

2021 ENGINE

Engine Mechanical - 2.8L (LWN) Diesel - Canyon, Colorado

SPECIFICATIONS

FASTENER SPECIFICATIONS

Single Use Non-Threaded Fasteners/Components

NOTE:

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

Application
Camshaft Plug
Camshaft Position Sensor Seal
Connecting Rod Bearing
Crankshaft Rear Oil Seal
Engine Coolant Thermostat Gasket
Engine Front Cover Gasket
Exhaust Gas Recirculation Cooler Gasket
Exhaust Gas Recirculation Pipe Gasket
Exhaust Gas Recirculation Manifold Gasket
Exhaust Manifold Gasket
Intake Manifold Gasket
Fuel Injector Combustion Seals
Fuel Injector Feed Pipe
Fuel Injection Fuel Return Hose Clip
Oil Filter Adapter Pipe Seal
Oil Level Indicator Tube Seal
Thermostat Bypass Hose Clamps
Throttle Body Gasket
Turbocharger Coolant Feed Pipe Gasket
Turbocharger Gasket
Turbocharger Oil Feed Gaskets
Turbocharger Oil Return Pipe Gasket
Valve Rocker Arm Cover Gasket
Valve Rocker Arm Cover Grommets
Valve Seals
Water Pump Inlet Pipe Seal

Single Use Threaded Fastener/Component Tightening Specifications

NOTE:

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

Application	Specification
	Metric (English)
Automatic Transmission Flex Plate Bolt	
• First Pass	50 N.m (37 lb ft)
• Second Pass	Loosen 90 degrees.
• Third Pass	25 N.m (18 lb ft)
• Final Pass	60 degrees
Connecting Rod Bolt	
• First Pass	30 N.m (22 lb ft)
• Final Pass	40 degrees
Crankshaft Bearing Cap Bolt	
• First Pass	50 N.m (37 lb ft)
• Final Pass	90 degrees
Crankshaft Sprocket Bolt	
• First Pass	100 N.m (74 lb ft)
• Final Pass	120 degrees
Cylinder Head Bolt - For NEW design cylinder head bolts that have captured washers	
• First Pass	30 N.m (22 lb ft)
• Second, Third, and Final Pass	110 degrees each pass, 330 degrees total
Cylinder Head Bolt - For OLD design cylinder head bolts that do NOT have captured washers	
• First Pass	30 N.m (22 lb ft)
• Second, Third, and Final Pass	85 degrees each pass, 255 degrees total
Engine Flywheel Bolt	
• First Pass	50 N.m (37 lb ft)
• Second Pass	Loosen 90 degrees.

NOTE:

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

Application	Specification
	Metric (English)
• Third Pass	25 N.m (18 lb ft)
• Final Pass	Tighten 60 degrees
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange
Lower Oil Pan Bolt	13 N.m (10 lb ft)

Reusable Threaded Fastener Tightening Specifications

NOTE:

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

Application	Specification
	Metric (English)
Air Conditioning (A/C) Compressor Bolt	25 N.m (18 lb ft)
Air Conditioning (A/C) Compressor Bracket Bolt	45 N.m (33 lb ft)
Balance Bolts	32 N.m (24 lb ft)
Balance Shaft Tube Bolts	10 N.m (89 lb in)
Ball Head Nut	5 N.m (44 lb in)
Camshaft Bearing Cap Bolt	11 N.m (97 lb in)
Camshaft Bearing Front Cap Bolt	11 N.m (97 lb in)
Camshaft Position (CMP) Sensor	11 N.m (97 lb in)
Camshaft Timing Pulley Bolt	
• First Pass	20 N.m (15 lb ft)
• Final Pass	60 degrees
Crankshaft Balancer Bolt	32 N.m (24 lb ft)
Crankshaft Position Sensor Bolt	5 N.m (44 lb in)
Crankshaft Position Sensor Bolt [2x]	15 N.m (11 lb ft)
Crankshaft Rear Oil Seal Housing Bolt	15 N.m (11 lb ft)
Cylinder Head Core Hole Plug	60 N.m (44 lb ft)
Direct Fuel Injection Fuel Rail Bolts	25 N.m (18 lb ft)
Drive Belt Tensioner	45 N.m (33 lb ft)
Engine Block Oil Gallery Plug	60 N.m (44 lb ft)
Engine Coolant Fan Bracket Bolt	45 N.m (33 lb ft)
Engine Coolant Temperature Sensor	15 N.m (11 lb ft)

NOTE:

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

Application	Specification
	Metric (English)
Engine Front Cover - Engine Front Cover to Engine Block	32 N.m (24 lb ft)
Engine Front Cover - Upper Oil Pan to Engine Front Cover	15 N.m (11 lb ft)
Engine Front Cover Hole Plug	40 N.m (30 lb ft)
Engine Mount Bolt- Left Side	70 N.m (52 lb ft)
Engine Mount Bolt- Right Side	
• First Pass:	85 N.m (63 lb ft)
• Final Pass:	45-60 degrees
Engine Mount Bracket Bolts - Left Side	100 N.m (74 lb ft)
Engine Mount Bracket Bolts - Right Side	
• First Pass:	85 N.m (63 lb ft)
• Final Pass:	45-60 degrees
Engine Oil Cooler Housing Bolt	10.8 N.m (96 lb in)
Engine Oil Cooler Inlet Pipe Bolt	15 N.m (11 lb ft)
Engine Oil Pressure Switch	35 N.m (26 lb ft)
Exhaust Gas Recirculation (EGR) Bracket Nut	10 N.m (89 lb in)
Exhaust Gas Recirculation (EGR) Cooler Bolt	15 N.m (11 lb ft)
Exhaust Gas Recirculation (EGR) Manifold Brace Bolt	58 N.m (43 lb ft)
Exhaust Gas Recirculation (EGR) Manifold Pipe Bolt - Short	11 N.m (97 lb in)
Exhaust Gas Recirculation (EGR) Manifold Pipe Bolt - Long	25 N.m (18 lb ft)
Exhaust Gas Recirculation (EGR) Valve Adapter Nut	25 N.m (18 lb ft)
Exhaust Gas Recirculation (EGR) Valve Bolt	9 N.m (80 lb in)
Exhaust Manifold Heat Shield Bolt	10 N.m (89 lb in)
Exhaust Manifold Nut	36 N.m (27 lb ft)
Exhaust Manifold Stud	32 N.m (24 lb ft)
Fuel Feed and Return Pipe Clip Bracket Bolt	12 N.m (106 lb in)
Fuel Feed Pipe	30 N.m (22 lb ft)
Fuel Return Pipe Bolt	5 N.m (44 lb in)
Fuel Injection Pump Drive Pulley Nut	88 N.m (65 lb ft)
Fuel Pump Bolt	25 N.m (18 lb ft)
Fuel Pump Nut	25 N.m (18 lb ft)
Fuel Injector Bracket Bolt	32 N.m (24 lb ft)
Fuel Injector Fuel Feed Pipes	30 N.m (22 lb ft)
Generator Bolt	33 N.m (24 lb ft)
Generator Bracket Bolt	45 N.m (33 lb ft)
Glow Plug	14 N.m (124 lb in)

NOTE:

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

Application	Specification
	Metric (English)
Heater Bracket Bolt	25 N.m (18 lb ft)
Intake Manifold Nut	12 N.m (106 lb in)
Intake Manifold Tuning Valve Vacuum Control Valve Bolt	7 N.m (62 lb in)
Map Sensor Bolt	9 N.m (80 lb in)
Oil Cooler Bolt	25 N.m (18 lb ft)
Oil Filter Adapter Bolt	10 N.m (89 lb in)
Oil Filter Cap	25 N.m (18 lb ft)
Oil Filter Cap Plug	4 N.m (35 lb in)
Oil Level Indicator Tube Bolt - Bolt	11 N.m (97 lb in)
Oil Level Indicator Tube Bolt - Stud	11 N.m (97 lb in)
Oil Level Switch Bolts [2x]	9 N.m (80 lb in)
Oil Pan Baffle	32 N.m (24 lb ft)
Oil Pan Deadener Bolt	10 N.m (89 lb in)
Oil Pan Drain Plug	25 N.m (18 lb ft)
Oil Pressure Relief Valve	40 N.m (30 lb ft)
Oil Pump Bolt	10 N.m (89 lb in)
Oil Pump Pressure Relief Valve Housing Bolt	15 N.m (11 lb ft)
Oil Pump Cover Bypass Hole Plug	35 N.m (26 lb ft)
Oil Pump Suction Pipe Bolt	15 N.m (11 lb ft)
Piston Oil Nozzle Bolt	11 N.m (97 lb in)
Power Steering Pump Bolt	25 N.m (18 lb ft)
Power Steering Pump Pulley	33 N.m (24 lb ft)
Throttle Body Bolt	11 N.m (97 lb in)
Timing Belt Rear Cover Bolt	11 N.m (97 lb in)
Timing Belt Front Cover Bolt - Upper	8 N.m (71 lb in)
Timing Belt Front Cover Bolt - Lower	10 N.m (89 lb in)
Timing Belt Tensioner Bolt	28 N.m (21 lb ft)
Transmission Adapter Bolt - Allen	69 N.m (51 lb ft)
Transmission Adapter Bolt - Hex	15 N.m (11 lb ft)
Transmission Adapter Plate Bolt - Allen	79 N.m (58 lb ft)
Transmission Adapter Plate Bolt - Hex	45 N.m (33 lb ft)
Turbocharger Brace Bolt	32 N.m (24 lb ft)
Turbocharger Nut	32 N.m (24 lb ft)
Turbocharger Coolant Feed Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Coolant Return Pipe Bolt	35 N.m (26 lb ft)
Turbocharger Oil Feed Pipe - at Engine Block	25 N.m (18 lb ft)
Turbocharger Oil Feed Line Pipe - at Turbocharger	25 N.m (18 lb ft)
Turbocharger Oil Feed Pipe Fitting Adapter	54 N.m (40 lb ft)
Turbocharger Oil Return Pipe Bolt	10 N.m (89 lb in)
Upper Oil Pan Bolt - M6	
• First Pass	15 N.m (11 lb ft)

NOTE:

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

Application	Specification
	Metric (English)
Second Pass	Loosen 90 degrees.
Final Pass	15 N.m (11 lb ft)
Upper Oil Pan Bolt - M8	
First Pass	32 N.m (24 lb ft)
Second Pass	Loosen 90 degrees.
Final Pass	32 N.m (24 lb ft)
Upper Oil Pan Hole Plug	40 N.m (30 lb ft)
Vacuum Pump Cover Bolt	6 N.m (53 lb in)
Vacuum Pump Hose Connector	13 N.m (10 lb ft)
Vacuum Pump Nut	11 N.m (97 lb in)
Valve Rocker Arm Cover Bolt	11 N.m (97 lb in)
Valve Rocker Arm Cover Stud	11 N.m (97 lb in)
Water Pump Bolt	32 N.m (24 lb ft)
Water Pump Drain Plug	20 N.m (15 lb ft)
Water Return Pipe Bolt	15 N.m (11 lb ft)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
2.8L (LWN) Diesel		
Oil Capacity - with Filter	5.6 Liters	6.0 Quarts

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.8 Liter	171 cu in
• RPO	LWN	
• Bore	94 mm	3.7008 in
• Stroke	100.05 mm	3.9390 in
• Compression Ratio	16.5:1	
• Maximum compression pressure variation between 2 cylinders	500 KPa	72.5 psi
• Idle Speed	760 RPM (ATX) 875 RPM (MTX)	
• Firing Order	1-3-4-2	
Block		
• Cylinder Bore Internal Diameter	94 mm	3.700 in
• Cylinder Bore Out-of-Round	0.007 mm	0.0003 in
• Cylinder Head Deck Surface Flatness - Flatness/Span	0.02 mm/75 mm 0.03 mm/106 mm 0.1 mm/400 mm	0.0008 in/2.95 in 0.0012 in/4.17 in 0.0039 in/15.75 in
Camshaft		
• Camshaft End Play - Maximum	0.350 mm	0.013 in
• Camshaft End Play - Minimum	0.150 mm	0.006 in
• Camshaft Inner Journal Diameter - at Cylinder Head	26.000 - 26.015 mm	1.027 - 1.033 in
• Camshaft Journal Clearance	0.03 - 0.075 mm	0.001 - 0.003 in
• Camshaft Lobe Lift - Exhaust - Production	4.5 mm	0.177 in
• Camshaft Lobe Lift - Intake - Production	4.5 mm	0.177 in
• Camshaft Outer Journal Diameter - at Crankshaft	25.95 mm	1.021 in
Connecting Rod		
• Connecting Rod Diameter - Large End	57.563 mm	2.266 in
• Connecting Rod Diameter - Small End	32 mm	1.26 in

Application	Specification	
	Metric	English
Cooling System		
• Thermostat Opening Temperature	80B°C	176B°F
Crankshaft		
• Crankshaft End Play	0.10 - 0.33 mm	0.004 - 0.013 in
• Crankshaft Journal Clearance - Maximum	0.075 mm	0.003 in
• Crankshaft Journal Clearance - Minimum	0.030 mm	0.0012 in
• Crankshaft Main Journal Diameter - Production	65 mm	2.559 in
Cylinder Head		
• Cylinder Head Height	135.5 mm	5.334 in
• Surface Flatness - Deformation Tolerance - Flatness/Span	0.05 mm/15 mm 0.075 mm Total	0.0019 in/0.59 in 0.0030 in Total
Exhaust Manifold		
• Surface Flatness - Deformation Tolerance	0.075 mm	0.0030 in
Intake Manifold		
• Surface Flatness - Deformation Tolerance	0.075 mm	0.0030 in
Lubrication System		
• Oil Capacity - with Filter	6.0 qt	5.7 L
• Oil Pressure - Minimum - Warm - at idle	70 KPa	10 psi
• Oil Pressure - Minimum - 3800 RPM	250 KPa	36 psi
• Oil Relief Valve Opening Pressure	500 KPa	72.5 psi
Oil Pump		
• Oil Pump Inner Rotor End Play - Maximum	0.01 mm	0.0004 in
• Oil Pump Inner Rotor End Play - Minimum	0.09 mm	0.0036 in
• Oil Pump Outer Rotor End Play - Maximum	0.09 mm	0.0036 in
• Oil Pump Outer Rotor End Play - Minimum	0.01 mm	0.0004 in
• Oil Pump Outer Rotor to Body Diameter Clearance - Maximum	0.130 mm	0.0051 in
• Oil Pump Outer Rotor to Body Diameter Clearance - Minimum	0.230 mm	0.0091 in

Application	Specification	
	Metric	English
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.25 - 0.65 mm	0.0098 - 0.0256 in
• Piston Ring End Gap - Second Compression Ring	0.30 - 0.45 mm	0.0118 - 0.0177 in
• Piston Ring End Gap - Oil Control Ring	0.25 - 0.50 mm	0.0098 - 0.0196 in
• Piston Ring to Groove Clearance - First Compression Ring	0.080 - 0.13 mm	0.0031 - 0.0051 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.070 - 0.110 mm	0.0027 - 0.0043 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.040 - 0.080 mm	0.0015 - 0.0031 in
Pistons and Pins		
• Piston Diameter - Production (as measured 39 mm from bottom of piston)	93.793 - 93.807 mm	3.6926 - 3.6932 in
• Piston Pin to Bore Clearance - Production	0.015 mm	0.0006 in
• Piston Pin Diameter	32 mm	1.26 in
• Piston Pin Length	70.7 - 71.0 mm	2.78 - 2.79 in
Valve System		
• Valve Face Angle	45 degrees 30'	
• Valve Head Diameter - Exhaust	29.4 mm	1.15 in
• Valve Head Diameter - Intake	32.0 mm	1.25 in
• Valve Lifters Diameter	11.994 mm	0.472 in
• Valve Seat Angle	45 degrees	
• Valve Seat Runout	0.6 mm	0.024 in
• Valve Seat Width - Exhaust	1.5 - 1.75mm	0.059 - 0.069 in
• Valve Seat Width - Intake	1.5 - 1.75mm	0.059 - 0.069 in
• Valve Spring Free Length	50.8 mm	2.00 in
• Valve Spring Installed Height - Closed Valve	38 mm	1.49 in
• Valve Spring Installed Height - Open Valve	29 mm	1.14 in

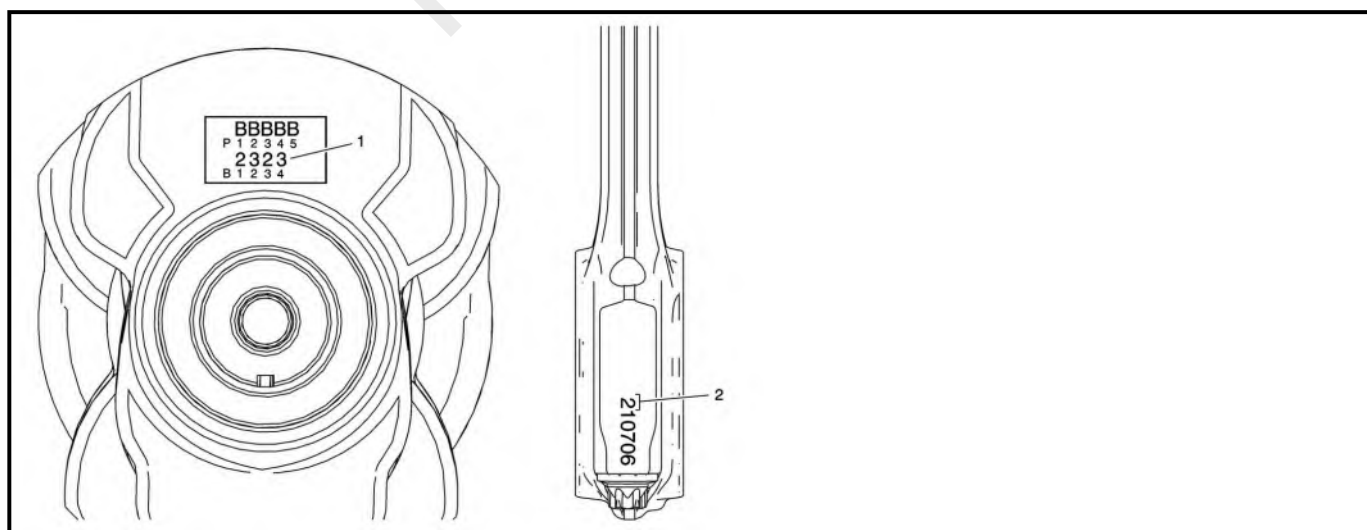
Application	Specification	
	Metric	English
• Valve Stem Diameter - Exhaust	5.96 mm	0.235 in
• Valve Stem Diameter - Intake	5.97 mm	0.235 in
• Valve Stem-to-Guide Clearance - Exhaust	0.040 - 0.070 mm	0.0016 - 0.0028 in
• Valve Stem-to-Guide Clearance - Intake	0.030 - 0.060 mm	0.0012 - 0.0024 in

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Bearing Front Cap	Sealant	1052943	-
Connecting Rod Bearing	Engine Oil	-	-
Cylinder Head Plug	Sealant	12345382	10953489
Fuel Injection Pump O-ring	Engine Oil	-	-
Fuel Injector	Cleaner	1052626	-
Lower Oil pan	Sealant	9273154	-
Engine Front Cover Hole Plug	Sealant	12345382	10953489
Parts Immersion Solvent	Cleaner	12345368	10953514
Piston	Engine Oil	-	-
Piston Ring	Engine Oil	-	-
Upper Oil Pan to Front and Rear Covers *	Sealant	19369831	19369832
Valve Rocker Arm Cover *	Sealant	19369831	19369832
Water Pump Drain Plug *	Sealant	12346004	10953480
* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant			

CONNECTING ROD BEARINGS SELECTION SPECIFICATIONS

Connecting Rod Bearings Selection Identification

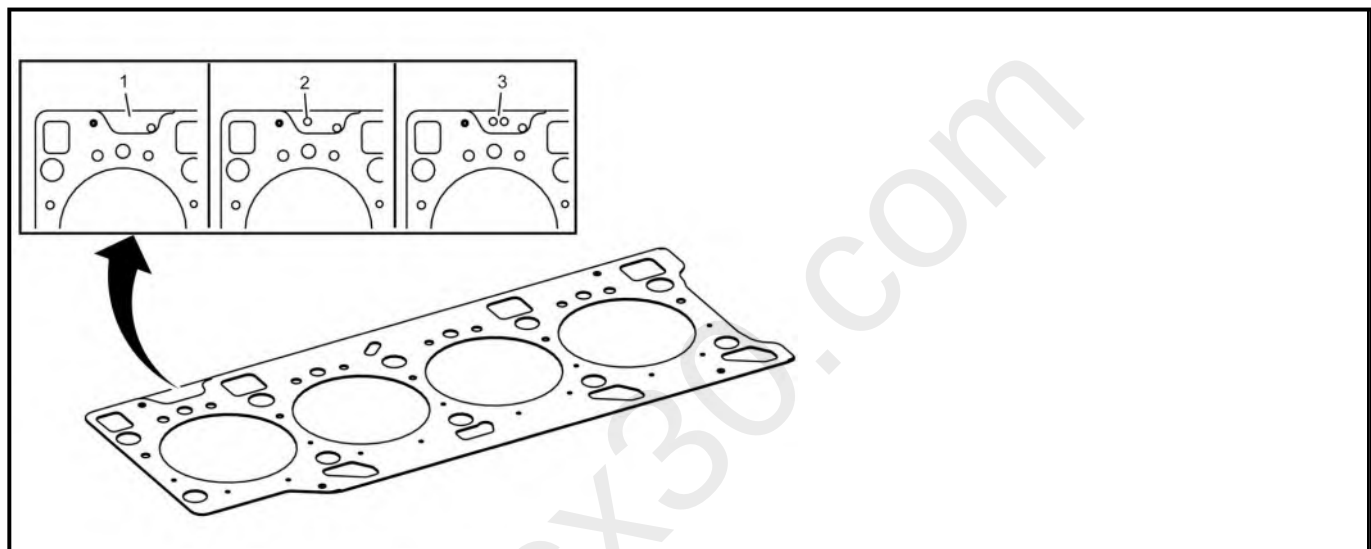


Callout	Component Name
1	Bearing Grade Specification
2	Connecting Rod Bore Specification

Connecting Rod Large End Bore Diameter	Bearing	Crankshaft Pin Diameter			
		4	3	2	1
		53.929 - 53.936	53.936 - 53.942	53.942 - 53.948	53.948 - 53.955
		Use This Bearing Color			
1 57.563 - 57.568	Upper Bearing	Blue	Blue	Red	Red
	Lower Bearing	Yellow	Blue	Blue	Red
2 57.568 - 57.573	Upper Bearing	Yellow	Blue	Blue	Red
	Lower Bearing	Yellow	Yellow	Blue	Blue
3 57.573 - 57.578	Upper Bearing	Yellow	Yellow	Blue	Blue
	Lower Bearing	Green	Yellow	Yellow	Blue
4 57.578 - 57.583	Upper Bearing	Green	Yellow	Yellow	Blue
	Lower Bearing	Green	Green	Yellow	Yellow

CYLINDER HEAD GASKET SELECTION SPECIFICATIONS

Cylinder Head Gasket Selection Specifications



Callout	Component Name
1	Grade A
2	Grade B
3	Grade C

Cylinder Head Gasket Thickness

Cylinder Head Gasket Grade	Specification	
	Metric	English
Grade A	1.10 mm	0.043 in
Grade B	1.20 mm	0.047 in
Grade C	1.30 mm	0.051 in

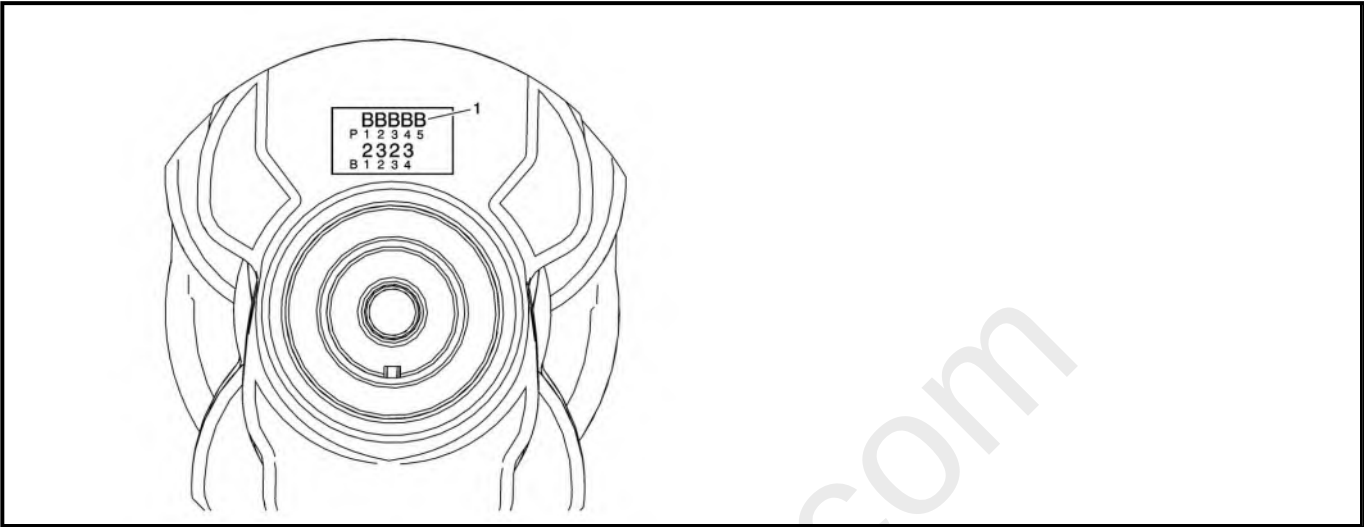
Cylinder Head Gasket Selection

Application	Specification	
	Metric	English
Distance from Piston at TDC to Cylinder Block Cylinder Head Gasket Thickness Piston Clearance	0.300 - 0.399 mm	0.0119 - 0.0158 in
	1.10 mm	0.0434 in
	0.701 - 0.800 mm	0.0276 - 0.0315 in
Distance from Piston at TDC to Cylinder Block Cylinder Head Gasket Thickness Piston Clearance	0.400 - 0.499 mm	0.0158 - 0.0197 in
	1.20 mm	0.0473 in

Application	Specification	
	Metric	English
Distance from Piston at TDC to Cylinder Block Cylinder Head Gasket Thickness Piston Clearance	0.701 - 0.800 mm	0.0276 - 0.0315 in
	0.500 - 0.600 mm	0.0197 - 0.0237 in
	1.30 mm	0.512 in
	0.701 - 0.800 mm	0.0276 - 0.0315 in

CRANKSHAFT BEARING SELECTION SPECIFICATIONS

Crankshaft Bearing Identification



Callout	Component Name
1	Bearing Grade Specification

Cylinder Block Seat Diameter	Bearing	Crankshaft Main Journal Diameter			
		D	C	B	A
		Use This Bearing Color			
A 64.993 - 65.000	Upper Bearing	Blue	Blue	Red	Red
	Lower Bearing	Yellow	Blue	Blue	Red
B 64.987 - 64.993	Upper Bearing	Yellow	Blue	Blue	Red
	Lower Bearing	Yellow	Yellow	Blue	Blue
C 64.981 - 64.987	Upper Bearing	Yellow	Yellow	Blue	Blue
	Lower Bearing	Green	Yellow	Yellow	Blue
D 64.974 - 64.981	Upper Bearing	Green	Yellow	Yellow	Blue
	Lower Bearing	Green	Green	Yellow	Yellow

DISASSEMBLED VIEWS

ENGINE ACCESSORY COMPONENTS

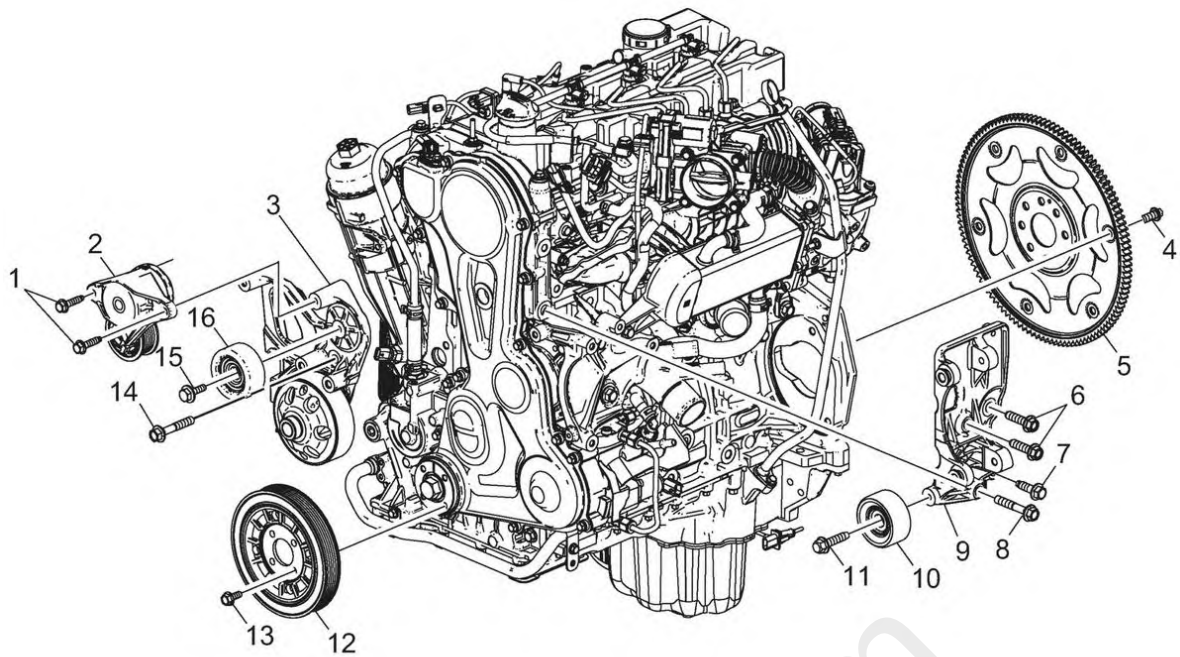


Fig. 1: Exploded View Of Engine Accessory Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt Tensioner Bolt [2x]
2	Drive Belt Tensioner
3	Engine Coolant Fan Bracket
4	Automatic Transmission Flex Plate Bolt [8x]
5	Automatic Transmission Flex Plate
6	Generator Bracket Bolt [2x]
7	Generator Bracket Bolt
8	Generator Bracket Bolt
9	Generator Bracket
10	Drive Belt Idler Pulley
11	Drive Belt Idler Pulley Bolt
12	Crankshaft Balancer
13	Crankshaft Balancer Bolt
14	Engine Coolant Fan Bracket Bolt
15	Drive Belt Idler Pulley Bolt
16	Drive Belt Idler Pulley

EXHAUST GAS RECIRCULATION (EGR) COMPONENTS

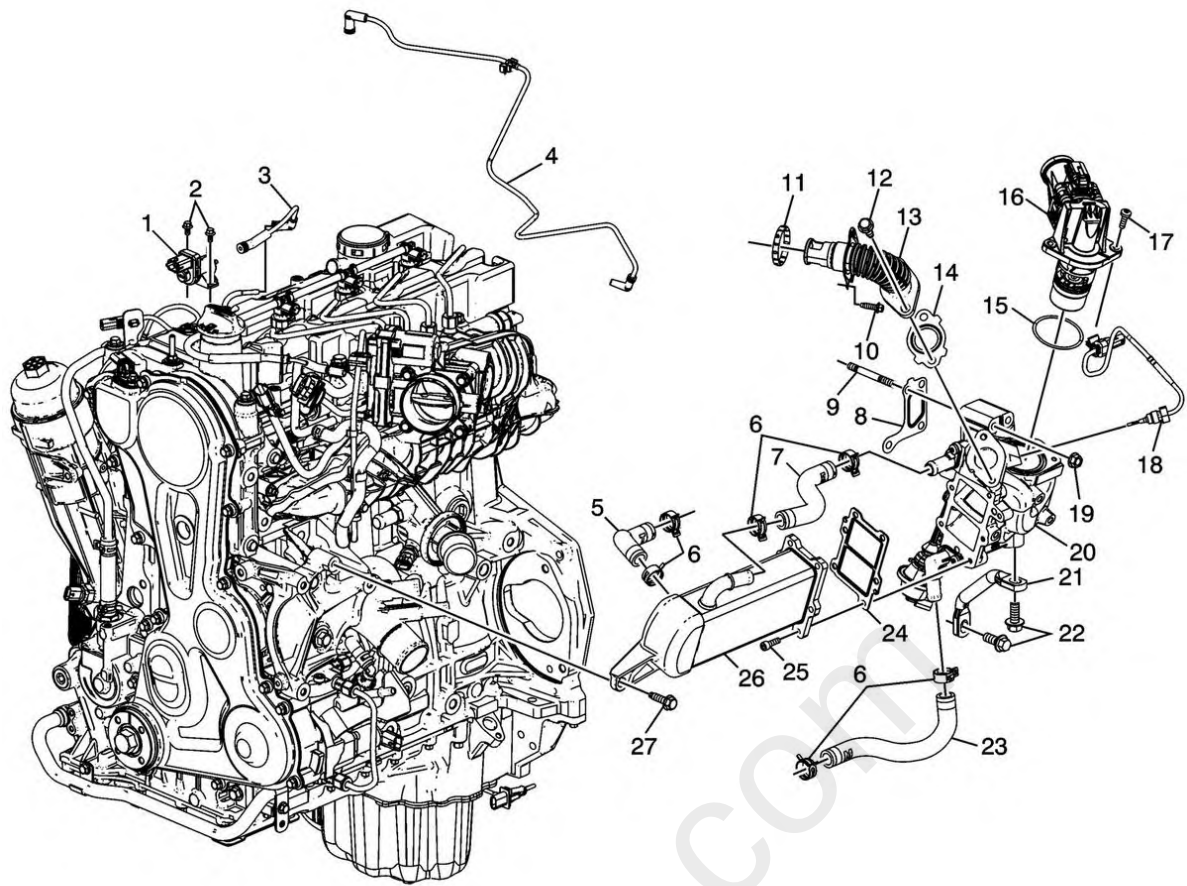


Fig. 2: Exploded View Of Exhaust Gas Recirculation Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Tuning Vacuum Control Solenoid Valve
2	Intake Manifold Tuning Vacuum Control Solenoid Valve Bolt [2x]
3	Exhaust Gas Recirculation Valve Vacuum Pipe
4	Exhaust Gas Recirculation Valve Vacuum Pipe
5	Exhaust Gas Recirculation Manifold Cooling Feed Hose
6	Thermostat Bypass Hose Clamp
7	Exhaust Gas Recirculation Manifold Cooling Feed Hose
8	Exhaust Gas Recirculation Manifold Gasket
9	Exhaust Gas Recirculation Valve Adapter Stud [4x]
10	Exhaust Gas Recirculation Pipe Bolt [2x]
11	Exhaust Gas Recirculation Pipe Gasket
12	Exhaust Gas Recirculation Pipe Bolt [2x]
13	Exhaust Gas Recirculation Pipe
14	Exhaust Gas Recirculation Pipe Gasket
15	Exhaust Gas Recirculation Valve Seal
16	Exhaust Gas Recirculation Valve
17	Exhaust Gas Recirculation Valve Bolt
18	Exhaust Gas Recirculation Valve Temperature Sensor
19	Exhaust Gas Recirculation Valve Adapter Nut
20	Exhaust Gas Recirculation Valve Machined Housing

Callout	Component Name
21	Exhaust Gas Recirculation Manifold Brace
22	Exhaust Gas Recirculation Manifold Brace Bolt [2x]
23	Exhaust Gas Recirculation Manifold Cooling Return Hose
24	Exhaust Gas Recirculation Cooler Gasket
25	Exhaust Gas Recirculation Cooler Bolt [6x]
26	Exhaust Gas Recirculation Cooler
27	Exhaust Gas Recirculation Cooler Bolt

EXHAUST MANIFOLD AND TURBOCHARGER COMPONENTS

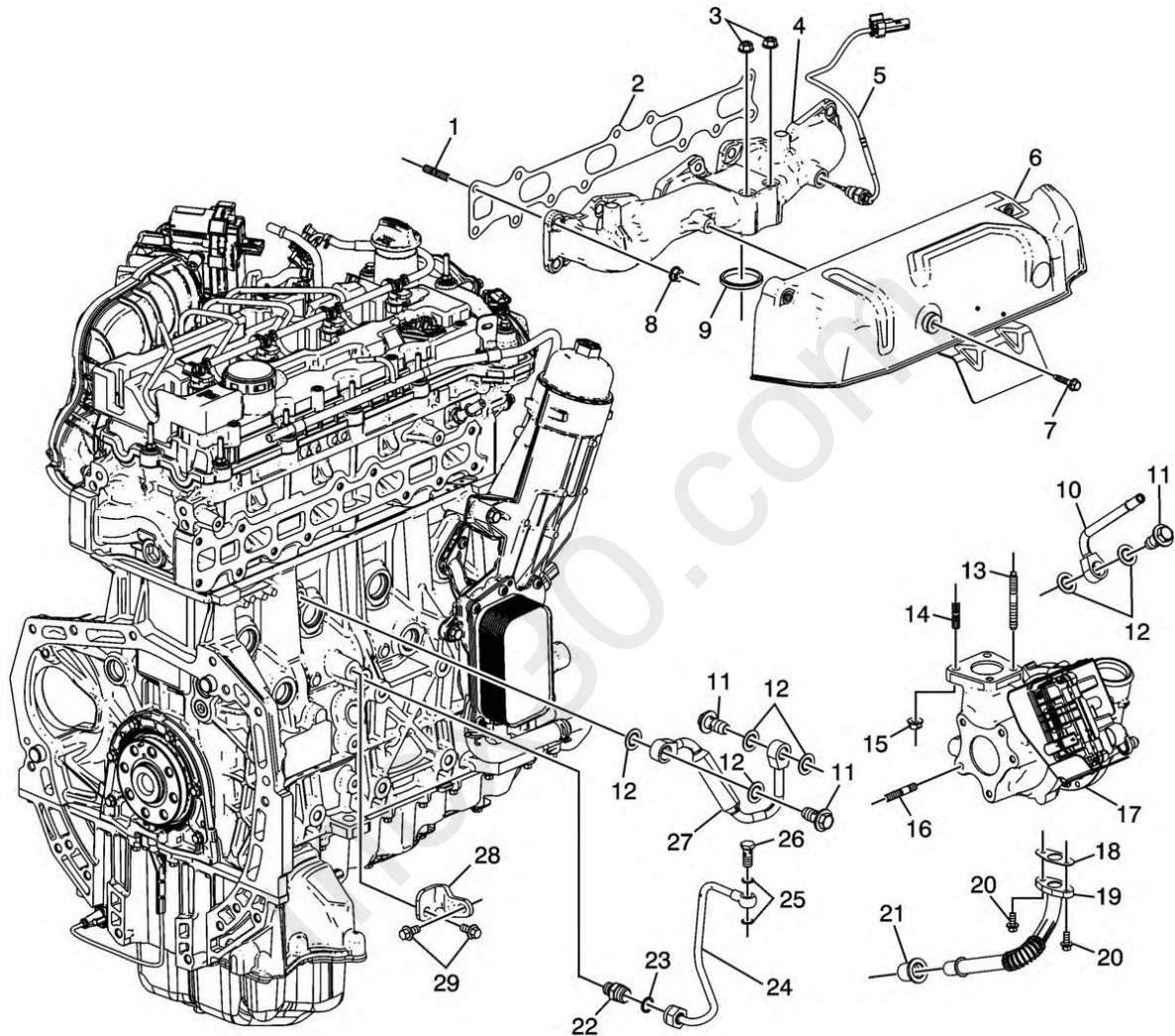


Fig. 3: Exploded View Of Exhaust Manifold And Turbocharger Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Stud [12x]
2	Exhaust Manifold Gasket
3	Turbocharger Nut [2x]
4	Exhaust Manifold
5	Exhaust Gas Recirculation Cooler Temperature Sensor
6	Exhaust Manifold Heat Shield
7	Exhaust Manifold Heat Shield Bolt [4x]
8	Exhaust Manifold Nut [12x]
9	Turbocharger Gasket
10	Turbocharger Coolant Return Pipe

Callout	Component Name
11	Turbocharger Coolant Feed and Return Pipe Bolt
12	Turbocharger Coolant Feed and Return Pipe Washer
13	Turbocharger Stud [2x]
14	Turbocharger Stud [2x]
15	Turbocharger Nut [2x]
16	Turbocharger Exhaust Pipe Stud [4x]
17	Turbocharger
18	Turbocharger Oil Return Pipe Gasket
19	Turbocharger Oil Return Pipe
20	Turbocharger Oil Return Pipe Bolt [2x]
21	Turbocharger Tube Seal
22	Turbocharger Oil Feed Pipe Fitting Adapter
23	Turbocharger Oil Feed Pipe Washer
24	Turbocharger Oil Feed Pipe
25	Turbocharger Oil Feed Pipe Gasket
26	Turbocharger Oil Feed Pipe Bolt
27	Turbocharger Coolant Feed Pipe
28	Turbocharger Brace
29	Turbocharger Brace Bolt [2x]

INTAKE MANIFOLD AND FUEL DELIVERY COMPONENTS

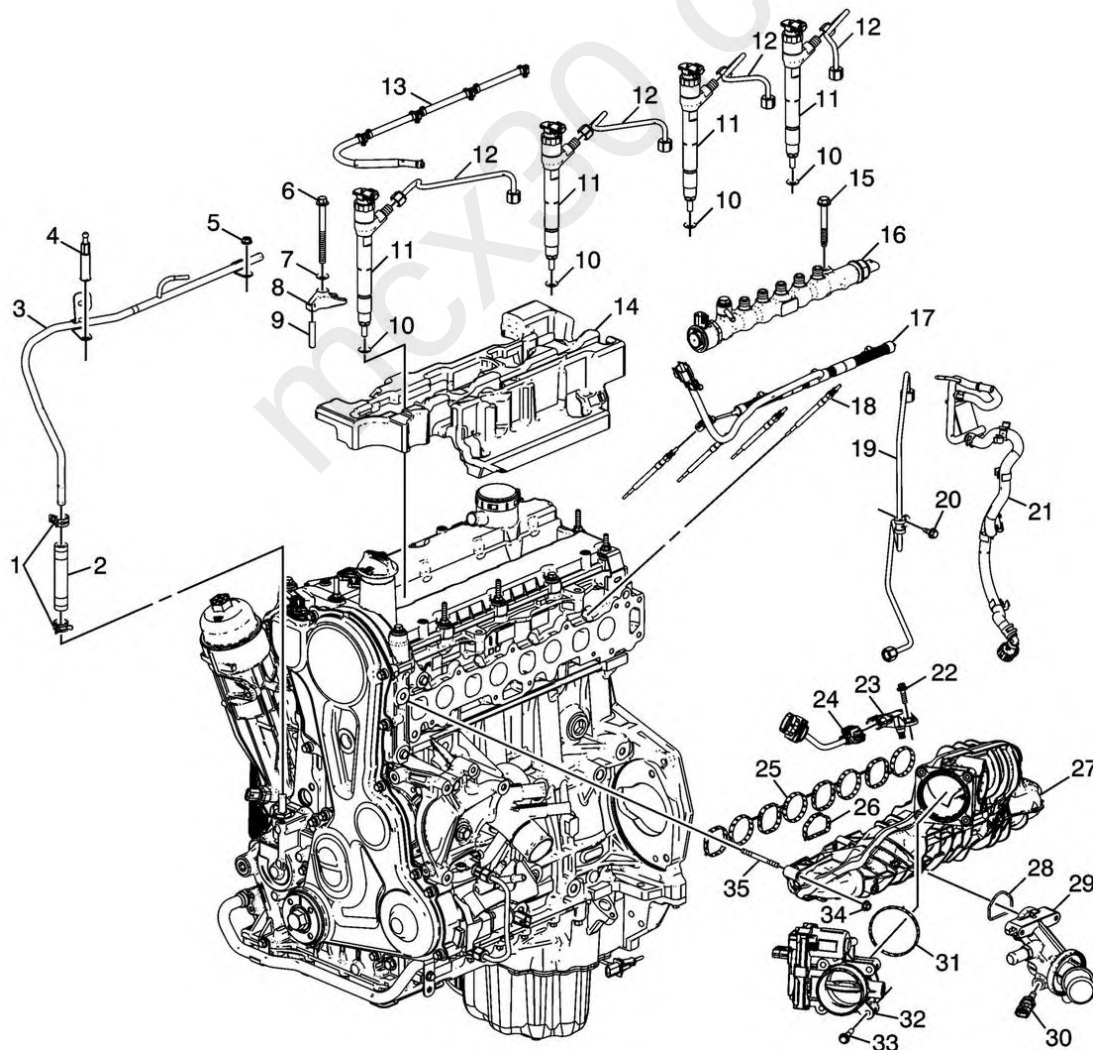


Fig. 4: Exploded View Of Intake Manifold And Fuel Delivery Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Hose Clip
2	Vacuum Pump Hose
3	Vacuum Pump Pipe
4	S. Ball Head Nut
5	Vacuum Pipe Nut
6	Fuel Injector Bracket Bolt
7	Fuel Injector Washer
8	Fuel Injector Hold Down Clamp
9	Fuel Injector Locating Pin
10	Fuel Injector Washer
11	Fuel Injector
12	Fuel Injection Fuel Feed Pipe
13	Fuel Return Pipe
14	Fuel Injector Deadener
15	Fuel Injection Fuel Feed Pipe Bracket Bolt
16	Direct Fuel Injection Fuel Rail
17	Diesel Glow Plug Wiring Harness
18	Glow Plug
19	Fuel Feed Pipe
20	Fuel Feed Pipe Bolt
21	Diesel Fuel Separator
22	Manifold Absolute Pressure Sensor Bolt
23	Manifold Absolute Pressure Sensor
24	Manifold Absolute Pressure Sensor Jumper Wire
25	Intake Manifold Gasket
26	Intake Manifold Gasket
27	Intake Manifold
28	Engine Coolant Thermostat Gasket
29	Engine Coolant Thermostat
30	Engine Coolant Temperature Sensor
31	Throttle Body Gasket
32	Throttle Body
33	Throttle Body Bolt
34	Intake Manifold Nut
35	Intake Manifold Stud

TIMING BELT AND COMPONENTS

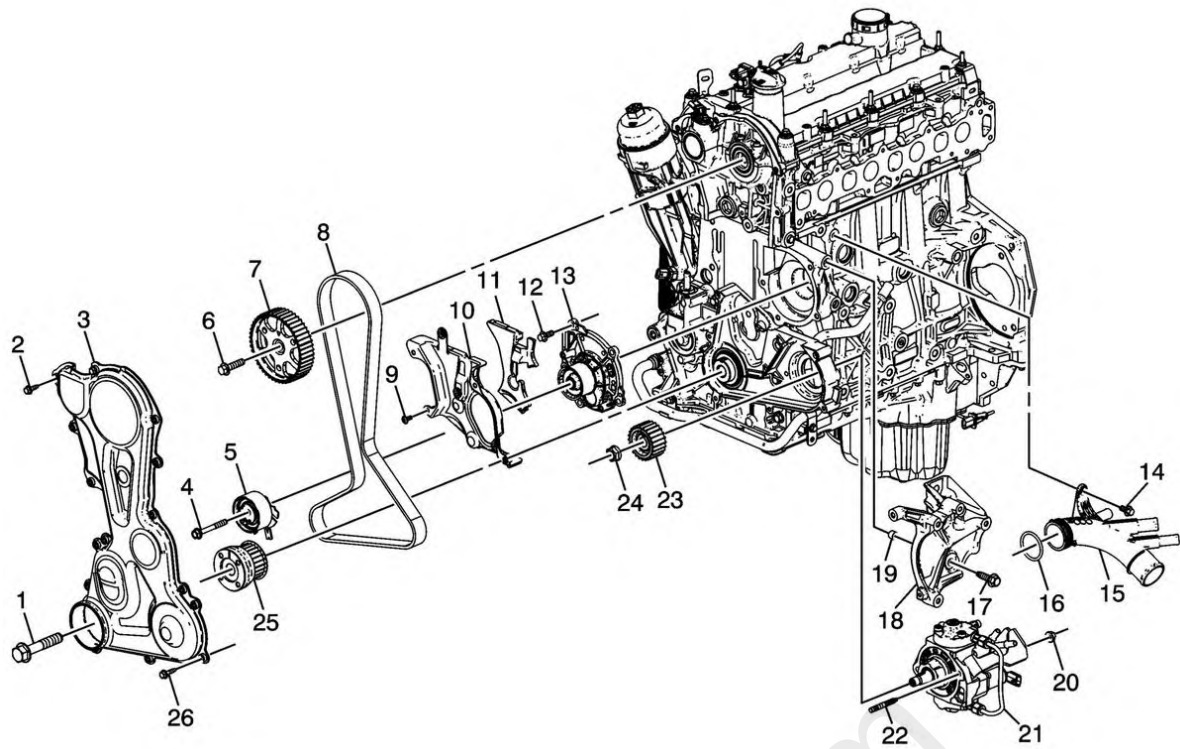


Fig. 5: Exploded View Of Timing Belt Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Sprocket Bolt
2	Timing Belt Front Cover Bolt [9x]
3	Timing Belt Front Cover
4	Timing Belt Tensioner Bolt
5	Timing Belt Tensioner
6	Camshaft Gear Bolt
7	Camshaft Timing Pulley
8	Timing Belt
9	Timing Belt Rear Cover Bolt [3x]
10	Timing Belt Rear Cover
11	Timing Belt Rear Cover Gasket
12	Water Pump Bolt [5x]
13	Water Pump
14	Water Pump Inlet Pipe Bolt
15	Water Pump Inlet Pipe
16	Water Pump Inlet Pipe Seal
17	Air Conditioning Compressor Bracket Bolt
18	Air Conditioning Compressor Bracket
19	Air Conditioning Compressor Bracket Locating Pin [2x]
20	Fuel Pump Nut
21	Fuel Pump
22	Fuel Pump Stud
23	Fuel Injection Pump Drive Pulley
24	Fuel Injection Pump Driven Sprocket Nut
25	Crankshaft Sprocket
26	Timing Belt Front Cover Bolt [6x]

CYLINDER HEAD AND COMPONENTS

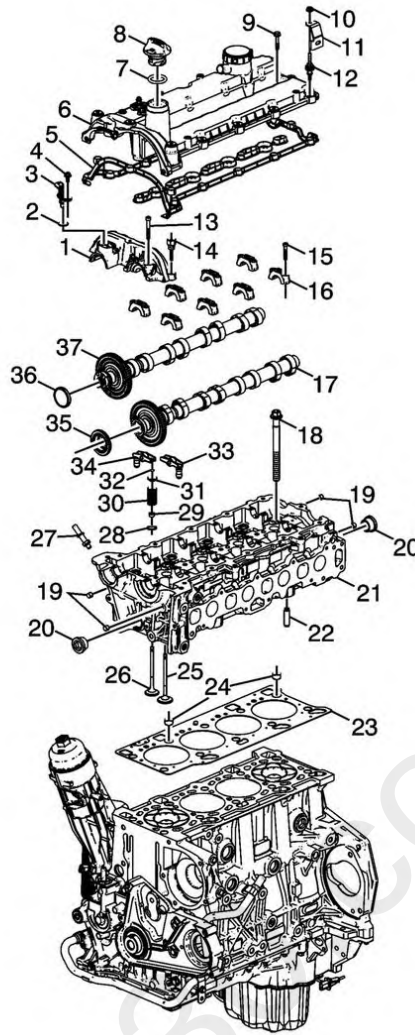


Fig. 6: Exploded View Of Cylinder Head Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Bearing Front Cap
2	Camshaft Position Sensor Seal
3	Camshaft Position Sensor
4	Camshaft Position Sensor Bolt
5	Valve Rocker Arm Cover Gasket
6	Valve Rocker Arm Cover
7	Oil Filler Cap Seal
8	Oil Filler Cap
9	Valve Rocker Arm Cover Bolt
10	Exhaust Temperature Sensor Connector Bracket Nut
11	Exhaust Temperature Sensor Bracket
12	Valve Rocker Arm Cover Stud
13	Camshaft Bearing Cap Bolt
14	Camshaft Bearing Front Cap Bolt
15	Camshaft Bearing Cap Bolt
16	Camshaft Bearing Cap
17	Intake Camshaft
18	Cylinder Head Bolt [10x]
19	Cylinder Head Core Hole Plug [4x]

Callout	Component Name
20	Cylinder Head Core Hole Plug [2x]
21	Cylinder Head
22	Valve Guide
23	Cylinder Head Gasket
24	Cylinder Head Locating Pin
25	Intake Valve [8x]
26	Exhaust Valve [8x]
27	Engine Water Outlet Adapter
28	Valve Spring Seat [16x]
29	Valve Stem Oil Seal [16x]
30	Valve Spring [16x]
31	Valve Spring Retainer [16x]
32	Valve Stem Key [16x]
33	Valve Rocker Arm - Intake
34	Valve Rocker Arm - Exhaust
35	Intake Camshaft Seal
36	Camshaft Plug
37	Exhaust Camshaft

OIL PAN AND COMPONENTS

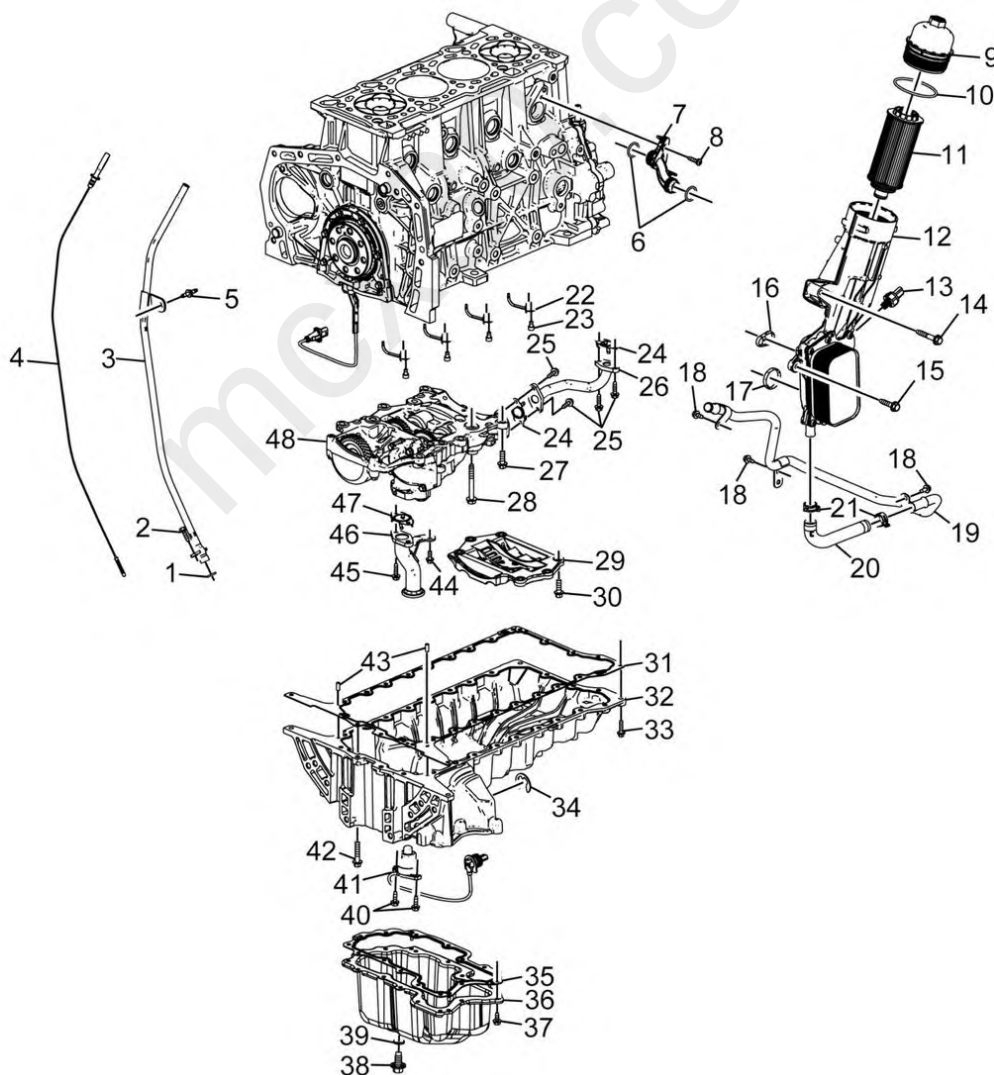


Fig. 7: Exploded View Of Oil Pan Components
 Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube Seal
2	Oil Level Indicator Tube Bolt
3	Oil Level Indicator Tube
4	Oil Level Indicator
5	Oil Level Indicator Tube Stud
6	Engine Oil Cooler Pipe Seal [2x]
7	Engine Oil Cooler Pipe
8	Engine Oil Cooler Pipe Bolt
9	Oil Filter Adapter Cap
10	Oil Filter Cap Seal
11	Oil Filter Element
12	Oil Filter Housing
13	Engine Oil Pressure Sensor
14	Oil Filter Housing Bolt [2x]
15	Oil Filter Housing Pipe Bolt
16	Oil Filter Gasket
17	Oil Filter Gasket
18	Engine Oil Cooler Inlet Pipe Bolt [3x]
19	Engine Oil Cooler Pipe
20	Engine Oil Cooler Inlet Hose
21	Engine Oil Cooler Inlet Hose Clamp
22	Piston Oil Nozzle [4x]
23	Piston Oil Nozzle Bolt [4x]
24	Oil Pump Suction Pipe Gasket [2x]
25	Oil Pump Suction Pipe
26	Oil Pump Suction Pipe Bolt [4x]
27	Crankshaft Balancer Bolt [7x]
28	Crankshaft Balancer Bolt [4x]
29	Oil Pan Baffle
30	Oil Pan Baffle Bolt [6x]
31	Upper Oil Pan Gasket
32	Upper Oil Pan
33	Upper Oil Pan Bolt [24x]
34	Engine Oil Level Sensor Lead Clip
35	Lower Oil Pan Gasket
36	Lower Oil Pan Bolt [14x]
37	Lower Oil Pan
38	Oil Pan Drain Plug
39	Oil Pan Drain Plug Seal
40	Engine Oil Level Indicator Switch Bolt [2x]
41	Engine Oil Level Indicator Switch
42	Upper Oil Pan Bolt [4x]
43	Oil Pan Locating Pin [2x]
44	Oil Pump Suction Pipe Bolt
45	Oil Pump Suction Pipe Bolt [2x]
46	Oil Pump Suction Pipe
47	Oil Pump Suction Pipe Gasket
48	Crankshaft Balancer

ENGINE FRONT COVER AND COMPONENTS

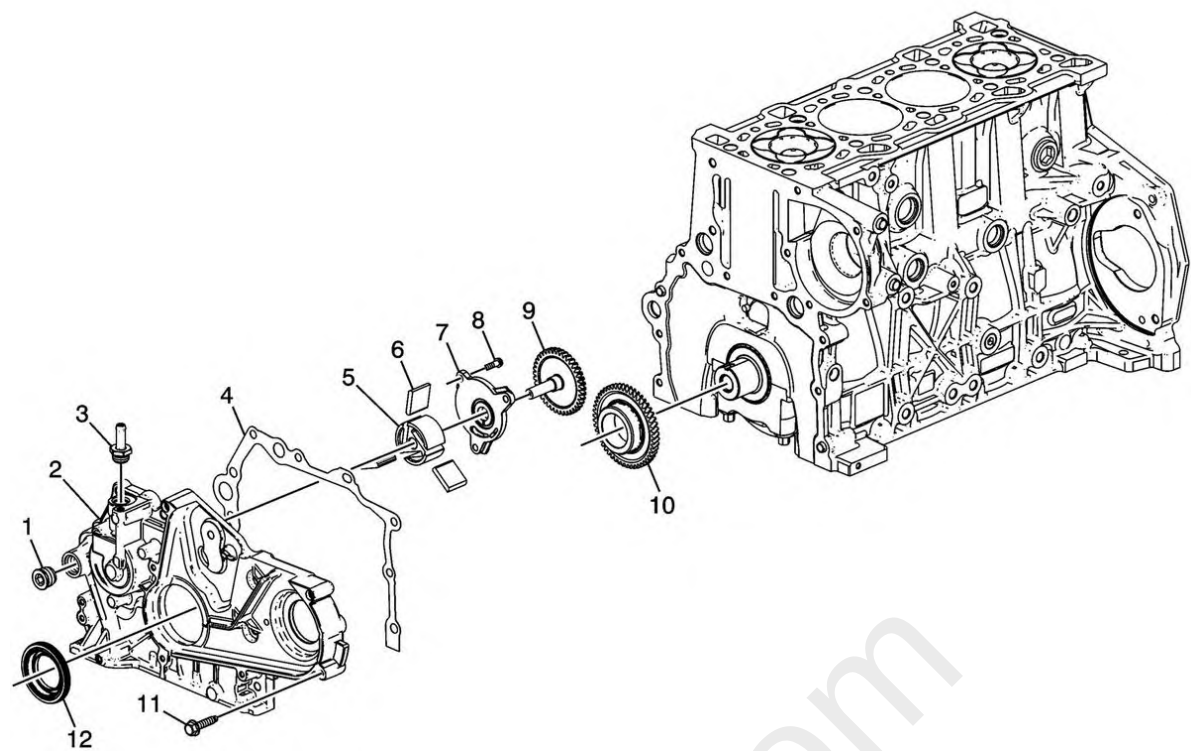


Fig. 8: Exploded View Of Engine Front Cover Components

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Front Cover Hole Plug
2	Engine Front Cover
3	Vacuum Regulator Valve
4	Engine Front Cover Gasket
5	Vacuum Pump Rotor
6	Vacuum Pump Vane [3x]
7	Vacuum Pump Housing Cover
8	Oil Pump Cover Bolt [3x]
9	Vacuum Pump Rotor
10	Oil Pump Drive Gear
11	Engine Front Cover Bolt [8x]
12	Crankshaft Front Oil Seal [3x]

ENGINE BLOCK AND COMPONENTS

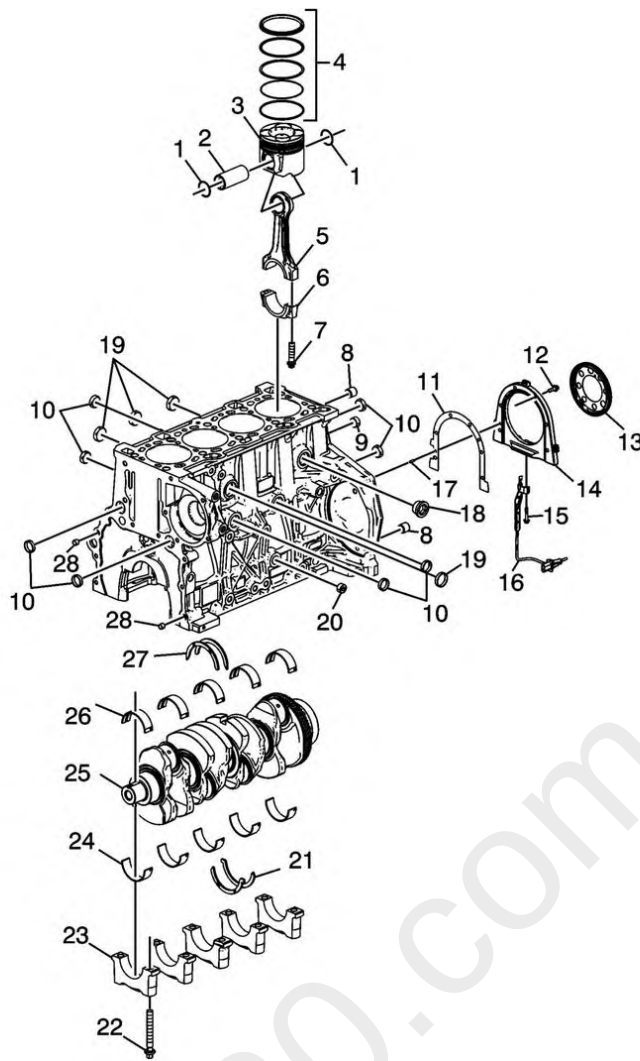


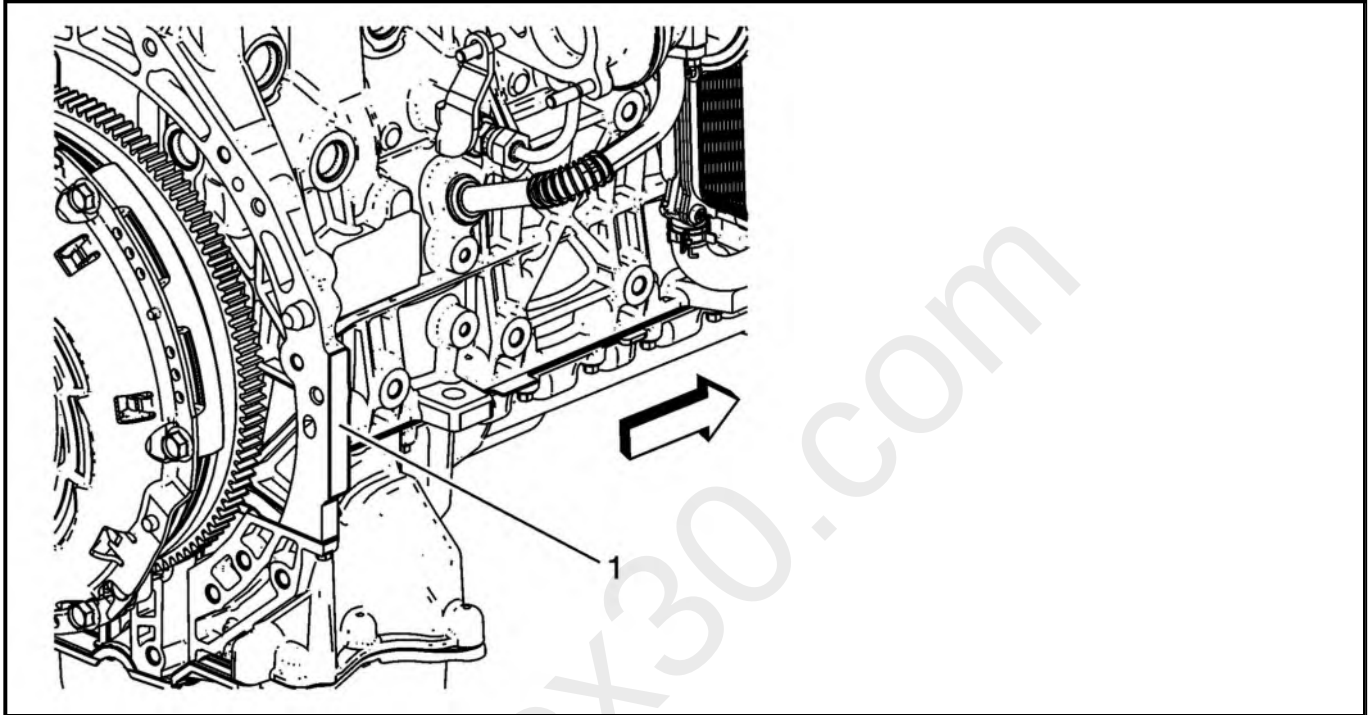
Fig. 9: Exploded View Of Engine Block Components

Courtesy of GENERAL MOTORS COMPANY

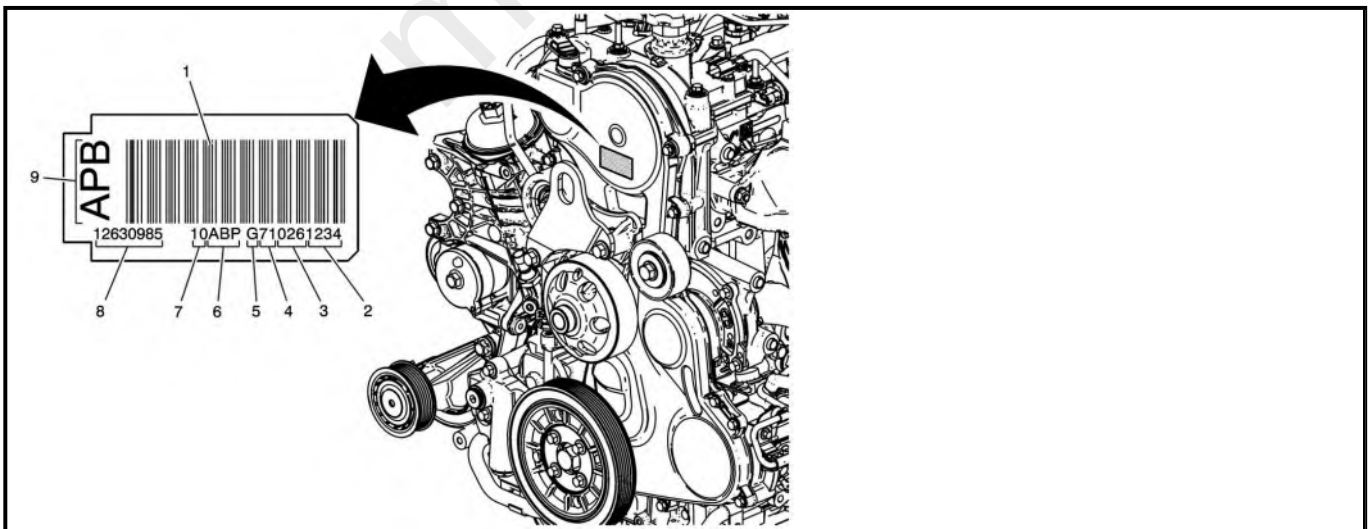
Callout	Component Name
1	Piston Pin Retainer
2	Piston Pin
3	Piston
4	Piston Ring
5	Connecting Rod
6	Connecting Rod Cap
7	Connecting Rod Bolt
8	Transmission Locating Pin
9	Engine Block Oil Gallery Plug
10	Engine Block Oil Gallery Plug [8x]
11	Crankshaft Rear Oil Seal Housing Gasket
12	Crankshaft Rear Oil Seal Housing Bolt [6x]
13	Crankshaft Position Sensor Exciter Ring
14	Crankshaft Rear Oil Seal Housing
15	Crankshaft Position Sensor Bolt
16	Crankshaft Position Sensor
17	Crankshaft Rear Oil Seal Housing Locating Pin
18	Engine Block Core Hole Plug
19	Engine Block Oil Gallery Plug [4x]
20	Engine Block Core Hole Plug

Callout	Component Name
21	Crankshaft Thrust Washer - Lower
22	Crankshaft Bearing Cap Bolt
23	Crankshaft Bearing Cap
24	Crankshaft Lower Bearing
25	Crankshaft
26	Crankshaft Upper Bearing
27	Crankshaft Thrust Washer
28	Engine Front Cover Locating Pin [2x]

ENGINE IDENTIFICATION



The engine serial number (1) is located on the right side rear of the engine block.



The engine identification label is located on the engine front cover.

- Barcode (1)
- Sequence Number (2)
- Julian Day (3)

- Calendar Year (4)
- Plant Code (5)
- Broadcast Code (6)
- Part Designation (7)
- Part Number (8)
- Broadcast Code (9)

DIAGNOSTIC INFORMATION AND PROCEDURES

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the Diagnostic Starting Point - 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 problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to Strategy Based Diagnosis.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine.
- 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

- [Fuel in Engine Oil](#)
- [Compressor Air Intake Turbocharger Whine Noise](#)
- [Compressor Air Intake Turbocharger Hissing Noise](#)
- [Compressor Air Intake Turbocharger Oil Leak From Compressor Seal](#)
- [Compressor Air Intake Turbocharger Oil Leak From Turbine Seal](#)
- [Engine Compression Test](#)
- [Cylinder Leakage Test](#)
- [Oil Consumption Diagnosis](#)
- [Oil Pressure Diagnosis and Testing](#)
- [Oil Leak Diagnosis](#)
- [Crankcase Ventilation System Inspection/Diagnosis](#)
- [Drive Belt Chirping, Squeal, and Whine Diagnosis](#)
- [Drive Belt Rumbling and Vibration Diagnosis](#)
- [Drive Belt Falls Off and Excessive Wear Diagnosis](#)
- [Drive Belt Tensioner Diagnosis](#)

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Condition	Action
Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt. Also worn, damaged, or misaligned accessory drive components or excessive pulley runout.	Abnormalities in the accessory drive belt 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. 1. Inspect the accessory drive components. 2. Repair or replace all damaged components.
Loose and/or damaged crankshaft balancer	A misfire code may be present without an actual misfire condition. 1. Inspect crankshaft balancer and balancer bolt. 2. Repair or replace all damaged components.
Loose torque converter bolts	A misfire code may be present without an actual misfire condition. 1. Inspect torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	A misfire code may be present without an actual misfire condition. 1. Inspect flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Restricted exhaust system	A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a misfire code. Possible causes of restrictions include collapsed or dented pipes, plugged mufflers and/or catalytic converters. Repair or replace all damaged components.

Condition	Action
Air in fuel system	1. Inspect fuel filter, fuel system for leaks and/or restrictions. 2. Repair or replace all damaged components.
Bent and/or worn valve pushrod	1. Inspect valve pushrod and valve rocker arm. 2. Repair or replace all damaged components.
Sticking valve	Carbon on the valve stem or valve seat may cause the valve to stick. 1. Inspect valves and valve guides. 2. Repair or replace all damaged components.
Damaged or misaligned timing gears	1. Inspect timing gears. 2. Replace all damaged components.
Worn or faulty camshaft lobes	1. Inspect camshaft lobes. 2. If damaged replace camshaft and all lifters.
Excessive piston-to-cylinder bore clearance	1. Perform cylinder leak down and compression tests. 2. Inspect the piston, piston rings and cylinder bore. 3. Repair or replace all damaged components.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. (Coolant consumption may or may not cause the engine to overheat.)	1. Perform cylinder leak down and compression tests. 2. Inspect the piston, piston rings and cylinder bore. 3. Repair or replace all damaged components.
Overfilled Crankcase	1. Check engine oil level with vehicle on a level surface. 2. Correct any overfilled condition. 3. Inspect for fuel leaks into the crankcase. Refer to Fuel in Engine Oil. 4. Repair any fuel leaks.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Condition	Action
Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt.	Abnormalities in the accessory drive belt 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. 1. Inspect the accessory drive components. 2. Repair or replace all damaged components.

Condition	Action
Worn, damaged, or misaligned accessory drive components or excessive pulley runout	A misfire code may be present without an actual misfire condition. 1. Inspect the accessory drive components. 2. Repair or replace all damaged components.
Loose and/or damaged crankshaft balancer	A misfire code may be present without an actual misfire condition. 1. Inspect crankshaft balancer and balancer bolt. 2. Repair or replace all damaged components.
Loose torque converter bolts	A misfire code may be present without an actual misfire condition. 1. Inspect torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	A misfire code may be present without an actual misfire condition. 1. Inspect flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	1. Perform cylinder leak down and compression tests 2. Inspect the piston, piston rings and cylinder bore. 3. Repair or replace all damaged components.
Excessive crankshaft thrust bearing clearance	Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit for and aft movement of the crankshaft and create a misfire code without an actual misfire condition. 1. Inspect the crankshaft end play and crankshaft thrust bearings. 2. Repair or replace all damaged components.
Overfilled crankcase	1. Check engine oil level with vehicle on a level surface. 2. Correct any overfilled condition. 3. Inspect for fuel leaks into the crankcase. 4. Repair any fuel leaks.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Condition	Action
Loose, worn or damaged rocker arm	1. Inspect valve rocker arm and rocker arm shaft. 2. Repair or replace all damaged components.
Loose valve rocker arm attachments	1. Inspect valve rocker arm and rocker arm shaft.

Condition	Action
	2. Repair or replace all damaged components.
Worn or damaged pushrods	1. Inspect the pushrods for excessive wear. 2. Inspect the pushrods for bent condition. 3. Inspect the pushrods for broken tip. 4. Replace pushrod if any damage is found.
Broken valve springs	1. Inspect valve springs. 2. Repair or replace all damaged components.
Worn and/or damaged valve rotator	1. Inspect valve rotators. 2. Repair or replace all damaged components.
Sticking valve	Carbon on the valve stem or valve seat may cause the valve to stick. 1. Inspect valves and valve guides. 2. Repair or replace all damaged components.
Worn or faulty camshaft lobes	1. Inspect camshaft lobes. 2. If damaged replace camshaft and all lifters.
Excessive valve lash	1. Check the valve lash adjustment, and correct if above specifications. 2. Repair or replace all damaged components.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Special Tools

- **EN-48974** EGR Cooler Pressure Tester Adapter Set
- **J-46901-1** Charge air Cooler Tester

Inspection	Action
DEFINITION: Base engine misfire with coolant consumption	
Preliminary Inspection	Verify that there are no external coolant leaks. Refer to Loss of Coolant .
Isolate Affected Cylinders	• Cylinder balance test with scan tool • Cooling system pressurization • Inspection of glow plugs • Compression test • Cylinder leakdown test
EGR System Inspection	1. Inspect EGR cooler using J-46901-1 tester and EN-48974-1 and EN-48974-2 adapters. 2. Replace the EGR cooler if any problem is found.
Cylinder Head Gasket Leakage	• Remove cylinder heads of the affected cylinder bank and inspect for damage.

Inspection	Action
	• Replace components as necessary.
Cylinder Head or Engine Block Damage	1. Inspect the cylinder heads for cracks and warpage. 2. Inspect the cylinder block for damage. 3. Inspect the cylinder block to head mating surface for straightness. 4. Replace components as necessary.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Condition	Action
Worn valve guides	1. Inspect the valves and valve guides. 2. Repair or replace all damaged components.
Worn valve stem oil seals	1. Inspect the valve stem oil seals. 2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	1. Perform cylinder leak down and compression tests to determine the cause. 2. Inspect the piston rings for low ring tension, broken or worn rings. 3. Inspect cylinder bore. 4. Repair or replace all damaged components.

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

Condition	Action
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and piston skirt, connecting rod, and cylinder bore. 2. Repair or replace all damaged components.
Damaged or faulty oil filter by-pass valve	1. Inspect the oil filter by-pass valve for proper operation. 2. Repair or replace as necessary.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Condition	Action
Low oil pressure	Insufficient or poor oil supply to valve train. 1. Perform oil pressure test. 2. Repair or replace all damaged components.

Condition	Action
Improper lubrication to the valve rocker arms	1. Inspect valve rocker arm and shaft, valve pushrod, oil filter bypass valve, oil pump and pump screen, and engine block oil galleries. 2. Repair or replace all damaged components.
Excessive valve lash	1. Check the valve lash adjustment, and correct if above specifications. 2. Repair or replace all damaged components.
Worn pushrod upper end ball	1. Inspect pushrod end ball. 2. Repair or replace all damaged components.
Bent valve pushrod	1. Inspect valve pushrod and valve rocker arm. 2. Repair or replace all damaged components.
Loose, worn or damaged valve rocker arm	1. Inspect valve rocker arm and rocker arm shaft. 2. Repair or replace all damaged components.
Loose valve rocker arm attachments	1. Inspect valve rocker arm and rocker arm shaft. 2. Repair or replace all damaged components.
Broken valve springs	1. Inspect valve springs. 2. Repair or replace all damaged components.
Worn and/or damaged valve spring shims, seats, or keys	1. Inspect valve spring shims, seats, and keys. 2. Repair or replace all damaged components.
Sticking valve	Carbon on the valve stem or valve seat may cause the valve to stick. 1. Inspect valves and valve guides. 2. Repair or replace all damaged components.
Missing or improperly positioned lifter guides	1. Inspect lifter guides. 2. Repair or replace all damaged components.
Worn or faulty camshaft lobes	1. Inspect camshaft lobes. 2. If damaged replace camshaft and all lifters.
Worn valve guide	1. Inspect the valves and valve guides. 2. Repair or replace all damaged components.
Damaged or misaligned timing gears	1. Inspect timing gears. 2. Replace all damaged components.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Condition	Action
Worn accessory drive components (abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of the system components.)	1. Inspect the accessory drive components. 2. Repair or replace all damaged components.
Low oil pressure	Insufficient or poor oil supply to crankshaft and connecting rod bearings. 1. Perform oil pressure test. 2. Repair or replace all damaged components.
Leaking and/or sticking fuel injection nozzle (A stuck fuel injection nozzle can cause a noise similar to a damaged piston, rod or rod bearing.)	1. Use the cylinder balance diagnostic procedure to help locate the cylinder that is the source of the noise. 2. If you cannot locate the cylinder that is the source of the noise, diagnose the engine for mechanical damage. 3. If it has been determined that the fuel injection nozzle is causing the noise, replace the fuel injection nozzle.
Loose and/or damaged crankshaft balancer	1. Inspect crankshaft balancer and balancer bolt. 2. Repair or replace all damaged components.
Loose torque converter bolts	1. Inspect torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	1. Inspect flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston, piston rings and cylinder bore. 2. Repair or replace all damaged components.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace all damaged components.
Misaligned or bent connecting rod	1. Inspect connecting rod and connecting rod bearings. 2. Repair or replace all damaged components.
Excessive connecting rod bearing clearance	1. Inspect the connecting rod bearings, connecting rods, crankshaft and crankshaft journals. 2. Repair or replace all damaged components.
Excessive crankshaft bearing clearance	1. Inspect the crankshaft bearings and crankshaft journals. 2. Repair or replace all damaged components.
Oil pump pickup tube or screen bent or loose	1. Inspect the oil pump pickup tube and/or screen.

Condition	Action
	2. Repair or replace all damaged components.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	Insufficient or poor oil supply to components. 1. Perform oil pressure test. 2. Repair or replace all damaged components.
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair or replace all damaged components.
Loose and/or damaged flywheel	1. Inspect the flywheel and flywheel attaching bolts. 2. Repair or replace all damaged components.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston rings for low ring tension, broken or worn rings, inspect cylinder bore. 2. Repair or replace all damaged components.
Excessive crankshaft thrust bearing clearance	1. Inspect the crankshaft end play and crankshaft thrust bearings. 2. Repair or replace all damaged components.
Excessive crankshaft bearing clearance	1. Inspect the crankshaft bearings and crankshaft journals. 2. Repair or replace all damaged components.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belt(s). 2. Remove the glow plugs. 3. Rotate crankshaft by hand at the balancer.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Inspect for fluid at glow plug hole. 2. Inspect for broken head gasket(s). 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	1. Remove the engine assembly. The torque converter bolts are not accessible with the engine installed to the transmission. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch.

Cause	Correction
	2. Rotate crankshaft by hand at the balancer.
Material in cylinder: • Broken valve • Piston material • Foreign material	1. Inspect cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. 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

Special Tools

- **EN-48974** EGR Cooler Pressure Tester Adapter Set
- **J-46901-1** Charge air Cooler Tester

Inspection	Action
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.	
Preliminary Inspection	Verify that there are no external coolant leaks. Refer to Loss of Coolant .
Isolate Affected Cylinders	• Cylinder balance test with scan tool • Cooling system pressurization • Inspection of glow plugs • Compression test • Cylinder leakdown test
EGR System Inspection	1. Inspect EGR cooler using J-46901-1 tester and EN-48974-1 and EN-48974-2 adapters. 2. Replace the EGR cooler if any problem is found.
Cylinder Head Gasket Leakage	• Remove cylinder heads of the affected cylinder bank and inspect for damage. • Replace components as necessary.
Cylinder Head or Engine Block Damage	1. Inspect the cylinder heads for cracks and warpage. 2. Inspect the cylinder block for damage.

Inspection	Action
	3. Inspect the cylinder block to head mating surface for straightness. 4. Replace components as necessary.

COOLANT IN ENGINE OIL

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed. 2. Inspect by performing a Cylinder Leak-Down Test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection , and Cylinder Head Replacement .
Warped cylinder head	Replace the cylinder head gasket. Refer to Cylinder Head Replacement .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.
Leaking engine oil cooler	Replace components as required.
Faulty water pump	Replace components as required.
Leaking cylinder head cup plug (under rocker cover)	Replace components as required.

FUEL IN ENGINE OIL

Definition: If fuel is suspected of leaking into the crankcase, the following procedure should be performed to verify the condition.

1. Remove the oil level indicator and allow oil to drop onto a clean white paper towel.
2. If the oil is diluted with fuel, it will become apparent as the towel wicks the fuel away from the drop of oil on the towel. The fuel will expand out in a ring around the oil droplet.
3. If fuel dilution is apparent, refer to [Fuel Leak Diagnosis](#), for diagnosis and repair. Inspect the vehicle for aftermarket performance accessories that may cause damage to the injection pump. After repairs are completed, perform the test again to verify the condition is corrected.
4. If no fuel dilution is present, verify the oil level and correct as needed.

COMPRESSOR AIR INTAKE TURBOCHARGER WHINE NOISE

Special Tools

J 46091 Charge Air Cooler Tester

Condition	Action
Some whine noise is normal. Compare to a known good vehicle.	
Leaking charge air cooler/pipes/hoses	Inspect for leaks in charge air cooler/pipes/hoses using J 46091 tester.
Worn turbocharger bearings	Visually inspect for evidence of compressor wheel to housing contact. If the turbocharger bearings are worn or damaged, inspect for a restricted turbocharger oil feed line.
Intake system leaks or obstructions	1. With the engine off, pressurize the intake system using J 46091 tester and inspect for intake manifold leaks. 2. Inspect for obstructions in the intake manifolds.

COMPRESSOR AIR INTAKE TURBOCHARGER HISSING NOISE

Condition	Action
Air inlet leaks or obstructions	Inspect for leaks or obstructions in the turbocharger inlet pipes/hoses.
Leaking charge air cooler/pipes/hoses	Inspect for leaks or obstructions in the charge air cooler/pipes/hoses using J 46091 charge air cooler tester
Leaking or restricted exhaust system	1. Inspect for a leak in the exhaust system. 2. Inspect for a restricted exhaust system.
Intake system leaks or obstructions	1. With the engine off, pressurize the intake system using J 46091 charge air cooler tester and inspect for intake manifold leaks. 2. Inspect for obstructions in the intake manifolds.

COMPRESSOR AIR INTAKE TURBOCHARGER OIL LEAK FROM COMPRESSOR SEAL

Condition	Action
NOTE: Oil in the turbocharger air inlet duct, oil on the compressor wheel, and oil throughout the charge air cooler system is normal with a closed PCV system. Do not attempt repairs for	

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

COMPRESSOR AIR INTAKE TURBOCHARGER OIL LEAK FROM TURBINE SEAL

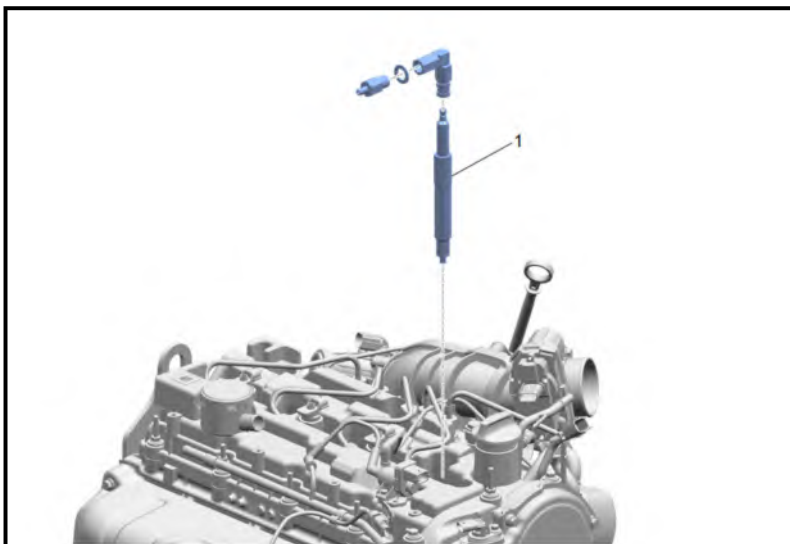
Condition	Action
Poor oil drainage from turbocharger	Inspect for a restricted turbocharger oil drain pipe.
Restricted crankcase ventilation system	Inspect for a restricted crankcase ventilation system.
Worn internal engine components	Inspect for excessive blowby or engine oil consumption.

ENGINE COMPRESSION TEST

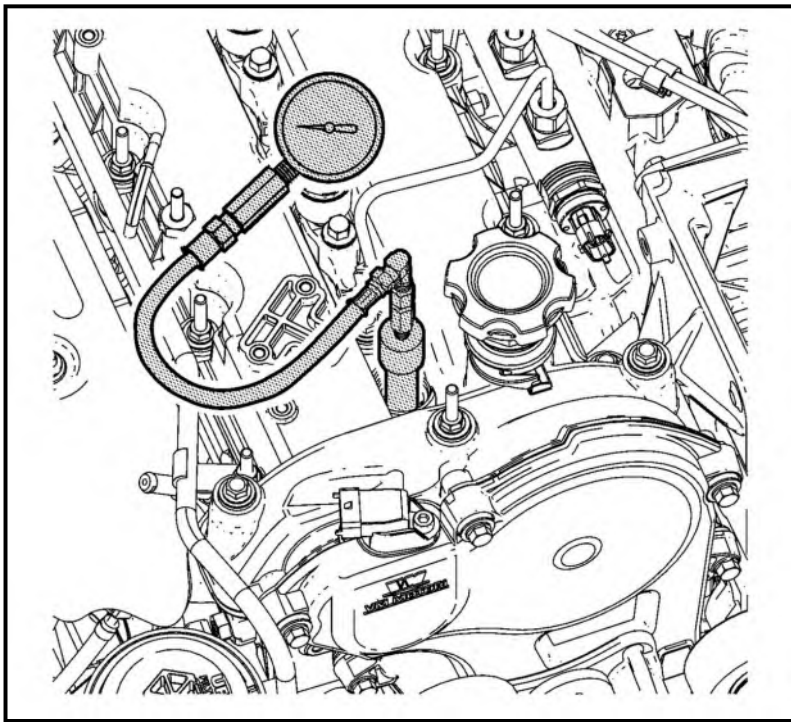
Special Tools

- **EN-51110** Compression Tester Adapter
- **EN-26999** Compression Gauge Adapter

1. Ensure that the vehicle's batteries are in good condition, and fully charged.
2. Operate the vehicle until the engine is at normal operating temperature.
3. Shut off engine.
4. Remove all of the fuel injectors. All of the fuel injectors must be removed from the engine during each cylinder test to obtain valid test results.
5. Prior to taking a compression reading, verify the cranking speed is greater than 140 RPM. If the cranking speed is below 140 RPM, repair the slow cranking speed condition before continuing with the compression test. Refer to [Engine Cranks Slowly](#) .
6. Install the **EN-51110** adapter (1) in the fuel injector hole for the cylinder that is being checked. Use the copper washer from the fuel injector to seal the **EN-51110** adapter (1) in the hole.



7. Connect the **EN-26999** gauge to the **EN-51110** adapter.



CAUTION: Do not add oil to any cylinder during a compression test as extensive engine damage may result.

CAUTION: Do not crank the engine using the ignition switch, as the fuel injectors and the glow plug circuits will be energized and engine damage may result.

8. Using a remote start switch, crank the engine for 6 compression strokes, puffs, for the cylinder being tested.
9. Observe the **EN-26999** gauge and note the reading as the compression test is being performed. A normal cylinder reading will be indicated if compression builds up quickly and evenly to the specified level. An abnormal reading will be indicated if compression is low on the first compression stroke, starts increasing on the following compression strokes but does not reach the specified level.
10. Record the compression reading for the cylinder just tested.
11. Disconnect the **EN-26999** gauge from the **EN-51110** adapter and remove adapter from the fuel injector bore.
12. Repeat steps 8 through 13 for all remaining cylinders. All 4 cylinders must be tested to obtain valid test results. Record the readings.
13. The minimum compression in any one cylinder is 2069 kPa (300 psi). There should not be more than 345 kPa (50 psi) difference between a suspect cylinder and the average compression of all 4 cylinders.

NOTE: Cylinder to cylinder variation may be at the high end of the specification on engines with less than 20, 000 km (12, 427 miles).

- Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
- Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes but does not reach normal.
- Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes.

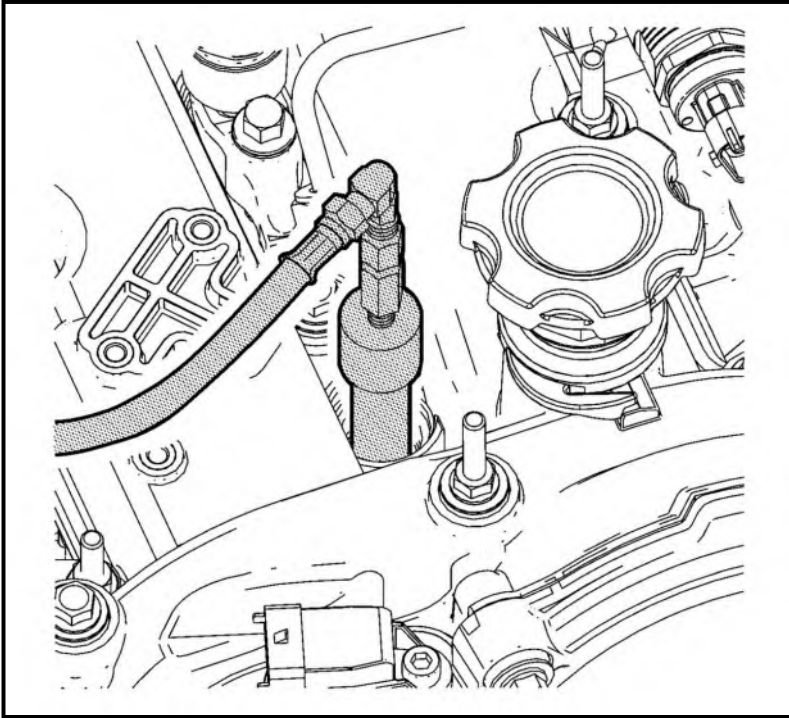
CYLINDER LEAKAGE TEST

Special Tools

- **EN-51110** Compression Tester Adapter
- **EN-35667-A** Cylinder Head Leakdown Tester

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

1. Disconnect the battery ground negative cable.



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

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

- Worn, burnt, or stuck valves
- Broken valve springs
- Incorrect valve lash
- Damaged valve train components
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

2. Remove the fuel injectors.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install **EN-51110** adapter and **EN-35667-A** tester.

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

5. Apply shop air pressure to **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 intake manifold tube, may indicate a worn, stuck or burnt intake valve, broken valve spring, incorrect valve lash or damaged valve train components.

- Air leakage sounds at the exhaust system tailpipe may indicate a worn, burnt, or stuck exhaust valve, broken valve spring, incorrect valve lash or damaged valve train components.
- Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube 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 gasket.

7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

The accepted rate of oil consumption, not due to leaks, is the use of 0.946 liter (1 qt) or less within 379 liters (100 gallons) of fuel used. This rate only applies to vehicles under warranty, maintained in accordance with the appropriate maintenance schedule, driven at legal speeds and within design intent of the vehicle.

Oil economy should not be tested until the vehicle has accumulated at least 8000 km (5000 mi) and the oil has been changed for the first time. During initial engine break-in periods before the first oil change, oil consumption may exceed 1.9 liters (2 qts) or more per 379 liters (100 gallons) of fuel used.

Checks	Causes
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to Oil Leak Diagnosis. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2 - 3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Oil residue in the charge air cooler system is normal with a closed PCV system • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or improperly fit to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Step	Action	Yes	No
DEFINITION: Low or no engine oil pressure indicates a potentially serious condition with all of the engine mechanical components. Once the cause of the low or no oil pressure condition has been identified, repair all collateral damage to the engine mechanical components as well as the initial cause of the condition.			
1	Check engine oil level. Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. Is the engine oil level between ADD and FULL on the oil level indicator?	Go to Step 2	-
2	1. Operate vehicle until engine reaches normal operating temperature. Refer to Engine Mechanical Specifications . 2. Park vehicle on a level surface. 3. Wait 15 minutes. 4. Check engine oil level. Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. Is the engine oil level between ADD and FULL on the oil level indicator?	Go to Step 3	-
3	Operate the engine and measure the engine oil pressure with the vehicle gauge or light. Refer to Engine Mechanical Specifications . Is engine oil pressure within specification?	System OK	Go to Step 4
4	1. Remove the oil pressure sender or engine block oil gallery plug. 2. Install a mechanical oil pressure gauge. 3. Operate the engine and measure the engine oil pressure with the mechanical oil pressure gauge. Refer to Engine Mechanical Specifications . Is engine oil pressure within specification?	System OK	Go to Step 5
5	Change the engine oil and filter. - Use only the GM service parts brand and recommended grade of engine oil specified for the vehicle. Refer to Owners' Manual. - Use only the GM service parts brand and recommended type of engine oil filter specified for the vehicle. Refer to Owners' Manual. Operate the engine and measure the engine oil pressure with the mechanical oil pressure gauge. Refer to Engine Mechanical Specifications . Is engine oil pressure within specification?	System OK	Go to Step 6
6	1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas: - Malfunctioning oil bypass valve - Oil pump worn or dirty - Oil pump-to-engine block bolts loose - Oil pump O-ring damaged or missing	Go to Step 7	Go to Step 1

Step	Action	Yes	No
	- Oil pump to oil pump pipe and screen assembly gasket missing or damaged - Oil pump pipe and screen assembly restrictions or damaged - Oil pump driven gear damaged or loose - Oil pump drive gear damaged - Oil cooler restrictions - Oil cooler O-rings damaged or missing - Excessive bearing clearances - Cracked, porous or restricted oil galleries - Oil gallery plugs missing or incorrectly installed - Damaged or missing oil spray cooling nozzles 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?		
7	Repair or replace all damaged or modified components. Is the repair complete?	Go to Step 1	-

OIL LEAK DIAGNOSIS

Special Tools

J 28428-E High-Intensity Black Light Kit

Step	Action	Yes	No
NOTE: 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.			

Step	Action	Yes	No
1	1. Operate the vehicle until it reaches normal operating temperature. 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 7	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. 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 7	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several kilometers/miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 7	Go to Step 5
5	Use J 28428-E black light kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 7	Go to Step 6
6	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 7	System OK
7	1. Inspect the engine for mechanical damage and repair or replace as necessary. Special attention should be shown to the following areas: • Plugged or malfunctioning crankcase ventilation system. Refer to Crankcase Ventilation System Inspection/Diagnosis.	Go to Step 8	System OK

Step	Action	Yes	No
	- Higher than recommended fluid levels - Higher than recommended fluid pressures - Plugged or malfunctioning fluid filters or pressure bypass valves - 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?		
8	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to Step 1	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Concern	Action
IMPORTANT: Oil in the charged air cooler, hoses, turbocharger, or intake manifolds is normal with a closed crankcase ventilation system. The maximum crankcase pressure is 4 kPa or 16 in of water at 3, 100 RPM measured at the oil level indicator tube.	
PVC check valve stuck closed	- Excessive crankcase pressure - Possible oil leaks. Replace the valve.
Odors	Normal situation
Noise	Cracked hoses
Smoke	Damaged PCV diaphragm
Excessive Oil Consumption	Damaged PCV diaphragm, missing or broken spring

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

2

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

3

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

4

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

6

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

10

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

12

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

14

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

15

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

16

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

17

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

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

Step	Action	Yes	No
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	CAUTION: Refer to Fastener Caution . 1. Tighten any loose fasteners. Refer to Fastener Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids.	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. 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.

2

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

3

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

4

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

5

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

9

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

11

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

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:			

Step	Action	Yes	No
	• Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove • The separation of the drive belt • A damaged drive belt • A worn drive belt idler pulley DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30 - 40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to Drive Belt Replacement . Did you correct the condition?	Go to Step 8	Go to Step 7
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 .	Go to Step 13	Go to Step 11

Step	Action	Yes	No
	1. Tighten any loose fasteners. Refer to Fastener Specifications . 2. Replace improper or missing fasteners. Did you complete the repair?		
11	Inspect for a bent water pump shaft. 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 two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5

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

6

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

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.			
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.	Go to Step 9	System OK

Step	Action	Yes	No
	Does the drive belt continue to fall off?		
9	Test the drive belt tensioner for operating correctly. Refer Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and 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
1	Remove the drive belt. Refer to Drive Belt Replacement . Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 4	Go to Step 2
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 4
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement . Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS

DRIVE BELT REPLACEMENT

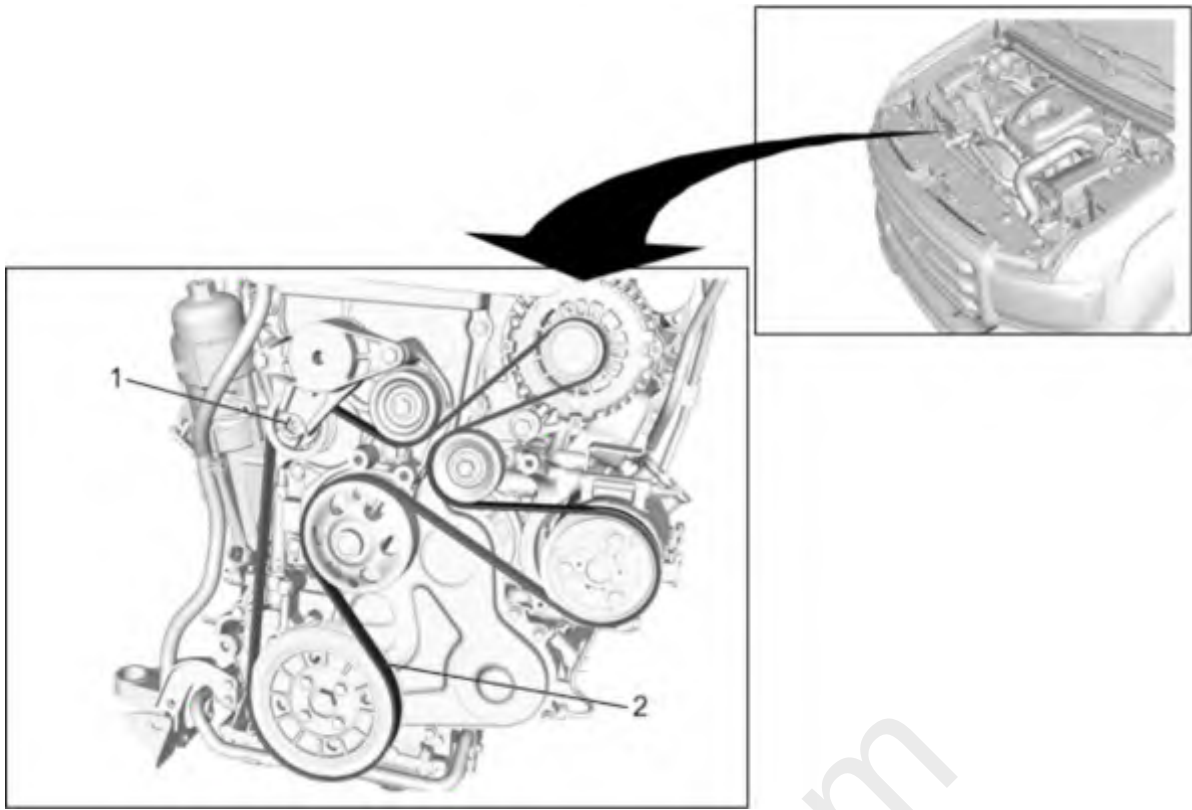


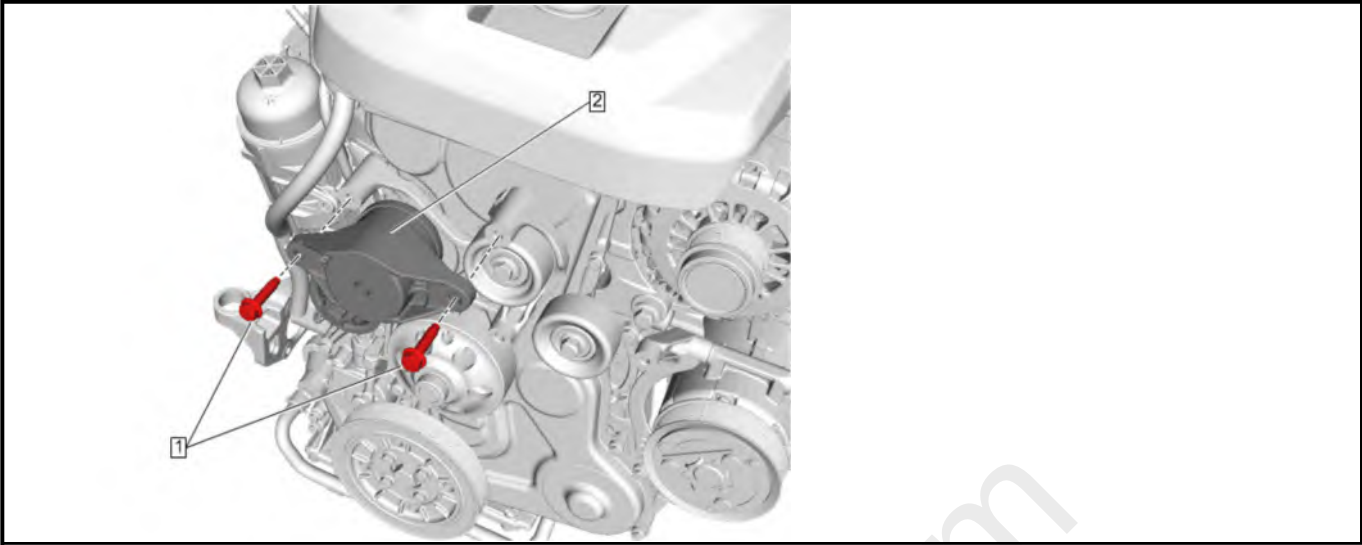
Fig. 10: Drive Belt Routing
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Drive Belt Tensioner Replacement</u> NOTE: The drive belt routes behind the drive belt tensioner pulley. Therefore, it is necessary to remove the drive belt tensioner when removing or installing the drive belt on the pulleys.	
1	Drive Belt Tensioner Procedure Rotate the drive belt tensioner counterclockwise to release the drive belt tension.
2	Drive Belt Procedure 1. Remove the drive belt from the pulleys and tensioner.

Callout	Component Name
	2. Clean and inspect the drive belt surfaces of all the pulleys for damage and proper alignment

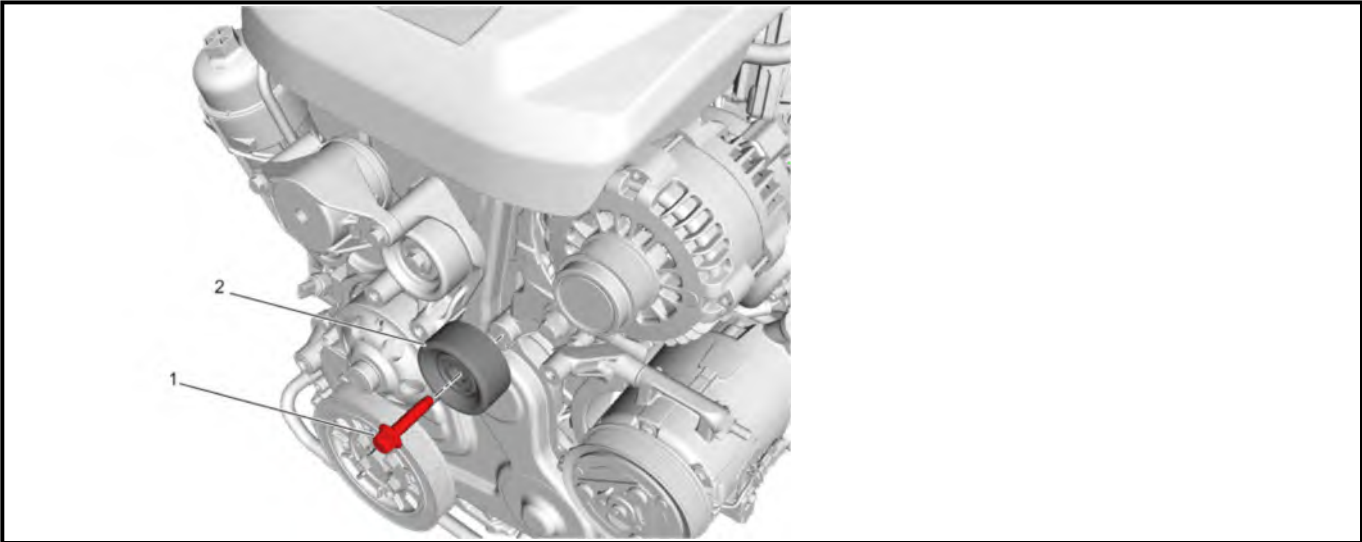
DRIVE BELT TENSIONER REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Drive Belt Replacement</u>	
1	Drive Belt Tensioner Fastener CAUTION: Refer to <u>Fastener Caution</u> . Tighten 25 N.m (18 lb ft)
2	Drive Belt Tensioner

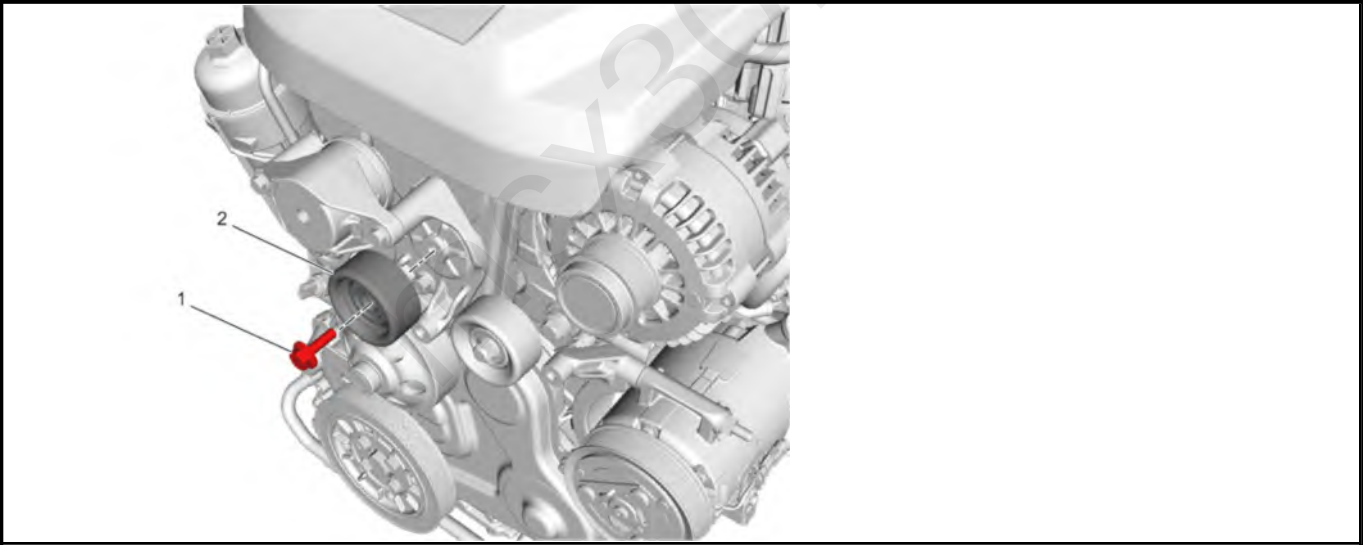
DRIVE BELT IDLER PULLEY REPLACEMENT - LEFT SIDE



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Drive Belt Replacement	
1	Drive Belt Idler Pulley Fastener CAUTION: Refer to Fastener Caution . NOTE: The drive belt idler pulley fastener is left-hand thread. Tighten 50 N.m (37 lb ft)
2	Drive Belt Idler Pulley

DRIVE BELT IDLER PULLEY REPLACEMENT - RIGHT SIDE

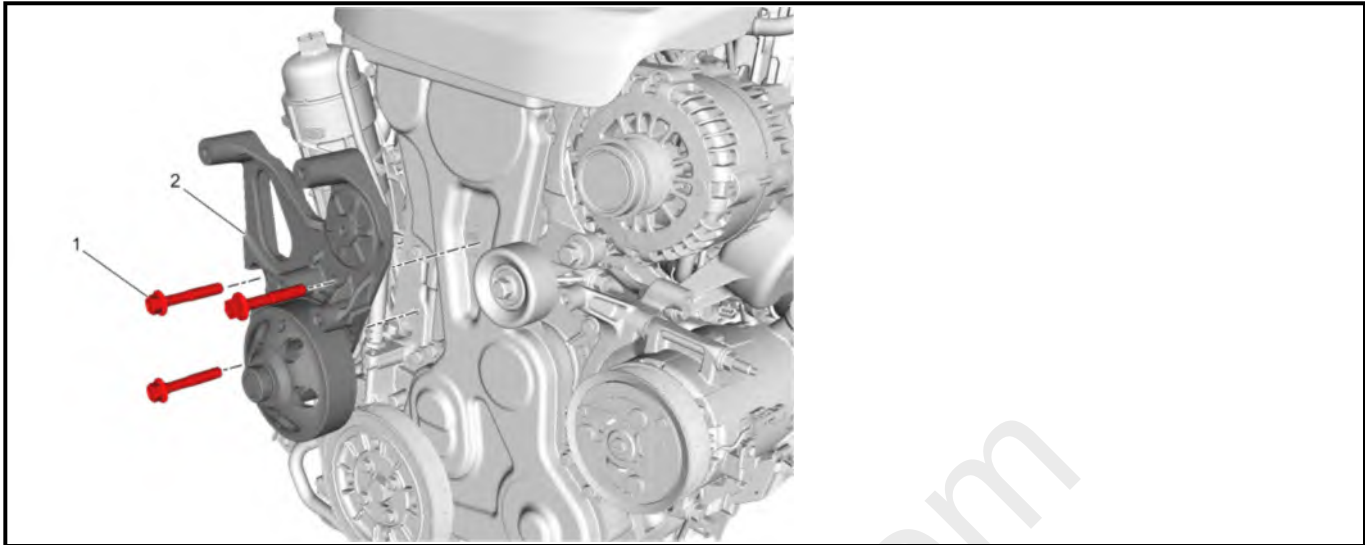


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Drive Belt Replacement	
1	Drive Belt Idler Pulley Fastener CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Tighten 45 N.m (33 lb ft)
2	Drive Belt Idler Pulley

ENGINE COOLING FAN BRACKET REPLACEMENT



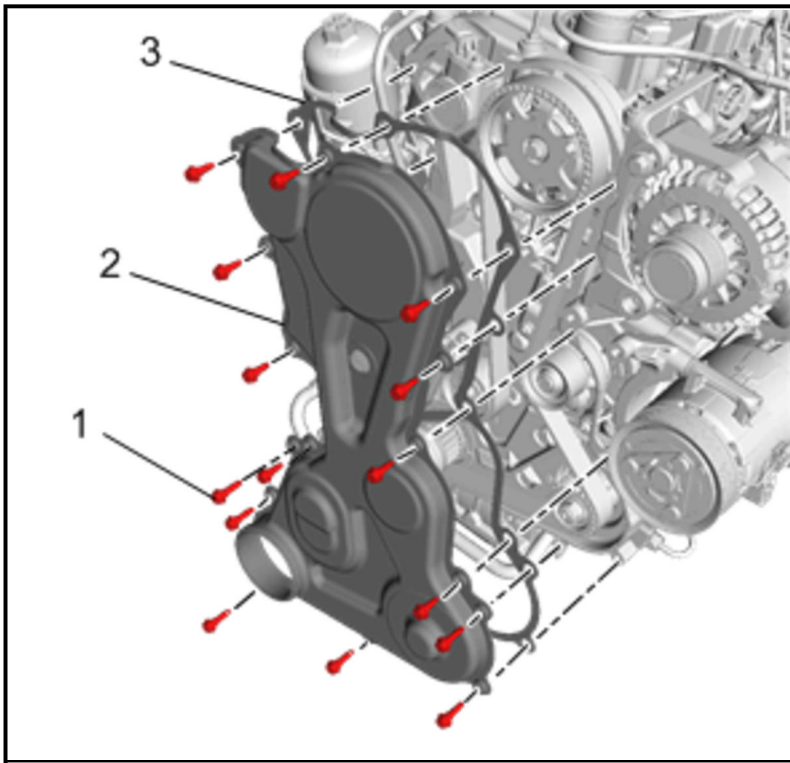
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Fan Blade Clutch Replacement (LWN) Drive Belt Idler Pulley Replacement - Right Side	
1	Engine Coolant Fan Bracket Bolt CAUTION: Refer to Fastener Caution . Tighten 45 N.m (33 lb ft)
2	Engine Coolant Fan Bracket

TIMING BELT FRONT COVER REPLACEMENT

Removal Procedure

- [Engine Cooling Fan Bracket Replacement](#) - Remove
- [Drive Belt Idler Pulley Replacement - Left Side](#) - Remove
- [Drive Belt Tensioner Replacement](#) - Remove
- [Crankshaft Balancer Replacement](#) - Remove
- [Intake Manifold Cover Insulator Replacement \(Top of Engine\)](#), or [Intake Manifold Cover Insulator Replacement \(Left Side\)](#) - Remove
- Timing Belt Front Cover Bolt (1) - Remove [15x]

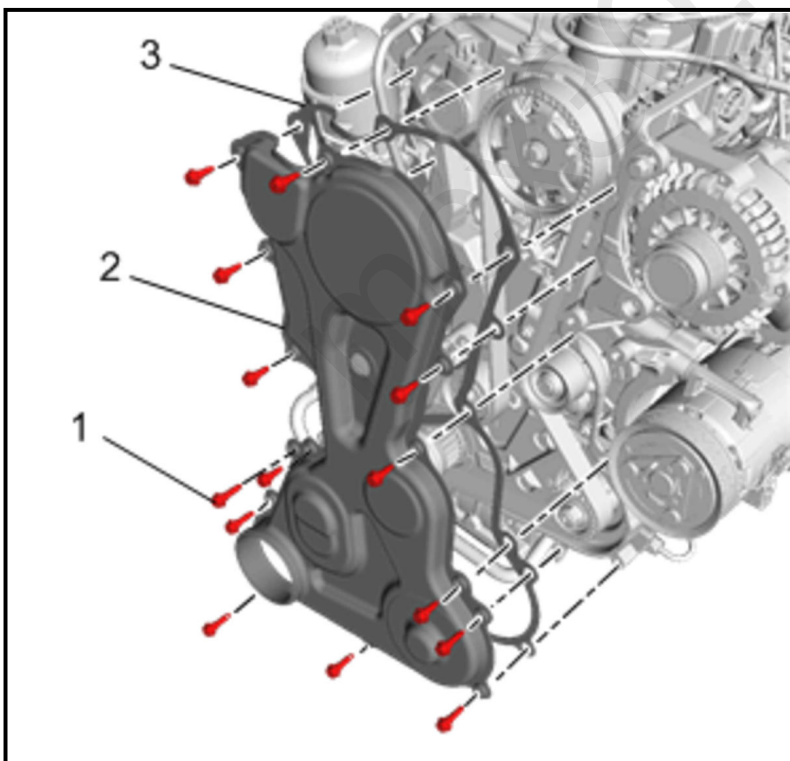


7. Timing Belt Front Cover (2) - Remove

8. Timing Belt Front Cover Gasket (3) - Remove and DISCARD

Installation Procedure

1. Timing Belt Front Cover Gasket (3) - Install

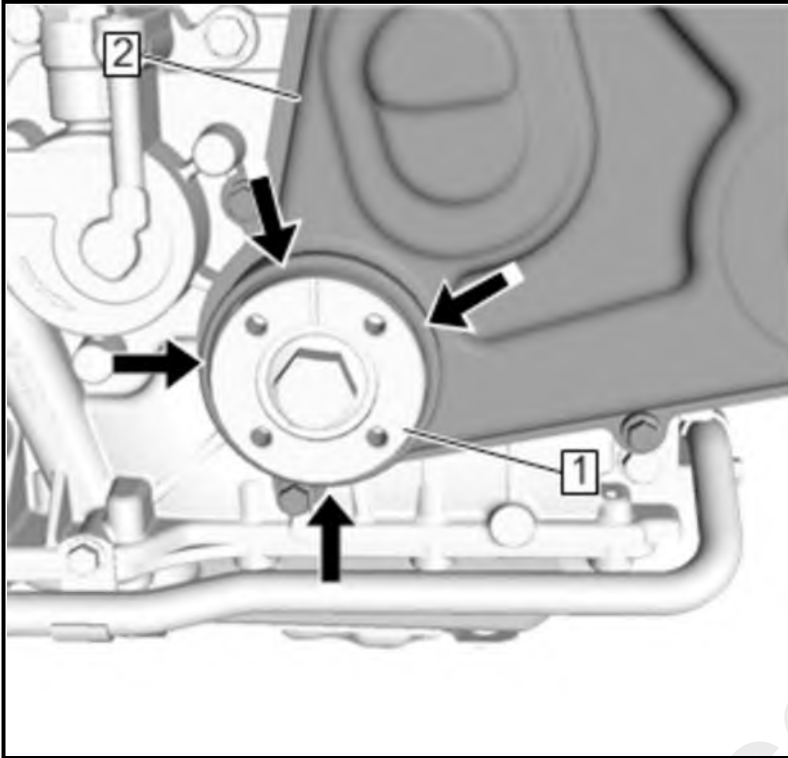


NOTE: Install a NEW gasket.

2. Timing Belt Front Cover (2) - Install

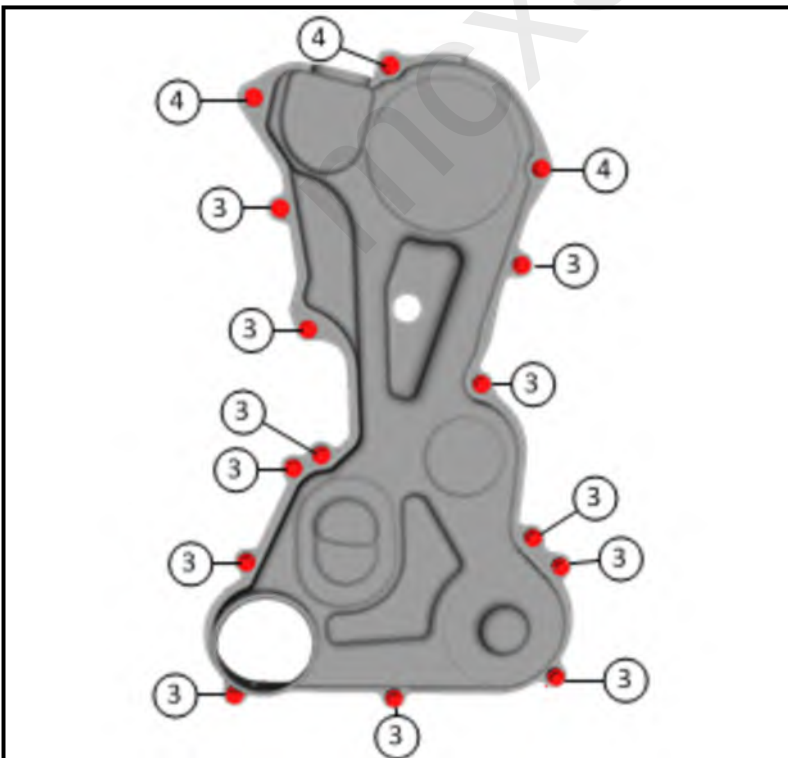
NOTE: Hand tighten only, final tightening will be performed after properly aligning the timing belt front cover to the crankshaft sprocket.

3. Timing Belt Front Cover Bolt (1) - Loosely install [15x]
4. Use a 0.01 mm feeler gauge around crankshaft sprocket (1) to ensure timing belt front cover (2) is not contacting crank sprocket.



NOTE: Start by ensuring there is proper clearance in the area of the arrows then confirm proper clearance throughout the crankshaft sprocket circumference.

5. Timing Belt Front Cover Bolt (3) Tighten 10 N.m (89 lb in) [12x]



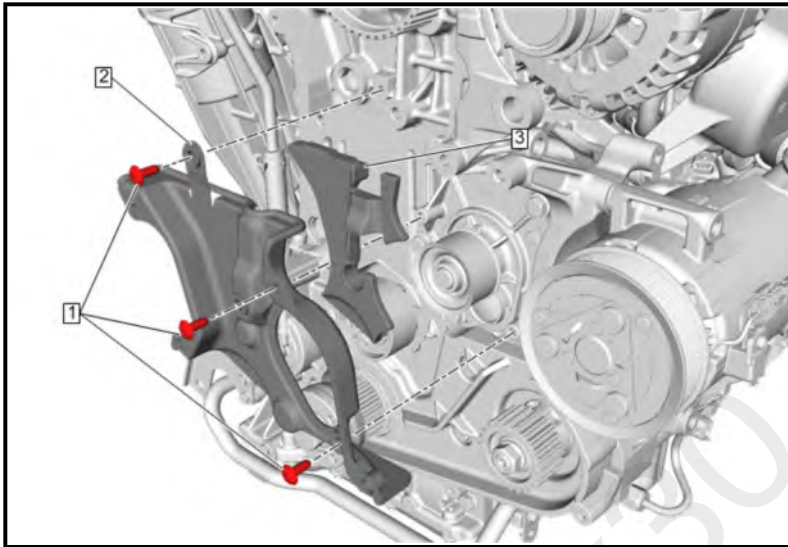
CAUTION: Refer to [Fastener Caution](#) .

NOTE: Once proper clearance is achieved between the timing belt front cover and the crankshaft sprocket, perform final tightening of the timing belt front cover bolts.

6. Timing Belt Front Cover Bolt (4) Tighten 8 N.m (71 lb in) [3x]
7. Engine Cooling Fan Bracket Replacement - Install
8. Drive Belt Idler Pulley Replacement - Left Side - Install
9. Drive Belt Tensioner Replacement - Install
10. Crankshaft Balancer Replacement - Install
11. Intake Manifold Cover Insulator Replacement (Top of Engine), or Intake Manifold Cover Insulator Replacement (Left Side) - Install

TIMING BELT REAR COVER REPLACEMENT

Timing Belt Rear Cover Installation



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Timing Belt Replacement</u>	
1	Timing Belt Rear Cover Bolt [3x] CAUTION: Refer to <u>Fastener</u> <u>Caution</u> . Tighten 11 N.m (97 lb in)
2	Timing Belt Rear Cover
3	Timing Belt Rear Cover Gasket

TIMING BELT REPLACEMENT

Special Tools

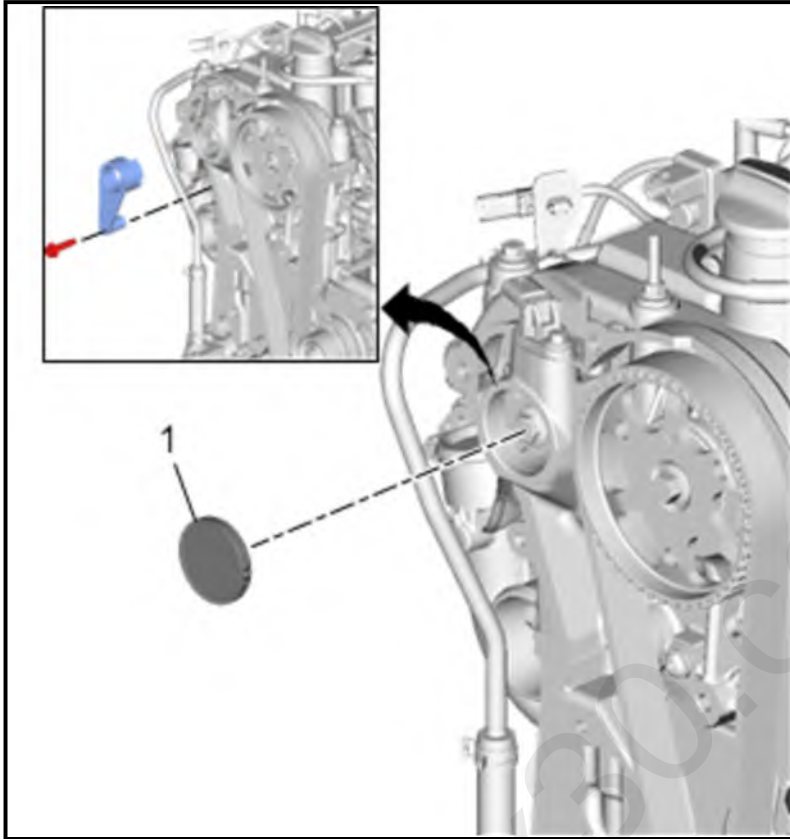
- EN-50025 Pulley Holding Wrench
- EN-51265 Crankshaft Locking Tool

- **EN-51025** Camshaft Timing Tool

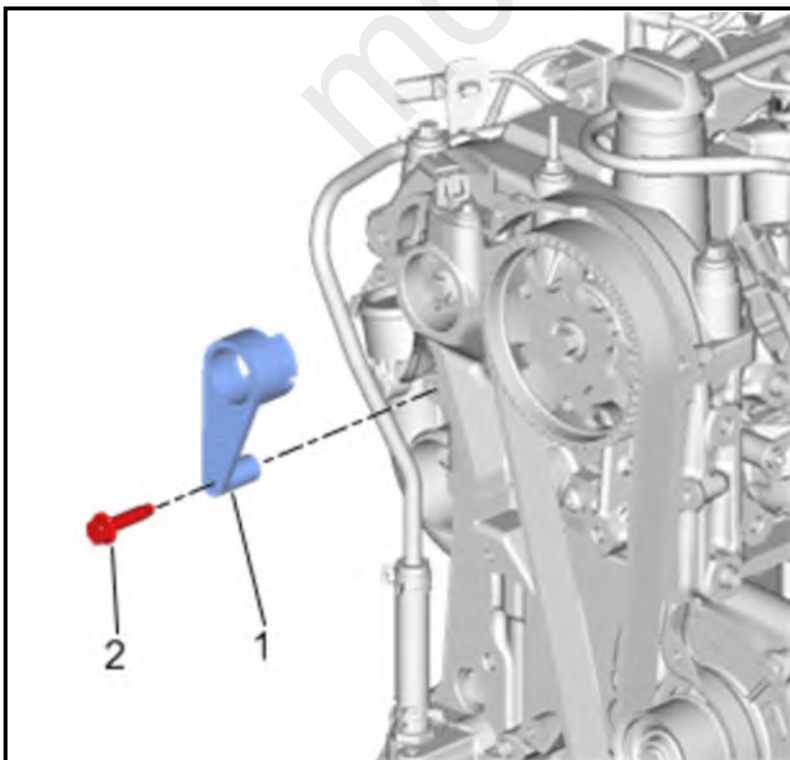
Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Timing Belt Front Cover - Remove - [Timing Belt Front Cover Replacement](#)
2. Remove and DISCARD the core plug (1).

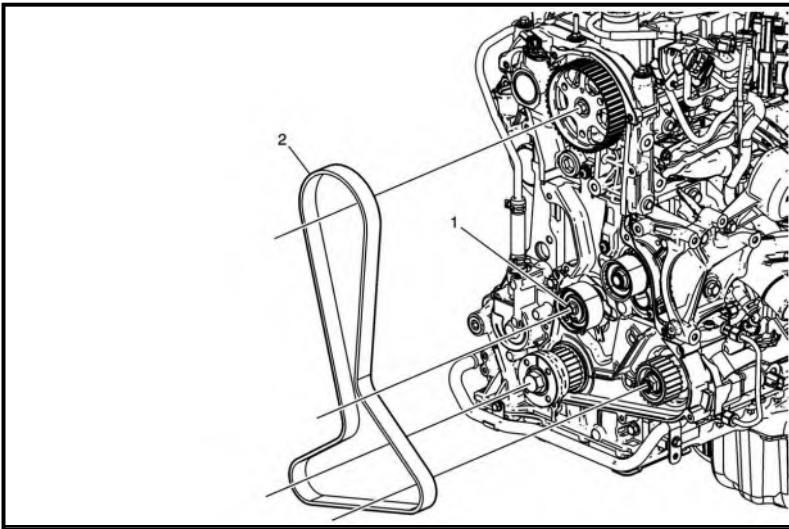


3. Install **EN-51025** timing tool (1) on the exhaust camshaft.



NOTE: Rotate the crankshaft balancer to allow the EN-51025 timing tool to be fully seated.

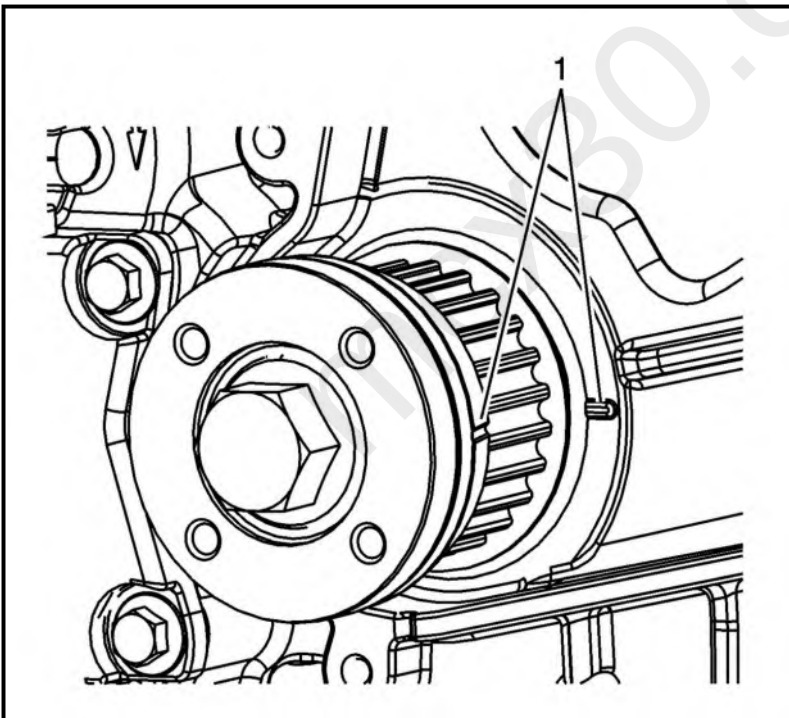
4. Timing Belt Tensioner Bolt (1) - Loosen



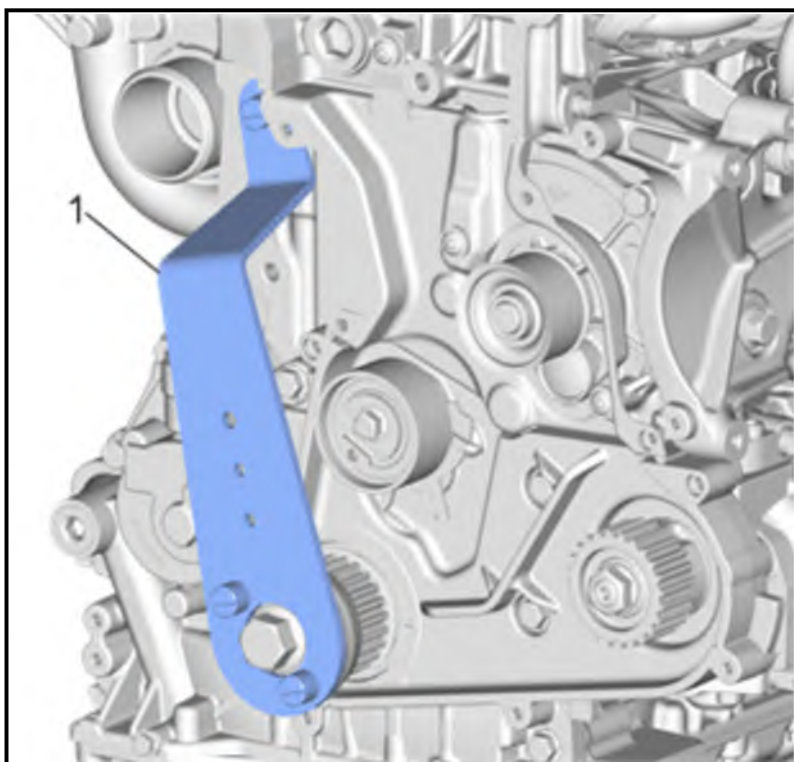
5. Timing Belt (2) - Remove

Installation Procedure

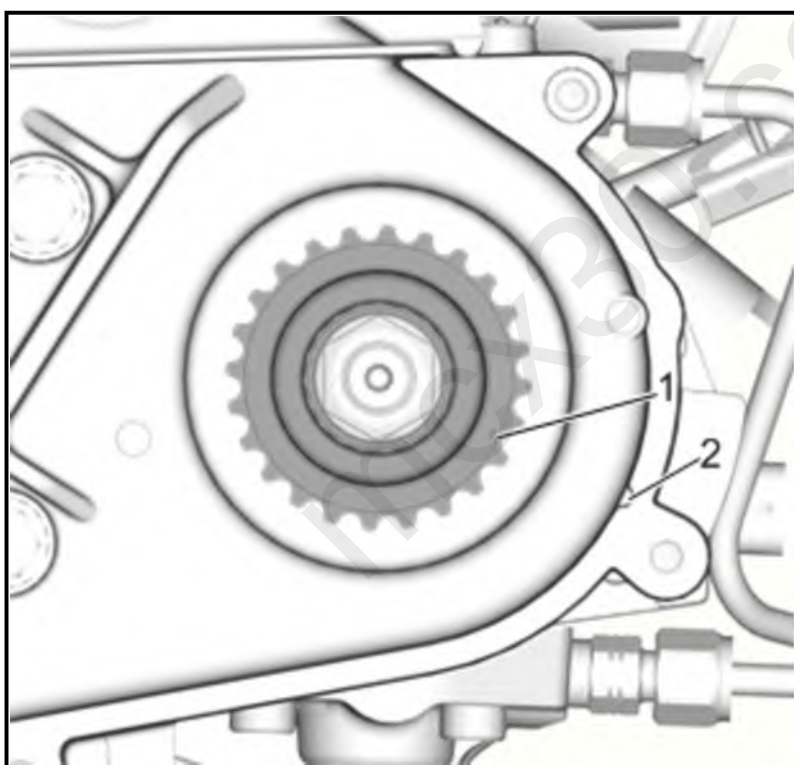
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees ATDC with the mark on the front cover (1).



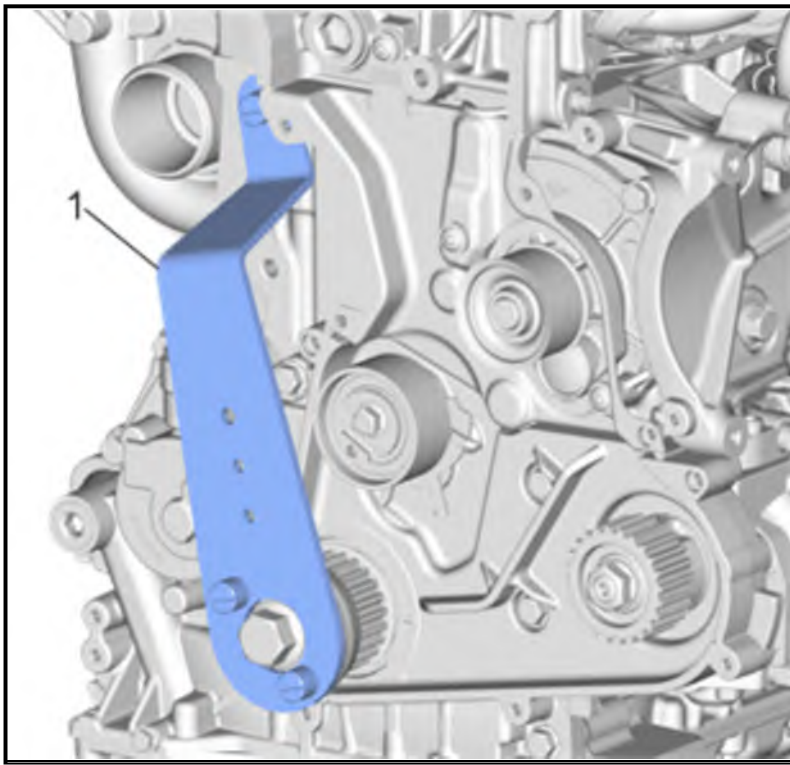
2. Install **EN-51265** locking tool.



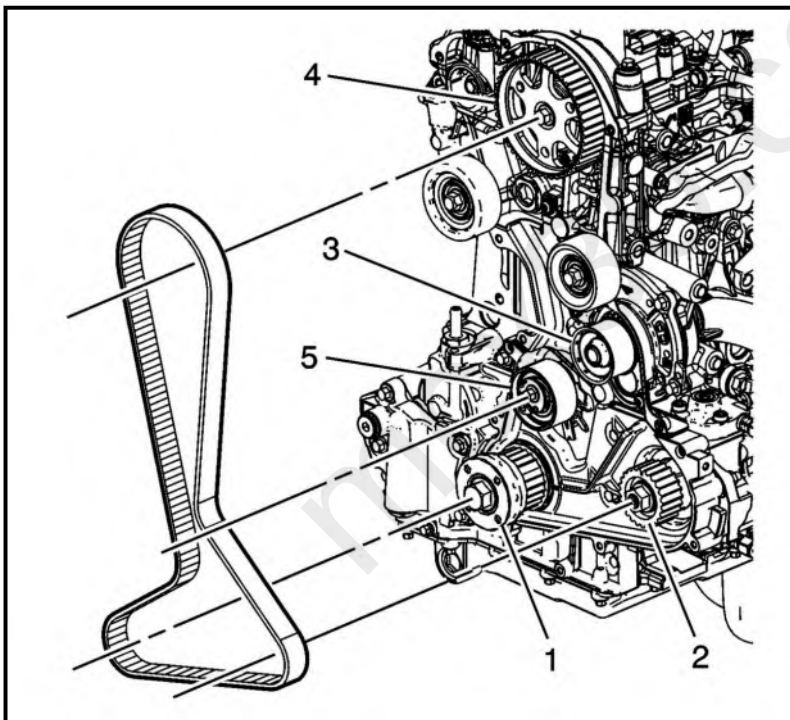
3. Align the fuel injection pump pulley timing notch (1) with the notch on the front cover (2).



4. Remove **EN-51265** locking tool.



5. Install the timing belt over the pulleys in the following order:

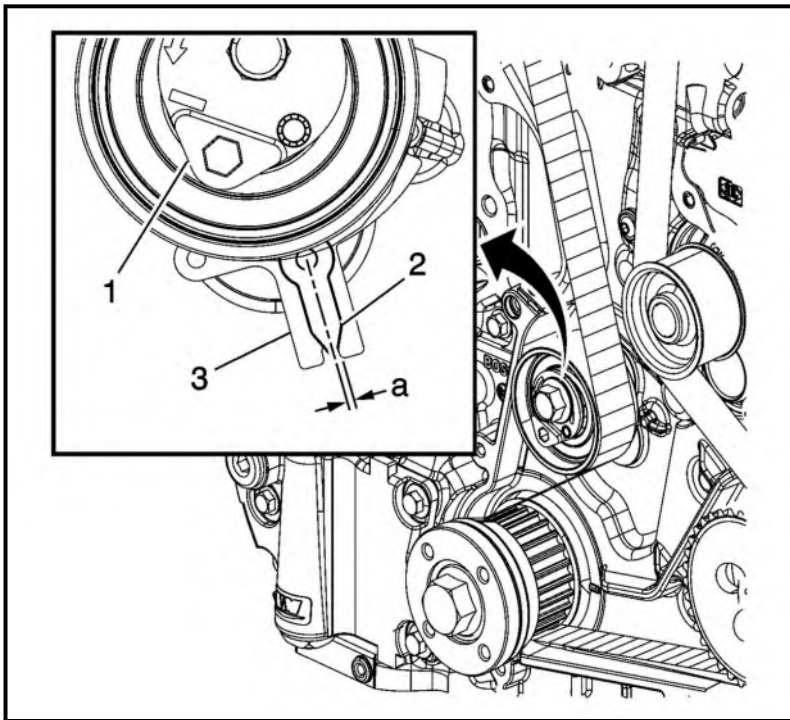


NOTE:

- Relieve the tensioner in order to fit the belt over the pulleys.
- The Intake Camshaft Pulley must be loose in order to install the timing belt, otherwise it will not fit over the tensioner pulley.

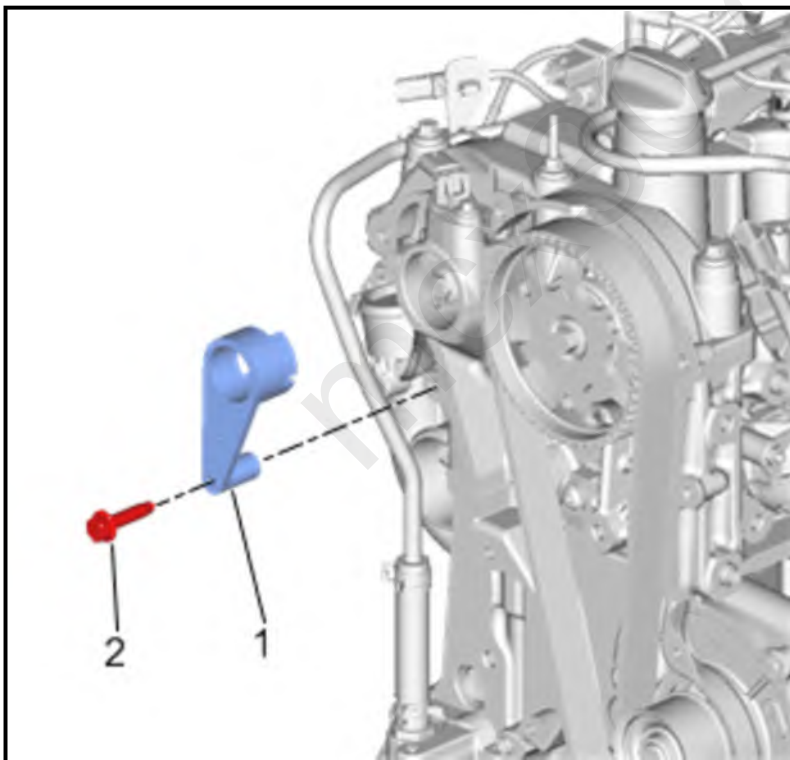
1. Crankshaft
2. Injector pump
3. Water pump
4. Camshaft
5. Tensioner

6. Move the tensioner pulley by rotating the plate (1) counterclockwise until the pointer (2) is positioned in the groove at the edge of the index (3), within 1 mm, dimension (a).



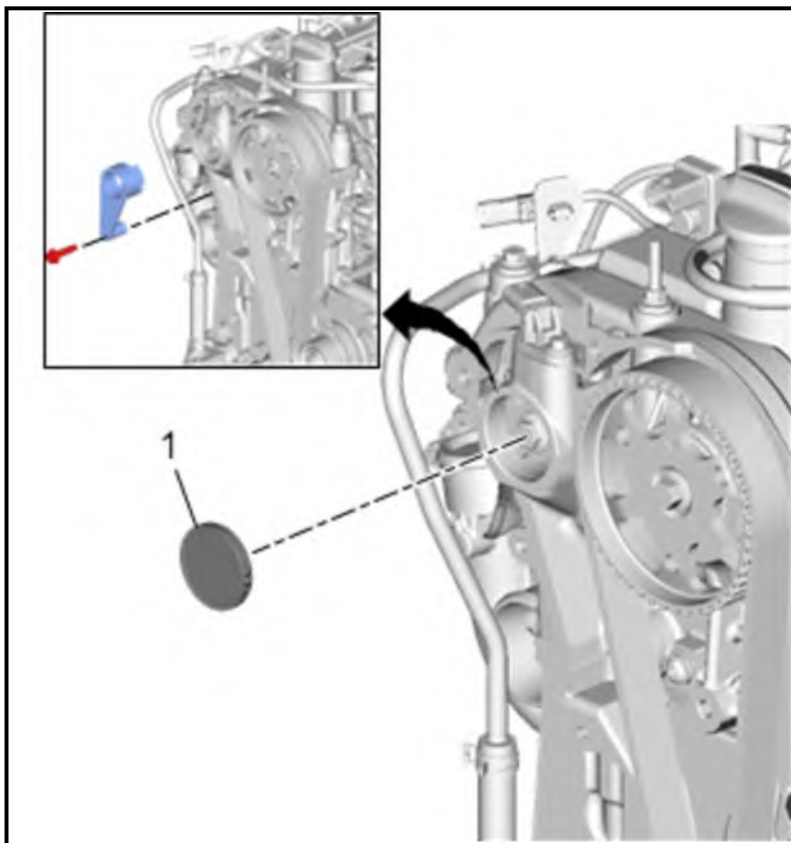
CAUTION: Refer to [Fastener Caution](#) .

7. Tighten the timing belt tensioner to 28 N.m (21 lb ft).
8. Remove the EN-51025 timing tool (1).



NOTE: Ensure the plug is fully seated in the bore.

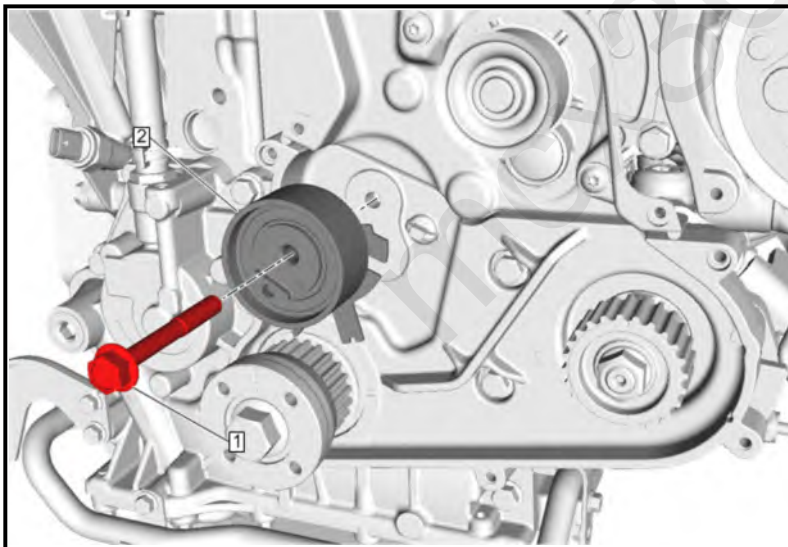
9. Rotate the engine two full revolutions to ensure proper alignment of timing marks.
10. Install a NEW plug (1).



NOTE: Ensure the plug is fully seated in the bore.

11. Timing Belt Front Cover - Install - [Timing Belt Front Cover Replacement](#)

TIMING BELT TENSIONER REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

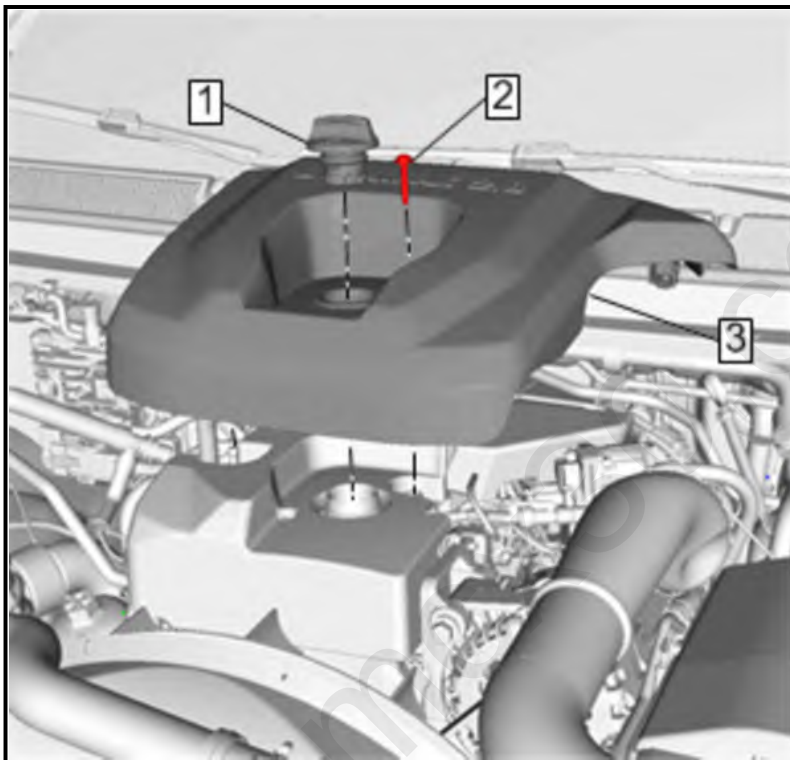
Callout	Component Name
Preliminary Procedure Timing Belt Replacement	
1	Timing Belt Tensioner Fastener CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Procedure 1. Loosely install 2. Properly adjust and tighten the timing belt tensioner during timing belt installation. Tighten 28 N.m (21 lb ft)
2	Timing Belt Tensioner

INTAKE MANIFOLD COVER REPLACEMENT

Removal Procedure

1. Engine Oil Filler Cap (1) - Remove



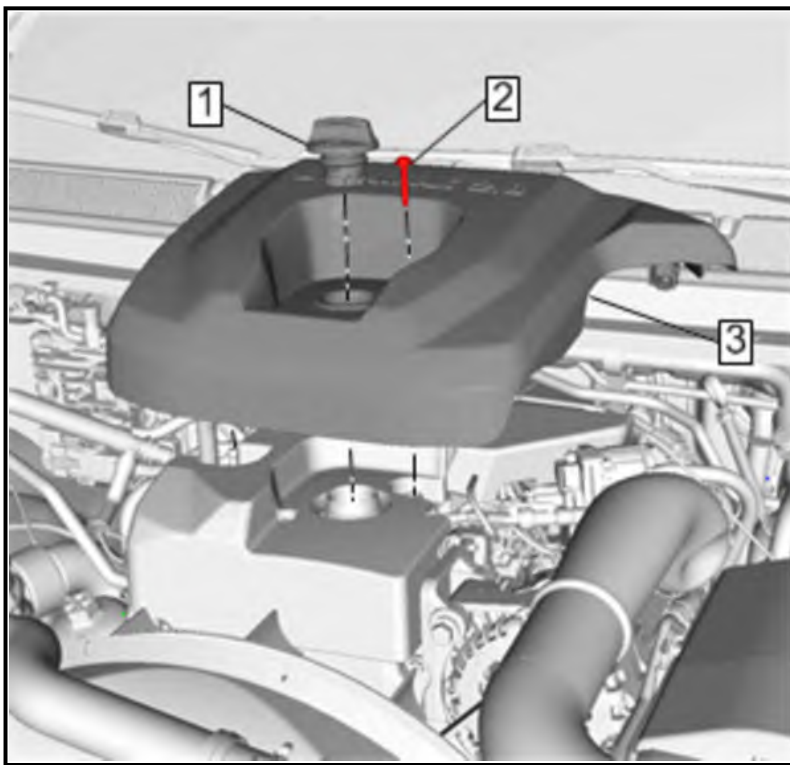
2. Intake Manifold Cover Fastener (2) - Remove
3. Power Brake Booster Vacuum Hose - Reposition - [Power Brake Booster Vacuum Hose Replacement \(LWN\)](#)

NOTE: Pull the intake manifold cover upward to remove.

4. Intake Manifold Cover (3) - Remove

Installation Procedure

1. Intake Manifold Cover (3) - Install



2. Power Brake Booster Vacuum Hose - Install - [Power Brake Booster Vacuum Hose Replacement \(LWN\)](#)

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

3. Intake Manifold Cover Fastener (2) - Install and tighten 10 N.m (89 lb in)

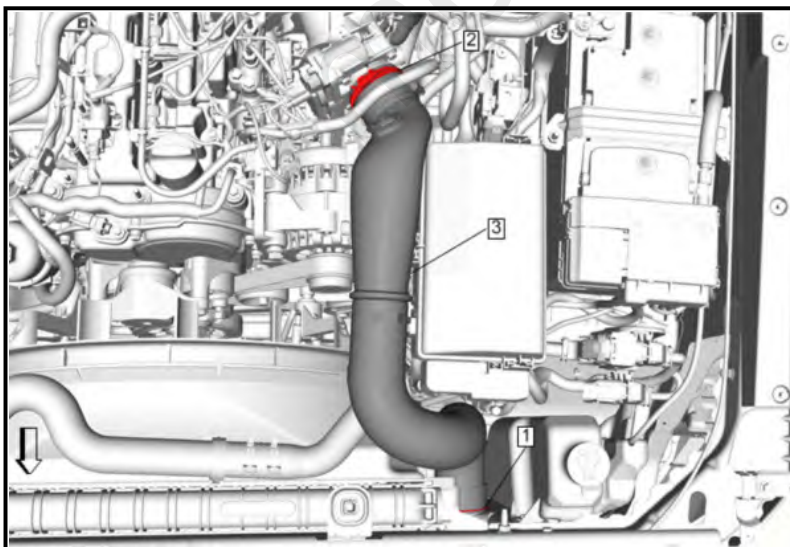
4. Engine Oil Filler Cap (1) - Install

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. [Battery Negative Cable Disconnection and Connection](#) - Disconnect

2. Charge Air Cooler Outlet Duct (3) - Remove - [Charge Air Cooler Outlet Duct Replacement](#)



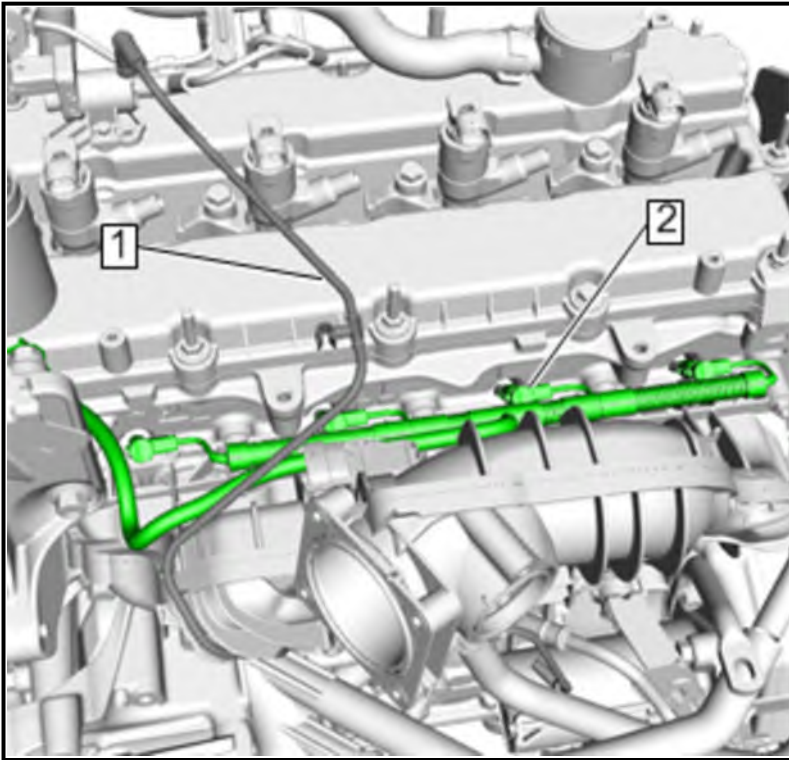
3. [Throttle Body Assembly Replacement](#) - Remove

4. [Fuel Injector Deadener Replacement](#) - Remove

5. Remove the exhaust gas recirculation valve assembly. [Exhaust Gas Recirculation Valve Replacement](#)

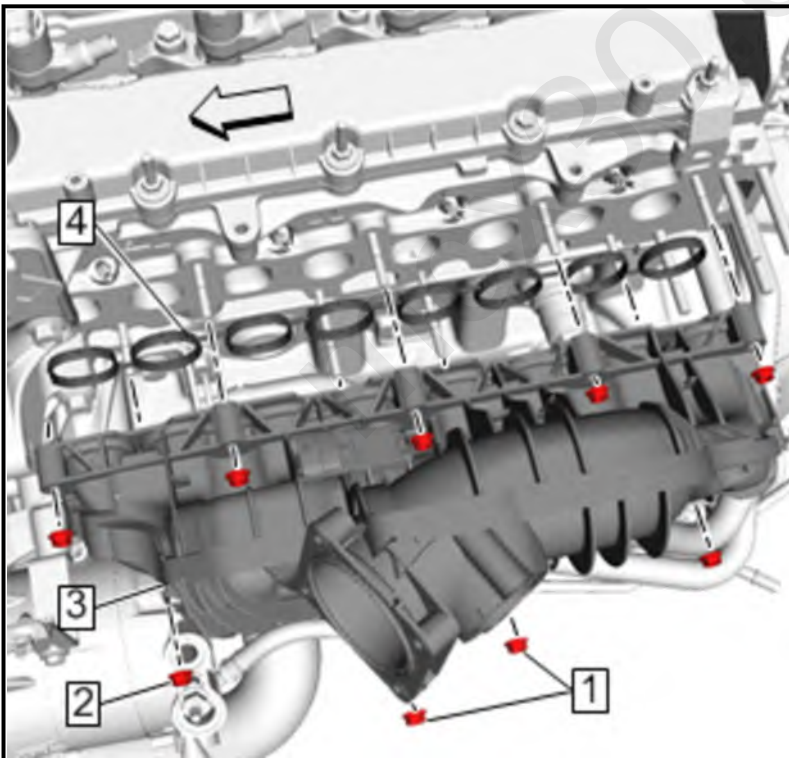
6. [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#) , or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#) - Remove

7. Wiring Harness (1) - Disconnect



8. Vacuum Pipe (2) - Remove

9. Intake Manifold Nut (1, 2) - Remove [9x]



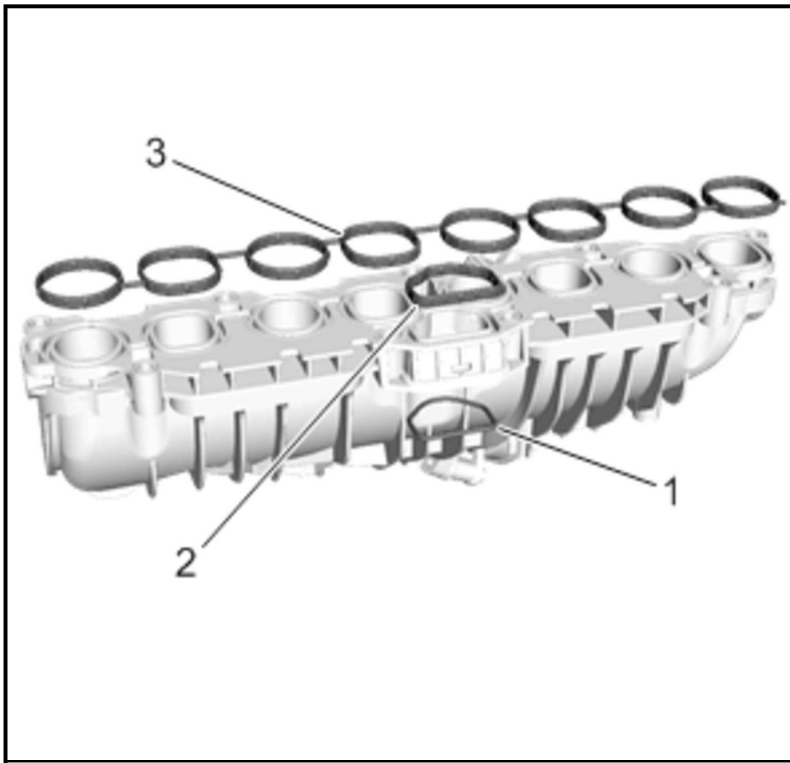
NOTE: Nuts (1) mount the engine coolant thermostat housing to the intake manifold and cylinder head.

1. **ENGINE COOLANT THERMOSTAT REPLACEMENT (LWN)** - Remove

2. Intake Manifold (3) - Remove

3. Intake Manifold Gasket (4) - Remove and DISCARD

10. Remove and DISCARD the gaskets (1-3).

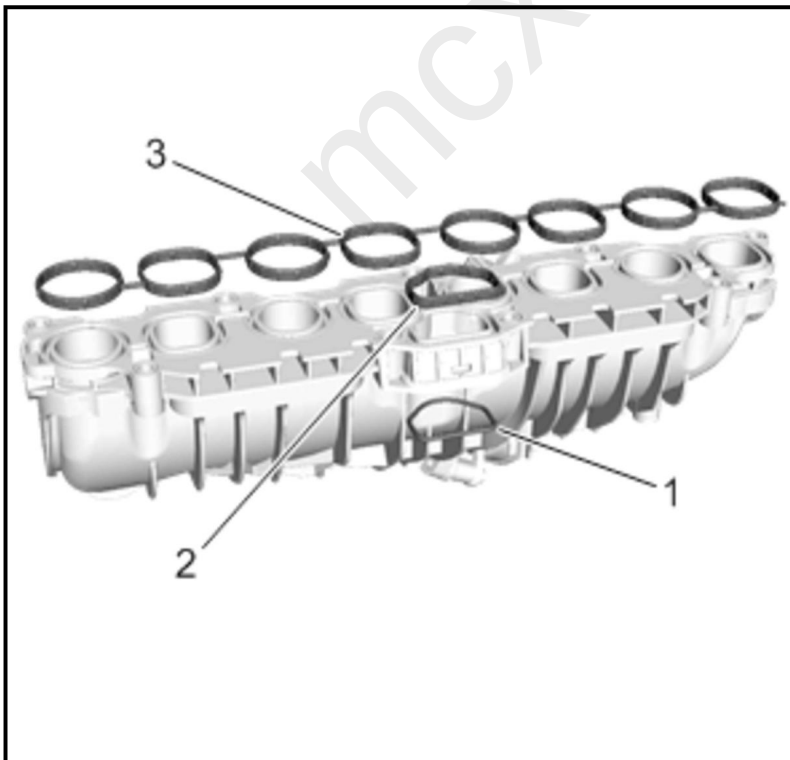


NOTE: The intake manifold has 3 gaskets, be sure to remove and DISCARD all three gaskets.

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

Installation Procedure

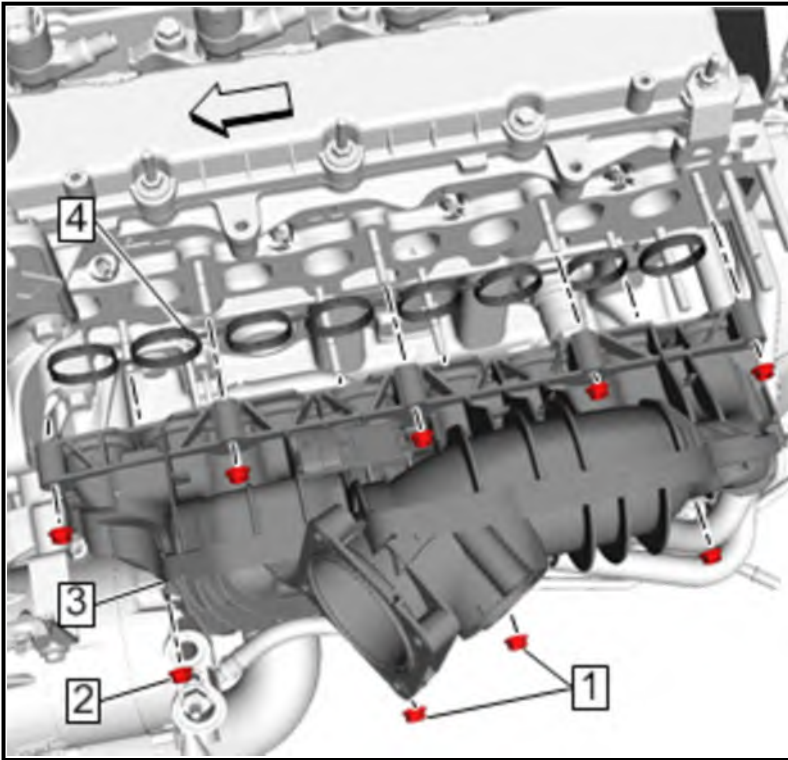
1. If replacing the intake manifold, transfer all necessary parts. [Intake Manifold Assemble](#)
2. Install a NEW intake manifold gasket. (3)



NOTE: Ensure that all 3 gaskets are replaced when installing the intake manifold.

3. Install a NEW thermostat housing gaskets (1 and 2).

4. Ensure the gasket (4) remains seated during intake manifold installation.



NOTE: Nuts (1) mount the engine coolant thermostat housing to the intake manifold and cylinder head. Hand start ALL nuts before final tightening sequence.

1. Intake Manifold (3) - Install
2. Intake Manifold Nut (2) - Install [7x]
3. **ENGINE COOLANT THERMOSTAT REPLACEMENT (LWN)** - Install
5. Tighten in the sequence shown.

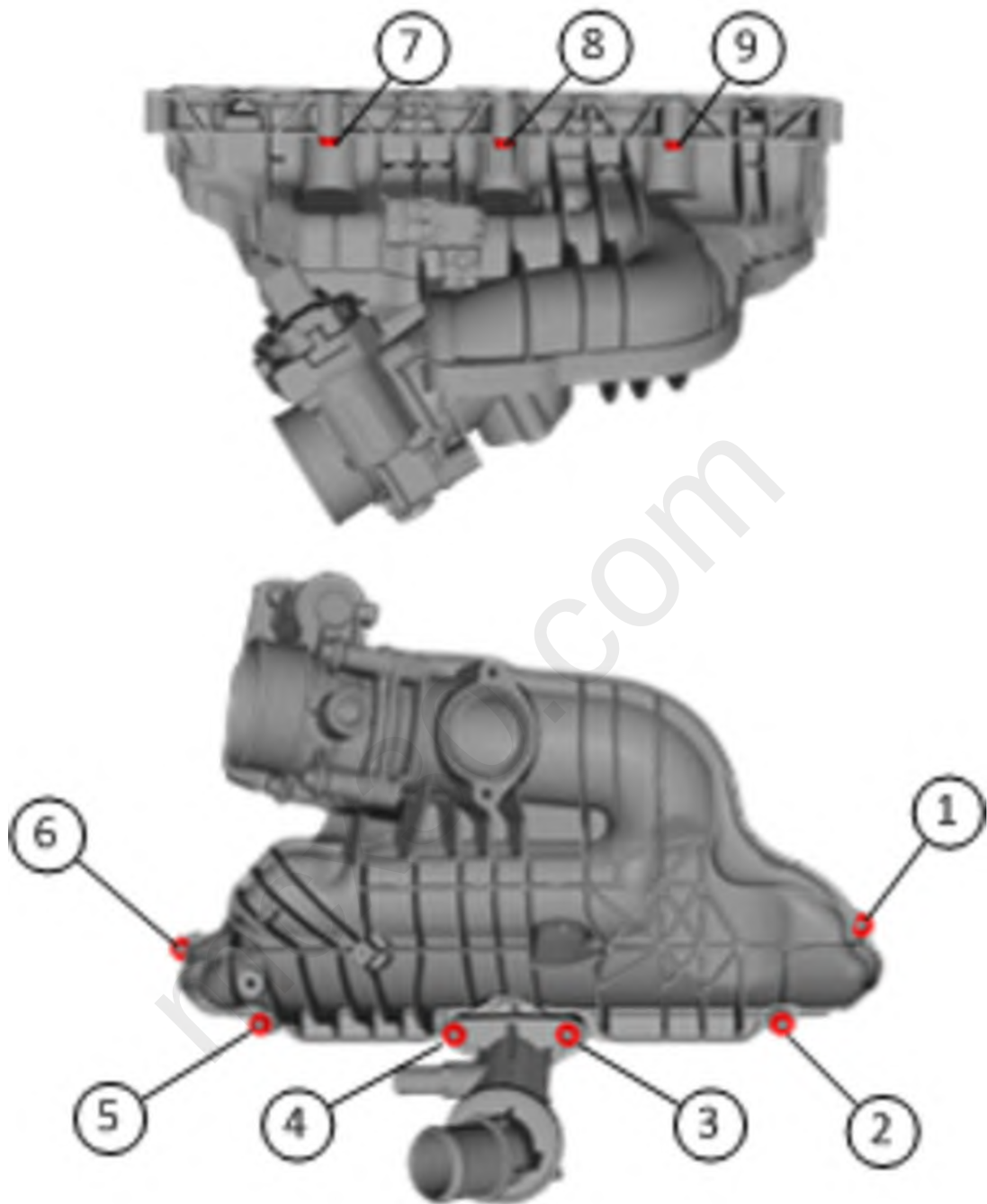
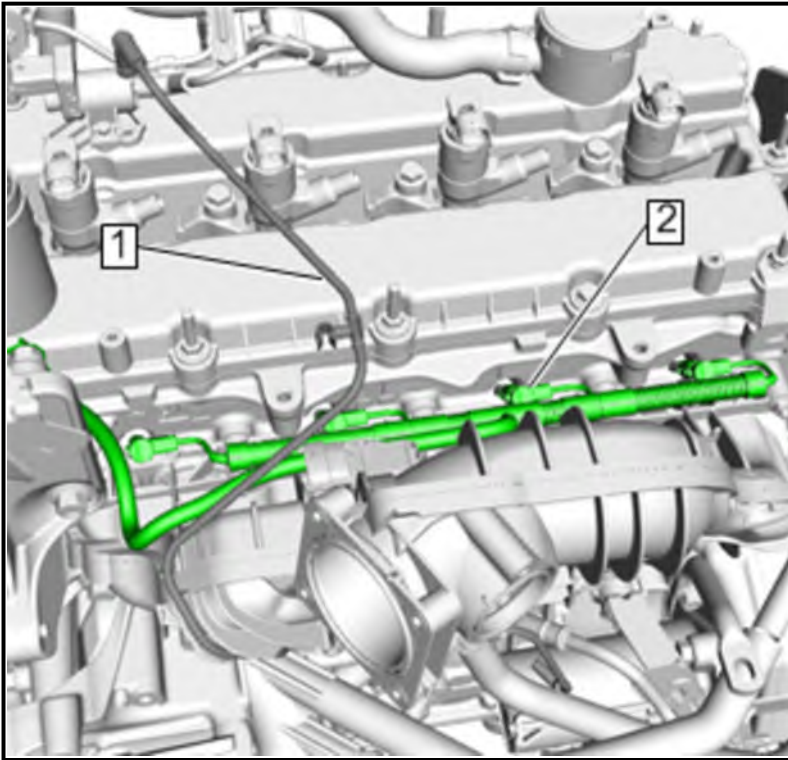


Fig. 11: Intake Manifold Nut Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

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

1. First pass, torque to 5 N.m (44 lb in): 1, 4, 6, 2, 3, 5.
2. Final pass, torque to 12 N.m (106 lb in): 1, 2, 3, 4, 5, 6, 7, 8, 9
6. Install the exhaust gas recirculation valve assembly. [Exhaust Gas Recirculation Valve Replacement](#)
7. [Fuel Injector Deadener Replacement](#) - Install
8. [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#) , or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#) - Install

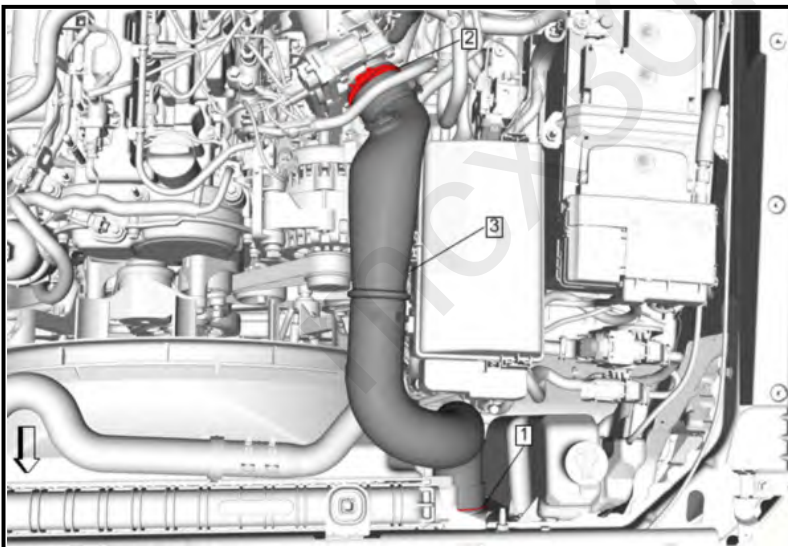
9. Wiring Harness (1) - Connect



10. Vacuum Pipe (2) - Install

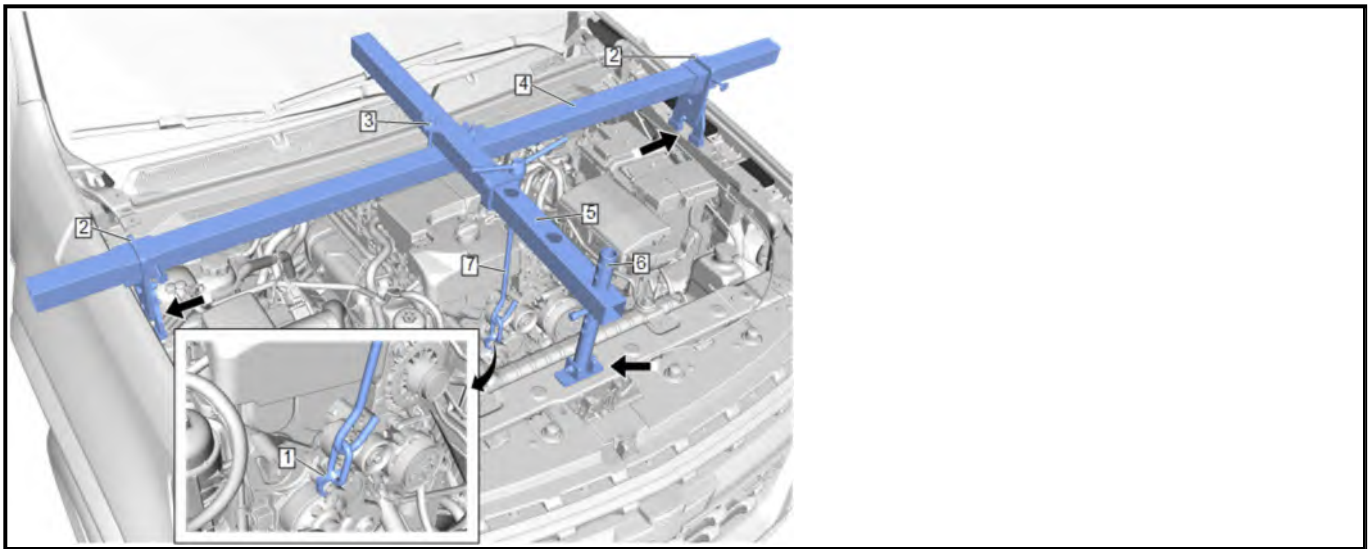
11. Throttle Body Assembly Replacement - Install

12. Charge Air Cooler Outlet Duct (3) - Install - Charge Air Cooler Outlet Duct Replacement



13. Battery Negative Cable Disconnection and Connection - Connect

ENGINE SUPPORT FIXTURE



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures 1. Engine Coolant Fan Shroud Replacement (LWN) 2. Drive Belt Tensioner Replacement 3. Front Compartment Side Sight Shield Replacement - Remove intake air splash shield retainers at the fender and reposition intake air splash shield. Intake Air Splash Shield Replacement	
Special Tools • EN-51007-1 Main Support Beam • EN-51007-3 Radiator Support Beam • EN-51007-4 Clamp • EN-51007-5 Support Leg, Front • EN-51007-6 Hook • EN-51007-7 Support Leg, Side • EN-36857 Engine Lift Bracket	
Equivalent regional tools: Special Tools .	
1	EN-36857 Engine Lift Bracket Procedure Engine Lift Bracket (1) - Install
2	EN-51007-7 Support Leg, Side Procedure NOTE: Ensure that the engine support fixture only contacts the frame in the area indicated by arrows. Do not install on

Callout	Component Name
	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

ENGINE MOUNT INSPECTION

CAUTION: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

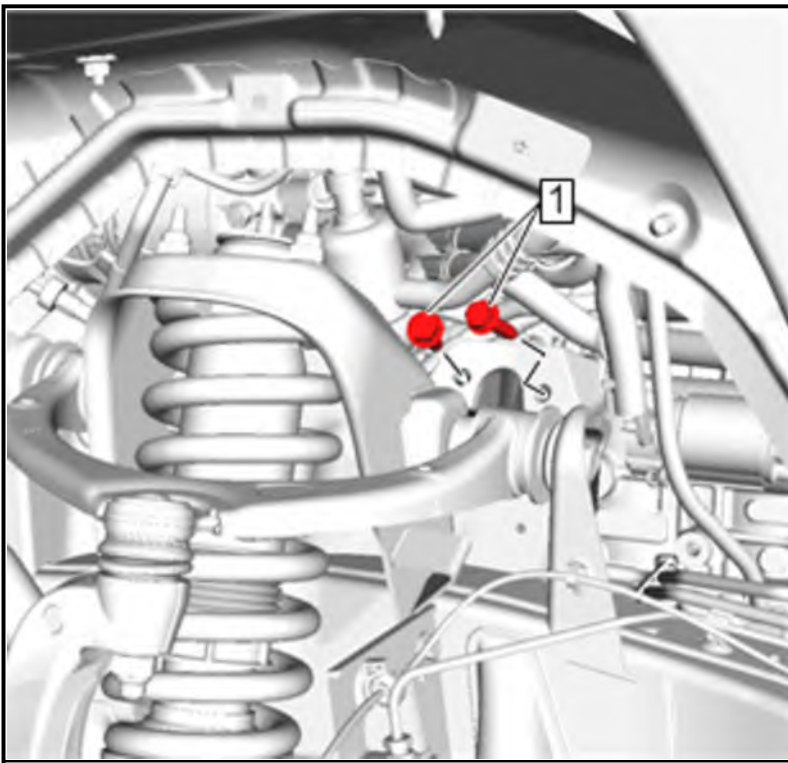
CAUTION: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

- Measure the engine movement at the engine mount in order to inspect for damage to the rubber portions of the mount.
 - Apply the park brake.
 - Start the engine.
 - Firmly apply and hold the primary brakes.
 - Have an assistant stand to the side of the vehicle in order to observe for engine movement.
 - Slightly load the engine shifting from drive to reverse a few times.
 - If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, inspect for loose engine mount bolts.
- If the engine mount bolt torque is within specifications, inspect the condition of the engine mount.
- Replace the engine mount if any of the following conditions exist:
 - Heat check cracks cover the rubber cushion surface.
 - The rubber cushion is separated from the metal plate of the mount.
 - There is a split through the rubber cushion.

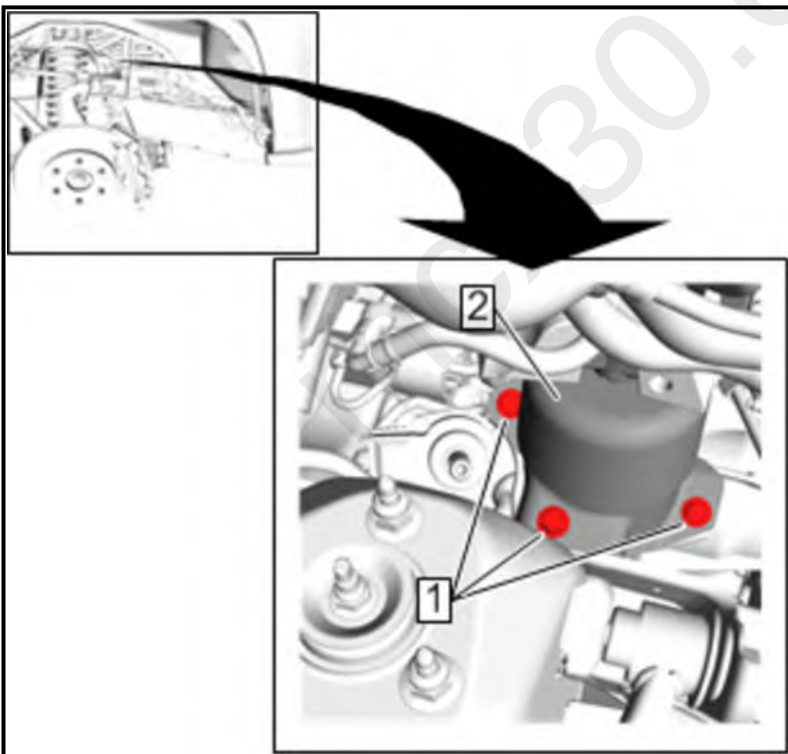
ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

- Intake Manifold Cover Replacement** - Remove
- Front Wheelhouse Liner Replacement (Without ZR2)** , or **Front Wheelhouse Liner Replacement (With ZR2)** , or **Front Wheelhouse Liner Replacement (Bison)** - Remove
- Engine Support Fixture** - Install
- Engine Mount Bracket Fastener (1) - Remove and DISCARD [2x]



5. Front Axle Propeller Shaft Replacement (Without Bison) , or Front Axle Propeller Shaft Replacement (With Bison) - Remove
6. Fuel Pump Fuel Feed Hose Replacement - Remove
7. Engine Mount Fastener (1) - Remove [3x]

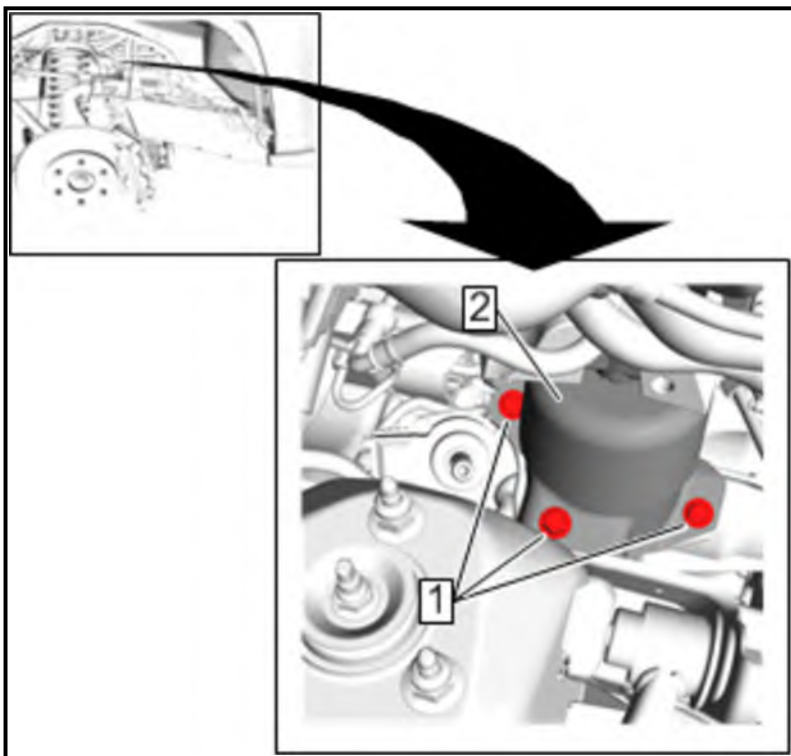


8. Engine Mount (2) - Remove

Installation Procedure

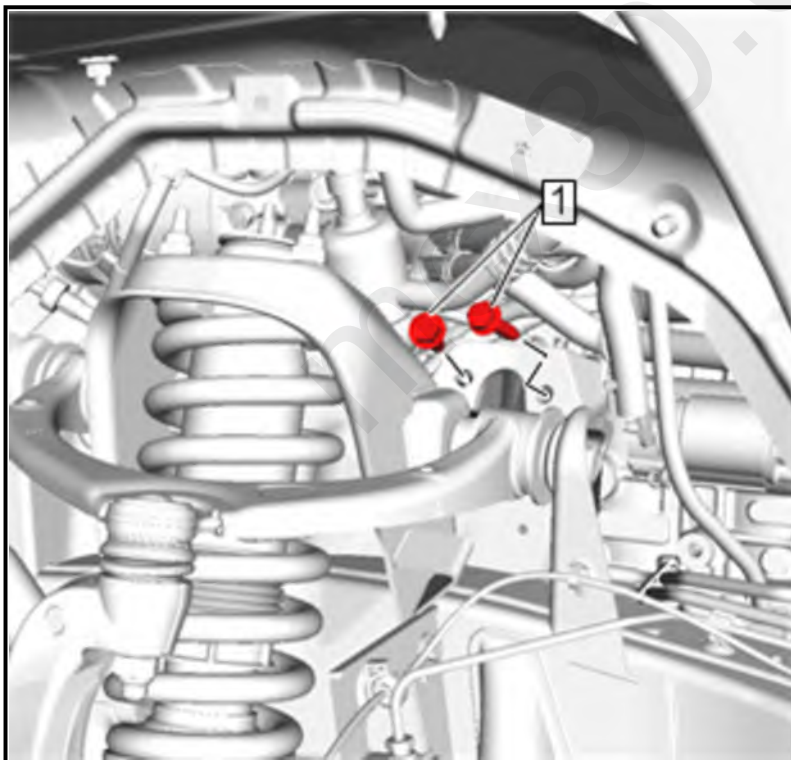
NOTE: For ease of installation, hand start all engine mount fasteners prior to tightening.

