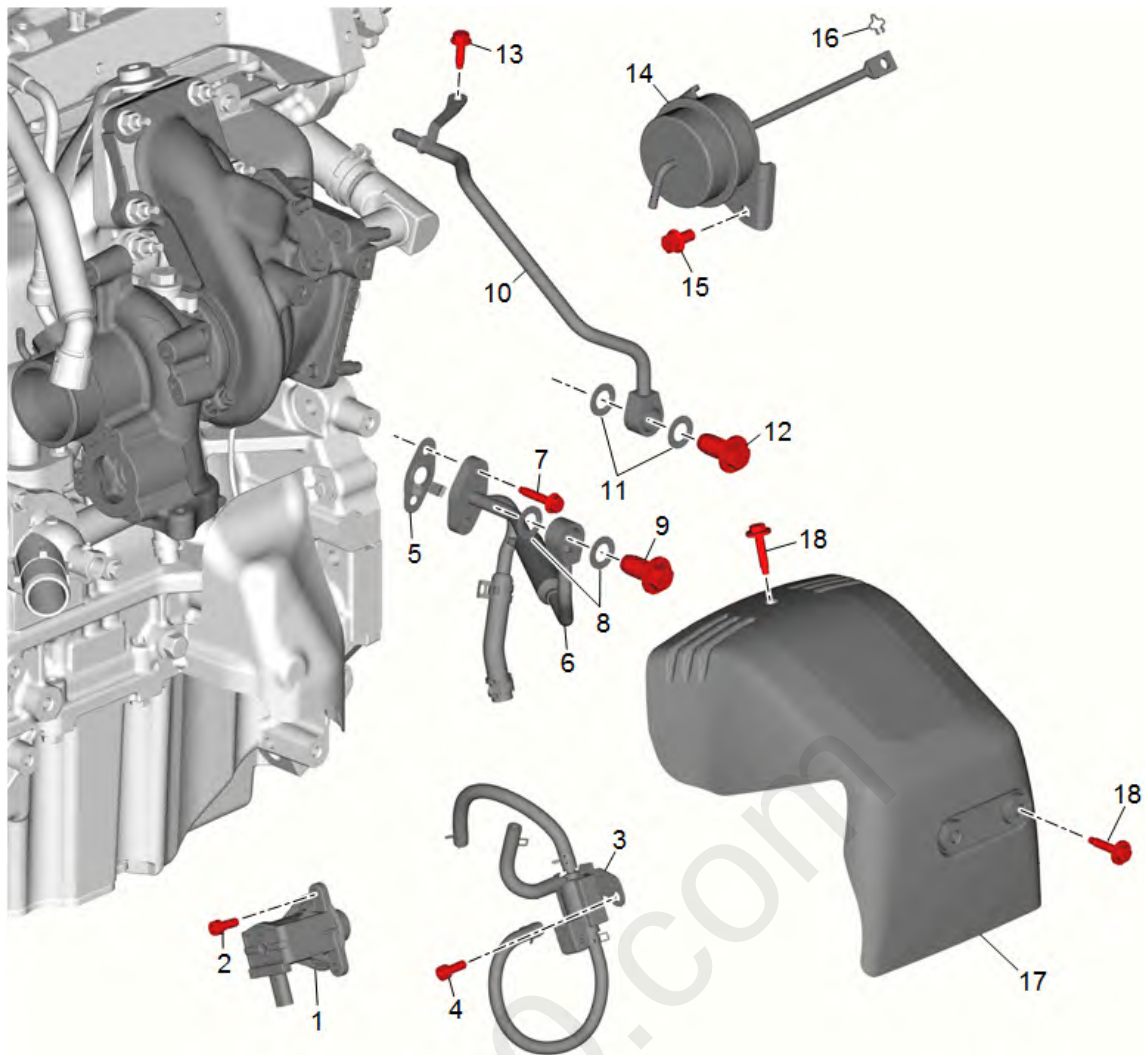


Fig. 584: Turbocharger Component
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Component Installation

Callout	Component Name
1	Turbocharger Air Bypass Valve Solenoid
2	Turbocharger Air Bypass Valve Solenoid Bolt tighten 8 N.m (71 lb in)
3	Turbocharger Wastegate Regulator Solenoid Valve Procedure Connect the turbocharger wastegate regulator solenoid valve hoses to the turbocharger.
4	Turbocharger Wastegate Regulator Solenoid Valve Bolt tighten 8 N.m (71 lb in)
5	Turbocharger Coolant Feed Pipe Gasket NOTE: Use a NEW gasket.
6	Turbocharger Coolant Feed Pipe
7	Turbocharger Coolant Feed Pipe Bolt tighten 10 N.m (89 lb in)

Callout	Component Name
8	Turbocharger Coolant Feed Pipe Washer NOTE: Use NEW washers.
9	Turbocharger Coolant Feed Pipe Bolt tighten 35 N.m (26 lb ft)
10	Turbocharger Coolant Return Pipe
11	Turbocharger Coolant Return Pipe Washer NOTE: Use NEW washers.
12	Turbocharger Coolant Return Pipe Bolt tighten 35 N.m (26 lb ft)
13	Turbocharger Coolant Return Pipe Bolt NOTE: One bolt retains the turbocharger coolant return pipe and the camshaft cover heat shield at the same location. tighten 10 N.m (89 lb in)
14	Turbocharger Wastegate Actuator
15	Turbocharger Wastegate Actuator Bolt tighten 8 N.m (71 lb in)
16	Turbocharger Wastegate Actuator Arm Retainer
17	Turbocharger Heat Shield
18	Turbocharger Heat Shield Bolt tighten 14 N.m (124 lb in)

INTAKE MANIFOLD INSTALLATION

Special Tools

- **EN-45059** Angle Meter
- **EN-50790** HP Fuel Pump Installation Alignment Gauge

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

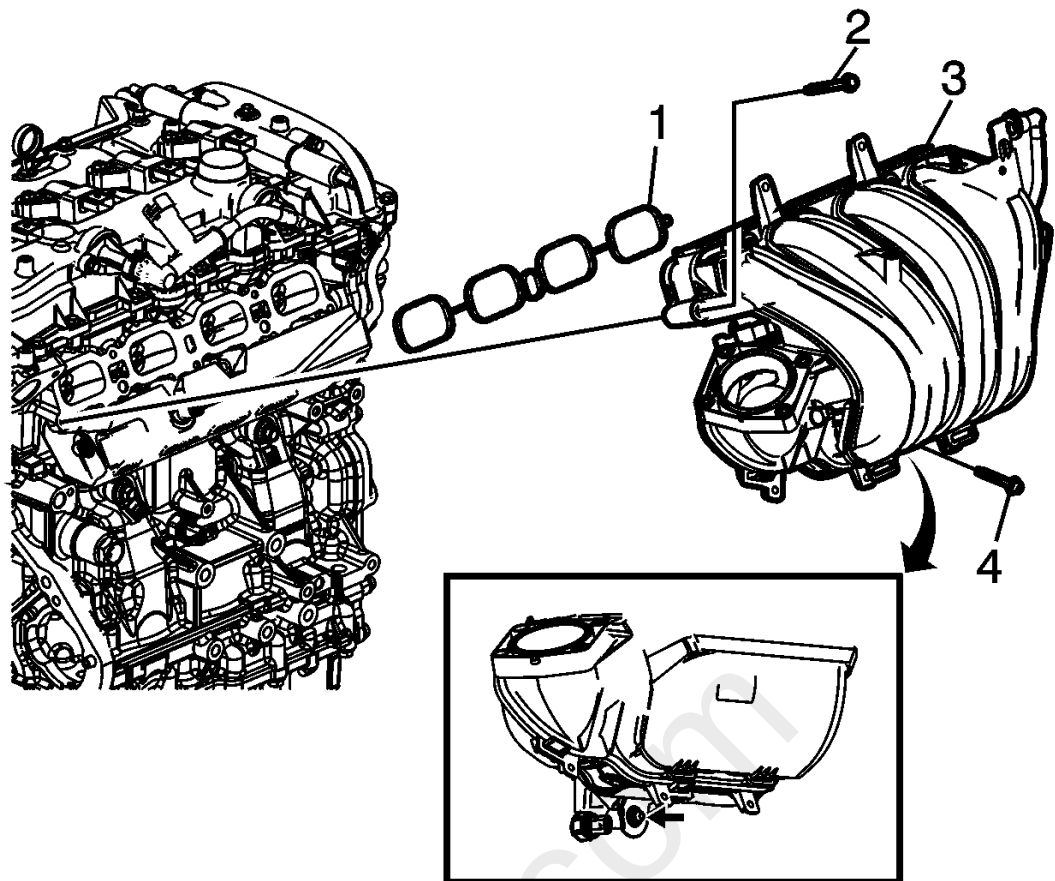


Fig. 585: Intake Manifold And Gasket

Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW gasket (1) on the intake manifold (3). Install the intake manifold and hand start the intake manifold bolts (2, 4).

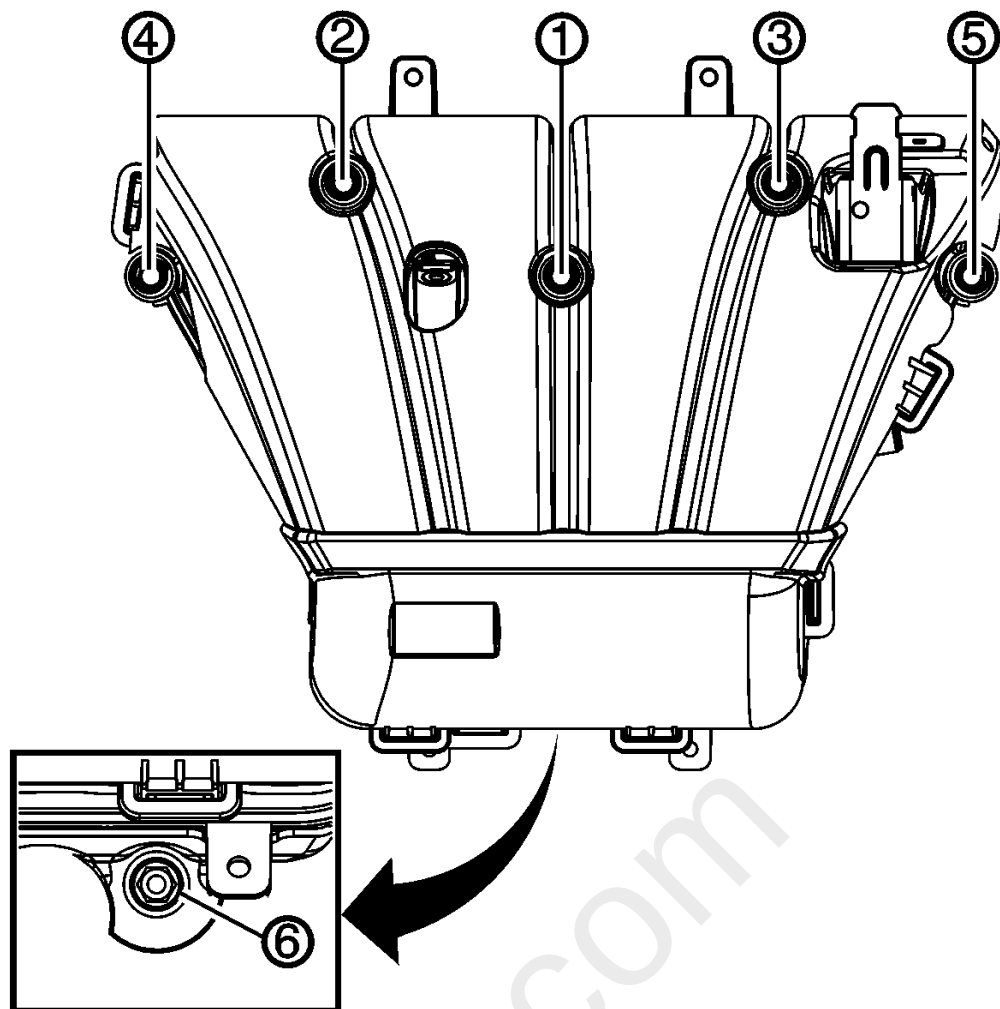


Fig. 586: Intake Manifold Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

2. tighten the bolts and nuts in sequence twice to 12 N.m (106 lb in).

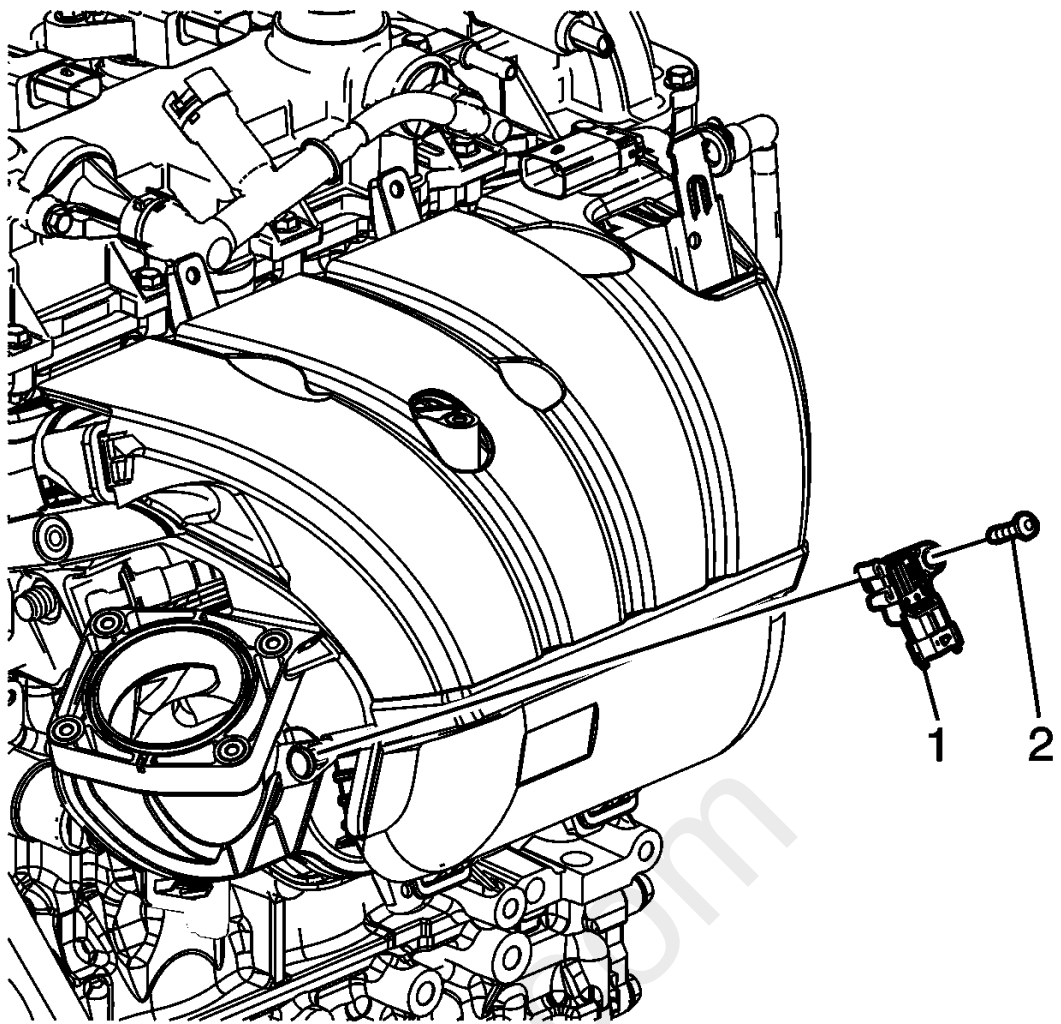


Fig. 587: MAP Sensor And Bolt

Courtesy of GENERAL MOTORS COMPANY

3. Install the MAP sensor (1) and bolt (2). tighten the bolt to 5 N.m (44 lb in).

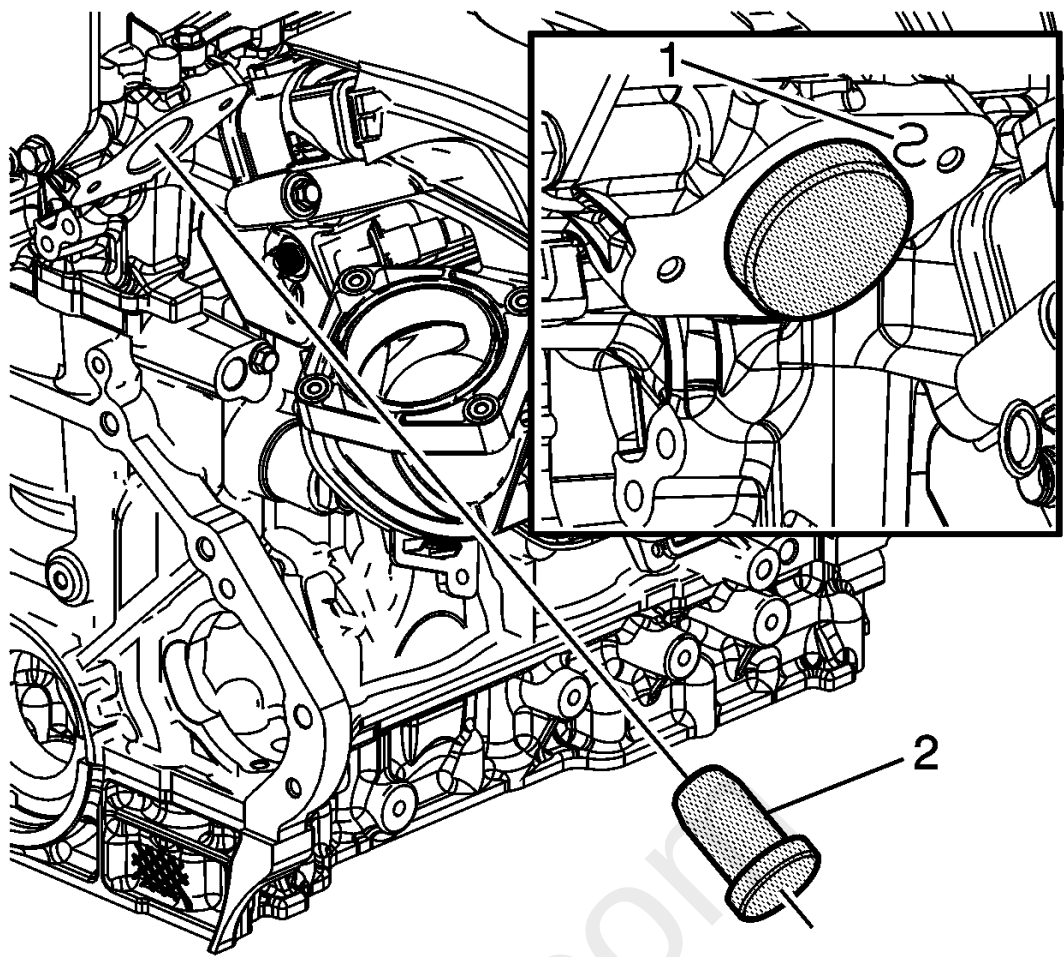


Fig. 588: View Of HP Fuel Pump Installation Alignment Gauge

Courtesy of GENERAL MOTORS COMPANY

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

4. Use the EN-50790 alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head (1).

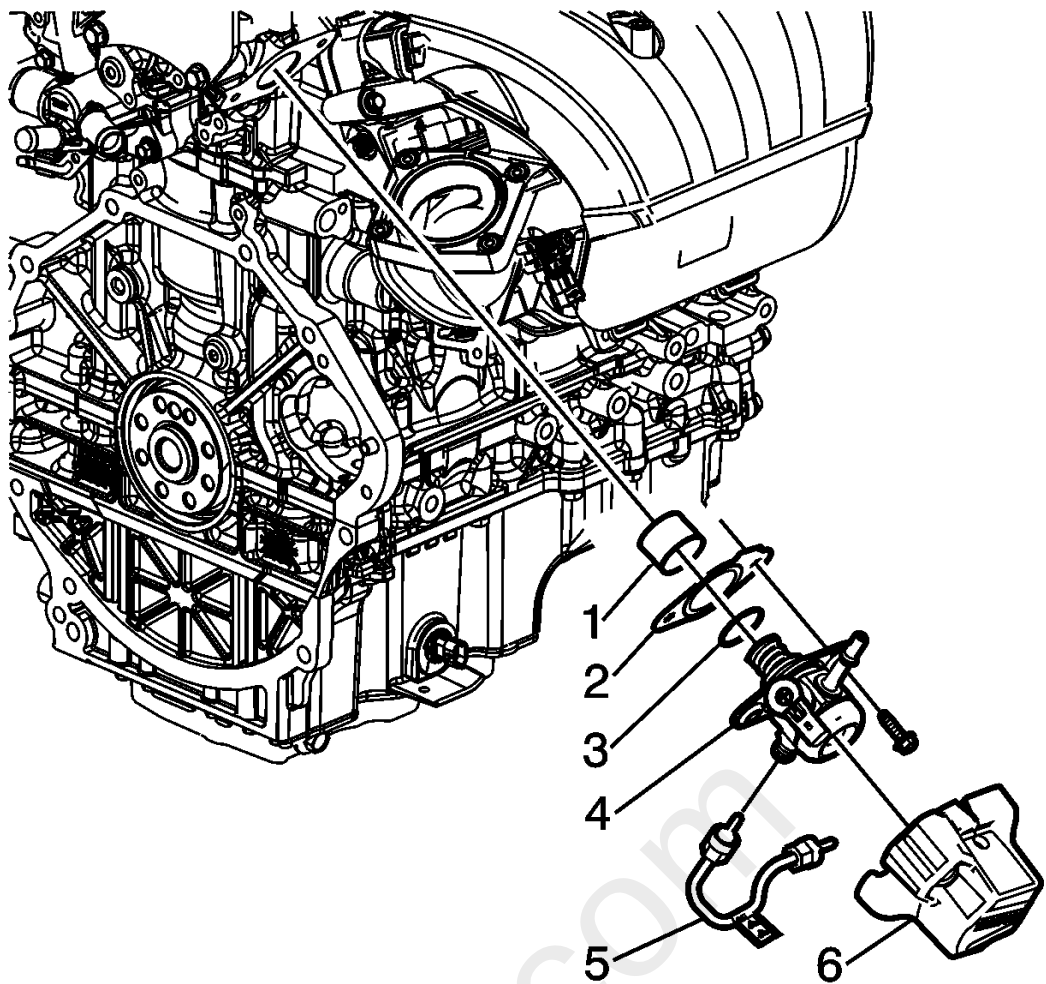


Fig. 589: High Pressure Fuel Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

5. Lubricate the high pressure fuel pump cylinder head bore with clean, silicone-free 5W30 engine oil.

NOTE: Ensure that the high pressure fuel pump roller lifter is oriented properly, and the camshaft is at base circle.

6. Lubricate the high pressure fuel pump roller lifter (1) with 5W30 engine oil and install into the cylinder head bore.
7. Lubricate the NEW O-ring (3) with one drop of clean engine oil. Install the NEW fuel pump housing O-ring (3).

NOTE: Ensure the fuel pump housing gasket (2) is properly aligned with the tab upward at the 2 O'clock position.

8. Install the NEW fuel pump housing gasket (2).
9. Install the fuel pump assembly (4).

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.

10. Apply threadlocker to the bolts, refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

11. Hand start the NEW fuel pump bolts evenly. tighten the fuel pump bolts evenly to 8 N.m (71 lb in) plus 50 degrees using the **EN-45059** meter.

12. Hand start both ends of the NEW fuel feed intermediate pipe (5).

1. tighten the fitting nut to the fuel rail to 15 N.m (11 lb ft).
2. tighten the fitting nut to the fuel pump to 15 N.m (11 lb ft).
3. tighten the fitting nut to the fuel rail a final pass to 30 N.m (22 lb ft).
4. tighten the fitting nut to the fuel pump a final pass to 30 N.m (22 lb ft).

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.

13. Install the fuel pump insulator (6).

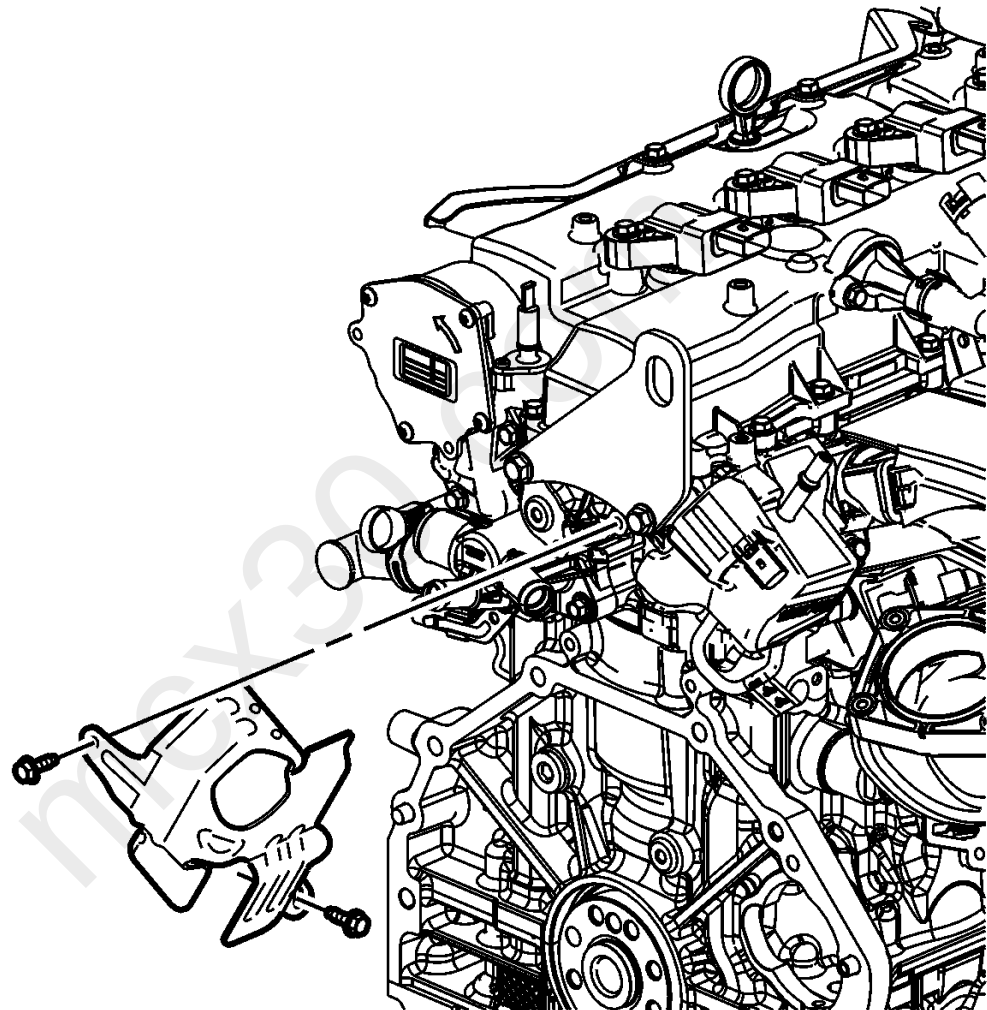


Fig. 590: Fuel Pump Cover Bolts And Cover
Courtesy of GENERAL MOTORS COMPANY

14. Install the fuel pump cover and bolts. tighten the bolts to 10 N.m (89 lb in).

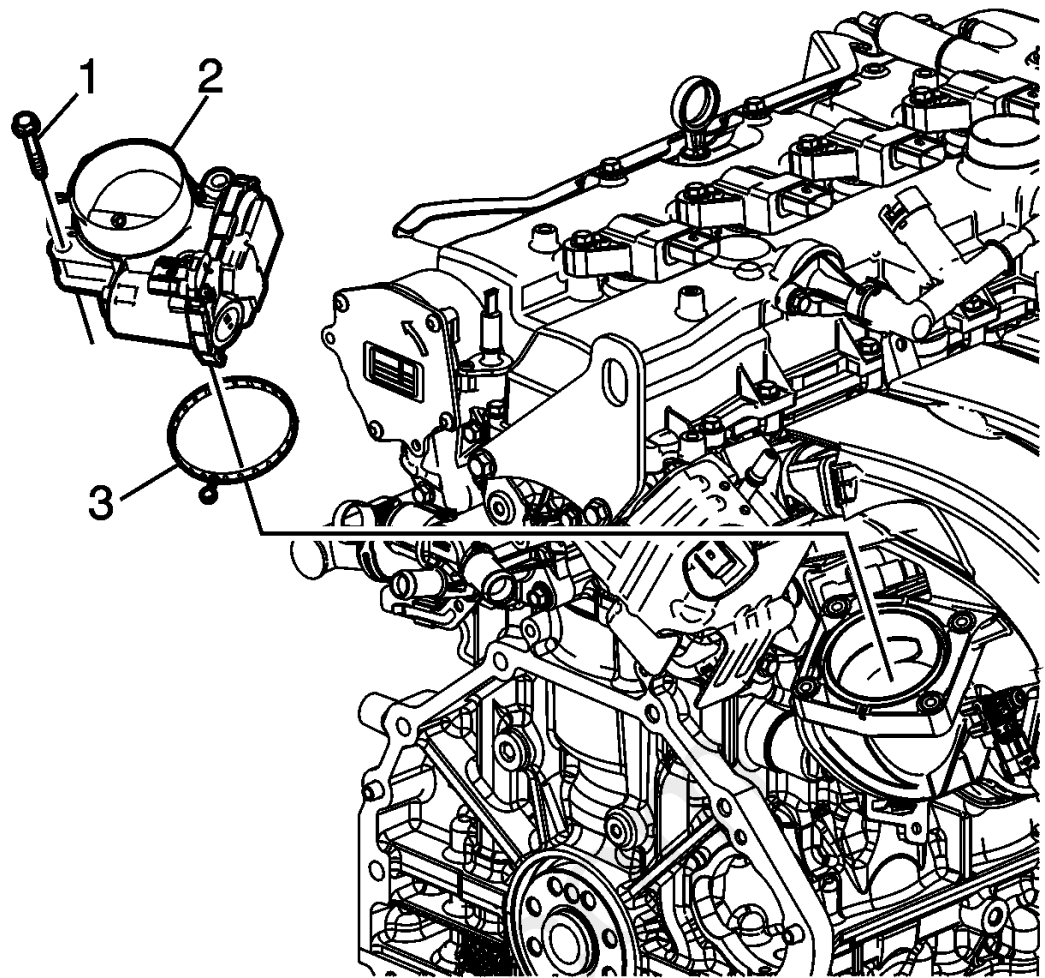


Fig. 591: Throttle Body Bolts

Courtesy of GENERAL MOTORS COMPANY

15. Install a new throttle body gasket (3).
16. Install the throttle body (2).
17. Install the throttle body bolts (1) and tighten to 10 N.m (89 lb in).

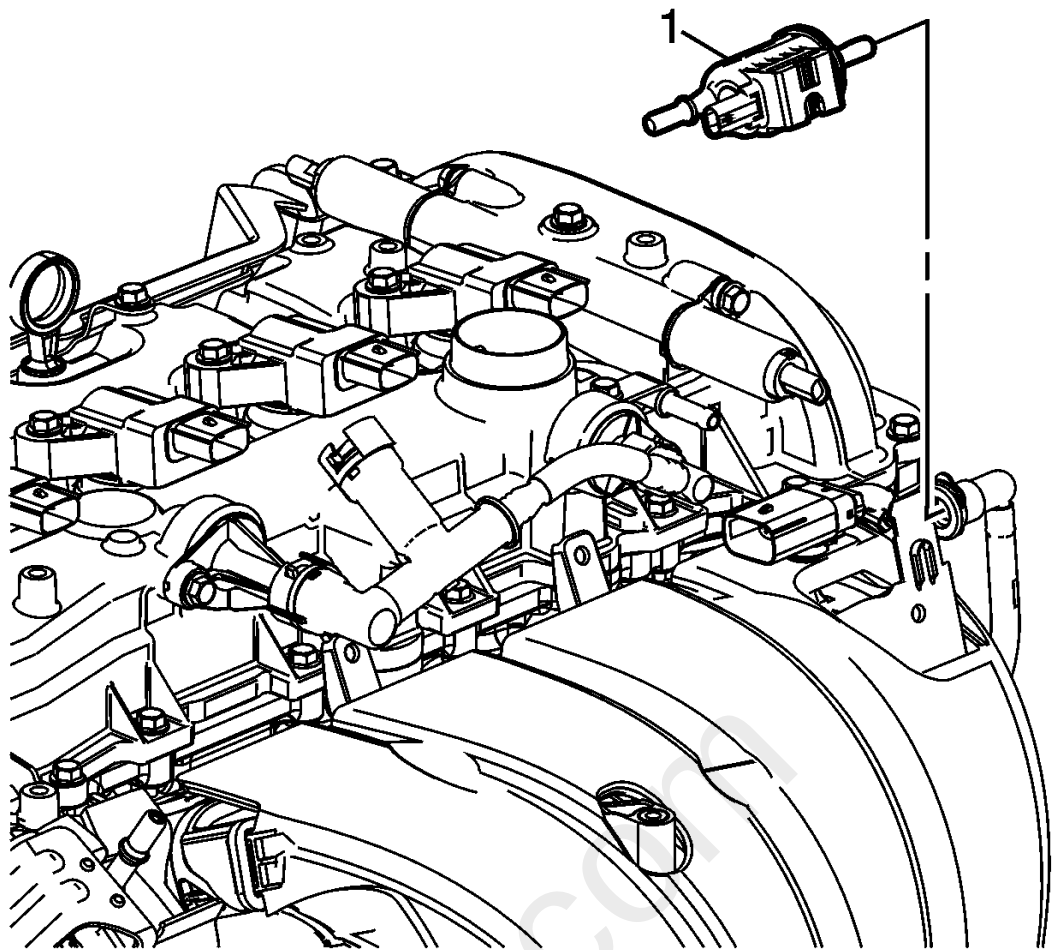


Fig. 592: EVAP Canister Valve

Courtesy of GENERAL MOTORS COMPANY

NOTE: Ensure the quick-connect is clean and free of debris. The latch should move freely prior to installation.

18. Install the EVAP canister valve (1) and connect the EVAP canister valve tube.

TURBOCHARGER INSTALLATION (1ST DESIGN TAMPER-PROOF PCV SYSTEM)

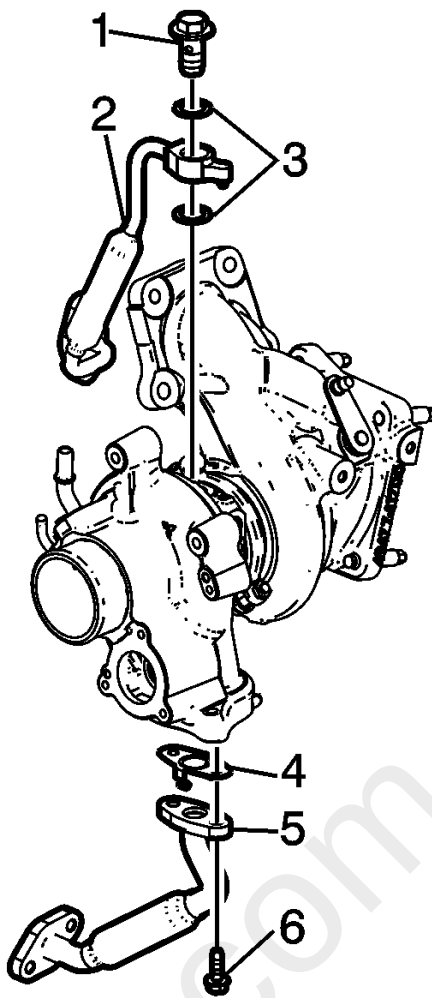


Fig. 593: Turbocharger Oil Feed Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: The exhaust pipe studs do not come installed on new turbochargers. If the turbocharger is being replaced, new studs will need to be installed.

1. Install the turbocharger oil feed pipe (2) and NEW washers (3) onto the turbocharger.

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

2. Install the turbocharger oil feed pipe bolt (1) and tighten to 35 N.m (26 lb ft).
3. Install a NEW turbocharger oil return pipe gasket (4).
4. Install the turbocharger oil return pipe (5) onto the turbocharger.
5. Install the turbocharger oil return pipe bolts (6) and tighten to 10 N.m (89 lb in).

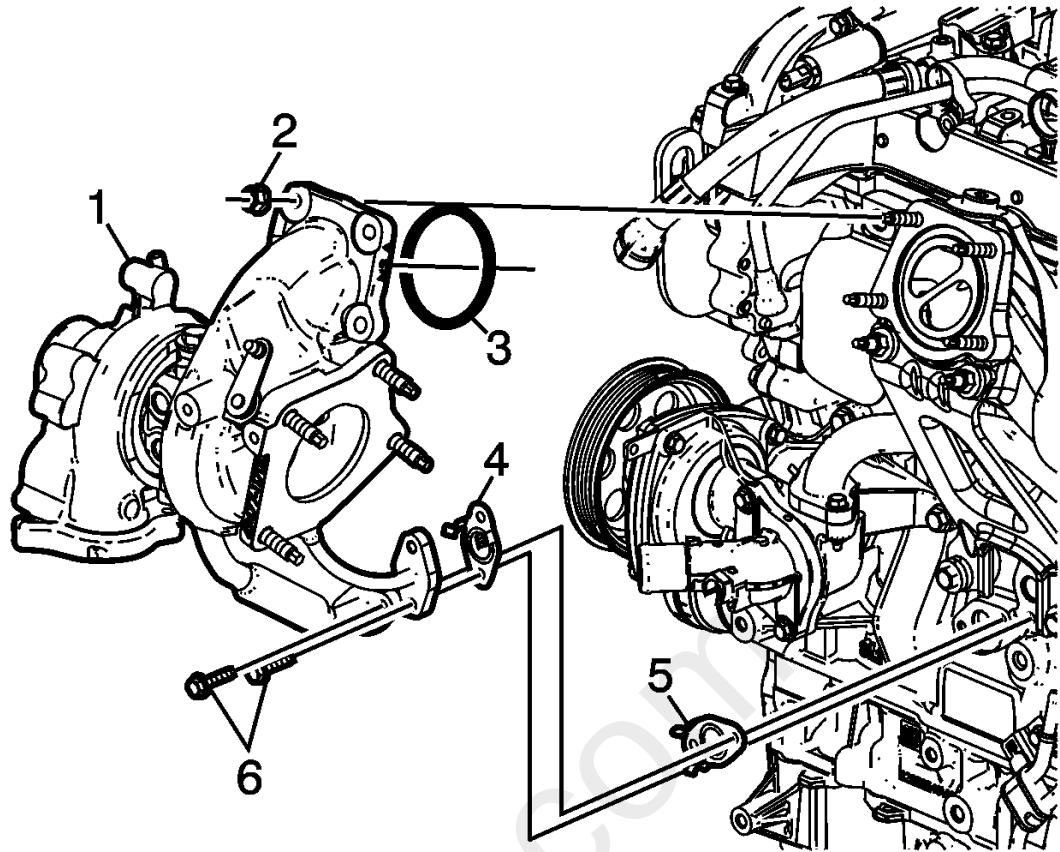


Fig. 594: Exploded View Of Turbocharger
Courtesy of GENERAL MOTORS COMPANY

6. Install a NEW turbocharger gasket (3) on the turbocharger.
7. Install NEW turbocharger oil feed and oil return pipe gaskets (4, 5).
8. Install the turbocharger (1).

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

9. Install NEW turbocharger nuts (2) finger tight.
10. Install the turbocharger oil feed and return pipe bolts (6) at the engine block. tighten the bolts to 10 N.m (89 lb in).

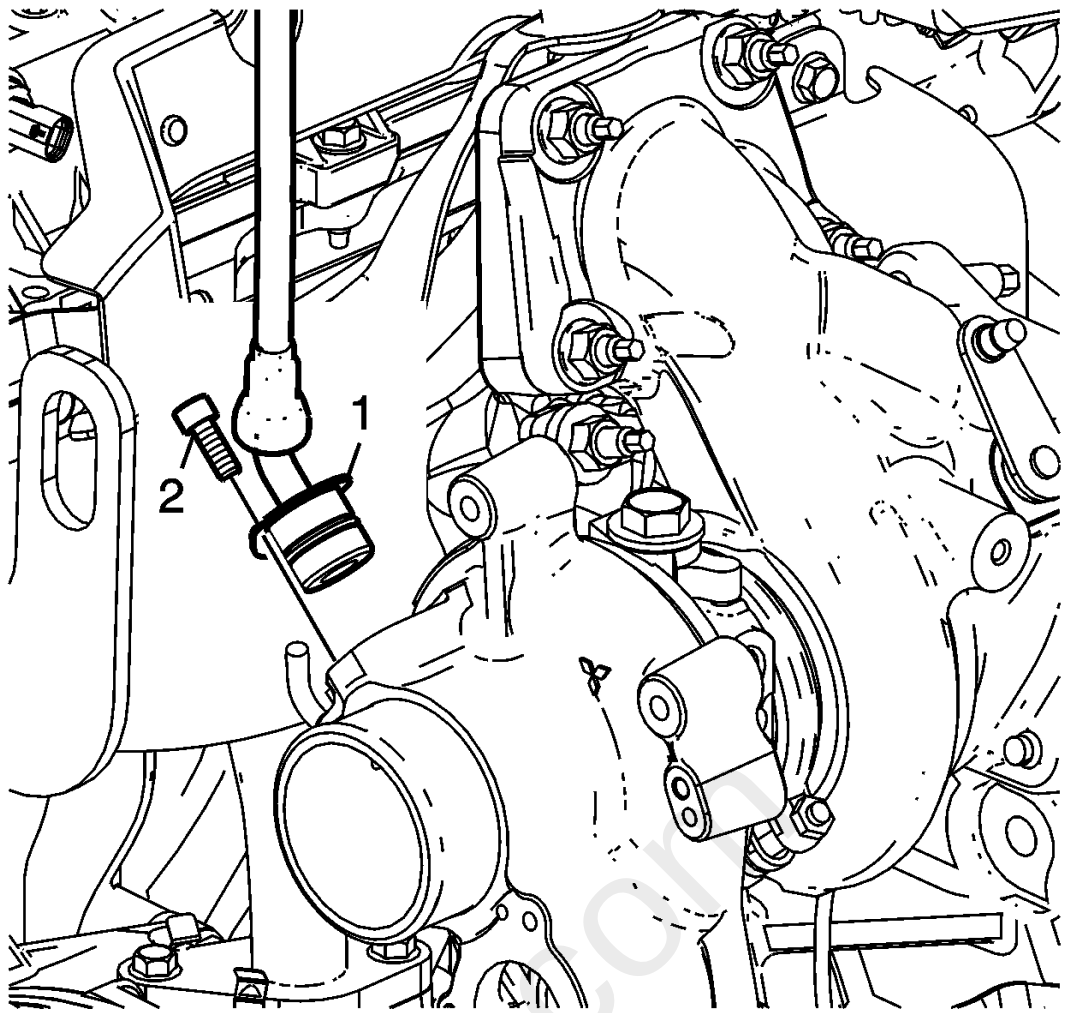


Fig. 595: PCV Hose Fitting Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE: The PCV hose and fitting assembly connection is permanent. Reinstall these components as an assembly unless new components are being used.

NOTE: Always ensure the PCV hose fitting O-Ring seal is free of cuts or abrasions each time the fitting is attached to the turbocharger.

11. Inspect the PCV hose fitting O-Ring seal and replace if necessary.
12. Install the PCV hose and fitting assembly (1) to the turbocharger. Install the PCV hose fitting assembly bolt (2) and tighten to 8 N.m (71 lb in).

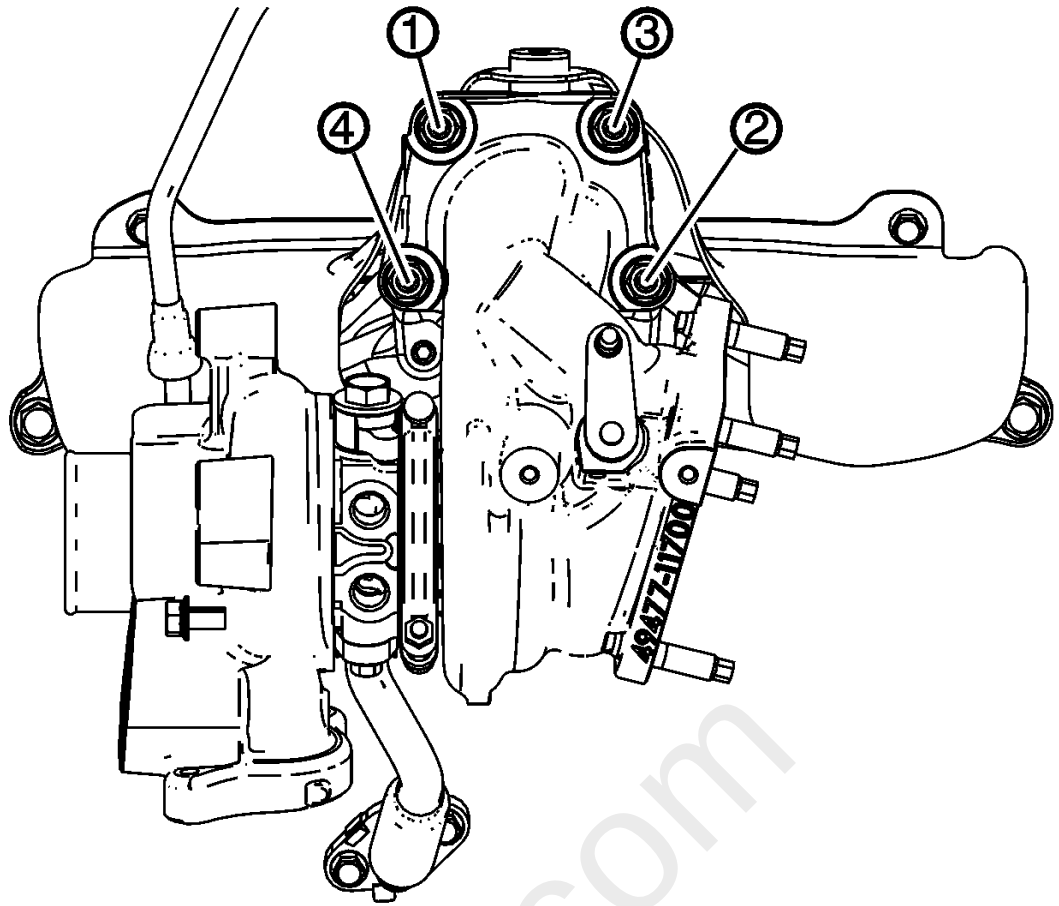


Fig. 596: Turbocharger Nut tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

13. tighten the turbocharger nuts in sequence to 30 N.m (22 lb ft) plus 90 degrees.

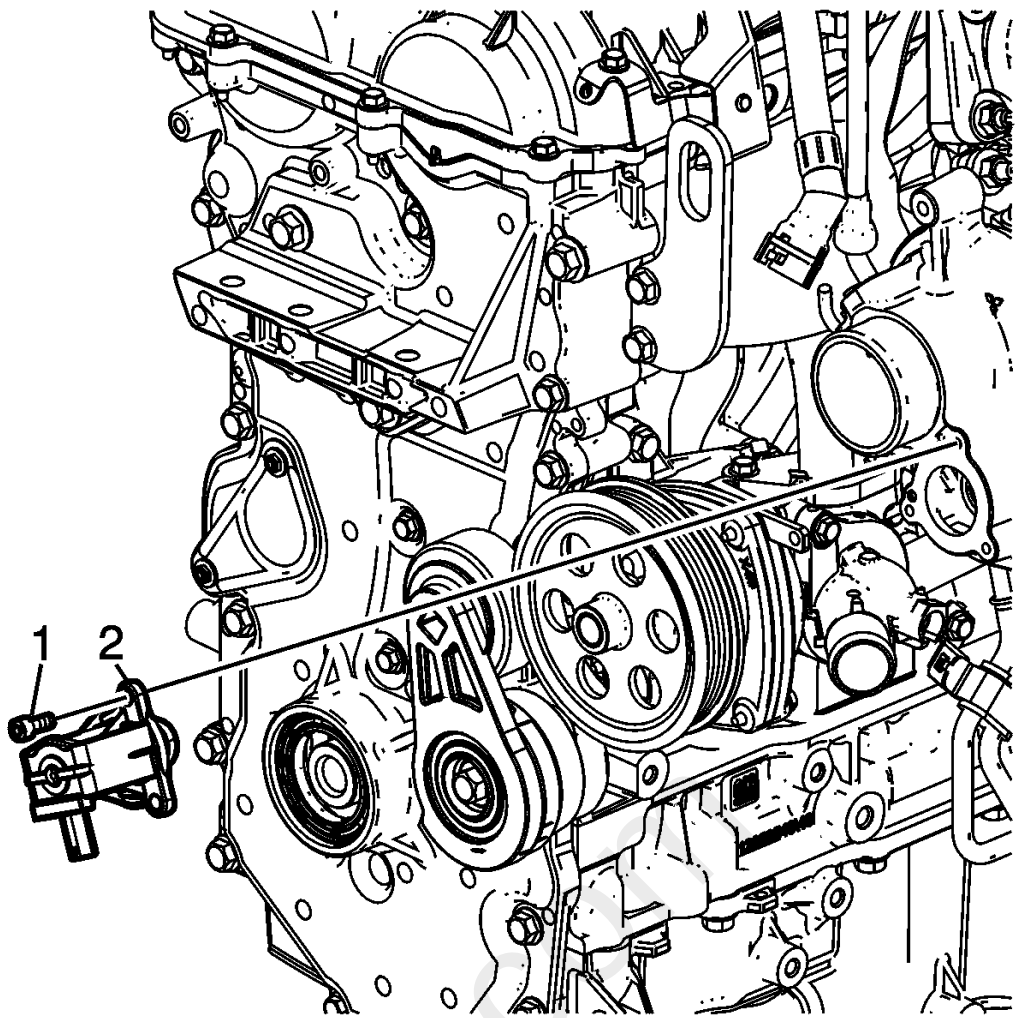


Fig. 597: Turbocharger Bypass Valve Solenoid Bolts
Courtesy of GENERAL MOTORS COMPANY

14. Install the turbocharger bypass valve solenoid (2).
15. Install the turbocharger bypass valve solenoid bolts (1) and tighten to 8 N.m (71 lb in).

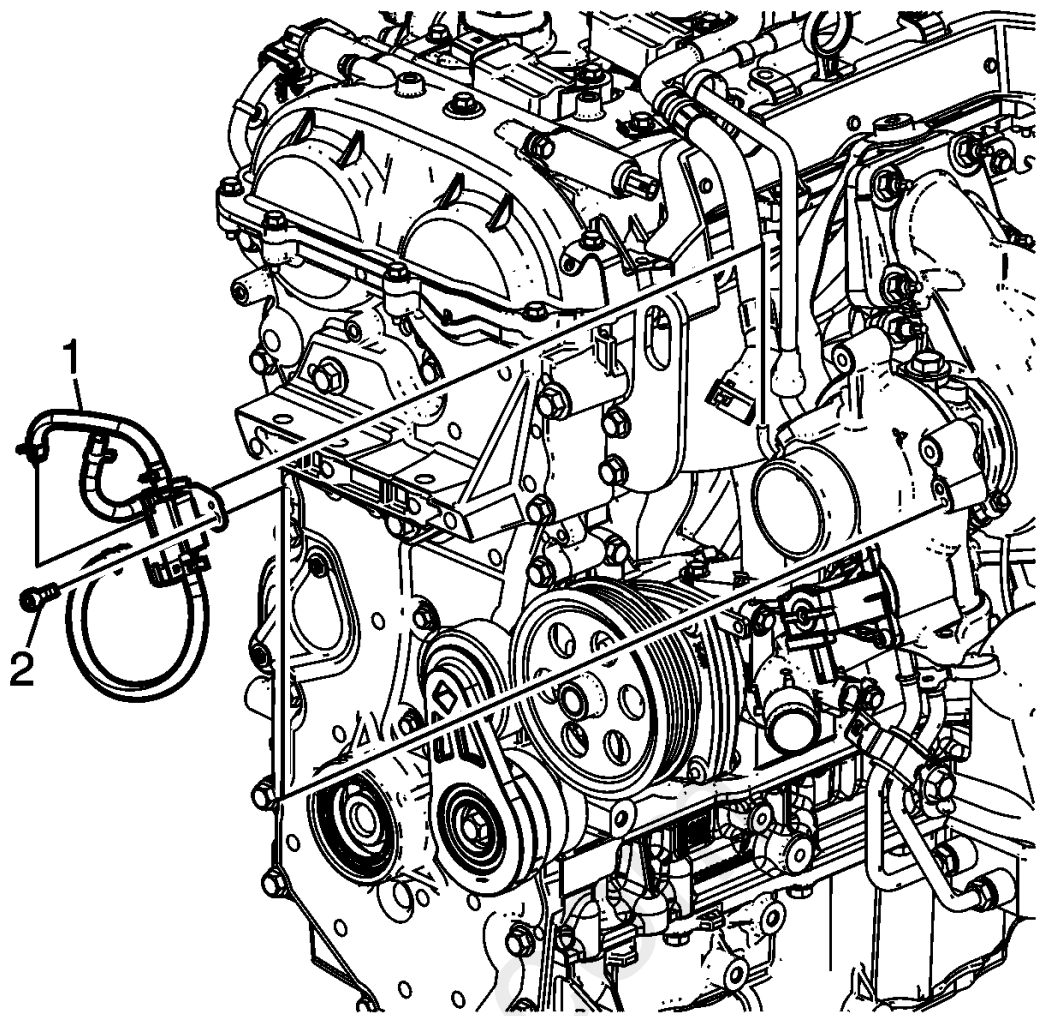


Fig. 598: Turbocharger Wastegate Regulator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

16. Install the turbocharger wastegate regulator solenoid valve (1).
17. Install the turbocharger wastegate regulator solenoid valve bracket bolt (2) and tighten to 8 N.m (71 lb in).
18. Connect the turbocharger wastegate regulator solenoid valve hoses to the turbocharger.