1. Engine Mount (2) - Install



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

2. Engine Mount Fastener (1) - Install and tighten [3x] 70 N.m (52 lb ft)
3. Engine Mount Bracket Fastener (1) - Install [2x]



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.

NOTE: Install NEW fasteners. (1)

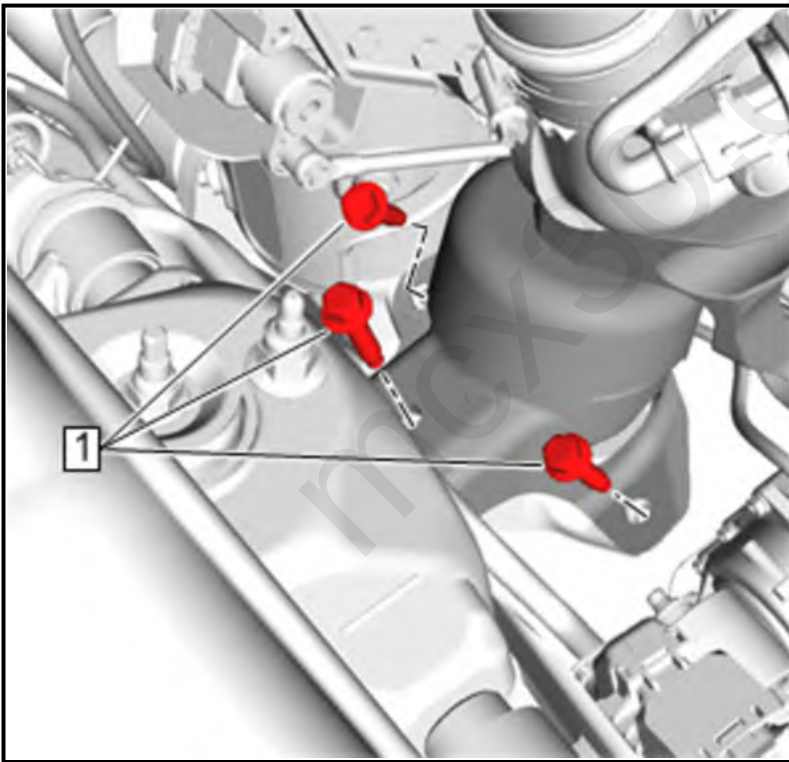
Tighten

1. First Pass 50 N.m (37 lb ft)
2. Final Pass 68 degrees
4. Engine Support Fixture - Remove
5. Fuel Pump Fuel Feed Hose Replacement - Install
6. Front Axle Propeller Shaft Replacement (Without Bison) , or Front Axle Propeller Shaft Replacement (With Bison) - Install
7. Front Wheelhouse Liner Replacement (Without ZR2) , or Front Wheelhouse Liner Replacement (With ZR2) , or Front Wheelhouse Liner Replacement (Bison) - Install
8. Intake Manifold Cover Replacement - Install

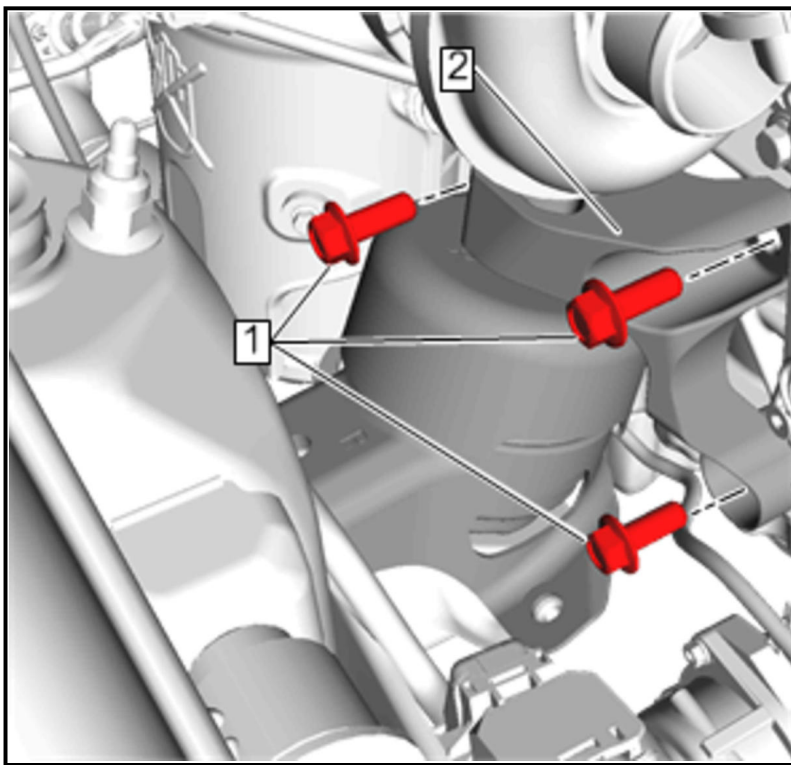
ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Intake Manifold Cover Replacement - Remove
2. Air Cleaner Assembly Replacement - Remove
3. Charge Air Cooler Inlet Duct Replacement - Remove
4. Engine Support Fixture - Install
5. Engine Front Mount Bracket Bolt (1) - Remove [3x]



6. Engine Mount Bolt (1) - Remove [3x]

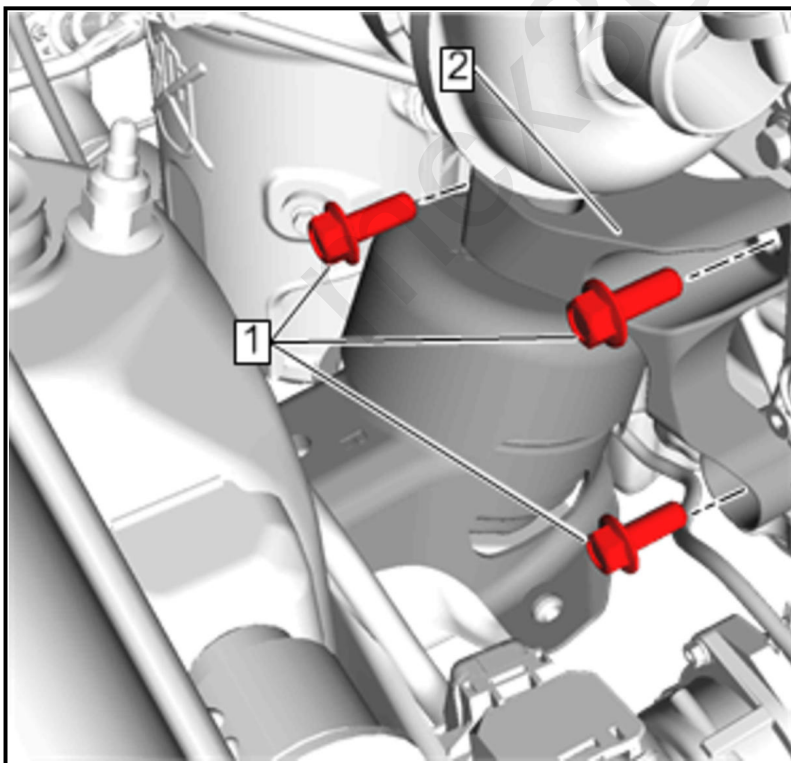


NOTE: Remove the engine mount and engine mount bracket as an assembly.

7. Engine Mount (2) - Remove

Installation Procedure

1. Engine Mount (2) - Install

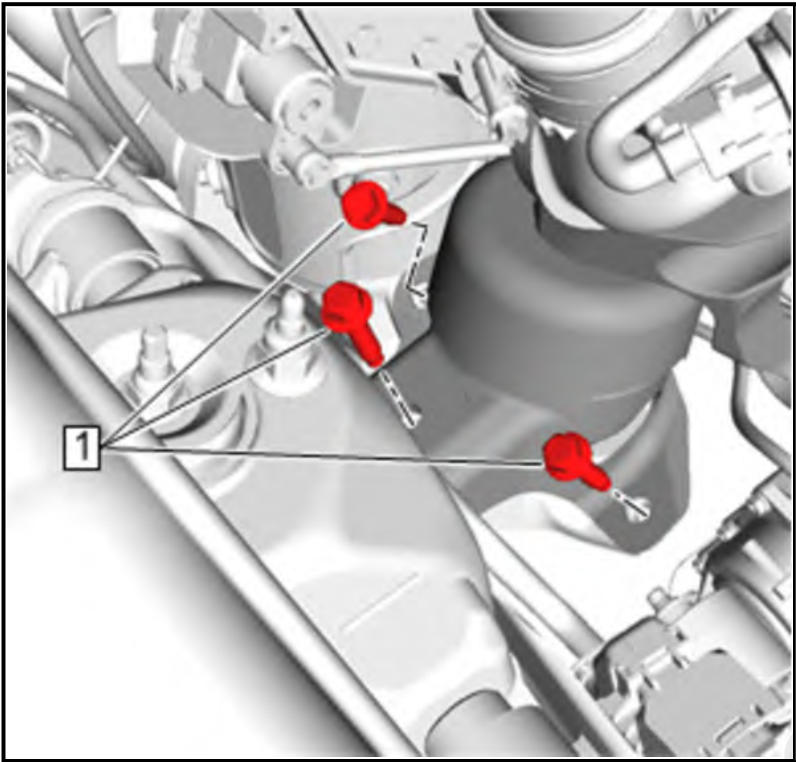


CAUTION: Refer to [Fastener Caution](#) .

NOTE:

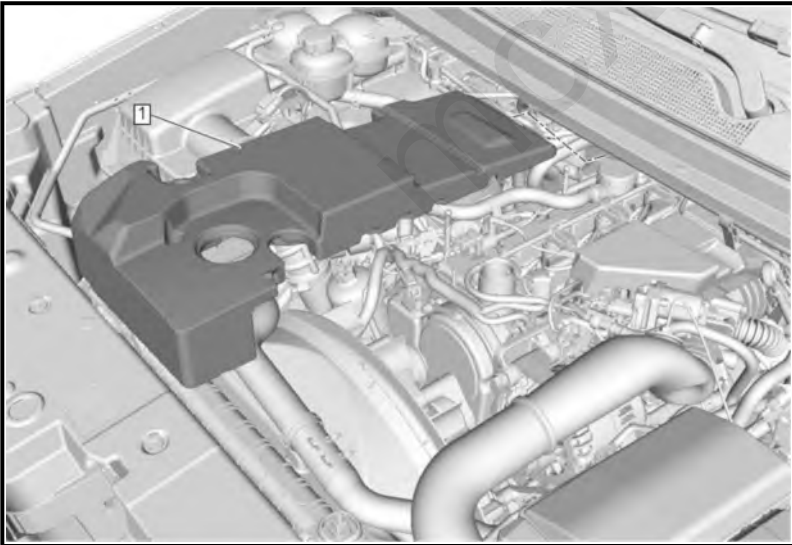
- Install the engine mount and engine mount bracket as an assembly.
- For ease of installation, hand start all engine mount fasteners prior to tightening.

- 2. Engine Mount Bolt (1) - Install and tighten [3x] 85 N.m (63 lb ft) 45 -60 degrees
- 3. Engine Front Mount Bracket Bolt (1) - Install and tighten [3x] 85 N.m (63 lb ft) 45 -60 degrees



- 4. Engine Support Fixture - Remove
- 5. Charge Air Cooler Inlet Duct Replacement - Install
- 6. Air Cleaner Assembly Replacement - Install
- 7. Intake Manifold Cover Replacement - Install

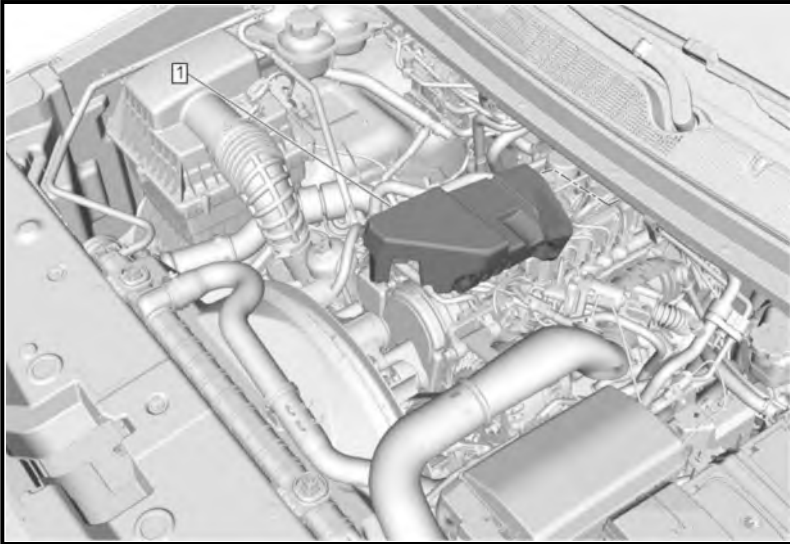
INTAKE MANIFOLD COVER INSULATOR REPLACEMENT (TOP OF ENGINE)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Intake Manifold Cover Replacement</u>	
1	Intake Manifold Cover Insulator

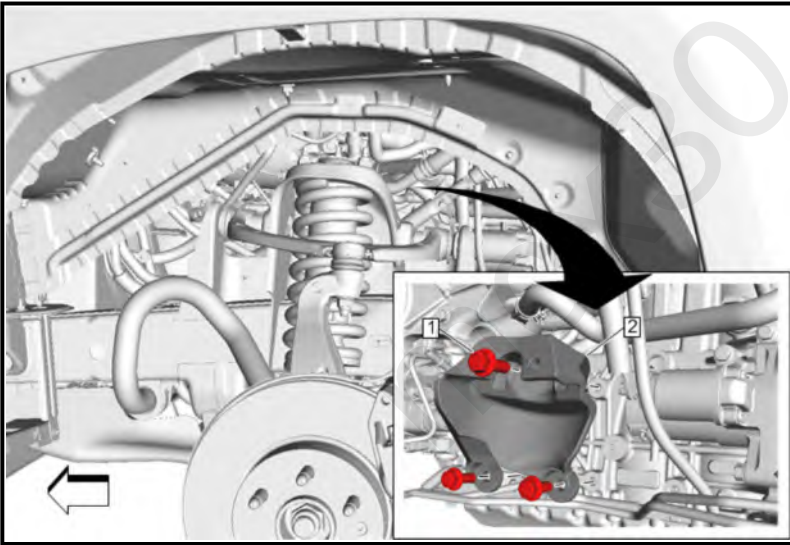
INTAKE MANIFOLD COVER INSULATOR REPLACEMENT (LEFT SIDE)



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure <u>Intake Manifold Cover Replacement</u>	
1	Intake Manifold Cover Insulator

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE



NOTE: Callouts in the following chart represent components shown in graphic above.

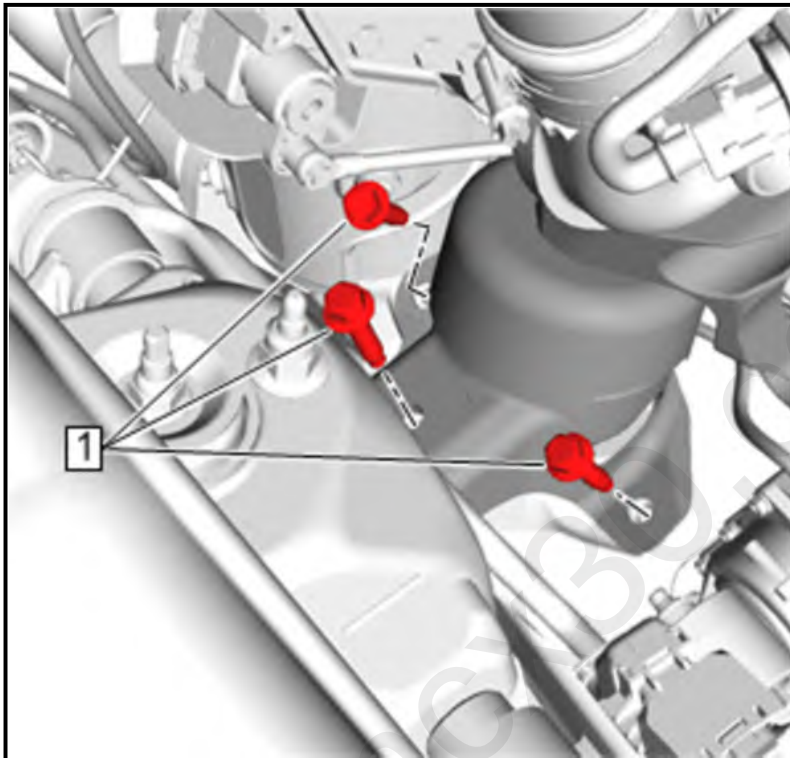
Callout	Component Name
Preliminary Procedure <u>Engine Mount Replacement - Left Side</u>	
1	Engine Mount Bracket Fastener CAUTION: Refer to <u>Fastener Caution</u> . Tighten

Callout	Component Name
	100 N.m (74 lb ft)
2	Engine Mount Bracket

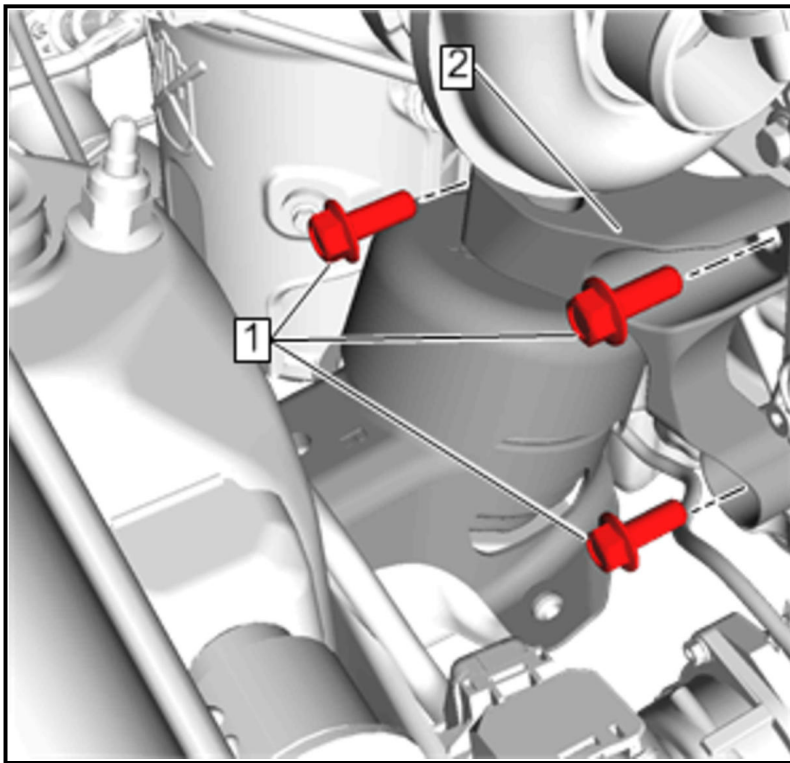
ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Intake Manifold Cover Replacement - Remove
2. Air Cleaner Assembly Replacement - Remove
3. Charge Air Cooler Inlet Duct Replacement - Remove
4. Engine Support Fixture - Install
5. Engine Front Mount Bracket Bolt (1) - Remove [3x]



6. Engine Mount Bolt (1) - Remove [3x]

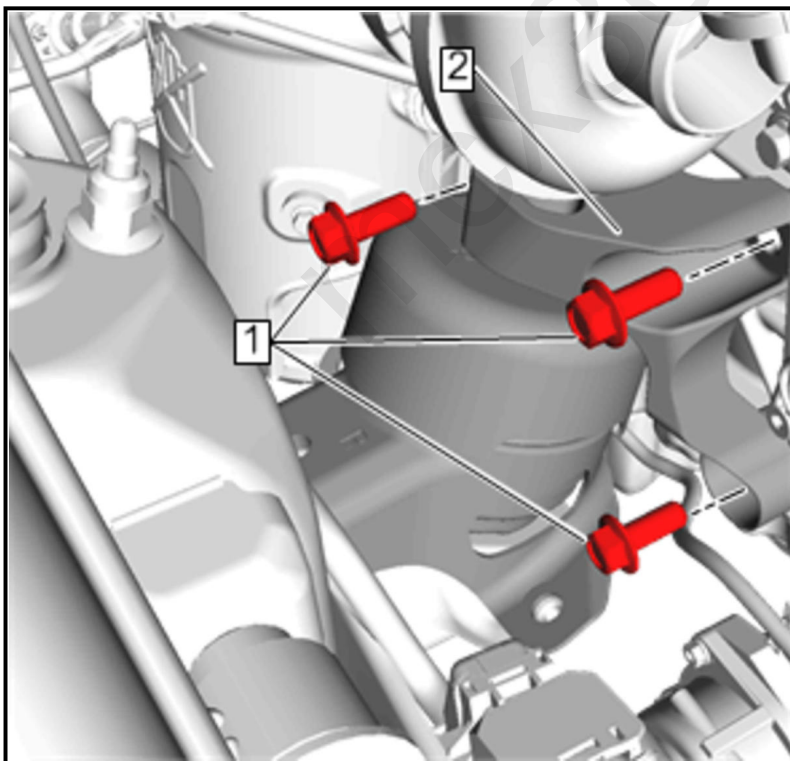


NOTE: Remove the engine mount and engine mount bracket as an assembly.

7. Engine Mount (2) - Remove

Installation Procedure

1. Engine Mount (2) - Install

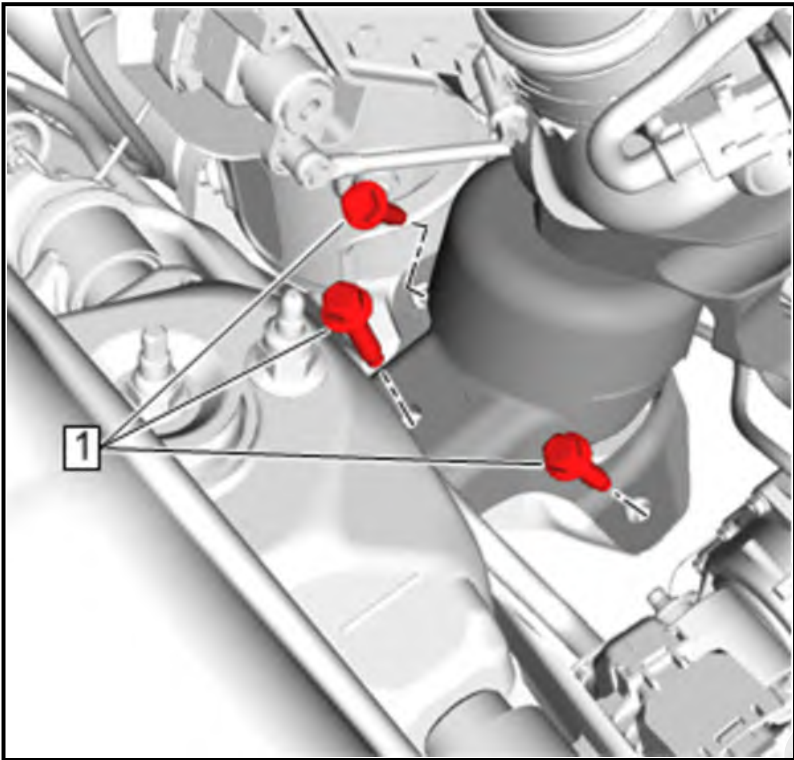


CAUTION: Refer to [Fastener Caution](#) .

NOTE:

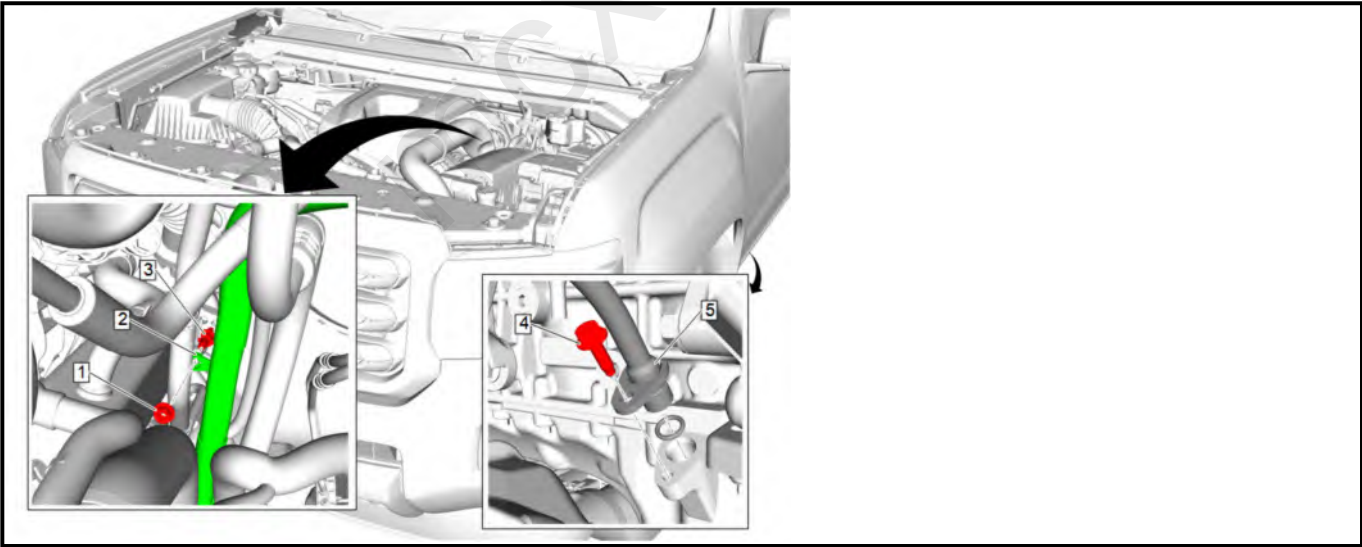
- Install the engine mount and engine mount bracket as an assembly.
- For ease of installation, hand start all engine mount fasteners prior to tightening.

2. Engine Mount Bolt (1) - Install and tighten [3x] 85 N.m (63 lb ft) 45 -60 degrees
3. Engine Front Mount Bracket Bolt (1) - Install and tighten [3x] 85 N.m (63 lb ft) 45 -60 degrees



4. Engine Support Fixture - Remove
5. Charge Air Cooler Inlet Duct Replacement - Install
6. Air Cleaner Assembly Replacement - Install
7. Intake Manifold Cover Replacement - Install

OIL LEVEL INDICATOR TUBE REPLACEMENT

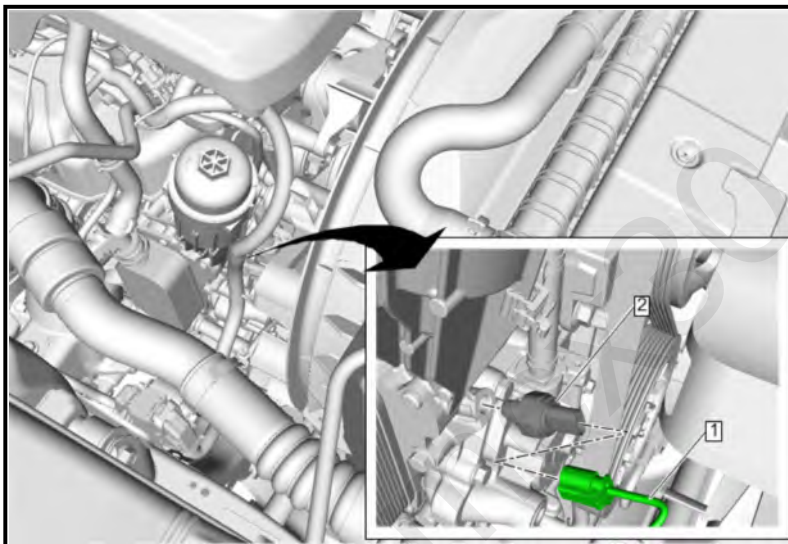


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Remove the left front wheelhouse liner. <u>Front Wheelhouse Liner Replacement (Without ZR2)</u> , or <u>Front Wheelhouse Liner Replacement (With ZR2)</u> , or <u>Front Wheelhouse Liner Replacement (Bison)</u>	
1	Wiring Harness Nut

Callout	Component Name
	CAUTION: Refer to Fastener Caution . Tighten 11 N.m (97 lb in)
2	Wiring Harness
3	Oil Level Indicator Tube Stud Tighten 11 N.m (97 lb in)
4	Oil Level Indicator Tube Fastener Tighten 11 N.m (97 lb in)
5	Oil Level Indicator Tube Procedure Install NEW oil level indicator tube seal.

ENGINE OIL PRESSURE SWITCH REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Air Cleaner Outlet Duct Replacement	
1	Electrical Connector
2	Engine Oil Pressure Switch CAUTION: Refer to Component Fastener Tightening Caution . Tighten

Callout	Component Name
	35 N.m (26 lb ft)

CYLINDER HEAD REPLACEMENT

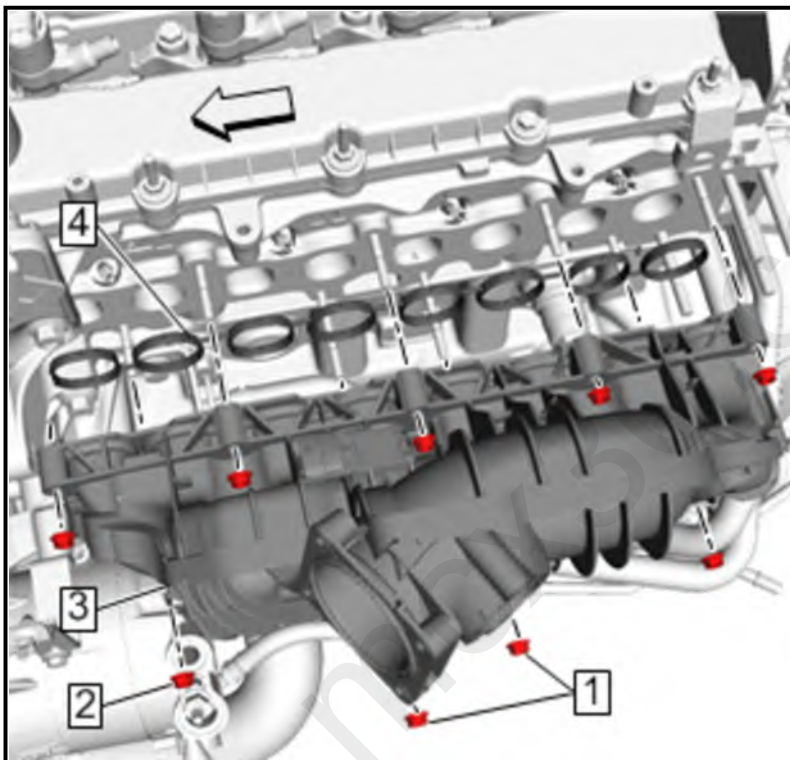
Special Tools

J 45059 Angle Meter

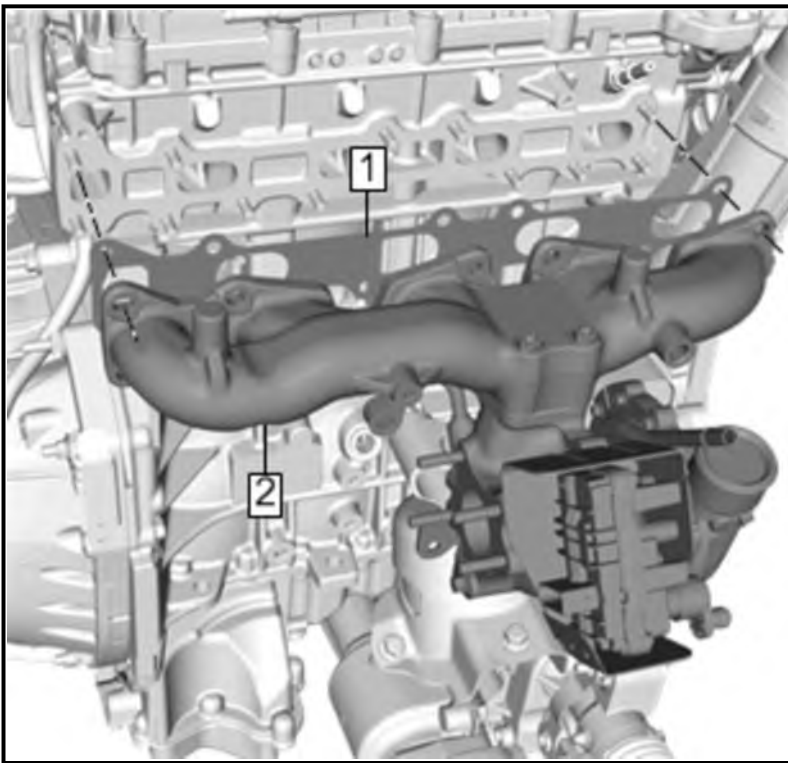
Equivalent regional tools: [Special Tools](#)

Removal Procedure

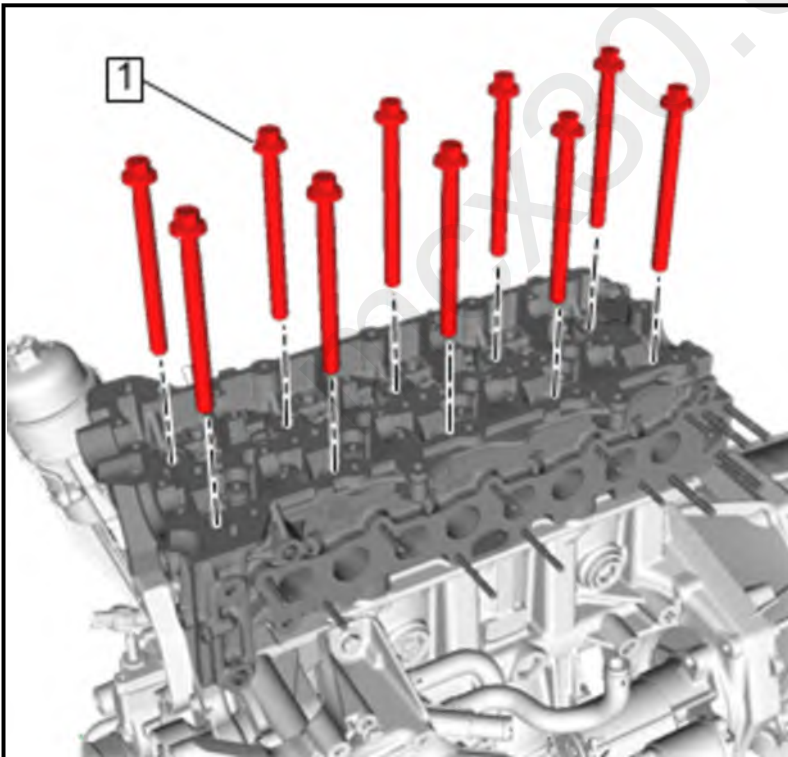
1. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#) - Drain
2. [Battery Negative Cable Disconnection and Connection](#) - Disconnect
3. Intake Manifold (2) - Remove - [Intake Manifold Replacement](#)



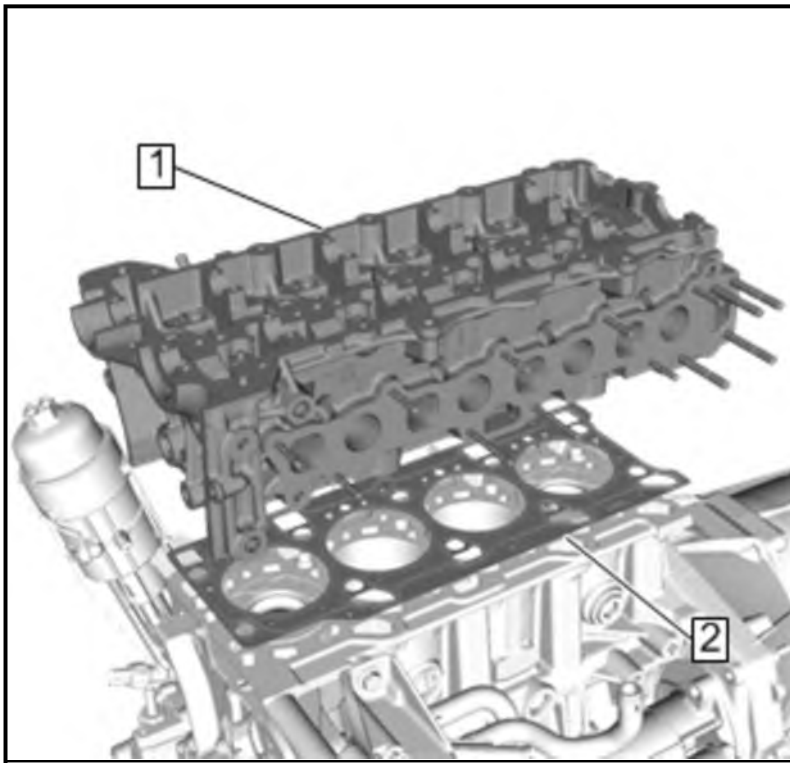
4. Exhaust Manifold and Turbocharger Assembly (2) - Remove - [Exhaust Manifold Replacement \(LWN\)](#)



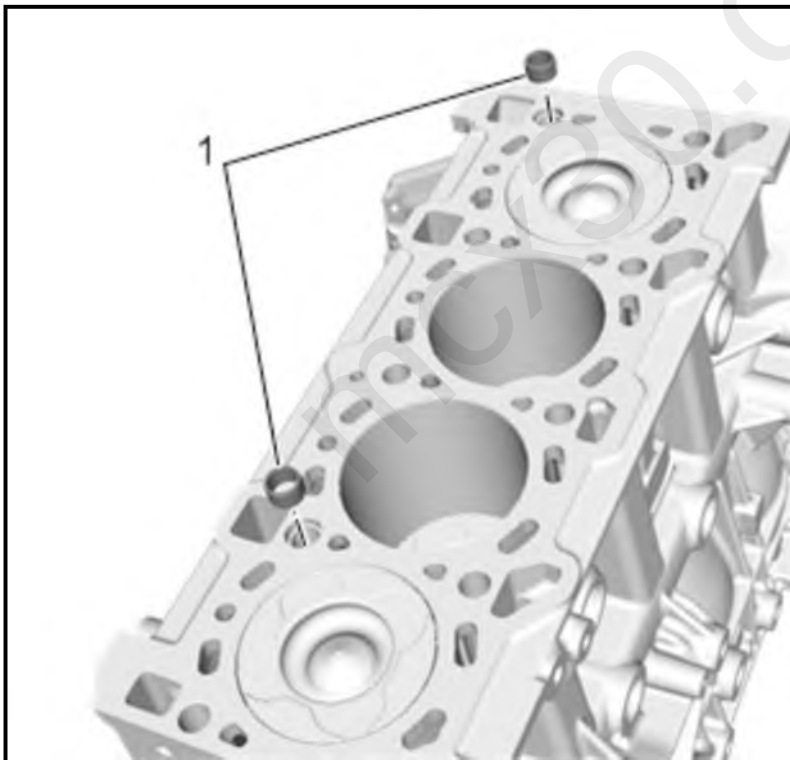
5. **Camshaft Replacement** - Remove
6. **Generator Bracket Replacement (LWN)** - Remove
7. **Glow Plug Replacement** - Remove
8. Cylinder Head Bolt (1) - Remove and DISCARD [10x]



9. Cylinder Head (1) - Remove



10. Cylinder Head Gasket (2) - Remove and DISCARD
11. Cylinder Head (1) - Clean and inspect - [Cylinder Head Cleaning and Inspection](#)
12. Ensure the cylinder head alignment pins (1) remain in the engine block.



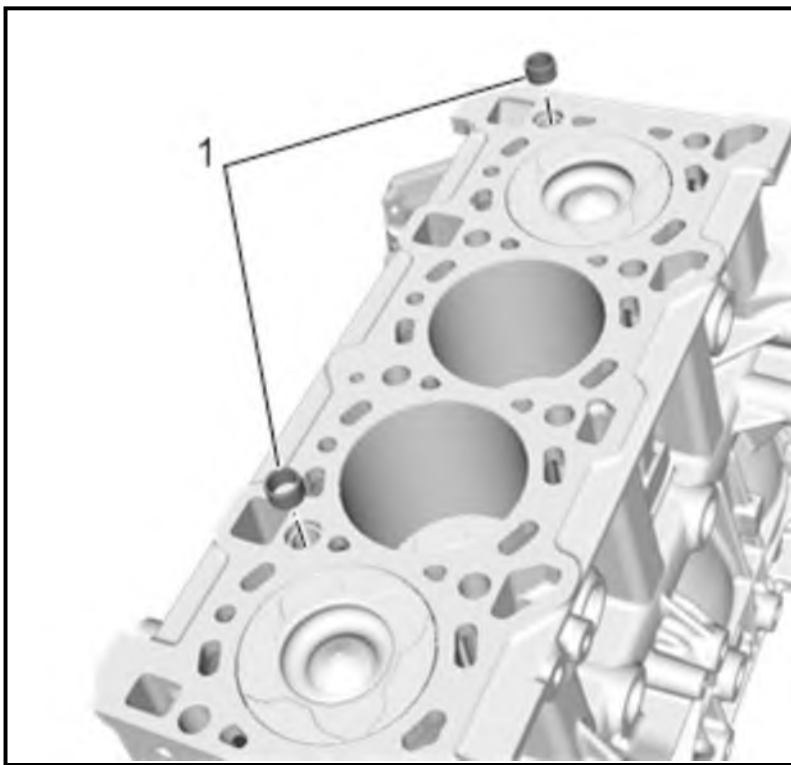
NOTE: If replacing the cylinder head, transfer all parts as necessary.

13. Cylinder Head - Disassemble Procedure - [Cylinder Head Disassemble](#)

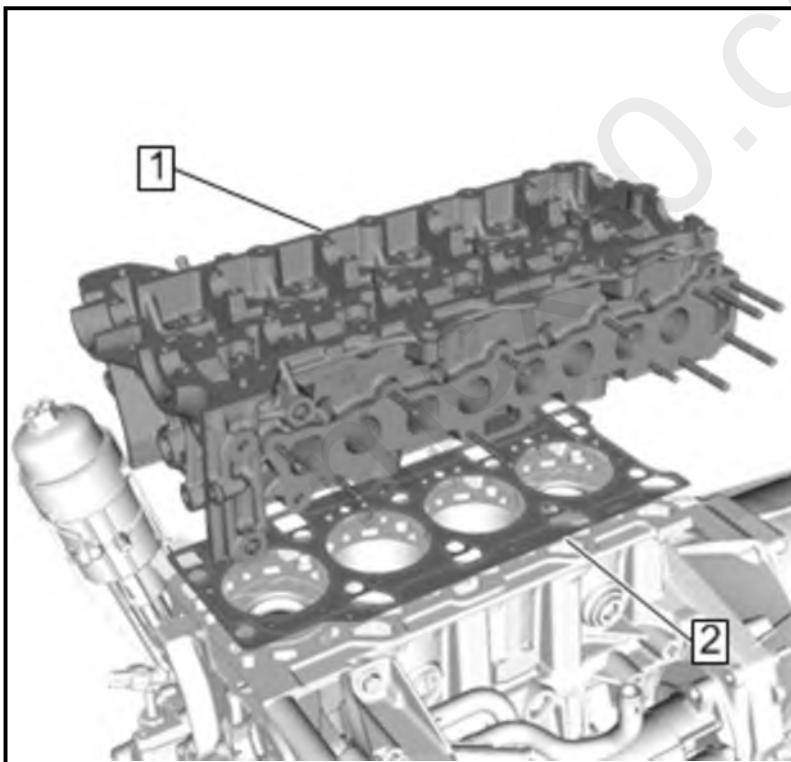
Installation Procedure

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

1. Cylinder Head - Assemble Procedure - [Cylinder Head Assemble](#).
2. Swap the cylinder head alignment pins (1) from the cylinder head to engine block as needed.



3. Clean all sealing surfaces.
4. Cylinder Head Gasket (2) - Install

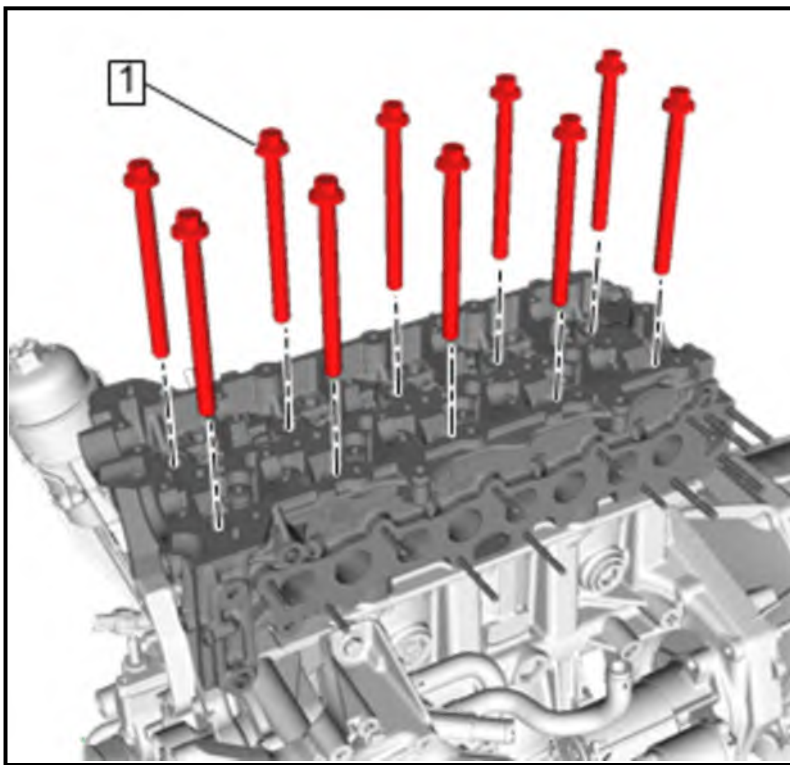


NOTE: Select the correct cylinder head gasket. [Cylinder Head Gasket Selection](#)

NOTE: Do not use any sealing material.

NOTE: Install a NEW gasket.

5. Cylinder Head (1) - Install
6. Cylinder Head Bolt (1) - Loosely install [10x]



NOTE: Install NEW bolts.

7. Tighten the bolts in the sequence shown.

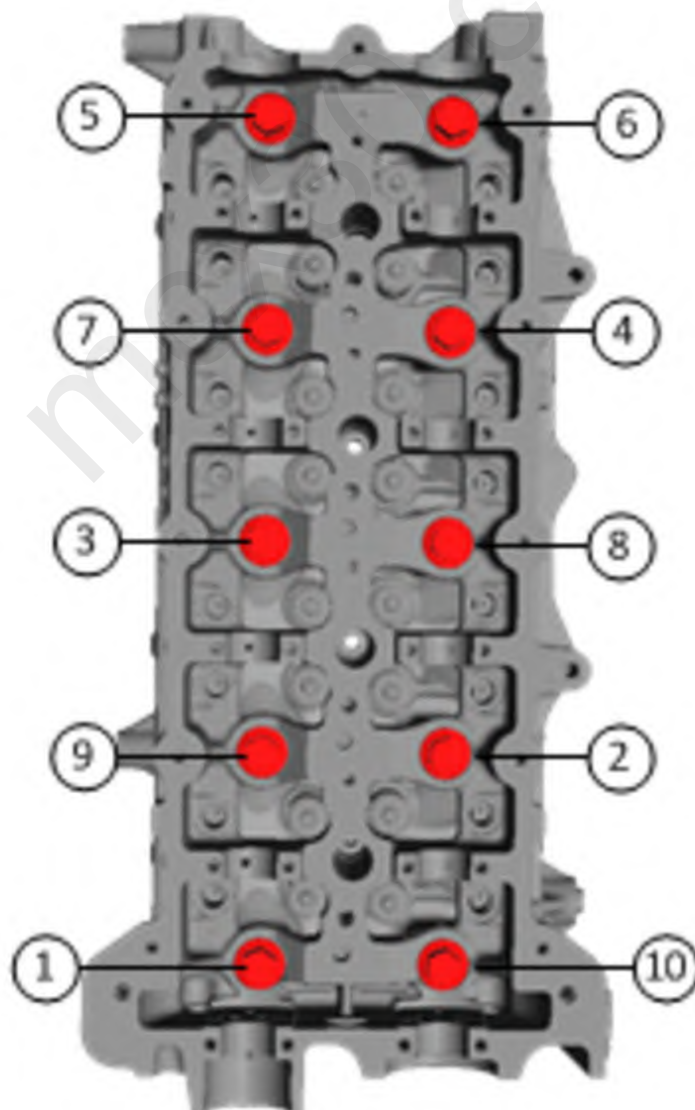


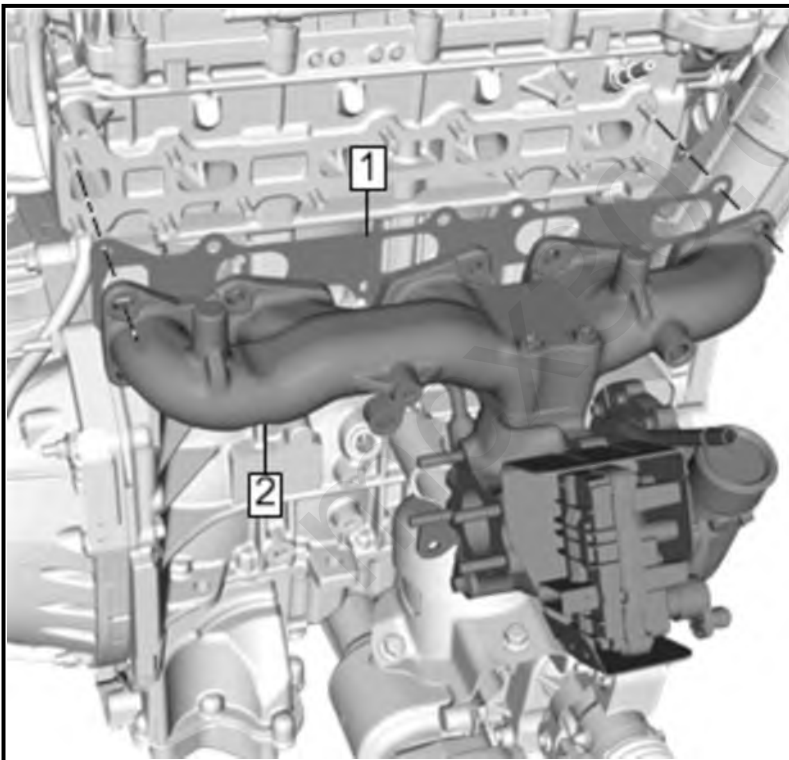
Fig. 12: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

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

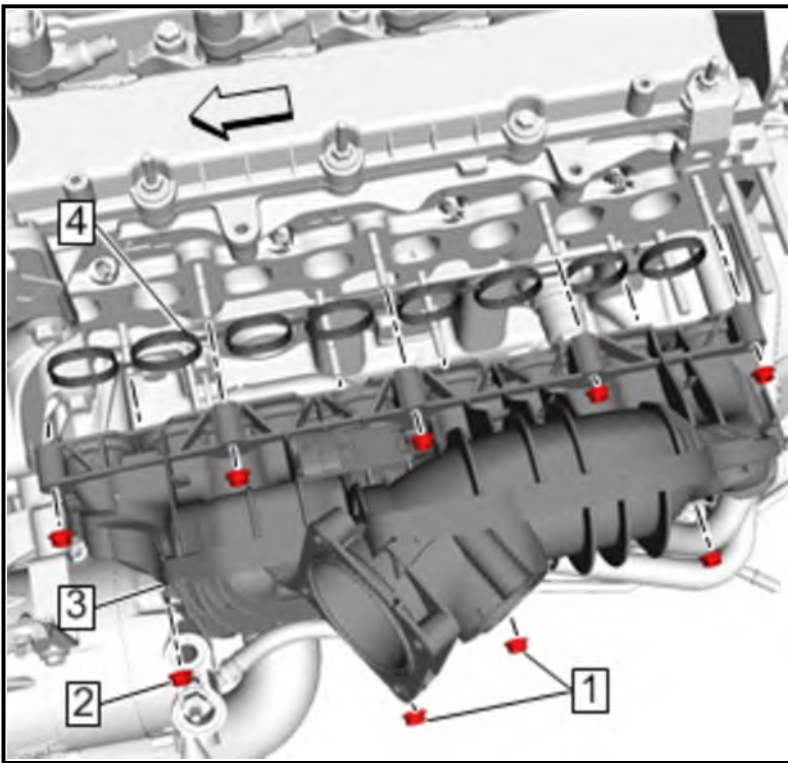
CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

Tighten

1. First Pass 30 N.m (22 lb ft)
2. Second Pass using **J 45059** meter, tighten the bolts in sequence an additional 110 degrees
3. Third Pass using **J 45059** meter, tighten the bolts in sequence an additional 110 degrees
4. Final Pass using **J 45059** meter, tighten the bolts in sequence an additional 110 degrees
8. [Glow Plug Replacement](#) - Install
9. [Generator Bracket Replacement \(LWN\)](#) - Install
10. [Camshaft Replacement](#) - Install
11. Exhaust Manifold and Turbocharger Assembly (2) - Install - [Exhaust Manifold Replacement \(LWN\)](#)



12. Intake Manifold (2) - Install - [Intake Manifold Replacement](#)

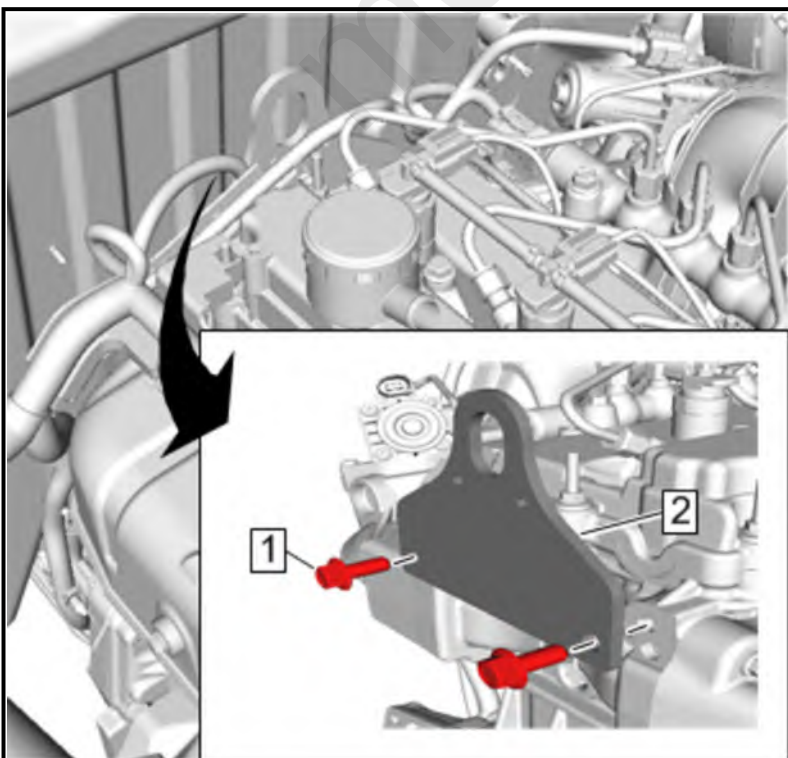


13. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#) - Fill
14. [Battery Negative Cable Disconnection and Connection](#) - Connect

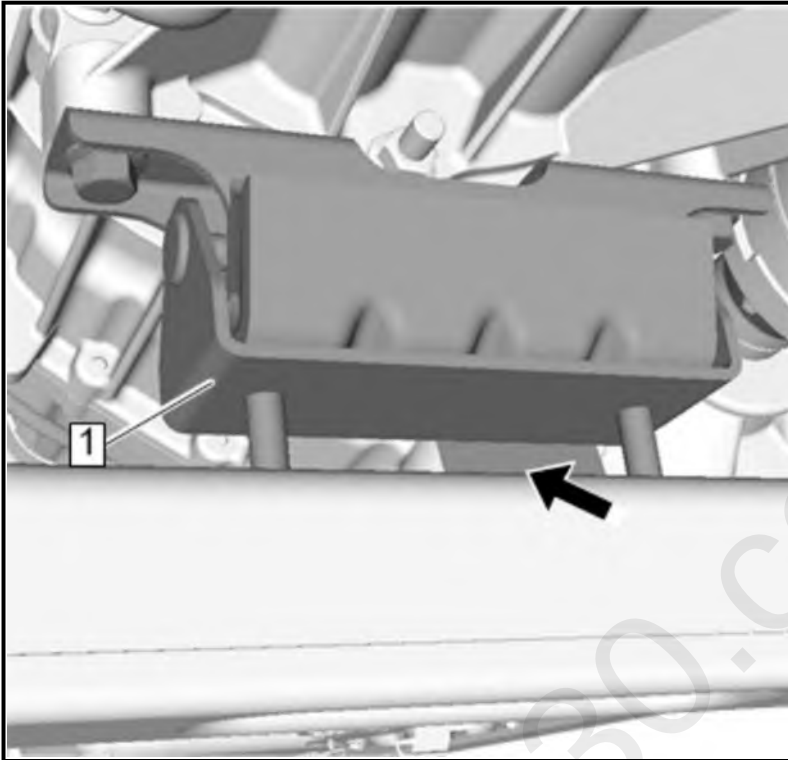
CYLINDER HEAD CORE HOLE PLUG REPLACEMENT

Removal Procedure

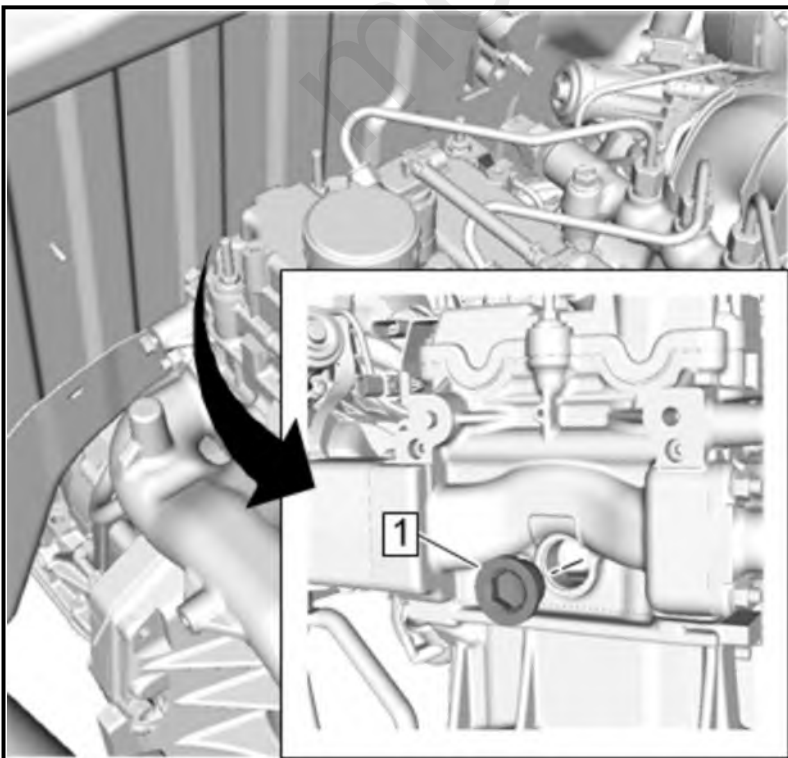
1. Drain the cooling system. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#)
2. Plenum Front Panel - Remove - [Plenum Front Panel Replacement](#)
3. Intake Manifold Cover - Remove - [Intake Manifold Cover Replacement](#)
4. {If equipped} Engine Lift Bracket Bolt (1) - Remove [2x]



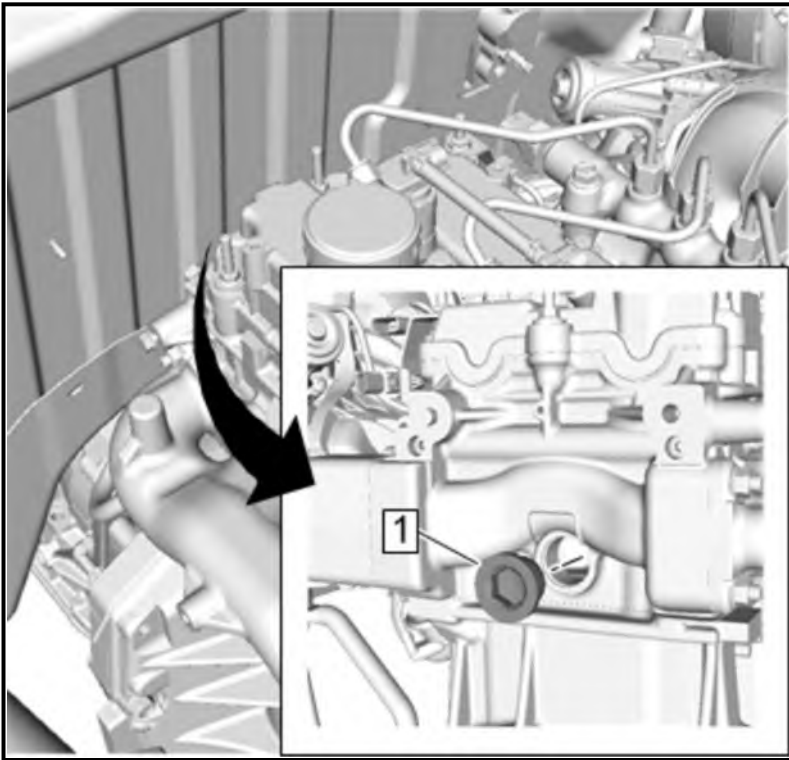
5. {If equipped} Engine Lift Bracket (2) - Remove
6. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)
7. Transmission Mount Nut @ Transmission Support Crossmember - Remove [2x] - [Transmission Support Crossmember Replacement \(4 Wheel Drive\)](#) , or [Transmission Support Crossmember Replacement \(2 Wheel Drive\)](#)
8. Using a suitable transmission stand/jack, slightly raise the transmission off the cross-member approximately 3-4 cm (1.5 in).
9. Insert a suitable spacer between the mount and cross-member to keep the transmission raised slightly.



10. Remove the support and lower the vehicle. [Lifting and Jacking the Vehicle](#)
11. Cylinder Head Core Hole Plug (1) - Remove and DISCARD



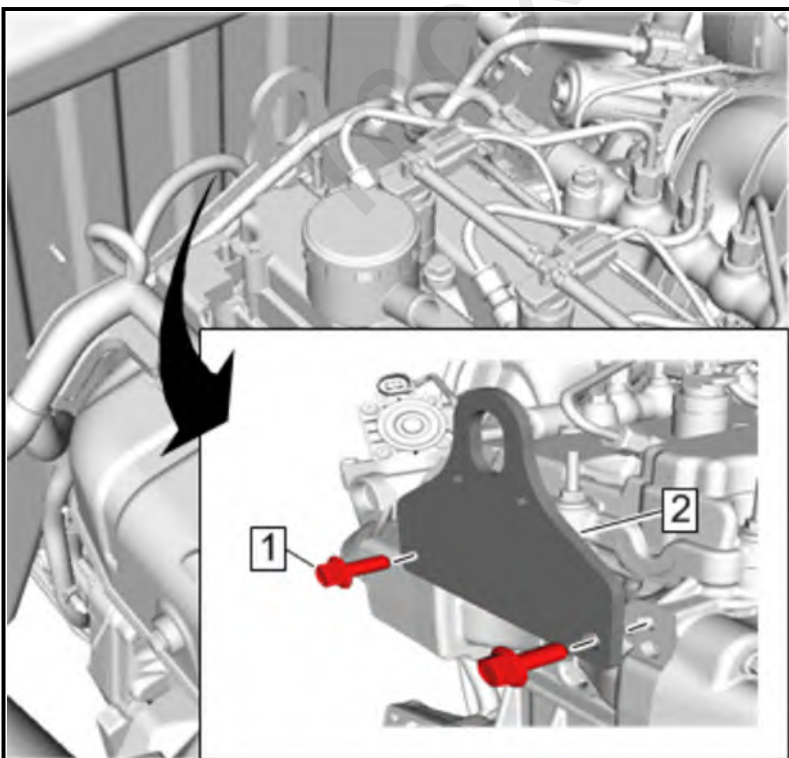
1. Cylinder Head Core Hole Plug (1) - Install and tighten 60 N.m (44 lb ft)



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

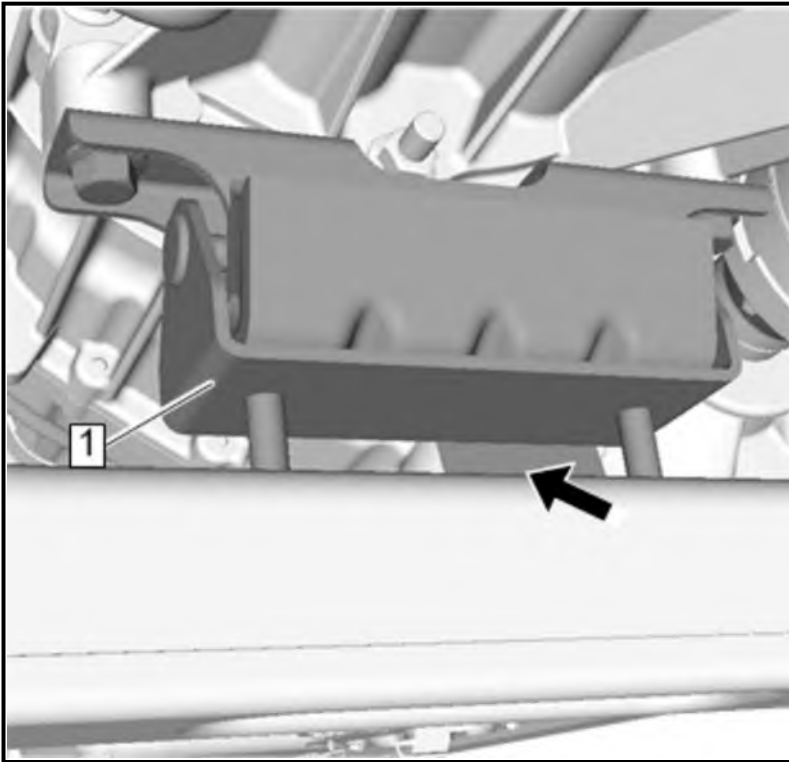
NOTE: Install a NEW cylinder head core plug.

2. Fill the cooling system. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#)
3. {If equipped} Engine Lift Bracket (2) - Install



4. {If equipped} Engine Lift Bracket Bolt (1) - Install and tighten [2x] 68 N.m (50 lb ft)
5. Raise and support the vehicle. [Lifting and Jacking the Vehicle](#)

6. Remove the suitable spacer from between the mount and cross-member.



7. Transmission Mount Nut @ Transmission Support Crossmember - Install and tighten [2x] - [Transmission Support Crossmember Replacement \(4 Wheel Drive\)](#) , or [Transmission Support Crossmember Replacement \(2 Wheel Drive\)](#)

8. Intake Manifold Cover - Install - [Intake Manifold Cover Replacement](#)

9. Plenum Front Panel - Install - [Plenum Front Panel Replacement](#)

CRANKSHAFT SPROCKET REPLACEMENT

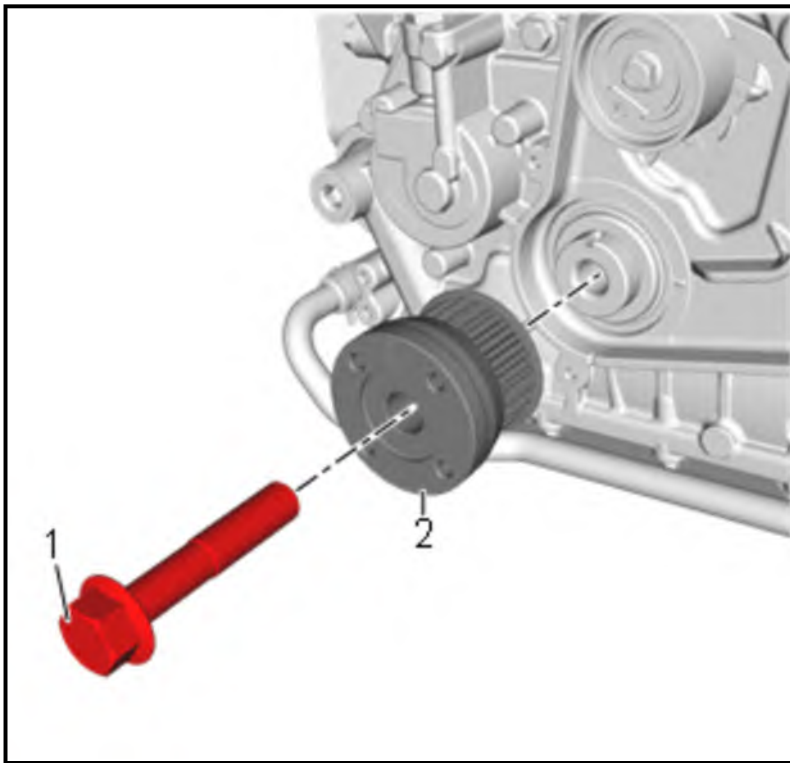
Special Tools

EN-52287 Balancer Holding Tool

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

Removal Procedure

1. Timing Belt - Remove - [Timing Belt Replacement](#)
2. Temporarily install the crankshaft balancer. [Crankshaft Balancer Replacement](#)

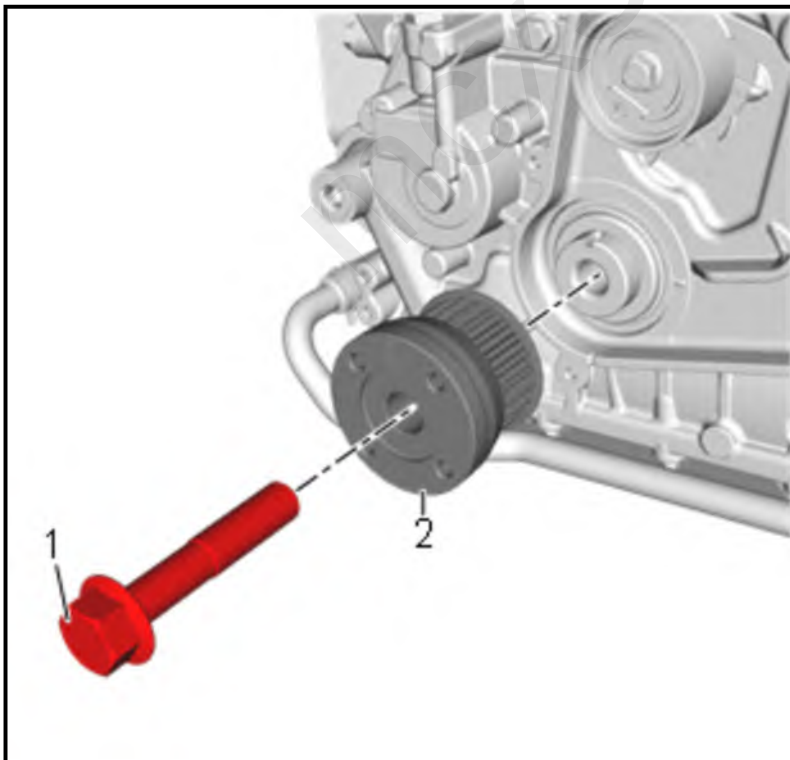


NOTE: The crankshaft timing pulley bolt is left hand thread.

3. While holding the crankshaft balancer with the EN-52287 Balancer Holding Tool, remove and discard the crankshaft pulley bolt (1).
4. Crankshaft Sprocket (2) - Remove

Installation Procedure

1. Crankshaft Sprocket (2) - Install



2. Temporarily install the crankshaft balancer. [Crankshaft Balancer Replacement](#)
3. While holding the crankshaft balancer with the EN-52287 Balancer Holding Tool, install the NEW crankshaft pulley bolt (1). [Engine Front Cover Installation](#)
4. Timing Belt - Install - [Timing Belt Replacement](#)

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

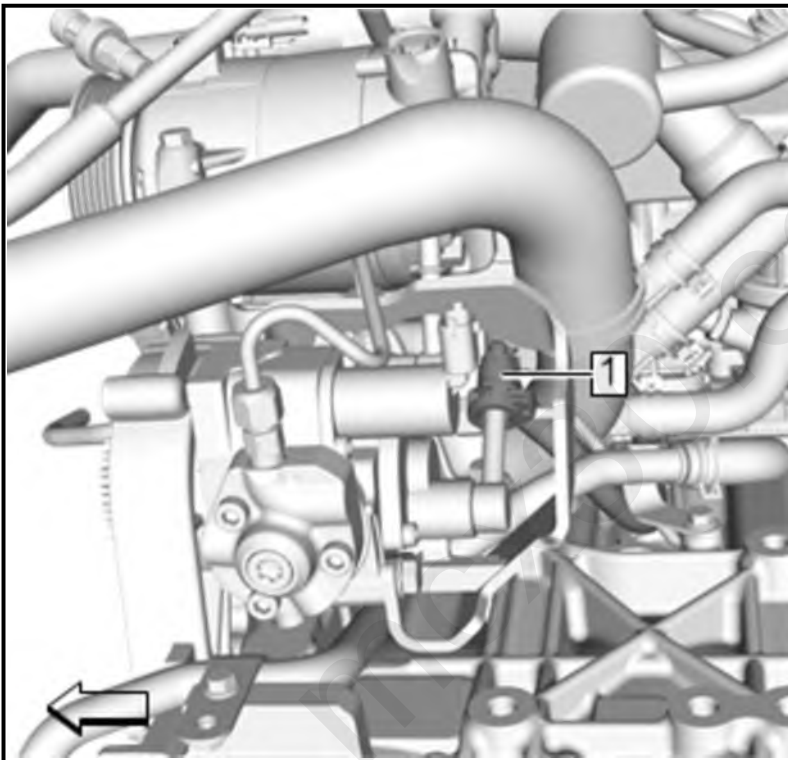
Special Tools

EN-46109-2 Guide Pins

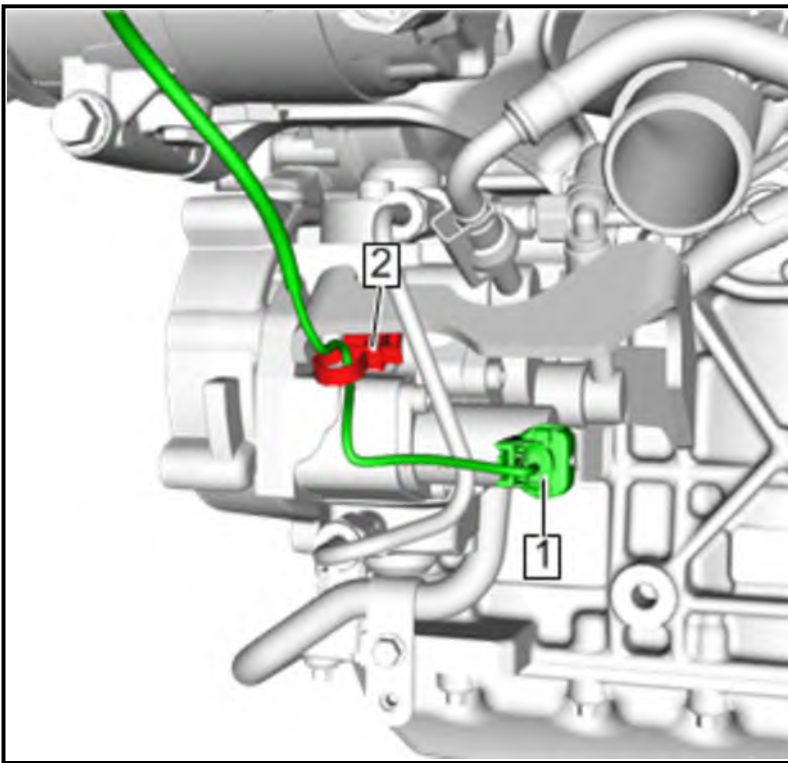
Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. Vacuum Pump Pipe - Remove - [Vacuum Pump Pipe Replacement](#)
2. Timing Belt Tensioner - Remove - [Timing Belt Tensioner Replacement](#)
3. Engine Oil Cooler Pipe - Remove - [Engine Oil Cooler Pipe Replacement \(LWN\)](#)
4. Upper Oil Pan - Remove - [Upper Oil Pan Replacement \(4 Wheel Drive\)](#), or [Upper Oil Pan Replacement \(2 Wheel Drive\)](#)
5. Fuel Pump Fuel Feed Hose (1) @ Fuel Injection Pump - Disconnect - [Fuel Pump Fuel Feed Hose Replacement](#)



6. Electrical Connector (1) - Disconnect



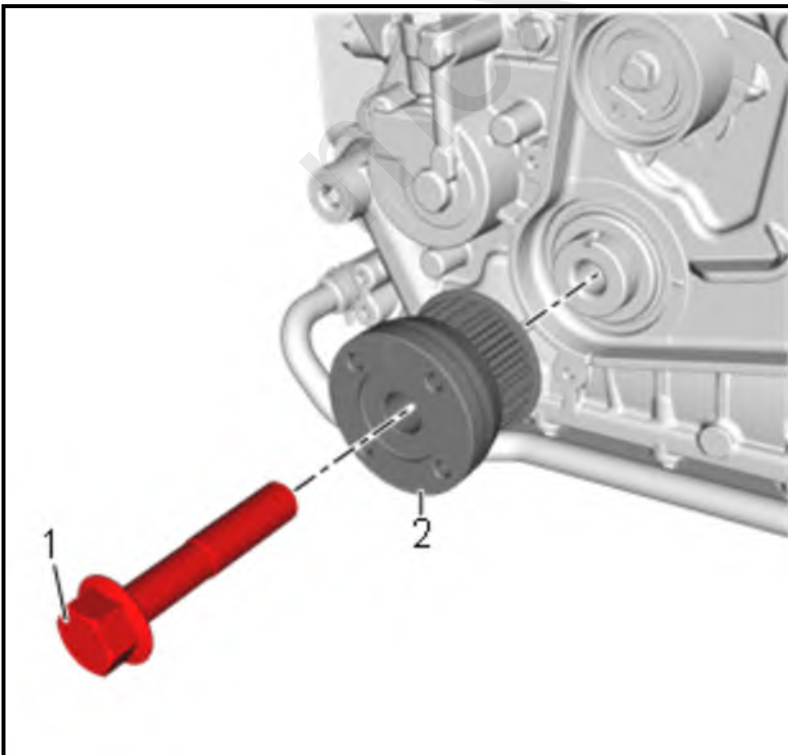
7. Wiring Harness Retainer (2) Unclip

NOTE: Disconnect fuel pump to fuel rail only.

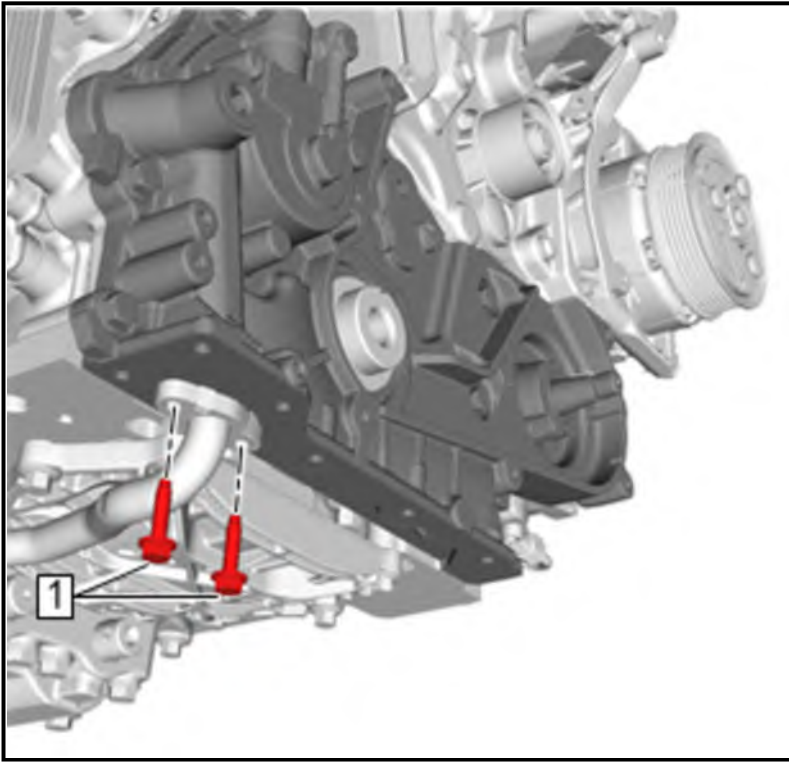
8. Fuel Injection Fuel Feed Pipe @ Fuel Injection Pump - Disconnect - [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#) , or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#)

9. Diesel Fuel Separator Hose @ Fuel Injection Pump - Disconnect - [Plastic Collar Quick Connect Fitting Service](#)

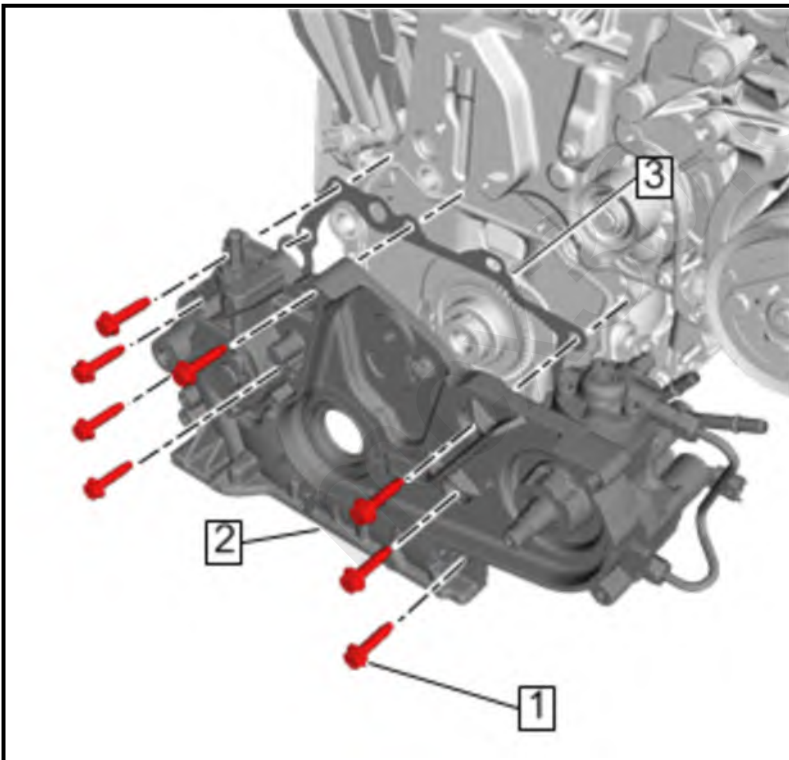
10. Crankshaft Sprocket (2) - Remove - [Crankshaft Sprocket Replacement](#)



11. Oil Pump Suction Pipe Bolt (1) - Remove [2x]



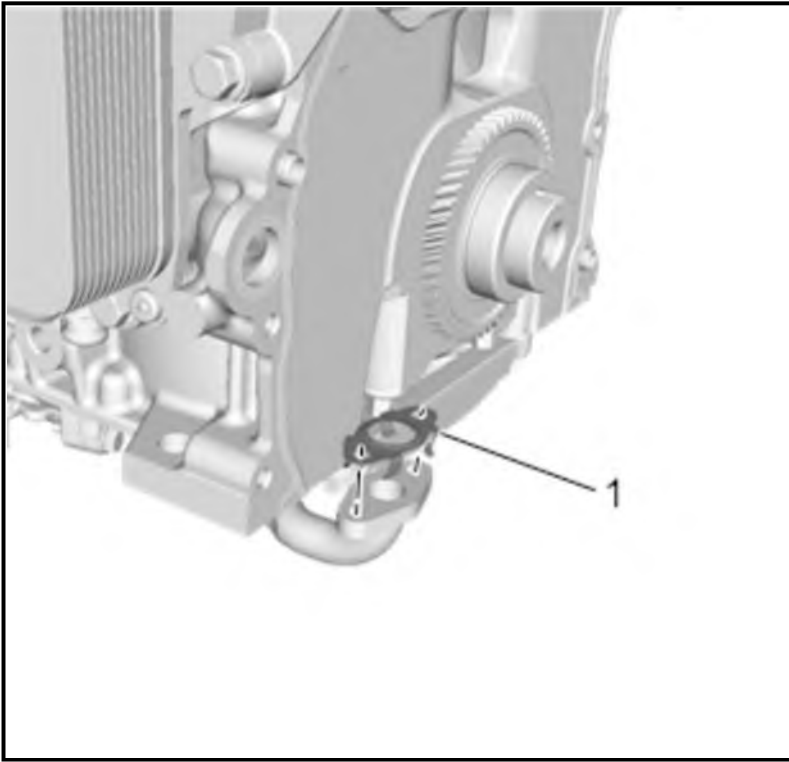
12. Engine Front Cover Bolt (1) - Remove [8x]



13. Engine Front Cover (2) - Remove

14. Engine Front Cover Gasket (3) - Remove

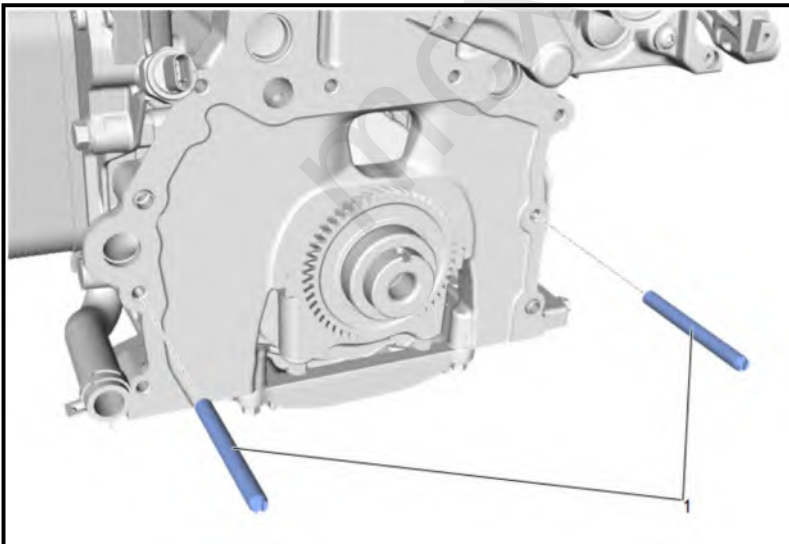
15. Oil Pump Suction Pipe Gasket (1) - Remove and DISCARD



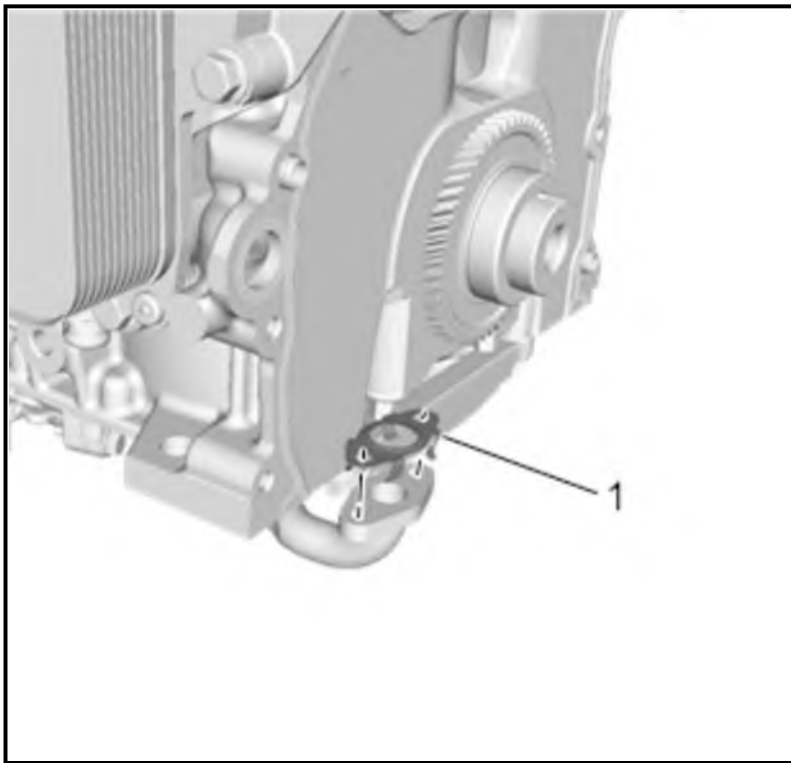
16. Fuel Injection Pump - Remove - [Fuel Injection Pump Replacement](#)
17. If re-installing the engine front cover, or replacing the crankshaft front oil seal refer to [Crankshaft Front Oil Seal Removal.](#)
18. Engine Front Cover - Clean and inspect - [Engine Front Cover Cleaning and Inspection](#)

Installation Procedure

1. If re-installing the engine front cover, or replacing the crankshaft front oil seal refer to [Crankshaft Front Oil Seal Installation.](#)
2. **EN-46109-2** Guide Pins (1) - Install [2x]

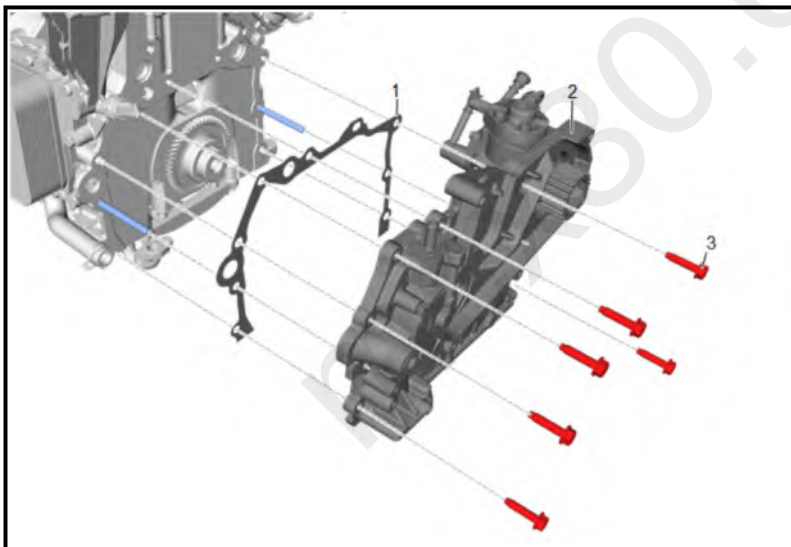


3. Oil Pump Suction Pipe Gasket (1) - Install

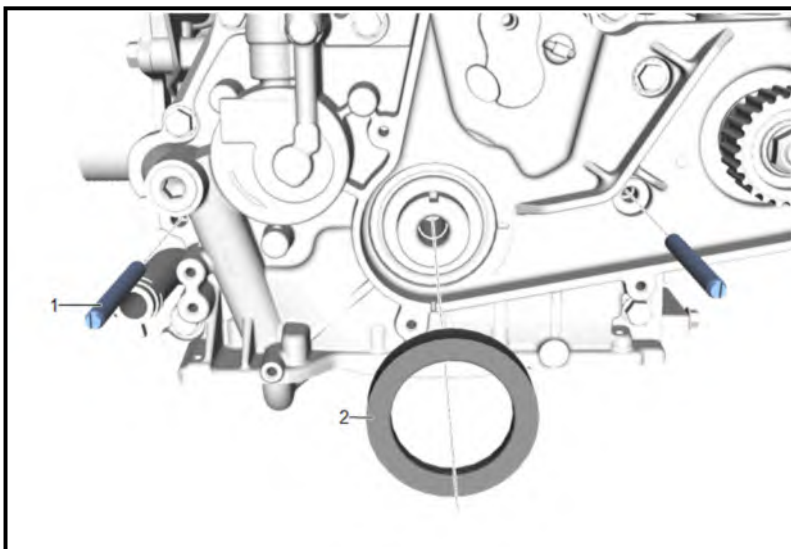


NOTE: Install a NEW gasket.

4. Fuel Injection Pump - Install - [Fuel Injection Pump Replacement](#)
5. Engine Front Cover Gasket (1) - Install

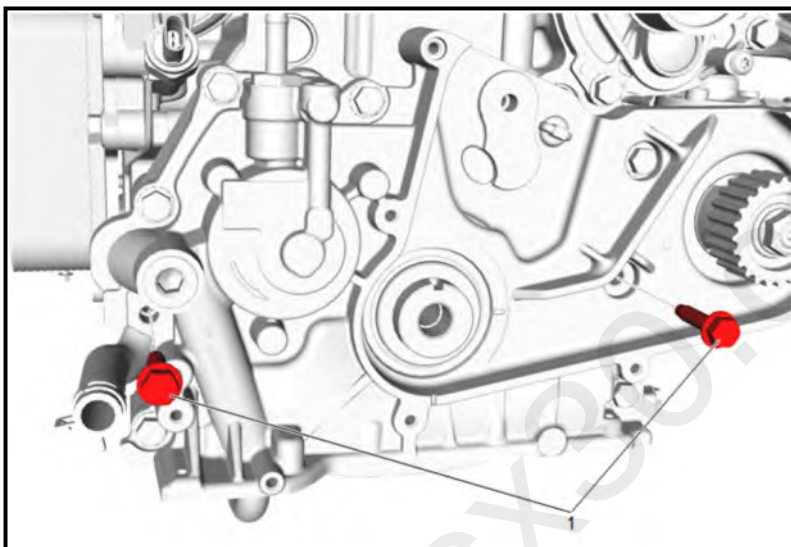


6. Engine Front Cover (2) - Install
7. Engine Front Cover Bolt (3) - Install, but do NOT tighten [6x]
8. **EN-46109-2** Guide Pins (1) - Remove [2x]

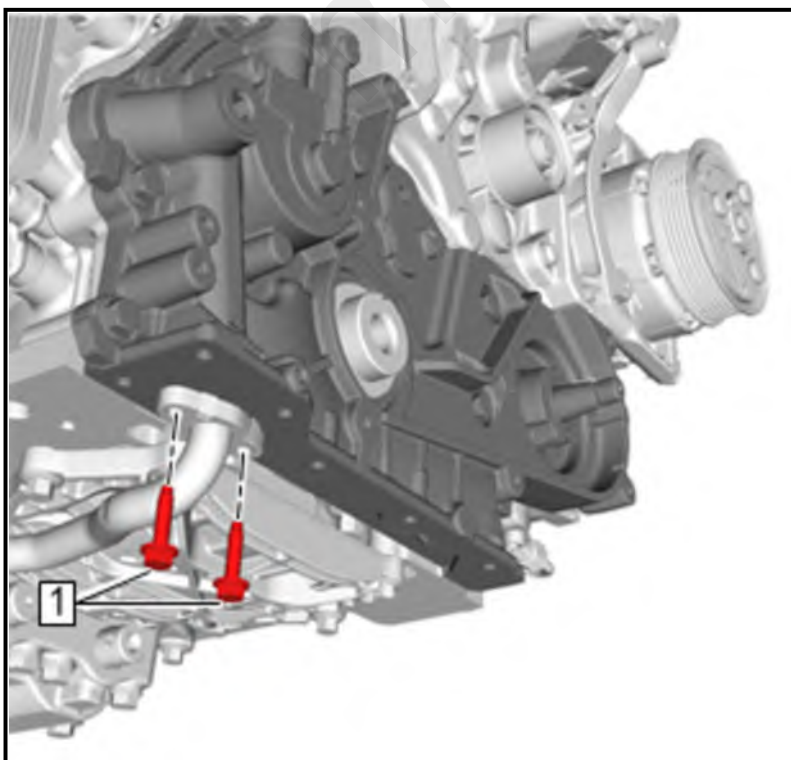


9. Crankshaft front oil seal installation sleeve (2) - Remove and DISCARD

10. Engine Front Cover Bolt (1) - Install, but do NOT tighten [2x]

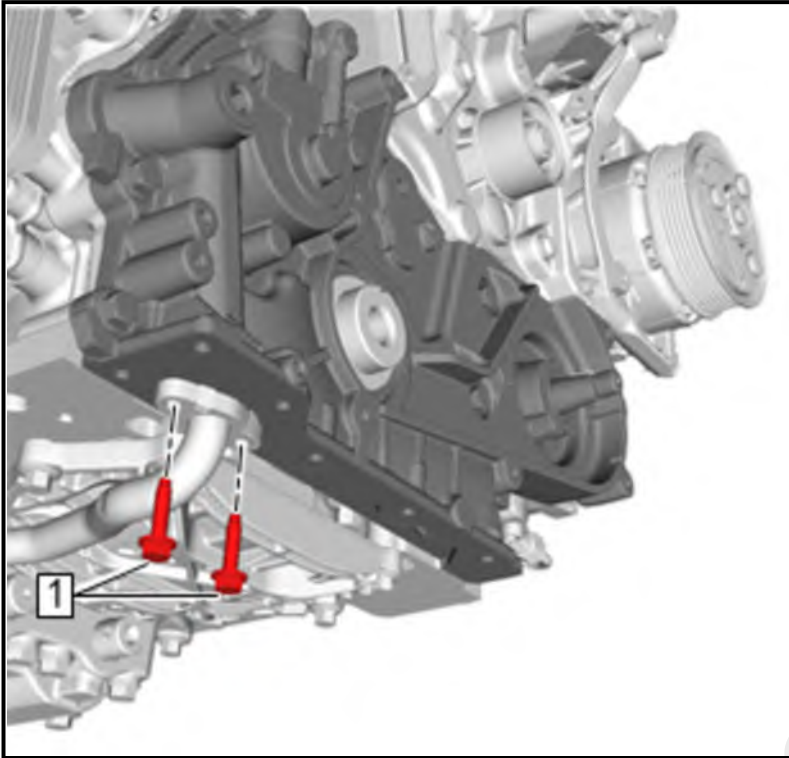


11. Oil Pump Suction Pipe Bolt (1) - Install, but do NOT tighten [2x]

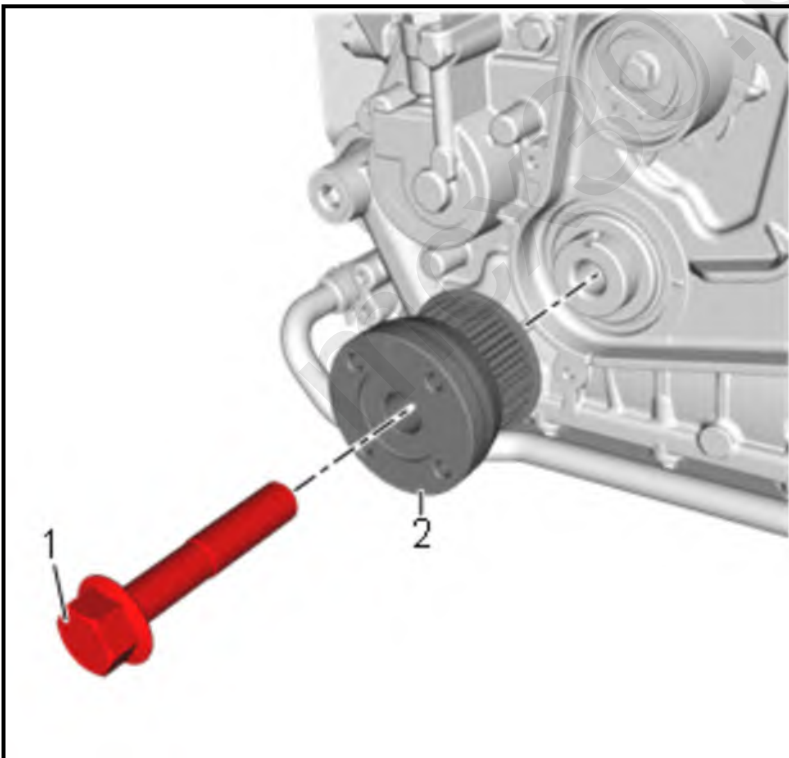


12. Engine Front Cover Bolt - Tighten in sequence [8x] - [Engine Front Cover Installation](#)

13. Oil Pump Suction Pipe Bolt (1) - Tighten [2x] 10 N.m (89 lb in)



14. Crankshaft Sprocket (2) - Install - [Crankshaft Sprocket Replacement](#)

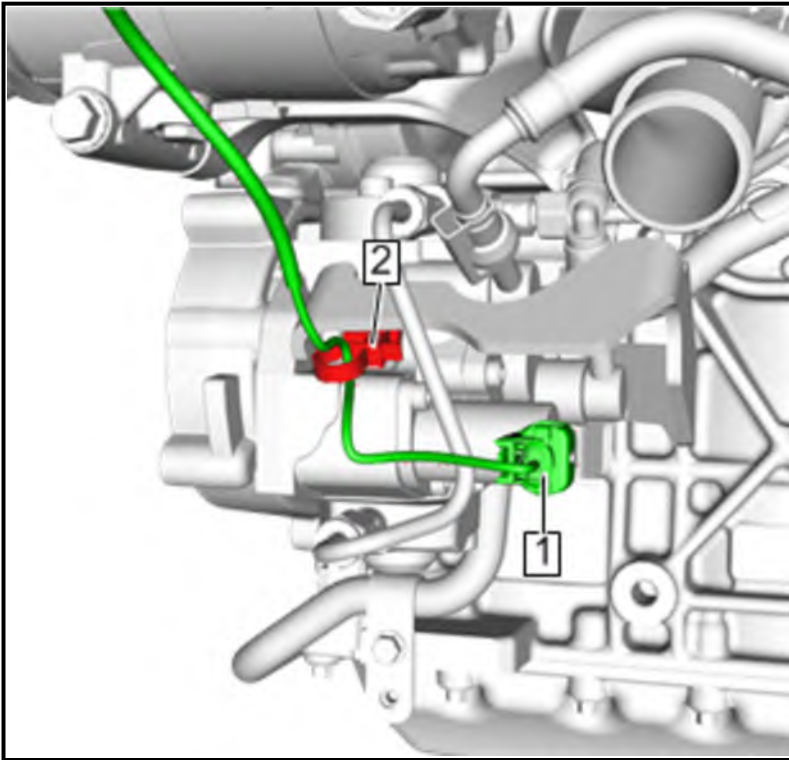


15. Diesel Fuel Separator Hose @ Fuel Injection Pump - Connect - [Plastic Collar Quick Connect Fitting Service](#)

NOTE: Disconnect fuel pump to fuel rail only.

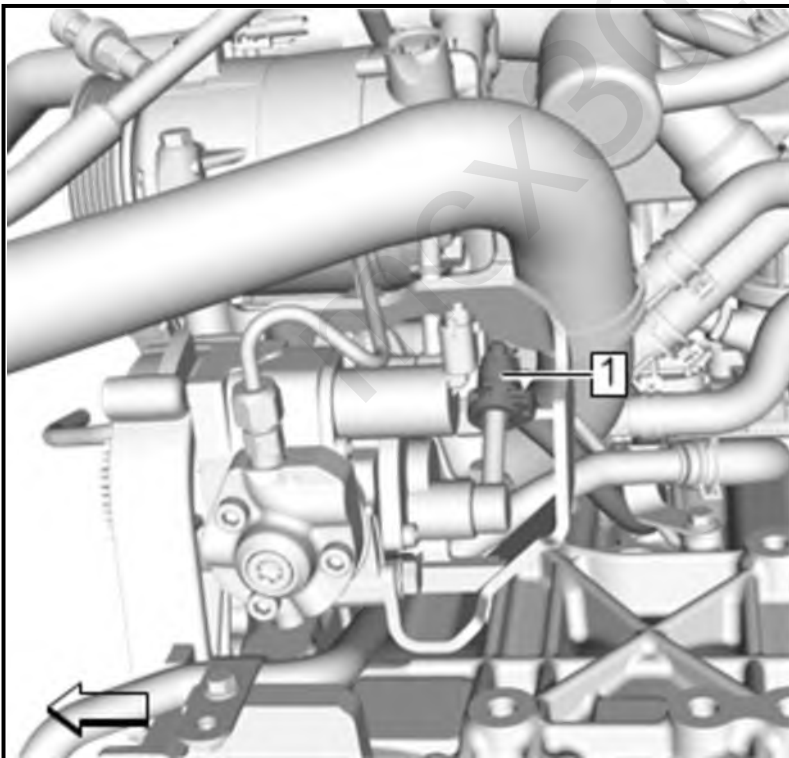
16. Fuel Injection Fuel Feed Pipe @ Fuel Injection Pump - Connect - [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#), or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#)

17. Electrical Connector (1) - Connect



18. Wiring Harness Retainer (2) Connect

19. Fuel Pump Fuel Feed Hose (1) @ Fuel Injection Pump - Connect - [Fuel Pump Fuel Feed Hose Replacement](#)



20. Upper Oil Pan - Install - [Upper Oil Pan Replacement \(4 Wheel Drive\)](#), or [Upper Oil Pan Replacement \(2 Wheel Drive\)](#)

21. Engine Oil Cooler Pipe - Install - [Engine Oil Cooler Pipe Replacement \(LWN\)](#)

22. Timing Belt Tensioner - Install - [Timing Belt Tensioner Replacement](#)

23. Vacuum Pump Pipe - Install - [Vacuum Pump Pipe Replacement](#)

CRANKSHAFT REAR OIL SEAL REPLACEMENT

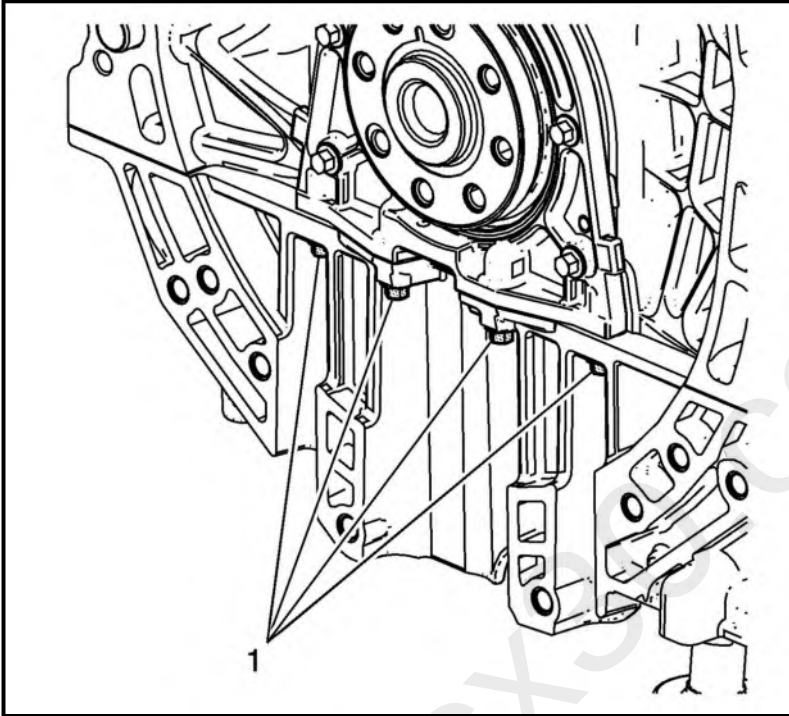
Special Tools

- EN-50026 Rear Main Seal Installer
- GE-8092 Driver Handle

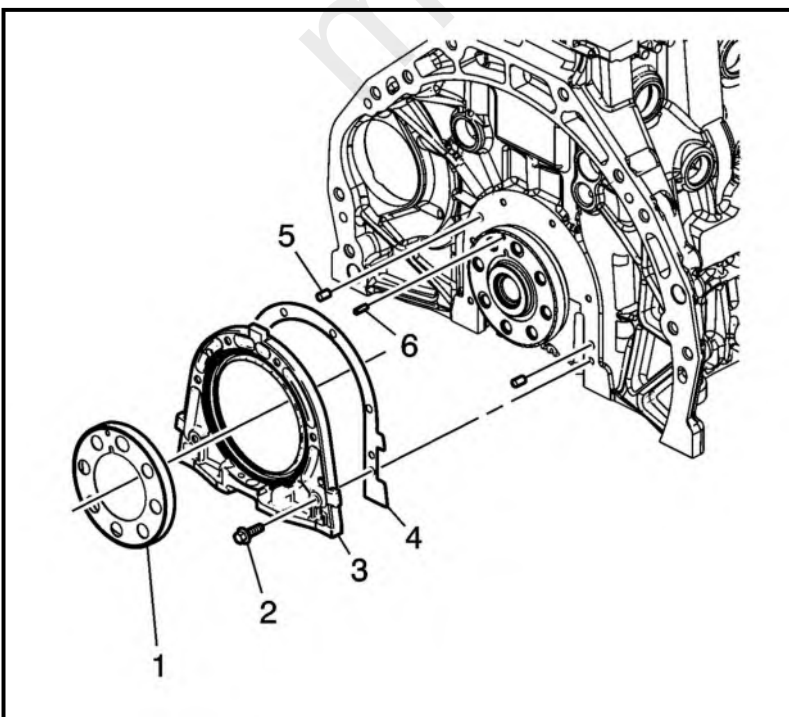
Equivalent regional tools: [Special Tools](#)

Removal Procedure

1. [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#) - Remove
2. Remove the oil pan bolts. (1)

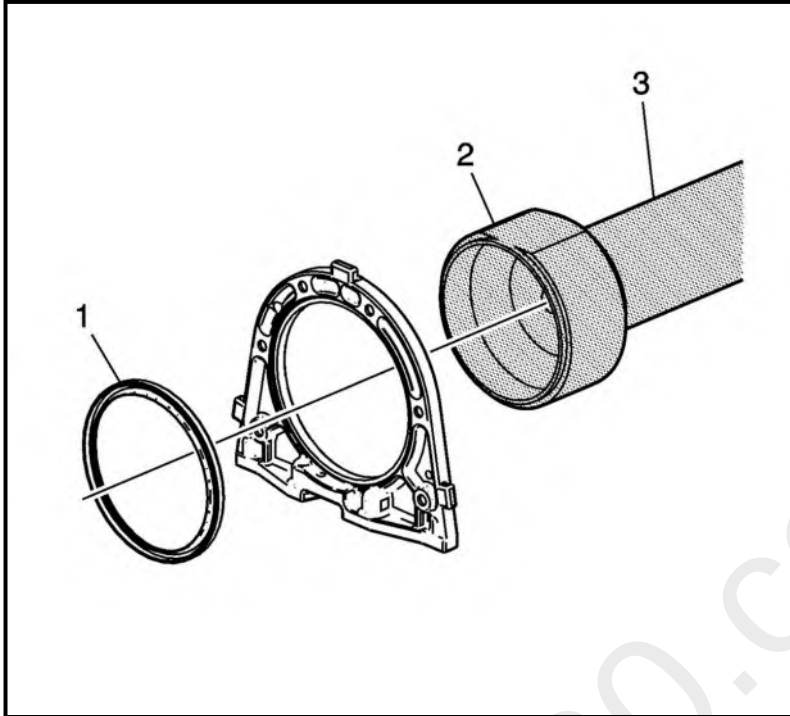


3. Crankshaft Position Sensor Exciter Ring (1) - Remove



NOTE: Ensure the crankshaft rear oil seal housing locating pin (5) and exciter ring locating pin (6) remain in the engine.

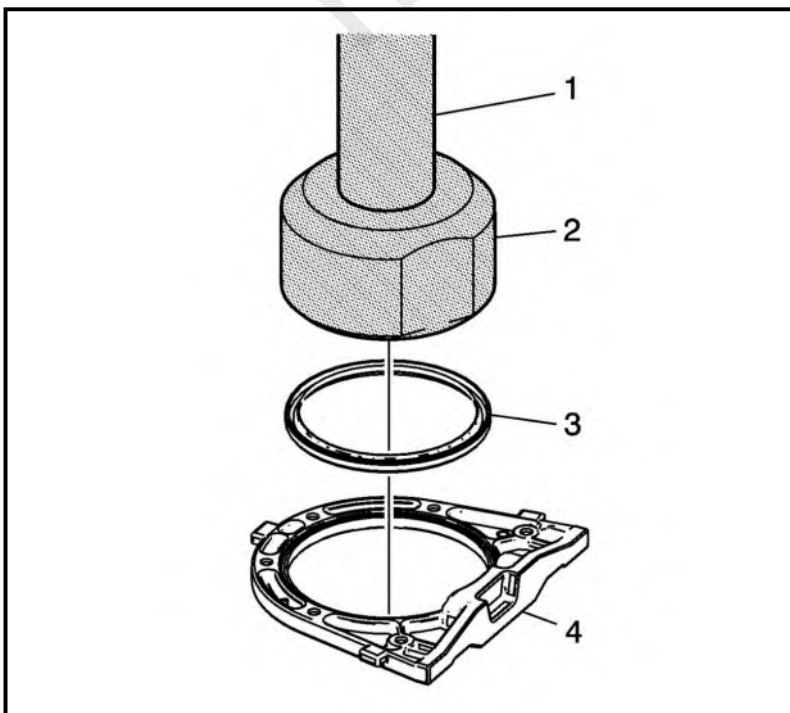
4. Crankshaft Rear Oil Seal Housing Bolt (2) - Remove [6x]
5. Crankshaft Rear Oil Seal Housing (3) - Remove
6. Crankshaft Rear Oil Seal Housing Gasket (4) - Remove
7. Remove and DISCARD the crankshaft rear oil seal (1) using the **EN-50026** installer (2) and **GE-8092** handle (3).



NOTE: The crankshaft rear oil seal must be driven out from the engine block side of the housing.

Installation Procedure

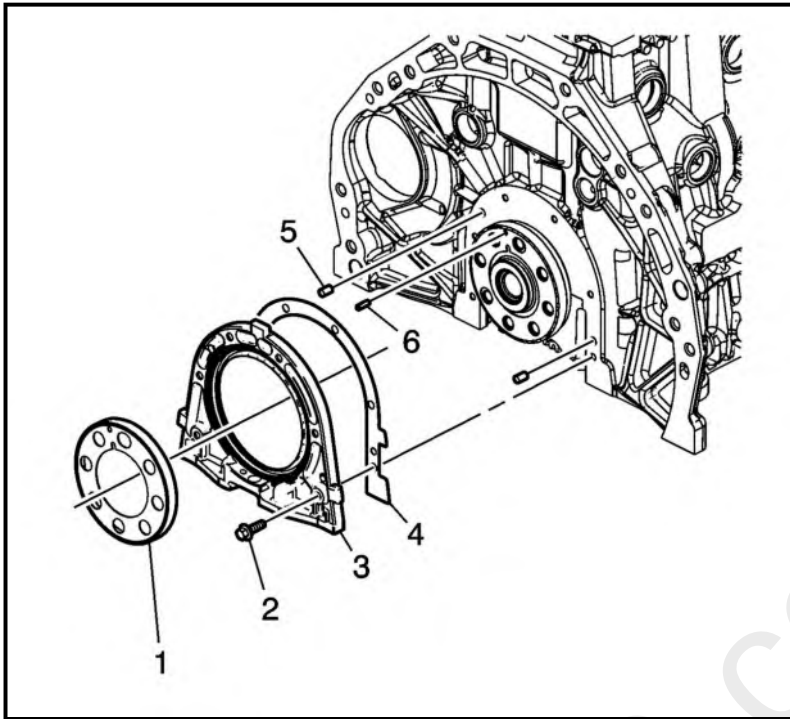
1. Install the NEW crankshaft rear oil seal (3) into the crankshaft rear oil seal housing (4) using the **EN-50026** installer (2) and **GE-8092** handle (1) until the seal bottoms out on the housing.



NOTE:

- The crankshaft rear oil seal must be installed with the cupped side of the seal facing the tool.
- The bottom edge of the crankshaft rear oil seal housing must hang off the edge of the bench to allow it to lay flat.

2. Crankshaft Rear Oil Seal Housing Gasket (4) - Install



NOTE:

If removed, install the crankshaft rear oil seal housing locating pin (5) and exciter ring locating pin (6).

NOTE:

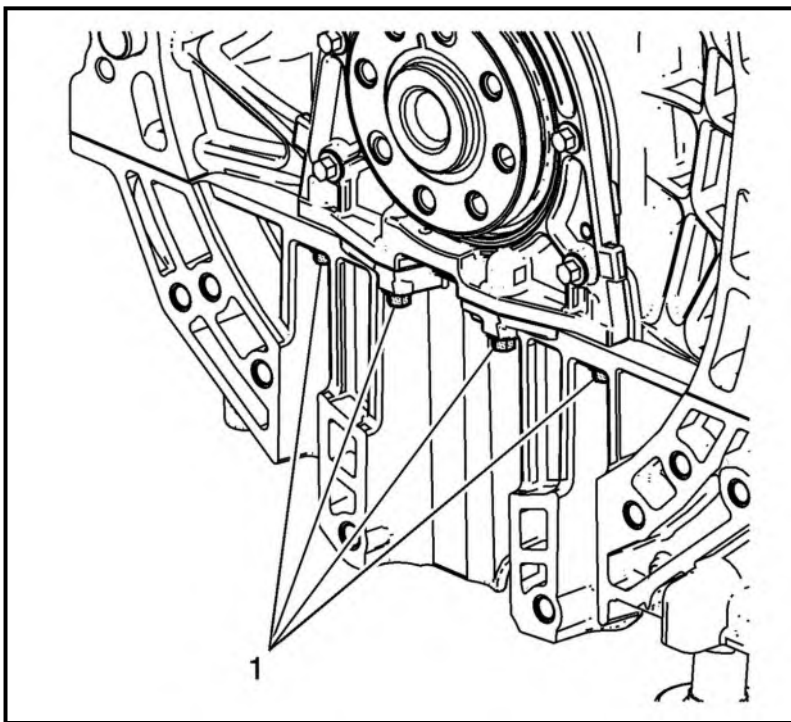
Lubricate the crankshaft sealing surface with engine oil. Adhesives, Fluids, Lubricants, and Sealers

3. Crankshaft Rear Oil Seal Housing (3) - Install

4. Crankshaft Rear Oil Seal Housing Bolt (2) - Loosely install [6x]

5. Crankshaft Position Sensor Exciter Ring (1) - Install

6. Tighten the oil pan bolts. (1) 15 N.m (11 lb ft)



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

NOTE: For ease of installation, hand start the rear oil seal housing bolts (1) at the oil pan before tightening the rear oil seal housing.

7. Tighten the bolts in the sequence shown. 15 N.m (11 lb ft)

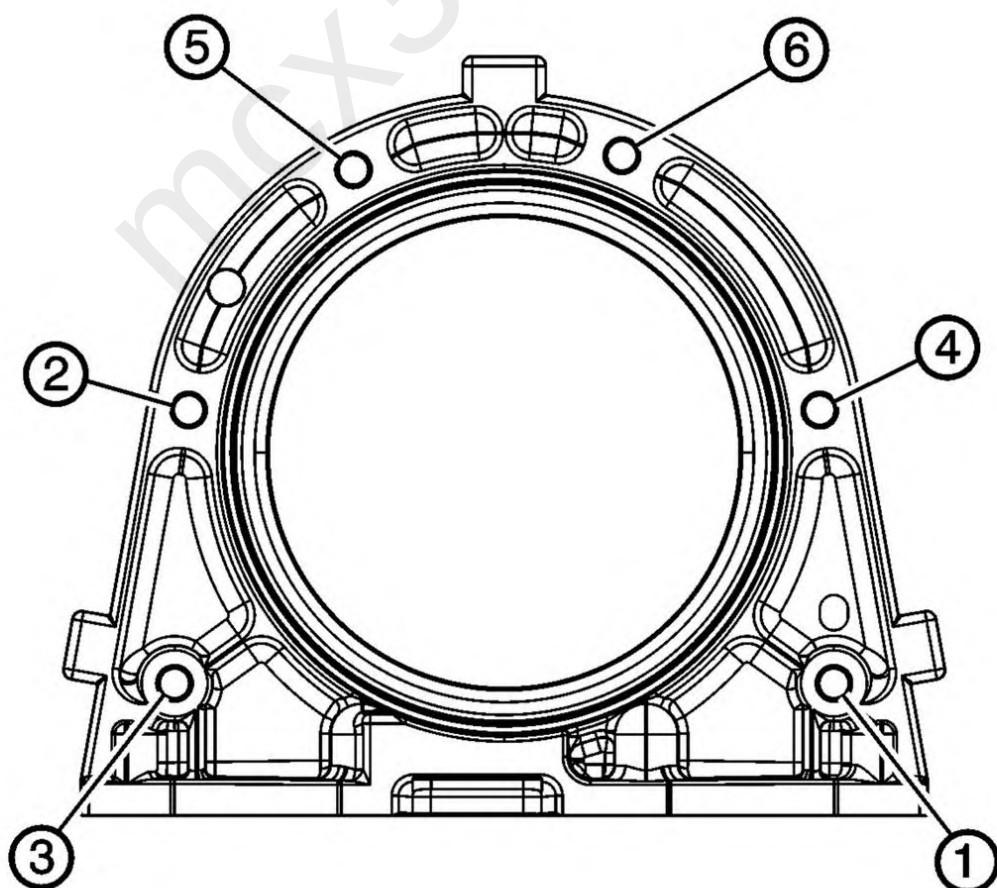


Fig. 13: Crankshaft Rear Oil Seal Housing Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

8. Transmission Replacement (LWN Diesel with 4WD) , or Transmission Replacement (LWN Diesel with 2WD) - Install

BALANCER REPLACEMENT

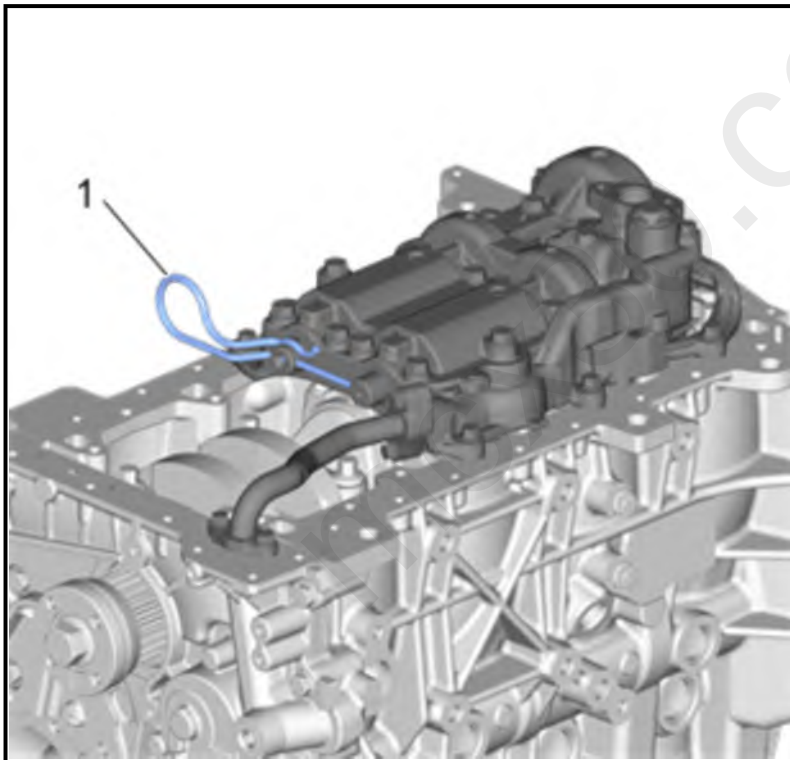
Special Tools

- EN-51265 Locking Tool
- EN-51162 Balancer Backlash Tool
- GE-7872 Dial Indicator

Equivalent regional tools: Special Tools

Removal Procedure

1. Upper Oil Pan Replacement (4 Wheel Drive), or Upper Oil Pan Replacement (2 Wheel Drive) - Remove
2. Rotate crankshaft to ensure that the balance shaft holes line up to install dowel to maintain timing.
3. Install GM P/N 12628143 balancer shaft gear pin (1) on the balance shaft assembly



NOTE:

- Install GM P/N 12628143 balancer shaft gear pin to the balancer shafts before removing the assembly to maintain timing and aid installation.
- If GM P/N 12628143 balancer shaft gear pin is not available, install a 4 - 5 mm dowel rod through the holes in both balancer shafts to maintain timing.

4. Remove the balance shaft assembly bolts in sequence shown.

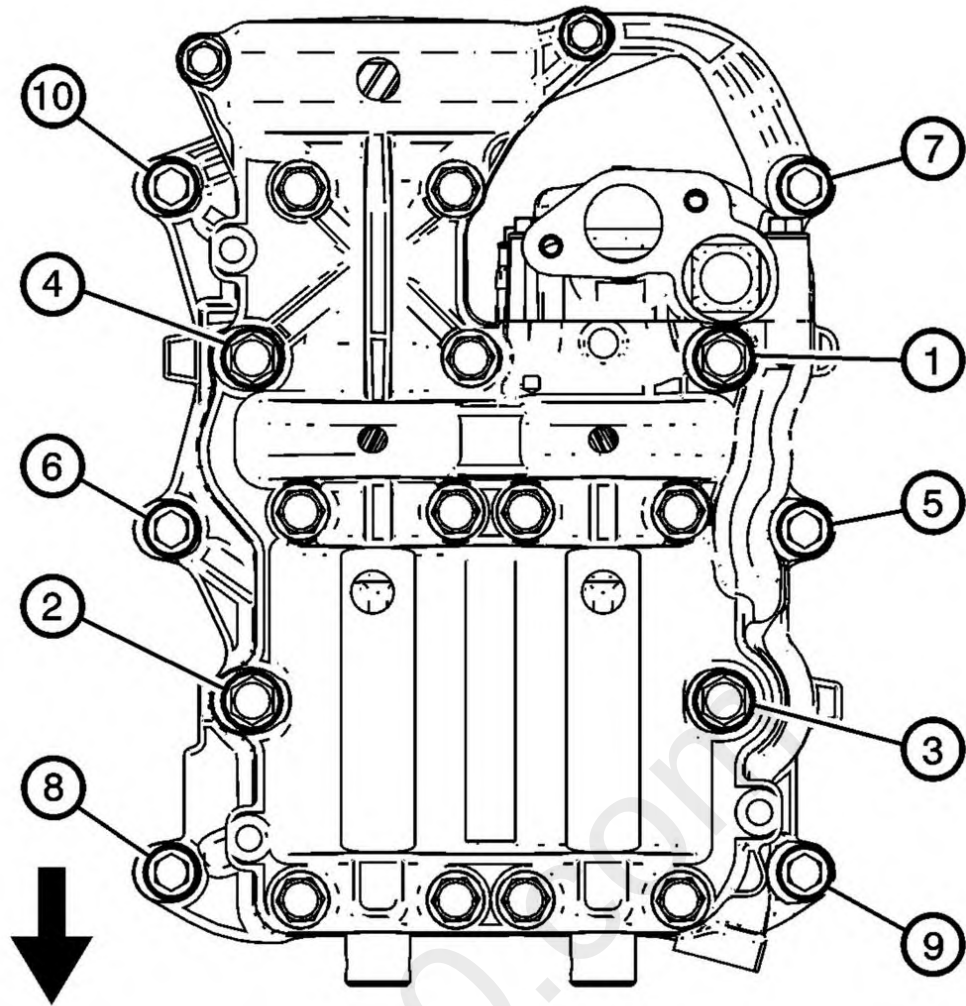
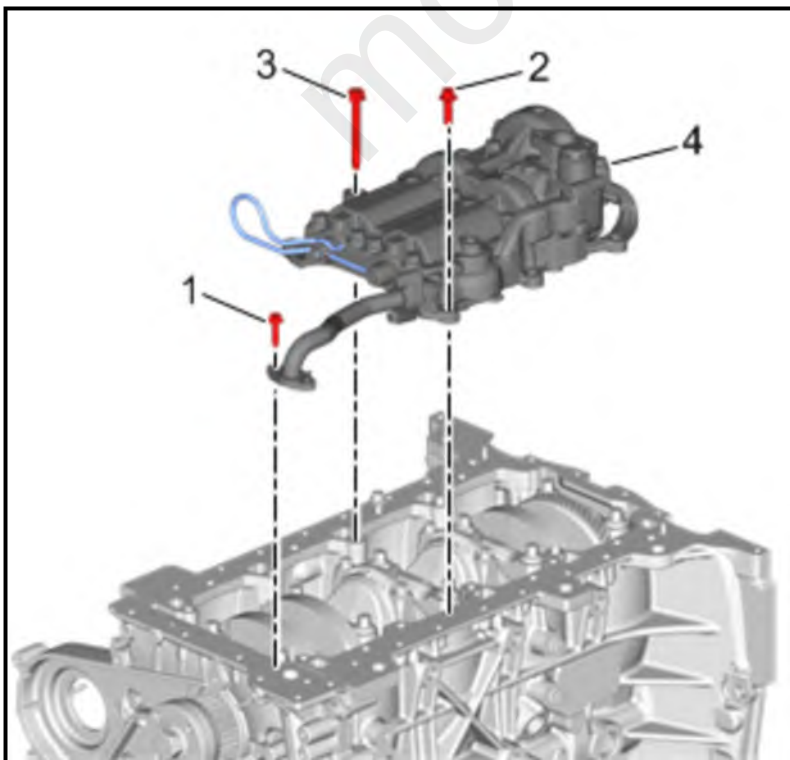


Fig. 14: Balance Shaft Assembly Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

5. Remove the balance shaft assembly bolts (1 - 3) and balance shaft assembly (4).

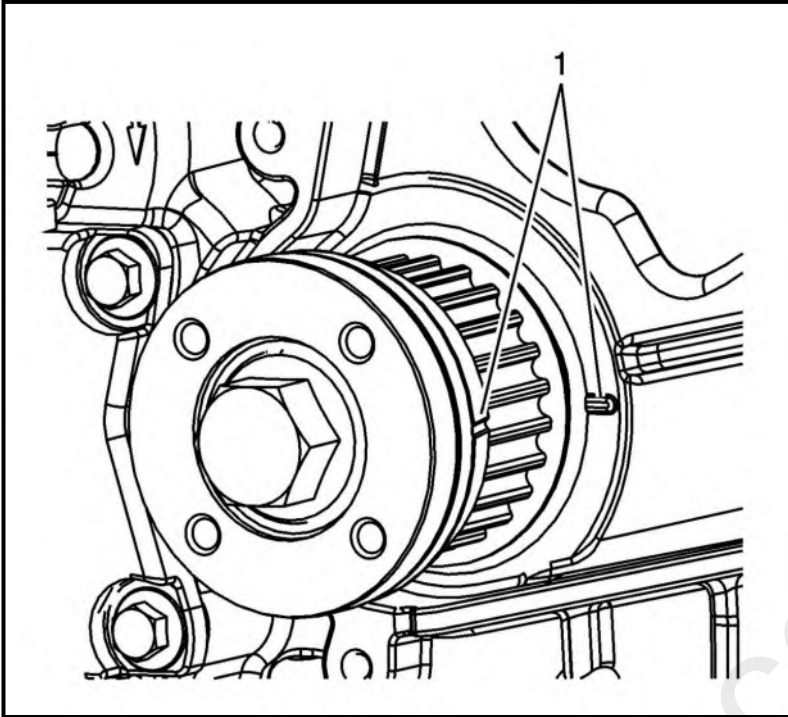


NOTE: If reinstalling the balancer, clean and inspect as needed.

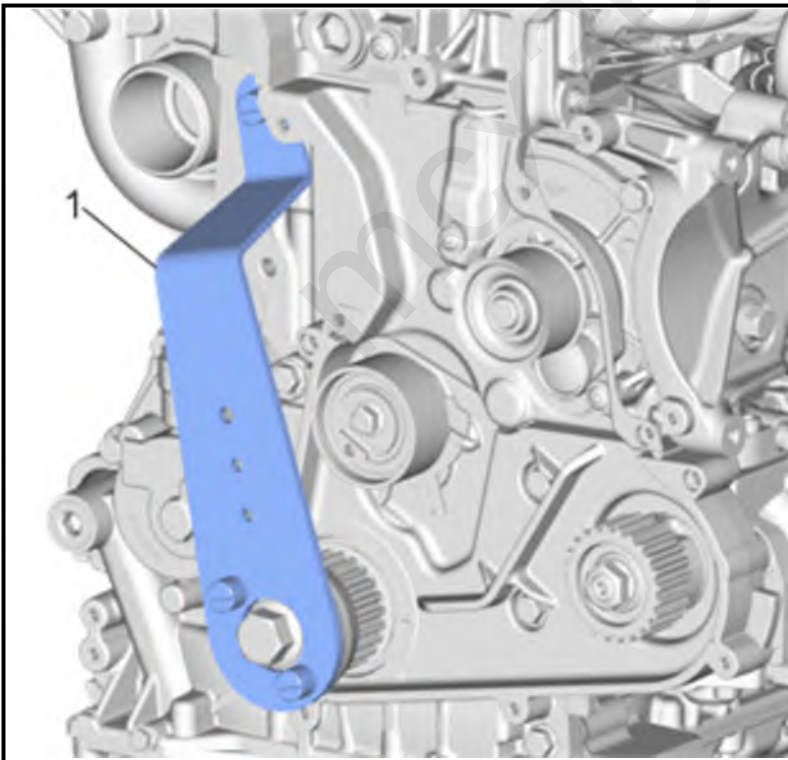
6. **Balancer Shaft Cleaning and Inspection** - Clean and inspect

Installation Procedure

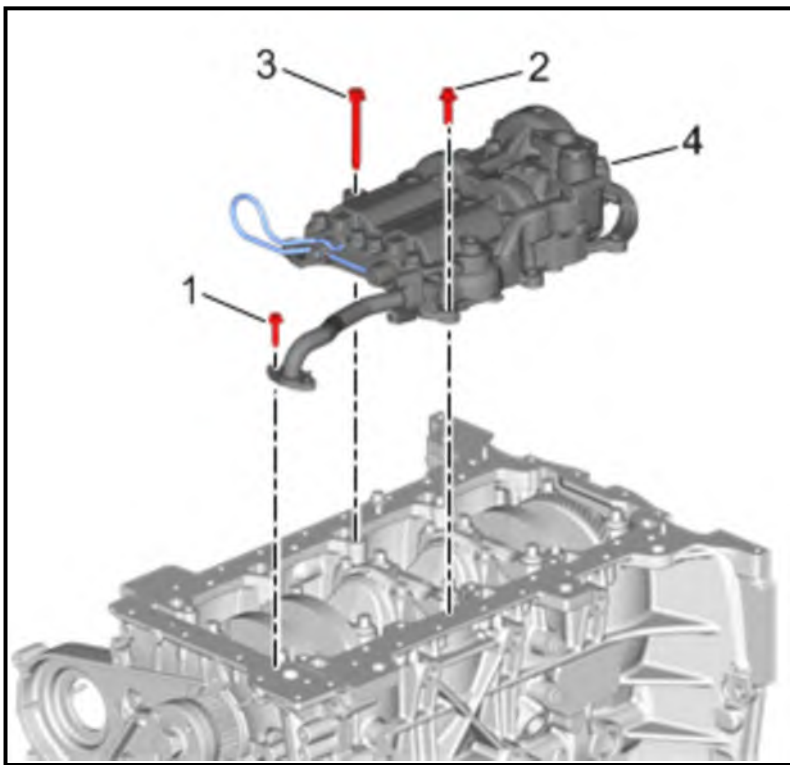
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees After Top Dead Center (ATDC) with the mark on the front cover (1).



2. Install the **EN-51265** locking tool.



3. Install the balancer assembly (4).



4. Install the balancer assembly bolts (1 - 3) and hand tighten.
5. Install the fasteners in sequence, hand tighten.

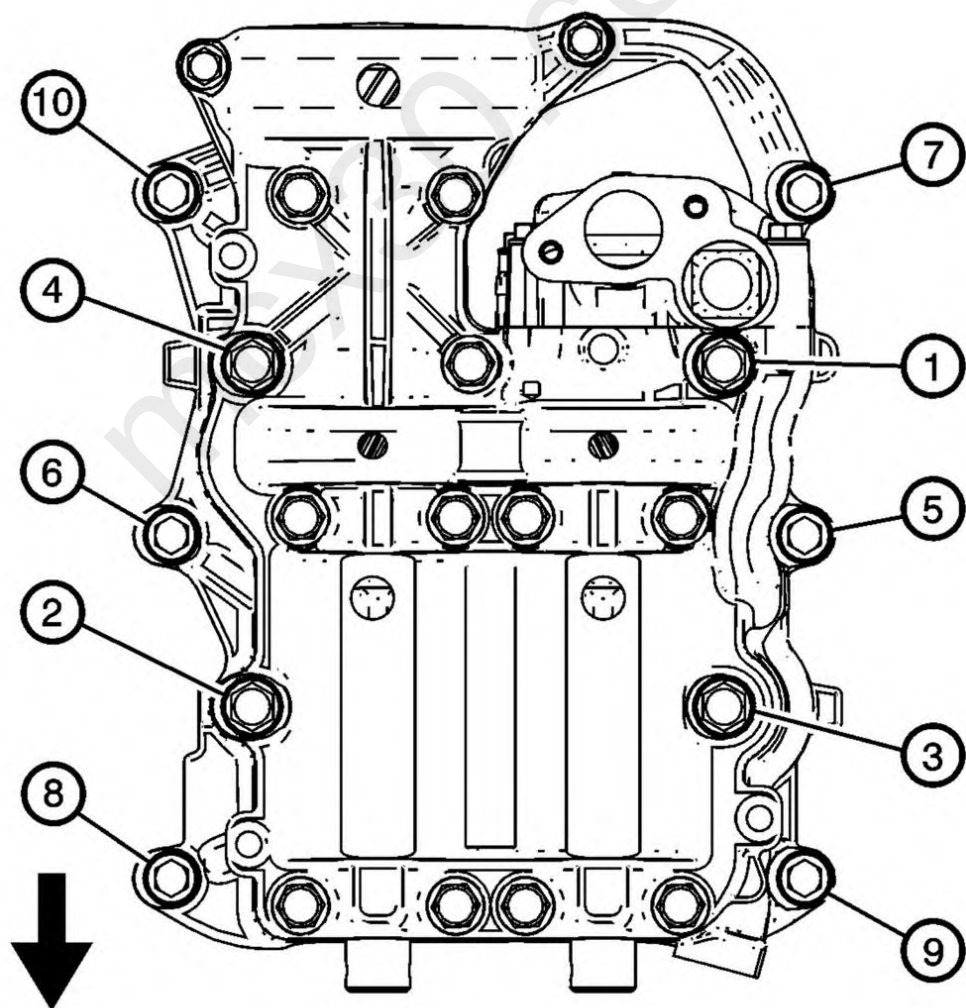
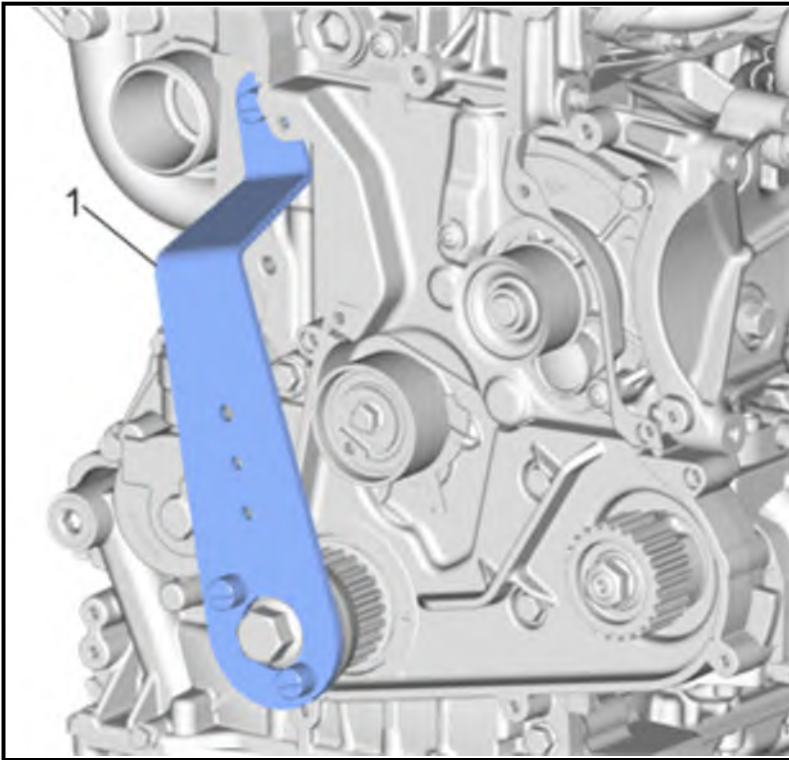
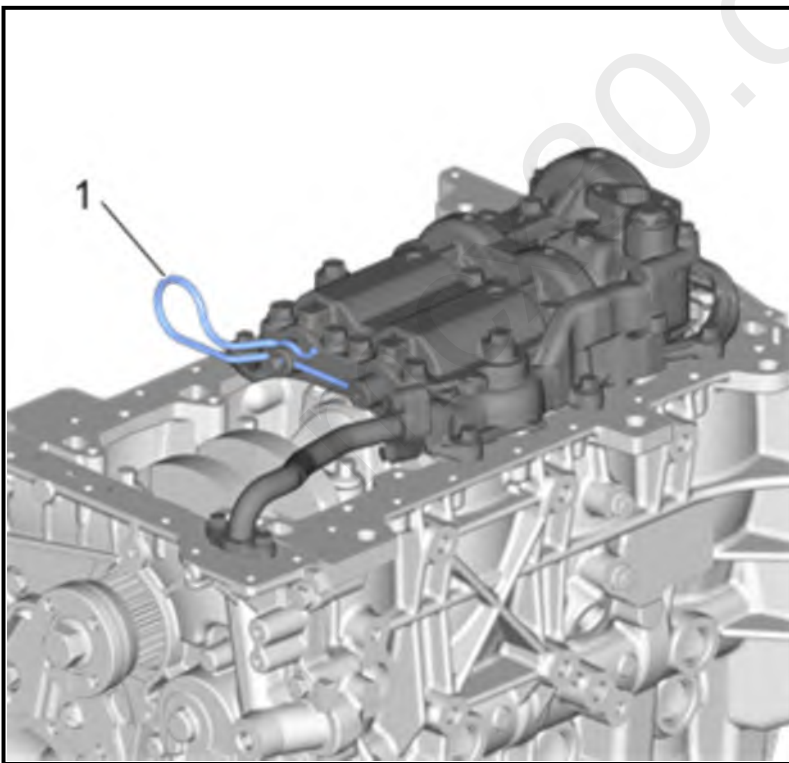


Fig. 15: Balance Shaft Assembly Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

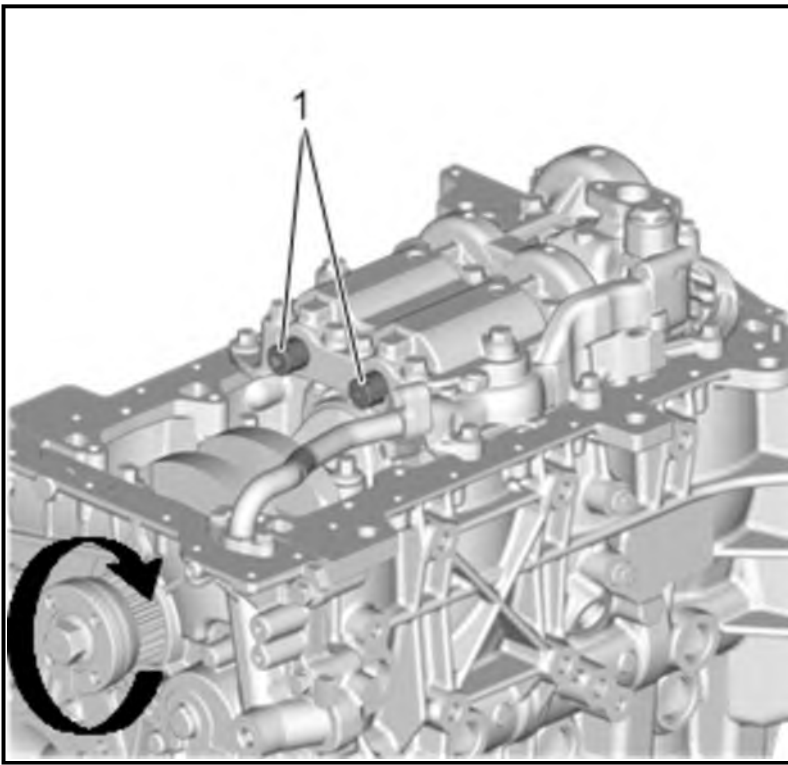
6. Remove the **EN-51265** locking tool.



7. Remove GM P/N 12628143 balancer shaft gear pin (1).

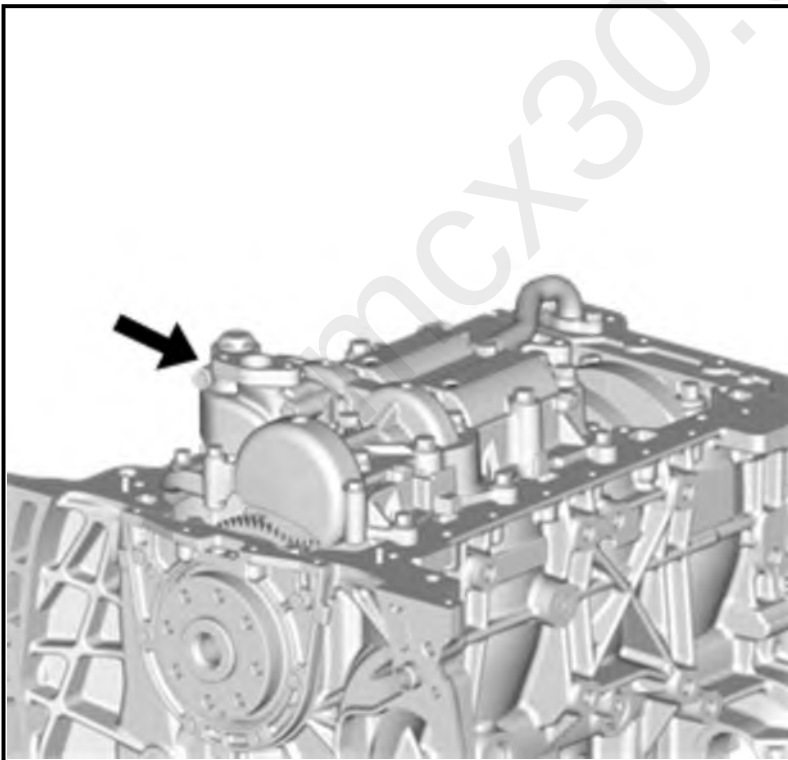


8. Rotate crankshaft 90 degrees until the flat on the balancer shaft (1) is facing the bottom of the engine.

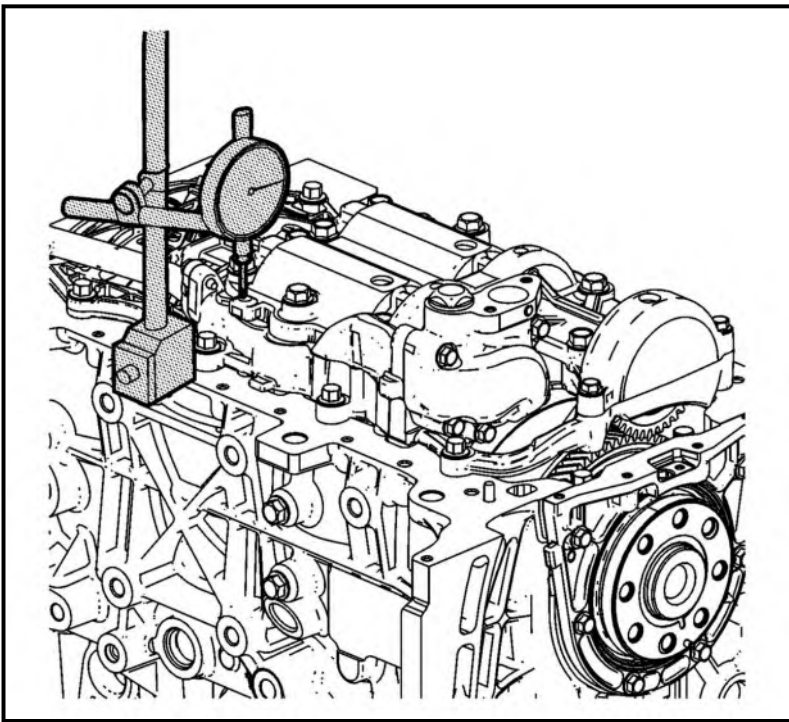


NOTE: A NEW balancer contains a coating on a portion of the drive gear which can lead to errors in backlash reading. The crankshaft must be rotated so that the coating is not in contact with the crankshaft gear.

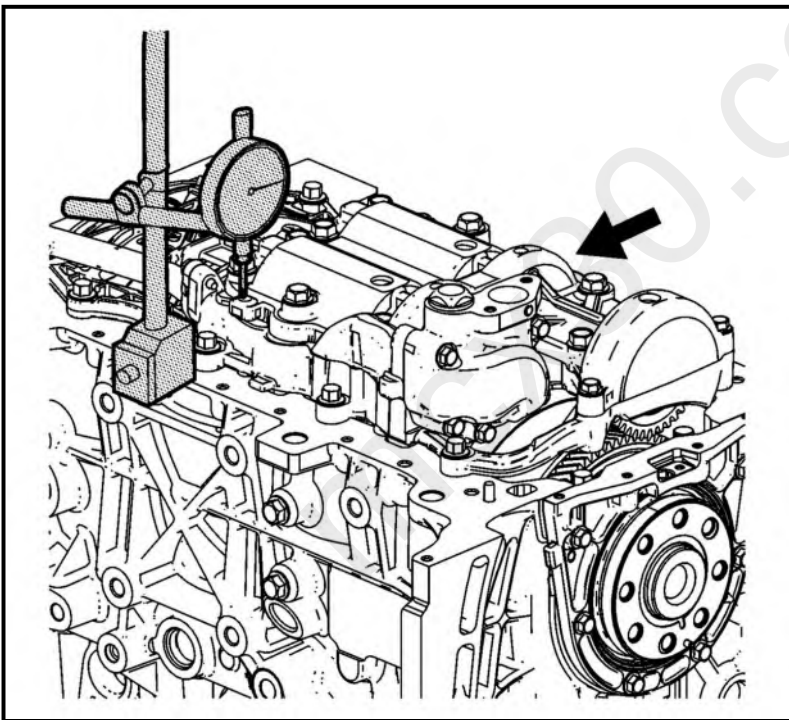
9. Push the balancer in the direction shown as far as it will go.



10. Position a magnetic dial gauge on the block and set the gauge to zero on the pad of the balancer.

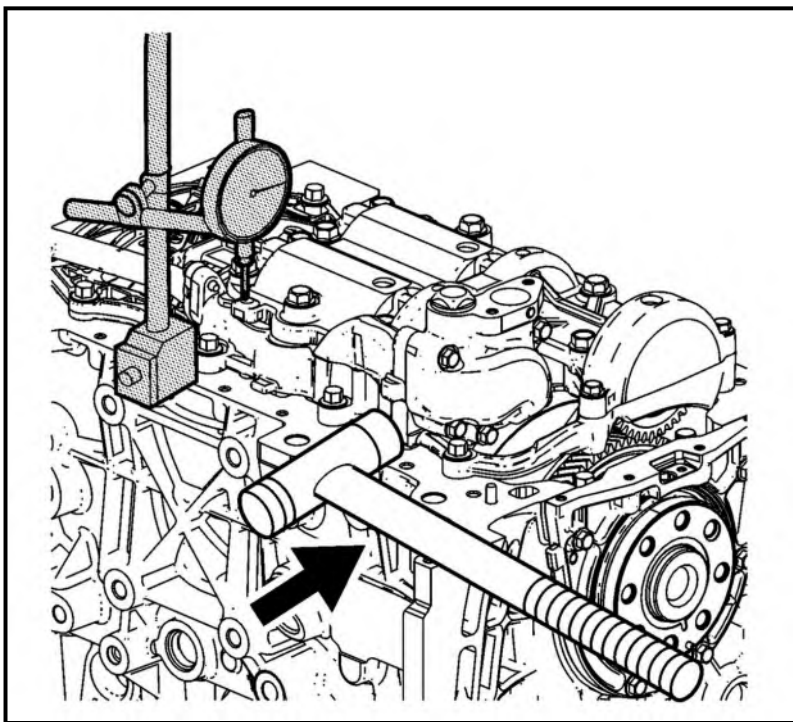


11. Push the balancer in the direction shown until the dial gauge reads at least 0.4 mm movement. The balancer is climbing over the crankshaft gear.



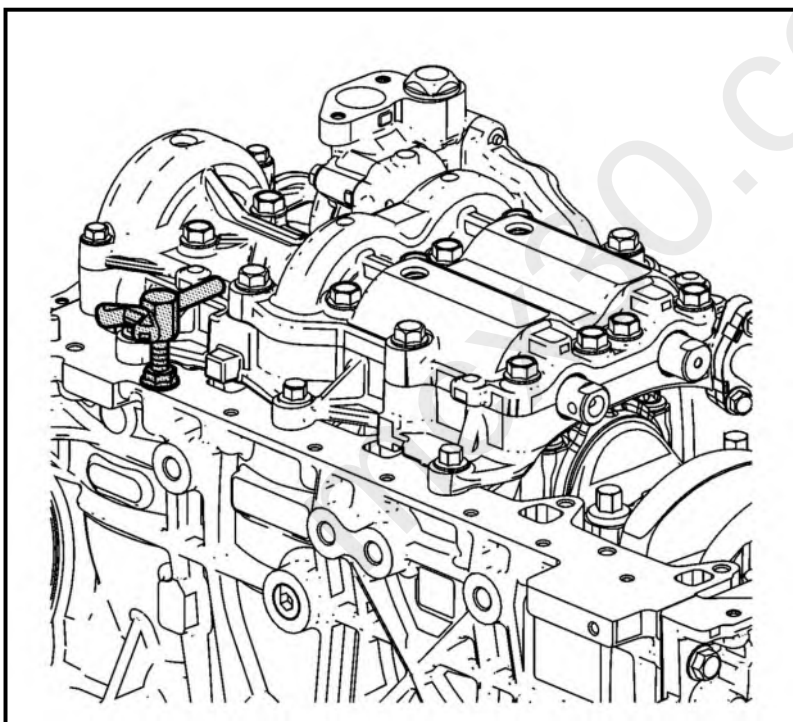
NOTE: The balancer may not move, this is normal.

12. Using a soft mallet, gently tap the balancer in the direction shown until the dial gauge reads 0.



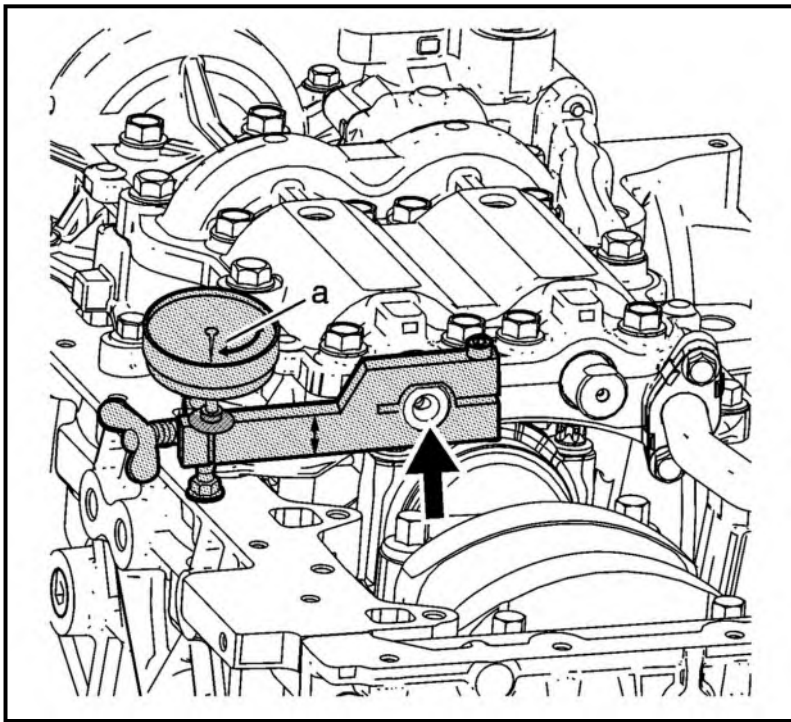
13. Hand tighten the balancer bolts.

14. Install **EN-51162 - 2** Pre-load Screw Assembly to the block in the position shown and tighten to the block.



15. Hand tighten the screw until it contacts the body of the balancer.

16. While pushing the balancer shaft toward the front of the engine with your thumb, use finger pressure to push up and down on the **EN-51162 - 1** Balancer Backlash Tool and read the total deflection on the dial indicator. The backlash specification is 0.06 - 0.15 mm (0.002 - 0.006 in).



17. Record the readings on the dial indicator.

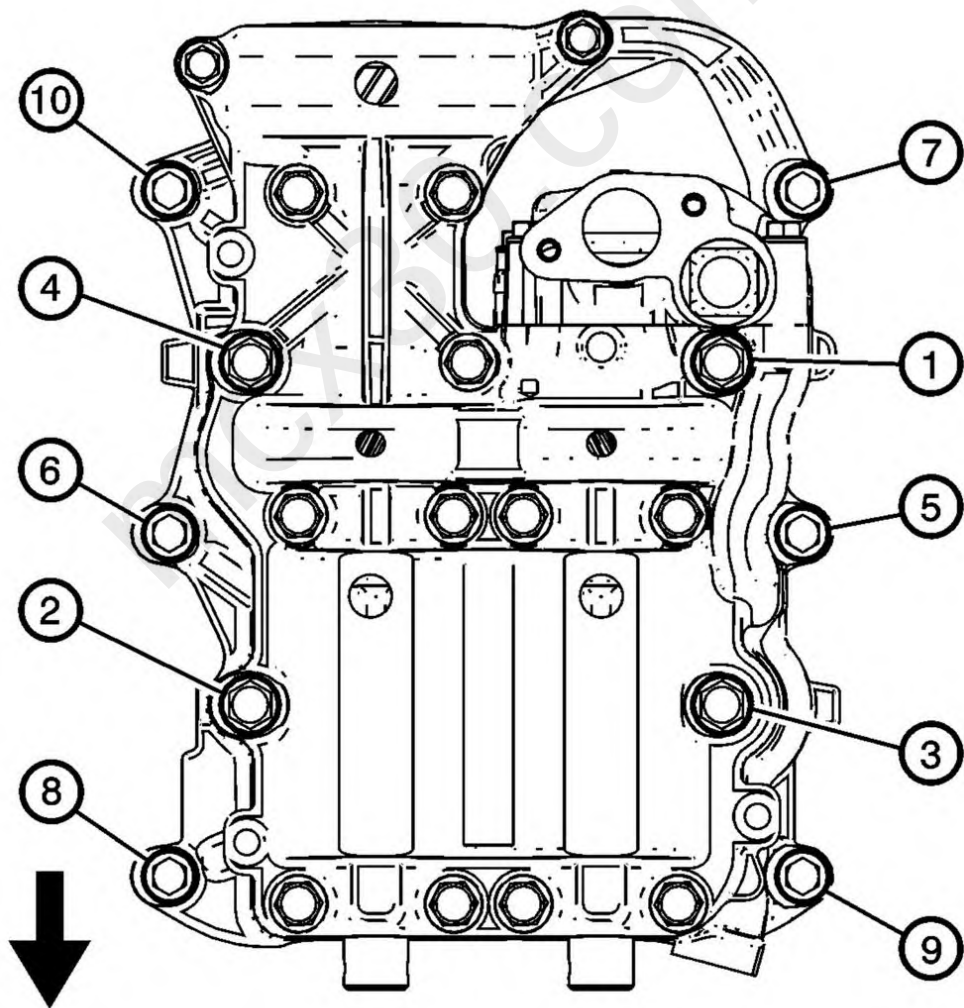
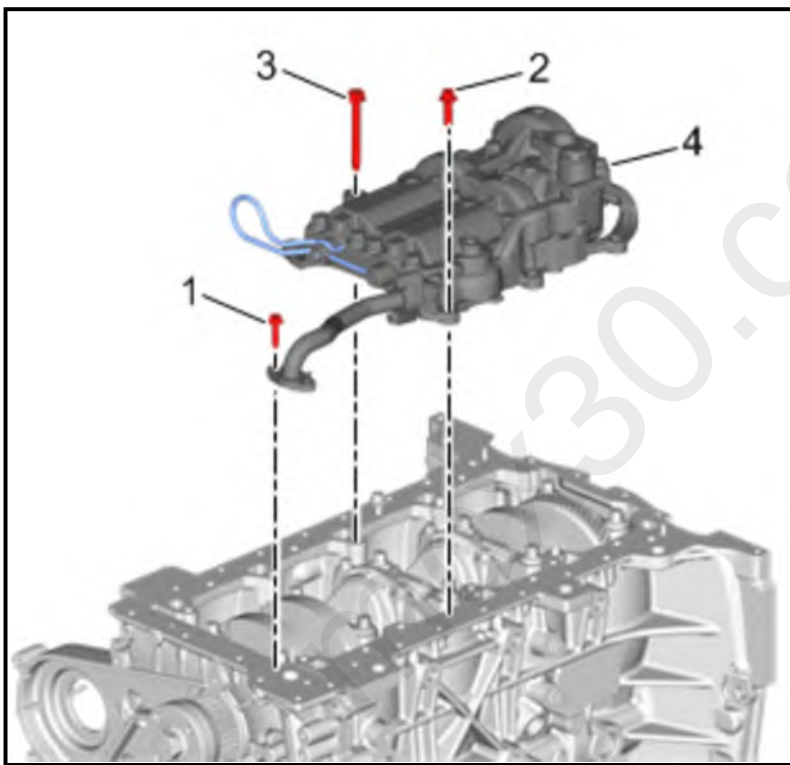


Fig. 16: Balance Shaft Assembly Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

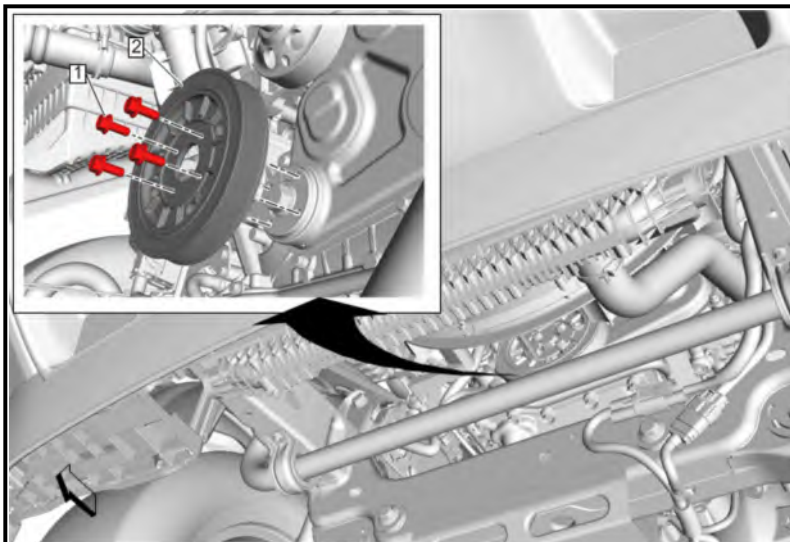
1. If the balancer backlash is correct or very close, tighten the balancer bolts in sequence to 32 N.m (24 lb ft) and check the backlash again. If the backlash is still correct after tightening, go to step 17.

2. If the balancer backlash is too high, go to step 15.
 3. If the balancer backlash is too low, go to step 16.
18. Backlash too high.
1. Slightly loosen the balancer bolts.
 2. Turn the Pre-load screw clockwise a very small amount.
 3. Hand tighten the balancer bolts.
 4. Repeat steps 13 and 14 to measure balancer backlash.
19. Backlash too low.
1. Slightly loosen the balancer bolts.
 2. Loosen the Pre-load screw counter-clockwise a very small amount.
 3. Gently tap the balancer on the right side with a rubber mallet to bring it in contact with the Pre-load screw.
 4. Hand tighten the balancer bolts.
 5. Repeat steps 13 and 14 to measure balancer backlash.
20. Tighten the balance shaft tube bolts (1) to 25 N.m (18 lb ft).



21. Remove the tools.
22. Upper Oil Pan Replacement (4 Wheel Drive), or Upper Oil Pan Replacement (2 Wheel Drive) - Install

CRANKSHAFT BALANCER REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedures Engine Coolant Fan Rear Shroud Replacement (LWN) Drive Belt Replacement	
1	Crankshaft Pulley
2	Crankshaft Pulley Bolt [4x] CAUTION: Refer to Fastener Caution . Tighten 32 N.m (24 lb ft)

ENGINE FRONT COVER REPLACEMENT

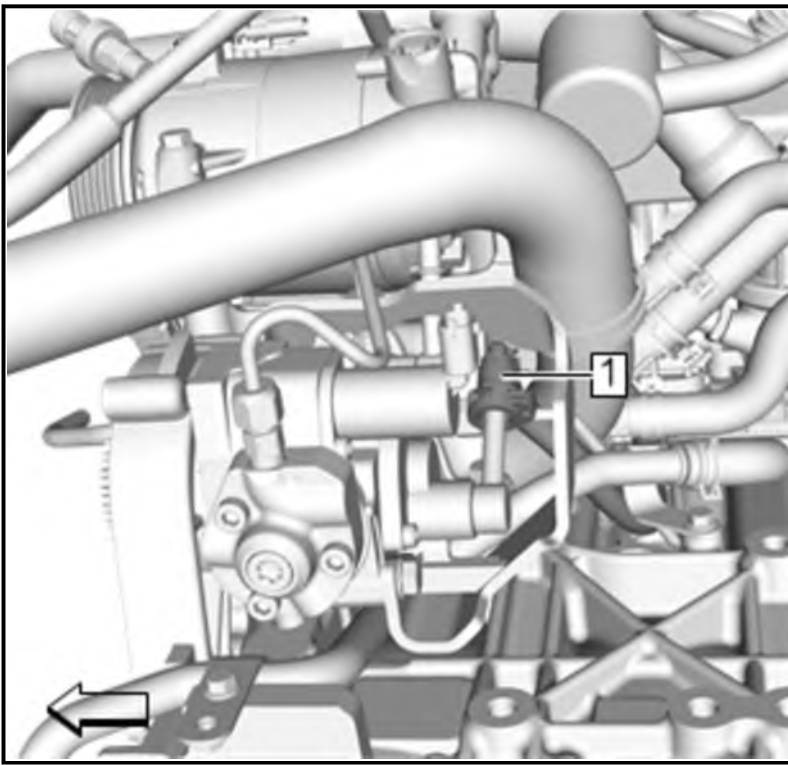
Special Tools

EN-46109-2 Guide Pins

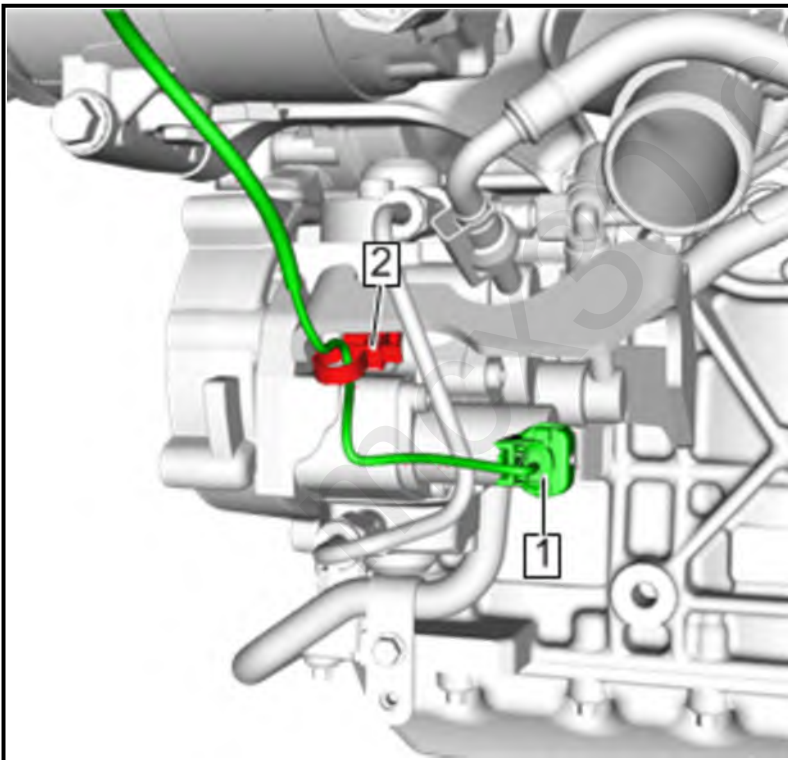
Equivalent regional tools: [Special Tools](#)

Removal Procedure

- Vacuum Pump Pipe - Remove - [Vacuum Pump Pipe Replacement](#)
- Timing Belt Tensioner - Remove - [Timing Belt Tensioner Replacement](#)
- Engine Oil Cooler Pipe - Remove - [Engine Oil Cooler Pipe Replacement \(LWN\)](#)
- Upper Oil Pan - Remove - [Upper Oil Pan Replacement \(4 Wheel Drive\)](#), or [Upper Oil Pan Replacement \(2 Wheel Drive\)](#)
- Fuel Pump Fuel Feed Hose (1) @ Fuel Injection Pump - Disconnect - [Fuel Pump Fuel Feed Hose Replacement](#)



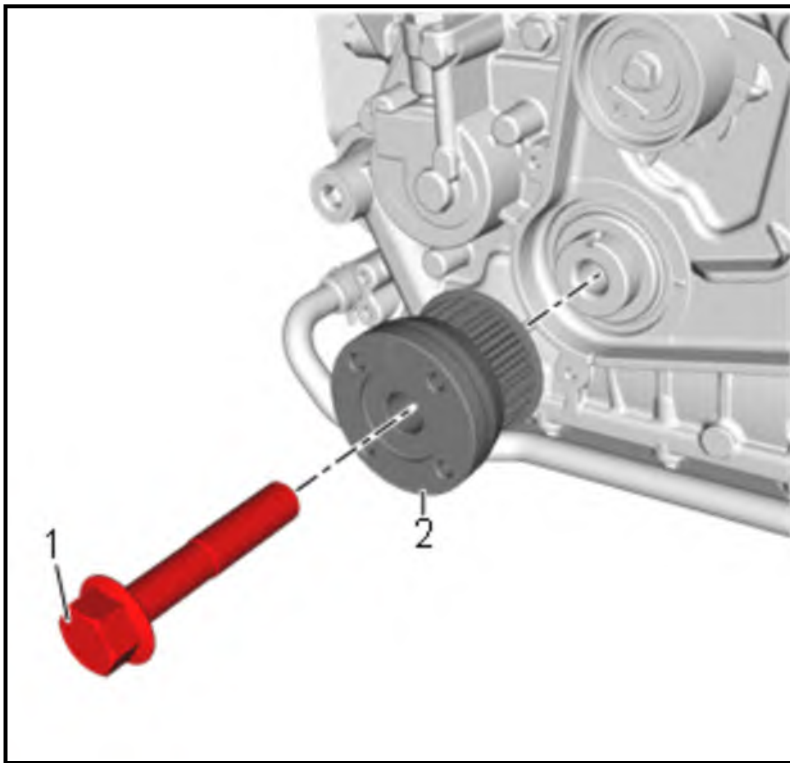
6. Electrical Connector (1) - Disconnect



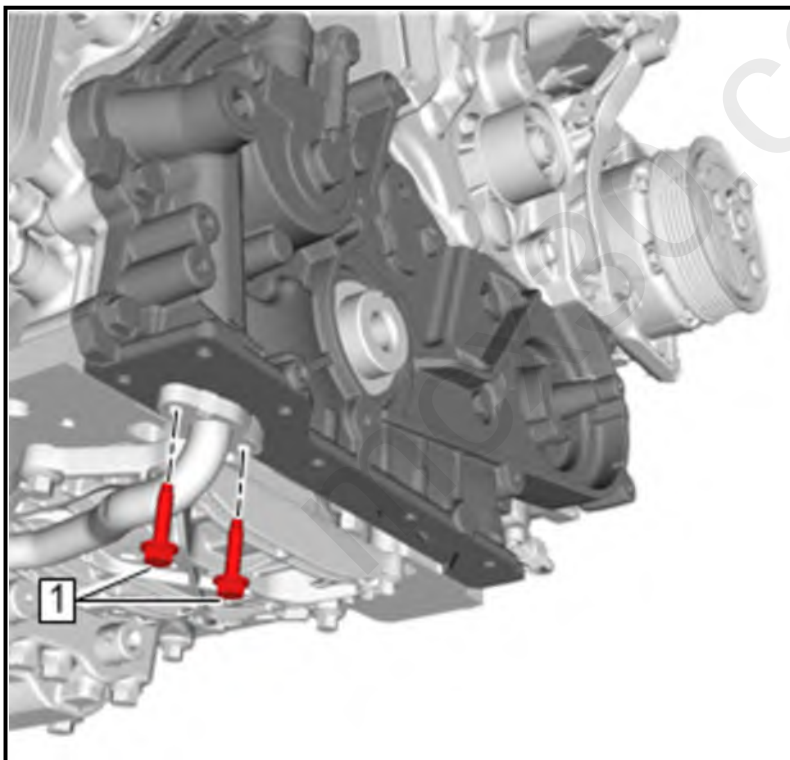
7. Wiring Harness Retainer (2) Unclip

NOTE: Disconnect fuel pump to fuel rail only.

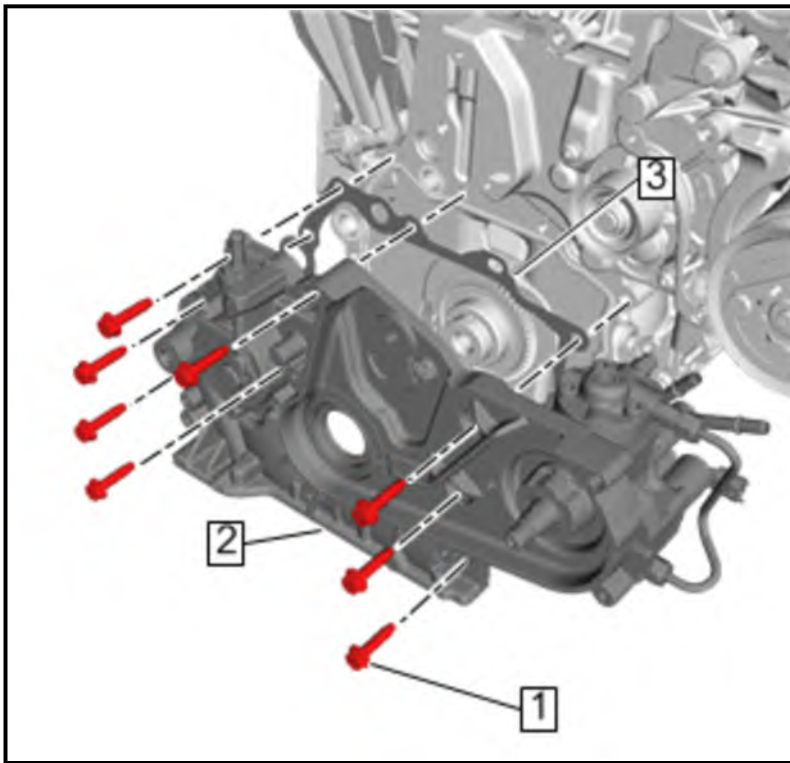
8. Fuel Injection Fuel Feed Pipe @ Fuel Injection Pump - Disconnect - [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#) , or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#)
9. Diesel Fuel Separator Hose @ Fuel Injection Pump - Disconnect - [Plastic Collar Quick Connect Fitting Service](#)
10. Crankshaft Sprocket (2) - Remove - [Crankshaft Sprocket Replacement](#)



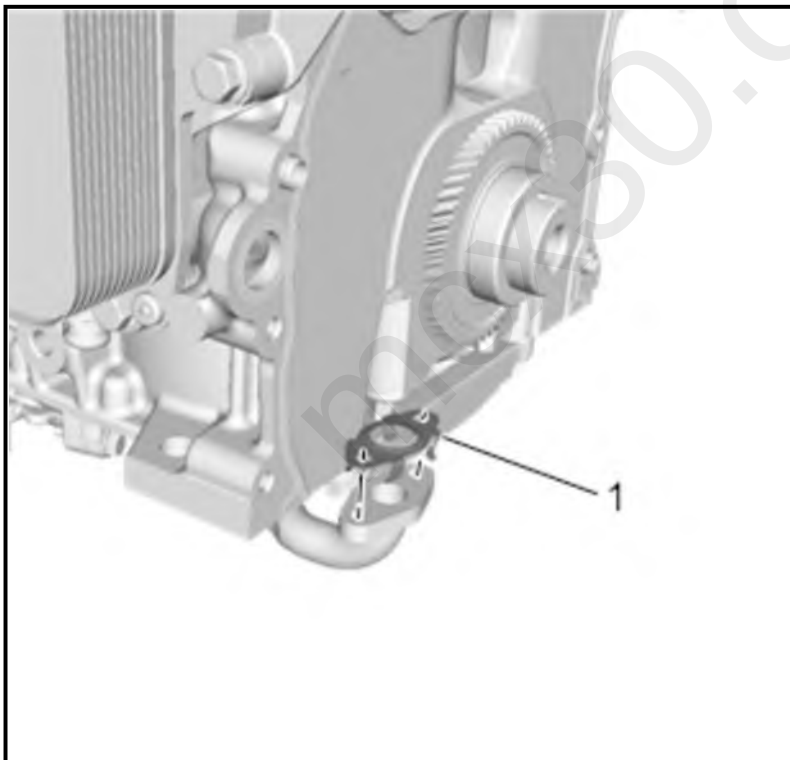
11. Oil Pump Suction Pipe Bolt (1) - Remove [2x]



12. Engine Front Cover Bolt (1) - Remove [8x]



13. Engine Front Cover (2) - Remove
14. Engine Front Cover Gasket (3) - Remove
15. Oil Pump Suction Pipe Gasket (1) - Remove and DISCARD

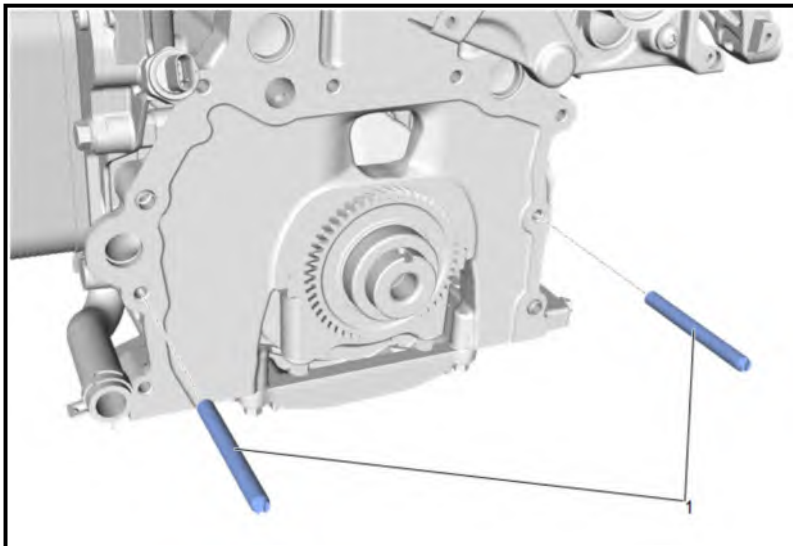


16. Fuel Injection Pump - Remove - [Fuel Injection Pump Replacement](#)
17. If re-installing the engine front cover, or replacing the crankshaft front oil seal refer to [Crankshaft Front Oil Seal Removal](#).
18. Engine Front Cover - Clean and inspect - [Engine Front Cover Cleaning and Inspection](#)

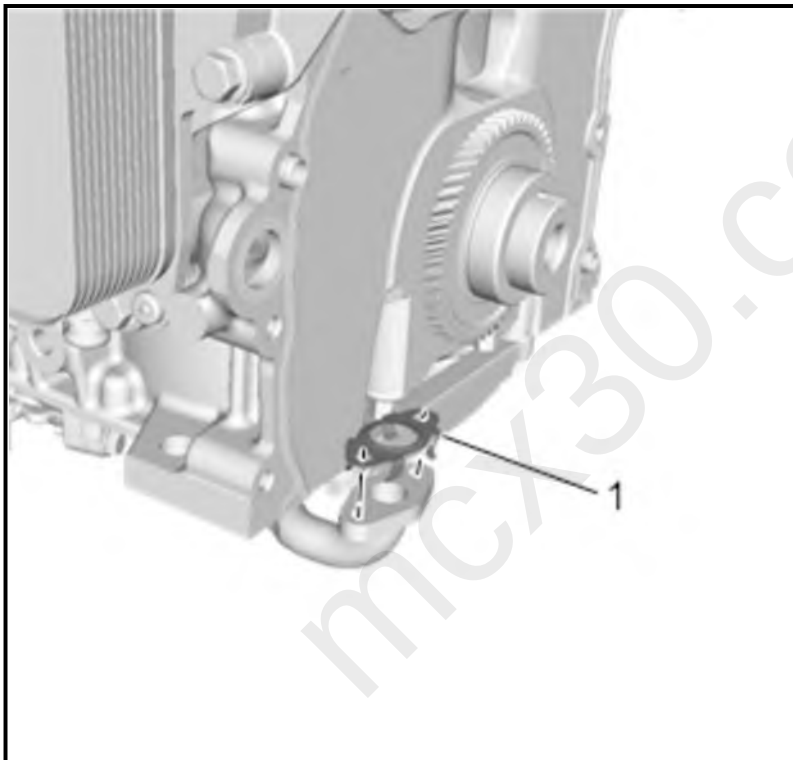
Installation Procedure

1. If re-installing the engine front cover, or replacing the crankshaft front oil seal refer to [Crankshaft Front Oil Seal Installation](#).

2. **EN-46109-2** Guide Pins (1) - Install [2x]



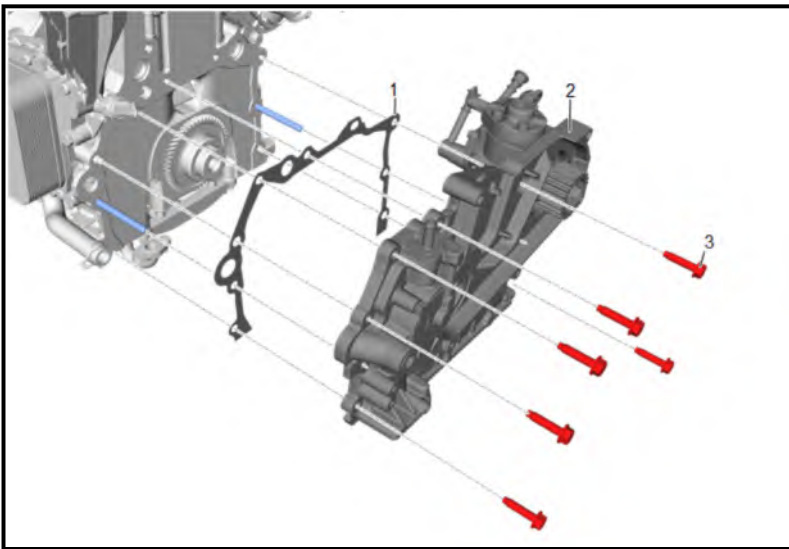
3. Oil Pump Suction Pipe Gasket (1) - Install



NOTE: Install a **NEW** gasket.

4. Fuel Injection Pump - Install - [**Fuel Injection Pump Replacement**](#)

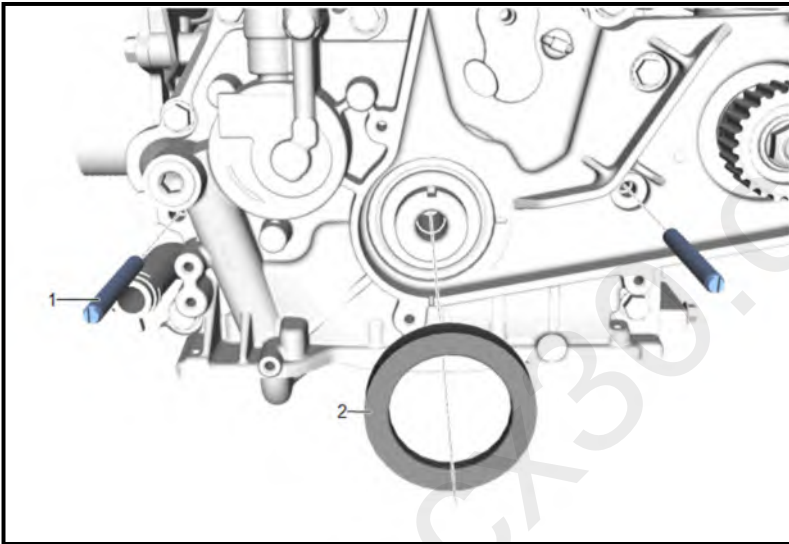
5. Engine Front Cover Gasket (1) - Install



6. Engine Front Cover (2) - Install

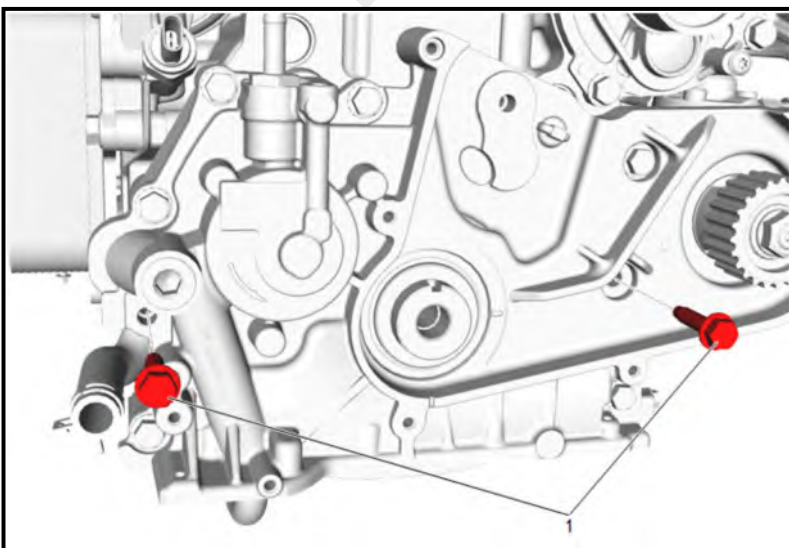
7. Engine Front Cover Bolt (3) - Install, but do NOT tighten [6x]

8. **EN-46109-2** Guide Pins (1) - Remove [2x]

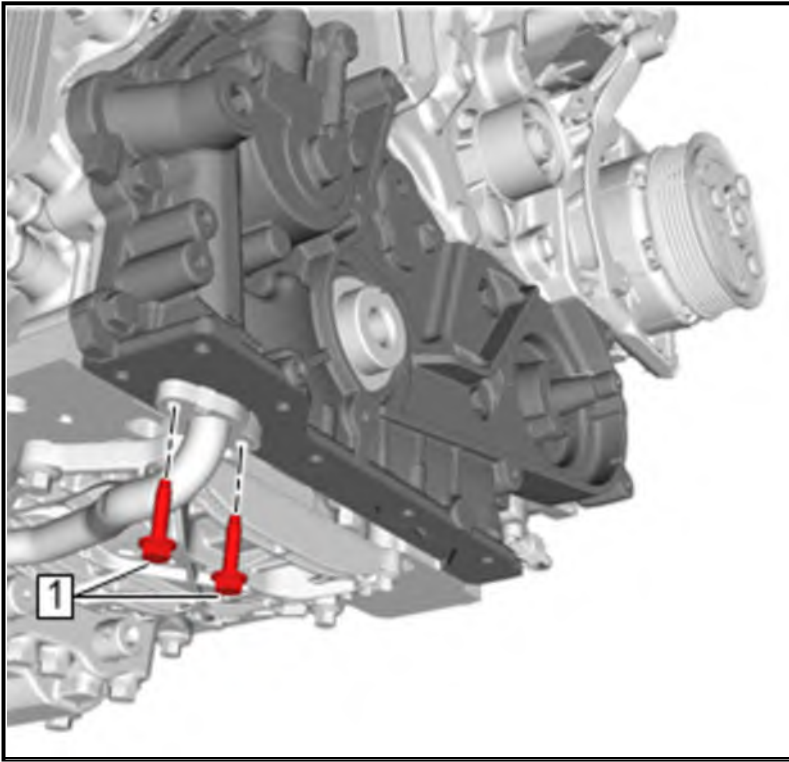


9. Crankshaft front oil seal installation sleeve (2) - Remove and DISCARD

10. Engine Front Cover Bolt (1) - Install, but do NOT tighten [2x]

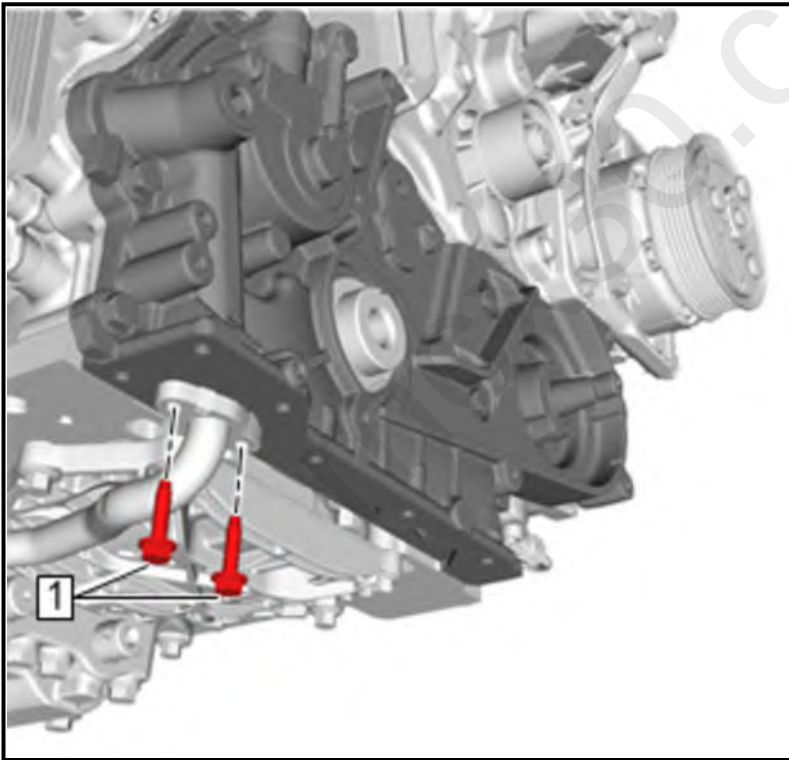


11. Oil Pump Suction Pipe Bolt (1) - Install, but do NOT tighten [2x]

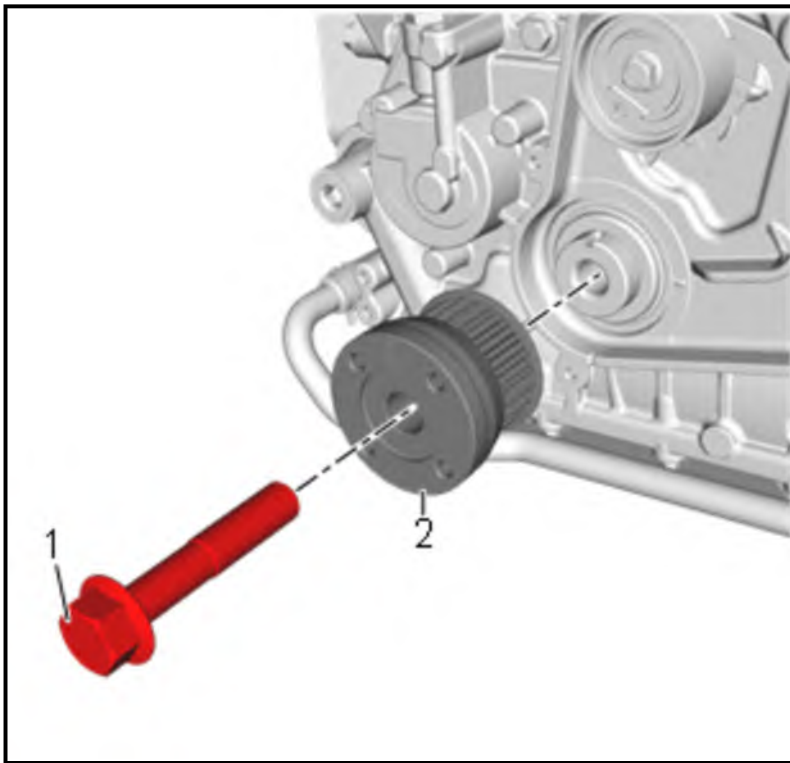


12. Engine Front Cover Bolt - Tighten in sequence [8x] - [Engine Front Cover Installation](#)

13. Oil Pump Suction Pipe Bolt (1) - Tighten [2x] 10 N.m (89 lb in)



14. Crankshaft Sprocket (2) - Install - [Crankshaft Sprocket Replacement](#)

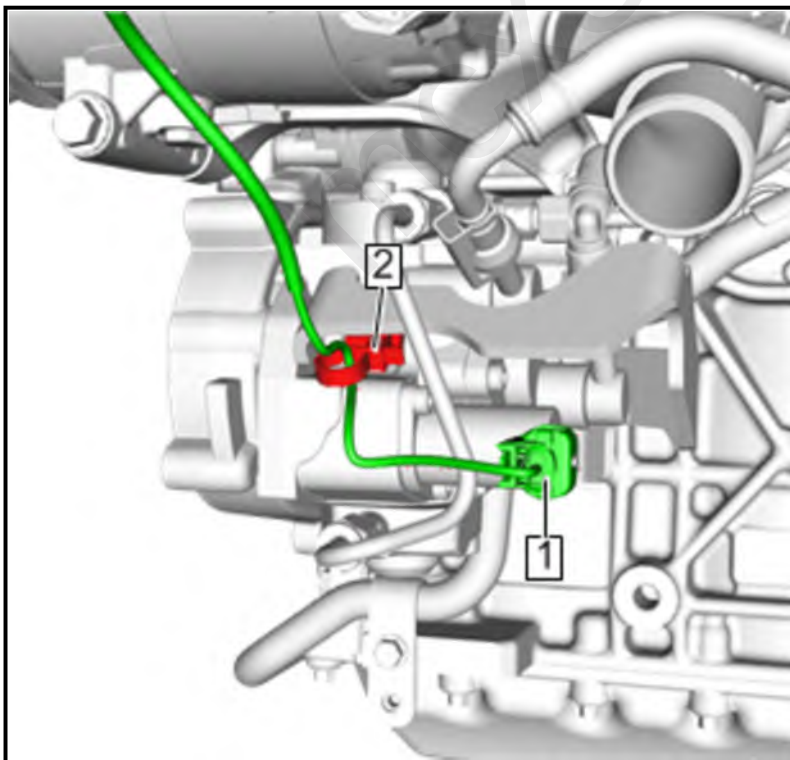


15. Diesel Fuel Separator Hose @ Fuel Injection Pump - Connect - [Plastic Collar Quick Connect Fitting Service](#)

NOTE: Disconnect fuel pump to fuel rail only.

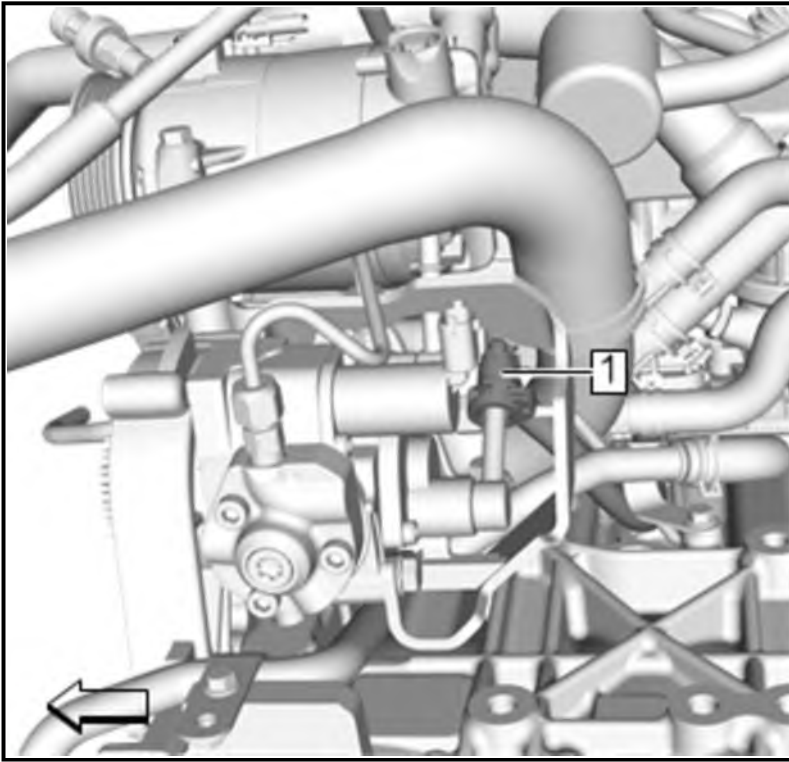
16. Fuel Injection Fuel Feed Pipe @ Fuel Injection Pump - Connect - [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Pump to Fuel Rail\)](#) , or [Fuel Injection Fuel Feed Pipe Replacement \(Fuel Injector to Fuel Rail\)](#)

17. Electrical Connector (1) - Connect



18. Wiring Harness Retainer (2) Connect

19. Fuel Pump Fuel Feed Hose (1) @ Fuel Injection Pump - Connect - [Fuel Pump Fuel Feed Hose Replacement](#)



20. Upper Oil Pan - Install - [Upper Oil Pan Replacement \(4 Wheel Drive\)](#), or [Upper Oil Pan Replacement \(2 Wheel Drive\)](#)
21. Engine Oil Cooler Pipe - Install - [Engine Oil Cooler Pipe Replacement \(LWN\)](#)
22. Timing Belt Tensioner - Install - [Timing Belt Tensioner Replacement](#)
23. Vacuum Pump Pipe - Install - [Vacuum Pump Pipe Replacement](#)

CAMSHAFT REPLACEMENT

Removal Procedure

1. [Valve Rocker Arm Cover Replacement](#) - Remove
2. [Camshaft Gear Replacement](#) - Remove
3. [Camshaft Position Sensor Replacement](#) - Remove
4. Remove the camshaft cap bolts in sequence.

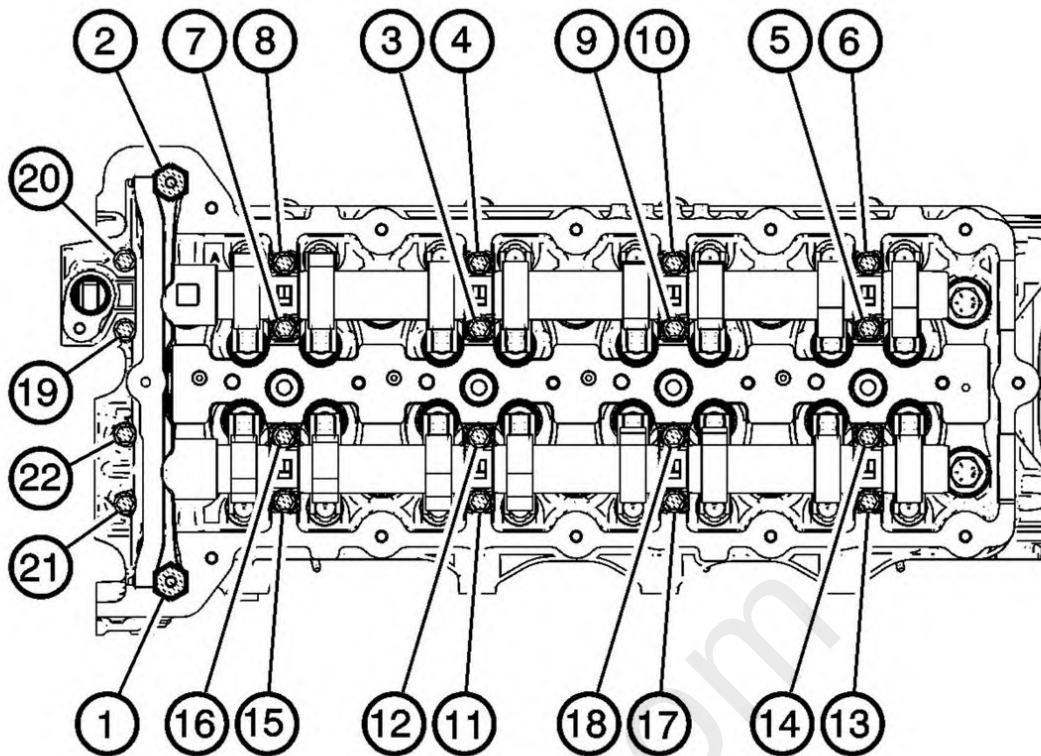
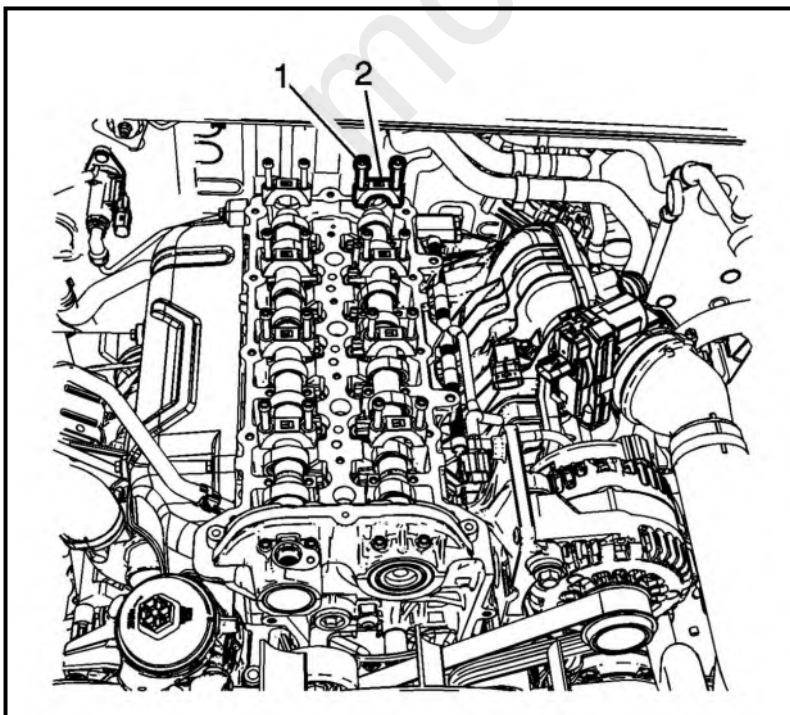


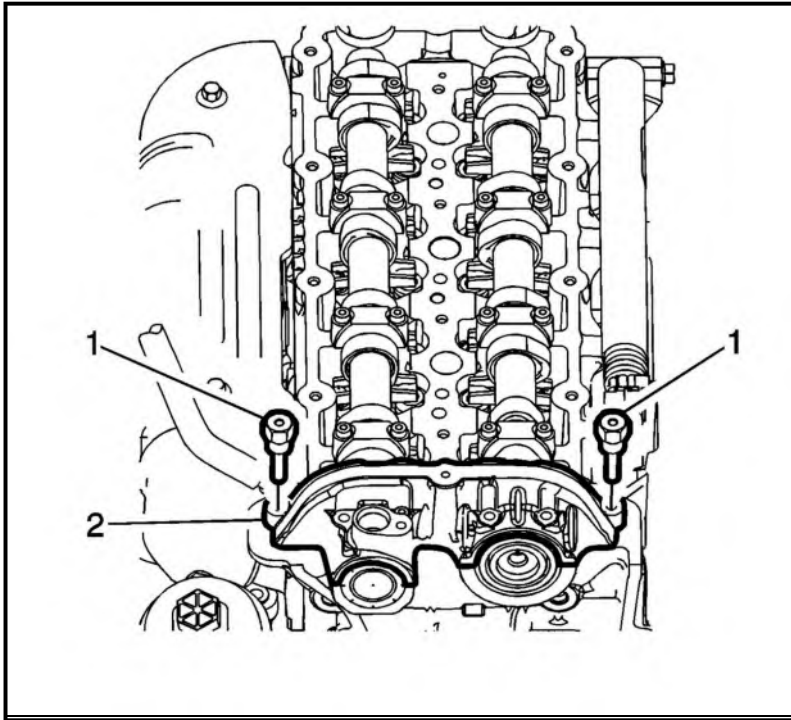
Fig. 17: Identifying Camshaft Cap Bolts With Removal Sequence
 Courtesy of GENERAL MOTORS COMPANY

5. Remove the camshaft cap bolts (1) and caps (2).

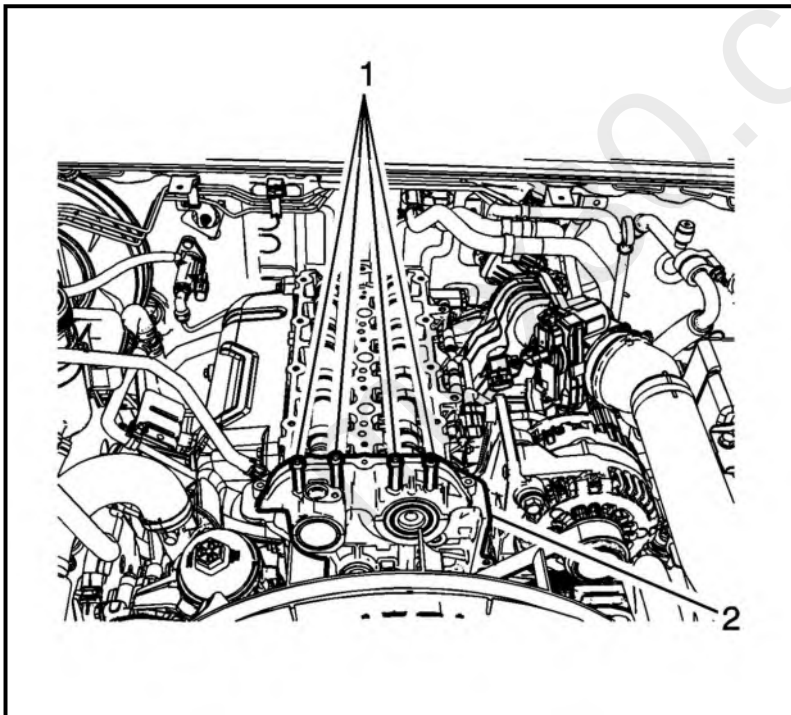


NOTE: Mark the camshaft caps before removal to ensure installation in their original location.

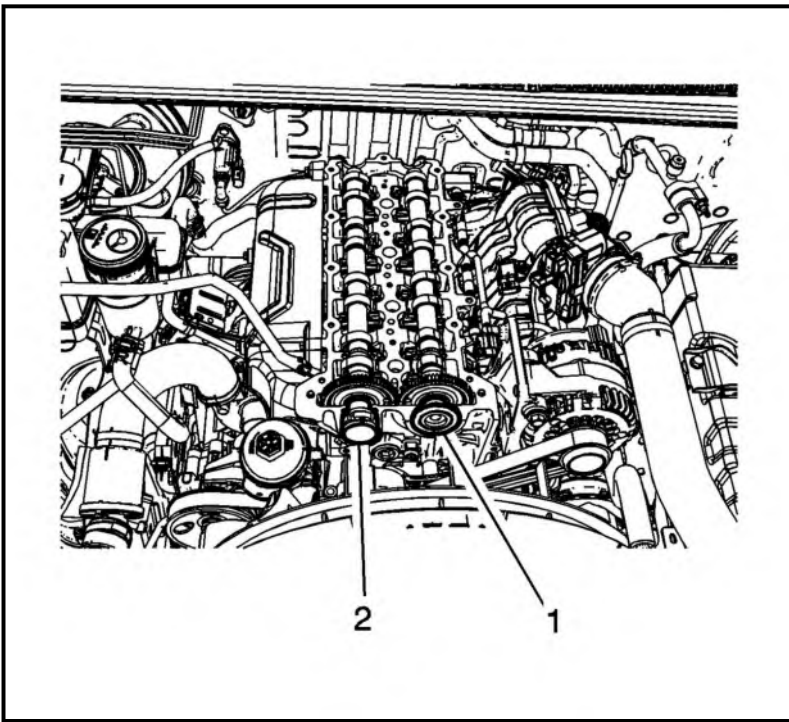
6. Remove the camshaft bearing front cap bolts (1).



7. Remove the camshaft cap bolts (1) and cap (2).



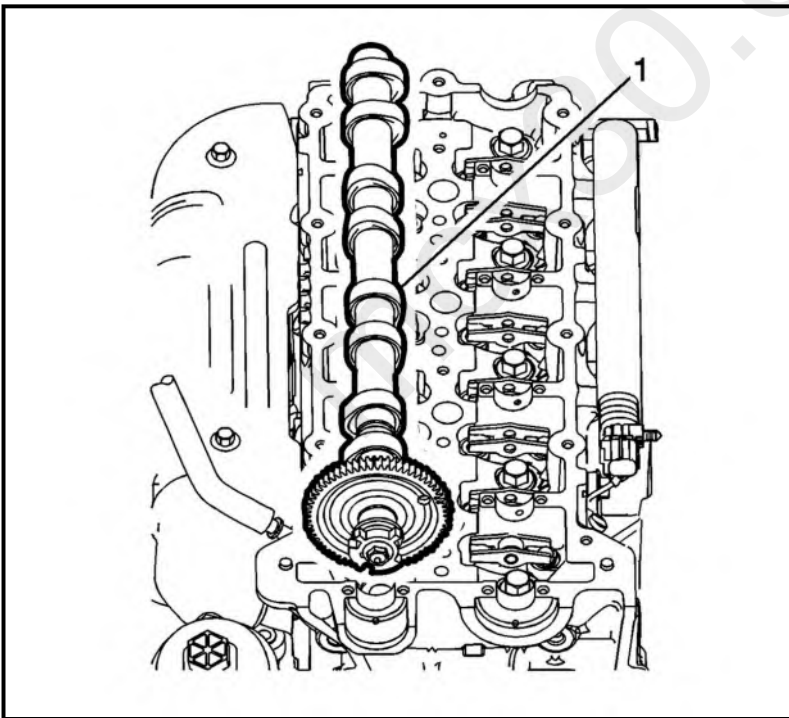
8. Remove the camshaft exhaust cap (2) and camshaft intake seal (1).



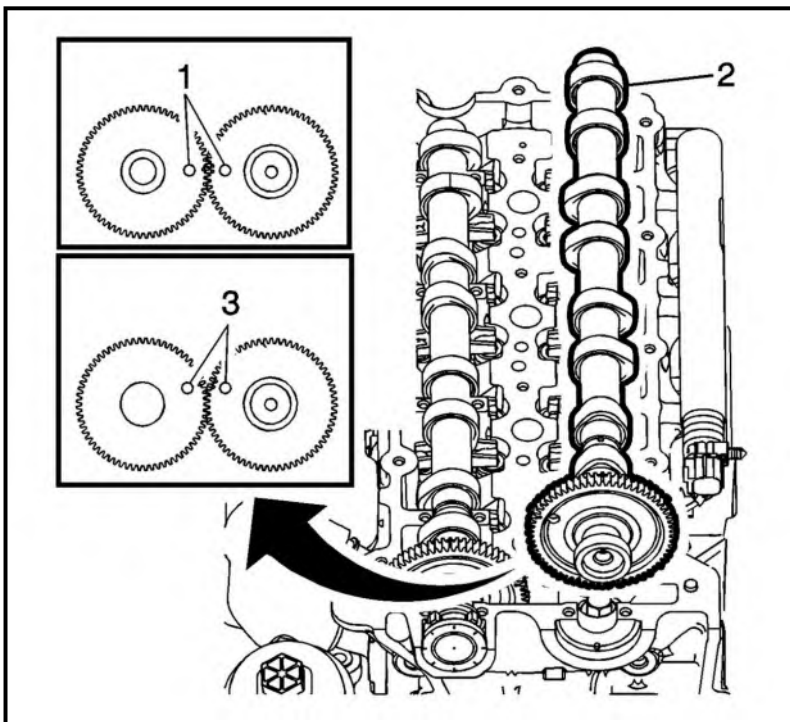
9. Remove the exhaust camshaft (2) and intake camshaft (1).
10. Clean and inspect [Camshaft Cleaning and Inspection](#)

Installation Procedure

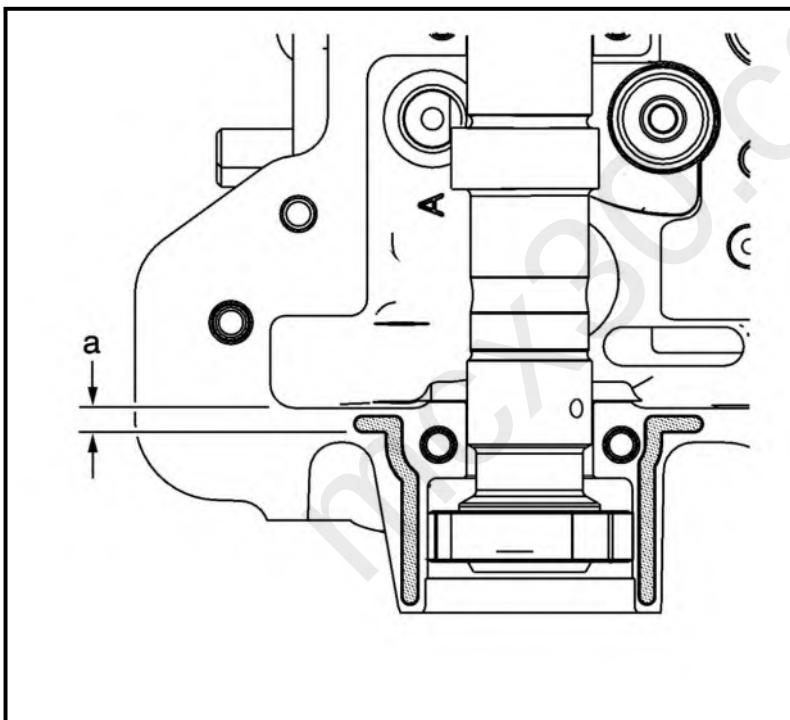
1. Install the exhaust camshaft (1).



2. Install the intake camshaft 2) so that the timing marks on the camshaft sprockets are aligned (1). The final, relaxed alignment (3) for the camshaft sprockets will result during normal installation of the components.



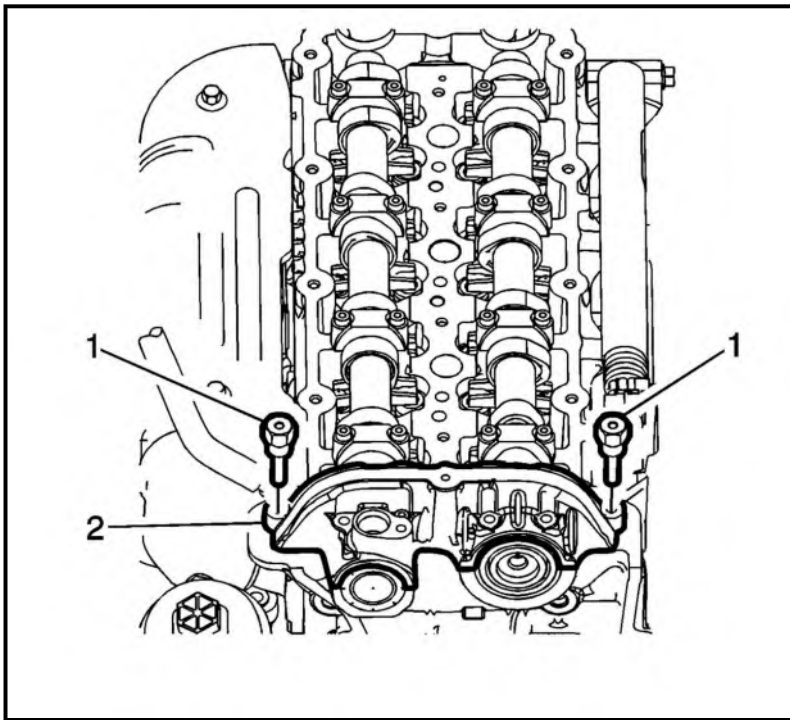
3. Apply a bead of sealant to the camshaft bearing front cap sealing surface. [Adhesives, Fluids, Lubricants, and Sealers](#)



NOTE:

- Ensure that all sealing material has been removed from the components, and the sealing surfaces are clean and free of contamination prior to applying the sealer.
- Install and align the front cap within 20 minutes of applying the sealer.
- Ensure the sealant does not drip into the intake or exhaust camshaft cap seats.
- Use a sponge to spread very carefully to the indicated areas.

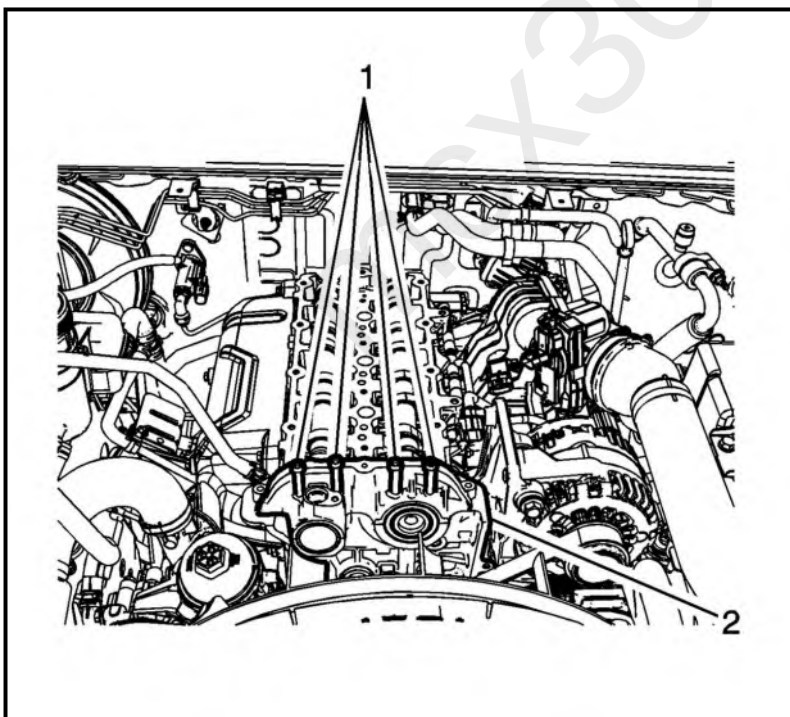
4. Inspect the intake and exhaust camshaft cap seats, and confirm that the seats are free of sealant.



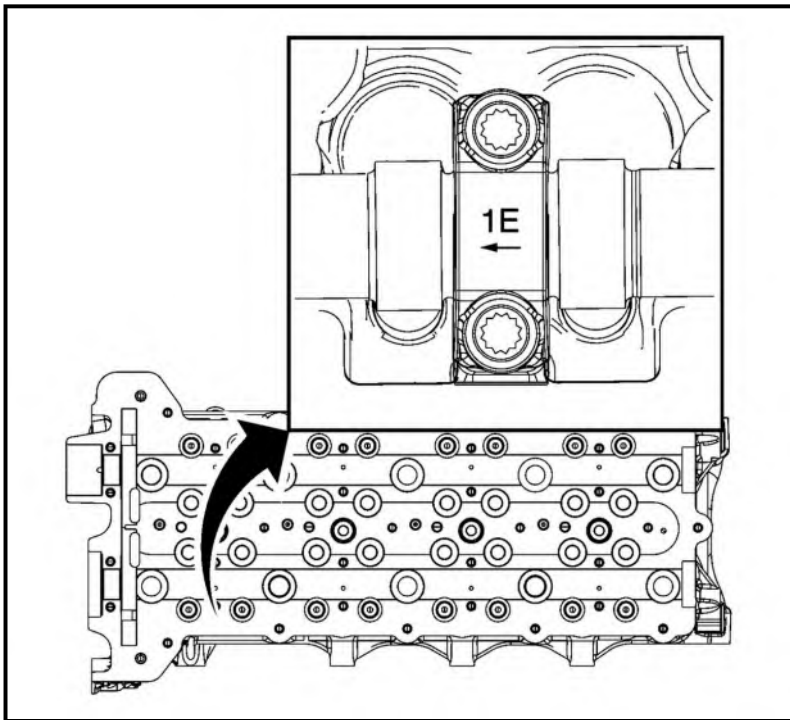
NOTE: It is critical during installation to ensure the bearing front cap and cylinder head alignment is correct and the mating surfaces are flush.

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

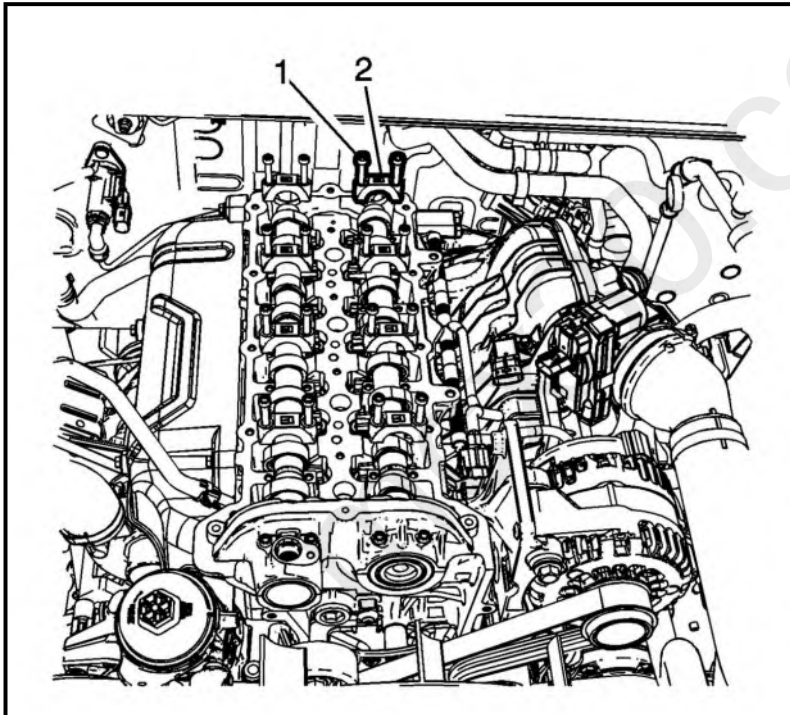
5. Install the camshaft bearing front cap (2). Tighten the cap bolts (1) to 11 N.m (97 lb in).
6. Install camshaft front cap bolts (1) and tighten to 11 N.m (97 lb in).



7. Match each camshaft cap to the correct location on the cylinder head. In the illustration, the camshaft cap is the first cylinder, indicated by the "1", on the intake side of the cylinder head, indicated by the "I". A camshaft cap on the exhaust side is indicated by an "E".



8. Install the camshaft caps (2) and bolts (1).



9. Tighten the cap bolts in sequence to 11 N.m (97 lb in).

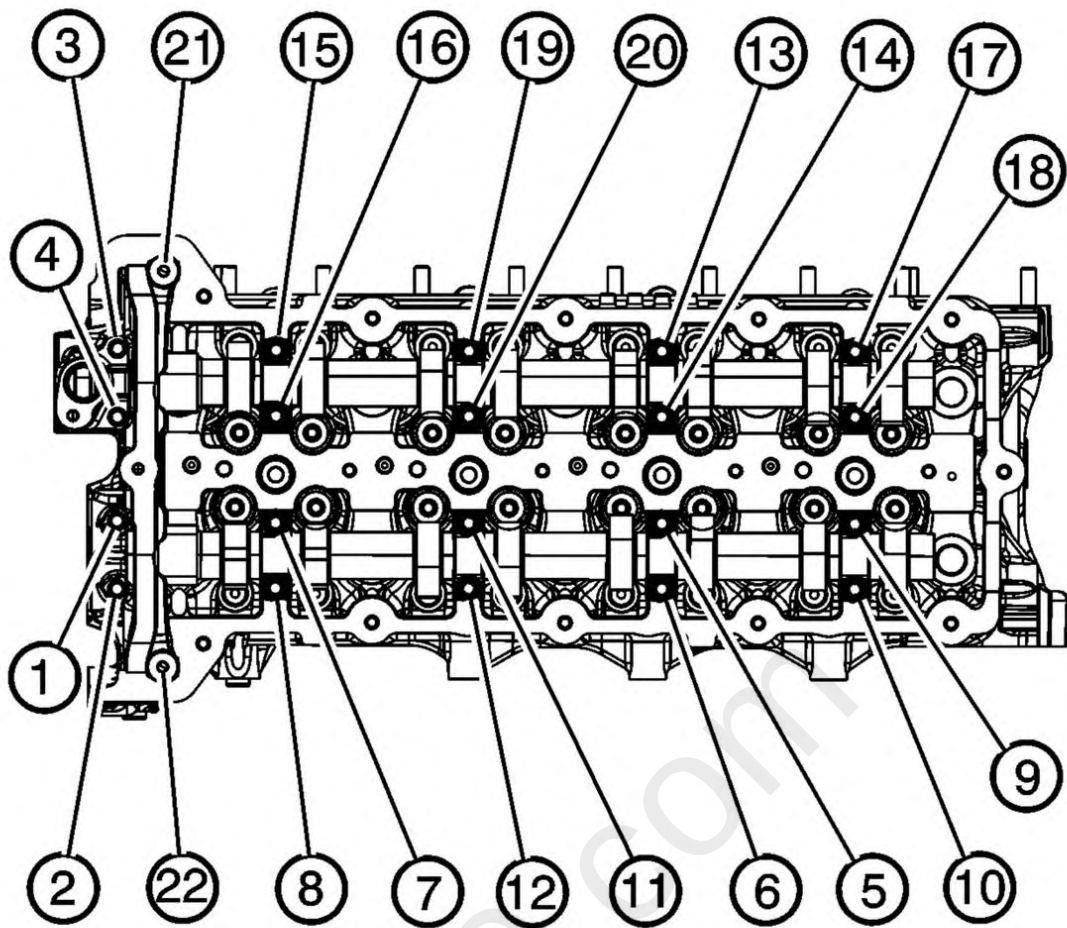
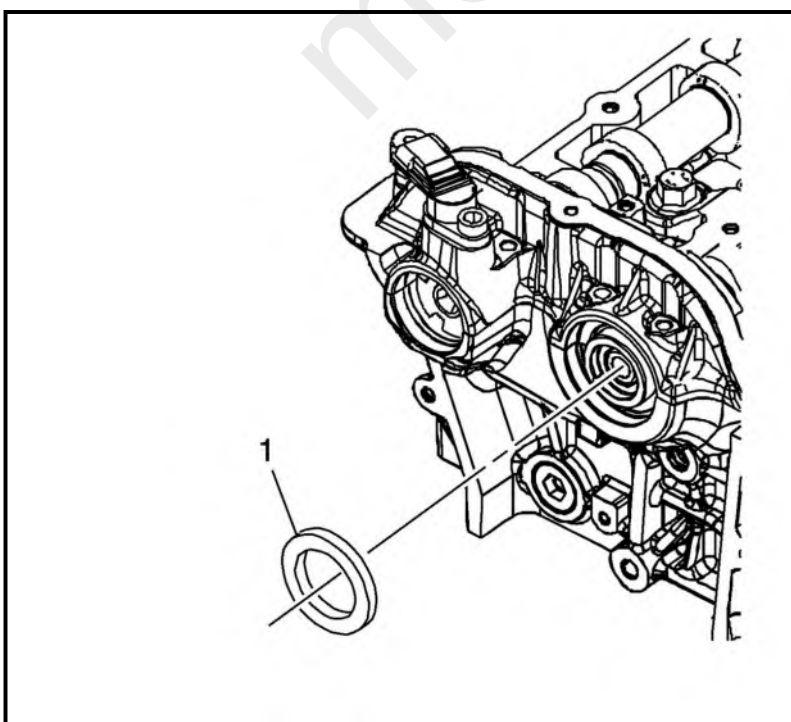


Fig. 18: Identifying Camshaft Cap Bolts With Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

10. **Camshaft Position Sensor Replacement** - Install
11. Install the intake camshaft oil seal (1).



12. **Camshaft Gear Replacement** - Install

13. Valve Rocker Arm Cover Replacement - Install

CAMSHAFT GEAR REPLACEMENT

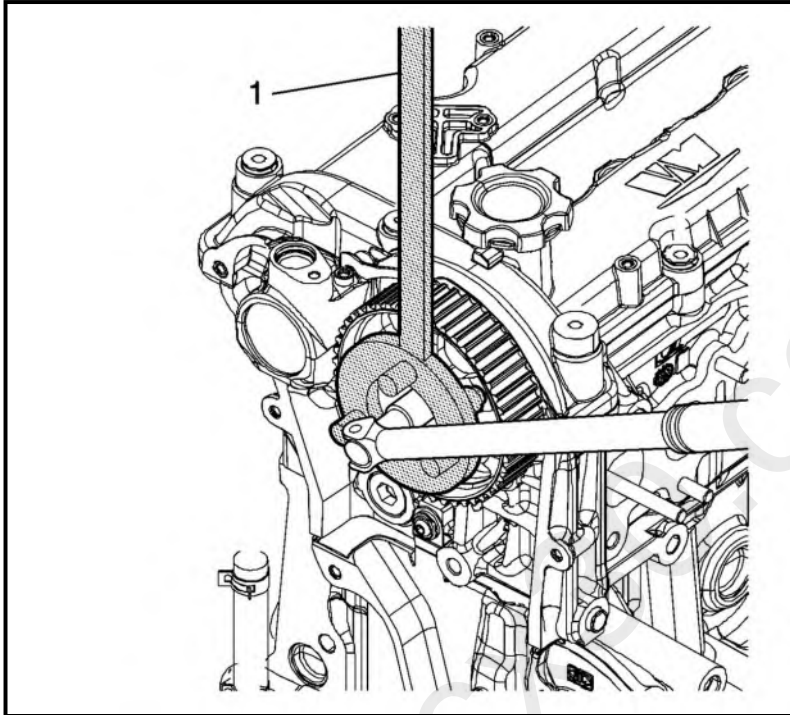
Special Tools

EN-50025 Pulley Holding Wrench

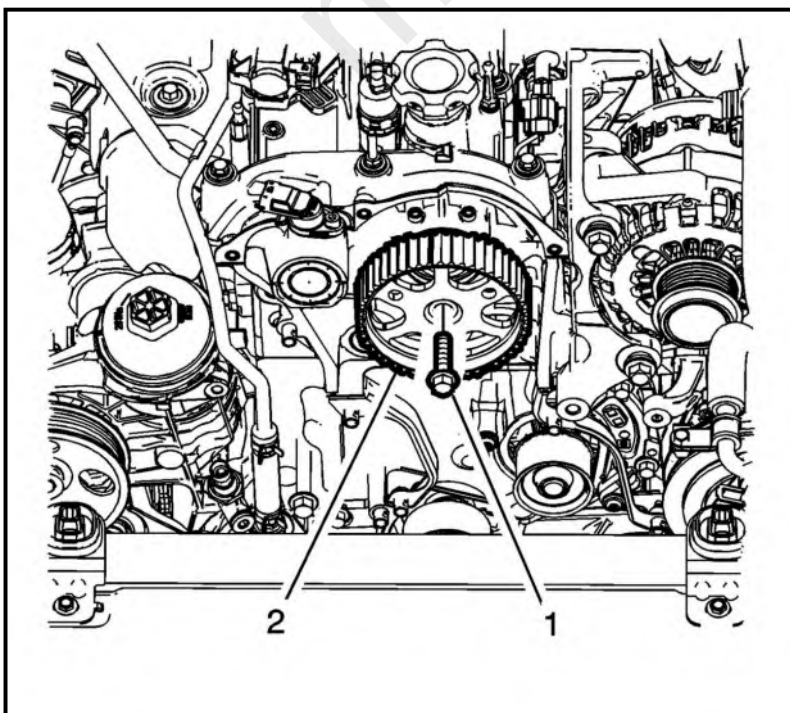
Equivalent regional tools: Special Tools

Removal Procedure

1. Timing Belt Replacement - Remove
2. Hold the camshaft timing pulley with the **EN-50025** wrench (1) and loosen the retaining bolt.



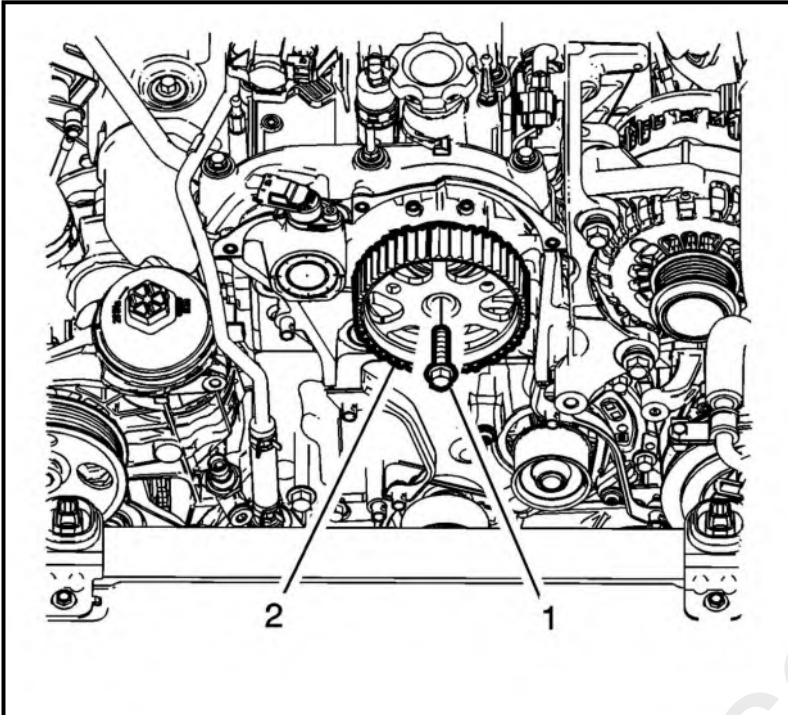
3. Camshaft Gear Bolt (1) - Remove



4. Camshaft Timing Pulley (2) - Remove

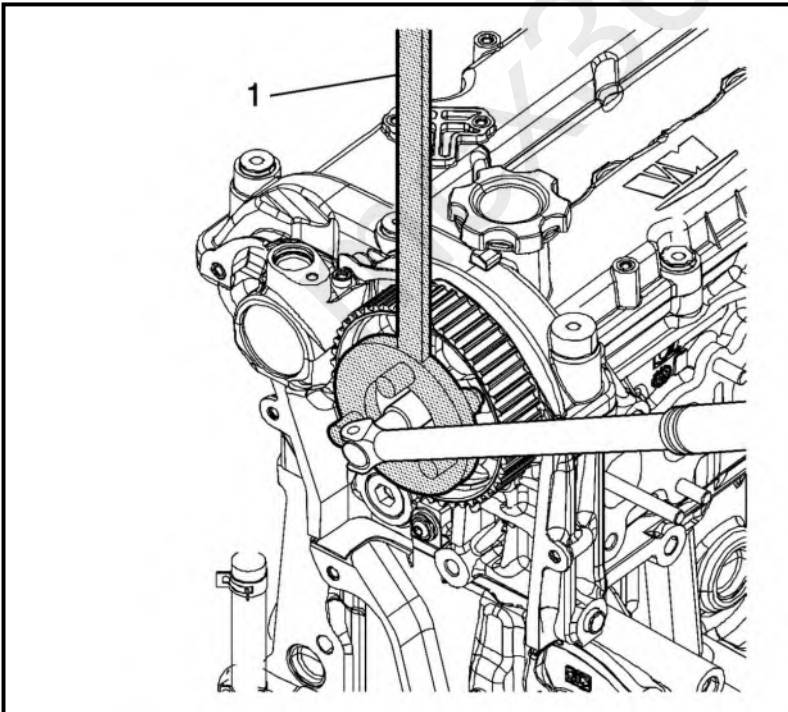
Installation Procedure

1. Camshaft Timing Pulley (2) - Install



2. Camshaft Gear Bolt (1) - Loosely install

3. Counter hold the camshaft timing pulley using the **EN-50025** wrench (1).



NOTE:

The EN-51025 wrench holding tool is installed during timing belt removal and installation but should **NOT** be used to hold the camshaft during camshaft gear bolt tightening. Always use the EN-50025 wrench to hold the camshaft timing pulley during tightening.

4. Camshaft Gear Bolt - Tighten

Tighten

1. First Pass: 20 N.m (15 lb ft)
2. Final Pass: 60 degrees
5. **Timing Belt Replacement** - Install

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

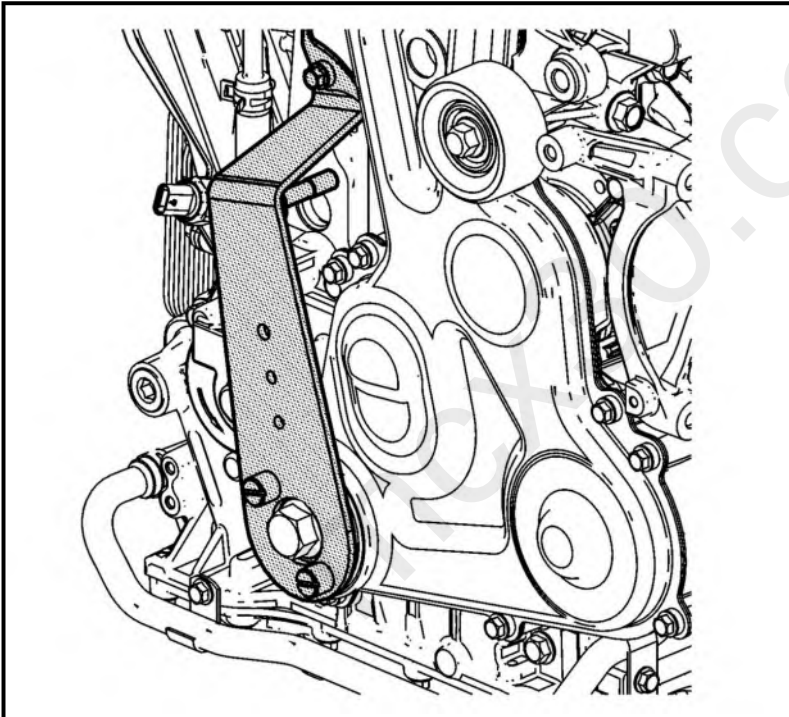
Special Tools

- EN-51265 Crankshaft Locking Tool

Equivalent regional tools: **Special Tools**

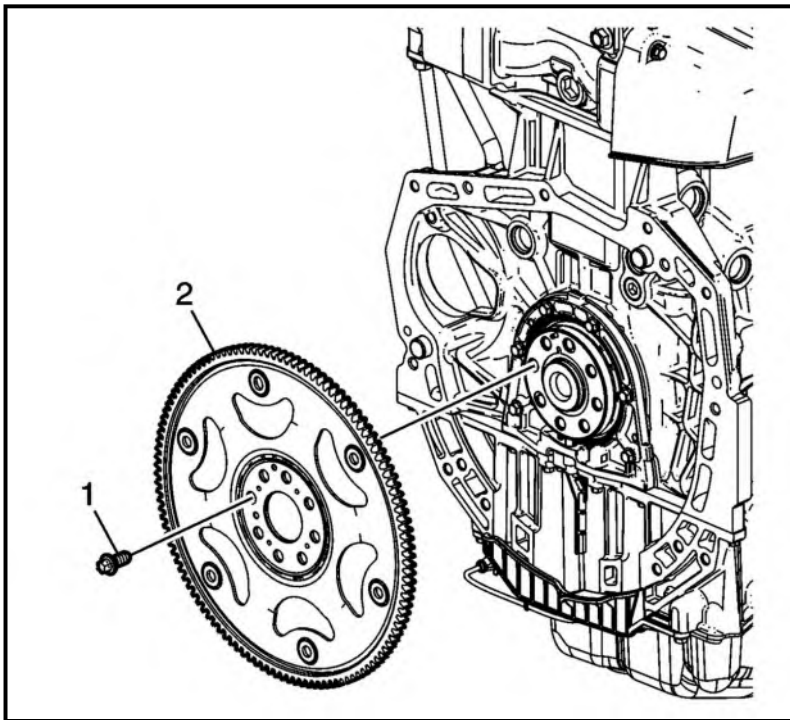
Removal Procedure

1. **Crankshaft Balancer Replacement** - Remove
2. **Engine Cooling Fan Bracket Replacement** - Remove
3. **Transmission Replacement (LWN Diesel with 4WD)** , or **Transmission Replacement (LWN Diesel with 2WD)** - Remove
4. Install the EN-51265 locking tool.



NOTE: Rotate the engine as necessary in order to align the EN-51265 locking tool bolt holes to the bolt holes in the crankshaft.

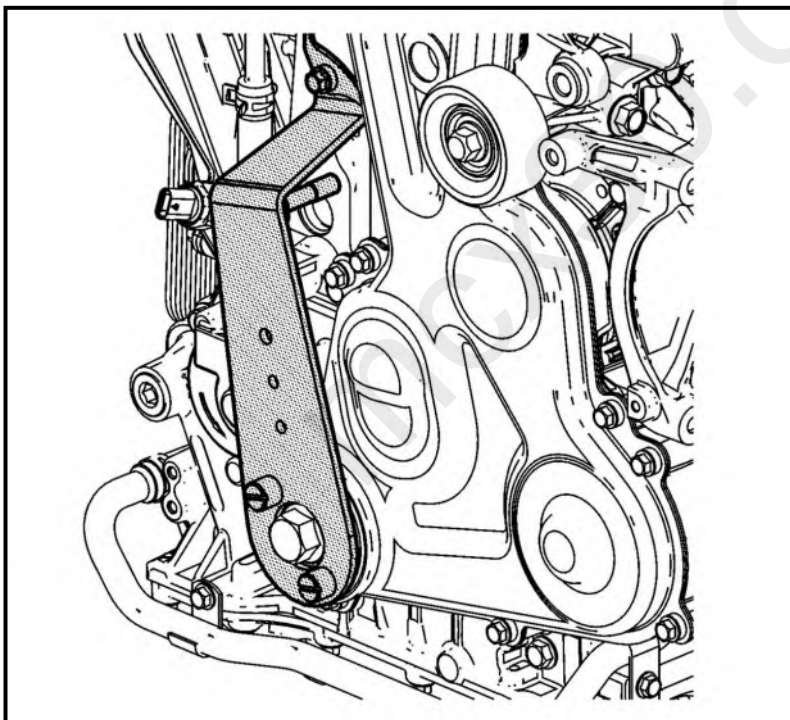
5. Automatic Transmission Flex Plate Bolt (1) - Remove and DISCARD [8x]



6. Automatic Transmission Flex Plate (2) - Remove

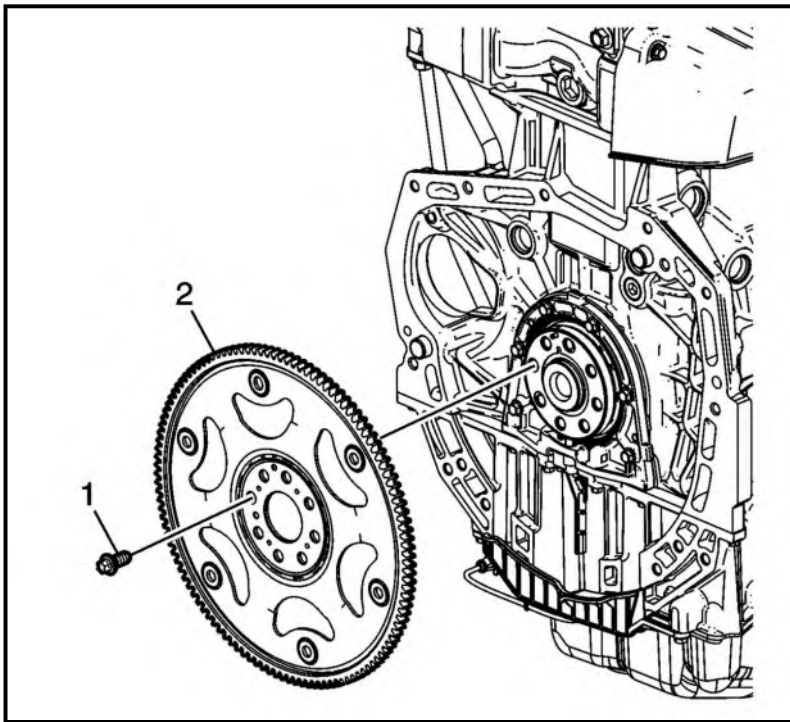
Installation Procedure

1. Install the **EN-51265** locking tool.



NOTE: Rotate the engine as necessary in order to align the EN-51265 locking tool bolt holes to the bolt holes in the crankshaft.

2. Automatic Transmission Flex Plate (2) - Install



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: Install NEW bolts.

3. Automatic Transmission Flex Plate Bolt (1) - Loosely install [8x]
4. Tighten in the sequence shown.

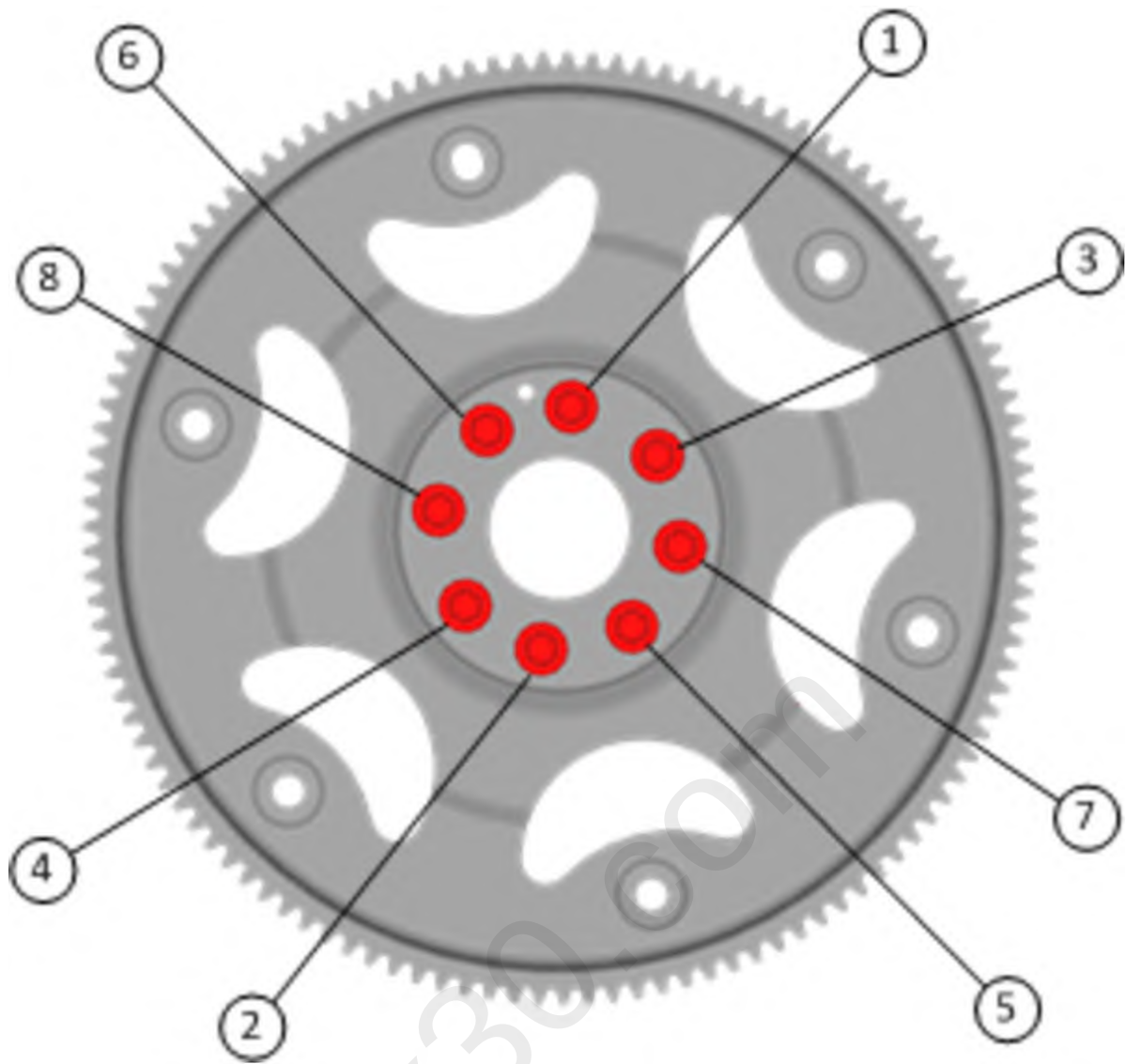


Fig. 19: Automatic Transmission Flex Plate Bolt Tightening Sequence

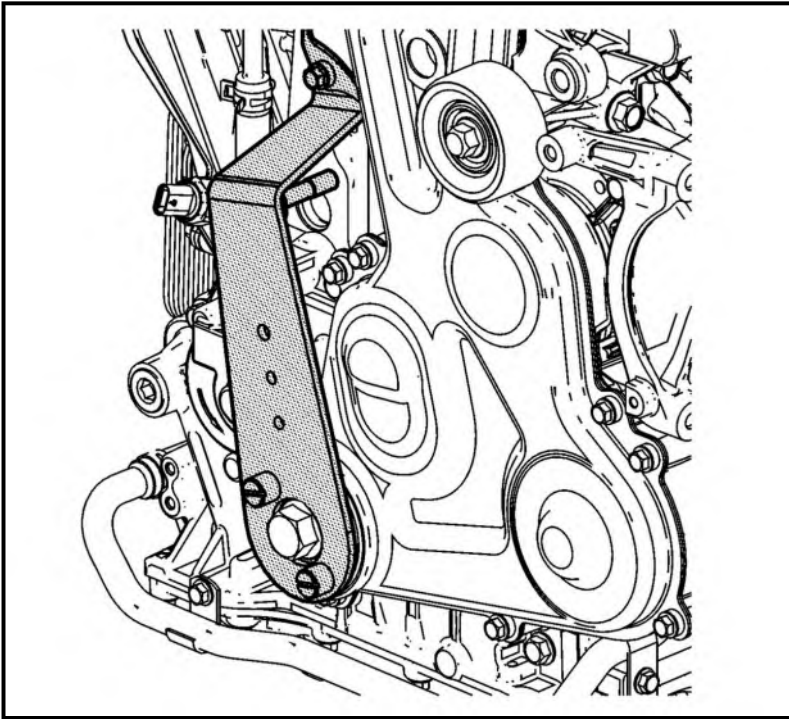
Courtesy of GENERAL MOTORS COMPANY

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

NOTE: After each bolt is tightened, mark the head with a dot of brown paint as evidence of correct tightening.

Tighten

1. First pass tighten to 50 N.m (37 lb ft)
2. Second pass loosen 90 degrees
3. Third pass tighten to 25 N.m (18 lb ft)
4. Final pass tighten 60 degrees
5. Remove the **EN-51265** locking tool.



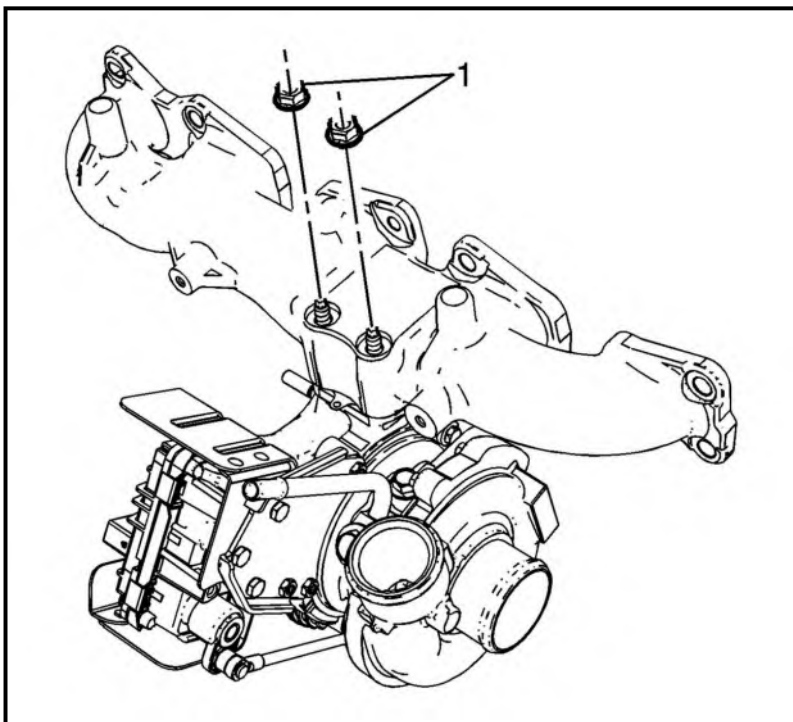
6. [Engine Cooling Fan Bracket Replacement](#) - Install
7. [Crankshaft Balancer Replacement](#) - Install
8. [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#) - Install

COMPRESSOR AIR INTAKE TURBOCHARGER REPLACEMENT

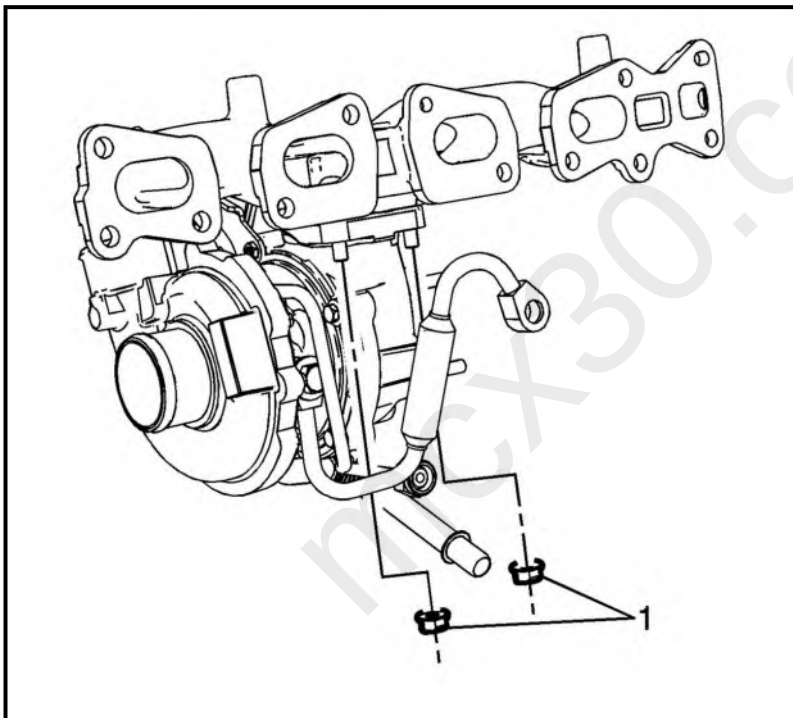
Removal Procedure

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

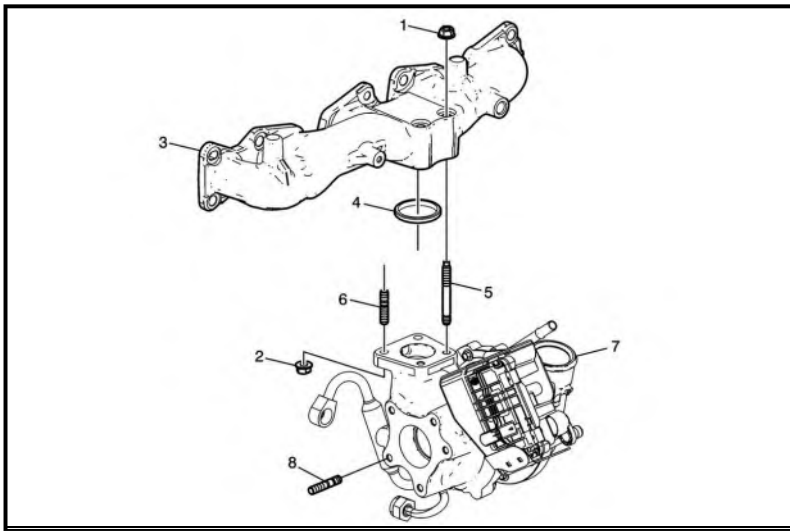
1. Remove the exhaust manifold. [Exhaust Manifold Replacement \(LWN\)](#) .
2. Remove the exhaust manifold to turbocharger nuts (1).



3. Remove the exhaust manifold to turbocharger nuts (1).



4. Separate the exhaust manifold (3) from the turbocharger (7).



5. Remove and DISCARD the turbocharger gasket (4).

NOTE: Do not loosen or remove actuator from turbocharger bracket.

6. For cleaning and inspection, refer to [Compressor Air Intake Turbocharger Cleaning and Inspection](#).

7. If installing a NEW turbocharger, perform the following.

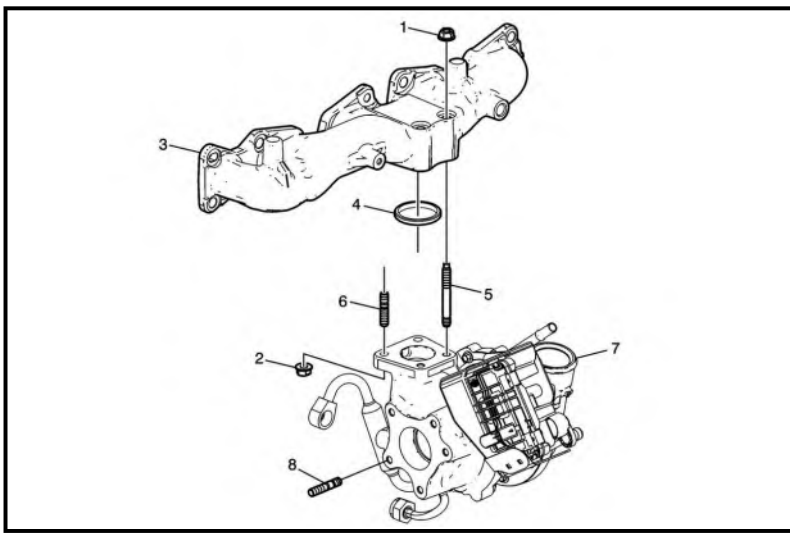
1. Turbocharger Oil Feed Pipe - Remove - [Exhaust Manifold and Compressor Air Intake Turbocharger Removal](#)
2. Turbocharger Coolant Feed Pipe - Remove - [Exhaust Manifold and Compressor Air Intake Turbocharger Removal](#)
3. Turbocharger Oil Return Pipe - Remove - [Exhaust Manifold and Compressor Air Intake Turbocharger Removal](#)
4. Turbocharger Coolant Return Pipe - Remove - [Exhaust Manifold and Compressor Air Intake Turbocharger Removal](#)

Installation Procedure

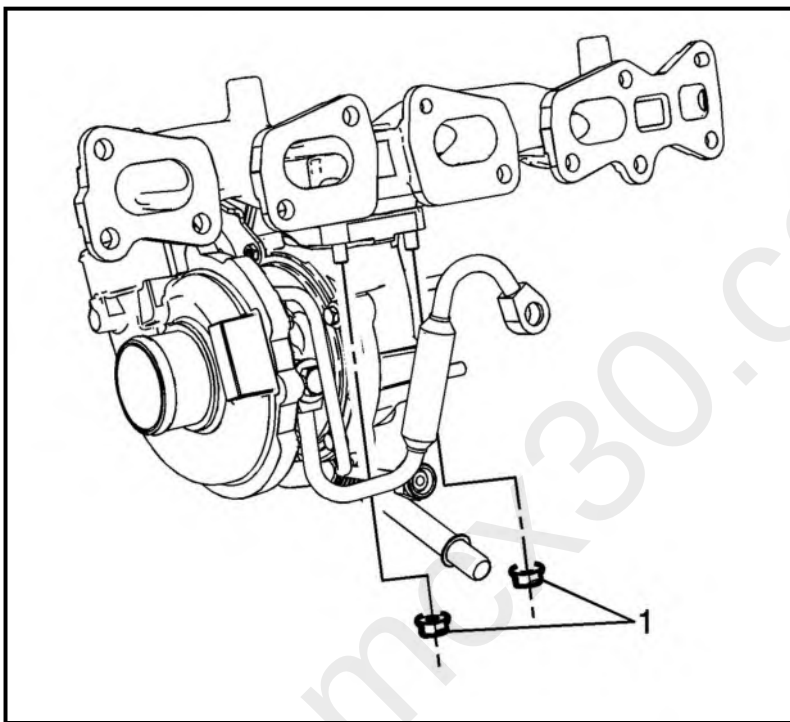
1. If installing a NEW turbocharger, perform the following.

1. Turbocharger Coolant Return Pipe - Install - [Exhaust Manifold and Compressor Air Intake Turbocharger Installation](#)
2. Turbocharger Oil Return Pipe - Install - [Exhaust Manifold and Compressor Air Intake Turbocharger Installation](#)
3. Turbocharger Coolant Feed Pipe - Install - [Exhaust Manifold and Compressor Air Intake Turbocharger Installation](#)
4. Turbocharger Oil Feed Pipe - Install - [Exhaust Manifold and Compressor Air Intake Turbocharger Installation](#)

2. Install a NEW turbocharger gasket (4).

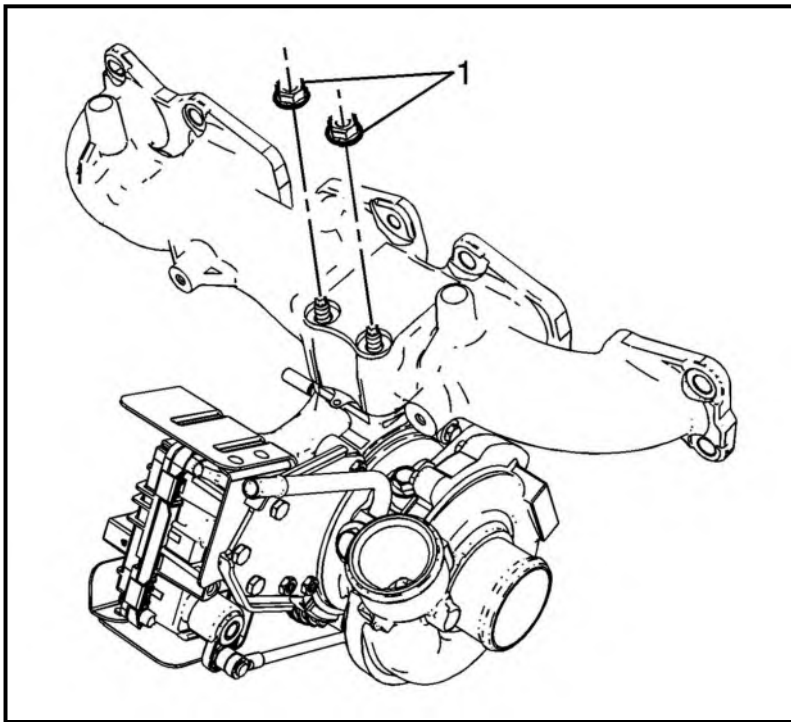


3. Install the exhaust manifold (3) to turbocharger (7).
4. Install the exhaust manifold to turbocharger nuts (1) and tighten to 32 N.m (24 lb ft).



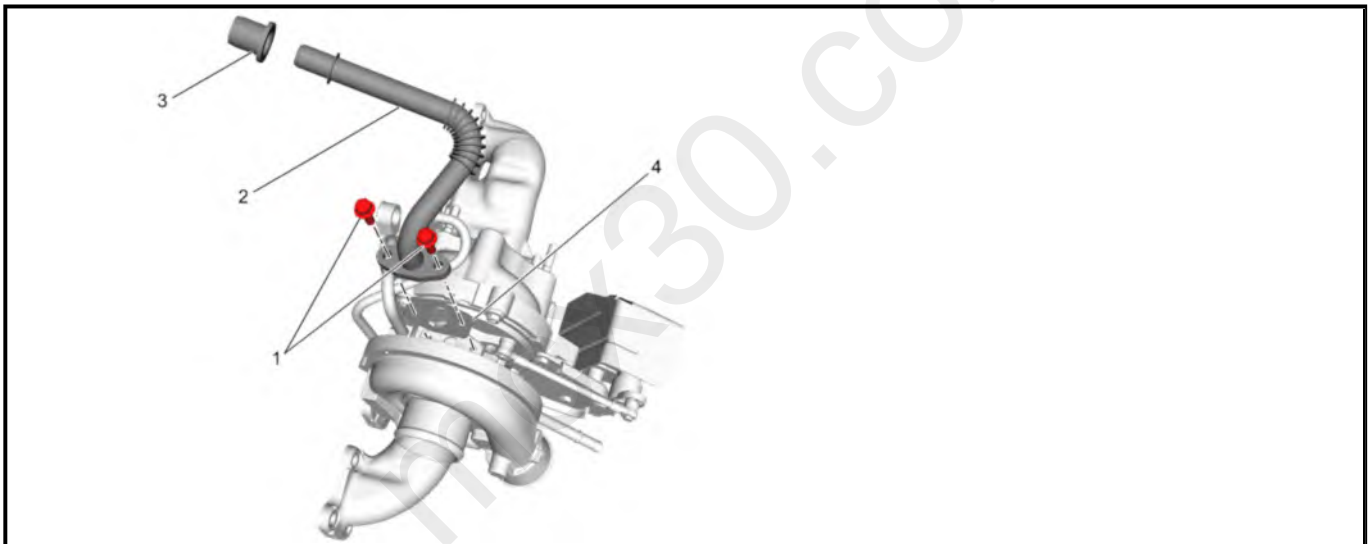
CAUTION: Refer to [Fastener Caution](#) .

5. Install the exhaust manifold to turbocharger nuts (1) and tighten to 32 N.m (24 lb ft).



6. Install the exhaust manifold. [Exhaust Manifold Replacement \(LWN\)](#).

TURBOCHARGER OIL RETURN PIPE REPLACEMENT

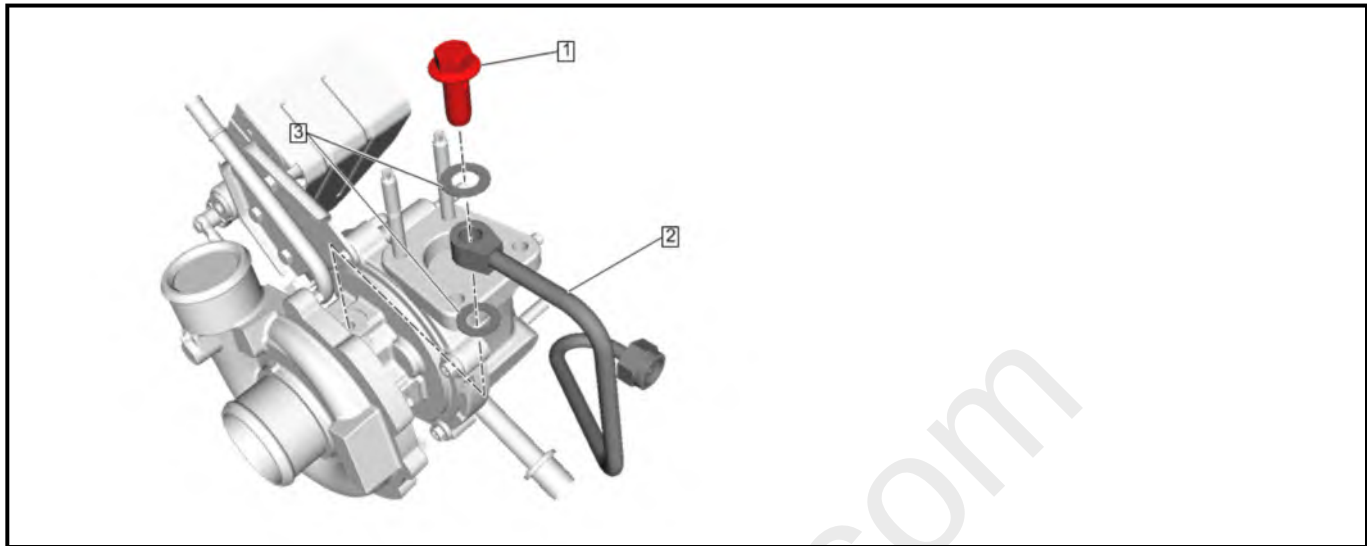


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
Preliminary Procedure Exhaust Manifold Replacement (LWN)	
1	Turbocharger Oil Return Pipe Fastener [2x] CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)
2	Turbocharger Oil Return Pipe

Callout	Component Name
3	Turbocharger Oil Return Pipe Seal Procedure Install a NEW seal.
4	Turbocharger Oil Return Pipe Gasket Procedure Install a NEW gasket.

TURBOCHARGER OIL FEED PIPE REPLACEMENT



NOTE: Callouts in the following chart represent components shown in graphic above.

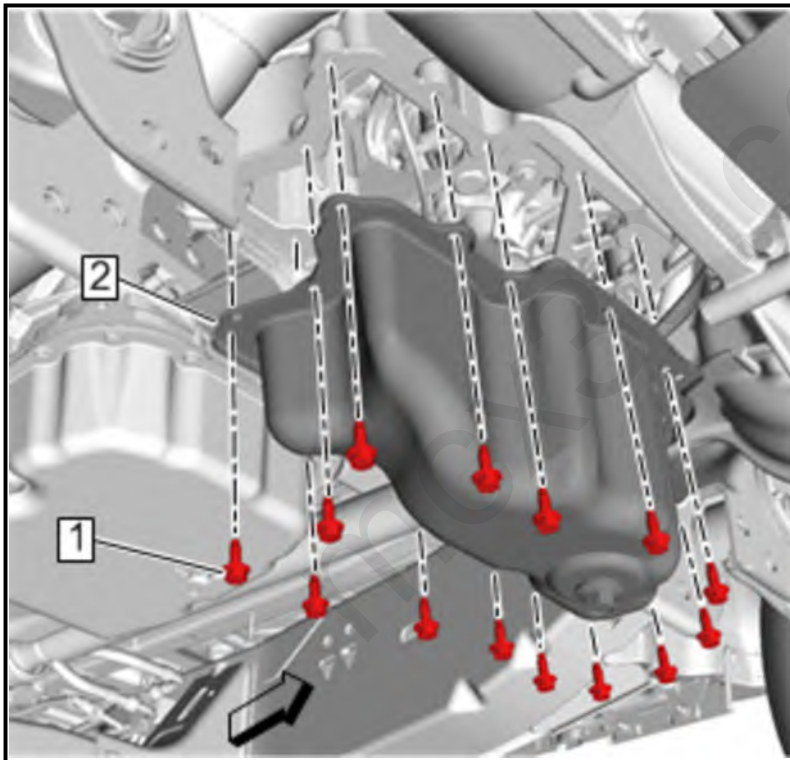
Callout	Component Name
Preliminary Procedure <u>Exhaust Manifold Replacement (LWN)</u> NOTE: For illustration purposes ONLY, the graphic is shown with the exhaust manifold removed from the turbocharger. It is not necessary to remove the exhaust manifold from the turbocharger.	
1	Turbocharger Oil Feed Pipe Bolt CAUTION: Refer to <u>Fastener</u>

Callout	Component Name
	Caution . Tighten 25 N.m (18 lb ft)
2	Turbocharger Oil Feed Pipe
3	Turbocharger Oil Feed Pipe Washer [2x] Procedure Install NEW sealing washers.

LOWER OIL PAN REPLACEMENT

Removal Procedure

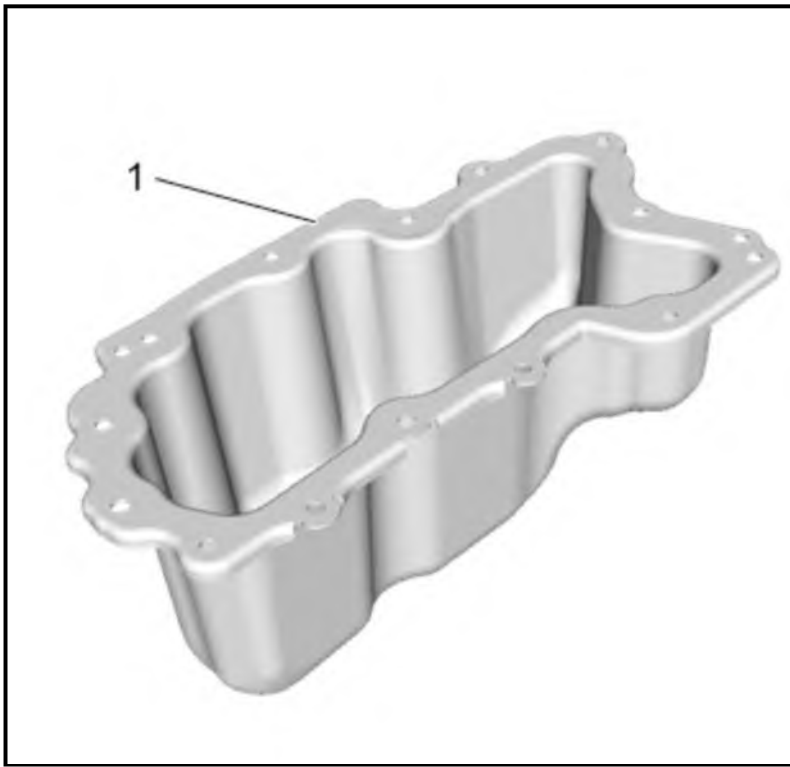
1. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
2. [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(4 Wheel Drive\)](#) , or [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(2 Wheel Drive\)](#) - Remove
3. Lower Oil Pan Bolt (1) - Remove [14x]



4. Lower Oil Pan (2) - Remove
5. Lower Oil Pan (2) - Clean and inspect - [Lower Oil Pan Cleaning and Inspection](#)

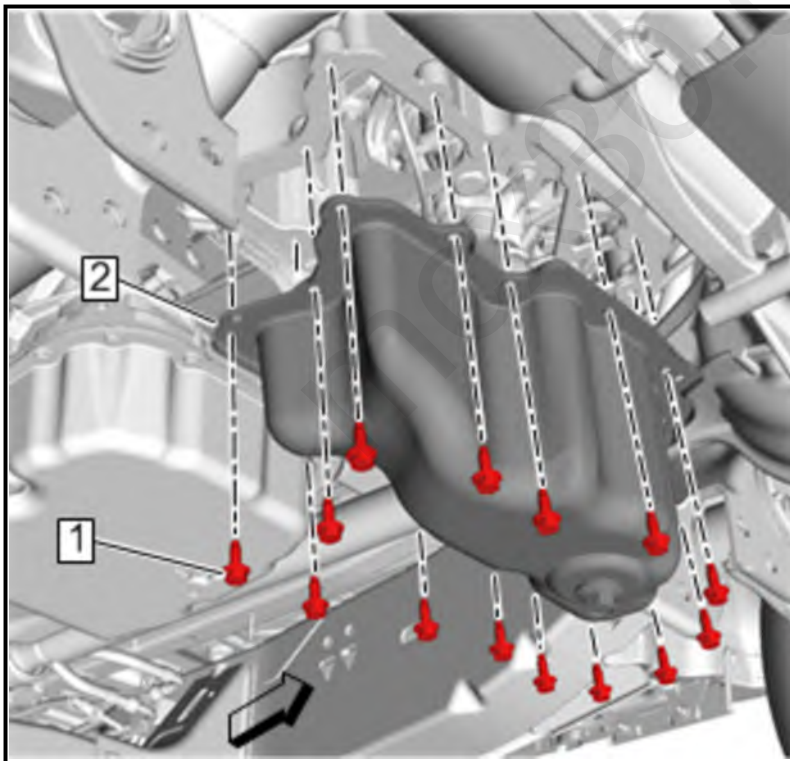
Installation Procedure

1. Apply a 5 mm (0.197 in) bead of sealant to the oil pan flange (1). [Adhesives, Fluids, Lubricants, and Sealers](#)



NOTE: Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

2. Lower Oil Pan (2) - Install



3. Lower Oil Pan Bolt (1) - Loosely install [14x]

4. Tighten the bolts in the sequence shown. 13 N.m (115 lb in)

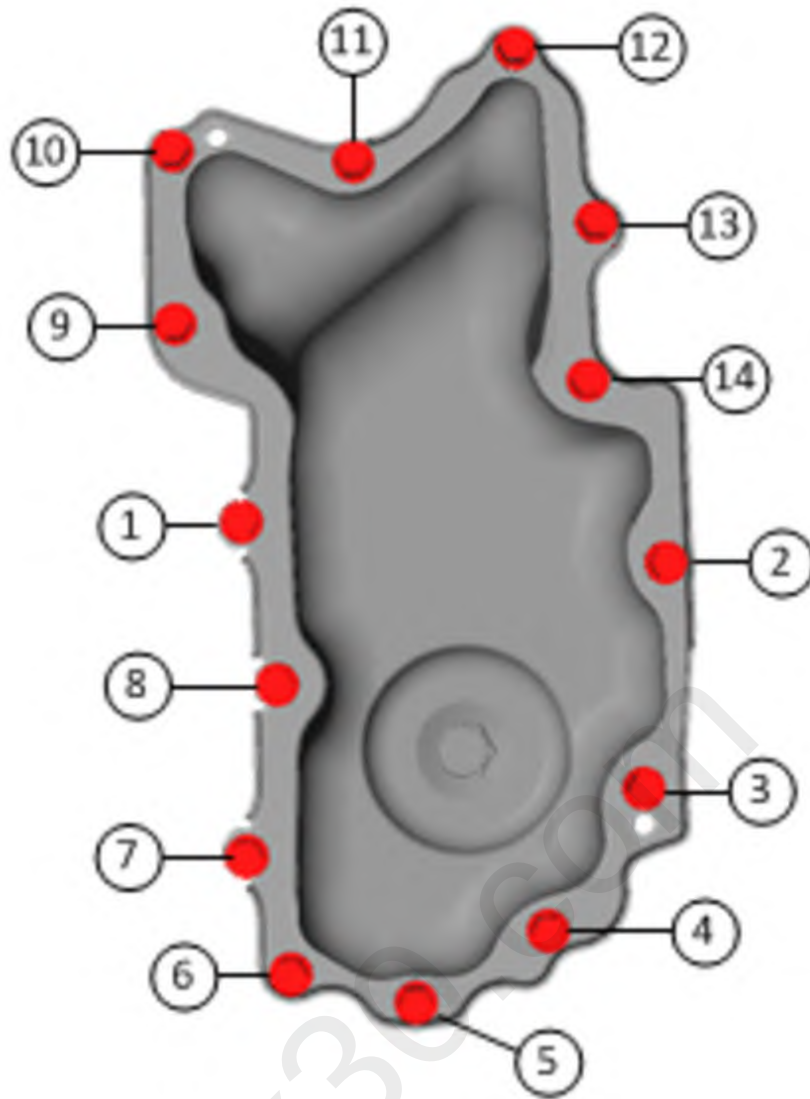


Fig. 20: Lower Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

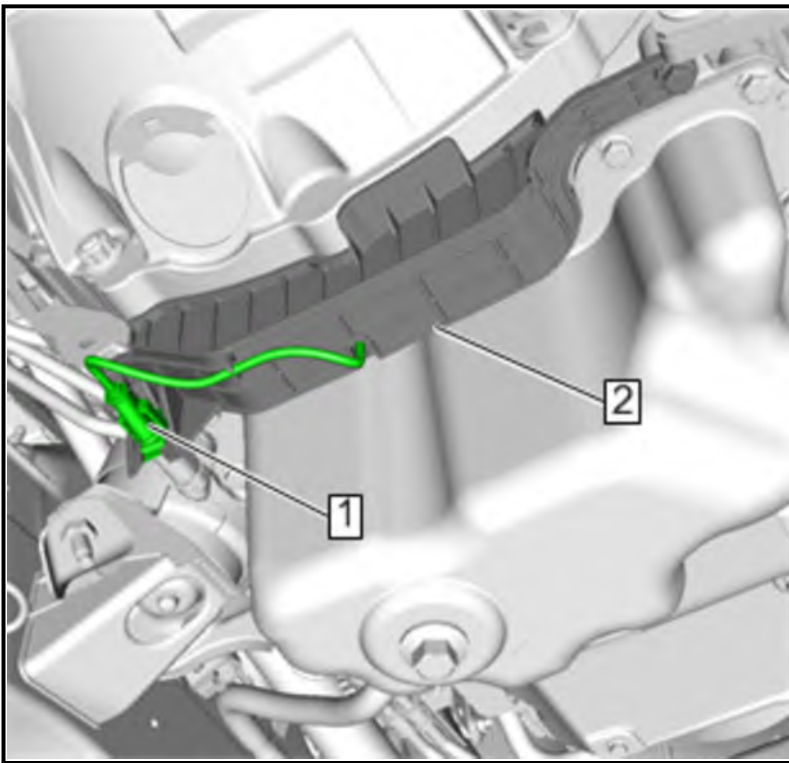
CAUTION: Refer to [Fastener Caution](#) .

5. [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(4 Wheel Drive\)](#) , or [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(2 Wheel Drive\)](#) - Install
6. Change the engine oil and filter. [Engine Oil and Oil Filter Replacement](#)

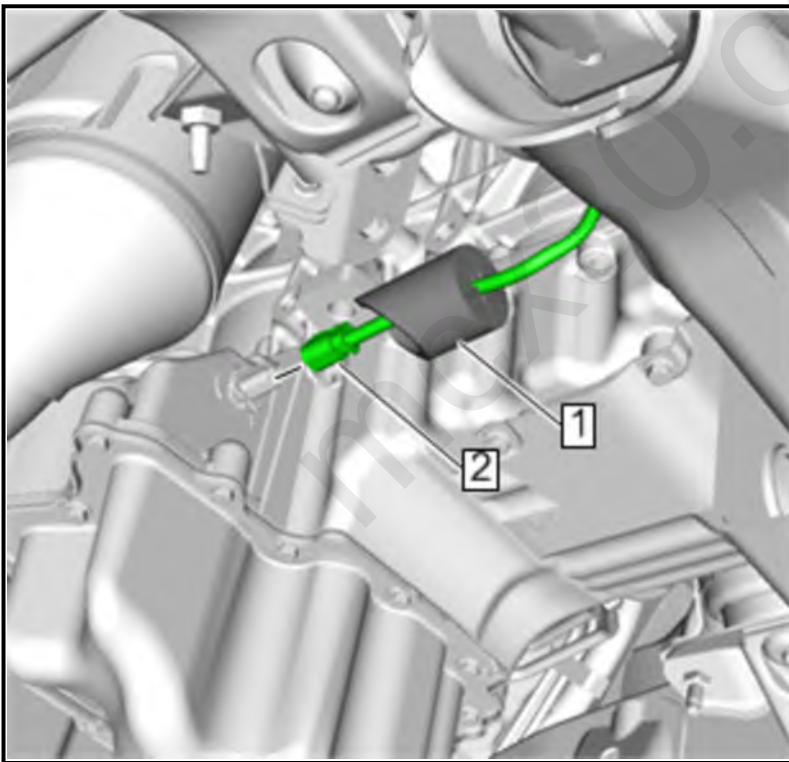
UPPER OIL PAN REPLACEMENT (4 WHEEL DRIVE)

Removal Procedure

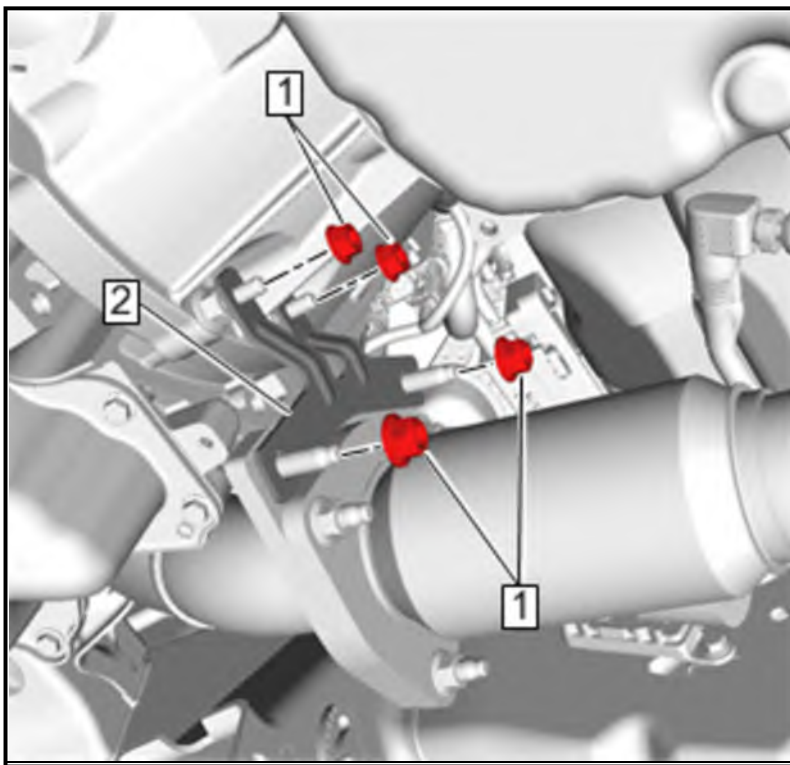
1. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
2. Drivetrain and Front Suspension Frame Front Crossmember - Remove - [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(4 Wheel Drive\)](#).
3. Front Axle - Remove - [Front Axle Replacement \(without ZR2\)](#) , or [Front Axle Replacement \(with ZR2\)](#).
4. Electric Belt Drive Rack and Pinion Steering Gear - Remove - [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(4WD\)](#).
5. Electrical Connector (1) - Disconnect



6. Crankshaft Position Sensor (2) - Remove - [Crankshaft Position Sensor Replacement](#)
7. Reposition the electrical connector sleeve (1).

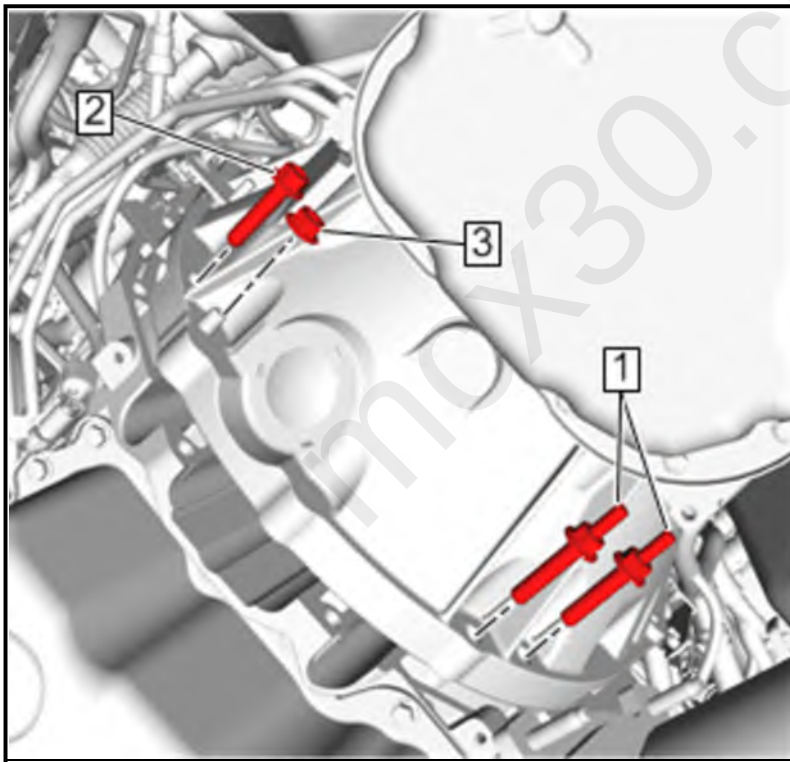


8. Electrical Connector (2) - Disconnect
9. Oil Level Indicator Tube - Remove - [Oil Level Indicator Tube Replacement](#)
10. Catalytic Converter Bracket Nut (1) - Remove [4x]



11. Catalytic Converter Bracket (2) Remove

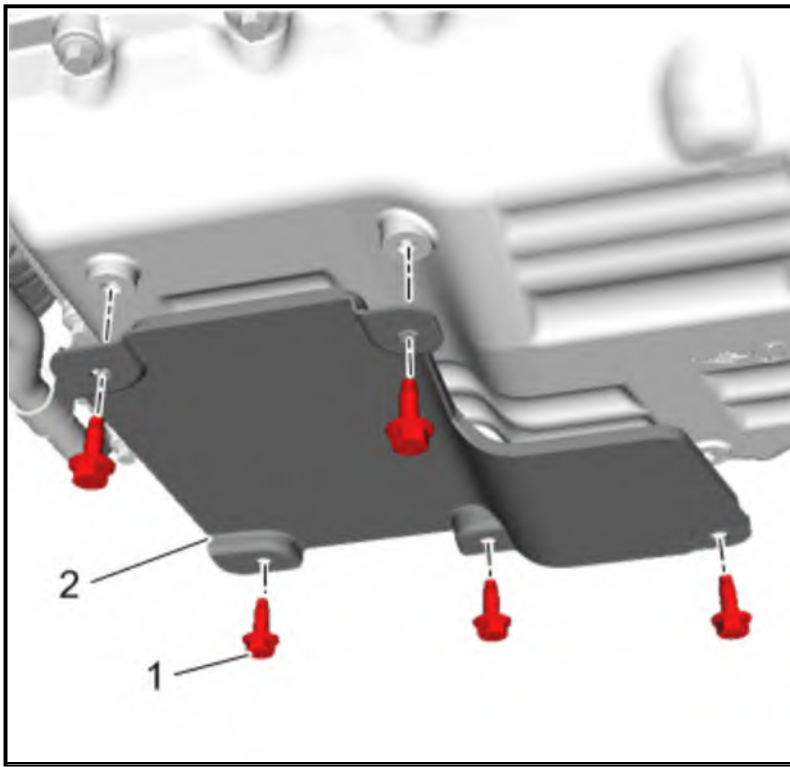
12. Transmission Bolt (1) - Remove [2x]



13. Transmission Bolt (2) - Remove

14. Nut (3) - Remove

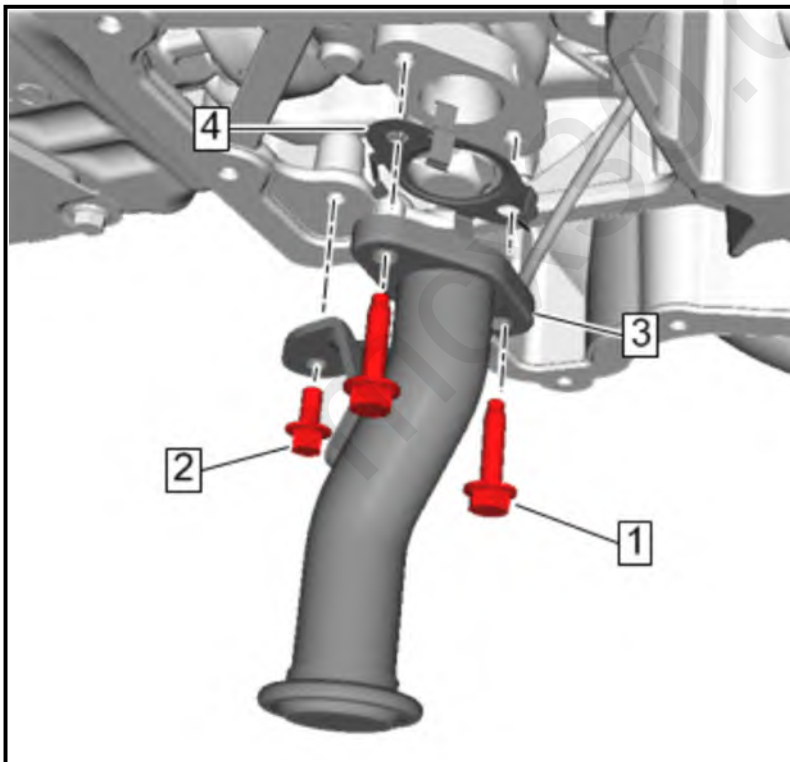
15. Oil Pan Deadener Bolt (1) - Remove



16. Oil Pan Deadener (2) - Remove

17. Lower Oil Pan - Remove - [Lower Oil Pan Replacement](#)

18. Oil Pump Suction Pipe Bolt (1) - Remove

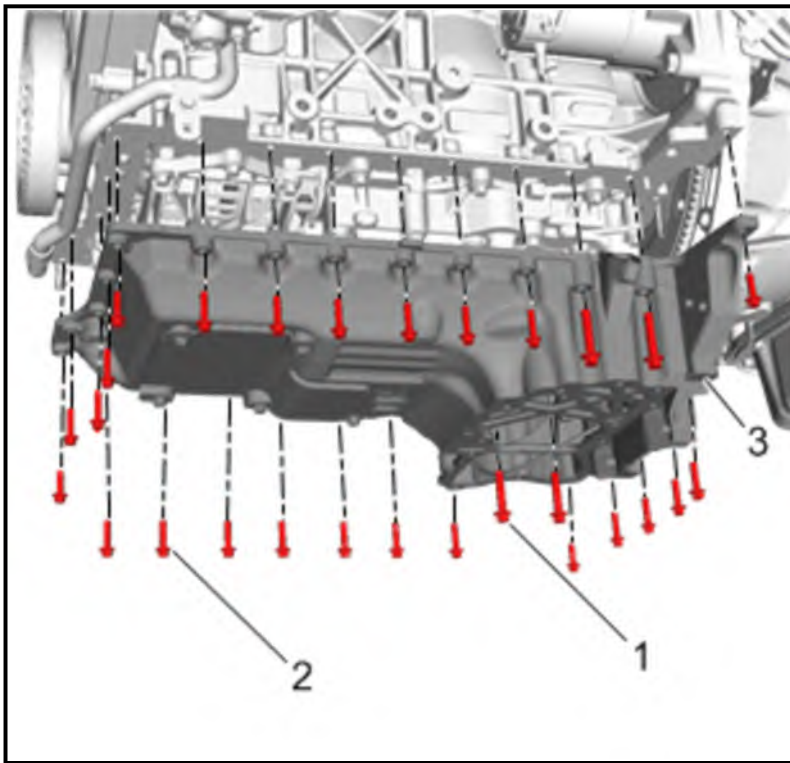


19. Oil Pump Suction Pipe Bolt (2) - Remove

20. Oil Pump Suction Pipe (3) - Remove

21. Oil Pump Suction Pipe Gasket (4) - Remove and DISCARD

22. Upper Oil Pan Bolt (1) - Remove [4x]



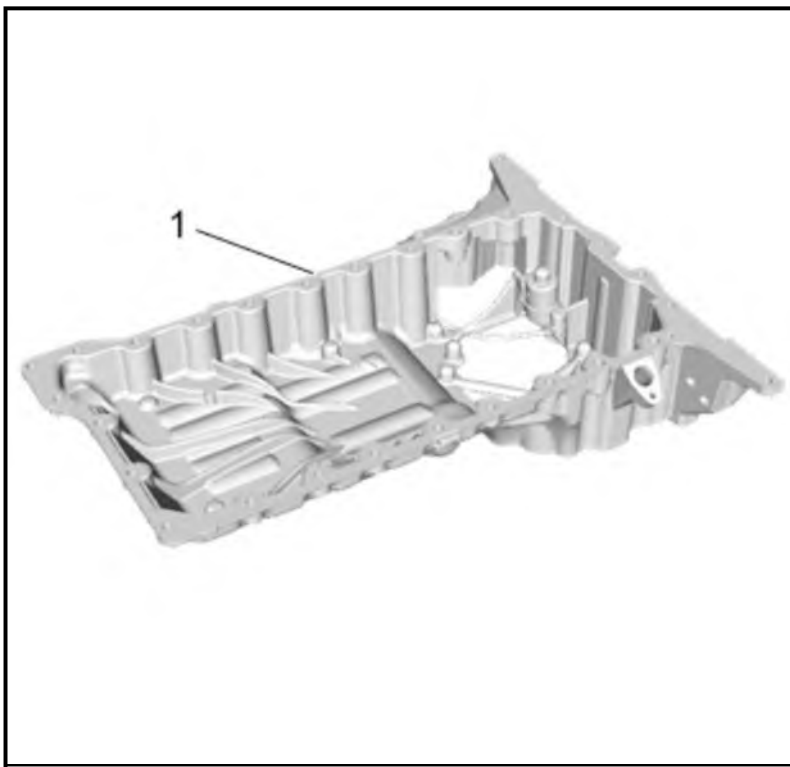
23. Upper Oil Pan Bolt (2) - Remove [24x]

NOTE: Do NOT remove the engine mount bracket fasteners.

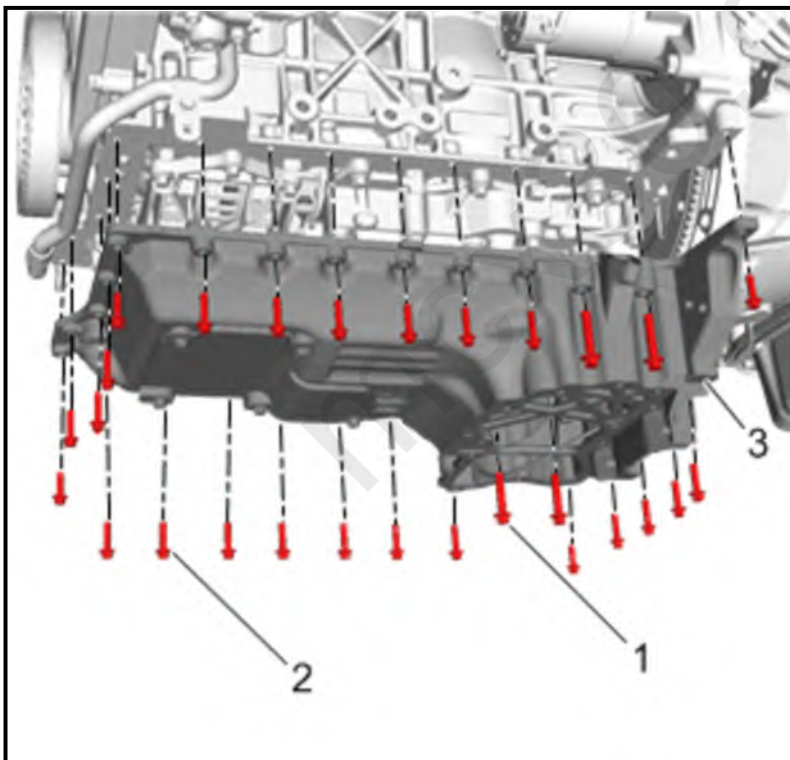
- 24. Remove and DISCARD the right side engine mount fasteners. [Engine Mount Replacement - Right Side](#)
- 25. Using a suitable lifting device, raise the powertrain assembly until the upper oil pan can be removed.
- 26. Upper Oil Pan - Remove
- 27. Upper Oil Pan (2) - Clean and inspect - [Upper Oil Pan Cleaning and Inspection \(LWN\)](#)
- 28. Transfer parts as necessary.

Installation Procedure

- 1. Review proper use of room temperature vulcanizing (RTV) sealant prior to installing sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)



2. Apply a **5 mm (0.197 in)** bead of sealant to the oil pan flange (1). [Adhesives, Fluids, Lubricants, and Sealers](#)
3. Upper Oil Pan - Install



4. Upper Oil Pan Bolt (2) - Loosely install [24x]
5. Upper Oil Pan Bolt (1) - Loosely install [4x]
6. Tighten the bolts in the sequence shown.

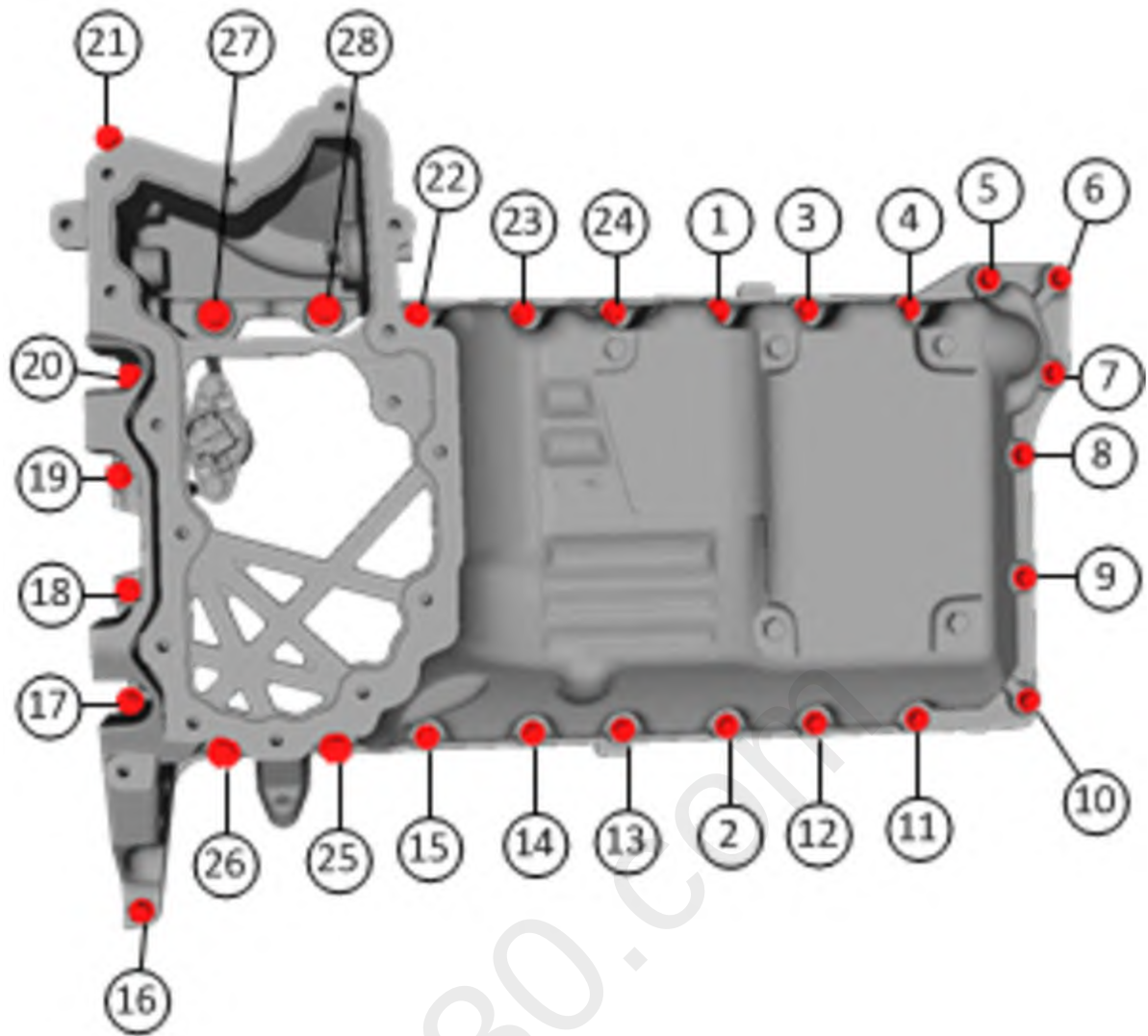
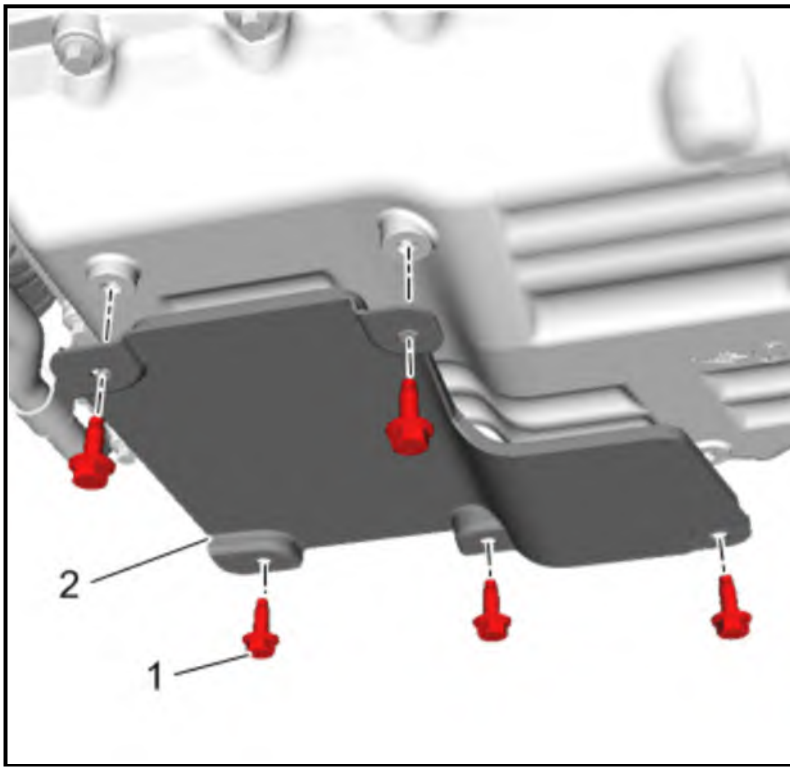


Fig. 21: Upper Oil Pan Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

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

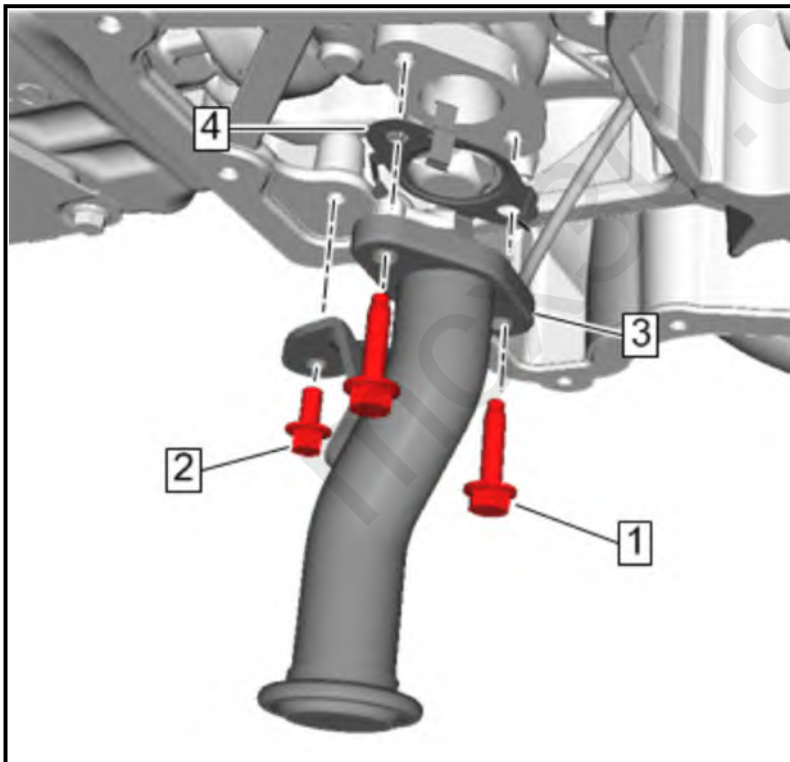
Tighten

1. First Pass bolts 1 - 24 15 N.m (11 lb ft) bolts 25 - 28 45 N.m (33 lb ft).
2. Final Pass bolts 1 - 24 15 N.m (11 lb ft) bolts 25 - 28 45 N.m (33 lb ft).
7. Lower the powertrain assembly.
8. Install the NEW right side engine mount fasteners. [Engine Mount Replacement - Right Side](#)
9. Oil Pan Deadener (2) - Install



10. Oil Pan Deadener Bolt (1) - Install and tighten 10 N.m (89 lb in)

11. Oil Pump Suction Pipe Gasket (4) - Install NEW



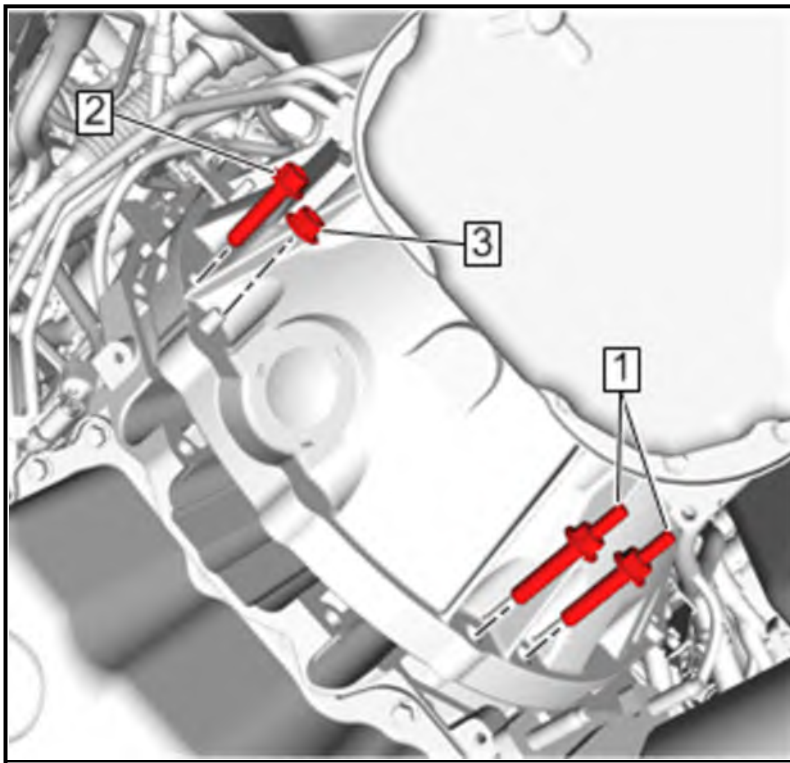
12. Oil Pump Suction Pipe (3) - Install

13. Oil Pump Suction Pipe Bolt (2) - Install and tighten 10 N.m (89 lb in)

14. Oil Pump Suction Pipe Bolt (1) - Install and tighten 10 N.m (89 lb in)

15. Lower Oil Pan - Install - **Lower Oil Pan Replacement**

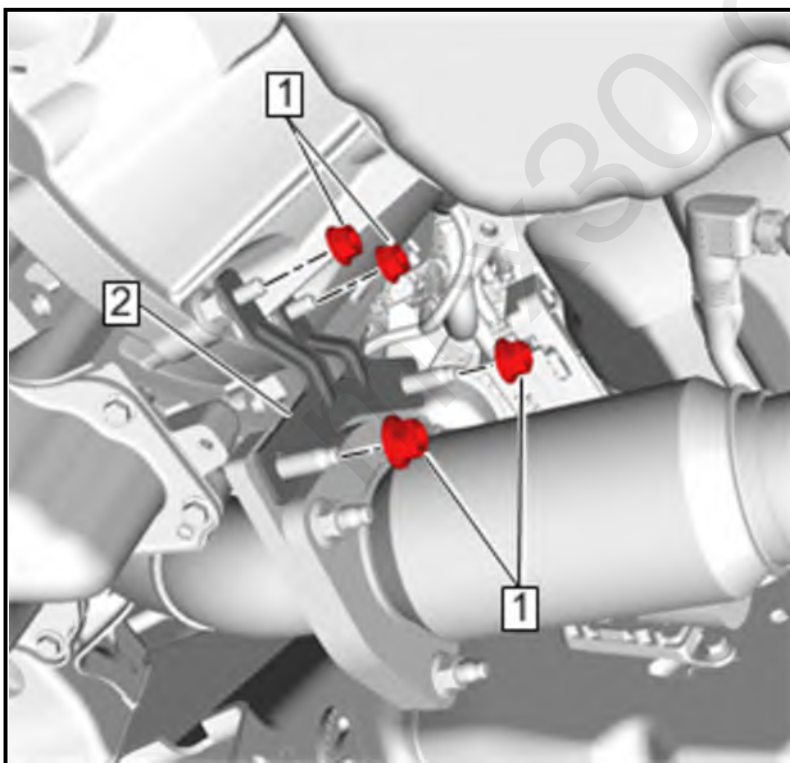
16. Transmission Bolt (1) - Install and tighten [2x] 50 N.m (37 lb ft)



17. Transmission Bolt (2) - Install and tighten 50 N.m (37 lb ft)

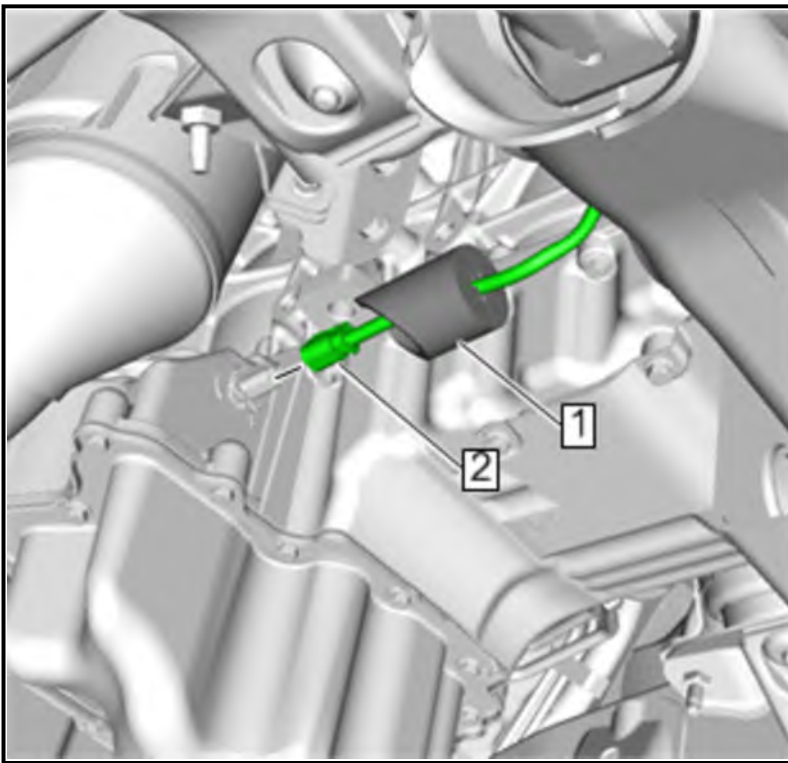
18. Nut (3) - Install and tighten 50 N.m (37 lb ft)

19. Catalytic Converter Bracket (2) - Install



20. Catalytic Converter Bracket Nut (1) - Install and tighten [4x] 22 N.m (16 lb ft)

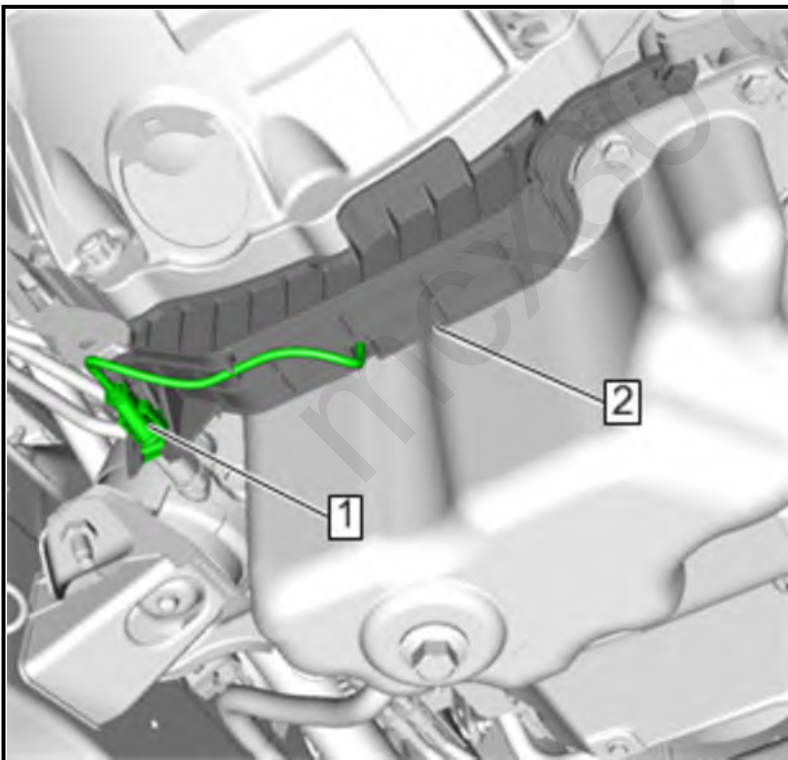
21. Electrical Connector (2) - Connect



22. Reposition the electrical connector sleeve (1).

23. Oil Level Indicator Tube - Install - [Oil Level Indicator Tube Replacement](#)

24. Crankshaft Position Sensor (2) - Install - [Crankshaft Position Sensor Replacement](#)



25. Electrical Connector (1) - Connect

26. Electric Belt Drive Rack and Pinion Steering Gear - Install -, or [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(4WD\)](#)

27. Front Axle - Install - [Front Axle Replacement \(without ZR2\)](#) , or [Front Axle Replacement \(with ZR2\)](#)

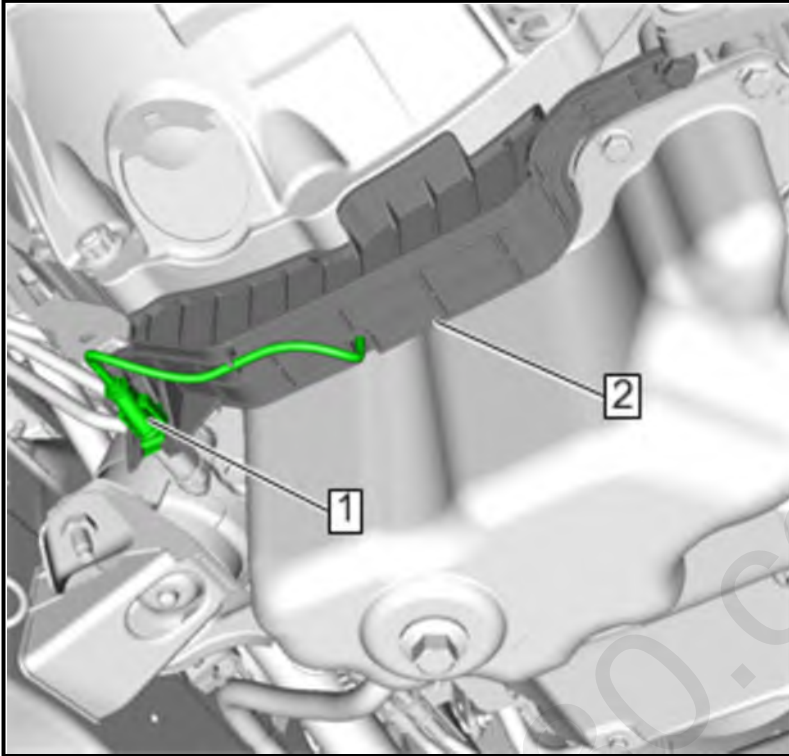
28. Drivetrain and Front Suspension Frame Front Crossmember - Install - [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(4 Wheel Drive\)](#)

29. Fill the engine oil to the proper level with NEW engine oil. [Engine Oil and Oil Filter Replacement](#)

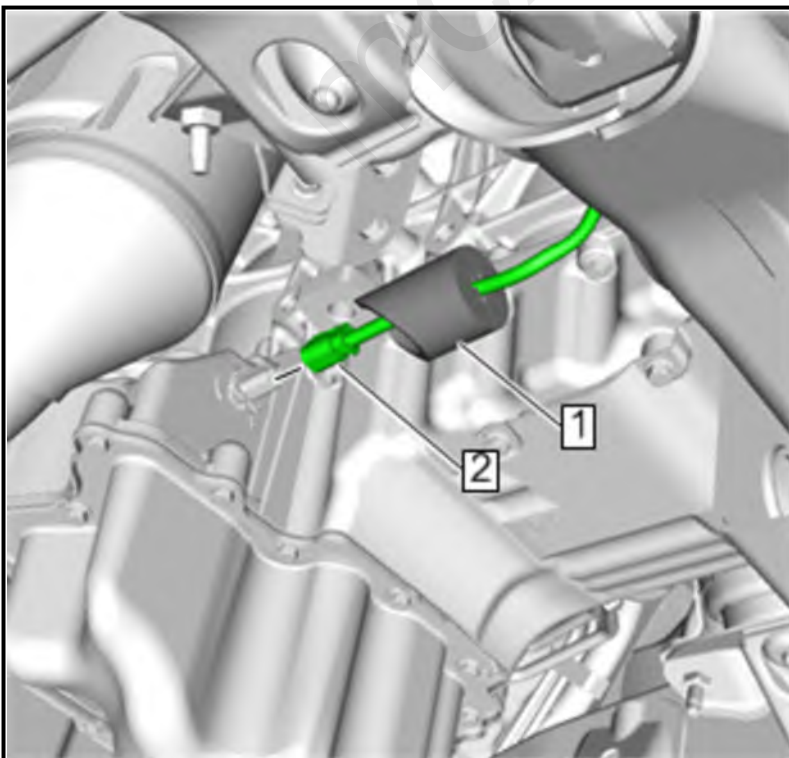
UPPER OIL PAN REPLACEMENT (2 WHEEL DRIVE)

Removal Procedure

1. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
2. Drivetrain and Front Suspension Frame Front Crossmember - Remove - [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(2 Wheel Drive\)](#)
3. Electric Belt Drive Rack and Pinion Steering Gear - Remove - [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(2WD\)](#)
4. Electrical Connector (1) - Disconnect



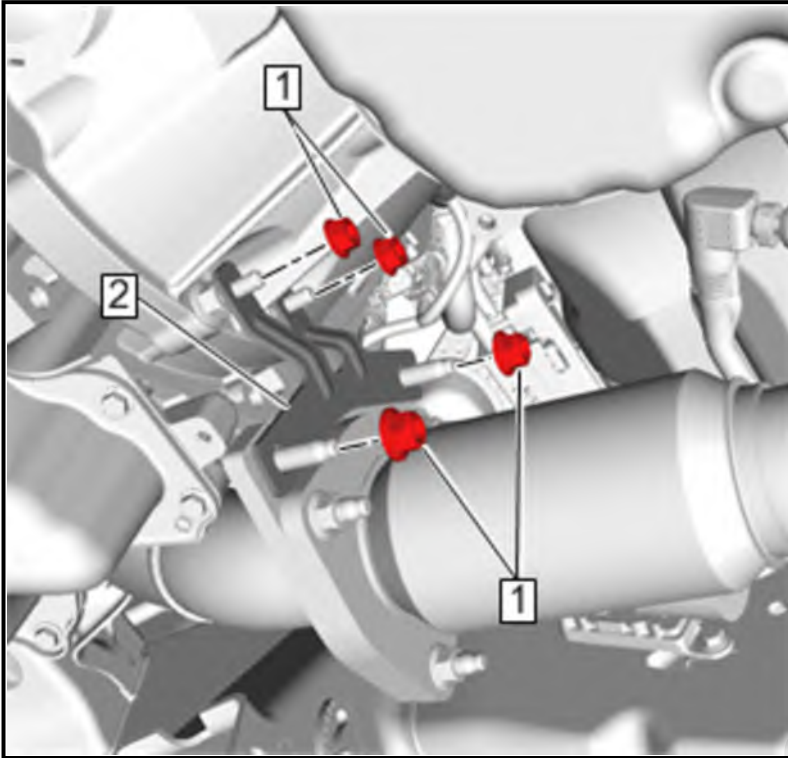
5. Crankshaft Position Sensor - Remove - [Crankshaft Position Sensor Replacement](#)
6. Reposition the electrical connector sleeve (1).



7. Electrical Connector (2) - Disconnect

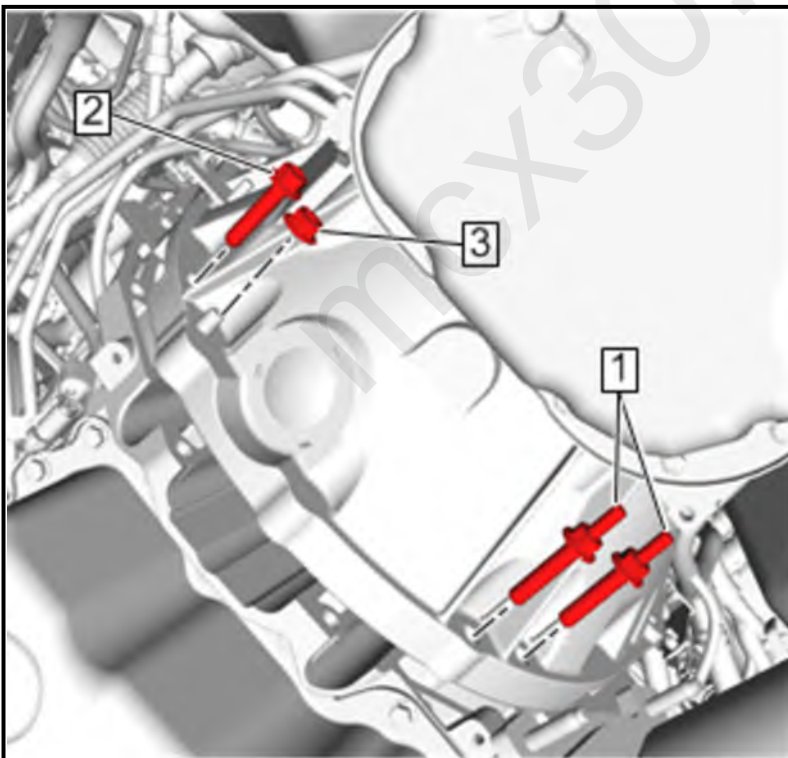
8. Oil Level Indicator Tube - Remove - [Oil Level Indicator Tube Replacement](#)

9. Catalytic Converter Bracket Nut (1) - Remove [4x]



10. Catalytic Converter Bracket (2) Remove

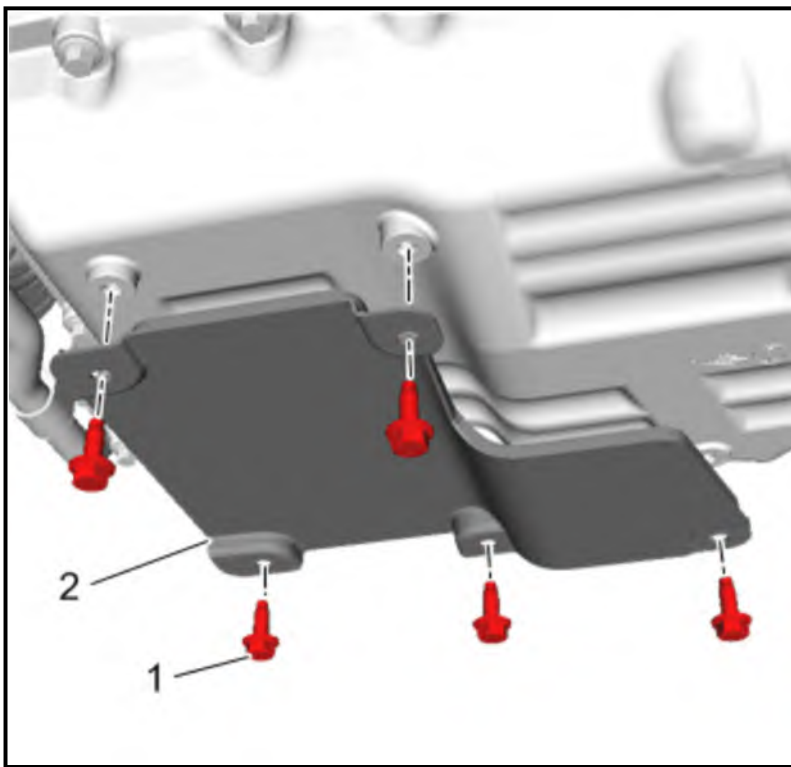
11. Transmission Bolt (1) - Remove [2x]



12. Transmission Bolt (2) - Remove

13. Nut (3) - Remove

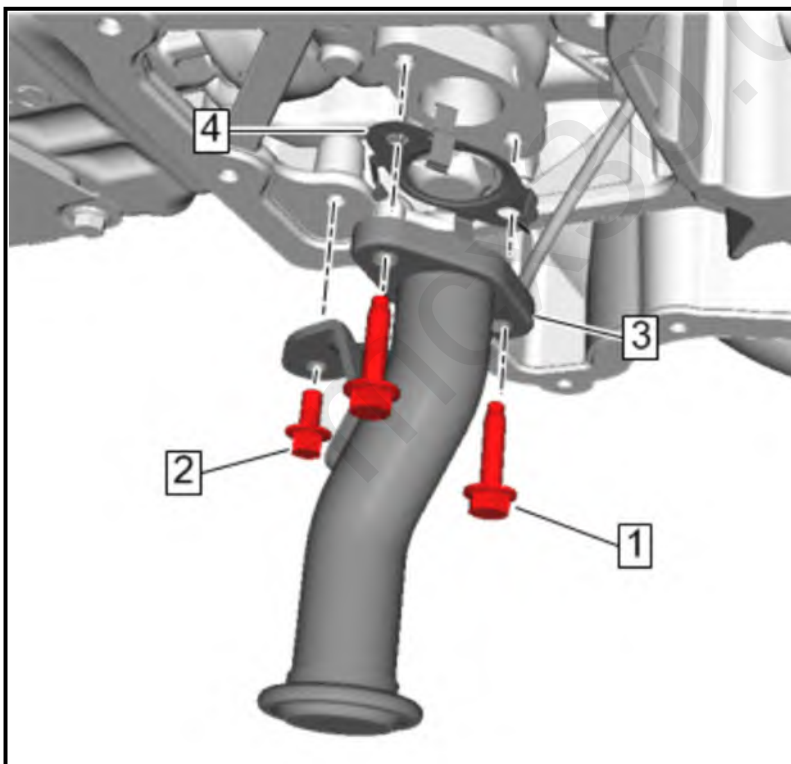
14. Oil Pan Deadener Bolt (1) - Remove



15. Oil Pan Deadener (2) - Remove

16. Lower Oil Pan - Remove - [Lower Oil Pan Replacement](#)

17. Oil Pump Suction Pipe Bolt (1) - Remove

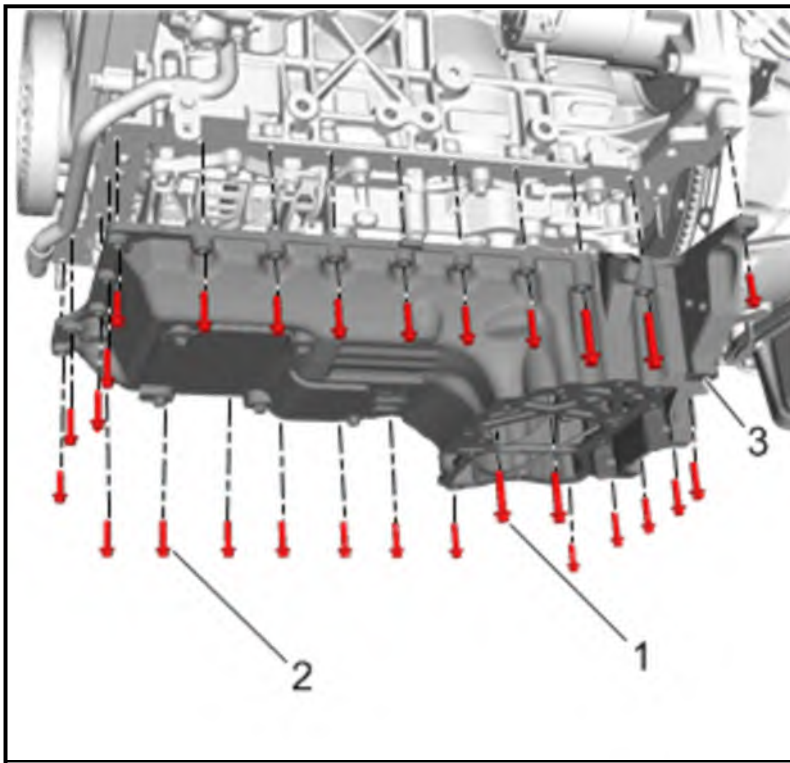


18. Oil Pump Suction Pipe Bolt (2) - Remove

19. Oil Pump Suction Pipe (3) - Remove

20. Oil Pump Suction Pipe Gasket (4) - Remove and DISCARD

21. Upper Oil Pan Bolt (1) - Remove [4x]



22. Upper Oil Pan Bolt (2) - Remove [24x]

NOTE: Do NOT remove the engine mount bracket fasteners.

23. Remove and DISCARD the right side engine mount fasteners. [Engine Mount Replacement - Right Side](#)

24. Using a suitable lifting device, raise the powertrain assembly until the upper oil pan can be removed.

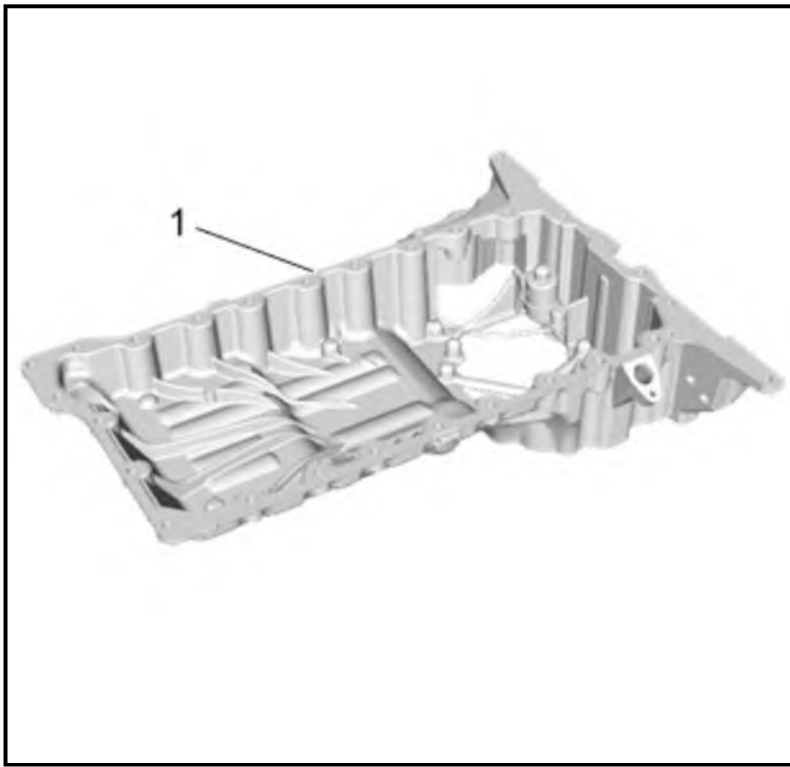
25. Upper Oil Pan - Remove

26. Upper Oil Pan (2) - Clean and inspect - [Upper Oil Pan Cleaning and Inspection \(LWN\)](#)

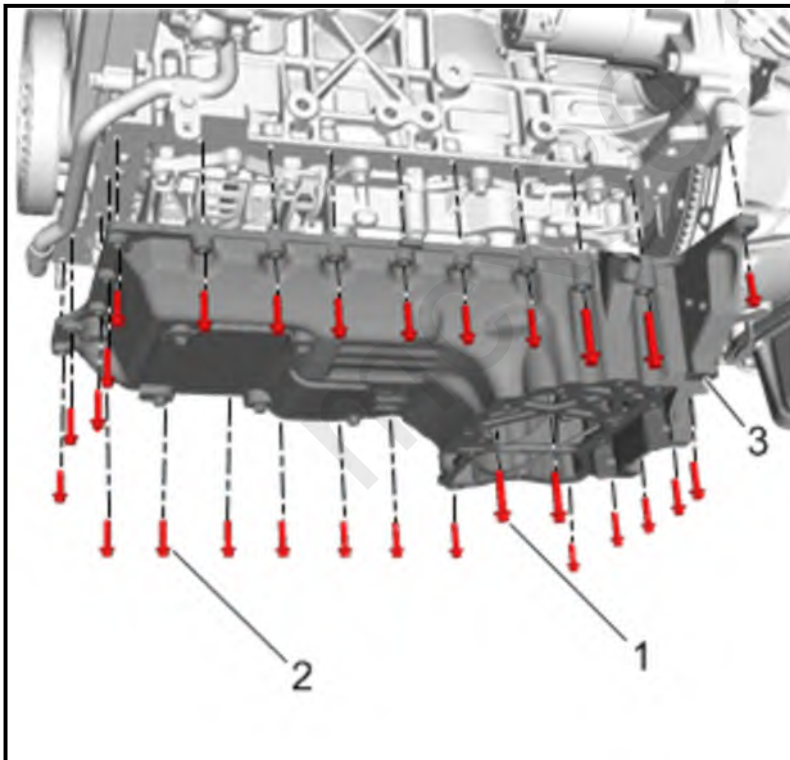
27. Transfer parts as necessary.

Installation Procedure

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



2. Apply a **5 mm (0.197 in)** bead of sealant to the oil pan flange (1). [Adhesives, Fluids, Lubricants, and Sealers](#)
3. Upper Oil Pan - Install



4. Upper Oil Pan Bolt (2) - Loosely install [24x]
5. Upper Oil Pan Bolt (1) - Loosely install [4x]
6. Tighten the bolts in the sequence shown.

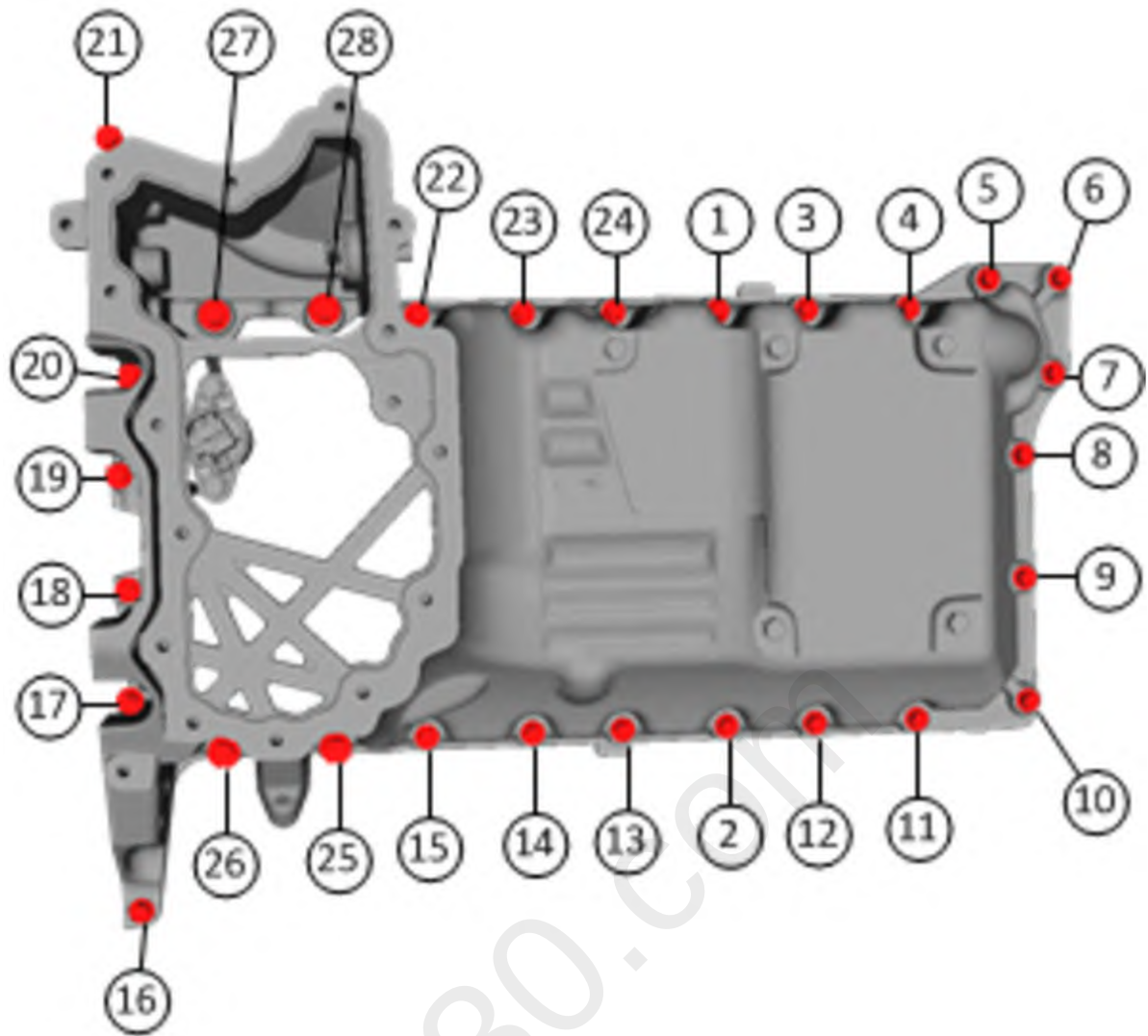
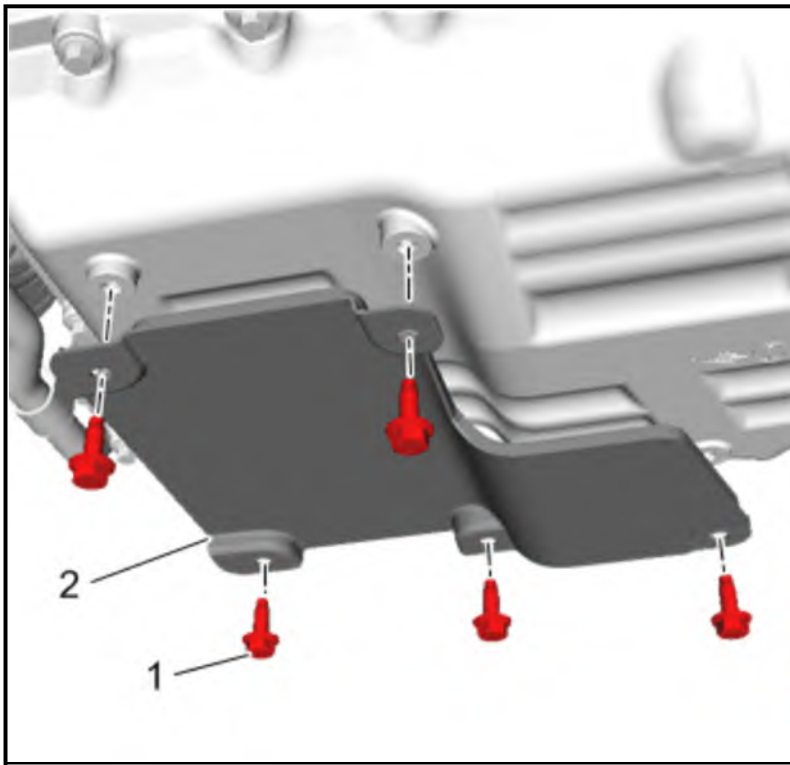


Fig. 22: Upper Oil Pan Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

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

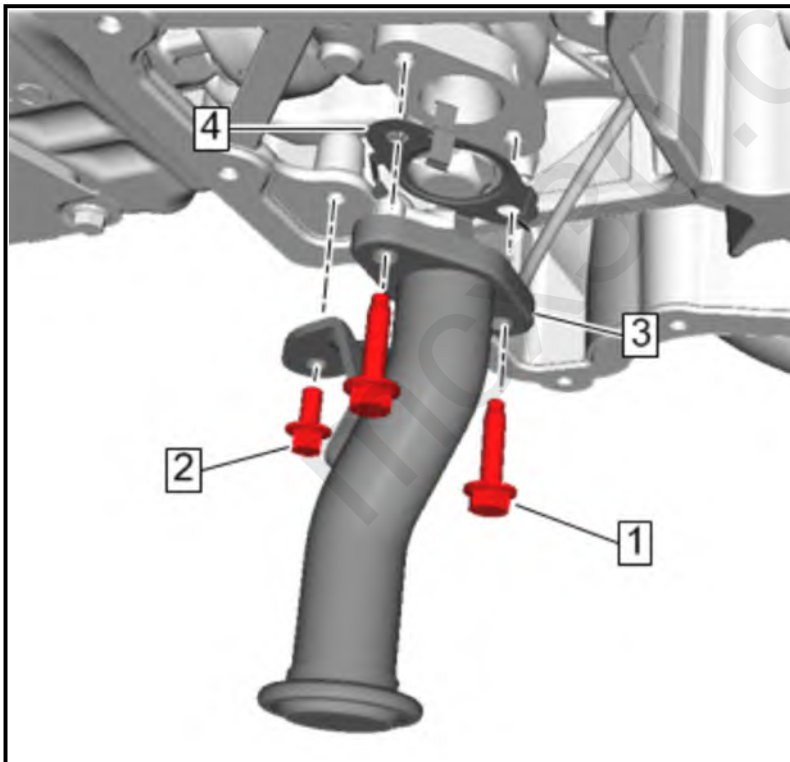
Tighten

1. First Pass bolts 1 - 24 15 N.m (11 lb ft) bolts 25 - 28 45 N.m (33 lb ft).
2. Final Pass bolts 1 - 24 15 N.m (11 lb ft) bolts 25 - 28 45 N.m (33 lb ft).
7. Lower the powertrain assembly.
8. Install the NEW right side engine mount fasteners. [Engine Mount Replacement - Right Side](#)
9. Oil Pan Deadener (2) - Install



10. Oil Pan Deadener Bolt (1) - Install and tighten 10 N.m (89 lb in)

11. Oil Pump Suction Pipe Gasket (4) - Install NEW



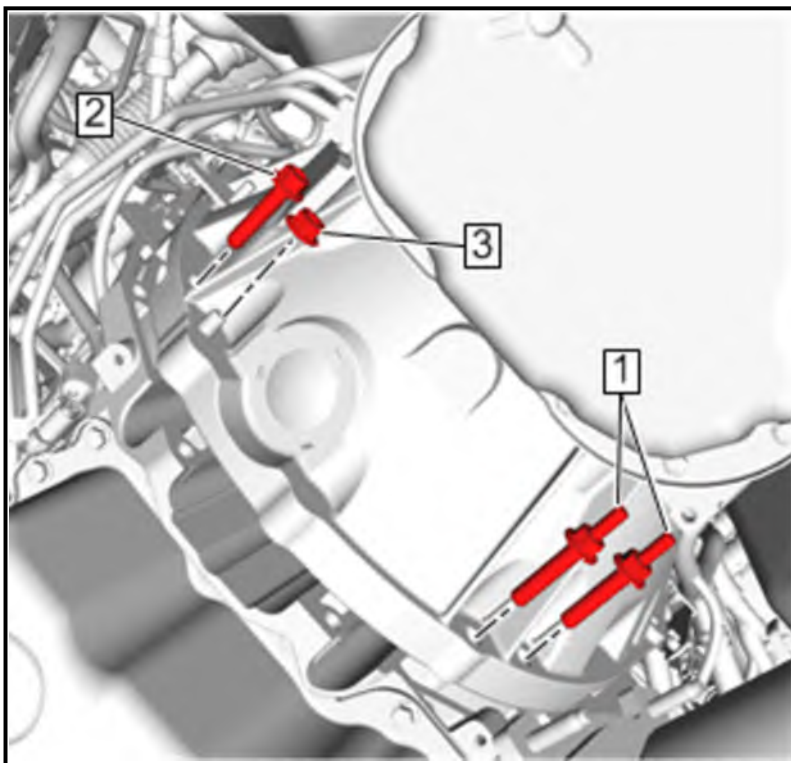
12. Oil Pump Suction Pipe (3) - Install

13. Oil Pump Suction Pipe Bolt (2) - Install and tighten 10 N.m (89 lb in)

14. Oil Pump Suction Pipe Bolt (1) - Install and tighten 10 N.m (89 lb in)

15. Lower Oil Pan - Install - **Lower Oil Pan Replacement**

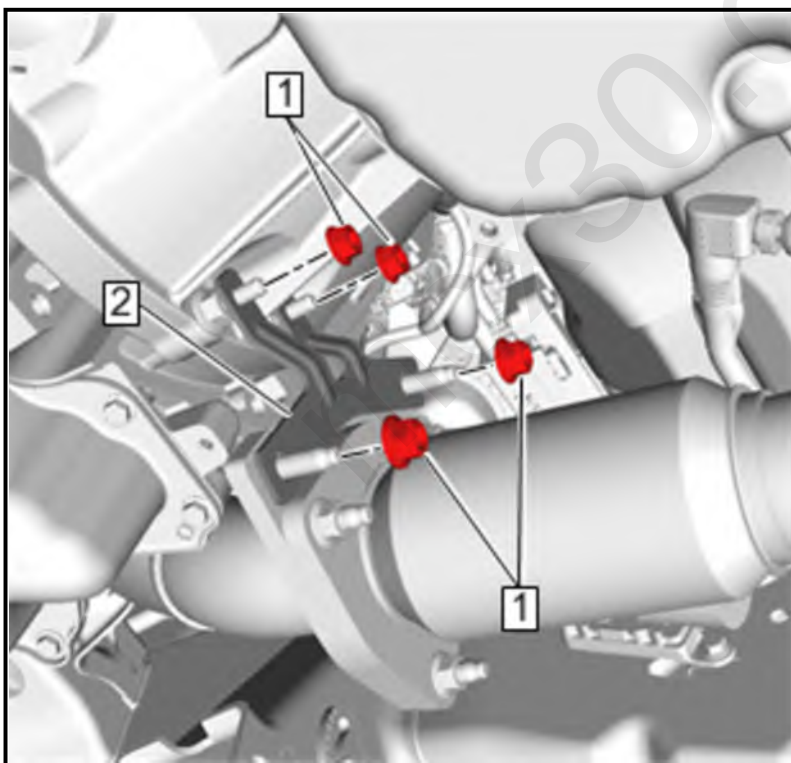
16. Transmission Bolt (1) - Install and tighten [2x] 50 N.m (37 lb ft)



17. Transmission Bolt (2) - Install and tighten 50 N.m (37 lb ft)

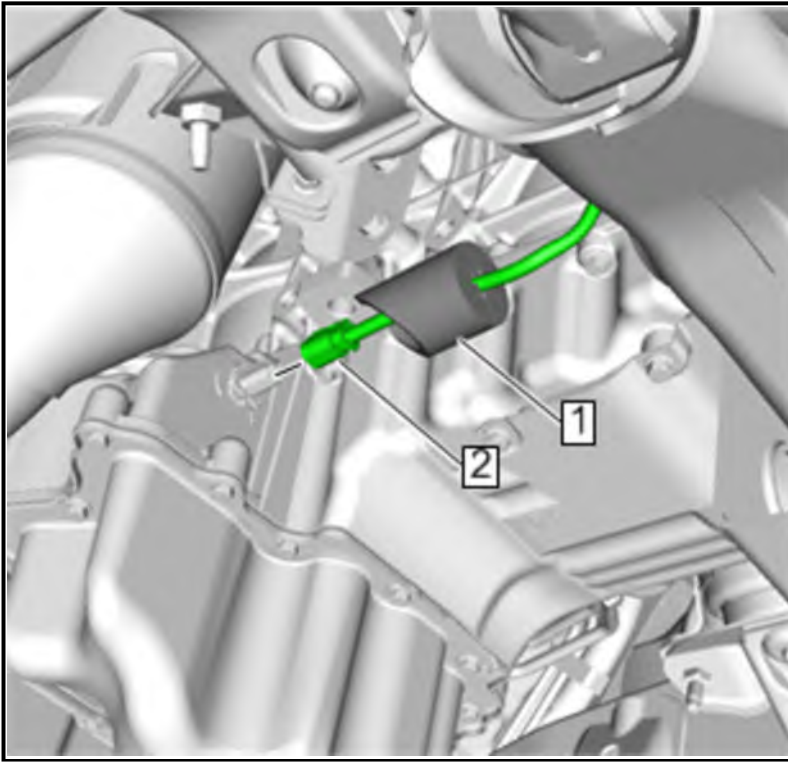
18. Nut (3) - Install and tighten 50 N.m (37 lb ft)

19. Catalytic Converter Bracket (2) - Install



20. Catalytic Converter Bracket Nut (1) - Install and tighten [4x] 22 N.m (16 lb ft)

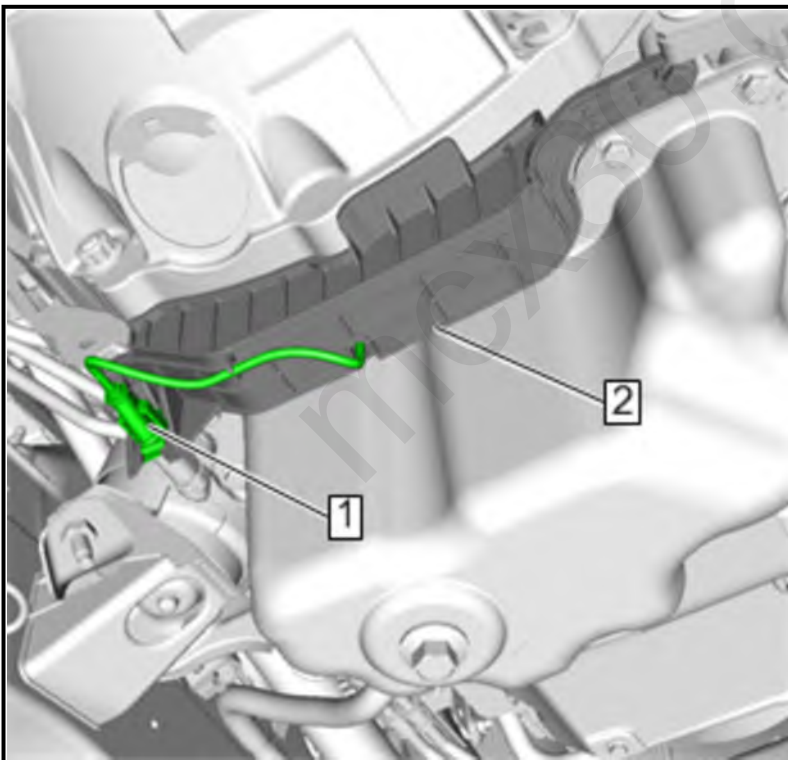
21. Electrical Connector (2) - Connect



22. Reposition the electrical connector sleeve (1).

23. Oil Level Indicator Tube - Install - [Oil Level Indicator Tube Replacement](#)

24. Crankshaft Position Sensor - Install - [Crankshaft Position Sensor Replacement](#)



25. Electrical Connector (1) - Connect

26. Electric Belt Drive Rack and Pinion Steering Gear - Install - [Electric Belt Drive Rack and Pinion Steering Gear Replacement \(2WD\)](#)

27. Drivetrain and Front Suspension Frame Front Crossmember - Install - [Drivetrain and Front Suspension Frame Front Crossmember Replacement \(2 Wheel Drive\)](#)

28. Fill the engine oil to the proper level with NEW engine oil. [Engine Oil and Oil Filter Replacement](#)

ENGINE REPLACEMENT

Special Tools

- EN-36857 Engine Lift Bracket

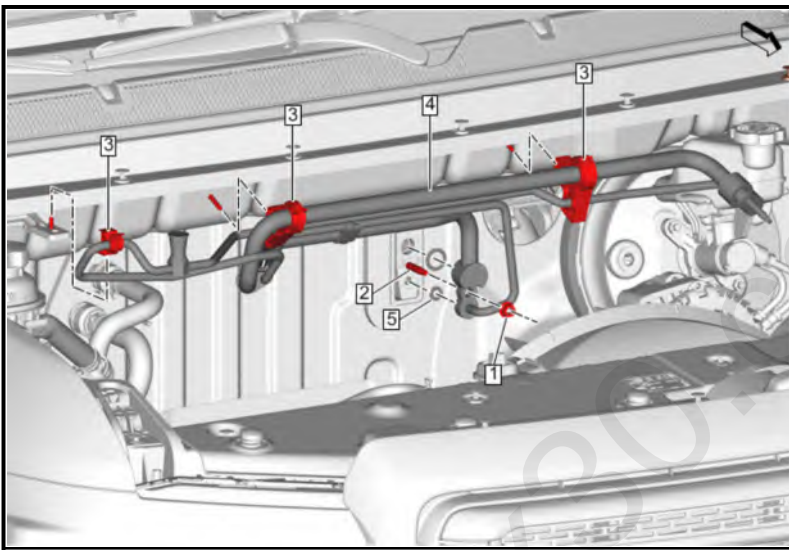
Equivalent regional tools: [Special Tools](#)

Removal Procedure

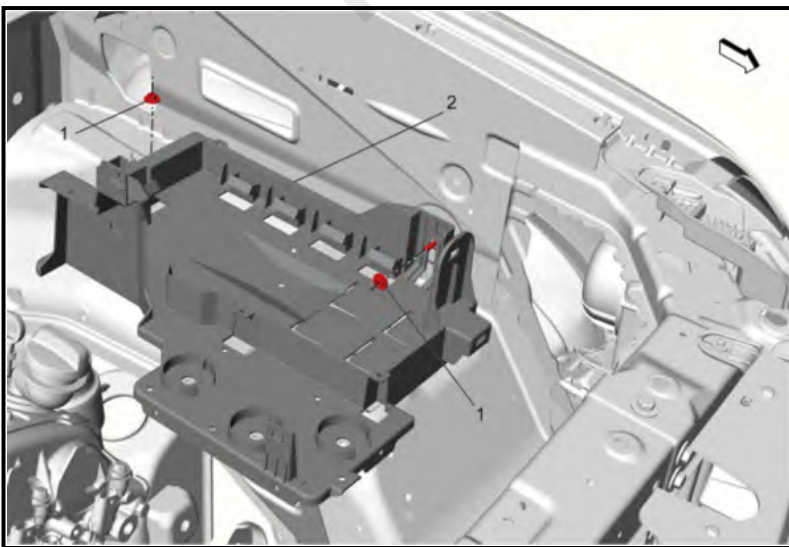
WARNING: Refer to [Diesel/Gasoline Vapors Warning](#) .

WARNING: Refer to [Safety Glasses Warning](#) .

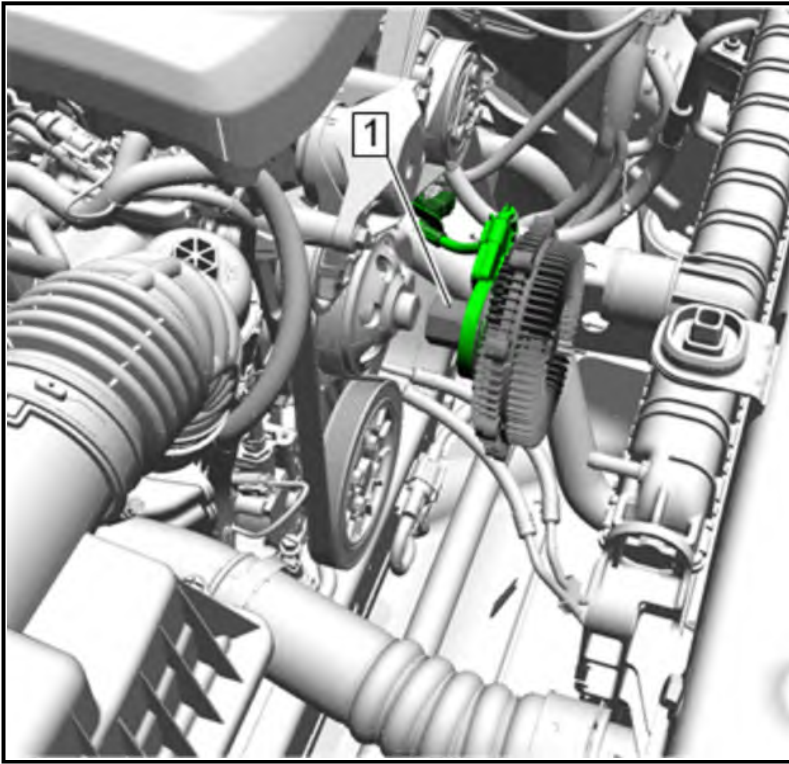
1. Turn OFF the engine, for 30 seconds before proceeding. This will purge the fuel pressure from the complete fuel system.
2. Hood - Remove - [Hood Replacement](#)
3. Air Conditioning Evaporator Hose - Remove - [Air Conditioning Evaporator Hose Replacement \(LWN\)](#)



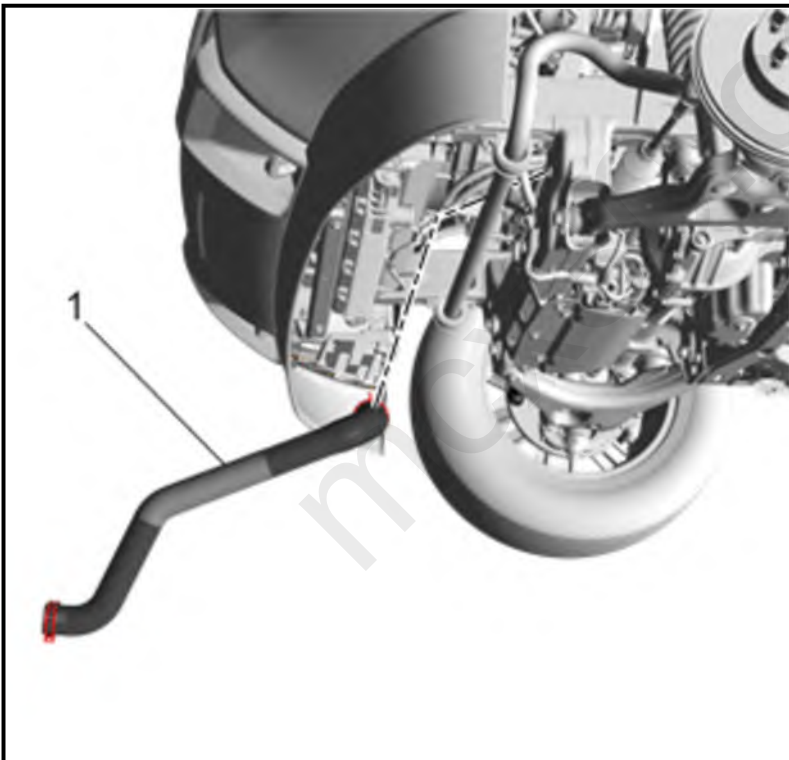
4. Drain the cooling system. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#).
5. Drain the engine oil. [Engine Oil and Oil Filter Replacement](#)
6. Battery Tray (2) - Remove - [Battery Tray Replacement](#)



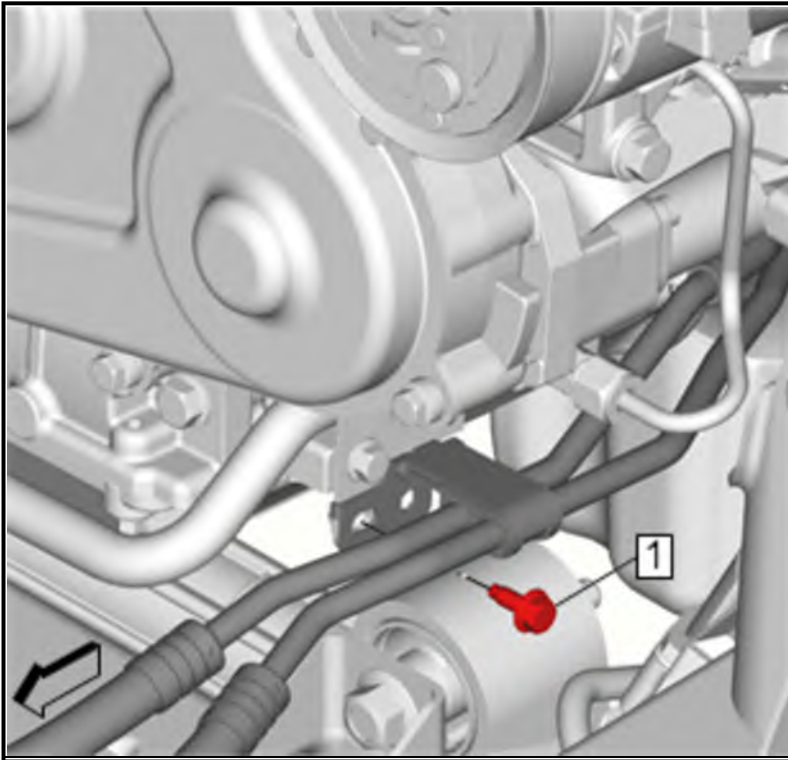
7. Radiator Inlet Hose @ Radiator - Remove - [Radiator Inlet Hose Replacement \(LWN Radiator Side\)](#) , or [Radiator Inlet Hose Replacement \(LWN Engine Side\)](#).
8. Fan Blade Clutch (1) - Remove - [Fan Blade Clutch Replacement \(LWN\)](#)



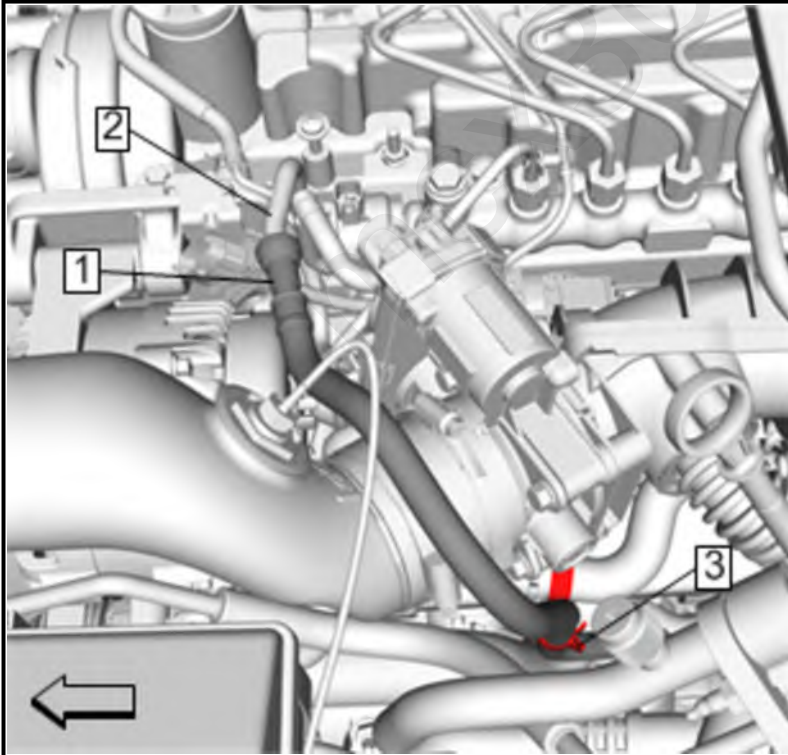
9. Radiator Outlet Hose (1) @ Radiator - Remove - [Radiator Outlet Hose Replacement \(LWN\)](#)



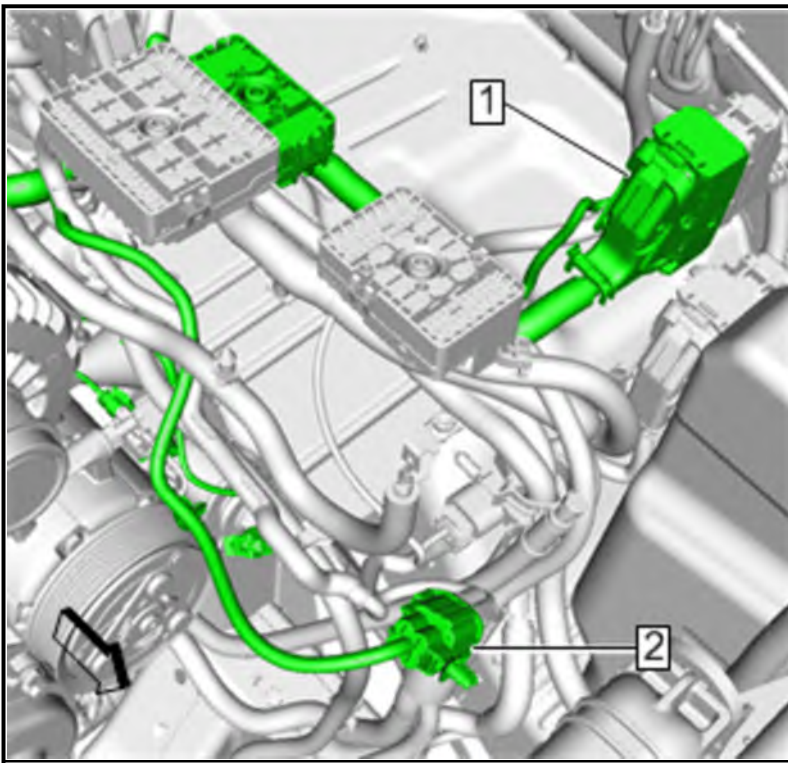
10. Transmission Fluid Cooler Pipe Clip Bolt (1) @ Bracket - Remove - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(LWN\)](#)



11. Charge Air Cooler Inlet Duct - Remove - [Charge Air Cooler Inlet Duct Replacement](#)
12. Charge Air Cooler Inlet Hose - Remove - [Charge Air Cooler Inlet Hose Replacement](#)
13. Air Conditioning Compressor Hose - Remove - [Air Conditioning Compressor Hose Replacement \(LWN\)](#)
14. Fuel Pump Fuel Return Hose (1) @ Engine (2) - Disconnect - [Metal Collar Quick Connect Fitting Service](#)

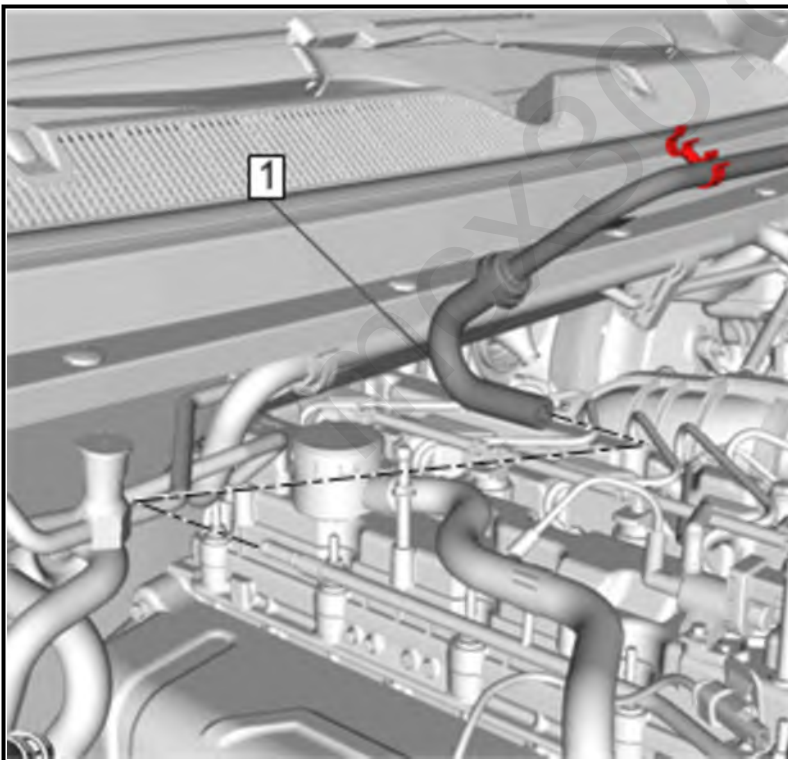


15. Electrical Connector (1, 2) - Disconnect



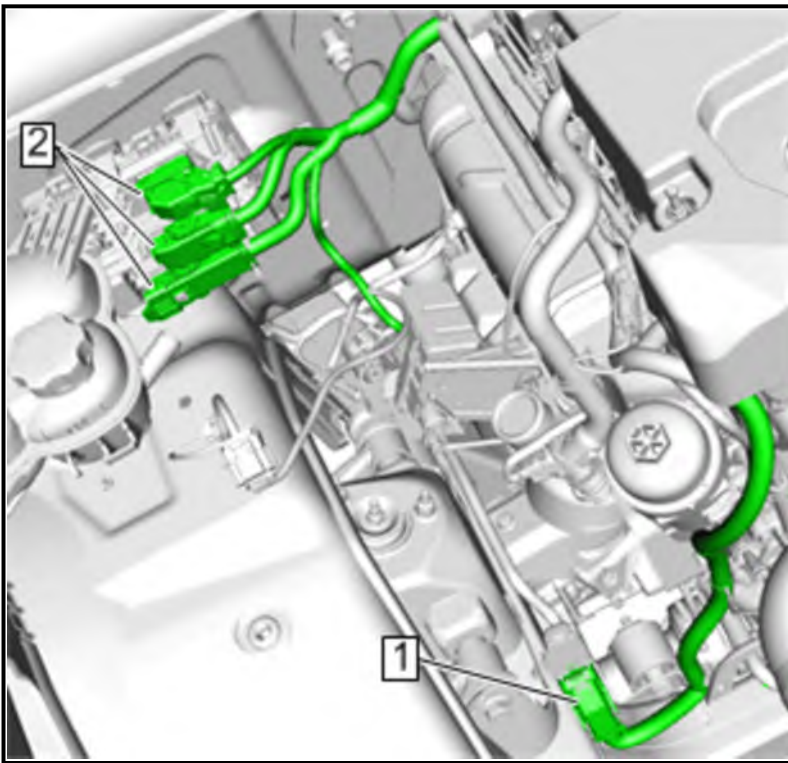
NOTE: Disconnect and reposition harness as necessary.