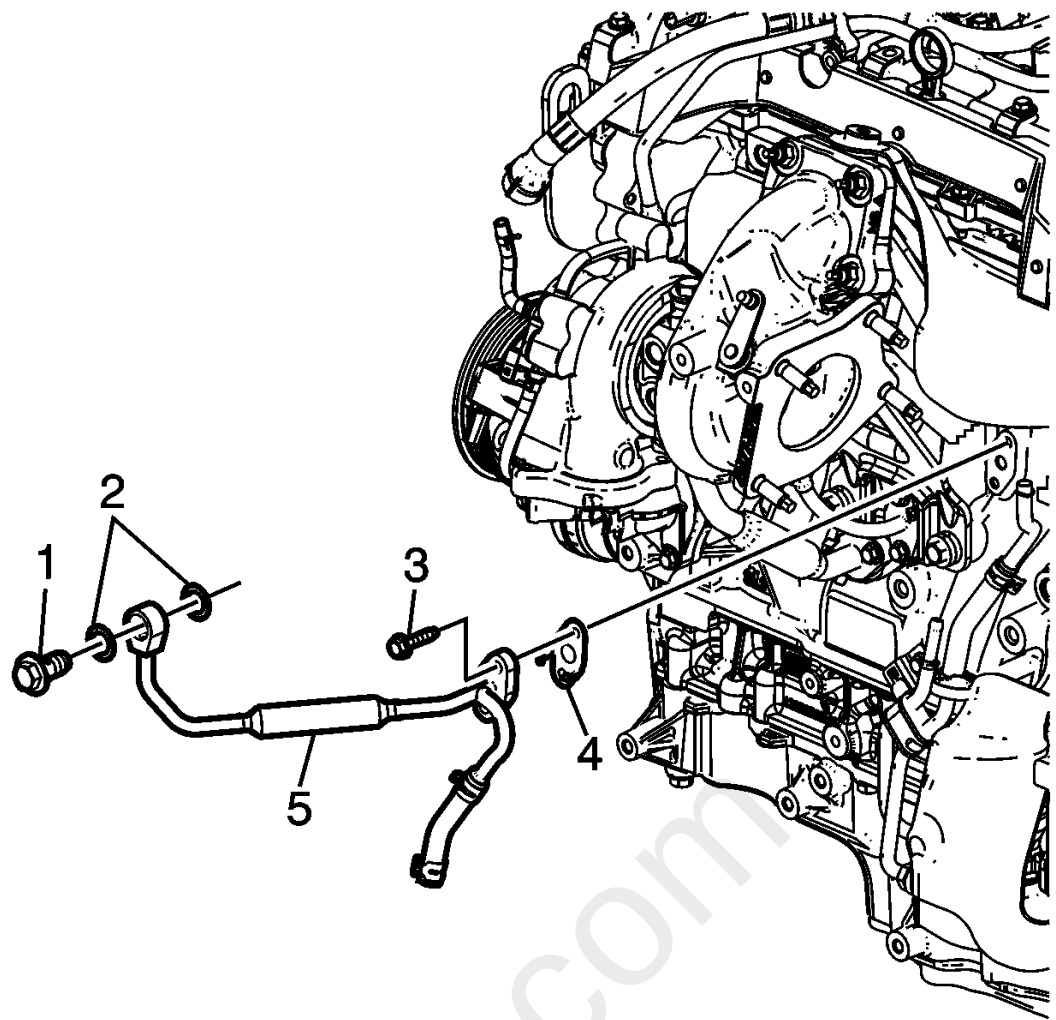


Fig. 599: Turbocharger Coolant Feed Pipe Bolts
Courtesy of GENERAL MOTORS COMPANY

19. Install the turbocharger coolant feed pipe (5) and NEW washers (2) on the turbocharger.
20. Install the turbocharger coolant feed pipe bolt (1) and tighten to 35 N.m (26 lb ft).
21. Install a NEW turbocharger coolant feed pipe gasket (4).
22. Install the turbocharger coolant feed pipe bolts (3) and tighten to 10 N.m (89 lb in).
23. Connect the turbocharger coolant feed pipe hose to the engine oil cooler.

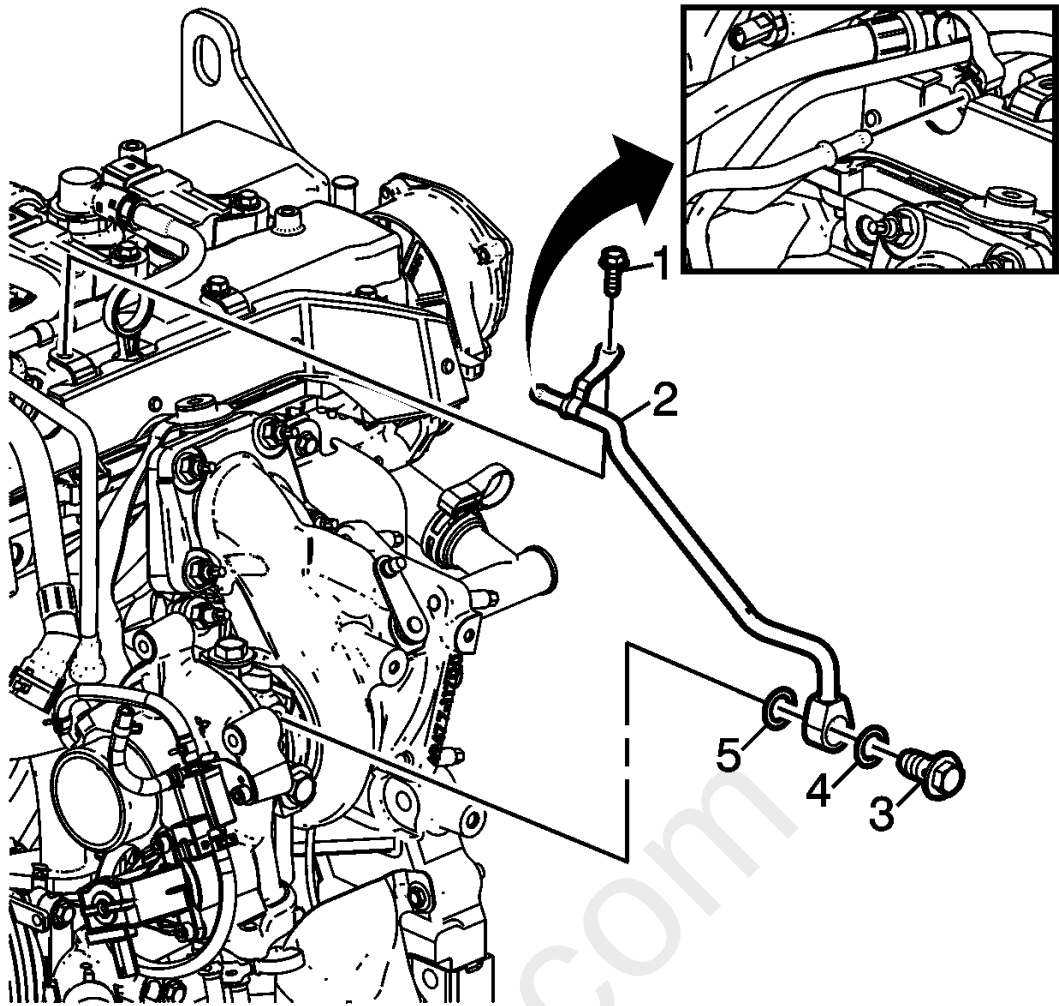


Fig. 600: Camshaft Cover Heat Shield Bolt
Courtesy of GENERAL MOTORS COMPANY

24. Install the turbocharger coolant return pipe (2) and NEW washers (4, 5) on the turbocharger.
25. Install the turbocharger coolant return pipe bolt (3) and tighten to 35 N.m (26 lb ft).
26. Connect the turbocharger coolant return pipe to the air bleed hose.
27. Install the camshaft cover heat shield bolt (1) that retains the turbocharger coolant return pipe (2) at the camshaft cover. tighten the bolt to 10 N.m (89 lb in).

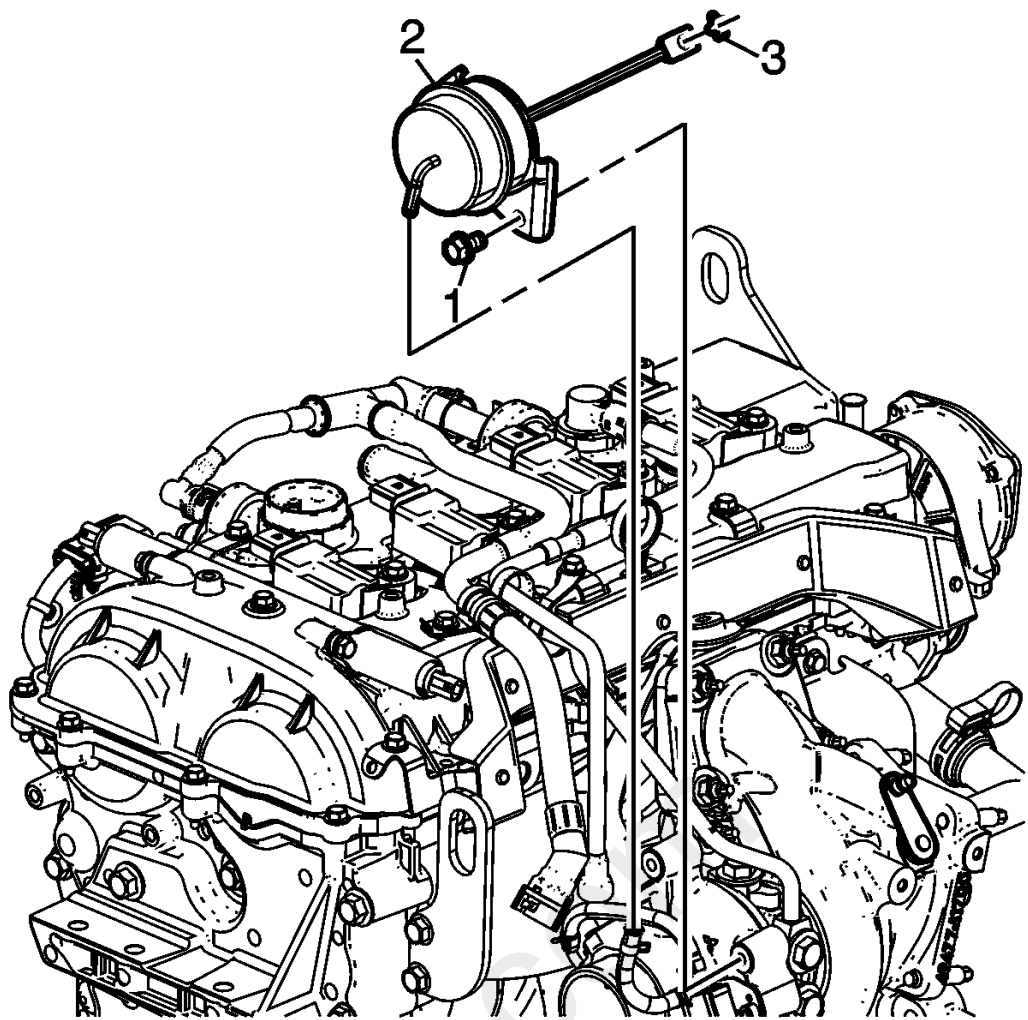


Fig. 601: Turbocharger Wastegate Actuator Arm Retainer

Courtesy of GENERAL MOTORS COMPANY

28. Install the turbocharger wastegate actuator (2) and actuator bolts (1) and tighten to 8 N.m (71 lb in).
29. Install the turbocharger wastegate actuator arm retainer (3).

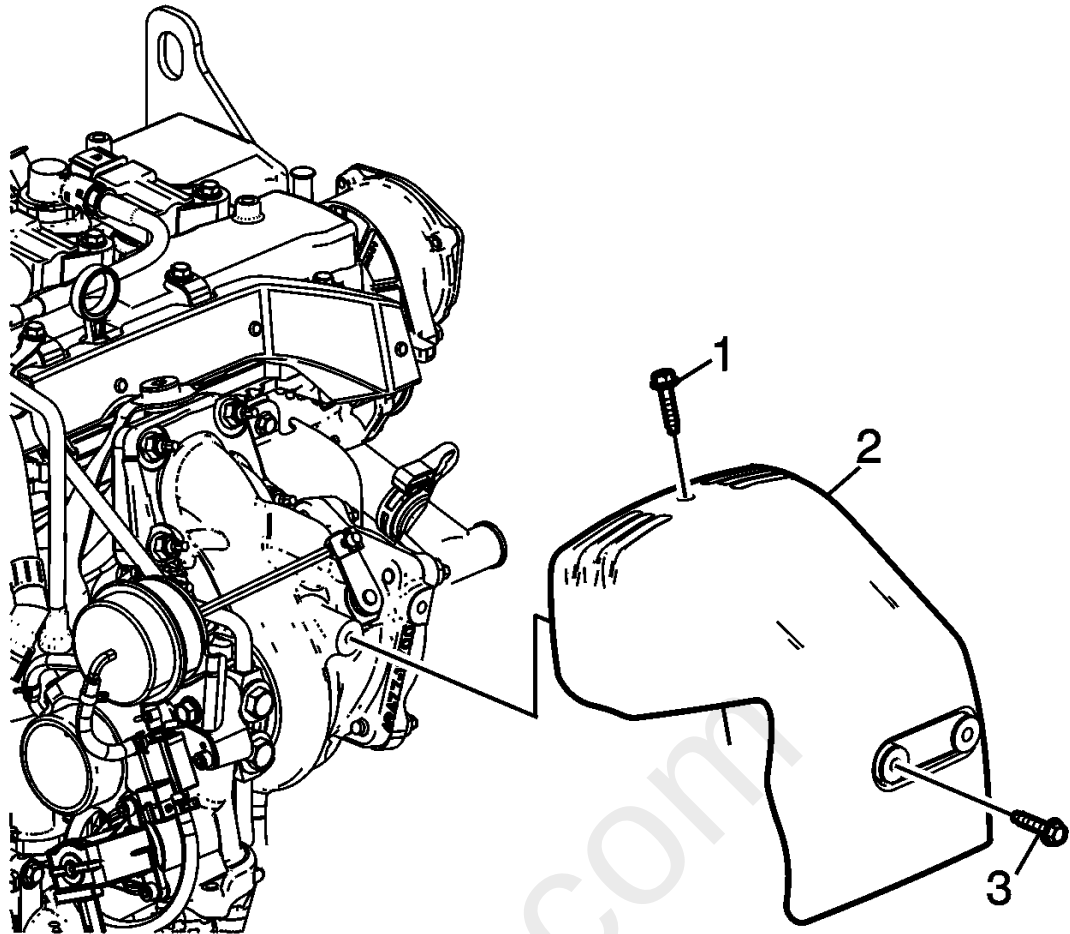


Fig. 602: Turbocharger Heat Shield Bolts
 Courtesy of GENERAL MOTORS COMPANY

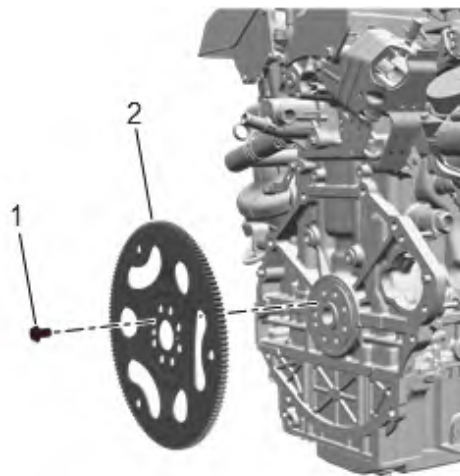
30. Install the turbocharger heat shield (2).
31. Install the turbocharger heat shield bolts (1, 3) and tighten to 14 N.m (124 lb in).

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

- **EN-51760** Flywheel Holding Tool
- **EN-45059** Angle Meter

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



CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE: Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

1. Install the flywheel (2) and hand start NEW bolts (1).

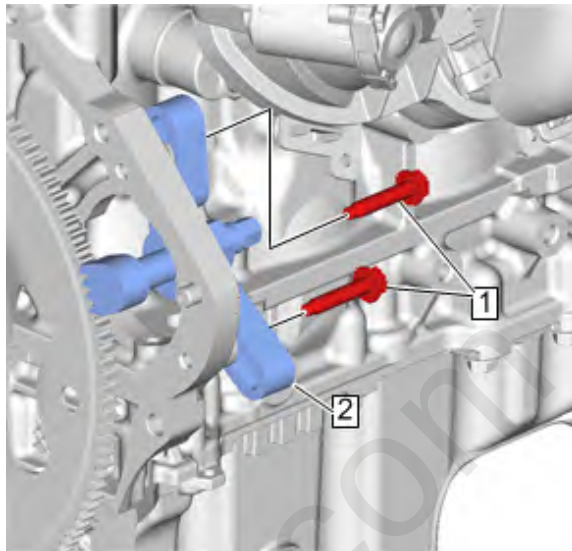


Fig. 604: Starter Motor Bolts
Courtesy of GENERAL MOTORS COMPANY

2. To prevent crankshaft rotation, install **EN-51760** flywheel holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

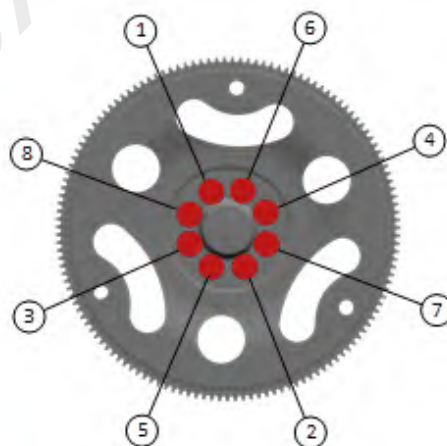


Fig. 605: Flex Plate Bolt tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

3. tighten the bolts evenly using the following procedure:
 1. tighten the bolts a first pass in sequence to 30 N.m (22 lb ft).
 2. tighten the bolts a final pass in sequence 40 degrees using the **EN-45059** meter.
4. Remove **EN-51760** flywheel holding tool.

Special Tools

- **EN-45059** Angle Meter
- **EN-48034** Crankshaft Balancer Installer
- **EN-51760** Flywheel Holding Tool

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

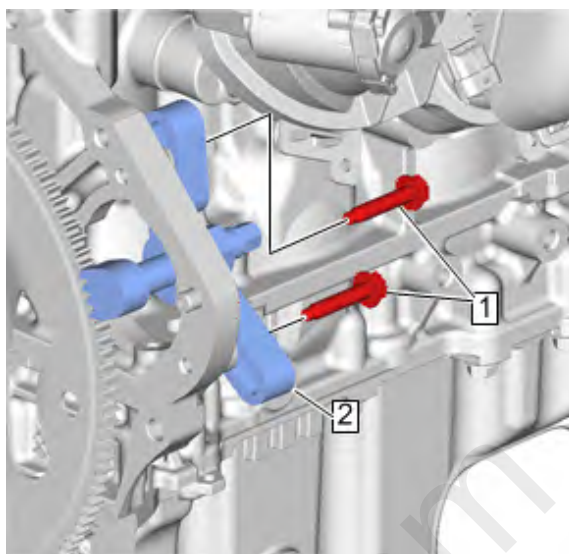


Fig. 606: Starter Motor Bolts

Courtesy of GENERAL MOTORS COMPANY

1. To prevent crankshaft rotation, install **EN-51760** flywheel holding tool (2) and starter motor bolts (1) at the starter motor location and engaging the flywheel.

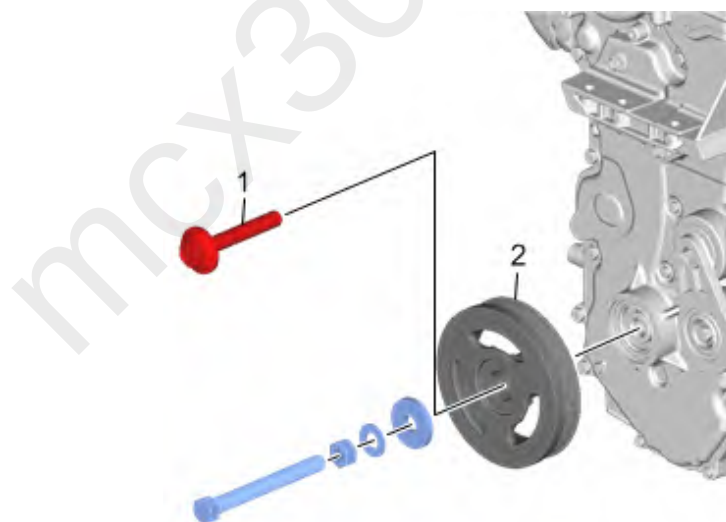


Fig. 607: Crankshaft Balancer, Bolt And Special Tool

Courtesy of GENERAL MOTORS COMPANY

2. Using **EN-48034** installer, install the crankshaft balancer (2).

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

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a **NEW** torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

3. Install a NEW crankshaft balancer bolt and washer. tighten the bolt to 150 N.m (111 lb ft) plus 140 degrees using the **EN 45059** meter.

4. Remove EN-51760 flywheel holding tool.

OIL FILTER INSTALLATION

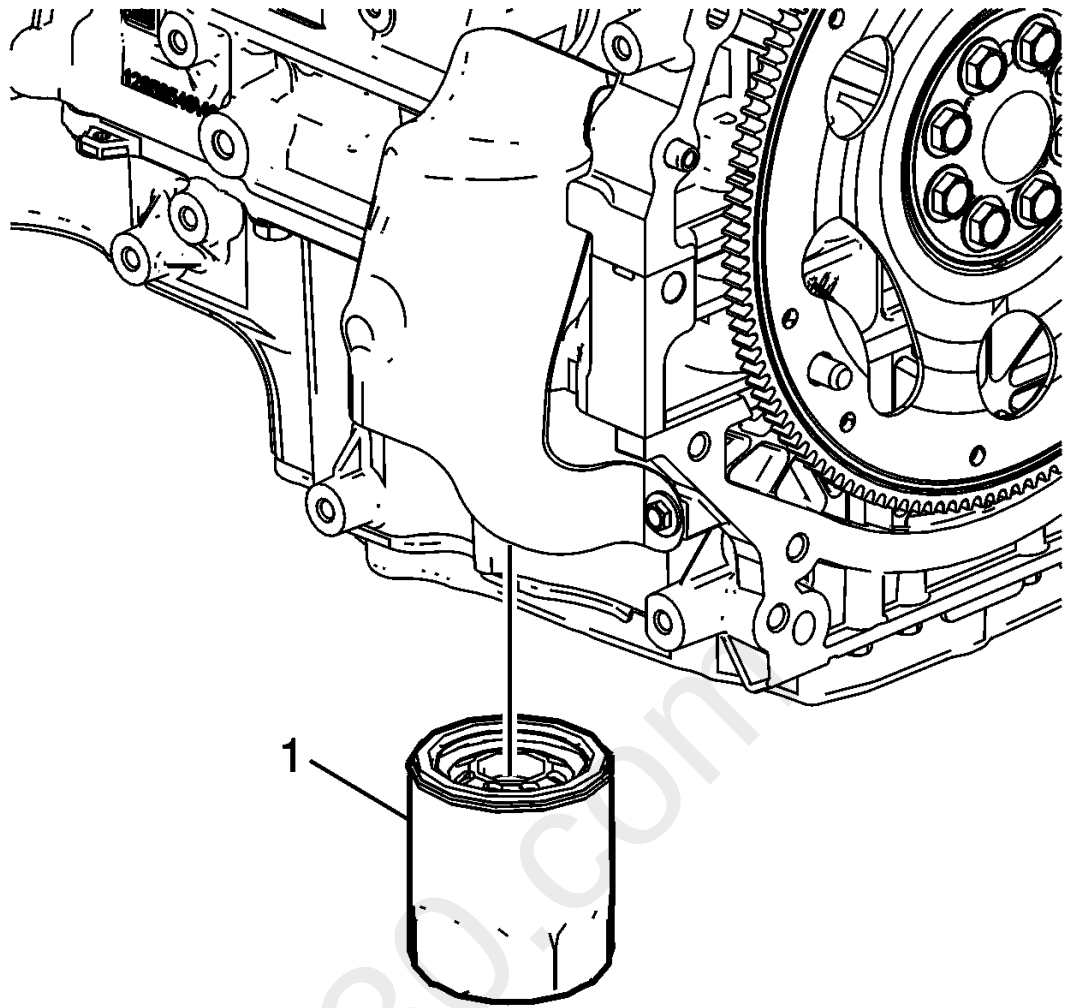


Fig. 608: Engine Oil Filter

Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the O-ring on the oil filter with 5W30 engine oil.
2. Install a new oil filter (1).

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

3. tighten the oil filter 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.

ENGINE PRELUBING

NOTE: This procedure is not used in Europe.

Special Tools

EN-45299 Engine Preluber

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

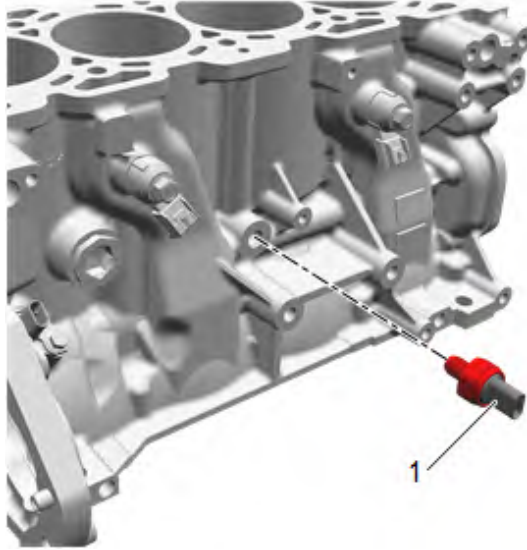


Fig. 609: Engine Oil Pressure Sensor

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 engine oil pressure sensor (1).
2. Install the M12 x 1.75 adapter P/N 509376.

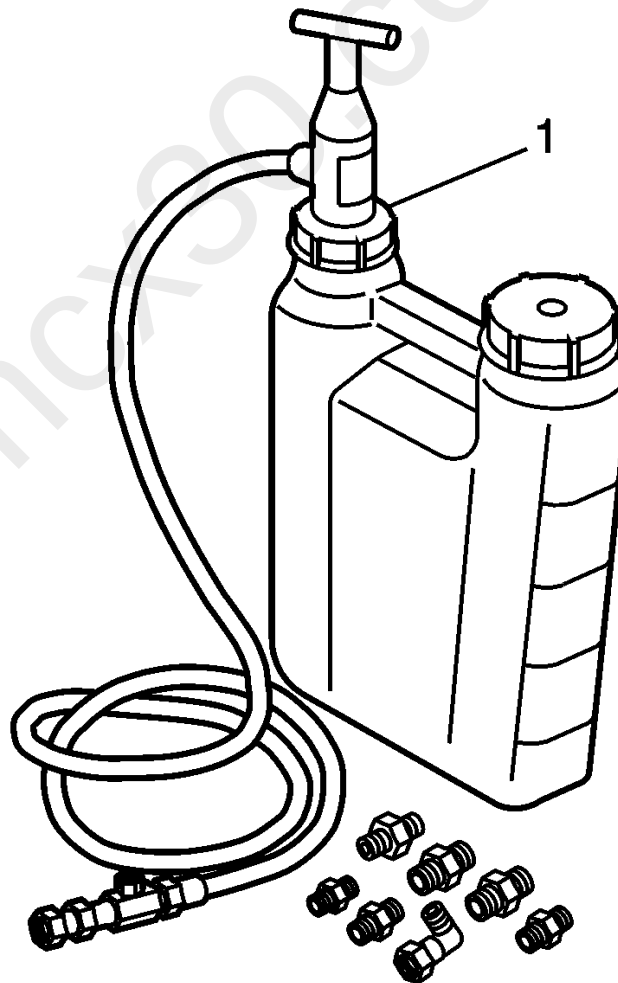


Fig. 610: View of Flexible Hose, Adapter and Preluber

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 engine oil pressure sensor and tighten to 35 N.m (26 lb ft).
7. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

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. A 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 a pressure differential that is determined by the engine control module (ECM) by means of a PWM solenoid, in order to control boost pressure. A compressor recirculation valve, also controlled by the ECM, prevents compressor surging and damage by opening during sudden throttle closures. When the recirculation valve is opened it allows the air to recirculate back to the turbocharger compressor inlet.

The turbocharger is connected to the engine oiling system by a supply and drain pipe. 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.

Charge Air Cooler Description

The turbocharger engine 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), enhancing performance because cooler air is denser in oxygen and 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.

Benefits of Dual Cam Phasing

The camshafts of the Ecotec 2.0 liter turbocharged engine have camshaft position sensors and camshaft position actuators that the ECM uses to accurately control the continuously variable intake and exhaust valve timing. This allows the combustion process to be optimized by the ECM to increase the response of the turbocharger, providing a more immediate feeling of power to the driver.

Benefits of Gasoline Direct Injection

In the Ecotec 2.0 liter turbocharged engine, the fuel is introduced directly into the combustion chamber during the intake stroke. As the piston approaches top-dead center, the mixture is ignited by the spark plug, thereby giving the name spark ignition direct injection. Direct injection allows the mixture to be leaner, with less fuel and more air at full power, and allows a slightly higher compression ratio, resulting in improved fuel consumption at part and full throttle.

The fact that the fuel is injected after the exhaust valve closes allows particularly high valve overlap values in certain engine operating ranges. This enhances the turbocharger response time. This would not be possible in a port fuel injection engine due to the fact that unburned fuel would escape through the open exhaust valve.

Direct injection's precise fuel delivery enables more complete combustion which reduces emissions particularly on cold starts.

Electronic Vacuum Pump

The purpose of the electronic vacuum pump, if equipped, is to keep the vacuum in the brake booster at an acceptable level under various operating conditions. The ECM monitors the input signal from the brake booster pressure sensor. When the vacuum in the brake booster is not in an acceptable range the control module will command the relay ON that controls the vacuum pump.

Recommendations for Service

The turbocharger is designed so that it does not require any special maintenance, and inspection is limited to a few periodic procedures. To ensure that the turbocharger's lifetime corresponds to that of the engine, the following engine manufacturer's service instructions must be strictly adhered to:

- Oil and filter change intervals
- Air filter change intervals
- Engine coolant change intervals
- Ignition system maintenance
- Injection system maintenance

The following causes are responsible for a majority of all turbocharger failures:

- Misdiagnosis of a non-failed turbocharger
- Penetration of foreign bodies into the turbine or the compressor
- Dirt or contaminants in the oil
- Inadequate oil supply and/or pressure
- Clogged oil return
- Higher than normal exhaust gas temperatures due to improper operation of the following:
 - The ignition system
 - The fuel injection system
 - The exhaust system

These failures can be avoided by regular maintenance.

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation

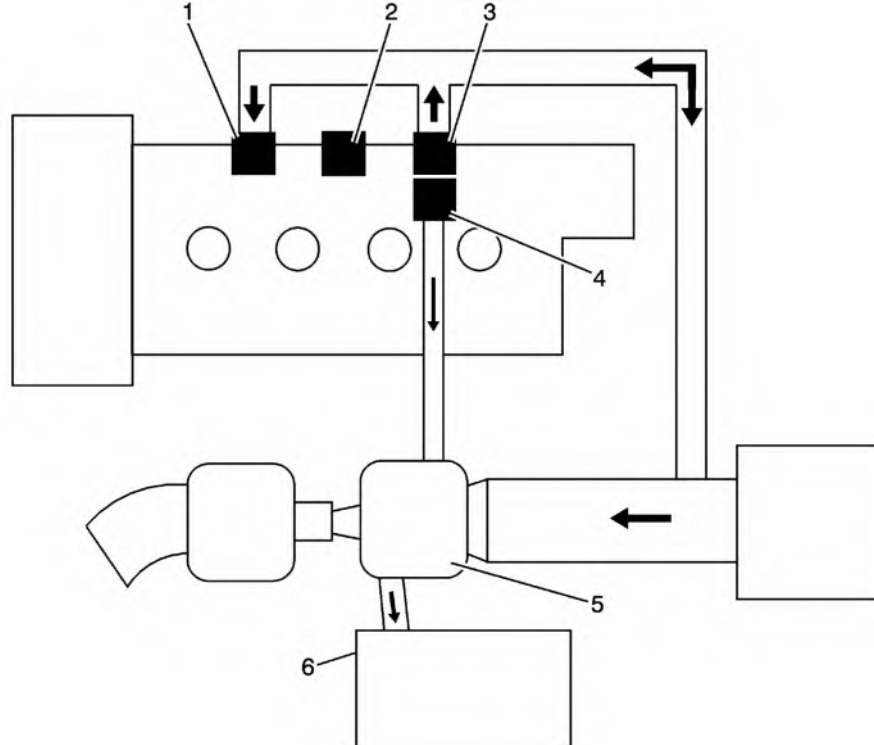


Fig. 611: Crankcase Ventilation System Components And Operational Diagram (LTG).

Courtesy of GENERAL MOTORS COMPANY

The primary control is through the positive crankcase ventilation (PCV) valve (2) which meters the flow at a rate depending on intake manifold vacuum. The PCV valve is an integral part of the camshaft cover. Fresh air is introduced to the engine through PVC (1) under normal operating conditions. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent valve (3) into the intake system to be consumed by normal combustion.

Only on turbocharged engines, there is a one way valve (2) in the camshaft cover in order to prevent the crankcase from being pressurized by positive pressure in the intake manifold when the turbocharger is in operation. When the turbocharger is operational, the pressure in the intake manifold can exceed atmospheric pressure which, without the one way valve, would force oil and PCV gases out of the camshaft cover and into the induction system, via the hose to the camshaft cover. This can cause coking of the throttle body and induction system, and can reduce the efficiency of both combustion and the intercooler system, in normal operation the PCV gases are drawn into the air stream post intercooler (6). However, when the turbo is spooled up the turbo can become the vacuum source for the vent system. PVC#4 controls the max. flow so the crankcase stays at a normal vacuum during normal operating conditions.

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 precision sand-casting. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the front of the engine. The cylinder block incorporates a

bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

Crankshaft

The crankshaft is cast nodular iron with 8 counterweights. The number 8 counterweight is also the ignition system reluctor wheel. The main bearing journals are cross-drilled, and the upper bearings are grooved. The crankshaft has a slip fit balance shaft drive sprocket. Number 2 main bearing is the thrust bearing. The crankshaft balancer is used to control torsional vibration.

Connecting Rod and Piston

The connecting rods are powdered metal. The connecting rod incorporates the floating piston pin. The pistons are cast aluminum. The piston rings are of a low tension type to reduce friction. The top compression ring is ductile steel with a molybdenum facing and phosphate coated sides. The second compression ring is gray iron. The oil ring is a 3-piece spring construction with chromium plating for applications without a turbocharger. For applications with turbocharger, the oil ring is a 3-piece spring construction with nitride plating.

Engine Block Cooling Baffle

The engine block cooling baffle is essential to proper engine coolant flow. The baffle's presence in the engine block is strategic and acts to direct the engine coolant flow around the bores for uniform cooling.

Oil Pan

The oil pan is die cast aluminum. The oil pan includes an attachment to the transmission to provide additional structural support.

Balance Shaft Assembly

The dual balancer shaft assembly is mounted to the lower crankcase located within the oil pan. The balance shafts are driven by a single inverted tooth chain that also drives the oil pump. The chain is tensioned by a hydraulic tensioner that is supplied pressure by the engine oil pump. This design promotes the maximum effectiveness of the balance shaft system and reduces noise and vibration.

Cylinder Head

The cylinder head is a semi-permanent mold. Pressed-in powdered metal valve guides and valve seat insets are used. The cylinder head incorporates camshaft journals and camshaft caps. The fuel injection nozzle is located in the intake port. The high pressure fuel pump is mounted on intake side.

Valves

There are two intake and two exhaust valves per cylinder. The head of the valve is made of a durable alloy. The valve shaft resists wear. Valve stem oil seals control oil consumption. Valve springs, valve spring retainers, and valve keys are assembled to return each valve to a closed position after each actuation of the rotating camshaft assemblies.

Camshaft

Two camshafts are used, one for all intake valves and high pressure fuel pump, the other for all exhaust valves and mechanical vacuum pump. The camshafts are cast iron.

Valve Lash Adjusters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft Drive

A roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

Intake and Exhaust Manifold

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

Mechanical Thermostat

The mechanical thermostat is positioned between the engine and the radiator. Its purpose is to control the flow of coolant to the radiator. The thermostat will not allow coolant flow through the radiator when cold, coolant flow occurs when the engine has warmed up. Once the engine reaches its operating temperature, generally about 95°C (203°F), the thermostat opens. This actuation of the thermostat starts to occur at 82°C (180°F), when the heated wax contained within a cylinder melts and rapidly expands, pushing the rod and valve assembly out of the cylinder, opening the valve. The temperature dependent actuation of the thermostat allows the engine to warm up as quickly as possible, the thermostat reduces engine wear, deposits and emissions. The open thermostat now allows the coolant to flow through the engine cooling circuit to maintain optimal operation temperatures, which is achieved by directing the hot coolant through the radiator for cooling and recirculation.

Variable Flow Oil Pump Assembly

The oil pump assembly is located within the oil pan. The oil pump assembly is fastened directly to the rear of the balancer shaft assembly and is driven by the rotation of the balance shaft spline.

The oil pump assembly possesses variable flow capability which is made possible by a shift of the circular vane arrangement and the actuation of an oil control valve assembly guided by the ECM. The variable flow capability of the pump optimizes oil flow to the engine components when needed. During performance maneuvers and acceleration the oil pump operates in a steady high pressure state. However, during steady low load touring speeds on level terrain the oil pump operates in a steady low pressure state.

The ECM guided "on" and "off" actuation of the oil control valve assembly allows the chamber to be pressurized which takes the switch from high to low pressure mode. The high pressure state of the chamber compressing the spring and shifting the center of the circular vane arrangement nearer to that of the balancer drive shaft, decreasing the difference of the volume of oil contained between each vane. It is this small variation in volume which produces the steady low pressure flow. It is in this mode that the pump behaves as a smaller pump.

Advantages of variable flow oil pumping modes:

- The high performance steady pressure mode is where engine temperatures and friction are reduced because the pump only delivers the oil that the engine requires.
- The low load touring steady pressure mode is where the volume of oil flow is reduced to even more efficient levels when engine requirements allow. This efficiency reduces the resistance on reciprocating component, allowing engine revolutions with less power resulting in fuel economy savings.

LUBRICATION DESCRIPTION

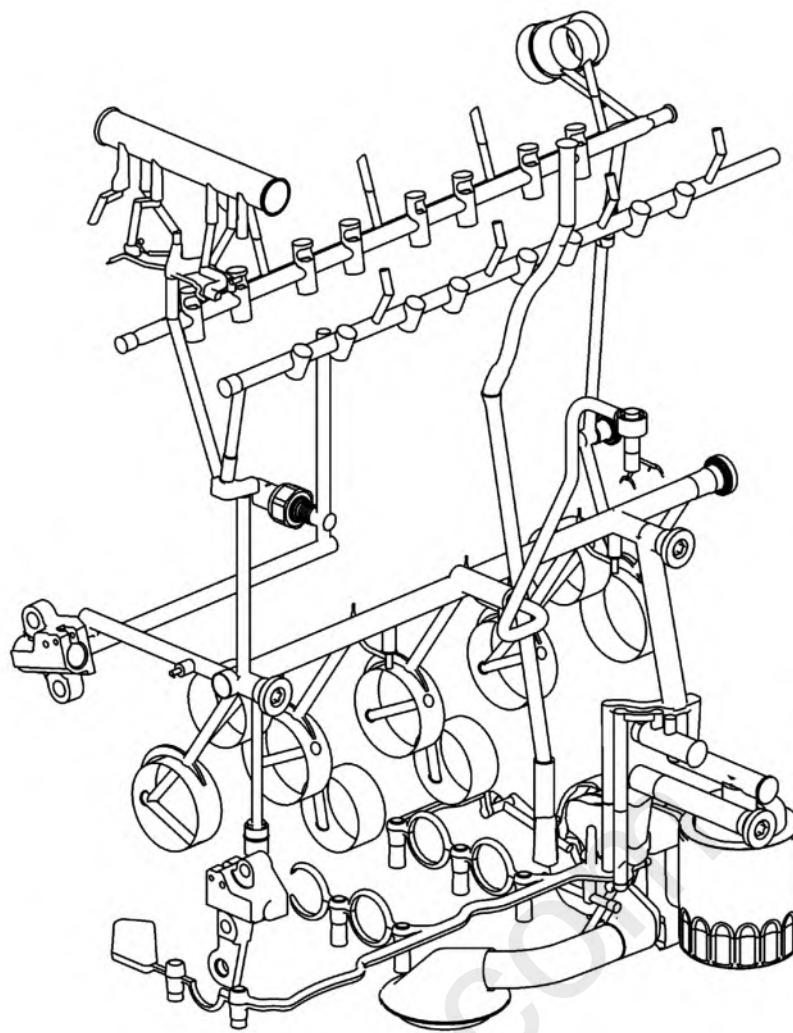


Fig. 612: Lubrication System (LTG)
Courtesy of GENERAL MOTORS COMPANY

Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, rocker arms, valve lash adjusters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the oil pump through a fixed inlet screen. The oil pump is driven by the balancer shaft assembly's sprocket. The oil pump body is attached to the rear of balancer shaft assembly. The pressurized oil passes through the cylinder head assembly restrictor orifice into the cylinder head's OCV and routed through passages cast into the camshaft cover assembly to each camshaft feed gallery and camshaft drip rail. OCV actuates the 2-Step intake rocker arm assemblies to control valve travel. The oil filter is a metal canister type. A by-pass valve in the filter assembly allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface, rocker arm, and drip rail. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

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

REPLACING ENGINE GASKETS

Special Tools

EN-28410 Gasket Remover

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

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **EN-28410** remover or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.
 - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.

- This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

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.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

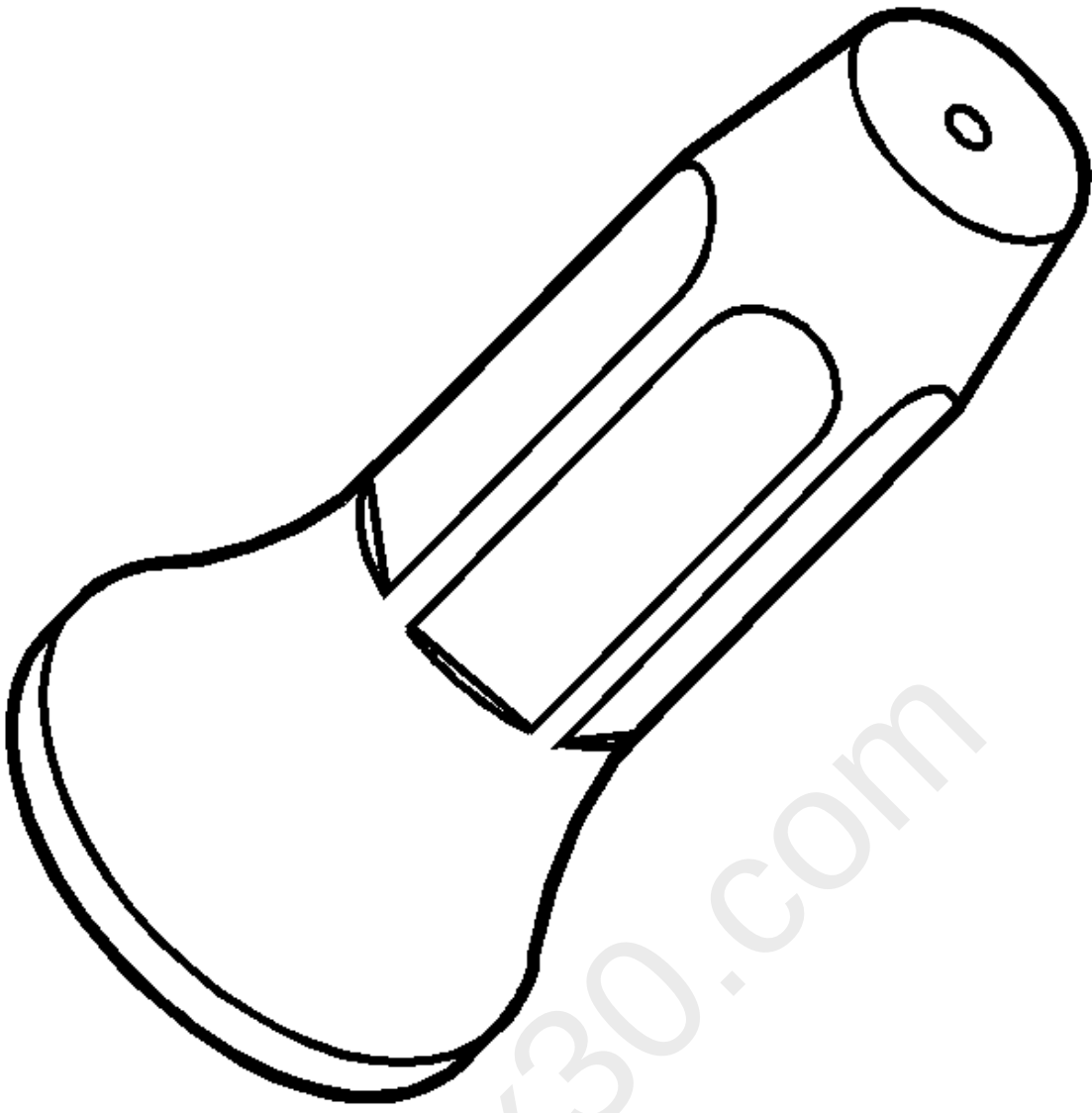
To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	DT-45866 J-45866 Input Shaft Seal Installer

Illustration	Tool Number/Description
	
	EN-8062 J-8062 KM-348 Valve Spring Compressor - Head Off

Illustration

Tool
Number/Description

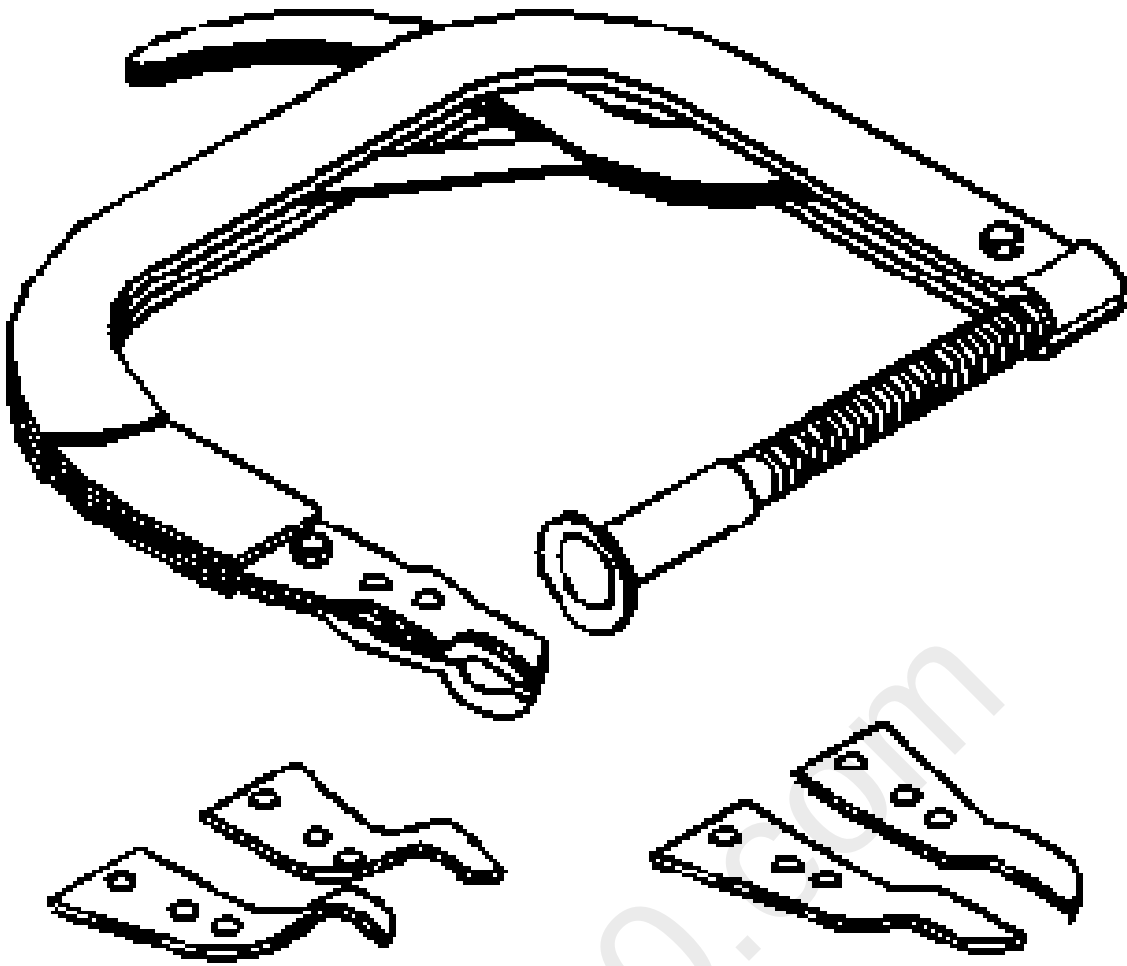


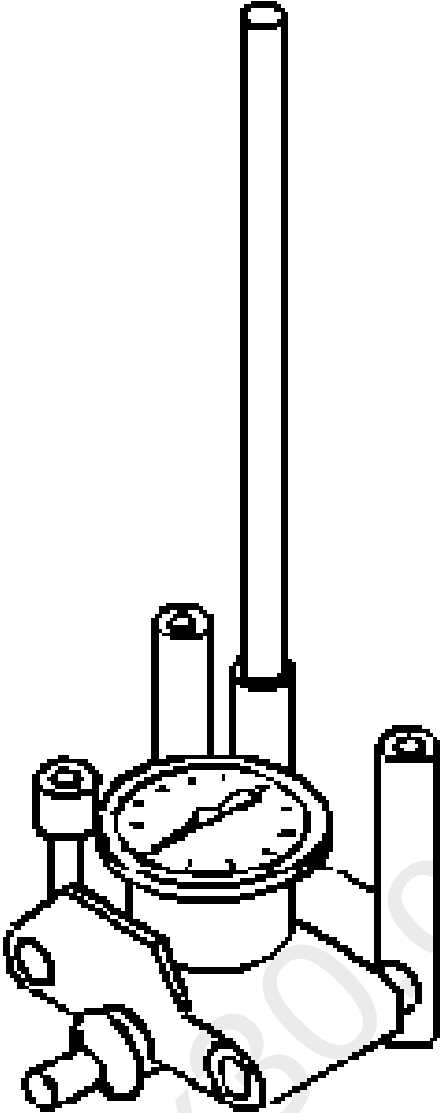
Illustration	Tool Number/Description
	EN-8087 J-8087 Cylinder Bore Gauge

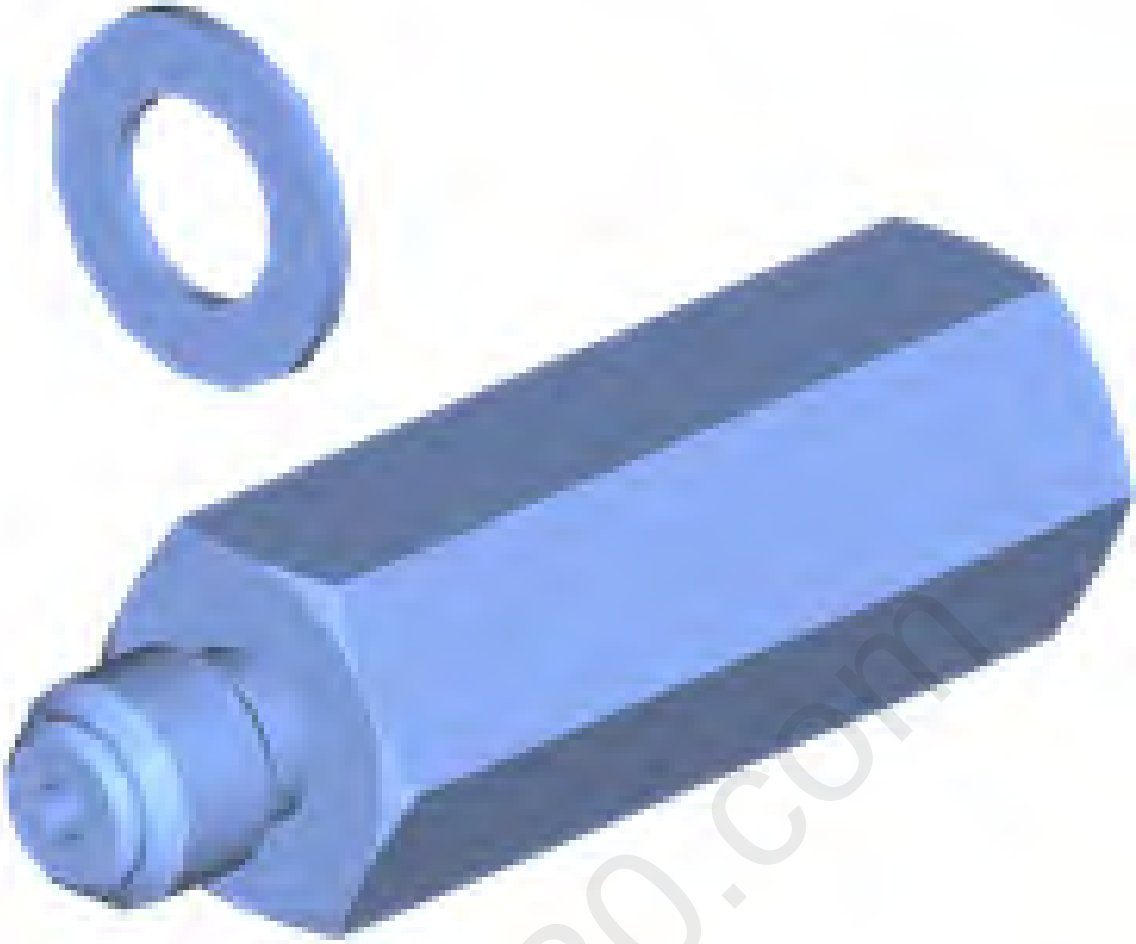
Illustration	Tool Number/Description
	EN-21867-850 J-21867-850 KM-498-B KM-6106 83 93 852 Oil Pressure Gauge Adapter
	EN-22738-B GE-22738-B J-22738-B J-9666 Valve Spring Tester

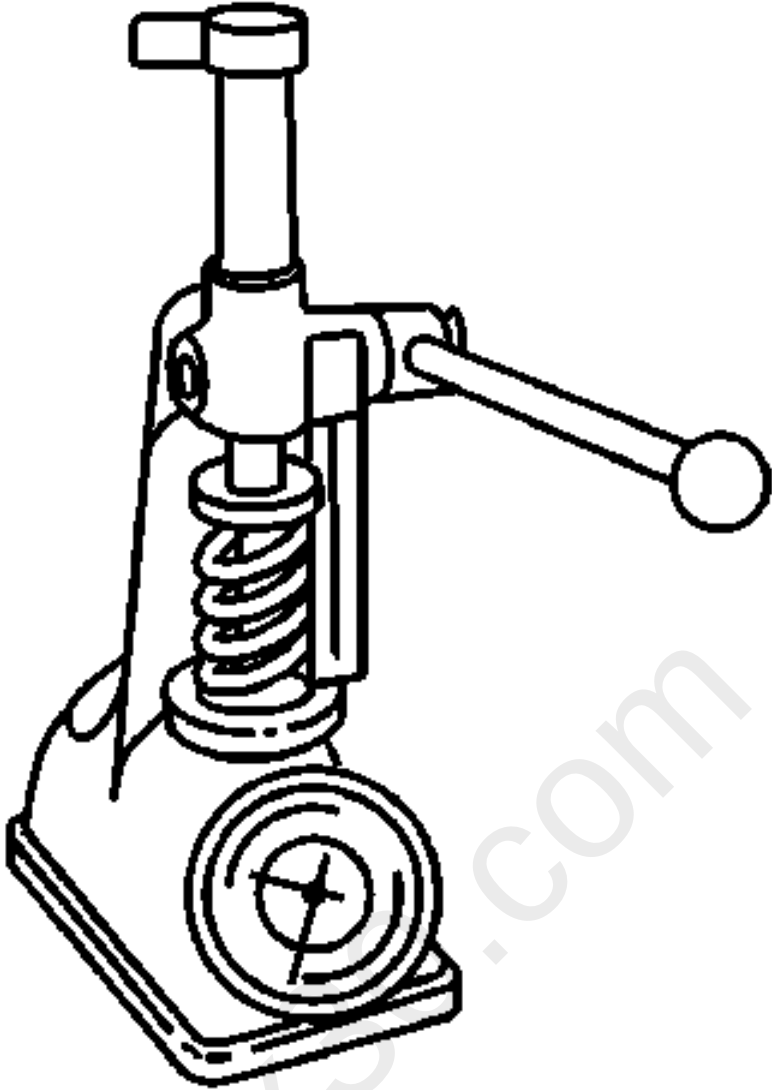
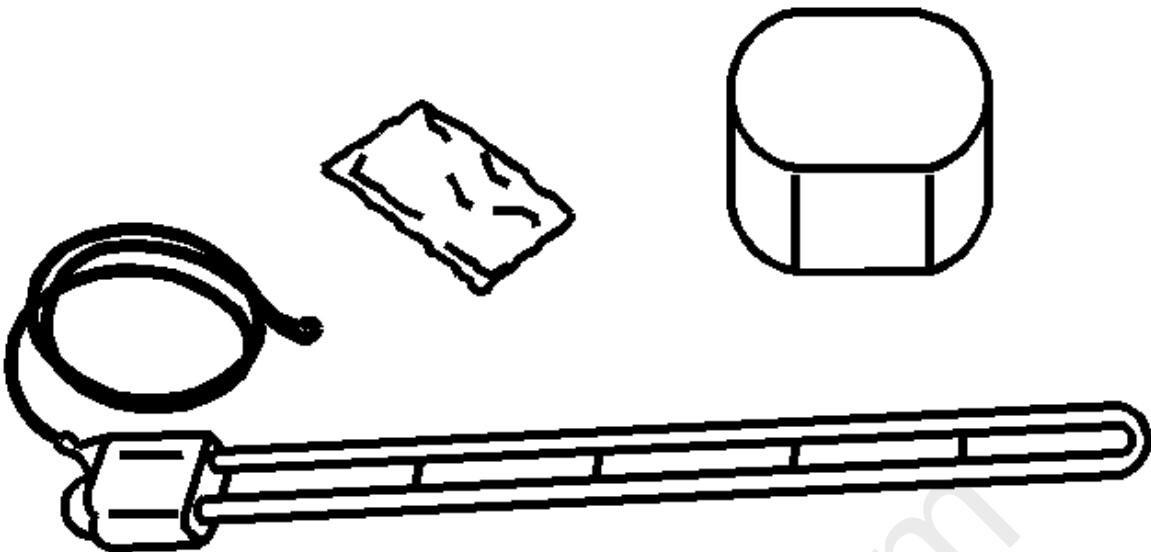
Illustration	Tool Number/Description
 A line drawing of a mechanical tool, possibly a press or a pump. It features a vertical rod with a handle at the top, a spring mechanism in the middle, and a circular base with a dial or gauge. The tool is mounted on a rectangular base. A watermark 'mex3.com' is visible across the drawing.	