16. Power Brake Booster Vacuum Hose (1) - Remove - [Power Brake Booster Vacuum Hose Replacement \(LWN\)](#)



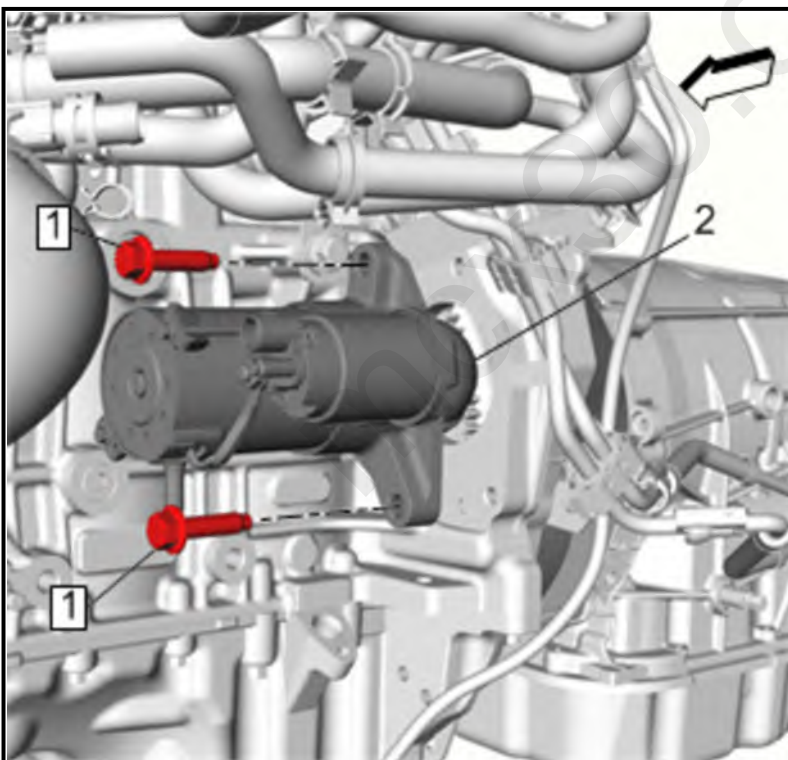
17. Radiator Surge Tank Inlet Hose @ Engine - Reposition away - [Radiator Surge Tank Inlet Hose Replacement \(LWN\)](#)

18. Electrical Connector (1) - Disconnect



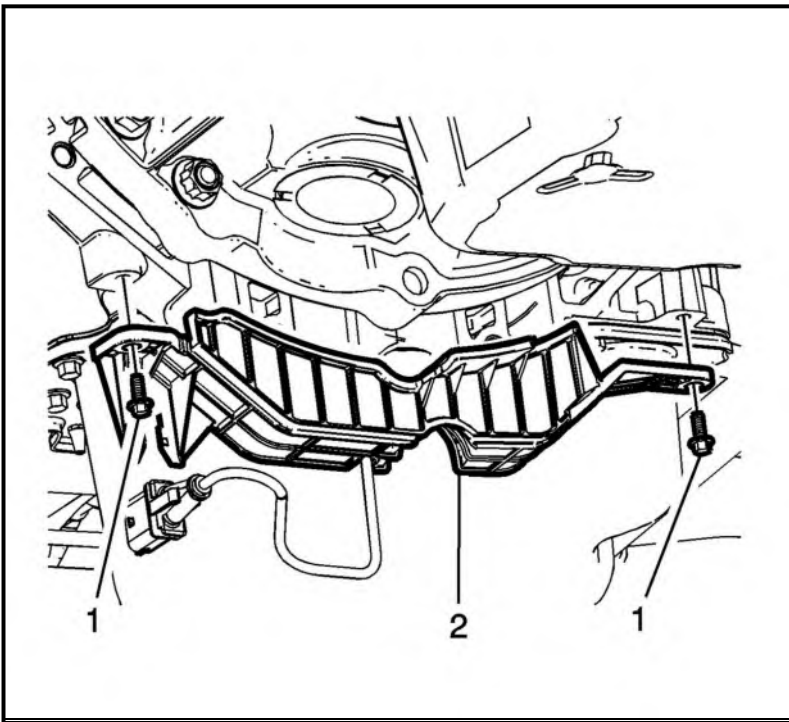
NOTE: Disconnect and reposition harness as necessary.

19. Starter (2) - Remove - [Starter Replacement \(LWN\)](#)

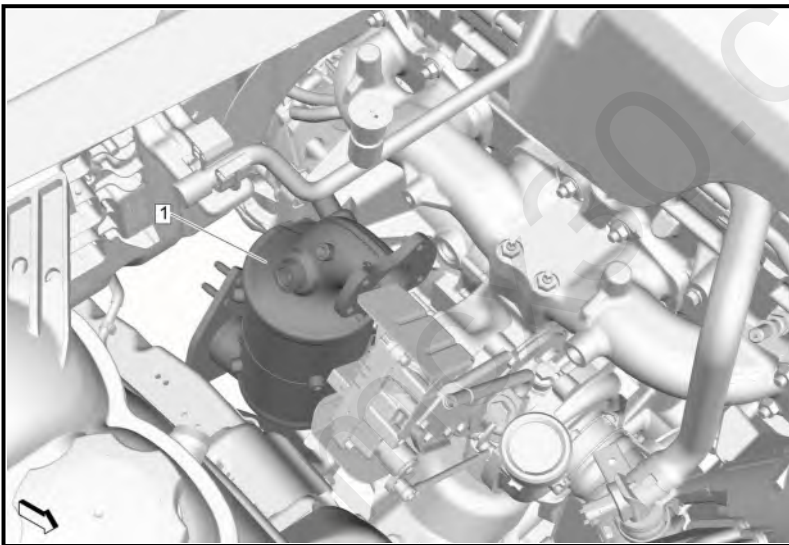


20. Remove the right flywheel inspection cover.

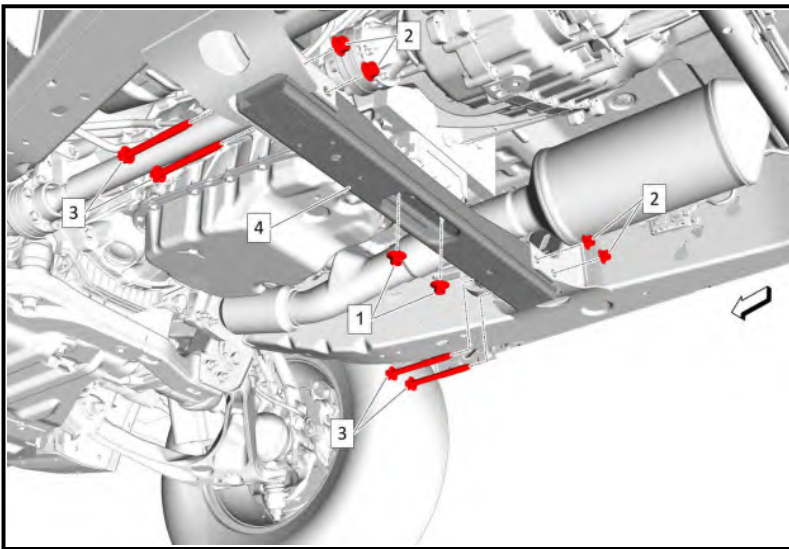
21. Remove the crank shaft position sensor access cover (2). [Crankshaft Position Sensor Replacement](#)



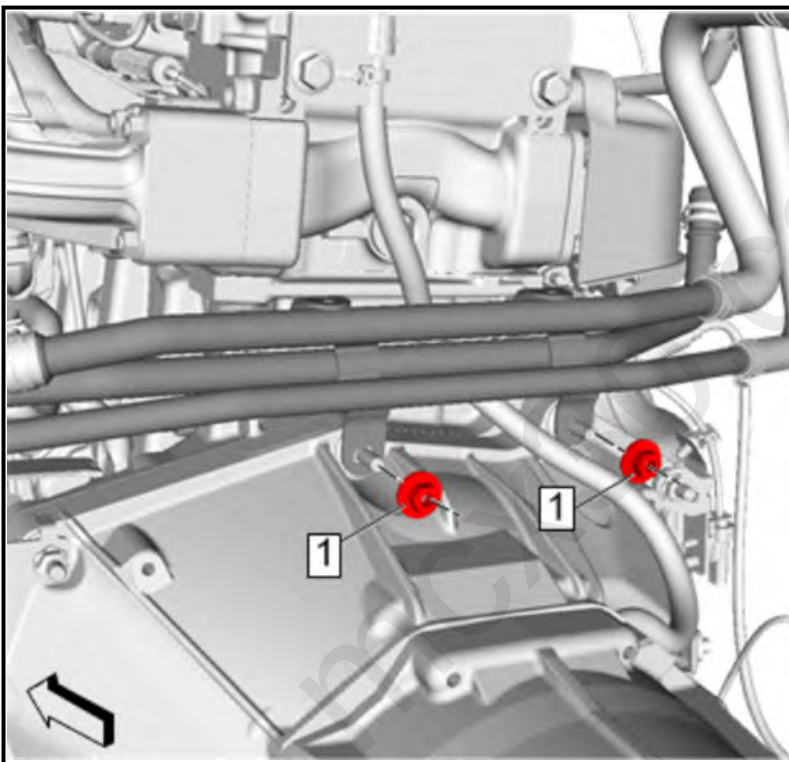
22. Mark the position of the flywheel to the torque converter.
23. Remove the 6 flywheel to torque converter bolts.
24. Catalytic Converter (1) - Remove - [Catalytic Converter Replacement \(LWN\)](#).



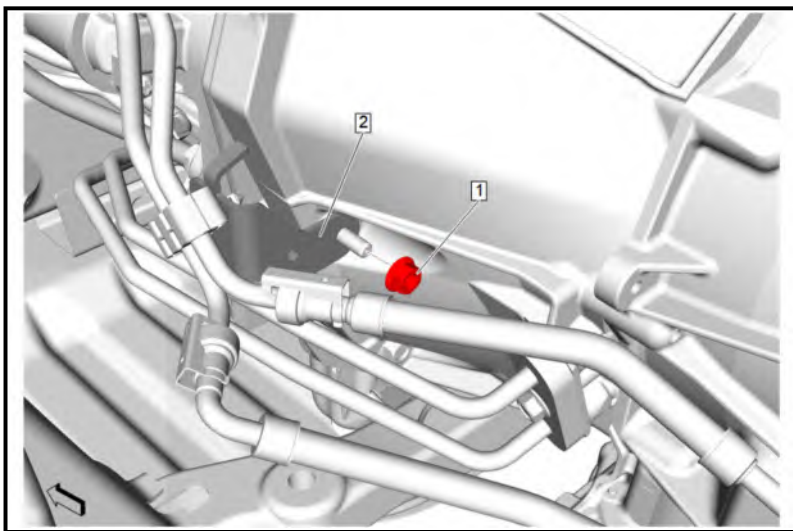
25. Support the transmission with a transmission jack.
26. Transmission Support Crossmember (4) - Remove - [Transmission Support Crossmember Replacement \(4 Wheel Drive\)](#) , or [Transmission Support Crossmember Replacement \(2 Wheel Drive\)](#).



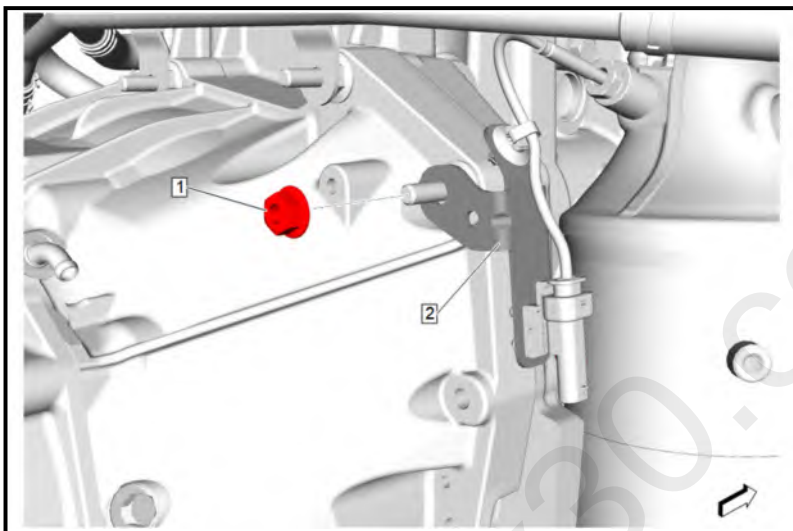
27. Lower the rear of the transmission to access the 2 radiator surge tank outlet pipe nuts. [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#).



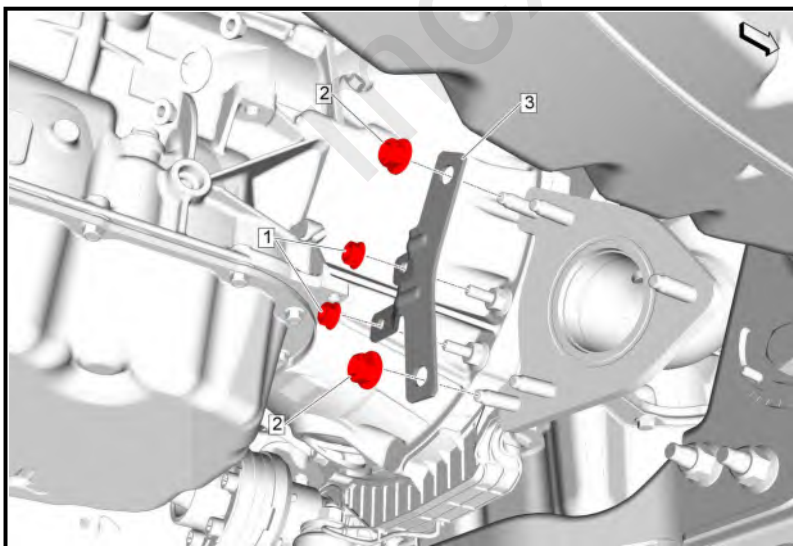
- 28. Remove the radiator surge tank outlet pipe nuts (1).
- 29. Remove the radiator surge tank outlet pipe off the 2 transmission studs.
- 30. Disconnect the fuel lines. [Metal Collar Quick Connect Fitting Service](#)
- 31. Remove the fuel injection fuel feed and return hose clip nut (1) and reposition bracket (2).



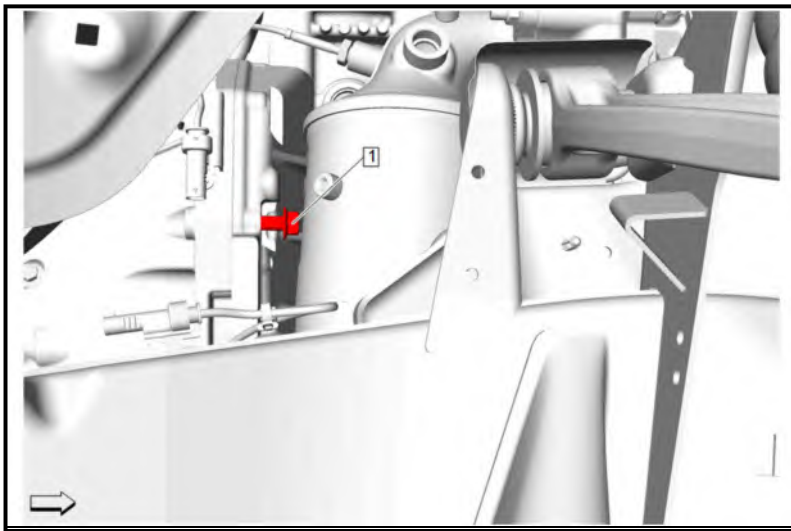
32. Remove the exhaust temperature sensor bracket nut (1) and reposition bracket (2).



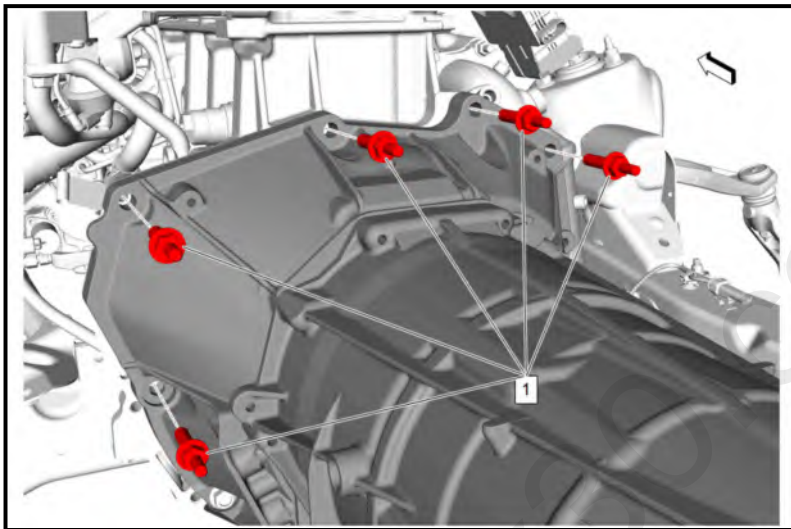
33. Catalytic Converter Brace Bracket (3) - Remove - [Catalytic Converter Replacement \(LWN\)](#)



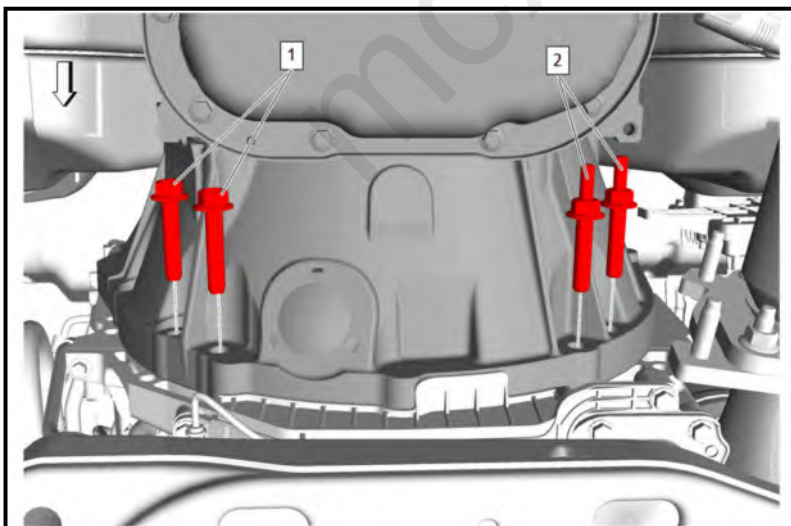
34. Transmission Bolt (1) - Remove



35. Transmission Stud (1) - Remove [5x]

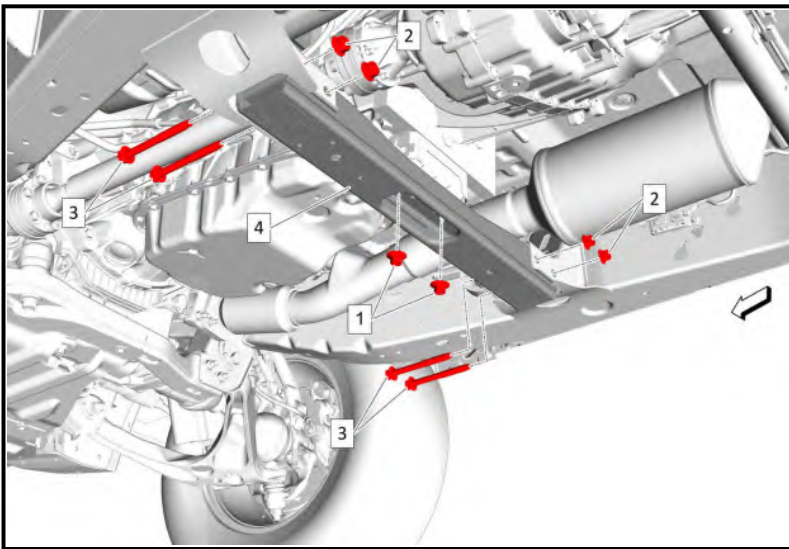


36. Transmission Bolt (1) - Remove [2x]



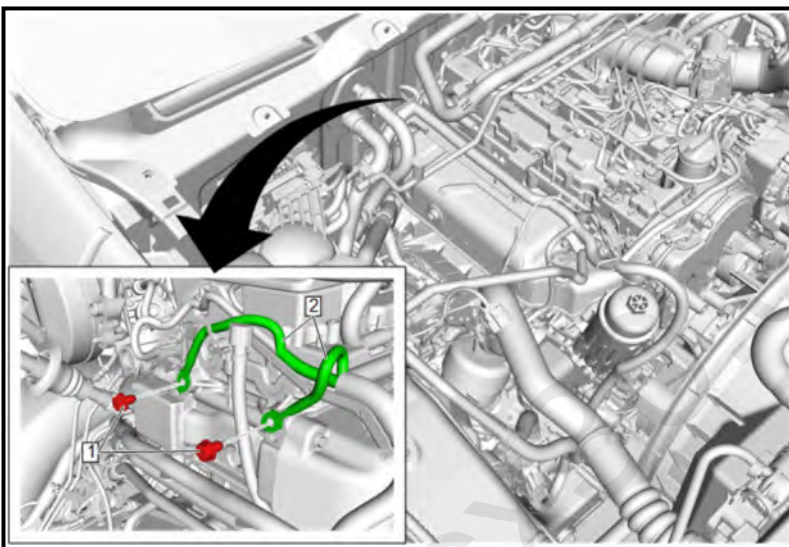
37. Transmission Stud (2) - Remove [2x]

38. Transmission Support Crossmember (4) - Install - [Transmission Support Crossmember Replacement \(4 Wheel Drive\)](#) , or [Transmission Support Crossmember Replacement \(2 Wheel Drive\)](#).



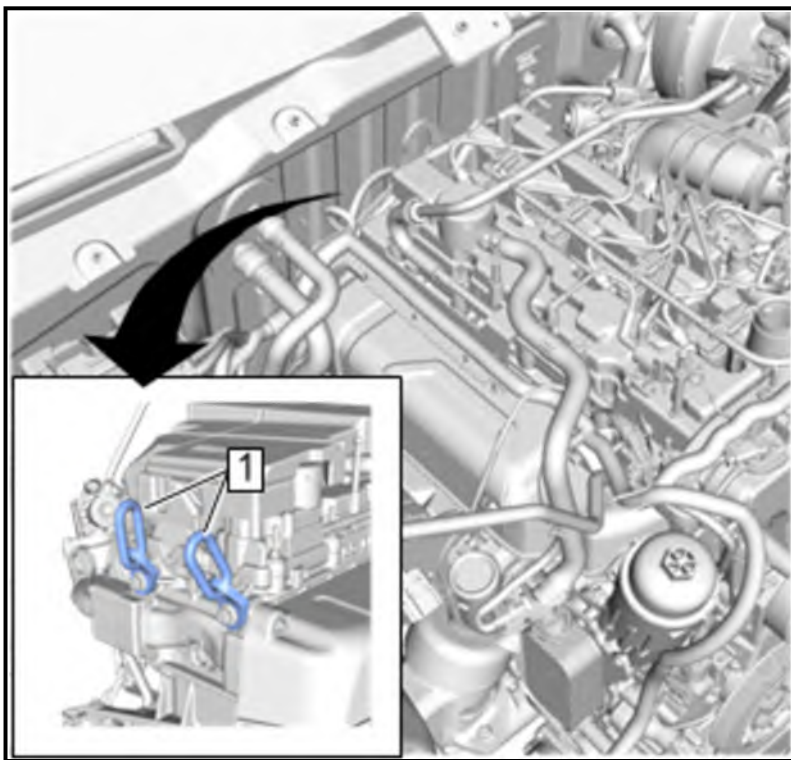
39. Remove the transmission jack.

40. Ground Cable Bolt (1) - Remove [2x]

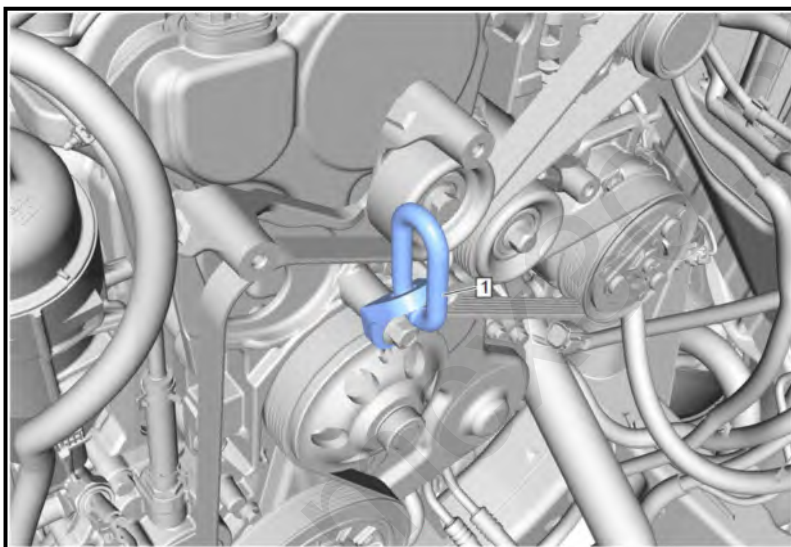


41. Ground Cable (2) Reposition

42. **EN-36857** Engine Lift Bracket (1) - Install [2x]

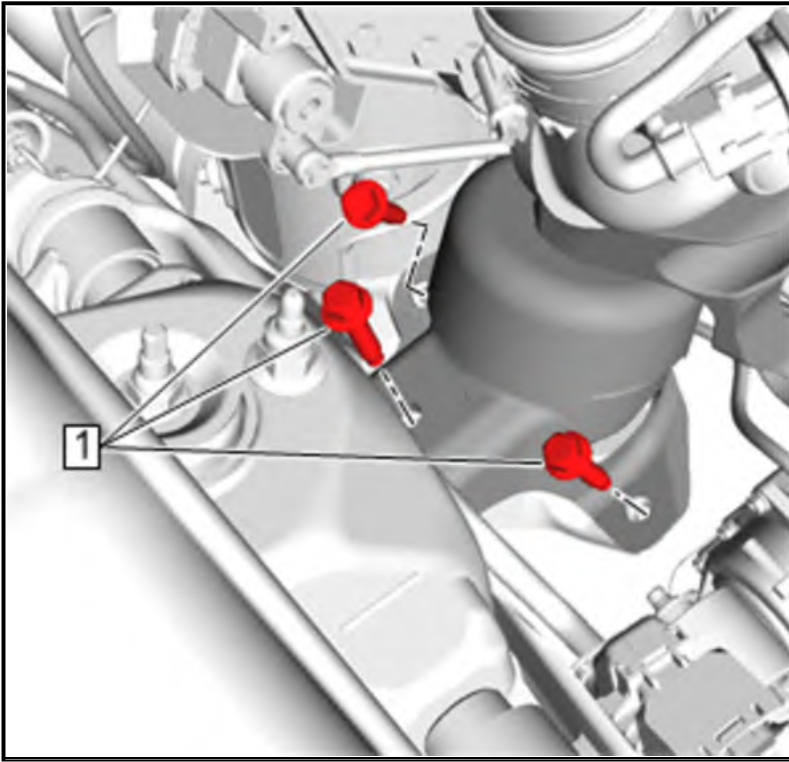


43. **EN-36857** Engine Lift Bracket (1) - Install

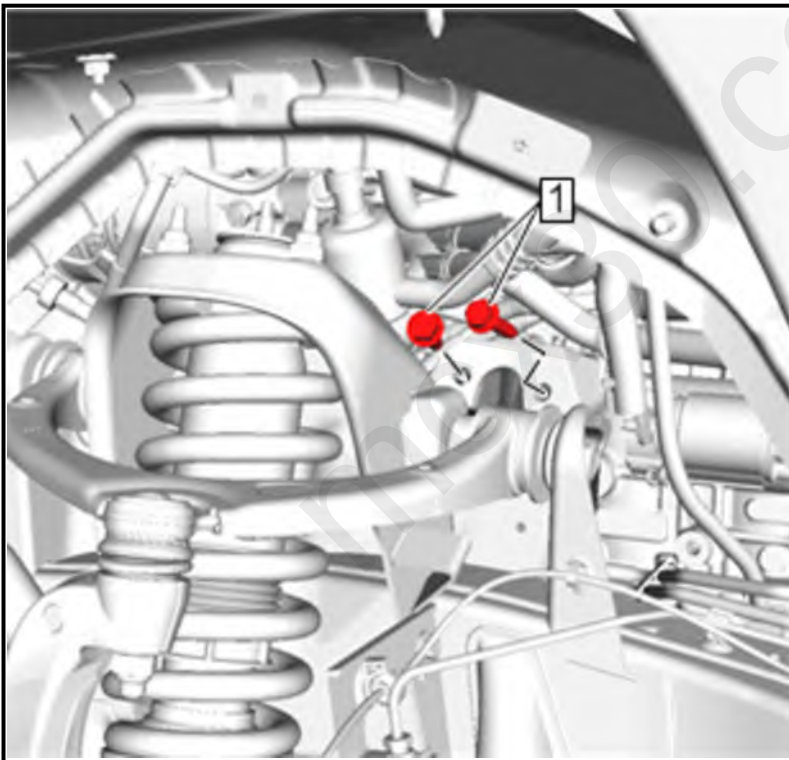


44. Install a suitable engine lifting device.

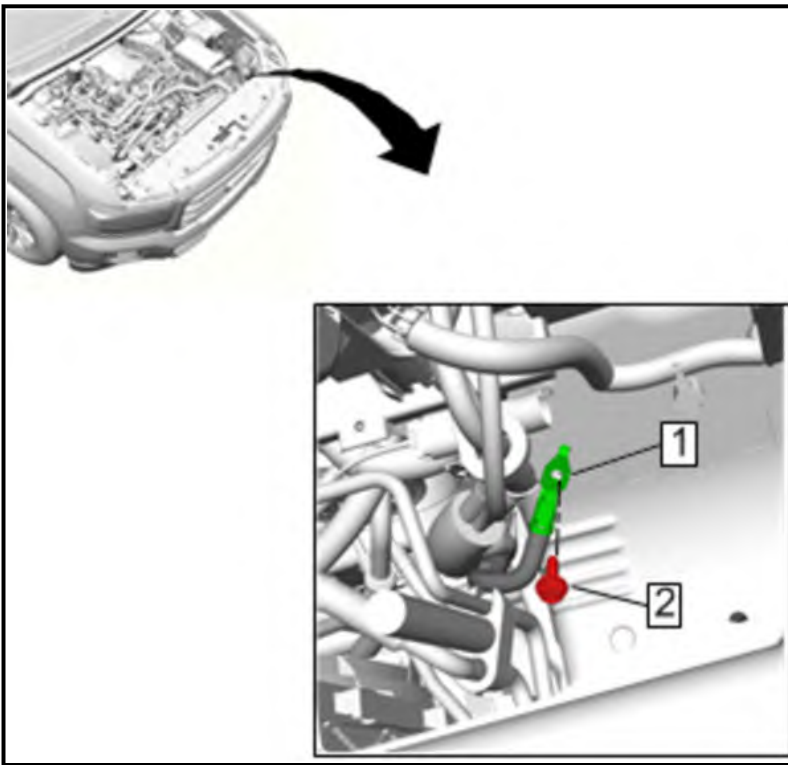
45. Engine Mount Bracket Bolt (1) - Remove [3x] - [Engine Mount Bracket Replacement - Right Side](#)



46. Engine Mount Bracket Bolt (1) - Remove [2x] - [Engine Mount Bracket Replacement - Left Side](#)

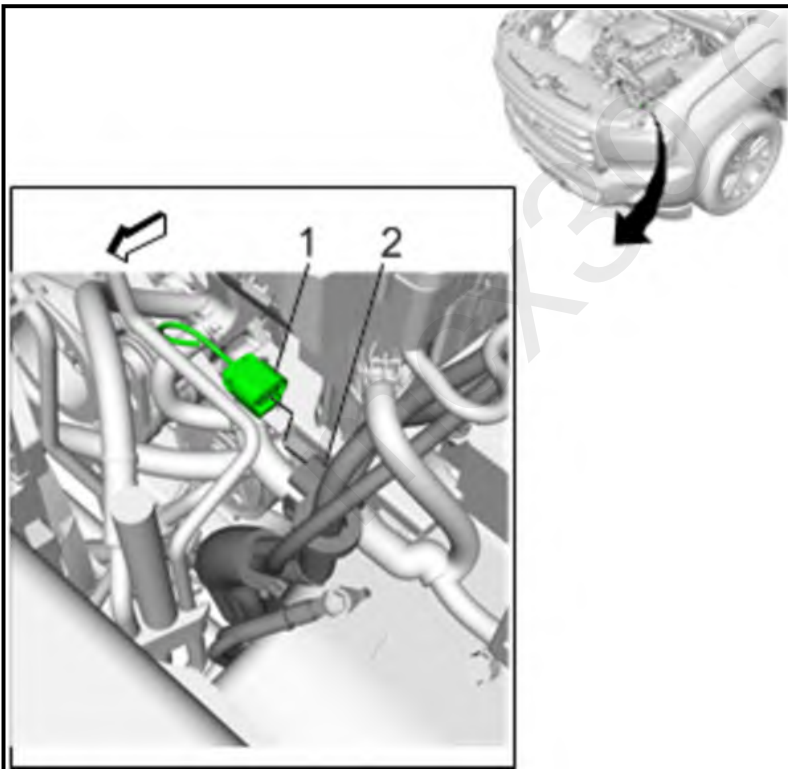


47. Battery Negative Cable Ground Fastener (2) - Remove

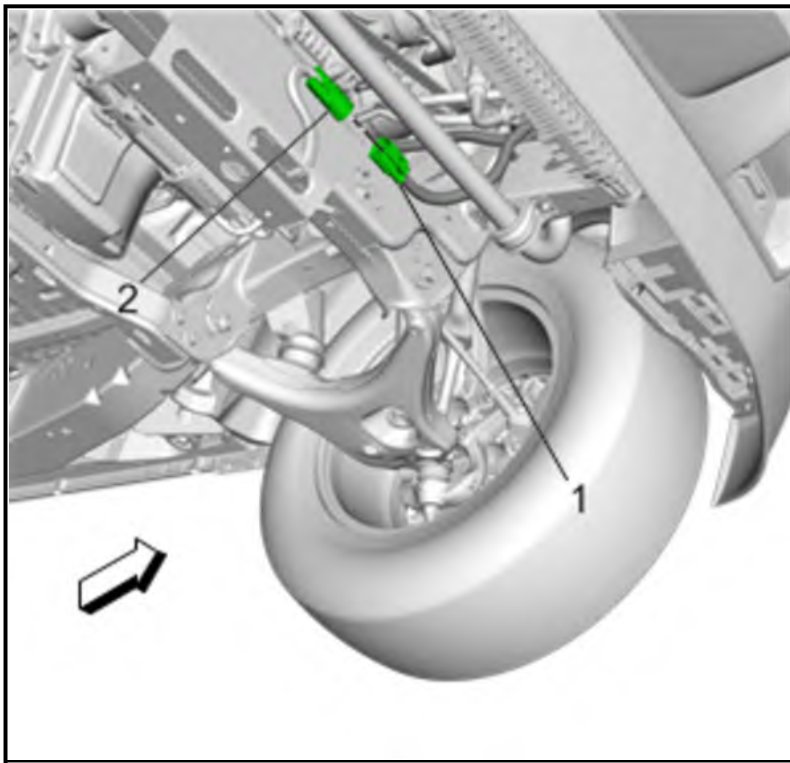


48. Battery Negative Cable (1) - Remove

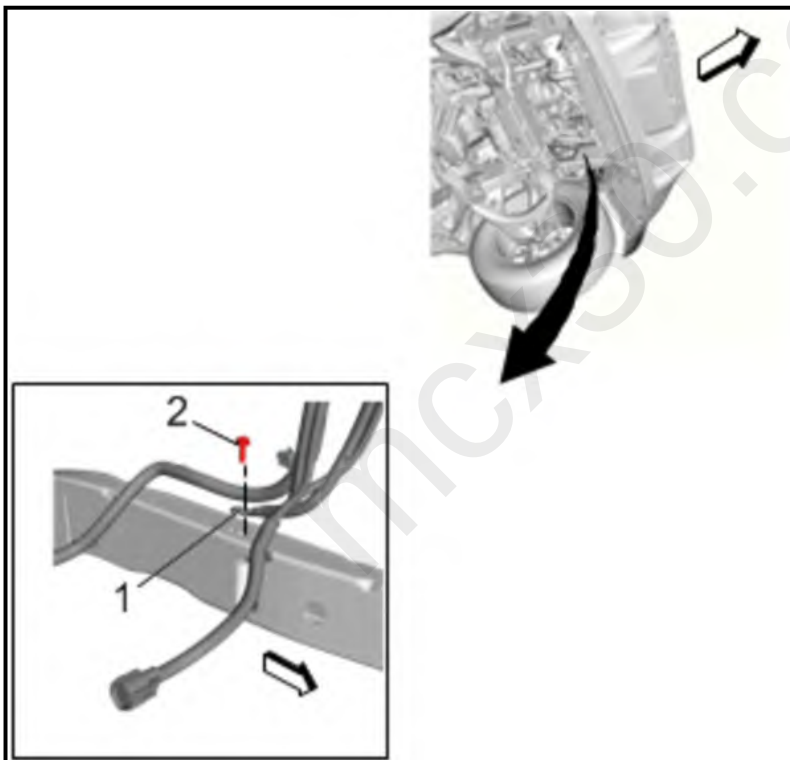
49. Electrical Connector (1) @ Battery Current Sensor (2) Disconnect



50. Disconnect the electronic power steering (EPS) connector (2), from the battery negative cable connector, attached to the front frame crossmember.



51. Battery Negative Cable Frame Ground Fastener (2) - Remove



52. Battery Negative Cable (1) - Remove

53. Ground Cable Bolt (1) - Remove



54. Ground Cable (2) Reposition

55. Disconnect remaining electrical connectors, hoses and vacuum lines as necessary.

56. Position a floor jack with a block of wood under the transmission to support the front of the transmission.

NOTE: A second technician is required.

57. Using a suitable lifting device, remove the engine from the vehicle while maintaining proper clearance of the following.

- Frame
- Vacuum lines
- Oil cooler lines
- Wiring harness
- Coolant pipes and hoses

58. Transfer components as necessary.

Installation Procedure

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

1. If the engine is replaced with a new engine or has been overhauled, perform the engine pre-lube procedure. [Engine Prelubing](#)

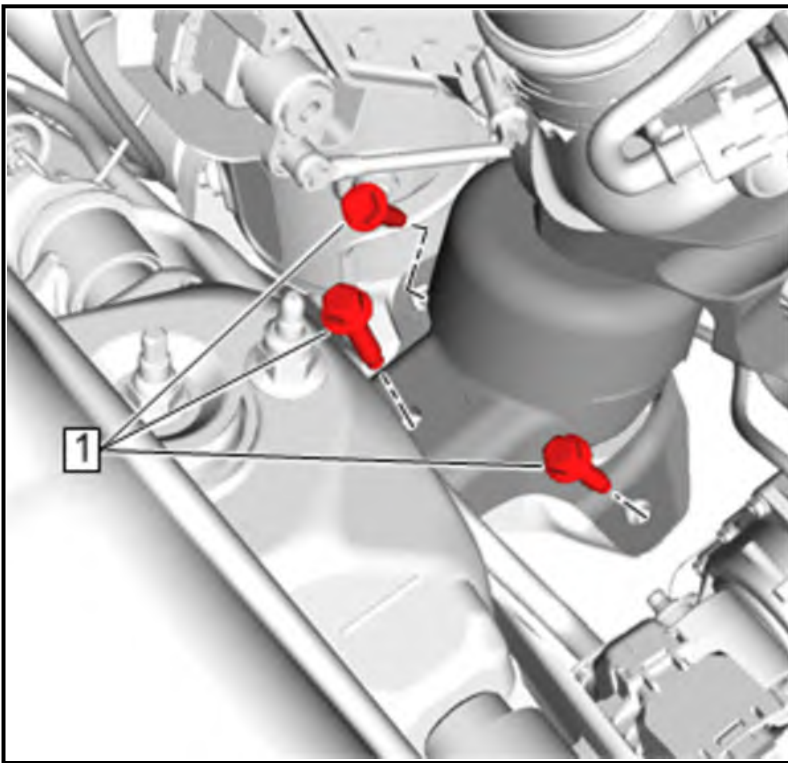
NOTE: A second technician is required.

2. Carefully lower the engine into the vehicle.

3. Ensure when lowering the engine the following items are clear from the frame.

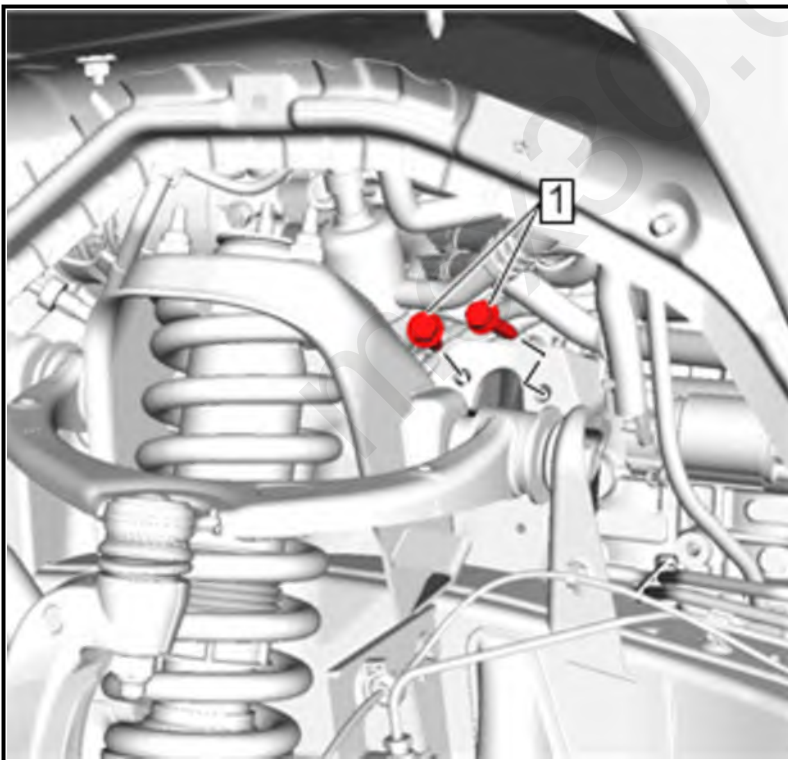
- Vacuum lines
- Oil cooler lines
- Wiring harness
- Coolant pipes and hoses

4. Engine Mount Bracket Bolt (1) - Install and tighten [3x] - [Engine Mount Bracket Replacement - Right Side](#)



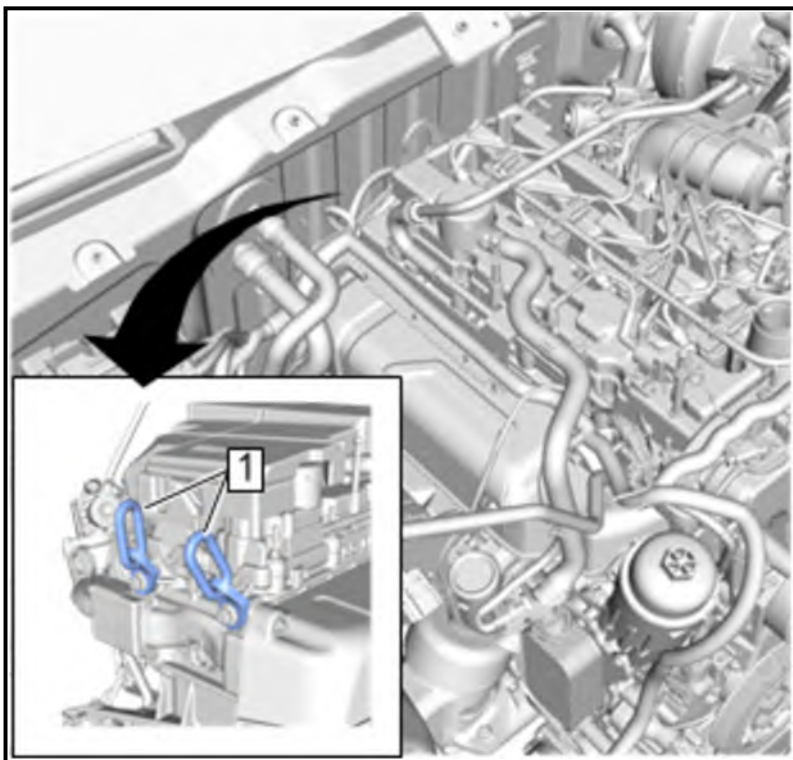
NOTE: Refer to the procedure link for torque specification.

5. Engine Mount Bracket Bolt (1) - Install and tighten [2x] - [Engine Mount Bracket Replacement - Left Side](#)

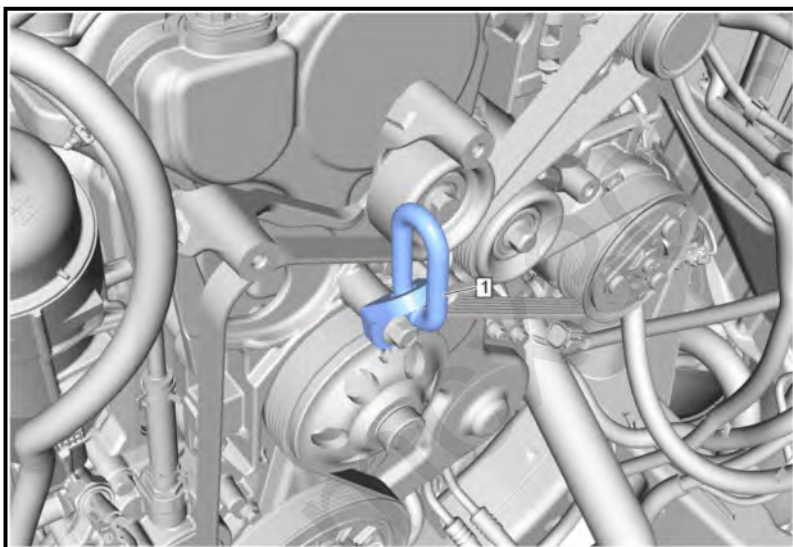


NOTE: Refer to the procedure link for torque specification.

6. Remove engine lifting device.
7. **EN-36857** Engine Lift Bracket (1) - Remove [2x]



8. **EN-36857** Engine Lift Bracket (1) - Remove

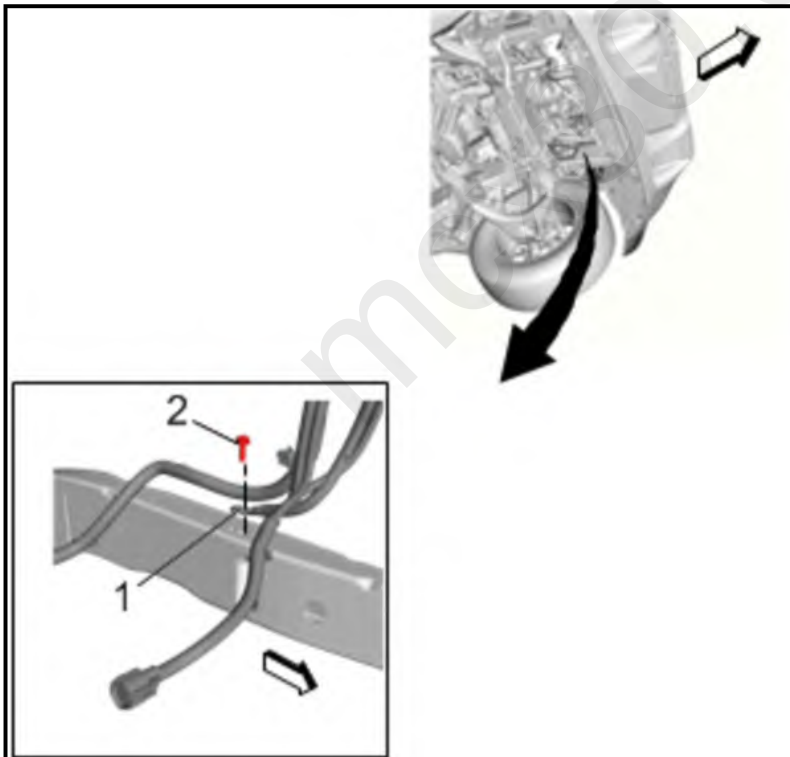


9. Ground Cable (2) - Reposition



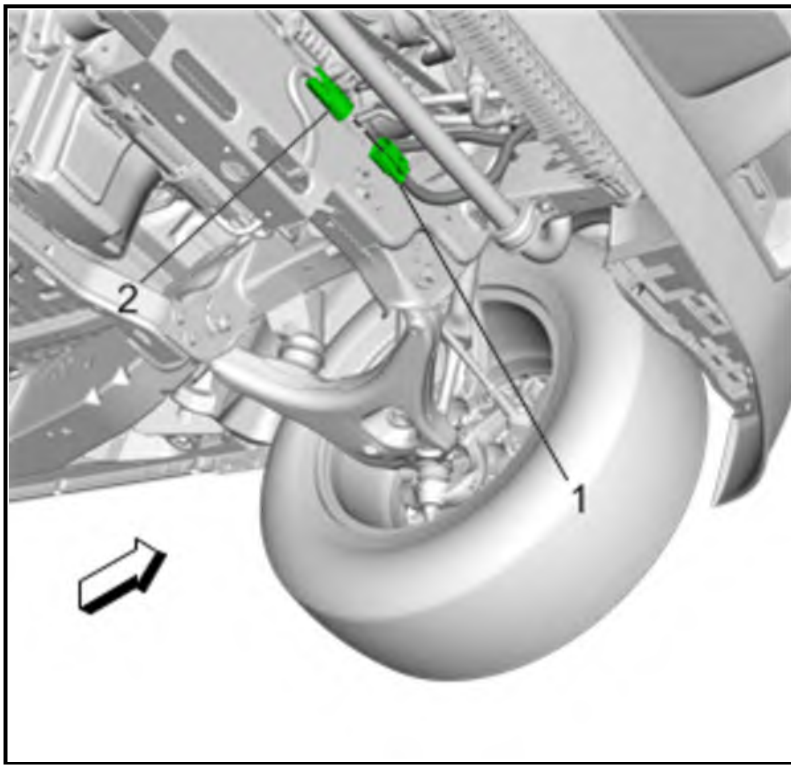
CAUTION: Refer to [Fastener Caution](#) .

10. Ground Cable Bolt (1) - Install and tighten 60 N.m (44 lb ft)
11. Battery Negative Cable (1) - Install

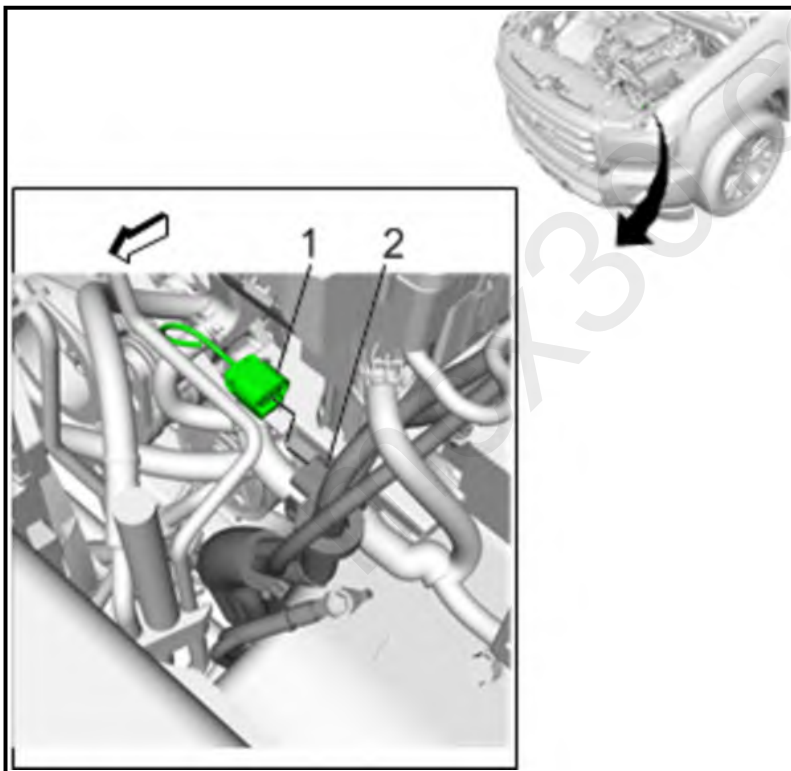


NOTE: Refer to the [procedure link](#) for torque specification.

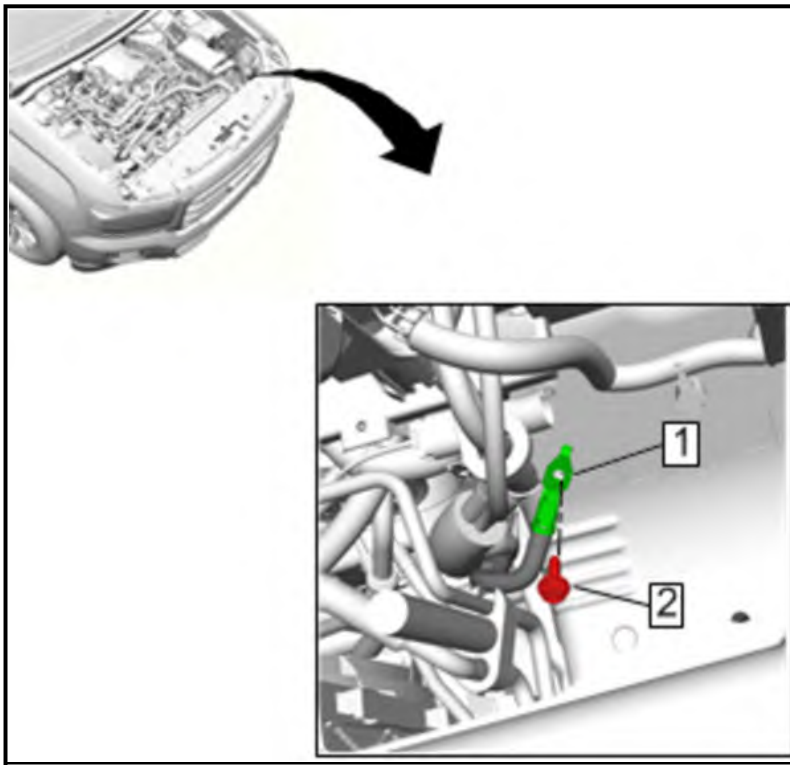
12. Battery Negative Cable Frame Ground Fastener (2) - Install and tighten - [Battery Negative Cable Replacement \(LWN with 2WD\)](#) , or [Battery Negative Cable Replacement \(LWN with 4WD\)](#)
13. Connect the electronic power steering (EPS) connector (2), to the battery negative cable connector, attached to the front frame crossmember.



14. Electrical Connector (1) @ Battery Current Sensor (2) Connect

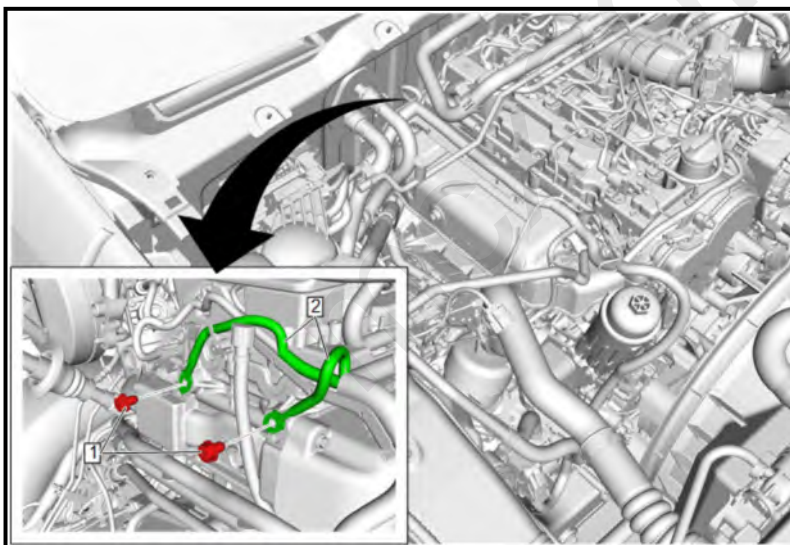


15. Battery Negative Cable (1) - Install

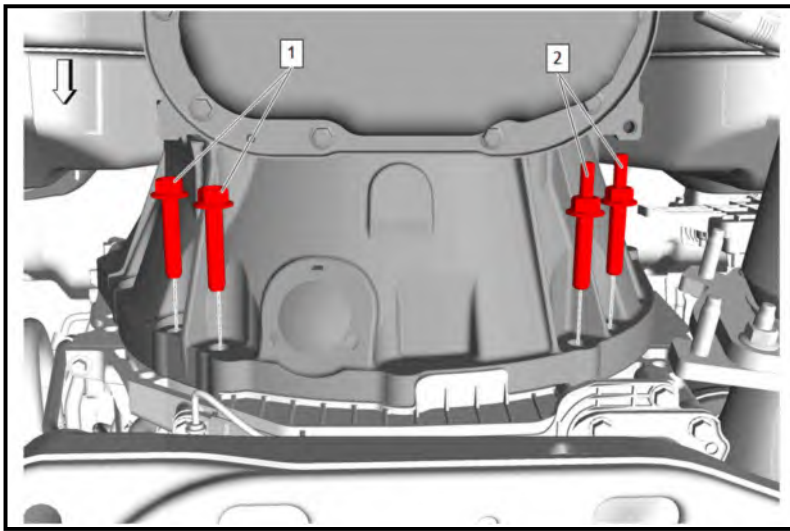


NOTE: Refer to the procedure link for torque specification.

16. Battery Negative Cable Ground Fastener (2) - Install and tighten - [Battery Negative Cable Replacement \(LWN with 2WD\)](#) , or [Battery Negative Cable Replacement \(LWN with 4WD\)](#).
17. Ground Cable (2) Reposition



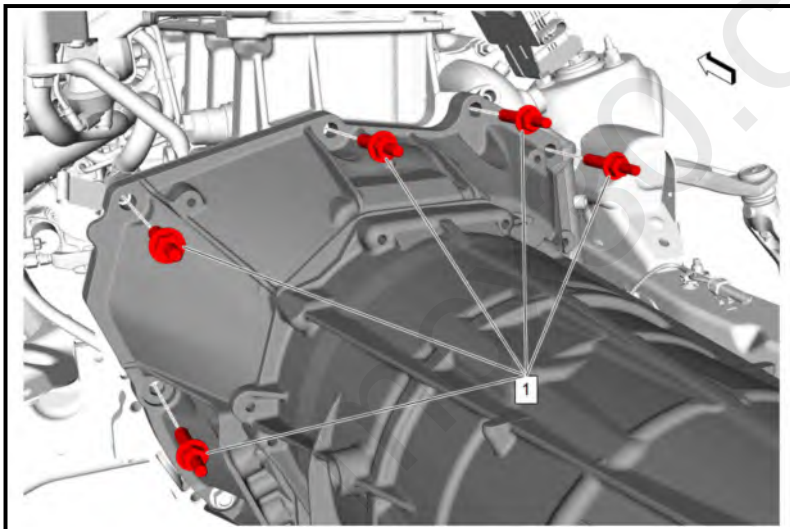
18. Ground Cable Bolt (1) - Install and tighten [2x] 40 N.m (30 lb ft)
19. Transmission Stud (2) - Install and tighten [2x] - [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#)



NOTE: Refer to the procedure link for torque specification.

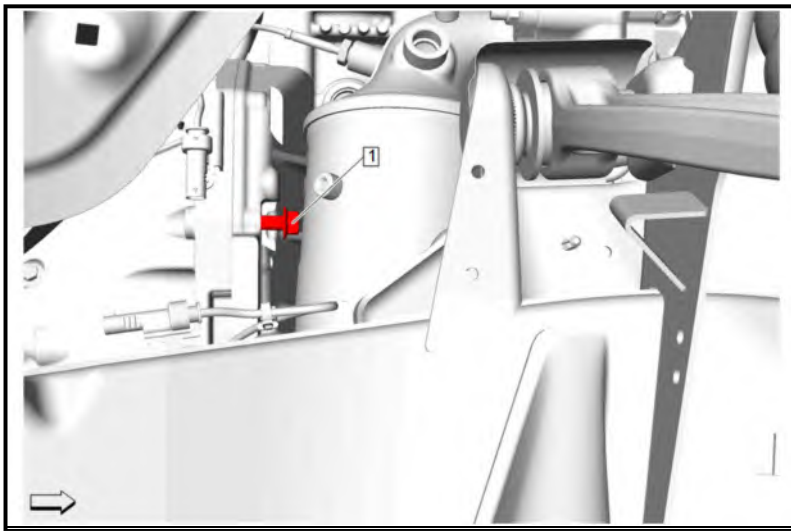
NOTE: Refer to the procedure link for torque specification.

- 20. Transmission Bolt (1) - Install and tighten [2x] - [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#).
- 21. Transmission Stud (1) - Install and tighten [5x] - [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#).



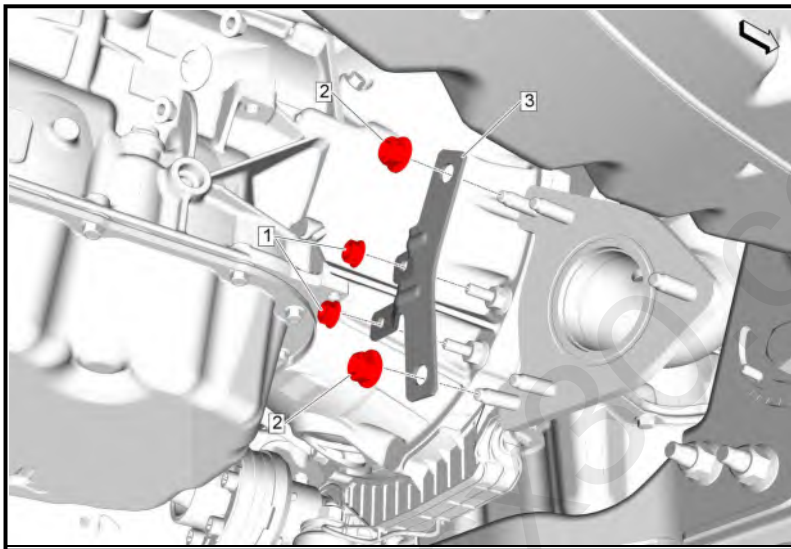
NOTE: Refer to the procedure link for torque specification.

- 22. Transmission Bolt (1) - Install and tighten - [Transmission Replacement \(LWN Diesel with 4WD\)](#) , or [Transmission Replacement \(LWN Diesel with 2WD\)](#).

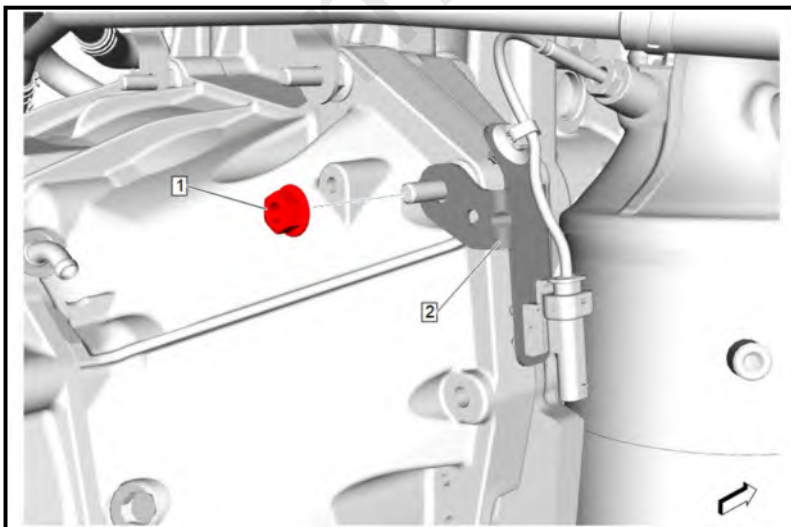


NOTE: Refer to the procedure link for torque specification.

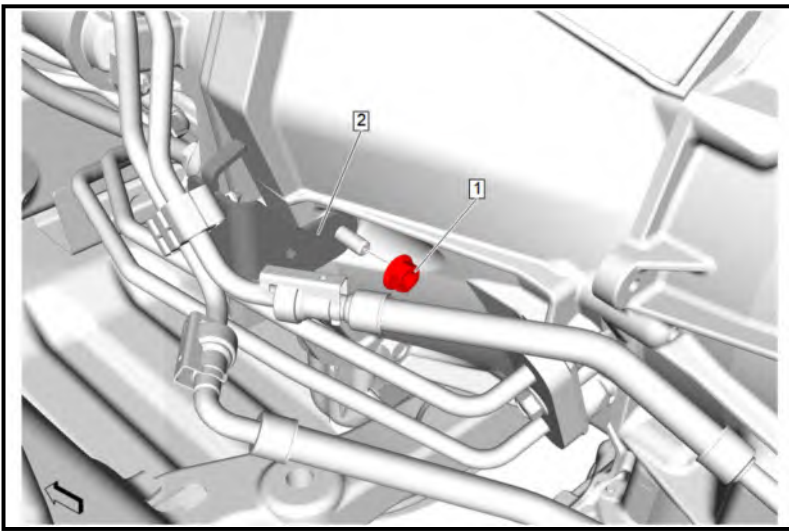
23. Catalytic Converter Brace Bracket (3) - Install - [Catalytic Converter Replacement \(LWN\)](#)



24. Install the exhaust temperature sensor bracket (2) and bracket nut (1) and tighten to 22 N.m (16 lb ft).



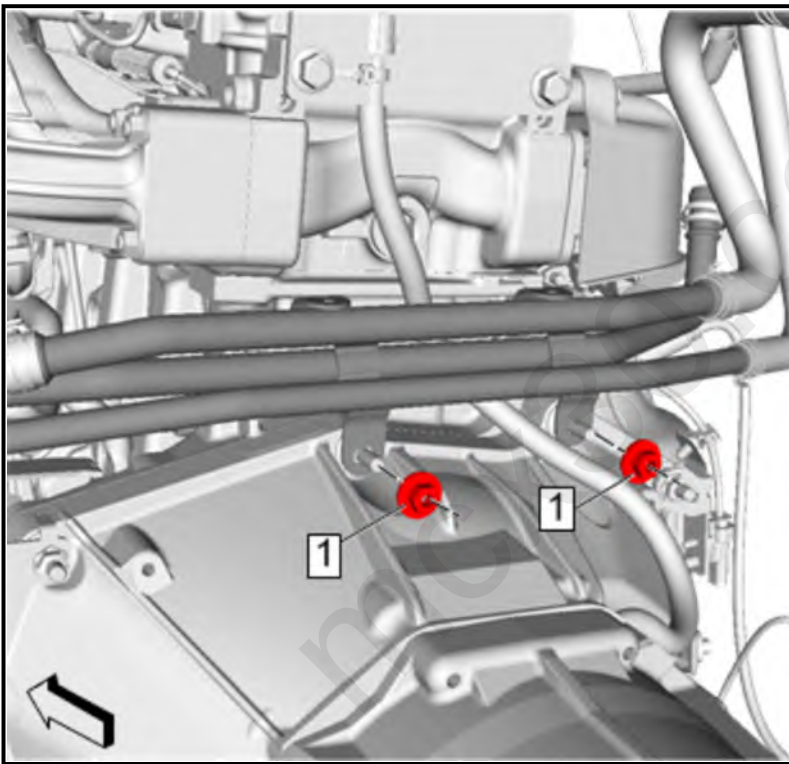
25. Install the fuel injection fuel feed and return hose clip bracket (2) and bracket nut (1) and tighten to 22 N.m (16 lb ft).



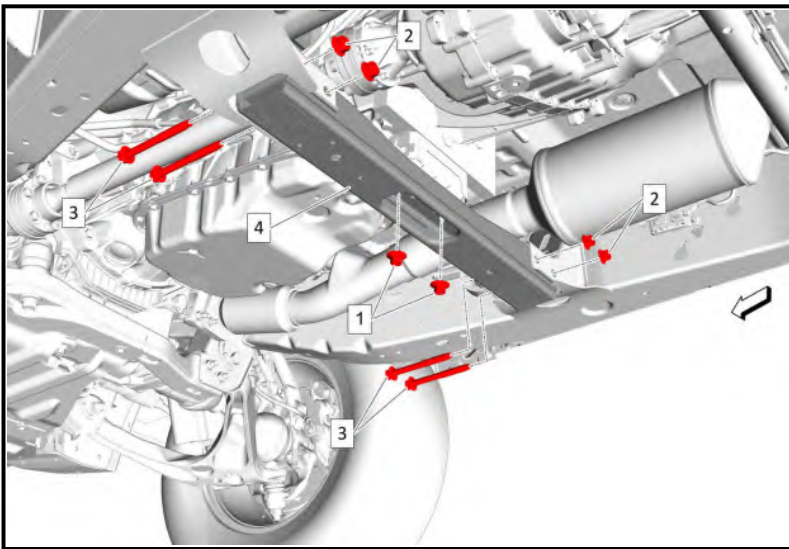
26. Connect the fuel lines. [Metal Collar Quick Connect Fitting Service](#)

27. Install the radiator surge tank outlet pipe to the 2 transmission studs.

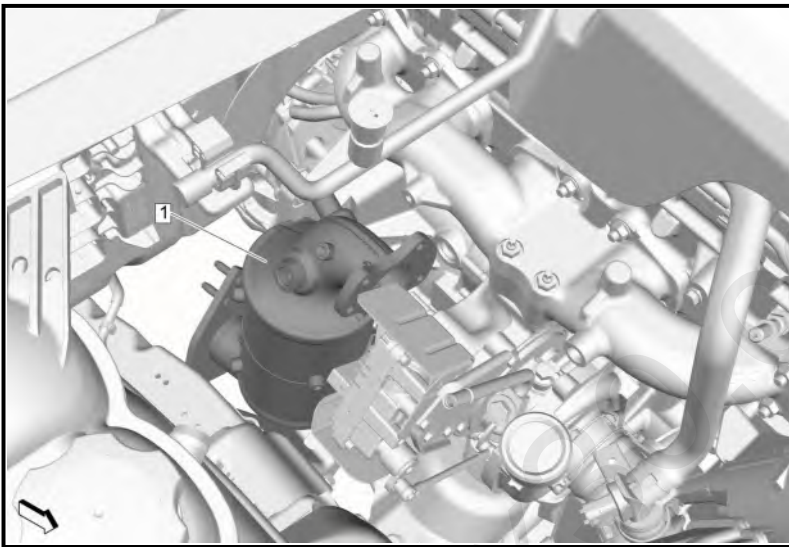
28. Lower rear of transmission and install radiator surge tank pipe nuts and tighten to 22 N.m (16 lb ft).



29. Transmission Support Crossmember (4) - Install - [Transmission Support Crossmember Replacement \(4 Wheel Drive\)](#) , or [Transmission Support Crossmember Replacement \(2 Wheel Drive\)](#).

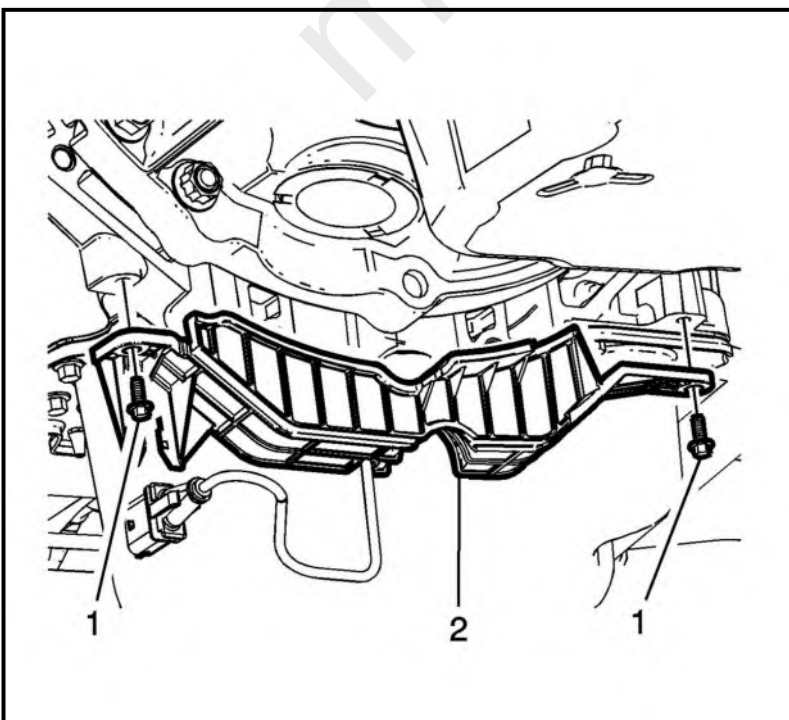


30. Catalytic Converter (1) - Install - [Catalytic Converter Replacement \(LWN\)](#)

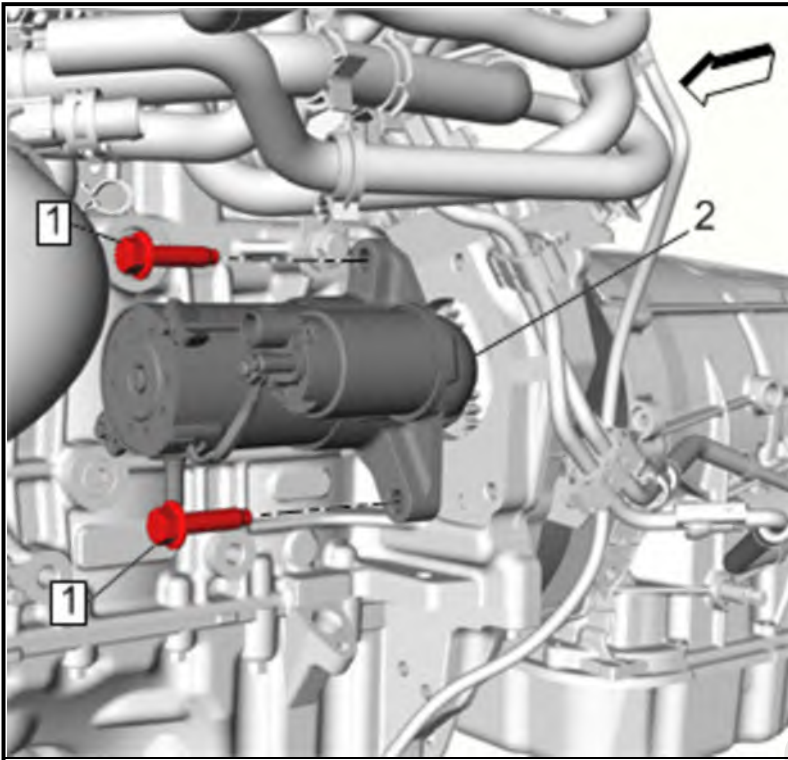


31. Install the 6 flywheel to torque converter bolts and tighten to 63 N.m (46 lb ft).

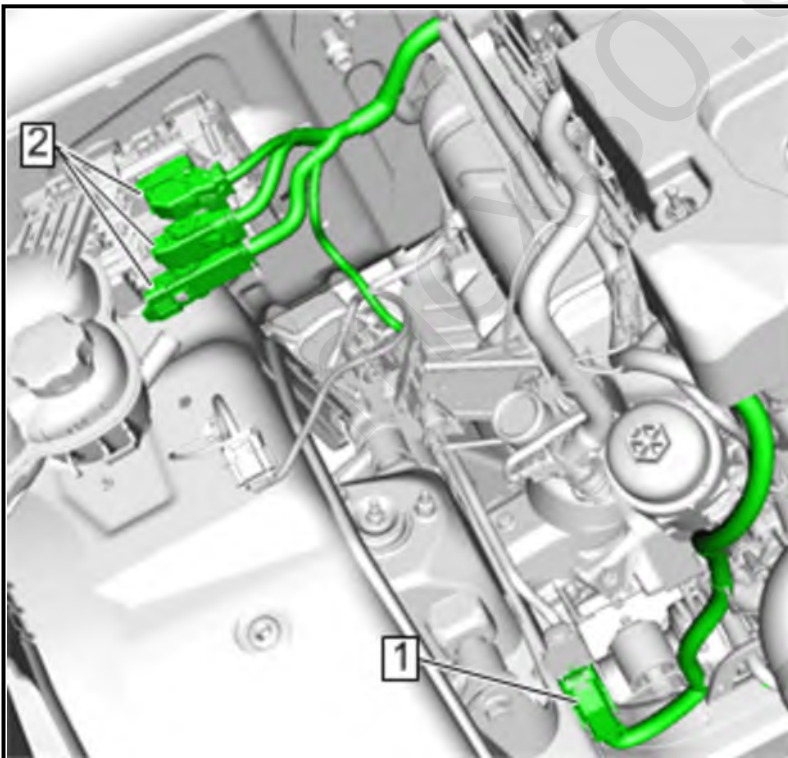
32. Install the crank shaft position sensor access cover (2). [Crankshaft Position Sensor Replacement](#)



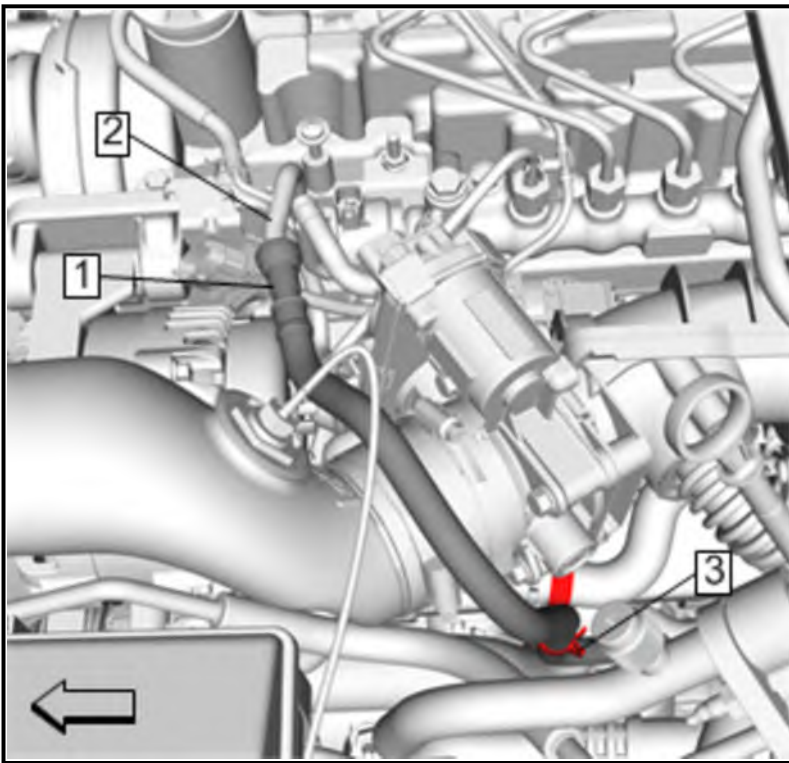
33. Install the right flywheel inspection cover.
34. Starter (2) - Install - [Starter Replacement \(LWN\)](#).



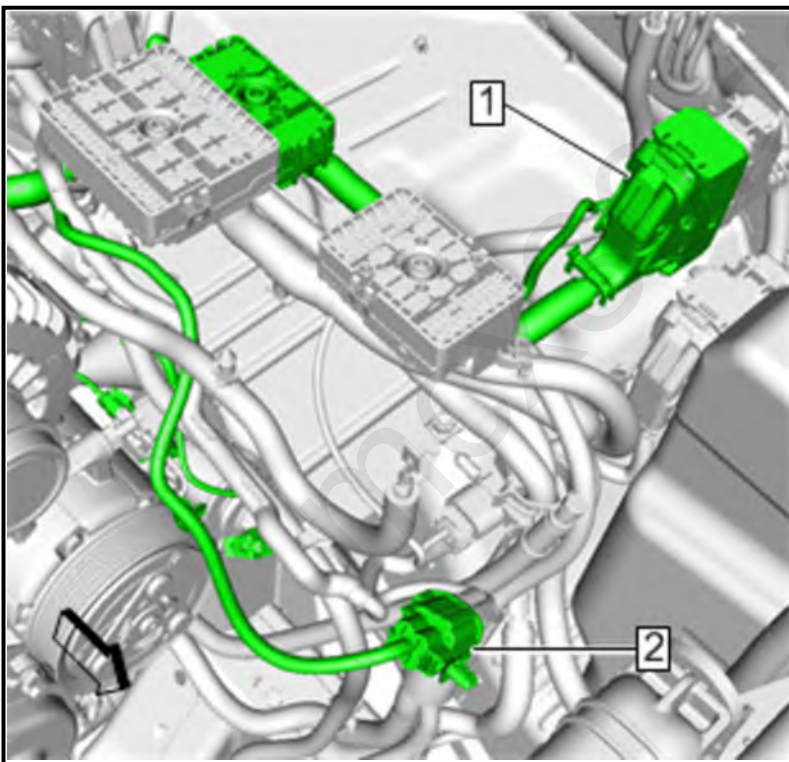
35. Electrical Connector (1) Connect



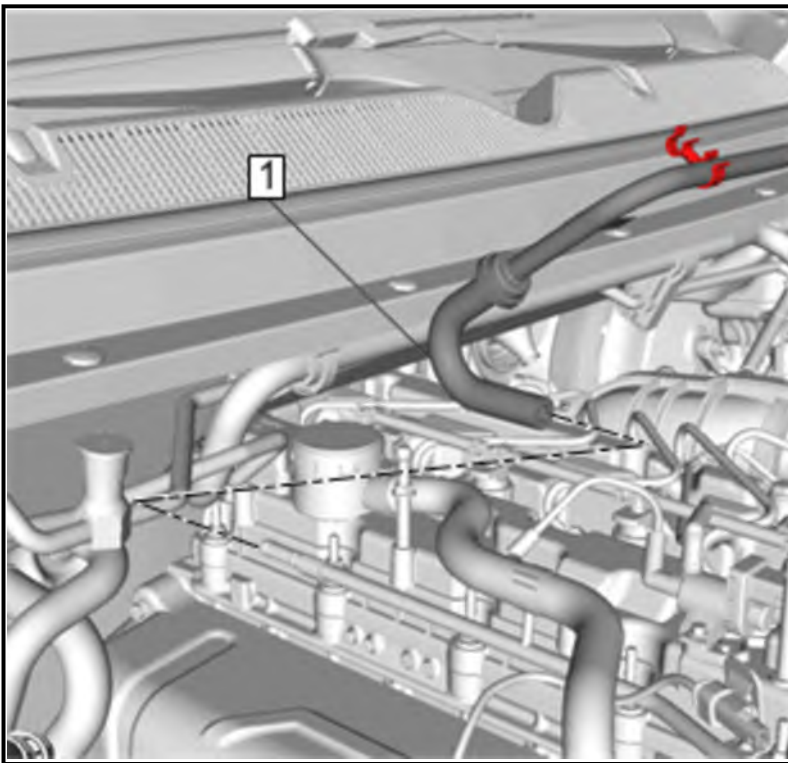
36. Fuel Pump Fuel Return Hose (1) @ Engine (2) - Connect - [Metal Collar Quick Connect Fitting Service](#)



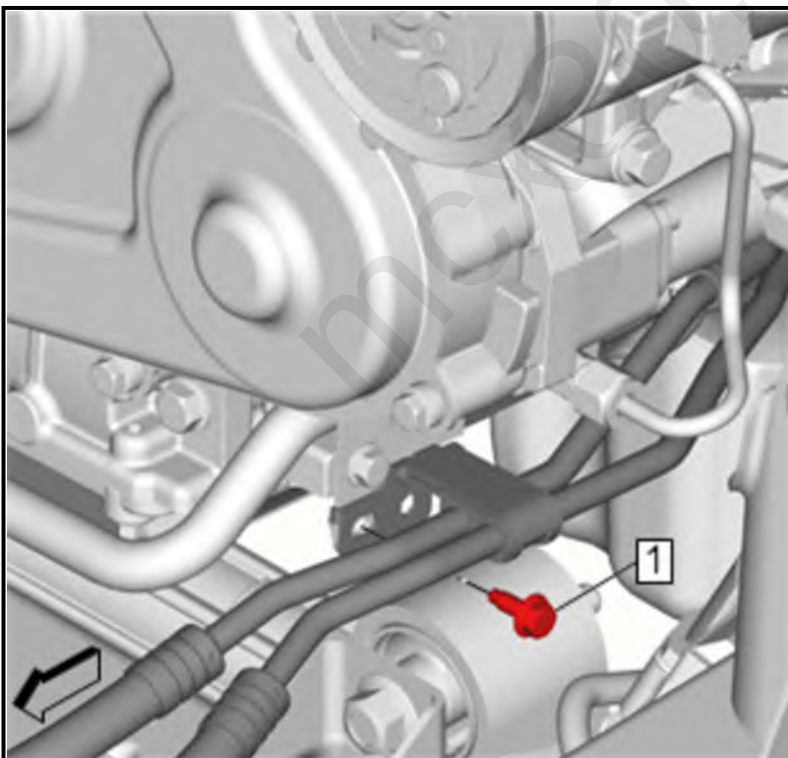
37. Electrical Connector (1, 2) - Connect



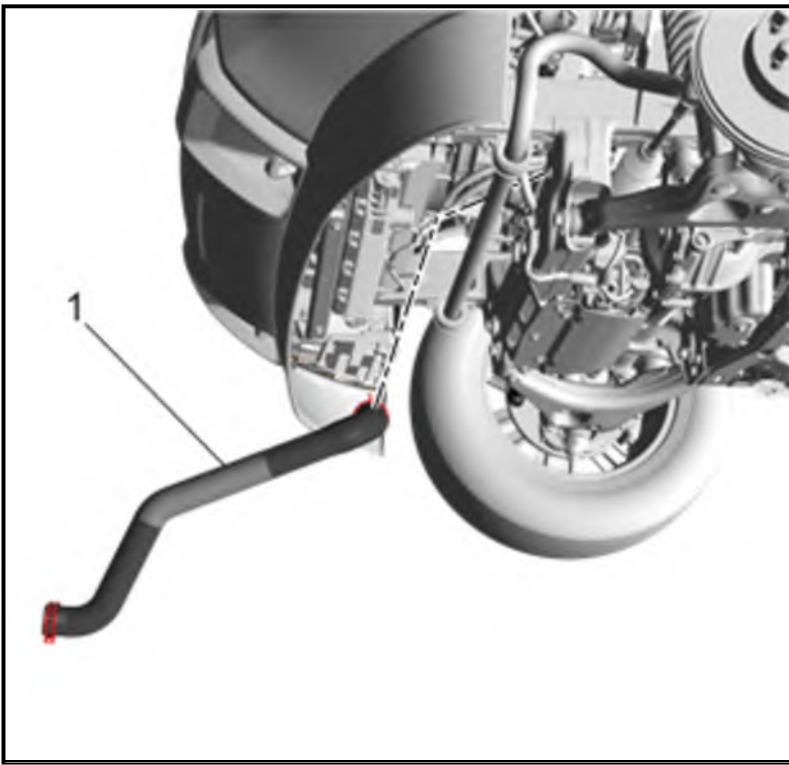
38. Power Brake Booster Vacuum Hose (1) - Install - [Power Brake Booster Vacuum Hose Replacement \(LWN\)](#)



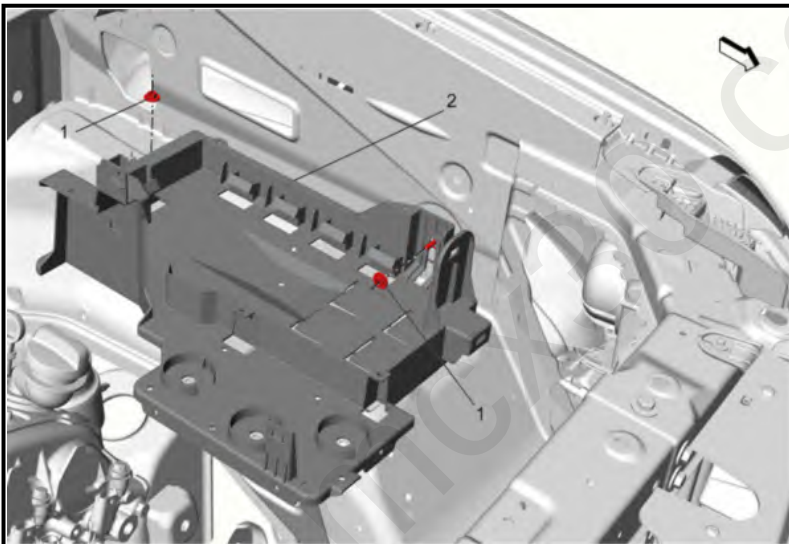
- 39. Air Conditioning Compressor Hose - Install - [Air Conditioning Compressor Hose Replacement \(LWN\)](#)
- 40. Charge Air Cooler Inlet Hose - Install - [Charge Air Cooler Inlet Hose Replacement](#)
- 41. Charge Air Cooler Inlet Duct - Install - [Charge Air Cooler Inlet Duct Replacement](#)
- 42. Transmission Fluid Cooler Pipe Clip Bolt (1) @ Bracket - Install - [Transmission Fluid Cooler Inlet and Outlet Pipe Replacement \(LWN\)](#)



- 43. Radiator Outlet Hose (1) @ Radiator - Install - [Radiator Outlet Hose Replacement \(LWN\)](#)

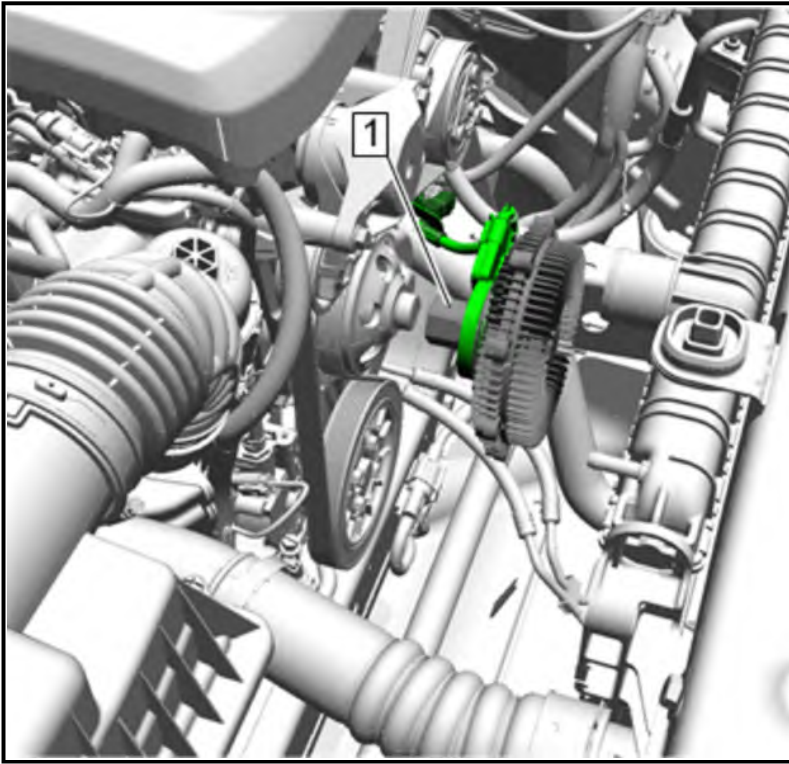


44. Battery Tray (2) - Install - [Battery Tray Replacement](#)

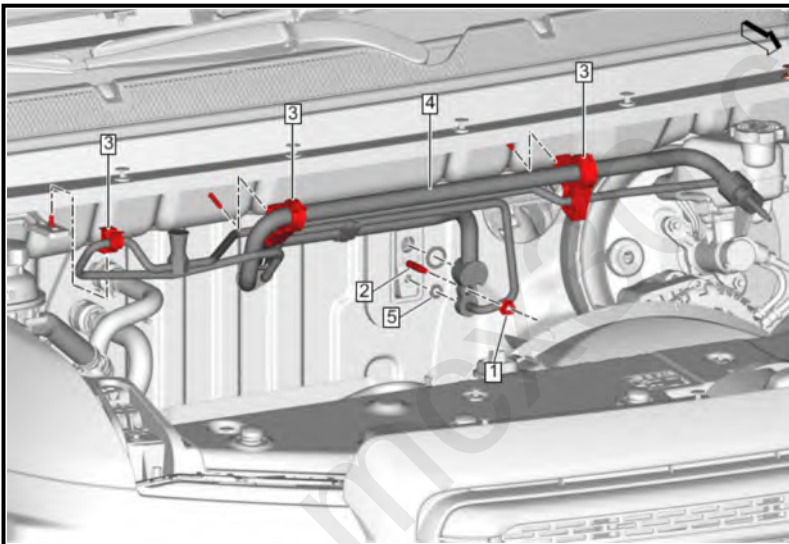


45. Radiator Inlet Hose @ Radiator - Install - [Radiator Inlet Hose Replacement \(LWN Radiator Side\)](#) , or [Radiator Inlet Hose Replacement \(LWN Engine Side\)](#)

46. Fan Blade Clutch (1) - Install - [Fan Blade Clutch Replacement \(LWN\)](#)



47. Air Conditioning Evaporator Hose - Install - [Air Conditioning Evaporator Hose Replacement \(LWN\)](#)



48. Hood - Install - [Hood Replacement](#)

49. Fill the cooling system to the proper level. [Cooling System Draining and Filling \(Static Fill\)](#) , or [Cooling System Draining and Filling \(Vac n Fill\)](#)

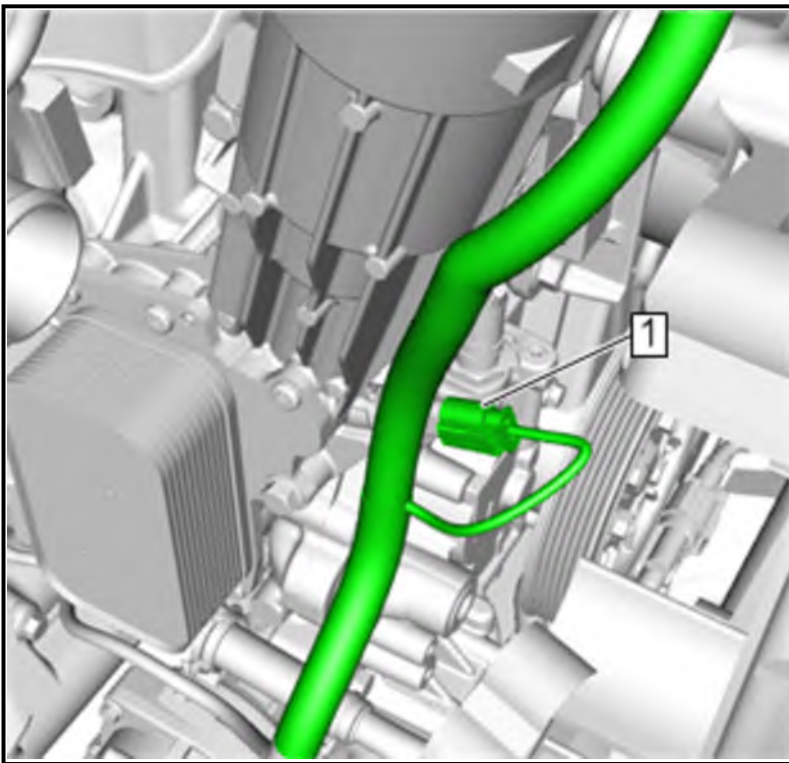
50. If reinstalling the engine, perform complete an engine oil change as needed. [Engine Oil and Oil Filter Replacement](#)

51. Perform the crankshaft position system variation learn procedure. [Crankshaft Position Variation Learn](#)

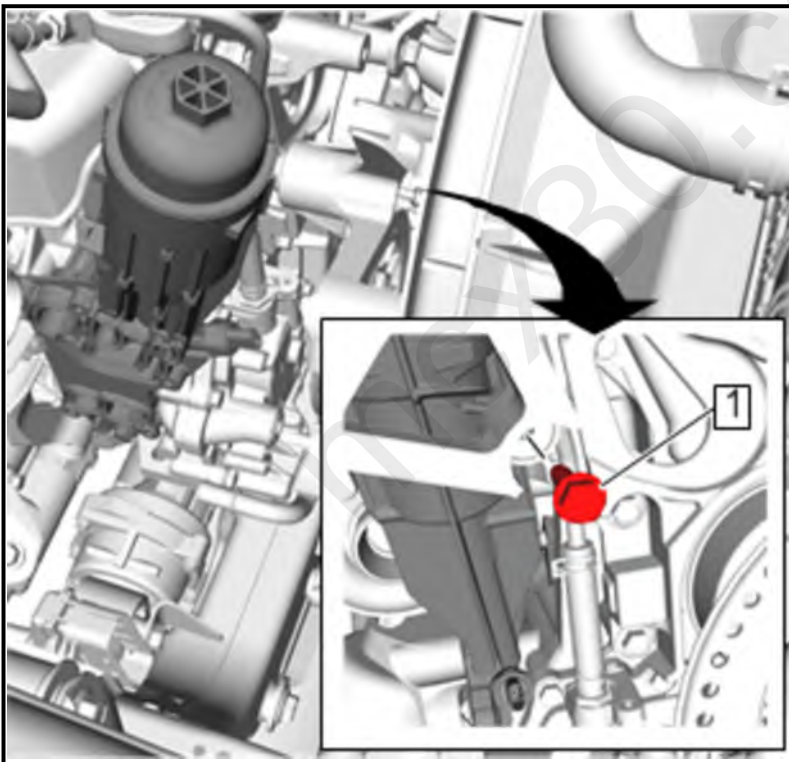
OIL FILTER ASSEMBLY REPLACEMENT

Removal Procedure

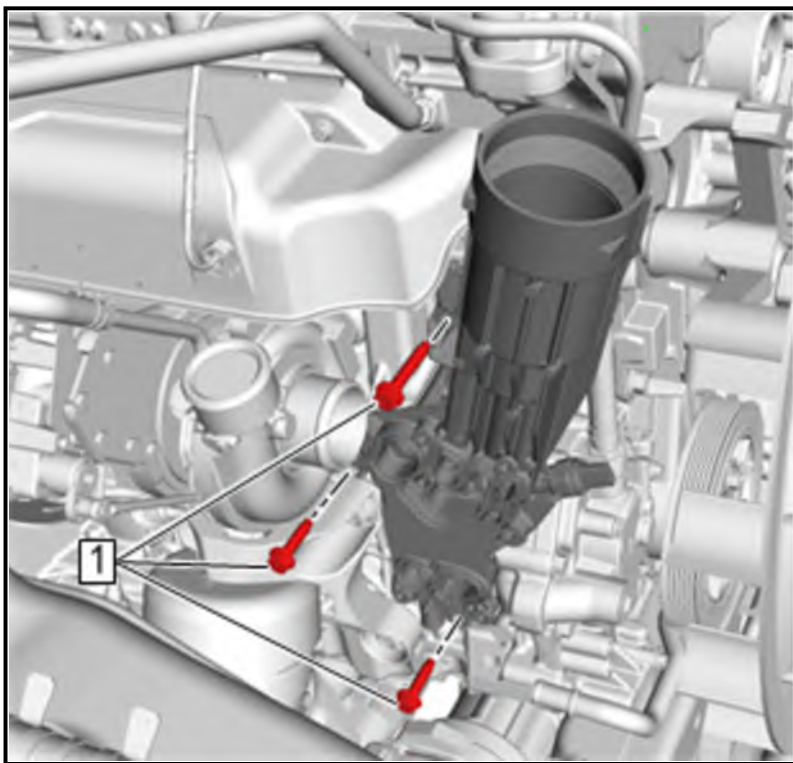
1. Remove and DISCARD the oil filter. [Engine Oil and Oil Filter Replacement](#)
2. [Air Cleaner Assembly Replacement](#) - Remove
3. [Charge Air Cooler Inlet Duct Replacement](#) - Remove
4. [Engine Oil Cooler Inlet Hose Replacement \(LWN\)](#) - Remove
5. Electrical Connector (1) Disconnect



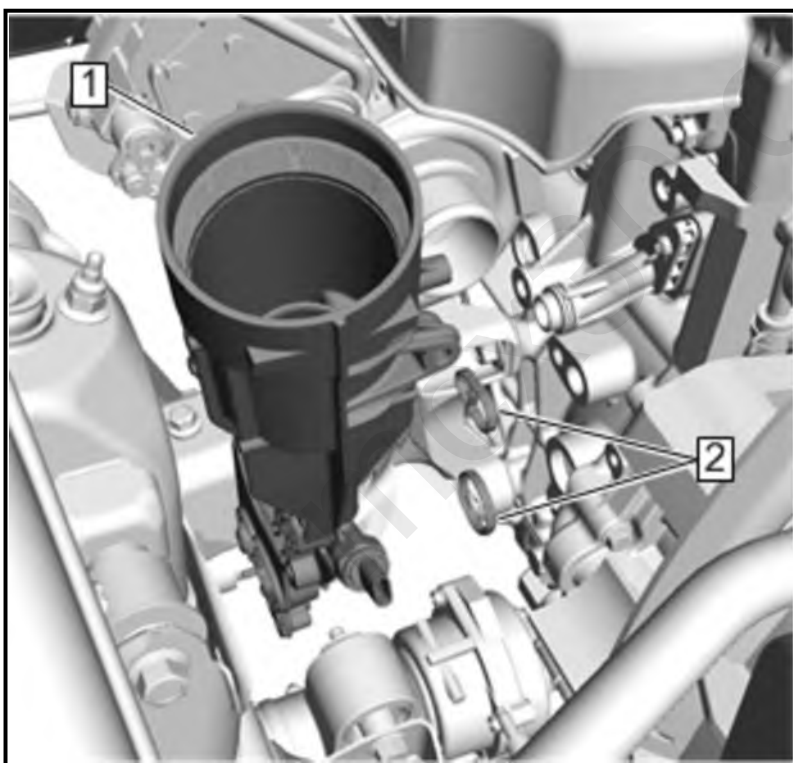
6. **Engine Oil Cooler Replacement (LWN)** - Remove
7. Engine Coolant Fan Shroud Bolt (1) - Remove



8. Oil Filter Assembly Bolt (1) - Remove [3x]

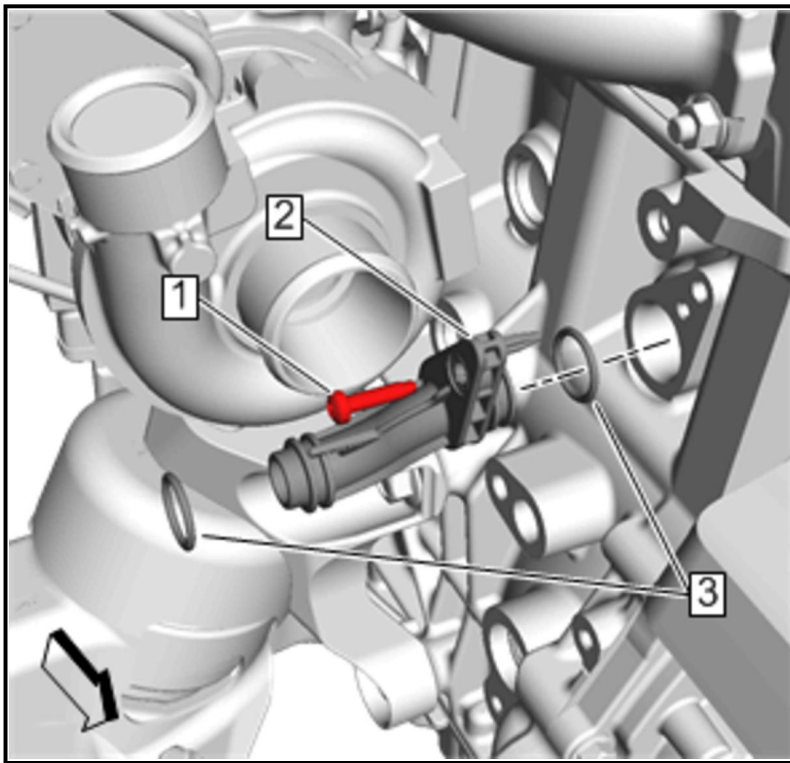


9. Oil Filter Assembly (1) - Remove



10. Oil Filter Assembly Seal (2) - Remove and DISCARD [2x]

11. Oil Filter Assembly Pipe Bolt (1) - Remove

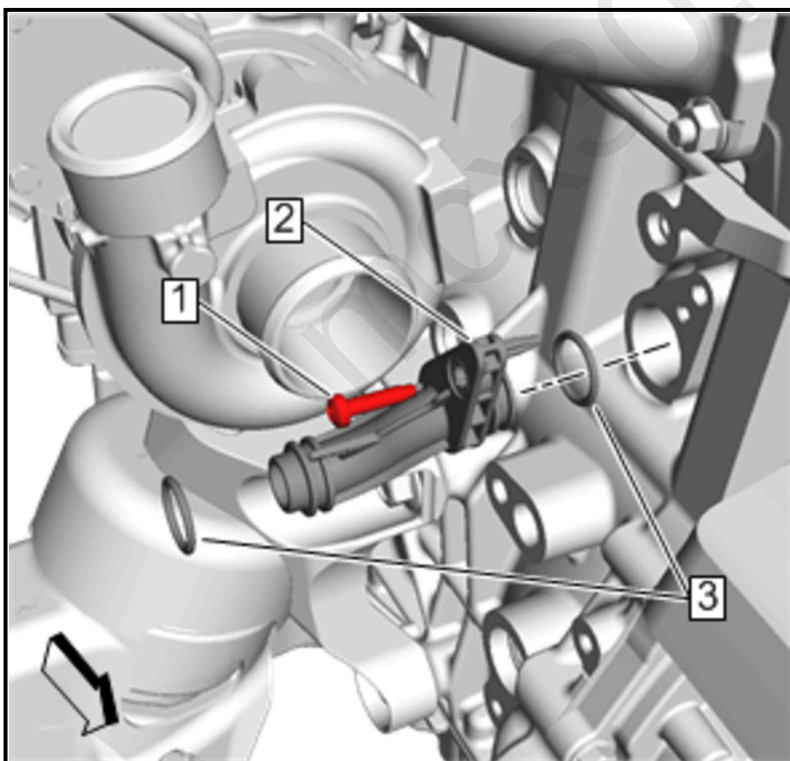


12. Oil Filter Assembly Pipe (2) - Remove

13. Oil Filter Assembly Pipe Seal (3) - Remove and DISCARD [2x]

Installation Procedure

1. Lubricate the seals with clean engine oil. [Adhesives, Fluids, Lubricants, and Sealers](#)



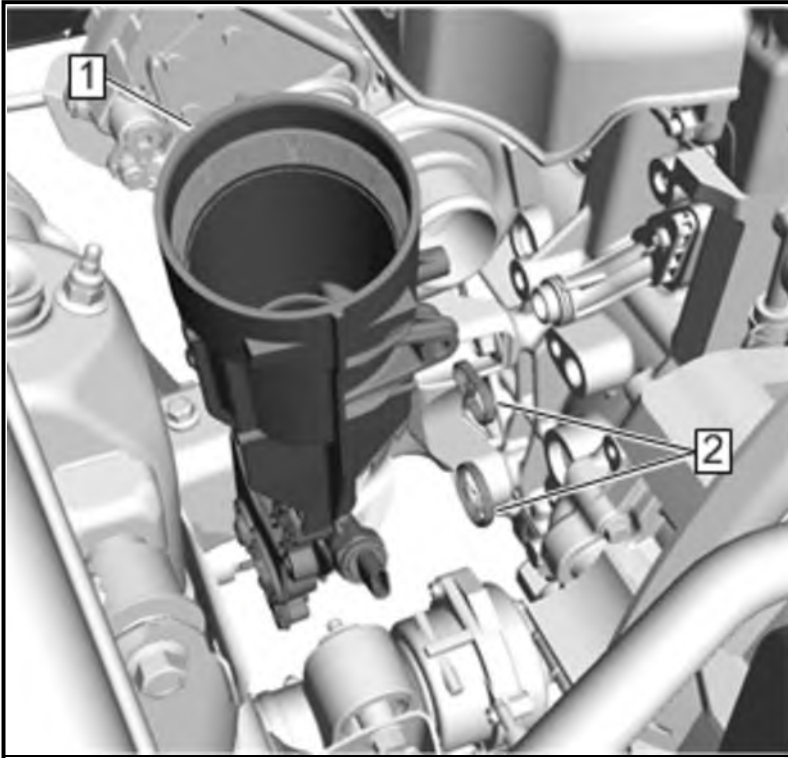
NOTE: Install a NEW seal. [2x]

Oil Filter Assembly Pipe Seal (3) - Install [2x]

2. Oil Filter Assembly Pipe (2) - Install

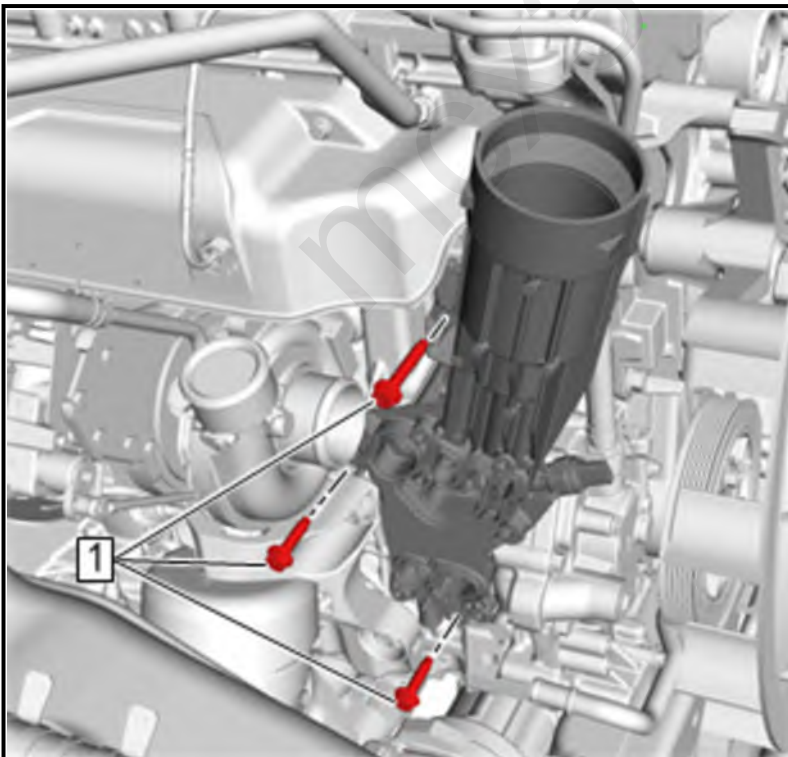
CAUTION: Refer to [Fastener Caution](#) .

3. Oil Filter Assembly Pipe Bolt (1) - Install and tighten 25 N.m (18 lb ft)
4. Oil Filter Assembly Seal (2) - Install [2x]

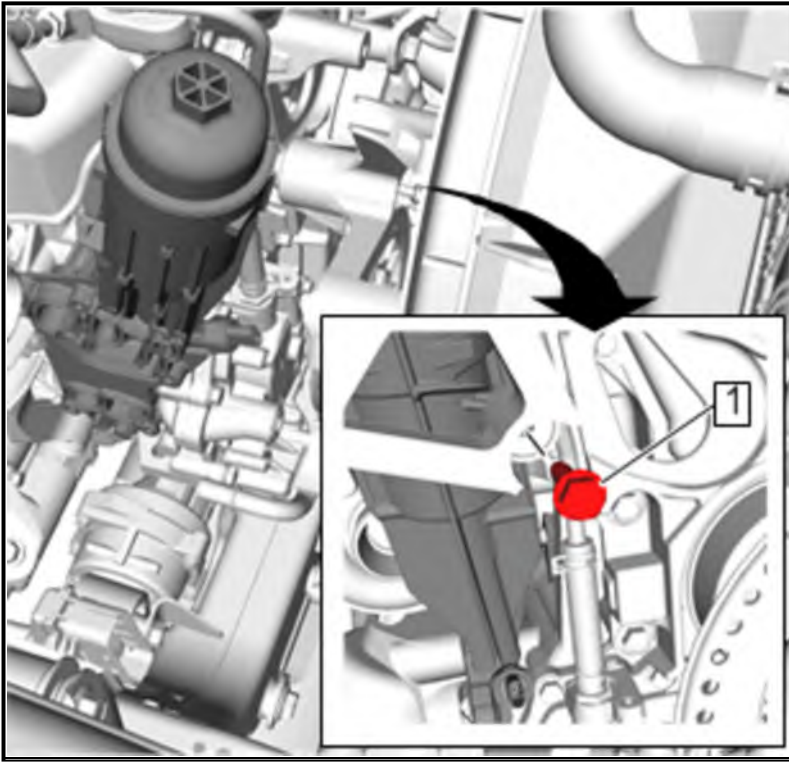


NOTE: Install a NEW seal.

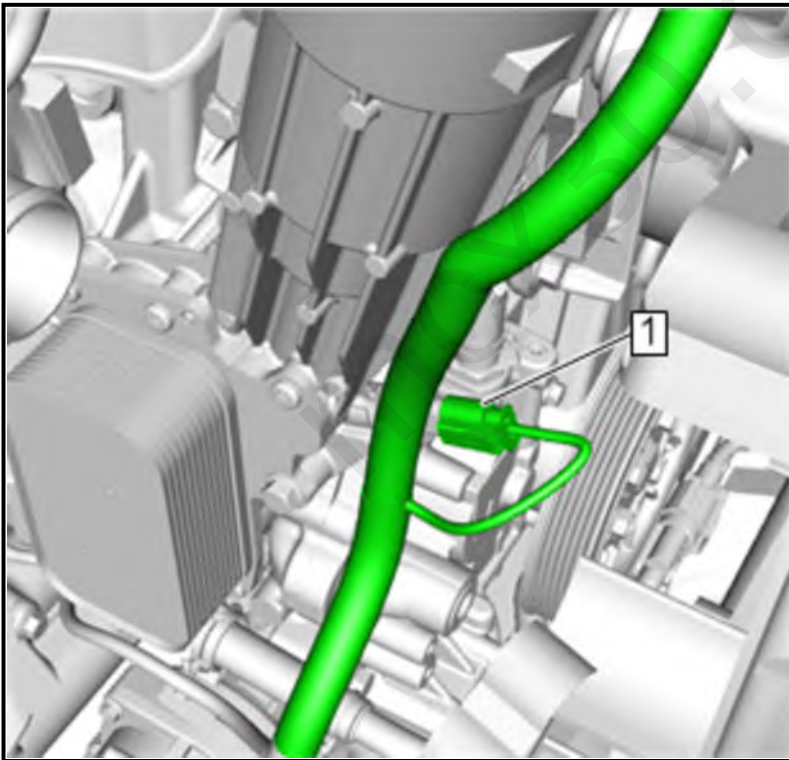
5. Oil Filter Assembly (1) - Install
6. Oil Filter Assembly Bolt (1) - Install and tighten [3x] 25 N.m (18 lb ft)



7. Engine Coolant Fan Shroud Bolt (1) - Install and tighten 22 N.m (16 lb ft)



8. Engine Oil Cooler Replacement (LWN) - Install
9. Engine Oil Cooler Inlet Hose Replacement (LWN) - Install
10. Electrical Connector (1) Connect

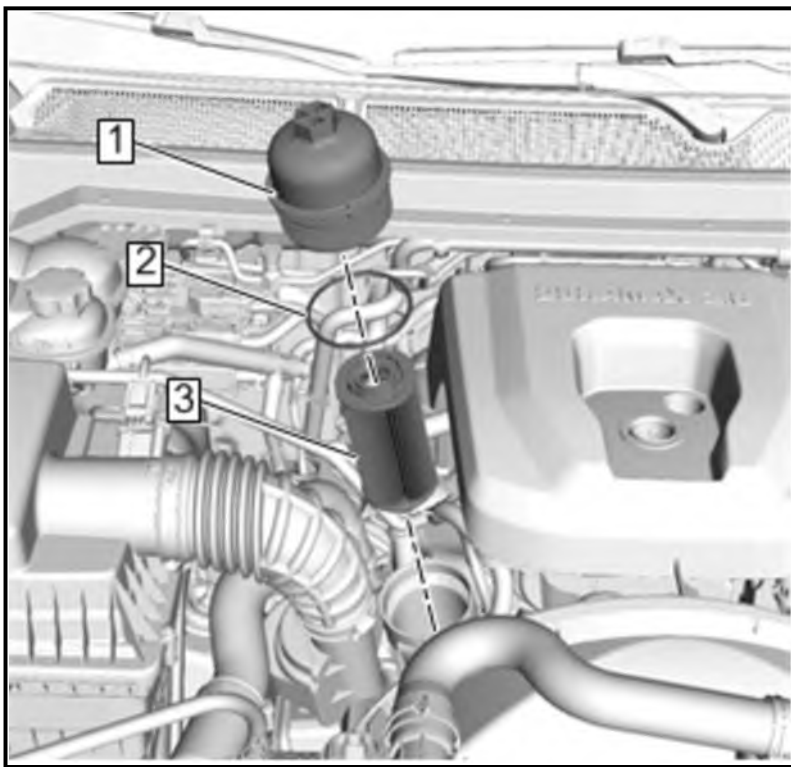


11. Charge Air Cooler Inlet Duct Replacement - Install
12. Air Cleaner Assembly Replacement - Install
13. Change the engine oil and filter. Engine Oil and Oil Filter Replacement

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

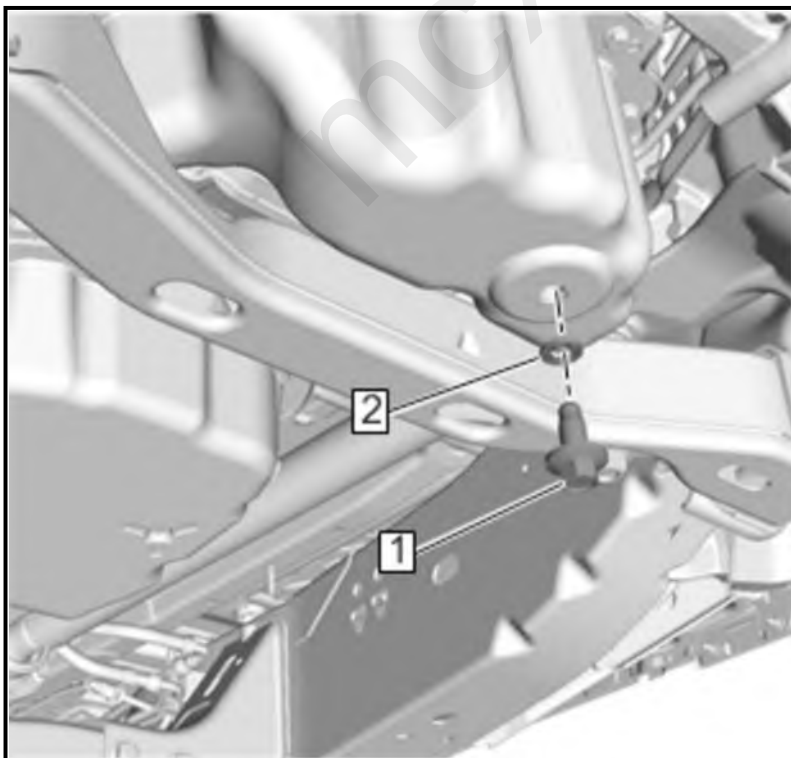
1. Oil Filter Adapter Cap (1) - Remove



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

NOTE: Use an oil filter wrench on the outside diameter of the oil filter adapter cap (1)

2. Oil Filter Adapter Seal (2) - Remove
3. Remove and properly dispose of the oil filter. (3)
4. Raise the vehicle. [Lifting and Jacking the Vehicle](#)
5. Place a drain pan under the vehicle.



6. Oil Pan Drain Plug (1) Remove
7. Allow the oil to drain completely.

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

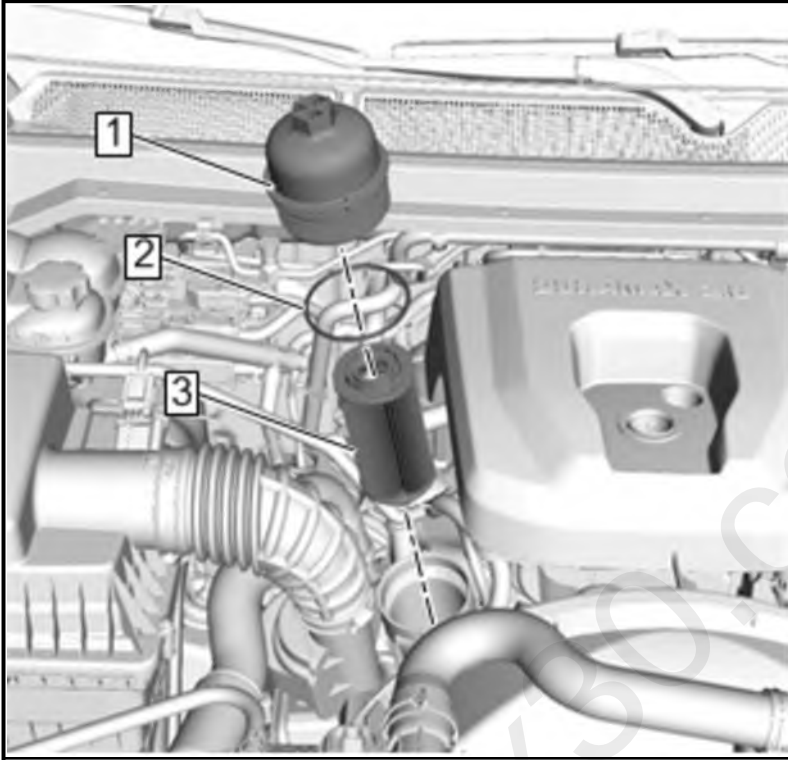
NOTE: Inspect the oil drain plug seal ring (2), replace only if damaged.

8. Oil Pan Drain Plug (1) - Install and tighten 25 N.m (18 lb ft).

9. Lower the vehicle.

Installation Procedure

1. Install a NEW oil filter. (3)



NOTE: Inspect the oil cap seal (2) and replace only if damaged.

2. Oil Filter Adapter Seal (2) - Install

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

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

NOTE: Use an oil filter wrench on the outside diameter of the oil filter cap to tighten the oil filter cap to tighten.

3. Oil Filter Adapter Cap (1) - Install and tighten 25 N.m (18 lb ft)

4. Fill the engine with the appropriate oil type and quantity. [Approximate Fluid Capacities](#) , and [Adhesives, Fluids, Lubricants, and Sealers](#)

CAUTION: Oil level checks done a few minutes after engine shut off (e.g. at gas station after fuel refill) may lead to a false low oil level reading. Do not top up in this case and follow the right procedure.

NOTE:

- Before checking the oil level, vehicle has to be on a horizontal surface and the engine needs to be switched off for at least 1 hour.
- Remove the oil dipstick and clean the tip with a cloth

- Insert the dipstick back into the original position, ensure it is fully inserted in to the tube
- Remove the dipstick to read the oil level
- The level is read using the grid side of the tip

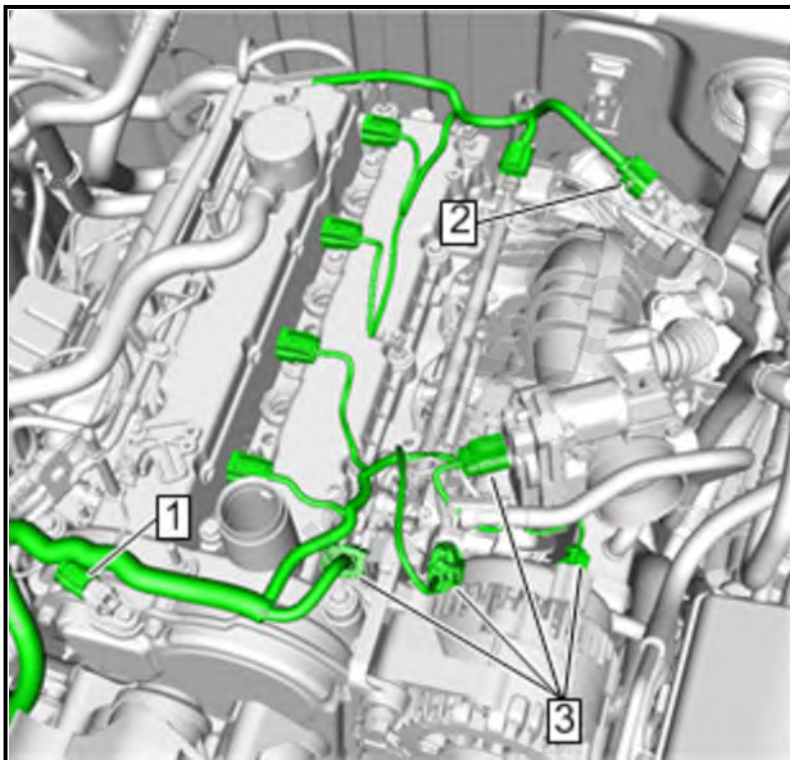
5. Check and correct the engine oil level.

6. Perform the engine oil life reset. [GM Oil Life System Resetting](#) , or [GM Oil Life System Resetting \(With Scan Tool\)](#).

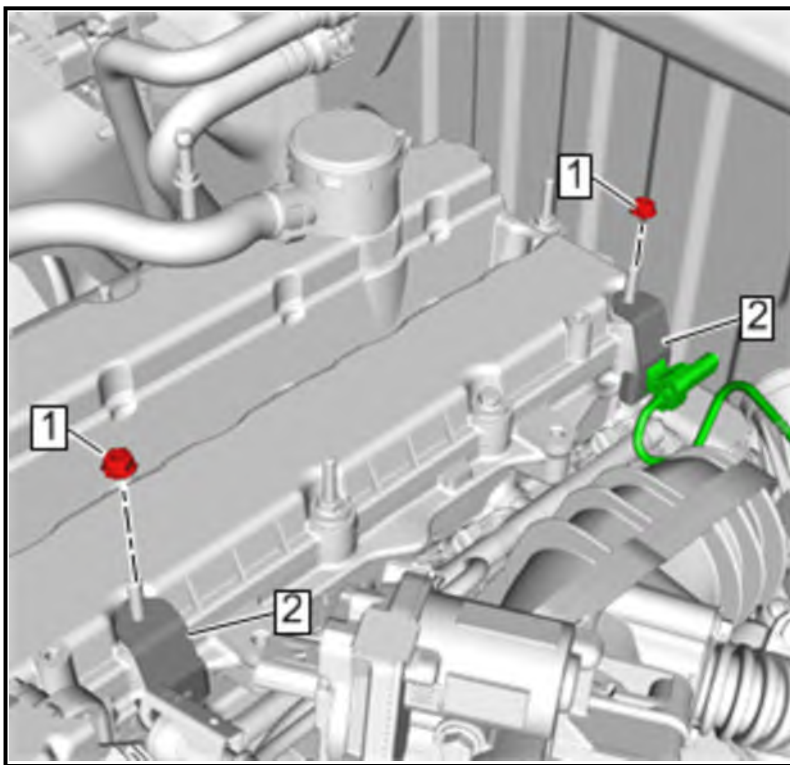
VALVE ROCKER ARM COVER REPLACEMENT

Removal Procedure

1. [Vacuum Pump Pipe Replacement](#) - Remove
2. [Fuel Injector Deadener Replacement](#) - Remove
3. [Fuel Injector Replacement \(Cylinder #1, #2, #3\)](#) , or [Fuel Injector Replacement \(Cylinder #4\)](#) - Remove
4. Camshaft Position Sensor - Remove - [Camshaft Position Sensor Replacement](#)
5. Generator Bracket - Remove - [Generator Bracket Replacement \(LWN\)](#).
6. Disconnect the electrical connectors. (1, 2 and 3)

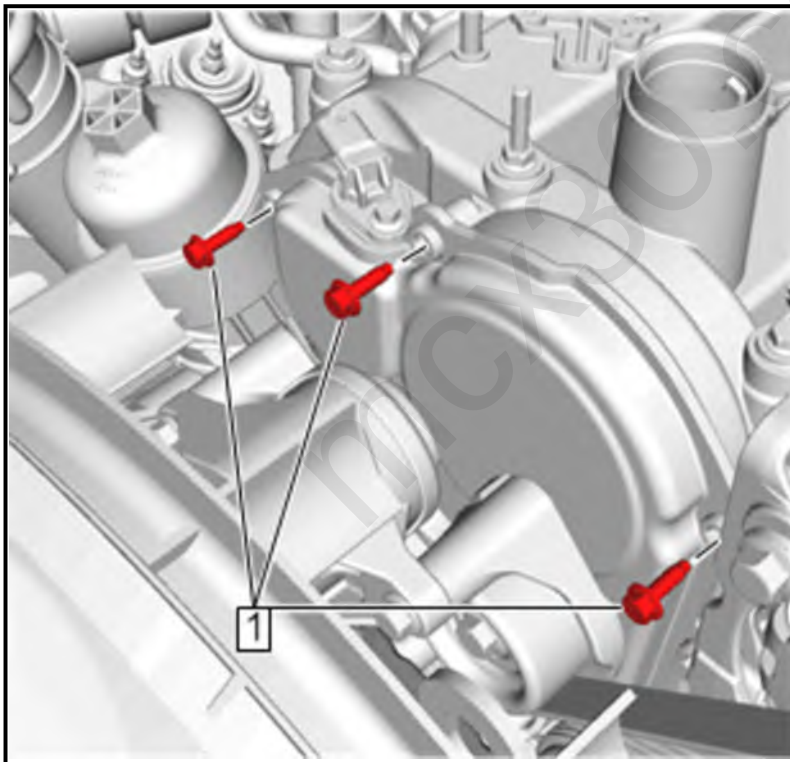


7. Engine Wiring Harness Bracket Nut (1) - Remove [2x]

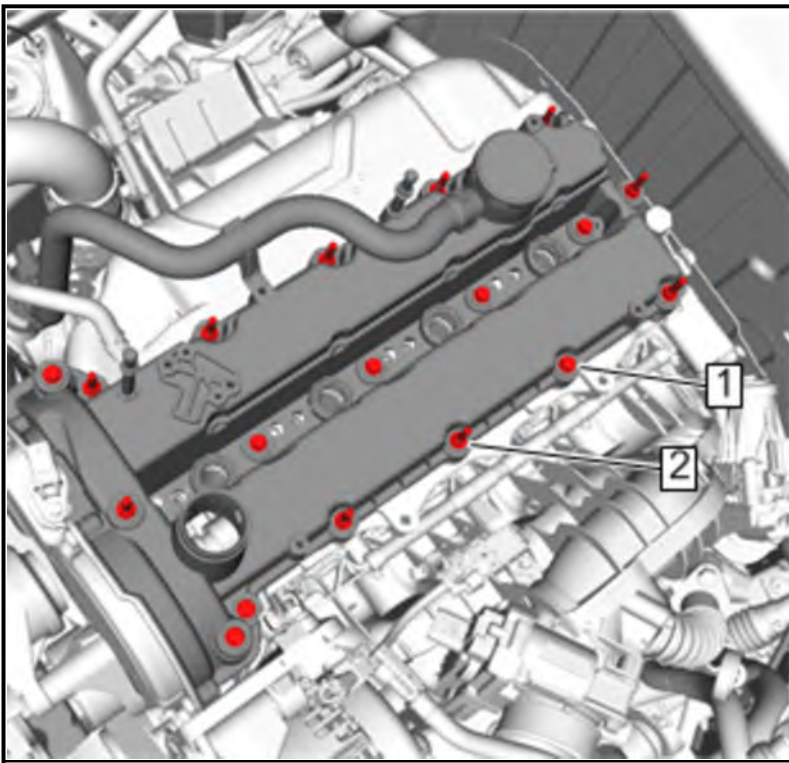


8. Wiring Harness Bracket (2) - Remove

9. Timing Belt Front Cover Bolt (1) - Remove [3x]



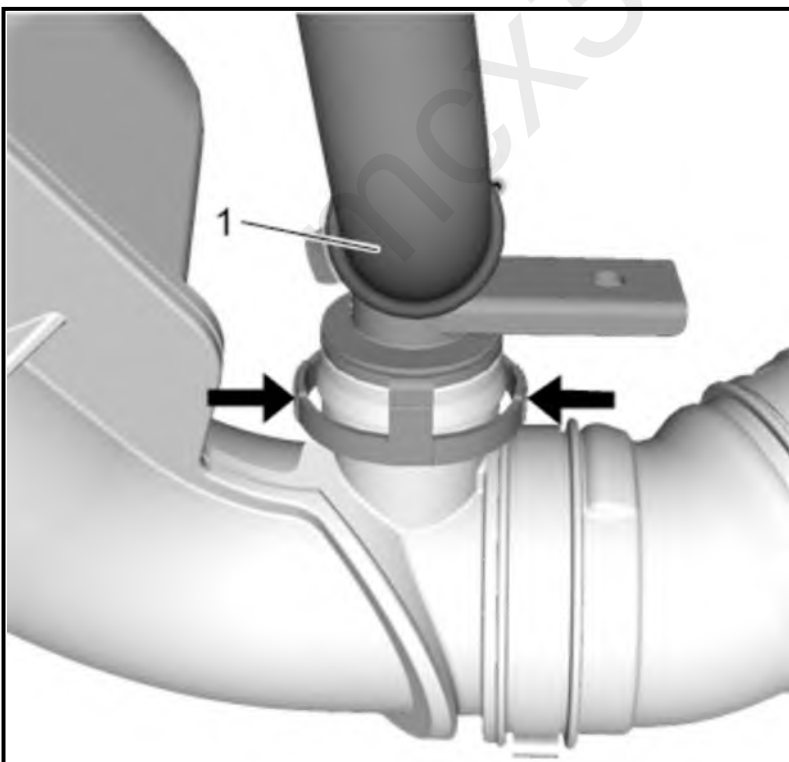
10. Valve Rocker Arm Cover Bolt (1) - Loosen [8x]



NOTE: The valve rocker arm cover bolts and studs are retained in the rocker arm cover, fully loosen the bolts to disengage them from the cylinder head.

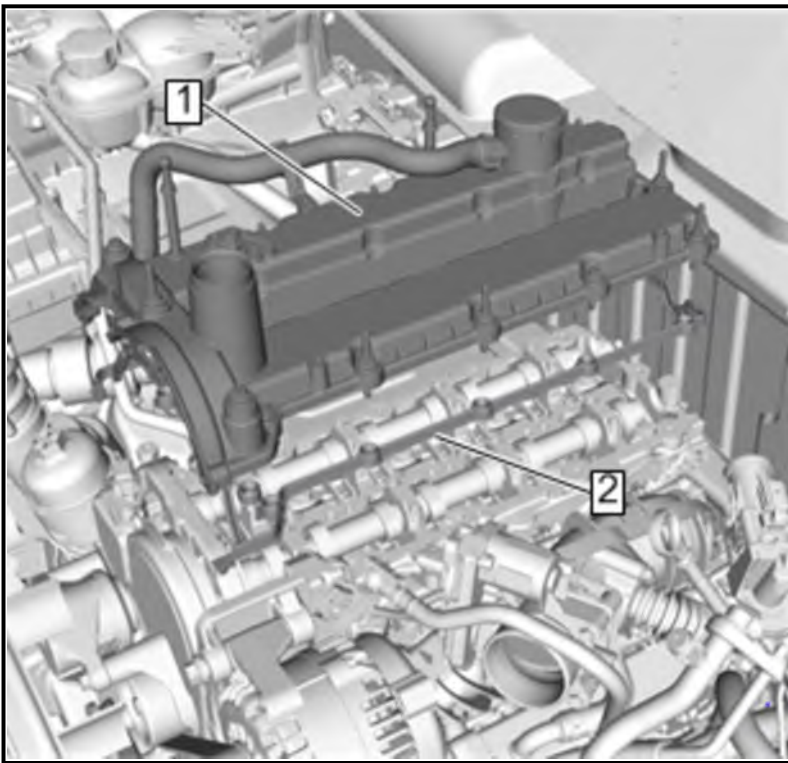
NOTE: Note the position of the valve rocker arm cover studs and nuts for proper installation.

- 11. Valve Rocker Arm Cover Stud (2) - Loosen [10x]
- 12. Positive Crankcase Ventilation Heater (1) - Remove



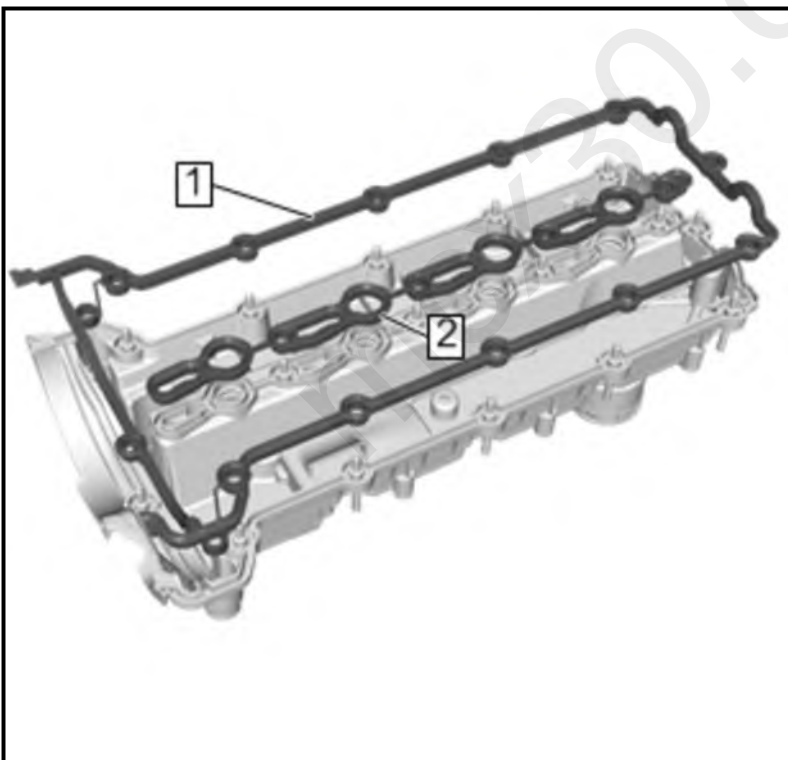
NOTE: Squeeze as indicated by the arrows to disengage then pull the PCV heater away from the air cleaner outlet duct.

- 13. Valve Rocker Arm Cover (1) - Remove



NOTE: Ensure that the complete valve rocker arm gasket (2) is removed with the valve rocker arm cover.

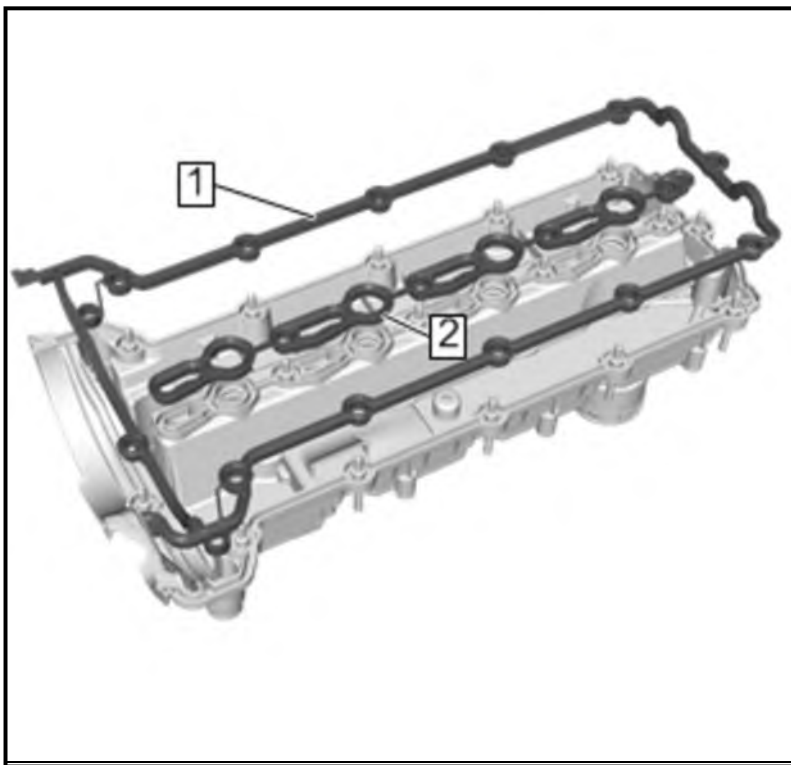
14. Valve Rocker Arm Cover Gasket (1, 2) - Remove and DISCARD



15. Valve Rocker Arm Cover Cleaning and Inspection - Clean and inspect

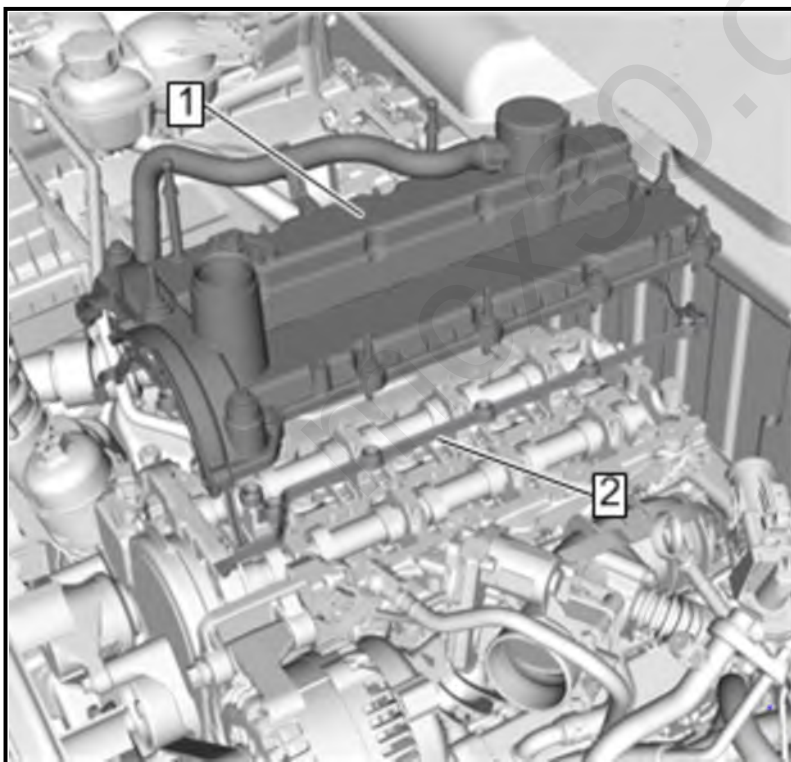
Installation Procedure

1. Valve Rocker Arm Cover Gasket (1, 2) - Install

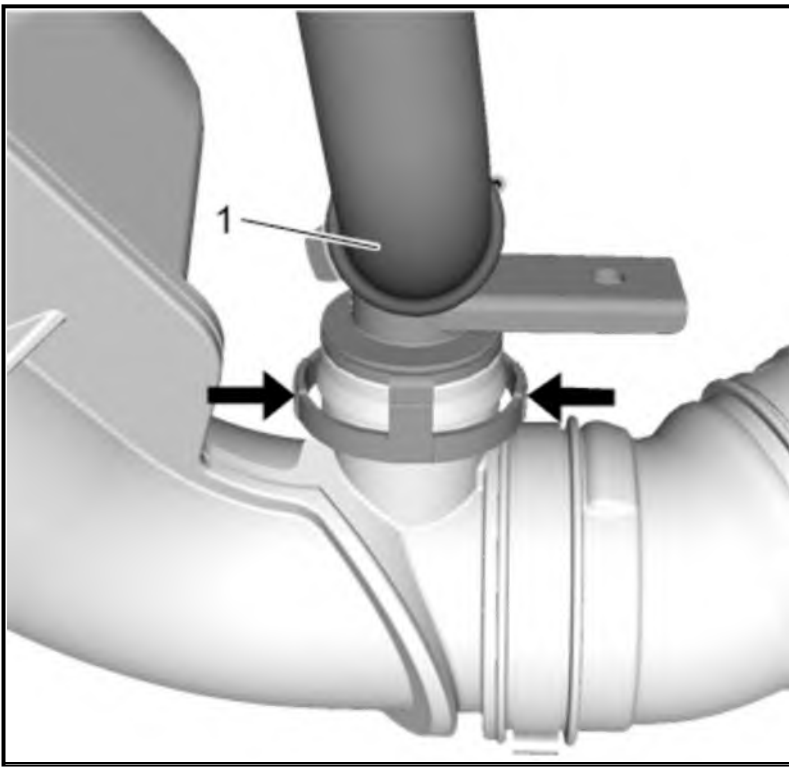


NOTE: Install NEW gaskets.

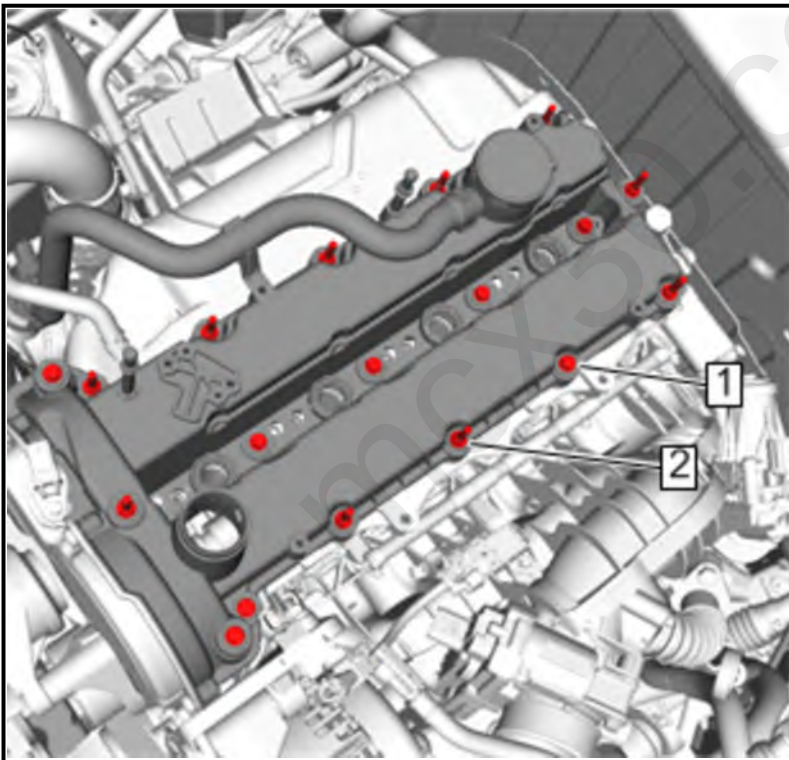
2. Valve Rocker Arm Cover (1) - Install



3. Positive Crankcase Ventilation Heater (1) - Install



4. Valve Rocker Arm Cover Bolt - Loosely install [8x]



NOTE: Ensure that the bolts and studs are installed in the previously noted locations.

5. Valve Rocker Arm Cover Stud - Loosely install [10x]

6. Tighten in the sequence shown. 11 N.m (97 lb in)

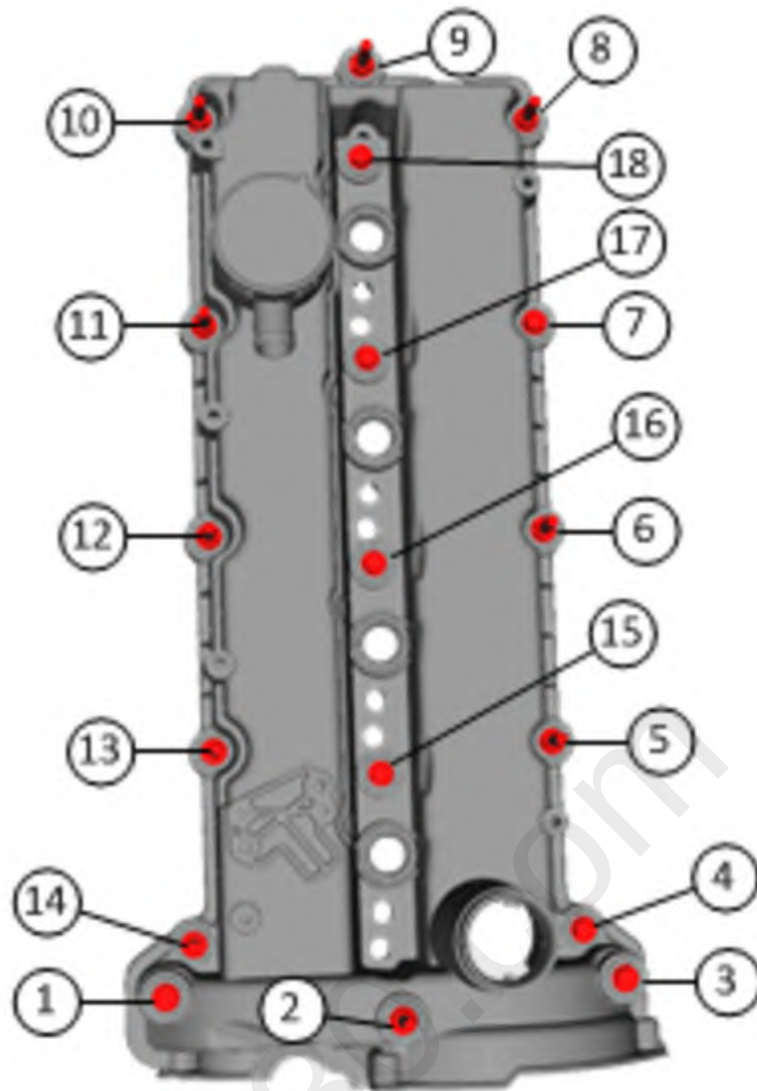
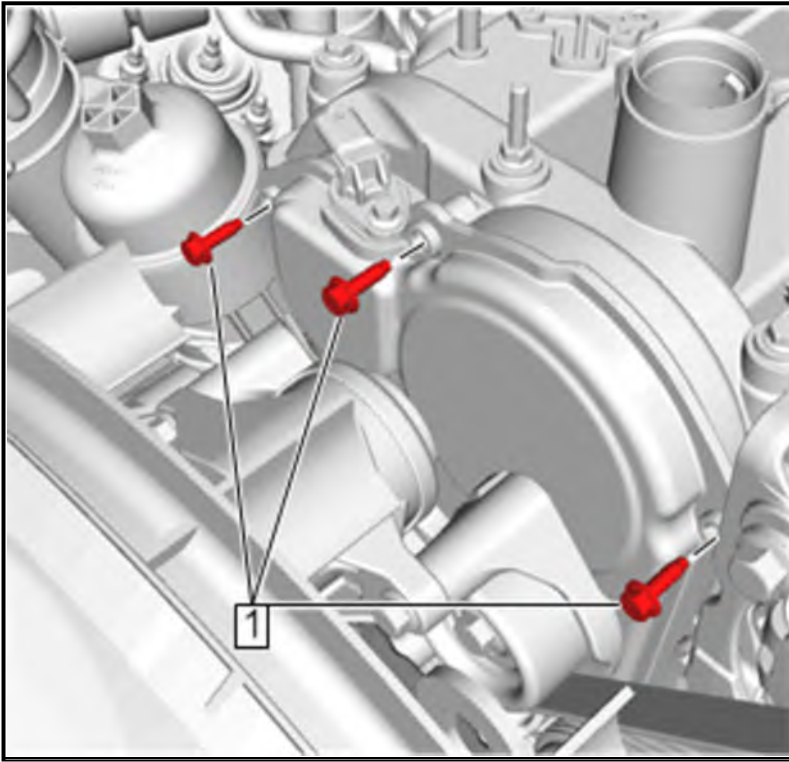


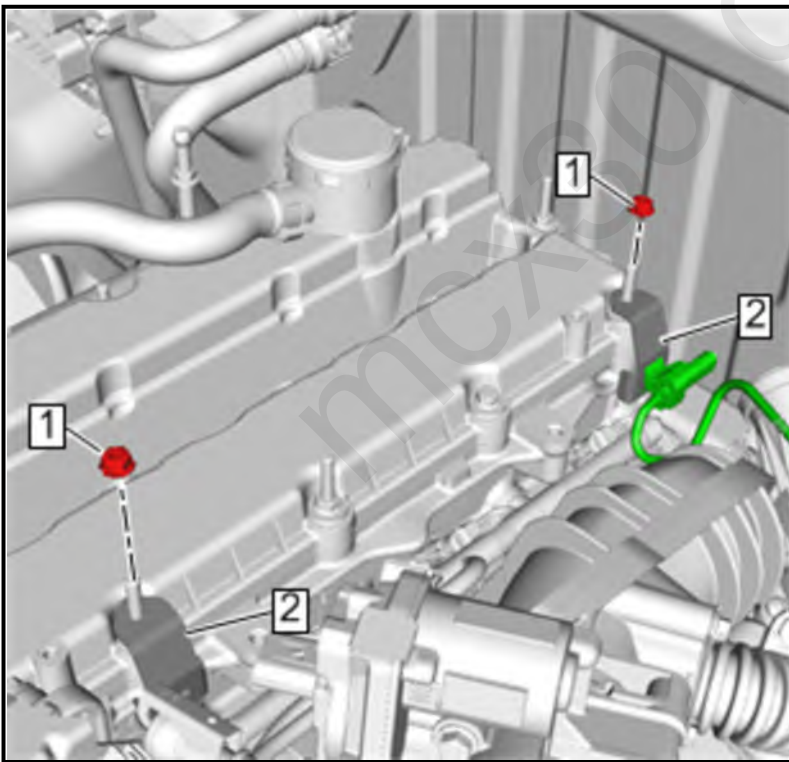
Fig. 23: Valve Rocker Arm Cover Bolt And Stud Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

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

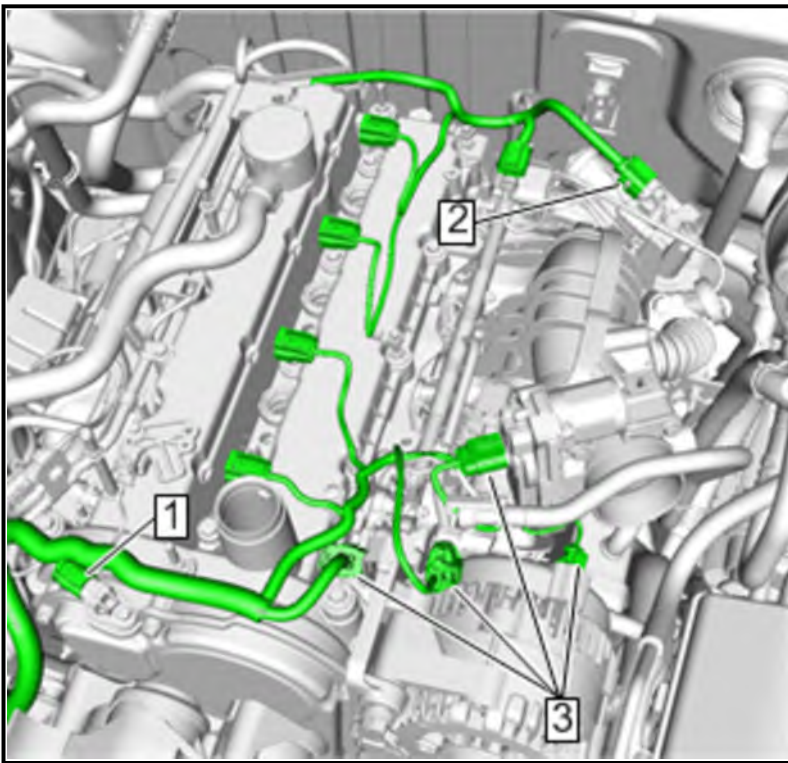
7. Timing Belt Front Cover Bolt (1) - Install and tighten [3x] 10 N.m (89 lb in)



8. Camshaft Position Sensor - Install - [Camshaft Position Sensor Replacement](#)
9. Generator Bracket - Install - [Generator Bracket Replacement \(LWN\)](#)
10. Wiring Harness Bracket (2) - Install



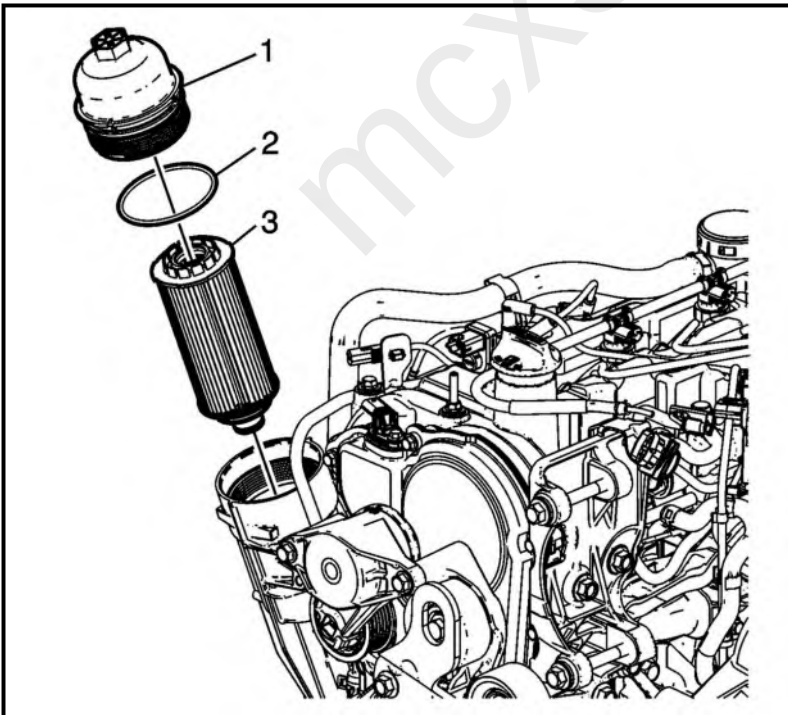
11. Engine Wiring Harness Bracket Nut (1) - Install and tighten [2x] 10 N.m (89 lb in)
12. Connect the electrical connectors. (1, 2 and 3)



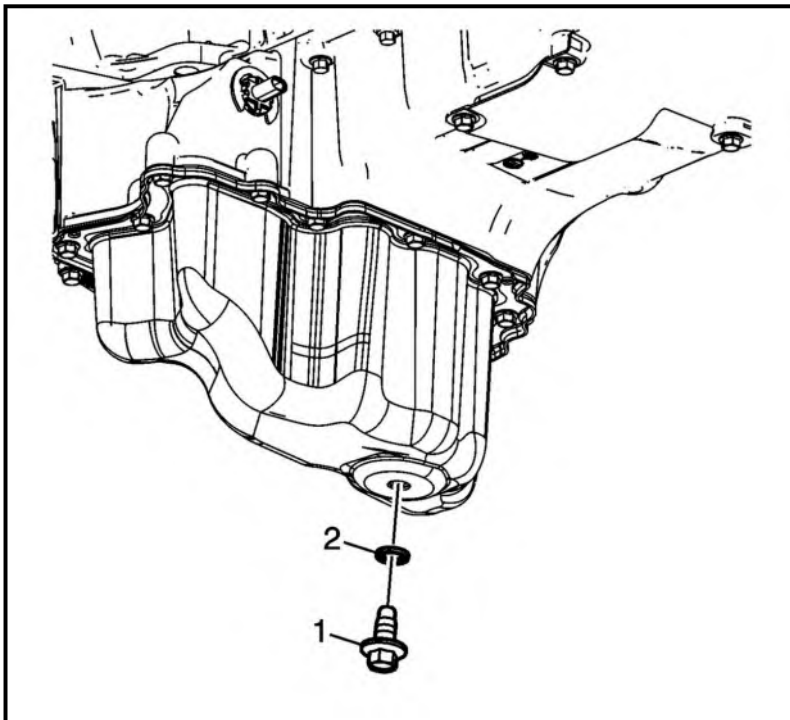
13. Generator Bracket - Install - [Generator Bracket Replacement \(LWN\)](#)
14. Camshaft Position Sensor - Install - [Camshaft Position Sensor Replacement](#)
15. [Fuel Injector Replacement \(Cylinder #1, #2, #3\)](#) , or [Fuel Injector Replacement \(Cylinder #4\)](#) - Install
16. [Vacuum Pump Pipe Replacement](#) - Install
17. [Fuel Injector Deadener Replacement](#) - Install

DRAINING FLUIDS AND OIL FILTER REMOVAL

1. Remove the oil filter cap (1) and O-ring seal (2).



2. Remove the oil filter (3) from the cap and discard.
3. Remove the oil pan drain plug (1) and seal (2). Allow the oil to drain out.



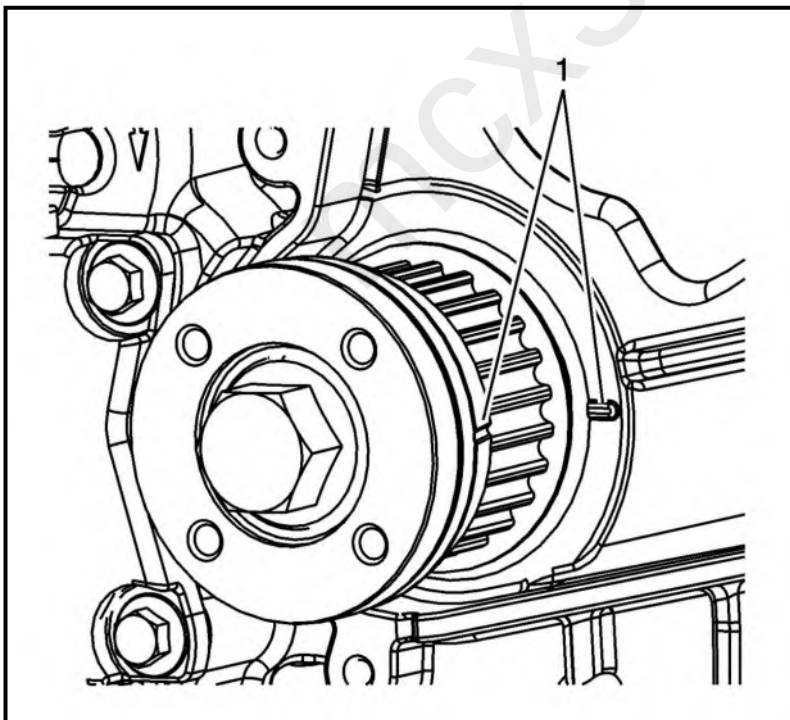
AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Special Tools

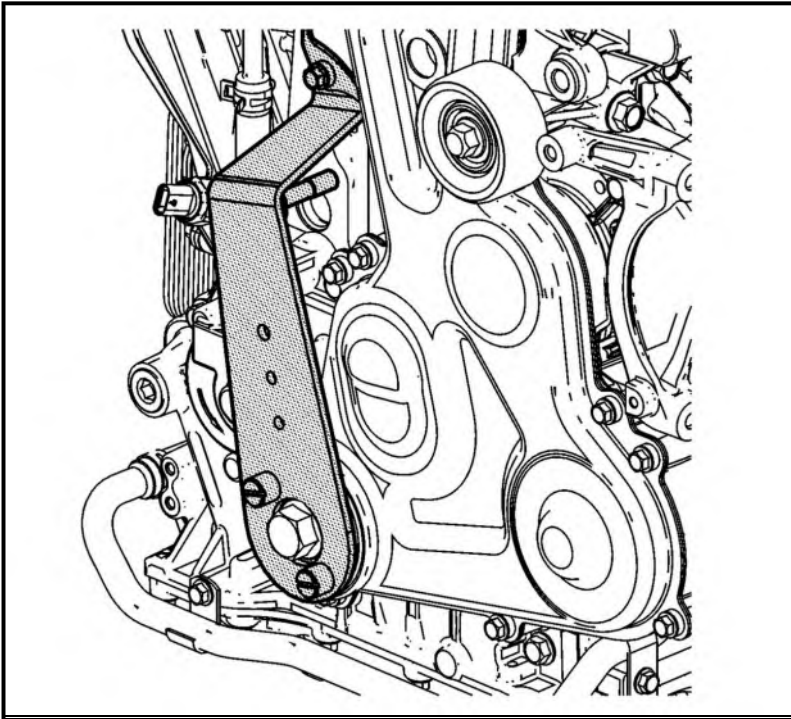
EN-51265 Crankshaft Locking Tool

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

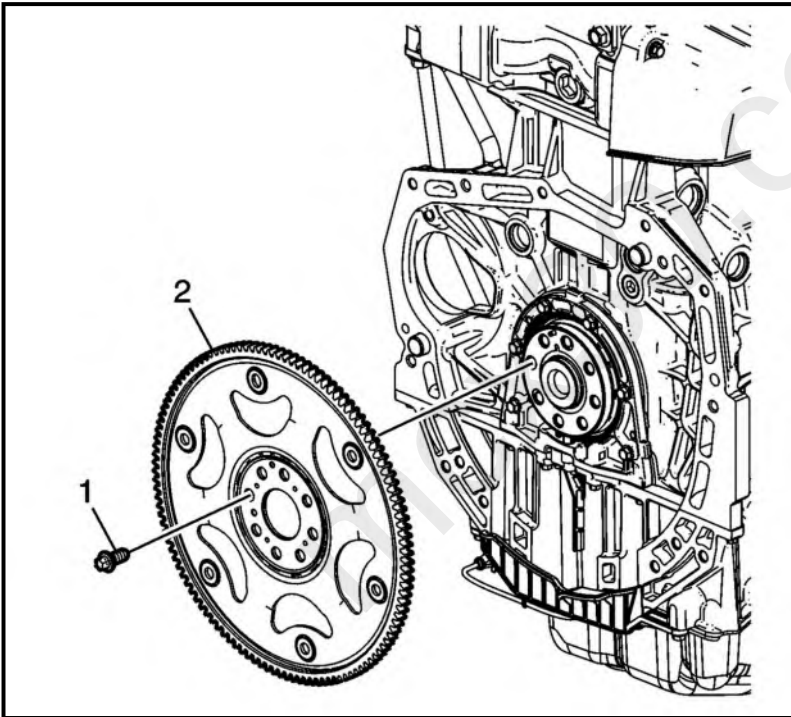
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees ATDC with the mark on the front cover (1).



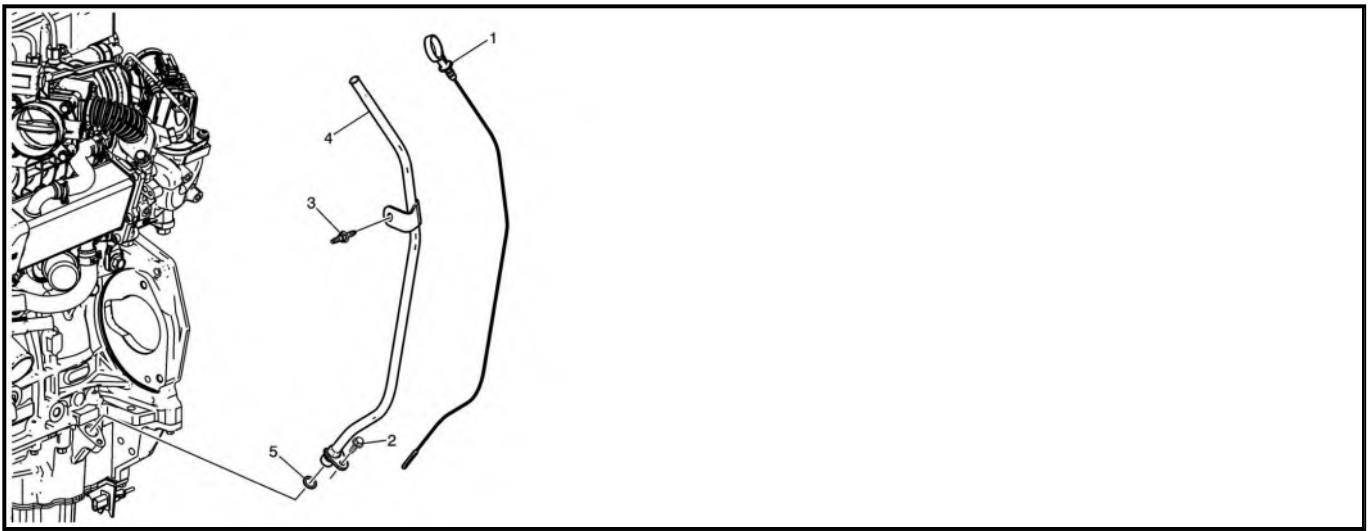
2. Install the **EN-51265** locking tool.



3. Remove the flexplate bolts (1) and flexplate (2).



OIL LEVEL INDICATOR AND TUBE REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Level Indicator
2	Oil Level Indicator Tube Bolt
3	Oil Level Indicator Tube Bolt
4	Oil Level Indicator Tube
5	Oil Level Indicator Tube Seal

ENGINE OIL COOLER REMOVAL

Engine Oil Cooler and Coolant Hose Clamp Removal

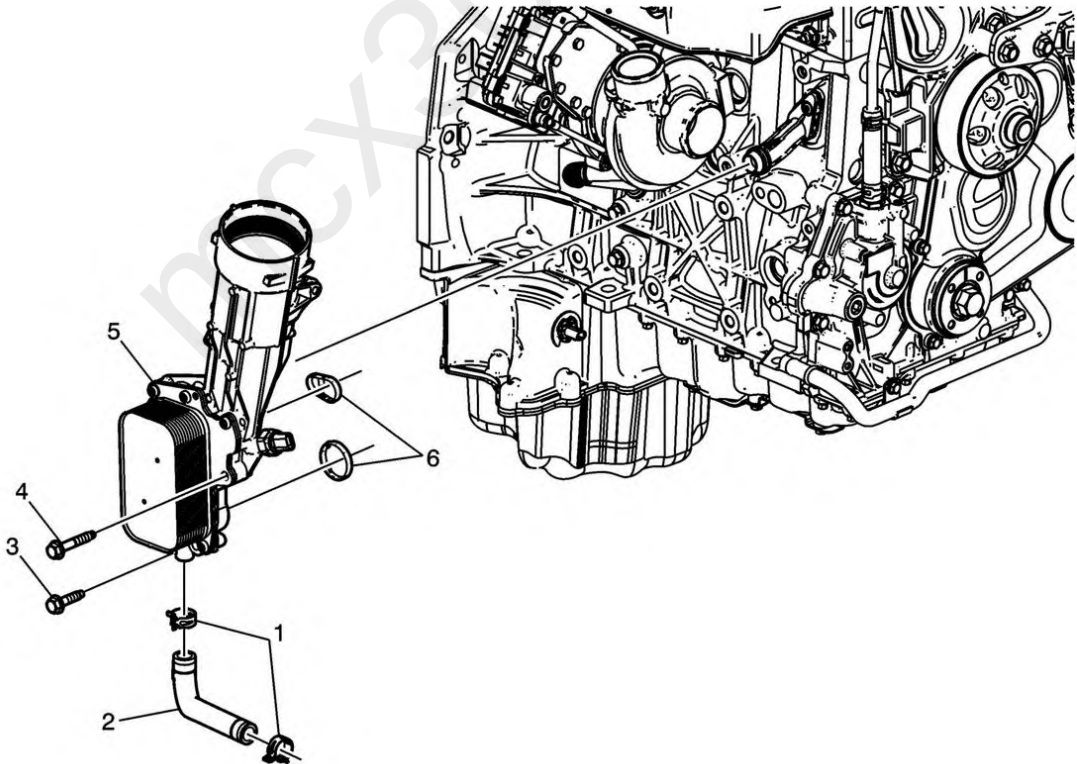


Fig. 24: Engine Oil Cooler And Coolant Hose Clamp Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Engine Oil Cooler and Coolant Hose Clamp Removal

Callout	Component Name
1	Engine Oil Cooler Inlet Hose Clamp
2	Engine Oil Cooler Inlet Hose
3	Engine Oil Cooler Bolt
4	Engine Oil Cooler Bolt
5	Engine Oil Cooler
6	Oil Filter Gasket
	NOTE: Discard gasket, it is not reusable.

Oil Filter Adapter Pipe Removal

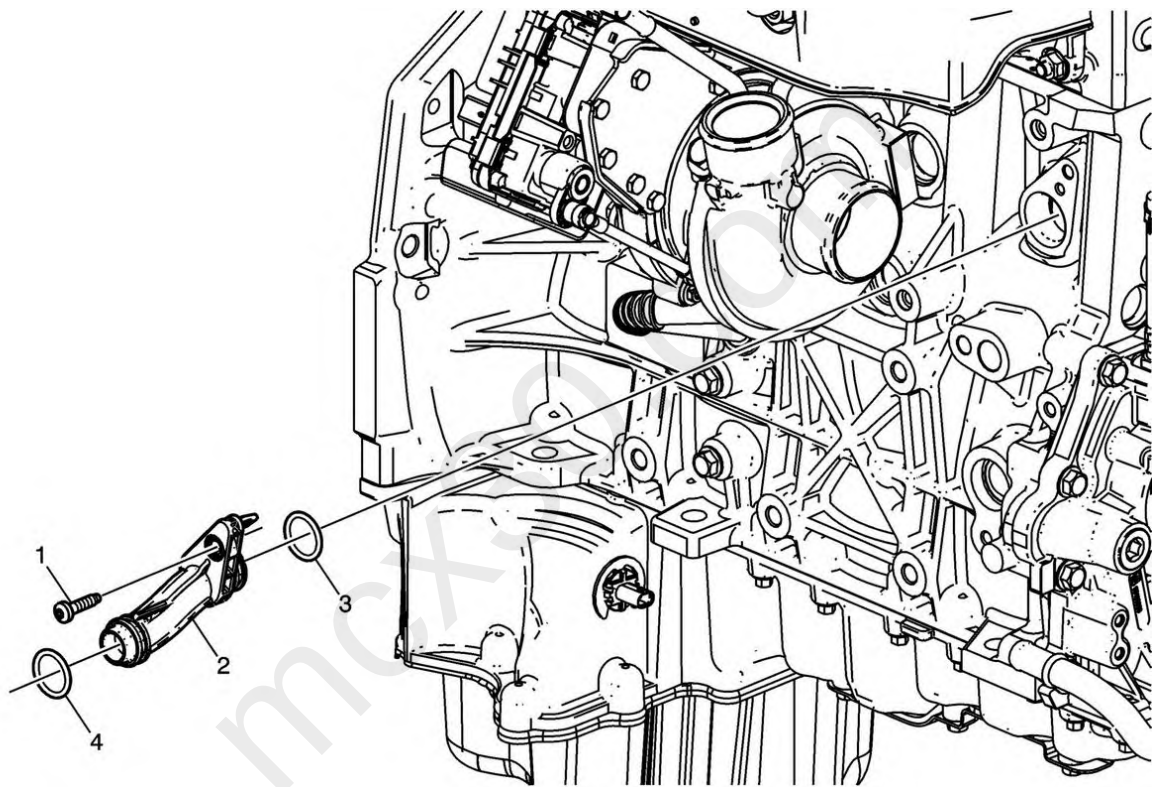


Fig. 25: Oil Filter Adapter Pipe Components Location

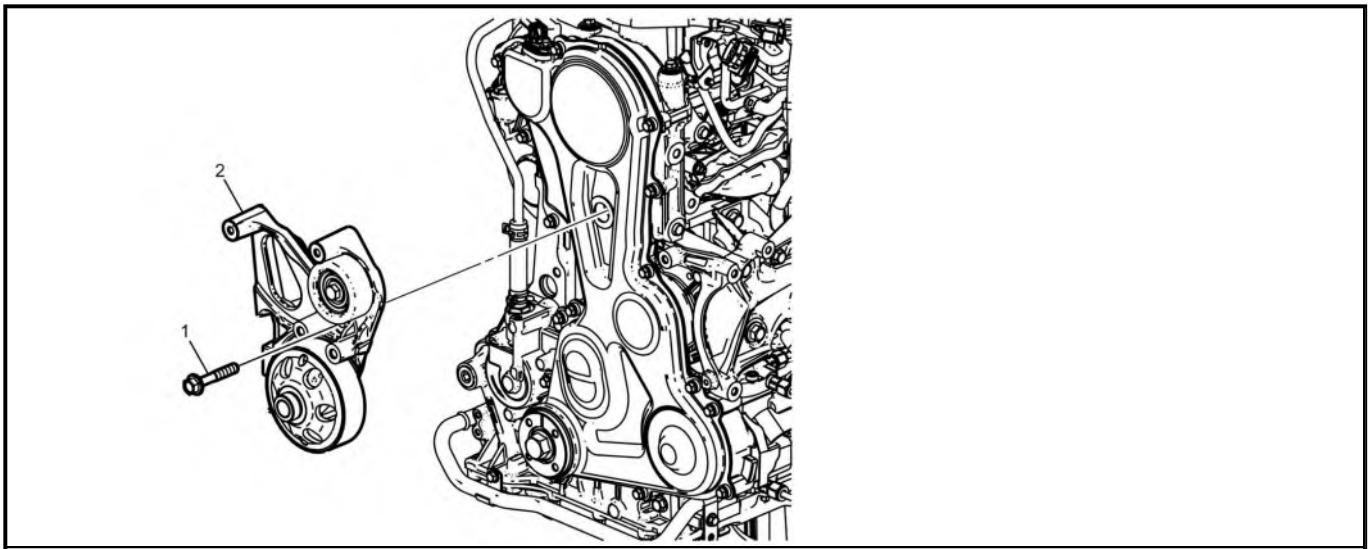
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Oil Filter Adapter Pipe Removal

Callout	Component Name
1	Oil Filter Adapter Bolt
2	Oil Filter Adapter Pipe
3	Oil Filter Adapter Seal
4	Oil Filter Adapter Seal

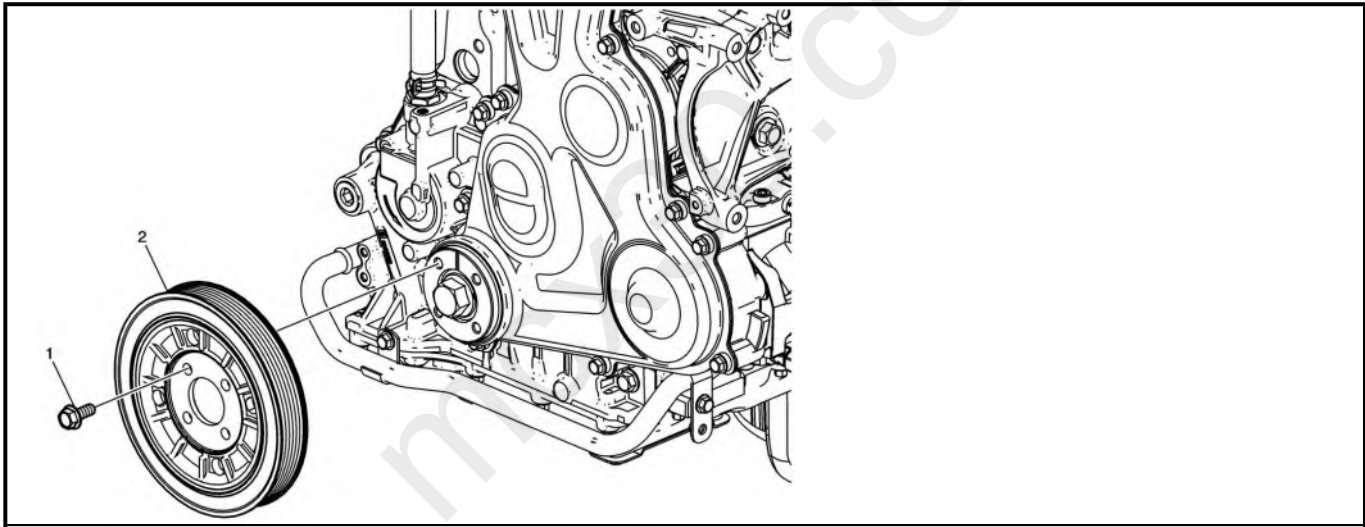
ENGINE COOLING FAN BRACKET REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Engine Coolant Fan Bracket Bolt
2	Engine Coolant Fan Bracket

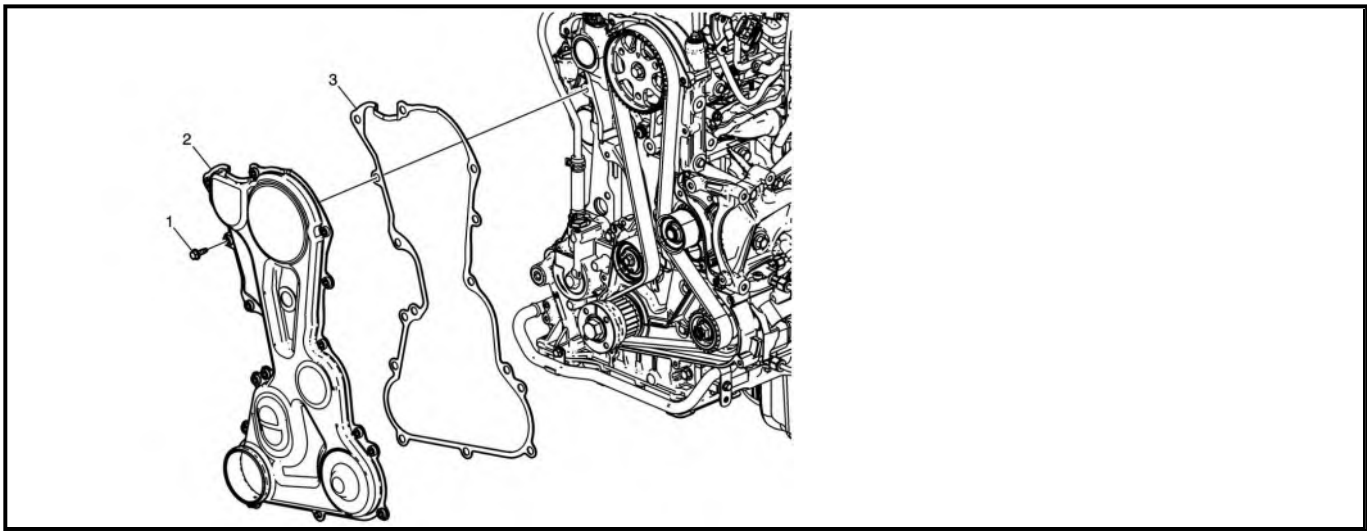
CRANKSHAFT BALANCER REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Crankshaft Balancer Bolt
2	Crankshaft Balancer

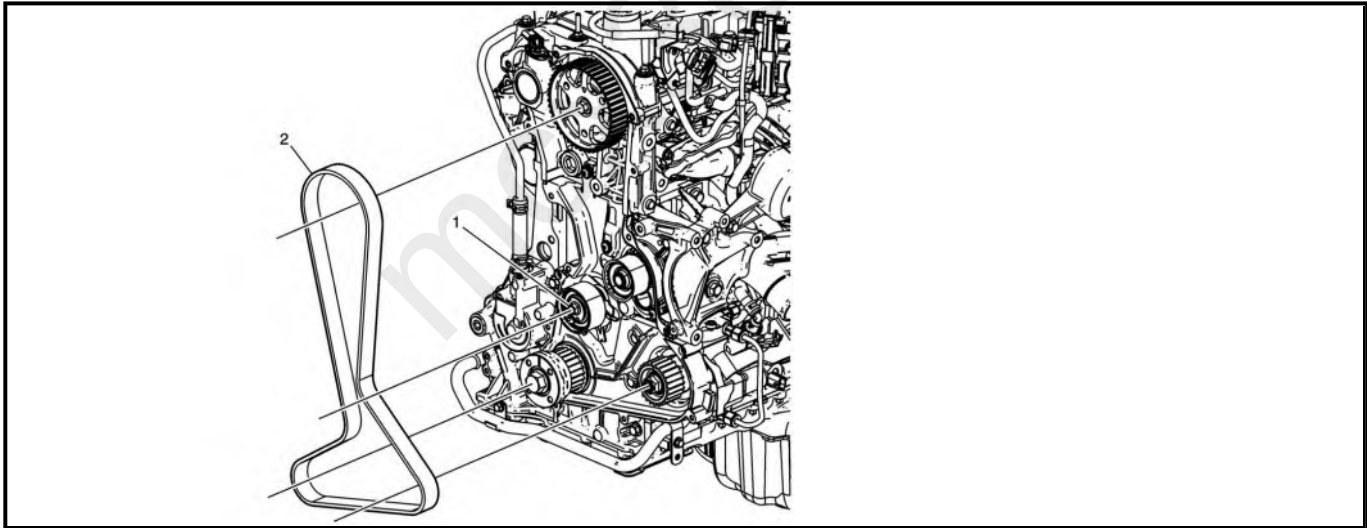
TIMING BELT FRONT COVER REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Front Cover Bolt [15x]
2	Timing Belt Front Cover
3	Engine Front Cover Gasket NOTE: DISCARD the gasket.

TIMING BELT REMOVAL

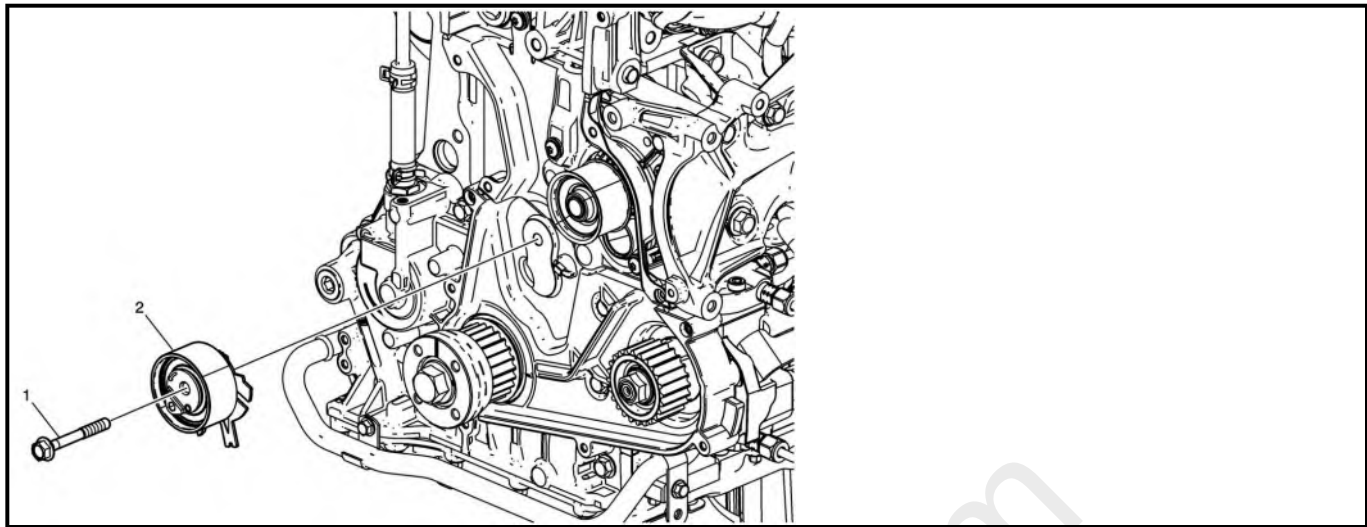


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Tensioner Bolt NOTE: Do not remove the bolt, just loosen it.

Callout	Component Name
2	Timing Belt Procedure Rotate tensioner clockwise to remove tension, then remove the timing belt.

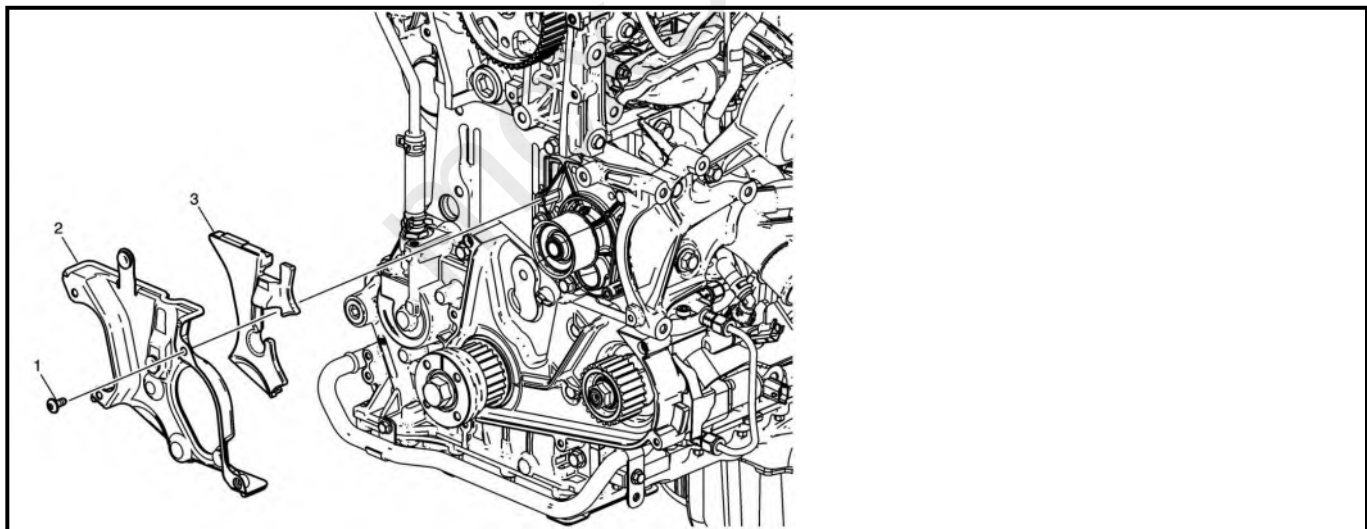
TIMING BELT TENSIONER REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Tensioner Bolt
2	Timing Belt Tensioner

TIMING BELT REAR COVER REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Rear Cover Bolt
2	Timing Belt Rear Cover
3	Timing Belt Rear Cover Gasket

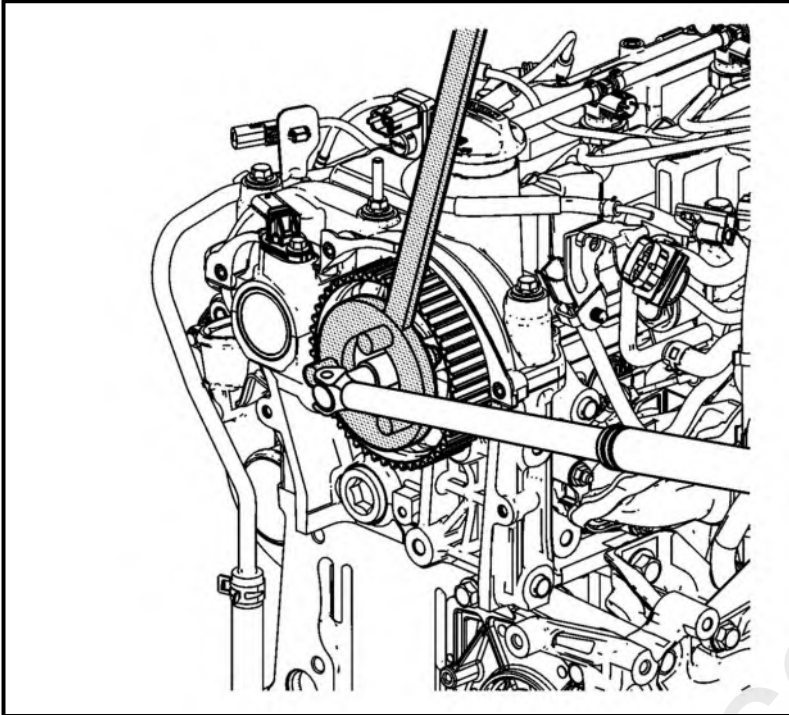
CAMSHAFT TIMING PULLEY REMOVAL

Special Tools

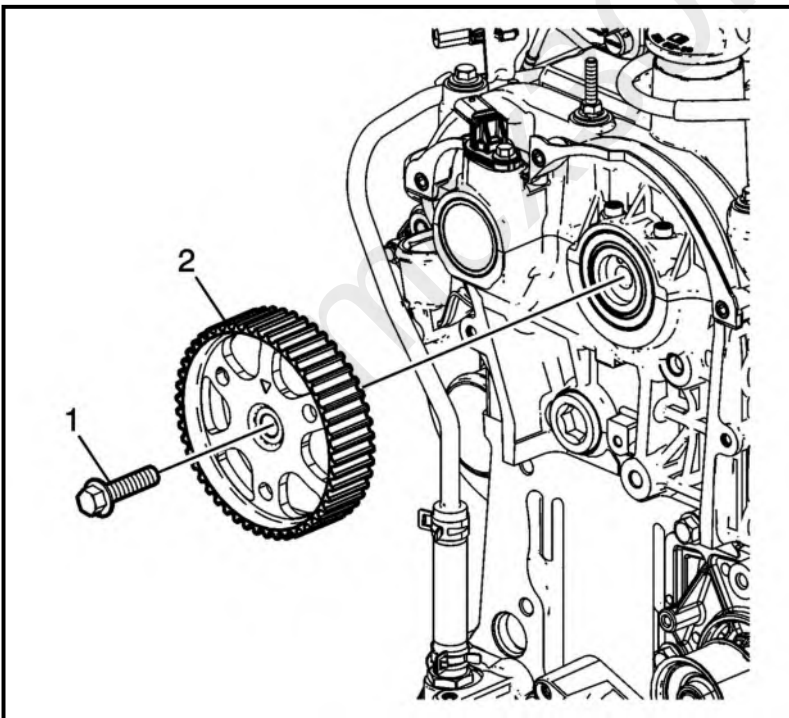
EN-50025 Pulley Holding Wrench

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

1. Hold the camshaft drive pulley with the **EN-50025** wrench and loosen the retaining bolt.



2. Remove the camshaft drive pulley bolt (1) and pulley (2).



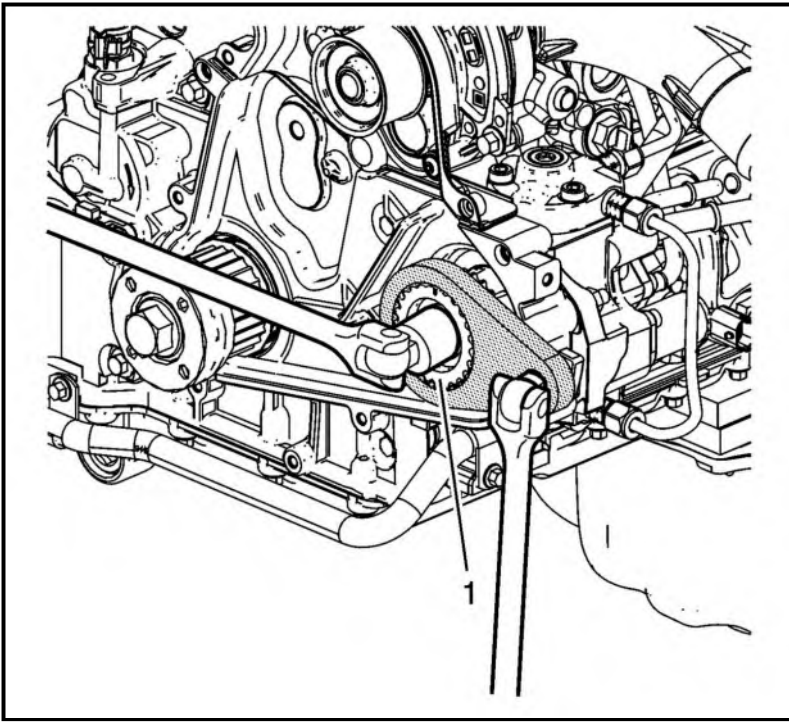
FUEL INJECTION PUMP DRIVE PULLEY REMOVAL

Special Tools

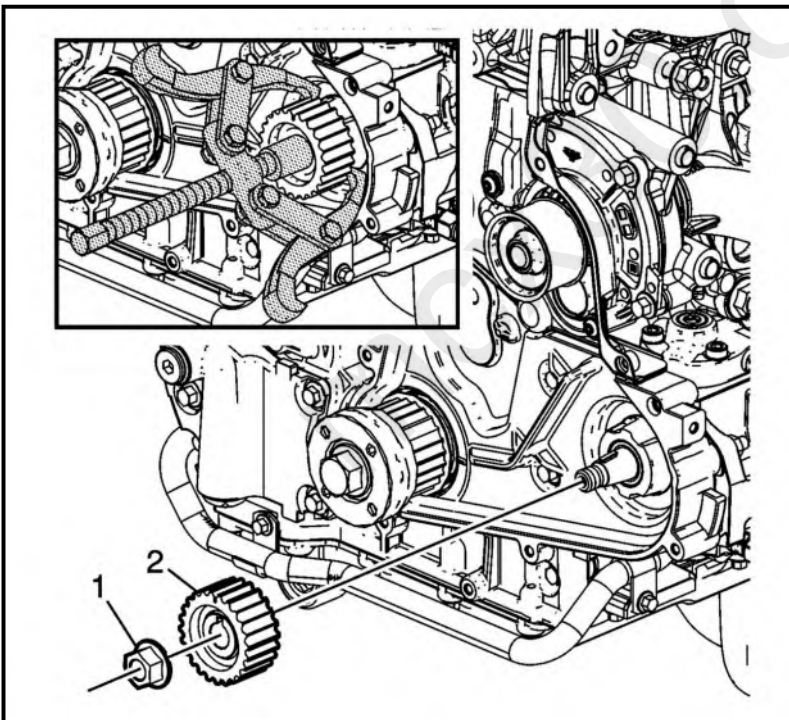
- **EN-51104** Injection Pump Sprocket Holder
- **DT-22888 - 20A** Universal Two Jaw Puller

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

1. Hold the fuel injection pump drive pulley (1) with the **EN-51104** holder and loosen the retaining nut.



2. Remove the fuel injection pump drive pulley nut (1) and pulley (2) using the **DT-22888 - 20A** Universal Two Jaw Puller.



WATER PUMP REMOVAL

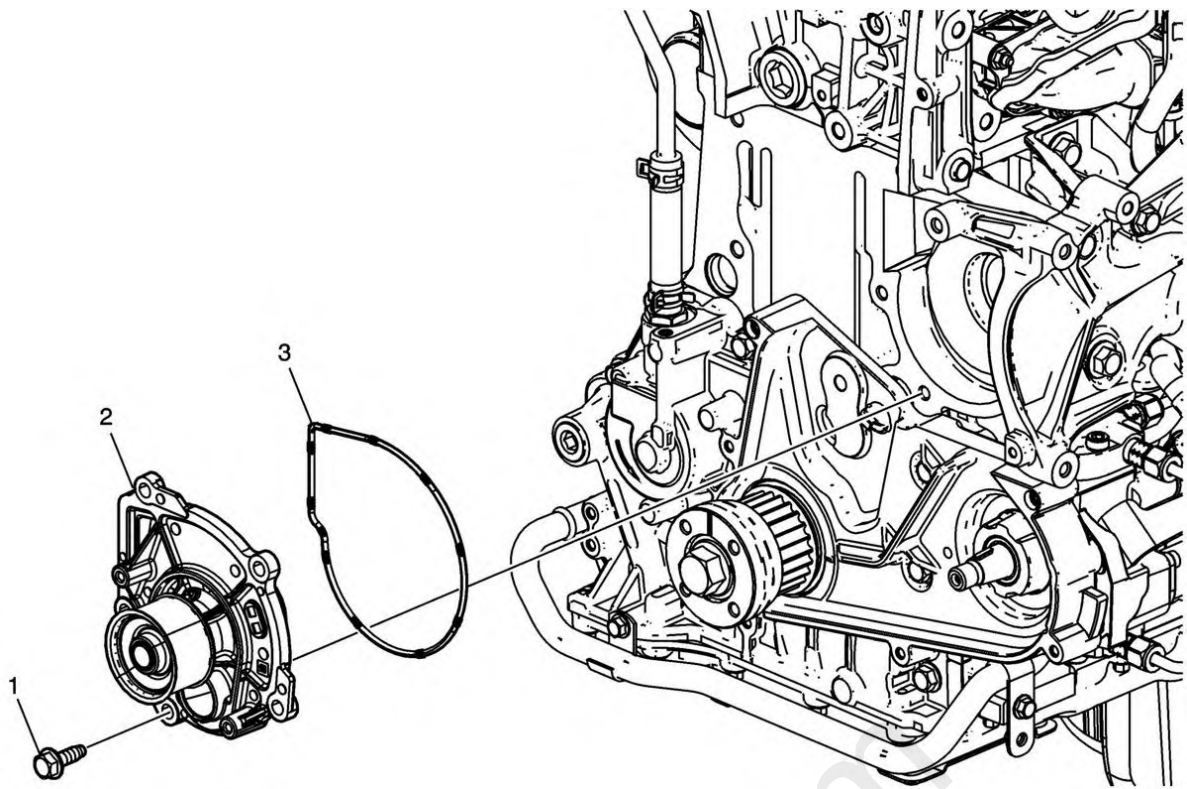


Fig. 26: Water Pump Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Water Pump Bolt
2	Water Pump
3	Water Pump Gasket NOTE: Discard gasket, it is not reusable.

EXHAUST MANIFOLD AND COMPRESSOR AIR INTAKE TURBOCHARGER REMOVAL

Exhaust Manifold Heat Shield and Turbocharger Oil Return Pipe Removal

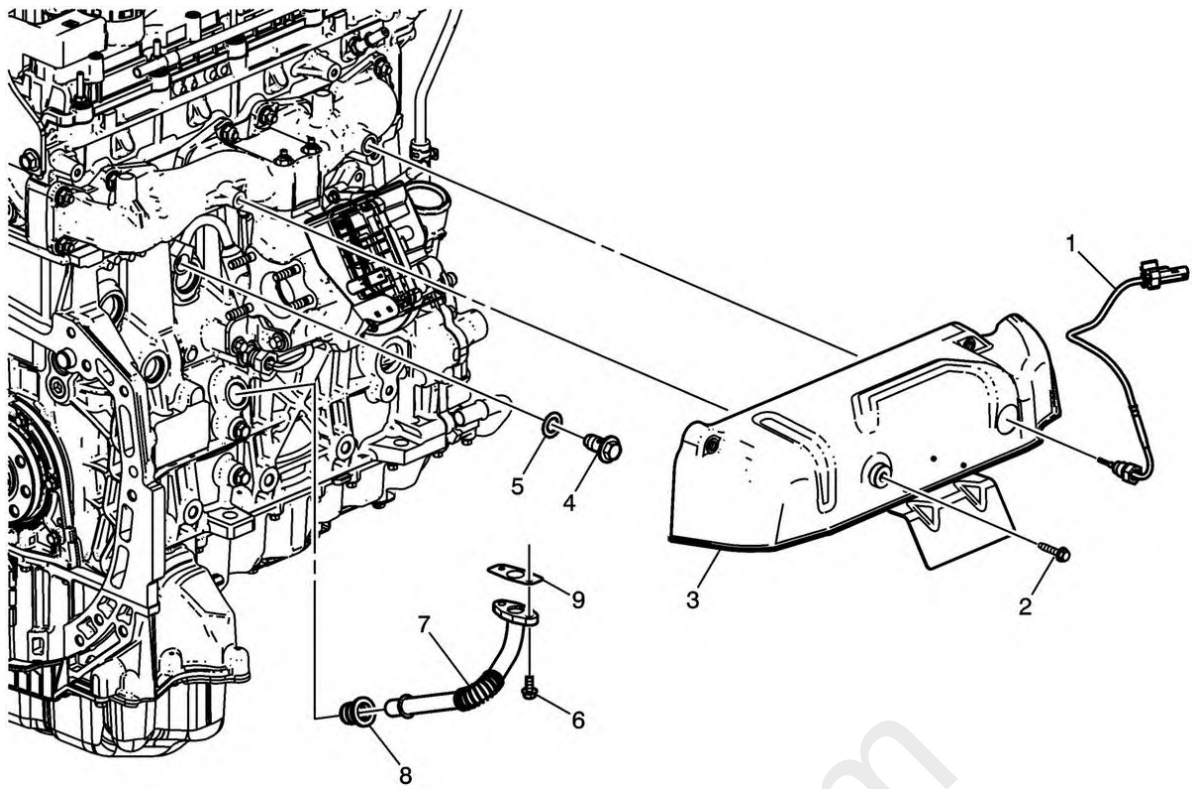


Fig. 27: Exhaust Manifold Heat Shield And Turbocharger Oil Return Pipe Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Exhaust Manifold Heat Shield and Turbocharger Oil Return Pipe Removal

Callout	Component Name
1	Exhaust Gas Recirculation Cooler Temperature Sensor
2	Exhaust Manifold Heat Shield Bolt
3	Exhaust Manifold Heat Shield
4	Turbocharger Coolant Feed and Return Pipe Bolt
5	Turbocharger Coolant Feed and Return Pipe Washer
6	Turbocharger Oil Return Pipe Bolt
7	Turbocharger Oil Return Pipe
8	Turbocharger Tube Seal
9	Turbocharger Oil Return Pipe Gasket
	NOTE: Discard gasket, it is not reusable.

Exhaust Manifold and Turbocharger Assembly Removal

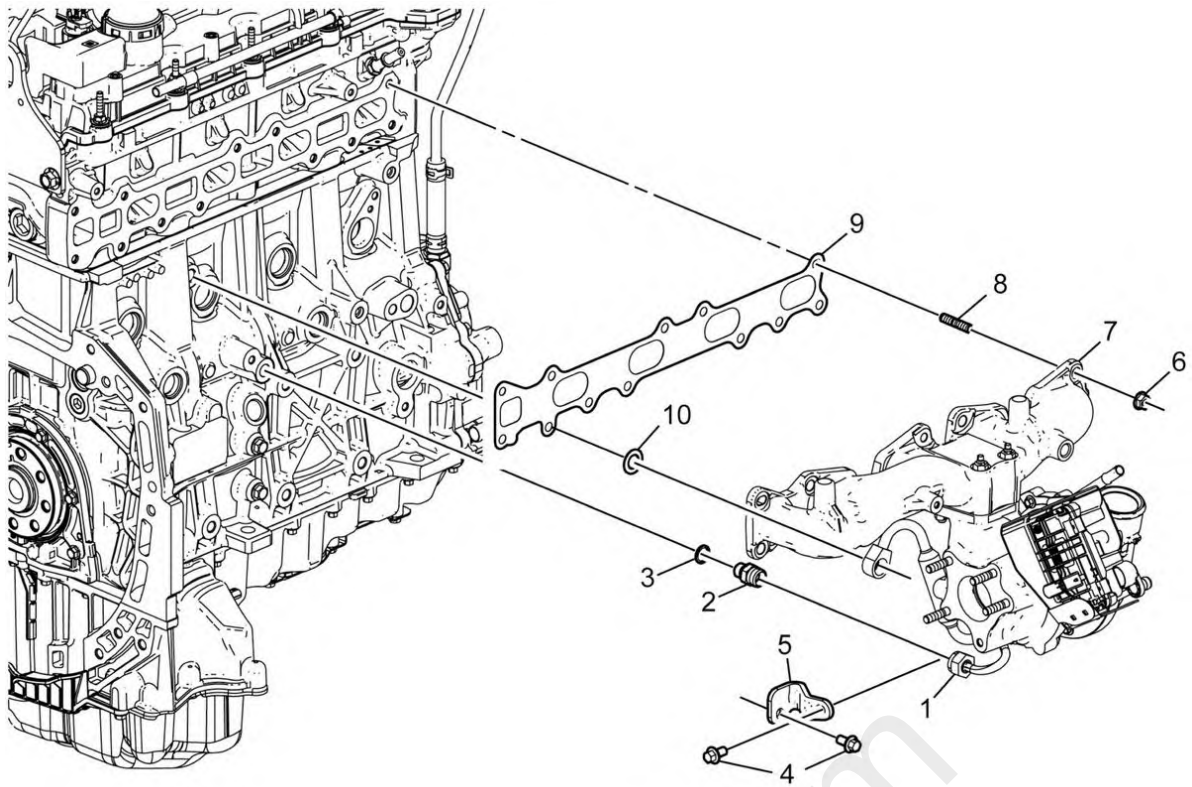


Fig. 28: Exhaust Manifold Heat Shield And Turbocharger Oil Return Pipe Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Exhaust Manifold and Turbocharger Assembly Removal

Callout	Component Name
1	Turbocharger Oil Feed Pipe Fitting
2	Turbocharger Oil Feed Pipe Fitting Adapter
3	Turbocharger Oil Feed Pipe Washer
4	Turbocharger Brace Bolt
5	Turbocharger Brace
6	Exhaust Manifold Nut
7	Exhaust Manifold and Turbocharger Assembly
8	Exhaust Manifold Stud
9	Exhaust Manifold Gasket NOTE: Discard gasket, it is not reusable.
10	Turbocharger Coolant Feed and Return Pipe Washer NOTE: Discard washer, it is not reusable.

Exhaust Manifold and Turbocharger Assembly Disassemble

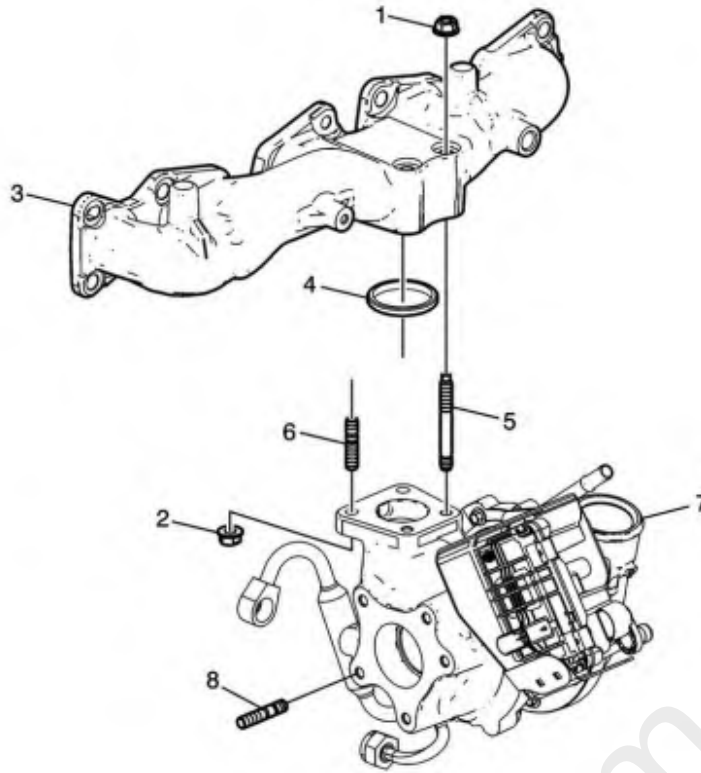


Fig. 29: Exhaust Manifold And Turbocharger Assembly Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Exhaust Manifold and Turbocharger Assembly Disassemble

Callout	Component Name
1	Turbocharger Nut
2	Turbocharger Nut
3	Exhaust Manifold
4	Turbocharger Gasket NOTE: Discard gasket, it is not reusable.
5	Turbocharger Stud
6	Turbocharger Stud
7	Turbocharger NOTE: Do NOT loosen or remove actuator from the turbocharger bracket.
8	Turbocharger Stud

Turbocharger Coolant Return Pipe, Oil Feed Pipe, and Oil Return Pipe Removal

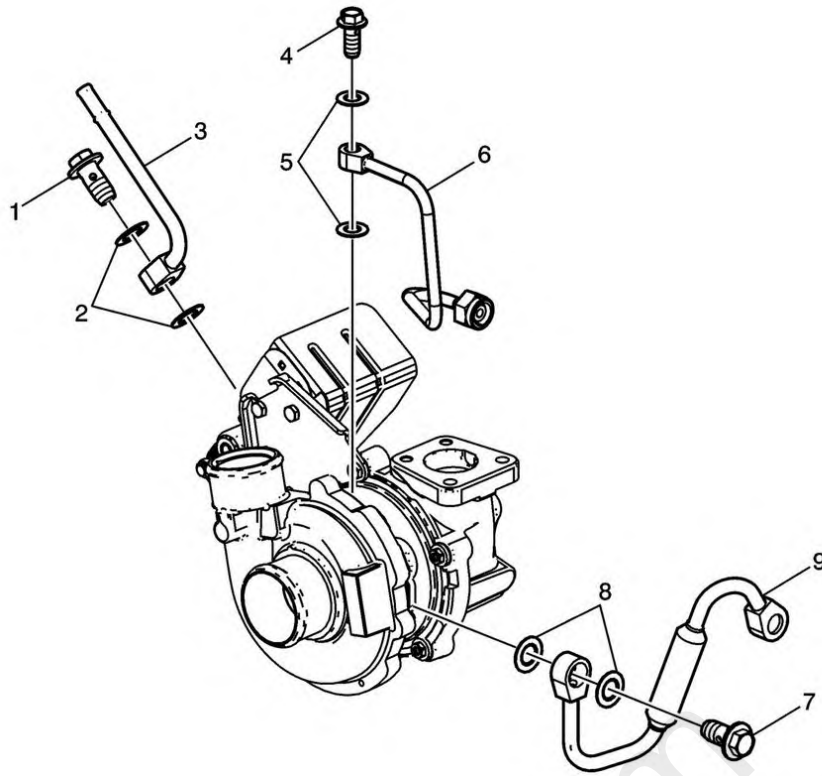


Fig. 30: Turbocharger Coolant Return Pipe, Oil Feed Pipe And Oil Return Pipe Components Location
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Turbocharger Coolant Return Pipe, Oil Feed Pipe, and Oil Return Pipe Removal

Callout	Component Name
1	Turbocharger Coolant Feed and Return Pipe Bolt
2	Turbocharger Coolant Feed and Return Pipe Washer NOTE: Discard washers, they are not reusable.
3	Turbocharger Coolant Return Pipe
4	Turbocharger Oil Feed Pipe Bolt
5	Turbocharger Oil Feed Pipe Gasket NOTE: Discard gaskets, they are not reusable.
6	Turbocharger Oil Feed Pipe
7	Turbocharger Coolant Feed and Return Pipe Bolt
8	Turbocharger Coolant Feed and Return Pipe Washer NOTE: Discard washers, they are not reusable.
9	Turbocharger Coolant Feed Pipe

EXHAUST GAS RECIRCULATION VALVE AND COOLER REMOVAL

EGR Pipe, Brace, and Hoses Removal

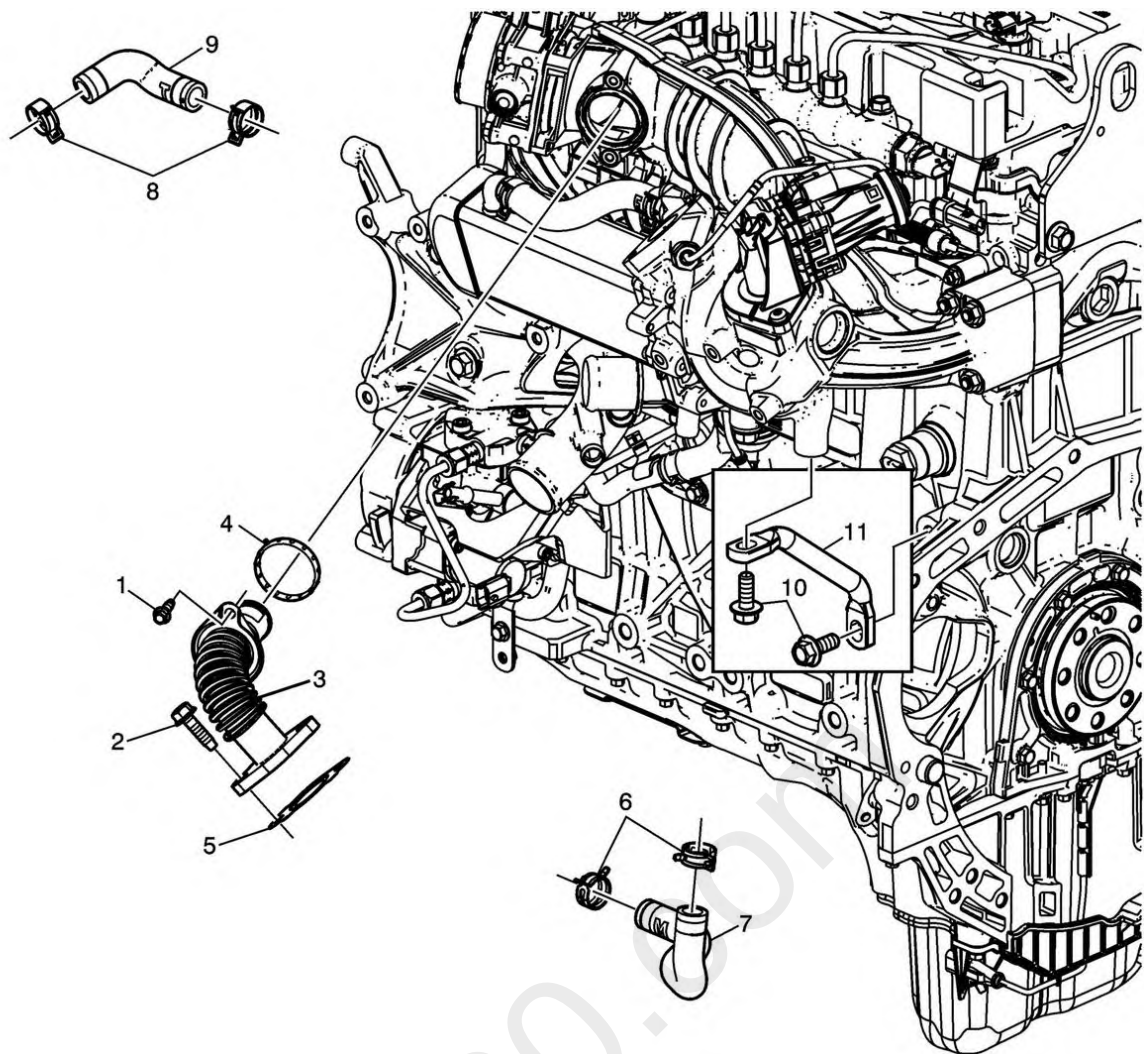


Fig. 31: EGR Pipe, Brace And Hoses Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Pipe, Brace, and Hoses Removal

Callout	Component Name
1	Exhaust Gas Recirculation Pipe Bolt
2	Exhaust Gas Recirculation Pipe Bolt
3	Exhaust Gas Recirculation Pipe
4	Exhaust Gas Recirculation Pipe Gasket NOTE: Discard seal, it is not reusable.
5	Exhaust Gas Recirculation Pipe Gasket NOTE: Discard seal, it is not reusable.
6	Thermostat Bypass Hose Clamp
7	Exhaust Gas Recirculation Manifold Cooling Return Hose
8	Thermostat Bypass Hose Clamp

Callout	Component Name
	NOTE: Remove and DISCARD the clamps.
9	Exhaust Gas Recirculation Manifold Cooling Feed Hose
10	Exhaust Gas Recirculation Manifold Brace Bolt
11	Exhaust Gas Recirculation Manifold Brace

EGR Assembly, Intake Manifold Tuning Valve Vacuum and Pipes Removal

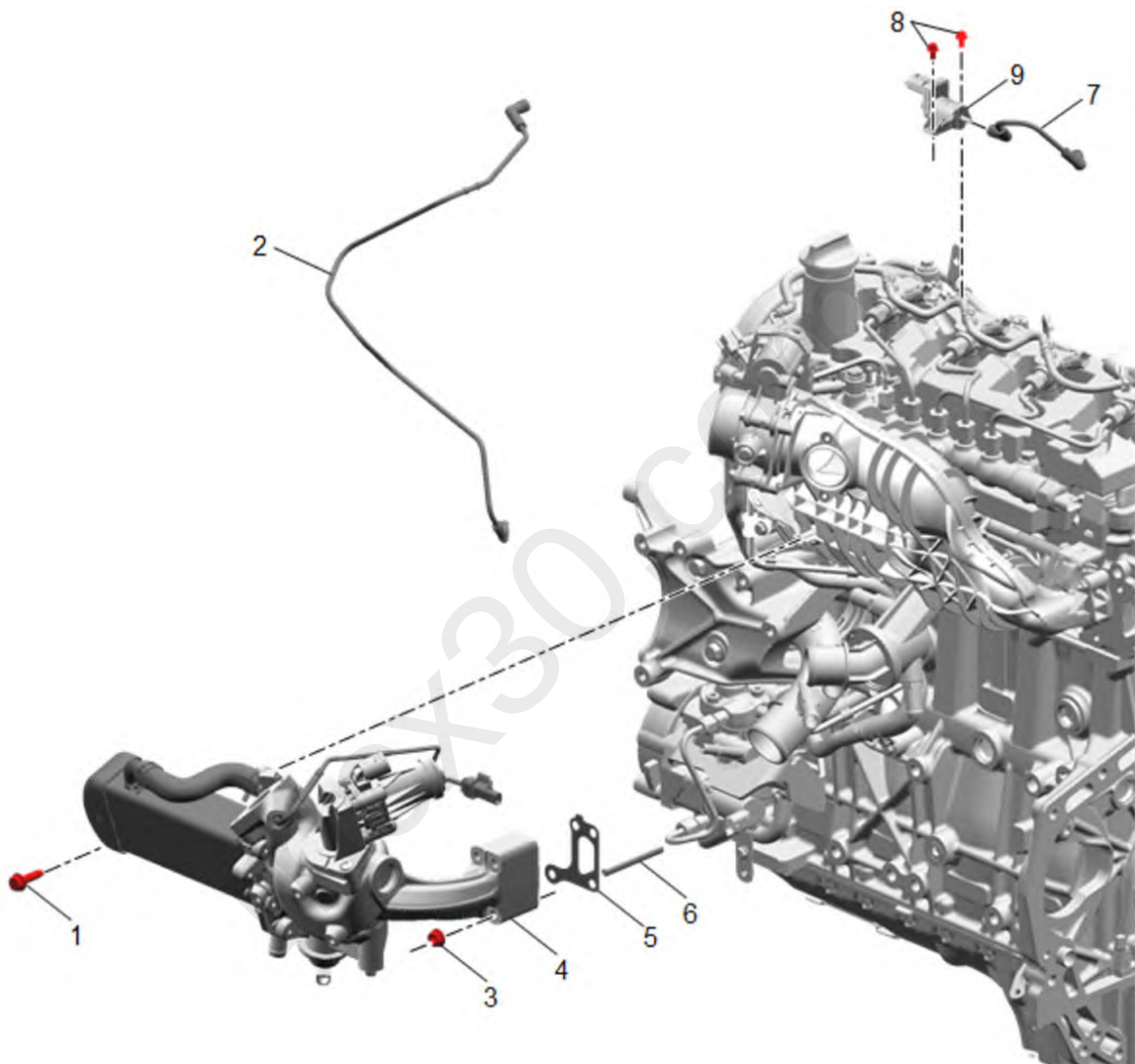


Fig. 32: EGR Assembly, Intake Manifold Tuning Valve Vacuum And Pipes Components Location
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Assembly, Intake Manifold Tuning Valve Vacuum and Pipes Removal

Callout	Component Name
1	Exhaust Gas Recirculation Cooler Bolt
2	Exhaust Gas Recirculation Valve Vacuum Pipe
3	Exhaust Gas Recirculation Valve Adapter Nut
4	Exhaust Gas Recirculation Valve and Cooler
5	Exhaust Gas Recirculation Valve Gasket

Callout	Component Name
	NOTE: Discard gaskets, they are not reusable.
6	Exhaust Gas Recirculation Valve Adapter Stud
7	Exhaust Gas Recirculation Valve Vacuum Pipe
8	Intake Manifold Tuning Vacuum Control Solenoid Valve Bolt
9	Intake Manifold Tuning Vacuum Control Solenoid Valve

EGR Cooler, Housing, and Cooling Feed Hose Removal

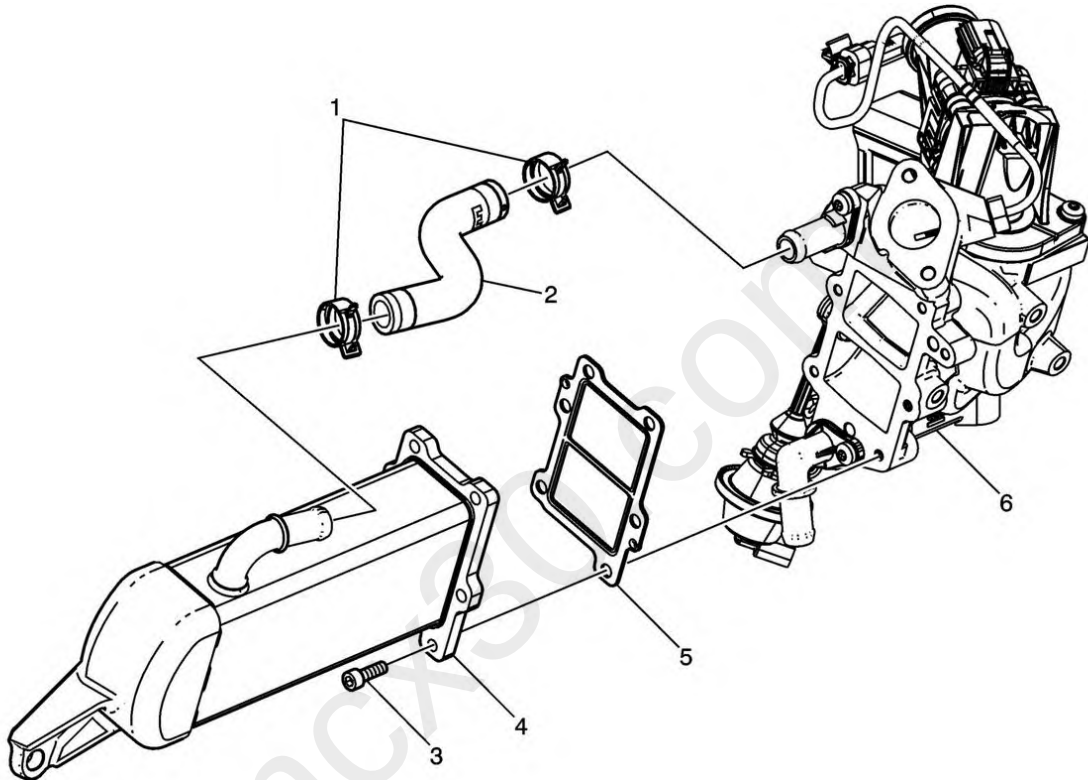


Fig. 33: EGR Cooler, Housing And Cooling Feed Hose Components Location

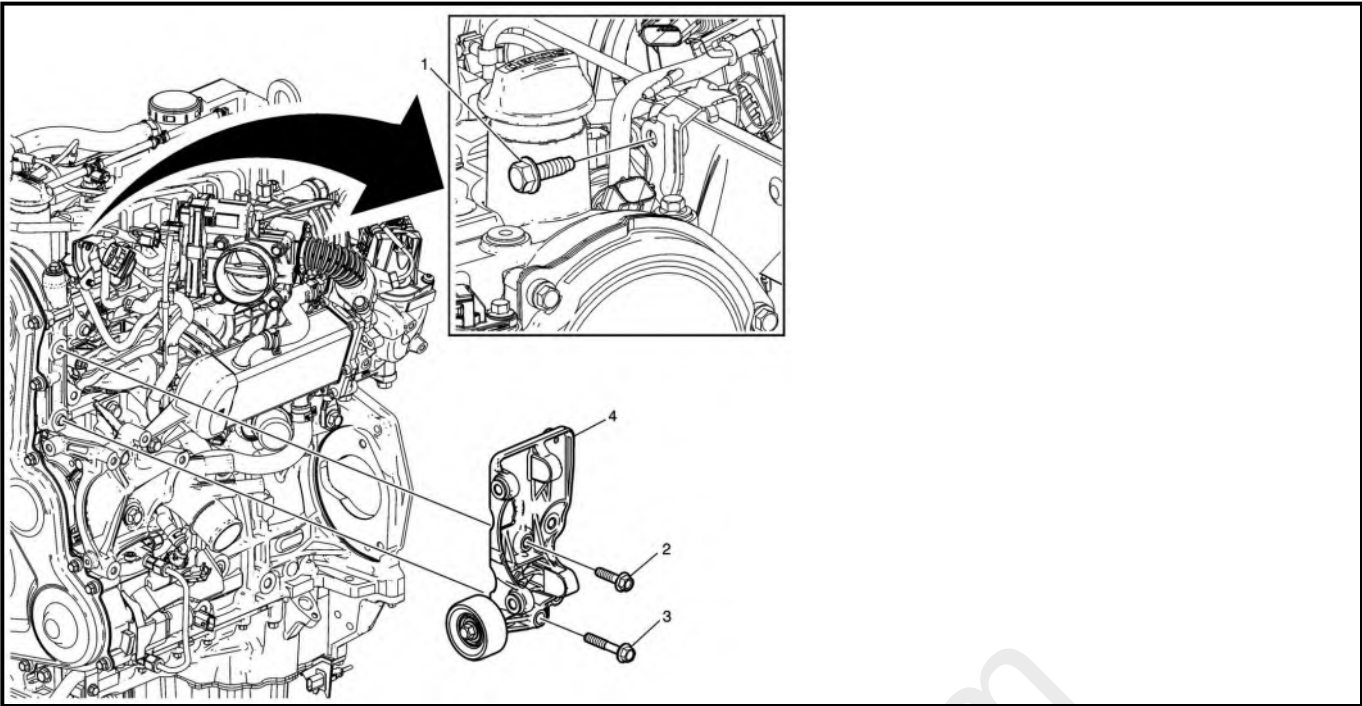
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Cooler, Housing, and Cooling Feed Hose Removal

Callout	Component Name
1	Thermostat Bypass Hose Clamp
2	Exhaust Gas Recirculation Manifold Cooling Feed Hose
3	Exhaust Gas Recirculation Cooler Bolt
4	Exhaust Gas Recirculation Cooler
	Exhaust Gas Recirculation Cooler Gasket
5	NOTE: Discard gaskets, they are not reusable.
6	Exhaust Gas Recirculation Valve Machined Housing

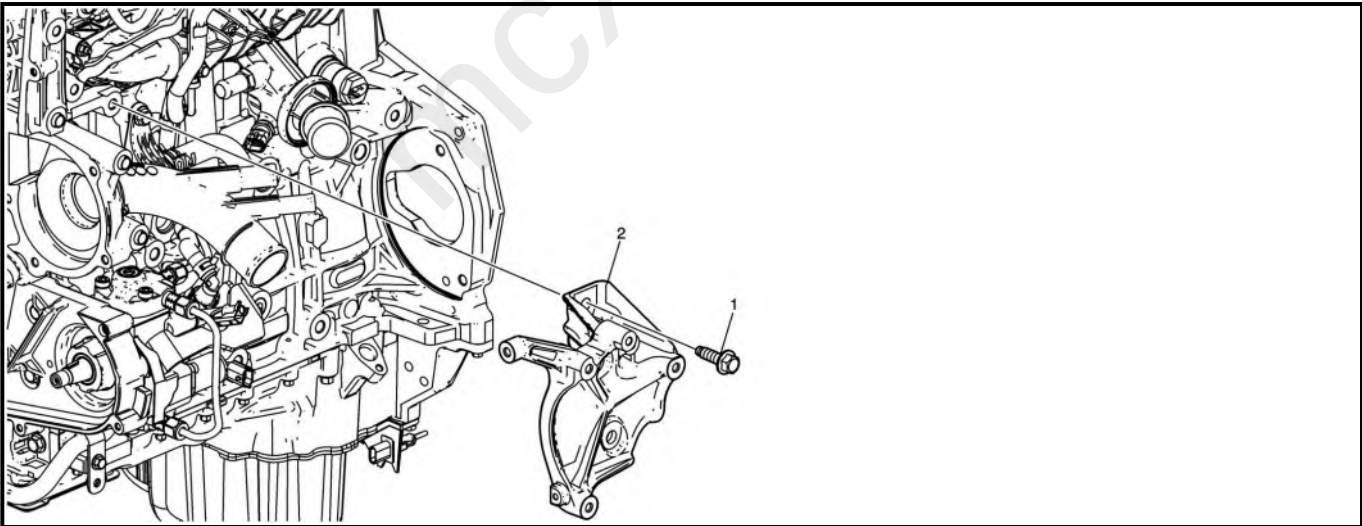
GENERATOR BRACKET REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Generator Bracket Bolt
2	Generator Bracket Bolt [2x]
3	Generator Bracket Bolt [2x]
4	Generator Bracket

AIR CONDITIONING COMPRESSOR BRACKET REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Air Conditioning Compressor Bracket Bolt [4x]
2	Air Conditioning Compressor Bracket

ENGINE COOLANT THERMOSTAT REMOVAL

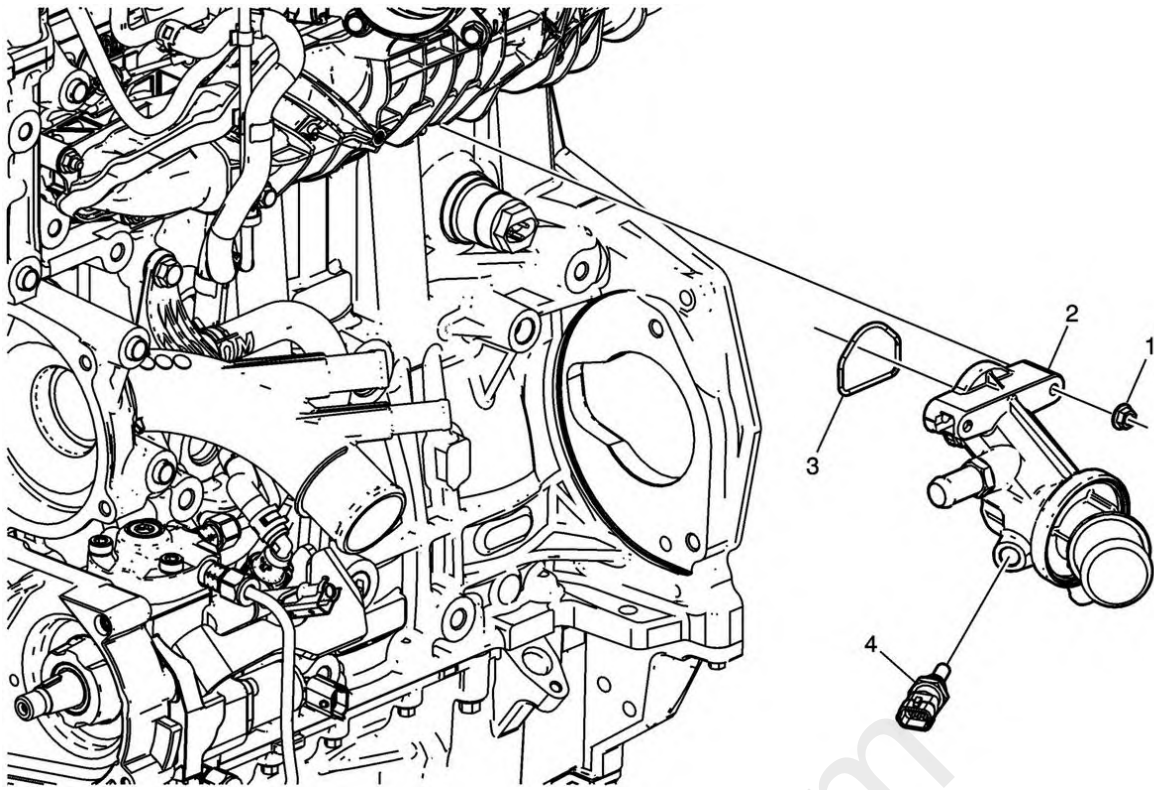


Fig. 34: Engine Coolant Thermostat Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Intake Manifold Nut
2	Engine Coolant Thermostat
3	Engine Coolant Thermostat Gasket NOTE: Discard gasket, it is not reusable.
4	Engine Coolant Temperature Sensor

WATER PUMP INLET PIPE REMOVAL

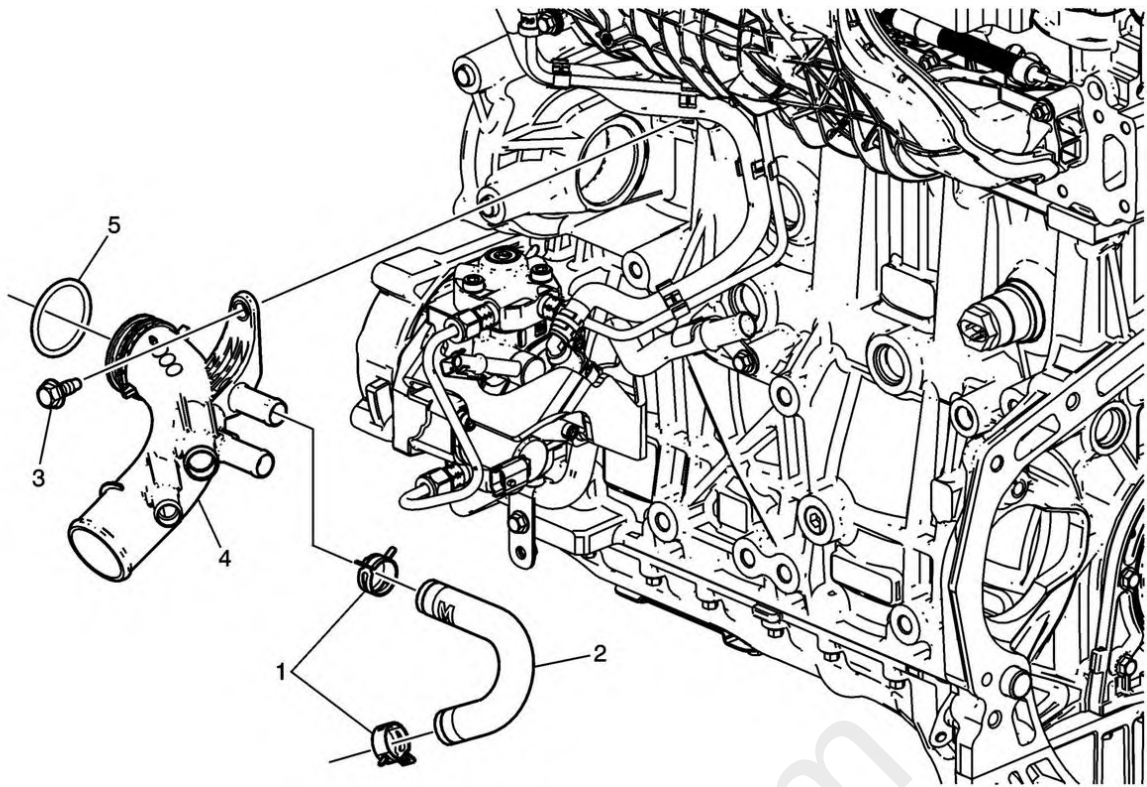


Fig. 35: Water Pump Inlet Pipe Components Location

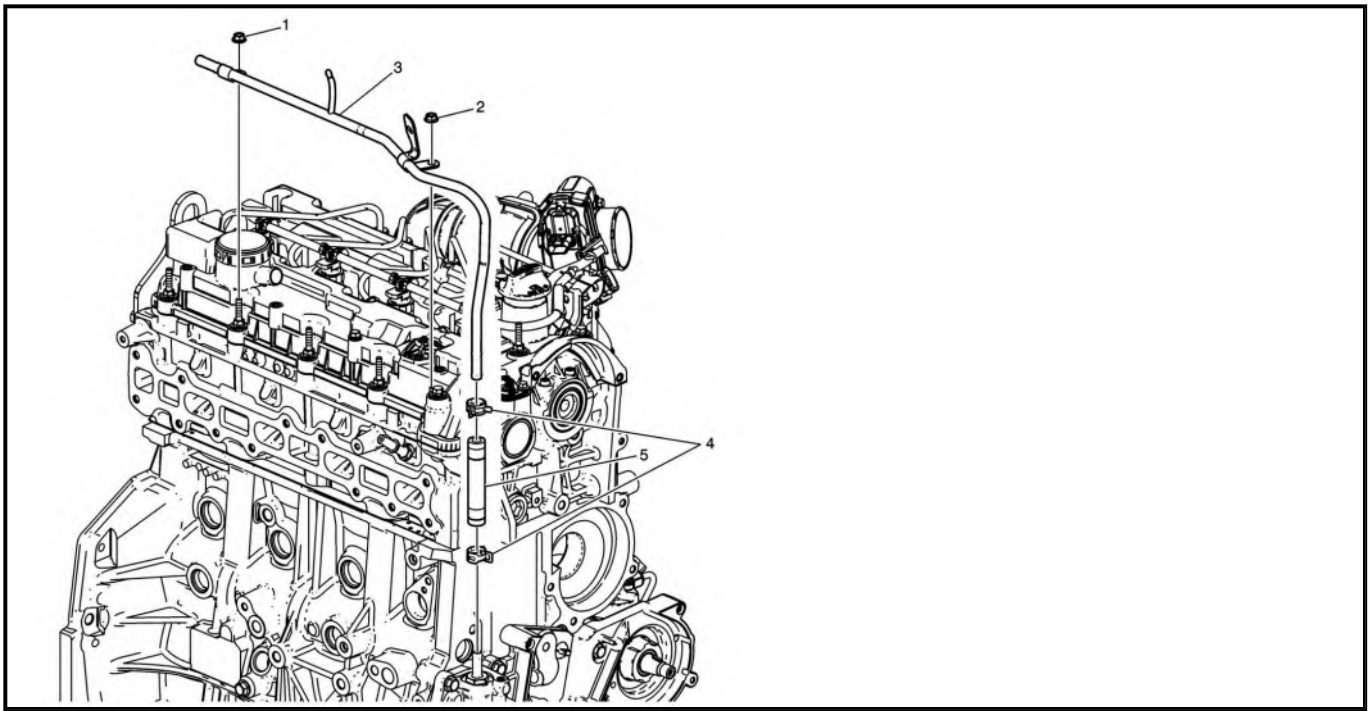
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Water Pump Inlet Pipe Feed Hose Clamp
2	Water Pump Inlet Pipe Feed Hose
3	Water Pump Inlet Pipe Bolt
4	Water Pump Inlet Pipe
5	Water Pump Inlet Pipe Seal NOTE: Discard seal, it is not reusable.

FUEL FEED PIPE AND FUEL RAIL REMOVAL

Vacuum Pump Pipe and Hose Removal



NOTE: Callouts in the following chart represent components shown in graphic above.

Vacuum Pump Pipe and Hose Removal

Callout	Component Name
1	Vacuum Pipe Nut
2	Vacuum Pipe Nut
3	Vacuum Pump Pipe
4	Vacuum Pump Hose Clip
5	Vacuum Pump Hose

Fuel Rail and Lines Removal

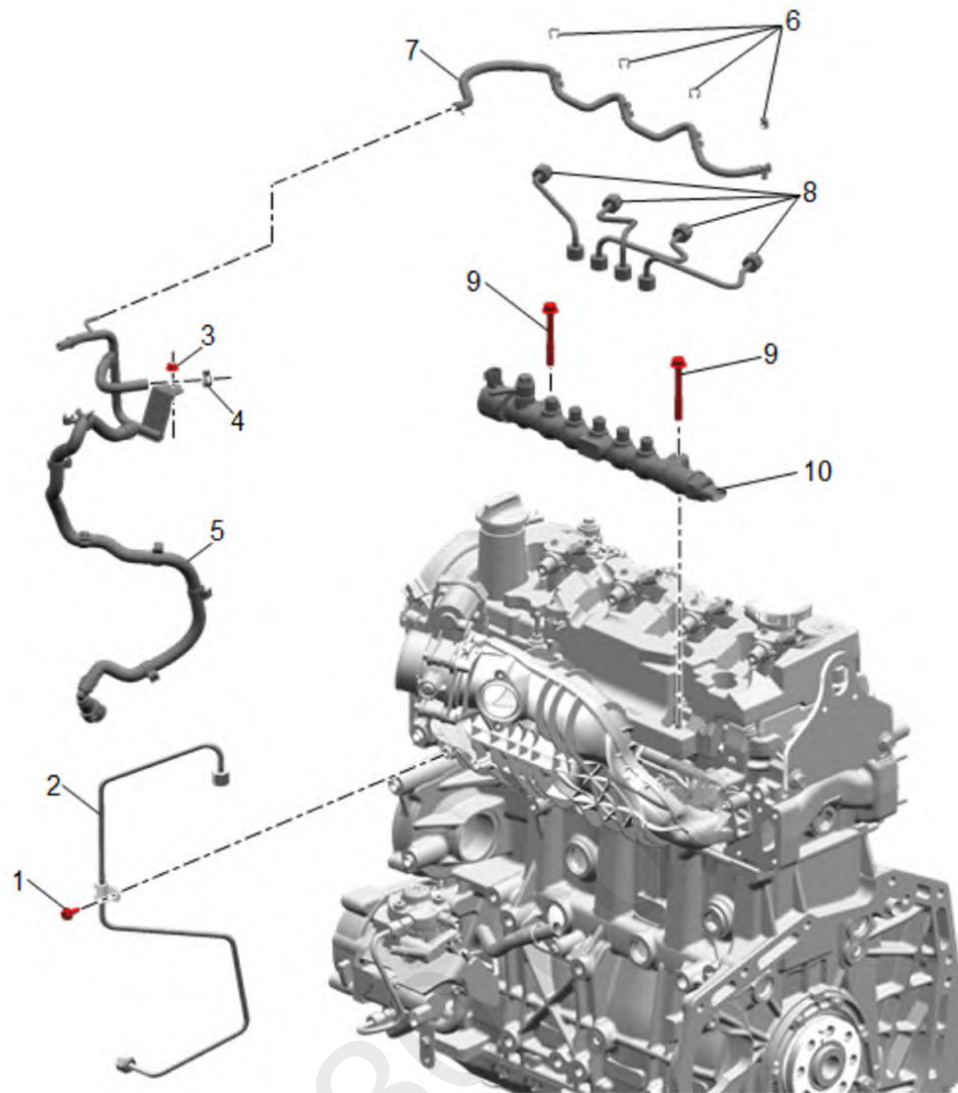


Fig. 36: Fuel Rail And Lines Components Location

Courtesy of GENERAL MOTORS COMPANY

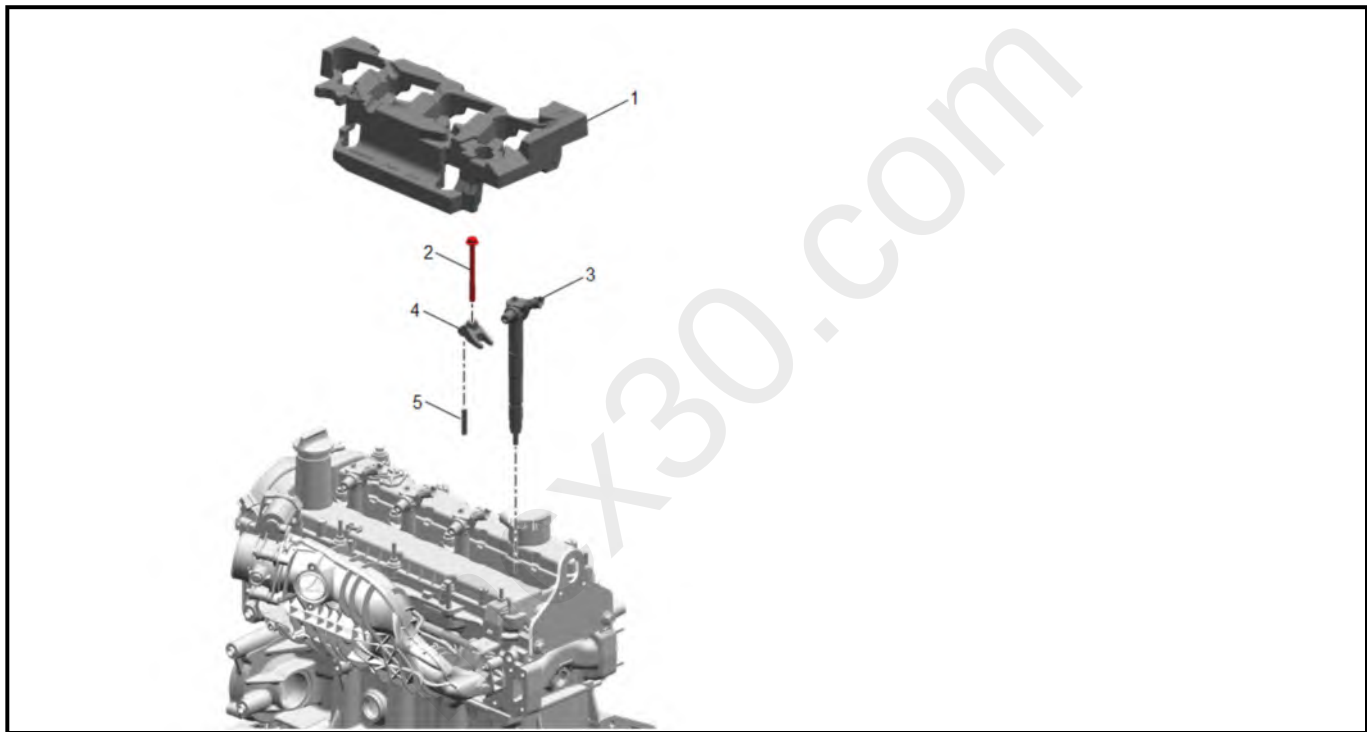
NOTE: Callouts in the following chart represent components shown in graphic above.

Fuel Rail and Lines Removal

Callout	Component Name
1	Fuel Feed Pipe Bolt
2	Fuel Feed Pipe NOTE: Discard after removal, High Pressure Pipes are not reusable.
3	Engine Wiring Harness Bracket Nut
4	Diesel Fuel Separator Hose Clamp
5	Diesel Fuel Separator
6	Fuel Injection Fuel Return Pipe Clip NOTE: Discard the clips, they

Callout	Component Name
	are not reusable.
7	Fuel Injection Fuel Return Pipe
8	Fuel Injector Fuel Feed Pipe NOTE: Discard after removal, High Pressure Pipes are not reusable.
9	Fuel Injection Fuel Feed Pipe Bracket Bolt
10	Direct Fuel Injection Fuel Rail

FUEL INJECTOR REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Fuel Injector Deadener
2	Fuel Injector Bracket Bolt NOTE: Clean debris from around the fuel injectors before removing to prevent contamination

Callout	Component Name
	from entering the cylinders.
3	Fuel Injector NOTE: • Be sure that the drift punch does not contact the injector bracket bolt threads. • The unique fuel injector flow rates are programmed into the ECM according to cylinder location. Mark the fuel injectors for correct re-installation to the same cylinders. Failure to do so may result in a poor drive-ability condition.
4	Fuel Injector Hold Down Clamp
5	Fuel Injector Locating Pin

INTAKE MANIFOLD REMOVAL

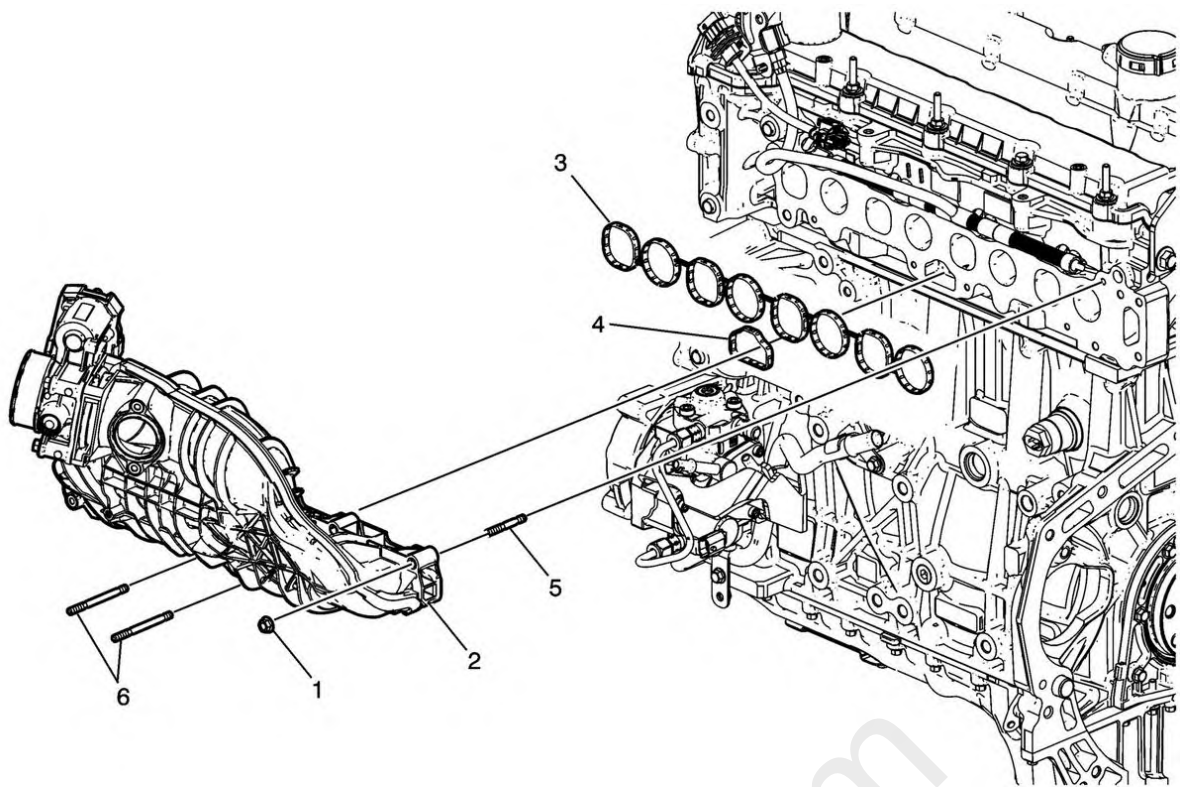


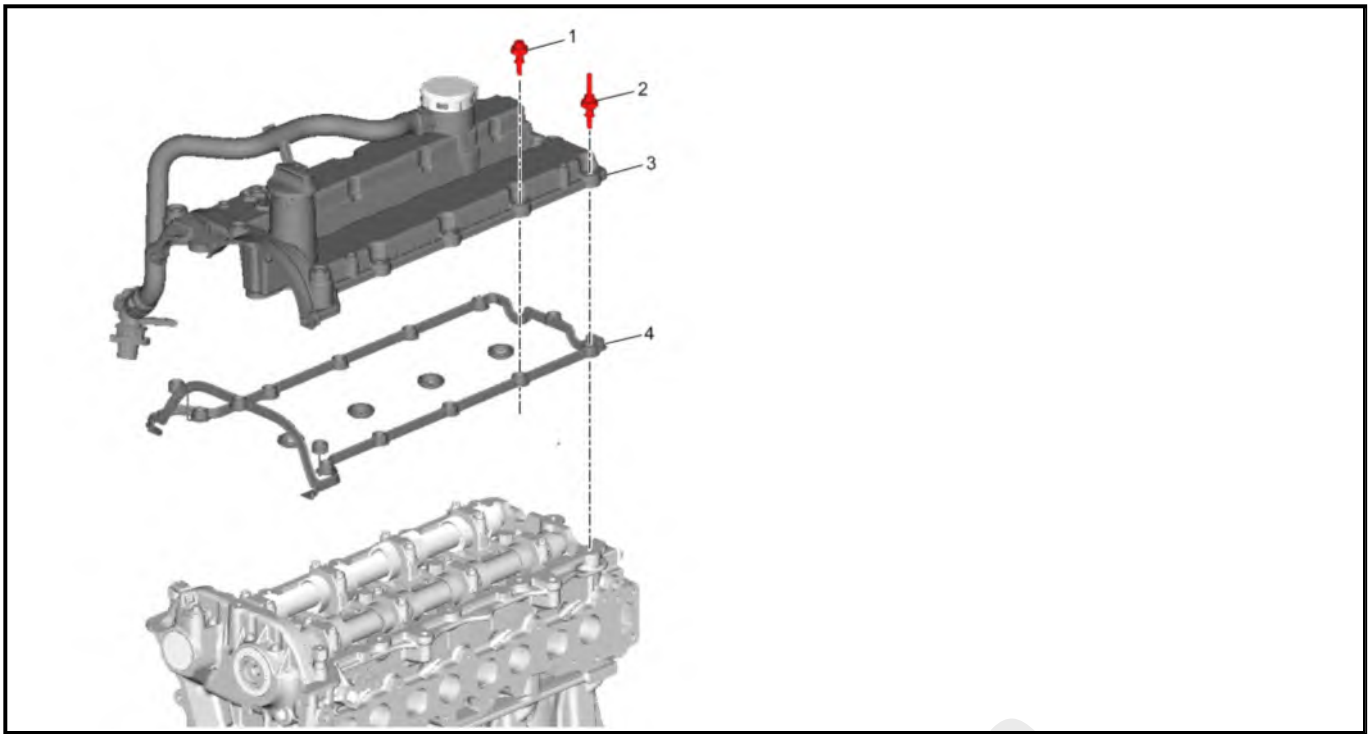
Fig. 37: Intake Manifold Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Intake Manifold Nut
2	Intake Manifold
3	Intake Manifold Gasket NOTE: Discard gasket, it is not reusable.
4	Intake Manifold Gasket NOTE: Discard gasket, it is not reusable.
5	Intake Manifold Stud
6	Intake Manifold Stud

VALVE ROCKER ARM COVER REMOVAL

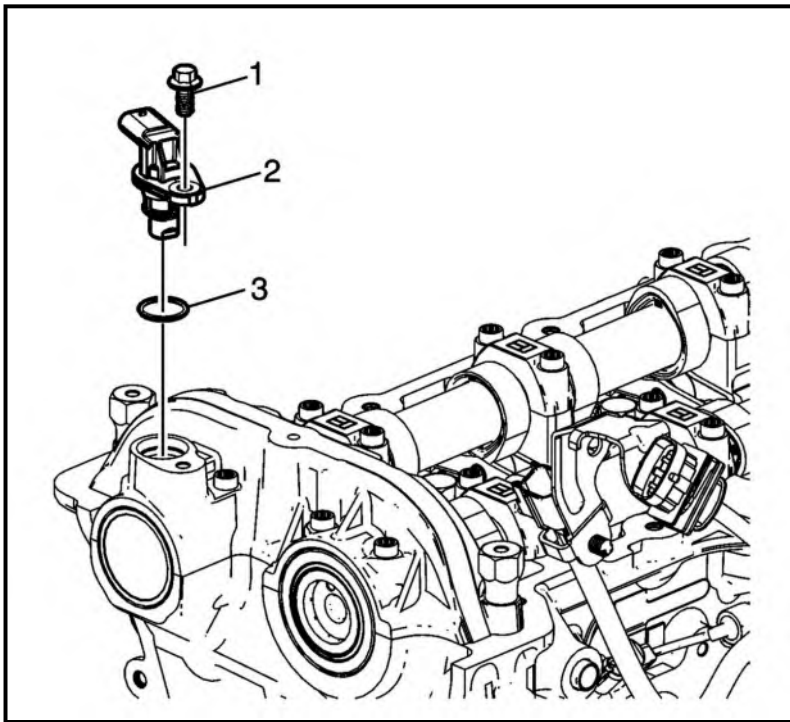


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Valve Rocker Arm Cover Bolt
2	Valve Rocker Arm Cover Stud
3	Valve Rocker Arm Cover NOTE: Do not cut or remove the PCV hose or clamps, it is a tamper proof system.
4	Valve Rocker Arm Cover Gasket NOTE: Discard gasket, it is not reusable.

CAMSHAFT REMOVAL

1. Remove the camshaft position sensor bolt (1) and sensor (2).



2. Remove and discard the camshaft position sensor seal (3).
3. Remove the camshaft cap bolts in sequence.

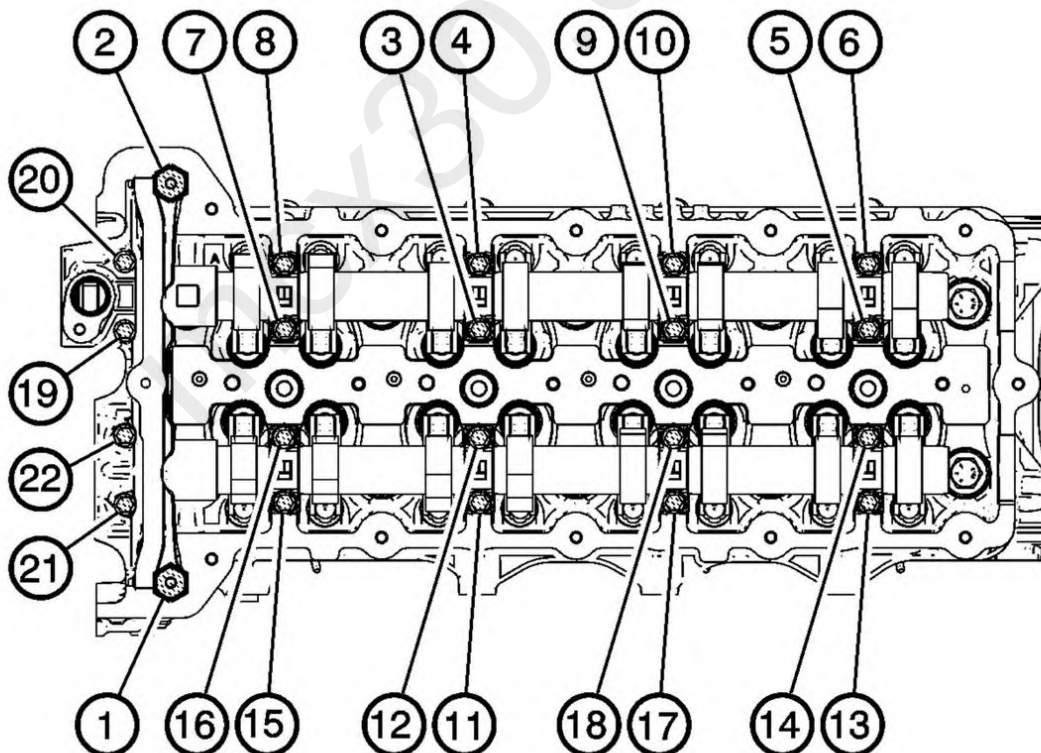
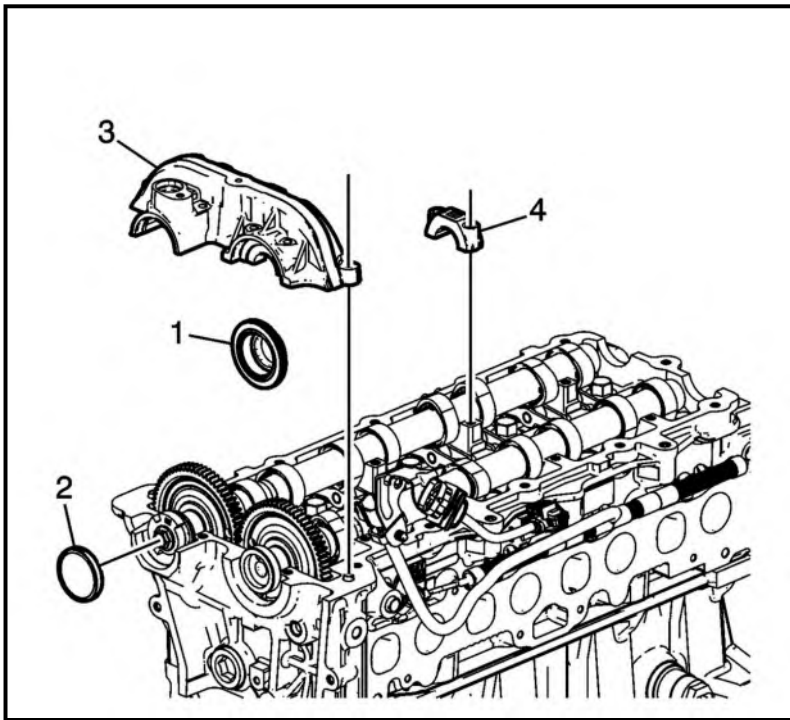


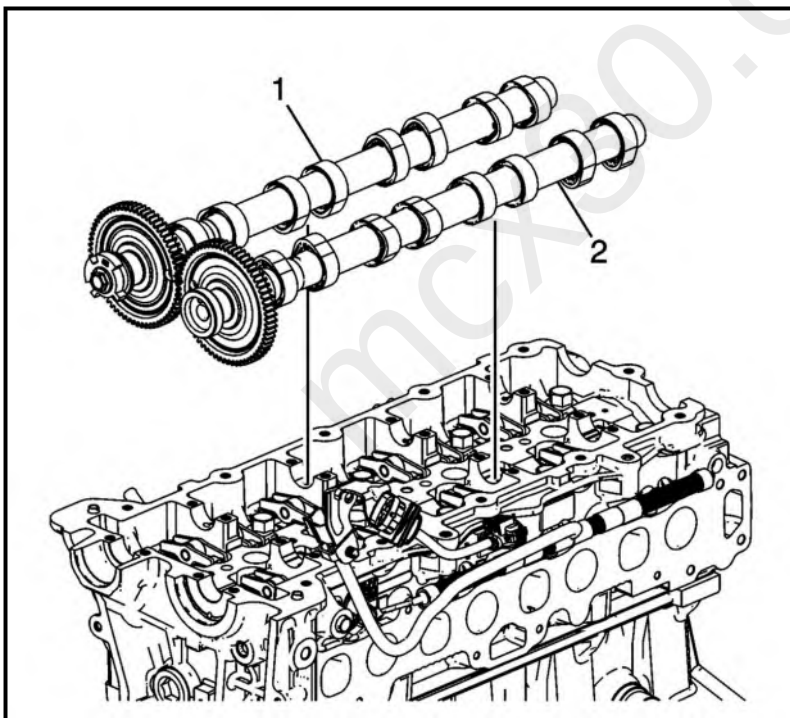
Fig. 38: Camshaft Cap Bolt Removal Sequence
 Courtesy of GENERAL MOTORS COMPANY

4. Remove the camshaft caps (3 - 4).

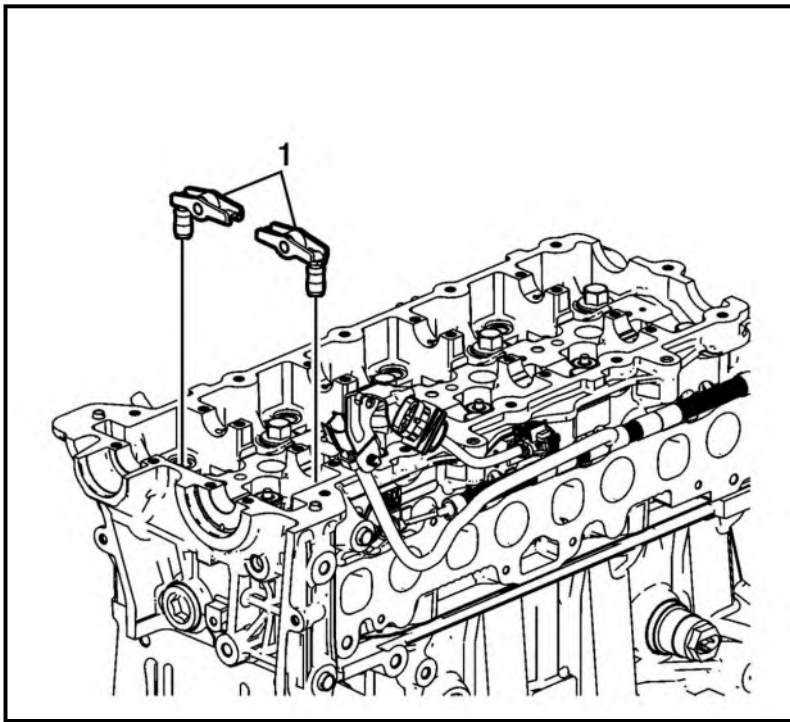


NOTE: Mark the camshaft caps before removal to ensure installation in their original location.

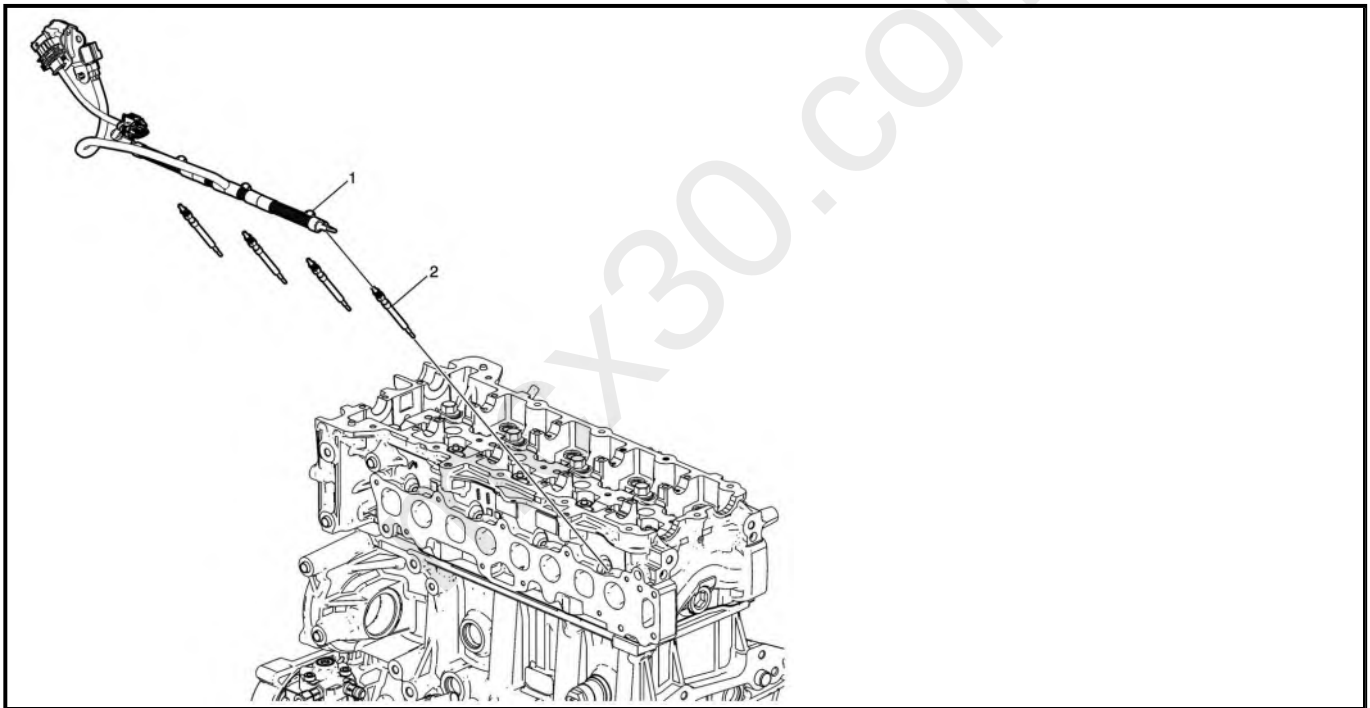
5. Remove the camshaft exhaust cap (2) and camshaft intake seal (1).
6. Remove the exhaust camshaft (1) and intake camshaft (2).



7. Remove the valve rocker arm and lifters (1) as an assembly.



GLOW PLUG REMOVAL

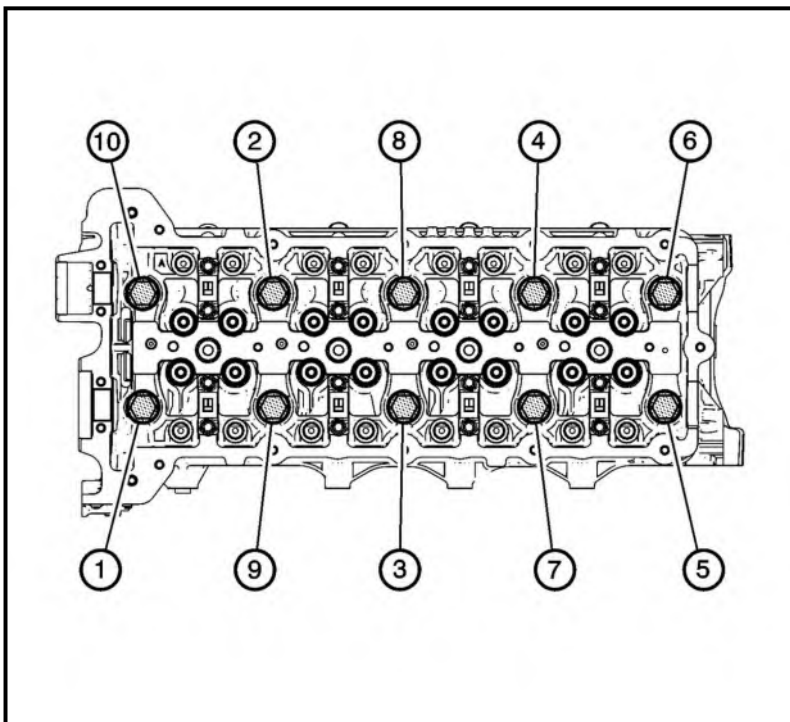


NOTE: Callouts in the following chart represent components shown in graphic above.

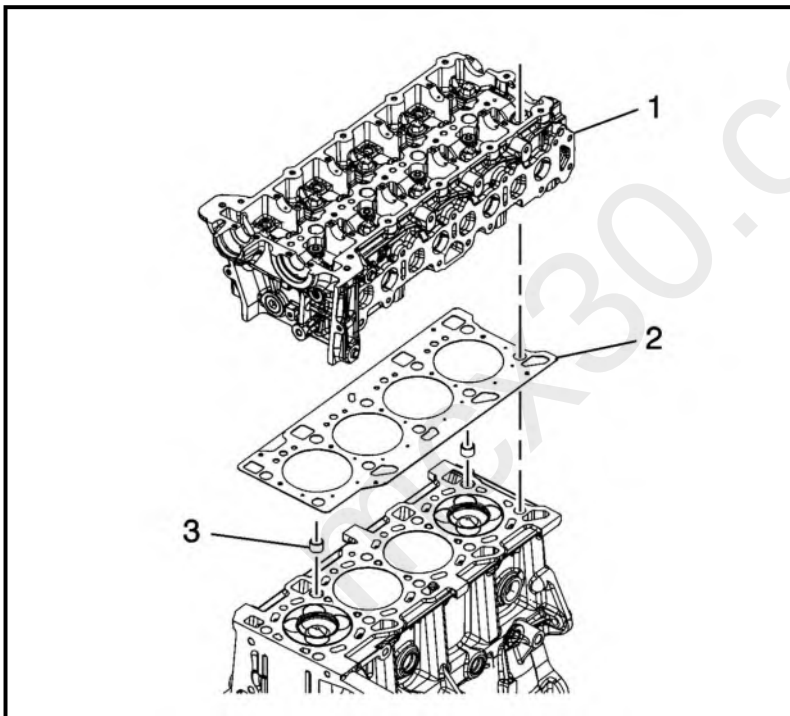
Callout	Component Name
1	Diesel Glow Plug Wiring Harness
2	Glow Plugs

CYLINDER HEAD REMOVAL

1. Remove the cylinder head bolts in sequence.



2. Remove the, cylinder head (1) and gasket (2).

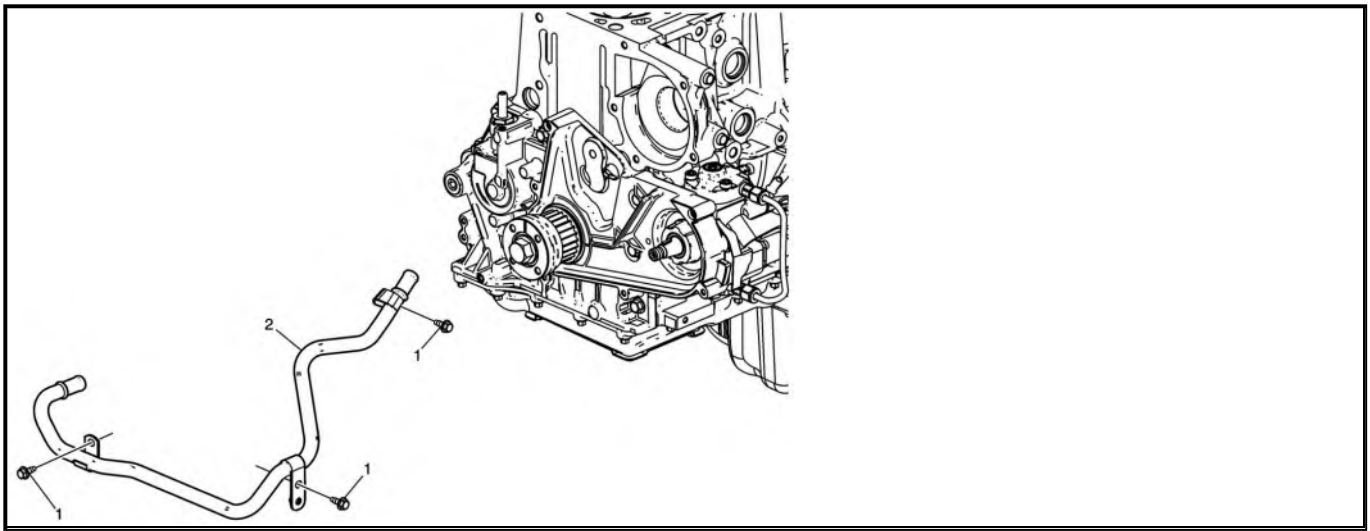


NOTE: Ensure that the glow plugs have all been removed before removing cylinder head.

3. Remove the cylinder head locating pins (3).

FUEL PUMP REMOVAL

Engine Oil Cooler Inlet Pipe Removal

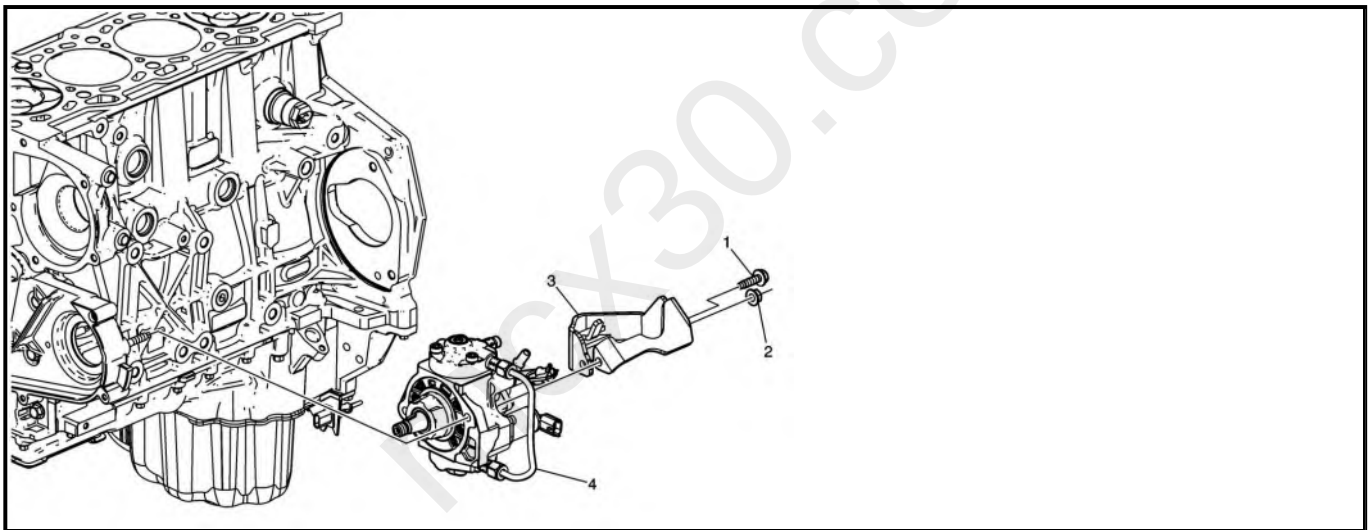


NOTE: Callouts in the following chart represent components shown in graphic above.

Engine Oil Cooler Inlet Pipe Removal

Callout	Component Name
1	Engine Oil Cooler Inlet Pipe Bolt
2	Engine Oil Cooler Inlet Pipe

Fuel Pump Removal

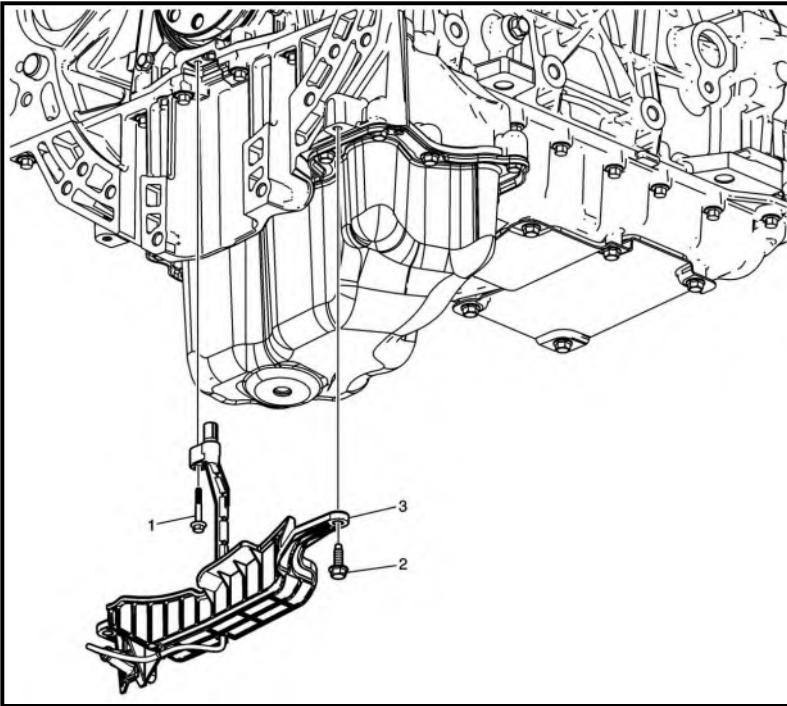


NOTE: Callouts in the following chart represent components shown in graphic above.

Fuel Pump Removal

Callout	Component Name
1	Fuel Pump Bolt
2	Fuel Pump Nut
3	Fuel Feed Hose Protector
4	Fuel Pump

CRANKSHAFT POSITION SENSOR REMOVAL

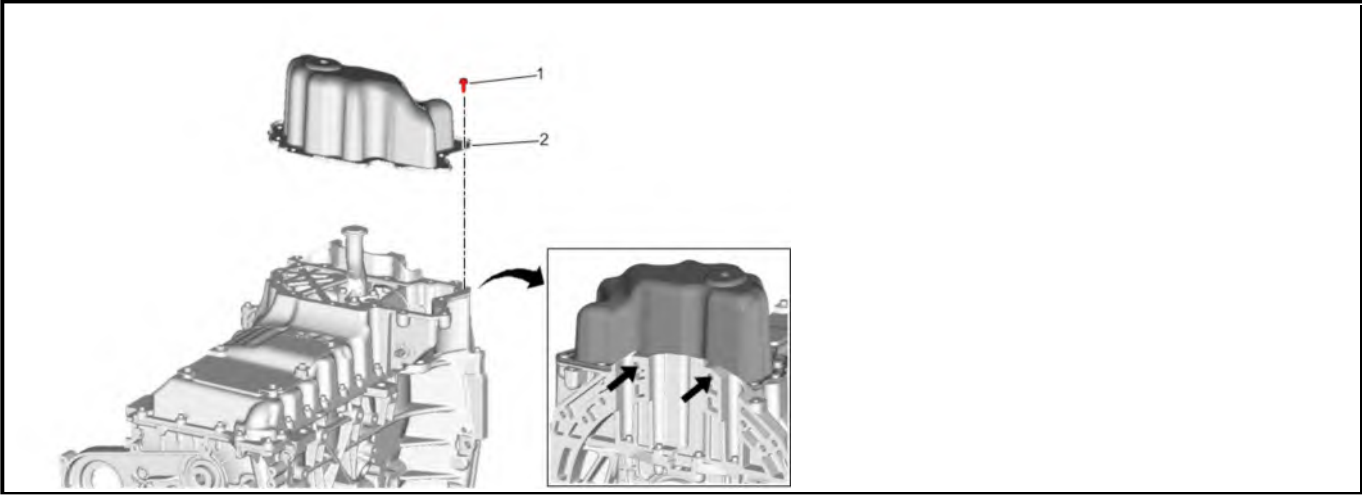


NOTE: Callouts in the following chart represent components shown in graphic above.

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

Callout	Component Name
3	Crankshaft Position Sensor

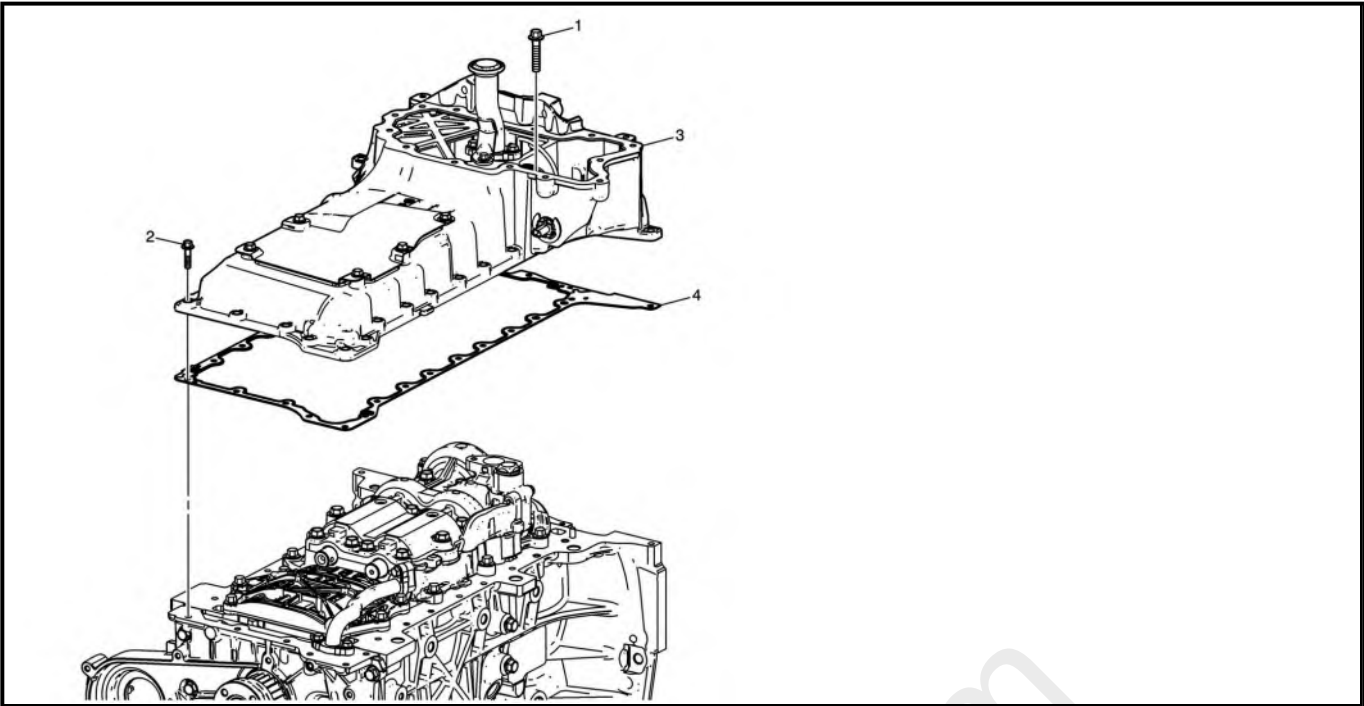
LOWER OIL PAN REMOVAL



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Lower Oil Pan Bolt
2	Lower Oil Pan NOTE: - Remove and DISCARD the bolts. - If the lower oil pan is difficult to remove. Then use two bolts and a shim to remove the oil pan. Thread the bolts through the indicated holes and hand tighten against the shim to break the seal.

UPPER OIL PAN REMOVAL

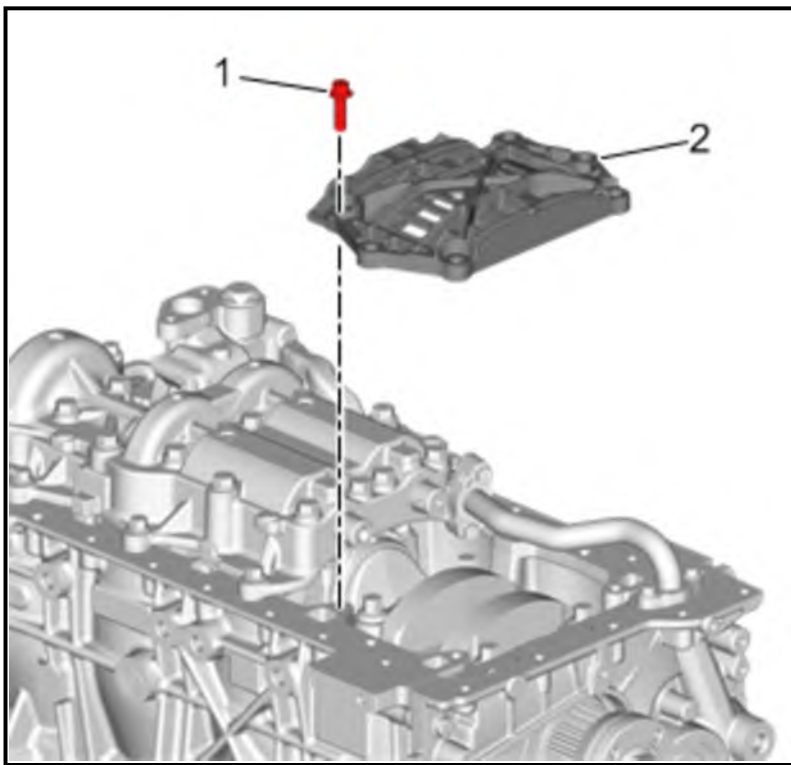


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Upper Oil Pan Bolt
2	Upper Oil Pan Bolt
3	Upper Oil Pan
4	Upper Oil Pan Gasket NOTE: DISCARD the gasket.

OIL PAN BAFFLE REMOVAL

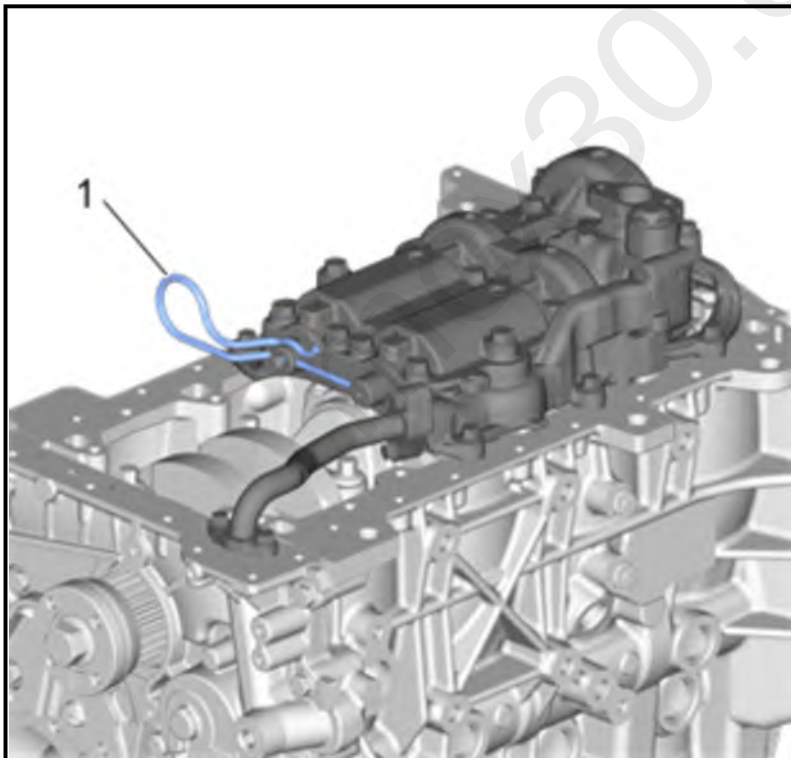
- 1. Remove the oil pan baffle bolts (1).



2. Remove the oil pan baffle (2).

BALANCER AND OIL PUMP REMOVAL

1. Install GM P/N 12628143 balancer shaft gear pin (1) on the balance shaft assembly.



NOTE:

- Install GM P/N 12628143 balancer shaft gear pin to the balancer shafts before removing the assembly to maintain timing and aid installation.
- If GM P/N 12628143 balancer shaft gear pin is not available, install a 4 - 5 mm dowel rod through the holes in both balancer shafts to maintain timing.

2. Remove the balance shaft assembly bolts in sequence shown.

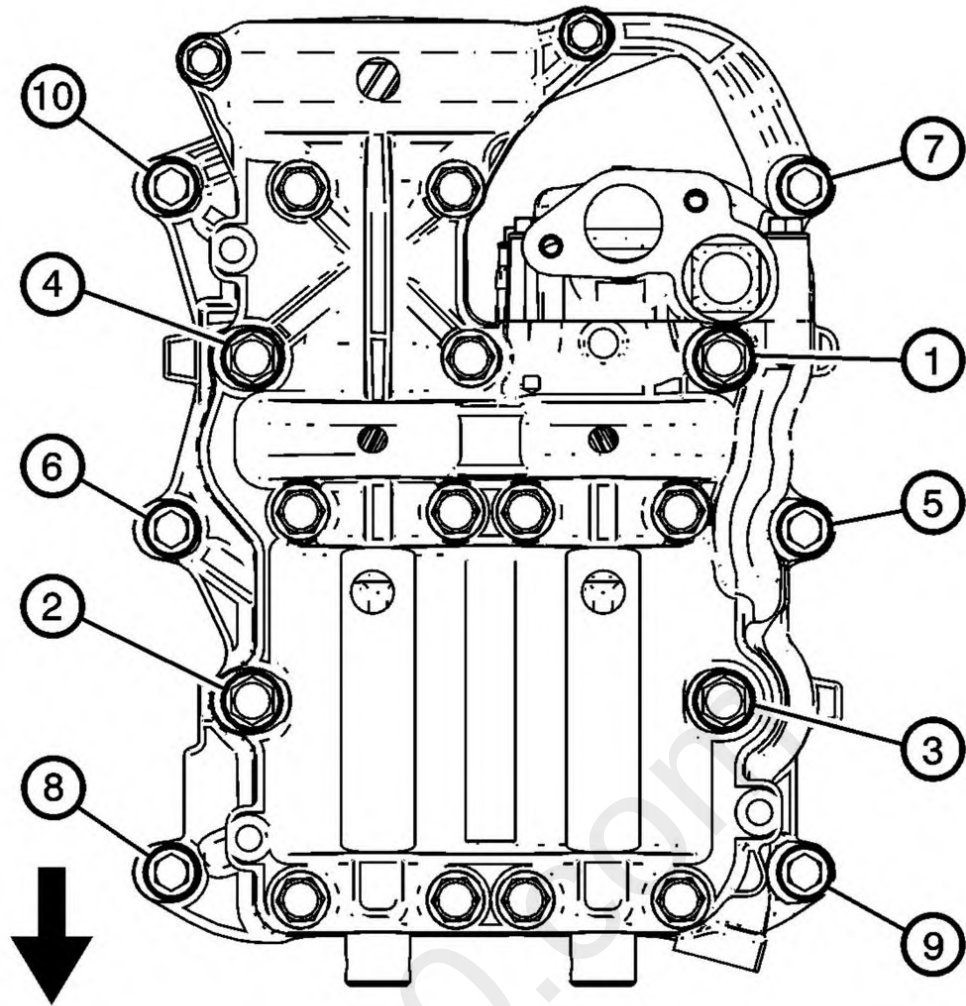
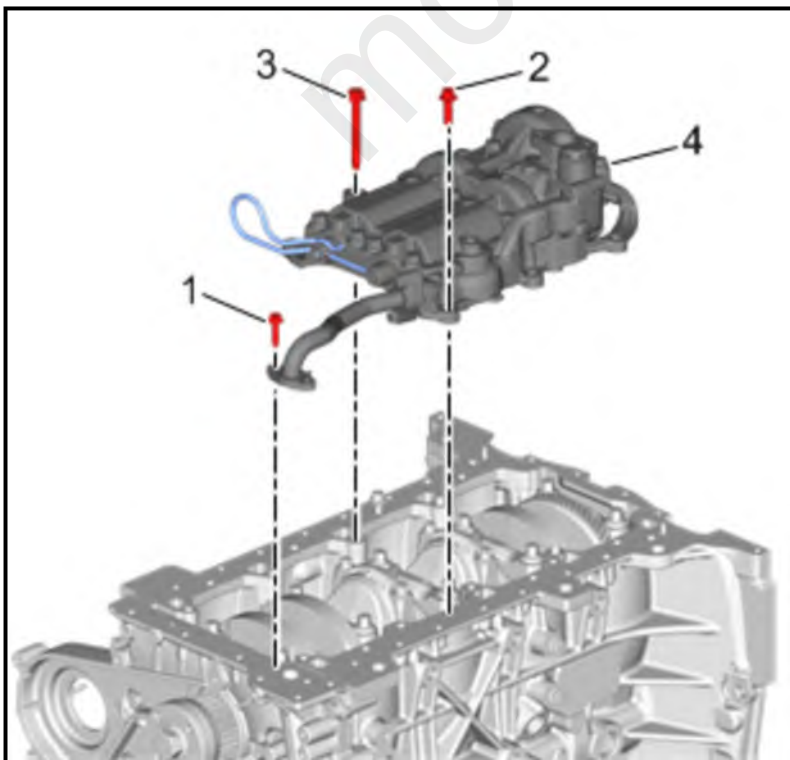


Fig. 39: Balance Shaft Assembly Bolt Removal Sequence

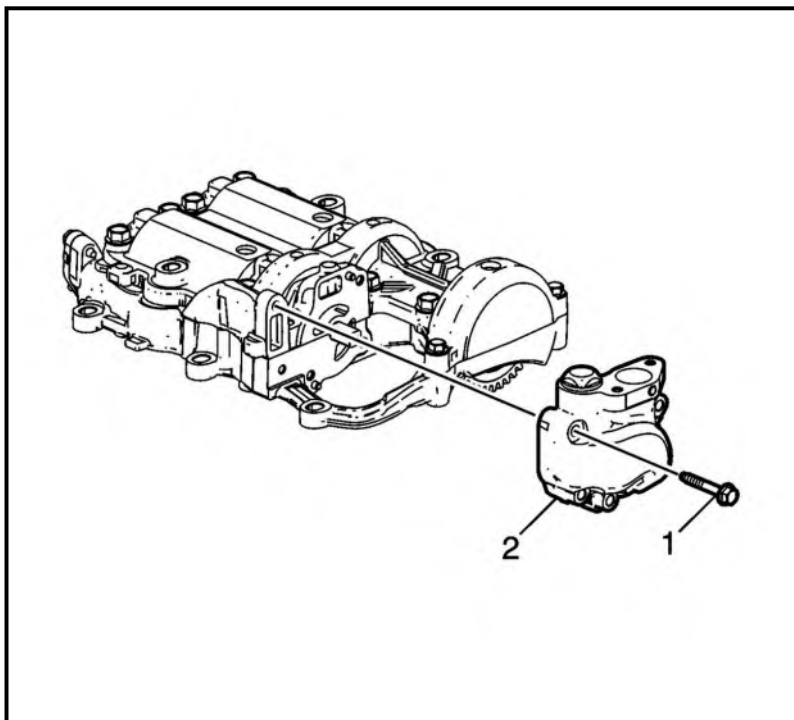
Courtesy of GENERAL MOTORS COMPANY

3. Remove the balance shaft assembly tube bolts (1) and balance shaft assembly (4).



OIL PUMP REMOVAL

1. Remove the oil pump bolts (1)



2. Remove the oil pump (2)

ENGINE FRONT COVER REMOVAL

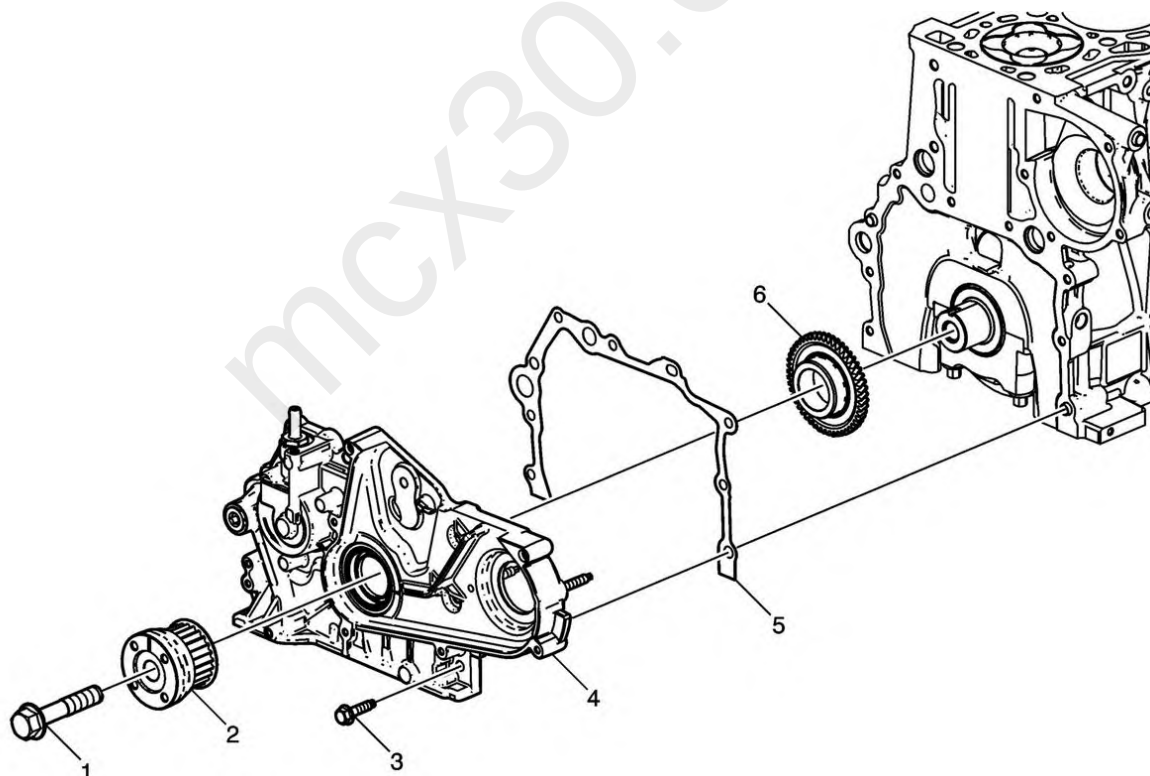


Fig. 40: Engine Front Cover Components Location

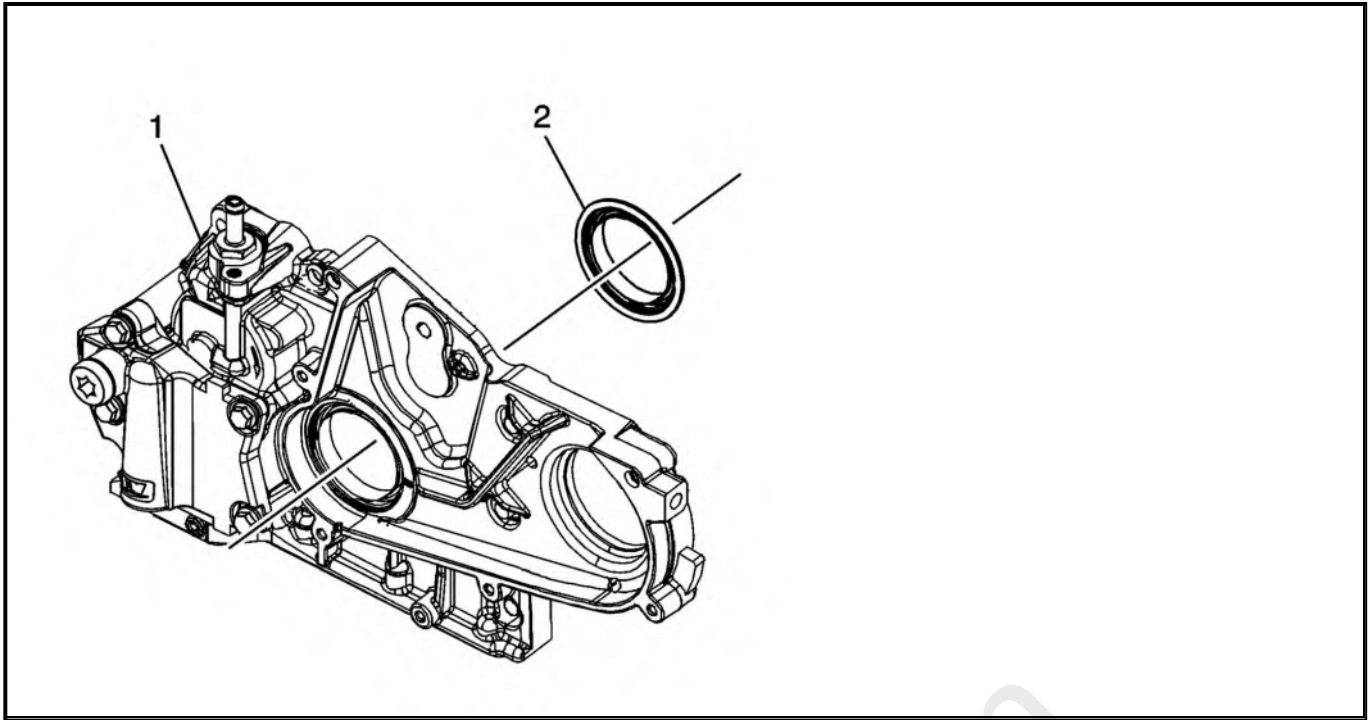
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Crankshaft Sprocket Bolt

Callout	Component Name
	CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: The crankshaft sprocket bolt is left hand thread. The keyway in the crankshaft should match up with the crankshaft sprocket and result in 90 B° ATDC.
2	Crankshaft Sprocket
3	Engine Front Cover Bolt
4	Engine Front Cover
5	Engine Front Cover Gasket
	NOTE: DISCARD the gasket.
6	Vacuum Pump Gear

CRANKSHAFT FRONT OIL SEAL REMOVAL



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

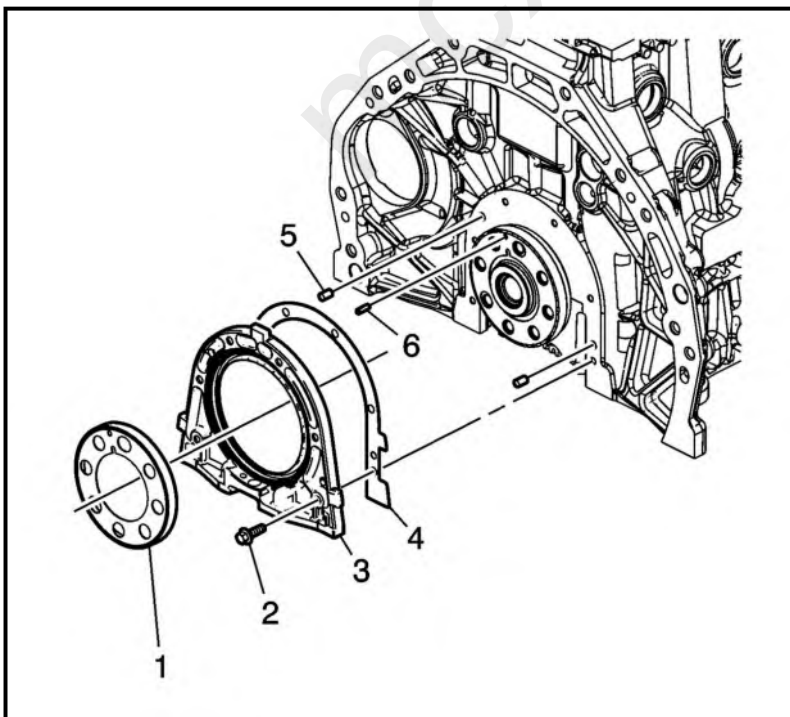
CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

Special Tools

- EN-50026 Rear Main Seal Installer
- GE-8092 Driver Handle

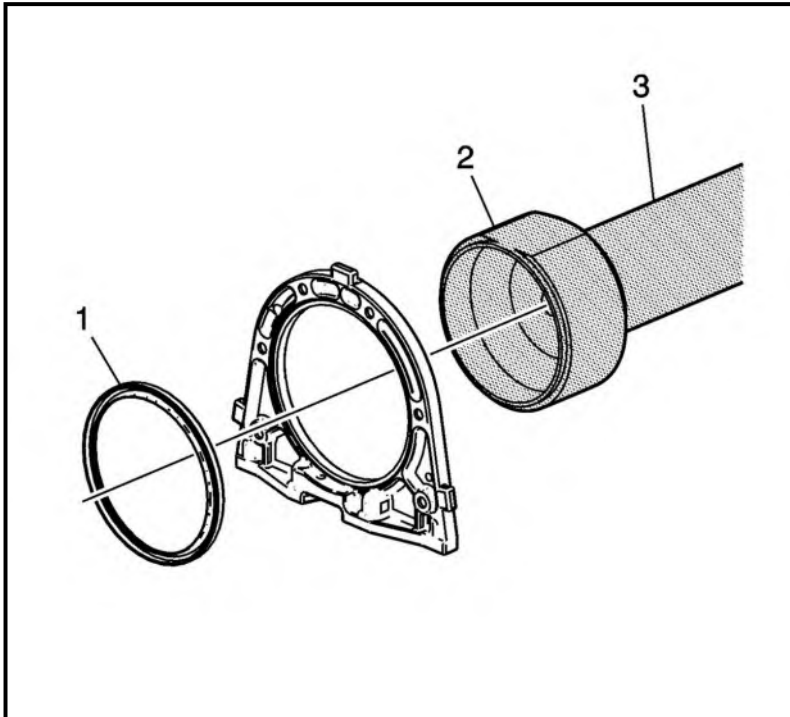
For equivalent regional tools, refer to [Special Tools](#)

1. Remove the crankshaft position sensor excitor ring (1) and locating pin (6).



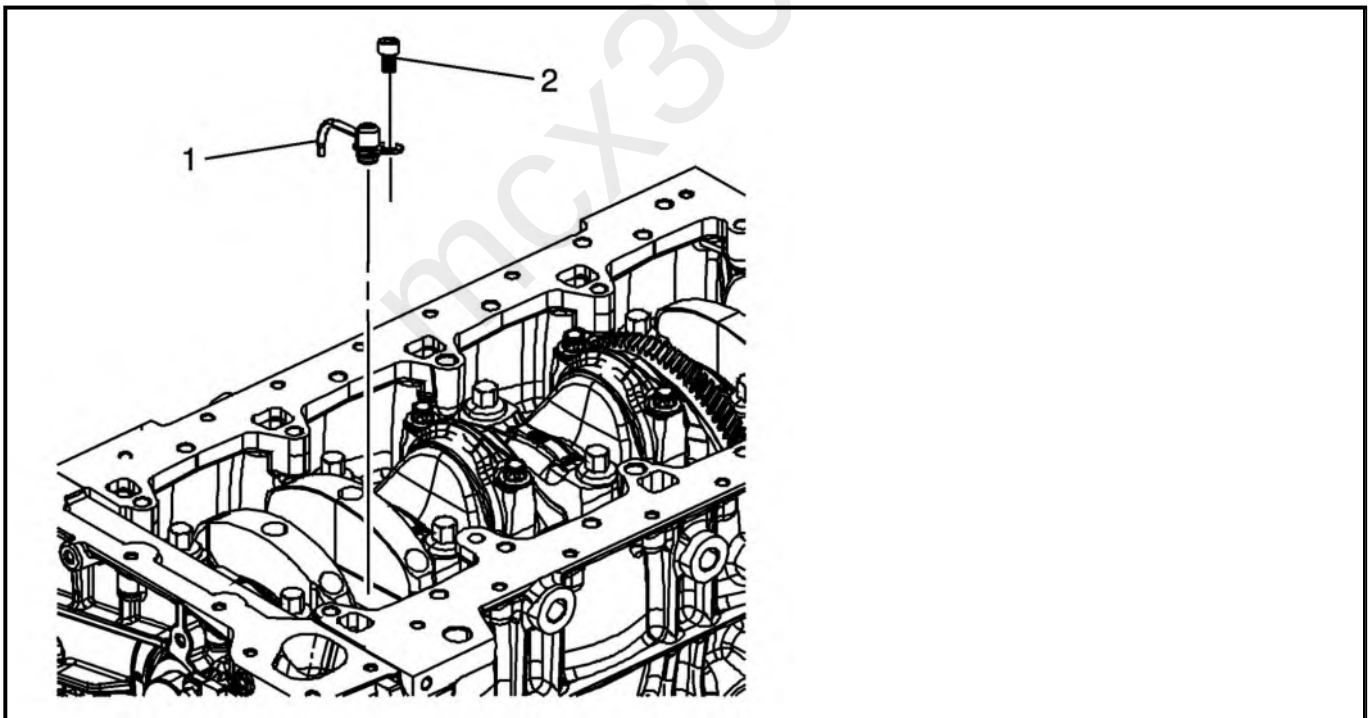
2. Remove the rear oil seal housing bolts (2) and seal housing (3).
3. Remove the rear oil seal housing gasket (4).

4. Remove the rear oil seal housing locating pins (5).
5. Remove the crankshaft rear oil seal (1) using the **EN-50026** installer (2) and **GE-8092** handle (3).



NOTE: The crankshaft rear oil seal must be driven out from the engine block side of the housing.

PISTON OIL NOZZLE REMOVAL



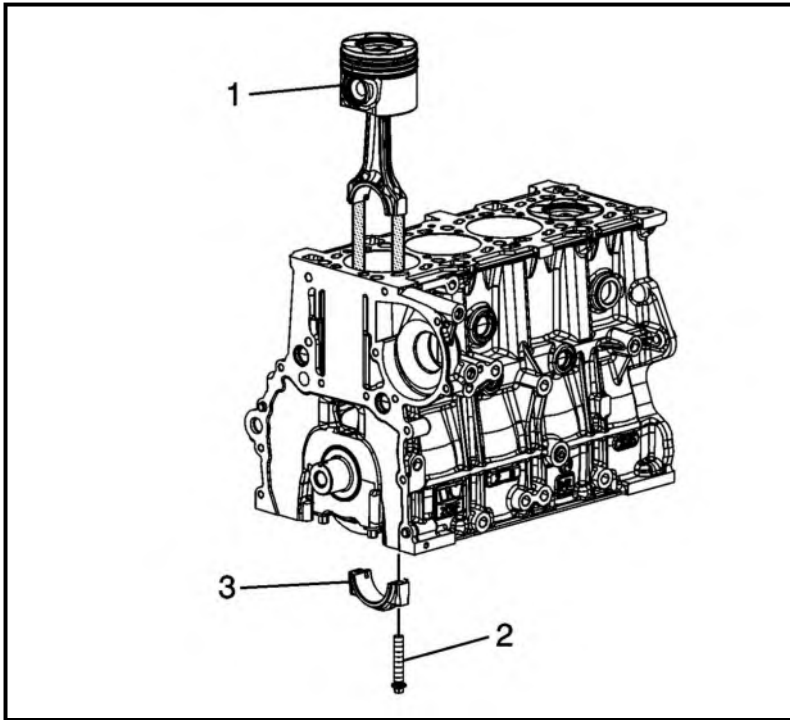
Remove the piston oil cooling nozzle bolt (2) and nozzle (1).

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

EN-50034 Connecting Rod Guides

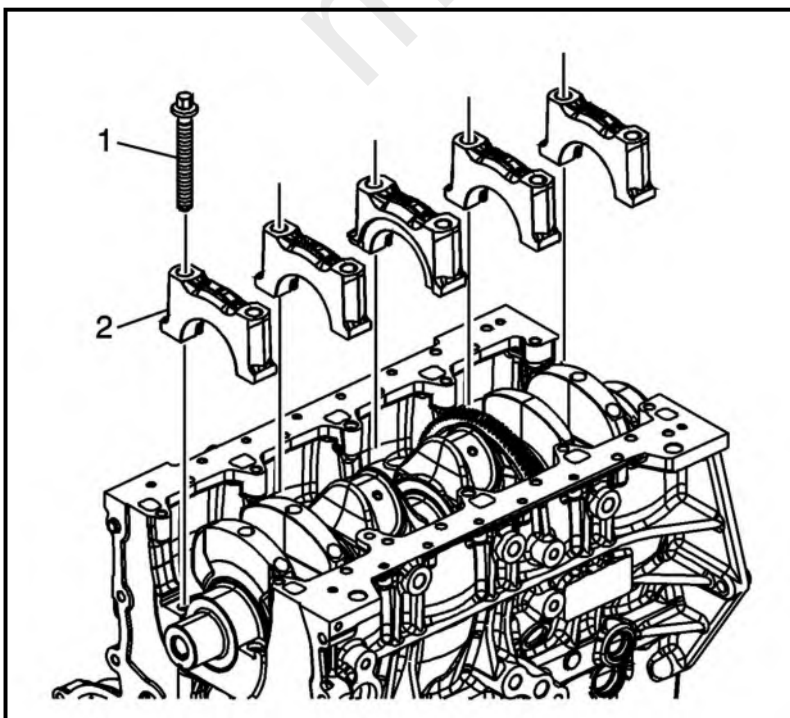
1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.



2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove the connecting rod bolts (2).
5. Remove the connecting rod cap (3).
6. Install **EN-50034** guides on the connecting rod bolts before removing the piston and connecting rod assembly.
7. Remove the piston and connecting rod assembly (1).

CRANKSHAFT AND BEARING REMOVAL

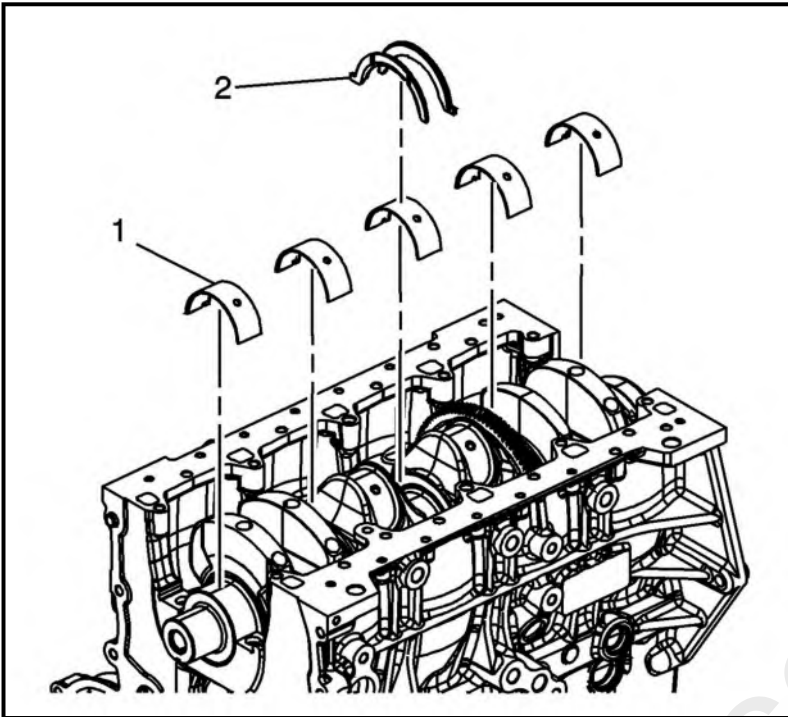
1. Remove the crankshaft bearing cap bolts (1) and caps (2).



NOTE:

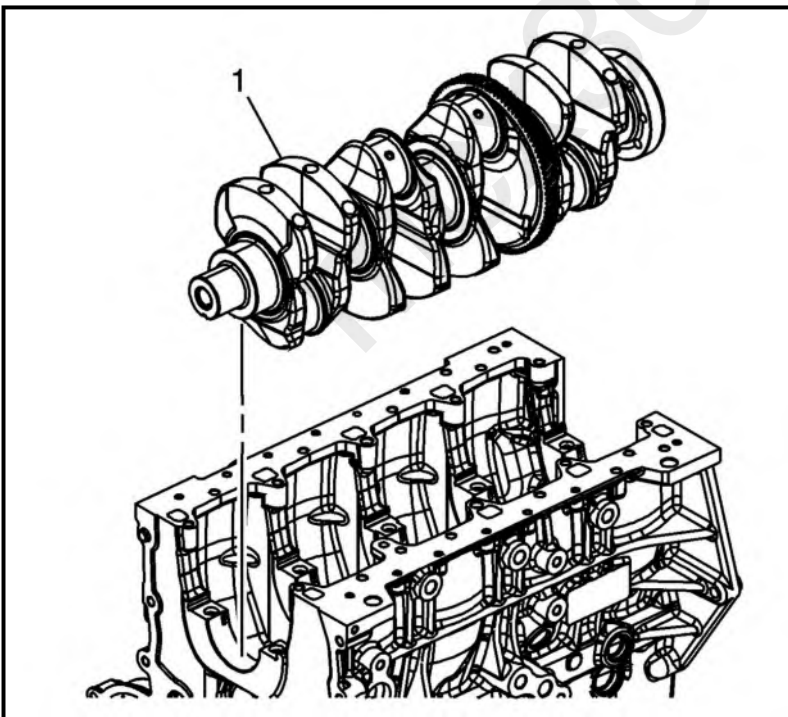
The number 3 main bearing cap can be loosened by installing a drift punch to the main cap bolt bore and working back and forth toward the left and right sides of the engine.

2. Remove the lower thrust bearings (2).

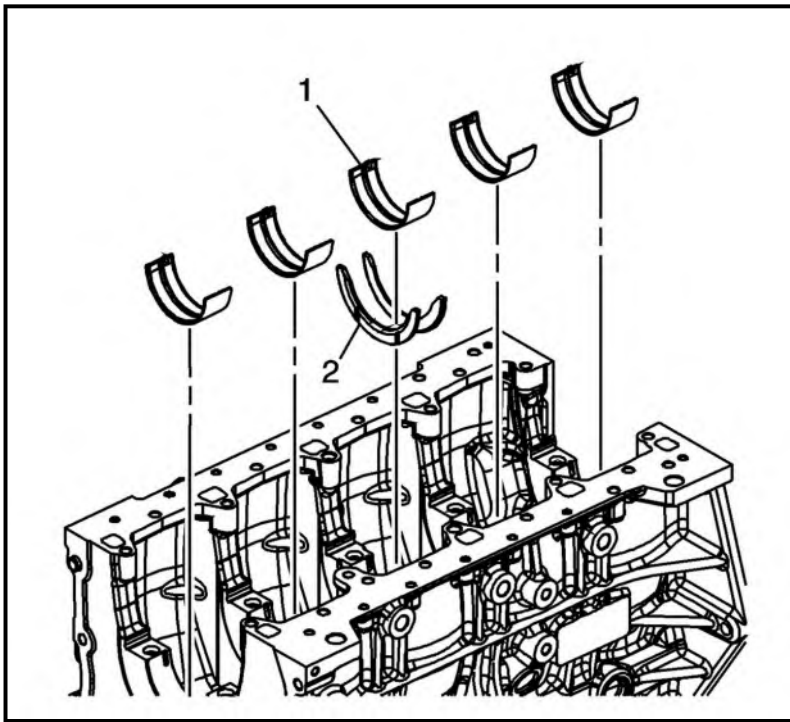


3. Remove the lower crankshaft bearings (1).

4. Remove the crankshaft (1).



5. Remove the upper crankshaft bearings (1) and thrust bearings (2).



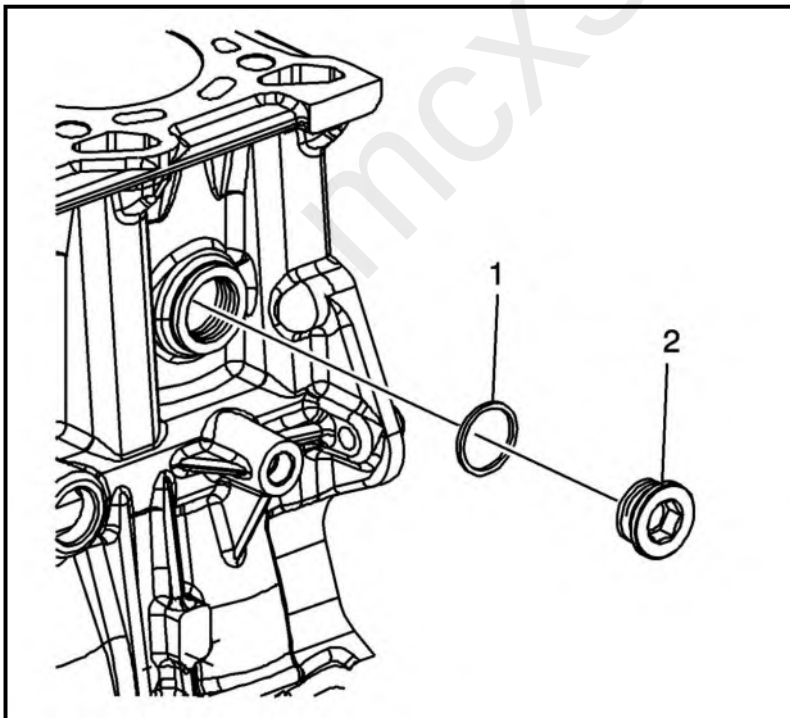
ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

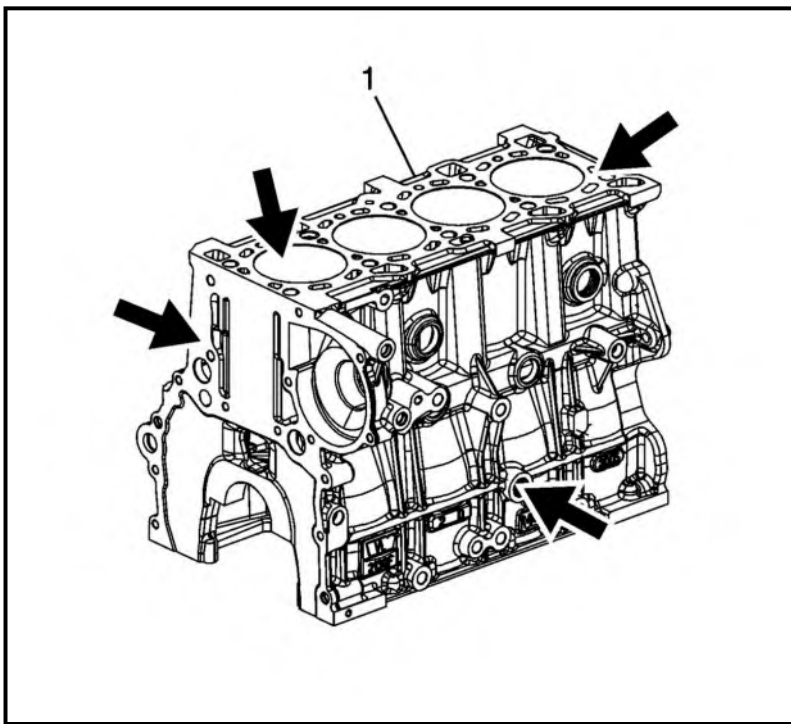
- **J-7872** Magnetic Base Dial Indicator
- **J-8087** Cylinder Bore Gauge

Equivalent regional tools: **Special Tools**

1. Remove the engine block plugs (2) and seals (1).



2. Clean the sealing material from the gasket mating surfaces.



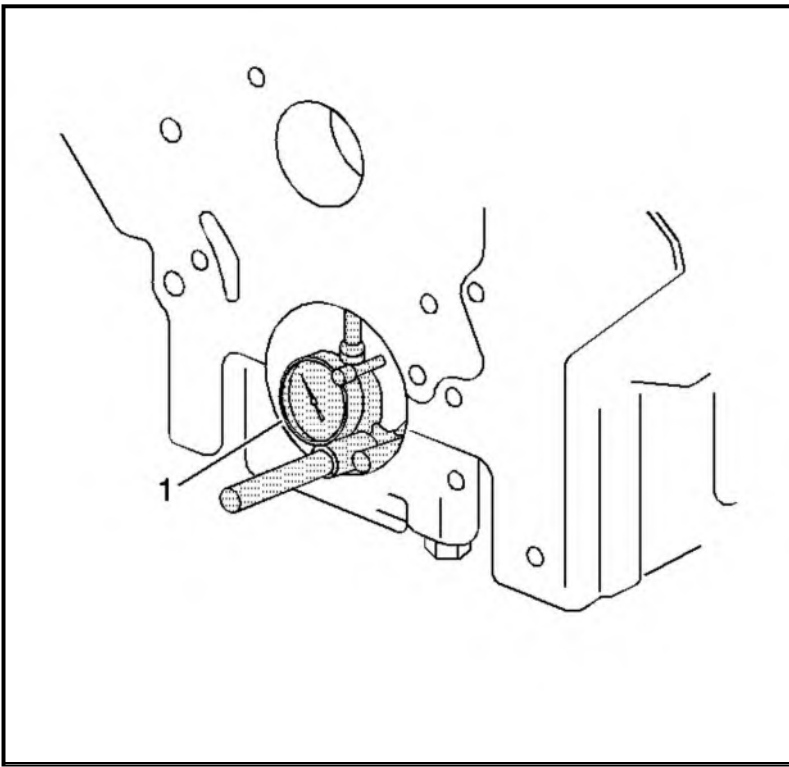
3. Clean the engine block (1) and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
4. Flush the engine block with clean water or steam.
5. Clean the oil passages.
6. Clean the blind holes.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. **Thread Repair**

NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

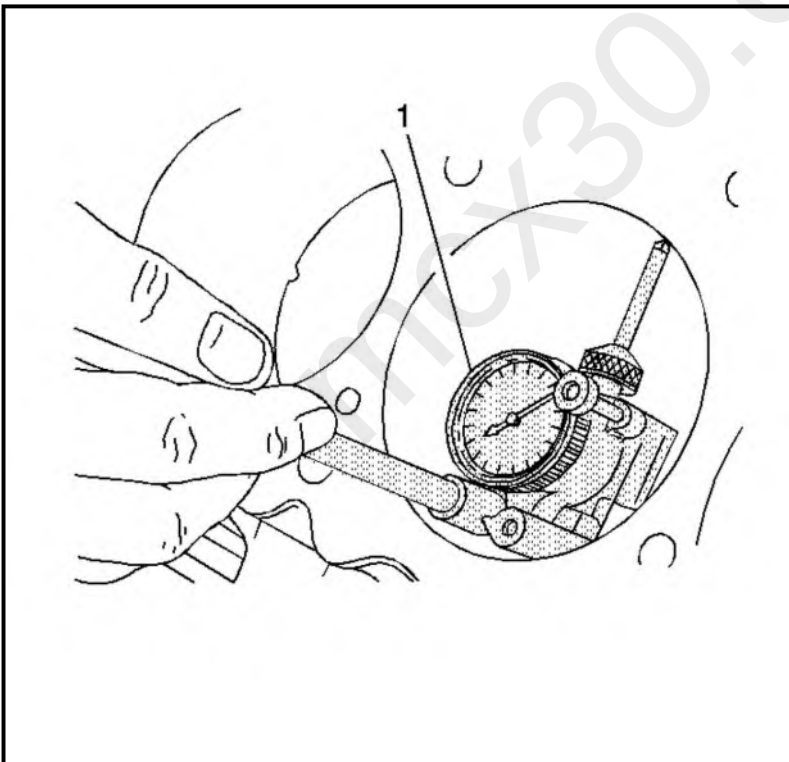
9. Use a straight edge and a feeler gauge to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
10. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.
11. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side.
12. Inspect the mating surfaces of the transmission face.

CAUTION: A broken flywheel may result if the transmission case mating surface is not flat.

13. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
 1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **J 7872** indicator.
 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.
14. Install the main bearing caps and bolts. Tighten the main bearing cap bolts to specification.



15. Inspect the crankshaft main bearing bores. Use the **J-8087** gauge (1) to measure the bearing bore concentricity and alignment. Refer to [Engine Mechanical Specifications](#).
16. Replace the engine block if the crankshaft bearing bores are out of specification.
17. Inspect the cylinder bores using the **J-8087** gauge (1). Inspect for the following items:



- Wear
- Taper
- Runout
- Ridging

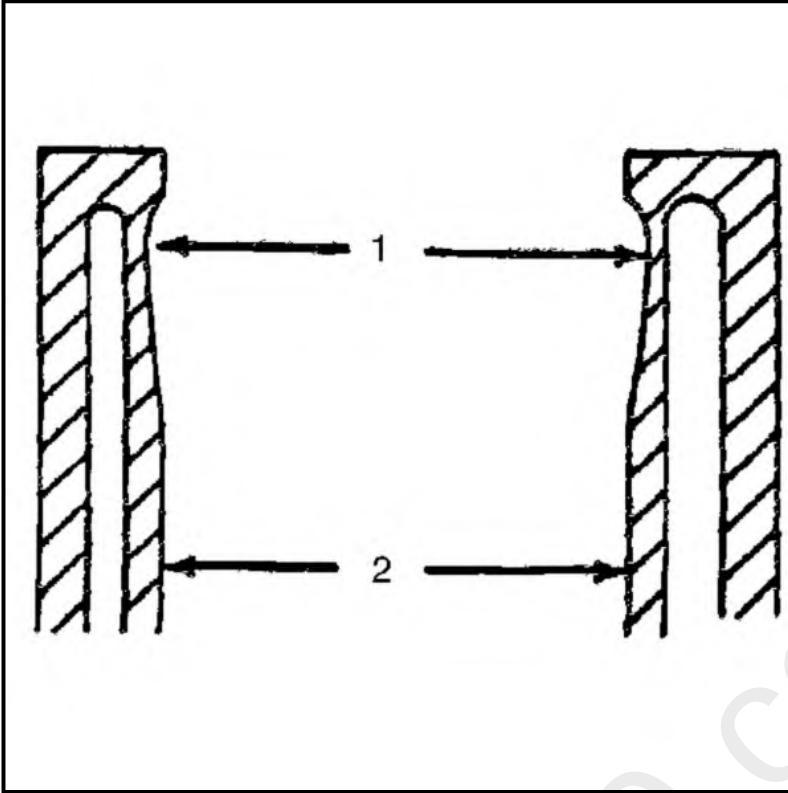
CYLINDER HONING

Special Tools

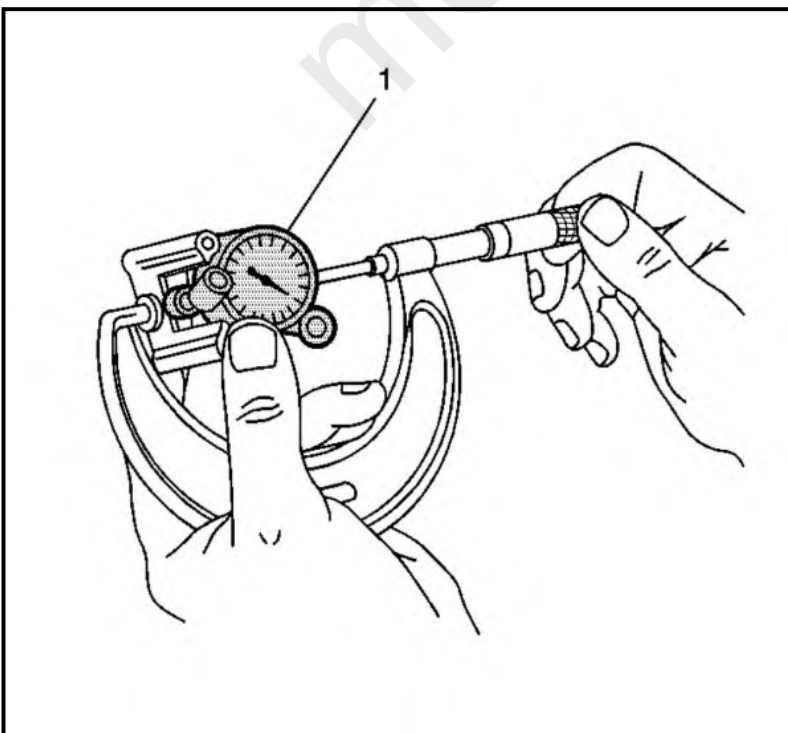
J-8087 Cylinder Bore Gauge

Equivalent regional tools: [Special Tools](#)

1. Measure the cylinder bore for out-of-round and taper.



2. Measure dimension (1) at 13 mm (0.5 in) below the head gasket surface. Measure dimension (2) at 100 mm (4 in) below the head gasket surface.
3. Measure the cylinder bores by setting the **J-8087** gauge (1) dial at zero in the cylinder at the point of the desired measurement. Lock the dial indicator at zero before removing the dial from the cylinder. Measure across the gauge contact points with an outside micrometer, with the gauge at the same zero setting as when the gauge was removed from the cylinder.

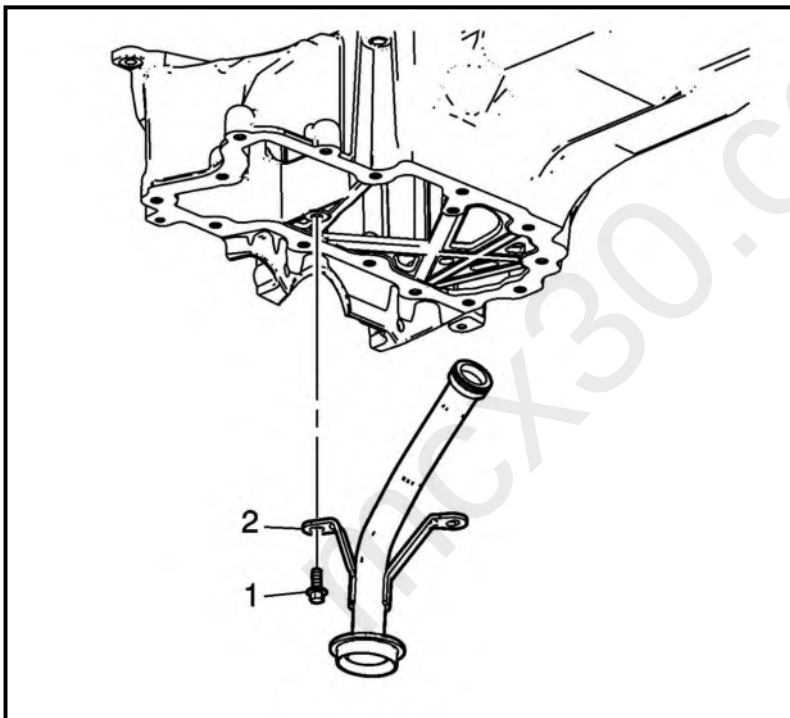


4. Fine vertical scratches made by the ring ends do not, by themselves, cause excessive oil consumption. Do not hone the cylinder in order to remove these scratches.
5. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. **Piston, Connecting Rod, and Bearing Installation**
 1. The honing stones must be clean, sharp, and straight.
 2. Move the hone slowly up and down to produce a 45 degree cross-hatch pattern.
 3. Clean the bore thoroughly with soap and water.
 4. Dry the bore.
 5. Rub clean engine oil in the bore.
 6. Re-measure the bore.
6. If the cylinder bore is out of specification, replace the block.
7. If honing is not required, clean the cylinder bores with hot water and detergent. Apply clean engine oil to the bore after washing and drying the bore.

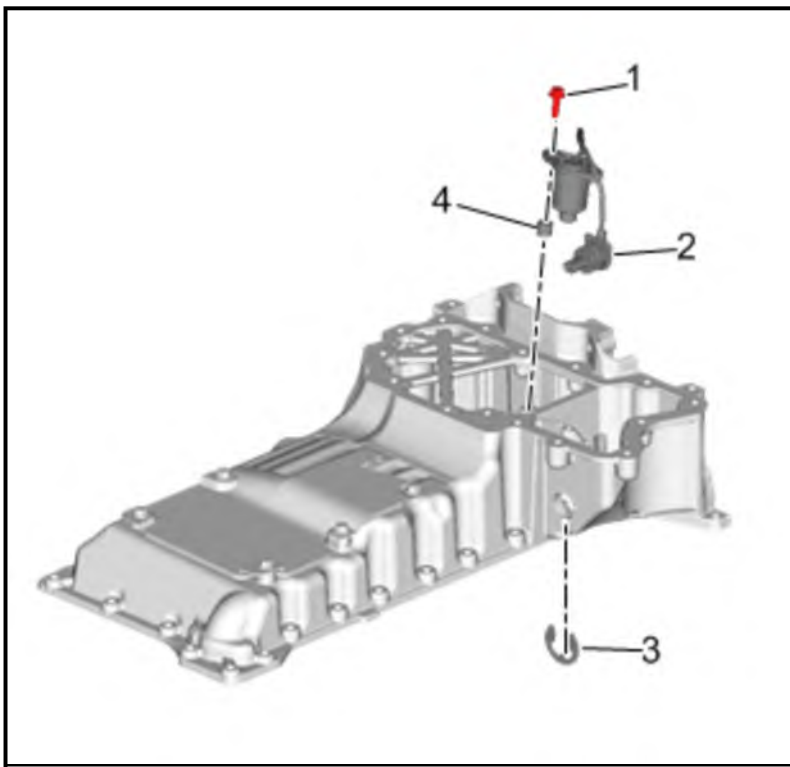
UPPER OIL PAN CLEANING AND INSPECTION (LWN)

Disassemble

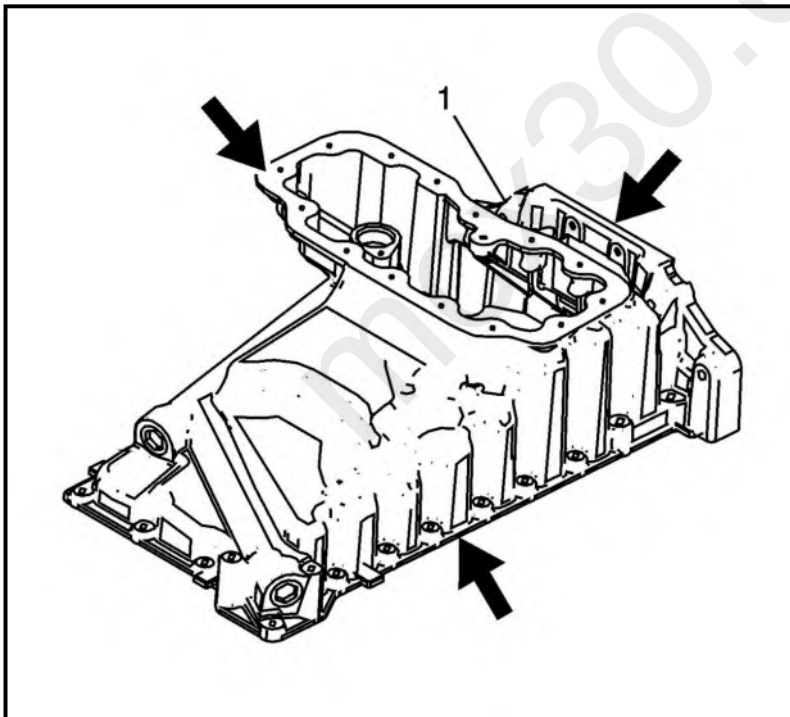
1. Remove the oil pump suction pipe bolts (1).



2. Remove the oil pump suction pipe (2).
3. Remove the oil level switch retainer (3).



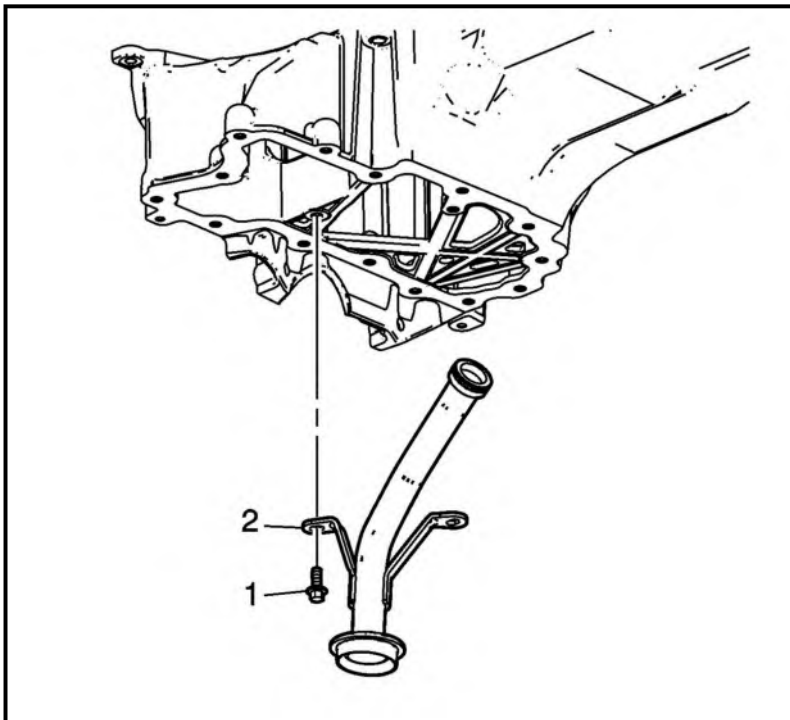
4. Remove the oil level switch bolts [2x] (1).
5. Remove the oil level switch (2) and spacers [2x] (4).
6. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)



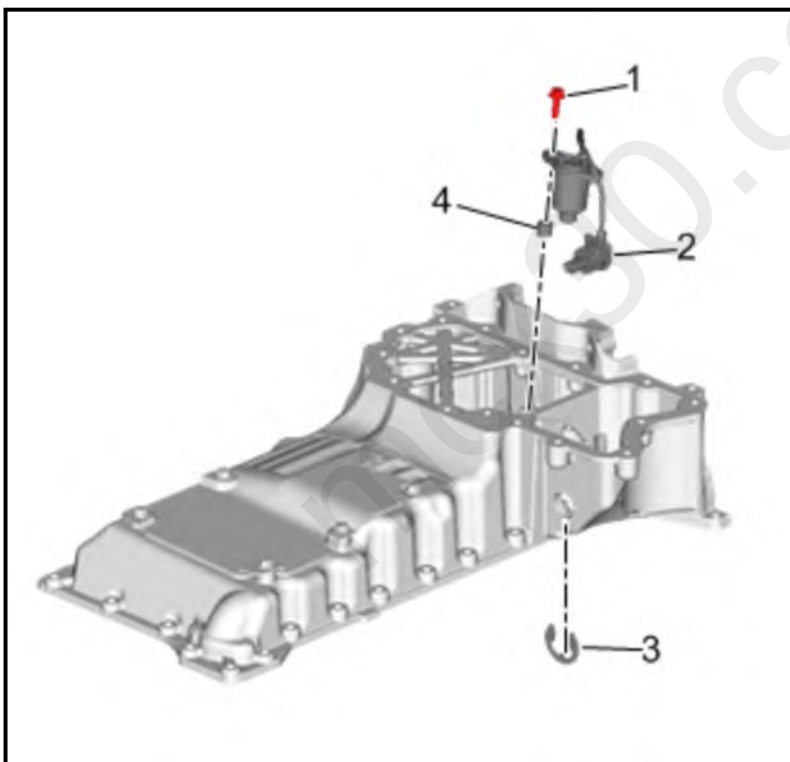
7. Clean the sealing material from the gasket mating surfaces on the upper oil pan (1).

Assemble

1. Install the oil pump suction pipe (2).

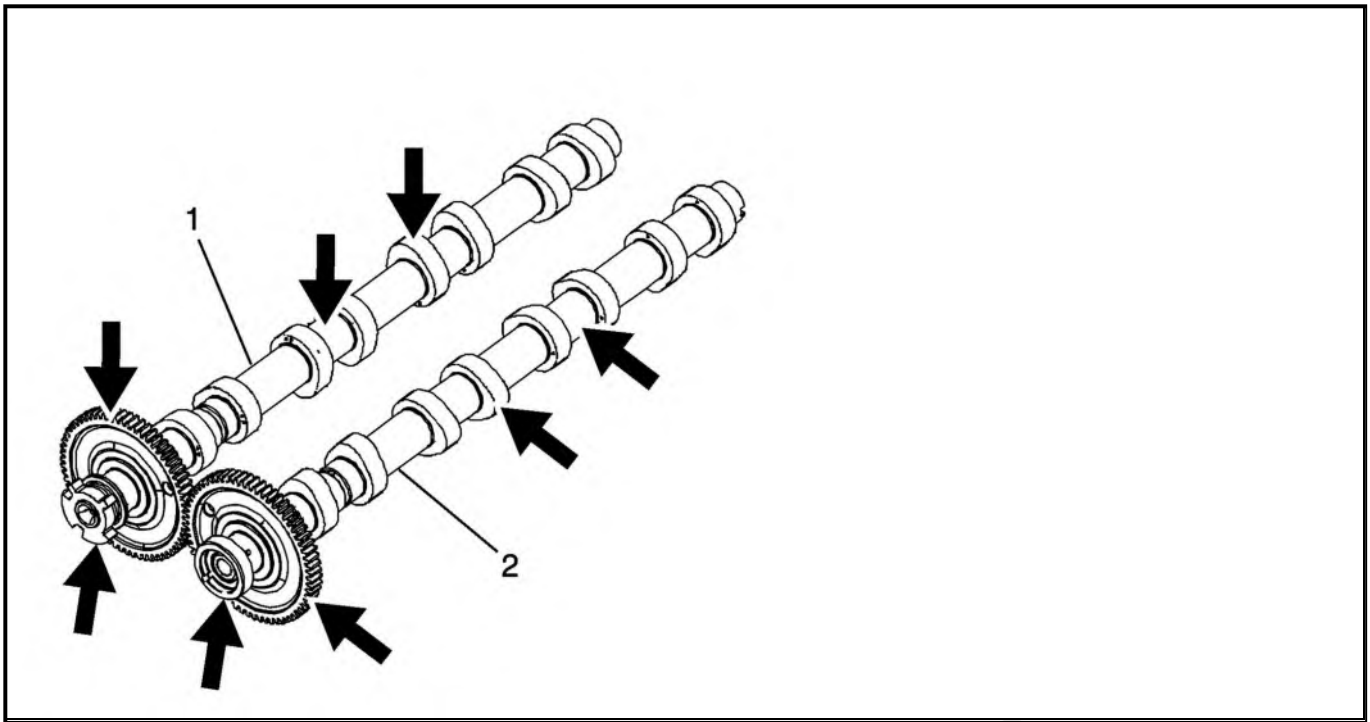


2. Install the oil pump suction pipe bolts (1). Tighten to 15 N.m (11 lb ft).
3. Install the oil level switch spacers [2x] (4) and the oil level switch (2).



4. Install the oil level switch bolts [2x] (1). Tighten to 9 N.m (80 lb in).
5. Install the oil level switch retainer (3).

CAMSHAFT CLEANING AND INSPECTION



Clean the intake camshaft (2) and exhaust camshaft (1) and perform the following:

- Wash the camshaft in solvent
- Inspect the camshaft journals and lobes for wear or scoring
- Inspect the camshaft sprocket alignment notch for damage
- Oil the camshaft

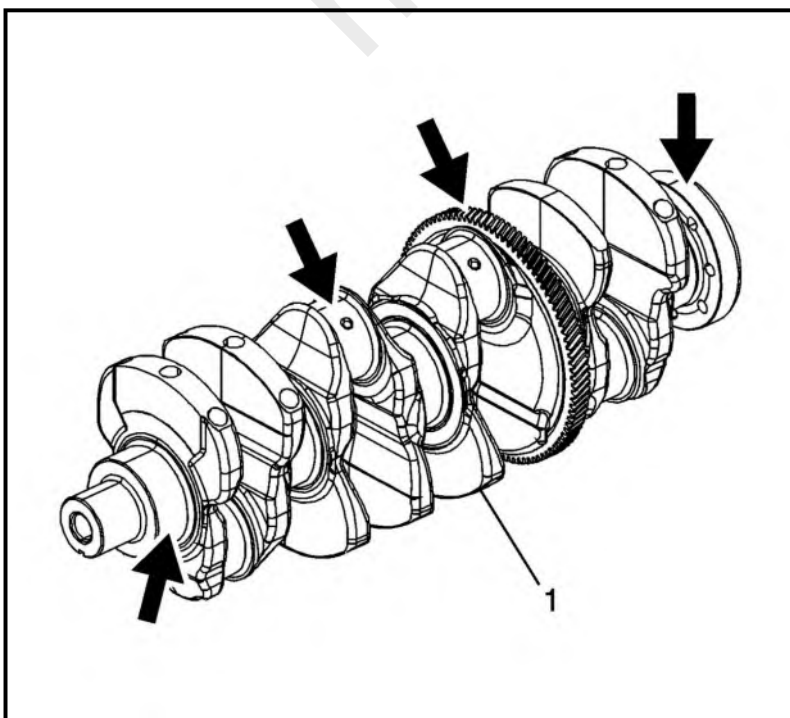
CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

J-7872 Magnetic Base Dial Indicator Set

Equivalent regional tools: [Special Tools](#)

1. Clean the crankshaft (1) with solvent.



NOTE: Use care when handling the crankshaft.

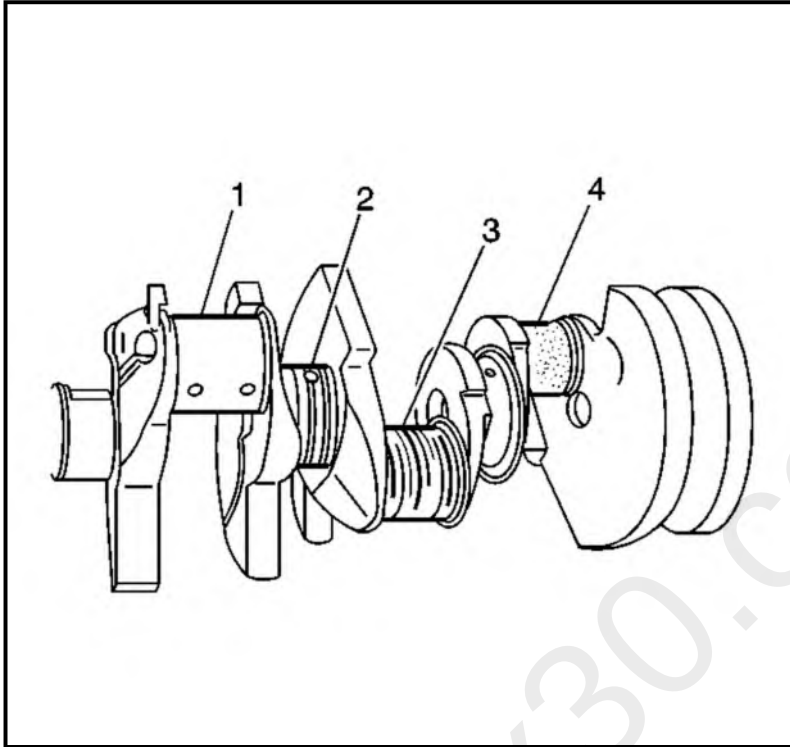
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

WARNING: Refer to [Safety Glasses Warning](#) .

3. Dry the crankshaft with compressed air.

4. Perform a visual inspection of the crankshaft for damage.

5. Inspect the crankshaft journals for wear (1). The journals should be smooth, with no signs of scoring, wear, or damage.

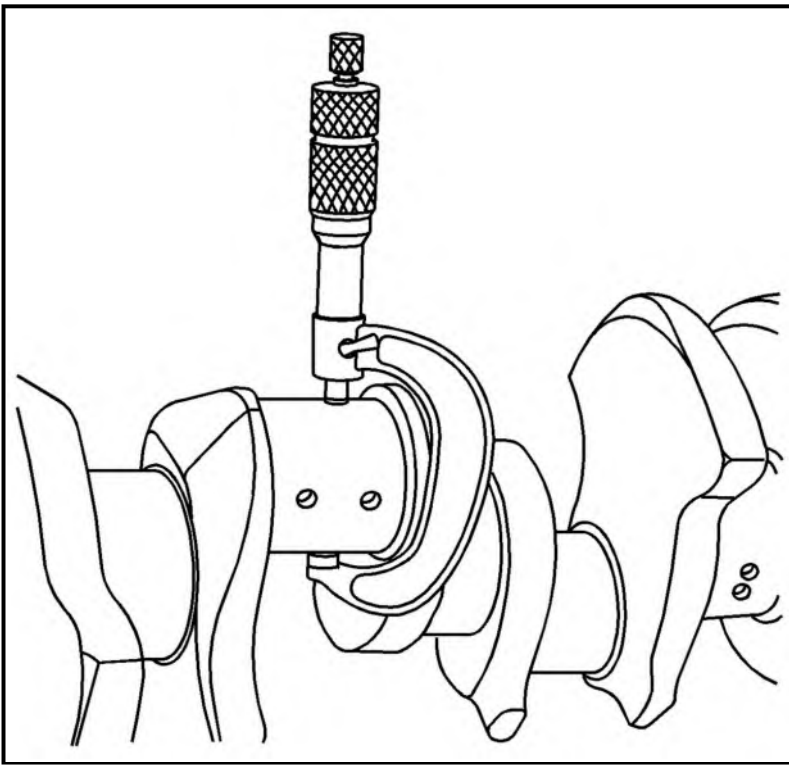


6. Inspect the crankshaft journals for grooves or scoring (2).

7. Inspect the crankshaft journals for scratches or wear (3).

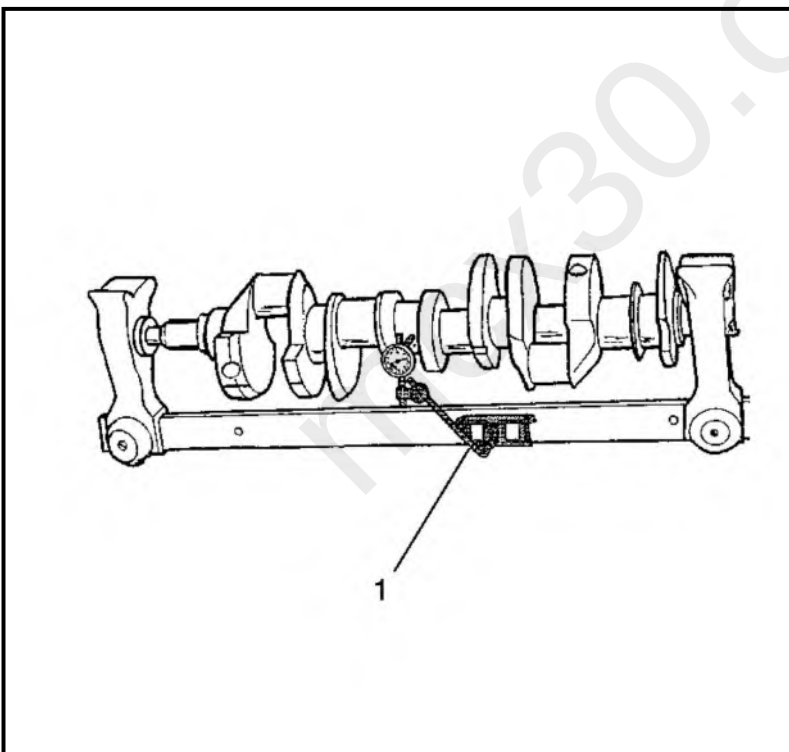
8. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

9. Measure the crankshaft journals for out-of-round.



10. Measure the crankshaft journals for taper.

11. Measure the crankshaft runout. Using wooden V-blocks, support the crankshaft on the front and rear journals.

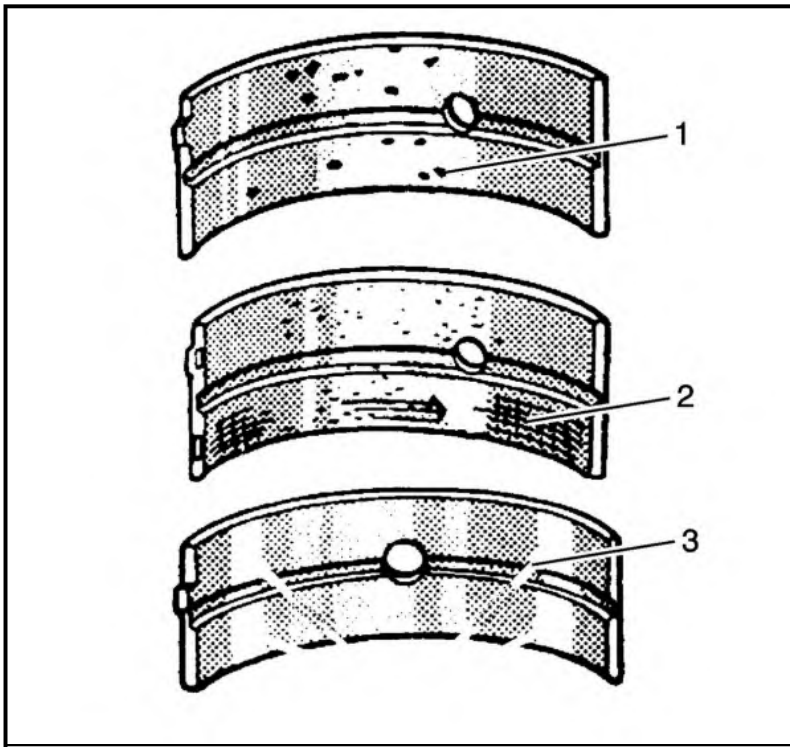


12. Use the **J-7872** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.

13. Use the **J-7872** indicator in order to measure the runout of the crankshaft rear flange.

14. Replace the crankshaft if the measurements are not within specifications.

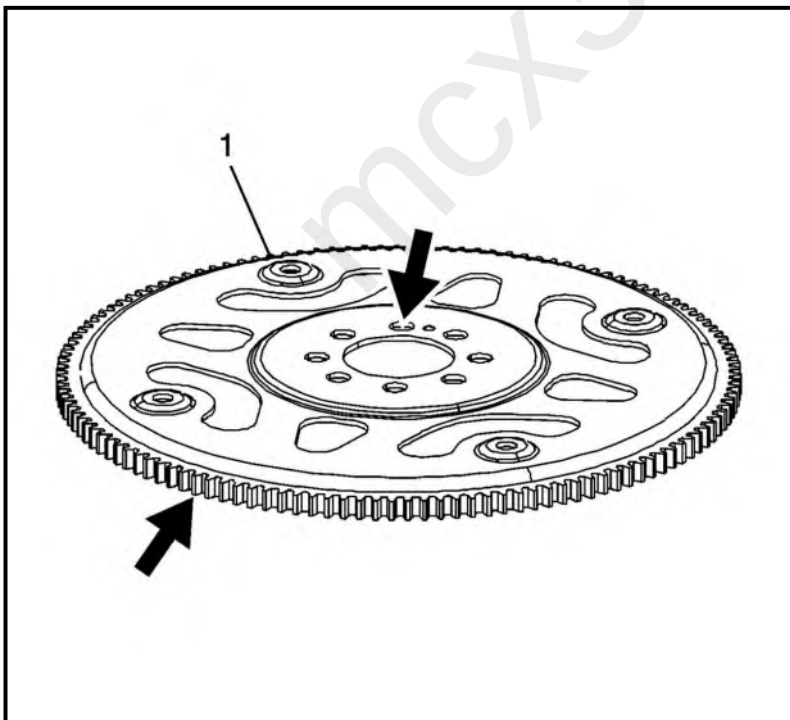
15. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.



16. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
17. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
18. 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.

FLYWHEEL CLEANING AND INSPECTION

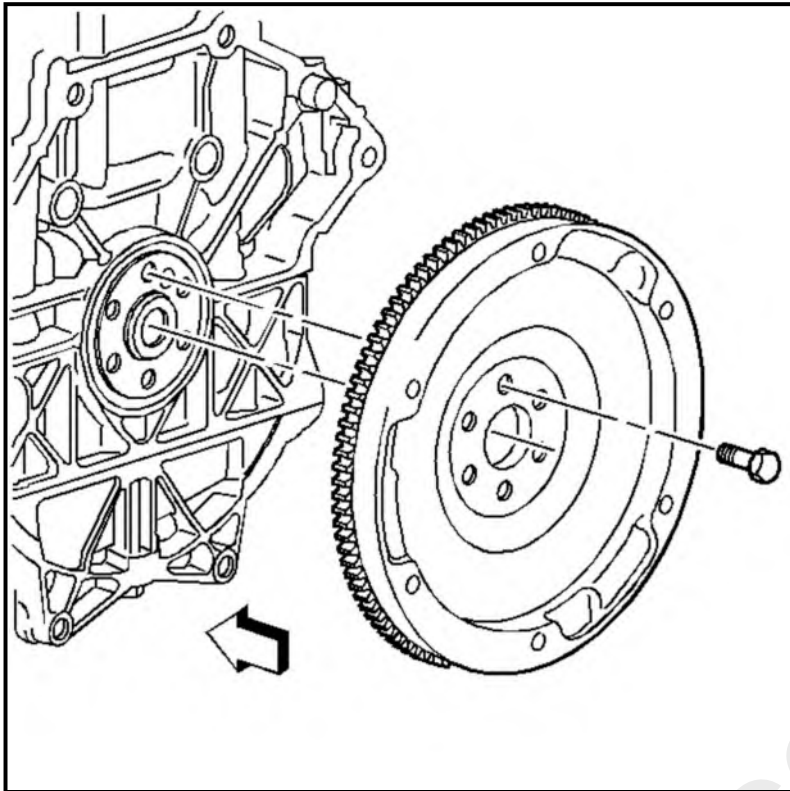
1. Clean the flywheel (1) in solvent.



NOTE: In order to maintain the proper component balance, contact surface taper, and heat transfer, manual transmission flywheels are NOT to be machined.

WARNING: Refer to [Safety Glasses Warning](#) .

2. Dry the flywheel with compressed air.
3. Inspect the manual transmission flywheel for the following:



- Damaged ring gear teeth
- Loose or improperly positioned ring gear

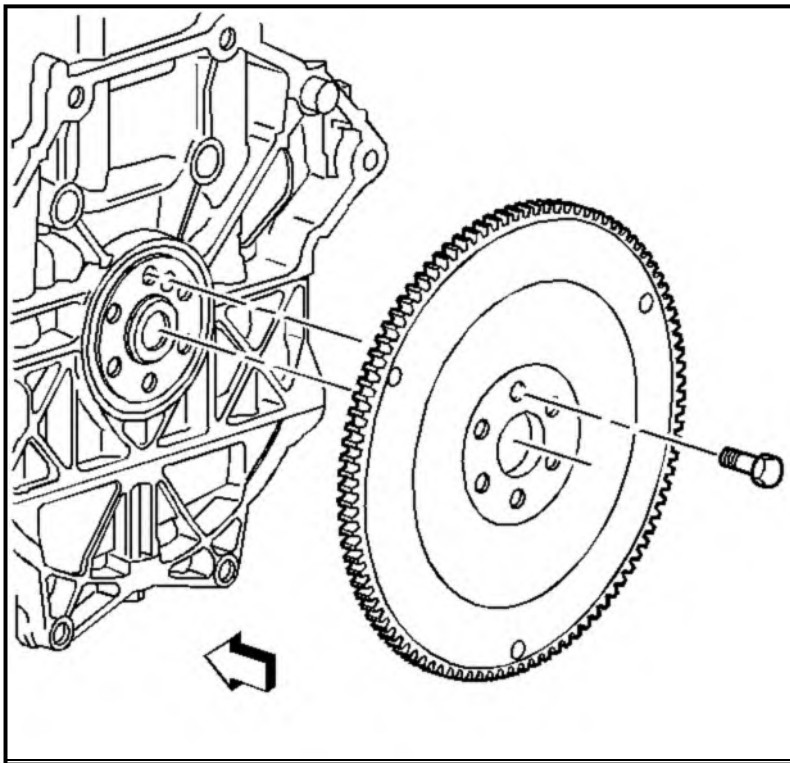
The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.

- A scored, grooved or damaged friction surface

4. Rotate the clutch side half of the flywheel.

- There should be play of up to ± 4 degrees of rotation before it engages the inner springs of the dual mass flywheel.
- A torque of 140 - 230 N.m (103 - 170 lb ft) should be obtained at 42 degrees of rotation.
- No scraping or grinding noises should be heard during rotation. Replace the flywheel if any conditions are found.