Illustration	Tool Number/Description
 A line drawing of a valve manometer assembly. The main component is a long, horizontal tube with a scale marked along its length. At the left end of the tube is a circular gauge or valve. Above the tube, there is a small, rectangular component and a cylindrical component. The entire assembly is shown in a simple, schematic style.	EN-23951 J-23951 Valve Manometer

mcx30.com

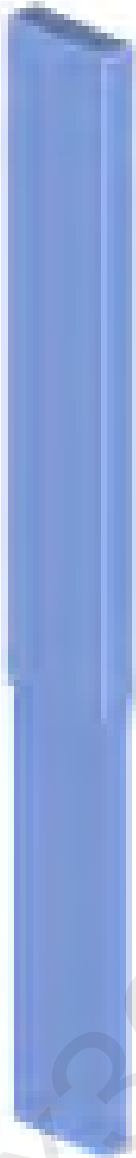
Illustration	Tool Number/Description
 A blue, L-shaped metal tool, likely made of steel, designed for removing gaskets. It has a long, straight handle and a shorter, wider flange at the end. The tool is shown vertically, with the handle pointing upwards. A faint watermark 'mcx30.com' is visible across the image.	EN-28410 J-28410 Gasket Remover

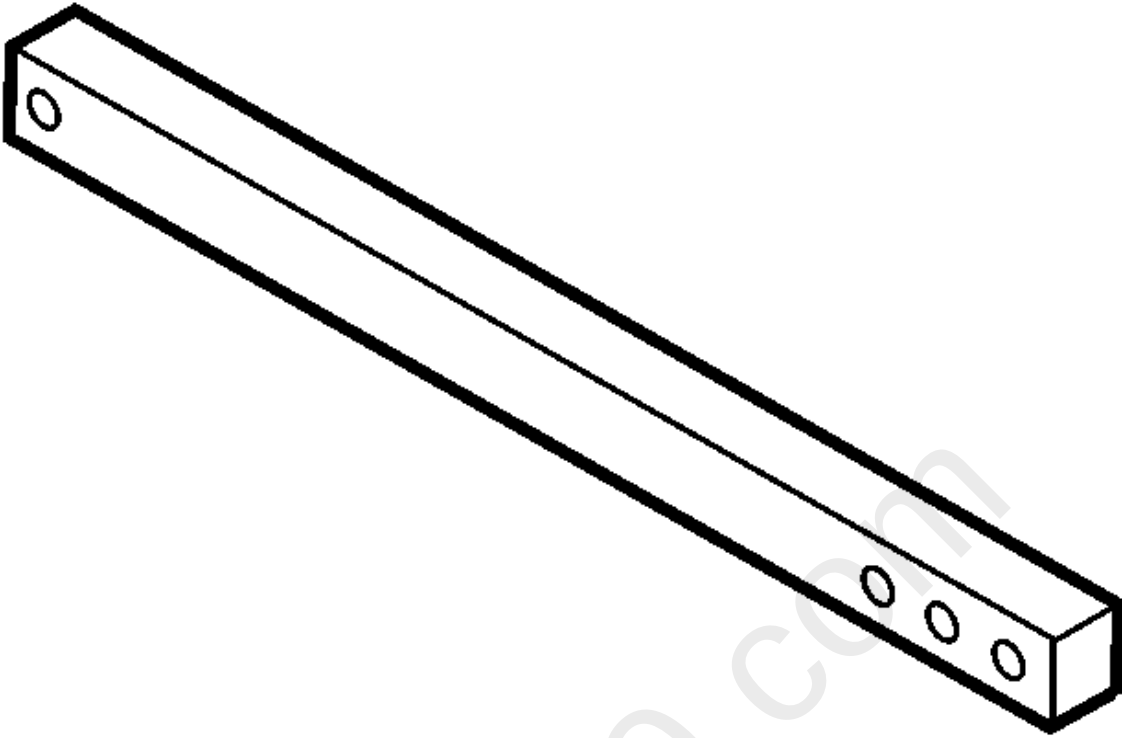
Illustration	Tool Number/Description
	EN-28467-518 J-28467-518 Engine Support Adapter - Main Support Beam

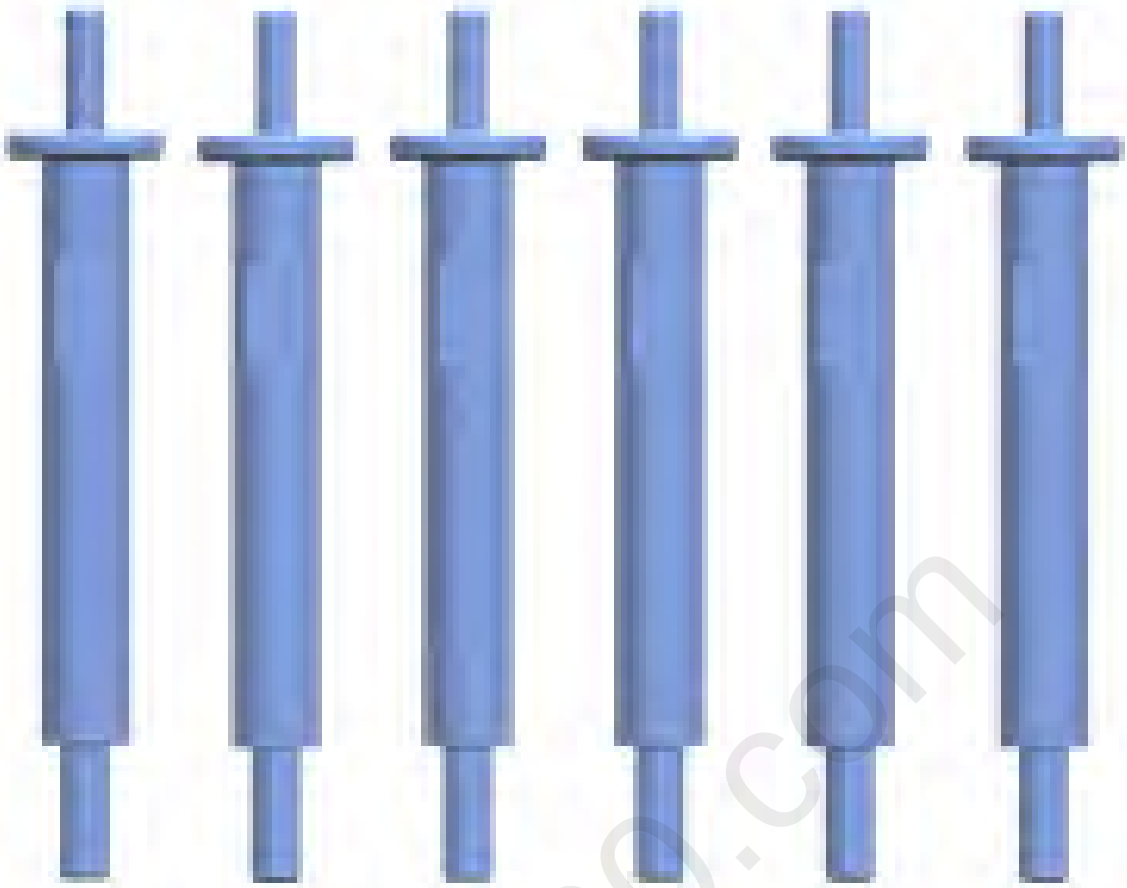
Illustration	Tool Number/Description
 The illustration shows six identical blue vertical beam adapters arranged in a horizontal row. Each adapter consists of a long central shaft with a horizontal flange at the top and another at the bottom. The shafts are slightly tapered, being wider at the top and bottom flanges. A large, light gray watermark 'mcx30.com' is oriented diagonally across the entire page, passing through the center of the adapters.	EN-28467-550 J-28467-550 Engine Support Beam Adapter

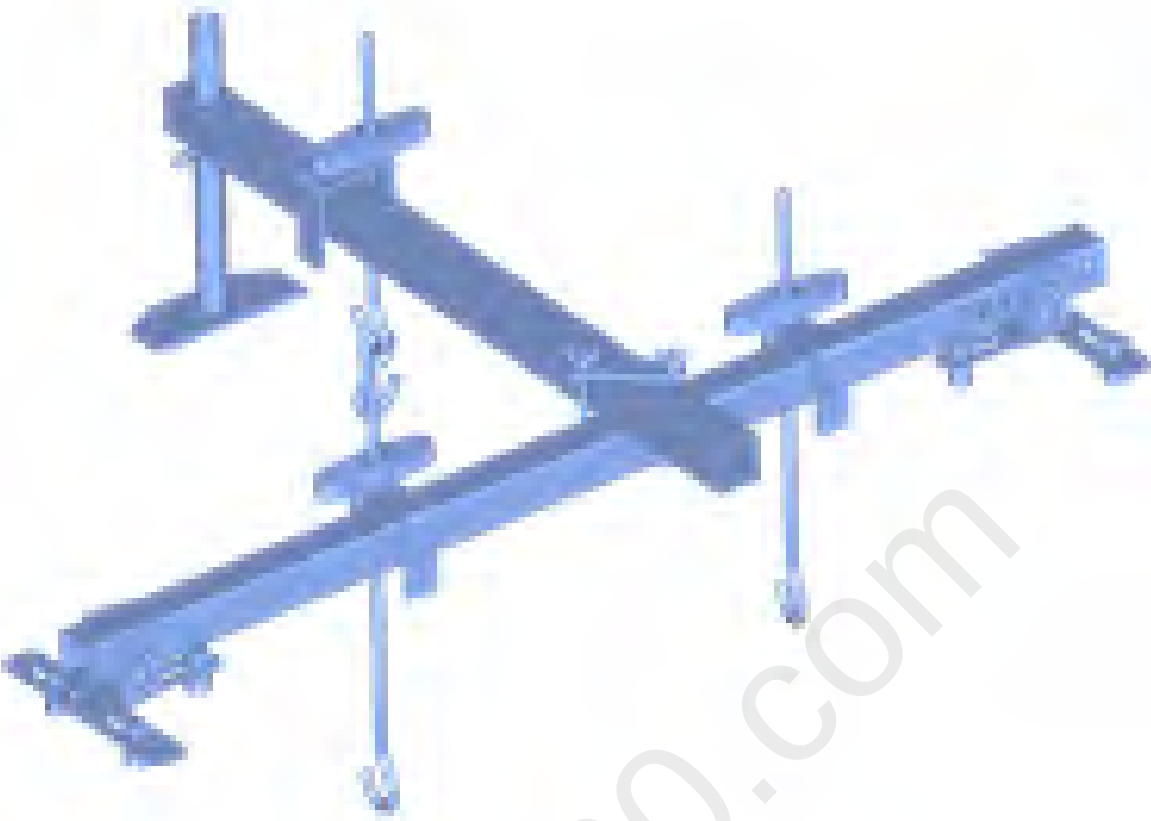
Illustration	Tool Number/Description
	EN-28467-B J-28467-B EN-51007 Universal Engine Support Fixture
	EN-34115 J-34115 Sprocket Bearing Installer

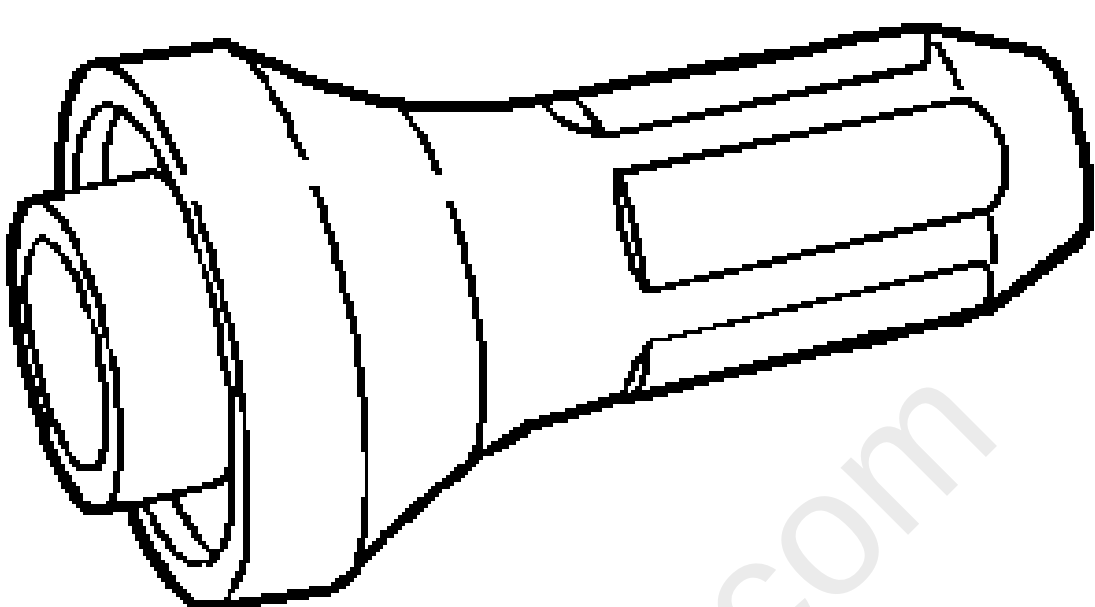
Illustration	Tool Number/Description
	
	EN-35667-A J-35667-A Cylinder Head Leakdown Tester

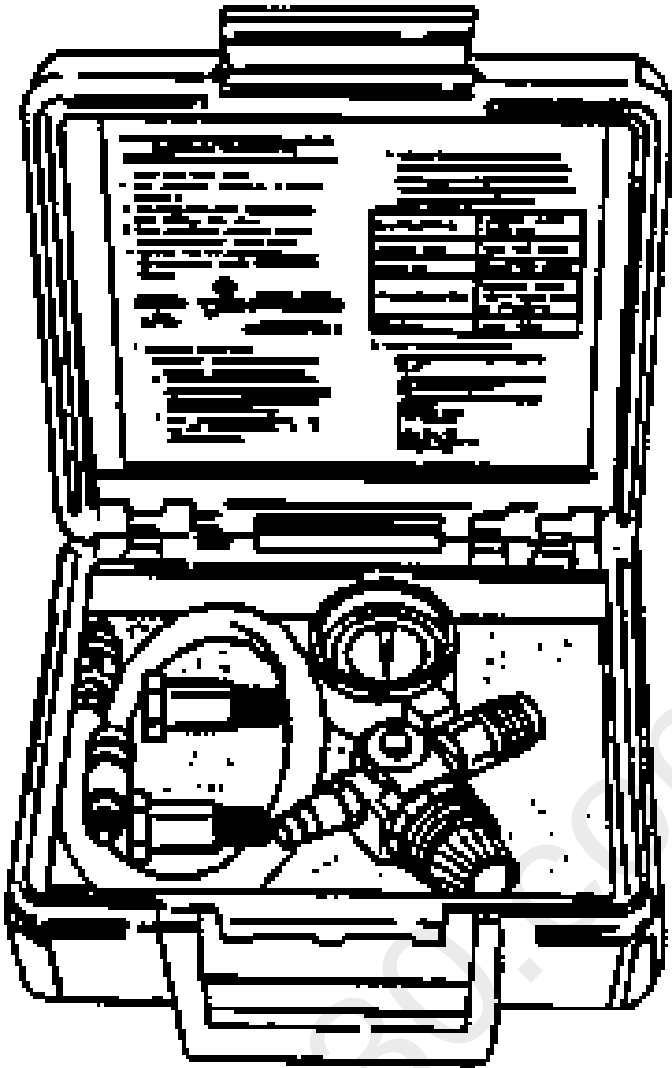
Illustration	Tool Number/Description
	

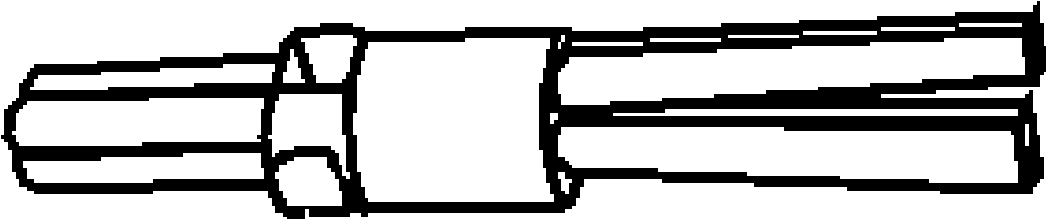
Illustration	Tool Number/Description
	EN-36017 J-36017 KM-840 - Removal KM-6152 - Installation Valve Seal Remover

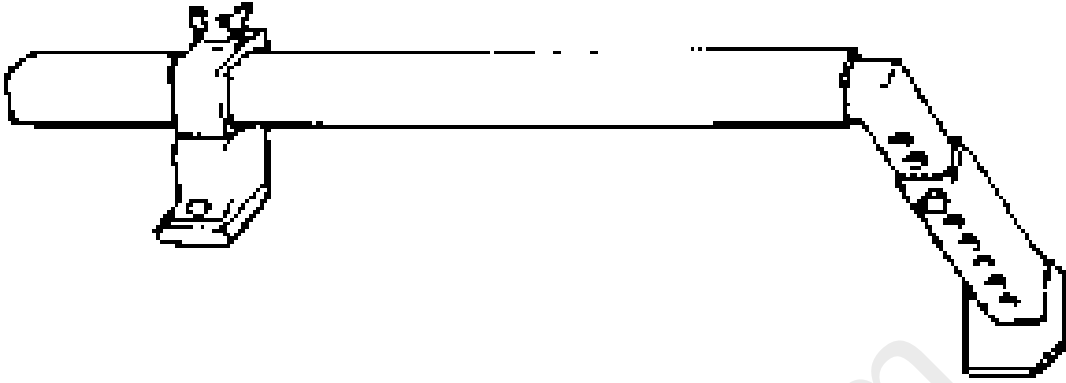
Illustration	Tool Number/Description
	EN-36462-A J-36462-A Engine Support Adapter Leg Set

Illustration	Tool Number/Description
	EN-36857 J-36857 Engine Lift Bracket

Illustration	Tool Number/Description
	EN-37281-A J-37281-A Injector Remover
	EN-38188 J-38188 Cylinder Head Broken Bolt Extractor Kit

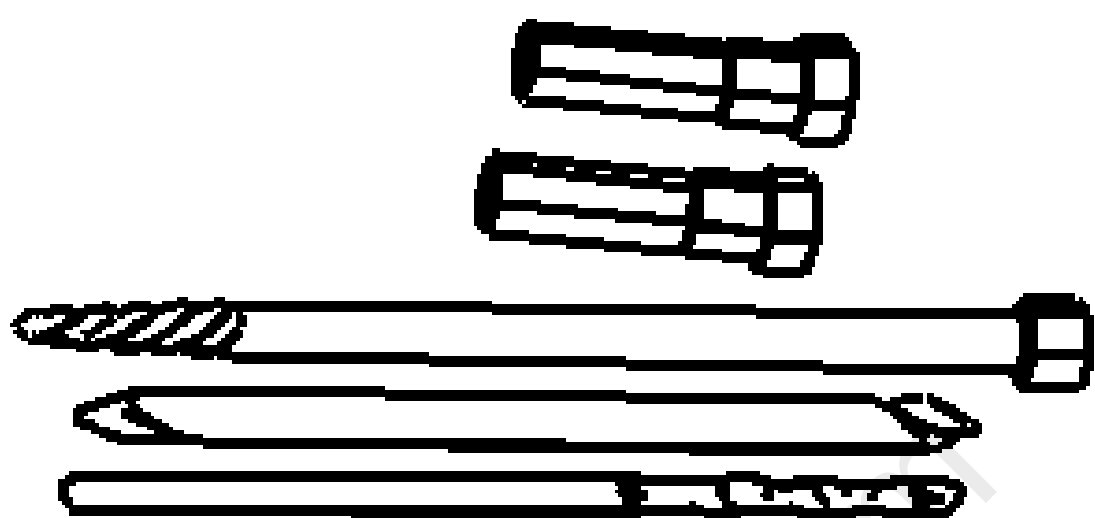
Illustration	Tool Number/Description
 A hand-drawn illustration of five tools. At the top are two identical cylindrical objects, each with a central vertical line and two horizontal lines near the ends, suggesting internal structure or segments. Below these are three long, thin tools. The first is a long rod with a flared, ribbed head on the left and a small rectangular flange on the right. The second is a long rod with a curved, hook-like head on the left and a small rectangular flange on the right. The third is a long rod with a flat, rectangular head on the left and a small rectangular flange on the right. A large, faint watermark 'mcx30.com' is visible diagonally across the illustration.	

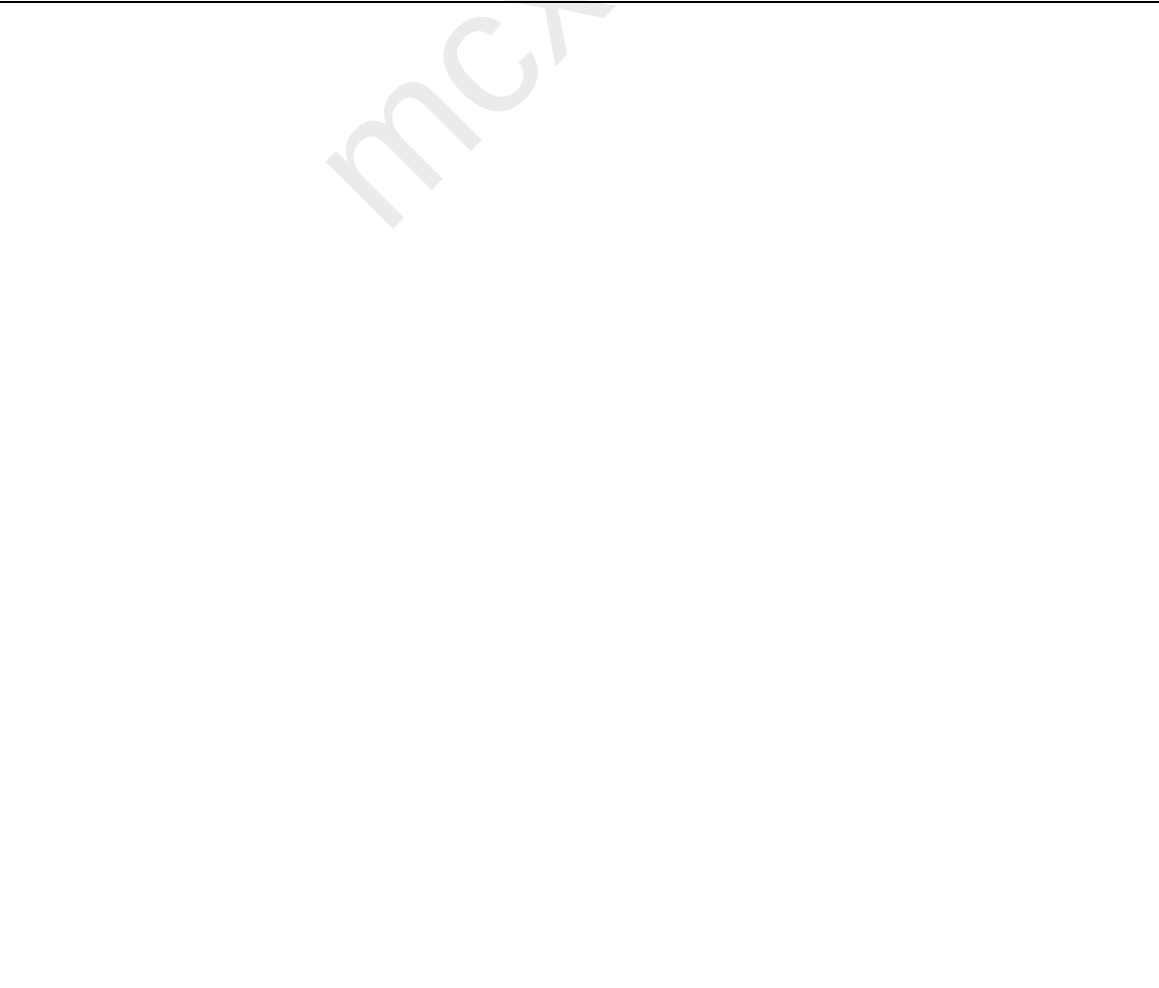
Illustration	Tool Number/Description
	EN-38416-2 J-38416-2 Crankshaft Button
	EN-39358 J-39358 83 94 785 Spark Plug Socket

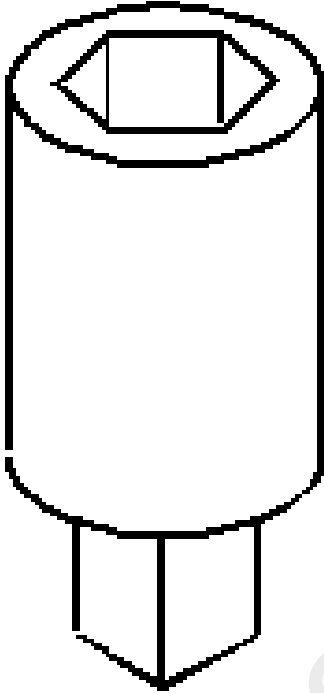
Illustration	Tool Number/Description
	

Illustration	Tool Number/Description
	EN-41816 EN-51577 J-41816 Crankshaft Balancer Remover
	EN-41816-2 J-41816-2 Crankshaft End Protector

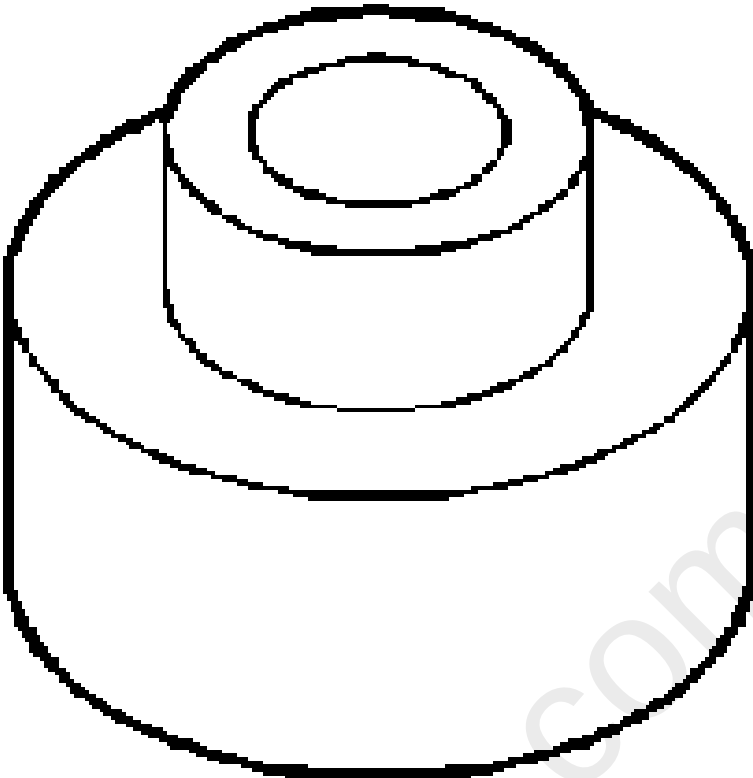
Illustration	Tool Number/Description
	

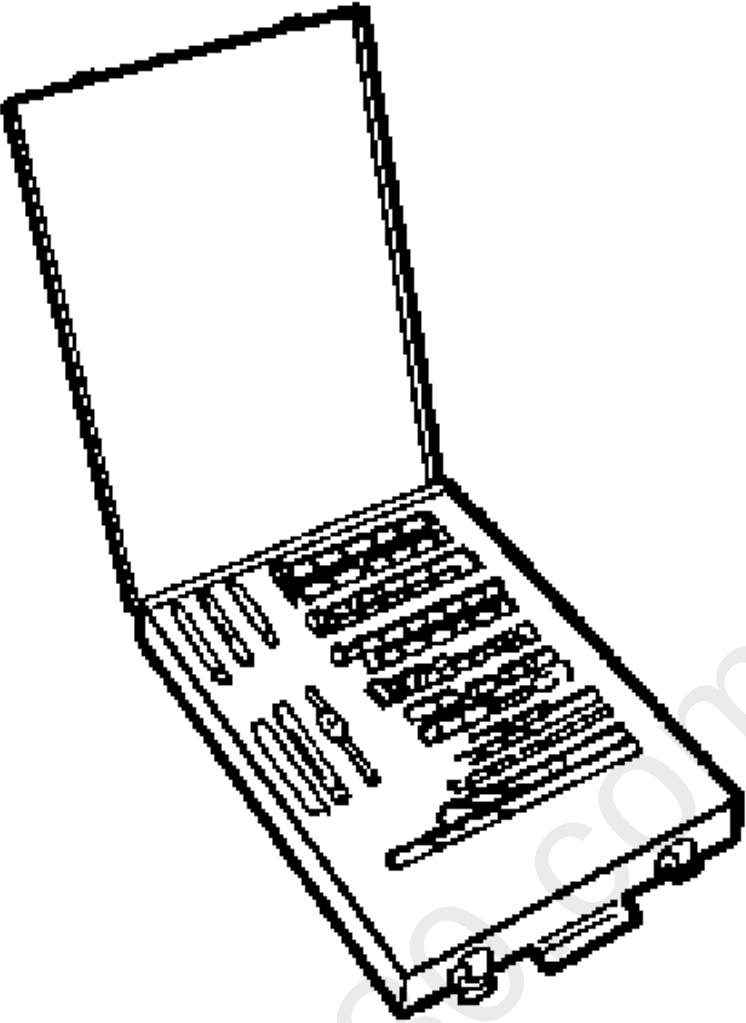
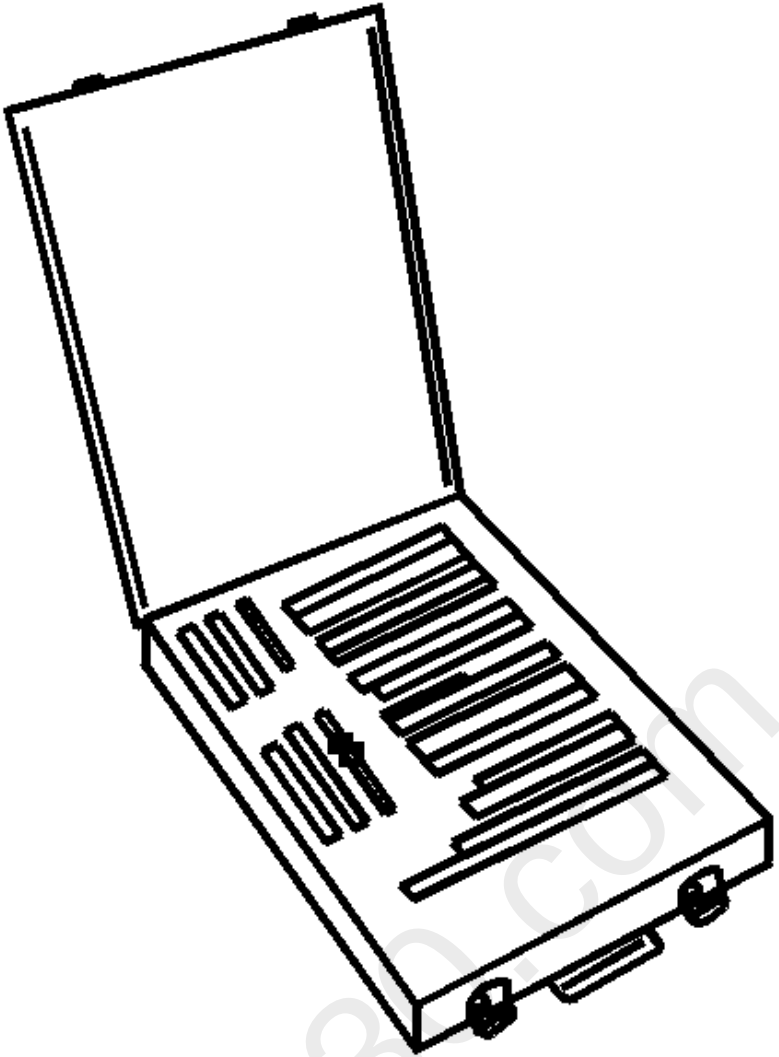
Illustration	Tool Number/Description
	EN-42385-700 J-42385-700 High Feature Thread Repair Kit

Illustration	Tool Number/Description
	EN-42385-850 J-42385-850 Thread Repair Kit

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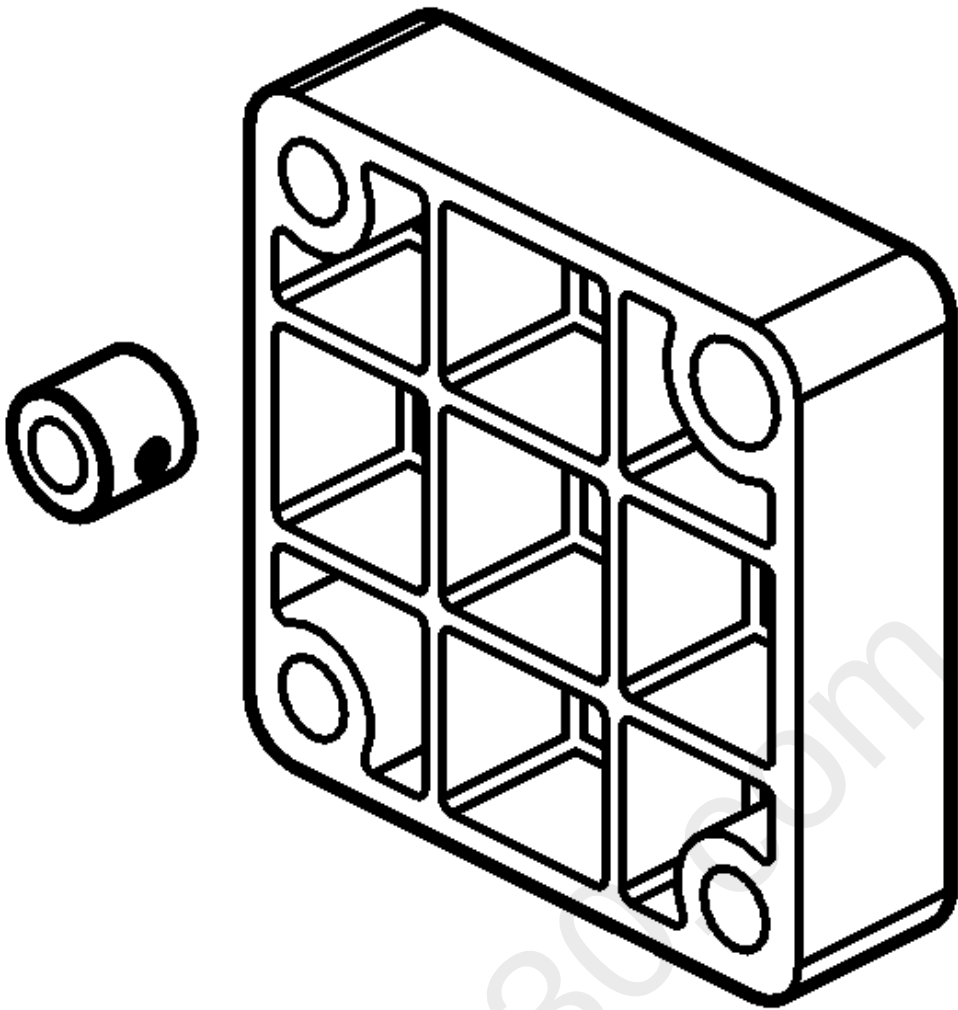
Illustration	Tool Number/Description
	EN-42385-880 Head Bolt Thread Repair Adapter Kit

Illustration	Tool Number/Description
	EN-43405-1 J-43405-1 Engine Support Fixture Adapter - Passenger Side

Illustration	Tool Number/Description
	EN-43405-2 J-43405-2 Engine Support Fixture Adapter - Driver Side

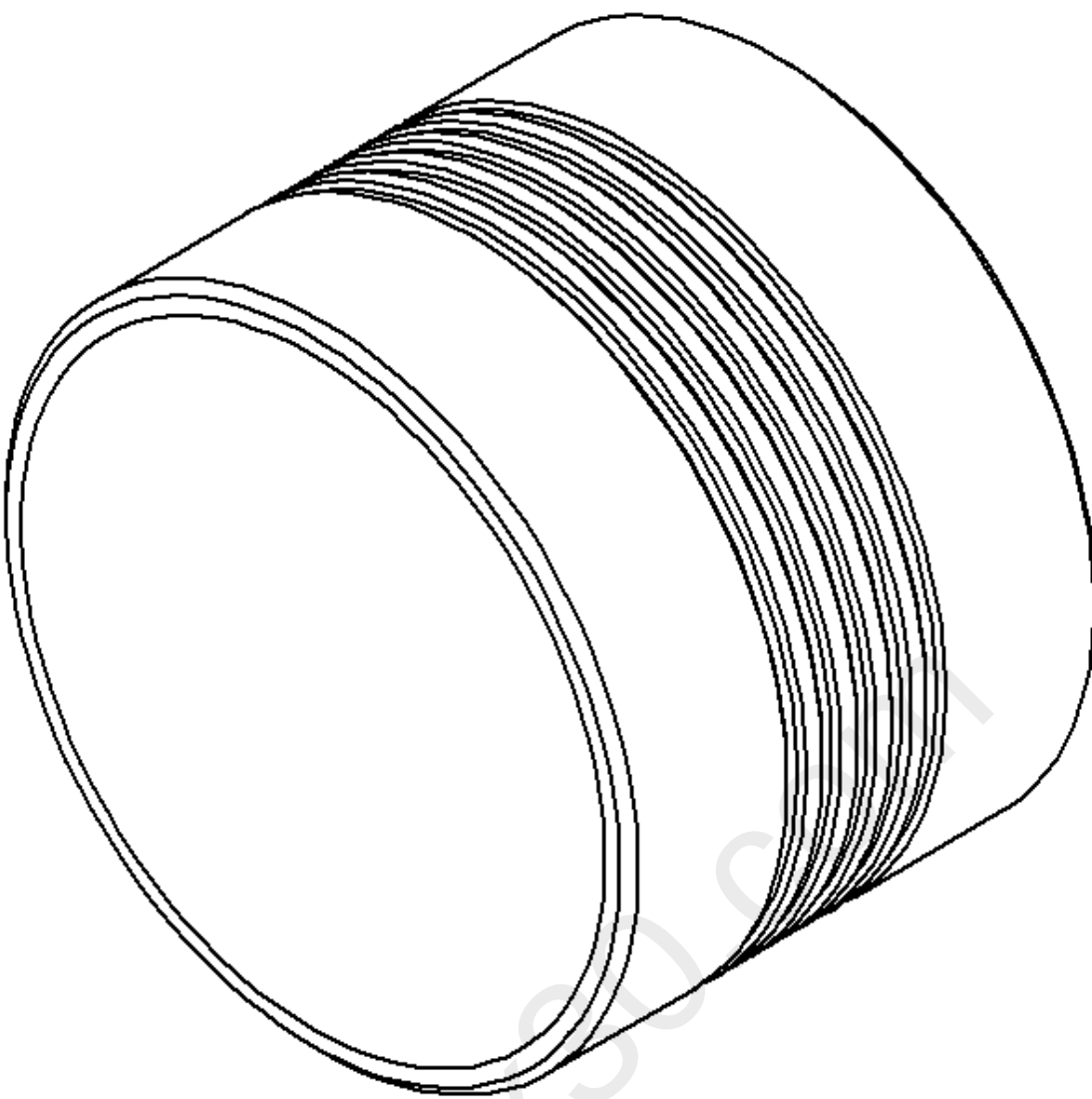
Illustration	Tool Number/Description
	EN-43953 J-43953 Piston Ring Compressor - 86 mm
	EN-43963 J-43963 KM-6149 Valve Spring Compressor (off car)

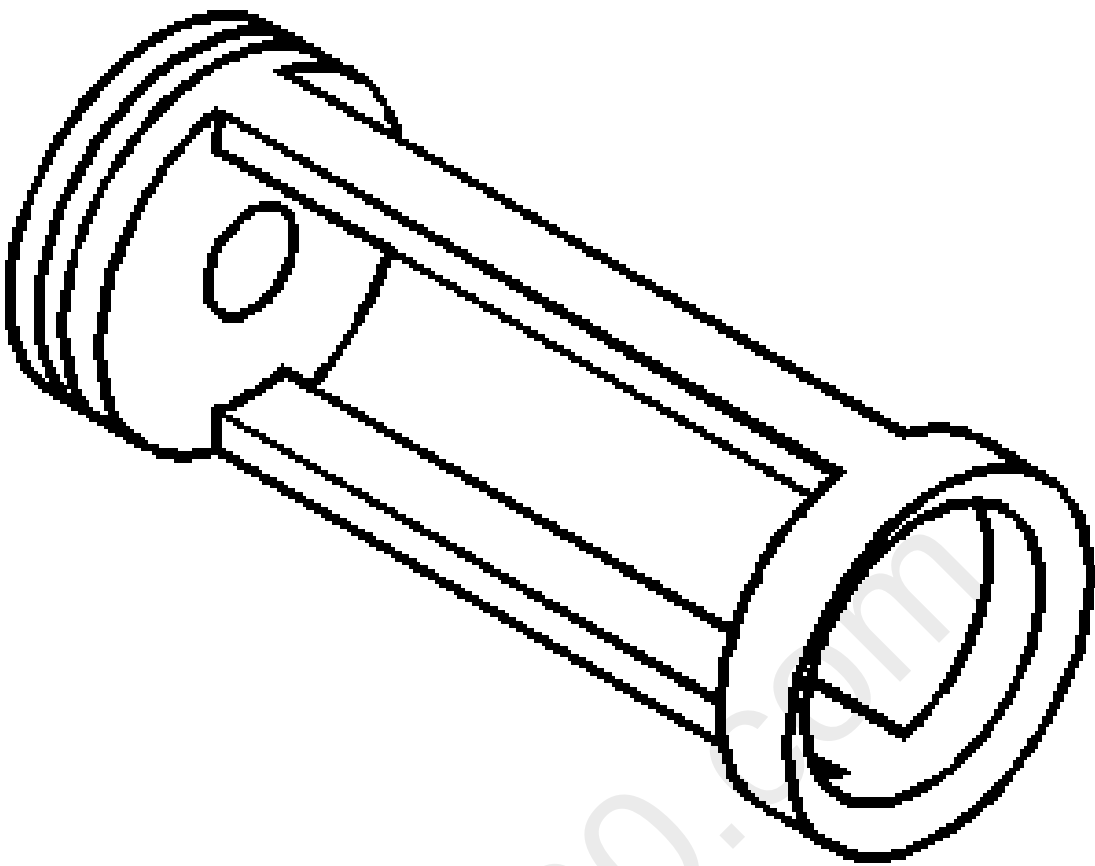
Illustration	Tool Number/Description
	

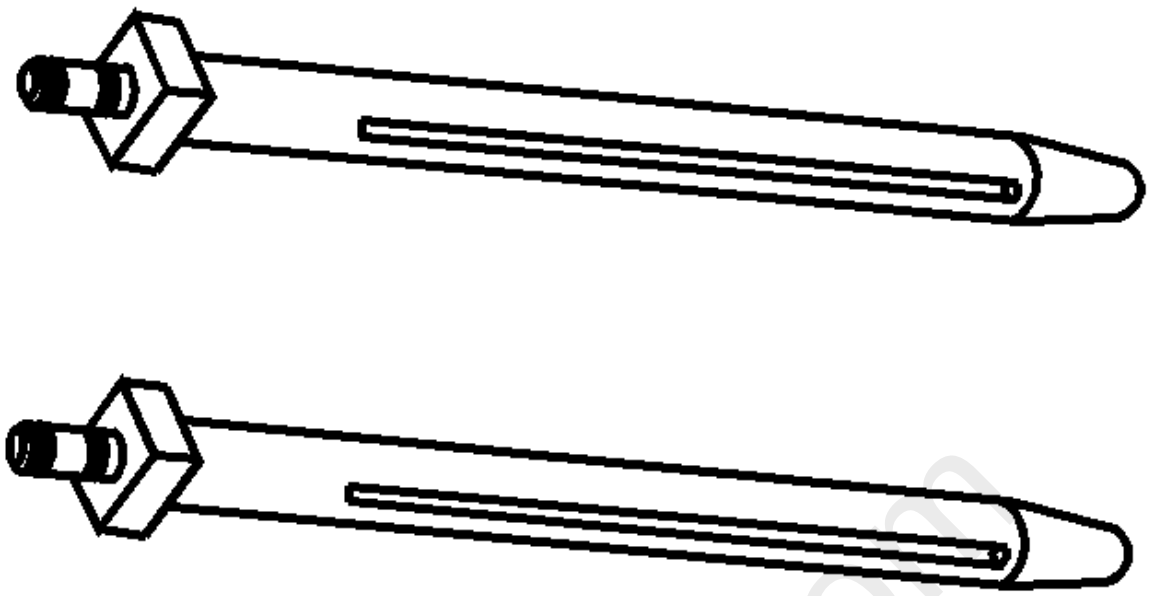
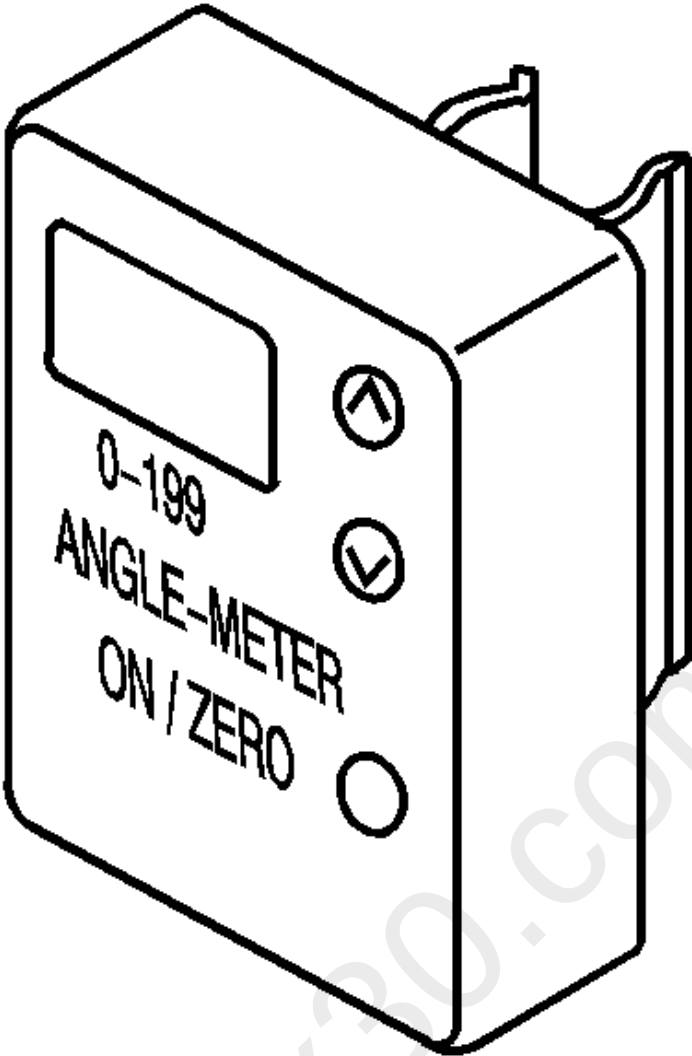
Illustration	Tool Number/Description
	EN-43966-1 J-43966-1 Connecting Rod Guides

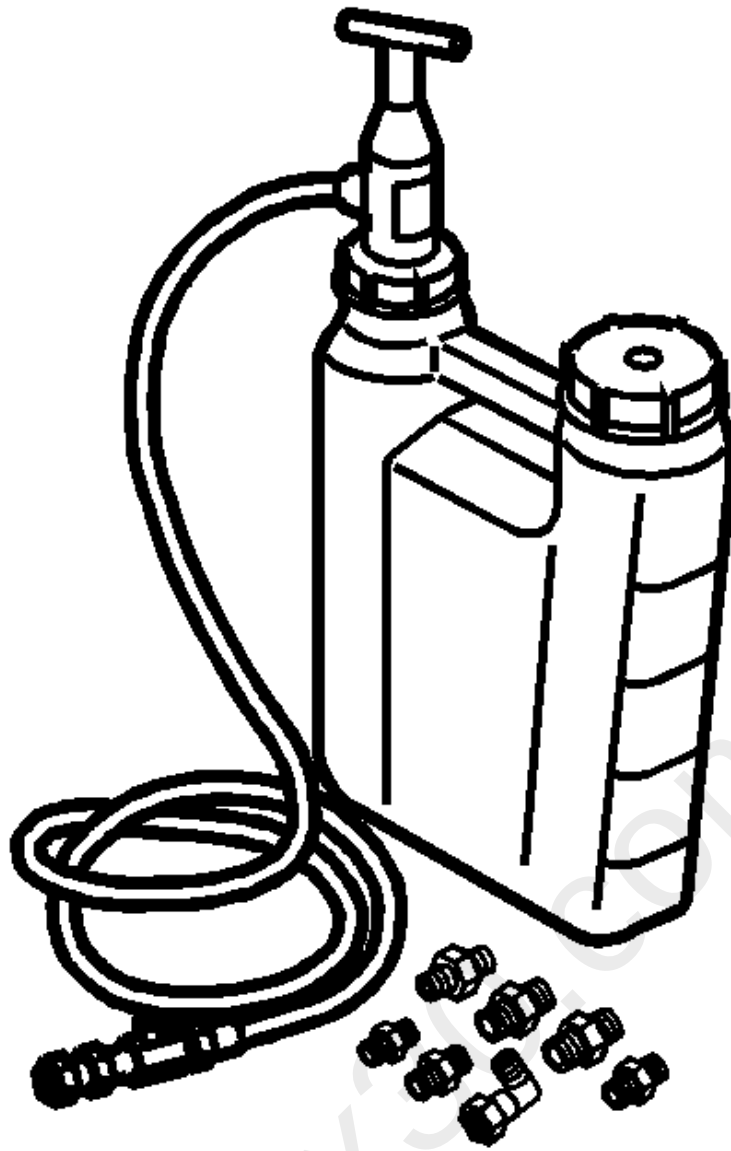
Illustration	Tool Number/Description
	EN-45025 J-45025 Belt Tensioner Wrench

Illustration	Tool Number/Description
	EN-45059 J-45059 KM-470-B Angle Meter

mex30.com

Illustration

Tool
Number/Description



EN-45299
J-45299
Engine Pre-Luber

Illustration	Tool Number/Description
	EN-46116 Valve Stem Seal Remover

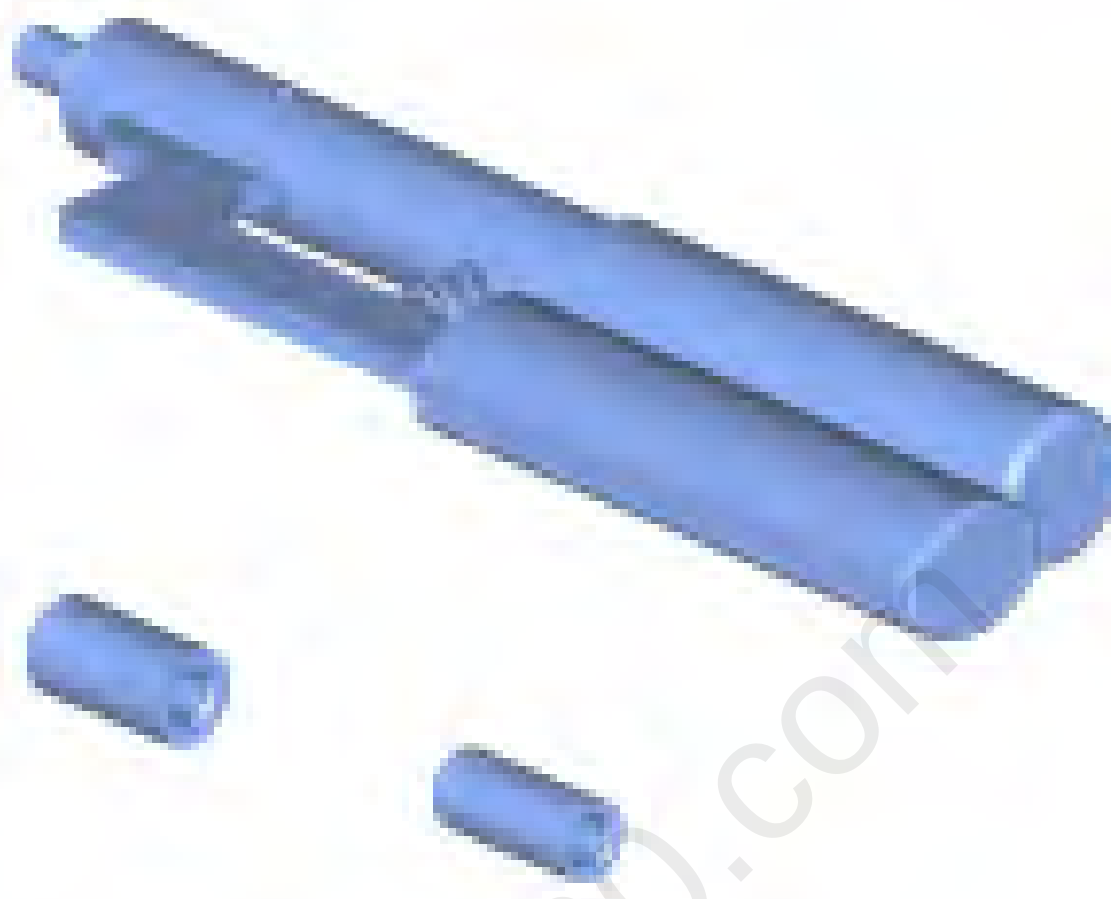
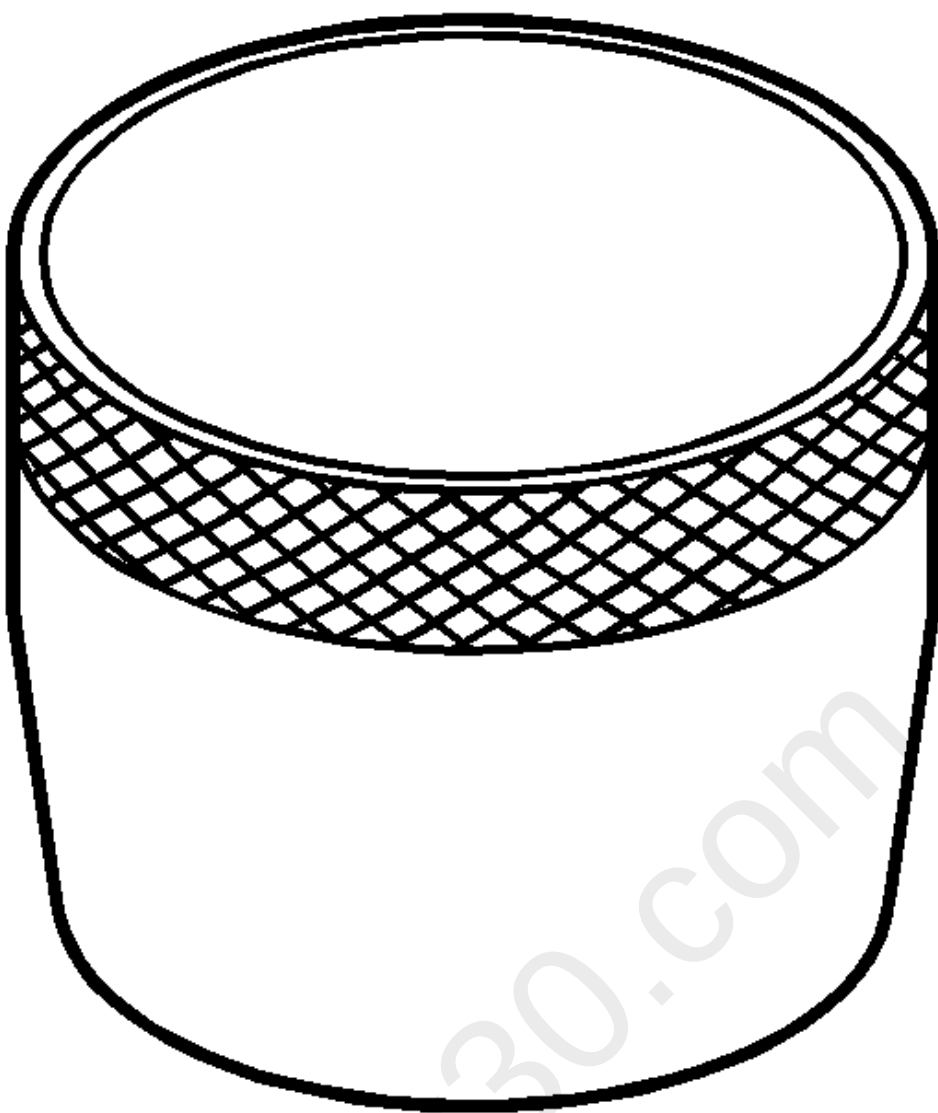
Illustration	Tool Number/Description
 The illustration shows a blue, cylindrical tool with a central slot and a small notch at one end. Two small blue pins are shown below the tool. A large, diagonal watermark 'mcx30.com' is overlaid on the image.	EN-46745 J-43654 Piston Pin Clip Remover/Installer

Illustration	Tool Number/Description
 A blue, cylindrical tool component, likely a piston pin clip remover/installer adapter, shown at an angle. The tool has a hollow interior and a smooth, metallic finish. A large, diagonal watermark 'mcx30.com' is visible across the image.	EN-46745-4 Piston Pin Clip Remover/Installer Adapter

Illustration	Tool Number/Description
	EN-47836 J-47836 Ring Compressor - 88 mm

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Illustration	Tool Number/Description
	EN-47909 Injector Bore and Sleeve Cleaning Kit

Illustration	Tool Number/Description
	EN-48034 Crankshaft Balancer Installer

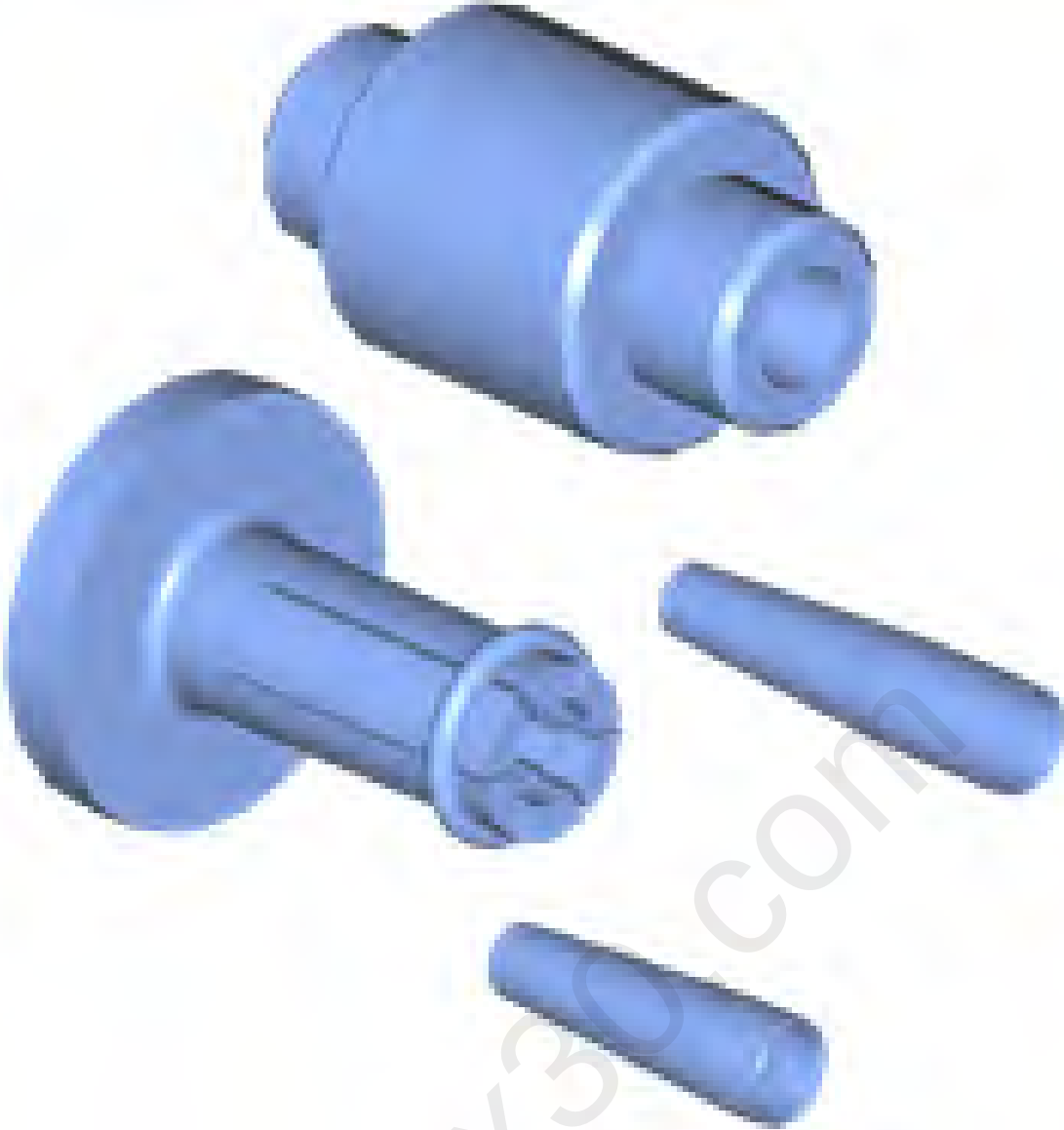
Illustration	Tool Number/Description
	EN-49245 Injector Seal Installer and Sizer

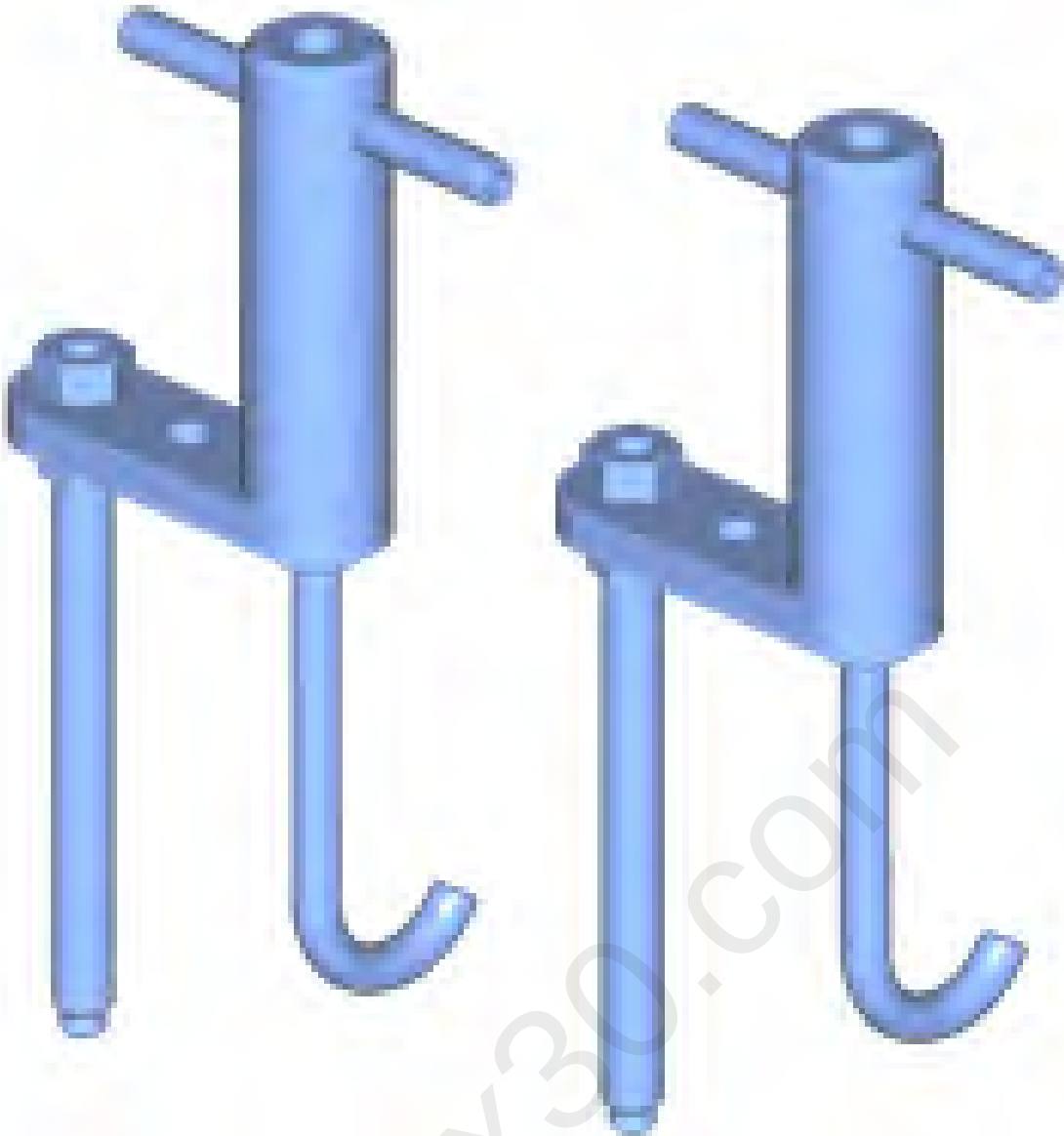
Illustration	Tool Number/Description
	EN-49248 Fuel Rail Assembly Remover

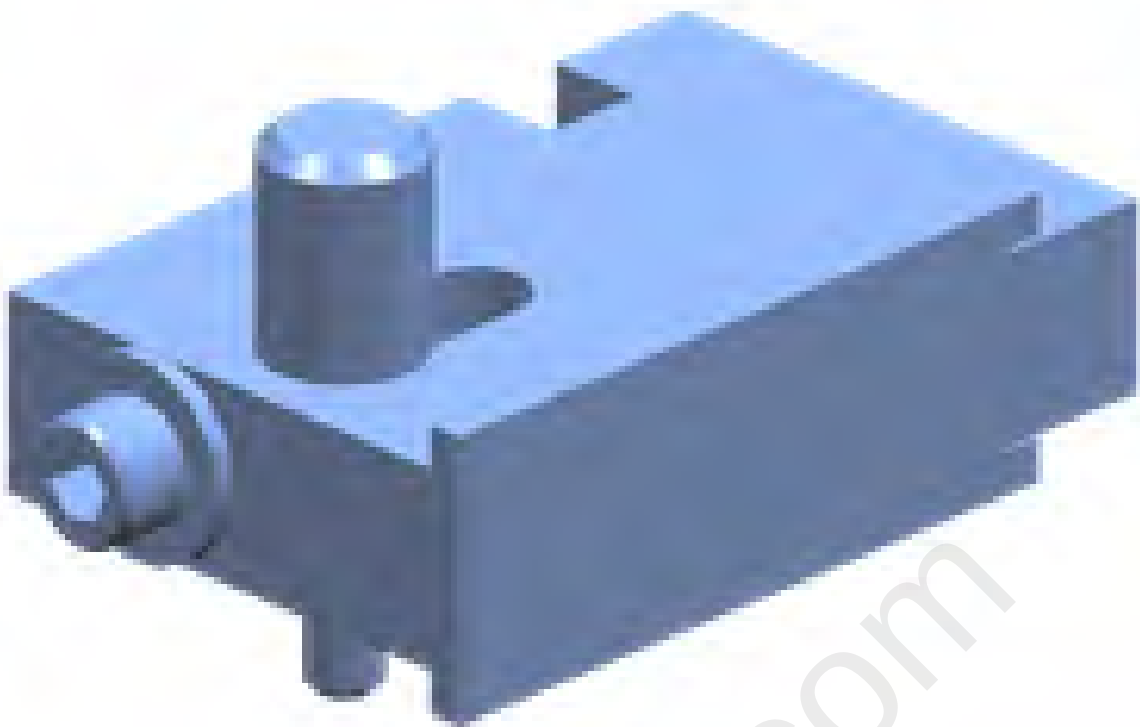
Illustration	Tool Number/Description
	EN-50656 Timing Chain Retention Tool Kit

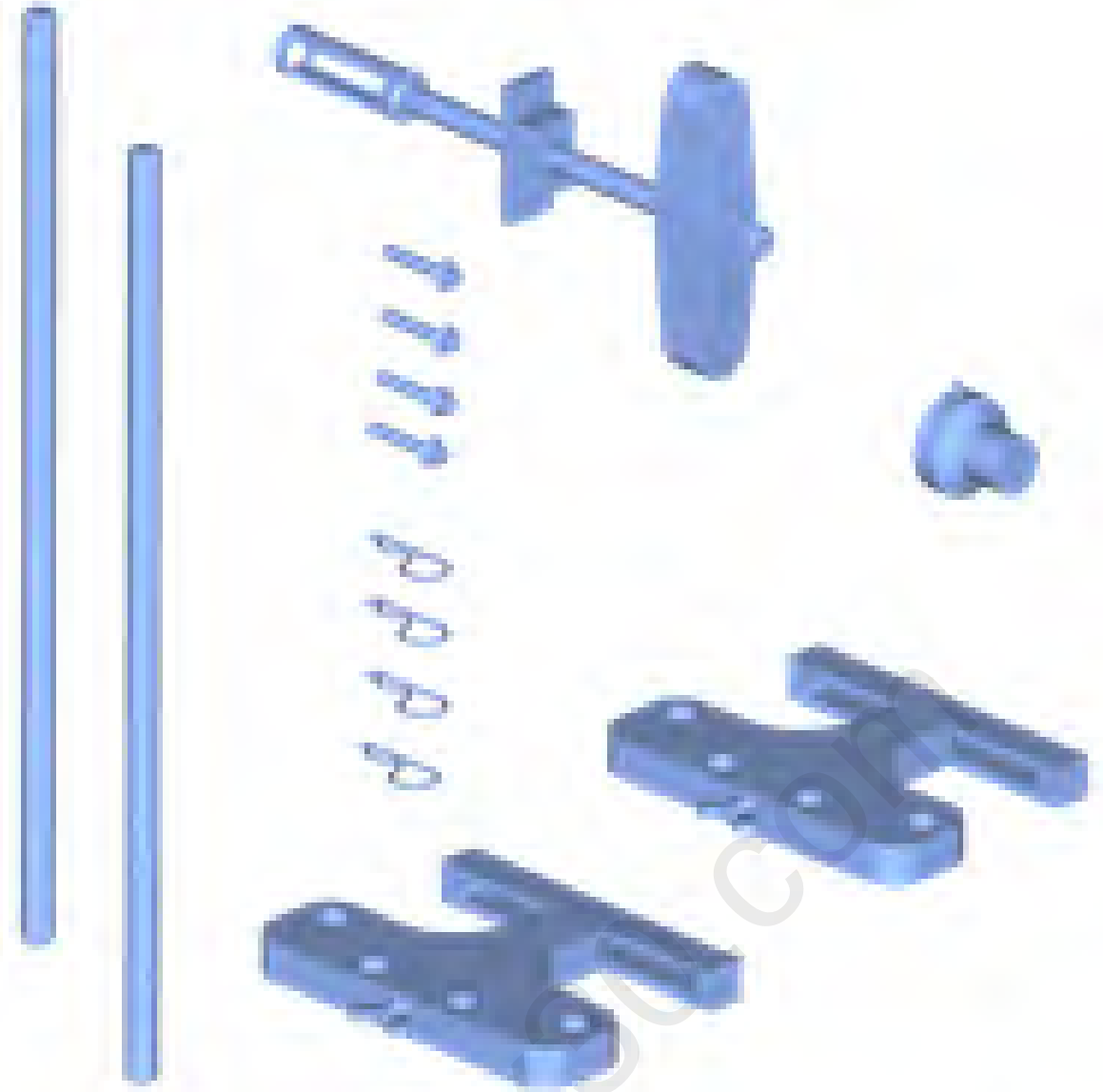
Illustration	Tool Number/Description
 An exploded view diagram of a valve spring compressor tool assembly. The components are shown in a disassembled state. On the left, there are two long, thin metal rods. In the center, there is a vertical stack of five small, cylindrical spacers. To the right of the spacers, there is a large, dark-colored metal component, likely the main body of the compressor, which has a central threaded rod passing through it. At the top of this rod is a small, circular, flat disc. Below the main body, there are two more large, dark-colored metal components, which appear to be the base or support blocks. A small, dark-colored, cylindrical component is also shown to the right of the main body. The entire assembly is rendered in a 3D perspective view.	EN-50717 Valve Spring Compressor

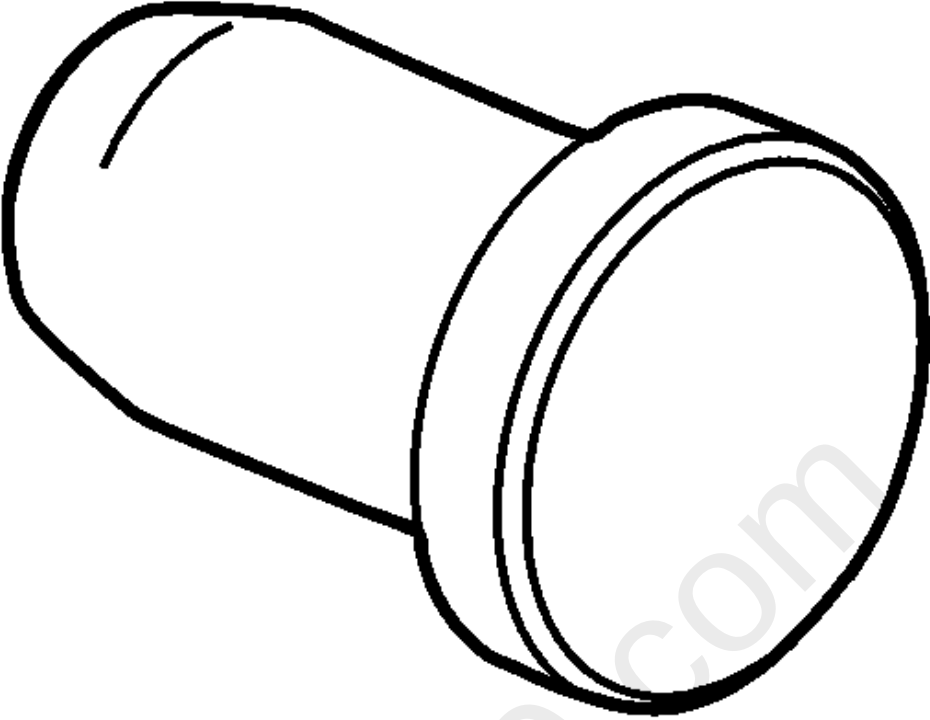
Illustration	Tool Number/Description
	EN-50790 High Pressure Fuel Pump Installation Alignment Gauge

Illustration	Tool Number/Description
	EN-50791 Fuel Injector Nozzle Installer - to Rail

Illustration	Tool Number/Description
 The image shows a blue metal camshaft actuator locking tool. It has a long, straight handle with a hole at the end. The head of the tool is curved and has a central opening. Two blue pins are shown next to the tool. A large, diagonal watermark 'mcx30.com' is visible across the image.	EN-50793 Camshaft Actuator Locking Tool

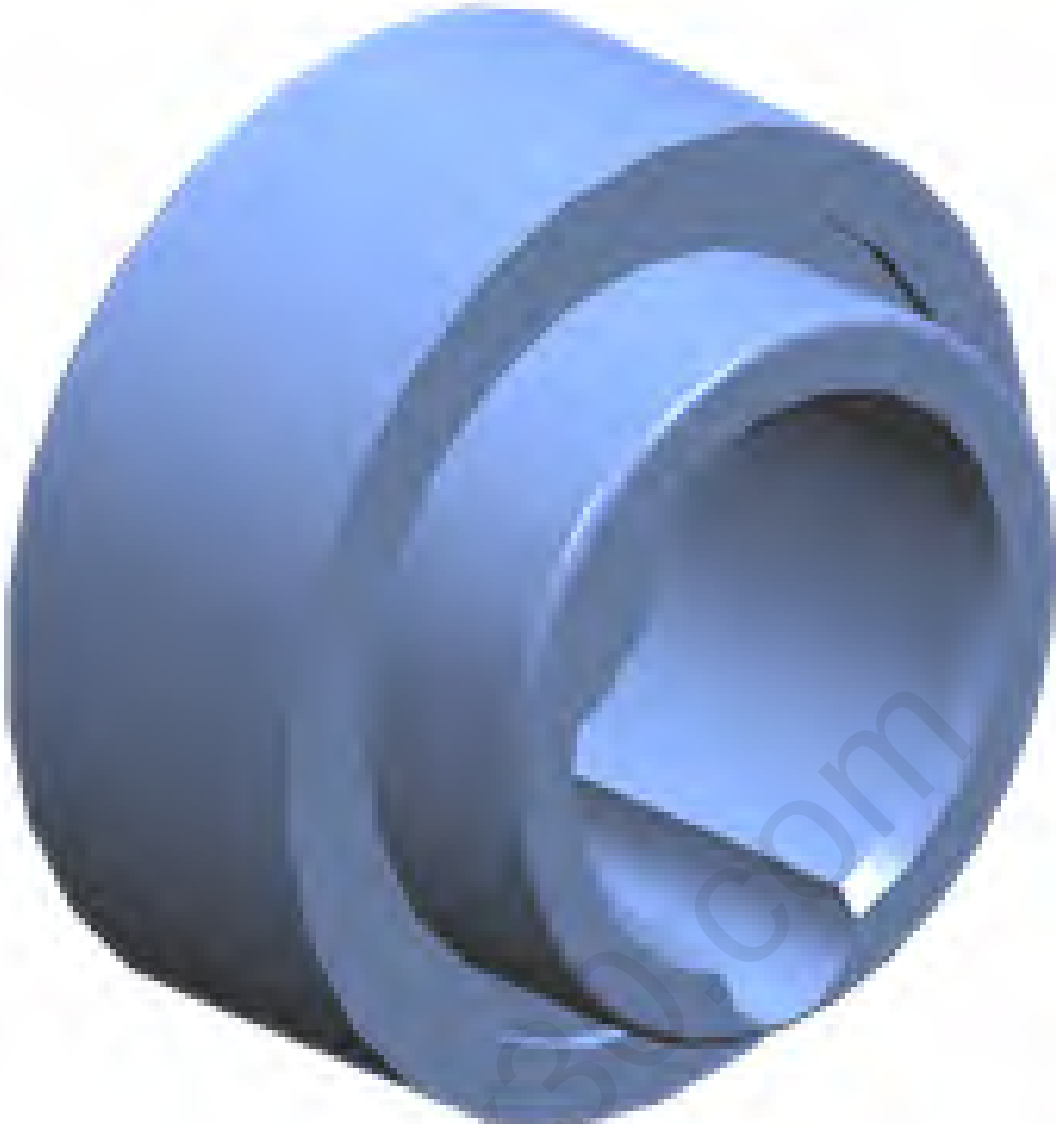
Illustration	Tool Number/Description
	EN-50820 Front Crankshaft Seal Installer

Illustration	Tool Number/Description
	EN-50837 Timing Chain Tensioner Retraction Tool

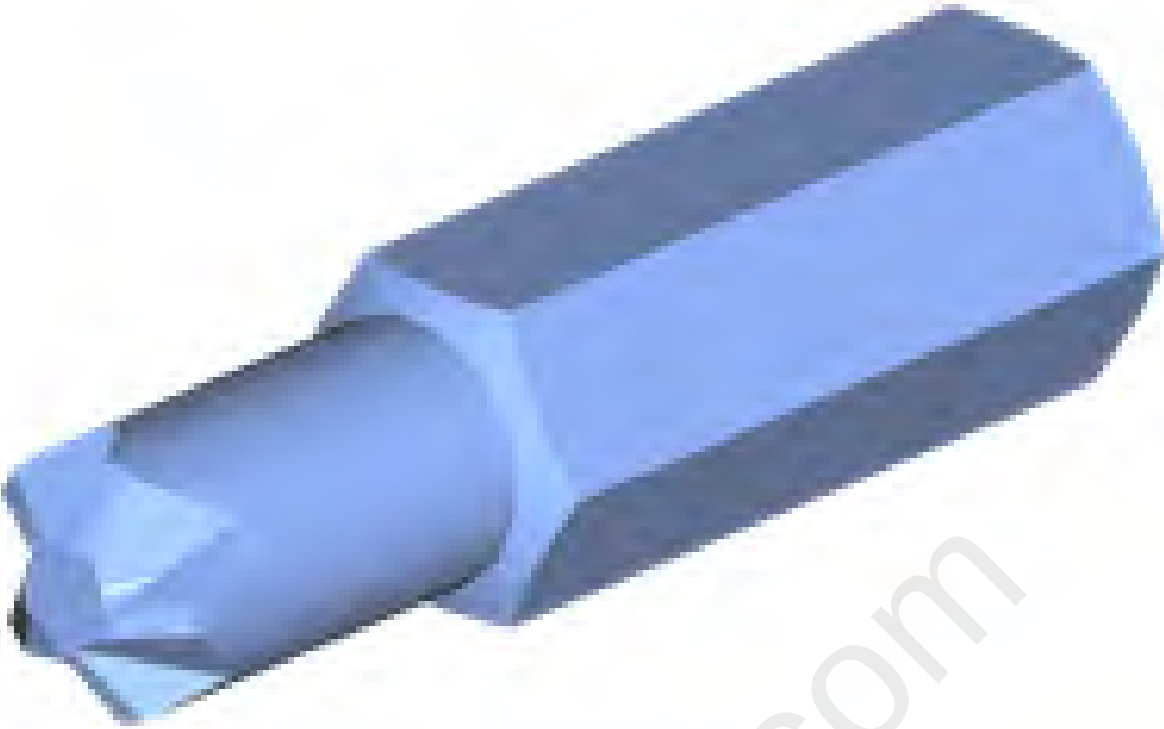
Illustration	Tool Number/Description
 A blue, hexagonal, tamper-proof drive bit with a square end. The bit is shown at an angle, highlighting its hexagonal body and the square-shaped tip. A watermark 'mcx30.com' is visible diagonally across the image.	EN-50956 Tamper Proof Drive Bit

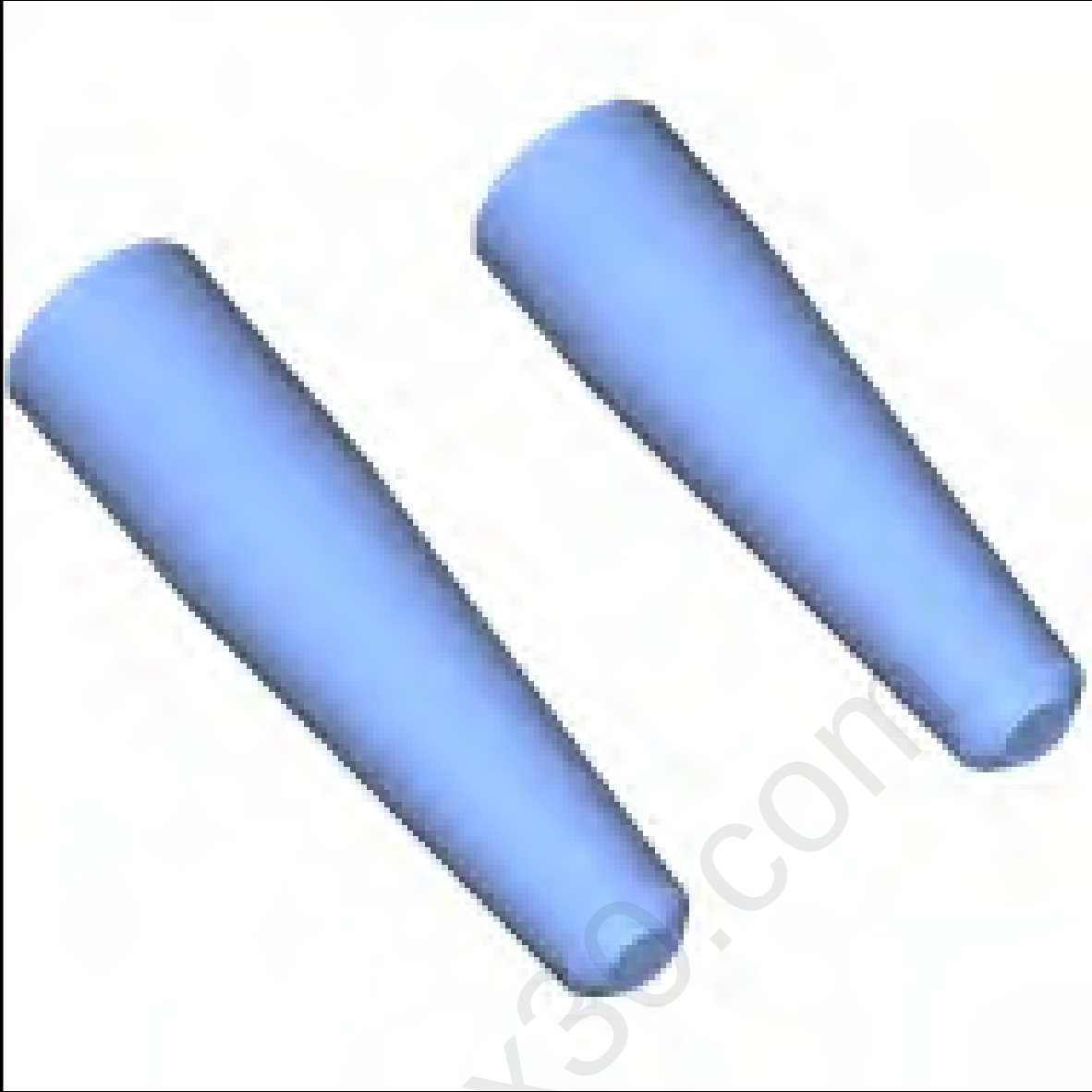
Illustration	Tool Number/Description
 The illustration shows two identical blue cylindrical tools, likely injector seal installers, positioned diagonally. They have a smooth, metallic finish and are shown from a perspective that highlights their length and circular ends. A faint watermark 'mcx350.com' is visible across the lower portion of the image.	EN-51105 Injector Seal Installer

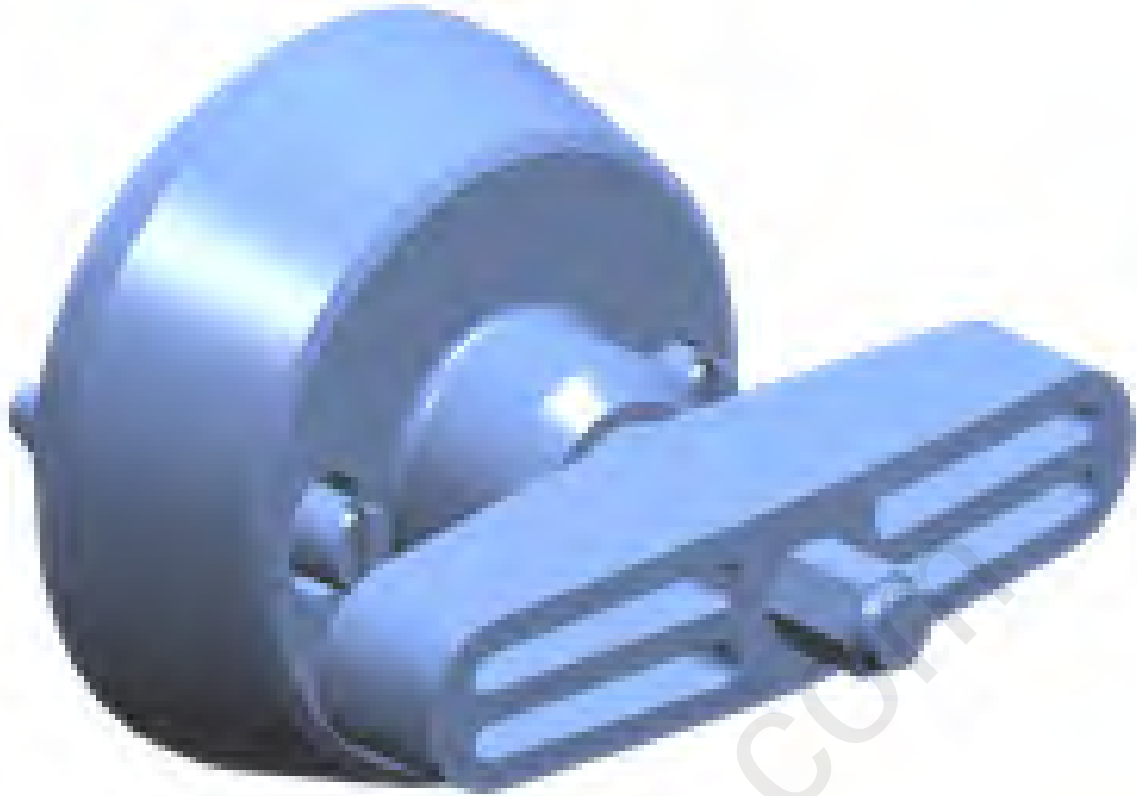
Illustration	Tool Number/Description
 A blue, dome-shaped mechanical seal installer tool. It features a large, rounded, hemispherical head and a long, rectangular handle attached to the side. The handle has several longitudinal ridges for grip. The tool is shown from a three-quarter perspective against a white background.	EN-51380 Seal Installer

Illustration	Tool Number/Description
 The illustration shows three blue metal tools. The largest is a C-shaped holder with a central circular opening and a small rectangular notch at the top. Below it is a smaller, similar circular holder. To the left of the smaller holder are two long, cylindrical rods. A large, light gray watermark 'mcx30.com' is diagonally across the image.	EN-51577 Balancer Holder and Remover

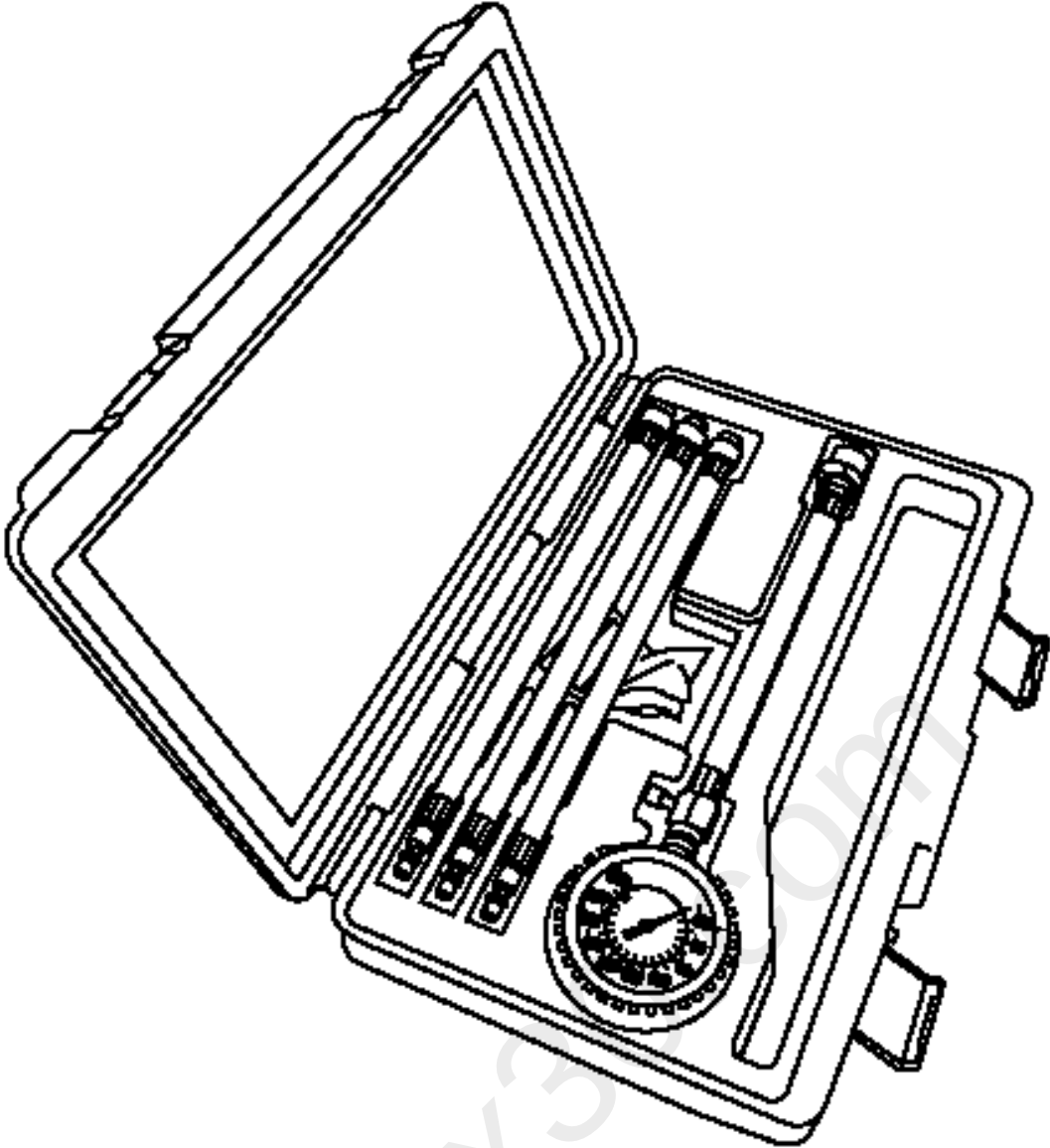
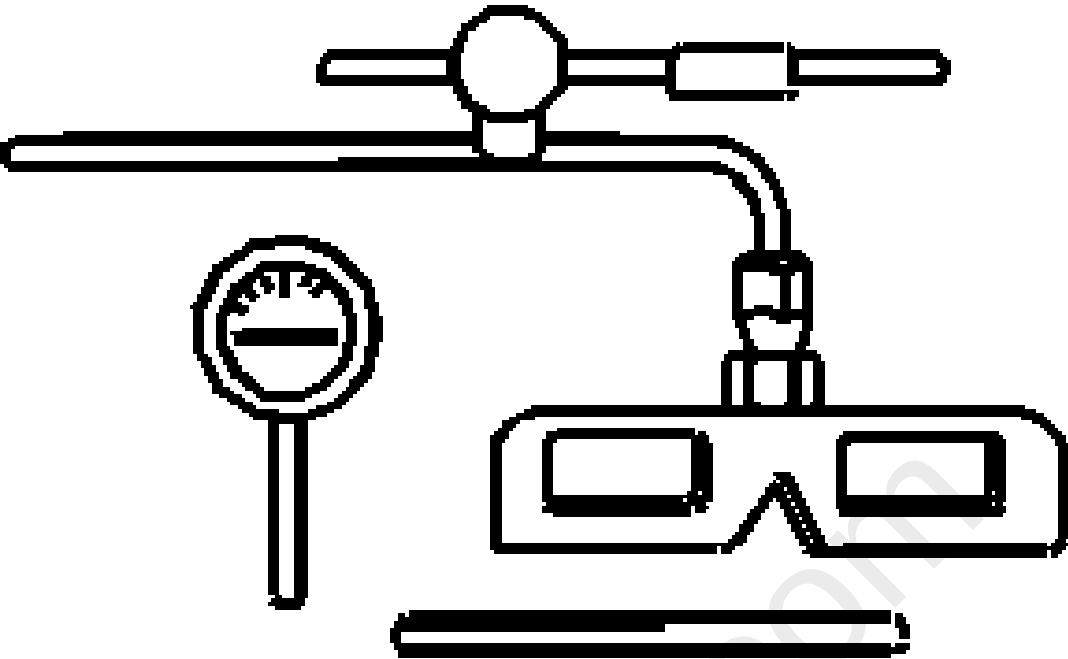
Illustration	Tool Number/Description
	EN-51749 Compression Gauge Tester Kit

Illustration	Tool Number/Description
	EN-51760 EN-50792 Flywheel Holder

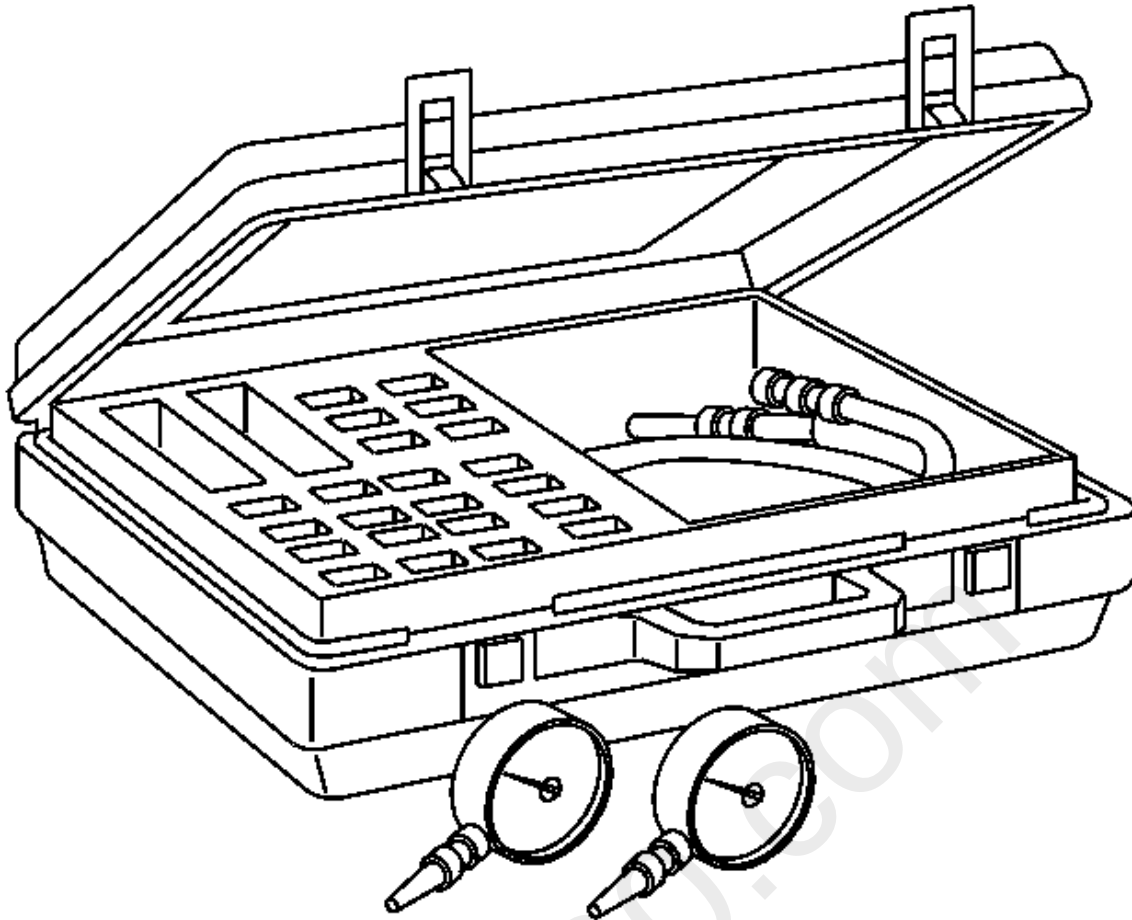
Illustration	Tool Number/Description
 Three blue 3D rendered engine support fixture adapter bolts are shown. Each bolt has a hexagonal base, a central threaded shaft, and a flange with a hexagonal hole. The bolts are arranged in a triangular pattern. A large, light gray watermark 'mcx30.com' is diagonally across the image. mcx30.com	EN-51768 Engine Support Fixture Adapter Bolts M8

Illustration	Tool Number/Description
	EN-52059 Engine Support Fixture Adapter Bolts M10
	GE-7872 J-7872 Magnetic Base Dial Indicator Set

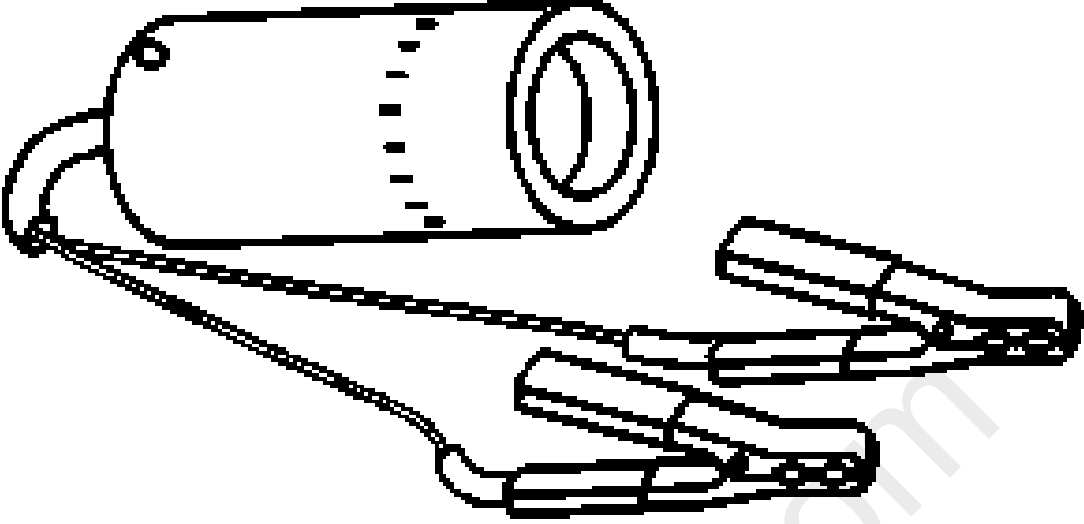
Illustration	Tool Number/Description
	

Illustration

Tool
Number/Description



GE-21867-A
J-21867-A
Oil Pressure Gauge
Kit

Illustration	Tool Number/Description
	GE-42220 J-28428-E J-42220 Universal 12V Leak Detection Lamp

2018 ENGINE
Exhaust - Equinox & Terrain

SPECIFICATIONS

FASTENER SPECIFICATIONS

Single Use Non-Threaded Fasteners/Components

NOTE: <i>All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.</i>	
Application	
Catalytic Converter Gasket	
Exhaust Gasket	
Exhaust Manifold 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>	
Application	Specification
	Metric (English)
Catalytic Converter Clamp (LH7)	6 N.m (53 lb in)
Exhaust Manifold Bolt (LTG)	20 N.m (15 lb ft)
Exhaust Manifold Bolt (LH7)	
First Pass:	20 N.m (15 lb ft)
Second Pass:	20 N.m (15 lb ft)
Final Pass:	20 N.m (15 lb ft)

Reusable Threaded Fastener Tightening Specifications

NOTE: <i>All fasteners listed in this table can be reused after removal.</i>	
Application	Specification
	Metric (English)
Catalytic Converter Brace Bracket Bolt (LTG, LYX)	22 N.m (16 lb ft)
Catalytic Converter Brace Bracket Nut (LYX)	22 N.m (16 lb ft)
Catalytic Converter Brace Bracket Nut (LH7)	22 N.m (16 lb ft)
Catalytic Converter Brace Bracket Nut @ Transmission Housing Stud (LYX)	58 N.m (43 lb ft)
Catalytic Converter Brace Nut {LH7}	22 N.m (16 lb ft)
Catalytic Converter Clamp (LH7)	25 N.m (18 lb ft)
Catalytic Converter Clamp Bolt (LYX)	15 N.m (11 lb ft)
Catalytic Converter Heat Shield Bolt (LTG)	10 N.m (89 lb in)
Catalytic Converter Heat Shield Bolt (LH7)	10 N.m (89 lb in)
Catalytic Converter Nut (LTG, LYX)	22 N.m (16 lb ft)
Catalytic Converter Nut @Turbocharger (LTG)	50 N.m (37 lb ft)
Catalytic Converter Stud (LH7)	9 N.m (80 lb in)
Exhaust Front Pipe Bracket Bolt (LTG)	22 N.m (16 lb ft)
Exhaust Front Pipe Hanger Bracket Bolt (LTG)	22 N.m (16 lb ft)

NOTE:

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

Application	Specification
	Metric (English)
Exhaust Front Pipe Nut (LH7)	22 N.m (16 lb ft)
Exhaust Front Pipe Nut (LTG, LYX)	22 N.m (16 lb ft)
Exhaust Front Underbody Heat Shield Retainer	1.5 N.m (13 lb in)
Exhaust Gas Recirculation Pipe Bolt (LH7)	10 N.m (89 lb in)
Exhaust Gas Recirculation Cooler Temperature Sensor-Position 1 (LH7)	45 N.m (33 lb ft)
Exhaust Intermediate Underbody Heat Shield Retainer	1.5 N.m (13 lb in)
Exhaust Manifold Brace Bolt (LTG)	25 N.m (18 lb ft)
Exhaust Manifold Brace Nut (LTG)	25 N.m (18 lb ft)
Exhaust Manifold Heat Shield Fastener (LTG)	14 N.m (10 lb ft)
Exhaust Muffler Heat Shield Retainer	1.5 N.m (13 lb in)
Exhaust Rear Muffler Insulator Bolt (LYX)	22 N.m (16 lb ft)
Exhaust Rear Underbody Heat Shield Retainer (LH7)	1.5 N.m (13 lb in)
Front Cradle Brace Bolt (LTG)	58 N.m (43 lb ft)
Turbocharger Heat Shield Bolt (LH7)	9 N.m (80 lb in)
Turbocharger Heat Shield Nut (LH7)	9 N.m (80 lb in)

DIAGNOSTIC INFORMATION AND PROCEDURES

SYMPTOMS - ENGINE EXHAUST

- Review the exhaust system description in order to familiarize yourself with the exhaust system components and the intended function of the components.
- All diagnostics on a vehicle should follow a logical process. Strategy Based Diagnostics is a uniform approach for repairing all systems. The diagnostic flow is the place to start when repairs are necessary and may always be used in order to resolve a system problem. For a detailed explanation, refer to [Strategy Based Diagnosis](#).

Visual/Physical Inspection

- Inspect for aftermarket or non-OEM devices such as, but not limited to; tailpipe extensions, headers, and exhaust cutouts. Any aftermarket exhaust system devices could affect the operation and proper performance of the exhaust system.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, engine temperature, engine load, and frequency of concern.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause any symptom.