5. Inspect the automatic transmission flywheel for the following:



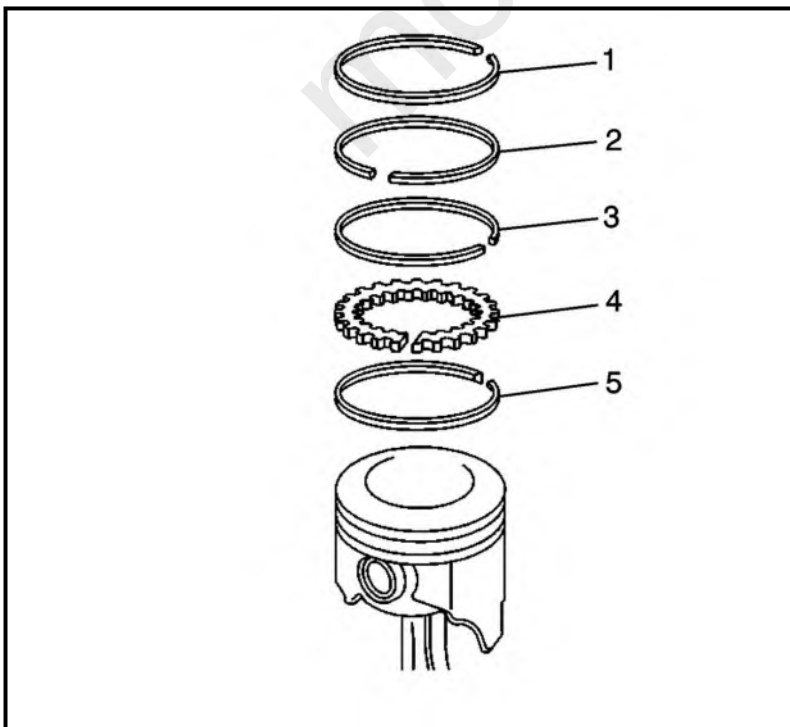
- Damaged ring gear teeth
- Stress cracks around the flywheel-to-crankshaft bolt hole locations
- Weight saving holes

PISTON AND CONNECTING ROD DISASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

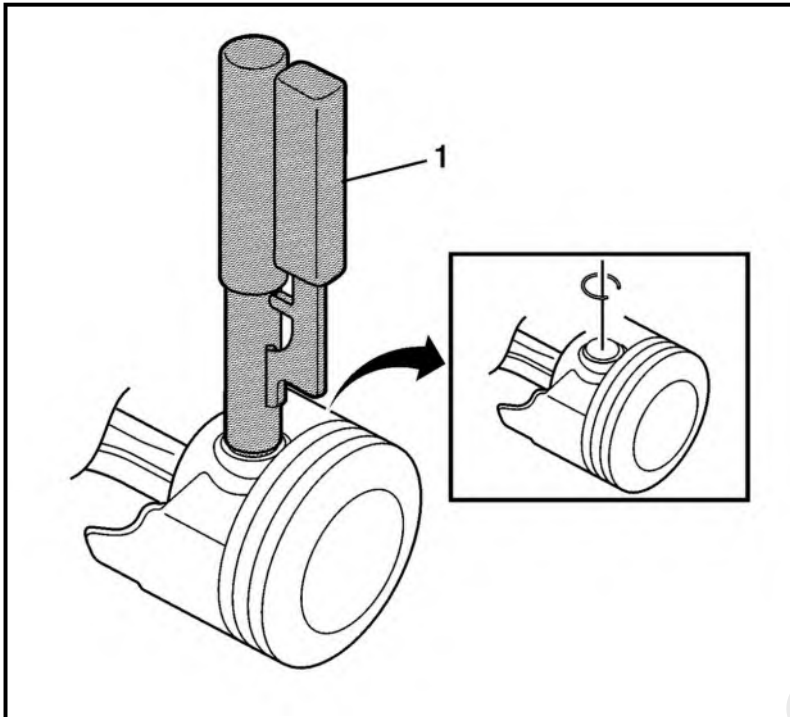
1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.



WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

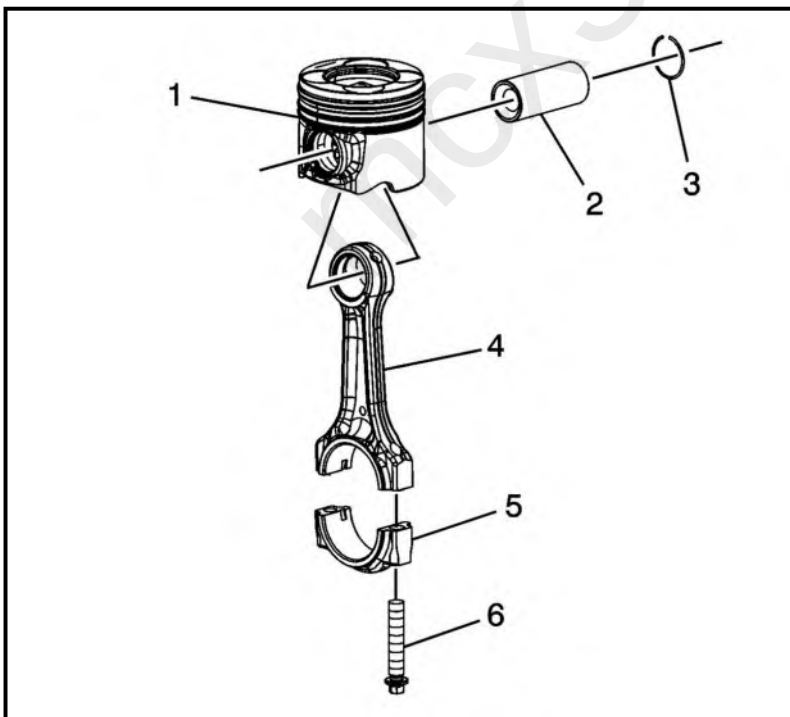
2. Remove the piston pin retainers using the **EN-46745** remover (1).



NOTE:

Two retainers hold the piston pins in place. No special tools are required to remove the piston pins. Ensure that the piston pin is not damaged. Do not reuse the retainers.

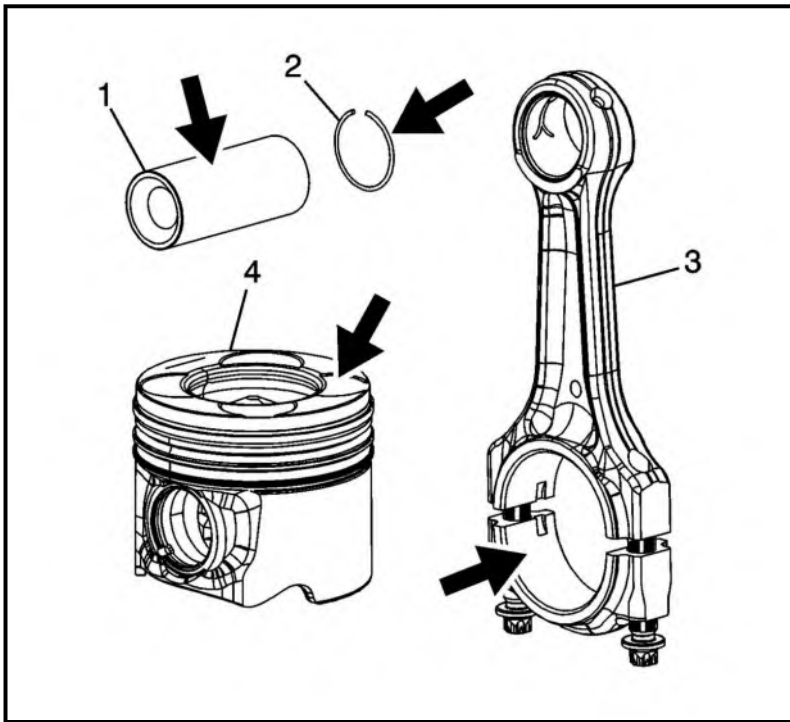
3. Remove the piston pin (2).



PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

1. Clean the connecting rods (3) in solvent and dry with compressed air.

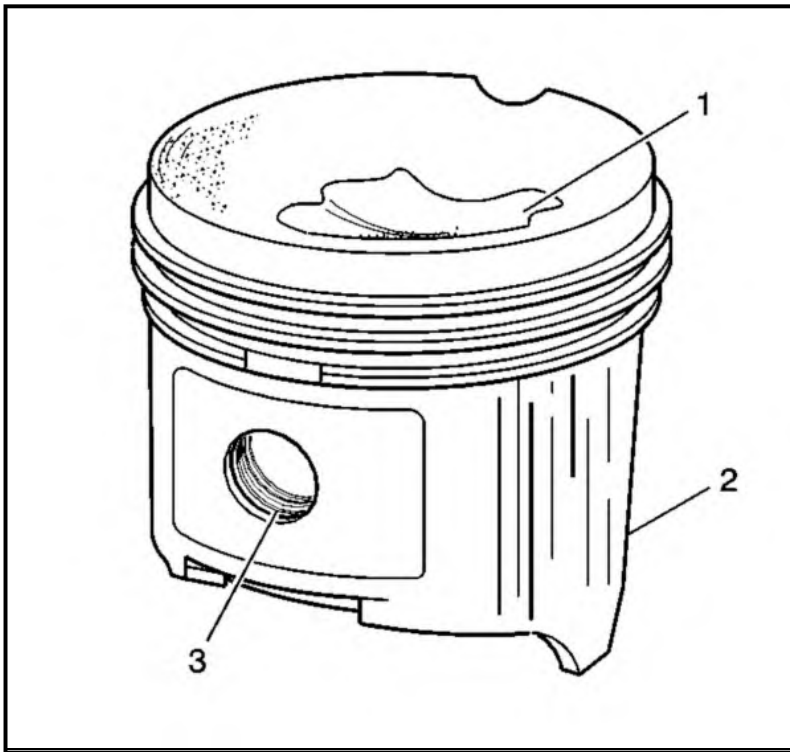


WARNING: Refer to [Safety Glasses Warning](#) .

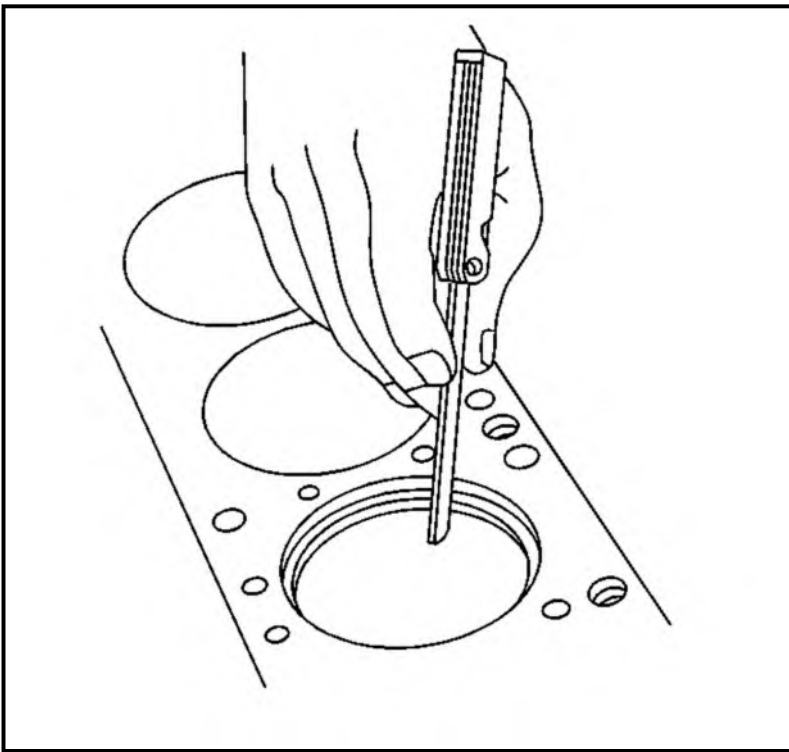
2. Inspect the connecting rods for the following:
 - Signs of being twisted, bent, nicked, or cracked
 - Scratches or abrasion on the rod bearing seating surface
3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT 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 (1) 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

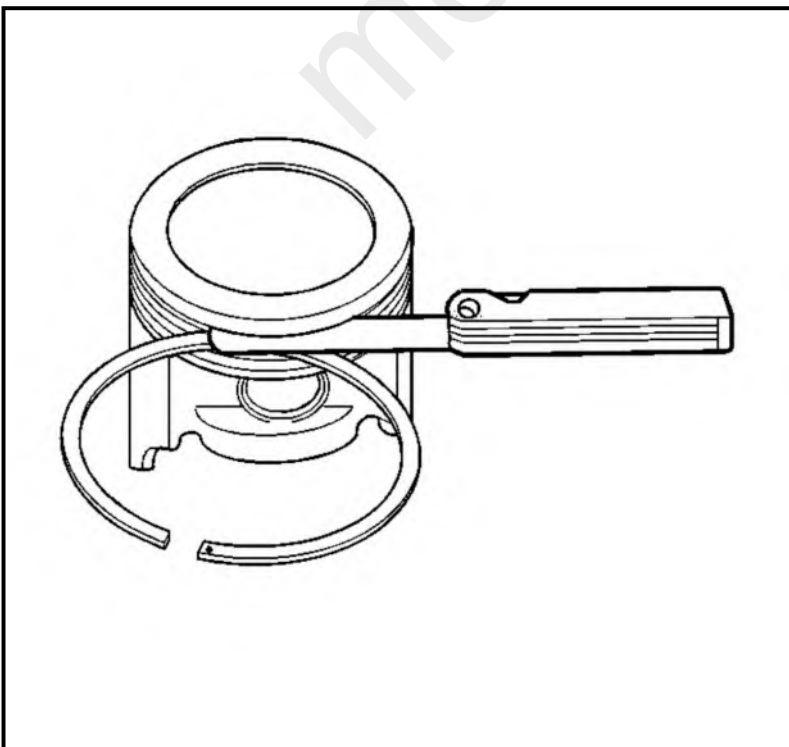
1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.



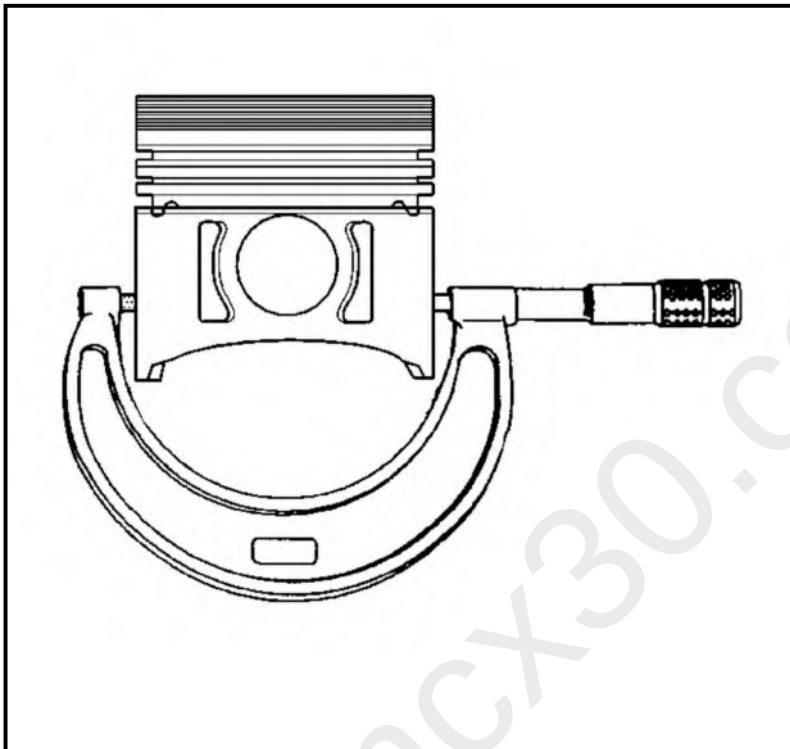
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts, or pin bosses
 - Ring grooves for nicks, burrs that may cause binding
 - Warped or worn ring lands
 - Eroded areas 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.
6. Measure the piston ring end gap using the following procedure:



1. Place the piston ring in the area of the bore where the piston ring will travel, approximately 25 mm or 1 inch down from the deck surface. Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gauges. Compare the measurements with those provided below:
 - The top compression ring end gap should be 0.20 - 0.40 mm (0.0060 - 0.015 in)
 - The second compression ring end gap should be 0.35 - 0.55 mm (0.0137 - 0.0216 in)
 - The oil ring end gap should be 0.25 - 0.76 mm (0.0098 - 0.029 in)
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.
7. Measure the piston ring side clearance using the following procedure:



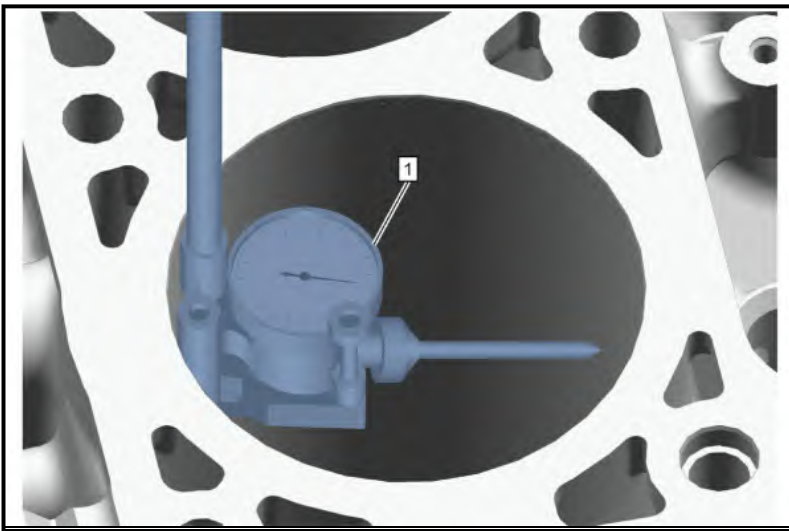
1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
2. With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
4. If the clearance is greater than specifications, replace the piston ring.
5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.
8. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
9. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.
10. Measure piston width using the following procedure:



1. Using an outside micrometer, measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
 2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
 3. The proper clearance specification for the piston is 0.010 - 0.041 mm (0.0006 - 0.0016 in).
11. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston.

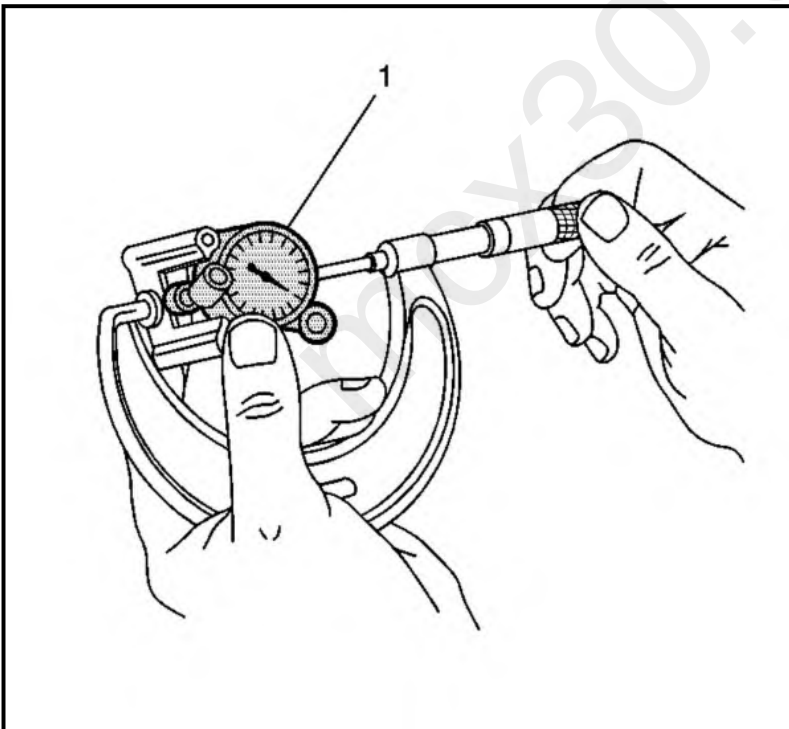
Piston Selection

1. Inspect the engine block cylinder bore. Refer to [Engine Block Cleaning and Inspection](#).

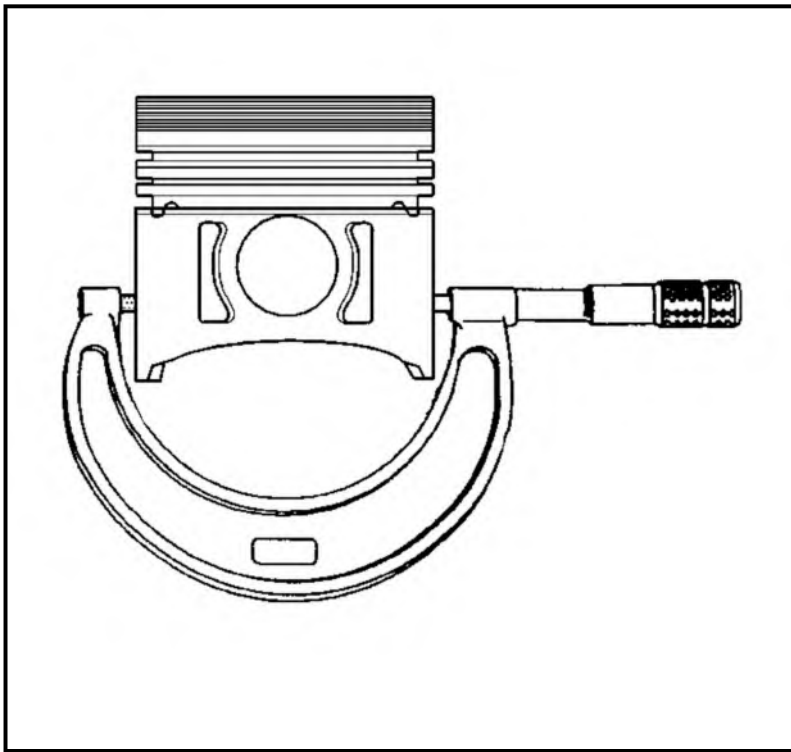


NOTE: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

2. Inspect the piston and the piston pin. Refer to [Piston, Connecting Rod, and Bearing Cleaning and Inspection](#).
3. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.
4. Measure the bore gauge (1) with a micrometer and record the reading.



5. With a micrometer or caliper at a right angle to the piston, measure the piston 14 mm (0.570 in) from the bottom of the skirt.



6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to [Engine Mechanical Specifications](#).
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to [Separating Parts](#).

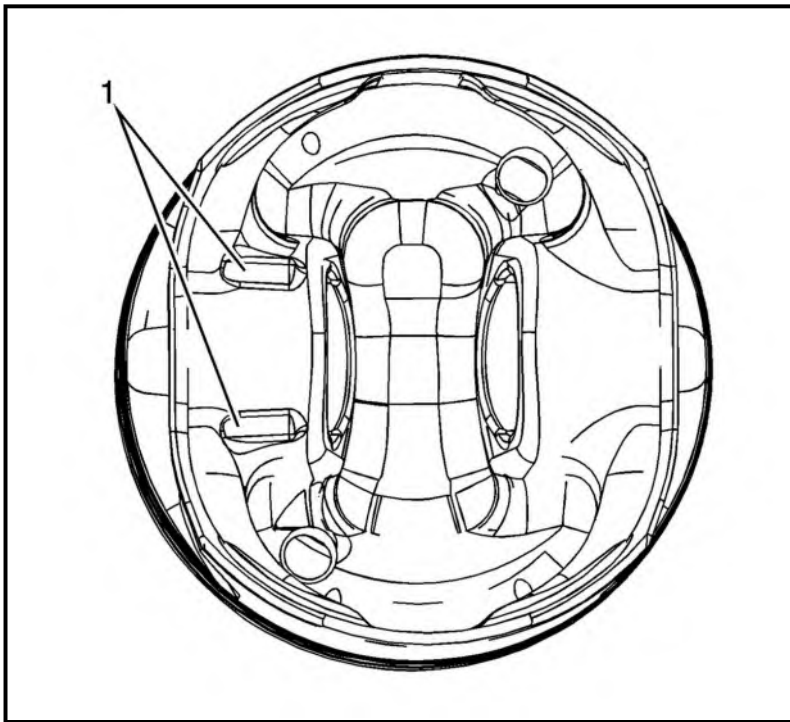
PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

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

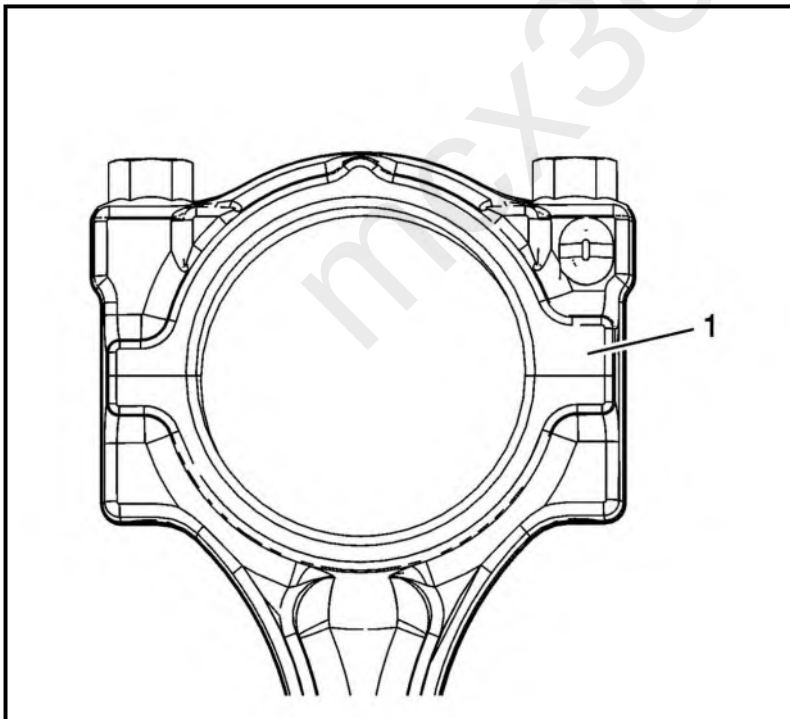
1. The cast boss (1), on the underside of the piston, must go to the rear of the block.



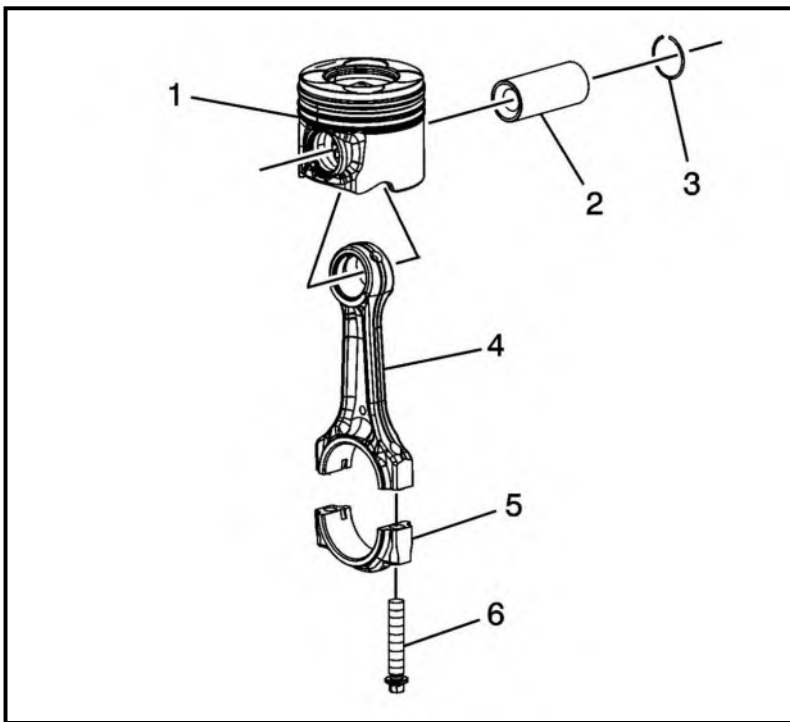
NOTE: Install the piston onto the connecting rod with the arrow oriented toward the front of the engine.

NOTE: The cast boss can be in either or both locations depending on displacement.

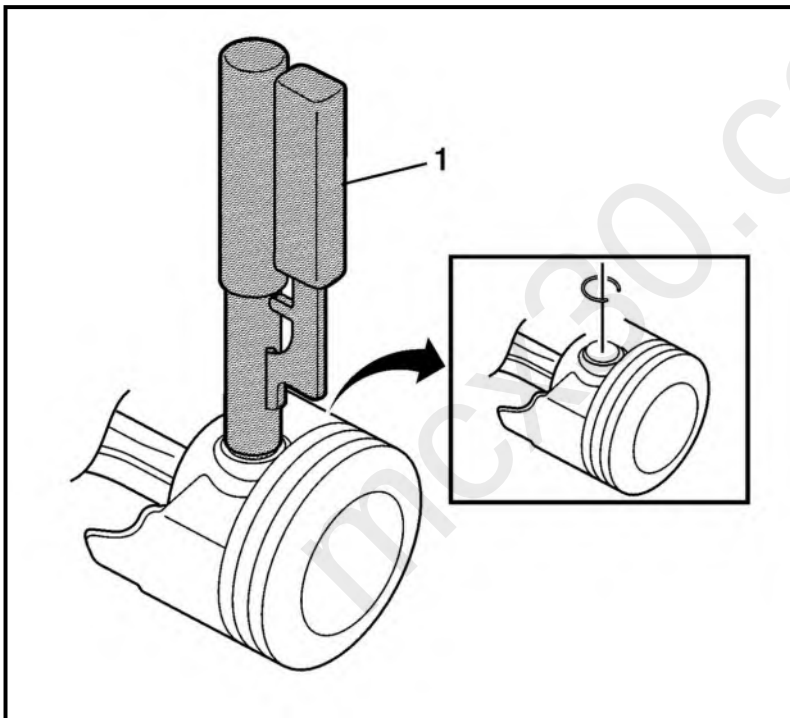
2. The larger feature (1), at the split line located on one side of the connecting rod, must go to the front of the block.



3. Assemble the connecting rod (4) and the piston (1).

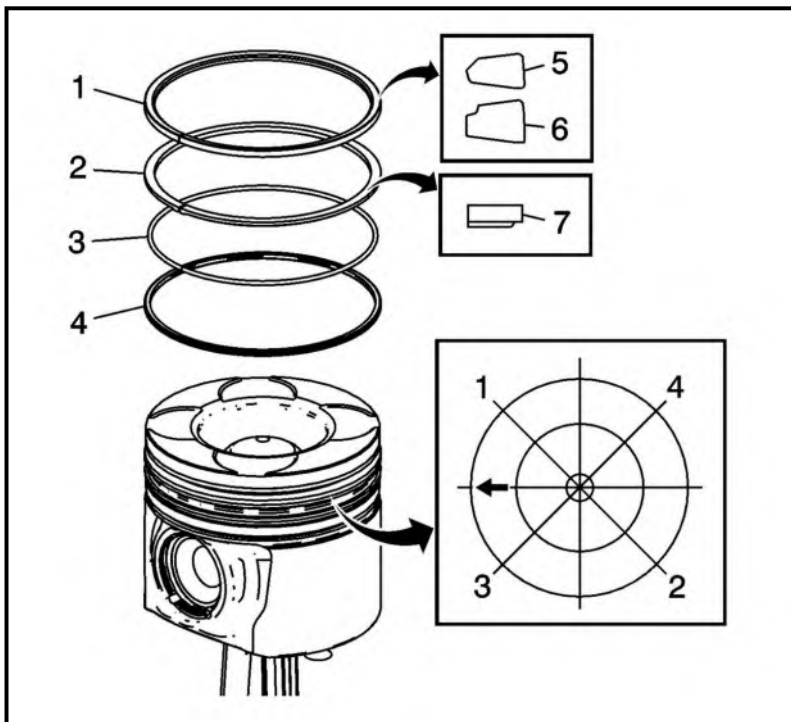


4. Use the following procedure to assemble the piston pin and the retainer:



CAUTION: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

1. Coat the piston pin with oil.
2. Install one side of one piston pin retainer into the retaining groove using **EN-46745** installer. Rotate the retainer until it is fully seated in the groove.
3. Install the connecting rod and the piston pin. Push the piston pin until it bottoms in the previously installed retainer.
4. Install the second piston pin retainer, using **EN-46745** installer (1).
5. Ensure that the piston moves freely.
5. Install the following components of the oil control ring assembly, bottom ring:



CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

NOTE: Ensure the 2.5L upper compression ring (5) or 2.8L upper compression ring (6) and lower compression ring (7) are orientated properly.

1. The oil ring rail (4)
2. The inner oil expander ring (3)
6. Install the lower compression ring, second ring (2). Place the manufacturer's mark facing up.
7. Install the upper compression ring, top ring (1). Place the manufacturer's mark facing up.
8. Install the piston rings so that the gaps are orientated as follows:
 - The upper compression ring (1) and lower compression ring (2) gaps should be 180 degrees from each other.
 - The inner oil expander ring (3) gap should be 180 degrees from the oil ring rail (4) gap.
 - The ASSEMBLED oil ring gaps should be 90 degrees from the compression ring gaps.

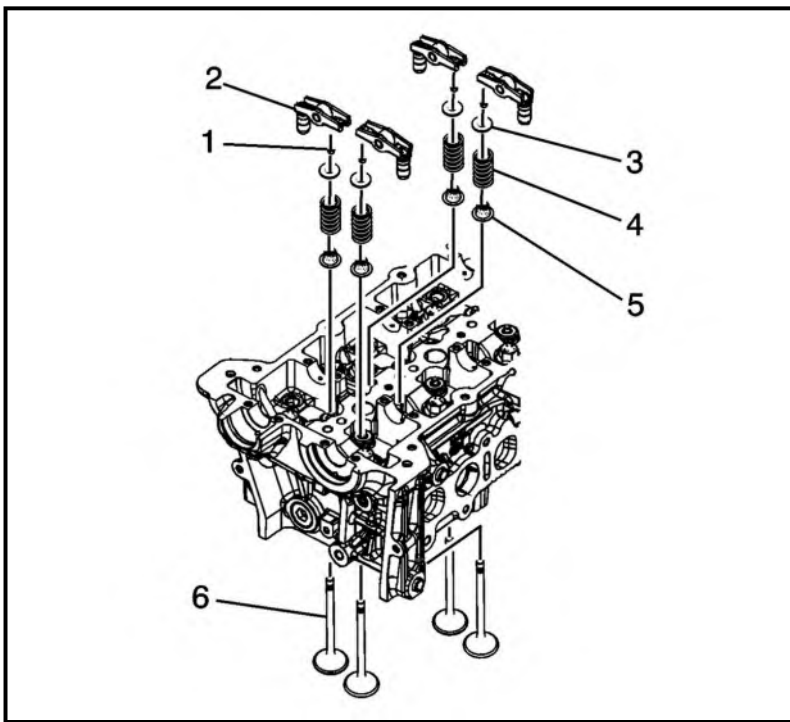
CYLINDER HEAD DISASSEMBLE

Special Tools

- **J-8062** Valve Spring Compressor
- **EN-46116** Valve Stem Seal Remover/Installer
- **EN-50031** Valve Spring Compressor (off-vehicle)

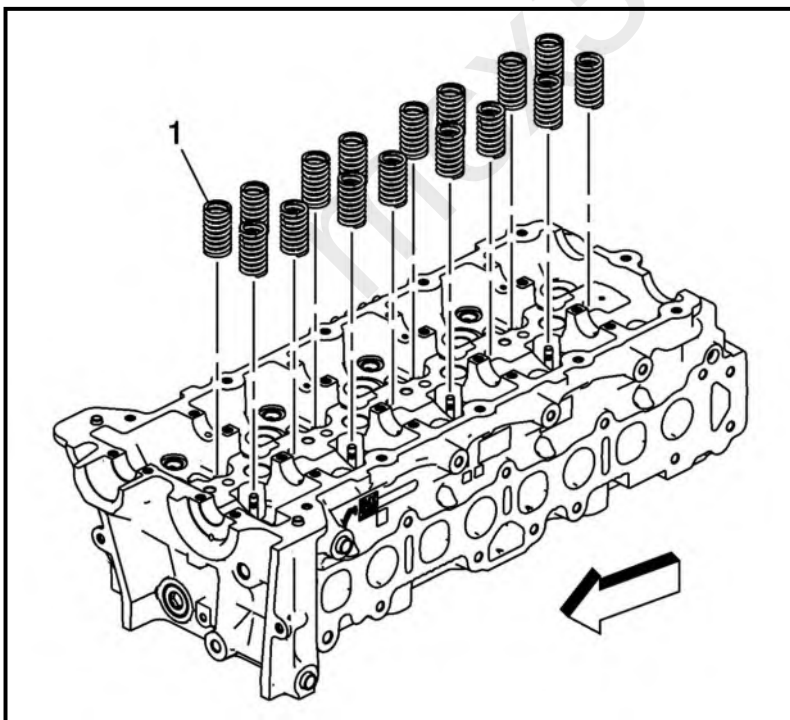
Equivalent regional tools: **Special Tools**

1. Remove the coolant air bleed hose fitting.

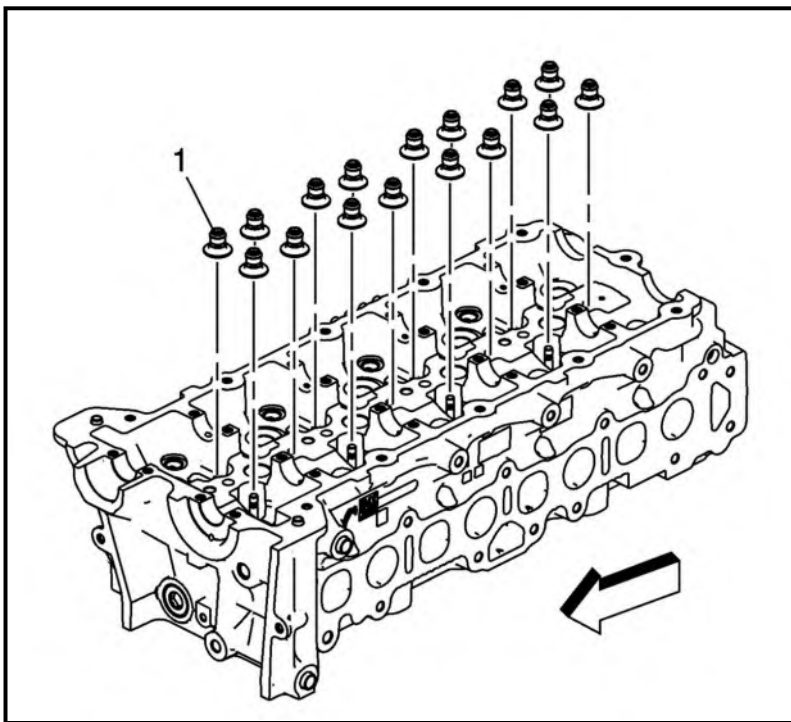


NOTE: Ensure that the valve train components are kept together and identified in order for proper re-installation in their original position.

2. Using the **J-8062** compressor and the **EN-50031** compressor, compress the valve spring (4).
3. Remove the valve keys (1).
4. Slowly release the **J-8062** compressor and the **EN-50031** compressor from the valve spring assembly.
5. Remove the retainer (3).
6. Remove the springs.

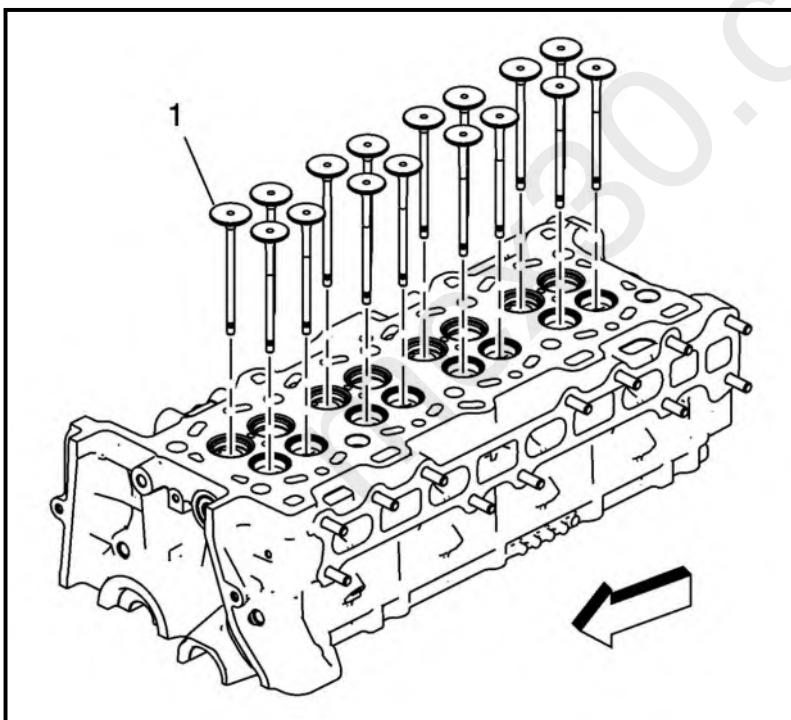


7. Remove the valve seal. Use the **EN-46116** remover. Do not reuse.



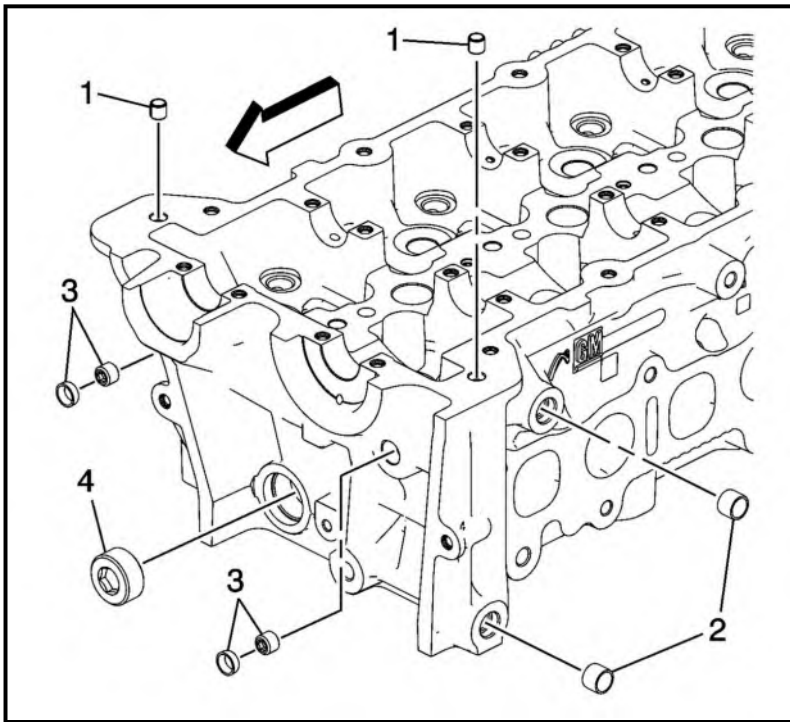
CAUTION: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

8. Remove the valve.



9. Remove the remaining valves.

10. Remove the cylinder head plugs.



CYLINDER HEAD CLEANING AND INSPECTION

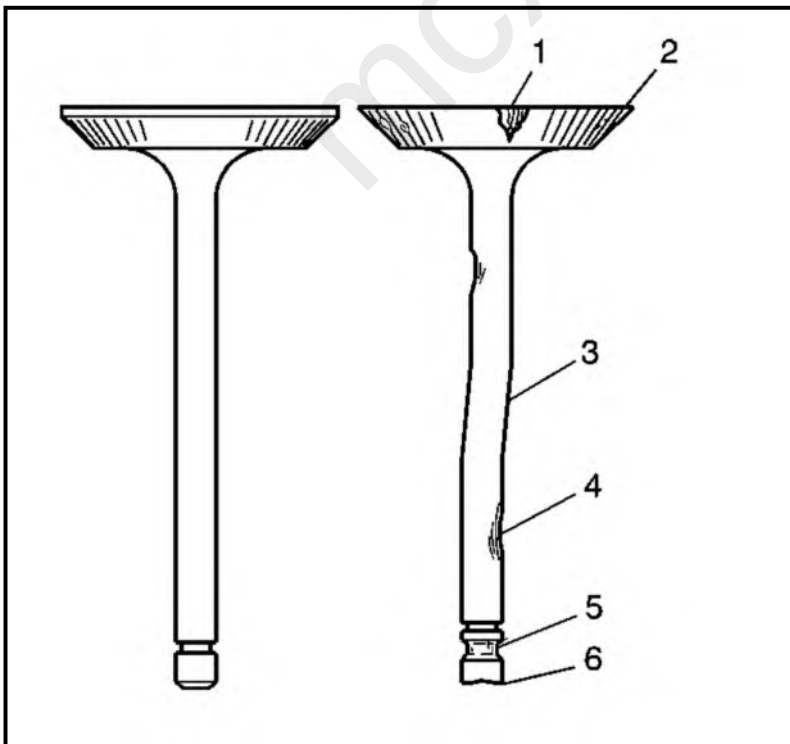
Special Tools

J-7872 Magnetic Base Dial Indicator

Equivalent regional tools: [Special Tools](#)

Valve Cleaning and Inspection

1. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush. Varnish can be removed by soaking in Parts Immersion Solvent GM P/N 12345368 (Canadian P/N 10953514) or equivalent.

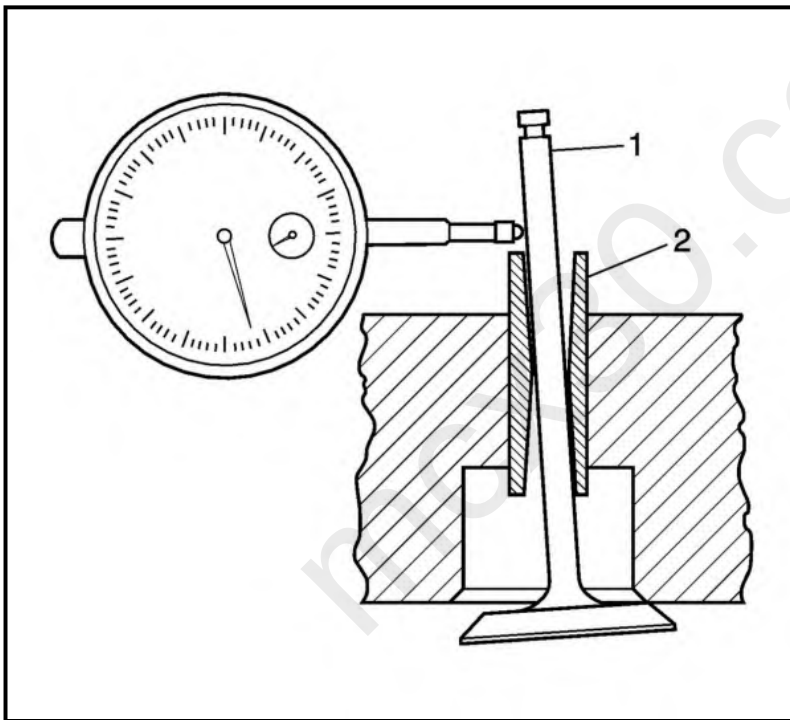


NOTE: Do not scratch the valve stem with the wire brush.

2. Clean the valve guides.
3. Inspect the valve stem for wear (4).
4. Inspect the valve keeper groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness and the valve head for bending or distortion (3) using V blocks. Bent or distorted valves must be replaced.
8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. The valves may be lightly lapped to the valve seats.

Valve Guide Measurement

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.



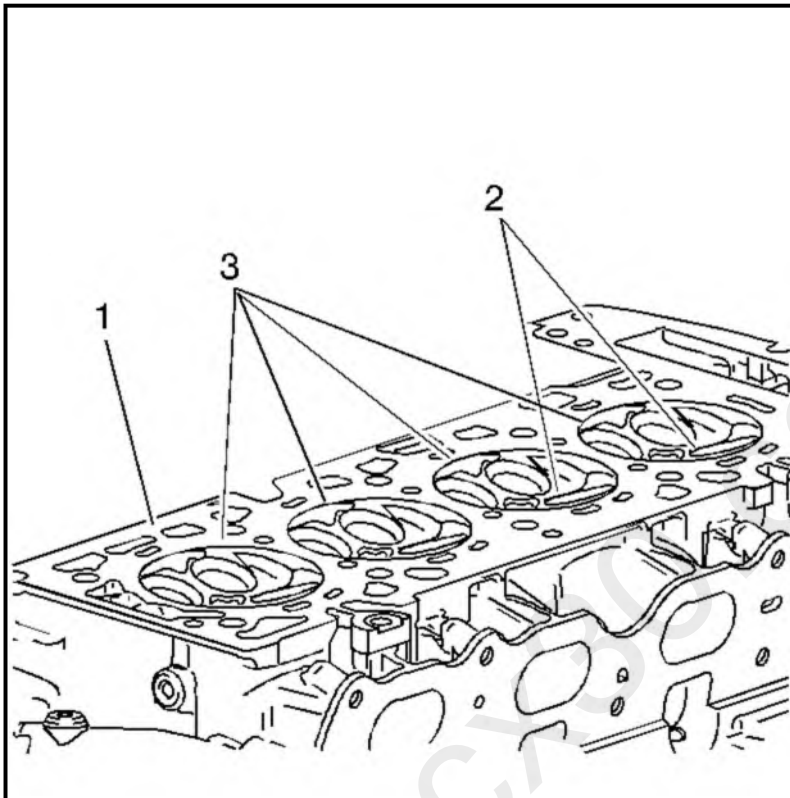
2. Clamp the **J-7872** indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to [Engine Mechanical Specifications](#) for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Cylinder Head and Gasket Surface Cleaning and Inspection

1. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:
 1. Improper installation
 2. Loose or warped cylinder head
 3. Missing, off location, or not fully seated dowel pins
 4. Corrosion in the seal area around the coolant passages
 5. Chips or debris in the cylinder head bolt holes
 6. Bolt holes in the cylinder block not drilled or tapped deep enough
2. Inspect the 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).

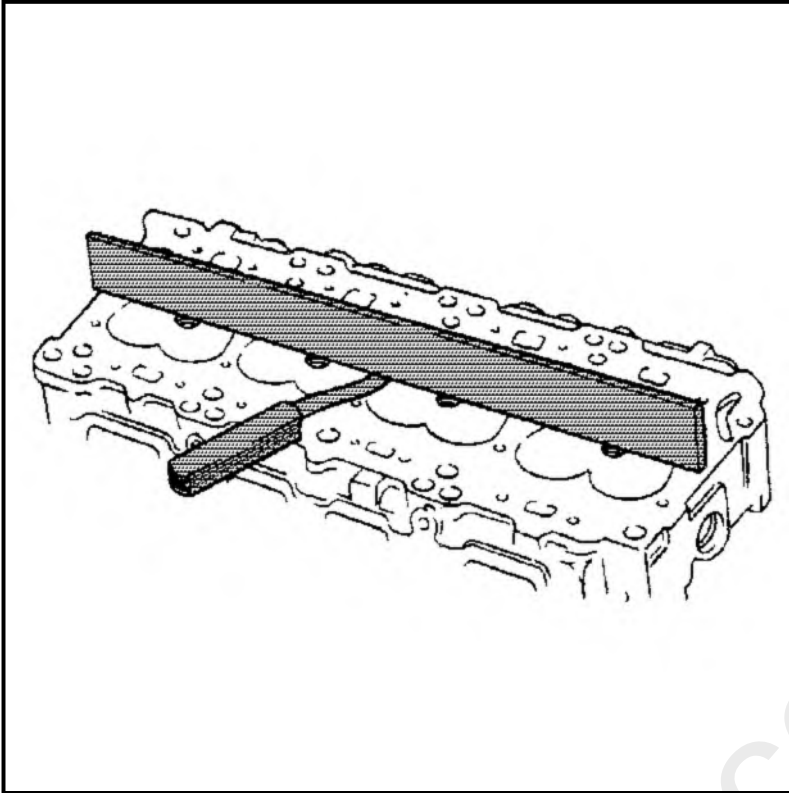
3. Clean the cylinder head bolts.

NOTE: Do not use a wire brush on any gasket sealing surface.

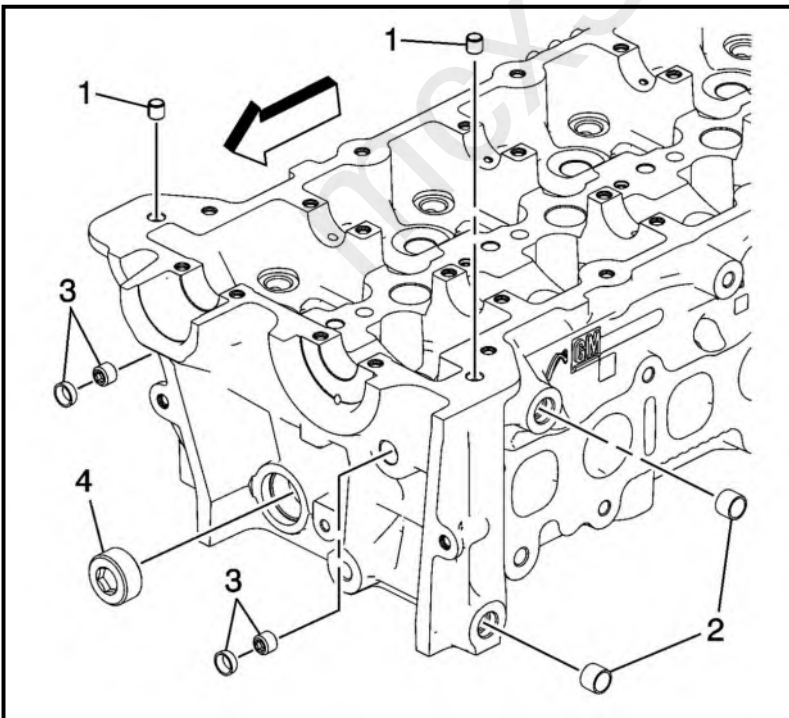
4. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
5. Clean the valve guides.
6. Clean the threaded holes. Use a nylon bristle brush.
7. Clean the remains of the sealer from the plug holes.
8. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
9. Replace all suspect bolts.
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.
12. 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.

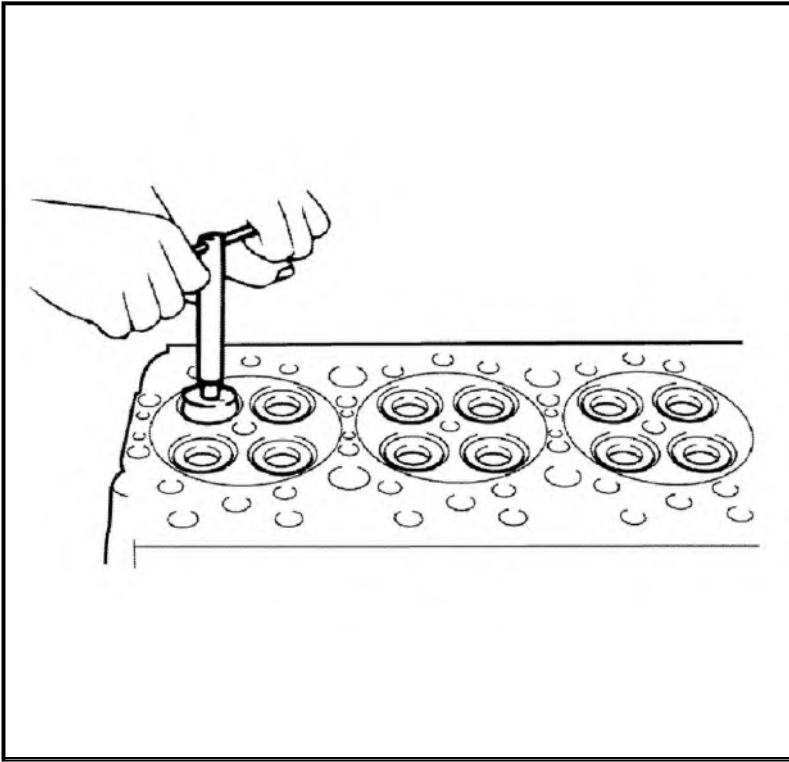


13. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
14. Inspect the sealing surfaces.
15. Inspect the cylinder head plugs.

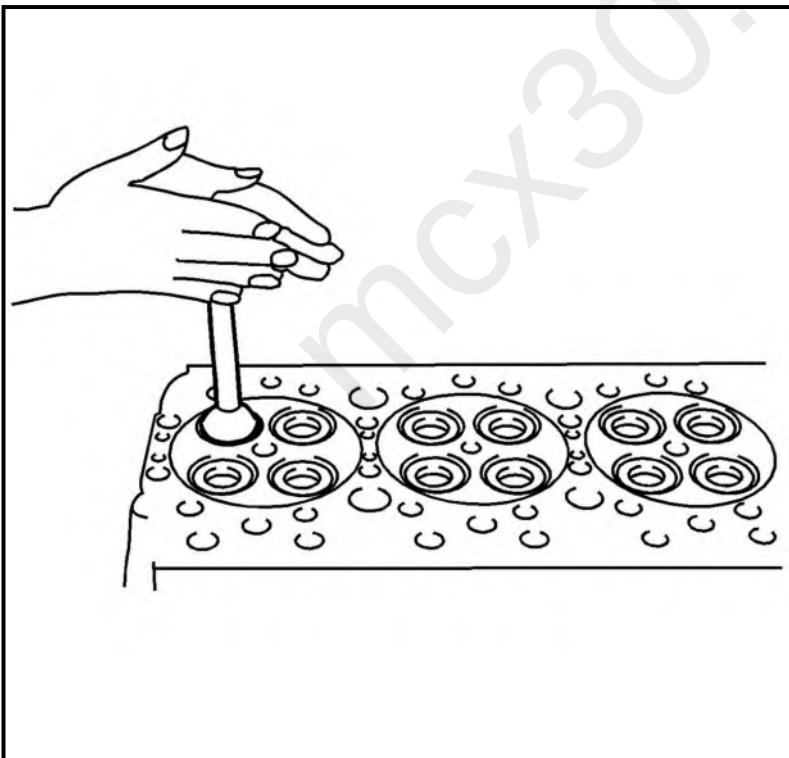


VALVE AND SEAT GRINDING

1. Remove the carbon from the valve guide and valve seat surface.



2. Resurface the valve face to 45 degrees. If valve margin falls below specifications after resurfacing then discard valve.
3. Use a suitable tool to bring the valve contact width to the standard value. The valve seat angle is 45 degrees.
4. Apply valve lapping compound to the valve seat surface.



5. Insert the valve into the cylinder head.
6. Turn the valve back and forth in its seat to lap the valve face to the valve seat.

CYLINDER HEAD ASSEMBLE

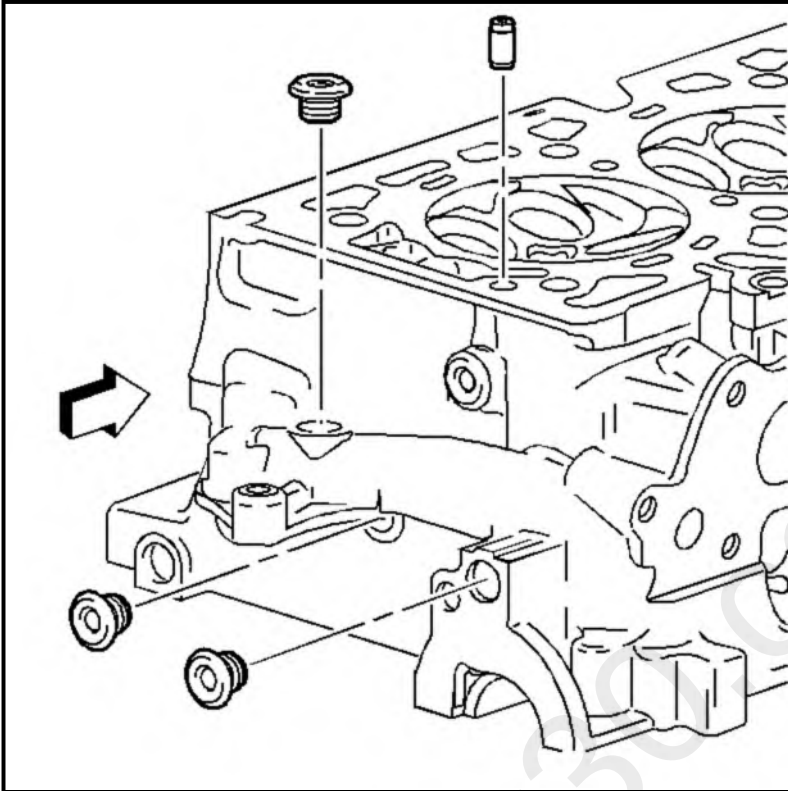
Special Tools

- **J-8062** Valve Spring Compressor

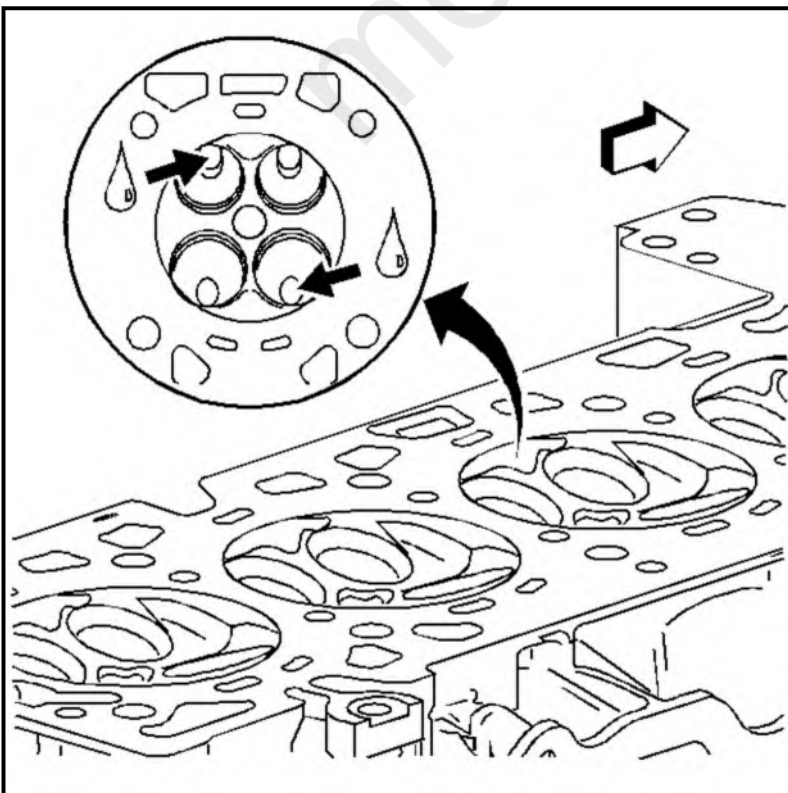
- **J-9666** Valve Spring Tester
- **EN-50031** Valve Spring Compressor (off-vehicle)
- **EN-50723** Valve Seal Installer

Equivalent regional tools: **Special Tools**

1. Install NEW cylinder head plugs. Coat the plugs with sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent.



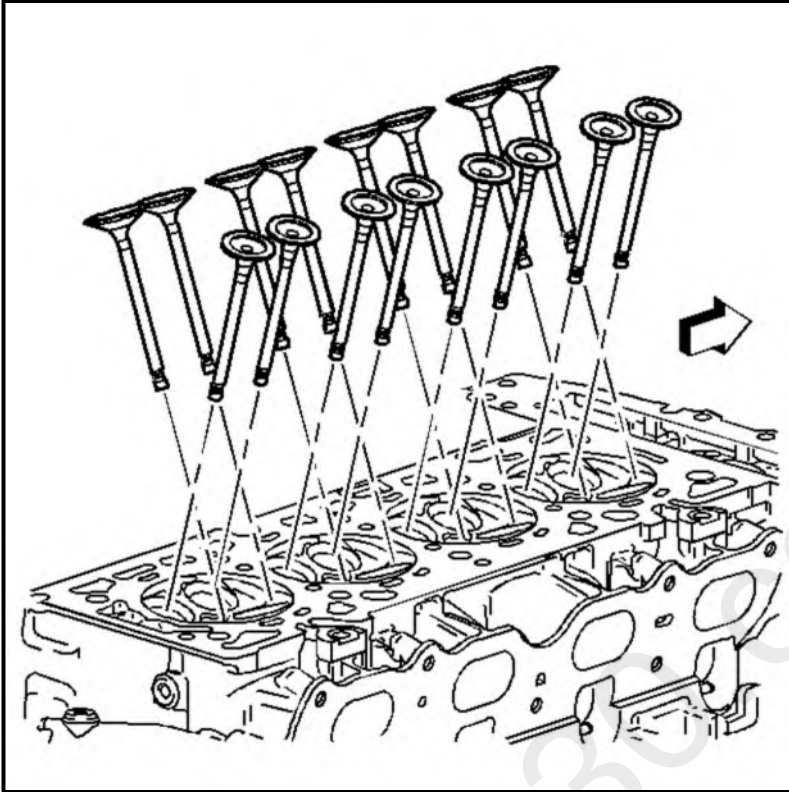
2. Tighten plugs to 60 N.m (44 lb ft)
3. Assemble the valves.



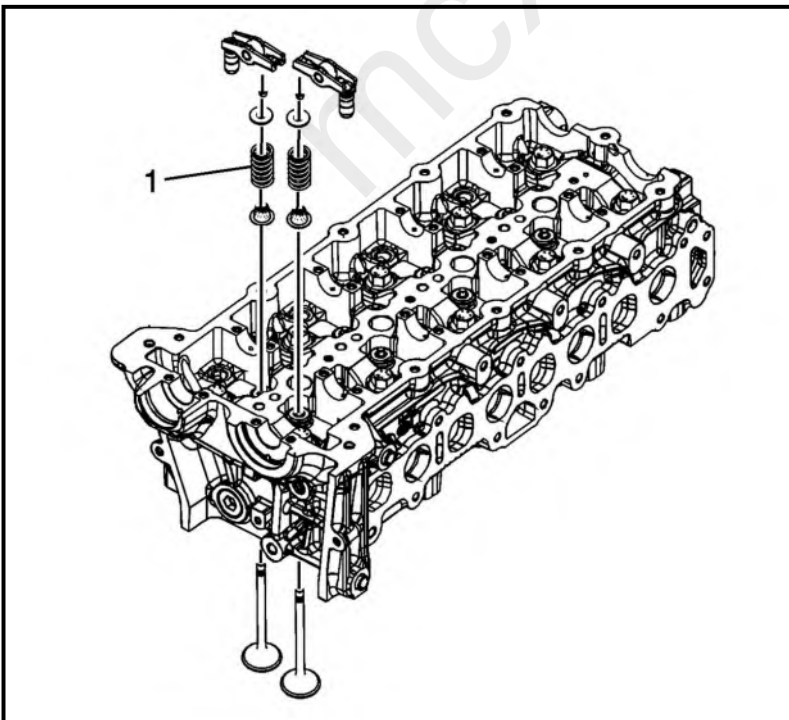
4. Use the following steps to measure valve runout:

1. Apply a dab of Prussian blue on the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.
2. Clean all traces of Prussian blue.
3. Apply a dab of Prussian blue on the valve seat and repeat the check. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.

5. Replace the valves, if required.

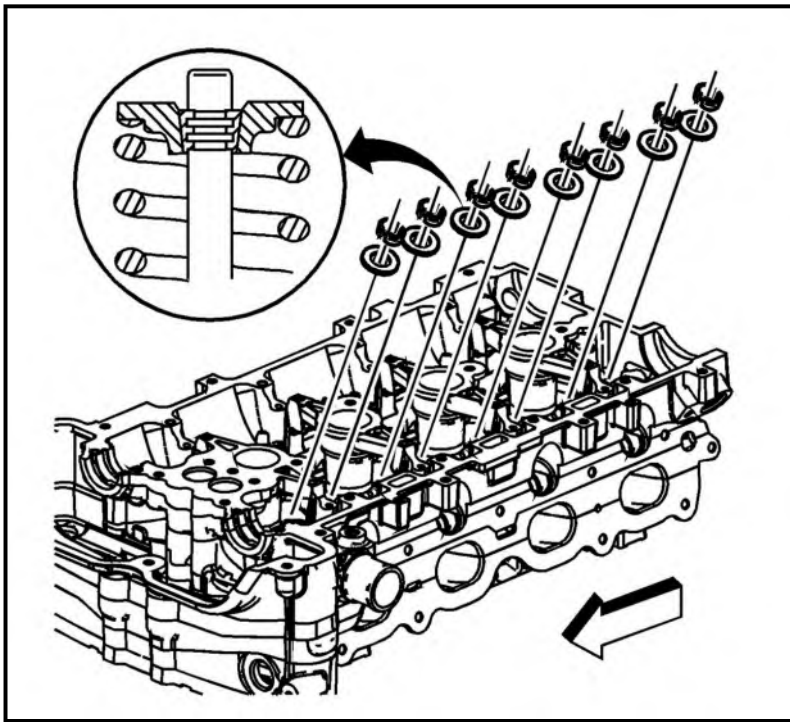


6. Install the NEW valve seals using the **EN-50723** installer. Fully seat the seals on the valve guides.



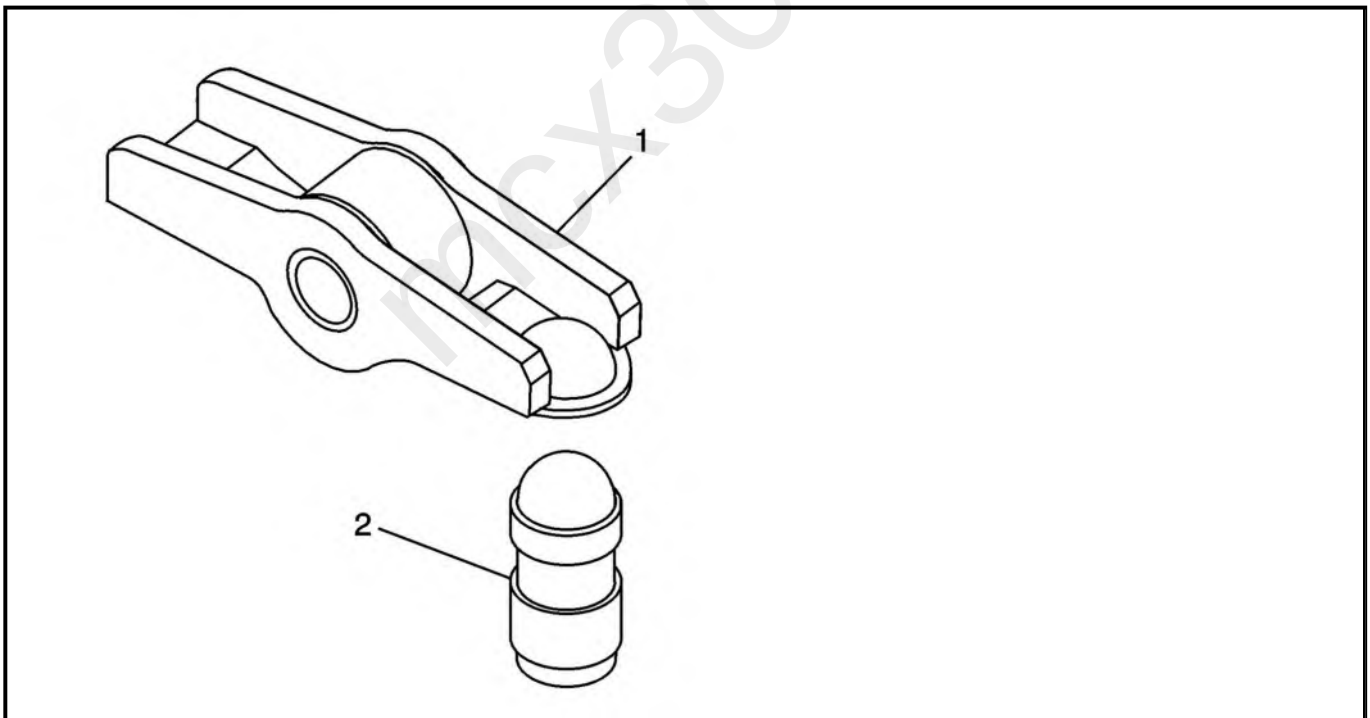
7. Install the spring (1).

8. Install the retainer.



9. Using the **J-8062** compressor and the **EN-50031** compressor, compress the valve spring.
10. Install the valve keys.
11. Slowly release the **J-8062** compressor and the **EN-50031** compressor from the valve/spring assembly.
12. Inspect for proper valve key seating.
13. Install the remaining valves, springs, and other components.

VALVE ROCKER ARM AND LIFTER CLEANING AND INSPECTION

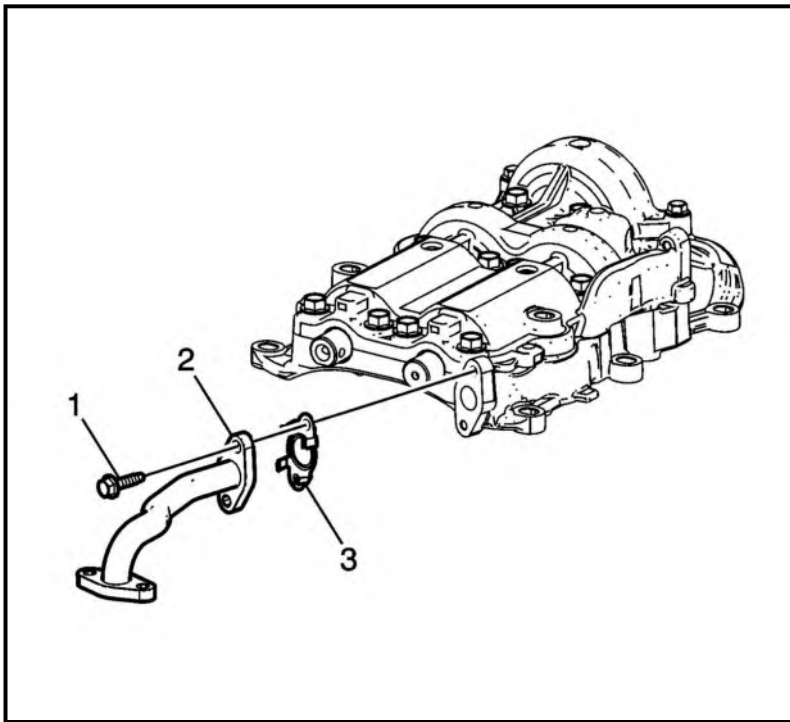


NOTE: Take care not to compress the valve lifters. Compressing the lifters may force the oil out, causing extended ticking upon initial startup.

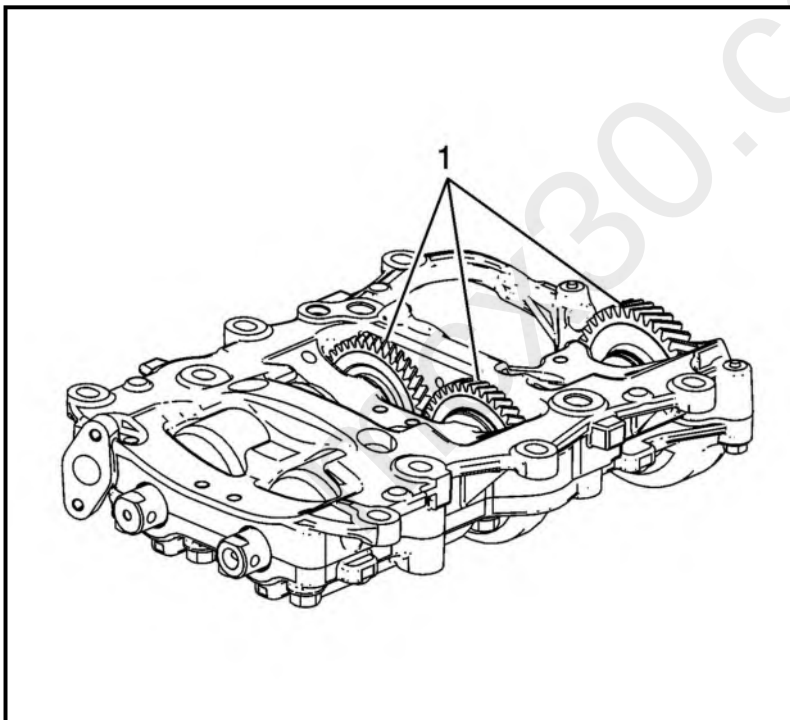
Clean and inspect the valve rocker arm (1) and lifters (2).

BALANCER SHAFT CLEANING AND INSPECTION

1. Remove the oil pump pipe bolts (1) and the pipe (2).



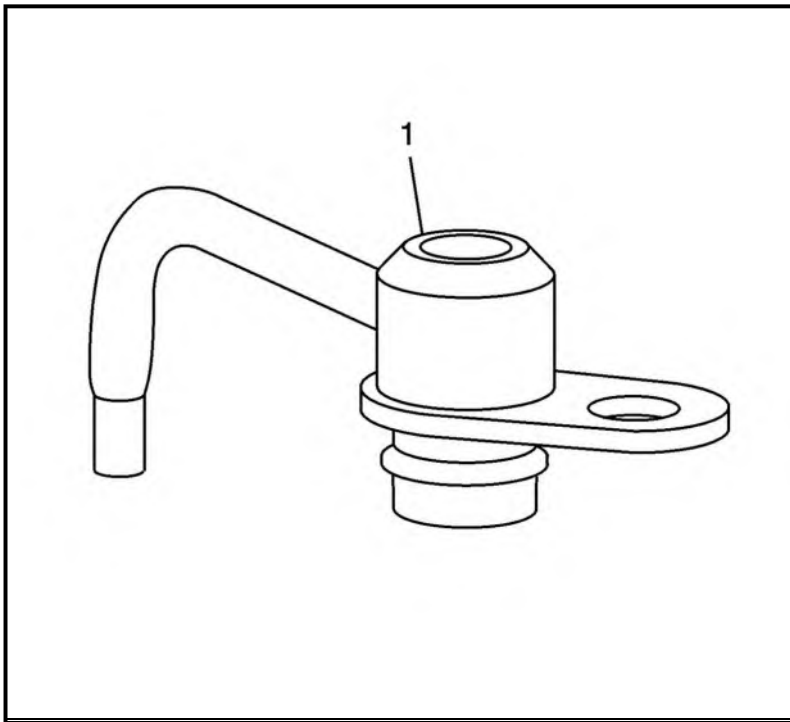
2. Remove and Discard the gasket (3).
3. Inspect the balance shaft gears (1) for wear or damage. Replace the balance shaft assembly if any damage is found.



4. Rotate the balance shaft. Replace the balance shaft assembly if any sticking, binding, or roughness is found.

PISTON OIL NOZZLE CLEANING AND INSPECTION

1. Inspect the piston oil cooling nozzle (1) for damage.

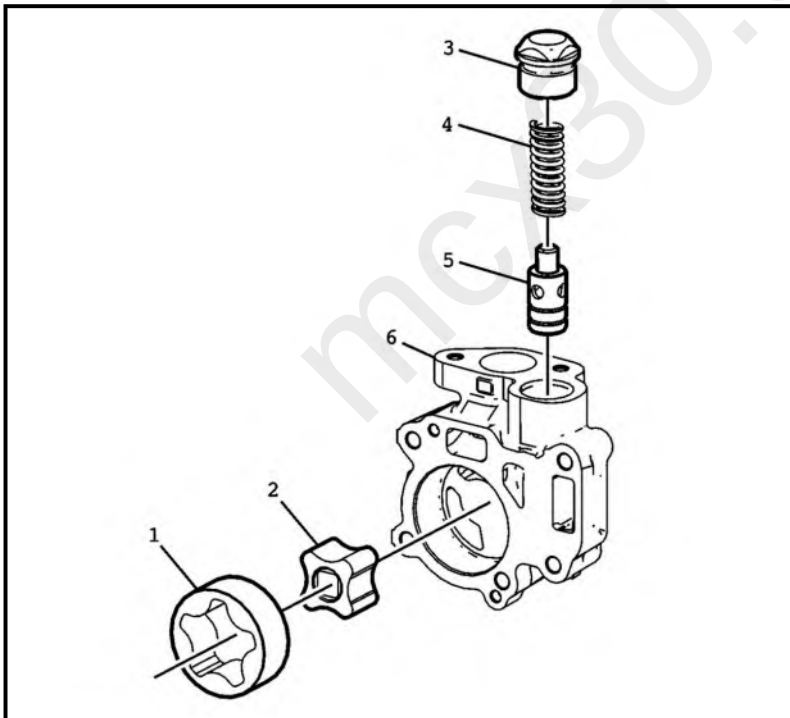


2. Replace the piston oil cooling nozzle if any damage is found.

OIL PUMP CLEANING AND INSPECTION

Disassemble

1. Remove the inner rotor (2) and outer rotor (1).



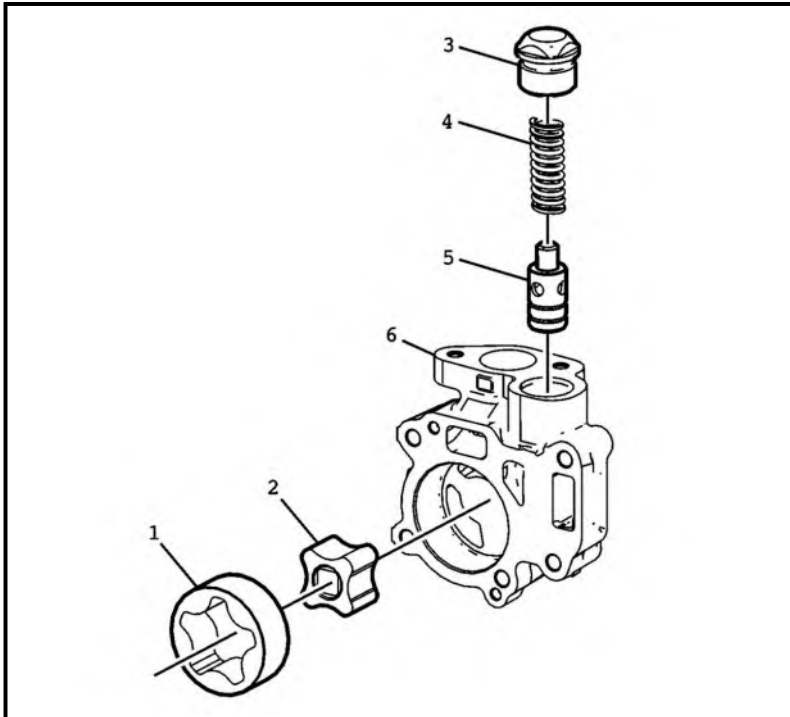
2. Disassemble the oil pressure relief valve (3 - 5).

WARNING: Refer to [Safety Glasses Warning](#) .

3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump for wear and scoring. Insure that all components are within specifications. Refer to [Engine Mechanical Specifications](#).
5. Replace the oil pump assembly if it is out of specification or damaged.

Assemble

1. Lubricate all oil pump parts with engine oil.

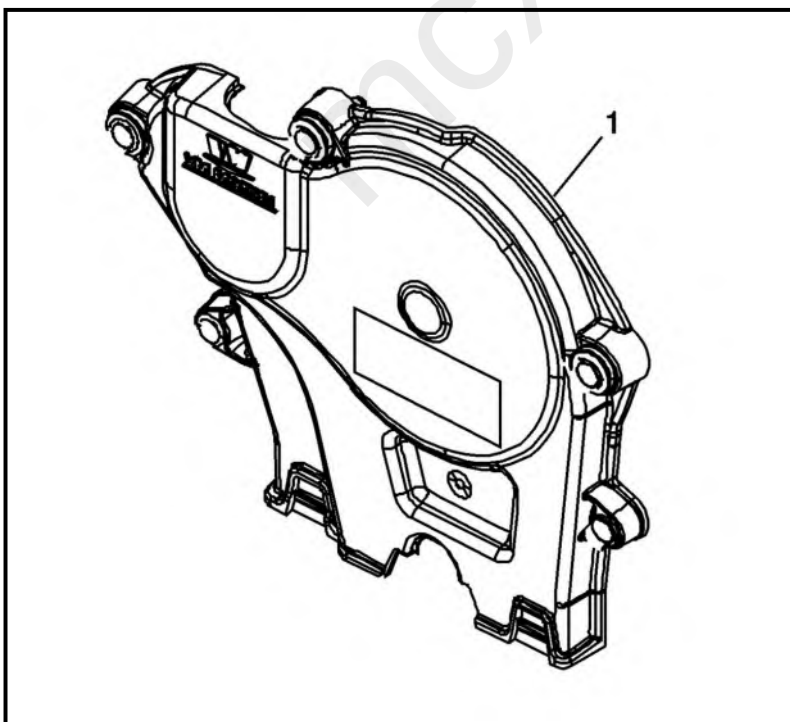


CAUTION: Refer to [Fastener Caution](#) .

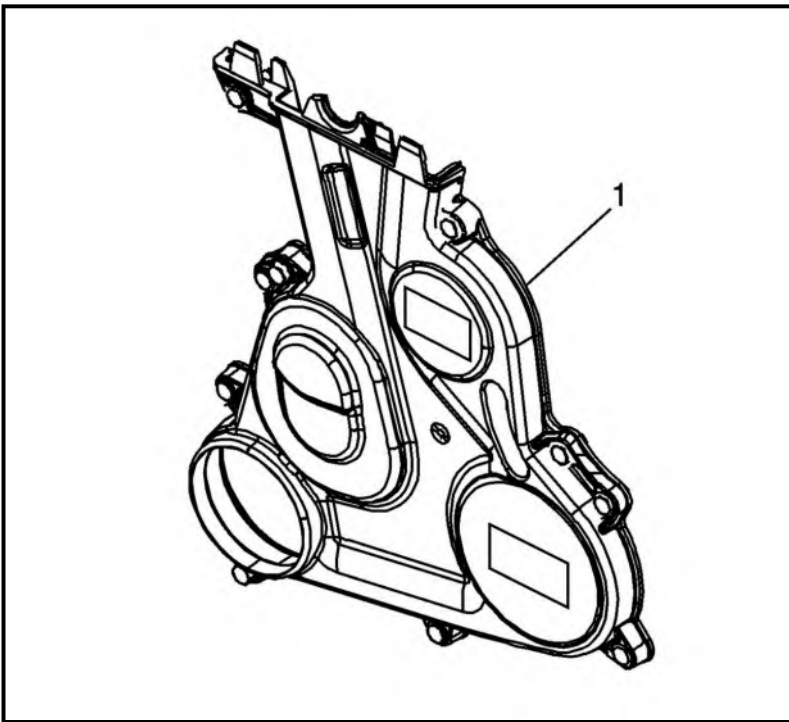
2. Assemble the oil pressure relief valve (3 - 5). Tighten the oil pressure relief valve plug to 40 N.m (30 lb ft)
3. Install the inner rotor (2) and outer rotor (1).

ENGINE FRONT COVER CLEANING AND INSPECTION

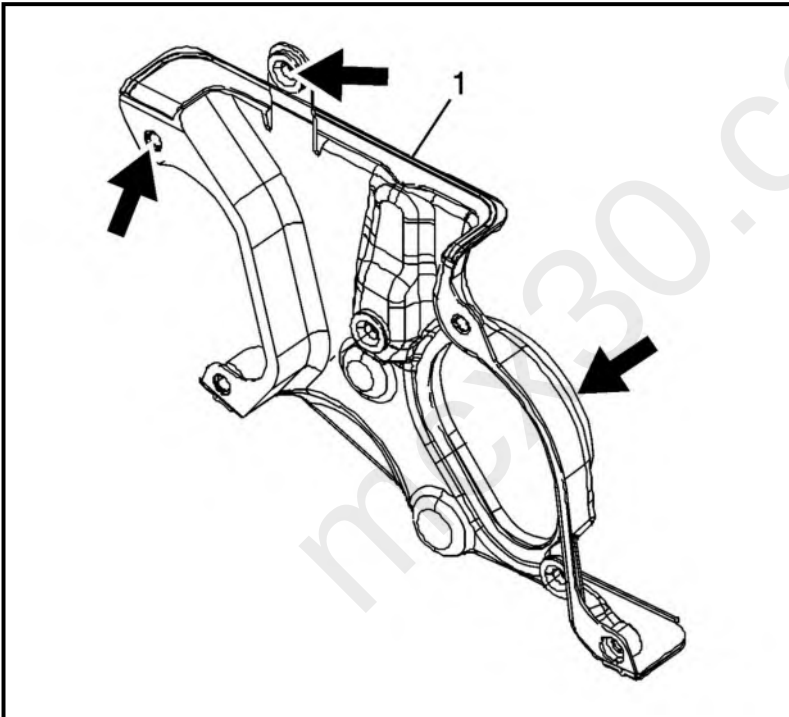
1. Clean and inspect the timing belt upper front cover (1).



2. Clean and inspect the timing belt lower front cover (1).

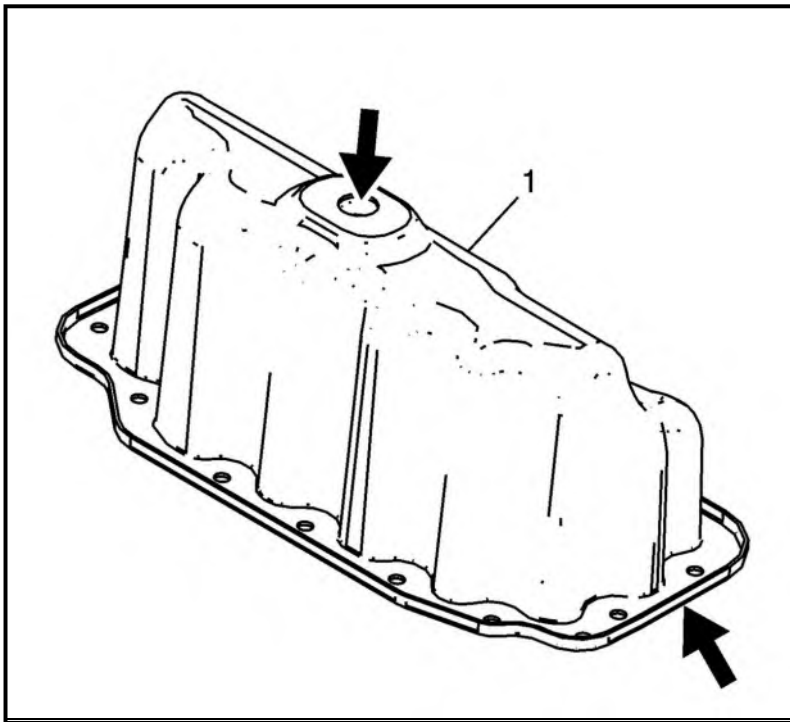


3. Clean and inspect the timing belt rear cover (1).



LOWER OIL PAN CLEANING AND INSPECTION

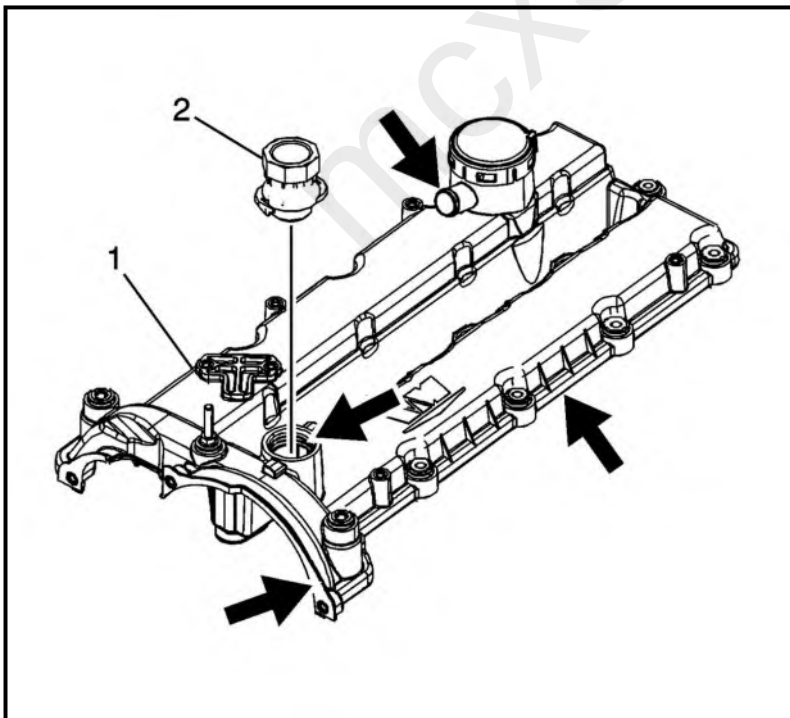
1. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)



2. Clean the oil pan mating surface.
3. Clean the oil pan (1). Remove all the sludge and the oil deposits.
4. Inspect the threads for the engine oil drain plug.
5. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
6. Inspect the oil pan baffle and pickup screen.
7. Repair or replace the oil pan as necessary.

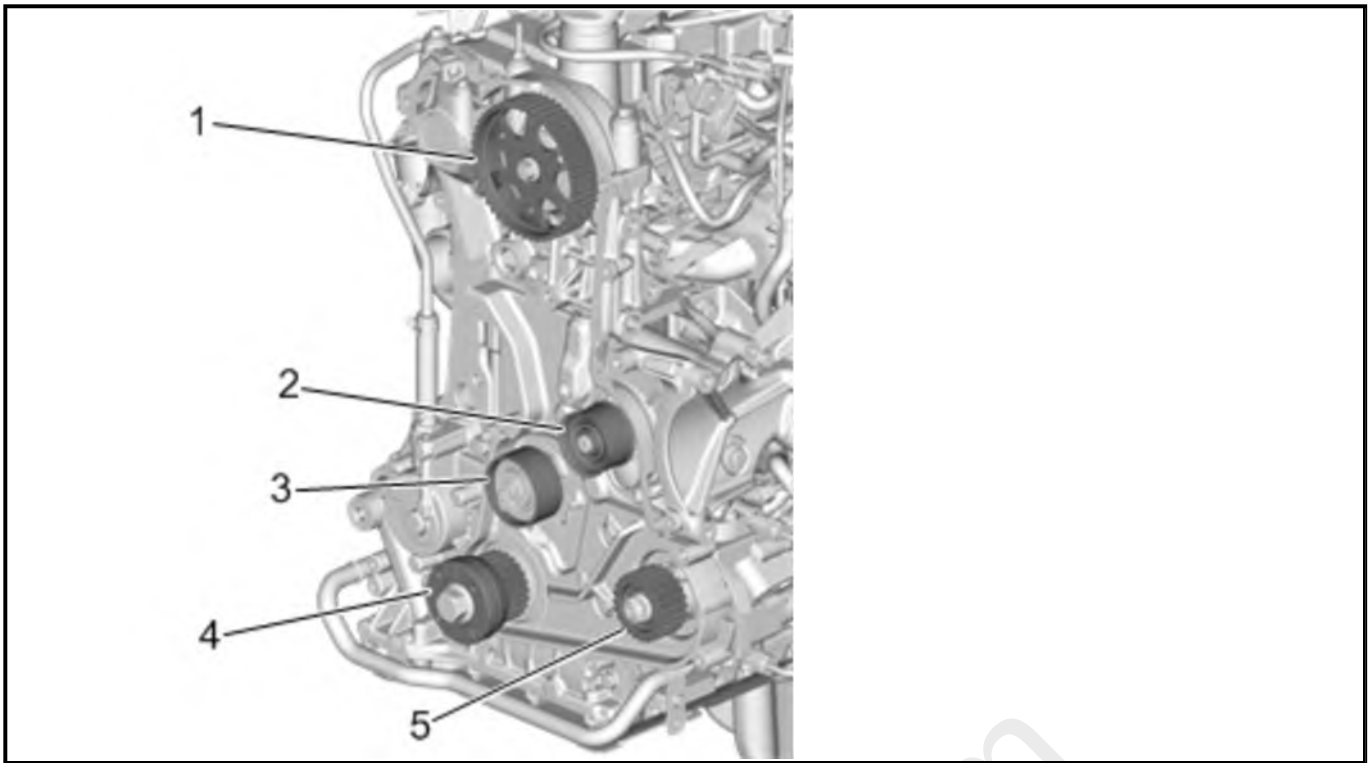
VALVE ROCKER ARM COVER CLEANING AND INSPECTION

1. Remove the oil filler spacer (2).



2. Clean and inspect the valve rocker arm cover (1).
3. Install the oil filler spacer.

TIMING BELT PULLEY CLEANING AND INSPECTION



Clean and inspect the timing belt pulleys (1 - 5).

INTAKE MANIFOLD DISASSEMBLE

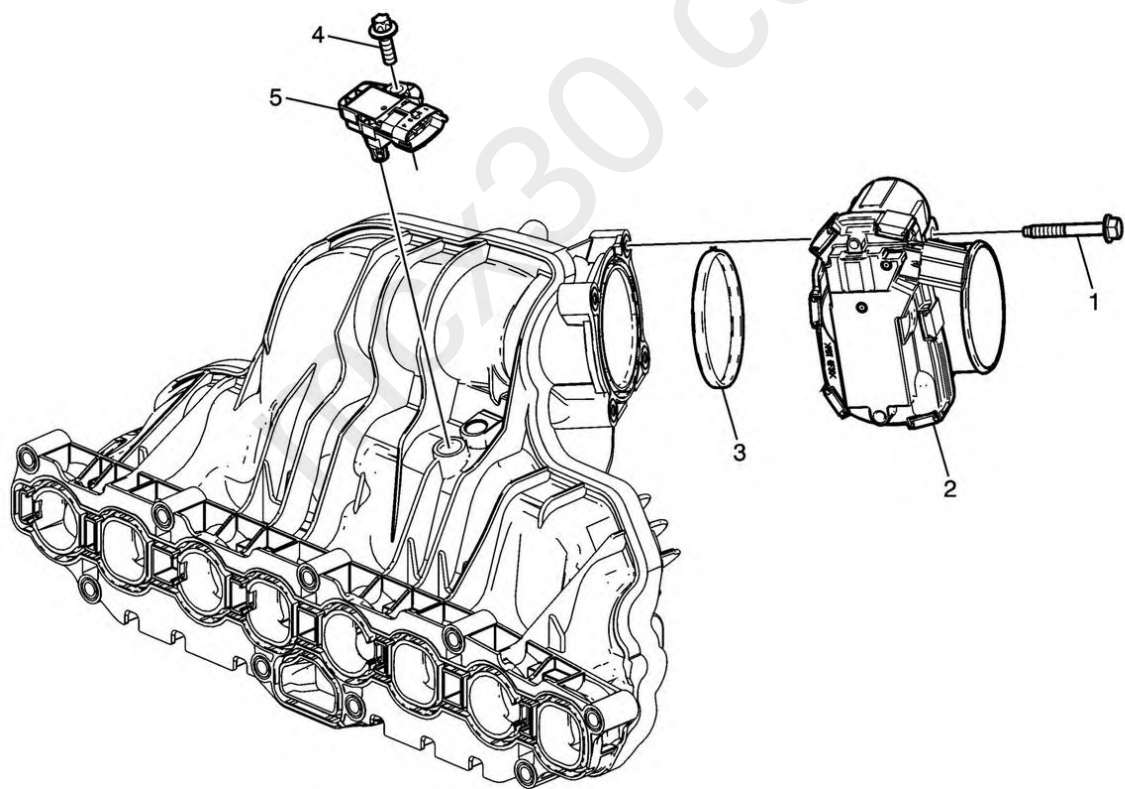


Fig. 41: Intake Manifold Components Location
 Courtesy of GENERAL MOTORS COMPANY

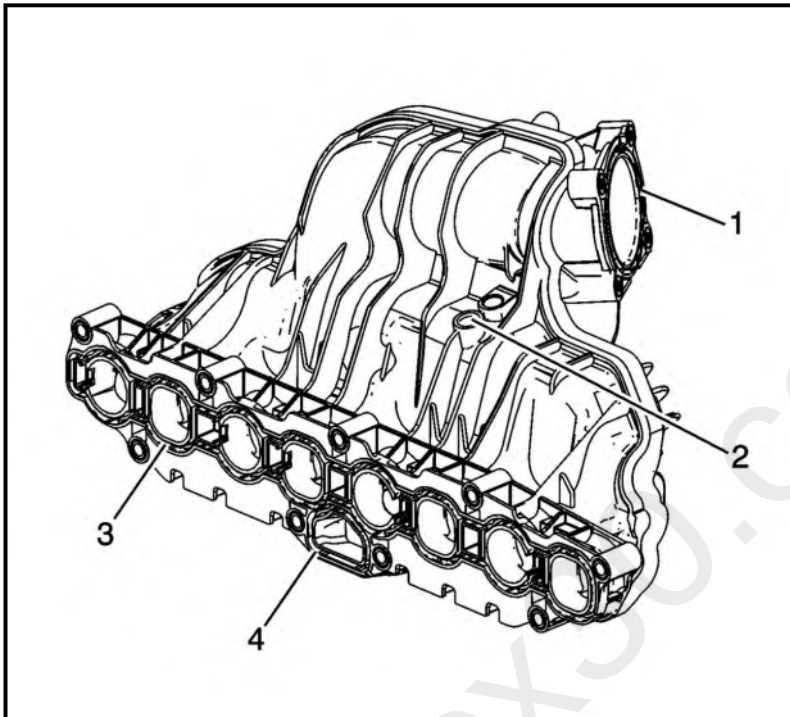
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Throttle Body Bolt
2	Throttle Body
3	Throttle Body Gasket

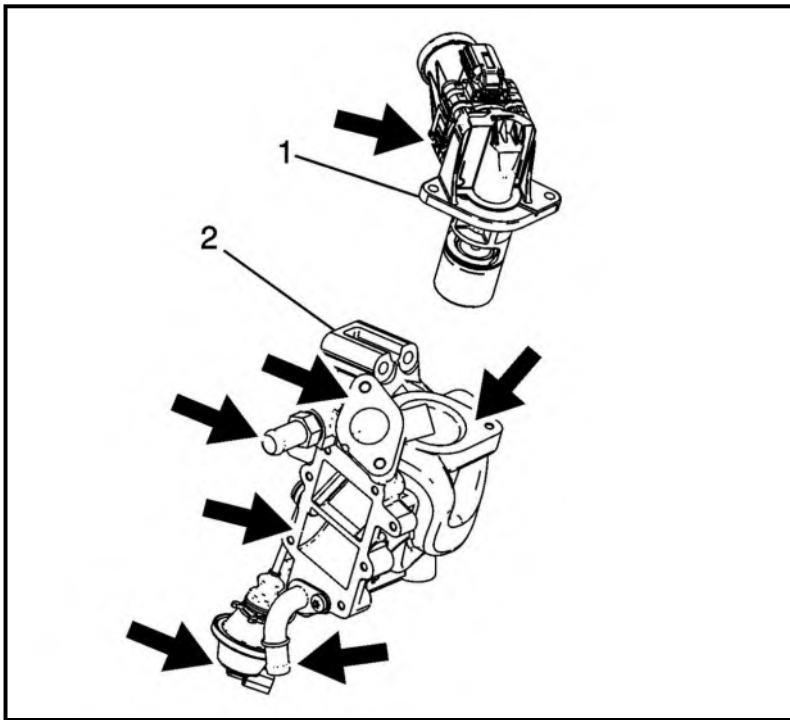
Callout	Component Name
	NOTE: Discard gasket, it is not reusable.
4	Manifold Absolute Pressure Sensor Bolt
5	Manifold Absolute Pressure Sensor

INTAKE MANIFOLD CLEANING AND INSPECTION

1. Clean the intake manifold mating surfaces.



2. Inspect the intake manifold (1) for damage.
3. Inspect the intake manifold for cracks near metallic inserts.
4. Inspect the crankcase ventilation passages in the intake manifold face for blockage.
5. Replace the intake manifold as necessary.
6. Clean the EGR valve housing (1).



7. Clean the EGR valve assembly (2).
8. Inspect the EGR valve assembly.
9. Replace the EGR valve assembly as necessary.
10. Apply 15 inHg to EGR valve.
11. Verify that the EGR valve opens.
12. Verify that EGR valve does not leak down.
13. Replace the EGR valve if any concern is found.

INTAKE MANIFOLD ASSEMBLY

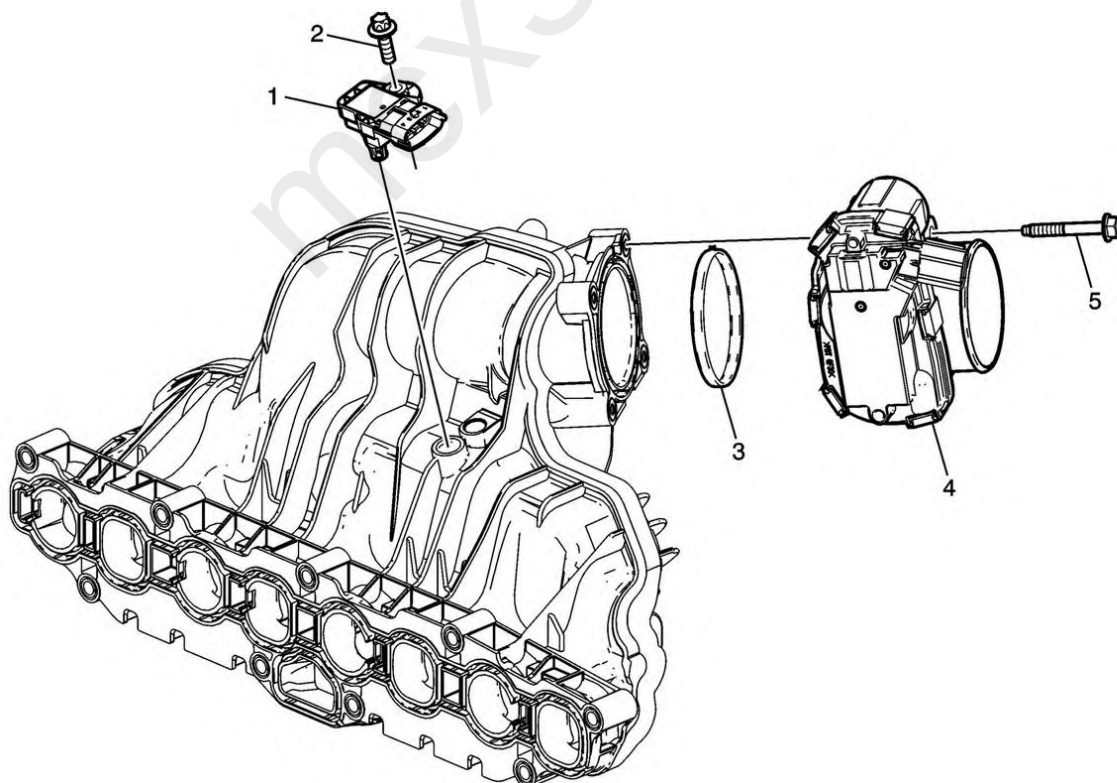


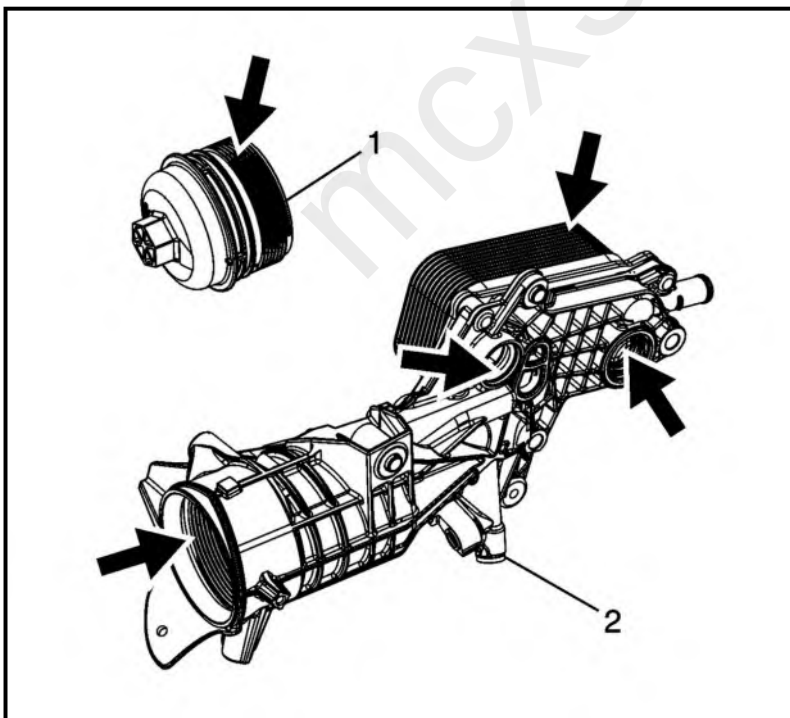
Fig. 42: Intake Manifold Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	MAP Sensor Manifold Absolute Pressure Sensor
2	Manifold Absolute Pressure Sensor Bolt CAUTION: Refer to Fastener Caution . Tighten 9 N.m (80 lb in)
3	Throttle Body Gasket NOTE: Install a NEW gasket. It is not reusable.
4	Throttle Body
5	Throttle Body Bolt Tighten 11 N.m (97 lb in)

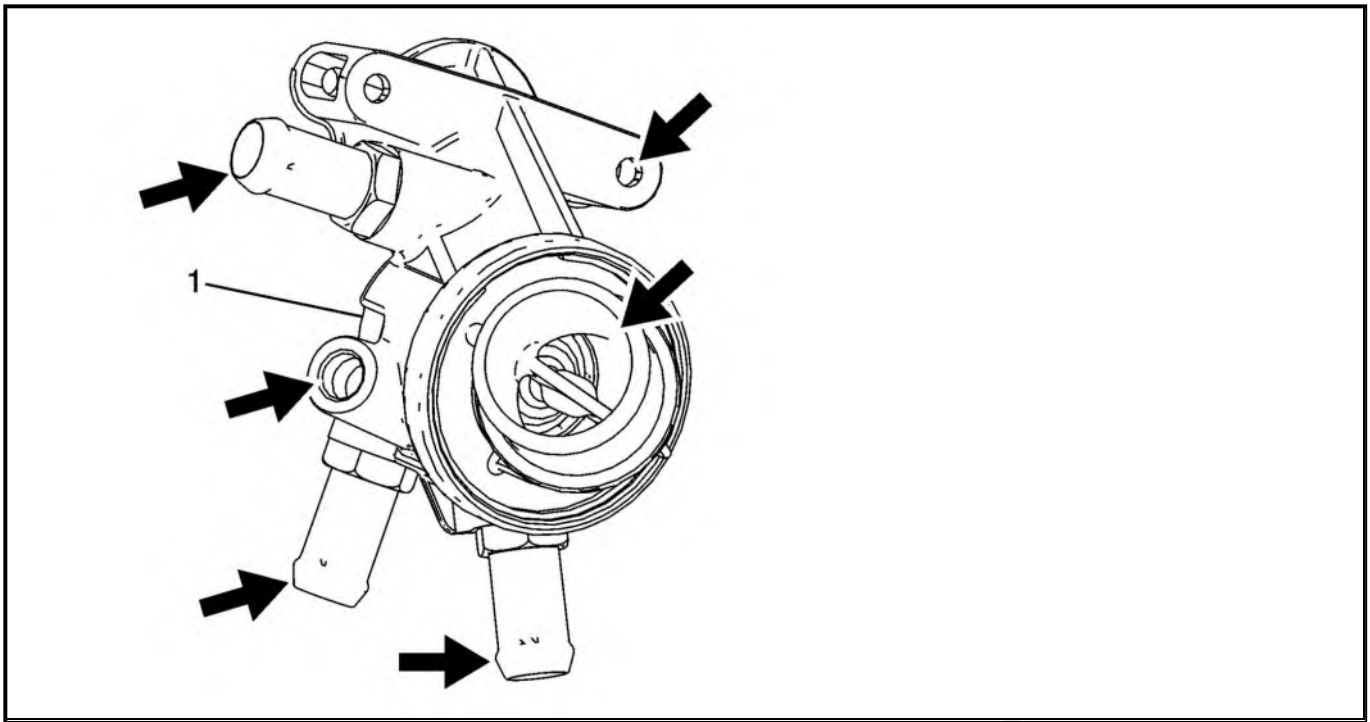
ENGINE OIL COOLER CLEANING AND INSPECTION

1. Clean and inspect the oil filter with cooler assembly (2).



2. Clean and inspect the oil filter cap assembly (1).
3. Replace the components as necessary.

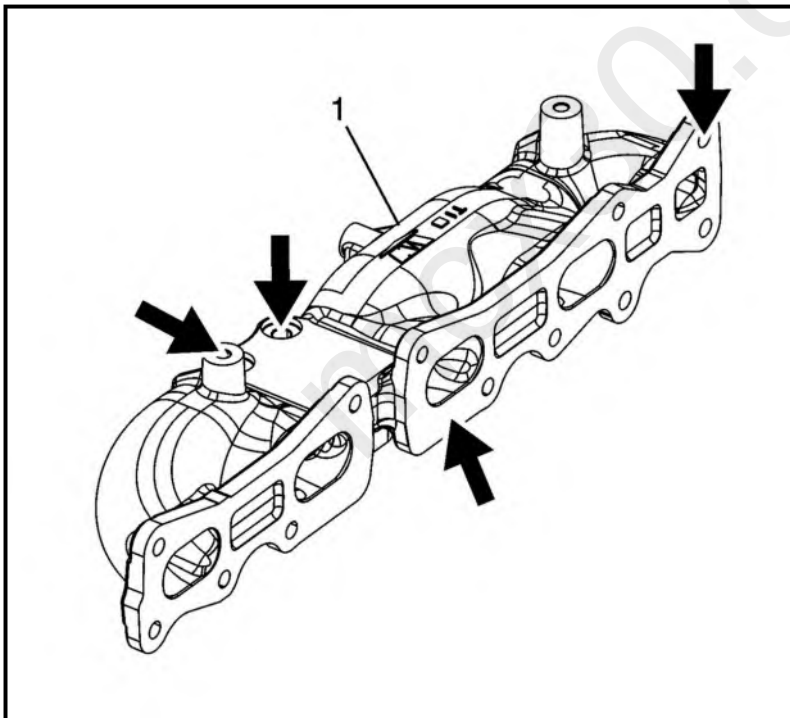
ENGINE COOLANT THERMOSTAT CLEANING AND INSPECTION



Clean and inspect the engine coolant thermostat assembly (1). Replace as necessary.

EXHAUST MANIFOLD CLEANING AND INSPECTION

1. Clean the exhaust manifold in solvent.



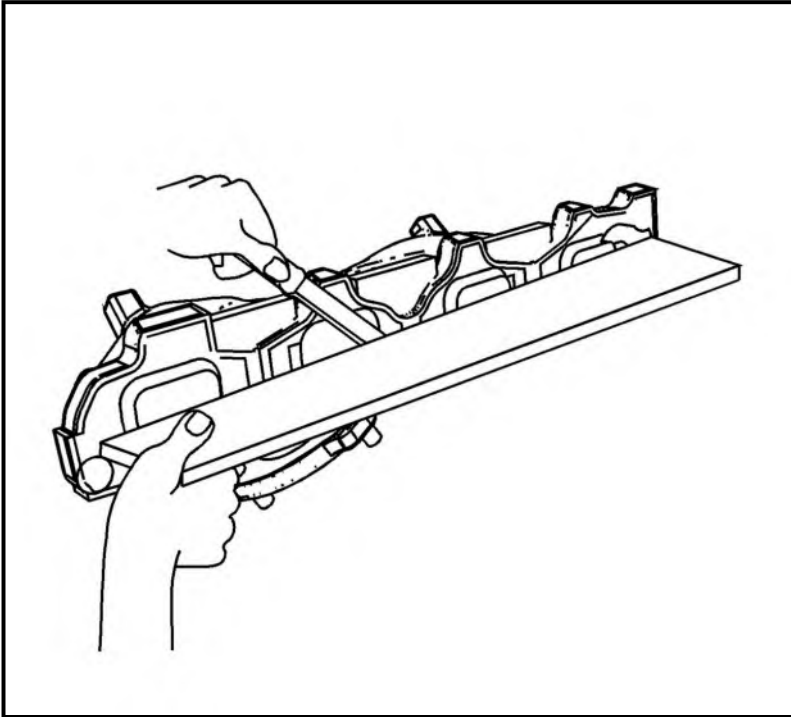
NOTE: Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.

WARNING: Refer to [Safety Glasses Warning](#) .

WARNING: Refer to [Safety Glasses and Compressed Air Warning](#) .

2. Dry the exhaust manifold with compressed air.

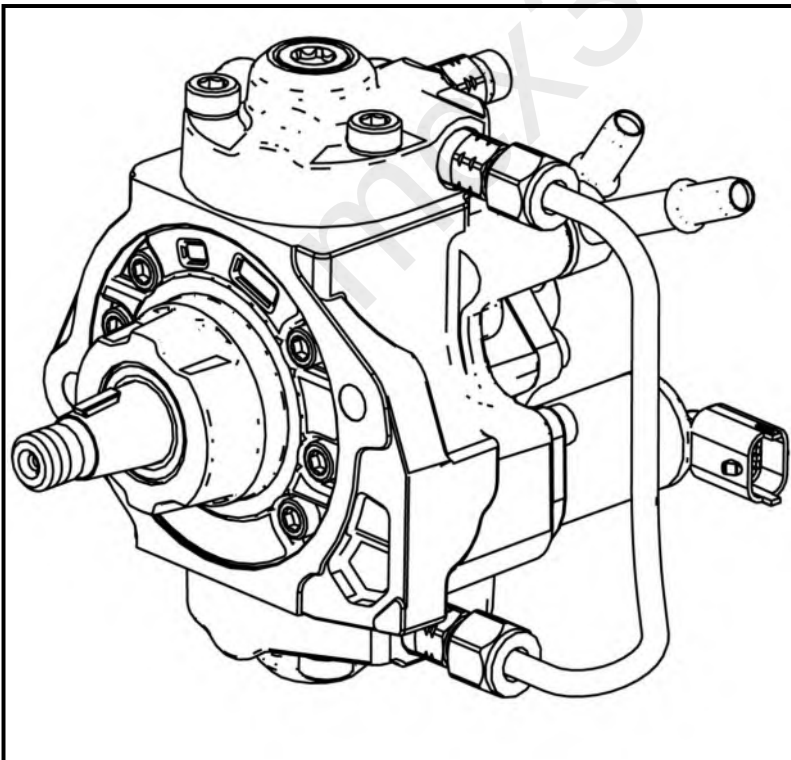
3. Inspect the heat shield for damage.
4. Use a straight edge and a feeler gauge and measure the exhaust manifold mounting face for warpage.



5. 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.

FUEL PUMP CLEANING AND INSPECTION

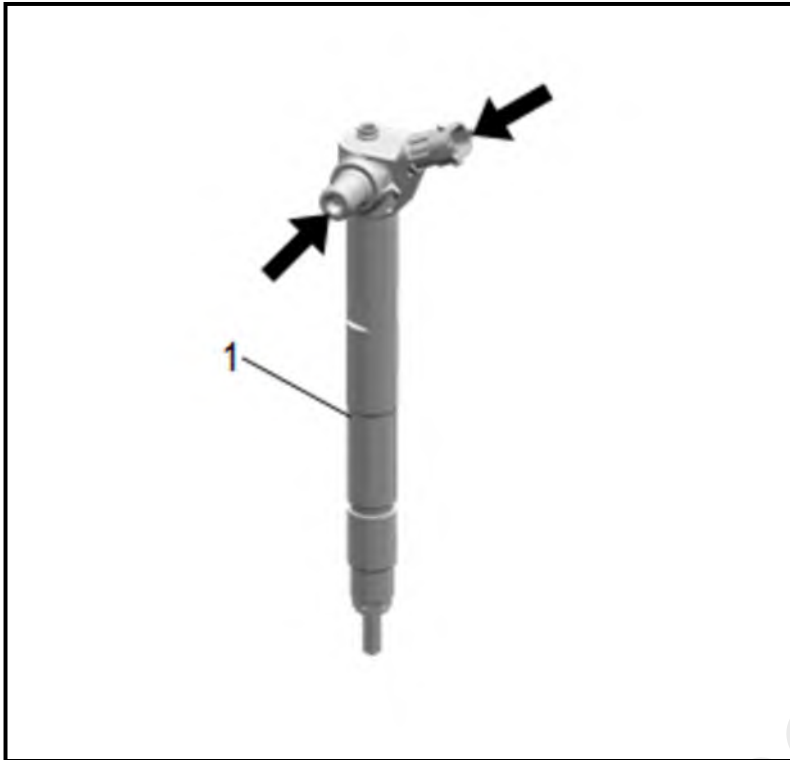
1. Clean all dirt and debris from the fuel pump surfaces.



2. Clean the fuel injection pump mating surfaces.
3. Inspect for any sign of leaking around pipe connections.
4. Replace component if any damage or leaks are found.

FUEL INJECTOR CLEANING AND INSPECTION

1. Use a soft bristle non-metallic brush and top engine cleaner, GM P/N 1052626 or equivalent, to remove any deposits from the fuel injector (1) nozzle tip and the copper washer sealing area before reinstallation.



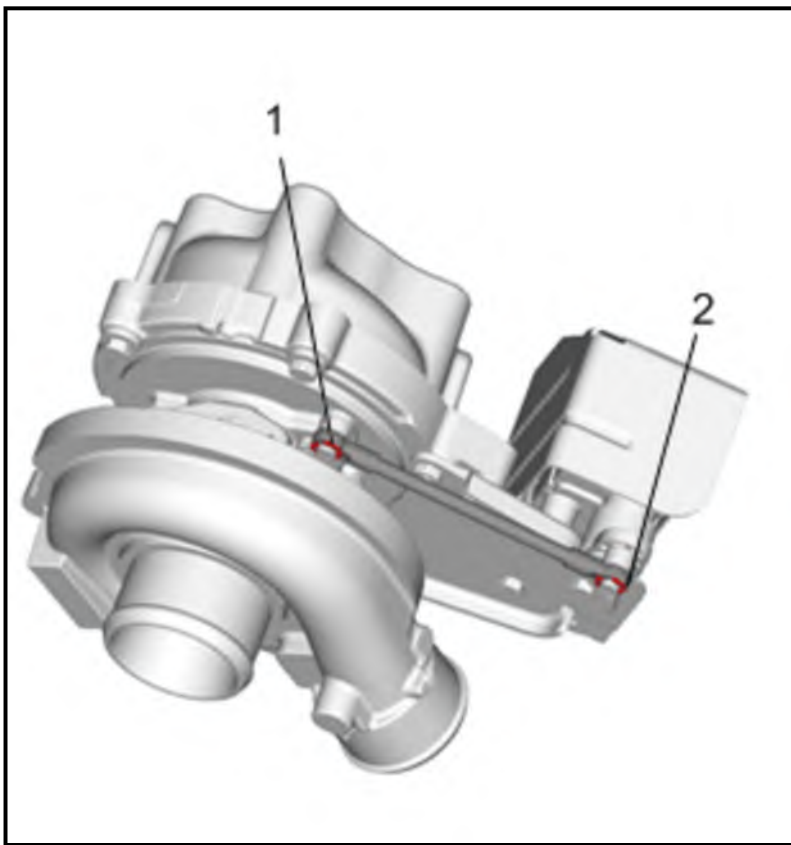
CAUTION: The fuel injector must be cleaned with the proper cleaning equipment. **DO NOT** use abrasive cleaning methods, such as a metallic brush, to remove deposits. Cleaning an injector with improper tools will damage the fuel injector.

NOTE: Remove the fuel injector combustion seals and discard.

2. Inspect the fuel injector nozzle tip for cracks, dents, or other damage.
3. Inspect the nozzle tip for any signs of discoloration

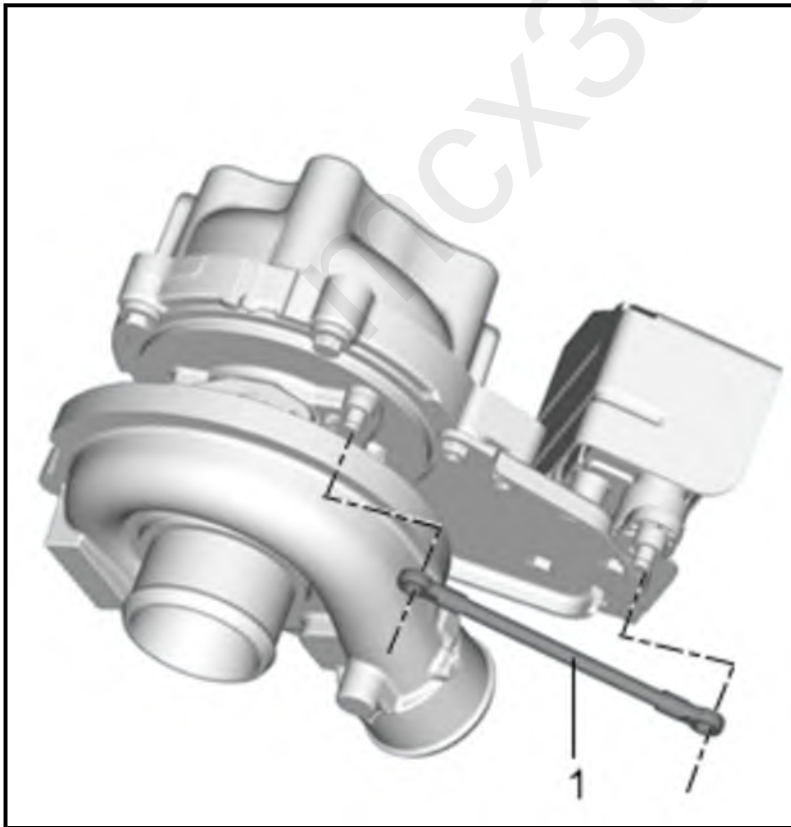
COMPRESSOR AIR INTAKE TURBOCHARGER DISASSEMBLE

1. Remove clips (1, 2) with a suitable tool, such as a screwdriver.

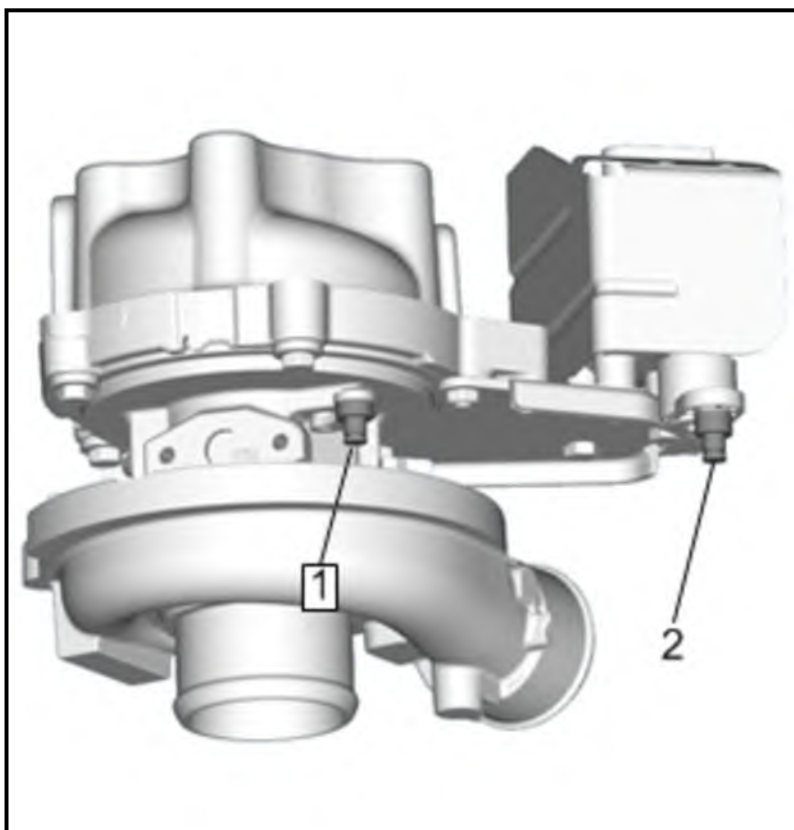


NOTE: Removal of both clips is needed for visual inspection and to allow reassembly of the rod without twisting the rod or pins. Do not apply any force on the actuator components and crank pin.

2. Remove the actuator rod (1).



3. Visually inspect the crank pin (1) and actuator pin (2). Ensure that the following conditions exist:



- Pins must be free of marks from clamping or shock.
- Pins should be free of excessive wear.
- Crank lever must be free of bending.

4. Visually inspect the actuator rod (1). Ensure that the following conditions exist:

- Rod must not present marks from clamping or shock.
- Rod must be free of any abnormal bends.
- Hole diameters are free of excessive wear.

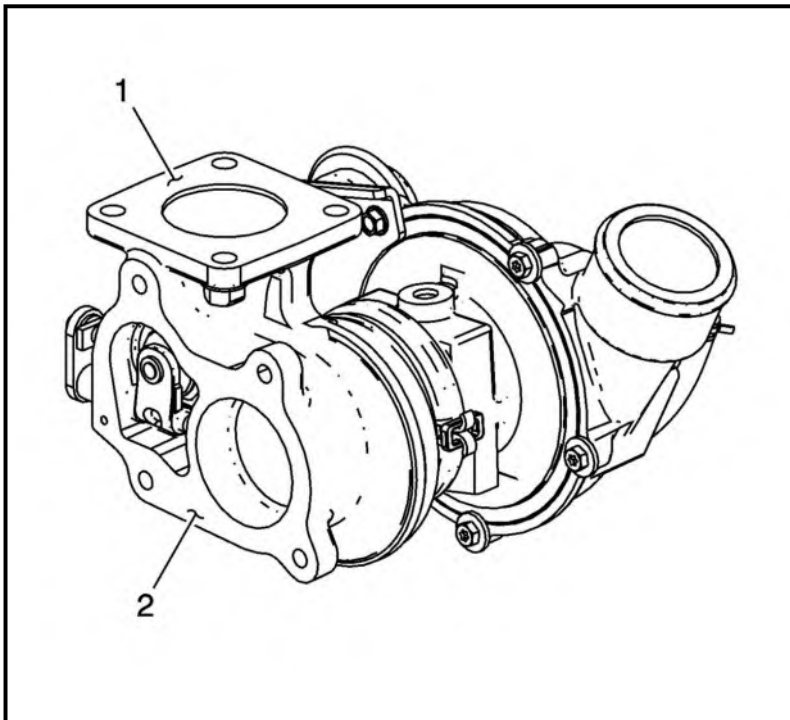
5. Measure the actuator rod and crank pin. Then compare values to the chart below. If the actuator rod or pin is outside of these values, a new turbocharger must be installed.

Component	Characteristic	Min Value	Max Value
Rod	Hole Inside Diameter	7.5 mm (0.295 in)	7.6 mm (0.299 in)
	Straightness	0.3 mm (0.0118 in)	0.5 mm (0.0196 in)
Pin	Outside Diameter	7.4 mm (0.291 in)	7.5 mm (0.295 in)

COMPRESSOR AIR INTAKE TURBOCHARGER CLEANING AND INSPECTION

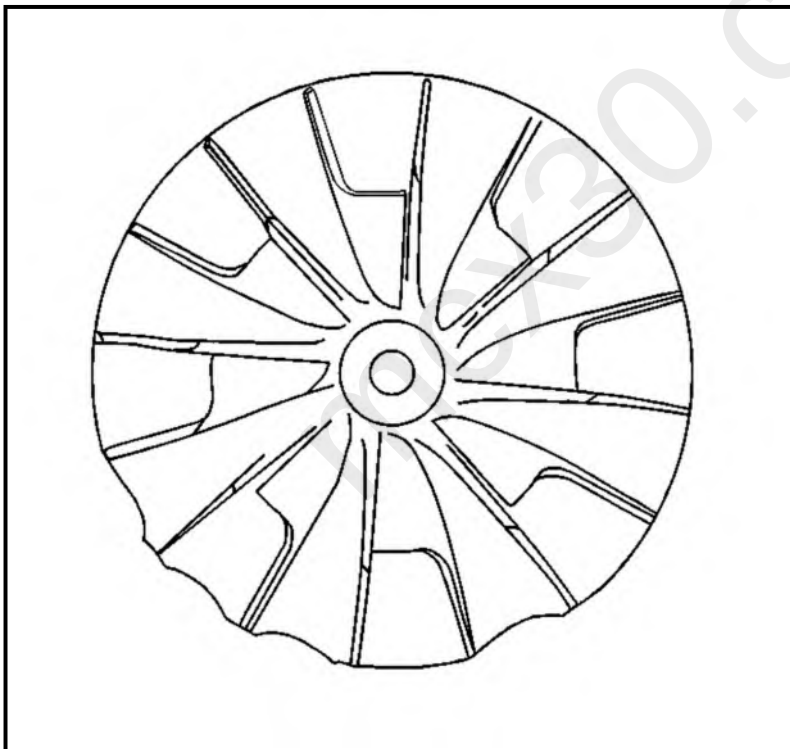
Completely inspect the turbocharger and all other engine components that may cause similar conditions before replacing the turbocharger. Use the following information to diagnose problems. The turbocharger is serviced as a complete unit.

1. Clean the turbocharger mating surfaces (1, 2).

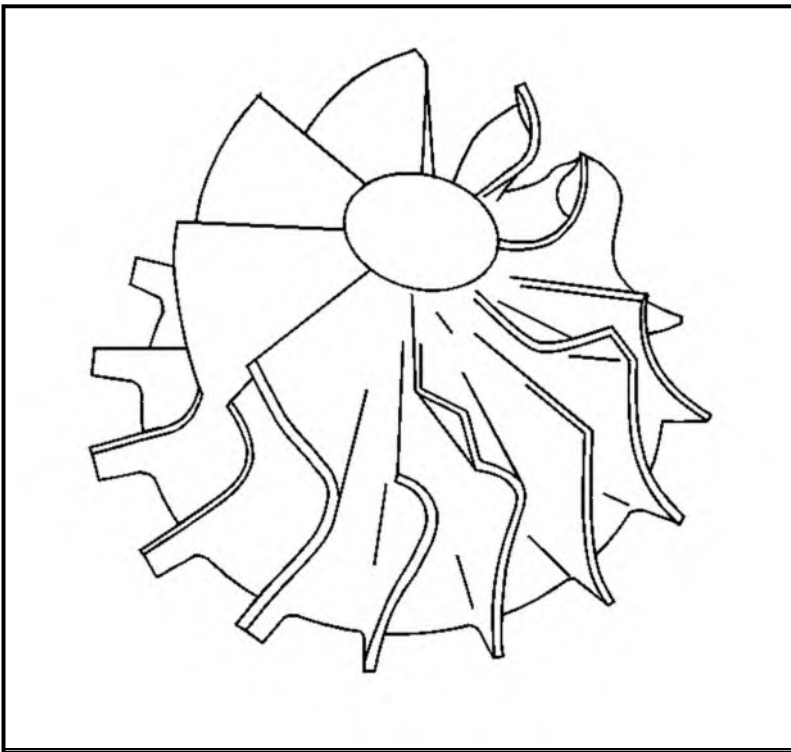


NOTE: Oil residue on the turbocharger compressor wheel is normal with a closed PCV system.

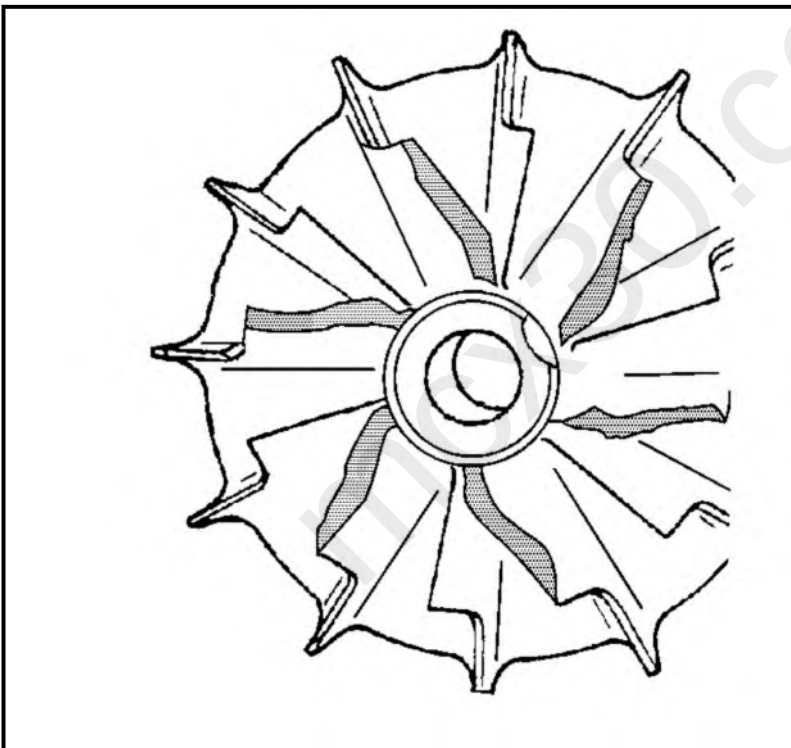
2. Inspect for damage to the compressor wheel, compared to a normal compressor wheel.



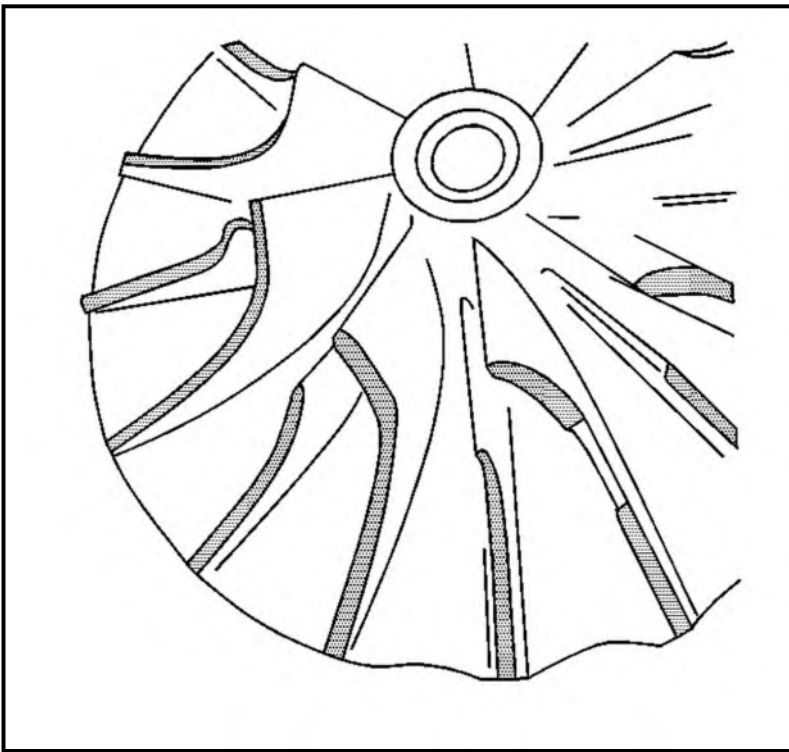
3. Inspect for damage to the compressor wheel, by a soft object.



4. Inspect for damage to the compressor wheel, by a hard object.



5. Inspect compressor blades for heavy rubbing.



6. Ensure that the following conditions do not exist on the compressor wheel blades:

- Cracks
- Bends
- Erosion of the blades
- Broken blades

7. Check the housing for signs of rubbing.

8. Clean the turbocharger inlet duct.

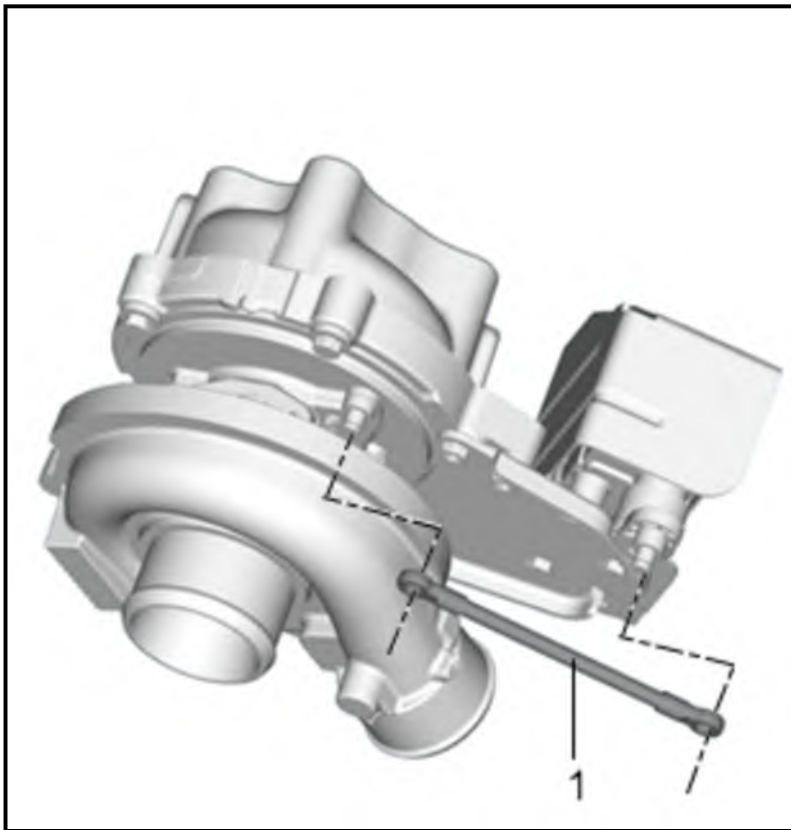
9. Clean the turbocharger inlet duct mating surfaces.

10. Inspect the turbocharger inlet duct for cracks.

11. Inspect the turbocharger inlet duct mating surfaces for damage.

COMPRESSOR AIR INTAKE TURBOCHARGER ASSEMBLE

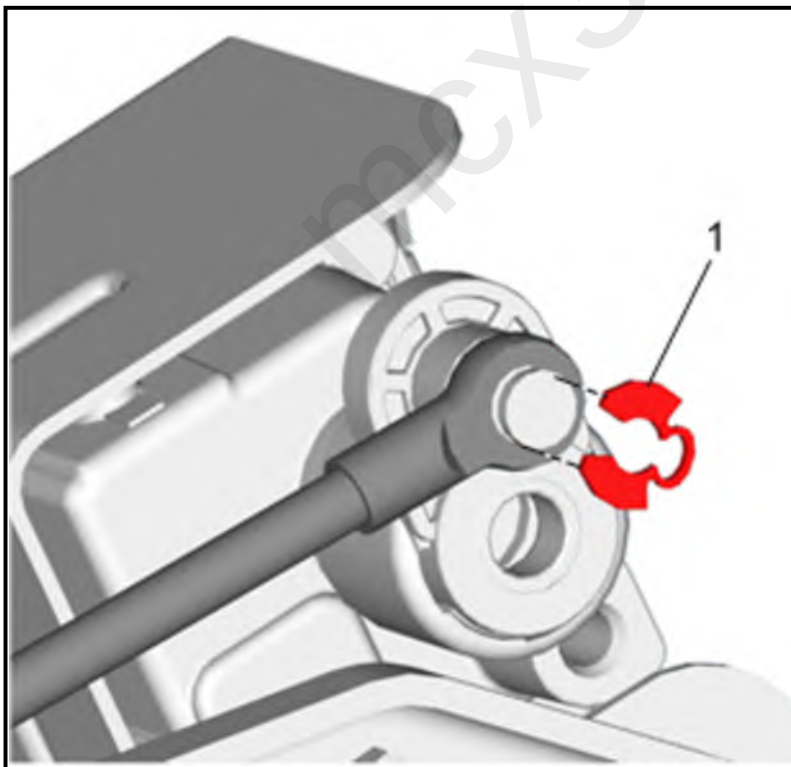
1. Install the actuator rod (1) onto the actuator and crank pin.



NOTE:

- Do not twist the crank or the actuator rod end during install.
- Do not replace the original actuator rod, as it is calibrated to the turbocharger.

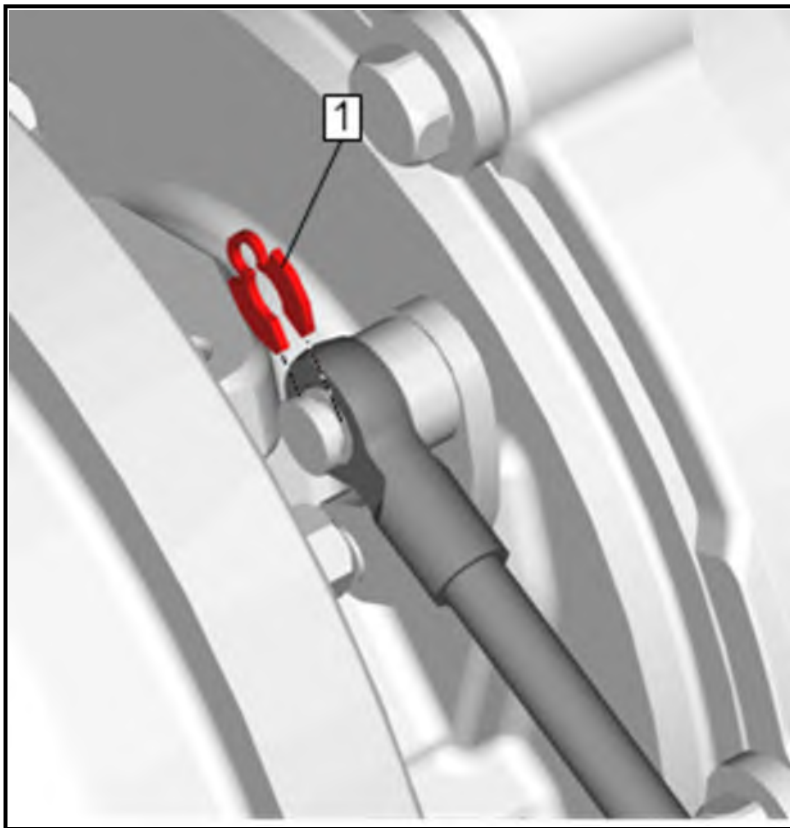
2. Manually introduce the clip (1) into the actuator pin groove. Use a suitable tool, such as pliers, to clamp the clip inside the groove.



NOTE:

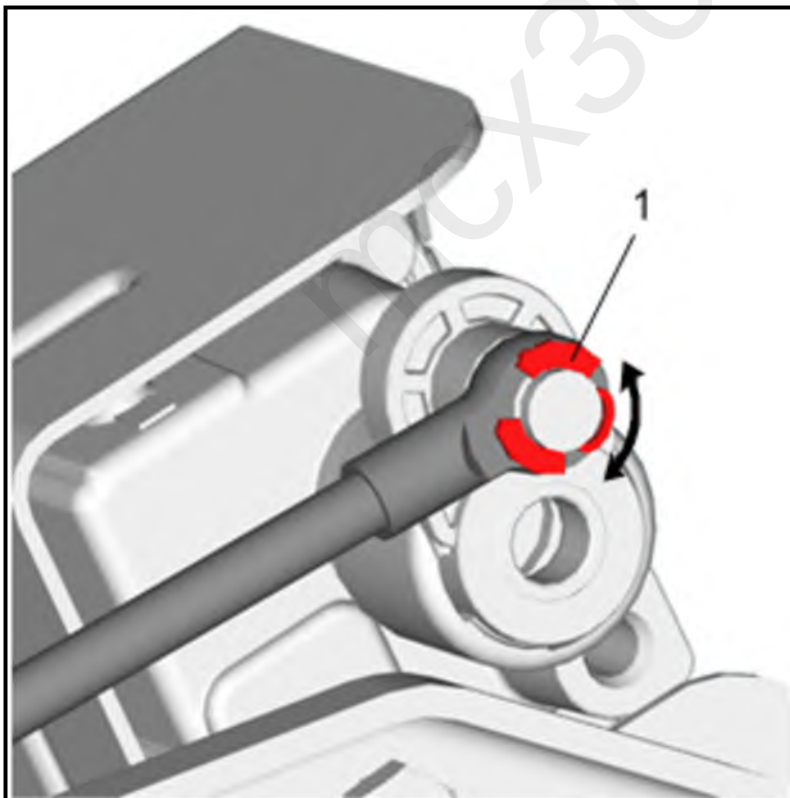
Do not deform, twist, or over clamp the clip.

3. Manually introduce the clip (1) into the crank pin groove. Use a suitable tool, such as pliers, to clamp the clip inside the groove.



NOTE: Do not deform, twist, or over clamp the clip.

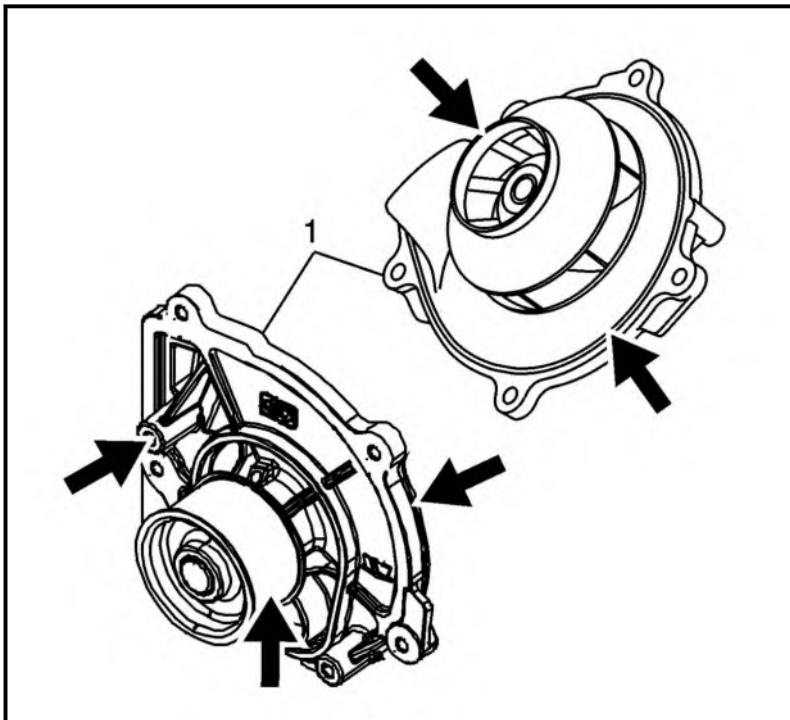
4. Manually rotate the actuator rod clips. If the clip is free in rotation, remove and replace with a new clip. If the clip continues to rotate freely, inspect the pin for visual signs of wear. Utilize good judgement and replace the clip or turbo as necessary.



NOTE: Do not use a tool when checking the rotation of the actuator rod clips.

WATER PUMP CLEANING AND INSPECTION

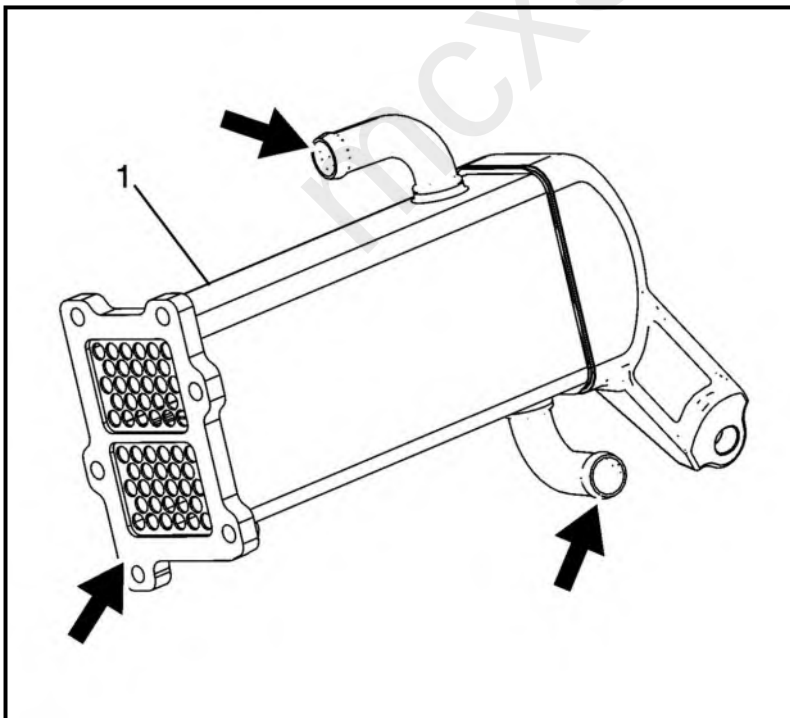
1. Clean the water pump assembly (1).



2. Clean the water pump mating surfaces.
3. Inspect the water pump gear for damage.
4. Inspect the water pump mating surfaces for damage.
5. Inspect the water pump shaft for looseness.
6. Inspect the water pump assembly for damage.
7. Replace the water pump if any damage is found.

EXHAUST GAS RECIRCULATION VALVE COOLER CLEANING AND INSPECTION

1. Clean and inspect the Exhaust Gas Recirculation Cooler (1).

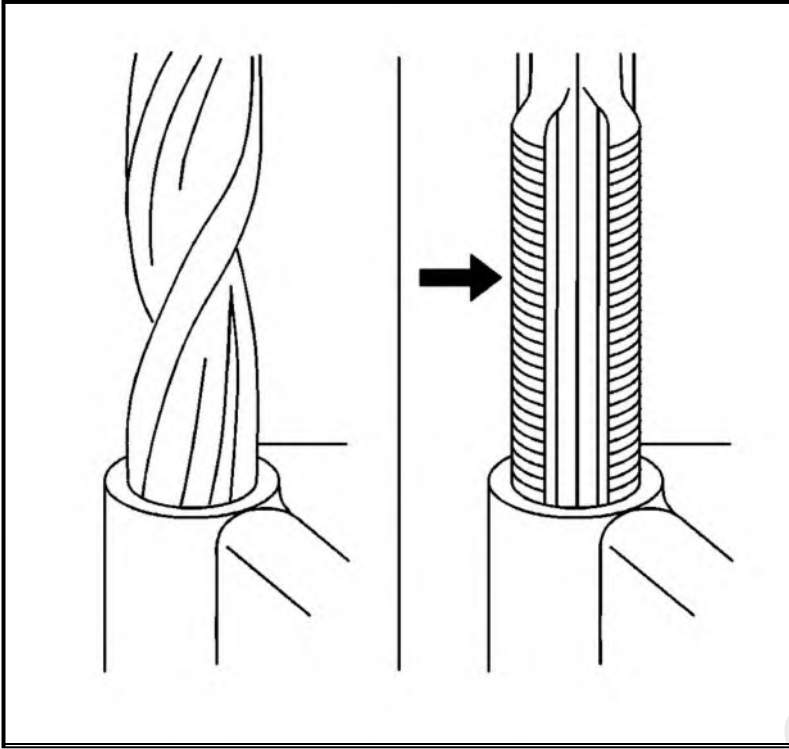


2. Clean and inspect the Exhaust Gas Recirculation Cooler Gasket surfaces.
3. Replace the Exhaust Gas Recirculation Valve or Exhaust Gas Recirculation Cooler if damaged.

THREAD REPAIR

General purpose thread repair kits are available commercially.

1. Always avoid any buildup of chips. Back out the tap every few turns and remove the chips.

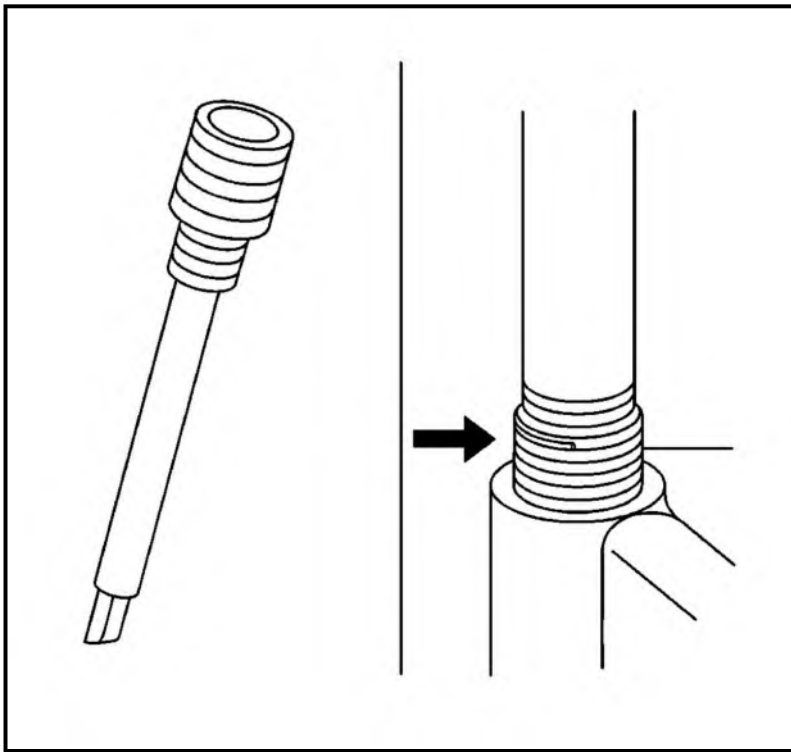


WARNING: Refer to [Safety Glasses Warning](#) .

NOTE: Refer to the thread repair kit manufacturer's instructions regarding the size of the drill and which tap to use.

Determine the size, the pitch, and the depth of the damaged thread.

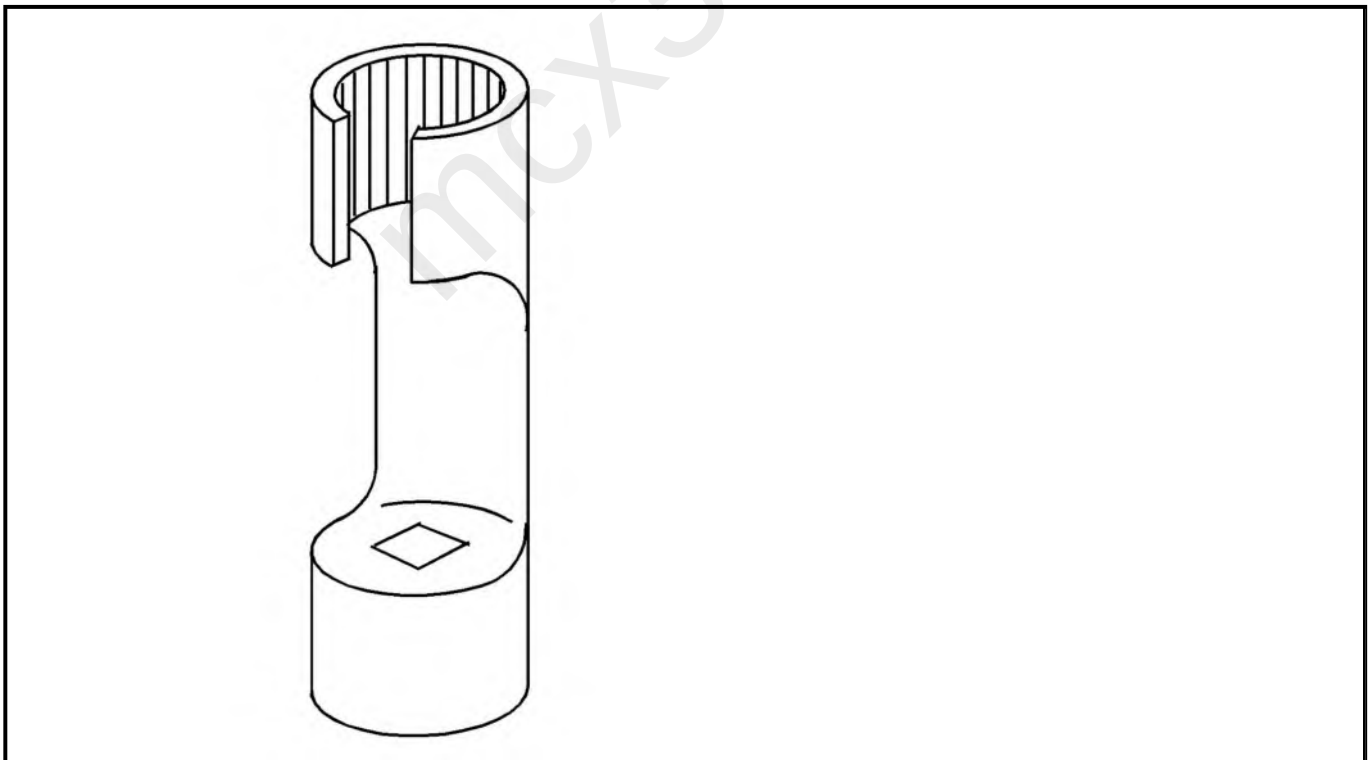
2. Adjust the stop collars on the cutting tool as needed. Tap the stop collars to the required depth.
3. Drill out the damaged thread.
4. Remove the chips.
5. Apply clean engine oil to the top thread.
6. Use the tap in order to cut new thread.
7. Clean the thread.
8. Screw the thread insert onto the mandrel of the thread insert installer. Engage the tang of the thread insert onto the end of the mandrel.



NOTE: The thread insert should be flush to 1 turn below the surface.

9. Lubricate the thread insert with clean engine oil - except when installing in aluminum - and install the thread insert.
10. If the tang of the thread insert does not break off when backing out the thread insert installer, break off the tang using a drift punch.

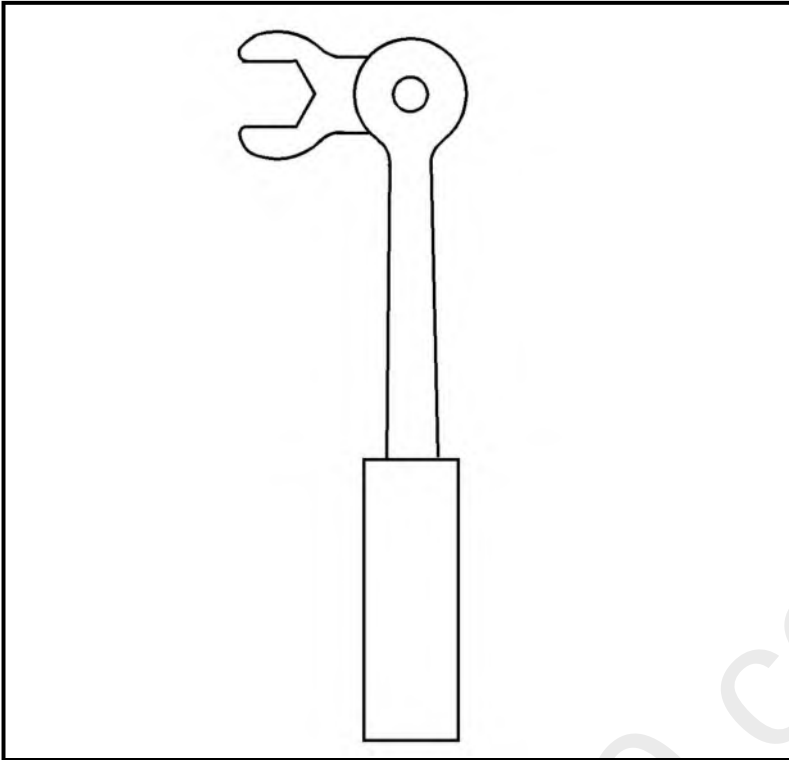
FUEL LINE TORQUING



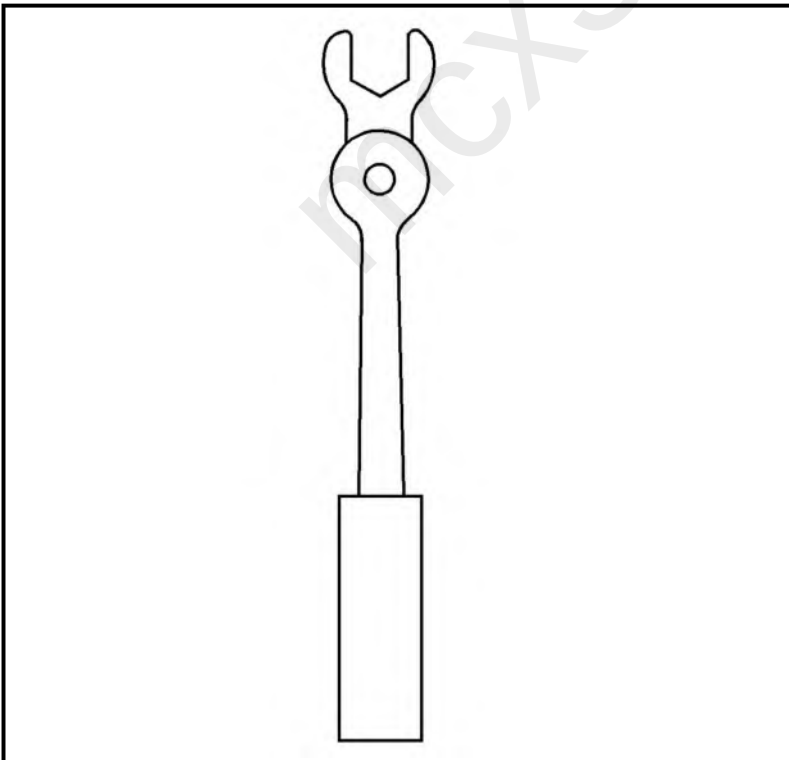
The torque of a fuel line fitting is critical to prevent fuel leaks in a high pressure direct injection fuel system. The preferred method is through the use of a flare nut socket. With the use of a flare nut socket, the torque wrench can be set to the listed torque specification. Refer to [Fastener Specifications](#).

If a crows foot is used to torque the fuel lines, then special attention to the position of the crows foot in relation to the torque wrench is required.

- If the crows foot is kept perpendicular (90 degrees) to the torque wrench during the entire tightening procedure, then the torque wrench can be set to the listed torque specification. Refer to [Fastener Specifications](#).



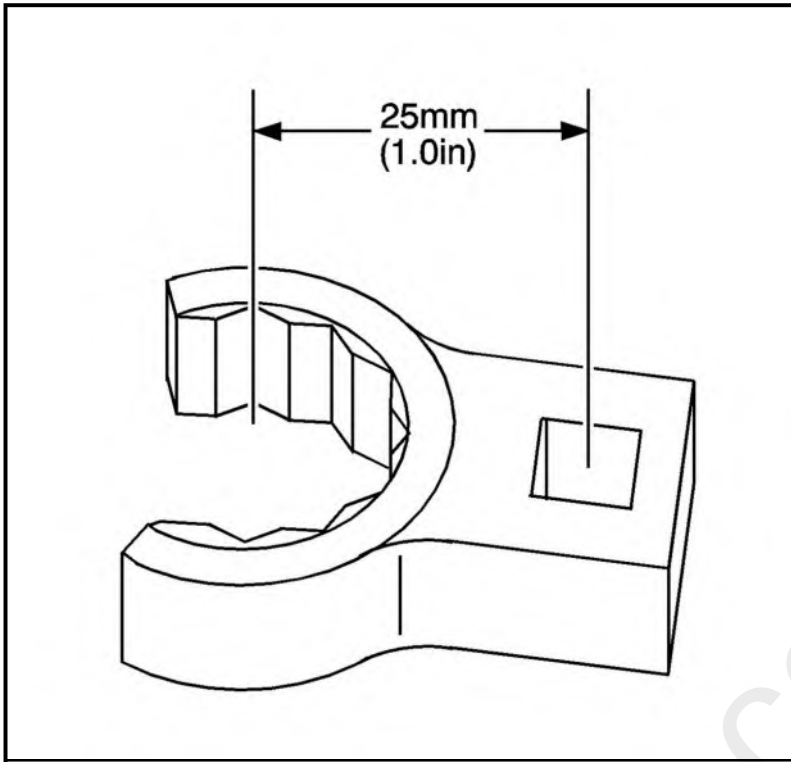
- If the crows foot is positioned straight with the torque wrench, then the torque setting needs to be corrected to compensate for the increased leverage.



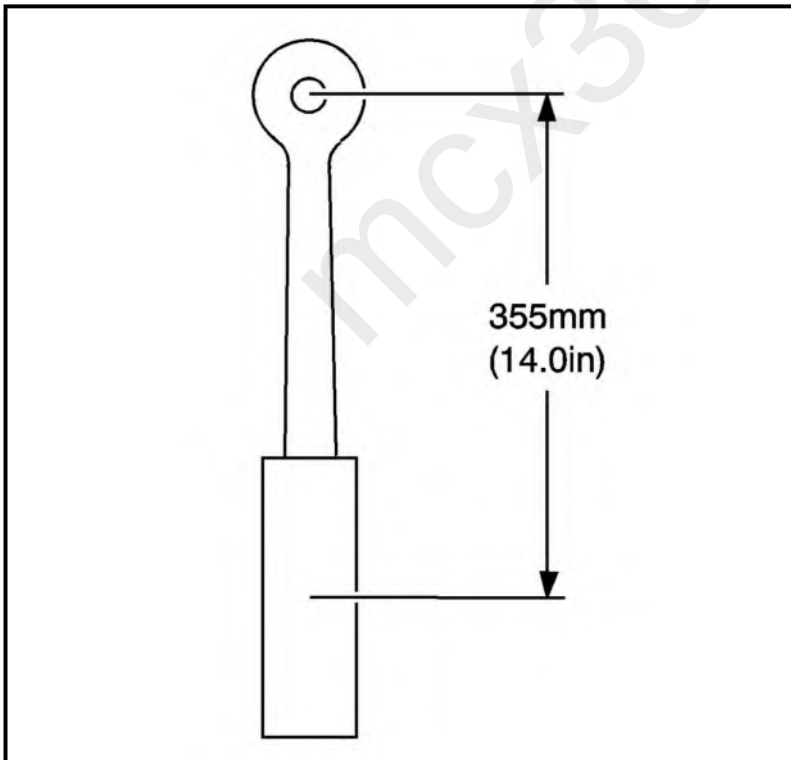
- If the crows foot is held at any position other than 90 degrees or inline to the wrench, more complex corrections of the torque setting are required, and therefore, positioning the crows foot in this manner is not recommended.

If it is necessary to position a crows foot in line with the torque wrench, the procedure for adjusting the torque specification is as follows:

1. Measure the distance between the center of the crows foot wrench end to the center of the square drive hole.



2. Measure the length of the torque wrench from the center of the square drive to the center of the handle.



3. Divide the measurement of the crows foot length by the torque wrench length. This figure is the percentage of additional torque, over the torque wrench setting, that will be applied to the fitting.
4. Subtract the results of step 3 from the number 1. This figure is the percentage of the listed torque specification that the torque wrench should be set to.
5. Multiply the results of step 4 by the listed torque setting. Refer to [Fastener Specifications](#). This figure is the proper setting the torque wrench should be set at when using a crows foot in line with the torque

wrench.

Example

1. Crows foot measurement = 25 mm (1.0 in)
2. Torque wrench measurement = 355 mm (14.0 in)
3. $25 \text{ mm} / 355 \text{ mm}$ (1.0 in / 14.0 in) = 0.07, or 7 %
4. $1 - 0.07 = 0.93$, or 93 %
5. $0.93 \times 41 \text{ N.m}$ (30 lb ft) = 38 N.m (28 lb ft)

SERVICE PRIOR TO ASSEMBLY

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

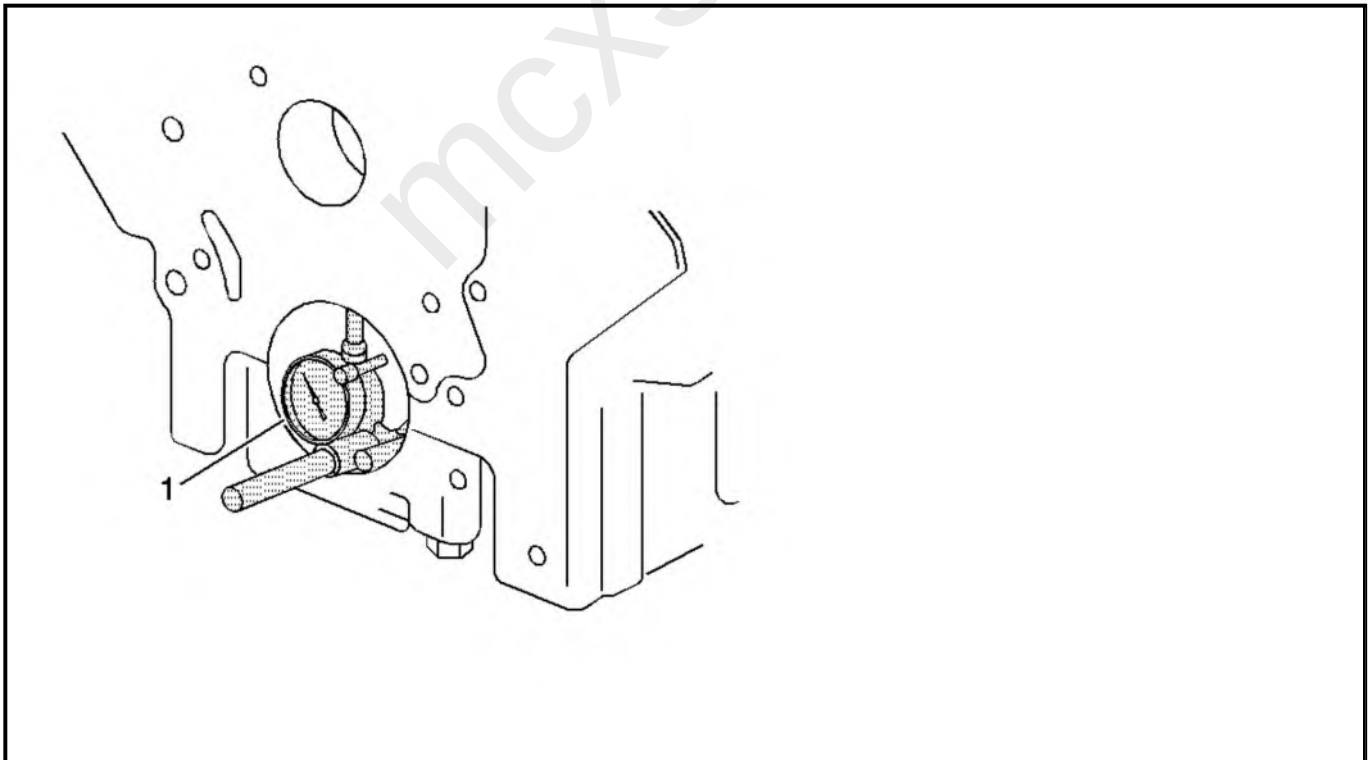
CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- EN 8087 Cylinder Bore Checking Gauge
- J 45059 Angle Meter

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

Crankshaft and Bearing Installation



NOTE:

If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **J 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.

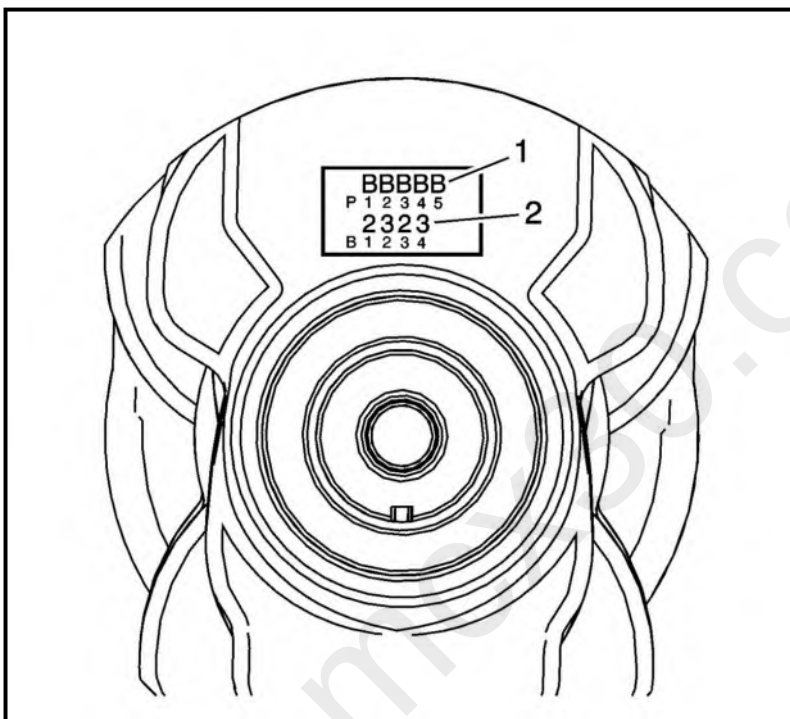
Bearing Selection

There are 3 methods to determine the correct replacement bearing size.

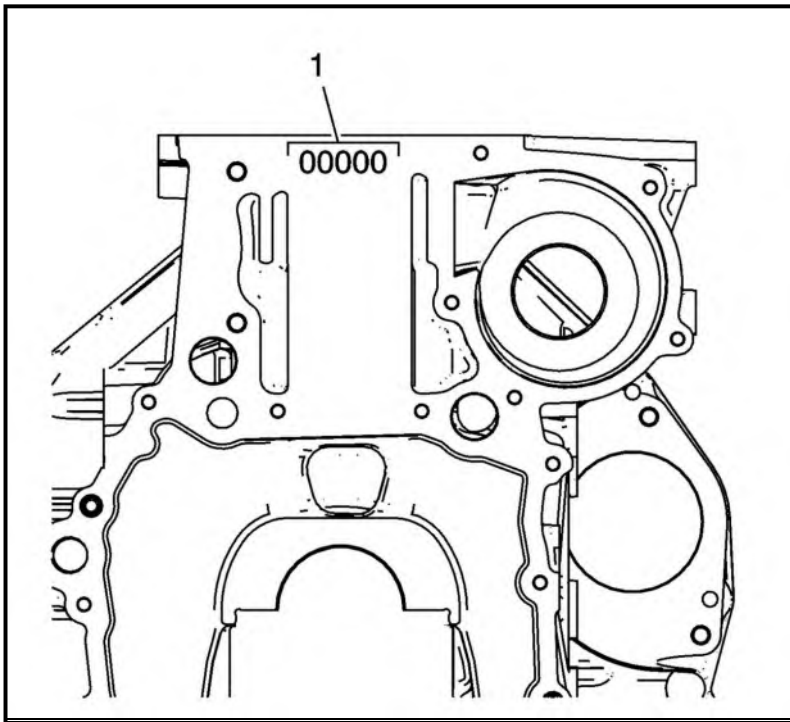
- Connecting Rod Bearing Grade Chart Method uses production markings on the crankshaft and the connecting rod to determine original bearing size.
- Micrometer method uses measurements of the crankshaft rod bearing journal and the connecting rod large end bore to determine the correct bearing size.
- Plastic gauging method is a way to verify the bearing clearance once the bearings are installed.

Connecting Rod Bearing Grade Chart Method

1. Inspect the bearing grade specifications located on the front crankshaft counterweight (1).



2. Inspect the main bearing bore specification located on the front of the engine block (1).



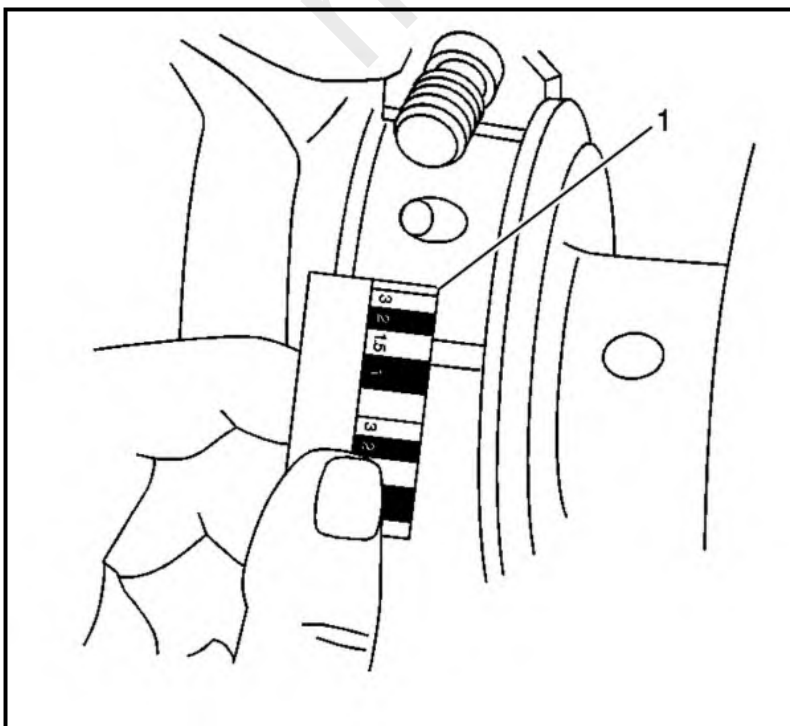
3. Determine the correct bearing grade. Refer to [Connecting Rod Bearings Selection Specifications](#).
4. Verify that the bearing clearance is within specification using the Plastic Gauging Method.

Micrometer Method

1. Install the main bearing caps and tighten the main bearing cap bolts to specification.
2. Measure the main bearing bore inside diameter in several places, 90 degrees apart, and average the measurements for each bore.
3. Measure the crankshaft main bearing journal diameter in several places, 90 degrees apart, and average the measurements for each journal.
4. Select the correct crankshaft bearings for each journal. Refer to [Crankshaft Bearing Selection Specifications](#).

Plastic Gauging Method

1. Clean the used bearing inserts.



2. Install the used bearing inserts.
3. Place a piece of gaging plastic across the entire bearing width.
4. Install the bearing caps.

CAUTION: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

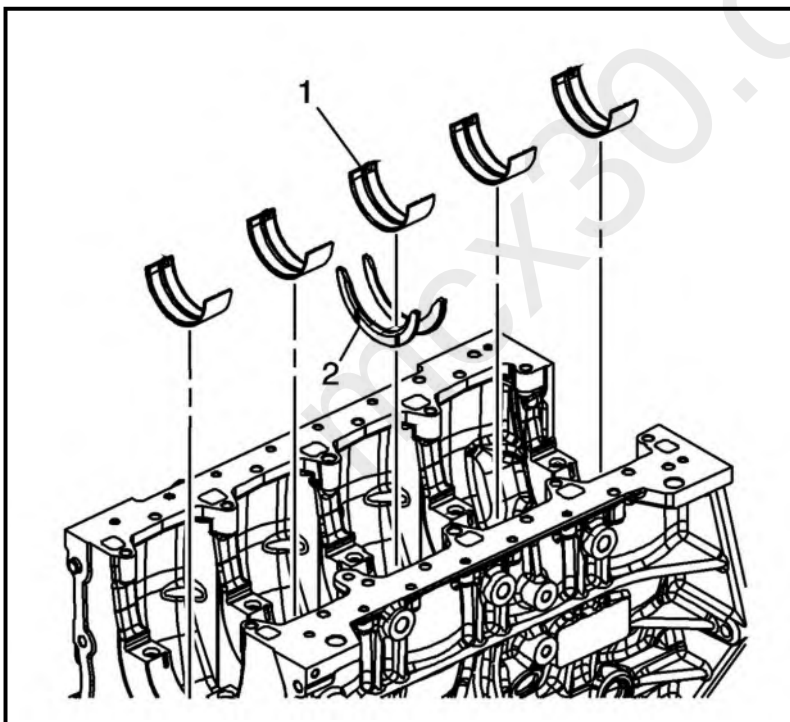
5. Install the bearing cap bolts to specification.

NOTE: Do not rotate the crankshaft.

6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale (1) printed on the gaging plastic package.
8. Remove the gaging plastic.
9. Select the correct crankshaft bearings, refer to [Connecting Rod Bearings Selection Specifications](#).

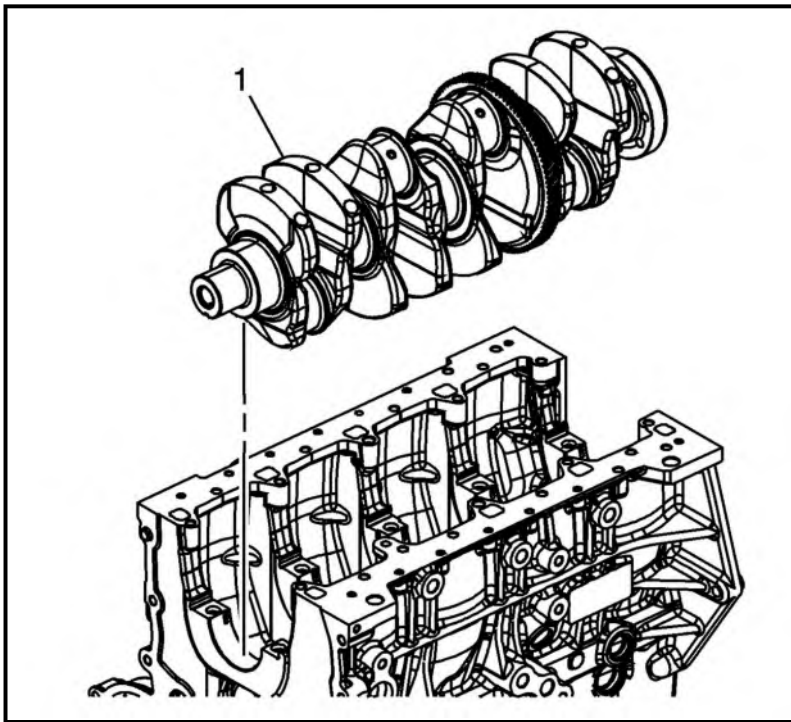
Crankshaft and Bearing Installation

1. Install the upper crankshaft bearings (1 and 2) and lubricate bearing surfaces with engine oil.

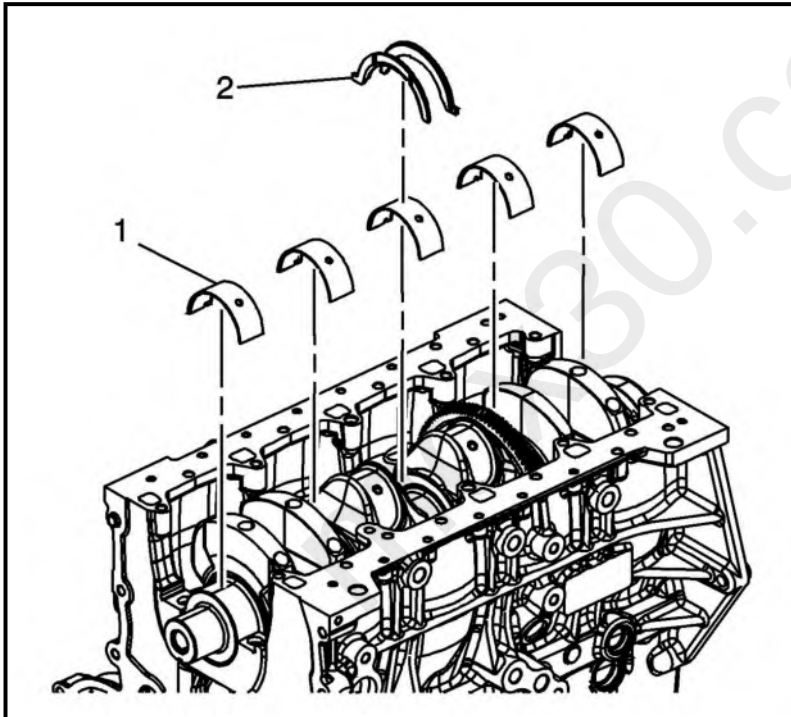


NOTE: The crankshaft bearings must be installed with the oil channels against the crankshaft and not the block or cap.