Intermittent

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

Symptom List

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

- Loss of power

Refer to [Restricted Exhaust](#)

- Poor acceleration

Refer to [Restricted Exhaust](#)

- Poor fuel economy

Refer to [Restricted Exhaust](#)

- Excessive smoke diesel

Refer to [Restricted Exhaust](#)

- Exhaust hissing noise

Refer to [Exhaust Leakage](#)

- Exhaust popping noise

Refer to [Exhaust Leakage](#)

- Exhaust rattle noise

Refer to [Exhaust Noise](#)

- Loud exhaust noise

Refer to [Exhaust Noise](#)

- Exhaust buzz, groan, hum noise

Refer to [Exhaust Noise](#)

RESTRICTED EXHAUST

Diagnostic Aids

WARNING: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.

For dual exhaust systems a quick check of exhaust flow will help determine which side of the exhaust system is restricted. The side that has less exhaust flow is the side that will be suspect, and diagnosis should begin there.

NOTE: This will not apply if the dual exhaust is equipped with an "H" pipe or similar configuration in which the exhaust flow would be equalized.

Test Description

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

4

The exhaust system has very low back pressure under normal conditions. If the exhaust system is restricted, a significant increase in the exhaust pressure is noticed on the **J-35314-A** Exhaust Back Pressure Gauge.

Removing the AIR check valve or HO2S sensor may set a DTC. When finishing this diagnostic table, be sure to clear all codes.

5

This step will isolate the catalytic converter from the remainder of the exhaust system.

8

Confirming that the condition has been fixed is essential. If the symptom still exists and the vehicle has a dual exhaust system, proceed to Step 2 and repeat diagnostic procedure on the opposite exhaust pipe.

Step	Action	Value(s)	Yes	No
1	Did you verify the customers complaint?	-	Go to Step 2	-
2	Did you review the exhaust symptoms diagnostic information and perform the necessary inspections?	-	Go to Step 3	Go to Symptoms - Engine Exhaust

Step	Action	Value(s)	Yes	No
3	Is the system equipped with dual exhaust?	-	Go to Diagnostic Aids	Go to Step 4
4	1. Remove the secondary air injection (AIR) check valve or the heated oxygen sensor (HO2S) that is in front of and closest to the catalytic converter. Refer to the affected component's service procedure. 2. Install the J-35314-A Exhaust Back Pressure Gauge in place of the AIR check valve or HO2S sensor. 3. Start the engine. 4. Increase and monitor the engine speed at 2, 000 RPM. 5. Observe the exhaust system back pressure reading on the gauge. Does the reading exceed the specified value?	14 kPa (2 psi)	Go to Step 5	Go to Step 8
5	1. Turn the engine off and place the ignition in the lock position. 2. Remove the J-35314-A Exhaust Back Pressure Gauge. 3. Re-install the AIR check valve/HO2S sensor. Refer to the affected component's service procedure. 4. Remove the post-catalyst HO2S sensor. Refer to the affected component's service procedure. 5. Install the J-35314-A Exhaust Back Pressure Gauge in place of the post HO2S sensor. 6. Start the engine. 7. Increase and monitor the engine speed at 2, 000 RPM. 8. Observe the exhaust system back pressure reading on the gauge. Does the reading exceed the specified value?	14 kPa (2 psi)	Go to Step 6	Go to Step 7
6	Inspect the exhaust system for the following conditions: • Damage in the exhaust pipe • Debris in the exhaust pipe • Muffler or resonator internal failure • Two-layer exhaust pipe separation Did you find and correct the condition?	-	Go to Step 8	-
7	Replace the catalytic converter. Refer to the affected component's service procedure. Did you find and correct the condition?	-	Go to Step 8	-

Step	Action	Value(s)	Yes	No
8	1. Remove the J-35314-A Exhaust Back Pressure Gauge. 2. Reinstall the AIR check valve or the post-catalyst HO2S sensor. Refer to the affected component's service procedure 3. Clear any codes. 4. Road test the vehicle in order to verify the repair. Did you correct the condition?	-	System OK	Go to Step 2

EXHAUST LEAKAGE

Problem	Action
WARNING: While engine is operating, the exhaust system will become extremely hot. To prevent burns avoid contacting a hot exhaust system.	
DEFINITION: An exhaust leak may show stains at the area of the leak. The leak may be felt by holding a hand close to the suspected areas or using a smoke pencil. The leak may make a popping or hissing noise. Refer to Symptoms - Engine Exhaust prior to beginning this table.	
Misaligned or improperly installed exhaust system components	• Align and tighten the exhaust system components to the specifications. Refer to Fastener Specifications. • Ensure the exhaust hangers are in the proper locations and not loose.
Exhaust leaks at the following connections: • Exhaust manifold to pipe • Flanges • Pipe clamps	Tighten the components to the specifications. Refer to Fastener Specifications .
Seals or gaskets leaking • Exhaust manifold to cylinder head • Exhaust pipes to exhaust manifold • Catalytic converter connection • EGR connections • AIR connections to the exhaust manifold or cylinder head	Replace the leaking seal or gasket. Refer to the affected components procedure for service.
Irregularities at the mating surfaces on the flange connections	Repair as required or replace the affected component. Refer to the affected components procedure for service.
Exhaust manifold cracked or broken	Replace the exhaust manifold. Refer to the affected component's procedure for service.
Exhaust system component connection welds leaking	Replace the leaking component. Refer to the affected component's procedure for service.
Muffler or resonator (if equipped) damaged or leaking at the seams	Replace the affected muffler or resonator. Refer to the affected component's procedure for service.

EXHAUST NOISE

Condition	Action
WARNING: While engine is operating, the exhaust system will become extremely hot. To prevent burns avoid contacting a hot exhaust system.	
DEFINITION: An audible or physical noise due to a faulty component or damaged components causing a loose or misaligned exhaust system resulting in a rattle or vibration noise, i.e. buzz, groan, hum. Refer to Symptoms - Engine Exhaust prior to beginning this table.	
Popping or hissing noise	Exhaust leak. Refer to Exhaust Leakage .
Loud exhaust	1. Compare to a known good vehicle. 2. Inspect for a damaged or failed muffler. 3. Repair or replace the affected component. Refer to the affected component's service procedure.
External rattle or vibration noise	1. Inspect for a bent or loose hanger, loose heat shield, or loose clamp. 2. Inspect for an exhaust pipe causing interference. 3. Repair or replace the affected component. Refer to the affected component's service procedure.
Internal rattle	1. Test the components by tapping with a rubber mallet to confirm a rattle. 2. Repair or replace the affected component. Refer to the affected component's service procedure.

REPAIR INSTRUCTIONS

EXHAUST MANIFOLD REPLACEMENT (LH7)

Removal Procedure

1. Remove Turbocharger - [Turbocharger Replacement](#)

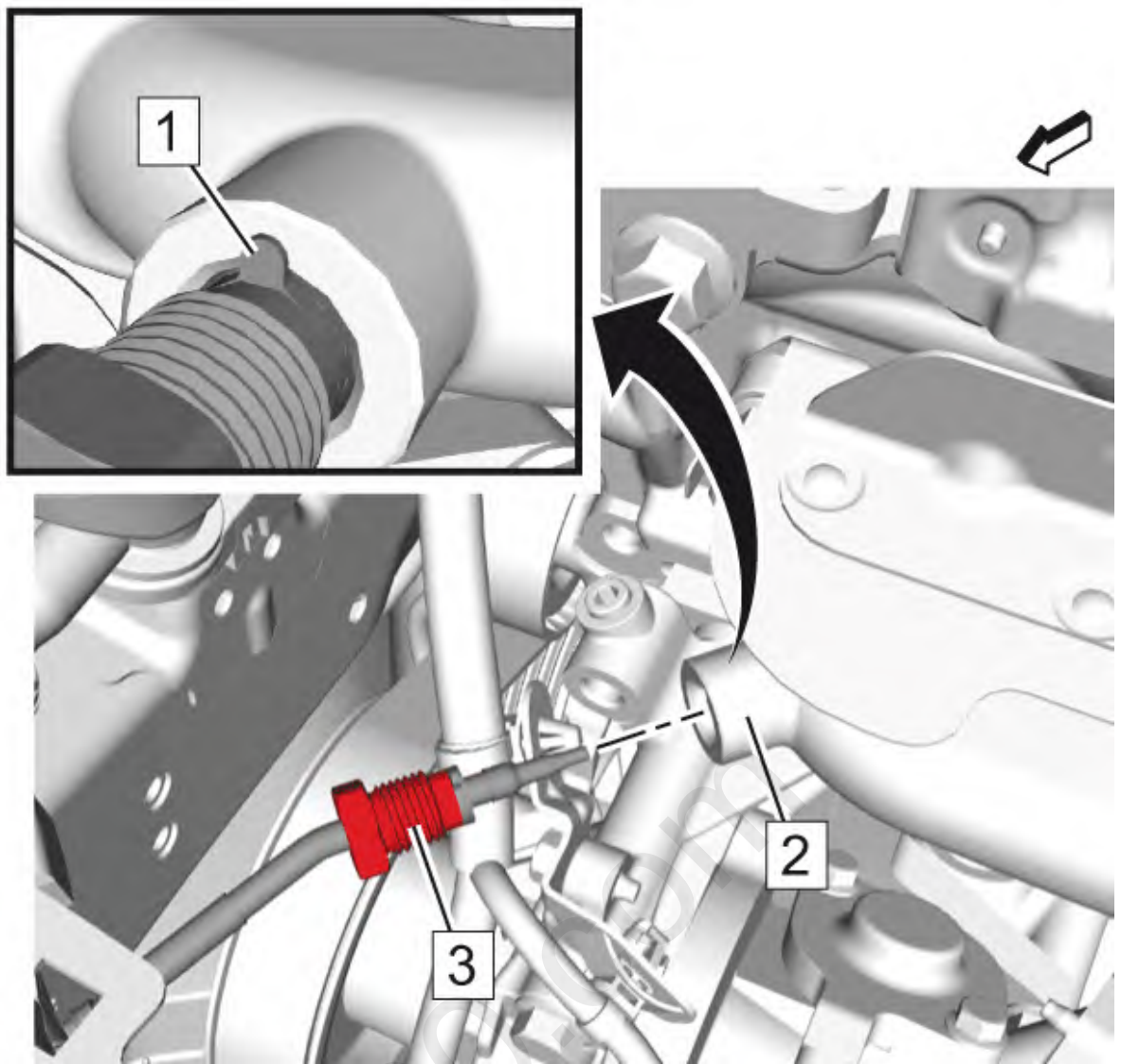


Fig. 1: Exhaust Gas Recirculation Cooler Temperature Sensor
 Courtesy of GENERAL MOTORS COMPANY

2. Remove Exhaust Gas Recirculation Cooler Temperature Sensor- Position 1(1) @Exhaust Manifold (2).

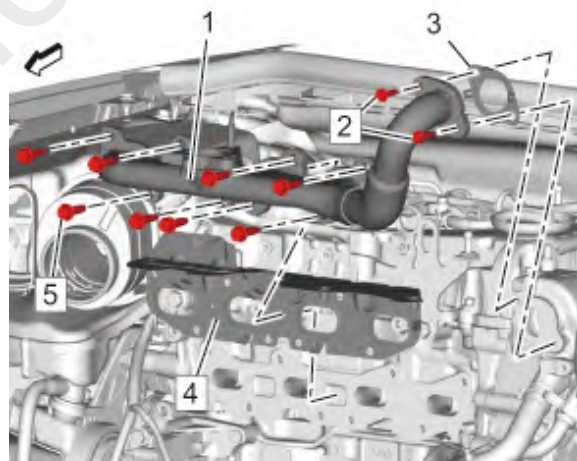


Fig. 2: Exhaust Gas Recirculation Pipe Bolt And Exhaust Manifold Bolt
 Courtesy of GENERAL MOTORS COMPANY

3. Remove Exhaust Gas Recirculation Pipe Bolt (2) - [2x]
4. Remove Exhaust Manifold Bolt (5) and DISCARD[8x]

NOTE: Do NOT bend the exhaust gas recirculation pipe.

5. Remove Exhaust Manifold (1).

6. Remove and DISCARD the exhaust manifold gasket. (4)
7. Remove Exhaust Gas Recirculation Pipe Gasket (3) and DISCARD

Installation Procedure

1. Re-cut the thread at the cylinder head for the 8 exhaust manifold bolts.

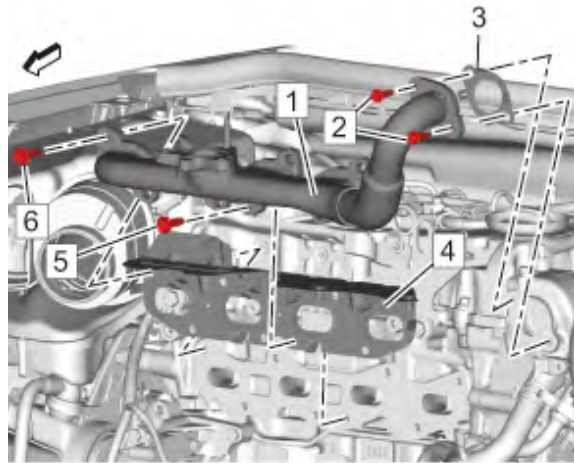


Fig. 3: Gas Recirculation Pipe Gasket

Courtesy of GENERAL MOTORS COMPANY

2. Install NEW Exhaust Gas Recirculation Pipe Gasket (3).
3. Install a NEW exhaust manifold gasket. (4)

NOTE: Do NOT grab the exhaust manifold during the assembly procedure at the EGR pipe as this is a sensitive part.

4. Install Exhaust Manifold (1).

NOTE: The service may offer bolts that are not microencapsulated. If this is the case apply thread lock agent to the bolt. If the fastener is microencapsulated, install NEW exhaust manifold bolts. DO NOT reuse the old bolts.

5. Install loosely the NEW 2 exhaust manifold bolts (5, 6).
6. Install loosely the 2 exhaust gas recirculation pipe bolts (2).

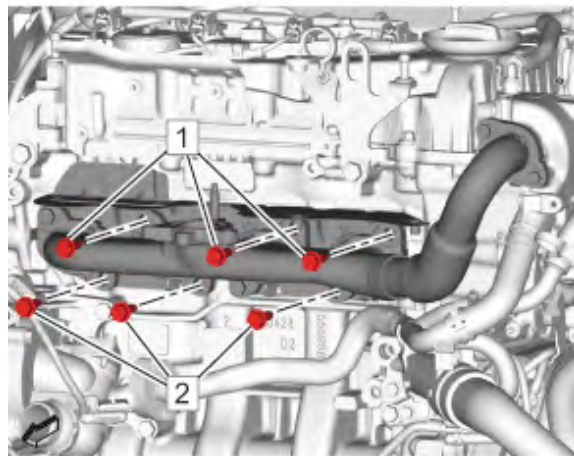


Fig. 4: Exhaust Manifold Bolts

Courtesy of GENERAL MOTORS COMPANY

7. Install loosely the NEW 6 exhaust manifold bolts (1, 2).

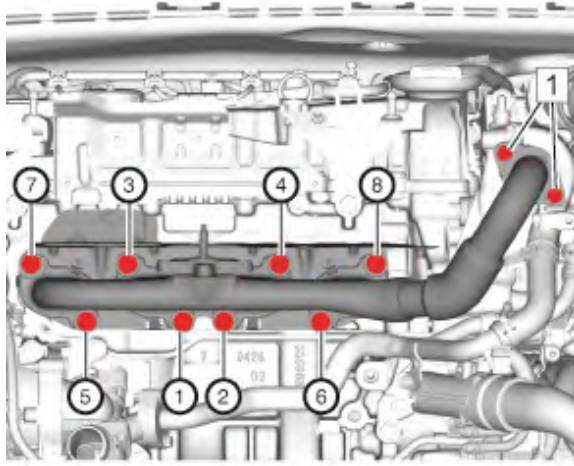


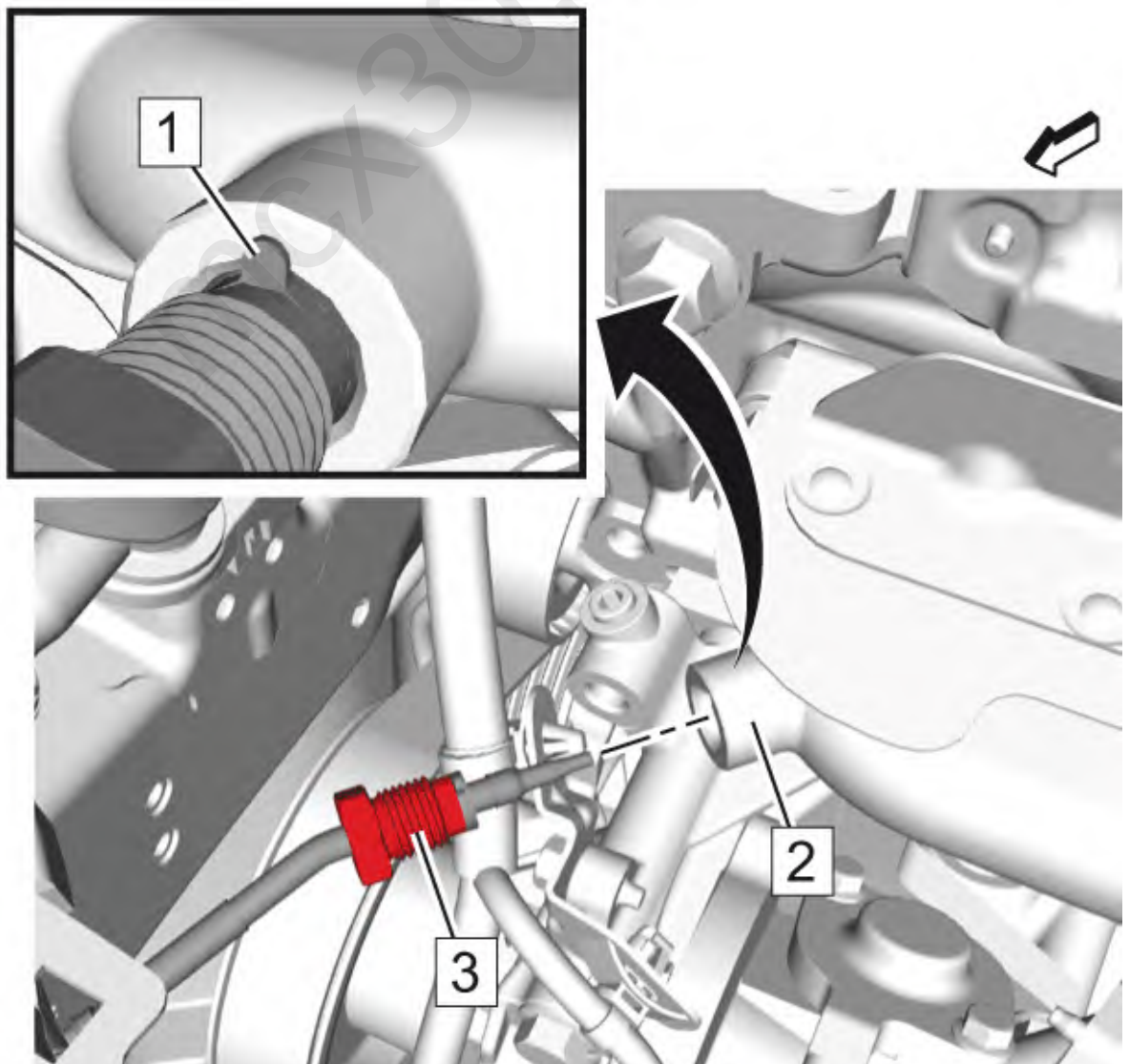
Fig. 5: Exhaust Manifold Bolt - Tighten In Sequence

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Fastener Caution

NOTE: The complete tightening procedure should be completed within 10 minutes.

8. Exhaust Manifold Bolt - Tighten in sequence [8x]
 1. First Pass: 27 N.m (20 lb ft)
 2. Second Pass: 27 N.m (20 lb ft)
 3. Final Pass: 27 N.m (20 lb ft)
9. Exhaust Gas Recirculation Pipe Bolt (1) - Tighten [2x] 10 N.m (89 lb in)



NOTE: The guide lug (1) must fit the groove.

10. Install Exhaust Gas Recirculation Cooler Temperature Sensor- Position 1 (3) and tighten 45 N.m (33 lb ft)
11. Install Turbocharger - [Turbocharger Replacement](#)

EXHAUST MANIFOLD REPLACEMENT (LTG)

Removal Procedure

WARNING: Refer to [Exhaust Service Warning](#) .

WARNING: Refer to [Eye Protection Warning](#) .

1. Remove Exhaust Manifold Heat Shield - [Exhaust Manifold Heat Shield Replacement \(LTG\)](#)
2. Remove Turbocharger - [Turbocharger Replacement \(1st Design Tamper-Proof PCV System\)](#)
3. Remove Exhaust Manifold Brace - [Exhaust Manifold Brace Replacement \(LTG\)](#)

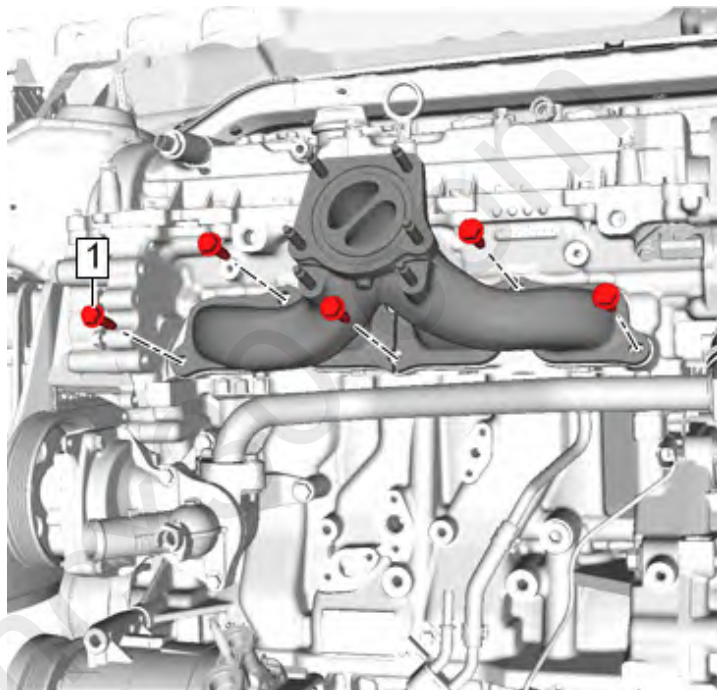


Fig. 7: Exhaust Manifold Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove Exhaust Manifold Bolt (1) and DISCARD

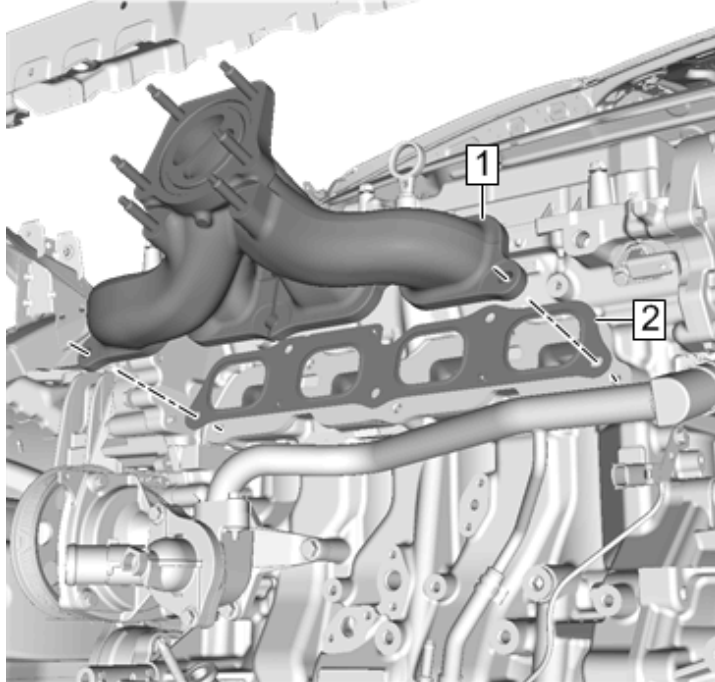


Fig. 8: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

5. Remove Exhaust Manifold (1)
6. Remove Exhaust Manifold Gasket (2) and DISCARD

Installation Procedure

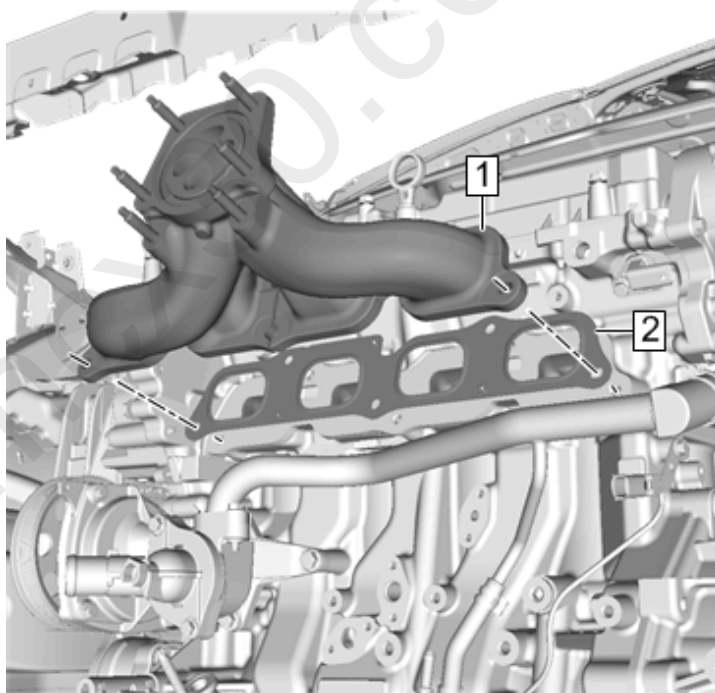


Fig. 9: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Install a NEW exhaust manifold gasket.**

1. Install Exhaust Manifold Gasket (2).
2. Install Exhaust Manifold (1).

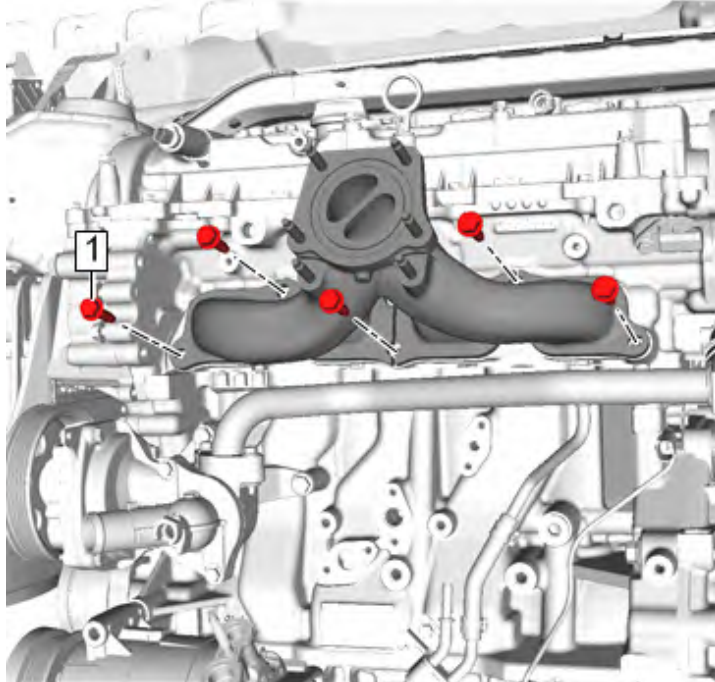


Fig. 10: Exhaust Manifold Bolt

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- Install **NEW** exhaust manifold bolts.
- Fasteners have adhesive patch and must be tightened to final torque within 5 minutes.

3. Install Exhaust Manifold Bolt and hand tighten

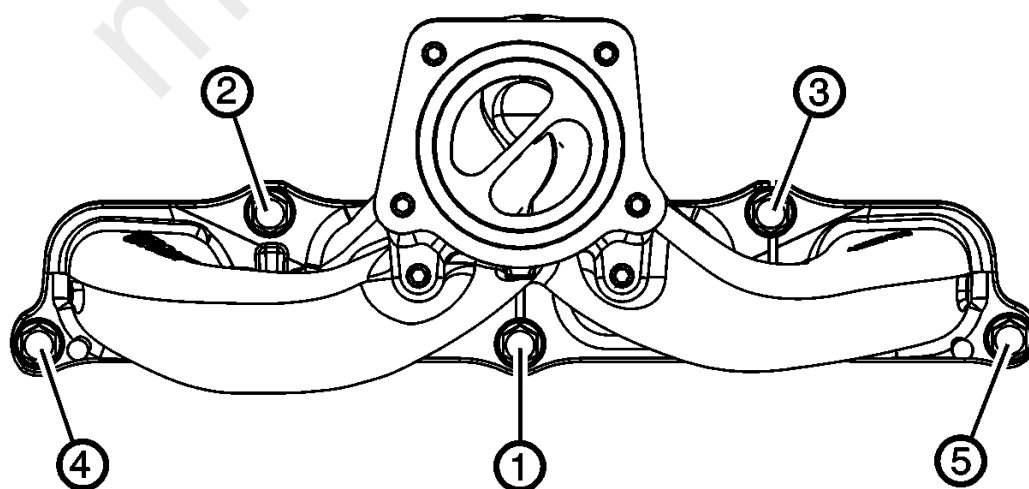


Fig. 11: Exhaust Manifold Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

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

4. Exhaust Manifold Bolt - Tighten in sequence
 1. First Pass: 20 N.m (15 lb ft)
 2. Second Pass: 20 N.m (15 lb ft)
 3. Final Pass: 20 N.m (15 lb ft)
5. Install Exhaust Manifold Brace - [Exhaust Manifold Brace Replacement \(LTG\)](#)
6. Install Turbocharger - [Turbocharger Replacement \(1st Design Tamper-Proof PCV System\)](#)
7. Install Exhaust Manifold Heat Shield - [Exhaust Manifold Heat Shield Replacement \(LTG\)](#)

EXHAUST MANIFOLD BRACE REPLACEMENT (LTG)

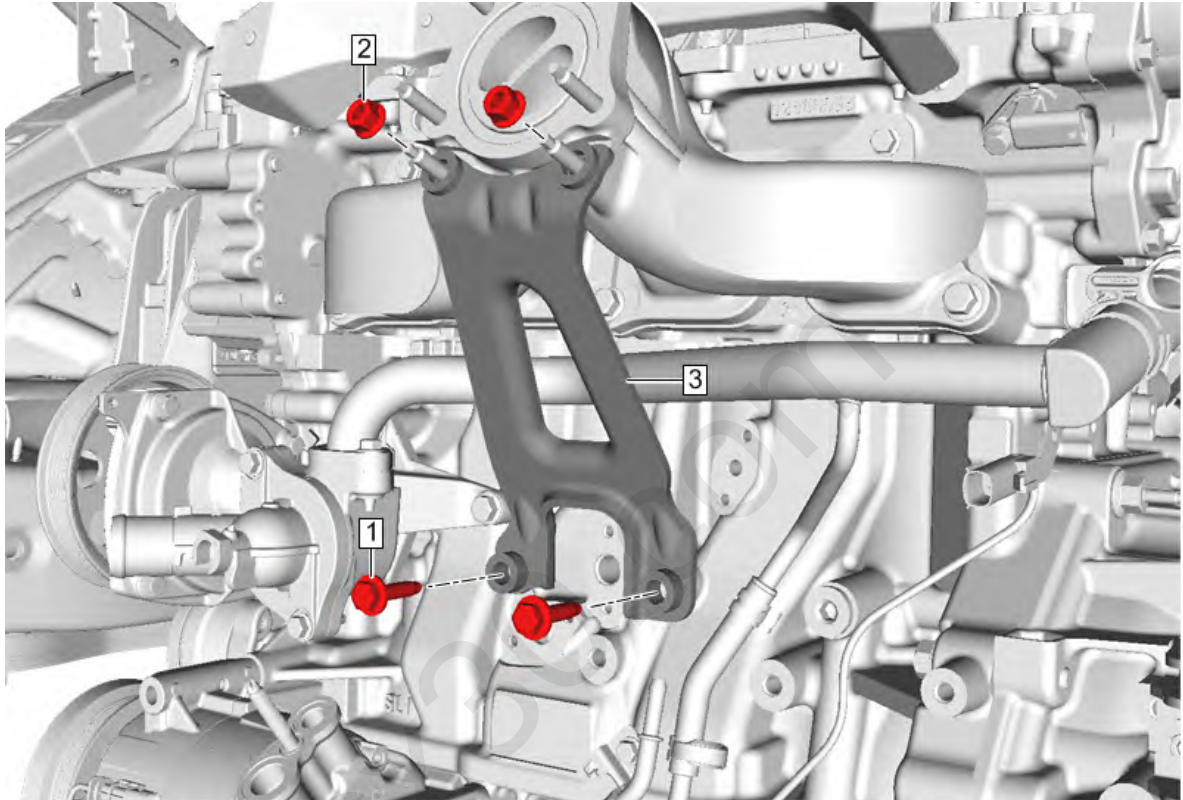


Fig. 12: Exhaust Manifold Brace
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Hot Exhaust System Warning .	
Preliminary Procedure Turbocharger Replacement (1st Design Tamper-Proof PCV System)	
1	Exhaust Manifold Brace Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten: 25 N.m (18 lb ft)
2	Exhaust Manifold Brace Nut (Qty: 2) Tighten: 25 N.m (18 lb ft)
3	Exhaust Manifold Brace

EXHAUST FRONT PIPE REPLACEMENT (LTG)

Removal Procedure

WARNING: Refer to [Hot Exhaust System Warning](#) .

WARNING: Refer to [Safety Glasses Warning](#) .

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

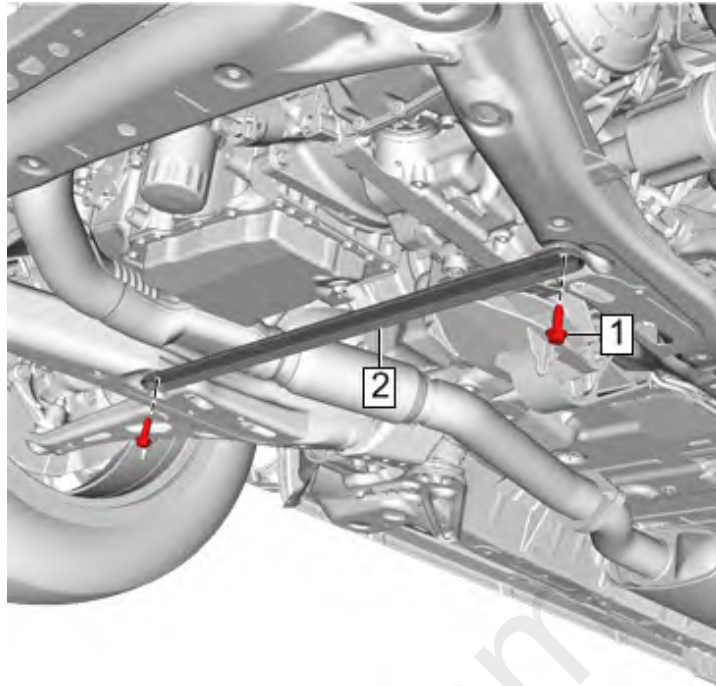


Fig. 13: Front Cradle Brace And Bolt

Courtesy of GENERAL MOTORS COMPANY

2. Remove Front Cradle Brace Bolt (1)
3. Remove Front Cradle Brace (2)

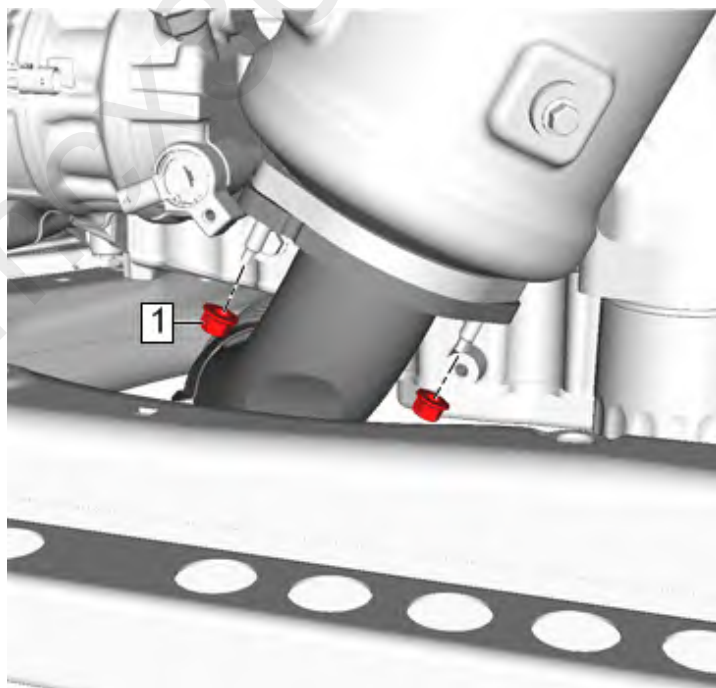


Fig. 14: Catalytic Converter Nut

Courtesy of GENERAL MOTORS COMPANY

4. Remove Catalytic Converter Nut (1).

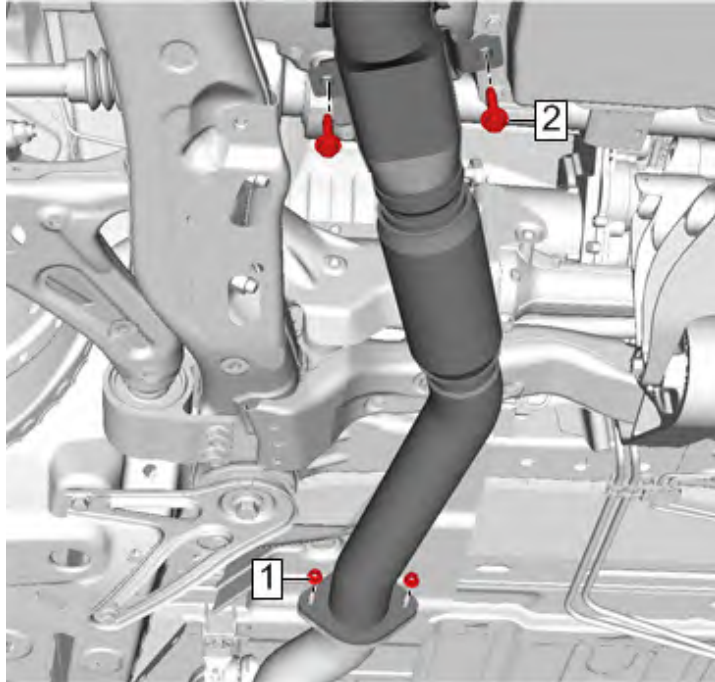


Fig. 15: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

5. Remove Exhaust Front Pipe Nut (1)
6. Remove Exhaust Front Pipe Bracket Bolt (2)

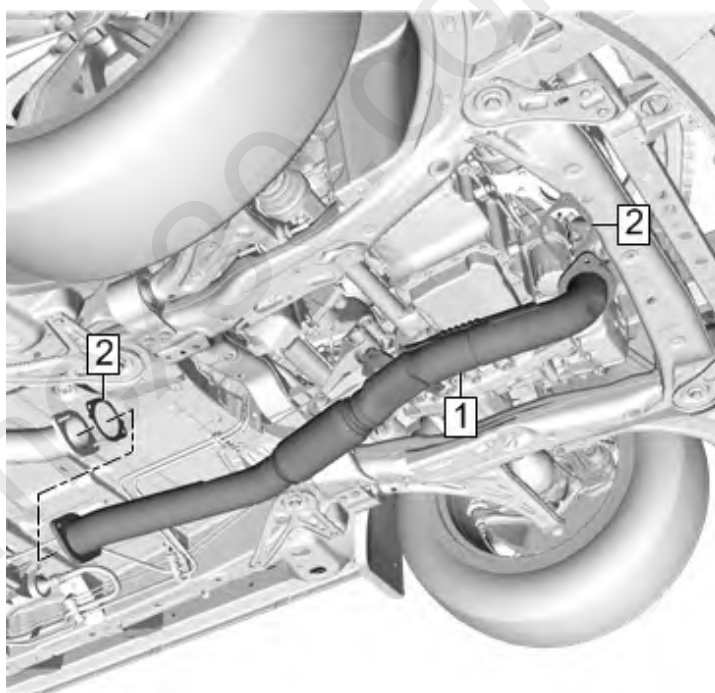


Fig. 16: Exhaust Front Pipe And Exhaust Gasket
Courtesy of GENERAL MOTORS COMPANY

7. Remove Exhaust Front Pipe (1).
8. Remove Exhaust Gasket (2) and DISCARD

Installation Procedure

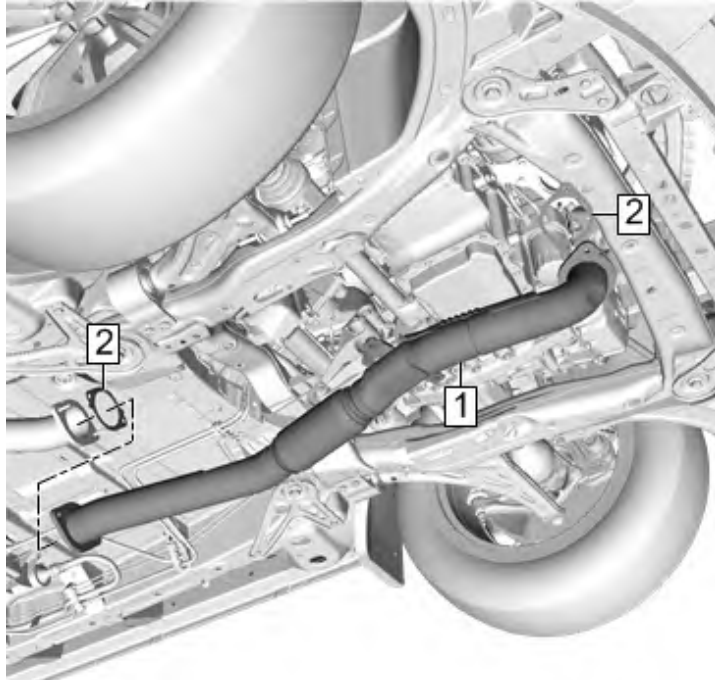


Fig. 17: Exhaust Front Pipe And Exhaust Gasket
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a NEW gasket.

1. Install Exhaust Gasket (2)
2. Install Exhaust Front Pipe (1)

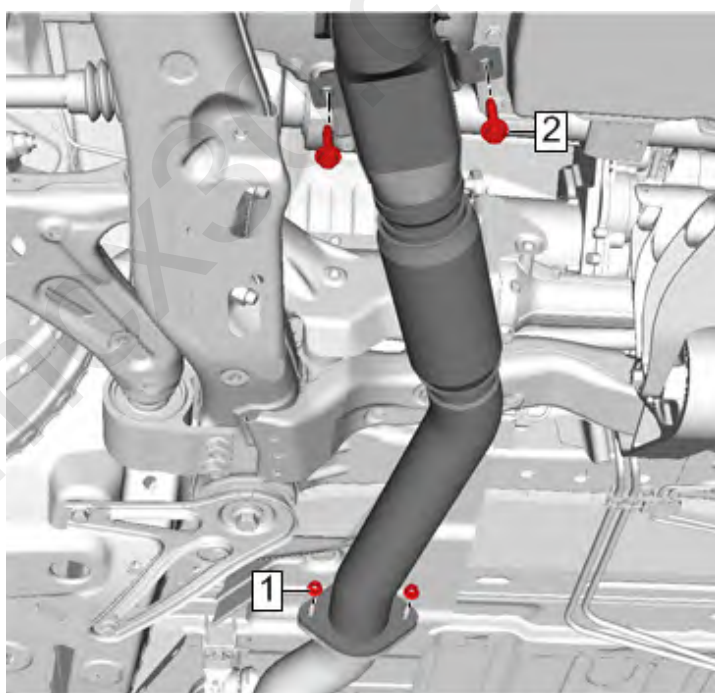


Fig. 18: Exhaust Front Pipe Nut
 Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Install Exhaust Front Pipe Bracket Bolt (2) and tighten 22 N.m (16 lb ft)
4. Install Exhaust Front Pipe Nut (1) and tighten 22 N.m (16 lb ft)

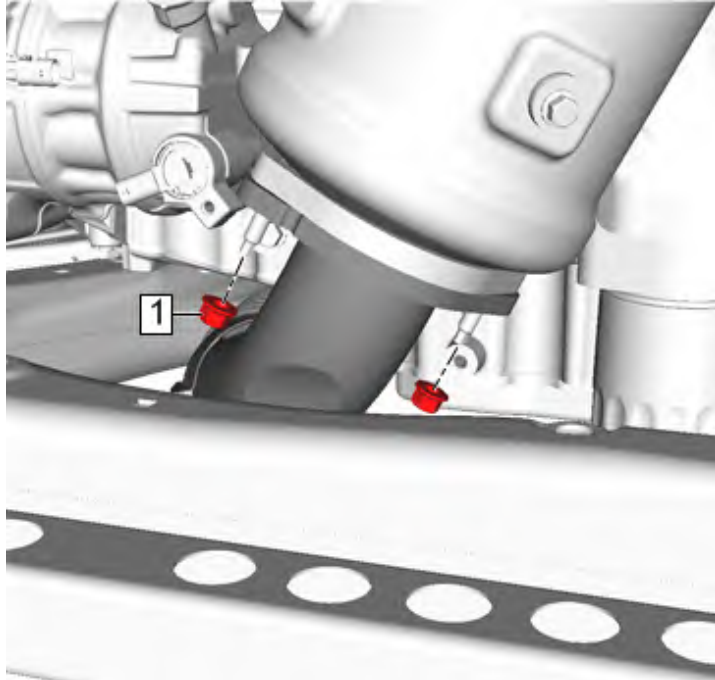


Fig. 19: Catalytic Converter Nut
Courtesy of GENERAL MOTORS COMPANY

5. Install Catalytic Converter Nut (1) and tighten 22 N.m (16 lb ft)

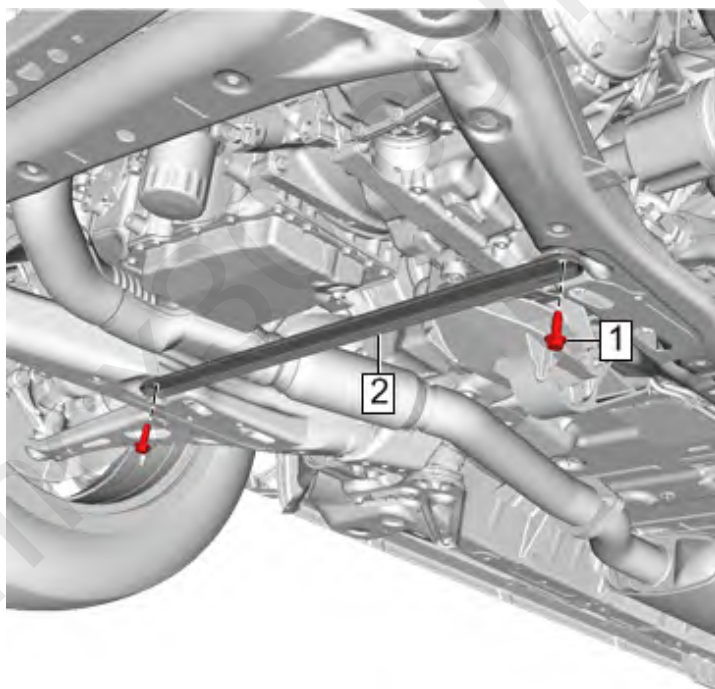


Fig. 20: Front Cradle Brace And Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Install Front Cradle Brace (2)
7. Install Front Cradle Brace Bolt (1) and tighten 58 N.m (43 lb ft)
8. Start the engine and check for exhaust leaks.

EXHAUST FRONT PIPE REPLACEMENT (LYX)

Removal Procedure

WARNING: Refer to [Hot Exhaust System Warning](#) .

WARNING: Refer to [Safety Glasses Warning](#) .

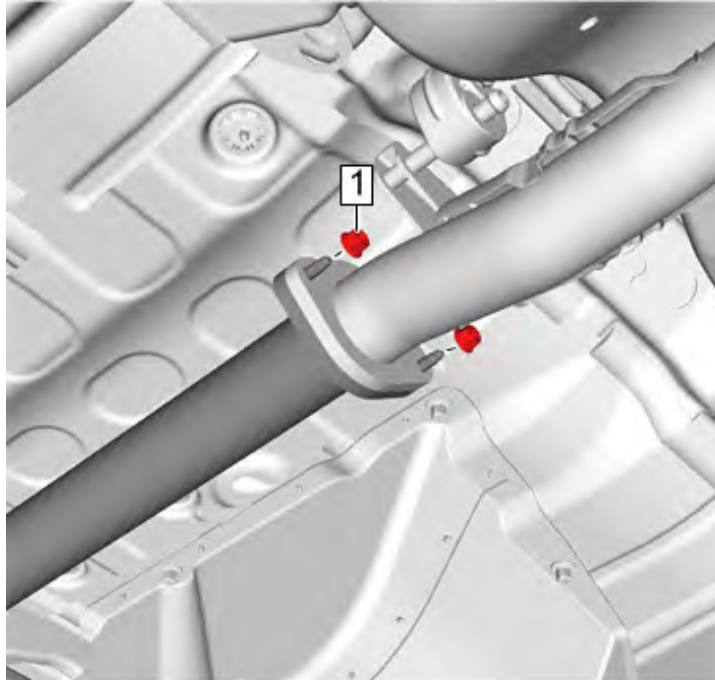


Fig. 21: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

1. Remove Exhaust Front Pipe Nut (1).

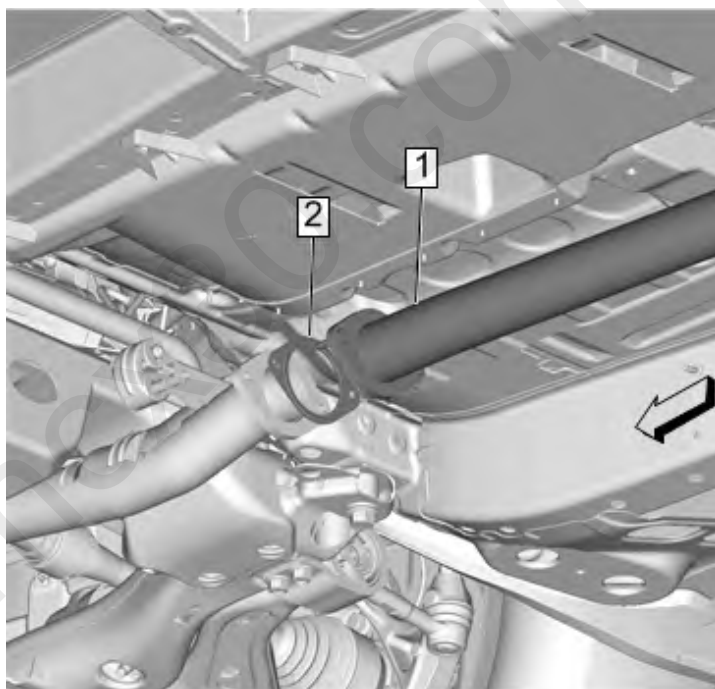


Fig. 22: Exhaust Muffler Assembly And Exhaust Gasket
Courtesy of GENERAL MOTORS COMPANY

2. Separate Exhaust Muffler Assembly (1) @Exhaust Front Pipe
3. Remove Exhaust Gasket (2) and DISCARD

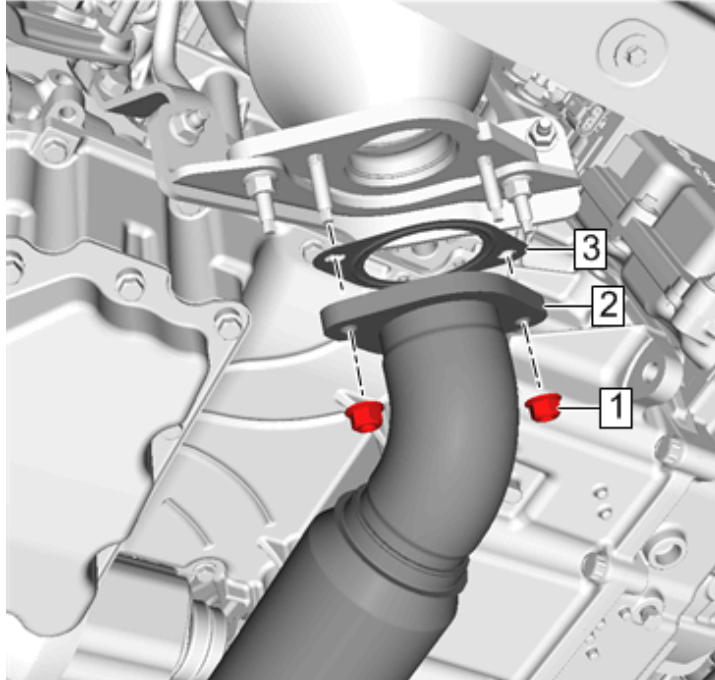


Fig. 23: Catalytic Converter Nut And Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Remove Catalytic Converter Nut (1)
5. Remove Exhaust Front Pipe (2)
6. Remove Exhaust Gasket (3) and DISCARD

Installation Procedure

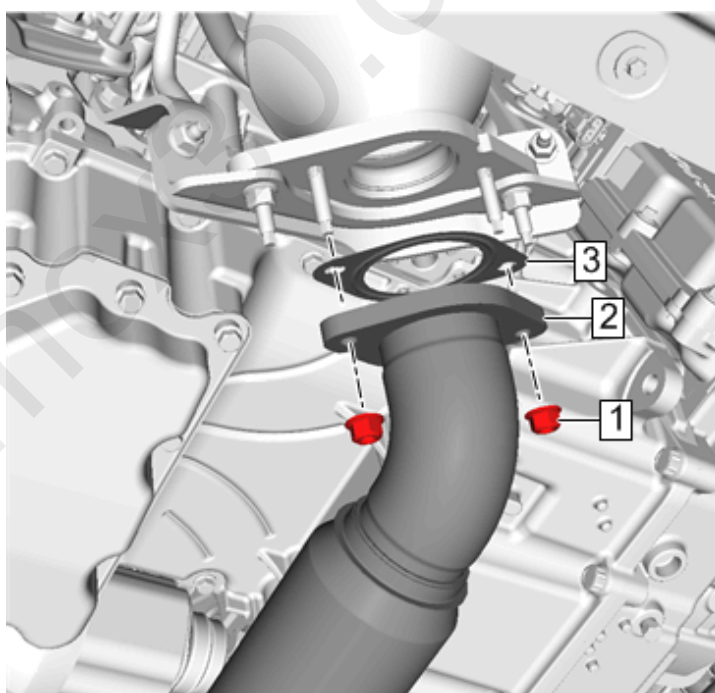


Fig. 24: Catalytic Converter Nut And Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW Exhaust Gasket (3).
2. Install Exhaust Front Pipe (2).

CAUTION: Refer to **Fastener Caution** .

3. Install Catalytic Converter Nut (1) and tighten 22 N.m (16 lb ft)

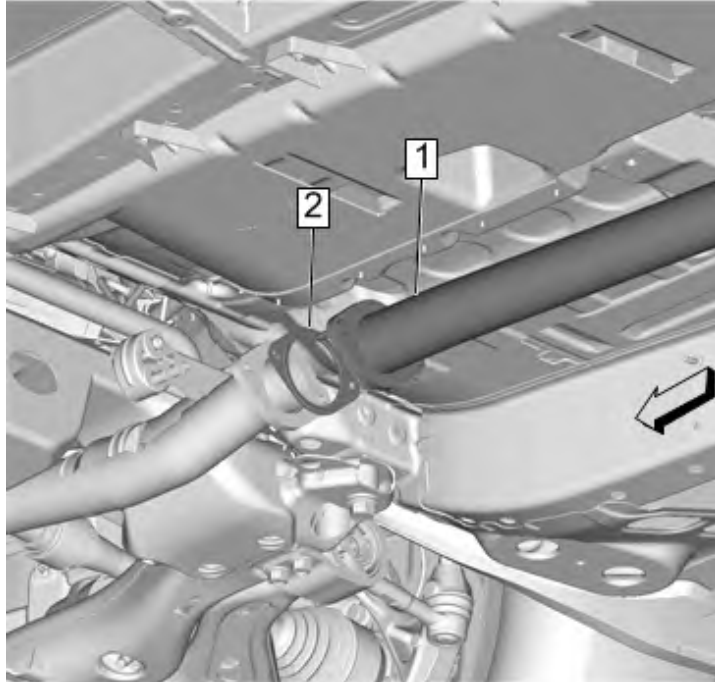


Fig. 25: Exhaust Muffler Assembly And Exhaust Gasket
Courtesy of GENERAL MOTORS COMPANY

4. Install a NEW Exhaust Gasket (2).
5. Install Exhaust Muffler Assembly (1) @ - Exhaust Front Pipe

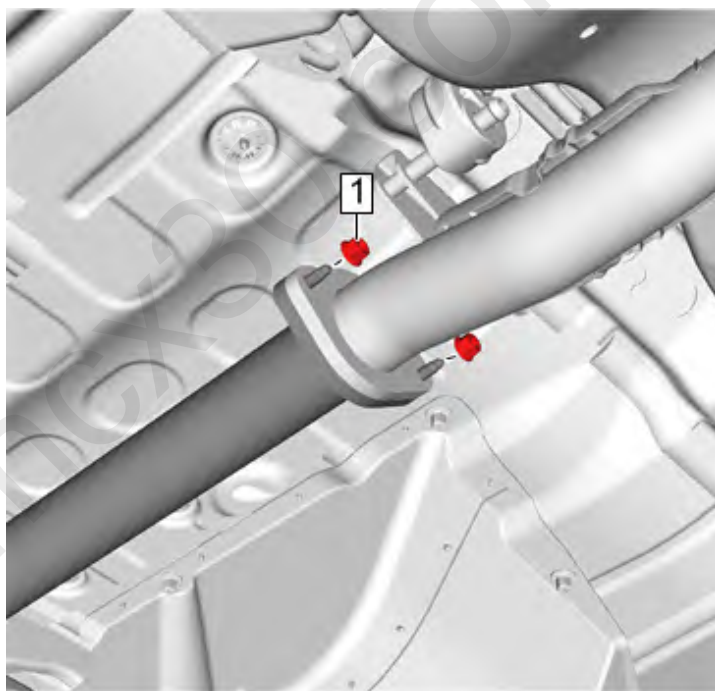


Fig. 26: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

6. Install Exhaust Front Pipe Nut (1) and tighten 22 N.m (16 lb ft)

EXHAUST FRONT PIPE REPLACEMENT (LH7)

Removal Procedure

WARNING: Protective Goggles and Glove Warning

WARNING: Exhaust Service Warning

1. Remove Front Cradle Brace - Front Cradle Brace Replacement

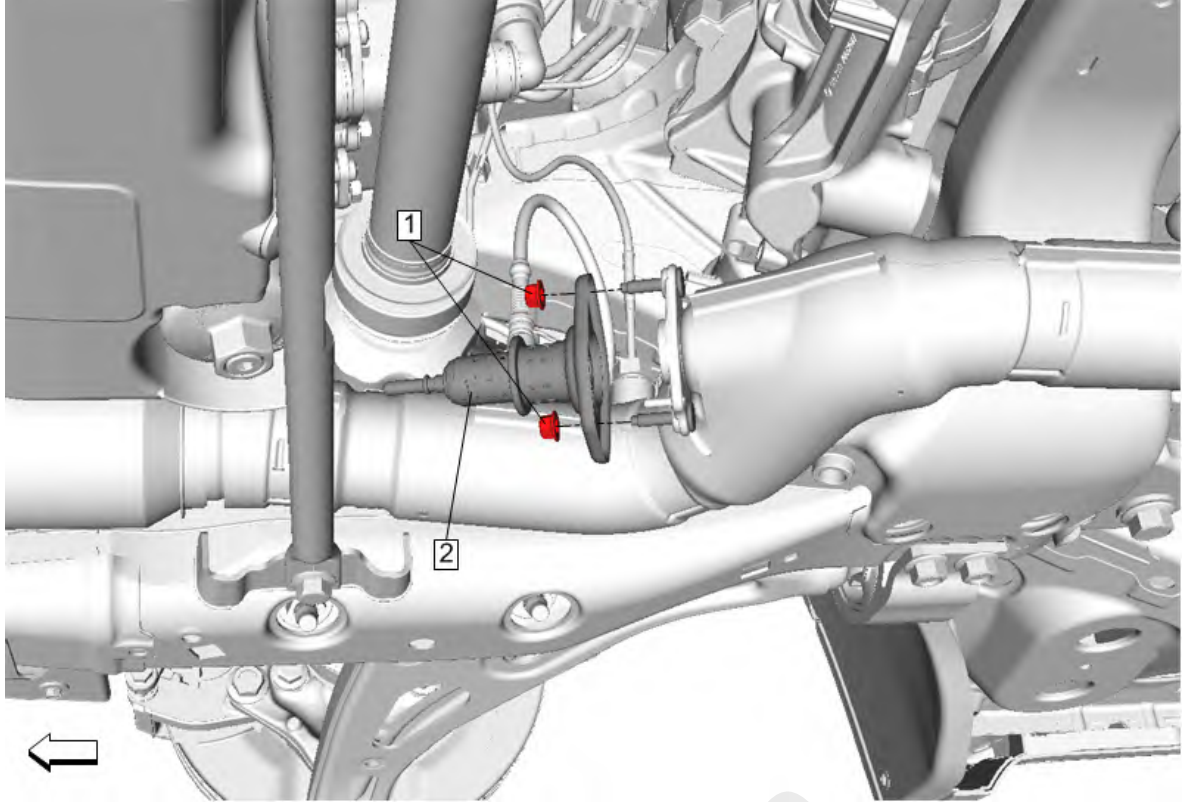


Fig. 27: Emission Reduction Fluid Injector Nut
Courtesy of GENERAL MOTORS COMPANY

2. Remove Emission Reduction Fluid Injector Nut (1) - [Emission Reduction Fluid Injector Replacement \(AWD\)](#) [Emission Reduction Fluid Injector Replacement \(FWD\)](#)
3. Position aside Emission Reduction Fluid Injector (2)
4. Remove Exhaust Particulate Sensor@Exhaust Front Pipe and position aside - [Exhaust Particulate Sensor Replacement](#)
5. Remove Exhaust Temperature Sensor - Position 3@Exhaust Front Pipe and position aside - [Exhaust Temperature Sensor Replacement - Position 3](#)

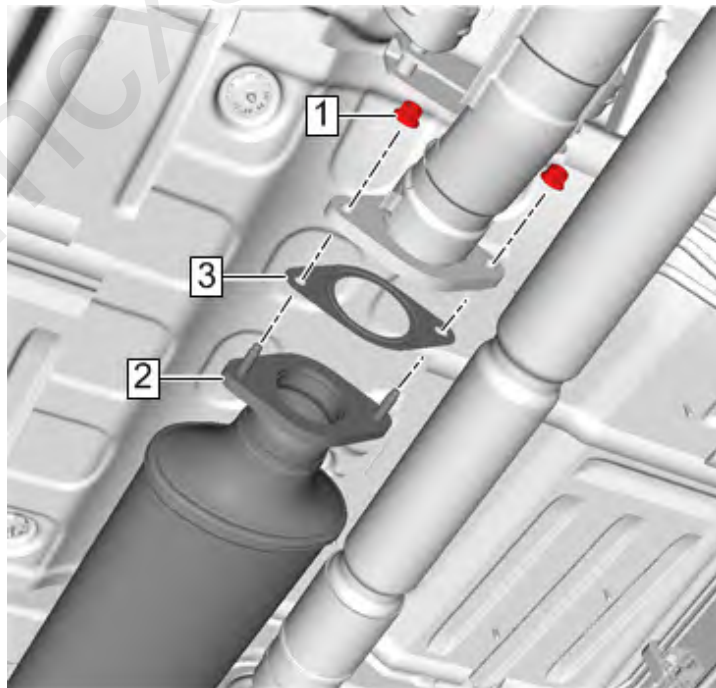


Fig. 28: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

6. Remove Exhaust Front Pipe Nut (1) - [Exhaust Muffler Replacement \(LH7\)](#)
7. Position aside Exhaust Muffler (2).

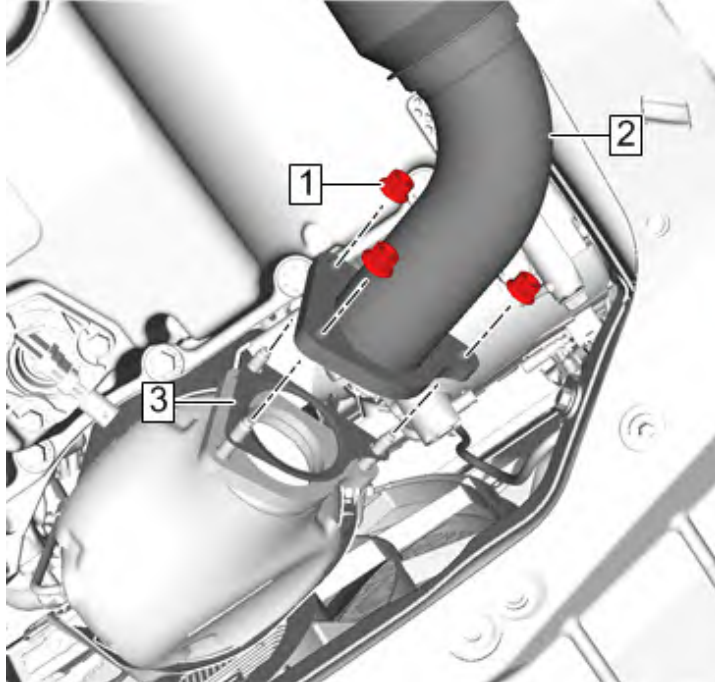


Fig. 29: Exhaust Front Pipe, Nut And Gasket
Courtesy of GENERAL MOTORS COMPANY

8. Remove Exhaust Front Pipe Nut (1)
9. Remove Exhaust Front Pipe (2).
10. Remove Exhaust Front Pipe Gasket (3) and DISCARD

Installation Procedure

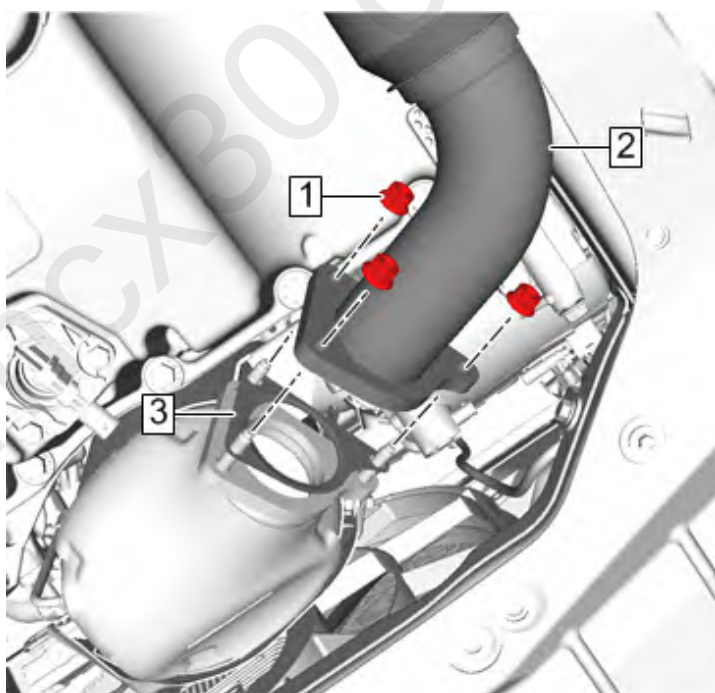


Fig. 30: Exhaust Front Pipe, Nut And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a NEW gasket.

1. Install Exhaust Front Pipe Gasket (3).
2. Install Exhaust Front Pipe (2).

CAUTION: Fastener Caution

3. Install Exhaust Front Pipe Nut (1) and tighten 22 N.m (16 lb ft)
4. Install Exhaust Muffler -Exhaust Muffler Replacement (LH7).

5. Install Exhaust Temperature Sensor - Position 3@Exhaust Front Pipe - [Exhaust Temperature Sensor Replacement - Position 3](#)
6. Install Exhaust Particulate Sensor@Exhaust Front Pipe - [Exhaust Particulate Sensor Replacement](#)
7. Install Emission Reduction Fluid Injector - [Emission Reduction Fluid Injector Replacement \(AWD\)](#),
[Emission Reduction Fluid Injector Replacement \(FWD\)](#)
8. Install Front Cradle Brace - [Front Cradle Brace Replacement](#)

EXHAUST REAR MUFFLER INSULATOR REPLACEMENT

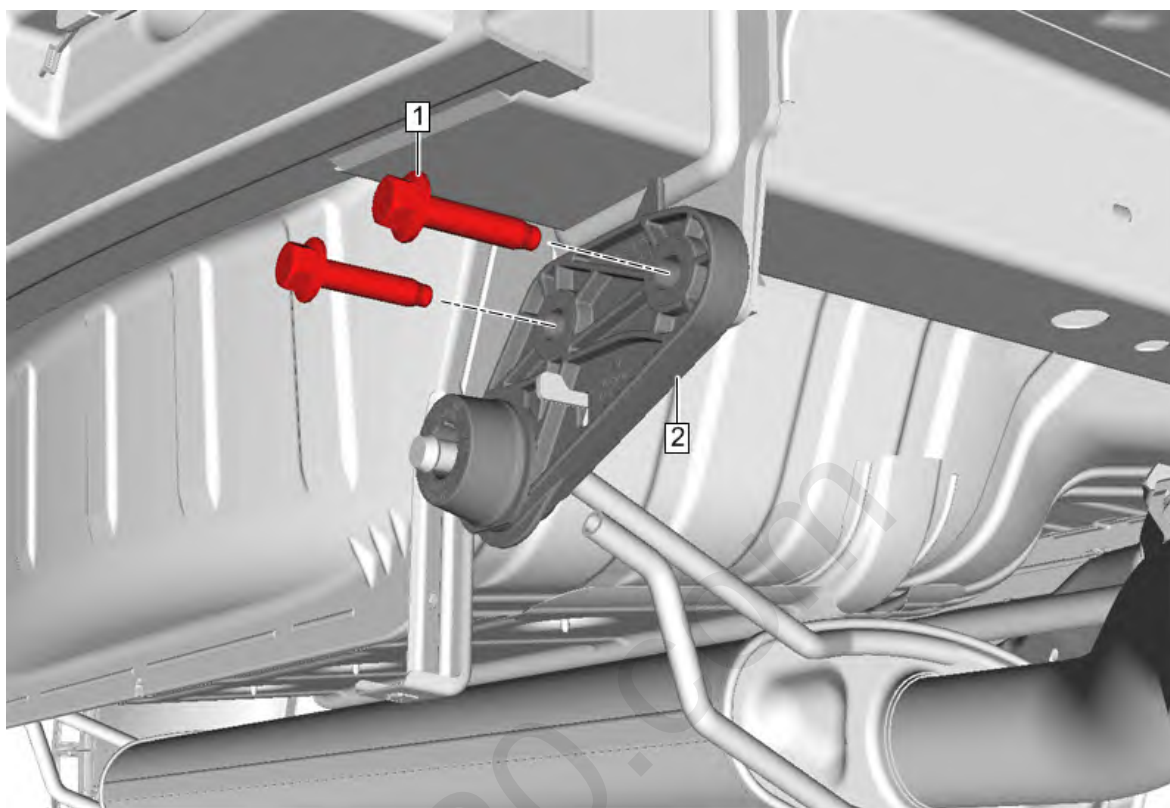


Fig. 31: Exhaust Rear Muffler Insulator Bolt-Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Lifting and Jacking the Vehicle	
1	Exhaust Muffler Insulator Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 22 N.m (16 lb ft)
2	Exhaust Muffler Insulator

OXIDATION CATALYTIC CONVERTER REPLACEMENT (LH7)

Removal Procedure

1. Remove Nitrogen Oxides Sensor- Position 1 - and position aside - [Nitrogen Oxides Sensor Replacement - Position 1](#)
2. Remove Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement \(LH7\)](#)
3. Remove Catalytic Converter Heat Shield - [Catalytic Converter Heat Shield Replacement \(LH7\)](#)
4. Remove Exhaust Temperature Sensor-Position 1 @Oxidation Catalytic Converter - Remove and position aside - [Exhaust Temperature Sensor Replacement - Position 1](#)
5. Remove Exhaust Temperature Sensor-Position 2 @Oxidation Catalytic Converter - Remove and position aside - [Exhaust Temperature Sensor Replacement - Position 2](#)

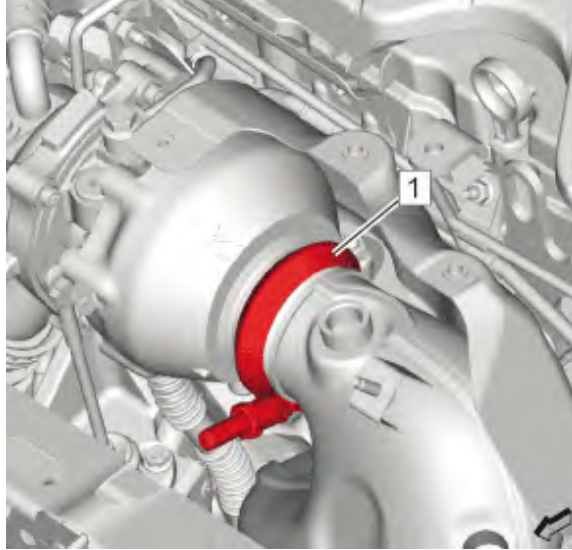


Fig. 32: Catalytic Converter Clamp

Courtesy of GENERAL MOTORS COMPANY

6. Loosen Catalytic Converter Clamp (1).
7. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

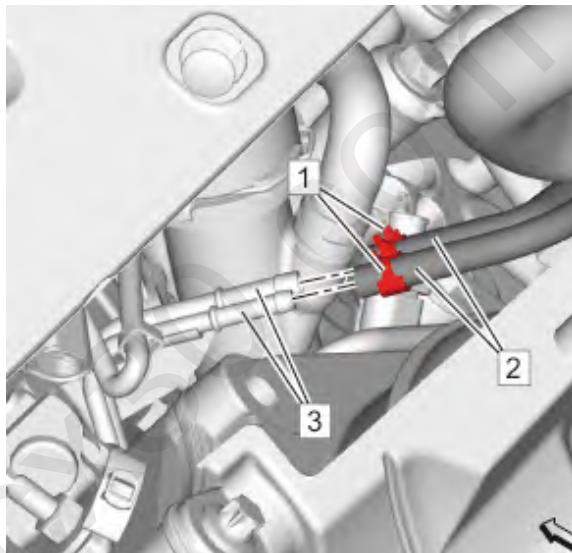


Fig. 33: Exhaust Pressure Differential Sensor Hoses And Pipes

Courtesy of GENERAL MOTORS COMPANY

8. Disengage Clamp (1) - [2x] - [Hose Clamp Replacement Guidelines - Spring Type](#)

NOTE: Mind the different hose diameters.

9. Remove the 2 exhaust pressure differential sensor hoses (2) from the exhaust pressure differential sensor pipes (3).

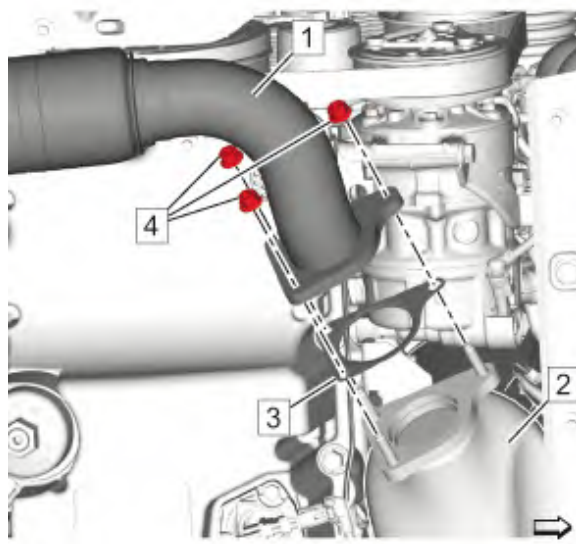


Fig. 34: Exhaust Front Pipe Gasket

Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not bend the exhaust flex pipe more than 10 degrees in any direction. Bending of more than 10 degrees or twisting in a range of ± 0.5 degrees will damage the exhaust flex decoupler.

10. Remove Exhaust Front Pipe Nut (4) - [3x]
11. Remove Exhaust Front Pipe (1) @Catalytic Converter (2).
12. Remove Exhaust Front Pipe Gasket (3) and DISCARD

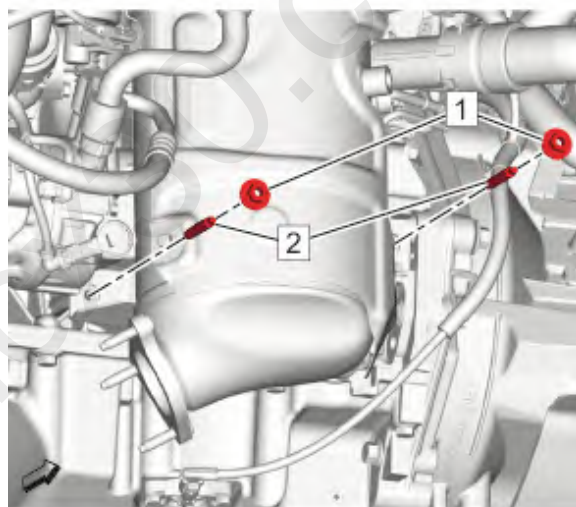


Fig. 35: Catalytic Converter Brace Nut And Catalytic Converter Stud

Courtesy of GENERAL MOTORS COMPANY

13. Remove Catalytic Converter Brace Nut (1) - [2 x]

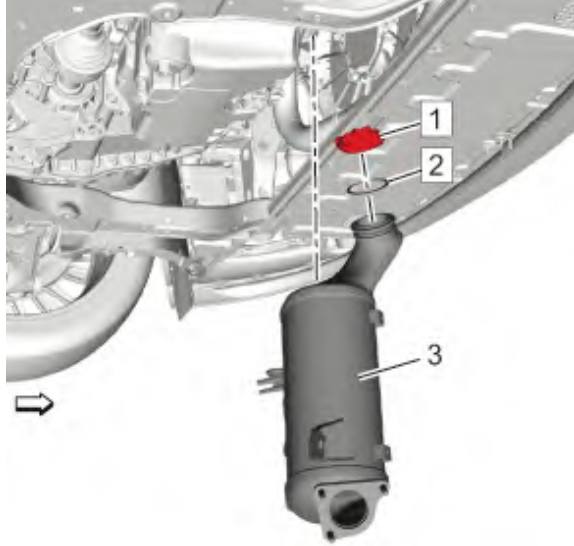


Fig. 36: Catalytic Converter, Clamp And Gasket
Courtesy of GENERAL MOTORS COMPANY

14. Remove Oxidation Catalytic Converter (3).
15. Remove Catalytic Converter Clamp (1) and DISCARD
16. Remove Catalytic Converter Gasket (2) and DISCARD

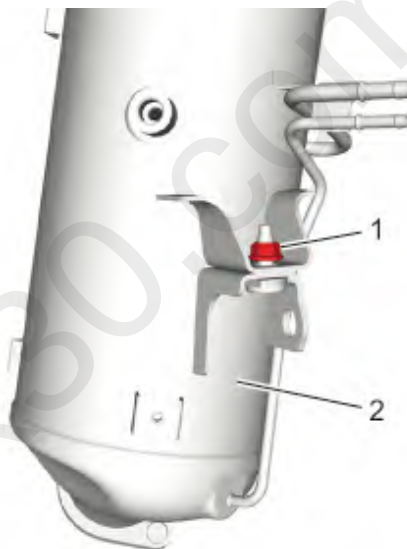


Fig. 37: Catalytic Converter Brace Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

17. Loosen Catalytic Converter Brace Bracket Nut (1) @Catalytic Converter (2)

Installation Procedure

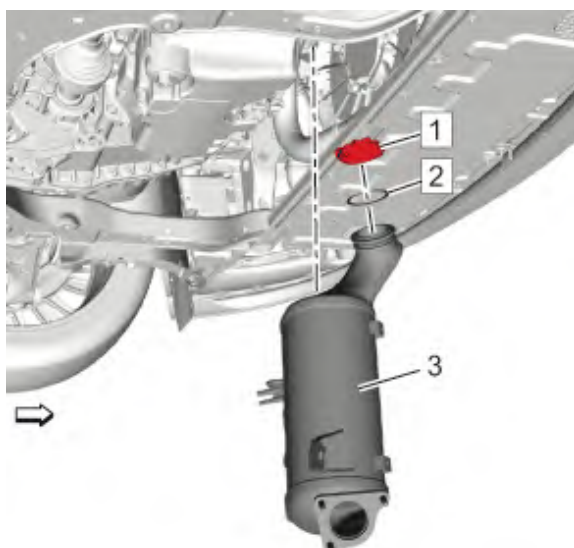


Fig. 38: Catalytic Converter, Clamp And Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW Catalytic Converter Gasket (2).
2. Loosely install the NEW catalytic converter clamp (1) to the catalytic converter (3).
3. Install Oxidation Catalytic Converter (3).

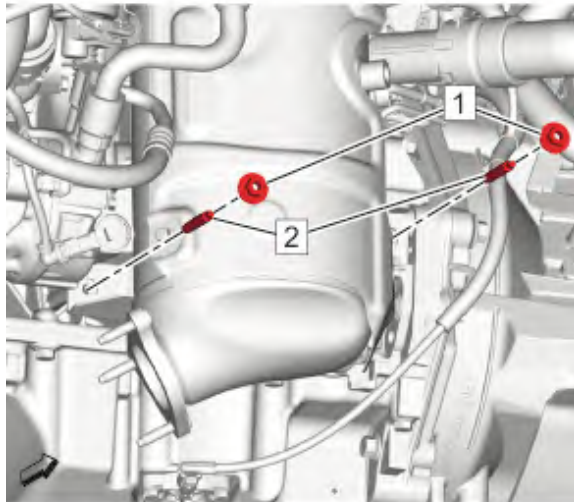


Fig. 39: Catalytic Converter Brace Nut And Catalytic Converter Stud
Courtesy of GENERAL MOTORS COMPANY

4. Install Catalytic Converter Brace Nut (1) and hand tighten [2x]
5. Lower the vehicle.

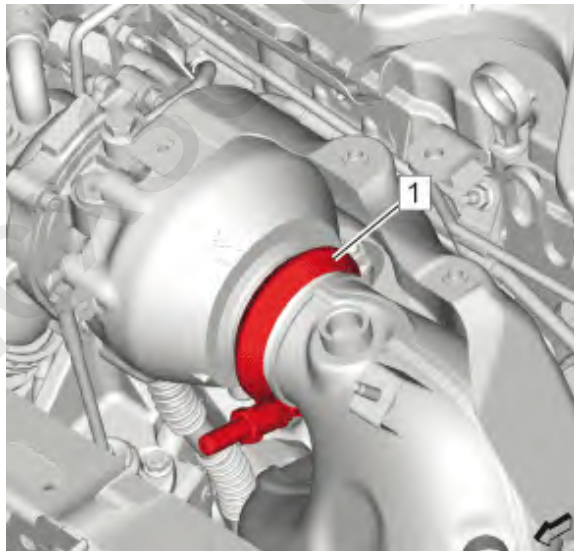


Fig. 40: Catalytic Converter Clamp
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Fastener Caution

6. Position the NEW catalytic converter clamp (1) and tighten to 6 N.m (53 lb in)
7. Raise the vehicle.

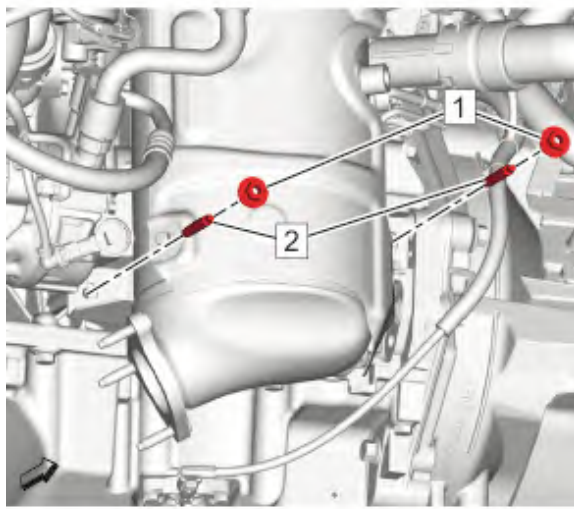


Fig. 41: Catalytic Converter Brace Nut And Catalytic Converter Stud
Courtesy of GENERAL MOTORS COMPANY

8. Install Catalytic Converter Brace Nut (1) and tighten [2x] 22 N.m (16 lb ft)

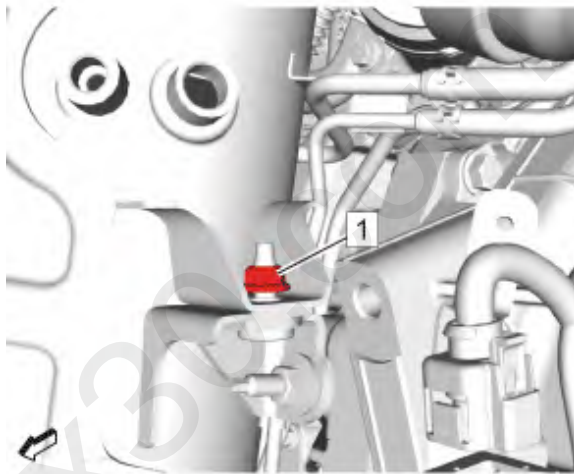


Fig. 42: Catalytic Converter Brace Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

9. Catalytic Converter Brace Bracket Nut (1) - Tighten 22 N.m (16 lb ft)
10. Lower the vehicle.

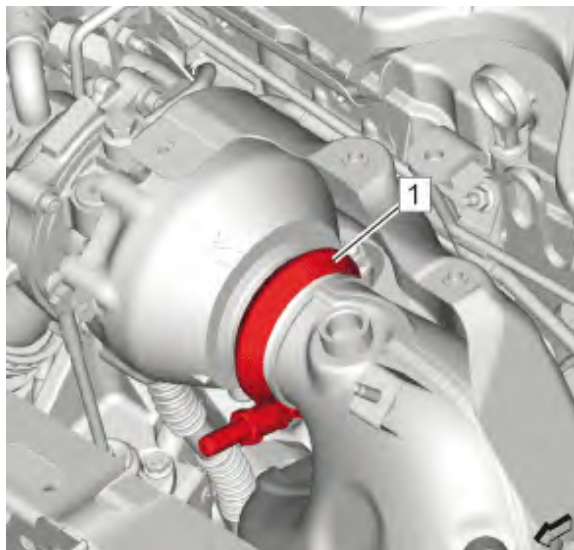


Fig. 43: Catalytic Converter Clamp
Courtesy of GENERAL MOTORS COMPANY

11. Catalytic Converter Clamp (1) - Tighten 25 N.m (18 lb ft)
12. Raise the vehicle.

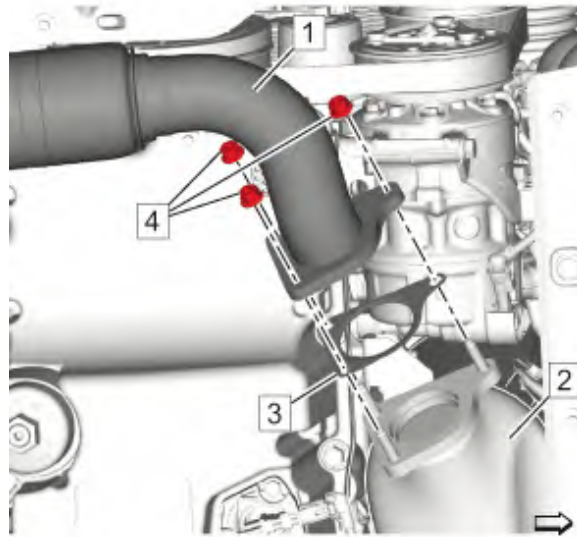


Fig. 44: Exhaust Front Pipe Gasket

Courtesy of GENERAL MOTORS COMPANY

13. Install Exhaust Front Pipe Gasket (1).

CAUTION: Do not bend the exhaust flex pipe more than 10 degrees in any direction. Bending of more than 10 degrees or twisting in a range of ± 0.5 degrees will damage the exhaust flex decoupler.

14. Install Exhaust Front Pipe (1)@Catalytic Converter (2).
15. Install Exhaust Front Pipe Nut (4) and tighten 22 N.m (16 lb ft) [3x]

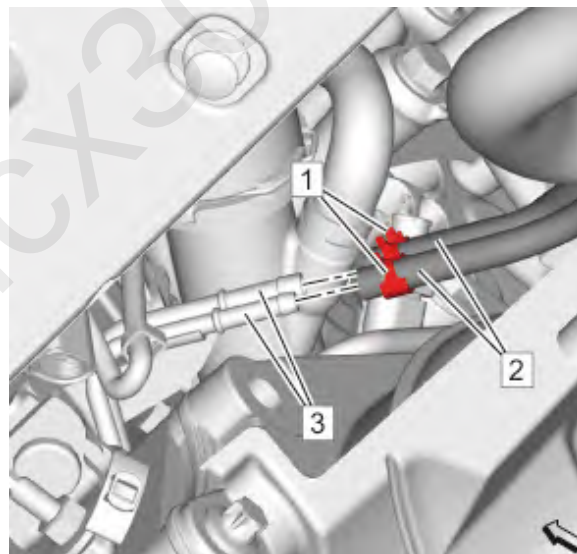


Fig. 45: Exhaust Pressure Differential Sensor Hoses And Pipes

Courtesy of GENERAL MOTORS COMPANY

NOTE: Mind the different hose diameters.

16. Install the 2 exhaust pressure differential sensor hoses (2) to the exhaust pressure differential sensor pipes (3).
17. Engage Clamp (1) - [Hose Clamp Replacement Guidelines - Spring Type](#)
18. Lower the vehicle.
19. Install Exhaust Temperature Sensor-Position 2 @Oxidation Catalytic Converter - [Exhaust Temperature Sensor Replacement - Position 2](#)
20. Install Exhaust Temperature Sensor-Position 1 @Oxidation Catalytic Converter - [Exhaust Temperature Sensor Replacement - Position 1](#)
21. Install Catalytic Converter Heat Shield - [Catalytic Converter Heat Shield Replacement \(LH7\)](#)

22. Install Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement \(LH7\)](#).
23. Install Nitrogen Oxides Sensor- Position 1 - [Nitrogen Oxides Sensor Replacement - Position 1](#)
24. If the Oxidation Catalytic Converter is replaced with new, a DPF Reset will need to be performed. [DPF Reset](#)

WARM UP THREE-WAY CATALYTIC CONVERTER REPLACEMENT (LYX)

Removal Procedure

WARNING: Refer to [Exhaust Service Warning](#) .

1. Remove -[Turbocharger Heat Shield Replacement](#)
2. Disconnect -[Heated Oxygen Sensor Replacement - Sensor 1](#)
3. Disconnect -[Heated Oxygen Sensor Replacement - Sensor 2](#)

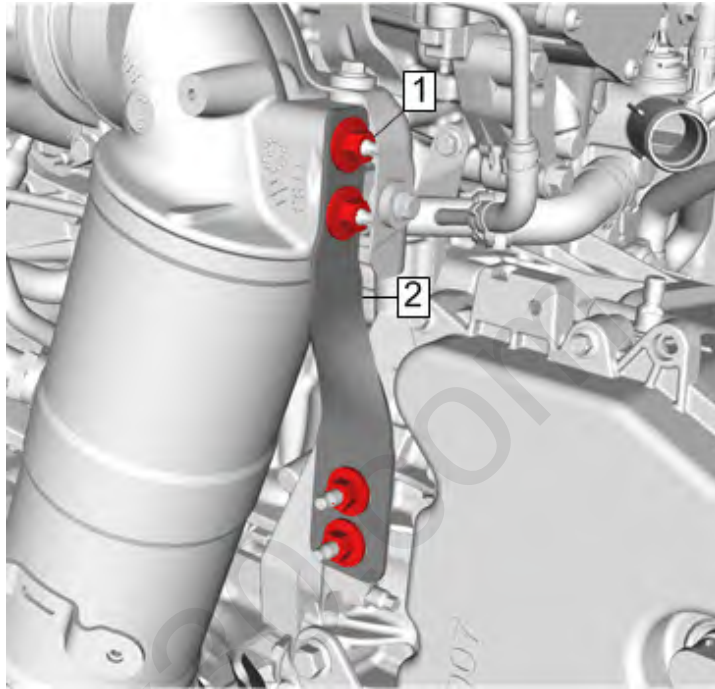


Fig. 46: Catalytic Converter Brace Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

4. Remove Catalytic Converter Brace Bracket Nut (1)
5. Remove Catalytic Converter Brace Bracket (2)

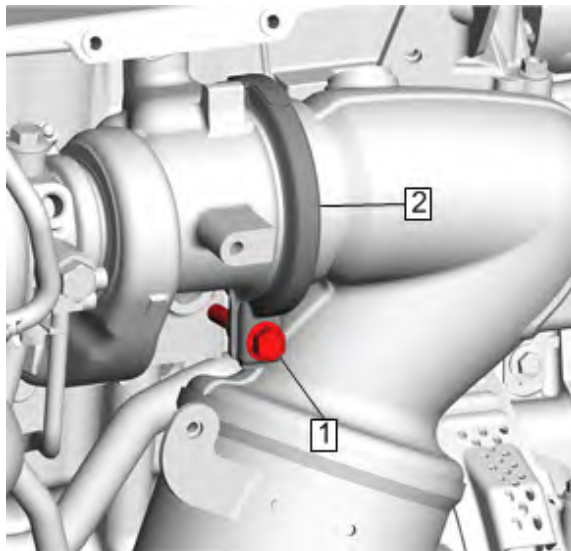


Fig. 47: Catalytic Converter Clamp Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Loosen Catalytic Converter Clamp Bolt (1)
7. Remove Catalytic Converter Clamp (2)

8. Disconnect Exhaust Front Pipe@Warm Up Three-Way Catalytic Converter - [Exhaust Front Pipe Replacement \(LYX\)](#)

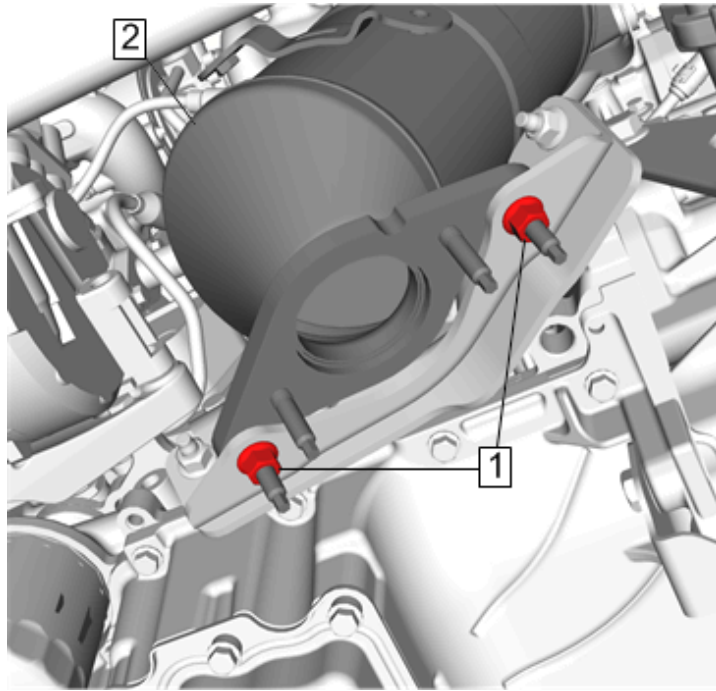


Fig. 48: Catalytic Converter Brace Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

9. Remove Catalytic Converter Brace Bracket Nut (1)
10. Remove Catalytic Converter (2)

Installation Procedure

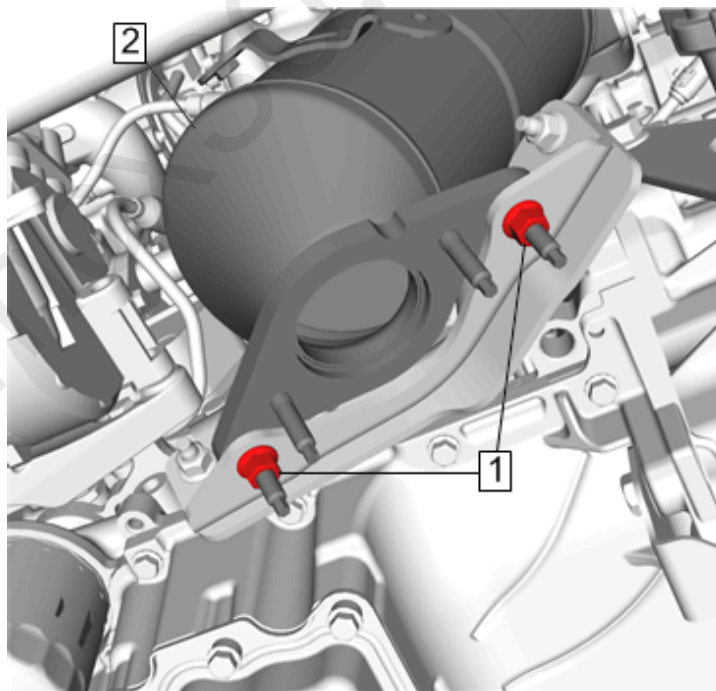


Fig. 49: Catalytic Converter Brace Bracket Nut
Courtesy of GENERAL MOTORS COMPANY

1. Install Catalytic Converter (2)

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

2. Install Catalytic Converter Brace Bracket Nut (1) and tighten 22 N.m (16 lb ft)
3. Disconnect Exhaust Front Pipe@Warm Up Three-Way Catalytic Converter - [Exhaust Front Pipe Replacement \(LYX\)](#)

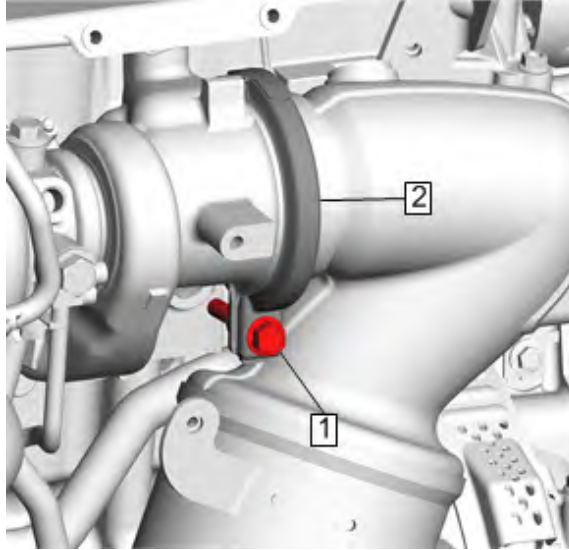


Fig. 50: Catalytic Converter Clamp Bolt

Courtesy of GENERAL MOTORS COMPANY

4. Install Catalytic Converter Clamp (2)
5. Catalytic Converter Clamp Bolt (1) - Tighten 15 N.m (11 lb ft)

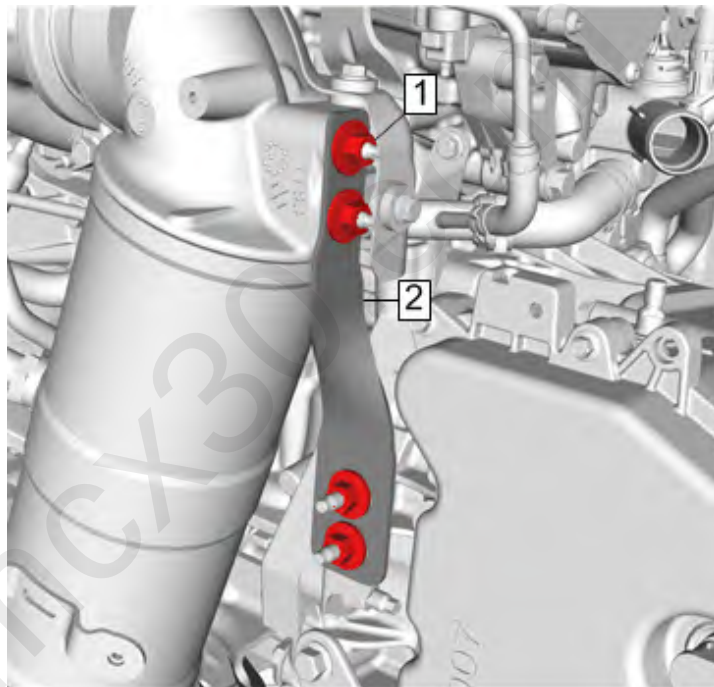


Fig. 51: Catalytic Converter Brace Bracket Nut

Courtesy of GENERAL MOTORS COMPANY

6. Install Catalytic Converter Brace Bracket (2)
7. Install Catalytic Converter Brace Bracket Nut (1) and tighten 22 N.m (16 lb ft)
8. Connect - [Heated Oxygen Sensor Replacement - Sensor 2](#) .
9. Connect - [Heated Oxygen Sensor Replacement - Sensor 1](#) .
10. Install - [Turbocharger Heat Shield Replacement](#)

WARM UP THREE-WAY CATALYTIC CONVERTER REPLACEMENT (LTG)

Removal Procedure

WARNING: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.

WARNING: Avoid contact with HOT components. Wear safety glasses and protective gloves to avoid personal injury.

1. Remove Exhaust Front Pipe - [Exhaust Front Pipe Replacement \(LTG\)](#).

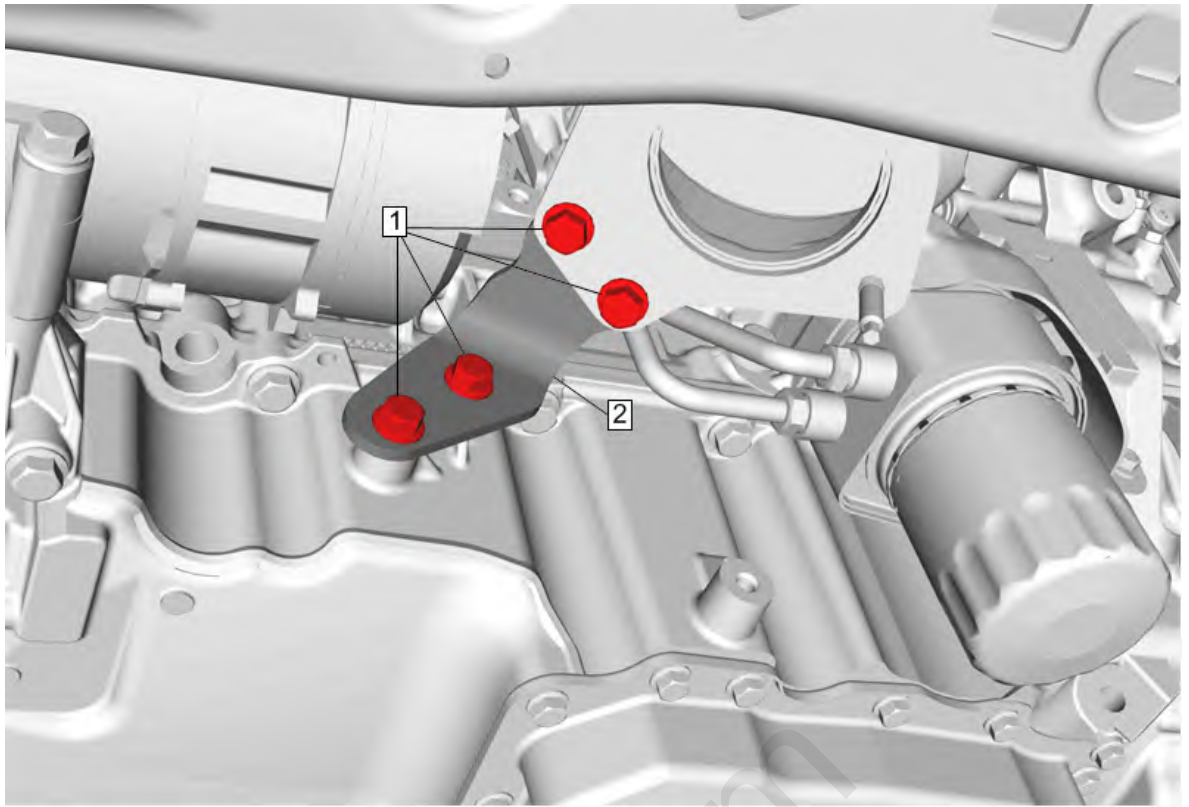


Fig. 52: Catalytic Converter Brace Bracket (LTG)
Courtesy of GENERAL MOTORS COMPANY

2. Remove Catalytic Converter Brace Bracket Bolt (1).
3. Remove Catalytic Converter Brace Bracket-Lower (2)

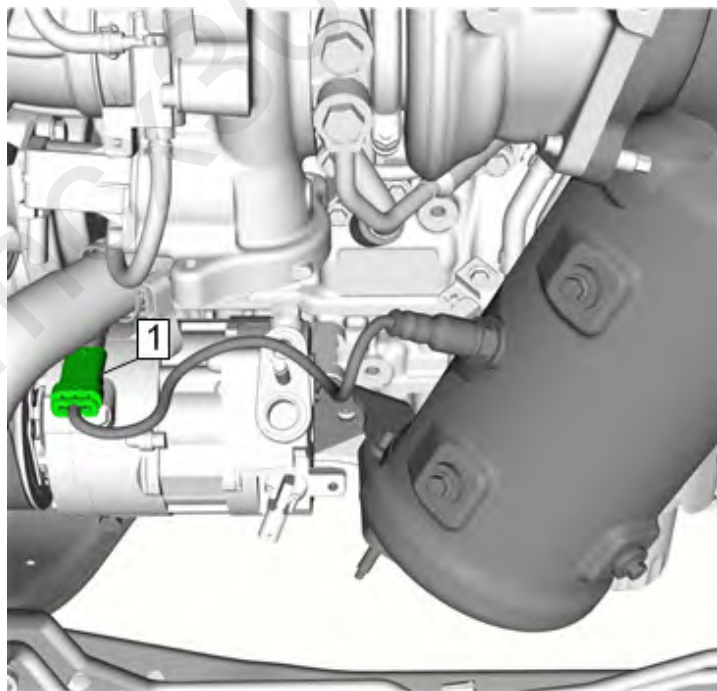


Fig. 53: Heated Oxygen Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Heated Oxygen Sensor Electrical Connector (1)
5. Lower the vehicle.
6. Remove Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement](#)

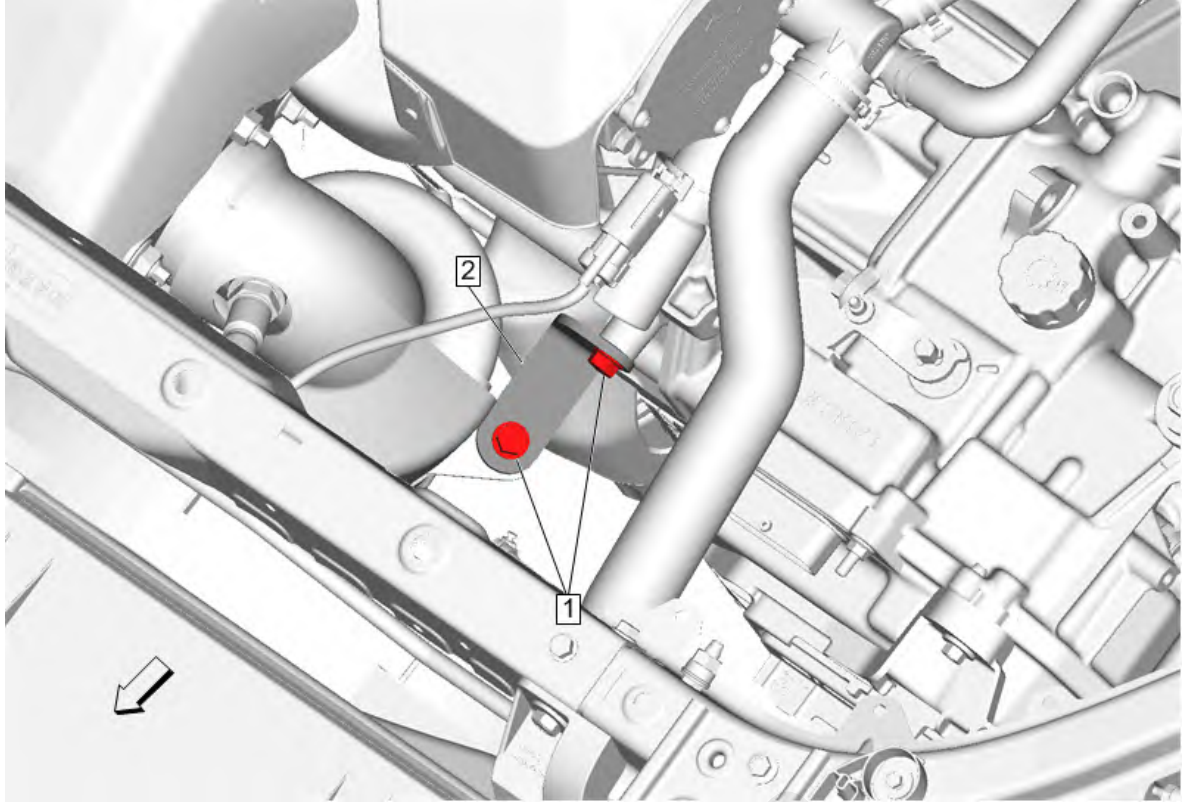


Fig. 54: Catalytic Converter Brace Bracket Bolt And Bracket-Upper
Courtesy of GENERAL MOTORS COMPANY

7. Remove Catalytic Converter Brace Bracket Bolt (1)
8. Remove Catalytic Converter Brace Bracket-Upper (2)



Fig. 55: Heated Oxygen Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

9. Disconnect Heated Oxygen Sensor Electrical Connector (1)
10. Remove Catalytic Converter Nut (3)

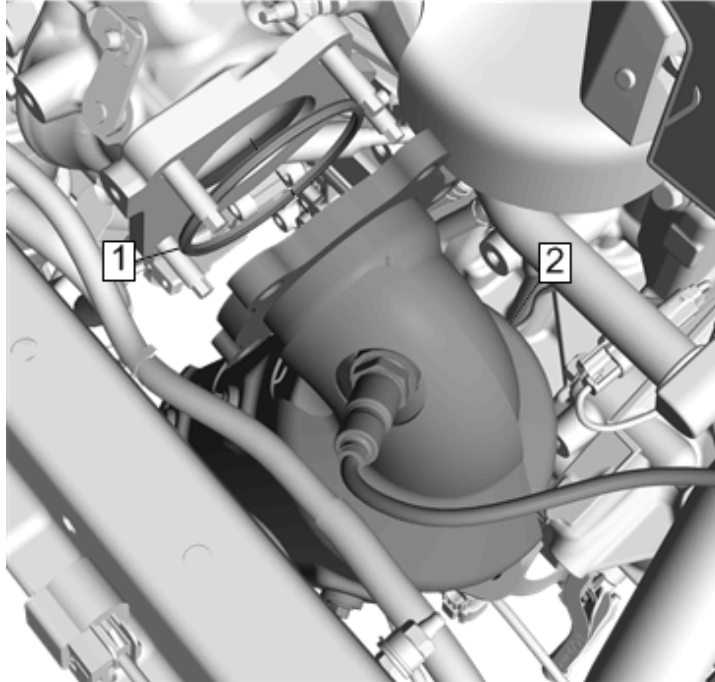


Fig. 56: Catalytic Converter Gasket

Courtesy of GENERAL MOTORS COMPANY

11. Remove Warm Up Three-Way Catalytic Converter (2)
12. Remove Catalytic Converter Gasket (1) and DISCARD
13. Transfer components as necessary.