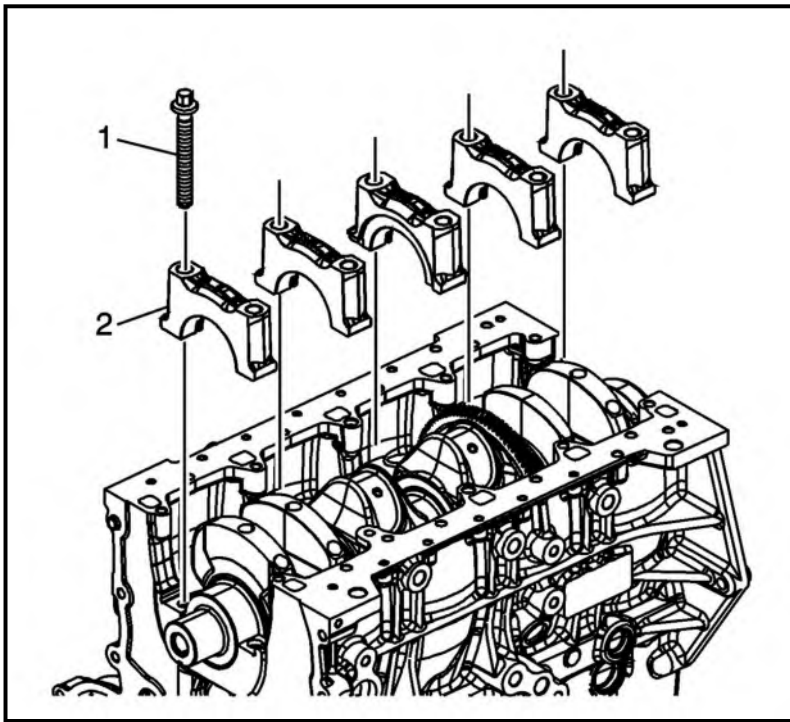
2. Install the crankshaft (1) on the journals.



3. Install the lower bearing halves (1 and 2). Apply oil to bearing surfaces.



4. Install the crankshaft bearing caps (2) and NEW crankshaft bearing cap bolts (1) finger tight.



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. Tighten the NEW crankshaft bearing bolts:

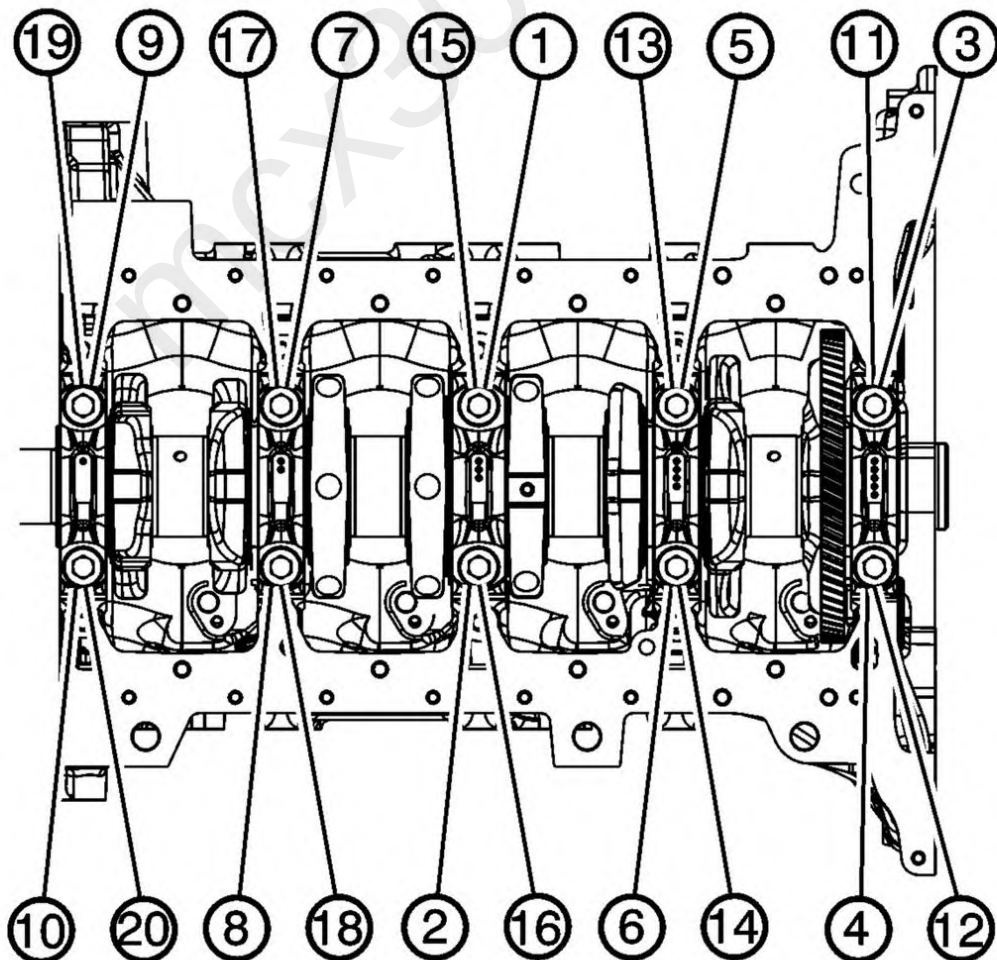


Fig. 43: Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

1. First pass: tighten the NEW bolts in sequence 50 N.m (36 lb ft)
2. Final pass: Using **J 45059** meter, tighten the bolts in sequence 90 degrees

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

- **EN-50034** Connecting Rod Guides
- **J-45059** Angle Meter

Equivalent regional tools: **Special Tools**.

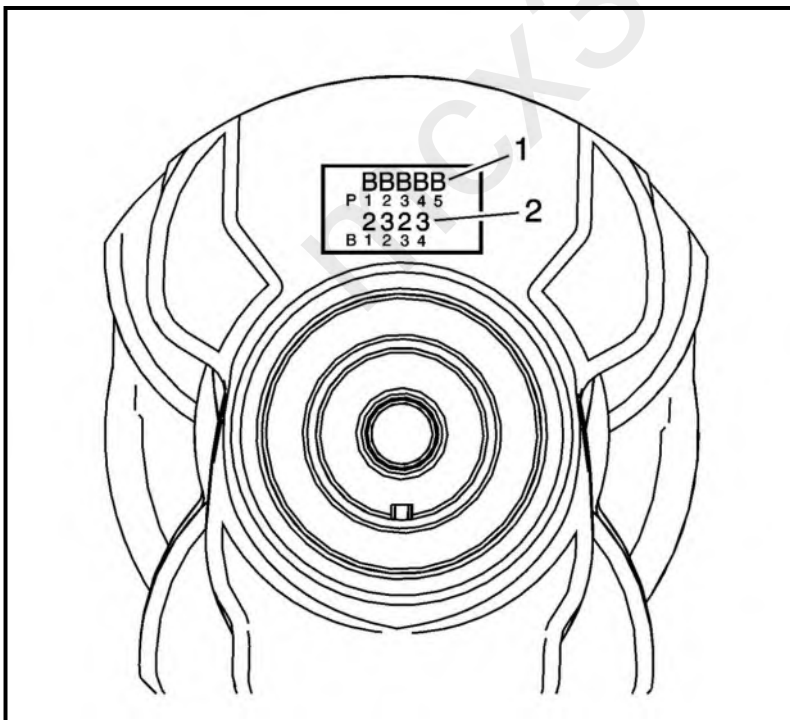
Bearing Selection

There are 3 methods to determine the correct replacement bearing size.

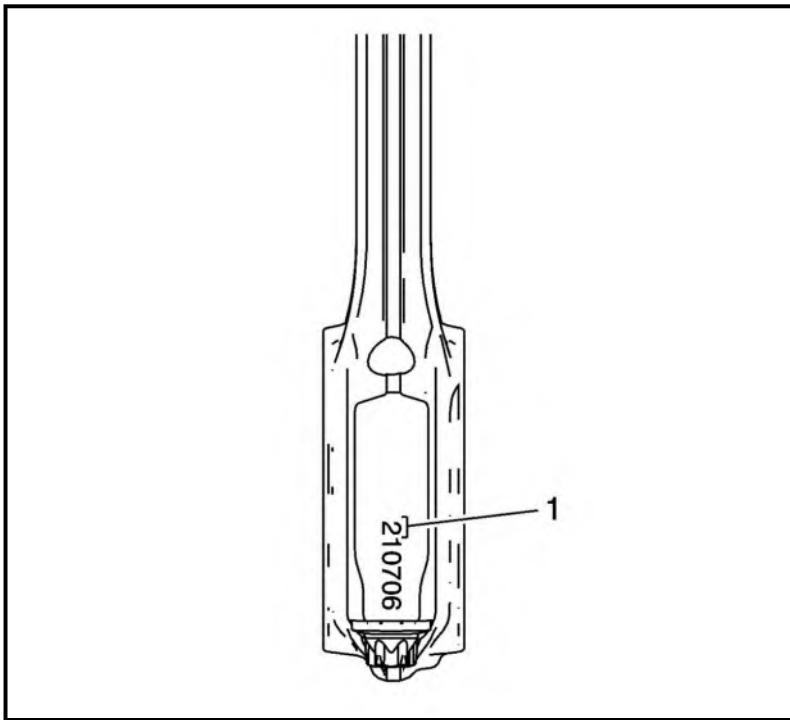
- Connecting Rod Bearing Grade Chart Method uses production markings on the crankshaft and the connecting rod to determine original bearing size.
- Micrometer method uses measurements of the crankshaft rod bearing journal and the connecting rod large end bore to determine the correct bearing size.
- Plastic gauging method is a way to verify the bearing clearance once the bearings are installed.

Connecting Rod Bearing Grade Chart Method

1. Inspect the bearing grade specifications located on the front crankshaft counterweight (2).



2. Inspect the connecting rod bore specification located on the side of the connecting rod (1).



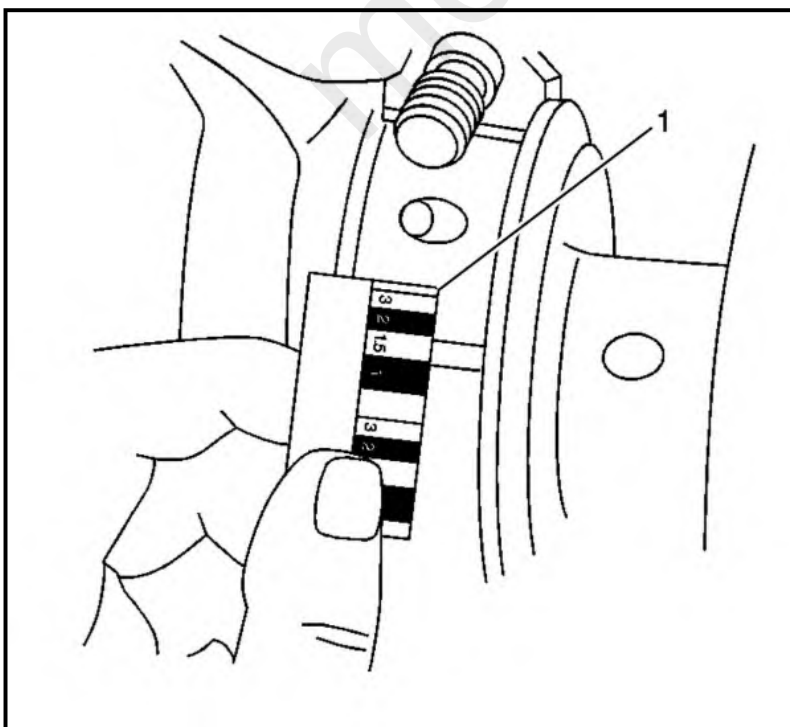
3. Determine the correct bearing grade. [Connecting Rod Bearings Selection Specifications](#)
4. Verify that the bearing clearance is within specification using the Plastic Gauging Method.

Micrometer Method

1. Install the connecting rod caps and tighten the cap bolts to specification.
2. Measure the connecting rod large end bore inside diameter in several places, 90 degrees apart, and average the measurements.
3. Measure the crankshaft pin diameter in several places, 90 degrees apart, and average the measurements.
4. Select the correct crankshaft bearings. [Crankshaft Bearing Selection Specifications](#)

Plastic Gauging Method

1. Clean and install the bearing inserts.



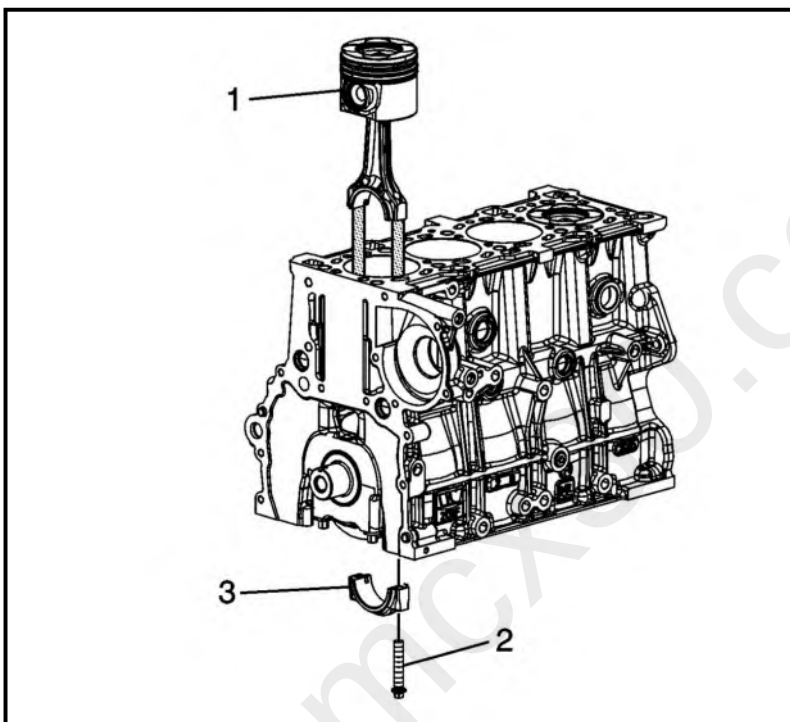
2. Install the piston and connecting rod assembly to the engine. [Piston, Connecting Rod, and Bearing Installation](#)
3. Place a piece of plastic gauging material across the entire bearing width.
4. Install the connecting rod caps and tighten the bearing cap bolts to specification.

NOTE: Do not rotate the crankshaft.

5. Remove the bearing cap, leaving the gauging plastic in place. It does not matter whether the gauging plastic adheres to the journal or the bearing.
6. Measure the gauging plastic at its widest point with the scale (1) printed on the gauging plastic package.
7. Remove the gauging plastic.
8. Select the correct connecting rod bearings. [Connecting Rod Bearings Selection Specifications](#)

Piston, Connecting Rod and Bearing Installation

1. Select the correct connecting rod bearings, refer to [Connecting Rod Bearings Selection Specifications](#).



2. Install the connecting rod bearings. Use NEW bearings.
 1. Install the bearing inserts into the connecting rod and the connecting rod cap (3).
 2. Lubricate the connecting rod bearings with engine oil.
3. Install the **EN-50034** guides into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod (1) installation.
4. Install the compressor, piston, and the connecting rod to the correct bore.
 1. Stagger each piston ring end gap equally around the piston.
 2. Lubricate the piston and the piston rings with engine oil.
 3. Do not disturb the piston ring end gap location.
 4. The piston must be installed so that the mark on the top of the piston faces the front of the engine.
 5. Place the piston in its matching bore.
 6. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
 7. Hold the compressor against the engine block until all the rings have entered the cylinder bore.
 8. Remove the connecting rod guides from the connecting rod bolt holes.

NOTE: Ensure that the connecting rod cap is properly oriented on the connecting rod.

5. Install the connecting rod cap.

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.

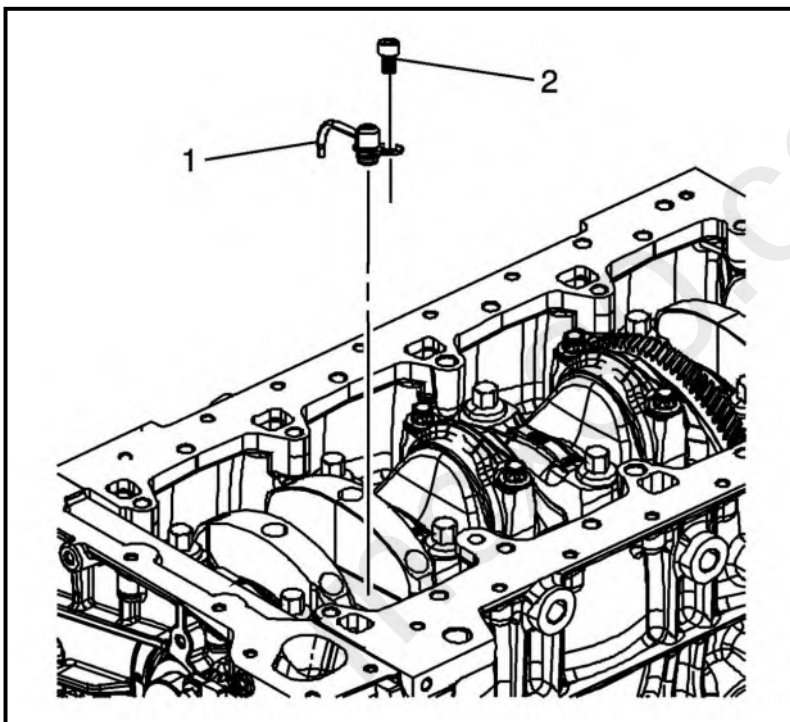
CAUTION: Refer to [Fastener Caution](#) .

6. Install the connecting rod bolts (2). Always use new bolts. Tighten the NEW connecting rod bolts to 30 N.m (22 lb ft), plus 40 degrees using the **J-45059** meter.

7. Install the remaining connecting rods and piston assemblies.

PISTON OIL NOZZLE INSTALLATION

1. Install the piston oil cooling nozzles (1).



CAUTION: The piston oil cooling nozzle must be aligned to direct oil towards the oil inlet hole on the bottom of the piston. Improper alignment of the piston oil cooling nozzle will allow insufficient oil lubrication to the piston and cause severe engine damage.

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

2. Install the piston oil cooling nozzle bolt (2) and tighten to 11 N.m (97 lb in).

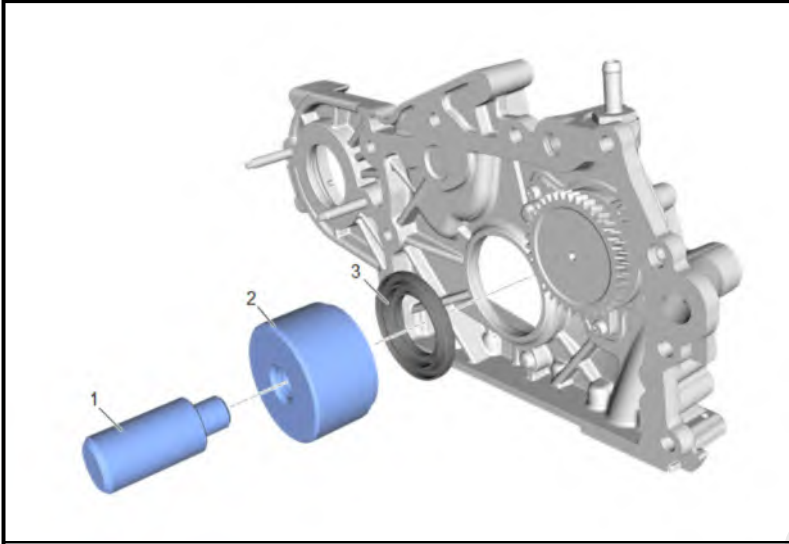
CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

- EN-42183 Driver Handle
- EN-50718 Crankshaft Front Seal Installer

Equivalent regional tools: **Special Tools**

1. Prepare the NEW crankshaft front oil seal for installation.
 1. Push the plastic installation sleeve out of the center of the crankshaft front oil seal.
 2. Flip the plastic installation sleeve 180 degrees.
 3. Re-insert the plastic installation sleeve into the center of the crankshaft front oil seal.
2. Install the **EN-42183** Seal Driver Handle (1) to the **EN-50718** Front Crankshaft Seal Installer (2).



3. Install the crankshaft front oil seal (3) to the **EN-50718** Front Crankshaft Seal Installer.
4. Using the **EN-50718** Front Crankshaft Seal Installer, carefully install the crankshaft front oil seal (3) to a depth of 2 mm, with the seal lip facing inward to the engine.

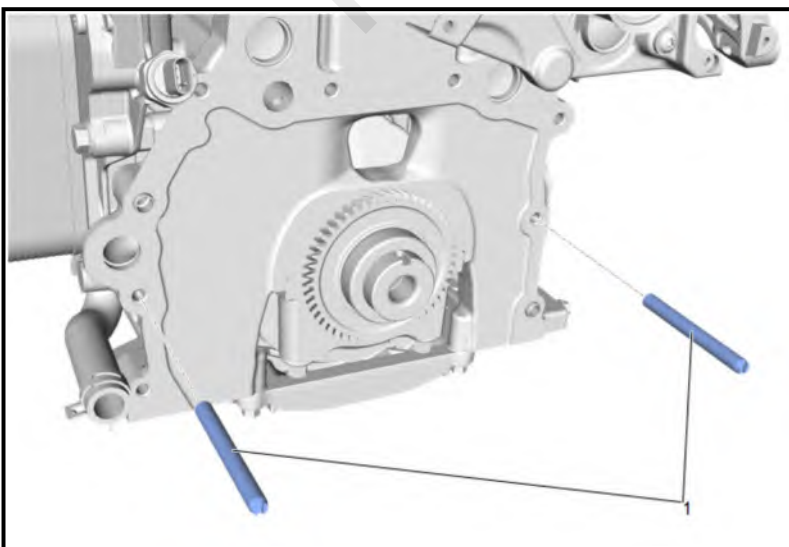
ENGINE FRONT COVER INSTALLATION

Special Tools

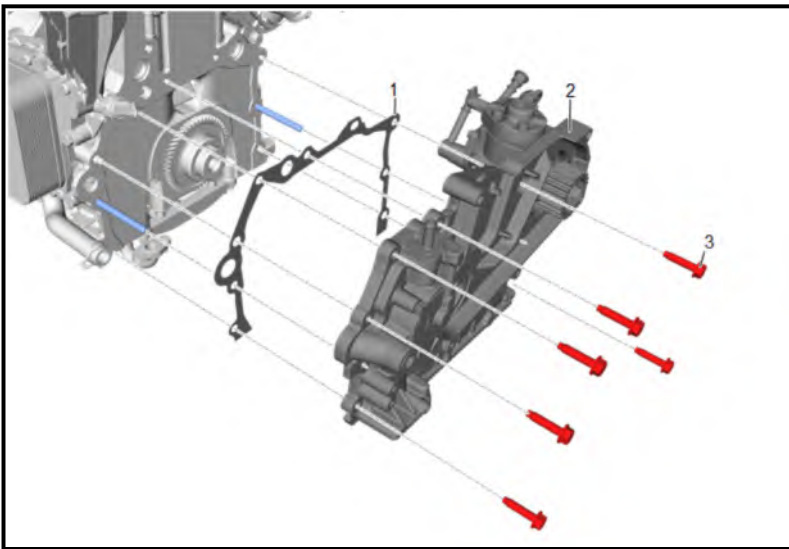
EN-46109-2 Guide Pins

Equivalent regional tools: **Special Tools**

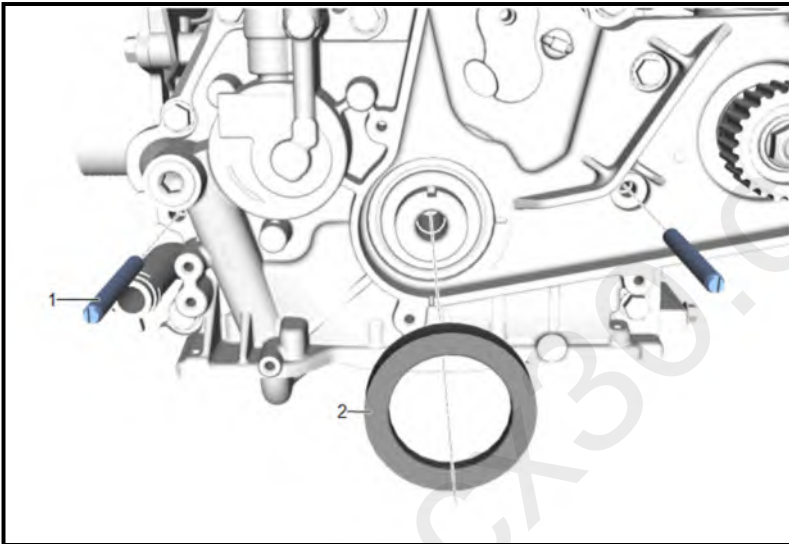
1. **EN-46109-2** Guide Pins (1) - Install [2x]



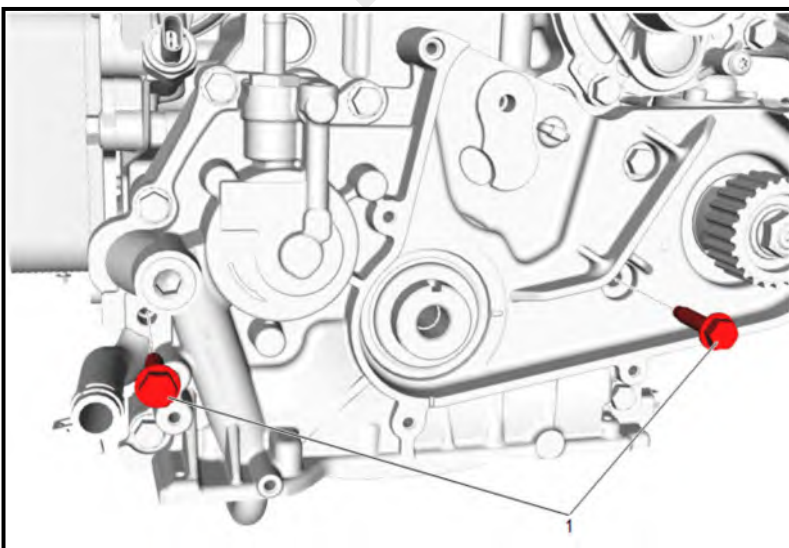
2. Engine Front Cover Gasket (1) - Install



3. Engine Front Cover (2) - Install
4. Engine Front Cover Bolt (3) - Install, but do NOT tighten [6x]
5. **EN-46109-2** Guide Pins (1) - Remove [2x]



6. Crankshaft front oil seal installation sleeve (2) - Remove and DISCARD
7. Engine Front Cover Bolt (1) - Install, but do NOT tighten [2x]



8. Engine Front Cover Bolt - Tighten in sequence [8x] 32 N.m (24 lb ft)

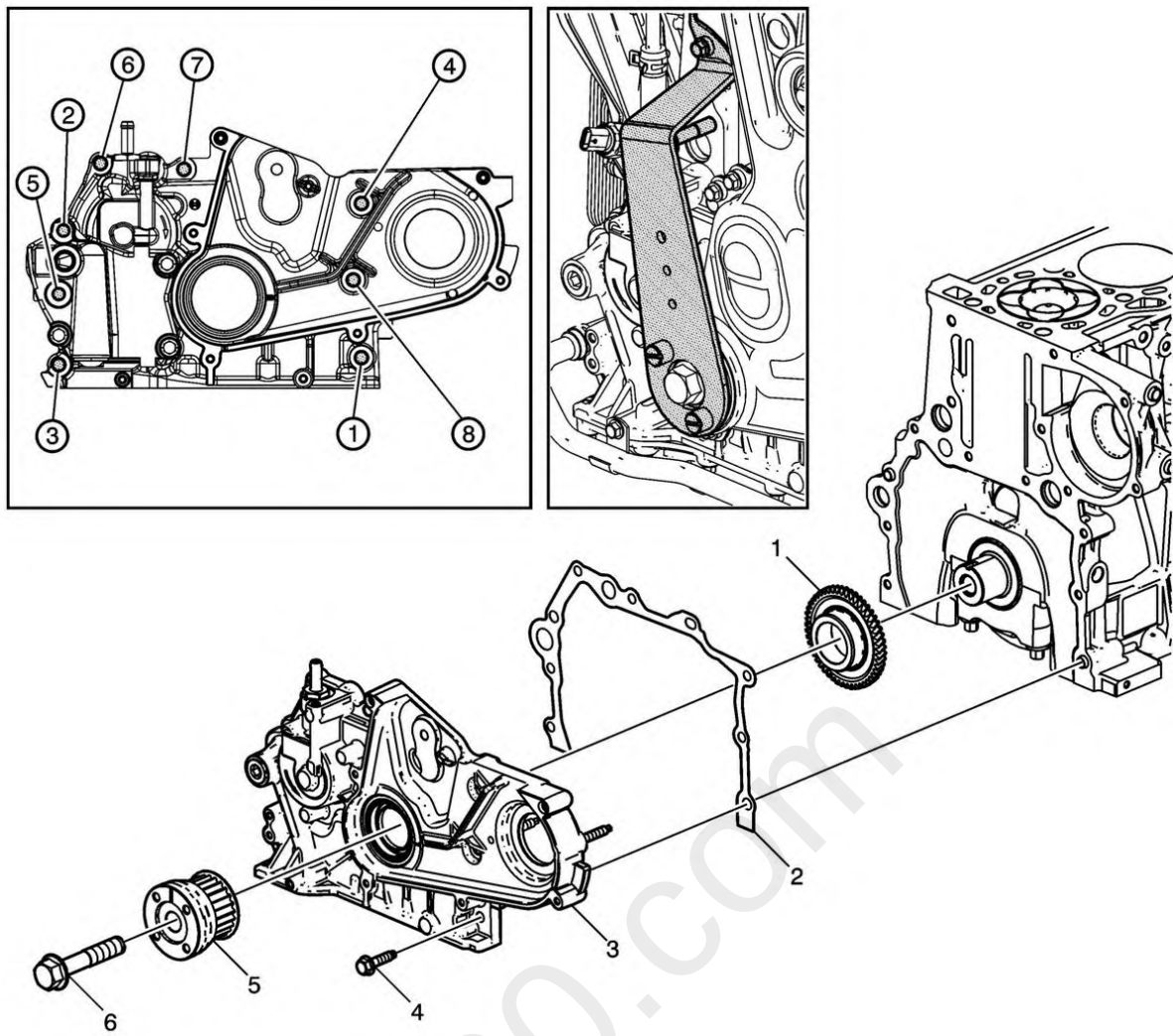
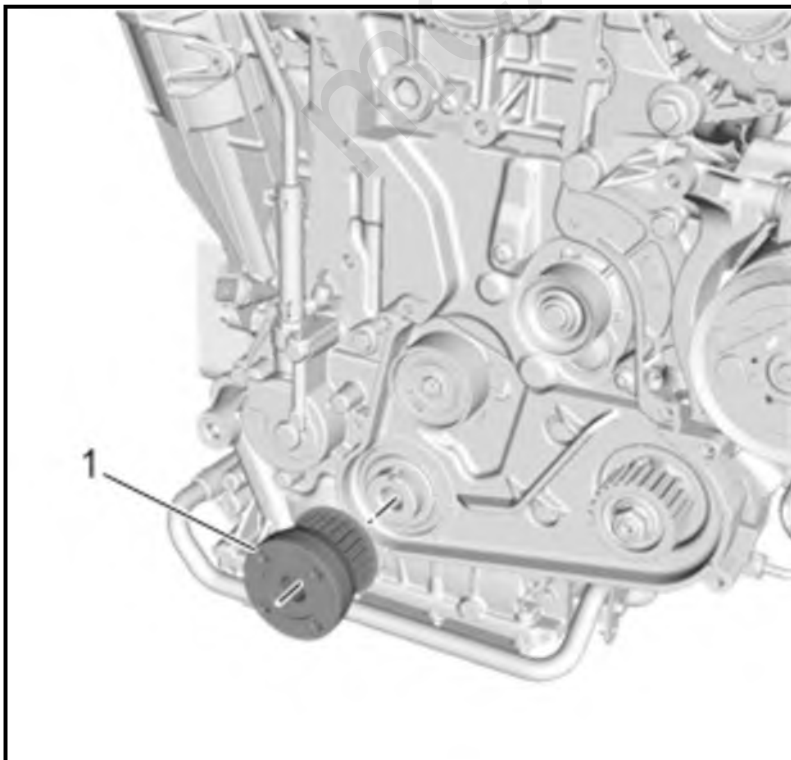
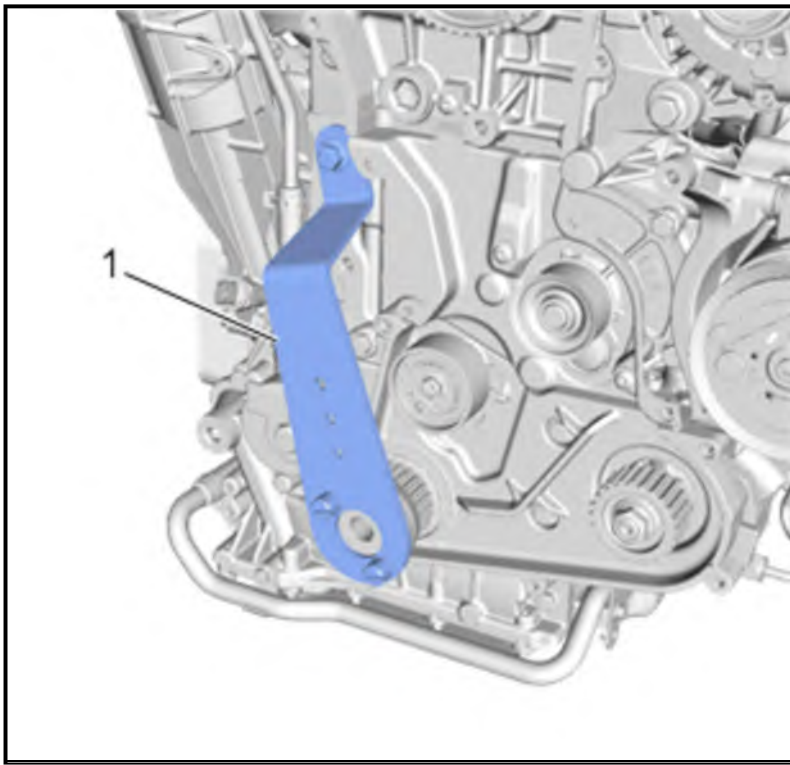


Fig. 44: Engine Front Cover Components With Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

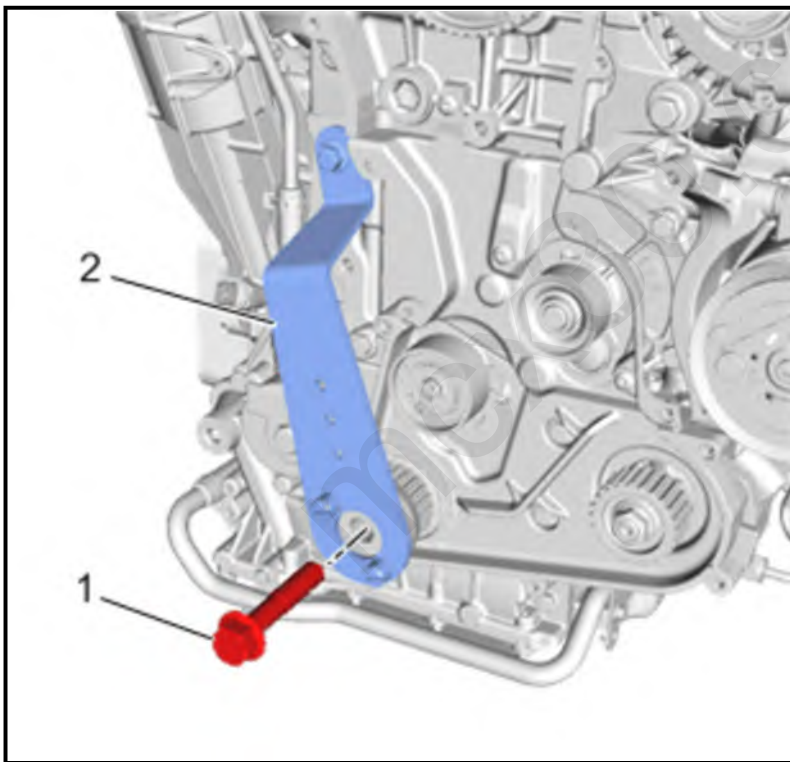
9. Crankshaft Sprocket (1) - Install



10. Install the **EN-51265** locking tool (1).



11. Crankshaft Sprocket Bolt (1) - Install



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

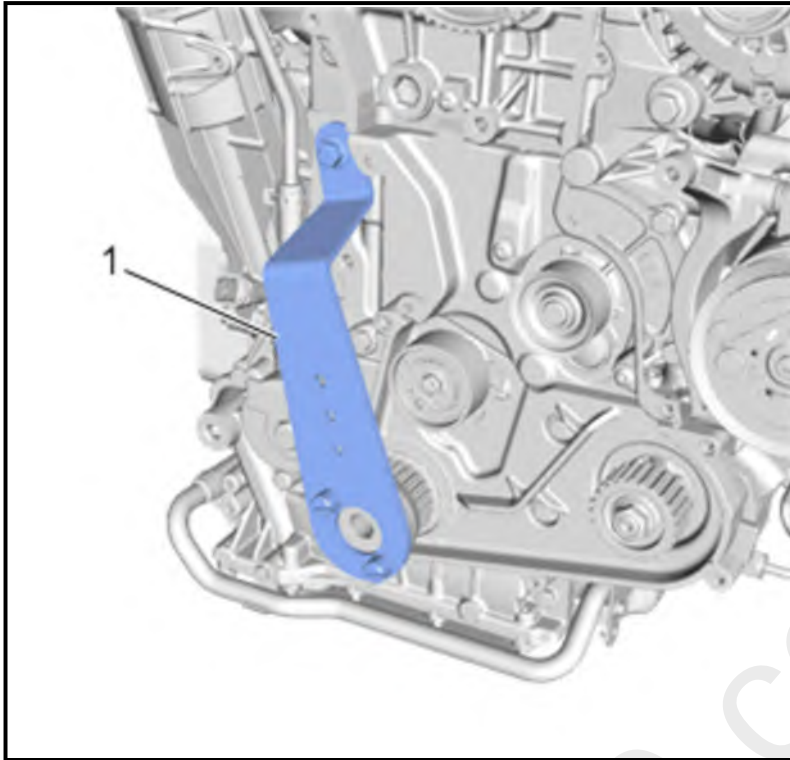
CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

NOTE: The crankshaft timing pulley bolt is left hand thread. The keyway in the crankshaft should match up with the timing pulley and result in 90B° ATDC.

NOTE: Install a NEW bolt.

Tighten

1. First Pass 100 N.m (74 lb ft)
 2. Final Pass an additional 120 degrees
12. Remove the **EN-51265** locking tool (1).



13. **Timing Belt Replacement** - Install

Engine Front Cover Installation

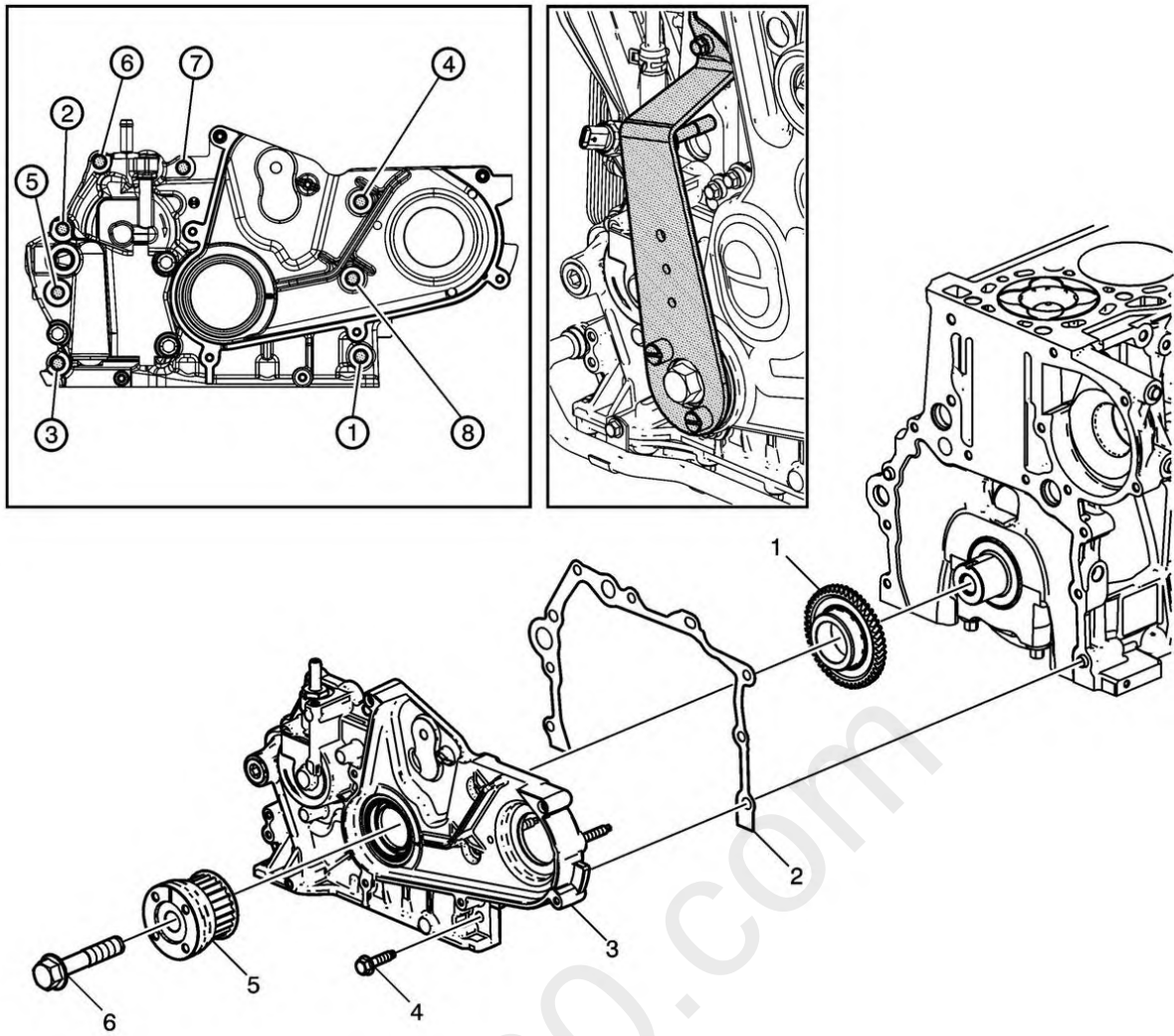


Fig. 45: Engine Front Cover Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Vacuum Pump Gear
2	Engine Front Cover Gasket NOTE: Use a NEW gasket.
3	Engine Front Cover
4	Engine Front Cover Bolt CAUTION: Refer to Fastener Caution . Tighten the engine front cover bolts in sequence to 32 N.m (24 lb ft).
5	Crankshaft Sprocket
6	Crankshaft Sprocket Bolt CAUTION:

Callout	Component Name
	This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. NOTE: The crankshaft timing pulley bolt is left hand thread. The keyway in the crankshaft should match up with the timing pulley and result in 90B° ATDC. Procedure 1. Install the EN-51265 locking tool (1). 2. Ensure that the timing mark on the crankshaft timing pulley is aligned at 90 degrees ATDC (1). 3. Tighten the bolt a first pass to 100 N.m (74 lb ft). 4. Tighten the bolt a final pass to 120 degrees. Special Tools EN-51265 Crankshaft Locking Tool For equivalent regional tools, refer to: Special Tools.

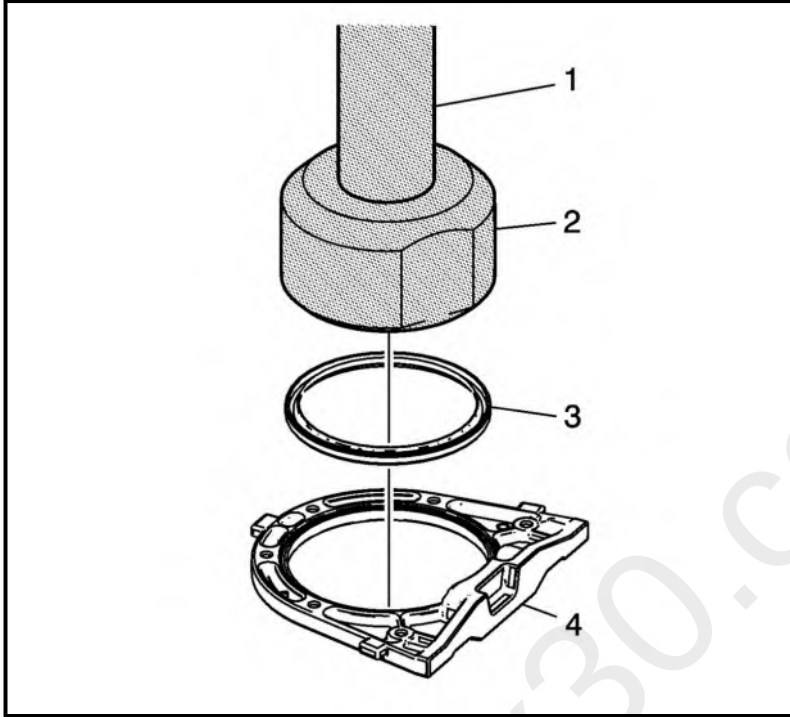
CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION

Special Tools

- **EN-50026** Rear Main Seal Installer
- **GE-8092** Driver Handle

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

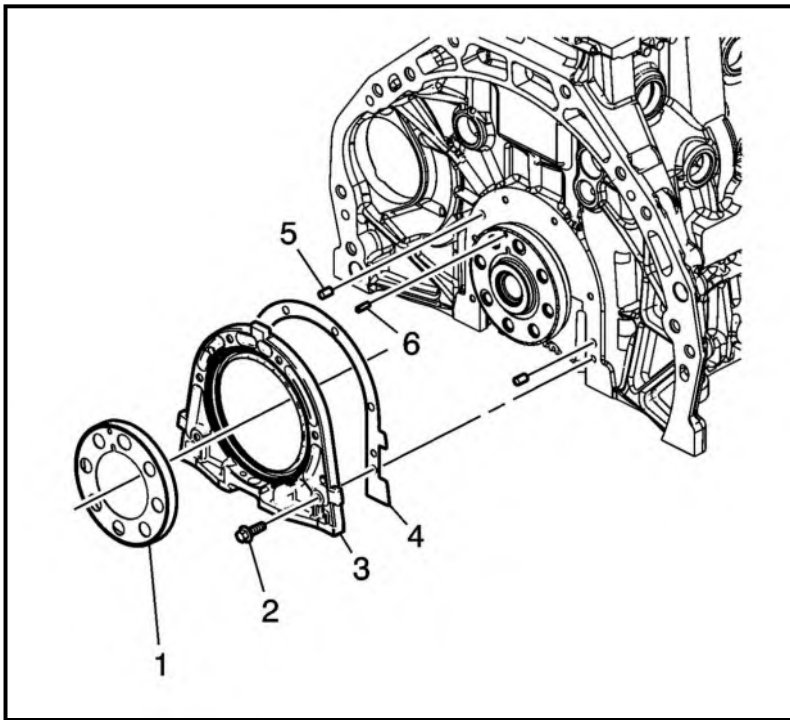
1. Install the NEW crankshaft rear oil seal (3) into the crankshaft rear oil seal housing (4) using the **EN-50026** installer (2) and **GE-8092** handle (1) until the seal bottoms out on the housing.



NOTE:

- The crankshaft rear oil seal must be installed with the cupped side of the seal facing the tool.
- The bottom edge of the crankshaft rear oil seal housing must hang off the edge of the bench to allow it to lay flat.

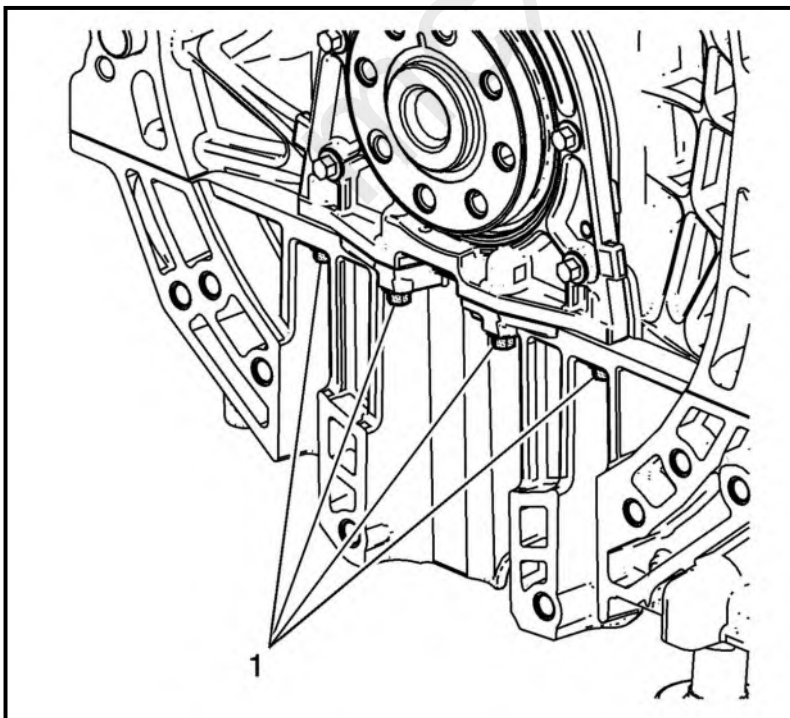
2. Crankshaft Rear Oil Seal Housing Gasket (4) - Install



NOTE: If removed, install the crankshaft rear oil seal housing locating pin (5) and exciter ring locating pin (6).

NOTE: Lubricate the crankshaft sealing surface with engine oil. Adhesives, Fluids, Lubricants, and Sealers

3. Crankshaft Rear Oil Seal Housing (3) - Install
4. Crankshaft Rear Oil Seal Housing Bolt (2) - Loosely install [6x]
5. Crankshaft Position Sensor Exciter Ring (1) - Install
6. For ease of installation, hand start the rear oil seal housing bolts at the oil pan (5).
7. Tighten the oil pan bolts. (1) 15 N.m (11 lb ft)



CAUTION: Refer to Fastener Caution .

8. Tighten the bolts in the sequence shown. 15 N.m (11 lb ft)

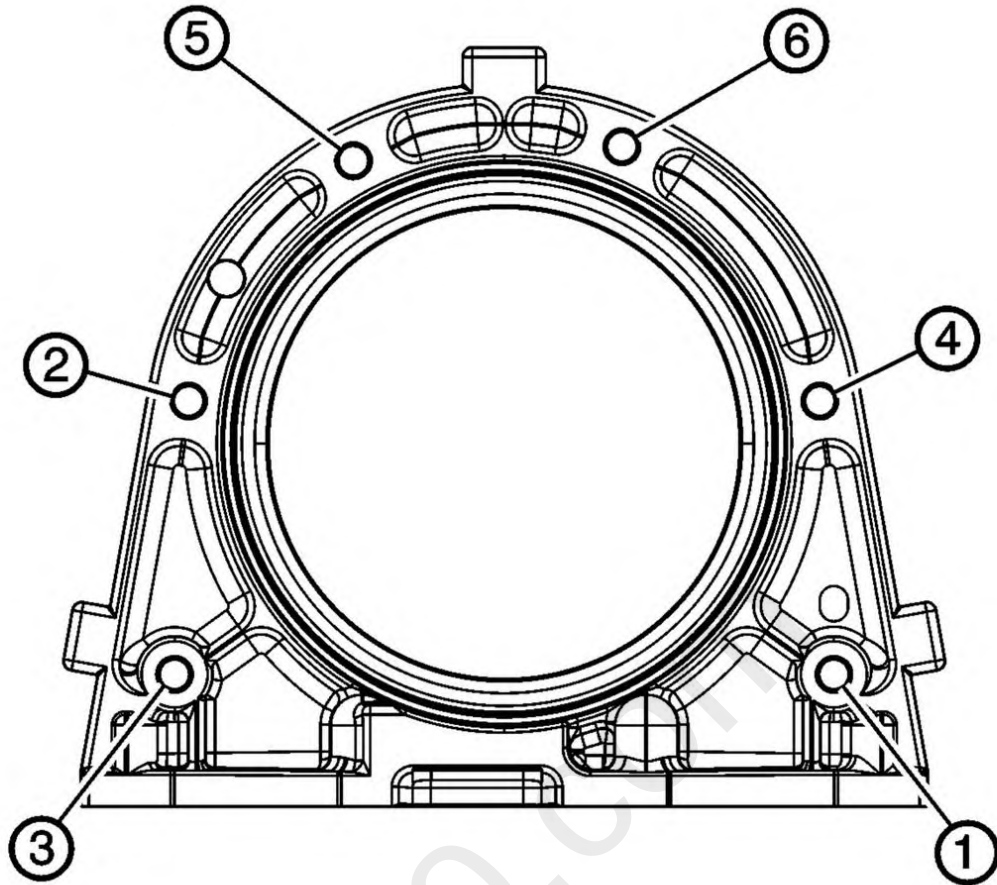
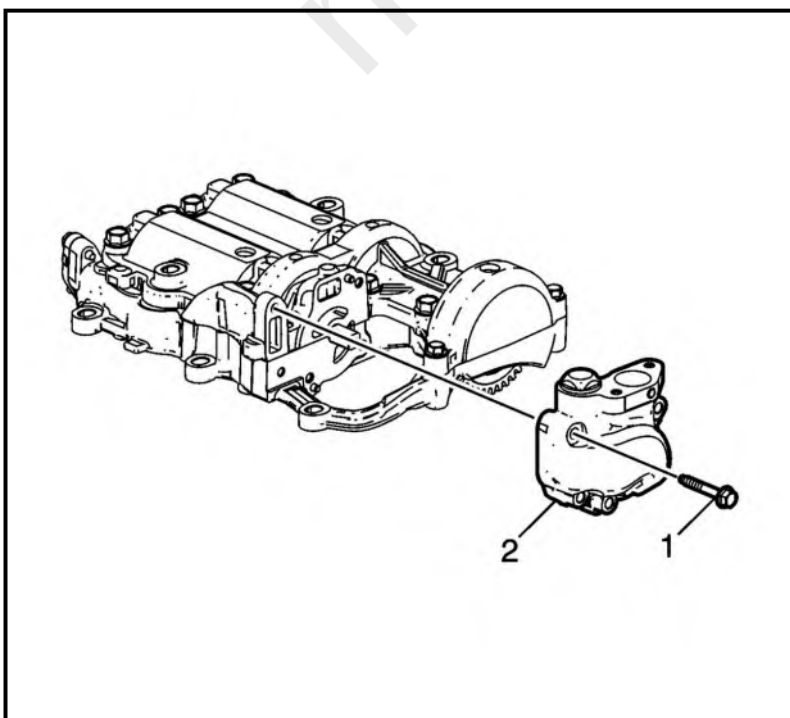


Fig. 46: Crankshaft Rear Oil Seal Housing Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

OIL PUMP INSTALLATION

1. Install the oil pump (2) and bolts (1).



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

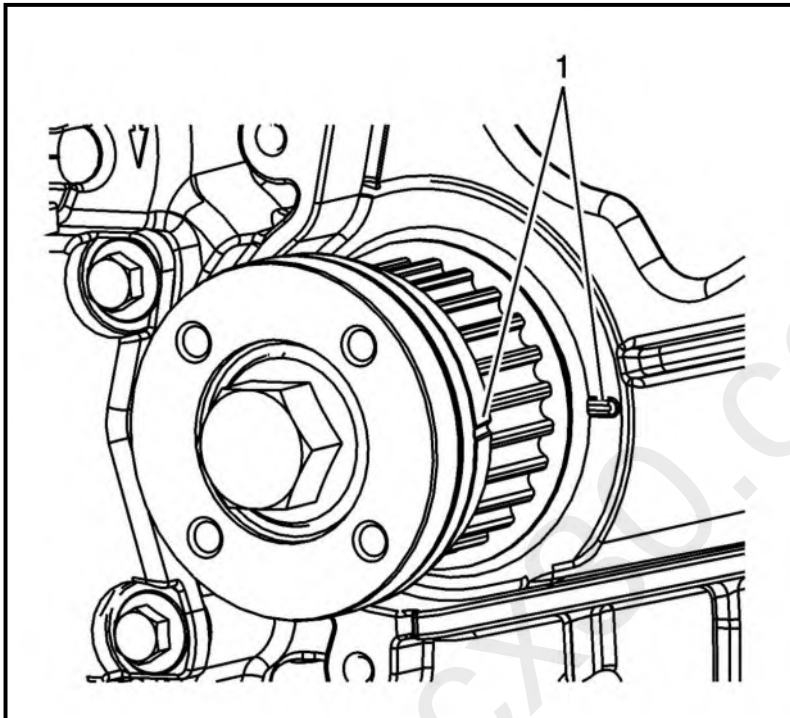
BALANCER AND OIL PUMP INSTALLATION

Special Tools

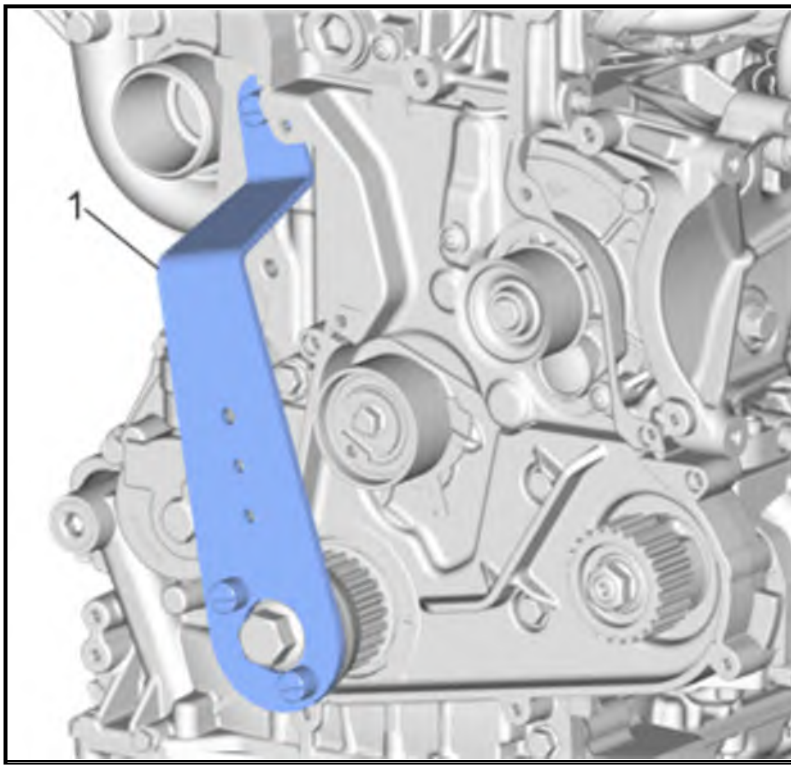
- **EN-51162** Balancer Backlash Tool
- **EN-51265** Crankshaft Locking Tool
- **GE-7872** Dial Indicator

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

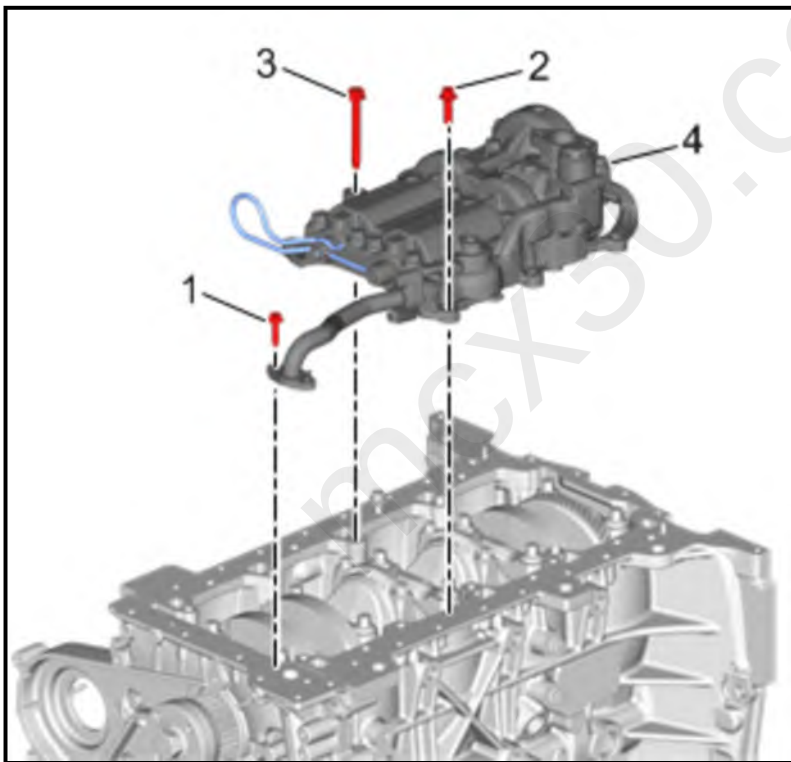
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees ATDC with the mark on the front cover (1).



2. Install **EN-51265** locking tool.



3. Install the balancer assembly (4).



Install the balancer assembly tube bolts (1) and hand tighten.

4. Install the fasteners in sequence, hand tighten.

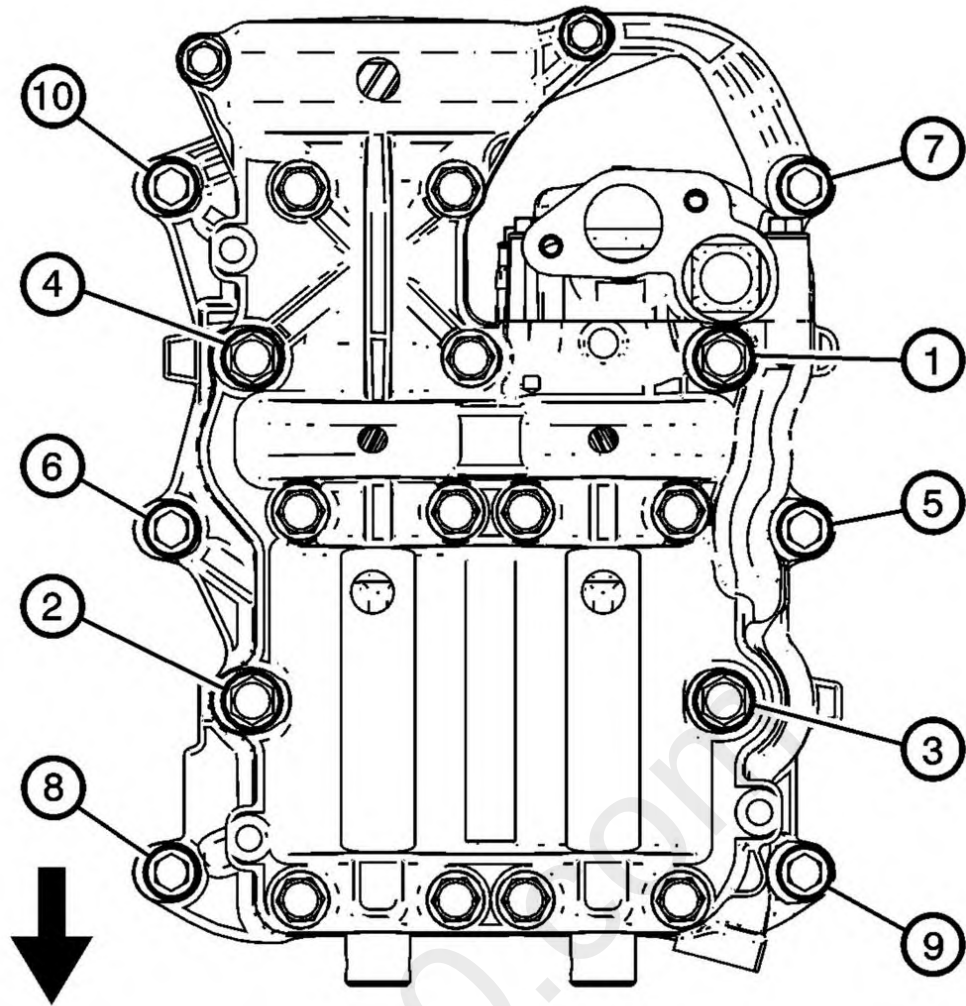
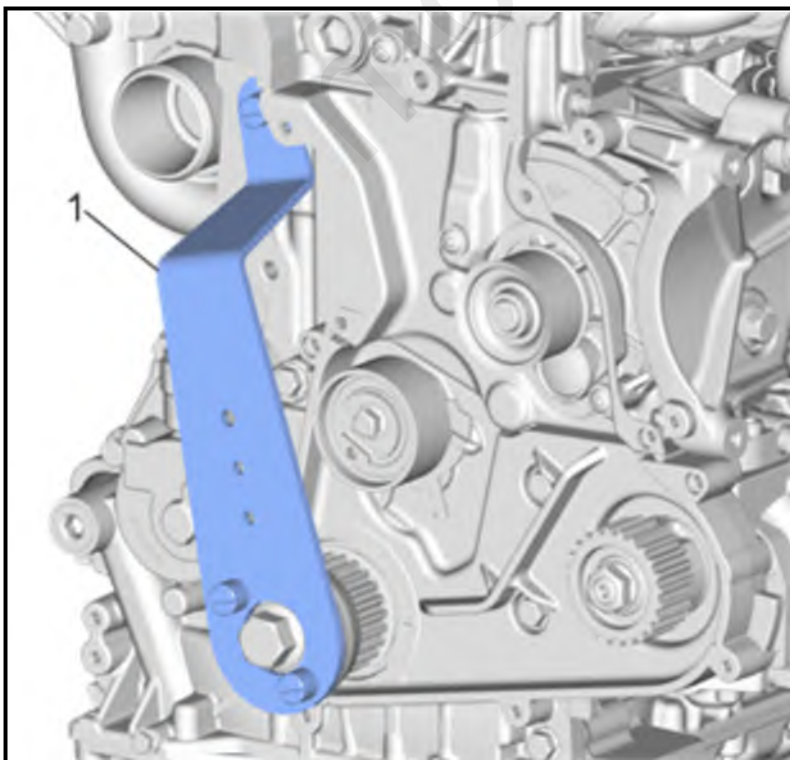
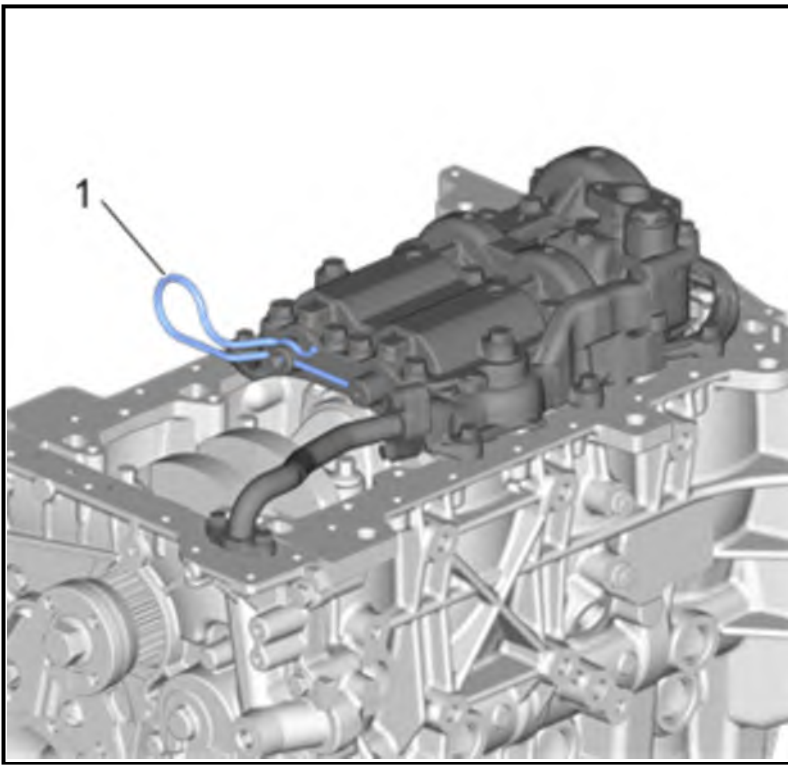


Fig. 47: Balance Shaft Assembly Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

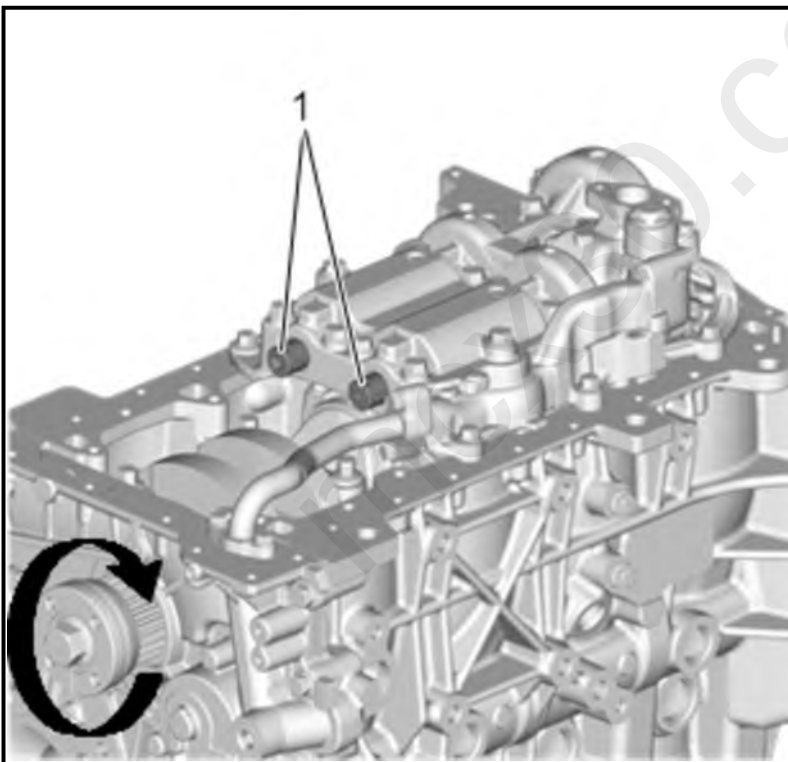
5. Remove EN-51265 locking tool.



6. Remove GM P/N 12628143 balancer shaft gear pin (1).

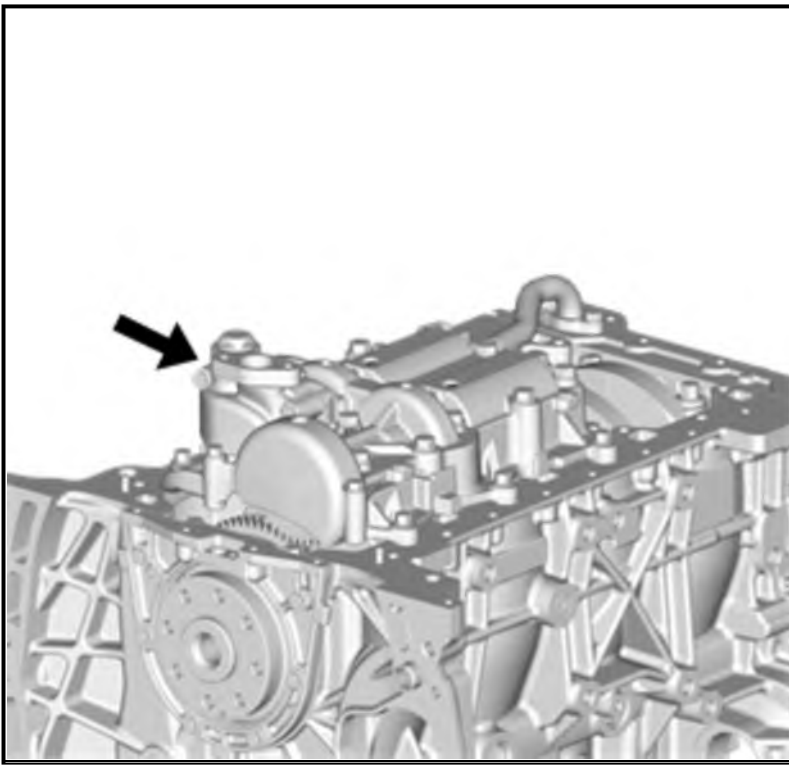


7. Rotate crankshaft 90 degrees until the flat on the balancer shaft (1) is facing the bottom of the engine.

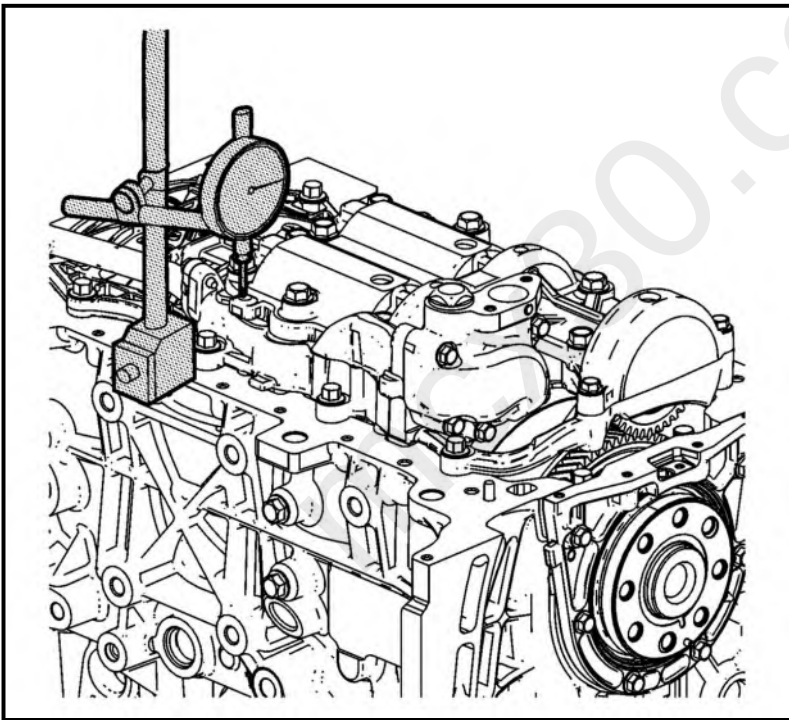


NOTE: A NEW balancer contains a coating on a portion of the drive gear which can lead to errors in backlash reading. The crankshaft must be rotated so that the coating is not in contact with the crankshaft gear.

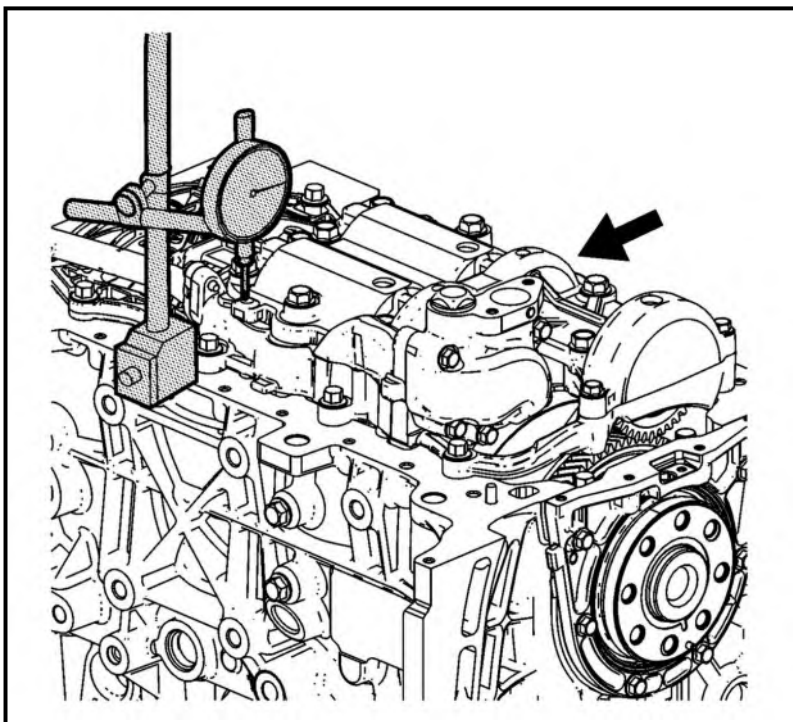
8. Push the balancer in the direction shown as far as it will go.



9. Position a magnetic dial gauge on the block and set the gauge to zero on the pad of the balancer.

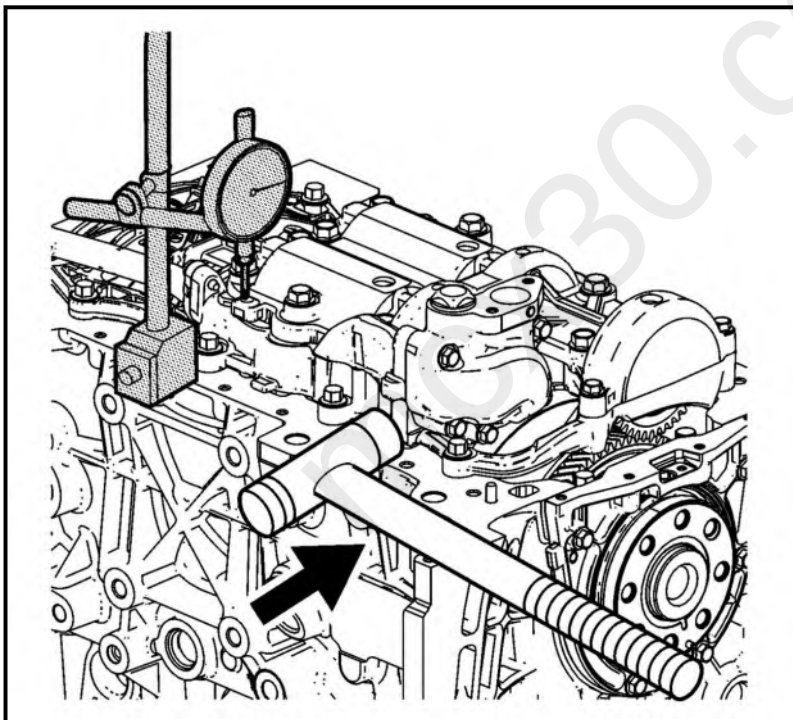


10. Push the balancer in the direction shown until the dial gauge reads at least 0.4 mm movement. The balancer is climbing over the crankshaft gear.



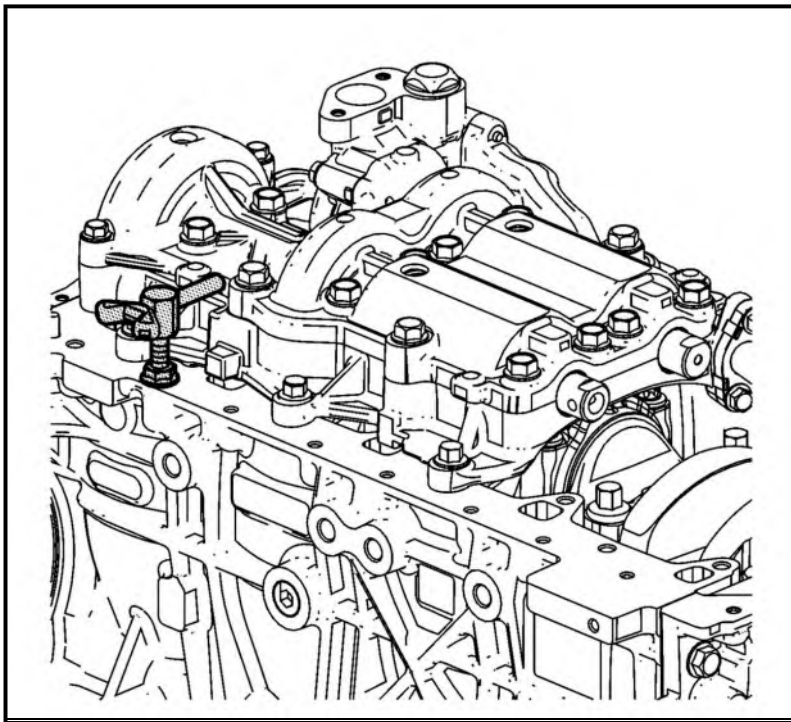
NOTE: The balancer may not move, this is normal.

11. Using a soft mallet, gently tap the balancer in the direction shown until the dial gauge reads 0.

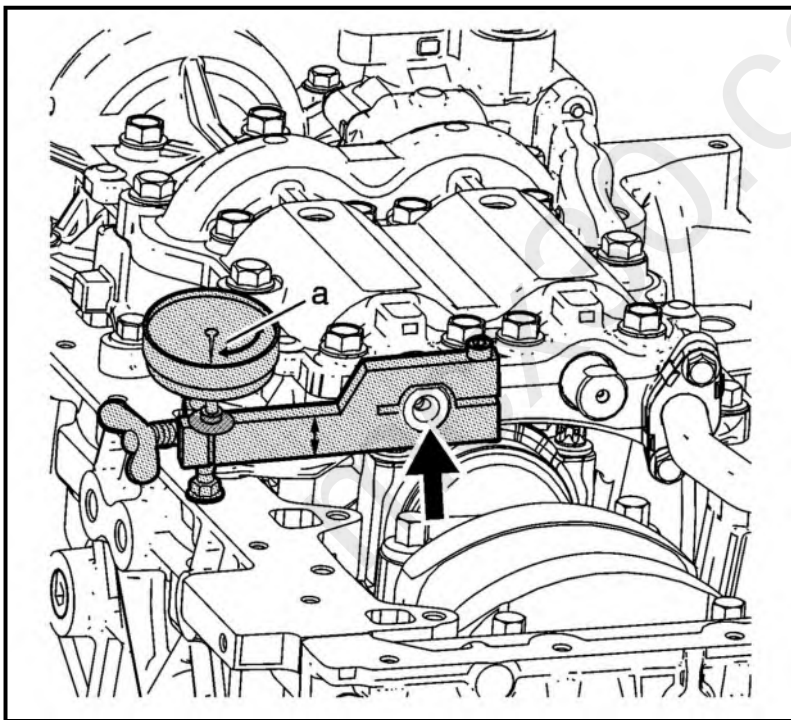


12. Hand tighten the balancer bolts.

13. Install **EN-51162 - 2** Pre-load Screw Assembly to the block in the position shown and tighten to the block.



14. Hand tighten the screw until it contacts the body of the balancer.
15. Install the **EN-51162 - 1** balancer backlash tool as shown.



16. While pushing the balancer shaft toward the front of the engine with your thumb, use finger pressure to push up and down on the **EN-51162 - 1** balancer backlash tool and read the total deflection on the dial indicator. The backlash specification (a) is 0.06 - 0.15 mm (0.002 - 0.006 in).
17. Record the readings on the dial indicator.

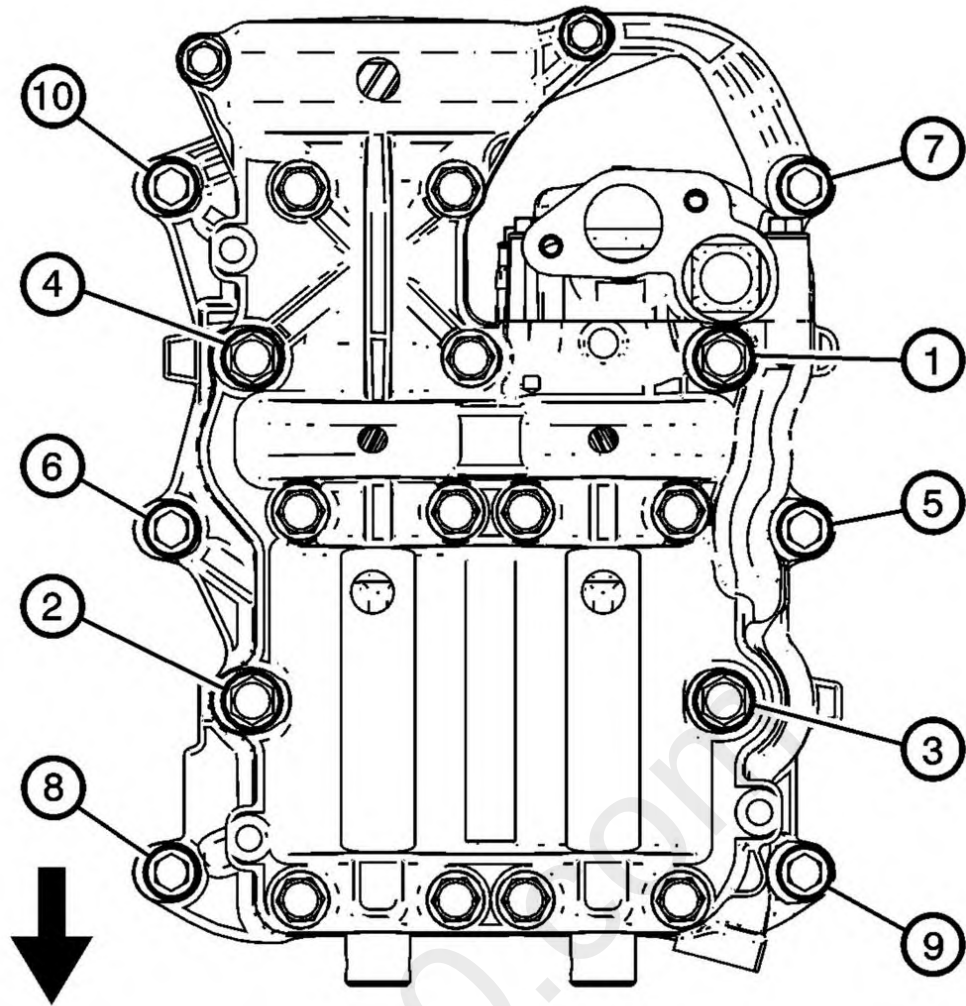
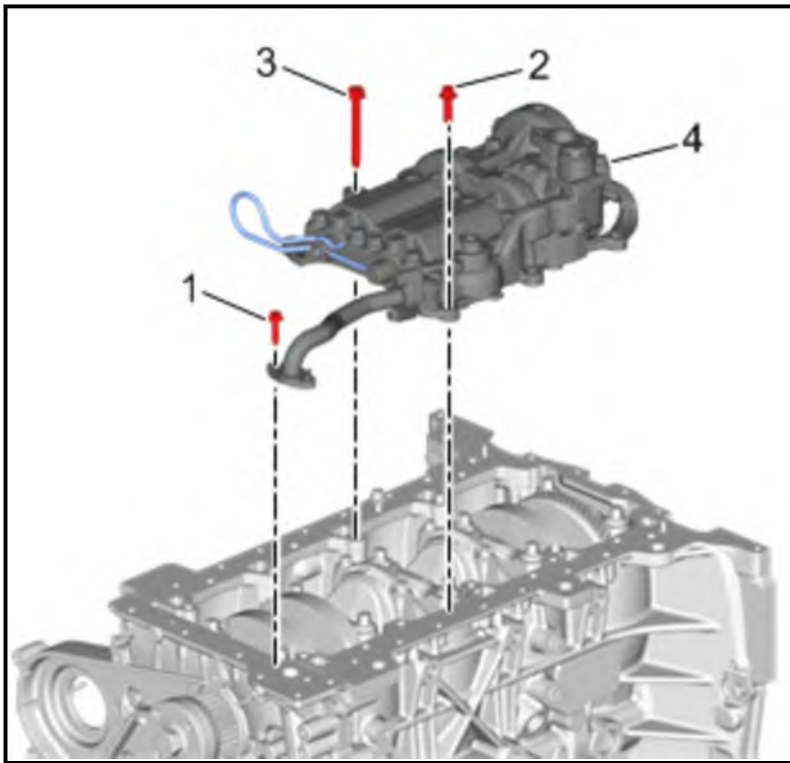


Fig. 48: Balance Shaft Assembly Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

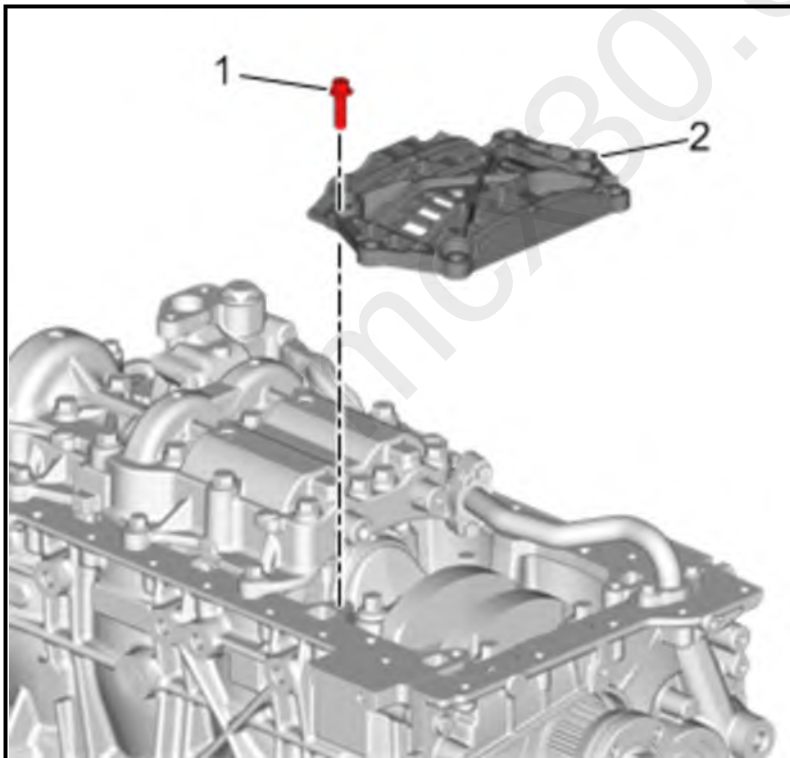
1. If the balancer backlash is correct or very close, tighten the balancer bolts in sequence to 32 N.m (24 lb ft) and check the backlash again. If the backlash is still correct after tightening, go to step 20.
2. If the balancer backlash is too high, go to step 18.
3. If the balancer backlash is too low, go to step 19.
18. Backlash too high.
 1. Slightly loosen the balancer bolts.
 2. Turn the Pre-load screw clockwise a very small amount.
 3. Hand tighten the balancer bolts.
 4. Repeat step 16 to measure balancer backlash.
19. Backlash too low.
 1. Slightly loosen the balancer bolts.
 2. Loosen the Pre-load screw counter-clockwise a very small amount.
 3. Gently tap the balancer on the right side with a rubber mallet to bring it in contact with the Pre-load screw.
 4. Hand tighten the balancer bolts.
 5. Repeat step 16 to measure balancer backlash.
20. Tighten the balance shaft tube bolts (1) to 10 N.m (89 lb in).



21. Remove the tools.

OIL PAN BAFFLE INSTALLATION

1. Install the oil pan baffle (2).



2. Install the oil pan baffle bolts (1) and hand tighten.

3. Tighten the bolts in sequence to 32 N.m (24 lb ft).

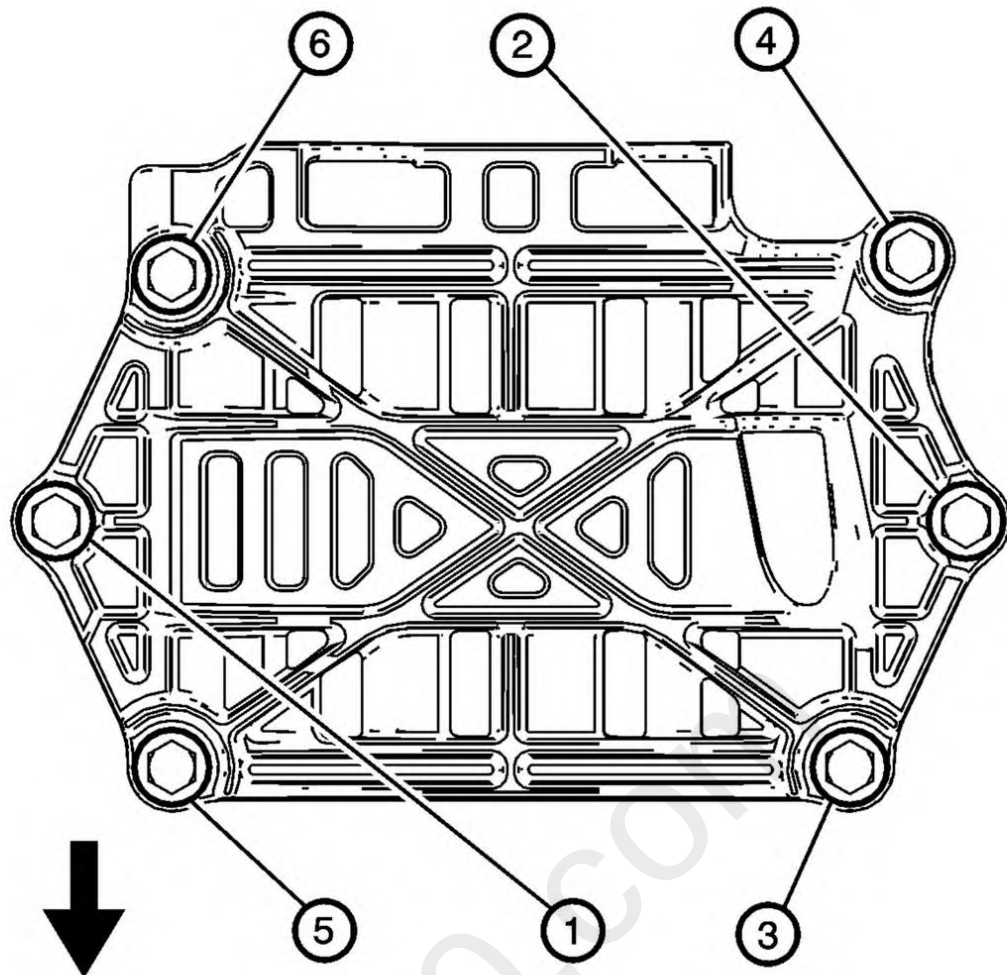


Fig. 49: Oil Pan Baffle Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

UPPER OIL PAN INSTALLATION

Upper Oil Pan Installation

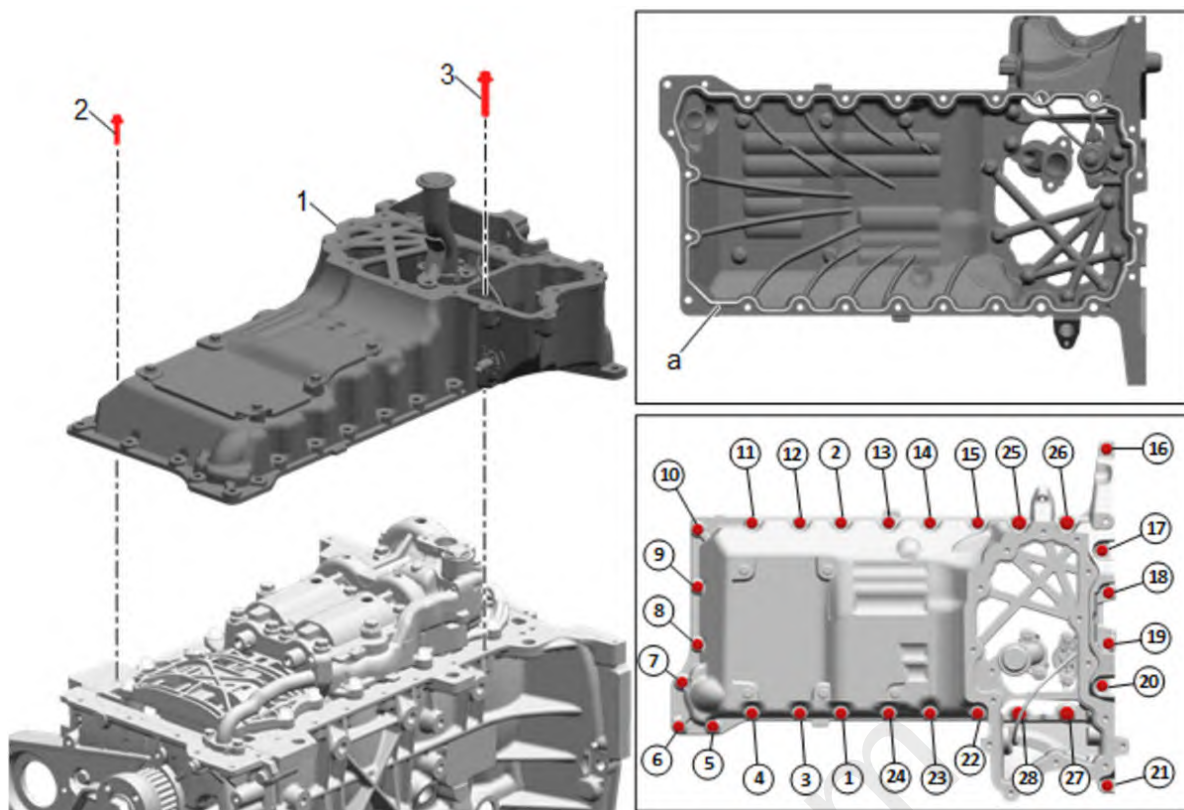


Fig. 50: Upper Oil Pan Bolt Tightening Sequence

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Upper Oil Pan Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 2. Apply a 5 mm (0.197 in) bead of RTV sealant as shown (a). <u>Adhesives, Fluids, Lubricants, and Sealers</u>
2	Upper Oil Pan Bolt (Qty. 24) CAUTION: Refer to <u>Fastener</u> <u>Caution</u> . Tighten 1. Tighten the bolts a first pass in sequence to: 15 N.m (12 lb ft) 2. Loosen the bolts for the second pass Loosen 90 degrees. 3. Tighten the bolts a final pass in sequence to: 15 N.m (12 lb ft)
3	Upper Oil Pan Bolt (Qty. 4) Tighten 1. Tighten the bolts a first pass in sequence to: 32 N.m (24 lb ft)

Callout	Component Name
	2. Loosen the bolts for the second pass Loosen 90 degrees. 3. Tighten the bolts a final pass in sequence to: 32 N.m (24 lb ft)

LOWER OIL PAN INSTALLATION

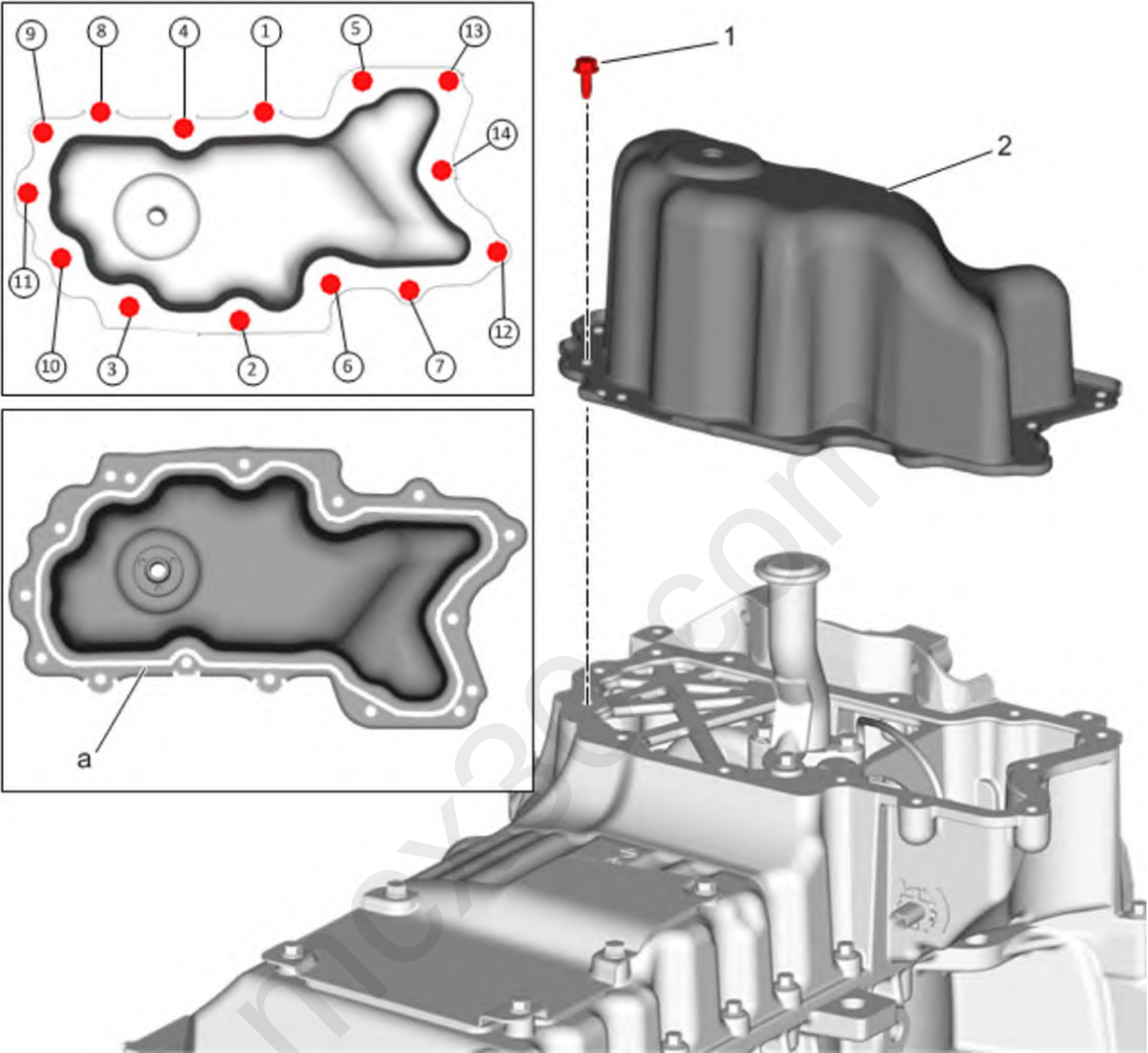


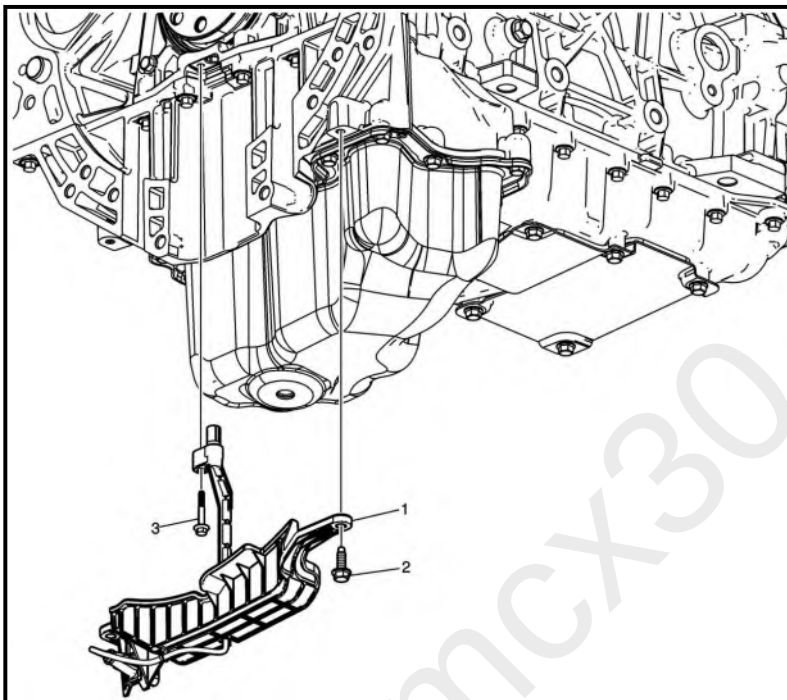
Fig. 51: Lower Oil Pan Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Lower Oil Pan Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 2. Apply a 5 mm (0.197 in) bead of sealant to the oil pan (a). <u>Adhesives, Fluids, Lubricants, and Sealers</u>
2	Lower Oil Pan Bolt (Qty. 14) CAUTION:

Callout	Component Name
	Refer to Fastener Caution . Procedure 1. Install the number 11 and 14 bolts loosely. Then install the number 1 and 2 bolts and torque to 13 N.m (115 lb in) 2. Install and tighten the remaining bolts in sequence to 13 N.m (115 lb in). NOTE: Use NEW bolts.

CRANKSHAFT POSITION SENSOR INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
CAUTION: Do not allow the crankshaft position sensor reluctor ring to come into contact with external magnetic fields or sharp metal objects. Do not drop the crankshaft	

Callout	Component Name
position sensor reluctor ring. Do not damage the rubberized encoder track. Failure to follow these precautions may cause damage to the component.	
1	Crankshaft Position Sensor
2	Crankshaft Position Sensor Bolt (Qty. 2) CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)
3	Crankshaft Position Sensor Bolt Tighten 5 N.m (44 lb in)

FUEL PUMP INSTALLATION

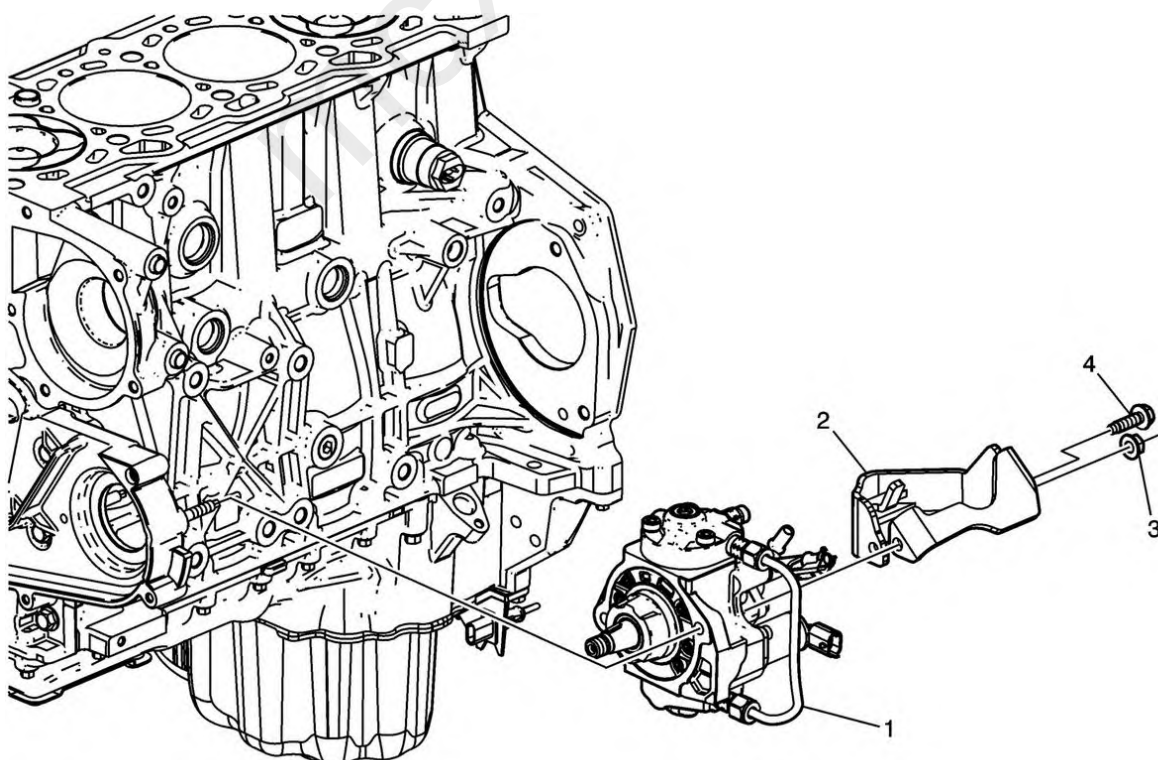


Fig. 52: Fuel Pump Components Location
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Fuel Pump Installation

Callout	Component Name
1	Fuel Pump
2	Fuel Feed Hose Protector
3	Fuel Pump Nut (Qty. 2) CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
4	Fuel Pump Bolt Tighten 25 N.m (18 lb ft)

Engine Oil Cooler Inlet Pipe Installation

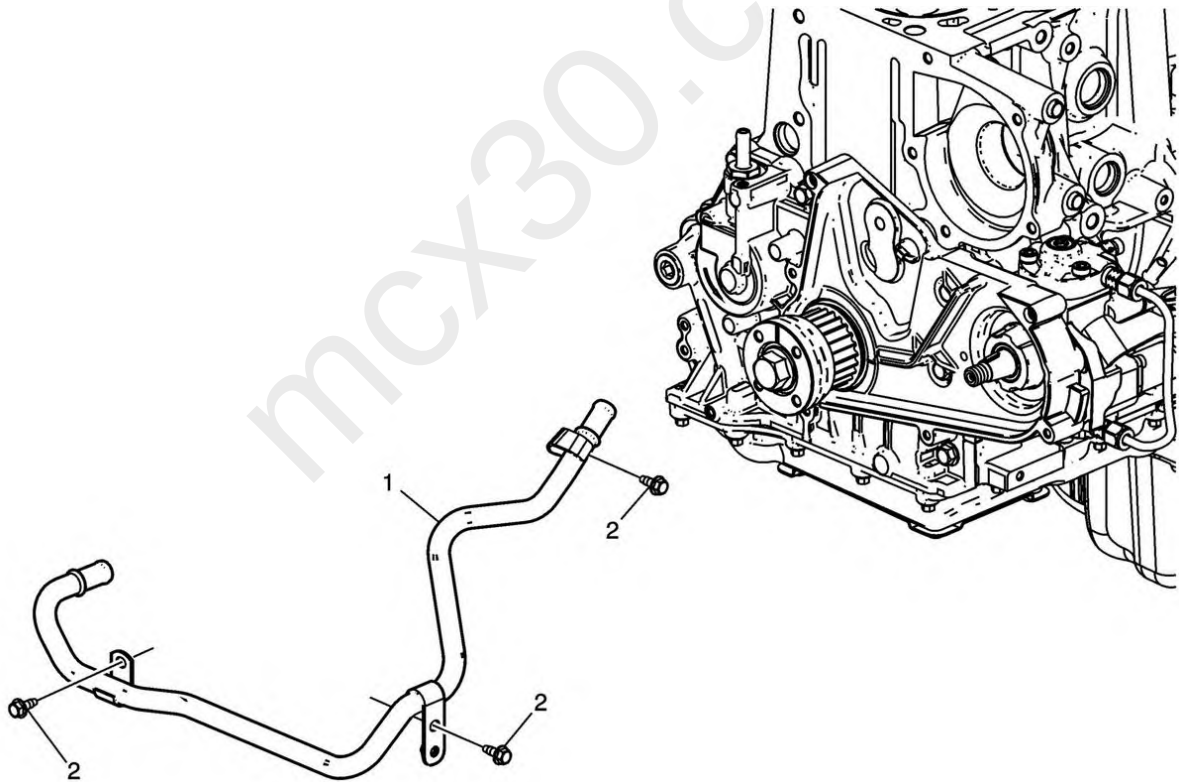


Fig. 53: Engine Oil Cooler Inlet Pipe Components Location
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Engine Oil Cooler Inlet Pipe Installation

Callout	Component Name
1	Engine Oil Cooler Inlet Pipe
2	Engine Oil Cooler Inlet Pipe Bolt

Callout	Component Name
	CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)

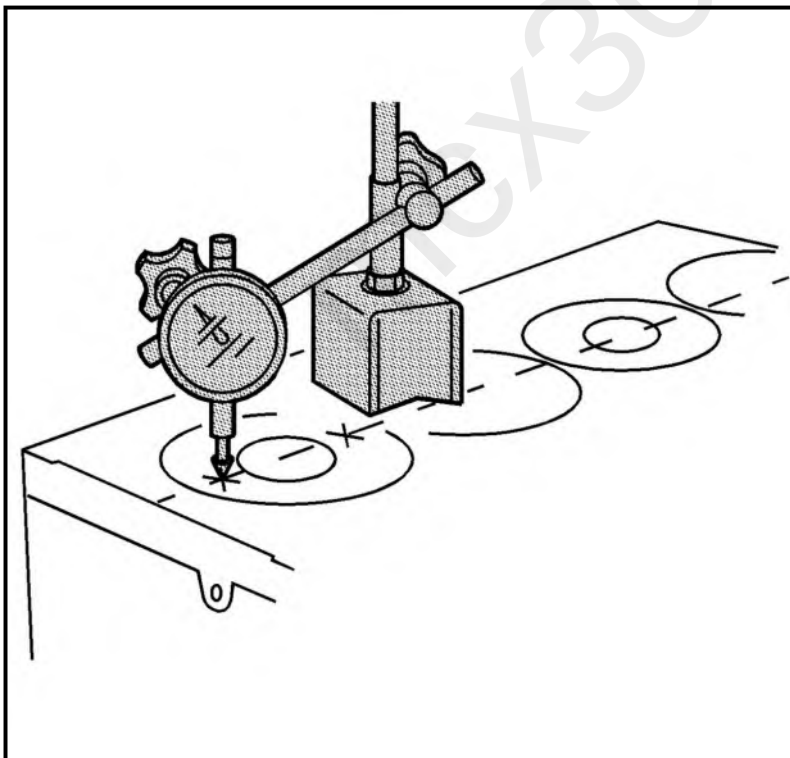
CYLINDER HEAD GASKET SELECTION

Special Tools

J 7872 Dial Indicator Set

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

1. If a reciprocating component (crankshaft, connecting rod, piston, or bearings) has not been replaced, install the same grade head gasket that was removed.
2. The cylinder head gasket thickness is determined by the piston head projection from the cylinder block deck surface. There are cylinder head gaskets available in three different thicknesses. Follow the procedure below and refer to [Cylinder Head Gasket Selection Specifications](#) to determine what gasket to use for each bank of cylinders.
3. Be sure the piston and cylinder deck are free of carbon, gasket material, or other objects that may give you an erroneous measurement.
4. Use **J 7872** dial indicator set to measure the piston projection across two different points on each piston.



1. Zero the dial indicator to the cylinder deck surface.
2. Place the dial indicator pointer on the piston top. Be sure the pointer is directly above the piston pin centerline to prevent inaccurate readings from piston rocking.
3. Rotate the engine to roll the piston through Top Dead Center while noting the maximum reading on the dial indicator.
4. Repeat procedure at the second measuring point on the piston.

5. Obtain the maximum piston projection value for that bank of cylinders.
6. Determine the gasket grade by the maximum piston projection value using the chart. Refer to [Cylinder Head Gasket Selection Specifications](#).

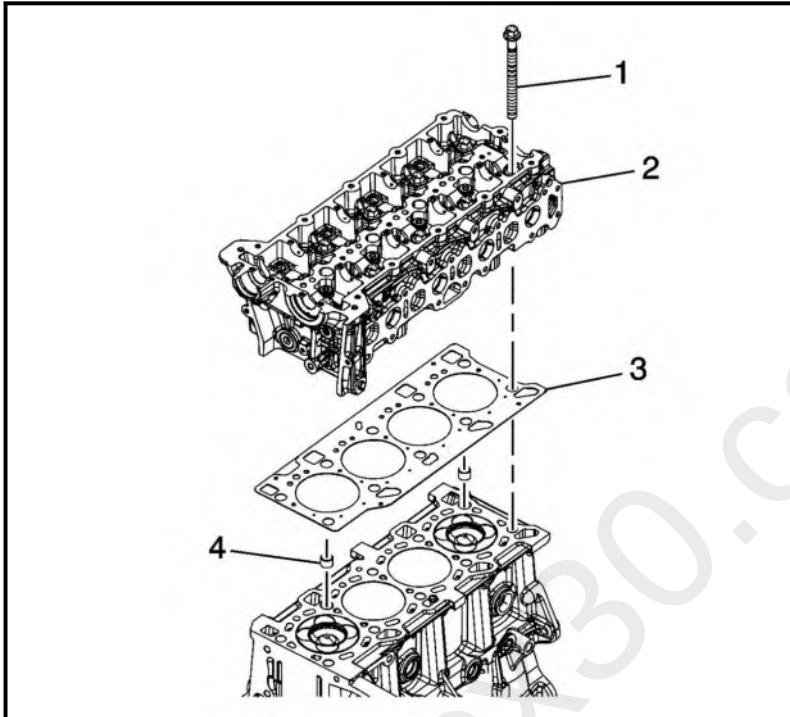
CYLINDER HEAD INSTALLATION

Special Tools

J-45059 Angle Meter

Equivalent regional tools: [Special Tools](#)

1. Install the cylinder head alignment pins (4) and gasket (3) to the block.



NOTE: Do not use any sealing material.

2. Install the cylinder head (2).

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 the NEW cylinder head bolts (1) finger tight.
4. Tighten the NEW cylinder head bolts:

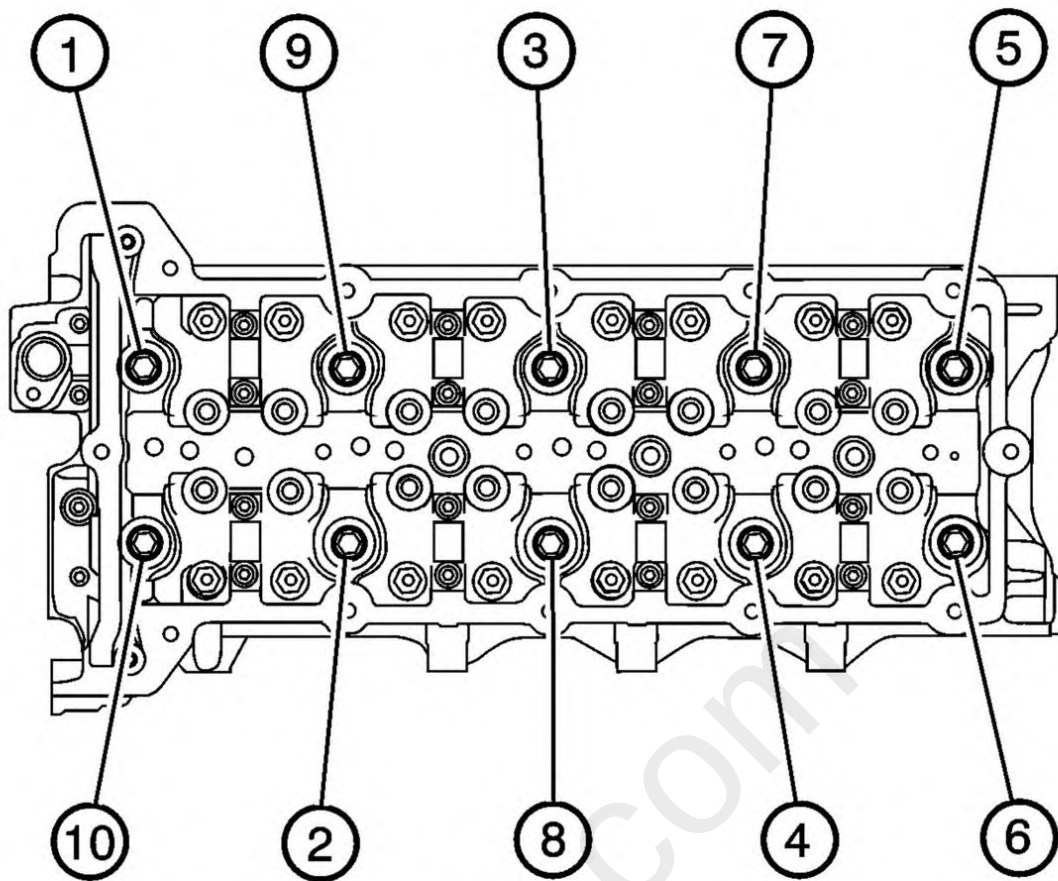


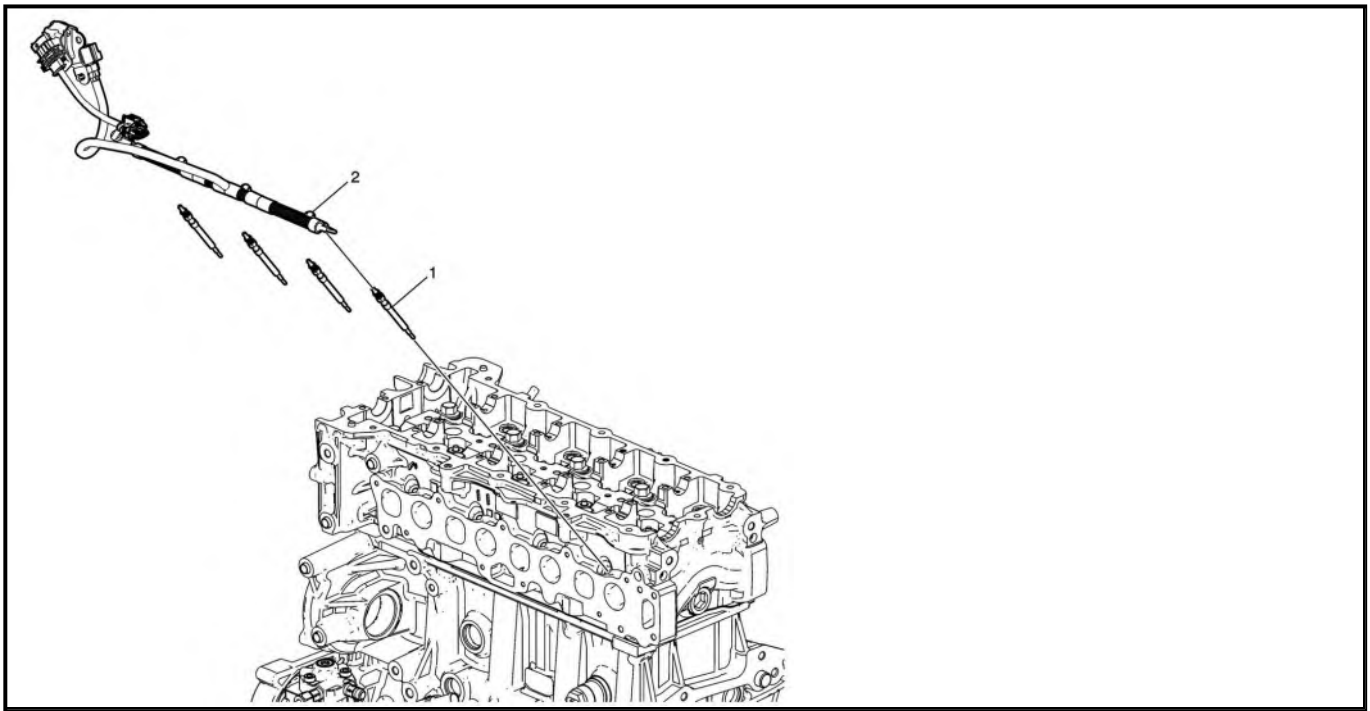
Fig. 54: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

NOTE: Always use new cylinder head bolts.

1. Tighten the NEW bolts in sequence to 30 N.m (22 lb ft)
2. Using **J-45059** meter, tighten the bolts in sequence an additional 110 degrees for the second, third, and final passes, for a total of 330 degrees.

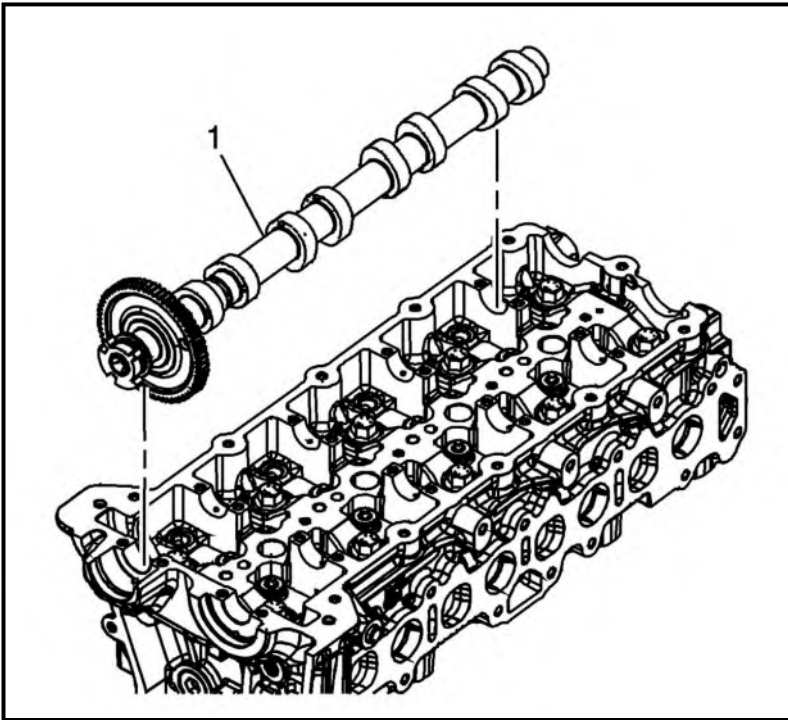
GLOW PLUG INSTALLATION



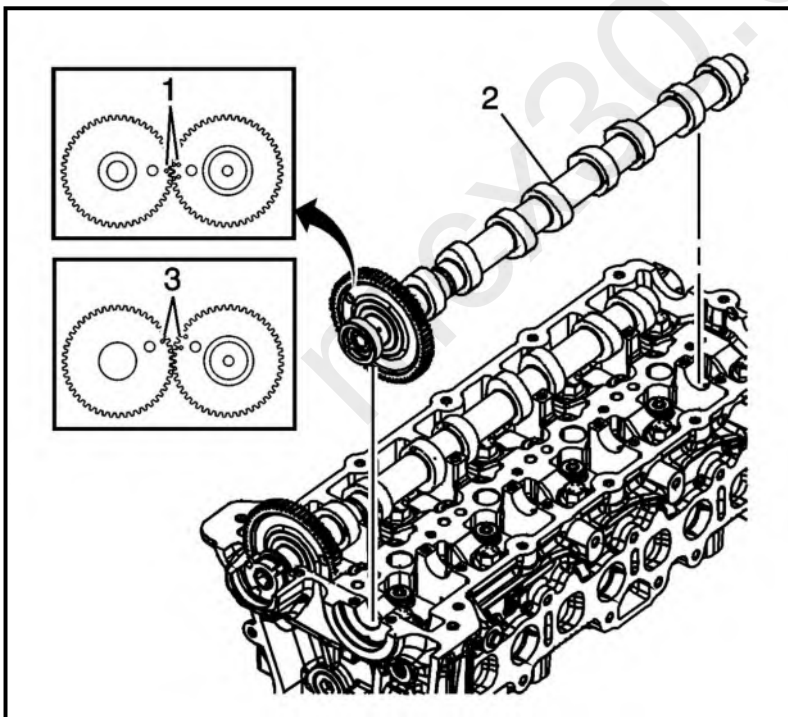
NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Glow Plugs CAUTION: Refer to Fastener Caution . NOTE: To aid in hand starting glow plugs into their bores, a hose or tube with an inner diameter of 4 mm (0.2 in) can be used as an extension when installed on the end of the glow plug. Tighten 14 N.m (124 lb in)
2	Diesel Glow Plug Wiring Harness

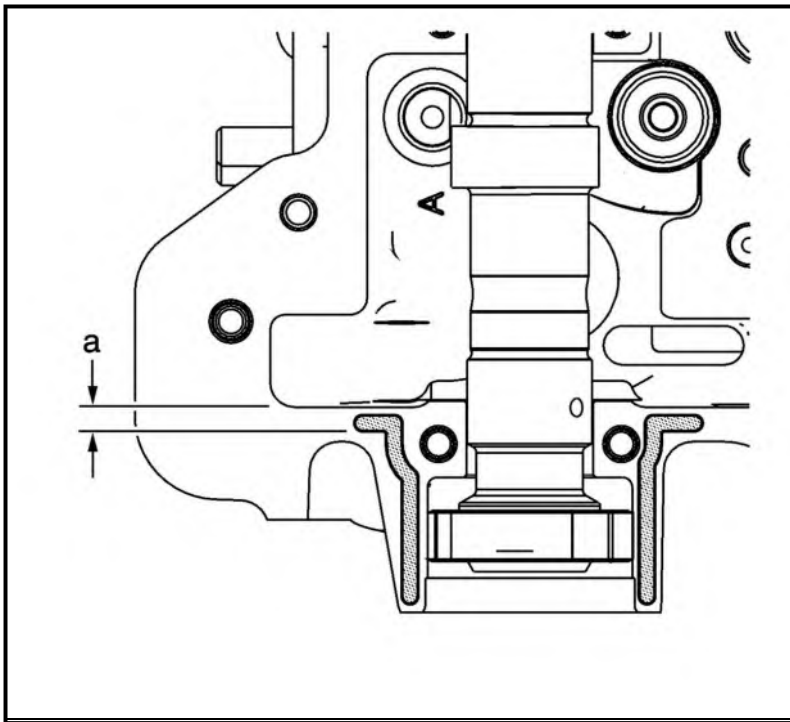
1. Install the exhaust camshaft (1).



2. Install the intake camshaft (2) so that the timing marks on the camshaft sprockets are aligned (1). The final, relaxed alignment (3) for the camshaft sprockets will result during normal installation of the components.



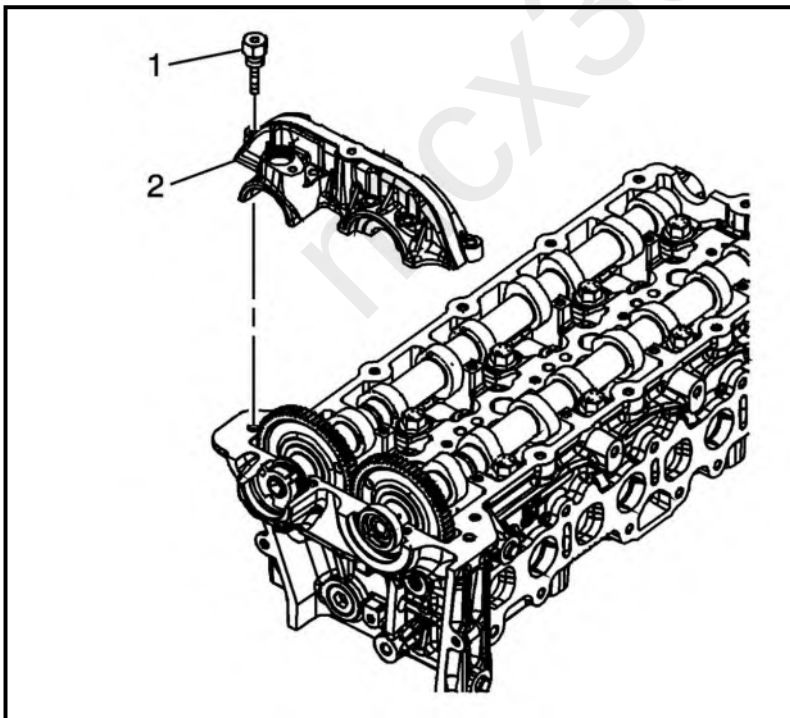
3. Apply a bead of sealant to the camshaft bearing front cap sealing surface. Refer to [Adhesives, Fluids, Lubricants, and Sealers](#) for the recommended sealant. Use a sponge to spread very carefully to the indicated areas.



NOTE:

- Ensure that all sealing material has been removed from the components, and the sealing surfaces are clean and free of contamination prior to applying the sealer.
- Install and align the front cap within 20 minutes of applying the sealer.
- Ensure the sealant does not drip into the intake or exhaust camshaft cap seats.

4. Inspect the intake and exhaust camshaft cap seats, and confirm that the seats are free of sealant.



NOTE:

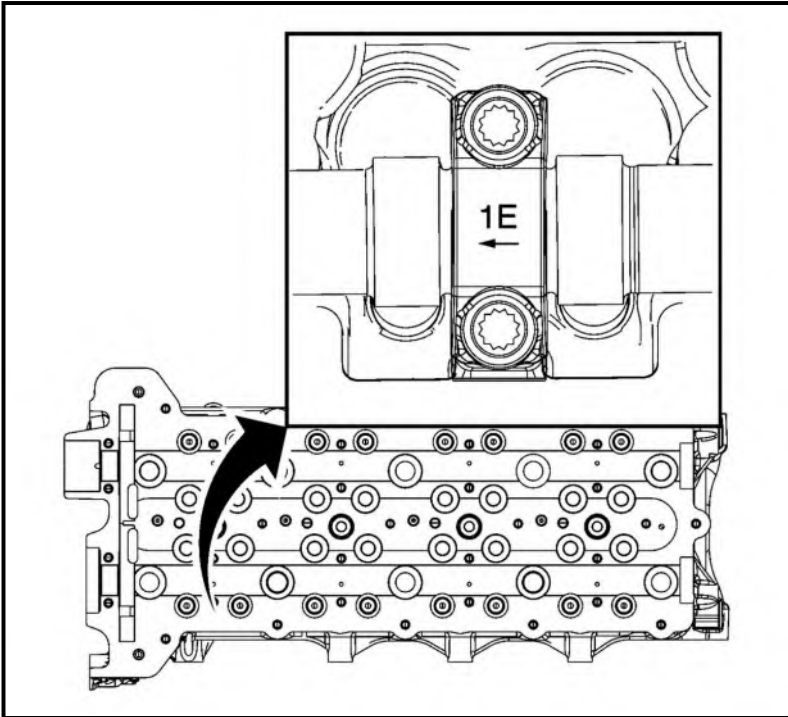
It is critical during installation to ensure the bearing front cap and cylinder head alignment is correct and the mating surfaces are flush.

CAUTION:

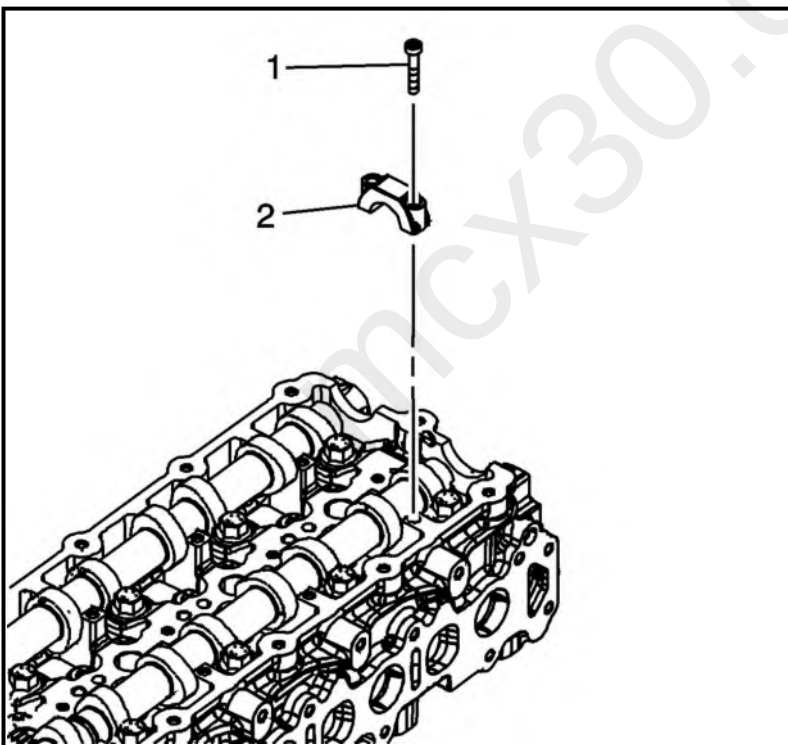
Refer to [Fastener Caution](#) .

5. Install the camshaft bearing front cap (2). Tighten the cap bolts (1) to 11 N.m (97 lb in).

6. Match each camshaft cap to the correct location on the cylinder head. In the illustration, the camshaft cap is the first cylinder, indicated by the "1", on the intake side of the cylinder head, indicated by the "I". A camshaft cap on the exhaust side is indicated by an "E".



7. Install the camshaft caps (2).



8. Tighten the cap bolts in sequence to 11 N.m (97 lb in).

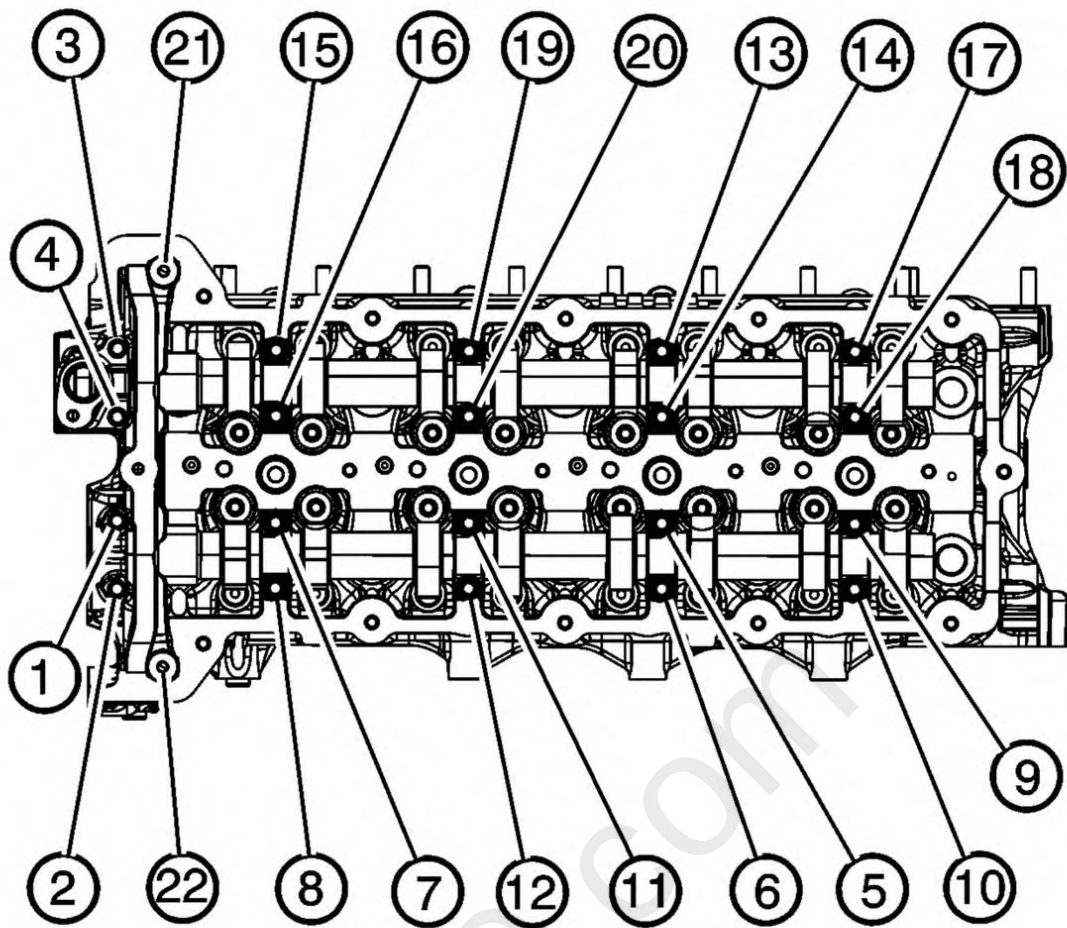
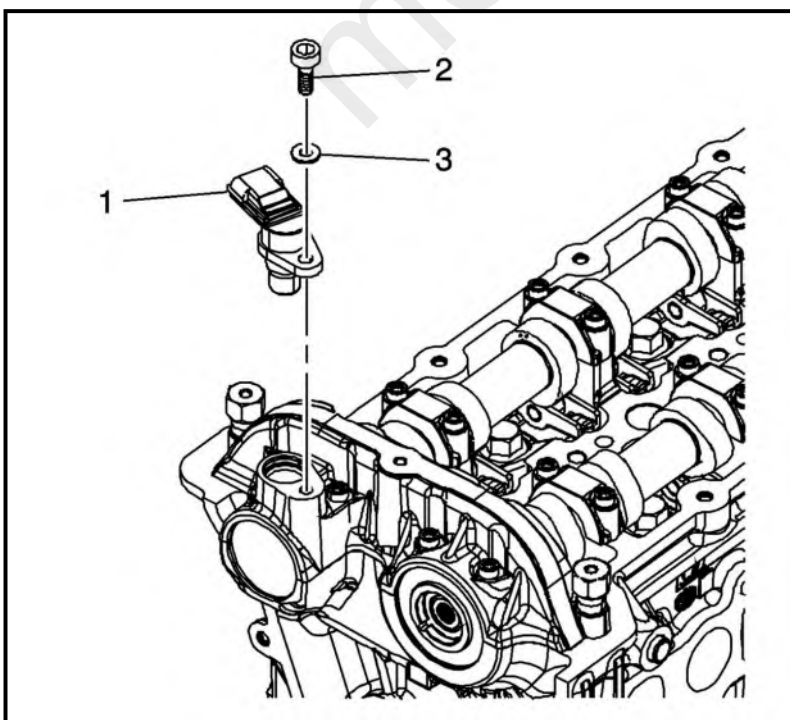
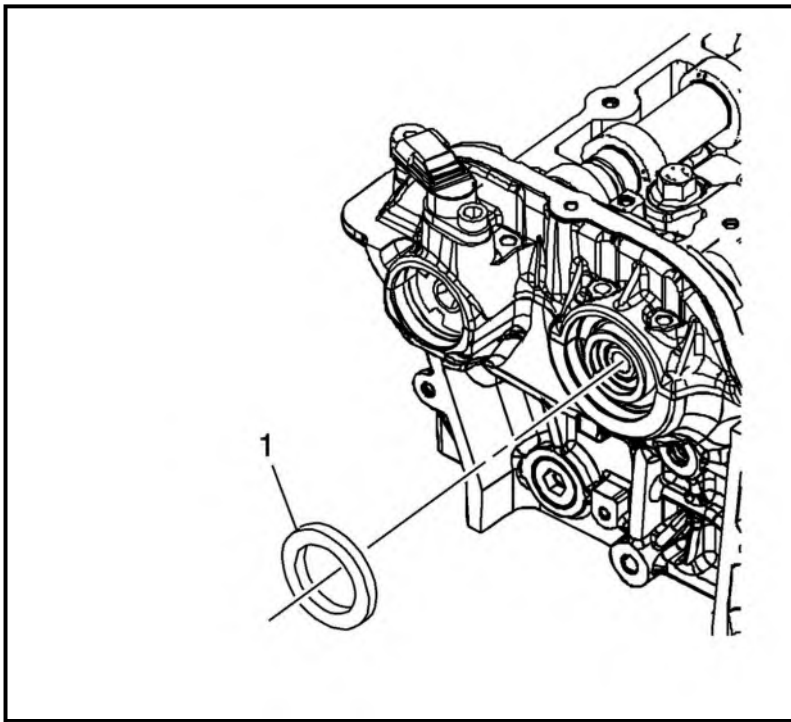


Fig. 55: Camshaft Cap Bolt Tightening Sequence
 Courtesy of GENERAL MOTORS COMPANY

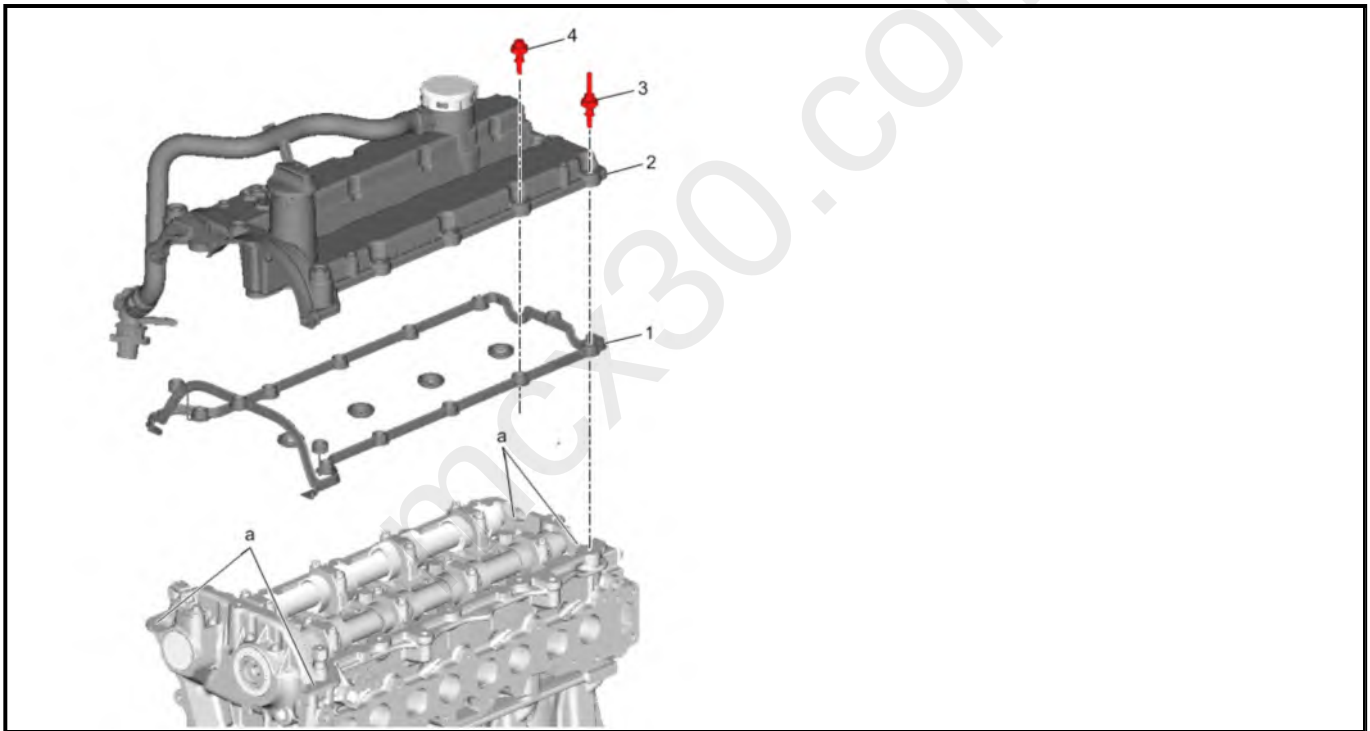
9. Install the camshaft position (CMP) sensor (1), washer (3), and bolt (2). Tighten the bolt to 11 N.m (97 lb in).



10. Install the intake camshaft oil seal (1).



VALVE ROCKER ARM COVER INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Valve Rocker Arm Cover Gasket NOTE: Use a NEW gasket.
2	Valve Rocker Arm Cover NOTE:

Callout	Component Name
	Do not cut or remove the PCV hose or clamps, it is a tamper proof system. Procedure 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. <u>Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant</u> 2. Apply a thin bead of sealant to the interface of the front camshaft cap and the valve rocker arm cover gasket sealing surface (a). 3. Apply a thin bead of sealant to the half moons of the cylinder head to camshaft cover joint (a).
3	Valve Rocker Arm Cover Stud CAUTION: Refer to <u>Fastener Caution</u> . Tighten 11 N.m (97 lb in)
4	Valve Rocker Arm Cover Bolt Tighten 11 N.m (97 lb in)

INTAKE MANIFOLD INSTALLATION

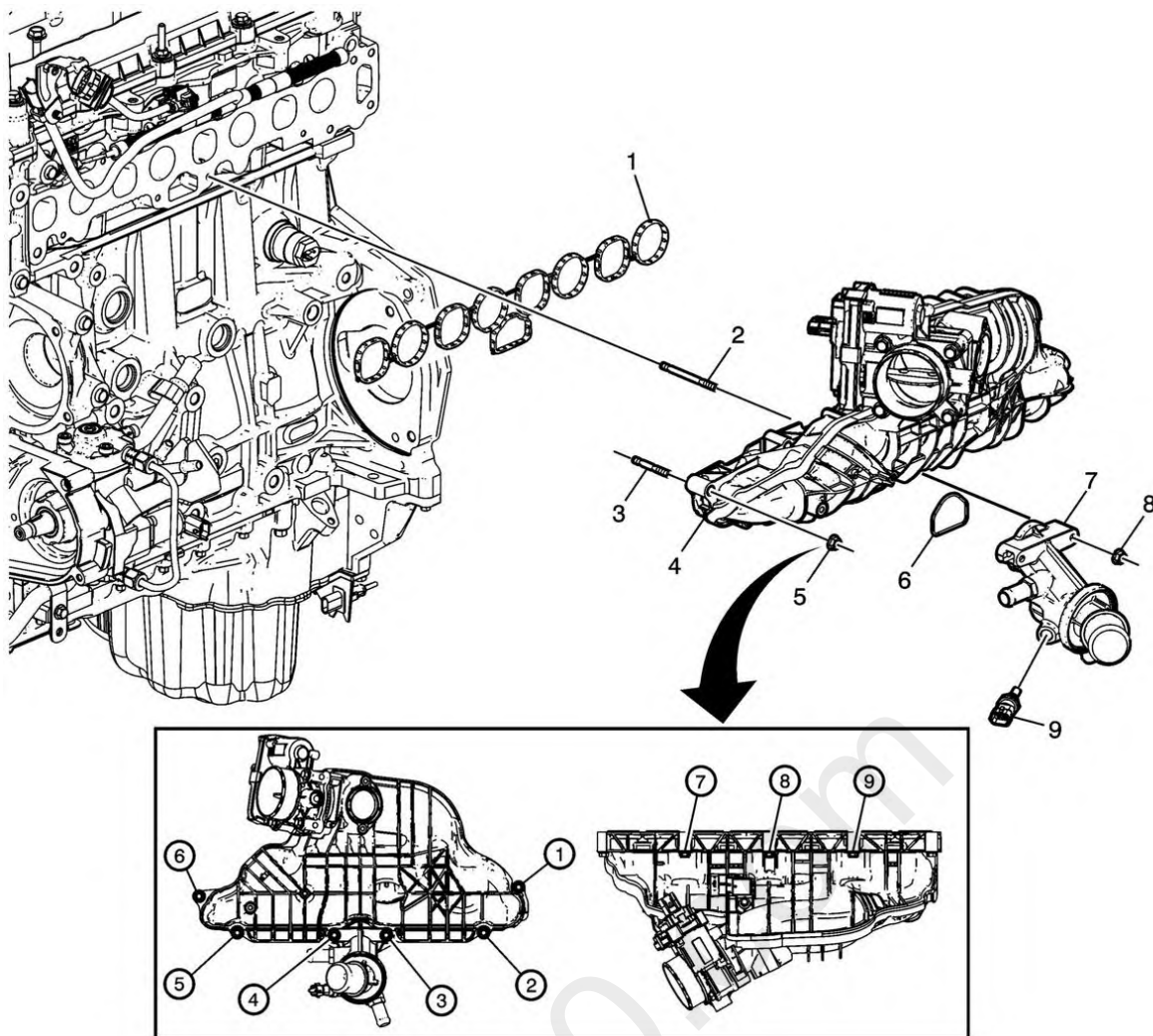


Fig. 56: Intake Manifold Components Location

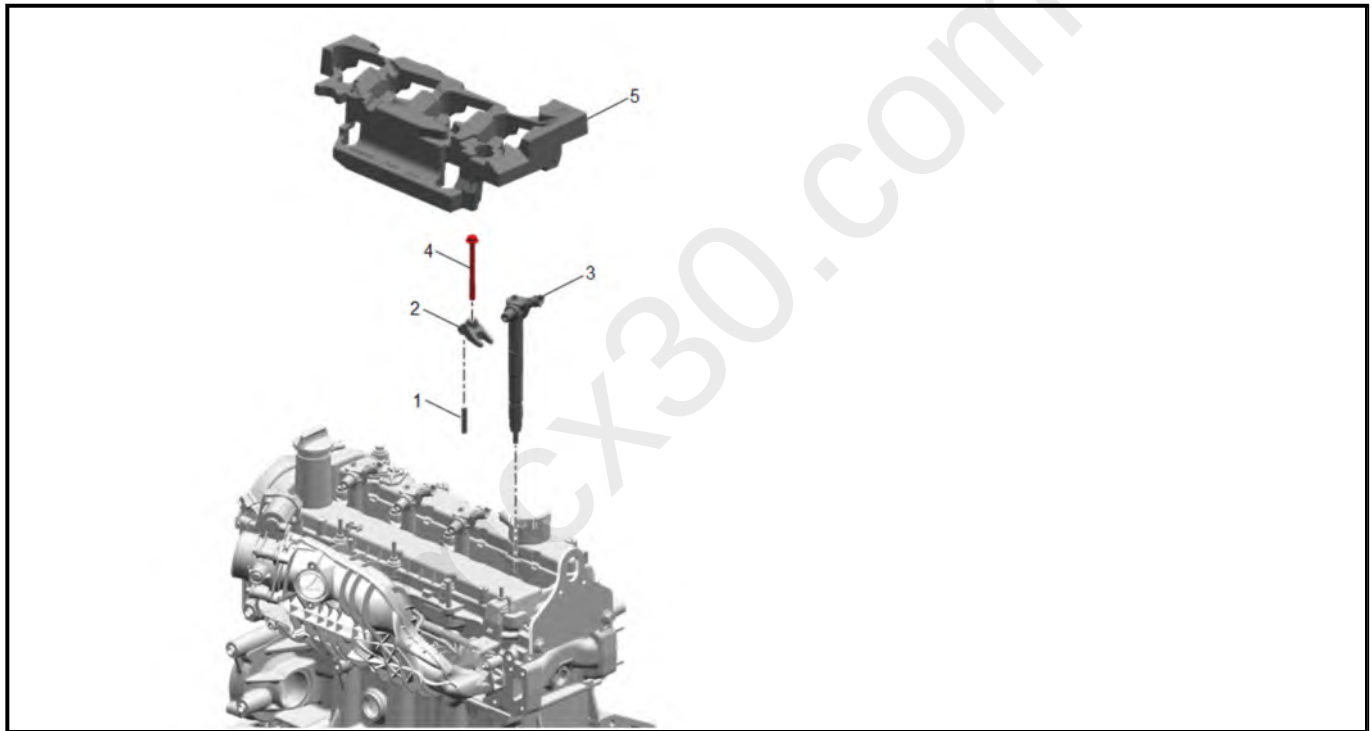
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Intake Manifold Gasket NOTE: Use a NEW gasket.
2	Intake Manifold Stud
3	Intake Manifold Stud
4	Intake Manifold
5	Intake Manifold Nut CAUTION: Refer to Fastener Caution . Intake Manifold Tightening Sequence 1. First pass, clamp to 5 N.m (44 lb in): 1, 4, 6, 2, 3, 5. 2. Final pass, torque to 12 N.m (106 lb in): 1, 2, 3, 4, 5, 6, 7, 8, 9

Callout	Component Name
6	Engine Coolant Thermostat Gasket NOTE: Use a NEW gasket.
7	Engine Coolant Thermostat
8	Intake Manifold Nut Intake Manifold Tightening Sequence 1. First pass, clamp to 5 N.m (44 lb in): 1, 4, 6, 2, 3, 5. 2. Final pass, torque to 12 N.m (106 lb in): 1, 2, 3, 4, 5, 6, 7, 8, 9
9	Engine Coolant Temperature Sensor Tighten 15 N.m (11 lb ft)

FUEL INJECTOR INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Fuel Injector Locating Pin NOTE: The unique fuel injector flow rates are programmed into the ECM according to cylinder location.

Callout	Component Name
	Mark the fuel injectors for correct re-installation to the same cylinders. Failure to do so may result in a poor drive-ability condition.
2	Fuel Injector Hold Down Clamp
3	Fuel Injector NOTE: Install NEW fuel injector combustion seals.
4	Fuel Injector Bracket Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 32 N.m (24 lb ft)
5	Fuel Injector Deadener

FUEL FEED PIPE AND FUEL RAIL INSTALLATION

Fuel Rail and Lines Installation

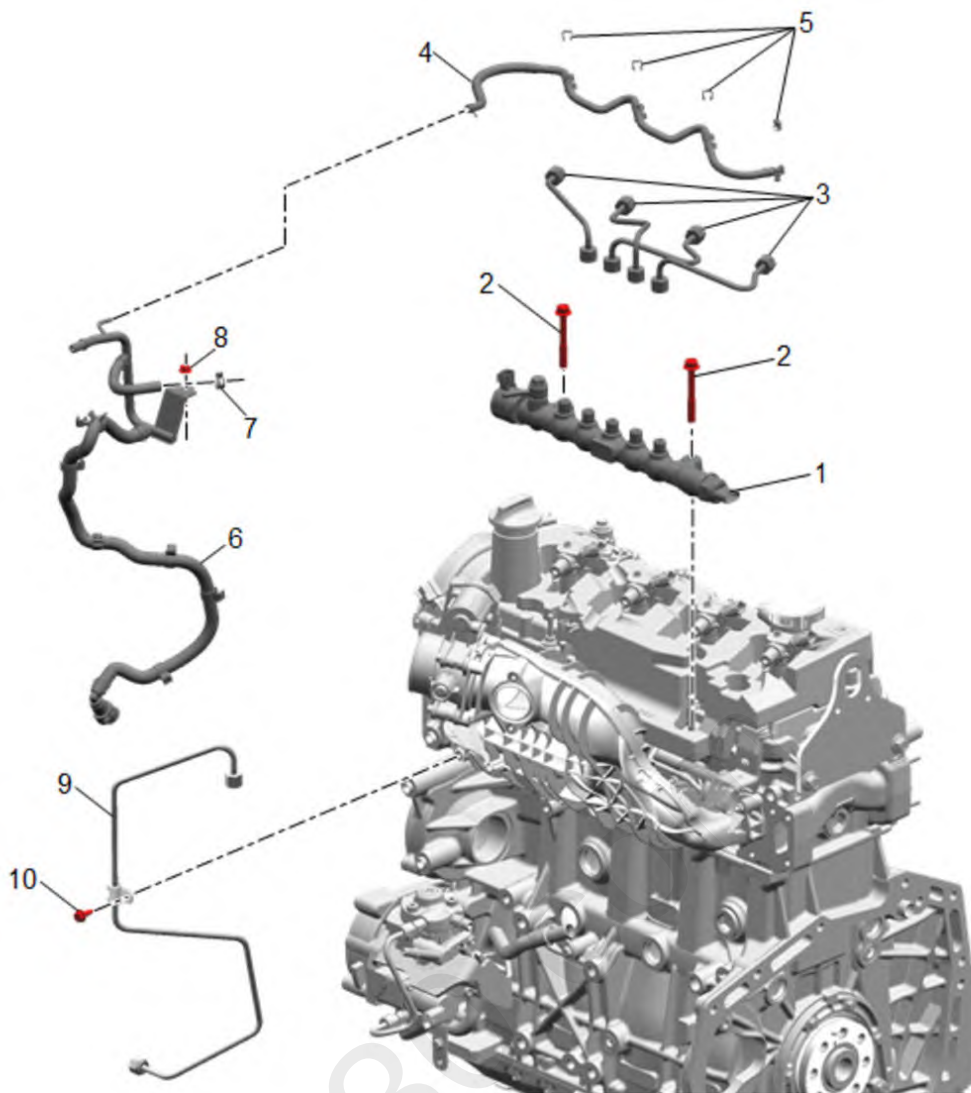


Fig. 57: Fuel Rail And Lines Components Location

Courtesy of GENERAL MOTORS COMPANY

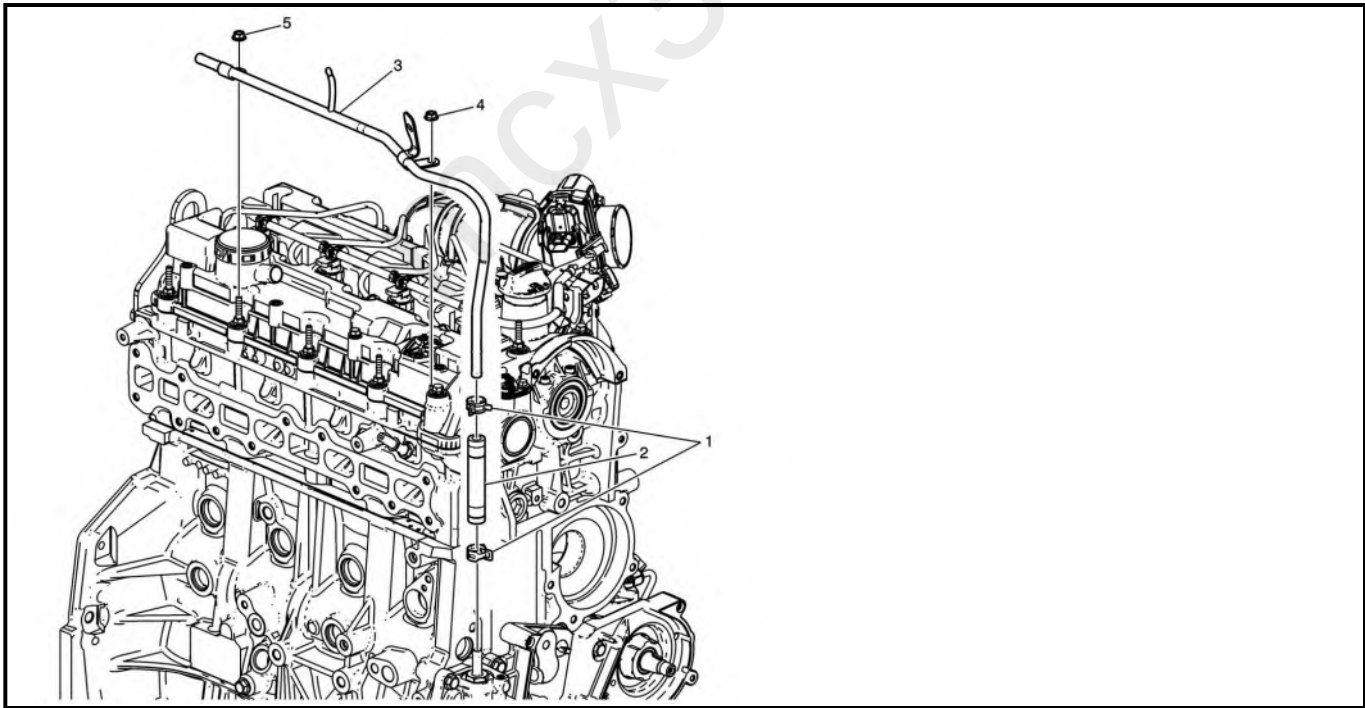
NOTE: Callouts in the following chart represent components shown in graphic above.

Fuel Rail and Lines Installation

Callout	Component Name
1	Direct Fuel Injection Fuel Rail
2	Fuel Injection Fuel Feed Pipe Bracket Bolt CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
3	Fuel Injector Fuel Feed Pipe NOTE: Must use NEW Pipes .

Callout	Component Name
	Tighten 30 N.m (22 lb ft)
4	Fuel Injection Fuel Return Pipe
5	Fuel Injection Fuel Return Pipe Clip NOTE: Install NEW clips.
6	Diesel Fuel Separator
7	Diesel Fuel Separator Hose Clamp Tighten 30 N.m (22 lb ft)
8	Engine Wiring Harness Bracket Nut Tighten 12 N.m (106 lb in)
9	Fuel Feed Pipe NOTE: Use a NEW fuel feed pipe.
10	Fuel Feed Pipe Bolt Tighten 5 N.m (44 lb in)

Vacuum Pump Pipe and Hose Installation



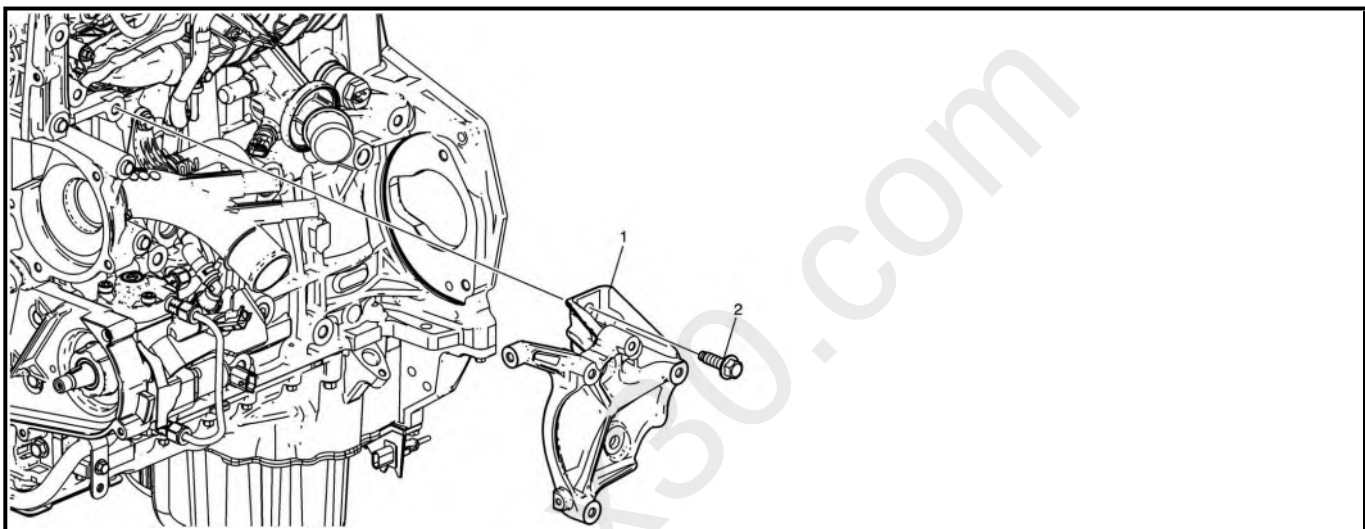
NOTE: Callouts in the following chart represent components shown in graphic above.