Installation Procedure

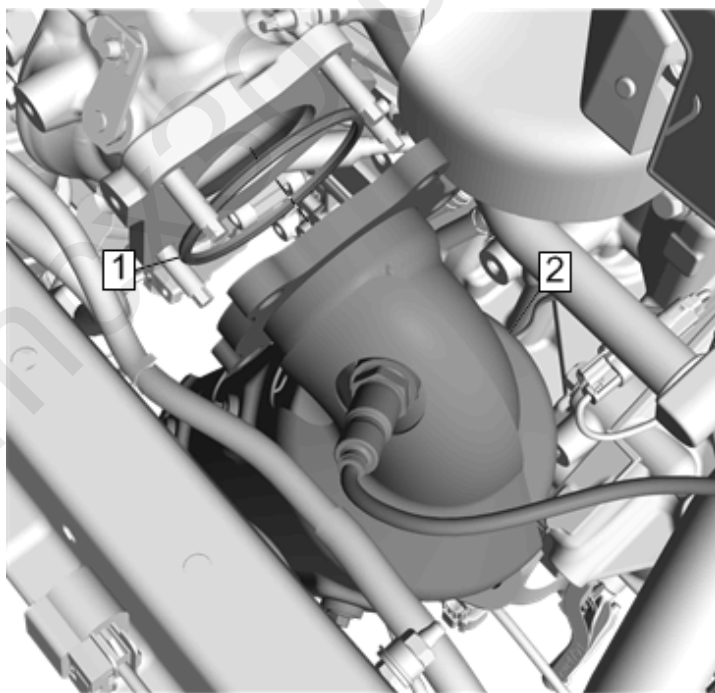


Fig. 57: Catalytic Converter Gasket

Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW Catalytic Converter Gasket (1)
2. Warm Up Three-Way Catalytic Converter (2).

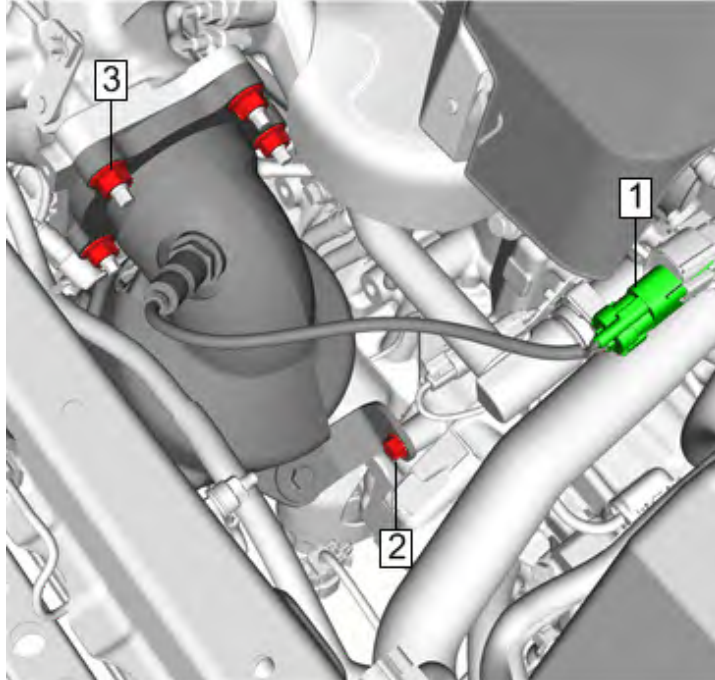


Fig. 58: Heated Oxygen Sensor Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

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

3. Install Catalytic Converter Nut (3) and tighten 50 N.m (37 lb ft)
4. Connect Heated Oxygen Sensor Electrical Connector (1).

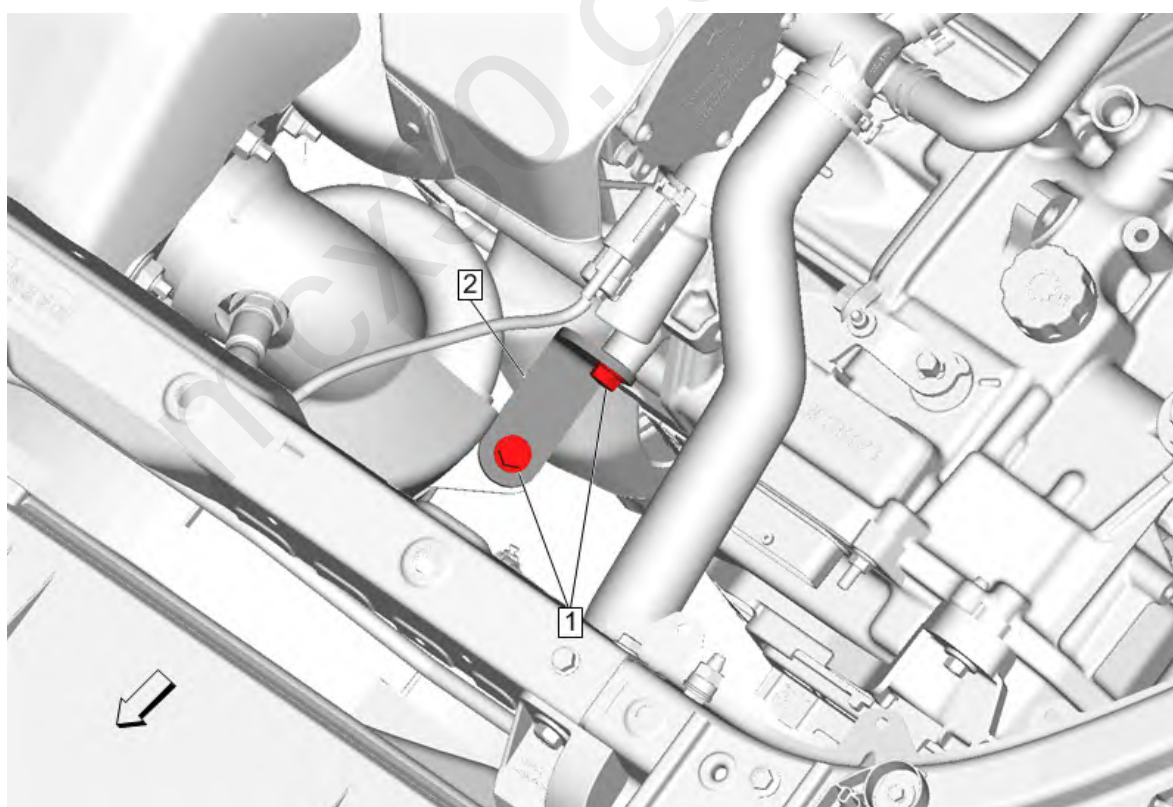


Fig. 59: Catalytic Converter Brace Bracket Bolt And Bracket-Upper
 Courtesy of GENERAL MOTORS COMPANY

5. Install Catalytic Converter Brace Bracket-Upper (2).
6. Install Catalytic Converter Brace Bracket Bolt (2) and tighten [2x] - [Catalytic Converter Brace Bracket Replacement \(LTG Lower\)](#)[Catalytic Converter Brace Bracket Replacement \(LTG Upper\)](#).
7. Install Turbocharger Heat Shield - [Turbocharger Heat Shield Replacement](#)
8. Raise and support the vehicle.

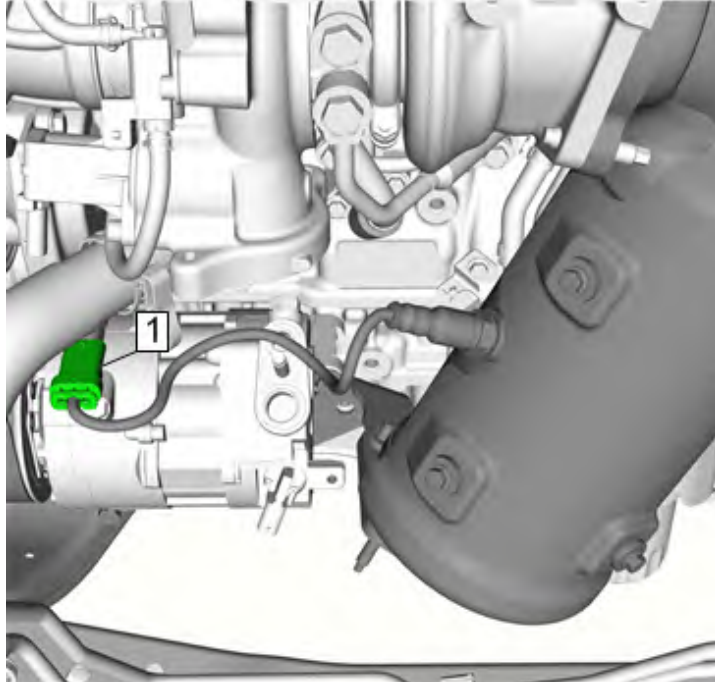


Fig. 60: Heated Oxygen Sensor Electrical Connector
 Courtesy of GENERAL MOTORS COMPANY

9. Heated Oxygen Sensor Electrical Connector (1)

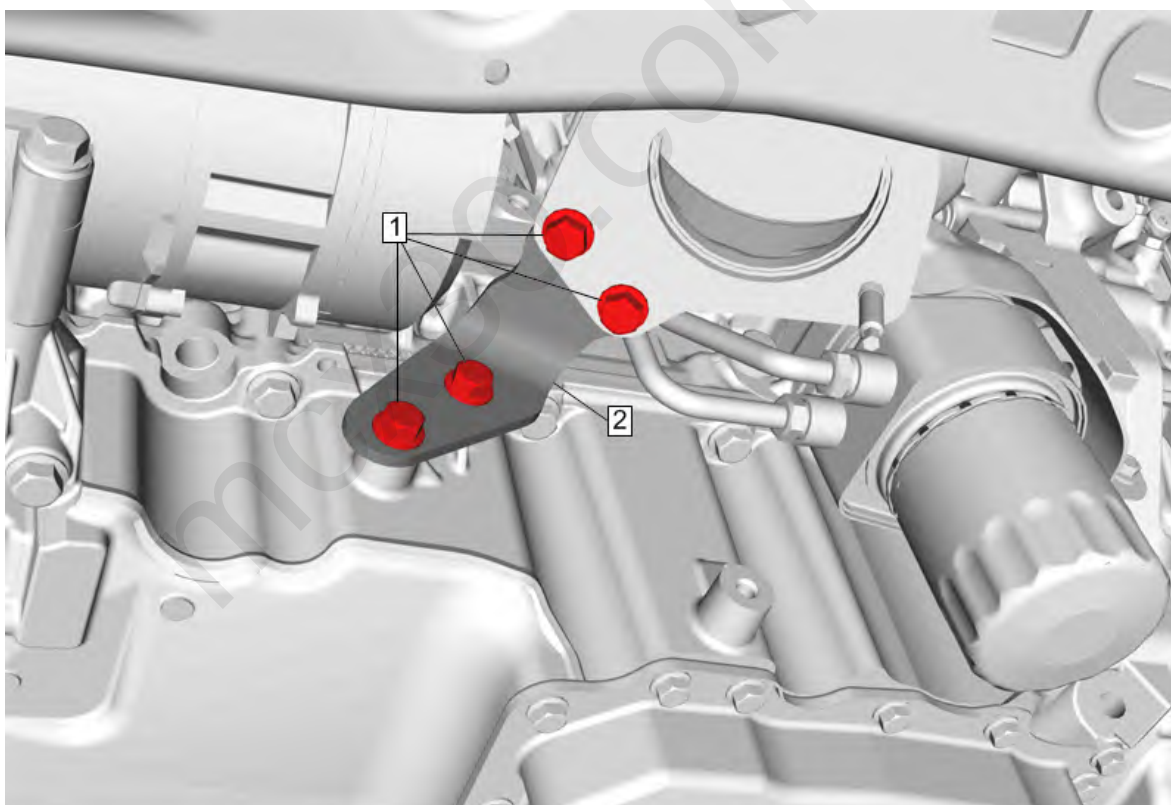


Fig. 61: Catalytic Converter Brace Bracket (LTG)
 Courtesy of GENERAL MOTORS COMPANY

10. Install Catalytic Converter Brace Bracket-Lower (2)
11. Install Catalytic Converter Brace Bracket Bolt (1) and tighten [4x] - **Catalytic Converter Brace Bracket Replacement (LTG Lower)****Catalytic Converter Brace Bracket Replacement (LTG Upper)**
12. Install Exhaust Front Pipe -**Exhaust Front Pipe Replacement (LTG)**
13. Start the engine and check for exhaust leaks.

CATALYTIC CONVERTER BRACE BRACKET REPLACEMENT (LOWER, LYX)

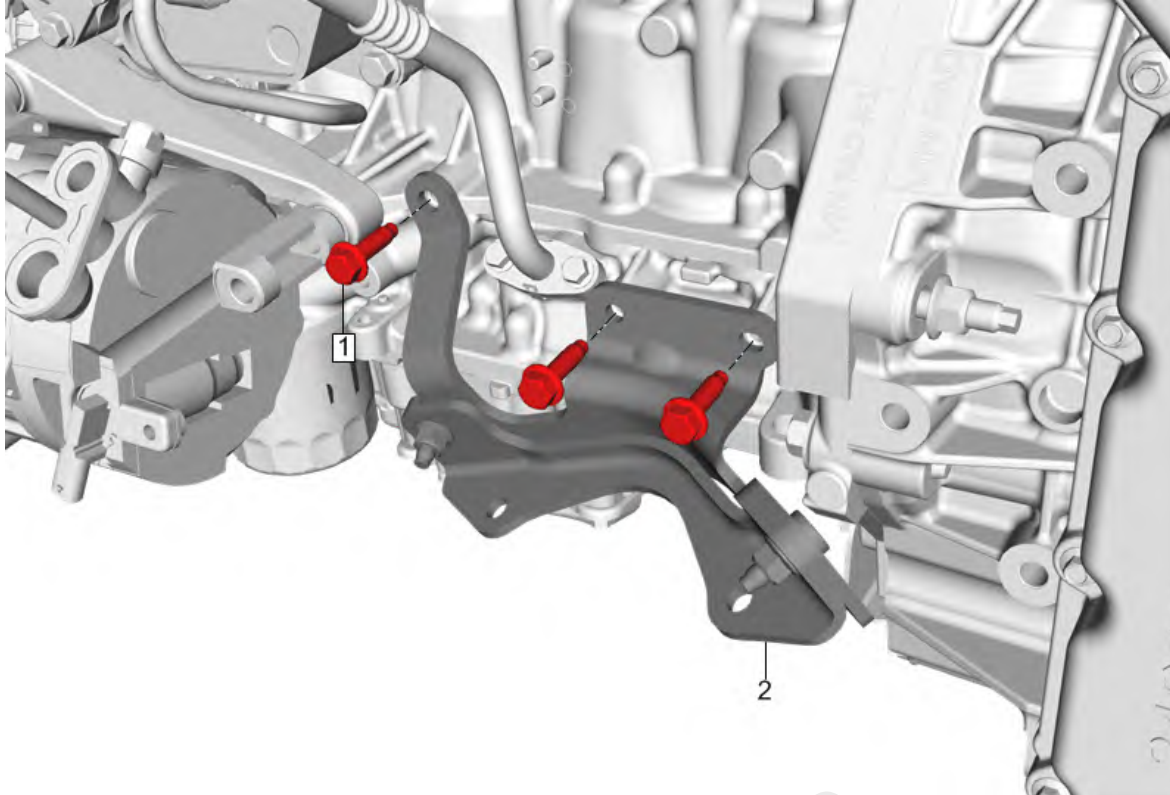


Fig. 62: Catalytic Converter Brace Bracket
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Warm Up Three-Way Catalytic Converter Replacement (LYX)	
1	Catalytic Converter Brace Bracket Bolt (Qty: 3) CAUTION: Refer to Fastener Caution . Tighten 22 N.m (16 lb ft)
2	Catalytic Converter Brace Bracket

CATALYTIC CONVERTER BRACE BRACKET REPLACEMENT (UPPER, LYX)

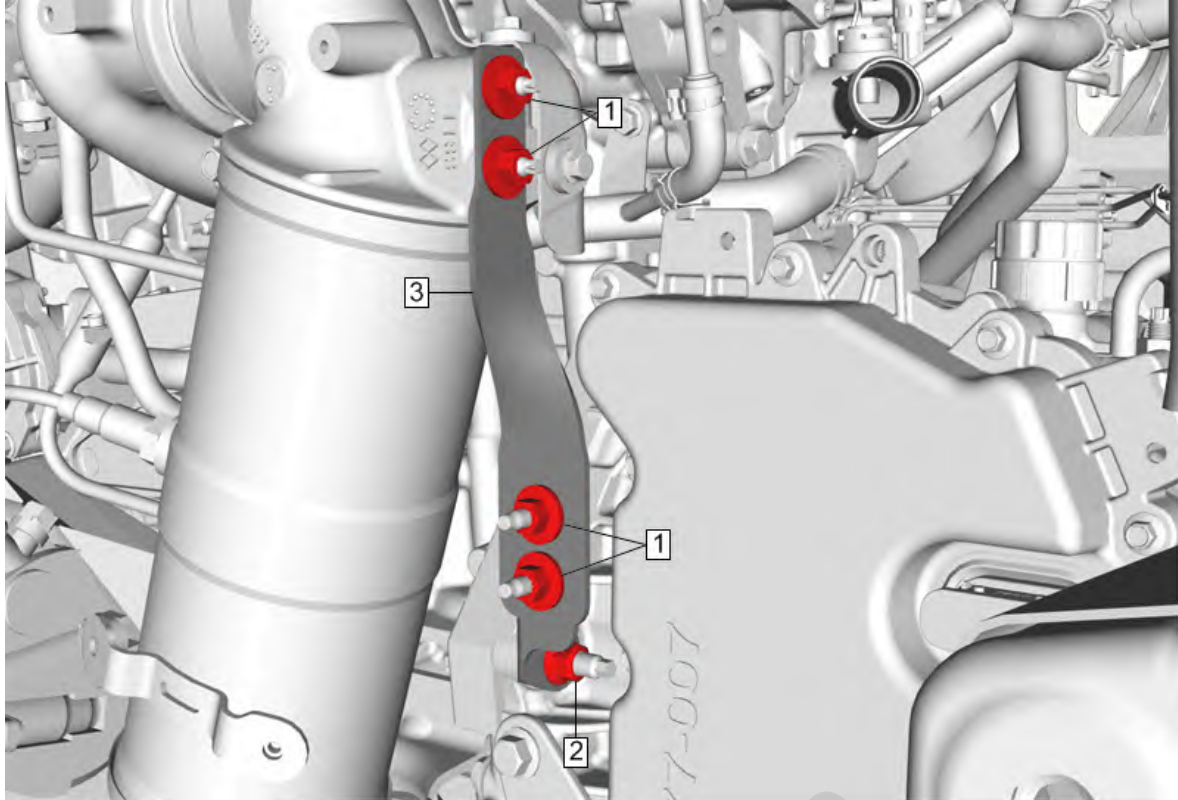


Fig. 63: Catalytic Converter Brace Bracket (Upper LFV)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Turbocharger Heat Shield Replacement</u>	
1	Catalytic Converter Brace Bracket Nut (Qty: 4) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 22 N.m (16 lb ft)
2	Catalytic Converter Brace Bracket Nut Tighten 58 N.m (43 lb ft)
3	Catalytic Converter Brace Bracket

CATALYTIC CONVERTER BRACE BRACKET REPLACEMENT (LTG LOWER)

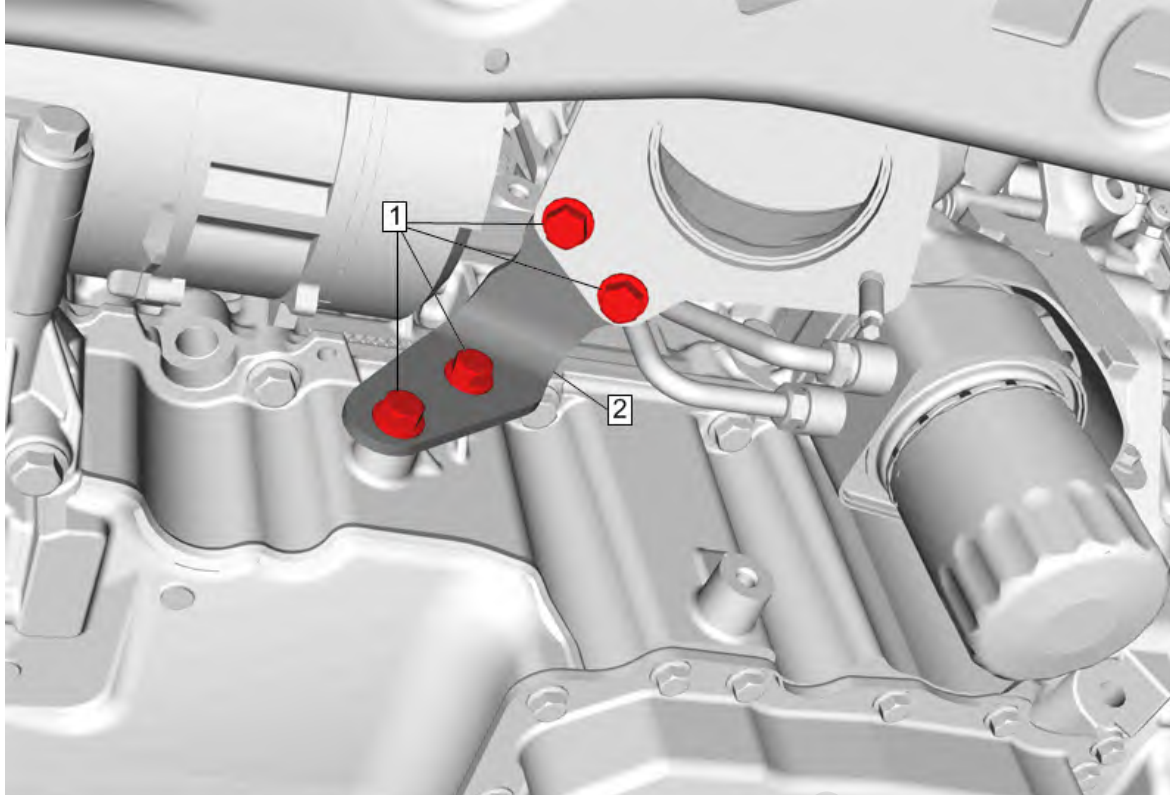


Fig. 64: Catalytic Converter Brace Bracket (LTG)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Lifting and Jacking the Vehicle</u>	
1	Exhaust Pipe Front Hanger Bracket Bolt (Qty: 4) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 22 N.m (16 lb ft)
2	Catalytic Converter Brace Bracket

CATALYTIC CONVERTER BRACE BRACKET REPLACEMENT (LTG UPPER)

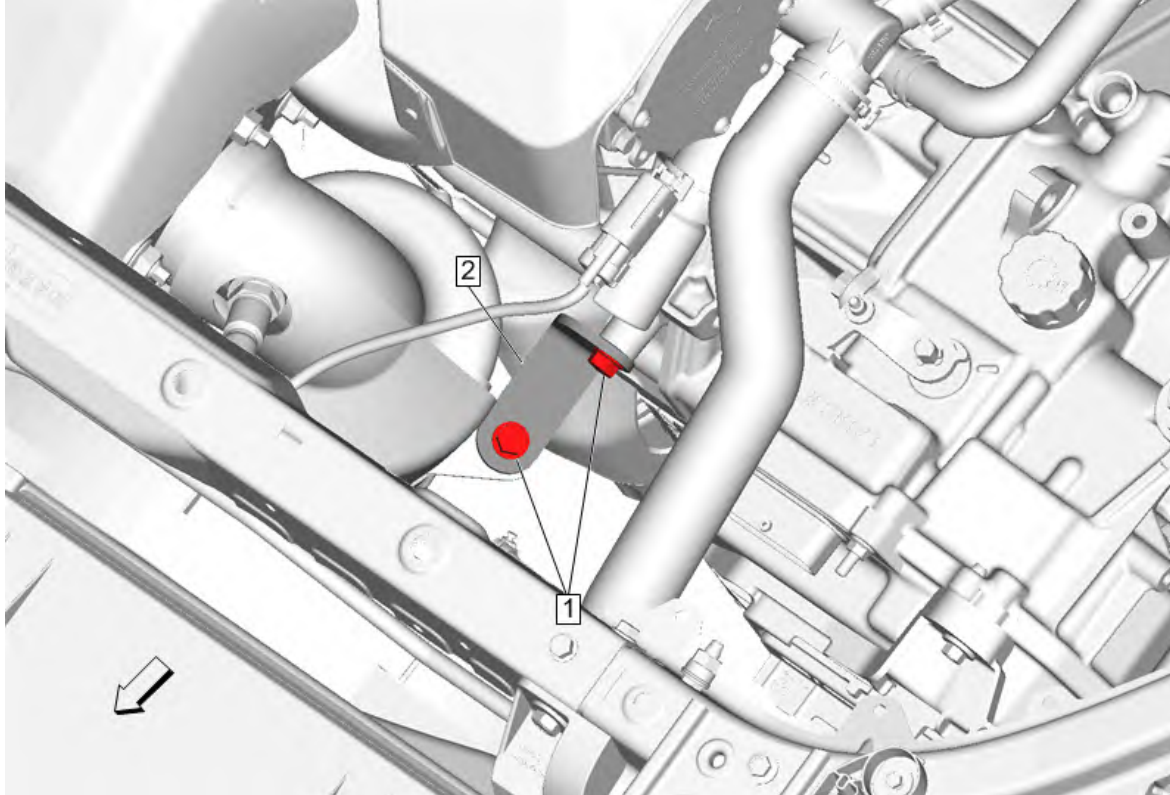


Fig. 65: Catalytic Converter Brace Bracket Bolt And Bracket-Upper
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Catalytic Converter Brace Bracket Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 22 N.m (16 lb ft)
2	Catalytic Converter Brace Bracket

EXHAUST REAR MUFFLER REAR HANGER REPLACEMENT

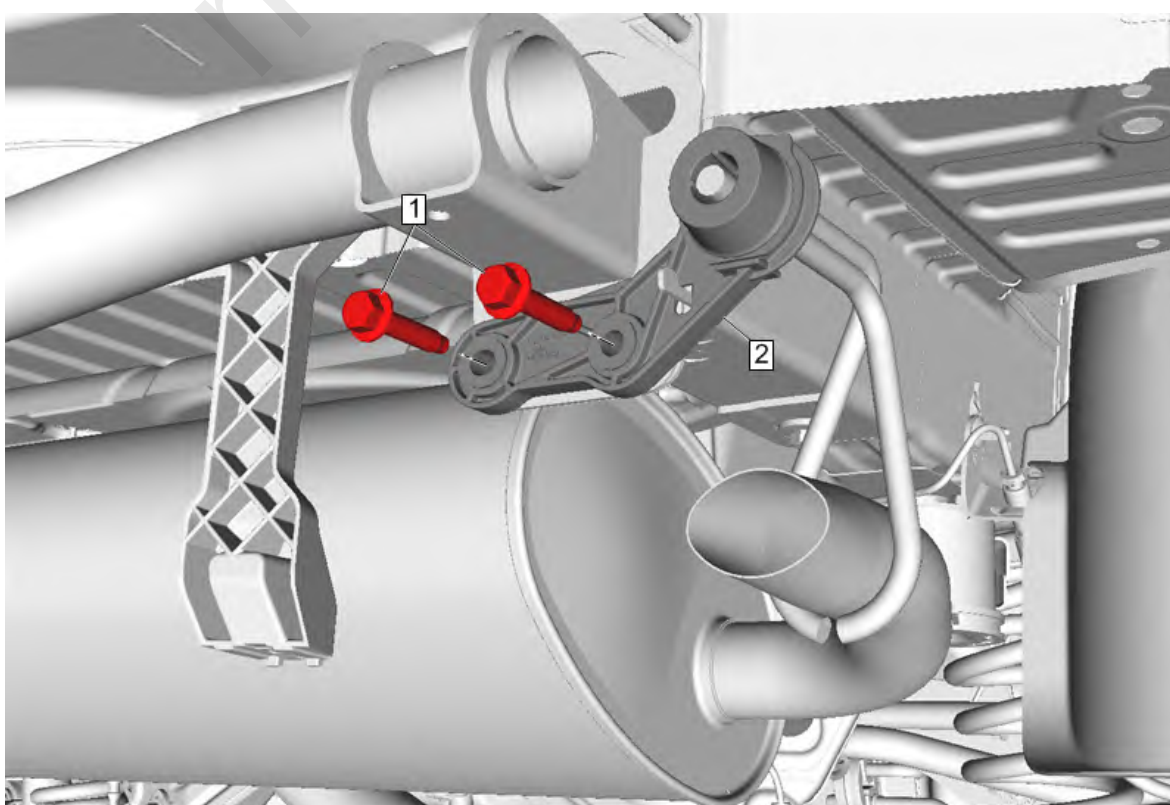


Fig. 66: Exhaust Rear Muffler Rear Hanger
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Lifting and Jacking the Vehicle	
1	Exhaust Rear Muffler Rear Hanger Bolt (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 22 N.m (16 lb ft)
2	Exhaust Rear Muffler Rear Hanger

EXHAUST MUFFLER REPLACEMENT (LTG, LYX)

Removal Procedure

WARNING: Refer to **Hot Exhaust System Warning** .

WARNING: Refer to **Safety Glasses Warning** .

1. Raise and support the vehicle. **Lifting and Jacking the Vehicle**

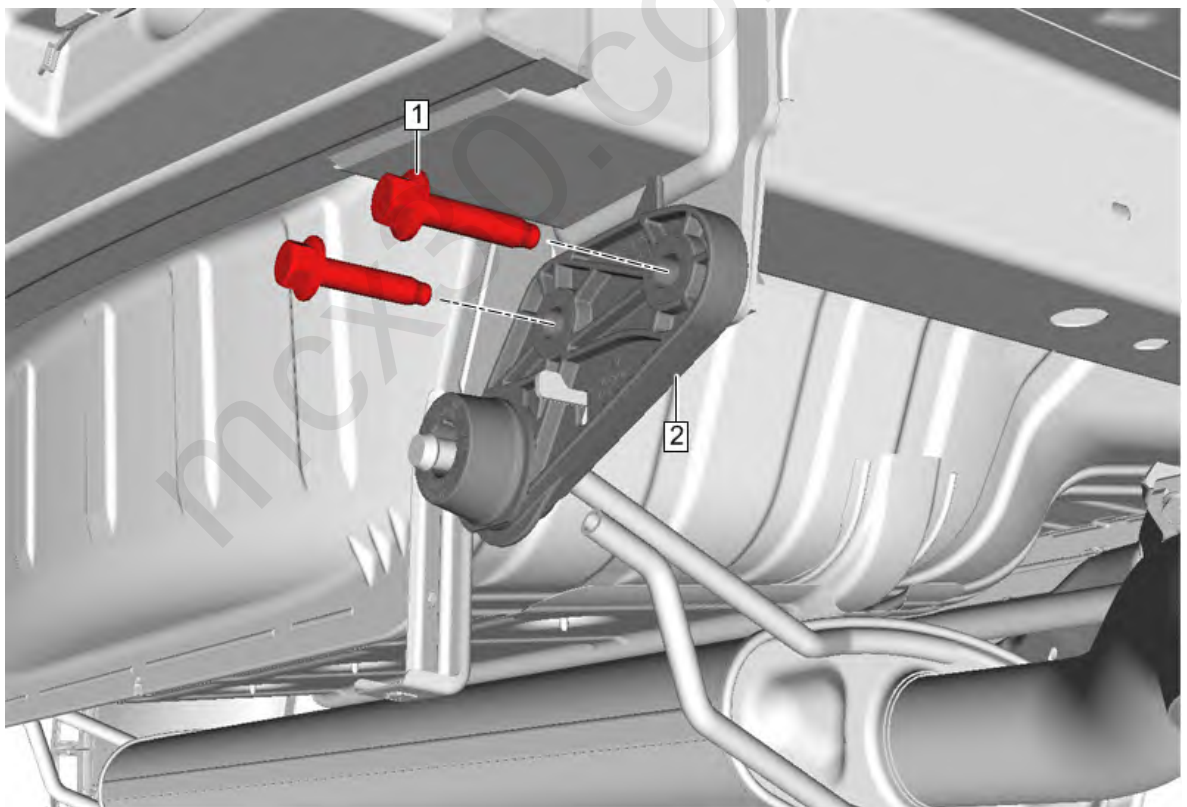


Fig. 67: Exhaust Rear Muffler Insulator Bolt-Right Side
Courtesy of GENERAL MOTORS COMPANY

2. Remove Exhaust Rear Muffler Insulator Bolt-Right Side (1)

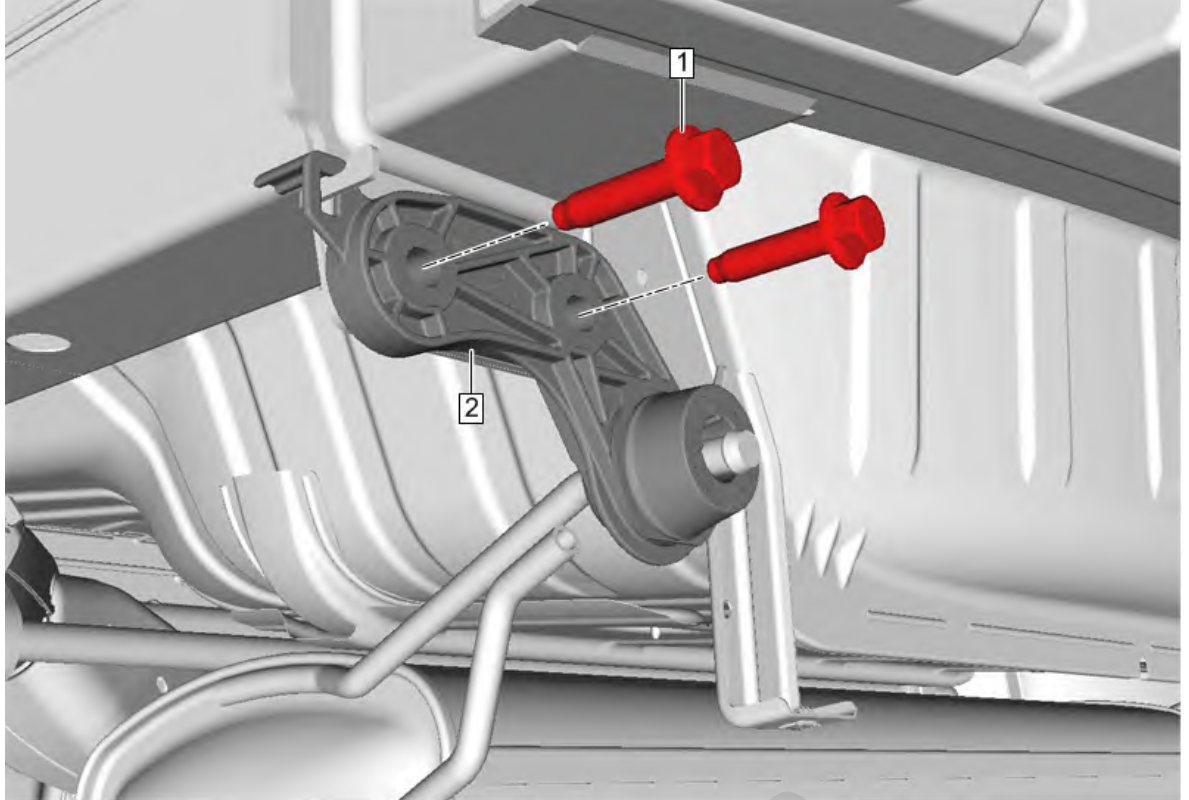


Fig. 68: Exhaust Rear Muffler Insulator Bolt-Left Side
Courtesy of GENERAL MOTORS COMPANY

3. Remove Exhaust Rear Muffler Insulator Bolt-Left Side (1)

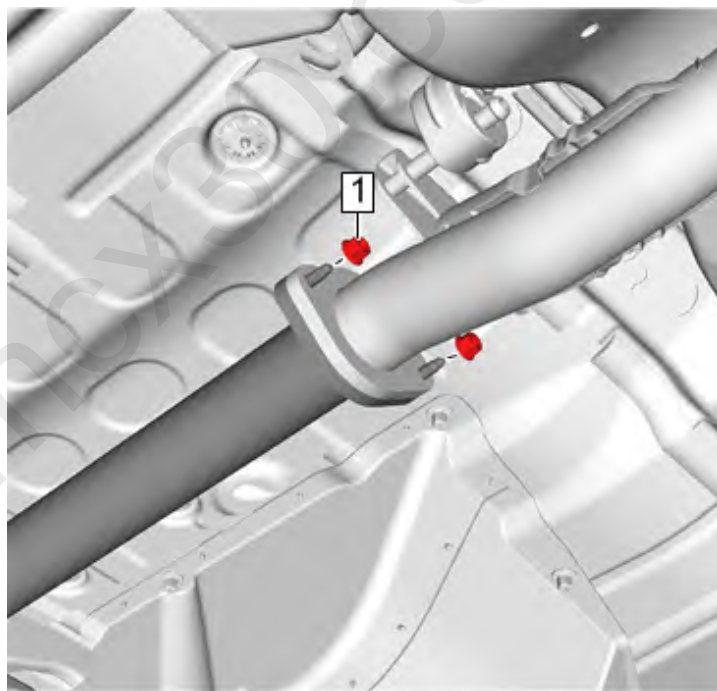


Fig. 69: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

4. Remove Exhaust Front Pipe Nut (1)

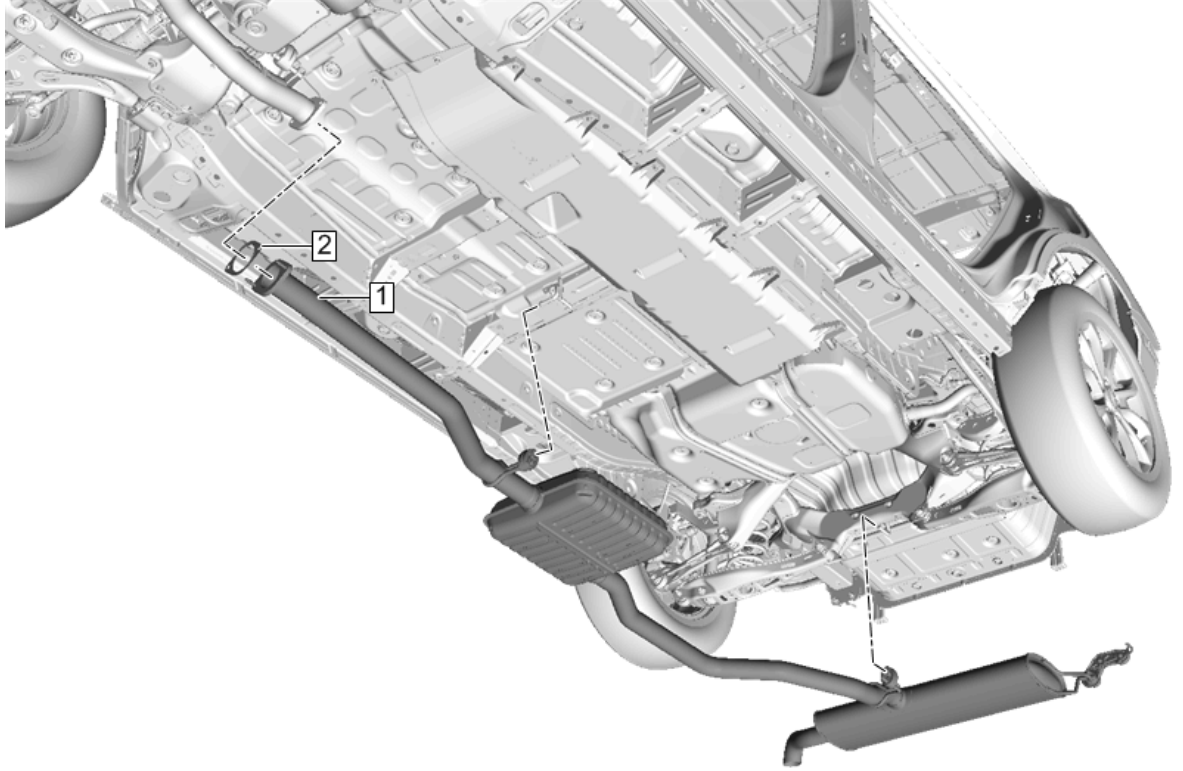


Fig. 70: Exhaust Muffler Assembly And Exhaust Gasket
Courtesy of GENERAL MOTORS COMPANY

5. Remove Exhaust Muffler Assembly (1)
6. Remove Exhaust Gasket (2) and DISCARD

Installation Procedure

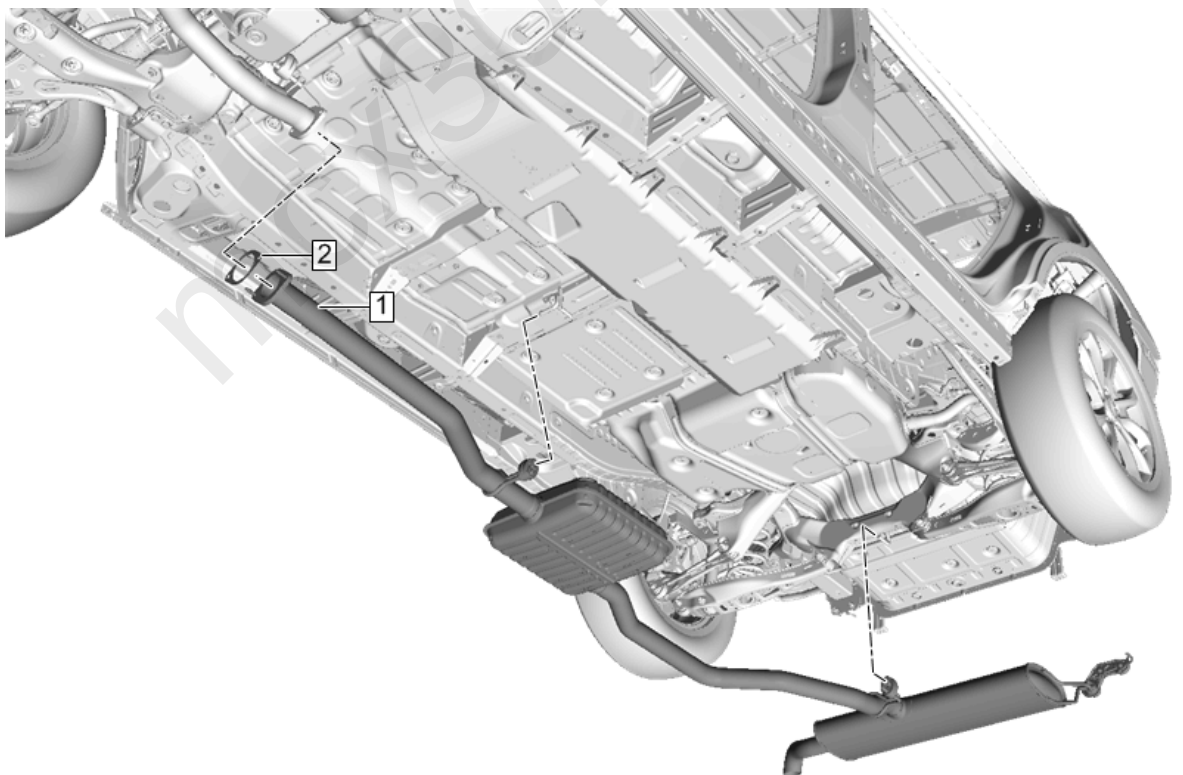


Fig. 71: Exhaust Muffler Assembly And Exhaust Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: Clean and lubricate the exhaust isolators for ease of installation.

NOTE: Install a NEW gasket.

1. Install Exhaust Gasket (2)

2. Exhaust Muffler Assembly (3)

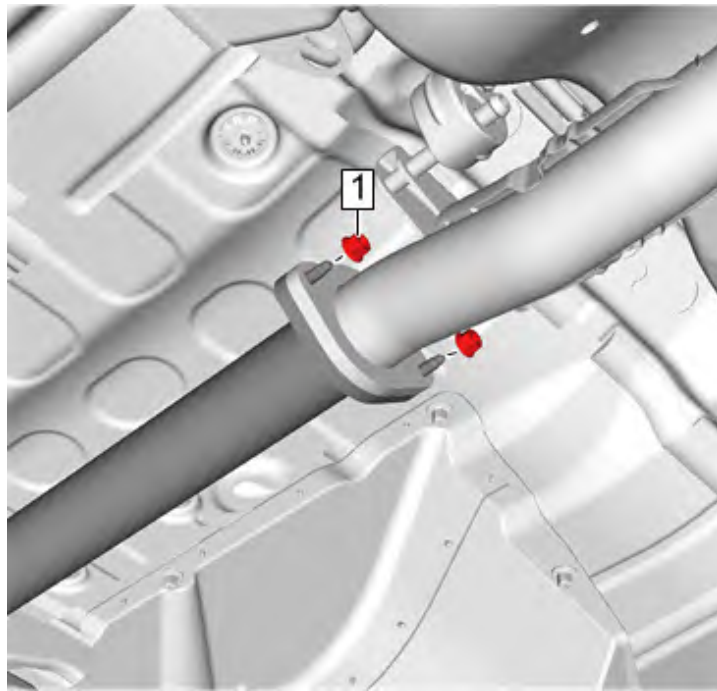


Fig. 72: Exhaust Front Pipe Nut
Courtesy of GENERAL MOTORS COMPANY

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

3. Install Exhaust Front Pipe Nut (1) and tighten 22 N.m (16 lb ft)

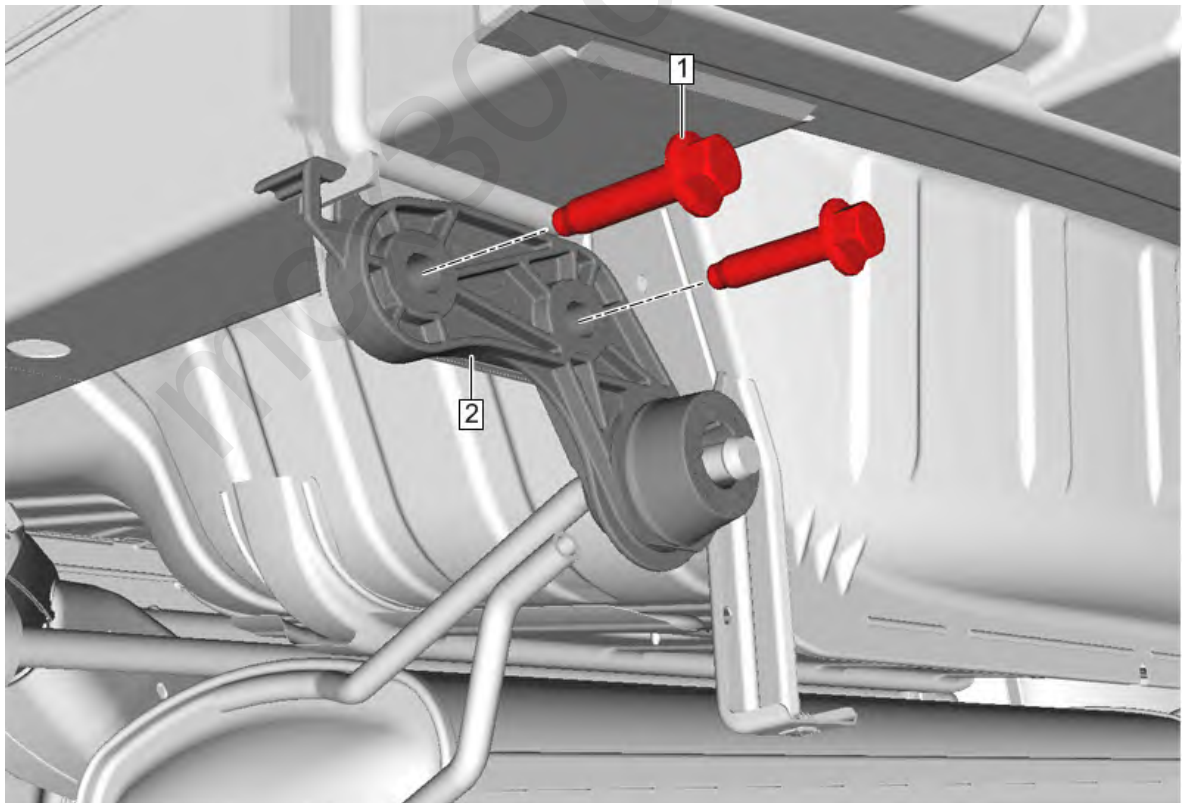


Fig. 73: Exhaust Rear Muffler Insulator Bolt-Left Side
Courtesy of GENERAL MOTORS COMPANY

4. Install Exhaust Rear Muffler Insulator Bolt-Left Side (1) and tighten 22 N.m (16 lb ft)

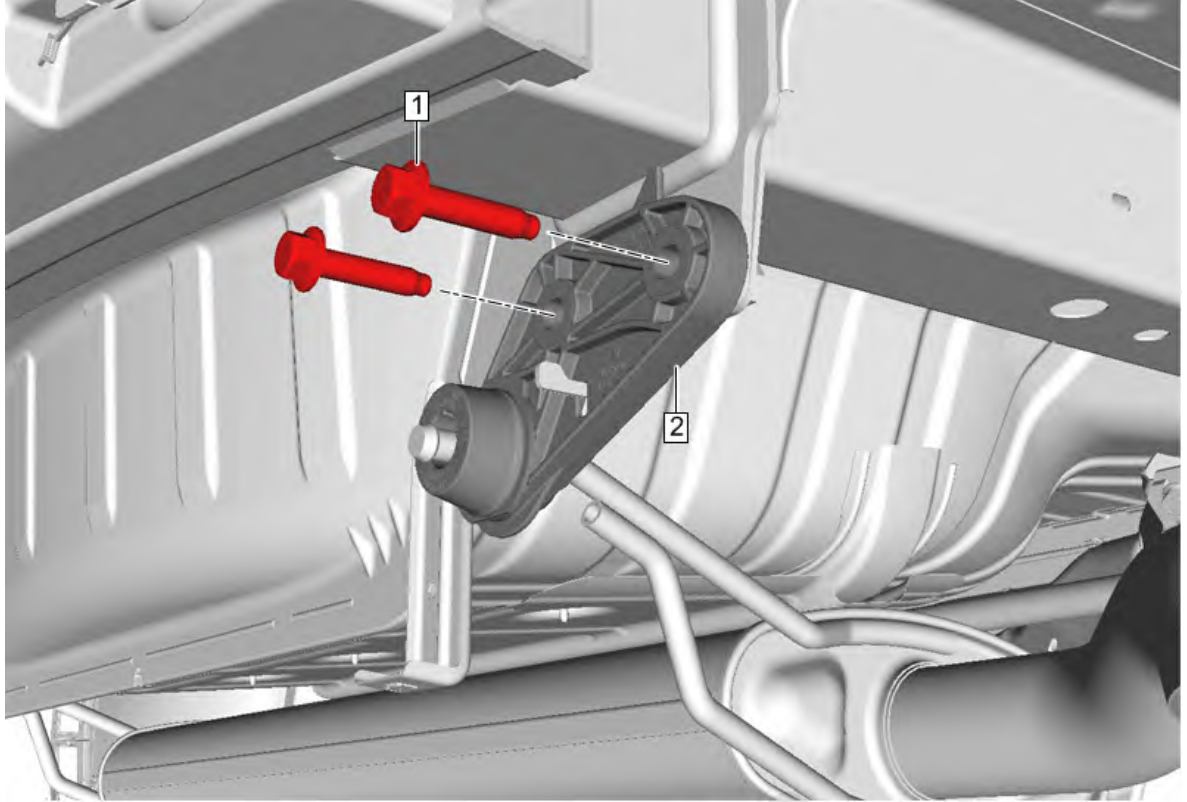


Fig. 74: Exhaust Rear Muffler Insulator Bolt-Right Side
Courtesy of GENERAL MOTORS COMPANY

5. Install Exhaust Rear Muffler Insulator Bolt-Right Side (1) and tighten 22 N.m (16 lb ft)
6. Lower the vehicle. [Lifting and Jacking the Vehicle](#)
7. Start the engine and check for exhaust leaks.