Vacuum Pump Pipe and Hose Installation

Callout	Component Name
1	Vacuum Pump Hose Clip
2	Vacuum Pump Hose

Callout	Component Name
3	Vacuum Pump Pipe
4	Vacuum Pipe Nut CAUTION: Refer to <u>Fastener</u> <u>Caution</u> . Tighten 5 N.m (44 lb in)
5	Vacuum Pipe Nut Tighten 5 N.m (44 lb in)

AIR CONDITIONING COMPRESSOR BRACKET INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Air Conditioning Compressor Bracket
2	Air Conditioning Compressor Bracket Bolt [4x] CAUTION: Refer to <u>Fastener</u> <u>Caution</u> . Tighten 45 N.m (33 lb ft)

WATER PUMP INLET PIPE INSTALLATION

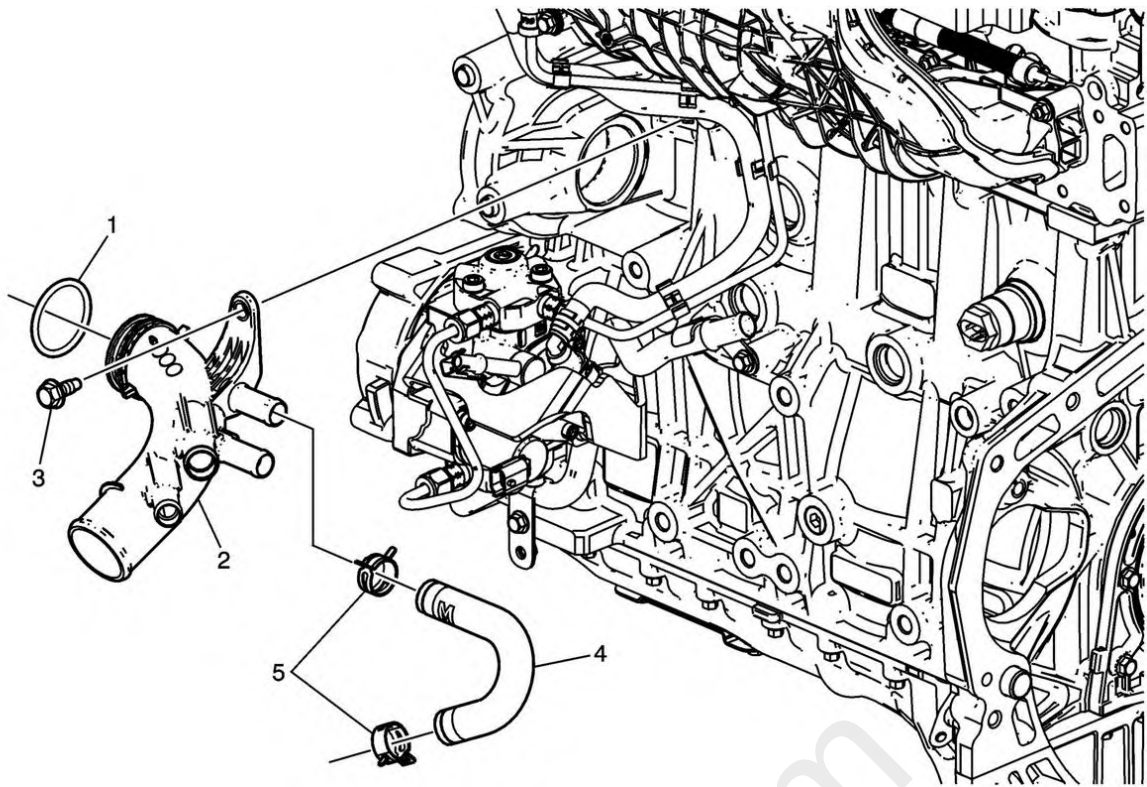


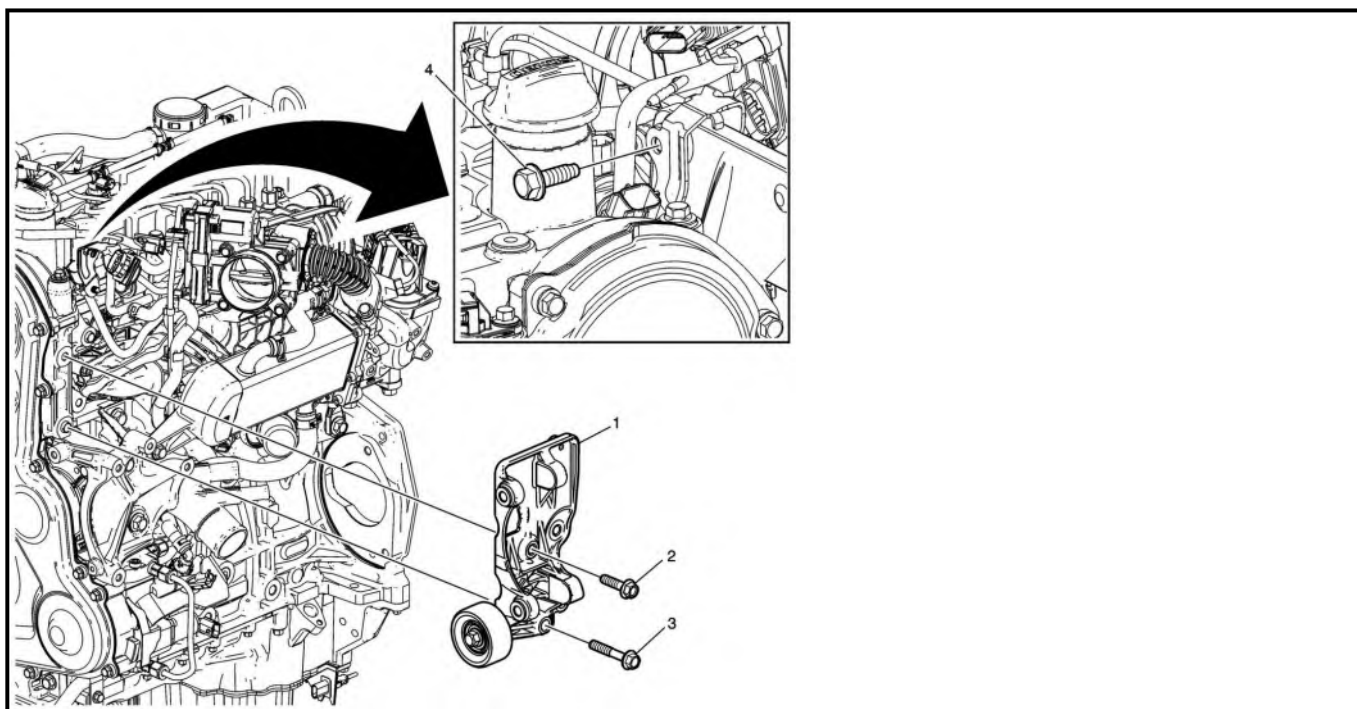
Fig. 58: Water Pump Inlet Pipe Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Water Pump Inlet Pipe Seal NOTE: Use a NEW seal.
2	Water Pump Inlet Pipe
3	Water Pump Inlet Pipe Bolt CAUTION: Refer to <u>Fastener Caution</u> . Tighten 25 N.m (18 lb ft)
4	Water Pump Inlet Pipe Feed Hose
5	Water Pump Inlet Pipe Feed Hose Clamp

GENERATOR BRACKET INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Generator Bracket
2	Generator Bracket Bolt [2x] CAUTION: Refer to Fastener Caution . Tighten 45 N.m (33 lb ft)
3	Generator Bracket Bolt [2x] Tighten 45 N.m (33 lb ft)
4	Generator Bracket Bolt Tighten 22 N.m (16 lb ft)

EXHAUST GAS RECIRCULATION VALVE AND COOLER INSTALLATION

EGR Cooler, Housing, and Cooling Feed Hose Installation

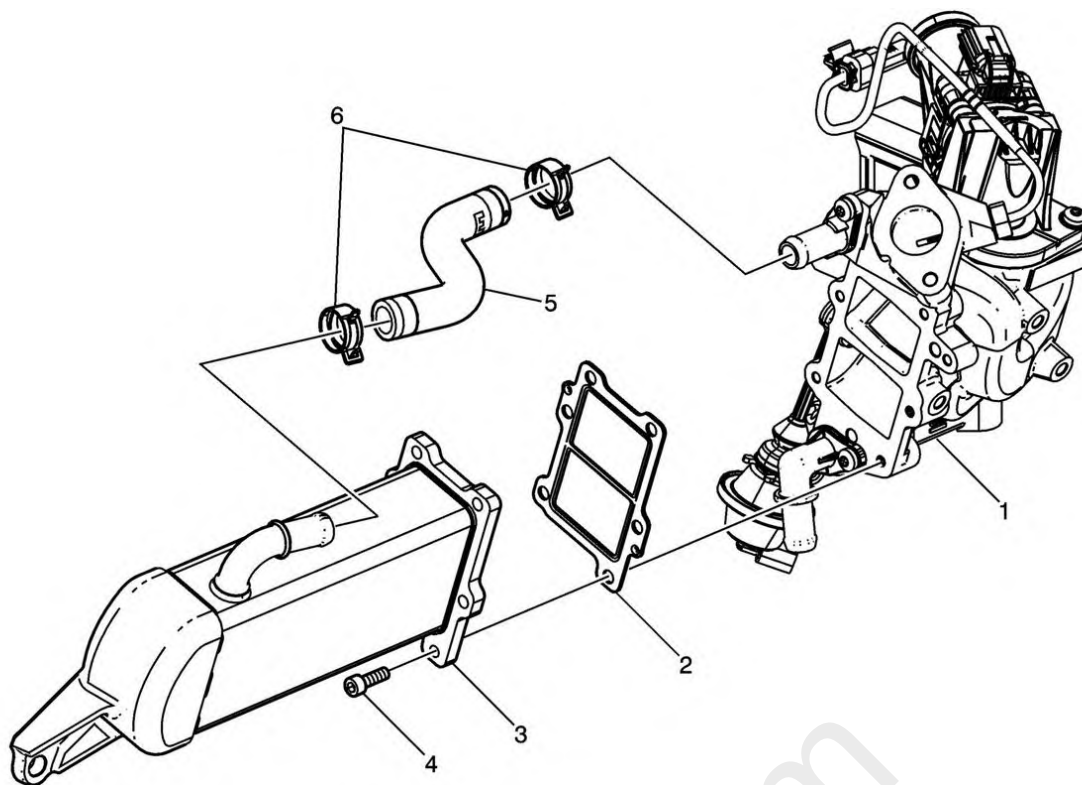


Fig. 59: EGR Cooler, Housing And Cooling Feed Hose Components Location

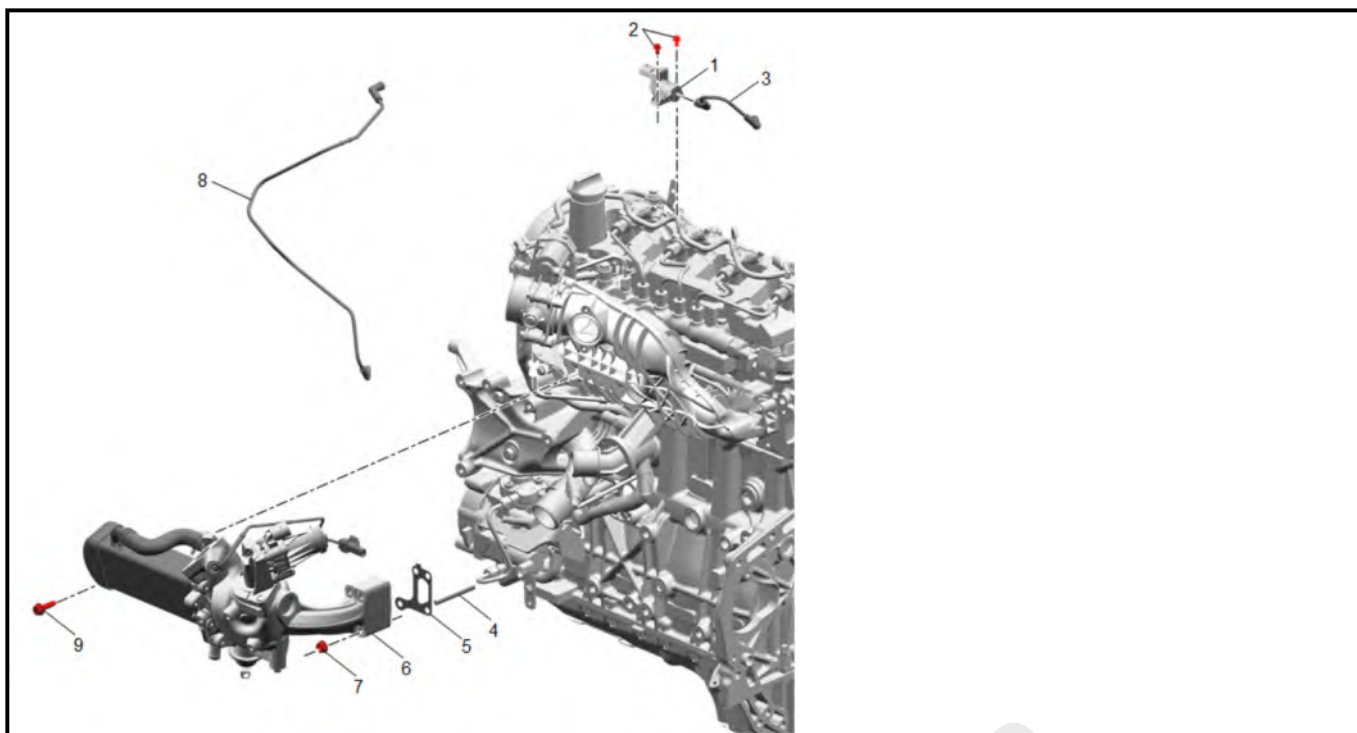
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Cooler, Housing, and Cooling Feed Hose Installation

Callout	Component Name
1	Exhaust Gas Recirculation Valve Machined Housing
2	Exhaust Gas Recirculation Cooler Gasket NOTE: Use a NEW gasket.
3	Exhaust Gas Recirculation Cooler
4	Exhaust Gas Recirculation Cooler Bolt CAUTION: Refer to Fastener Caution . Tighten 15 N.m (11 lb ft)
5	Exhaust Gas Recirculation Manifold Cooling Feed Hose
6	Thermostat Bypass Hose Clamp

EGR Assembly, Intake Manifold Tuning Valve Vacuum and Pipes Installation



NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Assembly, Intake Manifold Tuning Valve Vacuum and Pipes Installation

Callout	Component Name
1	Intake Manifold Tuning Vacuum Control Solenoid Valve
2	Intake Manifold Tuning Vacuum Control Solenoid Valve Bolt CAUTION: Refer to Fastener Caution . Tighten 7 N.m (62 lb in)
3	Exhaust Gas Recirculation Valve Vacuum Pipe
4	Exhaust Gas Recirculation Valve Adapter Stud
5	Exhaust Gas Recirculation Valve Gasket NOTE: Use a NEW gasket.
6	Exhaust Gas Recirculation Valve and Cooler
7	Exhaust Gas Recirculation Valve Adapter Nut Tighten 25 N.m (18 lb ft)
8	Exhaust Gas Recirculation Valve Vacuum Pipe
9	Exhaust Gas Recirculation Cooler Bolt Tighten 25 N.m (18 lb ft)

EGR Pipe, Brace, and Hoses Installation

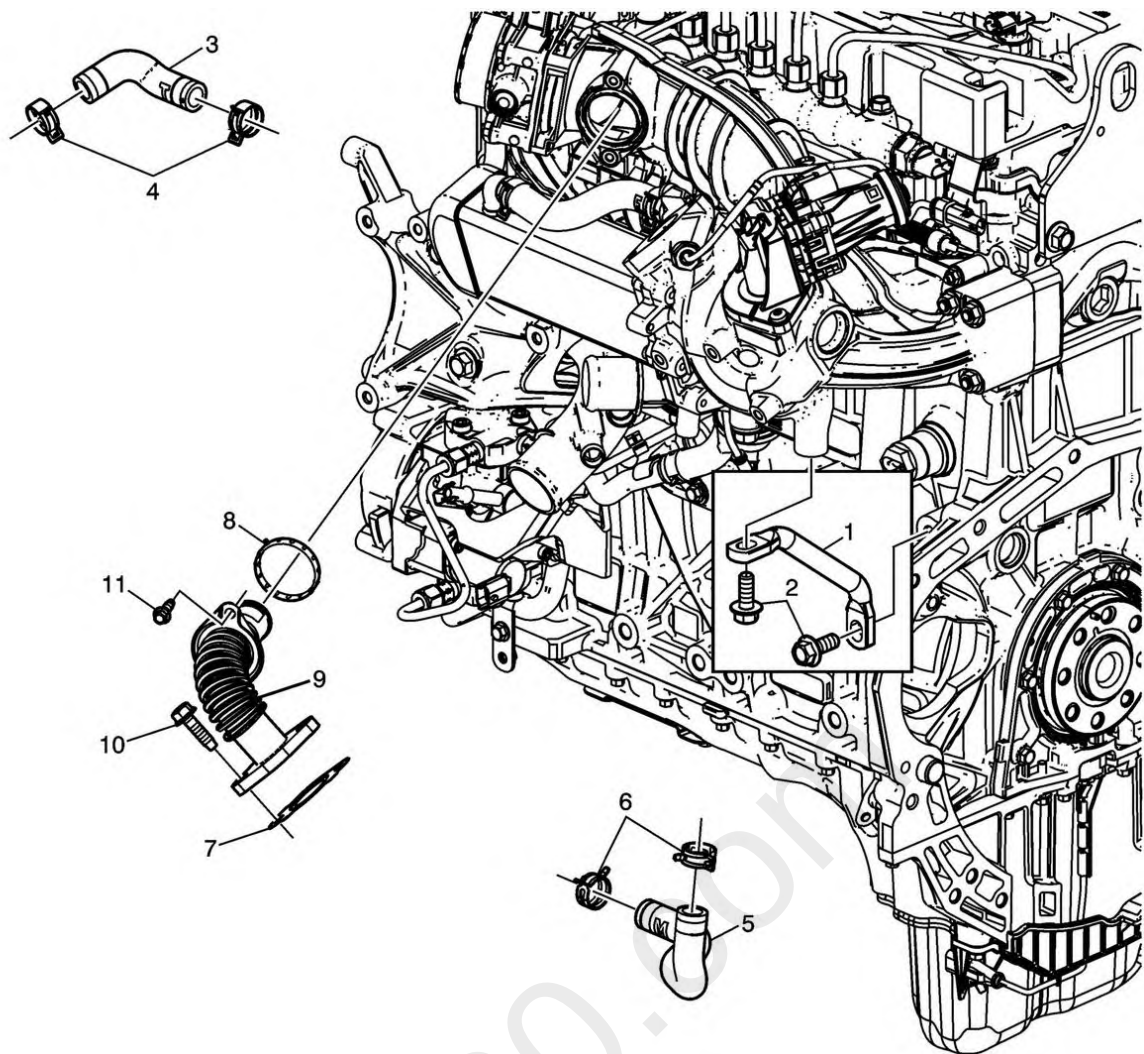


Fig. 60: EGR Pipe, Brace And Hoses Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

EGR Pipe, Brace, and Hoses Installation

Callout	Component Name
1	Exhaust Gas Recirculation Manifold Brace
2	Exhaust Gas Recirculation Manifold Brace Bolt CAUTION: Refer to Fastener Caution . Tighten 58 N.m (43 lb ft)
3	Exhaust Gas Recirculation Manifold Cooling Feed Hose
4	Thermostat Bypass Hose Clamp NOTE: Use NEW clamps.
5	Exhaust Gas Recirculation Manifold Cooling Return Hose
6	Thermostat Bypass Hose Clamp

Callout	Component Name
7	Exhaust Gas Recirculation Pipe Gasket NOTE: Use a NEW gasket.
8	Exhaust Gas Recirculation Pipe Gasket NOTE: Use a NEW gasket.
9	Exhaust Gas Recirculation Pipe
10	Exhaust Gas Recirculation Pipe Bolt Tighten 25 N.m (18 lb ft)
11	Exhaust Gas Recirculation Pipe Bolt Tighten 11 N.m (97 lb in)

EXHAUST MANIFOLD AND COMPRESSOR AIR INTAKE TURBOCHARGER INSTALLATION

Turbocharger Oil Return Pipe, Oil Feed Pipe, and Coolant Return Pipe Installation

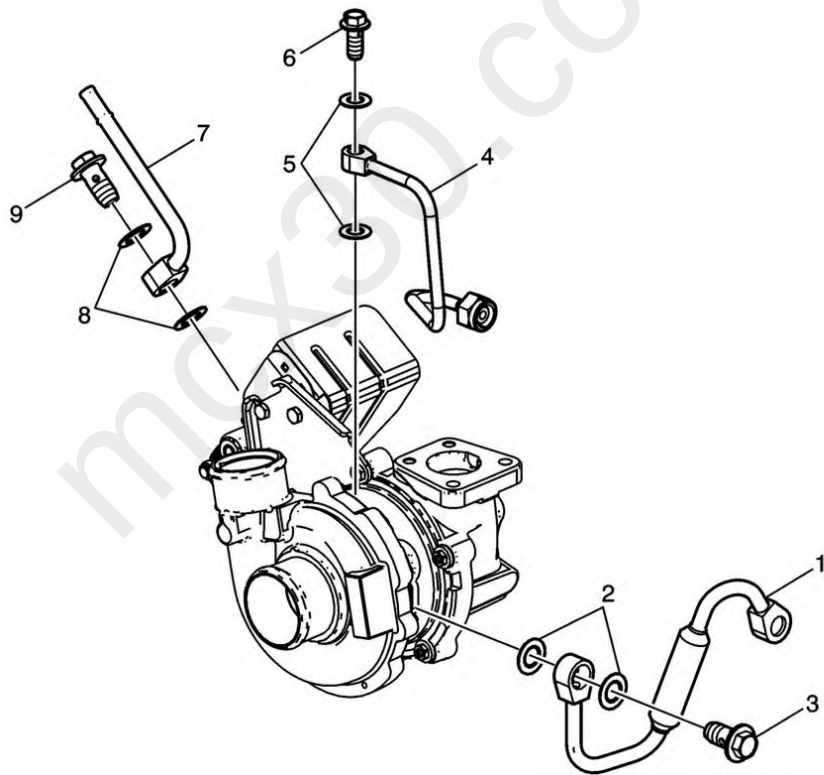


Fig. 61: Turbocharger Oil Return Pipe, Oil Feed Pipe And Coolant Return Pipe Components Location
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Turbocharger Oil Return Pipe, Oil Feed Pipe, and Coolant Return Pipe Installation

Callout	Component Name
1	Turbocharger Coolant Feed Pipe
2	Turbocharger Coolant Feed and Return Pipe Washer

Callout	Component Name
	NOTE: Use NEW gaskets.
3	Turbocharger Coolant Feed and Return Pipe Bolt CAUTION: Refer to Fastener Caution . Tighten 35 N.m (26 lb ft)
4	Turbocharger Oil Feed Pipe
5	Turbocharger Oil Feed Pipe Gasket NOTE: Use NEW gaskets.
6	Turbocharger Oil Feed Pipe Bolt Tighten 25 N.m (18 lb ft)
7	Turbocharger Coolant Return Pipe
8	Turbocharger Coolant Return Pipe Gasket NOTE: Use NEW gaskets.
9	Turbocharger Coolant Feed and Return Pipe Bolt Tighten 35 N.m (26 lb ft)

Exhaust Manifold and Turbocharger Assembly Assemble

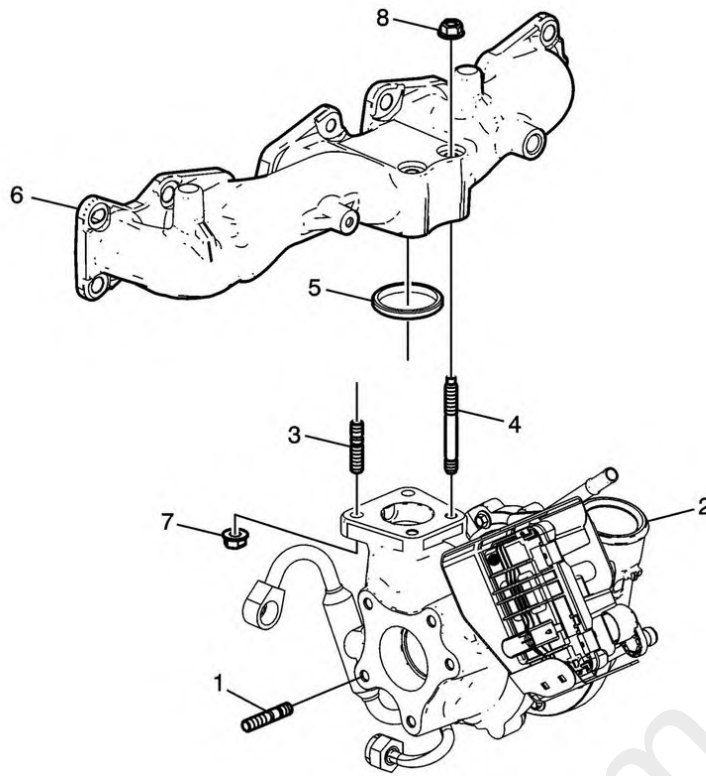


Fig. 62: Exhaust Manifold And Turbocharger Assembly Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Exhaust Manifold and Turbocharger Assembly Assemble

Callout	Component Name
1	Turbocharger Stud
2	Turbocharger NOTE: Do NOT loosen or remove actuator from the turbocharger bracket.
3	Turbocharger Stud
4	Turbocharger Stud
5	Turbocharger Gasket NOTE: Use a NEW gasket.
6	Exhaust Manifold
7	Turbocharger Nut CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Tighten 32 N.m (24 lb ft)
8	Turbocharger Nut Tighten 32 N.m (24 lb ft)

Exhaust Manifold and Turbocharger Assembly Installation

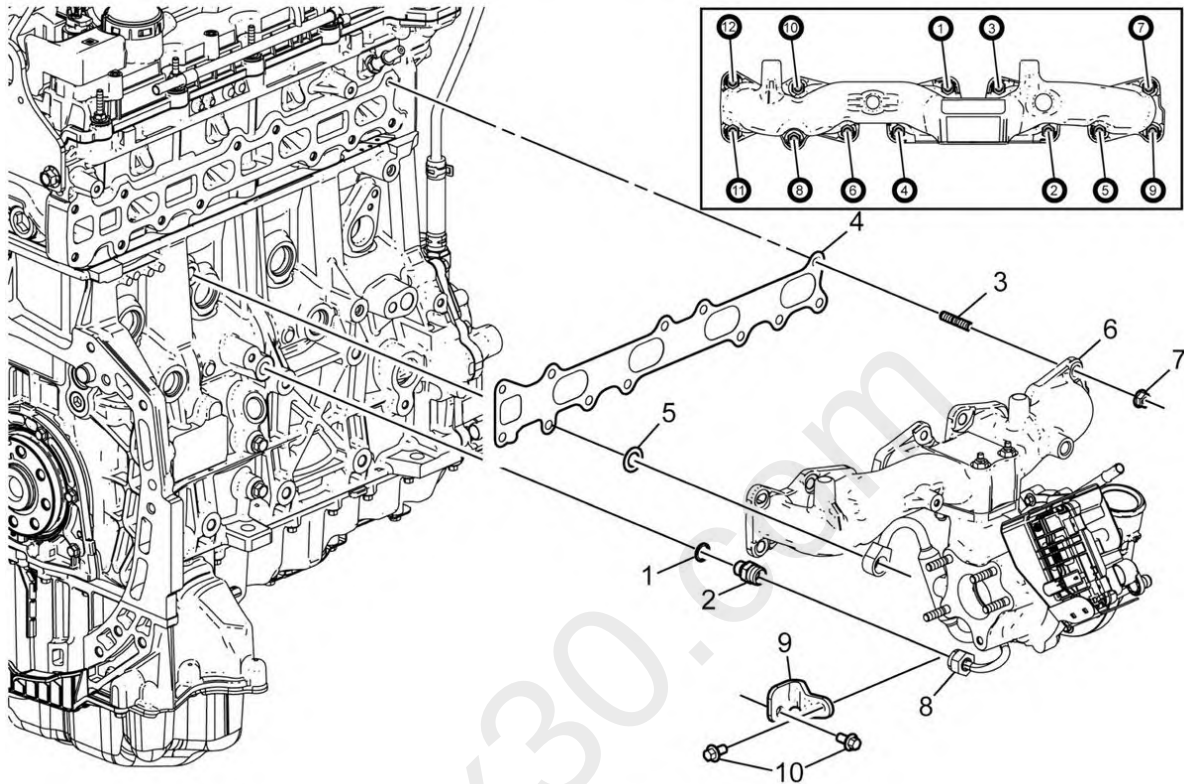


Fig. 63: Exhaust Manifold And Turbocharger Assembly Components Location

Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Exhaust Manifold and Turbocharger Assembly Installation

Callout	Component Name
1	Turbocharger Oil Feed Pipe Washer
2	Turbocharger Oil Feed Pipe Fitting Adapter CAUTION: Refer to Fastener Caution . Tighten 54 N.m (40 lb ft)
3	Exhaust Manifold Stud
4	Exhaust Manifold Gasket
	NOTE:

Callout	Component Name
	Use a NEW gasket.
5	Turbocharger Coolant Feed and Return Pipe Washer Tighten 36 N.m (27 lb ft)
6	Exhaust Manifold and Turbocharger Assembly
7	Exhaust Manifold Nut Tighten 1. First pass at 12 N.m (106 lb in) 2. Final pass at 32 N.m (24 lb ft)
8	Turbocharger Oil Feed Pipe Fitting Tighten 32 N.m (24 lb ft)
9	Turbocharger Brace
10	Turbocharger Brace Bolt Tighten 32 N.m (24 lb ft)

Exhaust Manifold Heat Shield and Turbocharger Oil Return Pipe Installation

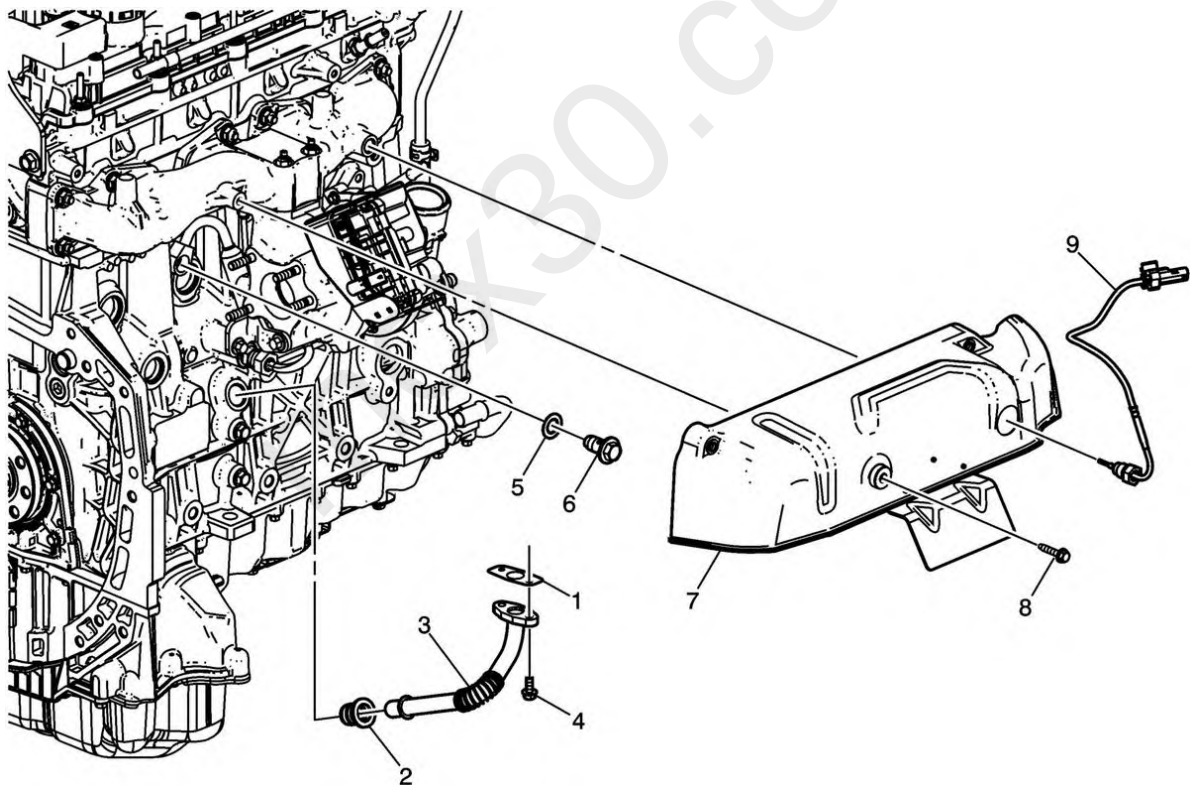


Fig. 64: Exhaust Manifold Heat Shield And Turbocharger Oil Return Pipe Components Location
Courtesy of GENERAL MOTORS COMPANY

Exhaust Manifold Heat Shield and Turbocharger Oil Return Pipe Installation

Callout	Component Name
1	Turbocharger Oil Return Pipe Gasket

Callout	Component Name
	NOTE: Use a NEW gasket.
2	Turbocharger Tube Seal NOTE: Use a NEW seal.
3	Turbocharger Oil Return Pipe
4	Turbocharger Oil Return Pipe Bolt CAUTION: Refer to <u>Fastener</u> <u>Caution</u> . Tighten 10 N.m (89 lb in)
5	Turbocharger Coolant Feed and Return Pipe Washer NOTE: Use a NEW washer.
6	Turbocharger Coolant Feed and Return Pipe Bolt Tighten 35 N.m (26 lb ft)
7	Exhaust Manifold Heat Shield
8	Exhaust Manifold Heat Shield Bolt Tighten 10 N.m (89 lb in)
9	Exhaust Gas Recirculation Cooler Temperature Sensor Tighten 45 N.m (33 lb ft)

WATER PUMP INSTALLATION

Water Pump Installation

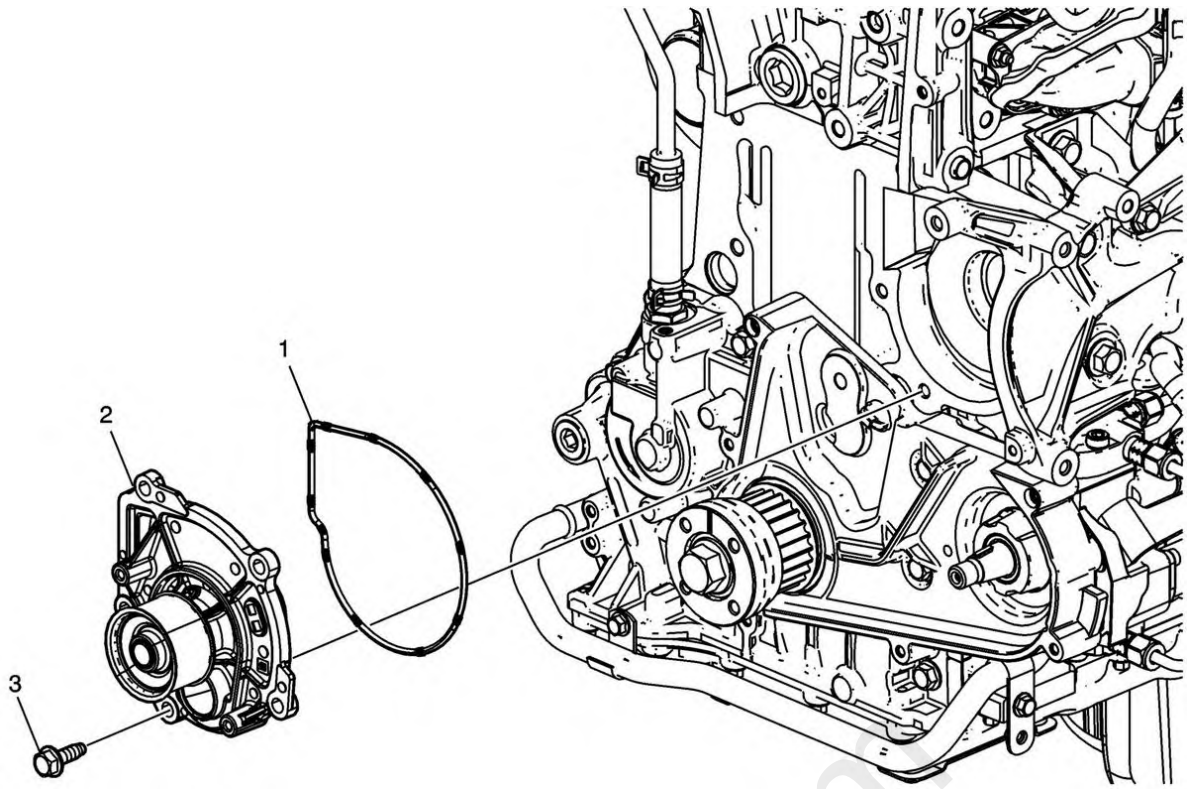


Fig. 65: Water Pump Components Location
 Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

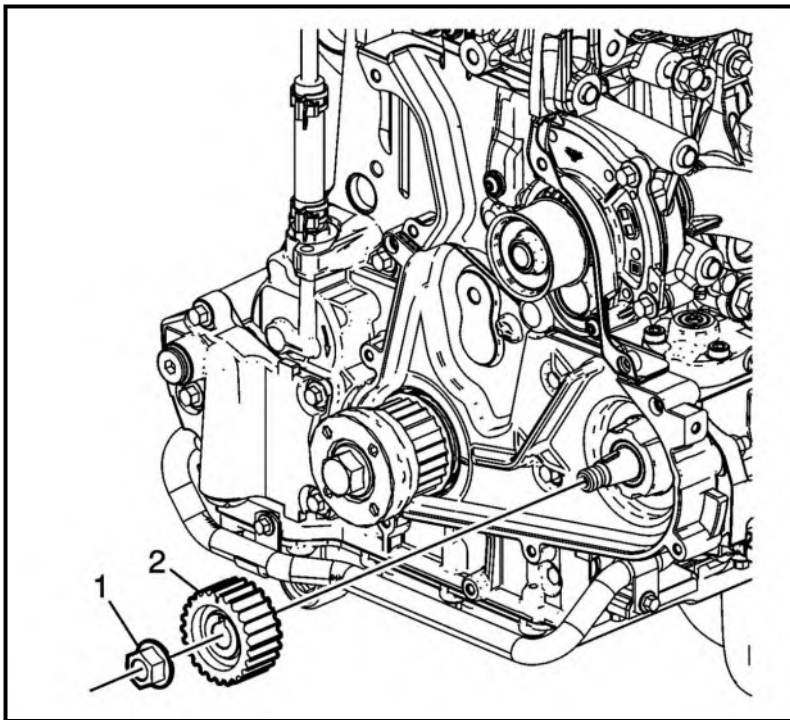
Callout	Component Name
1	Water Pump Gasket NOTE: Use a NEW gasket.
2	Water Pump
3	Water Pump Bolt CAUTION: Refer to Fastener Caution . Tighten 32 N.m (24 lb ft)

FUEL INJECTION PUMP DRIVE PULLEY INSTALLATION

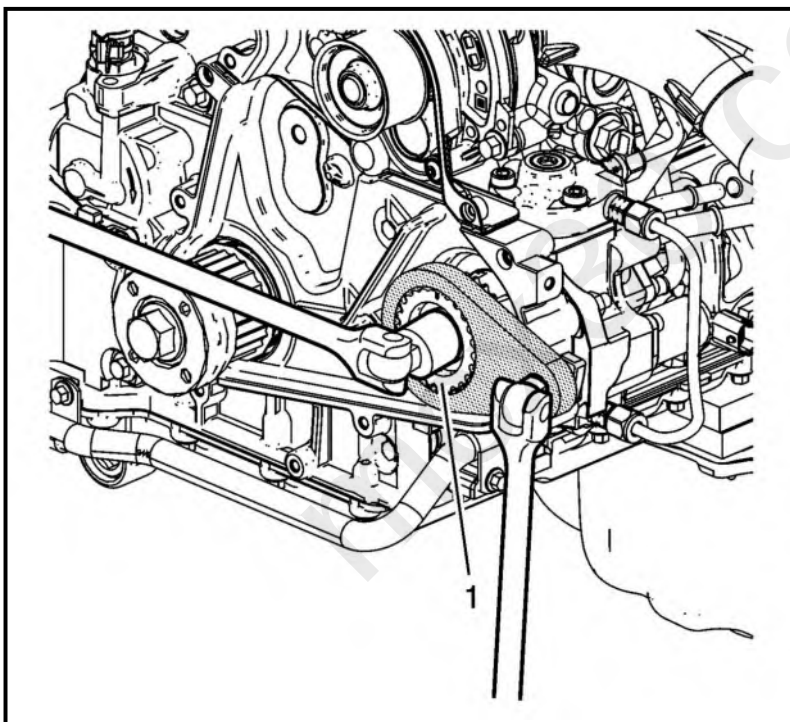
Special Tools

EN-51104 Injection Pump Sprocket Holder

1. Install the fuel injection pump drive pulley (2) and nut (1).



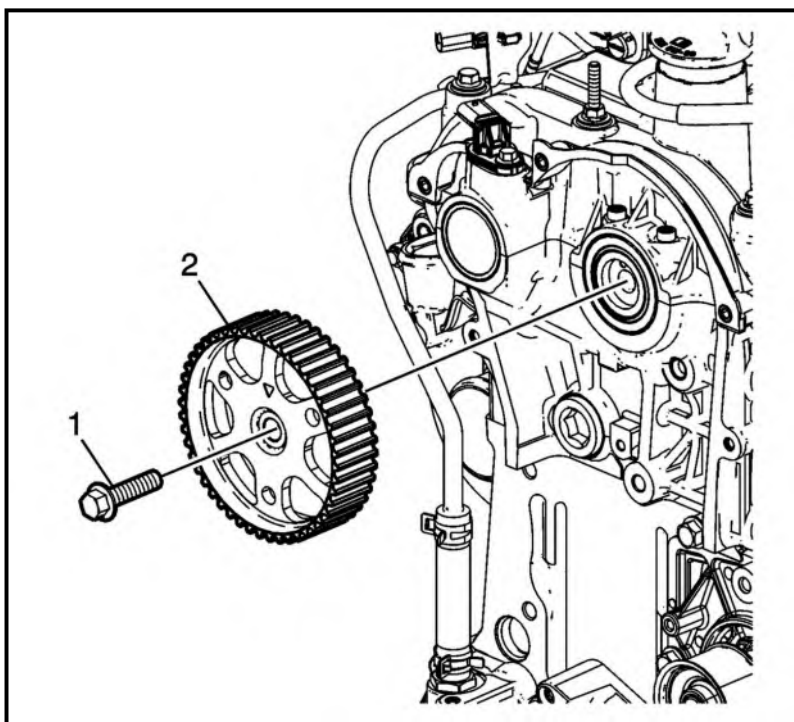
2. Hold the fuel injection pump drive pulley (1) with the **EN-51104** holder and tighten the retaining nut to 88 N.m (65 lb ft).



CAUTION: Refer to **Fastener Caution** .

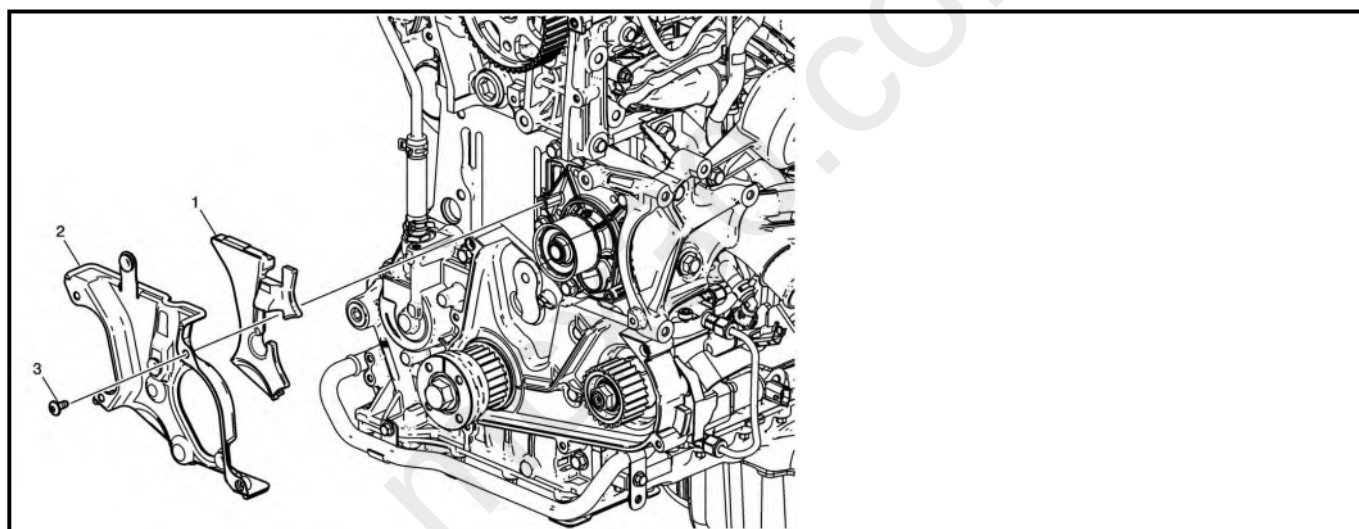
CAMSHAFT TIMING PULLEY INSTALLATION

1. Install the camshaft timing pulley (2) and bolt (1).



2. Tighten, but do not torque, bolt. Refer to [Timing Belt Installation](#) for final torque specification.

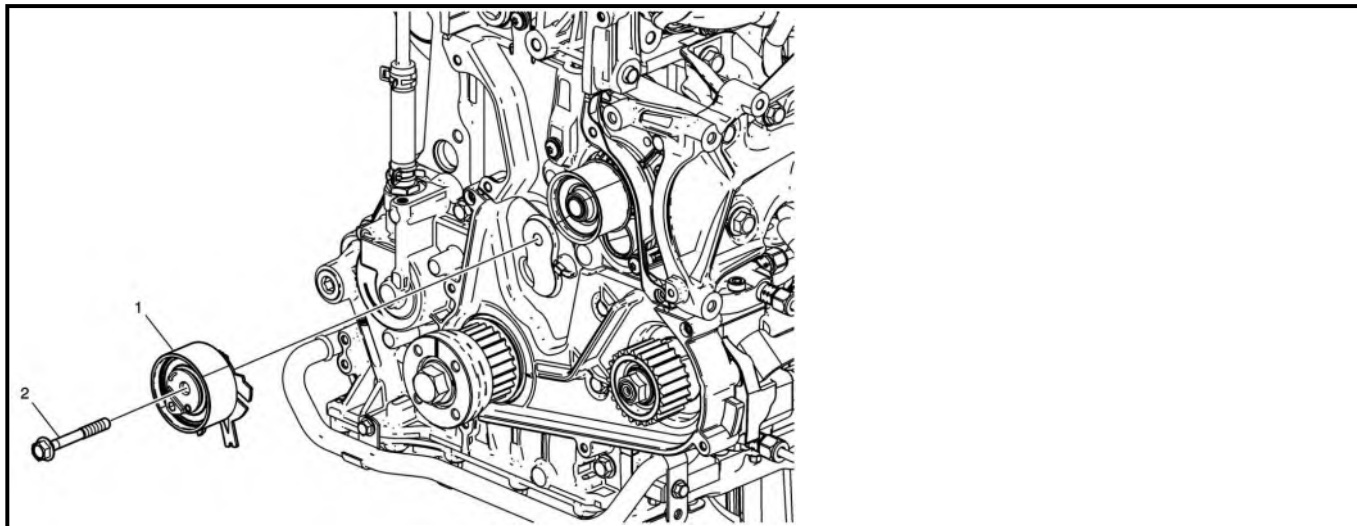
TIMING BELT REAR COVER INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Rear Cover Gasket
2	Timing Belt Rear Cover
3	Timing Belt Rear Cover Bolt CAUTION: Refer to Fastener Caution . Tighten 11 N.m (97 lb in)

TIMING BELT TENSIONER INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Timing Belt Tensioner
2	Timing Belt Tensioner Bolt
	NOTE: Install the bolt finger tight.

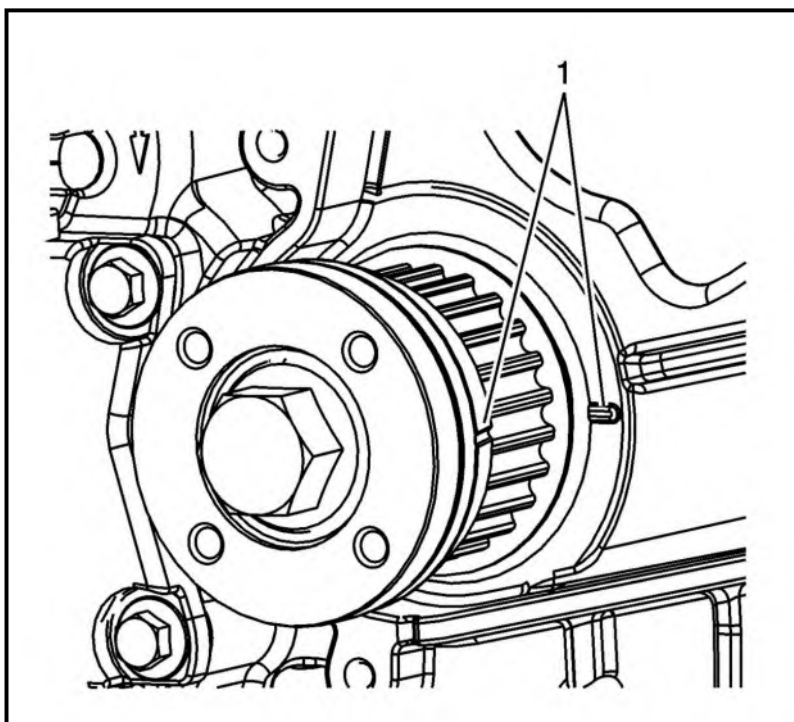
TIMING BELT INSTALLATION

Special Tools

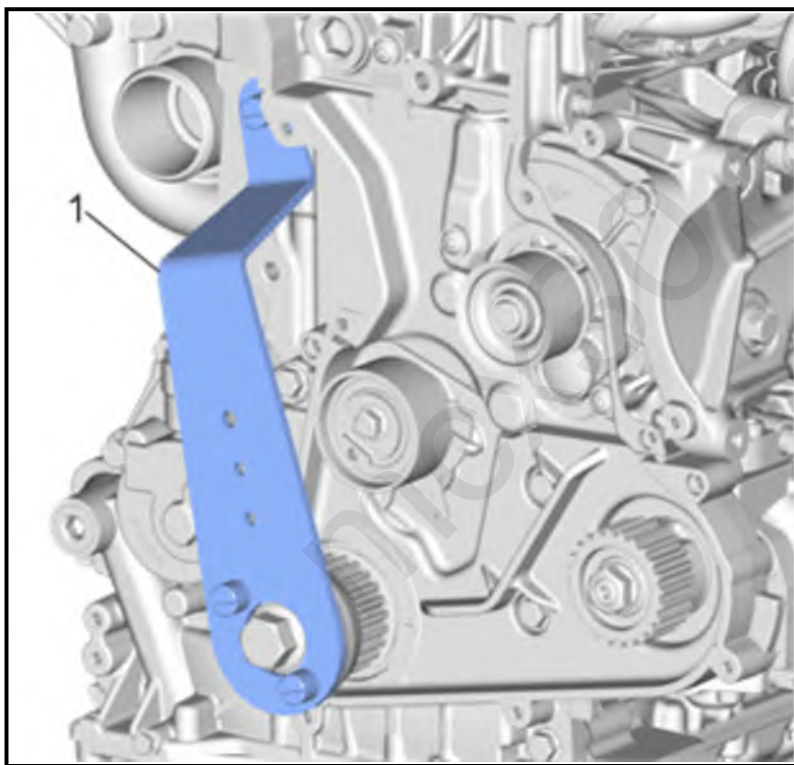
- EN-50025 Pulley Holding Wrench
- EN-51265 Crankshaft Locking Tool
- EN-51025 Camshaft Timing Tool

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

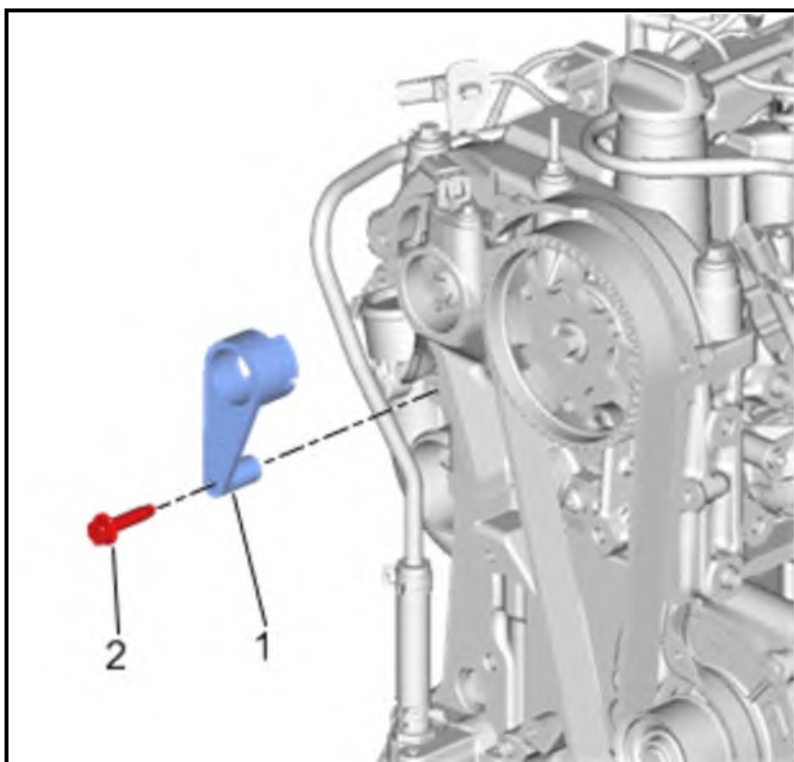
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees ATDC with the mark on the front cover (1).



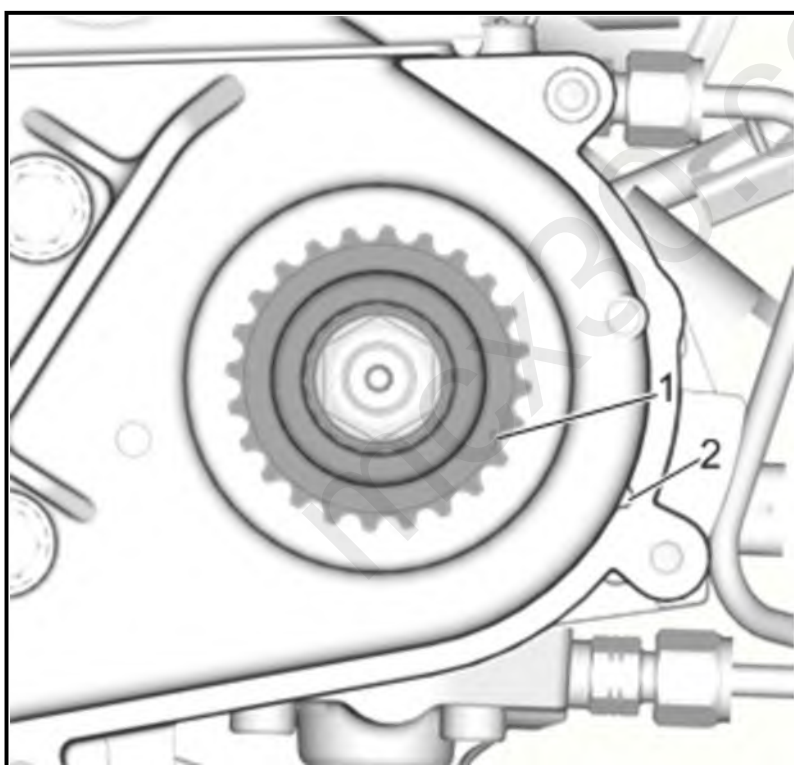
2. Install **EN-51265** locking tool (1).



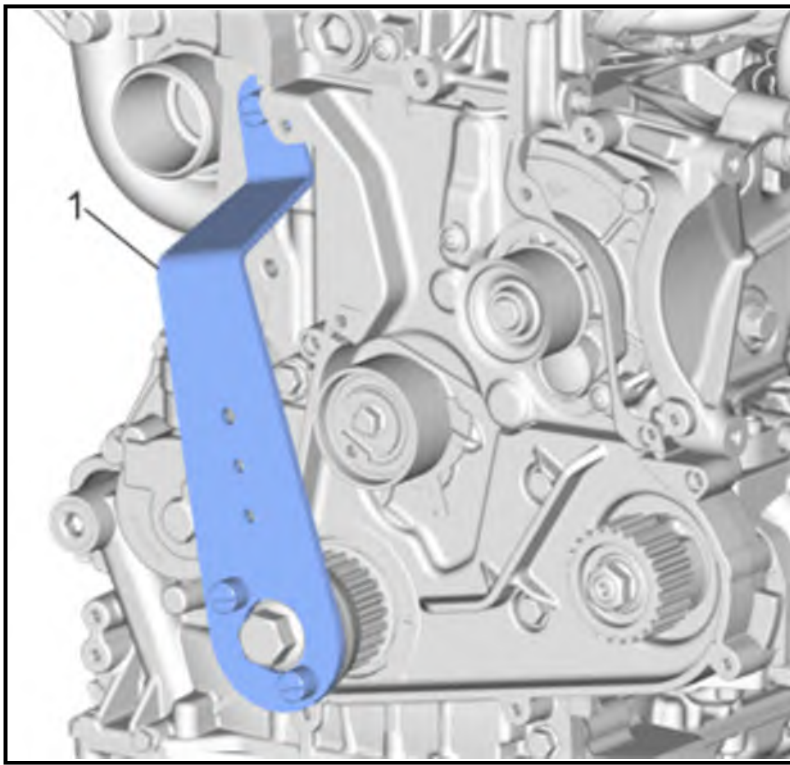
3. Install **EN-51025** timing tool (1) on the exhaust camshaft.



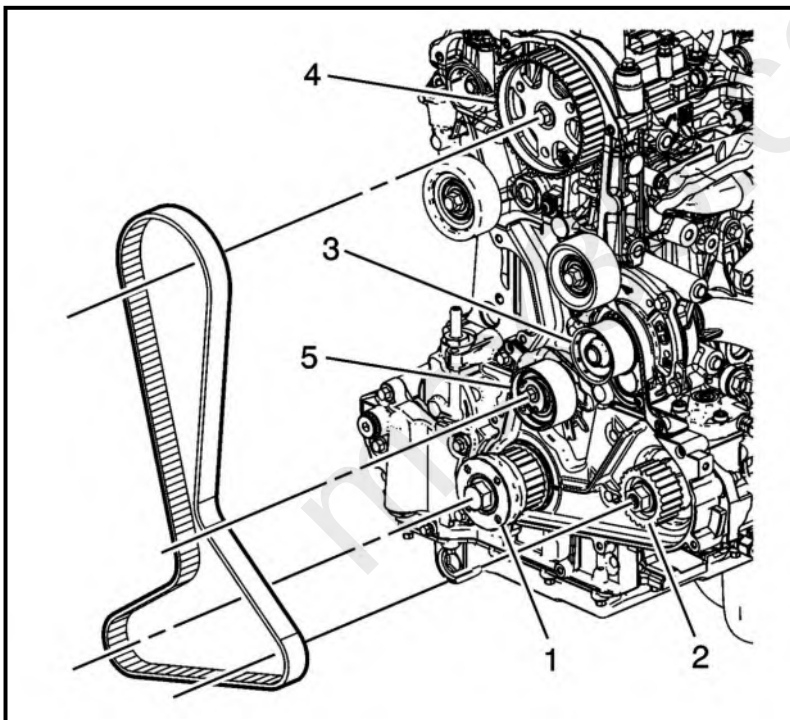
4. Align the fuel injection pump pulley timing notch (1) with the notch on the front cover (2).



5. Remove **EN-51265** locking tool (1).



6. Install the timing belt over the pulleys in the following order:

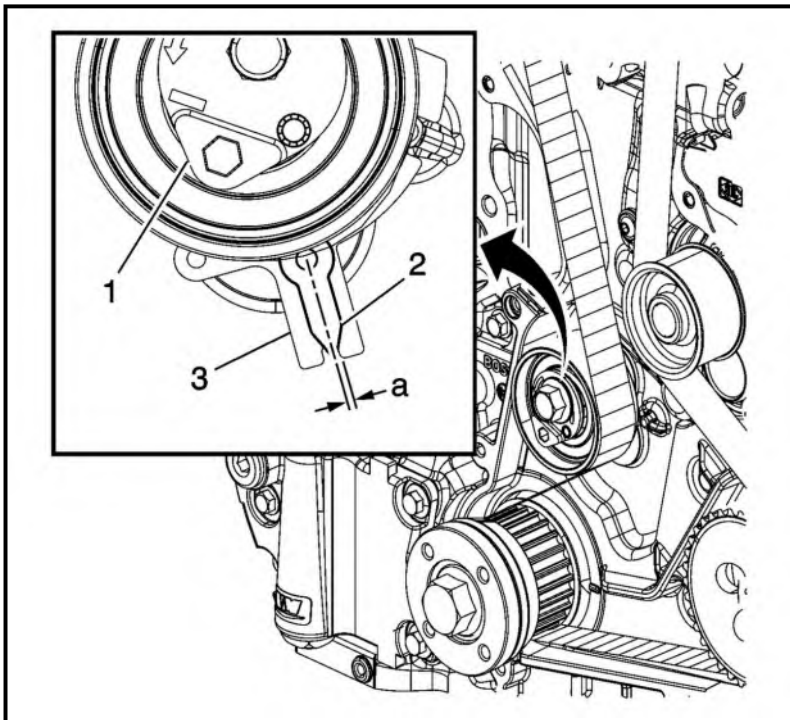


NOTE:

- Relieve the tensioner in order to fit the belt over the pulleys.
- The Intake Camshaft Pulley must be loose in order to install the timing belt, otherwise it will not fit over the tensioner pulley.

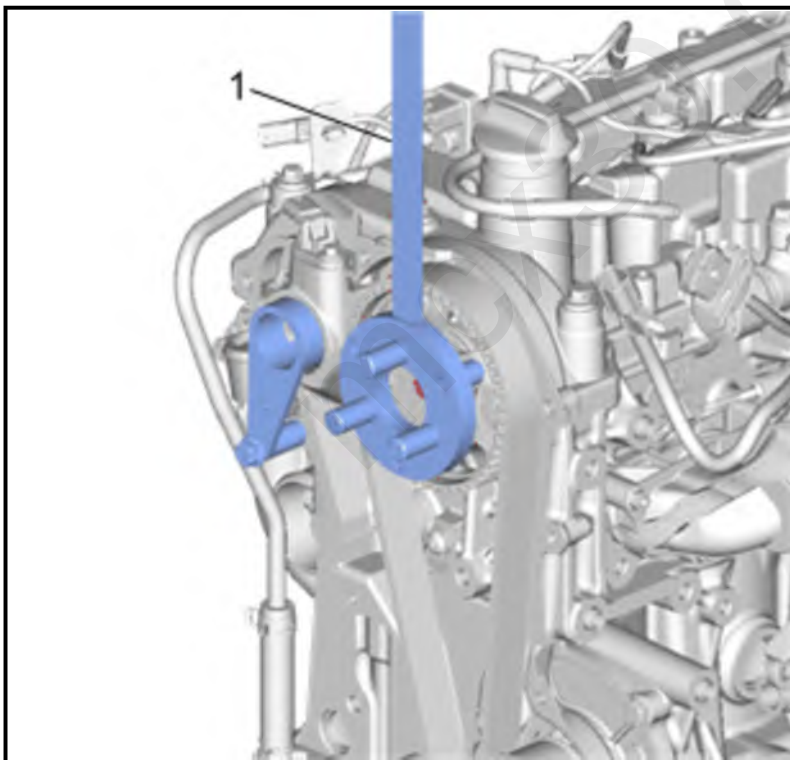
1. Crankshaft
2. Injector pump
3. Water pump
4. Camshaft
5. Tensioner

7. Move the tensioner pulley by rotating the plate (1) counterclockwise until the pointer (2) is positioned in the groove at the edge of the index (3), within 1 mm, dimension (a).



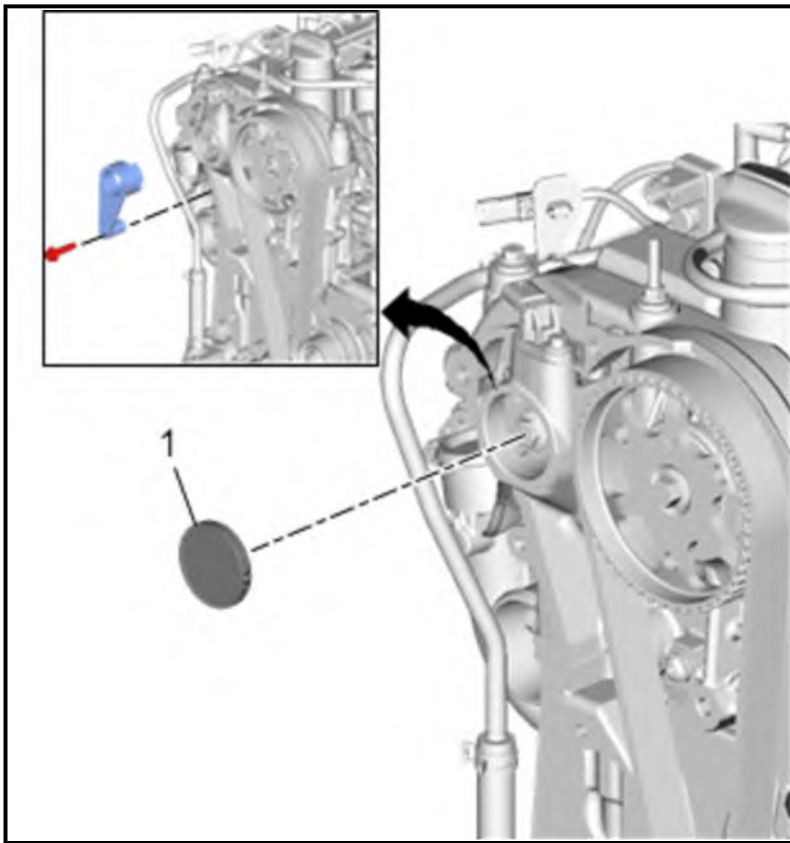
CAUTION: Refer to [Fastener Caution](#) .

8. Tighten the timing belt tensioner to 28 N.m (21 lb ft).
9. Hold the camshaft timing pulley with the **EN-50025** wrench (1) and tighten the retaining bolt.



NOTE: **EN-51025** holding tool is not designed for tightening applications. Always use **EN-50025** wrench when tightening the pulley bolt.

1. Tighten the bolt a first pass to 20 N.m (15 lb ft).
 2. Tighten the bolt a final pass an additional 60 degrees.
10. Remove the **EN-51025** timing tool.



11. Rotate the engine two full revolutions to ensure proper alignment of timing marks.

NOTE: Ensure the plug is fully seated in the bore.

12. install the NEW camshaft plug (1).

TIMING BELT FRONT COVER INSTALLATION

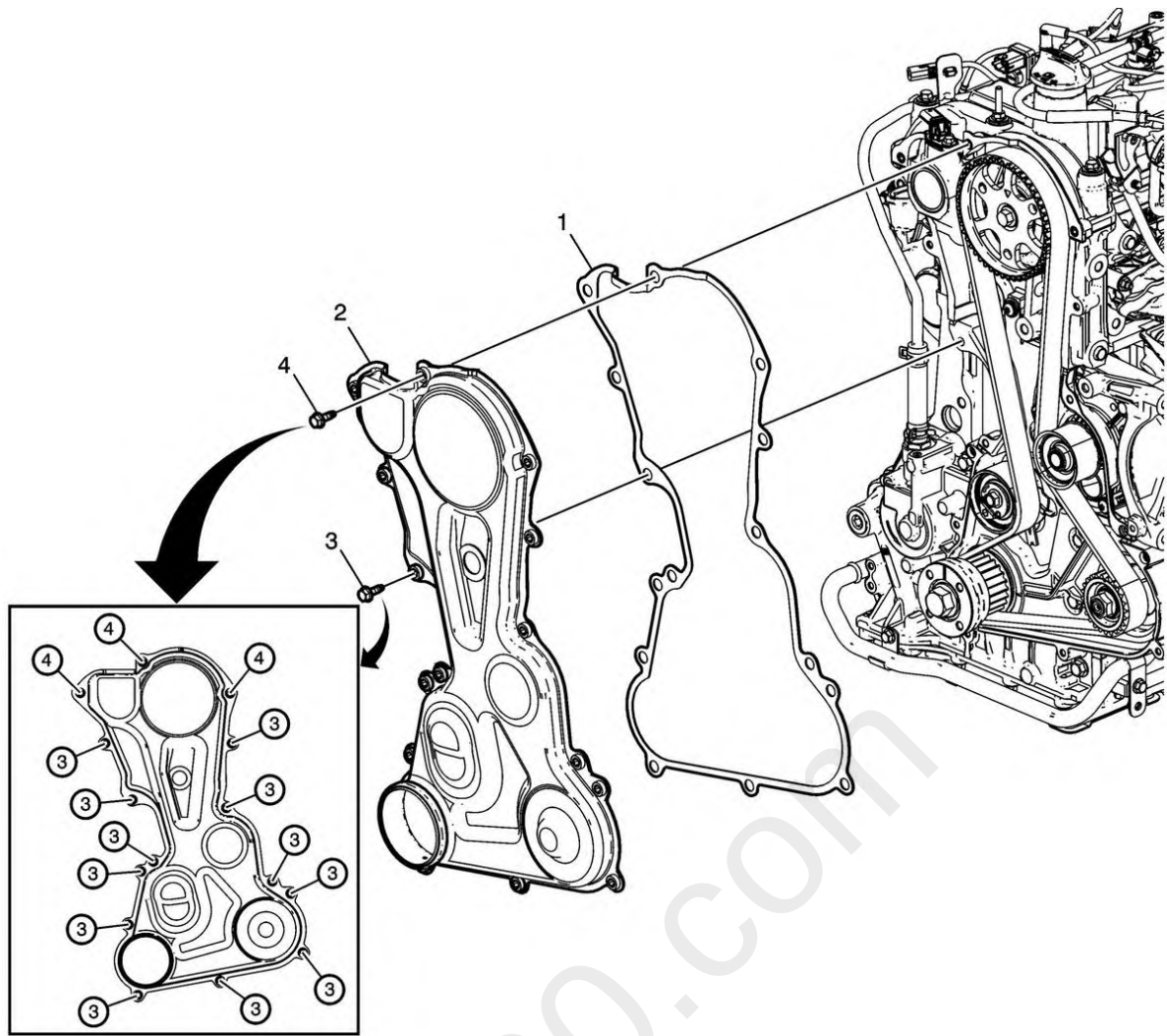


Fig. 66: Timing Belt Front Cover Components Location

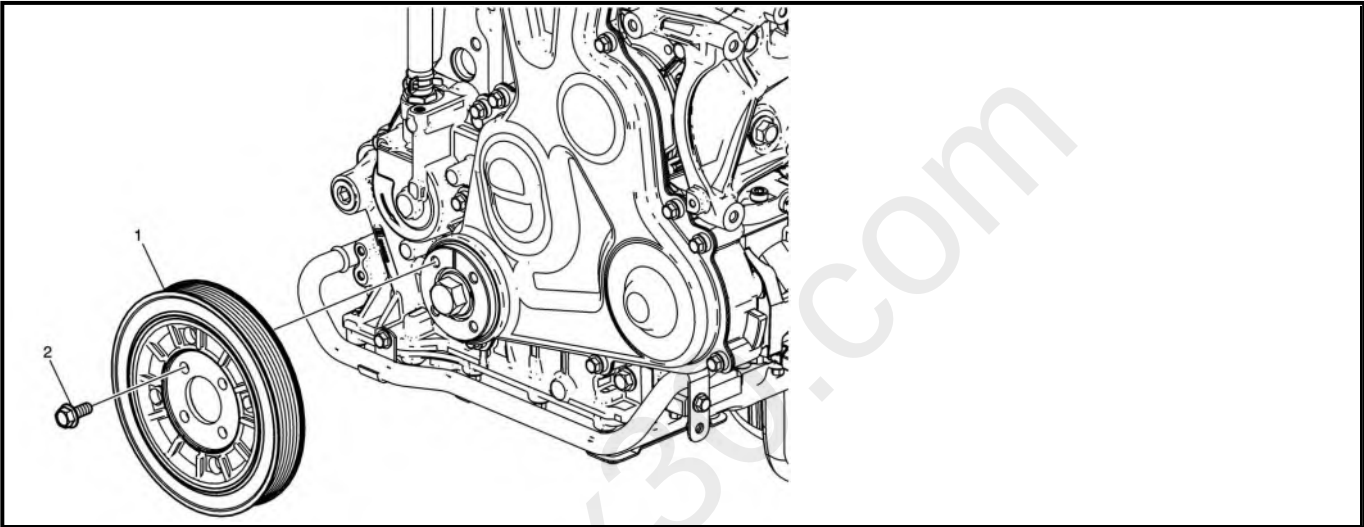
Courtesy of GENERAL MOTORS COMPANY

NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Engine Front Cover Gasket NOTE: Use a NEW gasket.
2	Timing Belt Front Cover
3	Timing Belt Front Cover Bolt Procedure 1. Install and hand tighten bolts. 2. Use a 0.01 mm feeler gauge around crank sprocket to ensure timing belt front cover is not contacting crank sprocket. 3. Tighten to specification as shown. CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Tighten 10 N.m (89 lb in)
4	Timing Belt Front Cover Bolt CAUTION: Refer to Fastener Caution . Tighten 8 N.m (89 lb in)

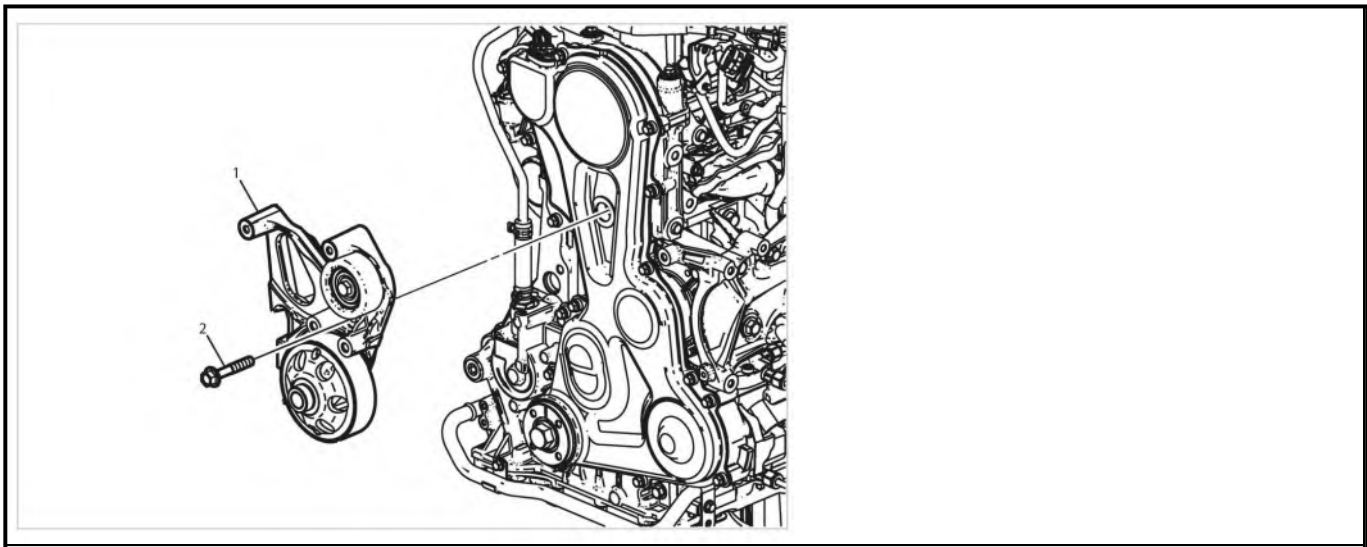
CRANKSHAFT BALANCER INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Crankshaft Pulley
2	Crankshaft Pulley Bolt CAUTION: Refer to Fastener Caution . Tighten 32 N.m (23 lb ft)

ENGINE COOLING FAN BRACKET INSTALLATION

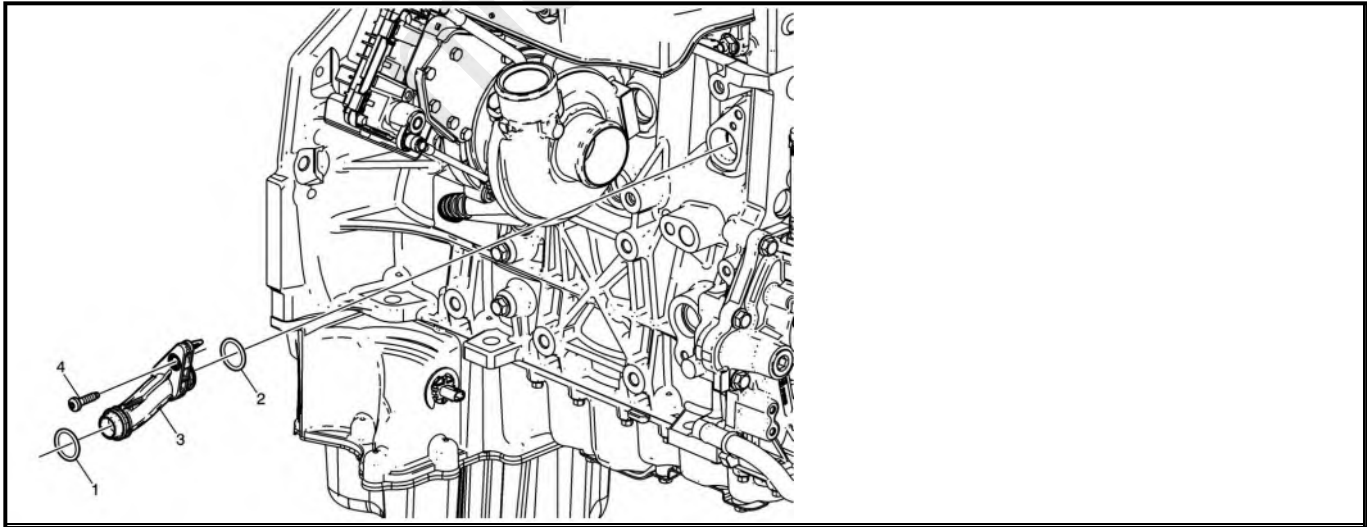


NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Engine Coolant Fan Bracket
2	Engine Coolant Fan Bracket Bolt CAUTION: Refer to Fastener Caution . Tighten 45 N.m (33 lb ft)

ENGINE OIL COOLER INSTALLATION

Oil Filter Adapter Pipe Installation



NOTE: Callouts in the following chart represent components shown in graphic above.

Oil Filter Adapter Pipe Installation

Callout	Component Name
1	Oil Filter Adapter Seal

Callout	Component Name
	NOTE: Use a NEW seal.
2	Oil Filter Adapter Seal NOTE: Use a NEW seal.
3	Oil Filter Adapter Pipe
4	Oil Filter Adapter Bolt CAUTION: Refer to Fastener Caution . Tighten 10 N.m (89 lb in)

Engine Oil Cooler and Coolant Hose Installation

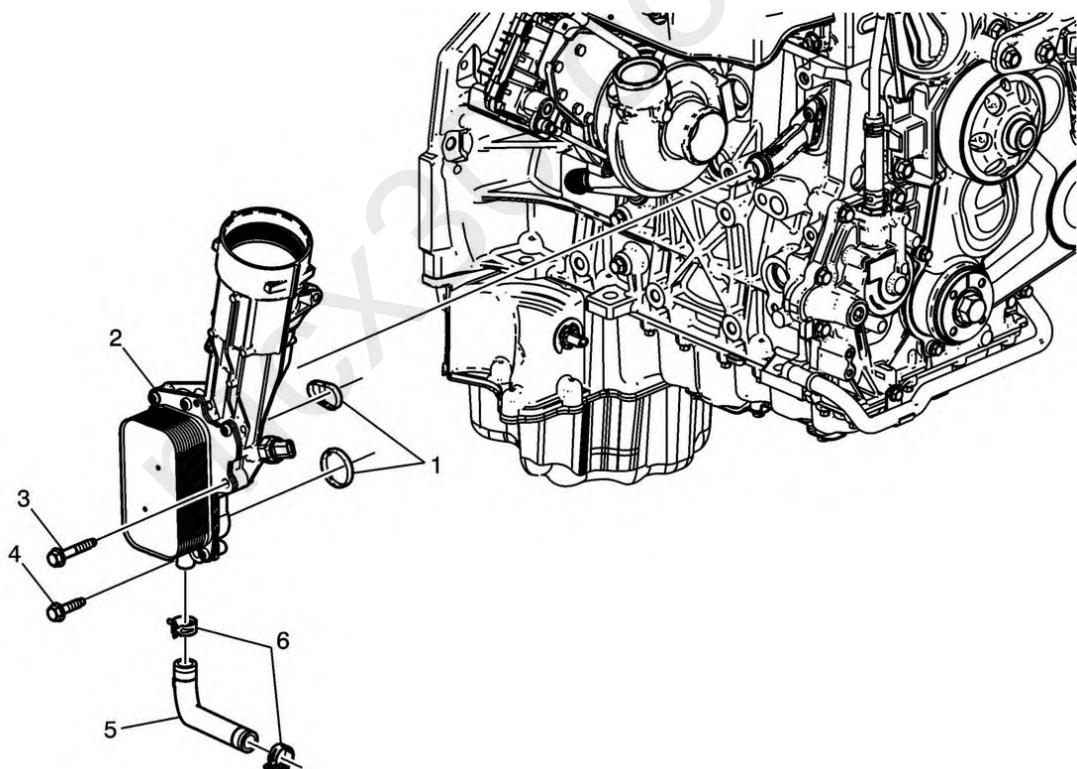


Fig. 67: Engine Oil Cooler And Coolant Hose Components Location

Courtesy of GENERAL MOTORS COMPANY

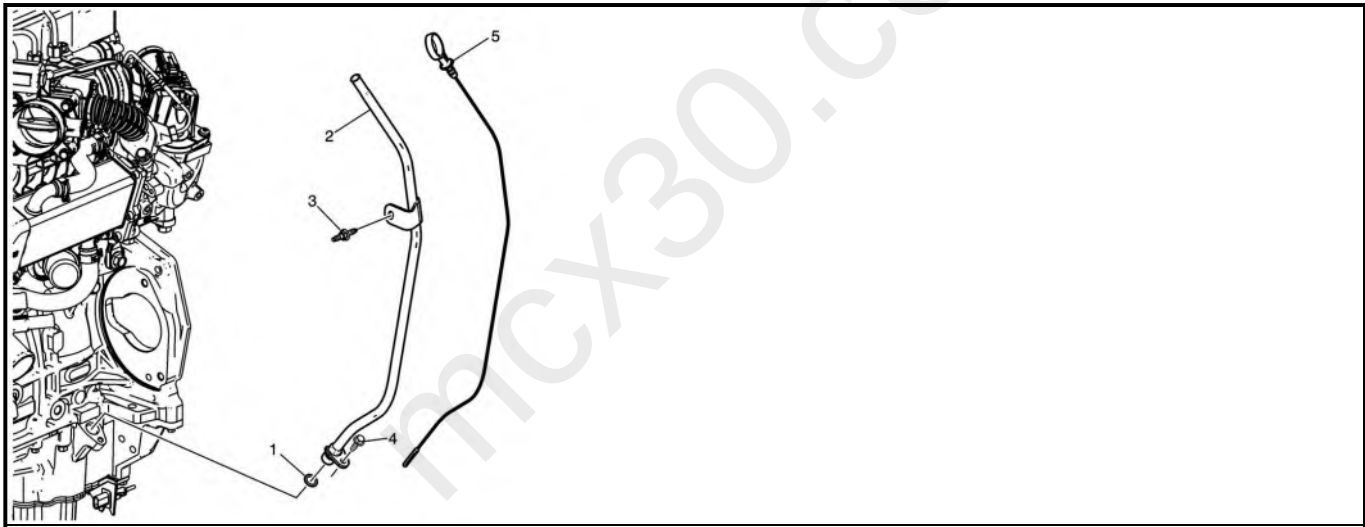
NOTE: Callouts in the following chart represent components shown in graphic above.

Engine Oil Cooler and Coolant Hose Installation

Callout	Component Name
1	Oil Filter Gasket NOTE:

Callout	Component Name
	Install NEW gaskets. They are not reusable.
2	Engine Oil Cooler
3	Engine Oil Cooler Bolt CAUTION: Refer to Fastener Caution . Tighten 25 N.m (18 lb ft)
4	Engine Oil Cooler Bolt Tighten 25 N.m (18 lb ft)
5	Engine Oil Cooler Inlet Hose
6	Engine Oil Cooler Inlet Hose Clamp

OIL LEVEL INDICATOR AND TUBE INSTALLATION



NOTE: Callouts in the following chart represent components shown in graphic above.

Callout	Component Name
1	Oil Level Indicator Tube Seal NOTE: Use a NEW seal.
2	Oil Level Indicator Tube
3	Oil Level Indicator Tube Stud CAUTION: Refer to Fastener Caution .

Callout	Component Name
	Tighten 11 N.m (97 lb in)
4	Oil Level Indicator Tube Bolt Tighten 11 N.m (97 lb in)
5	Oil Level Indicator

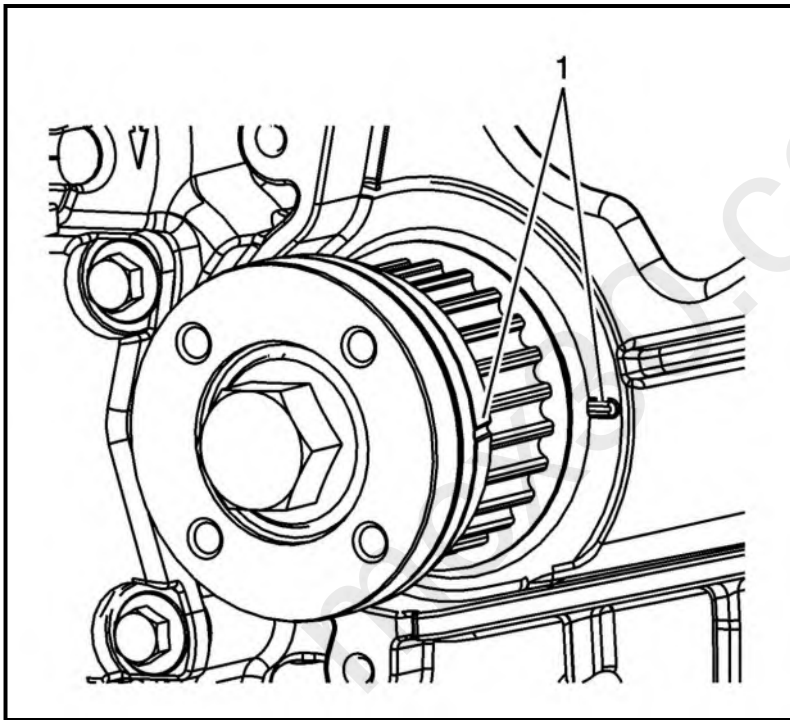
AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

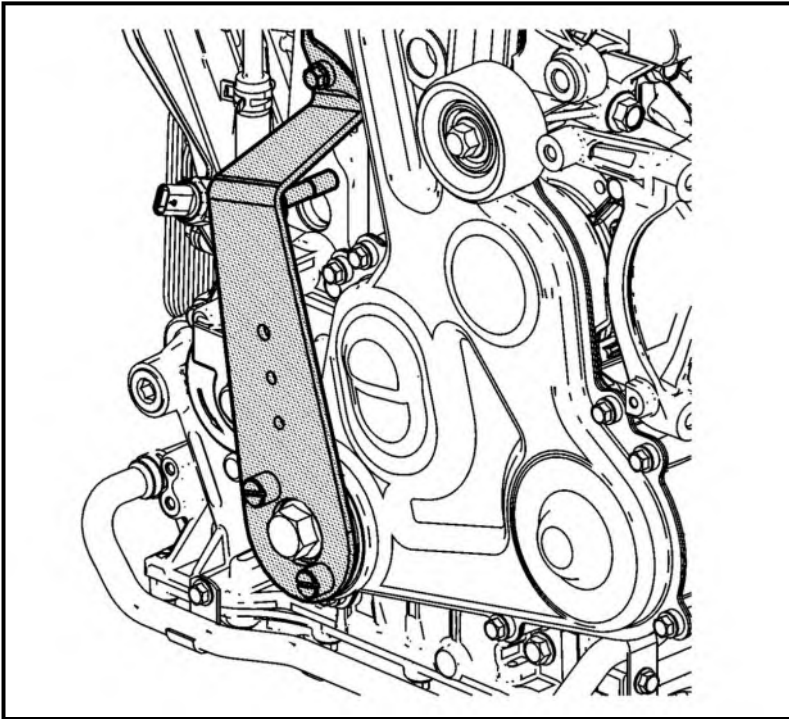
EN-51265 Crankshaft Locking Tool

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

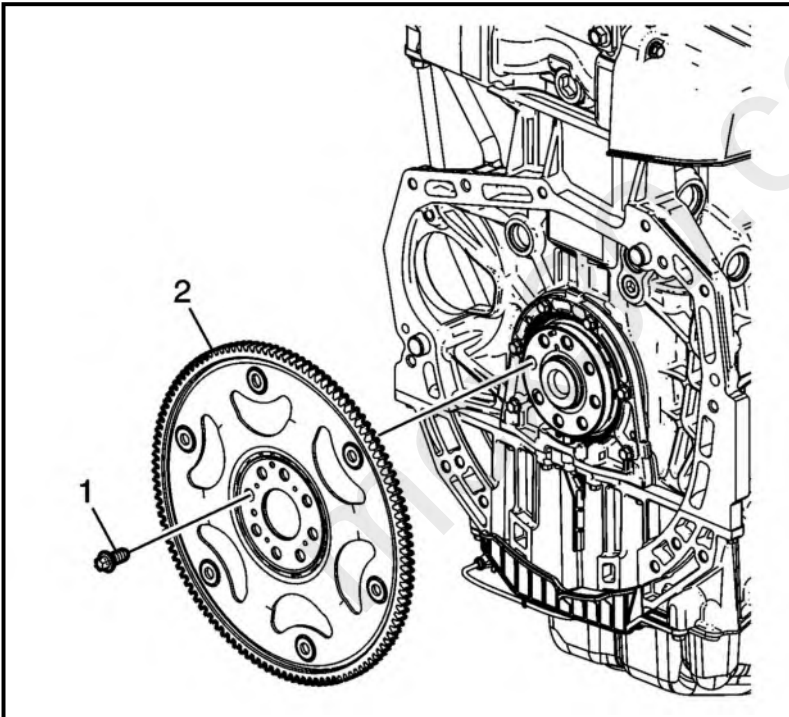
1. Ensure that the timing mark on the crankshaft timing pulley (1) is aligned at 90 degrees ATDC with the mark on the front cover (1).



2. Install the **EN-51265** locking tool.



3. Install the flex plate (2).



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 flex plate bolts (1) and hand tighten.

5. Tighten the NEW bolts in sequence to 50 N.m (37 lb ft).

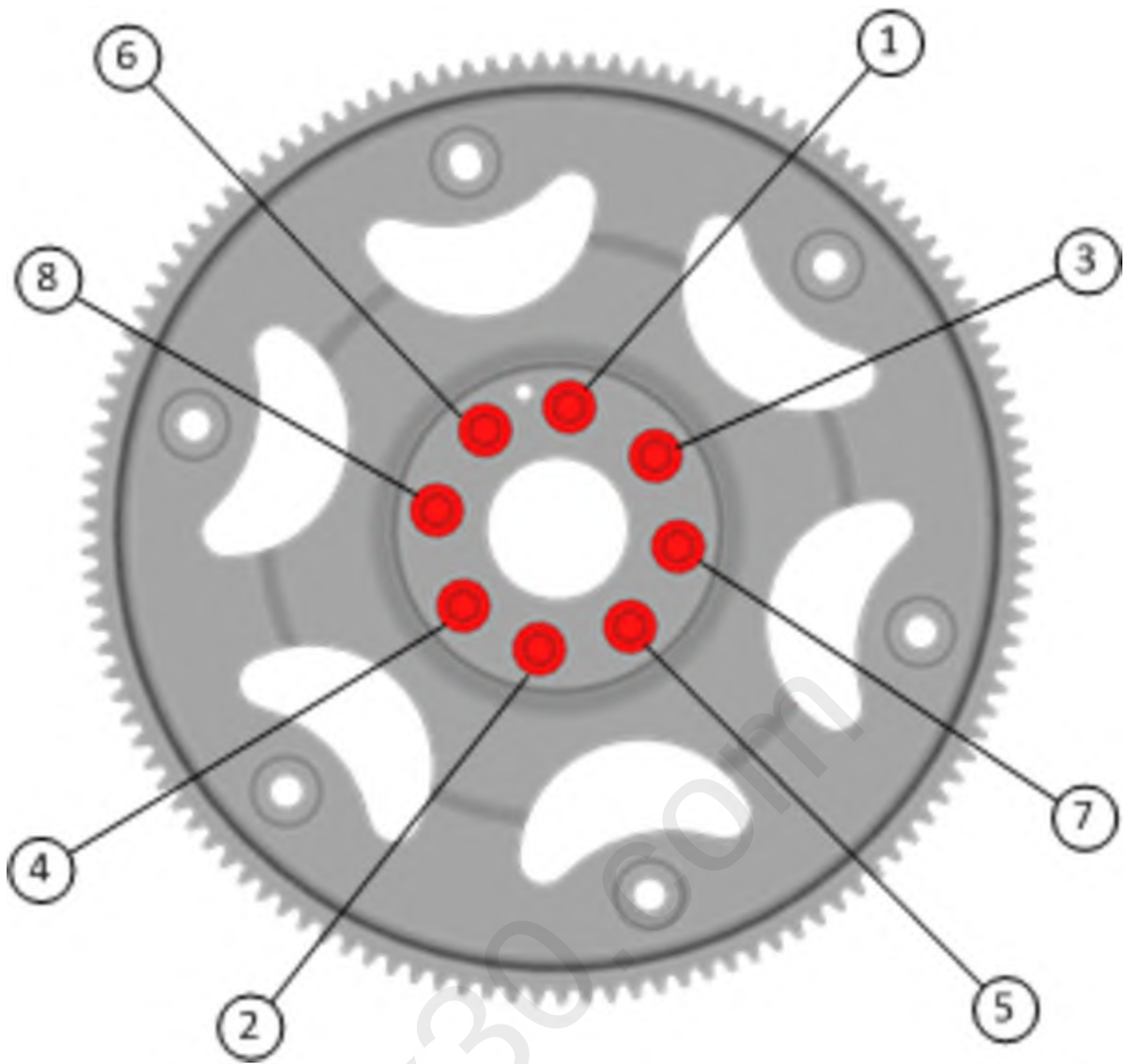
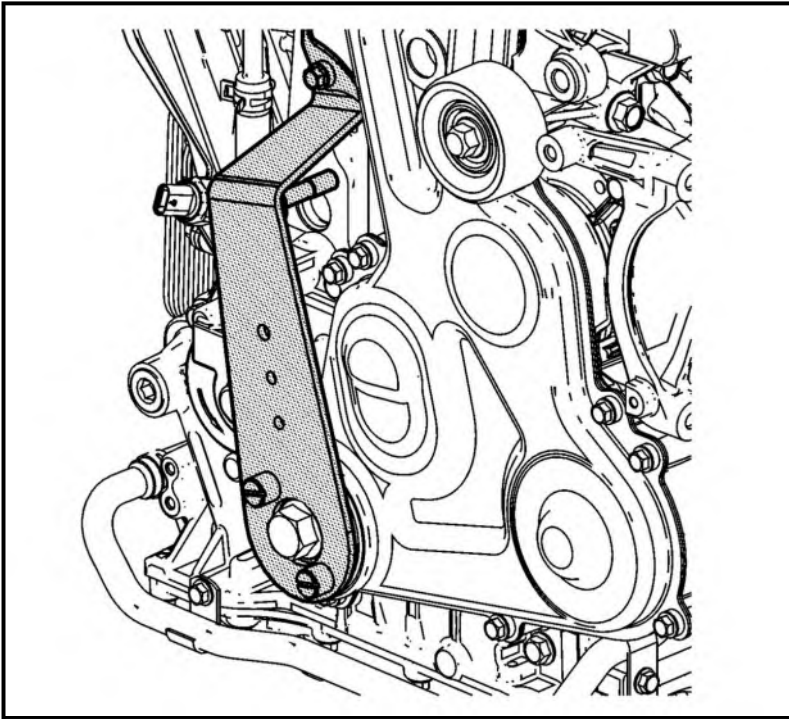


Fig. 68: Automatic Transmission Flex Plate Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to **Fastener Caution** .

6. Loosen the flex plate bolts 90 degrees.
7. Tighten the NEW flex plate bolts in sequence to 25 N.m (18 lb ft).
8. Tighten additional 60 degrees.
9. After each bolt is tightened, mark the head with a dot of brown paint as evidence of correct tightening.
10. Remove the **EN-51265** locking tool.



ENGINE PRELUBING

Special Tools

J 45299 Engine Preluber

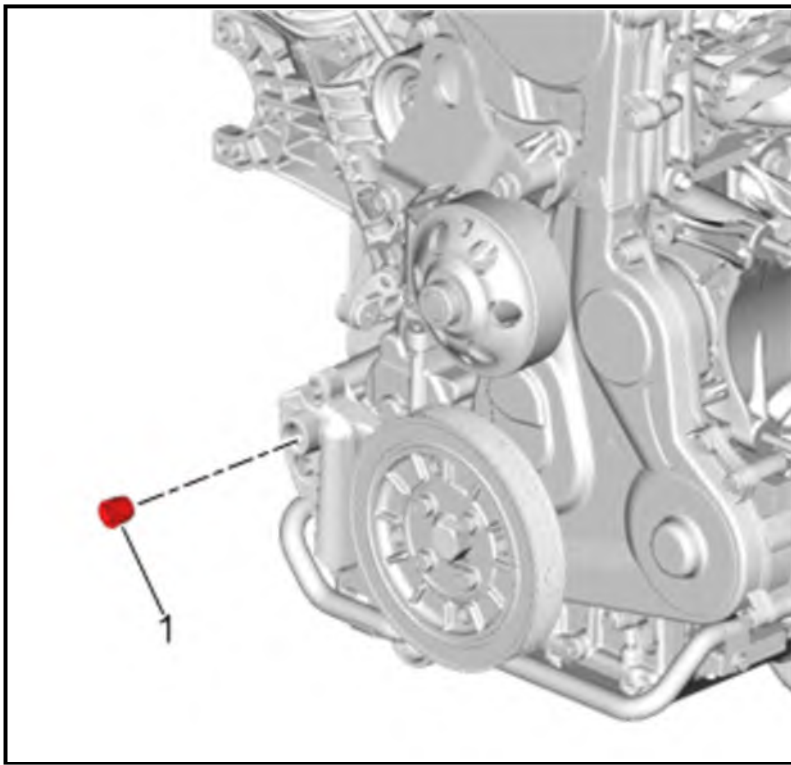
CAUTION: If any malfunction is experienced which may cause debris to enter the oil supply, you must replace the engine oil cooler and hoses if equipped. Debris in the engine oil cooler and oil cooler hoses may be pulled back into the engine causing severe engine damage.

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

NOTE:

- A constant/continuous flow of clean engine oil is required to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.
- Filter must be fitted in housing before filling with oil.

1. Remove the engine oil filter cap, and refit the oil filter back into the filter housing. Fill the filter housing with clean engine oil, and reinstall. Tighten the oil filter cap to 24 N.m (18 lb ft).
2. Remove the engine front cover hole plug (1).

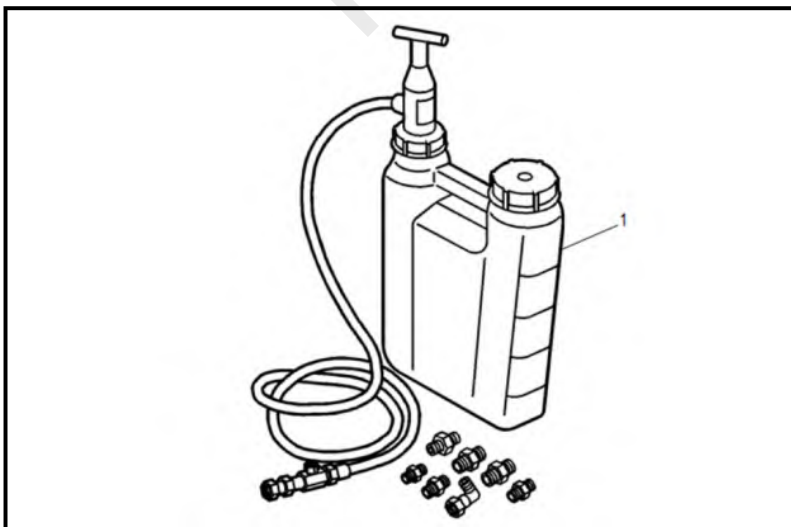


NOTE: This should be done anytime the engine sits for an extended period of time.

3. Fill the plug orifice with engine oil until level with bottom of plug hole. [Adhesives, Fluids, Lubricants, and Sealers](#)
4. Ensure proper use of room temperature vulcanizing (RTV) sealant. [Use of Room Temperature Vulcanizing \(RTV\) and Anaerobic Sealant](#)
5. Apply sealant to the oil pump cover bypass hole plug, refer to [Adhesives, Fluids, Lubricants, and Sealers](#).

Install the engine front cover hole plug (1) and tighten to 40 N.m (30 lb ft).

6. Remove the oil pressure sensor.
7. Install the M12 x 1.75 adapter P/N 509376.
8. Install the flexible hose to the adapter and open the valve.



9. Pump the handle on **J 45299** preluber to flow a minimum of 1 - 2 quarts of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
10. Close the valve and remove the flexible hose and adapter from the engine.

11. Install the oil pressure sensor and tighten to 14 N.m (124 lb in).
12. Top off the engine oil to the proper level.
13. Once engine is installed into vehicle, perform these steps:
 1. Ensure the vehicle battery has a full charge.
 2. When starting the car after priming, it is forbidden to crank engine if it does not start suddenly; in this case would be better to check the oil pump pre-lubing (repeat the prelubing procedure).
 3. Once engine has started, bring the engine speed to 1500 RPM instead of idling, in order to facilitate lubrication of camshaft bearings.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

A spring loaded membrane located in the tower of the camshaft cover maintains crankcase pressure. A baffle plate in the camshaft cover provides for oil separation from the crankcase gases. Crankcase gases are routed back to the air intake system.

Because of the use of a closed crankcase ventilation system, it is normal for slight oil residue to be found in the charge air and intake system.

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is grey cast iron with 4 cylinders arranged in-line. It is a deep skirt block with 2 bolt main bearing caps. There are 5 crankshaft bearings with the thrust bearing located at the third main bearing cap.

Crankshaft

The crankshaft is made from forged alloy steel. The rod and main journals are induction hardened for increased durability. A balance shaft drive gear is located at the rear of the crankshaft. The crankshaft position sensor exciter ring is sandwiched between the crankshaft and the flexplate/flywheel.

Connecting Rod and Piston

The connecting rods are forged steel and are fractured split. The piston pins are full floating. The pistons are made from aluminum alloy and have a graphite coated skirt.

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 (2.8L)

The balance shaft assembly is bolted to the bottom of the cylinder block. It is driven from a gear at the rear of the crankshaft. The balance shaft must be timed correctly to the crankshaft.

Cylinder Head

The cylinder head is made from aluminum alloy. Sintered powdered metal valve seats and valve guides are pressed into the cylinder head.

Valvetrain

The valvetrain is a belt driven overhead cam design. A belt drives the sprocket on the intake camshaft. The intake camshaft drives the exhaust camshaft through gears pressed onto each camshaft.

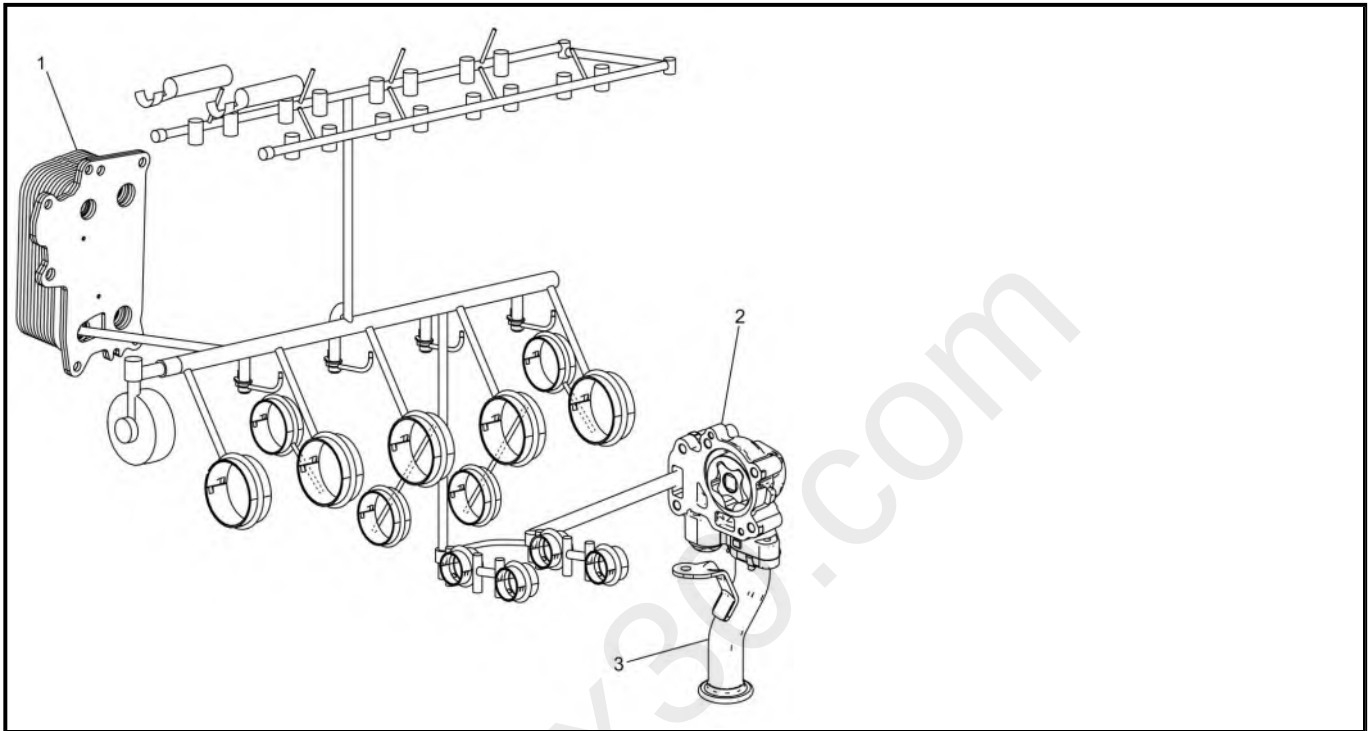
Valves

There are 2 intake and 2 exhaust valves per cylinder. Rotators are used on all of the intake valves. The rotators are located at the bottom of the valve spring to reduce valve train reciprocating mass. Positive valve stem seals are used on all valves.

Valve Lifters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

LUBRICATION DESCRIPTION



The gerotor style oil pump (2) is attached to the balancer assembly and is gear driven by the crankshaft. The oil pump draws oil through the suction pipe (3) and provides pressurized oil to the engine oil filter/cooler assembly (1) through a passage in the block. A pressure relief valve is mounted to the front cover. An oil filter bypass valve is located under the oil filter cap and opens at 1.5 bar. An anti-drainback valve is located at the oil inlet from the block. Cooled and filtered oil exits the oil filter/cooler assembly (2) and enters the main oil galley in the block. Branches from the main oil galley feed the following components:

- Cylinder head
 - Cam bearings
- Piston oil jets, opening pressure 1.5 bar
- Main bearings
 - Crankshaft
 - Connecting rod bearings
- Vacuum pump
- Balance shaft (2.8L)
- Turbocharger

Oil drainback passages on both sides of the cylinder head and block return oil to the pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. It should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice, even if not specifically stated.

Apply a liberal coating of engine oil to the friction areas during assembly. Use an engine preluber prior to the initial engine start after major engine repair. This will help protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

CAUTION: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.

When components are removed for service, they should be marked, organized or retained in a specific order for assembly. [Separating Parts](#)

At the time of installation, components should be installed in the same location and with the same mating surface as when removed.

Follow the fastener torque values and torque sequence as noted in the repair. Replace fasteners called out in the procedures to be discarded.

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

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to [Battery Negative Cable Disconnection and Connection](#) .

SEPARATING PARTS

NOTE: 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 reinstallation 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 lifters
- Valve lifters, guides, pushrods, pivot supports and rocker arms

- 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
- Coolant hose to pipe orientation / alignment to attaching components.
- Timing chains to timing sprocket for camshaft actuator repair / replacement

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- 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 specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

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 18B°C (65B°F) degrees or higher.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

CAUTION: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

NOTE: The bead size is critical and is easier to maintain consistency and application with a RTV dispensing tool. This also helps to eliminate waste.

- The surfaces to be sealed must be clean and dry.

- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

NOTE: Do not wait for the RTV sealant to skin over.

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- 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

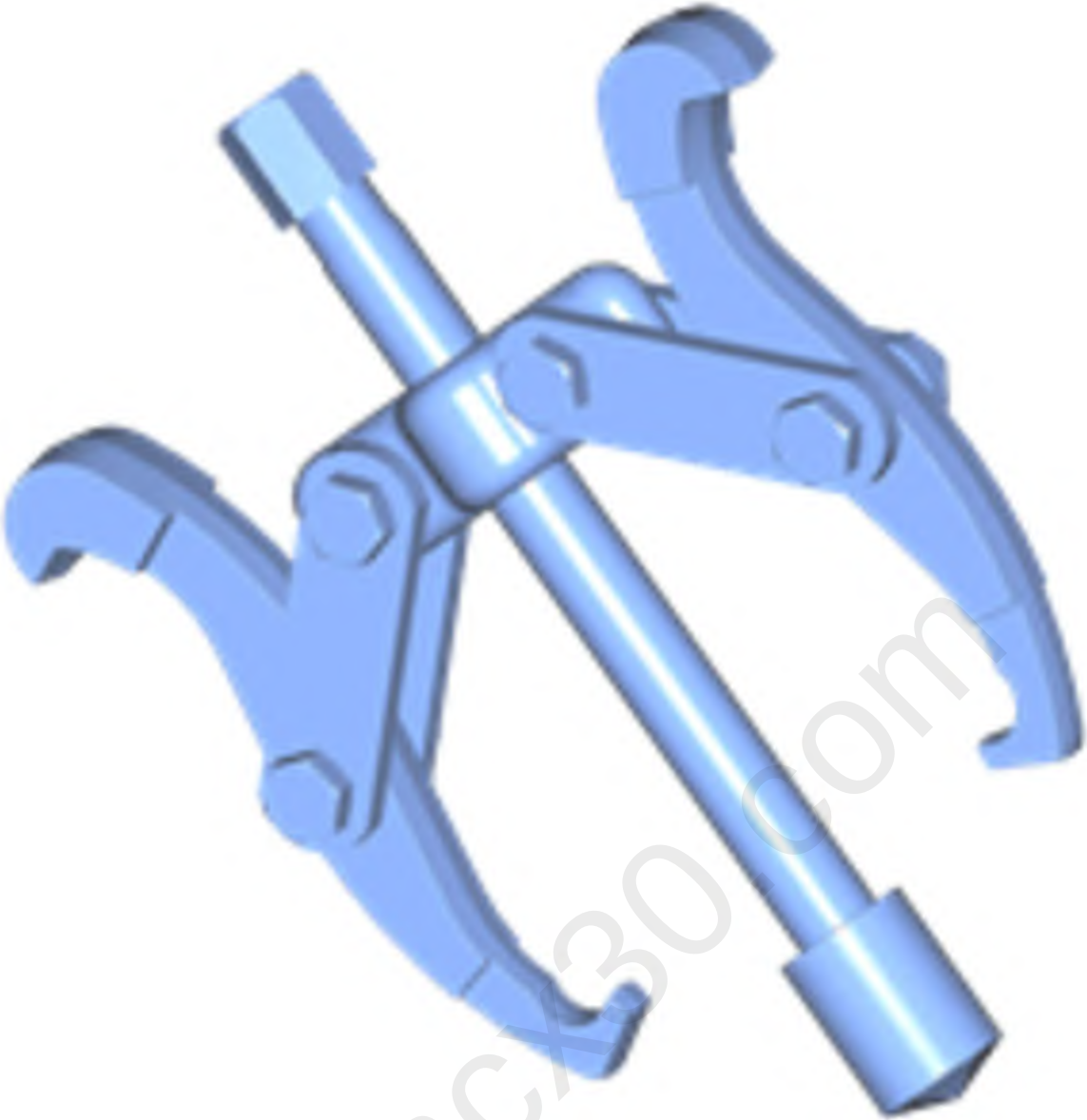
Illustration	Tool Number/ Description
	DT-22888 - 20A J-22888 - 20A K-161 A V-9304220 Universal Two Jaw Puller

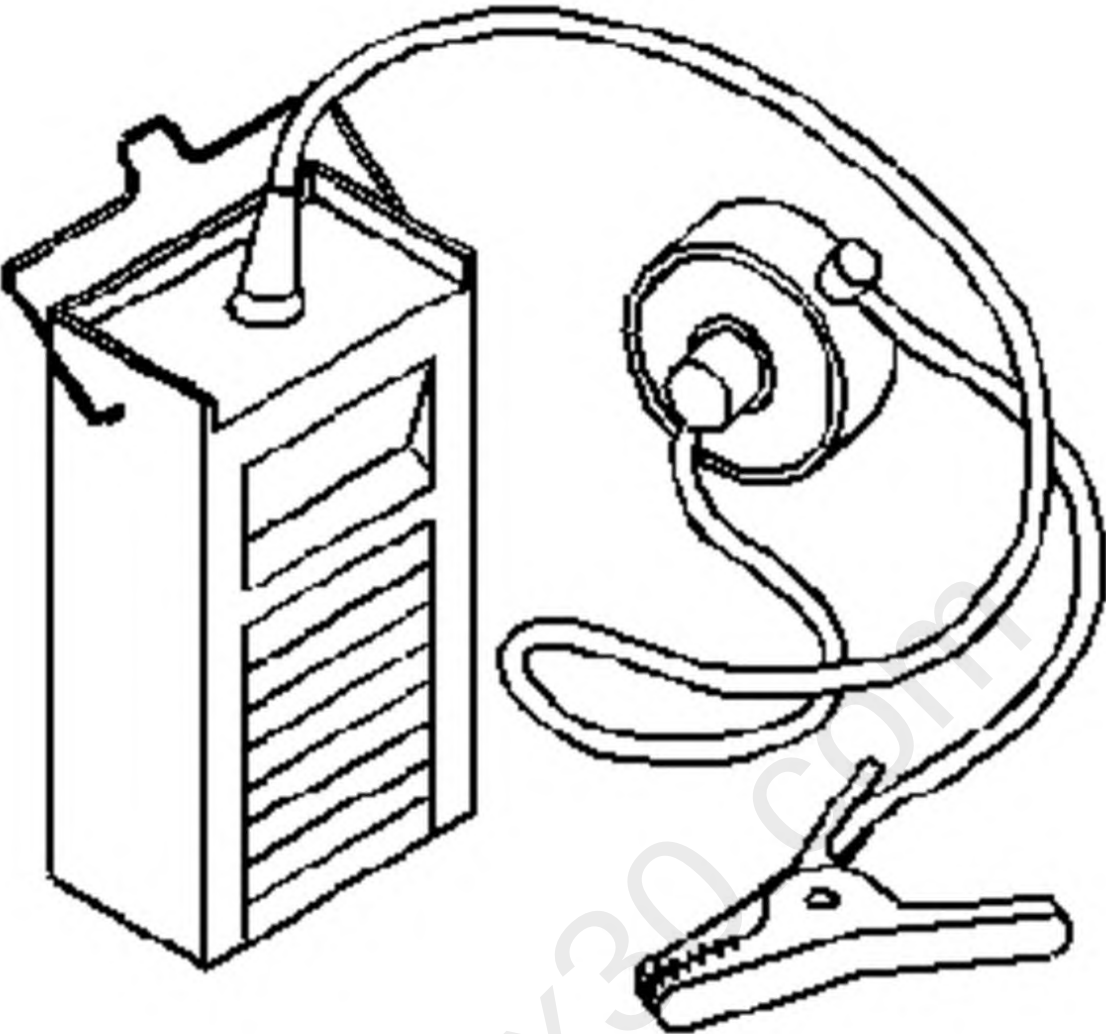
Illustration	Tool Number/ Description
	EN-8037 J-8037 Ring Compressor

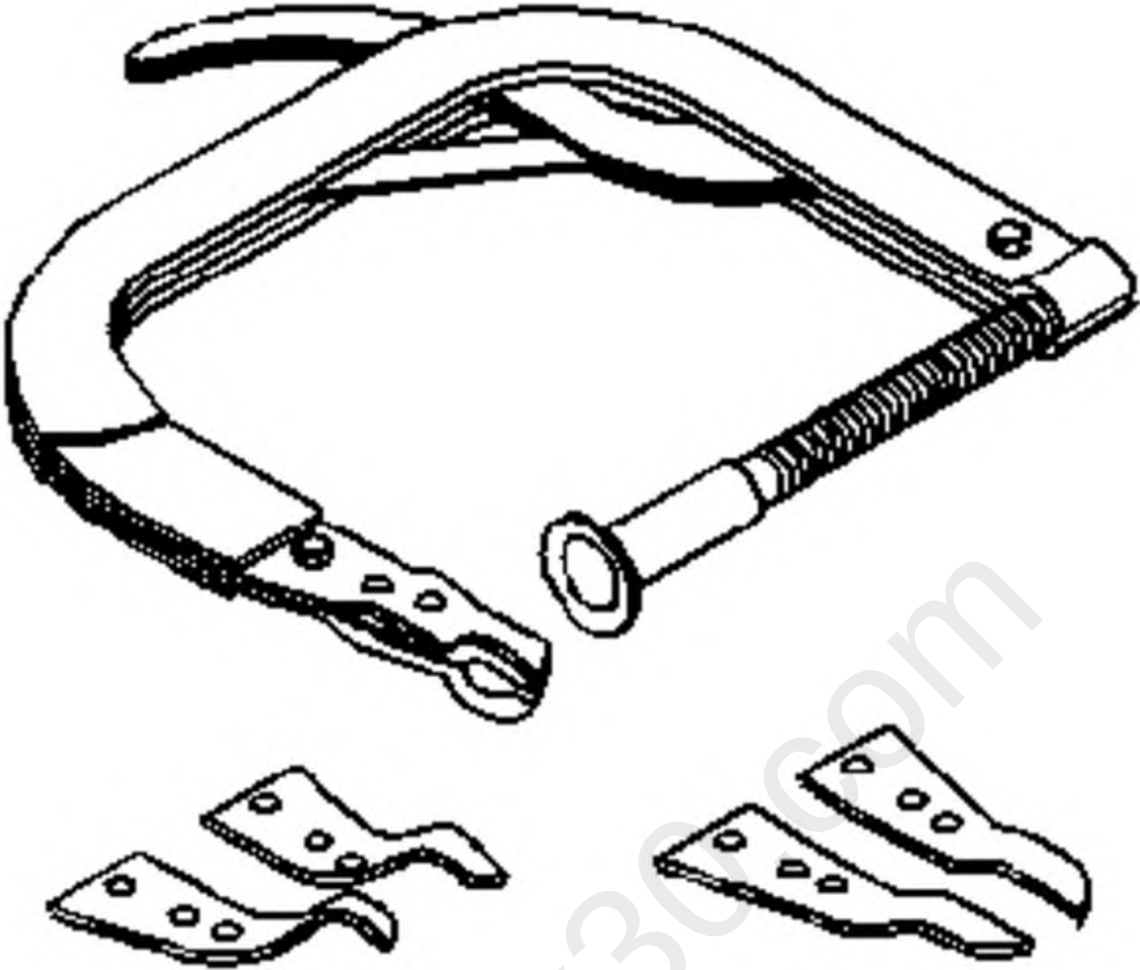
Illustration	Tool Number/ Description
 The illustration shows a valve spring compressor tool, which consists of a C-shaped frame with a threaded rod and a conical spring. The tool is used to compress the valve spring of an engine. Below the main tool, there are four small, irregularly shaped metal plates, each with three holes, which are likely used as spacers or guides during the compression process.	EN-8062 J-8062 KM-348 09916-14510 Valve Spring Compressor - Head Off

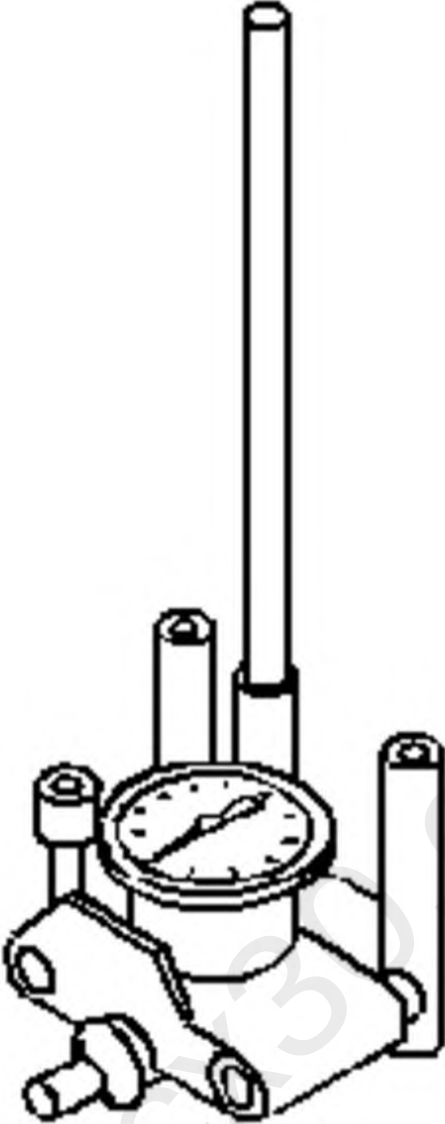
Illustration	Tool Number/ Description
	EN-8087 J-8087 Cylinder Bore Gauge

Illustration	Tool Number/ Description
 A blue compression gauge adapter. It features a circular gauge face with a needle and scale. A curved hose is attached to the bottom of the gauge, ending in a fitting. The entire tool is rendered in a solid blue color.	EN-26999 J - 26999 Compression Gauge Adapter

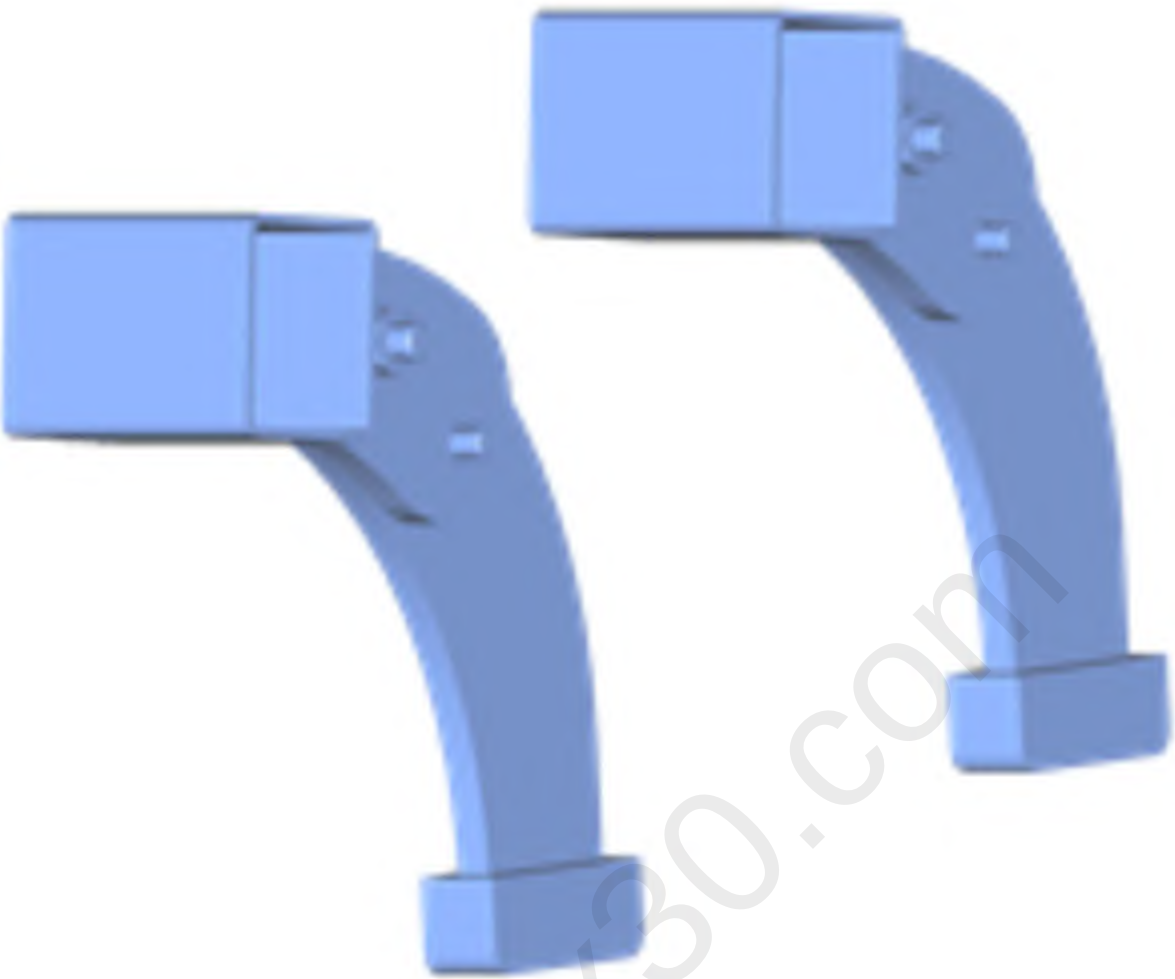
Illustration	Tool Number/ Description
	EN-28467-300 EN-51007-5 Engine Support Fixture Adapter

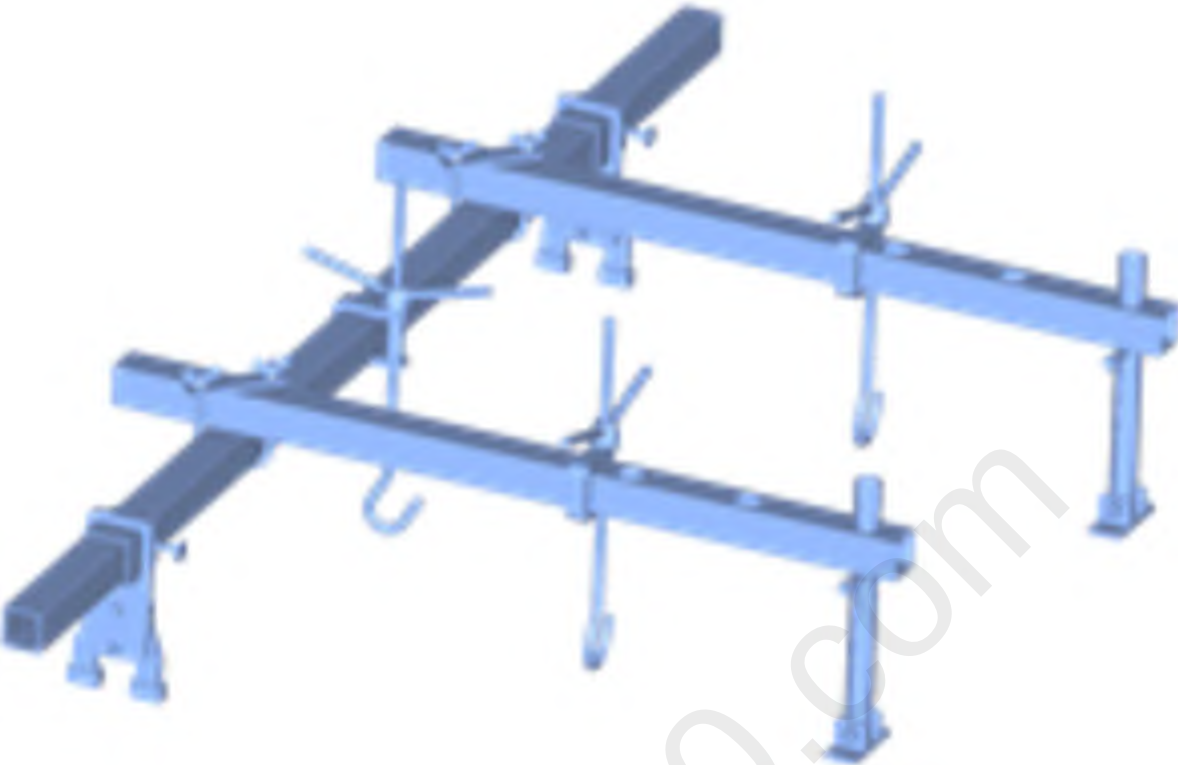
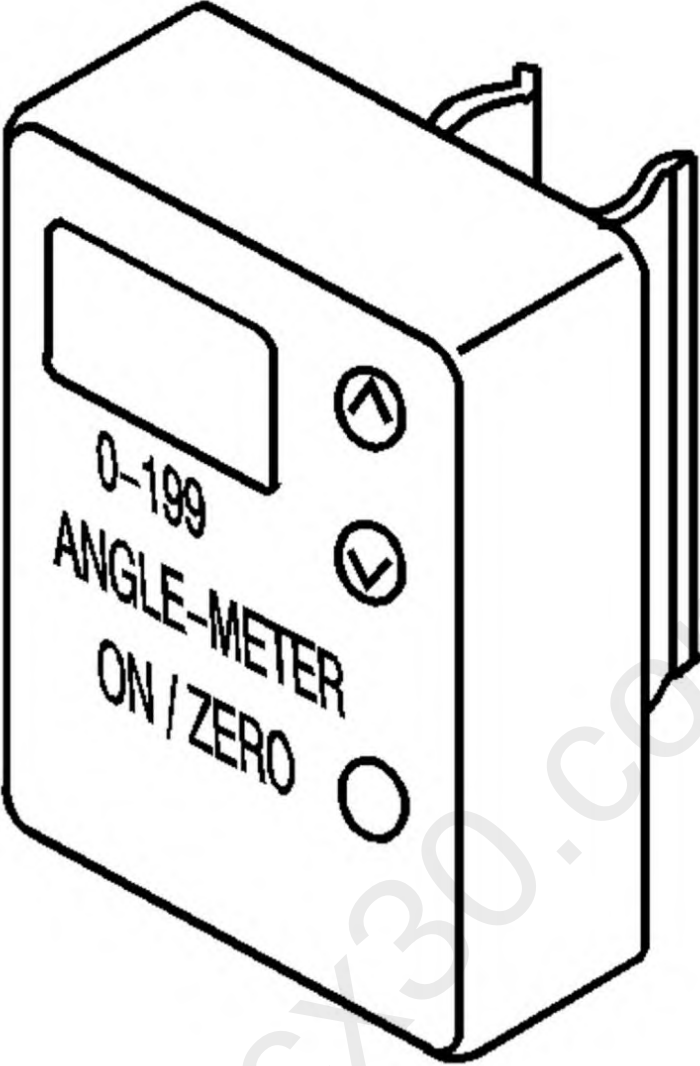
Illustration	Tool Number/ Description
	EN-28467-B J-28467-B EN-51007 Universal Engine Support Fixture

Illustration	Tool Number/ Description
	EN-35667-A J - 35667-A Cylinder Head Leakdown Tester

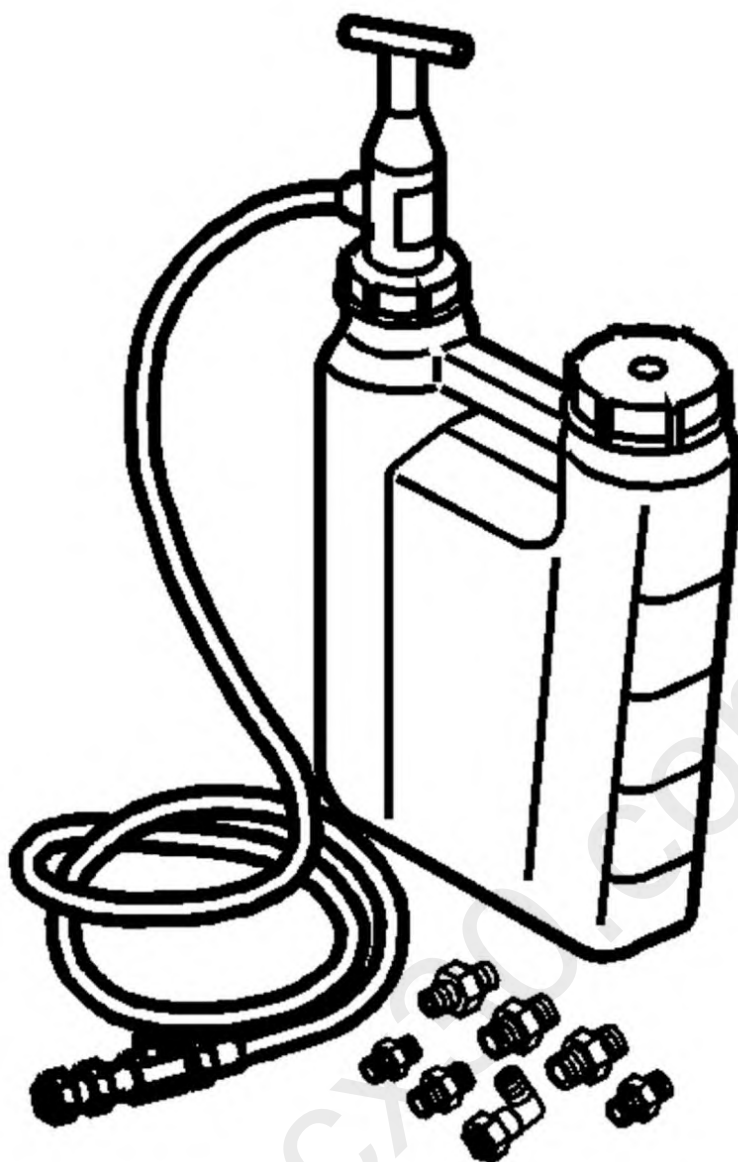
Illustration	Tool Number/ Description
	EN-36857 J-36857 Engine Lift Bracket

Illustration	Tool Number/ Description
	EN-42183 J-42183 Driver Handle

Illustration	Tool Number/ Description
	EN-45059 J - 45059 KM-470-B Angle Meter South America and Thailand - Use Local Equivalent

Illustration

Tool Number/
Description



EN-45299
J - 45299
Engine Pre-Luber

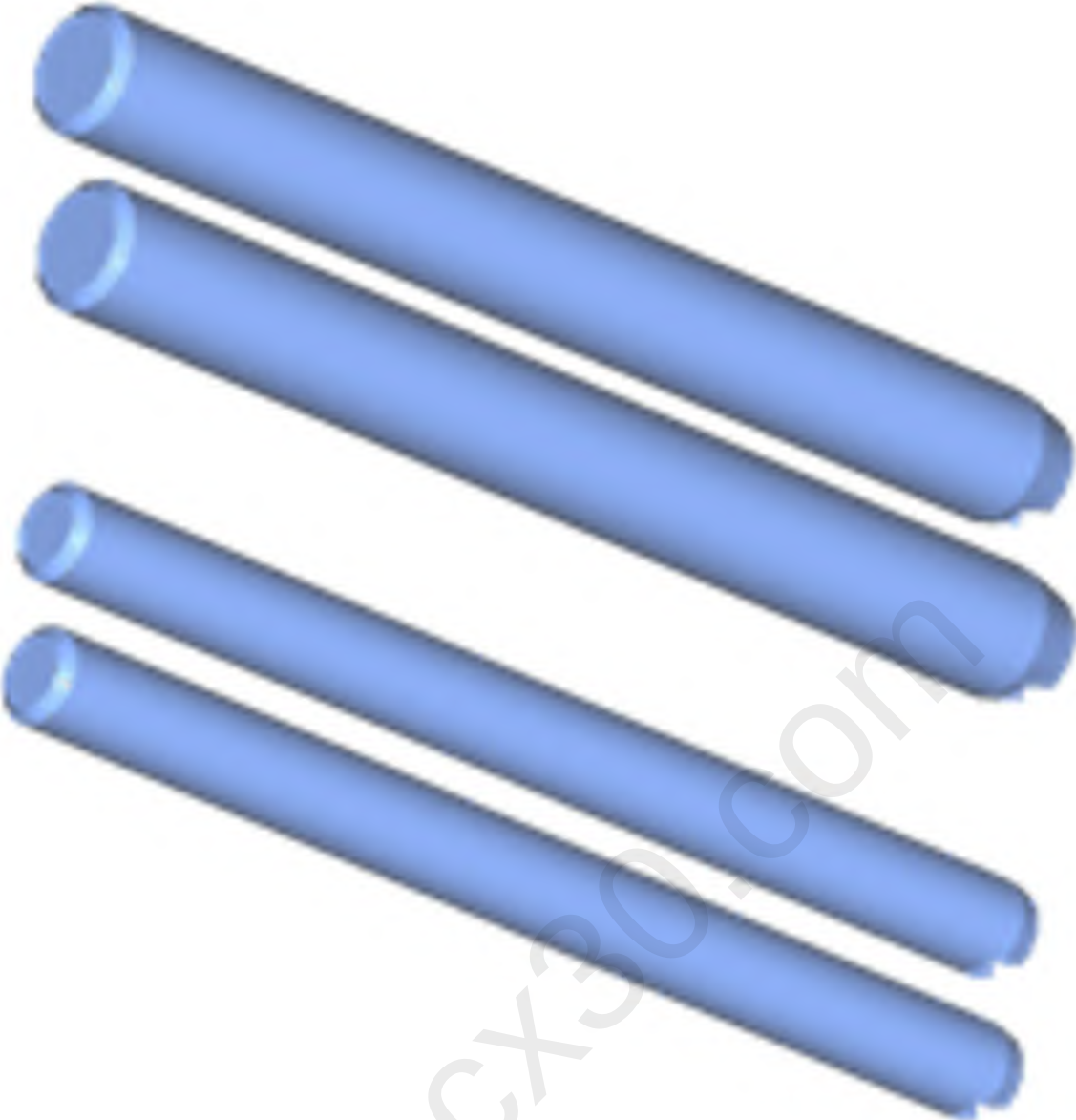
Illustration	Tool Number/ Description
 The illustration shows four identical blue cylindrical guide pins. They are arranged in a parallel, diagonal pattern, sloping downwards from left to right. Each pin has a slightly wider, flanged end on the right side. A large, light gray watermark 'mcx30.com' is oriented diagonally across the entire page, passing through the pins.	EN-46109 Engine Front Cover Installation Guide Pins

Illustration	Tool Number/ Description
 A blue-handled valve stem seal remover/installer tool. The tool features a long, thin metal shaft with a specialized tip designed for accessing and working on valve stem seals. The handles are made of blue plastic and are ergonomically shaped for grip. A watermark 'mcx30.com' is visible diagonally across the image.	EN-46116 Valve Stem Seal Remover/Installer

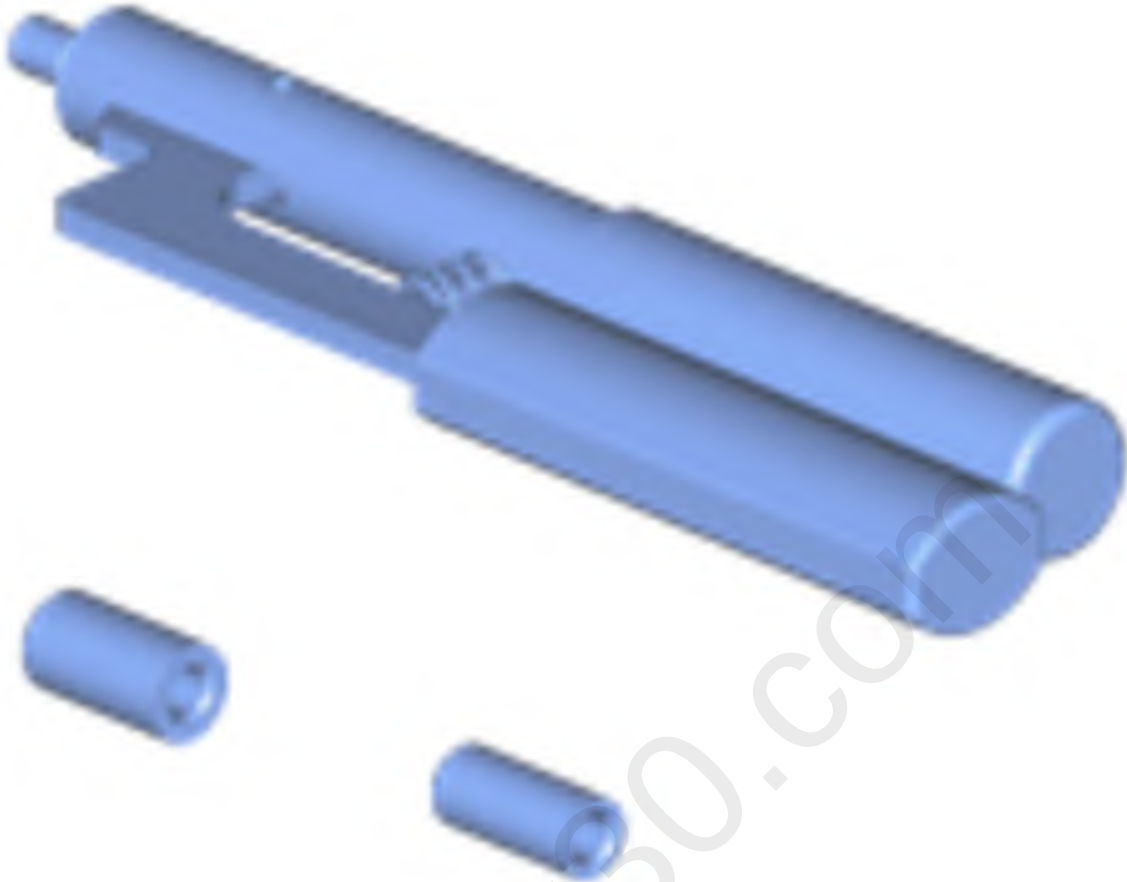
Illustration	Tool Number/ Description
	EN-46745 Piston Pin Clip Remover/Installer

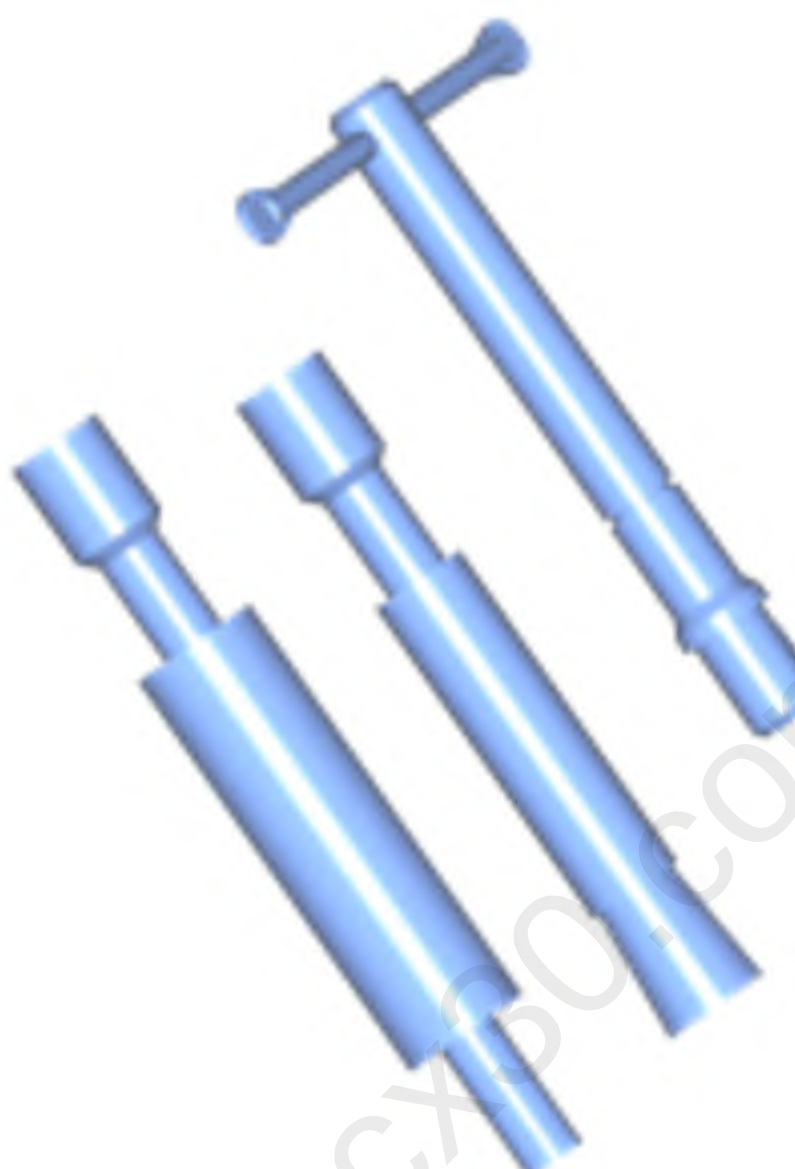
Illustration	Tool Number/ Description
 The illustration shows three blue metal tools used for injector cleaning. The top tool is a long rod with a T-handle at one end. The middle tool is a long rod with a sleeve attached to one end. The bottom tool is a shorter rod with a sleeve attached to one end. A large, light gray watermark 'mcx360.com' is diagonally across the image.	EN-47909 Injector Bore and Sleeve Cleaning Kit

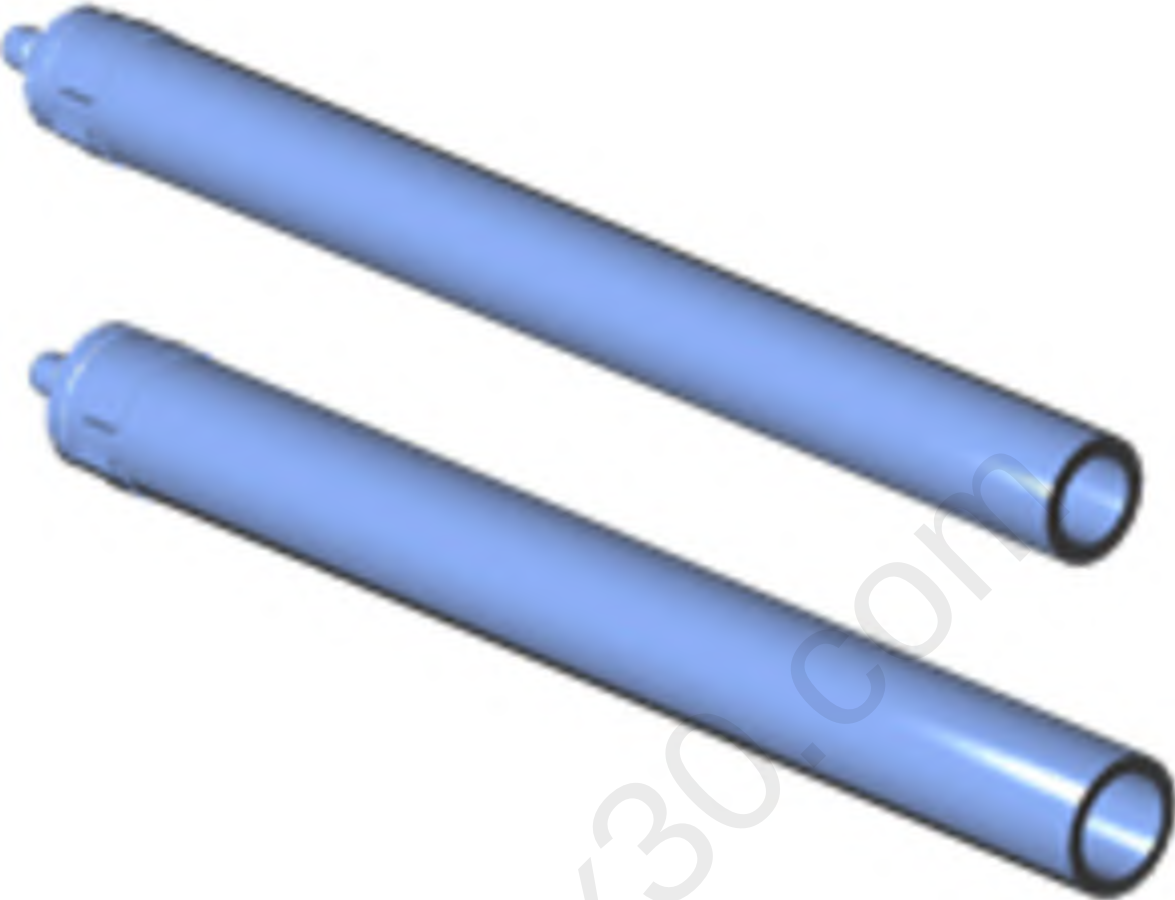
Illustration	Tool Number/ Description
 The illustration shows two identical blue cylindrical components, which are part of an EGR Cooler Pressure Tester Adapter Set. Each component has a threaded cap on one end and a smooth, open cylindrical body. They are positioned diagonally, one above the other.	EN-48974 EGR Cooler Pressure Tester Adapter Set

Illustration	Tool Number/ Description
	EN-50025 Pulley Holding Wrench

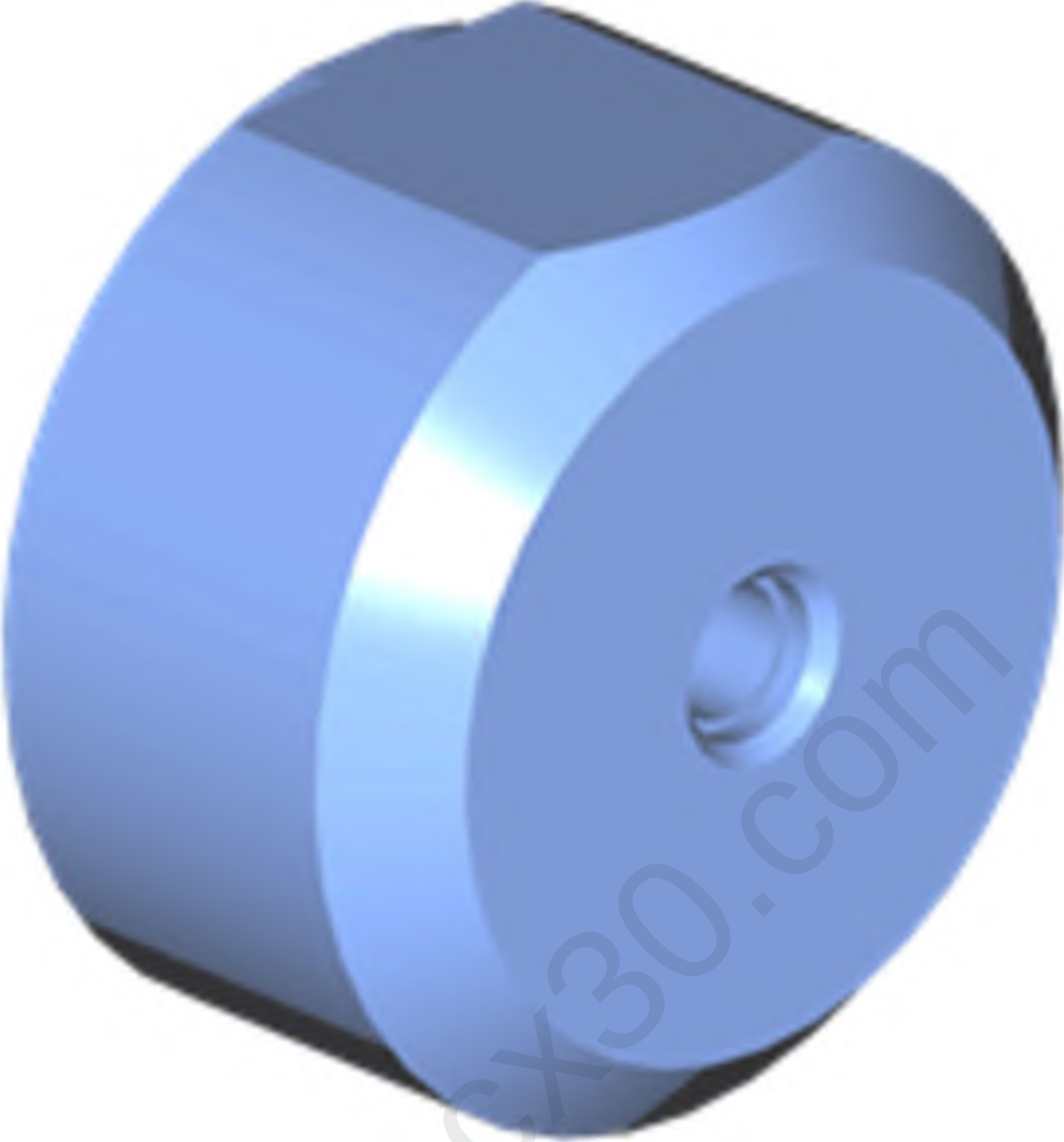
Illustration	Tool Number/ Description
	EN-50026 Rear Main Seal Installer

Illustration	Tool Number/ Description
	DT-51265 Crankshaft Locking Tool

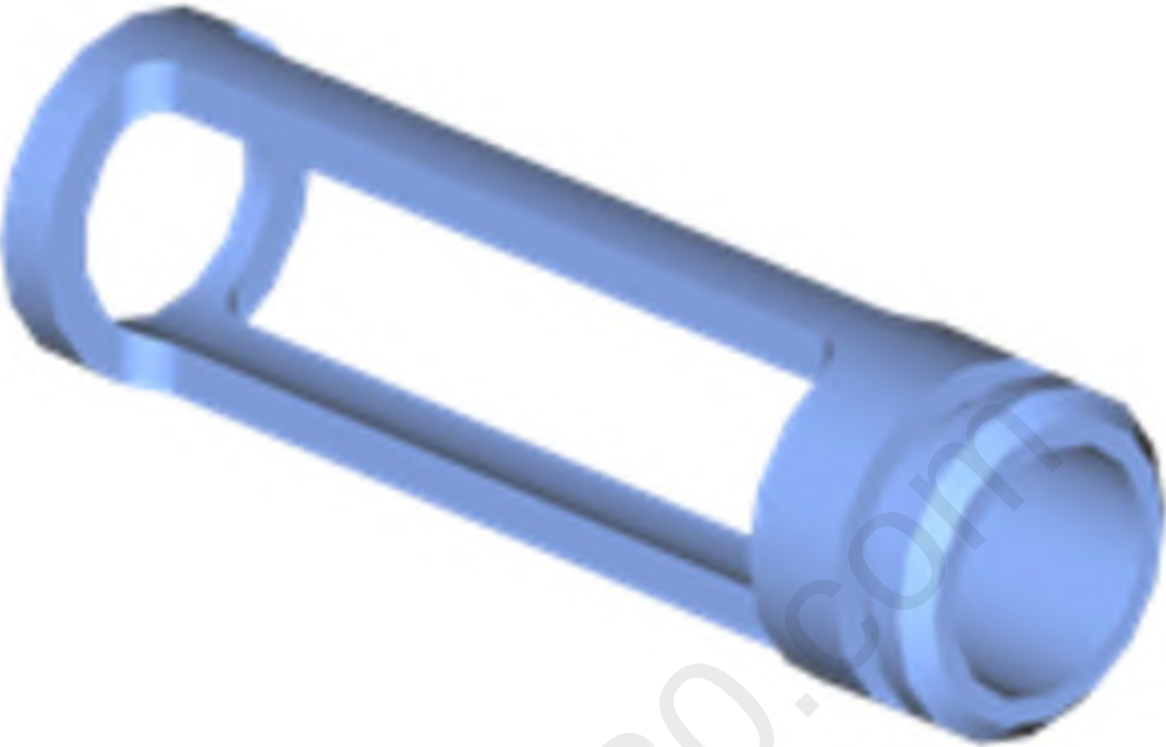
Illustration	Tool Number/ Description
	EN-50031 Valve Spring Compressor (off- vehicle)

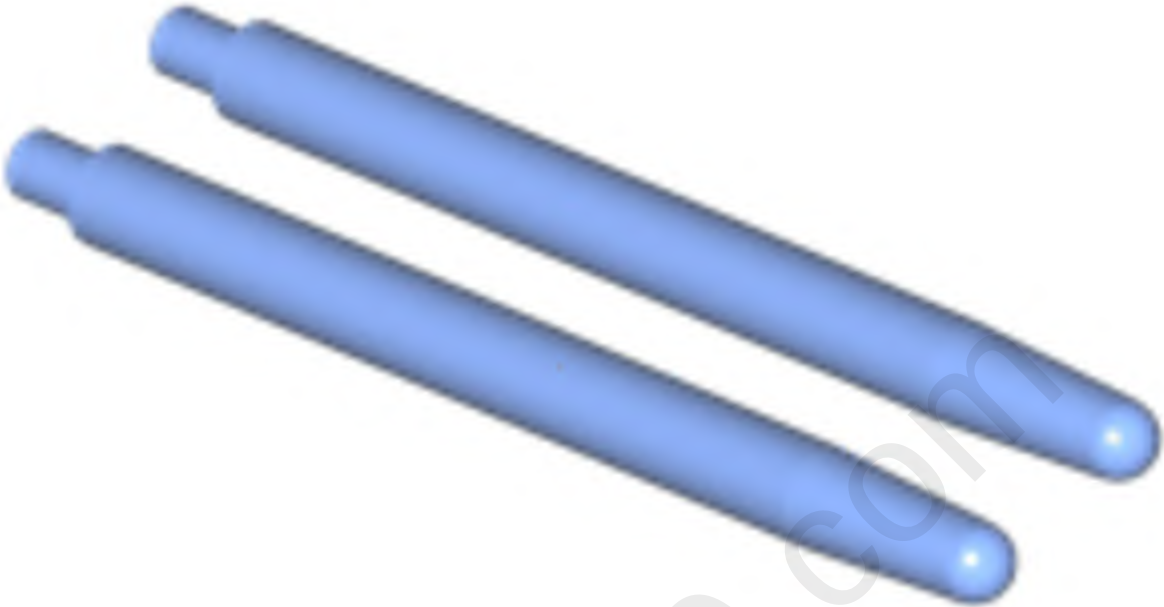
Illustration	Tool Number/ Description
 The illustration shows two blue, cylindrical connecting rod guides. They are positioned diagonally, with one slightly above and to the right of the other. Each guide has a slightly wider, flanged end on the left. A large, light gray watermark 'mcx30.com' is oriented diagonally across the entire page, passing through the illustration.	EN-50034 Connecting Rod Guides

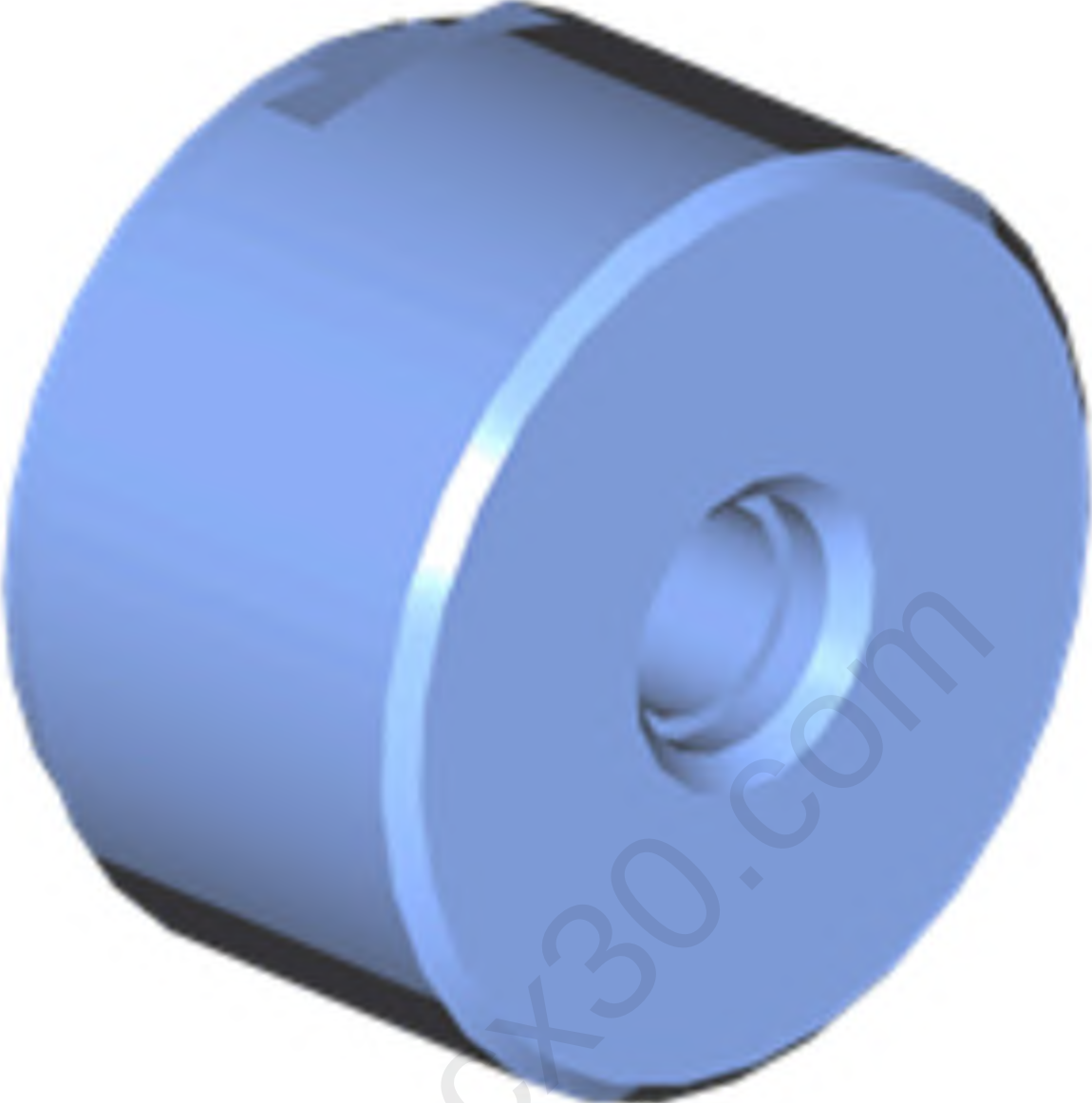
Illustration	Tool Number/ Description
	EN-50718 Crankshaft Front Seal Installer

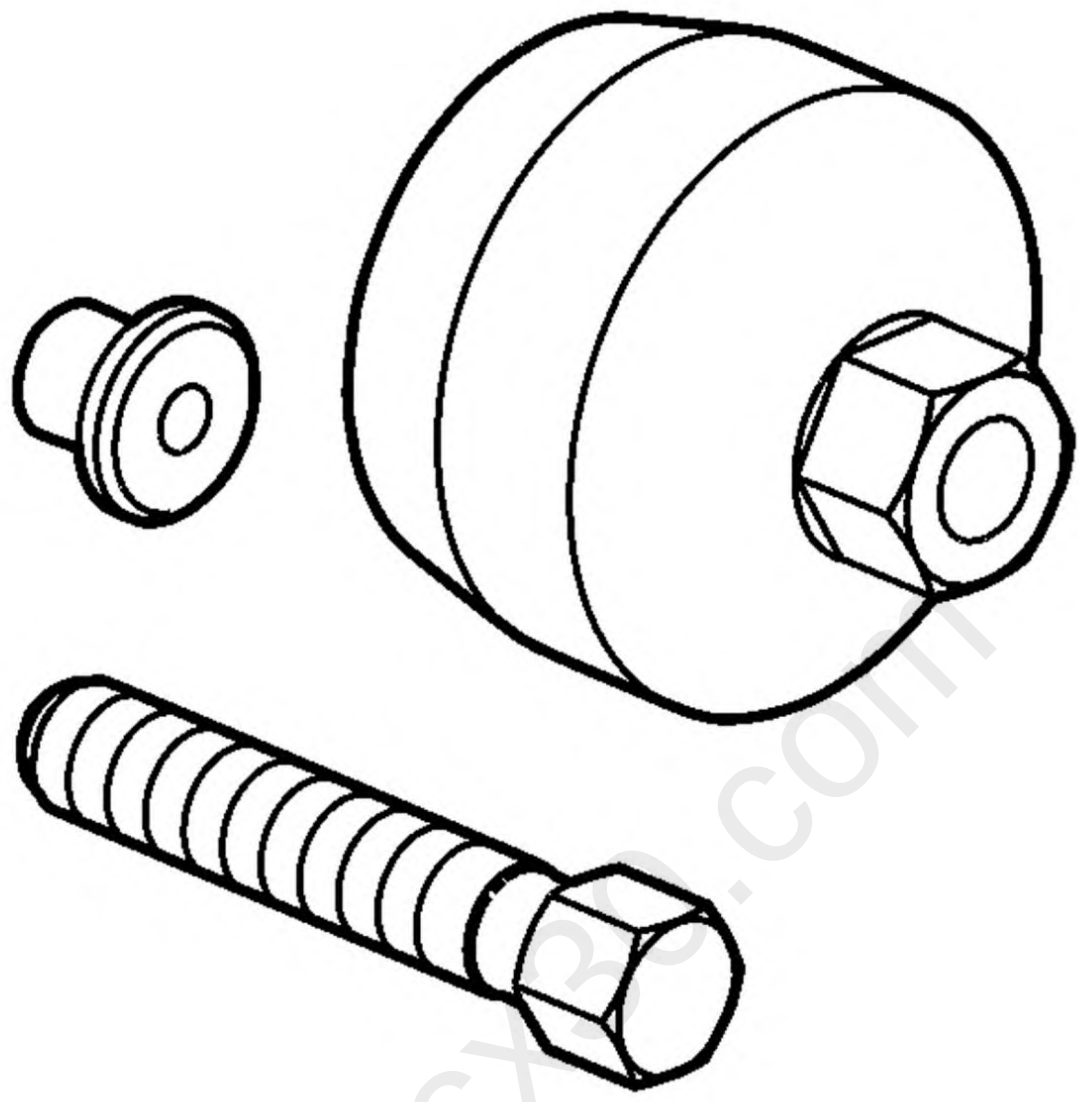
Illustration	Tool Number/ Description
	EN-50719 Crankshaft Front Oil Seal Remover

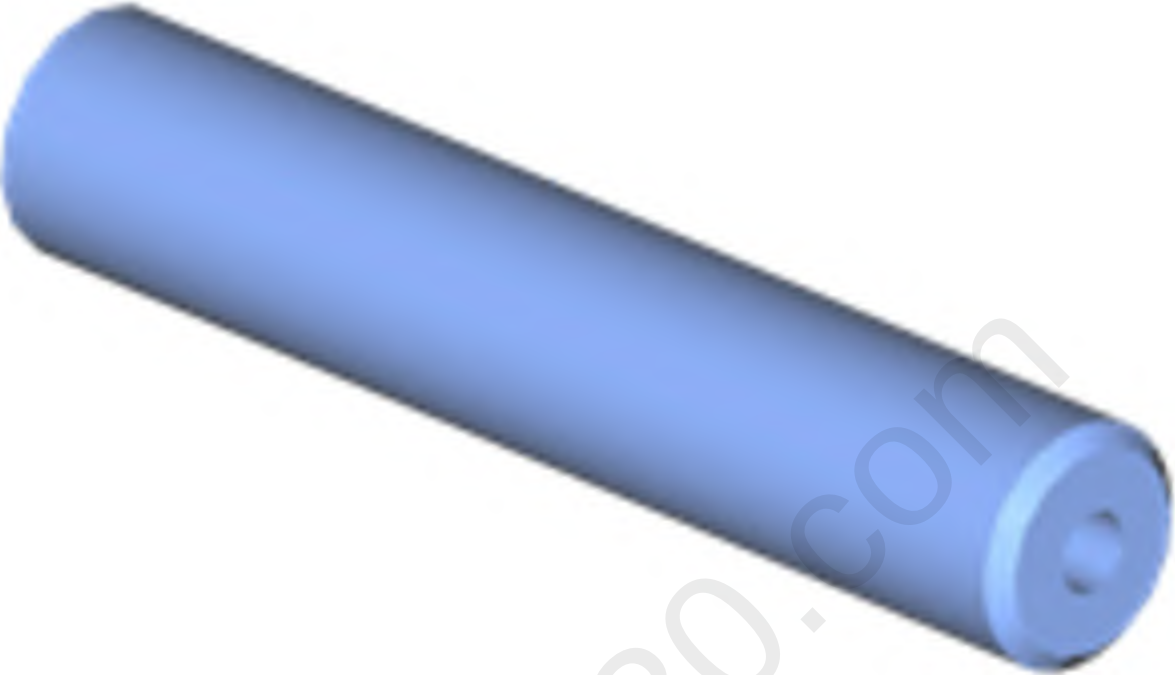
Illustration	Tool Number/ Description
	EN-50723 Valve Seal Installer

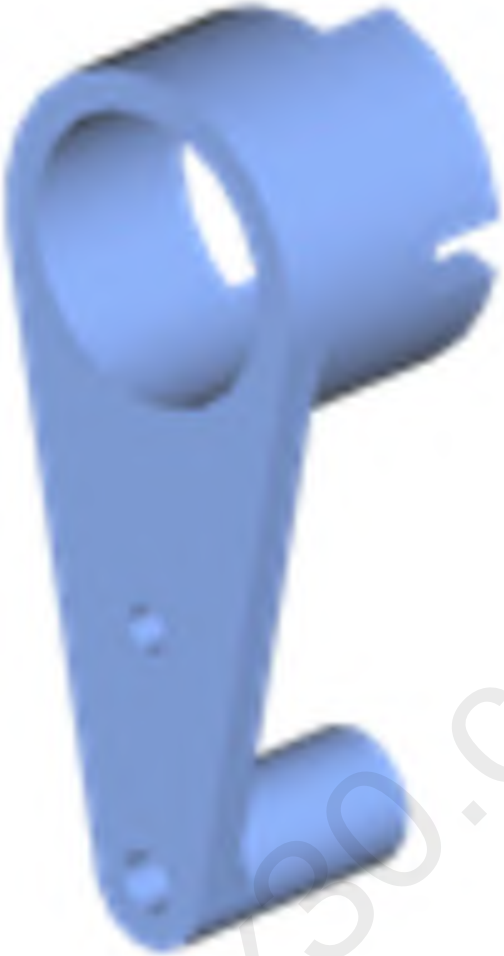
Illustration	Tool Number/ Description
	EN-51025 Camshaft Timing Tool

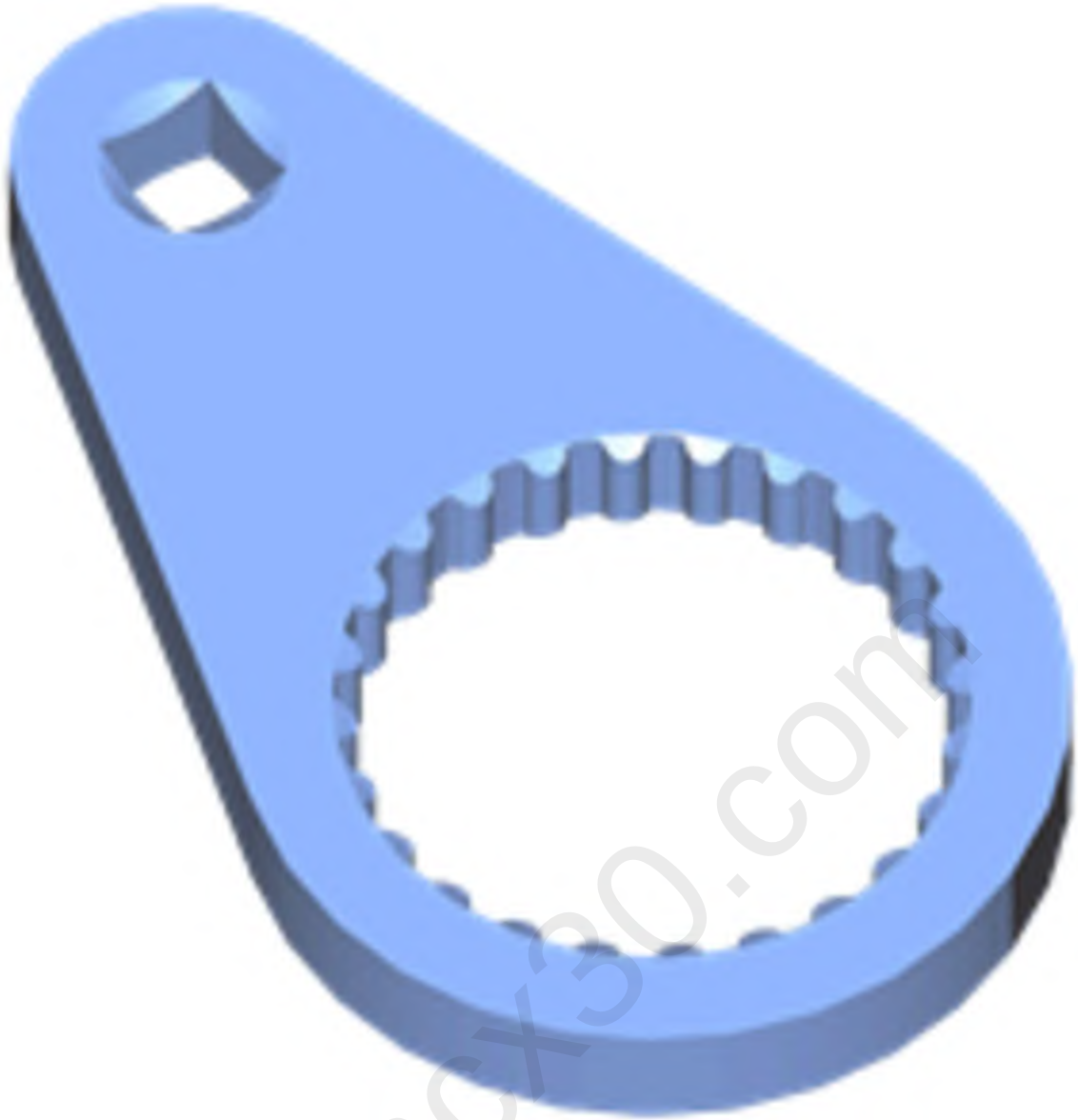
Illustration	Tool Number/ Description
 A 3D CAD model of a blue mechanical part, identified as an injection pump sprocket holder. The part has a generally U-shaped profile with a rounded outer edge. At the top left, there is a square-shaped hole. The central feature is a large circular opening with a gear-like or splined inner edge, designed to fit over a sprocket. The part is shown from an isometric perspective with soft shadows.	EN-51104 Injection Pump Sprocket Holder

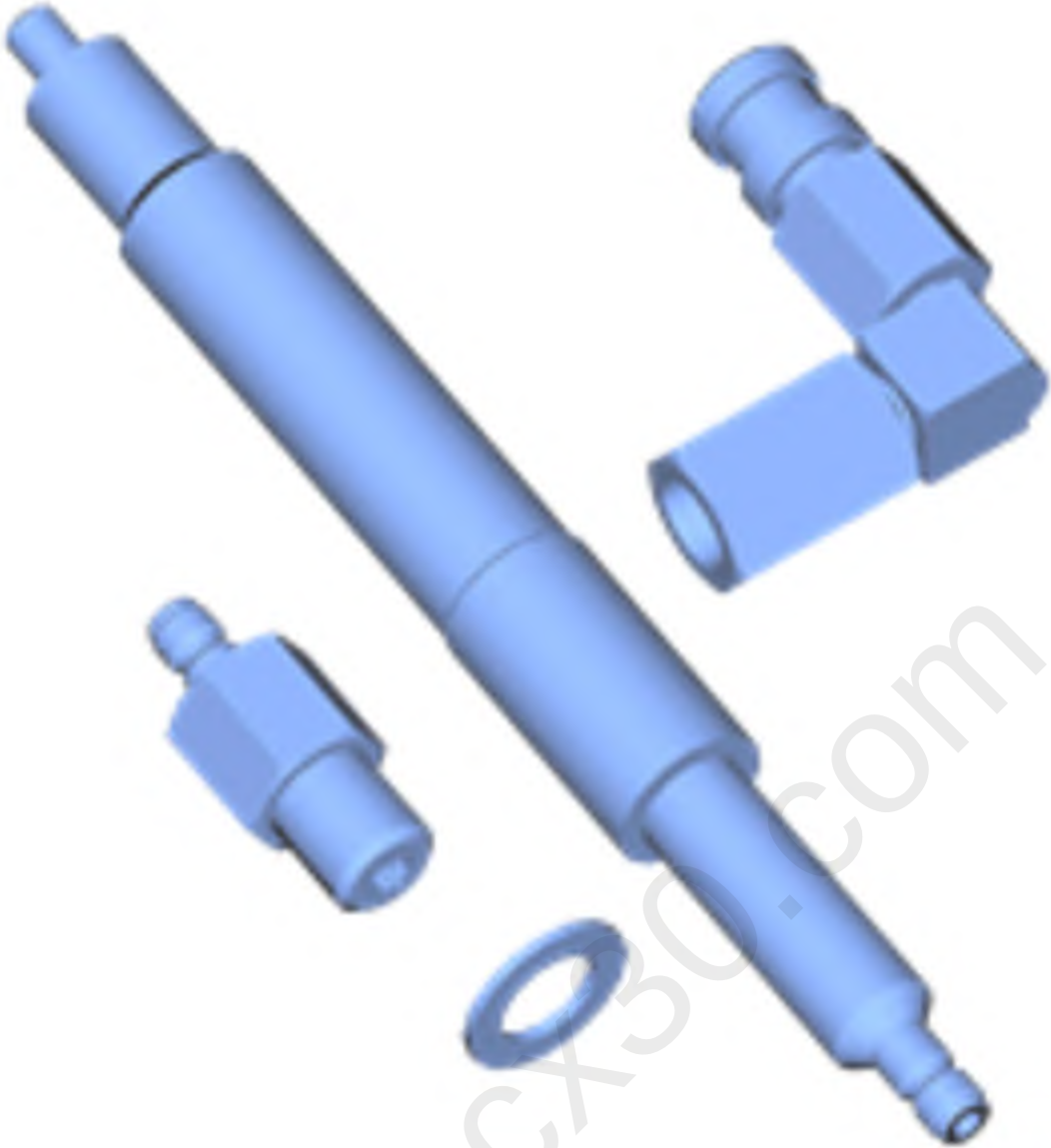
Illustration	Tool Number/ Description
	EN-51110 Compression Tester Adapter

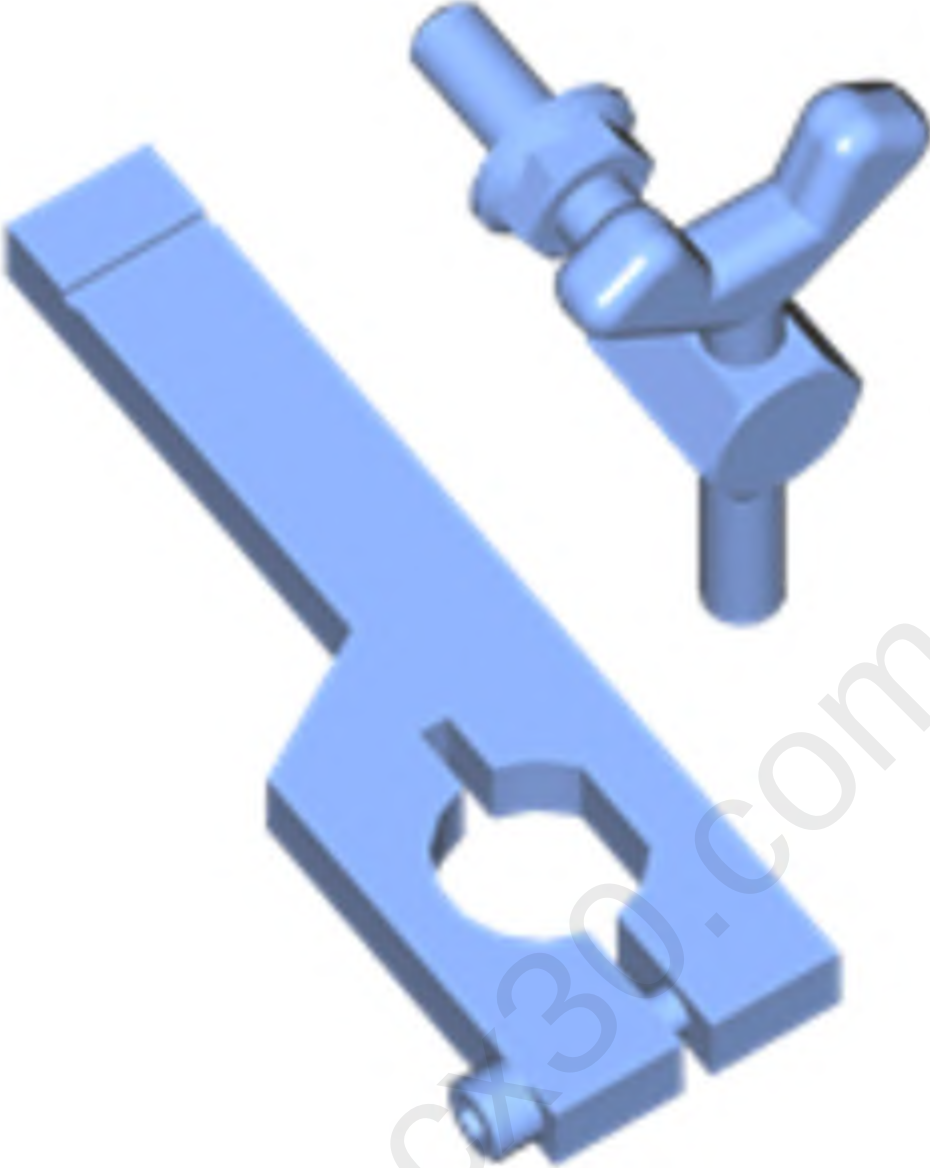
Illustration	Tool Number/ Description
	EN-51162 Balance Shaft Backlash Adapter

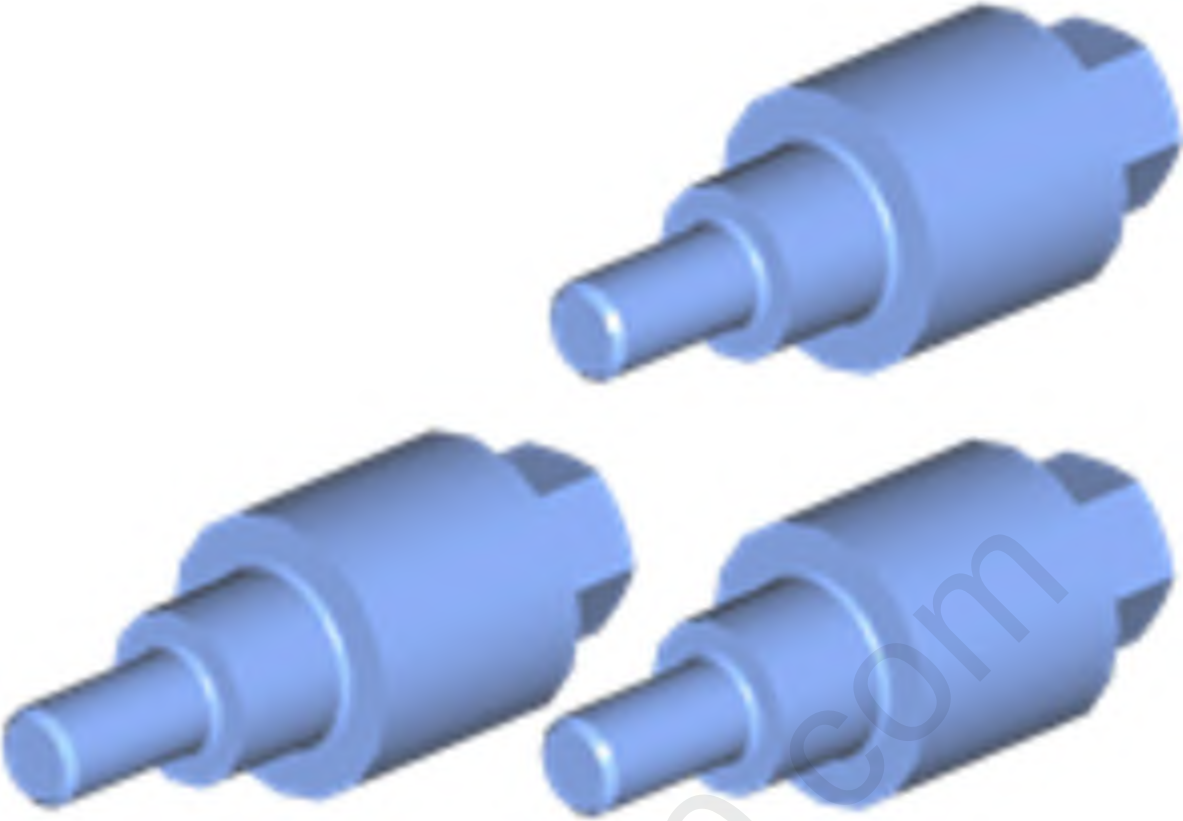
Illustration	Tool Number/ Description
	EN-51768 Engine Support Fixture Adapter Bolts M8

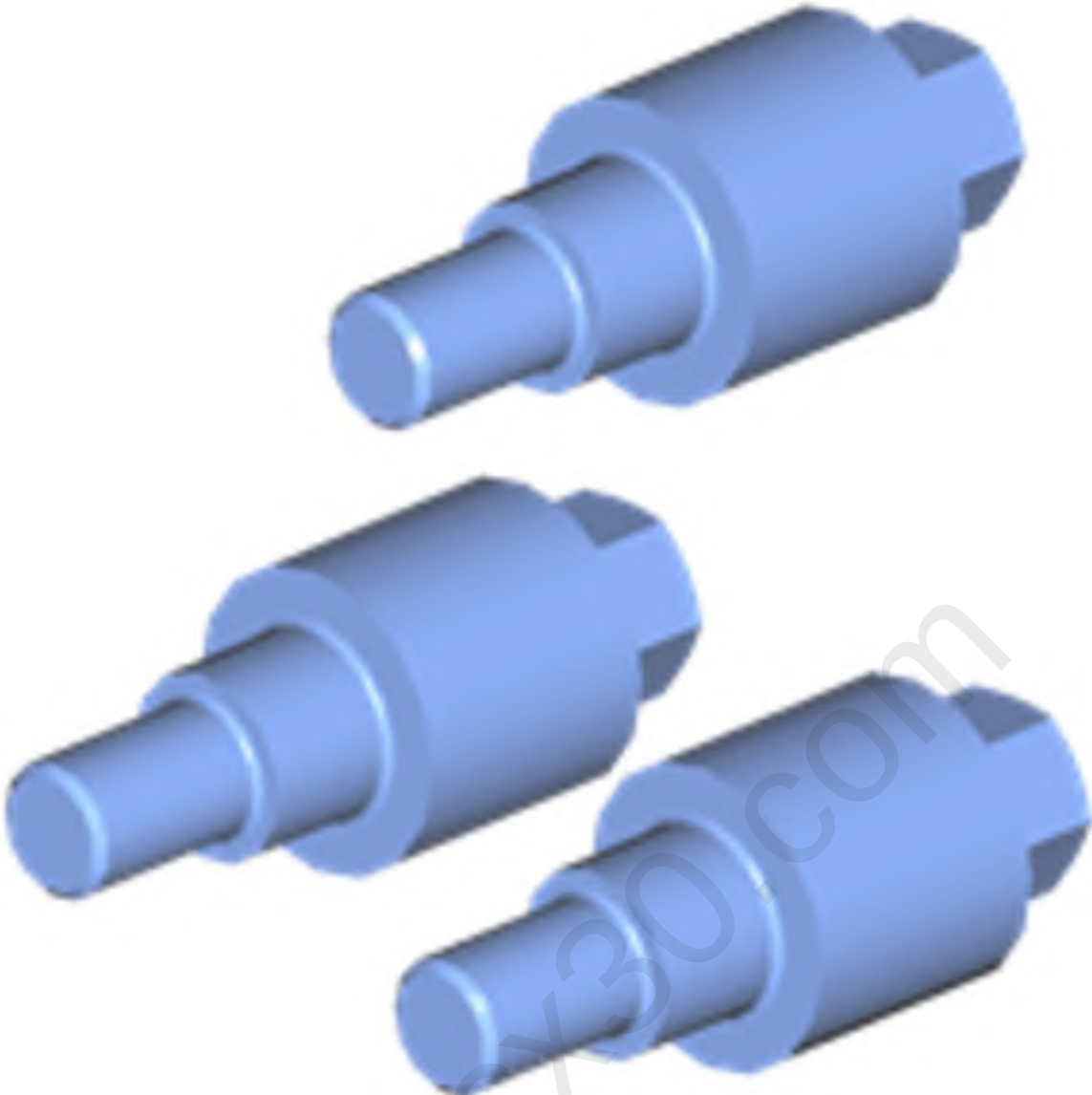
Illustration	Tool Number/ Description
	EN-52059 Engine Support Fixture Adapter Bolts M10

Illustration	Tool Number/ Description
 An exploded view diagram of the EN-52287 Balancer Holding Tool. The assembly consists of several components: a large cylindrical housing with a central bore and four mounting holes; a circular plate with a central hole and eight smaller holes around its perimeter; a rectangular base plate; and numerous pins, bolts, and washers. The components are arranged in a way that shows their relative positions and how they fit together. A watermark 'mcx30.com' is visible across the image.	EN-52287 Balancer Holding Tool

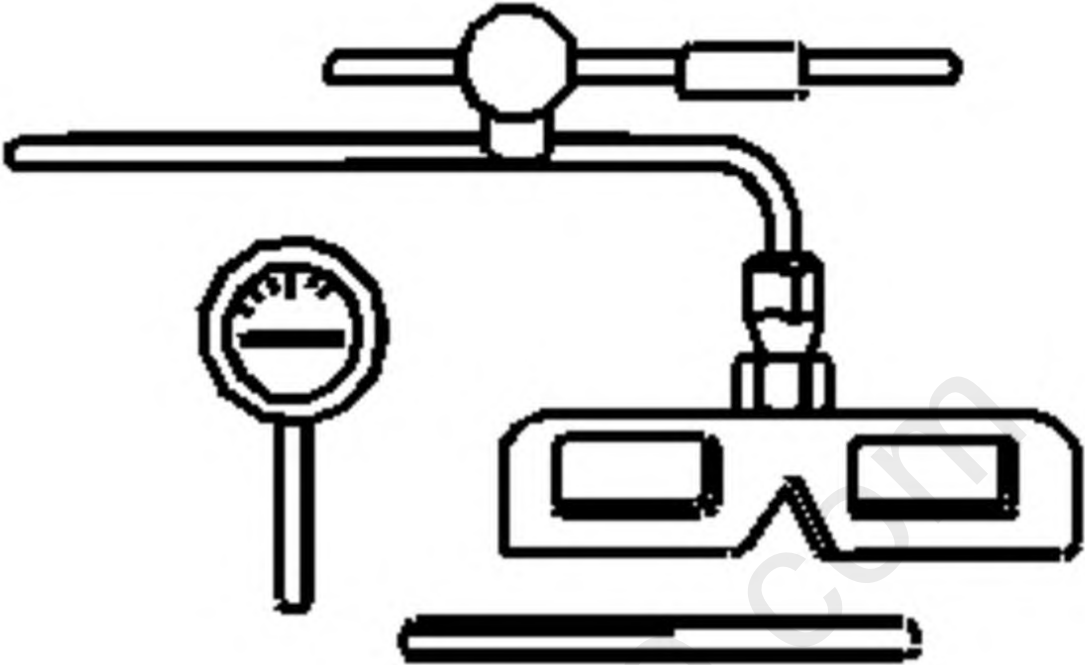
Illustration	Tool Number/ Description
	GE-7872 J-7872 Magnetic Base Dial Indicator

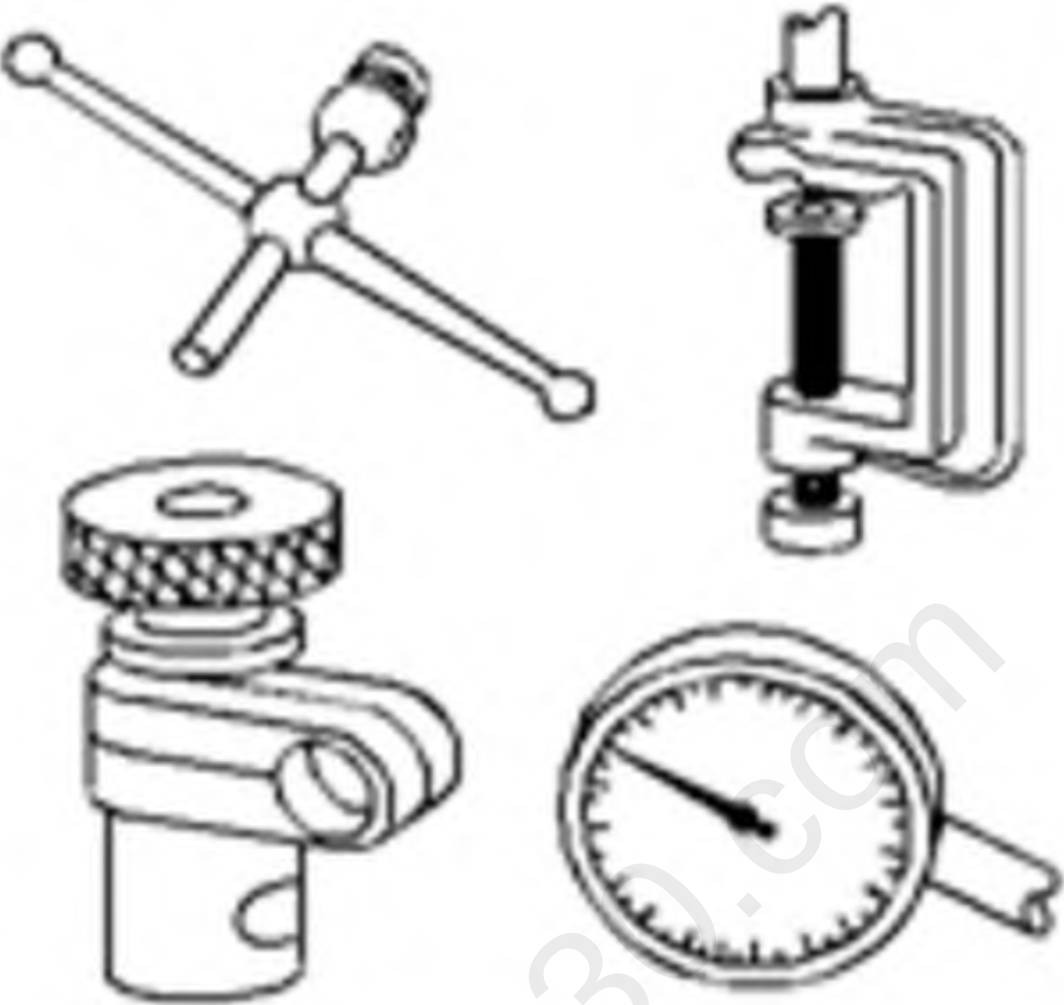
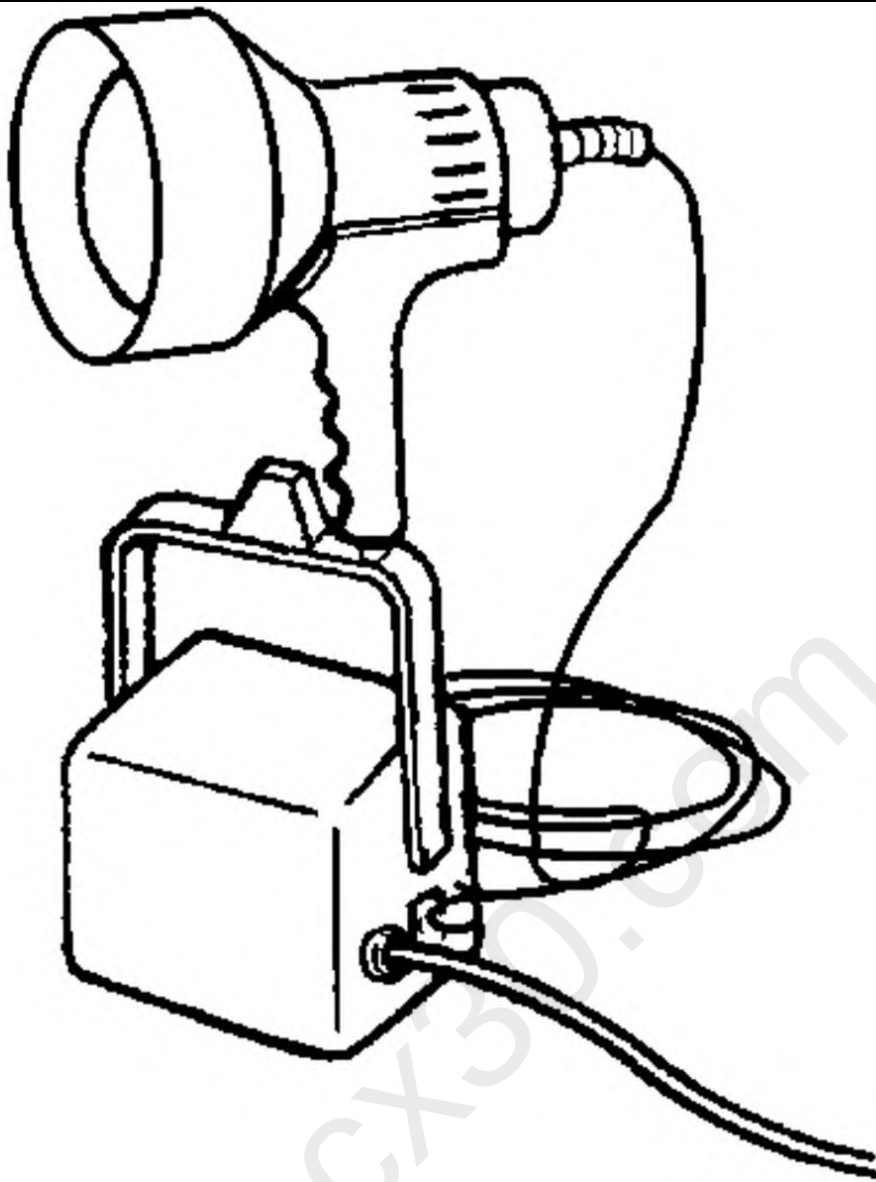
Illustration	Tool Number/ Description
 The illustration contains four technical line drawings of tools. In the top left is a three-armed star wrench with a central hexagonal body and three long, thin arms ending in rounded tips. In the top right is a C-clamp with a U-shaped frame, a threaded rod, and a conical foot. In the bottom left is a depth gauge consisting of a cylindrical base, a horizontal beam with a locking screw, and a circular graduated scale. In the bottom right is a dial indicator with a circular dial face showing a needle and scale, and a long, thin cylindrical rod extending from the back. A large, light-gray watermark 'mcx33.com' is oriented diagonally across the center of the illustration area.	J-8001 Dial Indicator Set

Illustration	Tool Number/ Description
	J-26900-13 Magnetic Indicator Base

Illustration

**Tool Number/
Description**



J-28428-E
High-Intensity
Black Light Kit

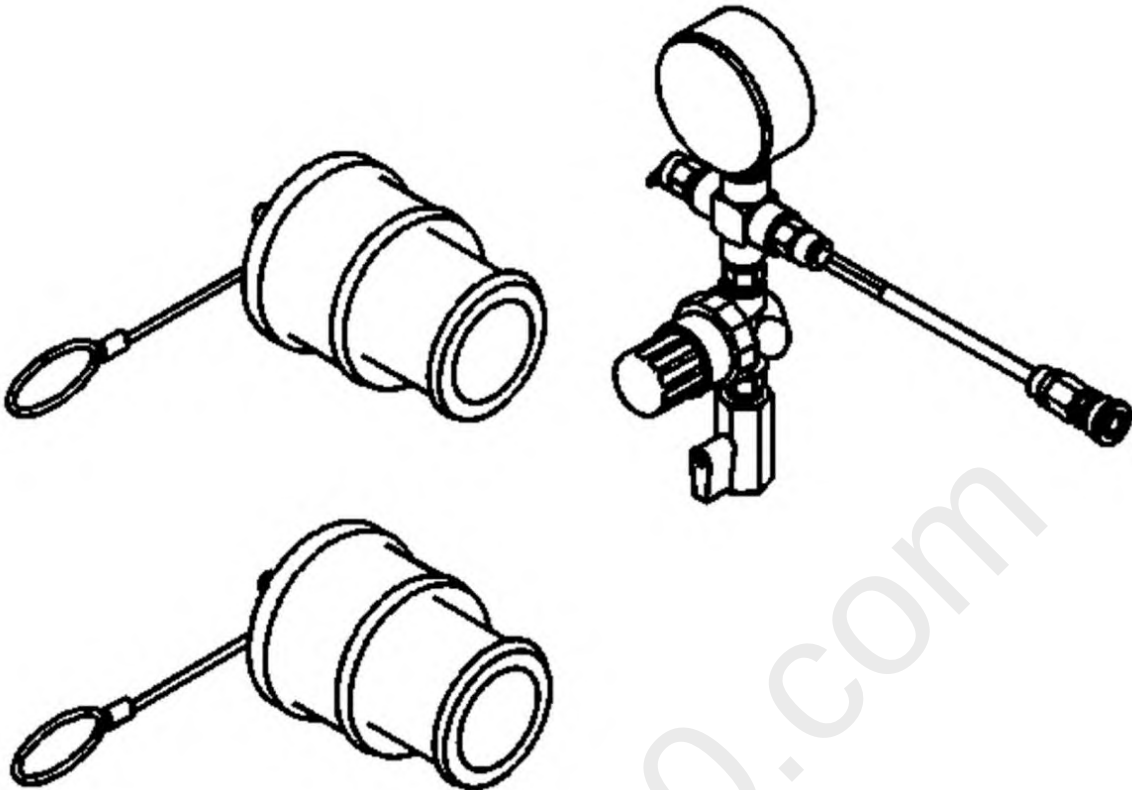
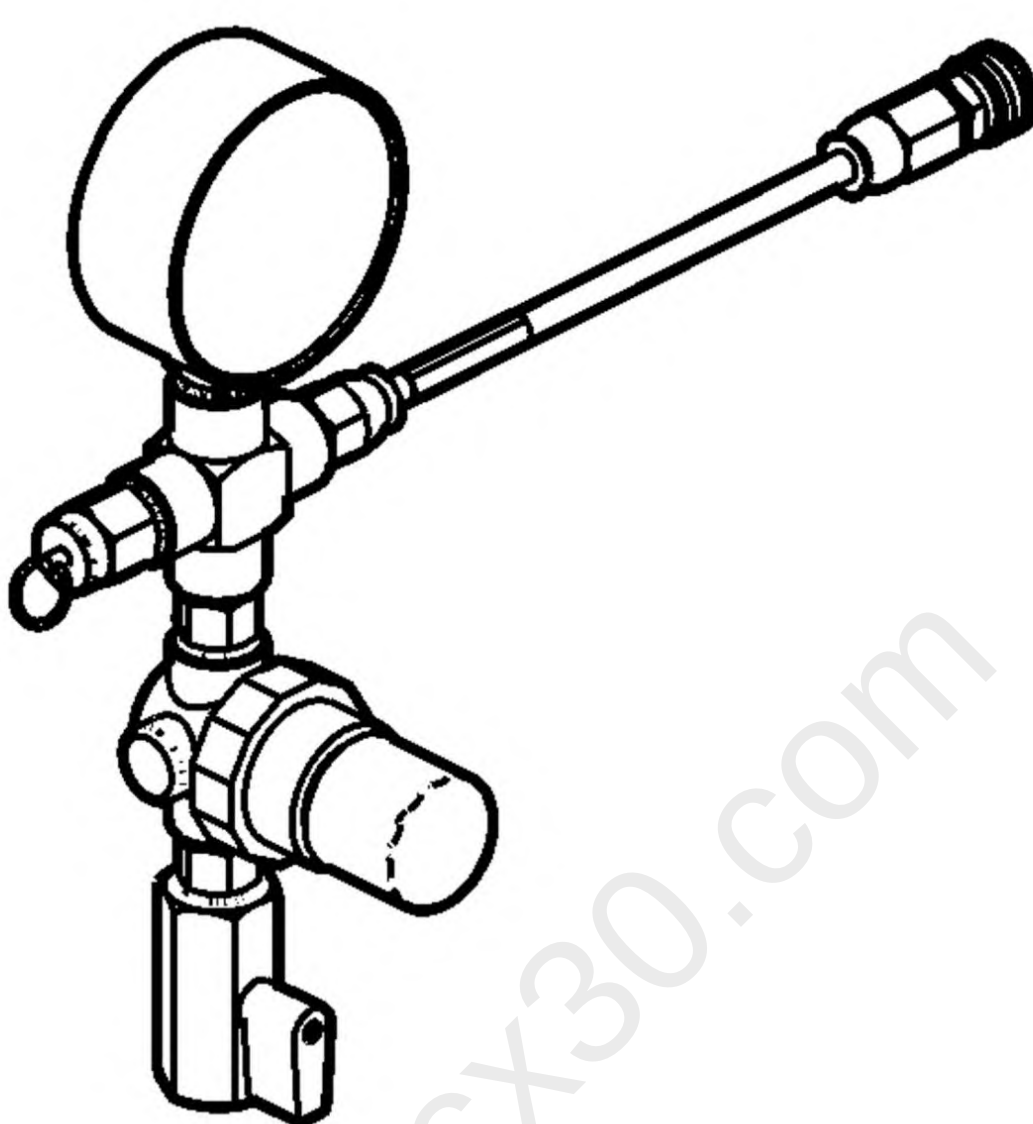
Illustration	Tool Number/ Description
	J-46091 Charge Air Cooler Tester

Illustration	Tool Number/ Description
	J-46901-1 Charge Air Cooler Tester