EXHAUST MUFFLER REPLACEMENT (LH7)

Removal Procedure

WARNING: [Protective Goggles and Glove Warning](#)

WARNING: [Exhaust Service Warning](#)

NOTE: Ensure care when repositioning Nitrogen Oxides Sensor 2. Do NOT bend the cable sharply at the base of either the sensing unit or sensor ECU in the final mounting position.

1. Remove Nitrogen Oxides Sensor-Position 2 and position aside - [Nitrogen Oxides Sensor Replacement - Position 2](#)

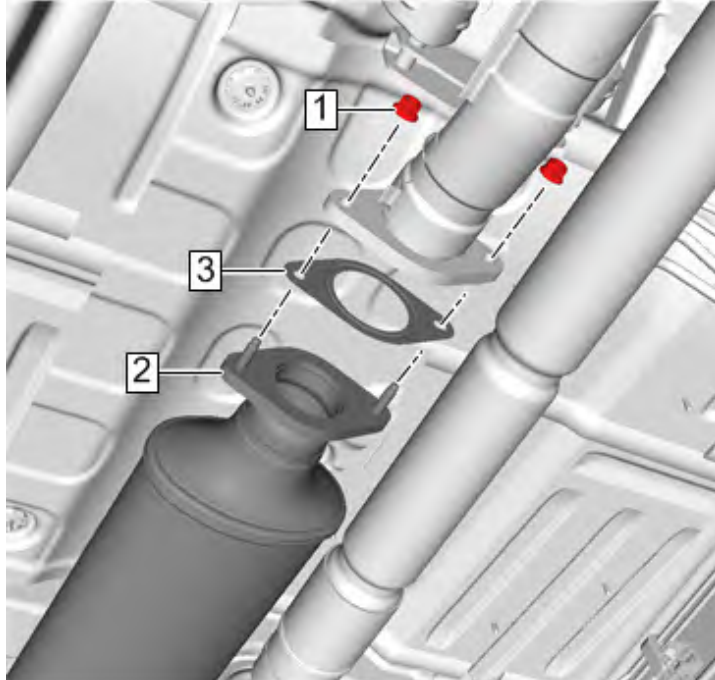


Fig. 75: Exhaust Front Pipe Nut

Courtesy of GENERAL MOTORS COMPANY

2. Remove Exhaust Front Pipe Nut (1)
3. Remove Exhaust Muffler (2)
4. Remove Exhaust Front Pipe Gasket (3) and DISCARD

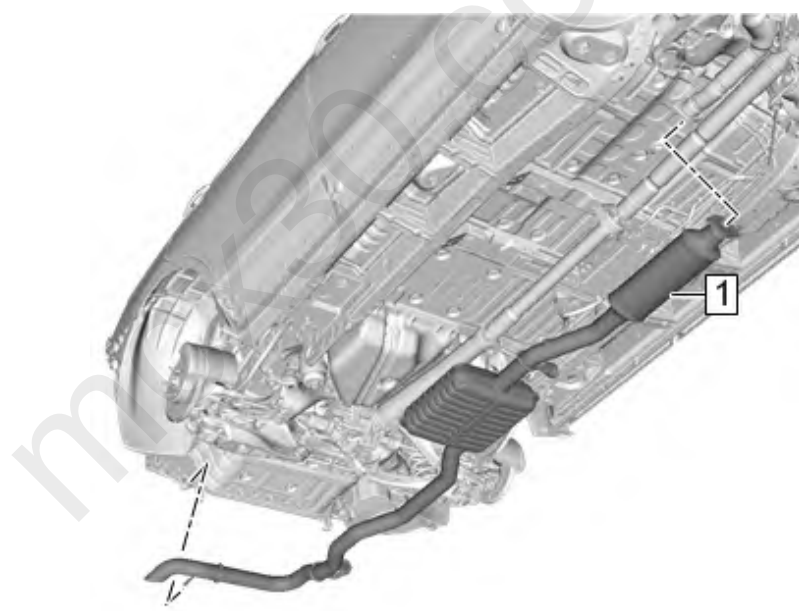


Fig. 76: Exhaust Muffler Assembly

Courtesy of GENERAL MOTORS COMPANY

5. Remove Exhaust Muffler Assembly (1)

Installation Procedure

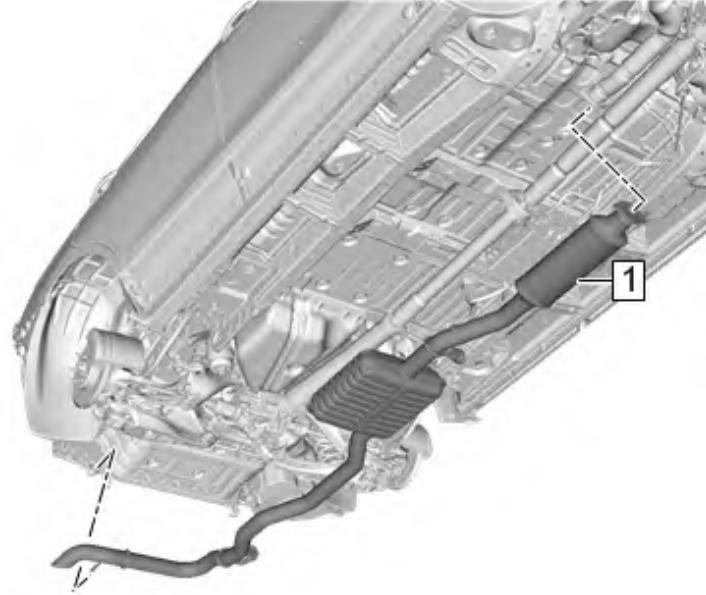


Fig. 77: Exhaust Muffler Assembly

Courtesy of GENERAL MOTORS COMPANY

1. With the aid of an assistant, position and install the exhaust muffler assembly.(1)

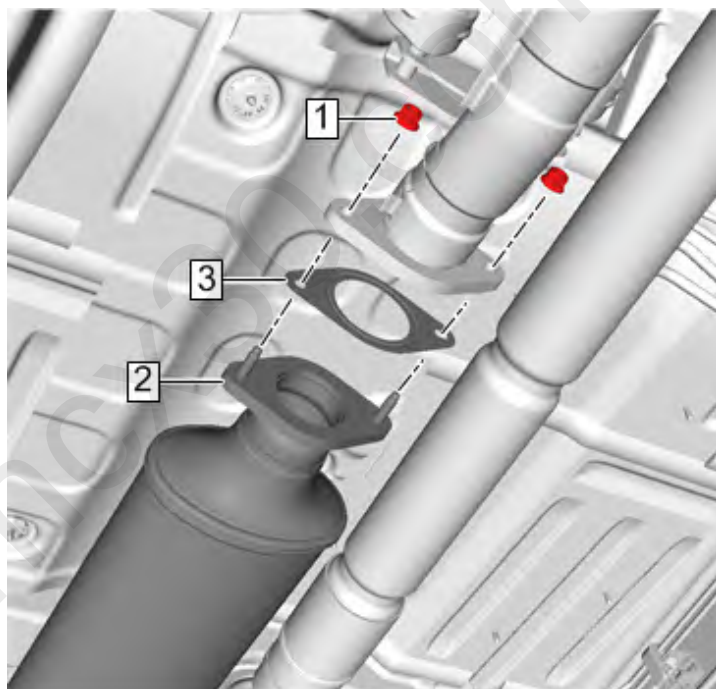


Fig. 78: Exhaust Front Pipe Nut

Courtesy of GENERAL MOTORS COMPANY

NOTE: Install a NEW gasket.

2. Install Exhaust Front Pipe Gasket (3)
3. Install Exhaust Muffler (2)

CAUTION: Fastener Caution

4. Install Exhaust Front Pipe Nut (1) and tighten 22 N.m (16 lb ft)

NOTE: Ensure care when repositioning Nitrogen Oxides Sensor 2. Do NOT bend the cable sharply at the base of either the sensing unit or sensor ECU in the final mounting position.

5. Install Nitrogen Oxides Sensor-Position 2 - Nitrogen Oxides Sensor Replacement - Position 2

6. If the replacing the Exhaust Muffler with new, perform the NOx Catalyst Reset. [NOx Catalyst Reset](#)
7. If replacing the Exhaust Muffler with new, perform the Diesel Particulate Filter (DPF) Regeneration Enable. [Diesel Particulate Filter \(DPF\) Regeneration Enable](#)

CATALYTIC CONVERTER HEAT SHIELD REPLACEMENT (LTG)

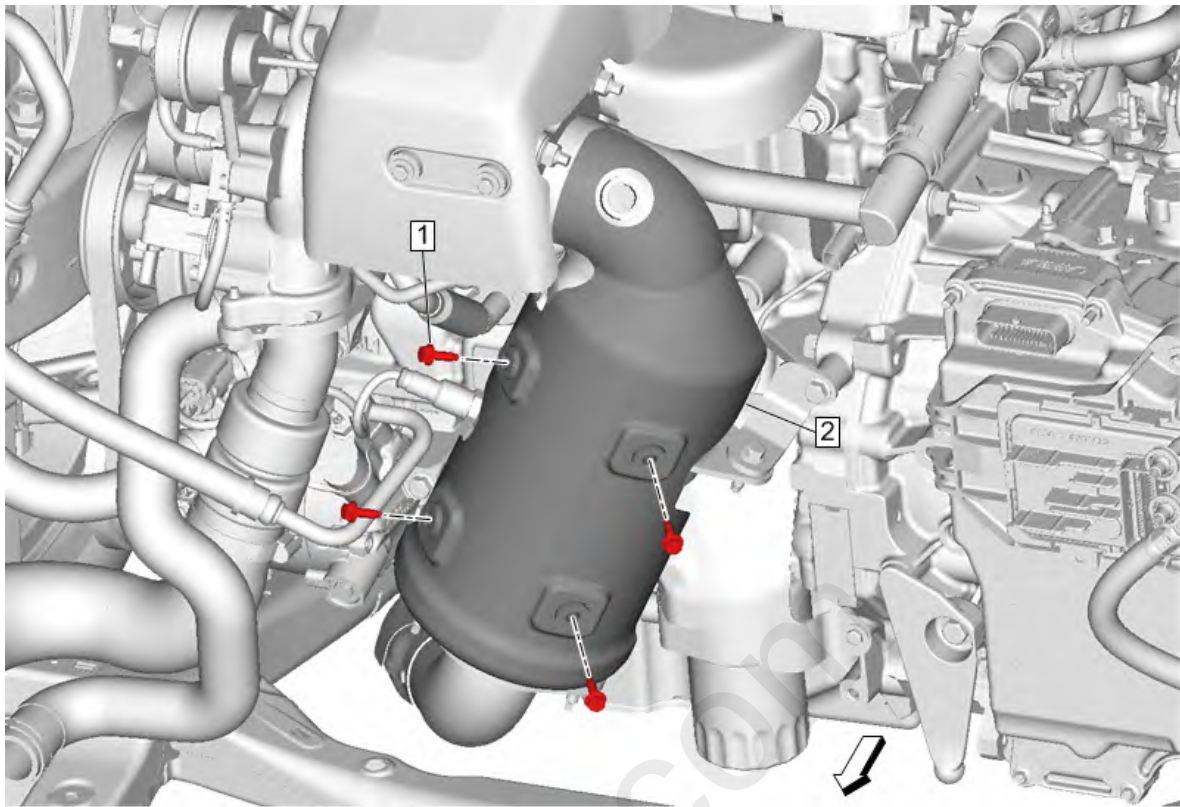


Fig. 79: Catalytic Converter Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool. WARNING: Avoid contact with HOT components. Wear safety glasses and protective gloves to avoid personal injury.	
Preliminary Procedure Heated Oxygen Sensor Replacement - Sensor 1	
1	Catalytic Converter Heat Shield Bolt (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Catalytic Converter Heat Shield

CATALYTIC CONVERTER HEAT SHIELD REPLACEMENT (LH7)

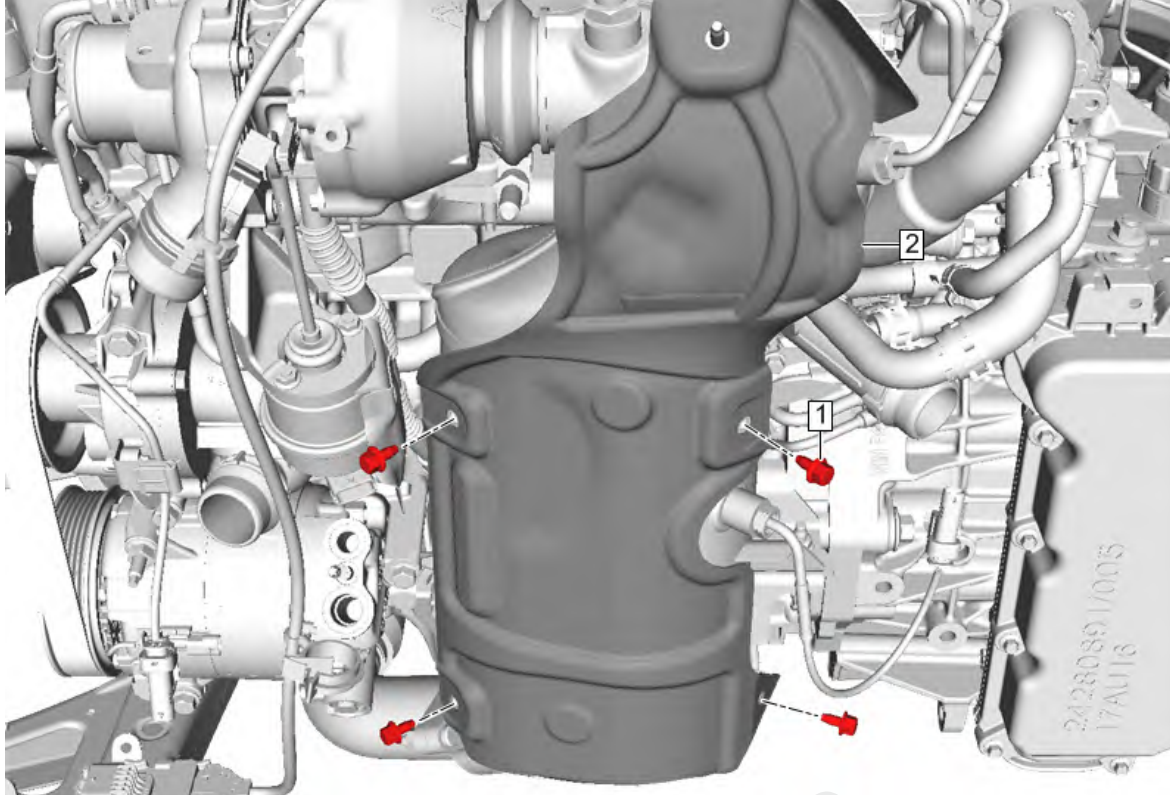


Fig. 80: Catalytic Converter Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Raise and support the vehicle. Lifting and Jacking the Vehicle 2. Turbocharger Heat Shield Replacement (LH7)	
1	Catalytic Converter Heat Shield Bolt (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)
2	Catalytic Converter Heat Shield

EXHAUST FRONT UNDERBODY HEAT SHIELD REPLACEMENT

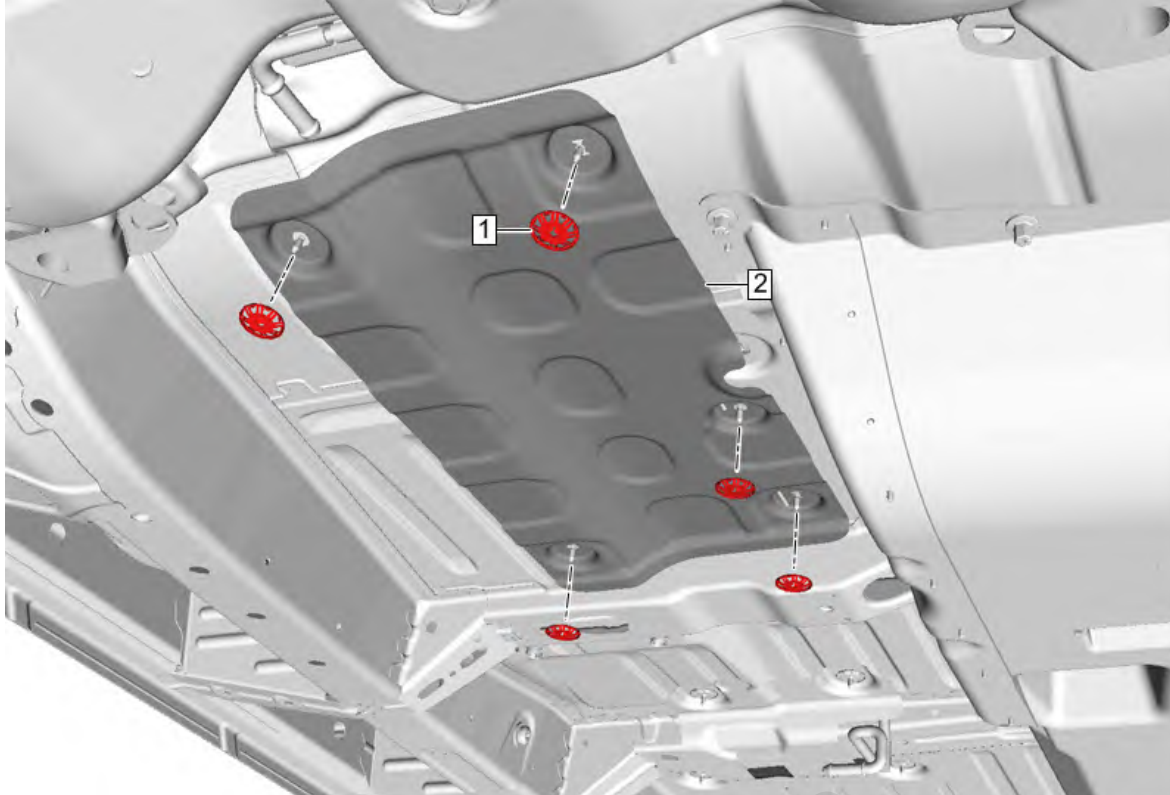


Fig. 81: Exhaust Front Underbody Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Lifting and Jacking the Vehicle</u>	
1	Exhaust Front Underbody Heat Shield Retainer (Qty: 5) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 1.5 N.m (13 lb in)
2	Exhaust Front Underbody Heat Shield

EXHAUST INTERMEDIATE UNDERBODY HEAT SHIELD REPLACEMENT

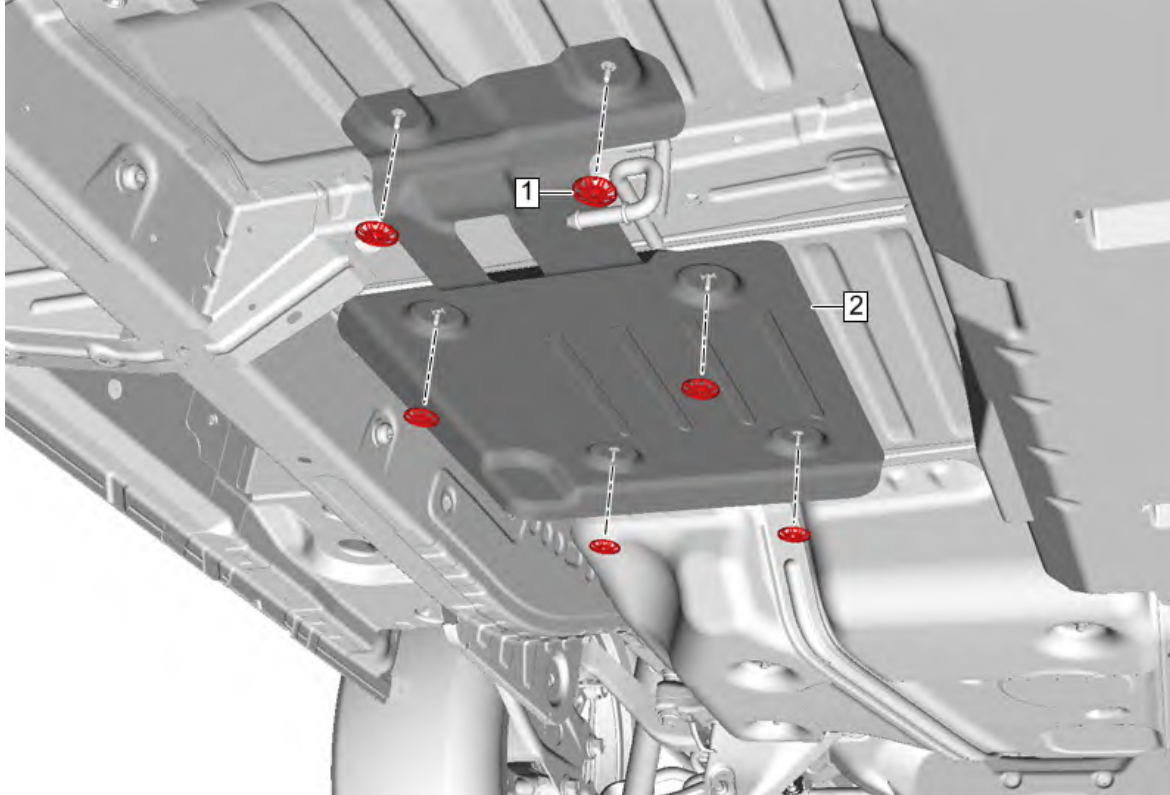


Fig. 82: Exhaust Intermediate Underbody Heat Shield

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Exhaust Muffler Replacement (LTG, LYX)Exhaust Muffler Replacement (LH7)</u>	
1	Exhaust Intermediate Underbody Heat Shield Retainer (Qty: 6) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 1.5 N.m (13 lb in)
2	Exhaust Intermediate Underbody Heat Shield

EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT (LTG)

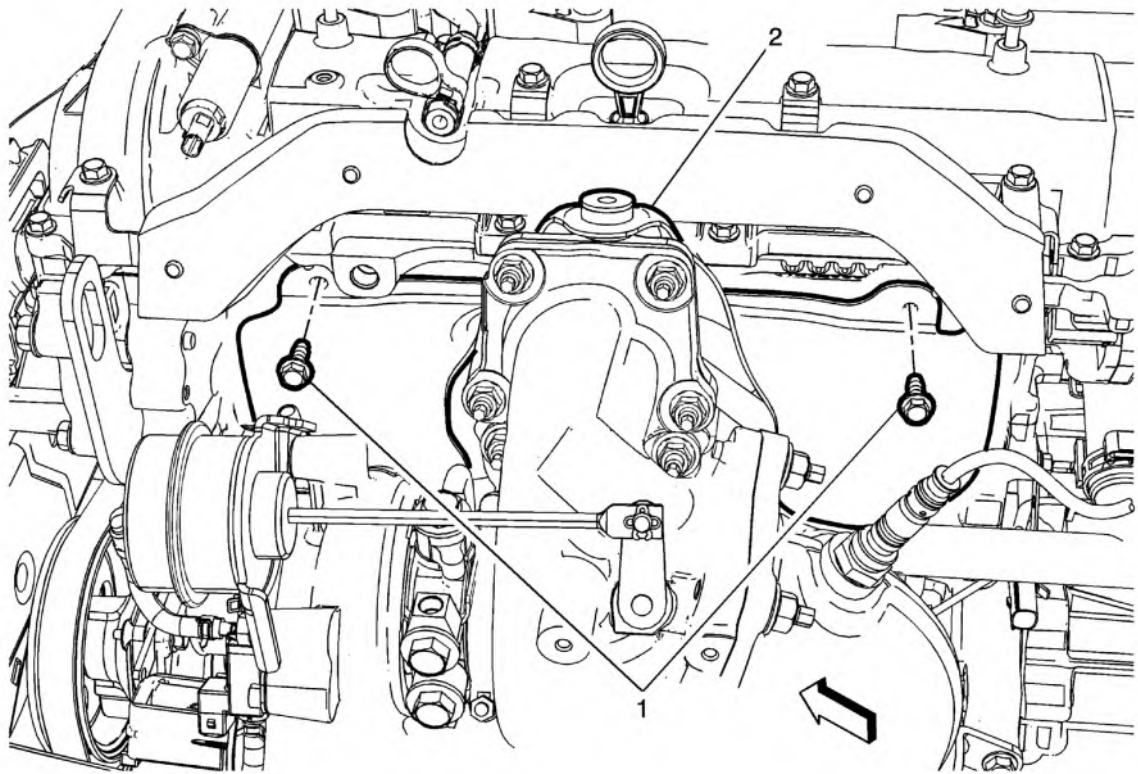


Fig. 83: Exhaust Manifold Heat Shield (LTG)
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Hot Exhaust System Warning .	
Preliminary Procedure Remove the turbocharger. Refer to Turbocharger Replacement (1st Design Tamper-Proof PCV System) .	
1	Exhaust Manifold Heat Shield Fasteners (Qty: 2) CAUTION: Refer to Fastener Caution . Tighten 14 N.m (10 lb ft)
2	Exhaust Manifold Heat Shield

TURBOCHARGER HEAT SHIELD REPLACEMENT (LH7)

Removal Procedure

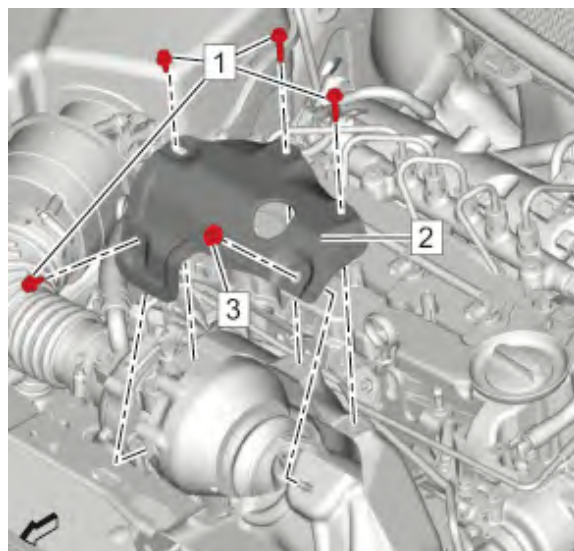


Fig. 84: Turbocharger Heat Shield, Bolts And Nut
Courtesy of GENERAL MOTORS COMPANY

1. Remove Turbocharger Heat Shield Bolt (1) - [4x]
2. Remove Turbocharger Heat Shield Nut (3).
3. Remove Turbocharger Heat Shield (2).
4. Remove Nitrogen Oxides Sensor-Position 1 @Oxidation Catalytic Converter and position aside - **Nitrogen Oxides Sensor Replacement - Position 1**

Installation Procedure

1. Install Nitrogen Oxides Sensor-Position 1 @Oxidation Catalytic Converter - **Nitrogen Oxides Sensor Replacement - Position 1**

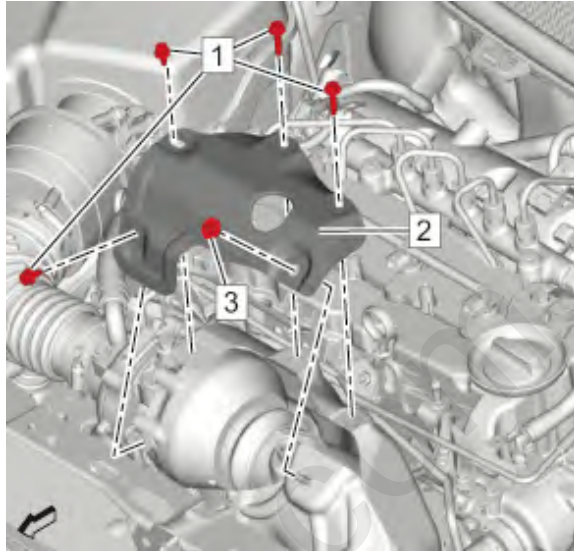


Fig. 85: Turbocharger Heat Shield, Bolts And Nut
Courtesy of GENERAL MOTORS COMPANY

2. Install Turbocharger Heat Shield (2).

CAUTION: **Fastener Caution**

3. Install Turbocharger Heat Shield Nut (3) and tighten 9N.m (80 lb in)
4. Install Turbocharger Heat Shield Bolt (1) and tighten [4x] 9N.m (80 lb in)

EXHAUST MUFFLER HEAT SHIELD REPLACEMENT

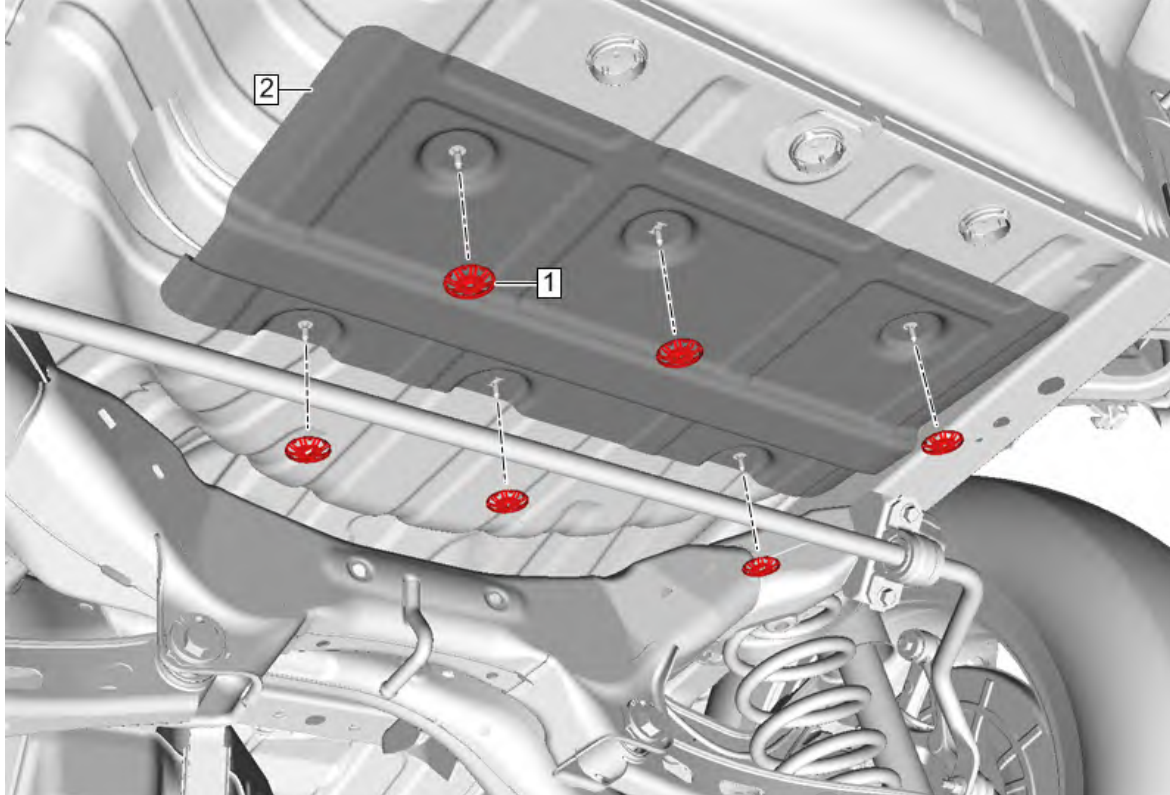


Fig. 86: Exhaust Muffler Heat Shield

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure <u>Exhaust Muffler Replacement (LTG, LYX)Exhaust Muffler Replacement (LH7)</u>	
1	Exhaust Muffler Heat Shield Retainer (Qty: 6) CAUTION: Refer to <u>Fastener Caution</u> . Tighten 1.5 N.m (13 lb in)
2	Exhaust Muffler Heat Shield

EXHAUST REAR UNDERBODY HEAT SHIELD REPLACEMENT (LH7)

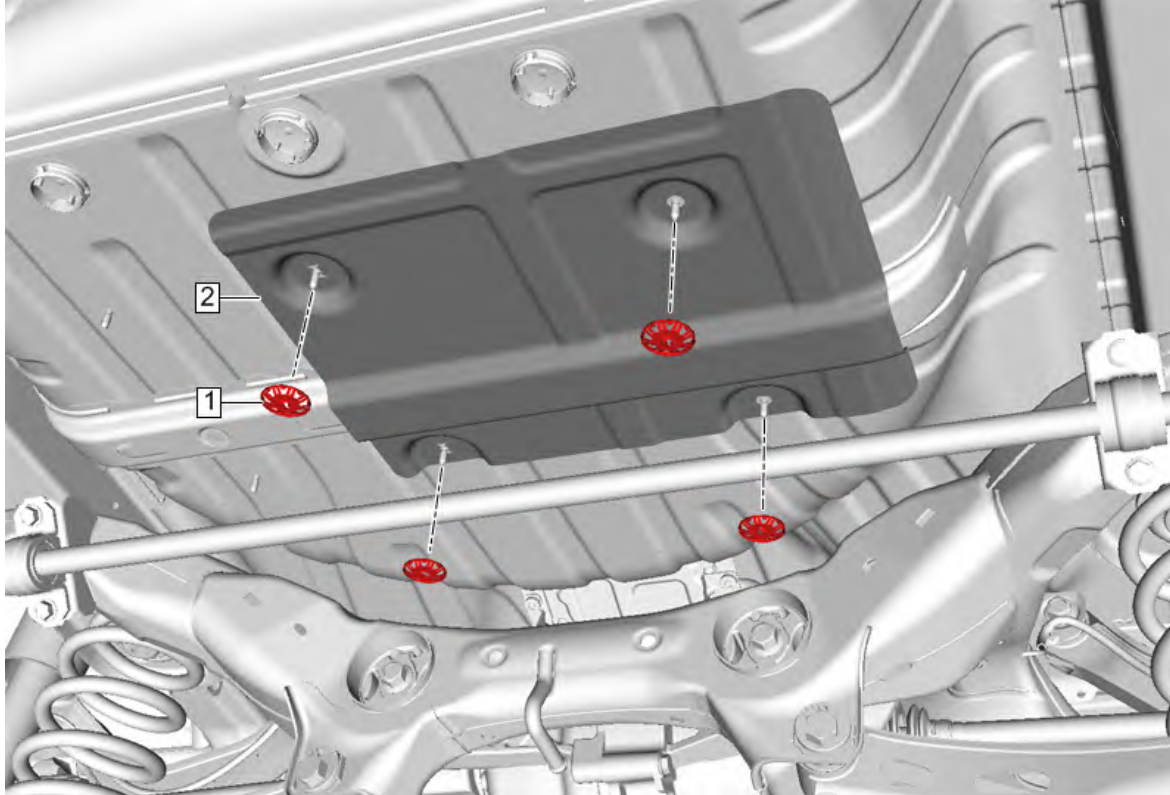


Fig. 87: Exhaust Rear Underbody Heat Shield
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Lifting and Jacking the Vehicle	
1	Exhaust Rear Underbody Heat Shield Retainer (Qty: 4) CAUTION: Refer to Fastener Caution . Tighten 1.5 N.m (13 lb in)
2	Exhaust Rear Underbody Heat Shield

DESCRIPTION AND OPERATION

EXHAUST SYSTEM DESCRIPTION

NOTE: Use of non-OEM parts may cause driveability concerns.

The exhaust system carries exhaust gases, treated by the catalytic converter, through a resonator, if applicable and into the exhaust muffler where exhaust noise is lessened.

In order to secure the exhaust pipe to the exhaust manifold, a flange and seal-joint coupling is utilized. The exhaust system may utilize a slip-joint coupling design with a clamp and a U-bolt or a flange connection with a gasket.

Exhaust hangers and rubber insulators help to support the weight of the exhaust pipe along with insulating any exhaust system vibration, rattle, or noise.

Exhaust hangers also space the exhaust system away from the underbody of the vehicle and allows the exhaust system to expand as the exhaust system warms up.

Exhaust heat shields are used to protect the body and other components from damage due to the heat from the exhaust system.

The exhaust system may be comprised of the following components:

- Exhaust manifold
- Exhaust pipes
- Catalytic converters
- Exhaust muffler
- Exhaust resonator, if equipped
- Exhaust tail pipe, if equipped
- Exhaust hangers
- Exhaust heat shields

Resonator

Some exhaust systems are equipped with a resonator. The resonator, located either before or after the muffler, allows the use of mufflers with less back pressure. Resonators are used when vehicle characteristics require specific exhaust tuning.

Catalytic Converter

The catalytic converter is an emission control device used to reduce hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) pollutants from the exhaust gas.

The catalytic converter is comprised of a ceramic monolith substrate, supported in insulation and housed within a sheet metal shell. The substrate may be washcoated with 3 noble metals:

- Platinum (Pt)
- Palladium (Pd)
- Rhodium (Rh)

The catalyst in the catalytic converter is not serviceable.

Muffler

The exhaust muffler reduces the noise levels of the engine exhaust by the use of tuning tubes. The tuning tubes create channels inside the exhaust muffler that lower the sound levels created by the combustion of the engine.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description

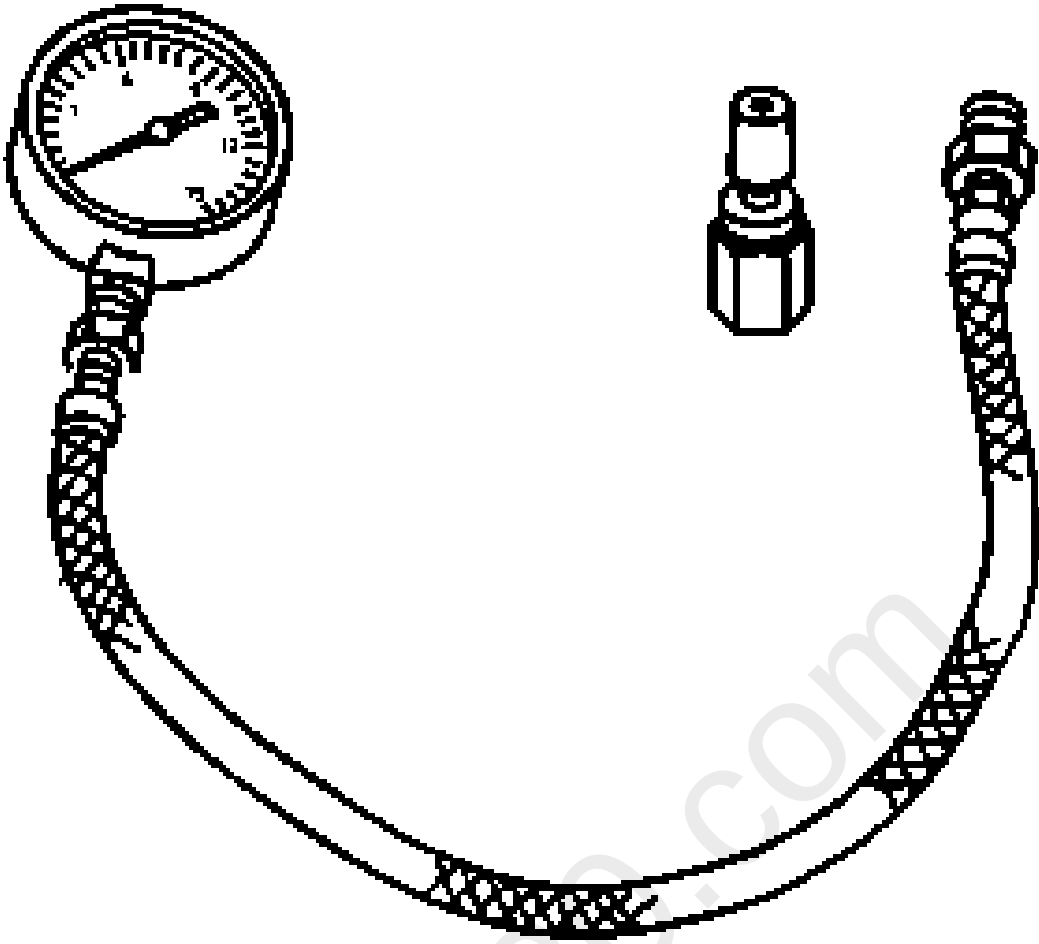
Illustration	Tool Number/Description
	EN-35314-A J-35314-A Exhaust Back Pressure Gauge

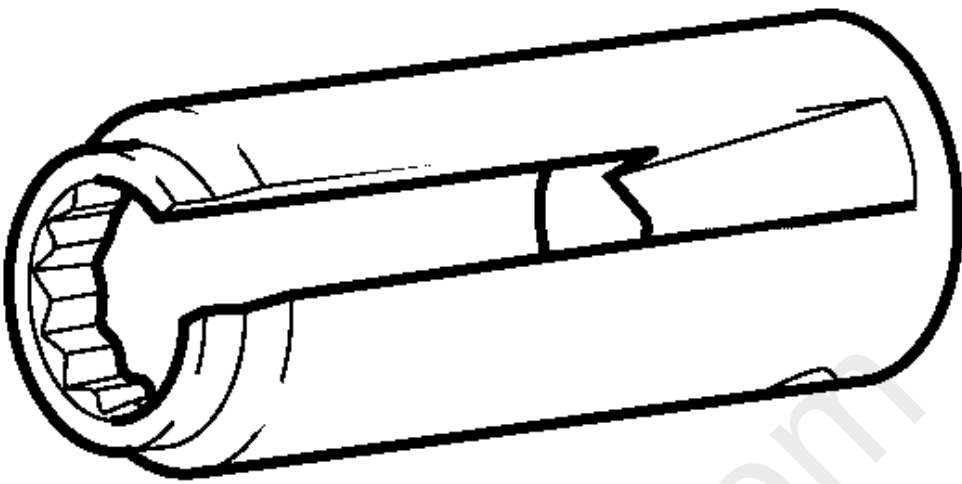
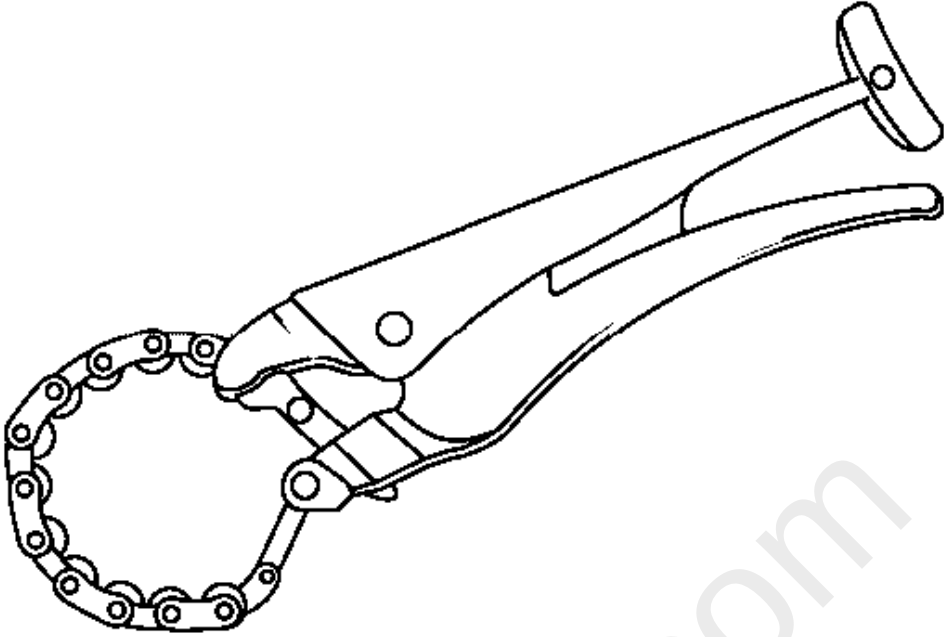
Illustration	Tool Number/Description
	EN-6179 EN-39194 - C KM-6179 J-39174-C EN-44626 J-44626 Heated Oxygen Sensor Remover/Installer

Illustration	Tool Number/Description
	CH-6614 MKM-6614 83 95 667 CH-0006785 3 - 0006785 Chain-type Pipe Cutter

2018 ENGINE**Maintenance And Lubrication - Equinox & Terrain****SPECIFICATIONS****APPROXIMATE FLUID CAPACITIES**

Maintenance Procedure	Link
Automatic Transmission Fluid Capacities - 6T40 (MNH, MNK) or 6T45 (MHG)	Approximate Fluid Capacities
Automatic Transmission Fluid Capacities - 9T45 (M3U) or 9T50 (M3D, M3H)	Approximate Fluid Capacities
Engine Controls and Fuel Capacities - 1.5L (LYX)	Approximate Fluid Capacities
Engine Controls and Fuel Capacities - 2.0 (LTG)	Approximate Fluid Capacities
Engine Heating and Cooling Capacities	Approximate Fluid Capacities
Engine Mechanical - 1.5L (LYX) Capacities	Approximate Fluid Capacities
Engine Mechanical - 1.6L (LH7) Diesel Capacities	Approximate Fluid Capacities
Engine Mechanical - 2.0L (LTG) Capacities	Approximate Fluid Capacities
Heating, Ventilation, and Air Conditioning Capacities	Approximate Fluid Capacities
Hydraulic Brakes Capacities	Approximate Fluid Capacities
Power Transfer Unit/Transfer Case Capacities - AAM	Approximate Fluid Capacities
Rear Drive Axle Capacities	Approximate Fluid Capacities

FLUID AND LUBRICANT RECOMMENDATIONS

Usage	Fluid/Lubricant
Automatic Transmission	DEXRON [®] -VI Automatic Transmission Fluid (GM Part No. 88865601, in Canada 19367328)
Diesel Exhaust After-treatment System	Diesel Exhaust Fluid (GM Part No. 19286291, in Canada 88865751) or diesel exhaust fluid that meets ISO 22241-1 or displays the API Diesel Exhaust Fluid Certification Mark.
Engine Coolant	50/50 mixture of clean, drinkable water and DEX-COOL [®] Coolant (GM Part No. 12346290, in Canada 10953464)
Engine Oil (Diesel)	SAE 5W-30 ACDelco dexos2 (GM Part No. 88865157, in Canada 88865338)
Engine Oil (Gasoline)	For the LYX 1.5L turbo engine, use SAE 0W-20 ACDelco dexos1 gen 2 full synthetic engine oil (GM Part No. 19352900). For the LTG 2.0L turbo engine, use SAE 5W-30 ACDelco dexos1 gen 2 full synthetic engine oil (GM Part No. 19293000, in Canada 19286321). Cold Temperature Operation: In an area of extreme cold, where the temperature falls below -29°C (-20°F), an SAE 0W-30 oil may be used. An oil of this viscosity grade will provide easier cold starting for the engine at extremely low temperatures.
Hood and Door Hinges	Multi-Purpose Lubricant, Superlube (GM Part No. 12346241, in Canada 10953474)
Hood Latch Assembly, Secondary Latch, Pivots, Spring Anchor, and Release Pawl	Lubriplate Lubricant Aerosol (GM Part No. 89021668, in Canada 89021674) or lubricant meeting requirements of NLGI #2, Category LB or GC-LB.

Usage	Fluid/Lubricant
Hydraulic Brake System	DOT 3 Hydraulic Brake Fluid (GM Part No. 19353126, in Canada 19299819)
Transfer Case (All-Wheel Drive)	Transfer Case Fluid (GM Part No. 88900401, in Canada 89021678)
Weatherstrip Conditioning	Weatherstrip Lubricant (GM Part No. 3634770, in Canada 10953518) or equivalent
Windshield Washer	Optikleen Washer Solvent (GM Part No. 1051515, in Canada 10951147)

MAINTENANCE ITEMS

Maintenance Procedure	Link
Approximate Fluid Capacities	Approximate Fluid Capacities
Fluid and Lubricant Recommendations	Fluid and Lubricant Recommendations
Maintenance Replacement Parts	Maintenance Replacement Parts
GM Oil Life System Resetting	GM Oil Life System Resetting (Without Scan Tool) GM Oil Life System Resetting (With Scan Tool)
Tire Rotation	Tire Rotation
Tire Pressure Indicator Sensor Learn	Tire Pressure Indicator Sensor Learn
Passenger Compartment Air Filter Replacement	Passenger Compartment Air Filter Replacement
Brake Pad Inspection	Brake Pad Inspection
Cooling System Draining and Filling	Cooling System Draining and Filling (GE 47716) Cooling System Draining and Filling (Static)
Hydraulic Brake System Bleeding	Hydraulic Brake System Bleeding (Manual) Hydraulic Brake System Bleeding (Pressure)
Air Cleaner Element Replacement - 1.5L (LYX)	Air Cleaner Element Replacement
Air Cleaner Element Replacement - 1.6L (LH7) Diesel	Air Cleaner Element Replacement
Air Cleaner Element Replacement - 2.0L (LTG)	Air Cleaner Element Replacement
Spark Plug Replacement - 1.5L (LYX)	Spark Plug Replacement
Spark Plug Replacement - 2.0L (LTG)	Spark Plug Replacement
Drive Belt Replacement - 1.5L (LYX)	Drive Belt Replacement
Drive Belt Replacement - 2.0L (LTG)	Drive Belt Replacement
Automatic Transmission Fluid Drain and Fill - 6T45 (MHG) or 6T50 (M2D)	Transmission Fluid Drain and Fill
Automatic Transmission Fluid Drain and Fill - 9T45 (M3U) or 9T50 (M3D, MEH)	Transmission Fluid Drain and Fill

MAINTENANCE REPLACEMENT PARTS

Replacement parts identified below by name, part number, or specification can be obtained from your dealer.

Part	GM Part Number	ACDelco Part Number
Engine Air Cleaner/Filter	23279657	A3226C
Engine Oil Filter		
• 1.5L L4 Gas Engine	12640445	PF64
• 1.6L L4 Diesel Engine	55588497	PF2264G

Part	GM Part Number	ACDelco Part Number
2.0L L4 Gas Engine	12640445	PF64
Fuel Filter		
1.6L L4 Diesel Engine	84186990	TP1016
Passenger Compartment Air Filter	13508023	CF185
Spark Plugs		
1.5L L4 Gas Engine	12673527	41 - 153
2.0L L4 Gas Engine	12647827	41 - 125
Wiper Blades		
Driver Side - 60.0 cm (23.6 in)	23368186	-
Passenger Side - 45.0 cm (17.7 in)	23353587	-
Rear - 30.0 cm (11.8 in)	84215609	-

MAINTENANCE

MAINTENANCE SCHEDULE

The Maintenance Schedule information will only be found in the Owner's Manual.

Refer to the Maintenance Schedule subsection of the Owner's Manual, or you may be able to use the search information function using the words Scheduled Maintenance.

GM OIL LIFE SYSTEM RESETTNG (WITHOUT SCAN TOOL)

When to Change Engine Oil

This vehicle has a computer system that indicates when to change the engine oil and filter. This is based on engine revolutions and engine temperature, and not on mileage. Based on driving conditions, the mileage at which an oil change is indicated can vary considerably. For the oil life system to work properly, the system must be reset every time the oil is changed.

On some vehicles, when the system has calculated that oil life has been diminished, a CHANGE ENGINE OIL SOON message comes on to indicate that an oil change is necessary. Change the oil as soon as possible within the next 1000 km (600 miles). It is possible that, if driving under the best conditions, the oil life system might not indicate that an oil change is necessary for over a year. However, the engine oil and filter must be changed at least once a year and at this time the system must be reset. For vehicles without the CHANGE ENGINE OIL SOON message, an oil change is needed when the OIL LIFE REMAINING percentage is near 0 percent. Your dealer has trained service people who will perform this work using genuine parts and reset the system. It is also important to check the oil regularly and keep it at the proper level.

If the system is ever reset accidentally, the oil must be changed at 5000 km (3, 000 miles) since the last oil change. Remember to reset the oil life system whenever the oil is changed.

How to Reset the Engine Oil Life System

The Engine Oil Life System calculates when to change the engine oil and filter based on vehicle use. Whenever the oil is changed, reset the system so it can calculate when the next oil change is required. If

a situation occurs where the oil is changed prior to a CHANGE ENGINE OIL SOON message coming on, reset the system.

If the vehicle does not have Driver Information Center (DIC) buttons:

1. Turn the ignition to ON/RUN, with the engine off. The vehicle must be in P (Park) to access this display. Press the trip odometer reset stem until OIL LIFE REMAINING displays.
2. Press and hold the trip odometer reset stem until OIL LIFE REMAINING shows "100%". Three chimes sound and the CHANGE ENGINE OIL SOON message goes off.
3. Turn the key to LOCK/OFF.

If the CHANGE ENGINE OIL SOON message comes back on when the vehicle is started, the engine oil life system has not reset. Repeat the procedure.

If the vehicle has Driver Information Center (DIC) buttons:

1. Turn the ignition to ON/RUN, with the engine off.
2. Press the vehicle information button until OIL LIFE REMAINING displays.
3. Press and hold the set/reset button until "100%" is displayed. Three chimes sound and the CHANGE ENGINE OIL SOON message goes off.
4. Turn the key to LOCK/OFF.

If the CHANGE ENGINE OIL SOON message comes back on when the vehicle is started, the Engine Oil Life System has not reset. Repeat the procedure.

GM OIL LIFE SYSTEM RESETTING (WITH SCAN TOOL)

When the system has calculated that oil life has been diminished, it will indicate that an oil change is necessary. A ENGINE OIL light message will come on. Change the engine oil as soon as possible within the next 600 miles (1000 km). It is possible that, if driving under the best conditions, the oil life system may not indicate that an oil change is necessary for over a year. However, the engine oil and filter must be changed at least once a year and at this time the system must be reset.

(If applicable) With Scan Tool

1. Ignition - On/Vehicle - In Service Mode
2. Select: Module Diagnostics
3. Select: K20 Engine Control Module
4. Select: Configuration/Reset Functions
5. Select: Reset Functions
6. Select: Engine Oil Life Reset
7. Enter the desired value
8. Select: Continue

GM FUEL FILTER LIFE SYSTEM RESETTING (LH7)

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](#)

Description

This procedure resets the control module learned values of the component/system: Fuel Filter

When to Perform the Procedure

Perform this procedure when the following component has been serviced:

- K20 Engine Control Module - Replaced

- Fuel Filter - Replaced

Conditions for Running the Procedure

Ignition = Run/Crank

Reference Information

Scan Tool Reference

Control Module References

With Scan Tool

1. Ignition - On/Vehicle - In Service Mode
2. Select: Module Diagnostics
3. Select: Engine Control Module
4. Select: Configuration/Reset Functions
5. Select: Reset Functions
6. Select: Fuel Filter Life Reset
7. Follow the instructions on the scan tool.

Without Scan Tool

1. Ignition - On/Vehicle - In Service Mode
2. Transmission in Park

NOTE: **The Fuel Filter Life will only display on the DIC if the Ignition is On, the vehicle is in Service Mode, and the gear selector is in Park.**

3. Display the Fuel Filter Life Remaining on the DIC. If the vehicle does not have DIC buttons, use the trip odometer reset stem.
4. Press and hold the SET/RESET button on the DIC, or the trip odometer reset stem if the vehicle does not have DIC buttons, for more than two seconds. The Fuel Filter Life Remaining will change to 100 percent.
5. Verify the procedure was successful.
 - **If the procedure was not successful**
Refer to: Step 1
 - **Go to next step: If the procedure was successful**
6. All OK.

Repair Instructions

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